Arctic Surface Air Temperatures for the Past 100 Years

Analysis and Reconstruction of an Integrated Data Set

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Introduction

Accurate fields of Arctic surface air temperature (SAT) are needed for climate studies, but a robust gridded data set of SAT of sufficient length is not available over the entire Arctic. The ACIA (2004) report exhibits a "data void" over the Arctic Ocean (Fig. 1).

Over the Arctic Ocean, the SAT data sets with wide spatial coverage begin in 1979 with buoy observations (Fig. 2) and satellite-derived surface temperatures.

We plan to produce authoritative SAT data sets covering the Arctic Ocean from 1901 to present, which will be used to better understand Arctic climate change.

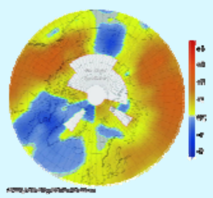

Figure 1. Trends in winter mean surface air temperature (SAT) over the Arctic from 1954–2003 (ACIA, 2004). Note the "data void" in SAT over the Arctic Ocean.

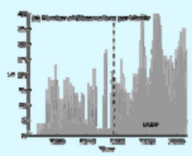

Figure 2. Number of observations over the Arctic Ocean. Note the increase in the number of in situ observations in 1979 with the advent of the International Arctic Buoy Programme (IABP).

Problem

However, there are discrepancies between the *in situ*, satellite-derived, and reanalysis data, e.g. the satellite estimates of trends show cooling over the Arctic during winter where the *in situ* estimates show warming (Fig. 3).

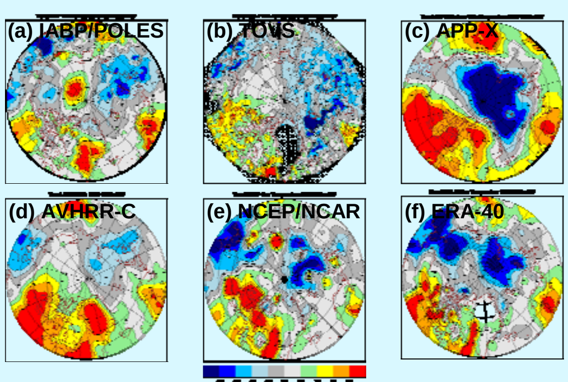

Figure 3. Trends in winter surface air temperature from 1982–1999 estimated from: analysis of *in situ* observations (a) IABP/POLES; satellite data: (b) TOVS; (c) APP-X; and (d) AVHRR-C; and reanalysis: (e) NCEP/NCAR; and (f) ERA-40. Note the large discrepancies between the trend estimates from the different data sets.

The Plan

- Reconcile the differences between the various SAT data sets obtained from *in situ* observations (Fig. 4), reanalysis, and satellites. These data will be filtered and bias-adjusted as appropriate.

- Produce an objectively analyzed, gridded field of SAT observations with error variances established through careful cross-validation, resulting in a "best estimate" field of SAT that minimizes the errors and biases in the original input data sets (e.g. Figs. 5 & 6).

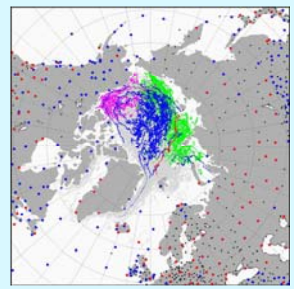

Figure 4. Map of *in situ* Arctic SAT observations. The dots over land show the locations of meteorological land stations. The colors indicate stations established prior to 1950 (blue), and "super stations" established by 1901 (red). Over the ocean the dots show the daily locations of IABP buoys (grey), Russian DARMS buoys (green), AIDJEX (magenta), the manned drifting stations (blue), and Nansen's ship Fram (red).

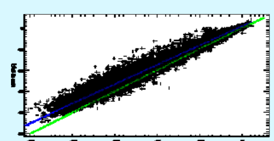

Figure 5. Comparison of daily averaged Surface Air Temperatures (SAT) from ERA-40 and North Pole (NP) Drifting Stations at corresponding gridpoints in ERA-40. Note that ERA-40 SATs are considerably warmer than NP observations across the temperature range. Differences are greatest for low (winter) temperatures. Blue line shows regression fit, green corresponds to 0 bias/gain=1.

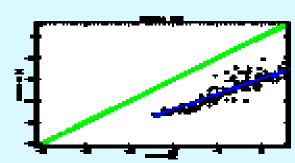

Figure 6. Comparison between the SAT observations from buoy 1301, which drifted between Ellesmere Island and Greenland, and the SAT estimates from ERA-40 at the coinciding locations. The SAT observations from the buoy appear to be consistently warm-biased indicating a possible calibration issue for this particular buoy, or ERA-40 may not be able to resolve subgrid-scale variations in SAT in the Canadian Archipelago.

- Produce a reconstructed gridded field of SAT from 1901 to present, using long-term records from "super-stations" and EOF reconstruction techniques (Fig. 7). We will conduct a careful error analysis on the reconstructed fields to provide error bars that vary in time and space to guide future climate analysis on this data set.

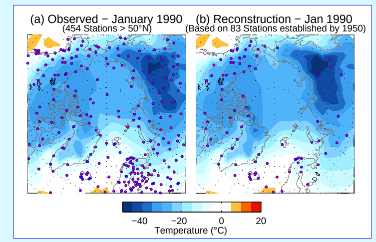

Figure 7. (a) Observed January 1990 SAT field from IABP/POLES analysis, and (b) reconstruction of this SAT field based on empirical orthogonal functions and land stations that were reporting in 1950. The red dots show the locations of the observations that we used in each analysis. These figures show how the observed SAT field can be reconstructed using EOF analysis and a limited number of observations.

Some Questions We Hope to Answer

- Are the increases in Arctic SAT the primary driver of decreases in sea ice extent (SIE)? If so, then why isn't there a comparable decrease in SIE during the 1930's (Fig. 8)?
- How does Arctic SAT vary on multi-decadal time scales? Are changes in Arctic SAT related to large-scale modes of variability (e.g. Arctic Oscillation) over the longer record?
- Do Global Climate Models correctly represent SAT variability over the Arctic Ocean?

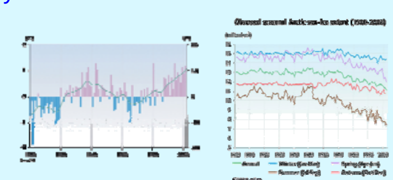

Figure 8. Annual average surface air temperature (SAT) anomalies relative to 1960–1990 based on land station data for the region 60°N – 90°N (left) and sea ice extent (right, ACIA 2004). Note that warmer SATs during 1920-1940 apparently had little effect on the ice extent during the same period.

Acknowledgements

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