Modification of a meso-scale model for nowcasting purposes : the AROME-nowcasting and AROME-airport projects.

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METEO-FRANCE

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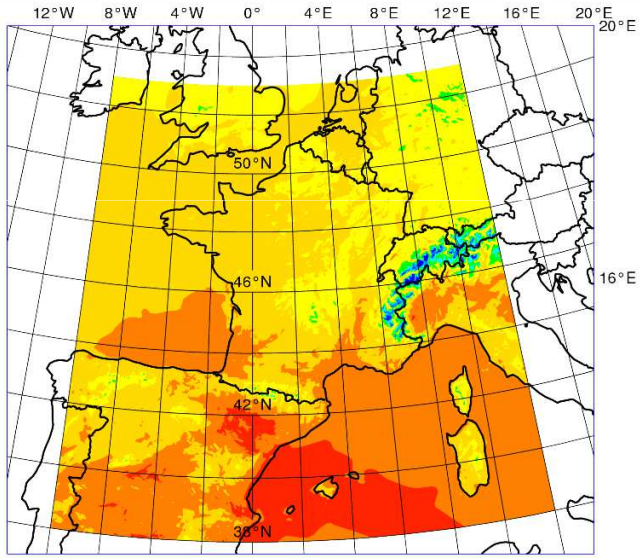
Outlines

1. Introduction
2. Numerical models for nowcasting challenges
3. Arome nowcasting
4. Arome airport

Introduction (1/3) : Mesoscale Forecasting

- For the past 10 years, lots of meteorological centres developed mesoscale weather models (with gridsizes at kilometric scale).
- Meteo-France developed the AROME model with the goal to better forecast heavy convection systems without the requirement of deep convection parameterization.
- Current configuration : horizontal resolution 2.5 km, 60 levels on the vertical, first level at 10m, 3dvar data assimilation with a 3-hours cycle, microphysical scheme with 4 distinct water species.
- These types of models definitely outperform convection-parameterized-type models (although the latter are not far behind !) and proved to model more realistically meteorological features (even if not always at the good position ☹)
- Lots of AROME model characteristics were derived from our global model (data assimilation for example) and had to be adapted to convective scale.



The AROME-France domain

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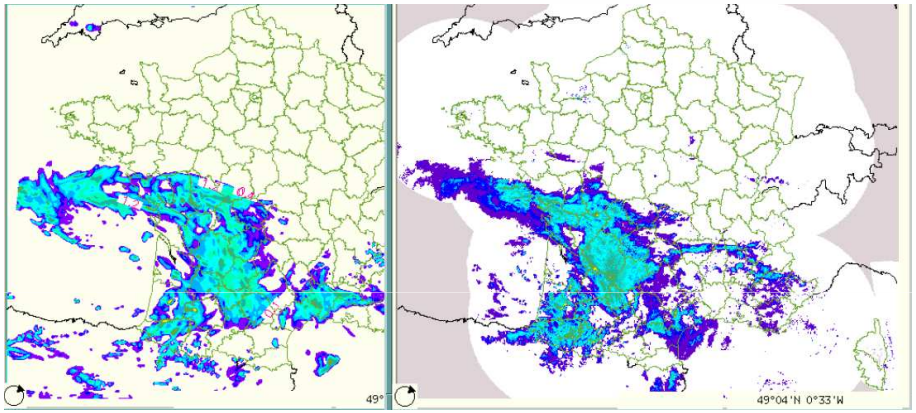
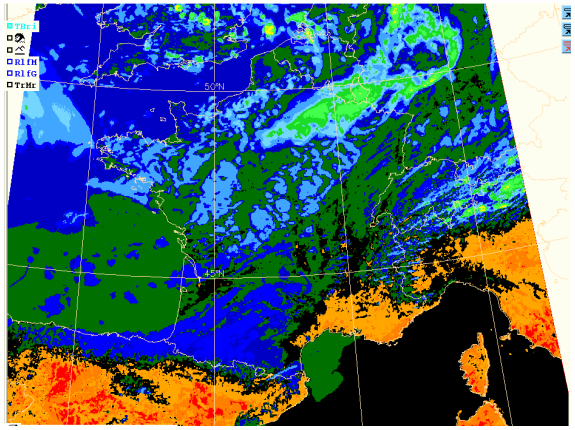
Introduction (2/3) : Today Mesoscale models

- Operational mesoscale models were designed to provide forecasts at time ranges beyond nowcasting (1~2 days, early morning for the afternoon).
- But judging by the reality of some forecasted fields there is a huge potential to use those fields for nowcasting purposes.

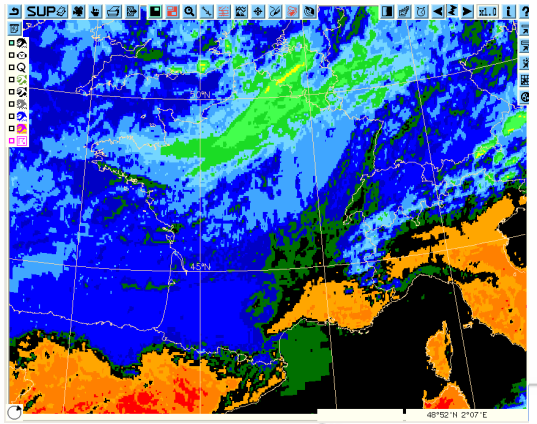


12h00 Forecasted radar reflectivites

Observed radar reflectivites



Forecasted IR radiances



Observed IR radiances

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Introduction (3/3) : numerical models for nowcasting

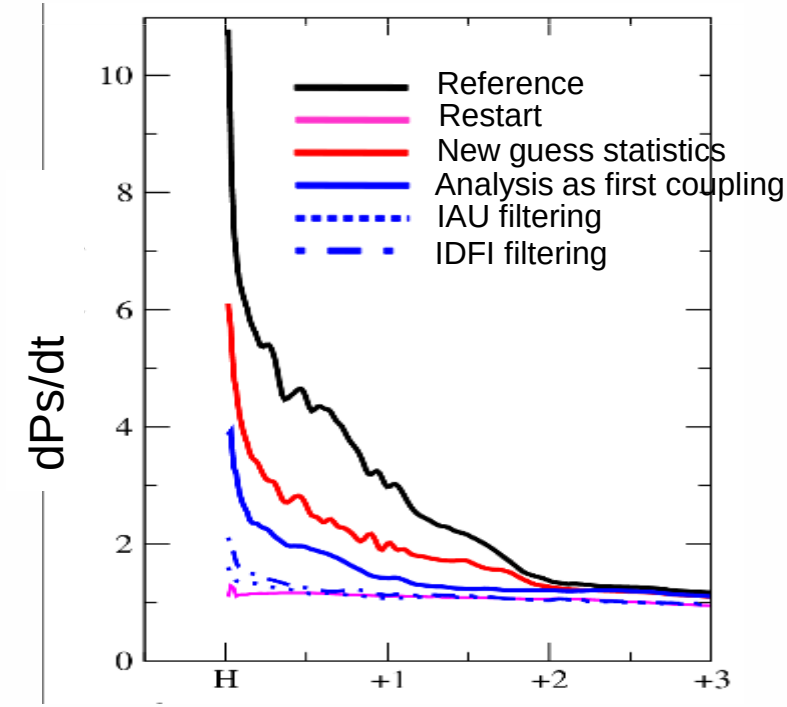
- There is an obvious potential for nowcasting with such refined models.
- A way to transform AROME forecast model into a nowcasting model is to perform more frequent forecasts with the use of more recent observations.

  ⇨ Arome nowcasting project
- Requirements of such a system :
  - Short delivery time (< 30 min) due to the short time-range of nowcasting (up to 6 hours)
  - Must cover a sufficiently large domain, since one of our client is aeronautic, we must cover one entire flight region
  - High density observations assimilation capacities
- Consequences :
  - Very short cut off : some observations might not have the time to reach our observation database system.
  - Asynchronous coupling technique must be used.
  - Configuration file comes from older forecasts.
- Some challenges for numerical models and nowcasting
  - Spin up issues
  - Specific data assimilation settings
  - Coupling strategies

2. Numerical models for nowcasting challenges

Spin up issues

- Spin-up encompass all the wrong behaviour of numerical models during the first timesteps.
- Becomes a problem for very short range forecasts.
- Can be diagnosed through surface pressure oscillations, in that case spin-up is the production of gravity waves due to the imbalance of initial files.
- Fast production of hydrometeors during the first timesteps is also another a kind of spin-up, in that case, the imbalance is linked to the different hydrometeors at the origin and in the borders. This type of issue can be diagnosed by spurious heavy rains during the first timesteps or wrong precipitation patterns next to the coupling zone.



Spinup as a function of time for different model configurations

We can observe that there is different ways of reducing dynamical spinup :

•Better guess statistics

•Analysis used as first coupling file

•Digital filtering techniques (IDFI or IAU)

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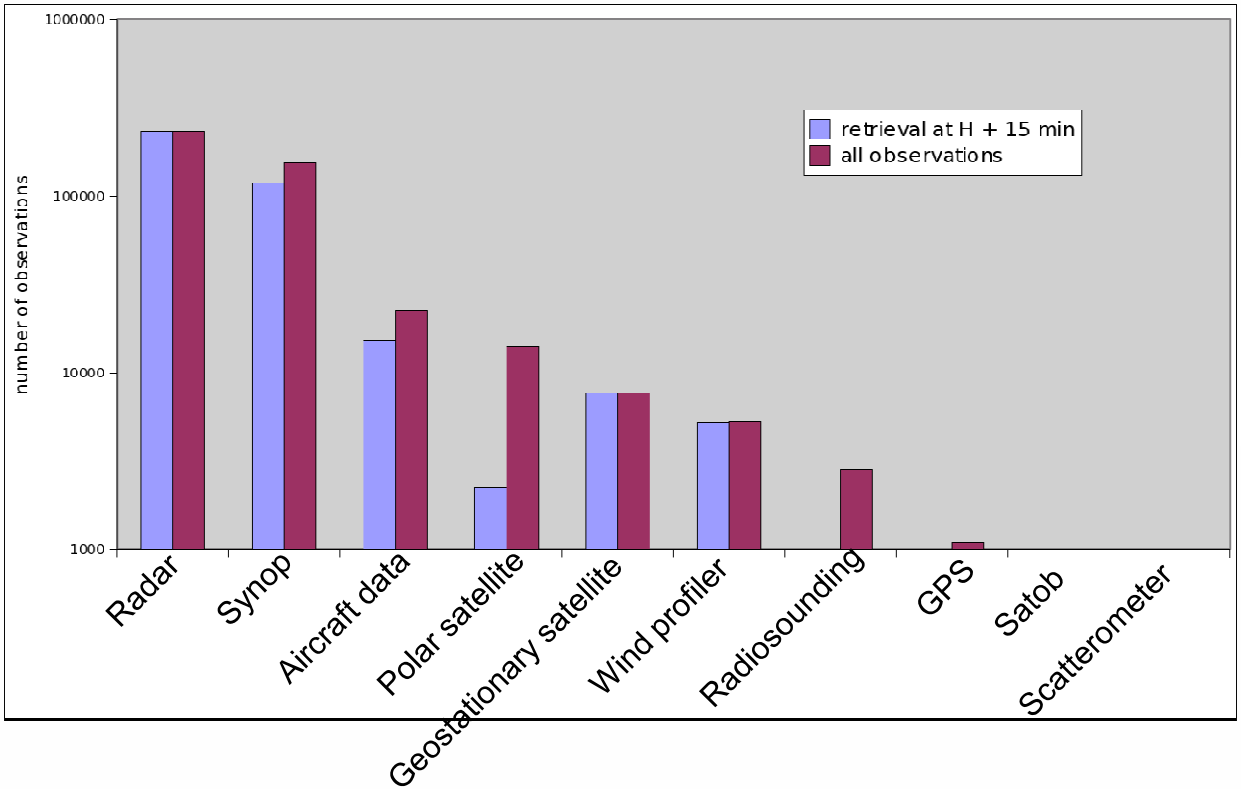
Loss of observations due to short cut off

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



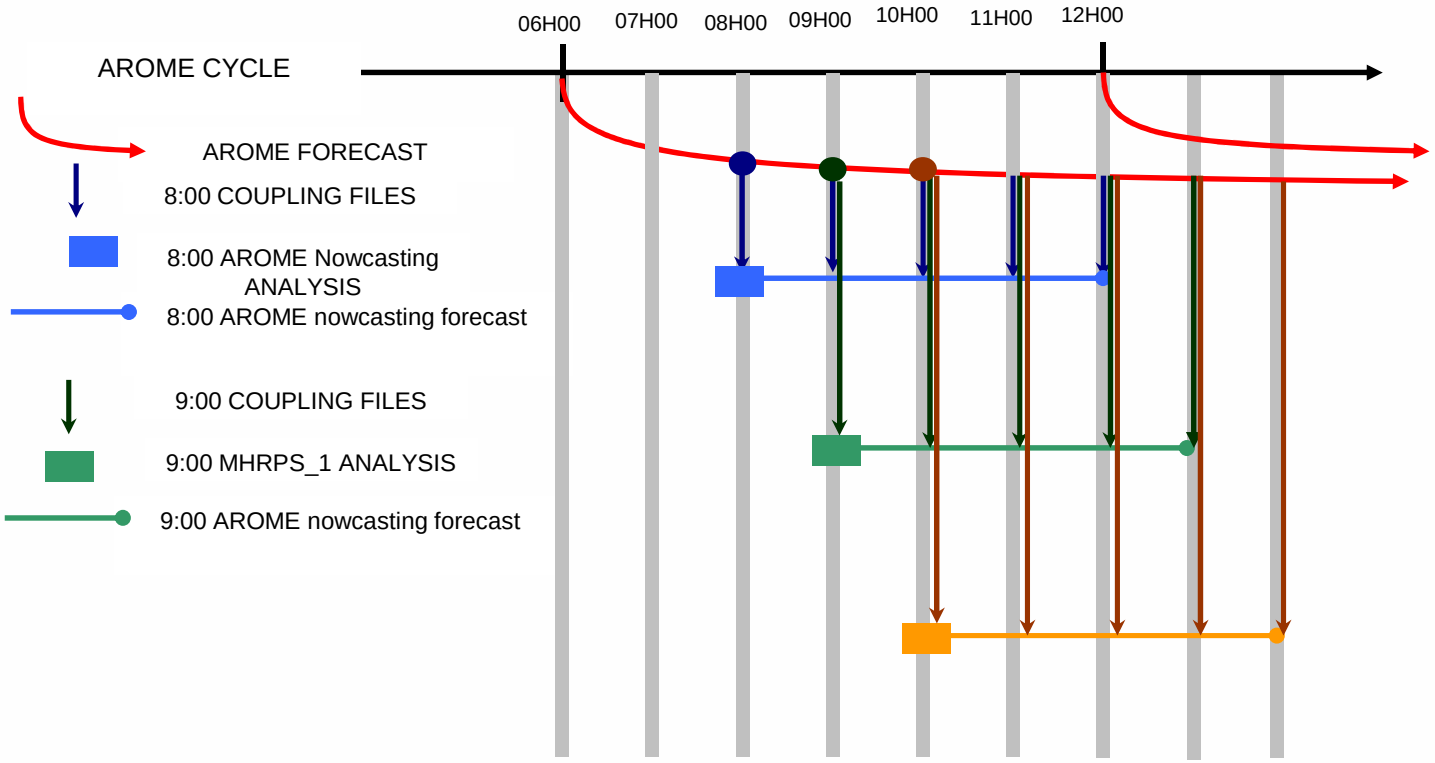
Difference in term of number of observations inside the assimilation
system with a 15 minutes cutoff
and no cutoff

- In spite of this observations loss a 15 minutes cut off seems to be fully acceptable
- Possibly some of the missing radiances radisoundings and GPS are more useful for long-term runs than for nowcasting purposes.

3. Arome Nowcasting

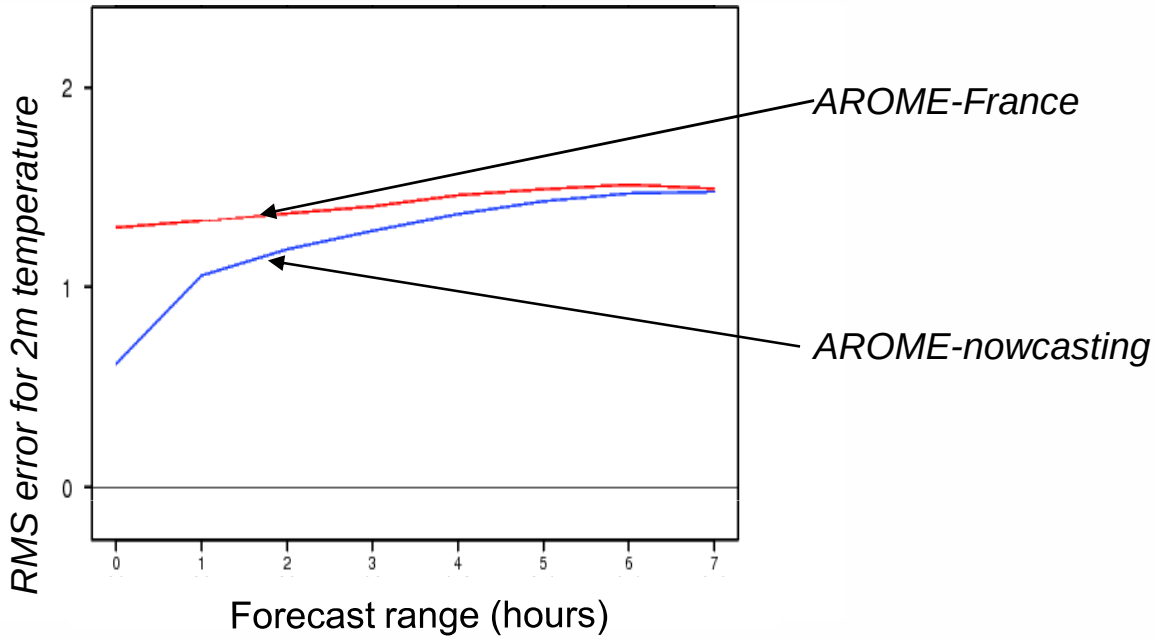
AROME-Nowcasting

AROME-nowcasting simplified diagram



- Boundary conditions are re-computed every hour from our AROME-France model.
- No cycling so far.
- No specific surface data assimilation, the initial conditions have to be taken from our AROME-France model once a day, and are cycled from previous forecast otherwise.

Arome-Nowcasting summary of the results

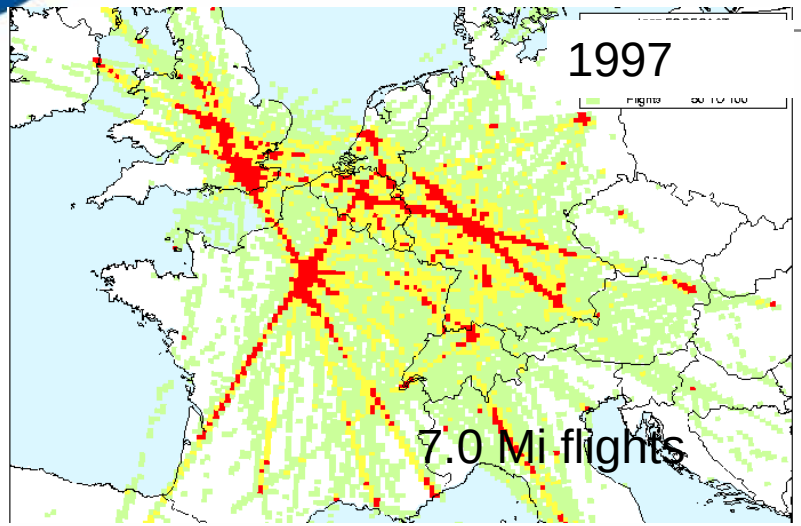


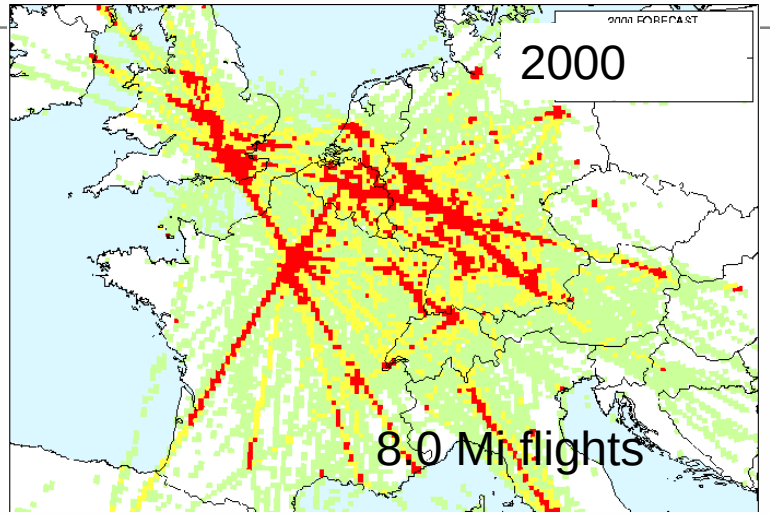
Comparaison AROME-France AROME-nowcasting for 2m temperature

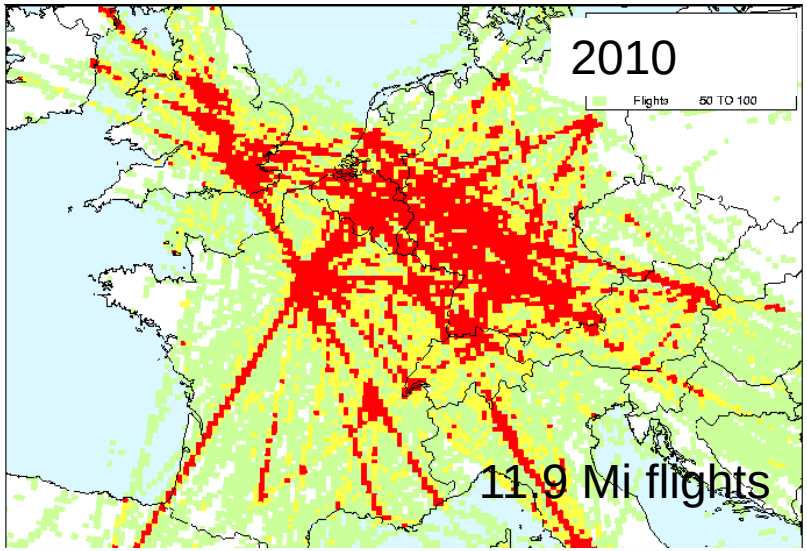
- The scores are better for most of the parameters.
- Surface pressure is worse in the 3 first hours of run, then is better, this illustrates the spin-up impact.
- After 3 hours the improvement is weak.

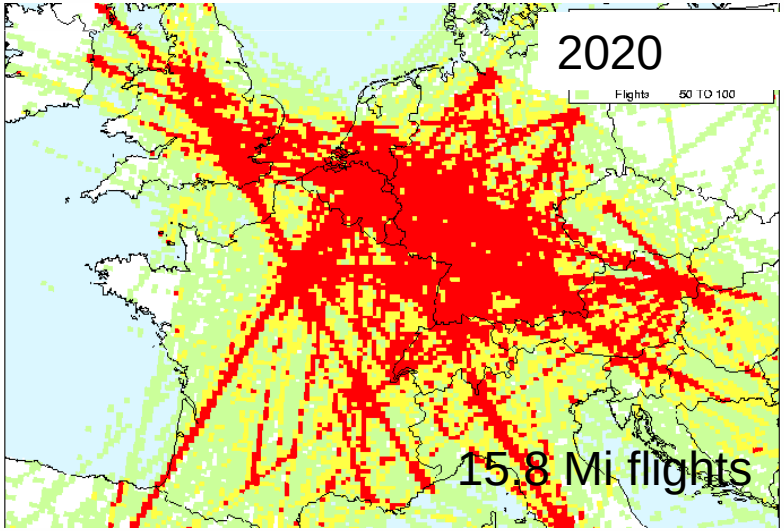
4. Arome-airport

Motivation









- Huge increase in air traffic, the idea is to reduce the delay between two take off and landing.

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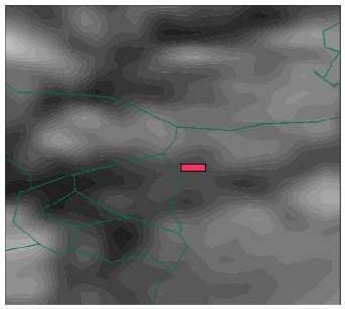
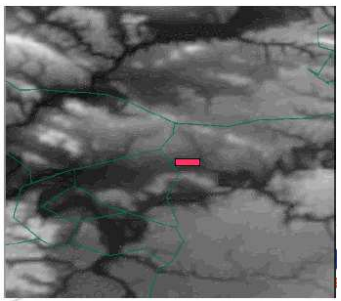
AROME airport configuration

- Part of a R&D project on Wake-Vortex prediction systems as part of the SESAR program (Single European Sky Air traffic management Research).
- The goal is to provide relevant parameters for Wake-Vortex prediction : temperature, humidity, wind but also Kinetic energy related parameters : Turbulent Kinetic Energy and Eddy Dissipation Rate.
- Typical nowcasting issue, we have to provide relevant parameters for a specific goal, people from air traffic management want “the best data available”.
- We plan to design an hectometric-scale model (0.5 km horizontal resolution), with a refresh analysis every hour up to 6 hours. It is an adaptation of the AROME-nowcasting configuration.

Wake Vortex after take off



Oragraphy at 2.5 km



Orography at 0.5 km

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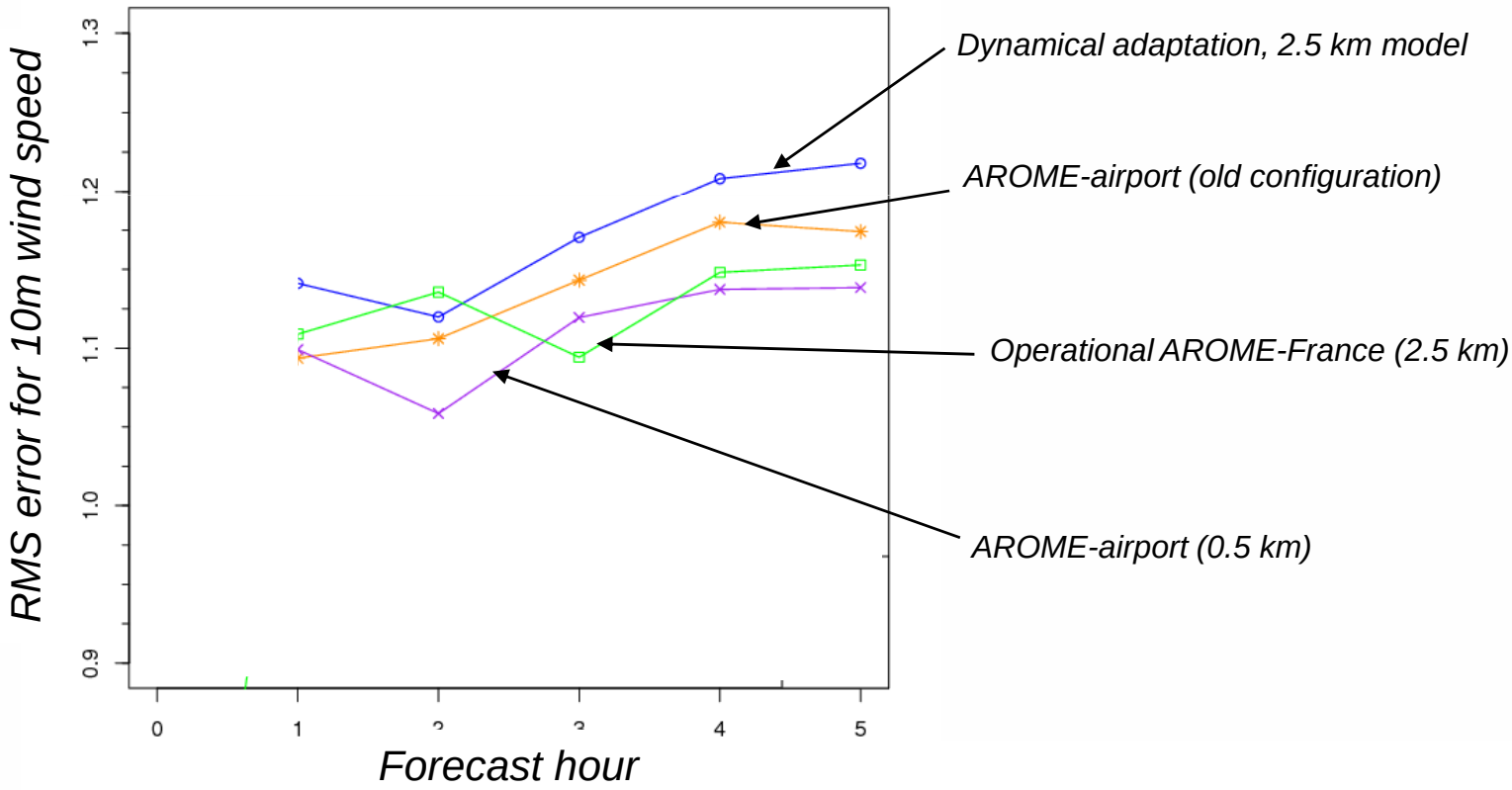
AROME airport configuration

- Justification of the 500m horizontal fine resolution : we hope with such a resolution to resolve explicitly a bigger part of the boundary layer kinetic energy, but we are limited by the computational cost.
- We still use a shallow convection scheme for parameterization of subgrid boundary layer movements.

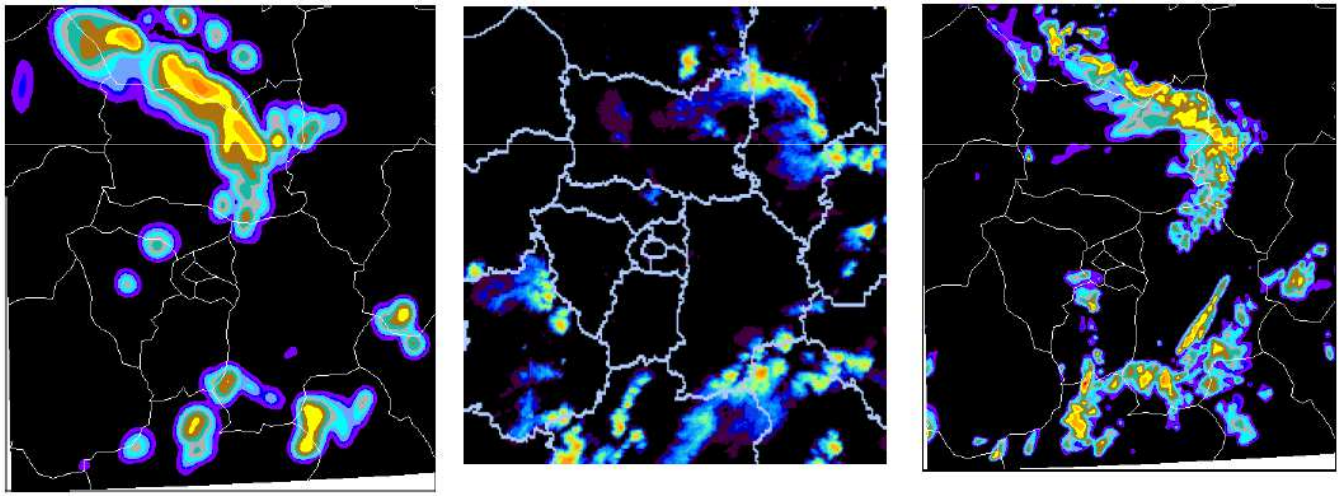
10m wind score for 3 weeks runs



- The AROME airport model increases wind forecast skill during the first two hours

AROME-airport configuration

- Deep convection representation can also be improved at 0.5 km resolution.
- Not only is the representation of convection closer to reality, but the timing of the event can also be much more realistic.



2.5 km model | Radar reflectivites | 0.5 km model

Simulated reflectivites from 6 hours forecasts at 2.5km (left), 0.5km (right). Radar reflectivities for the 05 june 2011, 18H00 UTC (center).

Conclusion

- Today mesoscale models are developed enough to provide useful forecasts to nowcasting systems.
- We developed in that spirit a mesoscale nowcasting model, with forecast every hour.
- The first version does not cycle its own one-hour forecast, but we might change that in the future.
- It was shown that due to the use of more recent observations in this system, we significantly increased forecast performance compared to our operational forecast system.
- AROME-airport is another product derived from our AROME-nowcasting configuration, it is meant to provide forecasts around a dedicated airport with a 0.5 km gridsize model. One goal is to feed a Wake-Vortex forecast model. It was shown that this configuration improved wind forecast inside the boundary layer.

Thank you for your attention !

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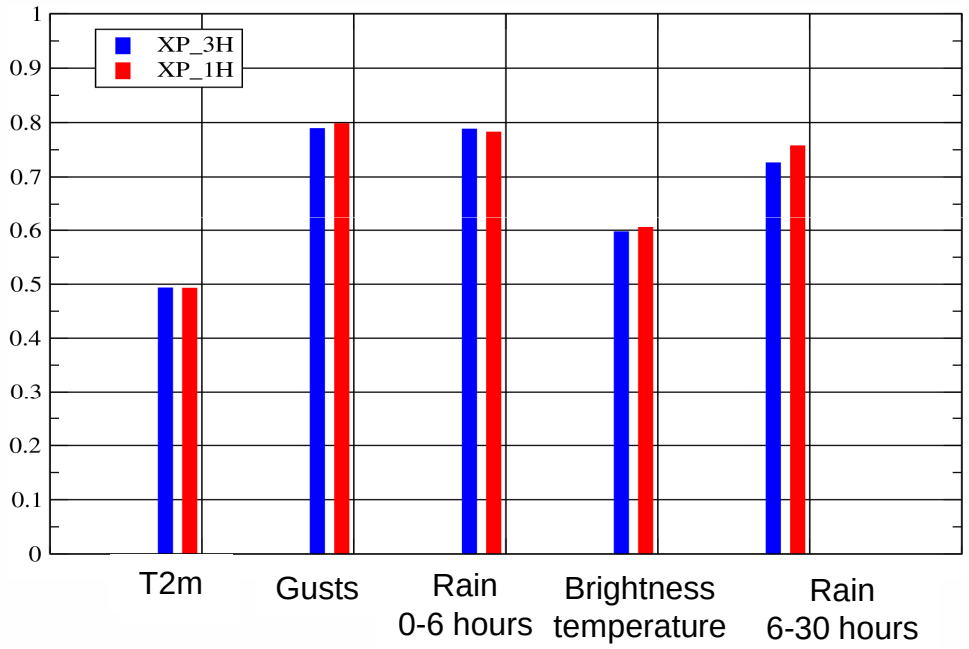
Cycling frequency

- NWP nowcasting induces more frequent analysis, ideal strategy would be to use the previous most recent forecast to feed the new analysis.
- So far we had difficulties improving our 3 hours cycle, but reducing the value of the guess model error and the computation of more adapted background error statistics helped us improving the system.

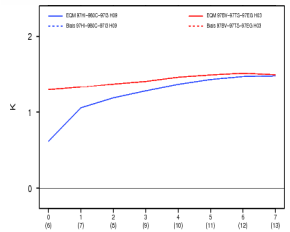


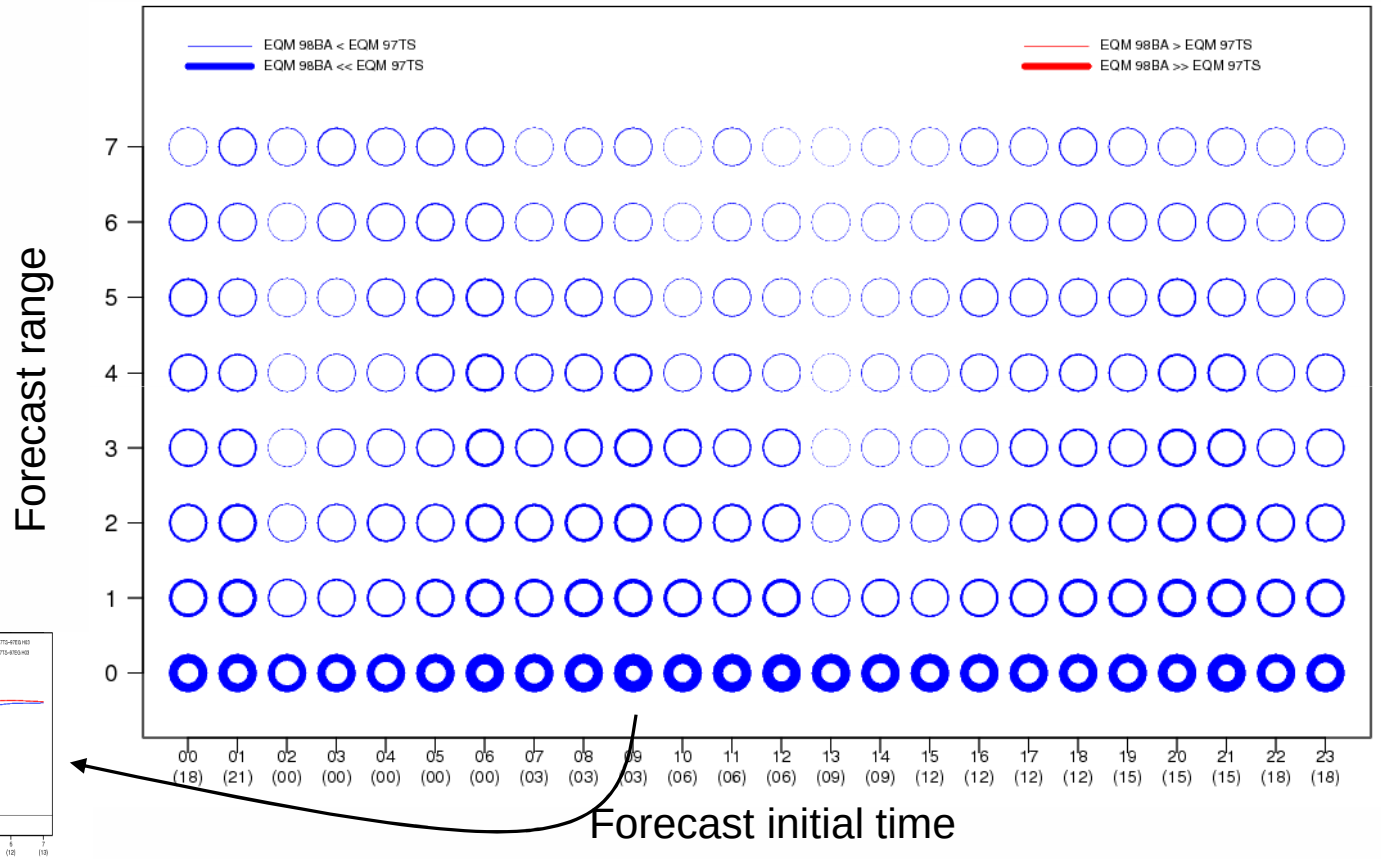
Comparaison of Skill scores for 1 hour and 3 hours cycles

- So the first version of our nowcasting system starts from a new analysis each time => to be improved later when we will be definitely satisfied of our 1 hour cycle.

Arome-Nowcasting

- Results shown here come from 3 testing periods (27 days total) over a 600x600 gridpoints domain for root mean square errors compared to temperature observations.





Comparison between arome nowcasting and arome operational as a function of forecast initial time and forecast range, the thicker the circle is the better Arome nowcasting is (the inner circle diameter corresponds to RMSE from Arome nowcasting, and the outer one corresponds to Arome operational).