Proposal Title: Assessing the quality of synoptic scale variability derived from the Twentieth Century Reanalysis Project
Institution: The Research Foundation of SUNY, Stony Brook University
Investigator: Edmund Kar-Man Chang

Abstract

Introduction of the problem and rationale:
Faced with the prospect of climate change due to global warming, detailed projections of how regional climate may change are needed for policy makers to assess different strategies for adaptation and mitigation. Currently, regional aspects of climate change still faces tremendous uncertainties, both in terms of the ability of global climate models to adequately simulate regional climate, as well as the need of a physically and dynamically consistent long term dataset to assess regional climate variability and to validate climate model simulations. Previous studies, including those by the PI, have shown that previous reanalysis datasets have spurious trends in the statistics of synoptic scale weather systems due to improvements in the observation system over time, and thus are not suitable for the characterization of decadal variability and trends of these systems. The new dataset from the 20th Century Reanalysis Project (20CR) is expected to suffer from less of such time dependent biases because it uses an advanced data assimilation system to assimilate only a single type of observations (surface pressure observations) that had undergone the least changes over time. However, the frequency and quality of observations ingested into 20CR have still undergone significant temporal variations over the 20th Century, thus the quality and consistency of the statistics of synoptic scale weather systems derived from the 20CR still needs to be assessed.

Brief summary of work to be completed:
The statistics of synoptic scale weather systems, in terms of variance/covariance statistics of mean sea level pressure and other quantities such as geopotential height, meridional wind, and temperature, will be derived from 20CR and compared directly to similar statistics derived from surface ship and upper-air radiosonde observations to assess the quality and consistency of such statistics derived from the 20CR. Since variability of synoptic scale weather systems and mean flow variability are closely tied to each other, statistical models will be used to assess whether the relationships between synoptic scale and mean flow variabilities are consistent throughout the 20th Century. Feature tracking statistics (including statistics of surface and upper level cyclones) will be derived from 20CR and compared to those derived from other reanalysis products to assess how changes in the observing system might have affected cyclone statistics. The completion of this project will result in better understanding of past variability of synoptic scale weather systems, and provide climate scientists with an assessment of the period over which synoptic scale variability derived from 20CR is consistent, and climate modelers with a validation of the dataset that they can use to assess climate model simulations, thereby resulting in better understanding of the ability of climate models to simulate and project changes in regional climate, resulting in improved assessment of the projected regional climate change by climate models.

Title: Regional and global evaluation of the CFS-R and 20th Century Reanalysis for the terrestrial water cycle.

PIs and Institutions: Eric F Wood, Princeton University

Abstract

Reanalysis data sets have become an important and integral resource for studying the water cycle at regional to global scales. Since the first NCEP/NCAR reanalysis data sets were released in the mid-1990s, their use has been cited over 6,000 times. Reanalysis data sets offer homogeneous, gridded data products that have found wide application as input forcing data for off-line hydroclimate models and regional coupled models, for carrying diagnostic analysis for climate studies and for bias correcting and downscaling coarse-scale climate models. Thus it is critical that CFS-R and 20CR be evaluated both in absolute terms against observational data on specific variables and for consistency with previous reanalysis products. Very recently, the global high resolution Climate Forecast System Reanalysis (CFS-R) has been completed at NCEP/NWS for 1979-2009, as well as the 20th Century Reanalysis (20CR) at ESRL.

It is proposed to evaluate CFS-R and 20CR data products for the terrestrial water cycle over 32 global river basins, and for selected variables globally. The project will focus on three important evaluations: The first will be traditional error and bias analysis using regional and global data sets developed, compiled and analyzed by the PI over the last decade. Variables will include precipitation, temperature, river discharge, changes in terrestrial water storage, surface radiation and heat flux, and atmospheric profiles of temperature and humidity. For all variables, the data sets are already archived with the PI and have been used for water cycle studies. In most cases multiple data sets are available for each variable, permitting uncertainty assessment for CFS-R and 20CR data products. The second tier evaluation focuses on the consistency between CFS-R (or 20CR) and recently completed reanalysis, which include ERA-40, ERA-interim, MERRA and NARR. It is important for the community have an assessment of CFS-R and 20CR data products relative to currently available reanalysis products. The third tier evaluation focuses on higher-level products important to hydroclimate analysis and modeling. Evaluations will include such variables as the trends and variability in CFS-R and 20CR time series, rain-day frequency statistics (critical to hydrologic modeling and applications), reproduction of large-scale climate events (like drought) and the frequency of heavy precipitation, and reproduction of observed teleconnections such as ENSO and western U.S. precipitation.

Carrying out the proposed comprehensive CFS-R and 20CR evaluation within the one year project is only feasible due to our ongoing and previous work in evaluating/validating currently available reanalysis products (e.g. ERA40, ERA-Interim, MERRA, NARR), with in-situ (e.g. gauge or radar precipitation, tower-based ET, station-based radiation), remote sensing retrievals (e.g. MW/IR derived precipitation, remotely sensed ET, GRACE derived terrestrial water storage and AIRS derived atmospheric water vapor and temperature), and land surface modeling (VIC) surface water and energy cycle variables. Our current research on estimating the terrestrial water cycle against multiple observational and modeling products will allow an evaluation of CFS-R and 20CR products in an important, broader context.

Proposal Title: Evaluating Dynamical States, Radiation Budgets, and Cloud Properties in the NCEP CFS-R and ECMWF ERA Interim Output

Institution: Joint Institute for the Study of the Atmosphere and Ocean, University of Washington
Investigators: Thomas P. Ackerman and Laura M. Hinkelman

Abstract

We propose to evaluate the dynamical states, radiation budget, and cloud properties of the NCEP Climate Forecast System Reanalysis (CFS-R) and the ECMWF interim reanalysis (ERA-I). (As time permits, we will also evaluate the NASA GMAO MERRA.) We will begin by comparing global TOA and surface radiation budgets for both shortwave and longwave radiation from the reanalysis output with data from CERES (at TOA) and the NASA/GEWEX Surface Radiation Budget (SRB) project on monthly to interannual timescales. We will then perform a cluster classification of atmospheric states for both CFS-R and ERA-I at the DOE SGP site and the DOE TWP site in Darwin, Australia. We will then compare (a) state classification results and probability of occurrence statistics from the two reanalyses, (b) cloud occurrence profiles for each reanalysis state with each other and observed cloud profiles, and (c) probability distributions of reanalysis physical variables (such as precipitation, cloud liquid water path, and cloud radiative effect) by state with observations. We intend to link simulator codes for MISR, MODIS, and ISCCP to the reanalysis output streams to produce simulated cloud top heights (or pressures) and optical depths. Joint histograms from the reanalyses will then be compared with similar histograms from observations on a regional basis. Our final product will be a summary statement of the accuracy of the reanalysis radiation budgets, their relative similarity of dynamical states, the accuracy of cloud profiles and other geophysical variables associate with these states, and the influence of cloud errors on radiative budget errors.

Using Historical Surface Data to Verify the Twentieth Century Reanalysis for Oceanographic Applications

University of Maryland, College Park
James A. Carton and Semyon A. Grodsky

Abstract

The Twentieth Century (20CRv.2) Reanalysis Project of Compo et al. (2010) more than doubles the time span covered by atmospheric reanalyses, and in addition uses an assimilation methodology that provides information about the accuracy of the reanalysis. Thus the 20CRv.2 potentially offers wonderful advantages for use in multi-decadal ocean circulation and climate studies. This proposal will help fulfill that promise by supporting exploration of the surface winds from the 20CRv.2 in two stages. The first stage will involve comparison of the 20CRv.2 and other multi-decadal reanalyses to wind observations such as those contained in ICOADS (which were not used in the 20CRv.2 assimilation) to estimate accuracy various space and timescales and to detect the presence of time-dependent biases. The second stage will involve examination of output from a simulation of an ocean general circulation model driven by reanalysis winds in comparison with the historical hydrographic record.

Evaluation of Reanalysis Products in the Arctic

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Abstract

How well can we estimate the state of the atmosphere and the rate it is changing in the polar regions in retrospective analyses? In the data sparse Arctic, atmospheric analyses are poorly constrained by observations and are strongly influenced by model parameterizations. There are currently seven different sets of global reanalysis products that are current or near current in temporal coverage: NCEP-1, NCEP-2, CFSR, 20CR, MERRA, ERA-Interim, and JRA-25 (definitions follow).

Retrospective analyses have been a critical tool in studying weather and climate variability for the last 15 years. Reanalyses blend the continuity and breadth of output data from a numerical model with the constraint of vast quantities of surface, radiosonde, and satellite observational data. The result is a long-term continuous and spatially complete data record. Reanalysis products are used in many different applications including evaluation of atmospheric circulation patterns and processes, change detection, the forcing of ice–ocean models, regional atmospheric models, land models, or air chemistry models, and for establishing the initial conditions for forecast models. Better understanding the strengths and weaknesses of these products will improve our ability to evaluate the long-term trends in the rapidly changing Arctic environment and may also improve our ability to make seasonal projections of sea ice and weather conditions in the Arctic.

In this focused study we will compare the monthly mean estimates of the surface and tropospheric air temperature, the surface pressure and winds, the total precipitation, and the surface and top-of-the-atmosphere radiative fluxes in a three-tiered set of analyses. The first-order comparisons will be made to independent point observations from a selected set of land stations and drifting ice stations. The second-order comparisons will be made of the statistical properties (mean, standard deviation, and extremes) of the fields from each of the reanalyses. Finally, the third-order comparisons will be made of the 30-year trends in the fields of each of the reanalyses. While this is an ambitious project to accomplish in just one year, we plan to use the economies of scale to perform the identical analysis procedures on all six of the reanalysis products.

The ultimate goal is to better understand the strengths and weaknesses of these products in a data-sparse region where the reanalysis models may differ the most. Better understanding of these products may improve the ability for NOAA to make seasonal projections of sea ice and weather conditions in the Arctic.

Comparison of Structure and Evolution Characteristics of Boreal Summer and Winter Intraseasonal Oscillations Derived from Reanalysis Products and Satellite observations

Principal Investigator: Dr. Tim Li
Department of Meteorology and IPRC, SOEST
University of Hawaii at Manoa
Co-PI: Dr. Xianan Jiang
Joint Inst. for Reg. Earth System Science & Engineering
University of California

PROJECT SUMMARY

The proposed project is to evaluate the performance of various latest reanalysis products in capturing the MJO 3D structures, particularly its vertical heating and humidity profiles, and MJO multi-scale characteristics and initiation processes. The reanalysis products to be evaluated include the NCEP Climate Forecast System (CFS) Reanalysis, the ESRL 100-year Historical Reanalysis, NASA MERRA, ERA-interim, and JMA reanalysis. Available observations from recently available satellite products and planned field campaigns will be used to validate the reanalysis products.

Firstly, we will diagnose and compare the 3D dynamic and thermodynamic structures at various phases of the MJO. Because of distinctive seasonal evolution characteristics, we will separate the boreal winter (November-April) and summer (May- October) seasons. We will examine the horizontal and vertical profiles of specific humidity and its relationships with MJO convection, vorticity, divergence, vertical motion, surface fluxes, SST, CAPE, and other dynamic and thermodynamic variables. A key variable to examine is the heating field. Daily 3D fields of apparent heating (Q1; Yanai et al. 1973) derived from the above reanalysis datasets will be compared with each other, and validated against TRMM estimate based on the "Trained" Radiometer Heating (TRAIN), Convective-Stratiform Heating (CSH), and Spectral Latent Heating (SLH) algorithms. We will evaluate the evolution of the heating profiles associated with shallow (congestus) convection, deep convection and stratiform clouds.

Secondly, we will evaluate and compare the multi-scale characteristics of the MJO in both the boreal winter and summer seasons. A focus will be on the structure and evolution of higher-frequency perturbations and their MJO-phase-dependent feature. A spatial-temporal wavelet transform method will be applied to separate higher frequency modes. The possible upscale feedback of higher-frequency perturbations to MJO will be examined with a new diagnostic strategy that separates the eddy interaction with ISO and slowly varying background mean flows. In addition, we will reveal the common features associated with the MJO initiation in the western equatorial Indian Ocean based on the diagnosis of the reanalysis products.

Title: Evaluate Recently Developed Reanalysis Projects
Institution: University of Miami Rosenstiel School of Marine and Atmospheric Science
Principal Investigator: Chidong Zhang, Ph.D.

Abstract

This proposal is submitted to NOAA Climate Project Office Modeling, Analysis, Prediction and Projection (MAPP) Program in Response to Funding Opportunity for FY2011. In this project, we will make efforts to contribute to the MAPP FY2011 theme of Evaluate Recently Developed Reanalysis Projects. The overall goal of this proposed project is to provide quantitative information that may guide us to properly use diabatic heating profiles from the recent reanalysis products: MERRA, CFS-R, and ERA-Interim. We propose to (i) quantify similarities and differences between Q1 (total diabatic heating estimated as a residual of heat budget) and QT (direct output of total diabatic heating) from the reanalyses, (ii) compare Q1 (and QT if they are equivalent) from the reanalyses to Q1 estimated using sounding data from selected field campaign, and (iii) define our current knowledge of diabatic heating profiles and its uncertainties by quantifying the agreement and discrepancies between diabatic heating profiles from the reanalyses. The research will be conducted at CIMAS/RSMAS, University of Miami, addressing CIMAS Theme 1: Climate Variability (Task 3).

Climatology and variability of tropical rainfall in the 20th Century Reanalysis.

PIs: Michela Biasutti and Mingfang Ting
Lamont-Doherty Earth Observatory, the Earth Institute at Columbia University

Summary

We propose to validate the climatology and variability of tropical rainfall in the 20th Century reanalysis, version 2 (20CRv2, Compo et al., 2010). To do so we will compare the reanalyzed precipitation to global satellite-based records for the most recent past, to several land-only datasets that go back to the beginning of the century, and to statistical reconstructions of marine precipitation (Smith et al., 2008, 2010).

Our first task will be to document rainfall biases both in terms of their monthly and seasonal patterns and in terms of the characteristics of daily precipitation. We will try to better understand the source of these biases by replicating the work of Biasutti et al. (2006), which diagnosed the strength of dynamical (i.e. convergence) and thermodynamical (i.e stability) control on rainfall in several GCMs and reanalyses.

Second, we will contrast the time-series of regional rainfall in the reanalysis and in observations. Some preliminary analysis for the African Sahel suggests that the 20CRv2 precipitation monthly anomalies depend strongly on the density of the observational records of surface pressure that are assimilated: when the synoptic spread in surface pressure is relatively low, the ensemble-mean monthly rainfall anomalies track observations very well, but when the spread is large, the correlation with observations drops below what we would expect from AMIP simulations.

Given the limited skill of the 20CRv2 reanalysis in reproducing historical variations of precipitation in data-sparse regions and periods, it is desirable to understand whether a MOS correction could be applied to the reanalyzed fields to create a trustworthy, complete record of rainfall. The idea behind a MOS correction is that models that do a poor job of simulating rainfall might still have skill at simulating the large-scale circulation associated with an observed rainfall anomalies.

If the reanalyzed time series of the tropical circulation is found to be accurate, and the relationship between circulation and rainfall is found to be stationary, then it would be appropriate to create a MOScorrected record of rainfall. Although the short duration of this project prevents us from producing such a record, we propose to test whether it would be possible. To do so, we will both validate the historical variations of key circulation indices (for example, the Southern Oscillation Index and the monsoon indices), and test the fidelity and stationarity of the relationship between regional rainfall anomalies and circulation anomalies.