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Multi-GNSS tomography: Case study of the flood in Europe in July 2021

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Due to climate change, intensive storms and severe precipitation will continue to happen, causing destructive flooding. These natural hazards have dramatic impact on humanity. In July 2021, a series of storms with prolonged rain episodes took place over Europe. Several countries were affected by severe floods that followed that rainfall, causing many deaths and material damage. A good understanding and forecasting of severe weather events is thus of uttermost importance.

This study is a combined effort of two research projects: Advanced MUlti-GNSS Array for Monitoring Severe Weather Events (AMUSE) funded by the German Research Foundation DFG and the ALARM äH2020 SESAR project from EU (https://alarm-project.eu). We highlight the interest of multi-GNSS tomography for the 3D-modelling of the neutral atmosphere refractivity and the water vapour density. We obtain these tropospheric parameters for the July 2021 flood in Germany and four tomographic solutions with different constraining options and time resolutions using either GPS only or multi-GNSS estimates. In the constrained solution, we take hourly a priori information from the numerical weather model ICON-D2 (provided by the German Weather Service, DWD), while in the stand-alone solution, the a priori is used only to initiate the tomography. Our investigations show that the stand-alone solution is producing more patterns of refractivity, especially for the multi-GNSS solution, while is it also temporally more stable. We compare the tomographic results with external observations such as radiosondes and GNSS radio occultations from Metop-A and Metop-B satellites. The results show that tomography is producing wetter conditions than the reference data sources. However, we can see the precursor information of the initiation of deep convection in the ground-based GNSS technique.