Ongoing developments on the use of observations in the AROME 3D-Var

J.-F. Mahfouf with many colleagues

CNRM/GMAP/OBS

Outline

- Current status of AROME 3D-Var
- Developments towards short-term applications
- Impact studies
- Developments towards medium-term applications

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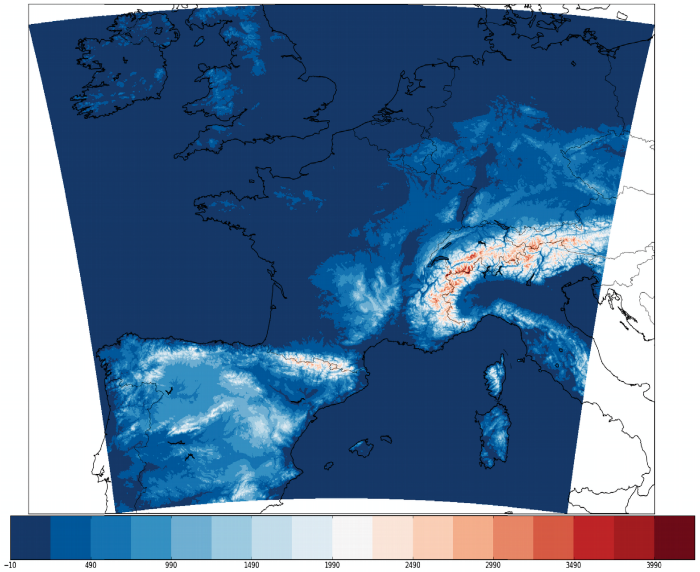
The convective scale model AROME-France

- Spectral limited area model derived from ARPEGE/ALADIN and Meso-NH (operational since 12/2008)
- Resolution: 1.3 km with 90 levels (top @10 hPa)
- 3D-Var system with 1-h assimilation window
- Most important observation types (number and DFS) :
  1. Surface (SYNOP, RADOME)
  2. Radar (DOW + RH from Z)
  3. Aircraft data
  4. Radiosoundings
  5. SEVIRI radiances
- AROME Nowcasting: hourly 3D-Var with very short cut-off (10 min) => mostly observation types (1) and (2)



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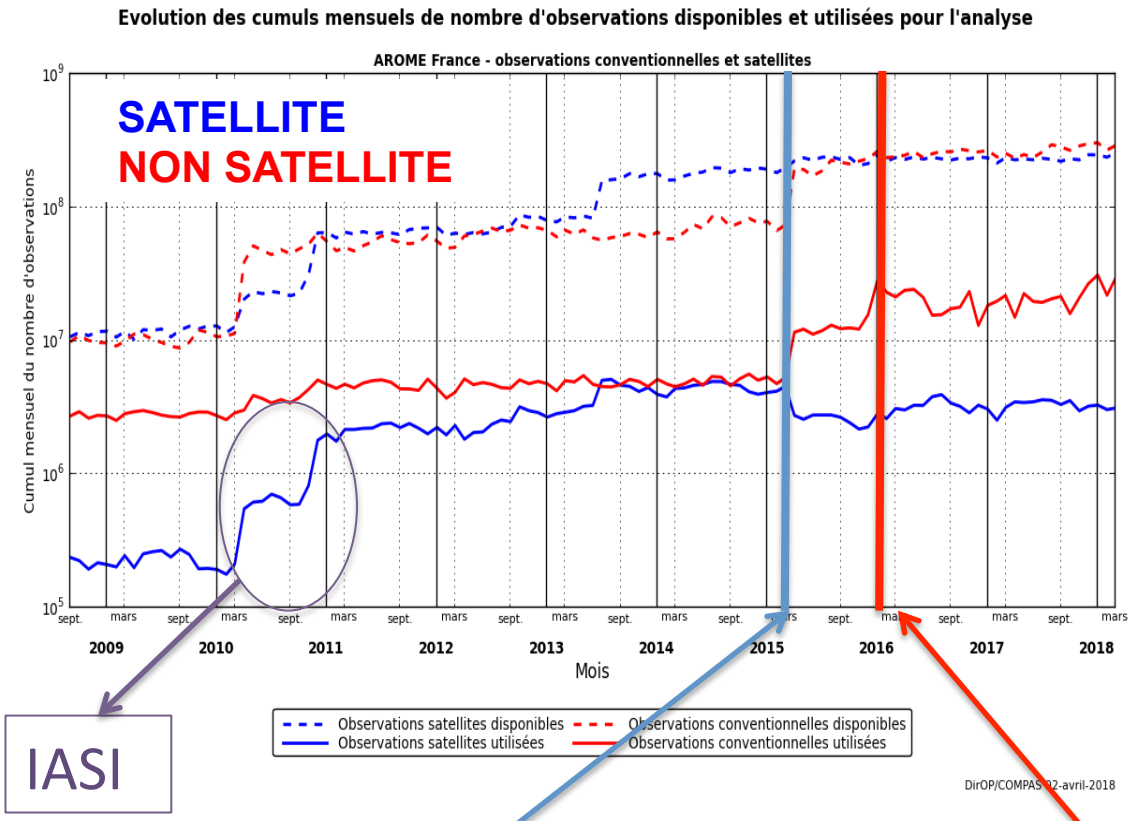
Evolution of observation usage



IASI

3D-Var 1 hour
Model top @10 hPa

Radar density
@ 8 km

Recent evolutions:

- Ground-based GNSS revised white list (12/2017)
- Revised cloud classification for MSG (SAF NWC)
- Replacement of METEOSAT-10 by METEOSAT-11 (02/2018)

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Ground-based GNSS activities

Extensive experimentation on VarBC in ARPEGE and AROME

Development of an observation operator for horizontal gradients (intermediate step towards **STD** assimilation)

$$\mathbf{STD} = MF_h.\mathbf{ZHD} + MF_w.\mathbf{ZWD} + MF_w.\cot(\theta)\,(\mathbf{G_N}.\cos(\phi) + \mathbf{G_E}.\sin(\phi))$$

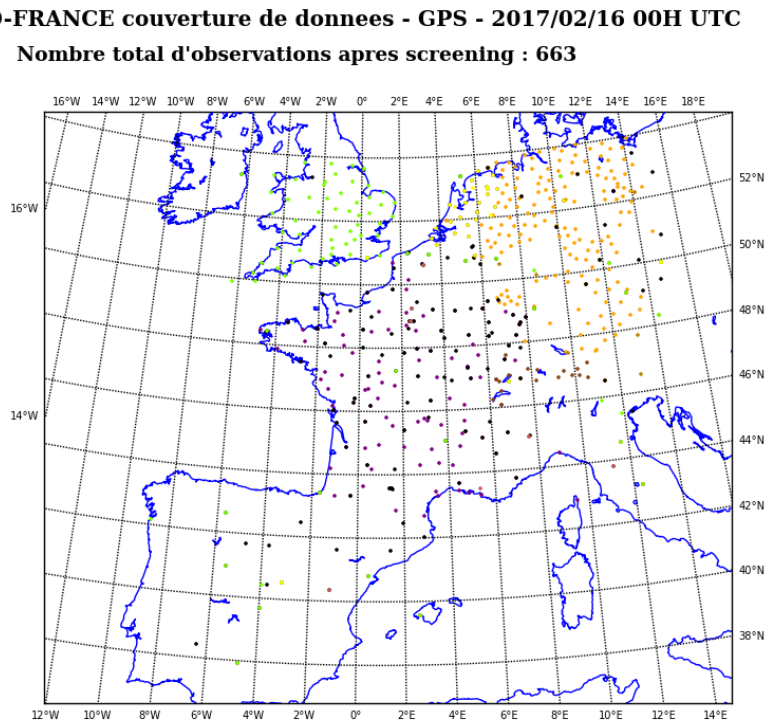
STD = Slant Total Delay
ZHD = Zenith Hydrostatic Delay
ZWD = Zenith Wet Delay
$\mathbf{G_N}$ and $\mathbf{G_E}$ = N-S and E-W gradients
MF = Mapping Functions
θ = elevation and ϕ = azimuth
N = refractivity

$$G_x = 10^{-6}\int z\left(\frac{\partial N}{\partial x}\right)dz$$

(Patrick Moll and Fatima Hdidou)

Assimilation in AROME

0 LPT
19 LPTR
90 METO
0 METG
174 GFZ
0 GOPG
0 GOP1
14 ASI
0 ASIC
144 ROBH
0 ROBQ
0 ROBG
31 KNM3
22 KNM4
30 BKG
139 SGN
0 SGN1
0 SGNC
0 IGE2
0 DITT



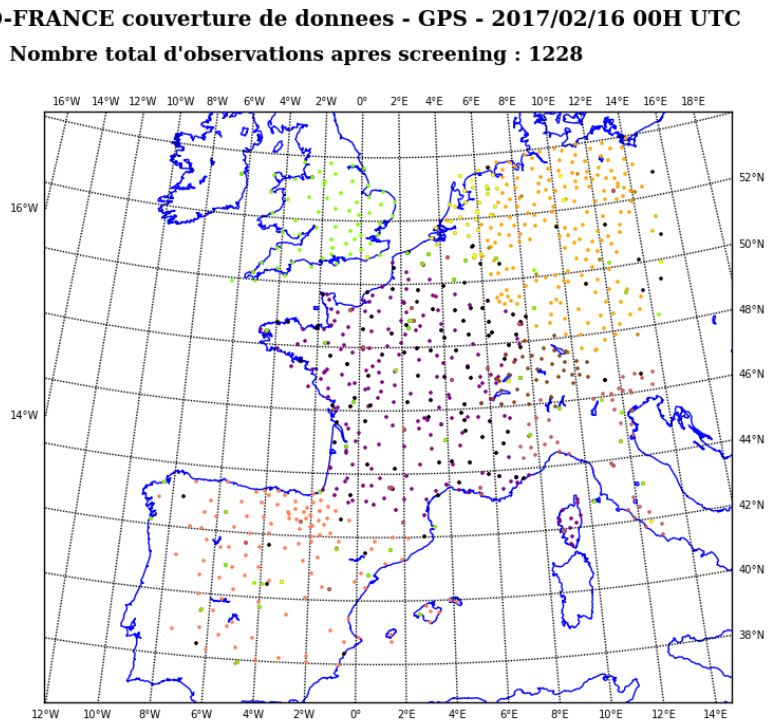
AROME France oper

Former list of AC/stations: 663

(Patrick Moll and Hervé Bénichou)

Assimilation in AROME

0 LPT
41 LPTR
114 METO
7 METG
213 GFZ
0 GOPG
0 GOP1
101 ASI
0 ASIC
176 ROBH
0 ROBQ
0 ROBG
37 KNM3
27 KNM4
50 BKG
307 SGN
0 SGN1
0 SGNC
155 IGE2
0 DITT



AROME France dbl

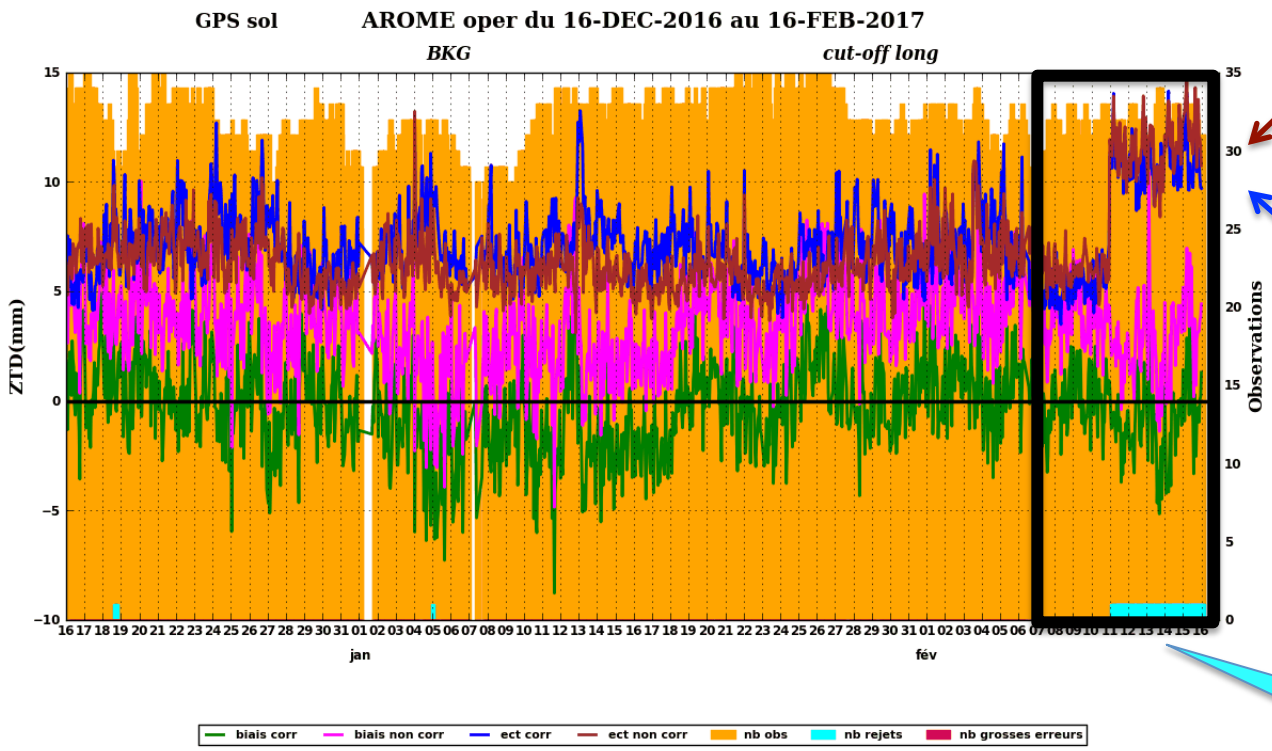
Major increase from:
IGE2, ASI, SGN

Revised list of AC/stations: 1228

Before revised thinning : **40 km**

(Patrick Moll and Hervé Bénichou)

Operational suite (AROME)



Std(O-F)

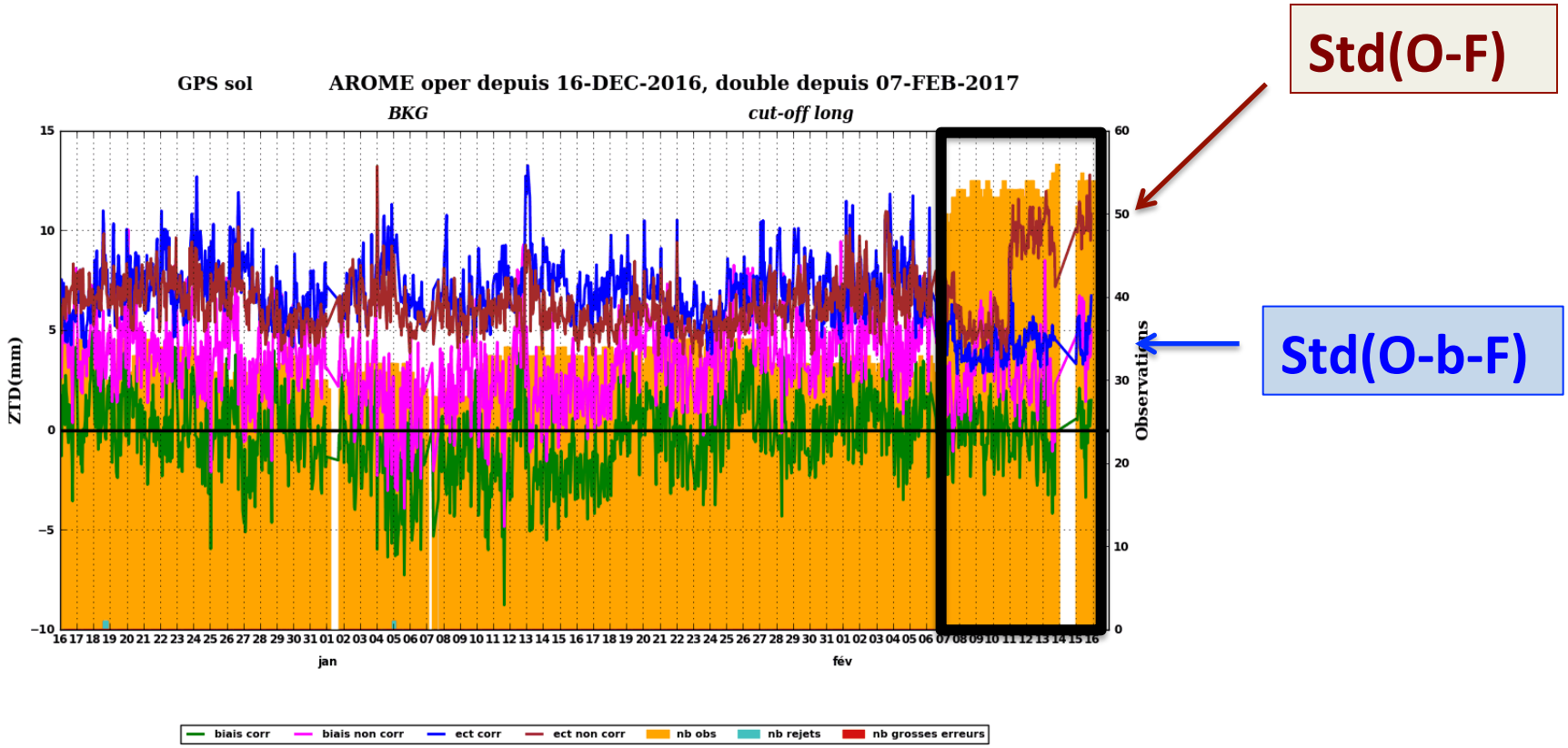
Std(O-b-F)

Rejected data

Static bias correction

(Patrick Moll and Hervé Bénichou)

Experimental suite (AROME)



Adaptive bias correction

(Patrick Moll and Hervé Bénichou)

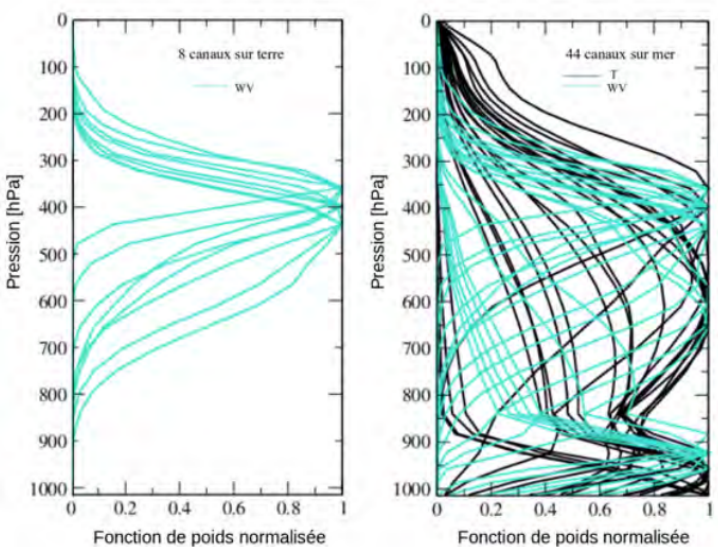
IASI channels over continents

Methodology similar to SEVIRI radiances over land (Guedj et al., 2011) since 2013

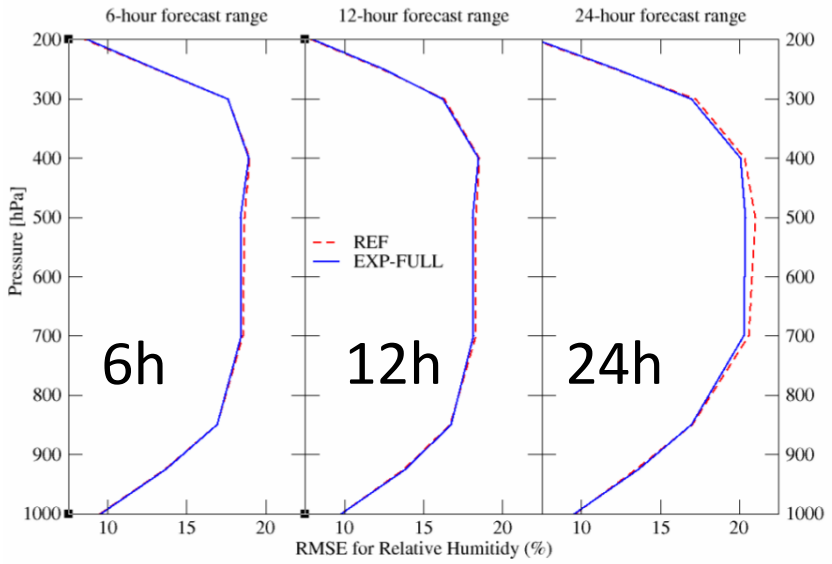
⇒ Inversion of T_s from a window channel (N°1194 – 10.6 μm) + use of IR emissivity atlas (University of Wisconsin)

REF : ε=0.98 - 8 channels (land) + 44 channels (sea)

EXP : ε=atlas - 43 channels (land) + 44 channels (sea)



Land Sea



RH forecast scores
15/01-> 28/02/2015

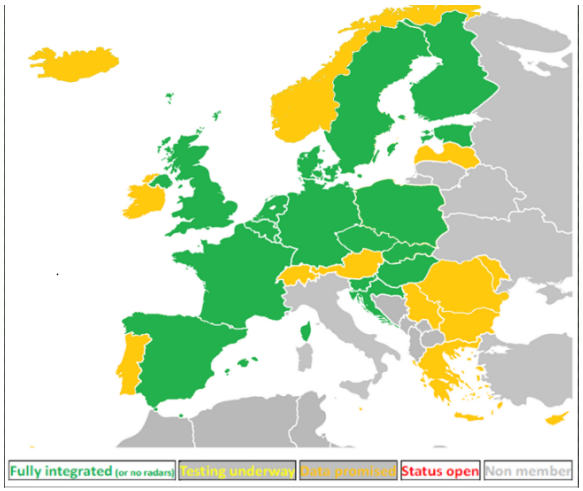
(Niama Bouckachaba, Vincent Guidard and Nadia Fourrié)

European radar data (OPERA)

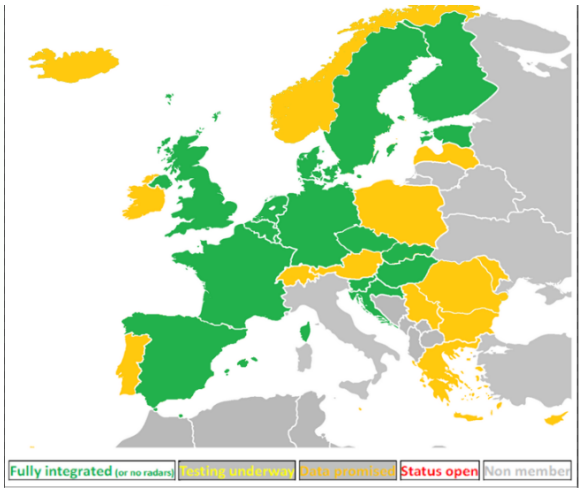
Use of OPERA radar data provided by OIFS (ODYSSEY) in HDF5 format => read / sampled / QC using Z_{raw} in BATOR

Z_filtered

Radial Wind



Z_raw



PROVIDED
NOT PROVIDED

Availability of **62** additional radars (Reflectivities and Doppler winds) in the AROME-France domain on top of **27** French radars

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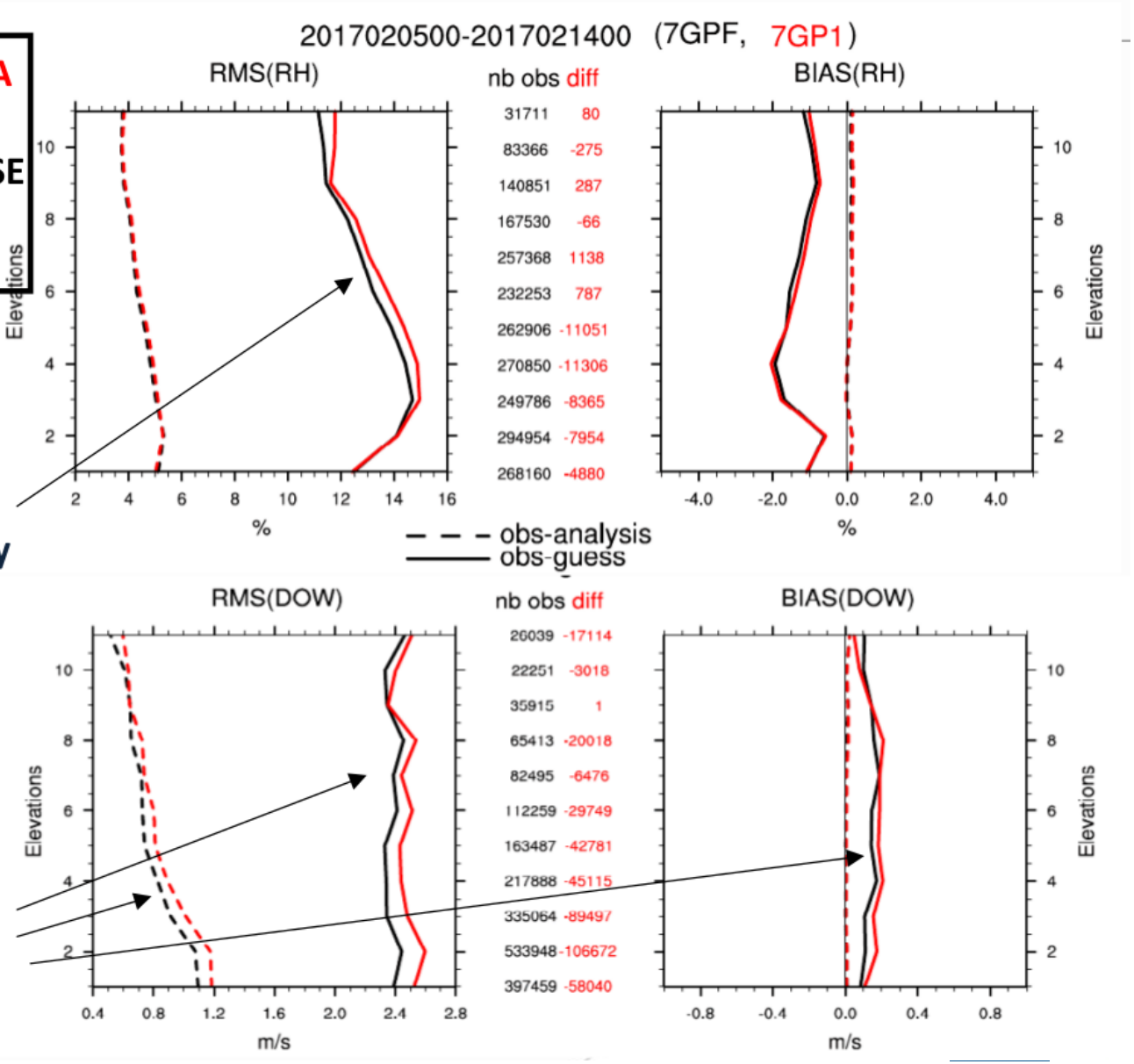
(Eric Wattrelot)

First monitoring against Arome

- RED: without OPERA foreign radars
- BLACK: OPTIMAL USE of OPERA foreign radars

Statistics of departures (Obs. assimilated):

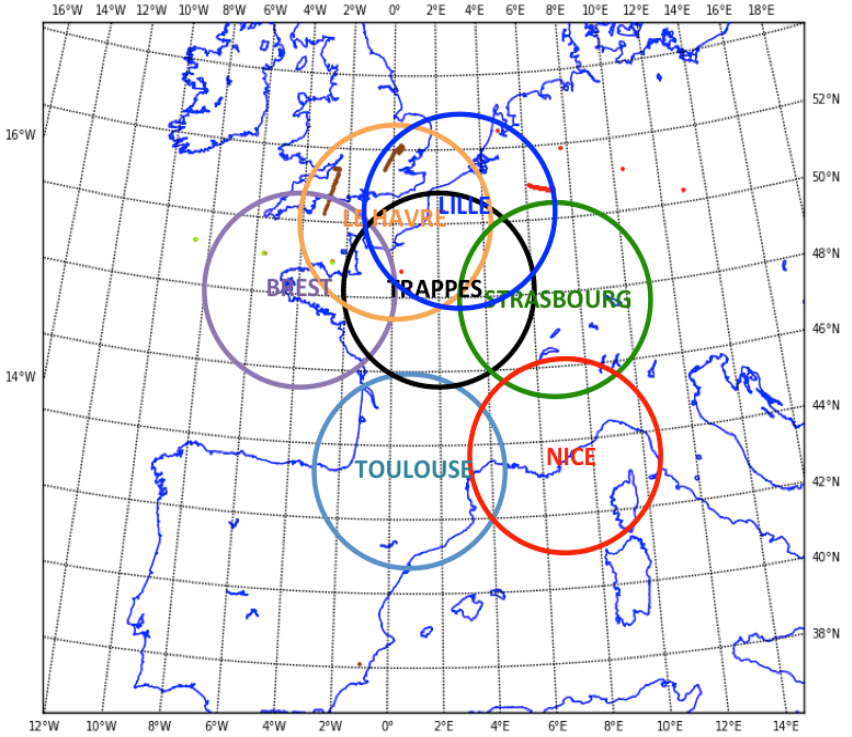
- Better fit of guess of relative humidity retrievals against all radars (french and foreign radars)
- Better fit of guess and analysis of radial wind against all radars (french and foreign radars)



(Eric Wattrelot)

Preliminary studies on MODE-S data

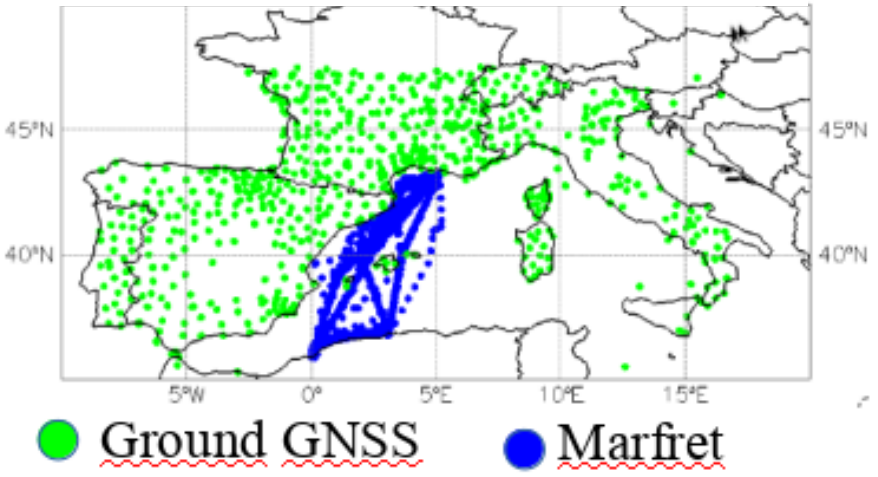
- Installation of 7 antennas over France by MF to receive aircraft data from MODE-S interrogations and ADS-B transmissions (2017)
- Collaborations with KNMI: data processor for Toulouse antenna + BUFR encoding of uncorrected winds
- Use of UKMO software for other antennas (BUFR encoding by MF)
- *Monitoring to start soon in AROME*
- *Development of a (variational) bias correction technique (heading correction)*
- *Use of MUAC MODE-S data*

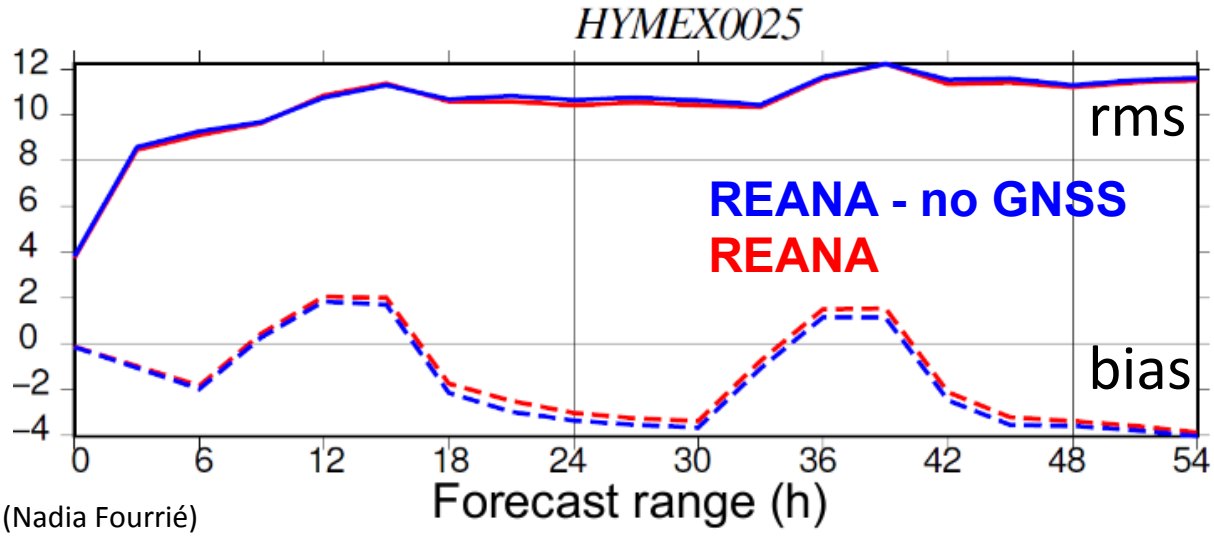


(Vivien Pourret)

Impact studies with AROME-WMED (HYMEX)

HYMEX reanalyses (09/2012 -> 11/2012)
Impact studies on additional observations
(HR radiosoundings, **reprocessed ground based GNSS**, Spanish radars, wind profilers, …)





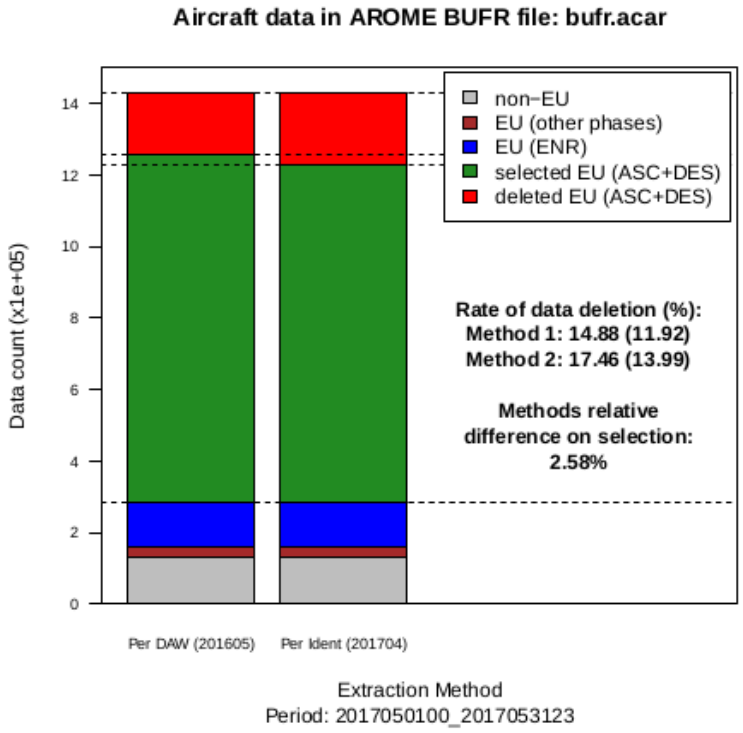
RH2m scores

(Nadia Fourrié)

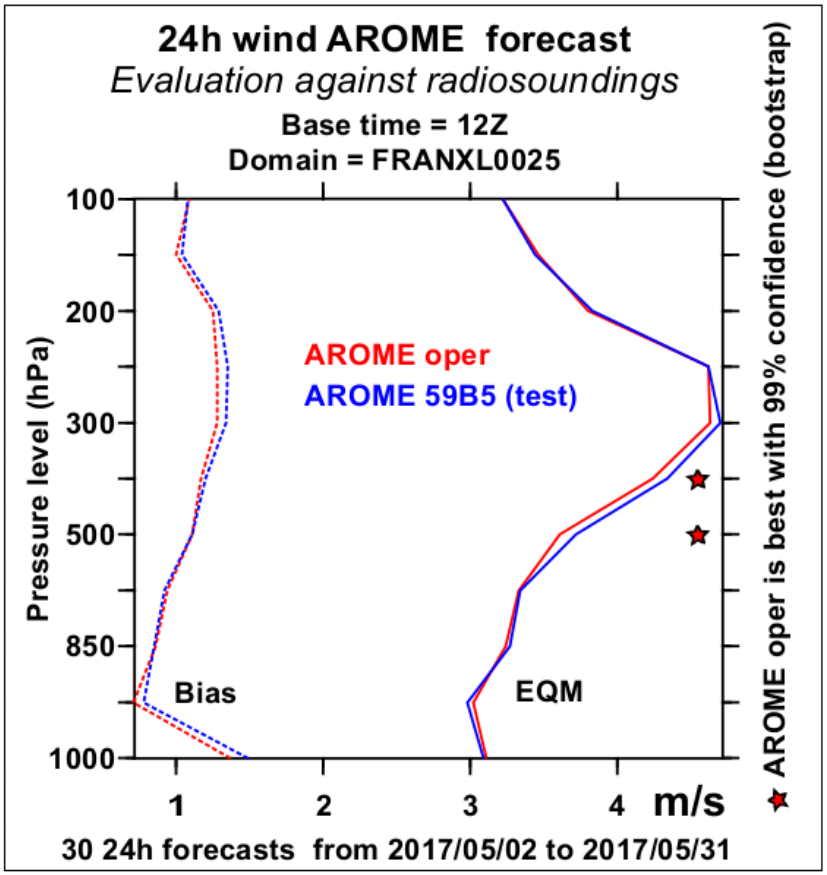
Impact studies on E-AMDAR

Experimental set-up in May 2017:

1) Reference experiment : E-AMDAR operationally assimilated
2) Denial experiment: withdrawal of additional E-AMDAR from French Airports



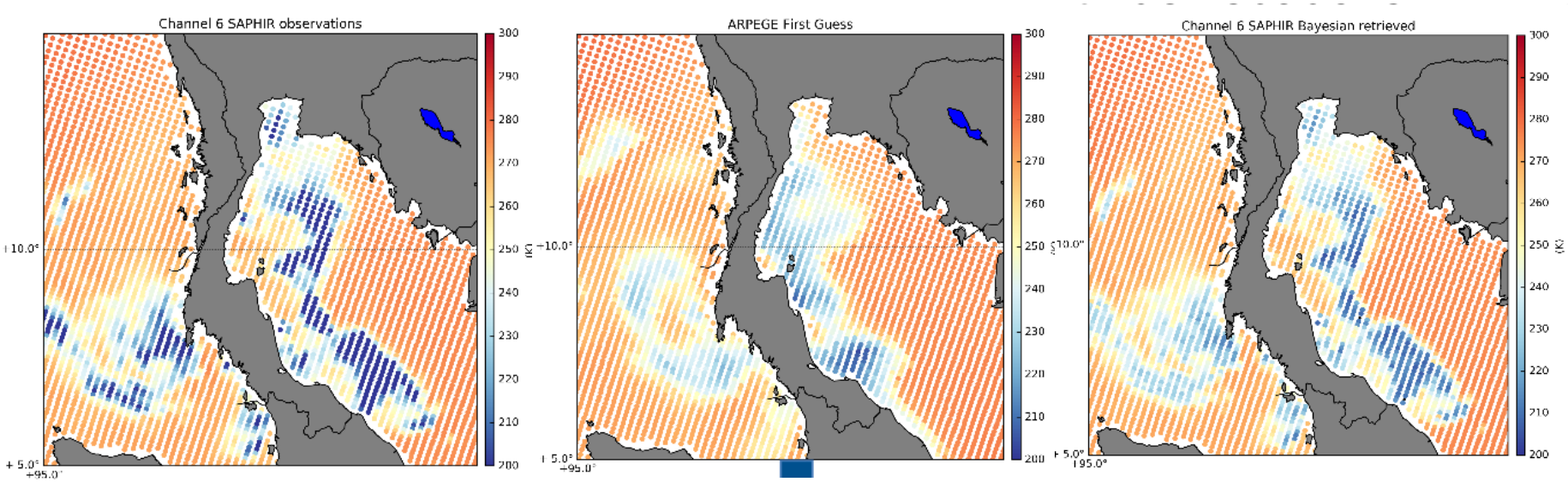
Reports withdrawn = 16 %



(Alexis Doerenbecher)

Assimilation of all-sky microwave radiances

- Simulation of MW radiances in rainy areas: RTTOV-SCATT
- Use of a Bayesian inversion to retrieve RH profiles (pseudo-observations) for assimilation
- First studies using ARPEGE with a prognostic convection scheme and SAPHIR/Megha-Tropiques Tbs @ 183 GHz



08/01/2017 00UTC

OBS BACKGROUND After INVERSION

SAPHIR Tb Channel 6

(Fabrice Duruisseau and Philippe Chambon)

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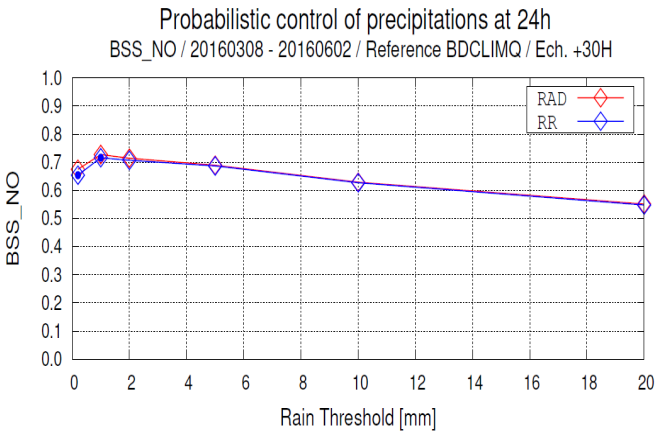
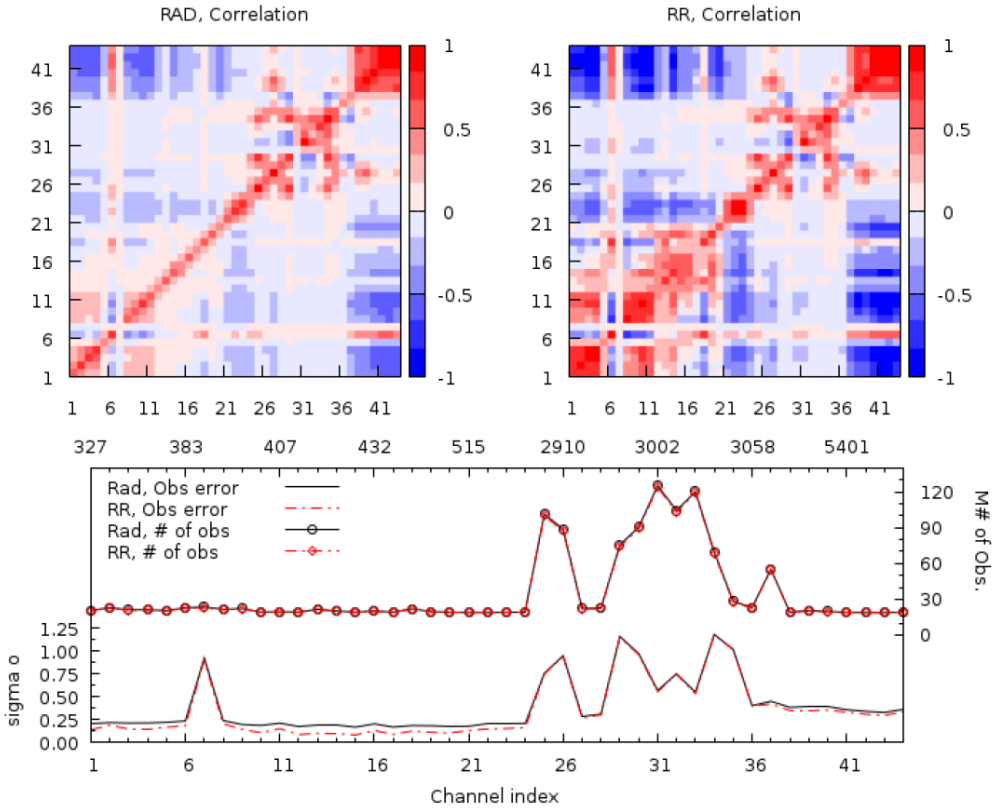
Preparatory studies on IRS/MTG

Assimilation of IASI Reconstructed Radiances (RR) in AROME from 300 PC scores

Main conclusions: neutral impacts on forecast scores ; importance of interchannel error correlations ; importance of RR assimilation in the global model ARPEGE (providing the VarBC coefficients)



Precipitation forecast scores
March -> June 2016 (3 months)



(Javier Andrey-Andres, Nadia Fourrié and Vincent Guidard)

Summary

- Short-term evolutions: VarBC for Ground-based GNSS, IASI channels over continents, inter-channel correlation errors for IR observations, radars from OPERA

- Medium-term evolutions: MODE-S/ADS-B aircraft data, all-sky microwave radiances (AROME Tropics), horizontal ZTD gradients, polarimetric radar data, infra-red radiances from IRS/MTG

- Importance of algorithmic evolutions: inclusion of hydrometeors in the control variable, 4D assimilation, spatial correlations of observation errors (*paper by Yann Michel recently published in QJRMS* **– https://doi.org/10.1002/qj.3249**).

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Thank you for your attention !