

Arctic System Reanalysis: Call for Community Involvement

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Arctic climate encompasses multiple feedbacks, the most important of which is the ice-albedo feedback. Enhanced Arctic changes, first recognized in the nineteenth century, increasingly are being observed across terrestrial, oceanic, atmospheric, and human systems, inspiring interdisciplinary research efforts, including the Study of Environmental Arctic Change (SEARCH) program, to understand the nature and future development of the Arctic system.

In response to the need for enhanced understanding outlined in the 2005 SEARCH Implementation Plan [*Arctic Research Consortium of the United States*, 2005], an ongoing Arctic System Reanalysis (ASR) project builds on previous programs to observe the Arctic climate. The ASR is a multi-institutional, interdisciplinary collaboration that optimally merges measurements and modeling to provide a high-resolution description of the region's atmosphere/sea ice/land system by assimilating a diverse suite of observations into a regional model. The project builds upon lessons learned from past reanalyses by optimizing model physics parameterizations and methods of data assimilation for Arctic conditions. The ASR, which is a partnership with the broader Arctic research community, represents a synthesis tool for assessing and monitoring variability and change in the Arctic system.

ASR Design

The ASR assimilation region extends well beyond the boundaries of the Arctic Ocean to include about one third of the Northern Hemisphere, so all river basins that drain into the Arctic Ocean are included (see Figure 1 inset). The ASR output will include gridded fields of temperature, radiation, winds, and numerous other variables at high spatial (10-kilometer) and temporal (3-hour) resolution, enabling detailed reconstructions of the Arctic system's state.

The first-generation ASR will span 2000–2010. A 30-kilometer-horizontal-resolution prototype (June 2007 to September 2008) will be distributed to the community by

March 2010. The ASR prototype period includes the unprecedented (in the observational record) sea ice minima during late summer 2007 and 2008 as well as several major Arctic observational programs.

The ASR should enable many applications. For example, ASR fields can serve as drivers for coupled ice-ocean and other models, and ASR will provide a focal point for coordinated model intercomparisons.

Moreover, the ASR will permit reconstructions of the Arctic system's behavior, thereby serving as a state-of-the-art synthesis tool for assessing and monitoring variability and change in the Arctic system. The system-oriented approach required for the project encourages collaboration between the Arctic terrestrial, sea ice, ocean, and atmospheric communities. Additionally, the reanalysis will build on prior investment in large Arctic field programs and on those conducted during the recent International Polar Year (IPY).

The ASR is designated as an IPY full project under the international Climate of the Arctic and its Role for Europe/Arctic System

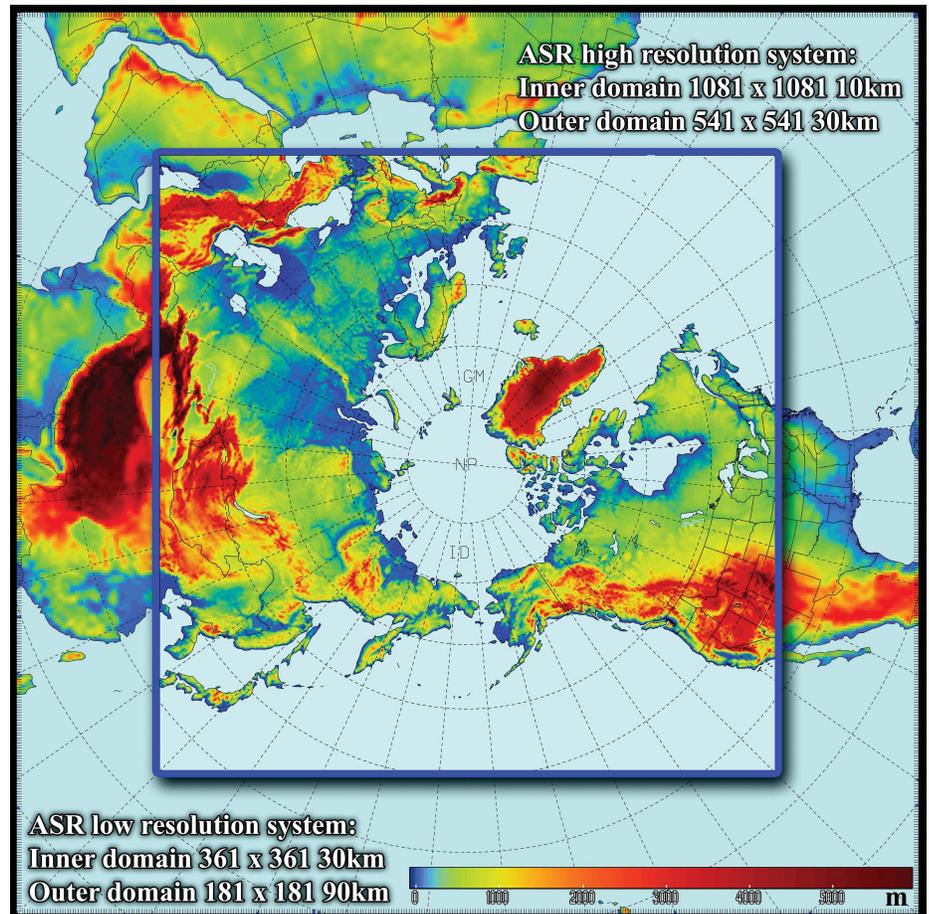


Fig. 1. Spatial coverage of the Arctic System Reanalysis (ASR) includes a 541×541 outer grid with 30-kilometer horizontal resolution and a 1081×1081 inner grid (inset) with 10-kilometer horizontal resolution. The outer grid provides smooth boundary conditions for the inner ASR grid. Grids are polar stereographic projections centered at the North Pole. Terrain height is shown by color scale. The low-resolution ASR configuration will be used to produce the prototype version spanning June 2007 to September 2008.

Reanalysis activity. IPY funding from the U.S. National Science Foundation's Office of Polar Programs provides the backbone of support for advanced development, production, and dissemination stages of the ASR. Start-up funding was supplied by the U.S. National Oceanic and Atmospheric Administration (NOAA).

Project administration requires close cooperation between the main participating institutions, facilitated by project meetings at least twice each year. The Polar Meteorology Group (PMG) of Byrd Polar Research Center at Ohio State University, Columbus, is the lead institution. Other key partners are the Mesoscale and Microscale Meteorology Division (MMM) and the Research Applications Laboratory (RAL) of the National Center for Atmospheric Research (NCAR), Boulder, Colo.; the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado at Boulder; and the Department of Atmospheric Sciences of the University of Illinois at Urbana-Champaign. Also, because the project requires extensive computing power, the ASR is being performed on the Ohio Supercomputer Center's (OSC) IBM Cluster 1350, known as Glenn, which recently was expanded to 8000 central processing units.

ASR Preparations

Before the high-resolution production phase is conducted, extensive tests of the ASR's components are required. To represent the physical processes, the primary ASR tool is the polar-optimized version of the Weather Research and Forecasting (WRF) model (<http://polarmet.osu.edu/PolarMet/pwrf.html>), a regional coupled atmosphere-land model. The PMG has developed and extensively tested "Polar WRF" for the three main Arctic environments: ice sheets, ocean/sea ice, and land. The stable

boundary layer, mixed-phase clouds, and surface energy balance were especially emphasized during the testing phase.

Arctic enhancements developed for the ASR project are being channeled through NCAR for release to the scientific community. For example, the fractional sea ice capability developed by the PMG is a standard WRF option beginning with version 3.1. The specified sea ice representation in the ASR is being enhanced by ice thickness distributions derived from remote sensing observations. Specified variable snow thickness over sea ice is also being represented.

Preparations for the ASR at RAL comprise improving representation of Arctic land surface processes by the Noah Land-Surface Model (LSM), which is coupled to WRF. Key goals include improving the representation of spring snowmelt and the soil temperature profile. In part, these improvements are achieved by adding an organic layer, deeper soil depths, and a zero-flux bottom boundary condition to Noah. To best represent the land surface in the ASR, high-quality fields will be obtained through High-Resolution Land Data Assimilation, driven by satellite data and run with the Noah LSM, which interacts periodically with WRF.

Fully assimilating the available Arctic observational data is an important challenge. The NCAR MMM has contributed considerable resources to enhance assimilation of in situ and remote sensing data in the polar regions, thus optimizing the advanced three-dimensional variational (3D-Var) data assimilation capabilities of WRF-Var. In assembling the varied data that are to be processed by WRF-Var, Jack Woolen of the National Centers for Environmental Prediction has provided access to operational data streams and valuable advice on their usage. While conventional weather reports and satellite measurements make

their way into the operational data sets, other important Arctic observations do not. These include the following data sets that will be incorporated into ASR: Greenland ice sheet automatic weather station reports, data from automated weather stations at northern Alaskan field sites, Multiangle Imaging Spectroradiometer (MISR) cloud-tracked winds supplied by the University of Illinois, Arctic snow water equivalent measurements supplied by CIRES, and most of the IPY field measurements. The ASR is soliciting additional Arctic data sets from the community for assimilation into ASR or for testing its output. The ASR for 2000–2010, which is scheduled for completion in autumn 2011, will be distributed to the scientific community by the NOAA Earth System Research Laboratory (formerly Climate Diagnostics Center) and by NCAR. Arctic researchers are sought to evaluate and critique the prototype ASR product. Potential ASR partners are welcome to convey their particular interests. For more information, visit <http://polarmet.osu.edu/PolarMet/ASR.html>.

Reference

Arctic Research Consortium of the United States (2005), Study of environmental Arctic change: Plans for implementation during the International Polar Year and beyond, report, 104 pp., Fairbanks, Alaska.

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