Preliminary results on number of comparisons to estimate the temperature bias in RS92 -> RS41 transition

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Introduction

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- To see this we have to understand the variability of in-situ differences
  $$dT = T^{41} - T^{92}$$
  at a certain altitude, and its standard deviation, say σ_{dT}.
- We will see that historical data may be used to assess σ_{dT} and hence to compute the number of observations needed to estimate the bias.

Summary

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- Preliminary results about Temperature in Lindenberg
- Some suggestions for the Management of change plan

In-situ intercomparisons

In principle in-situ intercomparisons may be based on various sampling plans. I focus here on two alternatives:

1. Odd Even days difference (OED) based on alternate soundings from the same station

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1. Odd Even days difference (OED) based on alternate soundings from the same station

$$dT_i = T^{41}_{2i+1} - T^{92}_{2i}$$

2. Dual soundings (DS) difference based on two sensors on the same baloon

$$dT_i = T^{41}_i - T^{92}_i$$

Bias estimate

- We assume that bias is additive and possibly related to some auxiliary variables x, so that

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$$T_i^{41} = T_i^{92} + b\left(x_i\right).$$

- The bias estimate is the sample average of n paired observations $\bar{dT}_n$
- The uncertainty of this estimate depends on the assumptions on dT.

Using historical data for σ^2_{dT}

Since we do not have historical observations of T^{41}, we can assume

$$b = 0$$

and use historical data of $RS92$ data only for assessing σ^2_{dT}.

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We consider the following assumptions[1] on dT:

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- Case 1 dT i approximately Gaussian, stationary and NOT autocorrelated (iid)
- Case 2 dT is NOT Gaussian distributed
- Case 3 dT is stationary and autocorrelated
- Case 4 σ^2_{dT} is NOT constant, being a function of x

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Uncertainty of dT - Case 1

If dT_i are incorrelated and $\bar{dT}_n$ can be assumed Gaussian than

$$Var\left(\bar{dT}_n\right) = \frac{\sigma^2_{dT}}{n}$$

and σ^2_{dT} can be easily estimated by the sample variance of dT_i.

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- For example, if $\sigma_{dT} = 1K$, and $\varepsilon = 0.2K$, the number of comparisons is given by:

$$n \geq \left(\frac{1.96 \times 1}{0.2} \right)^2 \cong 100$$

Case 2 - Non Gaussian comparisons

If dT_i are not Gaussian we have to consider this when we perform individual computations such as individual uncertainty assessment of the type

$$|dT| < k\sigma_{dT}$$

and/or when we compute simulations about dT.
If the degree of non normality is high, bias should be estimated using robust methods and the concept of uncertainty can be hardly based on the std σ.

Case 3 - Autocorrelated comparisons

If dT_i are stationary but autocorrelated above formulas do not hold, because, the lack of independence inflates the uncertainty. Indeed we have

$$Var\left(\bar{dT}_n\right) = \frac{\sigma^2_{dT}}{n}\left(1 + 2\sum_{i=1}^{n}\frac{n-i}{n}\rho\left(i\right)\right)$$

where $\rho\left(i\right)$ is the autocorrelation of dT at lag i.

Case 4 - Nonstationary comparisons

If dT_i are incorrelated but not stationary we may have that

$$Var\left(\bar{dT}_n\right) = \sigma^2\left(t\right)$$

and/or

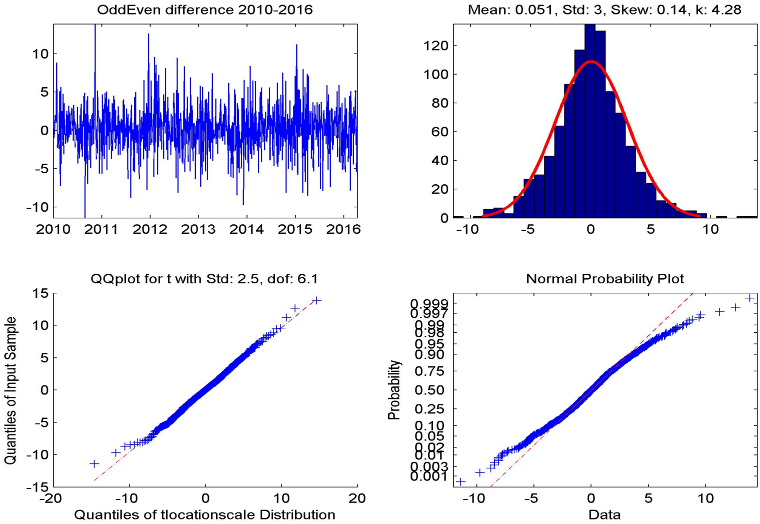
$$Var\left(\bar{dT}_n\right) = \sigma^2\left(x_t\right)$$

where x_t are ancillary information.

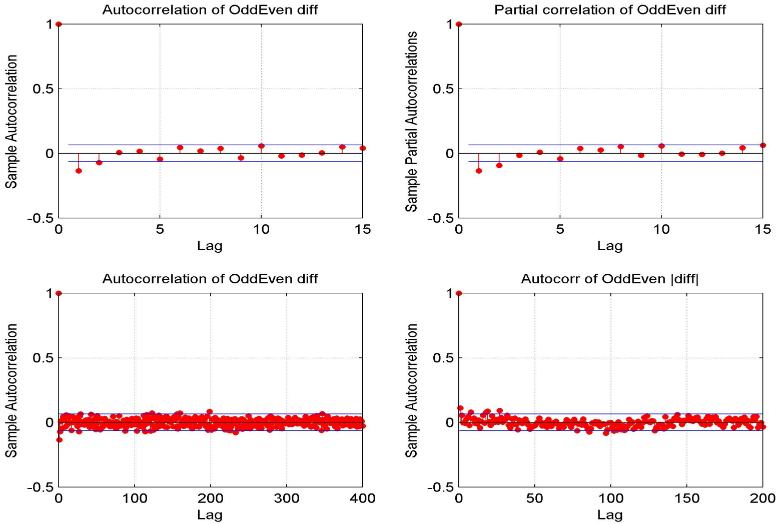
Lindenberg case study

Preliminary results on temperature at 12:00am, 300 *hPa*,
years 2010-2016
without ancillary information
main focus on OED apporach

Dsitribution of OED



Autocorrelation of OED



Case 1 - OED Lindenberg

For the OED approach we have

$$\sigma_{dT} = 3K.$$

and

$$n \geq \left(\frac{1.96 \times 3}{0.25}\right)^2 \cong 554$$

comparisons, that is about 3 years under the above *OED* sampling plan.

Case 1 (cont.)

IN THE IDEAL CASE, environmental variation is reduced using the twin soundings (DS) then

$$\sigma_{dT} = \sqrt{2}\sigma_T$$

where σ_T is the GRUAN standard deviation.
In the above Lindenberg case the average std at 300 hPa is $0.18K$ hence,

$$\sigma_{dT} = \sqrt{2}\sigma_T \cong 0.26K$$

and, using $\varepsilon = 0.1K$, we have

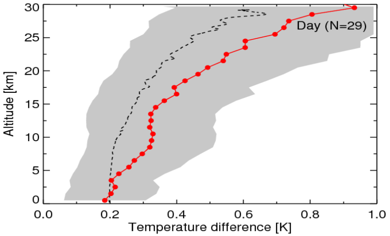
$$n \geq \left(\frac{1.96 \times 0.26}{0.1}\right)^2 \cong 26$$

or about one month for daily twin comparisons.

Case 1 (cont.)

σ_{dT} (K)	estimation error (K)	n of comparisons	estimation error (K)	n of comparisons	estimation error (K)	n of comparisons
3	0,1 *	3458	0,25	554	0,5	139
1,5		865		139		35
1		385		62		16
0,7		189		31		8
0,26		26		5		2

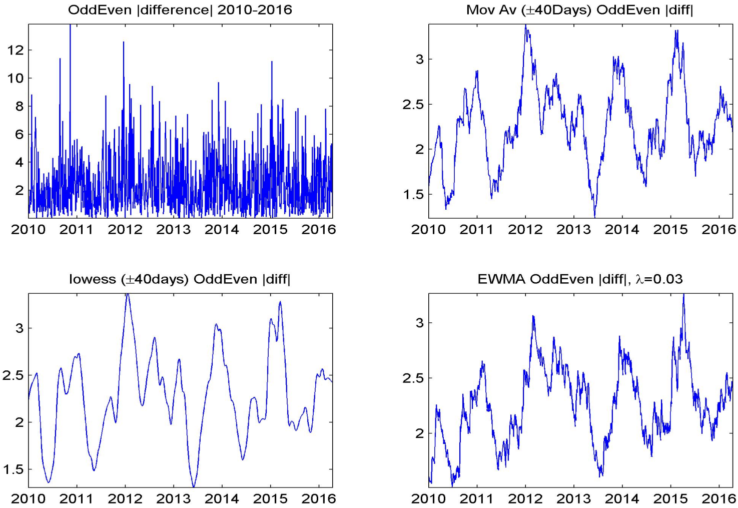
* Instrument resolution



[2]

[2] Figure is a courtesy of Ruud Dirksen (Dirksen et al. (*AMT*, 2014)

Case 4 - Smoothing absolute differences



Conclusions, Further developments and Suggestions for management of change

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- Using historical data is useful to understand comparison uncertainty and estimate the comparison duration in order to achieve a certain precision in bias estimation.
- OED soundings are chip but could have large uncertainty and hence long comparison duration.

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- Full profile using e.g. functional statistics as in Fassò et al. (*AMT*, 2014).

Management of change

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- A case/control analysis may help understanding the validity of the intercomparison champaign.
- Hence, in addition to twin soundings and OED soundings RS92-RS41,
  I suggest also some "control" twin soundings 92-92 (partialy available as above) and 41-41.

THANKS FOR YOUR ATTENTION