Progress and plans on observations and other features in Météo-France's assimilation systems

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Content

- Arpège 4D-VAR, Arpège ensemble assimilation (AEARP) & outlook
- Aladin models, Arome-France & outlook

Part 1

AEARP & ARPEGE

Main changes introduced in operations (September 25, 2012)

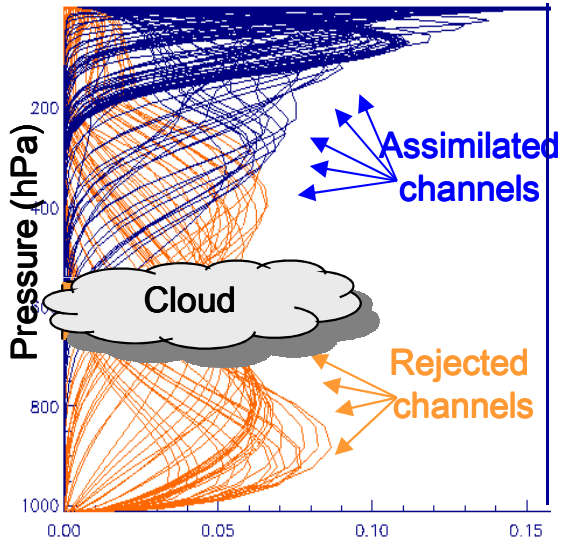
- CY37T1_op1
- Retuned oo's: AMSU-A, GPS-RO, TEMP, wind profilers, AIREP & ASCAT winds;
- Cloud (and rain) affected IASI radiances: CO2-slicing;
- Increase of number of observations: IASI (tropospheric channels over sea, stratospheric channels everywhere), EARS/IASI, ground-based GPS from EGVAP;
- Assimilation of RARS/ASCAT winds;
- Ensemble DA system: inflation of B(variances) for model error;
- adaptations in convection scheme; Arpège time-step reduced to 514 s & slight increase of horizontal diffusion;

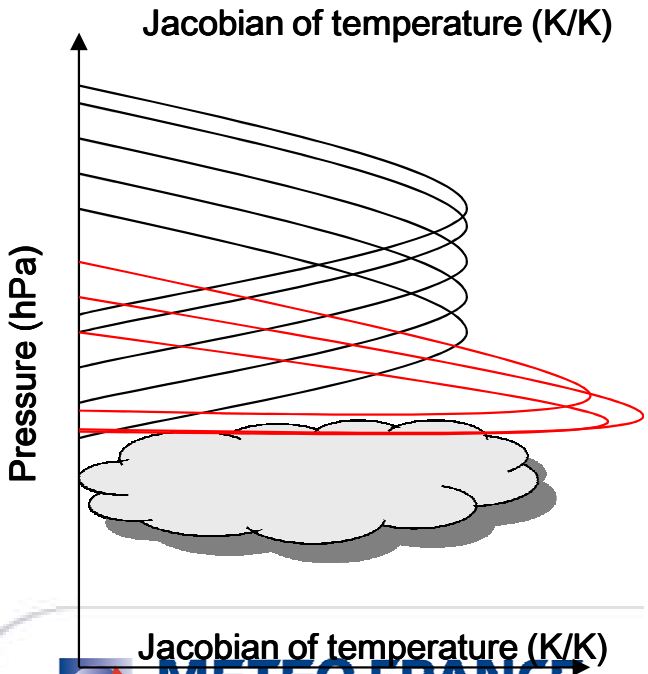
Assimilation of cloud-affected (IASI) radiances

History:

1. A good cloud detection (pixel-wise) is necessary
2. Reject cloud-affected radiances (Mc Nally & Watts 2003) and only assimilate clear-sky
3. Evaluate simple cloud parameters (Cloud Top Pressure, cloud fraction) assuming one single cloud layer

- **Assimilation for clouds between 950 hPa and 600 hPa over sea:**
  - **Information is in the Troposphere**
  - **If cloud detection or parameter evaluation was wrong, then the impact remains limited (because of the many other sources of observations in the Troposphere)**
  - **Assessing the nature and characteristics of the surface remains challenging**
  - **Many NWP models are not representing mid-level clouds very accurately**
  - **Clouds containing ice particles are difficult to model**
- Operational for AIRS data in Arpège (Feb'09) and Arome (April'10)





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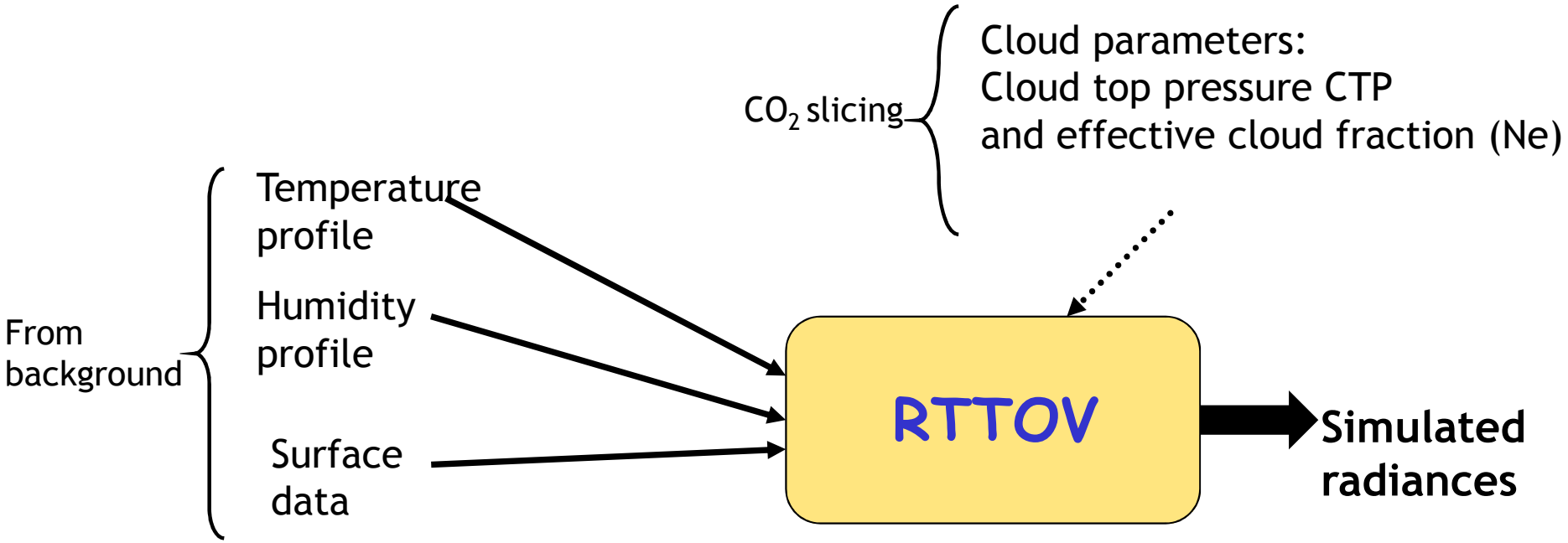
Simulation of IASI cloudy radiances

Current radiative transfer model



CTP and Ne retrieved with CO_2 slicing

Limitations of CO2 slicing method: detection of low-level clouds and cirrus.
Limitation of RTTOV: simplified cloud modelling : one single opaque cloud layer

Assimilation of AIRS/IASI cloudy radiances

Method used for the assimilation of AIRS/IASI cloudy radiances affected by mid- to low-level clouds

Cloud parameters determined with CO2slicing

Minimization of $F_{k,p}$

$$F_{k,p} = \frac{(R^{k}_{clr} - R^{k}_{obs})}{(R^{K_{ref}}_{clr} - R^{K_{ref}}_{obs})} - \frac{(R^{k}_{clr} - R^{k,p}_{cld})}{(R^{K_{ref}}_{clr} - R^{k_{ref},p}_{cld})}$$

Robs: observed radiance
Rclr: clear-sky radiance simulated from the model
Rcld: radiance with opaque cloud at pressure level p
k= channel of the CO2 band
Kref= reference channel (surface)
= 917.31 cm-1 (AIRS)
=> **CTP and Ne**

Cloud top pressure:

$$p_c = \frac{\sum p_{c,k} w_k^2}{\sum w_k^2}$$

$P_{c,k}$: pressure level minimizing $F_{k,p}$
W_k: derivative of $F_{k,p}$ wrt pressure

Effective cloud emissivity

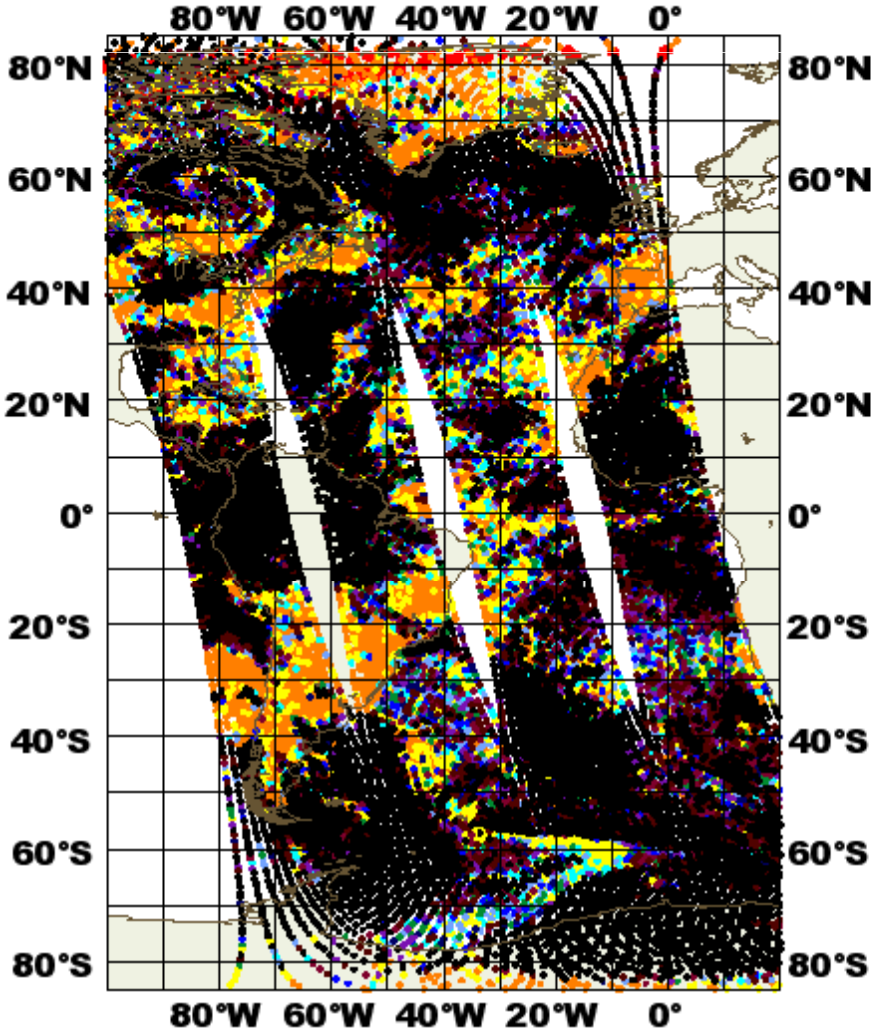
$$N_\varepsilon = \frac{(R^{k_{ref}}_{clr} - R^{k_{ref}}_{obs})}{R^{k_{ref}}_{clr} - R^{k_{ref}}_{cld}}$$

Use of the cloud cover from imager for the assimilation of cloudy IASI radiances

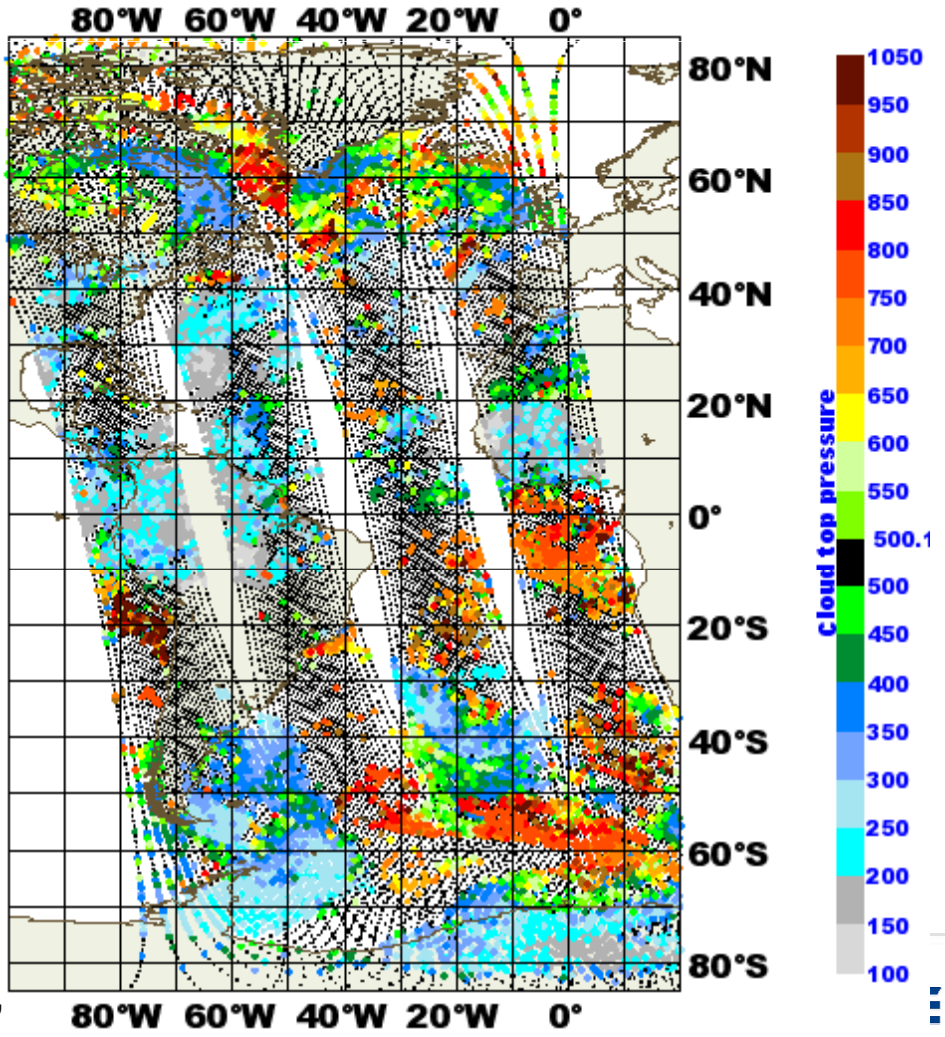
Retrieval of cloud top pressure if cloud-cover(AVHRR)=100%

Example for 19 September 2010 at 00 UTC

AVHRR cloud cover



Cloud top pressure



nki,

Method for the assimilation of AIRS/IASI cloudy radiances

With this method: we assimilate about 2% more data from the whole IASI dataset

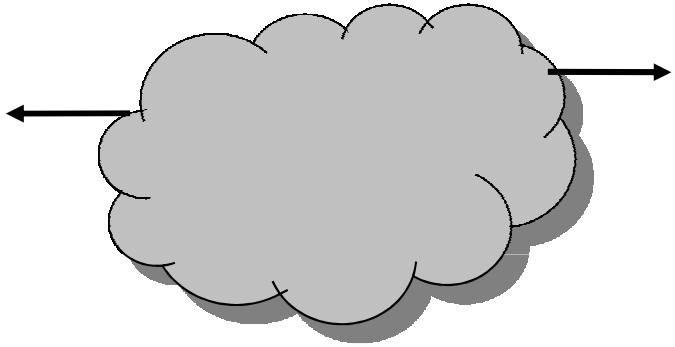
CO2-Slicing

If cldcv(AVHRR)=100%

Cloud parameter retrieval (CTP et Ne)

Use of CTP and Ne into RTTOV

Simulated spectrum



Cloud-Detect

(Mc Nally and Watts,2003)

Flag each channel

cloudy

clear

Input to assimilation

Assimilation of cloudy channels

IF 600hPa<CTP<950hPa and NE=1

Over sea

Assimilation of clear channels

AEARP double (Assimilation d'Ensemble ARPège)

- **ARPEGE changes** are included in the AEARP 4D-VARs
- **inflation of dispersion sizes, in order to take into account model error.** The inflation is of a factor about 1.2 (leading to an increase of spread by a factor 2 to 3, depending on field)

PEARP (Prévision d'Ensemble ARPège)

- **Adapted** to changes in AEARP
- **Adapted to the changes in convection** for those members using a convection closure based on humidity convergence.

(G. Desroziers, L. Berre, C. Labadie, L. Descamps)

Outlook for Arpège 4D-VAR

- Radiances over land (*on hold*)
- Cloud (and rain) affected radiances: assess benefit of model cloud water content for RTTOV-cloud
- Increase of number of observations: NPP/ATMS, NPP/CRIS, Metop-B data, Ocean-SCAT, Megha-Tropiques; geostationary (GOES & MTSAT) radiances;
- Revisited strategy for GPS ZTD blacklisting (allow more data to be assimilated);
- Start testing VarBC for GPS ZTD
- Simplified physics: convection and turbulence (stratiform precipitation and GWD already modified in 2010) – *on hold* -
- Ensemble DA system: feed wavelet structure function parameters
- Increase number of members in AEARP at constant total numerical cost
- Code system overhaul: towards object-oriented coding of the IFS/Arpège assimilation system (« OOPS ») => started with CY38

Part 2

Aladin Overseas & Arome-France

Modifications in ALADIN

- **ARPEGE changes** included in the ALADIN models
- **4 Aladin 3D-VAR configurations**:
  - France: stopped on March 27, 2012
  - La Réunion: cyclone warnings in the Indian Ocean area
  - Polynesia, New Caledonia, French Antilles & Guyana: coupling with IFS
- see also French national poster

(G. Faure, F. Bouyssel, F. Taillefer)

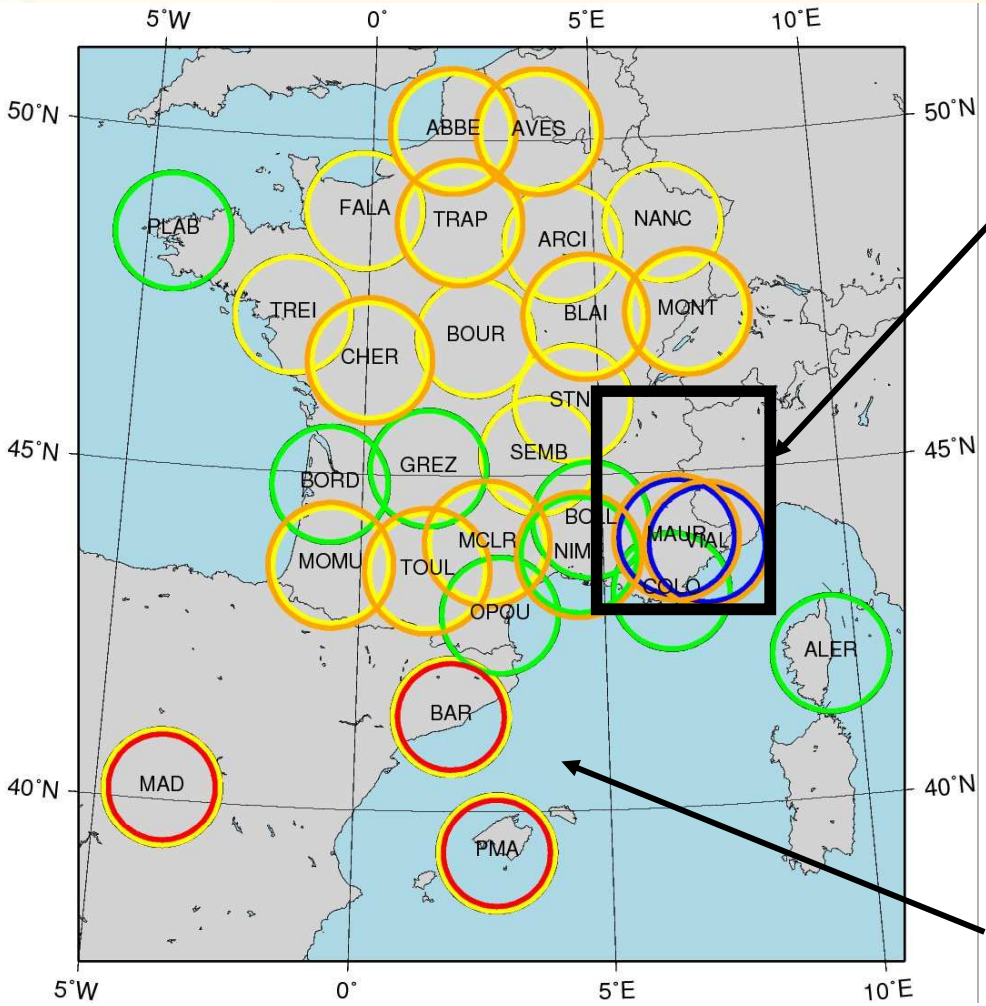
Modifications in AROME and R&D aspects (Sept'12)

- ARPEGE observations changes are included in AROME-France
- assimilation of Doppler radial winds from Plabennec radar site; monitoring of D-winds from Grèzes and X-band from St-Maurel;
- assimilation of SEVIRI over land;
- Assimilation of AMSU-A at higher density (80km instead of 125km)
- assimilation of more buoys in the CANARI OI for SST

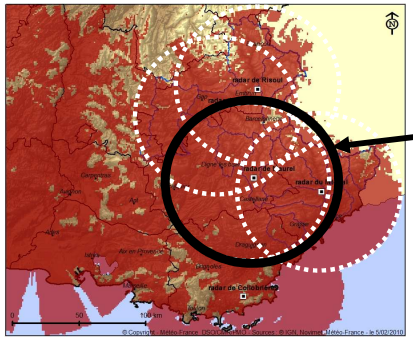
Use of GPS information in Arome-FR

- GPS ZTD are assimilated in Arome-FR (as well as Arpège)
- Expect more work on a dynamical selection of stations, using a more open blacklist (or a whitelist). Goal is to increase the volume of GPS data entering screening.
- Variational bias correction scheme for GPS data is coded in CY38 (by ECMWF). This is to be tested in MF's systems (GMAP and collaboration with Moroccan team)
- No work on R.O. nor tomography (some Research at GMME, *tbc*)

Changes in the radar network



There is a need for a radar coverage in this area: Rhytmme project (Hydrometeorological risks in Mediterranean mountainous: new X-band radars)



- **4 radars in 2013**
- **Mt-Vial currently cannot be used (poor quality for assimilation)**
- **Tests with Mt-Maurel**

Introduction of the Spanish radars (Madrid, Barcelona, Palma de Mallorca)

16 French radars in C band (yellow circles) and 3 Spanish radars in C band (red circles). 8 in S band (green circles). 12 polarimetric radars (orange circles) from which 2 radars in X band (blue circles)

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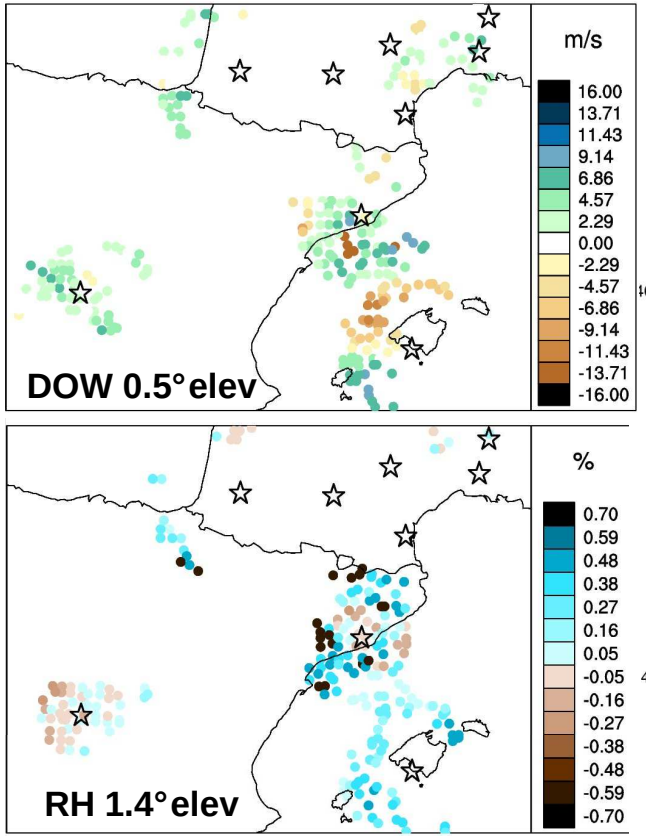
Assimilation of radars from AEMET

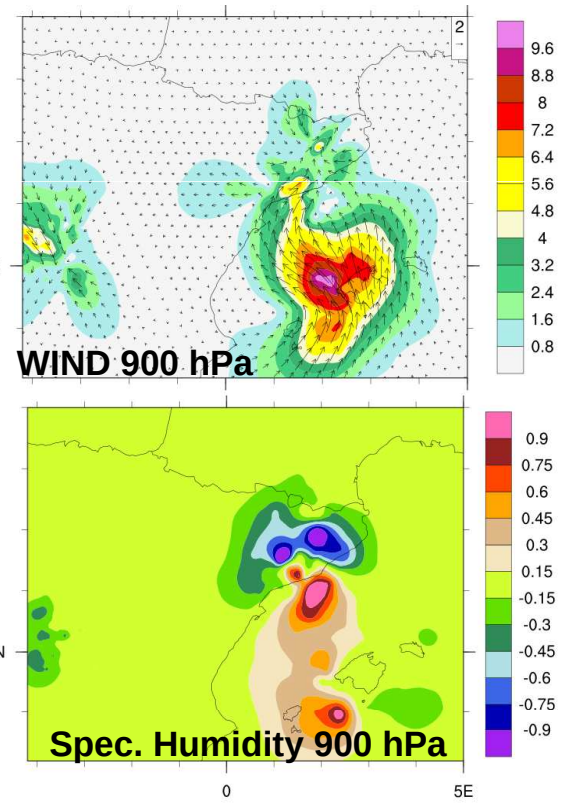
Preliminary experiments considering radars from Madrid, Barcelona and Palma de Mallorca:

- **2 elevations for the moment (0.5°and 1.4°), 120 km ranges, double PRF, Z, DOW and QF**
- **PPIs in polar coordinates (δr = 500m, δazimuth = 0.8°)**
- **non-meteorological clutters deduced from good signal using the Doppler spectrum (but not removed ! => possible ambiguity and bad quality of reflectivity!)**

Increments in observation space (DOW positive towards the radar)



Analysis differences with/without AEMET radars at 9 UTC



⇒ The whole processing chain has been validated and encouraging results have been obtained.

⇒ Tests in quasi-real time are planned in june/july in AROME WMED

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Impact of obs on analysis: DFS

- Regularly computed by our monitoring team (COMPAS), as a mean over all analyses of a day (8 for Arome-FR)
- DFS = Degrees of Freedom for Signal = statistical objective measure of the ability of an obs (group of obs) to modify the analysis:

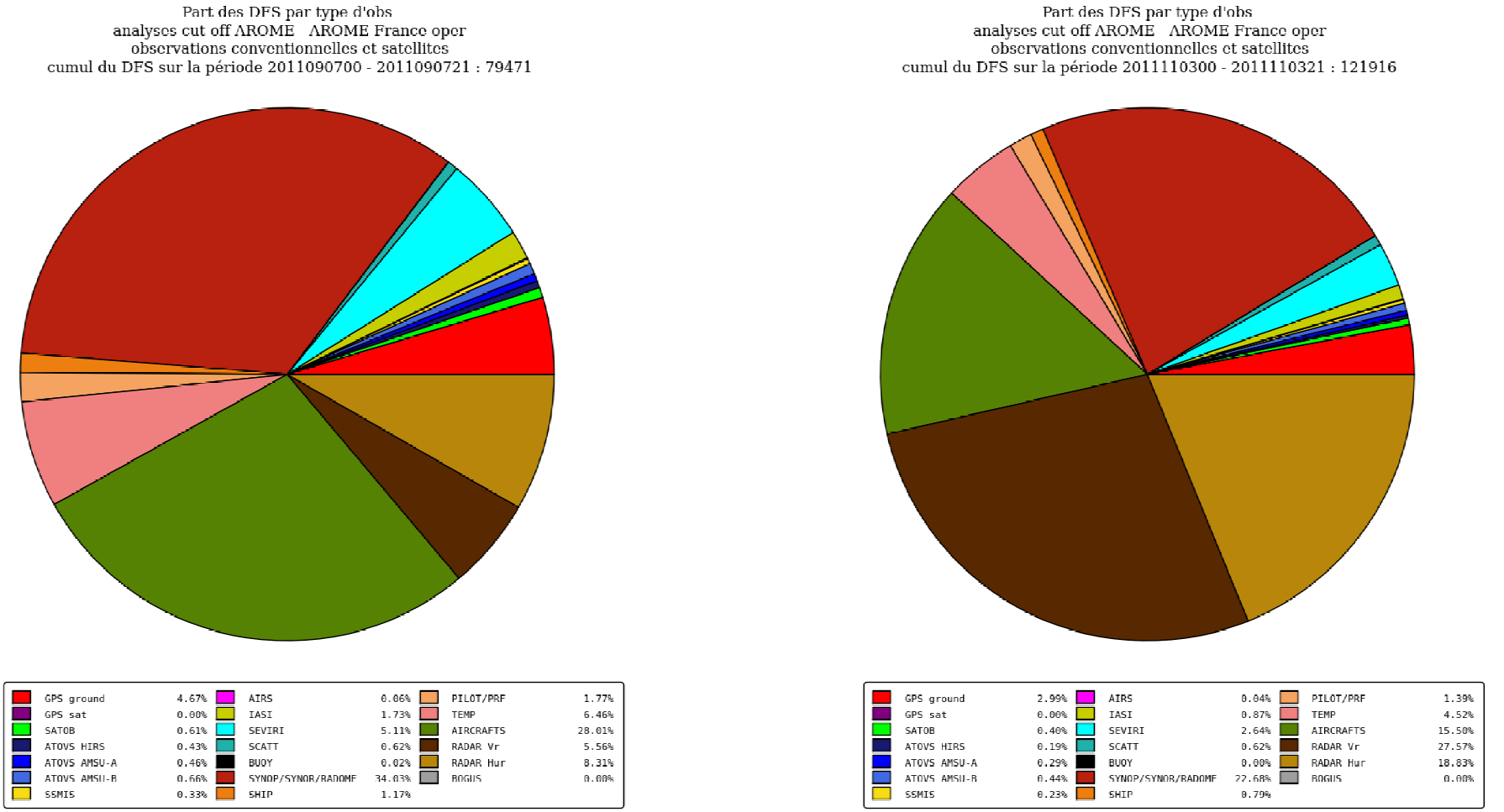
$$DFS = Tr\left(\frac{\partial(H\mathbf{x}^a)}{\partial(\mathbf{y}^o)}\right)$$

$$= Tr\left(\mathbf{HK}\right)$$

- DFS are computed using perturbed analyses (e.g. from ensembles)
- If R is block-diagonal:

$$DFS_i = Tr\left(\Pi_i \mathbf{HK} \Pi_i^{\mathrm{T}}\right)$$

Impact of obs on Arome-FR analysis



Non-rainy period of stats

Rainy period of stats

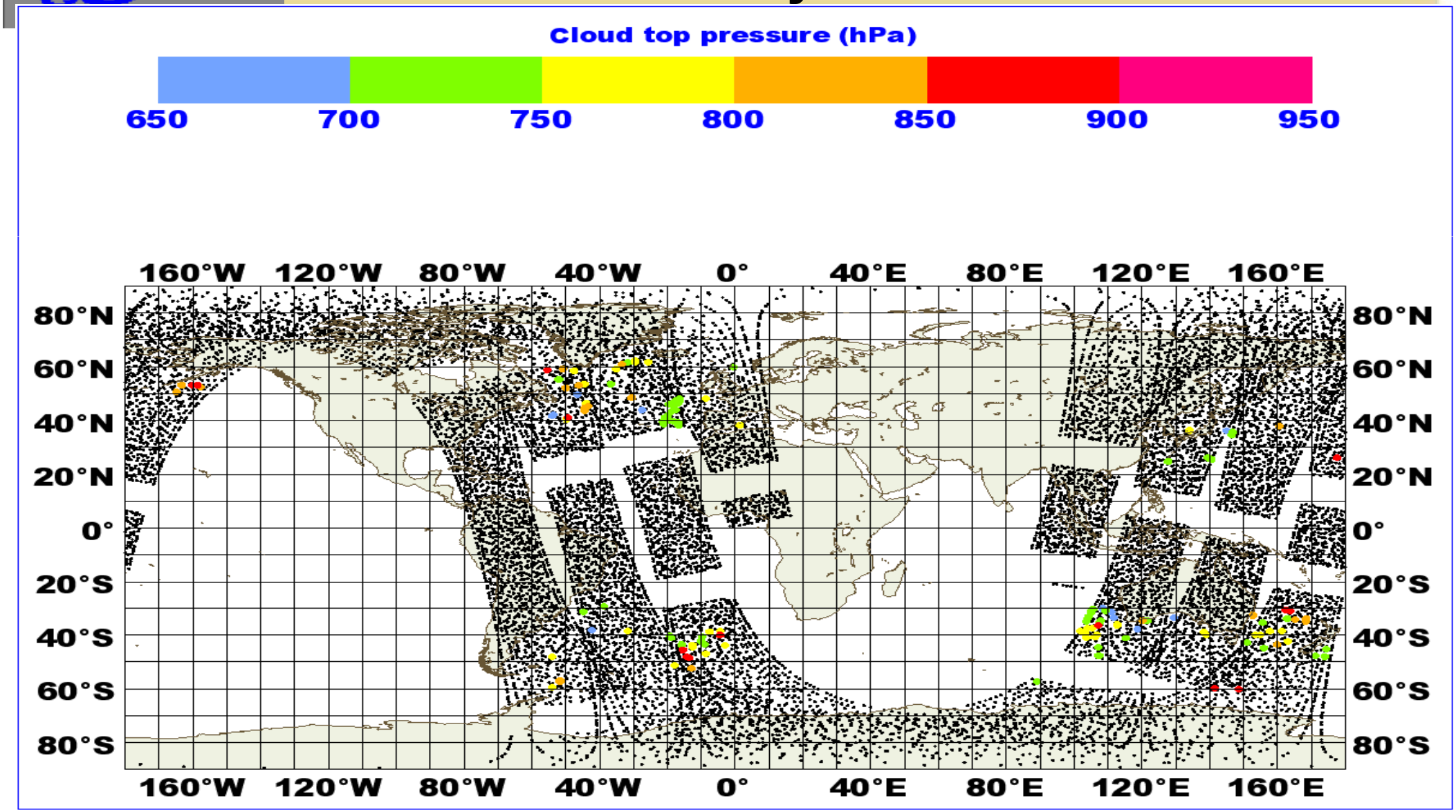
Outlook for LAMs

- Experiments with 1-hourly cycles (RUC) : in progress
- Use of ensemble assimilation information, situation-dependent aspects
- New tests with « Jk » term (weak constraint towards coupling data)
- Heterogeneous B matrix: extended control vector to accommodate for different structure functions (in masked areas), Montmerle & Berre (QJRMS, 2010).
- Radar:
  - assess impact of windmill signals,
  - evaluate assimilation of X-band radars from the RYTHMME network,
  - radar data exchange within HYMEX,
  - sensitivity studies towards the inclusion of a total precipitating hydrometeor content in c.v.
- Assimilate more ground-based GPS (re-visit blacklisting & VarBC)
- Increase number of vertical levels in Arome-FR: this increase probably requires to also increase the vertical layout in RTTOV-levels;
- Aladin applications at MF: assess benefit of denser observations
- Code system overhaul: towards object-oriented coding of the IFS/Arpège assimilation system (« OOPS ») => started with CY38

Kiitos huomiota

(thank you for your attention)

Added IASI cloudy observations



In color, for conditional test {totally cloudy & cloud top ∈ [650, 900 hPa]

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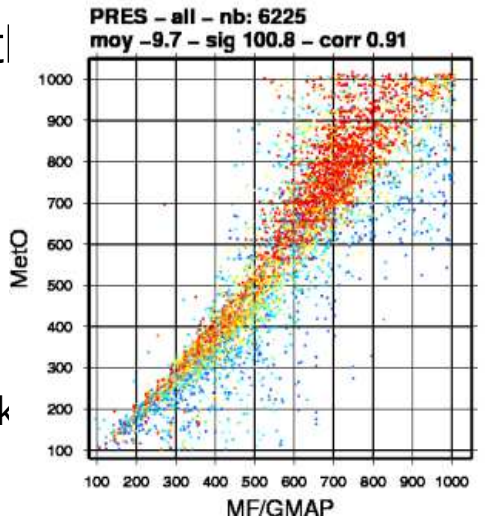
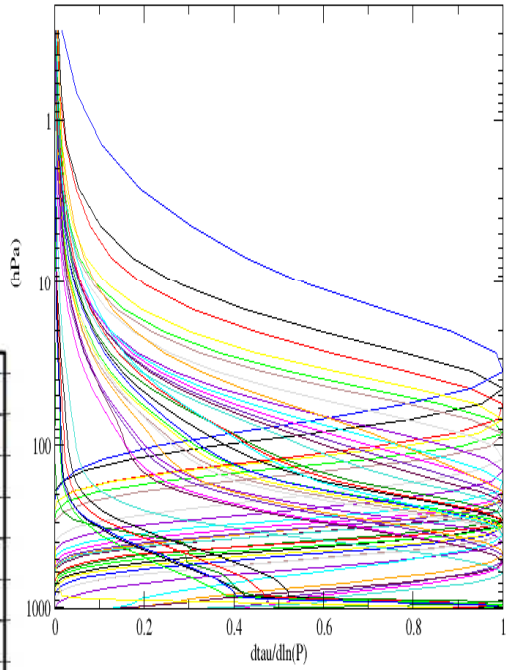
A short summary about the assimilation of cloudy radiances

- Cloud parameters retrieved with CO2slicing method (Pangaud et al, 2009, MWR).
- Small positive impact of the AIRS cloud-affected radiance assimilation on the forecast skill.
- In operations since February 2009 for the global model and since April 2010 for the mesoscale model AROME.
- Same methodology applied for IASI as the one used for A
  parameters determined with CO2slicing (36 channels)

Lavanant et al (2011) : good agreement of IASI cloud top pressure retrieved with our met
with top pressures provided by the other centers.





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The RHYTMME project

Radial wind

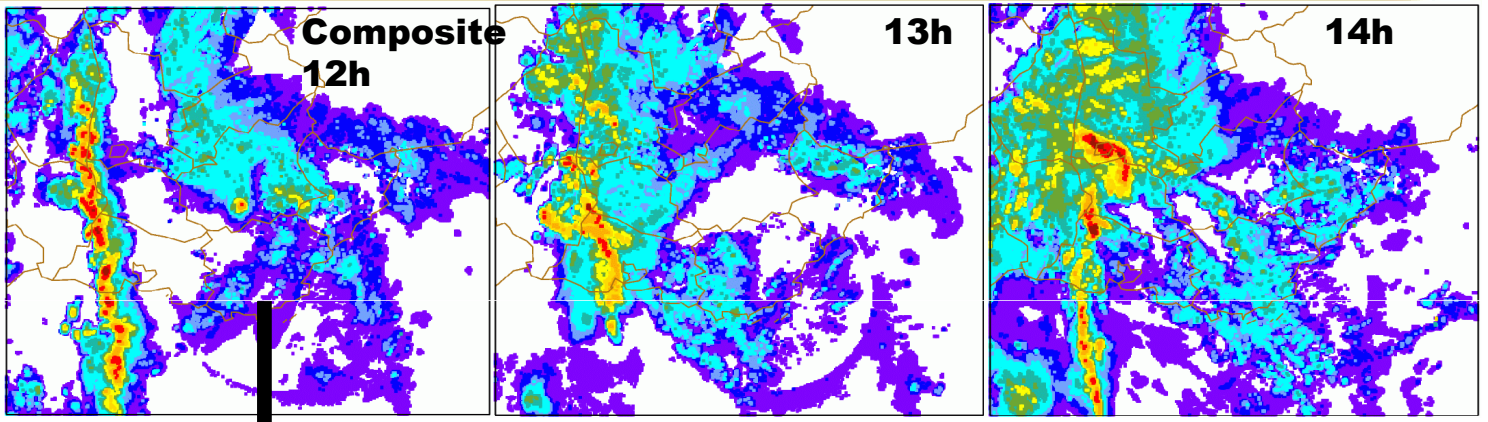
- Triple PRF needed for unfolding velocity.
- Ratio of PRF very close to 1 to get high velocity required for assimilation in NWP. Provides erroneous unfolding with low PRF used for X-band. Strong median filter is needed. A new first guess quality check threshold is applied for X-band: 15 m/s instead of 20 m/s !

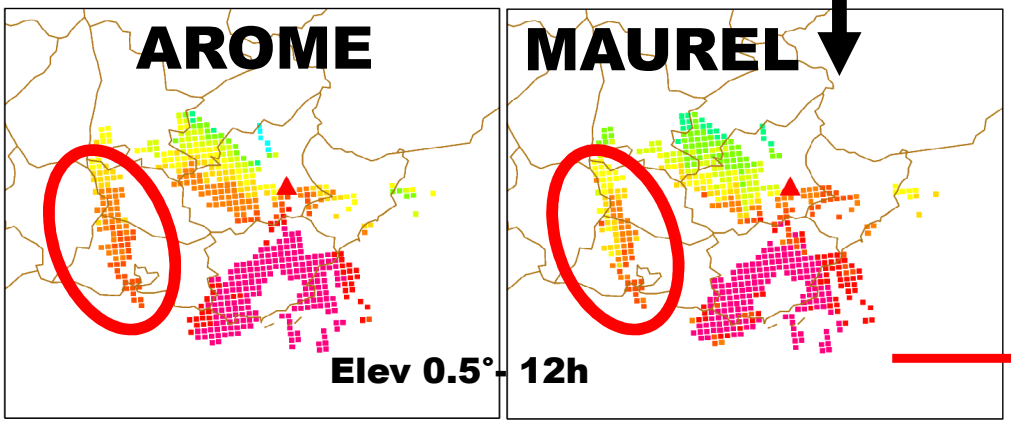
Reflectivity

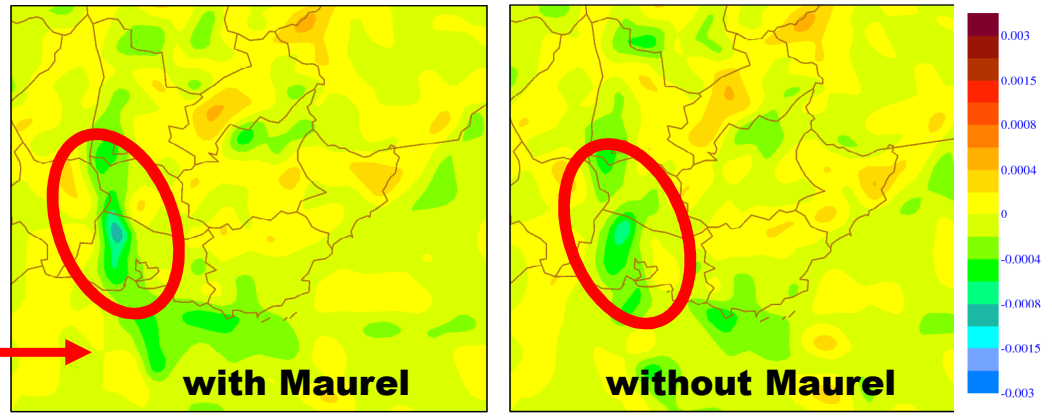
- Only the simple-polar reflectivity has been evaluated («Hitschfeld-Bordan » algorithm to correct reflectivity attenuation)
- Use of the differential phase ϕ_{dp} (to compute the Path Integrated Attenuation PIA) must still be evaluated.

The RHYTMME project: radial wind

- Despite quality problems with raw data, some case studies show consistent analysis increments (04/11/2011)
- Neutral scores over 10 cycled assimilation days (not shown)







900 hpa - Divergence analysis – 12h

⇒ Radial winds from Mt-Maurel monitored in AROME

⇒ Next step: evaluation in real-time in AROME WMED

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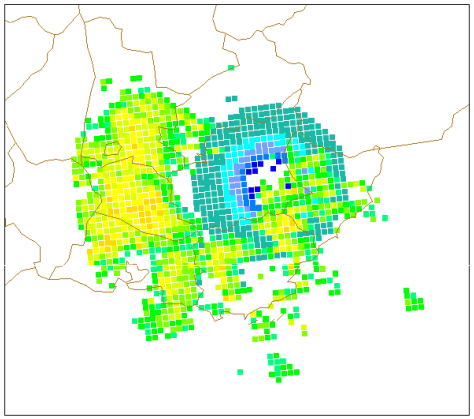
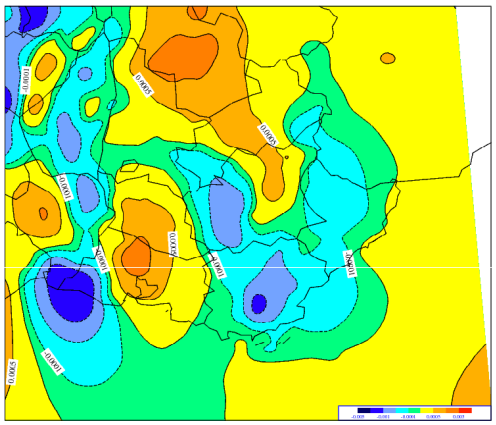
The RHYTMME project: reflectivity

- New consistent information (04/11/2011 – 00h) in analysis increments
- But possible negative QPF scores (not shown)
- Neutral or slightly negative scores over 10 cycled assimilation days (not shown)

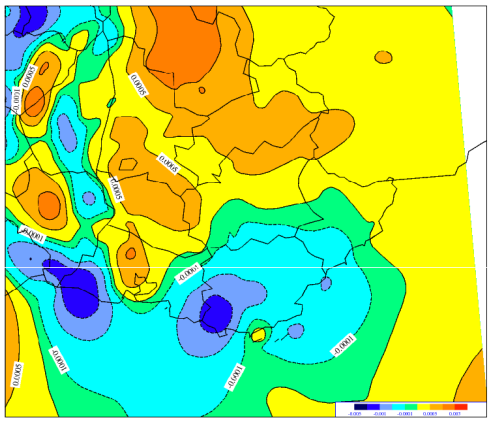
Obs 0.5°Maurel



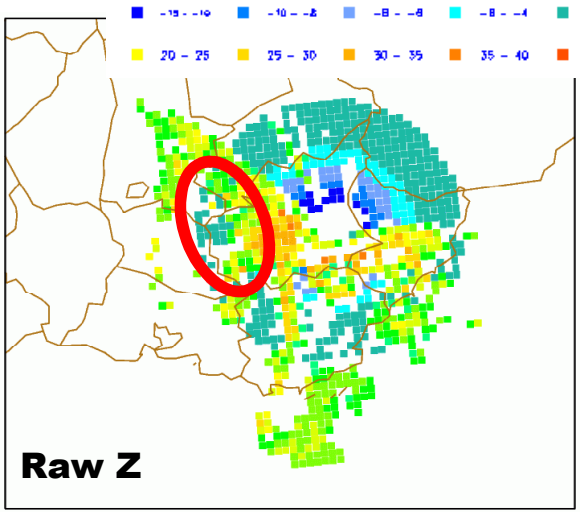
Specific humidity increments: level 4 2 (1530)

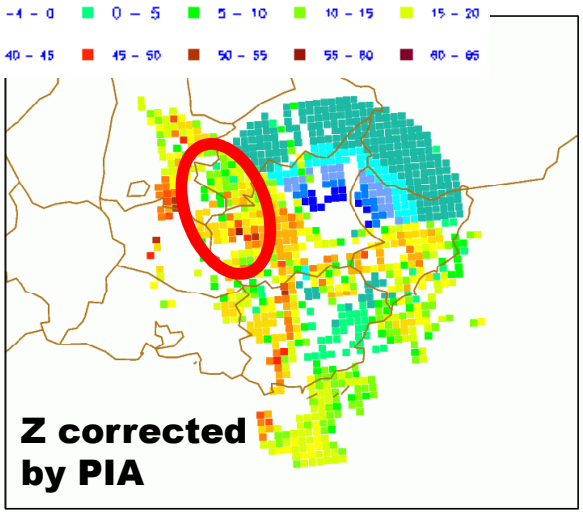


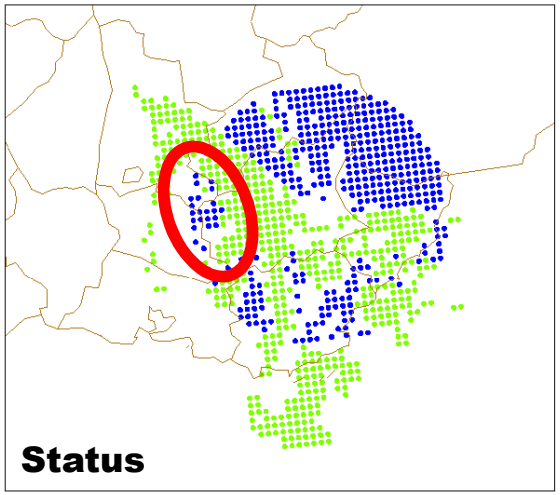
With Maurel



Without Maurel



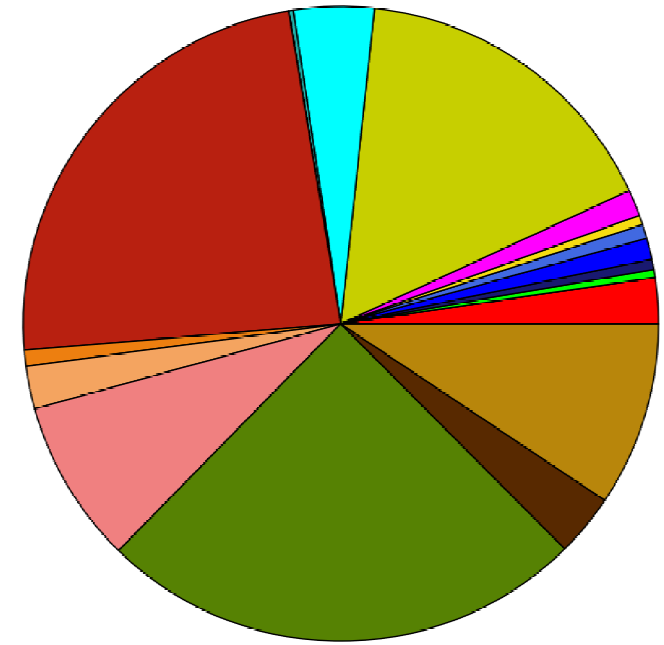




⇒ New assimilation tests with Path-Integrated Attenuation (PIA) information (dual polar) are underway: better reflectivity but loss of information in areas affected by signal extinction

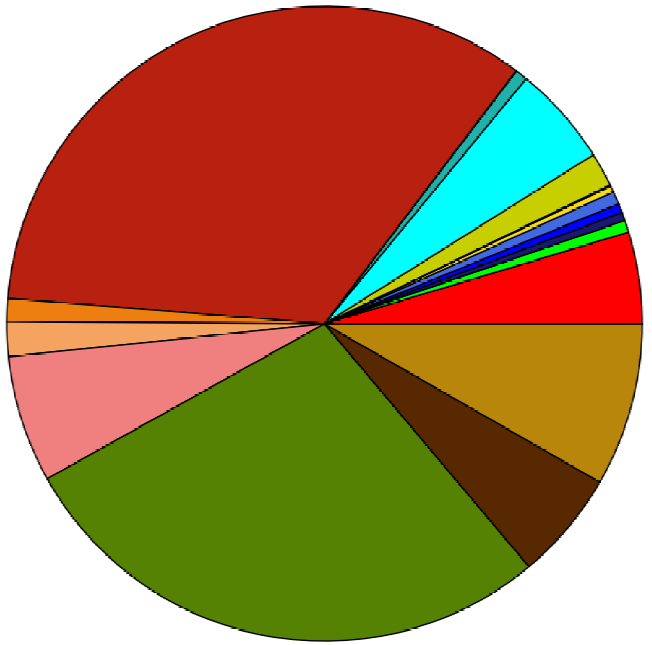
Impact of obs on Arome-FR analysis: no RR period

Proportions des nombres d'observations utilisées par type d'obs
analyses cut off AROME AROME France oper
observations conventionnelles et satellites
cumul du nombre d'observations utilisées sur la période 2011090700 - 2011090721 : 209513



GPS ground	2.34%	AIRS	1.35%	PILOT/PRF	2.17%
GPS sat	0.00%	IASI	16.41%	TEMP	8.35%
SATOB	0.40%	SEVIRI	4.09%	AIRCRAFTS	24.79%
ATOVS HIRS	0.53%	SCATT	0.23%	RADAR Vr	3.16%
ATOVS AMSU-A	1.07%	BUOY	0.01%	RADAR Hur	9.39%
ATOVS AMSU-B	0.72%	SYNOP/SYNOR/RADOME	23.69%	BOGUS	0.00%
SSMIS	0.48%	SHIP	0.82%		

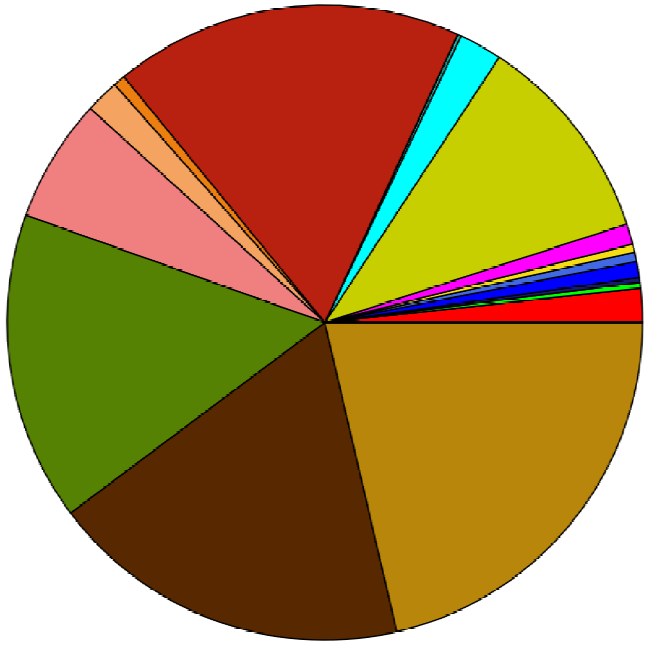
Part des DFS par type d'obs
analyses cut off AROME AROME France oper
observations conventionnelles et satellites
cumul du DFS sur la période 2011090700 - 2011090721 : 79471



GPS ground	4.67%	AIRS	0.06%	PILOT/PRF	1.77%
GPS sat	0.00%	IASI	1.73%	TEMP	6.46%
SATOB	0.61%	SEVIRI	5.11%	AIRCRAFTS	28.01%
ATOVS HIRS	0.43%	SCATT	0.62%	RADAR Vr	5.56%
ATOVS AMSU-A	0.46%	BUOY	0.02%	RADAR Hur	8.31%
ATOVS AMSU-B	0.66%	SYNOP/SYNOR/RADOME	34.03%	BOGUS	0.00%
SSMIS	0.33%	SHIP	1.17%		

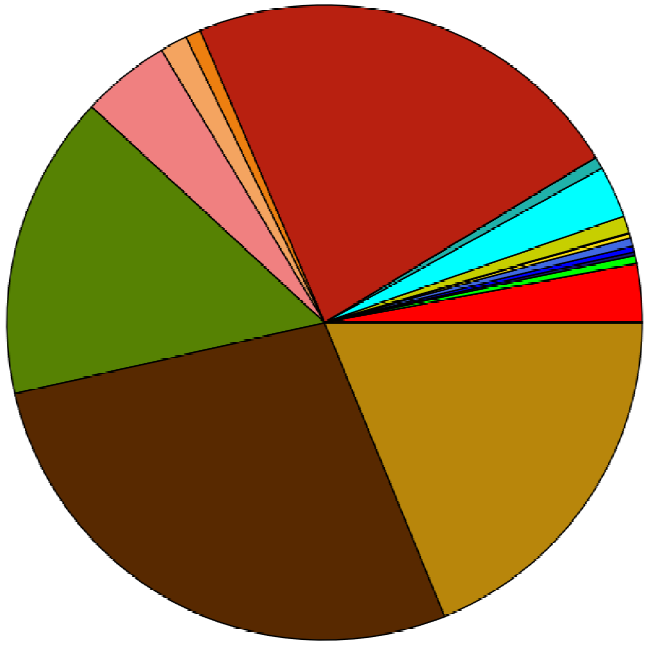
Impact of obs on Arome-FR analysis: rainy period

Proportions des nombres d'observations utilisées par type d'obs
analyses cut-off AROME - AROME France oper
observations conventionnelles et satellites
cumul du nombre d'observations utilisées sur la période 2011110300 2011110321 : 280292



GPS ground	1.74%	AIRS	1.05%	PILOT/PRF	1.71%
GPS sat	0.00%	IASI	10.73%	TEMP	6.29%
SATOB	0.29%	SEVIRI	2.19%	AIRCRAFTS	15.74%
ATOVS HIRS	0.25%	SCATT	0.18%	RADAR Vr	18.40%
ATOVS AMSU-A	0.81%	BUOY	0.00%	RADAR Hur	21.36%
ATOVS AMSU-B	0.49%	SYNOP/SYNOR/RADOME	17.77%	BOGUS	0.00%
SSMIS	0.41%	SHIP	0.60%		

Part des DFS par type d'obs
analyses cut-off AROME - AROME France oper
observations conventionnelles et satellites
cumul du DFS sur la période 2011110300 2011110321 : 121916



GPS ground	2.99%	AIRS	0.04%	PILOT/PRF	1.39%
GPS sat	0.00%	IASI	0.87%	TEMP	4.52%
SATOB	0.40%	SEVIRI	2.64%	AIRCRAFTS	15.50%
ATOVS HIRS	0.19%	SCATT	0.62%	RADAR Vr	27.57%
ATOVS AMSU-A	0.29%	BUOY	0.00%	RADAR Hur	18.83%
ATOVS AMSU-B	0.44%	SYNOP/SYNOR/RADOME	22.68%	BOGUS	0.00%
SSMIS	0.23%	SHIP	0.79%		