NOAA/NESDIS/NCDC Scientific Data Stewardship (SDS) Project

Announcement of Opportunity

Fiscal Year 2009

Selections (7)

Title: A Terrestrial Surface Climate Data Record for Global Change Studies

Investigator(s): **Eric Vermote (PI)**
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Lead Institution: **University of Maryland**

The overall objective of this proposal is to produce, validate and distribute a global land surface climate data record (CDR) using a combination of mature and tested algorithms and the best available polar-orbiting satellite data from the past to the present (1981-2009) and which can be extended into the NPOESS era. The data record will consist of one fundamental climate data record (FCDR), the surface reflectance product. Two Thematic CDR's (TCDRs) will also be derived from the FCDR, the normalized difference vegetation index (VI) and LAI/fAPAR. These two products are used extensively for climate change research and are listed as Essential Climate Variables (ECVs) by GCOS. In addition these products are used in a number of applications of long-term societal benefit. The two TCDRs will be used to assess the performance of the FCDR through a rigorous validation program and will provide feedback on requirements for the Surface Reflectance FCDR.

The record will use the best available data, addressing the dynamic data continuity of the input observations, which will be primarily from the AVHRR and MODIS with differing spatial resolutions 4km GAC (1981–present), 1km HRPT and LAC (1992–1998), 250m to 1km MODIS (2000-present). A gap in the data record from these two instruments for the 1999-2000 will be filled using a SPOT VEGETATION surface reflectance product (1km) generated by European GEOLAND2 project. The resulting product will be a consistent climate data record of the Land surface from 1981 to present.

The experience of the team in producing high quality coarse resolution land datasets through these of physically based methods for calibration, geolocation and atmospheric correction is unparalleled. The multi-agency composition of the team will help in the process of building a broad community consensus for the FCDR. The availability of the MODIS and AERONET record for intercomparison and the reuse of the MODIS Processing and Quality Assurance approaches are key to producing a long-term data record from AVHRR and MODIS. Special attention will be paid to product validation and developing realistic uncertainties needed for optimal exploitation of TCDRs. The validation will be linked to and benefit from previous and on-going international validation activities of the CEOS Land Product Validation Working Group. The data distribution will be undertaken by the MODAPS group at NASA GSFC utilizing the Land and Atmospheres Archive and Distribution System (LAADS). This proposal will build on the investigators' experience in developing long-term land data records under the NASA REASON LTDR project, which provides the mechanisms for adaptation of peer-reviewed algorithms, the product generation, distribution, validation and quality control of the Climate Data Record.

Title: Generating consistent radiance SDRs and deep-layer atmospheric temperature TCDRs from the MSU/AMSU/SSU temperature-sounding channels

Investigator(s): **Cheng-Zhi Zou (PI)**
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Lead Institution: **NOAA/NESDIS/StAR**

The Microwave Sounding Unit (MSU) and Advanced Microwave Sounding Unit (AMSU) on board the NOAA polar-orbiting satellites and NASA EOS and European MetOp satellites have provided critical atmospheric temperature measurements during the past 30 years. The Advanced Technology Microwave Sounder (ATMS) to be flown on the NPP/NPOESS program will carry the microwave sounding capability into the future. Before AMSU was available, the SSU (Stratospheric Sounding Unit) was the only instrument that made stratospheric temperature observations from 10 to 1 hPa. Together the MSU, AMSU, ATMS, and SSU comprise an indispensable Fundamental Climate Data Record (FCDR) for historical temperature change monitoring from the surface to the stratosphere.

Time-varying intersatellite biases exist in the pre-launch calibrated radiances that may cause spurious climate signals when these satellite measurements are used for climate product retrievals and reanalysis data assimilation. Deep-layer atmospheric temperature time series have been derived from the microwave sounder observations by different research groups; however, diverse trend results were obtained due largely to uncertainties in pre-launch calibrations. Post-launch intercalibration is required to reduce these biases for reliable climate monitoring and data assimilations in seamless weather and climate modeling.

We have developed intercalibration algorithm for the MSU instrument using simultaneous nadir overpasses, which results in a more accurate radiance dataset than pre-launch calibration in terms of significantly reduced intersatellite biases and bias drift. The improved radiances have been assimilated into the NCEP CFSRR (Climate Forecast System Reanalysis and Reforecast) and NASA MERRA (Modern Era Retrospective-analysis for Research and Applications) reanalysis systems. A historical MSU-based deep-layer atmospheric temperature *MSU/AMSU/SSU Radiance SDRs and Temperature TCDRs* 3 TCDR (Thematic Climate Data Record) has been generated from the recalibrated radiances and robust atmospheric temperature trends were obtained. In addition, community radiative transfer models (CRTM) were developed capable of dealing with critical calibration issues such as the CO2 gas leaking in the SSU instrument and Zeeman splitting effect in the AMSU stratospheric channels, providing feasibilities for construction of individual and further merged MSU/AMSU/SSU SDR and TCDR products.

We propose to develop climate quality, recalibrated radiance SDRs and deep-layer atmospheric temperature TCDRs from the raw measurements of the MSU/AMSU/SSU atmospheric temperature channels. This will include products form a single instrument on multiple satellites as well as merged products from different instruments, and it extends the current mature MSU SDR and TCDR to the AMSU/SSU instruments. The development will be built upon applications of state-of-art calibration technologies existing in the literature and an extensive research activity aimed at reducing intersatellite errors. Calibration issues to be dealt with include, but are not limited to, satellite orbital-decay, short overlaps between certain satellite pairs, orbital-drift related warm target contamination, nonlinear calibration, earth-location dependency in biases, antenna pattern effect, diurnal drift adjustment, limb-adjustment, residual bias correction and merging at the gridded product level, and stratospheric cooling effect in the MSU/AMSU mid-troposphere channels. The simultaneous nadir overpass (SNO) method will be used to help diagnose and remove intersatellite biases of different causes. The most-recently developed CRTMs for AMSU and SSU will be applied for bias removal of effects due to CO2 cell gas leaking and long-term atmospheric CO2 changes in the SSU measurement. Zeeman splitting effect in the AMSU stratospheric channels will be considered. Optimal view combinations will be applied to rectify frequency and scanning pattern differences between different satellites for satellite merging. Extensive and comprehensive validation efforts are designed to quantify the quality of the proposed SDRs and TCDRs using homogenized radiosonde, GPSRO, as well as inter-comparisons of the same TCDR product but derived by different research groups.

The project will be carried out through a collaborative effort among the science team members. The team will also collaborate with other teams within and external to NOAA to investigate different calibration issues and implement mature techniques into the proposed SDRs and TCDRs. If the proposal is successful, this team is willing to host a workshop to establish community consensus approaches through discussions with the calibration and data generation community and the SDS program management. The proposed research will take place over a three-year period.

Title: Extending Ozone Climate Data Records (CDRs) into the Ozone Mapping and Profiler Suite (OMPS) Era

Investigator(s): **Lawrence E. Flynn (PI)**

Lead Institution: **NOAA/NESDIS/StAR**

The NOAA operational satellite ozone monitoring program will be transitioning from the SBUV/2 instruments on the NOAA POES to the OMPS instruments on the NPOESS beginning with the launch of the NPP satellite in 2010. This project will create a system at NOAA/NESDIS to generate ozone CDRs from the OMPS measurements to continue existing records.

There are three main objectives for this proposed project. The first is to prepare and initiate the machinery and materials to seamlessly continue the Total Ozone Climate Data Records produced from measurements made by the SBUV(/2), TOMS, and OMI with those from the OMPS Nadir Mapper. The second is to take similar steps for the OMPS Nadir Profiler for the Ozone Profile Climate Data Records from the SBUV(/2) instruments. The third objective is to develop a capability to validate, refine, and reprocess OMPS Limb Profiler measurements to create high vertical resolution ozone profile products with good long-term stability to continue the record from limb and occultation instruments.

To achieve these objectives, we propose to do the following: develop OMPS-specific analysis and characterization tools, implement OMPS SDR and heritage ozone retrieval algorithms for reprocessing, implement newly developed ozone profile algorithms for the OMPS LP, and adapt the measurement and ozone product validation processes for OMPS records. We will leverage support under existing NESDIS programs including SBUV/2 CDR activities, IPO OMPS Calibration/Validation activities, and NDE OMPS preparations to jump start this work. There is already joint work with the NASA OMPS NPP Science Team as they develop the OMPS LP SDR and ozone profile retrieval algorithms.

The proposal request support to create a system with capabilities to track and refine the OMPS instruments' calibration and trending in the SDR reprocessing, to implement algorithm improvements and corrections in the EDR/CDR algorithm reprocessing, to perform validation and internal consistency analysis and intercomparisons, and to iteratively exercise these steps to generate stable long-term OMPS SDRs and ozone CDRs consistent with earlier records.

The work in this proposal will concentrate on producing good SDRs because they are source of good CDRs but it also includes the development of reprocessing capabilities for the ozone CDRs for two important reasons; The validation of the ozone CDRs implicitly validates the SDRs, and The applications for monitoring the ozone layers expected recovery over the next two decades will use the ozone CDRs.

Title: A Fundamental Climate Data Record of SSM/I, SSMIS and Future Microwave Imagers

Investigator(s): **Christian Kummerow (PI)**
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Lead Institution: **Colorado State Univ.**

The data record of operational microwave imager observations from SSM/I currently spans over two decades from 1987 to the present. The follow on to this successful series of sensors is the SSMIS, which is currently operational and will extend this record for at least the next decade. This, in turn, will be followed by the Microwave Imager/Sounder (MIS), which is being developed for the future NPOESS satellite series. The SSM/I sensors have a long history of climate applications from the early detection of the Arctic Sea ice decline to confirmation of the coupling between sea surface temperature and total precipitable water. Indeed, the robust retrievals of water vapor, surface wind speed, cloud water and precipitation from SSM/I make it a cornerstone for global hydrologic cycle research. The current proposal combines efforts from NESDIS and CSU that have experience in dealing with climate quality SSM/I brightness temperature records. NESDIS started in the early 1990s the developments of SSM/I operational products and made the product operational for NOAA and DoD users, and recently created new procedures for climate quality time series. CSU has created a L1C dataset of passive microwave sensors intercalibrated to data from the TRMM microwave imager.

Drawing on the expertise from both of these groups, the goal of this proposal is to identify and use the best approach from each group where this can be identified, or to fully understand and document differences in order to generate a completely transparent and documented Fundamental Climate Data Record (FCDR) of SSM/I and SSMIS brightness temperatures. Key to this effort will be the intercomparison and examination of calibration procedures and results that will provide not only the best possible product, but also an assessment of this product.

Title: A Recalibration of the AVHRR data record to provide an accurate and well parameterized FCDR

Investigator(s): **Jonathan Mittaz (PI)**
Andrew Harris, Univ. of Maryland

Lead Institution: **Univ. of Maryland**

As is becoming more and more apparent, the current calibration of the AVHRR sensor has introduced biases and errors which must be removed if we are to produce an accurate FCDR from the more than 25 years of AVHRR data. Recent work by us (Mittaz, Harris & Sullivan 2009) has shown that the observed biases and errors can be removed by using a completely new calibration methodology which has been derived using a physical calibration model to understand the complex issues in both the pre-launch and in-orbit data. This new methodology has been shown to be more accurate than the current operational calibration and is also able to remove the large and systematic biases found both in the pre-launch data as well as seen in in-orbit comparisons with other well calibrated sensors such as the AATSR and IASI.

In order to get the best FCDR we therefore propose to re-calibrate the historic AVHRR data using this new calibration to provide the most accurate AVHRR FCDR possible. Perhaps equally importantly, the new calibration method is also capable of predicting instrument gain during times when the on-board calibration data are affected by solar and/or Earthshine contamination and during times when there are thermal gradient problems over the internal calibration target (ICT). Solar contamination has been a significant problem for many NOAA platforms as their equator crossing times drift and our work on the in-orbit behavior of the AVHRR instrument also shows that the daytime segments of morning satellites at least may be affected by strong thermal gradients. The presence of such effects in the current data record will have lead to inconsistencies in the time series, for example, but our ability to predict the calibration over bad times should lead to a more consistent FCDR than is currently available. Further, we will be able to cope with changes in the AVHRRs thermal environment over time, something that has not been possible before.

We therefore propose to derive a new calibration by re-analyzing all the pre-launch data for all AVHRR sensors pre AVHRR/3, compare the AVHRR calibration will other accurate TOA radiance sources and derive a corrected in-orbit calibration, study long term calibration trends and remove them and use the predictive power of the new calibration to remove times when the AVHRR calibration system has been contaminated or corrupted. By doing this we will then obtain an accurate and consistent calibration to be used in the creation of the best AVHRR FCDR possible.

Title: A Product Development Team for Snow and Ice Climate Data Records

Investigator(s): **Jeffrey Key (PI)**
William Emery, University of Colorado
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Lead Institution: **NOAA/NESDIS/StAR**

Recent studies have shown that Northern Hemisphere sea ice extent and thickness have decreased dramatically in response to surface warming over the last 30 years. In the Antarctic, some ice shelves have recently collapsed due to rising temperatures, though responses to climate change in the continental interior are not as straightforward. While these studies generally agree that the Arctic and parts of the Antarctic have been warming, it is not clear how other aspects of the climate system have responded. For example, how do changes in surface and cloud properties interact and affect the surface energy budget? How do changes in the cryosphere affect global climate? How will the changes affect coastal communities and access to resources in the Arctic?

The availability, consistency and accuracy of cryospheric products are thus critical for a wide range of applications ranging from climate change detection, climate modeling, and operational uses such as shipping and hazard mitigation. In turn, full exploitation of cryospheric products can benefit greatly from the support provided by a coordinated group of data and applications experts. We propose to create a Cryosphere Product Development Team that will provide such coordination for the generation, validation, and archival of fundamental and thematic snow and ice climate data records (FCDR and TCDR) that the scientific community can use to help answer these and other questions about a changing global climate. We will coordinate existing and new products, establish “best practices”, and will update heritage products to allow NOAA to continue with their production and dissemination. Our focus is on products that can be derived from optical (visible, near-IR, and thermal IR) and passive microwave imagers. FCDRs will be created where necessary and used in the production of TCDRs.

We will build on our extensive experience in producing geophysical fields from satellite sensor data records (SDR). Our goal is to refine, extend, validate, document, and archive visible, infrared, and passive microwave cryosphere products. Snow and ice products exist for both heritage (AVHRR, SSM/I) and newer (MODIS, AMSR-E) instruments, and are planned for the future VIIRS and MIS sensors. We propose to merge the existing data into consistent time series, and use these series as a basis for transitioning to NPP and NPOESS products. We will build on existing efforts, coordinating with other funded products, as appropriate. We have assembled a polar products development team that is uniquely qualified for this effort.

This is a multi-institutional proposal from the NOAA National Environmental Satellite, Data, and Information Service (NESDIS), including its Cooperative Institute for Meteorological Satellite Studies (CIMSS)/University of Wisconsin, NASA Goddard Space Flight Center (GSFC), the University of Colorado (CU), and the National Snow and Ice Data Center housed within the CU/NOAA Cooperative Institute for Research in Environmental Sciences (CIRES).

Title: Developing a Climate Data Record for Total and Spectral Solar Irradiance

Investigator(s): **Peter Pilewskie (PI)**
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Judith Lean, Naval Research Laboratory
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Lead Institution: University of Colorado

Radiative energy from the Sun establishes the basic structure of the Earth’s surface and atmosphere and defines its external environment. Solar radiation powers the complex and tightly coupled circulation dynamics, chemistry, and interactions among the atmosphere, oceans, ice, and land that maintain the terrestrial environment as humanity's habitat. Natural variability on a wide range of temporal and spatial scales is ubiquitous in the Earth system, and this constant change combines with anthropogenic influences to define the net system state, in past, present, and future climates.

Although the difference between the Sun's radiative forcing in the present climate compared to a pre-industrial baseline is small, the uncertainty in solar forcing is comparable to that associated with greenhouse gases and aerosols [*IPCC Fourth Assessment,* 2007]. Seemingly small variations, or uncertainties, in solar irradiance represent large impacts on, or uncertainties in, the total energy input to the Earth. Total Solar Irradiance (TSI) measurements provide the only quantitative record constraining proxy and physical models used for estimating historical solar irradiances that are essential for a definitive understanding of the historical record of climate change. Establishing the baseline provides the foundation for evaluating all other forcings of climate change, particularly those caused by human activities. All such forcings act to change the climate by perturbing the planetary radiation balance.

The current uninterrupted 30-year TSI climate data record is the result of several overlapping instruments flown on different missions. Continuity of TSI measurements allows successive instruments to be linked to the existing TSI data record despite absolute offsets between instruments. This record clearly exhibits the Sun's variability over the 10 to 11 year solar cycle and on shorter time scales. A newer continuous record of Solar Spectral Irradiance (SSI) commenced with the launch of the NASA SORCE mission in 2003. The measurement of SSI is vital to understanding how solar variability over many time scales impacts climate and for validating climate model sensitivity to spectrally varying solar forcing. These data also provide the basis for improving synthetic solar spectra, which can be used to model paleoclimate and validate hypotheses on past and future climate change.

The long and continuous high-precision TSI record constrains the total energy available to drive the climate system. The newer SSI measurements provide the details to resolve the underlying mechanisms and terrestrial interactions responsible for sun-induced climate changes and they help to distinguish between natural and anthropogenic causes of climate change and preclude quantitative predictions of climate change. The measurements of TSI and SSI from the Total and Spectral Solar Irradiance Sensor (TSIS) were restored on NPOESS earlier this year because of their critical role in determining the natural forcings of the climate system and the high priority given it by the 2007 Earth Science Decadal Survey.

The primary objective of this proposal is to develop the baseline CDR of the solar irradiance, both the total solar irradiance (TSI) and the solar spectral irradiance (SSI). The baseline solar irradiance CDR is critically important for NOAA as test input and validation for the development of the NPOESS TSIS algorithms. Our TSIS CDR Product Development Team is assembled from investigators with SORCE and Glory heritage and with a keen understanding of radiometer calibration and performance, algorithm development and processing, and irradiance variability modeling necessary to insure the highest quality solar irradiance data records. The timely formation of the TSIS CDR Product Development Team now ensures establishing an accurate baseline solar irradiance CDR and is expected to enable the rapid and reliable generation of NPOESS solar irradiance Climate Data Records following the launch of TSIS on NPOESS C1.

The function of this team will be to insure data stewardship of TSI and SSI through the development of the TSIS Algorithm Theoretical Basis Document (ATBD); CDR development from current and heritage satellite instruments; construction of irradiance composites; development of related solar irradiance products and algorithms to be distributed to the broader community. The team will ensure an effective and technically robust utility of the solar irradiance CDRs by actively collaborating with users and recipients of these products, including the CDR Product Development Teams for energy balance, ozone and temperature remote sensing.

For this data Stewardship Program, the CDR Development Team proposed here maintains several of the duties of an NPOESS Operations and Algorithms Team (OAT) in that it will advise both NOAA and the LASP development team on the calibration effort and review the documentation associated with this plan. Funding for the actual calibration has been allocated through the instrument development contract, but there is currently no method to establish the scientific context of this effort. The remaining tasks for the TSIS CDR Product Development Team include planning for the effective utilization of TSIS data and its linkage to the TSI and SSI records, quantifying relationships of irradiance with various types of solar activity indicators, and articulating and demonstrating the relevance of solar irradiance for climate record change. None of these activities is funded by the NASA Goddard Space Flight Center contract with the University of Colorado, Laboratory for Atmospheric and Space Physics (LASAP) for the building of TSIS.

The proposing team is uniquely qualified to conduct this research. The contributing members include Principal Investigators and science team members on a number of current and future space-based missions (including TSIS on NPOESS C1) to measure solar irradiance, lead investigators in the role of the Sun in climate, and experts in the calibration and characterization of irradiance instruments. The facilities and resources at LASP, NRL, and NIST are fully sufficient for carrying out the proposed activities.-