Improving GNSS Zenith Wet Delay interpolation by utilizing tropospheric gradients: Results from the dense station network in Japan

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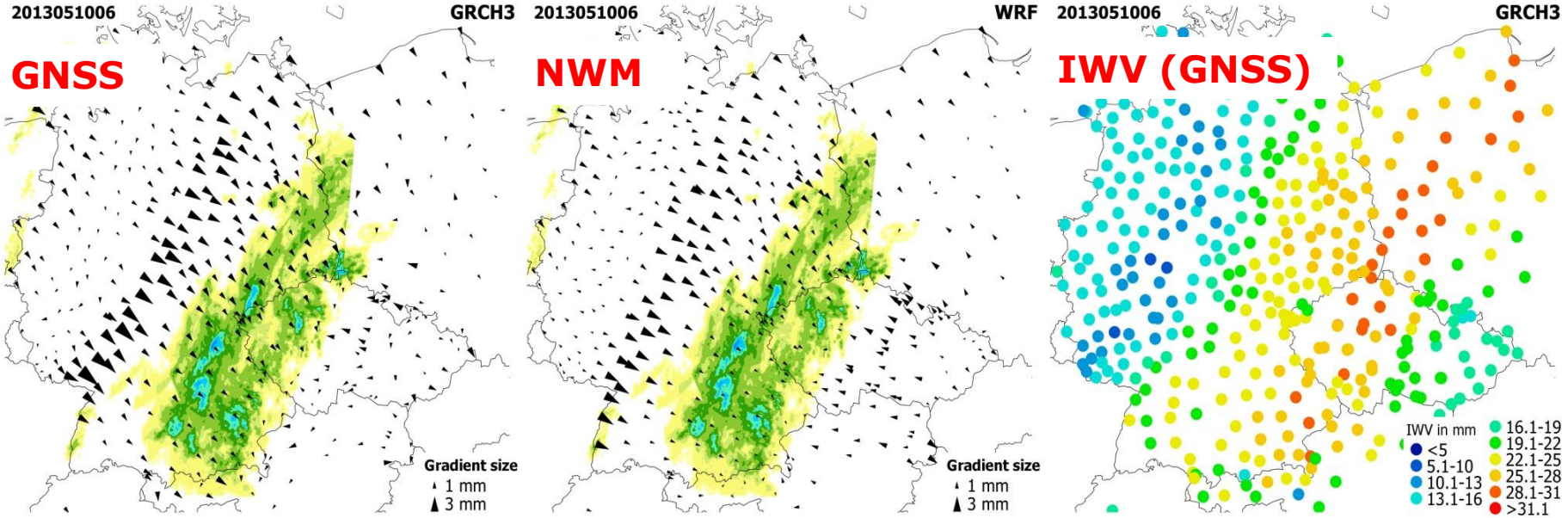
Tropospheric Gradients

Example from the benchmark campaign within the European COST Action ES1206:



Tropospheric Gradients point from dry to moist areas; they are related to horizontal Zenith Wet Delay (ZWD) gradients.

Therefore, can we improve ZWD interpolation?

Previous Work

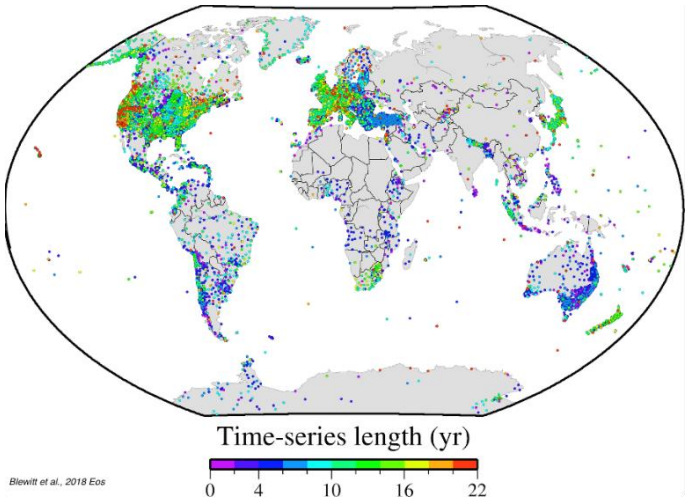
Zus, F.; Douša, J.; Kačmařík, M.; Václavovic, P.; Balidakis, K.; Dick, G.; Wickert, J. Improving GNSS Zenith Wet Delay Interpolation by Utilizing Tropospheric Gradients: Experiments with a Dense Station Network in Central Europe in the Warm Season, Remote Sensing 2019, 11, 674.

"… To do this we first prove the concept with simulated observations, that is, zenith delays and tropospheric gradients derived from a Numerical Weather Model. We show how tropospheric gradients can be converted to ZWD gradients. Then the ZWD gradients together with the ZWDs at selected reference stations are used in an inverse distance weighting interpolation scheme to estimate the ZWD at some target station. For a station configuration with an average station distance of 50 km in Germany and a period of two months (May and June 2013), we find an improvement of 20% in interpolated ZWDs when tropospheric gradients are taken into account. Next, we replace the simulated by real observations, that is, zenith delays and tropospheric gradients from a Precise Point Positioning (PPP) solution provided with the G-Nut/Tefnut analysis software. Here we find an improvement of 10% in interpolated ZWDs when tropospheric gradients are taken into account …"

This Work

- More than 1200 stations in Japan, average distance 20 km (GEONET)
- ZTDs (Zenith Total Delays) and Tropospheric Gradients from NGL:

  Blewitt, G.; W. C. Hammond; C. Kreemer
  Harnessing the GPS data explosion for interdisciplinary science, Eos 2018, 99

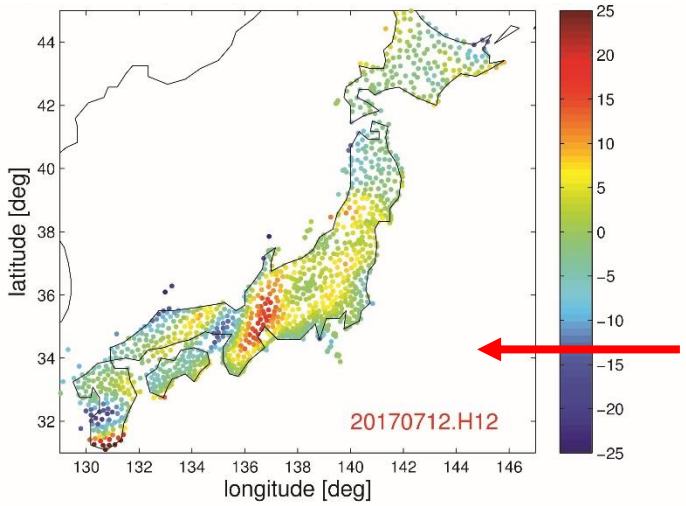


- Auxillary data, i.e., Zenith Hydrostatic Delays and Hydrostatic Gradients, are derived from the atmospheric reanalysis ERA5 (pressure, temperature and humidity fields are available every hour with a horizontal resolution of 0.25°)

The rest (interpolation method etc.) is the same as in previous work.

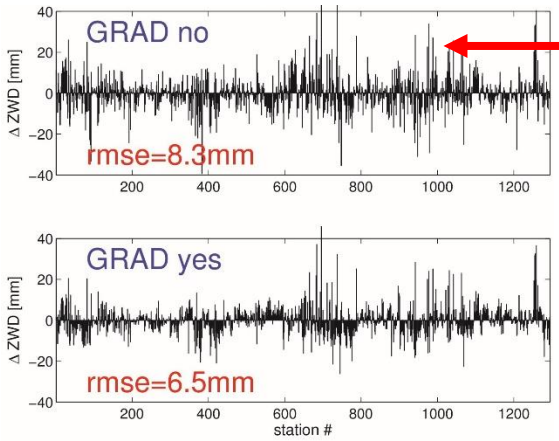
Case study: 12 July 2017 at 12 UTC

NWM



We start the investigations with NWM data. The purpose of utilizing simulated data is to prove the concept.

ZWD differences [mm] for the two interpolation strategies (with and without tropospheric gradients).

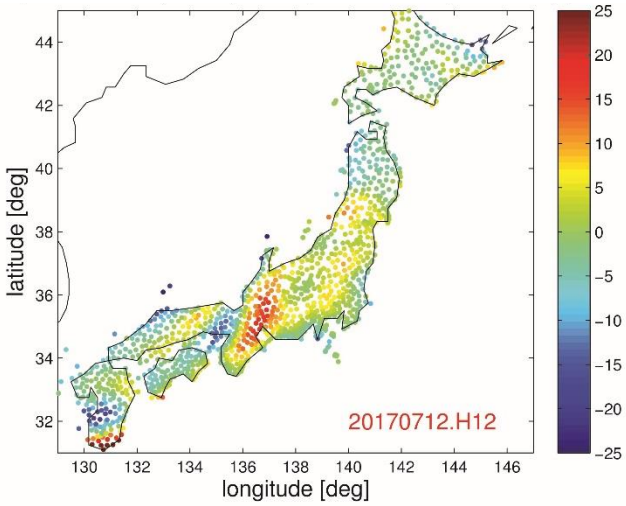


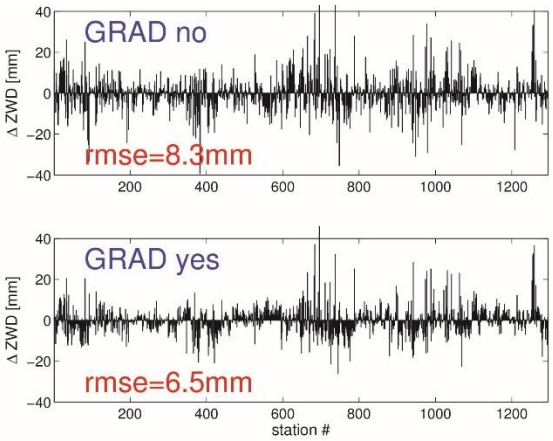
Upper panel: The ZWD errors when tropospheric gradients are not taken into account. Lower panel: The ZWD errors when tropospheric gradients are taken into account.

Improvement: 21%

Note: Improvement means reduction in rmse

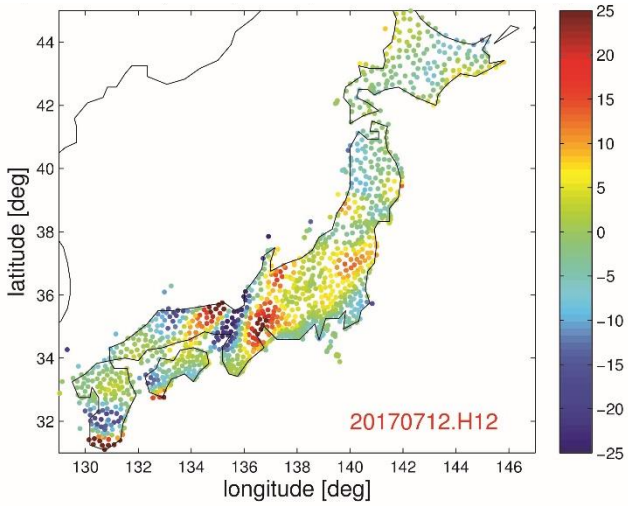
NWM

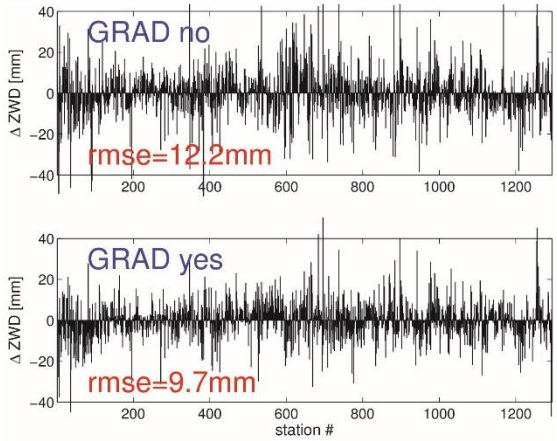




Improvement: 21%

GNSS

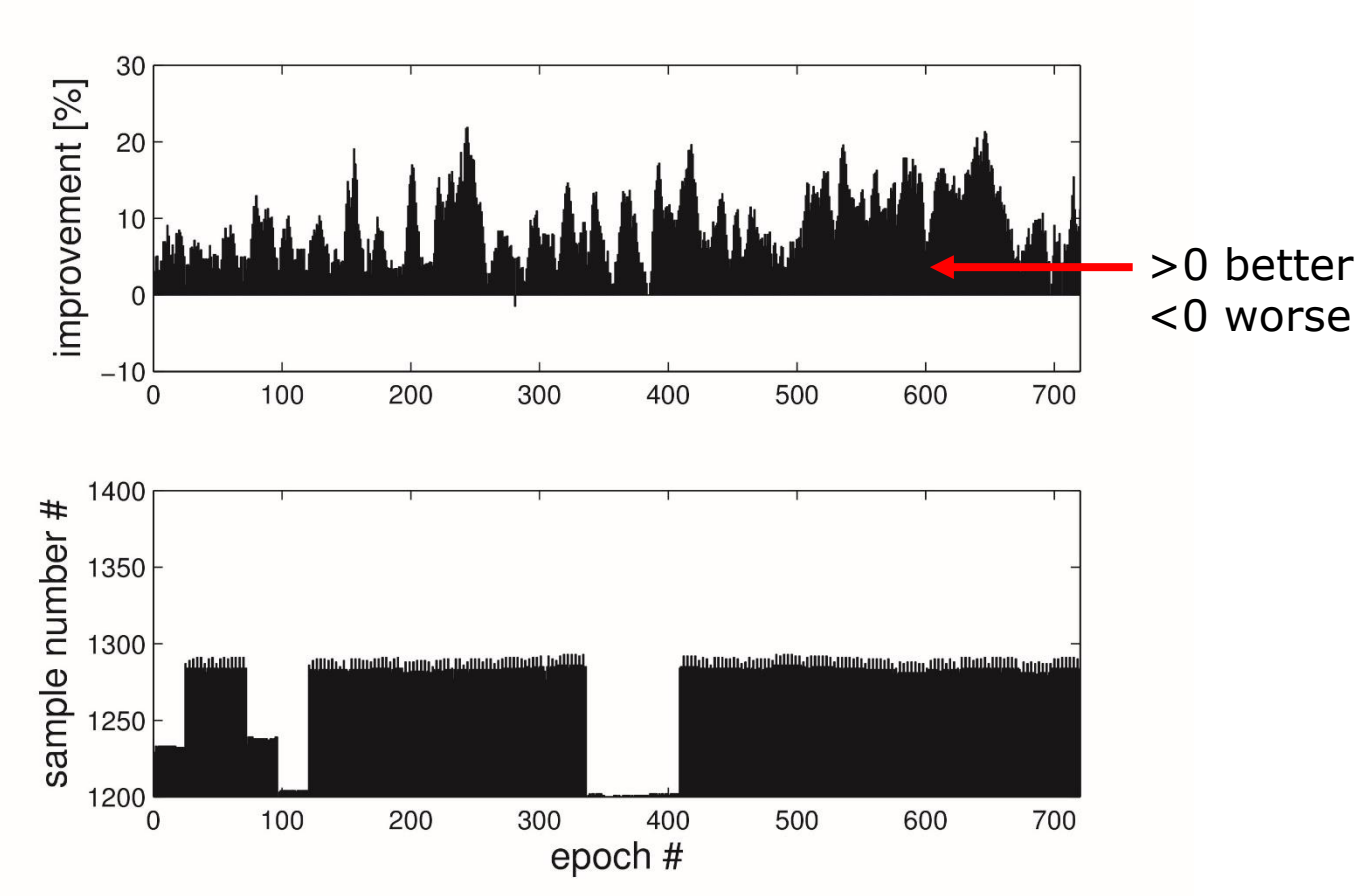




Improvement: 19%

Can we demonstrate such improvement for any epoch?

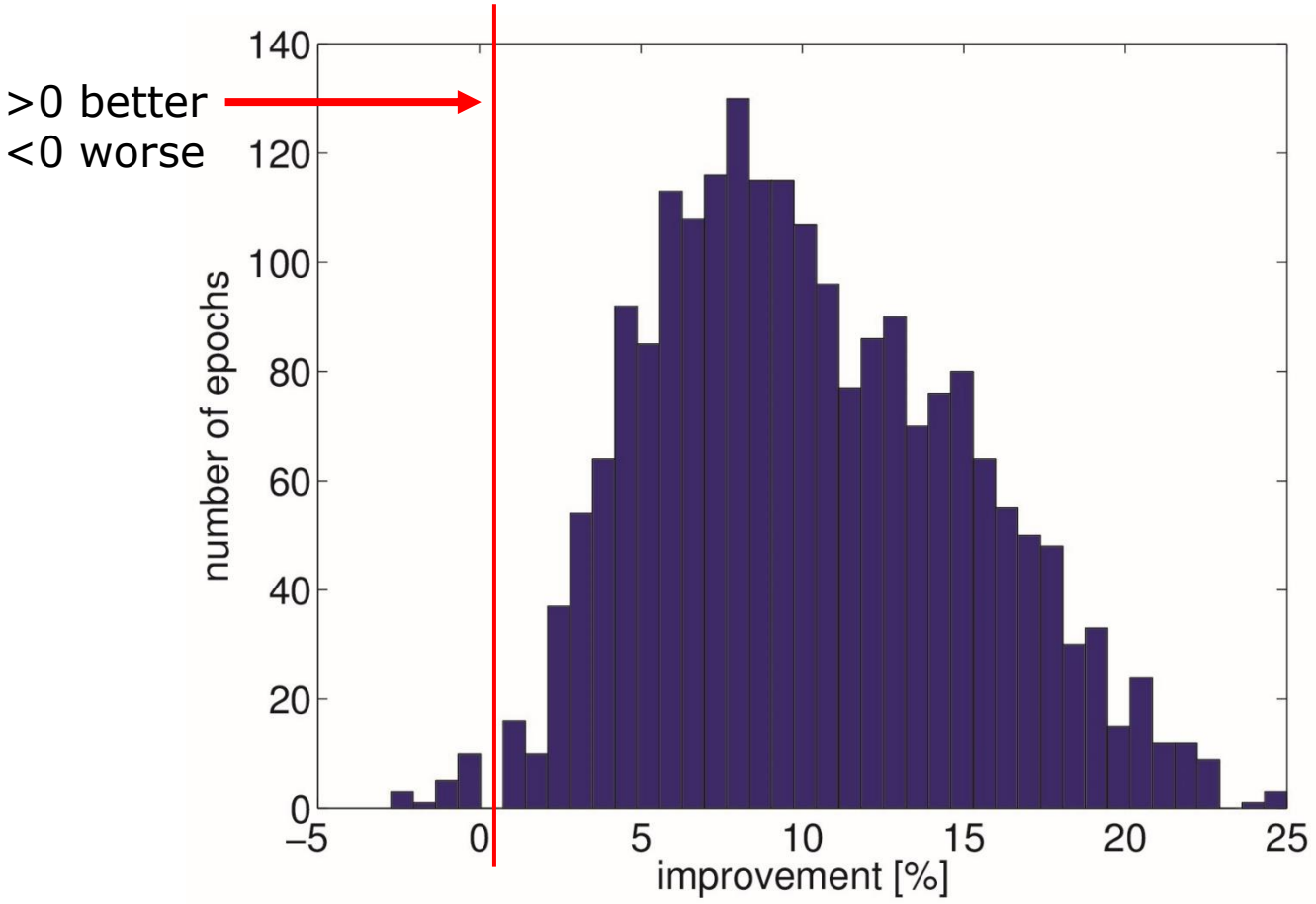
June 2017 (every hour)



Average improvement: 9%

Note: sample number means test station number

June, July and August 2017



Average improvement: 10%

Conclusion and Outlook

- We find an improvement of 10% in interpolated ZWDs when tropospheric gradients are taken into account and this is consistent with our previous work
- ZTDs are of high quality (this is known for a very long time now), the quality of tropospheric gradients can be certainly improved
- We will derive IWV fields (GNSS IWV Imaging)
- If we can improve the IWV field (2D), can we improve the WV field (3D)? We will assimilate ZTDs and tropospheric gradients into a NWM; first experiments started:

Zus, F.; Douša, J.; Kačmařík, M.; Václavovic, P.; Dick, G.; Wickert, J. Estimating the Impact of Global Navigation Satellite System Horizontal Delay Gradients in Variational Data Assimilation, Remote Sensing 2019, 11, 41

Thank you for your attention!