VERA-QC, approved Data Quality Control based on Self-Consistency

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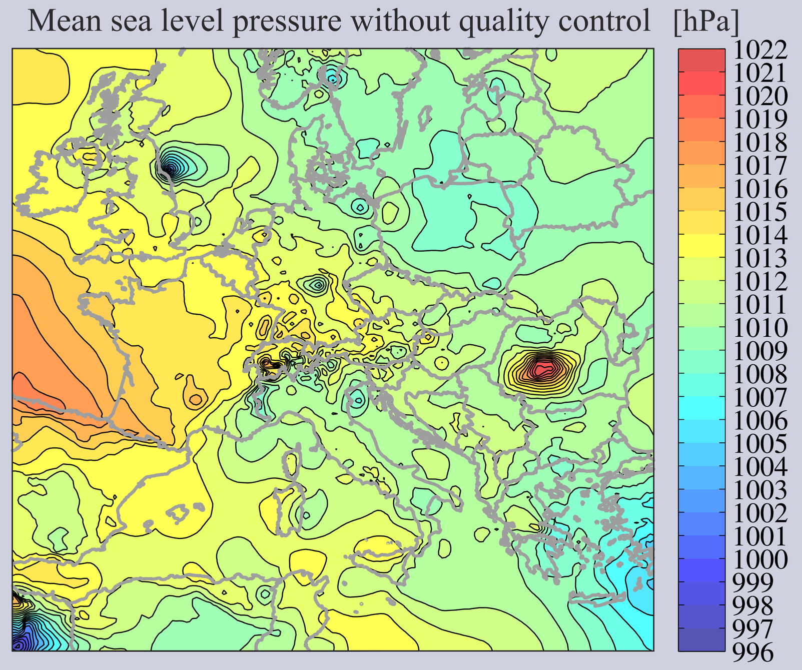
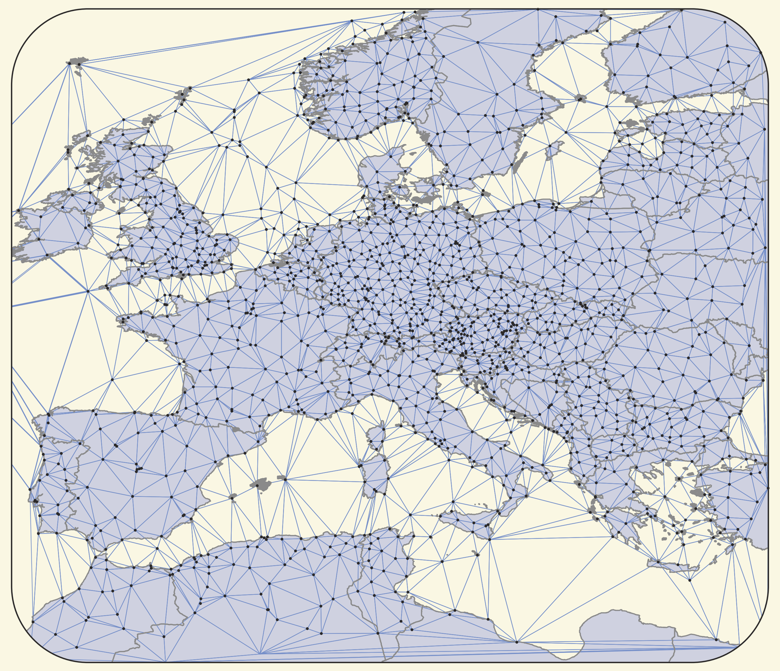
TROUBLESOME DATA?



1) MOTIVATION



Positions and connecting lines of reporting GTS weather stations on 17th February 2012, 1800 UTC.

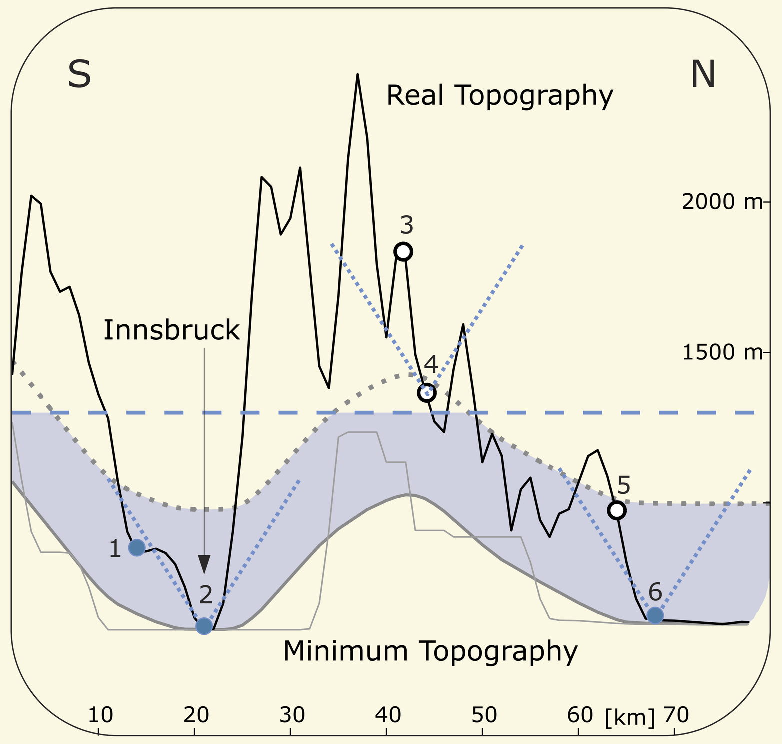
- Measurements are not always as accurate as required.
- Observations of high quality are indispensable for:
  - Generation of analyses
  - Nowcasting
  - Model verification
  - Collecting long-term time series
- Therefore, the quality control algorithm VERA-QC was developed.

2) METHOD

p_{red}, θ, θ_e, u, v, RR

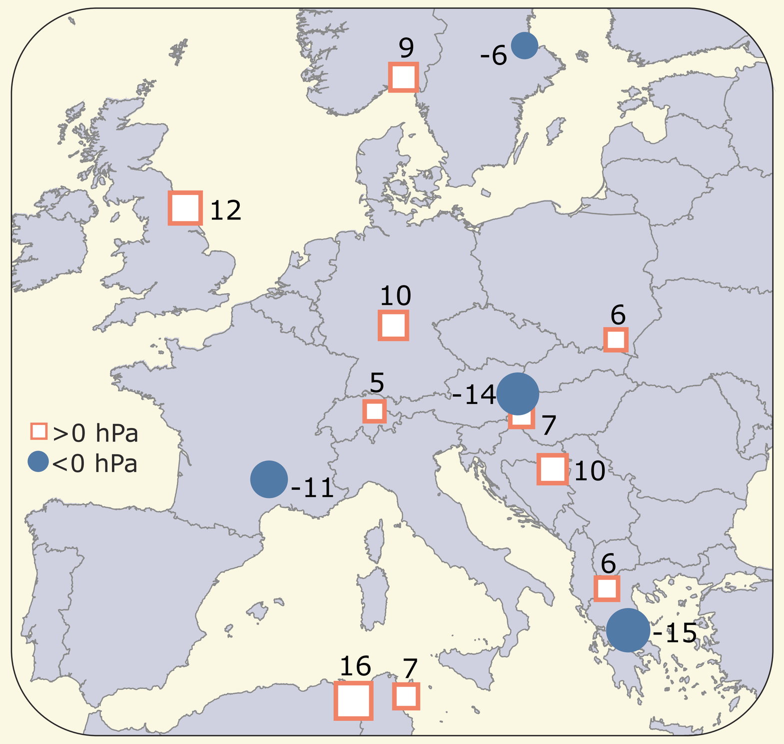
Station selection algorithm → Bias correction → Consideration of relative values → Limit check → Check for self-consistency (includes cluster treatment and gross error recognition) → Application of corrections → Statistics

2.1) Station selection algorithm



Only representative stations for valleys and plains are accepted (here: stations numbered 1, 2, and 6).

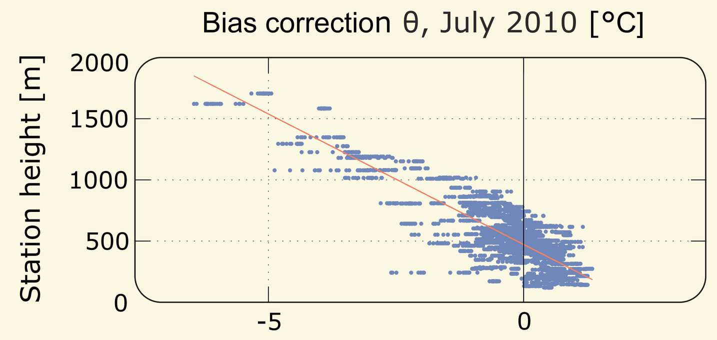
2.2) Bias correction



MSL-pressure bias for 31st July 2010. The bias correction is defined as median of a station's unweighted correction proposals collected within a parameter specific time interval in the past (e.g. the last 30 days).

2.3) Consideration of relative values

For avoiding a negative θ-bias for higher stations, relative values in comparison to the standard atmosphere are considered.



Strong dependence on height is due to the usage of dry-adiabatic lapse rate for computing θ.

2.4) Check for self-consistency

For parameters ψ featuring a high redundancy with regard to the observational network, the error free analysis field ψ_a should be smooth.

- A cost function J consisting of the squared curvatures C of the analysis field is to be minimized:

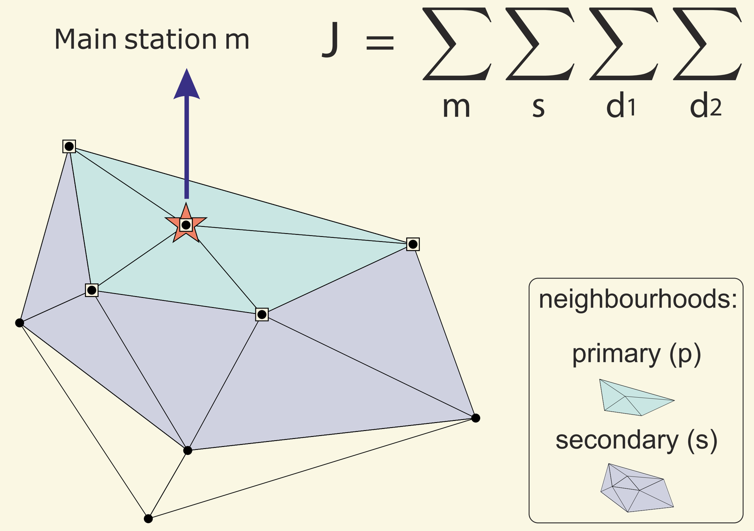
$$J(\Psi_a) = \sum_{n}^{N(G)} (C_{\Psi_a})_n^2 \rightarrow \min$$

Problem: ψ_a and its curvature are unknown

- $C(\psi_a)$ is approximated by a first order Taylor series around the curvature of the observed field $C(\psi_o)$:

$$J = \sum_m \sum_s \sum_{d_1} \sum_{d_2} \left[\frac{\partial^2 \Psi_o}{\partial d_1 \partial d_2} + \sum_p \frac{\partial}{\partial \Psi_p} \left(\frac{\partial^2 \Psi_o}{\partial d_1 \partial d_2} \right) \Delta\Psi_p \right]_s^2$$

unknown deviations



Exemplary station distribution illustrating the concept of finding natural neighbors

- For obtaining the unknown deviations, the cost function is differentiated with respect to all m observations ψ:

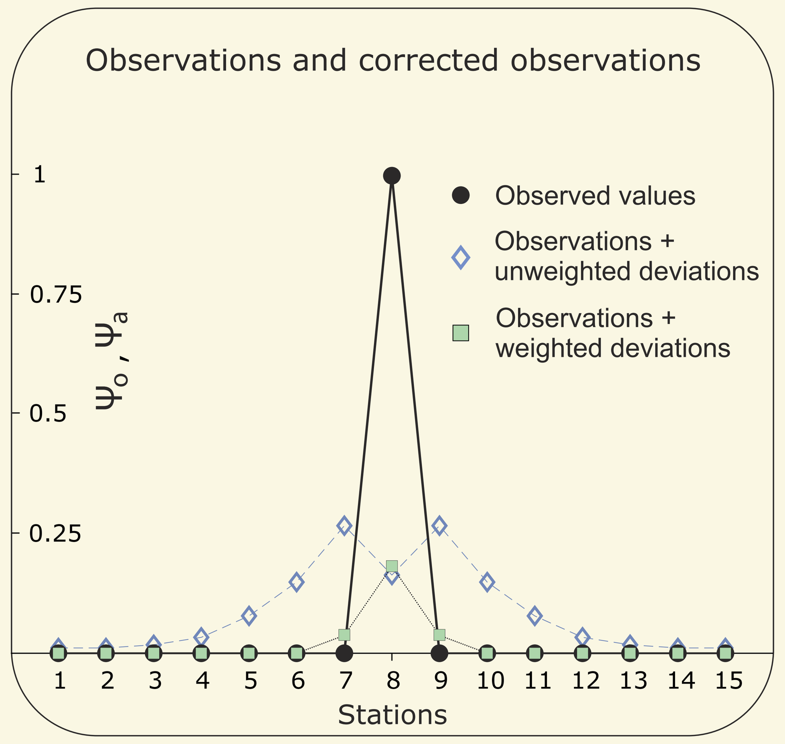
$$\frac{\partial J}{\partial \Psi_m} = 0$$

- Deviations are weighted according to the reduction of cost function they induce:

$$\Delta\Psi_{m,w} = W_m \cdot \Delta\Psi_m$$

$$W_m = \frac{J(\ldots,\Psi_m,\ldots) - J(\ldots,\Psi_m + \Delta\Psi_m,\ldots)}{J(\ldots,\Psi_m,\ldots)}$$

- A special cluster treatment allows applying the weighting method to station-clusters.

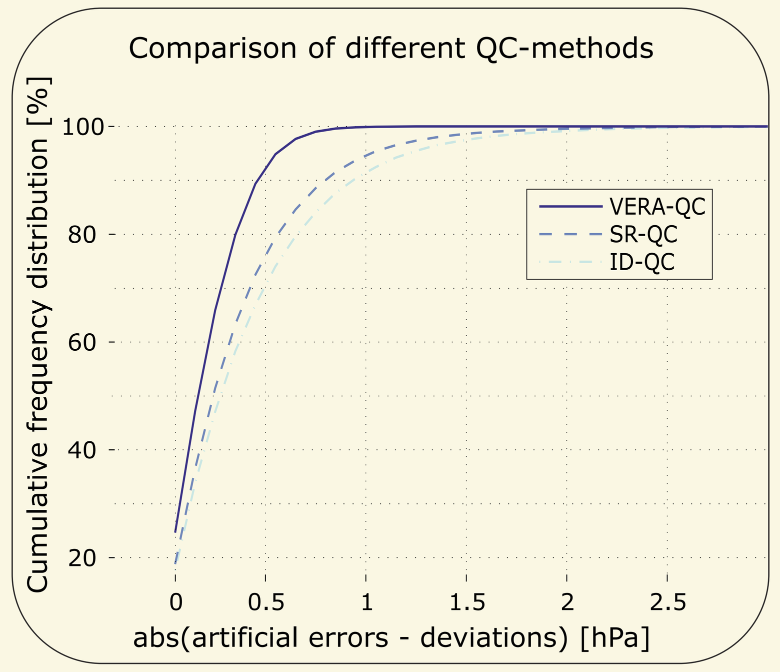


One-dimensional example of 15 stations, whereas no. 8 is an outlier. The application of weighted deviations results in satisfying error-correction without producing an error-propagation to neighboring stations.

- Weighted deviations constitute the basis for a decision tree:

$|\Delta\Psi_{m,w}| > th_1 \cdot \overline{|\Delta\Psi_w|}$ & $|\Delta\Psi_{m,w}| > th_2$ deviation statistics
- yes → gross error, discard observation
- no → $|\Delta\Psi_{m,w}| > th_3$
  - yes → correct observation by weighted deviations
  - no → accept observation as it is

3) EVALUATION OF METHOD



For comparison, a series of simulated pressure fields covering coastal, plain and alpine stations was generated. All three QC-methods were optimized in favor of best handling these cases.

VERA-QC is compared to two other spatial consistency checks using inverse distance (ID) and spatial regression (SR) interpolation.

Gross error recognition VERA-QC / SR-QC

		SIMULATED: GE	SIMULATED: no GE
RECOGNIZED	GE	689 / 680	3 / 13
RECOGNIZED	no GE	11 / 20	32497 / 32387

4) CONCLUSIONS

Primarily, VERA-QC proved itself as valuable preprocessing tool for the operational real time VERA analyses that also support forecasters of the Austrian aviation weather service (ACG, Austro Control GmbH).

References

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Mayer, D., R. Steinacker and A. Steiner: Innovations and Applications of the VERA Quality Control. submitted to: *Geoscientific Instrumentation, Methods and Data Systems*

VERA analyses of quality controlled meteorological observations: http://www.univie.ac.at/amk/veraflex/test/public/

Acknowledgments

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PROBLEM SOLVED!