Global historic in situ upper air data for climate change research

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The lack of homogenized upper air records back to the 1900s has been identified by the Intergovernmental Panel on Climate Change (IPCC) 4th assessment report as *a major source of uncertainty that causes serious limitations in our ability to diagnose climate change.* Radiosonde data are available back to the late 1930s, tracked balloons are available in sizeable numbers back to the 1920s. There may, however, be numerous changes in instrumentation that cause inhomogeneities which must be adjusted before they can be used in reanalyses or for climate research. There is extensive literature about inhomogeneities in radiosonde temperature and one study has shown that hundreds of stations had erroneous north alignments of up to 20 degrees during at least some periods beginning with the 1960s. Similar errors must be expected from tracked balloons, which have so far not been extensively checked for inhomogeneities.

Radiosonde data pose special problems (daily data, very short intervals between breaks, annual cycles in difference time series) which must be dealt with in the homogeneity testing method. We are developing a homogenization method (RAOBCORE 2.0, based on the previous RAOBCORE) that makes use of the background forecasts of climate data assimilation systems (reanalyses such as ERA-40, ERA-Interim and the 20th Century Reanalysis) as reference for break detection. One advantage of using multiple background time series and analyzing multiple parameters is that we can get more confidence if breaks occur in several difference series. The method analyzes the time series of differences between these forecasts and the radiosonde observations (so-called background departures) with a variant of the Standard Normal Homogeneity Test that incorporates a priori information from station metadata, if they are available.
The main aim is develop a unified and automatic homogenization system that analyzes and adjusts upper air temperature, wind (speed and direction) and humidity datasets together, using background forecasts from reanalyses as reference. Analyzing all parameters together increases the likelihood of finding breaks since it is more likely that a break occurs in all parameters if it is found in the difference series of one parameter.
For break size estimation, the method calculates the difference between the means of the background departures before and after the break.

It can be also shown that the quality of radiosonde observations and fields from the 20th Century Reanalysis is good enough for certain homogenization purposes back to the 1900s. In addition to the reanalysis fields and input observations, we use the IGRA and CHUAN archives and the first challenge was to obtain a merged and homogeneous archive (more than 5 thousand stations all over the globe).
Working with radiosonde data before 1957 (mainly CHUAN archive) involves nasty problems as nonstandard observation times and altitude levels instead of pressure levels. We interpolated the data to pressure levels using the 20CR geopotential as additional information source. This preliminary operation leads to more variance in the difference series but the homogeneity tests are still sensitive enough to find many inhomogeneities.

The 20th century reanalysis unfortunately shows substantial differences and jumps relative to ERA-40 and ERA_Interim, especially in the upper troposphere and lower stratosphere that limit its value as a reference for homogenization. It needs to be carefully assessed in how far they can be used as reference for the adjustment of breaks in temperature and wind time series. One possibility to assess the uncertainties involved is to construct reference series for adjustments also from neighboring radiosonde or PILOT series. This is, however, particularly challenging in the early period since the station network was then rather sparse outside the US and Europe. Another possibility will be the availability of a surface data only reanalysis from ECMWF, developed in the ongoing EC 7th framework programme project ERA-CLIM.
A web based (Javascript) viewer has been developed that allows to visualize and compare different time series easily and quickly, see:

http://srvx7.img.univie.ac.at/~lorenzo/DEVL_rrvis_2.0/html/ .

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