Development of Global 0.5 Degree Hourly Land Surface Air Temperature Data from 1948-2009 Based on the CRU In Situ Data as well as MERRA, ERA-40, ERA-Interim, and NCEP Reanalysis Data

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Land surface air temperature (Ta) is one of the fundamental variables in weather and climate observations, modeling, and applications. Its monthly mean has been computed as the average of daily maximum and minimum Ta, which is different from the true monthly mean temperature using hourly data, as long recognized. It is time to use the true mean temperature based on hourly observations for climate record and for model evaluations for several scientific reasons. First, while the maximum and minimum temperatures under a clear-sky condition over mid-latitudes usually occur in the early afternoon and in the early morning, respectively, the timing of the occurrences can be widespread under other conditions. Therefore, while daily maximum and minimum temperatures still have a clear physical meaning, their monthly mean (i.e., the average of values at different times of each day) is difficult to interpret physically. Second, even for the clear-sky condition, the average of daily maximum and minimum temperatures is different from the 24-hourly average, because the daytime warming is driven by solar radiation while the quasi-linear decrease of nighttime temperature is related to longwave radiative cooling. Just like all other meteorological quantities, there could be significant spatial heterogeneities in daily maximum and minimum temperatures (and hence in monthly mean temperature) due to a variety of geographic (e.g., elevation) and transient (e.g., cloud cover) factors. In contrast, transient factors would not affect as much the true monthly mean using hourly data. Because of the possible confusion of modelers about monthly mean versus true monthly mean, it is unclear which climate models compute monthly mean and which models compute true monthly mean in the comparison with the observed monthly mean (e.g., for the Intergovernmental Panel on Climate Change (IPCC) studies).

Since historical data don't include hourly Ta, efforts are still needed in developing such historical hourly air temperature data. Various reanalysis products have the potential to play such a role. In fact, three-hourly Ta data have been developed by adjusting the six-hourly reanalysis Ta data with the in situ monthly mean Ta data in several previous efforts. The diurnal cycle of the reanalysis data, however, is found to be unrealistic.

The main idea here is to use the in situ monthly maximum and minimum Ta data (rather than their average) to adjust the reanalysis diurnal cycle. In this way, we have developed a global 0.5 degree hourly Ta data from 1948-2009 based on the CRU TS3.1 in situ data as well as MERRA, ERA-40, ERA-Interim, and NCEP reanalysis data. Each of these reanalysis products has strengths and weaknesses. MERRA provides hourly data for a relatively short period; ERA-40 and NCEP provide 6-hourly data with the former more realistic and the latter providing the longest period of data; and ERA-Interim, representing the most recent product from ECMWF, provides three-hourly data. ERA-Interim also performs well compared with other reanalysis products in our evaluations. In our new product, the data priority follows the order of ERA-Interim, ERA-40, and NCEP. Therefore we use the ERA-Interim data from 1989-2009, the ERA-40 data from 1958-1988, and the NCEP data from 1948-1957. Our data development involves multiple steps, including obtaining the hourly values in the ERA-40 and NCEP data based on the MERRA hourly data, and adjusting these hourly values using the CRU monthly maximum and minimum Ta data. In this way the monthly maximum and minimum Ta values (as well as their average) from our final product are exactly the same as those from CRU at each grid cell, while our product also provides the consistent hourly Ta data.

Data uncertainty is a crucial component of any products. In our study, the same adjustment procedure has also been applied to various reanalysis products. The differences of the hourly

Ta data (e.g., in mean values, variability, and trend) from the adjustment of different reanalysis products during the common period provide a measure of the uncertainty of our product.

In this talk, we will evaluate the diurnal cycle of various reanalysis products, discuss the detailed steps of our data development, compare our new product with prior efforts using the CRU monthly mean Ta alone for adjustment, and present the global and regional differences of the mean, variability, and trend using the monthly mean (based on maximum and minimum values) and true monthly Ta data (based on hourly values).

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