Changes in the Arpège 4D-VAR and LAM 3D-VAR

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METEO FRANCE
Toujours un temps d'avance

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- Arpège 4D-VAR
- Arome-France
- Other applications: Aladin Overseas, LACE
- Outlook

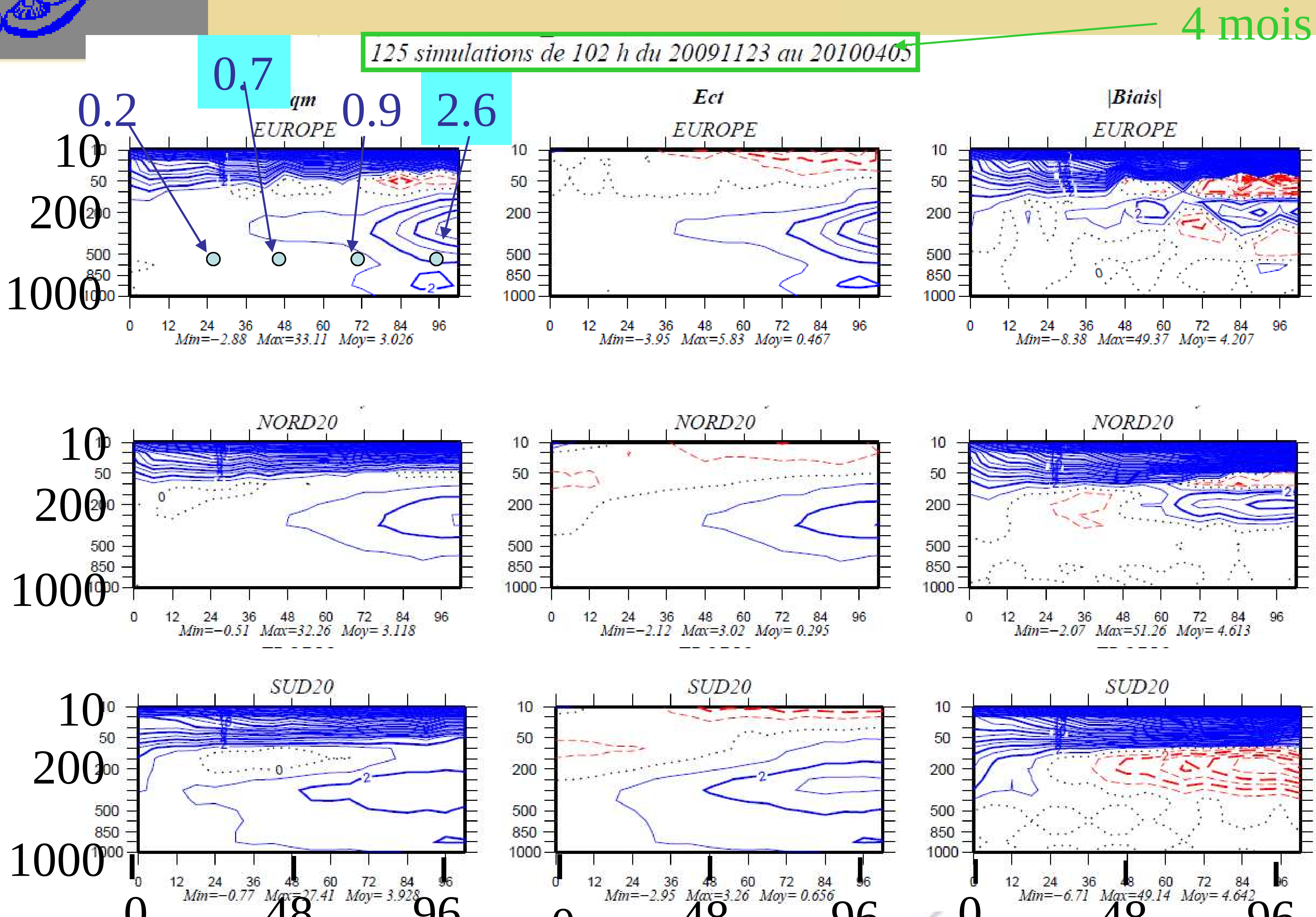
Arpège 4D-VAR and observations

ARPEGE E-suite (autumn/winter 2009/2010):

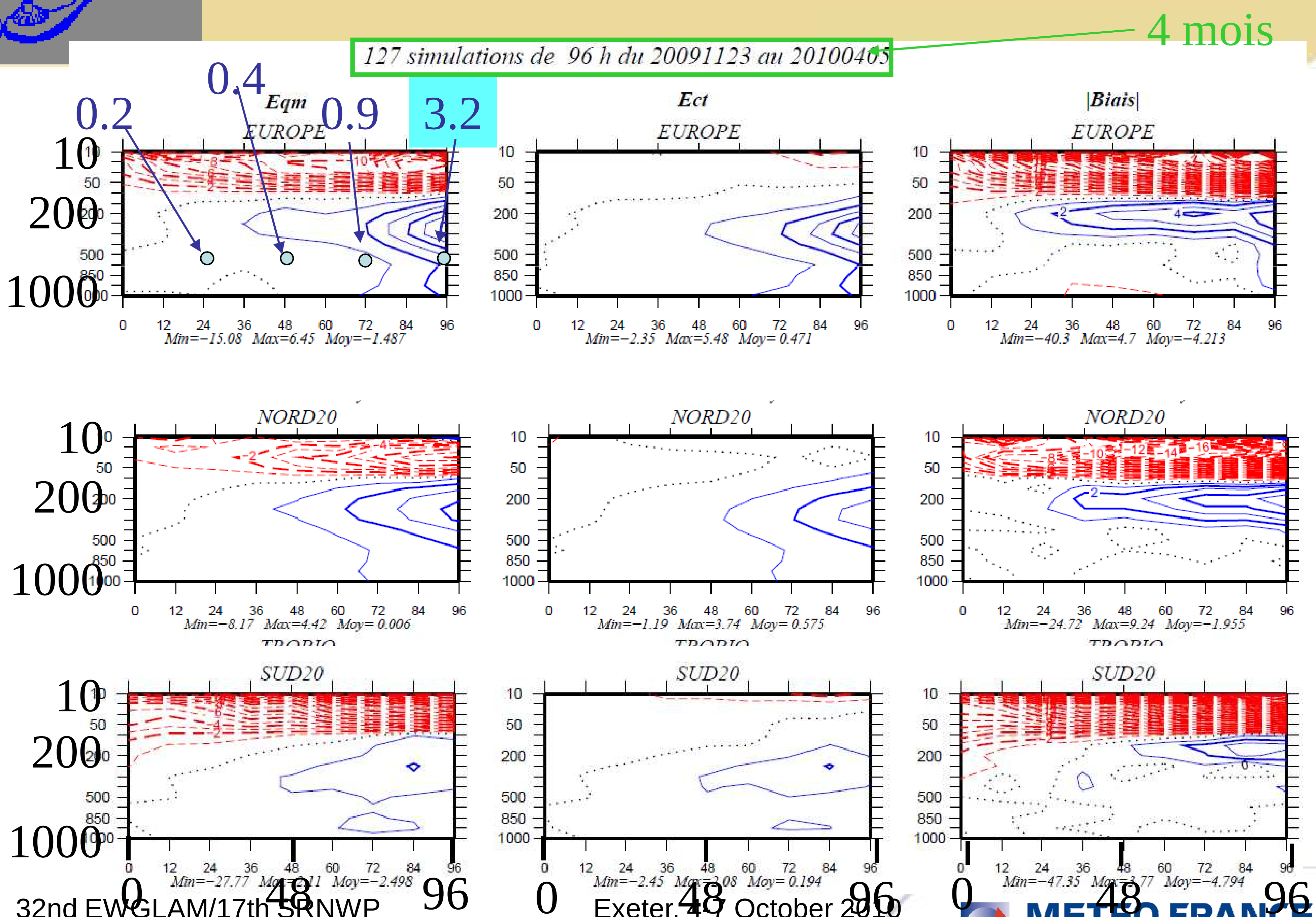
- new change of resolution of ARPEGE: T798C2.4L70
- new resolution for the 4D-VAR analysis increment: T107C1.0L70 (25 iterations) and T323C1.0L70 (30 iterations) with δt=1350 s;
- changes in the assimilation ensemble: L70
- Double the density of about all radiance types (change the scale of data use from one spot every 250 km to one every 125 km)
- assimilation of NOAA-19 channels;
- reactivate VarBC for channel 13 of AMSU-A
- extend the number of assimilated IASI channels (surface channels and WV channels),
- introduce a bias correction for MSLP observations (based on ECMWF practice)
- retuned error standard deviations: REDNMC from 2.0 to 1.6; σ_o multiplied by 0.9 globally
- Physics: new moist simplified physics version for TL/AD (based on Smith) including some microphysics;
- ALADIN-France: L70, slight increase of resolution to 7.5 km

This E-suite has been switched to operations on April 6, 2010.

Scores of Geopotential w/r to ECMWF analysis



Scores of Geopotential w/r to Radiosondes



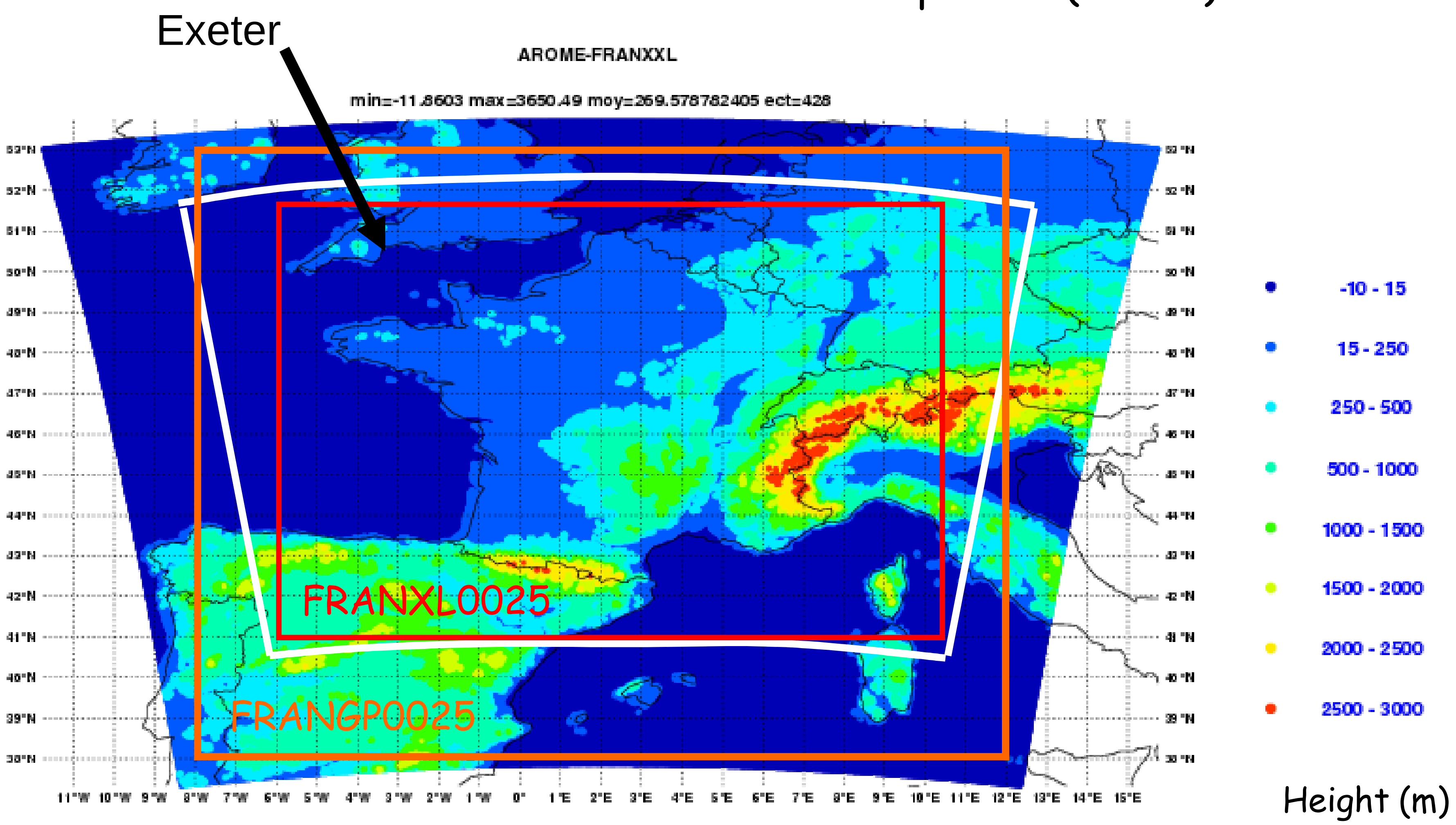
Currently tested changes:

"summer E-suite" (June/September 2010):

- Assimilation of SSMI/S from 2 satellites: DMSP F16 & F17
- radiosonde bias correction scheme for T (imported from IFS)
- assimilation of GRAS/METOP GPS occultation
- assimilation of low-peaking AMSU-A&B channels over sea-ice
- modified algorithm for handling ambiguous wind direction from METOP/ASCAT instrument
- use Synop RH2m observations in daytime
- use of ensemble assimilation σb's in the screening; use ensemble assimilation σb's for specific humidity in Jb
- TKE field is cycled (instead of restarting with default value 10-6)

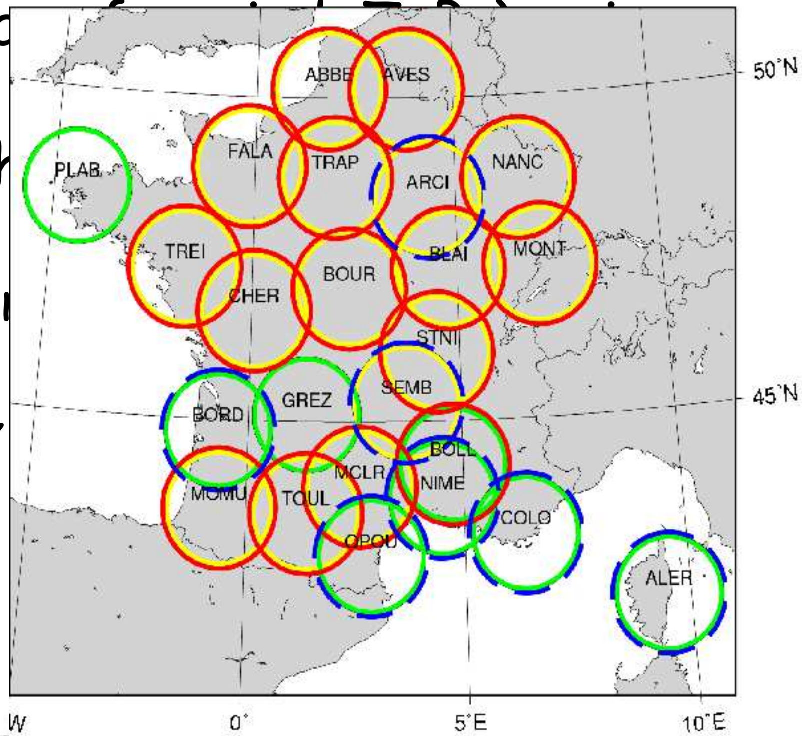
Extended AROME-France domain

750x720 points (+70 %)

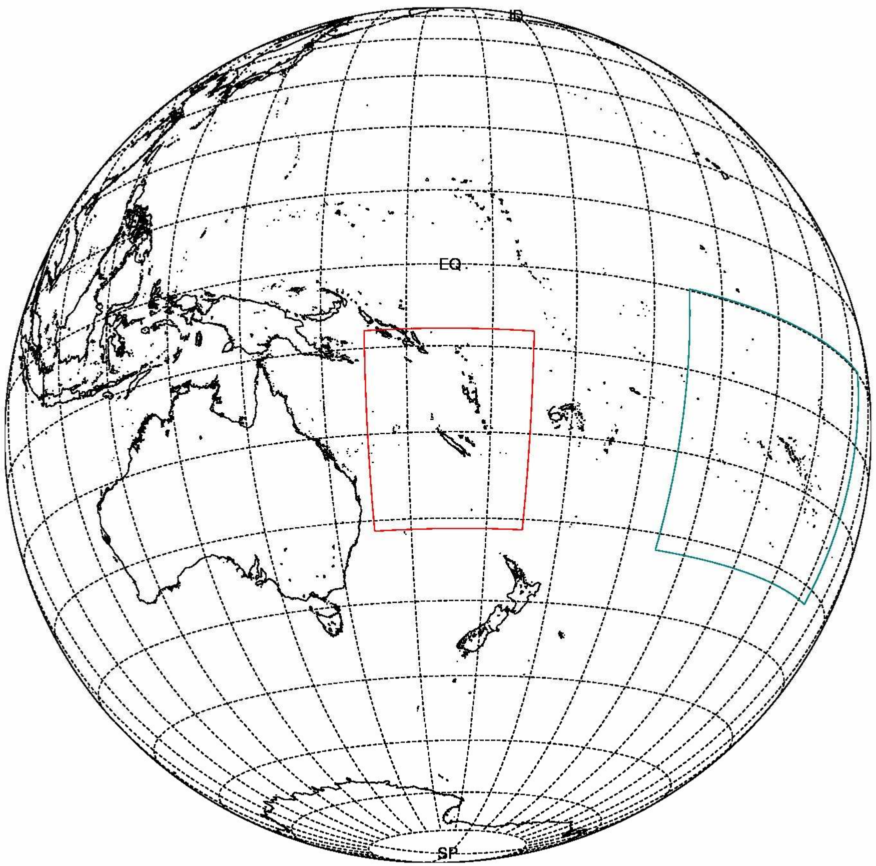


Other changes performed in the Arome assimilation

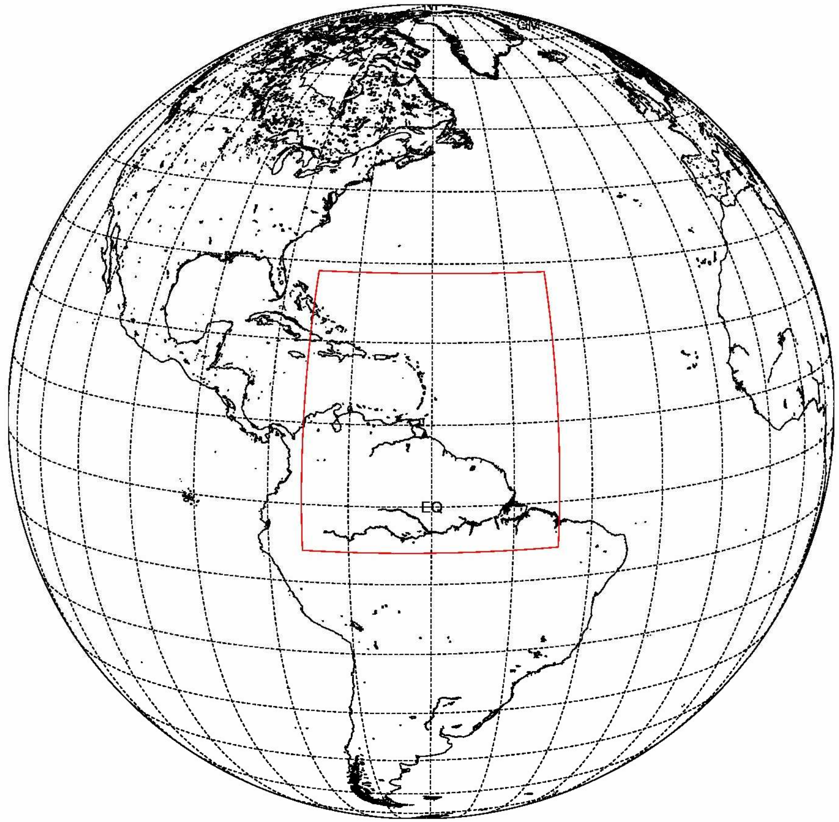
- Implement surface assimilation (based on O.I. Using increments of 2m T and RH)
- Assimilation of microwave channels from SSMI-S of DMSP F16&F17 (see ARPEGE)
- Increased density of obs for :
  - aircraft (25 km instead of 50 km)
  - IASI (80 km instead of 125 km)
- Use of background error variances from the Arpège EnsDA (structure, not mean) for humidity (as already is the c both screening and minimization
- Taking into account the big sensitivity of th simulator :
  - Increased number of assimilated observatio
  - Positive impact on creating/suppressing rain
- Assimilation of Doppler radar winds from 7
  - 5 coastal
  - + Sembadel + Arcis



Aladin Outre Mer (Overseas models)



- **Nouvelle-Calédonie**
- **Polynésie**
- **Antilles-Guyane**



Configuration

- 3D-VAR assimilation cycle
- SURFEX surface model (and later its assimilation)
- 54 h forecast range at 00 UTC and 12 UTC
- for assimilation cycle: 6 h forecasts at 06 and 18 UTC
- time step = 450 s, 10 km, 70 levels (as Aladin-France)
- 3 h coupling frequency, using in nominal mode IFS data at 16 km resolution
- B matrix derived for each domain by sampling over differences of 6 h fcts of members of the Arpège Ensemble Assimilation system (AEARP, 6 members), over 29 days
- Observations as in Arpège: conventional (Temp, Pilot, Synop, Airep), satellites (NOAA15,16,17,18, Metop A, ERS-2, Aqua, GPS Radio occultation)

Average amount of bits of data per 3D-VAR analysis in Aladin Antilles-Guyane v/s Aladin-Hungary

Obs type	Aladin Antilles-Guyane	Aladin-Hungary
SYNOP (incl. BUOYS)	550	1900
AIREP	2100	6700
WIND (SATOB / Profilers, …)	1800	600
TEMP (RS)	1200	4100
All radiances / NOAA-xx HIRS	30000	0
Scatterometer winds / NOAA-xx AMSU A/B	700	4400
GPS R.O. / MSG SEVIRI	140	2000

outlook

- Arpège:
  - Radiances over land
  - Cloud (and rain) affected radiances: CO2-slicing, assess benefit of model Qc for RTTOV-cloud
  - Simplified physics: convection and turbulence (stratiform precipitation and GWD already modified in 2009/2010)
  - Ensemble DA system
- Arome-France:
  - Use of ensemble assimilation information, situation-dependent aspects
  - New tests with « Jk » term (weak constraint towards coupling data)
  - Heterogeneous B matrix ?
  - Further improvement of radar data assimilation
- Aladin applications: operational validation of the Overseas models, convergence with Aladin/La Réunion, near-surface analysis
- Code system overhaul: towards object-oriented coding of the IFS/Arpège assimilation system (« OOPS »)

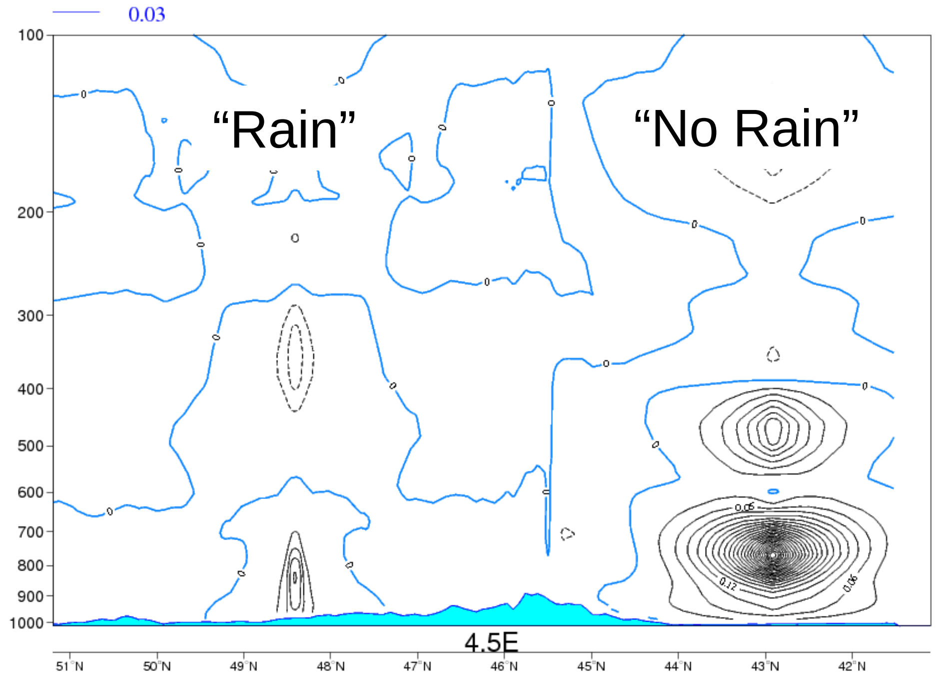
How to get cloud and precipitation-dependent statistics?

Heterogeneous B

Adapting ideas of Courtier (1998) and Buehner (2008), to use more suitable background error statistics in precipitating and non-precipitating areas in CVT:

$$\delta x = \alpha^{1/2} B_{np}^{1/2} \chi_1 + \beta^{1/2} B_p^{1/2} \chi_2$$

With: $\alpha^{1/2} = \mathbf{S}\mathbf{M}^{1/2}\mathbf{S}^{-1}$ and $\beta^{1/2} = \mathbf{S}(\mathbf{1}-\mathbf{M}^{1/2})\mathbf{S}^{-1}$
M: grid point mask deduced from observation (e.g radar reflectivities).
$\mathbf{B_p}$ and $\mathbf{B_{np}}$ being precipitating and non-precipitating background error covariances respectively.



Vertical Cross section of q increments
4 obs exp: Innovations of – 30% RH
At 800 and 500 hPa

⇒ Allows to consider simultaneously very different covariances that are representative of different weather regimes

⇒ Could be used in an ensemble flow-dependent B

Montmerle and Berre (2010)

Comparisons between structure functions

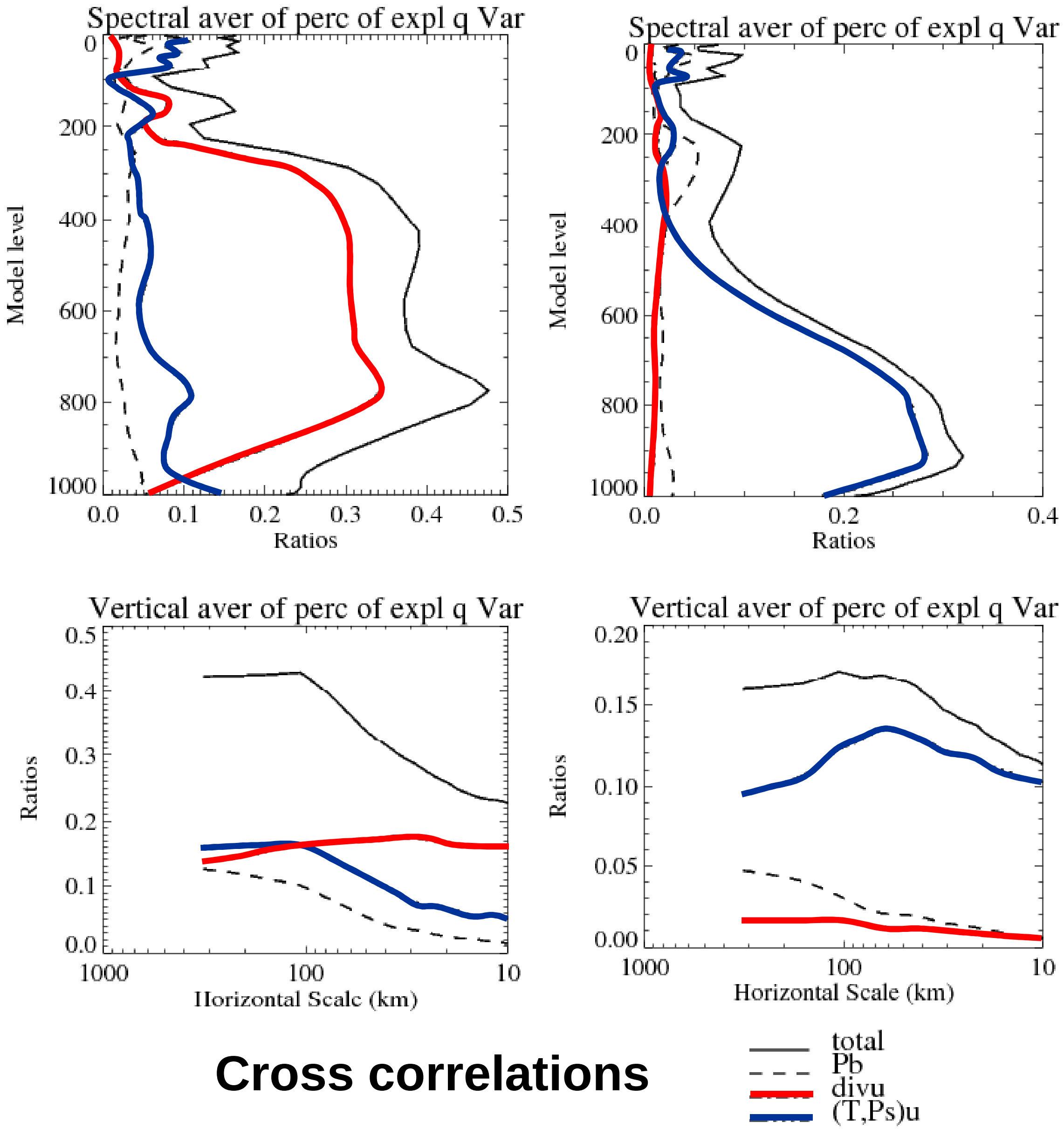
Multivariate formulation of errors:

$$
\begin{aligned}
\zeta &= \zeta \\
\eta &= \mathcal{M}\mathcal{H}\zeta + \eta_{\mathrm{u}} \\
(T,\, P_{\mathrm{s}}) &= \mathcal{N}\mathcal{H}\zeta + \mathcal{P}\eta_{\mathrm{u}} + (T,\, P_{\mathrm{s}})_{\mathrm{u}} \\
q &= \mathcal{Q}\mathcal{H}\zeta + \mathcal{R}\eta_{\mathrm{u}} + \mathcal{S}(T,\, P_{\mathrm{s}})_{\mathrm{u}} + q_{\mathrm{u}}
\end{aligned}
$$

In precipitating areas, σ_b(q) is mostly explained by η_u at mesoscale, whereas it is almost univariate and linked to the mass field in clear air

$\Rightarrow$ B_p et B_{np} are characterized by very different structure functions that are coherent with the model's physic in precipitating and non-precipitating areas respectivelly

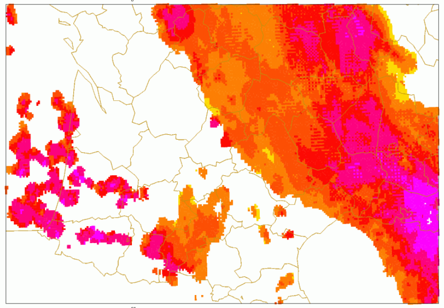
$\overline{\sigma}_b(q)$ $\mathbf{B}_\mathrm{p}$ $\mathbf{B}_\mathrm{np}$



Cross correlations

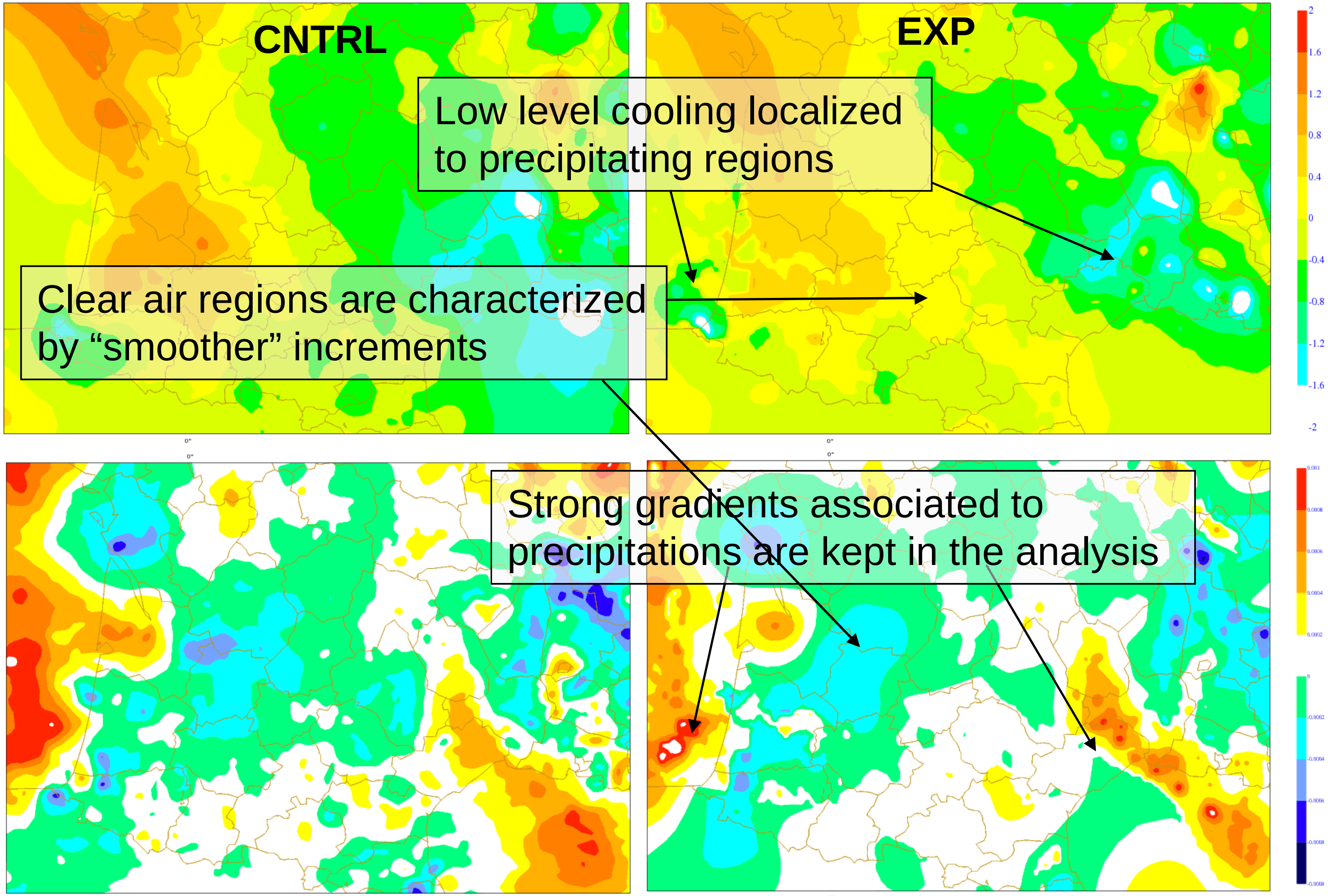
Real case experiment

CNTRL: AROME oper + Reflectivities
EXP: CNTRL using simultaneously (B_p, B_{np})
Mask deduced from observed reflectivities (zoom)

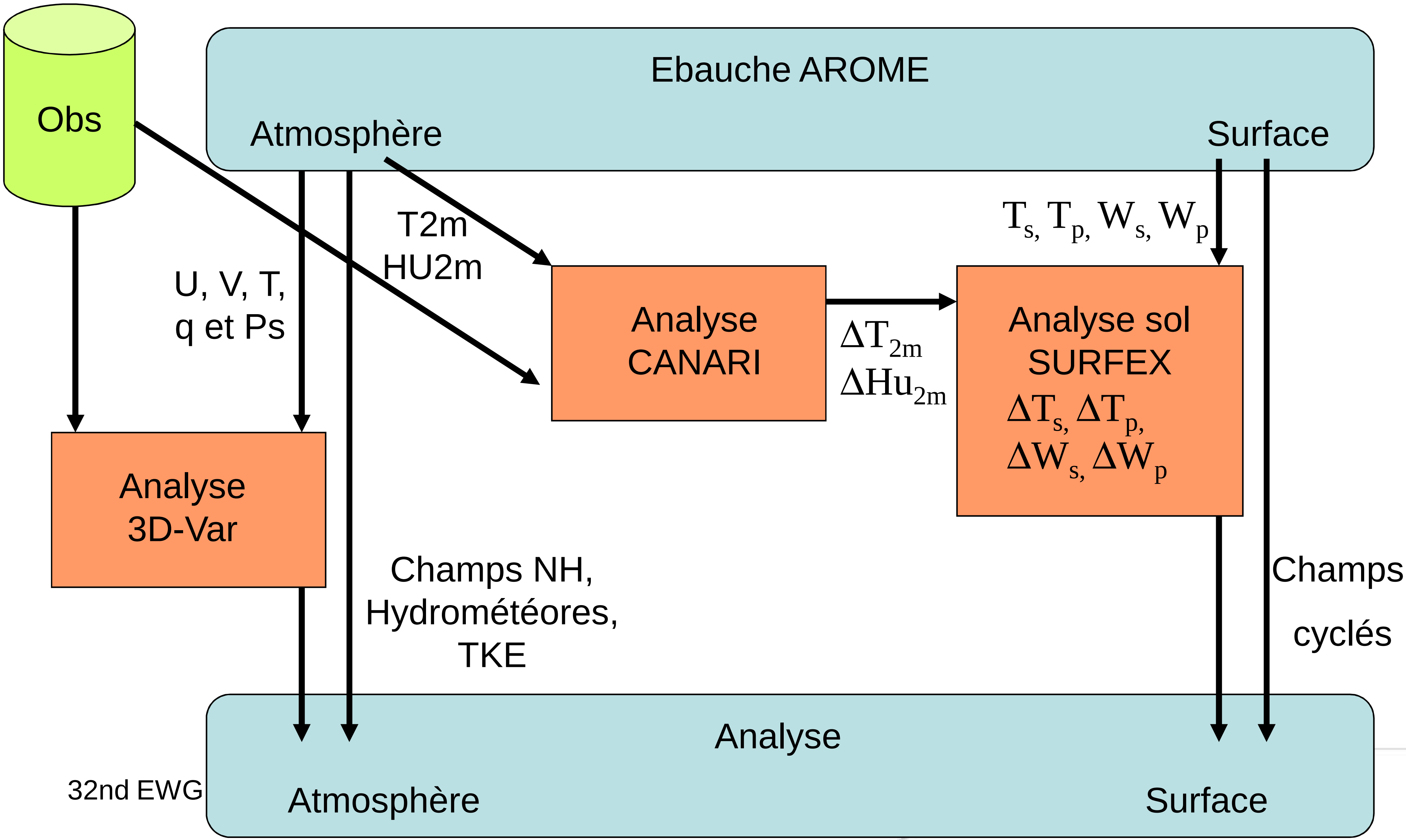


Inc(T)$_{950hPa}$

Inc(q)$_{800hPa}$

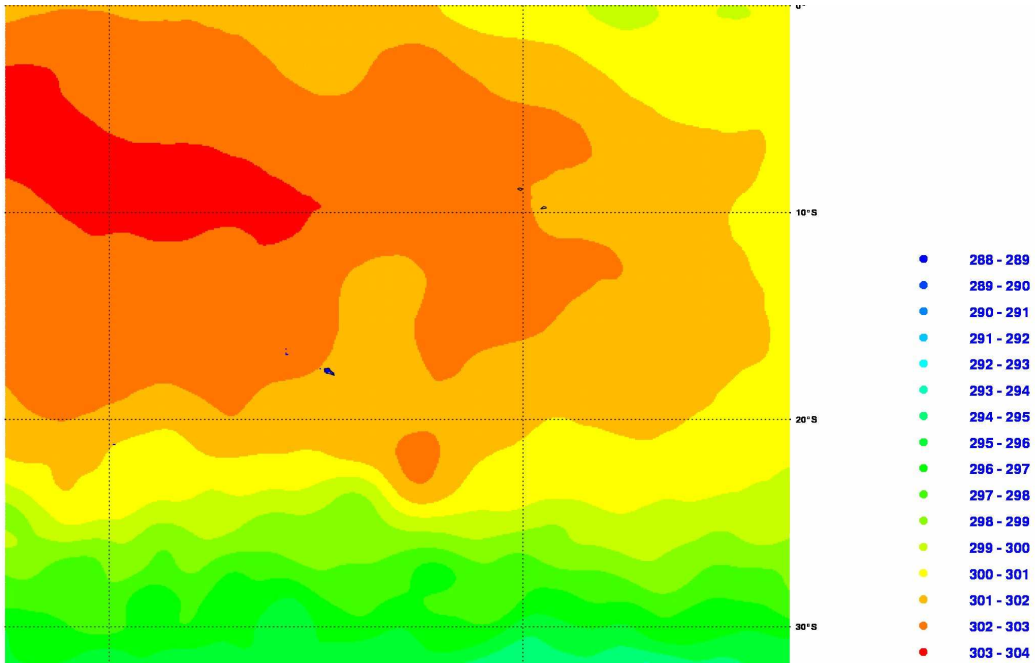


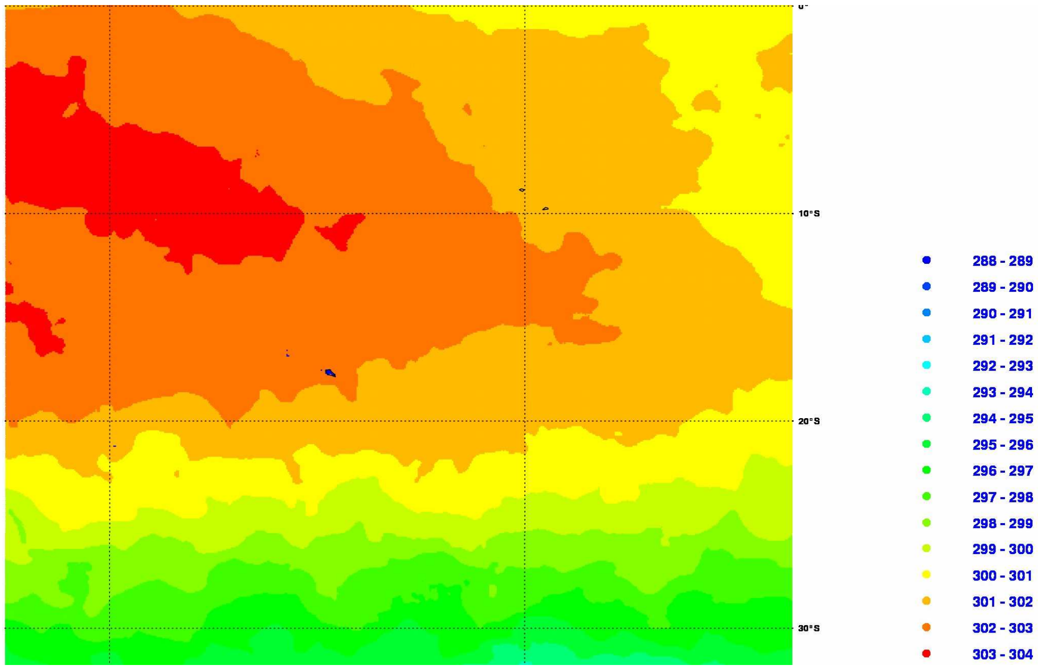
New surface assimilation dataflow



Perspectives – SST OSTIA

SST NESDIS (left) and OSTIA (right) over the domain « Polynésie »





SST for April, 9 2010