# Sensibility tests of the LIMA scheme in AROME

RC LACE stay report

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## Introduction

Last year I started to work on the initialization of aerosols in LIMA scheme in convective cases. During this stay I continued this work, and I compared the aerosol initialization with MOCAGE and MACC in fog cases.

The following experiments were carried out:

- ICE3 as a reference run,
- LIMA-REF as a reference among the LIMA runs, initialization with a constant value of 300 CCN per cubic meter,
- LIMA-MACC initialization with MACC fields,
- LIMA-MOCAGE initialization with MOCAGE fields.

These experiments were run only over a smaller domain around Bure in 39 cases between November 2015 and January 2016. The listed dates can be seen in Table 1.

| **October 2015** | **November 2015** | **December 2015** | **January 2016** |
|---|---|---|---|
| 17/10/2015 | 01/11/2015 | 01/12/2015 | 01/01/2016 |
| 18/10/2015 | 02/11/2015 | 05/12/2015 | 06/01/2016 |
| 20/10/2015 | 03/11/2015 | 10/12/2015 | 09/01/2016 |
| 21/10/2015 | 06/11/2015 | 12/12/2015 | |
| 22/10/2015 | 07/11/2015 | 16/12/2015 | |
| 23/10/2015 | 11/11/2015 | 17/12/2015 | |
| 25/10/2015 | 20/11/2015 | 23/12/2015 | |
| 26/10/2015 | 21/11/2015 | 26/12/2015 | |
| 29/10/2015 | 22/11/2015 | 30/12/2015 | |
| 30/10/2015 | 23/11/2015 | 31/12/2015 | |
| 31/10/2015 | 24/11/2015 | | |
| | 25/11/2015 | | |
| | 26/11/2015 | | |
| | 27/11/2015 | | |
| | 28/11/2015 | | |

*Table 1: Fog cases at Bure station*

In 2016 a conversion python script using epigram software was developed in order to convert and interpolate aerosol fields of MOCAGE and MACC.
MOCAGE initialization worked fine but there were problems with the conversion of MACC fields: two consecutive runs gave different results, and sometimes strange trapezoid shape occurred over the whole vertical column. After the right declaration of the variables the script worked properly.

From the default ICE3 scheme it is easy to access DDH files, however, we also wanted to gain DDH files from LIMA experiments. Unfortunately, it turned out that this improvement was not ready to be used during my stay, because the runs with DDH and without DDH gave different results in spite of the same initial conditions. Fortunately, we can plot the same variables from the historical (ICMSH) files with a python script, but because of the big size of these files this method was much slower and it offered less flexibility in plotting. Due to these limitations the measurements can be applied only in the plot of the ICE3 reference run produced from DDH.

**Number concentrations in the different sources**

The mixing ratio is the unit which is was used in the models where the aerosol fields come from, and these values belong to a given aerosol size. From these values the number concentrations are calculated with the help of the size distribution function. However, the parameters of this function are different in the two distinct models, so in spite of the similar mixing ratio values the number concentrations could be very different as well (see Figure 1 and 2).

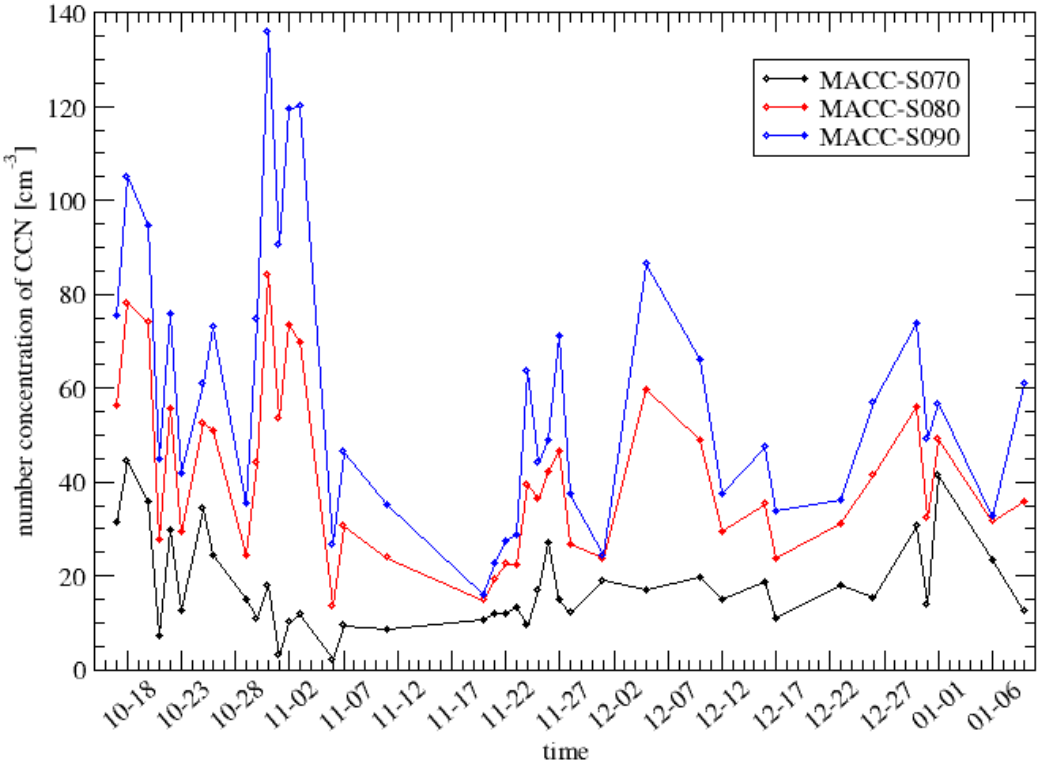


*Figure 1: Calculated averaged number concentrations of CCN at three model levels from MACC data*

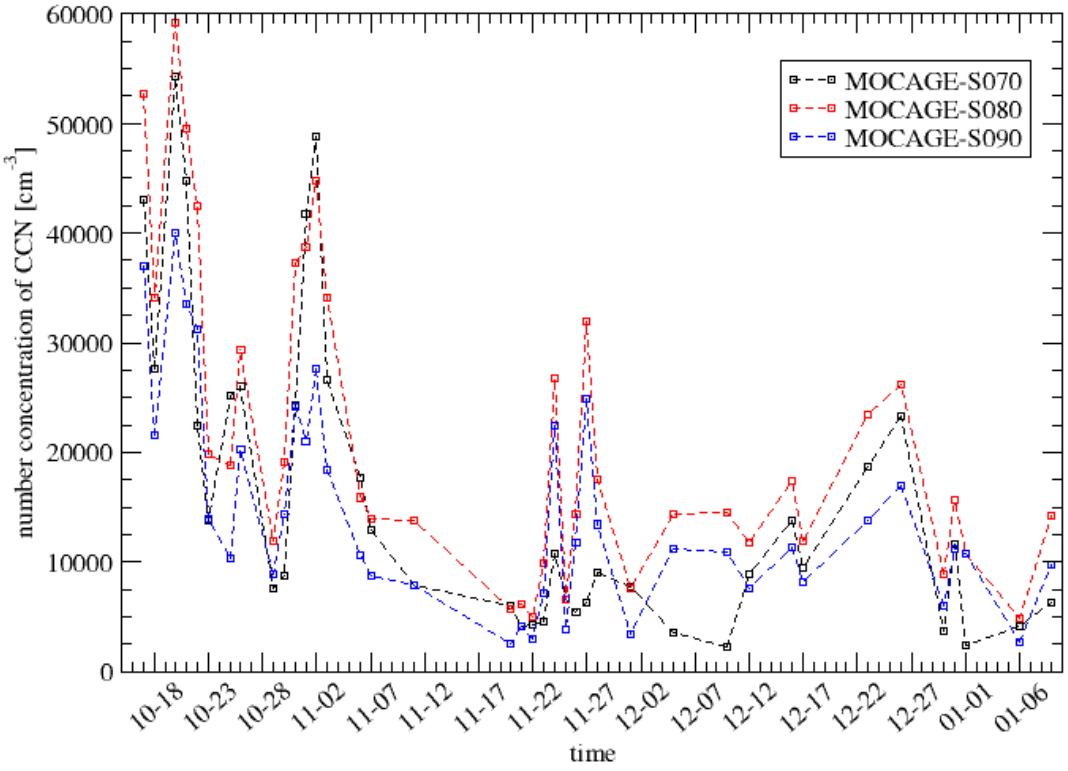


*Figure 2: Calculated averaged number concentrations of CCN at three model levels from MOCAGE data*

**Liquid water content**

After the first experiments it turned out that in these fog cases the cloud droplets sedimentation can play an important role. This is the reason why the model can produce low level water content. So the LSEDC variable from namelist was set to TRUE so that this setting helps to go closer to the reference ICE3 run where the subgrid condensation was switched on. Unfortunately it has not been implemented into the LIMA scheme yet but after seeing its importance, it will definitely happen. In the following, six experiments were plotted: the first two are the original ICE3 with and without subgrid condensation, the reference LIMA run with and without cloud sedimentation, and finally LIMA initialized from MACC and MOCAGE. In these figures in the top-left corner there is one of the ICE3 experiment values with the observations: the black horizontal line indicates the presence of fog at the given height from the measurements (it was measured at three levels). This figure was made from DDH, so this is the reason that this plot seems a little different, while the colorbar is the same as the others from the ICMSH files.

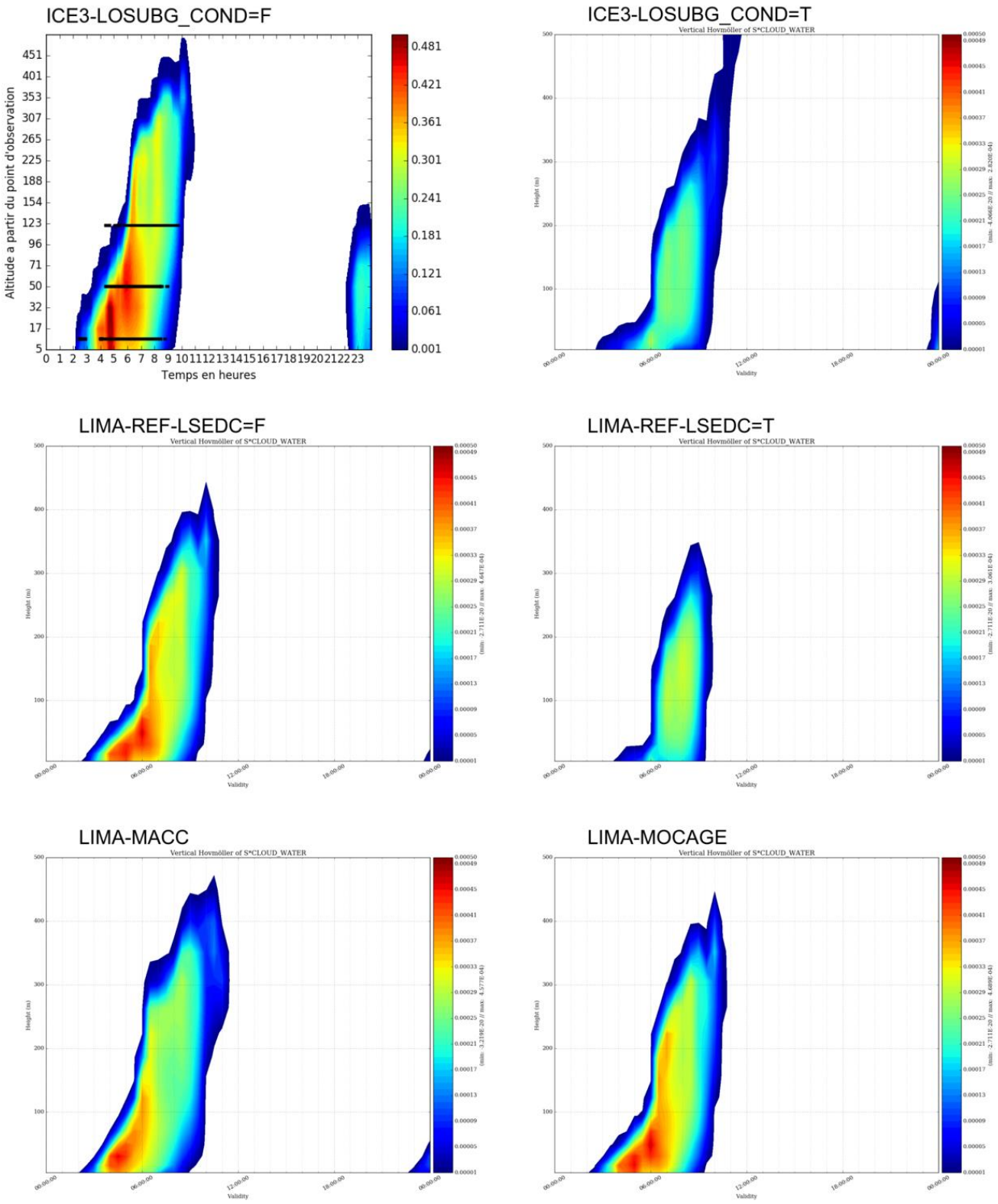


*Figure 3: Time-height cross section of **LWC** on 20th October 2015 in 6 different cases: ICE3 with (b) and without (a) subgrid condensation, LIMA-REF with (d) and without (c) cloud sedimentation, LIMA with MACC (e) and LIMA with MOCAGE (f). In figure (a) the black horizontal lines show the observations: the duration of the fog (3 levels: 10m, 50m, 120m*

**Case study: 20th October 2015**
On this date the fog appeared in the morning and it was measured at all of the three heights. In this case it was interesting that ICE3 without subgrid condensation gives more cloud water than with it, and similarly, in LIMA-REF without cloud sedimentation the LWC is higher (see Figure 3), and the duration of the fog is also longer. ICE3 without subgrid condensation forecasts fog for the next night as well, but there was no fog based on the measurements. This phenomenon can not be seen in the LIMA cases.

**Case study: 22nd October 2015**
In this case the fog lasted during the whole day and the models also gave low clouds (see Figure 4), but in some cases this cloud was not low enough (without subgrid condensation or cloud sedimentation). When LOSUBG_COND (ICE3) and LSEDC (LIMA) were switched on, the cloud base became lower and reached the surface similar to the observations. It can be seen that the MOCAGE experiment is very similar to the LIMA-REF run, meanwhile the LWC is lower in the MACC experiment. We suspect that in the MOCAGE case all CCNs are activated and above a certain number of aerosols they remain free. In MACC cases the number concentration is smaller, so fewer CCNs are activated, so the cloud droplets can grow larger and finally they fall down from the cloud, so the total precipitation is higher than in the other cases (see Figure 5).

**Case study: 1st November 2015**
According to the measurements there was fog in the morning, after that it dissolved and in the afternoon it appeared again, but this time the fog was thicker. As can be seen in Figure 6, the model with ICE3 predicts well the two foggy events but the second one begins later in the model. ICE3 with subgrid condensation gives lower LWC values with a little lower cloud top, and the fog formation in the second case begins earlier. In LIMA this second fog is less emphatic, moreover, in the case with cloud sedimentation the fogs almost completely disappeared. In parallel with this, the precipitation fields show high values in this case (see Figure 7).

## Summary

The experiments run during the stay have highlighted some problems with LIMA, so in the future we will try to focus on the followings:

- More thorough investigation into very high CCN numbers in LIMA-MOCAGE runs
- Fixing DDH problem in LIMA
- More detailed investigation into the temporal evolution of LIMA variables
- Rerunning LIMA-MACC and LIMA-MOCAGE experiments with cloud sedimentation

## Acknowledgment

I would like to thank Yann Seity for all his help and guidance during my stay. I found the discussions really useful with him and Benoit Vié this year again.

## References

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*Vié, B., Pinty, J.-P., Berthet, S., and Leriche, M.*: LIMA (v1.0): A quasi two-moment microphysical scheme driven by a multimodal population of cloud condensation and ice freezing nuclei, *Geosci. Model Dev.*, 9, 567-586, doi:10.5194/gmd-9-567-2016, 2016.

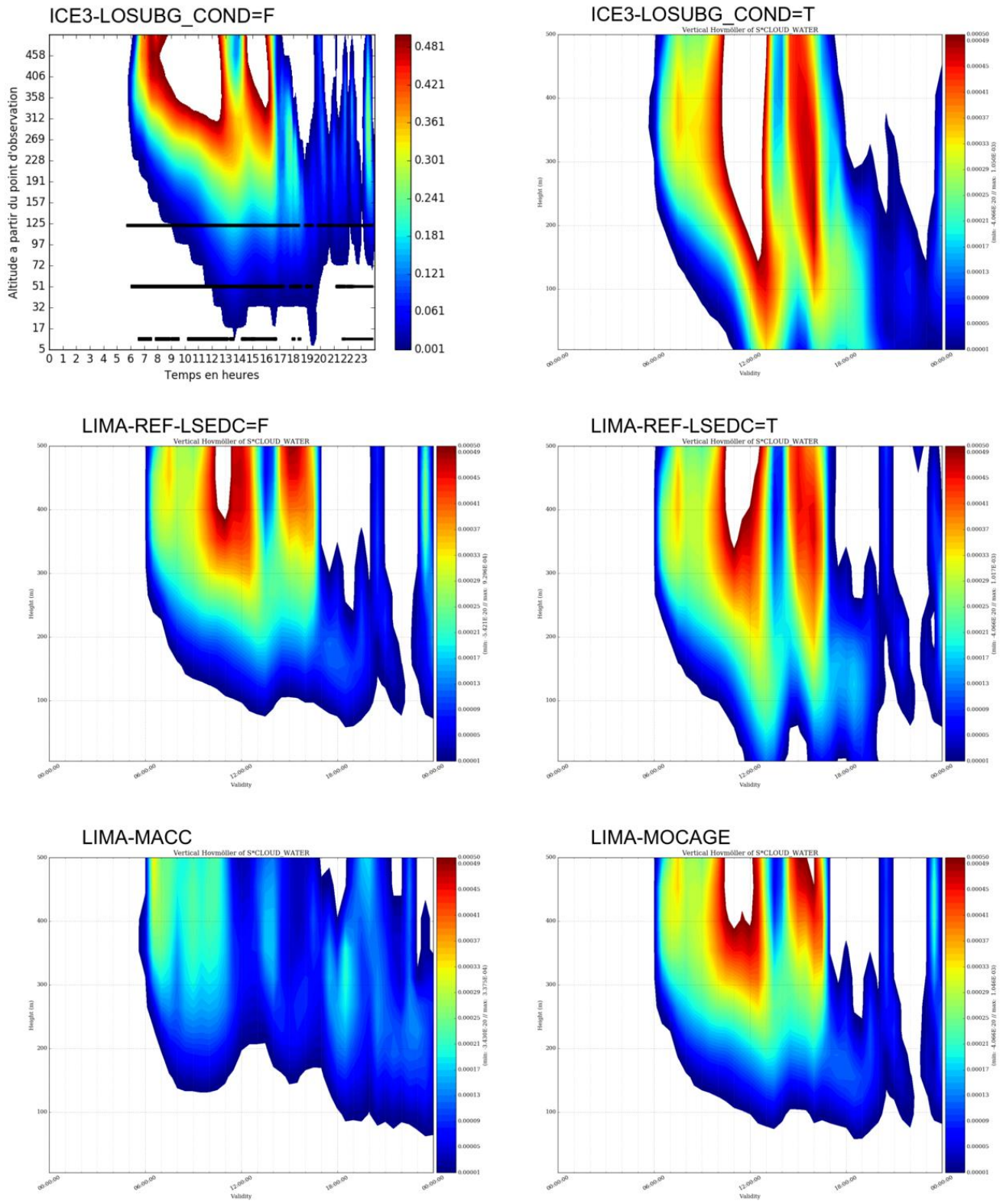


*Figure 4: Time-height cross section of **LWC** on 22nd October 2015 in 6 different cases: ICE3 with (b) and without (a) subgrid condensation, LIMA-REF with (d) and without (c) cloud sedimentation, LIMA with MACC (e) and LIMA with MOCAGE (f). In figure (a) the black horizontal lines show the observations: the duration of the fog (3 levels: 10m, 50m, 120m*

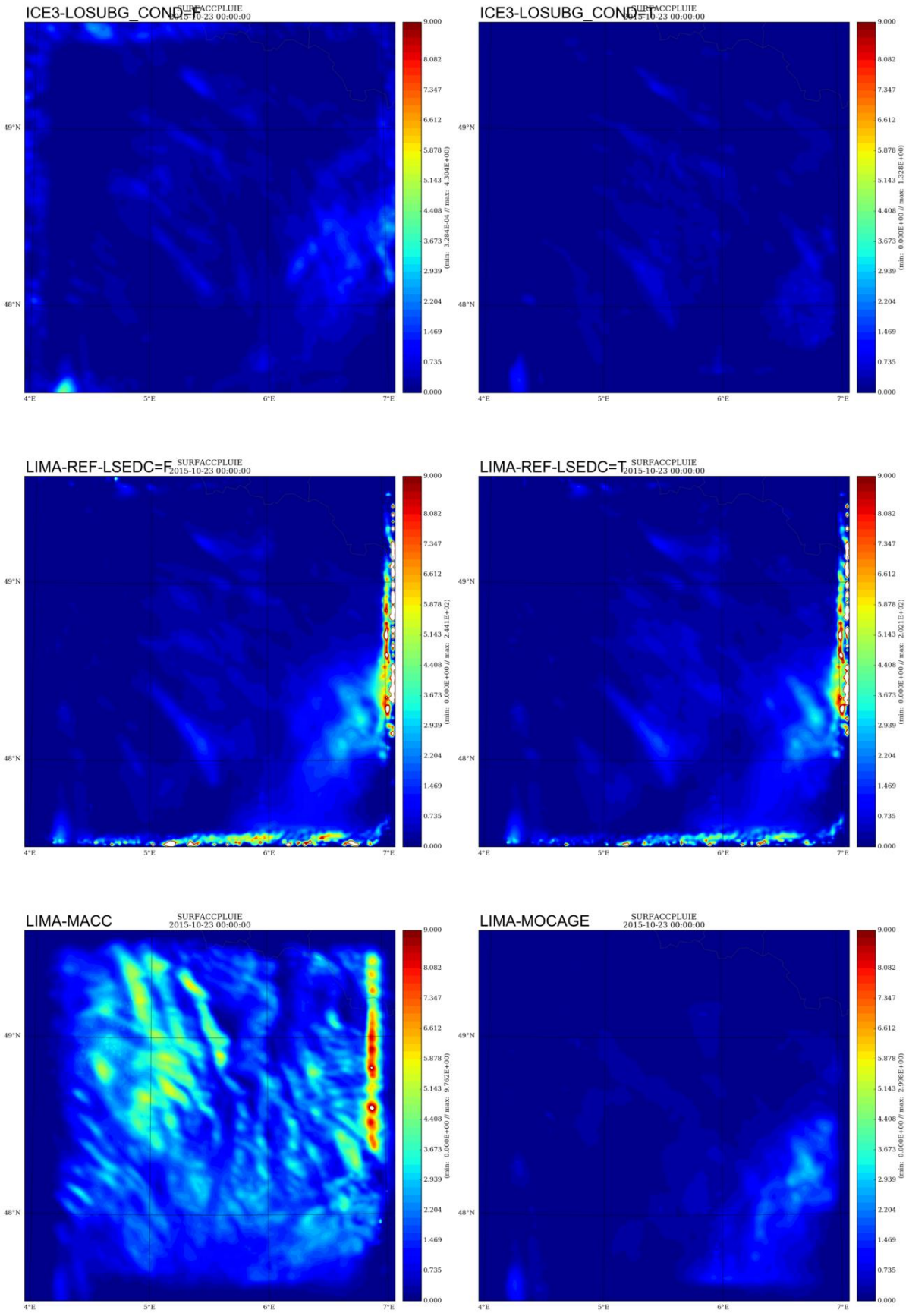


*Figure 5: 24-h **precipitation** fields on 22nd October 2015 in 6 different cases: ICE3 with (b) and without (a) subgrid condensation, LIMA-REF with (d) and without (c) cloud sedimentation, LIMA with MACC (e) and LIMA with MOCAGE (f)*

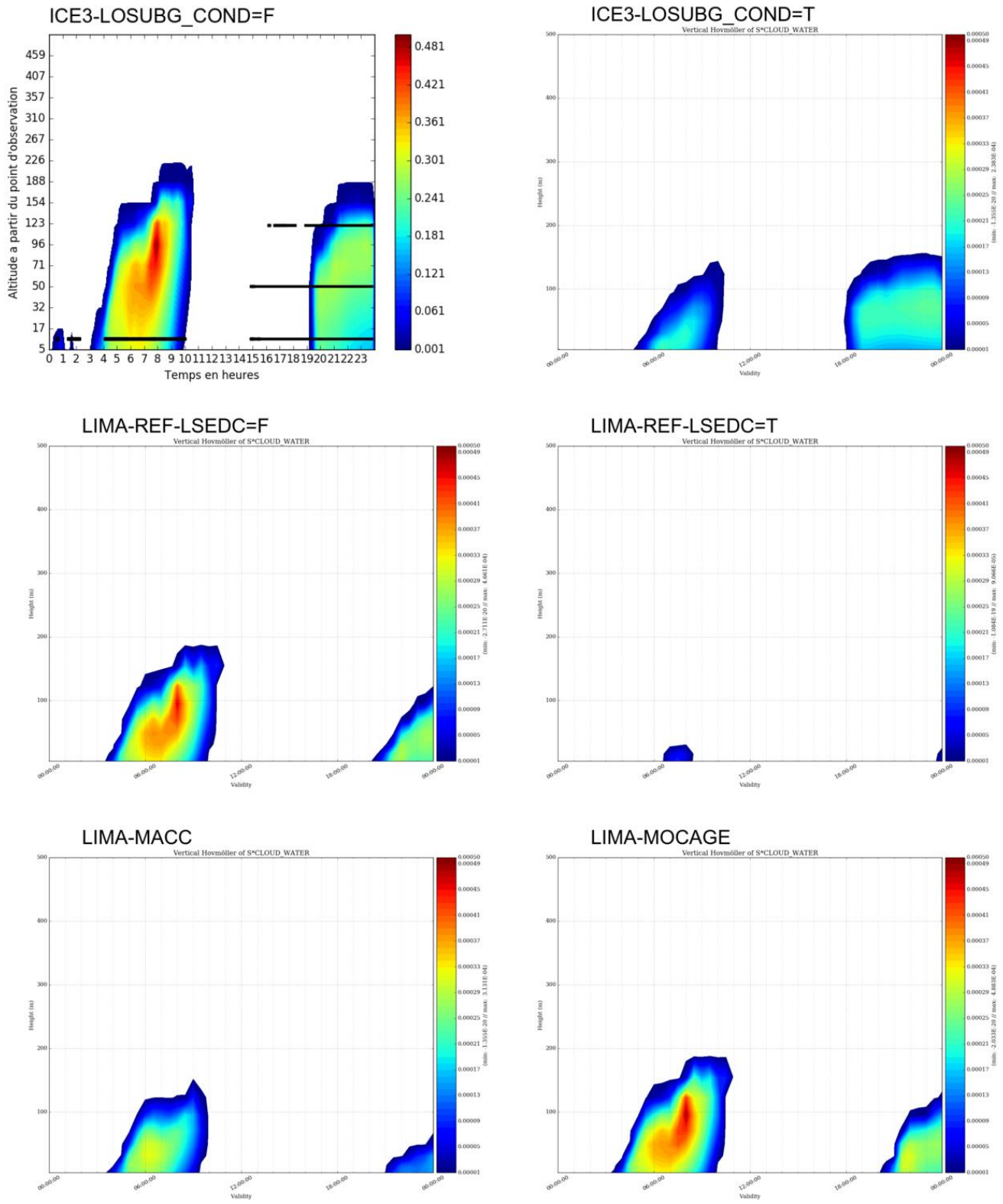


*Figure 6: Time-height cross section of **LWC** on 1st November 2015 in 6 different cases: ICE3 with (b) and without (a) subgrid condensation, LIMA-REF with (d) and without (c) cloud sedimentation, LIMA with MACC (e) and LIMA with MOCAGE (f). In figure (a) the black horizontal lines show the observations: the duration of the fog (3 levels: 10m, 50m, 120m*

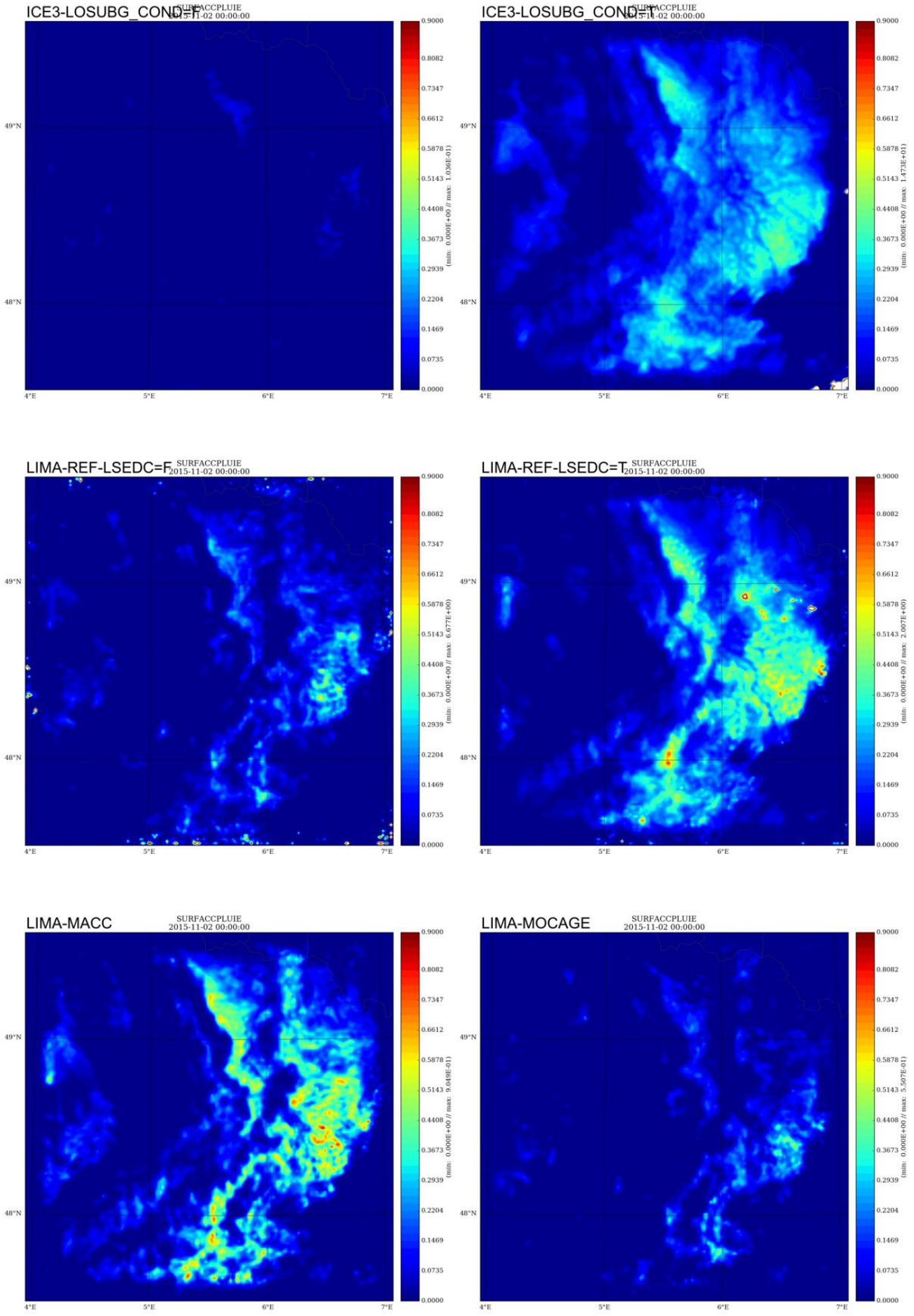


*Figure 7: 24-h **precipitation** fields on 1st November 2015 in 6 different cases: ICE3 with (b) and without (a) subgrid condensation, LIMA-REF with (d) and without (c) cloud sedimentation, LIMA with MACC (e) and LIMA with MOCAGE (f)*