Assimilation of GNSS and radar data in ALARO cy38t1 at RMIB

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Introduction

Goal: improve initialization of **moisture** variables in our LAM in order to obtain better **precipitation** and **cloud** forecasts, especially for **severe weather** events
Current operational set-up: ALARO-0, cy38t1, 4km horizontal resolution, **46** model levels, **180s** timestep
⇒ **Data assimilation** of moisture-related observations with a high temporal and spatial resolution:

Reflectivities and **radial velocities** from precipitation radars & Zenith Tropospheric Delay (**ZTD**) estimations from **GNSS** receivers

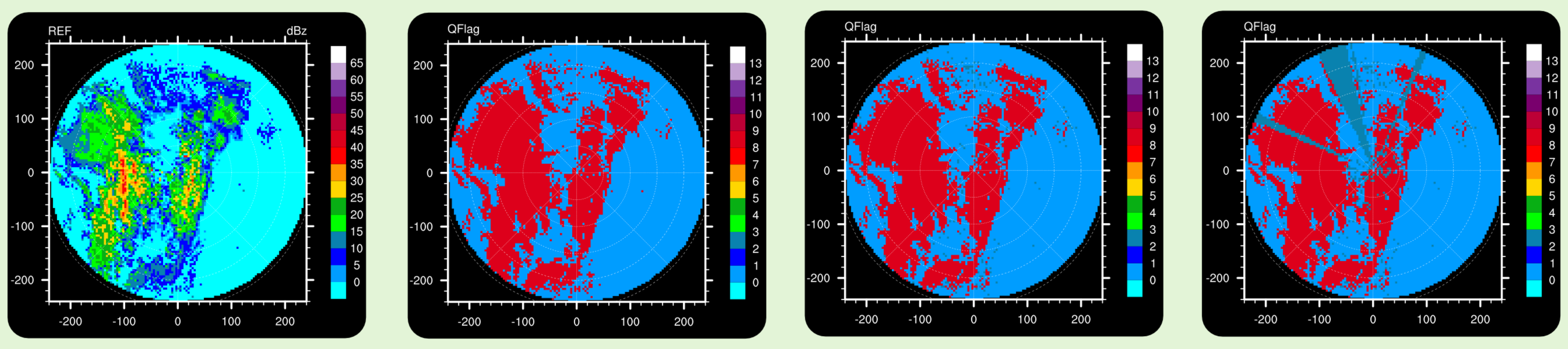
Preprocessing of radar data

- Preprocessing of radar data is done with the package **rmiradlib**, a local fork of **wradlib** (maintained by E. Goudenhoofdt, Department Observations, RMIB).

Dynamical clutter identification algorithms:
- precipitation **structure**
- correlation with **satellite** images (clouds)

Static (monthly updated) clutter identification:
- **static clutter** map
- **beam blockage** map

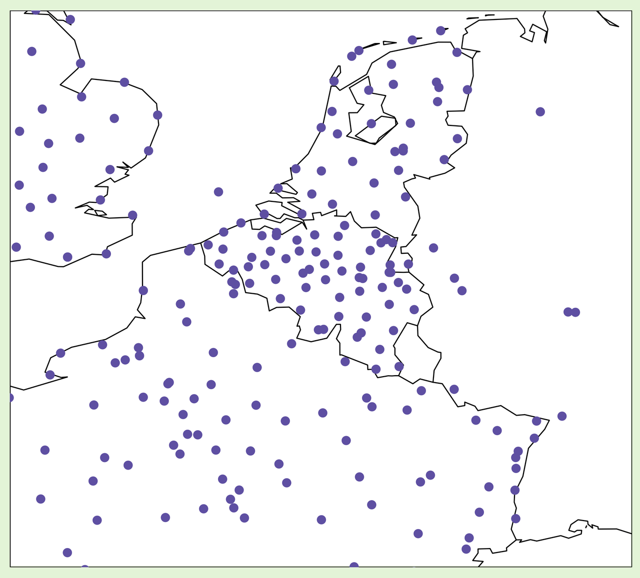
- Conversion of ODIM to MF-BUFR with extended **ConRad** [1] tool.

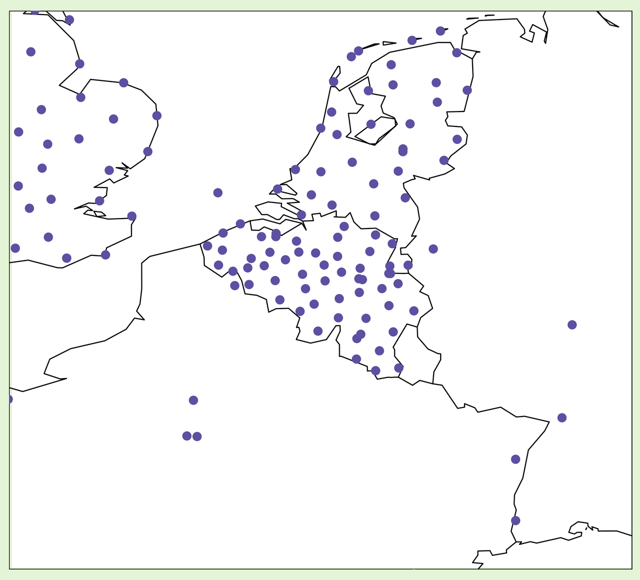

(a) (b) (c) (d)

- **Results** in MF-BUFR format: (a) "raw" dBz values; (b) categorized in rainy (red) and non-rainy (blue) data; (c) categorized, with dynamic quality flags (teal), (d) categorized, with dynamic and static quality flags (teal); note e.g. the beam blockage in the NNW direction.

Preprocessing of GNSS data

- The Royal Observatory of Belgium (**ROB**) [4] provides **hourly** updated Zenith Tropospheric Delay (**ZTD**) estimations, within the framework of E-GVAP.
- **Multi-GNSS** ZTDs are estimated if available: improves reliability and stability


"hourly" stations


"realtime" stations

- E-GVAP ascii files are converted straightforwardly into OBSOUL format, and assimilated as **SYNOP** data
- Ongoing work: whitelisting, bias correction, height-difference correction

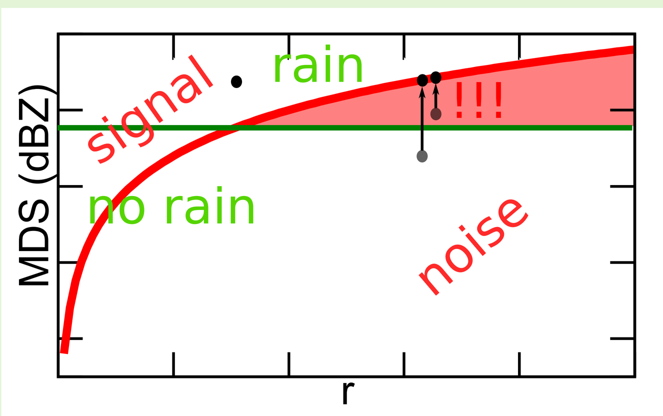
ZTD data assimilation

- **3D-Var**, using the ZTD observation operator [5, 6]:
  ∫(index of refractivity).dz over the model column above the GNSS receiver
  ⇒ function of **pressure, temperature** and **water vapor pressure**
- Constant error (will be removed through bias correction): part of the atmosphere above the highest model level.

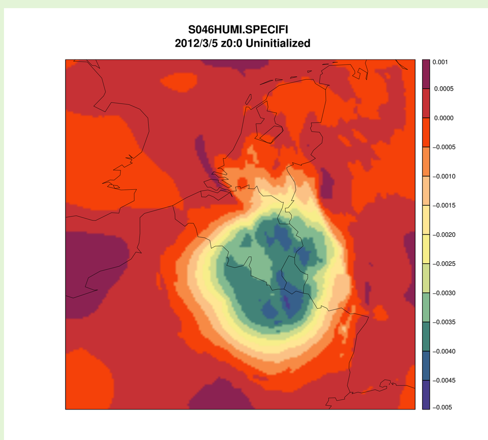
Radar data assimilation

Strategy: **1D + 3D-Var** [2]:
- First, use a **Bayesian 1D** approach to determine a **humidity profile** for each retained reflectivity observation: this is constructed as a a linear combination of nearby vertical columns, weighted by the departures between observed and simulated reflectivities (observation operator: reflectivity simulator **GPROF** [3]).
- Secondly, assimilate the constructed humidity profiles as if they were observations, using **3D-Var.**

Care should be taken how to treat non-rainy pixels and pixels at the MDS threshold level!



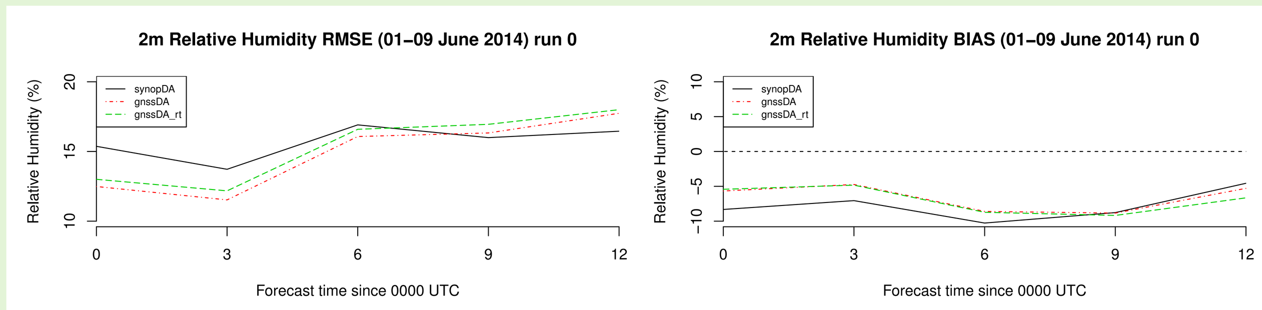
⇒ spurious drying?



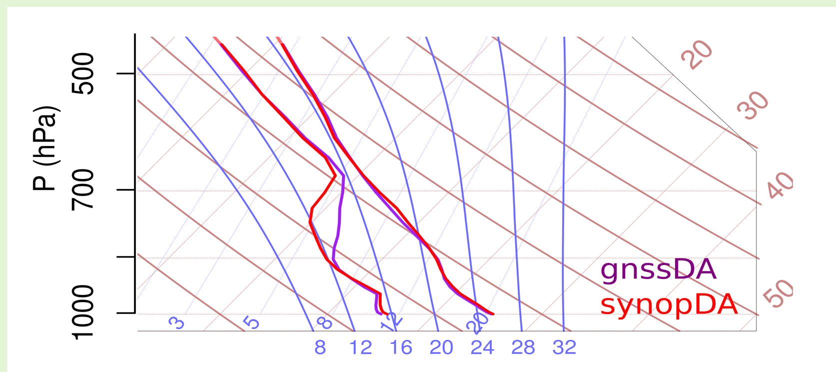
Results: work in progress

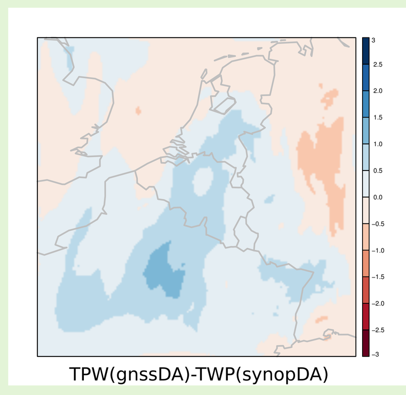
First results

Case study: Pentecost storm (June 7-8-9 2014): over €500M in damage claims
- Preliminary results for assimilation of SYNOP data + non-bias corrected ZTDs: **improved** RMSE and bias of the **2m relative humidity** for short (<9h) forecast range (gnssDA_rt uses the "realtime", and gnssDA the "hourly" stations shown above) compared to SYNOP data only.



- Impact of GNSS DA on pseudosoundings & total precipitable water (TPW):





Conclusions and outlook

Radar DA is not straightforward to set up:
- "Canonical" ODIM format: but still needs a lot of custom work to use in DA.
- Key information is missing from ODIM (e.g. radar sensitivity, MDS): format is targeted at nowcasting rather than NWP
  ⇒ Opportunity for next version of ODIM?
- Some technical issues remain, work on this is still ongoing
- Changes to the code are required for radar DA to work locally: e.g. blacklisting, rain thresholds, etc.

GNSS DA set-up went more smoothly:
- Canonical format (E-GVAP) which can easily be converted into OBSOUL.
- ZTDs are treated as SYNOP data.
- First experiments already show an improvement for short-range forecasts.

Next steps:
- Variational bias correction
- Spatial thinning, as the Belgian GNSS receiver network is quite dense.
- Validation of precipitation structure; test longer periods, more test cases.

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[1] Salomonsen, M., Grønsleth, M. S. et al., tech. report, 2012.
[2] Wattrelot, E., et al., Mon. Wea. Rev., 142(5), 1852-1873, 2014
[3] Caumont, O., et al., J. Atmos. Oceanic Technol., 23(8), 1049-1067, 2006.
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[6] Boniface, K., et al., Annales Geophysicae, Vol. 27, 27–35, 2009.

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