



Progress and plans in Arpège 4D-Var and
Arome-France 3D-Var

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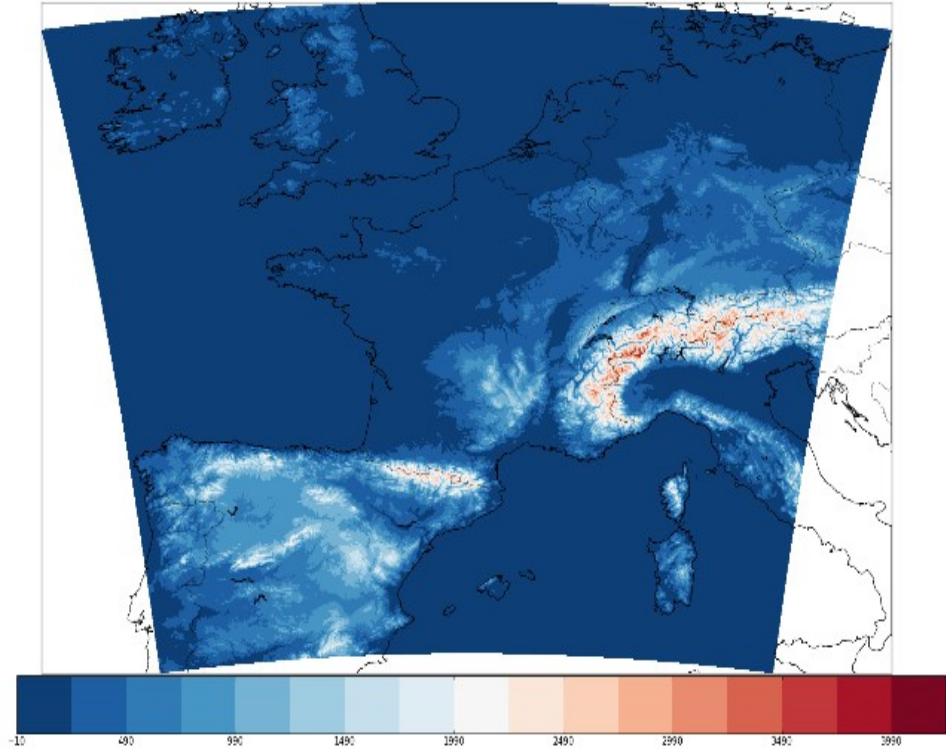
Aladin/Hirlam workshop
13-16 April 2015, Elsinore

Outlines

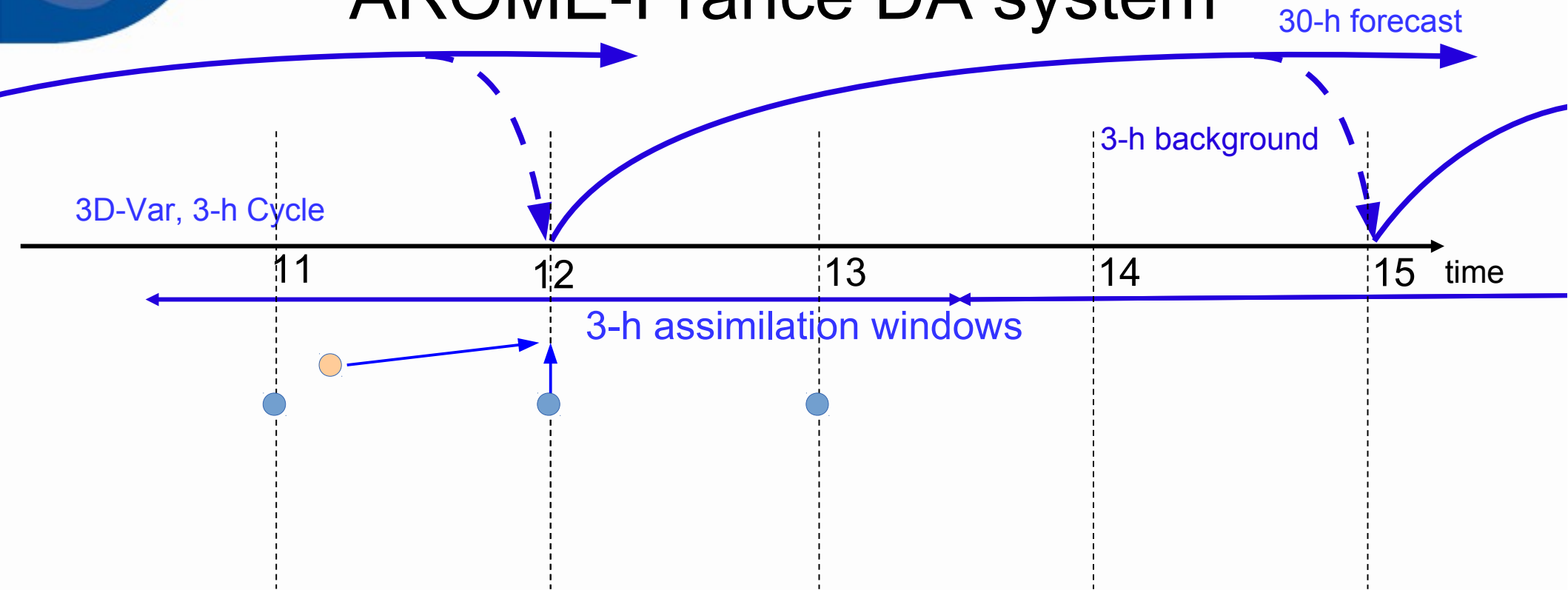
- AROME-France 3D-VAR : 1h cycle
- AROME-NWC system
- ARPEGE 4D-VAR DA system changes
- Plans 2015-2016-and beyond

AROME-France

- Spectral limited area non-hydrostatic model with explicit moist convection, in operations since December 2008.
- Horizontal resolution : 1,3 km
- 90 vertical levels (bottom at ~5m ; top at ~10hPa)
- Coupling files : hourly forecasts from global model ARPEGE
- Initial Conditions : 3D-Var at the model resolution in a 1-h continuous assimilation cycle :
 - U, V, T, q and Ps analyzed
 - hydrometeors, TKE and non-hydrostatic fields copied from the background
 - observations assimilated in the global model ARPEGE + radar observations (Doppler winds and reflectivity) + screen-level measurements (T2m, Hu2m)
 - Climatological B matrix (horizontally homogeneous and isotropic) estimated from an « off-line » AROME ensemble assimilation.

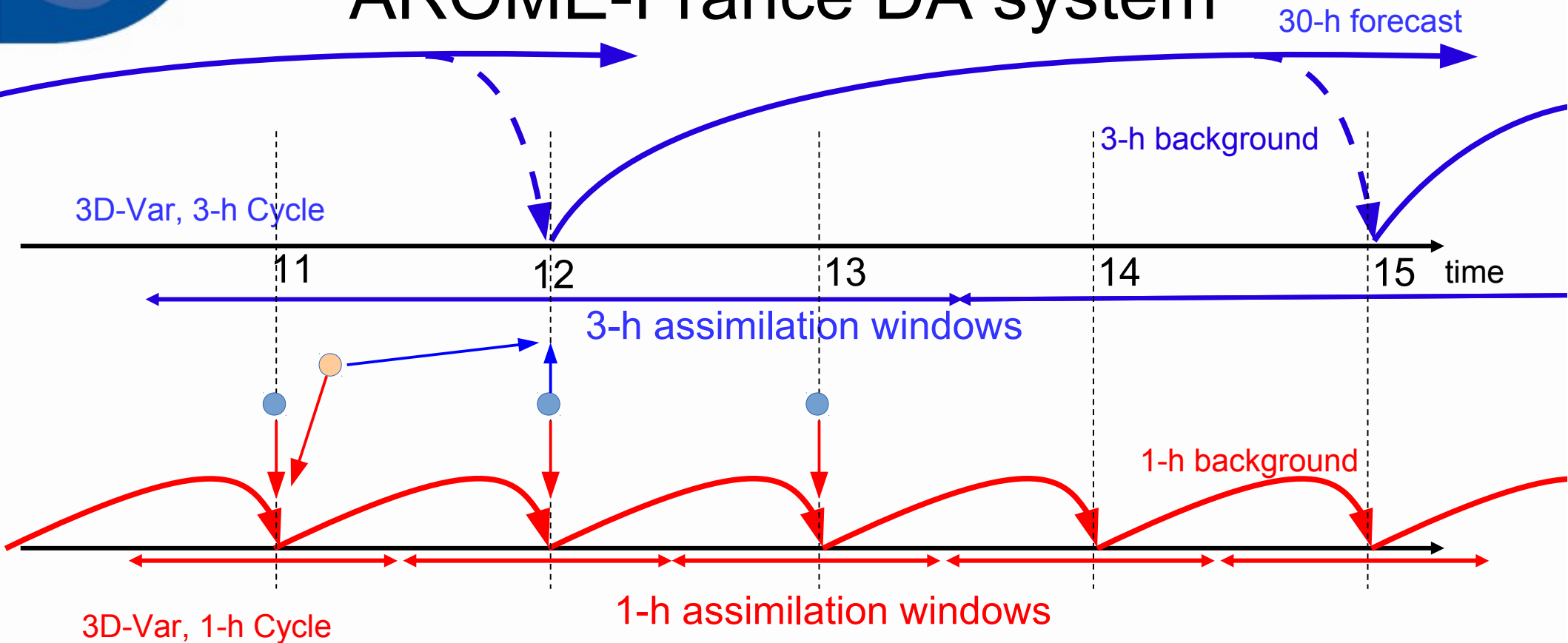


AROME-France DA system



- **3D-Var :**
 - Leads to crude approximations (observations are considered at the analysis time)
 - Observations performed at a high frequency rate at a given location are under-used (only one per assimilation window)
- **Planned evolutions for AROME :**
 - At long term : development of a 4D-EnVar system (as for ARPEGE)

AROME-France DA system



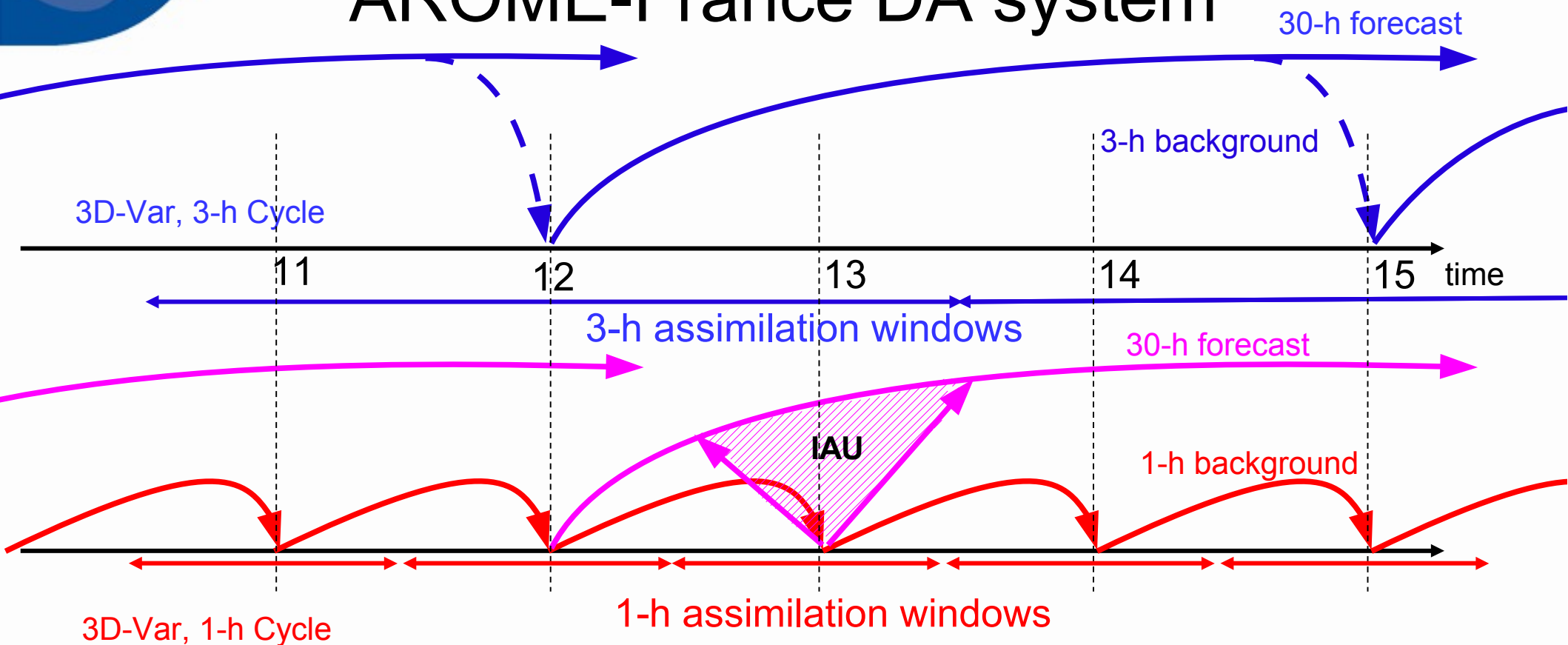
- **3D-Var :**

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- **Planned evolutions for AROME :**

- At long term : development of a 4D-EnVar system (as for ARPEGE)
- April 2015 : use of 3D-Var in a 1-h assimilation cycle

AROME-France DA system



- **Long range forecasts** (up to 30 h) using the analysis valid at H, and wait for the lateral boundary conditions provided by the global model ARPEGE forecast of the same analysis time.
- These forecasts are also able to benefit from the **analysed information at H+1** using the Incremental Analysis Update (IAU)
- IAU is not used for its filtering properties in the assimilation cycle

AROME Nowcasting (AROME-NWC)

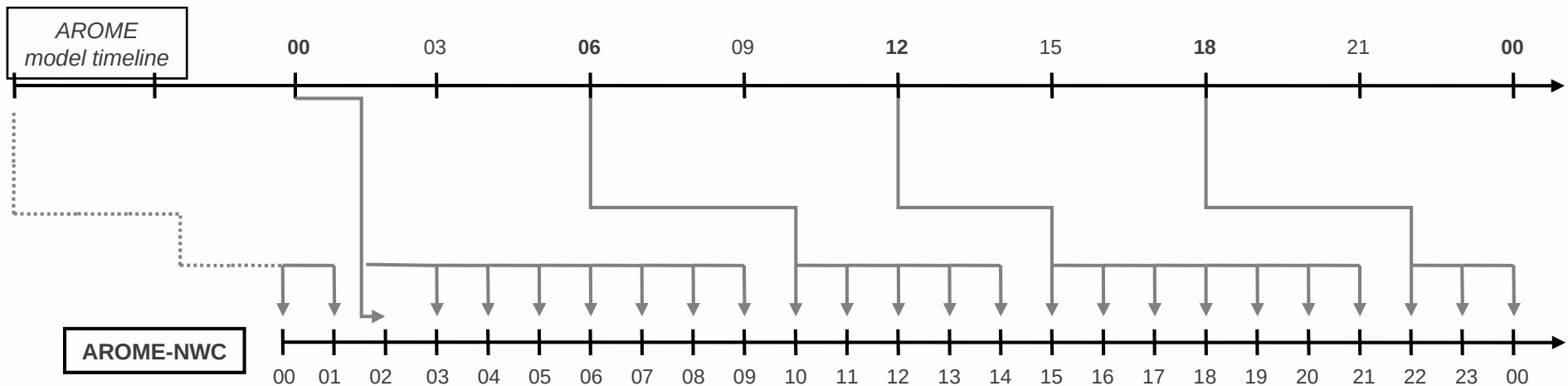
- **For nowcasting purposes, the AROME-NWC configuration performs an hourly analysis used to initialize short-term forecast (6-h) using**
 - the most recent available AROME-France forecast as first guess file :
 - A very short cut-off time : 15 minutes
- **AROME-NWC provides a very recent representation of the atmosphere at a given time. Its short forecast range enables NWC products to be available very quickly after the observation time, as required for nowcasting purposes.**
- **More information : see French poster**

Hourly AROME-NWC

The AROME nowcasting configuration (AROME-NWC) performs an hourly short-term forecast starting from an AROME-FRANCE first guess file (less spin-up compared to a cycled configuration).

It can be seen as a production cycle of the AROME-FRANCE assimilation cycle, for nowcasting purposes.

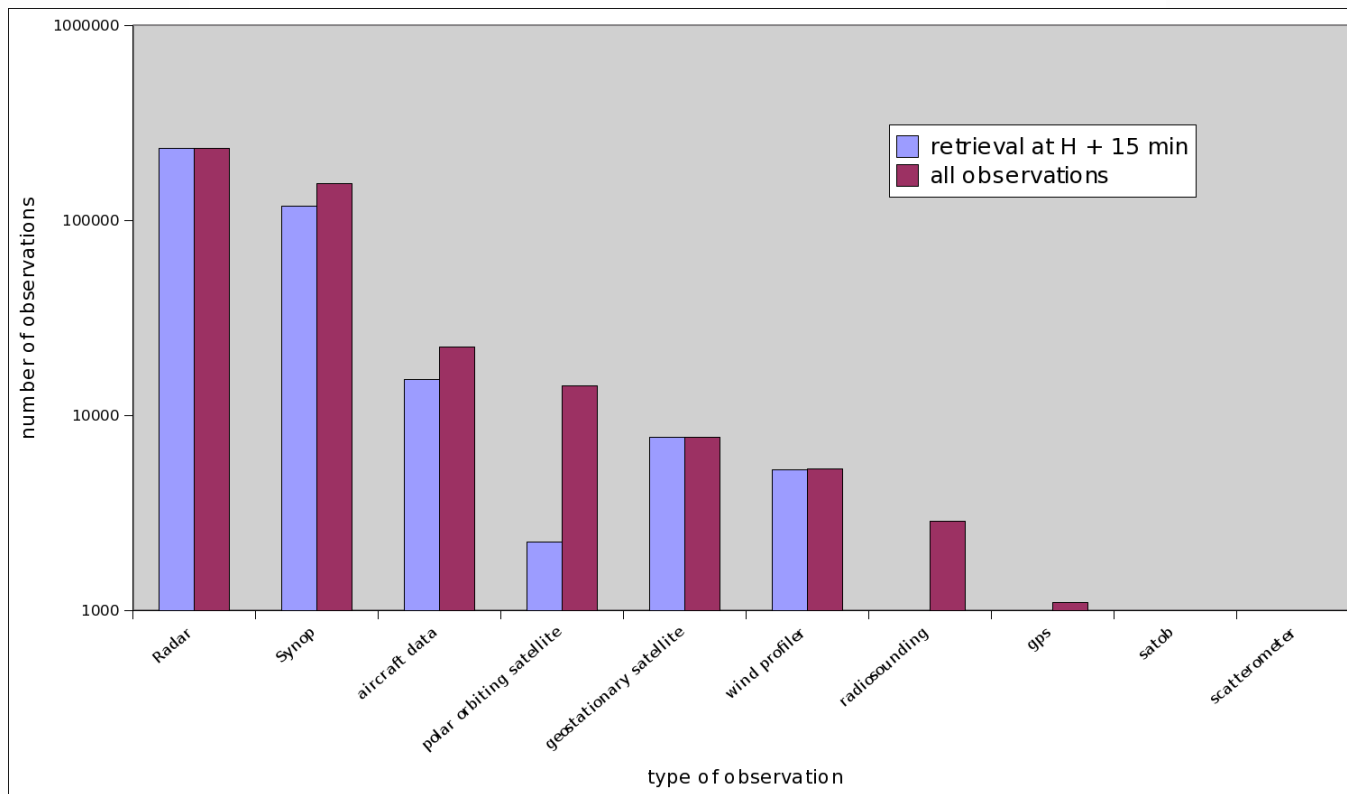
Same settings as AROME-FRANCE, shorter cut-off (15 minutes).



AROME-NWC configuration

Loss of observations due to short cut-off

- Due to the short cut-off time of nowcasting systems (~ 15 min), some observations are missing.



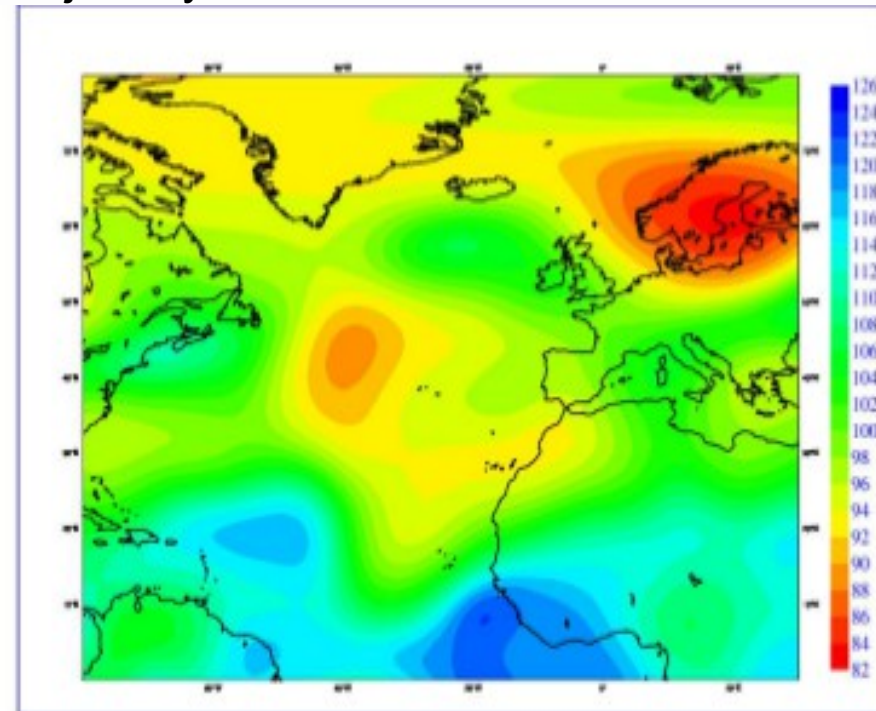
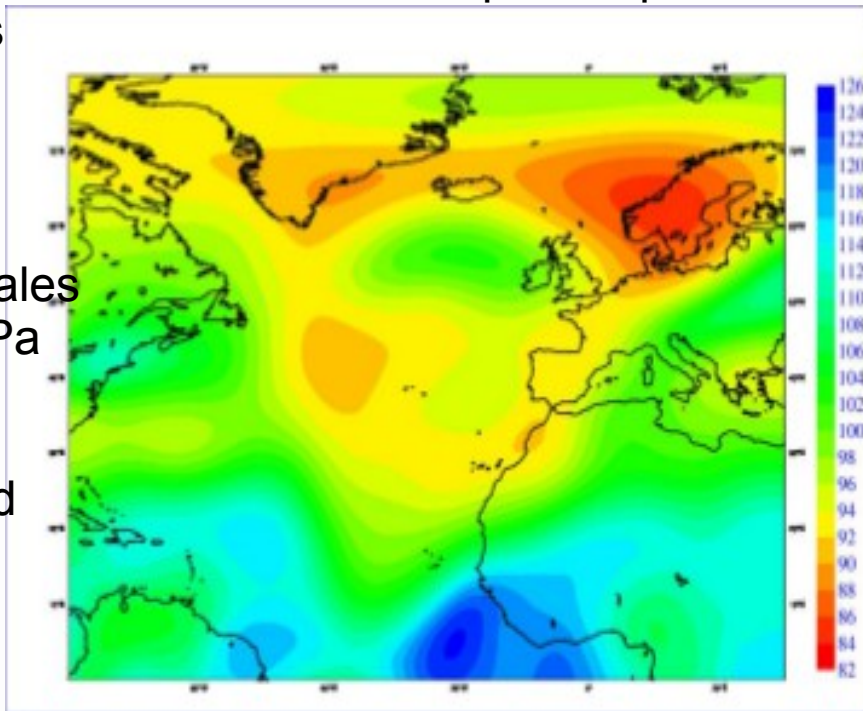
Difference in term of number of observations inside the assimilation system with a 15 minutes cutoff and no cutoff

- In spite of this loss of observations, a 15 minutes cut off seems to be fully acceptable
- Some of the missing observations, radiances, radisoundings and GPS, might actually be more useful for the performances of long-term forecasts, than for nowcasting purposes.

ARPEGE 4D-VAR

- TL1198C2.2L105
- 4D-VAR increments : TL149C1.0 / TL399C1.0
- 40 iterations in each inner loop (2)
- Linear balances switched off in stratosphere
- Jc-DFI applied only on Divergence and Psurf
- AEARP : 25 members ; TL479C1.0 ; TL149C1.0 in 4D-VARs
- 30 mn time slots
- Revised use of VarBC : compute departures for each trajectory and re-enter coeffs in outer loops

Lengthscales
Of 300 hPa
Wind for
15/11/13,
6UTC and
12 UTC

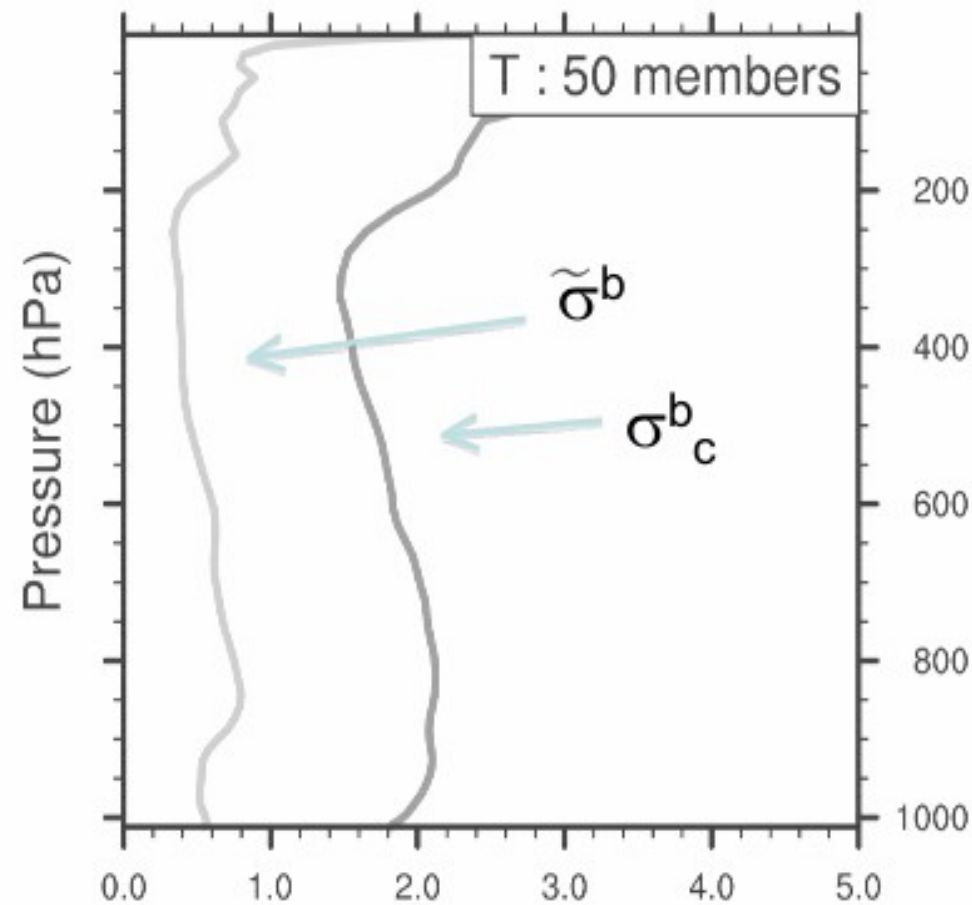


Perspectives : R&D efforts in LAM DA

- Ensemble variational data assimilation (EnVar) for Arpège and Arome, following a formulation proposed by Desroziers et al. (QJRMS, 2014)
- MF have stopped efforts for implementing EDA information inside the present LAM 3D-Var algorithm (e.g. gridpoint maps of σ_b)
- Arome EPS operational system : 2.5km, L90, 12 members, up to +48h fct range, planned for operations in 2016 (see *French poster*)
- A research trial version of LAM 4D-Var for Arome built up by P. Brousseau (collaboration with M. Lindskog)

Ensemble spread

$$\tilde{\mathbf{B}} = \frac{1}{L-1} \sum_{p=1}^L \left(\tilde{\mathbf{x}}_p^b - \langle \tilde{\mathbf{x}}^b \rangle \right) \left(\tilde{\mathbf{x}}_p^b - \langle \tilde{\mathbf{x}}^b \rangle \right)^T$$



Horizontally averaged background error standard deviations for Temperature

\mathbf{B}_c has been calibrated using a mix of summer convective and winter cases (Brousseau et al. 2011), whereas here $\tilde{\mathbf{B}}$ is computed for a winter case

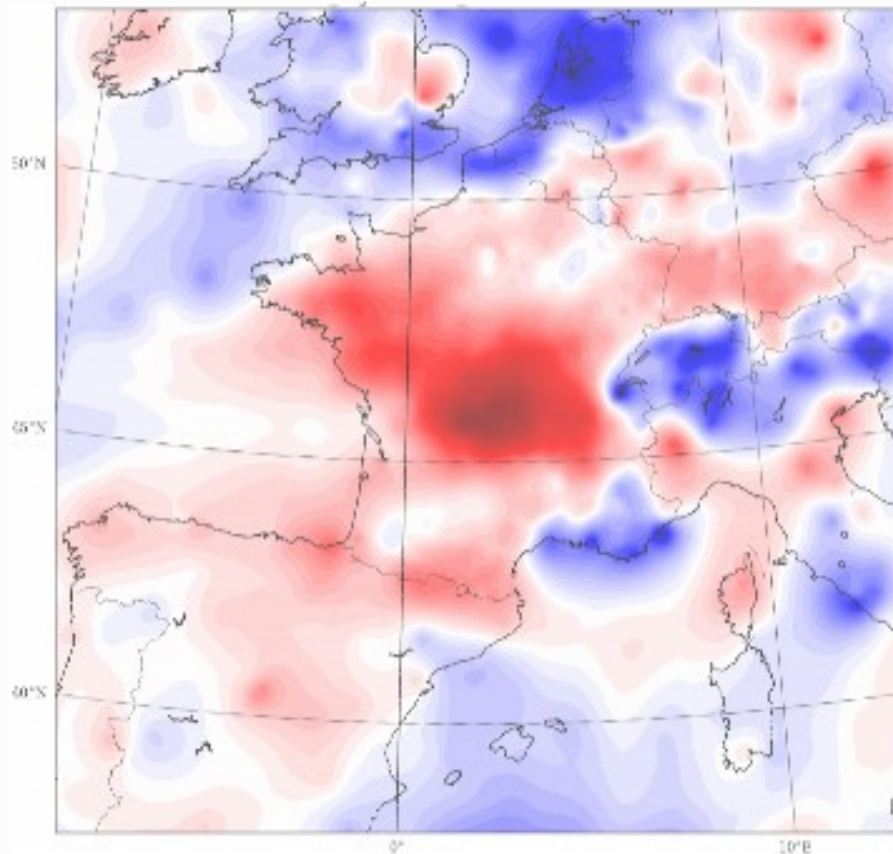
⇒ Less dispersion in $\tilde{\mathbf{B}}$

⇒ An inflation of 2 is applied to each perturbations

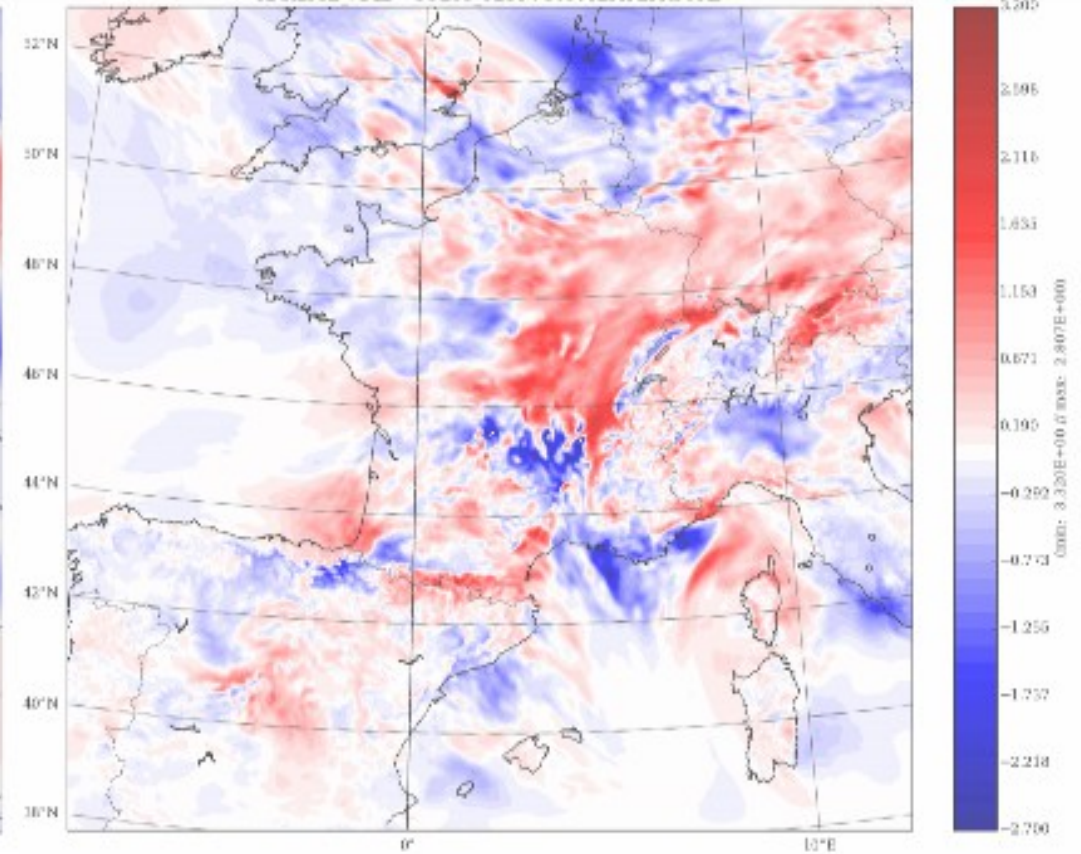
Impact on analyses

With conventional observations

3DVar



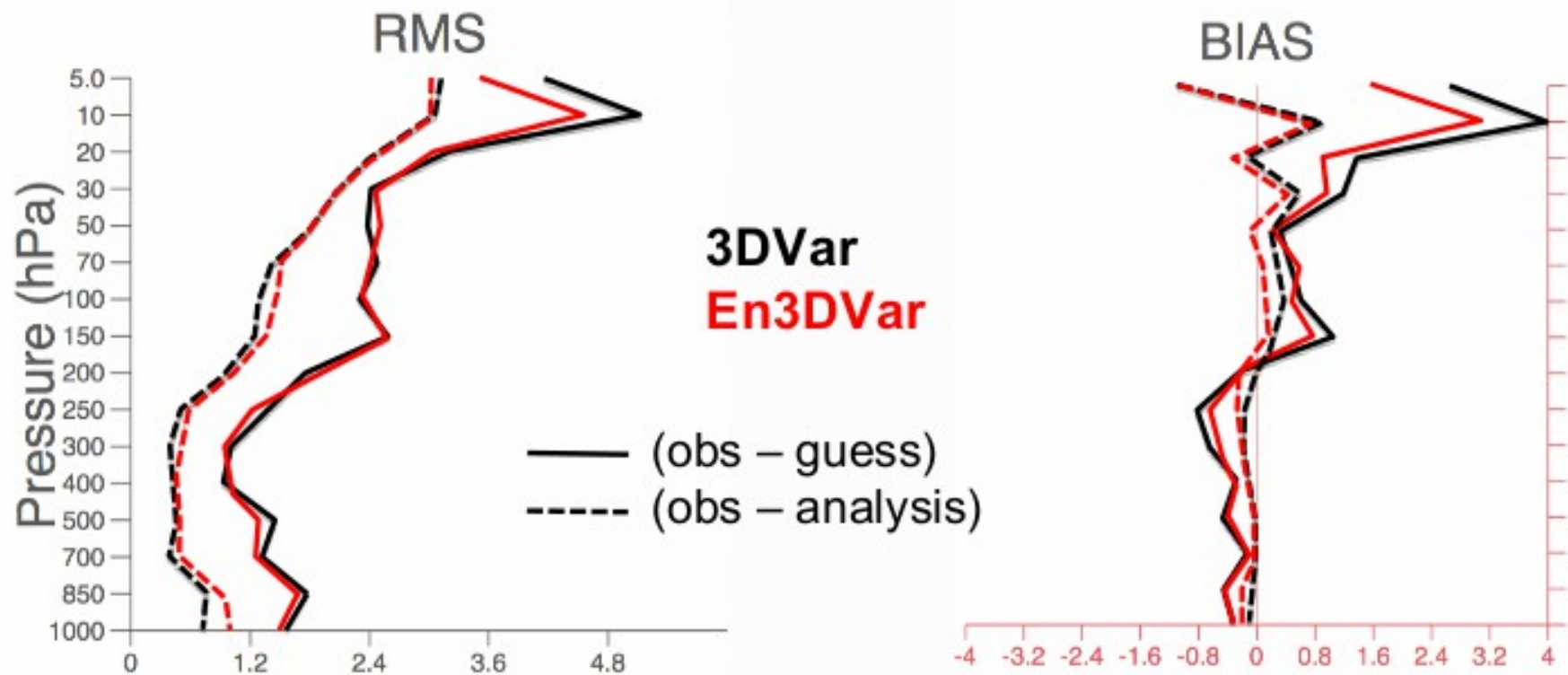
En3DVar



Horizontal cross-sections of T increments at 850 hPa

Impact on forecast

Scores against rawinsondes averaged over 5 assimilation times for Temperature



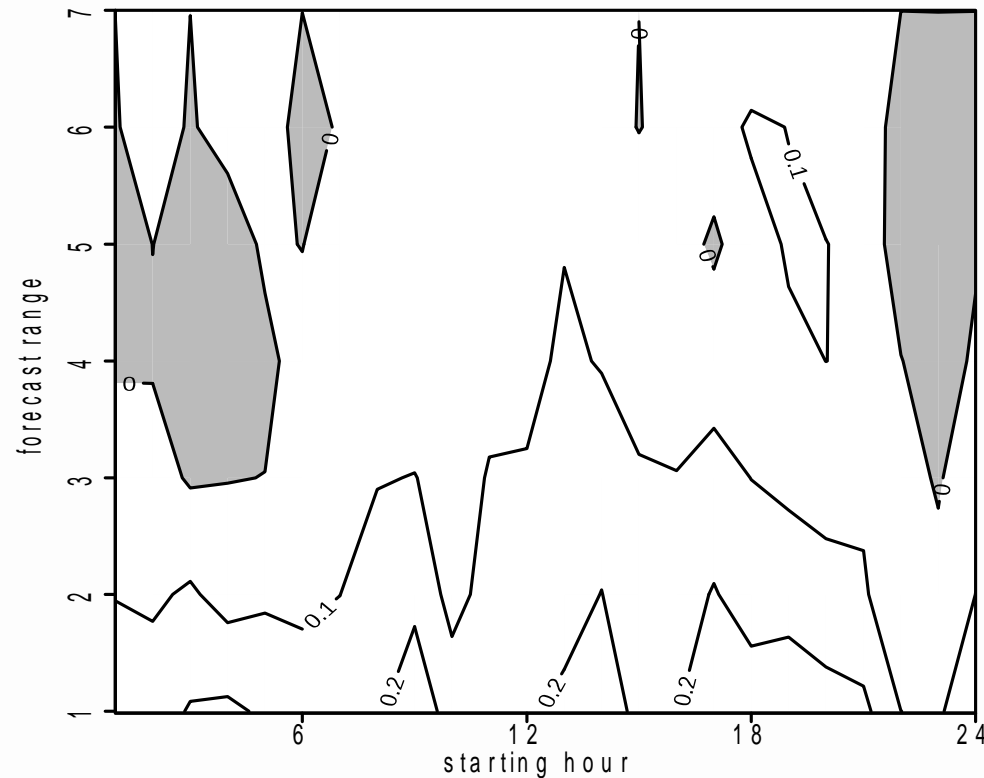
- ⇒ For T, improvements of (o-g) RMS values for almost all levels, reduction of the 3-h forecast bias above the tropopause
- ⇒ Overall, scores are neutral to slightly positive for 3h forecasts

Conclusions, perspectives

- ARPEGE : new observations (CY41T1, see *JFM's talk*), next changes otherwise more devoted to model (convection scheme, turbulence/mixing scheme, SURFEX)
- AROME operational DA : obs following ARPEGE changes (see *JFM's talk*), X-band radar, dual-polarized Doppler radar information (research at GMME)
- Exchange of *raw* radar volume data via OPERA : MF already send data to the OPERA hub, and invite other NMS to do so asap
- AROME : En3/4Dvar from the OOPS layer => localization, all observation types, optimization features, 4D features, filtering of covariances. See talks by T. Montmerle and Y. Michel at the ISDA (Feb 2015, Kobe, Japan) at <http://data-assimilation.jp/isda2015/program/program.php>

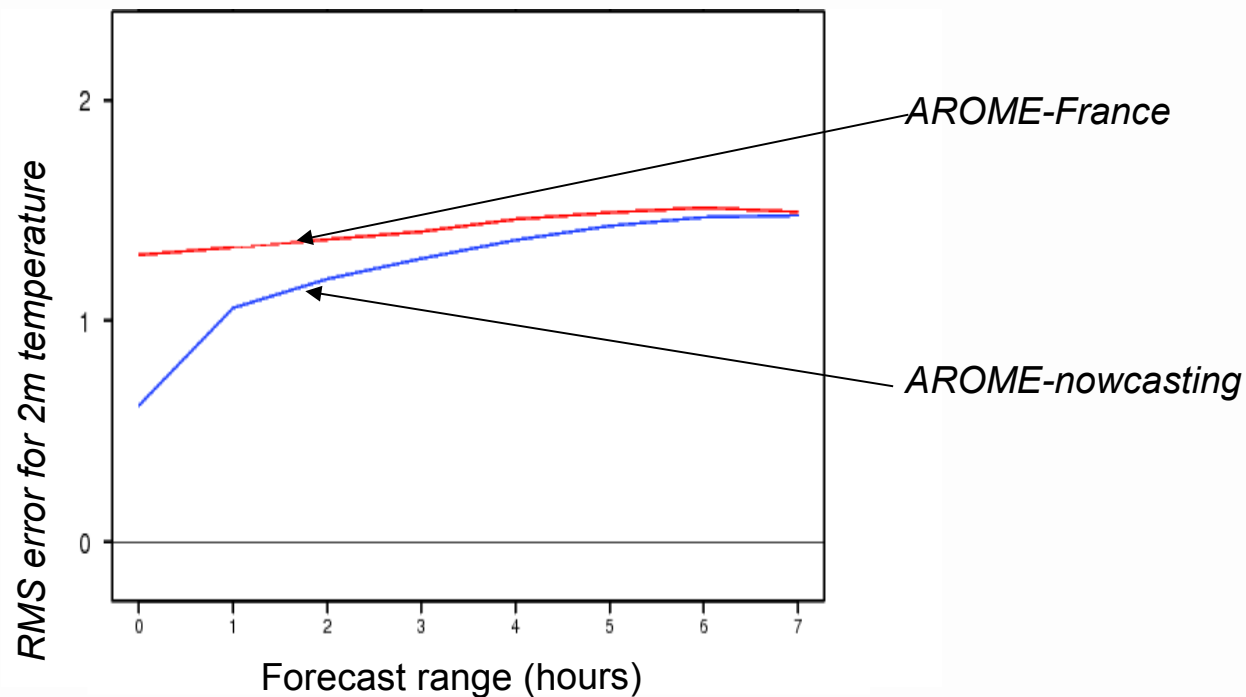
Hourly AROME-NWC

- Scores are better when compared to the AROME-FRANCE forecast available at the same time



Brier Skill Score (sum over various rain thresholds) as a function of the starting hour and the forecast range.

Arome-Nowcasting summary of the results



**Comparaison AROME-France AROME-nowcasting
for 2m temperature**

- The scores are better for most of the parameters.
- Surface pressure is worse in the first 3 hours of fct, then it is better, than for the nominal Aro-Fra system. This illustrates the impact of spin-up.
- After 3 hours, the improvement is weak.
- **Important : the improvement is mostly due to the rapid analysis cycle that “refreshes” AROME with more recent observations.**