ACCORD

A Consortium for COnvection-scale modelling
Research and Development

IRM

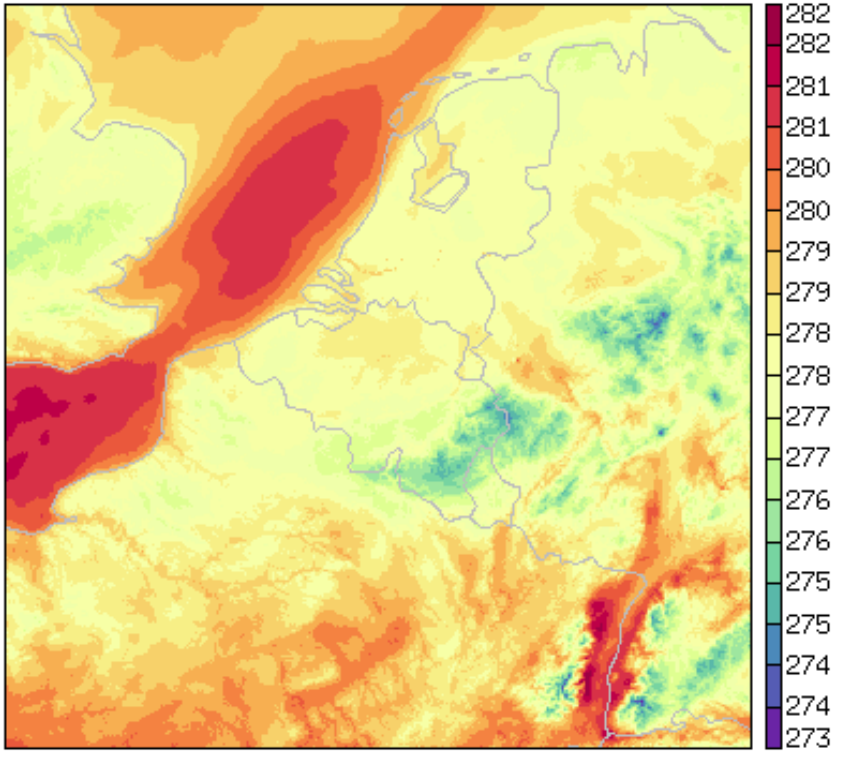
2021 Joint LACE Data Assimilation & DAsKIT Working Days,
Ljubljana, 22-24 September 2021

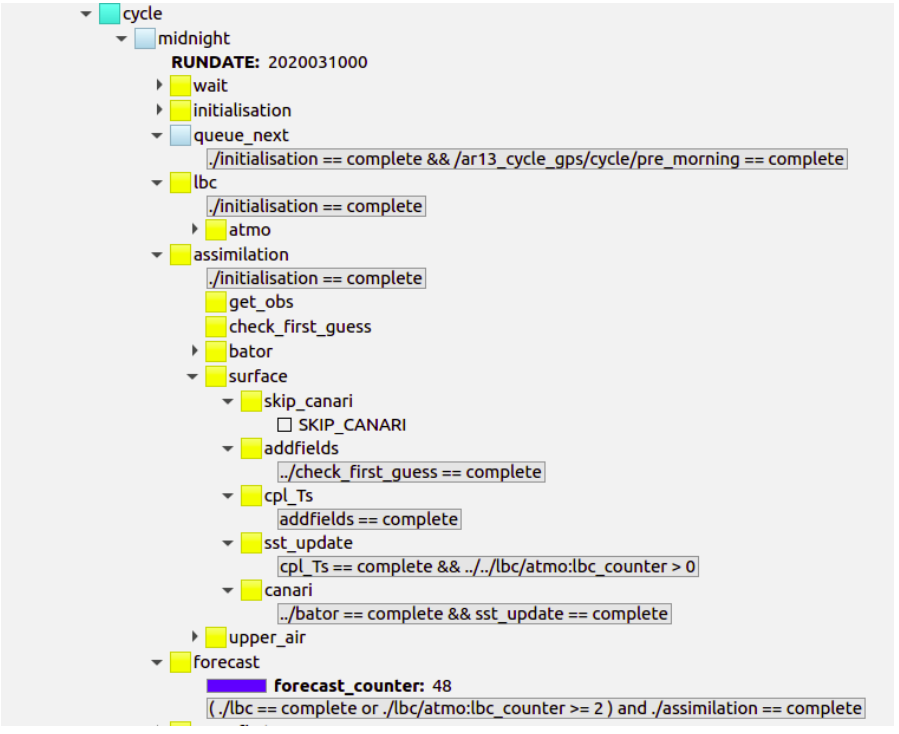
Assimilation of the ground based GNSS in 3DVar AROME

- AROME setting at RMI
- Stations selection procedure
- Passive assimilation and static bias evaluation
- Single obs exepriment
- Active assimilation
- Results & Conclusion

Operational AROME setting at RMI

Geometry	1.3km , 564x564 grid points , 87 levels
Cycle	43t2bf11
Coupling model	ARPEGE , every 1 hour
Forecast range	Up to 48
Surface initialisation	CANARI_Oimain
Upper-air initialisation	None
Observation	SYNOP (U10, T, H, Z)

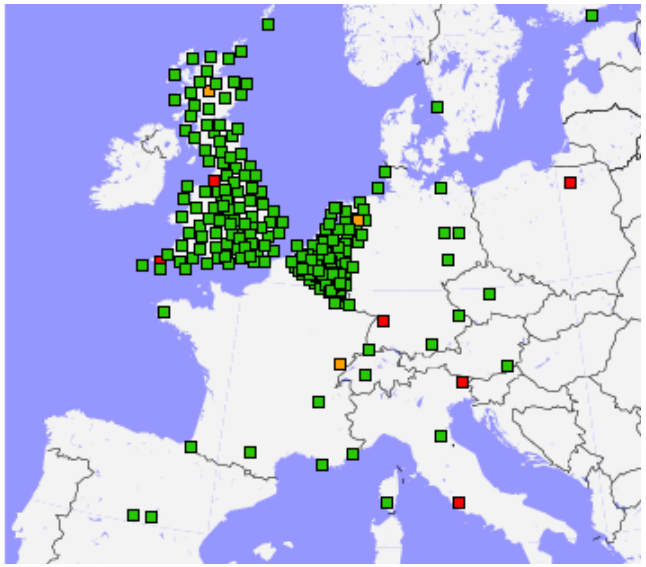




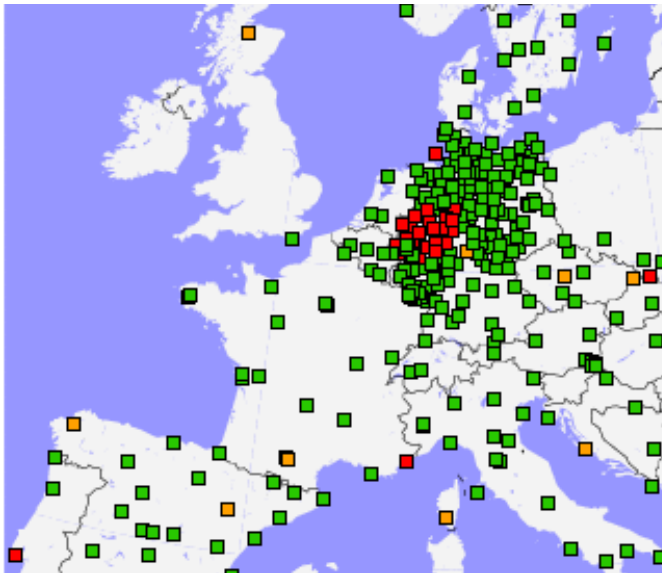
- 3 hours cycle RUC
- The suite is running on ecflow environnement

GNSS stations selection procedure

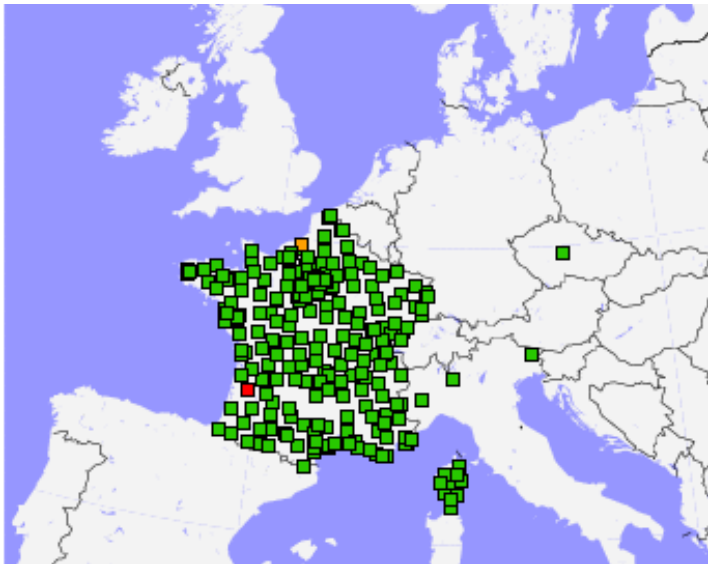
- The GNSS observations are collected from the GTS (ISXT*,ISXD* and ISXX*) in BUFR format.
- Identification of the stations contained in the recieved BUFR files
- Three E-GVAP centers are found in the GTS BUFR files(ROBQ, GF1R and SGN1)
- The observation frequency is 15 minute



ROBQ



GF1R

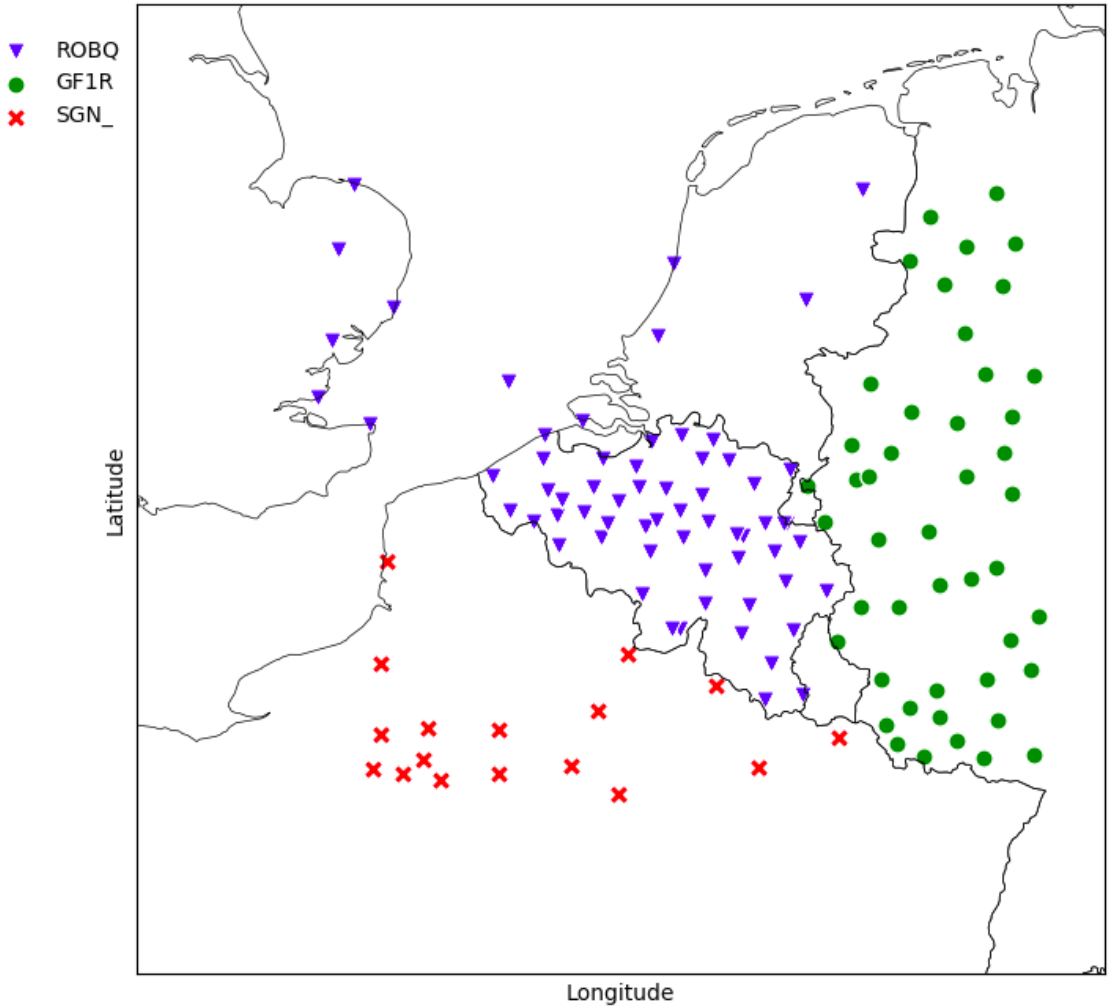


SGN1

GNSS stations selection procedure

- One station may be processed by multiple processing centers.
- The station-processing centre pair is selected which has the smallest standard deviation of observation minus guess.
- The pre-selection procedure led to the avalability of 128 GNSS stations included in the AROME Blegium domain

- 65 : ROBQ
- 46 : GF1R
- 17 : SGN1



Stations monitoring & static bias evaluation

- The objective of this part is to evaluate the static bias and standard deviation of each station individually, by the so called the «passive assimilation »

- In order to evaluate the ZTD static bias , the monitoring period from 01.01.2021 until 31.01.2021 is chosen

- The ZTD (Zenith Total Delay) measured by each station is comapared to its model counterpart without influencing the analysis

- Before the passive assimilation the whitelist (list_gpssol) contains the stations to be monitored by assuming that the static bias of each station is equal to zero.

- To avoid the station blacklisting, the variable **GPSOLMETHOD** should be set to « **MEAN** » or « **CENT** » in the namelist « namel_bator »

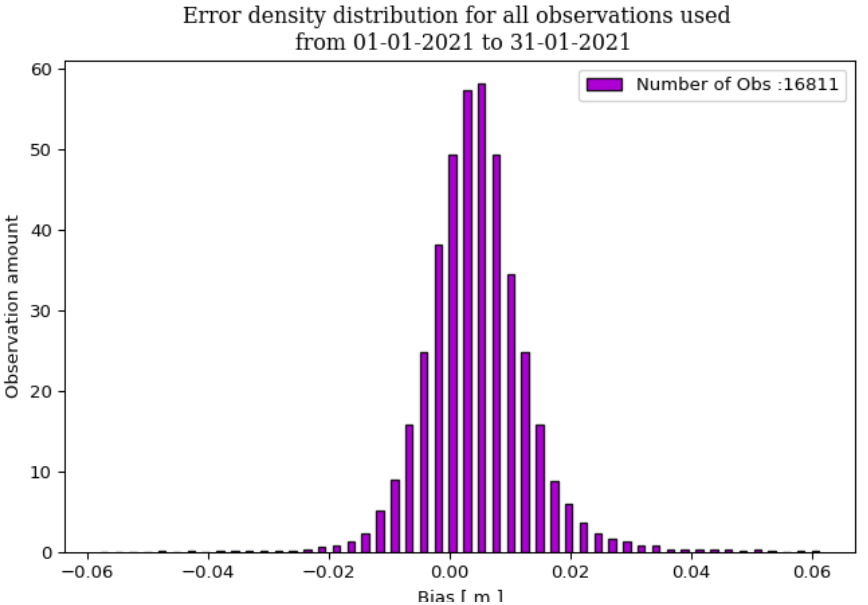
&BUFR
GPSSOLMETHOD= « CENT » or « MEAN »
/

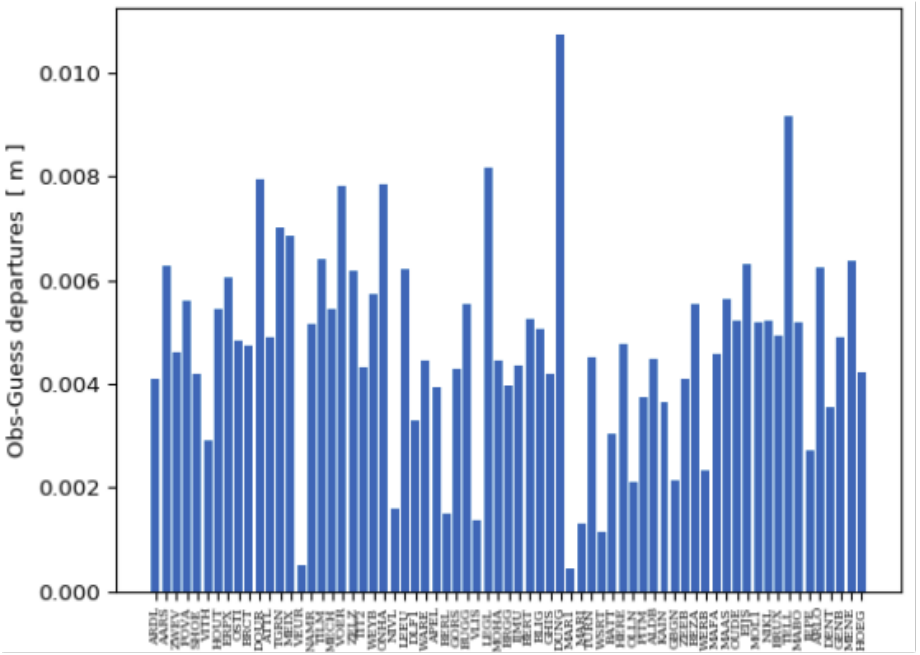
Station Name	Latitude	Longitude	Altitude	Period(minute)	ZTD bias (m)	Sigma ZTD (m)
BRUXROBQ	50.80	4.36	113.0	15.	0.0	0.0

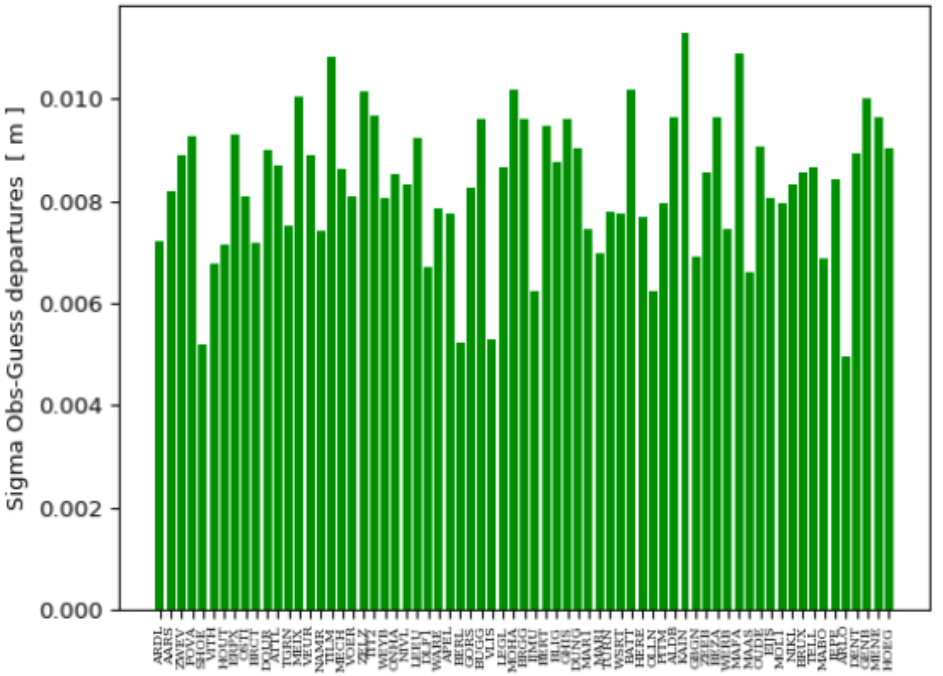
Stations monitoring & static bias evaluation

During the monitoring period :

- 128 stations are used and the static bias of each one is evaluated from the CCMA updated by the screening step.
- The stations mean biases show variations between ~2 and 13 mm (found from 16811 OMF pairs)
- The error distribution shows a gaussian shape with a slight shift to the positive values
- The monitored stations are added to the list_gpssol for active assimilation







Single obs experiment

- According to Smith and Weintraub (1953), the ZTD is the tropospheric wet part of the total refractivity integrated over the model levels.

$$ZTD = 10^{-6} \int_{zg}^{TOP} (k_1 \frac{P}{T} + k_3 \frac{e}{T^2}) dz$$

Where Zg is the station height , k1=77.6 K/hPa , k3=3.7391 10^5 , and TOP is the height of the last model level , 1 hPa currently in AROME

- In ARPEGE/IFS, an additional term was added into the observation operator

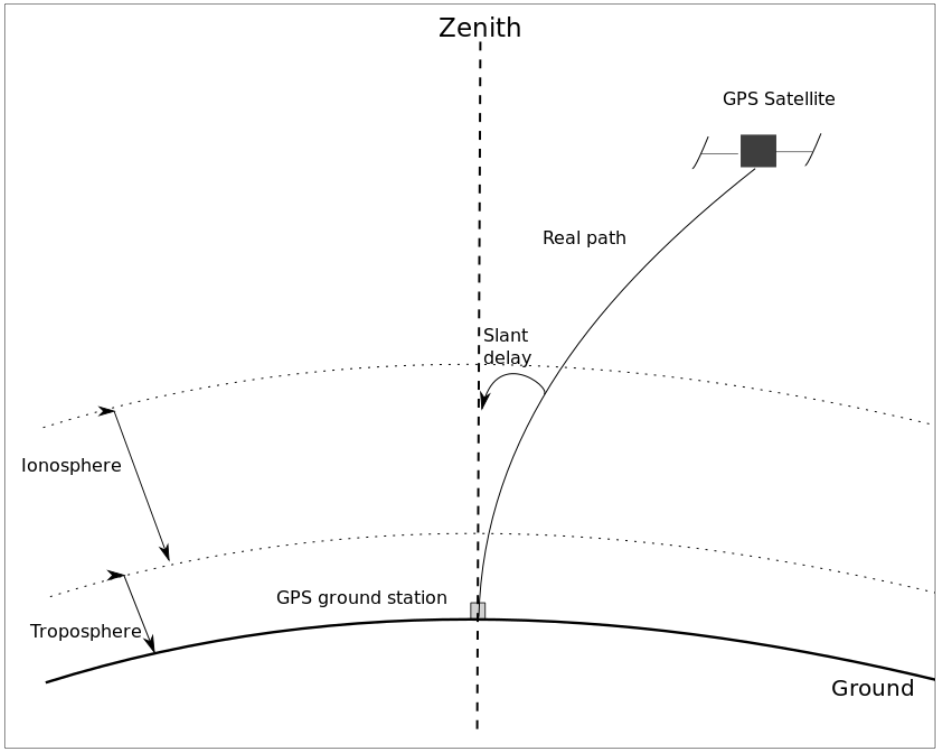
$$J_o^{ZTD} = \frac{1}{2} \left(H(x') - y' \right)^T R^{-1} \left(H(x') - y' \right)$$

x ' : The vecor of analysis increments

y' : Observation increments

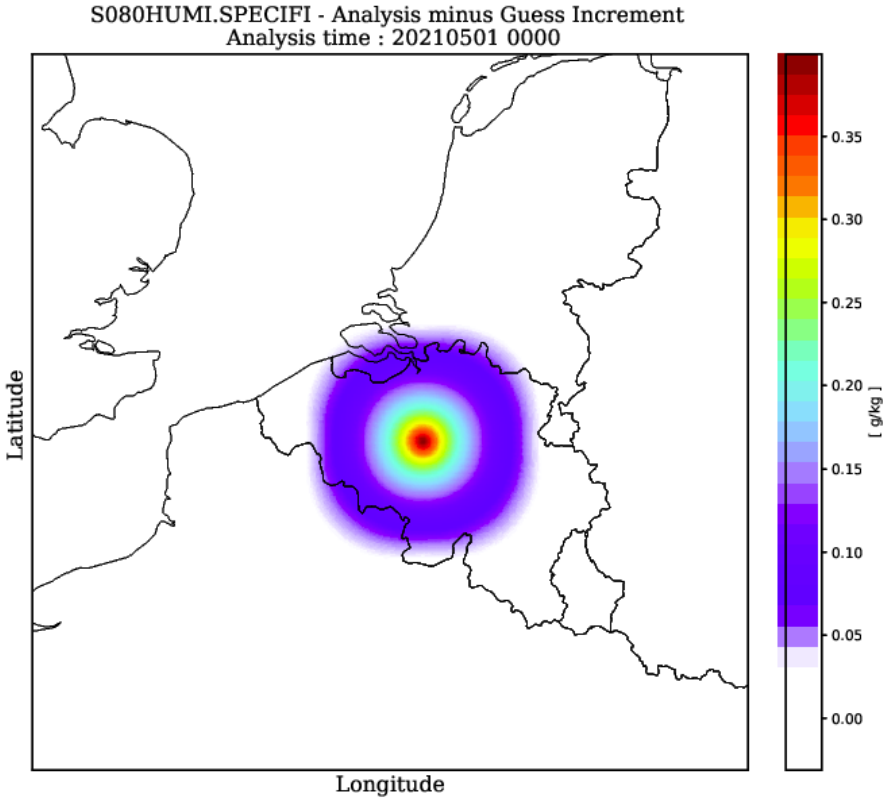
H : Observation operator

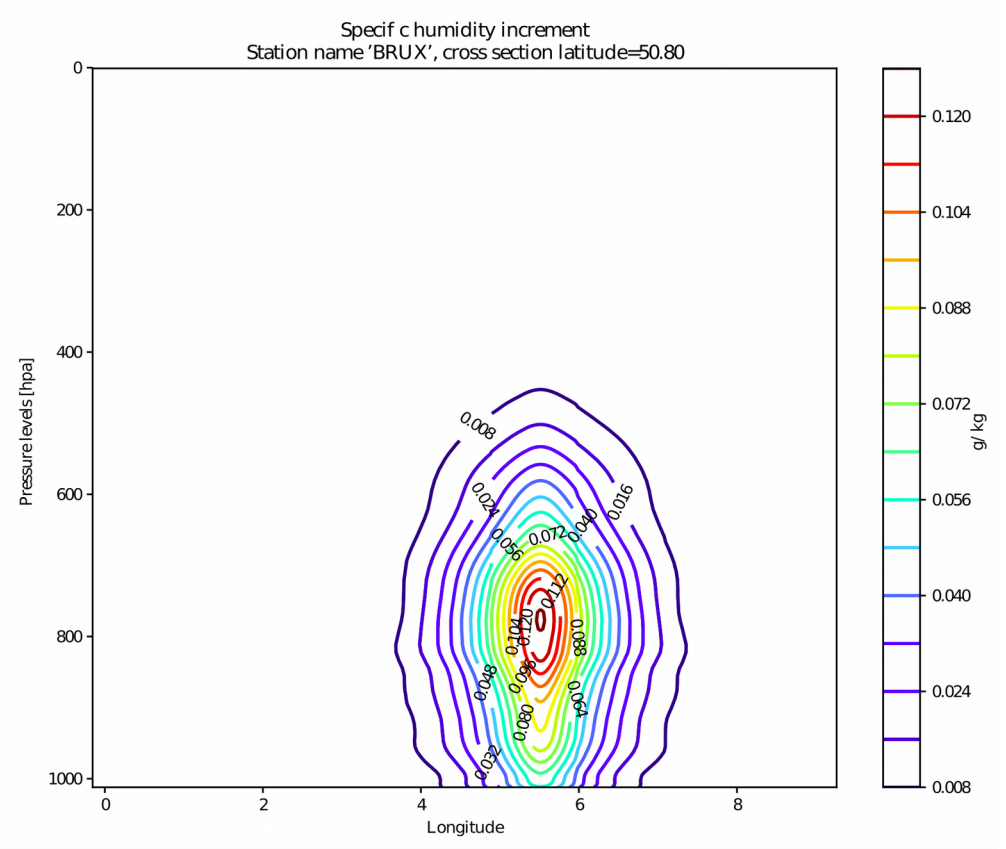
R : Observation covariance matrix



Single obs experiment

- The station BRUXROBQ is randomly chosen to evaluate the impact of a single station active assimilation
- The impact is largest in the low to middle troposphere with a maximum around 800 hPa
- The horizontal extent of increments is about 160 km
- The specific humidity increment (Analysis- guess) show positive values . The ZTD assimilation inscreases the analysis upper-air moisture





Active GNSS assimilation experiment

- In order to evaluate the impact of ZTD assimilation on the forecast, two experiements are carried out during 1-month period (01-05-2021 until 31-05-2021)

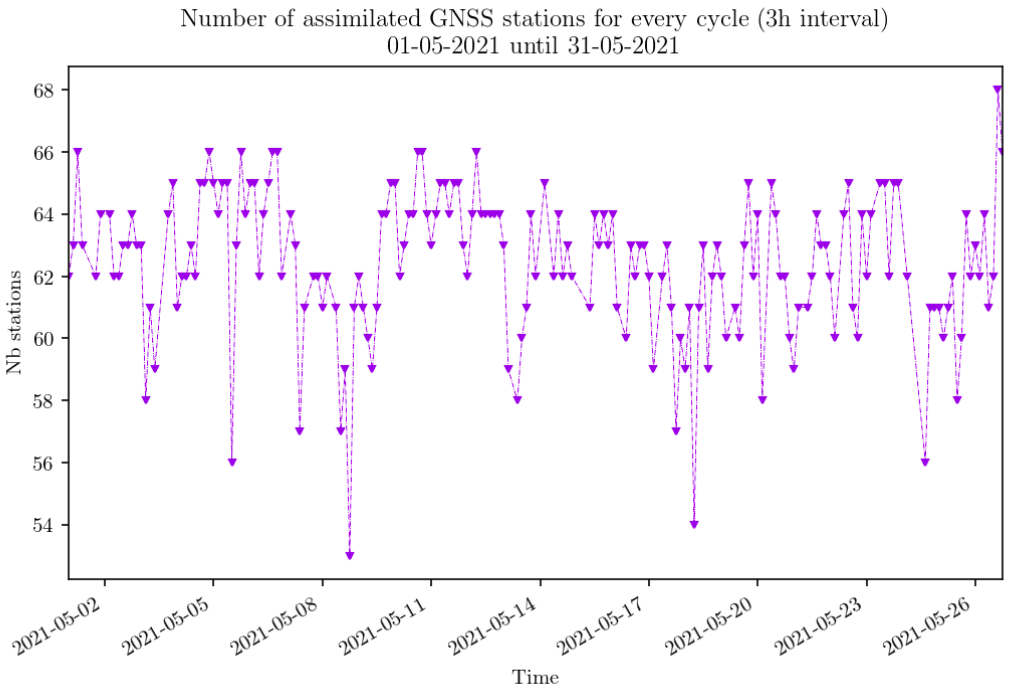
Experiment name	period	Assimilation technique	Assimilated parameters
AR13_OPER	01/05/2021 until 31/05/2021	CANARI	H2m,T2m,Z, U10 from SYNOP
ARGPS	01/05/2021 until 31/05/2021	CANARI+3DVar	• H2m,T2m,Z, U10 from SYNOP • U,V from AMDAR • U,V,T from TEMP • ZTD from GNSS

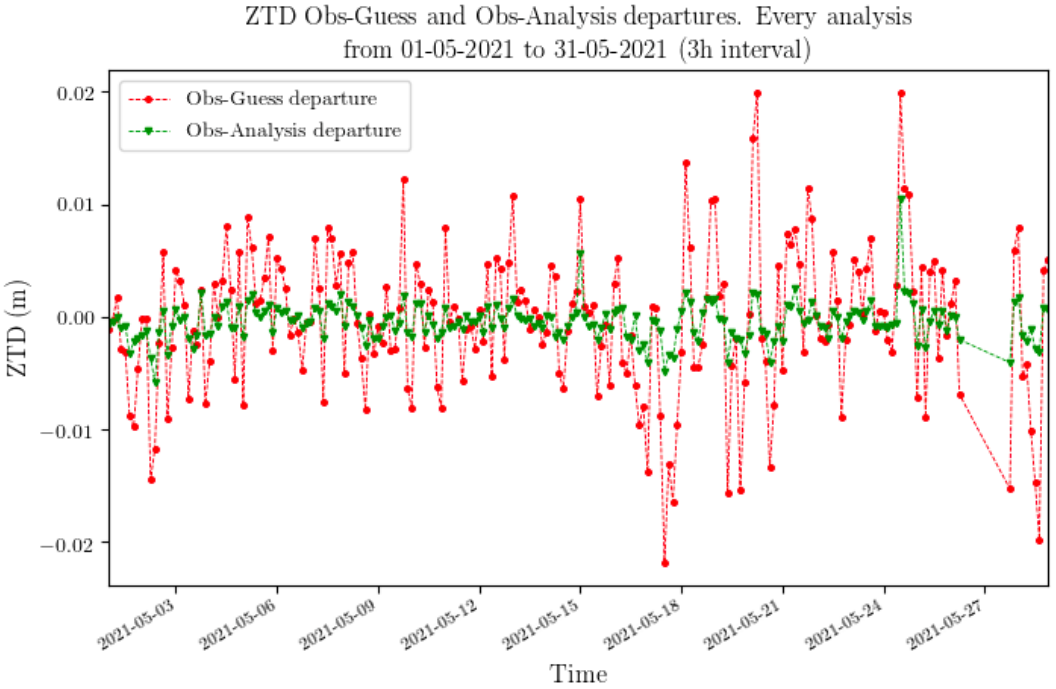
- The upper-air humidity is disabled in the observation operator from the AMDAR and TEMP using the namelist bloc NAMCOSJO during the minimisation (see the module yomcosjo.F90 in cy43t2)

&NAMCOSJO
NOTVAR(1,1)=-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1 ,-1,-1,-1,-1,-1 ,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,0,-1,
NOTVAR(1,2)= 0,0,-1,-1,-1,-1,0,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1….,
NOTVAR(1,5)= 0,0,-1,-1,-1,-1,0,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,-1,0,-1,-1,-1,-1,-1,-1….,
/

Impact on the initial departures

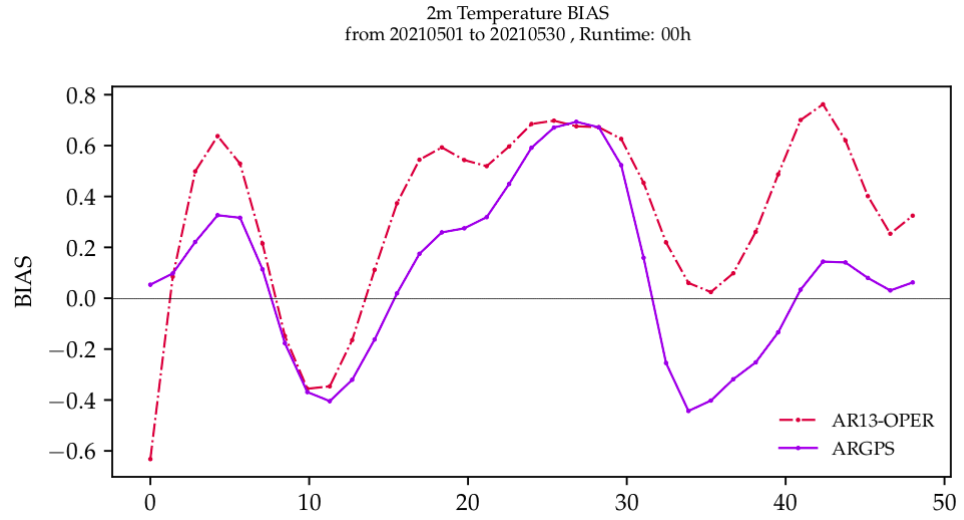
- The number of assimilated GNSS stations varies between ~54 and 68.
- The assimilation system tends to brought the model to the ZTD observation at every analysis cycle

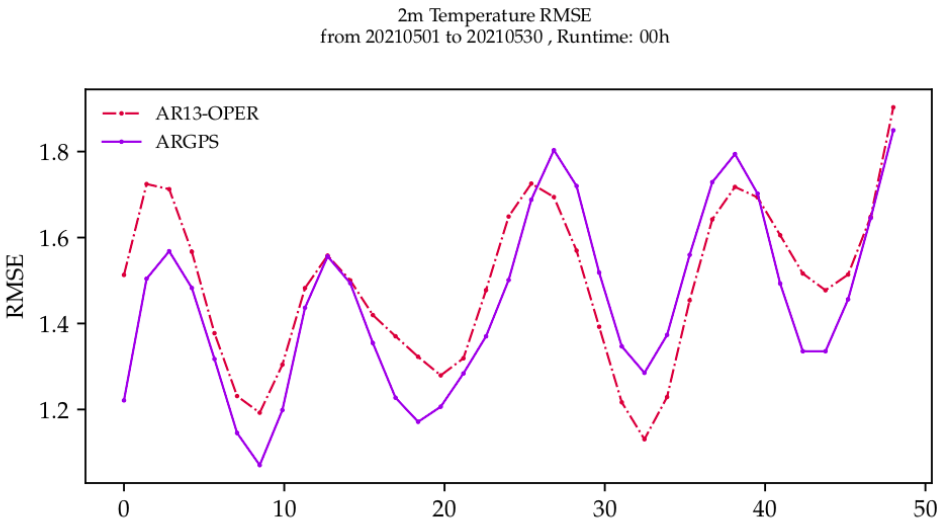


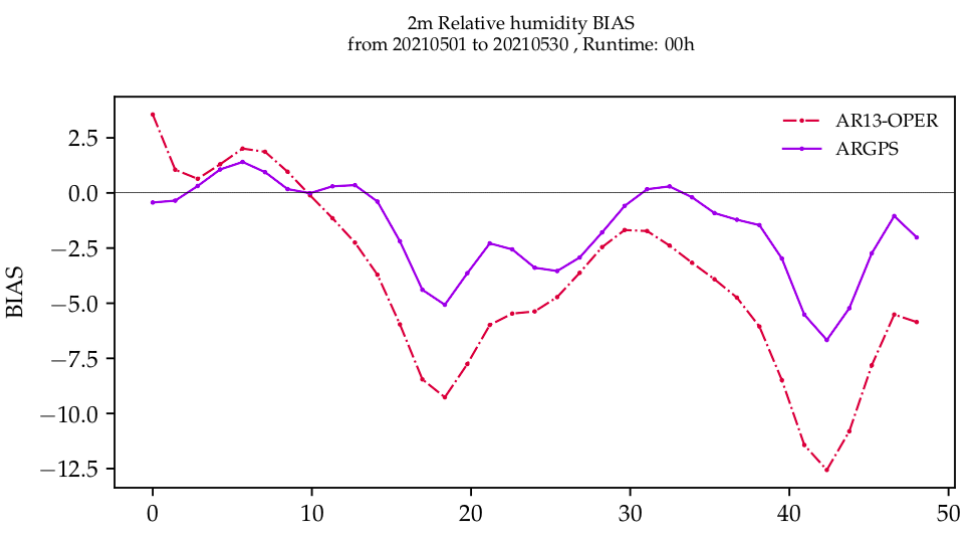


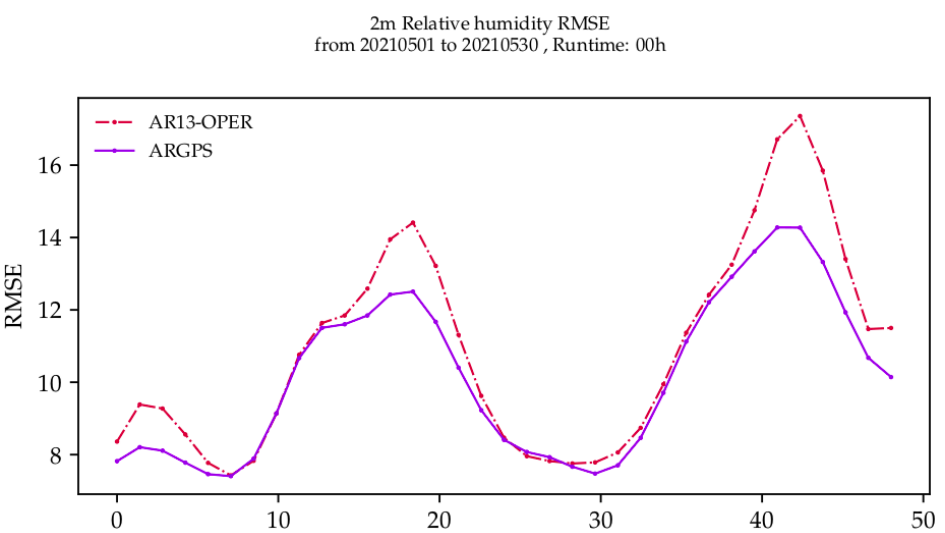
Impact on the surface parameters

- The 2m temperature and humidity verification is carried out using 22 synoptique stations.
- The pictures display the observation minus forecast (O - F).



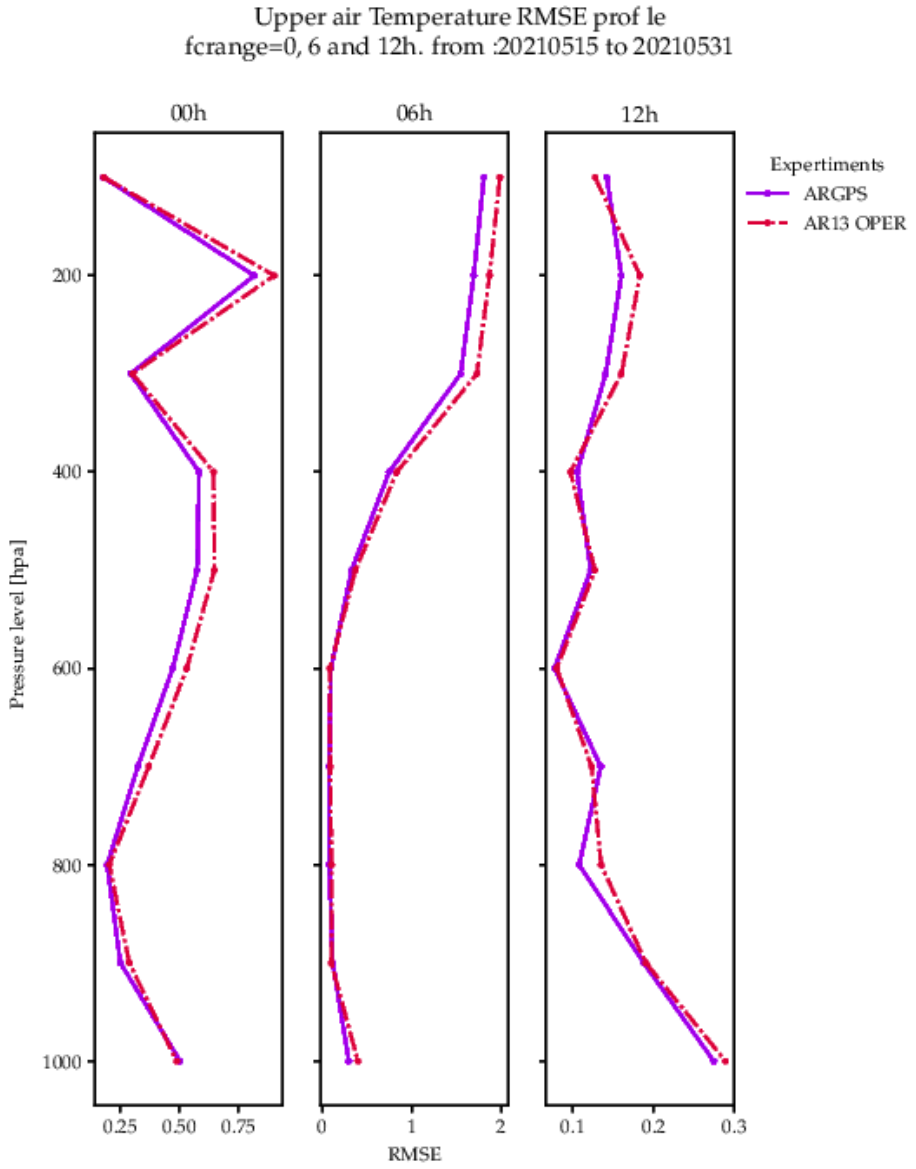


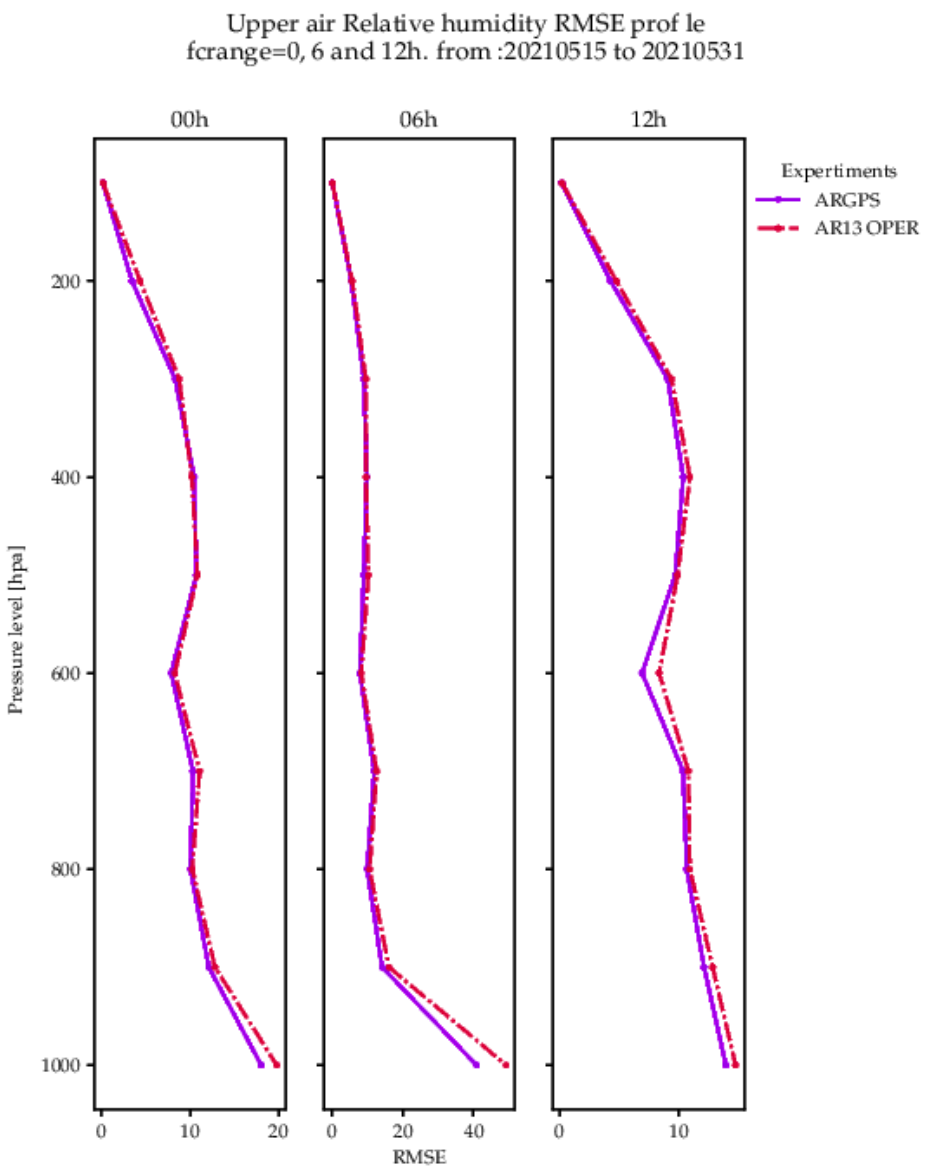




Impact on the upper-air forecast

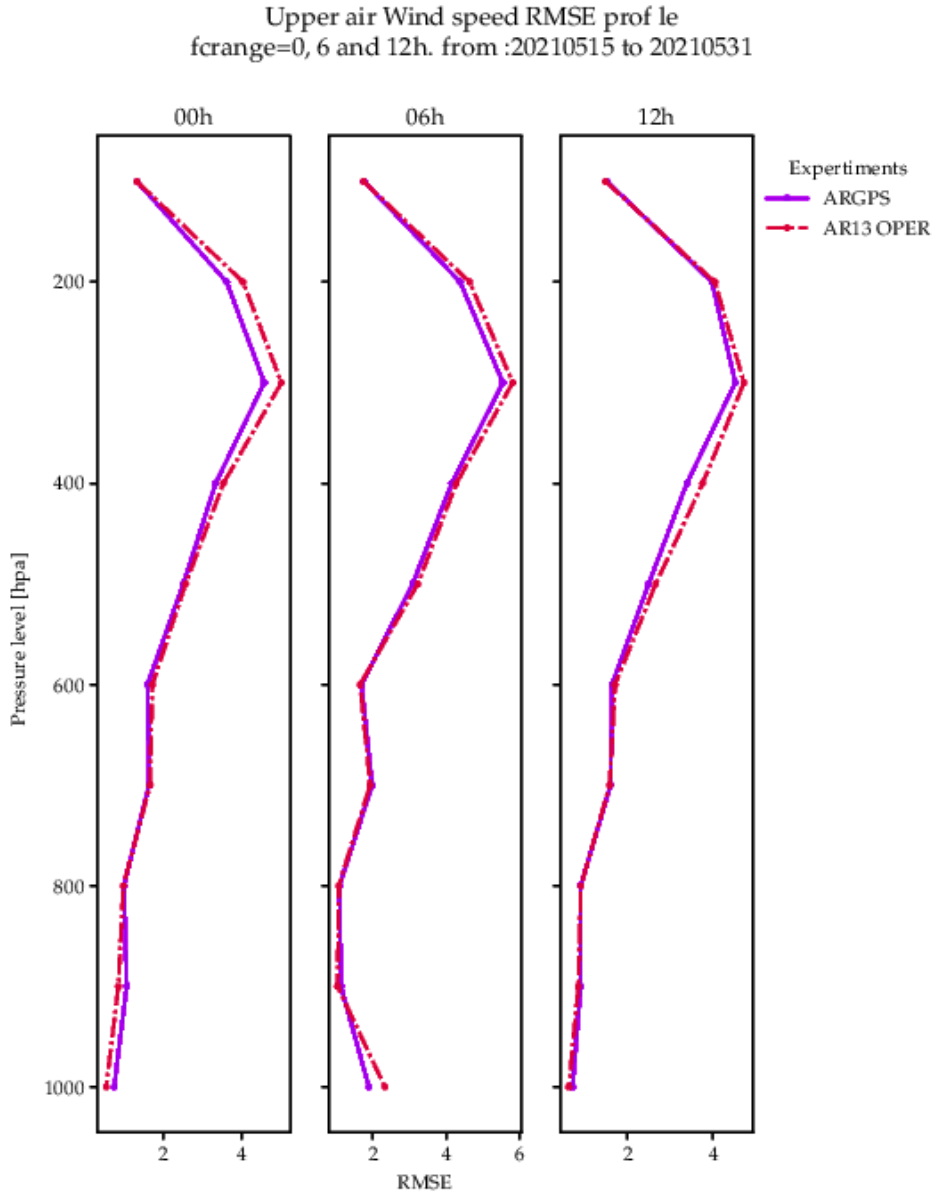
- The upper-air forecast are verified against 4 radio-sonding stations.
- The model value is extracted using nearest neighbor interpolation at every standard atmospheric level.

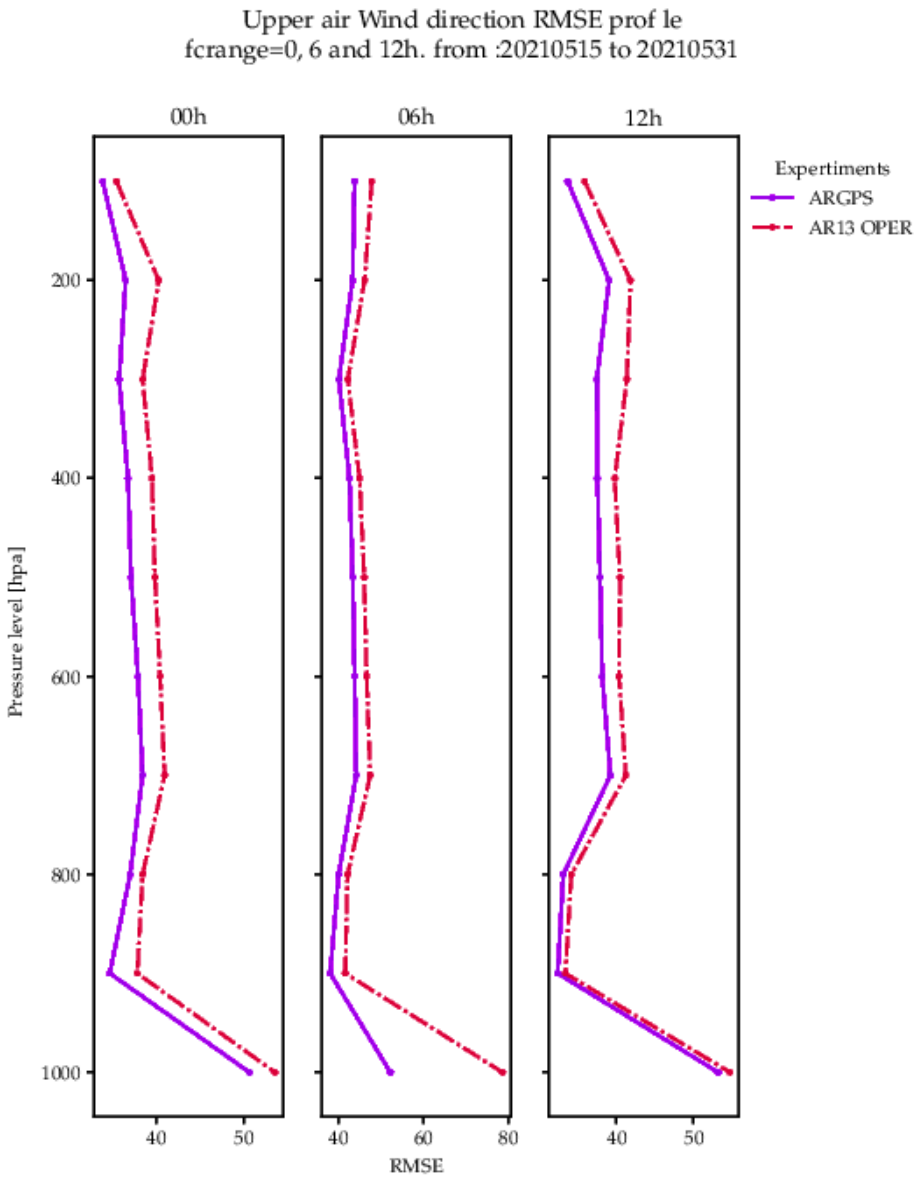




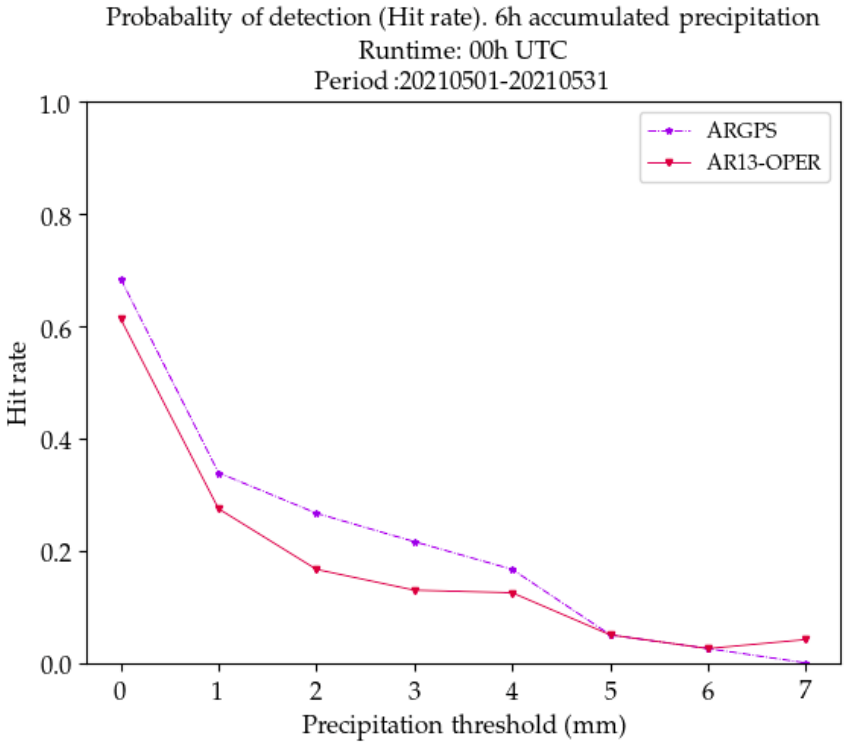
Impact on the wind forecast

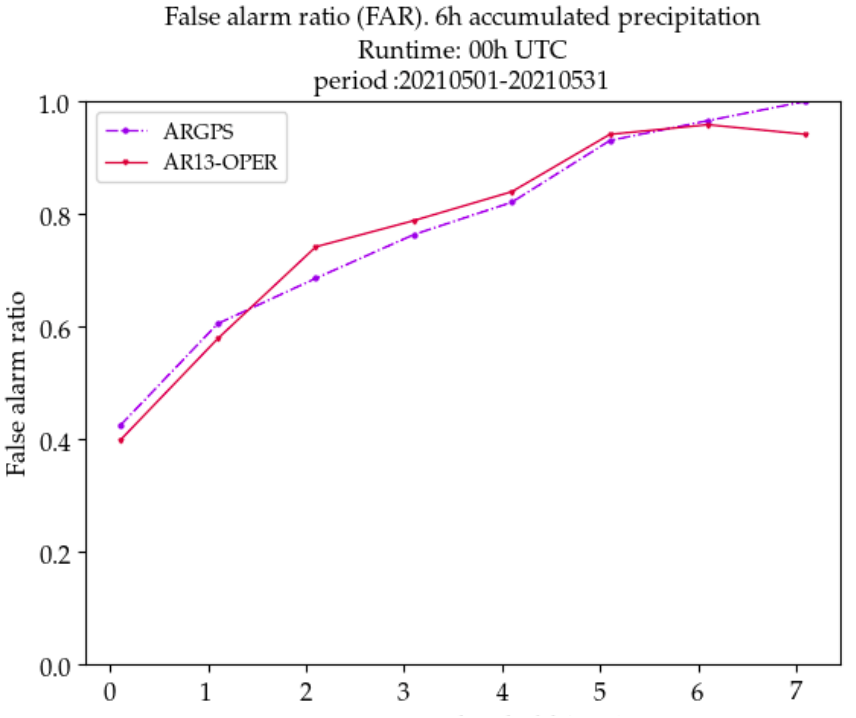
- The upper-air forecast are verified against 4 radio-sonding stations.
- The model value is extracted using nearest neighbor interpolation at every standard atmospheric level.

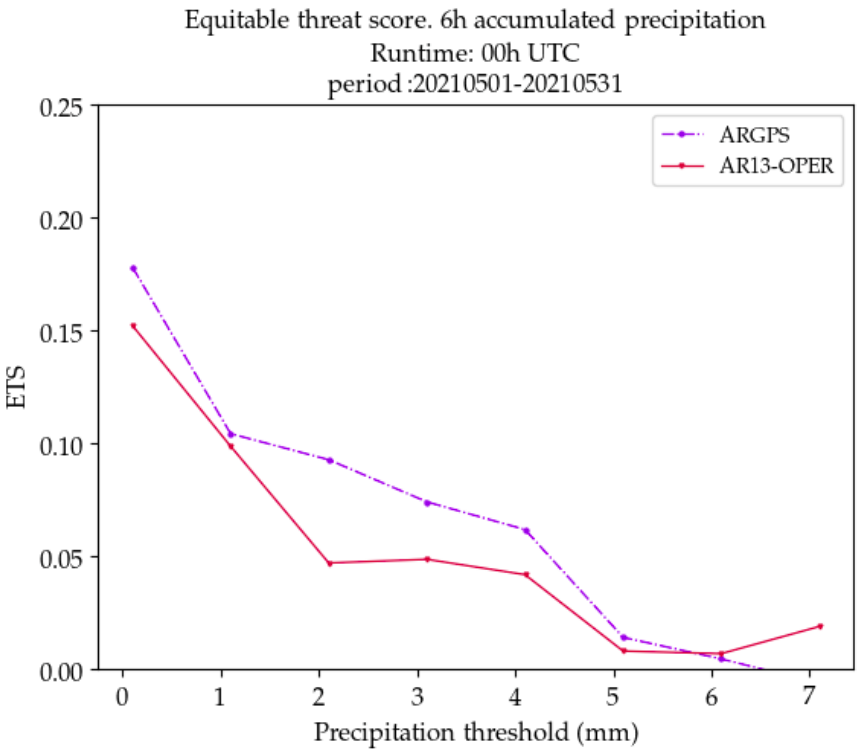




Impact on the precipitation skill







- Perfect forecast :
- POD = 1 , FAR =0 , ETS =1

Conclusion

- The stations used from three processing centers cover sufficiently the AROME Belgium domain
- The single station assimilation showed the horizontal and vertical extent of the increments over the model grid points
- The assimilation of the ZTD from GNSS have a potential to improve either surface and upper-air temperature and humidity forecast
- The use of GNSS ZTD has a positive impact on the small amount precipitation forecast skill

Future work

- Evaluation of the observation correlation and apply a possible thinning
- Compare the GNSS DA with static with VarBC