Advanced MUlti-GNSS Array for Monitoring Severe Weather Events (AMUSE): Project overview

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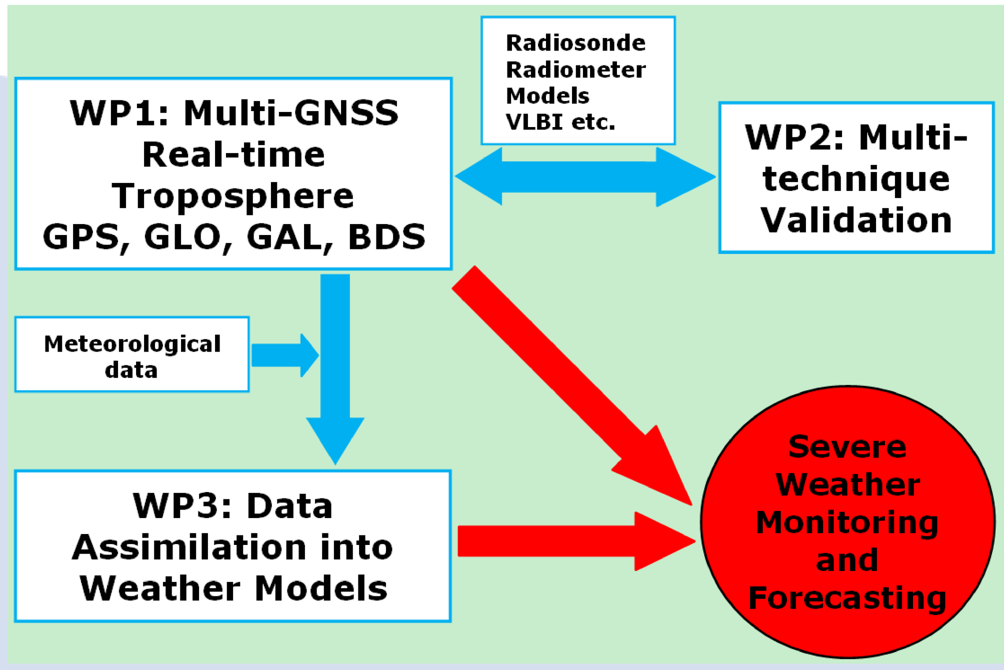
Introduction

AMUSE is a recent research project, funded by the DFG (German Research Council) and performed in close cooperation of TUB, GFZ and DWD during 2020-2022. AMUSE is aiming at developments of advanced ultra-rapid multi-GNSS products with a goal of improving the weather forecasts (especially severe events) in Germany in cooperation with the German Weather Service DWD.

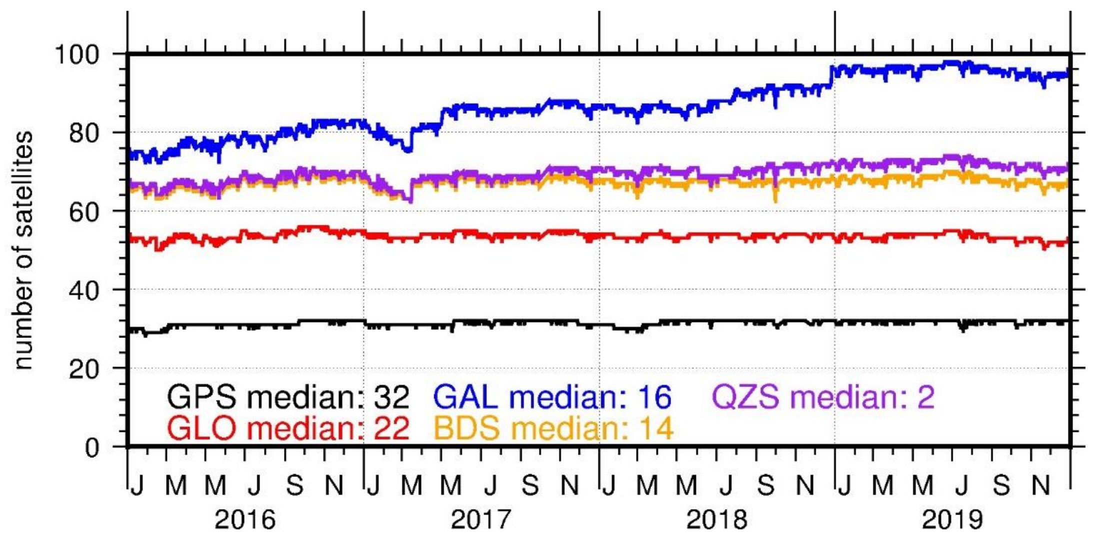
The main innovations are: 1) developments to provide **multi-GNSS** instead of GPS-only data, including GLONASS, Galileo and BeiDou; 2) developments to provide **high quality slant** observations, containing water vapor information along the line-of-sight from the respective ground stations; 3) developments to **shorten the delay** between measurements and the provision of the products to the meteorological services.

The project consists of three working packages (WP). In WP1, the multi-GNSS ultra rapid tropospheric products will be calculated using an in-house developed software EPOS. The GNSS-derived tropospheric products, such as Zenith Total Delays (ZTDs) and Integrated Water Vapor (IWV), will be delivered with a delay shorter than 15 minutes after each hour ('ultra-rapid' processing). Additionally, GFZ will provide Slant Total Delays (STDs) with a time resolution of 2.5 minutes. In WP2, for monitoring purposes, the GNSS estimates will be compared against external reference data in three categories: space-based techniques (e.g. VLBI/InSAR), conventional meteorological sensors (e.g. water vapor radiometer (WVR), radiosondes) and numerical weather models (NWM). The project work at TUB and GFZ will be complemented in WP3 by a contribution of DWD to investigate in detail and to quantify the forecast improvement, which can be reached by using the new generation GNSS meteorology data.

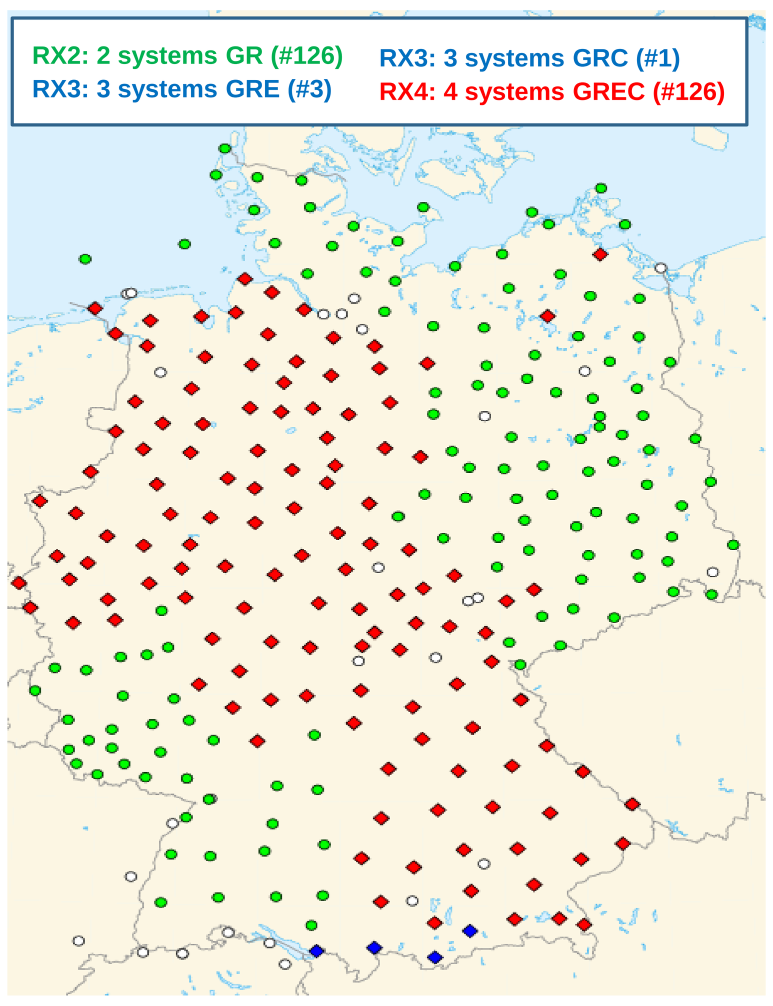


AMUSE working package flowchart

WP1: Ultra-rapid multi-GNSS products

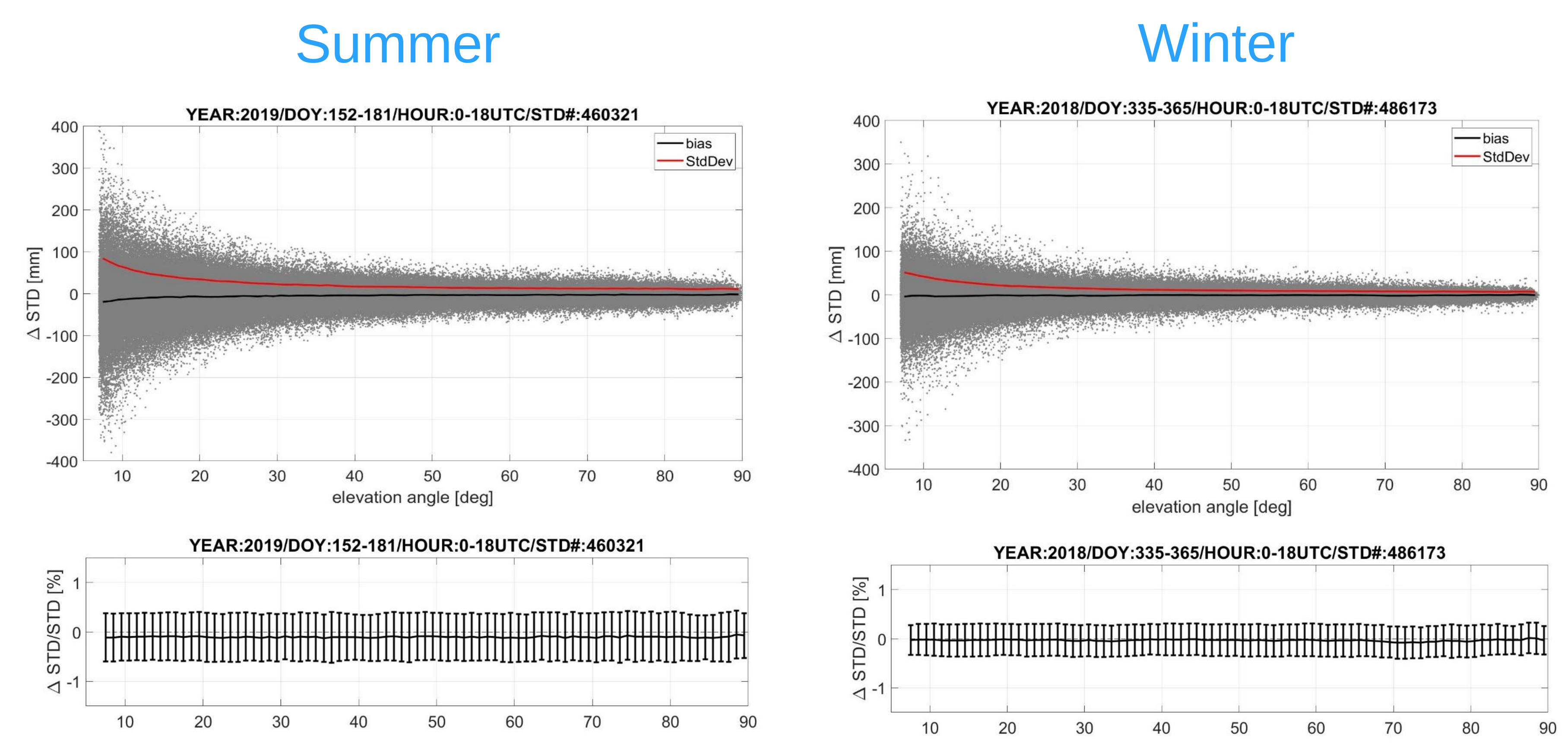


Currently, over 100 satellites are in orbit and transmitting data contributing to the multi-GNSS constellation. Courtesy: B.Männel (GFZ).

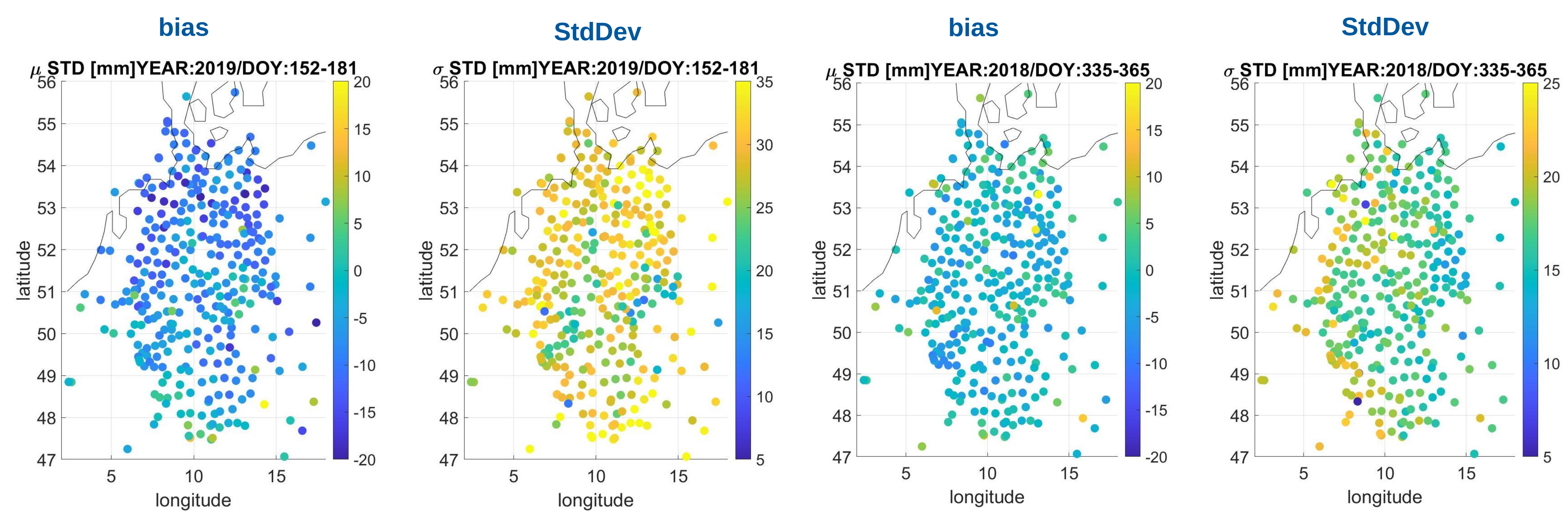


German SAPOS network consists currently of around 270 stations. Almost all of the stations are at least two-systems capable and half of them are four-systems capable as of March 2020. Courtesy: M.Bradke (GFZ).

WP2: Multi-technique validation

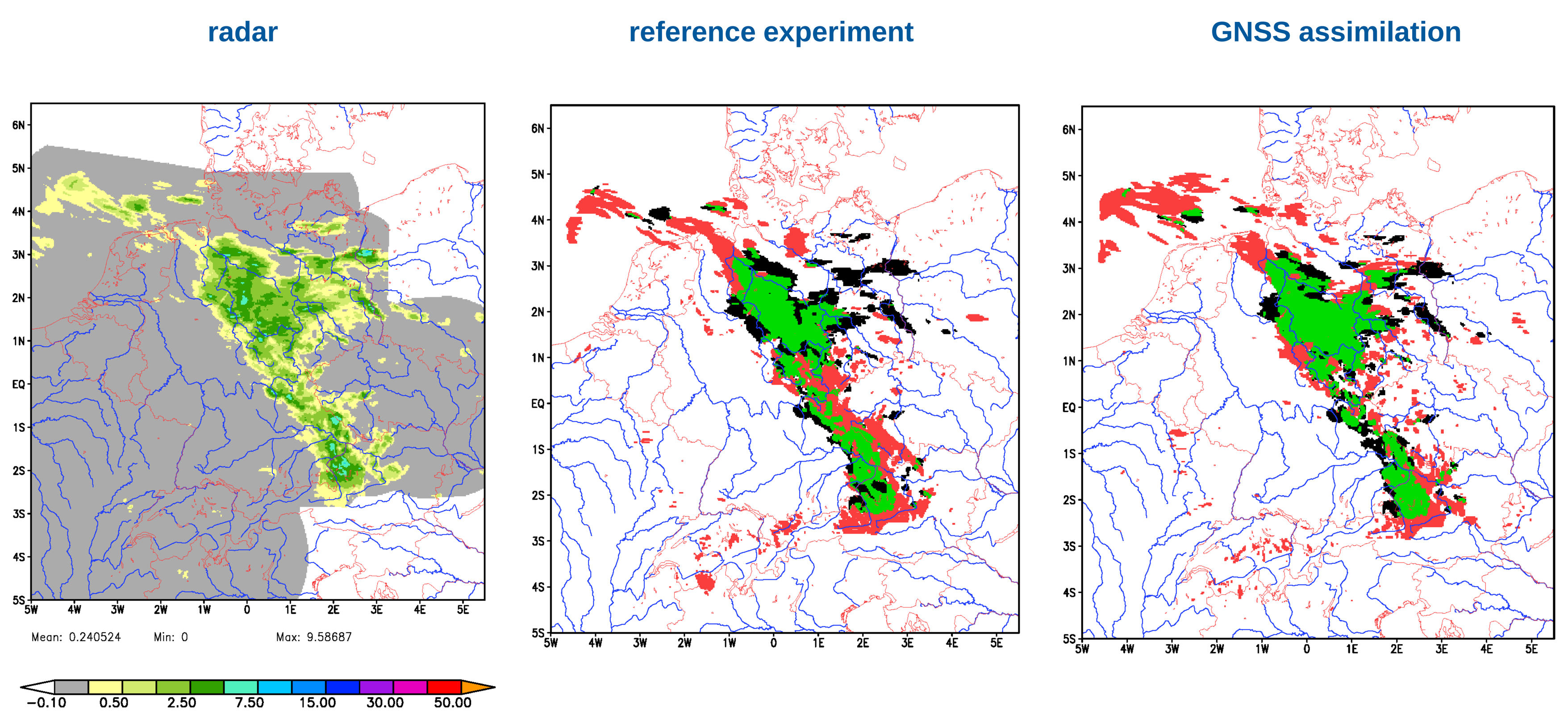


Comparison of GPS and NWM STDs for one summer month (June 2019) and one winter month (December 2018). The NWM STDs are ray-traced through the atmospheric reanalysis model ERA5. Top: the differeces between the observations and the model. The black line indicates the mean bias and the red line indicates the standard deviation. The differences are much larger for higher elevation angles. Bottom: the relative differences. The differences are always below 0.5%. There is no longer a dependence between the elevation angles and the differences.

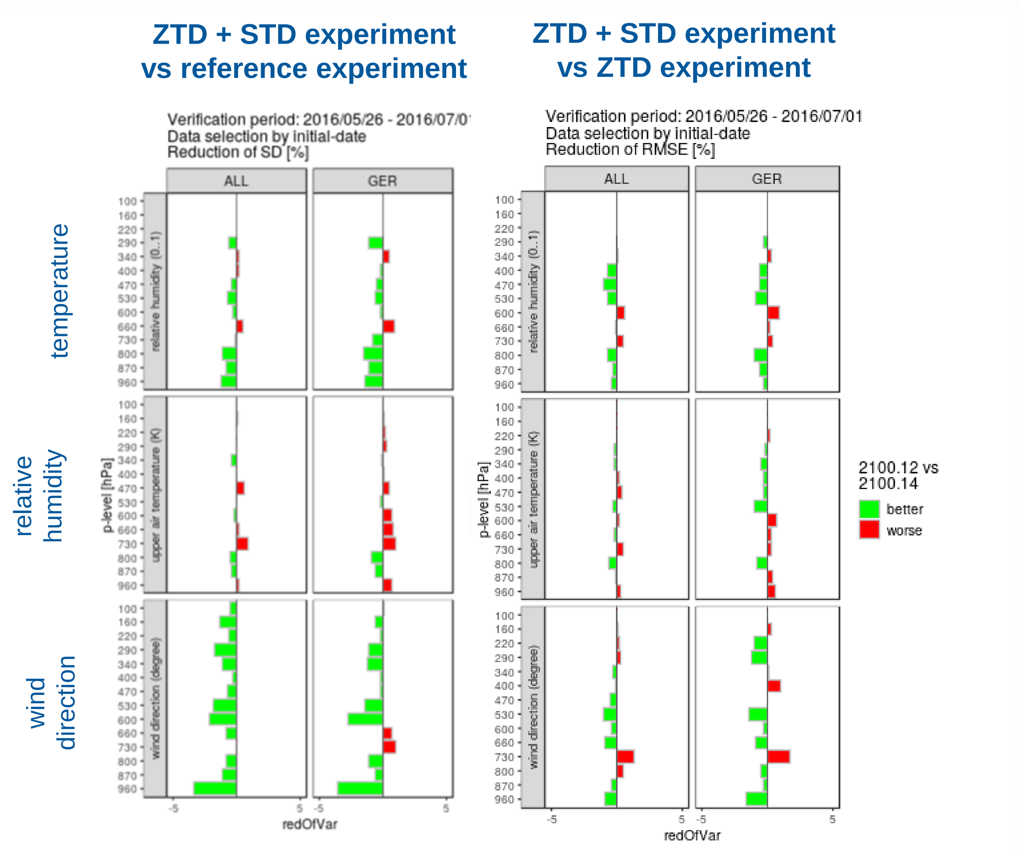


Site-specific biases and standard deviations of the differences between GPS and ERA5 STDs for all stations in Germany averaged from all elavation angles. The standard deviations are usually much larger in the summer.

WP3: Data assimilation into NWM



The results of precipitation forecast in Germany on 28 May 2014 (strong precipitation event) with high-resolution COSMO-DE model. Green: hits, red: false alarms, black: misses. The validation with the radar data proves that the assimilation of GNSS data improves the hit rate by 18% compared to the reference experiment.



Assimilation experiment in May/June 2016 using COSMO-DE model. The GNSS assimilation improves the forecasts by 1-4%. Adding the STDs to ZTDs improves the forecasts by 1-2%.

References

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