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Status of the ASSIMILATION of **GNSS ZTD** observations **AEMeT 2016**

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1) Status of ZTD GNSS assimilation in AEMet



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Paper published 2016 about the VarBC scheme on ZTD GNSS Data Assimilation:

Sánchez J. , Lindskog M., Thorsteinsson S. , Bojarova J., “*Variational bias correction of GNSS ZTD in the HARMONIE modeling system*”. Journal of Applied Meteorology and Climatology · March 2016 DOI: 10.1175/JAMC-D-15-0137.1

Variational Bias Correction of GNSS ZTD in the HARMONIE Modeling System

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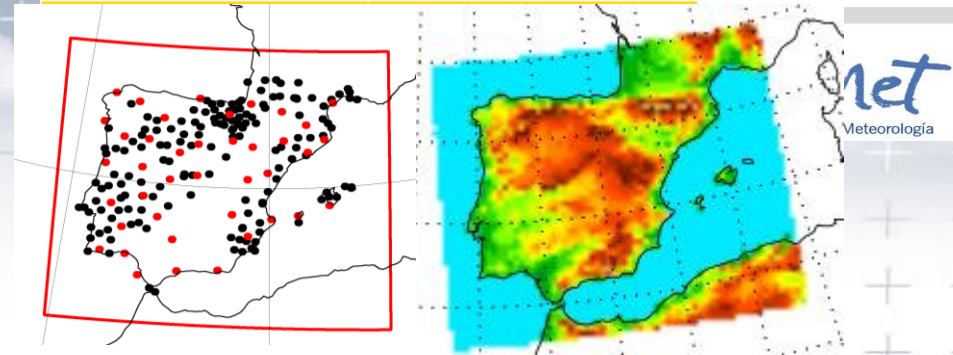
ABSTRACT

To fill the gap in the observation system for humidity, the HIRLAM-ALADIN Research on Mesoscale Operational NWP in Euromed (HARMONIE) limited-area high-resolution kilometer-scale model has been prepared for assimilation of Global Navigation Satellite System (GNSS) zenith total delay (ZTD) observations. The observation-processing system includes data selection, bias correction, quality control, and a GNSS observation operator for data assimilation. A large part of the bias between observations and model equivalents comes from the relatively low model top used in the HARMONIE experiments. The functionality of the different observation-processing components was investigated in detail as was the overall performance of the GNSS ZTD data assimilation. This paper contains an extensive description of the GNSS ZTD observation-processing system and a comparison of a newly introduced variational bias correction for GNSS ZTD data with an alternative static bias correction, as well as a detailed analysis of the impact of GNSS ZTD data, both in terms of statistical evaluations over a longer period and in terms of individual case studies. Assimilation of the GNSS ZTD observations with a variational bias correction has improved the quality of short-range weather forecasts for the moisture-related parameters in particular, both in a statistical sense and in individual case studies. The paper also discusses further improvements in the HARMONIE variational data-assimilation system that are needed to fully utilize the potential of high-resolution GNSS ZTD observations.

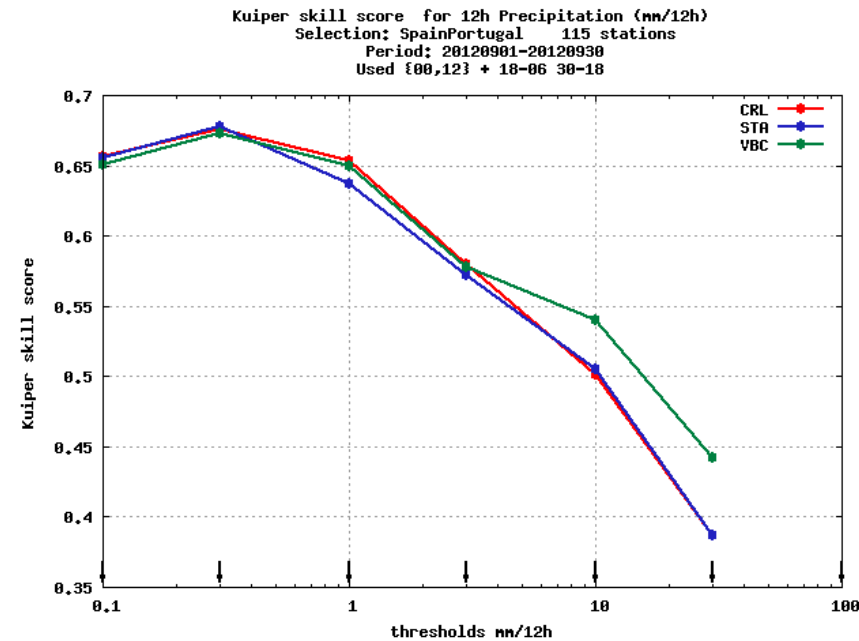
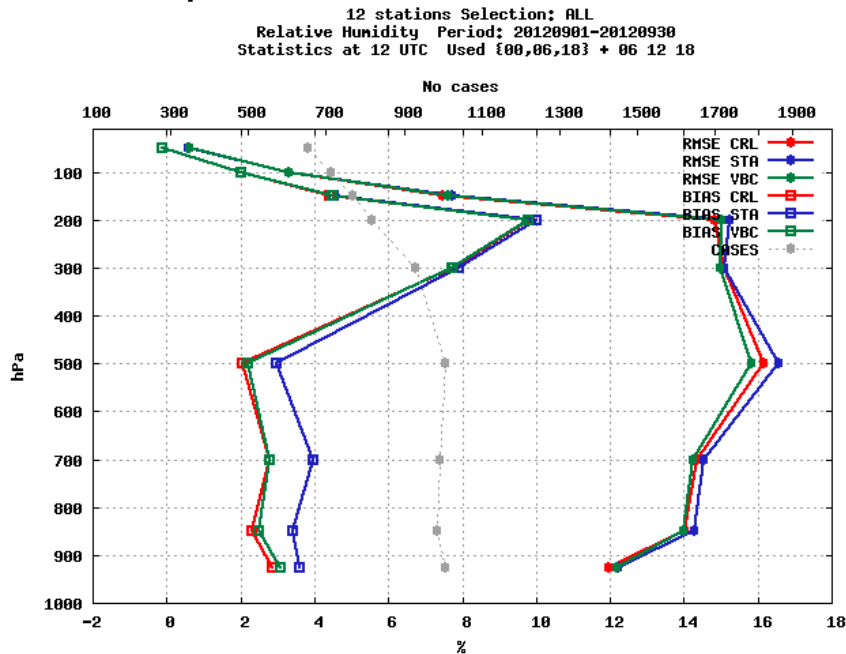
Variational bias correction of GNSS ZTD in the HARMONIE modeling system

J. Sánchez, M. Lindskog, S. Thorsteinsson, J. Bojarova

- Cy38h1beta3, LSMIX=yes, BD 3h.
- 3DVar 3h cycle: conv obs + GNSS ZTD 80 km thinning , (STABC and VBC)
- Domain: IBERIA_2.5, 2.5 km, and 65 v.l.
- Period of study: 1-30 September 2012



RH bias and RMSE



KSS 12 h precipitation

- ✓ Use of GNSS ZTD observations together with a variational bias correction is shown to **improve the short range weather forecasts**, both in a statistical sense and in individual case studies.
- ✓ For this domain, the improvement has been due to the ability of the GNSS ZTD observations to **dry** a too wet model state and therefore improve the precipitation scores.

1) Status of ZTD GNSS assimilation in AEMet



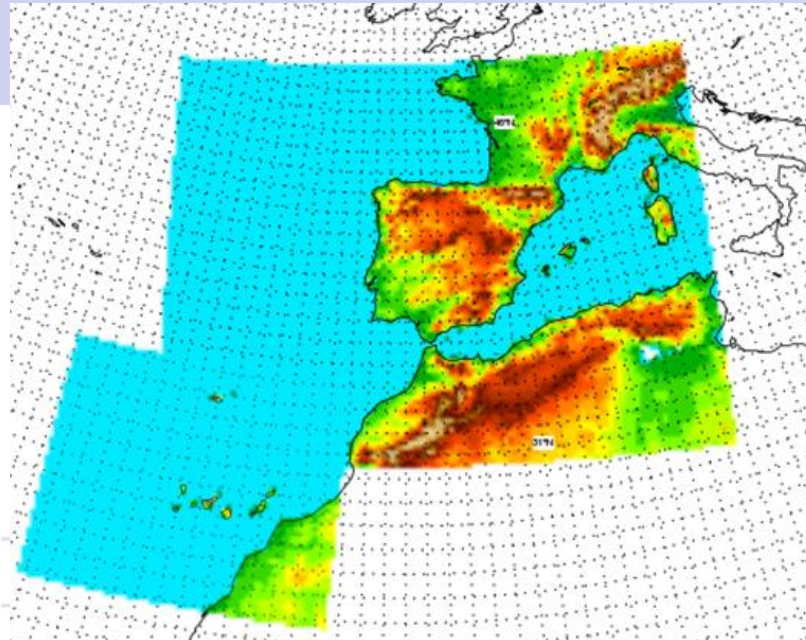
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AEMet operational suite on NIMBUS supercomputer 2016

- **Cy40h11b5** Harmonie-AROME Operational Cycle in AEMet: 3DVAR 3h Conventional observations
- TWO Parallel runs:
 - * Impact of assimilating GNSS ZTD +conv obs
 - * Impact of assimilating ATOVS +conv obs



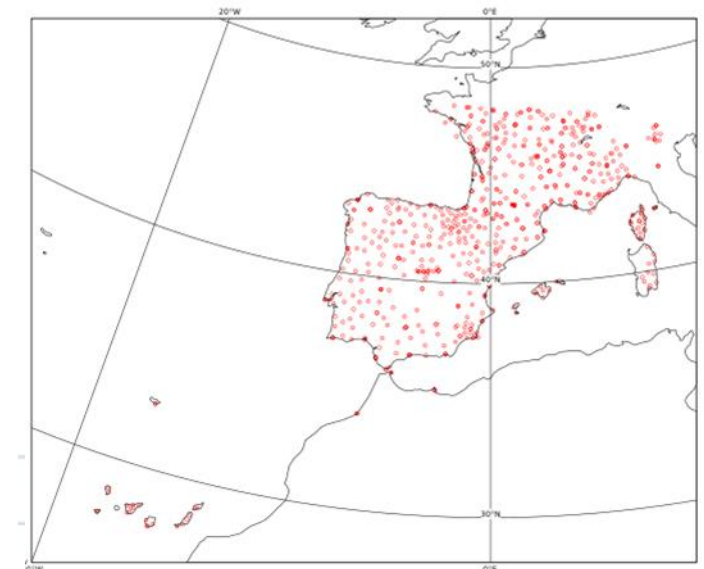
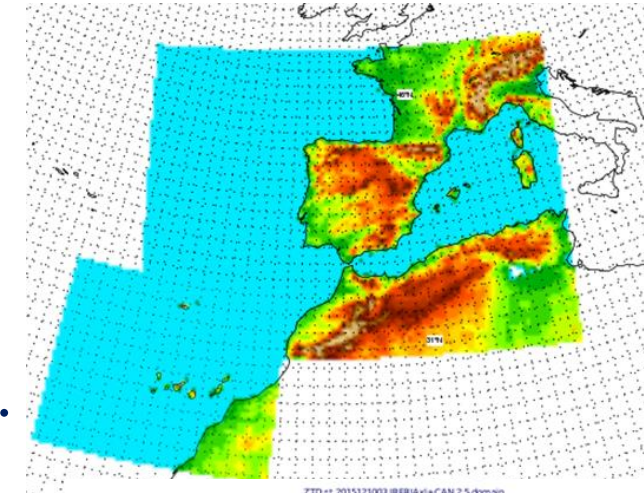
Two domains:

- Iberian Peninsula
- Canary Islands

- **Operational** Cy40h11b5 Harmonie-AROME cycle in AEMet -- two domains: Iberian Peninsula and Canary Islands

Conv obs: TEMP, AIREP,AMDAR,SYNOP,BUOY,SHIP and Pilot.

- **GNSS ZTD Parallel run:**
 - Cy40h11b5, LSMIX=yes, BD 1h,...
 - 3DVar 3h cycle: conv obs + GNSS ZTD
 - Domains: IBERIAxl_2.5,(and CANARY Islands 2.5 km), and 65 v.l.
 - **Period of study:** july-november 2016
 - GNSS ZTD observations:
 - from E-GVAP Program (ASCII, via ftp)
 - White list (783 sites)
 - Variational Bias



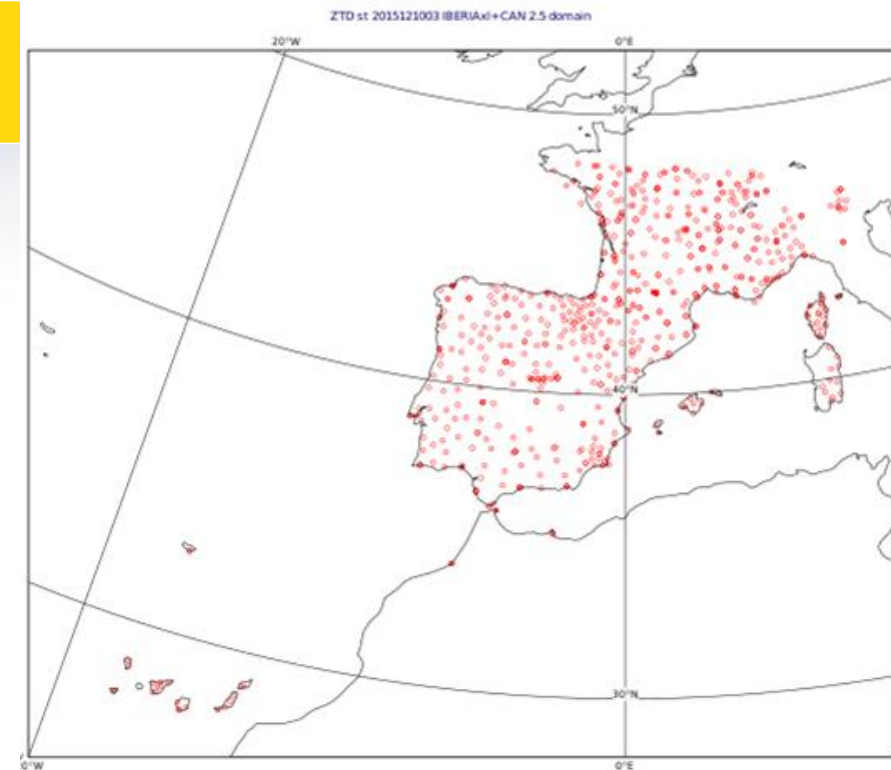
2) Recent experiments/results

Cy40h11b5

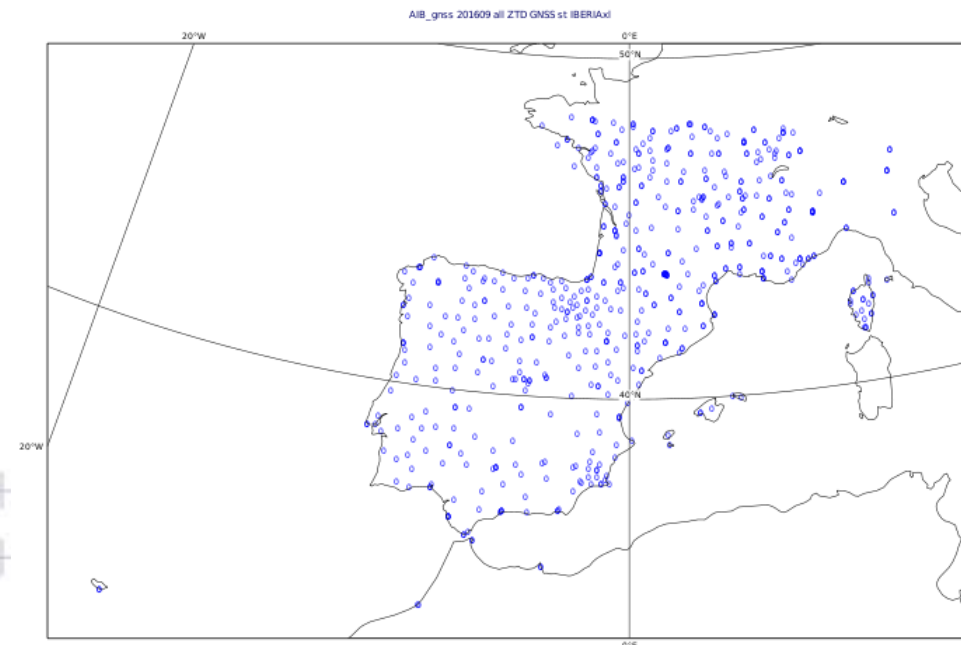
GNSS obs handling

- GNSS ZTD observations from E-GVAP Program (ASCII, via ftp) .
- Files from: ASI_, ROBH, SGN_, IGE2 and METO.
- Cut-off time: at 0040 /0140 the files are taken
- Use **White list** (783 sites),
 - temporal thinning (obs closest to an time),
 - no spatial thinning has been needed here (just some redundancy checks)
- Then just a quality control, a temporal thinning and a redundancy check
- Observation and bg errors similar order of magnitude but sigmao higher.

White List
783 sites



GNSS data
used
sep 2016

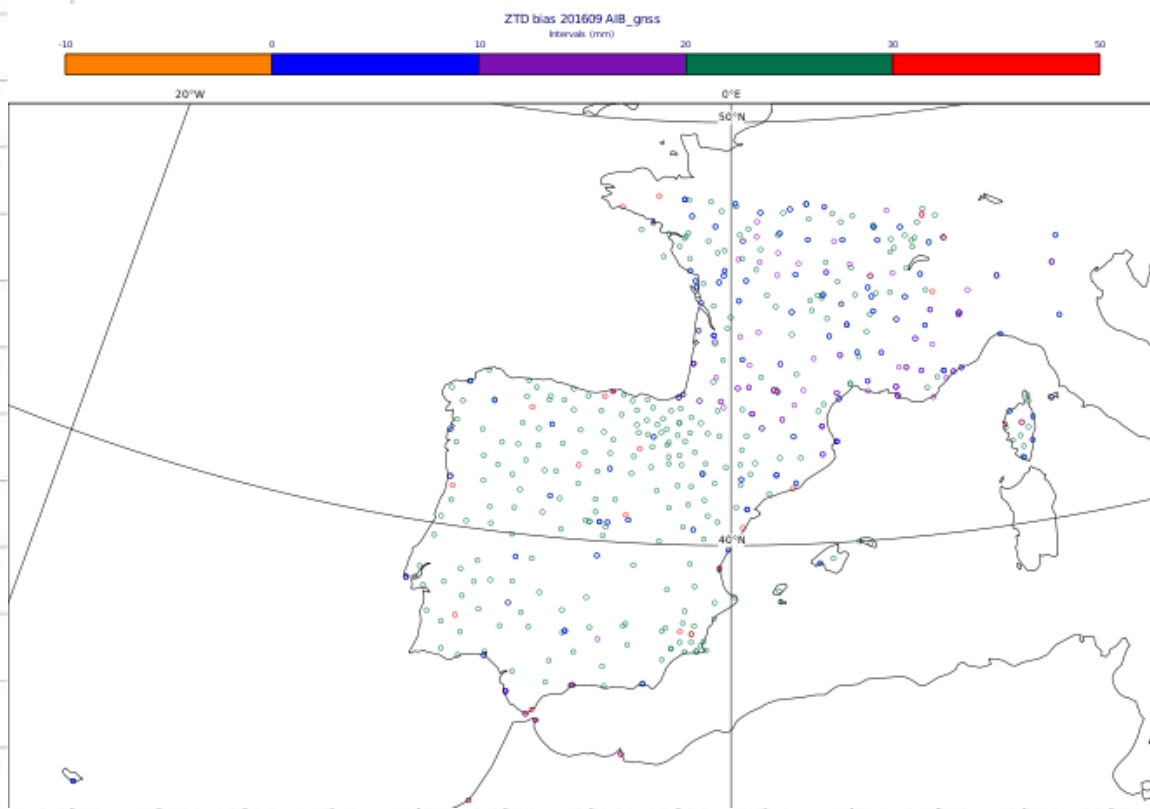


1) Status of ZTD GNSS assimilation in AEMet

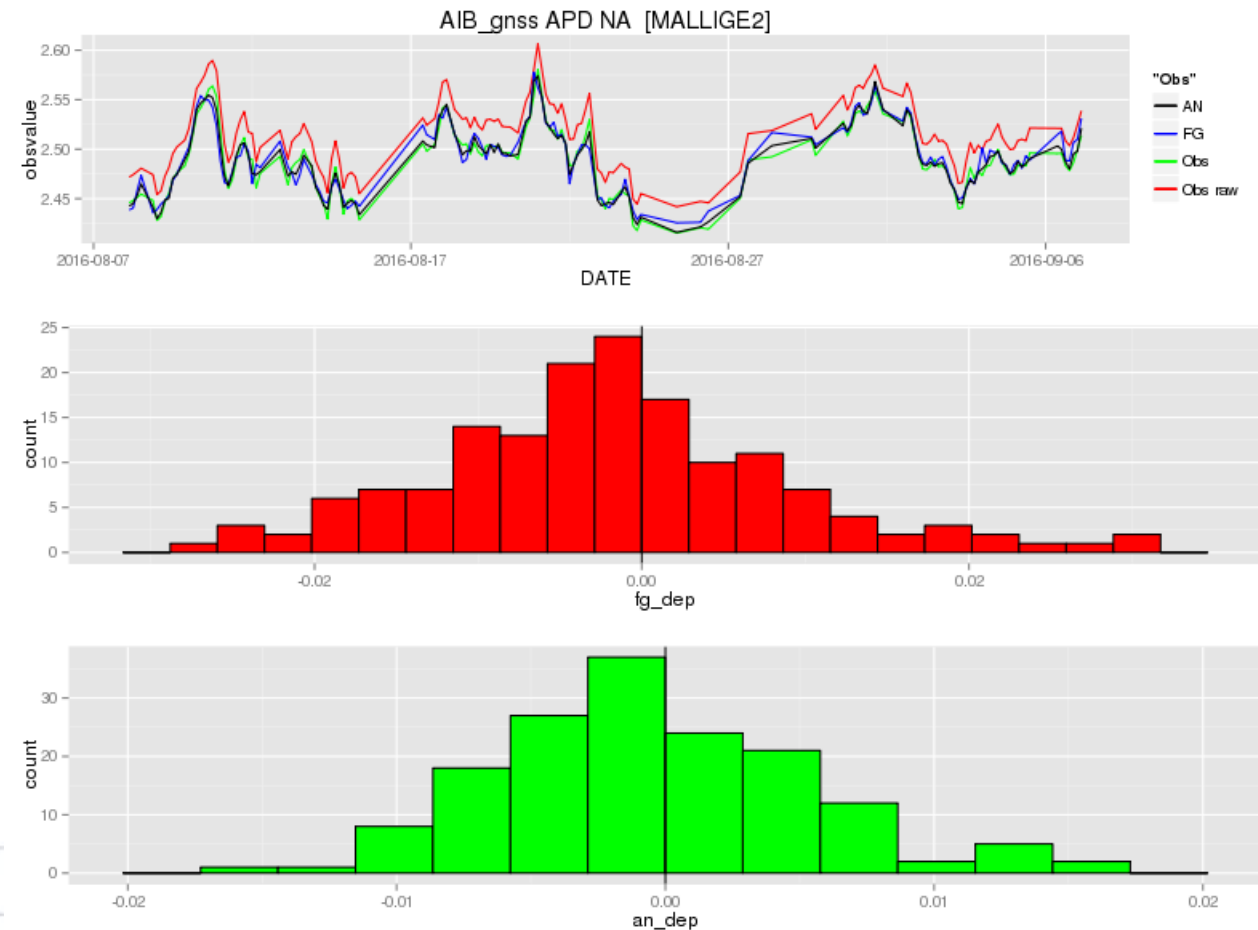
Cy40h11b5

VarBC of GNSS ZTD

- Variational Bias correction for the assimilation of GNSS observations: just constant offset.
- Start: VarBC coefficients calculated with a previous month of passive assimilation of these observations.



Monthly average BIAS for sep 2016: purple: 10-20mm, green 20-30 mm, red:>30mm.

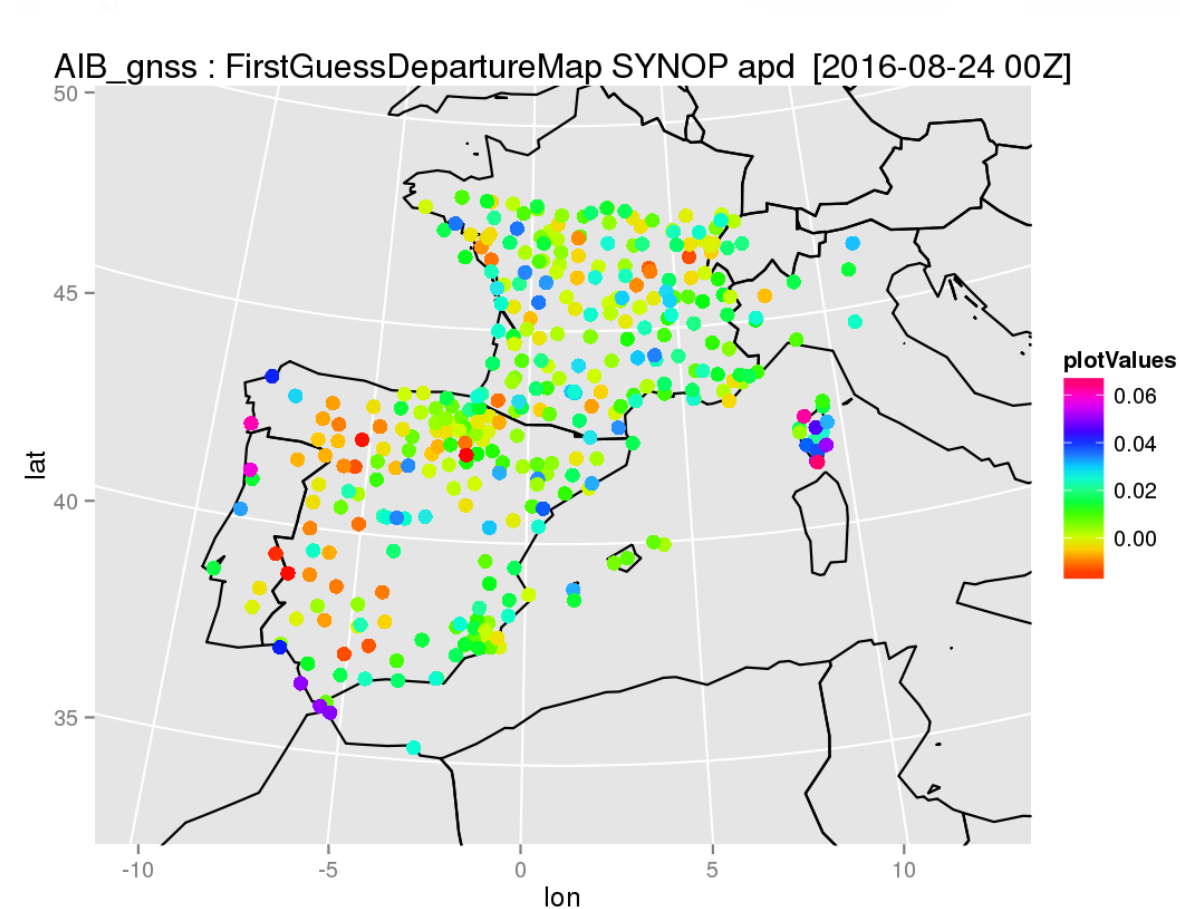


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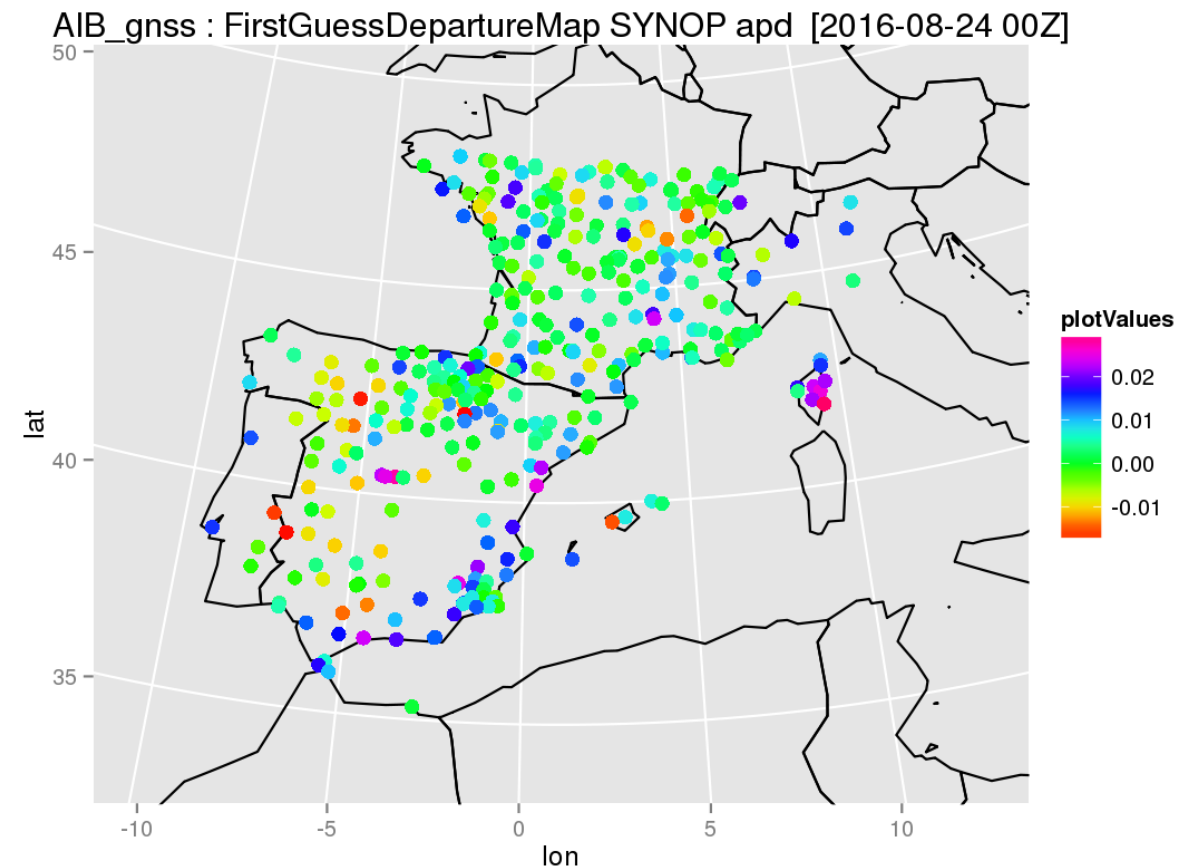
Cy40h11b5

VarBC of GNSS ZTD

- It can be seen in an example how VarBC correct the bias of most of sts...



SCREENING: raw obs-fg
Most values 0-20mm, some 40mm



MINIMIZATION: bias corrected obs-fg
Values around 10mm, some 20mm the most

NOTE: diferent color scale!!

1) Status of ZTD GNSS assimilation in AEMet

Cy40h11b5

Monitoring



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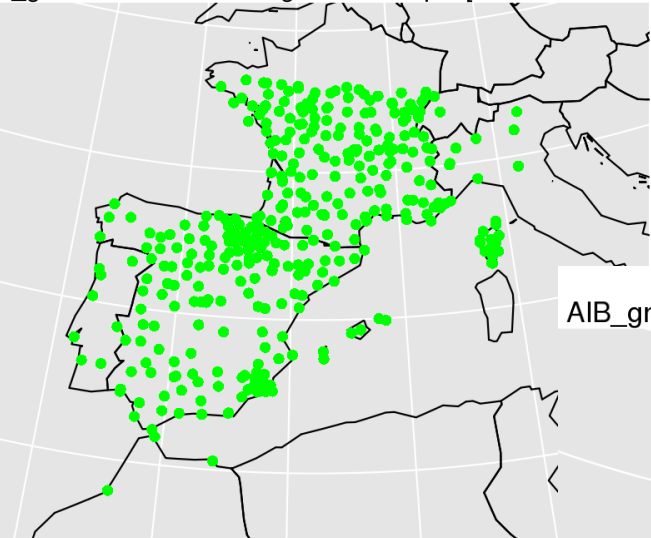
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- GNSS ZTD availability: obs usage, innovations..

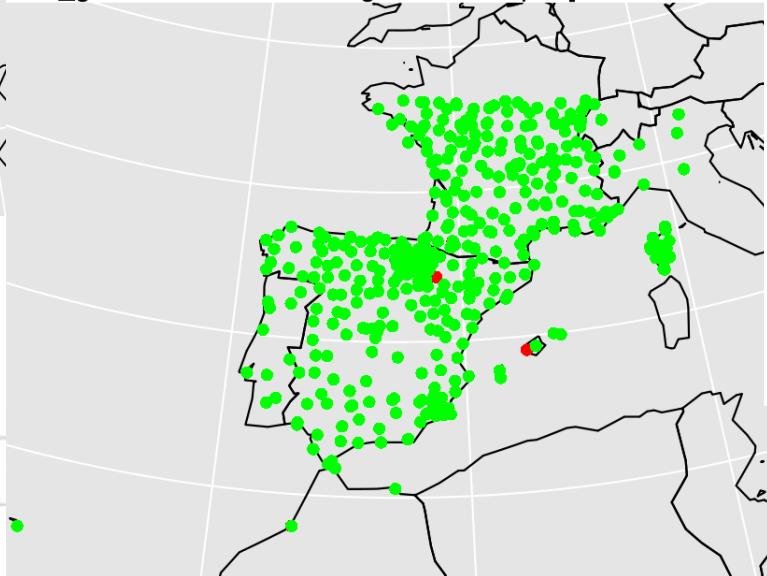
Fg-ob plot

B_gnss : ObservationUsage SYNOP apd [2016-08-23 00Z]



Obs usage

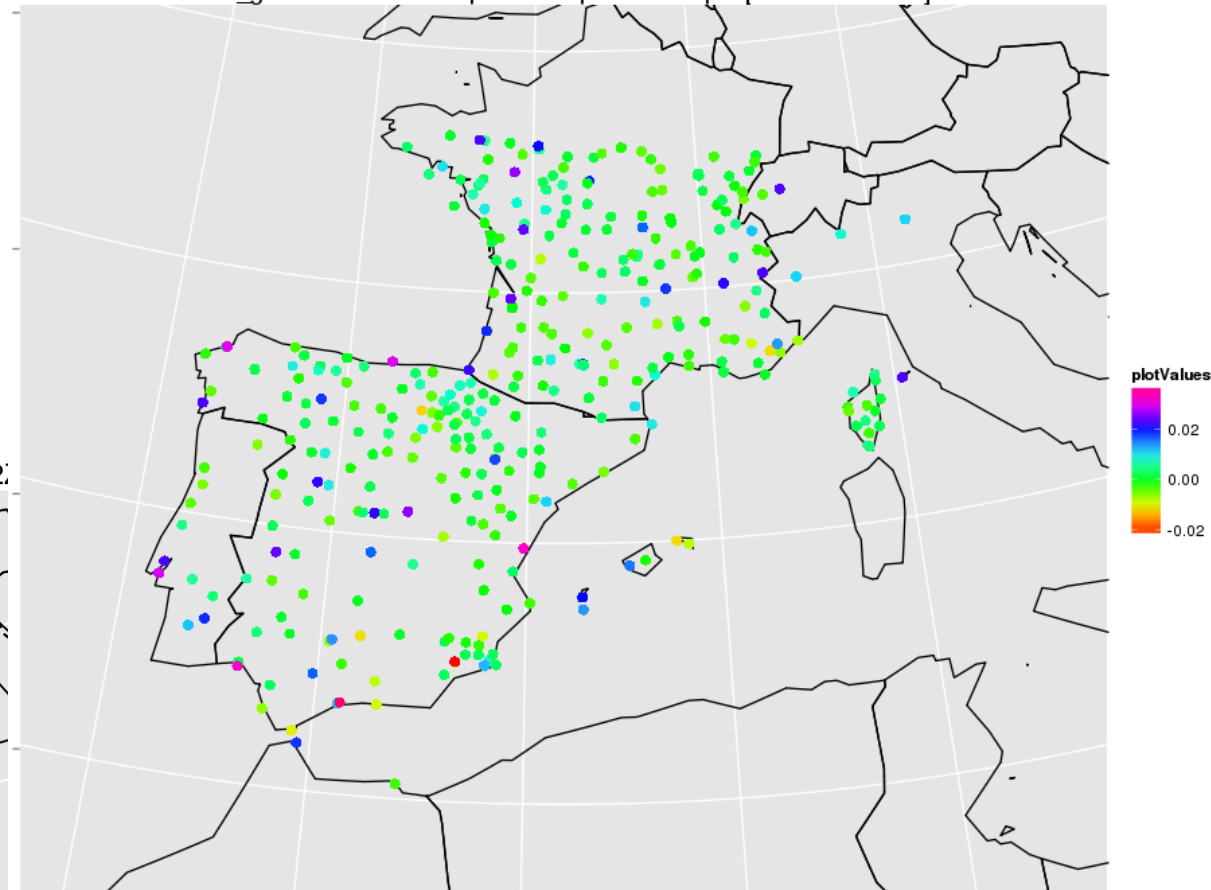
AIB_gnss : ObservationUsage SYNOP apd [2016-08-23 12Z]



Same day, at 00h
and 12h...

More obs at 12!

AIB_gnss : FirstGuessDepartureMap SYNOP apd [2016-11-30 06Z]



NHAGEN

Impact of GNSS Assimilation on a parallel run,
from **july 15th** to **november 20th** 2016:

Also compared with the impact of assimilation of T and humidity from ATOVS (AMSUA, AMSUB and MHS)

So three experiments are compared here:

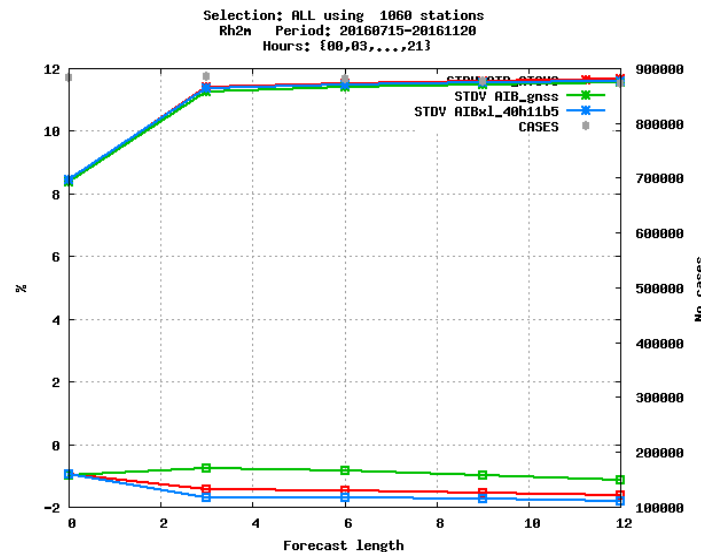
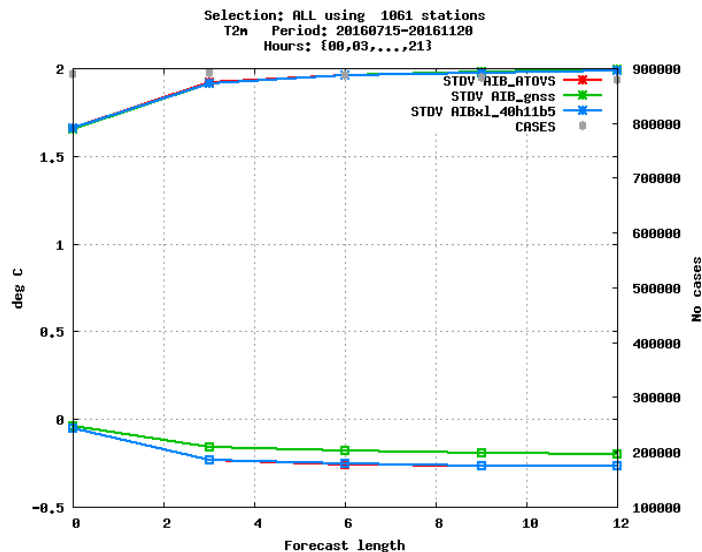
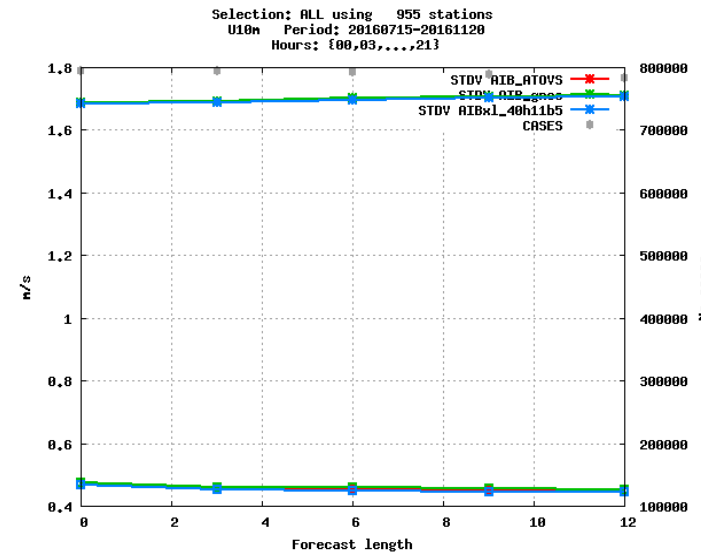
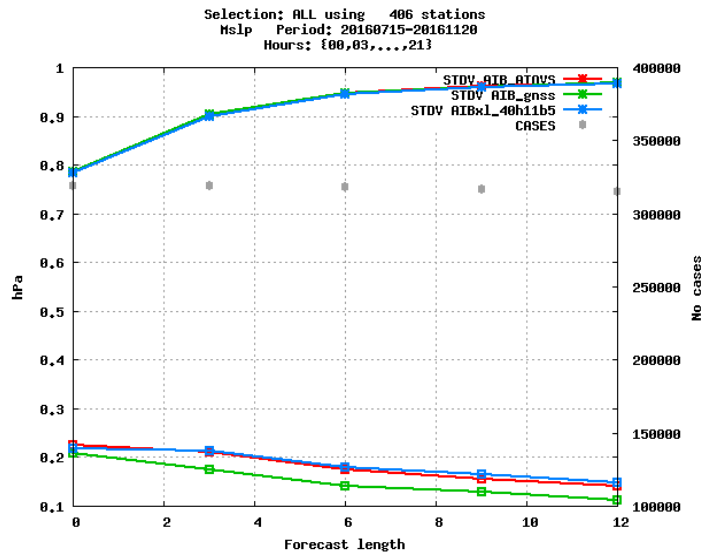
- **AIB_ATOVS**: ATOVS assimilation with VarBC + conventional observations
- **AIB_gnss**: GNSS ZTD assimilation with VarBC + conventional observations
- **AIBxl_40h11b5**: CONTROL conventional observations

(Joan Campins, Jana Sánchez-Arriola, María Díez, Beatriz Navascués, Javier Calvo , AEMet)

1) Status of ZTD GNSS assimilation in AEMet

Cy40h11b5

Results



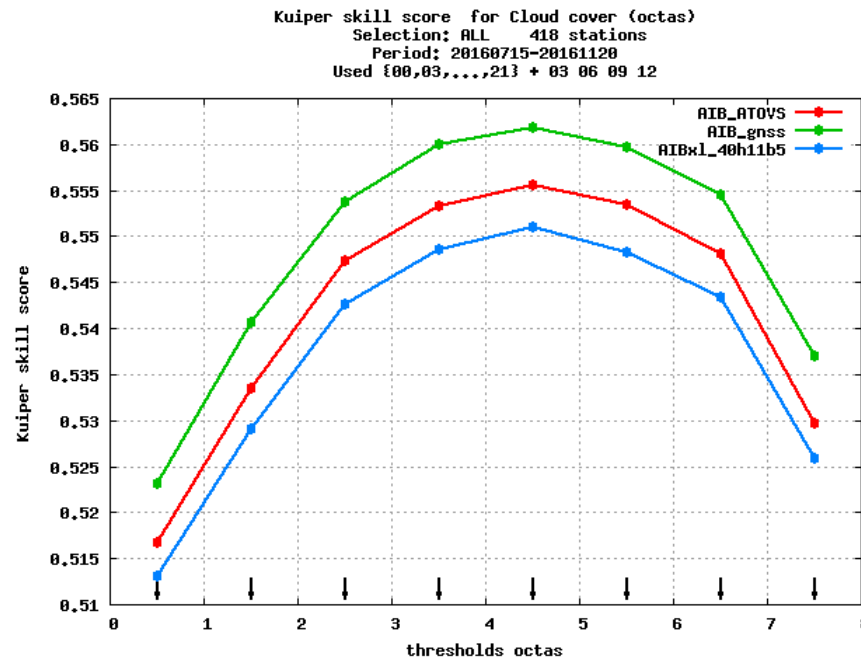
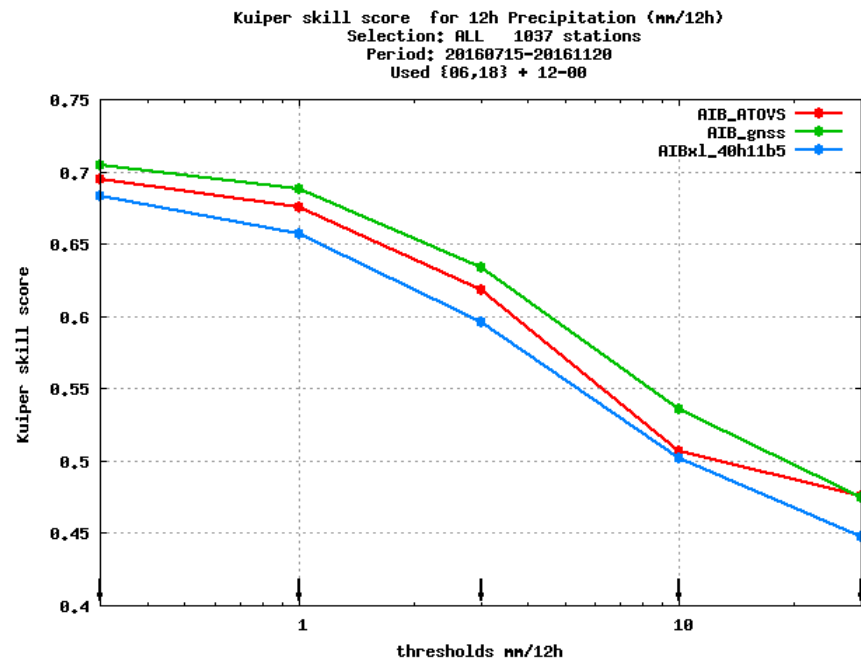
Current status of ZTD GNSS data assimilation in AEMet: **RESULTS**

Surface parameters

Mslp, u10m, T2m and RH2m
ATOVS, **GNSS**, **CONTROL**

The bias of mslp, T2m and RH2m is reduced when assimilating ZTD GNSS, while the impact for 10m wind is neutral.

1) Status of ZTD GNSS assimilation in AEMet



Current status of ZTD GNSS data assimilation in AEMet: **RESULTS**

KSS index

Kuiper Skill Score of 12h precipitation (mm/12h) and cloud cover

ATOVS, **GNSS**, **CONTROL**

*12h acc precipitation: the impact of assimilating these observations is positive for almost everything precipitation thresholds.

* cloud cover KSS index: clear positive impact when adding ZTD GNSS observations to the conventionals.

1) Status of ZTD GNSS assimilation in AEMet

Cy40h11b5

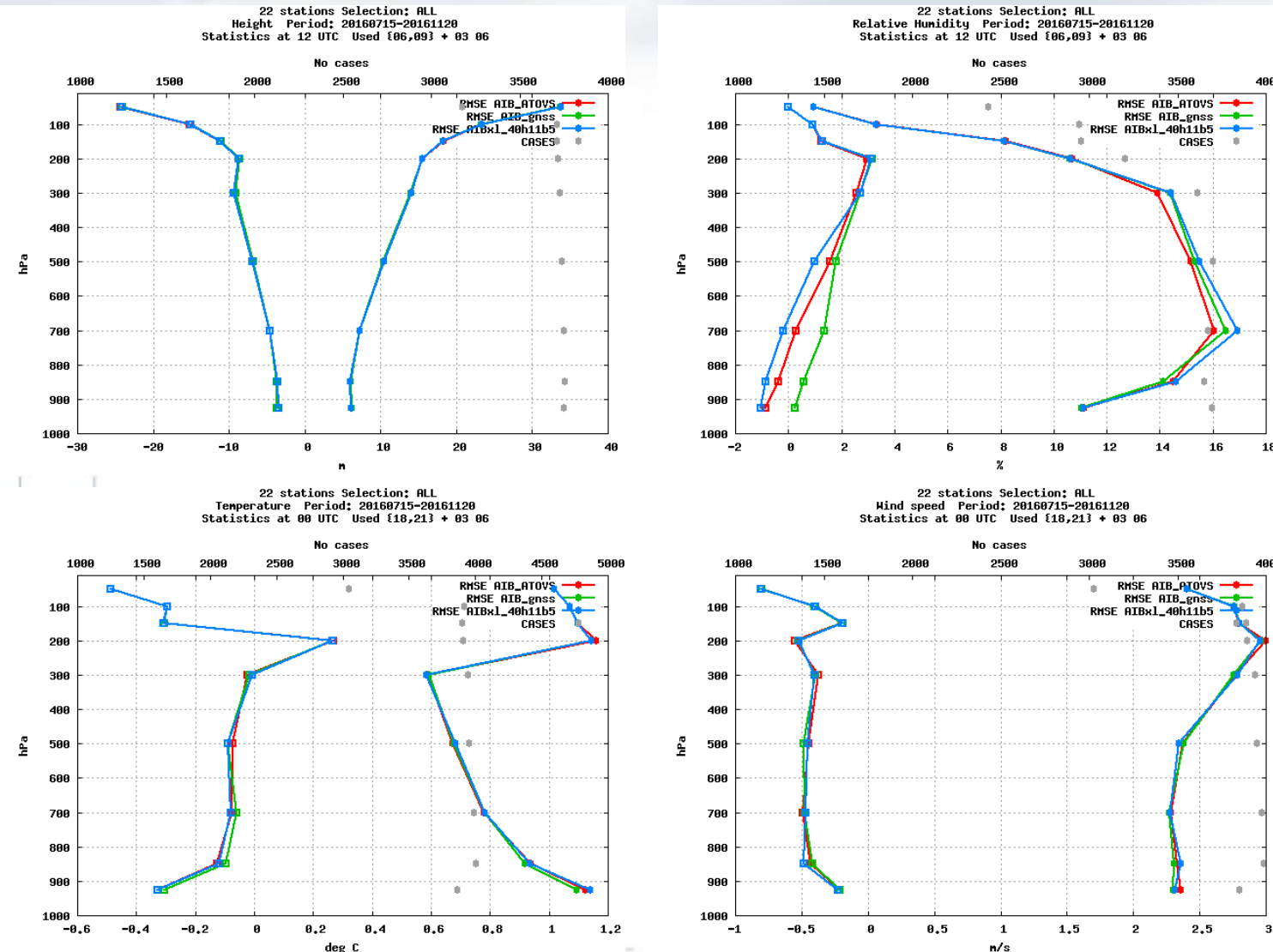
Results

Current status of ZTD GNSS data assimilation in AEMet: RESULTS

Vertical profiles

12 UTC VP for Height, RH, T and Wind Speed

ATOVS, GNSS, CONTROL

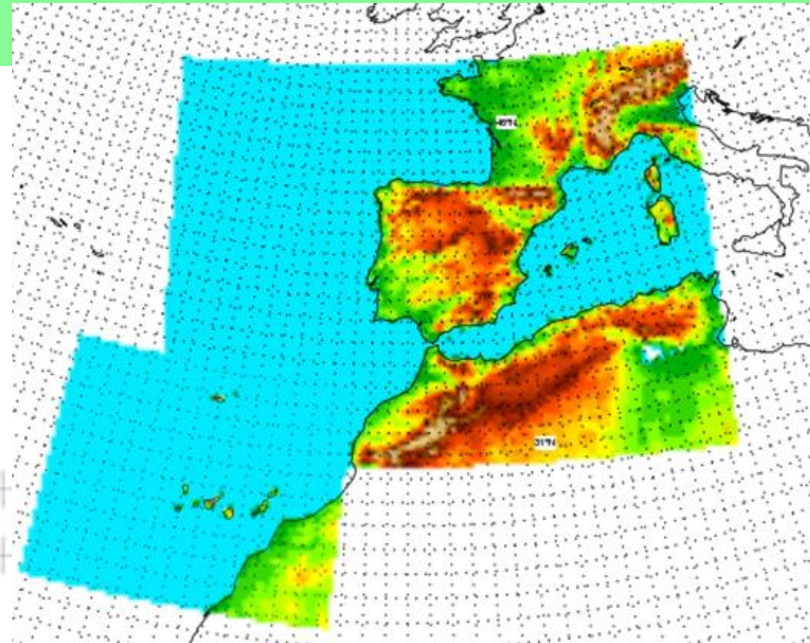


More details at the next Hirlam Newsletter..

J. Campins, J. Sánchez-Arriola, M. Díez, B. Navascués, J. Calvo, AEMet

AEMet operational suite on NIMBUS supercomputer 2016

- **Cy40h11** Harmonie-AROME 3DVar 3h cy conventional+ GNSS ZTD + ATOVS
- 4 Parallel runs:
 - * PASIVE GNSS and ATOVS
 - * Increasing thinning distances GNSS ZTD + ATOVS !
 - * GNSS ZTD + ATOVS sea + conv obs
 - * ...



Two domains:

- Iberian Peninsula
- Canary Islands

2) Conclusions and next steps

Cy40h11b5

1. A **parallel suite** of a **Cy40h11b5** Harmonie-AROME system for **IBERIAxl_2.5** domain have been prepared for assimilation of ZTD GNSS observations provided by the EUMETNET E-GVAP European program.
2. The coverage of GNSS ZTD observations, the VarBC behavior and the results obtained along the period from **July 2016 to November 2016** of this parallel run compared with the current Cy40h11b5 operational run that assimilates just conventional data, has been performed.
3. Verification plots show a **positive impact of all humidity related fields when assimilating ZTD GNSS observations** together with conventional observations and more for the lower troposphere that could be complementary with the impact seen for ATOVS observations for the higher troposphere.

2) Conclusions and next steps

Cy40h11b5

4. This positive impact when assimilating ZTD GNSS observations has been found although a **spatial thinning** of the GNSS observations hasn't been applied but just a quality control, a temporal thinning and a redundancy check of these observations has been made.
5. Due to the cutoff time (00.40) the number of ZTD GNSS obs each cycle wasn't very high.
6. There could have been more observations for each cycle if
 - the cut off time for the operational run in Aemet were longer
 - the availability of some of the observations over the domain could improve for some areas (like Portugal at night for example), so more observations could have been introduced into the system each cycle.It could be, in this case, that the spatial thinning would have been more necessary, so more investigation is being performed here.

2) Conclusions and next steps

Cy40h11

1. A **Cy40h11** Harmonie-AROME experiment assimilating : conventional + ZTD GNSS + ATOVS observations using the Variational bias Correction system for both of them at the same time, has been prepared and has started to run already at Nimbus supercomputer in Aemet.
2. Need to increase thinning distance for both :GNSS ZTD and ATOVS observations.
3. The same experiments are being performed over [Canary Islands domain](#) , and results to see the impact on that domain, will be ready soon.

THANK YOU..

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