Chinese-American Oceanic and Atmospheric Association

COAA 2003 Scientific Workshop

Research and Applications in Atmospheric, Ocean and Earth Sciences

Date: March 25, 2003 (Tuesday) 1— 5 p.m.

Place: Auditorium, Room 2400
Computer and Space Science Building
University of Maryland at College Park
College Park, Maryland

For information about COAA, Please go to: **http://www.coaaweb.org**

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Welcome

Dear Participants:

On behalf of the Board of Directors of the Chinese American Ocean-Atmosphere Association, we welcome you to the COAA 2003 Scientific Workshop: Research and applications in atmospheric, ocean and Earth sciences. The purpose of this workshop is to provide an opportunity for members and guests to present their research works, facilitates discussions and exchange of ideas and promotes networking among colleagues and fellow members. Thirteen papers on topics ranging from use of renewable ocean thermal energy, techniques and analyses of climate phenomena, remote sensing algorithms and applications, particulate transport and wave dynamics, and urbanization impact on climate, will be presented. Through your active and collegial participation, we hope that we can enhance networking among members and participants.

We thank the Board members for their support and the Meteorology Department, University of Maryland, College Park, for use of their facilities.

Long S. Chiu and Xiaofeng Li
Program Co-Chairs

AGENDA

1:00 p.m	Welcome and logistics
1:05 p.m	COAA and COAA 2003 Reports: **Dalin Zhang**
1:15 p.m	Revisit OTEC System**, Joseph Huang**, DOE
1:45 p.m	A Study of the Characteristics of White Noise Using the Empirical Mode Decomposition Method, **Zhaohua Wu**, COLA
2:00 p.m	The intensification and shift of the North Atlantic Oscillation in a global warming scenario simulation, **Zeng-Zeng Hu** and Zhaohua Wu, COLA
2.15 p.m	Intensity of hydrological cycles in warmer climates, **Fanglin Yang**, GEST/UMBC and GSFC and Arun kuman, Michael Schlesinger and Wanqiu Wang
2:30 p.m	Impact of urbanization and land use on climate change, **Ming Cai** and Eugenia Kalnay, UMCP
2:45 p.m	Application of TRMM and other NASA Earth Science Enterprise Products, **Zhong Liu**, GMU and GSFC/DAAC, William Teng, Hualan Rui and Long Chiu.
3:00 p.m	Break
3:30 p.m	Linear Atmospheric Response to ENSO associated SST Meridional Gradient, **Wilbur Y. Chen**, NCEP/NWS/NOAA
3:45 p.m	Role of particles in controlling the partitioning and transport of organic contaminants in the Chesapeake Bay, **Fung-Chi Ko**, Cheaspeake Biological Laboratory, UM Center for Environmental Sciences
4:00 p.m	The effect of surfactants on spilling breakers, **Xinan Liu** and James Duncan, University of Maryland, College Park
4:15 p.m	Effect of wave-current interactions on rip currents, **Jie Yu**, University of North Carolina at Chapel Hill
4:30 p.m	Atmospheric wind retrievals from satellite over the middle and high latitudes, **Cheng-Zhi Zou**, NOAA/NESDIS/ORA
4:45 p.m	Improved surface emissivity in land surface model and its impact, **Menglin Jin**, UMCP
5:00 p.m	Close of Technical Session
5:30 p.m	Dinner at Seven Seas Restaurant, Rt.1, College Park, Maryland

Revisit OTEC System

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The earth, covered more than 70.8% by the ocean, receives most of its energy from the sun. The sun irradiates every second about 380 million billion billion (3.8×10^{26}) Watts, and 17.5 million billion (1.75×10^{17}) of these Watts reaches the earth. That same percentage of solar energy hits the ocean's surface and atmosphere above, most directly in the tropical region. The solar thermal energy replenished each day by the sun in tropic oceans represents a tremendous pollution-free energy resource for human civilization. Ocean Thermal Energy Conversion (OTEC) utilizes the existing oceanic heat engine structure for power, generally similar to that of a car or jet engine. OTEC technology refers to a mechanical system that utilizes the natural temperature gradients that exist in the ocean between the warm surface water and the deep cold water, to generate electricity and produce other by-products. Hot ocean water is sucked in from the surface layer while deep ocean water is pumped from near the ocean bottom into evaporation and condensation cycles that can produce enough vapor steam to drive a turbine engine for generating electrical power and producing fresh water, etc. There are generally three types of OTEC cycles: closed-cycle plants utilize the evaporation of a working fluid, such as ammonia or propylene, to drive the turbine engine; open-cycle plants use the steam of flash vaporized warm sea-water at low pressure to run the turbine, and hybrid-cycle plants combine the two. OTEC requires very low operation and maintenance costs and NO fuel consumption.

OTEC possesses formidable potential capacity for renewable energy and offers a total elimination of greenhouse gases in producing power. In addition to electricity and drinking water, OTEC can also produce many valuable by-products such as: hydrogen, air-conditioning, aquaculture, fishery farming and even nutrient beers and mineral soft drinks. The potential of these by-products, especially drinking water, aquaculture and fishery farming, can easily translate into billions of dollars in business opportunities. Note that, though OTEC has the potential to change the future energy infrastructure in energy development and consumption of the world, it will take time, maybe several decades, to develop, build, and improve the technology and availability to supplement a portion of the gradually exhausting fossil energy. The OTEC issue needs to be revisited now! This paper will examine major advancements in technologies, evaluate costs and effectiveness, and assess overall market environment of the OTEC.

A Study of the Characteristics of White Noise Using the Empirical Mode Decomposition Method

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Based on numerical experiments on uniformly distributed white noise using the Empirical Mode Decomposition (EMD) method, we find that the EMD is effectively a dyadic filter; that the Intrinsic Mode Function (IMF) components are all normally distributed, and that the Fourier spectra of the IMF components are all identical and cover the same area on semi-logarithm period scale. We further deduce that the product of the energy density of IMF and its corresponding mean period is a constant, and that the energy density function is Chi-squared distributed. We derive the energy density spread function of the IMF components. Through these results, we establish a method to assign statistical significance of information content for IMF components from any noisy data.

Southern Oscillation Index data are used to illustrate the methodology developed here.

The intensification and shift of the North Atlantic Oscillation in a global warming scenario simulation

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The impact of global warming on the spatial and temporal character of the North Atlantic Oscillation (NAO) is investigated with a ECHAM4/OPYC3 CGCM global warming scenario simulation. It is shown that the meridional pressure gradient over the North Atlantic is significantly strengthened, and the two centers of action of the NAO, the Icelandic low and the Azores high, are intensified and shifted northeastward by 10 to 20 in latitude and 30 to 40 in longitude in the global warming scenario. The strengthened meridional pressure gradient results in a tendency toward the positive phase of a modified NAO index and an enhancement of its intensity. The shift of the centers of action leads to a failure in capturing the NAO change with the traditional definition of the NAO index. The intensification of the NAO is tied up with zonal mean state change, and the stationary wave change is associated with the shift of the centers of action of the NAO. In addition, it seems that the variances and frequencies of NAO variation at inter-monthly to interannual timescales are not affected much by the global warming. Warmed tropical oceans and intensified stratospheric polar vortex are the candidate mechanisms to interpret the NAO change in the global warming scenario.

Intensity of Hydrological Cycles in Warmer Climates

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The fact that the surface and tropospheric temperatures increase with increasing CO2 has been well documented by numerical model simulations; however, less agreement is found for the changes in the intensity of precipitation and the hydrological cycle. Here, starting from a simple energy budget argument and then utilizing a suite of numerical model experiments we demonstrate that while both the radiative heating by increasing CO2 and the resulting higher sea surface temperatures contribute to warm the atmosphere, they act against each other in changing the hydrological cycle. As a consequence, in a warmer climate forced by increasing CO2 the intensity of the hydrological cycle can be either more or less intense depending upon the degree of surface warming. The result explains in part why in the IPCC 2001 report the estimate of future hydrological cycle intensity by 19 CMIP2 models is much more uncertain than the estimate of the change in the surface and tropospheric temperature.

IMPACT OF URBANIZATION AND LAND USE ON CLIMATE CHANGE

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Anthropogenic activity can produce climate changes not only through the increase of greenhouse gases, commonly referred to as "global warming", but also from changes in land use, such as urbanization, agriculture, etc. Both types of changes tend to produce surface warming, so that their impacts have been very difficult to separate. The finding that atmospheric temperatures as measured by satellites and weather balloons have smaller warming trends than surface observations has been the subject of much discussion centered mostly on the quality of the data, but it could be partially explained by a predominance of land use effects over greenhouse warming near the surface. In the past, only the impact of urbanization on surface warming has been estimated by comparing observations in cities and suburbs with those in surrounding rural areas. Two methods used to classify meteorological stations into urban and rural are based on population data, and satellite measurements of night-light over the US, and their estimates of the impact of urbanization differ in magnitude (0.06C/century and 0.15C/century respectively). Here we subtract from the US surface temperature observations, the corresponding data derived from a 50-year Reanalysis that is sensitive to atmospheric but not to surface observations. We use the difference between these two trends to estimate the impact of urbanization and other land use changes on surface warming. The results indicate that maximum temperatures have declined somewhat (-0.02C/decade), and that most of this is explained by urban and other land use changes. On the other hand, land use changes account for only about 40% (+0.08C/decade) of the larger observed increase in minimum temperature, and for about half of the observed decrease in the diurnal temperature range. The impact on the observed mean surface temperature increase (0.27C/century) is larger than from previous estimates that only included urbanization.

Applications of TRMM and Other NASA Earth Science Enterprise Products

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Precipitation information is important to human activities. Accurate and timely information can greatly reduce loss of lives and property damages. Historical precipitation data can help researchers to understand seasonal and interannual variations.

The Tropical Rainfall Measuring Mission (TRMM) is a joint U.S.-Japan satellite mission to monitor tropical and subtropical (40 S - 40 N) precipitation and to estimate its associated latent heating. The TRMM satellite provides the first detailed and comprehensive dataset on the four dimensional distribution of rainfall and latent heating over vastly undersampled tropical and subtropical oceans and continents. The TRMM satellite was launched on November 27, 1997. TRMM data products, ranging from 3-hourly near-real-time to monthly, are archived at and distributed by the NASA Goddard Space Flight Center Earth Sciences (GES) DAAC.

Despite the relatively short history, the TRMM rainfall products have been widely used in many applications. For example, the monthly precipitation product has been used to monitor the severe drought in Afghanistan; the 3-hourly near-real-time precipitation product has been used to assess recent flood conditions in Mozambique and its neighboring countries.

The traditional way of obtaining information from data is, firstly, the researcher acquires a data product from a data provider, the product is processed and information is extracted through analysis and visualization. Data formatting, software capability, storage, etc. are obstacles to many application users. To allow users quick and easy access to precipitation information, the hydrology data support team (HDST) at the GES DAAC has developed a series of tools for accessing both the near-real-time and historical precipitation data and conduct simple analyses, such as, plotting time series and maps. The software are further developed to include sea surface winds from the NASA QuikSCAT, AVHRR NDVI, TOMS aerosols, TMI SST, etc. To detect climate changes/anomalies, it is necessary to have climate data for comparisons. Historical climate data, such as the Willmott's data set has also been included for climatology. We will present examples on application of these tools in support of research and decision-making, including the crop yield forecast of the UN program.

Linear Atmospheric Response to ENSO associated SST Meridional Gradient

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The El Nino events expand the warm SST and deep convection far into the Eastern equatorial Pacific region. On the other hand, the La Nina events retract westwards to result in even warmer and westwardly extended warm-pool. The regions exerting diabatic heating influence are therefore widely separated for the warm versus cold events and the responses in the extratropical atmosphere are speculated to be also far apart for the affected region. There are observations and model simulations supporting this scenario. Unfortunately, there are also observational and model results showing substantial disagreements: a near linear atmospheric response, showing co-location of the affected region, instead of a nonlinear response. This article attempts to shed further insights into this unsettled tropical-extratropical interaction and the relationship between them. In addition to resulting in widely separated diabatic heating regions as described above, most note-worthily is the ENSOs extreme events also result in near linear SST meridional differential in the NINO3.4 region where the interannual SST variability is most prominent. This near linear meridional temperature gradient, on seasonal and longer time scales, in turn results in near linear atmospheric responses in the upper-level tropics, subtropics, and extra-tropics. The observational and model simulation results of our current investigation provide strong support of this linear forcing mechanism instead of the nonlinear diabatic heating scenario.

Role of Particles in Controlling the Partitioning and Transport of Organic Contaminants in the Chesapeake Bay

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During the past decade, intensive studies have been conducted in the Chesapeake Bay to characterize organic contaminant partitioning to a variety of suspended and settling solids and to quantify the importance of sediment resuspension in supplying contaminant to the Bay's water column. Particle interceptor traps (sediment traps) were deployed in the water for 3-5 day periods to quantify the net flux of materials. The suspended particles were collected by high volume filtration and split into different size fractions. These samples were analyzed for hydrophobic organic contaminants (HOCs) including polychlorinated biphenyl (PCBs) and polycyclic aromatic hydrocarbons (PAHs) by using the gas chromatograph with electron capture detector and mass spectrometer, respectively. Particle settling fluxes varied seasonally with a strong resuspension signal apparent in traps deployed near the bottom. The magnitude of the sediment resuspension flux into the bottom waters demonstrates the dynamic nature of the Chesapeake Bay estuary, and also illustrates the variation of sediment-water interface averaged over ten fold higher than the surface water particle flux. Specific compound analysis of water particulates during the early spring suggests that the surface and bottom waters have substantially different particle populations. Organic contaminants are elevated in larger particles (>202 um), which are dominated by zooplankton, due to plankton grazing and bioaccumulation. HOC distribution coefficients (i.e. Kd, the ratio of the particle and dissolved concentrations) span several orders of magnitude, and are usually poorly correlated with their octanol-water partition coefficients (i.e. Kow). It is particularly intriguing that the observed partitioning behavior often differs considerably among the various particle characteristics. Overall, the organic contaminant incorporated into the settling particles burial in bottom sediments controls the cycling and long-term residence times in the Chesapeake Bay.

Effects of Wave-Current Interactions on Rip Currents

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When a wave breaks, wave momentum is transferred to generate nearshore currents in the surf zone. Two horizontal systems are of this origin: alongshore currents due to the across-shore variation of the alongshore momentum flux of obliquely incident waves, and rip currents due to the alongshore variation of the across-shore momentum flux of normally incident waves. For a long time it has been thought that currents are forced by waves but don't affect waves significantly, because currents are slow compared to the wave speed. This idea of one-way interaction of waves and currents has been reflected in many nearshore models for both systems.

The focus of this study is to examine the significance of wave-current interaction as it affects the subsequent development of rip currents. We consider the evolution of a weak rip current system which is due to a gentle alongshore variation in the topography. The dynamics of currents are described by the 2D shallow water equations which have a linear bottom friction and a wave forcing parameterization. The slow variations of the wave field, in terms of local wavenumber, frequency and wave amplitude, are described using the ray theory with the inclusion of energy dissipation due to breaking. We showed that neglecting the effects of currents on waves is not as justifiable for rip currents as it is for alongshore currents, even though the mathematical formulation for the two currents is similar. What has been overlooked is that the two currents are generated by different aspects of a wave property -wave radiation stress. The numerical results show that the offshore-directed rip currents interact with the incident waves to produce a negative feedback on the wave forcing, hence to reduce the strength and offshore extent of the currents. In particular, this feedback effect supersedes the bottom friction such that the circulation patterns become less sensitive to a change of the bottom friction parameterization. For unstable circulations, the onset of instabilities occurs at the feeder region close to the shore, rather than offshore at rip heads as predicted with no wave-current interaction. Instabilities are sensitive to the angle of wave incidence and the spacing of rip channels.

The Effects of Surfactants on Spilling Breakers

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Spilling breakers in the presence of two ambient surfactants (Triton X-100 and Sodium Dodecyl Sulfate) were studied experimentally. The waves were generated mechanically in a large tank (14.8 m long, 1.2 m wide and 1.0 m deep) and the temporal evolution of the wave crest profile was measured from high-speed movies. The dynamical properties of the water surface including the surface pressure isotherm, surface viscosity and surface elasticity were measured in-situ. With a relatively clean water surface, the breaking process begins with the formation of a round bulge on the wave crest and capillary waves that appear upstream of the leading edge (toe) of the bulge. As the flow becomes turbulent, the toe moves down the wave face and large-amplitude ripples grow between the toe and the crest. The changes in these profile structures as a function of the dynamical properties of the surfactants are discussed.

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Atmospheric wind retrievals from satellite soundings over the middle- and high-latitudes

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Detailed knowledge of the atmospheric motion over Antarctica is very important for understanding the Antarctic climate variability. Due to the sparseness of the radiosonde stations, current knowledge of the atmospheric wind structure over Antarctica depends crucially on the analysis/reanalysis systems. These model-based analyses have added to our understanding by helping to explain observed data. However, the models are ultimately only as good as the data available to them. Large errors have been found when these analysis/reanalysis winds are validated against independent radiosonde observations and satellite-derived cloud-drift and moisture winds.

This study attempts to derive the Antarctic atmospheric wind structure from satellite observations. Temperature soundings from the Television Infrared Observational Satellite (TIROS) Operational Vertical Sounder (TOVS) Pathfinder A dataset and a Special Sensor Microwave Imager (SSM/I) satellite-based surface wind field are used to derive the wind fields. The wind retrieval method used here is based on that developed by Zou and Van Woert (2002) in which the thermal wind derived from the satellite temperature soundings is added to the surface wind subject to the mass conservation constraint. In addition, a more generalized surface boundary condition is included in the retrieval algorithm so that it can retrieve the atmospheric wind over the plateau area such as the Antarctic continent. Results suggest that the satellite winds developed here exhibit some features similar to the satellite moisture winds when they are compared with each other at the assigned moisture wind level. However, the satellite-derived atmospheric wind structure shows significant differences from the NCEP/NCAR Rreanalysis-2 as well as other reanalysis winds over the Antarctic coast. The reasons for these differences will be discussed.

Improved Land Surface Emissivity Parameter in Land Surface Model and its Impacts

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The lack of observations of land surface emissivity (M-5^C) makes global climate model (GCM) conventionally set surface emissivity as constant, mostly as unit. This constant-emissivity assumption implies land surface as a blackbody and consequently induces errors in modeling the surface net radiation and their partitioning, especially over bare soil where emissivity is far from unit. Varying with surface type, soil moisture content, soil organic composition, vegetation density and structure, emissivity has evident seasonality and land-cover dependence. Accurate emissivity data are needed for model input in order to better simulate surface energy budget. In this work, we first converted EOS MODIS spectral emissivities into GCM-required broadband emissivity for use as surface boundary condition in a NCAR CAM/Community Land Model (CLM). NCAR model shows that better emissivity improves desert and semi-arid areas energy budget simulation because those areas have the maximum net longwave radiation and emissivity. Preliminary research studying desert of Arizona, USA indicates that after using the observed emissivity, simulated skin radiation and sensible and latent heat fluxes are improved by 1-5C and 10Wm-2, respectively.