An Investigation into the Impact of using Various Techniques to Estimate Arctic Surface Air Temperature Anomalies

Emma Dodd

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NERC SCIENCE OF THE ENVIRONMENT

University of Reading

Introduction

- Temperature changes are predicted to be more rapid in the Arctic compared to lower latitudes.
- Temperature changes are often estimated using time series of Surface Air Temperature (SAT) anomalies.

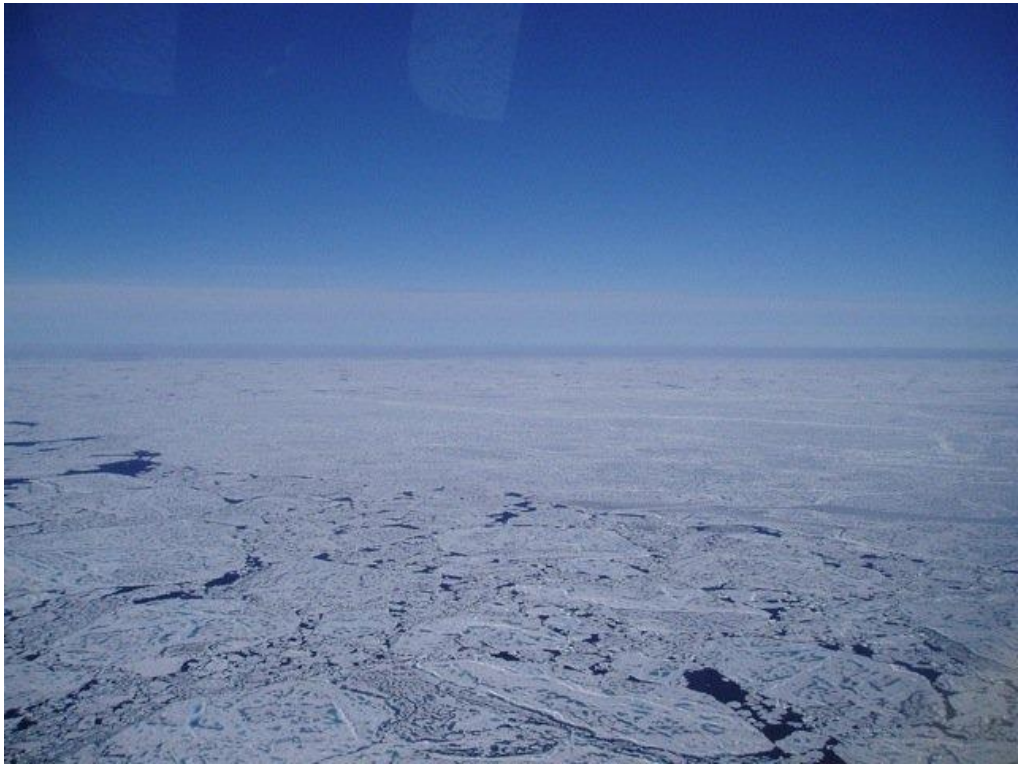
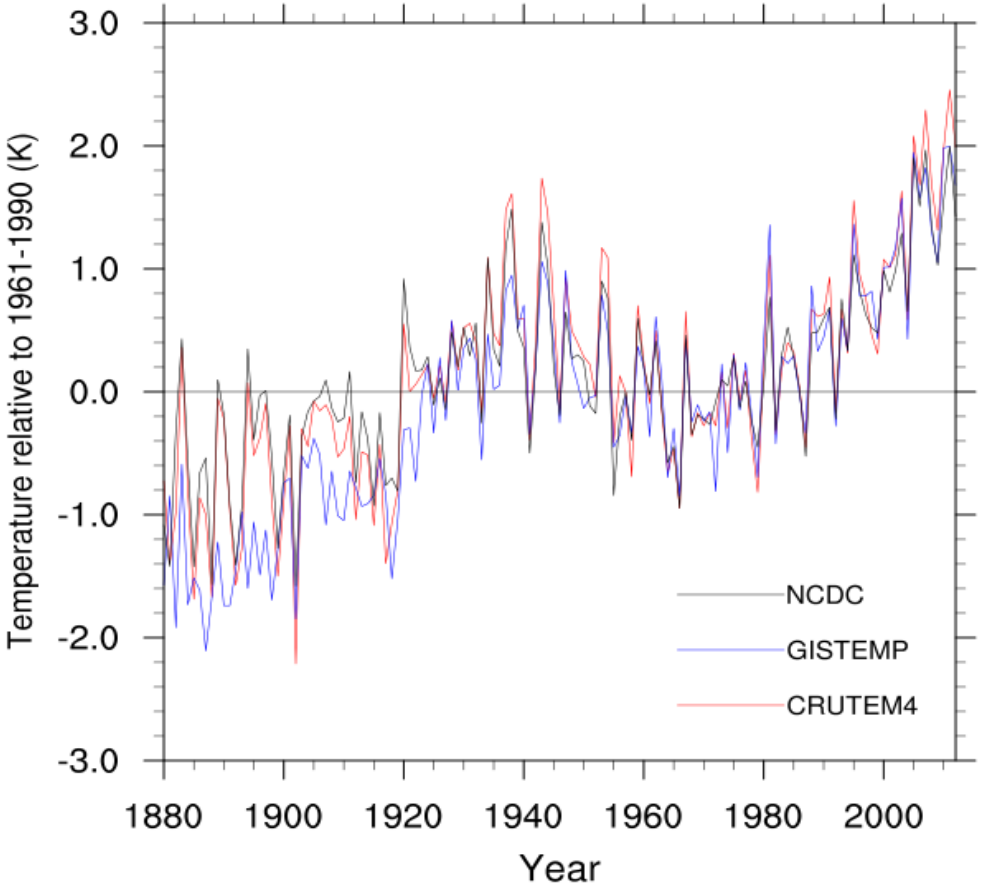


Photo of sea ice near Svalbard. From a NERC ARSF flight in summer 2003.

Introduction

- There are many different techniques that can be used to quantify SAT changes over the Arctic from sparse in situ measurements;
  - NCDC: interpolates where data is determined to be sufficient.
  - GISTEMP: linearly interpolates and extrapolates up to 1200 km away.
  - CRUTEM4: uses available in situ temperature measurements exclusively.



The annual Arctic SAT anomaly (K) over land relative to 1961-1990 for several temperature anomaly datasets.

How effectively do these techniques reconstruct Arctic SATs and Arctic SAT change?

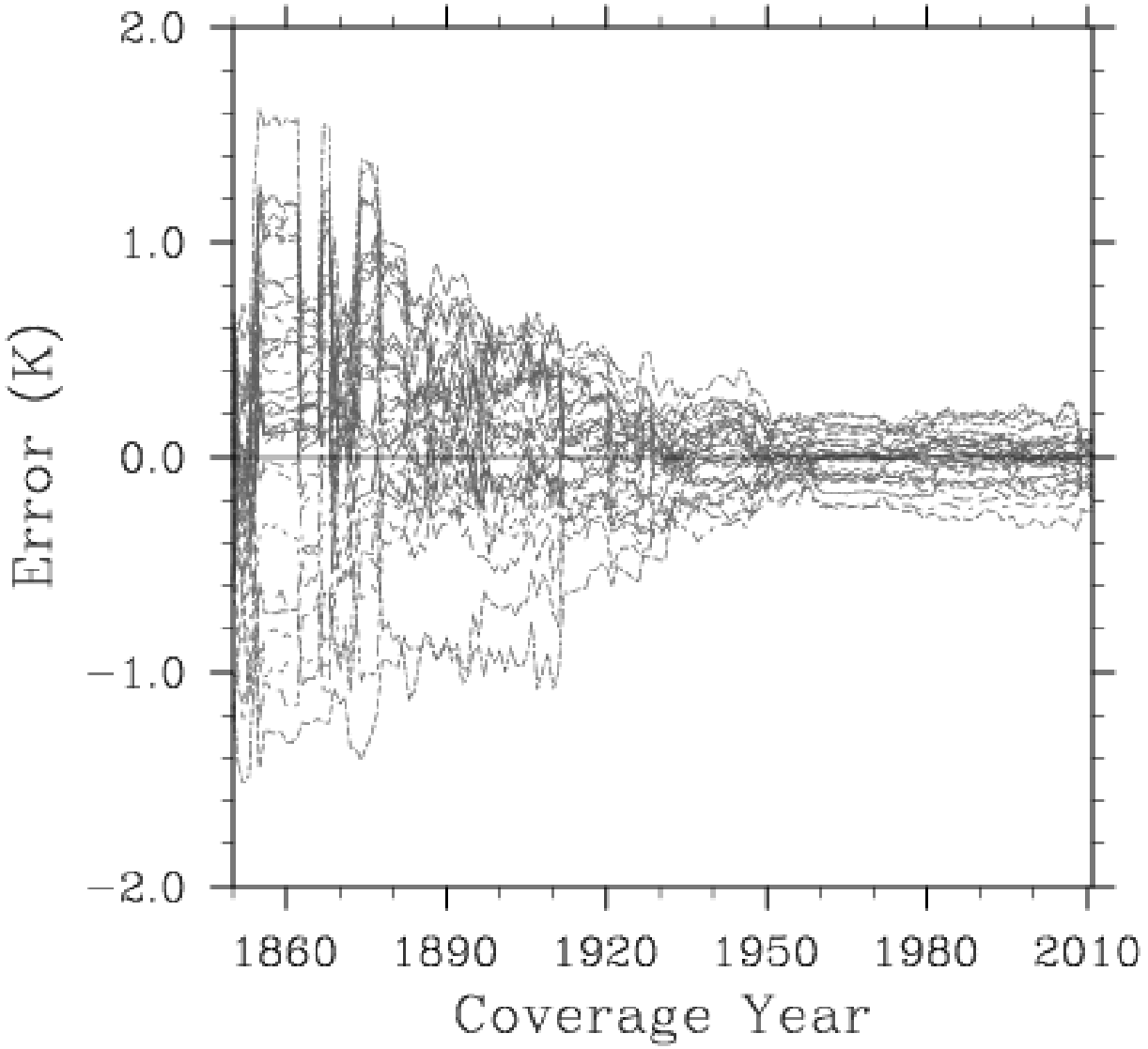
Aim:

- Investigate the degree of difference arising from using five different techniques to estimate Arctic SAT anomalies over land and sea ice using ERA-Interim reanalysis data as a testbed.

Two Investigations:

1) **Recent Decades:** The performance of the techniques between 1979 and 2011.

2) **Historical Coverage:** The effect of changing station coverage was simulated by creating an ensemble dataset of input anomalies between 1850 and 2011 using ERA-Interim data.



The error in annual Arctic anomalies estimated by Linearly Interpolating each year of ERA-Interim anomalies (1979-2011, each year is shown by one line) using historical station coverages (1850-2011).

Data and Techniques

Interpolating Techniques:

1. **Linear Interpolation** (based on the GISTEMP dataset method).
2. **Global Simple Kriging** (**GSK;** based on the Berkeley Earth dataset method).
3. **Global Ordinary Kriging** (**GOK;** similar to technique 2.).

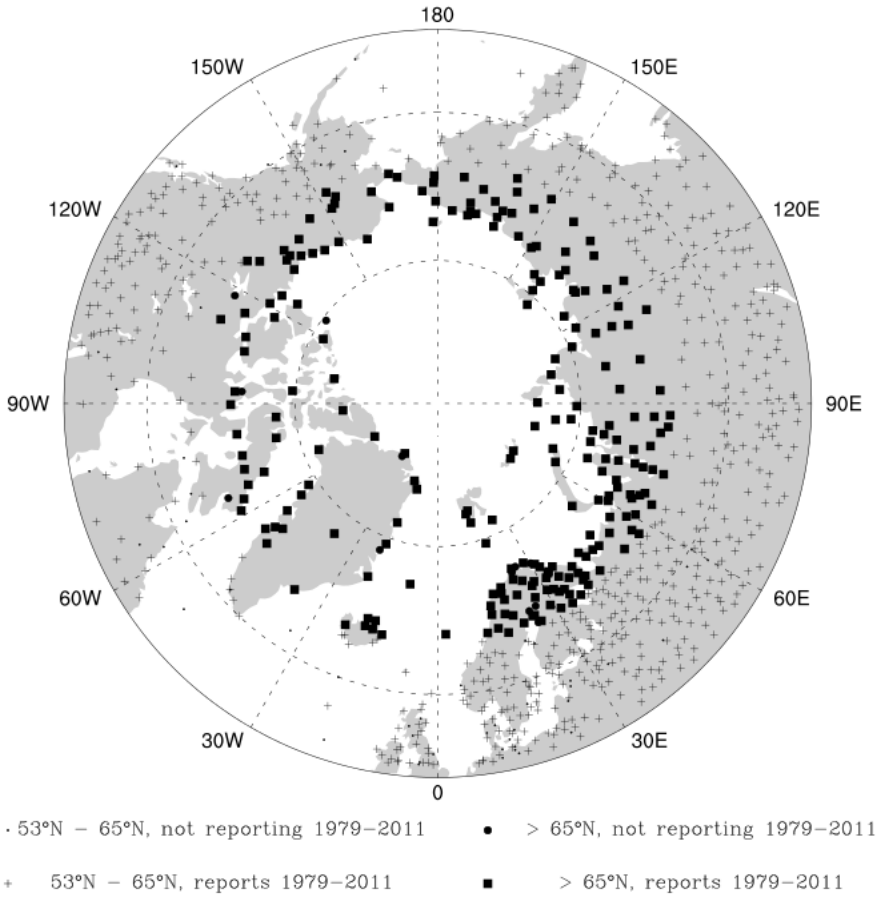
Non-Interpolating Techniques:

4. **Not Interpolating and Regridding** (based on the CRUTEM4 dataset method).
5. **Not Interpolating** (similar to technique 4. but not regridded).

Data and Techniques

- The techniques were applied to monthly SAT anomalies from ERA-Interim sampled at Arctic meteorological station locations.

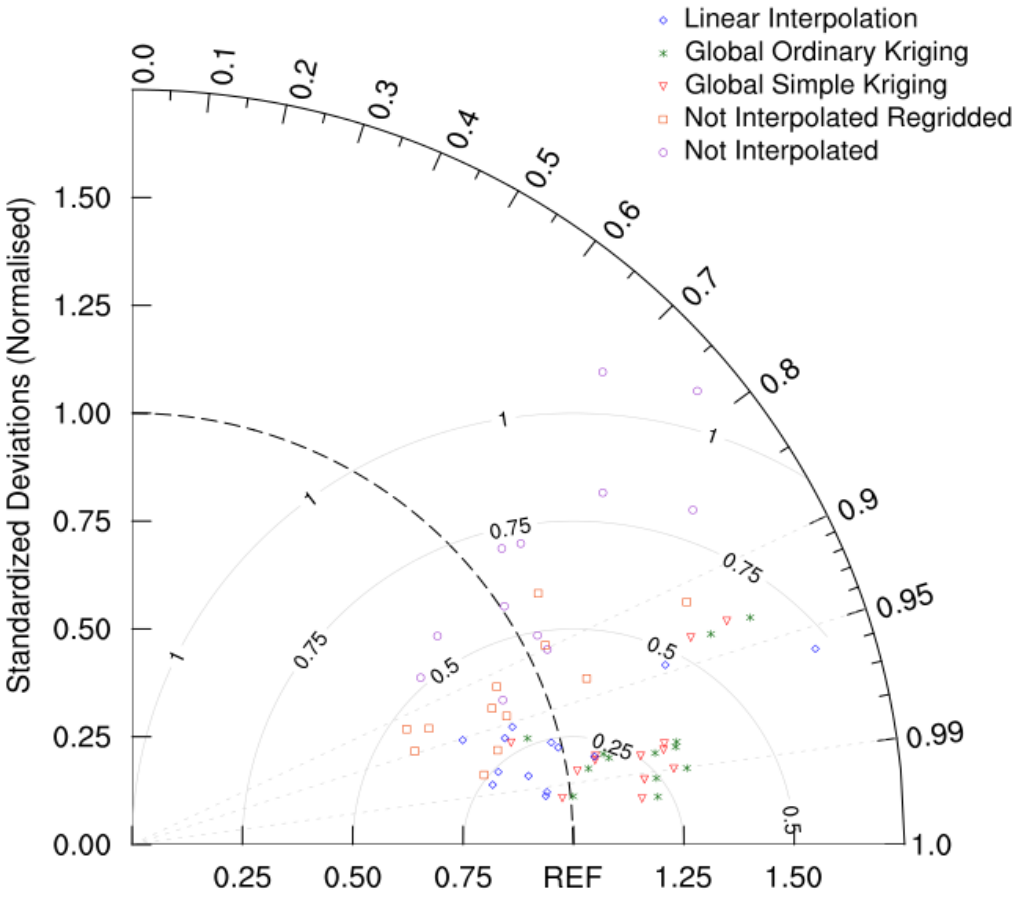
- The techniques yielded estimates of Arctic SAT anomalies which were compared to the reference dataset.



The locations of all meteorological stations in the CRUTEM4 databank.

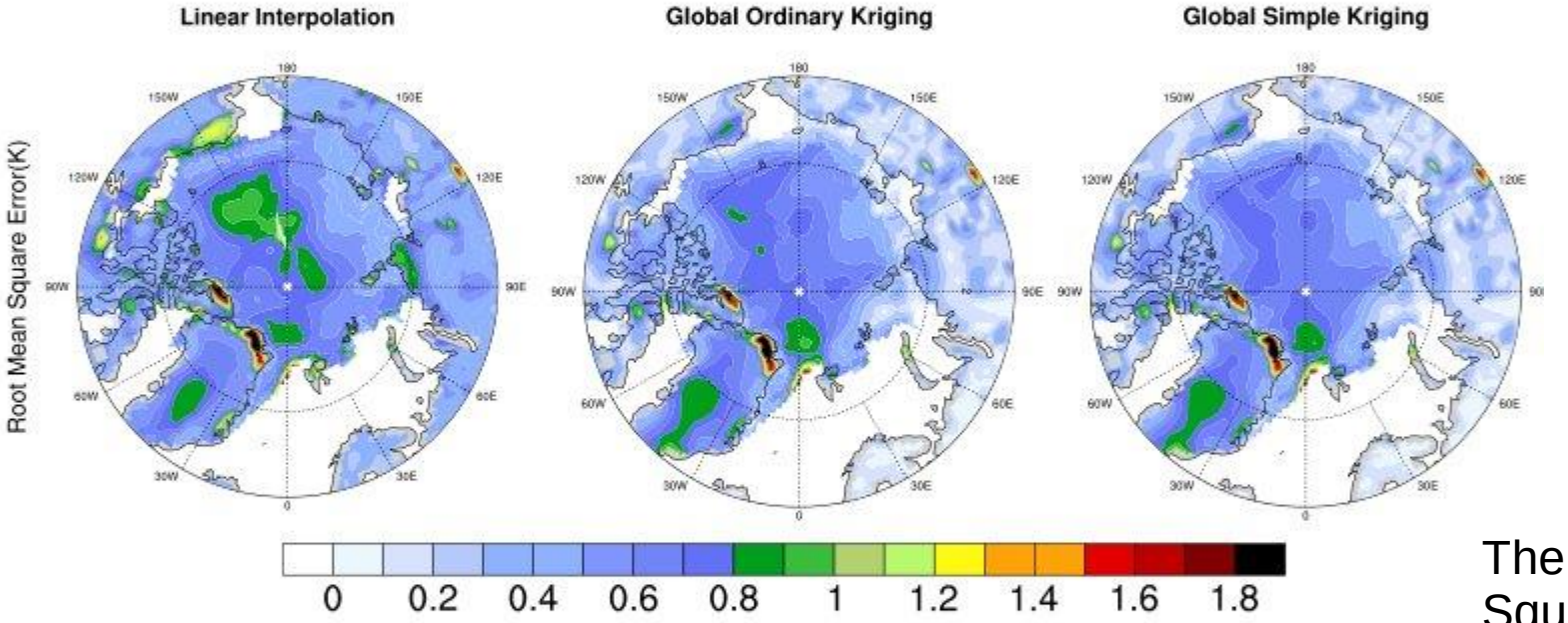
Recent Decades

- Interpolating techniques were more representative than non-interpolating techniques.
- Kriging techniques provided the smallest errors in estimates of Arctic anomalies.



A Taylor Diagram comparing estimated Arctic-average monthly anomalies produced by each technique to the reference. Each symbol represents a month of the year.

Recent Decades

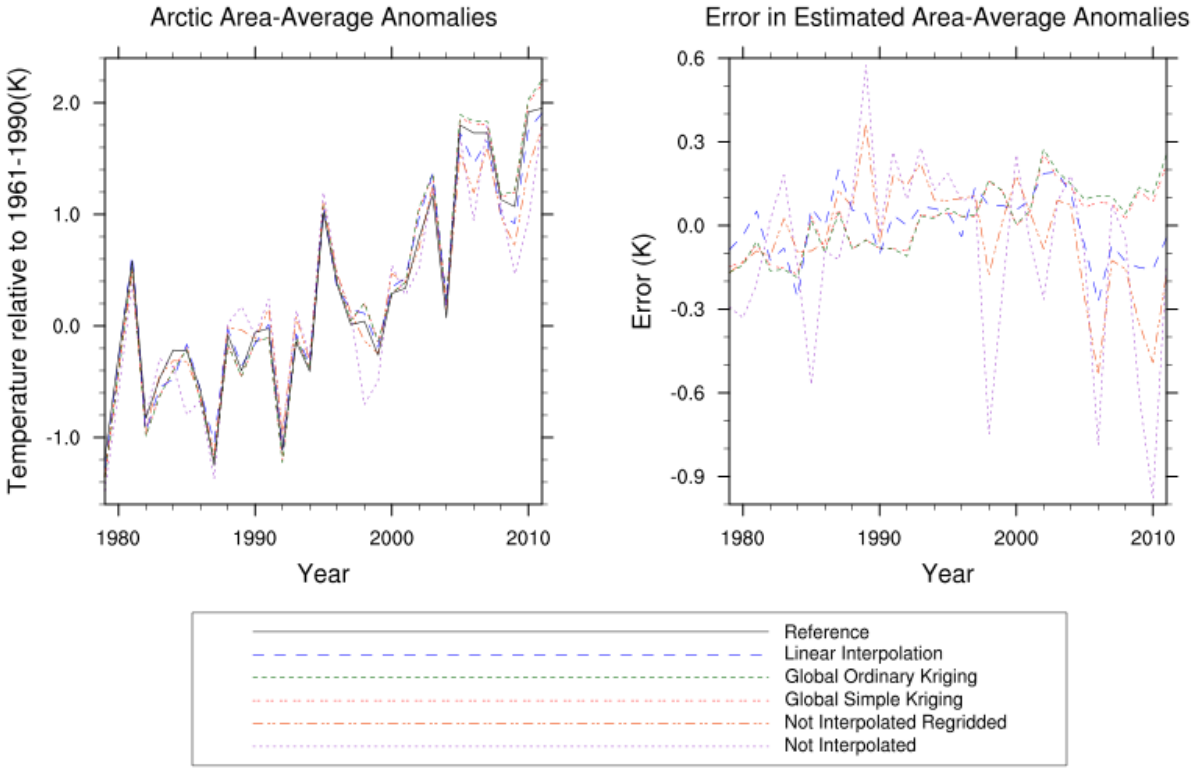


The Root Mean Squared Error for annual Arctic anomalies.

- GSK was the most accurate technique (when a representative mean was chosen), especially over areas of sea ice.

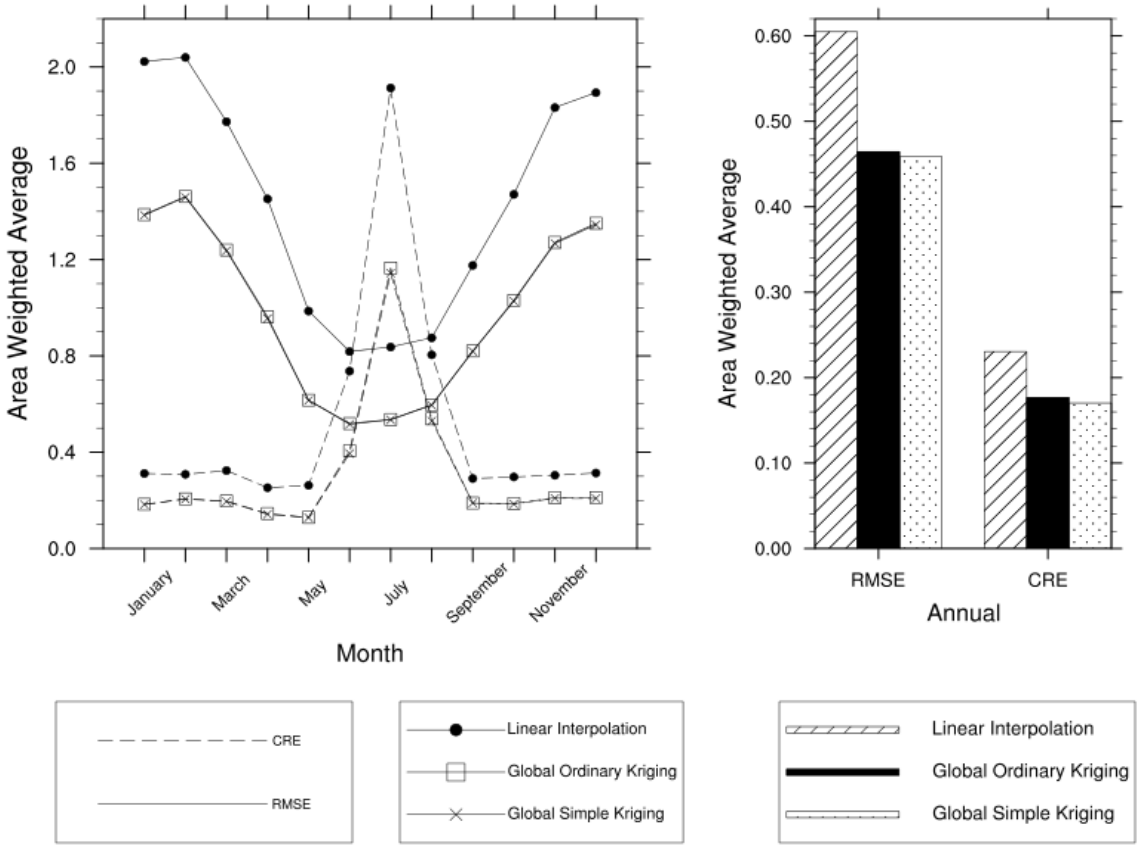
Recent Decades

- Non-interpolating Techniques provided the least representative anomaly estimates.



Time series of annual Arctic-average anomalies between 1979 and 2011 are shown in the graph on the left. The errors in estimated anomalies relative to the reference anomalies are shown on the right.

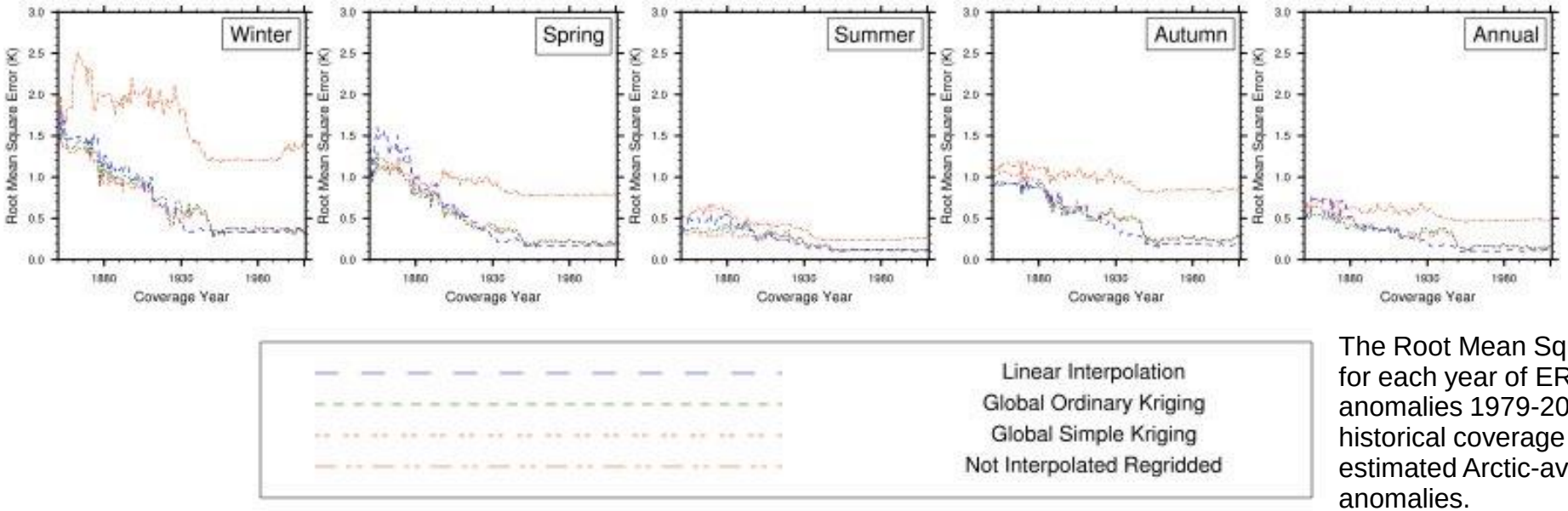
Recent Decades



- The errors in monthly Arctic-average anomalies were found to have a seasonal variation; errors were larger in winter than for other seasons and smallest in the summer.

The area-weighted average of the Root Mean Square Error and Compound Relative Error between estimated annual Arctic anomalies and reference anomalies in recent decades (1979-2011).

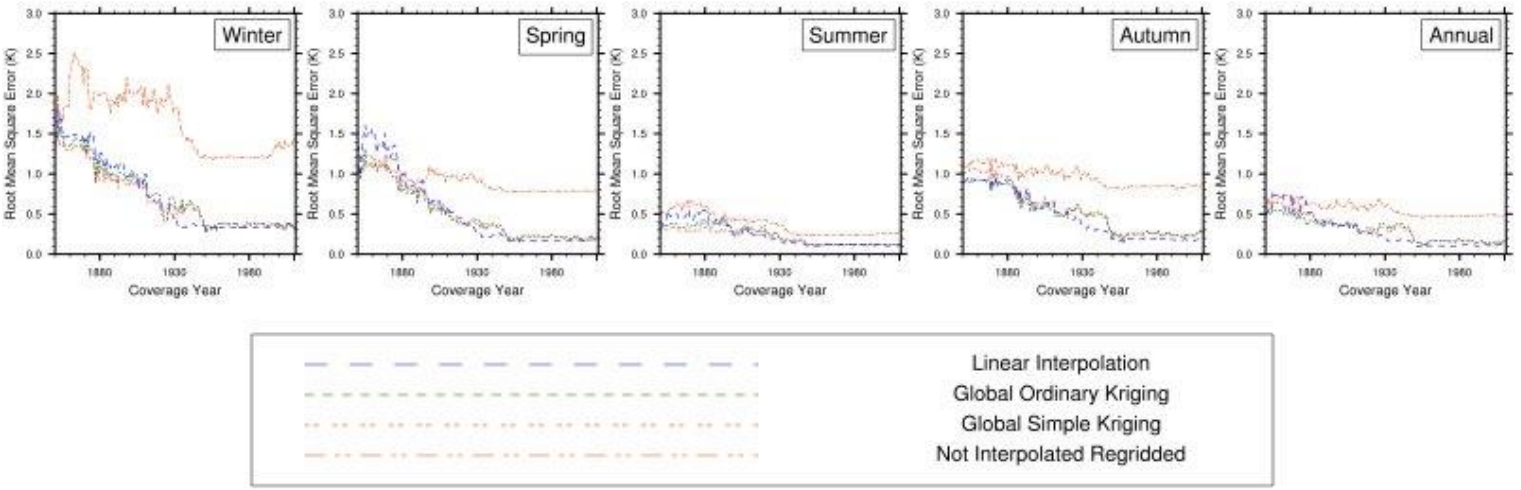
Historical Coverage



The Root Mean Square Error for each year of ERA-Interim anomalies 1979-2011 in each historical coverage year for estimated Arctic-average anomalies.

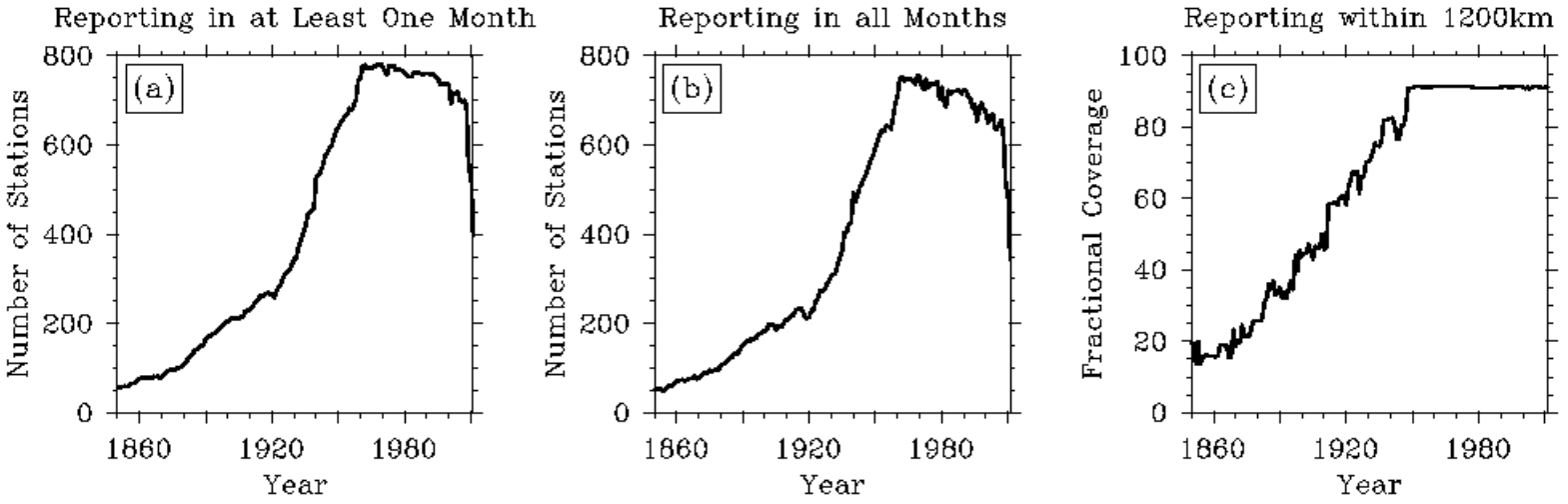
- All techniques had larger error values for earlier station coverages.

Historical Coverage



- The largest values occurred before 1890. After this they decreased until about 1950.
- Using pre-1950 historical coverages caused larger errors and a greater uncertainty; errors can be up to 2 K larger for earlier historical coverages.

Historical Coverage



The number of stations (a) reporting at least one temperature in each year, (b) the number reporting temperatures in all months of each year and (c) the percentage of grid cells with at least one station reporting within 1200km ('Fractional Coverage').

- The sparser observing network for earlier station coverages impacts the performance of all techniques leading to larger errors and a greater uncertainty in the estimated anomalies.

Conclusions

- Techniques which interpolated anomalies produced anomalies with smaller errors than non-interpolating techniques (relative to the reanalysis ‘truth’).
- Kriging techniques provided the smallest errors in estimates of Arctic anomalies.
  - Simple Kriging was often the best kriging method especially over sea ice.
- Non-interpolating techniques provided the least representative anomaly estimates.
  - But they serve as useful checks for confirming whether estimates from interpolating techniques are reasonable.
- All techniques were found to have larger errors for earlier station coverages. This results from the sparser observing network at the start of the temperature record.

Thank you for Listening

Any questions?