

Spatio-temporal consistency of the stochastic component of the ZTD time series over Europe

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Introduction:

1. Accuracy of meteorological applications, climate studies, and numerical weather prediction **depends on the quality** of the **zenith total delay** (ZTD) series.
2. Suggestions have been made that **ZTD quality** should even be treated as an **additional input** variable.
3. The character and quality of ZTD series are affected by several **uncertainties** related to the processes and models used to estimate them.
4. GNSS processing strategies **vary among analysis centers**.
5. ZTD parameters used in climate analyses, i.e., trends and seasonal signals, **remain almost unaffected** after changing the processing strategy – this is **encouraging!**
6. **Effect on the stochastic component** of the ZTD time series and its spatiotemporal properties **has not yet been addressed**.

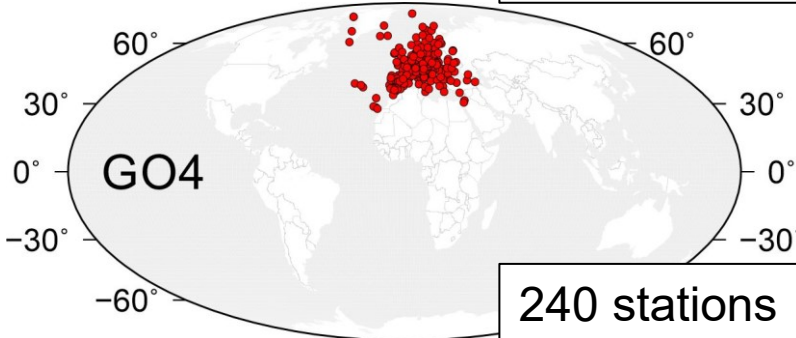
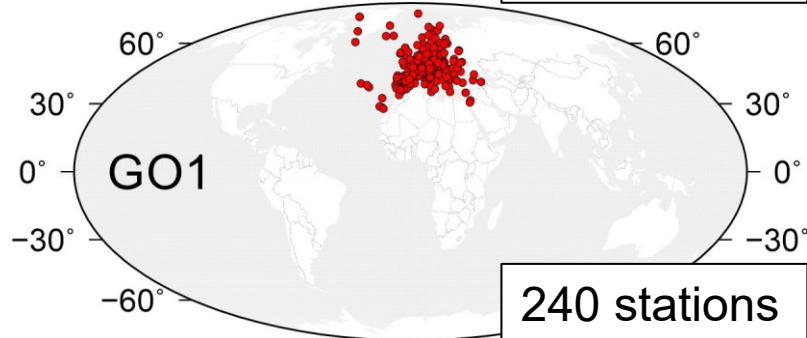
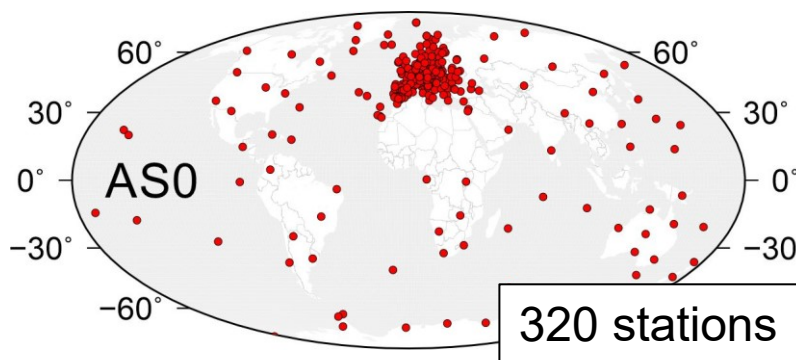
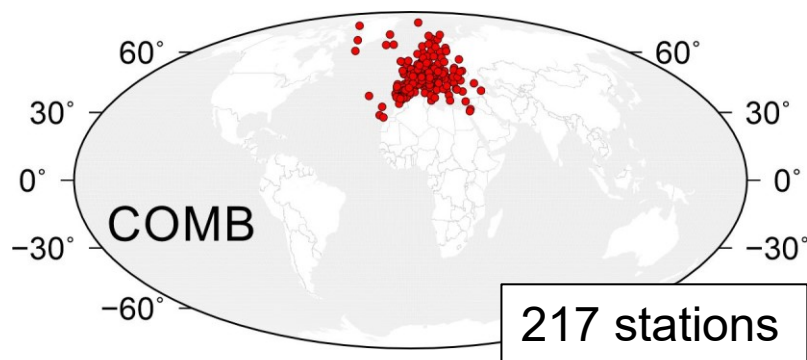
Datasets:

1. Four sets of ZTD time series produced within the framework of the EPN:

a) AS0: Centro di Geodesia Spaziale G. Colombo (ASI),

b) GO1 & GO4: Geodetic Observatory Pecny (GOP), and

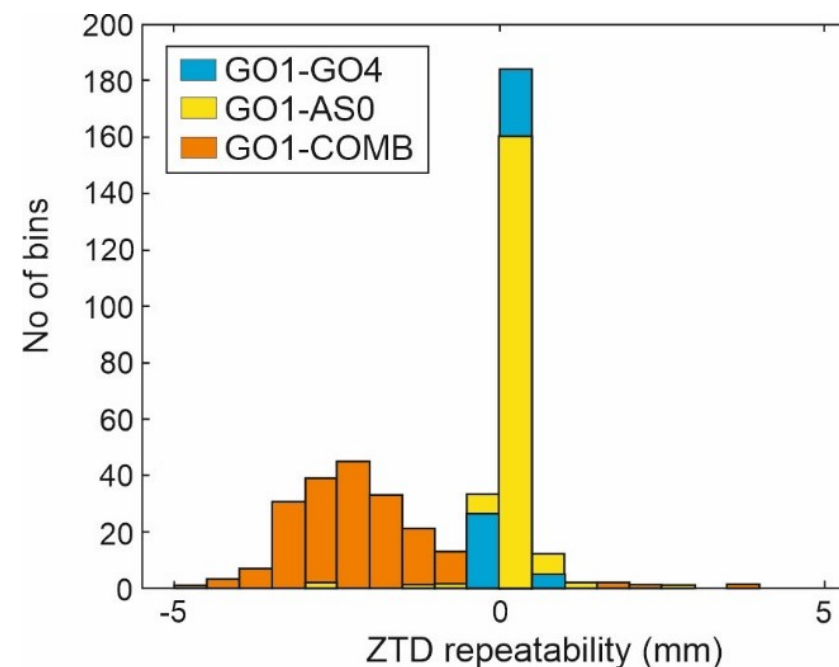
c) COMB: combined solution resulting from the second reprocessing campaign, EPN Repro-2.



Analysis Center	AS0	GO1	GO4
Software	GIPSY 6.2	Bernese 5.2	
GNSS system	GPS	GPS	
Solution type	PPP	Network	
Stations	Full EPN + IGS core stations	Full EPN	
Mapping functions	VMF	VMF1	VMF
Non-tidal atmospheric loading (NTAL)	No	No	Yes (model from TU Vienna)

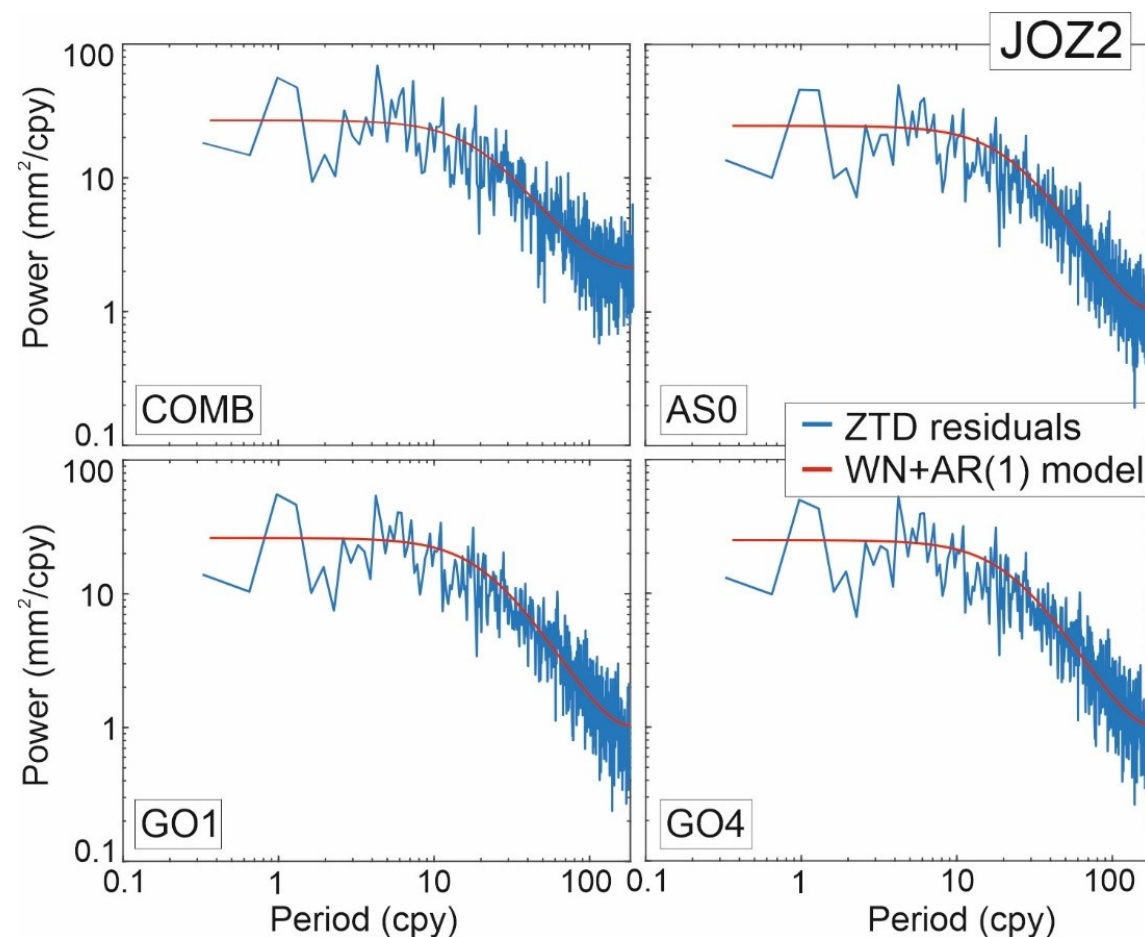
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 - c) COMB: combined solution resulting from the second reprocessing campaign, EPN Repro-2.
2. ZTD residuals are produced with least-squares estimation (trend, four seasonalities, manual iterative homogenisation).
3. **Consistency of solutions** examined for ZTD residuals.



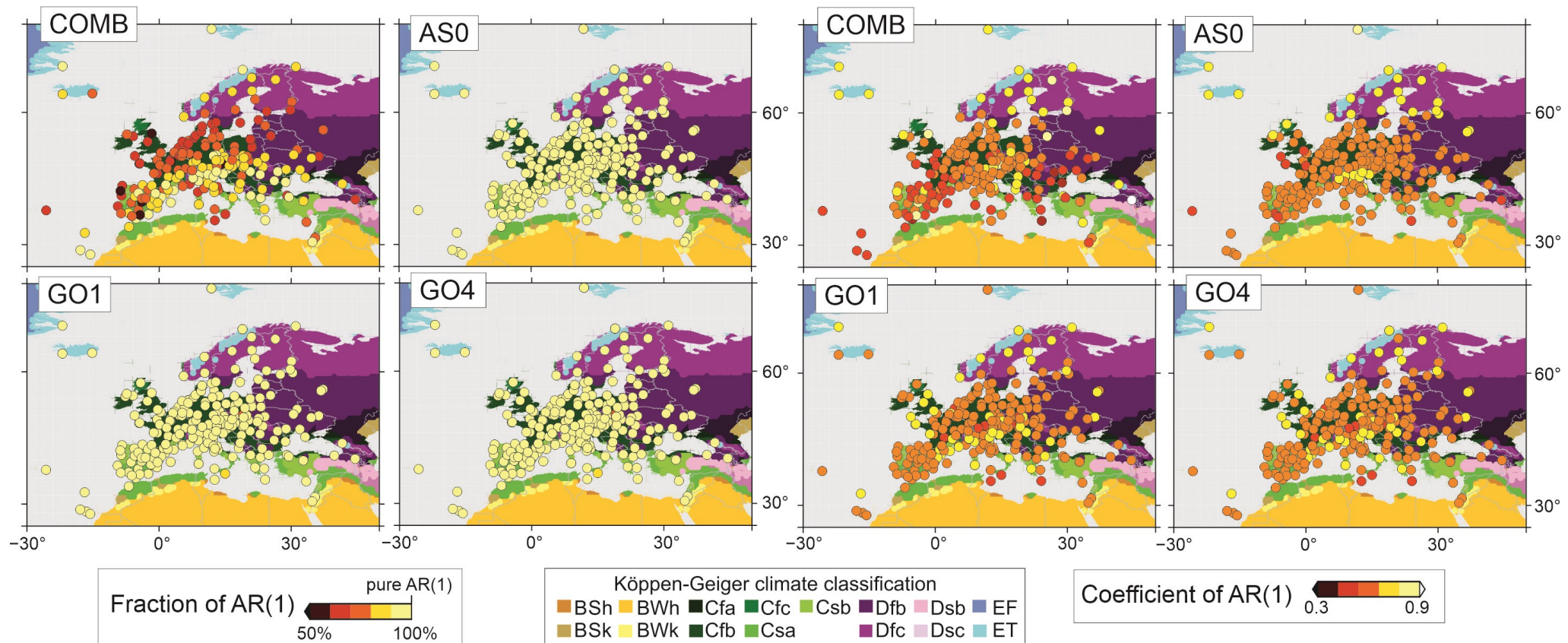
Temporal correlation:

1. Time-correlated variations in the ZTD residuals studied assuming white process combined with an autoregressive process (WN+AR(1)).



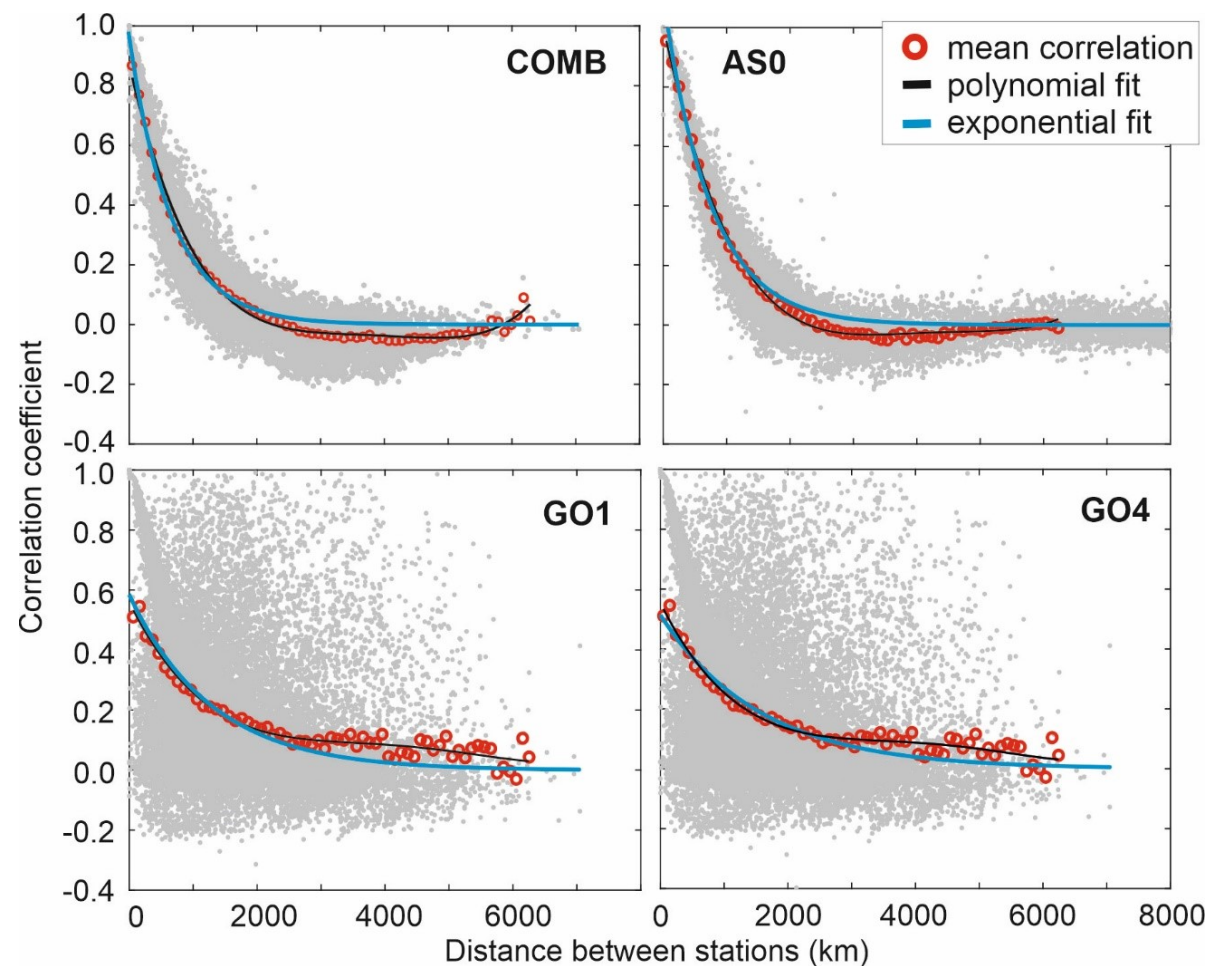
Temporal correlation:

1. Time-correlated variations in the ZTD residuals studied assuming white process combined with an autoregressive process (WN+AR(1)).
2. Combination **reduces the signal** for individual stations.



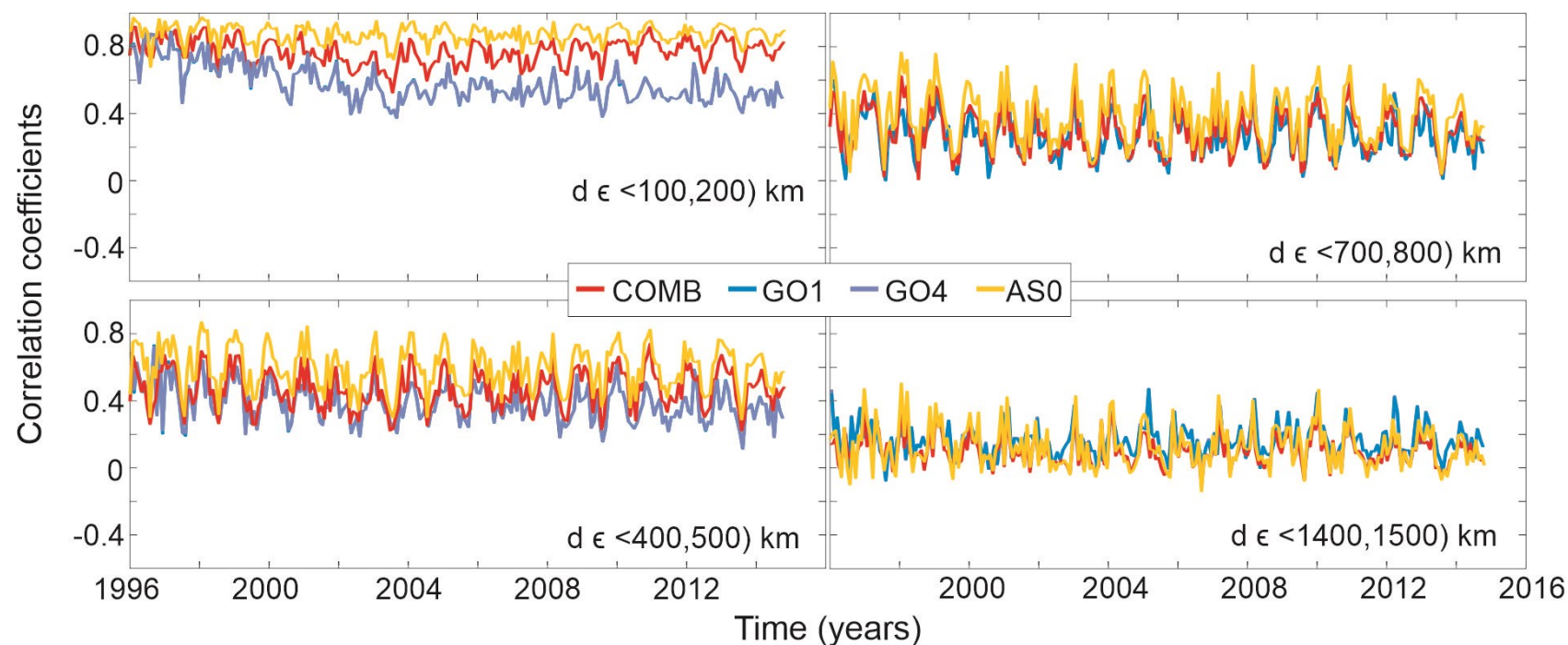
Spatial correlation:

- Correlation coefficients estimated for **all station pairs** for individual solutions, averaged for 63 equal distance classes of $d=100$ km (red dots).



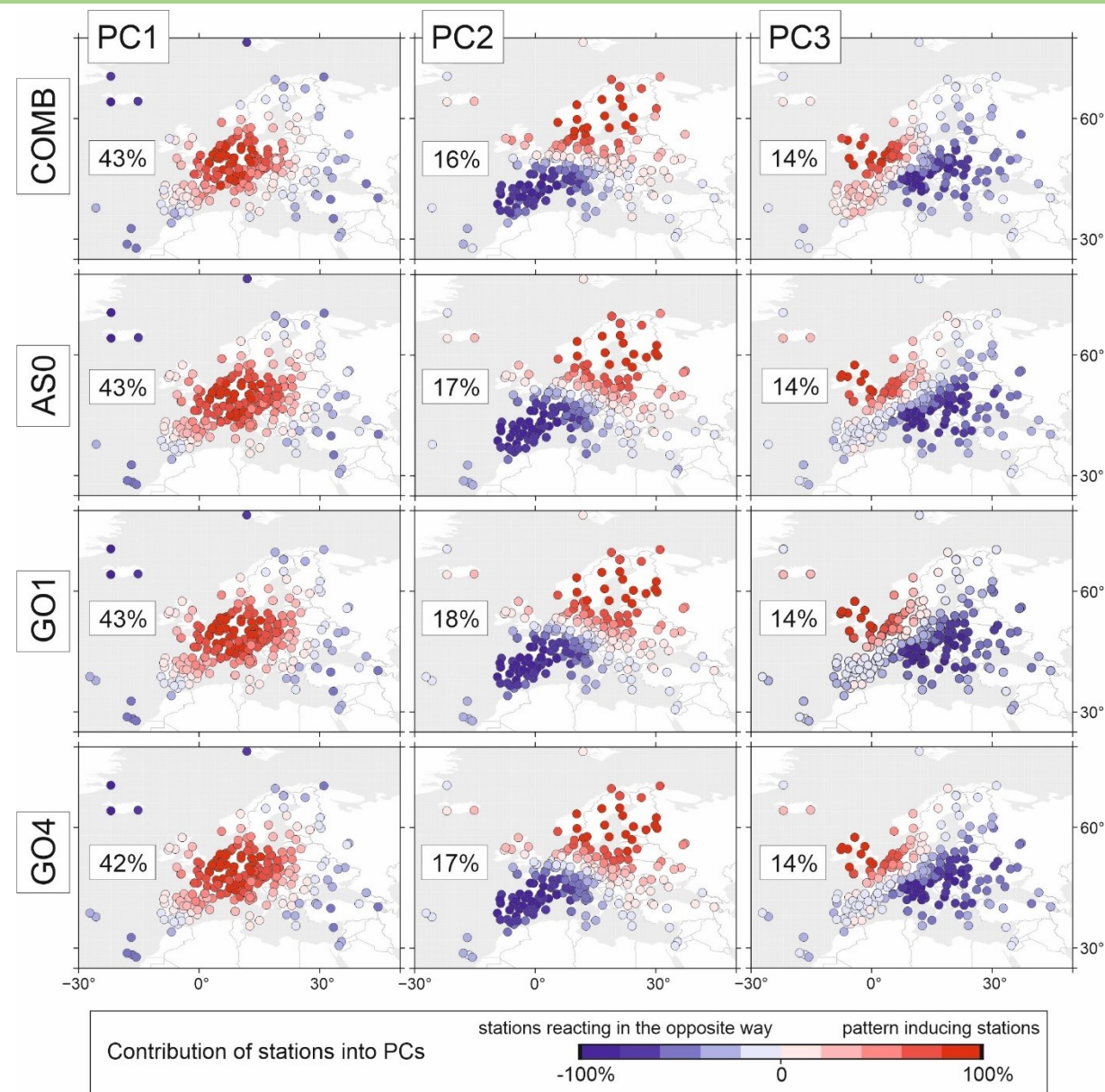
Spatial correlation:

1. Correlation coefficients estimated for **all station pairs** for individual solutions, averaged for 63 equal distance classes of $d=100$ km (red dots).
2. Spatial correlation coefficients **change with time**.
3. Clear **annual oscillations** with a maximum in January from the shortest distances up to 1,000 km.



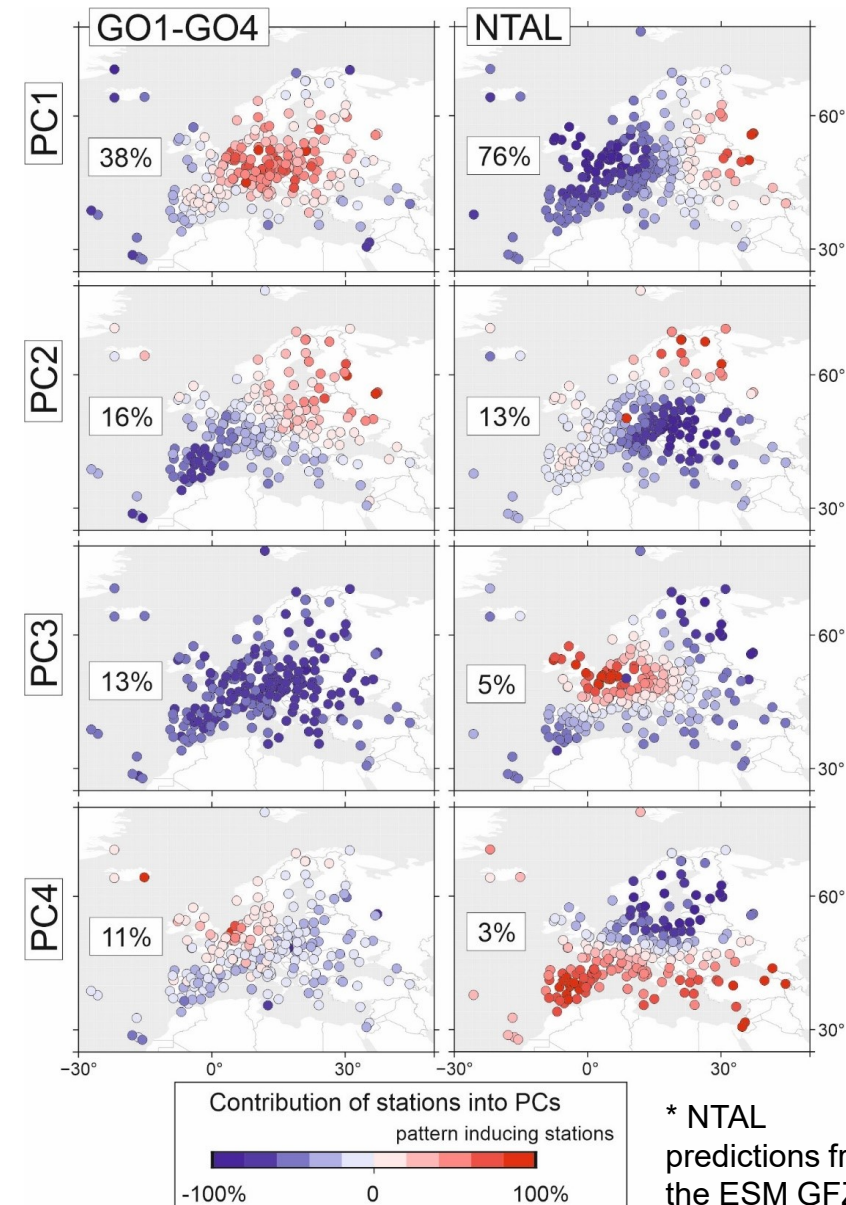
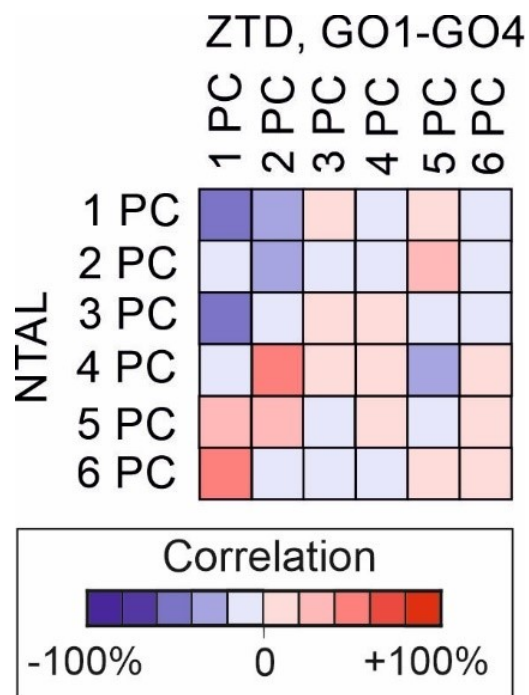
Spatial correlation:

1. ZTD residuals are examined using the pPCA approach.
2. First 3 PCs explain variance higher than 10%.
3. Significant (and high) correlation between PC levels from different solutions.
4. Responses to the 1st PC: most likely related to the barycenter of the EPN network or a continental-level response to variability in weather conditions.
5. Physical spatial properties of ZTD residuals remain intact between COMB and other solutions.
6. No significant difference between GO1 and GO4 solutions: no NTAL impact?



Impact of unmodelled NTAL:

1. GO1 and GO4 residuals differ in unmodelled NTAL.
2. No significant correlation noticed for the corresponding levels and between different levels.
3. This confirms the robustness of ZTD residuals with respect to the application of NTAL.



Conclusions:

1. ZTD residuals from the combined solution **are not consistent** with the ZTD residuals from the individual analysis centers; different temporal characteristics.
2. Correlation coefficients of the ZTD residuals estimated for station pairs **are time-varying** and **dependent on the distance** between stations. Causes? Intrinsic property of atmospheric variability or imperfections in physical models.
3. Spatiotemporal patterns present in the ZTD residuals over Europe **are consistent** between solutions and are also **physically meaningful**; combination procedure is not affecting spatiotemporal patterns.
4. Finally, omitting the non-tidal atmospheric loading (NTAL) model has a **negligible effect** on the ZTD residuals.

**THANK YOU VERY MUCH
FOR YOUR ATTENTION!**