An Analysis of Daily Surface Air Temperature over the Global Land

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Objective and Primary Features

- Objective
  - *To construct a new and improved analysis of daily maximum (T_{max}) and minimum (T_{min}) surface Air Temperature over the global land*
- Primary features of the new CPC daily T_{2m} analysis
  - *T_{max} / T_{min} on 0.05^o grid*
  - *Improved reference climatology with consideration of orographic effect*
  - *Capability of handling station data from both regular and irregular sources*
  - *Historical analysis for 1991-2021*

Outline

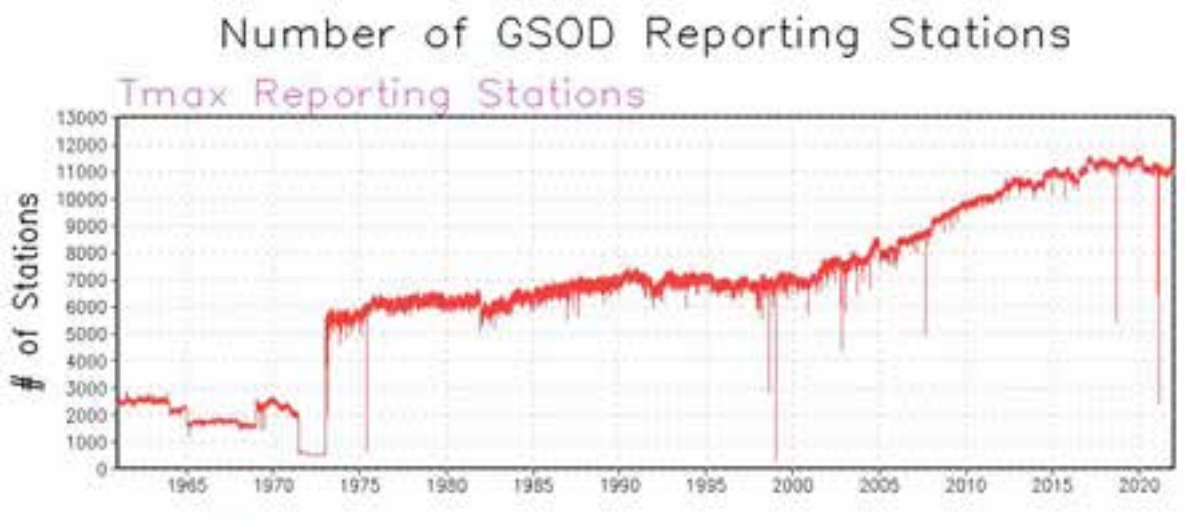
- Analysis strategy
- Station reports used for the analysis
- Construction of daily climatology
- Construction of the daily analysis
- Preliminary evaluation
- Summary and future work

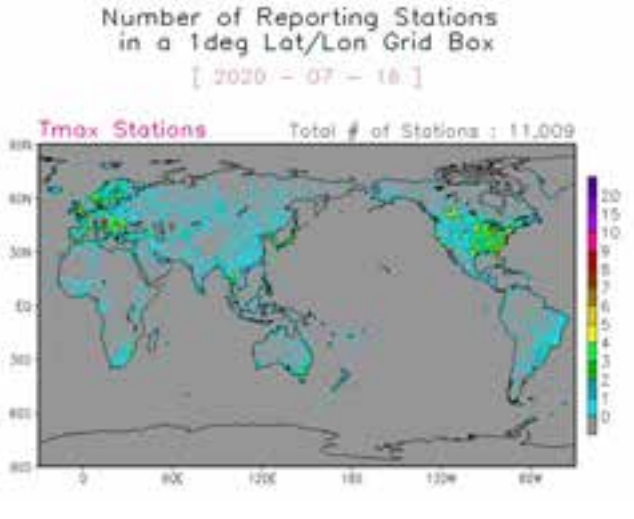
Analysis strategy

- Station report preparation
  - Collect data from NCEI, CPC and other sources. For the first version of the new analysis, station reports from NCEI GSOD, are utilized.
  - Quality control
- Daily climatology (1991–2020) construction
  - Based on three published sets
- Grid daily analysis
  - Interpolating anomalies at station locations to *0.05^o grid* using the algorithm of Shepard (1965)
  - Adding interpolated anomalies to climatology to form the analysis of the total fields

NCEI GSOD (Global Summary of Day) Station Reports

Data availability





- *Number of reporting stations increases with time, from ~6000 in 1970s to over 10,000 in 2000s;*
- *The station networks cover the global land reasonably well, with denser network over the US and the western Europe, eastern China, eastern South America, and sparse network over parts of Africa and northern South America*

NCEI GSOD Station Reports

Quality control

- Algorithm
  - *Departures from climatology are calculated for station observations;*
  - *Median and standard deviation of the departures at 11 neighboring stations are calculated for each target station*
  - *Reports at stations where the difference from the median is larger than three standard deviations is flagged and removed from the inputs for the analysis*
- QC results:

  On average, about 0.1% of the reports are flagged

Construction of daily climatology

- Use three published monthly grid climatology data sets with consideration of orographic effect (PRISM, CRU, then WorldClim)
- Upscale/downscale the available monthly climatology to 0.05° grid
- Convert the monthly climatology from respective base periods to 1991-2020
- Downscale the monthly climatology to daily climatology

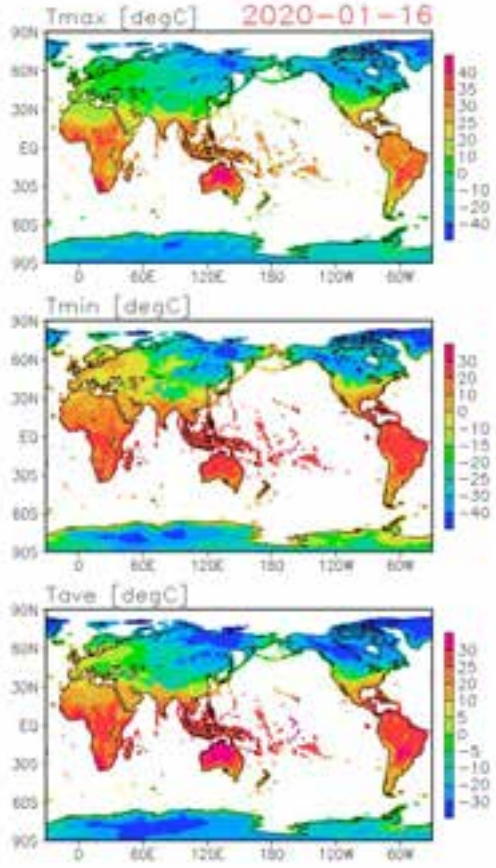
Construction of daily analysis

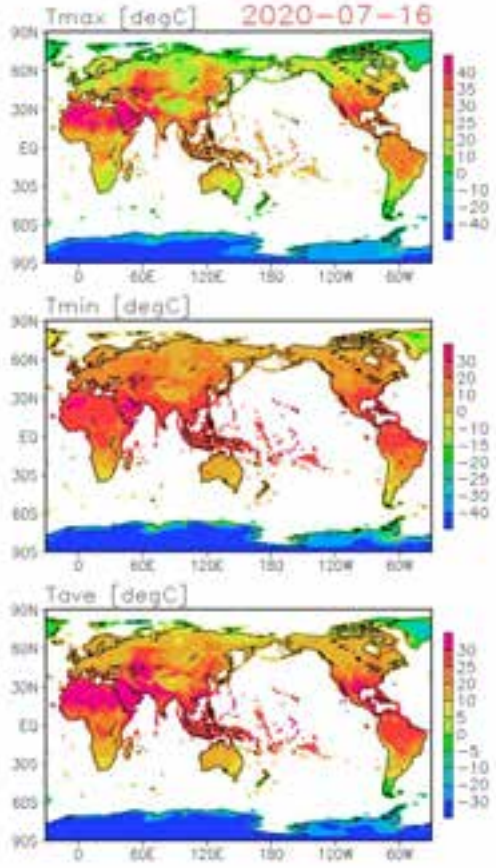
Method

- Grid analysis is constructed on a 0.05° grid over the global land;
- First, daily T_{max} / T_{min} anomalies are produced through interpolation of the anomalies at neighboring stations using the algorithm of Shepard;
  - *Initial searching distance is determined over the entire analysis domain within which 7 stations are available;*
  - *In calculating grid analysis at a grid point, if number of reporting stations within the initial searching distance is between 4-10, reports from all stations are utilized;*
  - *The search distance is expanded / narrowed down until number of reports is between 4 – 10;*
  - *The weighting is inversely to the square of the distance for stations within 1/3 of the searching distance and then inversely to the distance;*
  - *Directional correction is performed for the weighting so that reports from stations close to each other in a direction will receive reduced weight;*
- The interpolated anomaly fields are added to the grid daily climatology to get the grid analysis of daily T_{max} / T_{min}

Constructing of daily Analysis

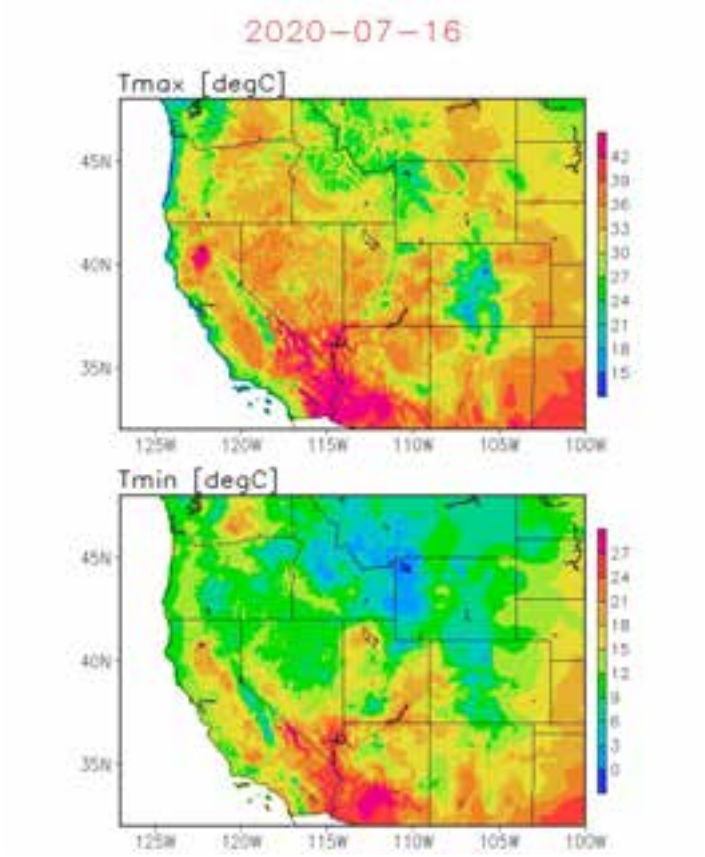
T_{max} / T_{min} Analysis for 16 Jan and 16 Jul of 2020

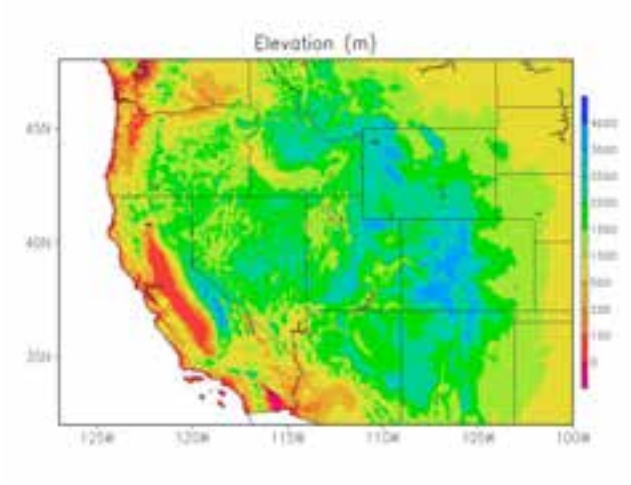




Constructing daily Analysis

Illustration of the Orographic Effect in the T_{max} / T_{min}

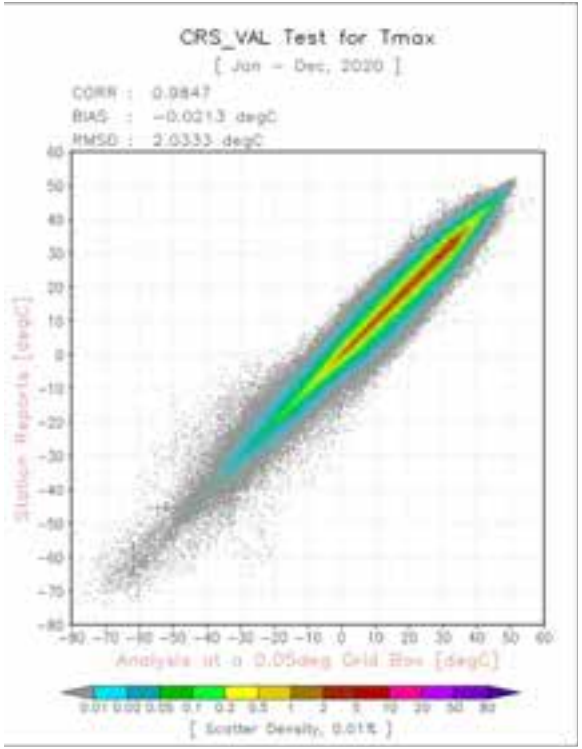


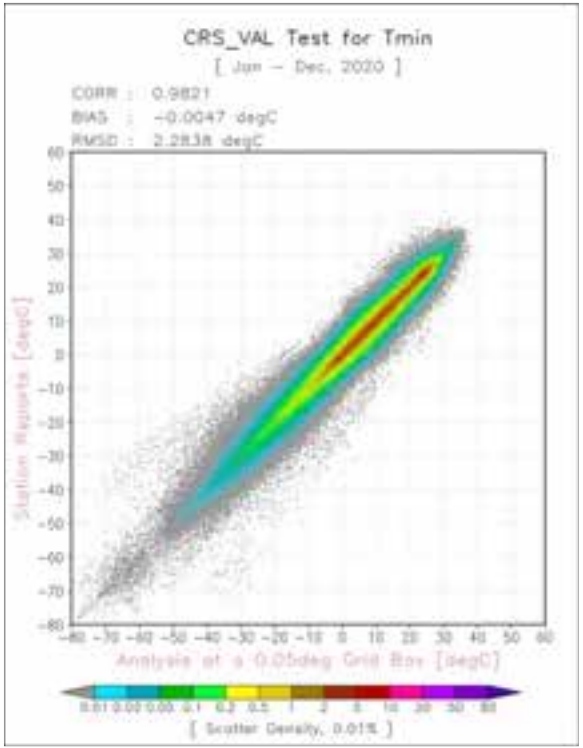


- *Orographic effect in surface air temperature is well represented in both the T_{max} and T_{min} analysis;*
- *This suggests that the new analysis captures spatial temperature variations associated with complex topography and is capable of handling changes in the input station networks over those regions*

Preliminary evaluation

Cross validation



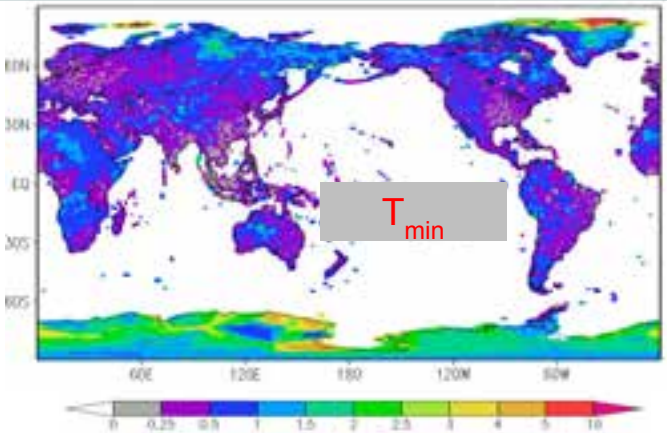


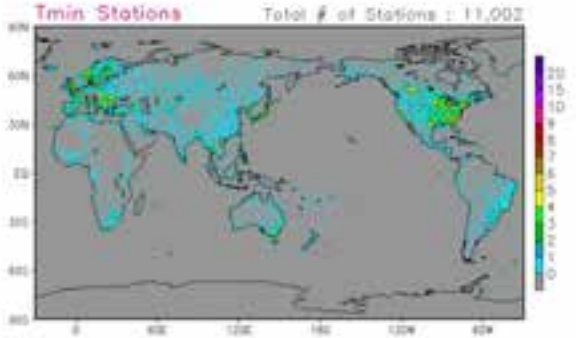
- *In a cross validation test, reports at 10% randomly selected stations are withdrawn from the inputs and the reports at the remaining 90% of the stations are infused into the system to generate the analysis. The reports at the withdrawn stations are then used as the independent observations to compare against the analysis at the grid boxes of the withdrawn station location;*
- *The above process is repeated 10 times so that report from each station is withdrawn once and used as the independent tests;*
- *Comparison statistics between the grid analysis and the withdraw station reports provide a quantitative evaluation of the analysis quality;*

- ***Results of the cross-validation tests show that the new analysis works quite well with a very high correlation and a negligible bias with the independent station data***

Preliminary evaluation

Cross validation: T2m uncertainty based on 10 cross-validation analyses for 2020





- *The uncertainty is less than 1K over most of the globe*
- *The uncertainty is generally smaller over areas of denser observations (US, western Europe, eastern China, eastern South America)*

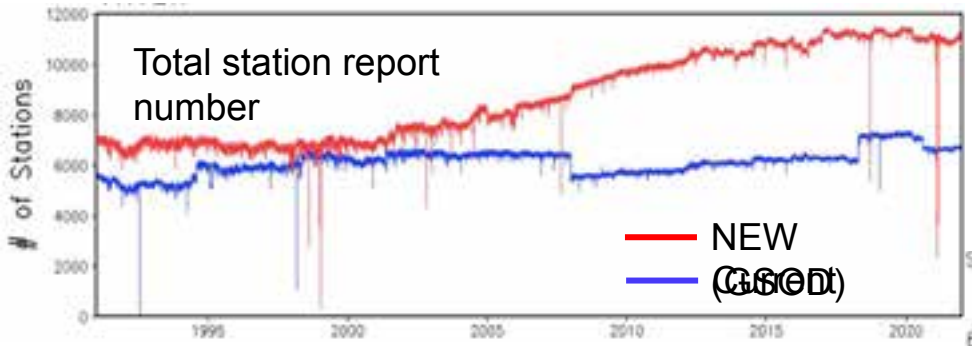
Comparison with the current CPC T_{2m} Analysis

Overview

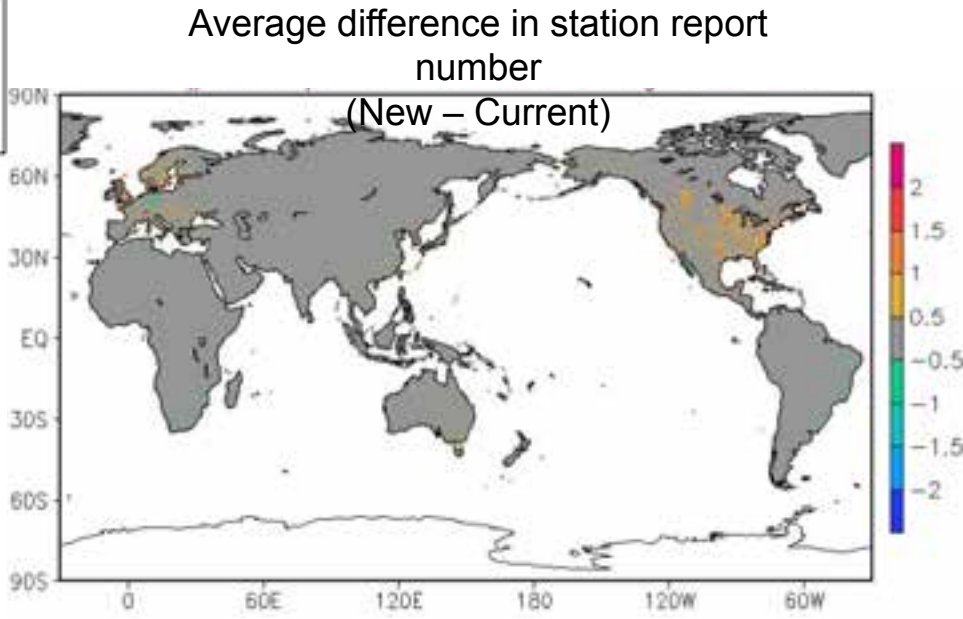
- The current CPC daily T_{2m} analysis (Developed about 15 years ago)
  - *Analysis domain from 60°S to 90°N on a grid of (1/6)°*
  - *Station data from the CPC GTS based data files* *(QZFL from 1979 to 2020 and CADB thereafter)*
  - *Reference climatology based on one available data set*
  - *Not flexible for reports from stations not listed in the historical station library*
- For comparison, both the new and the current daily analyses are regridded to a 0.5° grid

Comparison with the current CPC T_{2m} Analysis

3) Comparison Results for T_{max} (Difference in # of report stations in 0.05 deg boxes)

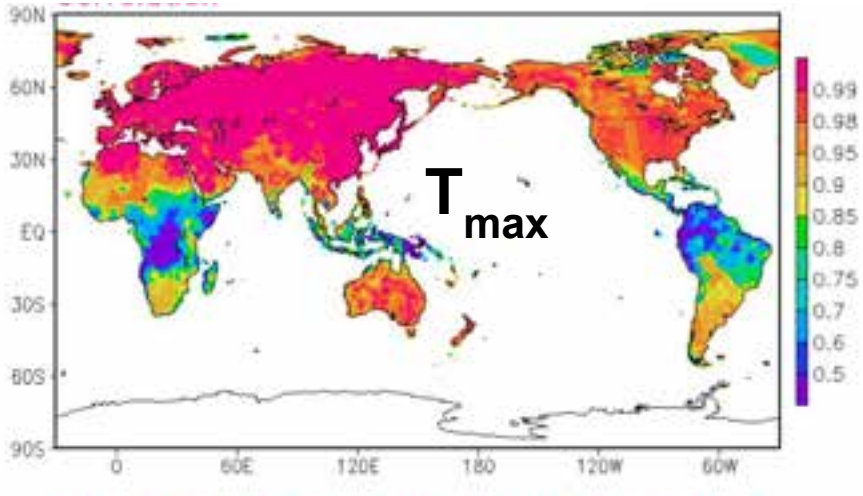


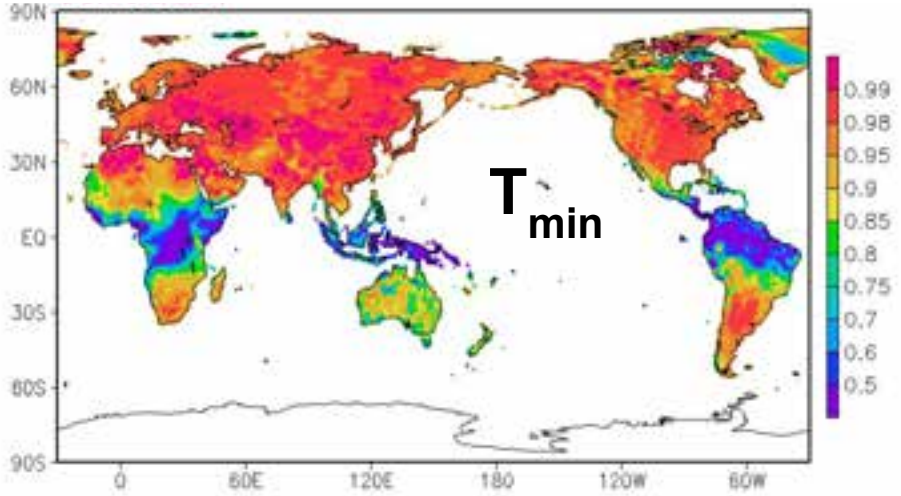
- *The GSOD consistently includes more stations reports, especially after 2008*
- *Spatially, more reports are available for the new analysis than for the current analysis, especially for the US and western Europe*



Comparison with the current CPC T_{2m} Analysis

Comparison Results for T_{max} (1991-2020 anomaly correlation)

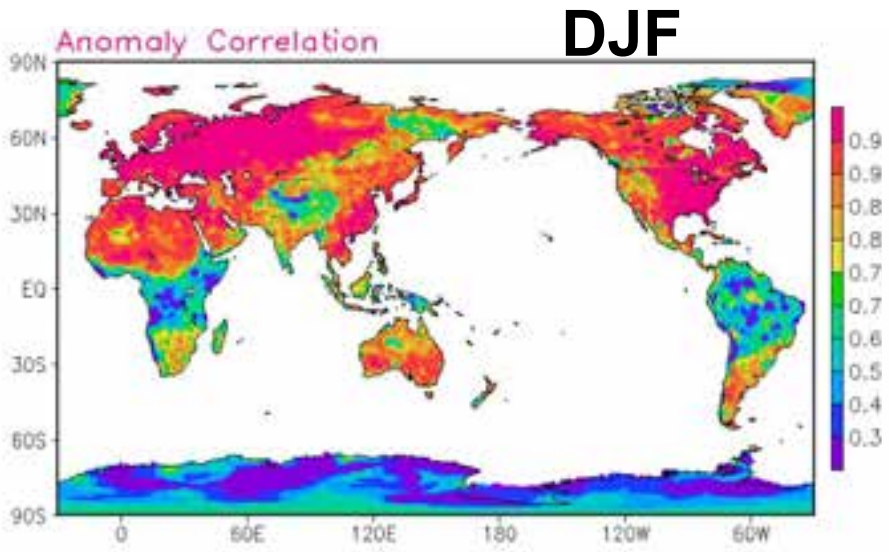


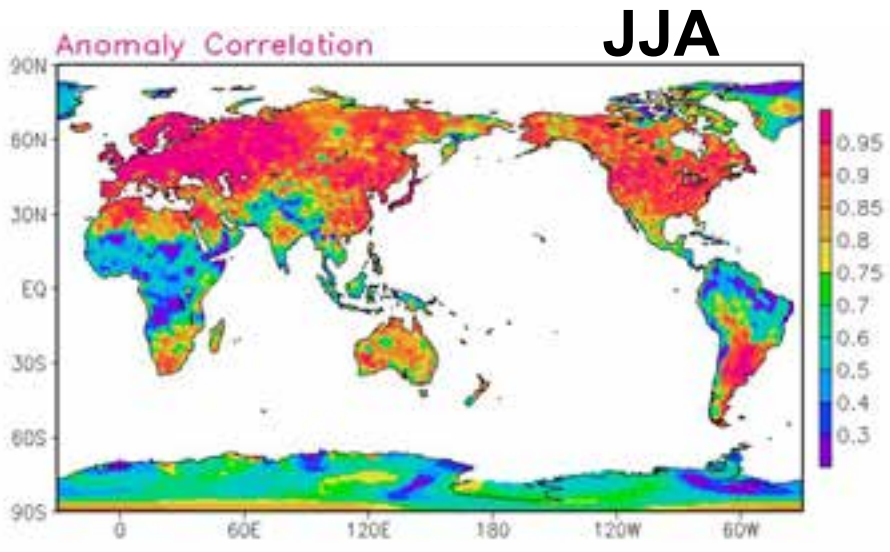


- *Correlation is high (> 0.9) over most of the globe for both Tmax and Tmin*
- *Correlation for Tmax is overall higher than that for Tmin*
- *Low correlation (<0.9) is often observed over regions of sparse station network (e.g. equatorial Africa, Southeast Asia, and equatiorial South America)*

Verifying T_{2m} in the CORe

1991-2020 anomaly correlation for DJF and JJA





- Anomaly correlation between CORe and the new analysis generally higher than 0.75 over most of the globe.
- Relatively low correlation (<0.75) over northern South America, parts of Africa, Antarctic, and Tibetan areas.

Summary

- Station data of daily surface air temperature are collected
- A new technique is developed for quality control
- The algorithm is improved
  - Using the state-of-the-art published climatology with more realistic orographic consideration and
  - Flexible for station reports irregular in both space and time
- The first version of the new grid analysis is produced for 1991 to 2021 using GSOD dataset

Future Work

- Further evaluate the first version of the analysis to optimize the analysis algorithm
- Complete a final historical analysis from 1981 or earlier to the present using all available input data (GSOD, GHCN-D, and others)
- Transition the system for real-time analysis