Climate Diagnostics Center

Summary of
Climate Dynamics and Experimental Predictions (CDEP)
Accomplishments and Plans FY05-06

Overview

CDC research goals supporting the NOAA/OGP CDEP/Applied Research Centers (ARCs) program include: improving understanding of forcing mechanisms influencing climate variability from subseasonal to millenial time scales; developing new forecast capabilities for estimating risks of high-impact events based on ENSO or other climate conditions; estimating and fully capitalizing on potential predictability related to ENSO as well as other modes of variability and non-ENSO related forcing; developing new forecast products to better serve user needs, particularly on regional scales; and ultimately, contributing to the development of new NOAA climate services.

Highlights of CDC Activities for FY05 and Plans for FY06

Sensitivity of Global Warming to the pattern of tropical SST warming

As part of a long-term project concerned with estimating atmospheric sensitivity to anomalous SSTs throughout the tropics, we estimated the sensitivities of global mean temperature and precipitation to SST forcing at different tropical locations using the NCAR CCM3.10 AGCM. For the DJF season we found that warm SST anomalies in the western Pacific increase the global mean temperature and precipitation, whereas warm anomalies in the Indian ocean have the opposite effect. This contrasting behavior is mostly associated with a single response pattern excited with opposite signs, depending on which side of the nodal line between the Indian and western Pacific oceans the forcing lies. An important implication of this result is that regional climate changes over the next century, and even the global mean signals, will depend sensitively on the precise spatial pattern of SST changes across this nodal line of sensitivity. A paper describing these results is in review.

Global Atmospheric Sensitivity to Tropical SSTs

We continued our comprehensive investigation of the sensitivity of the global atmospheric response to anomalous SST at 43 regularly spaced tropical locations using the NCAR CCM3.10 AGCM. The responses of target quantities of interest (such as the amplitude of the PNA pattern or precipitation in selected areas of North America) to forcing at the different locations were plotted at the forcing locations to produce tropical sensitivity maps. We found most such sensitivity patterns to differ markedly from the ENSO pattern of interannual SST variability, with highest sensitivity generally outside the eastern tropical Pacific. Another important general finding was the opposite sensitivity of many features of the remote response to SST forcing in the tropical Indian and western Pacific oceans. These results were presented at several conferences and symposia. Two journal articles are in preparation.

Understanding the Annular Atmospheric Response to Tropical Forcing

The leading pattern of observed northern hemisphere winter height variability exhibits an annular structure. To explore whether it can be excited by tropical Pacific SST variations, ensemble-mean responses to idealized SST anomalies at several equatorial longitudes were determined using NCEP's Seasonal Forecast Model (SFM) coupled to a slab mixed-layer ocean. Two distinct responses were obtained; a hemispheric pattern projecting on the annular mode, and a meridionally arched pattern confined to the Pacific-North American sector, for SST anomalies in the west and east Pacific respectively. Extratropical air-sea coupling was shown to further enhance the annular response to the west Pacific SST anomalies. A linear model diagnosis of these two distinctive responses revealed the primary importance of anomalous transient eddy forcing. In both cases, the anomalous transient eddy forcing was maximum near the Pacific jet exit, but with different meridional positions relative to the jet. We found that transient eddy forcing within the jet core efficiently excites a hemispheric annular response, whereas forcing away from the jet core induces a regionally trapped response. Tropical west Pacific SST anomalies are more efficient at exciting an annular response by this mechanism, with U.S. surface impacts substantially different from those usually associated with ENSO. A paper is in review.

Storm Track Predictability on Seasonal and Decadal Scales

We used large sets of AGCM runs made at NCAR and NCEP with prescribed observed SSTs over the past half-century to isolate the SST-forced part of extratropical stormtrack variations. We found a significant SST-forced stormtrack signal in many winters, but with substantially varying strengths and structures from winter to winter. The correlation of the SST-forced and observed stormtrack variations over the 50 winters was found to be high enough in the PNA sector to suggest useful predictability. We also found that most of the predictable signal was associated with tropical Pacific SST forcing. The long-term trend of the Pacific storm track in the 50-yr record was consistent with the stronger ENSO SST forcing in the second half of the record. A paper describing these and related results was published in the *Journal of Climate*.

Diagnosing Prospects for Improved U.S. Seasonal Forecast Skill

Are estimates of seasonal forecast skill levels over the U.S. derived from 50 years of forecast or hindcast data reliable indicators of their true levels? What are the error bars on such estimates due to inadequate sampling? We addressed this issue using 650 years of output from an unforced coupled model run (NCAR's CCSM2). The model has realistic ENSO variability, and its ENSO signal over the U.S. accounts for roughly the same fraction of interannual variance as the observed ENSO signal. Empirical multivariate 1-season lag relationships were developed between the model's tropical SSTs and U.S. surface air temperatures from the first 150 years of the run. Hindcasts were then made for the next 500 years, and the 50-year mean skill of wintertime 1-season U.S. surface temperature forecasts was estimated in the 10 50-year segments. These estimates were found to range from a low correlation skill of 0.1 to a high skill of 0.3, with a median value near 0.2 (perhaps coincidentally, close to the estimated 1950-1999 U.S. surface temperature skill). These variations arise purely from intrinsic coupled model noise. An important implication of our analysis is that the skill gains anticipated from future forecast system improvements (such as moving from "Two-Tier" to "One-Tier" forecasting methods) could well be masked by such random multi-decadal fluctuations of skill.

A critique of the dynamical "Two-Tier" method of predicting Asian monsoon rainfall.

Dynamical predictions of Asian monsoon rainfall have little or no skill. They are typically made using a "Two-Tier" procedure in which seasonal forecasts of tropical (and sometimes global) SSTs are first made using statistical or coupled dynamical models, and the predicted SSTs are then used to drive uncoupled AGCMs. The poor monsoon forecasts could thus be due either to poor SST forecasts or to the two-tiered strategy itself being fundamentally flawed. We believe the latter to be the case, because the skill of monsoon hindcasts made by driving 10 different uncoupled AGCMs with even perfectly predicted (i.e observed) SSTs remains poor. We examined the monsoon hindcast skill of partially coupled GCMs in which SSTs were prescribed in the central and eastern tropical Pacific but were allowed to evolve elsewhere through coupled interactions with the oceanic mixed layer. The skill of these hindcasts was significantly higher than that of the fully uncoupled hindcasts. Coupling over the tropical warm pool was crucial for this improvement. We further confirmed the flaw in the two-tiered prediction approach by examining the 1-season lead monsoon hindcast skill over 1959-2001 of 7 different fully coupled models participating in the DEMETER project. The median skill of these hindcasts was also higher than those of the uncoupled hindcasts. This is remarkable in view of the SST hindcast biases of the DEMETER models, which are absent in uncoupled model hindcasts by design. This study was published in *Geophysical Research Letters*.

Distinguishing between ENSO and non-ENSO tropical SST variability

The global response to non-ENSO related tropical SST variations is best investigated in models in which one has the ability to specify SST fields without the El Nino signal. Unfortunately, it has proved difficult to eliminate the ENSO signal from historical data sets without also eliminating all other variability in the interannual band, regardless of whether or not it is ENSO-related. We have developed a method, based on the observed patterns associated with ENSO variability, to identify and remove most of the evolving ENSO signal while retaining the broadband frequency signal not associated with ENSO. It is distinctive in that it defines ENSO as an evolving combination of SST patterns rather than the SST in say just the Nino 3.4 region. Among many applications, we propose to use this filter to investigate the link between the interannual and interdecadal components of tropical variability.

Interesting results using this filter have already been obtained and a paper submitted to the *Journal of Climate.* The analysis reveals remarkably similar El Niño signals in the equatorial Indian and north tropical Atlantic Oceans. The south tropical Atlantic signal leads Niño 3.4 SST anomalies by about 9 months. The time series of the non-ENSO global tropical SST trend is found to have a smooth parabolic structure. In unfiltered data, this trend conspires with El Niño to obscure a meridional tropical Atlantic dipole. This dipole is statistically significant in the filtered SST data.

Tropical Forcing of extratropical SST anomalies via the "Atmospheric Bridge"

ENSO-induced atmospheric changes can force the ocean far from the equatorial Pacific. As a result, the atmosphere can act like a "bridge" connecting ENSO-related SST anomalies with those in other parts of the world. Having already established the importance of the bridge in winter in previous studies, this year we used several observational data sets to diagnose the bridge to the

North Pacific in summer. The results show that ENSO-related increases in wind speed and cloudiness strongly cool the Kuroshio region in July and August. To explore the role of wind driven currents on the extratropical ocean's response to ENSO, we added Ekman transport to the ocean component of the GFDL AGCM/mixed layer model. The results show that Ekman transport enhances the North Pacific SST response to ENSO by roughly 25% to 33%. In related work, we also helped document the mean climate and climate variability of NCAR's CCSM3, including the atmospheric bridge and the winter-to-winter recurrence of extratropical SST anomalies.

Diagnosis of decadal variability in the tropical Pacific ocean

CDC scientists are pursuing these studies in a conceptual framework in which the tropics affect the extratropics through the atmosphere, and the extratropics feed back on the tropics through oceanic subtropical cells (STCs). They have developed diagnostics to investigate these interactions in observations and models. Using these diagnostics, and also through careful GCM experiments, they demonstrated a link between the excessive simulated SPCZ precipitation in the NCAR-CCSM3 and its cold and fresh equatorial bias through the equatorial upwelling of excessively cold and fresh subducted subtropical water. They also showed that the Atlantic equatorial undercurrent is maintained mostly by subducted South Atlantic water. Two manuscripts describing these results were submitted.

In a separate study, CDC scientists used output from an NCAR OGCM forced with observed surface fluxes to better understand the causes of decadal variability in the subtropical cell (STC) and SSTs along the equator. The low frequency variability in this simulation is close to observations. They showed that this variability is primarily controlled by wind stress forcing in the tropics rather than by wind or buoyancy forcing in the subtropics. The changes in the STC vary zonally across the Pacific in association with baroclinic Rossby wave adjustment, raising questions about the conventional emphasis on examining only zonal mean STC variability.

Low-frequency pycnocline variability in the northeast Pacific

In a study published in the *Journal of Physical Oceanography*, the output of an ocean general circulation model (OGCM) driven by observed surface forcing was used in conjunction with simpler models to investigate the physical mechanisms of pycnocline variability in the northeast Pacific during 1958-97, a period spanning the 1976-77 "climate shift". After 1977 the pycnocline deepened along the coast and shoaled in the central part of the Gulf of Alaska. The pycnocline depth changes diagnosed from the model output were consistent with the observed changes at two ocean stations in the Gulf of Alaska. A simple Ekman pumping model with linear damping was shown to account for a large part of the OGCM's pycnocline variability, especially in the central part of the Gulf. The Ekman pumping model did not perform as well along the coast, where coastal propagating disturbances were probably important. Indeed in the western part of the Gulf, the local Ekman pumping-induced changes were anti-correlated with the OGCM's pycnocline depth variations. Our analysis suggests that the pycnocline depth changes associated with the 1976-77 climate shift were not consistent with Sverdrup dynamics, raising questions about how the Alaska Gyre adjusts to low-frequency wind stress variability.

Tropical Atlantic SST influences on the NAO

A study of the extratropical and tropical Atlantic SST forcing of the NAO was published in the *Journal of Climate*. It suggests that the observational relationship between the fall North Atlantic horseshoe (NAH) SST anomaly pattern and the subsequent winter NAO, as identified in recent studies, cannot be accounted for by the NAH SST forcing of the NAO. Instead, this relationship may result from the seasonally evolving coupled extratropical response to persistent tropical SST forcing. We have since extended this work to clarify the effects of Ekman transports on the extratropical coupled response to the tropical SST forcing. To this end, we developed a new coupled model (AGCM_EML) by including the Ekman advection in the slab mixed-layer ocean. Large ensembles of experiments with the AGCM_EML forced by the same tropical SST anomaly were conducted. The results show that with the Ekman advection included, the tropical forcing induces a coupled NAO-SST tripole response earlier in the season, compared to that in the AGCM_ML (NDJ vs. FMA). As a result, the seasonality of the NAO response in the AGCM_EML is more consistent with observations. A journal article describing these results is in preparation.

Understanding the differences between the mid-Holocene and present climates

One way to build confidence in future climate projections is to assess our ability to simulate past climate changes, for which, unlike the future, at least some observational paleoclimatic verification data are available. For example, paleoclimatic evidence suggests that during the mid-Holocene epoch (about 6000 years ago) North America and North Africa were significantly drier and wetter, respectively, than at present. Modeling efforts using fully coupled climate models to attribute these differences to differences in orbital forcing and greenhouse gas levels have had limited success, especially over North America. In this study, the importance of a possibly cooler tropical Pacific ocean during the epoch (akin to a permanent La Nina-like perturbation to the present climate) in causing these differences was investigated. Systematic sets of AGCM experiments, with prescribed SSTs in the tropical Pacific and coupling to a mixed-layer slab ocean elsewhere, were performed. Our simulated responses to these changes were generally consistent with the available paleoclimatic records. We concluded that the net response to the orbital changes was to shift the North Atlantic ITCZ northward and make North Africa wetter. The response to the reduced greenhouse gas levels opposed but did not eliminate these changes. The northward shifted ITCZ also blocked the moisture supply from the Gulf of Mexico into North America. This drying tendency was greatly amplified by the local response to La Nina-like conditions in the tropical Pacific. A paper describing these results was accepted for publication in the *Journal of Climate*.

Tropical Climate Regimes and Global Climate Sensitivity in a Simple Setting

Most current climate models have trouble simulating tropical rainfall. In particular the Pacific ITCZ varies considerably from model to model. Even zonally averaged rainfall profiles show large structural uncertainties with some models exhibiting a distinct double ITCZ. Many models also have 1-2K biases in tropical SSTs. To better understand the connection between the two, we forced an AGCM coupled to a global slab ocean with *globally uniform* insolation. To our surprise, we obtained multiple tropical climate regimes, with radically different ITCZ structures for different strengths of the insolation. In order from the coldest to the warmest climates these were: a symmetric double ITCZ, a near-symmetric equatorial ITCZ, a transient asymmetric ITCZ, and a stable, strongly asymmetric ITCZ. Further diagnosis showed that air-sea coupling was essential for the establishment and maintenance of the strongly asymmetric ITCZ. Wind-evaporation-SST (WES) feedback, as well as the longwave radiative effects of clouds and water vapor on SSTs, were all important in maintaining the asymmetric regime. The existence of multiple ITCZ regimes even in a single AGCM, and their sensitivity to SST feedbacks, complicates the diagnosis of the ITCZ errors of climate models. It also questions the notion of a constant global mean surface temperature sensitivity to climate change, because climate sensitivity measured across a regime transition can be much larger than the sensitivity within a single regime. This study was published in the *Journal of Atmospheric Sciences*.

A stochastic perspective on atmospheric regime behavior

Extratropical circulation statistics are not strictly Gaussian. The generally small deviations from Gaussianity are often interpreted as implying the existence of distinct and persistent nonlinear circulation regimes associated with potentially greater predictability. In this study, we showed that such deviations can however also occur in a linear system perturbed by multiplicative (i.e., state-dependent) noise, but are associated with much lower predictability. In particular, allowing for such noise in the damping coefficient of large-scale linear Rossby waves can produce deviations from Gaussianity very similar to those seen in the probability distributions of the amplitudes of the dominant EOFs of observed weekly-averaged 750 mb streamfunction data of the past 52 winters. Thus the observed non-Gaussian probability distributions do not necessarily imply the existence of persistent nonlinear circulation regimes, but are instead more consistent with the distributions of a linear system perturbed by multiplicative noise. A paper describing these results was published in the *Journal of the Atmospheric Sciences*.

The effect of subtropical surface cooling on ENSO amplitude

The effect of enhanced subtropical surface cooling on ENSO through a subsurface "ocean tunnel" was investigated in a coupled model. The ocean tunnel is a water pathway connecting subtropical surface water to equatorial upwelling water. Subtropical surface cooling was induced in the model by reducing the local radiative-convective equilibrium SST. This led to stronger ENSO events, by the following mechanism. The cooler subtropical water cooled the equatorial undercurrent through the ocean tunnel. This increased the temperature contrast between the warm pool and the equatorial thermocline (the source of eastern equatorial Pacific upwelling water), resulting in stronger ENSO events in response to this destabilization. Our experiment provides further support for the "heat pump" perspective of ENSO dynamics, in which ENSO arises from a destabilization of the coupled Pacific climate by a meridionally varying heating of the Pacific, and then acts to reduce that instability. ENSO is thus a regulator of the long-term stability of the coupled Pacific climate. Our results also support the notion that SST variability in higher latitudes may influence equatorial SST variability through the ocean tunnel.

Accounting for sub-grid scale variability of cloud properties and radiative fluxes in GCMs

The fine structure of cloud properties is currently accounted for in large-scale models in terms of the assumed probabilities and overlap properties of sub-grid scale clouds. CDC scientists are rigorously testing such assumptions, and recently used a month-long cloud-resolving model simulation of continental convection to develop more realistic overlap assumptions. They also explored ways of improving the coupling statistical cloud schemes with atmospheric convection schemes, specifically mass-flux schemes. In related studies, they explored ways of verifying model cloud fields with cloud radar observations based on interpreting the modeled quantity as a probabilistic forecast at the observation point. Several papers were published on these topics.

A subseasonal forecast model including tropical and stratospheric influences

Our linear inverse model (LIM) of northern hemisphere weekly and longer-term variations, that was previously shown to be competitive with NCEP's forecast system at Week 2 and week 3 predictions, was further developed to include stratospheric influences. A study comparing and contrasting the stratospheric and tropical influences on extratropical variability and predictability is nearing completion. Perhaps its most important conclusion is that stratospheric influences are important in the Atlantic sector, whereas tropical influences dominate in the Pacific sector.

Clarifying the role of diabatic physics in the MJO

CDC scientists published at least 5 papers directly on this topic and related issues. They demonstrated the distinctive top-heaviness of the diabatic heating profile associated with relatively strong stratiform precipitation during MJO episodes, and that the column-integrated radiative heating variations are nearly in phase with precipitation variations during such episodes. They also investigated the impact of vertical wind shear on radiatively important cloud properties.

An Experimental MJO Prediction Website

Improved MJO predictions offer the possibility of increasing tropical and extratropical forecast skill at lead times of 1-4 weeks. Unfortunately, current GCMs have difficulty in representing the MJO and its associated multi-scale interactions of convection and circulation. Acting on recommendations from two recent NASA/NOAA workshops on subseasonal variability, CDC hosts a website where real-time and experimental MJO forecasts are objectively evaluated, and feedback provided to forecasters. Forecast contributions now number five statistical models, two GCM ensembles and a coupled ocean-atmosphere model, with more contributions pending. Forecasts of five different variables are displayed in a common graphical format for easy comparison. Results confirm that both the statistical and numerical prediction models have only marginal skill at Week 2, even for planetary scale variables like 200 mb velocity potential. The forecast skill of tropical precipitation is poor for all the available GCMs.

Subseasonal variations of South American rainfall

Regional and large-scale circulation anomalies associated with rainfall variations downstream of the South American low-level jet have been identified and compared to those in the South Atlantic convergence zone (SACZ). Composites of precipitation associated with strong jets show a rainfall pattern evolving from south to north. A similar evolution occurs during extreme precipitation events, and is associated with a distinct low-level jet near 20 S. Geopotential height, temperature, and large-scale wind composites suggest that this developing disturbance is tied to a midlatitude Pacific wavetrain turning equatorward after crossing the Andes. Similar composites based on SACZ rainfall reveal similar features but of opposite sign, suggesting that the phase of the wave as it crosses the Andes determines whether rainfall will be enhanced downstream of the jet or in the SACZ. The alternate suppression and enhancement of rainfall in these adjacent regions causes the precipitation "dipole" noted in many previous studies. We also found these precipitation anomalies to be statistically linked to the MJO, raising the speculation that the slowly varying precipitation dipole results from a preferred phasing of synoptic waves by variations of the planetary-scale ambient flow, that are themselves influenced to some degree by the MJO.

Feasibility of a reanalysis of the 20th century atmospheric circulation

Investigations of climate variability and global change are increasingly focused on understanding and predicting the changes of regional weather statistics. Assessing the evidence for such variations over the last century requires a daily tropospheric circulation dataset. The only available datasets for the early 20th century consist of error-ridden hand-drawn analyses of mean sea level pressure over the Northern Hemisphere. Modern data assimilation systems have the potential to improve upon these maps, but prior to 1948, few digitized upper-air sounding observations are available for such a reanalysis. We have investigated the possibility that some additional newly-recovered surface pressure observations may be sufficient to generate useful daily weather maps of the lower-tropospheric extratropical circulation back to 1890 over the Northern Hemisphere, and back to 1930 over the Southern Hemisphere. Indeed, we provide strong evidence that an advanced data assimilation system based on an ensemble Kalman filter could produce high-quality maps of even the upper tropospheric circulation using only the surface pressure observations. For the early part of the 20th century, the errors of such upper-air circulation maps for the Northern Hemisphere winter would be comparable to the 3-day errors of current operational weather forecasts. This study has generated great interest, and is due to appear in the *Bulletin of the American Meteorological Society*.

Some other CDEP Activities

CDC has been posting weather-climate forecast discussions on its website on a quasi-regular basis since December 2003. The discussions evaluate the real time global atmospheric circulation anomalies, utilize forecasts of the MJO available on the website, and make experimental subjective predictions of US temperature and precipitation for weeks 1 through 3. They also seek to link midlatitude synoptic events with the more slowly evolving MJO and teleconnection patterns with an emphasis on extreme events and circulation transitions. A subseasonal synoptic-dynamic model provides a framework for evaluating the prediction models and for forecasting circulation and USA temperature/precipitation anomalies.

CDC scientists continue to provide regular input to the production of the U.S. Drought Monitor. They monitor current climate conditions, especially in the western U.S,, and translate that information into the drought categories used in this product. To generate useful short to medium-range outlooks, they utilize bias-corrected CDC MRF forecasts to downscale temperature forecasts over western Colorado, and have developed a web page to make these user-friendly forecasts available to water resource managers at the Bureau of Reclamation and other agencies. They continue producing experimental seasonal forecasts based on tropical SSTs every month, and have created a web page to display 2-tier forecasts made using 6 different forecasts of the SSTs. On the state level, they regularly provide input to and make briefings at meetings of the Colorado Water Availability Task Force and other stakeholders on the current and projected evolution of ENSO-related anomalies and their implications for the southwestern U.S. Some experimental CDC forecasts are used by regional wildfire managers.

CDC scientists recently discovered an emerging long-term trend toward an increasing year-to-year variance (decreasing reliability) of streamflow across the major river basins in western North

America: Fraser, Columbia, Sacramento-San Joaquin, and Upper Colorado. They also demonstrated that a concurrent increase in the incidence of synchronous flows (simultaneous high or low flows across all four river basins) has resulted in expansive water resources stress. The observed trends are associated with trends in the wintertime atmospheric circulation and ocean temperatures, raising new questions on the detection, attribution, and projection of regional hydrologic climate change.

CDC continued to provide scientific support to the OGP-funded regional assessment on the effects of climate variability on water resources in the Interior West ("Western Water Assessment", or WWA). CDC scientists continued their frequent interactions with other federal and state agencies such as the Department of the Interior, including the Bureau of Reclamation and the Fish and Wildlife Service, and other user groups, such as the Denver Water Board, Colorado River Water Conservation District, and Colorado Drought Task Force. An important objective of this research is to learn how to better incorporate climate information and forecasts into water resource decisions in this highly water-sensitive region.

CDC continued to work closely with NCEP, particularly with EMC on the coupled model project and with CPC on Week-Two and seasonal climate forecasts. A CDC scientist spent six months at EMC in FY05 developing stochastic parameterizations for NCEP models, and is continuing that development in Boulder. In collaboration with the IRI, CDC conducted diagnostic and predictability analyses with models that are used for predictive purposes by the IRI and its partners.

CDC also continued its strong tradition of public outreach and service to the broader scientific community. CDC staff continue to provide numerous media interviews and specialized climate briefings, and continue to develop new webpages on its website explaining basic and applied CDC climate research in laymen's terms. Our web site contains links to many experimental and applied climate products that were developed at CDC under support from the CDEP/ARC program. Examples include prototype global risk assessments; climate probability distributions; interactive pages for calculating and displaying composite fields and correlations from NCEP Reanalysis data; operational analyses, US climate division data, ENSO climate risk pages, and a climate products information page that includes a broad range of operational and experimental climate products, particularly those developed by NOAA and its partners. CDC continues to serve as a primary redistribution point for the NCEP Reanalysis data set, providing netCDF versions of the reanalysis fields via the web or via tape (for larger requests) to users throughout the world. CDC is a core NOAA partner, with NCEP, NCDC, GFDL, and PMEL, in the NOAA Operational Model Archive and Distribution System (NOMADS) being developed to provide seamless access to geographically distributed climate model outputs

CDC continued updating and improving the recently re-named International Comprehensive Ocean-Atmosphere Data Set (I-COADS) under a cooperative project with NCAR and NOAA/NCDC. The new name recognizes the multinational input to the database while maintaining continuity of identity with COADS, which has been widely used. The recently released ICOADS-2.1 version of the dataset is the largest available set of in situ marine observations taken over the period 1784-2002. The ship observations include instrument measurements and visual estimates, whereas data from moored and drifting buoys are exclusively instrumental. The collection integrates data from many diverse sources that are inhomogeneous due to changes in observing systems and recording practices throughout the observing period of over two centuries. It is expected to be a key reference dataset for documenting long-term environmental changes, providing input to a variety of critical climate and other research applications, and as a basis for many derived products and analyses.

CDC-CDEP General Research Objectives, FY06

Most of the projects described in the previous sections are ongoing research efforts, and as such will continue into FY06. CDC's overall research emphasis will continue to be on applying its unique diagnostic expertise to help achieve CDEP's primary goal of improving the skill and usefulness of climate forecasts, in support of the IRI, NCEP, and regional assessments. Stronger collaborations continue to be developed with the IRI to support global seasonal predictions, as well as with GFDL on climate model diagnosis. Several CDC scientists are also beginning to evaluate and diagnose the NCEP atmospheric (GFS) and coupled (CFS) forecast systems.

CDC will continue major efforts in diagnostic and predictability research to further NOAA's capabilities in extreme events risk predictions; describing relationships between intraseasonal variations such as the MJO and seasonal-to-interannual climate predictions and predictability; clarifying ocean-atmosphere interactions on longer than ENSO time scales; assessing extratropical ocean-atmosphere processes and related prospects for predictability; establishing improved measures to estimate the confidence of climate forecasts; and developing the means to better communicate climate information to the public and decision makers. Specific research foci will include:

- Assessing effects of coupled processes on large-scale teleconnections
- Identifying impacts of decadal variability and long-term trends on climate predictability
- Improving methods of ensemble prediction and ensemble data assimilation
- Developing Linear Inverse Modeling (LIM) methods of diagnosis and prediction
- Developing stochastic approaches to modeling and parameterizations
- Improving probability forecasts through estimation of future probability distribution functions (PDF's) through large ensembles, multi-model approaches and other techniques
- Evaluating links between weather and climate for applications in climate forecasts (e.g., improved estimates of extreme event risks)
- Diagnosing physical processes using observations and a hierarchy of simple models

CDC will continue to provide a sustained infrastructure that enables NOAA to better meet current and emerging needs of users for climate data and forecasts. Examples include developing web-based products to improve access to available climate information, and simplifying interactive uses of climate data and forecasts. Such activities help to support the missions of the IRI, NCEP, and projects supported by OGP under its regional assessments and human dimensions programs.

On a final note, our future annual reports will reflect the fact that on October 1, 2005, NOAA-CDC merged into NOAA's Earth System Research Laboratory (ESRL) as part of its Physical Sciences Division. This change in no way affects its relationship with the CDEP/ARCs program. CDC also continues to maintain its identity as a Center within the Cooperative Institute of Research in Environmental Sciences (CIRES) at the University of Colorado.

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Peer-Reviewed Journal Articles by CDC Scientists (October 2004 – October 2005) (Names of CDC authors in bold)

Barsugli J, **Shin SI**, **Sardeshmukh PD**
Tropical climate regimes and global climate sensitivity in a simple setting
JOURNAL OF THE ATMOSPHERIC SCIENCES 62 (4): 1226-1240 APR 2005

Batstone CP, Matthews AJ, Stevens DP
Coupled ocean-atmosphere interactions between the Madden-Julian oscillation
and synoptic-scale variability over the warm pool.
JOURNAL OF CLIMATE 18 (12): 2004-2020 JUN 15 2005

Cahalan, Oreopoulos, Marshak et al. (16 authors; **R, Pincus** of CDC 6th)
The 13RC - Bringing together the most advanced radiative transfer tools for cloudy atmospheres.
BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY 86 (9): SEP 2005

Capotondi A, **Alexander MA**, Deser C, McPhaden MJ
Anatomy and decadal evolution of the Pacific Subtropical-Tropical Cells (STCs)
JOURNAL OF CLIMATE 18 (18): 3739-3758 SEP 15 2005

Capotondi A, **Alexander MA**, Deser C, Miller AJ
Low-frequency pycnocline variability in the northeast Pacific
JOURNAL OF PHYSICAL OCEANOGRAPHY 35 (8): 1403-1420 AUG 2005

Compo GP, **Sardeshmukh PD**
Storm track predictability on seasonal and decadal scales
JOURNAL OF CLIMATE 17 (19): 3701-3720 OCT 2004

Forman SL, Marin L, Pierson J, Gomez J, Miller GH, **Webb RS**
Aeolian sand depositional records from western Nebraska:
landscape response to droughts in the past 1500 years
HOLOCENE 15 (7): 973-981 NOV 2005

Hamill TM, Schneider RS, Brooks HE, Forbes GS, Bluestein, HB, Steinmberg M, Melendez D, **Dole RM**.
The May 2003 extended tornado outbreak
BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY 86 (4): APR 2005

Jain SL, **Hoerling M**, **Eischeid J**
Decreasing reliability and increasing synchroneity of western North American streamflow
JOURNAL OF CLIMATE 18 (5): 613-618 MAR 1 2005

Klein SA, **Pincus R**, **Hannay C**, Xu KM.
How might a statistical cloud scheme be coupled to a mass-flux convection scheme?
JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES 110 (D15):
Art. No. D15S06 APR 21 2005

Kumar KK, **Hoerling M**, Rajagopalan B
Advancing dynamical prediction of Indian monsoon rainfall
GEOPHYSICAL RESEARCH LETTERS 32 (8): Art. No. L08704 APR 21 2005

Liebmann B, Kiladis GN, Vera CS, et al.
Subseasonal variations of rainfall in South America in the vicinity of the low-level jet east of the Andes and comparison to those in the South Atlantic convergence zone
JOURNAL OF CLIMATE 17 (19): 3829-3842 OCT 2004

Liebmann B, Vera CS, Carvalho LMV, Camilloni IA, **Hoerling MP**, Allured D, Barros VR, Baez J, Bidegain M.
An observed trend in central South American precipitation
JOURNAL OF CLIMATE 17 (22): 4357-4367 NOV 2004

Lin JL, Zhang MH, **Mapes B**
Zonal momentum budget of the Madden-Julian oscillation: The source and strength of equivalent linear damping
JOURNAL OF THE ATMOSPHERIC SCIENCES 62 (7): 2172-2188 Part 1 JUL 2005

Liu ZY, **Shin SI**, **Webb RS**, Lewis, W, Otto-Bliesner BL.
Atmospheric CO2 forcing on glacial thermohaline circulation and climate
GEOPHYSICAL RESEARCH LETTERS 32 (2): Art. No. L02706 JAN 27 2005

Lundquist JD, Dettinger MD, Cayan DR
Snow-fed streamflow timing at different basin scales: Case study of the Tuolumne River above Hetch Hetchy, Yosemite, California
WATER RESOURCES RESEARCH 41 (7): Art. No. W07005 JUL 7 2005

Lundquist JD, Dettinger MD
How snowpack heterogeneity affects diurnal streamflow timing
WATER RESOURCES RESEARCH 41 (5): Art. No. W05007 MAY 6 2005

Mapes BE, **Lin JL**
Doppler radar observations of mesoscale wind divergence in regions of tropical convection
MONTHLY WEATHER REVIEW 133 (7): 1808-1824 JUL 2005

Mapes BE, Liu P, **Buenning N**
Indian monsoon onset and the Americas midsummer drought: Out-of-equilibrium responses to smooth seasonal forcing
JOURNAL OF CLIMATE 18 (7): 1109-1115 APR 1 2005

Pielke RA, Doesken N, Bliss O, et al. (9 authors, **K. Wolter** of CDC 9th)
Drought 2002 in Colorado: An unprecedented drought or a routine drought?
PURE AND APPLIED GEOPHYSICS 162 (8-9): 1455-1479 AUG 2005

Peng SL, Robinson WA, **Li SL**, **Hoerling MP**.
Tropical Atlantic SST forcing of coupled north Atlantic seasonal responses
JOURNAL OF CLIMATE 18 (3): 480-496 FEB 1 2005

Pincus R, **Hannay C**, Evans KF
The accuracy of determining three-dimensional radiative transfer effects in cumulus clouds using ground-based profiling instruments
JOURNAL OF THE ATMOSPHERIC SCIENCES 62 (7): 2284-2293 Part 1 JUL 2005

Pincus R, **Hannay C**, Klein SA, Xu KM, Hemler R.
Overlap assumptions for assumed probability distribution function cloud schemes in large-scale models
JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES 110 (D15): Art. No. D15S09 JUN 1 2005

Shinoda T
Impact of the diurnal cycle of solar radiation on intraseasonal SST variability in the western equatorial Pacific
JOURNAL OF CLIMATE 18 (14): 2628-2636 JUL 15 2005

Shinoda T, Han WQ
Influence of the Indian Ocean dipole on atmospheric subseasonal variability
JOURNAL OF CLIMATE 18 (18): 3891-3909 SEP 15 2005

Solomon A, Jin FF
A study of the impact of off-equatorial warm pool SST anomalies on ENSO cycles
JOURNAL OF CLIMATE 18 (2): 274-286 JAN 15 2005

Sun DZ, **Zhang T**, **Shin SI**
The effect of subtropical cooling on the amplitude of ENSO: A numerical study
JOURNAL OF CLIMATE 17 (19): 3786-3798 OCT 2004

Sura P, **Newman M**, **Penland C**, **Sardeshmukh PD**
Multiplicative noise and non-gaussianity: A paradigm for atmospheric regimes?
JOURNAL OF THE ATMOSPHERIC SCIENCES 62 (5): 1391-1409 MAY 2005

Wang XG, Bishop CH
Improvement of ensemble reliability with a new dressing kernel
QUARTERLY JOURNAL OF THE ROYAL METEOROLOGICAL SOCIETY 131 (607): 965-986 Part A APR 2005

Worley SJ, **Woodruff SD**, Reynolds RW, Lubker SJ, Lott N.
ICOADS release 2.1 data and products
INTERNATIONAL JOURNAL OF CLIMATOLOGY 25 (7): 823-842 JUN 15 2005

Zhang MH, Lin WY, Klein SA, et al. (20 authors; **R. Pincus** of CDC 13th)
Comparing clouds and their seasonal variations in 10 atmospheric
general circulation models with satellite measurements
JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES
110 (D15): Art. No. D15S02 MAY 3 2005