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# The 6th International Conference on Atmosphere, Ocean and Climate Change

## 第六屆大氣、海洋及氣候變化國際會議

### 日期 Date

2013年8月19日至21日(星期一至星期三)
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香港中文大學
The Chinese University of Hong Kong

### 專題研討 Thematic Session

- 氣候變化和應對方法 Climate Change and Our Actions
- 亞洲季風 Asian Monsoon
- 氣溶膠與氣候 Aerosol and Climate
- 雲與降水 Cloud and Precipitation
- 天氣預報及數值同化 Weather Forecasting and Data Assimilation
- 海洋，海氣交互作用和氣候 Ocean, Air-Sea Interactions and Climate
- 氣候變率與模擬 Climate Variability and Modeling
- 遙感觀測 Remote Sensing

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GEOGRAPHY & RESOURCE MANAGEMENT 地理與資源管理學系

香港氣象學會 Hong Kong Meteorological Society

# The Proceedings for

## The 6th International Conference on Atmosphere, Ocean, and Climate Change

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**Dr. Banghua Yan**

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**Prof. Zhanqing Li**

**Dr. Jingfeng Huang**


## EFFECTS OF AIR-SEA COUPLING ON THE BOREAL SUMMER INTRASEASONAL OSCILLATIONS OVER THE TROPICAL INDIAN OCEAN

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Abstract

The effects of air-sea coupling over the tropical Indian Ocean (TIO) on the eastward- and northward-propagating boreal summer intraseasonal oscillation (BSISO) are investigated by comparing a fully coupled (CTL) and a partially decoupled Indian Ocean (pdIO) experiment using SINTEX-F coupled GCM. Air-sea coupling over the TIO significantly enhances the intensity of both the eastward and northward propagations of the BSISO. The maximum spectrum differences of the northward- (eastward-) propagating BSISO between the CTL and pdIO reach 30% (25%) of their respective climatological values. The enhanced eastward (northward) propagation is related to the zonal (meridional) asymmetry of sea surface temperature anomaly (SSTA). A positive SSTA appears to the east (north) of the BSISO convection, which may positively feed back to the BSISO convection. In addition, air-sea coupling may enhance the northward propagation through the changes of the mean vertical wind shear and low-level specific humidity. The interannual variations of the TIO regulate the air-sea interaction effect. Air-sea coupling enhances (reduces) the eastward-propagating spectrum during the negative Indian Ocean dipole (IOD) mode, positive Indian Ocean basin (IOB) mode and normal years (during positive IOD and negative IOB years). Such phase dependence is attributed to the role of the background mean westerly in affecting the wind-evaporation-SST feedback. A climatological weak westerly in the equatorial Indian Ocean can be readily reversed by anomalous zonal SST gradients during the positive IOD and negative IOB events. Although the SSTA is always positive to the northeast of the BSISO convection for all interannual modes, air-sea coupling reduces the zonal asymmetry of the low-level specific humidity and thus the eastward propagation spectrum during the positive IOD and negative IOB modes, while strengthening them during the other modes. Air-sea coupling enhances the northward propagation under all interannual modes due to the persistent westerly monsoon flow over the northern Indian Ocean.

## IMPROVEMENT OF AEROSOL RETRIEVAL NEAR BOUNDARY-LAYER CLOUDS

Alexander Marshak, NASA/Goddard Space Flight Center
Rob Levy, NASA/Goddard Space Flight Center
Lorraine Remer, University of Maryland Baltimore County
Norman Loeb, NASA/Langley Research Center
Tamas Varnai, University of Maryland Baltimore County
Robert F. Cahalan, NASA/Goddard Space Flight Center

Abstract

We apply a two-layer model to correct 3D cloud radiative effects on aerosol retrievals near boundary-layer clouds. This is the first time that this method is being applied to a full MODerate-resolution Imaging Spectroradiometer (MODIS) granule. The process of the correction includes converting Clouds and Earth's Radiant Energy System (CERES) broadband flux to visible narrowband flux, computing the clear-sky radiance enhancement, and retrieving aerosol properties. We find that the correction leads to smaller values in aerosol optical depth (AOD), the Ångström exponent, and the small mode aerosol fraction (SMAF) of the total AOD. It also makes the average aerosol particle size near clouds larger than far away from clouds, which is more realistic than the opposite behavior observed in operational retrievals. We discuss issues in the current correction method as well as our plans to validate the algorithm.

## THE WORLD CLIMATE RESEARCH PROGRAMME: GRAND CHALLENGES FOR THE DECADE AHEAD

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Abstract

The World Climate Research Programme was established in 1980 under the joint sponsorship of the World Meteorological Organization (WMO) and the International Council for Science (ICSU) and, since 1993, the Intergovernmental Oceanographic Commission (IOC) of UNESCO. The main objectives for the WCRP since its inception have been to determine the predictability of climate and to determine the effect of human activities on climate. These objectives are just as valid today as they were 30 years ago. In addition, since 2005 as part of WCRP?s strategic planning at the time, there has been an additional overlay to the program focusing on an increasing range of practical applications of climate research of direct relevance, benefit and value to society.

Over the past several years the sponsors of the WCRP have started several new strategic initiatives. In 2009 in Geneva the WMO sponsored the World Climate Conference 3. The outcomes of which was the decision to establish a Global Framework for Climate Services to strengthen production, availability, delivery and application of science-based climate prediction and services. Three weeks after the World Climate Conference, under the auspices of the IOC, the oceanographic community convened in Venice for Ocean Obs 09 to strengthen and enhance the international framework for sustained world ocean observing and information systems supporting the needs of society about ocean weather, climate, ecosystems, carbon and chemistry. Looking to the future, ICSU initiated an Earth System visioning process, together with the scientific community and the international funding organizations. In parallel the International Group of Funding Agencies (IGFA) developed the Belmont Challenge that identified the need to deliver knowledge needed for action to mitigate and adapt to detrimental environmental change and extreme hazardous events. The outcomes of both the ICSU visioning and the Belmont Challenge have led to the proposal of a new 10 year initiative in Earth System Science for Global Sustainability known as Future Earth.

In response to these activities of its sponsors, over the past several years the WCRP leadership and its network of affiliate researchers have focused their efforts on: (a) coordinating international climate research, modeling and prediction in support of the priorities identified by WCRP sponsors and stakeholders; (b) developing a future research strategy and priorities in response to the rapidly emerging needs for science-based climate information for decision-making, in close consultation with the international science community; and (c) establishing a vigorous capacity-development initiative to train the next generation of scientists and research networks at the global and regional levels. As result of these efforts, this presentation will focus on the Grand Challenges in research of the physical climate system as identified by the WCRP for the decade ahead.

## NOAA COASTWATCH OKEANOS OCEAN COLOR OPERATIONAL PRODUCTION SYSTEM

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### Abstract

In recent years, the NOAA CoastWatch Okeanos Ocean Color Operational Production System (OPS) has been providing a series of high quality ocean color operational products for our user communities, e.g., 1 km daily and bi-monthly mean chlorophyll concentrations, and chlorophyll concentration anomaly compared to 61-day averages from MODIS/AQUA. The products of remote sensing reflectance at 667 nm are also available. The products have been beneficial in assessing water quality and tracking potentially harmful algal blooms in order to protect public health. For example, the chlorophyll concentration product has been used to understand and predict harmful algal blooms in the Gulf of Mexico by the NOAA CO-OPS. Recent efforts also continue to provide more MODIS/AQUA ocean color products to user community. The chlorophyll frontal operational products are expected to be available in June 2013. Operational products of Global Emiliania huxleyi (Ehux) bloom distribution may be available in 2013 if NOAA operational users are identified. More importantly, a new NOAA ocean color products Quality Assurance (QA) monitoring tool is also added to the Okeanos OPS. Many MODIS products will be extended to the NPP Visible/Infrared Imager Radiometer Suite (VIIRS) in 2014. Therefore, it is expected that our future operational ocean color product system offers additional valuable information

## NORTHERN HEMISPHERE SUMMER MONSOON INTENSIFIED BY MEGA-ENSO AND AMO

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Abstract

Prediction of monsoon changes in the coming decades is important for infrastructure planning and sustainable economic development. The decadal prediction involves both natural decadal variability and anthropogenic forcing. Hitherto, the causes of the decadal variability of Northern Hemisphere summer monsoon (NHSM) are largely unknown because the monsoons over Asia, West Africa, and North America have been studied primarily on a regional basis, which is unable to identify coherent decadal changes and the overriding controls on planetary scales. Here, we show that, during the recent global warming of about 0.4 $^{o}$C since the late 1970s, a coherent decadal change of precipitation and circulation emerges in the entirety of the NHSM system. Surprisingly, the NHSM as well as the Hadley and Walker circulations have all shown substantial intensification, with a striking increase of NHSM rainfall by 9.5% per degree of global warming. This is unexpected from recent theoretical prediction and model projections of the 21st century. The intensification is primarily attributed to a mega- El Niño / Southern Oscillation (a leading mode of interannual-to-interdecadal variation of global sea surface temperature) and the Atlantic Multidecadal Oscillation, and further influenced by hemispherical asymmetric global warming. These factors driving the present changes of the NHSM system are instrumental for understanding and predicting future decadal changes and determining the proportions of climate change that are attributable to anthropogenic effects and long-term internal variability in the complex climate system.

## ON THE CALIBRATION MONITORING OF THE S-NPP OZONE MAPPER PROFILER SUITE'S SENSOR DATA RECORDS

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Abstract

Launched on 28, Oct. 2011, OMPS opened its aperture door on 26 January 2012 and began the Earth observation mission. The OMPS on-orbit calibration was established during checkout and evaluation periods (EOC and ICV). To date in 2013, the sensor system calibration has been applied to produce OMPS Nadir Sensor Data Records (SDRs), and the resulting Environment Data Records (EDRs) evaluated through cross-comparisons with SBUV2 data. This paper defines the current provisional status of the OMPS SDRs; provides an evaluation of the combined performance of the orbital OMPS Nadir sensors coupled with the ground data processing system; and offers lessons learned during the one and a half years of operation. Examples of the sensors' short-term and limited long-term responses are provided to illustrate the on-orbit stability of the sensor suite.

## ON EMPIRICAL BIAS CORRECTIONS OF NPP CRIMSS OSS FORWARD MODEL

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1 I.M. Systems Group, Inc.
2 Science Systems and Applications, Inc.
3 Science and Technology Corporation
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## Abstract

The Cross-track Infrared Sounder (CrIS) and Advanced Technology Microwave Sounder (ATMS) are two critical sounding instruments onboard the Suomi National Polar-orbiting Partnership (NPP) satellite. CrIS and ATMS collect radiance, with excellent radiometric precision, in the upwelling infrared spectra and microwave spectra respectively. The Cross-track Infrared and Micrwoave Sounding Suite (CrIMSS) Enviromental Data Record (EDR) algorithm converts these radiances using a simultaneous retrieval technique to generate atmospheric vertical profiles of temperature, moisture, and other geophysical parameters. The CrIMSS EDR algorithm employs the forward model of Optimal Spectral Sampling (OSS), developed by AER. The OSS model is applied in calculations of both the IR and microwave (MW) radiances. However, because of errors in the forward model calculations due to the instrumental sensitivity to trace gases, uncertainties due to surface emissivity, etc., a bias always exists between the observed and computed radiances. Therefore, the CrIMSS algorithm requires a bias-correction component to account for the differences between the observed radiances and the forward model used in the retrieval algorithm. This work will demonstrate the empirical IR and MW bias corrections of the OSS forward model based on CrIS and ATMS data from the focus day on May 15, 2012. We use ECMWF profiles along with AIRS retrieval products and trace-gas climatologies to compute the empirical bias correction. We also confirmed the empirical bias corrections that were done by NASA/LaRC and compared the CrIMSS EDR profiles based on different empirical bias corrections from different clear case selections and current IDPS EDRs.

## URBANIZATION EFFECTS ON PRECIPITATION OVER THE PEARL RIVER DELTA

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## Abstract

The Pearl River Delta (PRD) is one the largest metropolitan regions in the world. Compared with other metropolitan regions in the world, the urbanization effects of the PRD on precipitation are seldom investigated. In this paper, based on the observatory data of 1961-2010, the different features of the precipitation between PRD and the surrounding nonurban regions are investigated by using statistical methods. Moreover, the contribution rate of urbanization on the precipitation over the PRD has been accessed by comparing the change rates of the precipitation between urban and nonurban regions during 1961-2010.

## THE IMPROVEMENT OF BOUNDARY LAYER SOUNDING FROM SATELLITE OBSERVATION

Chian-Yi Liu, National Central University (NCU), Center for Space and Remote Sensing Research (CSRSR)
Gin-Rong Liu, NCU/CSRSR
Tang-Huang Lin, NCU/CSRSR
Chung-Chih Liu, Minghsin University of Science and Technology

Abstract

Having accurate atmospheric thermodynamic state is critical for environmental research, especially the vertical temperature and moisture profiles within the atmospheric boundary layer. This study investigates the synergistic use of space-borne hyperspectral infrared radiances measurement and traditional surface observation to conduct the best estimation of atmospheric temperature and water vapor profiles. Compared the retrieval results from the original space-borne observation stand-along algorithm, atmospheric boundary layer temperature and moisture retrievals appear to be improved through the inclusion of the surface observation in the new developed algorithm. The statistics of retrieval performance by comparing with radiosonde observation suggest the improvement is not only at the lowest surface level but also within the planetary boundary layer. This demonstrates the benefit of surface observation in atmospheric sounding retrieval algorithm, and the boundary layer thermodynamic structure could be retrieved optimally from the use of both space-born and ground based observations.

## RECORD-BREAKING INCREASE IN TAIWAN TYPHOON RAINFALL IN THE RECENT DECADE: IS IT RELATED TO GLOBAL WARMING?

Chih-Pei Chang, Dept. of Atmospheric Sciences, National Taiwan University and Dept. of Meteorology, Naval Postgraduate School
Hung-Chi Kuo, Dept. of of Atmospheric Sciences, National Taiwan University
Yi-Ting Yang, Dept. of of Atmospheric Sciences, National Taiwan University

Abstract

In the 5th COAA conference in Taipei in June 2010, a special panel discussion debated the cause of record-breaking heavy rainfall of Typhoon Morakot (2009). The event became the largest meteorological disaster in Taiwan with huge economic and life losses, and the first natural disaster that triggered a change of government. Morakot was one of a series of TCs affecting Taiwan with extraordinary amount of rainfall since the late 1990s. Nine of the 12 wettest typhoons since hourly observations started in 1960 occurred in the 21st century. The debate centered on whether the heavy rainfall associated of these typhoons is due to global warming.

Here we show that the increasing trend of typhoon related intense rainfall in the last half Century is a local anomaly in the China summer monsoon region, and that most of the recently observed large increase in typhoon rainfall is the result of slowly moving TCs and their tracks relative to the meso-à scale terrain. In addition, stronger interaction between the typhoon circulation and southwest monsoon wind surges after the typhoon center moves into the Taiwan Strait may cause

a long-term trend of increasing typhoon rainfall intensity, which is not observed before the typhoon center exits Taiwan. The variation in the track cannot be related to the effects of global warming on western North Pacific TC tracks reported in the literature. The weaker steering flow and the stronger monsoon-TC interaction are consistent with the recently discovered multidecadal trend of intensifying subtropical monsoon and tropical circulations, which is contrary to some theoretical and model projections of global warming. There is also no evidence of a positive feedback between global warming-related water vapor supply and TC intensity, as the number of strong landfalling TCs has decreased significantly since 1960 and the recent heavy rainfall typhoons are all of weak to medium intensity.

## WHAT ARE THE MAJOR SOURCES AND PATHWAYS OF AIR CONTRIBUTING TO HEAVY POLLUTANT EPISODES IN HONG KONG?

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### Abstract

In this study, the PM10 concentration of 14 stations in Hong Kong from 2000 - 2009 was used to study the air pollution in Hong Kong during summer. The results of cluster analysis of 36 hours back trajectories arriving mid-afternoon in Hong Kong show a higher PM10 concentration is related to weak wind and north-easterly wind from continental China. For the cases of higher PM10 concentration, positive vorticities were mainly found near Taiwan regions, and half of these cases are related to the tropical cyclone (TC). The location of TC plays important role on the transportation of pollutant, which alter the dominant wind direction in summer, weaken the dispersion of regional pollutants and enhance the transportation of pollutant from inland China to Hong Kong.

## UNCERTAINTY ANALYSIS OF THE CLOUD RETRIEVALS USING A PERTURBATION METHOD

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### Abstract

Our study has shown that there are large systematic differences among various cloud retrievals. Uncertainty quantification of cloud retrievals becomes more and more important for both cloud process studies and modeling studies. This paper presents a simple yet general approach to estimate uncertainties in ground-based retrievals of cloud properties. This approach, called as the perturbation method, quantifies the cloud retrieval uncertainties by perturbing the cloud retrieval inputs and parameters within their error ranges. The error ranges for the cloud retrieval inputs and parameters are determined by either instrument limitations or comparisons against aircraft observations. I analyzed the relative contributions to the uncertainties of retrieved cloud

properties from the inputs, assumptions and parameterizations. As an example, I apply this approach to the Atmospheric Radiation Measurement (ARM) program baseline retrieval, MICROBASE. Results show that different influential factors play the dominant role in contributing to the uncertainties of different cloud properties. To reduce uncertainties in cloud retrievals, efforts should be emphasized on the major contributing factors for considered cloud properties. This study also shows high sensitivity of cloud retrieval uncertainties to different cloud types, with largest uncertainties for deep convective clouds. Limitations and further efforts for this uncertainty quantification method are discussed.

## IMPACT OF CLIMATE CHANGE ON RUNOFF IN THE UPSTREAM CATCHMENT OF THE FEILAIXIA RESERVOIR, SOUTH CHINA

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Zhi-Qing Chen and Jing-Guang Ma
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### Abstract

The upstream catchment of the Feilaixia reservoir in south China was chosen as the study area. Variable infiltration capacity (VIC) model with a spatial resolution of 0.25o?0.25o for each grid was developed in the study area, and the downscaling results of multiple model output from Phase 3 of the Coupled Model Inter-comparison Project (CMIP3) were coupled with VIC model to project the trend of runoff under A1B scenario. Results indicate that VIC model shows good performance in simulating discharge in the catchment, and it can satisfy the application requirements. The downscaling results of multiple model output from CMIP3 show a high correlation with recorded values, and can well simulate the distribution of the temperature and precipitation during the years. The runoff is sensitive to the climate change, the average annual runoff under the climate models from CMIP3 will decrease in the future (2020-2050), which is consistent with the change of precipitation for both spatial and temporal distribution. The average monthly discharge in June and August during the flood seasons will decrease significantly, indicating a possibility of flooding may decrease in the future.

## OCEAN AND METEOROLOGICAL DATA FROM IN-SITU OCEAN OBSERVING SYSTEMS

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### Abstract

Oceanographers and meteorologists require a lot of observations and measurements to achieve their aims of understanding and predicting the properties and dynamics of the atmosphere and the ocean. Although models and simulations can be powerful tools to study and predict atmospheric and oceanic processes of interest, observations are continually required to better understand, prove, validate, supplement, and enhance the latest environmental models. A large amount of data covering the vast area of the world's oceans is needed to better understand and

predict the ocean and atmosphere, along with dynamic interactions between the two.ÿ Additionally, continuous measurements and information collected across the world oceans (both coastal and offshore) provide essential support to the design and construction of coastal structures (e.g., jetties, breakwaters) and offshore structures (e.g., oil platforms, oil pipelines), safe and economic operations at offshore sites, monitoring and studying of coastal processes, safe navigation and sea transportation, and monitoring and control of oil spills and other marine pollutants. Ocean observing systems can measure and report a wide variety of oceanographic and meteorological parameters, such as wind speed, wind direction, atmospheric pressure, air temperature, water temperature, ocean waves, ocean currents, tide and water level, precipitation, visibility, solar radiation, conductivity, turbidity, dissolved oxygen, pH, and chlorophyll. Systems and techniques used for measuring oceanographic and meteorological parameters can be categorized as either in situ or remote sensing. Remote sensing technology has progressed rapidly in recent years, providing very powerful capabilities to measure across a wide range of observation area. However, in-situ techniques are still the fundamental and critical means for ocean observing, especially for long-term, continuous, or in-water observations. Since the ocean environment is a rough, challenging place for long-term survival of high precision ocean measurement systems, it places unique demands and challenges on in-situ sensors and related platforms for that will be deployed in long-term ocean observatories. Such conditions and related impacts are not easily simulated, tested, and assessed in laboratories or land based observing systems. Several major networks of in-situ ocean observing systems developed, established, operated, and maintained in United States will be presented and discussed. These networks include the Coastal Weather and Ocean Buoy Network (CWB), the Coastal-Marine Automated Network (C-MAN) land-based stations, the Tropical Atmosphere Ocean (TAO) climate buoy arrays, the Deepocean Assessment and Reporting of Tsunami (DART) buoy network, the National Water Level Observation Network (NWLON), the Physical Oceanographic Real Time Systems (PORTS), and the Chesapeake Bay Interruptive Buoy System (CBIBS). These networks, which include more than 500 long-term and nearly-real-time ocean observing platforms/systems, provided crucial ocean and meteorological data to studies, monitoring, warning, prediction, and understanding of all different kind of oceanic and atmospheric topics, such as weather, climate, ecosystems, airsea interaction, tsunami, marine navigation and transportation, etc. In this presentation, many ocean and meteorological events/cases from the data collected and reported by these in-situ ocean observing systems will be presented to demonstrate their effects, contributions, and influence on understanding of ocean and atmosphere sciences, providing better warning and prediction, and providing better information for marine operations and activities.

## INVESTIGATING THE RELATIONSHIP BETWEEN TROPICAL CYCLONES AND THE TROPICAL 10-60 DAY OSCILLATIONS OF THE WESTERN PACIFIC

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### Abstract

This study investigates the relationship between tropical wave disturbances and tropical cyclones of the western Pacific based on both observational and modeling analysis. First, we identify tropical disturbances that eventually developed into named tropical cyclones (TCd) versus those that did not (TCn), using OLR and the ERA-Interim reanalysis for the warm season (MJJAS) of 2004 and 2008. The data fields are separated into intraseasonal (30-60 day) oscillations (ISO), n=1 equatorial Rossby (ER) waves, and westward-moving TD-type synoptic scale disturbances based on a space-time filtering method (Wheeler and Kiladis 1999). A separate 3-8-day filtering is applied to the vorticity field to obtain synoptic-scale tropical disturbances which are used to identify TCn. The named TCs are identified using the JTWC best track data. A total of 35 TCd and 54 TCn are identified in the two years. A comparison is made for the number of developing and non-developing tropical cyclones formed in the convective and non-convective phases of the ISO as well as the positive- and negative-vorticity (at 850 hPa) of ER waves. The results show a clear contrast for convective ISO, and lower-level cyclonic circulation in ER waves. The above large-scale thermodynamic and flow fields all contribute to tropical disturbances to form developing TCs through heating, confluent zonal deformation, enhanced cyclonic vorticity, easterly vertical shear. A general tendency is evident for less frequent occurrence of non-developing TCs (TCn) when the large-scale condition is favorable for more developing TCs to form. For synoptic-scale TD-type disturbances, they are inseparable from non-developing TCs
We further clarify the above observed relationship in numerical experiments. We first remove different wave signals respectively to quantify the difference of intensity between simulation with and without wave signals. The results will be reported by Dr. Lin Ching and colleagues in the same meeting. Experiments are also being performed to analyze the causal relationship between tropical ER waves and TCd and TCn.

## RELATIONSHIP BETWEEN SUMMER RAINFALL ANOMALIES AND SUB-SEASONAL OSCILLATIONS IN SOUTH CHINA

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### Abstract

Sub-seasonal variability of summer (May-October) rainfall over South China exhibits two dominant timescales, one with a quasi-biweekly (QBW) period (10?20 days) and the other with an intraseasonal oscillation (ISO) period (20?60 days). A significant positive correlation (at a 99% confidence level) was found between the summer precipitation anomaly and the intensity of the QBW and ISO modes. By examining the composite structure and evolution characteristics, we note that the QBW and ISO modes are characterized by a northwest-southeast oriented wave train pattern with a pronounced baroclinic structure, moving northwestward. A marked feature is the phase leading of low-level moisture to convection. For the QBW mode, such a phase leading feature appears in both the strong and weak composites. However, for the ISO mode, this feature is only seen in the strong composite, but not in the weak composite.
It is found that when South China is anomalous wet, large-scale atmospheric conditions in the key QBW/ISO activity region are characterized by deeper moist layer, convectively more

unstable stratification, and greater ascending motion. Such environmental conditions favor the growth of the QBW and ISO perturbations. Thus, the high positive correlation between the summer precipitation and the sub-seasonal variability arises from the large-scale control of the summer mean flow to perturbations.

## RECENT PROGRESSES OF THE PROGRAM "CARBON BUDGET AND RELEVANT ISSUES IN RESPONSE TO CLIMATE CHANGE"——A STRATEGIC PRIORITY RESEARCH PROGRAM OF THE CHINESE ACADEMY OF SCIENCES

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Abstract

Anthropogenic greenhouse gases (GHG) emission has been identified as the major factor (or at least one of the major factors) in response to global warming in recent decades. Since it is closely related to global sustainable development and international duty of GHG reduction for every country in the world, China, as one of developing countries, is facing double tasks, i.e., to develop national economy and social welfare, and in the meantime, to reduce GHG emission and climate change is a scientific issue closely related to the Earth's carbon cycle and anthropogenic influence, which is a multi-disciplinary research topic. Based on the needs of national development and international negotiation for China, a Strategic Priority Research Program called "Carbon Budget and Relevant Issues in Response to Climate Change" of the Chinese Academy of Sciences is established.

According to the above key scientific questions, this program is divided into five project groups: GHGs emissions and monitoring technology; carbon sink by different ecosystems and it increasing technology; new generation climate system models for future climate projection and the facts and attribution of climate change during the past centuries; climate and ecology changes in the past ten thousand years and human being adaptation; policy suggestion for green development. The program has started since 2011. During the past two years? significant progresses have been made in all 15 research projects, including nation-wide investigation of GHG emissions, in particular, energy utilization efficiency in China, ecological carbon sink investigation and new carbon sink increasing technologies, climate system model development and climate change trend investigation based on instrumental observations and proxy data, new network of aerosol observations in China, past climate and ecology pattern in China, and some preliminary suggestion to the related policies for national carbon reduction.
In this paper, we will present some preliminary progresses.

## WILL CLIMATE CHANGE HAVE ITS GREATEST ECOLOGICAL IMPACT IN ARCTIC OR TROPICAL REGIONS? INSIGHTS FROM A MIGRANT SPECIES

David L. Thomson, University of Hong Kong
Akala LI Teng, University of Hong Kong

Abstract

Arctic temperatures are rising faster than tropical temperatures, so the greatest ecological impacts are widely expected to be in the far North, and tropical impacts are often assumed to be much smaller. This 'Arctic Impact Hypothesis' has however been challenged recently, with small but growing numbers arguing that tropical species in hot environments are already near their upper thermal limits where even small increases in temperature could decrease their fitness substantially. Currently, even the advocates of this minority view see their 'Tropical Impact Hypothesis' as a peculiarity of ectotherms, but here we look at whether it may in fact be a more general phenomenon. Even if endotherms can regulate their own body temperatures physiologically, their fates are still inextricably linked with the ectotherms upon which they depend.

To compare the ecological impacts of tropical and arctic climate change, we need to study endotherms in their natural environments where they are exposed not just to direct physiological effects of temperature, but also to any indirect effects on the systems and species upon which they rely. Tropical-Arctic migrants like the Grey Plover Pluvialis squatarola offer unusually good comparisons because they move between these regions, depending on both arctic and tropical systems in the course of their annual cycle. Grey Plovers have been counted annually in Deep Bay Hong Kong since 1979, and by looking at how their population growth rates respond to fluctuating temperatures both there and on their arctic breeding grounds, we can reconstruct and compare the overall effects of arctic and tropical temperature change on their fitness.
We developed a modeling framework which included detection probabilities and which allowed us to distinguish the effects of temperature on population growth rates, from the effects of temperature on the movement of birds into and out of Deep Bay. Our modeling framework also allowed us to reconstruct the arctic breeding location of the Deep Bay Grey Plovers even though this could not be observed directly.

We found that the relationship between fitness and temperature is indeed quadratic, rising to an optimum at 13.5?C and then declining. Contrary to the Arctic Impact Hypothesis, we found that the arctic breeding grounds are actually too cold for Grey Plovers and that fitness in fact increases as temperatures there rise. Consistent with the Tropical Impact Hypothesis, we found that Hong Kong is too hot, even in winter, and fitness there declines with temperature. Even if temperatures rise more in arctic than in tropical regions, this need not necessarily translate into greater ecological damage. Based on our findings for the Grey Plover, we conclude that warming at high latitudes can actually be beneficial, while even just slight warming in the tropics can have substantial negative effects. To our knowledge this is the first time that the Tropical Impact Hypothesis has been shown to apply for an endothermic species and we propose that it may indeed be a general phenomenon, not just a specific feature of ectotherms.

## THE MULTI-SCALE PREDICTION OF ONSET DATE OF SOUTH CHINA SEA SUMMER MONSOON AND ITS DRIVEN MECHANISM

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Abstract

The onset date of South China Sea summer monsoon (SCSSM) exhibits decadal variation with 15.4 years period and interannual variation with 5.3 years period. On interannual time scale, there are four regions with significant correlation between SSCSM onset dates and SST during previous winter. On decadal time scale, there are six regions with significant correlation between onset dates of SSCSM and SST during previous year (from last March to February). The optimal subset regression prediction method with the view of multiple time scales is developed as the new method of short-term climate prediction for onset date of SCSSM. The tests of independent samples from 1999 to 2008 and operational application for recent these years show that the multi-scale optimal subset regression prediction has better predictability and can offer important reference to operational prediction of short tern climate prediction for onset date of SSCSM.The sensitive experiments of cross-validation show that the previous winter tropical southwest Indian Ocean and tropical northwest Pacific are key oceanic regions affecting the interannual variation of South China Sea summer monsoon onset date. The warming of winter tropical southwest Indian Ocean is triggered by El Nino early onset, and maintained by air-sea interaction positive feedback process in tropical Indian Ocean and tropical northwest Pacific. The spring low-level easterly jet responding to warm SSTA in north Indian Ocean and anticyclone over Philippine Sea induce late onset of South China Sea summer monsoon. This is mechanism of South China Sea summer monsoon onset driven by ENSO. The warming of winter tropical northwest Pacific is triggered by tropical planetary east-west circulation induced by heating of strong Indian summer monsoon, and maintained by air-sea interaction positive feedback process in tropical northwest Pacific. The spring low-level westerly, part of Rossby wave forced by warm SSTA in tropical northwest Pacific, moves northward to 10§N, corresponding early onset of South China Sea summer monsoon. This is mechanism of South China Sea summer monsoon onset driven by monsoon.

## THE VARIABILITY OF METHANE FLUXES FROM A TEMPERATE OMBROTROPHIC PEATLAND IN CANADA

Derrick Y.F. LAI, Tim R. MOORE, and Nigel T. ROULET

Abstract

Northern peatlands contain one third of the world's soil carbon and play a key role in the global carbon cycle. Owing to the presence of predominantly anaerobic conditions, these peatlands may release some of the stored carbon to the atmosphere in the form of methane gas (CH4). This study investigated the spatial and temporal variations of CH4 flux measured by autochambers at the ombrotrophic Mer Bleue bog near Ottawa, Canada. Significantly higher CH4 emissions were found from Eriophorum-dominated than shrub-dominated chambers. For shrub-dominated sites, higher fluxes were obtained at hollows than hummocks. Seasonal peaks in CH4 emissions were partly related to plant photosynthetic activity. Water table was a major control of CH4 flux over time when the site was relatively dry, while peat temperature became more strongly correlated with CH4 flux during the wetter period when water table remained

high. Spatio-temporal modelling of peatland CH4 flux should take into account emission hotspots and changes in dominant environmental controls over the course of growing season.

## ROLE OF INDONESIAN THROUGHFLOW IN THE INTERANNUAL CLIMATE VARIATIONS AND PREDICTABILITY OF THE TROPICAL INDO-PACIFIC OCEAN

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Abstract

The role of Indonesian Throughflow (ITF) in forcing the tropical Pacific Ocean interannual variations is studied using lag correlations of observational data and dynamics studies based on numerical modeling. The significant lag correlation between the sea surface temperature anomalies (SSTA) in the southeastern Indian Ocean (SEIO) in fall and the SSTA over the Pacific cold tongue at the one-year time lag indicates potential predictability of ENSO beyond the period of one year. Significant correlations between the sea level anomalies (SLA) in SEIO in fall and the equatorial SLA in the Indonesian seas and in the western Pacific Ocean suggest that ITF play an important role in connecting the Indian Ocean Dipole (IOD) with the Pacific ENSO one year later. Significant correlation between SSTA in SEIO in fall with the subsurface temperature anomalies in the equatorial Pacific vertical section also support the oceanic channel dynamics of the two basins. Numerical simulations using a hierarchy of ocean models and climate coupled models have shown that the interannual sea level depressions in SEIO during IOD force enhanced ITF to transport warm water of the Pacific warm pool to the Indian Ocean, producing cold subsurface temperature anomalies, which propagate to the eastern equatorial Pacific and induce significant coupled oceanatmosphere evolution. The ocean channel dynamics of the two basins are found to persist through the spring barrier, suggesting the importance of ITF in the predictability of the ENSO events. The ability of the latest CMIP5 models to simulate and predict this inter-basin connection are assessed based on the above analyses.

## STOCHASTIC DYNAMICAL SIMULATION ON THE 100KYA CYCLES IN THE CLIMATE SYSTEM

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Zhou Xiuji, Zhao Ping, Chinese Academy of Meteorological Sciences, Beijing, China

Abstract

In this study, the dynamical mechanism of the 100Kya climatic cycles externally forced by the slight variation of the solar radiation is numerical simulated and analyzed from the perspective of stochastic dynamics. A new albedo model is constructed by the combination of the idealized albedo model and the geological evidence & observation fact of climate system firstly. After the new albedo model is introduced into the zero-dimensional energy balance equation, the characteristics of the climate system are simulated when the periodic and stochastic change of

solar radiation is taken into account simultaneously. The results show that, when the intensity of noise is up to a certain value, the phenomenon of stochastic resonance will be triggered. But the noise with this intensity may not exist in the observational facts. In order to explain the mechanism of 100Kya glacial-interglacial cycle forced by the weak solar radiation cycles, the stochastic dynamical influence of internal processes in climate system should be considered. The simulation analyses on the situation considering the external force and internal processes of climate system at the same time show that, when the proper and observational stochastic perturbation at present is introduced in the internal and external climate system, the stochastic resonance will also happen. In this situation, the contribution of stochastic perturbation of solar radiation to the 100Kya climate cycles is about 38%, which means the stochastic perturbation in the solar radiation has a crucial role for the global climate change.

## IDENTIFICATION OF THE BOUNDARY LAYER CONTROL FACTORS DURING SEVERE AIR POLLUTION EPISODES OVER THE CITY-CLUSTER OF PEARL RIVER DELTA, CHINA

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Abstract

As a consequence of industrialization and urbanization, air pollution over the city-cluster of the Pearl River Delta, China has been highlighted by the report of the Pearl River Delta Regional Air Quality Monitoring Network. Based on the high-resolution meteorological data, the air pollutants concentration data from the Monitoring Network, vertical sounding results, and numerical simulations with the application of MM5 model and HYSPLIT4.8 model, the boundary layer control factors over the city-cluster during severe air pollution episodes have been identified. A conceptual model that reveals the boundary layer control factors of the air quality over the city-cluster of the Pearl River Delta (PRD) has been successfully established. The air pollution in PRD has become a more comprehensive regional problem characterized by high frequency of haze events, photochemical pollution, and greater acidification of precipitation in recent years. The complex synoptic patterns in PRD associated with poor air quality could be summarized into 6 major categories. During the study period, the patterns of high pressure ridge extending over PRD, and PRD influenced by homogeneous high pressure, share a similar percentage with the highest frequency. In short term, transport effect of moderate flow, weak winds, local circulations, 3 types of air mass interaction, terrain blocking flow, near surface inversion, low mixing height and so forth are essential boundary layer factor control the local air quality. Conceptual model indicated that strong south and north dominating across the PRD region could bring in satisfactory air quality in PRD. Counterbalance of weaker winds from both directions and convergence zone induced by wind shear of distinct air masses over PRD could result in air quality deterioration. Weak winds and local circulations such as sea-land breeze, mountain-valley wind, heat island circulation and terrain blocking flow, accompanied by the intensive inversion near the surface served as the major triggers of severe pollution events. The conceptual model of boundary layer control factors over PRD has considerably summarized some common features of PRD.

## USES OF SUOMI NPP DATA FOR IMPROVING HURRICANE/TYPHOON FORECASTS

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Abstract

The Advanced Technology of Microwave Sounder (ATMS) and the Cross-track Infrared Sounder (CrIS) on board Suomi National Polar-Orbiting Partnership (SNPP) satellite provide data for profiling atmospheric temperature and moisture under all weather conditions and supporting continuing advances in data assimilation and NWP modeling. As of today, both ATMS and CrIS radiances are well calibrated and the SDR data (or Level1B radiances) have reached a provisional level for user applications. However, in operational Hurricane Weather Research and Forecast Model (HWRF), the satellite radiances have not been directly assimilated due to its reliance of the global analysis fields. This seminar will present our preliminary results from direct assimilation of satellite sounding radiances from NOAA, METOP and SNPP satellites in HWRF. The NCEP's Gridded Statistical Interpolation (GSI) scheme is configured for effective assimilation of upper-level sounding channels. The quality control and bias correction schemes in GSI are revisited and revised for optimal radiance assimilation. It is demonstrated that uses of ATMS and CrIS in HWRF improve the forecasts in track and intensity of Hurricane Sandy and Isaac.

## TYPHOONS' FORMATION ALERTS AND RAINFALL POTENTIALS WITH SATELLITE

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Abstract

The applications of satellite remote sensing observations in early detecting of typhoon formations and assessing of their rainfall potential are demonstrated in the study. In the first part, a dynamic computing coverage by considering the cluster size variation of the tropical cyclone system is used, and SSM/I and QuikSCAT satellite data is employed to estimate the total heat energy and relative vorticity, respectively, in finding better energy thresholds as typhoons will occur or not in the Northwest Pacific areas. In the second part, a method in constructing an improved tropical rainfall potential (I-TRaP) technique for mountainous regions by factoring in additional vital information. Using the original rainfall potential method as the basis, the typhoons' rotation speeds are estimated with geostationary satellite imagery and added to the new model. Furthermore, the changes in the typhoon rainfall patterns and rainfall intensity caused by the orographic effect are also considered together with the historical cases, thereby allowing the predicted rainfall patterns to be redistributed and rescaled to approximate the actual rainfall as close as possible. Typhoon cases which made landfall in the hilly and mountainous regions of Taiwan were retrieved with satellite observations and tested to demonstrate the technique's performance.

## EFFECTS OF ENERGY USE ON CLIMATE---BEYOND THE URBAN HEAT ISLANDS

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Abstract

The worldwide energy consumption in 2006 was close to 500 exajoules (5x10^20 joules), corresponding to an energy consumption rate of 16 Terawatts (TW). Energy consumption takes place mainly in populated metropolitan areas, causing waste heat release to the surrounding atmosphere there and contributing to the urban heat island effect. On the other hand, the populated regions are mostly over northern Hemisphere midlatitudes, where jet streams are strong. The concentrated waste energy release could interrupt normal atmospheric circulations, thereby affecting climate elsewhere. We explore this effect of energy use on climate using a global climate model. We made a large number of ensemble climate model simulations using the NCAR CAM3 climate model with and without the heat input into the atmosphere from energy consumption. We found that the extra heat from energy consumption can cause up to 1 degree of warming in winter seasons over northern latitudes of North America and Eurasian continents. The winter warming is associated with changes in the atmospheric circulation. In response to the energy consumption, the upper troposphere experiences a widening of the mid-latitude westerly jet stream and lower troposphere shows a strengthening of southwesterly flow in mid-latitudes. The enhanced warm air advection by the strengthened southwesterly flow in mid-latitudes causes the high latitude warming over the two continents in winter seasons. This warming helps to explain some missing warming in global models when compared with observations over the last 50 years. Our findings suggest that including energy consumption, in addition to the anthropogenic greenhouse gases and aerosols, could improve the current global warming simulations.

## CHARACTERIZATION OF DCC TARGETS WITH GOME-2 OBSERVATION FOR GOES CALIBRATION OF VISIBLE CHANNELS

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Abstract

In this study, we take the advantage of observation from Global Ozone Monitoring Experiment-2 (GOME-2) and AVHRR (Advanced Very High Resolution Radiometer) both onboard Metop-A satellite to apply deep convective cloud (DCC) calibration for visible channels of NOAA GOES satellite instruments. We have identified DCC in the region (180$^{o}$W, 180$^{o}$E, 20$^{o}$S, 20$^{o}$N) to characterize DCC temporal and spatial variation, and then investigate the spectral calibration uncertainty with DCC calibration to provide insights to improve SFR accuracy. Our analysis

shows that DCC occurrence is sensitive to the thresholds with the brightness temperature (BT) of AVHRR Channel 11æm (Ch4). The seasonal movement of DCC is largely in line with the movement ITCZ. Our analysis shows DCC with GOME-2 hyper-spectral observation is reliable as an invariant target. Results indicate that DCC method in this study helps to improve the convergence of the reflectance difference between MODIS and GOES SFRs in DCC pixels and quantify that the contribution due to SFRs difference to the bias can been narrowed to <1% with a small increasing tendency with reflectance in DCC pixels. With this DCC calibration we suggest that the lower O2 absorption may offsets the contribution from the wider right tailor of GOES-11 SRF, resulting in that the contribution from GOES-11 SRF is very close to MODIS SRF.

## EFFECTS OF CLIMATE AND EMISSIONS CHANGES ON THE FUTURE PARTICULATE MATTER POLLUTION IN THE U.S.

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Abstract

Simulations of ground-level PM2.5 pollution under different future climate and emissions scenarios were conducted using the Community Multiscale Air Quality Model (CMAQ) driven by the mesoscale model (MM5)-based regional climate model (CMM5). Observations from the EPA AQS (Air Quality System), IMPROVE (Interagency Monitoring of Protected Visual Environments), and CASTNET (Clean Air Status and Trends Network) network were utilized to evaluate the present-day PM2.5 simulations. CMAQ successfully re-produced the ground-level PM2.5 concentrations in rural and suburban areas, however substantial discrepancies were observed in urban areas such as San Joaquin Valley and Los Angeles Basin. We compared the present-day ground-level PM2.5 simulations with and without the Community Atmospheric Model with Chemistry (CAM-Chem) lateral boundary conditions (LBCs). The results show decreases of PM2.5 pollution in the U.S., revealing that CAM-Chem LBCs have less air pollutants transported into the U.S. compared with ?fixed? LBCs set default in the CMAQ model. Projections of future PM2.5 pollution suggest large reduction of PM2.5 pollution (~4.0 æg/m3 for A1B, and ~3.0 µg/m3 for A1Fi) in the eastern U.S., but slight increase (~1.0 µg/m3 for A1B, and ~1.0 µg/m3 for A1Fi) in the western U.S. Large increases of PM2.5 concentrations were observed near the Mexico-U.S. border, implying Mexico as an important source of PM2.5 pollution in the future. We also projected the future PM2.5 pollution under climate change only scenarios (A1B and A1Fi) with present-day emissions. Increases of PM2.5 levels exist ubiquitously (~0.3 µg/m3 for both A1B and A1Fi climate) over the U.S., except local decreases in Texas. These results reveal that effects of climate change alone are one order of magnitude lower than effects of emissions changes, and the selection of LBCs is essential to study the future PM2.5 pollution.

## THE IMPLICATION OF ATMOSPHERIC BLOCKING PATTERNS OVER URAL-SIBERIA ON THE EAST ASIAN WINTER CLIMATE

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Wen Zhou, City University of Hong Kong

Abstract

During boreal winter, the dominant modes of East Asian winter monsoon are closely related to the quasi-stationary Rossby wave train across Eurasia. In particular, an inverse phase relationship is present between East Asia and central Asia. When an atmospheric blocking persists near the Ural Mountains, it dynamically enhances the Siberian high and potentially results in severe cold air outbreaks in East Asia. As a consequence, a more (less) frequent occurrence of Ural blocking may be accompanied by a cooler (warmer) East Asia.

However, the linkage between Ural blocking and the East Asian winter monsoon also depends on its spatial feature. A winter Ural blocking is generally associated with an eastward shift of the Atlantic storm track, where the Ural Mountains is regarded as the third blocking peaks over the Northern Hemisphere. When the dominant blocking pattern is centered near the Ural Mountains (Eastern Europe), it tends to show a strong (weak) relationship with the Siberian high and the leading temperature pattern in the monsoon region. As inferred from some climate models, the blocking frequency may increase near the Ural Mountains, in contrast to a decrease of the climatological peaks over the Euro-Atlantic and the Pacific sectors. Therefore, one may be curious the role of blocking in the East Asian winter climate.

While previous works have evaluated the blocking and the East Asian winter climate separately, no such work has analyzed their linkage. This study attempts to assess their linkage under present and future climate conditions by using state-of-the-art CMIP5 models. Specifically, the results from historical scenario will be compared with the NCEP-NCAR reanalysis datasets.

## THE IMPACT ON EAST ASIA DUE TO THE VARIATION OF TRANSIENT WAVE AND STATIONARY WAVE

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Wen Zhou, City university of Hong Kong

Abstract

East Asia trough (EAT) is located at the Japan in the mid-troposphere. It is related to the cold surge outbreak over East Asia. When a transient short wave trough is propagating from the farther west continent to the region of East Asia trough, two troughs are merged together. This is a precursor to cold surge outbreak in East Asia. So a colder winter in East Asia is associated with a stronger EAT.

A method is designed to capture the propagation of transient wave. There are two preferred path of troughs. One path passes through the north of Lake of Baikal and another passes the south of

it. The propagation variation of the trough path is also related to the low frequency variation of planetary wave over East Asia. The transient short wave is likely chose a southern path when Siberian high and East Asia trough is stronger than normal. The short waves of southern path result in significantly stronger temperature drop over East Asia. In this study, 10 days low pass filter is used to transient wave and stationary wave. The variation and the influence of two kinds of wave are well studied.

## PERFORMANCE EVALUATION OF CMIP5 MODELS IN SIMULATING TEMPERATURE OVER SOUTHERN CHINA

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Abstract

The Fifth Assessment Report (AR5) of Intergovernmental Panel on Climate Change (IPCC) is scheduled to be released in late 2013. Its assessment will largely be based on the new set of global climate simulations from the Coupled Model Intercomparison Project Phase 5 (CMIP5). Government agencies and research institutes will also utilise these simulations to update their climate projection and impact assessment, either by dynamical downscaling or statistical downscaling. It is therefore crucial to evaluate the performance of the CMIP5 models.

In this study, performance of 31 CMIP5 models in simulating temperature over southern China during 1950-1999 is evaluated, using the NCEP 20th century reanalysis dataset version 2 (20CRv2) as the ground truth. The period 1950-1999 is chosen in the study in order to facilitate comparison with Coupled Model Intercomparison Project Phase 3 (CMIP3) models. The study assesses the performance of the models through analyzing systematic bias, root mean square error, Taylor diagram and secular trend.

Results show that the 31 CMIP5 models can simulate the annual cycle reasonably well but there exists significant cold bias in winter months (Dec-Feb). The largest root mean square error is observed in winter months with some figures reaching 4oC, but it is in general below 2oC in spring (Mar-May) and summer (Jun-Aug). Taylor diagrams show that model simulations have reasonably good spatial correlation with NCEP 20CRv2 data in spring and autumn (Sep-Nov) with correlation reaching 0.8 or above while the spatial correlation in winter is in general below 0.8. Model performance during summer shows disparity with some models attaining correlation as high as 0.9 but some falling to as low as 0.4. Trend analysis indicates that a majority of the models have significant warming trend during 1970-1999 in all seasons except spring, which is consistent with NCEP 20CRv2 data, suggesting that the models can indeed capture the warming trend over southern China in recent decades. As compared with CMIP3 models, the study revealed that the improvement in CMIP5 models is minimal despite the advance in model resolution. Implications of the results on downscaling will also be discussed.

## SIMULATION OF AEROSOL EFFECTS ON OROGRAPHIC CLOUDS AND PRECIPITATION USING WRF MODEL WITH A DETAILED BIN MICROPHYSICS SCHEME

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Abstract

The effects on orographic clouds and precipitation of aerosol loading and the position of polluted aerosol emission upwind from terrain have been investigated by simulating an idealized mixed-phase orographic cloud using the Weather Research Forecast (WRF) mesoscale model coupled with a detailed bin microphysics scheme. The results show that the orographic precipitation amount is reduced by about 30.9% in the polluted case (experiment Polluted) as compared with the clean case (experiment Clean), and the spillover factor (the fraction of the accumulated precipitation of leeward side to the total accumulated precipitation of the mountain) of experiment Polluted is about 0.2 larger than that of experiment Clean because of the effects of high aerosol loading suppressed the development of upslope warm phase processes and enhanced the advection of rain to the downwind side.

Sensitivity tests are conducted and compared for cases with different distances between source of polluted aerosol emission and the mountain range to investigate the response of cloud properties and precipitation to the distance of aerosol source upwind the mountain. Three cases with continuous emission of polluted aerosol particles at 100 km, 200 km and 300 km from left boundary, respectively, are conducted (experiment P1, experiment P2 and experiment P3). As compared to the experiment Clean, the total precipitation amount on the ground in experiment P1, P2 and P3 are reduced by about 15.5%, 23.1% and 30.5%, respectively, and the spillover factor of experiment P1, P2 and P3 are 0.74, 0.77 and 0.79 with prolonged duration of the effect of polluted aerosol on orographic cloud. Decreasing the distance between aerosol emission and terrain will increase the number concentration of cloud drops in small size range (<20?m in diameter) and reduce cloud droplet number in larger size range (>20 ?m in diameter).

## RECENT INCREASE IN HIGH TROPICAL CYCLONE HEAT POTENTIAL REGION IN THE WESTERN NORTH PACIFIC OCEAN AND THE NEW OCEAN COUPLING POTENTIAL INTENSITY INDEX

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Abstract

The Main Development Region (MDR) for tropical cyclones in the western North Pacific Ocean is the most active region in the world. Based on synergetic analyses of satellite altimetry and gravity observations, the subsurface ocean conditions in the western North Pacific MDR has found to become even more favorable for typhoon and super-typhoon intensification. Compared

to the early 1990s, the MDR is more favorable due to an increase in the subsurface warm water layer that is characterized by a 10% increase in both the depth of the 26 $o^oC$ isotherm (D26) and Tropical Cyclone Heat Potential (TCHP). In addition, the areas of high TCHP (≥ 110 kj cm-2) and deep D26 (≥ 110 m) have a 13% and 17% increase, respectively. As high TCHP and deep D26 regions are often associated with intensification to super-typhoon intensity, these ongoing warming requires close monitoring. This research also will report results from the Impact of Typhoons on the Pacific (ITOP) field campaign. Based on the in situ air-borne atmospheric and ocean pair observations during ITOP, we developed a new ocean coupling potential intensity (OCPI) index to revise the existing potential intensity index for tropical cyclones (Emanuel 1988). The main concept is to include ocean's subsurface contribution in estimating cyclone's potential intensity so as to reflect a more realistic potential from the entire ocean column, instead of only using sea surface temperature.

## A NEW APPROACH TO RETRIEVING CLOUD BASE HEIGHT OF MARINE BOUNDARY LAYER CLOUDS

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### Abstract

A novel approach is proposed based on calculated boundary-layer lapse rates, collocated observations of cloud top height (CTH) and temperature differences between cloud top and ocean surface from A-Train satellite constellation for estimating the cloud base height (CBH) of marine boundary layer clouds. The method takes advantage of the assumption that decrease of the temperatures within and below water clouds may follow the different approximately constant lapse rates in same region, respectively. The CBHs derived from the new method compare favorably with those obtained from instantaneous observations from active satellite sensors (CALIPSO and CloudSat) with a correlation coefficient of 0.79 and standard deviation of ñ0.27km (mean difference of 0.04km). An important advantage of this method is independent of boundary layer cloud types, optical thicknesses and illumination, thus may serve as a valuable supplement to daytime retrieval results based on passive remote sensing of scattered sunlight and to other methods treating different cloud types.

## INVESTIGATION OF THE INTER-ANNUAL VARIABILITY OF TYPHOON'S MAXIMUM POTENTIAL INTENSITY IN THE WESTERN NORTH PACIFIC OCEAN

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### Abstract

Western North Pacific Ocean is the most important and energetic tropical cyclone (TC) basins of the world. Each year the 20-30 tropical cyclones formed and intensified in the WNPO. They impose severe threat to a billion population and mega volume of economical activities in Asian countries. However, WNPO can be subject to large inter-annual variability, e.g. El Niño and La

Nina events. In addition, recent research has shown that there exist two different types of El Niño with distinctly different forms of warming in sea surface temperature. The Cold Tongue (CT) or the conventional El Niño o is characterized by warming in the eastern Pacific, typically in the Niño -3 region. The Warm Pool El Niño (or the date line El Niño) is characterized by warming near the international date line, i.e., in the Niño-4 region. Together with La Niña events, they introduce large-scale inter-annual variability in the coupled atmosphere-ocean system of the Pacific. These inter-annual variability can make significant modulation on TC activities through changes in the ocean and atmospheric environment. This study explores the inter-annual variability of the WNPO TC intensity using the Maximum Potential Intensity (MPI) index (Bister and Emanuel 2002).

## SUDDEN TRACK CHANGES OF TROPICAL CYCLONES IN MONSOON GYRES: IDEALIZED EXPERIMENTS

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Abstract

Sudden typhoon track changes are one of the major challenges in tropical cyclone forecasting. While these unusual phenomena occur within a few hours, the associated mechanisms are not clear. In the western North Pacific, observational analysis shows that monsoon gyres have an important influence on sudden typhoon track changes. In this study, idealized numerical experiments are conducted to examine the mechanisms for sudden typhoon track changes in monsoon gyres.

Numerical simulations show that the sudden northward track change happens when a tropical cyclone is initially located within the eastern semicircle of a larger-scale monsoon gyre, moving cyclonically toward the monsoon gyre center. The simulated sudden track change includes a westward slowdown and a northward speedup, which are very similar to observations and previous barotropic simulations. The interaction between the monsoon gyre and the embedded tropical cyclone leads to a cyclonical rotation of the tropical cyclone beta-gyres. The initial northward ventilation flow tends to the southwest or south, which slows down the northwestward movement of the tropical cyclone. Meanwhile, accompanying with the northwestward movement of the monsoon gyre with a relative steady translation speed due to its beta effect, the monsoon gyre catches up with the slowly-moving tropical cyclone and coalesces with it. The coalescence process enhances the Rossby wave energy dispersion of the tropical cyclone, leading to strong ridging about 500 km to the southeast of the tropical cyclone center. With the southwesterly winds from the monsoon gyre, strong southerly steering flows develop across the tropical cyclone and causes its sudden northward deflection and subsequent acceleration. Sensitivity experiments are also reported in the talk.

## EFFECT OF URBAN MORPHOLOGIES ON URBAN AIRFLOWS AND POLLUTANT DISPERSION IN URBAN-LIKE GEOMETRIES

Jian Hang, Zhiwen Luo, Mats Sandberg
Sun Yat-Sen University, Guangzhou, China

Abstract

Vehicle emissions have been confirmed the main sources of urban air pollution including aerosols and particles. Besides pollutant source control, urban ventilation is an effective approach to improve urban air quality. Studies are still required to understand how rural/marine wind ventilates urban canopy layer and removes ground-level pollutants released uniformly in street networks of urban areas. The link between urban morphologies and pollutants/aerosols removal process still remains unclear in a quantitative issue. Several idealized urban-like neighborhoods made of full-scale building arrays were first numerically studied under the validation of wind tunnel data. Turbulent airflows within and around urban areas were solved by Reynolds-Averaged Navier-Stokes (RANS) turbulence models. Besides the analysis of urban airflow field, some concepts including age of air, normalized pollutant transport rates and purging flow rate were also applied to quantify and evaluate the contribution of ventilation and pollutant removal by mean flows and turbulent diffusion and their net capacity. Wind directions, city size or total length of urban area, building area density and building height variations are confirmed significant factors to influence urban airflows, pollutant dispersion and urban ventilation. The methodologies applied in this research may provide effective approaches to quantify how to improve urban morphologies for better pollutant/aerosol dispersion in urban areas, meanwhile the results can provide some guidelines for sustainable urban planning and design.

## NUMERICAL MODELINE RESEARCH OF ROSSBY TOPOGRAHIC WAVE

Jiang Qin, SUN YAT-SAN UNIVERSITY

Abstract

This paper will research the formation and transmission mechanism of the Rossby waves and simulate the process in the computer. We use ROMS to simulate the waves,(1)you can see the detail process of the analysis of the control equations and boundary conditions; it shows the transform in different coordinates.(2)this paper introduce s the definition and calculation of the Beta-plane and f-plane;(3)it analyses the generation and transmission under the effect of the curvature of the earth and the terrain.as a result we can get the conclusion that in the terrain that the deep increasing along the y axis, the Rossby spread to the west in the Beta-plane, and Rosssby waves propagate in the Northern Hemisphere with the shallower side on their right in f-plane.

## EVALUATION AND REGIME-DEPENDENT ERROR DIAGNOSIS OF CLOUD AND WATER VAPOR SIMULATIONS IN CLIMATE MODELS USING NASA A-TRAIN SATELLITE OBSERVATIONS

Jiang, J.H., H. Su, C. Zhai, V.S. Perun, A. Del Genio, L.S. Nazarenko, L.J. Donner, L. Horowitz, C. Seman, J. Cole, A. Gettelman, M. Ringer, L. Rotstayn, S. Jeffrey, T. Wu, F. Brient, J-L. Dufresne, H. Kawai, T. Koshiro, M. Watanabe, T.S. L□cuyer, E.M. Volodin, T. Iversen, H. Drange, M.S. Mesquita, W.G. Read, J.W. Waters, B. Tian, J. Teixeira, and G.L. Stephens

California Institute of Technology

## Abstract

Using NASA A-Train satellite observations, we evaluate the accuracy of cloud water content (CWC) and water vapor mixing ratio (H2O) outputs from ~20 climate models submitted to the CMIP5, and assess improvements relative to their counterparts for the earlier CMIP3. We find more than half of the models show improvements from CMIP3 to CMIP5 in simulating column-integrated cloud amount, while changes in water vapor simulation are insignificant. For the CMIP5 models, the model spreads and their differences from the observations are much larger in the upper troposphere than in the lower or middle troposphere. Numerical scores are used to compare model performances in regards of to spatial mean, variance and distribution of CWC and H2O over the tropical oceans. Model performances at each pressure level are ranked according to the average of all the relevant scores for that level. We further developed a diagnostic framework to decompose the cloud simulation errors into the large-scale errors, cloud parameterization errors and co-variation errors. We find that the cloud parameterization errors contribute predominantly to the total errors for all models. Large-scale errors associated with thermodynamic parameters account for larger percentage of total errors than those associated with dynamic parameters. Lastly, the relevance of current satellite observations of clouds and water vapor to climate models' projections of future climate changes is explored.

## CLOUD-SCALE SIMULATION STUDING ON THE EVALUATION OF LATENT HEAT PROCESSES OF MESOSCALE CONVECTIVE SYSTEM ACCOMPANYING HEAVY RAINFALL: THE GUANGZHOU CASE

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Feiyun Guo and BaiYun
District Bureau of Meteorology, Guangzhou

## Abstract

The Weather Research and Forecasting (WRF) model is used to conduct simulation experiments at 3 km cloud-resolving resolution for the Guangzhou case. After verification of simulation results, we focus on studying three-dimensional structure of latent heating rates and latent heat budgets in different stages. The results show: (1) The experiment reproduces well the rain belt, the location and characteristics of rainstorm. The radar echo is reproduces well except in the west of the Pearl River Estuary. Therefore, it's deemed successful. (2) The distributions of heating processes near the rainstorm center during the development stage and the mature stage have some things in common: freezing locates above the zero degree layer, reaching a maximum rate at 500 hPa; above 300 hPa, deposition is the main heating process. However, the distribution of condensation is different: condensation is mainly found between 900 hPa and 300 hPa during the development stage, while it extends from 1000 hPa to 300 hPa during the mature stage. (3)

During the development stage, the total latent heating extends mainly from 900 hPa to 250hPa. From 900 hPa to 300 hPa, there is mainly condensation heating. From 300 hPa to 250 hPa, there is mainly a deposition heating effect. During the mature stage, the total latent heating extends from 1000 hPa to 200hPa. Below 300 hPa, condensation heating dominates. Above 300 hPa, there is mainly depositional heating. During the dissipating stage, all of the microphysical processes are very weak. (4) The convective motion of MCS causes the release of large amounts of latent heat, which affect the thermal and dynamic structure of MCS. The latent heat released by convection is the main source for the increase of vorticity. (5) The top two positive latent microphysical processes are water vapor condenses into cloud water and rain water collected by graupel. The dominant microphysical processes for releasing latent heat are different in different stages of MCS. During the development stage and the dissipating stage, the top three cooling microphysical processes are evaporation of rain water, evaporation of cloud water and sublimation of snow, respectively. However, the top three cooling microphysical processes during the mature stage are evaporation of rain water, melting of graupel and evaporation of cloud water, respectively.

## CLIMATOLOGICAL MEANS AND VARIATIONS OF TROPICAL PRECIPITATION AND ITS RELATIONSHIP WITH SURFACE TEMPERATURE FROM 15 YEARS OF TRMM DATA

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### Abstract

One of the key goals of the Tropical Rainfall Measuring Mission (TRMM, launched in late 1997) has been to define the spatial and seasonal climatological rainfall in the tropics as accurately as possible in order to quantify this key component of the hydrological cycle. Climatology of tropical surface rain has been developed based on a composite of fifteen years (1998-2012) of precipitation products from recent TRMM Version 7 (V7) data. The TRMM Composite Climatology (TCC) V7 consists of a merger of selected TRMM rainfall products over both land and ocean to give a TRMM-best? climatological estimate.

In addition to the mean precipitation estimate, the TCC also includes the variation among the three estimates at each point to give an estimate of the uncertainty in the mean value. For evaluation and validation purposes, a series of inter-comparisons will be carried out among TCC components, and ground-based observations. The TCC may have broad applications and should be useful to the user community interested in climate monitoring, climate variability studies, model initialization and verification, and comparison with other non-TRMM rainfall analyses.
The first-time use of both active [Precipitation Radar (PR)] and passive microwave [TRMM Microwave Imager (TMI)] instruments onboard the TRMM also provides the opportunity to examine the relations between tropical rainfall and surface temperature, using measurements from both passive and active microwave sensors. In an earlier study of 9-year TRMM V6 data analysis (Wang et al. 2008, JGR), it was found that the PR-based surface precipitation-temperature slopes do not confirm slopes based on passive microwave observations. We will re-examine the relation between tropical rainfall and surface temperature with the fifteen-year

TRMM V7 data. These relations will also be compared to those derived from Global Precipitation Climatology Project (GPCP) analyses.

## LIGHT PRECIPITATION SUPPRESSION OVER THE TAIHANG MOUNTAINS IN NORTHERN CHINA BY SUMMERTIME AIR POLLUTION: AN OBSERVATION AND MODELING STUDY

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Abstract

We analyze a 40-year record of daily average horizontal visibility (a proxy for aerosol concentration) and hourly precipitation observations from seven weather stations, including four stations located at the Taihang Mountains, during the summertime in northern China. No significant trend in annual total precipitation at almost all stations is found. However, apparent trends emerge if the hourly precipitation data are classified into four categories of intensity: very low, low, moderate and high). Light rains (very low and low precipitation intensities) have decreased considerably, whereas heavy rains have increased, especially at mountain stations. Over the same period at these stations, visibility has declined considerably. Both the frequency of occurrence and precipitation efficiency at the mountain stations have declined. Magnitudes of the orographic enhancement factor at two pairs of mountain-plain stations have decreased by 22% and 25%, respectively. Combing observation and modeling results appears to point toward the role of aerosols in modulating rainfall. Air pollution at upwind stations in the Northern China Plain likely suppresses precipitation over the mountain region due to the forced uplifting of the polluted air mass which gives rise to a greater number of smaller cloud droplets. This is unfavorable for the development of precipitation. To examine how aerosols impact precipitation over the observed region, simulations using the Weather Research and Forecasting model with full spectral-bin microphysics are conducted at the cloudresolving scale. Model results confirm the role of aerosol indirect effects in reducing the light precipitation amount and frequency over the mountain area.

## INFLUENCE OF THE BOREAL SUMMER ISO ON SUMMER RAINFALL IN INDIA AND EASTERN CHINA

Jiepeng Chen, Zhiping Wen, Center for Monsoon and Environment Research, Sun Yat-Sen University

Abstract

The tropical intraseasonal oscillation (ISO) is one of the major systems affecting on summer rainfall in Eastern China and India. The boreal summer intraseasonal oscillation (BSISO) index

defined by Kikuchi et al. (2012) can capture the principal characters of summer tropical ISO that over the northern Indian Ocean there is prominent northward propagation with weaker eastward propagation along the equator from Indian Ocean. In this study, using a real-time monitoring BSISO index and high resolution daily gridded rainfall data (Xie et al., 2007), rainfall anomalies over India and Eastern China associated with various phases of northward propagating BSISO life cycle is investigated and its possible mechanism is discussed. When the BSISO is in phase 1 and 2 (BSISO convective center is located over equatorial Indian Ocean, Bay of Bengal and eastern North Pacific), anomalous anticyclone is over western North Pacific which is benefit for transporting water vapor to Southern China while anomalous cyclone occupies Japan. Anomalous southerly from southern anticyclone and anomalous northerly from northern cyclone converge in Southern China, so rainfall anomalies are significantly increasing over Southern China. When in phase 3 and 4, rainfall anomalies are significantly increasing over Yangtze River Basin corresponding anomalous southern anticyclone shifting northward. Accompanying convective center northward propagating, positive rainfall anomalies continue to shift northward. Positive rainfall anomalies arrive at Yellow River-Huai River basin during phase 5 and 6. When in phase 7, rainfall anomalies are significantly decreasing over Southern China and Yangtze River Basin when BSISO convective center is located over western North Pacific and a pair of anomalous cyclones is over western North Pacific and Japan. Anomalous cyclone over western North Pacific northward shifts resulting in significantly decreasing rainfall over Yellow River-Huai River basin in phase 8. Positive rainfall anomalies over India are affected by anomalous strengthening convection from Indian Ocean and cross equatorial flow from Mascarene in phases 3-6, while it is opposite in phases 1-2 and 7-8. Positive rainfall anomalies over Eastern China are affected not only by anomalous strengthening convection from western North Pacific Ocean but also by descending motions over South China Sea enhancing north-south vertical circulation. The organized convections associated northward propagation of BSISO over the Indian and western Pacific regions contribute to anomalous rainfall in India and Eastern China, separately. When the convections dominate Indian Ocean which could trigger Rossby waves, the energy of Rossby waves affects Eastern China rainfall through westerly waveguide in phases 1-4.

## A STUDY OF REGIONAL AIR POLLUTION IN SPRING USING WRF/CMAQ MODEL OVER PEARL RIVER DELTA, CHINA

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Yerong Feng, Guangzhou Central Meteorological Observatory

### Abstract

As one of the three large economic regions of China, the regional air pollution, in which the primary is aerosol pollution, is serious over Pearl River Delta (PRD) region, China. In this study, WRF/CMAQ model was utilized to study regional air pollution in spring over PRD. Model performance was examined and evaluated by comparison with observations over PRD for a 28-day period from 1 to 28 March 2012. WRF model shows reasonable performance for major meteorological variables (i.e., temperature, relative humidity, wind speed) with correlation coefficient of 0.76-0.94. CMAQ model generally reproduces the spatial patterns and time series variations of air pollutions (SO2, NOX, O3, PM10 and PM2.5). The model successfully captured three air pollution episodes during 3-5 (episode I), 15-16 (episode II) and 26-27 (episode III) in

this month. The primary air pollutants are particle matter during episode I and II and ozone during episode III, respectively. Higher ratios of PM2.5/PM10 and lower visibilities were simulated during episode I and II than those during episode III, which were consistent with the observations. The reason for these differences was the dominate weather system during the air pollution episodes. Episode I and II occurred with the south wind over PRD, the relatively humidity were high, which was benefit to the chemical conversion process, especially aqueous chemical reactions. The main components in particle matter are sulfate and nitrate, which were contributed to the ratios of PM2.5/PM10 and low visibilities. Different with episode I and II, the dominate wind was by north during episode III, the relatively humidity was 50% or so. The sulfate mass concentrations were lower than those during episode I and II. In addition, the sulfate tracking diagnostic model configuration included in CMAQ was employed to determine the importance of the different formation pathways for sulfur dioxide conversion to sulfate. In general, oxidation pathways for SO2 are dominated by the aqueous-phase H2O2 reactions, catalysis by iron (Fe) and manganese (Mn) and the gas-phase OH.

## MOST PROBABLE HEIGHT OF GLOBAL AEROSOL LAYERS

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Abstract

Aerosol vertical inhomogeneities remain underrepresented in many aerosol retrieval algorithms, while aerosol size and refractive index are changing as functions of altitude because the water vapor mixing ratio and fallout size decrease with height. Ground and spaceborne lidar observations, such as the NASA Micro-Pulse Lidar Network (MPLNET) and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), provide us with unprecedented opportunity to improving our understanding of the 3D-spatial and temporal variability of global aerosol layers. Results inferred from lidar measurements indicate significant regional and seasonal dependence of most probable height of aerosol layers, which are not only associated with anthropogenic emissions but also strongly tied to weather systems and meteorological conditions. Results indicated that aerosol altitude can also vary significantly from day to night in its diurnal characteristics. Vertical profiles of aerosol layers for six regions of interests including Saharan Air Layer, Southeastern Asia, Southeastern Atlantic Ocean, Western African Monsoon, Amazon, Northwestern Pacific, were discussed in details. Impacts from relative aerosol height to cloud on aerosol climatic effect investigations are also discussed.

## SIMULATIONS OF THE FIRST INDIRECT EFFECT OF ANTHROPOGENIC SULFATE AND ITS IMPACT ON REGIONAL CLIMATE OF EAST ASIA

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### Abstract

Aerosol and its effects on climate have drawn more and more attentions in recently years. Using a modified Regional Climate Model Version3 (RegCM3), the spatial distribution and its first indirect radiative forcing (RF) on the regional climate over East Asia of sulfate aerosol during December 2008 to November 2009 are investigated. Affected by the general circulation and the conversion efficiency of aqueous phase from SO2 to SO42-, a well marked seasonal variation of sulfate distribution concurred with the general circulation and sulfate aerosol shows the highest concentration up to 27 g m-2 during July. The indirect RF due to sulfate aerosol at the top of atmosphere (TOA) and surface are negative, which leads to a cooling effect of the surface by 0.12oC and a reduction of precipitation by 0.01mm d-1. But the tendencies of the temperature and precipitation have significant diversity in space and seasons. Aerosols, which can be cloud condensation nucleus and modify the properties of clouds, affect the climate indirectly through cloud processes, which will make the climate feedback of aerosols more complex and elusive. This disharmony feedback occur for that once the net solar radiative flux is changed due to the aerosol, it will cause inevitable variations of other processes, such as the water cycle associated with energy exchange, and these processes will also have a impact on the climate.

## EMISSIONS OF NITROGEN OXIDES OVER CHINA RETRIEVED FROM SPACE: TRENDS, VARIABILITY AND IMPACTS ON PARTICULATE MATTER POLLUTION

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### Abstract

Nitrogen oxides (NOx ≡ NO + NO2) are important atmospheric constituents affecting the tropospheric chemistry and climate. They are emitted both from anthropogenic and from natural (soil, lightning, biomass burning, etc.) sources, and China has become a major region of increasing importance for anthropogenic sources.

In a series of studies, we use vertical column densities (VCDs) of tropospheric nitrogen dioxide (NO2) retrieved from satellite remote sensing to estimate anthropogenic and natural emissions of NOx over China. We separate anthropogenic emissions from lightning and soil sources over East

China for 2006 by exploiting their different seasonality. We evaluate variations in anthropogenic emissions at different time scales in response to the economic development of China, from the general growth in recent years to the economic downturn during late 2008 - mid 2009 to the holiday associated with the Chinese New Year. By examining trends of NOx emissions, measurements of particulate matter (PM) pollution, and coupled model simulations, we find the rapidly growing NOx emissions to be a key driver of recently deteriorating PM pollution over East China.

## IMPROVED RETRIEVAL OF TROPOSPHERIC NITROGEN DIOXIDE FROM SATELLITE REMOTE SENSING

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Hitoshi Irie, Center for Environmental Remote Sensing, Chiba University, Japan

### Abstract

Center for Environmental Remote Sensing, Chiba University, 1-33 Yayoicho, Inage-ku, Chiba 263-8522, Japan Vertical column densities of tropospheric nitrogen dioxide (NO2) retrieved from satellite remote sensing have been used extensively to study concentrations and emissions of nitrogen oxides (NOx). The NO2 data are however subject to uncertainties and assumptions embedded in the retrieval process. Here we present a detailed error analysis for NO2 retrieval from the Ozone Monitoring Instrument (OMI), focusing on several key assumptions including the treatments of aerosols, surface reflectance anisotropy, and vertical profile of NO2. We analyze the influences of these assumptions via an improved retrieval process. We explicitly account for aerosol optics (simulated by nested GEOS-Chem at 0.667§lon x 0.5 lat§and constrained by aerosol measurements), surface reflectance anisotropy, and high-resolution vertical profiles of NO2 (simulated by GEOS-Chem). Prior to the NO2 retrieval, we derive the cloud information using the same set of ancillary assumptions. We compare our retrieval to the widely used DOMINO v2 product, using as reference the MAX-DOAS measurements at three urban/suburban sites in East China and focusing the analysis on the 127 OMI pixels (in 30 days) closest to the MAX-DOAS sites. We find that our retrieval reduces the interference of aerosols on the retrieved cloud properties, thus enhancing the number of valid OMI pixels by about 25%. Compared to DOMINO v2, our retrieval improves the correlation with the MAX-DOAS data in the day-to-day variability of NO2 (R2 = 0.96 versus 0.72). It results in NO2 columns about 50% of the MAX-DOAS data on average, partly reflecting the inevitable spatial inconsistency between the two types of measurement. Through a series of tests, we find that excluding aerosol scattering/absorption can either increase or decrease the retrieved NO2, with a mean absolute difference by about 20%. It also affects nonlinearly the retrieved cloud fraction and particularly cloud pressure. Employing various surface albedo datasets slightly alters the retrieved NO2 on

average. The assumed vertical profiles of aerosols and NO2 also influence the retrievals of clouds and/or NO2. More MAX-DOAS measurements will help quantify the effects of ancillary assumptions in retrieving NO2.

## HOW AEROSOLS IMPACT DEEP CONVECTION, RADIATIVE FORCING AND CIRCULATION?

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### Abstract

Aerosol-cloud interaction is recognized as one of the key factors influencing cloud properties and precipitation regimes and remains one of the largest uncertainties in understanding and projecting climate changes. Reducing these uncertainties requires us to improve our understanding in how aerosols change cloud microphysical processes and its feedback to dynamics by serving as cloud condensation nuclei (CCN) and ice nuclei (IN). For deep convection clouds (DCCs), latent heat could be significantly changed through aerosol microphysical effects, which could impact circulation. At the same time, aerosol microphysical effects may produce large impact on the stratiform/anvil regimes, leading to significant climate impact. We have carried out modeling and observational studies to elucidate what factor plays the dominant role in terms of the invigoration of convection by aerosols, how convective life cycle is changed by aerosol microphysical effects, and what is the significance to radiative forcing. Some importance findings from those studies greatly enhance our understanding of aerosol-deep convection interactions, which provides the scientific basis to better parameterize aerosol effects on DCCs and large-scale circulation for regional and climate models.

## COUPLING OF A REGIONAL ATMOSPHERIC MODEL (REGCM3) AND A REGIONAL OCEANIC MODEL (FVCOM) OVER THE MARITIME CONTINENT

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Paola Rizzoli, M.I.T.
Elfatih Eltahir, M.I.T.
Pengfei X, M.I.T.

### Abstract

We describe a successful coupling of two regional models of the atmosphere and the ocean: Regional Climate Model version 3 (RegCM3) and Finite Volume Coastal Ocean Model (FVCOM). RegCM3 includes several options for representing important processes such as moist convection and land surface physics. FVCOM features a flexible unstructured grid that can match complex land and islands geometries as well as the associated complex topography. The coupled model is developed and tested over the Southeast Asian Maritime Continent, a region where a relatively shallow ocean occupies a significant fraction of the area and hence atmosphere-ocean interactions are of particular importance. The coupled model simulates a stable equilibrium climate without the need for any artificial adjustments of the fluxes between

the ocean and the atmosphere. We compare the simulated fields of sea surface temperature, surface wind, ocean currents and circulations, rainfall distribution, and evaporation against observations. While differences between simulations and observations are noted and will be the subject for further investigations, the coupled model succeeds in simulating the main features of the regional climate over the Maritime Continent including the seasonal north-south progression of the rainfall maxima and associated reversal of the direction of the ocean currents and circulation driven by the surface wind. Our future research will focus on addressing some of the deficiencies in the coupled model (e.g. wet bias in rainfall and cold biases in sea surface temperature) and on investigating the predictability of the regional climate system.

## STRATOSPHERIC STRUCTURE AND BLOCKING IN AN NWP MODEL

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MJP Cullen, UK Met Office

### Abstract

We show that the vertical structure of the atmosphere can strongly influence the climatology of tropospheric blocking. Following recent work on stratosphere-troposphere coupling, we invoke dynamical theory to argue that the development and decay of anomalous circulations is most efficient for a preferred aspect ratio of the flow, implying that the development of large-scale anomalies requires a large vertical scale. Evidence for this link comes from UK Met Office operational analyses. In particular, we find that the development of the large-scale tropospheric anomalies associated with blocking requires a vertical scale extending well into the stratosphere. This process is inhibited during periods of high stratospheric activity, when the vertical scale of tropospheric developments is restricted, leading to the persistence of large horizontal scales. Applications to a low-resolution climate model will also be discussed.

## A THEMATIC CLIMATE DATA RECORD (TCDR) OF ATMOSPHERIC TEMPERATURE DERIVED FROM SATELLITE MICROWAVE SOUNDING INSTRUMENTS USING 1D-VAR

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### Abstract

Microwave Sounding Units(MSUs) and the Advanced Microwave Sounding Unit (AMSU) on National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellites have measured the upwelling microwave radiation emitted from atmospheric oxygen and provided a long-term monitoring of atmospheric temperature. The AMSU instruments are similar to the MSUs, but they make measurements using a larger number of channels, thus sampling the atmosphere in a larger number of layers. By using the AMSU channels that most closely match the channels in the MSU instruments, a long-term climate data record of atmospheric

temperature can be. Both MSU and AMSU instruments were intended for day-to-day operational use in weather forecasting and thus are not calibrated to the precision needed for climate studies. A climate quality dataset can be extracted from their measurements only by careful inter-calibration of the distinct MSU and AMSU instruments.

With one-dimension variation (1D-Var) scheme, the solution in the retrieval starts from a first guess and converges to the final estimate based on a forward model and it's Jacobian. The final atmospheric profile solution found fits the brightness temperatures measurements closest. In addition to the retrieval, the degree of fitting (or convergence) is also an excellent metric for assessing the quality of the retrieval. The final atmospheric profile solution found fits the brightness temperatures measurements closest. In addition to the retrieval, the degree of fitting (or convergence) is also an excellent metric for assessing the quality of the temperature retrieval.

## MIXING WEIGHT DETERMINATION OF DUST/SOOT MIXTURE WITH MODIS DATA OVER ARID AREAS

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### Abstract

The effect of black carbon on the optical properties of polluted mineral dust is studied from a satellite remote-sensing perspective. By including the auxiliary data of surface reflectivity and aerosol mixing weight, the optical properties of mineral dust, or more specifically, the aerosol optical depth (AOD) and single-scattering albedo (SSA), can be retrieved with improved accuracy. Precomputed look-up tables based on the principle of the Deep Blue algorithm are utilized in the retrieval with MODIS observations. The mean differences between the retrieved results and the corresponding ground-based measurements are smaller than 1% for both AOD and SSA in the case of pure dust over the greater Cairo region. However, the retrievals can be underestimated by as much as 11.9% for AOD and overestimated by up to 4.1% for SSA in the case of polluted dust with an estimated 10% (in terms of the number-density mixing ratio) of soot aggregates if the black carbon effect on dust aerosols is neglected. For retrieving more accurate optical properties of dust/soot mixtures, this study aims at determining of the mixing weights of dust/soot mixtures with MODIS data.

## BLACK CARBON IN 3D MOUNTAIN/SNOW, RADIATIVE TRANSFER, AND REGIONAL CLIMATE CHANGE

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### Abstract

It is well-known that radiative transfer involving greenhouse gases holds the key to discussion of global climate radiative forcing. However, it is equally important to understand the potential

amplification of regional surface warming and mountain snowmelt produced by two associative radiative transfer processes: namely, light absorbing by black carbon (BC, soot) and solar flux transfer in 3D intense mountain/snow areas. Two specific mountain domains have been chosen for this study: the Sierra Nevada Mountains in the western United States, and the southern Tibetan Plateau. We show that, based on 10-year MODIS satellite data, snow albedo reduction from March to April is caused in part by the deposition of absorbing aerosols associated with an increase in aerosol optical depth. BC particles, which profoundly affect atmospheric vertical heating profiles by directly absorbing sunlight, have highly complex and often inhomogeneous morphologies. In particular, BC morphologies and their internal mixing states associated with snow grains have not been accounted for in modern radiative transfer and regional climate models concerning the evaluation of snow albedo reduction. We introduce a new theoretical development for the construction of fractal and complex soot aggregates by means of stochastic procedures through which their extinction efficiency, single-scattering albedo, and asymmetry factor can be evaluated on the basis of the geometric-optics and surface-wave approaches. We demonstrate that small soot particles on the order of 1 μm, internally mixed with snow grains of 50-100 μm, could effectively reduce snow albedo by as much as 5-10%.

Determining solar radiative transfer over 3D mountain/snow fields for application to climate models is a challenging task. We have developed a computational approach based on 3D Monte Carlo photon tracing simulation results for all sky conditions, which is followed by multiple regression analysis and parameterization for direct, diffuse, and coupled surface fluxes with reference to differences produced by 3D and conventional plane-parallel radiative transfer models in a 10x10 km2 domain. Using a coupled land-atmosphere model covering the western United States and based on WRF and CLM as the testbed, we illustrate that 3D radiative transfer has substantial impact on solar flux distribution, which in turn affects heat flux and temperature distributions over mountain/snow areas, consequently producing feedback to regional climate in terms of precipitation, snowmelt, and mountain cloud distributions. Finally, we discuss the importance of BC particles in the reduction of mountain/snow albedo vis-a-vis aerosol-snow-albedo feedback as a regional system that has an irreversible impact on regional climate and climate change.

## THE STRUCTURAL CHARACTERISTICS OF PRECIPITATION IN ASIAN-PACIFIC'S THREE MONSOON REGIONS MEASURED BY TRMM

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### Abstract

The three-dimensional structure of precipitation at seasonal scale in Asian-Pacific's three monsoon regions is investigated based on the TRMM data? The results show that : (1) The maximum seasonal variation of the relative proportional difference of convective precipitation and stratiform rain occurs in the East Asian monsoon region, the second occurs in Indian monsoon region, and the minimum is in the Northwest Pacific monsoon region. In both the

Northwest Pacific monsoon region and Indian monsoon region, the convective rain is proportionately larger than stratiform rain in all four seasons. (2) Cloud ice reaches its maximum at around 9km. Cloud water's maximum range is between 3 km and 4km. The large value area of precipitation ice is mainly between 4 km and 9 km. And the precipitation water particle is concentrated mostly below 4km. The largest content is from ground to 2 km. (3) The most remarkable variance of the content of cloud ice in Indian monsoon region occurs from spring to winter. And the content of cloud water in Northwest Pacific is always higher than those in other two regions. (4) The latent heat profile has a similar double-peak structure. The first peak is at 4km and the second peak is at 2km. In autumn and winter, latent heat is higher in Northwest Pacific than in other two regions. In all three regions, the release of latent heat is higher in summer and autumn than in spring and winter.

## CLOUD-SCALE SIMULATION STUDY OF TYPHOON HAGUPIT (2008) PART I: MICROPHYSICAL PROCESSES OF THE INNER CORE AND THREE-DIMENSIONAL STRUCTURE OF THE LATENT HEAT BUDGET

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Abstract

The Advanced Research WRF (ARW) version of the Weather Research and Forecasting (WRF) model is used to conduct simulation experiments with a 3km resolution for Typhoon Hagupit (2008). The primary results show the following: (1) The control experiment reproduces well the environmental field, track, storm propagation speed, intensity change, latent heating vertical profile of the typhoon inner core area ?and wind and precipitation distribution of the typhoon. (2) The average total latent heating profile of the inner core reaches its peak value at a height of 7 km. At heights below 500 m, there is mainly an evaporative cooling effect. From 1 to 4 km, mainly condensation heating is present. Above 10km, there is mainly a deposition effect. (3) Condensation heating exists principally within the inner flank of the cloud wall. Its maximum height is 2?5km, and can reach 11km. Melt cooling takes place in the outer flank of the cloud wall, whereas freeze heating is in the cloud wall, above the zero degree isotherm. (4) The large magnitude of microphysical process conversion rates is attributable to rainwater collected by graupel, melting of graupel, rainwater collected by snow, and water vapor condensation into cloud water. The dominant microphysical processes for releasing latent heat are water vapor condensation into cloud water and depositional growth of snow and cloud ice. The dominant microphysical processes for absorbing latent heat are evaporation of rainwater, sublimation of snow, and melting of graupel.

## STUDIES ON THE TROPICAL ATMOSPHERIC INTRASEASONAL OSCILLATION IN DIFFERENT REANALYSIS DATA

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Abstract

In this study, we analyze tropical intraseasonal oscillation's characteristics using three kinds of data(NCEP/NCAR reanalysis data?NCEP/DOE reanalysis data and ECMWF/ERA40 reanalysis data) in three climate states of 1961-1991,1971-2000 and 1981-2010?There is a significant 30-60d oscillation period of 200hPa zonal wind in different climate states of different reanalysis data. We can find different intraseasonal oscillation characterristics in different data and in different climate states. It is found that in the 1981-2010 climate state compared with the other two climate states (1971-2000 and 1981-2010), the tropical intraseasonal oscillation's annual cycle character is more pronounced which is strong in winter and summer and weak in summer and autumn; the tropical intraseasonal oscillation is more stronger in the tropical Indian Ocean and the tropical western Pacific Ocean, also its active areas extend east and become larger; The eastward propagating energy of the tropical intraseasonal oscillation centers more in 1-3 wave, while the westward propagating energy becomes weaker; The tropical intraseasonal oscillation's starting northward propagating time is later. It propagates southward strongly which spreads to the southern hemisphere in the beginning of May. NCEP/NCAR reanalysis data and NCEP/DOE reanalysis data match well in the tropical intraseasonal oscillation's spatial distribution, intensity and energy propagation. While NCEP/NCAR reanalysis data and ERA40 reanalysis data have some distinctions: the tropical intraseasonal oscillation? s oscillation periods center in 20-100d and its peak value is 55d of NCEP/NCAR reanalysis data, while its oscillation periods are 20-60d and its peak value is 50d of ERA40 reanalysis data; In the periods of 80-100d, the oscillation of ERA40 reanalysis data is stronger than that of NCEP/DOE reanalysis data; the tropical intraseasonal oscillation's variance contribution percent of NCEP/NCAR reanalysis data is a little less than that of ERA40 reanalysis data in the tropical Indian Ocean and the Tropical Western Pacific Ocean, while stronger than that of ERA40 reanalysis data in the Eastern Equatorial Pacific Ocean; From December to the middle of March, the tropical intraseasonal oscillation's intensity of ECMWF data is stronger than that of NCEP/NCAR reanalysis data. While from the middle of March to November, the tropical intraseasonal oscillation's intensity of ERA40 reanalysis data is weaker than that of NCEP/NCAR reanalysis data; the tropical intraseasonal oscillation 's oscillation phase of ERA40 reanalysis data is ahead of NCEP/NCAR reanalysis data about 10 days; The eastward propagating energy of the tropical intraseasonal oscillation of NCEP/NCAR reanalysis data is weaker than that of ERA40 reanalysis data, while the westward propagating energy is stronger than that of ERA40 reanalysis data. In the middle of July, the northward propagating of NCEP/NCAR data is weaker than that of ERA40 reanalysis data.

## CONTRASTING IMPACT OF EASTERN-PACIFIC AND CENTRAL-PACIFIC TYPES OF ENSO ON THE MOISTURE CIRCULATION OVER EAST ASIA-WNP

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Abstract

The impacts of the new type ENSO (CP type ENSO) and the conventional ENSO (EP type ENSO) show a great discrepancy on the moisture circulation over East China. The influence of CP type ENSO over East China is strong in the developing summer and fall, weak in the matured winter and decaying spring and summer; while that of EP type ENSO tends to be weak in the developing summer, strong during fall to the decaying summer. The responses of two key systems in the teleconnection between ENSO and the climate over East Asia, western Pacific subtropical high (WPSH) and the Philippine Sea anticyclone (PSAC), to two types of ENSO are investigated. It is found that the activity of the WPSH is not strongly affected by two types of ENSO in the developing summer; while it is strongly modulated by the EP type ENSO and weakly modulated by the CP type ENSO in the decaying summer. In the decaying summer of the EP type El Niño, the WPSH tends to be stronger, enlarges and shifts southwestward with its northern boundary remains nearly unchanged and located south to Southeast China in June. This helps bringing abundant moisture from tropical WNP into East China and converged over Southeast China. In the middle and late summer, the enhanced WPSH shifts northward. Strong moisture deficit takes place over Southeast China and abnormal moisture surplus takes place to the North. In the developing fall to decaying spring, great discrepancy exist in the activity of the PSAC and the WNP cyclone in the lower level between EP type El Niño and CP type El Niño. The PSAC tends to be strong, long lasting and show a eastward migration during EP type El Niño while it tends to be weak, short-lifetime and constrained over SCS without eastward migration during CP type El Niño. The cyclone over WNP tends to be weak and decays rapidly resulting from the eastward migration of PSAC during EP type El Niño while it tends to be strong and closer to East China in the early stage and persists for a long time after it migrates to tropical WNP as the PSAC is weak and constrained over SCS. Hence, the PSAC help bringing abundant moisture into East China during EP type El Niño while the WNP cyclone anomaly benefit the weaker southerly transport of moisture over East China in the developing fall and the weak anticyclone over SCS contributes to the weak abnormal convergence over Southeast China in the mature winter and over Yangtze River basin in the decaying spring of the CP type El Niño.

## INFLUENCE OF ENSO ON TROPICAL WAVE ACTIVITY IN WESTERN NORTH PACIFIC

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Abstract

The three-dimensional structure and evolution characteristics of tropical waves in the tropical western North Pacific (WNP) during El Niño and La Niña summers are investigated based on observational and reanalysis data. It is shown that the interannual variability of tropical wave activity is closely related to ENSO. A clear MRG-to-TD transition was observed during El Niño summers while such a transition is unclear during La Niña summers. The vertical structure of the TD-MRG waves appears equivalent barotropic during El Niño but becomes tilted eastward with height during La Niña. For the ER waves, their amplitude have a faster growth during El Niño

summers than during La Niña summers but their structures and propagation characters have no markedly changed. The diagnosis of barotropic energy conversion shows that both the rotational and divergent components of the background flow change associated with ENSO are responsible for energy conversion from the mean flow to the TD-MRG and ER perturbations.

## CLIMATE CHANGES OF ATLANTIC TROPICAL CYCLONE FORMATION

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### Abstract

While some studies linked the enhanced tropical cyclone (TC) formation in the North Atlantic basin to the ongoing global warming, other studies attributed it to the warm phase of the Atlantic multidecadal oscillation (AMO). Using the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) Twentieth Century Reanalysis (20CR) dataset, the present study reveals the distinctive spatial patterns associated with the influences of the AMO and global warming on TC formation in the North Atlantic basin.

Two leading empirical orthogonal function (EOF) patterns are identified in the climate change of TC formation on time scales longer than interannual.The first pattern is associated with the AMO and its spatial pattern shows the basin-scale enhancement of TC formation during the AMO positive phase. The second pattern is associated with global warming, showing enhanced TC formation in the east tropical Atlantic ($5^{o}$-$20^{o}$N, $15^{o}$-$40^{o}$W) and reduced TC formation from the southeast coast of the United States extending southward to the Caribbean Sea. In the warm AMO phase, the basin-wide decrease in vertical wind shear and increases in mid-level relative humidity and maximum potential intensity (MPI) favor the basin-wide enhancement of TC formation. Global warming suppresses TC formation from the southeast coast of the United States extending southward to the Caribbean Sea through enhancing vertical wind shear and reducing mid-level relative humidity and MPI. The enhanced TC formation in the east tropical Atlantic is due mainly to local increase in MPI or sea surface temperature (SST), leading to a close relationship between the Atlantic SST and TC activity over the past decades.

## A NUMERICAL EXPERIMENT FOR THE QUASI-BIWEEK OSCILLATION IN THE SOUTH CHINA SEA

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### Abstract

The tropical intraseasonal oscillation (ISO) includes other modes of variability such as the quasi-biweek, 30-60 days oscillation in the South China Sea (SCS). It is noticed that quasi-biweek ISOs are strongly coupled with the sea surface temperature (SST) in the SCS. The intraseasonal atmospheric convection influences SST through solar radiation, latent heat flux, and mixed-layer

entrainment, on the other hand, the induced SST fluctuations feed back to affect the intraseasonal convection. A solution to an atmosphere model (Weather Research and Forecasting, WRF) forced with daily SST produces ISO coupled with the strong intraseasonal interaction. The result shows an increased in latent heat and water vapor flux, convection, rainfall, and longwave radiation, and decreased shortwave radiation during the northward propagation of a quasi-biweek oscillation from the Pacific. Sensitivity experiment shows that a thermal damping of the positive SST anomalies could reduce upward heat fluxes from the SCS, which then stabilize the lower atmosphere. If the SST is reduced by $0.25^{o}$, the ISOs in the SCS is still present with weakened convective zones. If it is reduced by $0.5^{o}$ or $1^{o}$, the ISOs will not exist, the convection zone is confined in south of $15^{o}$N.

## A MODELING STUDY OF MULTI-SCALE NATURE OF TROPICAL CYCLONE ACTIVITIES IN JUNE 2004

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Abstract

Ammonia (NH3) in the atmosphere is primarily emitted from agriculture (animal husbandry and fertilizer use), crops, and biomass burning. Bottom-up estimates of ammonia emissions, based on agricultural/energy activities and emission factors, are subjected to large errors. Here we use the surface measurements of wet deposition fluxes and satellite observations of ammonia columns for 2007-2010, combined with a global 3-D model of atmospheric composition, to provide a top-down estimate of ammonia emissions over North China (31 $^{o}$ -43 $^{o}$ N, 109 $^{o}$ -121 $^{o}$ E). The optimized ammonia emissions over this region are 5.1 Tg N a-1, with a factor of 3 higher in summer than winter. We also examine the sensitivity of surface aerosol concentrations to ammonia emissions over North China. The sensitivity is much higher in winter than summer due to ammonium nitrate formation.

## COMPARISON AND APPLICATION OF PMW RAIN RATES OVER CHINA

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Abstract

As part of the collaboration between China Meteorological Administration (CMA) National Meteorological Information Centre (NMIC) and NOAA Climate Prediction Center (CPC), a new system is being developed to construct half hourly satellite precipitation estimate on a 0.05olat/lon grid over China by combining NOAA series, DMSP series, and CMA FY-3B Polar

Microwave rain rate with TMI rain rate. Foundation to the development of the PMW rain rate combining algorithm is the validation of those passive microwave (PMW) - based rain rate retrievals. Since FY-3B is new and not included as inputs to CMORPH, and other established high-resolution satellite precipitation products, we focus our work here on the validation and error quantification of the FY-3B PMW rain rate retrievals. This is done by comparisons with the combined PMW product (MWCOMB) of NOAA/CPC and against a gauge-based analysis of hourly precipitation over China derived from gauge reports of dense station networks.

Overall, the monthly mean rain rate distribution of FY-3B agrees very well with MWCOMB except for a little under-estimate over ocean. In the latitudinal profiles, we can see a very close agreement between the FY-3B retrievals and the MWCOMB over land, but there is an obvious general under estimates over ocean. Pattern correlation between FY-3B and MWCOMB is relatively high over both land and ocean. From more works on PDF check of 30-min precipitation, over a 0.25?a grid, we can clearly see FY3B presents lower PDF for weak precipitation, especially over ocean and reasonable agreements in PDF over land.

A gauge-based analysis of hourly precipitation derived from over 30000 station reports is used to validate FY-3B PMW rain rate. In order to compare, 7 PMW rain rate of different satellite, including TMI, NOAA-18, NOAA-19, Metop-A, DMSP-S16, DMSP-S17, DMSP-S18, are also compared with the gauge-based analysis. FY-3B's bias is a little higher than NOAA-18 over whole China, western China and eastern China. After the comparison, we use the PDF match method to combine all of those PMW rain rate to produce an East Asian PMW Rain rate Combination datasets (EAPRC). We compared EAPRC with MWCOMB. Due to EAPRC combined more PMW satellite than MWCOMB, EAPRC can cover more time and space over China. The daily rain rate calculated from EAPRC can be closer to gauge observation.

## AEROSOL EFFECTS ON DEEP CONVECTION OVER THE INDIAN REGION DURING ARM GVAX CAMPAIGN

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### Abstract

Using ground-based and satellite data during the Ganges Valley Aerosol Experiment (GVAX) in 2011, the aerosol effect on deep convection is examined. We have analyzed the aerosol indirect influence in effective radii of both water- and ice-clouds juxtaposed with the cloud and ice water amount. Convective cases were identified based on the ISCCP classification. The Indo-Gangetic Plain (IGP), which is a rapidly developing industrial section bounded by the Himalayas to the north, is the greatest source of both natural and anthropogenic aerosols of the Indian subcontinent. During the convective cases, area averaged AOD values cross 0.6 most of the times and the cloud fraction is higher (>0.9) with the ice cloud effective radius >15 μm, optical depth >20 and ice cloud water path >180 gm-2. The significant correlation between and aerosol and high clouds observed during these cases suggest that the aerosol direct effect in stabilizing

the PBL is overcome by the combined effect of large-scale uplifting and aerosol invigoration process. Detailed results will be provided in the presentation.

## PRIORITIZING AIR POLLUTION CONTROL AND CLIMATE CHANGE ADAPTION TO TACKLE FOOD INSECURITY IN THE MID-21STÝCENTURY

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Abstract

Global demand for food is expected to increase by 50% by year 2050, but the potential of future agricultural production to meet the growing demand is severely limited by both climate change and air pollution. In particular, surface ozone is a significant threat not only to public health but also to crop productivity. Future trends in ozone pollution depend on changes in anthropogenic emissions, land use and climate, whereas ozone itself is a major greenhouse gas that influences climate. A realistic assessment of future climate and air quality, essential for evaluating the impacts on agriculture, thus requires an integrated earth system modeling framework that simultaneously considers all these interactions. We use the Community Earth System Model (CESM) to simulate interactively 2000-to-2050 changes in climate and ozone concentration following two future economic scenarios (IPCC RCP4.5 and RCP8.5). We then develop and use a combination of statistical models to assess the individual and combined impacts of climate change and ozone pollution on the global production of four major crops: wheat, rice, maize and soybean. We show that wheat and rice production in major agricultural regions (e.g., US, Europe, China, India) is particularly sensitive to ozone pollution, decreasing by up to 40% for RCP8.5 in 2050 driven by more serious ozone pollution, but increasing by up to 40% for RCP4.5 due to aggressive ozone regulation. Maize production is more sensitive to climate change, and is reduced by up to 40% in both scenarios primarily due to warming. Soybean production is comparably sensitive to both climate change and ozone pollution. We show that on a global scale, climate change nearly doubles the rates of undernourishment in developing countries by 2050, but pollution control has the potential to completely offset such changes and ensure food security. We call for greater collaboration between air quality and land use managers to achieve coordinated goals concerning agriculture, energy use and public health.

## INVESTIGATION OF OCEAN'S BARRIER LAYER AND WARM OCEAN FEATURE ON TROPICAL CYCLONE'S INTENSITY CHANGE

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Abstract

Timely and accurate forecasts of tropical cyclones (TCs, i.e. hurricanes and typhoons) are of great importance for risk mitigation. Though in the past two decades there has been considerable, steady improvement in the track prediction, due to the complexity involved,

improvement on intensity prediction remains a major challenge. One of the critical issues identified is the role ocean's surface and subsurface thermal conditions play in TCs intensity variability. Existing studies have suggested the importance of warm ocean features (e.g. eddies) to favor TCs intensification (Lin et al. 2008 and 2009). Recently Balaguru et al. (2012) reports on the importance of ocean's subsurface barrier layer to favor TCs intensification. Both processes emphasize on the suppression of TC-induced sea surface temperature cooling to favor intensification. This research compares the two effects and quantifies the difference in their impacts.

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## THE IMPACT OF CHEMICAL COMPOSITION AND PARTICLE SHAPE ON THE RADIATIVE PROPERTIES OF POLLUTED DUST

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### Abstract

Although the effect of pure mineral dust to the global radiative forcing has been numerically estimated to be negative, the radiative effect cannot be well qualified for the dust transported to long distances where it interacts with the pollutants emitted from anthropogenic activities over a polluted place, meaning that the dust-climate interactions become perturbed by human activities. The mineral aerosol shape and their mixing states with other components, such as black carbon, organic carbon, brown carbon and water-soluble material, are the main sources of uncertainties in the radiative forcing estimation. Many previous transmission electron microscopy observations have indicated that most of the polluted dust particles are always mixed internally (one or several particles imbedded in a larger drop) or semi-externally (two or more particles physically contact and form an aggregation). And the core-shell structure is also found in many studies. In this study, the impact of complex chemical composition and particle shape on the scattering properties of both the single non-spherical and the aggregated polluted dust particles is investigated. For the single non-spherical particles, the scattering parameters (e.g. scattering phase function, single scattering albedo, extinction coefficient and absorption coefficient) were calculated by combining T-matrix method and the Maxwell-Garnett effective medium theory. And for the aggregates, the diffusion limited aggregation algorithm was used for generating aggregates with different numbers, morphological structures and sizes of spherical monomers, and then the core-mantle Generalized Multi-particle Mie (CMGMM) method was used to compute the scattering parameters.

## PRECIPITATION PROBABILITY OF CLOUDS OVER CHINA BASED ON ISCCP AND GROUND PRECIPITATION PRODUCTS

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Abstract

Clouds and precipitation have a great effect on global climate and the environment. Quantitative studies about the precipitation feasibility of different cloud types is of great value towards understanding the temporal-spatial distribution of clouds and precipitation and the conversion of cloud water within the atmosphere. ISCCP DX data based on satellite cloud observations made every three hours over China and surface gridded precipitation data from gauge observations collected by the National Meteorological Information Center during the year 2007 are used to study the precipitation probability of different cloud types. A declining trend in the probability of precipitation for certain cloud types is found, namely, 0.29, 0.27, 0.065, and 0.039 for nimbostratus, deep convective, stratocumulus and cumulus clouds, respectively. Another finding is that the precipitation probability of each cloud type decreases as precipitation intensity increases. This can be parameterized as log(b)=-0.7683(log(a))^2-1.4583log(a)-1.8834, R^2=0.9965, where a is the precipitation intensity, and b is the precipitation probability. We also find that precipitation in China mainly occurs in the summer. Through comparisons of the spatial distribution of precipitation probability, we find that the precipitation probability in southern China (0.15-0.30) is greater than that in northern China (0.10). Regions with maximum values are located in southwestern China (0.35-0.40), along the southeastern coast and in northeastern China (0.3). The region with the minimum in precipitation probability is northwestern China (0.1).

## DYNAMICAL RESPONSE OF THE SOUTH CHINA COSTAL MONSOON TROUGH TO MESOSCALE CONVECTIVE SYSTEMS ASSOCIATED WITH CONTINUOUS HEAVY RAINFALL PROCESS

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Abstract

On July 15 to 17, 2011, affected by a coastal Monsoon Trough (MT), Southern China endured continuous heavy rain with maximum daily precipitation over 260 mm. The precipitation characterized of unevenly distribution with extreme rainfall along western coastal areas, central parts and eastern parts of Guangdong Province, closely relating to the activities and recurrences of Mesoscale Convective Systems (MCSs). Due to the active convection during this period, the MT was characterized by upward development of cyclonic circulation from the surface to more than 300 hPa. Using NCEP FNL reanalysis data, surface observation data and hourly TBB data

from MTSAT-2, based on vorticity budget analysis, nonlinear balanced piecewise potential vorticity (PV) inversion technique, the present study documented the characteristic of the MT and evolution of the heavy-rain-producing MCSs' examined the mechanisms responsible for the upward development of cyclonic circulation and their influence on the sustained development of MT and recurrence of MCSs.

Results indicate that Southern China coastal MT manifests most structural features similar to the typical ITCZ, with a slightly southward tilted trough in vertical and moderate temperature and humidity contrasts in horizontal. Different to mid-latitude MCSs, which commonly generate in a baroclinic background environment, the organized development of MCSs within MT region shows to be more related to the available convective sustainability, a thermodynamic characteristic of environment induced due to the sustained influence of southwesterly monsoon Low Level Jet (LLJ). Budget analysis shows that the vorticity generation in MT region was mainly contributed by convergence effect associated with low-level convergent flows, and was transported upward by the strong vertical motions in the MCSs. Additionally, the upward development of cyclonic circulation in MT region might also be depicted as a result of the positive feedbacks between PV anomaly and cumulus convections. Piecewise PV inversion reveals that the intensification of cyclonic vortices in MT region was largely attributed to the PV perturbations associated with condensation heating. As the MCSs developed more strong and sustained, the condensation heating peak was lifted to a more elevated level, which caused abnormal PV appeared to the mid-troposphere and led to the MT cyclonic circulation develop upward. During this process, the intense MCSs in MT region induced northward ageostrophic flows to its southwest, through Coriolis torque, the westerly wind speed to the south of MCSs increased and LLJ developed, providing a favorable environment for convection initiated recurrently and developed into MCSs. All these reflect that the dynamical response of large-scale MT circulation to the MCSs condensation heating exerted an important influence on the occurrence of continuous heavy rainfall process.

## CYCLIC FLUCTUATIONS OF CLIMATE CHANGE EFFECTS ON THE ANNUAL CATCH OF GREY MULLET (MUGIL CEPHALUS L.) IN THE TAIWAN STRAIT

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Abstract

Grey mullet (Mugil cephalus L.) is one of the most important commercial species of fish of the coastal fisheries of Taiwan. In this study, we took advantage of unique long-term (1958 - 2009) records of grey mullet caught in Taiwan Strait to investigate influences of multi-timescale climatic indices on the annual catch of grey mullet. A wavelet analysis revealed that variations in climatic indices (the Pacific Decadal Oscillation (PDO), Oceanic Niño Index, and Western Pacific Oscillation) and sea surface temperatures (SSTs) might have affected the abundance of grey mullet migrating to Taiwan. Grey mullet catches showed fairly good correspondence with the annual PDO index. Results suggested that the PDO might play a role in affecting grey mullet which migrate, but increases in SSTs may also be an important reason for the decreased and

lower catches of grey mullet after 1980. Mean SSTs increased by 1.01°C at the Chang-Yuen Rise of Taiwan Strait from 1984 to 2009. The 20 °C isotherms of Taiwan Strait in winter also shifted from 23~24°N in 1958~1978 to north of 25°N after 1998. The fishing grounds of grey mullet also shifted to the north following changes in the 20 °C isotherm in Taiwan Strait. Finally, climate change scenarios of the IPCC A2 models suggested the 20 °C isotherm in Taiwan Strait will move to 25.5°N in 2050 and have crossed 26°N in 2075.

## SPACE-BASED MEASUREMENTS OF XCO2 IN CHINA DURING THE PAST THREE YEARS

Mingmin Zou, Liangfu Chen, Lin Su, Meng Fan, Shenshen Li, institute of remote sensing and digital earth, CAS

Abstract

Global warming is a serious environmental issue drawing increasing concerning from all round the world. The density and geographic distribution of CO2 is one of the key points in global change research. Measurements of the CO2 concentrations in the boundary layer of atmosphere are essential where most CO2 sources and sinks are located. Here we present a CO2 inverse method from space-based observations in short wave infrared band (SWIR). It is validated by comparison with ground-based measurements from TCCON and institute of remote sensing and digital earth, CAS. Besides, comparison to GOSAT L2 product is also done. Then, we present the distribution of seasonal and annual average of XCO2 from 2010 to 2012 in China. And the monthly trend of XCO2 changing is shown.

## PRELIMINARY COMPARISON OF MULTI-SOURCES CLOUD CLASSIFICATION PRODUCTS (FY-2E, ISCCP, CLOUDSAT AND SURFACE OBSERVATION) IN CHINA

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Le Zeng, National Meteorological Information Center, CMA, China
Runzhi Yang, National Meteorological Information Center, CMA, China
Shengjie Wang, Asset Operation Center, CMA, China
Junxia Gu, National Meteorological Information Center, CMA, China

Abstract

Except high/middle/low cloud, focus of the research on cloud classification have extended to the algorithm development, and the validation/comparison in recent years. According to FY-2E(3hr,5km), ISCCP(3hr,30km), Cloudsat(1.4km*2.5km*125) and surface observation(6hr) in China, the seasonal/inter-annual characteristics are analyzied in China and its sub-regions. The frequcy of most cloud types are found decreasing in surface observation from 1980, especially Cu hum and Ac. The differnct temporal-spatial characteristics of cloud classification results are to be studied further considering their distinct algorithms.Keyword: cloud classification, Cloudsat, temporal-spatial characteristics, comparison

## AN ANALYSIS OF THE EXTREME DRY SPELLS IN TAIWAN AND ITS RELATIONSHIP WITH EAST ASIAN MONSOONS VARIATIONS

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Research and Development Center, Central Weather Bureau, Taiwan

Abstract

An index DSidx is proposed to represent the overall dry extremes in Taiwan based on the 110 years of daily rainfall data from 1901-2010. The extreme dry event is identified as an event with less than 1% of the exceeding probability based on the climatology of longest dry spells in a 90-day window on daily basis at a station. DSidx is the total count of the stations that show extremely prolonged dry spells. Because the data at six stations are used, the number of DSidx ranges from 0 to 6. The daily DSidx are summed up using the 11-year window to illustrate the variations on the multi-decadal time scale. The result suggests the dry spell extremity in Taiwan has clear variability on multi-decadal time scale. The overall dry spell extremity has increased after 1960. The extremity is more sever during the summer months before 1990, while it is more sever during the winter months after 1990. The change of the dry extremes enhances the general concern about dry season becomes drier and wet season becomes wetter, although there is no correlation between the variations of DSidx and rainfall amount.. The summer dry spell extremes can be caused by the stronger and more westward extension of the western Pacific subtropical high pressure system. The winter dry spell extremes can be caused by weak East Asian winter monsoon.

## MULTI-SCALE PREDICTION OF THE ASIAN MONSOON IN THE NCEP CLIMATE FORECAST SYSTEM

Song Yang, Sun Yat-sen University, China

Abstract

This presentation is about prediction of the Asian monsoon by the NCEP Climate Forecast System, mainly CFS version 2. Seasonal prediction of various Asian summer monsoon components, including the East Asian Mei-yu rain band in June and July, and the East Asian winter monsoon will be covered. Sub-seasonal prediction focuses on the evolution and variations of tropical and subtropical monsoons on higher time scales including the quasi-biweekly oscillation. Prediction of the western Pacific tropical storms is also discussed. While the overall skill of seasonal prediction is attributed to the impact of ENSO, the effects of atmospheric internal dynamics and external factors on the skill of sub-seasonal prediction are clearly different, which will be addressed as well. In addition, the differences in results between AMIP and CMIP experiments, and between CFS version 1 and CFS version 2, will be discussed.

## IMPACT OF HUMAN ACTIVITY ON REGIONAL WARMING OVER ASIAN DRYLANDS

Xiaodan Guan, Jianping Huang , and Ruixia Guo

Key Laboratory for Semi-Arid Climate Change of the Ministry of Education, College of Atmospheric Sciences, Lanzhou University, China

Abstract

The surface air temperature trends over global land has been examined from 1901-2009. It is found that the warming trend was particularly enhanced in the boreal cold season (Nov. to Mar.) over semi-arid regions (with precipitation of 200 - 600 mm/y), especially in Asia mid-latitudes. It showed that the averaged temperature increase in the Asian mid-latitudes (30°N - 60°N) drylands was about 1.42, 1.50 and 1.56 higher than the increase for global, European and North American drylands, respectively. After removing the long-term trend, which may have been caused by well-mixed greenhouse gases, and internal dynamical variability, the adjusted temperature showed a significant positive correlation with population growth (99% confidence level) over the Asian drylands. The population growth over the Asian drylands showed a significant (99% confidence level) increase compared to Asian semi-wet and wet regions.

## OVERVIEW OF SEVEN SOUTH EAST ASIAN STUDIES (7-SEAS) IN SOUTHEAST ASIA

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9 Department of Chemistry, National Central University, Chung-Li, Taiwan
10 Research Center for Environmental Changes, Academia Sinica, Taipei, Taiwan
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12 NASA Headquarters, Washington DC, USA

Abstract

Initiated in 2007, the Seven South East Asian Studies (7-SEAS) seeks to perform interdisciplinary research in the field of aerosol-meteorology and climate interaction in the Southeast Asian region, particularly for the impact of biomass burning on cloud, atmospheric radiation, hydrological cycle, and regional climate. Participating countries include Indonesia, Malaysia, Philippines, Singapore, Thailand, Taiwan, Vietnam, and USA. A series of field experiments have been conducted during springtime biomass burning seasons in northern Southeast Asia, i.e., Dongsha Experiment in 2010, Son La Campaigns in 2011 and 2012, and BASELInE (Biomass-burning Aerosols & Stratocumulus Environment: Lifecycles and Interactions Experiment) in 2013, respectively. The main goals of Dongsha Experiment are (1) to develop the Dongsha Island (about 2 km2, 20o42'52 N, 116o43'51 E) in the South China Sea as an atmospheric observing platform of atmospheric chemistry, radiation and meteorological parameters, and (2) to characterize the chemical and physical properties of biomass-burning

aerosols in the northern SE Asian region. A monitoring network for ground-based measurements includes five stations from northern Thailand and central Vietnam to Taiwan, with a supersite at the Dongsha Island (i.e. Pratas Island) in South China Sea (or East Sea). The Mobile Air Quality Station of Taiwan EPA and NASA/COMMIT were shipped to Dongsha Island for continuous measurements of air quality, and aerosol physical/optical and vertical profiles. Aerosol chemistry sampling was performed for each station for characterizing the compositions of PM2.5/PM10 (some for TSP) including water-soluble ions, metal elements, BC/OC, Hg and dioxins. Enhanced sounding at Dongsha Island was launched four times per day during the intensive observation periods. This experiment provides a relatively complete and first dataset of aerosol chemistry and physical observations conducted in the source/sink region for below marine boundary layer and lower free troposphere of biomass burning/air pollutants in the northern SE Asia. Furthermore, the Son La Campaigns were conducted in Son La meteorological station (21.33 $^{o}$N, 103.9 $^{o}$E; 675 m MSL) in northern Vietnam to characterize the chemical and physical properties of biomass-burning aerosols over the aerosol-cloud interactive region. Experimental setup was similar to 2010 Dongsha Experiment. More recently, we have just completed the BASELInE from early February to mid-April, along the ?river of smoke aerosols? from near source regions over northern Thailand-Laos-Vietnam to receptor areas of Hong Kong, Dongsha and Taiwan to aid in the study of aerosol-cloud interactions in climatologically important cloud regimes of the monsoon system. The ultimate goal is to understand the interaction between natural/anthropogenic aerosols, clouds, and precipitation, which is a critical component of the mechanism that drives the hydrological cycle and fresh water distribution over the region. The BASELInE is an international collaboration between scientists from the USA (NASA, NRL, CSU) and from the region (Thailand, Vietnam and Taiwan). This presentation will give an overview of these 7-SEAS activities and their results, particularly for the characterization of biomass-burning aerosol at source regions in northern Thailand and northern Vietnam, and receptor stations in Taiwan, which is rarely studied.

## ON THE ORIGIN AND IMPACT OF ASYMMETRIC POLYGONAL EYEWALL AND MESOVORTICES IN THE RAPID INTENSIFICATION OF HURRICANE WILMA (2005)

Peter M. K. Yau, Department of Atmospheric and Oceanic Sciences, McGill University
Konstantinos Menelaou, Department of Atmospheric and Oceanic Sciences, McGill University
Yosvany Martinez, Meteorological Research Division, Environment Canada

Abstract

An analysis of a high resolution dataset from a realistic simulation of hurricane Wilma (2005) was performed to understand the mechanism for the formation of prominent polygonal eyewall and mesovortices during the rapid intensifying stage of the hurricane. The impact of these asymmetries on the intensity change of the hurricane vortex was assessed using the empirical normal mode (ENM) method and Eliassen-Palm (EP) flux calculations.

The results indicated that the eyewall of Wilma exhibited an early azimuthal wavenumber 4 (m = 4) asymmetry followed by a transition to lower wavenumber asymmetries. The simulated reflectivity and the spatial structure of potential vorticity (PV) anomalies strongly suggest that barotropic instability is the most likely driving mechanism for these asymmetries. From the

ENM analysis, it was found that the dominant modes for m = 4, and 3 asymmetries are vortex Rossby waves (VRWs) that possess characteristics of unstable modes, supporting the importance of barotropic instability. The EP flux calculations associated with these modes indicate that the VRWs act to decelerate the flow at the initial radius of maximum wind, while they act to accelerate the flow radially inside and outside of this location, suggesting that VRWs may provide a positive feedback to the intensification of the vortex.

The present results complement previous findings of theoretical and highly idealized numerical studies that polygonal eyewall and mesovortices are the result of barotropic instability, thereby furnishing a bridge between idealized studies and observations. The work also provides new insight on the role of asymmetries and VRWs in the intensification of hurricanes.

## EXPANSION OF GLOBAL DRYLANDS UNDER A WARMING CLIMATE

Qiang Fu, University of Washington and Lanzhou University
Song Feng, University of Nebraska-Lincoln

### Abstract

Global drylands encompassing hyper-arid, arid, semiarid, and dry subhumid areas cover about 41 percent of the earth's terrestrial surface and are home to more than a third of the world's population. By analyzing observations for 1948-2008 and climate model simulations for 1948-2100, we show that global drylands have expanded in last sixty years and will continue to expand in the 21st century. By the end of this century, the world's drylands under a high greenhouse gas emission scenario are projected to be 5.8X10**6 km**2 (or 10%) larger than in the 1961-1990 climatology. The major expansion of arid regions will occur over southwest North America, the northern fringe of Africa, southern Africa, and Australia, while major expansions of semiarid regions will occur over the north side of the Mediterranean, southern Africa, and North and South America. The global dryland expansions will increase the population affected by water scarcity and land degradations.

## EVALUATION OF MULTI-MODEL ENSEMBLE SYSTEM FOR SEASONAL AND MONTHLY PREDICTION

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2 Environment Modeling Center, NCEP/NWS/NOAA

### Abstract

Since August 2011, the realtime seasonal forecasts of U.S. National Multi-Model Ensemble (NMME) have been made on 8th of each month by NCEP Climate Prediction Center (CPC). The participating models are NCEP/CFSv1&2, GFDL/CM2.2, NCAR/U.Miami/COLA/CCSM3, NASA/GEOS5, IRI/ ECHAM-a & ECHAM-f. The NMME team at CPC collects three

variables, including precipitation, temperature at 2m and sea surface temperature from each modeling center, removes systematic errors, makes the grand ensemble mean in equal weight and provides the NMME forecast to the CPC operational seasonal and monthly outlook.

## IMPACT OF ENSO ON PRECIPITATION IN THE EAST RIVER BASIN, SOUTH CHINA

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5 Department of Biological and Agricultural Engineering and Department of Civil and Environmental Engineering, Texas A&M University, College Station, Texas, USA.
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### Abstract

The influence of El Niño – Southern Oscillation (ENSO) on seasonal precipitation at local scale (i.e. a size of one grid cell of a typical global climate model) is important for the local water supply, flood mitigation, and water resources management. This study analyzes the response of precipitation in the East River basin to the determining factors including Southern Oscillation Index (SOI), El Niño Modoki index (EMI), and sea surface temperature anomalies (SSTA) of Niño 1+2, Niño 3, Niño 4, and Niño 3.4. The eastern Pacific warming (EPW), central Pacific warming (CPW), and the eastern Pacific cooling (EPC) were defined to denote three types of the ENSO events. The precipitation during the ENSO period was tested by Mann-Whitney U test to detect whether its statistical behaviors are different from those in the normal period. Results show that (1) more precipitation in autumn and winter, and less precipitation in summer were detected in EPW. The EPW even caused extreme heavy precipitation in summer and winter; (2) less precipitation in spring, autumn and the annual totals were identified during CPW. And the precipitation patterns in summer between CPW and the normal years are different. CPW also might cause extreme heavy precipitation; (3) EPC brought about less precipitation in spring and winter and more precipitation in autumn. The precipitation in the middle East River basin decreased most remarkably; and (4) EMI was the only index with significant relationship with areal precipitation in April, while SSTA, SOI and EMI had significant correlations with precipitation from January to March.

## ATTRIBUTION OF THE RECENT SUMMER WARMING IN INDIAN OCEAN BASIN TO THE DECADAL CHANGE IN THE SEASONAL TIMING OF EL NIÑO DECAY PHASE

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Ming Cai, Florida State University, U.S. A.;
Guoxiong Wu, Institute of Atmos. Phys., Chinese Academy of Sciences

Abstract

This paper reports that, on top of the general warming trend in the Indian Ocean Basin (IOB) SST in the past 140 years, there exists an additional multidecadal-scale warming in the period from late 1940s to early 2000s, and this warming in IOB is particularly stronger in summer than in other seasons. Our analysis indicates that, the seasonal timing of the decay phase of El Niño events during this period has been delayed from spring to early summer since 1970s, while the seasonal timing of La Niña decay phase remains in spring season. The direct effect of the later decay of El Niño events is the lengthening of the delayed warming effect of El Niño on IOB SST into summer, attributing to the stronger IOB warming in summer from the late 1940s to the early 2000s.

## REGIONAL AND GLOBAL IMPACTS OF ASIAN POLLUTION

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Abstract

Aerosols interact directly and indirectly with the Earth's radiation budget and climate. For the direct effect, aerosols scatter and absorb solar radiation. Light scattering by aerosols changes the radiative fluxes at the top-of-atmosphere (TOA), at the surface, and within the atmospheric column, while aerosol absorption modifies the atmospheric temperature structure, decreases the solar radiation at the surface, and lowers surface sensible and latent fluxes, suppressing convection and reducing cloud fraction. Also, aerosols indirectly impact climate by altering cloud development, lifetime, precipitation, and albedo. Current understanding of the aerosol indirect effect remains highly uncertain, constituting the greatest uncertainty in climate predictions. Anthropogenic aerosols may influence the cloud processes and precipitation by serving as cloud condensation nuclei (CCN. In this presentation, the effects of aerosols from the Asian Pollution on various cloud systems, ranging from isolated cumulus clouds, mesoscale squall lines, to Pacific storm track, will be discussed to demonstrate the response of clouds and precipitation to an increase in aerosol concentrations.

## INFLUENCES OF THE PACIFIC-JAPAN TELECONNECTION PATTERN ON SYNOPTIC-SCALE VARIABILITY IN THE WESTERN NORTH PACIFIC

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2 International Pacific Research Center and Department of Meteorology, University of Hawaii, Hawaii

Abstract

This study investigates the influences of the Pacific-Japan (PJ) teleconnection pattern on synoptic-scale variability (SSV) in the Western North Pacific (WNP). The PJ pattern exhibits salient intraseasonal variations, with dominant peaks at 10-20 days and 20-50 days. During positive PJ phases, strengthened SSV is found in the WNP, with a much stronger and better-organized synoptic wave train structure. Such a synoptic-scale wave train, however, is greatly weakened during negative PJ phases. Examination of the vertical profiles of the observational data suggests that environmental parameters are generally more (less) favorable for the growth of synoptic disturbances under positive (negative) PJ conditions.

Observational results are further verified with an anomaly atmospheric general circulation model, which reveals faster (slower) growth of the synoptic-scale wave train when the environmental anomalies associated with positive (negative) PJ phases are incorporated into the summer mean state of the model. In addition, sensitivity experiments indicate that thermodynamic parameters of the planetary boundary layer (PBL) play a determining role in controlling the development of synoptic disturbances in the WNP. The increase (decrease) in PBL moisture during positive (negative) PJ phases enhance (suppress) perturbation moisture convergence and thus convective heating associated with SSV, leading to strengthened (weakened) synoptic-scale activity in the WNP.

## GISS GCMAM MODELED CLIMATE RESPONSES TO SPECTRAL SOLAR FORCING

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David Rind, NASA/GISS
Jeffrey Jonas, NASA/GISS
Peter Pilewskie, University of Colorado

Abstract

How spectral solar irradiance (SSI) varies and how Earth's climate would respond are hot topics in Sun-climate research. The climate can have a response to SSI variations even if the total solar irradiance (TSI) remains unchanged. Recent observations from Spectral Irradiance Monitor (SIM) on Solar Radiation and Climate Experiment (SORCE) indicate different spectral irradiance variations, both amplitude and phase, from previously models. We use the Goddard Institute for Space Studies (GISS) Global Climate Middle Atmosphere Model (GCMAM) to examine the climate responses to two types of spectral solar forcing, with one from reconstruction and the other based on SORCE observations. We show different ozone and temperature responses to the two solar forcing scenarios on decadal time scale (i.e., solar minimum minus solar maximum) and long- term trends on centennial time scales. We further discuss mechanisms for Sun Climate connection.

## INTERDECADAL VARIABILITY AND FUTURE CHANGE TREND OF THE EAST ASIAN SUMMER MONSOON RAINFALL UNDER THE GLOBAL WARMING

Ronghui Huang and Yong Liu
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Abstract

Characteristics of the interdecadal variability of the East Asian summer monsoon (EASM) rainfall during last 60 years are analyzed by using the observed precipitation data in China and the NCEP/NCAR reanalysis data. The results of this study are briefly summarized as follows:

1. Monsoon rainfall and water vapor transportation in the EASM system have significant temporal and spatial variabilities, i.e., they have obvious meridional tripole and dipole patterns in spatial distribution and significant interdecadal variability in time evolution. The spatial distribution of the EASM anomalies with the tripole pattern may be due to the effect of the East Asia/Pacific (EAP) pattern teleconnection propagating along the meridional direction over East Asia.
2. Summer monsoon rainfall, water vapor transportation and zonal mean zonal wind anomalies in East Asia experienced obvious interdecadal variations in the late 1970s, early 1990s and late 1990s, and they exhibited significant characteristic of meridional tripole pattern before the early 1990s, but it has become from meridional tripole pattern into meridional dipole since the late 1990s.
3. Not only the external forcing due to the interdecadal thermal anomaly of the tropical Pacific Ocean through the EAP pattern teleconnection plays an important effect on these interdecadal variations of the EASM, but also the ?Silk Road? pattern teleconnection propagating along the subtropical jet and the ?EU? pattern teleconnection along the polar front over Eurasian continent also play great effects on these interdecadal variations.

Both IPCC-AR4 and IPCC-AR5 projections of the future summertime IAP index defined from the EAP pattern teleconnection indicate that the EAP index may become negative from the mid-21th century under the global warming, indicating that summer monsoon rainfall may increase in the Yangtze River Basin, South Korea and Japan from the mid-21th century.

## SENSITIVITY OF CAM5 CLOUD SIMULATION TO ICE-NUCLEATION PARAMETERIZATIONS AND ITS IMPLICATION TO CLIMATE

Shaocheng Xie, Lawrence Livermore National Laboratory
Xiaohong Liu, Pacific Northwest National Laboratory
Chuanfeng Zhao, Beijing Normal University
Yuying Zhang, Lawrence Livermore National Laboratory

Abstract

Sensitivity of clouds and radiation simulations in the Community Atmospheric Model version 5 (CAM5) to the ice nucleation process is examined, with focuses on Arctic and Southern Ocean

Regions. Two ice nuclei (IN) schemes are tested. The new scheme is a physically based ice nucleation scheme that links the variation of IN number concentration to aerosol properties. The default scheme parameterizes the IN concentration simply as a function of ice supersaturation. The new scheme leads to a significant reduction in simulated IN number concentrations at all latitudes while changes in cloud amount and cloud properties are mainly seen in Arctic, middle latitude storm tracks, and Southern Ocean. In both Arctic and Southern Ocean regions, there is a considerable increase in mid-level clouds and a decrease in low clouds, which result from the complex interaction among the cloud macrophysics, microphysics, and the large-scale environment. The smaller IN concentrations result in an increase in liquid water path and a decrease in ice water path due to the slow-down of the Bergeron-Findeisen process in mixed-phase clouds. Comparison against both ground- and space-based observations at the two focused regions, the new IN scheme simulated clouds and radiation have considerable improvements. Overall, with the new IN scheme, CAM5 simulations show an increase in the optical depth of Arctic and Southern Ocean clouds, which leads to a stronger cloud radiative forcing (net cooling) at the top of the atmosphere.

## SOIL MOISTURE ASSIMILATION STUDY OVER CHIAN

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Abstract

Soil moisture plays an important role in land-atmosphere interactions. It is an important geophysical parameter in research on climate, hydrology, agriculture, and forestry. Soil moisture has important climatic effects by influencing ground evapotranspiration, runoff, surface reflectivity, surface emissivity, surface sensible heat and latent heat flux. At the global scale, the extent of its influence on the atmosphere is second only to that of sea surface temperature. At the terrestrial scale, its influence is even greater than that of sea surface temperatures. This paper presents a China Land Soil Moisture Data Assimilation System (CLSMDAS) based on EnKF and land process models, and results of the application of this system in the China Land Soil Moisture Data Assimilation tests. CLSMDAS is comprised of the following components: 1) A land process model? Community Land Model Version 3.0 (CLM3.0)?developed by the US National Center for Atmospheric Research (NCAR); 2) Precipitation of atmospheric forcing data and surface-incident solar radiation data come from hourly outputs of the FY2 geostationary meteorological satellite; 3) EnKF (Ensemble Kalman Filter) land data assimilation method; and 4) Observation data including satellite-inverted soil moisture outputs of the AMSR-E satellite and surface soil moisture observation data. Results of soil moisture assimilation tests from June to September 2006 were analyzed with CLSMDAS. Both simulation and assimilation results of the land model reflected reasonably the temporal-spatial distribution of soil moisture. The assimilated soil moisture distribution matches very well with severe summer droughts in Chongqing and Sichuan Province in August 2006, the worst since the foundation of the People's

Republic of China in 1949. It also matches drought regions that occurred in eastern Hubei and southern Guangxi in September.

## THE INTERANNUAL VARIABILITY AND INFLUENCING FACTORS OF THE WINTER INDIA-BURMA TROUGH

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Tongmei Wang, Department of Atmospheric Sciences,Sun Yat-sen University, China

Abstract

Based on precipitation data in 525 Chinese stations, HadISST data, NCEP – DOE II reanalysis data and monthly heating field data from 1979 to 2011, meanwhile, through Fourier Harmonic Decomposition, composite analysis and other commonly used meteorological statistical analysis methods, analyzed the corresponding circulation of the India-Burma trough's intensity index in winter, found the influencing factors from the thermodynamic point of view, and finally explored the possible mechanism of the factors. The main conclusions are as follows:

1 The trough's intensity variation in interannual scale is associated with the thermal conditions of plateau, subcontinent and Pacific. When plateau's diabatic heating anomaly is simultaneously positive in the east and negative in the west, India and Indo-China peninsula is synchronously positive or the Pacific is behaved the El Nino type, the India Burma trough will be enhanced.

2 Thermal conditions's possible mechanism for the intensity in plateau: The eastern plateau's diabatic heating anomaly is positive, and the west is negative. For the eastern ascending and western sinking motion in the vertical direction, derived from the thermal distribution, there arouses the cyclonic circulation in east and anticyclonic circulation in west. The two abnormal circulations result in the enhanced vorticity which makes the trough deeper.

3 Thermal condition's possible mechanism for the intensity in subcontinent: The positive diabatic heating anomaly in India and Indo-China peninsula leads to the upward movement that stimulates the cyclonic circulation above the subcontinent. Then the intensity can be increased.

4 Possible mechanism of El Nino in Pacific to the intensity: By PNA teleconnection, East Asia trough's weakening and the polar front zones's north-moving makes the winter monsoon weakens. Owing to the weakening, the intensity can be enhanced in the view of resistance. Related with the circulation resembling closely GIP (Indo-Pacific Gear), the convection is strengthened in the western Indian Ocean and weakened in the eastern Indian Ocean. The circulation makes the southern Indian Ocean along low latitude prevails east anomalous wind which becomes west anomalous wind cross the equator, joining the west anomalous wind along the low latitude of northern Indian Ocean, triggers cyclonic circulation above the bay of Bengal region, then the vorticity and intensity can be enhanced.

## STUDY ON THE TEMPORAL EVOLUTION AND SPATIAL DISTRIBUTION OF URBAN HEAT ISLANDS OVER PEARL RIVER DELTA IN RECENT TEN YEARS

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Abstract

Using observational data set of 20 weather stations over Pearl River Delta (PRD) area from the year 1999 to 2008, we analyze the characteristics of the temporal evolution and spatial distribution of urban heat islands (UHI) over this area. The PRD area is zoned three parts (e.g. West zone, Middle zone and East zone) according to the latitudes of the cities for the study of the UHIs in this paper. The results show that the mean UHI intensity over PRD is about 0.72°C and the highest value (0.95°C) of UHI intensity is located in Middle zone which coincide with fast urbanization in recent ten years. This spatial distribution of UHIs over PRD presents a tri-pole pattern, in which some megacities such as Guangzhou, Foshan, Dongguan and Shenzhou have higher UHI intensities. The UHI intensities also display obvious seasonal variation over PRD area and the maximum value of UHI (0.98°C) occurs in autumn which is approximately two times of the minimum (0.50°C) appearing in spring. Besides, we find the diurnal change of UHI intensity. The UHI in the nighttime is higher than that in the daytime and the difference is about 0.50°C. Finally, we discuss the relations between meteorological elements and the UHI intensities and probabilities. The results reveal that low cloud cover, relative humidity, wind speed and precipitation show significantly negative correlations with UHI probabilities, especially in the conditions of strong heat islands.

## LONG-TERM VARIATIONS OF BROAD-SCALE ASIAN SUMMER MONSOON CIRCULATION AND POSSIBLE CAUSES

Song Yang, Sun Yat-sen University
Renhe Zhang, Chinese Academy of Meteorological Sciences

Abstract

The widely-applied Webster-Yang index (WYI), which measures the broad-scale dynamical features of the Asian summer monsoon (ASM), has experienced robust interannual and interdecadal variations and a decreasing tendency, with apparent shifts in 1972. The WYI exhibits moderate variability and frequent positive phase before 1972, intensive interannual variability during 1972-1998, and an obvious decreasing tendency and mainly negative phase afterwards. The vertical-shear easterly anomalies over the tropics-subtropics and the anomalous vertical-shear anticyclonic circulation over Eurasia are the background for the decreasing WYI, associated with reduced summer precipitation around the Bay of Bengal and Sumatra.

On interdecadal time scales, the negative (positive) Atlantic Mutlidecadal Oscillation (AMO) is characterized by cooling (warming) in Eurasian tropospheric temperature (TT) via the North Atlantic Oscillation. Global warming manipulates the increasing tendency and the interannual variability of TT over the Indian Ocean. The mutual effects of AMO on Eurasian TT and global warming on India Ocean TT correspond to the similar decreasing tendency and interdecadal shift of the difference in TT between Eurasia and the Indian Ocean (EuTT-IOTT) with those of the ASM. Thus, the AMO and global warming seem to cause the interdecadal variability of ASM.

Although the interannual relationship between Niño3 SST and ASM weakens recently due to the weakening tendency of ASM, the Niño3 SST still plays an important role in ASM variability via EuTT-IOTT anomalies. In addition, the WYI in the NCEP-NCAR reanalysis shows a larger decreasing tendency for 1999-2010 compared to other reanalysis products, a plausible reason for the inconsistent variations between land-sea thermal contrast and the NCEP-NCAR WYI during that period

## GENESIS OF HURRICANE JULIA (2010) WITHIN AN AFRICAN EASTERLY WAVE: LOW-LEVEL VORTICES AND UPPER-LEVEL WARMING

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Abstract

While a robust theoretical framework for tropical cyclogenesis (TCG) within African easterly waves (AEWs) exists, little work explores the mesoscale development of low-level vortices (LLVs) in relation to deep convection, upper-tropospheric warming and surface mesolow pressure systems. In this study, the development of an LLV into Hurricane Julia (2010) is shown through a high-resolution Weather Research and Forecasting (WRF) model simulation with the finest grid size of 1 km. The results presented expand upon the connections between mesoscale disturbances and the AEW presented in previous studies while demonstrating the importance of upper-tropospheric warming for TCG.

It is found that the significant intensification (SI) phase of Hurricane Julia is triggered by upper-tropospheric warming and the subsequent hydrostatic pressure falls at the surface. The warming is able to intensify and expand during TCG due to persistent advective outflows of deep convection. Results confirm previous ideas by demonstrating that the critical latitude is a preferred location for mesoscale development while supplementing such work by showing the formation of upper-tropospheric warming and surface mesolows in the same location. It is shown that the surface mesolow enhances low-level convergence and enables the creation and conglomeration of mesovortices and bottom-up vorticity development of the LLV. The importance of the upper-tropospheric warming is exemplified in hydrostatic calculations made to estimate the time series of mean sea-level pressure (MSLP). Without the warming, it is shown the SI stage would have never taken place and the LLV that becomes Hurricane Julia would have never formed.

## HOW AEROSOLS AFFECT CONVECTIVE CLOUDS? OBSERVATIONS AND THEORY

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Hongbin Yu, UMD
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Abstract

With strong evidences from recent observations we show a range of aerosol effects on convective clouds, including both shallow and deep convection. For shallow convective clouds such as trade cumulus aerosols are shown to suppress their precipitation, increase their optical depth and increase the cloud fraction, resulting in strong radiative effects. For deep convective clouds, we show spectacular increase of lightning activity associated with increase in aerosols. Physical mechanisms, their symptom and their effects are discussed. Implications and future directions will also be speculated.

## CLASSIFICATION AND INVESTIGATION OF ASIAN AEROSOL ABSORPTIVE PROPERTIES

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Zhanqing Li and Maureen Cribb
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Abstract

Asian aerosols are among the most complex yet widely studied components of the atmosphere not only due to their seasonal variability but also their effects on climate change. Four Aerosol Robotic Network (AERONET) sites have been selected to represent aerosol properties dominated by pollution (Taihu), mixed complex particle types (Xianghe), desert-urban (SACOL), and biomass (Mukdahan) in East Asia during the 2001?2010 period. The volume size distribution, aerosol optical depths (AOD and AAOD), Angstrom exponent(AE and AAE), and the single scattering co-albedo (1-SSA) parameters over the four selected sites have been used to (a) illustrate seasonal changes in aerosol size and composition and (b) discern the absorptive characteristics of black carbon (BC), organic carbon (OC), mineral dust particles, and mixtures. A strongly absorbing mineral dust influence is seen at the Xianghe, Taihu, and SACOL sites during the spring months (MAM), as given by coarse mode dominance, mean AE < 1, and mean AAE > 1.5. There is a shift towards weakly absorbing pollution (sulfate) and biomass (OC) aerosol dominance in the summer (JJA) and autumn (SON) months, as given by a strong fine mode influence, AE > 1, and AAE < 1.5. A winter season (DJF) shift toward strongly fine mode, absorbing particles (BC and OC) is observed at Xianghe and Taihu (AE > 1 and AAE > 1.5). At Mukdahan, a strong fine mode influence is evident year round, with weakly and strongly absorbing biomass particles dominant in the autumn and winter months, respectively, while particles exhibit variable absorption during the spring season. A classification method using AE and 1-SSA is developed in order to infer the seasonal physico-chemical properties of the aerosol types, such as fine and coarse mode, weak and strong absorption, at the four selected Asian sites.

## INVESTIGATION OF THE SEASONAL VARIATIONS OF MARINE AND CONTINENTAL AEROSOLS, CLOUDS, AND THEIR INTERACTIONS WITH METEOROLOGICAL REGIMES

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Abstract

Aerosol physical and chemical properties and their interactions with clouds present the largest uncertainties in estimating anthropogenic forcing of climate change and in predicting future climates.Many global climate models do not account for the internal properties of aerosols and tend to over- or under-estimate their effects. Therefore, it is necessary to account for both the aerosol physico-chemical properties as well as the general climatology of a region when discerning the effects of aerosols and global climate change.

The primary goal of this study is to use case studies over the ARM SGP and Azores sites to address two Scientific Questions (SQ):
1) What are the seasonal variations and size distributions of aerosol properties over these two sites? Are there significant differences over continental and maritime regions?
2) Using the self-organization methods of Kennedy (2011) and Kennedy et al. (2013), what role does climatology play in the interactions of aerosols with low level clouds over both regions?
A multi-platform data analysis approach consisting of surface, satellite, and model output measurements will be used. Surface aerosol and cloud measurements will provide information on aerosol type (pollution, mineral dust, and biomass burning aerosols) and cloud microphysical properties (liquid water path, droplet number concentration, effective radius, and optical depth). The SOM technique (Kennedy, 2011) will provide the classified atmospheric states, such as general synoptic patterns, wind speed, humidity, and more importantly the different airmass source regions. In addition to this statistical method, we will investigate detailed special cases using the NOAA HYSPLIT backward trajectory model, combined with MODIS retrieved aerosol optical depth (AOD), in order to verify the origins and pathways of different types of aerosol properties (clean or polluted airmasses), which may impact the retrieved low cloud microphysics.

## SPACE-BASED OBSERVATION OF OCEAN-ATMOSPHERE EXCHANGES IN MOMENTUM, WATER, AND CARBON

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Abstract

Ocean Surface Stress is the turbulent transfer of momentum between the ocean and atmosphere. Our knowledge in the past mainly comes from wind. Turbulence is generated by wind shear (difference between wind and current) and buoyance (vertical density gradient). Scatterometer provides the first measurement of stress but have been promoted as a wind sensor. We are developing the first geophysical model function to directly retrieve stress rather deriving stress from wind retrieval.

Significant impacts are found in hurricanes and ocean fronts. We have also developed a method to retrieve ocean surface evaporation directly from the radiances measured by microwave radiometers, rather than computing evaporation through bulk parameters of wind and humidity gradients. The evaporation has been checked against total water exchange (evaporation-

precipitation) estimated from the divergence of moisture transport integrated through the depth of the atmosphere, also computed from spacebased measurements. A statistical model has been established and validated to estimate ocean surface partial pressure of carbon dioxide using spacebased sea surface temperature, chlorophyll, and salinity. From the partial pressure ocean-atmosphere exchange in carbon dioxide is computed over global oceans. The study links together the water/energy and carbon cycles.

## IMPACT OF ASSIMILATING MICROWAVE IMAGER RADIANCES ON TROPICAL CYCLONE ANALYSES AND FORECASTS

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Fuzhong Weng, Center for Satellite Applications and Research, NESDIS, NOAA
Banglin Zhang, Center for Satellite Applications and Research, NESDIS, NOAA

### Abstract

The impact of assimilating microwave imager radiance observations from the Special Sensor Microwave Imager Sounder (SSMIS) on analyses and forecasts of tropical cyclones (TCs) was studied using the NCEP's Gridpoint Statistical Interpolation (GSI) analysis system and the operational Hurricane Weather Research Forecast (HWRF) model. The quality control and bias correction schemes in GSI are revisited and revised for the use of microwave imager data in TC analyses and forecasts. The moisture field in the lower troposhpere and surface wind field were improved when compared to reanalyses and dropsonde observations. Analysis/Forecast cycling experiments were performed for the period of three TCs in 2012: Hurricane Sandy (22-30 October) and Isaac (22-29 August) in Atlantic and Typhoon Tembin (19-29 August) in western Pacific . It was demonstrated that uses of SSMIS imager data on board the Defense Meteorology Satellite Program (DMSP) F-16, F-17 and F-18 satellites improve the track and intensity forecasts of three TCs.

## PRECIPITATION CHARACTERISTIC OVER THE PEARL RIVER DELTA METROPOLITAN BASED ON THE SATELLITE AND GROUND OBSERVATIONS

Weibiao Li
Sun Yat-sen University

### Abstract

The Pearl River Delta Metropolitan (PRD), is one the largest metropolitan regions in the world containing a total area of about 11,300 square kilometers and having a population over 52 million. More and more intense rainfall disasters happen and cause heavy property loss and casualties for the past few years. We investigate the precipitation characteristic over the PRD based on the latest TRMM datasets (Version 7) and the nearly 40 years in situ observatory data. We discuss the features of space-temporal distributions, annual variation, seasonal variation and diurnal variation of precipitation over the PRD. During different seasons, under the different

weather systems control, the precipitation characteristic over PRD shows different patterns. Besides, we focus on the extreme precipitation. Compared with the surrounding areas, we speculate the extreme precipitation may be reinforced by the joint effect of the urbanization and climate change.

## Summer High Temperature Extremes in Southeast China Associated with the East Asian Jet Stream and Circumglobal Teleconnection

Weiwen Wang, Wen Zhou, Xin Wang, Soi Fong, Ka Cheng Leong

Summer high temperature extremes (HTEs) in Southeast China (south of 35oN and east of 105oE) are defined based on relative, seasonally varying thresholds, and their occurrences associated with atmospheric anomalies are investigated. Two key domains in the upper level that are associated with HTE variation, the exit and the tail of the East Asian Jet Stream (EAJS), are identified. Poleward displacement of the exit is associated with warming tropospheric temperatures over East Asia and tends to be linked with high HTE frequency, while enhancement of the tail is associated with cooling tropospheric temperatures in the northern Pacific and tends to be linked with low HTE frequency. Furthermore, these two domains are in essence two sectors of the phase-locked circumglobal teleconnection (CGT) pattern in the Northern Hemisphere. Linkages are found between HTEs in Southeast China and precipitation anomalies in the Indian summer monsoon region, and also in extratropical regions such as northeastern Europe. These teleconnections are set up through the CGT pattern associated with the westerly jet in the midlatitudes. These findings may be a source of variability and predictability of HTEs in Southeast China.

## DEVELOPMENT OF AN ARCHITECTURE FOR CLIMATE MONITORING FROM SPACE

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### Abstract

The development of an architecture for climate monitoring from space, proposed by the World Meteorological Organization, the Committee on Earth Observation Satellites (CEOS) and the Coordination Group for Meteorological Satellites (CGMS), calls for an international end-to-end framework of activities that ensures delivery of climate data records derived from satellite observations. The architecture shall respond to the requirements of WMO, GCOS, GEOSS and the broader climate application user community, for both the long-term monitoring of the Earth's climate system, and the characterization of climate extreme events in near-real time. It will build upon a constellation of research and operational satellites, either existing or planned by space agencies, supported by open data-sharing policies, contingency planning, data processing, stewardship and long-term preservation, validation mechanisms involving surface observations, and user interfaces.

The most relevant and comprehensive set of specific user requirements is provided by GCOS within their supplement ‘systematic Observation Requirements for Satellite- Based Products for Climate (GCOS-154) to the GCOS Implementation Plan (GCOS-138). The Global Framework for Climate Services (GFCS) Implementation Plan, recently approved by the World Meteorological Congress Extraordinary Session 2012 adds another dimension to the requirements in establishing a direct link to climate applications. It defines climate services as climate information prepared and delivered to meet users? needs. The GFCS describes a need for climate services in many application areas ranging from disaster risk reduction, agriculture and food security, water resources, health, to energy management, and highlights the need to support developing countries in particular.

Significant progress has been made over the last few decades in observing the Earth globally, with higher temporal and spatial resolution. However, a number of issues associated with satellite observation, data, and products for climate monitoring remain to be addressed. These include, among others, instrument calibration, the absence of documented measurement traceability and uncertainty budgets, as well as e.g. changes in the satellite observation time due to orbital drift during the lifetime of some sun-synchronous satellites.

Within the WMO context, the architecture shall be part of the space-based component of WMO Integrated Global Observing System (WIGOS). It would include the inter-calibration activities of the Global Space-based Inter- Calibration System (GSICS), the product generation efforts as done within the SCOPE-CM and should benefit of the training and capacity-building activities of the Virtual Laboratory (VLab). Existing in situ networks provide observations of some parameters that are difficult and/or impossible to measure from space, therefore enhancing synergy between in-situ and space-based observing systems is thus essential, and will be taken into account in the development of the architecture.

Representatives from CEOS, CGMS and the WMO Space Programme, have written a report titled, ‘strategy towards an Architecture for Monitoring Climate from Space?. The presentation will, based upon the key recommendations of the report, elaborate on WMO’s views on the development of such an architecture conceptually and physically, to ensure that the information flows (from requirements to implementation, and from observations to decision-making) are capable of meeting both policy and operational needs.

## THE EFFECTS OF AIR POLLUTION ON HEAVY PRECIPITATION IN THE PEARL RIVER DELTA

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### Abstract

A fully coupled meteorology-chemistry-aerosol mesoscale model (WRF-Chem) is used to assess the effects of aerosols on heavy precipitation in the Pearl River Delta. Two sensitive experiments are performed for two scenarios with and without pollutant emissions source. The modelling results showed that the precipitation time with pollutant emissions source in the Pearl River Delta more delayed than that without pollutant emissions source, and the range of main

precipitation center was decreased, along with the increase of the maximum value of precipitation rate. In terms of cloud microphysical conversions, the rate of autoconversion of cloud water into rainwater with the pollutant emissions source will increase.

## THE AEROSOL-MONSOON CLIMATE SYSTEM OF ASIA

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Abstract

In Asian monsoon countries such as China and India, human health and safety problems caused by air-pollution are worsening due to the increased loading of atmospheric pollutants stemming from rising energy demand associated with the rapid pace of industrialization and modernization. Meanwhile, uneven distribution of monsoon rain associated with flash flood or prolonged drought, has caused major loss of human lives, and damages in crop and properties with devastating societal impacts on Asian countries. Historically, air-pollution and monsoon research are treated as separate problems. However a growing number of recent studies have suggested that the two problems may be intrinsically intertwined and need to be studied jointly. Because of complexity of the dynamics of the monsoon systems, aerosol impacts on monsoons and vice versa must be studied and understood in the context of aerosol forcing in relationship to changes in fundamental driving forces of the monsoon climate system (e.g. sea surface temperature, land-sea contrast etc.) on time scales from intraseasonal variability (~weeks) to climate change (~ multi-decades). Indeed, because of the large contributions of aerosols to the global and regional energy balance of the atmosphere and earth surface, and possible effects of the microphysics of clouds and precipitation, a better understanding of the response to climate change in Asian monsoon regions requires that aerosols be considered as an integral component of a fully coupled aerosol-monsoon system on all time scales.

In this paper, using observations and results from climate modeling, I will discuss the coherent variability of the coupled aerosol-monsoon climate system in South Asia and East Asia, including aerosol distribution and types, with respect to rainfall, moisture, winds, land-sea thermal contrast, heat sources and sink distributions in the atmosphere in seasonal, interannual to climate change time scales. I will show examples of how elevated absorbing aerosols (dust and black carbon) may interact with monsoon dynamics to produce feedback effects on the atmospheric water cycle, leading to in accelerated melting of snowpack over the Himalayas and Tibetan Plateau, and subsequent changes in evolution of the pre-monsoon and peak monsoon rainfall, moisture and wind distributions in South Asia and East Asia.

## RECENT ADVANCES IN THE STUDY ON THE DYNAMICS OF THE ASIAN SUMMER MONSOON ONSET

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## Abstract

The surface wind can be a better indicator of the onset of the Asian Summer Monsoon (ASM) system than the 850-hPa wind. The use of the new ASM onset index and analysis of pentad-isochrones, based on both the seasonal reversal of surface wind and the evident enhancement of rainfall, demonstrated that the onset of the Tropical Asian Summer Monsoon (TASM) first occurs over the southeastern Bay of Bengal (BOB) in May. It then propagates eastward to the Indochina Peninsula and reaches the South China Sea (SCS) in mid-May and the tropical North West Pacific (NWP) in early June. The surface depression of the Indian summer monsoon originates near the equatorial Arabian Sea, and then propagates northward to South Kerala in southwestern India in early June, indicating the onset of the Indian Summer Monsoon (ISM). In addition, the Subtropical Asian Summer Monsoon (STASM) is first formed over the NWP southeast of Honshu, Japan, and then it expands westward and merges into the precipitation zone of the SCS monsoon in early June, forming a northeast-southwest rainy belt. Almost at the same time, the summer monsoon reaches southeastern China and the Baiu in Japan also starts. In mid-June, the rainfall belt shifts northward to the Yangtze River and the Korean peninsula corresponding to the start of the Meiyu and Changma. This paper also reviews some recent progress in dynamics studies on the ASM onset. In spring, an evanescent but strong warm pool is formed in the central?eastern BOB due to the combined forcing of the Tibetan Plateau and the large-scale land-sea distribution in South Asia. Due to the coupling between this warm pool at the surface and the pumping effect of the South Asia High (SAH) in the upper troposphere, a Monsoon Onset Vortex (MOV) usually develops over the eastern BOB, breaking the ridgeline of the subtropical high that is continuous in winter, resulting in the first onset of TASM over the BOB. Furthermore, the vertical easterly/westerly shear over the eastern/western BOB prompts/inhibits the convection and increases/decreases the surface sensible heat transfer from ocean to atmosphere, resulting in a monsoon onset barrier over the west coast of the BOB that prevents the westward propagation of the monsoon onset. Hence, the monsoon onset can expand only eastward followed by the successive onset of the SCS and the tropical West Pacific summer monsoon. The strong latent heat released by the monsoon rainfall induces the westward development of the SAH and the conspicuous strengthening of zonal asymmetric potential vorticity (PV) forcing. Accompanied by the mid-troposphere anticyclone over the Arabian Peninsula stimulated by strong local surface sensible heating, the depression near the equatorial Arabian Sea moves northward and grows to a monsoon onset vortex, causing the ISM onset.
Overall, the three phases (i.e., the BOB, the SCS, and the Indian summer monsoon onset) of the TASM onset that persist for about one month can be considered as a consequential process driven by certain dynamic-thermodynamic rules covering a specific geographic environment, including the Tibetan Plateau and the land-sea distribution in South Asia.

## MECHANISM OF DECADAL ABRUPT COOLING OF STRATOSPHERIC TROPICAL TEMPERATURE IN THE EARLY 1990S AS INFLUENCED BY THE PINATUBO ERUPTION

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### Abstract

Studies have suggested that one volcanic eruption can influence seasonal to inter-annual climate variations. This study indicates that the Pinatubo eruption in 1991 may have actually induced the stratospheric tropical decadal cooling recorded in the early 1990s. Using the NCEP/NCAR reanalysis and TOMS/SBUV satellite data, a decadal abrupt cooling of stratospheric tropical air temperature was found to have occurred in the early 1990s during a long-term descending trend. We generated the spatio- temporal structures of the decadal abrupt changes (DACs) for the stratosphere, and explored the relationship between the Pinatubo volcano eruption in 1991 and stratospheric tropical DACs in the early 1990s. Our results suggest that the eruption of Pinatubo prompted a decadal decrease of ozone by the activation of nitrate and sulfate volcanic aerosols on ClO free radicals. The stratospheric tropical heat absorbed by ozone decreased over a decadal time scale. As a result, decadal abrupt cooling of stratospheric tropical air temperatures occurred in the early 1990s, and may be attributed to the Pinatubo eruption. The results therefore indicate that one strong volcanic eruption can induce stratospheric tropical decadal climate variation.
Keywords: Pinatubo, volcanic eruption, stratosphere tropics, decadal abrupt cooling, ozone

## ENVIRONMENTAL PROPERTIES OF THE LINEAR MESOSCALE CONVECTIVE SYSTEMS DURING MEIYU PERIOD IN THE MIDDLE- LOWER REACHES OF YANGTZE RIVER AREA.

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### Abstract

Using Composite radar reflectivity data operational observation data and NCEP daily reanalysis data, the environmental characteristic of the linear MCSs that occurred in the Middle- lower reaches of Yangtze river area in June and July,2010 is composite analyzed. The middle- and upper-tropospheric storm-relative flow field is of primary importance in determining the organizational mode of linear mesoscale convection. The trailing stratiform MCS and the training line/adjoining stratiform MCS show front-to-rear storm-relative winds throughout their depth, the leading stratiform MCS are lower-tropospheric front-to-rear storm-relative winds, while upper-tropospheric rear-to-front storm-relative winds. The low and mid-level wind shears largely parallel to convection line for the training line/adjoining stratiform MCS but perpendicular to convection line for trailing stratiform MCS and leading stratiform MCS. The parallel stratiform MCS and the backbuilding/qusi-stationary MCS experienced significant middle- and upper-tropospheric line-parallel storm-relative winds, and the shear magnitude of the PS MCS is more lager. The training line/adjoining stratiform MCS on 8 July formed on the

cool/north side of a cold front and in unstable air conditions. The backbuilding/qusi-stationary MCS on 7 June formed in a changing high moisture and high θe surface environment. The most favorite environment for producing and developing a linear MCS is high temperature and high humidity.

## MODELING STUDY OF THE EFFECT OF ANTHROPOGENIC AEROSOLS ON DROUGHT IN THE LATE SPRING OF SOUTH CHINA

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Abstract

In this study, the mechanisms underlying the decadal variability of late spring precipitation in south China are investigated using the latest version 1 of Community Earth System Model (CESM1). We aim to unravel the effects of different climate forcing agents, such as aerosols and greenhouse gases (GHGs), on the decadal variation of precipitation with transient experiments from pre-industry (for year 1850) to present-day (for year 2000). Our results reveal that: (1) CESM1 can reproduce the climatological features of atmospheric circulation and precipitation for the late spring in south China; (2) Only simulations including the forcing of anthropogenic aerosols can reproduce the observed decreasing trend of late spring precipitation from 1950-2000 in south China; (3) Aerosols affect the decadal change of precipitation mainly by altering the large scale atmospheric circulation, and to a less extent by increasing the lower-tropospheric stability to inhibit the convective precipitation; (4) In comparison, other climate forcing agents, such as GHGs, have much smaller effects on the decadal change of spring precipitation in south China.

## SPACE-BORNE OBSERVATION OF TRACE GASES USING THERMAL INFRARED SOUNDERS

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Abstract

Hyperspectral sounders like Atmospheric InfraRed Sounder (AIRS, since August, 2002), the Infrared Atmospheric Sounding Interferometer (IASI, since 2008) and the Cross-track Infrared Sounder (CrIS, since 2012) on the NPP provides us the opportunity to measure atmospheric greenhouse gases, like CO2, CH4 and N2O. Although their vertical sensitivities to these GHG gases are mainly in the mid-upper troposphere and less in the troposphere, these measurements have provided valuable information on their distribution and transport in the atmosphere. Some of these data have been used in inverse modeling to improve the quantification of the sources of CO2 and N2O. This paper introduces the measurements of CO2, CH4 and N2O from NOAA and NASA with a focus on the measurements of CH4. Some recent development and results using these data will be presented.

# INCREASE OF SUMMERTIME THUNDERSTORM IN SOUTHEAST CHINA: POTENTIAL IMPACTS OF INCREASING AEROSOL LOADING

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## Abstract

This study utilizes 15 years of observations by lightning imager sensor (LIS) and by precipitation radar on board the Tropical Rainfall Measuring Mission (TRMM) to investigate the possible impacts of aerosol on intense convective activity in Southeast China. Surface observed thunderstorm occurrence, derived from weather reports of meteorology stations in this region, are also analyzed for the period of 1990-2012.

Both the surface observed thunderstorm activities in 70 plain stations and the LIS detected lightning occurrence are found to be significantly increased in summer time. TRMM radar data also show a significant increase in the storms? echo-top heights. Meanwhile, the regional averaged visibility decreased significantly. Furthermore, the significant inverse correlations of LIS derived lightning occurrence, PR derived storm height and surface recorded thunderstorm activity with visibility suggest that the increasing trends in both the intensity and the occurrence probability for convective activity is highly related with the aerosol loading in this region.

Similar to the increasing trend of thunderstorm activity, the regional averaged Convective Available Potential Energy (CAPE) during thunderstorm days significantly increased and correlated with visibility for the period of 1990-2012. Moreover, daily rain amount during thunderstorm day increased significantly whereas that of non thunderstorm day has no trend during the same period. Both the increased CAPE value during thunder day and contrast trends of daily rain amount for thunder day and non thunder day suggest the substantial elevated intensity in convective activity, which was likely caused by aerosol's invigoration effect.

Contrasted to the increasing trend of intense convective activity derived from 70 plain stations, thunderstorm days have no trend for the four mountain stations (all the altitudes are above 1100 m). The contrast in thunderstorm activity between plain and mountain, represented by the plain/mountain ratio, suggests the aerosol concentration contrast between mountain and plain may be the most possible reason since synoptic backgrounds are the same for southeast China. In fact, the climate/synoptic background can not have much difference for plain and mountain because the ratio in intense cloud day between plain and mountain stations has no trend during 1990-2012. Finally, the ratio in lightning yield per unit of rain day between plain and mountain stations increased significantly, suggesting the cumulated pollution aerosols in plain region invigorated thunderstorm whereas have less impacts on intense convections over regions with high altitude. All the results in this study indicate that high aerosol concentration in Southeast China seemed to enhanced the intense convective activity like thunder-lightning events in plain region.

## DEVELOPMENT OF INTENSE HELICITY AND VORTICAL HOT TOWERS IN HURRICANE BONNIE (1998)

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### Abstract

Three-dimension structures and evolution of helicity and vorticity generation with respect to vertical shear vectors during the rapid intensification (RI) and eyewall replacement cycle (ERC) was calculated in Hurricane Bonnie (1998) using a 4-km inner mesh (Zhu et al. 2004) over 5 days beginning 1200 UTC 22 August. We compared the model results to helicity distribution showed in Molinari and Villaro (2008). Results show that the helicity distribution is similar as that showed in Molinari and Villaro (2008). Furthermore we also get the 3-D structures and evolution of helicity of Bonnie. In the paper we also investigated the developments of Bonnie's " vertical hot towers" (VHTs) as described Montgomery et al. (2006) and Hogsett and Zhang (2009). VHTs and convective bursts in relation to CAPES, helicity, VWS, and relative vorticity during RI and ERC were studied. It is found that large helicity and VHTs are related to curved hodographs, like those for continental supercells. And in the paper we try to check to what extent helicity can be used to help understand the ERC, as shown in Zhu et al. (2004) and Hogsett and Zhang (2009), as showed as Xu and Wu (2003).

## DETECTION OF A COUPLED-S-SHAPED PATTERN IN THE NORMALIZED REFRACTIVITY ANOMALY IN THE EAST ASIA AND WESTERN NORTH PACIFIC AND ITS IMPLICATIONS

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### Abstract

In this paper, we perform an analysis of the atmospheric refractivity using GPS radio occultation (RO) data obtained from the COSMIC mission for the month of August 2009. A coupled-S-shaped pattern emerges in the atmospheric normalized refractivity anomaly (NRA) in the East Asia and western North Pacific between 20oN and 40oN. The S-shaped NRA is distributed from 150oE to 180oE in the western North Pacific subtropical high (WNPH) and is characterized by negative (positive) anomalies around 17.4 km and 3.4km (11.6km); the reverse S-shaped NRA is distributed from 90o to 120oE in the East Asia monsoon trough with reversed signs. This is called a coupled-S-shaped NRA pattern in this study. The mechanism for this pattern may be explained by the contrasting thermodynamic processes in the convective and non-convective regions. Spectra analysis results show that the NRA time series of the monsoon trough and the WNPH have different sub-monthly variability although they are strongly coupled in the monthly mean. Cross spectra analysis results show that the monsoon trough, the WNPH, and the in-between tropical cyclone (TC) in August 2009 present complicated multi-scale interactions. Our

results demonstrate that the refractivity of iso-height surfaces, which can be observed globally in high vertical resolution by the GPS RO technique, is a valuable thermodynamic variable to study the 3D atmospheric structures and variability. The scientific implications of the coupled-S-shaped pattern will be discussed at the conference.

## VARIABILITY OF THE INDIAN OCEAN SST AND ITS POSSIBLE IMPACT ON SUMMER WESTERN NORTH PACIFIC ANTICYCLONE IN THE NCEP CLIMATE FORECAST SYSTEM

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### Abstract

The NCEP Climate Forecast System version 2 (CFSv2) provides important source of information about the seasonal prediction of climate over the Indo-Pacific oceans. In this study, the authors provide a comprehensive assessment of the prediction of sea surface temperature (SST) in the tropical Indian Ocean (IO). They also investigate the impact of tropical IO SST on the summer anomalous anticyclonic circulation over the western North Pacific (WNPAC), focusing on the relative contributions of local SST and remote forcing of tropical IO SST to the WNPAC, which plays an important role in East Asian summer climate variability.

The CFSv2 captures the climatological features and the two dominant modes of summer tropical IO SST: the IO basin warming (IOBW) mode and the IO dipole (IOD) mode, as well as their relationship with El Niño-Southern Oscillation (ENSO). However, it overestimates the correlations of ENSO with IOBW and IOD, and underestimates the magnitude of IOD and summer IOBW. The CFSv2 captures climate anomalies related to IOBW but not those related to IOD. It captures the impact of summer IOBW on WNPAC via the equatorial Kelvin wave, which contributes to the maintenance of WNPAC in July and August. The WNPAC in June is mostly forced by local cold SST, which is better predicted by the CFSv2 compared to that in July and August. Air-sea interaction is important for the CFSv2 to reproduce the impact of IOBW on the WNPAC. The mechanism for WNPAC maintenance varies with lead time in the CFSv2.

## MARINE AND CONTINENTAL LOW-LEVEL CLOUD PROCESSES AND PROPERTIES

Xiquan Dong and Baike Xi
University of North Dakota

### Abstract

Low-level Clouds and their interactions with aerosols are extremely important parts of the climate system. Their treatment in climate models is one of the largest sources of uncertainty in predicting any potential future climate change. As concluded in Randall et al. (IPCC Chapter 8, 2008) ?Cloud feedbacks have been confirmed as a primary source of the inter-model differences,

with low clouds making the largest contribution. In this study, we will use 15 years of ARM SGP observations and 19 months of ARM AMF deployment at the Azores to partially answer the following questions:
1) What processes determine the formation, persistence and evolution of low-level clouds in both marine and continental climates?
2) What are similarities and differences between Marine and continental low-level cloud macrophysical, microphysical and radiative properties?

## LIFE AND DIURNAL CYCLES AND PROPERTIES OF MID-LATITUDE DEEP CONVECTIVE SYSTEMS

Xiquan Dong, Zhe Feng and Baike Xi
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Abstract

Deep Convective Systems (DCSs) have traditionally been divided into the deep convective precipitating portion and the non-precipitating anvil canopy. The former is important to the atmospheric hydrologic cycle because of the heavy precipitation in the convective cores (CC) and widespread precipitation in the stratiform rain (SR) regions, and the latter is dominant in the atmospheric radiation budget due to their extensive spatial coverage. In this study, we have developed a method to objectively identify DCSs and subsequently classify their CC, SR regions and AC through an integrative analysis of collocated ground-based NEXRAD and geostationary satellite data over the SGP region. We found that more DCSs occurred during late afternoon, producing peak AC fraction right after sunset. AC covers 3 times the area of SR and almost an order of magnitude larger than CC (Feng et al. 2011). We also used an automated satellite tracking method in conjunction with a recently developed multi-sensor hybrid classification to analyze the evolution of DCS structure in a Lagrangian framework over the central United States. Composite analysis from 4221 tracked DCSs during two warm seasons (May-August, 2010-2011) shows that maximum system size correlates with lifetime, and longer-lived DCSs have more extensive SR and AC. Maximum SR and AC area lag behind peak convective intensity and the lag increases linearly from ~1-hour for short-lived systems to more than 3-hours for long-lived ones (Feng et al. 2012).

Finally, a classic DCS case (May 20th, 2011) during the MC3E is presented in this study. Its classified components (CC, SR, AC) and their corresponding vertical structures and velocities from surface radar measurements, aircraft in-situ measured and GOES satellite-retrieved cloud macrophysical and microphysical properties will provide a ground truth for modelers to validate and improve their simulated DCS properties.

## EVALUATION OF CMIP5-IAP GCMS SIMULATED CLOUD FRACTION AND TOA RADIATION BUDGETS USING NASA SATELLITE OBSERVATIONS

Xiquan Dong, Erica Dolinar, and Baike Xi
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Abstract

The Intergovernmental Panel on Climate change (IPCC) recognized in its Forth Assessment Report (AR4) that clouds are one of the major contributors of uncertainty within climate models. The modeling community has accepted this statement and has excited the effort to fix the errors in their representation of clouds in general circulation models (GCMs). With the induction of the Fifth Phase of the Coupled Model Intercomparison Project (CMIP5), the opportunity to directly compare updated global simulations from many different climate models was possible. In this study, the outputs from 27 CMIP5 models are evaluated using observed data from NASA CERES and MODIS satellite observations during the period 2000-2008. One model in particular from the Institute of Atmospheric Physics (IAP) named FGOALS-g2 is also highlighted. Clouds induce both a warming and cooling affect, depending on their height above the ground and microphysical properties. It is these characteristics that will determine the radiation budget at the top of the atmosphere (TOA). The results from these models in their simulations of clouds and their effects on the TOA radiation budgets are inconsistent with observations. Based on 27 models ensemble mean, cloud fraction is undersimulated by approximately 3%, and total water path agrees with observations within 3 gm-2. The cloud fraction and total water path from FGOALS-g2, on global average, are 9% and 24 gm-2, respectively, less than observations. Reflected shortwave and outgoing longwave radiation fluxes tend to be better simulated globally than cloud fraction or total water path, but there are localized regions of discrepancy. More comprehensive tests were performed to test the validity of these models. By determining the biases in these models, we can then communicate with modeling centers to provide constructive feedback for improving their simulations.

## SATELLITE SOIL MOISTURE DATA PRODUCTS FROM NOAA AND CMA: ALGORITHMS, VALIDATION AND APPLICATIONS

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Abstract

Soil moisture has long been recognized as one of the critical land surface initial conditions for numerical weather, climate, and hydrological predictions and agricultural and societal water resources management. Satellite soil moisture data products have been generated since more than a decade ago. However, none of these satellite soil moisture data products has been used operationally in the prediction models and management practice because of their accuracy or reliability issues. A climatologically consistent and qualitatively reliable global soil moisture product, is thus in urgent need for these applications. A group of scientists from NOAA-NESDIS and China Meteorological Administration (CMA) are collaborating in generating soil moisture data products from various optical and microwave remote sensing satellites. This presentation will focus on the algorithm development and validation of the soil moisture Environmental Data Record (EDR) from AMSR2 after a general introduction of the soil moisture operational production system (SMOPS) developed at NOAA-NESDIS and the atmosphere-land exchange inversion model (ALEXI) implemented with USDA-ARS collaborators. Examples of

applications of these data products in numerical weather prediction and agricultural drought monitoring will be discussed. A multi-sensor soil moisture data merging system developed at CMA-NMIC will also be presented.

## MEASUREMENTS OF THE MICROPHYSICAL AND CHEMICAL PROPERTIES OF AEROSOL AND CLOUD PARTICLES ON HUANGSHAN MTS. OF CHINA

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Abstract

To characterize the chemical and physical properties of aerosol particles and their effects on cloud and precipitation at highly elevated locations of Southeast China, Based on observing data of atmospheric aerosols measured on the top of Mts. Huang, southeast China, the physical characteristics of aerosol particles, such as number concentration, size distribution and the relationships to meteorological factors were analyzed and compared under different weather conditions. The results show that the mean number concentration reached 3.14×103 cm-3 in spring, and 1.80×103 cm-3 in summer, and ultra fine particles (<0.1 μm) account for 79% and 68%, respectively, The number concentration distributions in spring and summer all exhibit a single peak, with the peak value appears in 0.04～0.12 μm in diameter. The accumulation mode particles dominate in volume concentration and surface concentration distributions. Fine particles increased during cloud free periods as compared with cloudy periods. It is also indicated that, the meteorological conditions such as wind direction and speed, relative humidity, play a crucial role in formation of fine particles. The CCN concentration has a distinctive diurnal cycle, and can be expressed with formula, while the parameters and show the continental characteristic of CCN in spring while maritime characteristics in summer. There is a positive correlation between aerosol number concentration and cloud condensation nuclei. A parameterization scheme for describing aerosol-cloud relationships is proposed.

## NUMERICAL SIMULATIONS OF THE EFFECTS OF DEEP CONVECTION ON THE CONCENTRATION AND SIZE-DISTRIBUTION OF AEROSOL PARTICLES AT THE UPPER TROPOSPHERE

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Abstract

A spectral bin microphysical scheme has been implemented into a cloud resolving model to investigate the effects of aerosol layers on cloud development and vertical transport of aerosols by deep convection. The parameterization of ice formation proposed by DeMott et al. (2010) is used for prediction of ice crystals. A convective cloud event occurred on 1 December 2005 in

Darwin, Australia is simulated using the coupled model, and is compared with available radar measurements. The results show that the main characteristics of the storm is well reproduced by the model, especially for the horizontal and vertical structure of convective core.

Aerosol layers located at five different altitudes are added purposely in order to understand how the aerosols transported to the UT by deep convection are sensitive to origin of the aerosol layers and the effect of aerosol layers on cloud development and dynamic structure of the cloud. The sensitivity tests show that aerosol particles originated from the boundary layer (case LAYER1) can be transported upward more efficiently as compared to that from mid-troposphere, due to the significantly increased vertical velocity in the development stage of convection through reinforced homogeneous freezing of drops. Aerosols enhanced at the altitudes above boundary layer, i.e., cases LAYER2 to LAYER5 have little influence on the cloud dynamical processes, but precipitation increases in most of the cases when an aerosol layer presents, except for the case when the added aerosol appears at 5.4-8.0 km (case LAYER3), in this case, the smaller graupel mass resulted in less precipitation.

For aerosol layers at mid-troposphere, the vertical profiles of aerosol appear two peak values after cloud processing, one at their initial layers and the other at the altitude of 12-14 km. Aerosol concentrations at the altitudes of 13.5 km are enlarged by factors of 7.71, 5.36 and 5.16 when aerosol layer exist at 0-2.2 km, 2.2-5.4 km and 5.4-8.0 km, respectively, and Aitken mode and part of accumulation mode (0.1-0.2 μm) particles can be transported to UT. When the layer lofted at the altitude above 12.6 km, upward convective transport has almost no influence on the size distribution of the aerosols at its initial level.

## WINTER-TO-SUMMER TRANSITION OF ATMOSPHERIC CIRCULATION OVER SUBTROPICAL EAST ASIA: DOES IT INDICATE THE EARLIEST LOCAL ONSET OF ASIAN SUMMER MONSOON?

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Abstract

This study describes the climatological winter-to-summer transition of atmospheric circulation over the subtropical East Asia with the NCEP/NCAR atmospheric daily reanalysis data and rainfall records in China. Observational analysis shows that the seasonal reversal of the tropospheric zonal land-sea thermal contrast for the subtropical East Asia (110-120°E, 22.5~30°N) occurs around at the 22nd pentad (during April 16-20), the earliest reversal within the Asian domain. Associated with the reversal, a significant seasonal transition of the large scale atmospheric circulation over the subtropical East Asia takes place from the winter pattern with barotropic vertical structure to the summer pattern with baroclinic structure, and instead of a local Hadley cell, a local meridional-vertical monsoon cell forms along the East Asian sector. Both observational analysis and numerical experiments with AGCM in which the feedback of condensational heating is switched on and off indicate that the winter-to-summer transition of atmospheric circulation over the subtropical East Asia is remarkably related to the convective condensational heating released by the persistent spring rainfall in South China. It is the heating that triggers a local onset of the baroclinic summer atmospheric circulation pattern over the

subtropical East Asia. This study suggests that the convective condensational heating released by the persistent South China spring rainfall that is believed to be formed by the specific topography including Tibetan Plateau is able to trigger the earliest local onset of Asian summer monsoon in the subtropical East Asia through changing zonal land-sea thermal contrast, even if the large scale meridional land-sea thermal contrast does not change in the tropical monsoon regions.

## INCREASED TROPICAL CYCLONE PRECIPITATION AREA WITH LOCAL SST

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Ming Zhao, Geophysical Fluid Dynamics Laboratory (GFDL), NOAA, US
Minghua Zhang, Stony Brook University, US

Abstract

Based on 12 years of TRMM precipitation retrievals and IBTrACS data with an objective method, we find tropical cyclone (TC) precipitation area increases significantly with local SST. A global 50-km GCM simulated TC also show similar expansion of precipitation area with local SST. However, in a uniformly warmed climate (plus 2 K), there is negligible increase of simulated TC precipitation area. It is the relative SST dominates TC precipitation area via an indirect path although the absolute SST significantly impacts TC precipitation intensity. As a type of extreme precipitation, TC precipitation change exceeds the moisture content increase in a warmer climate.

## INTERMEDIATE FREQUENCY ATMOSPHERIC DISTURBANCES: A DYNAMICAL BRIDGE CONNECTING WESTERN U.S. EXTREME PRECIPITATION WITH EAST ASIAN COLD

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Abstract

Atmospheric Rivers (ARs) are narrow bands of concentrated moisture transport in the atmosphere that are responsible for most extreme rainfall, flooding and mudslide events in the western U.S. during winter time. In this study, an AR detection algorithm is developed to investigate the downstream modulation of the eastern North Pacific ARs by another weather extreme, known as the East Asian Cold Surge (EACS), in both reanalysis data and high-resolution global model simulations. It is shown that following the peak of an EACS, atmospheric disturbances of intermediate frequency (IF, 10-30-day period) are excited downstream. This leads to the formation of a persistent cyclonic circulation anomaly over the eastern North Pacific that dramatically enhances the AR occurrence probability and surface precipitation over the western U.S. between 30oN and 50oN. A diagnosis of the local geopotential height tendency further confirms the essential role of IF disturbances in establishing the observed persistent anomaly. This downstream modulation effect is then examined in two simulations of the NCAR CCSM4 with different horizontal resolutions (T85 and T341) for the same period (1979-2005). The connection between EACS and AR is much better captured by the

T341 version of the model, mainly due to a better representation of the scale-interaction and the characteristics of IF atmospheric disturbances in the higher resolution model. The findings here suggest that faithful representations of scale-interaction in a global model are critical for modeling and predicting the occurrences of hydrological extremes in the western U.S. and for understanding their potential future changes.

## LONG TERM VARIABILITY OF RAINFALL POSSIBLY INFLUENCED BY ENSO INDEX IN TAIWAN

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### Abstract

This study used the gridded rainfall data produced by the Taiwan Climate Change Projection and Information Platform Project (TCCIP). The monthly data with a grid resolution of 5 km during 50 years (1960-2009) is thus available to get detailed spatial distribution of the rainfall. The empirical orthogonal function (EOF) analysis was applied to synthesize this large time and spatial-varying climate element. The first three modes can explain up to 87% of the total variance. The mode 1 (65%) shows a spatially coherent in-phase patter with the higher value concentrated in the southwest mountain area. The annual cycle in the time-varying amplitude shows peaks during southwest monsoon and typhoon seasons. The interannual variation associated with the mode 1 isn?t large until 2004, and there is no significant trend. The mode 2 accounted for 16% of the total variance, shows a northeast to southwest out-of-phase distribution. The dividing line roughly coincides with the Central Mountain Range (CMR). This mode reveals the rainfall brought by northeast monsoon and its interaction with the CMR slope, which become a rain shelter for the southwestern part. The interannual variation associated with the second mode infers influence of the ENSO event. During the winter time of La Niña years, the amplitude of mode 2 became significantly stronger than in the normal years; for example, it reaches to a positive anomaly of 40 mm/month in the northeast region of Taiwan in 1974. However, the anomaly in the El Niño years doesn?t show the same tendency. It had been found that the ENSO event can affect the climate in East Asia through the atmosphere'sST and mid latitude-tropical interactions. This study further verified this large scale variation of ocean-atmosphere interaction could be a remote driver of rainfall variability in Taiwan.

## PROCESS ANALYSIS OF TYPICAL AEROSOL POLLUTION IN AUTUMN OVER PEARL RIVER DELTA, CHINA

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Qi Fan, Department of Atmospheric Sciences, Sun Yat-sen University, Guangzhou, China
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Yerong Feng, Guangzhou Central Meteorological Observatory, Guangzhou, China

### Abstract

The mainly cause of air pollution episodes is different with the variation of season over PRD (Pearl River Delta), China. In autumn, especially in October, the PRD region was in the control of high pressure system, which was adverse to the diffusion of air pollutants and made it easy to cause the aerosol pollution episodes. The third-generation air quality modeling system (WRF-SMOKE-CMAQ) was utilized to figure out the physical and chemical mechanism of typical aerosol pollution in October, 2012 in this study. Three-nested domain was used in the simulation and the finest domain covered most of the cities in PRD. There were two pollution episodes in this month, one is from October 1 to 17, and the other is from October 19 to 26, during both of which the daily average AQI (Air Quality Index) exceeded 100. The observed mixing ratios of SO2, NO2, PM2.5 and PM10 at 62 site showed that the particulate matter attributed to the cause of air pollution. Statistic parameters such as IOA (Index of Agreement) and COR (Correlation Coefficient) were used to evaluate the model results and both WRF and CMAQ showed reasonable performance compared with the observations. The monthly variations of the observations were captured well by models. With process analysis equipped in CMAQ, horizontal transport, vertical transport, emission, chemistry, dry deposition and aerosol process to the predicted pollutants were discussed to explain the characteristic of regional aerosol pollution.

## CHARACTERISTICS OF THE SEASONAL VARIATION OF ANTHROPOGENIC AEROSOL AND ITS INTERACTION WITH EAST ASIA CLIMATE

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### Abstract

In this study, the anthropogenic aerosols' impact on East Asian climate is investigated using the NCAR Community Atmospheric Model version 5 (CAM5), a state-of-the-art climate model considering aerosol's direct, semi-direct and indirect effects. Five experiments were performed with prescribed monthly mean climatological SST and sea ice. Two experiments are perfomed with emissions of the year 2000 (PD experiment) and the year 1850 (PI experiment). The difference between PD and PI experiments represents the effect of all anthropogenic aerosols. Three additional experiments were performed in which sulfur (SO2 and sulfate), BC, and POM emissions used data from the year 1850, respectively, while keeping emissions of other aerosol species for the year 2000. Thus, the effects of all anthropogenic aerosols, and anthropogenic black carbon (BC), sulfate, and primary organic matter (POM) are decomposed from the difference between these simulations and PD runs. The radiative effect of the anthropogenic aerosols is the most significant in spring and summer, with the maximum center in South China during spring and in North China during summer. The indirect effect of the anthropogenic aerosols is the most significant in spring. The aerosol optical depth (AOD) and short flux change shows a northward movement from South China to China from February to August and a southward movement from October to December. The change of cloud droplet number concentration (CDNC) and cloud droplet effective radius at 850hPa is large in winter half year (from October to next April). The cloud liquid water path and short wave cloud forcing also

shows a northward movement. But the intensity becomes weak from spring to summer. Similar patterns in radiative flux, cloud and precipitation change are also found. It is a direct proof of the anthropogenic aerosols' impact on East China climate.

## POLEWARD EXPANSION OF THE HADLEY CIRCULATION IN CMIP5 SIMULATIONS

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Abstract

Observational analyses have demonstrated that the Hadley circulation has expanded poleward in recent decades. Important issues are what caused the widening of the Hadley circulation and whether the observed widening is related to anthropogenic forcing. In the present study, we use currently available simulations of the Coupled Model Intercomparison Project Phase-5 (CMIP5) to analyze changes in the width of the Hadley circulation. It is found that CMIP5 historical simulations with greenhouse gas (GHG) forcing generate a total widening of ~0.15°±0.06° in latitude (10 yr)-1 for the period 1979-2005, and the widening in CMIP5 historical simulations with all forcings is ~ 0.17°±0.06° per decade. Similar to that in CMIP3, the simulated poleward expansion in CMIP5 is much weaker than the observational reanalyses. In CMIP5 projection simulations for the 21st century, magnitudes of widening of the Hadley circulation increase with radiative forcing. For the extreme projected radiative forcing of RCP8.5, the total annual-mean widening of the Hadley circulation is ~ 0.17°±0.06°(10 yr)-1 in the 21st century. Although CMIP5 underestimates observed poleward expansion of the Hadley circulation, the results of this study suggest that the observed trends in the width of the Hadley circulation are caused by anthropogenic forcing and that increasing GHGs play an important role in the observed poleward expansion of the Hadley circulation, in addition to other forcings emphasized in previous studies.

## AN OBSERVATIONAL STUDY OF AEROSOL OPTICAL PROPERTIES AT MT. HUANG IN SUMMER

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Abstract

The scattering and absorption coefficients of atmospheric aerosols were measured to analyze the change of the daily average and the daily variations of aerosol optical properties under the condition of non-rain during July to August in 2011 at the Guangmingding meteorological observatory on Mt. Huang. And trajectory cluster analysis with Hysplit was applied to discern the impacts on aerosol optical properties for different air masses. The results showed that, the aerosol scattering played a dominant role in the total extinction. The average value(standard deviation) of the scattering coefficients (σsc), absorption coefficients (σab), single scattering albedo (SSA) and back scattering ratio (BSR) were 62.59(49.17) Mm-1, 5.49(3.67) Mm-1, 0.89(0.04) and 0.13(0.02), respectively. σsc , σab and SSA were high during the day and low at

night which were contrary to the backscattering ratio during the period. The clear diurnal variation reflected the important effect of activity of the boundary layer. Continental air masses from northwest (NW) and southwest (SW) and marine air mass from southeast (SE) defined by the back-trajectory analysis were the main air masses that influenced the observation site. And a marked difference among the aerosol properties occurred for different air masses. The highest value of the cluster-mean of σsc, σab and SSA appeared when the air masses moved from NW directions and the lowest value appeared when they came from SE. The results indicated the substantial secondary aerosol production during the long-range transport.

## MICROPHYSICAL, MACROPHYSICAL AND RADIATIVE IMPACTS OF AEROSOL ON DIFFERENT CLOUD SYSTEMS

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Yangang Liu
Brookhaven National Laboratory

Abstract

The Weather Research and Forecasting (WRF) model was previously adapted to include the aerosol indirect effect via a two-moment bulk microphysics scheme and the aerosol direct effect via a modified Goddard radiation scheme. Three cases from the March 2000 Cloud Intensive Observational Period campaign and three cases from 2009 RACORO field campaign at the Atmospheric Radiation Measurement's Southern Great Plains site were examined, including a developing low pressure system, a cold frontal passage, a series of non-precipitating or weakly precipitating stratus and cumulus, etc. The observed profile of the aerosol concentration from the in-situ measurements was used for the control run and the perturbations are made on the aerosol profile in the sensitivity studies. To investigate the effect of aerosol radiative effect, each profile was run with and once without the modified Goddard scheme for each case. For warm and stratiform precipitation events, generally a reduction of precipitation was found with more aerosols introduced. For mixed-phase and convective precipitation events, generally a nonlinear trend was found where the moderate profiles had the highest rain rates. Including or removing the direct effect proved to have a statistically significant effect of cloud fraction. In all the cases, the LWP roughly increased with the elevation of aerosol concentrations, corresponding to a decrease in surface shortwave radiation. The outgoing longwave radiation was mainly regulated by the cloud fraction, but had a lower magnitude of change than the shortwave radiation. Therefore, the changes of shortwave radiation induced by aerosols dominated the temperature variation. Results from this study suggest that aerosols play a critical role in macro and micro properties of different clouds and the precipitation efficiency. Meanwhile, the direct effect of aerosol has to be taken into account if we aim at an accurate assessment of the aerosol-cloud-radiation interaction in the different cloud systems.

## IMPACTS OF DIFFERENT TYPES OF EL NIñO ON THE EAST ASIAN CLIMATE?FOCUS ON ENSO CYCLES

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Abstract

The authors analyze the different impacts of eastern Pacific (EP) El Niño and central Pacific (CP) El Niño on East Asian climate, focusing on the features from El Niño developing summer to El Niño decaying summer. Unlike the "+ - +" anomalous precipitation pattern over East Asia and the equatorial Pacific during EP El Niño, an anomalous "- + -" rainfall pattern appears during CP El Niño. The anomalous dry conditions over southeastern China and the northwestern Pacific during CP El Niño seem to be resulted from the anomalous low-level anticyclone over southern China and the South China Sea, which is located more westward than the Philippine Sea anticyclone during EP El Niño.

The authors further examine different evolution features of the low-level anticyclone over the tropical northwestern Pacific between eastern Pacific (EP) El Niño events and central Pacific (CP) El Niño events. During EP El Nino, the low-level anticyclone shows an eastward movement from the northern Indian Ocean to the east of the Philippines. During CP El Nino, however, the anticyclone is mostly confined to the west of the Philippines. It is weaker, exhibits shorter lifetime, and is lack of eastward movement as compared to the Philippine Sea anticyclone (PSAC) during EP El Nino.

Investigation into the possible impact of Indian Ocean (IO) sea surface temperature (SST) on the evolution of low-level anticyclone during EP and CP El Niño indicates that both SST and low-level atmospheric circulation over the IO are related more strongly with EP El Niño than with CP El Niño. The IO SST tends to exert a more prominent influence on PSAC during EP El Niño than during CP El Niño.

## RELATIONSHIP OF THE INTERANNUAL VARIABILITY OF MOISTURE SOURCE OVER SOUTHERN INDIAN OCEAN DURING BOREAL SUMMER TO THE LOCAL SST AND ENSO

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2 National Meteorological Center, China Meteorological Administration, China
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Abstract

In boreal summer, the southern Indian Ocean (SIO) features more evaporation than precipitation and thus it is a moisture source region for the Asian summer monsoon rainfall. In the present study, the relationship of the interannual variability of moisture source over the SIO to the local sea surface temperature (SST) and the El Niño Southern Oscillation (ENSO) on the moisture source are compared. The authors identify one major coupled mode between the interannual variations of apparent moisture sink (<Q2>) and SST. Spatial structure of the major mode exhibits two key regions of moisture source, one over the western-central SIO where <Q2> is

negative, and the other to the northwest-north of Australia, where <Q2> is positive. In the corresponding map of SST, negative values are also seen in the former region, but are positive in the latter region. An increase in local SST enhances convection and ascent, leading to more precipitation. Over the western-central SIO, surface winds weaken corresponding to higher SST in the western-central SIO and lower SST to the northwest-north of Australia, leading to less oceanic evaporation. Thus, the variation of the moisture source over the westerncentral SIO is contributed by both precipitation and evaporation. ENSO amplifies anomalous moisture source induced by local SST anomalies. ENSO and local SST work cooperatively to influence the moisture source over the SIO.

## CLOUD OPTICAL AND MICROPHYSICAL PROPERTIES DERIVED FROM GROUND-BASED AND SATELLITE SENSORS OVER A SITE IN THE YANGTZE DELTA REGION

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### Abstract

Comprehensive surface-based retrievals of cloud optical and microphysical properties were made at Taihu, a highly polluted site in central Yangtze Delta region during a research campaign from May 2008 to December 2009. Cloud optical depth (COD), effective radius (Re) and liquid water path (LWP) were retrieved from measurements made with a suite of ground-based and space-borne instruments including Analytical Spectral Devices (ASD) spectroradiometer, a Multi-Filter Rotating Shadowband Radiometer (MFRSR) and Multichannel Microwave Radiometer Profiler (MWRP), and Moderate Resolution Imaging Spectroradiometer (MODIS) on Terra and Aqua satellites. It is found that the retrievals from zenith radiance measurements capture better the temporal variation of cloud properties than do retrievals from hemispherical fluxes. Annual mean LWP, COD and Re are 115.8 ± 90.8 g/m2, 28.5 ± 19.2, and 6.9 ± 4.2 μm. Over 90% of LWP is less than 250 g/m2. Most of COD (>90%) falls between 5 and 60 and ~80% of Re is less than 10 μ m. Maximum (minimum) values of LWP and Re occur in summer (winter); COD is highest in winter and spring. Raining and non-raining clouds have significant differences in LWP, COD and Re. Rainfall frequency is best correlated with LWP, followed by COD and Re. Cloud properties retrieved from the multiple ground-based instruments are also compared with those from satellite retrievals. On average, relative to surface retrievals, the mean biases of satellite retrievals in cloud LWP, COD and Re were -33.6 g/m2 (-26.4%), -5.8 (-31.4%), and 2.9 ?m (29.3%) for 11 MODIS-Terra overpasses; and -43.3 g/m2 (-22.3%), -3.0 (-10.0%) and -1.3 ?m (-

12.0%) for 8 MODIS-Aqua overpasses, respectively. These discrepancies indicate that MODIS cloud products still suffer from large uncertainties in this region.

### MODIFICATIONS TO SUB-GRID SCALE CLOUD REPRESENTATION AIMED AT IMPROVING SST SIMULATIONS IN THE ACCESS COUPLED-MODE

Zhian Sun[1], Charmaine FranklinDaohua Bi[1], Martin Dix[1], Xiaobing Zhou[1], Anthony C. Hirst[1], Yimin Ma[1], J. K. P. Shonk[1], Patricia Okely[2], and Kamal Puri
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Abstract

The Australian Community Climate and Earth-System Simulator (ACCESS) has been developed at the Centre for Australian Weather and Climate Research. It is a coupled modeling system consisting of ocean, atmosphere and land surface. The ACCESS atmospheric component is the UK Met Office Unified Model (UM). The initial results from the ACCESS coupled model had significant cold biases in the sea surface temperature (SST). It has been identified that the SST bias is largely due to errors in the representation of clouds. We have found that the use of the homogenous cloud distribution within model grid-boxes produced an underestimation of solar radiation reaching the surface, causing a cooling effect. The model cloud scheme does not produce enough high cloud cover, which also led to a cooling effect. These two deficiencies have been largely remedied by the implementation of the Triple-cloud scheme and a modification to the ice cloud fraction parameterization in the cloud scheme. These modifications have led to significant improvements in the simulation of SST in ACCESS.

### EMERGING SATELLITE OBSERVATIONS OF ABOVE-CLOUD AEROSOLS AND DIRECT RADIATIVE FORCING

Zhibo Zhang, UMBC

Abstract

Recently, global observations from the space-born lidar CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) have greatly improved our knowledge of the vertical distribution of aerosols and clouds. Using four years of CALIOP observations, Devasthale and Thomas [2010] located several geographical regions where elevated aerosols are often found above low-level liquid phase clouds. For example, during the austral winter and spring light-absorbing smoke aerosols originated from seasonal burning of the southwestern African Savannah are often observed over the bright stratocumulus decks over South-East Atlantic. Space-born lidar CALIOP and passive sensors with multi-wavelength, multi-angle and polarization capabilities onboard the A-Train provide unprecedented opportunities of observing aerosols that overlap low-level clouds and their direct radiative forcing. In this talk, I will first provide an overview of the significant progressed made in recent years in exploring these new aerosol remote sensing

capabilities. Then, I will talk about our recent research that aims to use a synergistic combination of passive and active sensors in A-train to better understand the optical and microphysical properties of transported smoke over South-East Atlantic region, which often overlaps low-level marine stratocumulus.

## MULTI-SENSOR REMOTE SENSING OF CLOUD MACROPHYSICAL AND MICROPHYSICAL PROPERTIES WITH THE A-TRAIN SATELLITES

Zhien Wang, Min Deng, and Damao Zhang, University of Wyoming
Jay Mace, University of Utah
Loknath Adhikari, Texas A&M University-Corpus Christi

Abstract

The A-train satellites provide the first space-based combined active (lidar and cloud radar) and passive measurements of clouds globally. Based on these new measurements, multi-sensor cloud retrieval algorithms are developed to provide cloud macrophysical and microphysical properties. This presentation discusses two CloudSat standard combined lidar-radar products (2B-CLDCLASS-lidar and 2C-ICE). Meanwhile, we will present a new mixed-phase microphysical retrieval algorithm by combining CloudSat, CALIPSO and MODIS measurements. This new algorithm can significantly reduce the bias of MODIS retrieved supercooled liquid water path. These data provide new way to study the 3-D distribution of global cloud properties and to study related cloud microphysical processes. Examples of using A-train data for cloud microphysical process study will be also presented.

## ASSESSING THE INFLUENCE OF REGIONAL SST MODES ON THE WINTER TEMPERATURE IN CHINA: THE EFFECT OF TROPICAL PACIFIC

ZHIHONG JIANG AND HAO YANG
Nanjing University of Information Science and Technology, Key Laboratory of Meteorological Disaster, Ministry of Education, China

Abstract

This study investigates the influence of different sea surface temperature (SST) modes on the winter temperature in China using the Generalized Equilibrium Feedback Assessment (GEFA). It is found that the second EOF mode of winter temperature in China during 1958-2010 shows a typical northeast-southwest (NE-SW) pattern, which is a major spatial mode of China winter temperature at interannual scales. The winter temperature of NE-SW pattern is forced mainly by SST modes in the tropical Pacific and Atlantic. For 2009/2010, the tropical Pacific El Niño mode and tropical Atlantic tripole mode have the largest contribution to the response. The physical mechanism of cold-northeast/warm-southwest (CNE-WSW) pattern is also explained in terms of GEFA of the responses of the atmospheric circulation. The northerly flow at low level transports cold air to north and northeast China, resulting in lower temperature there. Meanwhile, the anomaly meridional wind advects warm air from the southern oceans to southwest China, leading to warming there.

## RADIATIVE FORCING AND CLIMATE RESPONSE DUE TO BLACK CARBON IN SNOW AND ICE

Zhili WANG, Chinese Academy of Meteorological Sciences, Beijing 100081

Abstract

The radiative forcing and climate response due to black carbon (BC) in snow/ice are investigated by integrating observed effects of BC on snow/ice albedo into an atmospheric general circulation model (BCC_AGCM2.0.1) developed by the National Climate Center (NCC) of the China Meteorological Administration (CMA). The results show that the global annual mean surface radiative forcing due to BC in snow/ice is +0.042 W m-2, with maximum forcing found over the Tibetan Plateau and regional mean forcing exceeding +2.8 W m-2. The global annual mean surface temperature is increased 0.071$^{o}$C by BC in snow/ice. Positive surface radiative forcing is clearly shown in winter and spring and increases the surface temperature of snow/ice in the Northern Hemisphere. The surface temperatures of snow-covered areas of Eurasia and North America in winter (spring) are increased by 0.83 (0.6)$^{o}$C and 0.83 (0.46)$^{o}$C, respectively. Snow-melt rates are also increased greatly, leading to earlier snowmelt and peak runoff timings. With the rise of surface temperature in the Arctic, more water vapor could be released into the atmosphere, allowing for easier cloud formation, which could lead to higher thermal emittance in the Arctic. However, the total cloud forcing could be decreased due to the increasing of cloud cover, which will offset some of the cloud positive feedback mechanism.

## FACTORS FOR INTERANNUAL VARIATIONS OF SEPTEMBER-OCTOBER RAINFALL IN HAINAN, CHINA

Zhiping Wen, Center for Monsoon and Environment Research, Sun Yat-sen University, China
Xiao Feng, Center for Monsoon and Environment Research, Sun Yat-sen University, China
Renguang Wu, Institute of Space and Earth Information Science, Chinese University of Hong Kong, China
Jiepeng Chen, Center for Monsoon and Environment Research, Sun Yat-sen University, China

Abstract

The present study investigates the year-to-year variations of September-October rainfall in Hainan, China for the period 1959-2010. The dominant circulation anomalies feature a cyclone (an anticyclone) over the Indochina Peninsula and northern South China Sea, an anticyclone (a cyclone) over subtropical western North Pacific and lower-level convergence (divergence) over the Maritime Continent in the wet (dry) years. These circulation anomalies are responses to an east-west sea surface temperature (SST) anomaly pattern with negative (positive) SST anomalies in the equatorial central Pacific and positive (negative) SST anomalies around the Maritime Continent in the wet (dry) years. Although the SST anomaly pattern is similar (but with opposite anomaly), the SST signal in the equatorial central Pacific is more significant in the dry years than in the wet years. This difference indicates a larger case-to-case variability in the wet years than in the dry years. The large variability in the wet years is attributed to contributions of tropical cyclones (TCs) and intraseasonal oscillations (ISOs). There are more TCs impinging on Hainan

and the TC tracks are closer to the island in the wet years than in the dry years. The rainfall shows large intraseasonal variations with periods of 10-20 and 30-60 days during September-October in the wet years. The 10-20-day ISO originates from the Maritime Continent, whereas the 30-60-day ISO develops over tropical Indian Ocean and propagates northeastward to northern South China Sea. In contrast, the ISO signal is much weaker in the dry years.

## MODULATION OF THE TIBETAN PLATEAU SNOW COVER ON THE ENSO TELECONNECTION: FROM THE EAST ASIAN SUMMER MONSOON PERSPECTIVE

Zhiwei Wu[1], Jianping Li[2], Zhihong Jiang[1] and Tingting Ma[1]

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Abstract

The East Asian summer monsoon (EASM) may exhibit rather large variability between years characterized by the same ENSO phase. Such inconsistency reduces the EASM predictability based on ENSO. Results in this study show that the Tibetan Plateau snow cover (TPSC) exerts a modulating effect on ENSO teleconnections and ENSO significantly correlates with the EASM only during the reduced TPSC summers. Three-dimensional circulation structures are examined to manifest that the typical ENSO signals in reduced TPSC summers tend to be stronger than in excessive TPSC summers. Numerical and theoretical evidences indicate that the anomalously reduced TPSC can force positive geopotential height anomalies at the upper troposphere and weaken the jet streams across eastern Asia and northwestern Pacific. Governed by such basic state zonal flows, the extratropical Rossby wave response to the ENSO forcing usually has a larger amplitude and pronounced westward development. In such case, ENSO extends its influences to the eastern Asia and enhances its connection with the EASM.

## THE APPLICATION OF NEWTONIAN JERKY DYNAMICS IN INERTIAL INSTABILITY

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2 Institutes of Meteorology and Oceanography, PLA University of Science and Technology

Abstract

Newtonian jerky dynamics is applied to inertial instability analysis to study the nonlinear features of atmospheric motion under the action of variable forces. Theoretical analysis of the Newtonian jerky function is used to clarify the criteria for inertial instability, including the influences of the meridional distributions of absolute vorticity ($\zeta g$) and planetary vorticity ( the $\beta$ effect). The results indicate that the meridional structure of absolute vorticity plays a fundamental role in the dynamic features of inertial motion. Including only the $\beta$ effect (with the assumption of constant $\zeta g$) does not change the instability criteria or the dynamic features of the

flow, but combining the β effect with meridional variations in ζg introduces nonlinearities that significantly influence the instability criteria.

Numerical analysis is used to derive time series of position, velocity, and acceleration under different sets of parameters, as well as their trajectories in phase space. The time evolution of kinematic variables indicates that a regular wave-like change in acceleration corresponds to steady wave-like variations in position and velocity, while a rapid growth in acceleration (caused by a rapid intensification in the force acting on the parcel) corresponds to track shifts and abrupt changes in direction. Stable limiting cases under the f- and β-plane approximations yield periodic wave-like solutions, while unstable limiting cases yield exponential growth in all variables. Perturbing the value of absolute vorticity at the initial position (ζ0) results in significant changes in the stability and dynamic features of the motion. Enhancement of the nonlinear term may cause chaotic behavior to emerge, suggesting a limit to the predictability of inertial motion.

## A NEW METHOD FOR IDENTIFYING THE SEVERITY OF DROUGHT: A CASE STUDY IN SOUTHWEST CHINA

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Chen Wen, Center for Monsoon System Research, Institute of Atmospheric Physics, China

Abstract

Monthly/seasonal precipitation anomalies are frequently employed to quantify the severity of drought, such as many previous studies devoted to extreme drought events in summer of 2006 and autumn of 2009 to spring of 2010 over Southwest China. According to the multiscalar nature of drought, the monthly/seasonal precipitation anomalies can only reflect the drought at short time scales, i.e. meteorological or agricultural drought. Consequently, should also taken into account is the precedent precipitation deficits, which play a key role in triggering long term drought (hydrological drought) in the following months. Based on this consideration, the coincidence of drought at multiple time scales, which will produce extreme drought events affecting society and economy seriously, is proposed in this study as a new indicator to measure the severity of drought. An assessment over Southwest China demonstrates its effectiveness in quantifying severe drought. In contrast, from the perspective of seasonal precipitation anomaly alone, the drought in the summer of 1972 should be as serious as the one in the summer of 2006. In fact, however, the 2006 summer drought over Southwest China is more severe than the summer of 1972 due to the collaborative effect of drought occurred at different time scales, which is not the case in 1972 summer. This comparison further confirms the superiority of the proposed metric based on the overlap of droughts at multiple time scales over traditional approaches commonly adopted in relevant literature.

## ASIAN-PACIFIC OSCILLATION IN AUTUMN AND ITS RELATIONSHIPS WITH THE SUBTROPICAL MONSOON IN EAST ASIA

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Abstract

Based on NCEP/NCAR reanalysis 1961-2010, this work uses empirical orthogonal function (EOF) and composite analysis to study the distributions of zonal land-sea thermal contrast between Asia and the Pacific Ocean during transitions from the summer monsoon to the winter monsoon in East Asian subtropics, and investigates their interannual variations and their relationships with circulation systems of the East Asian subtropical monsoon. The findings are as follows. 1) In autumn, the interannual variations of the temperature deviation in the middle and upper troposphere show significant east-west out-of-phase teleconnection over Asia and central and eastern Pacific, i.e. the Asian-Pacific Oscillation, or APO. 2) While not as significant as in summer with regard to coverage and intensity, the APO shows interannual variations in autumn that well depicts the change in the intensity of the subtropical monsoon. In the strong (weak) APO year, the subtropical monsoon is strong (weak) and the winter monsoon is weak (strong) in East Asia as derived from the general circulation and wind field of the East Asian-Pacific region. 3) Over the past 50 years, the autumn land-sea thermal contrast tends to decrease in the Asia-Pacific region, with a significant interdecadal shift at the late-1970s.

## A ROBUST MULTI-SCALE MODELING SYSTEM FOR THE STUDY OF CLOUD AND PRECIPITATION PROCESSES

Wei-Kuo Tao, NASA Goddard Space Flight Center

Abstract

During the past decade, numerical weather and global non-hydrostatic models have started using more complex microphysical schemes originally developed for high-resolution cloud resolving models (CRMs) with 1-2 km or less horizontal resolutions. These microphysical schemes affect the dynamic through the release of latent heat (buoyancy, loading and pressure gradient), the radiation through the cloud coverage (vertical distribution of cloud species), and surface processes through rainfall (both amount and intensity).

Recently, several major improvements of ice microphysical processes (or schemes) have been developed for cloud-resolving models (Goddard Cumulus Ensemble, GCE, model) and regional scale (Weather Research and Forecast, WRF) models. These improvements include an improved 3-ICE (cloud ice, snow and graupel) scheme (Lang et al. 2010); a 4-ICE (cloud ice, snow, graupel and hail; Lang et al. 2013) scheme and a spectral bin microphysics scheme and two different two-moment microphysics schemes. These models have improved the radiative processes and their interactions with cloud and aerosol.

The performance of these schemes has been evaluated by using observational data from TRMM and major field campaigns. In this talk, we will present high-resolution GCE, WRF and MMF model simulations and compare the model results with observations [i.e., Typhoon (Morakot 2009 -an updated simulations), Anvil and Aerosol (AMMA 2006); MCSs (MC3E; 2010; diurnal

variation) and CloudSat/TRMM]. In addition, the main issues of the microphysics schemes in high-resolution (1-6 km grid spacing) numerical models will be discussed.

## CLIMATE CHARACTERISTIC AND VARIATION OF RAINSTORM IN SOUTH CHINA

Hongyu Wu

Institute of Tropical and Marine Meteorology, CMA, Guangzhou, China
Climate Characteristic and Variation of Rainstorm in South China

Abstract

Based on the daily precipitation data of 110 observational stations during 1961-2008 in South China, the climatic characteristic and variation of torrential rain days, rainstorm intensity and contribution which is in annual, the first and second flood season in South China were studied by using statistical diagnostic methods, such as linear regression analysis, Mann-Kendall test, wavelet analysis and the computation of trend coefficients. The result showed that the annual mean torrential rain days had a decreasing trend from coastal regions to inland in South China in recent 48 years, the highest center was in Dongxing of Guangxi（14.9 d）, the lowest center was in Longlin of Guangxi（3.2 d）. About 72% of the total torrential rain days occurred in the flood season with about 45% in the first season and 27% in the second season. The mean torrential rain days increased faintly in annual, the first and second flood season in South China, it wasn't obvious. There was the characteristic of interannual and interdecadal changes. The mean rainstorm intensity increased faintly in annual and in the first flood season in South China, since about 2005 it has become obviously. The mean rainstorm intensity has declined in the second flood season, but it wasn't obvious. The annual mean rainstorm contribution to the total rainfall increased obviously, but the mean contribution wasn't obvious in the first and second flood season. The wavelet analysis shows that the changes of torrential rain days, intensity and contribution which is in annual, the first and second flood season in South China had significant 2～3, 3～4 year periods.

## ABOUT AN INTERDECADAL CHANGE AROUND 1993 OVER EAST ASIA AND THE WESTERN NORTH PACIFIC

Renguang Wu, Institute of Space and Earth Information Science, the Chinese University of Hong Kong

Abstract

In recent years, an interdecadal change around the early 1990s over southern China, the South China Sea, and the western North Pacific has been identified in the literature. This interdecadal change includes changes in summer rainfall over southern China, the relationship between the East Asian and western North Pacific summer monsoons, the tropical cyclone activity over the South China Sea, the onset time of the South China Sea summer monsoon, the spectrum of the intraseasonal oscillations in the South China Sea as well as the sea level height along the South

China coast. In this talk, the speaker will review this interdecadal change and discuss the plausible reasons. In particular, the speaker will examine the roles of the tropical Indian Ocean warming and the Tibetan Plateau snow increase in summer rainfall increase over southern China based on observations and model experiments. The tropical Indian Ocean warming induces anomalous descent, leading to an anomalous lower-level anticyclone over the South China Sea and the western North Pacific. The increase in the Tibetan Plateau snow cover in winter and spring modulates the thermal contrast between the Tibetan Plateau and the surrounding regions, leading to an anomalous surface high pressure over Mongolia and North China. The anomalous southerly winds to the west of the South China Sea anticyclone and the anomalous northerly winds to the east of the Mongolia high pressure converge over southern China, enhancing upward and precipitation there. Details of the above processes will be presented in the talk. The speaker will also discuss the contributions of the South China Sea tropical cyclones to the summer rainfall increase over southern China.

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Chen, J., R. Wu*, and Z.-P. Wen, 2012: Contribution of South China Sea tropical cyclones to an increase in southern China summer rainfall around 1993. Adv. Atmos. Sci., 29(3), 585-598, doi:10.1007/s00376-011-1181-6.

## EVALUATION OF CLOUD VERTICAL STRUCTURE SIMULATED BY RECENT BCC_AGCM VERSIONS AGAINST CALIPSO-GOCCP OBSERVATIONS

Fang Wang, National Climate Center, CMA, China

### Abstract

In this study, the ability to simulate cloud vertical structure in 2.1 and 2.2 versions of BCC_AGCM with a lidar simulator has been evaluated against The GCM-Oriented CALIPSO Cloud Product (CALIPSO-GOCCP), focusing on cloud vertical features from both ISCCP-defined cloud types and cloud cover with finer vertical resolution (480 m). BCC_AGCM2.2 has the consistent dynamic core and physical processes with BCC_AGCM2.1 but with a higher horizontal resolution. Results show that both BCC_AGCM versions tend to underestimate global-mean total cloud cover (TCC), high cloud cover (HCC), middle cloud cover (MCC) and low cloud cover (LCC), only with the exception for HCC in BCC_AGCM2.1. Geographically, HCC is severely overestimated in the tropics particularly for BCC_AGCM2.1, while LCC is generally overestimated over extra-tropical lands but significantly underestimated over most of oceans especially for subtropical marine stratocumulus clouds. The most remarkable difference between the two models is that the global-mean cloud cover has a systematical reduction from BCC_AGCM 2.1 to 2.2 especially for high clouds.

By use of empirical orthogonal function (EOF) analysis, main cloud vertical leading modes are extracted. BCC_AGCMs have a good performance in reproducing EOF1 except with about 10% larger explained variance. The two models also capture the basic features of EOF3 but obvious deficiency exists in strength of eigenvector peaks. The largest simulation bias occurs in EOF2 characterized by downward shift and weakening of the 7-km eigenvector peak and a spurious

negative maximum around 18 km and also missing the planetary boundary layer (PBL) positive peak below 2 km. Furthermore we investigate the effects of cloud vertical structure on relative cloud radiative forcing (RCRF) in terms of principal components regression (PCR). Results show both BCC_AGCM versions successfully reproduce the sign of regression coefficients compared to CALIPSO. However, the relative extinction ability (means corresponding to unit change of PC) from PC1 is overestimated. For PC2 and PC3, the relative extinction ability is underestimated in BCC_AGCM2.1 while overestimated in BCC_AGCM2.2.

## INTERANNUAL MODULATION OF THE PACIFIC DECADAL OSCILLATION (PDO) ON THE LOW-LATITUDE WESTERN NORTH PACIFIC

Chau-Ron Wu, National Taiwan Normal University

### Abstract

To investigate the interannual variability in the northwestern Pacific, an empirical mode decomposition (EMD) was applied to 17-year Absolute Dynamic Topography (ADT) data west of Luzon Island, the Philippines. The mean sea surface height in this area is an appropriate index for the Kuroshio intrusion into the South China Sea (SCS). Significant interannual fluctuations were extracted by the EMD. The interannual variability was strongly correlated with the Pacific Decadal Oscillation (PDO) index, but not the El Niño'southern Oscillation (ENSO). This indicated the potential impact of the PDO on the circulation in the area. In the warm phase of the PDO (positive index), a southerly anomalous wind off the Philippines causes a northward shift of the North Equatorial Current bifurcation latitude (NECBL). This leads to a weakened Kuroshio off Luzon, favoring Kuroshio intrusion into the SCS. The northward migration of the NECBL also results in a weakened Kuroshio off southeast Taiwan and a larger Kuroshio transport off northeast Taiwan. The abundant westward propagating eddies impinging on the Kuroshio in the Subtropical Countercurrent region increases this transport. Although the ENSO has little effect on monsoonal winds during the warm PDO phase, it has a strong impact on the monsoon and meridional migration of the NECBL during the cold phase of the PDO. Therefore, NECBL variations only show a close correspondence with the ENSO during the cold PDO phase. Because the influence of the ENSO is not stationary, the impact of the PDO should be taken into account when examining interannual variability in the low-latitude western North Pacific.

## THE IMPLICATION OF ENSO ON ASIA-PACIFIC REGIONAL CLIMATE

Wen Zhou
School of Energy and Environment,City University of Hong kong

### Abstract

The objective of this research is to explore the impacts of El Niño-Southern Oscillation (ENSO) on tropical climate over Asia-Pacific region. In boreal winter, the strong or weak northerly anomalies due to the East Asian winter monsoon (EAWM), sweep across the continent to the costal regions, which might be favorable for the occurrence of an ENSO event. In boreal

summer, South China tends to experience less (more) rainfall, and more (less) temperature extremes, more super typhoons (more tropical storms) which might be in the mature phase of a warm(cold) ENSO event. It is also found that more frequent cold surges might be followed by less temperature extremes in the coming year.

In Particular, the summer moisture circulation anomaly over East Asia and the western North Pacific (WNP) couples well with the ENSO in a quasi-4-yr period. The anticyclone (cyclone) over the Philippine Sea region serves as a bridge in the quasi-four-year coupling. Its establishment and eastward extension modify moisture circulation over East Asia?WNP. Conversely, the easterly (westerly) wind to the south of the anticyclone (cyclone) is beneficial for the formation and eastward propagation of the Kelvin wave and, hence, to the development of the quasi-4-yr periodic ENSO episode. Further studies also suggest that the timing with which ENSO impacts super typhoon, typhoon and tropical storm varies and that their corresponding changes in frequency closely follow the evolution of the ENSO cycle. During the boreal winter, the dominance of blocking thermally enhances cold advection downstream. Ural-Siberian blocking may exist in the form of an eastward-propagating wave train. Be that as it may, the wave train signal across East Asia may be disturbed by the external effect of a strong ENSO event, which probably enhances (weakens) the westerlies near Siberia in its warm (cold) phase. The frequent occurrence of Ural-Siberian blocking potentially promotes a cold EAWM and vice versa, such as 2008 snowstorm in South China.

## CLIMATE CHANGES AND THE POTENTIAL RULES OF INCREASING AIR POLLUTION IN CHINA

Zhanqing Li, University of Maryland and Beijing Normal University

### Abstract

The climate of China has undergone significant changes over the past half a century when systematic measurements have been made. Of no doubt, causes for such changes are both natural and anthropogenic. For the sake of combating and migrating any adverse changes, it is imperative to understand and identify such causes. One prominent agent that could incur such changes is environmental degradation, especially air pollution that has shown general increasing trends. Aerosol particles can affect virtually all meteorological variables due to their direct and indirects effects on energy and water cycles. Heavy loading of aerosols reduce the amount of solar radiation reaching ground, that could lower surface temperature, reduce ocean-land contrast, whereas solar energy absorbed by aerosols alters atmospheric stability to have a feedback effect on atmospheric dynamics. By altering cloud microphysics and macrophysics, aerosols can also change cloud properties and precipitation frequency and amount. All of these can influence regional weather and climate in a dramatically. To tackle the problem and unravel various complex relations, data from both long-term routine measurements and intensive field experiments have been analyzed, together with some modeling studies, to tackle with the problems. Recent field experiments include the East Asian Study of Tropospheric Aerosols: an International Regional Experiment (EAST-AIRe), the East Asian Study of Tropospheric Aerosols and Impact on Regional Climate (EAST-AIRc), and Atmospheric Radiation Measurements (ARM) Mobile Facility mission in China (AMF-China). During these experiments, extensive measurements were made of aerosol optical, physical and chemical

properties and a suite of radiation quantities. By means of data analysis and modeling, we found signficant effects of aerosols on temperature, precipitation, fog and atmospheric circulation, attesting the significant roles of atmospheric environment on the regional climate and its changes in China.

## ENSEMBLE FORECAST: ASSESSING AND COMMUNICATING FORECAST UNCERTAINTY

Yuejian Zhu, NOAA/NWS/NCEP/EMC

### Abstract

In past decades, a skill of weather, water, and climate forecasts has been continuously improved through the use of new technologies, such as super computer system, enhanced observations, state-of-art numerical modeling and et al, but uncertainty can never be eliminated from the forecasts due to the chaotic nature of the atmosphere-land-ocean coupled system. For optimal decision making, users need to consider all possible scenarios of environmental prediction, not just the most likely outcome. As this need, the "Completing the forecast" was published by the National Research Council of the US Academy of Sciences (NRC, 2006), which is to character and communicate forecast uncertainty through ensemble forecasts.

Forecast uncertainty can be assessed either through traditional approaches based on error statistics of a single (or deterministic) forecast, or later developed dynamical approaches by using the ensemble forecasts. The traditional forecast process mainly focuses on the estimation of the expected value of the forecast distribution. However, the new approach to assess forecast uncertainty is based on an numerical ensemble forecast which is designed to mitigate the limitations of the traditional forecast process through considering observation/analysis uncertainties, and model uncertainties. Ensemble forecasts are the centerpiece of a proposed new forecast process where uncertainty is assessed, propagated, and conveyed throughout the entire end-to-end forecast process in a self-consistent manner. The systematic use of ensembles can maximize both the skill and utility of the forecasts, especially for time-varying user requirements in high impact and extreme events.

## OBSERVATIONAL STUDY OF THE ARIDITY EFFECT OF DUST AEROSOLS

Jianping Huang, Key Laboratory for Semi-Arid Climate Change of the Ministry of Education, College of Atmospheric Sciences, Lanzhou University, China

### Abstract

Dust aerosols play an important role in global climate by scattering and absorbing solar and terrestrial radiation, thereby influencing the radiation balance in the atmosphere. Asian dust often originates from the Taklimakan and Gobi deserts in late winter and spring. This dust is transported long distances by the prevailing westerlies, passing over the northeastern Asia and the Pacific Ocean, and reaching North America. During transport, dust aerosols not only reduce local air quality, and affect human, but also act as ice nuclei (IN) and cloud condensation nuclei

(CCN), thus changing the radiative properties of clouds, ice water paths, cloud lifetimes, and precipitation. To improve understanding and capture the direct evident of the impact of dust aerosol on semi-arid climate over Loess Plateau, the Semi-Arid Climate & Environment Observatory of Lanzhou University (SACOL) and Lidar network has been established since 2005. In addition, extensive studies concerning Asian dust and anthropogenic aerosols were conducted with several field experiments. We found that both local anthropogenic dust aerosols and natural dust aerosols that transported into arid/semi-arid region can significantly reduce the water cloud particle size, optical depth and LWP. A significant feature of dust-cloud-precipitation interactions over arid and semi-arid areas is that it creates a positive feedback loop. The feedback loop begins with a decrease in rainfall and a resulting deficit in soil moisture. This leads to an increase in the occurrence of dust storms. Consequently, dust aerosols in the atmosphere warm clouds, increase the evaporation of cloud droplets and further reduce the cloud water path (the semi-direct effect). This decreases the low cloud cover and water vapor amount, leading to less rainfall. The occurrence of dust storms would then increase, which could lead to even less rainfall. However, if dust aerosols are transported to wet regions (e.g., East Asia and Pacific regions) and suspended in the atmosphere, they may serve as a source of IN which can enhance ice formation by droplet nucleation, and intensify precipitation.

## COMPARISON OF CLOUD DISTRIBUTION OBTAINED FROM CALIPSO, CLOUDSAT AND CERES-MODIS

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### Abstract

The global cloud distributions obtained from CALIPSO, CloudSat and CERES-MODIS are investigated. Due to the sensitivity of MODIS sensor, the cloud mask algorithm of cloud retrieval often miss to identify the very thin (optically) ice cloud. Due to the limitation of the cloud mask algorithm, it often treats aerosols as clouds, especially in the desert regions. The purpose of this study is to find the regions where the cloud mask algorithm misses or misclassifies the cloud. The preliminary results found that the regions where clouds are often missed are the polar regions and around the equator and also found that the regions where clouds are misclassified are mainly over subtropical ocean.

## INTERDECADAL CHANGE OF THE TIBETAN PLATEAU FORCING AND THE EASTERN ASIAN MONSOON CHANGE

Yimin Liu, LASG, Institute of Atmospheric Physics, CAS

### Abstract

Data analysis based on station observations reveals that many meteorological variables averaged over the Tibetan Plateau (TP) are closely correlated, and their trends during the past decades are well correlated with the rainfall trend of the Asian summer monsoon. However, such correlation does not necessarily imply causality. Further diagnosis confirms the existence of a weakening

trend in TP thermal forcing, characterized by weakened surface sensible heat flux in spring and summer during the past decades. This weakening trend is associated with decreasing summer precipitation over northern South Asia and North China and increasing precipitation over northwestern China, South China, and Korea.

An atmospheric general circulation model, the HadAM3, is employed to elucidate the causality between the weakening TP forcing and the change in the Asian summer monsoon rainfall. Results demonstrate that a weakening in surface sensible heating over the TP results in reduced summer precipitation in the plateau region and a reduction in the associated latent heat release in summer. These changes in turn result in the weakening of the near-surface cyclonic circulation surrounding the plateau and the subtropical anticyclone over the subtropical western North Pacific, similar to the results obtained from the idealized TP experiment in Part I of this study. The southerly that normally dominates East Asia, ranging from the South China Sea to North China, weakens, resulting in a weaker equilibrated Sverdrup balance between positive vorticity generation and latent heat release. Consequently, the convergence of water vapor transport is confined to South China, forming a unique anomaly pattern in monsoon rainfall, the so-called ”south wet and north dry”. Because the weakening trend in TP thermal forcing is associated with global warming, the present results provide an effective means for assessing projections of regional climate over Asia in the context of global warming.

## A HIERARCHICAL FRAMEWORK FOR EVALUATING HIGH RESOLUTION CLIMATE MODELS

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Abstract

Predicting the regional hydrologic cycle at time scales from seasons to centuries is one of the most challenging goals of climate modeling. Because hydrologic cycle processes are inherently multi-scale, increasing model resolution to more explicitly represent finer scale processes is important. With advances in high performance computing, it is now feasible to run coupled atmosphere-ocean GCMs at horizontal resolution comparable to what RCMs use today. Global models with local refinement using unstructured grids have also become available for modeling regional climate. While they offer opportunities to improve climate simulations, significant efforts are needed to test their veracity for regional-scale climate simulations. This presentation describes a hierarchical framework to evaluate high resolution climate simulations from idealized aqua-planet experiments to AMIP-style simulations. The effects of model resolution and dynamical frameworks on the high resolution simulations will be discussed including comparison of simulations from global variable resolution and nested models and global simulations using different dycores and spatial resolutions in the Community Atmosphere Model (CAM) framework.

## APPLICATION OF FY SATELLITE DATA ON MESOSCALE ANALYSIS AND SIMULATION OF BEIJING 7.21 HEAVY RAINSTORM EVENT BY LAPS

Li Hongli, Wuhan Institute of Heavy Rain,CMA,Wuhan,China

Abstract

The heavy rainstorm occured in Beijing on July 21, 2012 is the most in the past 61 years. The average annual rainfall of Beijing is 170mm, and city average rainfall is 215mm. The maximum rainfall station Fangshan reaches 460mm. The area rainfall of 100mm or more accounts for more than 86% of the total area of Beijing. The rainstorm triggers flash floods in Fangshan area. 1.9 million people are affected. According to preliminary statistics, the economic losses of Beijing is nearly billion and 79 persons die.

FY satellite data is ingested by LAPS. According to 3km hourly analysis fields, we analyze the mechanism of the rainstorm. We use LAPS analysis field as initial field of WRF model to simulate this rainstorm. The results are shown as follows. During the heavy rain, Beijing was located on the south of high level jet where wind diverged and on the north of low level jet where wind converged. The coupling of upper and lower level jet streams provided the secondary circulation and strengthened the upward movement. The heavy rain in Beijing area was accompanied by the enhancement of vertical velocity, the development of vorticity and the situation of high-level divergence, low-level convergence.

## REVIEW OF RECENT ADVANCES ON OCEAN CIRCULATION STUDY IN THE WESTERN PACIFIC OCEAN

Dunxin Hu

Institute of Oceanology, Chinese Academy of Sciences

Abstract

Study on ocean circulation has been carried on for more than 70 years since Schott (1939). The focus of the present talk will be mainly on recent advances of the study with short looking back on history. Two field experiments in the western Pacific were made on-the-spot: CSK (Cooperative Study of Kuroshio:1960's-1970's) and TOGA/WOCE (1980's-1990's). CSK's symbolic result is the book of ?Kuroshio? and TOGA/WOCE results in a number of valuable papers with the New Guinea Coastal Undercurrent (NGCUC) and MUC (Mindanao Undercurrent) discovered in the western Pacific Ocean, unprecedented amount of data acquired, and TAO/TRITON buoy network established for ENSO prediction. In 2010 an international joint program of NPOCE (Northwestern Pacific Ocean Circulation and Climate Experiment) was launched with participation of 19 institutions from 8 countries. NPOCE activities including field experiments and some scientific highlights conducted and achieved in the last three years will be reviewed.

## IMPACTS OF CLIMATE CHANGE AND EXTREME WEATHER EVENTS ON ESTUARINE SYSTEMS

Ming Li, University of Maryland

Abstract

Estuaries and coastal oceans around the world have suffered from hypoxia, harmful algal blooms, and altered ecosystem productivity. These problems have primarily been attributed to anthropogenic nutrient enrichment, i.e., eutrophication. However, there is increasing evidence that climate variability has overwhelmed eutrophication in coastal ecosystems over the past 2 decades. There is also evidence that extreme weather events can cause dramatic disruptions with long-term impacts. To address these challenging interdisciplinary topics, we have developed coupled hydrodynamic-biogeochemical models for estuaries and coastal oceans. Using several estuarine systems on the U.S. East Coast as examples, I will show how sea level rise and changing river flow affect salt intrusion and circulation in two neighboring coastal bays with contrasting tides. I will also use a coupled model to diagnose physical and biogeochemical mechanisms driving interannual variability of estuarine hypoxia. Finally I will show how windy storms and wet storms affect the coastal systems. These studies demonstrate that changing climate and extreme weather events have become predominant drivers in estuaries and coastal oceans, requiring an increased focus in oceanographic research.

## CHANGES IN PRECIPITATION CHARACTERISTICS ASSOCIATED WITH AIR TEMPERATURE OVER NORTHERN EURASIA

Hengchun Ye, California State University, Los Angeles

Abstract

The significance of precipitation consists of not only the quantity, but also frequency, intensity, and the form it is supplied to the earth's land and its spatial distribution. This study uses the historical daily precipitation records of 517 stations across the northern Eurasia to reveal the sensitivity of precipitation changes in quantity, frequency, and intensity associated with surface air temperature in different seasons.

## LONG -TERM VARIATION OF HEAT SOURCES OVER THE TIBETAN PLATEAU AND ITS IMPACT ON CHANGE IN ASIAN SUMMER MONSOON

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Abstract

Based on NCEP and ERA-40 reanalysis datasets for 1948-2011 and snow data for 1961-2011 over the Tibetan Plateau (TP), the long-term variation of heat sources and sensible heat over the TP has been estimated , and then a correlative analysis between the preceding winter and spring snow and East Asian summer monsoon precipitation has been applied. The following conclusions have been derived:

(1)Due to weakening of the Asian summer monsoon, the major monsoonal rain belt has experienced an inter-decadal southward shift, thus leading to the anomalous precipitation pattern of droughts in north and floods in south.

(2)The inter-decadal variability of the land-sea thermal contrast between heat sources affected by the winter and spring snow over the Tibetan Plateau and SSTA variations in surrounding oceans is the dominating factor leading to weakening of the Asian summer monsoon.

(3)In recent 10-15years, the enhancement of land-sea thermal contrast has caused the northward advance of the monsoon rain belt from the Yangtze River basin to the Yellow- Huaihe river basins. This is related to a similar northward shift of positive correlation region between the winter and spring snow over TP and summer precipitation in East China.

(4) In the future, the East Asian summer monsoon will continue to enhance and the precipitation amount in North China will significantly increase, whereas the South Asian monsoon will continue to weaken, with precipitation patterns to change considerably.

## NORTH PACIFIC GYRE OSCILLATION AND THE OCCURRENCE OF WESTERN NORTH PACIFIC TROPICAL CYCLONES

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Abstract

This study examines the links between the North Pacific Gyre Oscillation (NPGO) and the occurrence of tropical cyclones (TCs) in the western North Pacific (WNP) at both inter-annual and decadal scales. Our major findings are summarized as follows: (1) NPGO makes significant impacts on the WNP TC frequency at both inter-annual and decadal time scales. The impacts of NPGO on WNP TC activity are more profound than those made by the Pacific Decadal Oscillation (PDO) and the El Niño Southern Oscillation (ENSO). (2) Niño 3 plays a more important role in modulating decadal WNP TC activity than Niño 3.4 and Niño 4. (3) Positive low-level relative vorticity and weak zonal vertical wind shear are responsible for the increase in WNP TC activity in negative NPGO phases. This study indicates that the NPGO and Niño 3 indices should be key factors for building a scheme for decadal prediction of occurrences of WNP TCs.

## NORTH ATLANTIC VENTILATION USING CHLOROFLUOROCARBONS AND IDEALIZED-TRACER SIMULATIONS

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Abstract

The simulated chlorofluorocarbon CFC-11 and 29 geographically defined CFC-11 tracers as well as 29 geographically defined idealized tracers are used to quantify the regional contribution to the ventilation of the North Atlantic Ocean in a global version of Miami Isopycnal Coordinate Ocean Model (MICOM) driven by the daily NCEP/NCAR forcing. Age tracers attached to 29 idealized tracers are also used to estimate the timescales for the water masses transports. Our results show that the simulated overturning circulation matches the available observed data for both intensity and variability, and the simulated distribution of CFC-11 concentration in the subtropical North Atlantic Ocean is in good agreement with the observations, particularly above 800 m in depth. We found that the sandwich--like distribution of CFC-11 concentration in the subtropical North Atlantic in both the observations and simulations is mainly caused by subduction from western and eastern subpolar North Atlantic, but the contribution of the former (56.0%) is almost four times larger than that of the latter (15.7%). We demonstrated that the ocean dynamics, instead of the source function, determine the annual and interannual variability in both dynamically active tracer (such as water temperature and salinity) and passive tracer (such as CFC-11 and idealized tracer) concentrations in the deep North Atlantic. The transit-time derived by optimum time lag approach shows a 9.3- to 13.6-year lag for the signals propagating from the western subpolar North Atlantic to the subtropical North Atlantic, which is generally consistent with that of about 10 years derived from the simulated apparent age. The study suggests that geographically defined tracers can be used as an efficient tool to investigate the source and spreading pathway of water, and to forecast the spreading and spreading time of environmental accidents such as the radioactive waste in the world oceans.

## ROLES OF 10-20-DAY OSCILLATION IN RAINSTORMS OF OCTOBER 2010 OVER HAINAN IN CHINA

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Chunhua Zhang, Hainan Meteorological Observatory, China
Maoqiu Jian, Department of Atmospheric Sciences, Sun Yat-sen University, China

Abstract

Hainan experienced two sustained rainstorm processes in October 2010, which are the most serious rainstorms in October during the last 60 years. It is of great importance to investigate the possible causes of the rainstorms for better understanding the evolution of Hainan rainfall. During August to October, 2010, the most dominant signal of Hainan rainfall is the 10-20-day oscillation. In the present paper, the roles of 10-20-day oscillation of convective activity and atmospheric circulation in rainstorms of October 2010 over Hainan are studied. During both the two rainstorm processes, Hainan is in the center of convective activity and under the control of the lower-troposphere cyclonic circulation. The convective center and the tropical low system are initiated in the western-central tropical Indian Ocean several days prior to the rainstorm in Hainan. Then the convective center propagates first eastward to the maritime continent

accompanied by the cyclonic circulation and then northward to the northern part of South China Sea-South China, causing the rainstorms in Hainan. The important feature of propagation also could be proved in the 10-20-day oscillations of the divergence and the vertical motion in the troposphere. In addition, the westward propagation of the convection from the tropical western Pacific to the southern South China Sea and the further northward propagation intensify the convective activity over the northern South China Sea-South China during the first rainstorm process. In the aspect of the vertical structure, the 10-20-day oscillation of the divergence and the vertical motion exhibits the downward propagation from the lower stratosphere to the upper troposphere over Hainan, also responsible for the more precipitation for the first rainstorm.

## STUDY ON RISE IN THE TROPICAL TROPOPAUSE HEIGHT FROM 1979 TO 2011

Zheng BinShi, Guangzhou Institute of Tropical and Marine Meteorology, China Meteorological Administration
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Abstract

The National Centers for Environmental Prediction (NCEP) / National Center for Atmospheric Research (NCAR) reanalysis data are used to analyze the variations of tropical (0-360§E?20§S-20§N) tropopause height during recent 30 years (1979~2011). The results indicate a linear trend of increase with 3.5 hPa decrease of tropopause pressure during these years, and tropical convections, total ozone and tropospheric air temperature have 7.84%, 25.97% and 25.64% of contributions, respectively. With the linear trend removed, tropical tropopause pressure behaves significant interannual variability and peaks periods at 18.2, 28.6 and 40 months. Both the total ozone and tropical tropospheric air temperature are response for 18.2-month period, and the ozone and tropospheric air temperature variability of 18.2 months are induced by boreal monsoon cell. 28.6 months period is attributed to the quasi-biennial variation of ozone induced by the lower stratospheric zonal wind of quasi-biennial oscillation. 40-month period in the tropical tropopause pressure is mainly responsible for the ENSO induced tropospheric variation of air temperature.

## SEASONALITY OF ATMOSPHERE-OCEAN INTERACTION IN THE SOUTH CHINA SEA

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Abstract

As a part of the tropical eastern Indian Ocean-western Pacific warm pool and the largest semienclosed marginal sea in the Western North Pacific, the South China Sea (SCS) displays remarkable air-sea interaction. Understanding the atmosphere-ocean interaction in the SCS and its roles in the regional climate is critical for regional climate prediction.

In this study, the OAFlux, OISST, GFDL assimilation, GPCP precipitation datasets are adopted to investigate the atmospheric and oceanic processes involved in the interannual air-sea

interaction in the SCS by comparing the simultaneous precipitation-SST and precipitation-SST tendency correlations. The seasonality and regionality of the atmosphere-ocean relationship is noticeable with an atmospheric forcing dominant in the Northern and Centered SCS during the local warm season, an oceanic forcing significant in the Northern SCS during the local cold season and a co-existing forcing developing in the Southern SCS from August to September. During April-May-June, the atmospheric forcing in the Centered SCS is characterized by prominent cloud-radiation effect, wind-evaporation effect and wind-driven current effect along the west coasts. During November-December-January, the regional convection responds to the anomalous SST in the Northern SCS through modulating the low-level convergence and the atmospheric stability. During August, the SST anomalies in the Southern SCS contribute positively to the anomalous precipitation with a relatively fast atmospheric response which in turn makes a negative contribution to the SST tendency anomalies.

The performances in regional atmosphere-ocean relationship in 24 selected models from advanced CMIP5 are evaluated. In the SCS, simulations among models vary with a wide range of spatial correlation coefficients and standard deviations. The models simulate better the precipitation-temperature tendency correlation than the precipitation-temperature correlation in four seasons with higher average pattern correlations and less differences among models. Improvements are suggested to be made in the model simulation for a better understanding of the regional air-sea interaction in the SCS.

## IMPACTS OF LAND AND SEA SURFACE TEMPERATURE ON THE SOUTH CHINA SEA SUMMER MONSOON ONSET

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This study investigates different impacts of surface temperature anomalies over land and sea on the interannual variability of the South China Sea summer monsoon onset. Analysis results suggest that surface temperature anomalies over the Asian continent and tropical Pacific exert different influences on the monsoon onset. A late monsoon onset is preceded by negative surface air temperature anomaly over the Asian continent, which changes the local Hadley cell and strengthens the western North Pacific subtropical high and the Philippine Sea anticyclone. In contrast, an early monsoon onset is preceded by negative sea surface temperature anomaly in the central-eastern tropical Pacific Ocean, which can modify the Walker cell and weaken the western North Pacific subtropical high and the Philippine Sea anticyclone.