# Exploring New Observations for Austria's AROME RUC Nowcasting System

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Zentralanstalt für Meteorologie und Geodynamik

# Overview



**Commercial Microwave Links**

**Train-Mounted GNSS Receivers**

**NETATMO-Stations**

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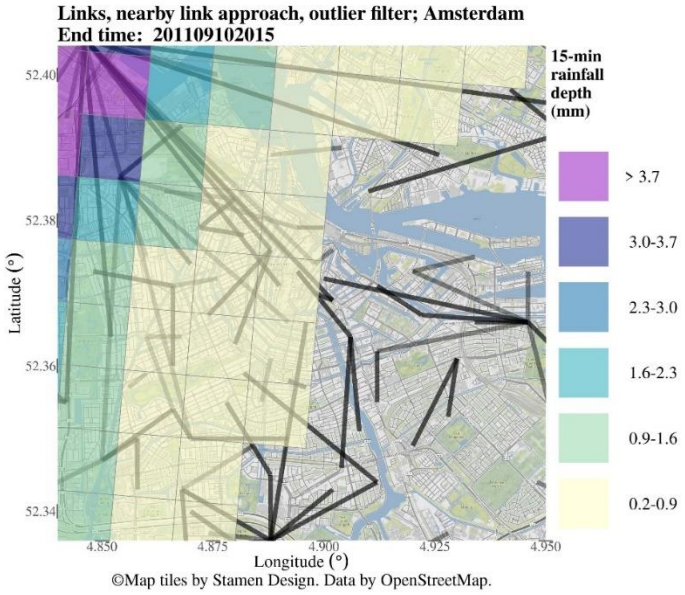
# LINK – Using data from commercial microwave links (CMLs) to obtain rain rates

- Collaboration between Drei-Hutchison, the University of Applied Sciences St. Pölten, he Hydrographic Service Styria, and ZAMG

- Cell phone towers are connected to each other using directed wireless connections , these commercial microwave links (CMLs) are attenuated by rain between the towers

- Knowing the signal strength over time allows to establish a base signal strenght (dry conditions) and estimate the rain between the towers as a function of frequency and length of the link.

- The **RAINLINK**[1] package by Overem et al. (2016) allows to calculate rain rates from such data for links operating from 11.5 to 40.5 GHz

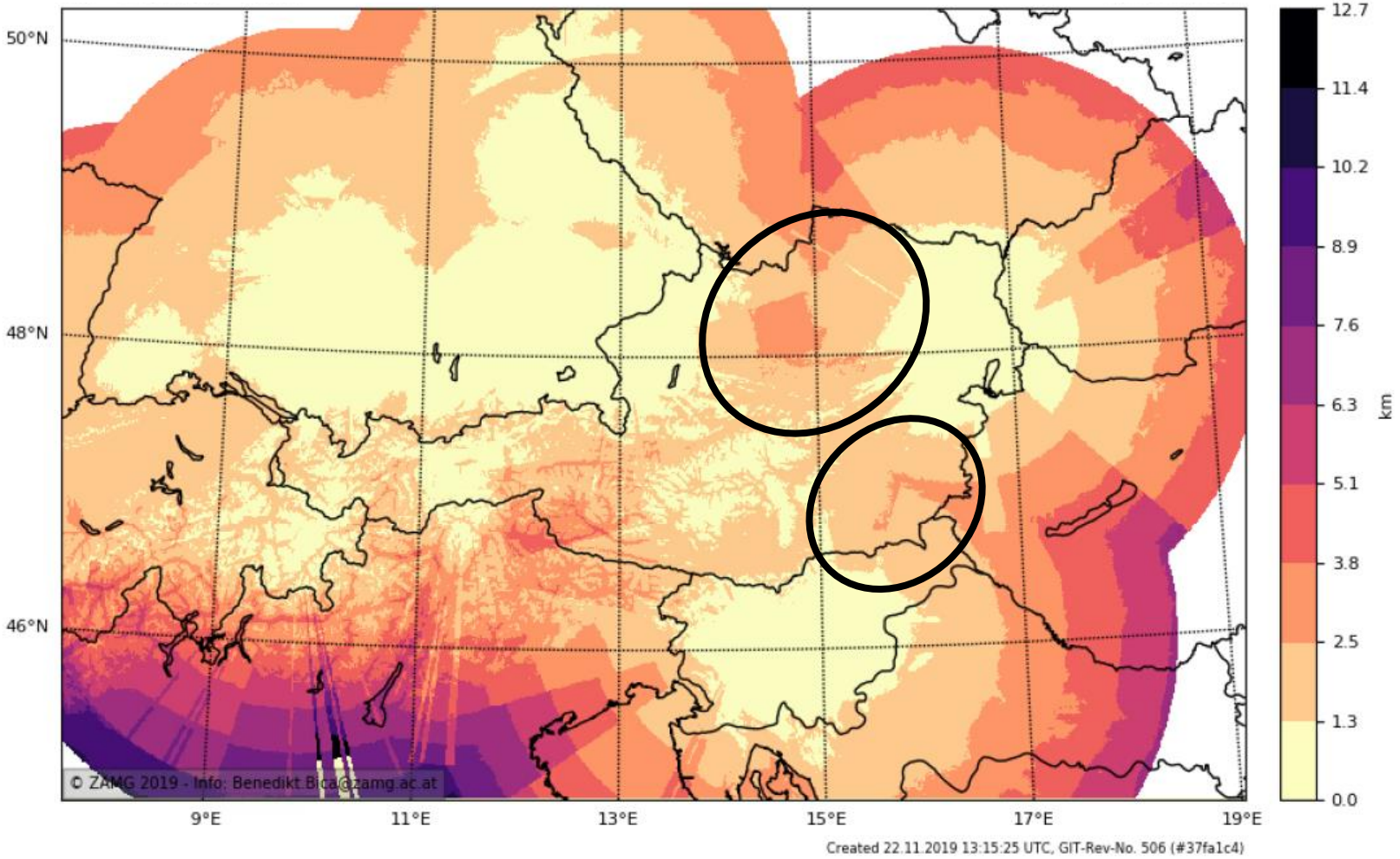



**Example output of RAINLINK, showing CMLs and gridded rain showing the center of Amsterda**

[1]Overeem, A., Leijnse, H., and Uijlenhoet, R., 2016: Retrieval algorithm for rainfall mapping from microwave links in a cellular communication network, Atmospheric Measurement Techniques, 9, 2425-2444, https://doi.org/10.5194/amt-9-2425-2016

# Motivation: Better sampling of lower altitude precipitation

**Altitude of lowest radar beam over Austria**




- Large parts of Austria are only covered by radar at higher altitudes
- Even relatively flat and densely populated areas are often not covered below 1 – 3 km

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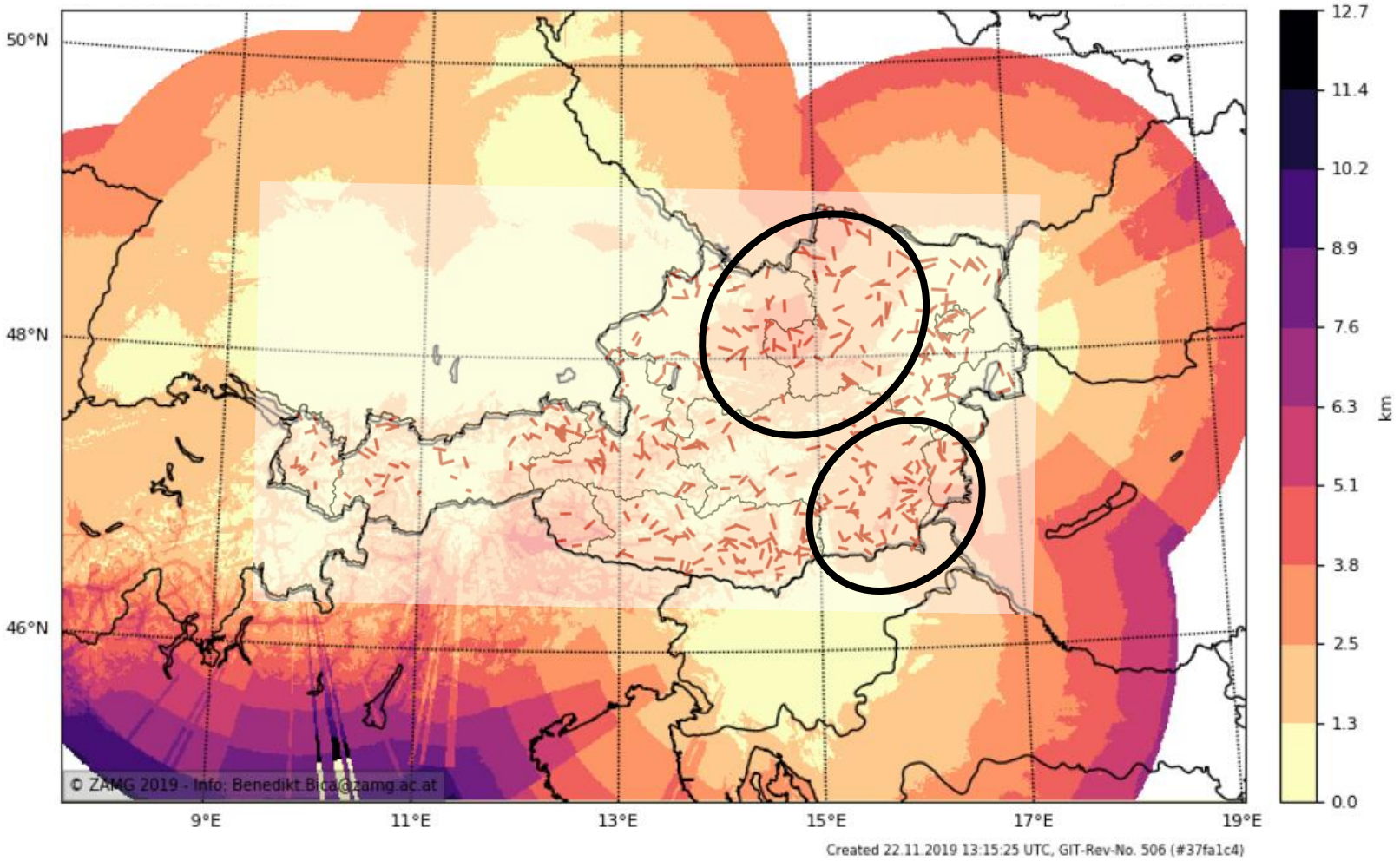


- Overlay of the 23 GHz CMLs, showing how they cover areas that are no well sampled by the radar at low elevations

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# Work on LINK-Data and Conversion into Rain Rates

**CML signal strenght data**
3 minute values of received signal strength

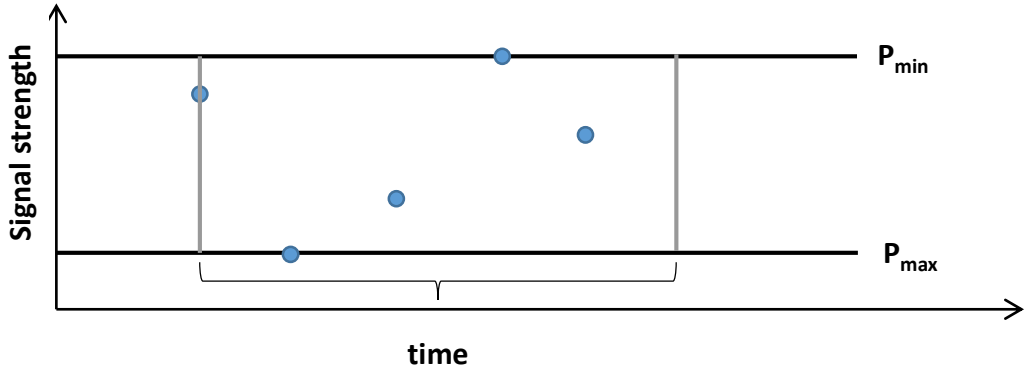
**Quality Control**

**Aggregate and convert**
15 minute intervals, reformat for processing

**Convert to rain rates**
Point observation of precipitation obtained using RAINLINK

**Genergate Gridded Analysis**
RAINLINK
INCA

**Assimilate into AROME**
For instance as 100% relative humidity at the mid-point of the link

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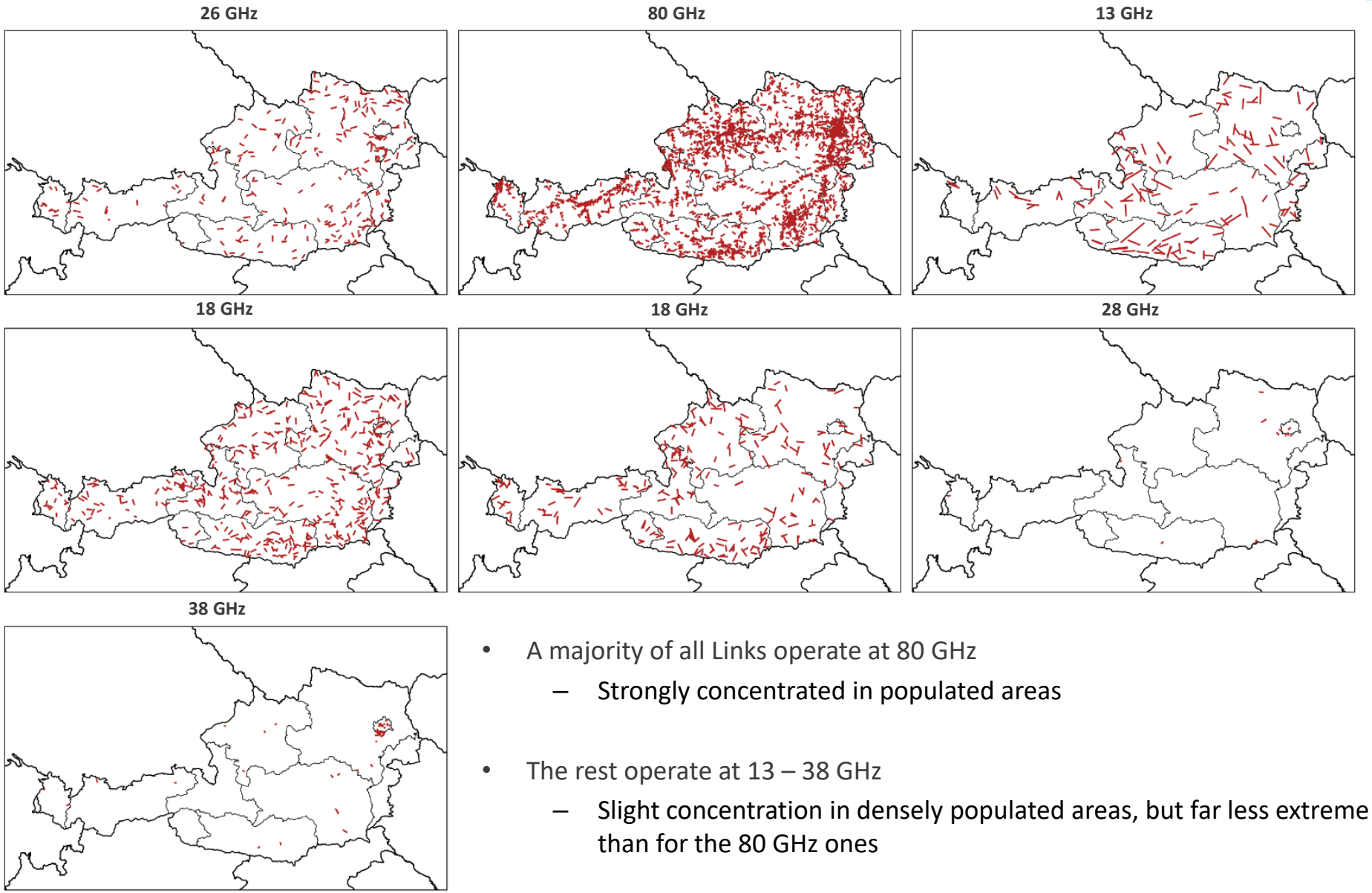
# Locations of CMLs over Austria




- A majority of all Links operate at 80 GHz
  - Strongly concentrated in populated areas
- The rest operate at 13 – 38 GHz
  - Slight concentration in densely populated areas, but far less extreme than for the 80 GHz ones

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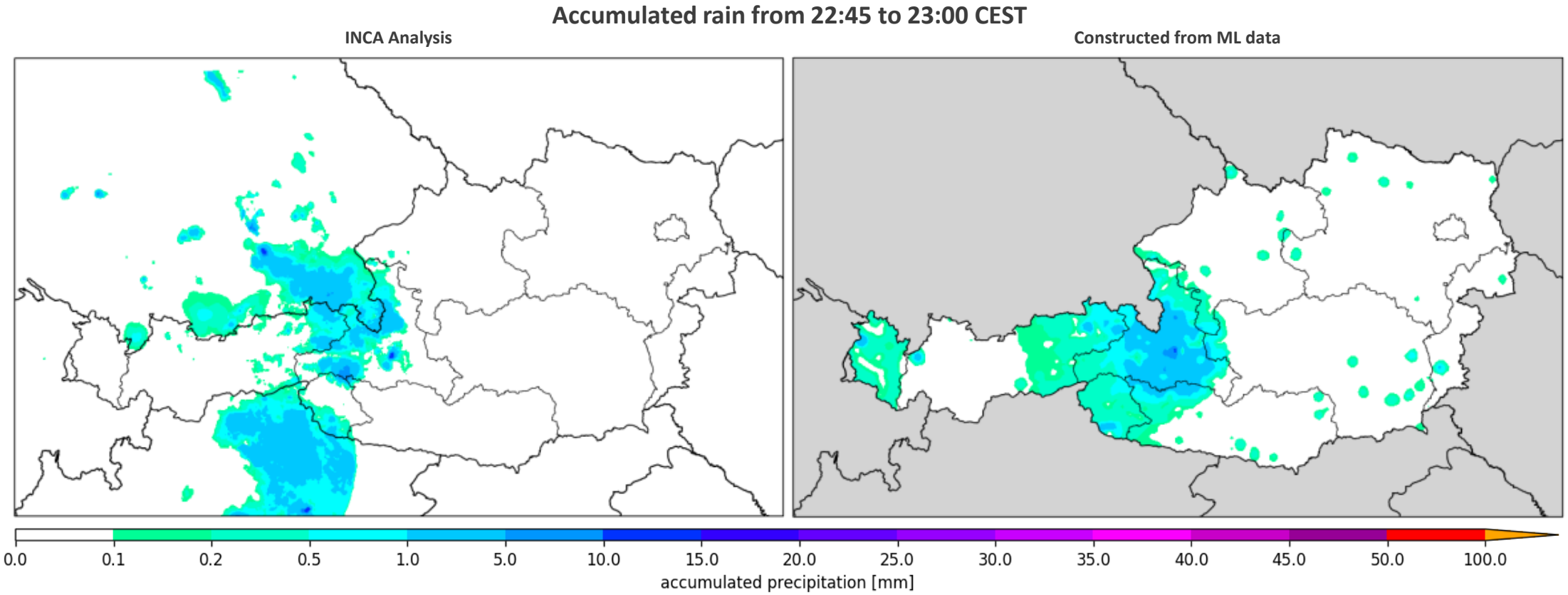
# Initial Results

- First results show that the **general area** of rainfall is **accurately reconstructed**

- However, more work is required to refine the intensity and extent of the rain, currently it‘s too widespread and there are some spurious rain signals (see western part of Austria)

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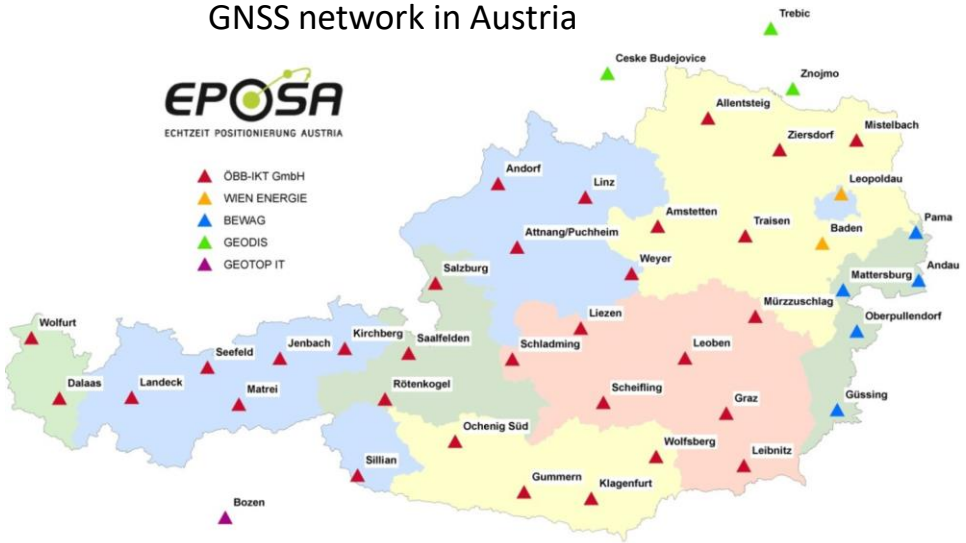
# ZTD retrieved from GNSS-receivers on trains

GNSS network in Austria




Railway track network in Austria


Source: OEBB 2017

**Current situation:**

- PhD thesis at TU-Vienna: *Tropospheric delay parameters derived from GNSS tracking on a fleet of fast-moving fleet of trains.* (Matthias Aichinger-Rosenberger)
- Approx. 1500 freight and passenger trains of the federal railway company have GNSS receivers, number increasing
- ZTD profiles with high resolution in space and time can be generated -> Potential to increase the number of ZTD observations.

**Project goal:** Evaluate whether the quality of ZTD data retrieved from trains is sufficient to be used in AROME-RUC 3D-Var

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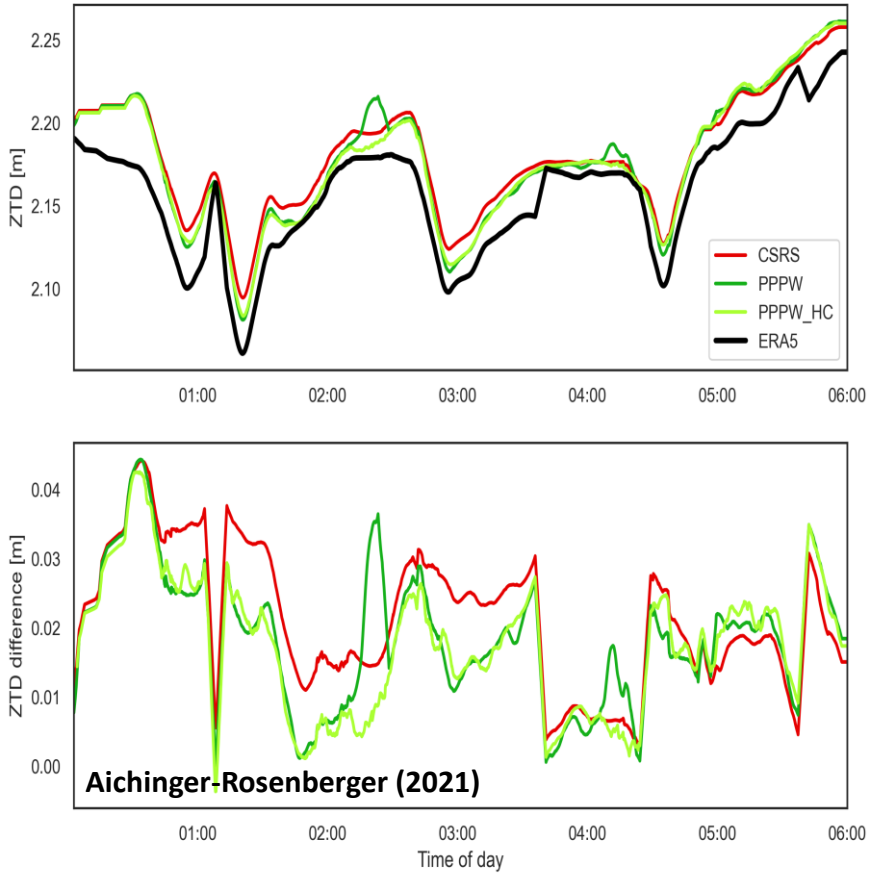
# ZTD retrieved from GNSS-receivers on trains

- PhD at TU-Vienna from Matthias Aichinger-Rosenberger dealt with the non-trivial retrieval of ZTD data from GNSS-receivers on trains.
- **Major challenges** have been an appropriate pre-processing and outlier detection in the data. Since only single-frequency observations are available a special treatment of the ionosphere has to be implemented. (PhD-thesis available online[1])

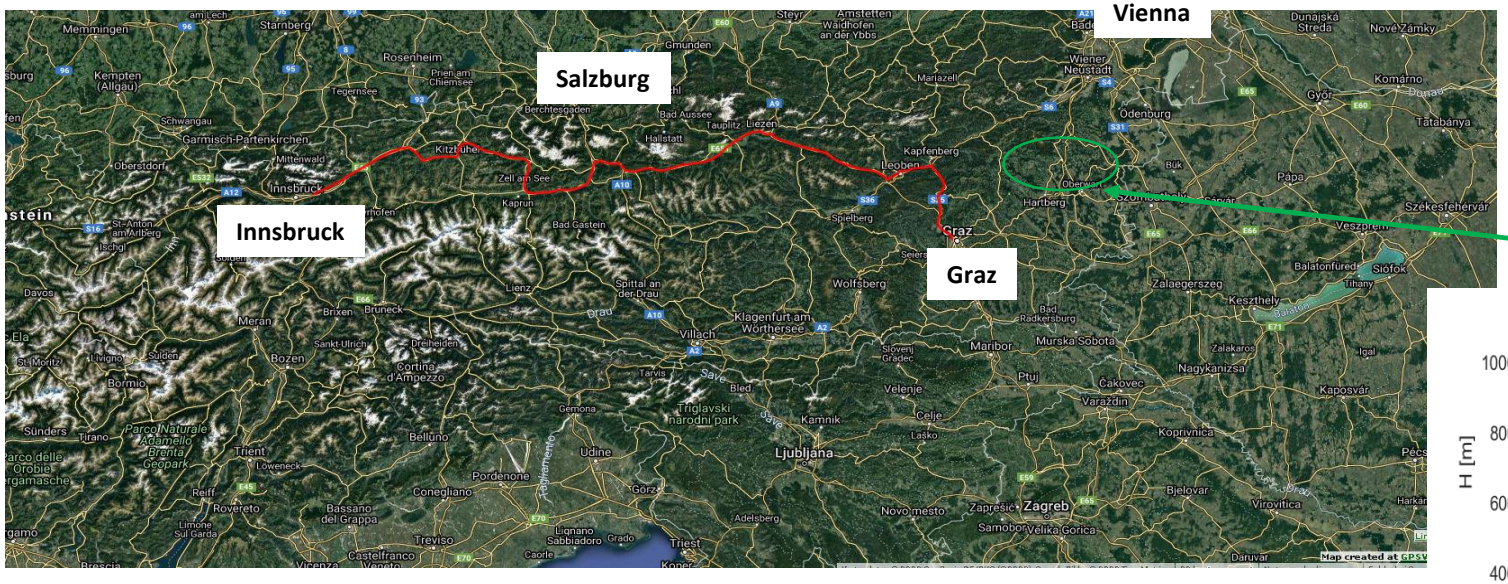
Evaluation of ZTD retrievals with ERA5 data showed a high correlation but magnitude of error varies between cases.

So far only a few test cases (single trains) are available, but a 2 weeks demonstration period is planned in summer 2021.

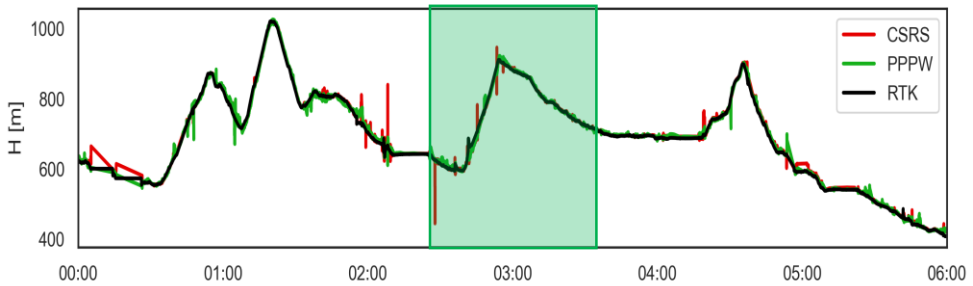



[1]*https://repositum.tuwien.at/bitstream/20.500.12708/17044/1/Aichinger-Rosenberger%20Matthias%20-%202021%20-20Tropospheric%20parameter%20estimation%20based...pdf*

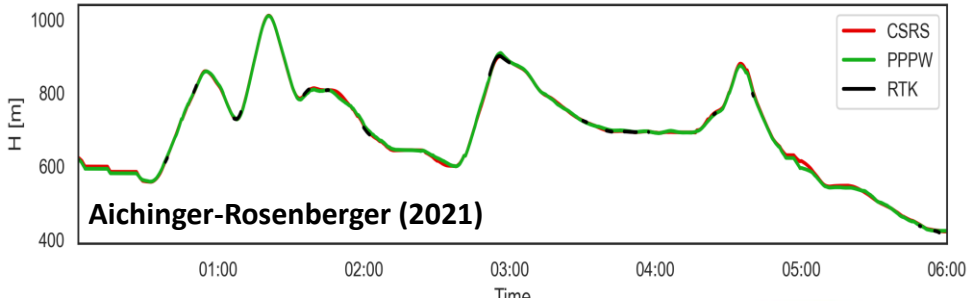
# ZTD retrieved from GNSS-receivers on trains




Raw time series of ellipsoid height from different processing methods




5min moving avg. time series of ellipsoid height




**Demonstration case 1.12.2019 (03 UTC run):**

- Train from Innsbruck to Graz, using values from 2:30 to 3:30 UTC for assimilation
- Travel time during night -> possibly less impact of ionosphere
- Train passes mountain ridge with altitudes of 1000m heights

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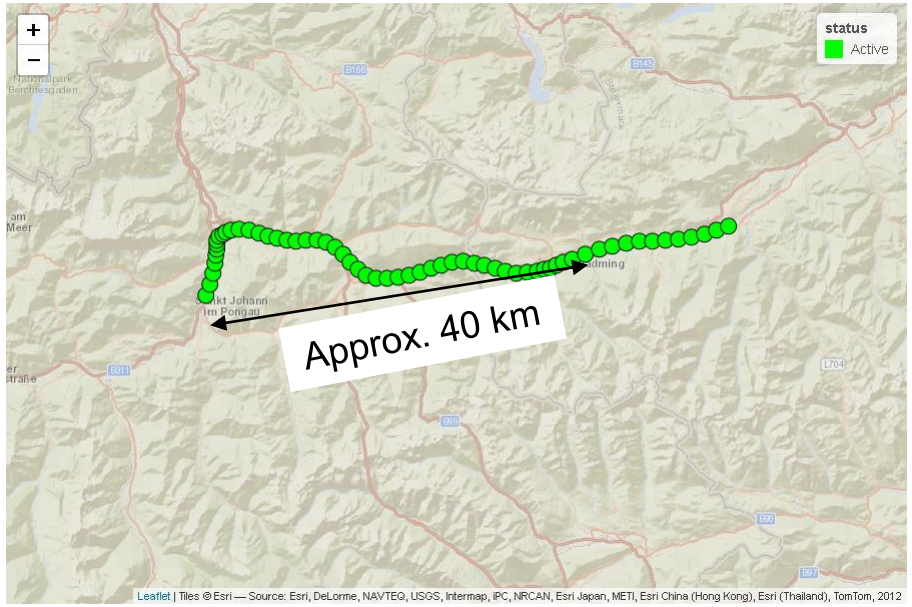
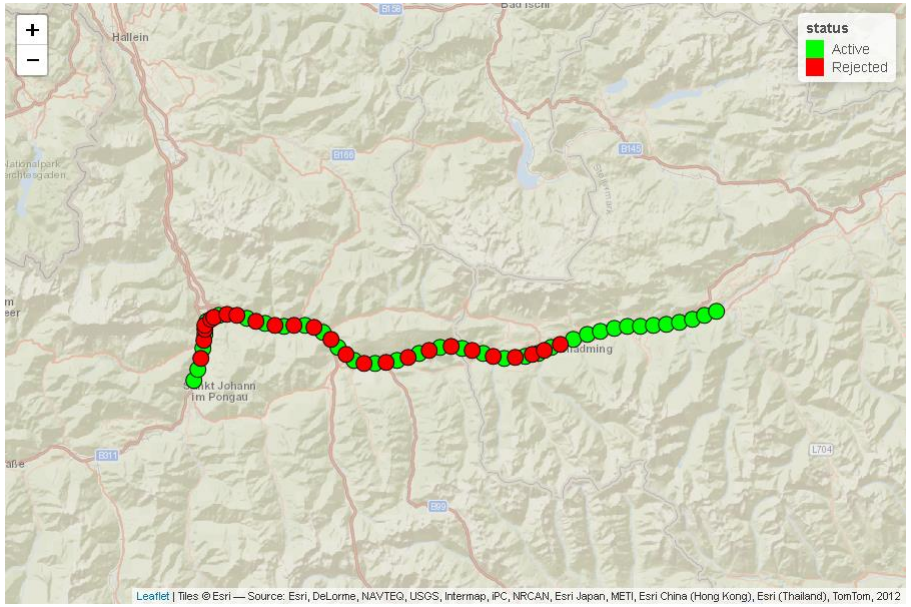
# ZTD retrieved from GNSS-receivers on trains

One obs every minute, no thinning




One obs every minute, spatial thinning (RSHIDIS = 1.2km)




**Main challenges for using ZTD from train GNSS-receivers:**

- Are observations of sufficient quality to be of use for AROME-RUC 3D-Var?
- How to setup data thinning for ZTD observations from trains?
- How to setup an efficient bias correction (static on the first step)?
- How to setup a continuous observation retrieval from trains? Currently data have to be downloaded manually from on board discs.

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# Assimilation of private weather station data in AROME-RUC

- ZAMG received one year (2019) of test data in json format from NETATMO (about 8000 stations in Austria, i.e. **over 20 times more** than there are national SYNOP/TAWES stations)
- almost all stations measure **MSLP, T2m, RH2m**, and **precipitation**, but only about 25% also have **10m wind**
- Python Titanlib (MetNo) from Github was used for quality control, including 4 checks (independent of any NWP data):
  1. **Range check** to remove non plausible extreme values
  2. **Buddy check** compare to average of surrounding stations
  3. **SCT check:** two times Optimal Interpolation analysis of the environment stations including vertical gradient (most time consuming, but most effective check)
  4. **Isolation check:** remove isolated stations for which no comparison to neighboured stations can be made
  5. **Additional modification:** Add Obs-Guess departure of first Screening to MSLP to reduce effect of incorrect station altitude (VARBC would probably be better)

- **for wind converted to u, v for QC and than back to speed/direction**
  - about 50% of stations flagged
  - for realtime nowcasting too slow (15min runtime for all variables) on current hardware

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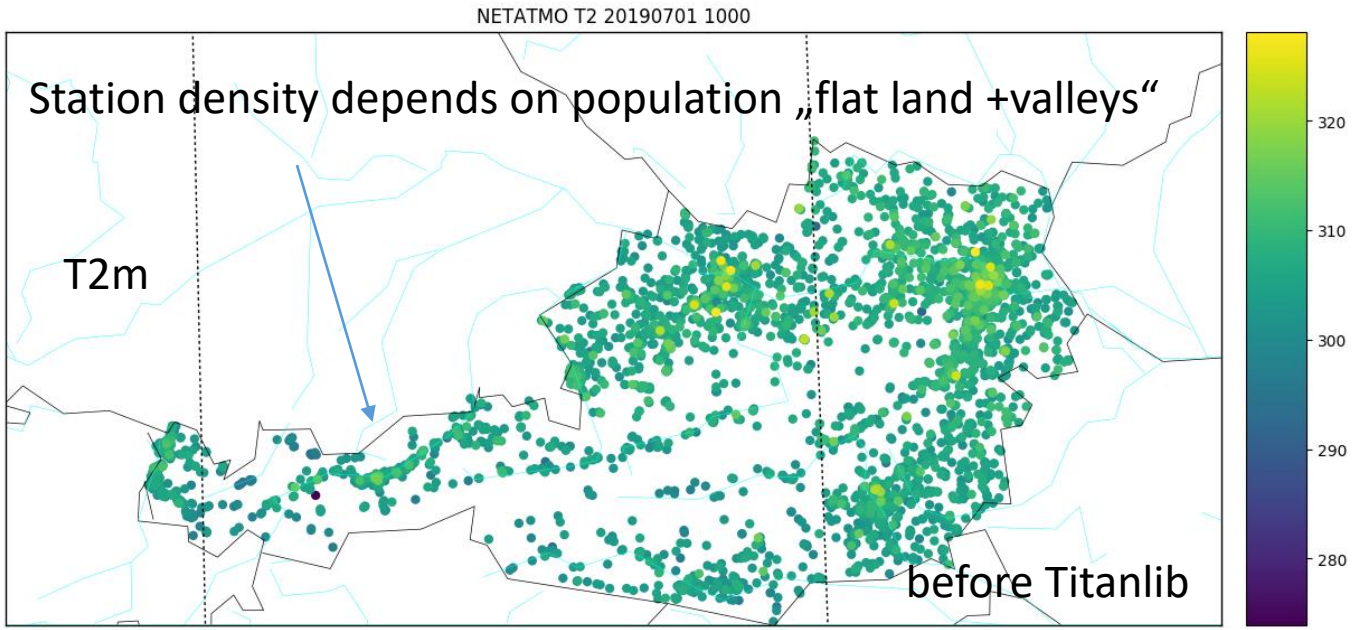


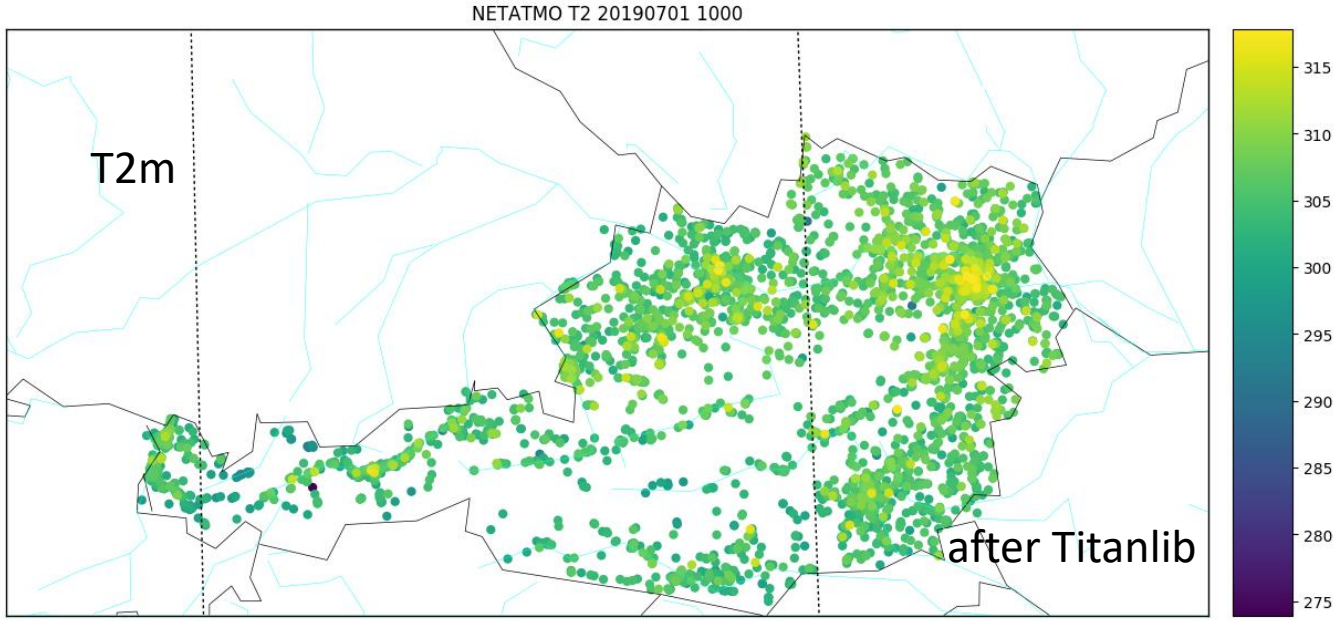


Jo in screening reduced
if Titanlib applied for
all variables!

After Titanlib similar values as for SYNOP
except geopotential (MSLP)

Converted to obsoul
Codetype 16 (RADOME)

Application in
3DVAR+CANARI-SOIL

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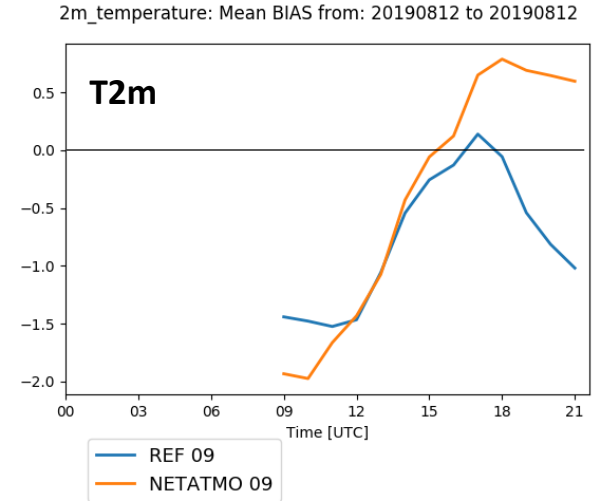
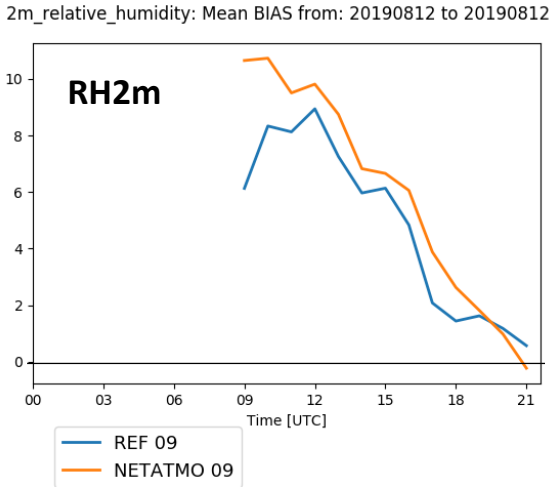
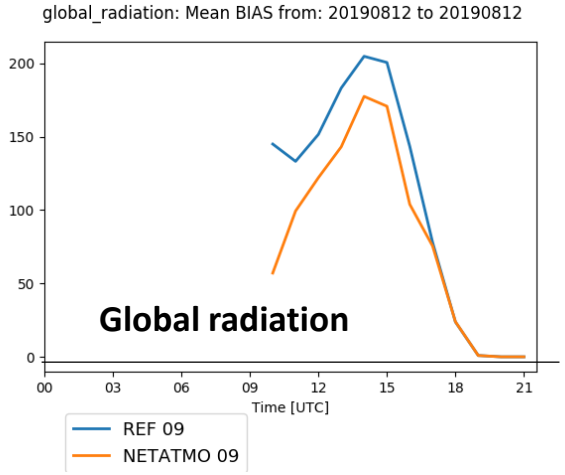
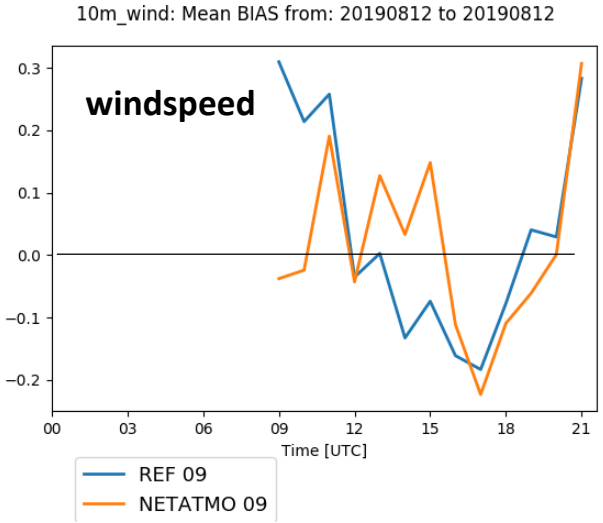
# Results: Case study 12 August 2019 09UTC after 9x cycling against Austrian SYNOP/TAWES

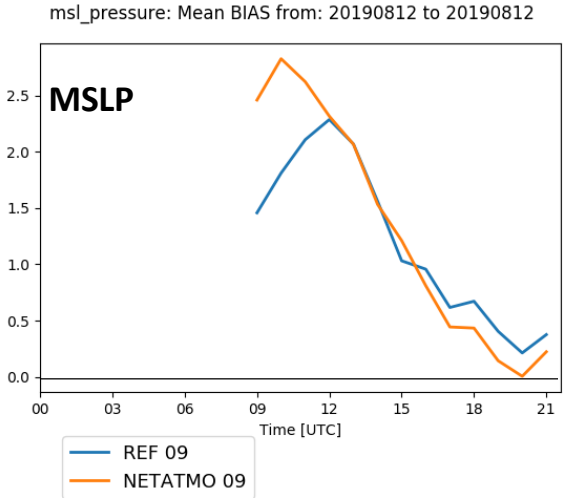
**BIAS**

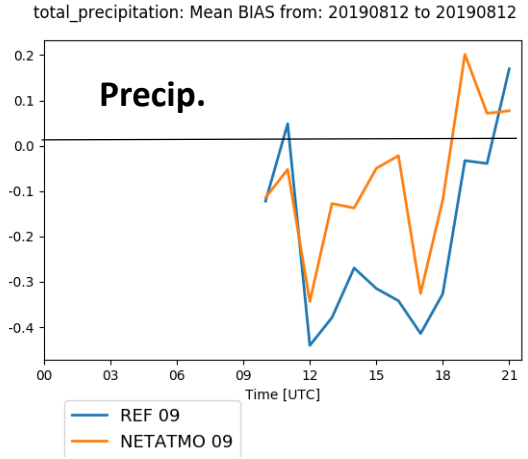



Rather mixed!

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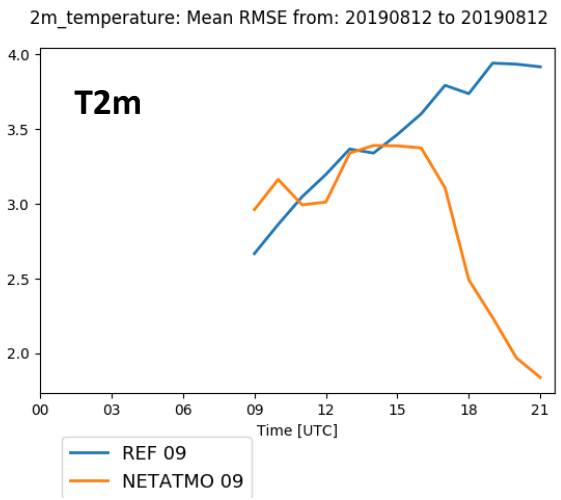
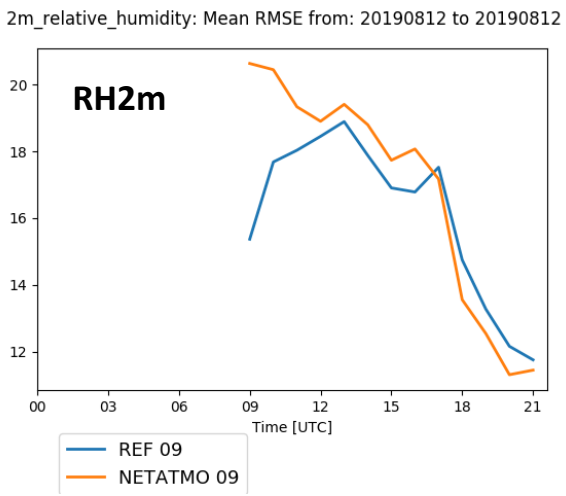
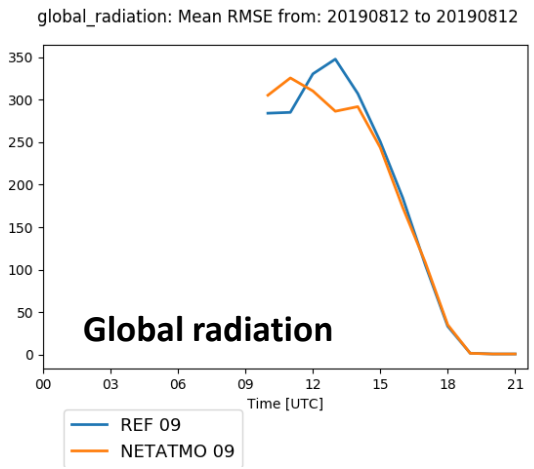
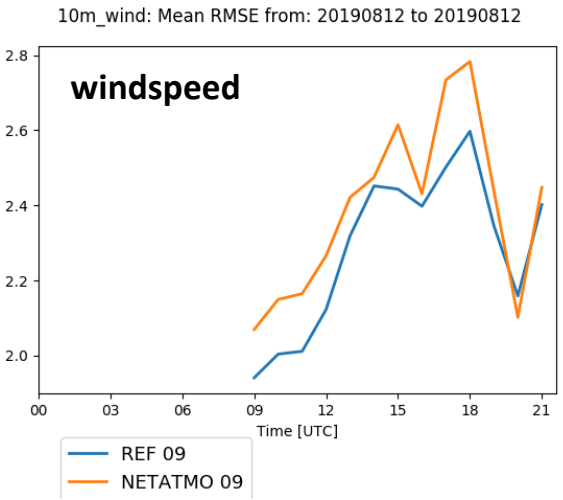
# Results: Case study 12 August 2019 09UTC after 9x cycling

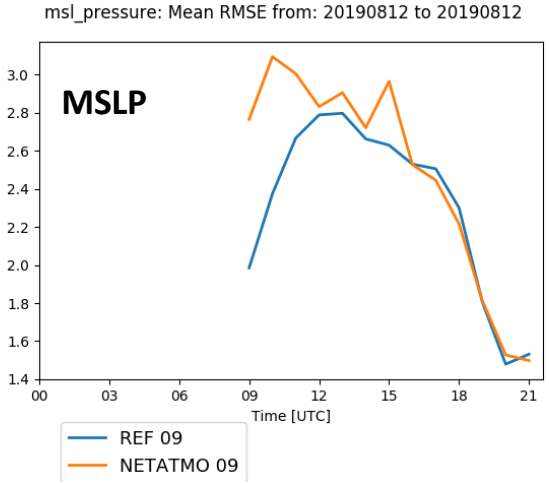
**RMSE**

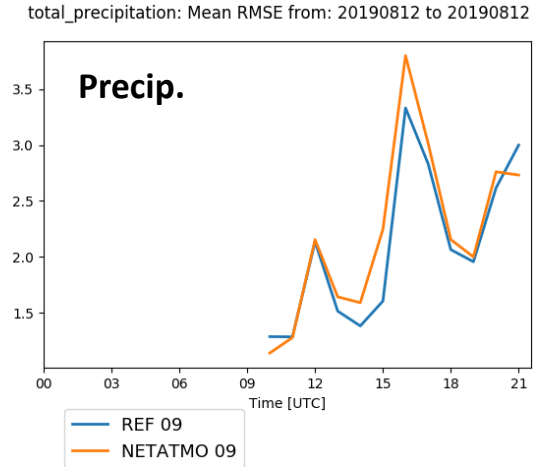



Rather mixed!

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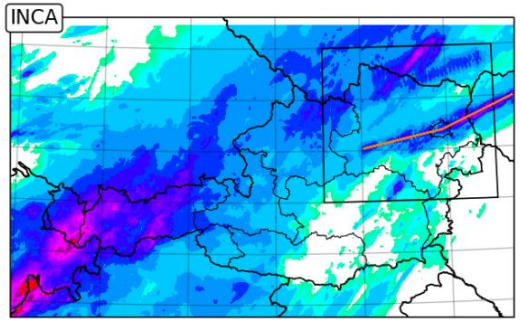
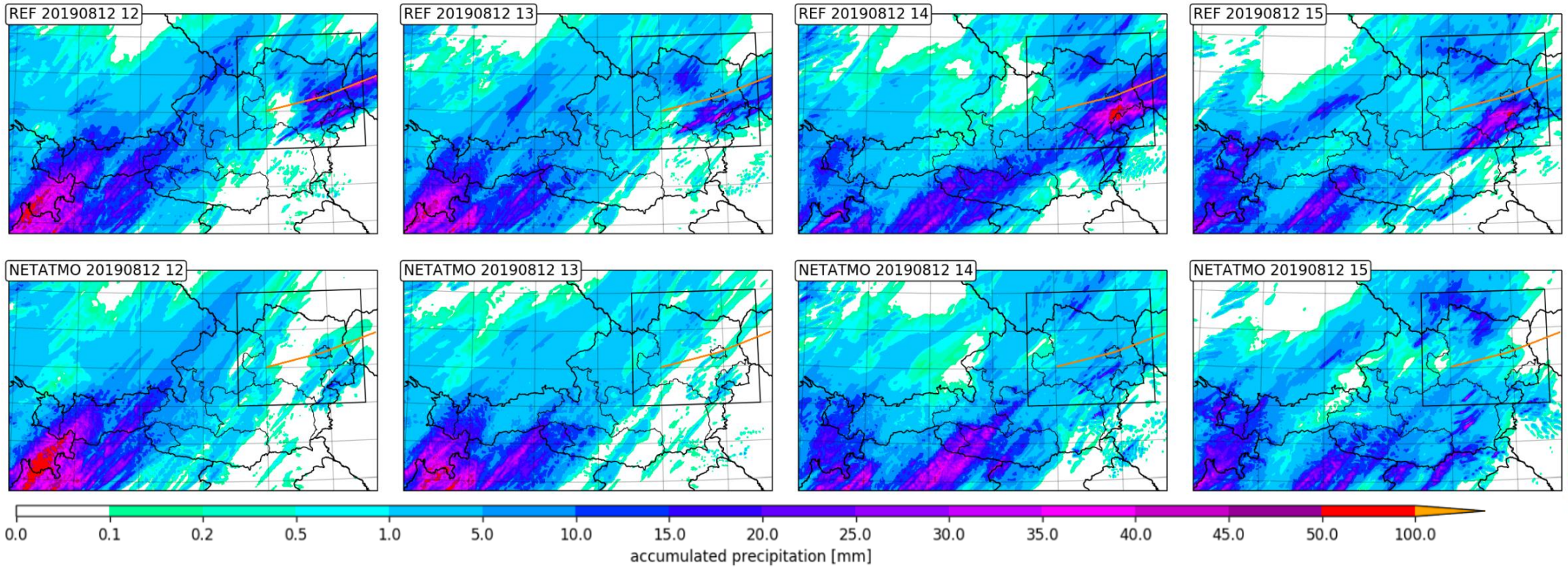
# Assimilation of NETATMO precipitation

- Use PWS within INCA 15min 1km gridded precipitation analysis including INCA quality control (rather strict filtering)
- Subjective comparison of gridded analyses and accumulated values of NETATMO at ZAMG is in good agreement with SYNOP/TAWES values
- Assimilate via latent heat nudging instead of classical INCA (SYNOP gauges+RADAR)
- Two case studies, results mixed, NETATMO has difficulty simulating the squall line over Vienna

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