Geodesy and Geospatial Engineering

VAPOUR

UNIVERSITÉ DU LUXEMBOURG

Luxembourg National Research Fund

EGU

# Analysis of GNSS sensed slant wet delay during severe weather events in central Europe

Addisu Hunegnaw, Hüseyin Duman, Gunnar Elgered, Yohannes G. Ejigu, Jan Dousa, Norman Teferle

**Abstract ID**:EGU22-12589
**Session**: NH1.4: Extreme meteorological and hydrological events induced by severe weather and climate change
**Date and Time**: Thu, 26 May, 08:53–08:59 | Room - C

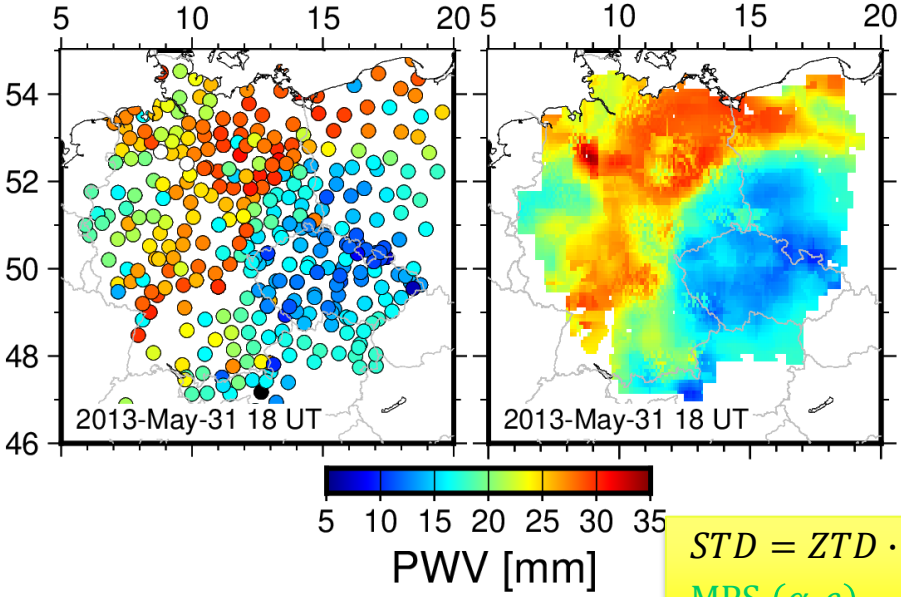
Presentation at EGU, Vienna, 26 May 2022, Session NH 1.4

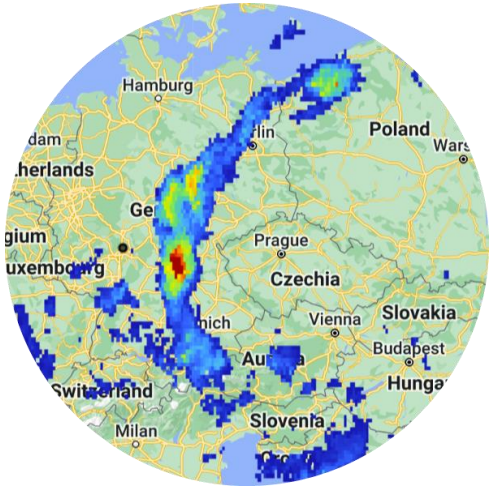
UNIVERSITÉ DU LUXEMBOURG

# Motivation

- GPS/GNSS has become a standard tool to characterise the water vapour field in the atmosphere
- The representation is commonly provided as the average water vapour field at a GPS station
- This assumes water vapour field horizontal homogeneity - this assumption is not always correct
- Here we try to reconstruct water vapour along the line-of-sight between GPS antenna and satellite (slant water). This holds the potential to offer more detailed information atmospheric  water vapour, especially in the presence of a severe weather event
- However, the slant water estimation is affected by site-specific and other unmodelled errors during GNSS processing

# Comparison of GPS-derived precipitable water vapour (PWV) and the global precipitation measurement (GPM) mission during severe weather events in western and central Europe, May 31, 2013.

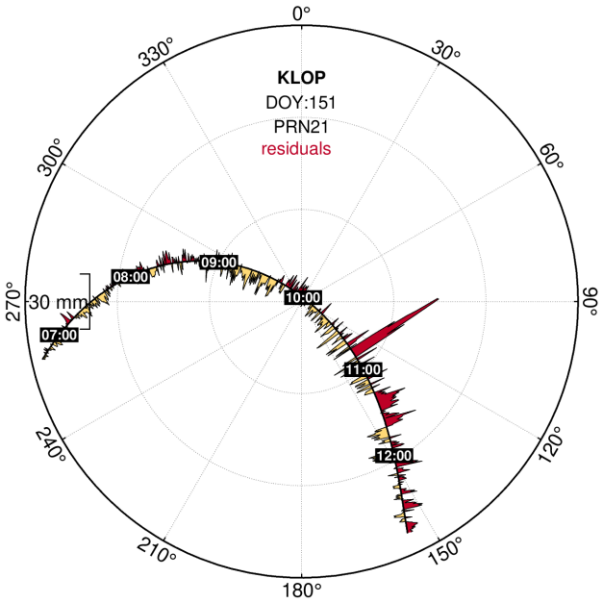


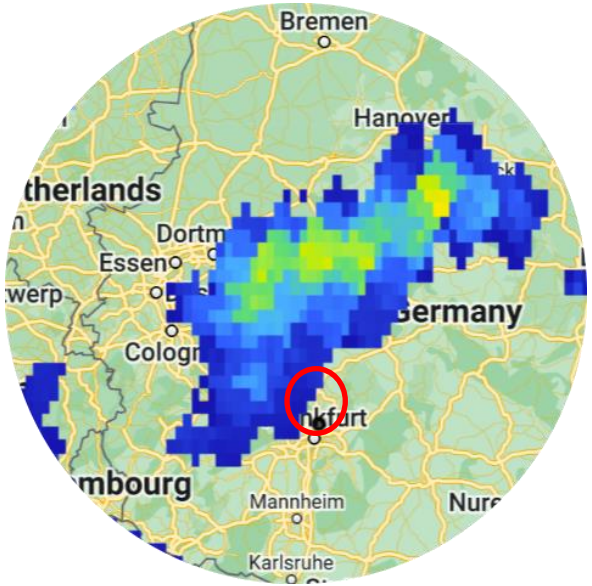




Precipitation from GPM 31 May 2013 18:00 UTC

$$STD = ZTD \cdot mf(\alpha) + \xi(\alpha, e) mf_{grd}(\alpha, e) + RES(\alpha, e) + \text{MPS}\ (\alpha, e)$$

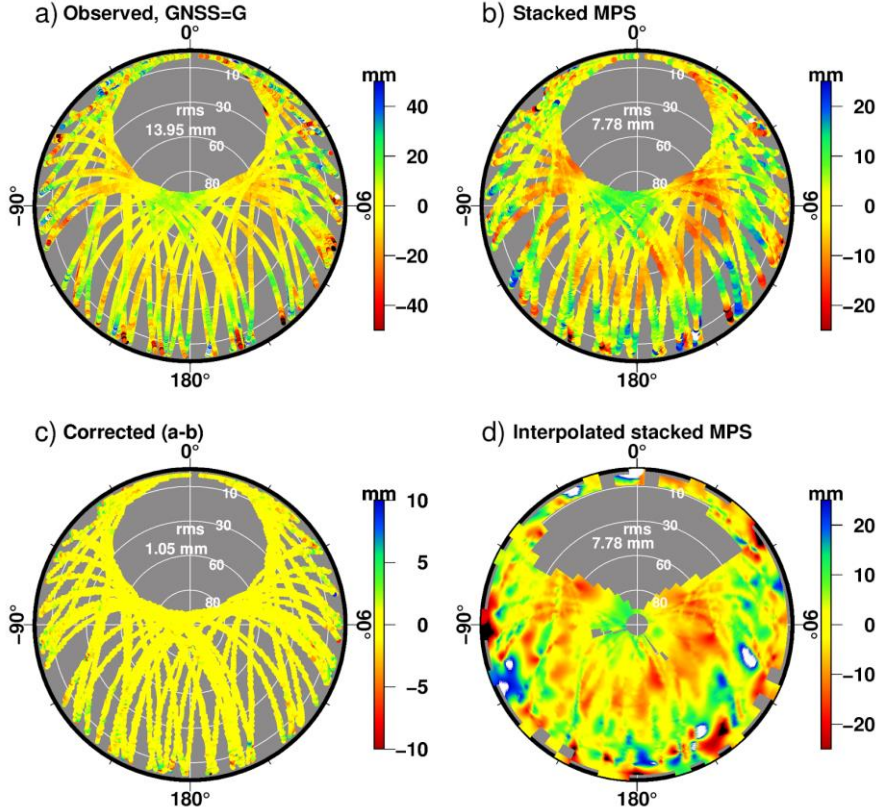
# Sky plots of the post-fit residuals at station KLOP, Germany, 31 May 2013 during the storm for satellite PRN21.




Line-of-site post-fit residuals estimated at GPS station KLOP, Germany (left) and the precipitation from GPM (right), at 10:30 UTC, May 31, 2013

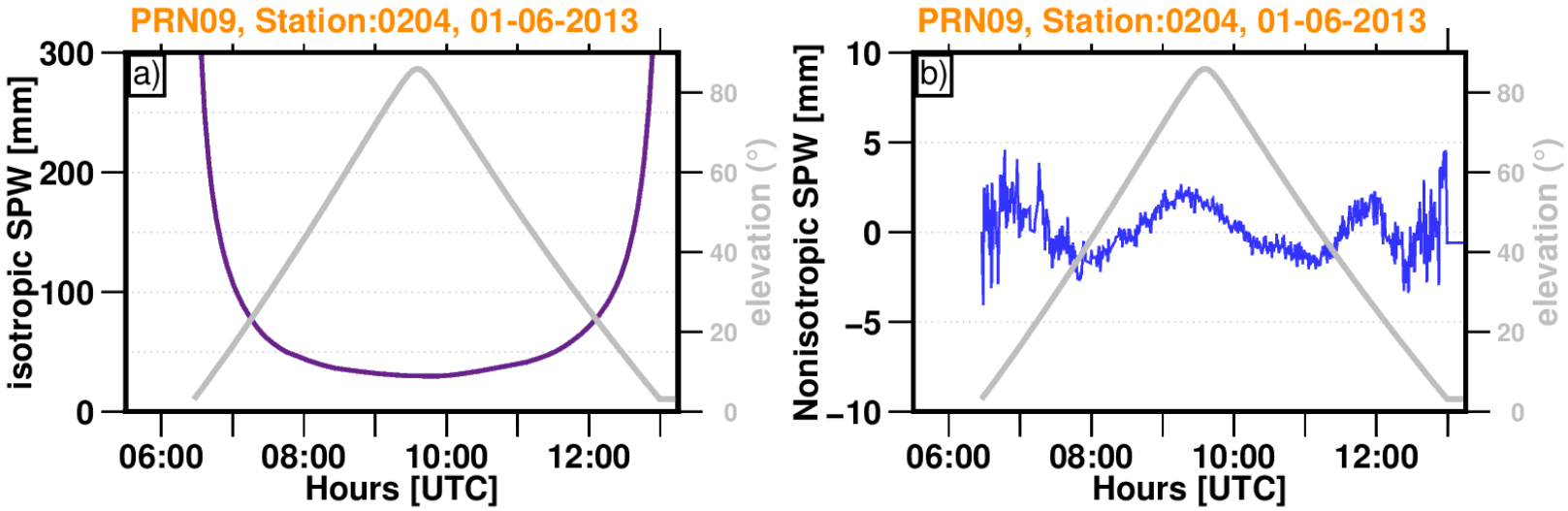
# Post-fit residuals and path stacking maps (MPS). To supress the errors, the residuals were averaged for 21 days. This map was incorporated to produce nonisotropic slant delay.




The multipath stacking supresses elevation and azimuth dependent site-specific multipath effects.

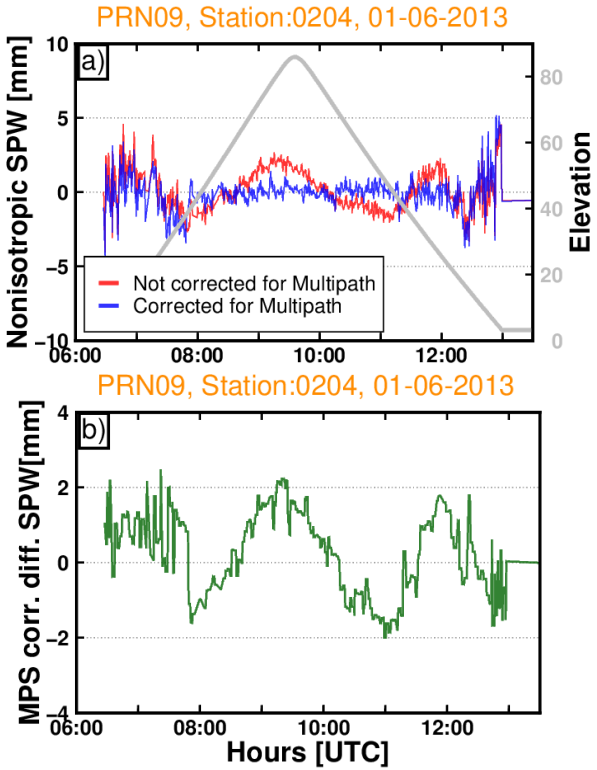
a) GPS raw post-fit residuals
b) Multipath stacked map
c) Corrected post-fit residuals
d) Iinterpolated MPS

# The isotropic and non-isotropic components of the slant precipitable water vapour for satellite PRN09 along the line-of-sight from station 0204




The isotropic (left) and non-isotropic (right) slant precipitable water vapour. The non-isotropic contribution can reach **10**% of the isotropic component.

# The effect of MPS on the estimate of the non-isotropic slant precipitable water vapour for station, 0204 for different satellites.

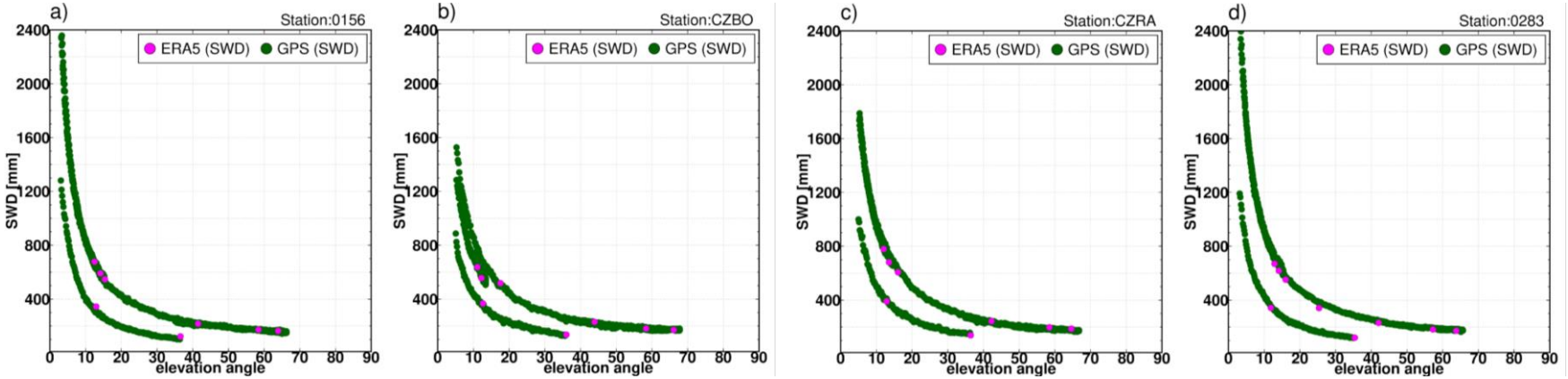



Non-isotropic (left) slant precipitable water vapour with multipath correction (in blue colour) and without multipath correction (in red colour) and their differences shown in dark-green colour for station 0204

For 0204, which is adversely affected by site-specific multipath, the peak variability difference can reach $2\ mm$.

Not correcting for multipath, $2\ mm$ variations can be nearly as large as $2\ mm$ in equivalent PWV at $80^{\circ}$elevation angle.

# Comparison of GPS slant wet delay (SWD) with ray-traced SWD from the ERA5 model. The ERA5 SWD is calculated hourly and GPS SWD every 30 seconds.




ERA5 has a low horizontal resolution and is unable to resolve small-scale water vapor features.

*ERA5 STD is computed from refractivity field developed by Zus et al., Radio Sci, 49(3): 207-216*

# Conclusions

- GPS post-fit carrier residuals increase during the passage of severe weather systems
- Site-specific multipath can adversely affect line-of-sight slant precipitable water vapour estimation

- Here the resulting non-isotropic slant precipitable water vapour component contribution can reach $10\%$ of the isotropic slant precipitable water vapour (the equivalent PWV).

- The slant wet delay from GPS agrees well with the ray-traced ERA5 derived slant wet delay