CPO Funded Projects

Modeling, Analysis, Predictions, and Projections Program (MAPP)

The MAPP Program builds upon the following CPO predecessor programs: Climate Dynamics and Experimental Prediction (Applied Research Centers, Climate Test Bed, Reanalysis), and the elements of Climate Prediction Program for the Americas (CPPA) and Climate Variability and Predictability (CVP) most closely related to MAPP's objectives; remaining elements of CPPA and CVP programs are included in the Earth System Science Program.

For a list of past Climate Test Bed projects, go to:
http://www.cpc.noaa.gov/products/ctb/funded_projects.shtml

Climate Prediction Program for the Americas (CPPA)

<table>
<tr><td>Primary Investigators (last names and affiliations)</td><td>Project Title</td><td>Year Funded</td></tr>
<tr><td>Ernesto H. Berbery, University of Maryland, College Park</td><td>Monitoring and Prediction of Hydroclimate over Pan America based on the Climate Forecast System Reanalysis and Reforecast Products</td><td>2009</td></tr>
<tr><td colspan="3">Abstract: The Climate Prediction Center (CPC) plans to upgrade its monitoring products by replacing its current system with a new reanalysis system, the Climate Forecast System Reanalysis and Reforecasts (CFSRR). The CFS Reanalysis (CFSR) is a next generation coupled data assimilation system that offers consistency between ocean, atmosphere and land analyses and, together with a higher resolution, is expected to improve the quality of products allowing for more precise diagnostics. The purpose of this research is to employ the CFSRR products to investigate the heat and moisture sources in the Pan American region, their links to variability and extreme events, and to translate this into useful information to improve the CPC monsoon monitoring and prediction activities over Pan America. The expected better forecasts of extreme events will also lead to improved CPC hazard assessments and drought prediction. Our work takes an integrated approach to the North and South American monsoon where the role of the IAS as a heat and moisture source will be assessed. The main goal of this proposal is to "improve the understanding of the mechanisms involved in the seasonal evolution and variability of the Pan American Monsoon, and provide support to the CPC task of monitoring and predicting hydroclimate on time scales from intraseasonal to seasonal". To address this goal, the following objectives are posed: (1) Evaluate and diagnose, from CFS Reanalysis products, the seasonal evolution of the heat and moisture sources of the Pan American monsoon system and their relation to circulation and precipitation; (2) Contribute to CPC monitoring activity by investigating the variability and extremes of the Pan American circulation and precipitation in the CFS Reanalysis; (3) Assess the ability of the CFS Reforecasts to predict hydroclimate of Pan America including drought/flood extremes, and apply the results to drought monitoring and hazard assessment. Our research will be done in close consideration of CPC needs. The co-PI works at CPC and therefore will ensure that our results are transitioned to operations in a timely manner. The PI has worked for many years in collaboration with NCEP scientists (EMC and CPC) and his research results have helped identify model deficiencies and improve parameterizations of the operational regional model.</td></tr>
<tr><td>Lance F. Bosart, University at Albany/SUNY</td><td>Intraseasonal and Interannual Variability of the North Pacific Jet Stream: A Governor of Seasonal Climate Predictability in the Americas</td><td>2009</td></tr>
<tr><td colspan="3">This proposal addresses the problem of how variability in the location and intensity of the North Pacific jet stream on intraseasonal and interannual time scales contributes to cool seasonal climate predictability and the occurrence of extreme weather events over the Americas. Fluctuations in the location and intensity of the North Pacific jet stream respond to ENSO on interannual time scales, the AO/MJO on intraseasonal and seasonal time scales, and the interaction of anomalous tropical heating anomalies with higher latitude upper-tropospheric disturbances on weekly to intraseasonal time scales. A better understanding of the physical processes that contribute to cool season climate variability and predictability over the Americas requires consideration of how the behavior of the North Pacific jet stream responds to tropical-extratropical and arctic-extratropical forcing on these time scales. Accordingly, this</td></tr>
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Allen Bradley and Anton Kruger, University of Iowa; Stuart S. Schwartz, University of Maryland Baltimore County	The Use of Retrospective Hydrologic Forecasts for Forecast System Improvement Using Hydrologic Forecast Verification Concepts	2009
Abstract: Long-range hydrologic forecasts on climate time scales, either from the National Weather Service (NWS) Advanced Hydrologic Prediction Services (AHPS), or as envisioned for nation-wide hydrologic outlooks, have significant potential use in water supply and drought management. But as is evidenced by recent research, advances in translating skillful climate information for hydrologic forecasting can only be achieved with a suitable archive of retrospective climate forecasts; such data sets provide an objective means for evaluating and correcting both the biases that exist in existing climate forecast products, and the inherent mismatch in scales between dominate climate and hydrologic processes. Likewise, for any long-range hydrologic forecasting system to be useful for water resources management, the generation and archival of retrospective hydrologic forecasts must be an integral component of the forecasting system. The objective of this project is to develop tools and techniques to use archives of retrospective hydrologic forecasts for systematic evaluation and improvement of long-range hydrologic forecasting systems for water resources applications. This will be accomplished by using previously developed capabilities for retrospective forecast generation with the NWS River Forecasting System (NWSRFS), and extending the scope and structure of the AHPS Verification System (AHPS-VS), a prototype system under development at IIHR, to (1) develop a broad suite of summary diagnostic verification measures suitable for evaluating and identifying forecast deficiencies on a regional or national scale, (2) develop optimal ways (based on Bayesian updating) to combine information from archive retrospective forecasts, with ensemble predictions of the operational system, to generate more skillful hydrologic ensemble products, and (3) develop methods to quantify improvements from changes to forecast system components based on rigorous statistical hypothesis testing. This work will build on our collaborations with the RFCs and the NWS Office of Hydrology, and is aimed at their goal of implementing the forecast improvement cycle paradigm within an operational hydrologic forecasting setting. Furthermore, the proposed system will		

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<tr><td colspan="3">Abstract: It is well recognized that atmospheric and hydrometeorological conditions in the Americas are affected by quasi-stationary tropical heating associated with El Nino and La Nina events, even though these events occur many thousands of kilometers away. What is less appreciated is that there are many other heat sources in the tropics that also have the potential to affect conditions in the Americas. These heat sources, associated with variations in SST or with intrinsic atmospheric phenomena including the Madden-Julian Oscillation, eastward propagating Kelvin waves and westward propagating mixed Rossby-gravity waves, can have a wide variety of three-dimensional structures and temporal behaviors. But because of the short observational record and the expense of AGCM experimentation, there has been no way to systematically study the remote effect of such sources on the Americas. The proposed study plans to address this situation by using the Fluctuation-Dissipation Theorem to produce a collection of linear operators that give the response of the atmosphere to tropical heating functions of arbitrary structure and temporal dependence. These operators will give the response in terms of the reaction of the mean circulation, synoptic eddy statistics, atmospheric moisture content, precipitation rate and the likelihood of extreme rainfall events. Some operators will be designed to give essentially the same response to such forcings as would be given by comprehensive atmospheric general circulation models. Others will give approximations of how nature would respond. As a result of encapsulating the response characteristics of the atmosphere in simple linear operators, the proposed study will be able to address questions that cannot be considered through observational analysis or AGCM experimentation. Using these operators the investigation will systematically determine and characterize how the remote response to heating is a function of the heating structure, of the geographical location of the heating, of the temporal behavior of the heating and of the season the heating occurs. The investigation will also use the response operators to address three specific topics related to predictability and the Americas. First, the operators will find those tropical heating patterns, on different time scales, that optimally influence circulation, rainfall, moisture transport, synoptic eddies, etc over the western US as these quantities relate to phenomena including West Coast rainfall, Great Plains drought and extreme rainfall events. Second, they will be used to find those heating patterns that optimally affect mean fields, including vertical shear and humidity, that affect the likelihood of tropical storms in the Inter-American Seas. Third, they will be used to construct Green's functions that indicate how heating at each position of the IAS affects specific atmospheric and hydrometeorological properties in neighboring regions. Together these results will determine whether there are sources of potential predictability in the Americas resulting from tropical heating on various time scales that has not been recognized and exploited to date.</td></tr>
<tr><td>Fei Chen, NCAR</td><td>Including the Impacts of Forest Disturbances in Western North America in Climate Models</td><td>2009</td></tr>
<tr><td colspan="3">Abstract: Forest structure plays a major role in forest hydro-climate through its impact on interception, surface radiation budgets, precipitation, soil moisture, evapotranspiration, snow accumulation and ablation, and subsequent runoff. Over the past decade, warming, severe drought periods, and dense forest conditions have resulted in unprecedented levels of forest mortality from bark beetle outbreaks and wildland fires across the western mountain regions of North America. These natural disturbances (insect infestation and wildland fire) significantly alter the physical and physiological properties (e.g., albedo, emissivity, roughness length, canopy resistance) of forests, and therefore affect land-atmospheric exchange, boundary layer structure, snow accumulation and ablation, and cloud characteristics and precipitation. Despite large disturbance areas, however, these physical processes are not represented in current regional and global climate models. The proposed study will combine field observations, remote sensing imagery, and modeling to a) improve the understanding of changes to physical and physiological properties following bark beetle outbreaks and wildland fires, b) include changes in these variables in regional climate models, and c) assess impacts on atmospheric and hydrologic processes. We will first quantify recovery trajectories of biophysical variables following natural disturbance. These findings will be utilized to improve representation of disturbances in the Noah land surface and the coupled Weather Research and Forecasting (WRF)-Noah regional climate models. We will then assess the effects of these disturbances in western forests on intraseasonal to interannual climate variability, focusing on warm season transport of heat and water vapor, and precipitation, and on cold-season snow accumulation, melt, and runoff. Specifically, we will:
1. Collect field observations and remote sensing data for the last ten years over the western mountain regions in North America (primarily focusing on US and Canada).
2. Analyze these data a) for model evaluation and b) to assess the recovery of physical and physiological parameters important for land surface modeling in forested regions following bark beetle outbreak and wildland fire.
3. Use the Moderate Resolution Imaging Spectroradiometer (MODIS) fire products to identify areas impacted by fire, and develop new MODIS-based products to detect tree mortality caused by bark beetle epidemics.</td></tr>
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4. Improve the presentation of these disturbances in the Noah land surface model through the use of more accurate land cover data and incorporation of modified model parameters and physical processes. 5. Perform 10-year uncoupled simulations to quantify the impacts of affected forests on surface exchange of heat and water vapor, precipitation, snow accumulation, and runoff, and evaluate simulations with observations. 6. Conduct ensembles of regional climate simulations with the enhanced WRF/Noah coupled model for selected years to investigate the impacts of the improved realism in representing the modified forest structures on intra-seasonal to interannual climate variability. Our study will be the first to 1) quantify the effects of natural disturbances on biophysical properties over large areas, 2) incorporate these impacts into land surface and regional climate models, and 3) assess impacts on intraseasonal to interannual climate variability.		
Qi S. Hu, University of Nebraska-Lincoln	Understanding and predicting tropical and North Atlantic SST forcing on variations in warm season precipitation over North America	2009
Abstract: The overall objective is to use diagnostic and modeling methods to decipher and understand physical processes/causal links that connect tropical and North Atlantic sea surface temperature (SST) variations associated with the Atlantic Multidecadal Oscillation (AMO) to changes in atmospheric circulation and warm season precipitation regimes for North America. The ultimate goal is to include representations of these processes in forecast models, and thereby improve predictions of summer rainfall variations at intraseasonal, interannual, and decadal timescales for North America, particularly the monsoon region and the central U.S. Scientific questions that will be addressed are: How do the heat and momentum flux anomalies arising from AMO forcing act to develop anomalous regional circulation and rainfall in North America during different phases of AMO? Are atmospheric eddy heat and momentum fluxes and circulation anomalies during different phases of AMO sufficient to account for observed summer rainfall regime changes in North America, and if so, how? How have Pacific Decadal Oscillation (PDO) and ENSO interacted with AMO effects on circulation/rainfall regimes for North America? How have spring soil moisture anomalies interacted with the specific warm season eddy heat and momentum flux anomalies for North America during different phases of AMO to modulate rainfall development and variation? How can the AMO forcing be included in forecasting models and improve summer rainfall predictions? Methods used include the Eliassen-Palm diagnostics, which will be used to quantify eddy heat, momentum, and energy fluxes driven by SST anomalies related to AMO and effects of these eddy fluxes on circulation and summer rainfall regimes for North American during different phases of AMO. Both general circulation model (GCM) and regional climate model will be used to determine AMO forcing and its modification by PDO and ENSO. Specifically, the atmospheric GCM will be integrated with observed SST forcing in the central and North Atlantic Ocean, and climatological SST elsewhere. Additional GCM runs with SST forcing from the Pacific Ocean will be made in order to identify their effects on the AMO induced circulation and rainfall patterns in North America. Regional model will be integrated with initial condition and lateral forcing from observations and GCM output in order to examine in detail changes in moisture and energy transports, precipitation development, and their intraseasonal and interannual variations during the different circulation regimes associated with AMO. Regional model also will be used to examine feedbacks of land surface processes (e.g., soil moisture) to the circulation anomalies and rainfall development during different phases of AMO. The expected key outcome is improved understanding of how summer rainfall variations on intraseasonal and interannual timescales are associated with the forcing from AMO and how these variations have changed during different phases of AMO (thus explaining also decadal timescale variations in summer rainfall in North America). This understanding will be communicated to forecasting modeling groups, with the ultimate goal of improving predictions of intraseasonal and interannual rainfall variations (including likelihood of floods) for North America.		
Xianan Jiang, UCLA	Two Dominant Modes of the Subseasonal Variability of the Eastern Pacific ITCZ: Connections between Extreme Events, Subseasonal and Interannual Variability	2009
Abstract: Recent analyses of boreal summer subseasonal variability (SSV) in the eastern Pacific (EPAC) have documented three new features that have bearing on weather/climate variability and predictability in the American sector [e.g., gulf surges, easterly waves, tropical cyclones, N. American monsoon (NAM)]. The first is that apart from the reported MJO-like eastward propagating feature of the 40-day mode in this region, analysis shows that this		

mode also exhibits northward propagation that is theoretically and observationally consistent with the "vertical shear" mechanism put forth to understand the northward propagation of Asian summer monsoon SSV (Jiang et al. 2004; Jiang and Waliser 2008a). The second new feature is the identification and preliminary characterization of a 20-day mode in the EPAC that is clearly separable from the 40-day mode and dominated by northward propagation (Jiang and Waliser 2008b). The third new feature stems from our preliminary analysis of the co-variability between these two modes that shows them to be anti-correlated on interannual time scales. The latter suggests that an aspect of the background state - possibly the strength of the easterly vertical shear which is likely tied to ENSO in some cases - might dictate the relative prevalence of these two modes, and in turn the weather/climate phenomena and extremes that they influence. There are a number of important issues and questions associated with these two modes that arise from these findings, including a need for: i) a more thorough observational description, ii) an understanding of their maintenance and propagation mechanisms, and iii) assessments of their predictability, connections to extreme weather events, and the capabilities of contemporary weather and climate models to forecast and/or represent these modes. With these needs in mind, along with the potential importance that these two modes play in American sector weather/climate, we propose the following research objectives: 1. More fully characterize the 40-day and 20-day modes, including their 3-dimensional dynamic and thermodynamic structures, air-sea fluxes and SST, and low-frequency variability. 2. Quantify the impact of these two modes, both individually and in combination, on extreme rainfall events (e.g., Gulf surges, easterly waves, tropical cyclones, N. American monsoon). 3. Based on item 1), determine the extent that the vertical shear versus air-sea interaction may be operating for these two modes to induce northward propagation. 4. Based on items 1) and 3), quantify aspects of the background state, including lower frequency variability, that may be responsible for the interannual prevalence of these two modes. 5. Determine how well the NCEP CFS/CFSRR and GFDL GCM predict and simulate these two SSV modes, including their interannual relationships and connections to extreme events. 6. Assess the predictability of these two SSV modes using the CFSRR and empirical models. Achieving the above objectives is key to fully characterizing how subseasonal variability in the EPAC influences boreal summer N. American weather and climate variability. This research directly addresses the CPPA goals of determining the "Sources and limits of climate predictability for the Americas at intraseasonal to interannual time scales", primarily in regards to "1) diagnostic analyses and modeling studies on climate predictability" in the American sector and secondarily to "3) predictability of the statistical occurrence of high-impact extremes".		
Jin Jiming, Utah State University	Modeling and Analysis of the Impact of Lakes on Seasonal and Interannual Climate Variability Over the Contiguous United States Using a Regional Climate Model	2009
In response to the NOAA request for proposals in the Climate Prediction Program of the Americas (CPPA), *we propose to use an advanced regional climate model coupled with a sophisticated lake model to identify the role of small lakes (which are typically unresolved and thus absent in coarse resolution climate models) in the regional climate system and quantify how lake-atmosphere interactions affect regional climate predictability at seasonal and interannual scales over the contiguous United States (CONUS)*. Global climate change has pronounced impacts on the well-being of our society at regional scales, and accurate prediction of regional climate is crucial for improved assessments of such impacts. However, process-level mechanisms and parameterizations related to the impact of lakes on regional climate predictability have not been adequately addressed. In this project, we will collaborate with the Environmental Modeling Center team at National Centers for Environmental Prediction (NCEP) to couple a sophisticated lake model into the Weather Research and Forecasting (WRF) model version 3.0. Using this coupled model, we will quantitatively study the contribution of lake processes to regional climate variations and better understand the key physical factors and mechanisms that regulate lake-atmosphere interactions over the CONUS where around 7% of its total area is occupied by lakes. The lake model to be used is retrieved from the Community Land Model version 3 (CLM3) developed by the National Center for Atmospheric Research (NCAR). This lake model has 10-layer water with the top layer as 0.1 m and the total depth as 50 m, and it explicitly describes water and heat flux exchanges between lake surfaces and the atmosphere, lake surface freezing-thawing processes, and snow on the ice. The land surface model we will choose within WRF is the unified Noah land surface model that is used in NCEP regional and global weather and climate forecasting models, and in many other research and		

forecasting institutions. This model is configured with four-layer soil, one-layer vegetation, and a snow layer. However, a lake scheme is ignored in this model where lake surface temperatures are inputted from the forcing data that are often derived from the coarse resolution global model output or remote sensing data. Thus, coupling the sophisticated lake model into Noah will be a necessary step in improving the Noah's capacity to better describe lake processes.

The coupled WRF-Noah-Lake (WNL) will be extensively calibrated and validated with in-situ observations and remote sensing data. Meanwhile, we will compare results from the WNL with those from our in-house version of WRF that has been coupled with CLM3 and the same lake model (WCL) and investigate how lakes interact with other land use types. Additionally, we will force both WNL and WCL with the 6-hr North American Regional Reanalysis (NARR) data at 32 km resolution to perform three sets of sensitivity simulations over the period of September 1996 through December 2002, where the first four-month simulations will be discarded to alleviate the impact of the initial conditions. The model spatial resolution will be set to 5 km to resolve the small lakes with an area down to 25 km2. The first set of six-year plus simulations will be carried out without lakes, where the lake points will be replaced with the soil and vegetation types of the closest neighboring land points. In the second set of simulations, we will use inputted NARR surface temperatures for lakes in the CONUS without operation of the lake model in both WNL and WCL. In the third set of simulations, the lake model in both WNL and WCL will be fully operated, where lake-atmosphere interactions will be dynamically simulated. Detailed analysis will be conducted with these simulations to explore the importance of lakes to regional climate predictability and the significance of lake-atmosphere interactions in the regional climate system. At the same time, we will investigate the contribution of lake processes to seasonal and interannual climate variations. *The results from this project will yield new advances in regional climate predictability, leading to a better understanding of the regional climate system and improved forecasts of regional climate and hydrological cycles.*

Ruby Leung, Battelle, Pacific Northwest Division; Xu Liang, University of Pittsburgh	The Role of Surface, Subsurface, and Vegetation Processes on Droughts	2009

Abstract: Drought is a recurrent feature in many parts of the U.S. Multi-year droughts, in particular, are very devastating and costly. Previous studies have suggested that droughts are initiated by seasurface temperature anomalies that induce changes in the atmospheric circulation, and hence moisture transport and precipitation. However, some studies have also suggested that once a drought is initiated, it may be prolonged or strengthened by regional scale land-atmosphere feedbacks. Because of the inherent longer time scale, both surface and subsurface processes may be particularly relevant for multi-years and decadal droughts. To realistically represent landatmosphere interactions, and their influence on droughts, we need to consider surface, subsurface and vegetation processes as an integrated system. We propose to focus our investigation on processes that are closely related to evapotranspiration and soil moisture, including: (1) hydraulic redistribution (also called hydraulic lift), (2) plant water storage, (3) dynamical interactions between regular/deep roots with the varying groundwater table and root growth during dry periods, and (4) response of plant phenology to drought.

We hypothesize that plants modulate droughts at the initial stage through hydraulic redistribution by roots, root growth, and changes in water storage to tap moisture in the deeper soil layers or groundwater table, and stomatal response to maintain transpiration. However, when the groundwater table falls below a critical level, droughts can be intensified and sustained as plants and surface processes become decoupled to subsurface processes such that reduced surface soil moisture and plants transpiration accelerate the drying through land-atmosphere interactions.

To test this hypothesis, we propose model development to include the effects of hydraulic redistribution and plant storage in the transpiration process, and integrate these effects with a stomatal conductance representation that explicitly considers the dependence of the net rate of photosynthesis and water use. We will also develop a simple plant model of seasonal leaf growth and root growth, and implement these developments in the Variable Infiltration Capacity (VIC) model, which already includes a dynamic representation of groundwater table, and to couple VIC with the Weather Research and Forecasting (WRF) model to simulate land-atmosphere interactions. Offline and coupled simulations will be performed to test our hypothesis, and to investigate the potential impacts of land use change and CO_2 on modifying the ability of vegetation to cope with droughts and influence droughts.

This proposal is responsive to the CPPA solicitation to investigate the predictability and mechanisms of droughts, with a particular focus on the role of local land surface interactions on the maintenance and amplification of droughts. The model development efforts proposed here will benefit NOAA as WRF is the primary mesoscale forecast model in operational use at NCEP/EMC, and will likely also be used for operational/experimental seasonal climate forecast at the regional scale.

Maloney E.D., Colorado State University; Xie S.P., University of Hawaii	Remote versus local forcing of intraseasonal variability in the IAS region: Consequences for prediction	2009

Abstract: Strong intraseasonal variability in hurricanes and other extreme events occurs over the Intra- Americas Sea (IAS) region during boreal summer. Observations and global and regional climate models indicate significant 50 day spectral peaks in precipitation, winds, SST, and synoptic-scale wave activity in the IAS region. While the global Madden-Julian oscillation (MJO) is likely a significant influence, the extent to which intraseasonal variability in the IAS region can be generated in isolation from remote influences is an open question. Of interest for prediction, evidence exists that strong MJO precipitation variability in the west Pacific can generate atmospheric Kelvin wave fronts that propagate eastward into the IAS region and initiate intraseasonal events. It is notable that the genesis of Hurricane Katrina coincided with propagation of a cold intraseasonal Kelvin wave from the west Pacific into Americas. If intraseasonal variability in the IAS region is primarily remotely forced, significant forecast lead time may exist for the onset of strong intraseasonal events in the IAS region. The following questions will be addressed in an observational and multi-model approach:

1. Is intraseasonal variability in the IAS region primarily locally or remotely initiated?

We will use regional and global models to assess the remote versus local control of intraseasonal variability in the IAS region. Lateral boundary conditions in the IPRC regional oceanatmosphere model (IROAM) will be modified to either admit or suppress intraseasonal dynamical signals entering the IAS domain from the west Pacific. Experiments will also be designed to suppress remote intraseasonal influences on the IAS region in a global general circulation model (NCAR CAM3 with relaxed Arakawa-Schubert convection).

2. How does remote forcing by intraseasonal Kelvin wave fronts initiate intraseasonal variability in the IAS region?

We intend to examine how intraseasonal Kelvin waves propagating into the IAS region from the west initiate intraseasonal convective events. A moist linear baroclinic model (mLBM) will be used to demonstrate the impact that west Pacific heating variations have on producing intraseasonal Kelvin waves that propagate out of the west Pacific and into the IAS region. QuikSCAT winds will be also used to test whether associated surface frictional convergence and wind-induced surface flux variations can initiate IAS convection.

3. What local feedbacks regulate intraseasonal variability in the IAS region?

Regardless of whether intraseasonal events in the IAS region are remotely or locally initiated, local feedbacks appear necessary to support such variability. Model sensitivity tests and observational tools will be used to examine the importance of ocean coupling, surface fluxes, and land-sea contrasts to intraseasonal variability. It will also be examined whether variations in tropical cyclones and synoptic-scale disturbances feedback onto the intraseasonal timescale through their impact on atmospheric moisture and energy budgets

4. What are the consequences of local or remote forcing for prediction of tropical cyclones?

Given the potential lead times provided by forcing of intraseasonal Kelvin waves in the west Pacific, and the time it takes these waves to reach the IAS region, we will explore whether exploiting such lead times improves skill in forecasting periods of enhanced and suppressed tropical cyclone formation in the east Pacific, Caribbean Sea, and Gulf of Mexico. The primary environmental variables regulating such cyclone variability will be examined.

Adam H. Sobel, Columbia University	The Madden-Julian Oscillation: Model Development and Diagnosis of Mechanisms	2009

Abstract: We propose a project with the following tightly coupled objectives: 1. Contribute to improving the simulation of the Madden-Julian Oscillation (MJO) in the Atmosphere Model 3 (AM3) of the Geophysical Fluid Dynamics Laboratory (GFDL); 2. Provide understanding of MJO physics by diagnosing the mechanisms operating in the AM3. To address Objective 1, we propose to test different triggering and physical assumptions in the Donner convective parameterization in AM3 including 1) setting a minimum entrainment criterion for deepest convective plumes, 2) increasing entrainment rates for cloud ensemble members, 3) modifying the treatment of mesoscale processes (including heating profiles), 4) gauging sensitivity to rain re-evaporation (precipitation efficiency), and 5) employing explicit relative humidity triggers. Diagnostics developed by the CLIVAR MJO Working Group and more targeted advanced diagnostics, including full moist static energy budgets, will be used to assess the MJO simulations produced by these different models.

To address Objective 2, we will first determine the AM3 simulation that produces the most realistic simulation of intraseasonal variability from the simulations done to address the first objective, and then use it to perform mechanism denial experiments which isolate the importance of various physical mechanisms for the MJO. These mechanisms including wind-evaporation feedbacks, cloud-radiative feedbacks, moisture-convection feedbacks,

frictional wave-CISK, and stochastic forcing from the extratropics. The impact of ocean coupling will also be examined. The proposed work will involve a close collaboration among scientists at Columbia University, Colorado State University, and University of Washington. Close contact will also be maintained with the Atmospheric Model Development Team at GFDL.		
Chunzai Wang, NOAA/AOML	Diagnostic and Modeling Studies on Impacts, Mechanisms and Predictability of the Atlantic Warm Pool	2009
Abstract: Our current CPPA-funded research, using the NCAR CAM3 and observations, has pointed out the importance of the Atlantic warm pool (AWP) for summer climate and hurricanes. AWP variability occurs on various timescales, with large AWPs being almost three times larger than small ones. The CAM3 runs show that the effect of the AWP is to weaken the summer North Atlantic subtropical high, especially at its southwestern edge, strengthen the summer continental low over the North American monsoon region, and weaken the easterly Caribbean low-level jet and its westward moisture transport. The model runs also show that a large AWP weakens the southerly Great Plains low-level jet, which results in reduced northward moisture transport from the Gulf of Mexico to the U.S. east of the Rocky Mountains and thus decreases the summer rainfall over the central U.S., in agreement with observations. Decreased rainfall, if it persists, can cause drought in North America. A large (small) AWP also reduces (enhances) the tropospheric vertical wind shear in the hurricane main development region and increases (decreases) the moist static instability of the troposphere, both of which favor (inhibit) the intensification of tropical storms into major hurricanes. Despite these modeling studies, we do not know the AWP predictability and the AWP impact on climate predictability in the Americas. We propose to continue our investigation of the AWP by diagnosing coupled models and by performing coupled model runs to assess and improve AWP predictability and its climate impacts. The diagnostic analyses will focus on mechanisms and climate impacts of the AWP in IPCC models and available data. These will include (1) variability of the AWP; (2) variability of the North Atlantic subtropical high; (3) variability of the easterly Caribbean low-level jet and its moisture transport; (4) variability of the southerly Great Plains low-level jet and its moisture transport; (5) the relationships of U. S. rainfall with the AWP, low-level jets and the North Atlantic subtropical high; (6) the effects of external influences versus local ocean-atmosphere processes on AWP variability; (7) the relationships among environmental factors contributing to Atlantic hurricanes; (8) extreme events such as tornados and Midwest floods and their relationships with moisture transport from the AWP region; and (9) models' biases in the AWP region and sources that contribute to the models' biases. The coupled model runs will use the Community Climate System Model version 3 (CCSM3). Our CCSM3 experiments will focus on AWP predictability and AWP impact on climate predictability. We will use an approach of "anomaly-coupling" to minimize the climatological biases in CCSM3 and thus to improve the model's ability in simulating AWP variability. We will also use the so-called "regional coupling" technique to isolate the climate impacts of the AWP from other known impacts, and the local air-sea feedbacks from the remotely forced impacts on the AWP. The proposed work directly addresses two of the FY09 CPPA's priorities: (1) "*Diagnostic analyses and modeling studies on climate predictability in the IAS region and IAS impact on climate predictability in the America*" and (2) "*predictability of the statistical occurrence of high-impact extremes in the U.S., such as floods, hurricanes, heat waves and winter storms*". When successfully combined with land-based models it is hoped that over a longer time frame this work will contribute to the regional implementation of data- and model-based outlooks for climate variability and danger alerts for floods and drought in the United States. In addition, our proposed work will provide a valuable guidance to the future development of process studies in the AWP region which is already endorsed by the CLIVAR-VAMOS Panel.		
Eric F. Wood, Princeton University, and Dennis P. Lettenmaier, University of Washington	Development of an experimental national hydrologic prediction system	2009
Abstract: *Introduction to the Problem:* CPPA supports research that will lead to improved operational intraseasonal to interannual climate and hydrologic predictions. Part of the overall goal of CPPA is to improve the use of NOAA seasonal forecast products for hydrologic and water resources applications, including the National Integrated Drought Information System (NIDIS). Through prior support from CPPA and its predecessor programs, the PIs have developed hydrologic and drought nowcast and forecast methods based on, among other CPPA-funded efforts, the North American Land Data Assimilation System (NLDAS). These efforts have lead to testbeds at both the		

University of Washington and Princeton University for advanced seasonal hydrologic forecast methods that utilize NOAA climate forecasts in real-time. These include ESP-based methods whose heritage derives from work within the NWS Office of Hydrologic Development, and climate forecasts produced by NCEP. We believe that we are now poised to integrate this previous work into a true national experimental hydrologic forecast system as envisaged in the CPPA Information Sheet ("*Develop U.S. nation-wide hydrologic outlooks...[and] demonstrate that nation-wide hydrologic forecasts can be applied at scales useful for water resources management*." The system we propose will combine land surface schemes developed over the last two decades with methods of improving hydrologic initial conditions (land data assimilation). We will also leverage from our previous work to produce unified reservoir storage forecasts on a national scale. A key aspect of the proposed system will be multi-model ensembles -- both multiple hydrologic models, as currently used to produce nowcasts in the UW Surface Water Monitor, and multiple climate model forecasts used in the current Princeton system for drought forecast and recovery purposes. *Rationale:* This proposal, which is a collaboration of Eric Wood at Princeton University (PU) and Dennis Lettenmaier at the University of Washington (UW), responds to the third area solicited on the CPPA Information Sheet (Hydrologic and water resources applications). It will integrate past CPPA-funded research by the PIs and others in the development and application of land surface models for ensemble hydrologic prediction purposes. The PIs have worked closely with the NCEP CPPA Core Project team, and will extend this collaboration to the OHD element of the Core Project and the Colorado and Ohio River Forecast Centers to integrate ongoing hydrologic applications work within NWS with CPPA research relevant to national scale hydrologic prediction. *Summary of work to be completed:* We will integrate the hydrologic forecast methods and products developed under previous CPPA research into an experimental national hydrologic prediction system through the following tasks. *1. Integrate existing UW and Princeton hydrologic forecast and drought recovery systems to produce seamless national hydrologic nowcasts and forecasts at a common spatial resolution; 2: Expand the unified system to include multiple land schemes; 3. Implement improved methods of parameter transfer from catchment-scale model implementation to the gridded national system; 4. Develop an ensemble seasonal reservoir storage capability for large reservoirs; 5: Implement methods for hydrologic forecast error estimation and forecast verification; 6: Develop methods of assimilating streamflow observations to overcome uncertainties in the first month(s) of seasonal hydrological forecasts; 7: Develop GFS-based near-term hydrologic forecast capability to improve month-1 outlooks and provide a seamless hydrologic forecast suite bridging weather and climate time scales.*		
Renguang Wu (Center for Ocean-Land-Atmosphere Studies)	Atmosphere-Ocean Interactions and Summer Rainfall Variability and Predictability in the Intra-Americas Region	2009
Abstract: This proposal will perform diagnostic and modeling studies to understand the roles of regional atmosphere-ocean interactions and remote forcing (ENSO and tropical Atlantic variability) in the interannual variability and predictability of summer rainfall in the Intra-Americas (IAS) region. The boreal summer IAS region is characterized by active convection and very warm water. This type of environment is similar to the Indowestern Pacific warm pool region in that the air-sea interactions are subtle and delicate, yet critical for climate variability. These air-sea interactions not only affect the local climate variability in the highly populated land areas in the IAS region, but also influence U.S. climate through modulating the moisture transport. The objective of the proposed research is to understand atmosphere-ocean feedbacks and identify limitations and successes of current models in simulating the atmosphere-ocean relationship in the IAS region. This objective will be attained through diagnostics of observations and model outputs and numerical experiments. First, the atmosphere-ocean relationship in observations will be documented by examining the local relationship between rainfall or surface heat flux and SST or SST tendency. The evolution of atmospheric and SST anomalies associated with ENSO and tropical Atlantic variability will be examined in detail to understand processes for their delayed impacts on summer rainfall in the IAS region. Second, the above analysis will be performed for NCEP CFS simulations and CFS retrospective forecasts to evaluate the ability of the CFS in characterizing the atmosphere-ocean feedbacks in the IAS region and to identify deficiencies and plausible reasons. Third, numerical experiments with the CFS will be performed with SST forcing (climatology or total) specified in the Pacific Ocean or the Intra-American Seas to demonstrate the impacts of ENSO and regional atmosphere-ocean coupling on the climate in the IAS region. Fourth, the predictability for summer rainfall in the IAS region will be estimated based on the CFS retrospective forecasts. This estimation will be done for ENSO and non-ENSO years and for normal and abnormal tropical Atlantic SST years in order to identify the potential impacts of ENSO and the tropical Atlantic Ocean on		

the predictability. The proposed study is anticipated to advance understanding of atmosphere-ocean interactions, roles of regional and remote forcing in summer rainfall variability, and potential predictability of summer rainfall in the IAS region, and to reveal potential problems of the CFS in regional atmosphere-ocean relationship in the IAS region.

Chidong Zhang, University of Miami	Role of Diabatic Heating Profiles in MJO Simulation and Prediction	2009

Abstract: The importance of the Madden-Julian Oscillation (MJO) in bridging weather and climate has been increasingly recognized. Meanwhile, the challenges of correctly reproducing the MJO in climate models and accurately predicting the MJO by operational forecast models have yet to be met. Our current knowledge on the MJO and its simulation/prediction has led us to believe that cumulus parameterization is the key to solving the problem. But we cannot foretell whether a particular cumulus scheme would able to produce the MJO or not. And the reason for a particular parameterization-model combination to be successful or otherwise in this regard is often unclear. Many possibilities have been proposed. In this project, we will test the following hypotheses:
Hypothesis I: Whether a model can produce sufficient low-level diabatic heating in the tropics on the MJO scale is a major determining factor for its success or failure in simulating or predicting the MJO.
Hypothesis II: The Maritime Continents act as a barrier to MJO simulation and prediction partially because model errors in diabatic heating profiles are larger there than over the open oceans.
These hypotheses will be tested using the WRF model and NCEP CFS. We will diagnose diabatic heating profiles in WRF simulations made with different cumulus schemes with a range of capability of producing the MJO. This will lead to an assessment on the extent to which the success and failure of cumulus parameterization in the same model are related to their diabatic heating profiles. We will conduct numerica experiments using WRF to see how its MJO simulations might be improved if more realistic low-level diabatic heating is produced by its cumulus parameterization and the extent to which cloud-resolving simulations are advantageous over those with cumulus parameterization because they produce more realistic diabatic heating profiles.
Meanwhile, subseasonal hindcast runs by NCEP CFS will be diagnosed to explore the degree to which variations in MJO prediction skills are related to errors in predicted diabatic heating profiles in comparison to those derived from NCEP reanalyses and sounding observations. In diagnoses of both WRF and CFS runs, we will pay special attention to diabatic heating profiles over the Maritime Continents.
Results from this research will advance our understanding of the MJO dynamics, help design a new metrics to evaluate cumulus parameterization schemes, identify a specific target for their improvement in the context of MJO simulations and prediction, and help NOAA to reach its Mission Goal: Understand climate variability and change to enhance society's ability to plan and respond.

Guang J. Zhang, Scripps Institution of Oceanography	Understanding and Improving the Simulation of Madden-Julian Oscillations in Global Climate Models	2009

Abstract: The Madden-Julian oscillation (MJO) is one of the most important modes of variability in the tropics. Significant progress has been made observationally in documenting its characteristics. In contrast, progress in numerical simulations of MJOs is much slower, particularly in global climate models (GCMs). A recent study shows that most of the GCMs that participated in the IPCC AR4 are deficient in MJO simulation. Possible causes for this include incorrect vertical heating profiles, lack of proper interaction between deep and shallow convection, lack of self-suppression process in convection, and inaccurate closure assumptions. All of these are related to convection parameterization. In this project, the PI proposes to improve the MJO and convection simulations in the NCAR and GFDL models by addressing these issues.
The methodology we use for the investigation is developing an improved convection parameterization by examining physical processes important to MJO development and carrying out sensitivity tests using the GCMs. We will focus on three factors that are deemed important to MJO: vertical convective heating profile, role of shallow convection, and role of convective downdrafts in providing a self-suppression mechanism for convection. Both observations and theoretical studies suggest that vertical heating distribution is important to MJO development. Since convective heating is largely determined by convective cloud mass flux, processes that affect the mass flux vertical distribution, e.g. lateral entrainment and detrainment, must be represented correctly in order to produce a realistic heating structure. We will use output from cloud-resolving model simulations of convection to determine the vertical structure of mass entrainment and detrainment, and use these results to constrain the entrainment and detrainment

rates in convection parameterization. Observations have also found that shallow convection plays an important role in MJO development by "preconditioning" the atmosphere for deep convection. To isolate, understand and eventually represent the roles of shallow convection in MJO simulations by GCMs, we will carry out a series of sensitivity tests. Finally, a recent study postulated that lack of self-suppression of convection in GCMs is responsible for most of the IPCC AR4 models' failure to produce a distinct peak in energy spectrum on MJO timescales. We hypothesize that one possible source of the problem is the lack of sufficient downdrafts. Since downdrafts can cool and dry the boundary layer air, it serves as an effective brake to cut the fuel for further convection. The strength of downdrafts in all convection parameterizations is seriously under-estimated. We will use the cloud-resolving model output to determine the vertical profile of downdrafts and use it to guide the parameterization of enhanced convective downdrafts. We expect that increased intensity of downdraft will lead to a more pronounced energy spectral peak at the MJO timescales. The PI plans to work closely with GFDL scientists. The parameterization scheme incorporating all the improvements from this project will be first tested using the NCAR GCM. It then will be incorporated into the GFDL model for further evaluation. With the additional evaluation, the PI expects an improved convection parameterization for better MJO simulation in the GFDL model.		
Bruce Albrecht, University of Miami, Rosenstiel School of Marine and Atmospheric Sciences	Studies of Cloud, Drizzle, Turbulence, and Boundary Layer Variability over the Eastern Pacific in Support of the VOCALS Regional Experiment	2008
Abstract: This project is designed to contribute to our understanding of the dynamical, turbulence, microphysical, and drizzle properties of extensive boundary layer cloud decks in the southeasterly trade winds. Specifically, we will contribute to key elements of the observational and modeling studies designed to address the VOCALS (VAMOS Ocean-Cloud-Atmosphere-Land-Study) science hypotheses involving aerosol-cloud-drizzle interactions within these climatically critical cloud systems. The proposed collaborative observational efforts will focus on in situ and remote sensing observations from systems operating on the RN Ron Brown (RB) in support of VOCALS REX during the planned Oct-Nov. 2008 cruises. Specifically, we will use radar observations to define the cloud microphysical, drizzle and turbulence characteristics in clouds associated with both coupled and decoupled boundary layers and relating these characteristics to the larger-scale variability associated with pockets of open cells (POCs), rifts and other aerosol/cloud variations observed from the ship, nearby research aircraft, or inferred from satellite observations. Turbulence and drizzle retrieval techniques that have been developed and applied to radar data sets collected previously will be applied to the Doppler moments and spectra from the stabilized W-Band radar to be operated by NOAA ESRUETL. In addition, we will operate the U. Miami (UM) WBand radar in a bi-static mode to provide drizzle characterizations within 30 m of the surface and to use the UM X-band radar to add dual-wavelength coverage of drizzle at heights above 200 m. The proposed observations and analyses will provide an unprecedented description of cloud, drizzle, and turbulence properties with high temporal and vertical resolution from continuous sampling of clouds and drizzle observed over the ship during the two three-week legs. These properties will be related to mesoscale cloud organization, boundary layer structure, surface fluxes, and macroscopic cloud characteristics obtained in collaboration with other investigators involved with the RB observations. We will continue our long-term collaborative efforts with Dr. Chris Fairall at NOAA ESRL with these efforts. The products from the radar analyses can be used to evaluate LES and estimate mass fluxes that can be used to evaluate parameterizations directly. The proposed turbulence, cloud and the drizzle retrievals will have a direct connection to the aerosol measurements from the RB to facilitate studies of I)th e effects of CCN on cloud and drizzle properties, 2) the effects of the evaporation of drizzle in modifying local aerosol spectra, and 3) defining cloud updraft statistics near cloud base for aerosol-cloud parameterizations. Broader Impacts: This study will be critical to graduate education and training and will include direct student involvement obtaining the ship borne observations and operating state-of-the-art remote sensing systems during VOCALS. The radar techniques to be developed and refined will have applications for other cloud and precipitation studies. This research is being carried out as part of the UM Cooperative Institute for Marine and Atmospheric Studies (CIMAS) and will contribute to two of its research themes: Theme I -Climate Variability and Theme 2: Air-Sea Interaction. Further, it will contribute to NOAA's strategic goal to "Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond".		
Ray Arritt, Eugene S. Takle, William Gutowski, Christopher J. Anderson, Iowa State University, Masao Kanamitsu, Scripps Institution of	Multi- RCM Ensemble Downscaling (MRED) of Multi-GCM Seasonal Forecasts	2008

Oceanography, L. Ruby Leung, Pacific Northwest National Laboratory, Hann-Ming Henry Juang, NCEP		
Abstract: The past success of RCMs in simulation and quasi-predictive modes comes from the ability of their higher resolution to better resolve: 1) the influence of orography, especially the role of regional elevated heat sources as central forcing mechanisms for monsoon circulations; 2) the diurnal cycle, especially the low-level nocturnal jets prominent, for example, in south central U.S. 3) summer season nocturnal precipitation maxima associated with these nocturnal jets; 4) SST gradients in nearby coastal ocean areas; 5) mesoscale convective complexes, which play a dominant role in summer precipitation anomalies; and 6) winter snow cover and snowmelt, especially in high orography areas. While there is a plethora of RCM simulation mode studies fully prognostic RCM studies are sparse, though some are emerging. To explore the utility and value of fully prognostic RCMs in operational seasonal to interannual climate prediction, CPPA is sponsoring a wider assessment and demonstration of fully prognostic RCM executions as part of its FY08 call. Each participating RCM will include a regional atmospheric model coupled to a regional land model, with or without coupling to a regional ocean model driven by a global coupled model. The specific goal is to involve multiple RCM groups to execute multiple RCMs in fully prognostic mode from global seasonal predictions in hindcast mode spanning multiple years across more than two decades. Such fully prognostic RCM seasonal forecasts will be comprised of several members from each participating RCM over a period of 27 years (1982-2008) or longer. The atmospheric and SST forecasts for these fully prognostic RCM seasonal predictions will be provided initially by the current NCEP Climate Forecast System (CFS), then the next version of the CFS system that will be available in 2009/2010 and finally the next version of the NASA coupled model that will also be available in the 2009/2010 time frame The coupled global forecasts and regional forecasts will be distributed to CPPA and other researchers via a public server. Each participating RCM must span at least the entire Coterminous United States (CONUS), with the spatial resolution of each RCM to be at least 35 km (close to that of the NCEP North American Regional Reanalysis, which will be a key validation tool). Additionally, each PI will use their own procedures for initializing their RCM atmospheric/land/ocean states. As potential sources of these initial states, NCEP and NASA will provide 1) the initial atmosphere, ocean and land states of their global models, 2) the atmosphere and land states of the updated NCEP Regional Reanalysis and 3) the land states of the NCEP Global Land Data Assimilation System. CPPA anticipates that most participating RCMs will not be initially coupled to a regional ocean model and hence NCEP and NASA will also offer the bias corrected CFS and NASA SST predictions as the source of global SST fields for use by the RCMs. The FY08 RCM prediction experiment will focus on the winter season. The members for the ensemble predictions must be executed from initial conditions on 10 separate days for both the NCEP CFS current and next model versions and NASA next model version during Nov. and Dec. and hence must be 5-6 month long forecasts that span from Dec. 1 through April 30. Altogether then, each participating PI must execute their chosen RCM in fully prognostic mode for 30 members (10 CFS current, 10 CFS next, 10 NASA next) of 5-6-month forecasts (at least 27 years x 30 members for the winter season beginning Dec. 1). Moreover, each PI must be able to execute all their RCM predictions on their own computing resources. The following dual benchmarks will be used for determining the "value added" of the fully-predictive multi-RCM seasonal predictions over and above those of the CFS suite: 1) comparison to the empirically or statistically downscaled and bias-corrected global predictions of the parent CFS and NASA models that provided the predicted lateral boundary conditions and 2) comparison to empirical seasonal prediction tools, such as ENSO compositing, Optimal Climate Normals (OCN), or CCA (Canonical Correlation Analysis). Other benchmarks will be established in the course of the experiment. Of special interest will be determining the added value of an RCM ensemble. The long RCM hindcast set is critical for quantifying the RCMs' ability to capture realistic interannual variability and to cast the RCM predictions more skillfully in terms of anomalies from each RCM's own climatology. Most importantly, the long 27-year RCM hindcasts are needed to compute CONUS skill maps with those of the CFS and NASA global model skill maps.		
Mathew Barlow, University of Massachusetts Lowell	Remote and regional forcing of US drought	2008
Abstract: Recent successes in simulating some aspects of severe US droughts suggest the potential for		

predictability of these economically catastrophic events. However, we do not yet have a good understanding of how well the droughts can be reproduced and to what extent errors in the simulations represent model limitations versus non-deterministic factors. Here we will tackle a key part of this problem, the role of convection in different parts of the Pacific in forcing severe US drought. This will both increase our understanding of the basic physical processes involved in forcing US drought and allow us to address an important predictability question: how much would improvements in the model's simulation of tropical convection improve our ability to simulate, and perhaps predict, severe US drought?

The goals of this project are to better understand the influence of Pacific convection on US precipitation during the three most severe droughts of the 20th century - the 1930s dustbowl, the1950s drought, and the 1999-2001 drought (still continuing, in some areas) - and the extent to which errors in the simulation of tropical convection limit our ability to correctly model US drought. The objectives of the proposed work are to: 1) identify the main areas of deep convection anomalies in the Pacific associated with the three droughts, 2) examine the influence of individual centers on each other and on US precipitation using both a GCM and a linear model, and 3) assess model limitations through comparison of AMIP-style drought simulations with "perfect" forcing simulations. We hypothesize: 1) severe US drought results from the combined nonlinear effects of both remote forcing, in the central and western Pacific, and regional forcing, in the eastern Pacific; 2) regional convective anomalies in the eastern Pacific not only influence central US precipitation but are also influenced by it, resulting in feedback between the two areas; and 3) accurate simulation of severe US drought is sensitive to the accurate reproduction of convective anomalies in the Pacific.

Observational analysis, linear modeling experiments, and full atmospheric modeling with the NCAR CAM will be used to identify the key centers of convection in the Pacific and examine their influence on US drought. We will use reconstructed ocean precipitation, reanalysis precipitation and vertical velocity, island stations, and ship reports to examine the centers for the 1950s and 1930s drought. The CAM has been modified so that convection patterns can be specified; we show the feasibility of our proposed observational and modeling approaches in a pilot analysis. The proposed work is directly relevant to the FY08 CPPA research area 3, predictability and mechanisms of drought. The proposed work will improve understanding and model simulation of large and regional-scale processes that influence surface hydrology over North America, and identify sources of model error in limiting predictability.

Alan Brewer, NOAA/ESRL	Shipboard Observations and Modeling of Aerosol-Cloud-Precipitation- Dynamical interactions in the South Eastern Pacific	2008

Abstract: The Southeast Pacific (SEP) climate is a tightly coupled system involving poorly understood interactions between aerosol, clouds and marine boundary layer processes, and ocean dynamics. The unique system is very sparsely observed, yet its variations have important impacts on global climate. VOCALS (VAMOS Ocean-Cloud-Atmosphere-Land Study) is an international CLIVAR program the major goal of which is to develop and promote scientific activities leading to improved understanding of the SEP ocean-atmosphere-land system. The VOCALS science program consists of two main themes: 1) aerosol, clouds, and precipitation (the focus of this proposal), and 2) ocean-atmosphere-land coupling.

We propose to study aerosol-cloud-precipitation interactions in stratocumulus during the VAMOS1 Ocean-Cloud-Atmosphere-Land Study (VOCALS). Our study comprises an observational component that will use NOAA's High Resolution Doppler Lidar (HRDL) to monitor aerosol structure and boundary layer dynamics in non-precipitating and precipitating regimes; and a modeling component which will simulate aerosol-cloud-precipitation interactions in a large eddy simulation model (LES). The lidar observations will provide unique information on (i) the sub-cloud clear-air dynamics of pockets of open cells (POCs) and their evolution; (ii) the effect of aerosol on cloud microphysics (in conjunction with other observations); and (iii) high resolution dynamical profiles over the course of the month-long experiment. We will develop an instrument simulator within the model to refine scanning strategies prior to deployment, and to compare the observed dynamical features of POCs with the modeled features. Lidar-derived dynamical profiles will be used to evaluate the LES and support parameterization efforts in larger scale models. The outcome of this work will be a significantly improved understanding of aerosol-cloud interactions in the Southeastern Pacific (SEP), and in particular, of the formation, evolution, and maintenance of POCs. ge and regional-scale processes that influence surface hydrology over North America, and identify sources of model error in limiting predictability.

Leo J. Donner, Jean-Christophe	Using VOCALS to develop and evaluate stratiform cloud	2008

Golaz, NOAA/GFDL	parameterizations incorporating sub-grid vertical velocity variability	
Abstract: We propose to participate in VOCALS Modeling and Regional Experiment (REx) using the GFDL GCM. The representation of clouds and aerosols in the GCM and the interaction between them will be the focal point of our participation. VOCALS-REx collected data will provide a unique dataset to carefully evaluate GCM prediction of aerosols and clouds in the VOCALS study region. In turn, speci c GCM experiments will be conducted to test some of the VOCALS-Rex synergy hypotheses. Speci cally, we plan to test the effect that anthropogenic aerosols exert on the GCM cloud eld. We also intend to investigate whether a poor representation of the marine boundary layer clouds and coastal winds contribute to systematic coupled GCM errors. Because the GFDL GCM climatology suffers from a negative cloud bias in the VOCALS-Rex study region, we also propose to implement and test a new boundary layer cloud parameterization. A key feature of this new parameterization will be the incorporation of sub-grid variability of vertical velocity, temperature and moisture. In particular, the sub-grid vertical velocity information will allow for a more realistic treatment of the activation of cloud condensation nuclei (CCN) in stratiform clouds, and therefore a more realistic representation of the interaction between anthropogenic aerosols and clouds.		
Christopher Fairall, Simon DeSzoeke, NOAA /ESRL, S. Yuter, North Carolina State University	Ship-based Observations of Air-sea Interaction and Stratocumulus Cloud-Aerosol-Drizzle Processes in VOCALS	2008
Abstract: Marine stratocumulus regions are important components of the earth radiation budget, yet models simulate the climate over these regions with critical errors. Improving understanding of aerosol-cloud-precipitation interactions within marine stratocumulus will help improve numerical modeling of cloud radiative properties at a range of model spatial and time scales. This proposal focuses on understanding the air-sea interactions associated with the atmospheric boundary layer coupling with the stratus deck off northern Chile, a sparsely observed region. The emphasis will be on observing and parameterizing aerosol-cloud-drizzle processes and their influence on the surface forcing of the ocean (radiative and turbulent). We propose a ship-based measurement program to obtain statistics on key surface, boundary layer, low-cloud macrophysical and microphysical, and radiative properties relevant to the VOCALS-REx field program planned for Oct. 2008 in the vicinity of the Woods Hole Oceanographic Institution's climate buoy at 20 S 85 W. Our activities will supply three types of essential observations: 1. C-band Doppler radar observations of the evolution of cloud and precipitation structures, necessary for understanding cloud processing of aerosols and feedbacks proposed for the maintenance of POCs. 2. Atmospheric soundings, providing the basic state of the atmosphere for all components of VOCALS REx and modeling activities. 3. Ship-based time series of cloud, surface, and flux properties to quantify air-sea interaction and close heat budgets of the upper ocean and atmospheric boundary layer. The observations will be made with the NOAA Earth Systems Research Laboratory (ESRL) seagoing flux and cloud observing system plus the ESRL wind profiler and scanning C-band Doppler radar resident on the research vessel Ron Brown. We will operate a second observing system (fluxes and bulk cloud properties) on a UNOLS research vessel proposed by Clayton Paulson (OSU). This proposal will be a collaborative effort between ESRL and North Carolina State University (NCSU) with ESRL investigators (Fairall and de Szoeke) taking responsibility for fluxes and cloud/PBL observations and NCSU investigators (Yuter) taking responsibility for the C-band radar and rawinsonde observations on the Ron Brown and the MicroRainRadar observations on the UNOLS ship. This study will also utilize VOCALS observations to analyze performance in this region of coupled global climate models used in the 4th IPCC assessment, of a large-eddy simulation cloud/aerosol model effort by G. Feingold, and of a coupled regional atmosphere-ocean model from the University of Hawaii. This proposed work will be done in collaboration with R. Weller (WHOI), the University of Miami (cloud radars), the Pacific Marine Environmental Laboratory (aerosols), Oregon State University (second ship), and the University of Hawaii (DMS flux). Yr 1 activities will focus on cruise preparation and data collection during the cruise. Yr2 activities will yield quick look products, initial versions of quality controlled products and intercomparisons. Final quality controlled data sets suitable for research available from VOCALS PIs will be available in Yr 3. Our plan is to integrate our ship-based data with that from other investigators and modeling teams in Yrs 3 and 4.		
Huei-Ping Huang, Yochanan Kushnir, Richard Seager, Lamont-Doherty	The Mechanisms and Predictability of Multi-basin Influences on North American Droughts	2008

Earth Observatory, the Earth Institute at Columbia University		
Abstract: This study aims to determine quantitatively the combined influences of the sea surface temperature (SST) anomalies in the tropical and subtropical Indo-Pacific Ocean, the tropical and subtropical Atlantic Ocean, the Intra-Americas Sea, and the Near-American Seas on North American droughts, and the mechanisms that facilitate the SST-drought connection on seasonal to decadal time scales. Analyzing ensemble general circulation model (GCM) and idealized dynamical model simulations, the proposed work will determine the optimal multi-basin combinations of SST anomaly patterns for producing rainfall anomalies over North America and assess the predictability for North American hydroclimate variability related to specific combinations of multi-basin SST anomalies. To accurately attribute predictability to regional SST anomalies, GCMs that are partially coupled to a mixed-layer ocean will be used to quantify the inter-basin interactions among the SST anomalies in the context of SST-drought connection. The dynamical mechanisms, including tropically forced stationary wave, the excitation of zonally symmetric circulation anomalies, and dynamically induced re-routing of moisture fluxes, will be studied using a hierarchy of general circulation and simplified dynamical models. The anticipated new results from this project will contribute to the practical goal of improving the framework of seasonal-to-interannual prediction of North American hydroclimate that utilizes the information from the SST anomalies of all major ocean basins.		
Dennis P. Lettenmaier, University of Washington	Seasonal hydrologic and drought predictability using the University of Washington west-wide seasonal hydrologic forecast system	2008
Abstract: The University of Washington west-wide seasonal hydrologic forecast system was designed to serve as a testbed for advanced seasonal hydrologic forecasting methods and hydrologic data assimilation approaches for the western U.S. The companion National Surface Water Monitor (SWM) provides nowcasts of soil moisture and gridded runoff production with daily updates across the continental U.S. domain. It is designed to assist in identification of areas currently experiencing drought. At present, hydrologic forecasts are made by the west-wide system at almost 250 streamflow forecast points west of the Mississippi River in real-time for lead times from six months to one year, with updates twice monthly during the winter season and monthly during the rest of the year. Several forecast methods are or have been used, including Ensemble Streamflow Prediction (essentially resampling from the climatological record); categorical ESP using ENSO and PDO classifications, a synthetic ensemble variation of the CPC's "official" forecasts, and statistical downscaling of the NCEP Climate Forecast System. We also produce a near real-time soil moisture product for all of the western U.S. and Mexico. Leveraging from our current CPPA project which has developed the west-wide system and the SWM, we now propose to exploit these systems to address three questions of immediate interest to CPPA: 1) *What are the primary controls on hydrologic predictability in the western U.S., particularly under drought conditions, and have these controls shifted with time as the climate of the western U.S. has warmed?; 2) What is the value added through dynamical downscaling in hydrological and hydrological drought forecasting in the western U.S.?; and 3) What are the primary controls on hydrological and soil moisture drought over the western U.S. and Mexico, and how best can evolving droughts be identified?* At its core, the question of hydrologic predictability has to do with how much influence hydrologic initial conditions (snow and soil moisture storage) have on the evolution of hydrologic conditions over the forecast period, as contrasted with the impact of uncertainty (lack of forecast skill) in the land surface hydrologic forcings over the forecast period. These relationships are complicated by hydrologic processes that are dependent on elevation and gradients across some of the major river basins (for instance, the lower Colorado basin is strongly influenced by monsoon precipitation, whereas the upper Colorado is not). We intend to conduct exhaustive analyses to better understand this balance. In its CPPA call, NOAA solicits proposals for dynamic downscaling of NCEP global (CFS) forecasts ("Project to evaluate seasonal predictions from regional climate models"). We intend to utilize the results of this project, and in particular, downscaled forecasts that would be produced via an independent proposal of John Roads (or others, depending on the success of particular proposals) to evaluate, across the western U.S., the implications of statistical downscaling (presently implemented in the west-wide system) as compared with dynamic downscaling. The key questions with respect to hydrologic drought relate to hydrologic prediction and predictability under abnormally low runoff conditions. Our work in this area will seek to understand the nature and causes of hydrologic prediction errors across the western U.S. and Mexico under past drought conditions. We will emphasize in particular apparent differences in hydrologic forecast biases in extreme low flow years in the Colorado River basin, and in other major western U.S. rivers. This proposal responds directly to priority areas 2 (Hydrologic applications of NCEP multi-model seasonal hindcasts), and 3 (Predictability and mechanisms of drought) of the CPPA call.		

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Xin-Zhong Liang and Kenneth E. Kunkel, Illinois State Water Survey, University of Illinois at Urbana-Champaign	CWRF Downscaling Seasonal Climate Prediction over the United States	2008
Abstract: We propose to fully participate in the CPPA initiative for a systematic assessment of the regional climate model (RCM) downscaling enhancement to multiple global coupled general circulation models (GCMs) seasonal climate predictive skill. This will include execution of the downscaling predictions of the Climate extension of the Weather Research and Forecasting model (CWRF) from all GCMs (10 CFS current, 10 CFS next, 10 NASA next) winter forecasts for the period of 1982-2008 as designed by CPPA; submission of the CWRF outputs to the CPPA central data server; and collaboration with other CPPA-funded groups to assess whether RCM downscaling can enhance the GCMs' seasonal predictive skill. To capitalize on the model execution, we will optimize the CWRF prediction system such that all inputs (initial, surface and lateral conditions) are most realistically represented; quantify the RCM downscaling enhancement on predicting USA precipitation and terrestrial hydrology interannual variability. We recognize that NCEP is developing an ensemble system with multiple coupled GCMs' for climate prediction and will continuously improve its performance, and that the degree of RCM downscaling skill enhancement may thus change from the assessment based on the present products. Our proposed optimization of the CWRF downscaling system and prediction approach, however, can be generally applied and will likely maximize the skill enhancement when improved NCEP products are available.		

Brant Liebmann, CIRES/ESRL, Carolina Vera, University of Buenos Aires	Intraseasonal Variability of South American Precipitation	2008

Abstract: The purpose of this proposal is to better understand intraseasonal variations of precipitation, with emphasis on a dipole with anomalies of opposite sign, in South America on scales ranging from synoptic to the Madden-Julian oscillation. The focus will be on an improved description of the remote forcing associated with the development of convection over tropical and subtropical South America on this range of time scales. Particular attention is paid to the MJO, as it is the only intraseasonal oscillation whose potential predictability has been demonstrated. One of the most prominent signals in intraseasonal variability is the South American convection dipole. The dipole exists most robustly in precipitation as simultaneous anomalies of opposite sign with one center over northeastern Argentina and the other over the South Atlantic convergence zone. The anomalies encompass the most heavily populated and intensively farmed area of South America, including the mega-cities of Sao Paulo, Buenos Aires, and Rio de Janeiro. Variations of the dipole seem to be related to most of the features of the South American climate, including the monsoon and the low-level jet. Its sign is also related to the phase of the MJO, but the dominant period of variability is of higher frequency.

Teleconnection studies have indicated that intraseasonal variability over South America can be forced by Rossby wave propagation linked to intraseasonal events in the Pacific Ocean. It is not yet understood, however, whether development of convection over South America on intraseasonal time scales is due to changes in the structure and propagation of the synoptic waves from the Pacific into the continent or whether the slowly varying background flow in the vicinity of South America is influenced by tropical intraseasonal variability, resulting in different propagation characteristics. The importance of intraseasonal variability has been identified in the skills of medium-range weather forecasts in the Pan-American sector. Models seem to have more skill during periods of strong convective activity associated with the MJO. Nevertheless, the ability of the seasonal prediction models in reproducing the dipole variability as well as the large-scale conditions determining the convection development in South America on intraseasonal time scales still needs to be better assessed.

The study will be primarily observational, although we will validate the signal from general circulation models. The proposed research will address these questions:

1. Which are the most relevant mechanisms associated with the remote forcing of the seesaw pattern development over South America on intraseasonal scales?
2. What is the interaction between the high-frequency perturbations and the MJO in central and eastern South Pacific? How much of the dipole variability is accounted by such interaction?
3. What are the links between interannual, intraseasonal and high-frequency variability over central and eastern South Pacific and South America regions? How do they impact year-to-year changes of the dipole pattern?
4. How well do the current climate models reproduce the dominant mechanisms associated with remote forcing over South America on intraseasonal scales?

Lixin Lu, Roger A. Pielke, Sr., Univeristy of Colorado	Dynamical Downscaling Global Climate Models' Seasonal Predictions Atmospheric Modeling System (RAMS)	2008

Abstract: Understanding Earth-system climate variability and change requires solving the challenge of representing relatively small-scale terrestrial processes within the context of relatively large scale (100s-km grid increment) atmospheric/climate models. An additional challenge is to define how changes in the large-scale processes will affect local climate-related terrestrial processes. Because many hydrologic and ecologic processes occur at spatial scales that are 2- to 3-orders-of- magnitude smaller than global climate models, methods are needed to translate global atmospheric features to the local scales relevant to terrestrial processes. In addition, high-resolution methodologies are required to provide information at spatial scales directly applicable to understanding the impact of a changing climate on critical socio-economical sectors. The inherent mismatch in spatial scales between global atmospheric and local terrestrial processes represents a critical challenge to any Earth-system modeling program. The overall objective of this proposal is to use state-of-the-art Regional Atmospheric Modeling System (RAMS), dynamically and progressively downscaling from global Climate Forecast Systems (current and next versions of NCEP CFS, and NASA coupled model, at 100skm grid increment) to a regional domain that covers the conterminous United States at 30-km grid increment. Our numerical experiment design will strictly follow the protocols defined in the white paper of CPPA FY2008 announcement (revised version). During the cold season, the

precipitation is largely dependent on synoptic-scale mid-latitude storms and orographic dominant mesoscale processes. Driven by the same atmospheric and SST forcings, RAMS will be compared with other RCMs, and evaluated against observations and reanalysis (NARR) to see if the simulations capture the climatology and interannual variability of temperature and precipitation distributions. As a result, the overall strengths and weaknesses of the modeling systems will be identified, as well as the consistent model biases.		
J. David Neelin, Benjamin R. Lintner, University of California, Los Angeles	Drought Mechanisms, Teleconnections, and Convective Margins	2008
Abstract: An understanding of the mechanisms that generate drought conditions over tropical land regions in models and observations is important to the interpretation of climate variability, as well as to the prediction of climate change impacts. Under prior funding, we introduced diagnostics that we propose will add to the set of tools with which drought mechanisms can be assessed. One of our principal foci in this proposal is the spatial transition between strong convecting and nonconvecting conditions over tropical land regions. The near-edge environments of tropical convection zones-the convective margins-exhibit considerable sensitivity to climate forcings across a wide range of temporal scales, such as tropospheric warming associated with El Niño or high-frequency perturbations to the inflow of air masses from outside of the convection zone. In previous work supported by CPPA, we have begun characterizing the behavior of convective margins under certain conditions, identifying those factors that determine where the margin occurs. We propose here to extend the convective margins framework to include land surface-atmosphere feedbacks, trajectory analysis, factors such as air mass source and modification, and quantitative assessment of the convective threshold. We propose to use these diagnostics to analyze convective margin variability and relationships to droughts in models and observations. Our general approach will emphasize the dialogue between simple models and more complex models, as well as observed and reanalysis data: the simple models (including process-based prototypes and an intermediate level complexity model) will be used primarily for generating and testing hypothesis, while the more complex models (general circulation models) and observations will be used for validation, sensitivity assessment, and robustness estimation. One target is to identify the factors that make certain locations along convective margins strongly susceptible to droughts. We further propose that by breaking down the causes of convective margin anomalies by such factors as changes in inflow air mass source region, diabatic changes prior to convective onset, and changes in the convective threshold, we can contribute to addressing drought attribution. This can be used both on observed events and to assess differences among models.		
Michael Notaro and Zhengyu Liu, University of Wisconsin-Madison	Impact of Vegetation on North American Climate	2008
Abstract: Vegetation-climate feedbacks remain poorly understood despite their potential usefulness in climate predictability. There have been very few studies of observed feedbacks, limiting our understanding primarily to simplified modeling experiments. We propose to focus on two regions, the North American monsoon region and boreal forest, with important hydrological feedbacks in the former and feedbacks to temperature in the latter. We will apply a lagged covariance method to statistically quantify instantaneous local vegetation feedbacks in both regions, using observational data and output from two coupled models, FOAM-LPJ and CCSM3. Estimates of observed vegetation feedbacks, based on satellite vegetation data and observed climate data, will be computed at varying resolutions and serve as an observational benchmark against which models can be compared. We will develop and apply a new non-local vegetation feedback assessment to statistically quantify non-local feedbacks from vegetation over both regions, particularly since vegetation likely produces a non-local effect on precipitation due to the atmospheric transport of transpired water. We will investigate the possibility of a negative vegetation feedback on precipitation over the Southwest U.S. as found over North Africa in our mid-Holocene simulation of FOAM-LPJ. The statistical approach to quantifying simulated vegetation feedbacks will be evaluated dynamically through explicit ensemble experiments. For this initial value problem, we will impose initial anomalies in vegetation and perform a series of ensemble experiments aimed at isolating the atmospheric and oceanic response to the vegetation anomalies. We will investigate the impact of vegetation variability over the North American monsoon region and also the boreal forest on climate variability through a set of interactive and fixed vegetation cover experiments, including ones that isolate the impact of variability in leaf cover or vegetation cover. The influence of vegetation and SSTs on North American droughts will be analyzed to aid in their prediction. Finally, we will apply both a conceptual climate-ecosystem model and offline LPJDGVM biosphere model to study equilibrium states and abrupt vegetation change over the two study regions, including the role of vegetation feedbacks and climate variability.		
Mutlu Ozdogan, University of	The Role of Irrigated Croplands in North American	2008

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<tr><td>Wisconsin, Matthew Rodell, NASA's Goddard Space Flight Center</td><td>Hydroclimatic Regimes</td><td></td></tr>
<tr><td colspan="3">Abstract: We propose to quantify the effects of crop irrigation on water and energy cycle variables over North America. Irrigation accounts for nearly 90% of the world's consumptive use of fresh water, and irrigated croplands have been shown to influence the terrestrial water balance and land-atmosphere interactions on local to regional scales. However, these hydrologic and climatic effects are not well quantified, particularly at regional to continental scales. Furthermore, accurate initialization of land surface moisture and energy states in numerical weather prediction models is known to enhance short term to seasonal forecast skill, yet there is still room for improvement. Realistic initialization has been shown to be important in the summer in the central US, where irrigated agriculture is widespread. Hence there is great potential for improving forecasts through the treatment of irrigation in the land surface components of operational prediction systems. Therefore, the primary objective of the proposed research is to address this challenge by incorporating irrigation and a broader range of crop types, based on high resolution satellite observations, into three land surface models (LSMs). The three LSMs, Noah, Catchment, and the Common Land Model (CLM), are the land components of the operational forecast systems of NOAA, NASA's Global Modeling and Assimilation Office (GMAO), and the National Center for Atmospheric Research, respectively. All three are embedded in NASA's Land Information System (LIS), which will facilitate the proposed enhancements while reducing redundancy. LIS will enable us to drive the LSMs at high resolutions in uncoupled and, later, coupled modes, using observation based parameter and forcing inputs archived by the North American and Global Land Data Assimilation System (LDAS) projects. We will perform experimental simulations to test the influence of irrigation and explicit crop types on regional to continental scale water and energy budgets. These will include a comparison of results from the three LSMs, which may or may not vary significantly in their responses to irrigation. The analysis will help to quantify the effects of irrigation on landatmosphere- interactions over North America and hence provide insight towards the improvement of operational weather and climate predictions.</td></tr>
<tr><td>Soroosh Sorooshian, Xiaogang Gao, Kuo-lin Hsu, and Jialun Li, University of California, Irvine</td><td>Investigating the Southwestern United States hydroclimate intraseasonal variability for enhancing land surface representations in a regional climate model</td><td>2008</td></tr>
<tr><td colspan="3">Abstract: Research to understand and forecast the regional hydroclimate over the Western U.S. mountainous region at intraseasonal scales is critical to the operational agencies (regional and local) faced with decisions that affect the region's population and economics. A key scientific issue in regional climate forecasting is how to enhance the representation of landscape variations in forecast modeling systems.
Previous studies on southwestern regional hydroclimate have shown that to understand the region's atmosphere-land exchanges of water and energy and properly downscale the forecasting variables to the scales required by various hydrological applications, we need to improve our capability of modeling intraseasonal landscape variations. In particular, understanding the behavior of snow variations during the winter and spring and the vegetation changes before and after the North American monsoon are two of the critical factors. We propose to apply a stochastic technique that combines a Sequential Bayesian Filter with Monte Carlo implementation (SBF-MC) to assimilate satellite-based snow mass and vegetation property data into a coupled land-atmosphere Regional Climate Model (RCM). The SBF-MC technique, which can treat nonlinear and non-Gaussian physical systems and produce ensemble assimilations and forecasts, has been applied successfully to lower-order models in many fields. Using SBF-MC in the sophisticated RCM is an innovative method that holds promise, but also challenging. This proposal describes how our research will address the challenges involved in snow and vegetation data assimilations using the SBF-MC technique.</td></tr>
<tr><td>David Toll, NASA/GSFC, Brian Cosgrove, NASA-SAIC, Paul Houser, CREW/GMU, Jiarui Dong, NASA-UMBC/GEST, and Luis Gustavo de Goncalves, NASA-NPP/ORAU</td><td>NASA Land Information System Development, Application and Validation for Improving Ensemble Hydrologic Prediction in Support of NOAA NWSRFS</td><td>2008</td></tr>
<tr><td colspan="3">Abstract: The NOAA National Weather Service (NWS) has 13 River Forecast Centers providing daily stream flow forecasts through their River Forecast Systems (RFS) at more than 4,000 points throughout the U.S. to address a range of issues, including peak and low flow predictions as well as river floods and flash floods. Quantifying the RFS hydrologic prediction uncertainty is a primary need for NWS RFCs to identify the risk associated with the predictions and to identify areas of needed improvement. These uncertainties arise from errors in the estimation of</td></tr>
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the RFS forcings such as precipitation and radiation, estimates of initial and boundary conditions, model physics, and model parameters. One of the leading approaches for quantifying these uncertainties is through the use of "*ensemble forecasts*", where the traditional single prediction of a most likely forecast event, is replaced by an ensemble of models and forecast uncertainties. This presents the challenge of how to properly condition the multi-model ensemble to encompass reality with reasonable uncertainty. We propose to address this challenge by exploring multi-model ensemble initialization, calibration and constraint (data assimilation) within the Land Information System (LIS). By enhancing LIS's calibration and data assimilation tools for multi-model ensemble application, and including multi-model ensemble channel routing, we will enable a platform for improved NWSRFS ensemble streamflow predictions. This project will partially leverage ongoing NASA - NOAA activities, utilizing the LIS multi-model data assimilation and data integration capability in conjunction with OHD hydrologic prediction expertise to study ensemble streamflow predictions for selected NOAA and HEPEX test beds. The proposed work will build on a recently initiated NASA Applied Sciences Program (ASP) project, "Improving NOAA/NWS River Forecast Center Decision Support with NASA Satellite and Land Information System Products". We propose to expand this applications project to *develop* critical aspects of LIS which will directly support NOAA NWS RFCs and OHD within the CPPA "Improving Ensemble Hydrologic Predictions" framework. Specifically we propose to further develop and evaluate a multi-model data integration and assimilation system, LIS, to provide improved ensemble hydrologic predictions in support of NOAA NWSRFS flow estimates primarily through cooperative work with NOAA OHD and Hydrologic Ensemble Prediction Experiment (HEPEX) Test Bed partners. Specific LIS enhancements will be implemented to enable this goal.1) Improve LIS hydrology by integrating the NOAA HL-RDHM channel routing routine into LIS, and by adding the USGS hydrological Precipitation-Runoff Modeling System (PRMS) and NOAA Sacramento Distributed models to LIS. We also will extend our preliminary LIS-Noah Distributed routing routines to work with the other LIS models. 2) LIS data assimilation development of toolbox capabilities such as Ensemble Kalman Filtering for incorporating NASA satellite products. 3) LIS model parameter optimal estimation-test and apply a multi-objective sensitivity analysis algorithm and parameter estimation framework based on similarity concepts to reduce hydrologic prediction uncertainties. This proposed effort will build on ongoing NASA and NOAA research. By combining LIS multi-model ensemble simulation techniques with NASA research activities aimed at reducing hydrologic model uncertainties (i.e.,implementation of data assimilation of satellite data along with inclusion of automatic parameter estimation techniques), we hypothesize that streamflow and other hydrological predictions can be improved. We propose to develop, evaluate and validate these ensemble streamflow forecasts through using the HEPEX Great Lakes Test Bed (http://hydis8.eng.uci.edu/hepex/testbeds/GreatLakes.htm) and the soon to implemented NOAA OHD Core Test Bed (Oct., 2006, Pedro Restrepo, personal communication).		
Huug van den Dool and Yun Fan, Climate Prediction Center NCEP/NOAA	Predictability of Drought and other near surface extreme events in the Americas	2008
Abstract: A climate extreme is an anomalous event that departs significantly from its normal state for a certain duration of time, and a certain spatial extent. Drought, flood, cold surge and heat wave are examples of near surface climate extremes. Climate extreme events exhibit variations in both the spatial and temporal domains. Our knowledge for the causes and mechanism of these climate extremes is limited. CPPA is seeking "scientific investigations to improve predictive understanding and simulation of the roles of SST forcing and local land surface interactions in the initiation, maintenance, and demise of drought and other extreme events throughout the Americas on seasonal to interannual time scale." Therefore, one of most important tasks for us is to establish an objective definition based on some thresholds (i.e. amplitude, duration and spatial extent). The definition has to be developed and then used to identify such events in the Americas over a multi-decade period of time, and hopefully include all cases of known serious impacts on the human society and ecological systems. Using the above developed definition, and a variety of land surface plus attendant datasets and other prediction tools we have at our disposal, we will focus on exploring what are the most important initial and boundary conditions for the extreme climate events and where they are located, and develop predictive understanding why some extreme climate events are more predictable than others, and eventually improving prediction for these extreme climate events which will have potentially great obvious benefit.		
Guiling Wang , University of Connecticut	Soil Moisture-vegetation-precipitation Feedback Over North The Search for Observational Evidence	2008

Abstract: The objective of this project is to seek from observational and reanalysis data evidence of positive soil moisture/vegetation-precipitation feedback over North America, and to facilitate the application of land surface conditions in operational prediction at seasonal and sub-seasonal time scales. This project will help address several research priorities of the NOAA Climate Prediction Program for the Americas (CPPA): (1) to better understand the role of ocean and land surface forcing and feedback processes in droughts over North America and to understand and predict North American hydroclimatic regimes; (2) to help develop research forecasts utilizing soil moisture and interactive vegetation; (3) to determine the sources and limits of predictability of warm season precipitation over North America and to improve operational prediction. Theoretical and numerical modeling studies support the notion of positive land-atmosphere feedback over North America, indicating that land surface conditions such as soil moisture have the potential to serve as apredictor for future precipitation. However, operational application of this relationship suffers from the lack of clear observational evidence for positive feedback between soil moisture and precipitation. In this project, we propose four related hypotheses that can be summarized as "*Direct evidence of positive soil moisture-precipitation feedback from observations and re-analysis data can be masked by the impact of large-scale (regional and global) oceanic forcing and negative vegetation feedback*. *The lagged soil moisture-precipitation correlation is stronger and more significant under certain type of global oceanic forcing; this correlation is stronger (weaker) over regions (and seasons) where (when) positive vegetation feedback is dominant than where (when) negative vegetation feedback is dominant*. *The generally weak lagged soil moisture-precipitation correlation from observation is not inconsistent with results from numerical models that simulate a strong soil moisture-precipitation coupling*." To evaluate these hypotheses, we propose to examine the relationship between soil moisture/vegetation and subsequent precipitation and to examine how antecedent vegetation influences the sensitivity of precipitation to antecedent soil moisture after the impact of large-scale oceanic forcing is extracted. This will be done through a 2-step categorized correlation analysis we propose. In addition, we propose to use the lagged correlation based on output from a model with strong soil moisture-precipitation coupling as guidance for what makes a strong coupling in observation, and to address whether climate models overestimate the strength of soil moisture-precipitation coupling. Through this project we hope to demonstrate clear observational evidence for the positive feedback between soil moisture/vegetation and precipitation, and to address several critical issues clouding the land-atmosphere interactions research field. It is expected that this project will help pave the way for land surface conditions to eventually serve as an important predictor in operational climate prediction at the seasonal and sub-seasonal time scales.		
Hailan Wang, University of Maryland at Baltimore County (UMBC), Siegfried Schubert, NASA/GSFC, Junye Chen and Phillip Arkin, University of Maryland at College Park	Roles of ENSO and Slowly Varying SST Modes in Influencing the Development of Drought over the United States: A Modeling Study	2008
Abstract: While the droughts in the U.S. as an entirety have been extensively examined in the past, their detailed development, i.e., initiation, sustenance and demise, has received much less attention. With the greatly increasing vulnerability of the human society to drought, the understanding of the temporal evolution of the U.S. droughts with respect to the spatial extent, severity and persistence is of critical importance to the society. This proposal aims to investigate the roles of El Niño-Southern Oscillation (ENSO) and leading slowly varying SST modes, i.e., Global Warming (GW), Pacific Decadal Variability (PDV), and Atlantic Multidecadal Variability (AMV), in *initiating, sustaining* and *terminating* past major U.S. droughts during the period 1948-present, and address the relative roles of these slowly varying SST modes in modulating ENSO teleconnection over the U.S. This proposal is directed to the NOAA Climate Program Office's FY 2008 Announcement of Opportunity for the Climate Prediction Program for the Americas (CPPA), and addresses the research priority of "predictability and mechanisms of drought". The investigation will proceed using GCM simulations. The use of the GCM modeling approach is justified based on prior modeling research which finds that the current generation climate models are capable of reproducing the major droughts over the U.S. from the early twentieth century to the present, when forced with the observed SST. Using established statistical approaches, we will extract the SST anomalies associated with ENSO and the slowly varying SST modes from the observed SST, and force a GCM with various combinations of these SST anomalies globally and over selected ocean basins. On the basis of these GCM simulations, we will 1) examine the role of ENSO in initiating, sustaining and terminating the major droughts over the U.S. during 1948-present; 2) investigate the roles of the leading slowly varying SST modes, i.e., the GW, PDV, and AMV, in maintaining the past U.S. droughts, particularly the multi-year ones, and 3) determine the *relative roles* of these leading low-frequency SST		

modes in modulating the influence of ENSO over the U.S. droughts. Established diagnostic tools, including a diagnostic nonlinear stationary wave model and stationary wave flux analysis, will be used to identify dynamical mechanisms accounting for the drought related atmospheric circulation anomalies over the U.S., and to establish their connection to the ocean surface temperature anomalies in the GCM simulations and observations.		
Robert Weller, Fiammetta Straneo, Woods Hole Oceanographic Institution	Upper Ocean Response Under the Stratus Deck	2008
Abstract: We propose to investigate the response of the upper ocean under the persistent stratus cloud deck found west of Peru and Chile to forcing by air-sea fluxes, by the gyre-scale circulation, by fluxes associated with westward propagating eddies, and by vertical mixing. In doing so we will quantify and better understand the surface meteorology and air-sea fluxes of heat, freshwater, and momentum across the region, the space/time variability of the upper ocean and of sea surface temperature under the stratus cloud deck, and the oceanic and coupled processes that govern the state and evolution of the upper ocean there. The domain we would investigate would be a several degree wide swath centered at 20°S extending from the shore westward out to the long-term surface mooring at 85°W. This swath spans the nearshore region where coastal upwelling dominates cooling out to where the offshore Ekman transport has little contribution and we have as yet not quantified all the processes that maintain the temperature and salinity of the upper ocean. This work is proposed as part of the cooperative VOCALS (VAMOS Ocean Cloud Atmosphere Land Study, where VAMOS is Variability of the American Monsoon System) Regional Experiment (REx) that will focus on this region in October-November 2008 and is closely linked to our ongoing work at the STRATUS Ocean Reference Station (a long-term surface mooring with climate quality surface meteorological data) at 20°S, 85°W. We will use two moorings, shipboard sampling, and profiling ARGO floats in this swath to: (1) observe with good vertical and temporal resolution at the two mooring sites the surface meteorology, air-sea fluxes, and structure and variability of the upper ocean (temperature, salinity, horizontal velocity); (2) assess the spatial homogeneity of the SST and upper ocean structure and thus the representativeness of the temporal evolution at the two moorings; (3) assess the spatial variability of the surface meteorology and air-sea fluxes; (4) map the mesoscale ocean variability and locate a feature that will be the focus of joint ship and aircraft studies in VOCALS Rex; (5) use that mapping plus broad scale sampling to quantify horizontal advective fluxes of heat and salinity; and (6) collect shipboard data while on station (for 6 to 14 days) at each of the two moorings and at the selected mesoscale feature. The two moorings will be in place for a year, and the profiling ARGO floats will continue to return temperature, salinity, and oxygen profiles for up to four years. An additional aspect of our effort will be setting the longer term context for VOCALS REx through analyses of these ongoing data as well as data collected in the past in this region. We will work with coupled, atmospheric, and ocean modelers to improve their model's abilities to replicate the vertical structure of the ocean in the swath, including the SST and ocean mixed layer depth, to use realistic surface meteorology and air-sea fluxes when forcing ocean models or to produce in their atmospheric or coupled models realistic surface forcing fields, and in atmospheric and coupled models produce the variability of clouds seen at the buoys and from the ship.		
Eric F. Wood, Princeton University	Identifying Mechanisms of US Drought Initiation, Persistence and Recovery using Observations, Reanalysis and Climate Model Data	2008
Abstract: *Introduction to the Problem:* Drought is the costliest natural hazard in the US. While forecasts and realtime assessments of drought offer the potential to mitigate drought impacts, our ability to predict the onset, development and recession of drought is insufficient. The reasons for this are the lack of data about large scale variability and more importantly, insufficient understanding of hydrologic and weather mechanisms that lead to drought initiation, persistence and recovery. The generally poor predictive ability of seasonal climate models to forecast drought reflects this. While there is a large body of research related to climate processes and drought mechanisms, they tend to focus on after the establishment of the drought conditions. In general, precipitation variability and drought occurrence are driven by a combination of variability of advected atmospheric moisture and the strength of local recycling, but the question remains as to the relative influence of each. For the central US, the remotely advected component is observed to be larger than the local component, with the Pacific (Gulf of Mexico) as the winter (summer) moisture source, but this will be differ regionally. At larger scales, SSTs may influence drought occurrence and forms the basis for seasonal climate forecasts. But even when observed SSTs are used in seasonal forecast models, the skill in precipitation is low. Inclusion of land surface wetness, makes some		

improvements for some models in some areas indicating that our understanding, and our ability to model, the mechanisms of drought initiation, persistence and recovery are weak.
Rationale: Collectively current research results point towards predictable features of drought development, and indicate potential linkages through moisture transport and local feedbacks. However, there has been little study into identifying the precursors of drought, mechanisms of regional persistence, and drought recovery. The proposed research is directly relevant to the goals of the CPPA element "Predictability and mechanisms of extreme events/drought", which seeks research "to improve predictive understanding and simulation of the roles of SST forcing and local land surface interactions in the initiation, maintenance, and demise of drought..." The proposed research addresses this through our overall research question: "*What are the mechanisms for initiation, maintenance and recovery of large scale drought in the US and do seasonal forecasts models (specifically NCEP CFS) represent well these mechanisms?*" This question consists of three sub questions: 1) *What are the atmospheric and land surface precursors to drought? 2) What are the mechanisms that can be verified that prolong drought 3) What are the processes that lead to drought recovery and do seasonal prediction models replicate these*?
Summary of work to be completed: Our approach is based on considerations of the large scale atmospheric-land water budgets and the synthesis of existing datasets, and consists of the following tasks: 1. Evaluate drought occurrence and their space-time evolution using observation driven simulations of 20th century land hydrology. 2. Evaluate land-atmosphere water budgets and moisture sources for US regions from observational, reanalysis and remote sensing derived datasets. 3. Identify/classify the precursors to drought in terms of the land-atmosphere water budgets and how they diverge from their climatological mean and the likelihood of drought initiation given atmospheric moisture sources and soil moisture anomalies. 4. Investigate mechanisms for drought maintenance by using analytical models of recycling to explore the role of local and remote reinforcement of drought. 5. Identify conditions for drought recovery. Concurrent analysis of drought events and moisture advection will be used to identify what conditions are necessary to recover from drought. 6. Assessment of predictive tools. Using the previously identified relationships we will evaluate how well seasonal hindcasts of the NCEP Climate Forecast System are able to replicate the mechanisms for drought initiation, maintenance and recovery.

Yongkang Xue, UCLA	Downscaling of CFS Seasonal Predictions Using Regional Climate Model Coupled with SSiB Land Scheme	2008

Abstract: This proposal responds to the new CPPA initiative organizing a wider assessment of fully-prognostic regional climate model (RCM) executions to assess whether RCM seasonal predictions can surpass the skill of the operational NCEP global Climate Forecast System (CFS) and other coupled models, and to explore the methodology of dynamic downscaling in the RCM prediction mode. Coupled models will provide lateral boundary conditions for RCMs. Although dynamic downscaling using RCMs has become common practice, the ability of RCMs to carry out such applications has not been systematically and comprehensively investigated.
Studies have revealed that a number of factors affect the RCMs' ability to carry out dynamic downscaling. We have conducted a series of experiments to explore the role of a number of factors/processes, such as spatial resolution, initial atmospheric and land surface conditions, domain size and position, quality of the driving forcing data, and vegetation, snow, and soil moisture processes, in dynamic downscaling in the RCM simulation mode and the RCM semi-prognostic mode. Our study indicates that in these two RCM downscaling modes, the coupled Eta/Simplified Simple Biosphere Model (SSiB) is able to properly carry out dynamic downscaling under certain conditions.
In this project, we plan to employ the coupled Eta/SSiB to conduct a series of regional predictions as indicated in the White Paper. Based on previous RCM downscaling studies, we conjecture that in the RCM fully-prognostic mode, RCMs have downscaling ability and are able to provide additional skillful regional detail not available in coarse scale global models' predictions under certain conditions. Furthermore, we hypothesize that RCMs in the RCM prediction mode will provide additional large-scale seasonal forecasting skill under certain circumstances. These conditions will be investigated in this project.
The focus in this project will be on the coupled models' wintertime forecasts, and the initial forecast ensemble will be comprised of 10 members over a period of 22+ years (from 1982 to 2003+) for the forecast period December 1 - April 30, with initial dates at 00 UTC and 12 UTC from November 23 through November 30. The model domain will cover the conterminous US at approximately 32-km resolution. In this project, we will analyze the simulation bias, root-mean-square-error for precipitation, surface temperature and other variables, and anomaly correlations of the CFS and RCM, as well as Equitable Threat Score to evaluate RCM prediction. In addition, we will apply spectral analysis as done in our previous RCM studies to quantitatively examine the RCM's downscaling ability,

especially its ability to produce small-scale information. Furthermore, diagnostic analyses will be conducted to link improvements in downscaled forecasting skill to regional forcings, different factors/processes, as well as physical/dynamic mechanisms.
We will provide hydrometeorological outputs required by the Central Analysis Team to the NCEP central server. We will join the regular communication among funded CPPA PIs, especially Dr. Ray Arritt and his colleagues' "Multi- RCM Ensemble Downscaling (MRED) of Multi-GCM Seasonal Forecasts" group, for discussions on experiments and time line, and participate in the model assessment and analyses. We will support the Central Analysis Team's activity and continue our collaboration with Dr. Ken Mitchell, Dr. Zavisa Janjic, and Dr. Roger Pielke, Sr., for RCM downscaling studies.