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How accurately do we know the temperature of the surface of the earth?

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The earth's surface temperature is important in a variety of applications including global warming. We analyze six monthly series from 1880 – 2012, each produced with different methodologies with uncertainties (errors) estimated using various data sets, statistical assumptions and models. In the first part of this presentation, we estimate the relative error, by systematically determining how close the different series are to each other, the relative error at a given time scale is quantified by the root mean square fluctuation in the difference between the series as well as the difference between individual series and the average of all the available series. By examining the differences systematically from months to over a century, we find that the standard short range correlation assumption (e.g. that errors are autoregressive type processes) is untenable, that the differences in the series have long range statistical dependencies and that the relative errors are roughly constant between one month and one century – varying only slightly between ±0.03 and ±0.05 C.
In the second part of the presentation, we estimate the absolute errors by making a stochastic model of both the earth temperature and a model of how the error varies with time scale. The temperature model combines a fractional Gaussian noise (fGn) for the natural variability with a superposed linear model of the anthropogenic warming. The error model has three components: a (conventional) white noise measurement error, a missing data bias and an areal reduction factor (bias). Whereas the white noise error has only short term correlations, the second – due differing amounts of missing data – is a random process of the same statistical type as the temperature but with an amplitude that depends on the amount of data missing from each set. The third correction is a "scale reduction factor" that takes into account the fact that the space-time resolution of each data set is not quite correct. We find that up to about 10 -20 years scales, the leading error comes from missing data whereas at longer scales (related to anthropogenic warming), it comes from the scale reduction factor. In contrast, the classical white noise error is either second or third order in importance over the whole range from one month to over 100 years. Overall, from two months to over 100 years in time scale, the absolute error is mostly in the range between ±0.03 and ±0.05 C, although it increases to about 0.1oC at centennial scales.