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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 statistical assumptions and models. In the first part of this presentation, we estimate the error in a new way, by systematically determining how close the different series are to each other, the 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 is untenable, that the differences in the series have long range statistical dependencies and that the error is roughly constant between one month and one century – varying only slightly between ±0.03 and ±0.05oC.

In the second part of the presentation, we make 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 fGn has long range statistical dependencies with fluctuation exponent H = -0.1. The error model has three components: a 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 (fGn) but with an amplitude that depends on the amount of data missing from each set. The third correction is an "areal reduction factor" that takes into account the fact that the space-time resolution of the data (here monthly, at 5ox5o) is not quite correct. We use the six global series to estimate the amplitudes each term and find that up to about thirty years, that the leading error comes from missing data whereas at longer scales, it comes from the areal 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 error is in the range between ±0.03 and ±0.05oC.