Bias correction of radiosonde observations

Leopold Haimberger

University of Vienna
Althanstraße 14, 1090 Vienna, Austria
leopold.haimberger@univie.ac.at

1. Introduction

Radiosonde records contain valuable information for climate change research from the 1940s onwards. Since they are affected by numerous artificial shifts, time series homogenization efforts are required. For this purpose a new homogenization technique (RAOBCORE = RAdiosonde OBservation COrrection for REanalyses) that uses time series of temperature differences between the original radiosonde observations (obs) and background forecasts (bg) of an atmospheric climate data assimilation system (ERA-40) has been developed and applied to the global radiosonde temperature dataset (Haimberger 2006). The time series of the bg (from ERA-40 from 1958-2001 and from the operational ECMWF data assimilation system from 2001 onwards) are used as reference to homogenize the obs records. It adjusts not only artificial breaks in the radiosonde time series but also their climatologies. This step is required when equipment with nonnegligible temperature biases has been used even in the most recent part of the time series. In addition the seasonal cycle of the radiation error, which is particularly evident in polar regions and at longitudes near 90E and 90W, can be reduced by a method similar to the ERA-40 radiosonde bias correction system described by Andrae et al. (2004). As such the resulting dataset, which starts in 1958, is particularly suited as input for climate data assimilation efforts.

2. Results

In the period 1958-2005 more than 6500 breaks could be detected and adjusted in the radiosonde temperature dataset. Trends and day-night differences are spatially much more homogeneous after the adjustment. An example are temperature trends over Alaska for the period 1979-2004 at the 50 hPa level, shown in Fig. 1.

Spatial consistency is only one desirable goal of homogenization. The main aim of homogenization is the recovery of the natural climate signal (trends in particular) from the original records. With a series of sensitivity experiments it could be shown that RAOBCORE reduces the global mean stratospheric cooling trend evident in the unadjusted radiosonde dataset (row UNADJ in table 1), which is considered spuriously strong. The amount of reduction is, however, sensitive to the treatment of the ERA-40 background time series, which is used as reference for homogenization. Since the bg contains several breaks in the global mean and also exhibits almost no stratospheric cooling (which is not supported by existing upper air temperature products, see Fig. 3.4 in Karl et al. 2006), its global mean has been adjusted as described by Haimberger (2006). Using the adjusted background as a reference, the stratospheric cooling trends in the period 1979-2004 are reduced by 0.15K/decade in the global mean and by 0.25K/decade in the tropics (row RAOBCORE in table 1). If the adjustment of the global mean bg is not applied, the reduction of the stratospheric cooling in the adjusted radiosonde dataset is much stronger (row NOBGC). There is also more warming in the troposphere. Except for the too weak cooling of the tropical stratosphere the unadjusted bg is a possible alternative to the adjusted bg, particularly from 1990 onwards, when there is good correspondence between the undadjusted bg and upper air temperatures derived from radiances of the Microwave Sounding Unit (MSU). The difference between the two realizations RAOBCORE and NOBGC must therefore be interpreted as uncertainty. It is about as large as the known uncertainty of existing upper air radiosonde and satellite-derived datasets Karl et al. 2006).

3. Conclusions and recommendations

The RAOBCORE homogenization method could improve the global radiosonde dataset in various aspects, particularly in terms of spatial consistency of both trends and day-night differences. Since RAOBCORE relies on the ERA-40 background forecasts as a reference, it is sensitive to breaks or spurious trends in the bg. Some inhomogeneities could be identified in the global mean obs-bg time series (Haimberger 2006), but already the attribution of these to the radiosondes or to the background is problematic. Even if the bg can be identified as error source (studies like Uppala et al. 2006 are helpful in this respect), the spatial structure of the adjustment to be applied remains uncertain. Therefore the global mean trend uncertainty of the RAOBCORE dataset is the order of 0.3 K/decade for the 50-100 hPa level of 0.05 K/decade for the tropospheric layer mean, which is similar to other homogenized radiosonde datasets. In order to reduce it, the properties of the bg and the satellite observing system used in ERA-40 must be analyzed further.

The homogenization method could adjust many breaks in the pre-satellite era and seems well suited for the adjustment of even earlier records, collected e.g. by Bronnimann (2003). In order to have a homogenized radiosonde dataset ready from 1939 onwards, it appears useful to perform a pilot data assimilation for the period 1939-1958. The collected obs-bg departures would be quite beneficial for homogenization purposes. There are ongoing activities to apply RAOBCORE to wind data as well. Several inconsistencies in the radiosonde winds could already be identified. Radiosonde wind adjustments appear again particularly useful for the early years where many ascents delivered only PILOT soundings.

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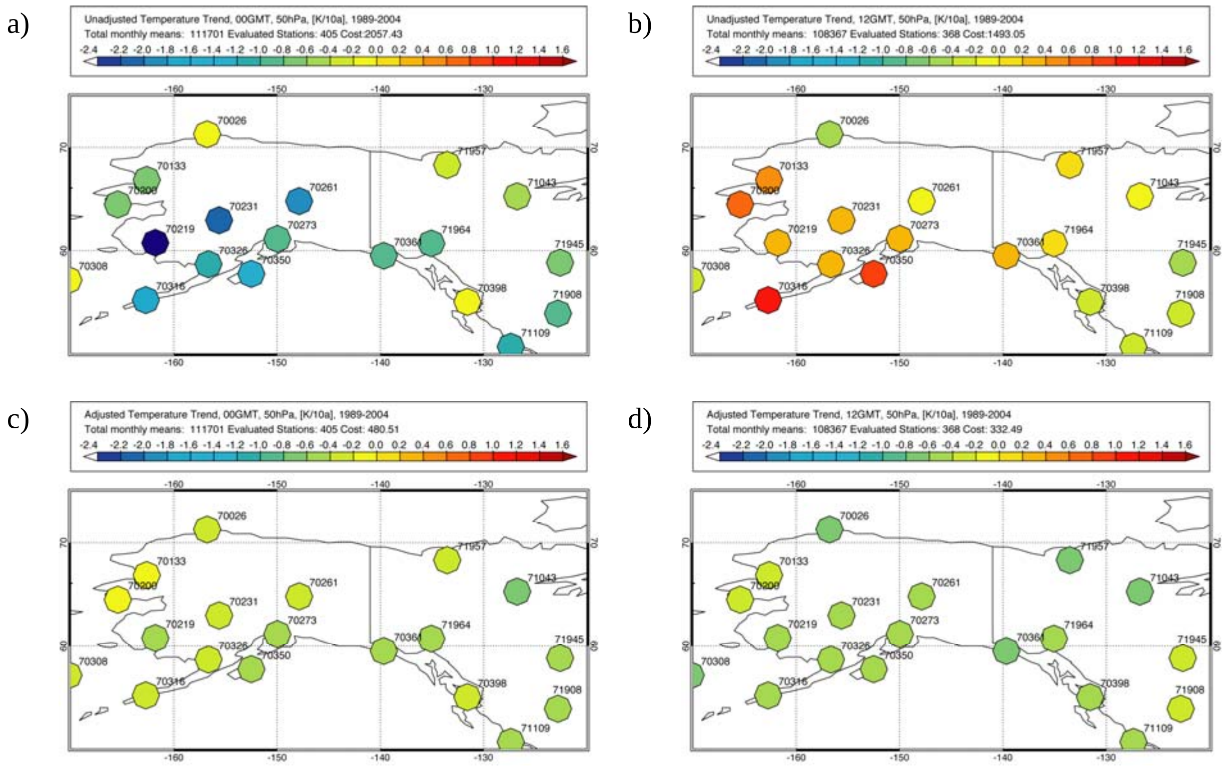

Figure 1: Radiosonde temperature trends 1989-2004 in K/decade over Alaska/Northern Canada at 50 hPa. a) unadjusted obs(00GMT) time series, b) from unadjusted obs(12GMT), c) from adjusted obs(00GMT) and d) from adjusted obs(12GMT). Numbers are WMO stationIDs.

Table 1: Results from sensitivity experiments with RAOBCORE. Trends in K/decade for Globe and Tropics (in braces) valid for period 1979-2004. Break count is total number of breaks detected, including about 760 adjustments of climatologies

Acronym	**Description**	**50-100 hPa Trend**	**300-850 hPa Trend**	**Break Count**
UNADJ	Unadjusted radiosondes	-0.83(-0.94)	0.09(-0.01)	
RAOBCORE	RAOBCORE best estimate	-0.68(-0.69)	0.10(0.02)	6505
NOBGC	No adjustment of bg	-0.42(-0.31)	0.15(0.06)	6367