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Abstracts

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Openning Session

Keynote Speakers:

Norden E. Huang, Title (TBD)

A01 Nonstationary analysis of Climate Variability

Conveners: Zhaohua Wu, COLA

Bin Wang, IAP, CAS

A0101 Amplitude-Frequency Modulated Annual Cycle: An Alternative Reference Frame for Climate Anomaly

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Anomaly is something which deviates from the standard or expected, and is an irregularity which may be difficult to explain using existing rules or theory. The definition of anomaly involves a reference frame from it the deviation can be determined. When a reference frame is changed, the corresponding anomaly is changed. As a consequence, the physical explanations for the anomaly may change as well.

In climate science, anomaly is often the deviation from its annual cycle. Traditionally, this annual cycle is assumed to be an exact repeat of itself year by year. However, such a repeatable annual cycle is assumed based on the perception of the annual evolution of the Earth's orbit and rotation. Such assumption is often wrong when the annual cycle of a climate variable is concerned and the nonlinearity of climate system is considered.

In this talk, we reexamine the reference frame for climate anomaly. We demonstrate that a more appropriate reference frame for climate anomaly should be the amplitude-frequency modulated annual cycle (MAC) that allows the change of annual cycle. We also introduce a new method to extract MAC in climate data.

With MAC, we can define an alternative copy of anomaly. Based on the anomaly with respect to MAC, we reexamine the physical mechanisms such as the "reemergence" mechanism and the apparent ENSO phase locking to annual cycle. We find that the "reemergence" mechanism may be better interpreted as a mechanism for explaining the change of annual cycle rather than for explaining the interannual to interdecadal persistence of SST anomaly. We also find that the apparent ENSO phase locking is largely due to the residual annual cycle (the difference of the MAC and the corresponding traditional annual cycle) contained in the traditional anomaly, and hence, can be interpreted as a scenario of a part of annual cycle phase locked to annual cycle itself. The delayed oscillator model of ENSO is used to verify the argument.

Two more examples of the implications of MAC to the methodology of climate study are also presented. We illustrate the problems of concepts such as "decadal variability of summer (winter) climate" in the climate study and suggest more logically consistent concepts of interannual or/and decadal variability of climate. We also point outthe drawbacks related to the stationary assumption in previous studies of extreme weather and climate and propose a non-stationary framework to study extreme weather and climate.

The concept of amplitude-frequency modulated annual cycle, a method to extract it, and the implications of amplitude-frequency modulated annual cycle in climate study presented in this study constitute our efforts to construct an alternative framework for climate study, especially for climate variability of interannual to decadal timescales.

A0102 Ensemble mean dynamics and noised-induced destabilization (Invited)

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Various phenomena in the atmosphere and ocean systems involve feedbacks and interactions between slow and fast processes. For instance, the two-way interaction between synoptic eddy and low-frequency flow (SELF), which we refer to as the SELF-feedback, plays an important role in the low-frequency variability of the atmospheric circulation. The interaction between ENSO and MJO and westerly wind bursts (WWB) can have great impact on the ENSO dynamics. These interactions may be modeled by linear dynamics system with state dependent noise or multiplicative noise. A new framework is proposed to study the ensemble mean dynamics through a second closure. A new kind of general instability, referred as to noise-induced instability for the slow subsystem is found and it can be captured by the ensemble–mean dynamics. Examples are shown that this kind of instability may play an important role in the dynamics of ENSO and NAO.

A0103 The Day after Tomorrow: global impacts of Atlantic thermohaline shutdown (Invited)

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We explore the adjustment of the global climate to an abrupt slowdown of the Atlantic Meridional Overturning Circulation (AMOC) in a coupled general circulation model, with particular focus on global energetics, and teleconnection mechanisms to the tropics. The slowdown is induced by a sudden freshwater perturbation in the North Atlantic. Reduction in the AMOC decreases northward ocean heat transport and increases North Atlantic sea ice cover, leading to cooling in the northern high latitudes. This cooling results in a local reduction to the top of atmosphere (TOA) radiative heat loss and an increase in northward atmospheric heat transport. Energy for the increased northward atmospheric heat transports comes from a combination of increased downward radiative flux at the TOA in the southern tropics and anomalous heating from the ocean in the northern tropics, both consequences of the southward shift in the Intertropical Convergence Zone. Hence, viewed in the energetics framework, the atmospheric response to an AMOC slowdown extends throughout the Northern Hemisphere and into the tropics, and suggests an intimate coupling between the two regions.

Detailed examination of the transient adjustment in the north Atlantic reveals clues on teleconnection mechanisms to the tropical climate. The initial adjustment in the midlatitudes is a southward shift of the subpolar-subtropical gyre boundary that anomalously cools the midlatitude oceans around 35-40°N. Teleconnection to the tropical north Atlantic is dominated a wind-evaporation-SST mechanism (WES) that drives stronger subtropical trades and cools the tropical north Atlantic, and resulting in a cross-equatorial flow and southward ITCZ displacement. However, ocean dynamical feedbacks to the strengthened trades – in particular an anomalous geostrophic current that advects colder midlatitude waters into the subtropical surface ocean – complicates the response from solely thermodynamic considerations. Ocean baroclinic adjustment to reduced deep water formation in the North Atlantic increases the volume of surface waters in the tropical Atlantic and retards the cooling effect by the atmosphere in the tropical north Atlantic, but otherwise appears to have relatively small effect on the surface climate. Our results thus highlight the central role of atmospheric-surface ocean mechanisms in high latitude teleconnections to the tropical marine climate.

A0104 Diurnal variation of atmospheric precipitable water over the globe from ground-based GPS measurements

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A global, 10-year (1997-2006), 2-hourly data set of atmospheric precipitable water (PW) has been produced from ground-based Global Positioning System (GPS) measurements of zenith path delay (ZPD) and will be continually updated. The PW data are available every two hours at about 350 International GPS Service (IGS) ground stations from 1997 to 2006. Global PW diurnal variations are studied using the GPS dataset. The PW diurnal cycle has a magnitude of 0.4-1 mm over most of stations in summer and is weaker in other seasons. The diurnal cycle peaks around noon in winter and in late afternoon in summer and fall, and has wide distributions (from noon to early morning) in spring. Diurnal variations of PW are studied at different regions for four seasons. The PW diurnal cycle in Europe that has the densest GPS network (110 stations) is strongest in summer with amplitude of ~0.6 mm and is slightly weaker in fall and winter, but is negligible in spring. The PW in Europe peaks at noon, late afternoon (1600-1800 LST) and early evening (2000-2200 LST) in winter, fall and summer, respectively. The PW diurnal cycle in 30°-70°S, Northern Hemisphere Mountains and Darwin has similar phase in four seasons but different amplitude. More and detailed analyses will be done in the future to document and understand PW diurnal variations by co-relating with the diurnal cycle of other variables, such as precipitation and surface temperature.

A0104 Ensemble Empirical Mode Decomposition with Application to the Pollutant Data

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Our research is to develop the HHT methodology, and then apply the improved HHT method for climate and other related studies.

Abstract

Ensemble Empirical Mode Decomposition (EEMD) is used to analyze the nonlinear and nonstationary ozone concentration data. Our approach consists of shifting an ensemble of white noise-added signal and treats the mean as the final true result. The ozone concentration of Wan-Li station in Taiwan is used to illustrate the power of this new method. Our results show that, at an urban station, the ozone concentration fluctuation has various cycles that include semi-diurnal, diurnal, weekly, and seasonal time scales. These results serve to demonstrate the anthropogenic origin of the pollutant.

Submit to: A01 Nonstationary analysis of Climate Variability
Presentation: Oral

A02 Tropical Ocean and Atmosphere

Conveners: Dalin Zhang, UMD

Song Yang, NOAA

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A0201 Spring rainfall variability in Taiwan and ENSO

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The study aims at investigating the complex relationships between spring (February-April) rainfall in northern Taiwan and the major El Niño-Southern Oscillation (ENSO) event. Analysis results disclose four major relationship types during 1970-2003: El Niño-anomalous wet (EN-w) type, La Niña-anomalous dry (LN-d) type, El Niño-anomalous dry (EN-d) type, and La Niña-anomalous wet (LN-w) type. The EN-w and LN-d (EN-d and LN-w) types show a positive (negative) correlation between the ENSO-related sea surface temperature (SST) and spring rainfall anomalies, and have total 9 (5) member years. The ENSO-spring rainfall relationship is dominated by the positive correlation.

Primary difference in ENSO between the positive-correlation and negative-correlation types turns out to be a zonal displacement of anomalous SST centers in the tropical eastern Pacific. The positive-correlation types exhibit major SST anomalies centering near or to the east of 150^0W, which induce an anomalous low-level anticyclone (cyclone) in the Philippine Sea (southeast of Taiwan) during the El Niño (La Niña) event. The outer follows of this anomalous anticyclone (cyclone) enhance (suppress) moisture transport from the South Chin Sea into Taiwan, resulting in its increased (decreased) spring rainfall. For the negative-correlation types, their major anomalous SST centers displace westward to the west of 150^0W. Subsequently, an anomalous low-level anticyclone (cyclone) occurs over Asia (northwest of Taiwan) during the El Niño (La Niña) event. This anomalous anticyclone (cyclone) brings anomalous dry (moist) air into Taiwan, leading to its suppressed (enhanced) spring rainfall.

This study also finds that the variability of the Pacific subtropical high (PSH) over the western Pacific is closely connected with these four major relationship types. The EN-d (LN-w) type of the negative-correlation category concurs with a moderate westward expansion (a moderate eastward retreat) in the western-Pacific section of the PSH, while the EN-w (LN-d) type of the positive-correlation category is concurrent with a southward displacement (a strong eastward retreat) of the PSH.

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Section: Air-Sea-Land Interactions (104)
Preferred presentation: oral

A0202 Significant Change of Extratropical Natural Variability Associated with Tropical ENSO Anomaly

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It is well documented that the extra-tropical atmosphere responds prominently to heating anomalies in the Tropics. When the anomalous tropical forcing is El Nino (La Nina)–like, the North Pacific jet stream strengthens (weakens) and extends eastward and slightly southward (retracts backward). Accompanying this change is below (above) normal northeastern Pacific geopotential heights. There is no controversy with respect to the existence of an ENSO influence in the northeast Pacific. What is not universally agreed upon is the effect of ENSO upon the natural variability over the ENSO-sensitive region of the northeast Pacific.

The natural variability over the North Pacific, where the influence of tropical El Nino–Southern Oscillation (ENSO) events is substantial, is examined to determine whether there is a large change owing to a difference in the ENSO forcing anomaly. The hindcast ensemble runs of the Seasonal Forecast Model of the National Centers for Environmental Prediction are analyzed for this assessment. Four sets of 10-member ensemble hindcasts out to 7 months with T42 horizontal resolution and another four sets with T62 resolution are examined in detail. The results consistently indicate that the natural variability, on both seasonal and monthly time scales, is significantly smaller during El Nino boreal winters than during La Nina boreal winters. The implication is that the predictability on both seasonal and monthly time scales over the North Pacific is potentially higher during El Nino winters than during La Nina winters.

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A0203 Interactive Prediction-Observation System to Possibly Increase Predictability of Heavy Rain Events by Using Mesoscale Ensemble: a Simulation Study

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The current operational numerical weather prediction is a one-way system, i.e. observation impacts a model forecast but no feedback from the model forecast to impact observation. This one-way practice is not sounding both scientifically and economically. Therefore, interactive (two-way) prediction-observation system is one of the THORPEX goals, which is usually referred to adaptive or targeted observation. Targeted observation is now in its infant stage. The current limited research efforts are mainly focusing on cold season, large-scale pressure system such as cyclone and trough which has relatively higher predictability but not on notoriously less predictable precipitation especially the warm season, mesoscale convection-related heavy rain events.

This research proposes an Ensemble-Based Interactive Targeting (E-BIT) method. The method is easy to apply, target/forecast interest-oriented and subjective or human interactive based on a real-time mesoscale ensemble prediction system (MEPS). The MEPS could first quantify the uncertainty of the targeted weather system to see if special treatment is needed in observation and analysis. If large uncertainty is found associated with the target, the MEPS could also be used to identify the possible source areas or sources causing the large uncertainty. Accordingly, special adaptive observation or treatment could be carried out to possibly reduce the uncertainty associated with the target system. A simulation study was performed to two precipitation events (one convective and another stratiform) with a 10-member, bred vector-based mesoscale ensemble using the NCEP Regional Spectral Model (RSM) to prove the concept of this E-BIT method.

A0204 Evaluating the Impacts of Global Warming and Natural Cycle on the Atlantic Hurricane Activity

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ABSTRACT: The year 2005 was a record-breaking year for Atlantic Hurricanes with 27 named storms and 15 hurricanes. However, the present year (2006) has been a relatively quiet season in terms of hurricane activity. The exact cause of the heightened Atlantic hurricane activity in recent years associated with natural climate variability or global warming is still a controversial issue. The problem may lie in the definition of traditional Atlantic Multidecadal Oscillation (AMO) index, which contains the contribution from the global mean. Based on the fact that the southern hemisphere (SH) is almost free of the AMO, we propose a corrected AMO index merging its contribution with those from other natural cycles, removing from the main development region (MDR) sea surface temperature (SST) and obtaining a residual term, which should mainly contain the global warming effect. Statistical analysis shows that the natural variability has about ~60 year cycle,with no evident cycle in the global warming residual. During recent three decades, increased global warming trends coincided with the upward phase of natural cycles and increased SST appreciably and made the SST effects become dominant. Another issue may be the time scale, on an intra-decadal/decadal scale, global warming is found to significantly influence the duration of intense hurricane stages, which is on the rise in recent years. However, the short-term (annual) variations in the Atlantic hurricane activity is still partially linked to natural climate variability.

A0205 Simulations and Seasonal-Interannual Predictions of the Asian Summer Monsoon in NCEP's Operational Climate Forecast System

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Analysis of the retrospective ensemble predictions (hindcasts) of NCEP Climate Forecast System (CFS) indicates that the model successfully simulates many major features of the Asian summer monsoon including the climatology and interannual variability of major precipitation centers and atmospheric circulation systems. The model captures the onset of monsoon better than the retreat of the monsoon, and it simulates the East-Southeast Asian monsoon more realistically than the South Asian monsoon. The CFS predicts the major anomalous patterns of monsoon precipitation several months in advance. It also depicts the interactive oceanic-atmospheric processes associated with the precipitation anomalies reasonably well in different time leads. Overall, the skill of monsoon prediction by CFS mainly comes from the impact of El Niño/Southern Oscillation (ENSO), especially during the onset years of ENSO.

The CFS produces weaker-than-observed large-scale monsoon circulation, due partially to the cold bias over the Asian continent. It tends to overemphasize the relationship between ENSO and the Asian monsoon, as well as the impact of ENSO on the Asian and Indo-Pacific climate. A higher-resolution version of CFS captures the climatology and variability of Asian monsoon more realistically. The largest improvement occurs to the simulations of precipitation near the Tibetan Plateau and over the tropical Indian Ocean associated with the zonal dipole mode. The analysis suggests that the NCEP's next operational model may perform better in simulating and predicting the climate over Asia and the Indo-Pacific Oceans.

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A0206 Observation and Simulation of Summertime High-Frequency Activities in Relation to the Intra-Seasonal Oscillation in the Northwestern Pacific Ocean

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Abstract

This study performs observational analysis and model simulation of the intra-seasonal oscillation (ISO) and high-frequency variations (or typhoon activities) over the northwestern Pacific Ocean in June 2004. Observational analysis is based on the NCEP-NCAR Reanalysis 2 (R2) data, and the MM5 model with a grid size of 30 km is used to conduct a 37-day simulation from 25 May to 2 July 2004 which includes a pronounced ISO event. The ISO signal is specified into the MM5's initial and boundary conditions by nudging the R2 reanalysis wind field with a 20-day low-pass filter. The high-frequency variations (HFVs) and typhoon activities are then generated by MM5's internal dynamics.

It is found that the simulated HVFs are highly sensitive to the magnitude of the nudging coefficient, which serves as a control of the specified ISO strength. Two strong nudging (with an e-folding time scale of 1 day) results in too weak HVFs, but too weak nudging (with an e-folding time scale of 20 days) produces too strong HVFs which are significantly different from the R2 reanalysis. With appropriate nudging of an e-folding time scale of 7 days, the monthly MM5 simulation can capture the HVFs and typhoon genesis which are in close agreement with the R2 reanalysis.

Several physical mechanisms have been proposed to explain the tropical cyclone genesis over the northwestern Pacific Ocean: Rossby wave energy dispersion, synoptic-scale wave train, and wave accumulation in the confluent monsoon flows. The proper simulated HVFs and typhoon activities will be used to diagnose the dominant mechanism of tropical cyclone genesis, and investigate the interaction between the typhoon activities and the background ISO in the northwestern Pacific Ocean in June 2004.

A0207 Associated Large-scale Characteristics in Stratified Tropical Cyclone Dataset

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Abstract

Tropical cyclone intensity forecasting is still a challenging problem, and the Statistical Hurricane Intensity Prediction Scheme (SHIPS) model based on multivariate statistical regression model is the best operational intensity forecasting model. In this work, the association rule discovery algorithm is applied on the stratified input data for the SHIPS model to shed some light on the roles of multiple associated physical processes in tropical cyclone development at various intensity scales. The association rule algorithm has identified strong connections among multiple attributes used in SHIPS, which basically describe the same physical process via different methods. Analysis on stratified data shows that a faster northwards storm motion is favored for intensifying tropical storms than for intensifying hurricanes. Intensifying tropical storms prefer a higher convergence in the upper atmosphere than weakening tropical storms, while intensifying hurricanes prefer lower convergence values. The persistence of the intensity and the vertical shear in the atmosphere are the two most important factors for the development of a tropical cyclone except for category 4 hurricanes where the northward storm motion and the higher upper-level convergence dominate in weakening hurricanes.

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A0208 A mechanism for the formation of concentric eyewall in hurricanes

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ABSTRACT

The concentric eyewall is often observed in intense hurricanes. The small inner eyewall could be replaced by an outer one. Such eyewall replacement may result in a rapid change in intensity. It is still not clear how the concentric eyewall forms and how it replaces the inner eyewall.

We studied this problem using a simple barotropic model and also the full-physics model MM5. Starting from idealized conditions, it was shown that a double eyewall structure forms in a hurricane-like vortex in both models. There is also clear evidence that vortex Rossby waves were excited. The mechanism for double eyewall formation was then analyzed using the empirical normal mode (ENM) method. The results indicated that wave-mean flow interaction near the critical radius may offer an explanation for the formation of the concentric eyewall.

A0209 Advances in Understanding the Interaction between Tropical Intra-Seasonal Oscillation and underlying Ocean

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Tropical Intra-Seasonal Oscillation (TISO) is a prominent climate variability originated from the Indo-Pacific warm-pool region. Its recurrent nature with a period of 20-90-day offers an opportunity to bridge the gap between weather forecast (~1 week) and climate outlook (~1 month). The TISO propagates northward to regulate the wet-and-dry spells of Asian Summer Monsoon and moves eastward to affect the initiation and growth of the El Nino. Through tropical-extratropical teleconnection, it also impacts the rainfall variability over the North America. The TISO has traditionally been viewed as an internal atmospheric phenomenon. A long debated issue is ***in what degree the atmosphere-ocean coupling contributes to the TISO***.

Significant SST fluctuations on the intraseasonal timescales were observed during FGGE and MONEX periods in late 70th and the possible contribution of active air-sea coupling on the development of TISO was proposed then. The TOGA-COARE campaign in early 90th renewed this issue by discovering coherent SST variations associated with two strong TISO events in the equatorial western Pacific. Analysis of oceanic mixed-layer heat budget and numerical modeling experiments demonstrated that the observed intraseasonal SST anomalies are largely explained by the surface heat and momentum flux changes driven by the eastward-moving TISO. But whether the TISO-forced SST anomalies actively feed back to the TISO or just a passive oceanic response is still an unanswered question. Since late 90th, the successful launch of Microwave Radiometers aboard the TRMM satellite has provided an unprecedented high-quality SST dataset, which reveals that coherent SST variability is a unanimous signature associated with both boreal-summer and winter TISO.

A series of modeling and observational studies recently have been conducted to better understand the interaction between TISO and underlying ocean. The questions we have addressed include: (i) Are there characteristic differences between the TISO simulated by an atmosphere-ocean coupled model and by an atmosphere-only model? (ii) Could are-sea coupling impact the predictability of the TISO? (iii) What are the physical processes through which SST feeds back to the TISO? Our major findings have been summarized in the following. First, two different solutions of TISO exist, respectively, in the coupled model and atmosphere-only model; The TISO simulated in the coupled model is more realistic in terms of the intensity and the rainfall-SST relationship relative to that in the atmosphere-only model. Second, the active air-sea coupling significantly extends the predictability of TISO over the entire Asian-western Pacific region by about one week. Finally, SST feeds back to the TISO through moistening/warming up the atmospheric boundary layer and enhancing surface convergence ahead of the TISO-related deep convection. The atmospheric mean state (e.g., easterly shear) acts as an “amplifier” to further enhance the positive feedback.

A0210 Source Regions of Intraseasonal Oscillations in the Tropical Atmosphere

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Since the discovery of the tropical intraseasonal oscillations (ISO) in the early 1970s many studies have postulated and examined various mechanisms for the ISO. The fact that these mechanisms can explain many different aspects of observed ISO also suggests that multiple mechanisms may have existed and functioned simultaneously, and likely interacted, in development of ISO. What specific mechanisms are working and interacting to generate individual ISO, and under what conditions? What are the characteristics, e.g., wavelength and phase speed, of the waves generated from the different mechanisms and interactions? To address these questions requires knowing where the ISO are generated, because in such source regions these mechanisms and interactions are most distinctive and may be detected. By gathering and analyzing the data in the source regions the information that may lead to the answers to these questions can be extracted. This study proposes a fixed beamformer method. After being tested, it is applied to the ECMWF interpolated data grids as its sensor arrays to identify ISO source regions in the tropical Indian and Pacific Ocean region. Major results show three ISO source regions in the tropical Indian Ocean, the western tropical Pacific and the eastern tropical Pacific for the ISO events in 1974-2002, albeit thesource in the eastern ropical Pacific is much weaker than the other two and becomes more active during El Nino years. These sources could be active simultaneously and produce visually continuous eastward propagation ISO. In some situations the propagating signals were strongly strengthened over the downstream ISO source regions, a new explanation of the observed chains of embedded centers of strong wind and convection anomalies in most propagation ISO. When some or all these sources produced their own strong ISO in other situations the local ISO became less cohesive with each other and yielded disconnected quasi-stationary ISO. While improving understanding of the observed structures and differences of the ISO, these results show that different ISO could result from different mechanisms that play more important roles in different dynamic and thermodynamic conditions at different source regions. Understanding these conditions and ISO sources could lead to improving predictions of the tropical ISO.

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A0211 Rapid Filamentation Zone in A Numerically Simulated Tropical Cyclone

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In a recent study, Rozoff et al. (2006) proposed a mechanism to explain the weak-echo annulus (or moat) outside of the primary eyewall of a tropical cyclone observed on radar images. By this mechanism, the moat is controlled by the strain-dominated flow outside the radius of maximum wind in which all scalars are filamented and deep convection is supposedly highly distorted and even suppressed. This strain-dominated region is defined as the rapid filamentation zone wherein the filamentation time is shorter than the overturning time of deep convection. An attempt has been made in this study to test the hypothesis in a full physics tropical cyclone model under idealized conditions and to extend the concept to the study of the inner core dynamics of tropical cyclones. The foci of this paper are the evolution of the rapid filamentation zone during the storm intensification, the potential roles of rapid filamentation in organization of fine-scale, inner spiral rainbands and the damping of high azimuthal wavenumber asymmetries in the tropical cyclone inner core.

Our results show that instead of suppressing deep convection, the strain flow in the rapid filamentation zone outside of the elevated potential vorticity core provides a favorable environment for the organized, fine-scale, inner spiral rainbands. Although the moat in the simulated tropical cyclone is in the rapid filamentation zone, it is mainly controlled by the subsidence associated with the overturning flow from eyewall convection and downdrafts from the anvil stratiform precipitation outside of the eyewall. It is thus suggested that rapid filamentation may play a secondary role in the formation of the moat in tropical cyclones. Although the deformation field is determined primarily by the structure of the tropical cyclone, it can have a considerable effect on the evolution of the storm. Because of strong straining deformation, asymmetries with azimuthal wavenumber > 4 are found to be damped effectively in the rapid filamentation zone. The filamentation time thus provides a quantitative measure of the stabilization and axisymmetrization of high wavenumber asymmetries in the inner core by shearing deformation and filamentation.

A0212 Tropical cyclogenesis from the ITCZ

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A0213 Radiative effect of cirrus with different optical properties over the Tropics

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The radiative effects of cirrus clouds are evaluated based on observations extending over a period of six years (2000–2005) from the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Clouds and the Earth's Radiant Energy System (CERES) over the Tropics (25°S−25°N). The cloud radiative effect (CRE) shows a positive sign for optically thin cirrus (total-column cloud optical depth: $\tau < 10$) and a negative sign for thicker clouds ($\tau \geq 10$), regardless of the region and season. Since a considerable portion of tropical ice clouds comprises thin cirrus clouds (>60%), their net effective CRE (net CRE × cloud amount) is roughly twice as strong as that of thicker clouds; the modulation of the net radiative flux by variations in thin cirrus (particularly with $1 \leq \tau < 9$) dominates—up to 15 W m^{-2}—that by thicker clouds. These results suggest that thin cirrus has a significant effect on the tropical energy balance.

A0214 Recent decadal change in the western North Pacific summer monsoon–ENSO relationship and its impact on tropical cyclone activity

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Abstract

The present study has investigated the decadal climate shift in the relationship between the western North Pacific (WNP) summer monsoon (WNPSM) and El Niño–Southern Oscillation (ENSO) around 1993–1994 and its impact on the WNP tropical cyclone (TC) activity. The correlation coefficient between the WNPSM index averaged over June–August (JJA(0)) and the Southern Oscillation Index (SOI, negative values are correspond to warm phase of the ENSO) during previous winter (D(–1)JF(0)) is about 0.5 for the period 1979–2005. That is, the cold (warm) phase of the ENSO tends to occur during previous winter when the following WNPSM is strong (weak). However, the simultaneous correlation during JJA(0) is –0.39, which implies that the phase of the ENSO is possibly reversed in the previous spring. Interestingly, it is found that there exists a remarkable decadal change of the contemporary relationship between WNPSM and ENSO. The 1-month lead, simultaneous, and 1-month lag correlations during JJA(0) are 0.14, 0.05, and –0.21, respectively, in 1979–1993 (D1) and –0.71, –0.82, and –0.79, respectively, in 1994–2005 (D2). This considerable change implies the ENSO-related transition of the sea surface temperature (SST) primarily occurred during summer (previous spring) in D1 (D2), indicating that the ENSO-related SST transition became faster in D2 compared to in D1. This also demonstrates that the atmosphere–ocean state has been changed to biennial mode from 4–5 years ENSO-related mode. From the SST record, the SST tended to be already warm in JJA(0) in the strong WNPSM years in D2.

With regard to this obvious decadal change, the TC activity has been systematically changed since the mid-1990s. We found that a prominent increase of the correlation between the TC genesis frequency and the WNPSM in D2, compared to in D1 (0.22 for D1 vs. 0.89 for D2). Also, the TC occurrence frequency which is defined as the number of recorded 6-hourly TC center locations in each 5°×5° grid box shows a significant difference between D1 and D2. In D2, the TC occurrence frequency increases east of 140°E during strong WNPSM season, like the variability associated with an El Niño. This may be due to the simultaneous fluctuation of the WNPSM and the ENSO. The increase of the TC activity east of 140°E results in the concurrent increase in Japan and the North Pacific basin. The WNPSM-related anomalous cyclone expands to the northeast in D2, compared to in D1. The northeastern fringe of this circulation may exert anomalous southeasterlies to the midlatitude westerly region. This recent change in the steering flows may cause the increase of the TC activity over Japan.

A0215 A Cloud-resolving Numerical Simulation of the Formation of Typhoon Nari(2001)

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Abstract

In this study, the formation of Typhoon Nari(2001) are explicitly simulated using the Penn State-NCAR nonhydrostatic mesoscale model (MM5v3.6) on the tow-way interactive, quadruply nested grid (36/12/4/1.33km). The model is initialized at 1200 UTC 5 September 2001 with ECWMF T106 analysis enhanced by rawinsondes, surface observations, and daily Sea Surface Temperature(SST) archived at NCAR. A 96-h intergration ending at 12:00UTC 9 September 2001 was made, which covers the stages during that Nari developed from a tropical cyclone to typhoon.

As verified against satellite image and the best analysis, the model captures reasonable well the evolution of the structure of the storm, in particular, the model reproduces reasonably well the time evolution of the minimum surface pressure and the first half of the looping track. Further examination shows that widespread convective hot towers(VHTs) develop sporadically at Nari's periphery during its incipient stage. More deals about the role of VHTs in tropical cyclogenesis will be discussed.

A03 Aerosol, Trace Gases and Climate

Conveners: Shi-Keng Yang, NOAA

Guangyu Shi, IAP, CAS

A0301 Cohesive NOAA SBUV/(2) Total Ozone Dataset and Application to Trend Analysis

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Abstract:
Utilizing measurements from the operational NOAA polar orbiting satellites, the Climate Prediction Center has compiled a long term SBUV/2 Total Ozone dataset. The compilation is aimed to achieve the level of quality suitable for trend analysis. Adjustments based on satellite equatorial crossing times, inter-satellite biases are implemented for cohesiveness. The SBUV/2 data set is compared with Dobson and Brewer observations. This zonal dataset spans from 1979 through 2006.

One of the significant questions that exist with respect to the atmospheric total ozone is whether or not the atmosphere is on the path to "ozone recovery" due to the implementation of the Montreal Protocols and its amendments. While a plot of the monthly global average total ozone indicates a relative increase since about 1993, the actual answer to the above is made more complicated by the impact of the eruption of Mt. Pinatubo in 1991which resulted in the ozone minimum in 1992-1993

We use a statistical trend algorithm to analyze the SBUV(/2) data. This hockey-stick algorithm allows for a change in trend and examines the effect of the Mt. Pinatubo eruption on the computations. We examine the timing of the inflection points to delineate the confidence one can ascribe to the "ozone-change" computations in both a physical as well as a statistical sense.

A0302 Saharan dust storm detection using multiple sensors

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Each year, thousands of tons of dust from the Saharan desert are blown into the Atlantic Ocean. Many studies have shown the significant impacts of Saharan dust on the weather and climate systems of tropical Atlantic Ocean. It has been found that Saharan dust storm may affect the genesis and intensity of hurricanes over the Atlantic Ocean. So it is important to monitor Saharan dust and estimate its properties. Satellite remote sensing has becoming the primary approach for dust storm detection. Many methods have been proposed to discriminate dust from cloud and surface features. In this study, approaches for detecting Saharan dust storm and estimating the intensity are evaluated by using multiple sensors, including MODIS, AIRS, OMI and CALIPSO. MODIS and AIRS datasets for major Saharan dust events during the past years, and OMI and CALIPSO datasets for recent dust events, are collected and analyzed. The combination of multi-sensor measurements shows good potential for estimating the intensity of Saharan dust storms at both day-time and nigh-time, and is very helpful to study the impacts of Saharan dust storms on regional weather and climate systems.

A0303 Near Real Time SO2 / Volcano Monitoring Using High Spectral Resolution Satellite Data

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Detecting SO2/Volcano eruptions in a timely manner is very important for reducing the risk of the aircraft and hazard control. Advanced sounders with high spectral resolution onboard the new generation of environment satellites provide the opportunity to improve the temperature, moisture profile retrievals, as well as the trace gas products. Launched on May 4, 2002 on the AQUA-EOS satellite, the Atmospheric Infrared Sounder (AIRS) (Aumann et al. 2003) is the first of a new generation of high spectral resolution infrared sounder having 2378 channels measuring outgoing radiance between 650 cm-1 and 2675 cm-^{1}. Various trace gas products have been derived from AIRS observations. In this paper we will illustrate the near real SO2/volcano monitoring system that has been setup in NOAA/NESDIS/STAR. Based on the SO2 signatures of the AIRS observation, this system detects the events of SO2 and possible volcano eruptions, automatically send out email messages to the end users, and post the corresponding images and data to the website. The system, case studies and global distributions of possible volcano eruptions will be described. Some comparisons with other SO2 products such as those derived from TOMS and OMI will also be presented. Potential future improvements of the system will be discussed. Same system can be developed for other advanced sounders, such as IASI and CrIS.

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A0304 Effects of Aerosols on Tropical Convective Cloud Systems Simulated by a Cloud-Resolving Model

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Abstract:

A cloud-resolving model (CRM), which is implemented with an advanced double-moment microphysics scheme and a state-of-the-art radiative transfer scheme, is used to simulate tropical deep convective cloud objects (DCCO) identified from a Clouds and the Earth's Radiant Energy System (CERES) data product. A tropical deep convective cloud object is defined as a contiguous patch of cloudy regions that is composed of individual CERES footprints which are overcast, have optical depth and cloud top height greater than 10 and 10 km, respectively, and are located between 25^{o}S and 25^{o}N.

Two ensembles of simulations, utilizing different aerosol properties, are performed for 68 DCCO observed during March 1998 (strong El Niño) over the tropical Pacific. In one ensemble, an observed mean size distribution of aerosols is used. In the other, the number concentration of aerosols is increased by an amount based on observational evidence.

Cloud physical properties, such as precipitation, outgoing longwave radiation and albedo at the TOA, vertically integrated hydrometeor mixing ratios, as well as cloud-scale dynamics, are analyzed in terms of their summary histograms for each ensemble. The differences between two summary histograms are quantitatively represented by Euclidean distance. A bootstrap procedure is then applied to determine whether the difference between two summary histograms is statistically significant. More detailed results will be presented at the meeting.

A0305 A New Model of Bi-directional Ammonia Exchange between the Atmosphere and Biosphere

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Abstract

A new multi-layer canopy resistance model of bi-directional NH_3 exchange is presented. This new model, which is based on the Multi-Layer BioChemical deposition (MLBC) model (Wu et al., 2003a and 2003b), incorporates a parameterization for the ammonia stomatal compensation point which is theoretically derived to consider the effects of leaf temperature and apoplastic concentrations of NH_4^+ and H^+. The new ammonia stomatal compensation point scheme accounts for the effects (i.e., feedback) of NH_3 emission and deposition on the dynamics of apoplast $[NH_4^+]$ and $[H^+]$. The new model is evaluated against bidirectional NH_3 fluxes measured over fertilized soybeans. Driven by the feedback of NH_3 emission and deposition, modeled apoplastic $[NH_4^+]$ and $[H^+]$ have significant diurnal variation. When the ammonia stomatal compensation point is included in the model, the general patterns of observed deposition and emission are reproduced. Mean difference of modeled NH_3 fluxes between the runs with and without the feedback mechanism is significant at the 95% confidence interval. Model predictive capability is improved with using a dynamic stomatal compensation point over using a constant stomatal compensation point. While the stomatal flux is shown to be an important process in the regulation of canopy-scale fluxes, it appears that exchange with leaf surface water and soil may also be important.

A0306 Aerosol-cloud-precipitation interactions in the Pearl River Delta

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Aerosols are part of the climate system that affects both the hydrological cycle and energy cycles. The adverse effects of anthropogenic aerosol on human health have been convincingly demonstrated. The aerosol impact on climate is not so clearly established. Their presence is crucial for the formation of clouds and hence precipitation type, amount and processes. Aerosols associated with burning of biomass have been shown to inhibit rain formation. Aerosols also reflect and absorb shortwave radiations, causing surface cooling and upper level heating, thus contributing to stabilize the atmosphere. Because of their shortwave absorption, they act as elevated atmospheric heat sources and induce low level convergence, and hence possibly early onset of the monsoon system.

The Pearl River Delta (PRD) has experience tremendous growth in recent years and the emission of pollution has stress the environment. The PRD is situated in a cloudy and rain prone area, hence the presence of aerosol will impact the cloud and precipitation processes. The Institute of Space and Earth Information Science is assembling remote sensing and ground-based data sets to examine the aerosol-cloud-precipitation interactions in the PRD. Preliminary results show an increase of aerosol loading derived from the Moderate Resolution Interferometer Spectroradiometer (MODIS) in the PRD region for the period 2000-present. This increase is modulated by a strong seasonal cycle, with an amplitude that is almost as large as the mean. This increase in accompanied by a decreasing trend of the water phase of the effective cloud radius. Analyses of rain types derived from TRMM Precipitation Radar and TRMM Microwave Imager show a small dip in this region which may be related to the change in the covective/stratiform partitioning. Results on the analysis of variability and trends in rain frequency and rain types will be presented and their association with aerosol variations discussed.

I01 Air-Sea Flux I, II

Conveners: Menglin Jin, UMD

Chung-Lin Shie, NASA GSFC

I0101 Reviving the Production of Goddard Satellite-based Surface Turbulent Fluxes (GSSTF) Dataset

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We propose to resume processing and to reprocess the Goddard Satellite-based SurfaceTurbulent Fluxes (GSSTF) dataset. This dataset has been widely used by the scientific community for global energy and water cycle research, and regional and short period data analysis since its official release in 2000/2001. Accurate sea surface fluxes measurements are crucial to understanding the global water and energy cycles. The oceanic evaporation that is a major component of the global oceanic fresh water flux is particularly useful to predicting oceanic circulation and transport. Remote sensing is a valuable tool for global monitoring of these flux measurements. The GSSTF algorithm has been developed and applied to remote sensing research and applications. The latest version (version 2) of GSSTF covers the data period starting from July 1987 and ended in December 2000.

The objective of this project is to continually produce a uniform data set of sea surface turbulent fluxes derived from remote sensing data and analysis that have been and continue to be useful for global energy and water flux research and applications. Our approach is first to update the algorithm codes with bug fixes found over the years and reported by users and developers. The data set will then be reprocessed and brought up-to-date using improved input datasets. The input datasets include a recently released NCEP sea surface temperature analysis, a uniform (across satellites) surface wind and microwave brightness temperature data from the Special Sensor Microwave Imagers (SSM/I) on board the Defense Meteorological Satellite Program (DMSP) satellites produced by the Wentz of Remote Sensing Systems (RSS). To gauge the improvement of the dataset over the previous version and provide error/confidence estimates, the surface fluxes will be compared with historical field experimental data and buoy observations. Error estimates of the flux products will be included in the documentation.

I0102 Using MODIS and TRMM observations to assess aerosol-clouds-rainfall relation over China sea

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This paper provides a prototype study on combining the advanced satellite observations of rainfall, clouds, and aerosol to address rainfall variations in-duced by aerosol indirect effect. Monthly satellite observations from the Tropical Rainfall Measuring Mission (TRMM) and Moderate Resolution Imaging Spectro-radiometer (MODIS) for Julys of 2000-2005 were analyzed to assess how urban aerosols affect clouds and rainfall over east China and off China sea. Over ocean, at the monthly scale, in July, the aerosol-cloud relation is evident for both light and heavy rainfall events, namely, the cloud effective radius decreases with the increase of aerosol optical thickness (AOT). However, only a weak aerosol-rainfall relation is detectable during light rainfall cases (i.e., rainfall rate <2.5mm/day) and that is most likely for warm clouds-induced rainfall only. On the contrary, over land, cloud effective radius did not show any evident relation with the change of aerosols, suggesting that aerosol process is not the only physical process affecting clouds, and that dynamic processes such as convection may play an equally critical role to compensate the effects of aerosols on clouds. The different features of aerosols' effects over land versus ocean further reveal the complexity of aerosol-cloud-rainfall interaction.

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I0103 Mapping high sea winds from space: A global climatology

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High winds at sea are feared by sailors, but their distribution is poorly known because ships have avoided them as much as possible. The accumulation of space-borne scatterometer measurements now allows a global mapping of high winds over the ocean. The QuikSCAT data of seven years since July 1999 show that high-wind events, defined as wind speeds greater than 20 m/s ("strong gale" and higher on the Beaufort scale), mostly happen in winter and two types of high-wind events are identified. Over coastal regions, land orography is the major cause of high winds, forcing wind jets of various types. Over the open ocean, high winds tend to be collocated with the extratropical storm tracks, along which migratory low- and high-pressure systems travel eastward. In companion, tropical cyclones do not leave a strong signature in the climatology of high wind occurrence except in the western Pacific east of Taiwan. In the extratropics, sea surface temperature (SST) fronts and their meanders significantly change the frequency of high-wind events. For example, high winds occur twice or more as often over the warmer than the colder flank of the Gulf Stream, and over the warm than cold meanders of the Antarctic Circumpolar Current. The collocation of frequent high winds and SST fronts are not a mere coincidence as sharp SST gradients anchor storm tracks, which in turn sustain the surface westerlies against friction with lateral heat and momentum flux. Both the large mean speed and high variance of wind increase the probability of high winds. Implications for navigation safety, oceanographic and climate research are discussed.

I0104 The Comparison between IASI and AIRS Observations

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Abstract: Infrared Atmospheric Sounding Interferometer (IASI) is the first Fourier Transform spectrometer on boarding the operational meteorological satellite. The polar orbit satellite METOP-1 satellite give the IASI the ability to monitor most of the earth surface spots twice per day with 8461 channels observations that cover the spectrum from 645 to 2760 cm-1. IASI observation spectrum resolution is 0.5cm-1 with sampling step 0.25 cm-1 per spectrum. The high spectrum resolution observation on the METOP-1 satellite which has 9:30am equator local crossing time will play the important role in NPOESS for operational meteorology and climate monitoring. Comparing with the first operational high spectral resolution Infrared sensor AIRS (Atmospheric Infrared Sounder), the IASI has broader spectrum coverage and high spectral resolution.

IASI unique high spectrum resolution infrared observations at 9:30am provide valuable information to operational numerical weather prediction systems. The assimilation of IASI data will yield direct benefits to increase the accuracy of ocean-atmosphere models. The comparison between these two high spectral resolution observations is the necessary step to obtain the consistency in assimilating the data from different instruments. At same time this comparison is important to the future observation integration processing and climate study. In this presentation, we will show the preliminary comparison results between these two satellites and evaluate IASI observations.

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I02 Ocean-Atmosphere Coupling Models

Conveners: Fangli Qiao, FIO, SOA

Manli Wu, NASA GSFC

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I0201 Satellite Observations and Cloud-resolving Modeling of Boundary-layer Cloud Systems

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This presentation will give an overview of satellite cloud observations and cloud-resolving modeling of boundary-layer cloud systems performed at NASA Langley Research Center. The satellite observations use the CERES (Clouds and the Earth's Radiant Energy System) Level-2 footprint data from NASA's TRMM (Tropical Rainfall Measuring Mission) satellite. Cloud systems are identified using a cloud-object approach, which identifies a cloud object as a contiguous patch of cloudy footprints that possess similar cloud physical properties. Both the frequencies of occurrence and statistical distributions of cloud physical properties for cumulus, stratocumulus and overcast cloud object types are analyzed, with an emphasis on their differences and similarities between the tropical and subtropical regions. Single and joint probability density function analyses of cloud properties are performed. Results indicate that cloud microphysical properties are similar but cloud macrophysical properties are different between the two regions for a given cloud-object type. The latter are related to the differences in the matched atmospheric states as represented by variables such as the vertical velocity at 700 hPa and the low tropospheric stability.

A cloud-resolving model is used to understand physical processes of boundary-layer cumulus and stratocumulus clouds. This CRM is implemented with both the low- and third-order turbulence closure (LOC and TOC) schemes. The CRM with the TOC scheme does not rely on the development of resolved-scale circulations to produce clouds because of an adequate parameterization of subgrid-scale transports, while that with the LOC scheme does. Because of this distinction, the initiation of boundary-layer clouds is delayed and the simulated cloud characteristics are more sensitive to the horizontal grid spacing used in the LOC simulations. There are also fundamental differences in the equilibrium cumulus and stratocumulus fields simulated by the two versions of the CRM. The resolved-scale circulations become stronger in the LOC simulations in order to compensate for the lack of subgrid-scale turbulent transports as the horizontal grid size is increased. The opposite is the case in the TOC simulations because there is less need to parameterize turbulent transports at higher spatial resolutions. The different proportions of resolved-scale and subgrid-scale circulations between the LOC and TOC simulations impact the mean boundary-layer thermodynamic structures in all boundary-layer cloud cases. This result further illustrates the importance of properly representing turbulent processes in CRMs.

I0202 Development of an NCEP Concurrency ESMF Version of the Operational Global Ensemble Forecast System (GEFS) and its Application in Representing Model Related Uncertainty

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An NCEP concurrency ESMF version of the operational Global Ensemble Forecast System (GEFS) was developed and used to represent model related uncertainty with a stochastic perturbation scheme and to fit the restrictive operational high performance requirement. Weather forecast uncertainty contains two parts, the initial condition uncertainty and forecast model uncertainty. In the current GEFS, the model related uncertainties are neglected although it causes significant bias in the mean forecast. Using stochastic noise to represent unpredictable small-scale variability in the ECMWF ensemble forecast system and the UK Met Office model appear to have beneficial effect on forecast skills and synoptic variability. Based on their works, research is being conducted to develop an effective stochastic perturbation scheme to represent the GEFS model related uncertainties. The preliminary results of a simplified stochastic perturbation scheme are very encouraged. For further complicated stochastic perturbation scheme research requirement and to apply it on NCEP operational system, we need to develop the much powerful ESMF concurrency GEFS. The Earth System Modeling Framework (ESMF) project is a large, multi-agency collaboration. It is a single executable framework that allows components to run sequentially, concurrently, or in a mixed mode. It consists of a Superstructure Layer that contains grid components and couplers and an Infrastructure Layer of utilities for parallel communication, regridding tools, time conversion routines, and other functions. ESMF can structure large, multi-component applications so that they are easy to use and extend, and achieving performance portability on a wide variety of parallel architectures. ESMF components are linked to a powerful ESMF Virtual Machine (VM) construct which offers integrated parallelization and a generic representation of the high performance computing hardware and software environment. The ESMF VM makes the ESMF GEFS concurrent run management to be easier and efficient. In concurrency ESMF GEFS there are two ESMF components: the Gridded Component, which is the original global forecast model, and the Coupler Component, which will couple all ensemble members, add the stochastic perturbations and create new ensemble initial condition group for the next ensemble run step. All Gridded Components and Coupler Components possess initialize, run, and finalize methods with standard ESMF interfaces. In ESMF GEFS, we can run any number of the ensemble member concurrently and can run any number of the initial perturbed run steps. For each initial perturbed ensemble run step we can set up resolution, start time, run duration time, time step length and all inputted control parameters individually for every ensemble member. Thus it can greatly help to choose the best stochastic perturbation scheme. Besides, due to the nonlinear property of the scale ability of parallel computing, the ESMF GEFS will reduce about 35\% computational cost comparing to using single job sequential run method. In current ESMF GEFS experiments, we use one control run and N perturbed ensemble members. The model state variables in each of the ensemble members runs starting with different initial conditions are periodically or non-periodically processed to generate a perturbation tendency field. Then using N different random combinations of the N perturbation tendency fields to perturb the model states of the N ensemble members. Results show that the stochastic perturbation ESMF GEFS can significantly improving the ensemble mean forecast and the ensemble based probabilistic forecast. The system is tested with an ensemble forecast experiment, in which one unperturbed control run and 10 perturbed ensemble members are integrated concurrently and they exchange information periodically. The model state variables of the ensemble members are stochastically perturbed every 6 hours. The perturbations added to the ensemble members are based on 10 different random combinations of the 10 ensemble-control differences in finitely estimated tendency. Results show significant improvement in the ensemble mean forecast and ensemble based probabilistic forecast.

I0203 Upper Ocean Coupling in a Global Climate Model to Increased CO_2

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The climate response to increasing CO_2 is investigated in a coupled global model with an upper ocean component. The upper ocean model (UOM) is designed such that it approaches to equilibrium in about 30 years, at least an order of magnitude faster than a conventional full depth ocean model. The model shows a weaker global warming compared to other coupled atmosphere/ocean GCMs when there is no snow/ice feedback. The UOM response is also somewhat weaker compared to a slab ocean model coupled with an atmosphere GCM. The UOM exhibits a longer (~11 years) response time scale to changed forcing than in a slab ocean model (~5 years) over the first few decades, and it shows a continuing but more modest evolution beyond this period. The precipitation changes under global warming in the two models are similar. The roles of the potential feedback processes in upper and abyssal ocean will be discussed.

I0204 Linking the Pacific Meridional Mode to ENSO: An observational and coupled model analysis

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Intriguing evidence is presented that a significant number of El Nino events over the past four decades are preceded by a distinctive warming at the sea-surface accompanied by a southwesterly wind anomaly in the vicinity of the Intertropical Convergence Zone during the boreal spring. This phenomenon, known as the Meridional Mode (MM), is shown to be inherent to the thermodynamic coupling between the atmosphere and ocean. It acts as an effective conduit for extratropical atmospheric influence on ENSO. A coupled model, consisting of an atmospheric general circulation model (CCM3.6) and a Zebiak-Cane type of Reduced Gravity Ocean model, is developed to further examine the details. Among the many novel features of this coupled model is a noise filter algorithm designed to suppress internal atmospheric variability in the coupled system. Extensive numerical experiments have been conducted. The results show that this modeling tool can not only give a realistic simulation of ENSO, but also demonstrate that the MM plays a vital role in the seasonal phase-locking behavior of ENSO.

I03 Data Assimilation for Oceans and Atmosphere

Conveners: Tsann–wang Yu, Howard University

Jiang Zhu, IAP, CAS

I0301 Coupling of Physical Processes and Dynamics in 4-D VAR Data Assimilation

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This paper discusses recent advances in research and developments in four dimensional variational (4-D VAR) data assimilation methodologies for weather and climate models of oceans and atmosphere. In particular, data assimilation methodologies which have recently been under very active developments using WRF (Weather Research and Forecast) models for mesoscale weather and climate predictions are reviewed. These include the tangent linear models and their adjoints which are used in 4-D VAR data assimilation for an efficient computation of the gradient of a cost function with respect to initial conditions. They are also used to compute fast growing modes (singular vectors) in order to span the phase space for ensemble prediction systems**.** The success of these applications lies in the ability of adiabatic tangent linear models to accurately describe the development stage of baroclinic waves in mid-latitudes. After the development stage, diabatic processes become very important near the surface through momentum dissipation and in the free atmosphere through latent heat release. A proper specification of the distribution of diabatic heating produced by PBL processes, convection and radiation is critically important for the tropical circulation. Characteristics of these methodologies together with tangent linear models and their adjoints are discussed.

A current thrust in the 4-D variational data assimilation development is to include a simplified linear physics package into the tangent linear and adjoint models used in the incremental variational formulation with WRF mesoscale models. This paper first investigates the numerical aspects of coupling physical processes and atmospheric dynamics in numerical weather and climate models. Three coupling strategies are studied: split-time, sequential and parallel coupling schemes. Numerical results using these coupling schemes with a WRF mesoscale model are presented, which show that results are sensitive to various coupling strategies. Further, results show that the best coupling strategy is a combination of the three schemes, and it is problem dependent. The merits of the best coupling strategy are discussed. The paper next investigates numerical aspects associated with coupling of linearized dynamics and physical processes in the 4-D VAR data assimilation schemes. These physical processes include PBL parameterization, convective and radiative effects, microphysics, and surface orographic effects, among many others. This paper particularly examines the linearization properties of a simplified atmospheric boundary layer linearization scheme based on the vertical diffusion equations, in which the exchange coefficients are function of local Richardson number and wind shear. Preliminary results are discussed of applying this PBL linearization scheme in a 4-D VAR data assimilation experiment with a WRF mesoscale forecast model.

I04 Air-Sea-Land Interactions

Conveners: Long Chiu, Chinese U. of Hong Kong

I0401 The annual cycle of the energy budget: Global mean and land-ocean exchanges

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The mean and annual cycle of energy flowing into the climate system and its storage, release, and transport in the atmosphere, ocean, and land surface are estimated with recent observations. An emphasis is placed on establishing internally consistent quantitative estimates with a full discussion and assessment of uncertainty. At the top-of-atmosphere (TOA), adjusted Earth Radiation Budget Experiment (ERBE) and Clouds and the Earth~Rs Radiant Energy System (CERES) satellite retrievals are used, while in the atmosphere National Center for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) and European Centre for Medium Range Weather Forecasts (ECMWF) reanalysis (ERA-40) estimates are used. The net upward surface flux (FS) over ocean is derived from the residual of TOA and atmospheric budgets, and is compared with direct calculations of ocean heat content (OE) and its tendency (dOE/dt) from several ocean temperature datasets. Over land FS from a stand-alone simulation of the Community Land Model forced by observed fields is used. A comprehensive depiction of the budget based on ERBE fluxes from 1985 to 1989 and CERES fluxes from 2000 to 2004 is constructed that matches best estimates of the global, global-ocean, and global-land imbalances. In addition, the annual cycle of the energy budget during both periods is examined and compared with dOE/dt.

The near balance between net TOA radiation (RT) and FS over ocean and thus with OE, and between RT and atmospheric total energy divergence over land, are documented both in the mean and for the annual cycle. However, there is an annual mean transport of energy by the atmosphere from ocean to land regions of 2.2±0.1 PW (1015 watts) primarily in the northern winter when the transport exceeds 5 PW. The global albedo is dominated by a semiannual cycle over the oceans, but combines with the large annual cycle in solar insolation to produce a peak in absorbed and net radiation in February, somewhat after the perihelion, and with the net radiation 4.3 PW higher than the annual mean, as it is enhanced by the annual cycle of outgoing long-wave radiation that is dominated by land regions. In situ estimates of the annual variation of OE are found to be unrealistically large. The analysis herein thus establishes a basis for further regional investigation of the energy budget in a companion manuscript and for subsequent model evaluation. Challenges in diagnosing interannual variability in the energy budget and its relationship to climate change are identified in the context of the episodic and inconsistent nature of observations.

I0402 US Support to VOCALS Program (VAMOS Ocean-Cloud-Atmosphere-Land Study)

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VOCALS (VAMOS Ocean-Cloud-Atmosphere-Land Study) is an international program aiming at better understanding and modeling physical and chemical processes central to the climate system of the Southeast Pacific (SEP) region. The climate of the SEP region is tightly coupled, involving interactions between the ocean, the atmosphere, and the land that are poorly understood. VOCALS will examine SE Pacific aerosol-cloud-drizzle feedbacks, the air-sea fluxes under the stratus clouds, the dynamics of the ocean surface layer in the eastern boundary current region off South America, including diurnal and near-inertial ocean response to surface forcing and the role of ocean eddies in moving cold water offshore, and the interaction of low cloud, SST, and the rugged terrain of western South America. The VOCALS program has one field component supported by numerical modeling and prediction components. Multi-disciplinary intensive observational datasets will be obtained during VOCALS-REx from several platforms including aircraft, research vessels, and a surface land site.

In US, currently NOAA (Climate Prediction Program for the Americas (CPPA) and Atmosphere Chemistry Program) and NSF (Climate and Large Scale Dynamics Program, Physical Oceanography Program and Atmosphere Chemistry Program) plan to support VOCALS field campaign and modeling studies starting from FY2008.

I0403 Changes in Continental Freshwater Discharge from 1949-2004

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ABSTRACT

A new data set of continuous monthly streamflow from 1948-2004 at the farthest downstream stations for world's 925 largest ocean-reaching rivers has been created for community use. Available new gauge records are added and the data gaps are filled with streamflow simulated by a land surface model (namely the Community Land Model Version 3 or CLM3) forced with observed precipitation and other atmospheric forcing. This network of gauges covers ~80 × 10^6 km^2 or ~68% of global actively drained areas and accounts for about 73% of global total runoff. The CLM3-simulated streamflow is significantly (and often strongly) correlated with the observations for most of the rivers and thus are used to fill the missing data gaps through linear regression. The new data set has improved homogeneity and enables us to more reliably assess decadal and long-term changes in continental freshwater discharge into the oceans. The model-simulated runoff ratio over drainage areas with and without gauge records is used to estimate the contribution from the areas not monitored by the gauges in deriving the total discharge into the global oceans.

Results revealed large variations in continental discharge at the interannual to decadal time scales. These variations are correlated with the Southern Oscillation Index (SOI) for the discharge into the Pacific, Atlantic, Indian, and global oceans as a whole (but not with discharges into the Arctic Ocean and the Mediterranean and Black Seas), consistent with previous regional analyses. Consistent with previous reports, we found a large upward trend in the water-year discharge into the Arctic Ocean (~0.21 × 10^{-3} Sv yr^{-1}) from 1949-2004. For the other ocean basins and the global oceans as a whole, the discharge data show downward trends, which are statistically significant for the Pacific (–0.43 × 10^{-3} Sv yr^{-1}) and global oceans (b = –0.58 × 10^{-3} Sv yr^{-1}). Except for the Arctic discharge, precipitation changes are found to be the main cause for the discharge trends and large interannual to decadal variations, although the CLM3 simulation also suggests influences of surface temperature and other atmospheric forcing (e.g., through enhanced evaporation). For the Arctic drainage areas, the upward trends in streamflow are not accompanied by increasing precipitation, especially over the Siberia. The CLM3 simulation suggests that recent surface warming has induced decreasing trends in snow cover and soil ice water content over the northern high-latitudes, which contribute to the runoff increases in these regions. Our results contradict the notion that continental runoff has increased during the recent decades.

[$] The National Center for Atmospheric Research is sponsored by the U.S. National Science Foundation.

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I0404 Soil Moisture Estimation with Multiple MODIS SRB Measurements

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Abstract

Great efforts have been done for remote sensing of vegetation water content from space such as the application of normalized difference infrared index (NDII) and normalized difference water index (NDWI). However, very few studies are focusing on soil moisture estimation with satellite optical measurements. The satellites measured surface reflectances are mixed results of signals reflected from vegetation and bare soils, soil moisture retrieval from optical measurements will thus require adequate consideration of these two signals and efficient approaches to separate them. It is found that water stress causes physiologic changes in vegetation and soil, which in turn causes different variations in vegetation and soil spectral signature. The major objective of this paper is to investigate the potentials of solar reflective measurements for soil moisture estimation by correcting vegetation effects employing the fact that there exists a combination of spectral signatures, which varies with the moisture conditions, where the effect of vegetation is minimized. The Moderate Resolution Imaging Spectroradiometer (MODIS) has 7 solar reflective bands (SRB) covering from the visible to short wave infrared (SWIR) region with 500m resolution, providing a good opportunity for this study. A soil moisture-reflectance model is coupled with leaf and canopy reflectance model to simulate reflectances over the study area. Regression analysis is performed between the soil moisture and simulated reflectances. Then the relationship is validated with ground observations and used to map soil moisture with satellite measurements. Since this regression relationship includes information of multiple MODIS SRB measurements which account for the different spectral response to water content change of soil and vegetation, it is more suitable for enhancing and extracting soil water information for regions mixed with vegetation. By applying these regression relationships to MODIS SRB measurements, soil moisture at 500m resolution is estimated. Such improvements are expected to be significant for drought monitoring and fire risk detecting applications.

I0405 Sahel Rainfall, African Dust Outbreaks and Hurricane Peak Intensity

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Abstract

The Saharan Air layer (SAL), which is associated with African dust outbreaks, forms as air moves across the Sahara Desert, containing substantial amounts of mineral dust. While the relationships of Sahel rainfall with African dust outbreaks and Atlantic hurricane activity have been documented in previous studies, analyses of various independent datasets show that the Sahel rainfall, SAL activity and hurricane peak intensity in the Atlantic basin are highly correlated. The long-term trend in hurricane peak intensity generally follows the Sahel rainfall and SAL activity. The decreasing trend in hurricane intensity by the mid-1980s was associated with the enhancing SAL activity (drying relative humidity and enhancing vertical shear) and the severe drought in the Sahel, while the recent moderate increasing trend in hurricane intensity is consistent with the weakening SAL activity (wetting relative humidity, weakening vertical shear and decreasing dust load) and the ameliorating Sahel drought. This study suggests that the SAL may act as a link between the summer African monsoon and Atlantic hurricane activity.

I05 Global Environment Protection

Conveners: Peiying Li, NMEPC, SOA

I0501 Climate based model for West Nile Culex Vectors in the Northeastern USA

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Many models have been developed over the years to describe vector borne diseases. While models can be extremely useful for conceptualizing the relative role of different parameters in the vector borne disease cycle, few models have been developed that are employed on a regular basis in vector borne disease studies. We sought to develop reliable predictive models by focusing on *Culex* species that may be important in vector borne diseases.

We developed a mosquito population model driven by *Development* and *Mortality* function, which are temperature dependent.

Previous studies have suggested a correlation between rainfall and mosquito abundance, but none have been developed specifically for Culex with a rainfall parameter. In this study, we created a *moisture index* based on 7 days cumulative rainfall and evaporation, studied the correlation between rainfall and 1st instar larvae and adults mosquito population abundance, and developed a function for *daily egg laying rate* depends on the *moisture index* added to the model.

In addition photoperiod is known to be important in induction of diapause and we incorporated these parameters into our model.

We utilized the mosquitoes adult capture data for the model validation by averaging the daily capture over a weekly period. Our model was further optimized by a parameter-space search within a biological bound.

The results showed a good timing for population early rising (early warning) and ending. To date, the best t model predicts adult populations for different years, with *r* values - between adult's population number from the model and the adult capture from trap, ranging from 0.43 to 0.83.

This model can develop to a complete model to present population dynamic of each life stage include larvae, which may provide a good timing for the mosquito control.

I0502 Algorithm for oil slick detection in the South China Sea by SAR imagery

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Abstract: Oil pollution causes marine ecological disasters that result in great damages of the quality and productivity of marine environment and involve great expenses in clear-up operations. The impact of oil pollution is not only related to the quantity but also on location, season, ocean depth, meteo-marine conditions. Oceans in south-east Asia are among the busiest in the world. Several major international shipping routes pass through this region connecting the Pacific Ocean to the Indian Ocean.

In order to enhance oil spill observation remote sensing measurements can be exploited. Synthetic Aperture Radar (SAR) mounted on board satellite platforms is an important tool in oil spill monitoring due to its wide area coverage and day and night all-weather surveillance capability. In this paper, a new algorithm is proposed for the semiautomatic detection, characterization, and classification of oil slicks detected in SAR imagery. The experimental results performed on ASAR images have demonstrated the efficiency of the proposed approach.

O01 Ocean Dynamics

Conveners: Xinan Liu, UM

Changlong Guan, OUC

O0101 The effects of surfactants and wind on spilling breaking waves

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The effects of both surfactants and wind on breaking waves that are generated mechanically are explored in a wind wave tank. The tank is 11.8 m long, 1.1 m wide and 1.8 m high (1.0 m of water, wind speeds up to 10 m/s) and a wave maker, which resides at the upwind end of the tank, is used to generate a wavetrain with a central frequency of 1.15 Hz under various wind speeds. Wave profiles along the center plane of the tank are measured with an LIF technique that utilizes a high-speed digital movie camera. The measurement system is mounted on an instrument carriage that can be set to move along the tank with the speed of the breaking crests. Measurements are performed with clean water and water mixed with various concentrations of Triton X-100, a soluble surfactant. Surface dynamic properties are characterized with a Langmuir trough combined with a Whilhelmy plate and longitudinal wave device. The effects of the surfactant and wind on fine-scale features of breaking events are studied and the changes of these features are correlated with the measured surface dynamic properties and wind speeds.

O0102 Interannual Sea Level Variations in the South Pacific from 5S-28S

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Abstract

TOPEX/Poseidon/Jason1 satellite altimeter observations for the 11 year period from January 1993 – December 2003 show that in the South Pacific most of the interannual sea level variability in the region 5S – 28S is west of 160W. This interannual variability is largest from about 5S – 15S and 155E – 160W, reaching a root mean squared (RMS) value of over 11 cm. Calculations show that this interannual sea level signal can be described by first and second baroclinic vertical mode Rossby waves forced by the curl of the interannual Ekman transport. This curl, which tends to be positive during El Niño and negative during La Niña, generates positive sea level anomalies during El Niño and negative sea level anomalies during La Niña that increase westward in amplitude in accordance with Rossby wave dynamics. The sea level anomalies are not exactly in phase with the curl forcing because Sverdrup balance does not hold – vortex stretching also contributes to the response.

East of 160W is a large 'quiet' region of low interannual sea level variability, especially south of about 15S. This is surprising because there is no flow into the coast and so the interannual sea level amplitude of equatorial origin should be constant along the coast, resulting in a source of westward propagating Rossby waves of considerable amplitude. The large low variability region results because coastal sea level amplitude falls between 5S to 15S so the Rossby wave source south of 15S is weak. During El Niño the sea level is higher than normal at the coast so the southward fall in anomalous sea level implies, by geostrophy, that there is an anomalous onshore flow. This flow feeds an anomalous 30-50 km wide shelf edge southward El Niño current of up to 20 cm/sec. During La Niña the sea level is lower than normal at the coast and the flows reverse, a narrow anomalously northward shelf edge flow feeding a broad offshore flow between 5S and 15S. South of 16S the coastal flow is much weaker.

O0103 Dynamical analysis of ocean mesoscale eddy-induced internal waves using linear theories

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Abstract: This study aims to explore generation mechanisms of the ocean internal wave (IW) using the dynamical analysis methods based on linear theories. Historical cruise measurements and recent synthetic aperture radar (SAR) observations of mesoscale eddies show that the IW packets exist inside the mesoscale eddies. This coexistence phenomenon and inherent links between the two different scale processes are revealed by solving governing equations and boundary conditions for the IW disturbance in a cylindrical coordinate system. The theoretical solutions indicate that the instability of eddy current field provides the dynamical mechanism to IW generation. The energy equation of the IWs indicates that the waves exchange the energy with the eddy during their growth or dispersion. The dispersion relations derived from the solvable conditions of governing equations show the IW propagation is modified by the instability of eddy current field.

The theoretical models are used to explain the above observations of the mesoscale eddy-induced IWs. The derived IW dispersion relation agrees with the field observation inside the Gulf Stream eddy. The two-dimensional waveform solution of the anticyclonic eddy-induced IW packet appears as ring-shaped curves, which contains the typical features of eddy stream lines. The comparison of theoretical solutions to the structure of the IW packets on SAR images shows a good agreement on the major features.

O0104 Numerical representation of the Mediterranean outflow water in the Gulf of Cádiz

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We have evaluated a regional scale simulation of the Mediterranean outflow by detailed comparison with field data obtained in the 1988 Gulf of Cádiz Expedition. Our ocean model is based upon the Hybrid Coordinate Ocean Model (HYCOM) and includes the Richardson number-dependent entrainment parameterization of Xu et al. [2006]. Provided the model is given realistic topography and sufficient resolution, it reproduces naturally the major, observed features of the Mediterranean outflow in the Gulf of Cádiz: the downstream evolution of temperature, salinity and velocity profiles, the mean path and the spreading of the outflow plume as it descends the continental slope, and most importantly, the localized, strong entrainment that has been observed to occur just west of the Strait of Gibraltar. A series of experiments have been carried out to define the sensitivity of simulated outflow water properties to some model and some geophysical variables. A converged solution is found to require roughly 0.08° resolution in the horizontal and about 10 isopycnal layers spanning the density of the initial and equilibrated outflow. Coarser resolution in either direction leads to generally less vigorous outflow currents and to lessened entrainment. Thus coarse resolution in this model leads to a denser, deeper equilibrated outflow. In much the same way, when the bottom topography is strongly smoothed or otherwise altered, the simulated outflow loses the realistic downstream evolution that is present at higher resolution. We have used the highly resolved model to investigate the response of the Mediterranean outflow water to a change in the freshwater balance over the Mediterranean basin or a change in the North Atlantic Central Water (NACW) through which the outflow descends. The results are like those of the Marginal Sea Boundary Condition of Price and Yang [1998]. Specifically, the volume transport of the product water is equally sensitive to a change in the source water density or the oceanic water density, while the T/S properties of the product water are much more sensitive to the change in oceanic water, NACW. Therefore more saline Mediterranean deep source water would be expected to generate a greater volume of Mediterranean product water having only slightly greater salinity.

O02 Coastal Ocean Dynamics

Conveners: Ming Li, UMD

Daji Huang, SIO, SOA

O0201 Assessing the impacts of climate variability and extreme weather events on coastal systems – Perspectives from Chesapeake Bay, U.S.A.

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Abstract

Anthropogenic nutrient enrichment has contributed to the degradation of water quality and decline of ecosystem productivity in coastal systems worldwide. In many coastal regions, there has been a major public commitment to reduce nutrient loading and reverse this trend of declining water quality and habitat conditions. Despite these efforts, more estuaries and coastal oceans are experiencing deteriorating rather than improving water quality conditions. A major impediment to developing a successful restoration strategy is the complicating effect of climate variability. Large inter-annual fluctuations in river flow result in highly variable nutrient loading to coastal waters while episodic wind events and longer-term changes in water temperature exert more subtle and poorly understood controls on key biogeochemical processes. Using Chesapeake Bay as an example, I will review recent research directed at discerning the impact of interannual climatic variability and extreme weather events on the coastal systems. Annual climate patterns in the mid-Atlantic region of U.S. have been highly variable in recent years, exemplified by 1996 and 2003, two of the wettest years in a century, and 2001, one of the driest years. These closely spaced, contrasting climatic conditions led to ecosystem-scale differences in plankton biomass and production. The frequency of intense tropical storms has also increased significantly since 1970, producing dramatic regional impacts on water quality and ecosystem productivity. In this talk I will discuss how interannual variability of freshwater flow drives commensurate variability of nutrient loading and plankton production, obscuring long-term trends associated with eutrophication. I will also discuss how extreme weather events such as hurricanes and tropical storms affect the plankton production and water quality.

O0202 The Effect of Correcting Errors in Initial Conditions and Upper Boundary Conditions on Storm Surge Forecasts Using 4D-Var approach

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Abstract

In this study, 4-dimensional variational data assimilation (4D-Var) approach is applied to correct the errors in the initial conditions or the upper surface boundary conditions (or both) for storm surge forecasts. The Princeton Ocean Model (POM) and its adjoint model are employed to perform a set of identical twin experiments to adjust the initial conditions or the upper surface boundary conditions (or both). By introducing errors into either the initial conditions or the upper surface boundary conditions (or both) in the control run, the model-generated "pseudo-observations" of water level on every ocean grid point of the model domain are assimilated into POM and its adjoint model to correct these errors by setting different control variables in 4D-Var. The results indicate that if the forecasting errors are attributed to the incorrect initial conditions, adjusting the initial conditions by setting the initial conditions as control variables is effective for 4D-Var to improve storm surge simulation. The same conclusion is reached when the forecasting errors are attributed to the erroneous upper boundary conditions. It does not work for 4D-Var to adjust the wrong source of errors to improve storm surge simulation. If the forecasting errors are attributed to both incorrect initial conditions and incorrect upper boundary conditions, then adjusting both the initial conditions and the upper boundary conditions is the best way for 4D-Var to improve storm surge simulation. In practice, we do not know whether the errors are caused by initial conditions or surface boundary conditions, therefore it is better to adjust both initial and surface boundary conditions in adjoint data assimilation.

O0203 Stability of shallow water semi-geostrophic models

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Semi-geostrophic (SG) model is an important model in geophysical fluid dynamics. Due to its unique dynamical features, its shallow water version has important applications in upwelling fronts in coastal oceans.

In the talk conservation equations of two important dynamic quantities--- pseudo-energy and -momentum with both finite and small amplitudes are presented. Nonlinear and linear stability criteria are then derived based on the two conservation equations. The impact of basic state, model parameters (such as Rossby number) and the lateral boundary conditions on the stability of shallow water SG model will be discussed analytically and numerically.

O0204 Observations and Dynamic Analyses of Internal Solitons Generated at the Columbia River Plume Front

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Abstract

In this study, we present observations of large amplitude internal solitons generated at the Columbia River plume front. The observations were conducted on June 10, 2006 during the River Influences on Shelf Ecosystem (RISE) cruise. Scale analyses of the internal solitons suggest that the river plume generated large amplitude solitons are strongly nonlinear waves, and their dynamic properties do not conform to weakly nonlinear theories of Korteweg-de Vries (KdV), Joseph and Kubota (finite-depth), and Benjamin and Ono (deep-water). The high-order KdV theory is used to analyze the internal solitons. The comparison between the theoretical predictions and the vessel data shows that the difference is less than 8% and 3% for half-width and soliton phase speed, respectively, and the high-order KdV model is much better than the weakly non-linear theories to predict the soliton dynamic parameters. The internal solitons generate a non-harmonic velocity field, and result in horizontal transports. Based on the high-order KdV model, we develop theoretical and numerical solutions of the soliton induced upper layer horizontal transport and Lagrangian water parcel transport distance, which show the water particle drift during the internal soliton passage and reflect the roles of the internal solitons on the exchange between the plume and ambient coastal water.

O02 **Coastal Ocean Dynamics**
Oral Presentation

O0205 Water Quality Modeling in the Cape Fear River Estuary andbAdjacent Coastal Region, North Carolina

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ABSTRACT

In order to examine system responses to high river discharge events and nutrient loading variations from the drainage basin, a coupled three-dimensional hydrodynamic and water quality model was applied in the Cape Fear River Estuary (CFRE) and its adjacent coastal region. An empirical equation was introduced in the model to represent light limitation for phytoplankton growth due to chromophoric dissolved organic matter (CDOM). The model was calibrated against water-level variation, salinity distribution, and water quality variables including chlorophyll *a* (chl *a*), nitrite plus nitrate, and phosphate. Model results show that in the upper to middle estuary, light limitation controls phytoplankton growth while in the lower estuary phytoplankton growth appears to be more limited by light intensity during high flow periods, but by nutrient availability during low flow periods. In the coastal ocean affected by the CFRE plume, nutrient availability is usually the dominant limiting factor for phytoplankton production. Two sensitivity tests were conducted to predict the biological response in Chl *a* concentrations to reductions in nutrient loading and river discharge. Although both tests resulted in the same reduction in nutrient fluxes, quite different system responses were simulated by the model. By reducing river discharge, water column irradiance was enhanced, nutrients introduced from the drainage basin tended to be consumed more within the CFRE, and less were exported to the coastal region. Phytoplankton growth was enhanced and chl *a* concentrations within the CFRE were higher. In contrast, by reducing nutrient (total nitrogen (N) and phosphorus (P)) concentrations at the head of the estuary, nutrients introduced from the drainage basin tend to bypass the estuary system, and enter the coastal region. Chl *a* concentrations within the CFRE remained low (less than 5 μg l^{-1}), possibly a result of light limitation as well as nutrient reduction. The supply of light limiting substances in the river water created a negative feedback mechanism on riverine nutrient enhancement of phytoplankton growth. The estuary acted as a buffer zone for chl *a* exported to the coastal region, with chl *a* fluxes across the river mouth appearing to be insensitive to loading changes. In contrast, nutrients exported from the estuary were greatly influenced by variations in river discharge, but were less sensitive to nutrient conditions at the head of the estuary.

O03 Indian Ocean Variability

Conveners: Renguang Wu, IGES/COLA

Weidong Yu, FIO, SOA

Li Li, TIO, SOA

O0301 Seasonality of air-sea interactions in the southeastern equatorial Indian Ocean

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Sea surface temperature (SST) anomalies can induce anomalous convection through surface evaporation and low-level moisture convergence. This SST forcing of the atmosphere is indicated in a positive local rainfall-SST correlation. Anomalous convection can feedback on SST through cloud-radiation and wind-evaporation effects and wind-induced oceanic mixing and upwelling. These atmospheric feedbacks are reflected in a negative local rainfall-SST tendency correlation. As such, the simultaneous rainfall-SST and rainfall-SST tendency correlations can indicate the nature of local air-sea interactions. Based on the magnitude of simultaneous rainfall-SST and rainfall-SST tendency correlations, the authors will demonstrate that the nature of air-sea interaction in the southeastern equatorial Indian Ocean displays strong seasonality and there are three distinct regimes of local air-sea interactions. The relative importance of SST forcing and atmospheric forcing differs in these regimes. During boreal summer, the rainfall-SST tendency correlation is negative and larger than the rainfall-SST correlation. In this regime, anomalous convection and circulation is primarily driven by remote forcing and shortwave radiation contributes significantly to the SST tendency. During late fall-early winter, large and positive rainfall-SST correlation is accompanied by positive but weaker rainfall-SST tendency correlation. In this regime, local SST forcing contributes significantly to rainfall and circulation anomalies and a positive wind-evaporation feedback works for maintaining the existing SST anomalies. During late winter-early spring, large positive rainfall-SST correlation is accompanied by negative rainfall-SST tendency correlation. In this regime, local SST forcing also contributes significantly to atmospheric variability; however, a negative cloud-radiation feedback contributes to the decay of SST anomalies. These regimes exist in other regions of the tropical Indo-Pacific Ocean as well. The relationship of the regimes to seasonal mean changes will be discussed.

O0302 Dynamics of the intraseasonal oscillations in the Indian Ocean South Equatorial Current

Lei Zhou and Raghu Murtugudde
AOSC/ESSIC, University of Maryland, College Park, Maryland

Markus Jochum
National Center for Atmospheric Research, Boulder, Colorado

Abstract

The spatial and temporal features of intraseasonal oscillation in the southwestern Indian Ocean are studied by analyzing a model simulation for the Indo-Pacific region. The intraseasonal oscillation has periods from 40-days to 80-days, with a wave length of ~650 km. It propagates westward as Rossby waves, with a phase speed of ~25 cm s^{-1}. This indicates that the intraseasonal oscillations in the southwestern Indian Ocean should have close relations with those in the southeastern Indian Ocean. By calculating the barotropic and baroclinic energy conversions, it is found that the baroclinic instability is the main driver for these intraseasonal oscillations. The first baroclinic mode dominates during most times but during boreal winter and spring, the second mode contributes significantly and often equally. Consequently, the intraseasonal oscillations are strong in boreal winter and spring. The atmospheric intraseasonal oscillations are not responsible for the oceanic intraseasonal oscillations in our model. But the relations between these two still need more investigations.

O0303 Asymmetry of the Indian Ocean Dipole

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Abstract

The mechanism for the asymmetry of SST anomaly (SSTA) between the positive and negative phases of the Indian Ocean dipole (IOD) is investigated with both the observational data and the SINTEX-F coupled model output. The asymmetry of IOD primarily arises from asymmetric SSTA skewness in the east pole. The following two air-sea feedback processes are major factors that lead to the asymmetry. The first is attributed to the asymmetry of the SST-convection-cloud radiation feedback. As the eastern equatorial Indian Ocean off Sumatra is a region of permanent climatological mean convection, a positive SSTA in situ would lead to enhanced convection and thus a negative cloud radiation feedback, whereas a negative SSTA with modest amplitude may lead to a negative heating (by reducing the mean convection). At a critical value, a cold SSTA may completely suppress the mean convection and lead to cloud-free. Below this critical value, a negative SSTA leads to no additional negative heating, and as a result, the anomalous heating keeps the constant even thought the SSTA may further drop. This nonlinear atmospheric heating process is crucial in contributing the asymmetry in the cloud-radiation-SST feedback, this is, while a warm SSTA experiences a continuous thermal damping due to negative shortwave cloud radiation forcing, a cold SSTA is free of such a thermal damping after it reaches a critical amplitude, latter of which is determined by the intensity of climatological mean convection in the region. This is partially responsible for the asymmetric development of positive and negative IOD episodes. The second process is attributed to the asymmetry in the thermocline-SST feedback. A positive (negative) SSTA may deepen (shoal) thermocline depth through induced westerly/easterly anomalies over the central equatorial Indian Ocean and induce local anomalous downwelling (upwelling). During the mature phase of IOD (SON), the amplitude of the seasonal mean upwelling is weak. Thus a negative thermocline depth anomaly in accompany with anomalous upwelling may readily change the SSTA through induced subsurface temperature anomalies, while a positive thermocline depth anomaly in accompany with anomalous downwelling may hardly impact the SST. This asymmetric thermocline-SST feedback differs significantly from that in the eastern equatorial Pacific during El Nino. The asymmetric feedback characteristics appear in both the observations and the SINTEX-F coupled simulations.

O04 Western Pacific Warm-pool

Conveners: Chunzhai Wang, NOAA/AOML

Faming Wang, IO, CAS

O0401 Effects of local dynamical and thermodynamical forcings on interannual Sea surface temperature variations in the eastern equatorial Pacific

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Abstract

This paper uses ocean general circulation model to examine the relationship between local wind stress, net heat flux and sea surface temperature variations on interannual time scale in the eastern equatorial Pacific. Effects of local dynamical forcing (wind stress) and thermodynamical forcing (heat flux) can be examined by comparing outputs from control run with full forcings and masked runs without either dynamical or thermodynamical forcings in the eastern Pacific. Local dynamical forcing provides mechanisms to make ENSO warm events stronger and last longer, especially during major ENSO warm events. Local thermodynamical forcing acts as a negative feedback to damp interannual SST anomalies generated by dynamical processes.

Session: A02, Tropical Ocean and Atmosphere
Presentation Preference: Oral

O0402 Impact of the Atlantic Warm Pool on Western Hemisphere Climate and Hurricanes

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The Atlantic Warm Pool (AWP) with a large body of warm water is comprised of the Gulf of Mexico, the Caribbean Sea, and the western tropical North Atlantic. Located to its northeastern side is the North Atlantic Subtropical High (NASH) that produces the tropical easterly trade winds. The easterly trade winds carry moisture from the tropical North Atlantic into the Caribbean Sea where the flow intensifies forming the Caribbean Low-Level Jet (CLLJ). The CLLJ then splits into two branches: One turning northward and connecting with the Great Plains Low-Level Jet (GPLLJ), and the other one continuing westward across Central America into the eastern North Pacific. The easterly CLLJ and its moisture transport are maximized in the summer and winter, whereas they are minimized in the fall and spring. This semi-annual feature results from the semi-annual variation of sea level pressure in the Caribbean region owing to the westward extension and eastward retreat of the NASH. The summertime strong easterly CLLJ is associated with a maximum of sea level pressure, a relative minimum of rainfall (the mid-summer drought), and a minimum of tropical cyclogenesis in July in the Caribbean Sea.

The NCAR community atmospheric model ensemble runs show that the AWP variability largely affects the summer climate of the Western Hemisphere and Atlantic hurricane activity. The climate response to the AWP's heating extends beyond the AWP region to other regions such as the eastern North Pacific. Both the sea level pressure and precipitation display a significant response (low pressure and increased rainfall) to large AWPs, in areas located in the western tropical North Atlantic and in the eastern North Pacific. In response to the pressure changes, the easterly CLLJ is weakened, as is its westward moisture transport. The model runs also show that a large AWP weakens the southerly GPLLJ, which results in reduced northward moisture transport from the Gulf of Mexico to the United States east of the Rocky Mountains and thus decreases the summer rainfall over the central United States, in agreement with observations. Since the climate response to the North Atlantic SST anomalies is primarily forced at low latitudes, this study implies that reduced rainfall over North America due to the warm phase of the Atlantic multidecadal oscillation may be partly due to a decrease in AWP-induced northward moisture transport associated with more frequent large summer warm pools. The model experiments show that a large AWP reduces the tropospheric vertical wind shear in the main hurricane development region and increases the moist static instability of the troposphere, both of which favor the intensification of tropical storms into major hurricanes.

O05 Decadal Ocean Variability

Conveners: C. K. Tai, NOAA NESDIS

Lixin Wu, OUC

O0501 Decadal sea level changes all over the world as revealed by TOPEX Altimetry

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Abstract:

Sea level trends computed using nine years of TOPEX data reveal a rich variety of geographical variations, the most important of which is the fact that most of the sea level rise are accounted for by the shallow regions of the sea.

O0502 Lower Thermocline Circulation in the South Pacific

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Abstract--Thermostad is observed at temperatures near 13ºC in the eastern equatorial Pacific. Circulation of this water mass represents part of a meridional overturning cell (termed Lower Thermocline Cell or LTC) in the Pacific, one analogous to the Subtropical Cells (STCs) but extends slightly deeper and to higher latitudes. Because of the LTC, variability in the subtropical region can be conveyed to the equator, allowing the subtropical South Pacific water to have a direct influence on the vertical structure of the thermocline and the sea surface temperature (SST) of the "cold tongue", as well as the eastern-boundary SST, among other things, being closely related to the ENSO and Pacific decadal variability. Some preliminary results on the origin and pathway of the thermostad water will be presented, which we believe will initiate a more complete understanding of how the shallow STCs relate to lower thermocline waters originating in the South Pacific and how variabilities in these waters contribute to climate variability.

O06 South China Sea

Conveners: Tony Y. Song, JPL

Dongxiao Wang, SCSIO, CAS

O0601 Sub-mesoscale Dynamics in South China Sea: Applications of Satellite SAR Data

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Y. Tony Song
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Abstract

The previous results have indicated that satellite SAR is a powerful sensor to detect the ocean processes. Its all weather and all time capacities break through restrictions of cloud cover and darkness, and its imaging resolution up to tens meters enable to detect the fine structure of the ocean processes. In particular, SAR instruments are highly sensitive to the variation of spatial distribution of the sea surface roughness, which results from modulation effects of dynamical processes in the ocean and lower atmosphere.

In recent years, we have applied satellite SAR data to ocean internal wave (IW) studies in South China Sea. Methods using SAR image to determine the characteristic half width of internal soliton have been developed. The SAR images are used to determine statistical features of IWs. The results show the interannual and seasonal variability of IW occurrence frequency. The SAR images are also used to analyze dynamics of sea bottom topograaphic waves in the Taiwan Strait. Using Argos satellite-tracked surface drifter trajectory data and ENVISAT (European satellite) ASAR (advanced synthetic aperture radar) images acquired by Hong Kong Satellite Remote Sensing Ground Receiving Station, dynamics of sub-mesoscale ocean vortex trains in Luzon Strait are analyzed. The major results obtained by these studies will be reviewed in this talk.

O07 Sea Ice and Climate

Conveners:

Zhanhai Zhang, PRI, SOA

O0701 Ice-ocean-oil spill modeling system in Beaufort Sea and oil spill modeling in sea ice environments

Meibing Jin, Jia Wang, Kohei Mizobata and Haoguo Hu

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Abstract

Oil developments in the Beaufort Sea coast pose a potential threat on the pristine Arctic Ocean environment and many important marine resources, e.g., protected species of marine mammals and sea birds. A sea ice–ocean–oil spill model system was developed as part of the oil spill contingency management plans in the region. The system consists of two parts: a 3-dimensional coupled ice–ocean model and an oil spill trajectory model specialized for sea ice environments. The coupled ice-ocean model consists of a multi-category sea ice model and the Princeton Ocean Model (POM). The model was applied to the vast Chukchi and Beaufort Seas with a high-resolution (~3.9km). The open boundary conditions of oceanic and sea ice fluxes are from a high-resolution (1/6 degree by 1/4 degree) global ice-ocean model by Center for Climate System Research (CCSR), University of Tokyo, which is one of the Intergovernmental Panel on Climate Change (IPCC) models. The model runs from 1990 to present and the results are compared with SSM/I ice concentration, mooring CTD and ADCP data. Simulations of oil spill released in different times are used to demonstrate seasonal and inter-annual variations of the oil spill impacts. Sensitivity studies of oil drift with and without sea ice cover are conducted to test the new algorithm and illustrate how sea ice influences both oil trajectories, and the physical and chemical transformations of the spilled oil.

O08 Marine Biogeochemical Processes

Conveners: Fungchi Ko, NMMBA, TW

Xiaoru Wang, FIO, SOA

Song Sun, IO, CAS

O0801 Polycyclic aromatic hydrocarbon distributions and associations with chemical characteristics in Kenting coastal waters, Taiwan

Fung-Chi Ko[1,2], Ya-Hsin Liu[1], Jing-O Cheng[1], Chung-Wei Hua[1,2], Ping-Chieh, Hsieh[3], Meng-Der, Fan[3], Chon-Lin Lee[3]
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Abstract
Partitioning of polycyclic aromatic hydrocarbons (PAHs) between particulate and dissolved phases control their environmental fate and transport in aquatic systems. Highly variable physical and biological processes complicate the analysis of PAH cycling in the coastal waters. As an initial effort to characterize inventories and distributions of PAHs in the Kenting coastal waters, the field cruises were contracted seasonally to collect the water samples through the water column (1m and 15m) in 2006 to examine spatial and temporal variability in particulate and dissolved PAH concentrations and their interactions with suspended particles including plankton. Samples were separated into particulate (C_p) and dissolved (C_d) phases using 1 um glass fiber filters. Each phase was analyzed for 40 PAHs. Distribution coefficient (K_d) of each PAH was measured by the particulate PAH divided by its dissolved concentration. Concentration profiles of PAHs in the Kenting coastal waters indicate that compositional differences in PAH particle-water distributions were a function of seasonal variation across the year. Although the portion of this study was based on a limited number of samples, the preliminary mass balance calculations indicated that in 2006 on an annual scale, fluvial contributions of PAHs to the Kenting coastal waters was relatively negligible and that atmospheric deposition and coastal erosion may have been the most significant source of PAHs into the waters. Since the Kenting area is not the industrial spot, we conclude that the origins of atmospheric PAHs to the waters may be dominated by traffic and that variation of distributions may be dependent on the local wind direction.
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O0802 Development of Microbial Mat Community in Shallow Water Petroleum-gas Seepage off the Coast of Central California

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Abstract: Abundant microbial mat communities were discovered in shallow water petroleum-gas seepages along the coast of Central California. To investigate the development of microbial mat communities in these seep areas and their roles on gas and petroleum oxidation, a time series of in-situ incubation were conducted at Shane Seep — a typical marine petroleum-gas seep located in shallow water off the coast of Central California. Removable modular surface were deployed at Shane Seep for microbial mat growth and at 30 m away from the seep as control. Individual surface module was sampled weekly for a period of four months at both sites. Biomass accumulated on the modular surface from seep area was much higher than that from control. Visual observation confirmed white or grey mat covered most of the modules collected from the seep area. At several timepoints, black or brown spots were also detected in the mat. The collected mat samples were scraped from the modular surface for microscopy observation, carbon and nitrogen abundance measurements, isotope analysis, lipid analysis and etc.. Light microscopy examination observed that gram negative filamentous bacteria were dominant in most of the mat samples. Scanning Electron Microscopy (SEM) imaging showed the filaments were 5-20 μm in diameter and Energy Dispersive Spectrometry (EDS) showed high sulfur component in the multi granule structure in the cell, exhibiting the features of sulfur-oxidizing bacteria. Isotope analysis showed $\delta^{13}C$ of the microbial mat communities ranged from -11.3‰ to -37.5‰ with enrichment-depletion-enrichment periodic variation, indicating multi carbon sources were utilized for development of the mat communities at different growth time. Lipid analysis identified more than twenty fatty acids, including 16:0, 14:0, 16:1 series, 18:1 series, 15C, 17C series and etc.. The $\delta^{13}C$ values of these fatty acids varied from about -20‰ to -55‰ and the most depleted $\delta^{13}C$ occurred in 16:1 series. In depleted 16:1 series, methanotroph biomarkers 16:1(6) and 16:1(8) were detected, indicating the contribution of methanotroph on the depletion of carbon for the microbial mat community. Besides sulfur-oxidizing bacteria and methanotropy, some other bacteria species were observed.

Submit to: Session **O08, Marine Biogeochemical Processes**

O09 Marine Natual Materials and Drugs

Conveners: Meiyu Geng, OUC

Guangyou Li, FIO, SOA

O10 Marine Ecosystem

Conveners: Fei Chai, Maine U.

Huasheng Hong, Xiamen University

O1001 Primary Productivity and pCO_2 variations in the China Seas during 1990-2004: a Three-Dimensional Physical-Biogeochemical Modeling Study

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The biological productivity and carbon cycle in the marginal seas contribute significantly to the global budget estimates. The key factors regulating productivity and carbon fluxes vary regionally, such as the China seas (Yellow Sea, East China Sea, and South China Sea). Regional comparative studies are needed to investigate these controlling factors in the China Seas. In this modeling study, a Pacific basin physical-biogeochemical model is used, which is driven with daily air-sea fluxes from the NCEP reanalysis for the period from 1990 to 2004. The analysis has been focused on the similarities and discrepancies in modeled simulated primary productivity and the partial carbon dioxide (pCO_2) in the China Seas. On the seasonal time scale, the modeled air-sea CO_2 flux in the China Seas range from a sink during winter (Dec.-Feb.) to a source in summer (June-Aug.). Yellow Sea has strongest seasonal variability, and it's weakest in the South China Sea. The temperature and biological productivity regulation on pCO_2 are compared for the different regions as well as the temporal variation. The model results suggest that the temperature plays a dominated role in controlling the spatial and temporal variations of pCO_2, especially in the South China Sea. The biological productivity during spring is important in determining pCO_2 in the Yellow Sea and East China Sea. In general, the pCO_2 increases in China Seas between 1990 and 2004, which is due to the anthropogenic increase of atmospheric pCO_2. The inter-annual variation of biological productivity and carbon cycle in the China Seas, along with the anthropogenic CO_2 uptake, will be discussed.

O1002 Seasonal and Interannual Variability of Carbon Cycle and Productivity in South China Sea: a Three-Dimensional Physical-Biogeochemical Modeling Study

Guimei Liu[1,2], Fei Chai[1,*] , Huijie Xue[1], Lei Shi[1], Yi Chao[3]

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The South China Sea (SCS) exhibits strong variations of climate and physical processes ranging from mesoscale to ENSO dynamics, which influence carbon cycle and biological productivity in the region. We have developed and used a Pacific basin-wide physical-biogeochemical model to investigate physical variations, ecosystem responses, and biogeochemical consequences. The Pacific basin-wide circulation model, based on the Regional Ocean Model Systems (ROMS) with 50-km spatial resolution, is forced with daily air-sea fluxes derived from the NCEP reanalysis between 1990 and 2004. The biogeochemical processes are simulated with the Carbon, $Si(OH)_4$, Nitrogen Ecosystem (CoSINE) model consisting of multiple nutrients and phytoplankton groups and detailed carbon cycle dynamics. The ROMS-CoSINE model is capable of reproducing many observed features and their variability in the SCS. We analyze the model results with focusing on the factors controlling air-sea CO_2 flux in the SCS. The integrated air-sea CO_2 flux over the entire SCS shows a strong seasonal cycle, with the SCS releases CO_2 to the atmosphere during the summer, and takes CO_2 from the atmosphere during the winter. On the annual mean basis, the SCS is a weak source of carbon to the atmosphere with a rate of 0.32 mol/m^2/yr. Model sensitivity studies indicate ocean temperature is the most important factor controlling pCO_2 in the surface water, which in turn determines the air-sea CO_2 flux variability in SCS. The regional difference in terms of air-sea CO_2 flux and their controlling mechanisms will be presented. The modeled primary production also varies seasonally with the highest value of 400 mg C/m^2/day during the winter, and the lowest value of 150 mg C/m^2/day during the summer. The modeled annual mean export production is 46.5 mg C/m^3/day, which yields the export to primary production ratio of 0.19. The factors controlling the primary, new, and export productivity in several key regions of the SCS will be discussed.

O11 Ocean Remote Sensing I, II

Conveners: Yuanzhi Zhang, CUHK, Hong Kong

Xiaofeng Li, NOAA/NESDIS/STAR

Delu Pan, SIO, SOA

O1101 Monitoring of harmful algal blooms (HABs) from satellite-based observations over coastal waters around Hong Kong and its vicinity

Yuanzhi Zhang, Guiwu Wang, Hui Lin, Chaoyang Fang

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Abstract

Blooms of autotrophic algal and some heterotrophic protists are increasingly reported in the coastal areas over the world and collectively formed as harmful algal blooms (HABs). Such blooms are always attributed to two major factors. One is natural process such as circulation, upwelling relaxation, and river flow. The other is eutrophic status resulted from anthropogenic loadings. Although the latter is usually considered as the main reason of all blooms, it is not the case in many instances. In addition, it is commonly accepted that occurrences of these phenomena are increasing over the world's oceans, but the reasons for this apparent increase remain debated and include not only eutrophication but also increased observation efforts in coastal areas.

Satellite remote sensing is a valuable tool in obtaining information on the processes taking place in the surface of sea and coastal waters. A major advantage of satellite-based observations over traditional measurements of algal blooms is to provide spatial and temporal domain of their characteristics and distributions. With currently advanced satellite-based data (e.g., MODIS, MERIS and ASAR), a large number of variables concerning water quality conditions such as chlorophyll-a (Chl-a), total suspended matter (TSM), yellow substance, turbidity, eutrophication, salinity and sea surface temperature (SST) could be observed on a regular basis. There has been a lot of research on algal blooms since 1960s. They are traditionally studied and performed by taking ship-borne water samples and analysing the samples in the laboratory and/or by doing on-site measurements. But there are few studies on remote sensing of HABs detection and specific algorithms from combined optical and microwave data. Therefore, this study will focus on the development of new algorithms for HABs monitoring from satellite-based observations and the analysis of HABs in relation to eutrophication, salinity, and SST in coastal waters around Hong Kong and its vicinity.

O1102 Estimating internal solitary waves propagation velocity in South China Sea by using multi-sensor images

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Internal waves occur frequently in northern of South China Sea. Satellite SAR images show that wave crest lines may reach as long as 250 km. The largest amplitude of internal wave retrieved from field observation is about 170m. The research of internal waves in SCS is very important. Internal wave traveling speed is an important parameter in propagation forecasting, which is dominated by water stratified structure. The traditional method to estimate the velocity is under the hypothesis of two close internal wave packets in same image are generated by tide interaction with bottom topography and separated one tidal cycle. In SCS this hypothesis is not true in many cases. With the development of remote sensing, more and more remote sensing images can get. Many optical images also can observe internal waves, especially MODIS. It is possible that combine quasi-simultaneous remote sensing image to research internal wave propagation feature. In this paper, 10 pairs of images are collected, covering sea area from around 19º to 22º N latitude and from 111º to 119º E longitude. The internal wave propagation velocity distribution is obtained. The speed is in proportion to water depth. The largest 7 kn is in deep ocean near Luzon Strait, and the small one-1 kn in continental shelf. The results are also compared with field data. The upper mixing layer depth is estimated by the propagation speed.

O1103 All-weather Monitoring for Cloud-prone and Rainy Area: The Satellite Remote Sensing Ground Receiving Station of the Chinese University of Hong Kong (CUHK)

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The Satellite Remote Sensing Ground Receiving Station of the Institute of Space and Earth Information Sciences at CUHK (hereinafter referred as "the Station") has been in full operations since 1st January 2006, and has been providing ENVISAT ASAR data, value-added services as well as professional trainings to research institutes, government organizations and private sectors in Hong Kong, South China and the neighboring regions.

The region of coverage of the Station is a cloud-prone and rainy area which was frequently struck by natural disasters such as landslides and subsidence, earthquakes, tsunamis, floods and typhoons, leading to severe civilian casualties and economic loss. The Station receives radar image from the ENVISAT Remote Sensing Satellite. The unique position of the ground station in Hong Kong allows monitoring of environment and natural disaster for the most part of China and all its coastal waters, Hong Kong and neighbouring regions.

Up to March 2007, the Station has acquired and archived over 2,000 ENVISAT ASAR Images covering countries such as China, Korea, Philippine, Vietnam, Thailand, Southern Japan and Northern Malaysia etc. and supported numerous coastal and oceanic environmental monitoring projects. They include sea ice monitoring in Bohau Bay area; Pearl River near-shore environment monitoring; ocean internal wave monitoring; red tide monitoring; ocean wind mapping; flood monitoring and control along the Changjiang River and post-disaster damage assessment for typhoons BILIS and SAOMA.

In the long run, the Station will serve as a platform to enhance technology collaboration between Hong Kong and mainland Chain, accelerating the development of the remote sensing industry in the greater Pearl River Delta region. This presentation will outline the developments of the Station, describe results of the supported projects, data products and professional services provided by ISEIS and outline a strategic plan for future development.

O1104 The Development Research of a GIS for Satellite Ocean & Atmosphere Remote Sensing

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Abstract

With the wider adoption of GIS in oceanography and the rapid development of ocean measuring techniques, it is clear that the traditional commercial GIS is limited for solving marine environment problem because of its high dimensionality and dynamic nature.

In this paper, a new system architecture is presented, which will enable even profound functions of GIS both in the management of satellite remote sensing data and the research of mesoscale and large-scale phenomenon of the global ocean and atmosphere, on the basis of which, the prototype of a Marine and Atmospheric GIS (MAGIS) was developed. This new architecture based on a double-core structure consisting of data sets, which are able to describe high-dimensional dynamic motions and the functions of data analysis and visualization. Aiming at management and organization of the two cores, the Marine and Atmospheric Spatial-Temporal Data Model (MASTDM) and the Spatial-Temporal Work Flow Management System (STWFMS) were designed and developed. MASTDM, capable of the integration of multi source satellite remote sensing data, as well as compatible with the functions of data analysis and visualization, is used as the data model for MAGIS. STWFMS will be applied for the establishment and management of the process model (functions sequence) for a research. Based on the MASTDM and the STWFMS, we have, from the bottom layer, built a system prototype that is competent for the seamless integration of management, analysis, and visualization of ocean and atmosphere satellite remote sensing data, and some case studies are developed under in the MAGIS.

O1105 Mountain wakes in the vicinity of Hong Kong International Airport (HKIA) as revealed in Synthetic Aperture Radar (SAR) images

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Abstract: Mountain wake near HKIA, especially that associated with the mountainous Lantau Island south of the airport, could be observed by the Doppler LIght Detection And Ranging (LIDAR) system at the airport. LIDAR measurements reveal part of the wake (up to about 10 km). SAR images provide a view of the full size of the mountain wake in the vicinity of HKIA. The wakes revealed by the SAR images under two different wind regimes will be discussed in this paper, namely, northeast monsoon in the winter and easterly wind in early autumn. For northeasterly wind, a "bending" wake is found to the north of HKIA and a broad wake extending to about 2 times the width of Lantau Island is observed downstream of the western side of this island. Under the prevalence of the easterly wind, the wake of Lantau Island is shown to extend as far as the western side of the Pearl River Estuary, some 20 km downwind of the island. Based on the available observations from SAR, the size of the mountain wake in easterly wind conditions seems to be related to the stability of the troposphere. The wake could extend across the whole Pearl River Estuary when there is a temperature inversion within the boundary layer. SAR images are found to be useful in the understanding and monitoring of mountain wake near HKIA, albeit their relatively low frequency of data availability.

Session: O11 – Ocean Remote Sensing
Presentation: Poster

O1106 Remote Sensing of Ocean Properties in the Coastal Regions

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In the remote retrieval of the ocean near-surface properties, it is crucial to accurately remove the atmospheric and ocean surface effects from the sensor-measured signals. This process, which corrects more than 90% of sensor-measured signals, is often termed as atmospheric correction. The atmospheric correction algorithm for Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) uses two near-infrared (NIR) bands at 765 and 865 nm (748 and 869 nm for MODIS) for retrieval of aerosol properties with assumption of the black ocean at the NIR wavelengths. Modifications are implemented to account for some of the NIR ocean contributions for the productive but not very turbid waters. For the turbid waters in the coastal regions, however, ocean could have significant contributions in the NIR, leading to significant errors in the satellite-derived ocean water-leaving radiances. For the shortwave infrared (SWIR) wavelengths, water has significantly larger absorption than those for the NIR bands. Thus, the black ocean assumption at the SWIR bands is generally valid for turbid waters. In this presentation, I provide overview of the SeaWiFS/MODIS atmospheric correction algorithm that is currently used for deriving the ocean color products. The new approach using the SWIR bands for atmospheric correction is then described. I demonstrate advantages of the new approach by comparing ocean color results derived from the SWIR atmospheric correction method and from the standard method. Results show that, in the turbid waters, the ocean color products using the SWIR bands are significantly improved, while for the open oceans both methods produce very similar results. Specific examples from the MODIS-derived ocean color products along the China east coastal regions will be presented and discussed.

O1107 Analysis of ocean current features in spaceborne SAR images

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Abstract Satellite remote sensing of ocean features with synthetic aperture radar (SAR) depends upon the interaction of microwaves and short ocean waves. As described in the literature, the intensity variations in SAR imagery are caused by variations in the normalized radar cross section (NRCS) resulting from the dynamic ocean surface. Mesoscale ocean features can be imaged by SAR because the variation of current velocities associated with these features modulates the sea surface Bragg wave spectra. In this study, we provide evidence of SAR observations of internal waves and solitons, tidal convergence fronts, and bottom sand ridges.

Oceanic internal waves and solitons are frequently observed on the continental shelf during the summer season, when the ocean is stratified. These waves, generally generated at tidal frequency, propagate along the density interface as highly coherent packets with several wave crests in each packet. During the evolution of the internal solitons, they may go through the polarity conversion from elevation waves to depression waves, exhibit soliton fission, and change their propagation velocity. In this study, we show the characteristics of SAR observed internal solition propagation. Using South China Sea (SCS) as an example, we also calculate the maximum tidal body forcing and are able to find the main generation location for the internal solitons in the SCS.

Strong tidal-current-induced axial fronts usually exist in coastal bays and tidal channels. These fronts are caused by the convergence of the surface tidal currents. The convergence can be a result of various mechanisms. The interaction of tidal fronts, short Bragg waves and intermediate surface gravity waves will modulate the sea surface roughness and induce large variations in NRCS across the current or water mass fronts. We present SAR frontal features observed the along axial fronts in the Cook Inlet and Yangze River. These fronts are believed to exist in strong tidal inlets. A diagnostic tidal model is developed. We demonstrate that tidal velocity in the inlet can produce significant convergence at certain tidal stages.

Shallow water bathymetry features were first discovered on radar images in 1969. Since then, numerous studies have been conducted to understand the imaging mechanism for shallow-water coastal bathymetry. It has been found that under low wind and strong tidal current conditions, shallow water bathometry features, e.g.., sand ridges or sea mountains, can be imaged by SAR instruments. In this study, several well-known sand ridges in the Bohai Sea, China are shown in a RADARSAT-1 standard SAR image. Contrary to the existing one-dimensional radar model, which requires that the tidal current velocity vector be more or less normal to the direction of the sand ridge orientation, the sand ridges which are parallel to the tidal currents are shown very well on the SAR image. In this study, a community ocean model has been applied to demonstrate the temporal variations of the current divergence and convergence which are induced by the along-sand-ridge-direction current and ridge interaction. These variations in divergence and convergence allow the sand ridges to be imaged by the SAR. We provide a new current/bathymetry interaction mechanism that explains the SAR imaging of ocean bottom sand ridges under these conditions.

We also present SAR observations of a headland eddy, long-lasting anticyclonic eddies in the Gulf of Alaska, and other mesoscale oceanic features.

O1108 Sea Surface Temperature Analysis with Kernel-Based Principal Component Analysis Technique

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Session preference: O11

Principal Component Analysis (PCA) has been extensively used in different fields including earth science for spatial pattern identification. However, the intrinsic linear feature associated with standard PCA prevents scientists from detecting nonlinear structures. Kernel-based principal component analysis (KPCA), a recently emerging technique, provides a new approach for exploring and identifying nonlinear patterns in scientific data. In this paper, we apply the KPCA technique into the analysis of Sea Surface Temperature (SST). We compare the results from KPCA with those from nonlinear PCA based on neural network and study the dependency on the parameters of the kernel function.

O12 Coastal Zone Development and Management

Conveners: Joseph Huang, NOAA

Shuxian Sun, FIO, SOA

Sangyun Wu, FIO, SOA

O1201 Governance and Management of the United States Coastal Zone

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Abstract:

Managing growth and development along the coasts is perhaps the greatest challenge for coastal managers. Even though it only accounts for approximately 17% of the land mass in the United States, the coastal zone is home to over half of the population. In many places, this development and growth has lead to adverse impact such as degraded water quality, loss of habitat, and greater susceptibility to storm damage. Managing growth and development will only become more challenging as people continue to move to the coasts.

In the United States of America, the federal, state and local governments each have a role to play in managing the growth and development of the coasts, but what that role is for each of these three levels of government can vary widely around the country. There are 35 coastal states and territories, each with their own laws and legal institutions to manage the coastal zone, and each with a different interaction between the state and the local governments. The management of the coastal zone, therefore, does not follow one legal structure, but dozens.

This presentation will provide a brief overview of the primary federal law that controls management of the U.S. coasts, the Coastal Zone Management Act that established a partnership between the federal government and the coastal states to encourage development while protecting the environment. The presentation will then proceed to provide examples from various states around the country of the different ways the state and local governments relate to each other in managing the coasts. These examples will show a myriad of ways that governance structures are organized between different levels of government to accomplish coastal management, as well as highlight some of the strengths and weaknesses of the U.S. governance structures. The presentation will conclude with some hypotheses about what the near future holds for coastal management in the United States.

O1202 Ground Deformation Monitoring in Hong Kong Coastal Areas with Advanced Radar Remote Sensing Technology

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Urban ground subsidence has long been a problem mostly concerned in Hong Kong coastal areas as over 10% of urban area built on the reclaimed land from sea. Moreover, Hong Kong has a subtropical sea climate and the average annual rainfall exceeds 2000 mm. The tropically weather conditions, together with more than 70% of the land on hilly terrains, lead to a high occurrence of landslide events and pose a significant landslide risk to the community and geotechnical constraint to developments. These ground deformation hazards threaten human activities and cultural heritage, thus influencing the socio-economic conditions of Hong Kong coastal areas. Driven by safety requirement and legal liability, local/regional government and civil engineering industry have great demands on ground displacement monitoring.

Satellite Permanent Scatterers Interferometry (PSI) is a promising radar remote sensing technology that offers low cost, large-coverage deformation monitoring and up to sub-millimeter accuracy. In this study, with PSI technique experiments have been carried out on a series of ENVISAT ASAR images to monitor ground deformations in Hong Kong coastal areas. Results indicate that Hong Kong International Airport had still ground subsidence (up to 30mm) in year 2006, and a slight ground lift was monitored in Disneyland after 2 year of the completion of reclamation.

Special session (one hour)

Data to Support Ocean-Atmosphere Research

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The Research Data Archive (RDA) at NCAR is a valuable data resource for ocean-atmosphere research, has worldwide appeal and access, and is managed with advanced methods that allow easy growth and data preservation. The RDA has been built up over the past 40 years, including some collaboration with China, and is now over 500 distinct datasets, 500 thousand files, and 100 Terabytes (TB). A significant portion of the RDA supports ocean-atmospheric research. There are many valuable datasets in the categories of observations, ocean analyses, and ocean and atmosphere reanalyses.

Web based descriptions of all RDA datasets are available online, automatically updated when changes are made, maintained in a consistent form, and have clearly identify data access options. The RDA is stored in the NCAR Mass Storage System (MSS) and a copy of many significant datasets is available directly over the Internet. About 12 TB of data are directly available and there are procedures to request and methods to serve all dataset in the RDA.

The RDA is managed using a system of people and integrated software. The central software foci are database systems. Collectively, the RDA Data Bases (RDADB) provide relationships that map all data files into datasets, methods to easily create new and expand existing datasets, manage standard metadata, register users, track a full spectrum of RDA metrics, and document disaster recovery and backup procedures. The RDADB software and its related products along with geosciences educated people that build the archives and interfaces makes the RDA beneficial to many users and efficient to maintain. As a simple example, the second largest national user group, next to the U.S., is the P.R. of China with over 800 unique individuals and 6.5 TB of data downloaded.

The RDA grows by adding 15-20 new datasets each year and has plans to increase the Internet available data to about 28 TB in the next year or two. The RDA is an important collection and we often seek international collaborations to share and exchange data with the primary goal of building large, organized, and easy to use open access archives for the worldwide scientific community.