Can we Assess the Impact of Estimating Arctic Surface Air Temperature Anomalies with Global Simple Kriging using In Situ Data?

Emma Dodd[1], Chris Merchant[1], Nick Rayner[2], Colin Morice[2]

[1]University of Reading, Earley Gate, PO Box 243, Reading, RG6 6BB, UK
[2]Met Office Hadley Centre, Exeter, UK

1. Introduction

The degree of difference arising from using several different techniques to estimate Arctic Surface Air Temperature (SAT) anomalies over land and sea ice was investigated using ERA-Interim reanalysis data as a 'truth'[1]. Can we validate the results of this perfect data study using in situ data?

Global Simple Kriging (**GSK**) was applied to in situ SAT data. An estimate of the error in these in situ data study estimated anomalies was produced and compared to the reanalysis results.

The 'Double Difference' Statistic:

$$D = \Delta A - \Delta P$$

$$\Delta A = [\, A_{(x,t+i)} - A_{(x,t)} \,] \qquad \Delta P = [\, P_{(x,t+i)} - P_{(x,t)} \,]$$

D is the double difference statistic; an estimate of the error in the difference between estimated anomalies.
$A_{(x,t)}$ is the estimated calender month SAT anomaly in grid cell x and year t.
$P_{(x,t)}$ is the calender month average SAT (≥10 days of data) from a drifting platform in grid cell x and year t.
$A_{(x,t+i)}$ is the estimated calender month SAT anomaly in grid cell x for a different year; t+i.

2. Data and Techniques

- **GSK** (the most representative technique in the ERA-Interim study[1]) was applied to monthly SAT anomalies from CRUTEM4[3] meteorological stations. The technique yielded estimates of Arctic SAT anomalies over land and sea ice.
- The accuracy of these in situ data study estimated anomalies was assessed using independent in situ data sources:
  - **Validation over Land:** monthly SAT anomalies from 63 independent land stations in the ISTI[4] Stage 3 monthly databank.
  - **Validation over Sea Ice:** 'Drifting Platforms'; North Pole Drifting Stations (NPDS) and Cold Regions Research and Engineering Laboratory Ice Mass Balance Buoys (IMBs). The accuracy of anomalies over sea ice was estimated using a **'double difference' statistic** due to a lack of traditional normals or a climatology.
- The error in the estimated anomalies were calculated and error metrics were produced. The metrics from the in situ data study were compared to the reanalysis study metrics.

3. Validation over Land

- The monthly average metrics have the same seasonal pattern; larger values in winter and smaller in summer, vice versa for CRE (Compound Relative Error). The size of the metrics are also very similar (Figure 1).
- There are some slight differences between the in situ data study and reanalysis study metrics, probably due to the use of in situ data (local effects, noise, inhomogeneities) and incomplete spatial coverage (most of the independent land stations are located in Scandinavia, Figure 2).

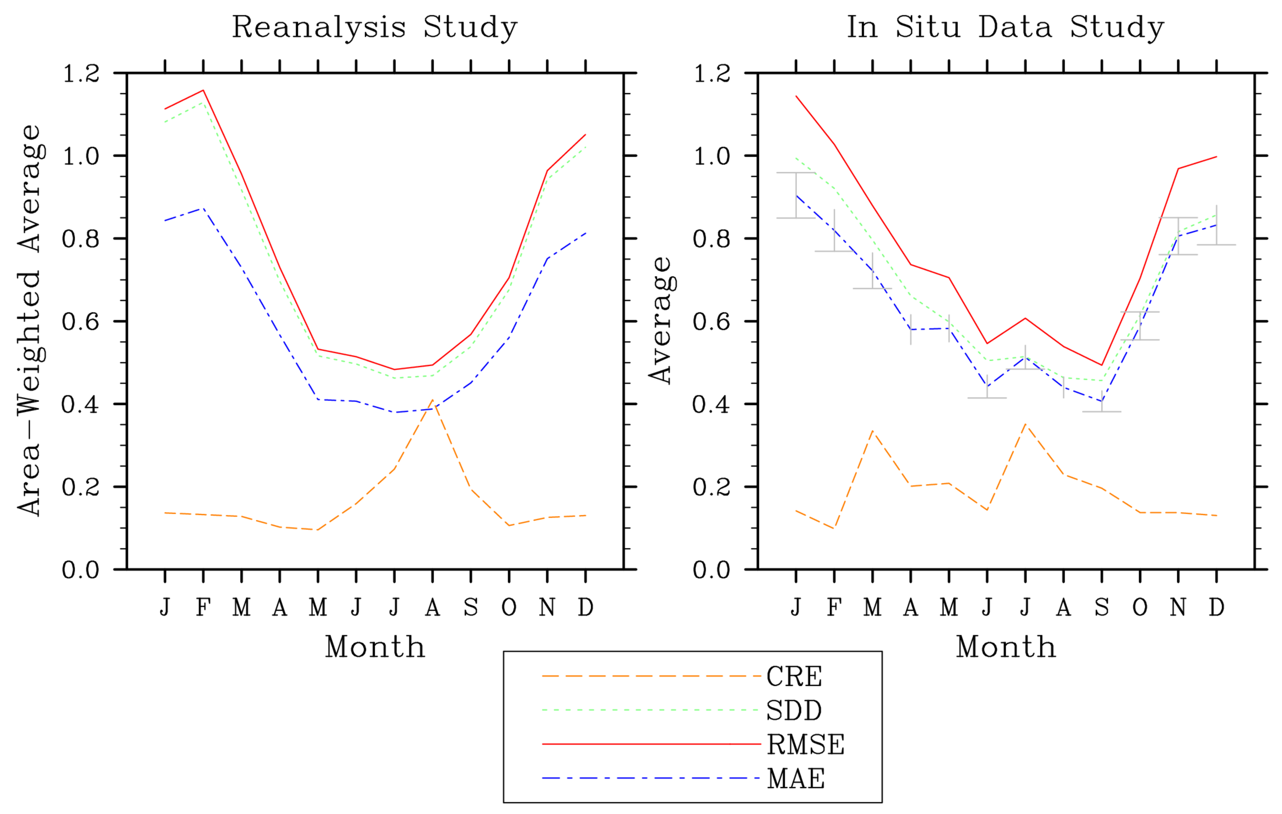

Figure 1: The monthly area-weighted average and monthly average of the MAE, RMSE, SDD and CRE for the reanalysis study and in situ data study respectively over land. Confidence intervals are given in grey for the validation data. All metric values are in K except for CRE.

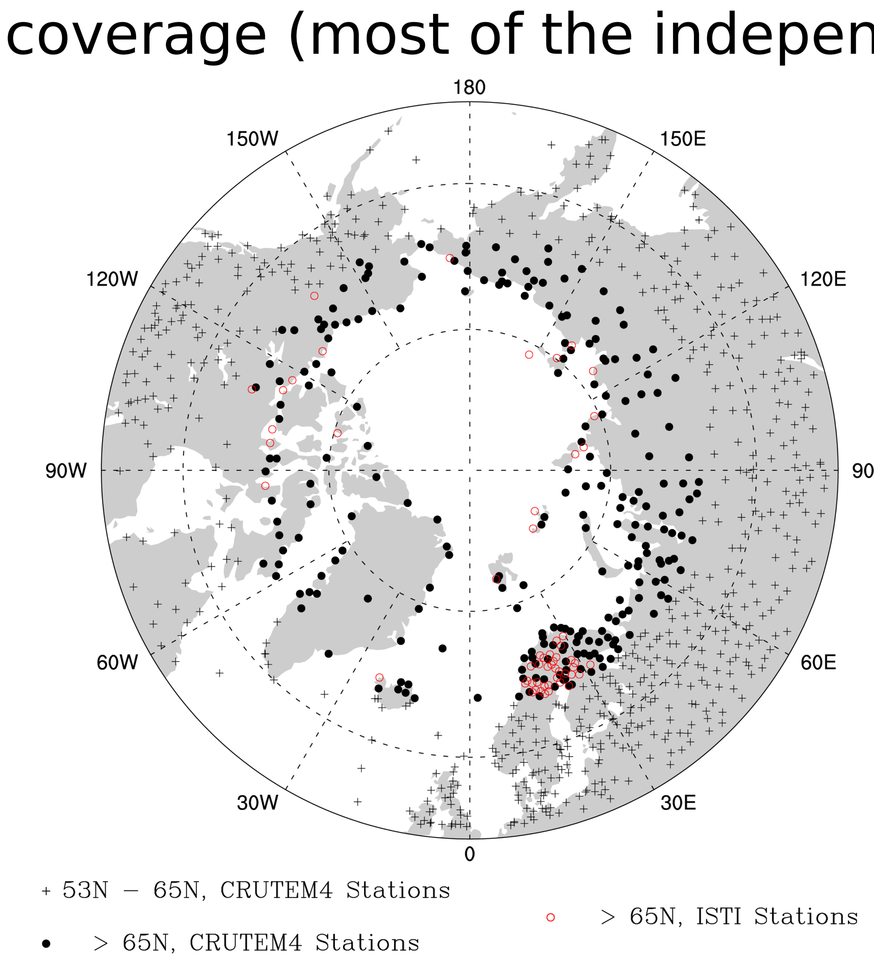

Figure 2: The coverage of CRUTEM4 stations and the independent land stations from ISTI[4].

4. Validation

- Most months show the same seasonal pattern for the in situ data study and reanalysis study metrics (Figure 3).
- NPDS in situ data study metrics are larger than expected in April; fewer NPDS report for the whole of April than any other month (Figure 4) which reduces data availability in this sparsely sampled area resulting in an extremely small sample of double differences. IMB metrics are also larger than expected in March due to reduced data availability.
- NPDS and IMB in situ data study metrics are around twice as large as the reanalysis study metrics (Figure 3). This is due to the small sample size of these data sources and the use of the double difference statistic (Figure 3).

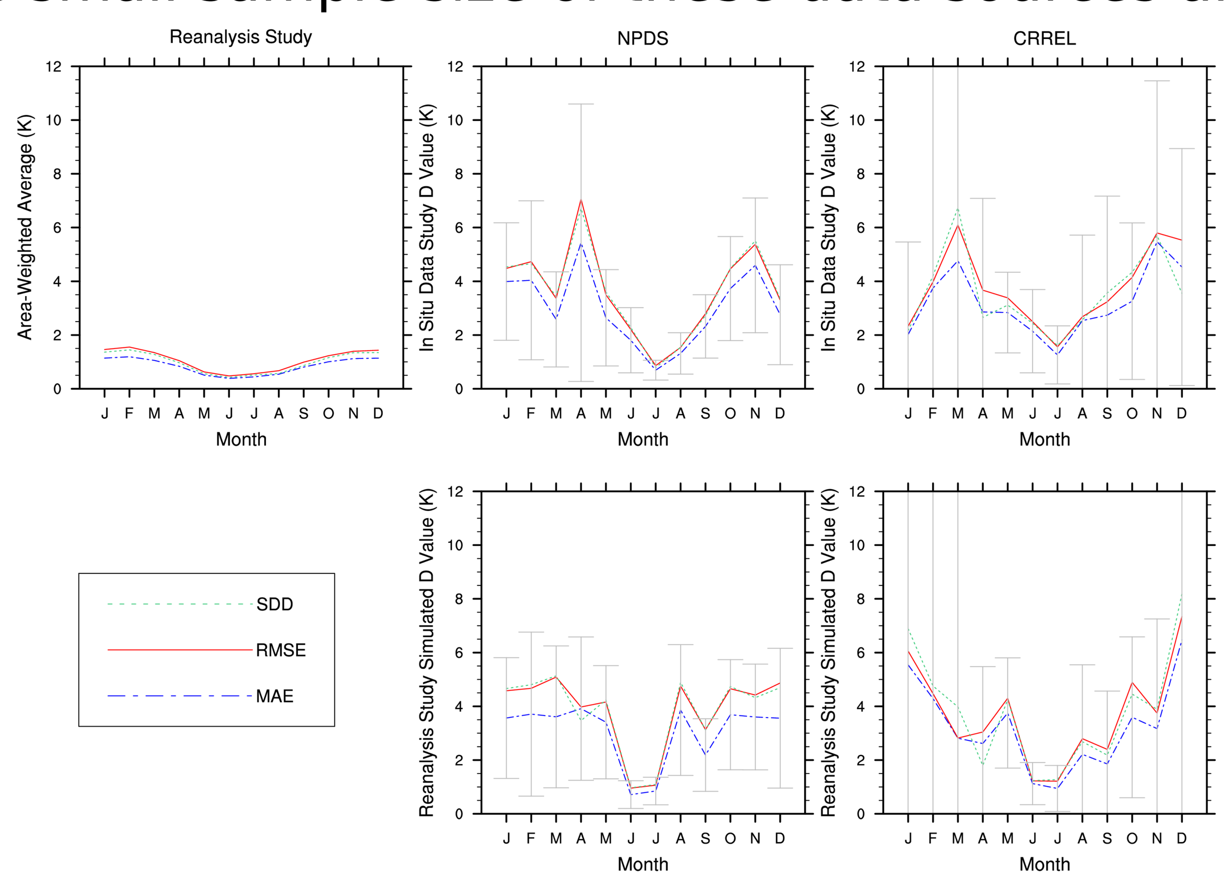

Figure 3: Monthly average of the MAE, RMSE, SDD and CRE for the reanalysis study and in situ data study (assessed using NPDS and IMBs) over sea ice. The reanalysis study simulated value of D (double difference) was created from the reanalysis data using the double difference statistic and sampled to the same grid cells and months as the drifting platforms.

Confidence intervals are given in grey.

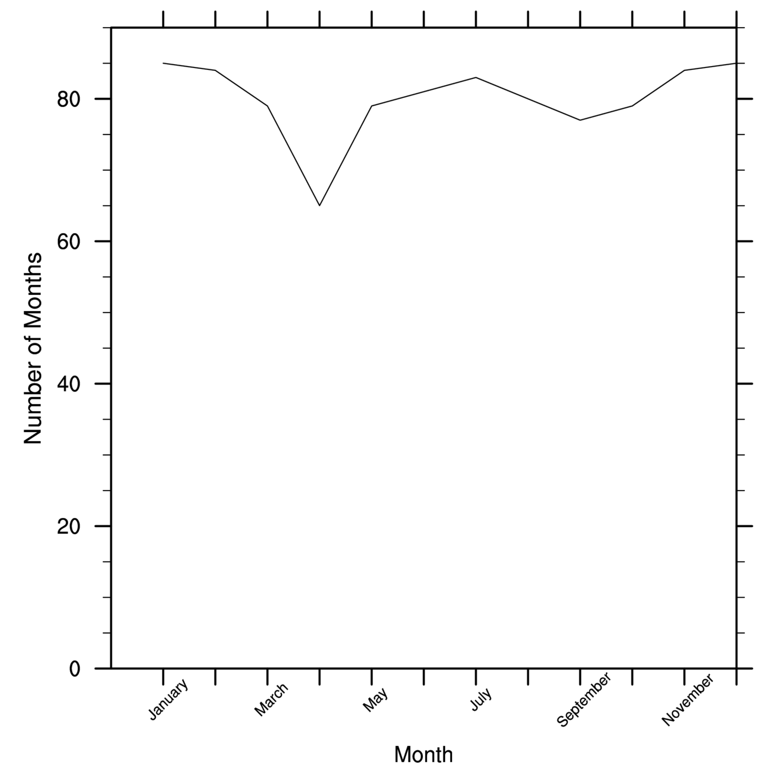

Figure 4: The number of months between 1950 and 2013 where NPDS report for the whole month.

5. Conclusions

The in situ study metrics over land are very close to the reanalysis study metrics. Over sea ice the metrics have a similar seasonal pattern and size (once the sample size and double difference statistic are accounted for). However, the confidence intervals are large and the sample size is very small so caution is needed in drawing conclusions from this data. This highlights the difficulty of investigating SATs over sea ice where data records are sparse.

References

1. Dodd et al. An Investigation into the Impact of using Various Techniques to Estimate Arctic Surface Air Temperature Anomalies (submitted to *Journal of Climate*)
2. R Rohde et al. Berkeley Earth Temperature Averaging Process. *Geoinformation and Geostatistics: An Overview* 1:2, 2013
3. P.D Jones et al. Hemispheric and large-scale land-surface air temperature variations: An extensive revision and update to 2010. *JGR-Atmospheres,* 117:29,2012.
4. P.W. Thorne et al., Guiding the Creation of A Comprehensive Surface Temperature Resource for Twenty-First-Century Climate Science. Bull. Amer. Meteor. Soc., 92, 2011.

Contact: E.M.A.Dodd@pgr.reading.ac.uk