Exploring New Observations for Austria's AROME RUC Nowcasting System

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Overview

Commercial Microwave Links

Train-Mounted GNSS Receivers

NETATMO-Stations
Commercial Microwave Links

Train-Mounted GNSS Receivers

NETATMO-Stations
Using data from commercial microwave links (CMLs) to obtain rain rates

- Collaboration between Drei-Hutchison, the University of Applied Sciences St. Pölten, the 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 strength (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.

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Motivation: Better sampling of lower altitude precipitation

- 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
Motivation: Better sampling of lower altitude precipitation

- Overlay of the 23 GHz CMLs, showing how they cover areas that are no well sampled by the radar at low elevations.
Work on LINK-Data and Conversion into Rain Rates

CML signal strength data
3 minute values of received signal strength

Quality Control

Convert to rain rates
Point observation of precipitation obtained using RAINLINK

Aggregate and convert
15 minute intervals, reformat for processing

Generate Gridded Analysis
RAINLINK INCA

Assimilate into AROME
For instance as 100% relative humidity at the mid-point of the link
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
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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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
• **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-%2020Tropospheric%20parameter%20estimation%20based...pdf
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
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
Station density depends on population “flat land + valleys“

T2m

before Titanlib

T2m

after Titanlib

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

BIAS

Rather mixed!
Results: Case study 12 August 2019 09UTC after 9x cycling

Rather mixed!
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