LACE
nwp central europe

Assimilation of GNSS ZTD observations in AROME Hungary

Mate Mile with contributions from Ersin Kucukkaraca, Xin Yan and Szabolcs Rozsa

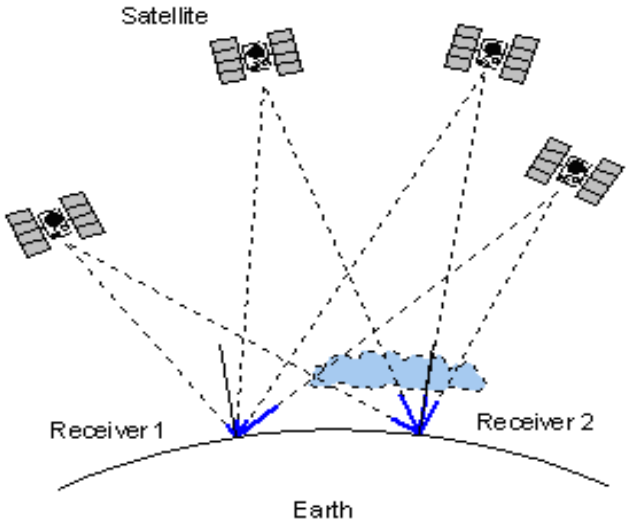
DHMZ SHMÚ OMSZ ZAMG ROMANIA ANM

Outline

- GNSS ZTD observations
- AROME DA system in Hungary
- Assimilation of GPS ZTD
  - SGOB ZTD observations
  - Pre-processing and bias correction
  - Results of assimilation studies
- Conclusion and Outlook

GNSS ZTD

- The zenith total delay (ZTD) is the time-delay (converted to distance) of GPS signal transmitted by Global Navigation Satellite System (GNSS).
- The tropospheric delay depends on the refractivity (N)
- Refractivity can be expressed (Smith and Weintraub, 1953)



$$ZTD = \int_{z=h}^{TOA} [n(z) - 1] dz .$$

$$N = p_d \frac{K_1}{T} + p_v \left(\frac{K_2}{T} + \frac{K_3}{T^2} \right),$$

n – refractivity index
p_d – partial pressure of dry air
p_v – partial pressure of water vapour
T – temperature
K_1, K_2, K_3 – constants

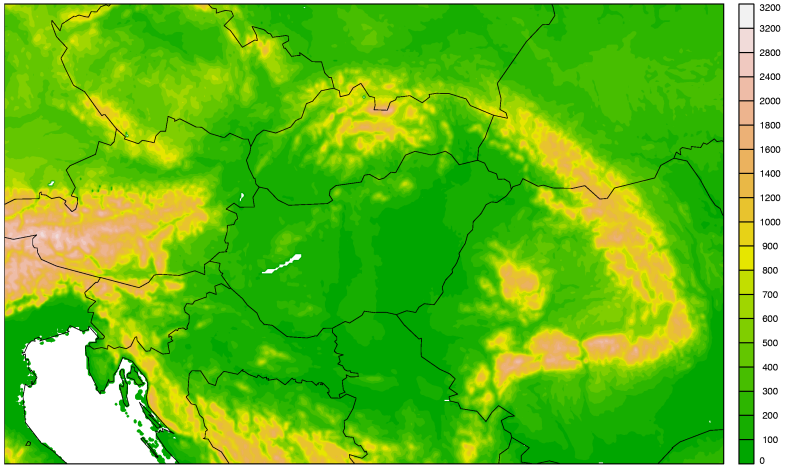
AROME DA in Hungary (reminder)

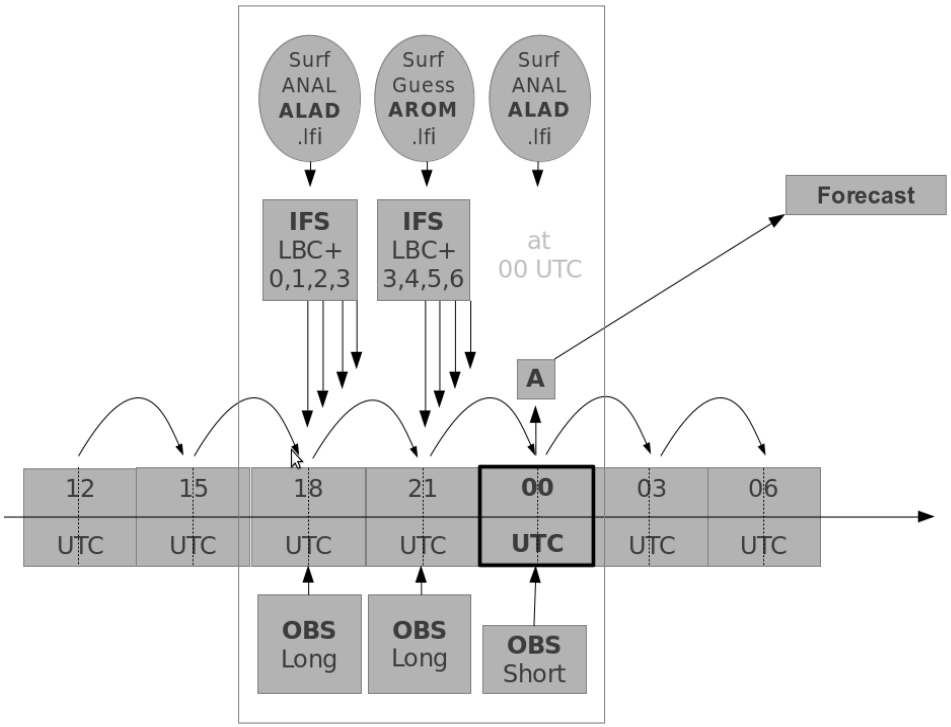
- 3h Rapid Update Cycle
  (8 3DVAR analyses per a day)

- No surface assimilation for
  soil parameters
  (surface updated from 8km
  ALADIN soil analysis and
  previous AROME runs)

- Background error statistics
  based on ensemble DA
  approach

- Recently Conventional obs.
  are used





Assimilation of GNSS ZTD

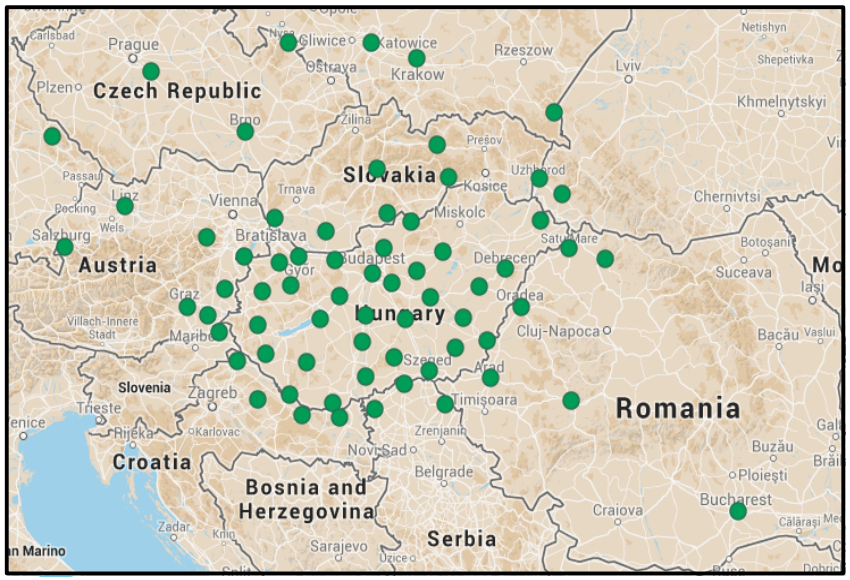
used SGOB ZTD observations

- The GPS ZTD observations are disseminated in EGVAP format which has to be converted to OBSOUL ASCII for assimilation

- Hungarian ZTD observations are availabe through SGOB network (included in E-GVAP) in hourly frequency.

- Impact studies have been made with AROME 3DVAR for January and July of 2014.

Ground-based GPS receiver stations in SGOB network



Selected stations during assimilation (67 – 68 stations inside AROME domain)

Data pre-processing
(GNSS ZTD)

- Pre-processing GPS ZTD requires specific procedure

- The whitelist approach is used which means data can be active only from trusted sites

- Selection criteria:

    - large time availability
    - small stde of OMG departures
    - not too big absolute bias
    - OMG departures are Gaussian (Chi-squared test)
    - small difference between station height and model ground surface height

Pre-processing method: Poli et. al. 2007
Criteria for AROME: Yan et. al. 2008

Data pre-processing
(GNSS ZTD)

- Due to pre-processing the whitelist is created which contains station list and bias information

- Before the GPS ZTD obs goes into the assimilation ODB the bias will be removed → static bias correction

- ZTD observations are considered as Obstype 1 (surface observations)

```
[mmate@wfma:/home/mmate/tools/gps_staticbc]$ cat list_gpssol_arhu
ARADGVAP       46.1966       21.3554          125. 60. -0.016960219 11.28   0.0113
BAIAGVAP       47.6759       23.5697          231. 60. -0.000275941  7.99   0.0080
BALEGVAP       46.2045       18.9495          112. 60. -0.006709932  8.77   0.0088
BAR1GVAP       45.9824       17.4665          128. 60. -0.003218381  8.63   0.0086
BBYSGVAP       48.7765       19.1607          445. 60.  0.001722462  8.65   0.0086
BJELGVAP       45.9196       16.8533          143. 60. -0.003562498  8.21   0.0082
BODOGVAP       46.7644       16.0983          294. 60.  0.006369335 10.06   0.0101
BUCUGVAP       44.4865       26.1390          108. 60.  0.007135644 10.01   0.0100
BUTEGVAP       47.5050       19.0662          137. 60.  0.001566373 11.26   0.0113
CAKOGVAP       46.4106       16.4474          177. 60. -0.001471891 10.53   0.0105
CSORGVAP       47.6358       17.2601          134. 60.  0.004178979 10.93   0.0109
DEBRGVAP       47.5544       21.6396          142. 60. -0.000535828 10.73   0.0107
DEVAGVAP       45.9017       22.9251          203. 60.  0.005253346 10.14   0.0101
DUJVGVAP       46.9874       18.9497          166. 60. -0.002379719  8.88   0.0089
FLDBGVAP       46.9769       15.8906          302. 60.  0.006479082 10.89   0.0109
FUZEGVAP       47.7738       20.4260          123. 60. -0.000560436  9.88   0.0099
GANPGVAP       49.0596       20.3332          705. 60. -0.000417075  8.72   0.0087
GKU4GVAP       48.1817       17.1806          152. 60.  0.007437017  8.96   0.0090
GOPEGVAP       49.9390       14.7931          548. 60. -0.001952579  8.62   0.0086
GRAZGVAP       47.0910       15.5013          493. 60.  0.008622837 10.99   0.0110
GYFCGVAP       47.7107       17.6435          141. 60.  0.003555313 10.42   0.0104
GYOMGVAP       46.9563       20.8365           99. 60. -0.001194127 10.89   0.0109
GYULGVAP       46.6694       21.2869          108. 60. -0.001093339 10.30   0.0103
HALAGVAP       46.4544       19.4959          149. 60. -0.005791767 10.69   0.0107
JASZGVAP       47.5300       19.9303          107. 60.  0.000872849  9.53   0.0095
KAPOGVAP       46.3857       17.8072          159. 60. -0.002497314  8.86   0.0089
KATOGVAP       50.2787       19.0453          292. 60.  0.001125930  7.25   0.0073
KECSGVAP       46.9298       19.7113          132. 60. -0.002468762 10.17   0.0102
KIKIGVAP       45.8525       20.4739          100. 60. -0.003855951  9.20   0.0092
KRAWGVAP       50.0915       19.9306          227. 60. -0.001417542  9.05   0.0091
LINZGVAP       48.3342       14.2903          290. 60.  0.013162532  8.69   0.0087
MONOGVAP       47.3803       19.4550          151. 60. -0.000613884 10.37   0.0104
```

Pre-processing method: Poli et. al. 2007
Criteria for AROME: Yan et. al. 2008

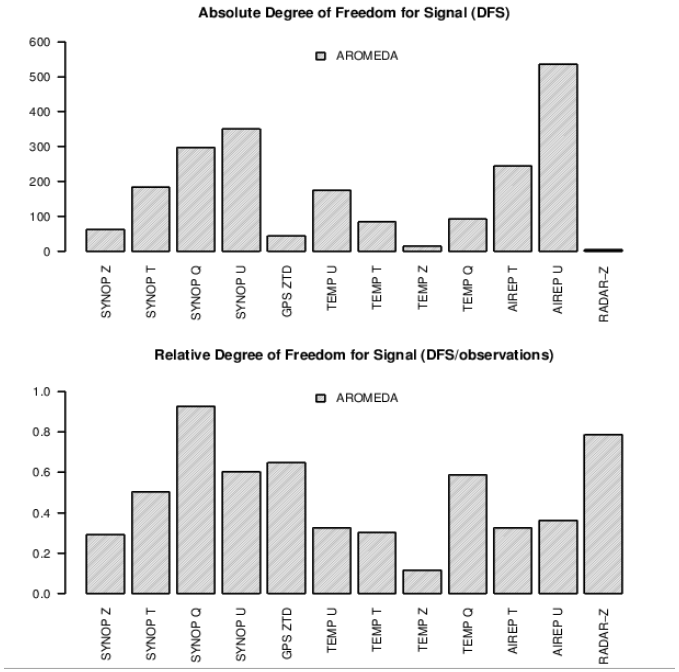
Impact on analysis
(GNSS ZTD)

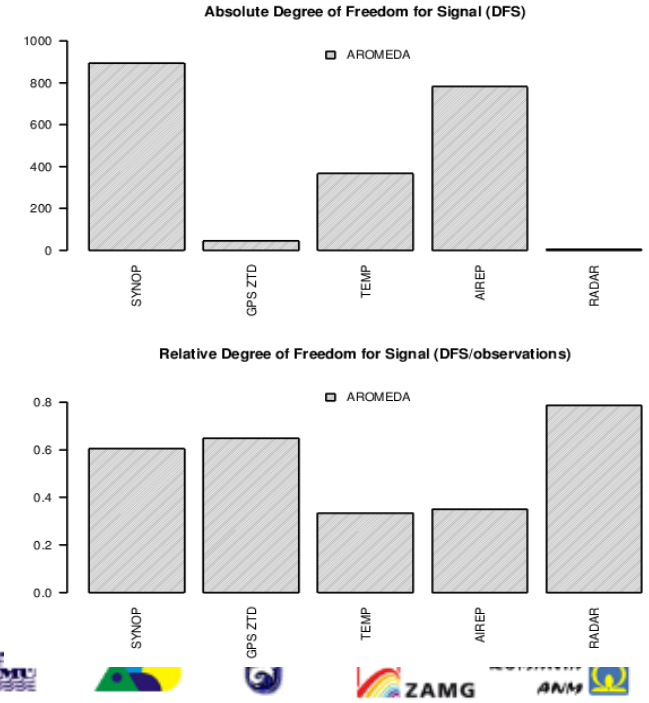
- To evaluate the impact of obs on analysis, DFS was computed (demonstrated on one analysis at 12UTC January 03. 2014.)

- Absolute contribution of GPS ZTD is moderate

- Relative importance of “humidity” observations

- GPS is one of the most important component of the DA system concerning relative DFS (among SYNOP,TEMP,AIREP,RADAR)





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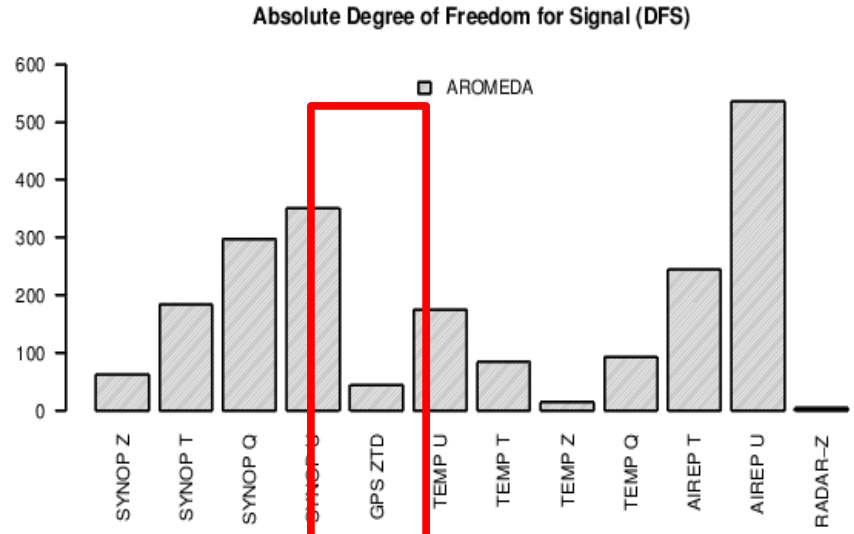
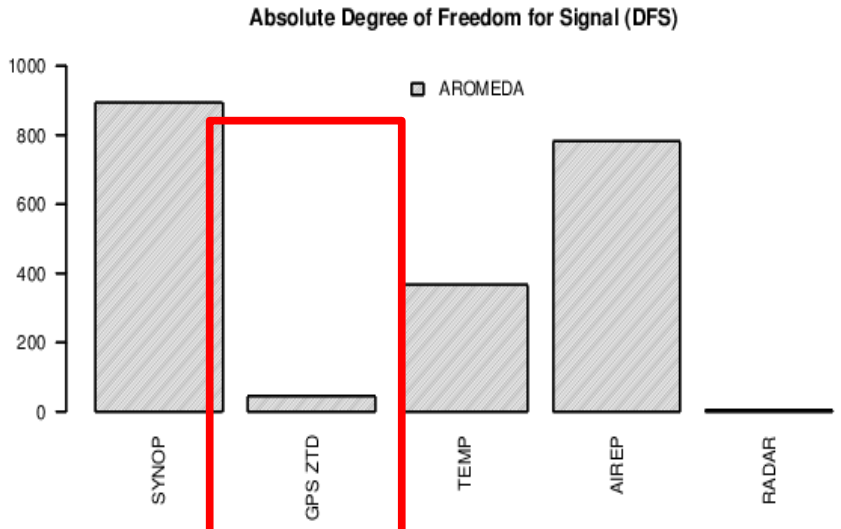
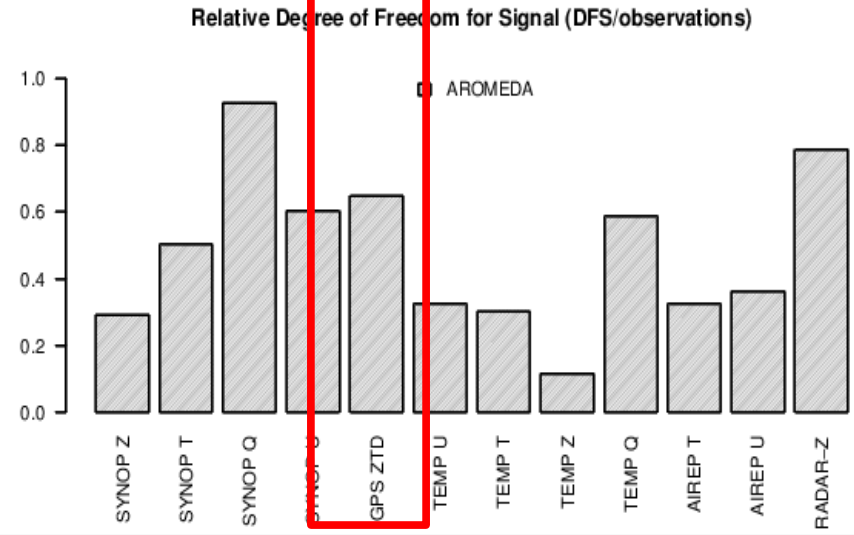
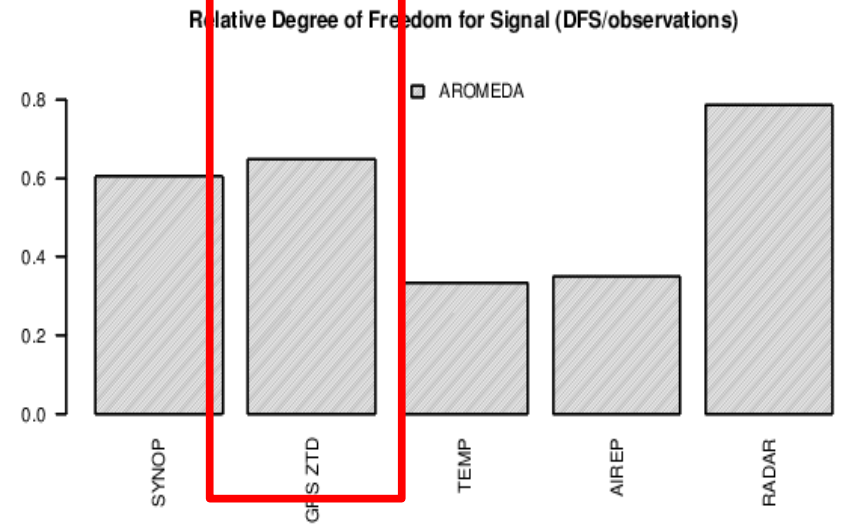






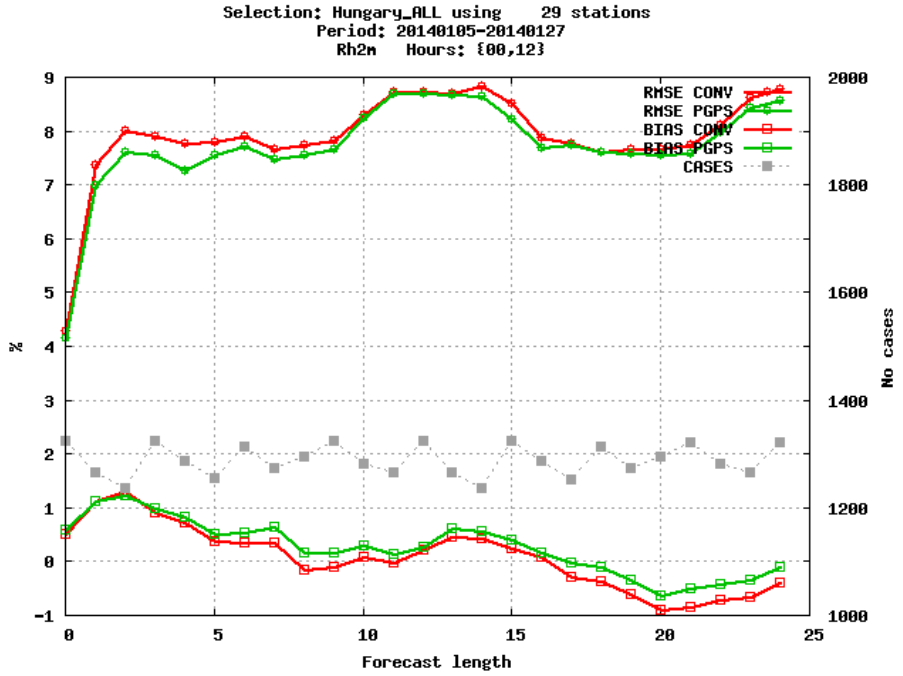


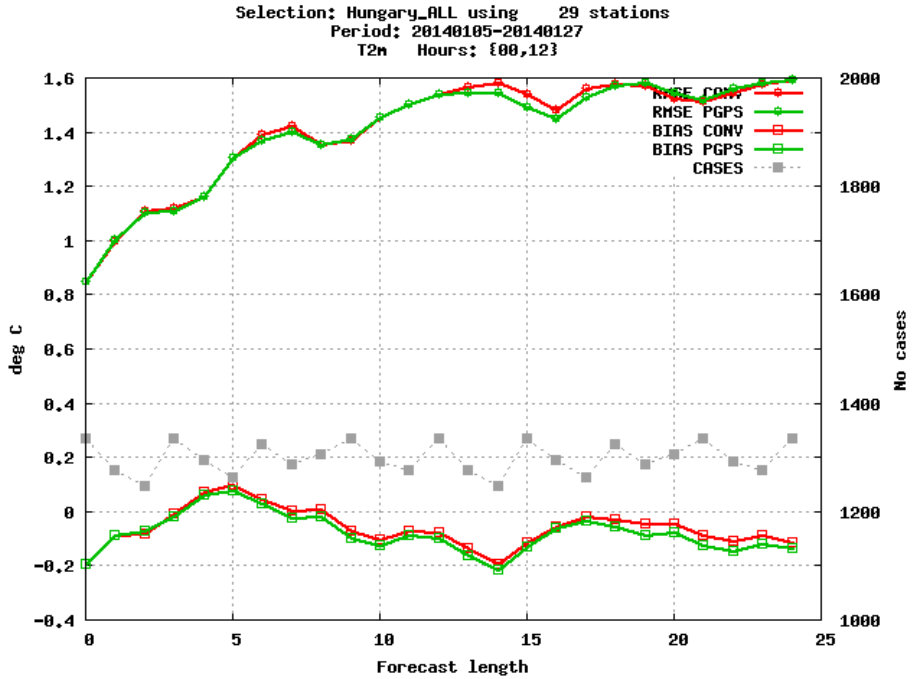
Verification results
(January 2014)

- 67 ground-based GPS stations were selected i.e. presented in GPSSOL WHITELIST.
- ZTD observations were assimilated on the top of conventional ones in AROME 3DVAR 3h RUC.

HARMONIE verification
2014.01.05. - 01.27.

AROME CONV - Red
AROME PGPS – Green





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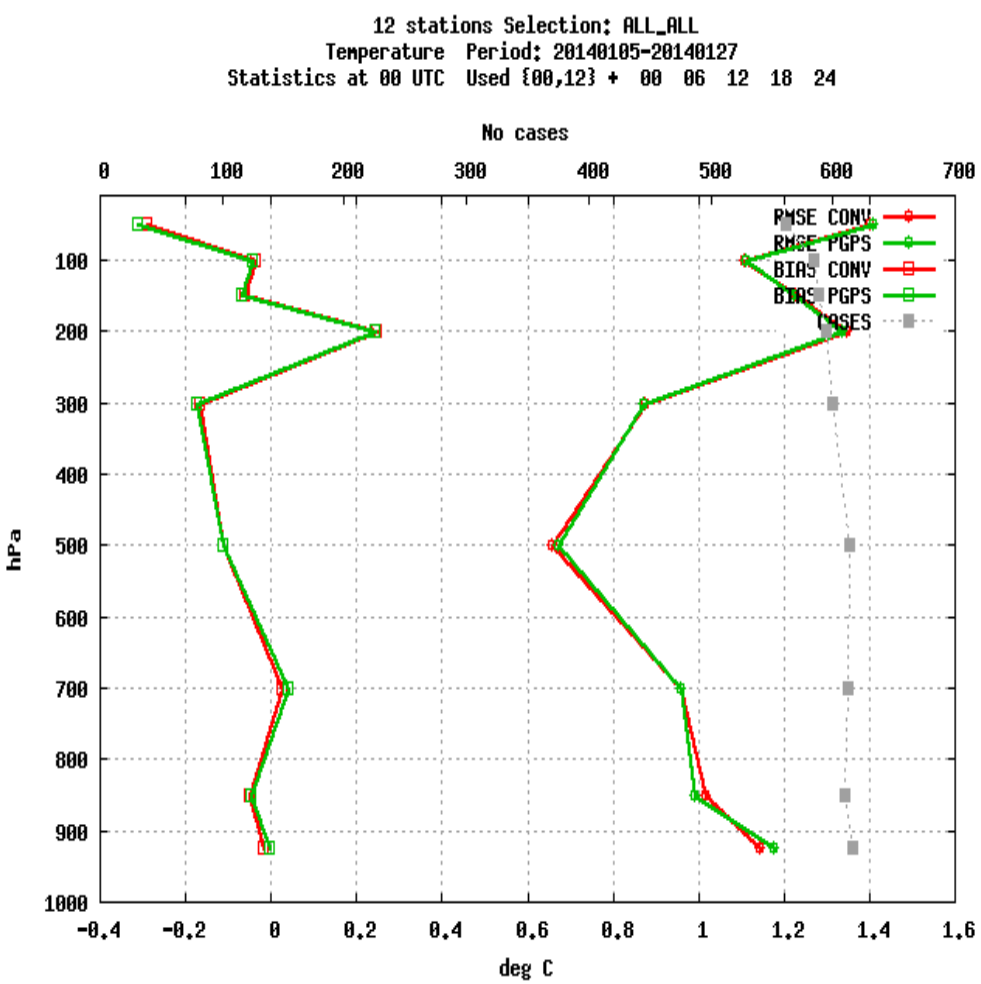

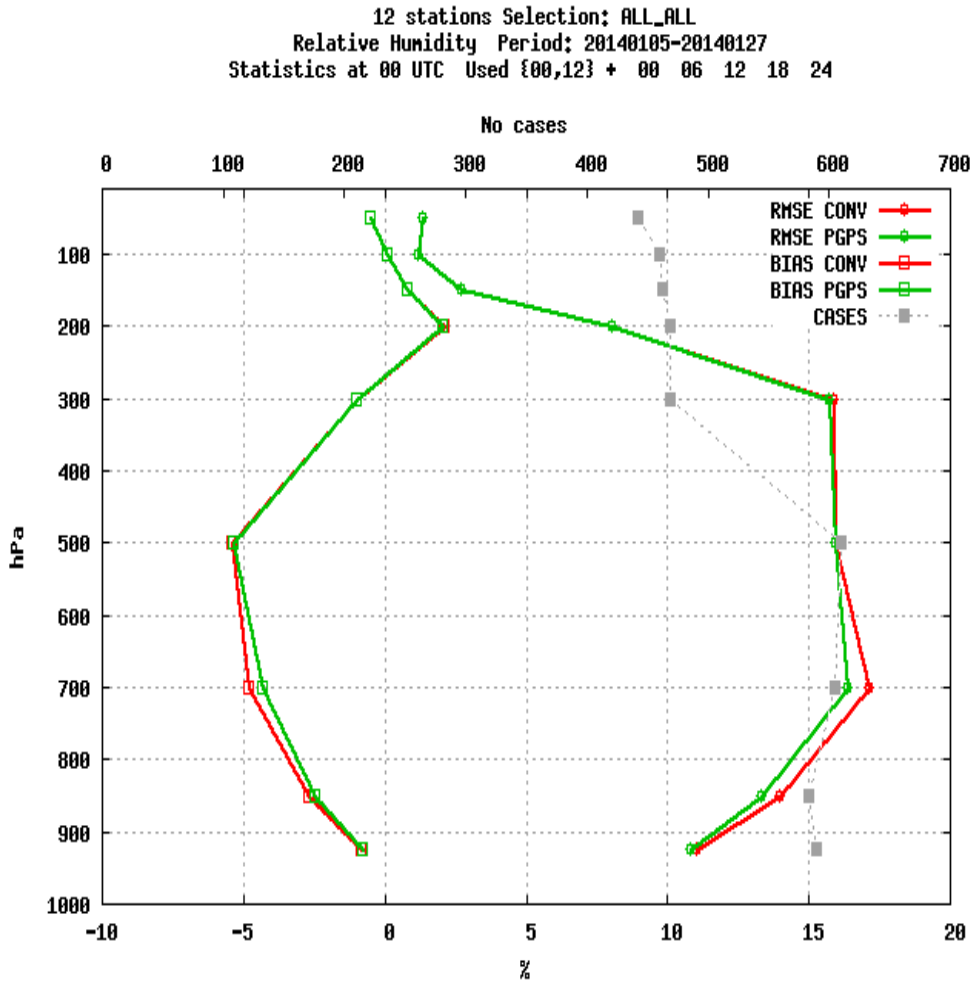

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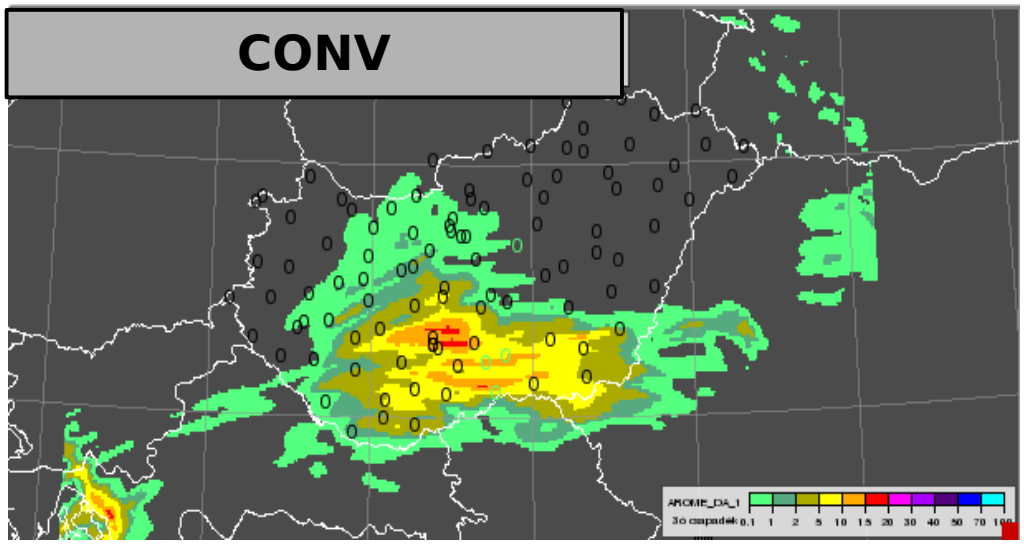

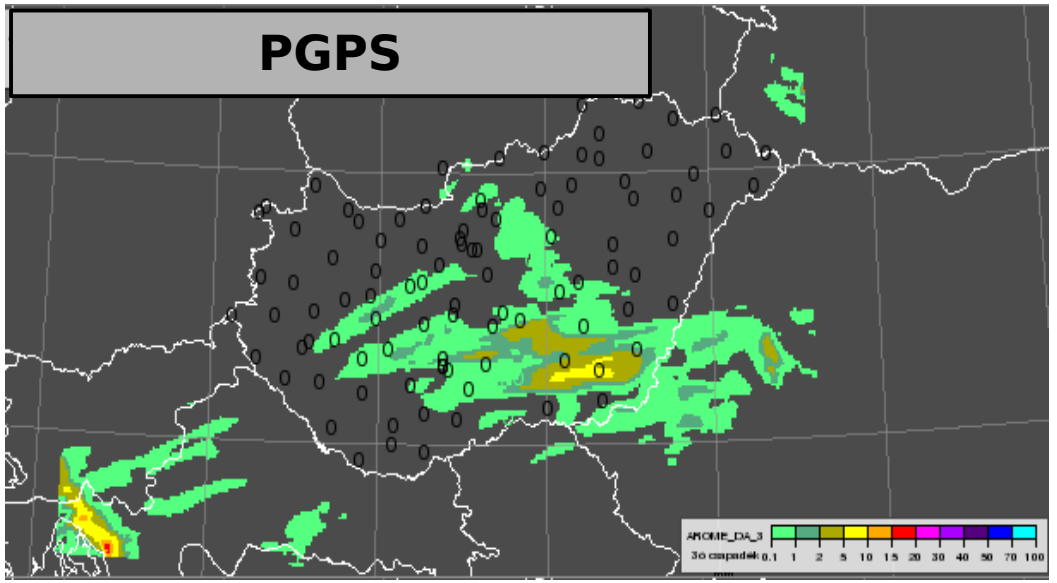

Verification results
(July 2014)

- 68 ground-based GPS stations were selected i.e. presented in GPSSOL WHITELIST.
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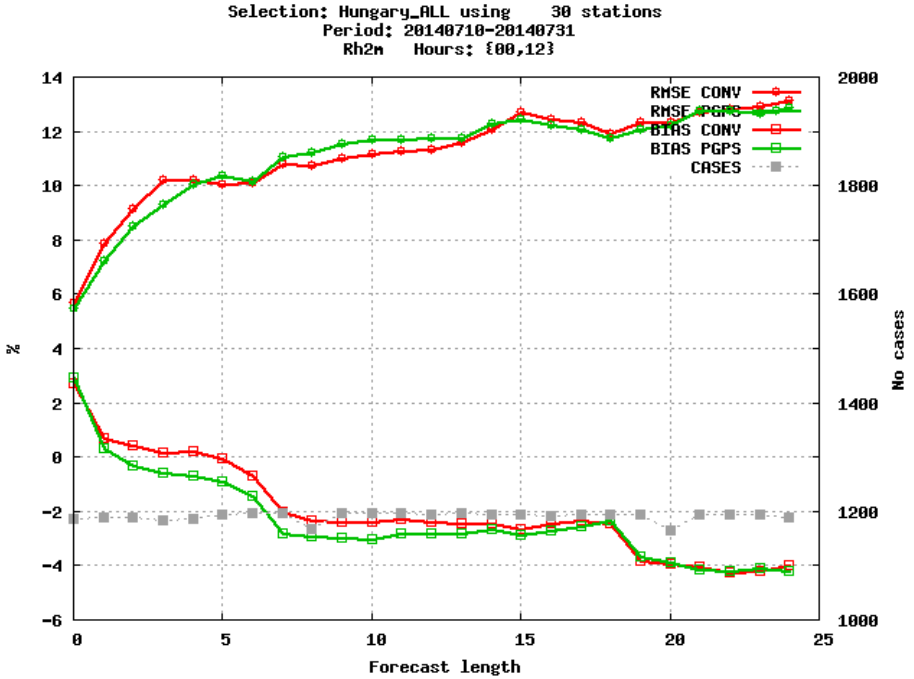
HARMONIE verification
2014.07.10. - 07.31.



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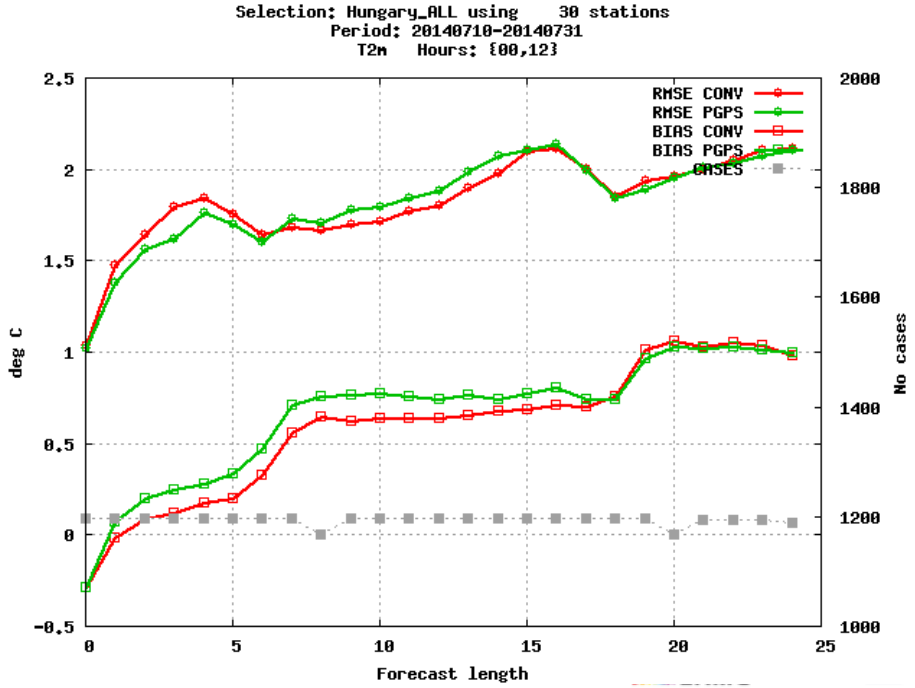

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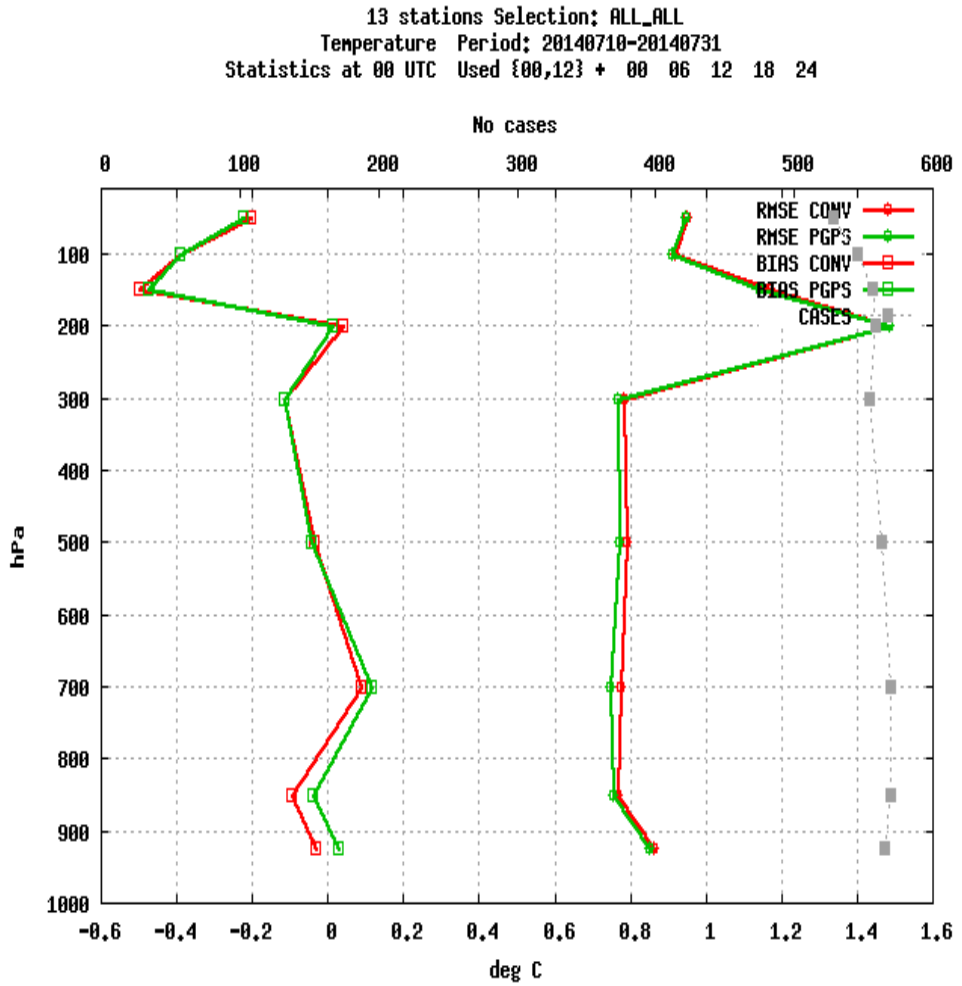
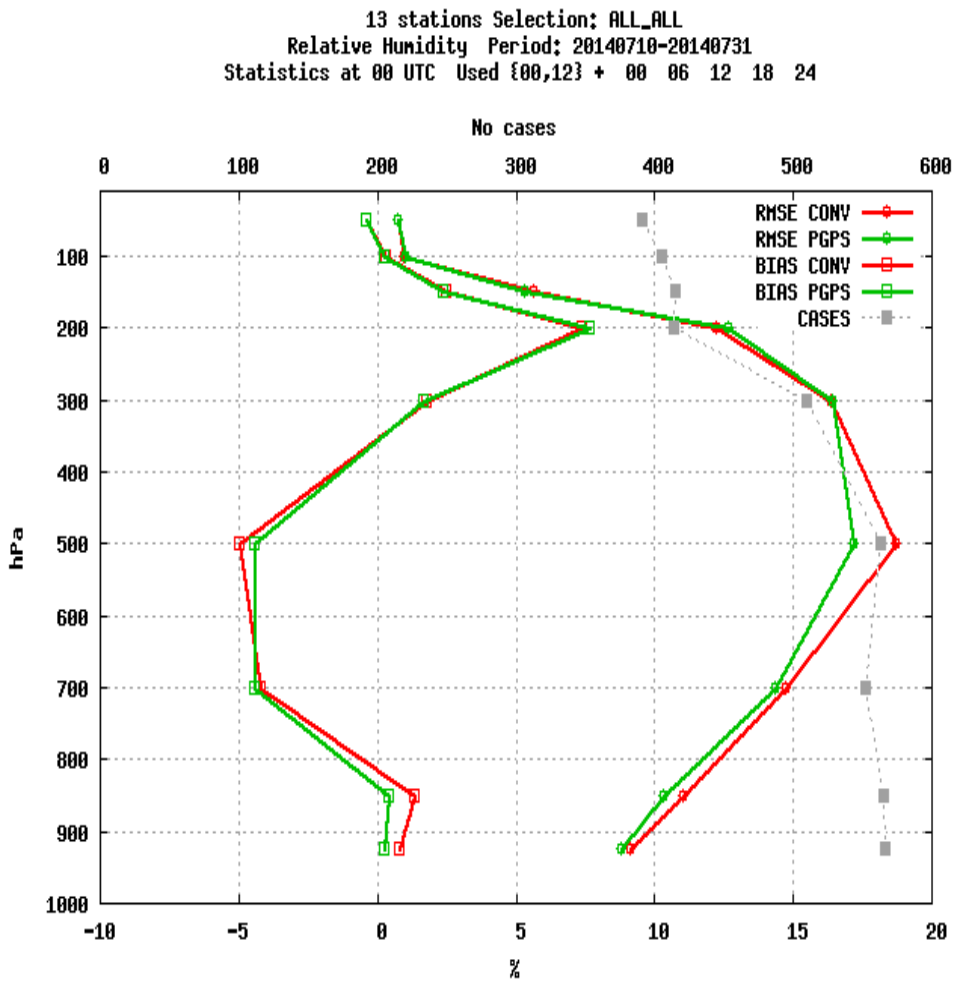


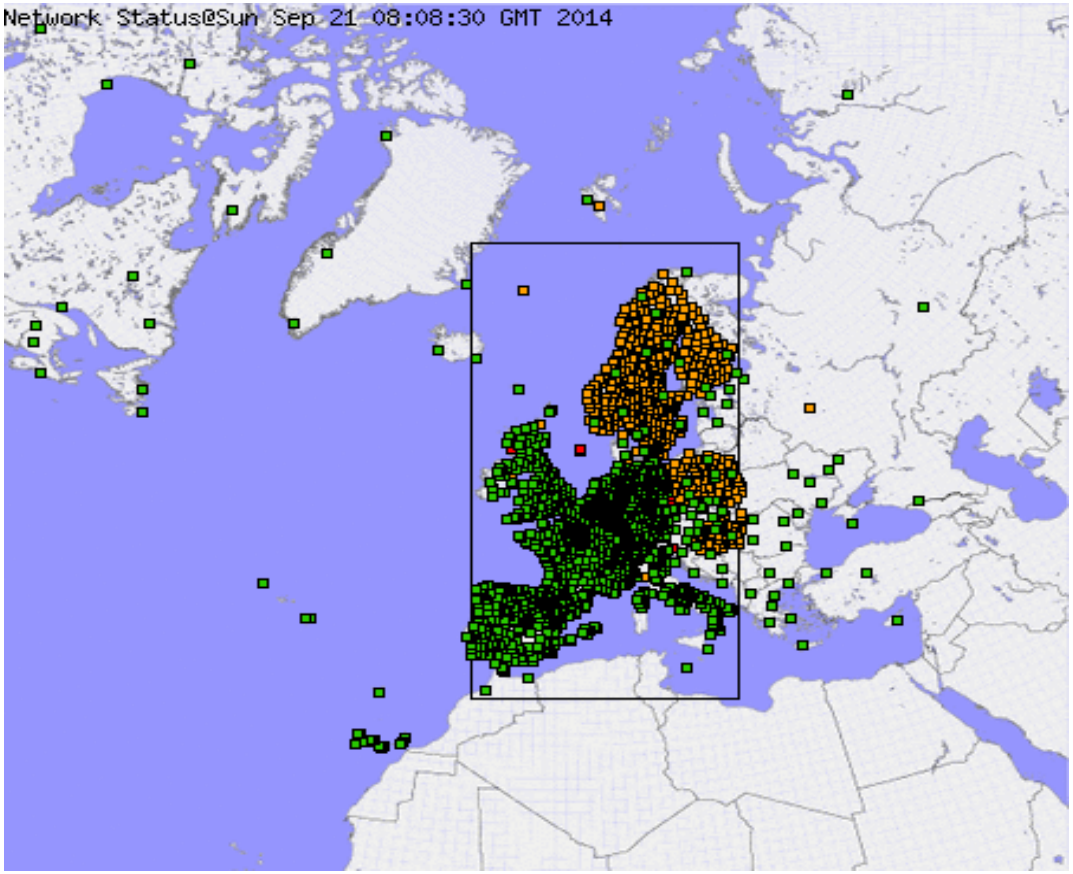


Conclusion and Outlook

- E-GVAP network (SGOB including) provides good data coverage over our domain and mostly Europe
- Regarding relative DFS, GNSS ZTD has important contribution in the system
- Good potential to improve humidty analysis and forecast especially in winter
- Further tuning of pre-processing procedure is needed
- Comparison of static and variational bias correction is ongoing (based on CY38t1)

GNSS ZTD and EUMETNET

- EUMETNET Water Vapour Programme E-GVAP has a fast growing network collecting and controlling ground-based GPS receiver stations
- With an E-GVAP membership, everyone can use ZTD observations from the network.
- Currently Hungary and Croatia are the only members of E-GVAP from LACE countries
- If You want to use ZTD in assimilation and become E-GVAP member: contact with Henrik Vedel (hev@dmi.dk)
- (E-GVAP membership costs roughly 400 EUR/year or less)



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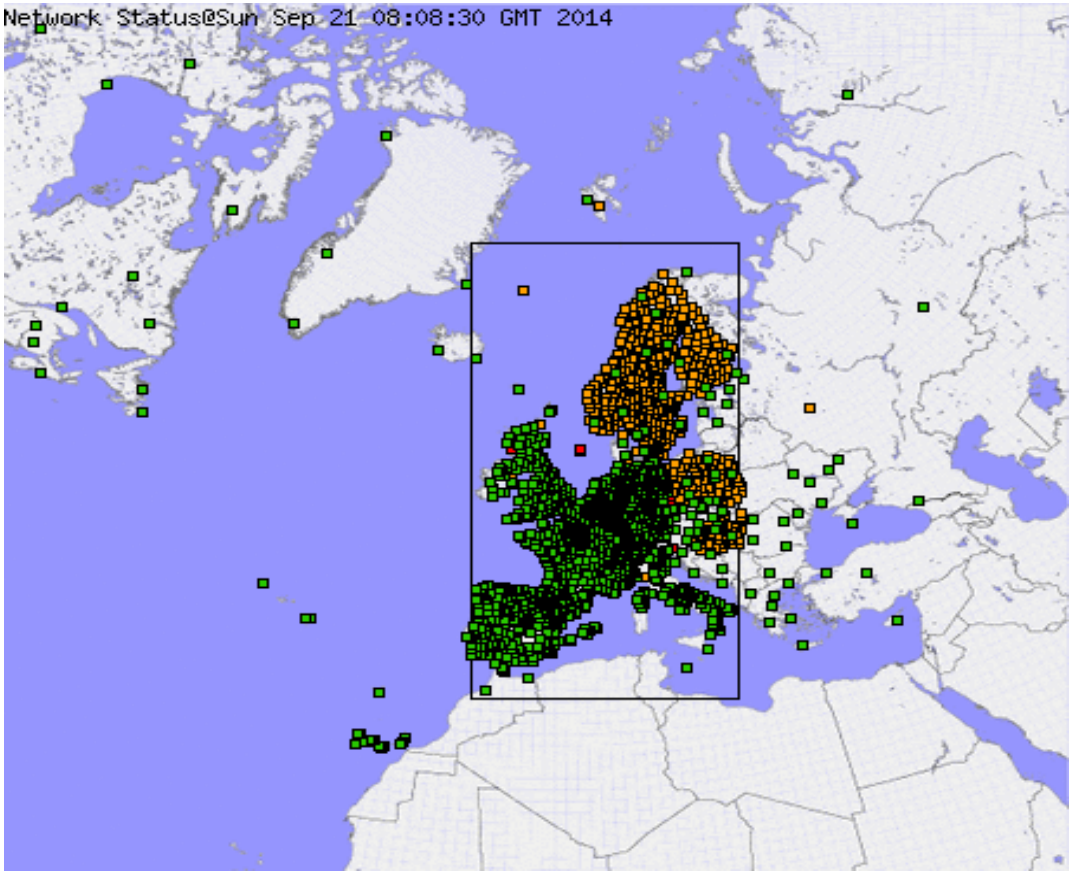

Thank You for your attention!