

## EVALUATIONS OF AROME DURING SOFOG3D CAMPAIGN

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Météo-France - CNRM/GMAP/PROC

# AROME configuration

## - 2 grids :

1250m L90 : 1<sup>st</sup> level at 5m

500m L156 : 1<sup>st</sup> level at 1m

Philip et al., 2016

## - Run of 00 UTC

## - 48h lead time

## - Focus lead time :

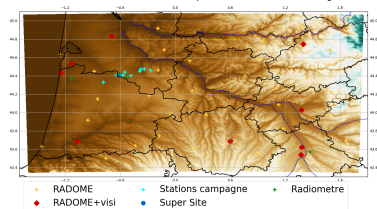
+19-+24 = beginning of night

+25-+30 = middle of night

+31-+36 = end of night / morning

## - SO forecast domain

Stations d'observations couvertes par le domaine AROME-SoFog3D



## - Reference (=operationnal) :

resolution : 1250m L90

microphysics : ICE3

deposition : no

# 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** (Pinty and Jabouille, 1998) – 1 moment scheme , operational scheme  
(fixed  $N_c$ )

**LIMA** (Vié et al., 2016) – 2 moment scheme (prognostic  $N_c$  ; aerosols  
initialized with a constant vertical profile) but without subgrid condensation

- Several sensitivity tests

With (wid) and without (wod) **deposition** term

With (wisc) and without (wosc) **subgrid condensation**

- **Statistics on the 6 months campaign**
- IOPs studies

# Impact of resolution

With the operational configuration : ICE3 microphysics without deposition

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

		DR	FAR	FBI
1250mL90	ICE3 R00	56	38	0.91
500mL156	ICE3 R00	67	44	1.2

More fog forecast by 500mL156 grid :

- best detection rate but ...
- more false alarms

DR = Detection Rate; FAR = False Alarm Rate; FBI =  $\frac{\text{Nb forecasted events}}{\text{Nb observed events}}$

# Impact of deposit

ICE3 microphysics with deposit : to reduce the liquid water content overestimation in fog  
Constant speed of 2cm/s



*Deposit measurement*

*Credit : Yann SEITY*

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

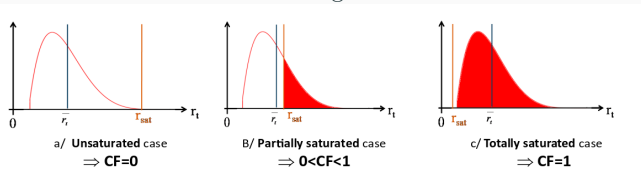
			DR	FAR	FBI
1250mL90	ICE3	R00	56	38	0.91
1250mL90	ICE3 + deposit	R00	45	35	0.69
			DR	FAR	FBI
500mL156	ICE3	R00	67	44	1.2
500mL156	ICE3 + deposit	R00	64	43	1.13

- Decrease of DR 1250mL90
- Smaller impact in 500mL156 grid : first level at 1m (VS 5m to 1250mL90)

DR = Detection Rate ; FAR = False Alarm Rate ; FBI =  $\frac{\text{Nb forecasted events}}{\text{Nb observed events}}$

# Impact of subgrid condensation

Take account of subgrid condensation



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

		DR	FAR	FBI
1250mL90	ICE3 wisc wod R00	56	38	0.91
1250mL90	ICE3 wosc wod R00	38	30	0.53

- Much less fog forecast by ICE3 wosc (2/5 events missed)

- Change LIMA version with adding of subgrid condensation

DR = Detection Rate ; FAR = False Alarm Rate ; FBI =  $\frac{\text{Nb forecasted events}}{\text{Nb observed events}}$  ; wod = without deposition ; wid = with deposition ; wosc = without subgrid condensation ; wisc = with subgrid condensation

# Impact of microphysical scheme

ICE3 (1-moment scheme) VS LIMA (2-moment scheme)

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

		DR	FAR	FBI
1250mL90	ICE3 wisc wid R00	45	35	0.69
1250mL90	LIMA wisc wid R00	44	46	0.83
		DR	FAR	FBI
500mL156	ICE3 wisc wid R00	64	43	1.13
500mL156	LIMA wisc wid R00	64	49	1.26

- **Close results between ICE3 and LIMA WITH subgrid condensation (recently added in the scheme).**

DR = Detection Rate ; FAR = False Alarm Rate ; FBI =  $\frac{\text{Nb forecasted events}}{\text{Nb observed events}}$  ; wod = without deposition ; wid = with deposition ; wosc = without subgrid condensation ; wisc = with subgrid condensation



# Statistics on the 6 months

Previous statistics on the beginning of the night (+19 to +24) :

- A lot of no detection
- Not enough fog events forecasted

		DR	FAR	FBI
1250mL90	ICE3 R00	43	43	<b>0.75</b>
500mL156	ICE3 R00	59	49	1.15

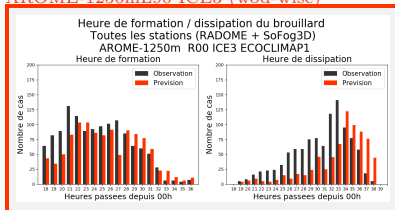
Previous statistics on the end of the night/morning (+31 to +36) :

- Many false alarms
- Too many fog events forecasted

		DR	FAR	FBI
1250mL90	ICE3 R00	39	<b>53</b>	0.84
500mL156	ICE3 R00	61	<b>61</b>	<b>1.55</b>

# Formation and dissipation fog statistics

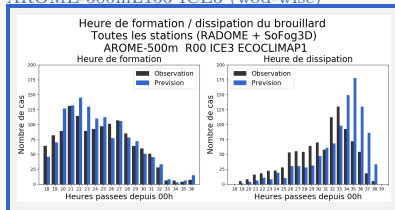
## AROME-1250mL90 ICE3 (wod-wisc)



Formation  
Lead time

Dissipation  
Lead time

## AROME-500mL156 ICE3 (wod-wisc)



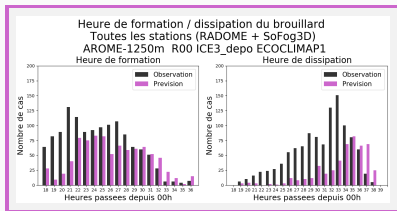
Formation  
Lead time

Dissipation  
Lead time

- Model delay in formation, especially by 1250mL90
- Model delay in dissipation in 1250mL90 and 500mL156
- Too long events forecast (not shown)

# Impact of microphysical scheme

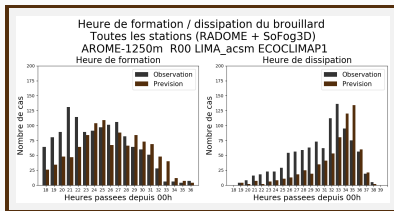
## AROME-1250mL90 ICE3 (wid-wisc)



Formation  
Lead time

Dissipation  
Lead time

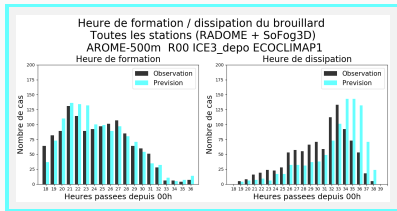
## AROME-1250mL90 LIMA (wid-wisc)



Formation  
Lead time

Dissipation  
Lead time

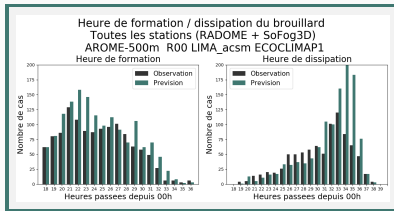
## AROME-500mL156 ICE3 (wid-wisc)



Formation  
Lead time

Dissipation  
Lead time

## AROME-500mL156 LIMA (wid-wisc)



Formation  
Lead time

Dissipation  
Lead time

Close results between ICE3 and LIMA

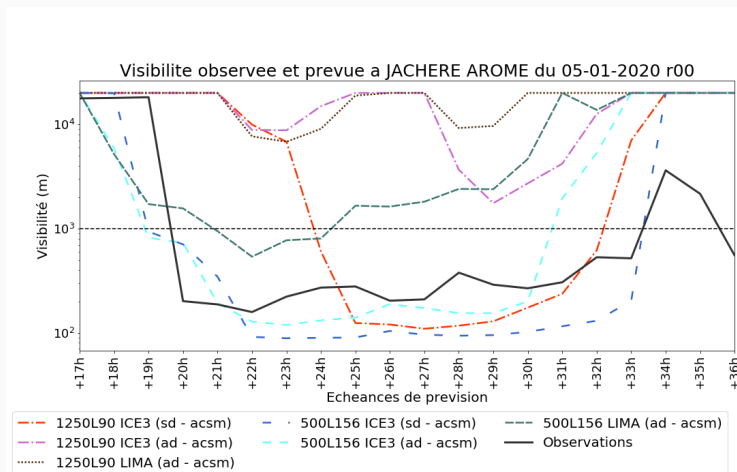
## To resume formation and dissipation study

- More fog forecast by 500m L156 grid
- Deposition : stronger impact at 1250mL90 grid
- We have to take into account subgrid condensation
- With subgrid condensation : ICE3 and LIMA are close
- Delay in formation with 1250m L90 grid (ICE3 and LIMA)
- Delay in dissipation fog (ICE3 and LIMA)

- Statistics on the 6 months campaign
- **IOPs studies**

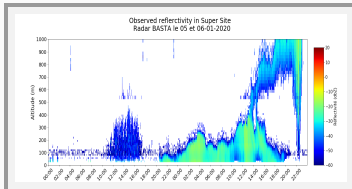
# IOP-6 – 5<sup>th</sup> to 6<sup>th</sup> January 2020

One of the most developed event of campaign  
But different models configuration performed bad.

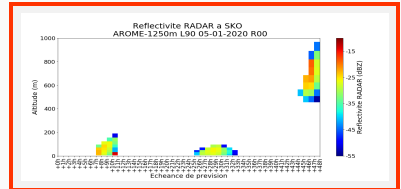


# IOP-6 – RADAR BASTA vs RADAR simulations

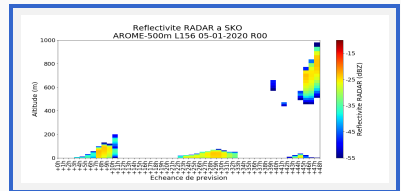
BASTA observations



AROME-1250m ICE3



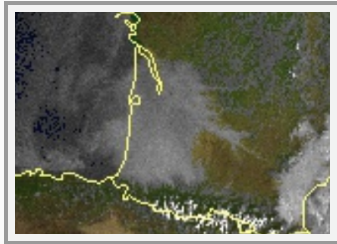
AROME-500m ICE3



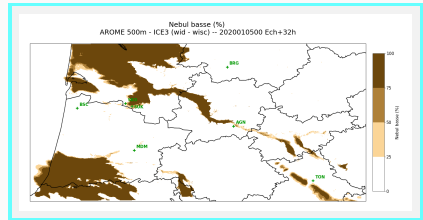
Not enough vertically developed.

# IOP-6 – Low cloud at 08h UTC the 6<sup>th</sup> January

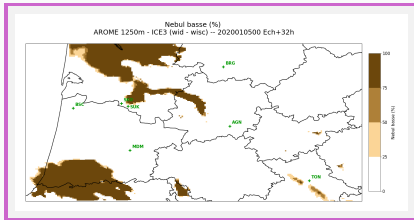
Satellite visible observation



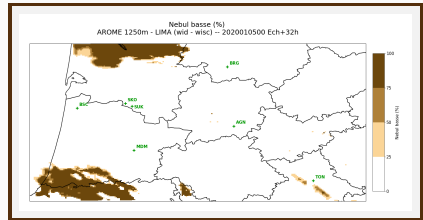
AROME 500m L156 ICE3 (wid - wisc)



AROME 1250m L90 ICE3 (wid - wisc)



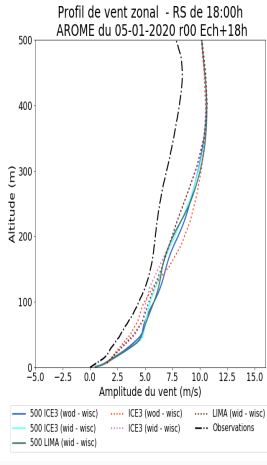
AROME 1250m L90 LIMA (wid - wisc)



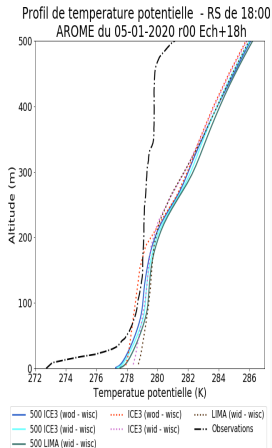


# IOP-6 – Radiosounding at 18h UTC – initial condition of the night

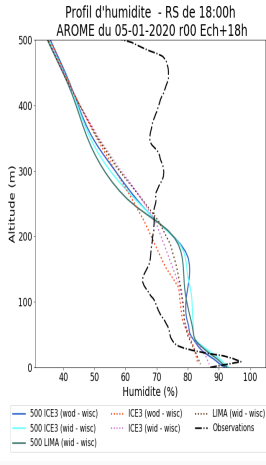
## Wind strength



## Potential temperature



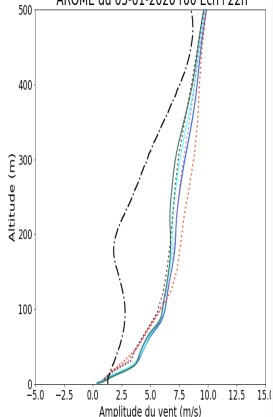
## Humidity



# IOP-6 – Radiosounding at 22h UTC – Fog formation

## Wind strength

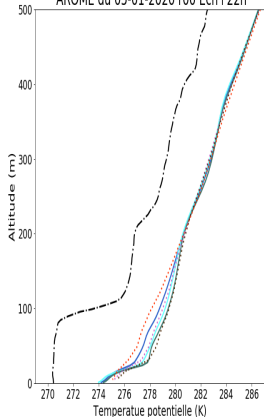
Profil de vent zonal - RS de 21:43h  
AROME du 05-01-2020 r00 Ech+22h



— 500 ICE3 (wod - wisc)    ···· ICE3 (wod - wisc)    ···· LIMA (wid - wisc)  
— 500 ICE3 (wid - wisc)    ···· ICE3 (wid - wisc)    ···· Observations  
— 500 LIMA (wid - wisc)

## Potential temperature

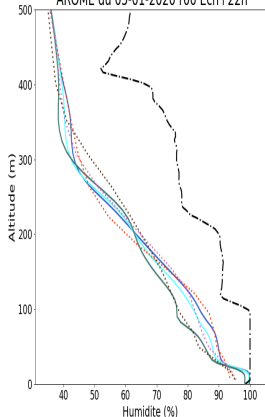
Profil de temperature potentielle - RS de 21:43h  
AROME du 05-01-2020 r00 Ech+22h



— 500 ICE3 (wod - wisc)    ···· ICE3 (wod - wisc)    ···· LIMA (wid - wisc)  
— 500 ICE3 (wid - wisc)    ···· ICE3 (wid - wisc)    ···· Observations  
— 500 LIMA (wid - wisc)

## Humidity

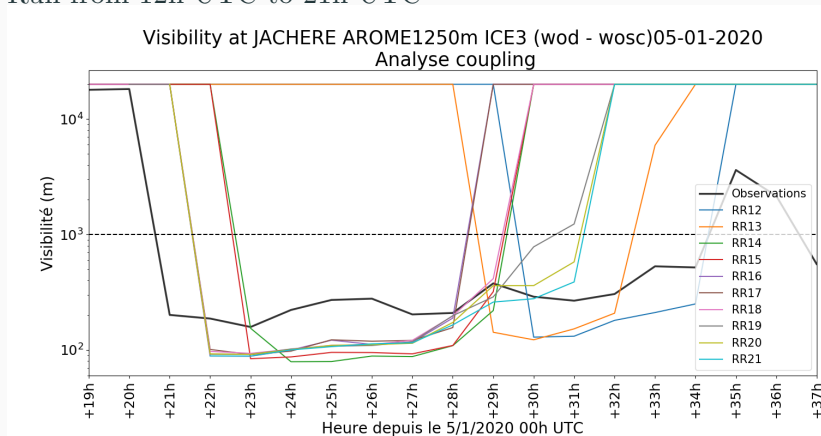
Profil d'humidite - RS de 21:43h  
AROME du 05-01-2020 r00 Ech+22h



— 500 ICE3 (wod - wisc)    ···· ICE3 (wod - wisc)    ···· LIMA (wid - wisc)  
— 500 ICE3 (wid - wisc)    ···· ICE3 (wid - wisc)    ···· Observations  
— 500 LIMA (wid - wisc)

# IOP-6 – Best forecast with better initial conditions

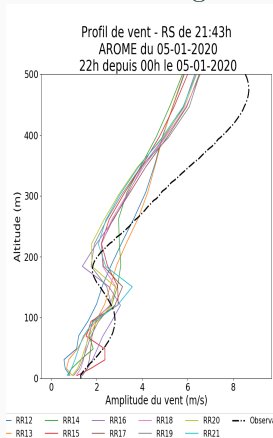
Coupling with AROME analyses  
Run from 12h UTC to 21h UTC



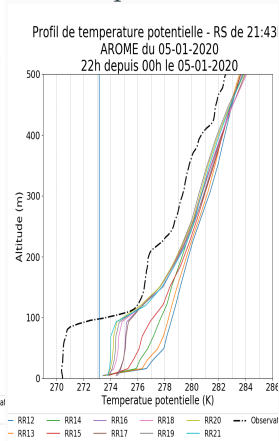
Good fog forecast in formation with Run 16 and after.

# IOP-6 – Best forecast with better initial conditions

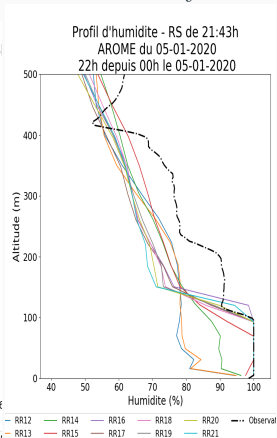
## Wind strength



## Potential temperature



## Humidity



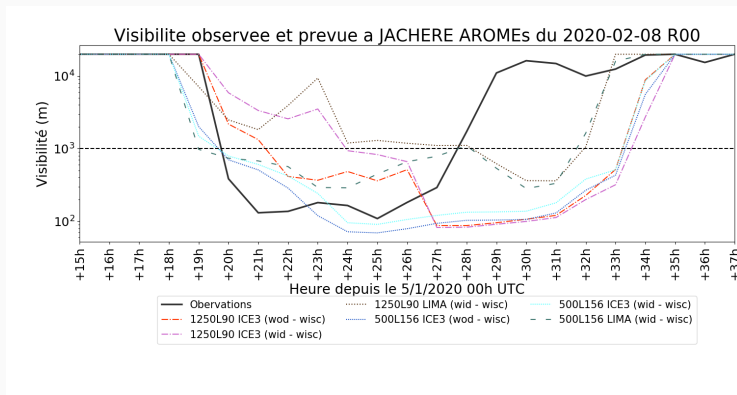
Best profiles

Fog not enough developed in the model (horizontally and vertically)

- Not explained by microphysics
- Can be corrected with better initial conditions

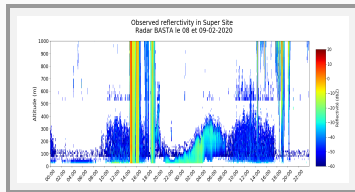
Night from 8<sup>th</sup> to 9<sup>th</sup> February 2020

Delay in formation to 1250L90 ICE3 and dissipation to 1250L90 ICE3 and 500L156 ICE3

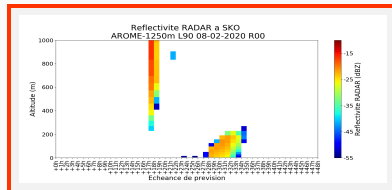


# IOP-11 – RADAR BASTA vs RADAR simulations

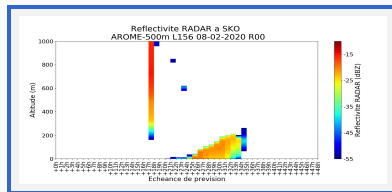
## BASTA observations



## AROME-1250m ICE3



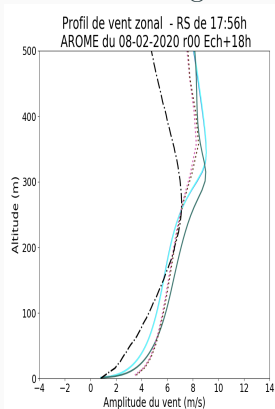
## AROME-500m ICE3



- Not enough vertically developed.
- Fog to stratus observed near 5 UTC not forecast in models (always fog)

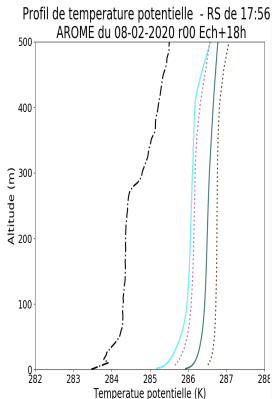
# IOP-11 – Radiosounding at 18 UTC – initial condition of the night

## Wind strength



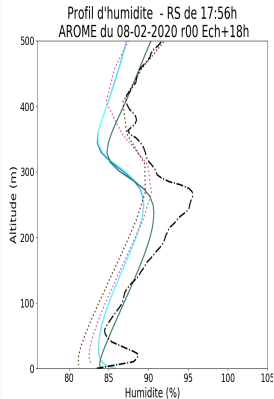
— 500 ICE3 (wod - wisc)    ..... 1250 ICE3 (wod - wisc)    ..... 1250 LIMA (wid - w  
— 500 ICE3 (wid - wisc)    ..... 1250 ICE3 (wid - wisc)    ..... 1250 LIMA (wid - w  
— 500 LIMA (wid - wisc)    ..... Observations

## Potential temperature



— 500 ICE3 (wod - wisc)    ..... 1250 ICE3 (wod - wisc)    ..... 1250 LIMA (wid - w  
— 500 ICE3 (wid - wisc)    ..... 1250 ICE3 (wid - wisc)    ..... 1250 LIMA (wid - w  
— 500 LIMA (wid - wisc)    ..... Observations

## Humidity



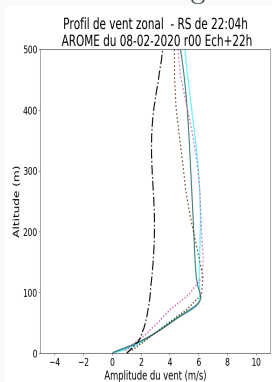
— 500 ICE3 (wod - wisc)    ..... 1250 ICE3 (wod - wisc)    ..... 1250 LIMA (wid - w  
— 500 ICE3 (wid - wisc)    ..... 1250 ICE3 (wid - wisc)    ..... 1250 LIMA (wid - w  
— 500 LIMA (wid - wisc)    ..... Observations

- too hot but correct stability and wind



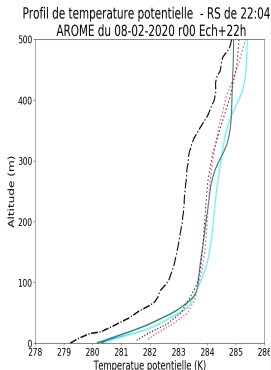
# IOP-11 – Radiosounding at 22 UTC – Fog formation

## Wind strength



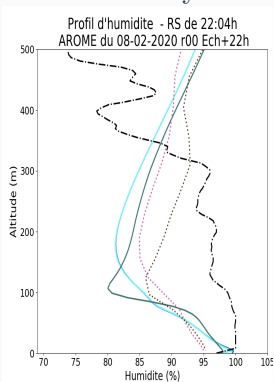
— 500 ICE3 (wod - wisc)    - - - 1250 ICE3 (wod - wisc)    - - - 1250 LIMA (wid - w  
— 500 ICE3 (wid - wisc)    - - - 1250 ICE3 (wid - wisc)    - - - Observations  
— 500 LIMA (wid - wisc)

## Potential temperature



— 500 ICE3 (wod - wisc)    - - - 1250 ICE3 (wod - wisc)    - - - 1250 LIMA (wid - w  
— 500 ICE3 (wid - wisc)    - - - 1250 ICE3 (wid - wisc)    - - - Observations  
— 500 LIMA (wid - wisc)

## Humidity

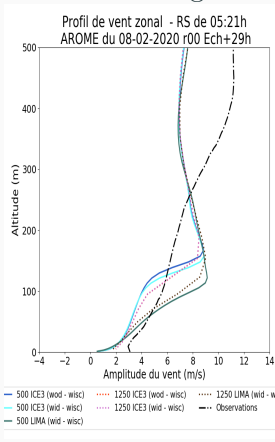


— 500 ICE3 (wod - wisc)    - - - 1250 ICE3 (wod - wisc)    - - - 1250 LIMA (wid - w  
— 500 ICE3 (wid - wisc)    - - - 1250 ICE3 (wid - wisc)    - - - Observations  
— 500 LIMA (wid - wisc)

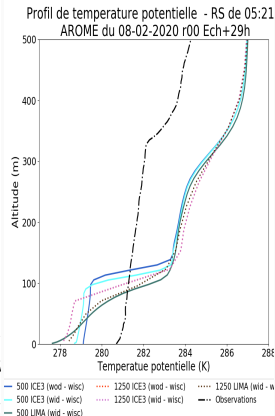
- correct stability
- too dry in 1250m L90 grid
- wind inversion not present in observation

# IOP-11 – Radiosounding at 05 UTC – initial condition of the night

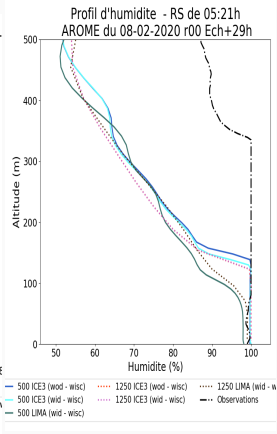
## Wind strength



## Potential temperature



## Humidity



dissipation of fog in observation but the profile is saturated

- Aerosols CAMS for LIMA
- Change visibility formulation for LIMA
- Use microphysics measurements to validate LIMA
- Study a false alarm IOP (IOP-8)
- Continue to study the IOP-11

Thanks for your  
attention  
Questions ?

# General statistics – microphysics comparison

## Lead time +19 - +24

		DR	FAR	FBI
1250mL90	ICE3 (wid-wisc) R00	30	41	0.5
1250mL90	LIMA (wid-wisc) R00	28	55	0.62
1250mL90	ICE3 (wid-wisc) R00	56	48	1.09
1250mL90	LIMA (wid-wisc) R00	55	57	1.27

## Lead time +31 - +36

		DR	FAR	FBI
1250mL90	ICE3 (wid-wisc) R00	47	57	1.09
1250mL90	LIMA (wid-wisc) R00	40	67	1.22
1250mL90	ICE3 (wid-wisc) R00	57	61	1.45
1250mL90	LIMA (wid-wisc) R00	56	65	1.61

# General statistics – Modification of $N_c$

## Lead time +19 - +24

				DR	FAR	FBI
1250mL90	ICE3	$N_c = 300.cm^{-3}$	R00	44	45	0.79
1250mL90	ICE3	$N_c = 100.cm^{-3}$	R00	35	45	0.63
1250mL90	ICE3	$N_c = 50.cm^{-3}$	R00	35	50	0.69

## Lead time +25 - +30

				DR	FAR	FBI
1250mL90	ICE3	$N_c = 300.cm^{-3}$	R00	59	38	0.96
1250mL90	ICE3	$N_c = 100.cm^{-3}$	R00	53	37	0.85
1250mL90	ICE3	$N_c = 50.cm^{-3}$	R00	51	40	0.85

## Lead time +31 - +36

				DR	FAR	FBI
1250mL90	ICE3	$N_c = 300.cm^{-3}$	R00	62	55	1.37
1250mL90	ICE3	$N_c = 100.cm^{-3}$	R00	57	57	1.32
1250mL90	ICE3	$N_c = 50.cm^{-3}$	R00	56	59	1.35

# General statistics – comparison between run

## Lead time +19 - +24

		DR	FAR	FBI
1250mL90	ICE3 R00	44	45	0.79
1250mL90	ICE3 R12	33	39	0.53
1250mL90	ICE3 R12	38	36	0.60

## Lead time +25 - +30

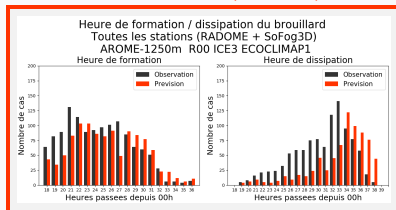
		DR	FAR	FBI
1250mL90	ICE3 R00	59	38	0.96
1250mL90	ICE3 R12	54	29	0.76
1250mL90	ICE3 R12	54	28	0.75

## Lead time +31 - +36

		DR	FAR	FBI
1250mL90	ICE3 R00	62	55	1.37
1250mL90	ICE3 R12	58	51	1.18
1250mL90	ICE3 R12	58	51	1.17

# Impact of deposition

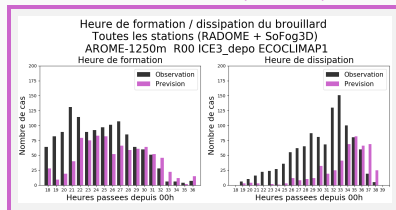
## AROME-1250mL90 ICE3 (wod-wisc)



Formation  
Lead time

Dissipation  
Lead time

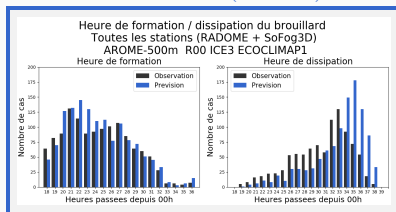
## AROME-1250mL90 ICE3 (wid-wisc)



Formation  
Lead time

Dissipation  
Lead time

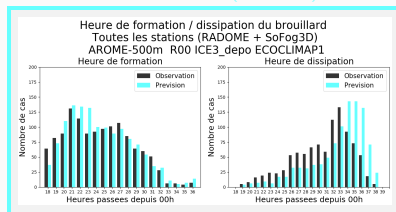
## AROME-500mL156 ICE3 (wod-wisc)



Formation  
Lead time

Dissipation  
Lead time

## AROME-500mL156 ICE3 (wid-wisc)

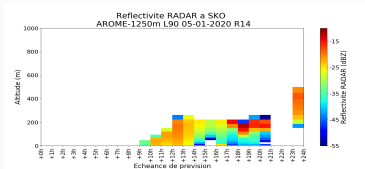
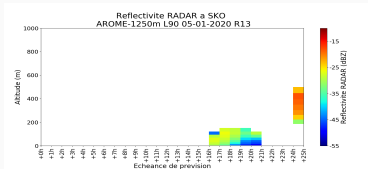
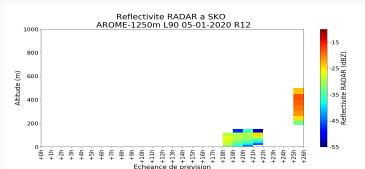
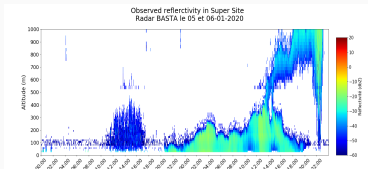


Formation  
Lead time

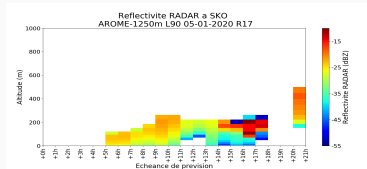
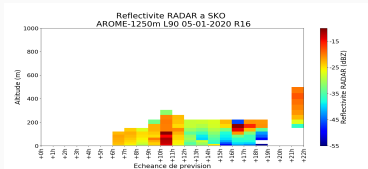
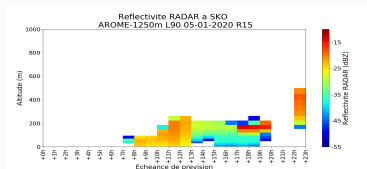
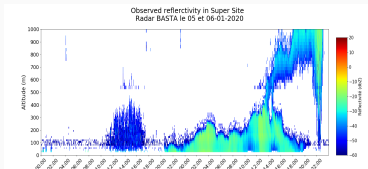
Dissipation  
Lead time



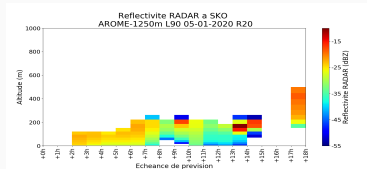
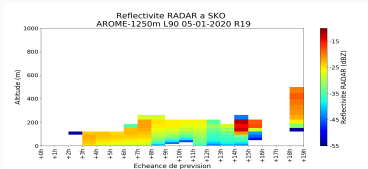
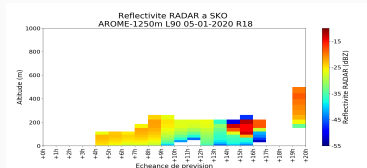
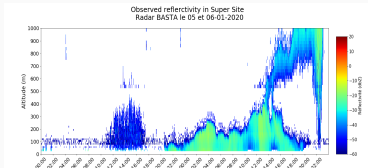
# IOP- 6 – RADAR simulation for different Run



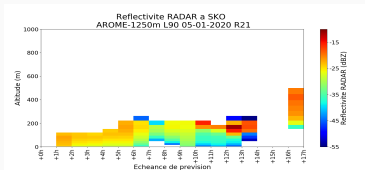
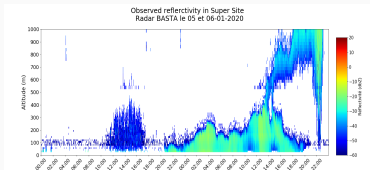
# IOP- 6 – RADAR simulation for different Run



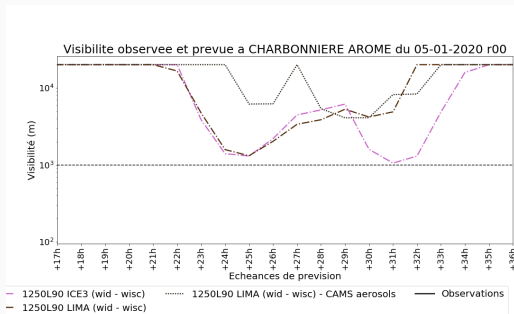
# IOP- 6 – RADAR simulation for different Run



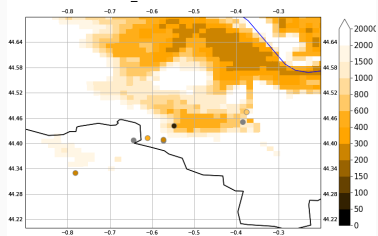
# IOP- 6 – RADAR simulation for different Run



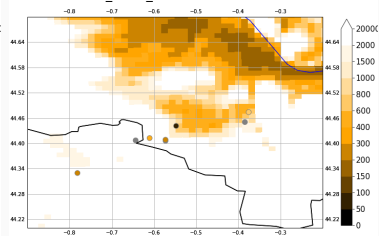
# IOP- 6 – CAMS aerosol



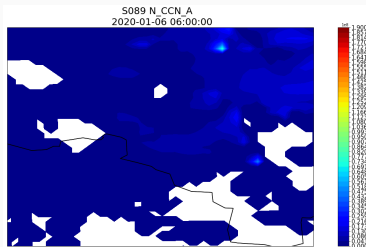
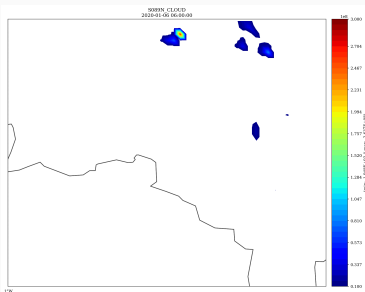
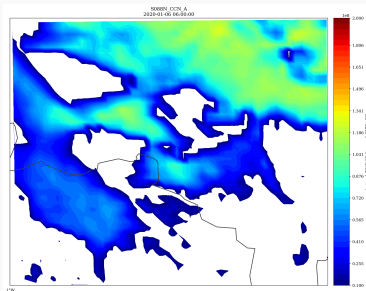
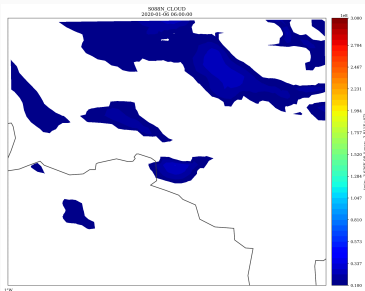
Observed and forecast visibility  
AROME 1250m - LIMA\_acsm -- 05-01-2020 R12 Ech+18h



Observed and forecast visibility  
1250m - LIMA\_acsm\_aerosol -- 05-01-2020 R12 Ech+18h

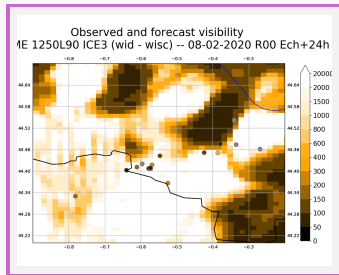


# IOP- 6 – CAMS aerosol

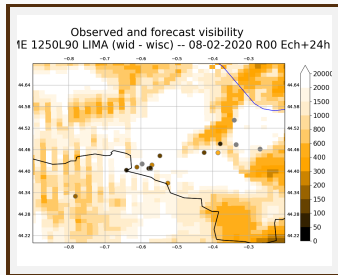


# IOP- 11 – Visi 2D Lead time +24

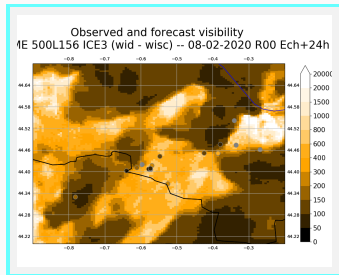
AROME-1250mL90 ICE3 (wid-wisc)



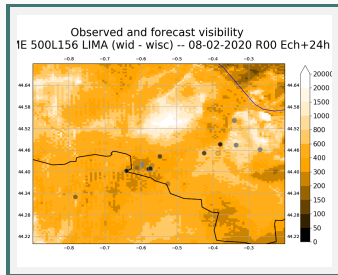
AROME-1250mL90 LIMA (wid-wisc)



AROME-500mL156 ICE3 (wid-wisc)



AROME-500mL156 LIMA (wid-wisc)



- [1] A. Philip, T. Bergot, Y. Bouteloup, and F. Bouysse. The Impact of Vertical Resolution on Fog Forecasting in the Kilometric-Scale Model AROME : A Case Study and Statistics. Weather and Forecasting, 31(5) :1655–1671, 2016. doi : 10.1175/WAF-D-16-0074.1. URL <https://doi.org/10.1175/WAF-D-16-0074.1>.
- [2] J. Pinty and P. Jabouille. A mixed-phase cloud parameterization for use in a mesoscale non-hydrostatic model : simulations of a squall line and of orographic precipitations. Proceedings of the AMS conference on cloud physics, 1998.
- [3] B. Vié, J.-P. Pinty, S. Berthet, and M. Leriche. Lima (v1.0) : A quasi two-moment microphysical scheme driven by a multimodal population of cloud condensation and ice freezing nuclei. Geoscientific Model Development, 9(2) :567–586, 2016. doi : 10.5194/gmd-9-567-2016. URL <https://gmd.copernicus.org/articles/9/567/2016/>.