

**NOAA/NESDIS/NCDC Scientific Data Stewardship (SDS) Project
FY 2009 Announcement of Opportunity
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Selections (7)**

Title: Development of a radiation climate data record combining ERBE and AVHRR

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A recent analysis of radiation measurements at the top of the atmosphere (TOA) indicates that the Earth's radiation budget over the tropics has changed between the 1980s to the 1990s; outgoing longwave irradiance increased by 1.6 W m⁻² and reflected shortwave irradiance decreased by 3.0 W m⁻². Because TOA radiation budget variability is highly correlated with cloud cover variability, the results suggest that a significant change in the cloud cover occurred between 1980s to the 1990s. In addition, recent analyses indicate that downwelling shortwave radiation at the surface decreased in the 1980s, but the trend was reversed in the 1990s. We propose to use data from the Earth Radiation Budget Experiment (ERBE) and Advanced Very High Resolution Radiometer (AVHRR) on NOAA 9 and 10 to produce the same suite of advanced cloud-radiation data products currently being produced by the CERES program using data from CERES and MODIS on the Terra and Aqua platforms (and eventually CERES and VIIRS on NPP and NPOESS). The ERBE scanners on NOAA 9 measured broadband shortwave, longwave and total radiances from February 1985 to January 1987, and the ERBE scanner on NOAA 10 measured from January 1987 to May 1989. The objective is to extend the mature long-term CERES climate data records back in time so that cloud-radiation changes from the 1980s onwards can be studied in an accurate and consistent manner. Merging ERBE and AVHRR data enables the retrieval of cloud and aerosol properties over ERBE scanner footprints and improved TOA radiative fluxes from new, more advanced angular distribution models built from CERES radiances from the TRMM, Terra, and Aqua satellites. To ensure consistency between the ERBE and CERES scanner periods, a high level of relative accuracy can be achieved by using overlapping Earth Radiation Budget Satellite (ERBS) nonscanner active cavity radiometer measurements as a transfer standard between the NOAA 9 and 10 ERBE scanner data and the CERES scanners on TRMM, Terra and Aqua. The new dataset will enable irradiance changes to be examined by cloud type and region and provide net radiation at top-of atmosphere and surface. In addition, it will offer an independent source of the TOA and surface radiation budget data that can be directly compared with International Satellite Cloud Climatology Project (ISCCP) data, which cover both ERBE and CERES periods.

Title: The Development of AMSU FCDR's and TCDR's for Hydrological Applications

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Current passive microwave sounder data, used in hydrological applications, are derived from POES satellites for which the primary mission is operational weather prediction. These data are not calibrated with sufficient stability for climate applications. A properly calibrated FCDR needs to be developed to enable the utilization of these data for TCDR and Climate Information Records and to extend their application into the NPOESS era (e.g., POES/AMSU to NPP/ATMS to NPOESS/ATMS). Once developed, TCDR's for water cycle applications (precipitation, water vapor, clouds, etc.) will be developed for use as key components in international programs such as GEWEX, CEOS and GPM; collaborators on this project hold key roles in many of these programs.

Passive microwave sounder data have proven their worth in more than just tropospheric temperature and moisture monitoring. NOAA/NESDIS generates operational products from the Advanced Microwave Sounding Unit (AMSU) focused on the hydrological cycle (e.g., rainfall, precipitable water, cloud water, ice water, etc.) through two product systems known as the Microwave Surface and Precipitation Products Systems (MSPPS) and the Microwave Integrated Retrieval System (MIRS). MSPPS has the longest legacy dating back to NOAA-15 (July 1998) while MIRS is an advanced, 1DVar retrieval system that is portable to different passive MW sensors thus making it attractive for multi-sensor TCDR generation. MSPPS and MIRS products are archived at NCDC and are being widely used in the scientific community. As we enter the NPOESS era, AMSU-A and AMSU-B (and its successor, MHS) will be replaced with the ATMS sensor, first to be flown on NPP, then on all of the NPOESS spacecraft. These data offer the unique opportunity to develop CDR's that can contribute to other satellite time series with similar capabilities such as the DMSP SSM/I and SSMIS, the TRMM TMI, and Aqua AMSR-E. This project will focus on the development of AMSU FCDR's for the AMSU-A window channels and the AMSU-B/MHS sensor.

This project will utilize established methods to generate FCDR's and take "multiple paths" to determine which methodology is the most applicable to AMSU. This will include a workshop during the first year of the project focused on water cycle CDR's. The generation of TCDR's is a necessary step to assess the accuracy of the FCDR's; similar results by multiple methods yield

confidence and uncertainty estimates in the CDR's. By project completion, an 11-year (2000 – 2010) AMSU CDR is anticipated.

Title: Re-Calibrating HIRS and Evaluating Associated Impact on Cloud and Moisture Properties

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The Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin – Madison is proposing to establish a large Development Team to recalibrate all infrared measurements of High-Resolution Infrared Radiation Sounder (HIRS) against reference measurements from the Infrared Atmospheric Sounding Interferometer (IASI) on the European Meteorological Operational Satellite (METOP) platform. This work will reprocess the Fundamental Climate Data Record (FCDR) of Thermal Infrared Sounder Sensor Data Record (SDR) one year before and after a HIRS sensor transition and evaluate the impact of that reprocessing on cloud and moisture CDRs as part of the Scientific Data Stewardship of Climate Data Records.

CIMSS already has in-house experience with a 28 year record of HIRS data; we propose to use that expertise in re-calibrating the METOP infrared spectral bands on HIRS with IASI as the reference and then going backwards in time via simultaneous nadir overpasses (SNO) and intercomparisons with geostationary simultaneous observations (GSO) to establish accurate and well characterized calibrations for all HIRS (using those on METOP as the reference). The goal is to establish a consistent set of radiance measurements tied to modern absolute references. To accomplish the GSO intercomparison, CIMSS proposes to use IASI and AIRS (Atmospheric Infrared Sounder) to re-calibrate the geostationary (GEO) sounder infrared (IR) channels. This algorithm has been developed at CIMSS; the proposed effort will go backward in time to get consistent radiances on all the GEO sounders (radiosondes will be incorporated as necessary to assist). The use of GSOs will add additional sampling and statistics to the SNO calibration transfer approach. The in-house CIMSS/SSEC data holdings, coupled with the existing SSEC data processing system, enables efficient reprocessing that will enable investigation of diurnal effects on cloud and moisture 30-year trends.

The re-calibrated and characterized radiance measurements, along with algorithm advances established with the Moderate resolution Imaging Spectroradiometer (MODIS), will be used to reprocess the HIRS derived cloud products (particularly cloud amount, cloud top pressure, and

associated error structures) and to produce climate quality atmospheric clear sky water vapor products (including total precipitable water, TPW, and upper tropospheric humidity, UTH). It has been found that relatively small changes in the HIRS radiances can translate into large differences in the cloud and water vapor products. The product consistency during transition periods from one sensor to another will be used as a measure of the recalibration.

Climate change is associated with changes in surface properties, cloud coverage, cloud properties, and tropospheric moisture. Large uncertainties still remain in the global and regional distributions of these parameters. The data sets resulting from this work are critical to setting a baseline satellite data sets that support IPCC observational needs.

Title: Creating UTH-Related FCDRs from IR and Microwave Sensors Cross-Calibrated by In Situ Measurements from Commercial Aircraft

Investigator(s): **Zhengzhao Luo (PI)**
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Upper-tropospheric humidity (UTH) remains one of the least well-measured and most poorly understood components of the water vapor cycle. Although occurring in very small amounts, its radiative effects are significant in determining the energy budget of the earth's climate system and the overall climate sensitivity. The goal of this proposal is to bring together all the UTH-relevant radiance data from multiple satellites and process them to establish a long-term, global radiance record from which a climate record of UTH variations can be retrieved and UTH research may be conducted.

A unique aspect of this proposal is its calibration component. Instead of just cross checking one satellite with another, we propose to bring in an independent and highly accurate calibration anchor – the MOZAIC (Measurement of Ozone and Water Vapour by Airbus In-Service Aircraft) project. Another key feature of the proposal is the emphasis on microwave data. Although IR UTH radiances (near wavelengths of 6.3 - 6.7 μm) have been intensively studied in the past for FCDR purpose, their microwave counterpart (~ 183 GHz) has received much less attention. By collocating the IR and microwave observations, we can also exploit the insensitivity of the microwave to cloud contamination. Finally, we will produce a single, homogeneous record of UTH-related radiances (starting from 1992 because microwave UTH data are only available from then), while preserving the separate parallel versions of each type of UTH-related radiances (some of which date back to late 1970s) for different applications. The matched MOZAIC/satellite dataset, which is a subset of the original data and provides the anchor for inter-calibration of all the radiances, will also be delivered along with the calibrated radiance dataset.

The proposed study here addresses questions that are directly related to the SDS's program objectives and priorities. "Mature algorithms" will be applied to "multiple satellites and sensors which together span climate-relevant time periods". Also, the UTH FCDR as proposed here is specifically identified as an "initial priority parameter" solicited by this announcement, namely, "thermal infrared and microwave sounder SDR (Sensor Data Record)". Finally, as part of the NOAA Cooperative Institute, NOAACREST Center, our proposed activities fit in with the Center's "Hydroclimate" theme and will expand the activities, which currently focus on the lower troposphere, to include the cold upper troposphere.

Title: The Development of a 20-year Database of Ocean Surface and Near-Surface Properties Suitable for Climate Analyses

**Investigator(s): Carol Anne Clayson (PI)
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Lead Institution: Florida State University (FSU)

In the proposed project, surface and near-surface parameters of wind speed, temperature, and humidity will be derived from a combination of satellite observations, with a focus on the use of these variables towards determination of the air-sea turbulent heat fluxes. This research falls directly in line with the Thematic CDR's FY 2009 Priority focus on the Earth's energy and water cycles. The goal is the production of a long-term (20 year) set of surface and near-surface parameters leading to fluxes with consistent, homogeneous errors that have been subjected to a rigorous error analysis.

We will develop, using information gained from the SeaFlux Intercomparison Project, a 20-year time series (1987 – 2007) of sea surface temperature and 10-m temperature, wind speed, and specific humidity at a 3-hourly, 0.25° resolution over the global oceans. These products will be developed for the specific focus of accurate determination of the surface turbulent fluxes. The unique aspects of this proposal include (1) a new approach for satellite-based (SSM/I) retrieval of near surface (10m height) air temperature and atmospheric humidity on a 3 hourly to 24 hourly scale; (2) an extension of a previously-developed validated algorithm using AVHRR data to determine skin surface temperatures resolving the diurnal cycle with additional microwave and ATSR data; (3) calculation of surface turbulent fluxes on these scales from data not derived from numerical weather prediction (NWP) models; and (4) an investigation of the strengths and weaknesses of gridding that will be optimized to minimize regional and global biases in the fluxes.

The TCDRs will be compared against the tens of thousands of measurements available from the SeaFlux Database, in addition to research vessel observations, which are quality controlled and archived at Florida State University (FSU) through the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative. Additional research vessel, buoy, and volunteer observing ship observations will be targeted to widen and better examine the parameter space. Using research vessel observations takes advantage of these mobile platforms' ability to sample

temperature and humidity in a wide range of ocean regimes (from the equator to the polar oceans) on short time scales, allowing for averaging of the data on a scale that matches the satellite footprint. The bulk surface turbulent fluxes, based on the satellite retrievals, will also be compared to available in situ flux observations that have been collected on these research vessels that are closely collocated in space and time to the satellite observations.

Title: Calibration of Historical and Future AVHRR and GOES Visible and Near-Infrared Sensors and the Development of a Consistent Long-Term Cloud and Clear-Sky Radiation Property Dataset

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A stable and consistent set of imager radiances is an essential component of any long-term climate data record (CDR). We propose to establish a coherent reflected radiance Fundamental CDR (FCDR) for the AVHRR and geostationary satellite (GEOsat) imagers extending back to 1978. In addition we propose to provide a Thematic CDR using the calibrated AVHRR imagers to retrieve cloud properties that are consistent with MODIS and the future VIIRS instruments. We will be applying mature and robust calibration algorithms, the Nearly Simultaneous Raymatched Technique and the Deep Convective Cloud Technique (DCCT). These methods were used to uncover errors in the MODIS and TRMM VIRS records for visible and infrared calibrations. We have been applying them in real time but need to consolidate and quality control the results so that they may serve as CDRs and can be applied to historical AVHRR and GEOsat data. A set of uncertainties will be developed by applying the two methods to different combinations of satellites. The FCDR will consist of cloud amount, phase, optical depth, effective particle size, height, and temperature. It will be consistent with the CERES MODIS cloud properties, which have a reliable 8-year record and will continue on VIIRS. Slight modifications to the algorithms will be made for 4-channel AVHRR data. The results of this analysis should be extremely valuable for climate studies. We will be collaborating with other CDR teams to ensure non-redundancy and optimization of the products.

Title: Construction of Consistent Microwave Sensor Temperature Records and Tropopause Height Climatology using MSU/AMSU Measurements, GPS RO Data and Radiosonde Observations

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Accurate temperature trend estimates are crucial for monitoring decadal climate variability and for understanding climate change forcing mechanisms. Over the past decade, the roughly 30 years of Microwave Sounding Unit (MSU) and the Advanced Microwave Sounding Unit (AMSU) measurements that are on board the National Oceanic and Atmospheric Administration (NOAA) series of polar-orbiting satellites have been extensively used for climate temperature trend detection. Even though these satellite missions use similar instruments, the equatorial crossing times of the NOAA satellite orbits drift in local time after launch. Because the MSU/AMSU operational calibration coefficients were obtained from pre-launch datasets, the orbital changes on MSU/AMSU measurements after launch may not be completely accommodated by these calibration coefficients. Different MSU/AMSU missions do contain different measurement biases that actually vary with times and locations due to on-orbit heating or cooling of the satellite components. This leads to extra difficulties for the usage of MSU/AMSU temperature trends for climate analysis. Identification of the long-term changes in tropopause temperature structure (i.e., tropopause height) in the upper troposphere and lower stratosphere (UTLS) has, over the past decade, become a focus for understanding important climate variations and processes. However, due to poor vertical resolution and/or measurement uncertainty, traditional observations and most satellite measurements in this region have not been well suited for these studies. Recently, the Global Positioning System (GPS) Radio Occultation (RO) technique has been proven to be a mature global observation technique and is ideally suited for climate trend detection. GPS RO produces global data coverage without the need for calibration or bias correction. In addition, because GPS RO data do not contain orbit drift errors and are not affected by on-orbit heating and cooling of the satellite components, they are very useful for identifying the MSU/AMSU time/location dependent biases for different NOAA missions. With very high precision and vertical resolution, GPS RO data are also very suitable for use in detecting the change of tropopause height in the UTLS. Building on the previous NOAA SDS grant NA07OAR4310224, in this study, we propose to carry out three tasks: (i) To use GPS RO data from 2001 to 2012 as climate benchmark datasets to quantify the MSU/AMSU temporal and spatial temperature anomalies, which would help to define a better approach for constructing MSU/AMSU temperature records from 1979 to 2012; (ii) To generate a long-term climate quality temperature dataset by reprocessing thirty-three years (1979-2012) of MSU/AMSU data. The 'adjusted' MSU/AMSU data and identified RO-consistent radiosonde data in the period of 2001 to 2009 (from the previous study) and from 2009 to 2012 will serve as reference data to calibrate other overlapped MSU/AMSU data from 1979 to 2001; (iii) To use GPS RO soundings collected from multi-RO missions but processed using a consistent processing package to construct tropopause height climatology from 2001 to 2012 that is consistent with changes in temperature and tropopause structure estimated by radiosondes.