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Assimilation of Radio Occultation from Commercial Satellites over Austria (AROSA) – Synthetic Observation Experiments

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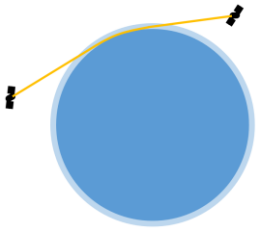
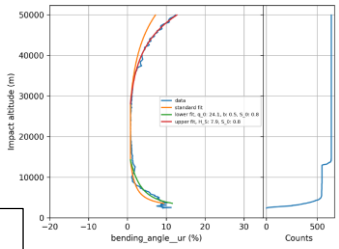
1. AROSA and GPSRO Data



GPSRO observations consist of bending angles from a signal between two satellites. The angle depends on the change in density along the path of the ray, which in turn is a function of temperature and moisture.

$$\epsilon_o = \begin{cases} S_0 + q_0\left(\frac{1}{\sqrt{z}} + \frac{1}{z_1^b}\right) & z < 14 \\ S_0 & 14 \le z < 28 \\ S_0 e^{\left(\frac{z - z_{top}}{H_S}\right)} & z > 28 \end{cases}$$

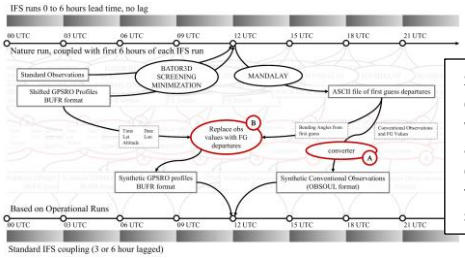
GPSRO bending angle error as a function of height from Scherllin-Pirscher et al. (2011)



GPSRO bending angle error from Eq. 1 visualized

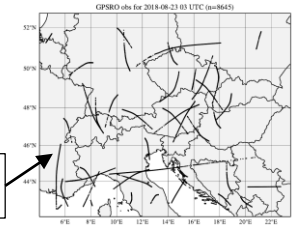
Error characteristic provided by the Wegener Center, implemented into AROME for the use in ensemble data assimilation experiments

3. Experiment Desgin, Nature Run, and Synthetic Data



Synthetic data is used to emulate an environment where more profiles are available, synthetic obs-ervations are generated from a model run which serves as artificial truth

Python scripts use the ASCII output from MANDALAY to replace the bending angles from real GPSRO profiles with the first guess values and generate synthetic conventional obs in obsoul format



Approximately 40 to 60 profiles are assimilated evey three hours

Four ensembles running for 48 hours:

Control Ensemble:	Operational configuration of AROME Austria with real obs
Conventional Only:	AROME Austria, assimilating only synthetic conventional[1] obs
GPSRO Only:	AROME Austria, assimilating only synthetic GPSRO obs
Full Synthetic:	Assimilating both, synthetic conventional and GPSRO obs

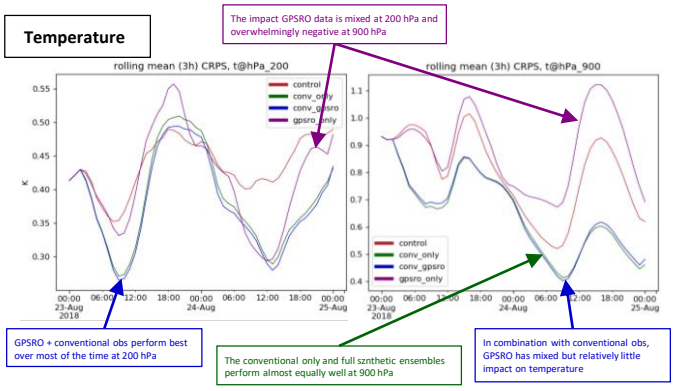
The presented experiment consists of **4 ensembles with 11 members** each with 3 hour cycling, resulting in a total of of just over 700 simulations and up to over 80 model fields per output time over the second day.

[1] **Surface stations, radiosondes, and aircraft data**

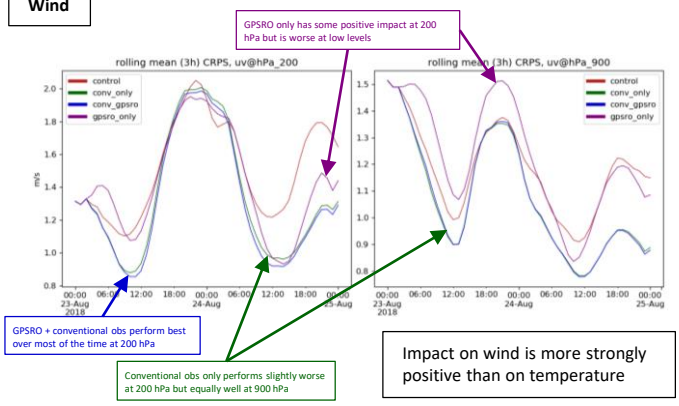
2. Verification Results

The **C**ontinuous **R**anked **P**robability **S**core (**CRPS**) is an integral of the difference between observed and simulated probability of an event over all thresholds in an ensemble – equal to mean absolute error for deterministic forecasts. It is used to compare the four ensembles.

Temperature



Wind



Impact on wind is more strongly positive than on temperature

4. Conclusions and Discussion

- The **synthetic data ensembles outperform the control ensemble** for almost all metrics
- The **conventional observations have a large impact** and clearly **positive** throughout all levels
- The **GPSRO observations have a mixed impact**, with more **positive results mostly at higher levels** and mixed to negative impact at low levers

Discussion

While the amount of simulations (over 700) may sound high, a 48 hour period is **too small** for completely **robust** results. The current findings indicate a **potential**, albeit small, **gain to be had from GPSRO data**. However, the results also show the problem of using GPSRO data in the context of a mesoscale model which already assimilates high density data like aircraft data.

References: B. Scherllin-Pirscher , A. K. Steiner , G. Kirchengast, Y.-H. Kuo , and U. Foelsche (2011): *Empirical analysis and modeling of errors of atmospheric profiles from GPS radio occultation*. Atmos. Meas. Tech., 4, 1875–1890, 2011

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