Impact of the vertical resolution on AROME fog prediction

Quick summary of Alexandre Philip's doctoral thesis works, defended on 17/10/2016

Philip A.,T. Bergot, Y. Bouteloup and F. Bouyssel 2016 : The Impact of Vertical Resolution on Fog Forecasting in the Kilometric Scale Model Arome : A case Study and Statistics. *Wea. Forecasting*, **31**, 1655-1671

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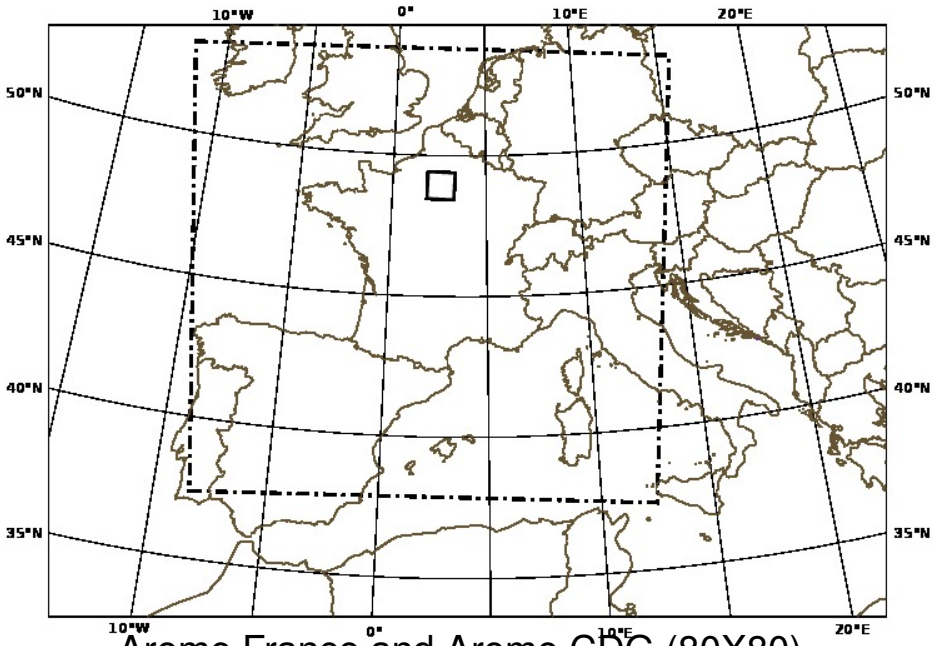
Plan

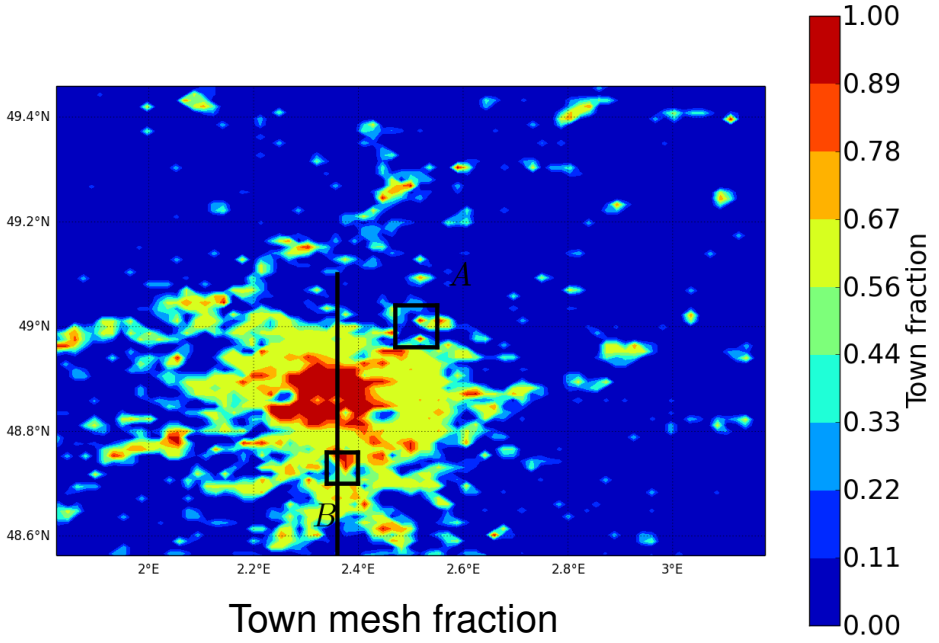
Thesis works overview

- Arome model at operational horizontal resolution (1.3km)
- Small domain (80X80) around CDG coupled to operational Arome model
- 3 vertical resolutions has been tested
- Attempt to parametrize a fine vertical resolution near the ground
- Detailed study of the radiation case of the night from 22 to 23 October 2012
- Statistical study over 2011-2012 winter

Simulation domain



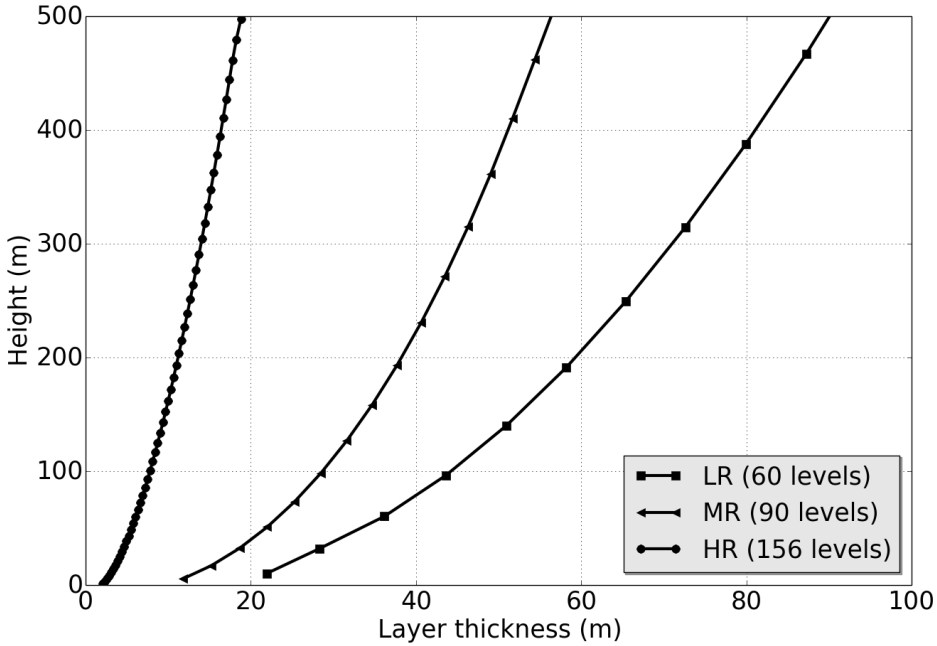
Arome France and Arome CDG (80X80)



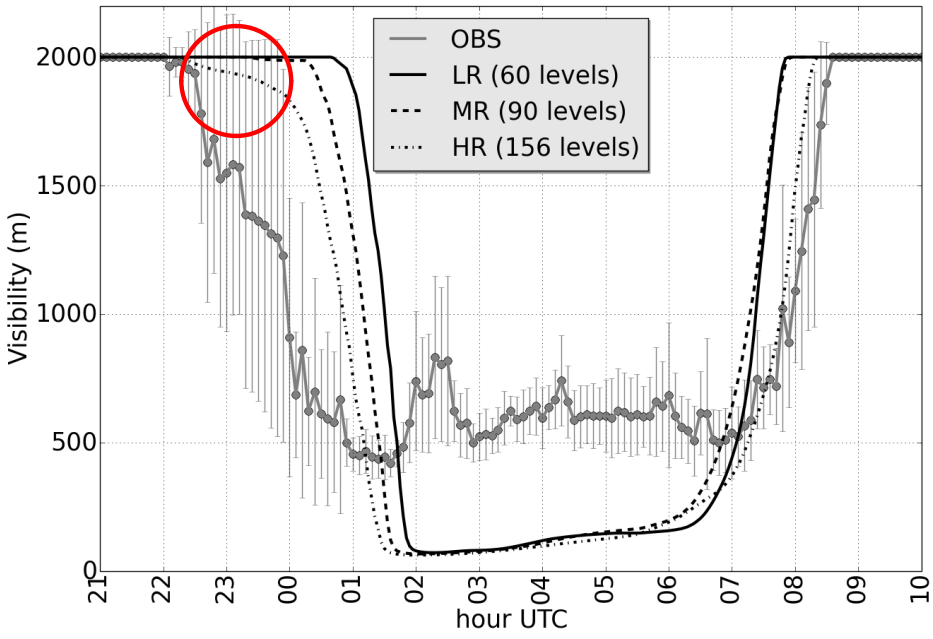
Town mesh fraction

Description of the 3 vertical resolutions used

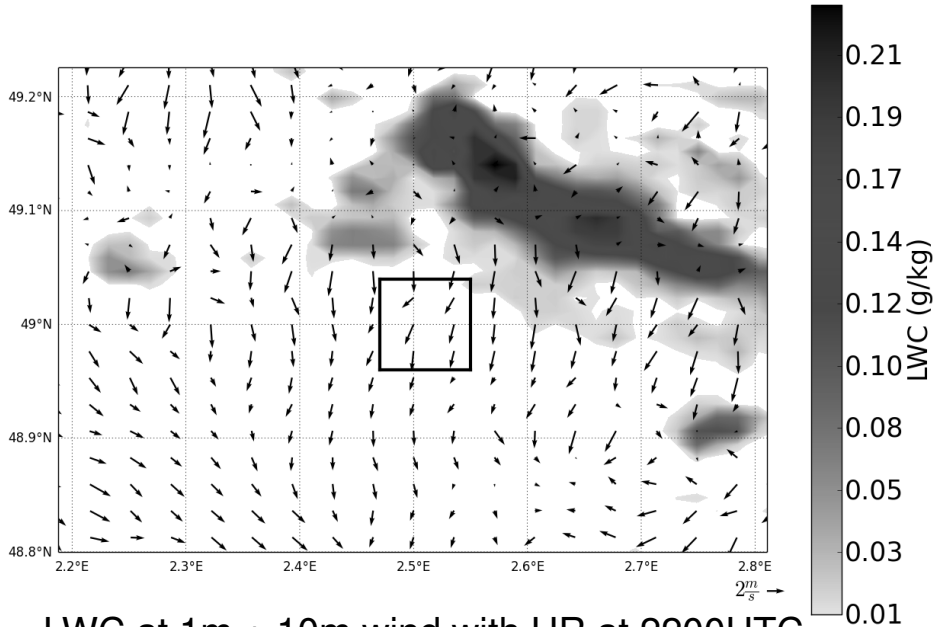
- LR : 60 levels first level at 10m (operational at the beginning of the thesis)
- MR : 90 levels first level at 5m (operational)
- HR : 156 levels first level at 1m



22/10/2012 radiation case



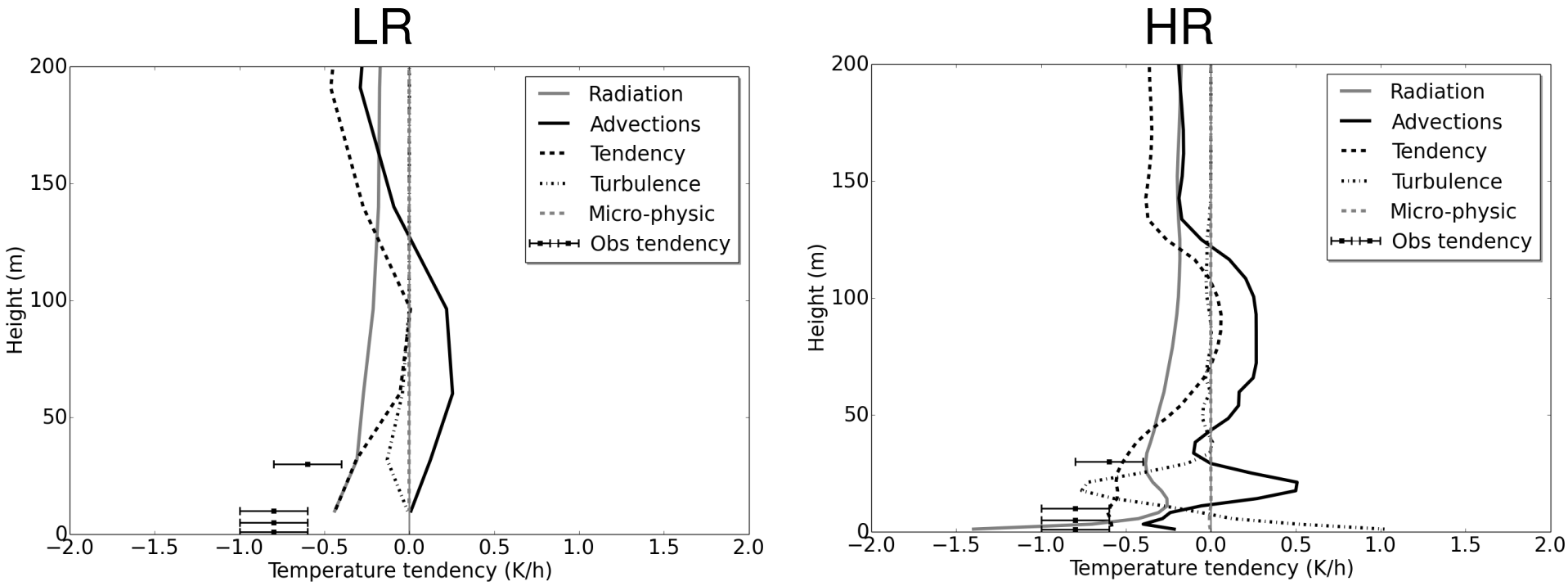
Visibility on the airport area



LWC at 1m + 10m wind with HR at 2200UTC

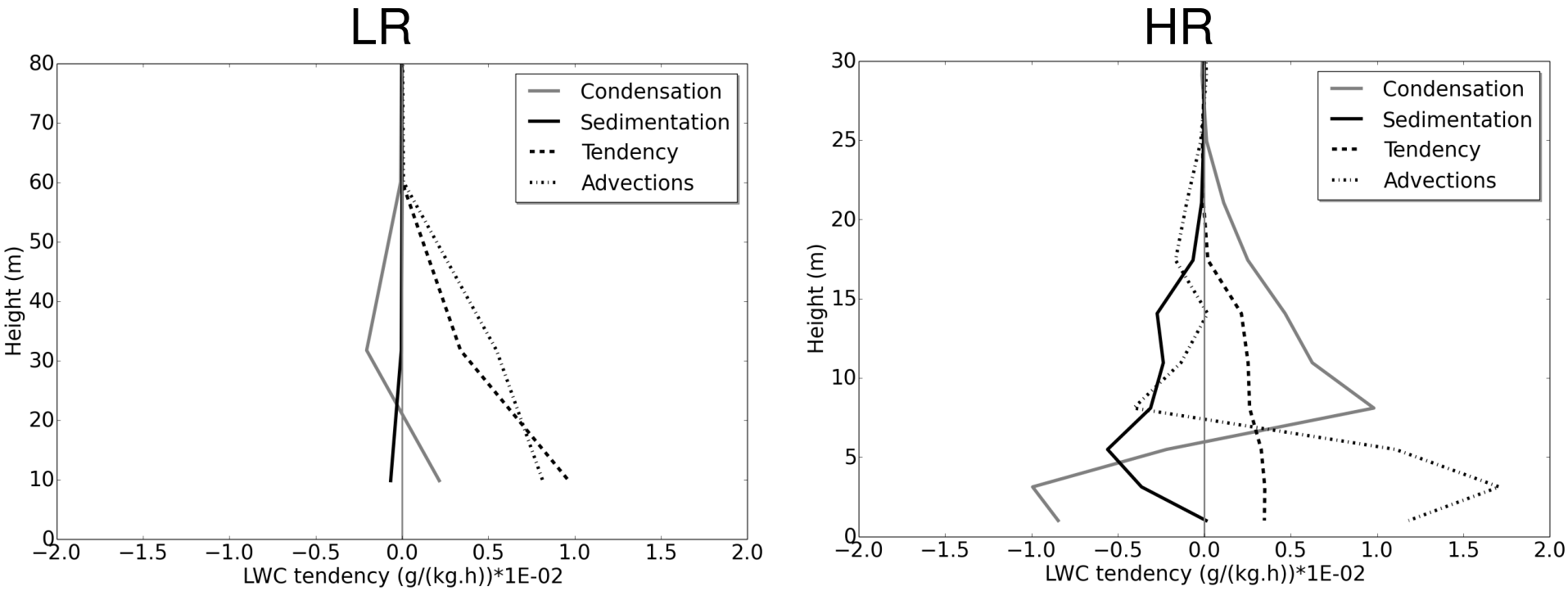
- HR visibility simulation during the formation phase is in better agreement with observations than MR/LR
- Local circulations close to the surface are more pronounced with HR
- MR and LR have similar behavior

Temperature budget at 2200 UTC



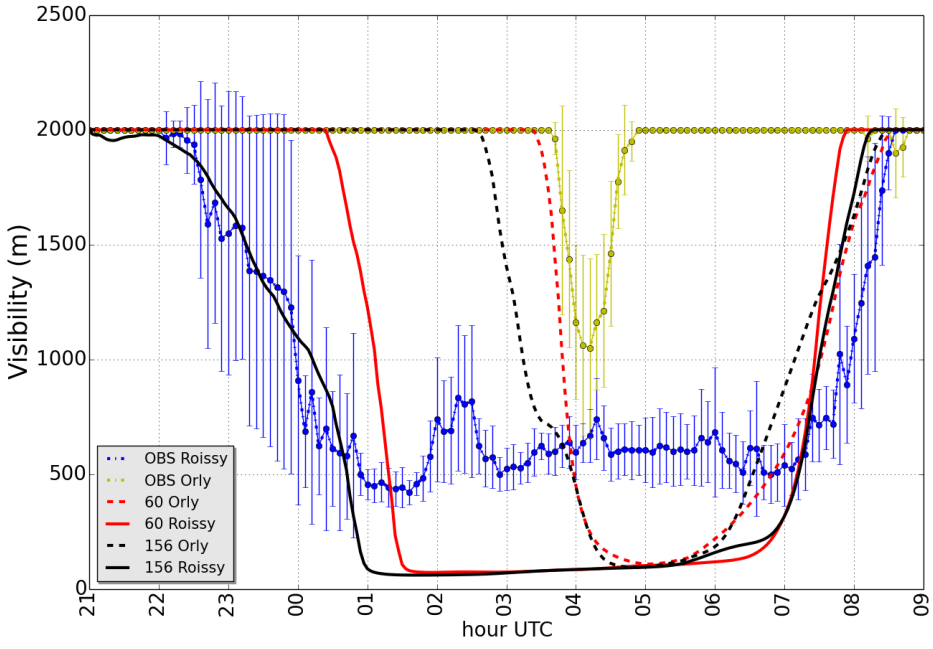
Temperature budget (Kh^{-1}) for LR and HR configurations at 2200 UTC. Solid gray, solid black, dashed black, dotted black, and dashed gray curves correspond, respectively, to the radiation, advection, tendency, vertical turbulence, and microphysical terms. Observed tendencies at 1, 5, 10, and 30m are represented by the black squares. The accuracy is represented by the error bar.

Liquid water budget

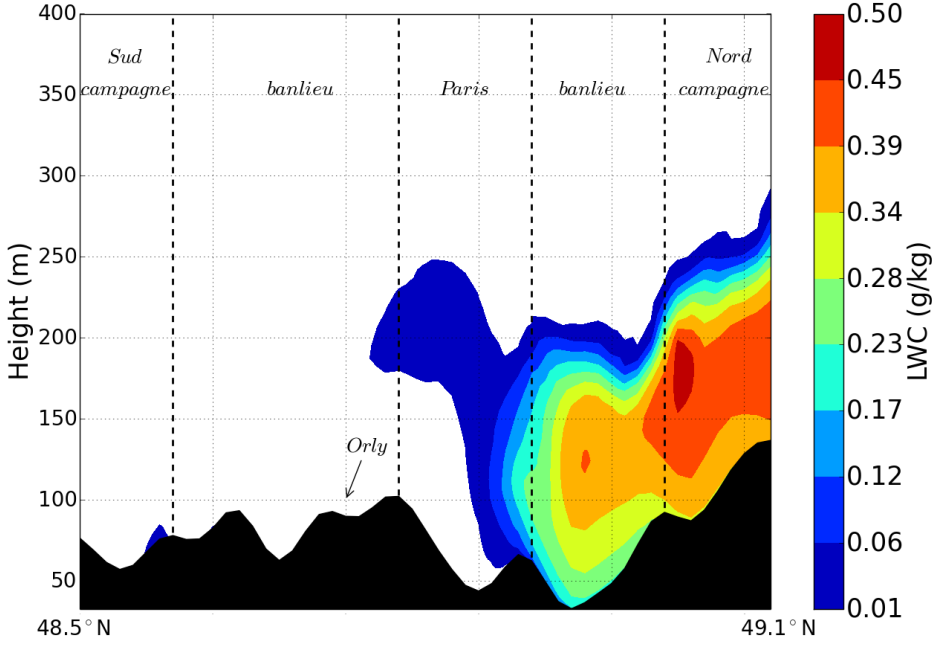


Liquid water budget ($gkg^{-1}h^{-1}$) for LR at 0100 UTC and HR at 2300 UTC. Solid gray, solid black, dashed, and dotted curves correspond, respectively, to the condensation, sedimentation, tendency, and advection terms.

Orly airport view of the 22 October case



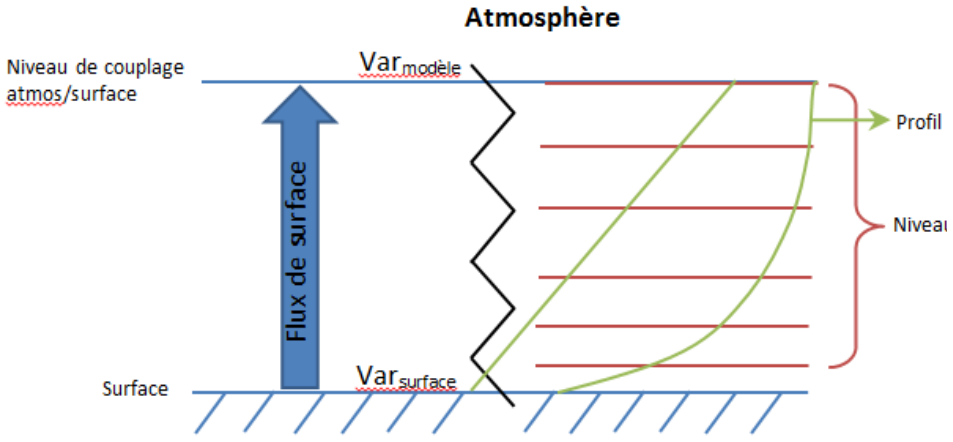
Visibility over airports areas



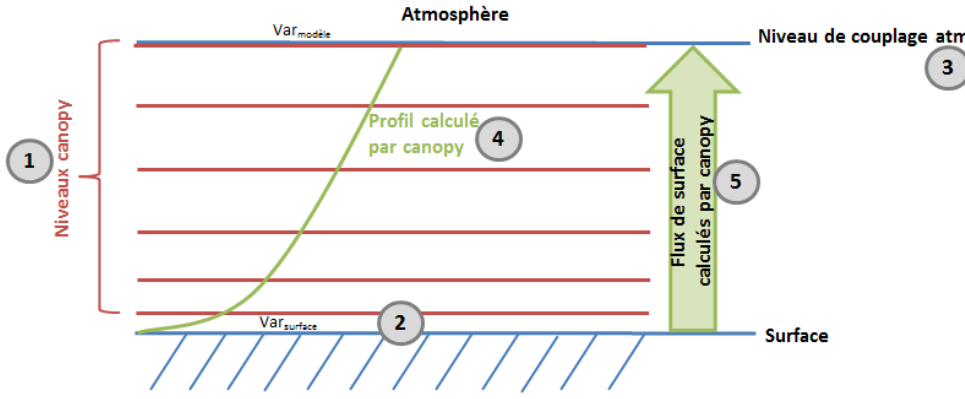
Vertical cross section at 2 UTC

- Fog becomes a stratus above Paris
- At Orly this event is a Cloud-Base-Lowering fog
- At Orly HR brings nothing more

Parametrization of a fine vertical resolution



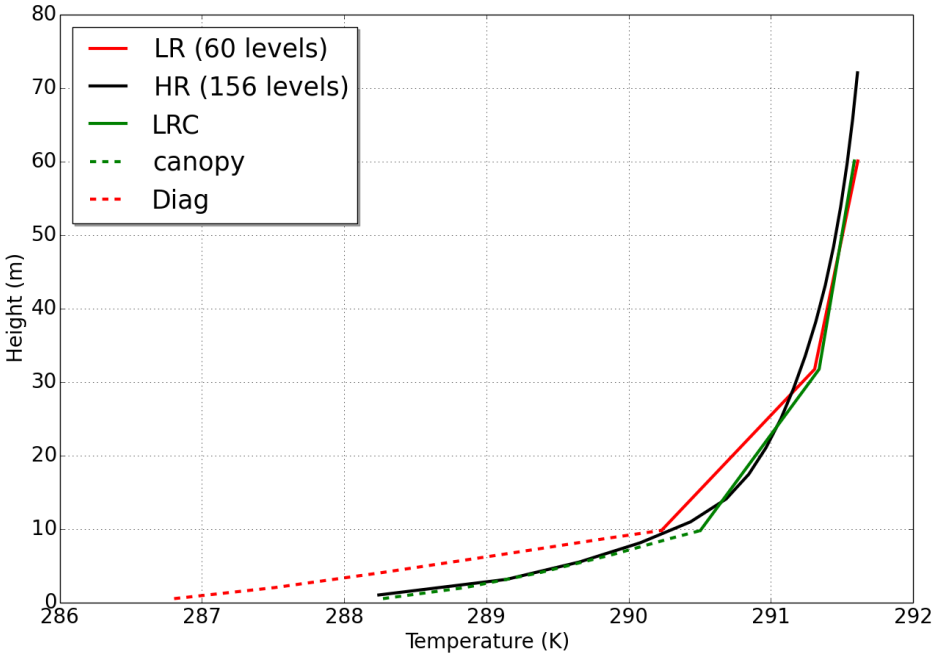
Diagnostic ⇒ simple interpolation

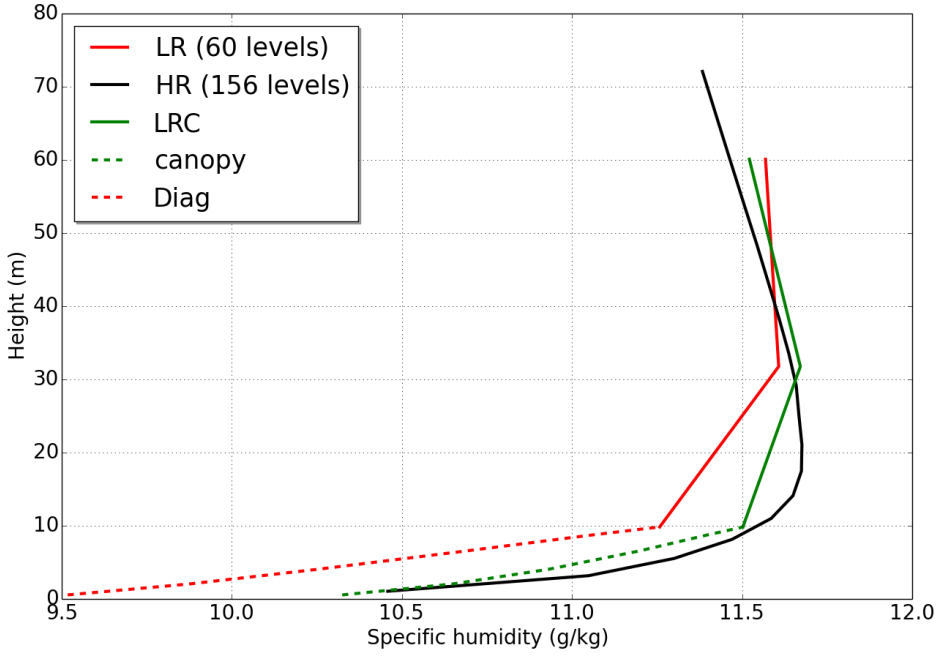


Canopy

- The first technicals is a simple interpolation driven by stability functions
- Canopy is a prognostic TKE scheme which interacts with the surface
- In the both cases an adjustment to saturation has been introduced

Temperature and humidity profiles at 22 UTC

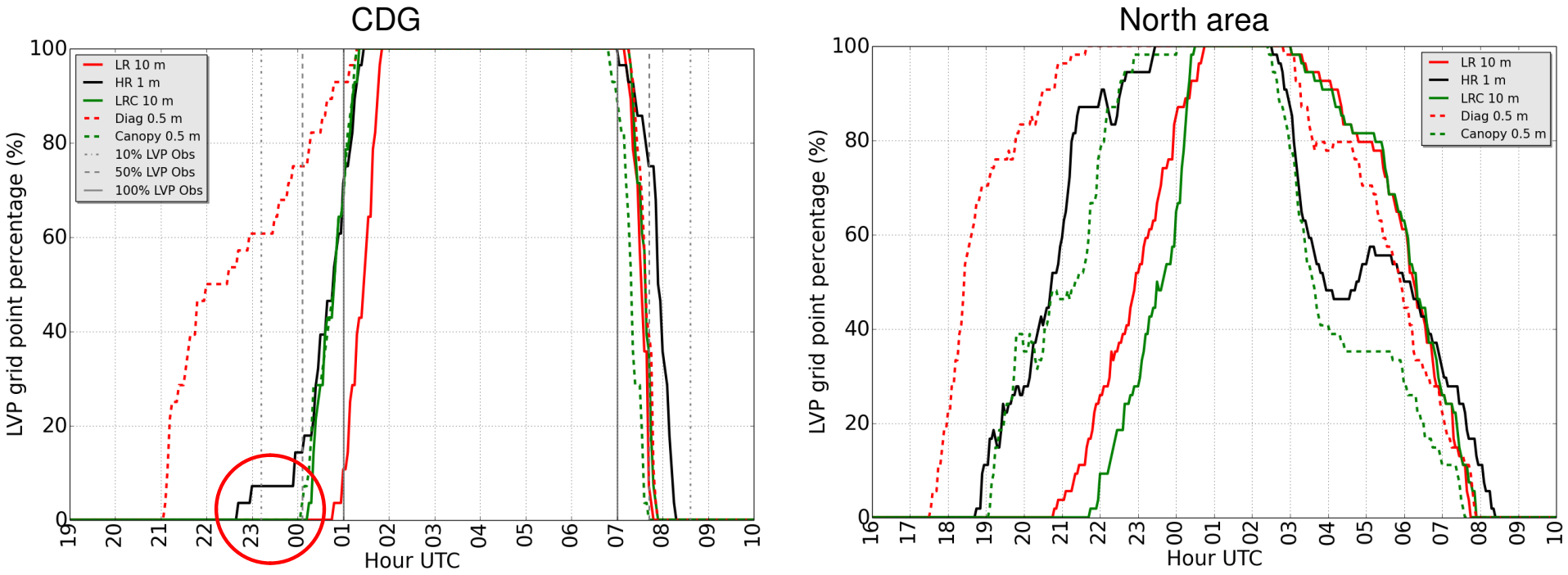




Temperature and humidity profiles at 22 UTC

- Canopy improves Low Resolution profiles
- Canopy reconstructs good profiles below the first level

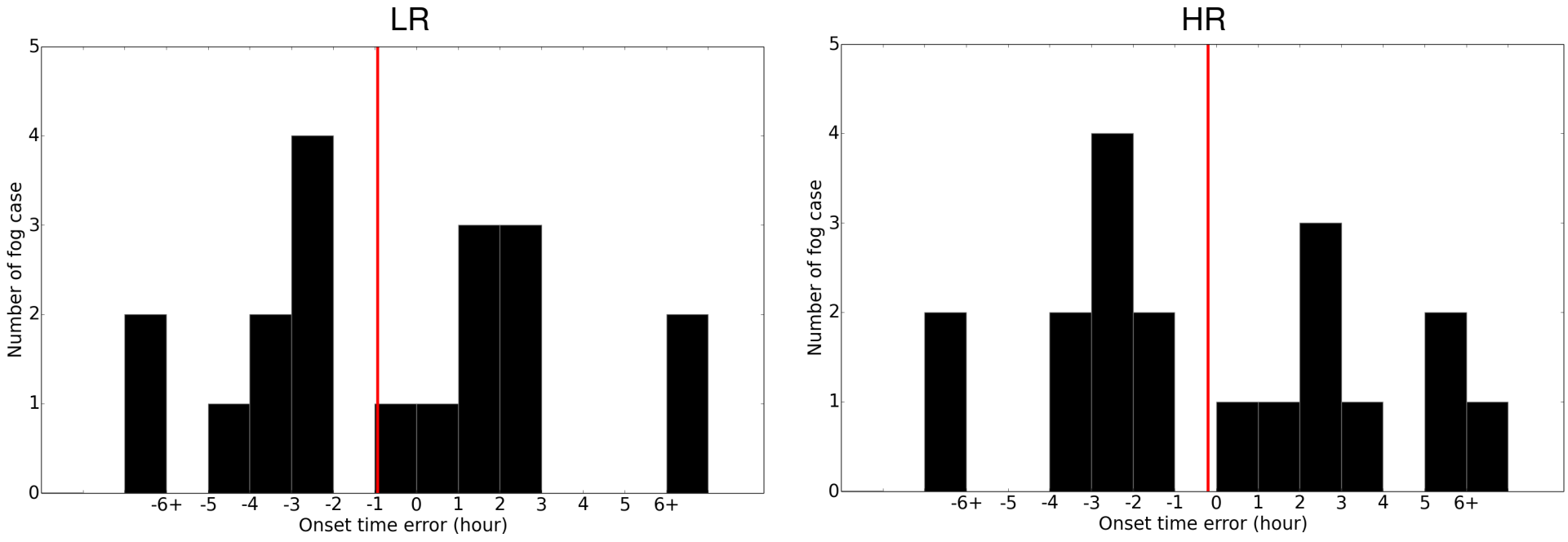
Onset of fog at CDG and a little further North



Temporal evolution of the percentage of grid points under foggy conditions at CDG (left) and a little further North (right)

- Diag method brings nothing more
- Canopy improves onset of radiation fog
- At CDG, at the beginning, fog is radiation/advective

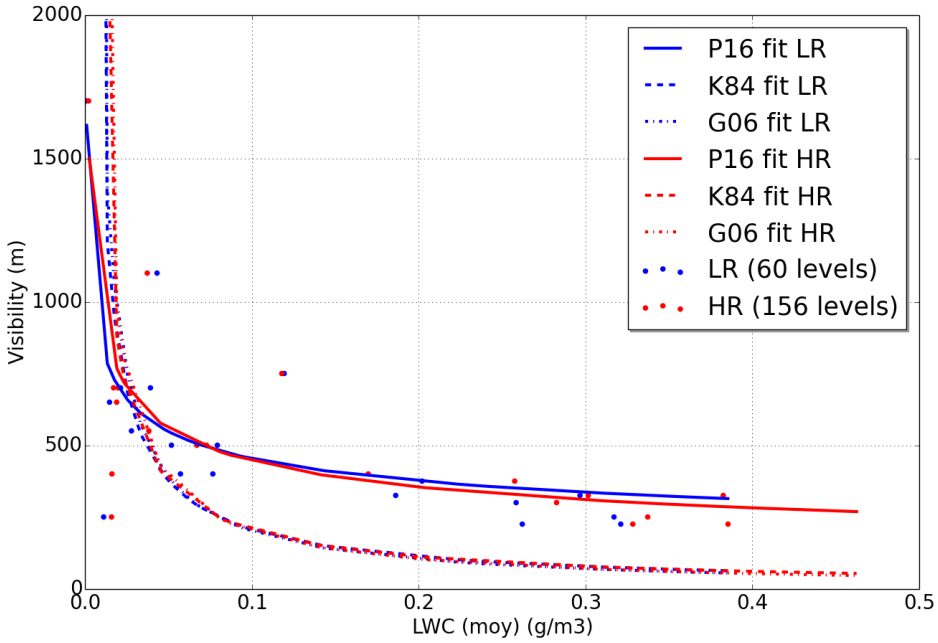
Summary of the statistical study



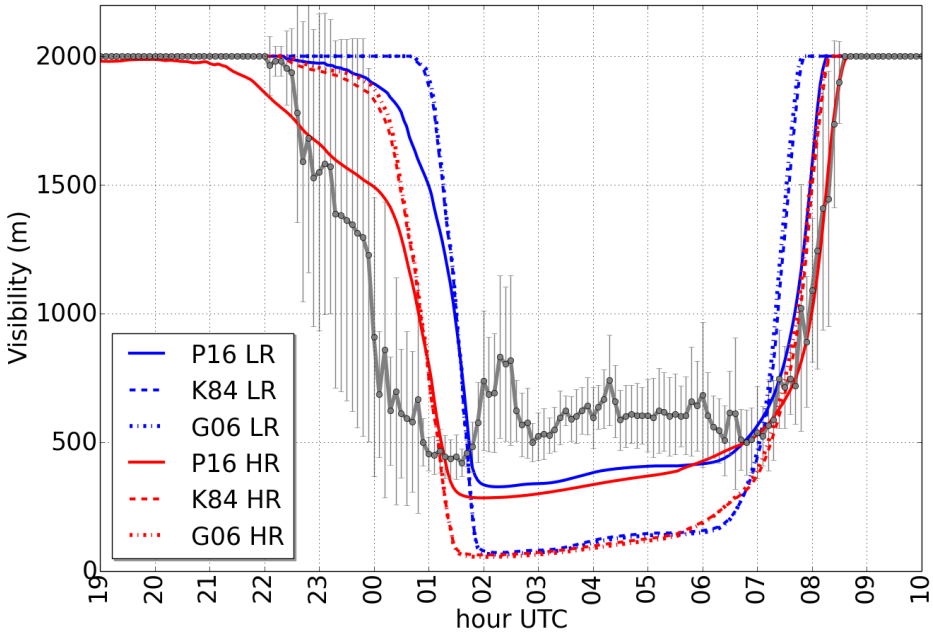
Frequency distribution histogram of the onset time error

- The statistical study confirms that high vertical resolution simulates fog earlier
- On the other side, high resolution does not improve the forecast quality
- The Cloud-Base-Lowering fogs are not well simulated by the model no matter what vertical resolution is used
- Arome model predicts low clouds but the height of ceiling is not well simulated

Adjustment of the Kunkel's visibility formula



Relation LWC/visibility and adjustment curves (HR in red, LR in blue)



Application to the case of 22 October

- Arome predicts a too large LWC near the surface
- It's possible to adjust Kunkel's formula (1984)

Conclusions and perspectives

Conclusions

- A fine vertical resolution near the ground is necessary to have a good description of various meso-scale processes involved during the fog formation phase
- The fine vertical resolution simulates stronger horizontal heterogeneities consequently more fog events over the winter season but it not improves the quality (Too many false alarms)
- In case of radiation fog Canopy improves the chronology of fog formation
- Canopy increases horizontal heterogeneities
- Cloud-Base-Lowering fogs are not well simulated by Arome
- Arome predicts a too large LWC near the surface but it's easy to adjust a formula of the Kunkel's type

Conclusions et perspectives

Perspectives

- Add a radiative interaction with the LWC produced by Canopy
- Parameterize horizontal advection in Canopy (is it possible ?)
- Understand why the ceiling of the stratus does not move down (too much turbulence ? boundary layer too dry ?)
- Improve micro-physics in particular the interaction between cloud liquid water and vegetation and buildings