Sensibility tests of the LIMA scheme in AROME

RC LACE stay report

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Introduction

LIMA (Liquid Ice Multiple Aerosols) scheme is a two-moment microphysical scheme, which was developed in MESO-NH to improve modeling of the complex aerosol–cloud interactions. For now the scheme has been implemented in AROME model and the test of the scheme in AROME is still ongoing. During this stay some sensibility tests were planned in fog cases, but unfortunately because of technical difficulties only one day was investigated in more details.

As it was experienced in ICE3 scheme, different vertical and horizontal resolution has a big impact to the forecast of fog events, so LIMA was supposed to be tested on different resolution, but finally there were successful runs only on 1250 m horizontal and 90 levels vertical resolution during the LACE stay (two times two weeks long). In this experiment a smaller area was tested with Garonne valley, where Meteo France colleagues are planning to perform a field campaign.

The experimental run with LIMA was carried out with some modifications of LIMA scheme: it contained some upgrades and in this version the radiation scheme also used the number concentrations of aerosols from the LIMA scheme. At first we use cycle 42 but after the failure of the first two weeks, we took a try with cycle 45 too and finally we got a working version with 1250 m horizontal and 90 levels vertical resolution. A six-months long winter period has been run by the beginning of the second part of the stay, so after that the aim was to evaluate some statistical characteristics from this data. Since the modifications concerned the radiation scheme, we were interested in the radiation liquid water as well, but at this point we run into some difficulties, and the computation of statistical characteristics for the whole period were failed due to lack of time.

In the previous experiments with ICE3, Kunkel scheme was used to determine the visibility. There is fog if the visibility is less than 1 km near the surface, so that liquid water content (LWC) is larger than $6.4419*10^{-6}$ kg/m³. If the vertical resolution defines 90 levels, the lowest model level is around 5 m, and only this model level was used to calculate fog. We wanted to plot cloud fraction and the radiation liquid water fields too, but we had problems with these fields. Luckily by the end of the stay it was managed to fix this issue, that helped us to interpret the results properly.

Based on the Kunkel scheme, cloud base and cloud top was calculated from LWC values. The 4th January 2017 was a foggy day, this day was investigated further. The results from the runs with ICE3 and LIMA can be seen on the figures at the end of this report. Unfortunately LIMA underestimates the cloud, especially in the northern part of the domain.

Experiments on the first two weeks (8th October – 19th October 2018)

Since my last visit some changes in LIMA scheme has happened in Meso-NH that has not been implemented in AROME yet. The changes concern not only the microphysics but also the radiation scheme. At first we wanted to handle and test the radiation and microphysical modifications separately. In the following we collected the experiments that we tried to run with different settings. In the tables the success of the runs can be seen. For these experiments cy42t1 was used.

Previous LIMA version:

Work: 1250m+L90,500m+L90 TSTEP=15s

Not work: 1250m+L156,500m+L156 both with TSTEP= 15s, 500m+L156 with TSTEP=5s (error: NaN in LIMA and hidrometeor average values after some TSTEPS)

Radiation modification:

Namelist variables	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6
NICEOPT	3	3	3	3	3	3
NSWICEOPT	--	--	--	--	3	3
NLWICEOPT	--	--	--	--	3	3
NLIQOPT	3	4	4	4	4	4
NSWLIQOPT	--	--	--	4	4	4
NLWLIQOPT	--	--	--	4	4	4
NRADIP	3	4	3	3	3	4
NRADLP	2	4	4	4	4	4
	WORK	NOT WORK	NOT WORK(?)	WORK	WORK	NOT WORK

Error after some TSTEPS
Error message: nothing special
Based on /home/seity/pack/LIMA\@cy42_main.01/ → I copied it to my directory /home/homonnaiv/pack/LIMA\@cy42_main.01/ and put the radiation modifications into it.

Benoit's LIMA modification:

His reference pack: WORK, but his modifications: NOT WORK.

set-conc-lima.F90	+	-	-	+
apl_arome.F90	+	+	+	+
aro_lima.F90	+	+	+	+
ini_lima_cold_mixed.F90	+	-	-	-
lima_cold_sedimentation.F90	+	-	+	+
lima_warm.F90	+	+	+	+

lima_warm_nucl.F90	+	-	+	+
lima_warm_sedim.F90	+	-	+	+
modd_budget.F90	+	-	-	-
modd_param_lima.F90	+	-	-	-
others				+USE MODI_SET_CONC_LIMA in aro_lima.F90
	NOT WORK	WORK	WORK	NOT WORK

Error TSTEP=0

Error message: nothing special

forrtl: severe (408): fort: (3): Subscript #3 of the array PGFL has value -99999999 which is less than the lower bound of 1

Packs:

LIMA@cy42_main.01: LIMA from Yann + radiation modifications
LIMA_fog@cy42_main.01: LIMA from Benoit and his modifications
LIMA_test@cy42_main.01: LIMA from Benoit (ref pack) + some modifications (no ini_lima_cold_mixed + modd_budget + modd_param_lima)
LIMA_mod@cy42_main.01: this will be the merged pack (radiation and Benoit's modification)

Results on the second two weeks (3rd December – 15th December 2018)

By the following two-week stay Yann Seity has managed to debug these modfications on his PC (he used cy45t1). When I arrived in December an experiment for a longer period was ready to study. The plan was that some statistical characteristics in connection with fog would be calculated, so I prepared a python script to compute cloud base and cloud top based on the liquid water content, and mean number concentartions of aerosols in the fog. Averaged LWC content in the cloud was also calculated.

After we plotted the cloud fraction it turned out that there is a bug somewhere, because we got very strange value, and the radiation liquid water fields were also suspicious. By the end of the stay we found this bug, but we had time to rerun only one day, not the whole period. On the Figures 1 and 2 cloud fraction and radiation LWC fields can be seen with the bug and after bugfix.

The calculations of other statistical characteristics did not concern the previously mentioned bug, so meanwhile we were investigating the bug, a python script was created to calculate some characteristics. In order to determine the fog area, we used the Kunkel scheme as mentioned before: where the visibility decreased below 1 km (this correpsonds LWC higher than $6.4419*10^{-6}$ kg/m^3) that volume was considered to be the fog cloud. We use this definition to determine the cloud base and cloud top as well. At first these two variables were determined on model levels, but later the conversion to pressure levels and heiht levels was also carried out using some built-in epygram routines. We computed the average values of LWC and the number concentrations in the fog, but unfortunately this former one does not work well, and I could not fix this during my stay, so this field can be seen on the Figure 3 but it is important to keep in mind that it is not too realistic.

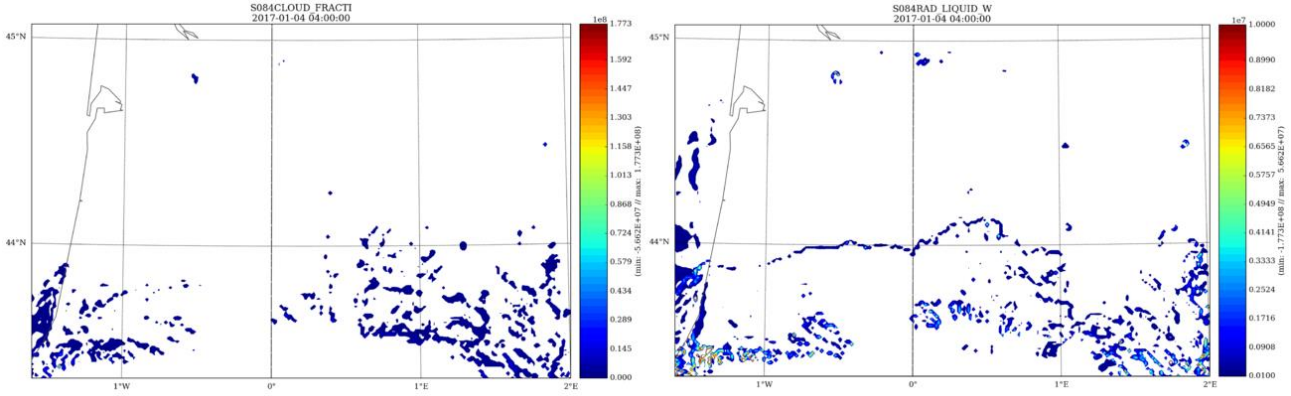

Figure 1.Wrong cloud fraction and radiation liquid water

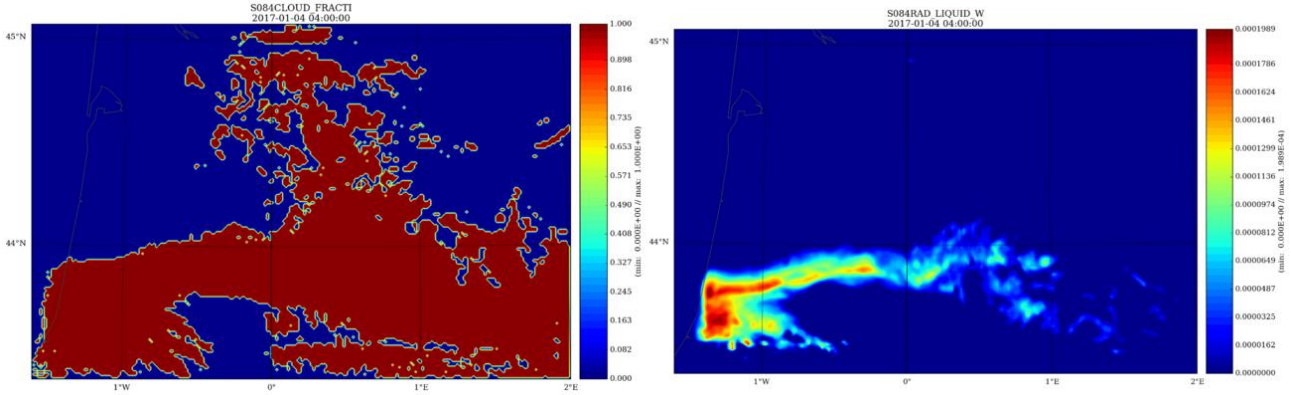

Figure 2. Proper cloud fraction and radiation liquid water

The comparison of LIMA scheme with ICE3 on this selected day shows that LIMA gives less fog and fog appears only in the southern part of the domain (see Figure 3, 5 and 6). On Figure 4 the number concentrations of aerosols show that most of the aerosols became activate with the LIMA scheme.

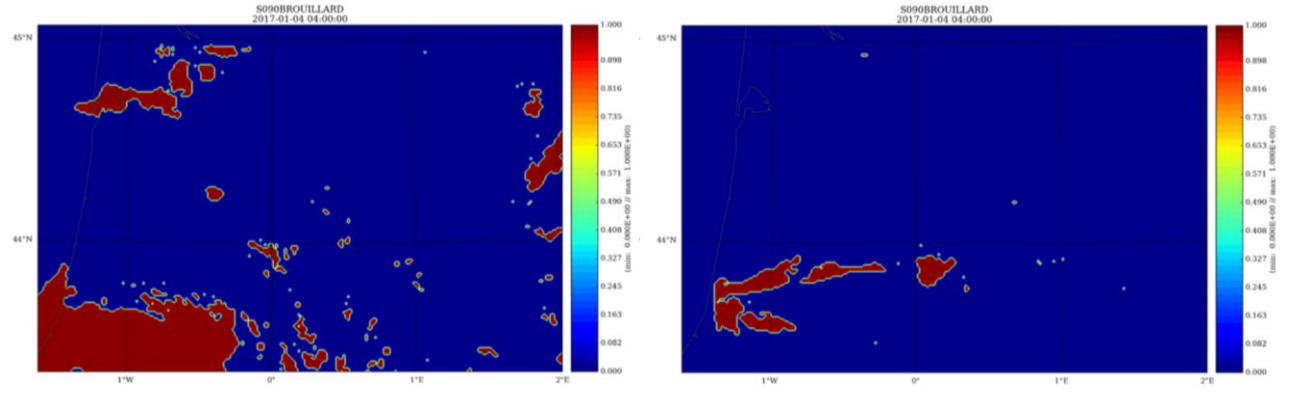

Figure 3. Fog with ICE3 (left) and LIMA (right) scheme on 4th January 2017 (00UTC run +4h forecast).

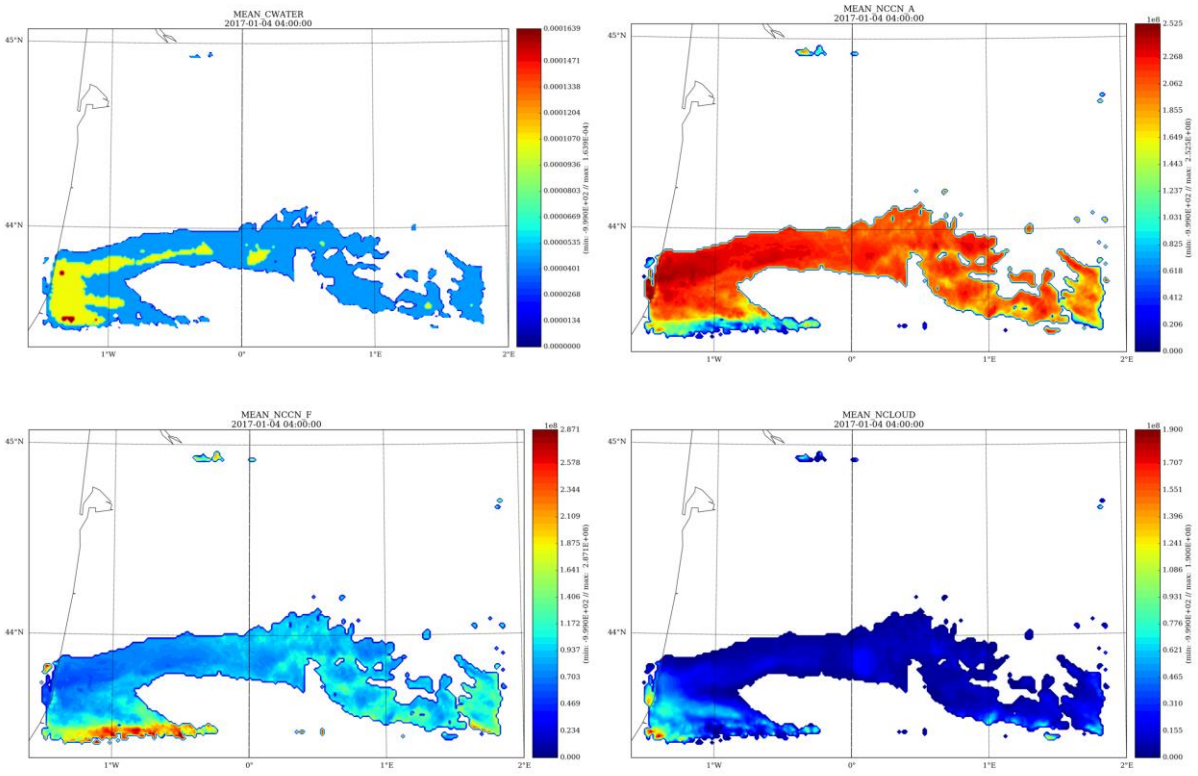

Figure 4. Average value fields of LWC (top left), number concentration of activated aerosols (top right), number concentration of free aerosols (bottom left) and number concentration of cloud droplets (bottom right) with LIMA scheme on 4th January 2017 (00UTC run +4h forecast).

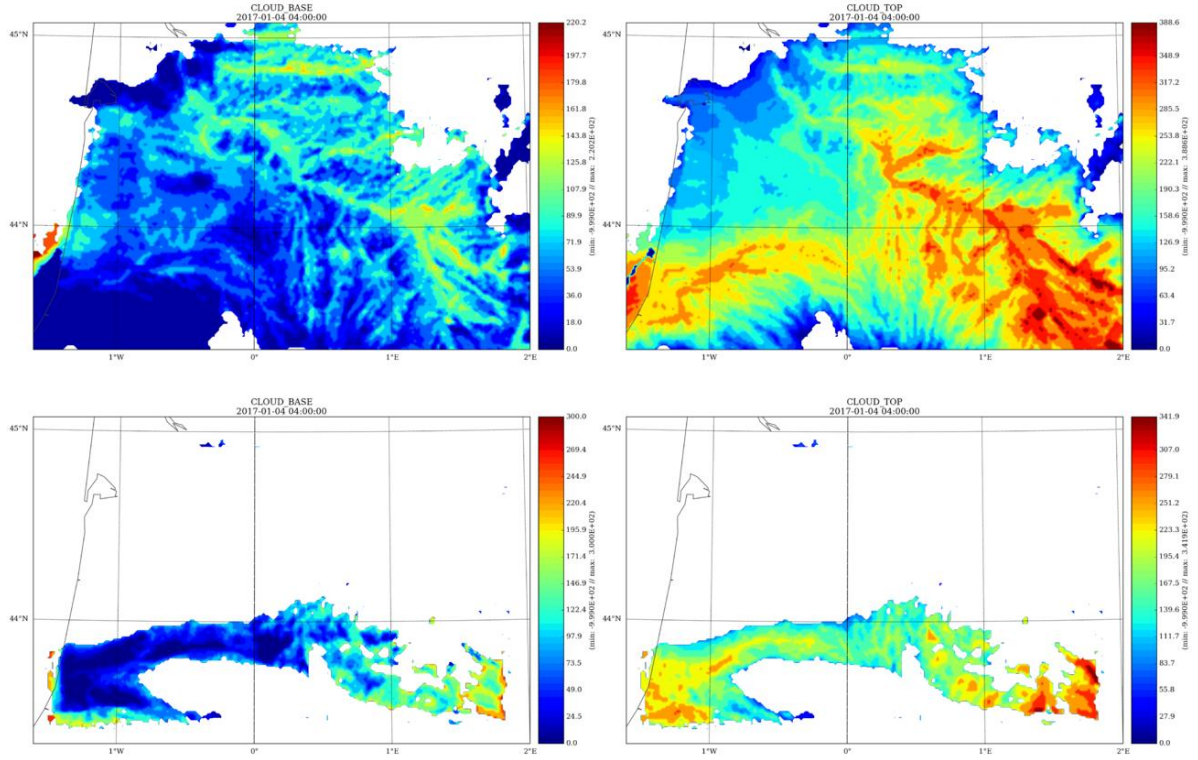

Figure 5. Cloud base (left) and cloud top (right) fields with ICE3 (top) and LIMA (bottom) scheme on 4th January 2017 (00UTC run +4h forecast).

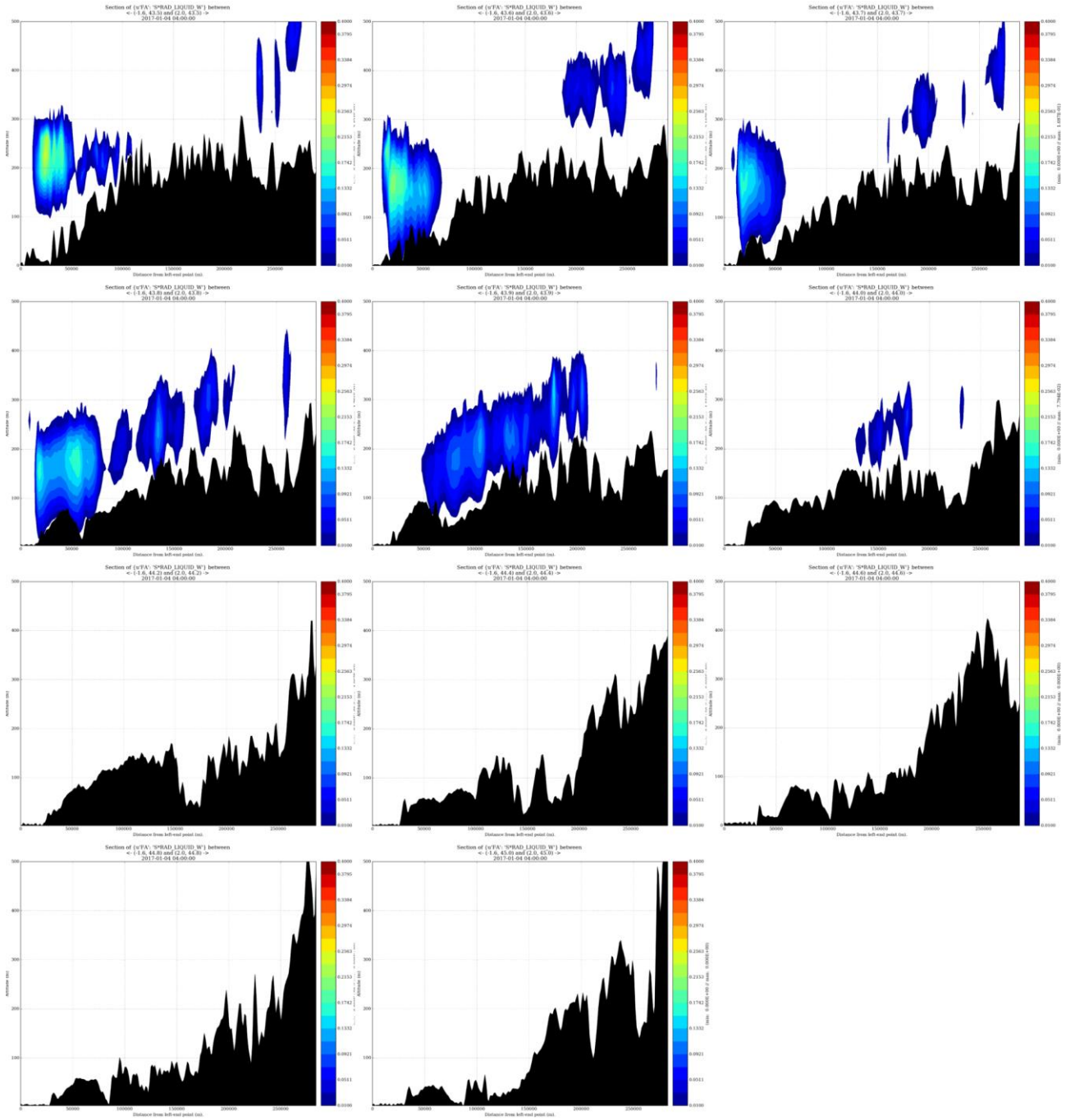

Figure 6. Horizontal cross sections of LWC along the following latitudes: 43.5°N, 43.6°N, 43.7°N, 43.8°N, 43.9°N, 44.0°N, 44.2°N, 44.4°N, 44.6°N, 44.8°N, 45.0°N (00UTC run +4h forecast).