Tests about the use of aerosols models to initialize AROME number of cloud droplets in ICE3

Météo-France stay report

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1 Introduction

Fog formation is a complex phenomenon involving microphysical processes which occurs under specific weather situations. It is well known the fact that numerical models have difficulty predicting such features like the onset, development and dissipation of the fog. Therefore, a good microphysical parametrization in the numerical fog modelling is essential. An important microphysical parameter is the number of cloud droplets which can modify the structure and the dynamics of the fog. The limited area model AROME uses a fix number of cloud droplets in the one moment mycrophysical scheme ICE3 ($N_c = 300$ /cm^3 over the land and $N_c = 100$ /cm^3 over the sea). In the near future, in order to improve the modelisation of complex aerosol - clouds - precipitation interactions a new two moments microphysics scheme developped in Meso-NH it is planned to be used. In the meanwhile, an intermediate strategy has been tested.

For this stay, several simulations were performed using the input aerosol fields, from MOCAGE and MACC in order to initialize the number of cloud droplets. In ICE3, the NCC in only used in the cloud water sedimentation process. This was done for a foggy day, using AROME model at 2.5km horizontal resolution and 60 vertical levels, cy40-op1.05, over the France domain.

2 Files transformation

The MOCAGE input file which is an FA file was taken from cougar:
gmgec/mrgm/mrgm204/MOCAGEHM/svgdePREVAIR and the MACC input file, which is a GRIB1 file, was taken from MARS archive *http://apps.ecmwf.int/datasets/data/macc_reanalysis/*

Unfortunately, the 901 configuration (which transforms the GRIB files from MARS archive into ARPEGE files) or the Fullpos configuration were not able to read these fields.
The fields from MOCAGE and MACC inputs were converted from one geometry to another using a tool written in python by S. Riette. The 3D MOCAGE/MACC fields and the 3D pressure field are linear interpolated on the horizontal grid of AROME model (staying on the vertical grid of MOCAGE/MACC and then this result is interpolated on the AROME vertical grid).
From MOCAGE (0.5° x 0.5° horizontal resolution, L47 hybrid levels going from surface up to 5 hPa, with aprox. 8 levels in the PBL; the thickness of the lowest layer is about 40 m) we used 6 bins available for each type of aerosol: sea salt , black carbon and organic matter acting as cloud condensation nuclei (CCN). From MACC (T255L60) just 3 bins of sea salt aerosol, one for hydrophilic organic matter and for sulphate. In the next figures there are some examples with the most consistent fields.

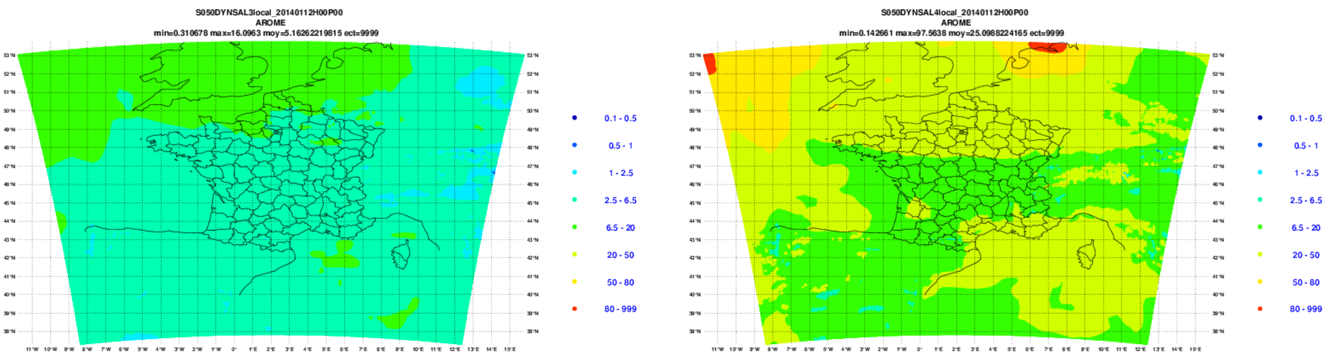

Figure 1: MOCAGE Sea Salt Aerosols Mixing Ratio x E10: left - DYNSAL3 and right - DYNSAL4

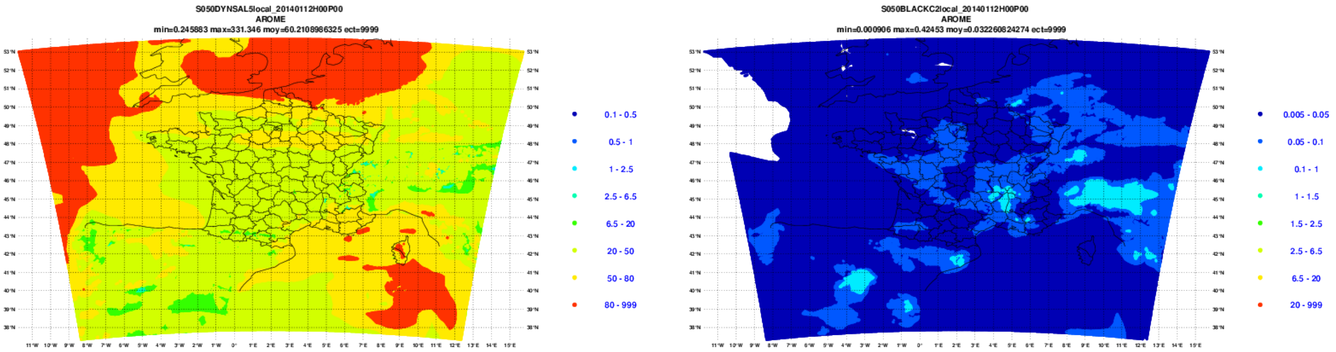

Figure 2: MOCAGE Sea Salt Aerosols Mixing Ratio x E10 - left - DYNSAL5 and right - Hydrophilic Black Carbon Aerosol Mixing Ratio - BLACKC2

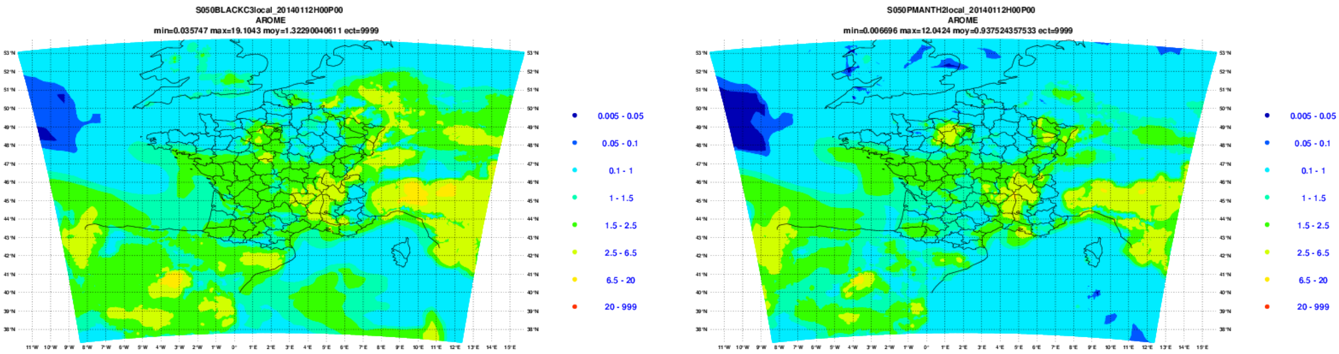

Figure 3: MOCAGE Hydrophilic Black Carbon Aerosol Mixing Ratio x E10 -left - BLACKC3 and right -Hydrophilic Organic Matter Aerosol Mixing Ratio - PMANTH2

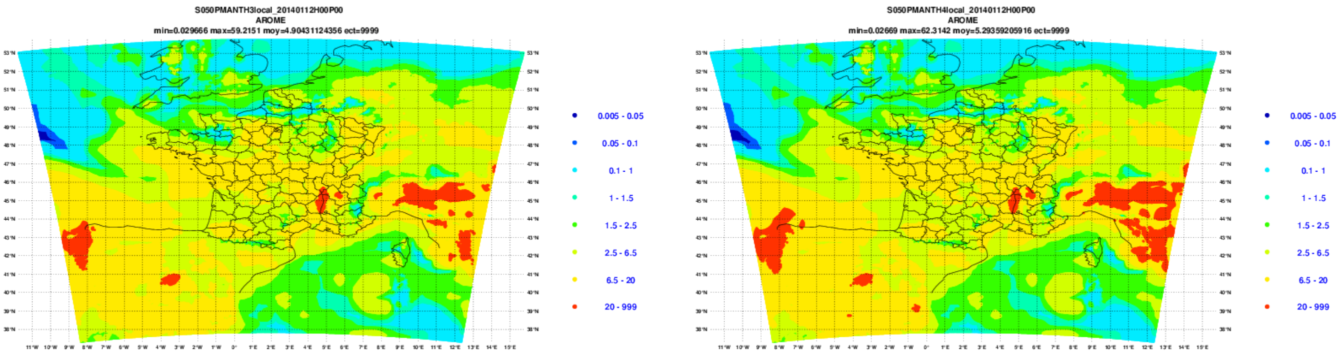

Figure 4: MOCAGE Hydrophilic Organic Matter Aerosol Mixing Ratio x E10: left - PMANTH3 and right - PMANTH4

In fig. 5, the maximum values for all the MOCAGE and MACC aerosols fields are shown. As we can see, for MOCAGE, the sea salt aerosol bin DYNSAL5 has the most impact, while for MACC is the sea salt aerosol bin AERMR03 [5 - 20 um].

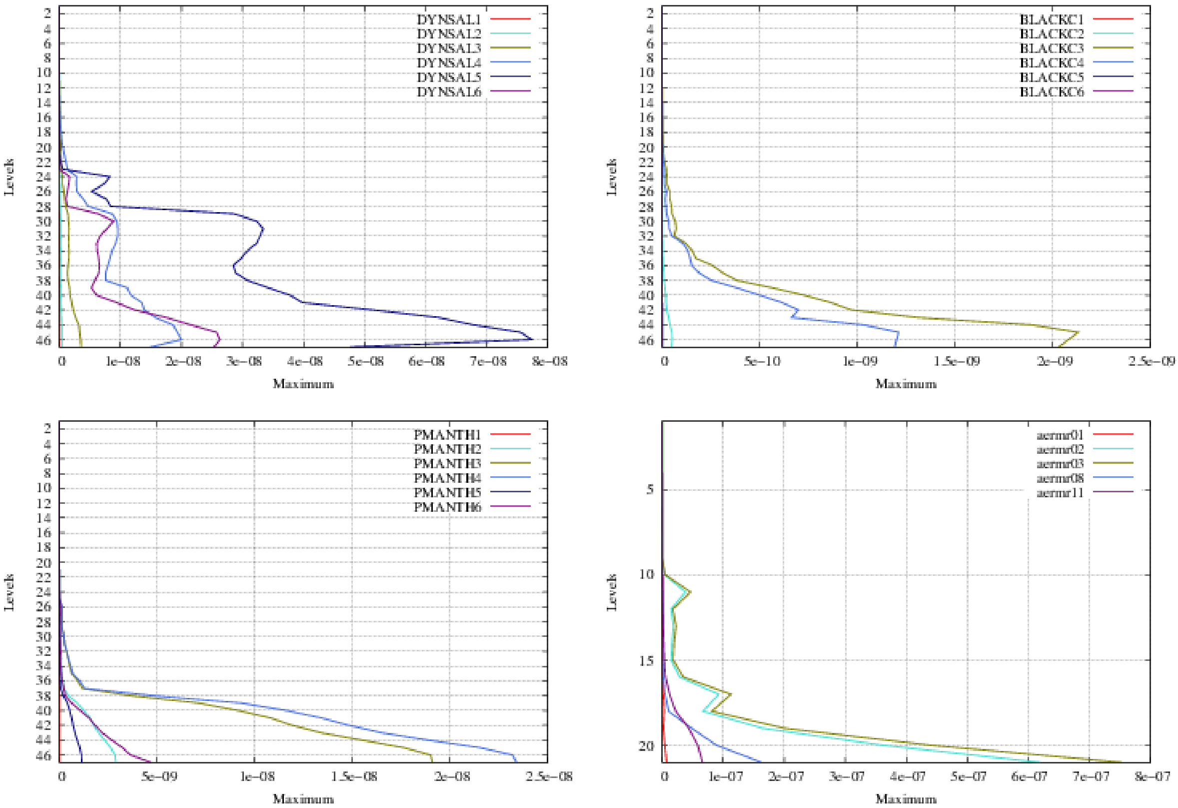

Figure 5: MOCAGE aerosols: up - sea salt (DYNSAL) and black carbon (BLACKC); bottom: organic matter (PMANTH) and MACC aerosols;12th January 2014, France domain

3 Code modifications

The new pack is on beaufix : "/home/gmap/mrpe/pietrisim/pack/cy40_op1.05.IMPI411IFC1301.2x.pac
The EZDIAG structure was used in order to initialize the aerosol fields in NAMGFL namelist. The five new variables were added into NAMPARAR namelis: RMAXAER (which was initialize in suparar.F90 routine with the maximum value 1.80733e-07), RMINNCC, RMAXNCC, LMACC and LMOCAGE.
hpace*1cmThe formulae to convert the total mass of aerosols in cloud droplet concentration is:
$NCC = (RMINNCC + NCC * (RMAXNCC - RMINNCC)/RMAXAER * 1E6$
The modified routines are:

- arpifs/phys_dmn/apl_arome.F90;
- arpifs/phys_dmn/suparar.F90;
- mpa/micro/externals/aro_rain_ice.F90;
- mpa/micro/internals/rain_ice.F90;
- arpifs/module/yomparar.F90;
- arpifs/namelist/namparar.nam.h

4 Case study: 12 January 2014

The fog event was analyzed in this study occured on the 12th of January 2014. The general weather condition during this fog event was characterized by an high-pressure ridghe over Central Europe and a vast Atlantic trough.

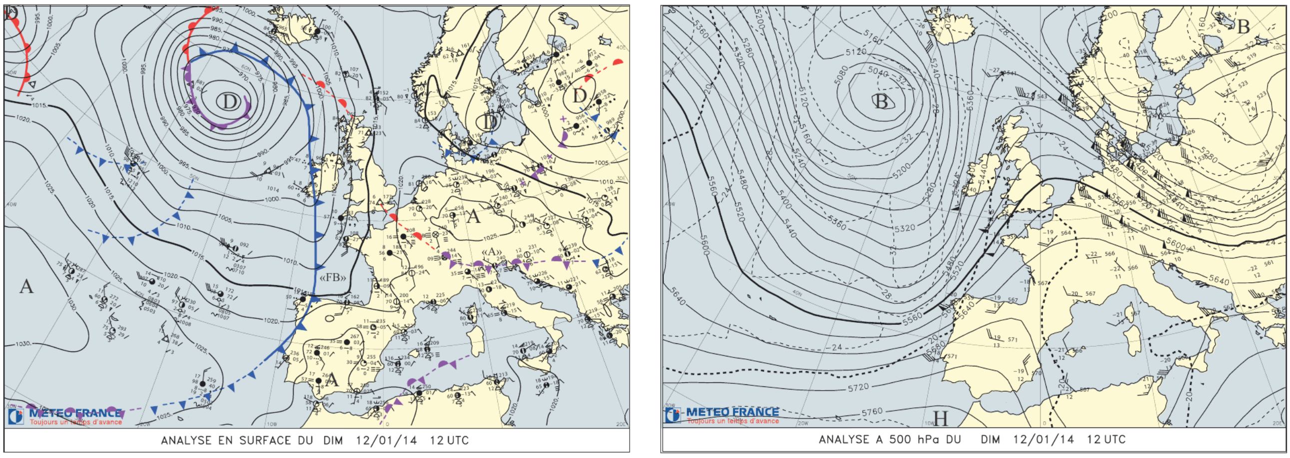

Figure 6: Surface analyse (left) and Altitude analyse at 500 hPa (right) for 12th of January

The performed simulations were compared with the reference one.

- 85QF - experiment with input aerosols fields from MOCAGE;
- 85R2 - experiment with input aerosols fields from MACC;
- 85QI - reference

We plot the 2D horizontal fog distribution of the most important parameters for the fog phenomen. Bellow is one example of cloud water content at the lowest model level.

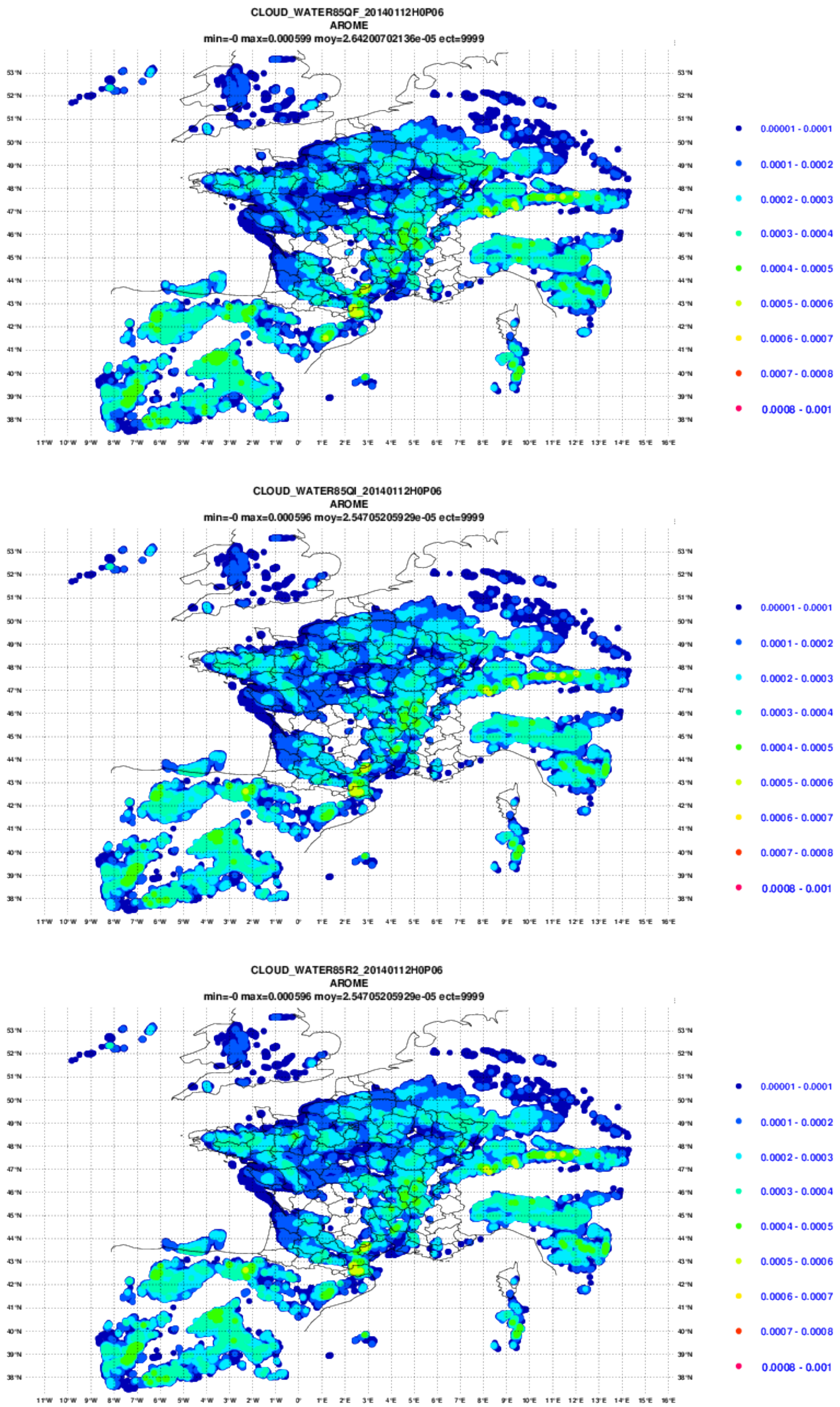

Figure 7: Cloud water content at the lowest model level: up - MOCAGE experiment; middle - Reference and bottom - MACC experiment; 12th of January 2014, run 00 UTC + 6h

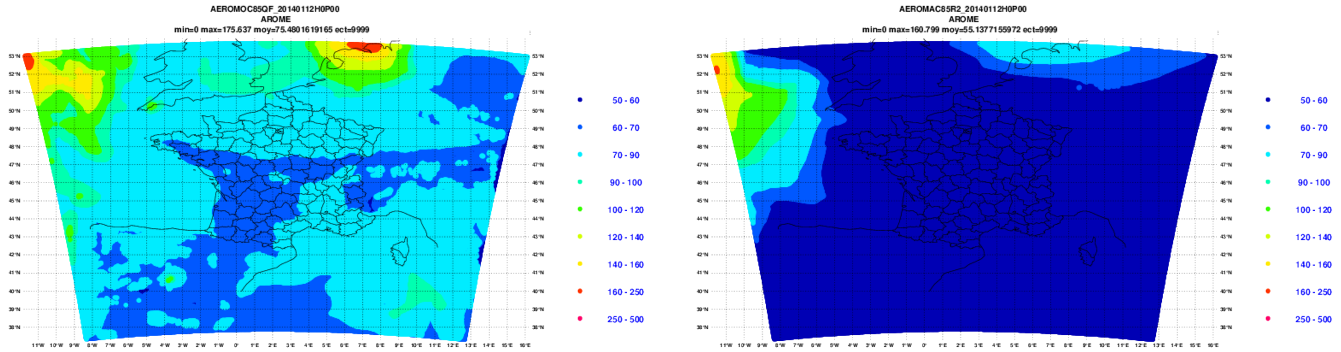

Figure 8: Cloud droplet number for the lowest model level: left - MOCAGE experiment and right - MACC experiment

Using ddhtools, for the foggy day, we plot the time evolution of vertical profiles over Paris (PARI), Picardie (PICA), Bretagne (BRET) and Normandie (NORM) areas, for

- relative humidity (not shown);
- cloud cover;
- liquid water.

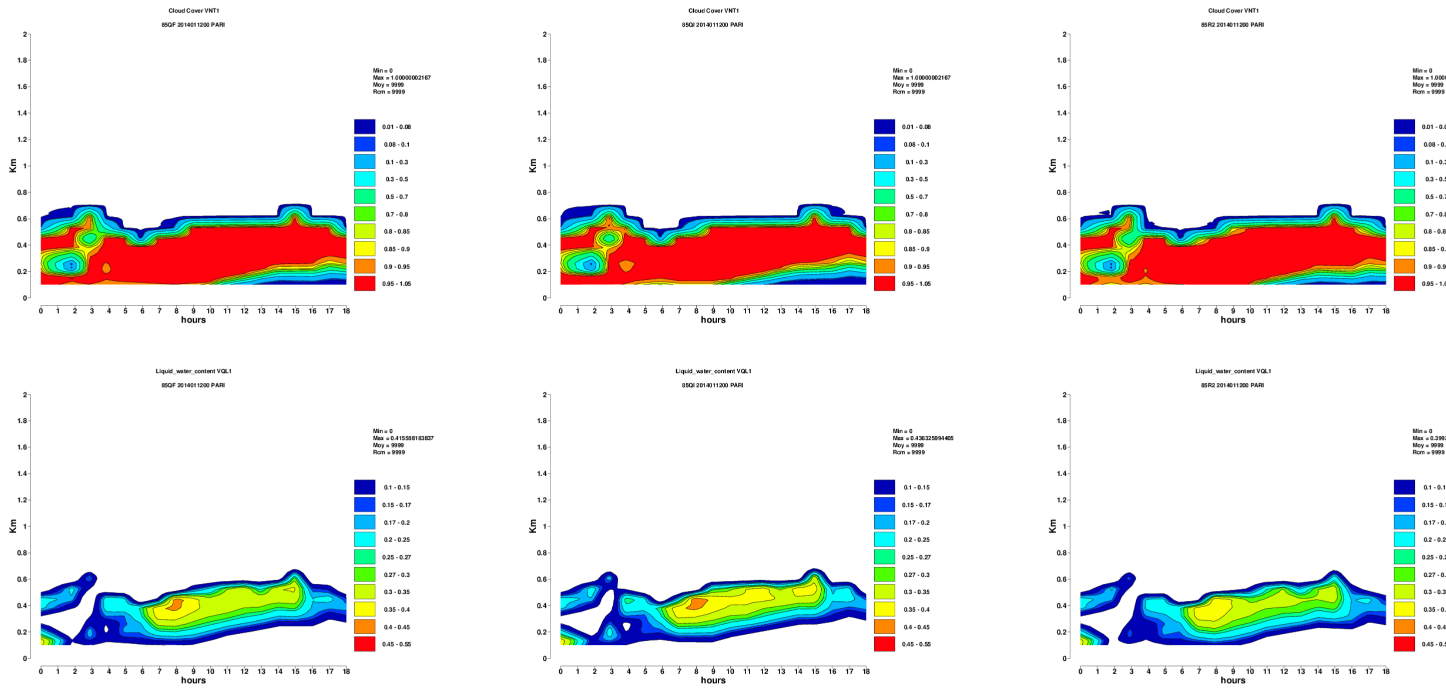

Figure 9: Time evolution of vertical profile for cloud cover (up) and liquid water content (bottom) for PARIS area: left - MOCAGE experiment, middle - Reference and right - MACC experiment

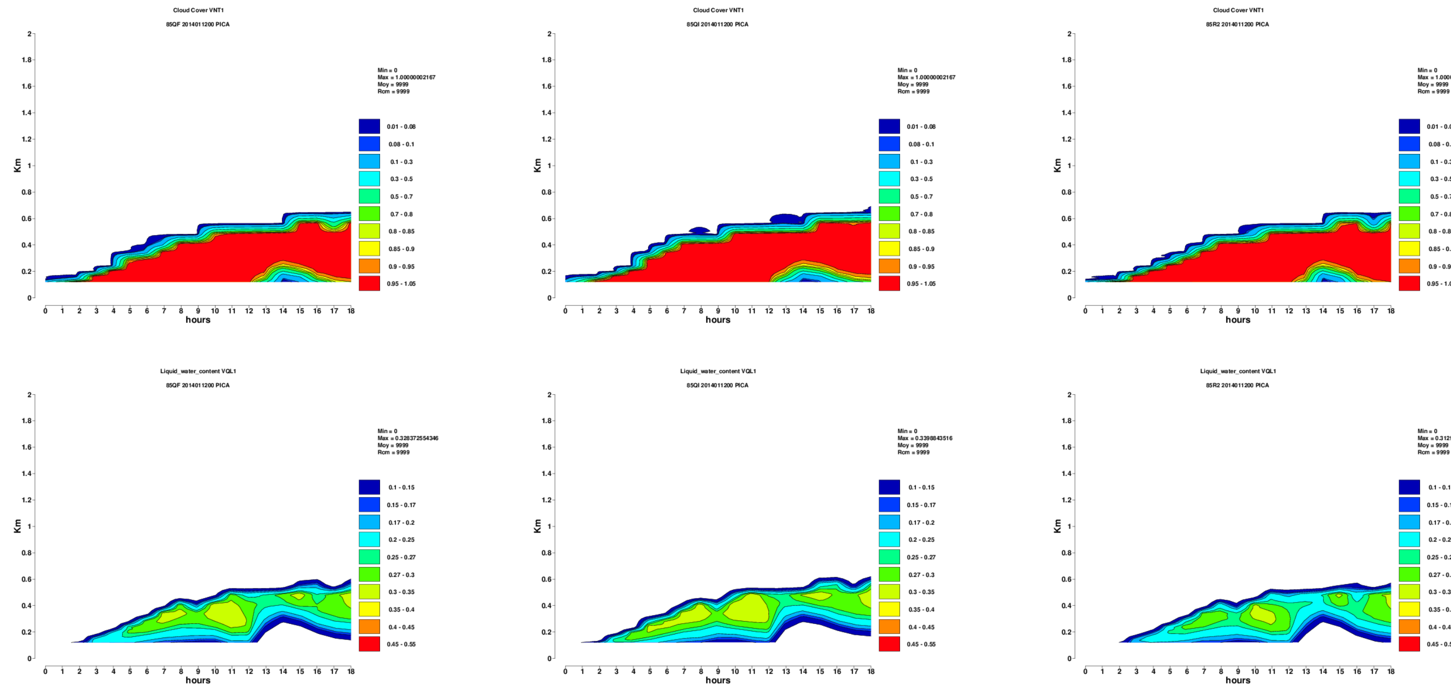

Figure 10: Time evolution of vertical for cloud cover (up) and liquid water content (bottom) for Picardie area: left - MOCAGE experiment, middle - Reference and right - MACC experiment

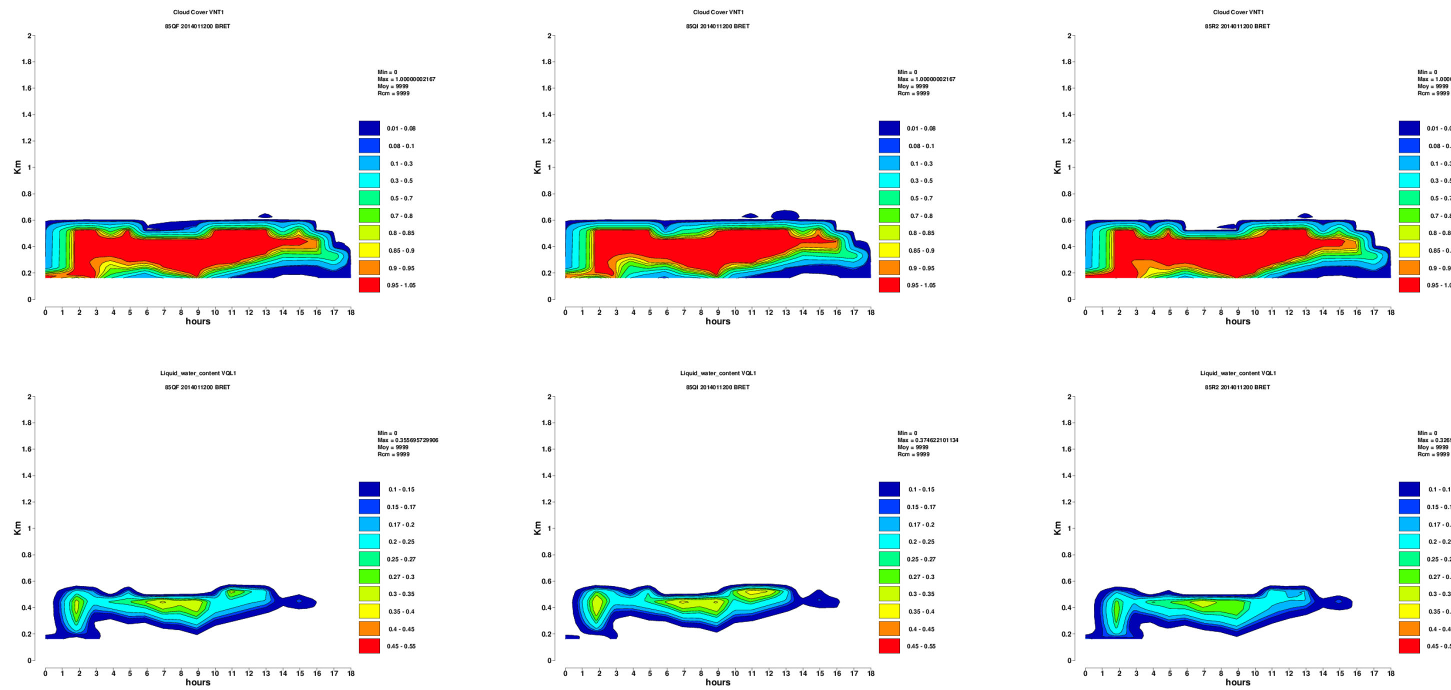

Figure 11: Time evolution of vertical profile for cloud cover (up) and liquid water content (bottom) for Bretagne area: left - MOCAGE experiment, middle - Reference and right - MACC experiment

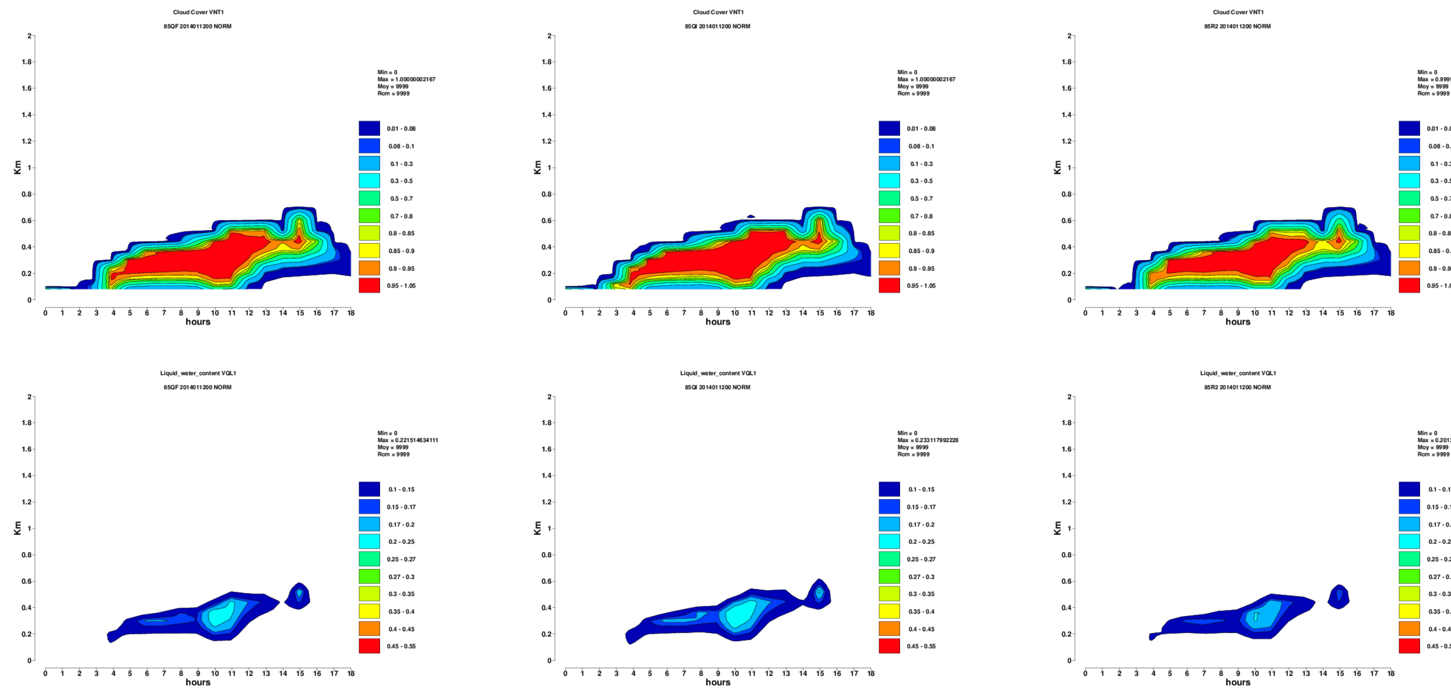

Figure 12: Time evolution of vertical profile for cloud cover (up) and liquid water content (bottom) for Normandie area: left - MOCAGE experiment, middle - Reference and right - MACC experiment

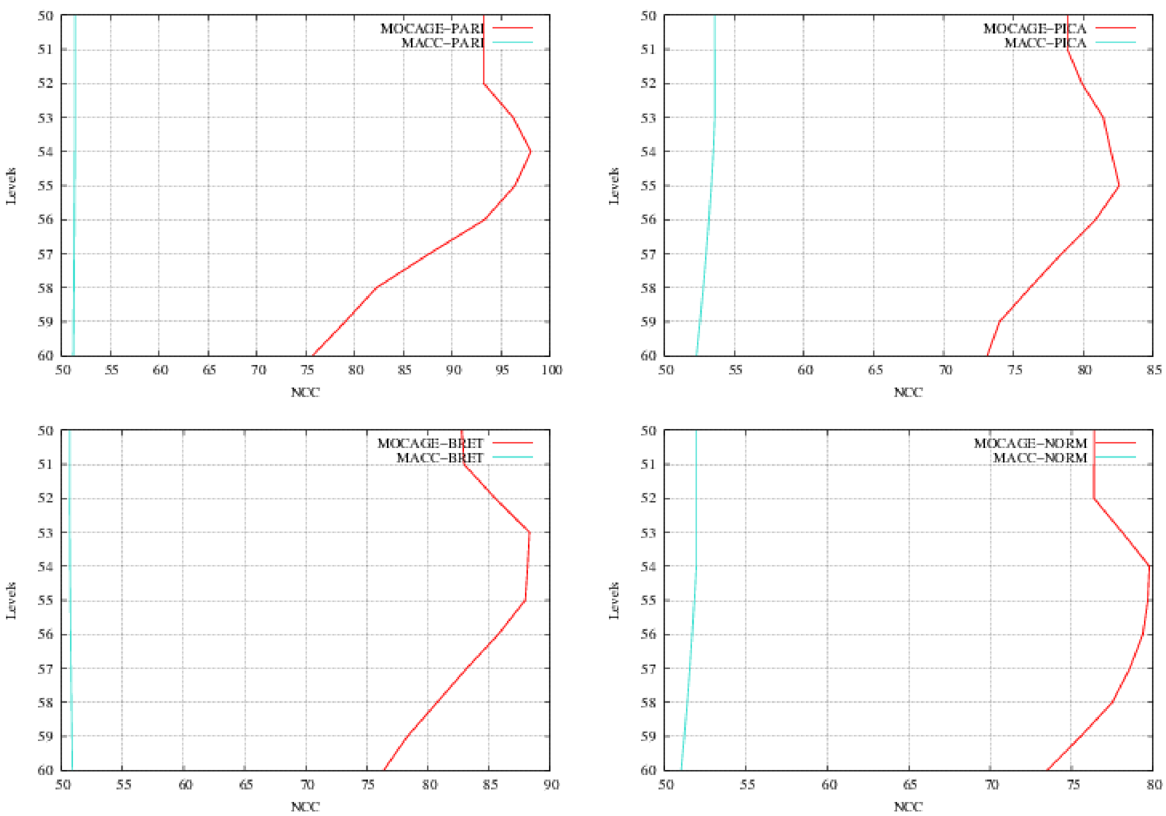

Figure 13: Vertical profile of total cloud droplets for all the four areas: up - Paris and Picardie and bottom - Bretagne and Normandie

5 Conclusions

- on the 2D horizontal fields the differences between the fields of the experiments are not too big (Fig.7);
- as it is observed from the vertical profile of the last 10 model levels, the MOCAGE NCC has bigger values than MACC NCC (Fig.13), as it is also seen in the 2D plots of Fig.8;
- for all four areas, for the experiment with input aerosols fields from MACC, the liquid water content has the smallest values comparing with the other experiment and the reference one. It is probabily due to smaller NCC which led to bigger cloud droplet (this causes to fog to dissipate sooner);
- the shape of the cloud cover field is the same for all the chosen areas in both experiments; Also, it is noticeble that comparing with the reference, the fog formation is delayed with one hour for Picardie area (Fig.10); also the fog dissipation is delayed with one hour for Paris area (Fig.9) ;

6 Outlook

- to redo such test using AROME at 1.3km, L90;
- to add NCC impact on radiative code interface;
- take into account the individual aerosols mass in the conversion mass to NCC;
- test on a longer period;
- work on 901 and Fullpos configurations (link with Interoperability project) in order to be able to read MACC/MOCAGE fields directly.

Acknowledgments
We particularly thank Sebastian Riette for the development of the "converto" phyton tool.
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References

[1] Y. Seity, P. Brousseau, S.Malardel, G. Hello, P. Benard, F. Bouttier, C. Lac, and V. Masson, 2011, *The AROME-France Convective-Scale Operational Model, MWR, 139, 976-991*;

[2] M.Civiate, G.Kaufmann, E.Blot, J.Ridao, 2012, *Vers une prévision numérique 3D du brouillard pour Paris-CdG: tests de sensibilité à la microphysique*;