Search Element 6

Observations for SEARCH: Data Integration for Arctic Reanalysis and Change Detection

Progress, August – December 2003

Summary, Major accomplishments

Provided 39 new monthly precipitation stations for the ASR from data sets R6 and R7. While a small percentage of the current total of 13,647 stations in the "Grand Archive" (about 900 in any one year), location is everything, and most of the new stations are on the previously blank Russian coast.

Published Meteorological Data from the Russian Arctic, 1961-2000, http://nsidc.org/data/G02141.html with 51 stations.

Obtained data set R7 of daily precipitation from 66 Russian coastal stations from V. Radionov, AARI. These have been given to P. Groisman for eventual bias correction and inclusion in the NOAA NCDC GDCN database.

Completed preliminary assessment of precipitation data sets, including documenting overlap between data sets (more work will be done in the background). Work is summarized in this and the last progress report, as well as in the precipitation data spreadsheet, and on B. Raup's SEARCH pages.

Coordinated work that resulted in the conversion of NIC arctic sea ice charts from GIS to EASE-Grid format, for 1972-2003. Data are available on request.

Contributed to analysis of 2003 sea ice extent minimum, presented poster on the minimum at October SEARCH meeting.

Attended CLIMAR-II, made preliminary assessment of SST data possibilities for ASR and CCD (below).

Precipitation

Refer to the updated Precipitation Data Spreadsheet for details on the referenced data sets. High priority has been to add stations for the ASR effort led at CU by Mark Serreze. See also the "Discussion" on precipitation in the June-July 2003 progress report.

- Mapped stations from all data sets of interest to reanalysis (highlighted in yellow on precip spreadsheet), with exceptions of data sets E3 and E6 (have been unable to obtain these as yet)
- Created individual station list files and a merged station list file for the highlighted mapped data sets. These files include position, country, station number, station name, and year range, and were created to make it easier to quickly assess the overlap between data sources. These files are located at http://cires.colorado.edu/~braup/SEARCH/. (The merged, non-redundant combination of data from most highlighted data sets is being created under the ASR effort, termed the "Grand Archive".)
- Documented overlap between selected data sets, including station numbers and record years http://cires.colorado.edu/~braup/SEARCH/.
- Obtained data set R7 of daily precipitation from 65 Russian coastal stations from V. Radionov, AARI. These data required extensive reformatting, and were compared with a previous delivery of data that AARI had provided for the EWG Meteorological Atlas that had never been published due to errors in the data. The point by point comparison is available from http://cires.colorado.edu/~braup/SEARCH/. I've concluded that the new data delivery includes more data than an earlier (1999) delivery to NSIDC, and that the data have undergone additional quality control, notably in the way "trace", missing, and no precipitation" are encoded. However, there are five stations common to both R6 and R7, for which differences in monthly totals were noted. We are looking into these differences. Draft documentation for the data set has been prepared. Data are available in a standardized format from http://cires.colorado.edu/~braup/SEARCH/.
- The R7 data were provided to P. Groisman (see Contacts) who will eventually include in his adjusted data set, the "gold standard" for Russian precip measurement.
- Published (documented and put in on-line catalog) R6 [http://nsidc.org/data/G02141.html] These data from 51 stations include other meteorological parameters as well.
- R1 and C2 were removed from the NSIDC catalog, because they duplicate data available from NCDC. A note documenting why they were removed and referring users to NCDC is now in the catalog.

The following planned tasks were not carried out because they are properly tasks for the ASR team, although we can help with these if needed.

- Look into the effect of using data sets with differing adjustments (e.g. C1 and C3) or unadjusted with adjusted, data in reanalysis
- Look into the effect of inhomogeneities in reanalysis (e.g. inhomogeneities in R4, R5, R6 due to unadjusted wetting corrections)

Planned Tasks, Precipitation

- Complete publication of R7 (put on line in public NSIDC catalog) AFTER discrepancies in data from some stations with data from the same stations in GDCN, RIHMI, and in R6 archives are explained.
- Track down Russian stations missing from the Grand Archive. Am in correspondence with Vuglinsky concerning the possibility of additional stations beyond what was provided to Serreze and others for RIMS/CHAMP work.
- Publish R5 (Yang, 1999) and R4. These are already in the Grand Archive but we will make them publicly available.
- Continue to try to acquire E3 and E6.

Contacts:

Provided daily R7 to P. Groisman, NCDC, who needs daily (not monthly) precip data in order to apply corrections. In response to the question "is it possible to adjust these data for the change in gauge type?" he responded that corrections to about 15 of the stations were developed and published by Bogdanova et al. in Russian Meteorol. and Hydrol. The methodology is described in their paper in J. Hydrometeorol. (2002). "Eventually, when we accumulate synop data for the entire period of observations, we 'll apply this methodology to all arctic stations (currently our synop data are only up to 1984 and we delay the processing." (email of 10/21/03)

Received a description of Daqing Yang's project to use the NCDC Global Surface Summary of the Day v6 as the basis for unbiased precip estimates. His work will use the daily data to get correction factors for monthly data. Result will be monthly correction factor maps. Our interest in this work is that it should increase the number of stations for which bias adjusted monthly data are possible (since we have many data sets with stations for which monthly but not daily totals are available, and previously, it has been impossible to adjust these monthly totals.) Daqing confirms that it should be possible to keep the database up to date as time goes on.

Corresponding with A. Ohmura re: a Greenland data set mentioned on the APDA site with more stations than are currently in the Grand Archive.

Sea Surface Temperature

A quick first look at some SST issues follows. I'll need input from the Reanalysis and Change Detection teams on what, if anything, to pursue here.

SST and Reanalysis

ERA-40 uses UKMO's HadISST for pre 1981 and NOAA's 2DVAR, a precursor to Optimum Interpolation Sea Surface Temperature Analysis version 2 (OIv2, see below) for post 1981. This was done because the UKMO's SST analyses (GISST and later HadISST) were considered best in the early period, while the NOAA (Reynolds and others) analyses were considered best in the later, satellite era period. The NOAA and UKMO products had a major inconsistency in the treatment of SST in the marginal ice zone. This has been resolved in the latest versions of these analyses.

OIv1 was NOAA's weekly operational SST analysis for many years. In November 2001, the OI fields were recomputed for late 1981 onward. The new version is OI.v2

HadISST, OIv1, OIv2,and 2DVAR all use COADS in situ data as well as satellite (AVHRR) data.

OIv2 (Reynolds et al, Journal of Climate 2002) improves on OIv1 with a better satellite data bias correction and better treatment of SST in the MIZ.

The OIv2 bias correction is improved by a new OI algorithm that allows week to week persistence in the bias correction, which is important in data sparse areas. The bias correction is also improved by more and better in situ data. OIv1 used a preliminary version of COADS, and only up to 1990, after which GTS data were used. OIv2 uses the latest release of COADS through 1997 (and GTS data after.)

Oiv1 set SST = -1.8 for all areas of sea ice concentration less than 50%, leading to SSTs that were too cold in the MIZ. Oiv2 uses the HadISST equation for SST in sea ice, and, like HadISST,

uses bias corrected SSM/I ice concentrations as input (Rayner et al, JGR,2003). This led to significant improvements at high latitudes.

2DVAR was used for ERA40 (N. Rayner, Pers. Comm). 2DVAR includes the sea ice algorithms of OIv2 and an improved satellite bias correction, but requires less computer storage resources than does OIv2. Results are similar but OIv2 has slightly lower rms difference from truth (buoy SSTs) than does 2DVAR. Reynolds et al (2002) believe the 2DVAR error would be improved by a smaller correlation scale for the bias correction step, but this is possible only where in situ data support it, i.e. not in the Arctic.

The NOAA OIv2 seems the only available option for ASR without a significant amount of work. It might be improved by working on the satellite data bias that still remains, eg. by using AMSR data, or by processing AVHRR in delayed mode. (Reynolds et al look at Pathfinder AVHRR as an example of delayed mode processing, and find that while daytime biases are less, nighttime are greater). As ECMWF says, "Analysis of sea-surface temperature (SST) is a specialized activity", which is why they turn to NOAA and UKMO partners for these products.

More on NOAA OI analysis:
http://www.emc.ncep.noaa.gov/research/cmb/sst_analysis/

Some on ERA 40 data assimilation:
http://www.ecmwf.int/research/era/Project/Plan/Project_plan_2.html#pgfId-171349

BAMS paper on global SST analyses and implecations for reanalysis, somewhat dated but useful:
http://www.cgd.ucar.edu/cas/papers/bams99/index.html

HadISST and O1v2/2DVAR references:

Rayner, N.A., D.E. Parker, E.B. Horton, C.K. Folland, L.V. Alexander, D.P. Rowell, E.C. Kent, and A. Kaplan, Global analysis of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century, *Journal of Geophysical Research*, 108 (D14), doi:10.1029/2002JD002670, 2003.

Reynolds, R. W., N. A. Rayner, T. M. Smith, D. C. Stokes and W. Wang, 2002: An improved in situ and satellite SST analysis for climate. J. Climate, 15, 1609-1625.

SST Climatologies

PSC climatology

Polar science center Hydrographic Climatology (PHC) (A Global Ocean Hydrography with a High Quality Arctic Ocean W. Ermold and M. Steele, *Polar Science Center/Applied Physics Lab/University of Washington)* is probably best arctic SST climatology, and offers subsurface information as well.

See http://psc.apl.washington.edu/POLES/PHC2/Summary02.html

> Our Climatology provides temperature and salinity data at 1X1 degree intervals for all the earth's oceans, down to a depth of 5500m, at incremental depths identical to those provided in the National Oceanographic Data Center's (NODC) World Ocean Atlas (WOA). This global climatology is the combination of NODC's 1998 world climatology (WOA), the EWG Arctic Ocean Atlas (AOA), and select Canadian data provided by the Bedford Institute of Oceanography (BIO). While the NODC data includes the Arctic Ocean, the AOA data provides a better description of this region. Neither of these data

fields provides a good representation of the Canadian Archipelago region and nearby bays in the winter months. The data from the Bedford Institute of Oceanography allowed us to bridge this data hole. These three data sets were merged using an optimal interpolation routine such that our PHC retains the high quality world description provided by the WOA while improving the Arctic with the AOA fields and Canadian data.

In summary, PHC = WOA (Levitus) '98 everywhere except in our arctic domain, where we have blended in the AOA field (from EWG), and the BIO data to produce a better arctic.

Also of interest may be a data set derived by Aagaard and collaborators based on an "enhanced version" of the Gore-Chernomyrdin EWG data base that was presented at the October 2003 SEARCH meeting and will be made available on-line. Includes data on halocline, Atlantic layer, etc.

CPC climatology:

There is a climatology based on OI.v2 Reanalysis fields available on-line. It was developed at the Climate Prediction Center using the method of Reynolds and Smith (1995) and Smith and Reynolds (1998). This climatology is described in:
http://www.cpc.noaa.gov/products/predictions/30day/SSTs/sst_clim.html

See notes from CLIMAR II for more on SST observations and climatologies.

SST and Change Detection

Per Reynolds et al., there are globally averaged differences of 0.05 deg C over decadel scales in SST analyses, "not negligible" for monitoring and change detection purposes. Should we look for better regional analyses, or do our own?

Other

Other contacts

Discussions with Yanling Yu, Harry Stern and Hanna Magda (NIC) lead to the conversion at NSIDC of arctic-wide NIC charts in e00 format to EASE-Grid format to enable Yu and Stern to complete work on changes in arctic fast ice area. There are now EASE-Grid versions of NIC charts from 1972-2003 available by request from NSIDC. These will eventually be published on-line.

Talked with R. Colony about historical data that might be suitable for "rescue" or broader publication. These included:

- AIDJEX meteorological data, 1970, 1972, 1975-1976. *In custody of Roger Anderson, APL.* 1975-1976 data are on EWG met atlas.

- RAMS (Random Access Measurements), *pre IABP, pre-Argos buoys. 1975-1978. Not in any one place. Could start with Roger Anderson at APL for US. Also Canadian (used by oil companies) and Norwegian (try T. Vinje).*

- Canadian data from Beaufort Sea drilling platforms. *Program in 70's for weather forecasting. Ask Canadian Climate Center, or Ed Hudson.*

- FRAM-CEAREX data. *ONR sponsored ice camps, 6-8 weeks in duration, ask Jamie Morison or Carl Wales.* NSIDC CEAREX CD has CEAREX from 9/88-5/89, as well as EUBEX and MIZEX data.

- Canadian programs LOREX, CEASAR (1977-1978?). *Drift stations of 6-8 mo duration. Contact Canadian Outer Continental Shelf program.*

- Meteorological data from Sedov? *Roger has oceanographic data.*

- Met data from US Coast Guard operations in Beaufort. *North Wind cruises in 1965 or 1967. also East Siberian Sea. Contact Lou Codespodi (sp?) in Maryland ocean research center.*

- Met data from US Navy ice stations at Pole Springs camps for mid 1970s through mid 1990s *US Naval Oceanographic Office. Carl Wales would know possibly.*

- Snow data from US Navy ice stations at NP *Contact Terry Tucker*

Second JCOMM Workshop on Advances in Marine Climatology (CLIMAR-II), Brussels, 19 – 21 November 2003.

Some notes that may be of interest to ASR and Change Detection teams follow:

While the Arctic was rarely mentioned, this workshop featured talks on methods of dealing with sparse data, and overviews of data collections, that made it worth attending.

Data bases of ship data are being compiled with records beginning as early as 1750. Most of the interesting and valuable marine data are getting into COADS [http://www.cdc.noaa.gov/coads/], though there is a significant time lag with some of it. Much progress has been made in quantifying uncertainty in I-COADS, and estimating measurement and sampling error, especially in the work from Hadley Center and Southhampton. The problem of how to use these data for climate change detection remains. Uneven sampling (ship tracks in all COADS data) affects derivation of trends, and statistics at COADS cell level. This problem is compounded if the desire is to make gridded fields, and compounded further still in the Arctic. For example S. Gulev presented work on sampling errors in ship observation based flux climatologies. He uses NWP products to get at errors due to spatial and temporal inhomogeniety in the data record. The sampling error is greater than observational error in all of Arctic and southern oceans. Morrissey showed a method for separating sampling error from true monthly variance in COADS data. Both references may be of use if we use gridded observational data for change detection.

None-the-less, some have made climatologies of COADS data, e.g. SWH. COADS includes a SST climatology. There is an on-line interface for COADS data from 1784-2002. Adaptive QC trims data with a fixed or varying climatology. NRT access to GTS data will be available through COADS in Sept 2004.

Regarding SST, major efforts are underway to secure and analyze the metadata needed for bias corrections before historical measurements can be used to construct climatologies (For example, there are significant and time varying differences between bucket and intake temperatures). D. Parker presented a new 150-year analyses of SST from I-COADS. Special bias corrections were applied to make the analysis useful for climate change detection. The error was about 1 degree in 1850, now it is less than 0.1 degree. Potential improvements include blending with unbiased

satellite SST for recent years, and "careful" use of reananlysis. Sparse though it is, it may be best of the long term SST climos for near the arctic.

The NODC Ocean Climate Laboratory has produced an objective analysis of SST and salinity based on the World Ocean Database 2001. The on-line version is updated monthly. A quarter degree grid resolves coastal features better than the product it's replacing. However, it has few Arctic data points.

Analysis of errors in another NOAA SST product based on optimal assimilation of AVHRR, ship, buoy, and sea ice edge data was presented by Reynolds, with an assessment of where additional buoys would be needed to drive down error. A goal of 0.8 deg error per 10 deg grid cell is exceeded by 2 buoys (or ship data) in the grid. All of Antarctica is a problem area, would require 150 buoys south of 20 south. The Arctic was not shown.

Ken Casey, NOAA NODC, compared SST climatologies with satellite data and in situ I-COADS obs. Climatologies were Reynolds and Smith ERSST v1 based on COADS; operational NESDIS 50 km (e.g. for coral reef hot spotting); NOAA/NASA AVHRR Pathfinder (v4) 9km; RSMAS/NODC AVHRR Pathfinder (v5) 4 km. Not yet evaluated were HADSST, JPL, WOD (the NODC collection). Pathfinder climos outperform the others, with the RSMAS/NODC Pathfinder, which will eventually cover 1981-present, the best.

Harris spoke on an effort at OAR to reprocess 20 years of AVHRR data. (Will include snow cover, NVDS, etc.)

Gentemenn spoke on AMSR –E and TRMM derived SSTs, free from Rmt Sensing Systems web site. Their algorithm relies on a radiative transfer model rather than in situ data for SST, resulting in much better Arctic coverage.

Regarding winds and waves, similar metadata issues as for temperature are being addressed in order to identify spurious trends. ERA 40 wind and wave data are the most easily accessible (there is a Global Wave Climatology Atlas), but we are warned of possible inhomogenitey when assimilation of TOVs radiances, SSM/I derived winds, and ERS-1 altimeter wave heights begins.

Regarding SLP, a new WMO group is working with real-time and historical sources "to promote the development of high quality analysis of SLP". Hadley Centre and the GHCN project are setting up an international monthly pressure data base (terrestrial). They may be able to get London and Paris SLP back to 17th century, impt because differences may give a fuller record of NAO. A talk by Compo showed that historical SLP allows " reanalysis before radiosonde era", and that surface pressure obs alone produce a good 6- hourly analysis even at 1895 densities (error of about 40 m, about equivalent to 3 day forecast error).

Additional informal meeting notes of mine are posted. A workshop proceedings is in preparation and will be published on CD-ROM in a month or so by the WMO Secretariat. An article will be published in April, and posted on the on the ICOADS web site:
Parker, D., E. Kent, S. Woodruff, D. Dehenauw, D.E. Harrison, T. Manabe, M. Meitus, V. Swail, and S. Worley, 2004: The Second JCOMM Workshop on Advances in Marine Climatology. WMO Bulletin (submitted).

SEARCH Open Science Meeting, Seattle WA. 27-30 October 2003

Presented poster recent sea ice extent minima.

Plans

Plans are subject to change based on ASR and Change Detection team input.

- Start assessment of frozen ground data sets.

- The Sea Ice Index [http://nsidc.org/data/seaice_index/] currently includes data from 1988-present. We plan to extend it back to the beginning of the satellite data record (1979). We will need to come up with an approach for making the data sets that cover the entire time span consistent.

- Based on the success of the sea ice index, we will develop a similar frozen ground and snow cover products.

- If time allows we will pursue the most promising leads on historical data from Roger Colony (see Contacts).

Hours spent:

80 hours September, B. Raup
80 hours October, B. Raup
80 hours December, B. Raup
Approximately 80 hours August – December, F. Fetterer, leveraged from other NOAA funding.