Very High Resolution Arctic System Reanalysis for 2000-2011

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The Arctic is home to some of the most rapid climate changes during recent decades. Previous global reanalyses, however, disagree on tropospheric trends for the Arctic. In response, a very high resolution regional reanalysis with an Arctic-optimized model is nearing completion for 2000-2011. The Arctic System Reanalysis (ASR) includes atmospheric, sea ice and land surface representations. Through atmospheric and land data assimilation, combined with analyzed sea ice concentration and thickness, a broad-based set of historical data streams from the surface and space are merged. The square domain of the ASR, centered at the North Pole and covering about one third of the land area of the Northern Hemisphere, includes all of the northward flowing rivers that empty into the Arctic Ocean. Numerical simulation of the atmosphere and land are performed with the polar-optimized version of the Weather Research and Forecasting model (Polar WRF), which includes the Noah land surface model. Data assimilation capabilities are provided by the WRF variational data assimilation (WRF-Var) for the atmosphere and High Resolution Land Data Assimilation System (HRLDAS) for Noah. Polar WRF's Noah includes improved specifications for the following sea ice attributes: extent, concentration, thickness, albedo and snow cover. WRF-Var assimilates NCEP-PREPBUFR observation data (in-situ surface and upper air data, remotely-sensed retrievals and satellite radiance data). HRLDAS is a vital component of ASR that assimilates snow cover and depth, observed vegetation fraction and albedo. The current HRLDAS uses NASA, NESDIS, and NOAA satellite observations to describe these surface properties. The T255 (0.7 degrees) horizontal resolution ERA-Interim reanalysis surface and upper air model level data are used to provide the initial and lateral boundary conditions.

Four primary institutions participate. The lead institution is the Polar Meteorology Group (PMG) of Byrd Polar Research Center (BPRC) at The Ohio State University. The BPRC PMG component includes (1) leading the development of the atmospheric parameterizations and sea ice treatment for Polar WRF and (2) managing the numerical computations for the first generation ASR. The Mesoscale and Microscale Meteorology Division (MMM) of the National Center for Atmospheric Research (NCAR) has optimized the WRF-Var system for data assimilation of Arctic observations, and verified that the WRF-Var system correctly assimilates all atmospheric data streams. The Reseach Applications Laboratory (RAL) at NCAR improved the Noah-based High Resolution Land Data Assimilation System for use over Arctic land areas. The University of Illinois (UIUC) has primary responsibility for (1) organization and evaluation (including some quality control) of the various input data streams for the ASR, (2) data archiving, and developing data access and visualization tools, and (3) contributing analyzed values of sea ice concentration and thickness over the Arctic Ocean. The Cooperative Institute for Research in Environmental Sciences at the University of Colorado-Boulder (CIRES/CU) focused on (1) providing quality-controlled data for the land surface data assimilation in collaboration with NCAR, (2) evaluation of the ASR products, and (3) working with UIUC to test and refine web tools to assure an optimal, user-friendly configuration.

The ASR is being performed on the Ohio Supercomputer Center's (OSC) IBM Cluster 1350 by the BPRC PMG that has extensive experience performing multi-decadal and multi-terrabyte regional simulations in the polar regions. Currently, the ASR data assimilations with reduced resolution with nested grids (90 km outer domain; 30 km primary domain) have been performed from 2000 to 2010 at OSC and are known as ASR-Interim. Polar WRF version 3.3.1, WRF-Var version 3.3.1 and HRLDAS are used for the data assimilations. This version of ASR produces 6 TB of raw output in netCDF format (uncompressed) per year.

The annual total accumulated precipitation from the ASR-Interim and from ERA-Interim are very similar. The added benefit of higher resolution with the ASR-Interim data assimilation (30 km for ASR versus ~80 km for ERA-Interim) can be seen along the mountainous western North America, southeast Greenland, southeast Iceland, and western Scandinavia where more detailed and realistic features are evident in ASR. The results of ASR-Interim and ERA-Interim for 11 years are compared with 3-h observations from more than 6,000 surface stations across the ASR domain obtained from the National Climatic Data Center (NCDC). High skill in resolving surface pressure variations is found, along with good skill for 2-m temperature and dew point temperature. The ASR-Interim analysis skill for 10-m wind speed, 2-m dewpoint, 2-m temperature and surface pressure is superior to that of ERA-Interim.

Based upon the very encouraging results with the nested domain data assimilation for 11 years (ASR-Interim), the ASR team will perform 12 years (2000-2011) with 30 km outer domain and 10 km primary domain. The newest versions of Polar WRF, WRF-3DVar improved by NCAR, and Noah Land Data Assimilation will be used for the final run. The target date for completion is September 2012. Raw output data set size is 54 TB in netCDF format per year. ASR data are distributed by NCAR's Research Data Archive and NOAA Earth System Research Laboratory (ESRL).

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