Climate Model Development Task Force
List of MAPP funded projects per area

[Note: Projects that are relevant to more than one area are repeated as necessary]

Model Development

- A CPT for Improving Turbulence and Cloud Processes in the NCEP Global Models PI: Krueger (MAPP-CTB)
- CPT to improve cloud and boundary layer processes in GFS/CFS PI: Bretherton (MAPP-CTB)
- Improving the Prognostic Ozone Parameterization in the NCEP GFS and CFS for Climate Reanalysis and Operational Forecasts PI: Compo
- Improving the landsurface components of Climate Forecast System Reanalysis (CFSR) PI: Ek

Software Modeling Infrastucture

- Software modeling infrastructure: Couple NCEP EMC NEMS to MOM5/ice for more capable CFSv3 and single framework for EMC/CPC PI: DeLuca

Data Assimilation

- Exploration of advanced ocean data assimilation schemes at NCEP PI: Carton
- Improving the Prognostic Ozone Parameterization in the NCEP GFS and CFS for Climate Reanalysis and Operational Forecasts PI Compo
- Strategies to Improve Stratospheric Processes in Climate Reanalysis PI: Long
- Research towards the next generation of NOAA Climate Reanalyses PIs: Kumar and Compo
- Improving the landsurface components of Climate Forecast System Reanalysis (CFSR) PI: Ek
- Evaluating CFSR AirSea Heat, Freshwater, and Momentum Fluxes in the context of the Global Energy and Freshwater Budgets PIs: Yu and Xue

Model/Analyses Evaluation

- COLA: Predictability and Prediction of Climate from Days to Decades PI: Kinter
- Evaluating CFSR AirSea Heat, Freshwater, and Momentum Fluxes in the context of the Global Energy and Freshwater Budgets PIs: Yu and Xue

Exploration of advanced ocean data assimilation schemes at NCEP

Principal Investigator: James A. Carton (UMD)
Co-Principal investigators: Eugenia Kalnay (UMD), David Behringer (NOAA/NCEP), and Hendrik Tolman (NOAA/NCEP)

Funding dates: August 1, 2013 to July 31, 2014

(2) Abstract

The first task will be to upgrade NCEP's Global Ocean Data Assimilation System (GODAS) from the current 3DVar system implemented in 2003 to the ensemble Local Ensemble Transform Kalman Filter (LETKF). GODAS serves as the ocean component of the integrated atmosphere-ocean analysis system, in turn providing the initial conditions for NCEP's atmosphere/ocean Climate Forecast System, version 2, (CFSv2). The second task will be to combine the 3DVar and LETKF systems to form a hybrid version of GODAS. We will explore the effectiveness of this hybrid system to represent timeevolving local correlations due, for example to fronts or currents, while at the same time maintaining large-scale correlations. An additional task will be to examine the computational efficiency of the hybrid filter relative to its 3DVar and LETKF alternatives.

The proposal will bring together researchers from the University of Maryland experienced in the development and use of LETKF with NCEP researchers who have overseen development of 3DVar-GODAS and the first two versions of the CFS. The rationale for proposed work is: 1) It will result in an upgrade of the ocean analysis system to one that will be analogous to NCEP's 3DVar-hybrid Gridpoint Statistical Interpolation system (GSI) used for atmospheric analysis. This upgrade will allow the next generation CFS to gain the benefit of a more integrated atmosphere-ocean-land analysis system in which both ocean and atmosphere components use coupled ensemble-based estimates of flux error at the interface. 2) The implementation of LETKF in GODAS will provide NCEP with a more flexible ocean analysis system, for example simplifying the inclusion of new observational data sets like sea surface salinity and providing an error estimate for the ocean state. This flexibility is important to allow NCEP to implement assimilation upgrades to both GODAS (using a MOM-based model) and the eddy-resolving Real-Time Ocean Forecast System (RTOFS) (using a HYCOM-based ocean model). The new development work proposed here will be carried out in NCEP's computing environment thus facilitating the integration of the resulting system into operations.

This proposal addresses the NOAA Next Generation Strategic Plan's call to 'create accurate and reliable estimates of the state of the ocean, including its temperature, salinity, and motion fields for accurate forecasts and assessments'. Likewise it addresses the Climate Program Office Strategic

Climate Objective: I *Improve Scientific Understanding*, specifically the goals of improved monitoring and improving initial conditions to explore '*useful predictions of climate variability and change for the next one to three decades*'. Within the Modeling, Analysis, Predictions, and Projections (MAPP) program 2013 Call the developments described in this proposal address Priority Area 1: Research to Advance Climate Reanalysis and Research Focus 2: Integration among Earth System reanalysis components by improving the integration of the atmospheric and ocean analysis systems.

Improving the Prognostic Ozone Parameterization in the NCEP GFS and CFS for Climate Reanalysis and Operational Forecasts

Abstract to the NOAA MAPP Program, NOAA-OAR-CPO-2013-2003445

Principal Investigator: *Dr. Gilbert P. Compo,* University of Colorado/CIRES and NOAA ESRL, gilbert.p.compo@noaa.gov

Co-Principal Investigators: *Dr. Jeffrey S. Whitaker ,*NOAA, Earth System Research Laboratory, jeffrey.s.whitaker@noaa.gov; *Dr. Prashant D. Sardeshmukh ,*University of Colorado/CIRES and NOAA ESRL, prashant.d.sardeshmukh@noaa.gov; *Mr. Craig Long*, CPC Principal Investigator, NOAA, National Centers for Environmental Prediction, CPC, craig.long@noaa.gov; *Dr. Shrinivas Moorthi*, EMC, NOAA, National Centers for Environmental Prediction, shrinivas.moorthi@noaa.gov; *Dr. Sarah Lu*, EMC Principal Investigator, NOAA, National Centers for Environmental Prediction, EMC, sarah.lu@noaa.gov; *Dr. John P. McCormack*, NRL Principal Investigator, Naval Research Laboratory, Space Science Division, john.mccormack@nrl.navy.mil

The objective of this proposal is to improve the representation of stratospheric ozone (O3) and water vapor in NOAA's climate reanalyses. This work will also improve NOAA's simulation, analysis, and forecasting of weather and climate variability, including forecasts of UV radiation to protect public health. A complete treatment of O3 photochemistry is too computationally intensive for current models. Therefore, a parameterization is included in the current NCEP Global Forecast System (GFS) atmosphere/land model used in the 20th Century Reanalysis and operational forecasts, and also used in the coupled Climate Forecast System (CFS) Reanalysis and operational CFSv2. The GFS parameterization for the time tendency of O3 is based on parts of NRL's CHEM2D Ozone Photochemistry Parameterization (CHEM2D-OPP). It includes terms representing net production and loss and a dependency on the ozone mixing ratio itself. It is based on gas-phase chemistry of the late-20th century, which includes the depletion of ozone by chlorofluorocarbons (CFCs). For climate reanalyses and climate modeling extending back to the early 20th century or earlier, before large quantities of CFCs began to be released into the atmosphere, a new version of this parameterization is needed to represent pre- CFC stratospheric O3 chemistry. To understand, analyze, and predict atmospheric variability in the 21st century, the parameterization should utilize additional interactions included in CHEM2D-OPP that affect stratospheric O3. Stratospheric water vapor is also an important radiative constituent. Its representation in the GFS will also be improved, paving the way for improved assimilation of satellite radiances and for interactive chemistry.

In this proposal, a more advanced O3 parameterization using the full CHEM2D-OPP and an improved treatment of stratospheric water vapor will be implemented for use in new versions of the GFS, CFS, and next generation NOAA climate reanalysis systems. The O3 parameterization

will include the effect of changes in temperature, changes in the vertical distribution of O3, and the time-variation of CFCs. As a first step, the parameterization will be tested with two modes, one for times before CFCs and one for times after CFCs began to be released in large quantities. The team will also implement a new stratospheric H2O climatology as a necessary first step toward future implementation of parameterized H2O photochemistry. The upgraded parameterization and new climatology will be tested in climate reanalyses and weather and climate simulations. The impact of the new O3 and water vapor treatments on reanalysis, GFS medium-range forecast skill, and CFS climate simulations will be evaluated using comparisons with both historical and modern O3 and temperature observations throughout the troposphere and stratosphere as well as with UV radiation observations.

This project is directly related to both foci of Priority 1 of the MAPP call for proposals. It is also directly relevant to NOAA's Next-Generation Strategic Plan goals for climate adaption and mitigation. As noted by the WMO Global Framework on Climate Services, reanalyses are a key component of the climate information needed for informed decision making for climate change mitigation and adaption. This proposal directly addresses the MAPP call to pursue research on "Outstanding issues in atmospheric reanalysis", in particular by attempting to "overcome the impact of model bias" and "exploit new data". Improved stratospheric ozone and water vapor representations will both reduce model error in the first guess fields and permit more effective assimilation of satellite radiances affected by these constituents. The improved stratospheric O3 and water vapor will also be an important contribution to foci 2 as explicit chemistry begins to be included in Earth System analyses.

Strategies to Improve Stratospheric Processes in Climate Reanalysis

Principal Investigator: Craig Long *NOAA/NWS/NCEP/Climate Prediction Center*
Co-Investigators:
Judith Perlwitz *Univ. of Colorado/CIRES and NOAA/ESRL/Physical Sciences Division*
Fabrizio Sassi *NRL/Space Science Division/Near Space Environments Geospace Science and Technology Branch*

1) Abstract

The primary purpose of the reanalysis effort is to advance climate studies by eliminating fictitious trends caused by model and data assimilation changes that occurred in real time. Reanalyses are to represent the observations as closely as possible and could be used as surrogates where observations are not available. Each generation of reanalyses has improved upon its predecessor in many ways by: reduction of errors, increased spatial and vertical resolution, and addition of more variables. The current generation of reanalyses provides more information about the stratosphere than previous versions. This is important for monitoring the impacts of climate change and ozone depletion on the stratospheric circulation and the stratospheric interactions with the troposphere. Assessments of the stratosphere in the latest generation of reanalyses revealed several issues that may hinder the full use of these reanalyses for climate studies. This was particularly true for the NOAA Climate Forecast System Reanalysis (CFSR). This reanalysis contains jumps in data records during stream transitions, warming trends in the upper stratosphere between streams, poor representation of the Quasibiennial Oscillation (QBO) winds, ozone observations not being assimilated in the upper stratosphere, and poor representation of water vapor above the tropopause. It is important to rectify these issues before the next NOAA reanalysis effort.

We propose to address the climate objectives outlined in the NOAA Next Generation Strategic Plan (NGSP) and a major CPO/Modeling, Analysis, Predictions, and Projections (MAPP) Program priority: Research to Advance Climate Reanalysis, particularly "issues with the quality of reanalyses in the stratosphere" by improving the characterization of the stratosphere in reanalysis by building upon research conducted following the CFSR. We propose to: reduce the impacts of data inhomogenuity on temperature and ozone, to improve the thermal structure of the upper stratosphere, improve the representation of the QBO winds and residual circulation in the tropics, and improve the depiction of ozone and water vapor in the stratosphere. Success in providing these improvements will lead to a better characterization of the stratosphere. A well characterized stratosphere may enable better weather and climate research and services by: 1) providing a more accurate depiction of past weather and climate conditions, 2) improving the monitoring of current climate conditions, and 3) enabling the attribution of climate variations and change by comparison with past conditions.

Research towards the next generation of NOAA Climate Reanalyses
Abstract to the NOAA MAPP Program, NOAA-OAR-CPO-2013-2003445

Principal Investigator: Dr. Arun Kumar, NOAA, National Centers for Environmental Prediction, arun.kumar@noaa.gov

Co-Principal Investigators: Dr. Gilbert P. Compo, CIRES/NOAA ESRL Lead Investigator, University of, Colorado/CIRES and NOAA ESRL, gilbert.p.compo@noaa.gov; Dr. Jeffrey S. Whittaker, NOAA, Earth System Research Laboratory, jeffrey.s.whitaker@noaa.gov; Dr. Prashant D. Sardeshmukh, University of Colorado/CIRES and NOAA ESRL, prashant.d.sardeshmukh@noaa.gov; Dr. Russell Vose, NCDC Lead Investigator, NOAA/National Climatic Data Center, russell.vose@noaa.gov

Abstract

The fidelity of new reanalysis datasets (MERRA, 20CR, CFSR, ERA-Interim) at representing climate variability of the 20th century has enabled significant advances in climate research. In this research proposal, we will investigate known shortcomings of these datasets, while developing a framework for a new NOAA Climate Reanalysis (NCR) system to ameliorate them. The NCR will eventually have four "streams" to meet the various user needs for reanalysis information:

Stream 0: Boundary-forced, 1850-present "AMIP" simulation with large ensemble
Stream 1: Historical, 1850-present using only surface data
Stream 2: Modern, 1946-present using only surface and conventional upper air data
Stream 3: Satellite, 1973-present using quality-controlled satellites, Global Positioning System Radio Occultation, and surface and conventional upper air data.

One of the foci of this research will be to use observing system experiments. In these, the 2000-2010 observing system is reduced to that of selected historical periods to investigate the impact to the time-varying quality and density of the observing system and determine ways to reduce this impact. We will use innovative methods to assess the relative importance and impact of model errors and observational errors on the quality and homogeneity of the reanalysis fields, with particular attention to reducing or eliminating spurious jumps and trends. The framework for the NCR system will leverage recent advances in operational data assimilation for global weather prediction, as well as newly digitized observational datasets and global model improvements. While initially focusing on the atmosphere to develop the NCR framework, this project will serve as the basis for further NCR efforts, incorporating advancements generated by other projects supported by MAPP, such as integration of ocean, chemistry, and land components and the treatment of observational and model biases. International coordination and data sharing with NOAA's reanalysis partners at NASA, ACRE, ECWMF, and JMA and synergies from the

NOAA Reanalysis Task Force will be crucial in achieving the project's goals on a limited budget.

This project is directly related to foci 1 of Priority 1 of the MAPP call for proposals. It is directly relevant to NOAA's Next-Generation Strategic Plan goals for climate adaptation and mitigation. As noted by the WMO Global Framework on Climate Services, reanalyses are a key component of the climate information needed for informed decision making for climate change mitigation and adaption. The NGSP recognizes that a strong scientific basis is needed for developing “climate adaptation and mitigation” strategies, which will require “improved scientific understanding of the changing climate system and its impacts” and “assessments of current and future states of the climate system.” For NOAA to achieve these objectives, we must develop climate reanalysis products that are free of artificial trends and that provide reliable information about the frequency of weather and climate extremes. This proposal directly addresses the MAPP call to pursue research on “Outstanding issues in atmospheric reanalysis”, in particular by attempting to “overcome the impact of data inhomogeneities due to changes in the observing system and data biases”, “overcome the impact of model bias”, “better quantify uncertainties in reanalysis data including the impacts of data and model error”, and “exploit new data”.

ABSTRACT

Title: Improving the land-surface components of Climate Forecast System Reanalysis (CFSR)

Investigators:
Michael Ek, Jesse Meng, Jiarui Dong, Youlong Xia, Rongqian Yang (NCEP/EMC), Kingtse Mo (NCEP/CPC), Dennis Lettenmaier, Bart Nijssen (Univ. Wash.), Eric Wood, Justin Sheffield (Princeton Univ.)

Global reanalyses, starting with the NCEP/NCAR reanalysis in the mid-1990s, are widely used as surrogates for space time observations in both the atmosphere and the land surface (and, to a lesser extent, the oceans). Early (e.g. NCEP/NCAR) reanalysis land surface products had many problems, including discontinuities near the beginning of the satellite era in the 1970s, and unrealistic land surface variables (such as soil moisture) resulting from updates to some land surface variables intended to resolve deficiencies in atmospheric moisture and moisture transport profiles. These issues have been mitigated to some extent in more recent reanalyses (e.g., Climate Forecast System Reanalysis (CFSR), ERA-40 and ERA-Interim and the North American Regional Reanalysis, NARR). Nonetheless, the fidelity of land variables from land atmosphere reanalyses remains questionable. We believe that the land data assimilation system used in upcoming reanalyses can be enhanced via improved (1) land characterization data sets (e.g. vegetation type and soil texture class, and the characterization of urban areas, etc.), (2) atmospheric forcing data sets (e.g. precipitation, downward solar and longwave radiation), (3) assimilation of near-real time land states (e.g. surface skin temperature, albedo, soil moisture, snow extent, vegetation greenness and density), (4) land-model spin-up procedures, and (5) downscaling techniques for forcing data and land states. We intend to investigate options for making these improvements, in the context of an enhanced CFSR framework. Additionally, currently missing in reanalyses is the inclusion of some key variables in the land surface water budget, such as groundwater, streamflow (routed to the mouths of major rivers), and lakes, reservoirs (managed), and wetlands. All of these are needed to complete the water cycle for a fully-coupled system, and to account for feedbacks to the atmosphere and coupling between the terrestrial and atmospheric budgets (e.g. over long periods river discharge from a region equals net atmospheric convergence into the region, so errors in river flow predictions must manifest themselves in the atmospheric moisture fields). We intend to investigate inclusion of such representations in the context of the new Noah-MP land surface modeling framework, which will be the land surface scheme for NCEP's next generation reanalyses. Co-PIs Lettenmaier and Wood have extensive experience in representation of the above variables in the context of the VIC land model, and some of the VIC parameterizations may be transferred to Noah-MP as needed. Furthermore, all co-Is have extensive experience in development of model evaluation data sets, through programs like NLDAS and GLDAS, which we will draw from.

A CPT for Improving Turbulence and Cloud Processes in the NCEP Global Models

Lead P.I.: Steven K. Krueger, University of Utah
Co-PIs: Shrinivas Moorthi (NCEP/EMC), Robert Pincus (CIRES/U of Colorado), Dave Randall (Colorado State University), Peter Bogenschutz (NCAR).

Convection, turbulence, clouds, and precipitation occur across a wide range of scales, from hundreds of kilometers to hundreds of meters, and clouds at all scales strongly influence weather. Small shallow cumulus strongly affect the planetary albedo and produce a significant amount of precipitation, while turbulence and cloud processes largely control the radiatively significant transition between stratocumulus and shallow cumulus. Deep convection produces a large fraction of the Earth's precipitation. The stratiform clouds generated by cumulus detrainment are important radiatively. The interaction between (relatively) largeand smallscale processes is also important:
the diurnal cycle of precipitation over land, which essentially all weather and climate models simulate poorly, arises through interactions among the turbulent boundary layer, shallow cumulus convection, and deep cumulus convection. Representing the interactions between turbulence, clouds, deep convection, and radiation are of key importance for predicting weather and climate. Global models parameterize the effects of processes that occur on scales near or below the horizontal grid spacing, including turbulence, convection, and associated cloud and radiation processes. Current global forecast models use grid spacings of a few tens of kilometers; in the next few years the mesh size is expect to be less than ten kilometers. Conventional parameterizations of deep convection rely on assumptions that are fundamentally inconsistent with such highresolution models. Smaller clouds such as shallow cumuli, however, will not be even partially resolved in the foreseeable future. Developing parameterizations that work well across a range of parameterized and explicit phenomena is a significant challenge.
Our hypothesis is that the NCEP global models can be improved by installing an integrated, selfconsistent description of turbulence, clouds, deep convection, and the interactions between clouds and radiative and microphysical processes. We therefore propose a CPT to unify the representation of turbulence and SGS cloud processes and to unify the representation of SGS deep convective precipitation and gridscale precipitation as the horizontal resolution decreases.
Both of these unifications are physically based and both have been extensively tested against LES and CRM results. We will improve the representation of smallscale phenomena by implementing a PDFbased subgridscale turbulence and cloudiness scheme that would replace the boundary layer turbulence scheme, the shallow convection scheme, and the cloud fraction schemes in the GFS and CFS. We will improve the treatment of deep convection by introducing a unified parameterization that scales continuously between the simulation of individual clouds when and where the grid spacing is sufficiently fine and the behavior of a conventional parameterization of deep convection when and where the grid spacing is coarse. We will improve the representation of the interactions of clouds, radiation, and microphysics in the GFS/CFS by using the additional information provided by the PDF-based SGS cloud scheme. The team will evaluate the impacts of the model upgrades with metrics used by the NCEP shortrange and seasonal forecast operations.
Our proposal is relevant to the MAPP Program's competition for Research to Advance

Climate and Earth System Models. The project will help to achieve the first of the NOAA NextGeneration Strategic Plan climate objectives, an improved scientific understanding of the changing climate system and its impacts, by improving two core capabilities: understanding and modeling, and predictions and projections.

Evaluating CFSR Air-Sea Heat, Freshwater, and Momentum Fluxes in the context of the Global Energy and Freshwater Budgets

Lead Principal Investigator: Dr. Lisan Yu, Senior Scientist, Department of Physical Oceanography, MS 21, Woods Hole Oceanographic Institution, Woods Hole, MA 02543-1535, Tel: 508-289-2504, Email: lyu@whoi.edu

Co-Investigator: Dr. Yan Xue, National Centers for Environmental Prediction, Climate Prediction Center, 5830 University Research Court, College Park, MD 20740, Tel: 301-683-3390, Email: Yan.Xue@noaa.gov

2. Abstract-Priority Area 1, Research to Advance Climate Reanalysis Type II

This proposed research aims at providing a comprehensive assessment of the partially coupled Climate Forecast System Reanalysis (CFSR) by NOAA NCEP in representing air-sea heat, freshwater, and momentum fluxes in the context of the global energy and water budgets. The proposed research addresses the MAPP call on improving our ability to "better quantify uncertainties in reanalysis data including the impacts of data and model error", and addresses the climate objectives of NOAA's Next Generation Strategic Plan (NGSP) with particular focus on providing quantitative assessments of current state of the climate system.

The CFSR is the first and only reanalysis that incorporates a coupled atmosphere-oceanland climate system with an interactive sea-ice component, and the one that has the finest spatial resolution (~0.5°) ever produced by any reanalysis. Evidence has clearly pointed to the advantages and strengths of the finer-resolution coupled CFSR reanalysis in characterizing airsea fluxes at regional and global scales, but biases/errors in the CFSR flux components at various temporal scales have also been reported. The biases/errors appear to have significant impact on the estimates of the energy and water budgets over the global oceans. Currently, the CFSR produces a global energy imbalance of 15 Wm-2, which is about 10 Wm-2 higher than the estimates from the earlier NCEP reanalyses. We recognize that balancing the global energy/water budgets has long been a challenging issue, with global energy budgets differing considerably, from 2 to 30 Wm-2, when computed using reanalyzed, ship-, and satellite-based flux products. However, the global energy/water budgets are central to the understanding of climate variability and climate changes produced by the reanalyses. A good knowledge of the impact of biases/errors in surface flux components on the global budget estimates will be highly beneficial to not only the users of CFSR products but also the developers for the next-generation Earth System reanalysis. Therefore, this proposed assessment study will analyze the biases/errors in the CFSR surface fluxes in the context of the global energy/water budget and will also compare the CFSR with the earlier and the latest reanalyses as value-added evaluation.

The proposed approaches include: (i) in situ validation, in which a database consisting of more than 130 flux buoys is used as ground truth for identifying and quantifying biases/errors in

flux products; (ii) spectral analysis, in which ship- and satellite-based global flux analyses are used as reference to evaluate and characterize the regional and global spectral structures of flux products, and (iii) dynamical diagnosis, in which dynamic constraints (such as energy and freshwater budgets in an enclosed volume) are used to test the physical consistency of flux products with ocean state variables (temperature and salinity).

The primary objectives of the proposed research are to (i) identify the strength and weakness of the CFSR surface flux components by comparison with in situ flux measurement, satellite-based analyses and other reanalyses products and understand the sources of biases, (ii) examine the effect of spatial resolution in improving the accuracy and spatial structure of CFSR fluxes on regional and global scales, (iii) investigate the use of physical constraints together with ocean state variables to diagnose and understand the uncertainties in CFSR air-sea fluxes.

The significance of the proposed research is in the potential to (i) establish a baseline that can be used to help determine the scope and extent of the CFSR surface fluxes to be applied; (ii) improve our understanding of the state-of-estimation of air-sea fluxes in latest reanalyses; (iii) obtain new insights on the cause of the discrepancies in global energy/freshwater budget estimates based on air-sea fluxes; and (iv) obtain practical recommendations for future improvement of air-sea flux estimation in reanalyses.

Title: CPT to improve cloud and boundary layer processes in GFS/CFS

Principal Investigators for this project:
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Abstract

A Climate Process Team (CPT) is proposed to improve cloud and boundary layer processes in NCEP's Global Forecast System (GFS) and Climate Forecast System (CFS) models. **The intended CPO program/competition is MAPP (Research to Advance Climate and Earth System Models)**. The CPT will be a multi-institution collaboration between the University of Washington (CPT lead PI: Christopher Bretherton), the Jet Propulsion Laboratory (PI: Joao Teixeira), NCEP's Environmental Modeling Center (PI: Hualu Pan), and GFDL (PI: Chris Golaz; Co-PI: Ming Zhao). It is a sequel to a current MAPP-funded CPT on the subtropical stratocumulus to cumulus transition that builds on progress already made by this CPT and addresses MAPP's goal of leveraging the involvement of multiple NOAA climate modeling centers within a limited budget. The primary goal is to simultaneously improve the cloud climatology, energy budget, and operational forecast skill of the GFS and the next-generation CFS. A secondary goal is to identify weather regimes where clouds are either forecast much better or much worse by GFDL global climate models vs. GFS, as a step toward improving cloud-related parameterizations in both models.

Our current CPT found that both the operational GFS and CFS severely under-predict cloud amount, water content, and cloud radiative impact over most of the globe, producing unacceptably large global and regional biases in the net top-of-atmosphere and surface energy budgets. Reducing

these biases would provide a strong foundation for reducing systematic errors in extended-range and seasonal forecasts. Our current CPT developed a portable single-column version of the operational GFS, which was used to improve the boundary-layer and shallow cumulus parameterizations, modestly improving global cloud distributions. We also developed a new cloud fraction parameterization that somewhat increases GFS-simulated global cloudiness, and a new eddy-diffusivity mass-flux scheme for GFS that combines the simulation of turbulence and shallow cumulus convection. The proposed CPT will try to advance these first steps into a GFS version which has clouds whose radiative properties are simulated as skillfully as in leading climate models, while at the same time maintaining or improving conventional measures of weather forecast skill. Our strategy involves careful testing and improvement of the microphysics and precipitation parameterizations, single-column and global analysis of the fidelity of parameterized cloud-turbulence-precipitation interactions in the revised GFS, and detailed comparisons of cloud simulations in hindcasts by GFS and two GFDL models, AM3 and HiRAM.

Relevance to NOAA Next-Generation Strategic Plan and targeted competition: The targeted MAPP competition requests CPTs of the type we propose in our focal area of clouds and cloudradiative
processes, involving multiple NOAA climate modeling centers and external experts.
Our goal of improving clouds in the NCEP and GFDL climate models supports NOAA's NGSP goals of 1) improving scientific understanding of the changing climate and 2) providing better assessments of climate system change, variability and impacts, both of which require reliable, comprehensive climate models.

COLA: Predictability and Prediction of Climate from Days to Decades

Principal Investigator: J. Kinter
Co-Investigators: B. Cash, T. DelSole, P. Dirmeyer, B. Huang, B. Klinger, V. Krishnamurthy, J. Lu, E. Schneider, P. Schopf, J. Shukla, C. Stan, D. Straus

Period: 1 August 2014 – 31 July 2019

COLA seeks to characterize and quantify the predictability and realizable skill in predicting Earth's climate variability on time scales from days to decades. COLA's prior line of research, which has helped establish a scientific basis for intraseasonal to interannual (ISI) predictability in a changing climate and has fostered the transition of climate predictability research results to operational use, will be continued and expanded. The proposed work will also include a rigorous multi-scale evaluation of the physical processes and mechanisms of climate variability at days-to-decades time scales. It builds on prior results to establish a unified probabilistic framework for predictability of variations over days-to-decades in a changing climate. The work will be carried out in a multi-model context using the state-of-the-art national models, including the CFS supported by NOAA. The prospect of much higher resolutions in global models is critically important to this research. COLA also will contribute directly to the development of the next generation seamless prediction system for U.S. operational climate forecasting.

Software modeling infrastructure: Couple NCEP EMC NEMS to MOM5/ice for more capable CFSv3 and single framework for EMC/CPC.

PI: Cecelia DeLuca, NOAA/ESRL Environmental Software Infrastructure and Interoperability (NESII) Group, Co-PIs Balaji (GFDL) and Mark Iredell (EMC)

NESII team members: Gerhard Theurich, Tony Craig, Fei Liu
NCEP Partners at CPC/EMC: Mark Iredell, Avichal Mehra, Hendrik Tolman, Jun Wang, Shrinivas Moorthi, Xingren Wu, David Behringer, Bin Li
GFDL Partners: Balaji, Niki Zadeh, Zhi Liang

Tasks:

- Deliver NOAA Environmental Modeling System (NEMS) coupled to Modular Ocean Model 5 (MOM5) and CICE sea ice model, ready for initial scientific validation. (Complete Mar 2014)
- Iterate with scientists to advance the design, implementation, and validation of the coupled modeling system. This will include a meeting in February 2014 at NCEP involving the NESII team, NCEP developers, and GFDL participants. (Complete Dec 2014)
- (GFDL task) Split CICE ice model into multiple components (fast thermodynamics and elastic-viscous-plastic dynamics) for use in the GFDL and NEMS coupled system. (Complete Oct 2014)

Current Status (February 2014): Completed a working (on the technical level) one-way coupled system with fields passed from the Global Spectral Model (GSM) to MOM5 under the NOAA Environmental Modeling System (NEMS). The system is set up to allow concurrent execution of the GSM and MOM5 components.

Next Steps: The initial two-way coupled system under NEMS will include GSM, MOM5, and CICE components. The next steps will involve implementing the transfer of fields from MOM5 to GSM, wrapping CICE in the standard component interfaces used in NEMS, introducing CICE into the build system, and prototyping initial interactions between NEMS, MOM5, and CICE. As these steps occur, the internals of the mediator (coupler) component in NEMS will be updated to support the interactions. The target timeline for having the two-way coupled system technically running is end of March 2014.

The initial technical system delivered in March 2014 will require additional modification during the scientific validation process, in response to scientific findings and requirements. This initial system will also require further technical evaluation and optimization.

For more information:
https://www.earthsystemcog.org/projects/nuopc/gfdlplans
and
https://www.earthsystemcog.org/projects/nuopc/nceplans