Forecasting low level clouds and fog with Arome

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Workshop on Parameterization of Stable Boundary Layer in Numerical Weather Prediction Models

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cnrs INSU Observer & comprendre

METEO FRANCE Toujours un temps d'avance

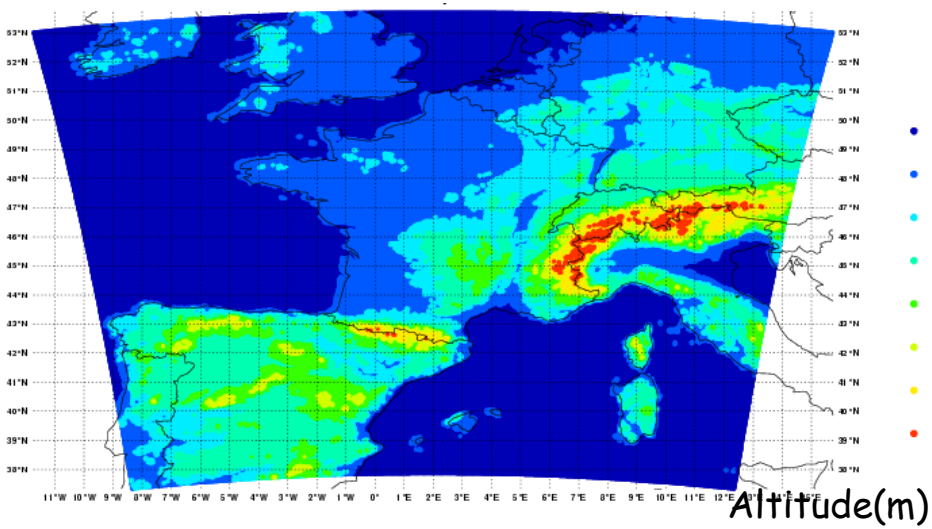
Outline

- ✓ Introduction
- ✓ Fog diagnostic based on Arome
- ✓ Recent modifications and vertical resolution
- ✓ Cloud droplet concentration
- ✓ Perspectives

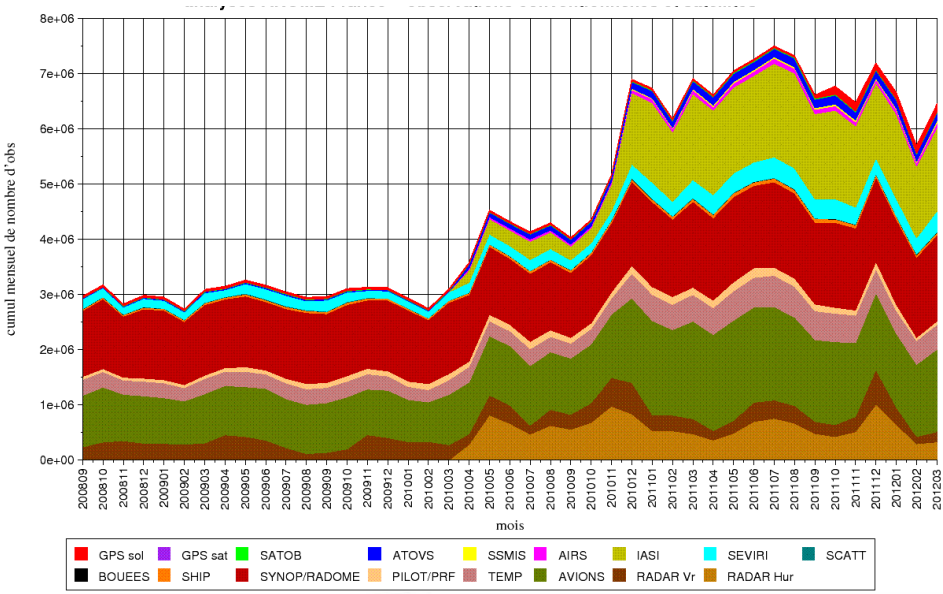
AROME-France

- ✓ Limited area spectral non-hydrostatic convective scale model
- ✓ Operational since December 2008
- ✓ Resolutions : Dx=2.5km , 60 vertical levels, Dt=60s
- ✓ 3D-Var with a 3h assimilation window
- ✓ Hourly coupling to global Arpege model
- ✓ 4 daily 30h forecasts at 0,6,12,18h UTC

Computational domain (750x720x60)



Monthly evolution of observations number



RADARS **AIRCRAFTS** **SYNOP/RADOME**

IASI **SEVIRI** **TEMP** **Ground GPS**

AROME physical parameterizations

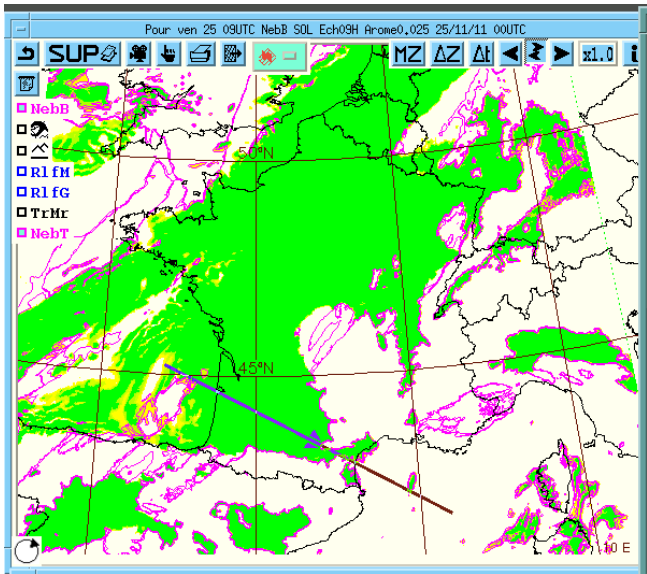
	Atmospheric physics
Vertical diffusion	1.5 closure scheme with prognostic TKE (Cuxart et al., 2000) modified according (Cheng et al., 2002)
Mixing length	Non local mixing length (Bougeault and Lacarrere, 1989)
Shallow convection	Dry and moist shallow convection. Surface flux closure. (Pergaud et al, 09)
"Resolved" Clouds	Statistical scheme with possibly mixed symmetric (Gaussian) and asymmetric (Exponential) functions. (Bougeault, 82)
Microphysics	1 moment bulk scheme with prognostic var. for cloud droplets, rain, ice crystals, snow and graupel (Pinty & Jabouille, 98)
Deep Convection	None
GWD	None
Radiation	ECMWF codes : LW=RRTM (Mlawer, 97) SW=old IFS scheme (Fouquart, Morcrette)

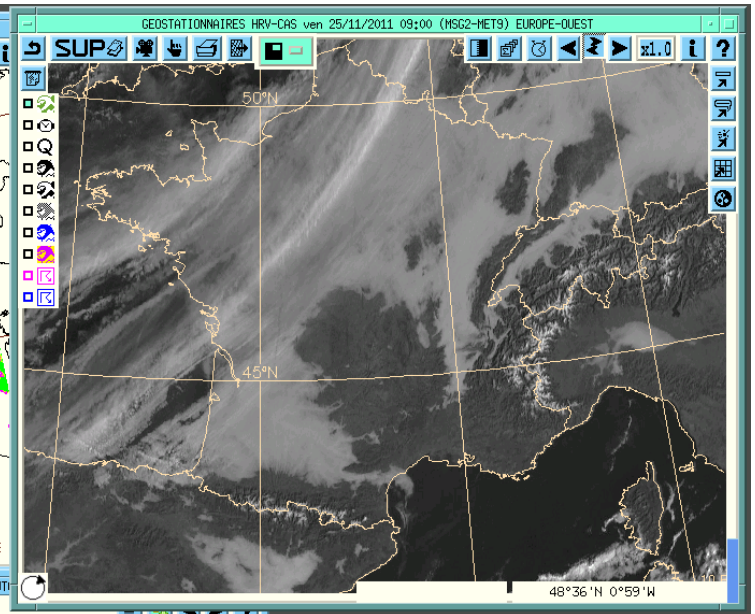
	Surface physics
Orography Physiography	GTOP030 and HWSD 30 arc-second, ECOCLIMAP 1km (Masson et al., 03)
Surface type	Land, Town, Sea, Inland water
Soil and vegetation	ISBA 3L: Force restore scheme. Prognostic temperature, liquid and solid water (Noilhan and Planton, 89)
Snow	1 layer : prognostic SWE, albedo, density (Douville, 95).
Open water	ECUME:bulk iterative parameterization (Belamari and Pirani, 07)
Inland water	Charnock's formulation
Town	TEB: Urban canyon concept (Masson, 00)
SBL	Extra layers between lowest model level and surface. 1D prognostic turbulence scheme. (Masson, 08)

Example of nice low level cloud forecast

25/11/2011 at 9h UTC

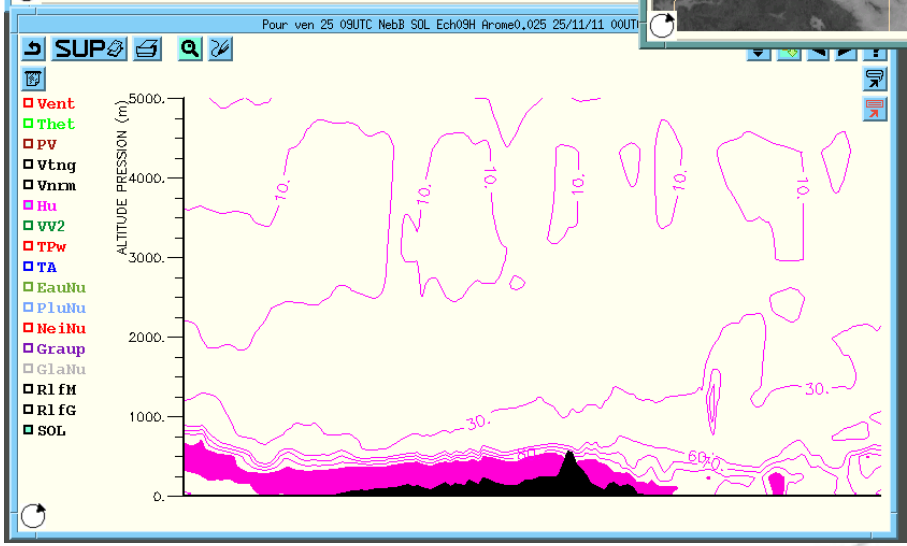
Arome
low cloudiness
forecasted at 9h





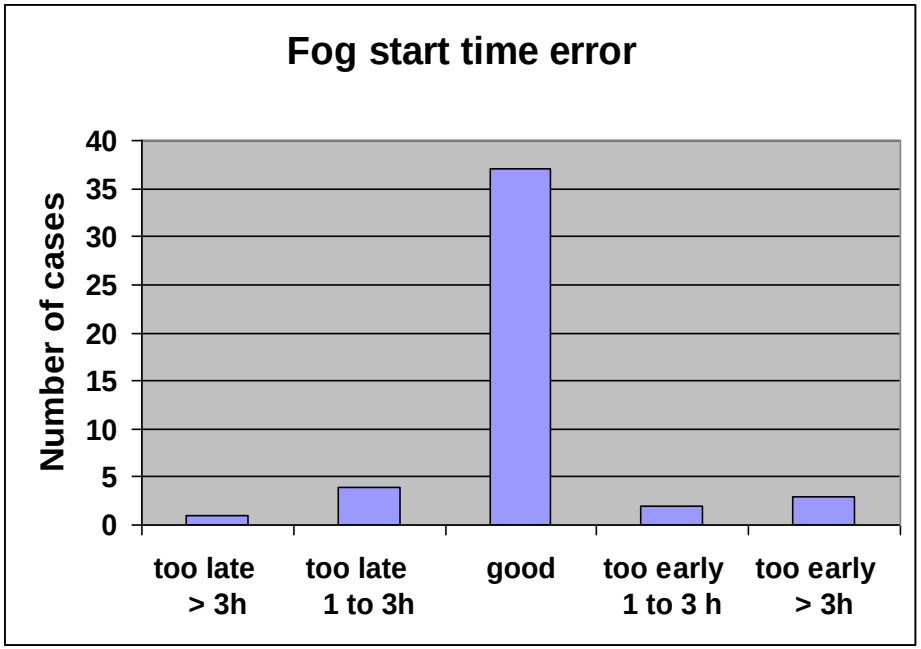
MSG

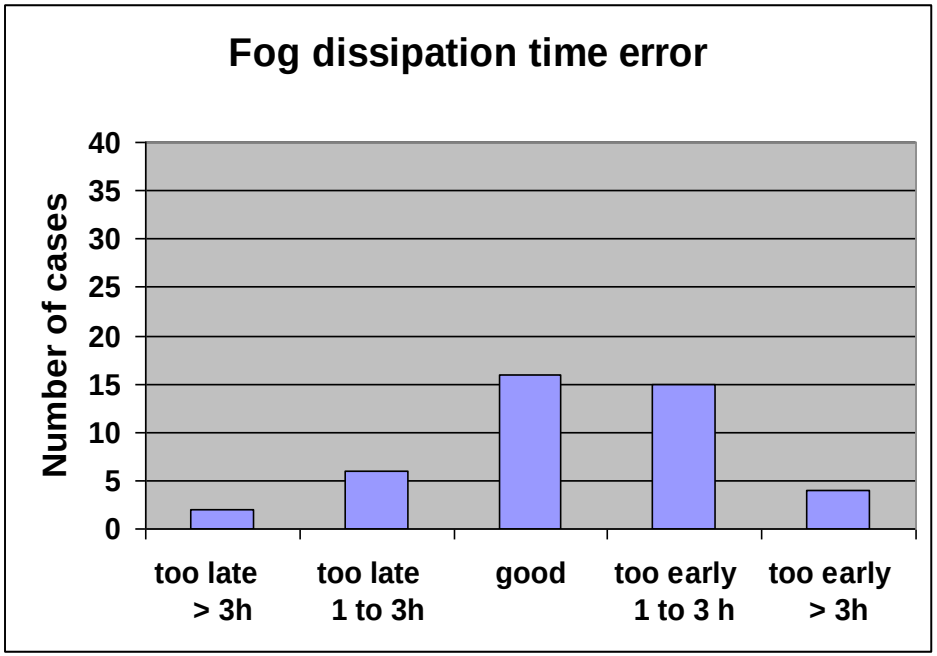
Arome
relative humidity
forecasted at 9h



AROME : Forecasters' Point of View

Fog





⇒ No bias for the fog formation

⇒ Tends to dissipates fogs too early

(B. Mornet – Nov 2010)

Fog diagnostic with Arome

Arome data used :

- (Wind)_10m
- HU=mean(2m, 20m, 50m)
- (Q_liq)_20m → Kunkel (JAM, 1984) → horizontal visibility

  Reference : internal report « Besson, Lafaysse, Morillo, 2007 »

Fog (<=1000m)

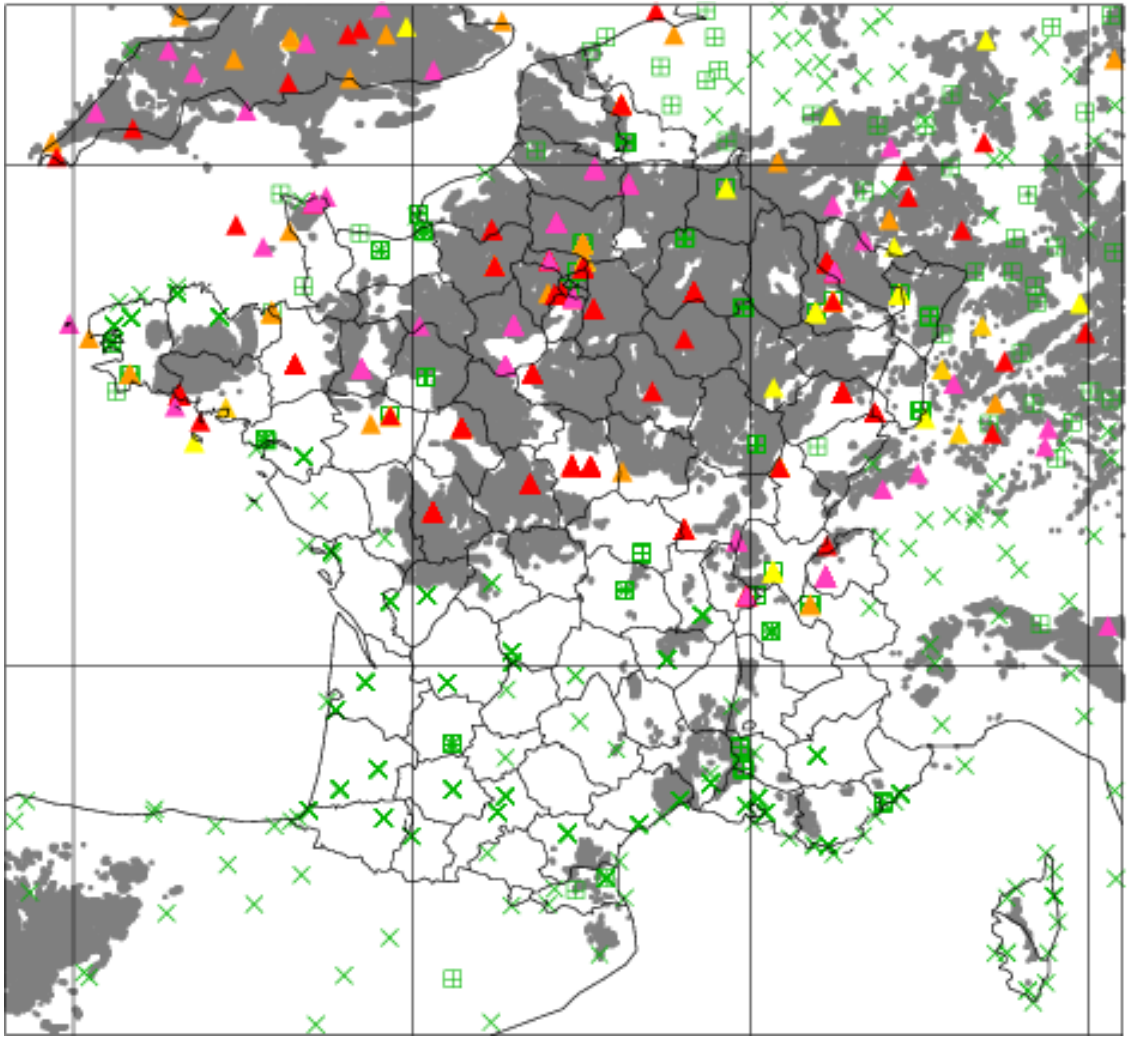
if

- HU ≥ 98 % or Kunkel's visibility ≤ 1000m

and

- 3.5 m/s ≤ (Wind)_10m ≤ 5 m/s : **moderate (in pink)**
- 1 m/s ≤ (Wind)_10m ≤ 3.5 m/s : high (**in grey**)
- (Wind)_10m ≤ 1 m/s : **moderate (in pink)**

Fog diagnostic with Arome



29 December 2010 at 6 UTC

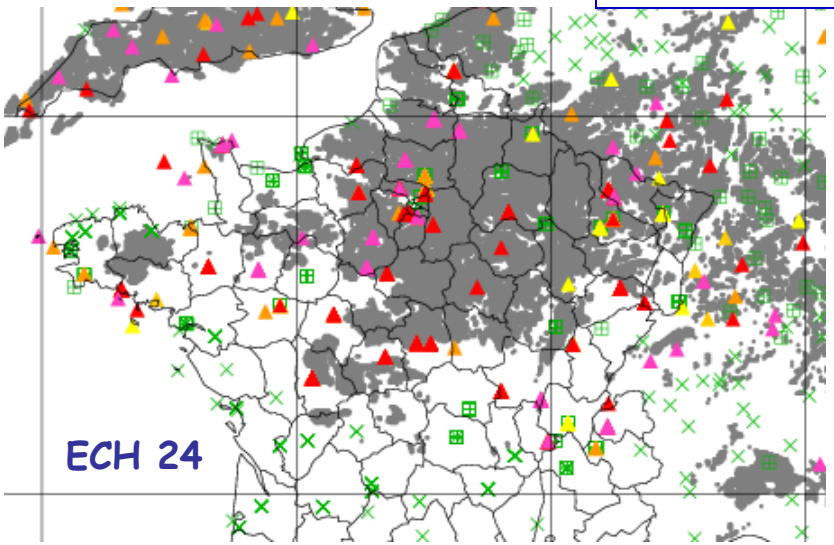
Fog diagnostic from Arome 6h forecast

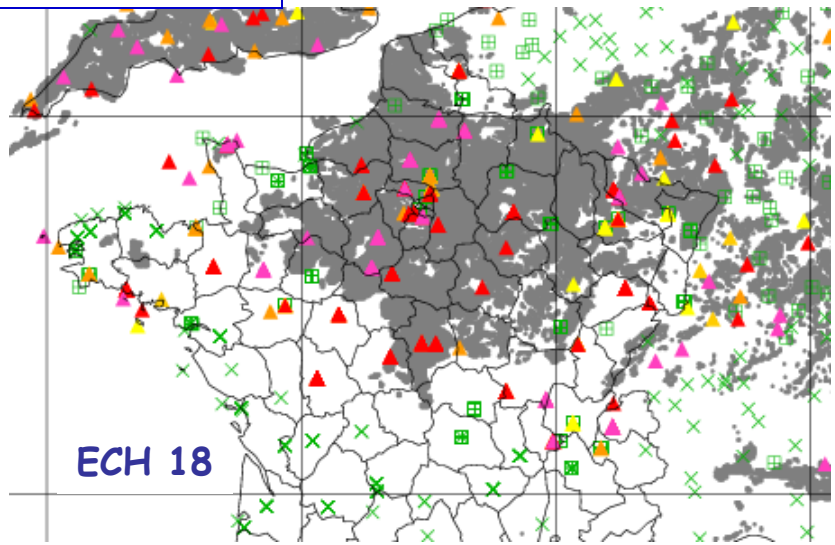
Observed visibility

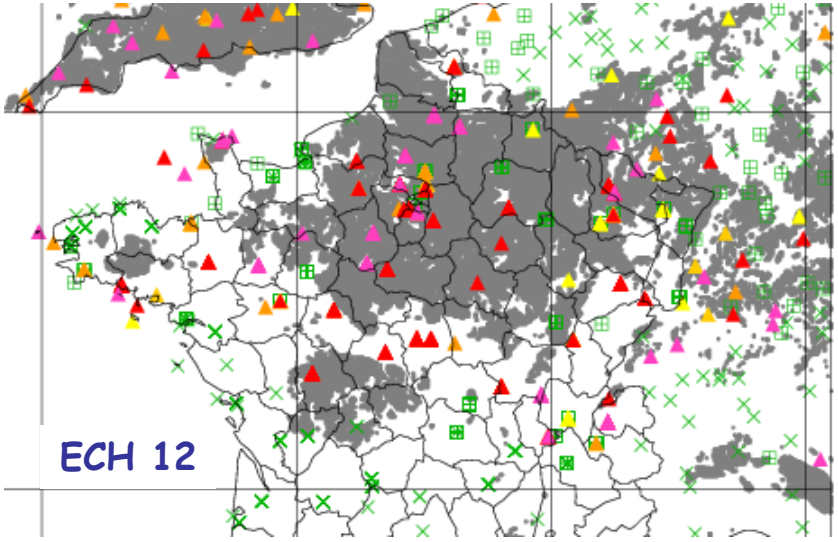
5000 - 0.700 10 ^{4}	1000 - 5000
800 - 1000	600 - 800
400 - 600	200 - 400
0 - 200	

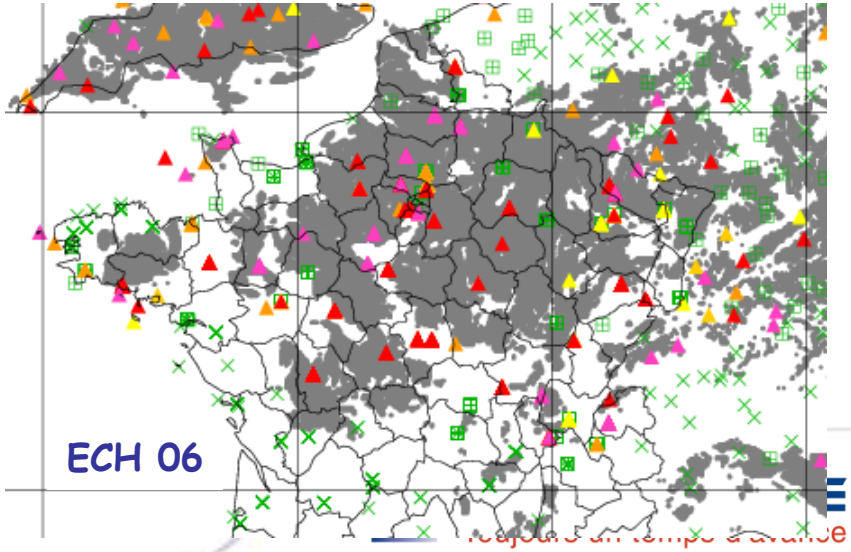
Fog diagnostic with Arome

29 December 2010 at 6 UTC

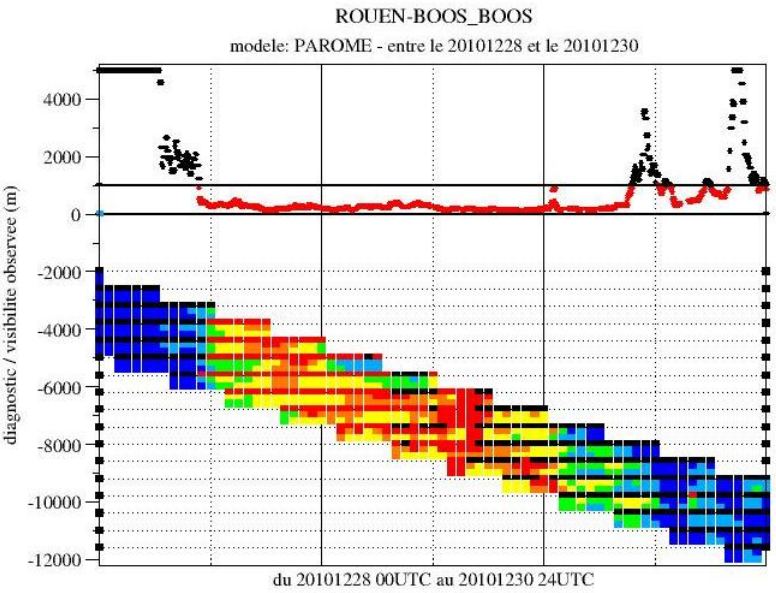


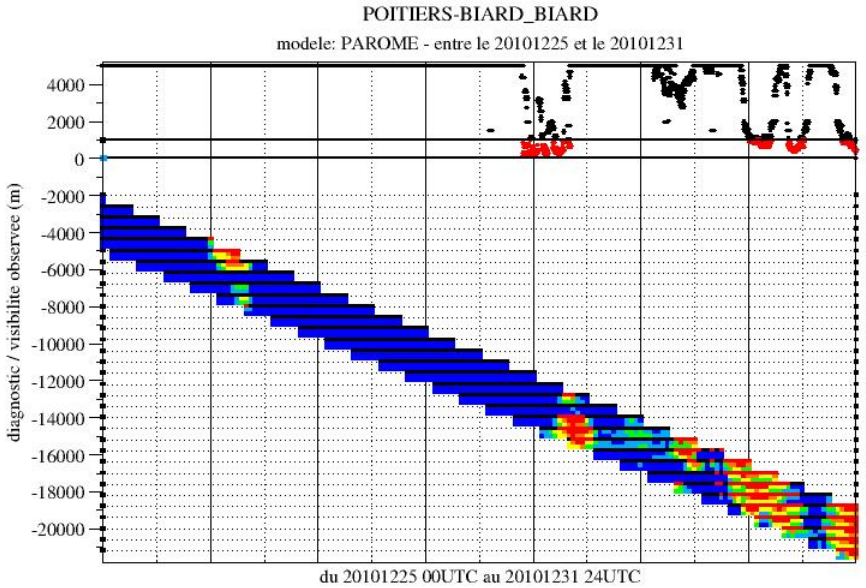


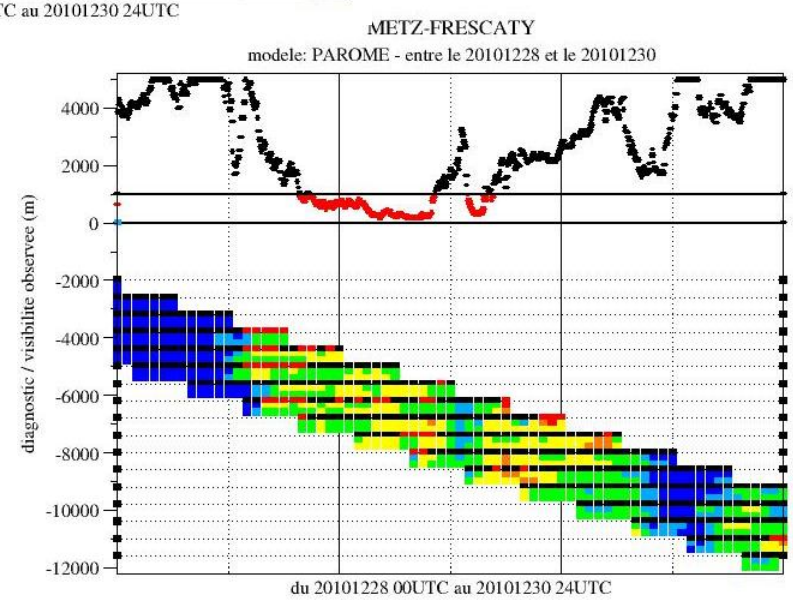




Fog diagnostic with Arome





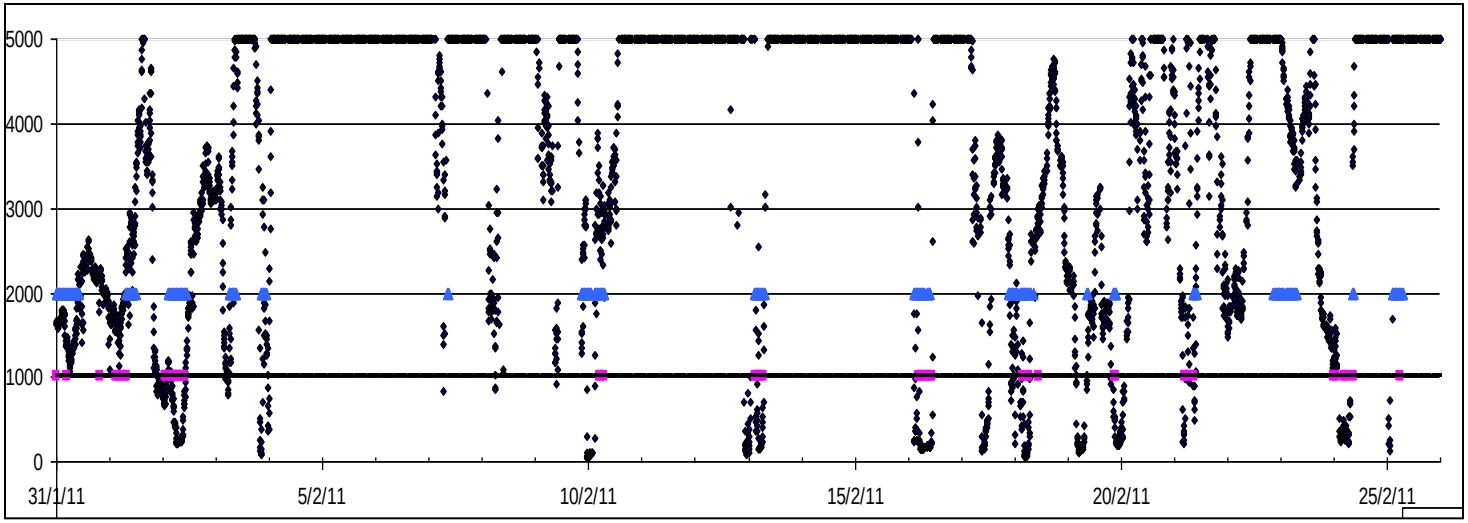


Comparaison with COBEL on Roissy

COBEL (Bergot et al., 2005) : 1D operational model for FOG forecast on airports.

Characteristics: - Very high vertical resolution (1st level : 25cm)
- Local assimilation scheme
- Physics adapted to fogs (but warm 1-moment microphysics)

✓ Comparison between 3h and 8h forecast

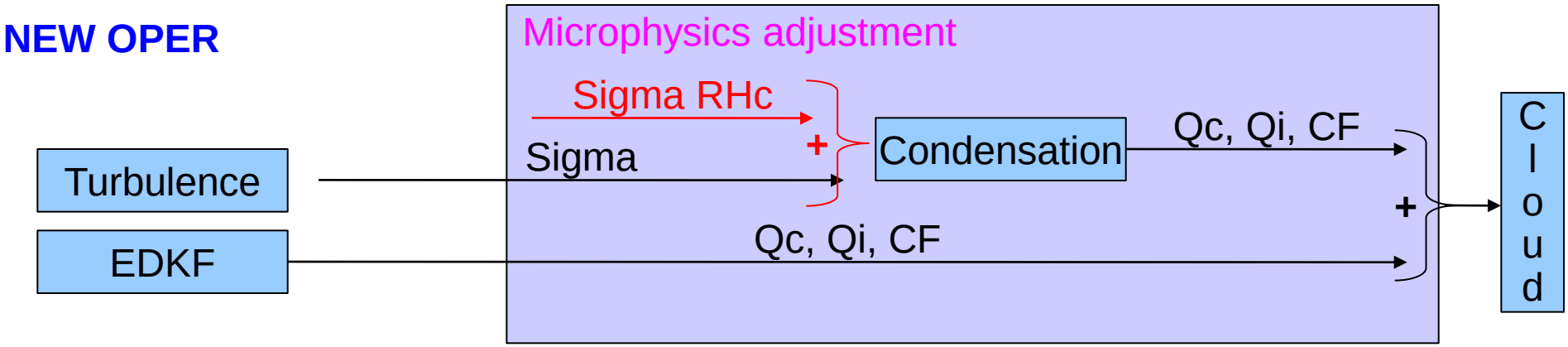


Modification for subgrid clouds

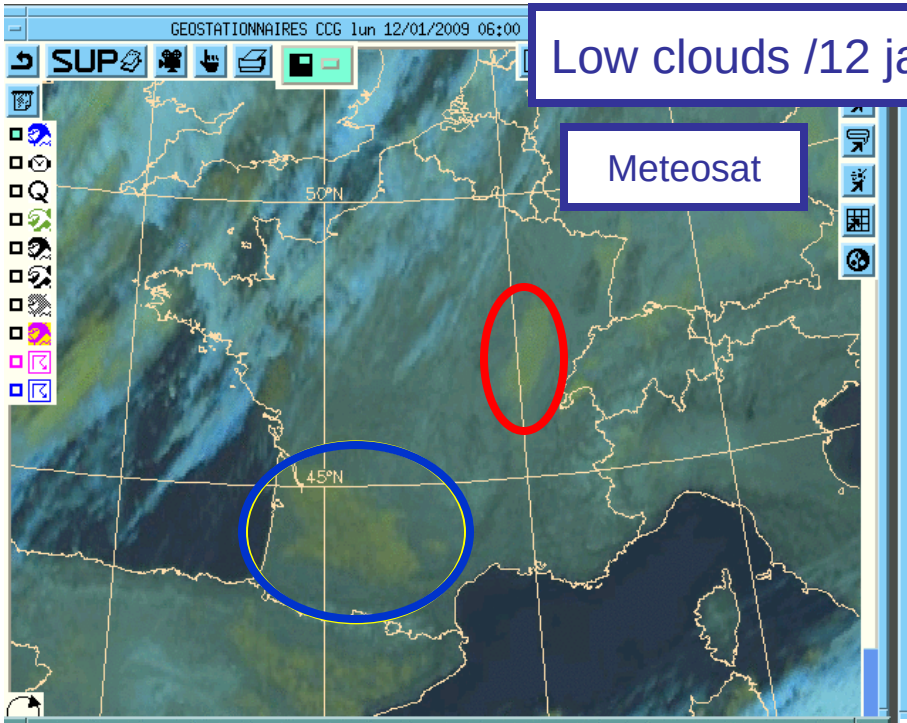
- AROME statistical cloud scheme uses $Q = \frac{q_t - q_{sat}}{\sigma_s}$ (=normalized distance to saturation)

  In the previous version, σ_s comes from turbulence, but in stable situation, this term is too weak and AROME did produce clouds only for HU≥100%

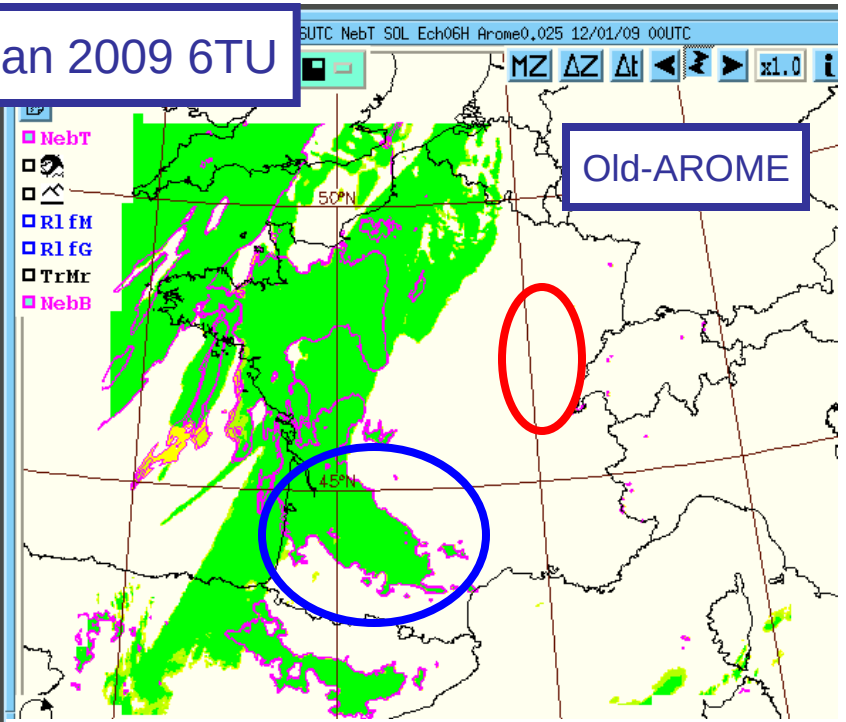
Following Wim de Roy ideas, we add σ_{RH_c} and $\sigma_s = \sqrt{\sigma_{turb}^2 + \sigma_{RH_c}^2}$ $\left(\begin{array}{l} \alpha = 0{,}02 \\ \sigma_{RH_c} = \alpha \times q_{sat} \end{array} \right)$



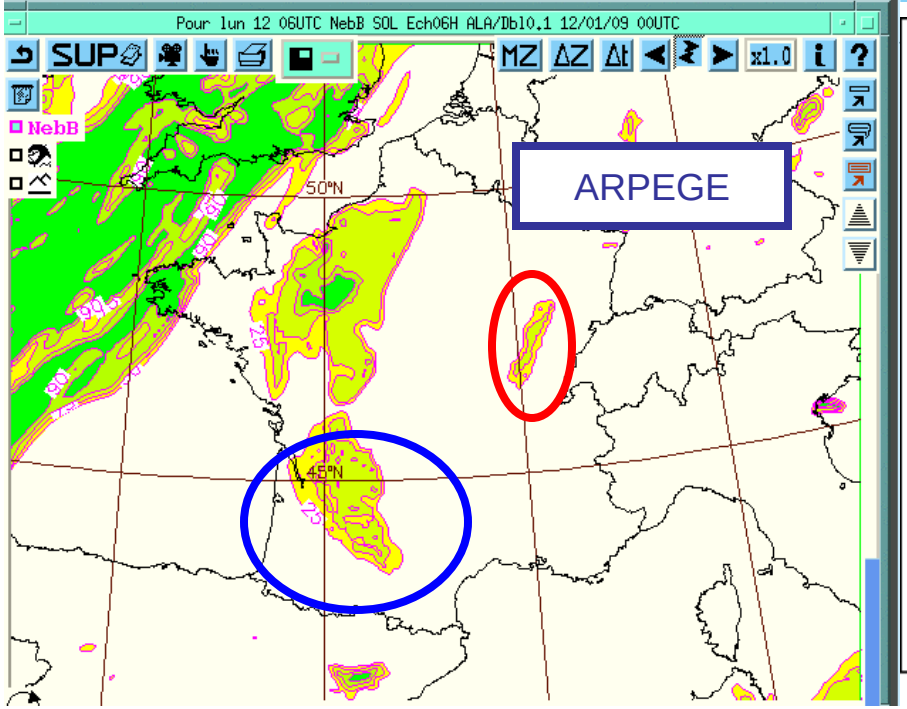
Low clouds /12 jan 2009 6TU



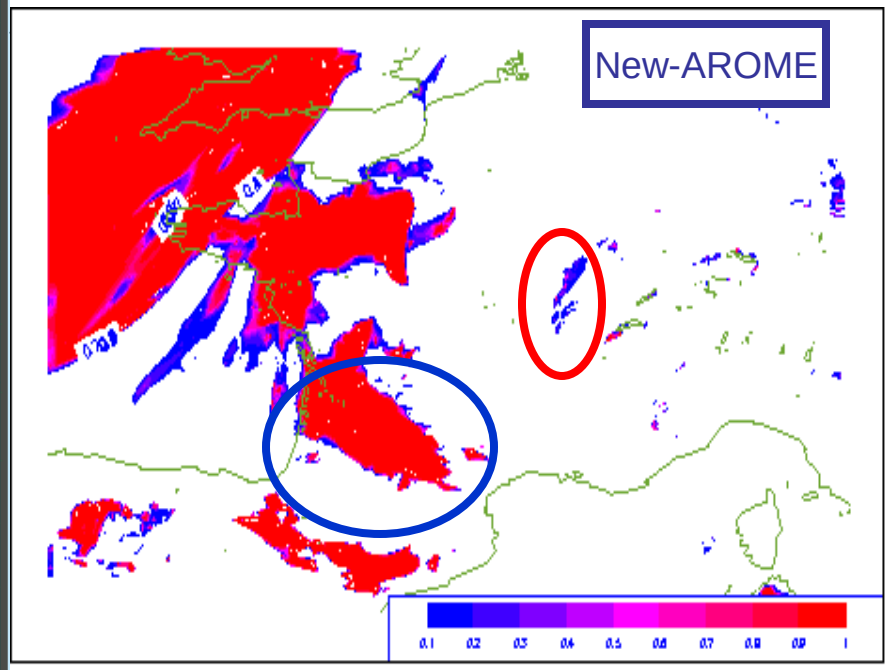
Meteosat



Old-AROME



ARPEGE

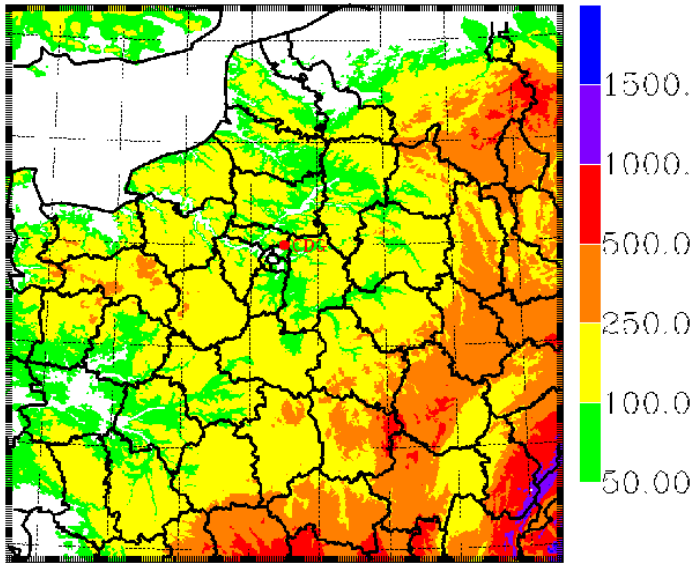


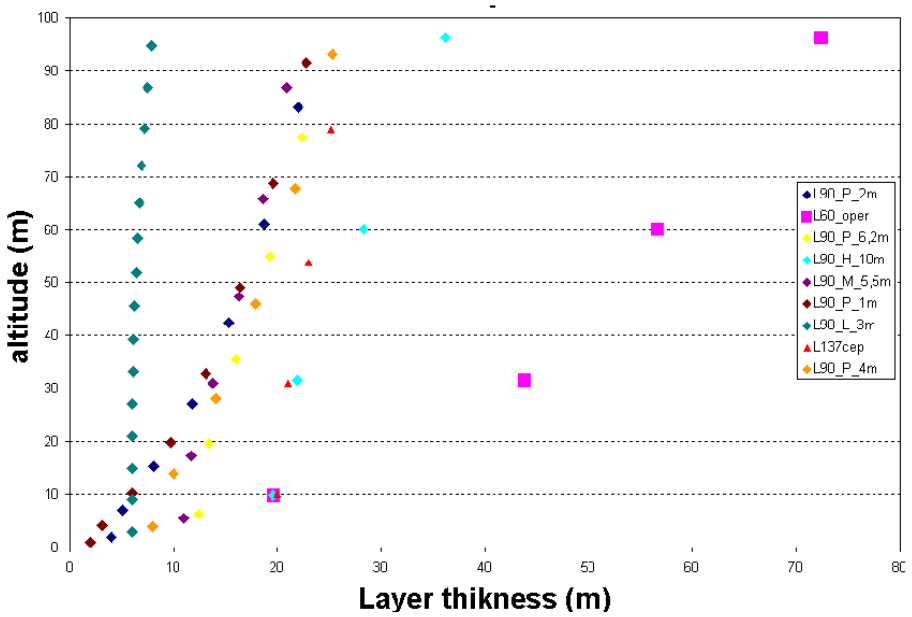
New-AROME

Vertical resolution

Preparation of future Arome-France configuration: (2.5km, L60) -> (1.3km, L90)

Test several vertical resolution over Paris Charles de Gaulle airport using ParisFog observation campaign. Arome domain created at 1.3km, 480x480 gp, 45s

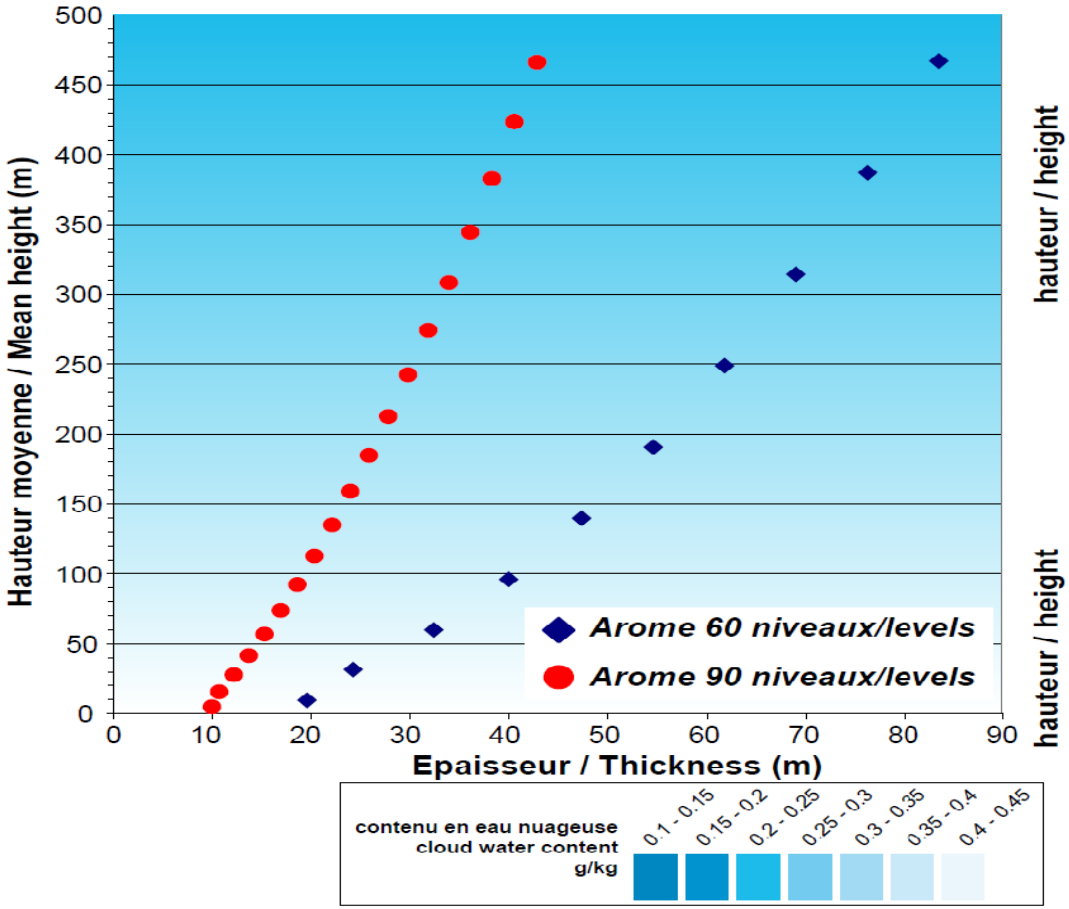




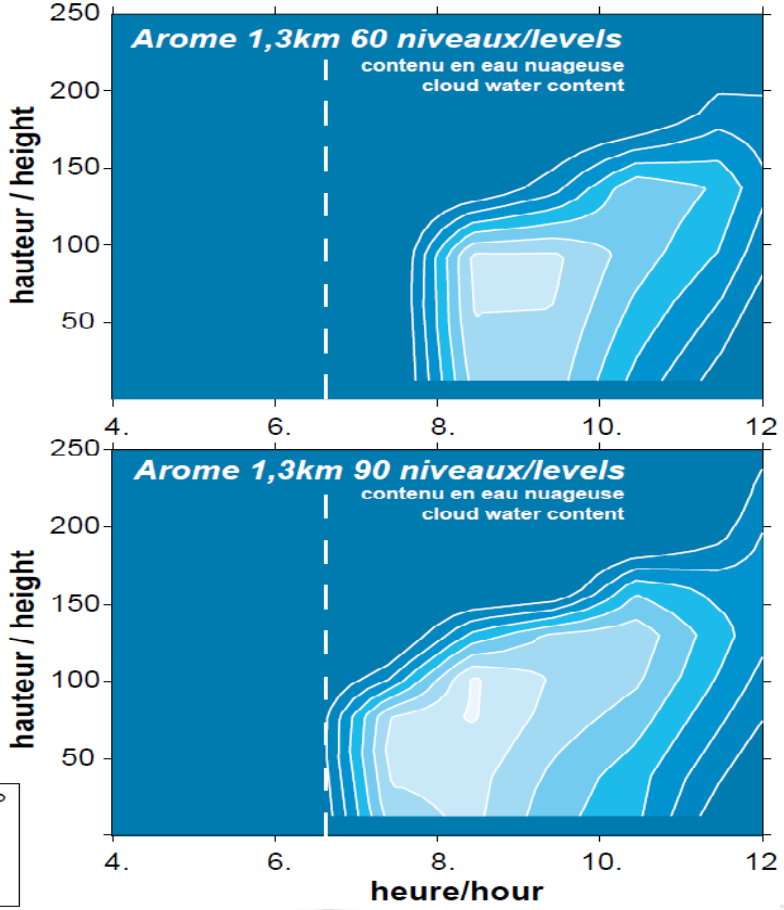
POI	16 November 2010	19 November 2010	30 November 2010
START	04UTC	04UTC30	01UTC
END	07UTC	09UTC	05UTC30
DURATION	3h	4h30	4h30
LWC max (g/m^3)	0.29	0.141	0.212
LWC medium (g/m^3)	0.036	0.038	0.039

Vertical resolution

Vertical resolution near the surface

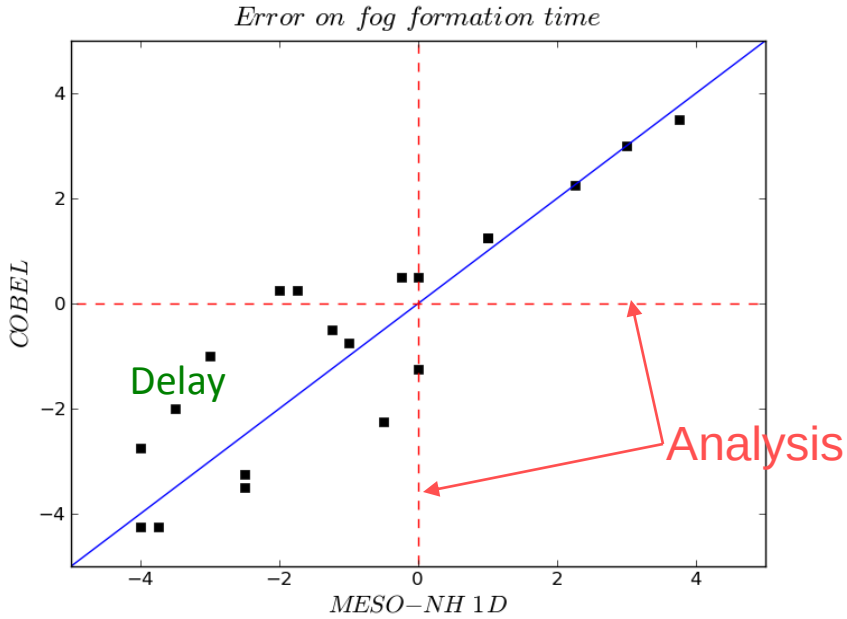


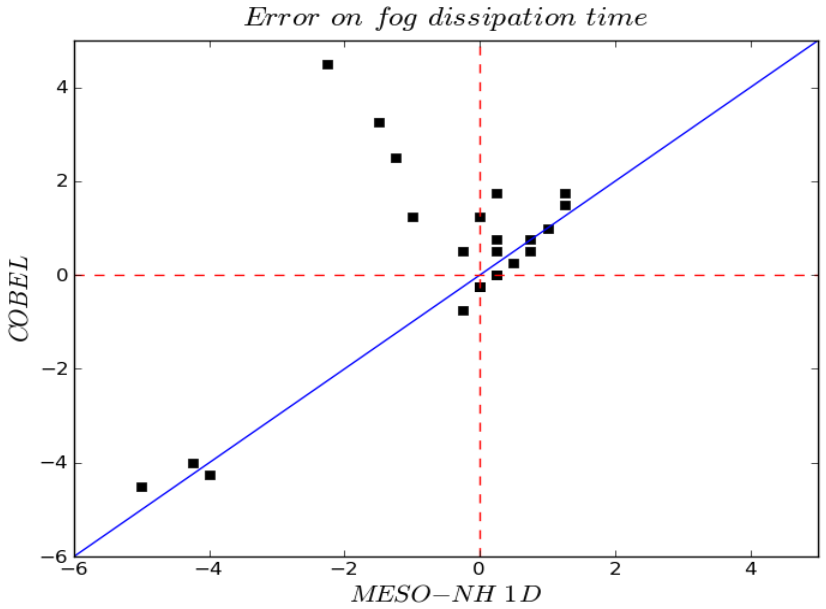
Arome forecasts over Roissy from operational analysis 20101115r18



Comparison COBEL and MESO-NH/AROME 1D

Evaluation of AROME/Méso-NH 1D on radiative fogs on CDG airport for 2 winters :



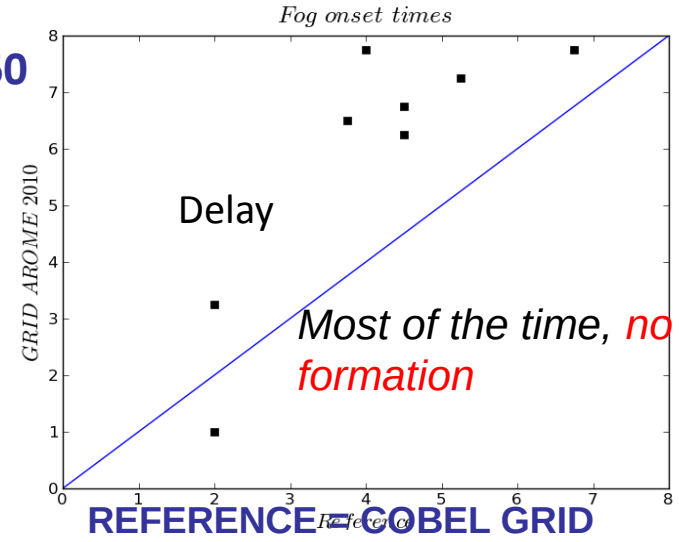


Same vertical resolution (COBEL grid), same surface scheme (7 vertical levels)

Comparison COBEL and MESO-NH/AROME 1D

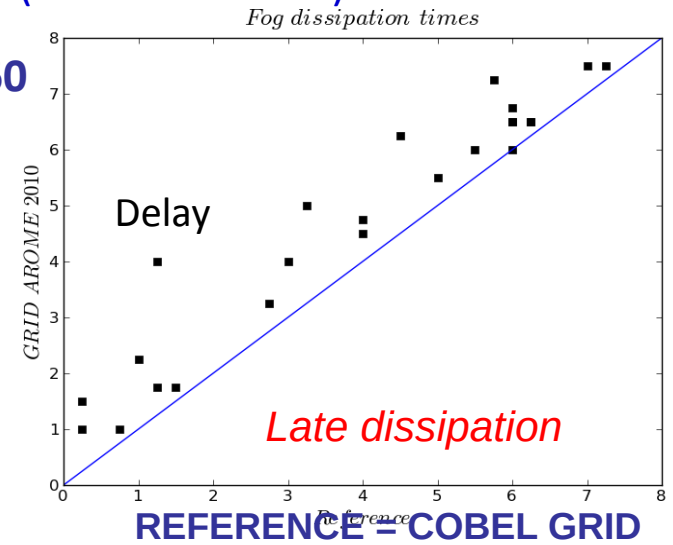
Same surface scheme (7 vertical levels)

L60



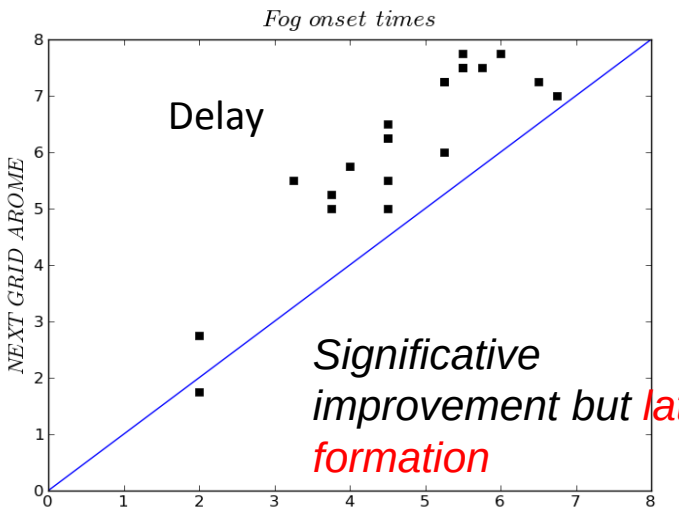
REFERENCE = COBEL GRID

L60



REFERENCE = COBEL GRID

L113



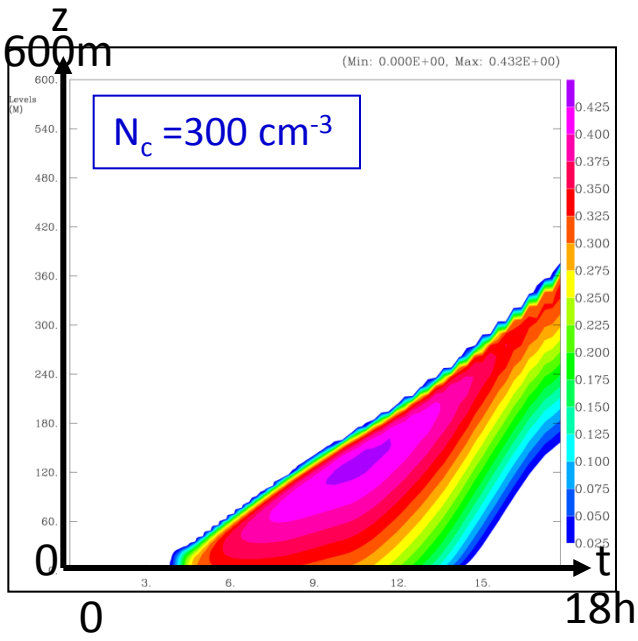
REFERENCE = COBEL GRID

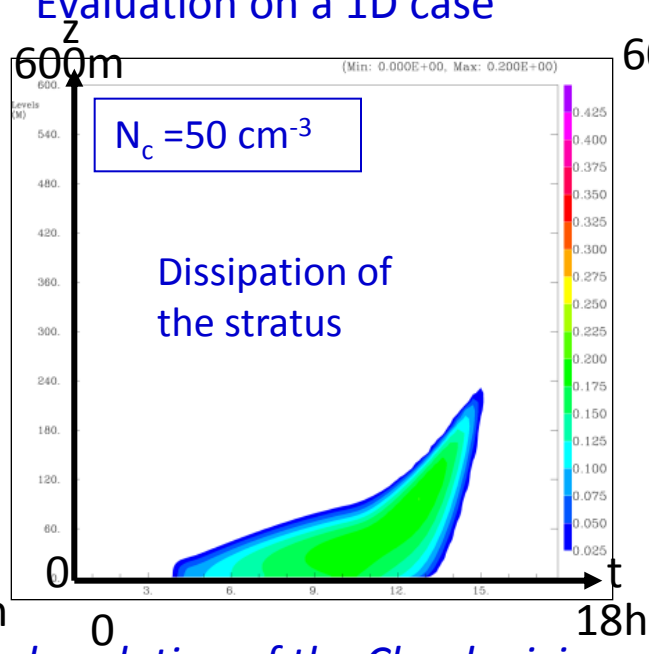
On the importance of the vertical resolution (especially the 1st levels)

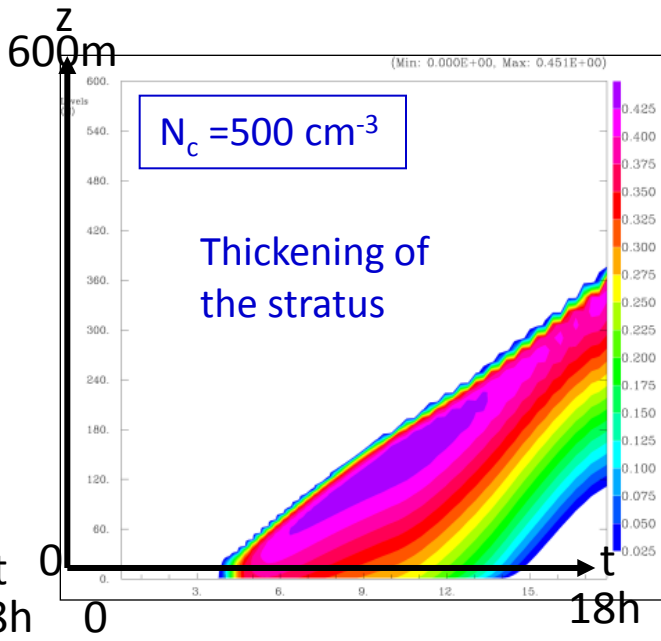
Sensitivity to cloud droplet concentration

With ICE3, droplet concentration (N_c) fixed : N_c = 300 cm^{-3} on land, N_c = 100 cm^{-3} on sea
Interest to introduce a N_c variability, conserving a 1-moment scheme (ICE3) ?
N_c modifies droplet sedimentation and the SW radiative properties

Evaluation on a 1D case







Temporal evolution of the Cloud mixing ratio content

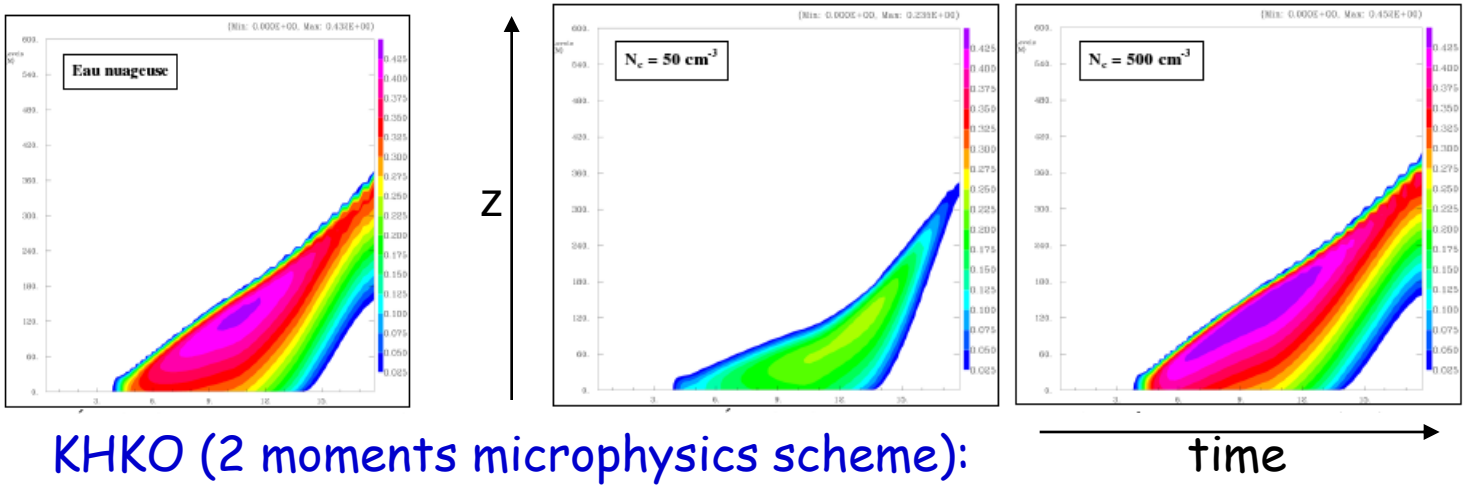
Fog onset and dissipation times are not significantly modified, only the thickness of the cloud (impact on T2M)

→ How to initialize Nc (PM of MACC analysis)?

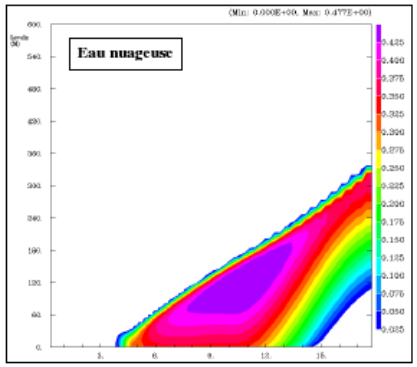
Simulation of polluted/non polluted areas with ICE3

Fog case studies of variation of Nc in microphysics and radiation

ICE3 Ref (Nc=300 cm-3)



KHKO (2 moments microphysics scheme):



Impact of a more sophisticated 2-moments microphysics scheme is reduced.

-> Perspective : use an aerosol analysis to initialise Nc ?

Perspectives

- ✓ R&D on forecasting fog with Arome will continue with high priority
- ✓ Preparation of future Arome configurations: 1.3km for Arome-France and 500m for smaller domain (vertical resolution, etc.)
- ✓ Investigate ways to have a finer vertical resolution in the physics, in priority near the ground in a similar way than CANOPY
- ✓ Try to improve initialization of cloud droplet concentration with real time informations (MACC, MOCAGE, ??)
- ✓ Research studies: 2-moments microphysical scheme, aerosols, LES with MESO-NH of radiation fog for process study (Dx~1m, Dz~1m)


Thank you
for
your attention