Understanding Arctic Surface Temperature Differences in Reanalyses

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Introduction

Reanalyses in the Arctic are widely used for model evaluation and for understanding contemporary climate change. Nevertheless, differences among reanalyses in fundamental meteorological variables including surface air temperature are large. A review of surface temperature differences is presented with a particular focus on differences in contemporary reanalyses.

An important consideration is the significant differences in Arctic surfaces, including the central Arctic Ocean, the Greenland Ice Sheet, and non-glaciated land (Fig. 1).

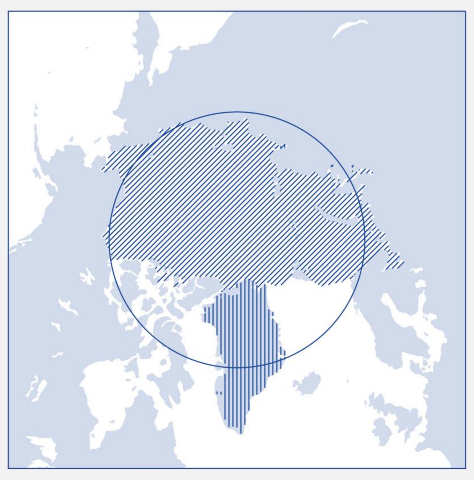


Figure 1. Different areas considered in the study. The central Arctic Ocean encompasses the region of perennial sea ice cover. The land mask for each reanalysis is used for averaging the regions on native grids.

While there is significant correlation among reanalyses in annual time series, there is substantial disagreement in mean values. For the period 1980-2013, the trend in annual temperature ranges from 0.3 to 0.7K per decade. Over the central Arctic Ocean, differences in mean values and trends are larger.

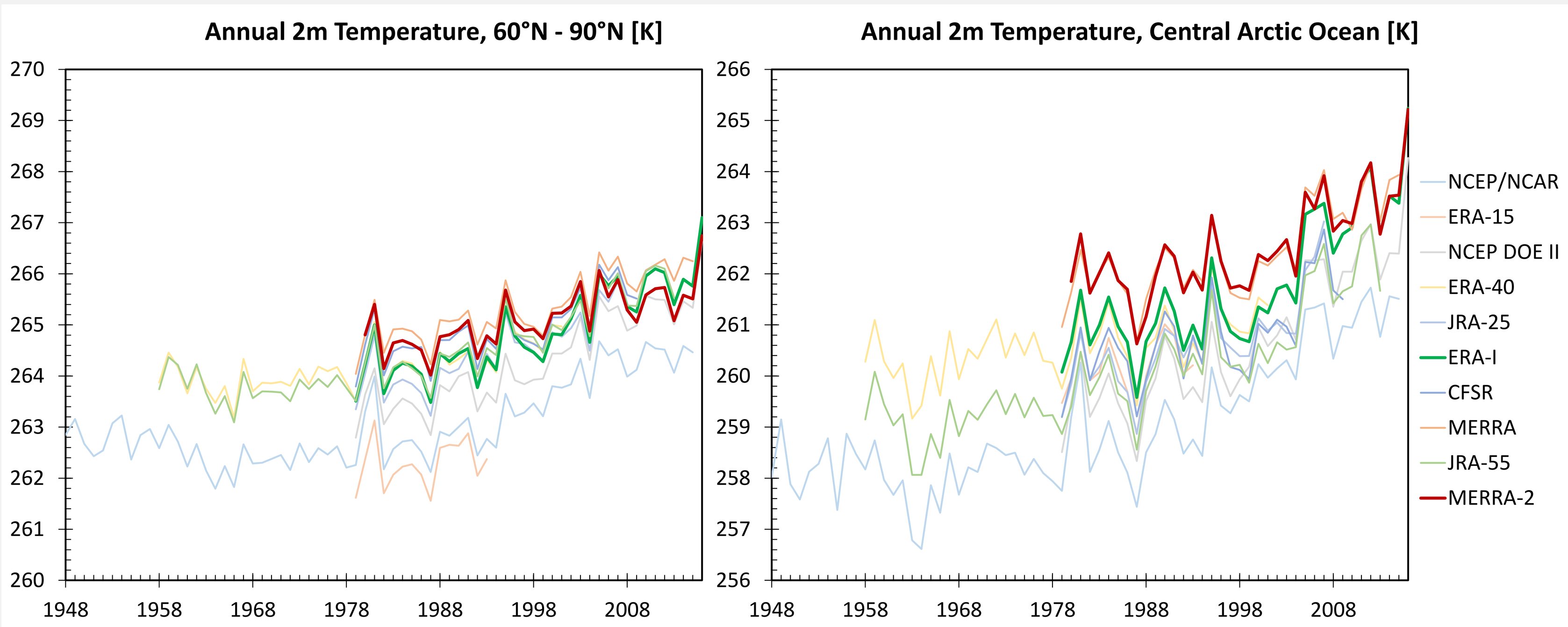


Figure 2. Time series of annual 2m air temperature (K) from nine global reanalyses averaged for (left) the north polar region (60°N–90°N) and (right) the central Arctic Ocean.

Most of the uncertainty is associated with winter months. This is likely associated with the constraint imposed by melting processes (i.e. 0°C), rather than seasonal changes to the observing system.

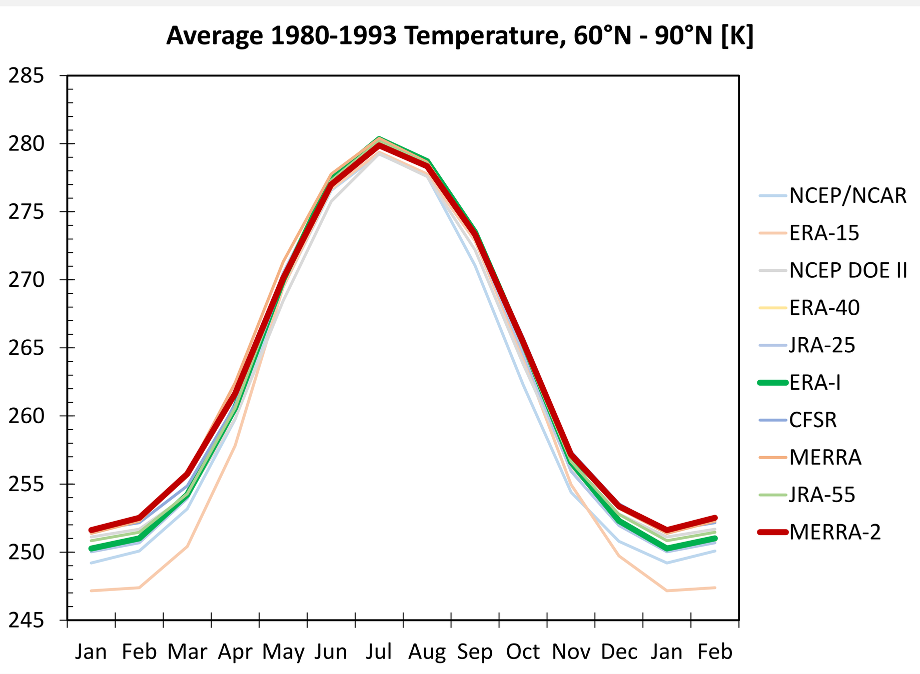


Figure 3. Average annual cycle for the north polar cap (60°N – 90°N) for common period 1980-1993.

Greenland Ice Sheet (GrIS)

Observed surface melting over the last decade lend importance to the use of reanalyses for the GrIS for understanding processes in the context of regional and hemispheric circulation changes. Averaged temperatures indicate considerable differences in both winter and summer. Deficient topography is significant in some reanalyses. In comparisons with Summit station, discrepancies in transitional seasons are suggestive of solar zenith angle dependency issues with surface albedo.

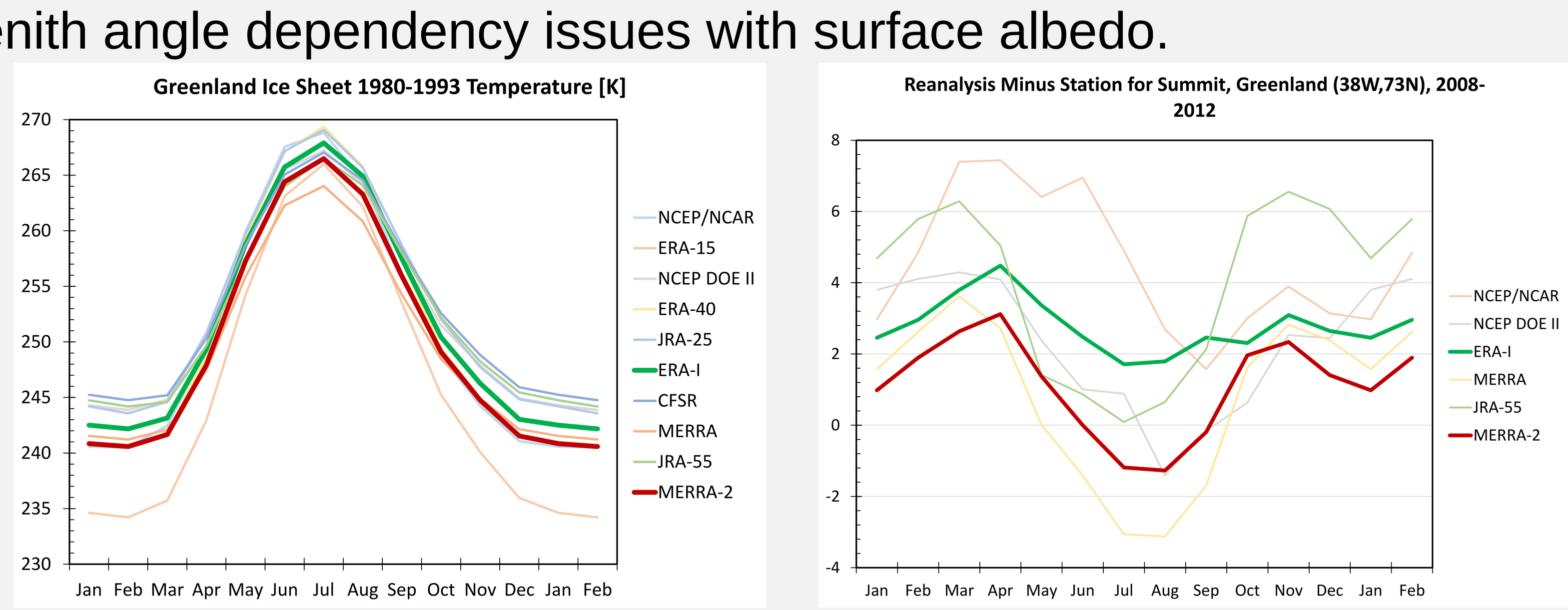
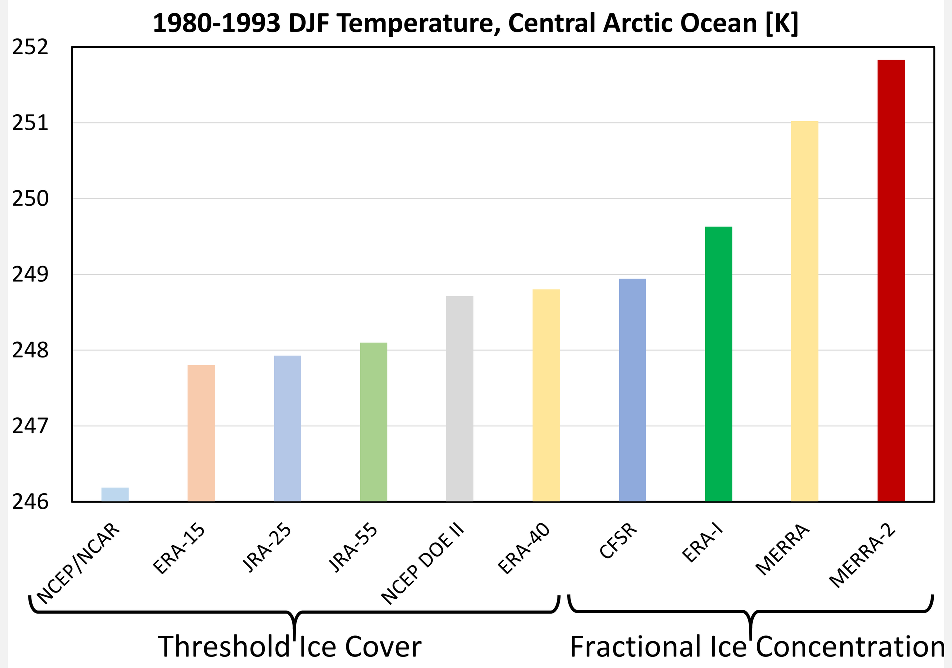


Figure 4. Average annual cycle for (left) 1980-1993 for the full GrIS, and (right) differences with Summit Station, 2008-2012.

Arctic Ocean

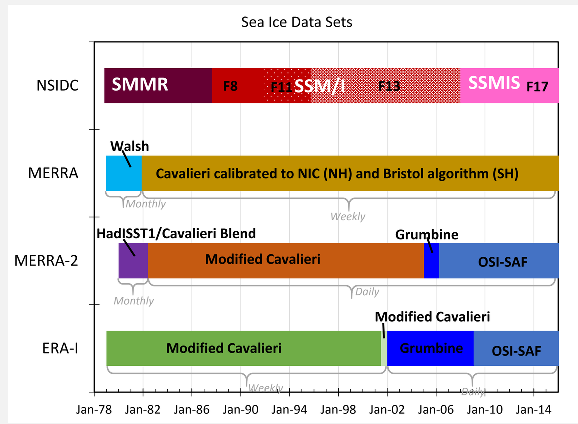
There are many sources of discrepancy for Arctic Ocean temperatures. But the sea ice representation is a good place to start looking. Many earlier reanalyses used a threshold (0 or 1) ice cover. These tend to be colder.

Figure 5. Average wintertime temperature for 1980-1993 overlapping period.



Among contemporary reanalyses, SST and sea ice are blended from multiple sources. Within the Reynolds daily data set used in MERRA-2, the transition from Cavalieri to Grumbine in 2005 appears to be a discontinuity. While ERA-I compares more closely to observations in the early period (e.g., with Russian NP stations), deficiencies in the sea ice data sets are also apparent.

Figure 6. Time series of sea ice data sets used in reanalyses.



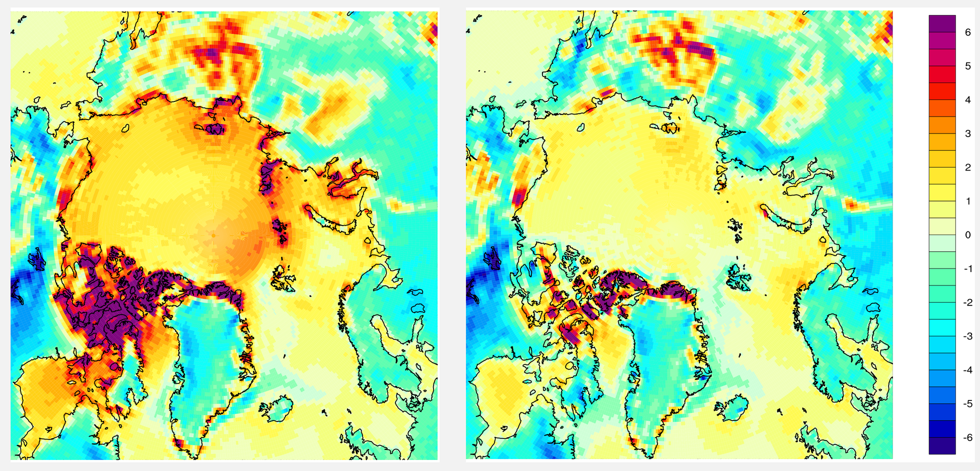


Figure 7. MERRA-2 Minus ERA-I temperature for DJF (left) 1980-2004, and (right) 2010-2016. In the latter period, both reanalyses used the same boundary data.

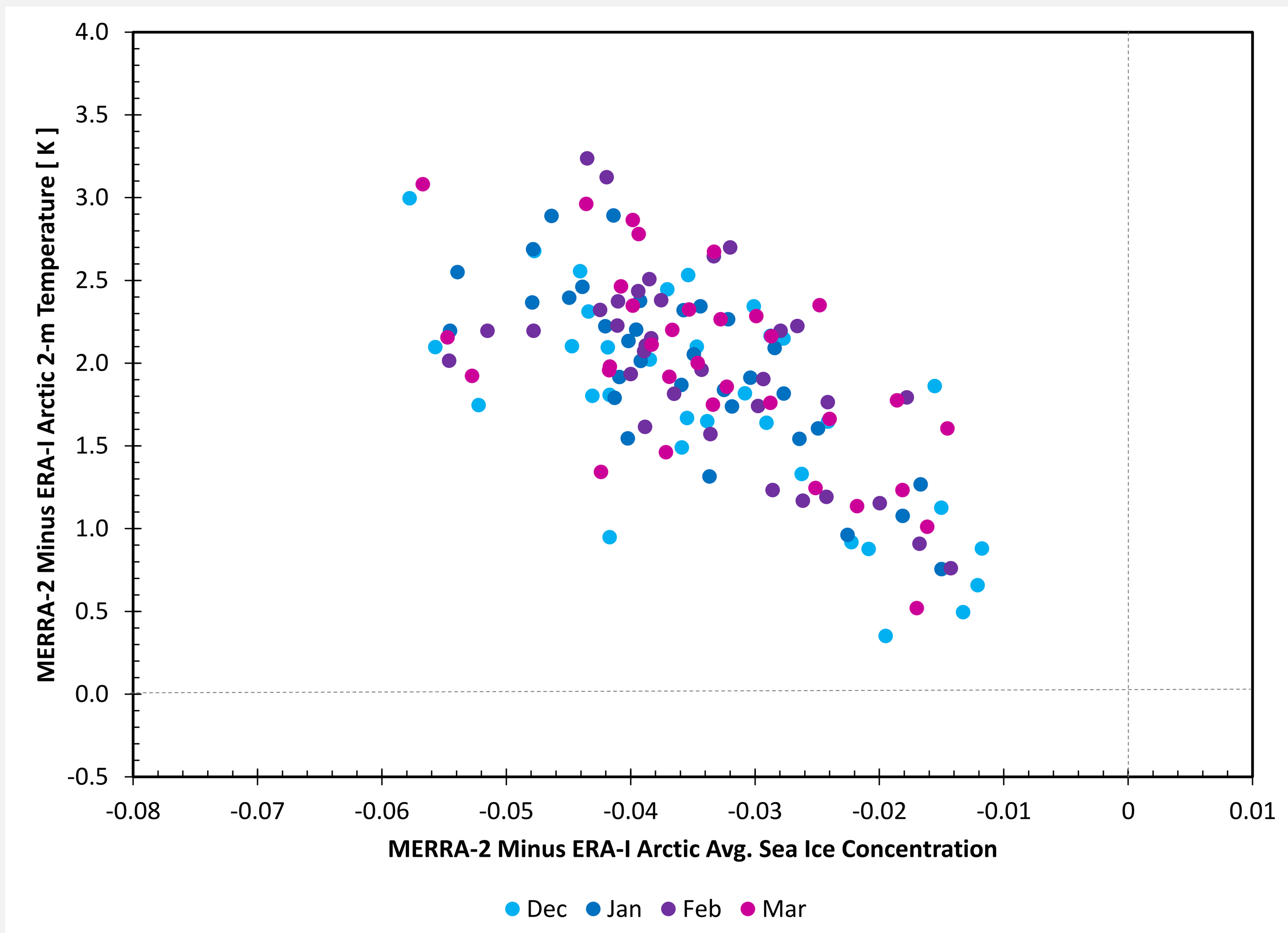


Figure 8. Scatter of MERRA-2 minus ERA-I temperature, versus MERRA-2 minus ERA-I sea ice concentration. Each point indicates an average over the central Arctic Ocean for an individual month.

Discussion

Differing treatments of Arctic cloud radiative processes likely influence temperature differences among reanalyses. Nevertheless, the treatment of ice sheet surfaces and sea ice in particular remain overly simplistic in reanalyses. The use and blending of sea ice data sets as boundary conditions leads to trouble. Current reanalyses do not account for spatial or interannual variability in sea ice albedo or sea ice thickness. These may both be significant factors in recent temperature trends.

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