Quality Control of Selected Historical Radiosonde Temperature Observations from 1948 – 1966

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1 Introduction

Presently available reanalysis products largely lack of estimates on their uncertainty. Despite this limitation, the geoscientific community makes heavy use of those products in terms of an uncontested reference for the mean climate state at a given location [x,y,z] and time [t].

In order to give an estimate about the uncertainty in the reanalysis at each grid point, it is worth comparing the reanalysis with independent observations, particularly during the data-sparse years prior to 1966. This again requires a thorough assessment of the errors within these observations. This poster presents first steps in both the uncertainty analysis of the observations as well as in their comparison with the NCEP/NCAR (NNR) reanalysis.

The Comprehensive Historical Upper Air Network (CHUAN; [4]) was used to extract a sample pair of homogenized radiosonde records from different station networks. Table 1 gives a survey of the sources of errors in these observations.

Uncorrected errors	Corrected errors in CHUAN
Uncorrected radiation, $\sigma_{rad,u}$	Radiation, σ_{rad}
Uncorrected lag, $\sigma_{lag,u}$	Lag, σ_{lag}
Interpolation (from the significant points to pressure levels), σ_{interp}	Changes in station location
Instrumentation, σ_{instr} – consisting of error terms for the sensor *cali*bration, *proc*essing procedures, *balloon* shape, temperature *sensor*, and *misc*ellaneous additional minor sources of uncertainty.	Changes in station instrumentation
Pressure (altitude) error, σ_{alt}	

Table 1. *Sources of errors in radiosonde data.*

2 Error Concept

$$\sigma_{obs} = \sqrt{\sigma_{instr}^2 + \sigma_{alt}^2 + \sigma_{interp}^2 + \sigma_{rad,u}^2 + \sigma_{lag,u}^2} \leq \sqrt{(0.9\ \mathrm{K})^2 + (0.15\ \mathrm{K})^2 + (0.2\ \mathrm{K})^2 + (0.8\ \mathrm{K})^2} \approx 1.23K \qquad [1]$$

$$\sigma_{instr} = \sqrt{\sigma_{calib}^2 + \sigma_{proc}^2 + \sigma_{balloon}^2 + \sigma_{sensor}^2 + \sigma_{misc}^2}$$

The observation error σ_{obs} [x,y,z,t] can be expressed as the square root of the sum of the variances of the individual (independent) error contributions. The error terms are explained in Table 1. Note that the total error estimate of 1.23 K determined in [1] is valid for the worst case only, i.e. for the potentially highest uncorrected lag and radiation error of 0.8 K. An alternative error estimate is presented in box 3.

When performing a linear correlation between two stations from different networks (box 4), the standard deviation of the residuals σ_{res} corresponds to the sum of the square roots of the observation errors of both stations, plus an error term σ_{rep} for the representativeness:

$$\sigma_{res} = \sqrt{\sigma_{obs,1}^2 + \sigma_{obs,2}^2 + \sigma_{rep}^2} = \sqrt{(2.46\ K)^2 + \sigma_{rep}^2}$$

3 Station Selection and Metadata

Selection

- Daily mean observations from radiosonde stations Jokioinen (Finland, 23.48E, 60.82N) and Tallinn (Estonia, 24.8E, 59.42N) (Figure 1)
- Different station networks
  → $\sigma_{obs,1}$ is independent of $\sigma_{obs,2}$
- Overlap in observations from 1957-01-01 till 1966-12-31
- Climatological and spatial distance rather small
  → low σ_{rep} in the free atmosphere

Metadata

- Changes in sonde types are known, but specific error values were not retrieved (Table 2)
  → station comparison may yield rough estimates to sonde type differences
- Standard deviation of the Finnish sonde observations with respect to other available sondes depending on day/night ascent and pressure level: $0.8 \leq \sigma_{obs,FI} \leq 1.2$ [5]

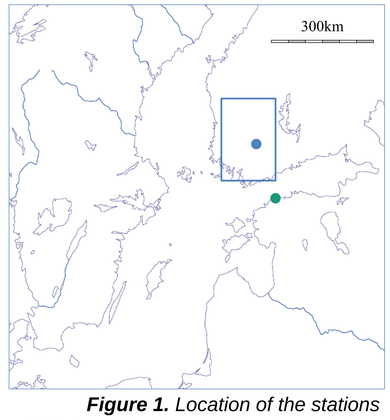

Figure 1. *Location of the stations Jokioinen (blue) and Tallinn (green). The blue rectangle frames the approximate location of the NNR gridcell (see box 4).*

Jokioinen			Tallinn	
Year	Sonde type	Misc. events	Year	Sonde type
1957	Vaisala RS11	Change in observation time from 02 & 14 UCT to 00 & 12 UTC?	1957	RZ049
1959	Vaisala RS12		1958	A22
1960	**Vaisala RS38**	Vaisala RS38 erroneous	1960	**RZ049**
1966	Vaisala RS13/15			

Table 2. *Metadata events and their corresponding year of occurrence. Sonde types in bold are additional sondes used in parallel to the previous models at the given year. Radiation corrections were introduced to stations within the former Soviet Union in 1962 [2,3].*

4 Results and Outlook

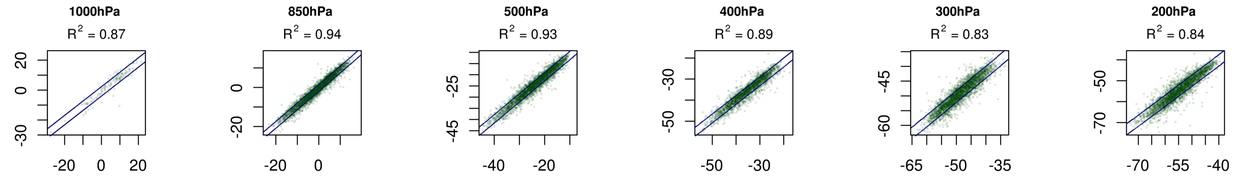

Figure 2. *Scatterplots of daily mean temperature observations on selected pressure levels for station pair Jokioinen – Tallinn. Blue lines indicate the 2σ spread of the residuals from the linear regression of both data sets. The given coefficients of determination are valid for the respective pressure levels. Axes in units of K.*

Station – Station

- Figure 2 shows the residuals; their standard deviation is shown in Fig. 3
  → overall agreement is good
- Pressure error increases with altitude and peaks at 50 hPa (Figure 3)
  → error is most likely explained by the different instrumentation
- High standard error of the temperature at 1000 hPa due to σ_{rep}
- Derive σ_{rep} at tropopause from the more pessimistic estimate of σ_{obs}

  $\sigma_{rep,50hPa} = \sqrt{\sigma_{res,50hPa}^2 - (2.46\ K)^2} = \sqrt{2.91^2 - 2.46^2} K \approx 1.55\ K$

  → Instrumentation error was probably underestimated for that height; might be due to a higher error of the observations in Tallinn
- Low resolution of vertical profile obscures variability at PBL / inversions

Station – NNR

- Station data was not or only partly (since 1962) assimilated into NNR
- Shows better agreement (Figure 3 & 4)
  → is valid for the selected grid cell only
- σ_{res} is smaller than for station-station comparison (R^2 higher)
- Lack of uncertainty estimates in the reanalysis
  → if σ_{rep} was known, the uncertainty in the reanalysis would correspond to the uncertainty in the observations [x,y,z,t]

Outlook

- Establish comprehensive database of uncertainty in CHUAN
- Compare CHUAN with reanalyses and reconstructions
- Create an atlas of the comparisons

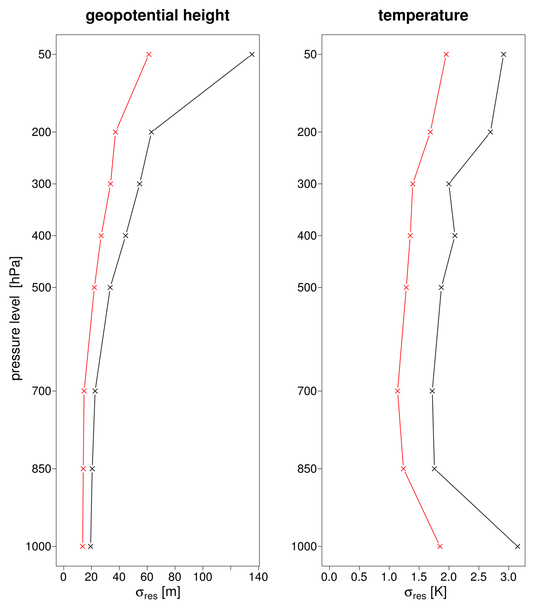

Figure 3. *Standard error of the residuals of both temperature and geopotential height for station-station regression (black) and station-NNR regression (red).*

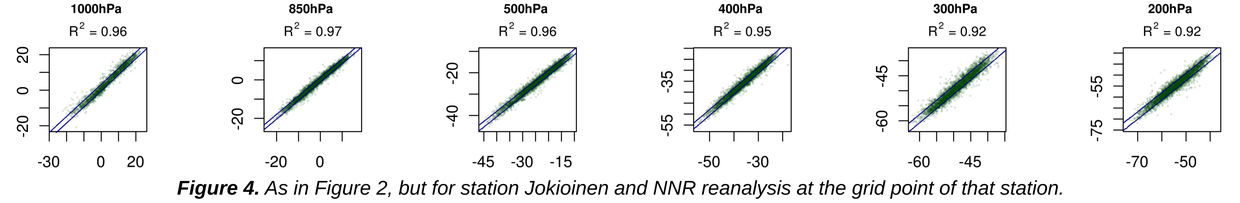

Figure 4. *As in Figure 2, but for station Jokioinen and NNR reanalysis at the grid point of that station.*

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