Year 1 Report

DEVELOPMENT OF AN INTEGRATED NORTHERN HEMISPHERE SNOW AND ICE OPERATIONAL CLIMATE DATA RECORD

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Project Overview

This project is designed to: (1) develop mature Northern Hemisphere terrestrial snow and sea ice CDRs with known levels of uncertainty and with community-standard metadata; (2) assemble mature Northern Hemisphere terrestrial snow and sea ice data products into an integrated snow and ice CDR; and (3) provide the snow and ice CDR in multiple grids, on multiple time steps, and in multiple formats for the research community, decision-makers, and stakeholders.

Throughout the project, we are seeking community feedback via an Advisory Council and through town hall meetings at the American Geophysical Union fall conference to ensure that our CDR will meet community needs. The integrated CDR will be provided via the Rutgers Global Snow Lab web site (http://climate.rutgers.edu/snowcover/) on several time steps (daily through annual), in various grids (e.g., Equal-Area Scalable Earth, 1° x 1°), and in various formats (e.g., text, netCDF, flat binary) for access by the community. The integrated CDR will also be distributed to relevant national data centers. Upon completion of this project, the CDR will begin the transition to operational production at a NOAA center by introducing production into the ongoing operations at the Rutgers' National Climatic Data Center's Applied Research Center satellite facility. Once production confidence is fully attained and all requisite data archives and metadata are completed, the final transfer of processing to a NOAA operational center will take place. At that point, our study team will be performing scientific data stewardship activities only. This project is dovetailing well with a related effort that is funded by

the NASA MEaSURES initiative. This SDS project has major foci associated with operational and community aspects of our integrated snow-ice CDR. Meanwhile the NASA effort is geared more to the research side of things and concentrates on our developed products, their integration and how our research-quality CDR aligns with the principles expressed in a recent NRC report. In other words, within the SDS project, we are developing the "framework for integrating the mature CDRs". For NASA, we mainly focus on putting together our own records, but for NOAA, we are explicitly trying to develop a framework to bring in other data records. Furthermore, within the SDS project we are developing "known levels of uncertainty and community-standard metadata"; this doesn't appear in the NASA project as an objective. Thus our NOAA effort focuses a bit more on the issue of error and uncertainty analysis.

Milestones for the first year of the project have been met or are in the process of being completed. These include: (1) collecting existing snow cover and melt onset data records, including metadata information; (2) establishing an advisory committee and obtaining advice on CDR; and (3) holding a town hall at the fall 2008 AGU meeting. We also have begun to embark on efforts tied in with the general project goals. The following discusses efforts to date regarding microwave, visible and station snow products, the project web site, and the advisory group.

Microwave mapping of snow melt onset over sea ice

Fundamental CDRs (FCDRs) must be generated with the highest possible accuracy and stability. The FCDRs are the “building blocks” for the TCDRs, although it is important to note that the FCDR consistency is more of an issue for the passive microwave record than for the visible record. Accordingly, we focus most of these efforts on the passive microwave record.

Assessment of the FCDRs is occurring explicitly, but much of this effort is entwined with the other efforts discussed below and with the development of TCDRs. For example, the SSM/I processing errors discovered by co-I Anderson (see Molthan and Anderson 2005) were originally discovered while producing data records of snow melt onset date over sea ice. This effort resulted in a reprocessing of SSM/I data at NSIDC, and the reprocessed data are now incorporated into this project’s ongoing work. At this point, the current generation of FCDRs of passive microwave products (AMSR and SSM/I) through the National Snow and Ice Data Center (NSIDC) appear adequate for the proposed effort.

As noted by the seminal NRC report on CDRs (NRC 2004), sensors should be thoroughly calibrated, including nominal calibration of sensors in-orbit, vicarious calibration with in situ data, and satellite-to-satellite cross-calibration. Nominal in-orbit calibration issues are based on satellite development and operational control and are beyond the scope of this work. However, part of this project is to assess the data records with respect to vicarious calibration with in situ data and satellite-to-satellite cross-calibration.

We have started the process to assess the consistency of the passive microwave data. The sea ice melt onset dates are being analyzed by regions established in Drobot and Anderson (2001) and updated through 2008. The melt onset dates and sea ice concentration data have been geo-referenced and put into GIS format for the development of a Northern Hemisphere cryospheric

data set. Snow cover is also being geo-rectified into the same grid as the passive microwave data. Discussions with Walt Meier (University of Colorado) have been initiated to acquire his SDS sea ice product into our data stream. An example of the coverage and data is given in Figure 1.

The goal is to generate a hemispheric view of the sea ice and snow cover data with a quality assurance flag associated with each data point. Therefore, a user will be able to collect data from any point and ascertain the accuracy of the data. During the melt season, for example, the melt onset algorithm will be used to flag sea ice data that are under melt conditions, which might have an effect on concentration values. If melting is not taking place then the confidence in the data will be higher. We also plan on incorporating several sea ice algorithms to produce the best ice concentration. Again if all algorithms produce similar results then the flag will have a high confidence, if there are differences then the flag will have a lower confidence. Other influences on the accuracy of the value will also be investigated, such as atmospheric conditions and ice type.

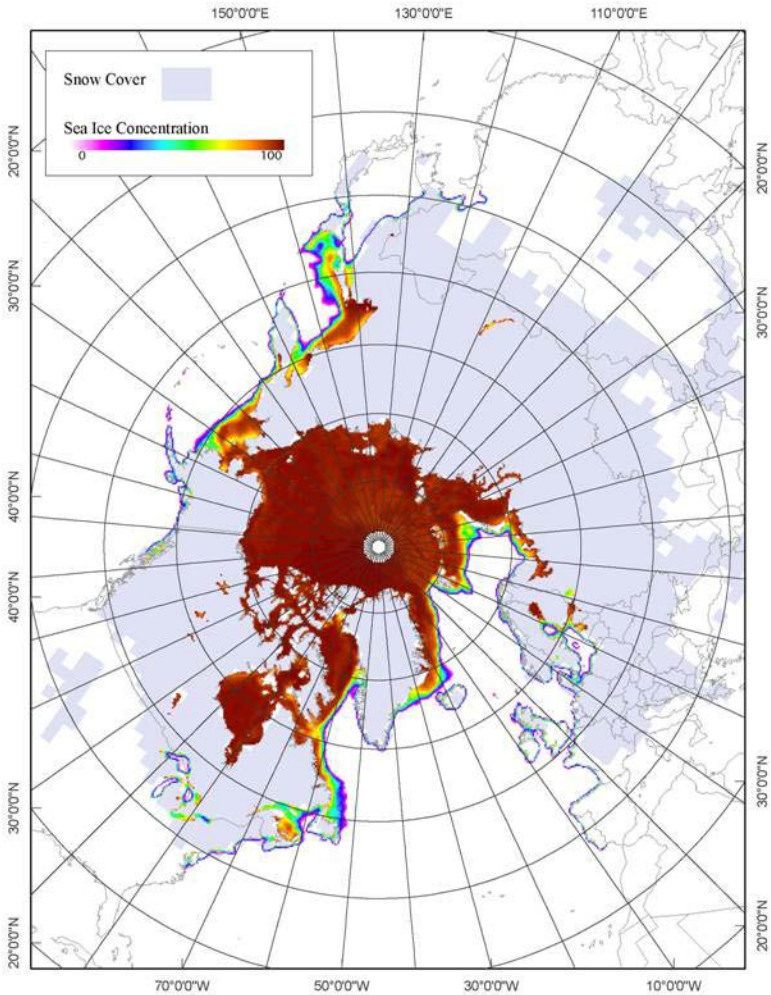

Figure 1. March 5, 2005 coverage of Northern Hemisphere sea ice and continental snow cover. Sea ice extent is from the boot-strap approach of Comiso (1999 updated 2008). Snow cover is from the NOAA IMS product that has undergone quality control at Rutgers.

Microwave mapping of continental snow extent

This work is not being supported directly by this grant. It is being performed by Tom Mote at the University of Georgia, as a continuation of an earlier NOAA collaborative effort with Robinson and as part of Mote's current participation on our complementary NASA MEaSURES project team. This will be part of our SDS project historical database, and, like other "external" datasets evaluated during this project, will likely be incorporated into operational product development. The effort regarding the development of terrestrial snow cover TCDRs from microwave data involves: (1) vicarious calibration of the microwave terrestrial snow candidate TCDRs to existing in situ records, particularly the existing snow depth station data, (2) calibration of the microwave terrestrial snow candidate TCDRs to the visible satellite record, and (3) assessment of the relative differences in the AMSR and SSM/I satellite terrestrial snow candidate TCDRs. The comparison (currently 1992-2005) to in situ records involves frequency maps of differences and summary statistics between a gridded North American snow product from in situ data and the passive microwave products, as described in the project proposal. Examples of these difference maps are available on the Rutgers Global Snow Lab web site. Comparisons between the in situ and microwave snow depth are also being done in conjunction with ongoing work by S. Quiring (Texas A&M). Additionally, a similar comparison has been made between the microwave product and a 1° latitude by 1° longitude version of the NOAA weekly charts. Examples of these comparison maps are also available on the GSL web site. Updates of the SSM/I and AMSR based terrestrial snow candidate TCDRs have been produced through summer 2008. Sets of frequency maps of differences and summary statistics are being produced, but are not yet complete. Additional cross-validation will be required as NSIDC transitions from the use of the SSM/I F-13 satellite to other satellites.

Visible mapping of snow extent

Visible products of continental snow extent also began to be addressed in year 1. In particular, this was with regard to a standardization issue affecting the lengthy NOAA visible snow map record. Also, in conjunction with the MEaSURES project and in cooperation with Dr. Dorothy Hall at NASA, comparisons of the NOAA product with the cloud-gap filling for the MODIS visible map product will permit further comparisons and integration of MODIS maps with the NOAA visible product (prior to moving on to an integrated visible, microwave and station product).

We are in the final stages of developing a continental snow extent CDR using the weekly NOAA visible snow maps (11/67-5/99) and NOAA daily IMS snow maps (6/99-present). This has involved identifying and correcting for mapping discontinuities within the weekly era and between the weekly and daily maps. For instance, grid cells denoted as patchy snow during the earlier years of the weekly product were at times digitized as fully covered. These have been eliminated from the database. So too have mountainous regions which at some times of the year were digitized as snow covered on the lower resolution weekly maps when evidence discerned from a climatologic study of the weekly and daily maps and from examining a two-year blindly mapped overlapping interval for the two products show these grid cells to be far less than half snow covered.

Station mapping of snow extent and depth

Prior to the onset of the project, daily in situ snow cover observations from US and Canadian Cooperative observing stations had been assembled into a database of daily 1° x 1° maps of snow cover from 1950 through 2003 (as part of the Robinson and Mote NOAA-sponsored project). Currently, the database is being updated through 2008. Former Soviet Union daily data from the 20th century, some other European data, and some Chinese data are being acquired and will be mapped. These efforts also involve collecting as much metadata as possible.

Project web site

At this time, the focus of our project web site is on the NOAA snow product. We have also posted North American microwave-derived snow extent maps, North American station-derived snow extent maps, and some preliminary assessments of agreement/disagreement amongst the visible, microwave and station mapping of North American extent.

An international array of individuals maintains an interest in the databases and derived information. For the vast majority, a visit to the project website (http://climate.rutgers.edu/snowcover) suffices to meet their needs. In 2008, 15,595 individuals visited the site at least once. Visitors clearly found the site useful, as there were 11,791 returning visitors over the course of the year. Visits came from 102 countries, with the top ten from greatest to least including the U.S., Russia, United Kingdom, Netherlands, France, Sweden, Canada, Germany, Italy and Spain. 44% of the visitors came directly to the site, suggesting they have it bookmarked. 42% arrived from a referring site, indicating a number of other websites contain a link to our site. The remaining 14% found the site through search engines.

For those seeking further information concerning the data or wishing to obtain all or portions of the gridded databases, individual consultations occur via phone or email and data. Most often these involve making all or portions of a database, including metadata, available for the customer to download. Follow up interactions often occur. In 2008, we provided data to 27 individuals, and already in 2009 seven requests have been or are in the process of being satisfied. Recent contacts have been primarily from the international academic community, although the USGS, USDOE, NASA, NCEP, NCAR and Meteo France from the government sector and three private firms also received data in 2008. Five requested the station product, the remainder sought one of our gridded satellite products.

With the ongoing updating of databases currently found on the site and the additional population of the site with the many single-source and blended CDRs being developed over the course of this project, we expect web site activity to continually increase. So too, do we expect increased interaction with those seeking consultation regarding the products.

Project advisory committee

Our efforts to establish an advisory committee continue. As a first step, we convened a town hall meeting at the annual American Geophysical Union meeting this past December. The

purpose of the gathering was to assess and discuss needs and uses for cryospheric CDRs. In addition to the 5 project investigators, 20 others attended and several others participated via teleconference. Those participating included individuals from several US universities and research centers, including NSIDC. Several Canadian agencies were represented, along with a UK university, and individuals from the World Meteorological Organization headquarters and their Climate and Cryosphere (CliC) initiative. This discussion began the process of obtaining community feedback on snow CDRs, and we soon plan to invite several attendees (along with several others) to serve on the advisory committee.

Other synergistic activities

Our project team helped organize oral and poster sessions at the Fall 2008 AGU meeting where cryospheric CDR topics were discussed. D. Robinson and S. Drobot presided over these sessions; which included: "An Icy Mélange I: Cryospheric Climate Data Records and Intriguing Outliers" (poster) and "An Icy Mélange III: Cryospheric Data Records and Yesterday's Behavior" (oral).

Co-I Anderson chairs the PoDAG committee. In the process he is learning more about the process of submitting data sets into the NSIDC data archive from MEaSURES projects

PI Robinson contributed to the State of the Climate reports for 2007 and 2008 that are published in the *Bulletin of the American Meteorological Society*.

Publications and Presentations

To date, there has not been a manuscript published that explicitly cites our SDS grant. However a number of project-related presentations made (most with accompanying abstracts). These include:

Anderson, M.R., S. Drobot, and A. Molthan, 2008: Passive Microwave Bad Scans and the Importance of Satellite Data Version Numbers, Fall Meeting of the American Geophysical Union, San Francisco, CA.

Drobot, S.D., J.A. Maslanik, W. Emery, B. Blazey, and C. Fowler, 2008: Spatial and temporal trends in Arctic temperature climate data records, Fall Meeting of the American Geophysical Union, San Francisco, CA.

Drobot, S.D., J.A. Maslanik, W. Emery, B. Blazey, and C. Fowler, 2009: Spatial and temporal trends in Arctic temperature climate data records, Annual Meeting of the American Metrological Society, Phoenix, AZ.

Robinson, D.A., 2008: Historical evaluation of NOAA snow maps. Snow Mapping Workshop, National Ice Center, Suitland, MD.

Robinson, D.A., 2008: Elements of Successful Cryospheric Climate Data Records. American Geophysical Union Fall Meeting. San Francisco, CA.

Robinson, D.A. & T. Estilow, 2008: A Northern Hemisphere Snow Extent Climate Data Record. American Geophysical Union Fall Meeting. San Francisco, CA.

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Comiso, J. 1999, updated 2008: *Bootstrap sea ice concentrations from NIMBUS-7 SMMR and DMSP SSM/I*. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

Drobot, S.D., and M.R. Anderson, 2001: An improved method for determining snowmelt onset dates over Arctic sea ice using scanning multichannel microwave radiometer and Special Sensor Microwave/Imager data. *Journal of Geophysical Research*, 106:24,033-24,050.

Molthan, A. L., and M. R. Anderson, 2005: Problematic data in the DMSP SSM/I data sets. 8th Conference on Polar Meteorology and Oceanography, American Meteorological Society, San Diego, CA.

NRC, 2004: *Climate Data Records from Environmental Satellites*. National Academies Press. Washington, DC. 150 pp.