Observing Networks for Arctic Climate and Weather

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Just What Is “Arctic”?

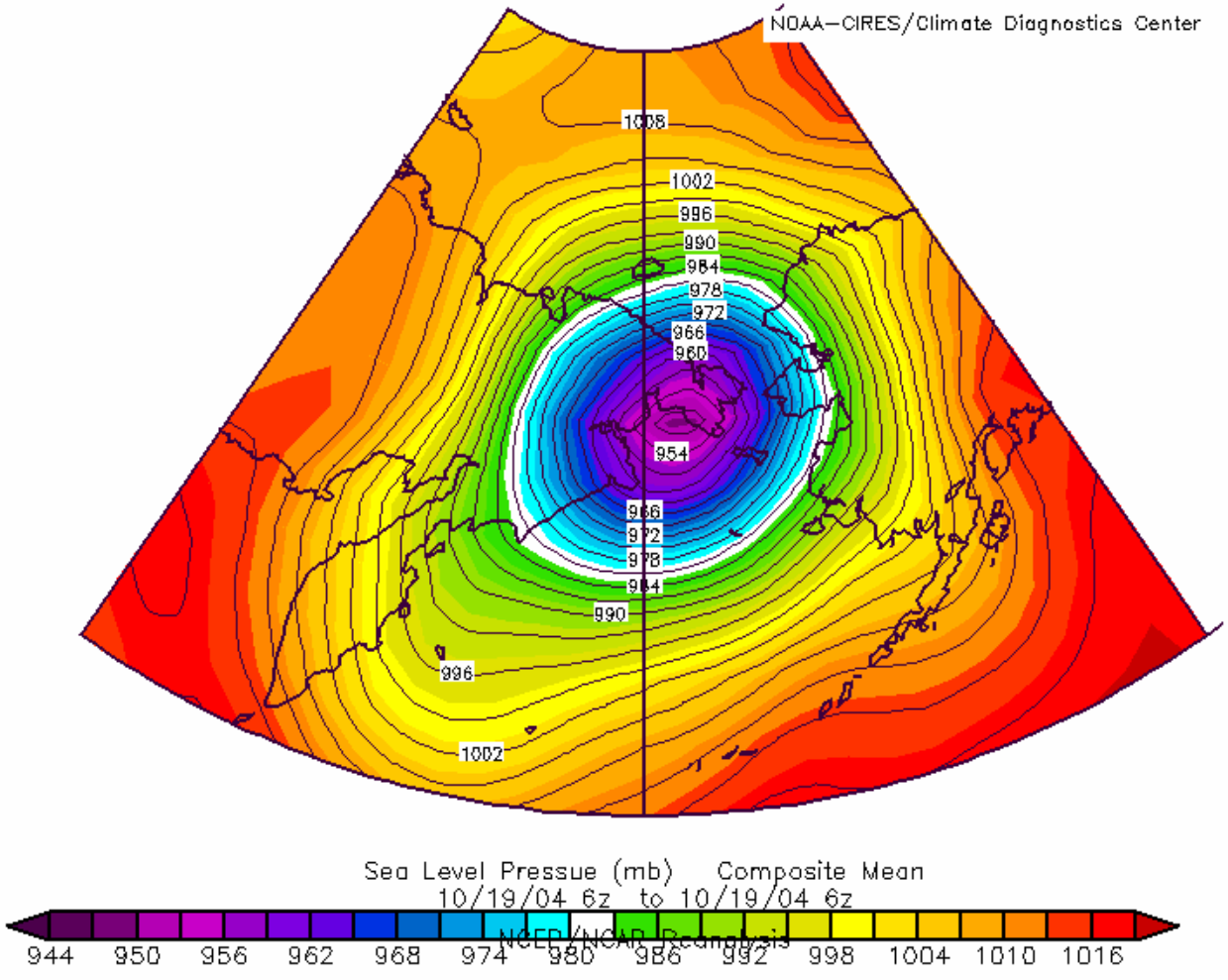
We Select

- Arctic Ocean
- Greenland Ice Sheet …and …
- The rivers which empty into the Arctic Ocean and maintain its near surface stratification

Thus our Arctic extends from ~45°N to the North Pole

Selected Weather and Climate Features and their Resolvability with Current Arctic Observations

- Climate Modes
  - e.g., Arctic Oscillation/NAO, PNA
  - Yes, we can resolve these large-scale features with current observations
- Weather
  - e.g., Synoptic-scale cyclones
  - Reasonably, but some shortcomings – see next slide
- Mesoscale Phenomena
  - Polar lows, sea breezes, barrier winds, katabatic winds
  - Insufficiently resolved
- Sea Ice
  - Extent, fractional coverage, thickness, albedo, snow cover, melt ponds
  - Yes Yes No ? ? ??
- Land
  - Snow cover, SWE, permafrost, vegetation, lakes
  - Yes ? ? Yes ?

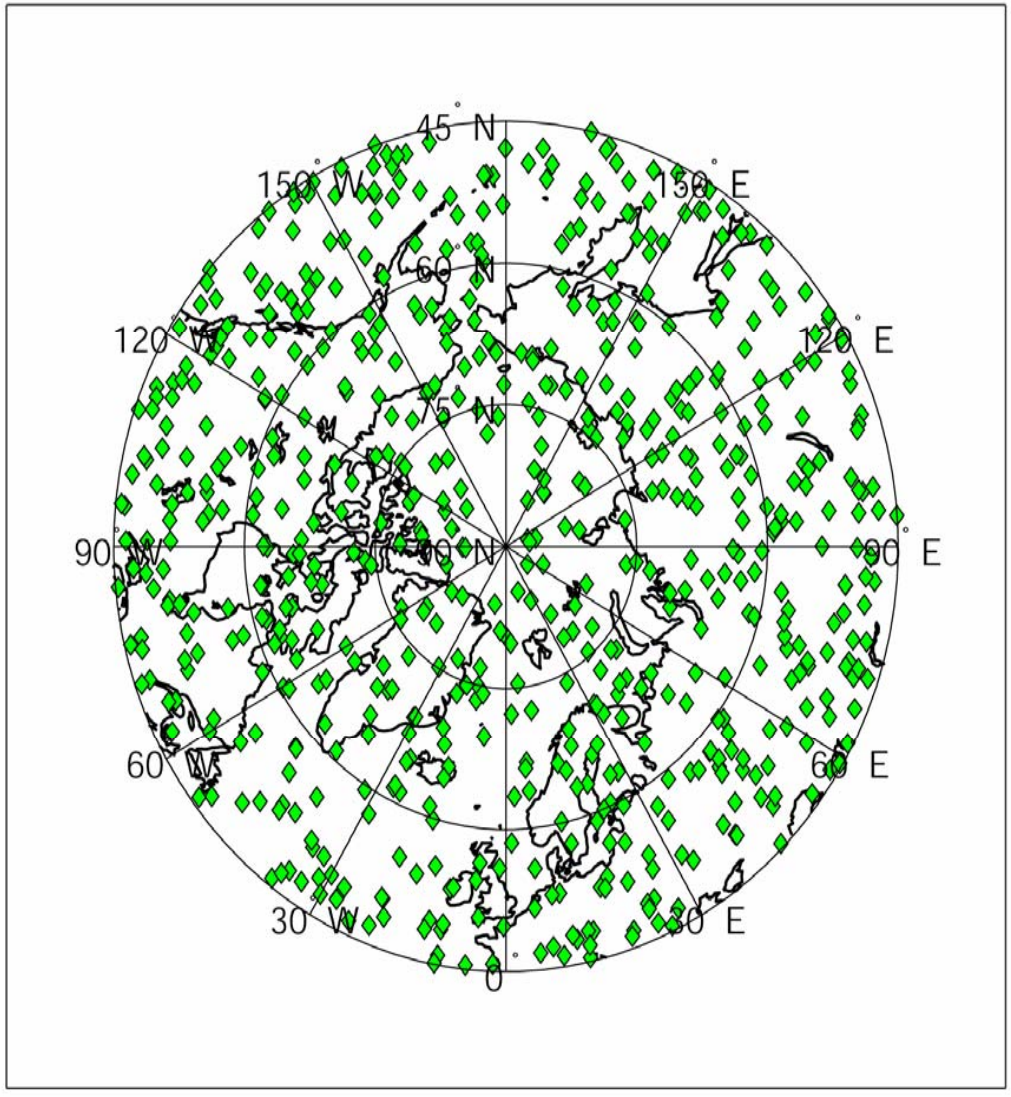


The storm of 19 October 2004 as depicted by the NCEP/NCAR global reanalysis. Contours represent isobars of sea level pressure at increments of 3 hPa. [from visualization package of NOAA Climate Diagnostics Center]

The Figure shows an intense storm depicted in the NCEP/NCAR reanalysis for 19 October 2004. This storm, which led to flooding of downtown Nome, Alaska, has a central pressure of 949 hPa in the reanalysis. The actual central pressure deduced by the National Weather Service was as low as 941 hPa.

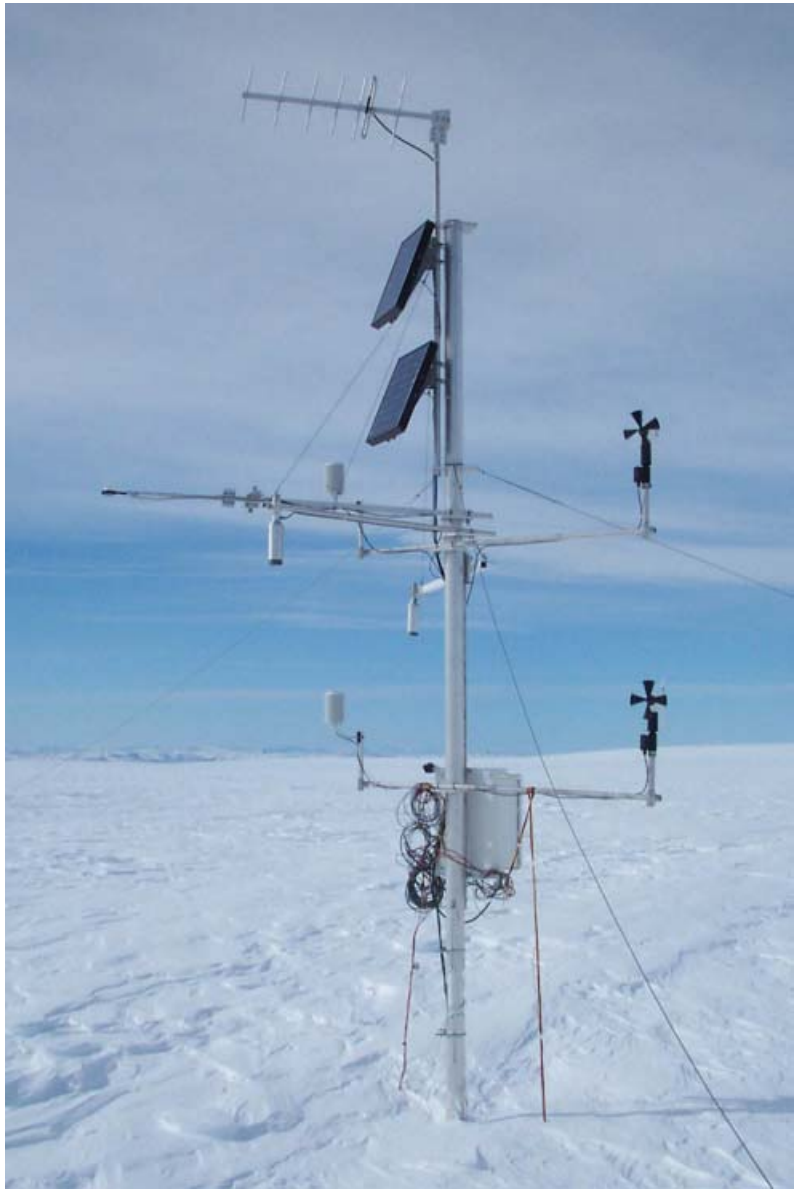
3 Critical Components for an Integrated Arctic Observing System

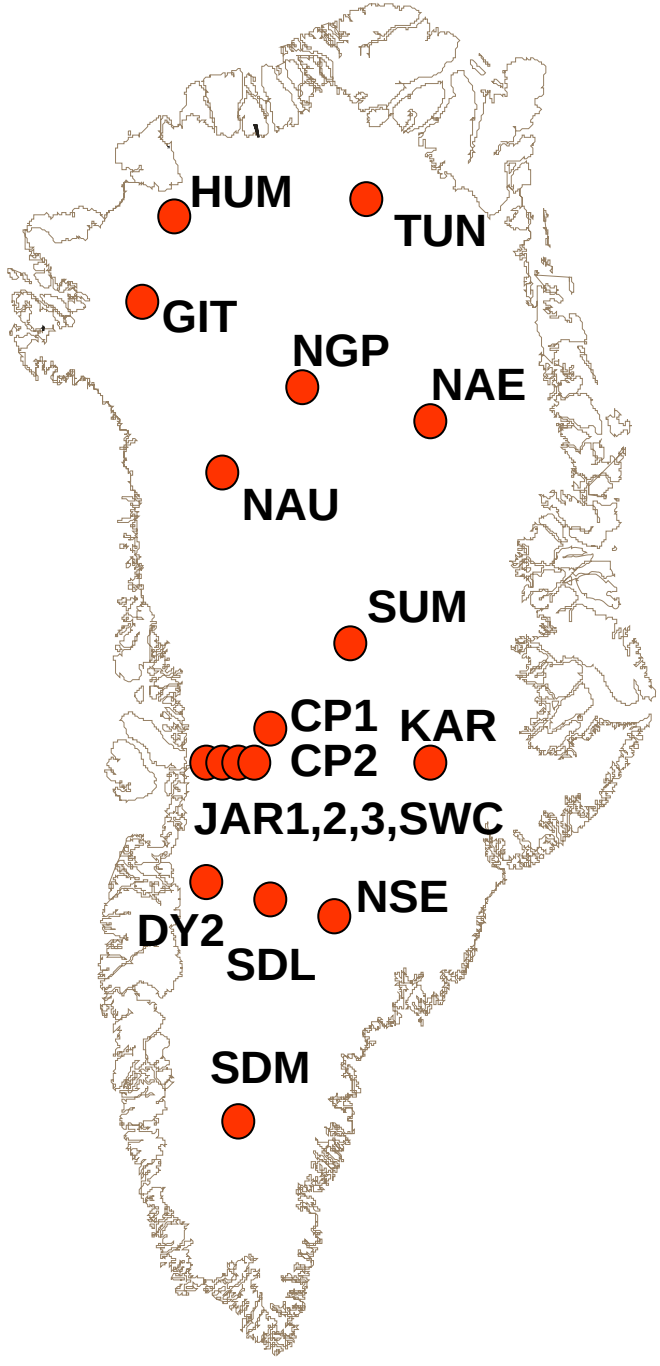
- Remote Sensing Observations
  - only way to obtain comprehensive regional coverage
- Numerical Modeling
  - Fills gaps in the system
  - Maintains physical consistency in the system
- In-situ Observations
  - Provides the ground truth to calibrate the system



Typical distribution of COSMIC GPS radio occultation soundings (green dots) over a 24-hour period over the Arctic.

Greenland Climate Network (GC-Net)





Steffen and Box (2001), JGR

Arctic System Reanalysis (ASR)
an NSF-Funded IPY Project

1. Rapid climate change appears to be happening in the Arctic. A more comprehensive picture of the coupled atmosphere/land surface/ ocean interactions is needed.

2. Global reanalyses encounter many problems at high latitudes. The ASR would use the best available description for Arctic processes and would enhance the existing database of Arctic observations. The ASR will be produced at improved temporal resolution and much higher spatial resolution.

3. The ASR would provide fields for which direct observation are sparse or problematic (precipitation, radiation, cloud, ...) at higher resolution than from existing reanalyses.

4. The system-oriented approach would provide a community focus including the atmosphere, land surface and sea ice communities.

5. The ASR would provide a convenient synthesis of Arctic field programs (SHEBA, LAII/ATLAS, ARM, ...)

ASR Outline

A physically-consistent integration of Arctic data
Including the enhanced observations of the Sustained Arctic Observing Network (SAON)

Participants:

Ohio State University - Byrd Polar Research Center (BPRC)
- and Ohio Supercomputer Center (OSC)
National Center Atmospheric Research (NCAR)
University of Colorado
University of Illinois

High resolution in space (<20 km) and time (3 hours)

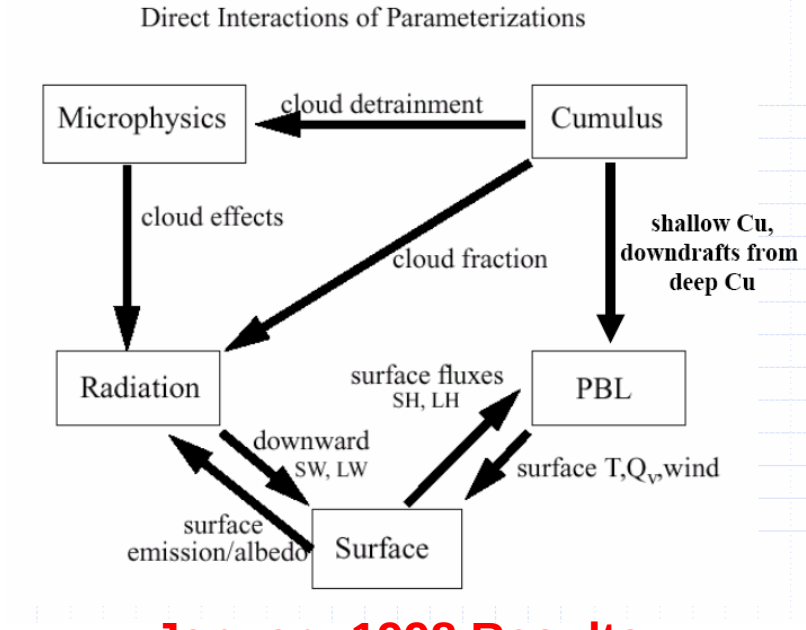
Begin with years 2000-2010 (EOS coverage)

ASR Numerical Model: Polar WRF

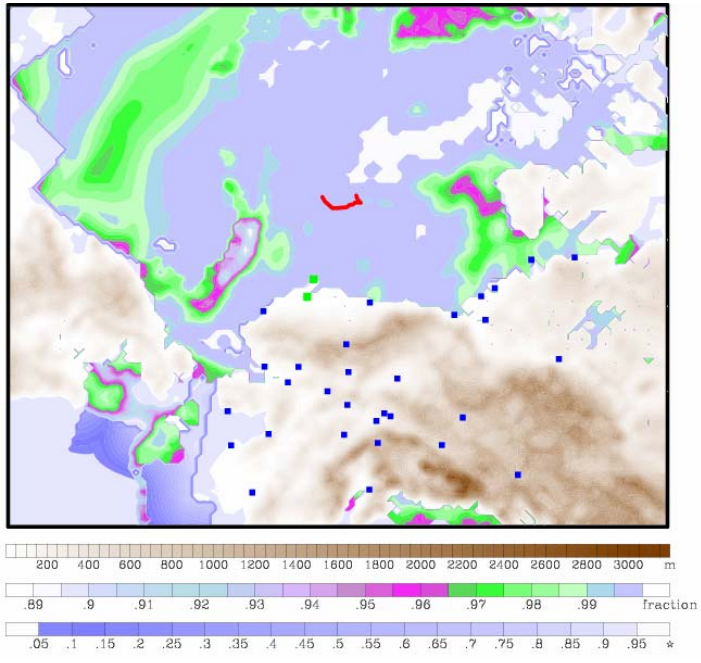
Weather Research and Forecasting Model

Polar Optimization:

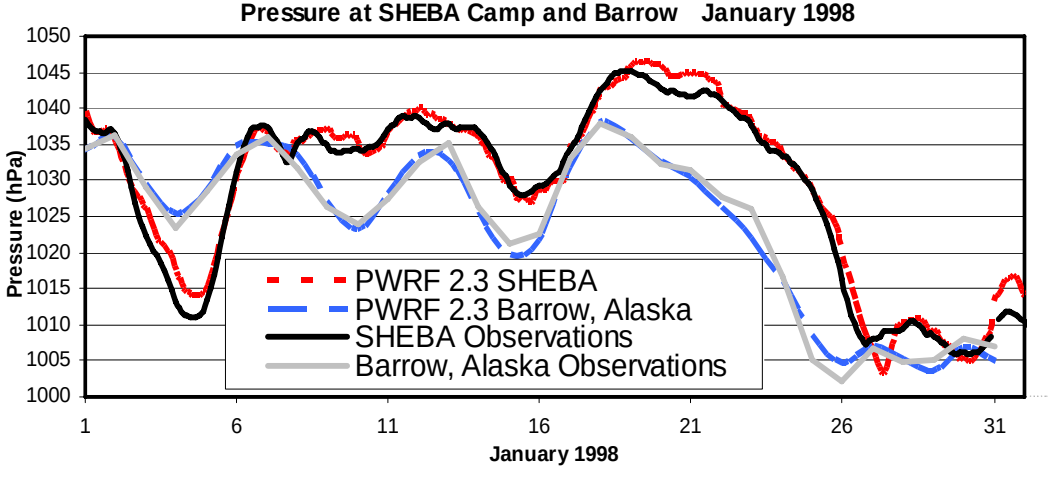
- Fractional sea ice
- Sea ice albedo
- Morrison microphysics (2-moment)
- Noah LSM modifications
- Heat transfer through snow and ice



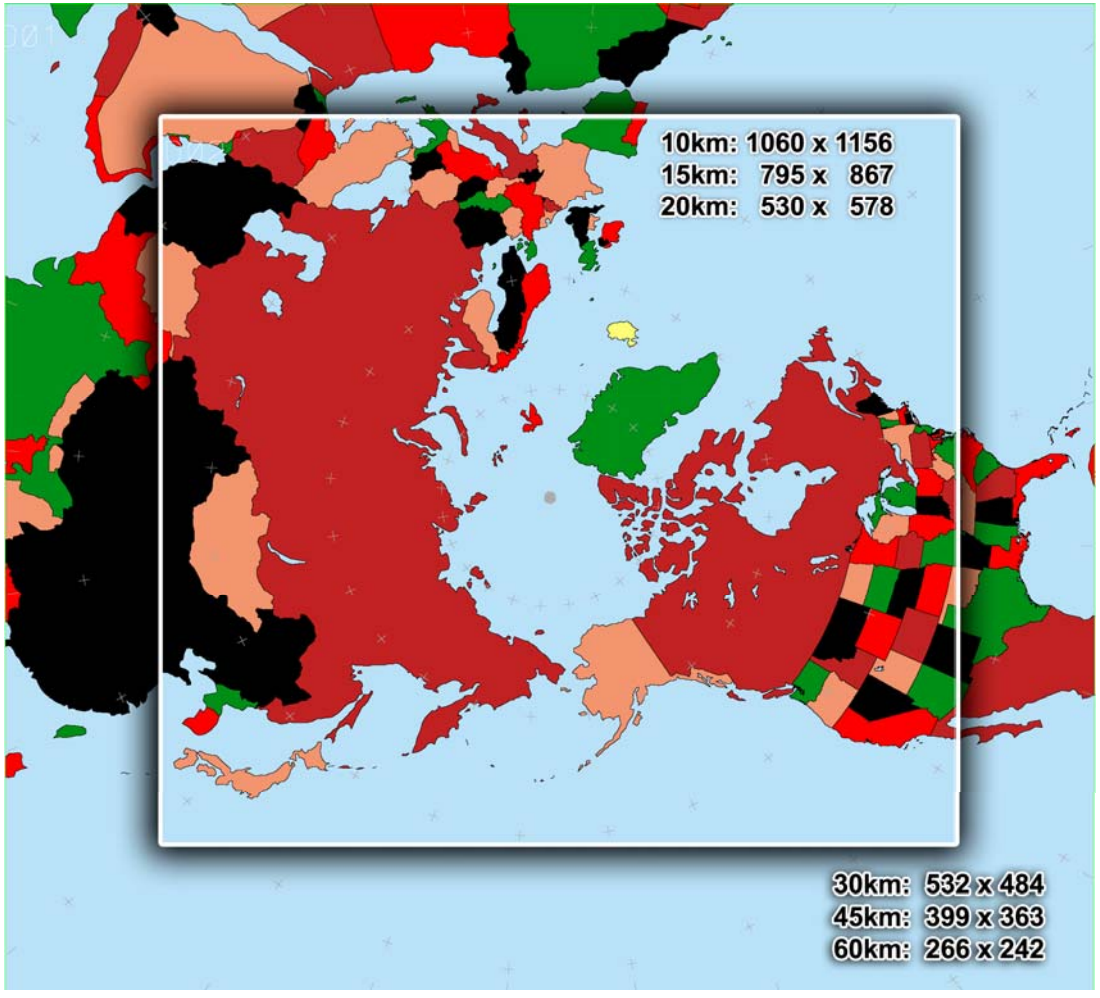
SHEBA 1997/8 Grid



January 1998 Results



ASR High Resolution Domain



Outer Grid:
~45 km resolution

Inner Grid:
~15 km resolution

Vertical Grid:
~60 levels

Inner Grid includes Arctic river basins

Optimizing the Arctic Observing Network Using the ASR Framework

- Observing System Experiments (OSEs) are numerical model-based experiments to test the impact of existing observations. Sometimes called “data denial” experiments.

- Observing System Simulation Experiments (OSSEs) are numerical experiments that test impacts of future observing systems, e.g., new satellite sensors and AWS.

- Determine the observations needed to optimize the observing system.

Key Points for SAON

- New Data Sources
- Weather and Climate Applications
- Combining Remote Sensing, Modeling and In-situ Observations
- Data Assimilation
- Bringing Observations, Modeling and Data Users together
- Arctic System Reanalysis as a Synthesis
- Better Integrated Use of Resources
- User Friendly Data Handling