Interpolating and Extrapolating Temperature Anomalies Across the Arctic

An Investigation using ERA-Interim and Meteorological Station Coverage between 1850 and 2011

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1. Introduction

Previously I have investigated the affect of using various techniques (Linear Interpolation, Not Interpolating, Global Ordinary Kriging and Global Simple Kriging) to estimate Arctic Surface Air Temperature (SAT) anomalies from sparse ERA-Interim data (1979-2011). I found that kriging techniques provided the most representative estimates of both trends and patterns in the anomalies and Arctic area-weighted timeseries of anomalies and that Global Simple Kriging was the most representative.

But which interpolation techniques are most representative of Arctic area-weighted SAT anomaly timeseries when using station coverages between 1850 and 2011?

2. Methodology

- Monthly Surface Air Temperature (SAT) anomalies were produced from ERA-Interim data (1979-2011) using a ten year climatology (1990-1999). These anomalies were used as a reference dataset of expected anomalies.
- The locations of all meteorological stations in the Arctic and surrounding areas (above 53°N) in the CRUTEM4 databank were identified[1]. Anomalies from the ERA grid cell nearest each station were used as station location timeseries.
- The station location timeseries for each year of ERA-Interim data (1979-2011) were masked according to whether each station reported a SAT in each month between 1850 and 2011 .
- The techniques were then applied to the masked station location timeseries to create ensemble dataset of SAT anomalies for each technique.
- I investigated how well each ensemble member (1979-2011) is estimated by each technique from each year's station coverage (1850-2011) by comparing the estimated area-weighted anomalies to the area-weighted reference anomalies.

3. Techniques

Linear Interpolation (LI): The temperature anomaly at each ERA-Interim grid cell over land and sea ice (>15% ice cover) is a linearly weighted average of the station location anomalies within 1200 km. This follows the method employed by the GISTEMP temperature anomaly dataset[2].

Global Ordinary Kriging (GOK): Kriging techniques are geostatistical techniques for interpolating variables. I have used Ordinary Kriging (assumes the variable has a constant but unknown mean) which uses a global variogram (used for all grid cells) for all months and years.

Global Simple Kriging (GSK): Simple Kriging is Ordinary Kriging which assumes a constant mean. Here I use the same variograms and equations as for GOK but assume a mean of 0. This is the mean assumed in the Berkeley Earth Surface Temperature dataset which also uses a method of Simple Kriging[3].

4. Uncertainties

The spread of the ensemble member errors shows the uncertainty in estimating different Arctic SAT anomaly patterns using each station coverage.

- For all techniques and anomalies the uncertainty is greatest before ~1880 and then decreases until ~1930 when the uncertainty reaches its lowest values and remains relatively constant (e.g. Fig. 1).
- **Before 1930** the standard deviations (σs) for kriging technique ensemble members are smaller in 80% (annual), 91.25% (winter) , 83.75% (spring), 77.5% (summer), 66.5% (autumn) of coverage years respectively (Fig. 2).
- **After 1930** the σs for LI ensemble members are smaller for 100%, 43.34%, 96.34%, 100% and 97.56% of coverage years respectively (Fig. 2).
- **On average** the LI σs are smaller for annual and autumn anomalies between 1850 and 2011.

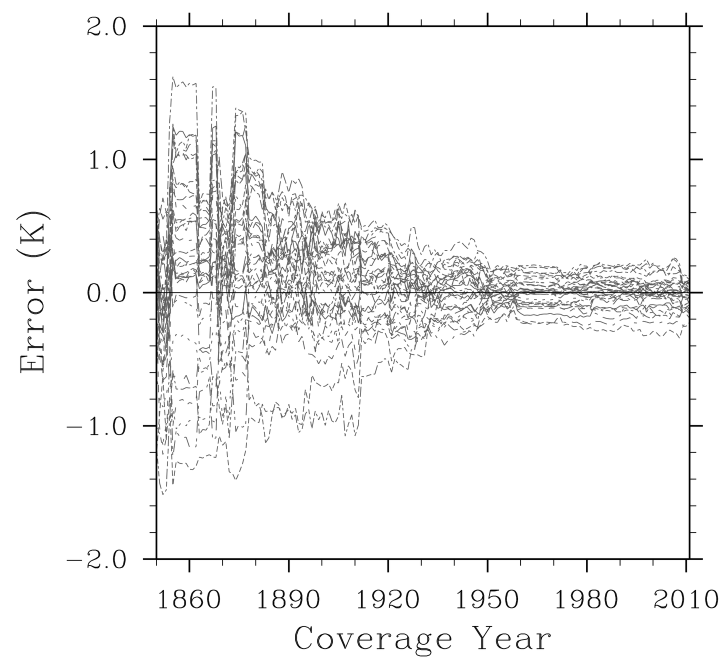

Fig. 1: The error in annual Arctic SAT anomalies produced by Linearly Interpolating each ensemble member (each year shown by one line) using each coverage year.

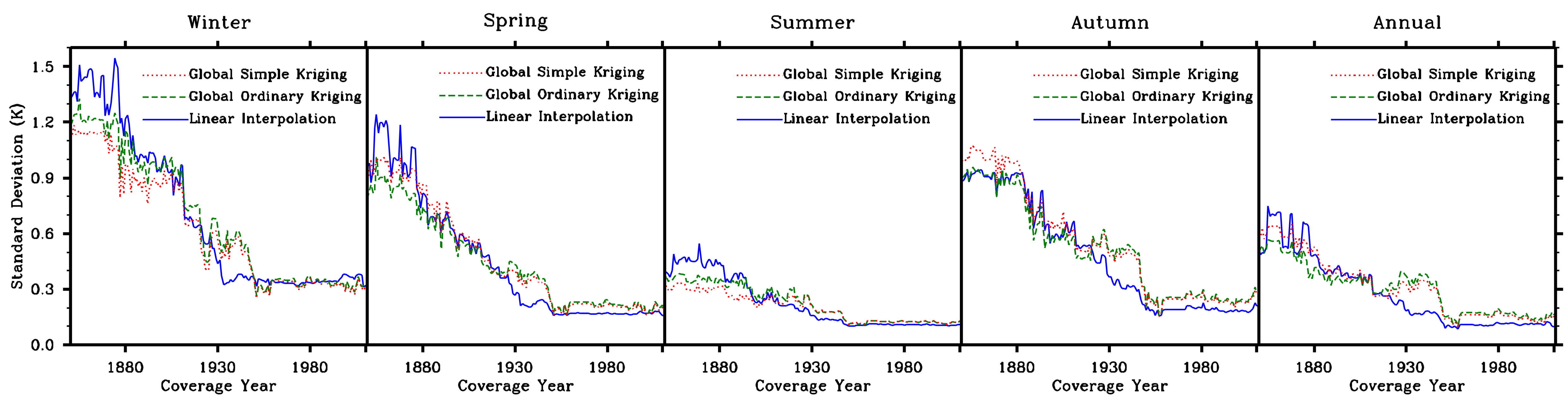

Fig. 2: The standard deviation of ensemble member errors for each coverage year for seasonal and annual Arctic SAT anomalies produced using Linear Interpolation, Global Ordinary Kriging and Global Simple Kriging.

5. Average Errors

- **The average errors show the same trends and patterns as the uncertainties.**
- Mean Absolute Errors (MAEs) are larger in for earlier coverage years before decreasing in size.
- Before 1930 the MAE for kriging technique ensemble members are smaller for the majority of coverage years whereas after 1930 the MAE for LI ensemble members are smaller for the majority of coverage years(Fig. 3). On average LI MAEs are smaller for annual and autumn anomalies.

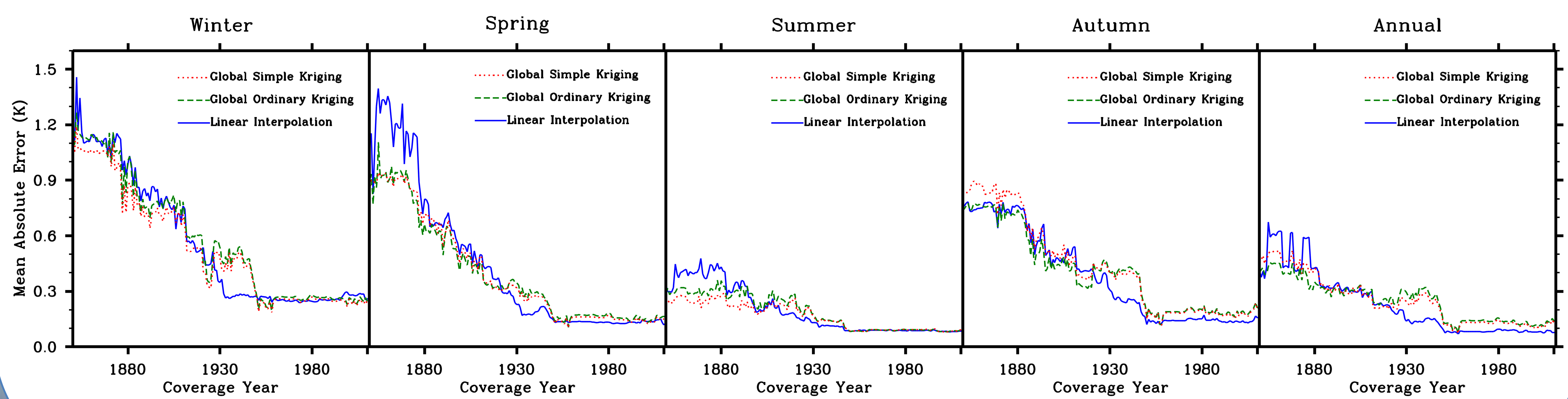

Fig. 3: The Mean Absolute Error for ensemble members for each coverage year (1850-2011) for seasonal and annual Arctic SAT anomalies produced using Linear Interpolation, Global Ordinary Kriging and Global Simple Kriging.

Summary

Kriging techniques estimate anomaly patterns with a smaller uncertainty and smaller average errors before 1930. GSK is often better than GOK. After 1930 LI is on average more likely to estimate anomalies with smaller errors than GOK or GSK.

Contact

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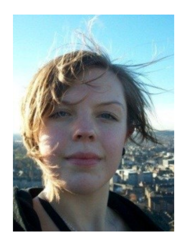

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2. 4. P.D Jones, D.H Lister, T. J. Osborn, C. Harpham, M. Salmo, and C.P. Morice. Hemispheric and large-scale land-surface air temperature variations: An extensive revision and update to 2010. *Journal of Geophysical Research-Atmospheres,* 117:29,2012.
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