Project Summary

We propose to establish and maintain a web-based informed guide to selected climate data sets of relevance to the evaluation of Earth System Models (ESMs). The proposed work has two main objectives related to ESM evaluation and these are identified as high priority needs of the World Climate Research Programme (WCRP): 1) to evaluate and assess selected climate datasets, and 2) to provide "expert-user" guidance and advice on the utility and limitations of selected climate datasets. The proposed work will advance the evaluation of ESMs from a system perspective, including those models participating in the upcoming IPCC AR5 and CMIP5 activities, and as such directly addresses the goal of the proposal solicitation "to improve upon and expand on current modeling capabilities in order to substantively contribute to the advancement of reliable regional and decadal climate predictions", and that of Type 1 proposals in particular as an "incubator and capacity/community building activit[y]". Increasingly, there are multiple versions of datasets on a single variable, all legitimate but generated with a different algorithm, quality control, error adjustments, and data processing and analysis, as well as multiple comprehensive gridded "reanalyses". The proliferation of datasets makes it difficult for individual scientists to know which are most appropriate for specific applications, including evaluation and analysis of increasingly complex and comprehensive ESMs. A unique feature of this "*Informed Guide*" will be expert-user commentary on the strengths and limitations of individual data sets from the researchers who construct and evaluate the data. As such, it will serve to facilitate and enhance access to relevant climate data archives for diagnostic analyses and model evaluation. A method such as a web-based "forum" will be devised to enable informed commentary by researchers and also to accommodate variables and datasets not within our own expertise. Each component of the earth system will be addressed, including the atmosphere, ocean, land, cryosphere, and biosphere. The project will leverage the expertise already within NCAR and the Climate Analysis Section in particular. Consideration will also be given to hosting workshops to help achieve these objectives, in close collaboration with the WCRP and U.S climate services needs. University collaboration is an important aspect of the proposed work, as demonstrated by the letters of collaboration from the University of Washington (Professor John Michael Wallace), the University of Alaska-Fairbanks (Professor John E. Walsh), and the University of Maryland (Professor Sumant Nigam).

Intellectual Merit

There is a critical need for assessment of observational data sets and guidance on their appropriate usage for the purpose of evaluating and improving ESMs. These activities are vital to the integrity of observational, modeling and prediction studies of climate variability and change. The Climate Analysis Section team at NCAR is a world-class leader in the evaluation and assessment of data sets, and the project described here is not done anywhere else.

Broader Impacts

With many reprocessing and reanalysis projects producing new datasets that have yet to be vetted, and a proliferation of datasets on the same variable, the project and service proposed here has been called for with very high priority both nationally and internationally. The WCRP Working Group on Coupled Modeling (WGCM) working group has led to new demands for observational assessments and dataset availability for evaluating the forthcoming CMIP5 model runs. There is also very strong support for this activity within universities, as evidenced by accompanying letters of support from several leaders in this area. The results of this work will greatly assist students and all scientists working with climate data. The results will be available to everyone and it is planned to have an interactive web presence to enable commentary and questions. Participation by students and others is welcomed.

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For font size and page formatting specifications, see GPG section II.B.2.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

Project Description

I. Results from prior NSF support

Clara Deser P.I.: *"Climate Response to Future Changes in Arctic Snow Cover and Sea Ice: A New Perspective from the High-Resolution NCAR CCSM3" Michael Alexander and Robert Tomas, co-P.I.s NSF Arctic System Science Program Award ARC-0629300 Amount: $477,948 Period: FY07-09.*

This project investigates the impacts of projected future changes in Arctic sea ice and high-latitude terrestrial snow cover on the global atmospheric circulation and climate by means of atmospheric model experiments with the high resolution version of the NCAR atmospheric general circulation model (CAM3). In these experiments, sea ice cover (concentration and thickness) or snow cover (extent, depth and age) for the present (1980-1999) and future (2080-2099) are prescribed as lower boundary conditions to CAM3 and obtained from the Community Climate System Model Version 3 under observed (1980-99) or projected "A1B" scenario (2080-99) atmospheric radiative forcing conditions. The climate response to future Arctic sea ice loss is largest during autumn and winter when the change in the net surface energy flux is greatest, despite that sea ice loss is greatest in summer. This response consists of warming and moistening of the high latitude continents, with some impact on atmospheric circulation. The response to snow cover changes is weaker than that to sea ice, with the largest effects during spring and autumn.

Publications

1) Lawrence, D., A. Slater, R. Tomas, M. Holland, and C. Deser, 2008: Accelerated Arctic land warming and permafrost degradation during rapid sea ice loss. *Geophys. Res. Lett.*, **35**, L11506, doi:10.1029/2008GL033985.

2) Deser, C., R. Tomas, M. Alexander, and D. Lawrence, 2010: The seasonal atmospheric response to projected Arctic sea ice loss in the late 21st century. *J. Climate*, **23**, 333-351, 10.1175/2009JCLI3053.

3) Tsukernik, M., C. Deser, M. Alexander, and R. Tomas, 2009: Atmospheric forcing of Fram Strait sea ice export: A closer look. *Climate Dyn.*, doi:10.1007/s00382-009-0647-z.

4) Alexander, M. A., R. Tomas, C. Deser and D. Lawrence, 2010: The Atmospheric Response to Projected Terrestrial Snow Changes in the Late 21st Century. *Submitted to J. Climate*.

Aiguo Dai P.I: "*Studying the Causes of Recent Drought and Monsoon Changes over East Asia Using NCAR and GFDL Models" (SGER #OCE-0740011) through the CLIVAR DRICOMP project; amount $30K, 2008-2009.*

This grant was used to train and support a visiting PhD student to work on the causes of recent decadal changes in precipitation over East Asia and associated monsoonal circulation changes. Results showed that recent warming in the tropical Pacific is a major cause for the observed weakening of the East Asian Summer Monsoon circulation since the 1970s.

Publications:

Li, H., A. Dai, T. Zhou, and J. Lu, 2010: Response of East Asian summer monsoon to historical SST and atmospheric forcing during 1950-2000**.** *Climate Dynamics*, **34**, 501-514.

Schubert, S., D. Gutzler, H. Wang, A. Dai, T. Delworth, C. Deser, K. Findell, R. Fu, W. Higgins, M. Hoerling, B. Kirtman, R. Koster, A. Kumar, D. Legler, D. Lettenmaier, B. Lyon, V. Magana, K. Mo, S. Nigam, P. Pegion, A. Phillips, R. Pulwarty, D. Rind, A. Ruiz-Barradas, J. Schemm, R. Seager, R. Stewart, M. Suarez, J. Syktus, M. Ting, C. Wang, S. Weaver, and N. Zeng, 2009: A USCLIVAR project to assess and compare the responses of global climate models to drought-related SST forcing patterns: Overview and results. *J. Climate*, **22**, 5251–5272.

"Terrestrial freshwater fluxes and discharge"; amount $386,084, 2003-2006 (Grant #ATM-0233568) NSF water cycle program. The grant was used to support and train a young PhD scientist (T. Qian, now at Ohio State University), who worked to create a historical forcing data set for driving the Community Land Model (CLM) and other land models and to quantify and attribute recent changes in terrestrial water cycle over the U.S. and the mean global water cycle. It also resulted in the creation of two global data sets for community use: (http://www.cgd.ucar.edu/cas/catalog/surface/dai-runoff/index.html) a global streamflow and discharge data set that has been used to quantify recent changes in global streamflow and runoff, and the global Palmer Drought Severity Index (PDSI) data set that has been used to quantify recent drought changes over the globe (http://www.cgd.ucar.edu/cas/catalog/climind/pdsi.html).

Publications (Total 13, 5 listed here):

Dai, A., T. Qian, K. E. Trenberth, and J. D Milliman, 2009: Changes in continental freshwater discharge from 1948-2004. *J. Climate*, **22**, 2773-2791.

Dai, A., K. E. Trenberth, and T. Qian, 2004: A global data set of Palmer Drought Severity Index for 1870-2002: Relationship with soil moisture and effects of surface warming. *J. Hydromet.*, **5**, 1117-1130.

Qian, T., A. Dai, K. E. Trenberth, and K. W. Oleson, 2006: Simulation of global land surface conditions from 1948-2004. Part I: Forcing data and evaluation. *J. Hydromet.*, **7**, 953-975.

Qian, T., A. Dai, and K. E. Trenberth, 2007: Hydroclimatic Trends in the Mississippi River Basin from 1948-2004. *J. Climate*, **20**, 4599-4614.

Trenberth, K. E., L. Smith, T. Qian, A. Dai and J. Fasullo, 2007: Estimates of the global water budget and its annual cycle using observational and model data. *J. Hydromet.*, **8**, 758-769.

II. Introduction

Evaluation of Climate and Earth System Models (CSMs and ESMs) with observational data sets is a key step in assessing model performance and an important pre-requisite for credible decadal and regional climate prediction. Such assessment has become increasingly difficult, however, as models are becoming more complex and our understanding of the variability and trajectory of the climate system deepens. One outstanding issue is the nature of the adequacy of the observational record for the purpose of model evaluation. Observational datasets contain inherent limitations, for example measurement uncertainties, and for climate records, a major hindrance is the lack of continuity of calibrated records over extended periods of time (Trenberth et al. 2007b). The recent proliferation of observational data sets, including retrospective reanalysis products and newly available satellite measurements, has enhanced our understanding of the climate system and its processes but has also led to a bewildering number of similar data sets. This proliferation demands an assessment of the various observational products and their usefulness for different purposes, as well as documentation of the differences among the datasets and an informed commentary on their utility. The purpose of this project is to provide the modeling and observational communities with information and guidance in choosing among multiple versions of data sets on a particular variable. As such, it will enhance the CSM and ESM evaluation effort at a crucial phase of the upcoming Climate Modeling Intercomparison Project Phase 5 (CMIP5; Taylor et al. 2009) intended for use in the next IPCC Assessment Report. It will also serve as a community resource for observational studies of climate variability and change.

There are several ongoing activities that are extremely relevant to our proposed work. The Global Space-based Inter-calibration System (GSICS), for instance, was created to enhance and sustain calibration and validation of satellite observations, to intercalibrate critical components of the Global Climate Observing System (GCOS) to climate quality benchmark observations and/or reference sites, and to provide corrected observations and/or correction algorithms to the user community for current and historical data. The Sustained Co-Ordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM) promotes inter-comparison of global climate datasets of Essential Climate Variables (ECVs) and related variables derived from satellite data through post-processing of the calibrated data produced under the GSICS process. Its objective is continuous and sustained provision of high-quality ECV satellite products on a global scale. The European Space Agency (ESA) has funded the Climate Change Initiative (CCI) which is focused on better establishing the climate data records of 20 ECVs as defined by GCOS. The GEWEX Radiation Panel (GRP) is also leading a major effort to reprocess space-based observations in a consistent manner so the variables all "see" the same atmosphere.

Certainly, such activities are leading to much improved quality datasets for climate purposes, but they still have problems and there are already many datasets on different ECVs from different satellite products and groups. Moreover, the differences among the resulting variables are often much larger than the climate change signals being sought in the data, and importantly the differences are very difficult for users to deal with. The fact is that users, including modelers, most often do not appreciate the subtleties of the different products and how they may be used.

There are also many web-based catalogs of climate data sets containing a wealth of useful information on data type, length of record, data accessibility, file formats, etc. As well as our own from the Climate Analysis Section (CAS) of NCAR, *(http://www.cgd.ucar.edu/cas/catalog/),* examples of such catalogs are those at the *IRI (http://iridl.ldeo.columbia.edu/), NASA-GISS (http://data.giss.nasa.gov/), NASA-ASDC (http://eosweb.larc.nasa.gov/), JISAO (http://jisao.washington.edu/data/), NOAA-PSD (http://www.esrl.noaa.gov/psd/), NCAR-CISL (http://dss.ucar.edu/) and NCDC (http://www.ncdc.noaa.gov/oa/ncdc.html).* While these catalogs are extremely useful in their own right, an uninformed user may be at a loss as to which dataset to select for their particular purpose.

The proliferation of new datasets, alongside the older versions, demands an assessment of the products and their usefulness for various purposes. The intent of the proposed "*Informed Guide to Selected Data Sets with Relevance to the Evaluation of Earth System Models*" or *Informed Guide* for short, is to provide expert-user guidance on the various data sets so that the user understands their strengths and limitations and the purposes for which they are best suited. To this end, evaluation and assessment of the various data sets, including information on inhomogeneities, error bars, known biases, and intervals of greatest confidence, will also be documented.

III. Proposed Work

1) A web-based "Informed Guide to Climate Data Sets with Relevance to the evaluation of ESMs"

a) Background

Several years ago, the PI and one of the co-PIs (C. Deser and J. W. Hurrell) developed a first-generation *Informed Guide* that received broad recognition within the climate community. Its main purpose was to provide a selection of widely used and vetted climate data sets, along with expert user guidance, for observational studies of climate variability and change. Due to lack of resources, this web-based guide (see www.cgd.ucar.edu/cas/guide/) is no longer an actively maintained site. However, it provides an important foundation for the project put forth in this proposal, and demonstrates the "proof-of-concept" idea of a community website that offers expert-user guidance on the strengths and limitations of various climate data sets.

As an example from this previous effort, we discuss how a user may find a suitable data set for sea level pressure (SLP), a common variable used to characterize the low-level atmospheric circulation. As a first step, the user is directed to: http://www.cgd.ucar.edu/cas/guide/Atmos/Surface/slp.html . This page presents a selected set of gridded SLP archives, with information on period of record, resolution, and a brief description. The user can then choose a particular data set from the list given, such as for example the ICOADS product (http://www.cgd.ucar.edu/cas/guide/Data/coads.html), where he/she will find additional information including: a high level overview of the data in the "Technical Overview" link; information on strengths and weaknesses of the data based on user experience along with strategies for making optimal use of the data, in the "Expert User Guidance" link; a selected bibliography of publications discussing and using the data in the "Relevant Articles" link; and global maps of the distribution of observations for each 20-year period of record in the "Coverage Maps" link. As another example, a user may be interested in finding information on cryospheric datasets including sea ice and snow cover. These datasets have received "Expert User Guidance" from William Chapman (University of Illinois) on the "Walsh and Chapman Northern Hemisphere Sea Ice Dataset", and from Professor David Robinson (Rutgers University) on the "Rutgers University Snow Cover Dataset" that he oversees.

b) Proposed Work

The proposed effort will build on the previous *Informed Guide* by including a more comprehensive suite of climate variables relevant for ESM evaluation, each one accompanied by commentary by selected experts from the climate community. The intent is not to overwhelm the user with as many climate data sets as possible, but to provide those that have been most carefully evaluated and assessed to facilitate appropriate use. We will seek expert commentary from national and international colleagues at universities, federal laboratories, and other agencies. Our previous experience has shown the climate research community is eager to contribute "expert-user guidance". Thus, it is our vision that the proposed enhanced *Informed Guide* will become a community resource through the broad participation by climate researchers worldwide (see also the supportive *letters of collaboration* accompanying this proposal).

The organization and structure of the proposed *Informed Guide* will build upon our previous work and expand in the following ways.

1) The proposed *Informed Guide* web-based interface will facilitate the search and decision making process involved in selecting appropriate data sets for a particular application. It will contain up-to-date links, general descriptions, appropriate references and expert commentary on datasets commonly used in climate evaluation. In addition, a mechanism for creators of new datasets to contribute to the central repository will be provided.

2) Critical to the success of the *Informed Guide* will be a mechanism for users to communicate with the developers and contribute to its development, expansion and refinement. Toward that aim, a friendly user-developer web-based forum will be established to facilitate communication. Users can register and post questions and answers about various datasets and their handling. The forum would be actively monitored; comments would be quickly posted and questions answered.

3) In addition to providing guidance and commentary on observational datasets, the proposed *Informed Guide* will be enhanced to include approaches and strategies for model evaluation from experts in the field. This will include statistical methodologies for comparing the model and observations with respect to time-averages, variability, extremes, and trends in various climate parameters. For example, how many years are needed to assess whether the model climate and the observed climate are the same within a given error tolerance? This question may be addressed using standard statistical approaches such as those presented in Wehner (2000) and Taschetto and England (2008) and our aim will be to provide guidance in the application of these approaches.

In addition to addressing these statistical issues, the *Informed Guide* will provide insights and commentary on other issues that arise frequently in the evaluation of models, both generally and targeted towards coupled model archives including the CMIP3 and imminent CMIP5 archives. For example, the *Informed Guide* will address issues such as how to best evaluate various model configurations (e.g. AMIP, slab-ocean, fully-coupled) and how to account for the inevitable differences in imposed forcing that exist between models and nature. In addition, issues inherent to model evaluation, such as those that arise in comparing simulated clouds, which can have extent but no water path and therefore are radiatively inactive, with observed clouds, which often are subject to finite detection thresholds and spatial extents that depend uniquely on the observing platform. Similarly, the *Informed Guide* will include discussion of the structural contrasts that exist between observations and models, such as for example in the computation of cloud radiative forcing – where models simply remove clouds from the radiative calculation whereas observations rely on opportunities to observe clear-sky conditions and are therefore biased towards certain meteorological regimes. These and similar issues are an inevitable consideration in model evaluation and thus their recognition and discussion is deemed to be an essential component of the guide. Where possible the *Informed Guide* will provide heuristic examples and approaches for dealing with these and a host of related issues.

4) For each dataset, a set of standard figures will be made available that provide basic visual information, for example time series of global and regional averages, maps of the data for particular time periods, etc. For selected suites of datasets (*e.g.,* Reanalysis Products), comparisons including simple differences and Taylor diagrams will be made available, as in:

(http://www.cesm.ucar.edu/experiments/ccsm4.0/diagnostics/b40.1850.track1.1deg.006/atm_863-892-obs/set14/set14_ANN_SPACE_TIME_obsc.png]

5) Selecting the datasets to be used is one aspect of diagnostic analysis and model evaluation. The second aspect is handling and processing the data. The datasets used in climate research occur in a variety of data formats. Most commonly, these include GRIB-1, GRIB-2, netCDF-3, netCDF-4, HDF4, HDF4-EOS2, HDF5 and HDF5-EOS. Even for experienced climate researchers, these disparate formats can be bewildering and intimidating; for graduate students even more so. The *Informed Guide* will include data format descriptions, as well as examples and tutorials of accessing and processing the data; see the Data Management Plan for more details. As a first step towards this enhanced web-interface for the *Informed Guide*, we have constructed the following proto-type: http://www.cgd.ucar.edu/cas/igcds/icoads.html using SLP as example. This proto-type incorporates some of the proposed elements discussed above,

including an "Overview Table" of each data set, a "Quick Links" to data sets organized by components of the climate/earth system, a dataset "Search" box, and a means for users to contribute data set guidance via a web "forum".

2) Proposed Datasets and Approaches to Evaluation and Assessment

The second part of our proposal in support of the "*Informed Guide for Climate Data Sets of Relevance to ESMs*" concerns the evaluation and assessment of relevant observational data sets. Here we describe some of the data sets pertinent to ESM evaluation that we plan to incorporate into the *Informed Guide*, along with some possible "expert-user" contributors. This is by no means an exhaustive list, constrained in part by space limitations. New datasets will be included as they become vetted by the climate research community. Also, over time the breadth of data sets will be expanded to include additional variables such as those related to biological component of the climate system and the carbon cycle.

The past decade has seen a proliferation of global data sets for evaluating the atmospheric, oceanic and terrestrial components of Earth System Climate Models. These datasets consist primarily of:

1) atmospheric and coupled reanalyses - which provide a holistic view of the climate system but are impacted by discontinuities in assimilated data streams,
2) satellite retrievals - which are aimed estimating specific fields on a global or near global scale but suffer from instrument loss and drift; and of particular note are all of the GEWEX datasets, which are being reprocessed. These include surface fluxes over ocean and land, as well as cloud, radiation, precipitation and water vapor products.
3) ocean products and analyses – which combine various in situ observations and reconstruction techniques, and combine in situ data with surface altimetry to simulate ocean conditions on global scale. Both are subject to major challenges related to sampling inadequacies and instrument inhomogeneity.
4) land surface data sets – which include soil moisture, runoff and streamflow measurements derived from in situ measurements and satellite retrievals used for quantifying terrestrial climate variations and changes, as well as for validating and initializing land surface models.
5) cryospheric data sets – which include sea ice (concentration, thickness, motion) and snow cover (extent and depth) derived from in situ measurements and satellite retrievals.
6) other data sets will be included as this activity develops. In particular it is expected that biological datasets such as FAPAR and NPP, carbon cycle measurements, and so on could be included too, with appropriate contacts being led by scientists from the Terrestrial Sciences Section at NCAR.

Fundamental to our approach in evaluating these fields is the notion that substantial insights can be realized from the simultaneous consideration of multiple independent data streams and the application of appropriate closure constraints. Doing so often requires expertise across multiple domains and substantial resources and the proposed efforts thus highlight the need for involvement of an institution such as NCAR and a group such as the Climate Analysis Section of which the PI and co-PIs are members. The following is a discussion of a subset of the above to illustrate the issues and what can be done about them.

1. Reanalyses

Atmospheric analyses provide a synthesis of the available observations in the context of a physical model. The reanalyses that have been conducted have used a stable data assimilation system and have produced fairly reliable atmospheric climate records that have enabled (i) climatologies to be established; (ii) anomalies to be calculated; (iii) empirical and quantitative diagnostic studies to be conducted; (iv) exploration and improved understanding of climate system processes to be developed; and (v) model initialization and validation to be performed. These products provide the essential foundation for an accurate assessment of current climate, diagnostic studies of features such as weather systems, monsoons, El Niño-Southern Oscillation (ENSO) and other natural climate variations, seasonal prediction, and climate predictability. The reanalyses have provided a vitally needed test bed for model improvement on all time scales, especially for seasonal-to-interannual forecasts. Moreover, the basic assimilation and prediction systems are improved as deficiencies are identified and corrected by applying them both in reanalysis and routine weather and climate prediction. Besides improvement in the assimilating model and much better resolution, the datasets that have been analyzed have also evolved. Nonetheless, a serious problem is effects of changes in the observing system that produce spurious changes in the perceived climate. As a result, trends and low frequencies have been unreliable, and this problem is exacerbated by model bias.

Reanalyses have evolved from first generation products (NCEP/NCAR and NCEP/DOE reanalyses, often referred to as Reanalysis 1 (R1) and Reanalysis 2 (R2); Kalnay et al, 1996; Kanamitsu et al 2002) to second generation products, namely the ECMWF ERA-40 (Uppala et al. 2005) and the Japanese Meteorological Agency 25-year reanalysis (JRA-25) (Onogi et al. 2007). These latter products have addressed some of the short-comings of R1 and R2, but many of the problems tied to observing system changes and model deficiencies remain.

Further reanalyses are underway and planned. A new reanalysis of the atmosphere, ocean, sea ice and land over 1979-2009 is being produced by NCEP under a project referred to as the Climate Forecasting System Reanalysis (CFSR). The NASA/Global Modeling and Assimilation Office (GMAO) atmospheric global reanalysis project is called the Modern Era Retrospective-Analysis for Research and Applications (MERRA) (Bosilovich et al. 2006). ECMWF is currently producing ERA-Interim (Simmons et al. 2007), a global reanalysis of the data-rich period since 1989. Relative to the ERA-40 system, ERA-Interim incorporates many important model improvements such as resolution and physics changes, the use of four-dimensional variational (4D-Var) data assimilation, and various other changes in the analysis methodology. Following the successful completion of the JRA-25, the second Japanese atmospheric reanalysis project JRA-55 started in 2009. A promising new ensemble of reanalyses based solely on surface observations, and sea level pressure and sea surface temperature observations in particular, is underway with a goal to provide over 100 years of reanalyses along with uncertainty estimates (Compo et al. 2006). The historical reanalysis project, the Twentieth Century Reanalysis Project (C20r), is using a state-of-the-art data assimilation system and surface pressure observations to generate a six-hourly, four-dimensional global atmospheric dataset spanning 1891-2008 to place current atmospheric circulation patterns into a historical perspective. A summary of the active reanalyses, their vintage and approximate resolution is given in Table 1.

Comparisons of products from the different reanalyses reveal a wide variety of results, strengths and weaknesses, and reanalyses have mostly not been useful for climate change studies (Trenberth et al. 2007b). Large differences occur in energy related quantities compared with observations (Trenberth et al. 2009), and differences of precipitation with observationally based analyses reveal large errors (e.g., Trenberth and Smith 2008; Bosilovich et al. 2008).

Reanalysis	Horiz. Res.	Dates	Vintage	Status
NCEP/NCAR R1	T62	1948-present	1995	Ongoing
NCEP-DOE R2	T62	1979-present	2001	Ongoing
CFSR (NCEP)	T382	1979-present	2009	thru 2009, ongoing
C20r (NOAA)	2°	1891-2008	2009	complete, in progress
ERA-40	T159	1957-2002	2004	Done
ERA-Interim	T255	1989-present	2009	Ongoing
JRA-25	T106	1979-present	2006	Ongoing
JRA-55	T319	1958-2012	2009	Underway
MERRA (NASA)	0.5°	1979-present	2009	thru 2009, ongoing

Table 1. Summary of the main atmospheric reanalyses that are current or underway, with the horizontal resolution (latitude; T159 is equivalent to about 0.8°), the starting and ending dates, the approximate vintage of the model and analysis system, and current status.

The four global atmospheric reanalyses that have been released in the last year, as well as the planning for several regional reanalyses, provide an unprecedented opportunity to both evaluate variability across a wide range of timescales and quantify uncertainty relating to the various methodologies employed. The large number of data sets, however, also presents a considerable challenge for investigators in determining the products that best suit their analysis objectives. A major goal of the proposed effort is therefore to evaluate and assess these reanalyses in accord with the critical need for such activities, for instance as identified by the WCRP Observation and Assimilation Panel (see http://www.wmo.int/pages/prog/wcrp/AP_WOAP.html as well as the recent meeting report: http://www.wmo.int/pages/prog/wcrp/documents/Report_WOAP4_5.2010.pdf). Our group has an established track record of involvement in reanalysis evaluation and has served on the advisory committees engaged in the development of several of these products. We are actively involved in efforts to assess the MERRA data set, and have ongoing interactions with the expert users in this group, though these activities fall short of the more comprehensive assessment of reanalyses that is required by the community and that is put forth in this proposal. Nonetheless as our preliminary assessments of MERRA have shown that while some transitions in the observing system have been well addressed in the recent generation of reanalyses, such as for the transition to SSM/I in 1988, others feature spurious effects, such as the transition from TOVS to ATOVS data streams in the late 1990s, that are likely to be an issue for many, if not all, of the recently released reanalyses. Moreover the benefits of novel reanalysis techniques, such as the 4-dimensional variational assimilation scheme employed at ECMWF and the coupled framework of the CFSR have yet to be widely investigated and documented. Thus there exists a substantial community need to evaluate these reanalyses, document their relative strengths and weakness, and identify the major areas of concern and advancement highlighted by each.

Suggested Expert Users: Kevin Trenberth, NCAR; Michael Bosilovich, NASA; Suranjana Saha, NOAA; Dick Dee, ECMWF.

2. Satellite Retrievals

Satellites are the dominant source of global high-quality climate monitoring observations and they help provide the best estimates of rainfall, temperature, humidity, clouds, and energy fluxes on a global scale. Our group has an established record of applying satellite retrievals to climate issues involving both the energy and water cycles, and climate analyses generally (e.g., Trenberth and Caron 2002; Trenberth et al. 2007a; Fasullo and Trenberth 2008; Trenberth and Smith 2008; Trenberth et al. 2009). Moreover, our recent involvement as members of the CERES Science Team has provided us with substantial experience in the application of these data in diagnosing recent climate events and evaluating models. The involvement has also established strong ties with expert users within the satellite community through frequent interaction and collaboration.

These experiences have underscored the challenges that exist in exploiting the satellite record for climate monitoring and model evaluation purposes. These challenges arise in large part due to discontinuities and drift in the satellite record, calibration and sampling issues, and the relative brevity of the satellite record. It is essential to both communicate these issues and provide expert guidance to the community at large as how best to deal with them. Previous efforts in our group have focused on assessing retrievals water vapor, for example in SSM/I and NVAP (Trenberth et al. 2005; Wentz 1997), rainfall such as for example in GPCP and CMAP (Adler et al. 2003; Trenberth et al. 2007a; Xie and Arkin 1997), and clouds and energy fluxes such as in ISCCP, ERBE and CERES (Fasullo and Trenberth 2008; Trenberth et al. 2001; Trenberth et al. 2009; Wielicki et al. 1996; Zhang et al. 2004). We anticipate that continuing commentaries on these satellite products will be of use to the community. Moreover, with the upcoming release of a variety of products from the NASA A-Train Constellation, which includes CLOUDSAT and CALIPSO, we foresee the need to report on these new and largely unfamiliar satellite retrievals through similar evaluations.

Our work has highlighted the importance of considering satellite calibration, discontinuities, and drift (Trenberth 2002; Fasullo and Trenberth 2008). However we believe that additional issues also exist and should be part of community guidance. For example, in regards to model evaluation, it is imperative to communicate the methodological contrasts involved in estimating cloud radiative forcing in models versus observations and the implications this may have for evaluating clouds. Additionally, communicating the contrasts between clouds as observed and the representation of clouds in models, which for example may be simulated as having spatial extent but zero water path and therefore be radiatively inactive, is envisioned to be a key aspect of such guidance. Moreover, in line with our perspective on the utility of simultaneous consideration of multiple data streams, our group also has the ability to provide commentaries on systematic biases in these products, such as for example by comparing closure in the energy and water cycles and their mutual implications. While other complexities also exist their discussion here is limited by space. The key point however is that CAS is a group with substantial involvement in both the observational and modeling activities, and thus it is ideally suited for addressing challenges in applying observational datasets which in many regards involve bridging the gaps that exist between these communities.

Suggested Expert Users: Norman Loeb, NASA and other members of the CERES Science Team; K. Trenberth, NCAR, J. Fasullo, NCAR; the GEWEX Radiation Panel.

3. Ocean Products and Analyses

A recent example highlighting the need for data assessment and inter-comparison is the study of 20th century sea surface temperature (SST) trends by Deser et al. (2010). SST, a fundamental physical parameter of the climate system, is well suited for monitoring climate change due to the oceans' large thermal inertia compared with that of the atmosphere and land. Accurate determination of long-term SST trends is hampered, however, by poor spatial and temporal sampling and inhomogeneous measurement practices (Hurrell and Trenberth 1999; Rayner et al. 2009). As a result, 20th century SST trends are subject to considerable uncertainty, limiting their physical interpretation and utility as verification for climate model simulations. This uncertainty is especially evident in the tropical Pacific where even the sign of the centennial trend is in question (Vecchi et al. 2008). Deser et al. (2010) in evaluating 20th century SST trends from a variety of data sources including un-interpolated archives, found that some reconstructions exhibit statistically significant cooling in the eastern equatorial Pacific, while all of the un-interpolated data sets exhibit a statistically significant warming trend. Further, the warming trend is corroborated by independent measurements of night-time marine air temperatures and other physically-related climate variables such as cloudiness, rainfall and sea level pressure.

Similarly, Reynolds and Chelton (2010) show results from 6 different SST products and highlight a number of significant differences among them. The diurnal cycle and how that is dealt with is an ongoing issue, especially when different sensors are used. Infrared space-borne sensors see the skin temperature, microwave instruments see a cm or so below the surface, buoys make measurements at more like 1 m below the surface while ship measurements can be 10 m below the surface and better represent the bulk temperature but may be influenced by engine room heat. These relate to one another in complex ways, and there is need to document and evaluate them.

There are about 20 different analyses of ocean temperatures and ocean heat content (see Palmer et al. 2010; Lyman et al. 2010) with large discrepancies among them. They include products from the Estimating the Circulation and Climate of the Ocean (ECCO, Kohl et al. 2007) project, NCEP Global Ocean Data Assimilation System (GODAS, Behringer and Xue 2004), NOAA's World Ocean Atlas 2009 (Levitus et al. 2009), GFDL's Ocean Data Assimilation system (Zhang et al. 2009), the Japanese Meteorological Agency analysis (Ishii and Kimoto 2009) and the Simple Ocean Data Assimilation System (Carton et al. 2000). While these multiple data sets offer unprecedented insight into the state of the ocean as a function of location, depth, and time, they also represent a considerable challenge for the user community. Early versions of the data provided by Expendable Bathythermograph (XBT) were plagued by drop rate corrections that altered the perceived depth of the instruments and thus distorted the vertical scale of reported observations and led to significant errors in integrated quantities, such as for ocean heat content (Gouretski and Koltermann 2007). Significant uncertainty also resulted from sampling deficiencies, particularly in the Southern Hemisphere, where observations at depth were infrequent or absent altogether (Trenberth and Fasullo 2008).

In recent years the density of raw data on which these analyses are constructed has increased considerably with the introduction of several thousand Argo floats into the oceans, which greatly improve the sampling of the southern oceans. However, incorporating these data into global analyses has proven to be a considerable challenge and substantial challenges remain in developing a consistent data record (Lyman et al. 2010). Through cross-checking of these data with closure constraints from the top of atmosphere energy budget, informed commentaries on the merits of the various data products, along with those that merge other ocean observations with the Argo floats (e.g., Trenberth and Fasullo 2010), can be made and it is these insights, and their dissemination to the community, that are instrumental to our proposed efforts.

Sea level rise from altimetry (e.g., Nerem et al. 2010) has been analyzed by at least 5 groups. While the linear trends from these analyses are comparable, ranging between 3.1 and 3.3 mm yr^{-1} across the various products (not shown), substantial inter-product variability exists on interannual timescales. The difference relates primarily to measurement biases, errors in measurement corrections such as for wave height, instrument drift and changes in satellites. The contrast between products precludes meaningful analyses related to a range of vital issues including the mean state of the climate, and hydrologic variability associated with ENSO and other modes of low frequency variability. There is therefore a critical need to distinguish among the products and provide a commentary as to which are most consistent with corroborating fields, such as the eustatic contribution of sea level from snow and ice melt over land, from GRACE for example, and thermosteric contributions related to variability in the energy budget (Trenberth and Fasullo 2008). As investigators are often unaware of the significant inter-product differences exist, a major component of our efforts will be to increase awareness of such issues and to provide a means for addressing them.

Suggested Expert Users: Josh Willis, NASA-JPL; Sidney Levitus, NOAA; Steven Nerem, University of Colorado; Clara Deser, John Fasullo and Oceanography Section, NCAR

4. Land Surface Data Sets

There are many hydro-climate data sets over land that are useful for quantifying terrestrial climate variations and changes, as well as for validating and initializing land surface models, which are an important component of Earth System Models.

a. Soil moisture

In-situ observations of soil moisture within the top 1m depth or so are unavailable over most land areas. There are some regional or national networks with routine soil moisture measurements such as the Oklahoma Mesonet (http://www.mesonet.org/), but the archived data from these networks are often not freely available to the public and the research community. Considerable efforts have been made to collect and compile historical soil moisture data and create the Global Soil Moisture Data Bank (http://climate.envsci.rutgers.edu/soil_moisture/) (Robock et al. 2000), which contains records of varying length (10-40 years) of in-situ soil moisture measurements, often a few times a month at several levels within the top 1m depth from Illinois, China, Mongolia, India, and parts of the former USSR.

Large efforts have also been devoted to create estimates of soil moisture fields using land surface models forced with realistic precipitation and other atmospheric forcing data, such as the Global Soil Wetness Project (http://grads.iges.org/gswp; Dirmeyer et al. 2006), the North America Land Data Assimilation System (NLDAS) (Mitchell et al. 2004), the Global Land Data Assimilation System (GLDAS) (http://ldas.gsfc.nasa.gov/; Rodell et al. 2004), and others (e.g., Nijssen et al. 2001; Qian et al. 2006; Sheffield and Wood 2008). Current state-of-the-art land surface models can capture many of the spatial and temporal variations in soil moisture; but model results often contain mean biases and may deviate from the true soil moisture evolution because of uncertainties in model parameters, model physics, and forcing data, and because efforts to assimilate sparse in-situ soil moisture measurements (Robock et al. 2000) into the models have made little progress.

Because of its sensitivity to near-surface soil moisture content (Prigent et al. 2005), low-frequency (<20 GHz) microwave brightness temperature (T_b) seen by satellites has been widely used to estimate soil moisture (e.g., McCabe et al. 2005; Yang et al. 2007; Sahoo et al. 2008). However, because most current microwave channels are also sensitive to vegetation coverage and other near-surface conditions, the retrieved soil moisture content still contains large errors (Sahoo et al. 2008).

Suggested Expert Users: Alan Robock, Rutgers University; Paul Dirmeyer, COLA; Aiguo Dai and Terrestrial Sciences Section, NCAR.

b. Runoff and streamflow

Runoff is a 2-D field similar to evaporation and precipitation. Like evaporation, it is difficult to directly measure. As a result, there are no runoff data sets from direct measurements that can be used to validate land models. There are efforts to estimate runoff fields using water balance models forced with observed precipitation and calibrated with streamflow data. One such product is the long-term mean, composite monthly runoff data set created jointly by the GRDC (http://grdc.bafg.de) and the University of New Hampshire (UNH) (http://www.r-arcticnet.sr.unh.edu/v3.0/index.html; C. Vörösmarty and B. Fekete, now at City College in New York City) (Fekete et al. 2002), which is commonly used to evaluate model-simulated runoff fields. However, monthly time series of runoff fields are currently unavailable.

Streamflow integrates runoff fields over the upstream drainage areas. It is routinely estimated at many stream-gauge stations from measurements of water levels and other information. These gauge data are archived by many national hydrological centers such as the U.S. Geological Survey (http://nwis.waterdata.usgs.gov/nwis/), Water Survey of Canada (http://www.wsc.ec.gc.ca/hydat/H2O/), African hydrological network AOC-HYCOS (http://aochycos.ird.ne/INDEX/INDEX.HTM), and Brazilian Hydro Web (http://hidroweb.ana.gov.br/). The GRDC, UNH and NCAR ((http://dss.ucar.edu/catalogs/ranges/range550.html) websites have a number of streamflow datasets. Dai et al. (2009; http://www.cgd.ucar.edu/cas/catalog/surface/dai-runoff/index.html) have merged available streamflow records from these sources (including the national archives) to create a global streamflow and continental discharge data set (up to 2006) for world's largest 925 ocean-reaching rivers. These streamflow and discharge data have been used to validate climate models (e.g., Oleson et al. 2008).

Suggested Expert Users: Aiguo Dai, NCAR; B. M. Fekete and C. J. Vörösmarty of City College of NYC; J. D. Milliman, College of William and Mary, Virginia

c. Atmospheric forcing data sets for driving land surface models

In land surface modeling and development of land models (such as CLM4) for Earth climate system models, atmospheric forcing data are often required to drive a land model. These data often include surface air temperature, precipitation, humidity, wind speed, and radiation. Some model groups previously used surface data directly from atmospheric reanalyses, which are shown (e.g., Qian et al. 2006) to contain large mean biases and spurious changes. Recently, a few groups have created global atmospheric forcing data sets based on observed precipitation and temperature data sets and other observation-based estimates. These include the data set created by NCAR (Qian et al. 2006; http://www.cgd.ucar.edu/cas/catalog/surface/clmf/index.html), Princeton University (Sheffield et al. 2006; http://hydrology.princeton.edu/data.pgf.php), a French group (Ngo-Duc, et al. 2005) and a Japanese group (Hirabayashi et al. 2008). Substantial differences exist among these data sets with regard to which and how observational datasets were used to derive the forcing data, some of which are 3-hourly and some are daily.

Suggested Expert Users: Eric Wood and J. Sheffield, Princeton University; Aiguo Dai, NCAR

d. Palmer Drought Severity Index (PDSI)

The PDSI is one of most-widely used drought indices over the U.S. and many other regions. In contrast to other precipitation-based drought indices (Dai 2010), the PDSI considers the surface water balance, not just precipitation. Tree ring reconstructed PDSI for the last several hundreds to one thousand of years over North America and Asia by Cook et al. (2010) are available from NCDC (http://www.ncdc.noaa.gov/paleo/pdsi.html). Global PDSI since 1850 based on observed precipitation and
temperature data are available from NCAR (Dai et al. 2004;
http://www.cgd.ucar.edu/cas/catalog/climind/pdsi.html).

Self-calibrated PDSI for Europe and North America are available from CRU (van der Schrier et al. 2006; http://www.cru.uea.ac.uk/cru/data/drought/). NOAA monitors U.S. current drought conditions using the PDSI (http://www.drought.noaa.gov/index.html).

Suggested Expert Users: Aiguo Dai, NCAR; Ed Cook, Columbia University; Phil Jones, CRU; Dave Easterling NCDC.

e. Other land data sets

There are a number of other terrestrial data sets useful for validating the land component of a climate system model. These include data for terrestrial water storage from GRACE satellite observations (Chen et al. 2005); surface heat, water and CO_2 fluxes from field experiments such as the LBA (http://earthobservatory.nasa.gov/Features/LBA/) and flux towers (http://www.fluxnet.ornl.gov/fluxnet/index.cfm). We will provide detailed information and guidance on these data sets, making use of the expertise in applying these dataset to validate land models at NCAR (e.g., Oleson et al. 2008; Stöckli et al. 2008).

Suggested Expert Users: Jay Famiglietti, UC, Irvine; K. Oleson, NCAR; R. Stöckli, CSU

5. Cryospheric Data Sets

a. Sea Ice

There are numerous versions of sea ice concentration datasets, each with a different algorithm and error characteristics, and none clearly superior in performance. Passive microwave remote sensing instruments provide sea ice extent information day or night, clear or cloudy, and have a near-complete record since late-1978. However, there are many limitations of passive microwave imagery. For instance, the instantaneous field of view (sensor footprint) is large, ~25-50 km, limiting the precision of the ice edge location and concentration at the ice edge. In addition, passive microwave instruments are sensitive to the effects of snow cover, liquid, brine volume change, melt ponds, and ice temperature. These effects can result in both overestimation and underestimation of sea ice amounts depending on seasonal and local conditions. Atmospheric emission can also affect the microwave signal. Thin ice also tends to be underestimated by algorithms that convert brightness temperature estimates into ice concentration. In general, biases in sea ice concentration are ~5% during winter (Steffen et al., 1992; Kwok, 2002), with higher errors in summer due to surface melt (Steffen et al., 1992). However, significantly higher errors have been found, depending on surface and atmospheric conditions (e.g., Andersen et al., 2007). Additional data sets are being developed to include information on sea ice thickness and motion (e.g., Brejvik et al., 2010 and references therein).

Suggested Expert Users: W. Chapman (U. Illinois); J. Key (U. Wisconsin); M. Serreze (NSIDC); R. Kwok (JPL); M. Holland (NCAR); K. Steffen (U. Colorado)

b. Snow cover

Frei (2010) provides an up-to-date review of the various snow cover data sets, summarized as followsTwo of the most widely used products for snow extent are the Interactive Multisensor Snow and Ice Mapping System (IMS) and Moderate Resolution Imaging Spectroradiometer (MODIS). The IMS snow extent data set is based primarily on visible wavelength observations, and covers the period from around 1967 to present, constituting the longest remotely sensed environmental time series that has been derived in a near-consistent fashion (Matson and Wiesnet 1981; Robinson et al. 1993; Helfrich et al. 2007). NASA provides a hierarchy of products based on MODIS snow observations, which are designed to satisfy the needs of a variety of users (all available at NSIDC). These include a swath product which contains images with data from regions associated with actual satellite overpasses; daily and 8-day composite tile products which are mapped onto a sinusoidal projection and available in 10 degree lat/lon tiles; as well as daily, 8-day composite, and monthly products available in the Climate-Modeling Grid at two spatial resolutions (0.05 or 0.25 degree) (Hall et al. 2002; Riggs et al. 2005). An 8-day composite is considered useful because in many regions, particularly at high latitudes, persistent cloudiness limits the number of days available for surface observations. Additional products include Passive Microwave satellite estimates

from the Scanning Multichannel Microwave Radiometer (SMMR) instrument (1978 through 1987), and the Special Sensor Microwave / Imager (SSM/I) instrument (1987 through present) although some compatibility issues between the two products exist (Armstrong and Brodzik 2001; Derksen and Walker 2003; Brodzik et al. 2007). The new generation EOS instrument is the Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E), available since 2002. This instrument provides a full suite of measurement bands to make it spectrally compatible with both SMMR and SSM/I at higher spatial resolution (Kelly et al. 2004; Derksen et al. 2005).
Suggested Expert Users: A. Frei (Hunter College); D. Robinson (Rutgers U.); G. Gong (Columbia U)

Readiness

As a National Center, high strategic priorities for the Climate Analysis Section are Community Data Sets and Community Software. Activities include the acquisition, evaluation, improvement, and restructuring of datasets, development of high-level derived products, and facilitation of access and on-line documentation. Especially prominent datasets are merged SST and sea ice, many new derived products from atmospheric reanalyses, and a complete set of air-sea flux histories and forcing for global coupled ocean sea-ice models. These datasets form the foundation for scientific studies and evaluating climate models and many are available on a variety of grid configurations and data formats. Derived products include documentation of the global energy and water cycles and their changes over time.

CGD in partnership with CISL remains devoted to outreach and teaching of data processing software, in particular the NCAR Command Language (NCL), which provides scientists with a robust, supported software tool for file handling, computations, and high quality graphics.

Planned workshops

As a part of the activities planned, NCAR would like to host one or more workshops to further the assessment and dataset information activities. This activity will also enable the expansion of data sets into the realm of biogeochemistry. As a small group, we could host a modest workshop of up to 20 people for 3 days devoted to a particular variable or small subset of variables. The aim would be to have a show and tell (beauty contest) of different products for the same variable along with some diagnostics about their characteristics, and sufficient documentation so that the origin of differences in approaches or algorithms can be determined. The characteristics include metrics of smoothness and spatial structure, global and regional means and annual cycles, trends, and metrics of temporal variability. The participants would be members of the teams who produced the dataset as well as diagnosticians who have worked with the data. One outcome would be detailed information for the *Informed Guide* to datasets.

Before we implement such an activity, however, we would survey other groups and agencies nationally and internationally to see whether they wish to join with us, cosponsor the activity, and make for a larger effort. Nationally, NCDC is engaged in developing climate data records and we have had contact with program managers (such as Chris Miller of NOAA) and principals such as John Bates (NCDC) and Mitch Goldberg (NESDIS). NASA is also interested in such activities especially insofar as they relate to satellite derived variables or products. Internationally, we would work through the World Climate Research Programme (WCRP) Observations and Assimilation Panel (WOAP) and the GEWEX Radiation Panel. Support may also be forthcoming from NCAR as part of summer colloquia and student educational and training programs, and our University collaborators would be instrumental in helping bring these to fruition.

Work Plan

The new Project Scientist will be the primary person in charge of the dataset assessment activity while the Associate Scientist will be in charge of developing the web based interface for the *Informed Guide*.
Year 1: The first year will be devoted to building the web-based interface for the *Informed Guide*, to provide a basis for the subsequent development of the *Informed Guide*, and to begin to populate it. A start will also be made on assembling knowledge about assessment and evaluation of data sets with which

we have expertise, and developing strategic contacts with the broader Earth System Science community for future involvement in the project.
Year 2: The second year will focus on gathering knowledge on data assessment and evaluation, broadening the scope of the data sets to those beyond our own expertise from members of the community, and developing the portion of the *Informed Guide* related to approaches to model evaluation. The second year will also be a time to begin a solid assessment activity funded by this project to fill in gaps. We envision one or more publications in a forum such as EOS or BAMS to publicize this project and to enable broad community involvement. A publication dealing with some dataset evaluations is also likely. We may also hold a workshop to gain input from the broader community if we can garner the requisite resources.
Year 3: The third year will be more intense assessment of datasets, all the while encouraging and responding to the community as the *Informed Guide* is populated. Again, we envisage publications on datasets as the assessment reaches a stage of maturation for each.

Relevance to Proposal Solicitation

Evaluation of Climate and Earth System Models (CSMs and ESMs) with observational data sets is a key step in assessing model performance and an important pre-requisite for credible decadal and regional climate prediction. The proposed work will advance the evaluation of ESMs from a system perspective, including those models participating in the upcoming IPCC AR5 and CMIP5 activities, and as such directly addresses the goal of the proposal solicitation "to improve upon and expand on current modeling capabilities in order to substantively contribute to the advancement of reliable regional and decadal climate predictions", and that of Type 1 proposals in particular as an "incubator and capacity/community building activit[y]". The purpose of this project is to provide the modeling and observational communities with information on observational data sets including their strengths and limitations as well as guidance in choosing among multiple versions of data sets on a particular variable.

Intellectual Merit

There is a critical need for climate observation datasets for several purposes. A primary need is to establish the climate data record and document how the climate has changed. A particular need is for observations and their analyses to evaluate and improve climate models. For climate data records, continuity of calibrated records is needed over extended periods of time. Many observations are made for weather forecasting or other operational purposes and these, and the global analyses which utilize them, are apt to contain uncertainties that must be quantified. Consequently, careful scrutiny of the observations and correction for inhomogeneities are essential, and an assessment is needed for how well this is done. The assessments and information provided in this project is vital to the integrity of and to enable many other studies of climate variability and change, in order to satisfy the fundamental axiom of "know thy data" before exercising it. The Climate Analysis Section team is foremost in the world in leading evaluations and assessments of datasets, and the project described here is not done anywhere else.

Broader Impacts

With many reprocessing and reanalysis projects producing new datasets that have yet to be vetted, and a proliferation of datasets on the same variable, the project and service proposed here has been called for with very high priority both nationally and internationally. The WCRP Global Climate Model (WGCM) working group has led new demands for observational assessments and dataset availability for evaluating the forthcoming CMIP-5 model runs. This has been debated and responded to more comprehensively by the WCRP Observations and Assimilation Panel (see recent reports), and some agencies, such as ESA, are responding. The Climate Analysis Section at NCAR has long had components of evaluating and improving climate datasets as part of a community data activity and this is now being extended and upgraded to respond to the needs. There is also very strong support for this activity within universities, as evidence by accompanying letters of support from several leaders in this area.

This activity will serve as a community resource through broad participation by university and other climate researchers worldwide. It will also benefit society through improved understanding, modeling, and prediction of climate and earth system variability and change. The results of this work will greatly assist students and all scientists working with climate data. The results will be available to everyone and it is planned to have an interactive web presence to enable commentary and questions. Participation by students and others is welcomed.

Project Personnel

The project will be conducted by the members of the NCAR Climate Analysis Section, including the PI, co-PIs and the new Project Scientist and Associate Scientist who will be hired. As a group, we represent a broad range of expertise on observational climate data sets, evaluation and assessment of these data, diagnostic analysis of climate variability and change, and CSM and ESM model evaluation and diagnostics. Further, the participation of the NCAR CCSM and CESM models in the upcoming IPCC AR5 means that we are very close to the modeling efforts and thus are in a unique position to contribute to their evaluation in a highly effective manner. We note that J. Hurrell (co-PI) is head of the CC(E)SM project and co-chairs the CLIVAR Scientific Steering Group, and K. Trenberth (co-PI) has chaired WOAP for 4 years, and now chairs the GEWEX Scientific Steering Group. We also have considerable expertise in providing data to the broad research community and relevant experience with web interfaces for both data retrieval and analysis (e.g., NCL, CAS data catalog). C. Deser (PI) will be responsible for overseeing the project, with input from the co-PIs as appropriate.

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