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STATISTICAL STUDY ON AROME FORECAST DURING SOFOG3D – SENSITIVITY TESTS ON PARAMETRIZATION AND MODEL RESOLUTION
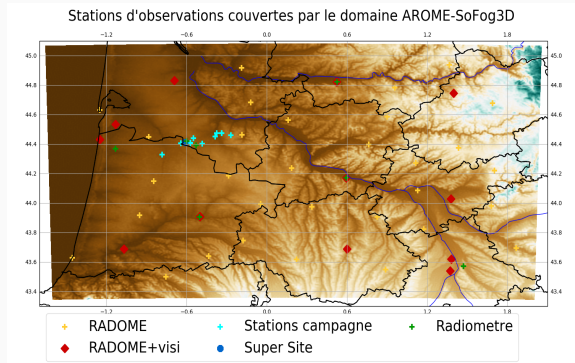
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30 March 2021

AROME simulations

- Use of AROME on a small domain, initialized with AROME operational analyses, coupled with AROME operational forecasts (Seity 2011)
- 2 grids :

horizontal resolution	vertical levels	first level	
1250m	90	5m	1250mL90
500m	156	1m	500mL156

- A small domain covering the South West of France

Orography in AROME-500m on its forecast domain and location of observations

Stations d'observations couvertes par le domaine AROME-SoFog3D

RADOME   Stations campagne   Radiometre
RADOME+visi   Super Site

AROME simulations – sensitives tests

Comparison of several model configurations

- two resolutions
1250mL90 - like operational model
500mL156 - hectometric and finer vertical resolution evaluation

- two microphysical schemes
ICE3 – 1 moment scheme , operational scheme (fixed N_c)
LIMA – 2 moment scheme (prognostic N_c ; aerosols initialised with a constant vertical profile) but without subgrid condensation

- Several sensitivity tests
Whith (wid) and without (wod) **deposition** term
In ICE3, with (wisc) and without (wosc) **subgrid condensation**
In ICE3, modification of N_c (default $300 cm^{-3}$, test $100 cm^{-3}$ and $50 cm^{-3}$)

- **Deposition** : the liquid water content of the first level above the ground is deposed on the vegetation with a constant speed (2cm/s but this value could be tuned)

- **Subgrid condensation** : is to allow condensation on a part of the grid from turbulence and shallow convection schemes. When the prognostic mean qv over the model grid is below qsat. A variance proportional to the saturation total water specific humidity acts as in classical relative humidity cloud schemes (e.g., Rooy et al., 2010) : cloud fraction between 0 and 100 %.
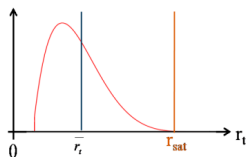
a/ **Unsaturated** case
$\Rightarrow$ **CF=0**
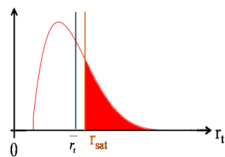
B/ **Partially saturated** case
$\Rightarrow$ **0<CF<1**
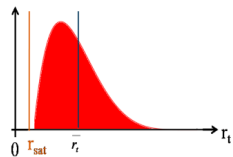
c/ **Totally saturated** case
$\Rightarrow$ **CF=1**

Plan

- Statistical scores on the 6 month campaign

- Formation and dissipation fog statistics

- Liquid Water Path statistics on super site

- Surface heterogeneity

- IOP-6

Statistical study on the 6 months campaign

Statistic on all stations (RADOME and stations near super site) : between 11 and 18 stations

Use of visibility diagnostic with 1000m threshold (Kunkel 1984)

$$Visi = \frac{ln(0.02)}{144.7(LWC)^{0.88}}$$

Découpage des échéances modèles pour l'étude statistique
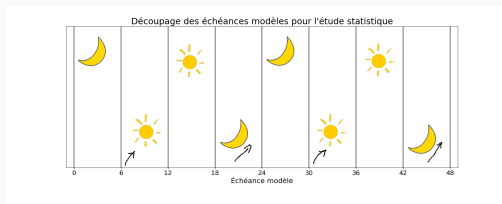
Detection Rate – $DR = \frac{GF}{GF+ND}$ False Alarm Rate – $FAR = \frac{FA}{GF+FA}$

No Detection Rate – $NDR = \frac{ND}{GF+ND}$

Frequency Bias Idex – $FBI = \frac{GF+FA}{GF+ND}$

GF = Good Forecast ; ND = No Detection ; FA = False Alarm

Middle of the night – Impact of resolution

Lead time since 00h the forecast day : +25h à +30h

			DR	FAR	NDR	FBI
1250mL90	ICE3 R00	wod - wisc	59	38	41	0.96
500mL156	ICE3 R00	wod - wisc	69	43	31	1.21

			DR	FAR	NDR	FBI
1250mL90	ICE3 R00	wid - wisc	49	34	51	0.74
500mL156	ICE3 R00	wid - wisc	67	41	33	1.15

More fog forecast by simulation with 500mL156 grid :
- Best detection rate
- Bad false alarm rate

- Less no detection

wid = with deposition ; wod = without deposition ; wisc = with subgrid condensation ; wosc = without subgrid condensation

Lead time since 00h the forecast day : +25h à +30h

			DR	FAR	NDR	FBI
1250mL90	ICE3 R00	wod - wisc	59	38	41	0.96
1250mL90	ICE3 R00	wid - wisc	49	38	51	0.74

			DR	FAR	NDR	FBI
500mL156	ICE3 R00	wod - wisc	69	43	31	1.21
500mL156	ICE3 R00	wid - wisc	67	41	33	1.15

- **Decrease of detection** rate
- Very **little impact on false alarm** rate
- **Lower impact on 500mL156 grid** because the first level at 1m
compared to 1250mL90 (first level 5m)

wid = with deposition ; wod = without deposition ; wisc = with subgrid condensation ; wosc = without subgrid condensation

Lead time since 00h the forecast day : +25h à +30h

			DR	FAR	NDR	FBI
1250mL90	ICE3 R00	wod - wisc	59	38	41	0.96
1250mL90	ICE3 R00	nc=100 (wod-wisc)	53	37	47	0.85
1250mL156	ICE3 R00	nc=50 (wod-wisc)	51	39	49	0.85

Very little impact of fixed N_c modification

wid = with deposition ; wod = without deposition ; wisc = with subgrid condensation ; wosc = without subgrid condensation

Middle of the night – Impact of subgrid condensation

Lead time since 00h the forecast day : +25h à +30h

Lead time since 00h the forecast day : +25h à +30h

			DR	FAR	NDR	FBI
1250mL90	ICE3 R00	wod - wisc	59	38	41	0.96
1250mL90	ICE3 R00	wod - wosc	40	30	60	0.58

Decrease of fog event forecast by 1250mL90 ICE3 wosc

- Bad detection rate

- 2/5 events missed

wid = with deposition ; wod = without deposition ; wisc = with subgrid condensation ; wosc = without subgrid condensation

Lead time since 00h the forecast day : +25h à +30h

			DR	FAR	NDR	FBI
1250mL90	ICE3 R00	wod - wosc	40	30	60	0.58
1250mL90	LIMA R00	wod - wosc	31	41	69	0.52
1250mL90	LIMA R00	wid - wosc	27	37	73	0.43

- Less fog forecasted by LIMA
- Similar score between ICE3 wosc and LIMA wosc
LIMA don't have subgrid condensations.

If we compare ICE3 with and without subgrid condensation, the score are a lot improved with sc scheme. So we expect that it would be the same thing for LIMA

wid = with deposition ; wod = without deposition ; wisc = with subgrid condensation ; wosc = without subgrid condensation

Lead time since 00h the forecast day : +19h à +24h

			DR	FAR	NDR	FBI
1250mL90	ICE3 R00	wod - wisc	44	45	56	0.79
500mL156	ICE3 R00	wod - wisc	60	50	40	1.2
1250mL90	ICE3 R00	wid - wisc	32	41	68	0.54
500mL156	ICE3 R00	wid - wisc	56	49	44	1.11
1250mL90	ICE3 R00	nc=100 (wod-wisc)	35	45	65	0.63
1250mL90	ICE3 R00	nc=50 (wod-wisc)	35	50	65	0.69
1250mL90	ICE3 R00	wod - wosc	21	39	79	0.34
1250mL90	LIMA R00	wid - wosc	12	48	88	0.23
500mL156	LIMA R00	wid - wosc	28	39	72	0.46
1250mL90	LIMA R00	wod - wosc	14	45	86	0.26

Many no detection (except 500mL156 ICE3 wod and 500mL156 ICE3 wid)

wid = with deposition ; wod = without deposition ; wisc = with subgrid condensation ; wosc = without subgrid condensation

Middle of the night − +25 to +30

Lead time since 00h the forecast day : +25h à +30h

			DR	FAR	NDR	FBI
1250mL90	ICE3 R00	wod - wisc	59	38	41	0.96
500mL156	ICE3 R00	wod - wisc	69	43	31	1.21
1250mL90	ICE3 R00	wid - wisc	49	38	51	0.74
500mL156	ICE3 R00	wid - wisc	67	41	33	1.15
1250mL90	ICE3 R00	nc=100 (wod-wisc)	53	37	47	0.85
1250mL156	ICE3 R00	nc=50 (wod-wisc)	51	39	49	0.85
1250mL90	ICE3 R00	wod - wosc	40	30	60	0.58
1250mL90	LIMA R00	wid - wosc	27	37	73	0.43
500mL156	LIMA R00	wid - wosc	38	38	62	0.62
1250mL90	LIMA R00	wod - wosc	31	41	69	0.52

- **Same results but with a slightly better score** : DR, FAR and NDR improved in the middle compared to the beginning.

wid = with deposition ; wod = without deposition ; wisc = with subgrid condensation ; wosc = without subgrid condensation

Lead time since 00h the forecast day : +31h à +36h

			DR	FAR	NDR	FBI
1250mL90	ICE3 R00	wod - wisc	62	55	38	1.37
500mL156	ICE3 R00	wod - wisc	66	58	34	1.57
1250mL90	ICE3 R00	wid - wisc	53	53	47	1.13
500mL156	ICE3 R00	wid - wisc	61	58	39	1.47
1250mL90	ICE3 R00	nc=100 (wod-wisc)	57	57	43	1.32
1250mL90	ICE3 R00	nc=50 (wod-wisc)	56	59	44	1.35
1250mL90	ICE3 R00	wod - wosc	47	50	53	0.93
1250mL90	LIMA R00	wid - wosc	29	51	70	0.6
500mL156	LIMA R00	wid - wosc	30	54	70	0.66
1250mL90	LIMA R00	wod - wosc	33	56	67	0.74

- **Model forecast really too many fog events** compare to observations.

- **A lot of false alarms**

wid = with deposition ; wod = without deposition ; wisc = with subgrid condensation ; wosc = without subgrid condensation

At the beginning, at the end, is there an issue ?

High NDR at the beginning of night
High FAR at the end of the night/morning

Plan

Statistics on all stations (RADOME and stations near super site) : between 11 and 18 stations

For each forecast, between +19 and +36 lead time :
- what is the first hour of fog formation ?
- what is the last hour of fog dissipation ?
- how many fog events during the night ?
- how long is each fog event ?
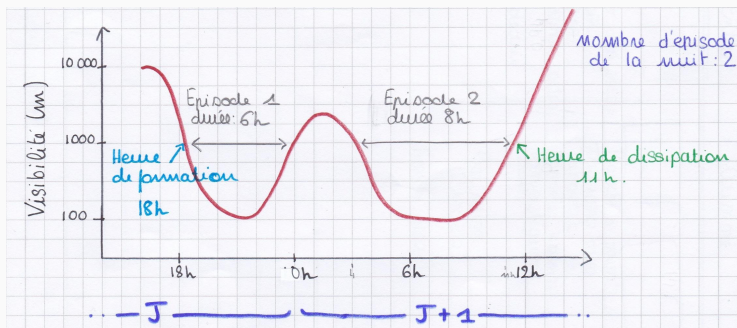
Formation and dissipation fog statistics – Impact of resolution

AROME-1250mL90 ICE3 (wod-wisc)
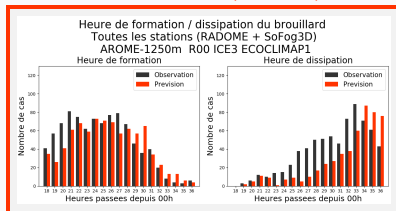
AROME-500mL156 ICE3 (wod-wisc)
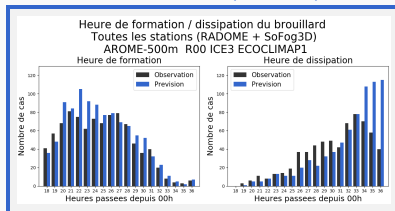
- Model delay in fog formation at 1250mL90.
- Better with 500mL156
- Model delay at the dissipation for both configurations

AROME-1250mL90 ICE3 (wod-wosc)

AROME-1250mL90 LIMA (wod-wosc)

- ICE3 wosc and LIMA wosc are close

Formation and dissipation fog statistics – Impact of N_c value with ICE3 (wod-wisc)

AROME-1250mL90 ICE3 (wod-wisc)

$N_c = 100 cm^{-3}$

AROME-1250mL90 ICE3 (wod-wisc)

REF : $N_c = 300 cm^{-3}$
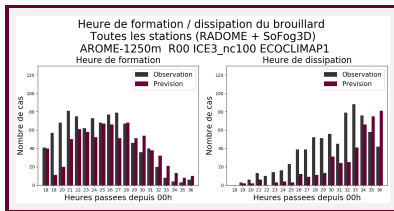
AROME-1250mL90 ICE3 (wod-wisc)

$N_c = 50 cm^{-3}$
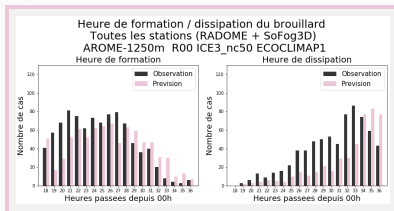
Low impact on formation and dissipation with test on N_c

Number and duration of fog events by night

AROME-1250mL90 ICE3 (wod - wisc)
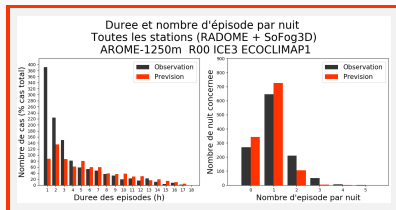
AROME-500mL156 ICE3 (wod - wisc)
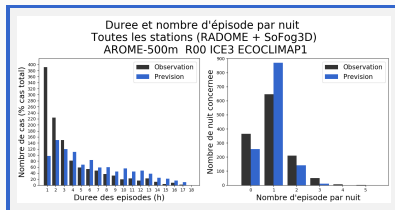
AROME-1250mL90 ICE3 (wod - wosc)
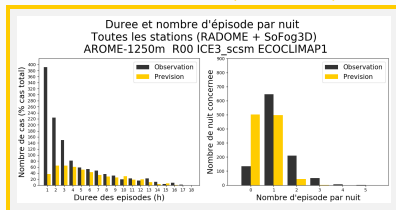
AROME-1250mL90 LIMA (wod - wosc)
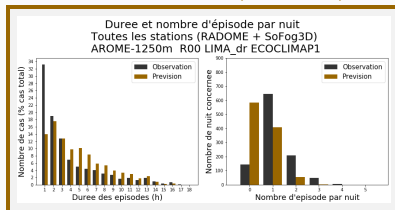
- Too few events with short duration in forecast (all configurations)
- Too many events with long duration in forecast by 1250mL90 ICE3 and 500mL156 ICE3
- No forecast of multiple events in one night (more than 3)

Plan

- Statistical scores on the 6 month campaign

- Formation and dissipation fog statistics

- Liquid Water Path statistics on super site

- Surface heterogeneity

- IOP-6

Liquid Water Path (LWP) statistics only in super site

- Radiometer observations - uncertainty on measurement of 10 g/m^2
- Two inversion methods to get LWP observed : RPG (constructor)
- Only with super site radiometer for the moment

Between lead time +19 and +36 (or for obseravtion between 19h the J-day and 6h the J+1-day), I keep the LWP if the minimum visibility on the past hour is lower than 1000m.

AROME-1250mL90 ICE3 (wod - wisc)

AROME-500mL156 ICE3 (wod - wisc)

- No visible impact

LWP statistics – Impact of subgrid condensation

AROME-1250mL90 ICE3 (wod - wisc)
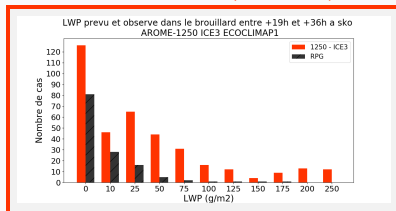
AROME-1250mL90 ICE3 (wod - wosc)
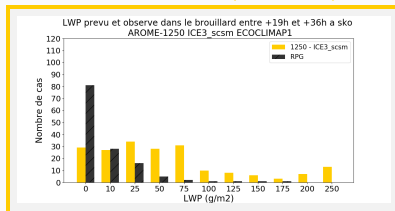
- Decrease in low LWP forecast

LWP statistics – Impact of microphysical scheme

AROME-1250mL90 ICE3 (wod - wosc)
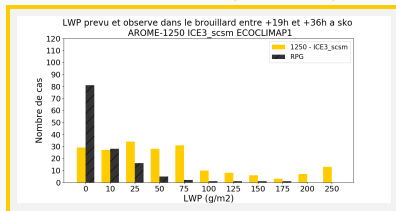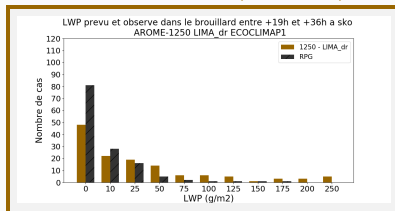
AROME-1250mL90 LIMA (wod - wosc)

- Decrease in low LWP forecast

LWP statistics – Impact of deposition

AROME-1250mL90 ICE3 (wod - wisc)
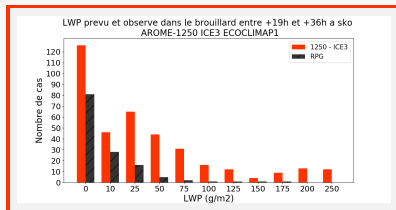
AROME-1250mL90 ICE3 (wid - wisc)
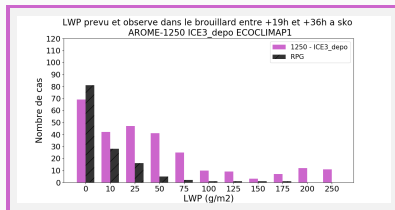
- Decrease of overestimation in thin fog with 1250mL90 ICE3 wid
- No change in fog with high LWP
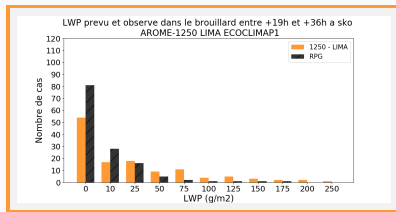
AROME-1250m LIMA

AROME-500m LIMA
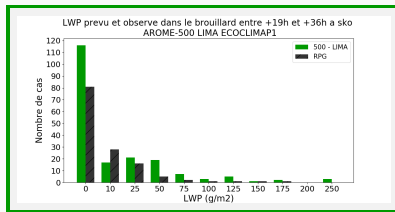
- Less overestimation of LWP with AROME-1250m LIMA
- Forecasted LWP in better agreement with observations with AROME-1250m LIMA

Plan

- Statistical scores on the 6 month campaign

- Formation and dissipation fog statistics

- LWP statistics on super site

- **Surface heterogeneity**

- IOP-6

On 6 stations near SoFog3D super site (I only keep the data for which there are no missing values)
Relation between number of station impacted by fog in observations and in forecast (nearest grid point)
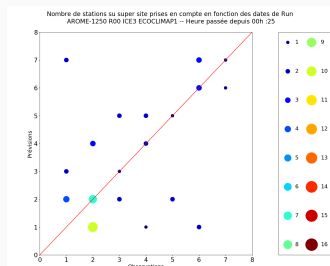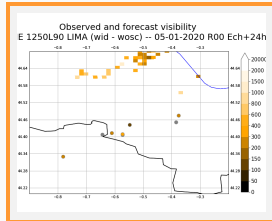
Surface heterogeneity – lead time +25
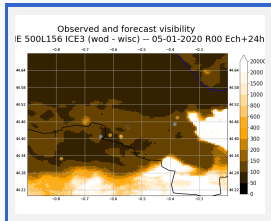

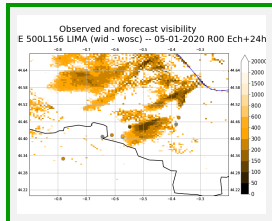1250mL90 ICE3 (wod - wisc)   1250mL90 ICE3 (wid - wisc)   1250mL90 LIMA (wid - wosc)
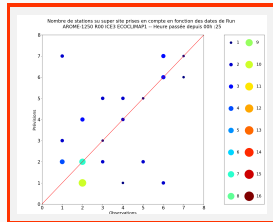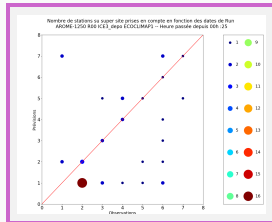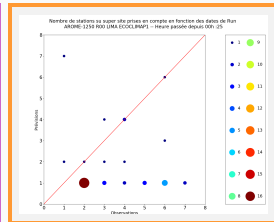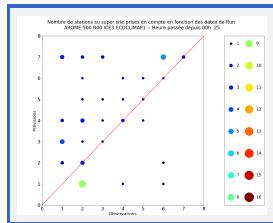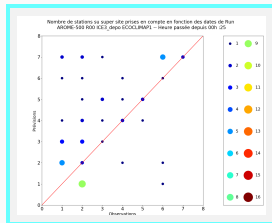
500mL156 ICE3 (wod - wisc)   500mL156 ICE3 (wid - wisc)   500mL156 LIMA (wid - wosc)
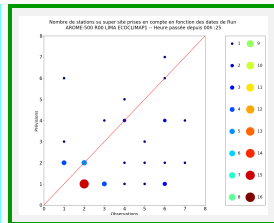
- 1250mL90 ICE3-> near diagonal
- 500mL156 ICE3 with and without deposit -> more stations in forecast
- 1250mL90 and 500mL156 - LIMA -> more stations in observations

Plan

- Statistical scores on the 6 month campaign

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- IOP-6

IOP-6 : night from 5th to 6th January 2020
One of the most vertically developed fog of the campaign

We choose this IOP because different model configurations
performed bad

Observed reflerctivity in Super Site
Radar BASTA le 05 et 06-01-2020

Visibilite observee et prevue a jachere AROMEs du 2020-01-05 R00
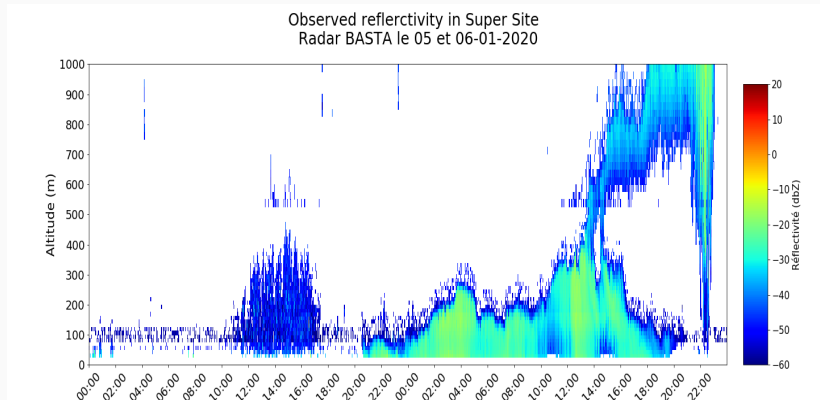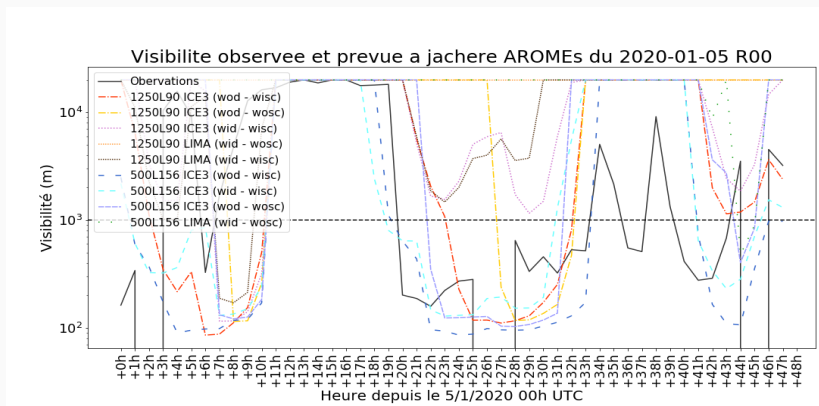
- At formation : 5h late to 1250mL90 - ICE3 ; perfect to 500mL156 - ICE3 and 500mL156 - ICE3+depot ; 8h late to 1250mL90 - ICE3 (wosc)
- At dissipation : perfect to 500mL156 - ICE3 ; 1h early to 1250mL90 - ICE3 ; 2h early to 500mL156 - ICE3+depot
- Similitude between 1250mL90 - ICE3+depo and 1250mL90 - LIMA wisc

Beginning of fog at super site in observation

1250mL90 ICE3 (wod - wisc)
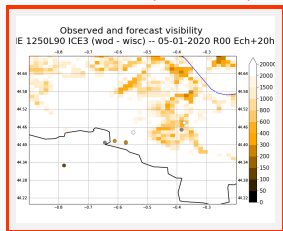
1250mL90 ICE3 (wid - wisc)
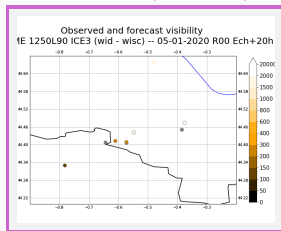
500mL156 ICE3 (wod - wisc)
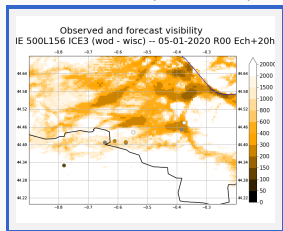
500m ICE3 (wid - wisc)
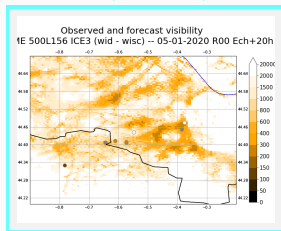
1250mL90 - ICE3 : no fog in super site but fog near

Beginning of fog at super site in observation
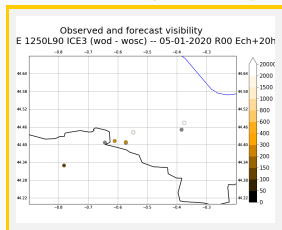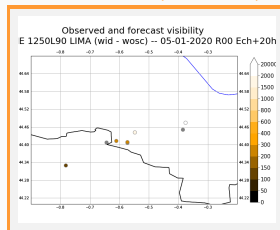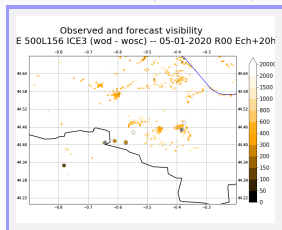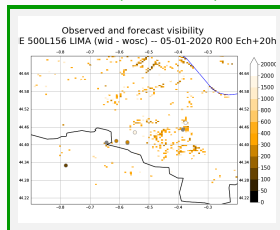
500mL156 - ICE3 wosc and 500mL156 - LIMA wosc : some patch of fog
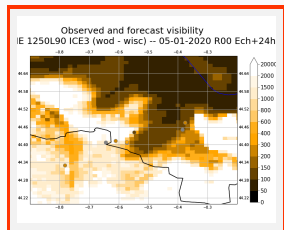
1250m ICE3 (wod - wisc)

1250m ICE3 (wid - wisc)
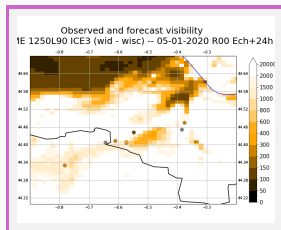
500m ICE3 (wod - wisc)
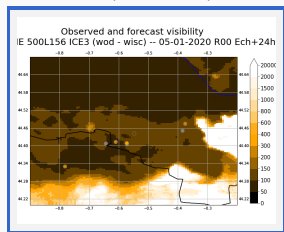
500m ICE3 (wid - wisc)
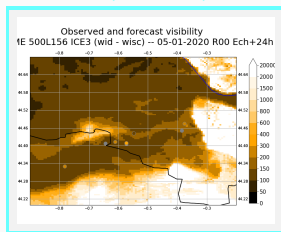
Fog near super site in AROME-1250mL90 ICE3 (wod - wisc) and in
AROME-1250mL90 ICE3 (wid - wisc)

Too low visibility forecast by 500m with ICE3 simulations
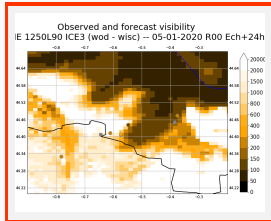
1250mL90 ICE3 (wod - wisc)   1250mL156 ICE3 (wod - wosc)   1250mL90 LIMA (wid - wosc)
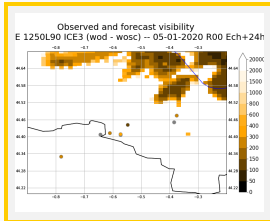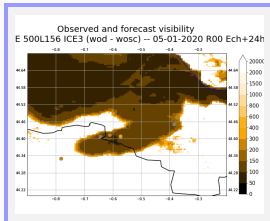
500mL156 ICE3 (wod - wisc)   500mL156 ICE3 (wod - wosc)   500mL156 LIMA (wid - wosc)

Less fog in simulation without subgrid condensation

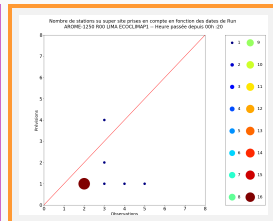500mL156 LIMA wosc fog near super site
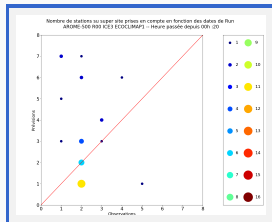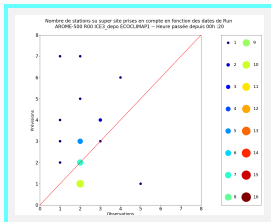
1250mL90 ICE3 (wod - wisc)
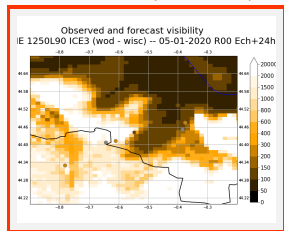
1250mL90 LIMA (wid - wisc)
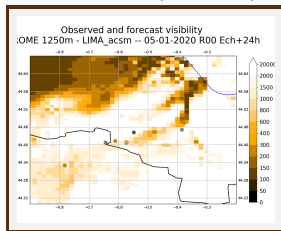
1250mL90 ICE3 (wod - wosc)
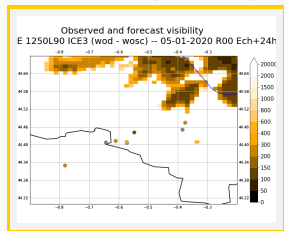
1250mL90 LIMA (wid - wosc)
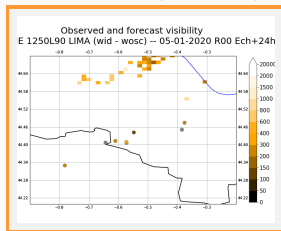
1250L90 LIMA wisc no fog in super site but fog forecasted near !

LWP observee et prevue a jachere AROMEs du 2020-01-05 R00
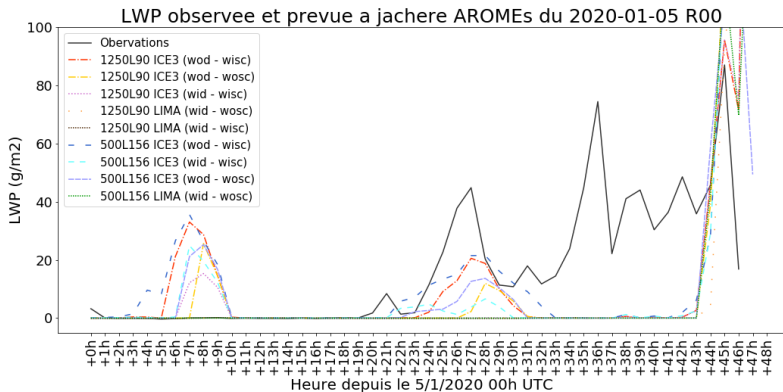
- Increase of LWP between +23 and +27 in observation
- In model, when there is LWP signal, the increase is present.
- Same comment for the decrease the next hour

Outlook

- LIMA with the subgrid condensation over the 6 months

- Initialisation of aerosols in LIMA from CAMS analyses

- Using a more apropriate visibility formulation in LIMA
(taking into account the prognostic N_c)

- Using other radiometers to LWP statistics

- Compare model with microphysics measurements, cloud radar

LWP prevu et observe dans le brouillard entre +19h et +36h a sko
AROME-1250 ICE3 ECOCLIMAP1

Formation and dissipation fog statistics – Impact of deposition

AROME-1250mL90 ICE3 (wod-wisc)

AROME-500mL156 ICE3 (wod-wisc)

AROME-1250mL90 ICE3 (wid-wisc)

AROME-500mL156 ICE3 (wid-wisc)

1250mL90 ICE3 (wod - wisc)
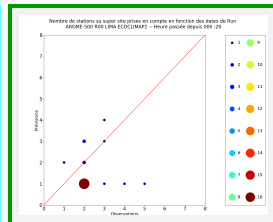
1250mL90 ICE3 (wid - wisc)

1250mL90 LIMA (wid - wosc)

500mL156 ICE3 (wod - wisc)
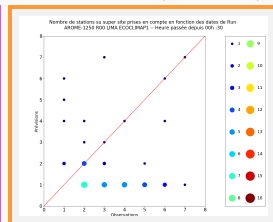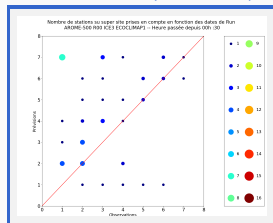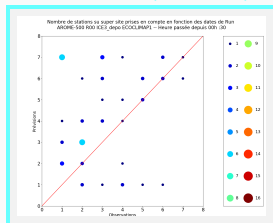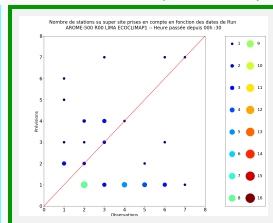
500mL156 ICE3 (wid - wisc)

500mL156 LIMA (wid - wosc)

1250mL90 ICE3 (wod - wisc)

1250mL90 ICE3 (wid - wisc)

1250mL90 LIMA (wid - wosc)

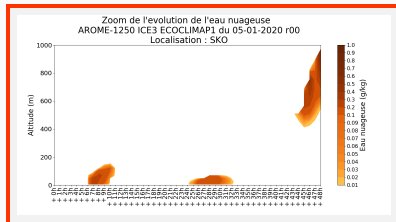**500mL156 ICE3 (wod - wisc)**

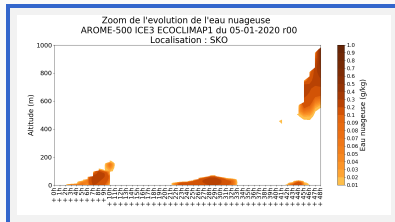**500mL156 ICE3 (wid - wisc)**

500mL156 LIMA (wid - wosc)
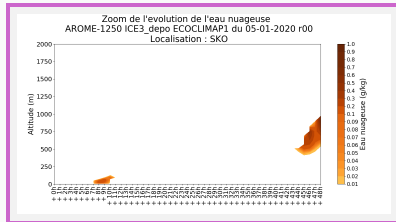
Ql profile forecast
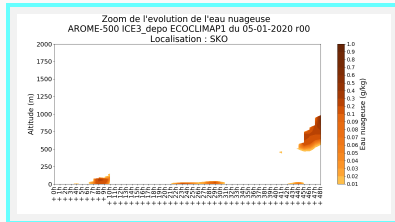
AROME-1250mL90 ICE3 (wod-wisc)

AROME-500mL156 ICE3 (wod-wisc)
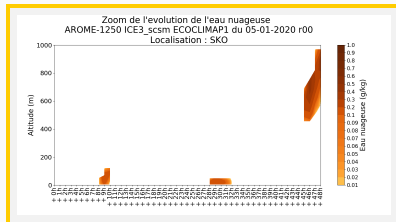

AROME-1250mL90 ICE3 (wid-wisc)

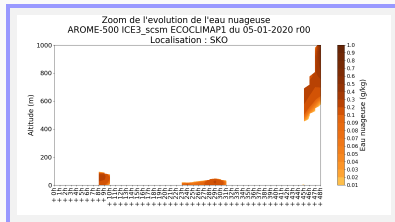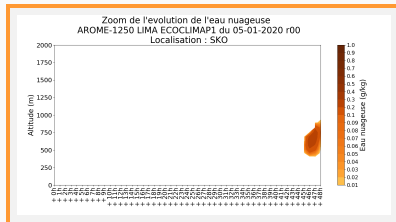AROME-500mL156 ICE3 (wid-wisc)
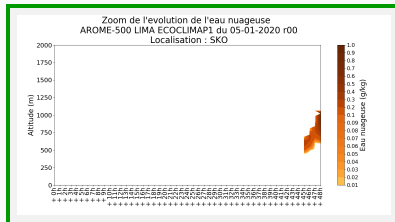
Ql profile forecast

AROME-1250mL90 ICE3 (wod-wosc)

AROME-500mL156 ICE3 (wod-wosc)

AROME-1250mL90 LIMA (wid-wosc)

AROME-500mL156 LIMA (wid-wosc)
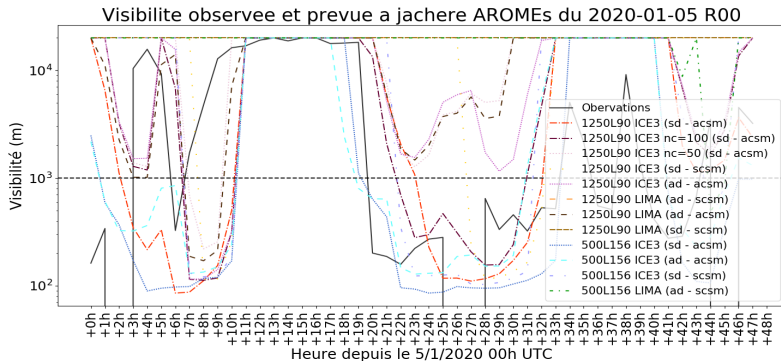
Visibilite observee et prevue a jachere AROMEs du 2020-01-05 R00

LWP observee et prevue a jachere AROMEs du 2020-01-05 R00
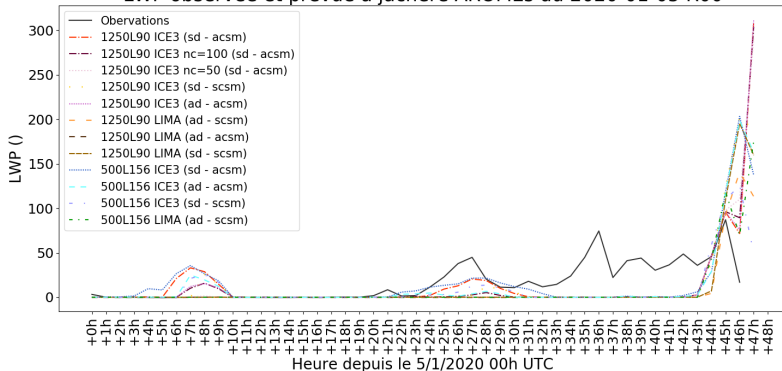
Liquid Ice Multiple Aerosols (LIMA)

= a 2-moments microphysics scheme developped in Meso-NH in order to improve the modelisation of complex aerosols – clouds – precipitations interactions

B. Vié, J.-P. Pinty
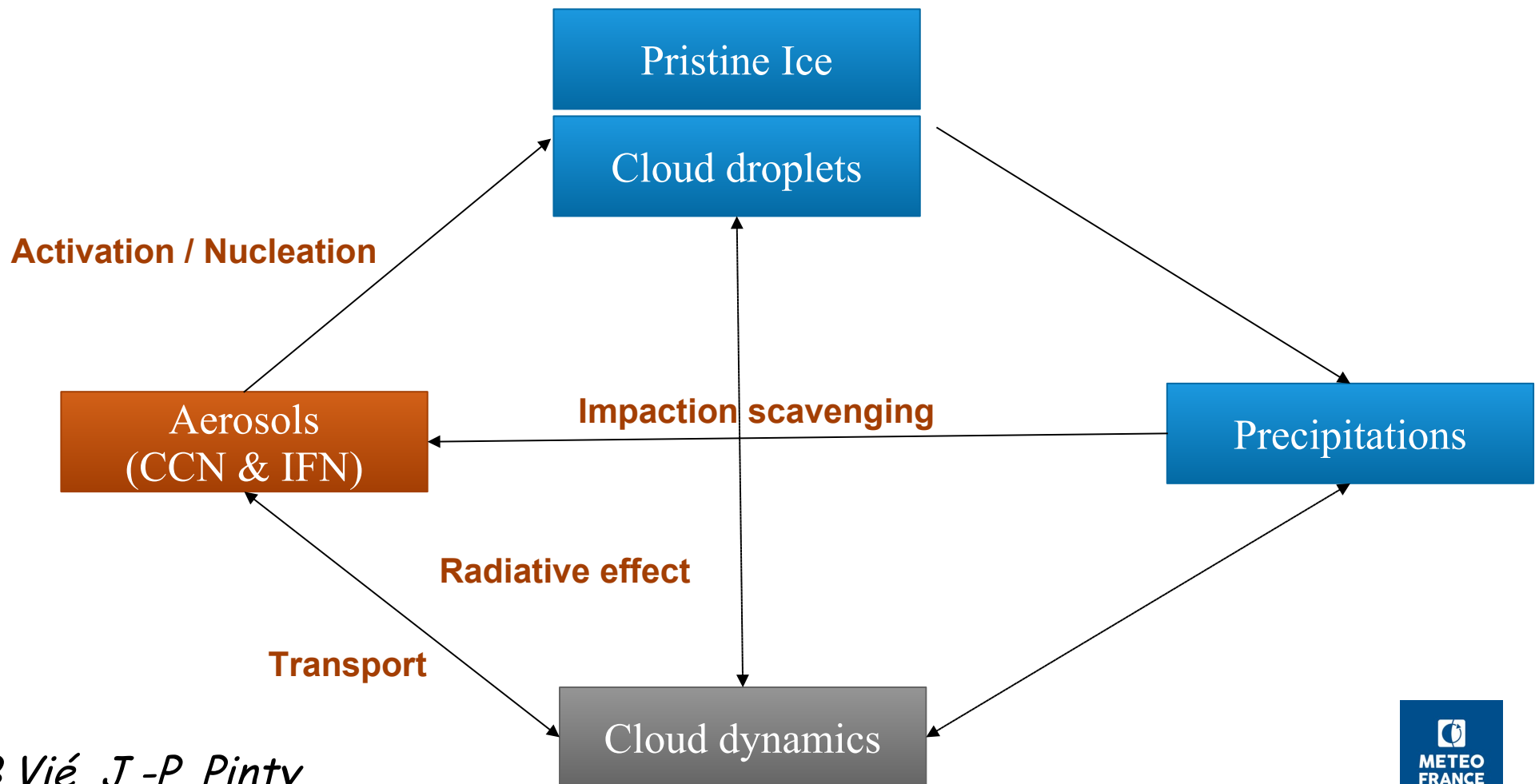
New microphysics scheme : Liquid Ice Multiple Aerosols (LIMA)

- Prognostic 3D variables in LIMA

  - Mixing ratios (kg.kg^{-1}) : r_C, r_R, r_I, r_S, r_G

  - Concentrations (kg^{-1}) : N_C, N_R, N_I ← NEW

  - Aerosol concentrations (kg^{-1}, for each mode) : N_{Free}, $N_{Activated}$ ← NEW

- New / Modified processes compared with ICE3

  - Activation / nucleation of aerosols
  - Impaction scavenging of aerosols by rain
  - More physical representation of autoconversion.
  - Over-saturations remains more easely than in ICE3

METEO
FRANCE

LIMA : Aerosols initialisation

MACC

MMR kg.kg^{-1}

LIMA aerosol population

(Number concentrations (kg^{-1}) !)

Sulfate

Sea salt (3 bins)

Hydrophilic OM

Hydrophobic OM

Hydrophilic BC

Hydrophobic BC

Dust (3 bins)

◣ CCN

Sulfate

Sea salt

◣ Coated IFN

Hydrophilic OM/BC

◣ IFN

Hydrophobic OM/BC

Dust

METEO FRANCE