AROME FORECAST REPORT

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SOFOG3D workshop - 12^{th} June 2023

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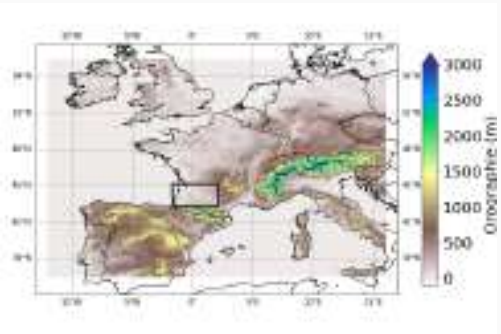
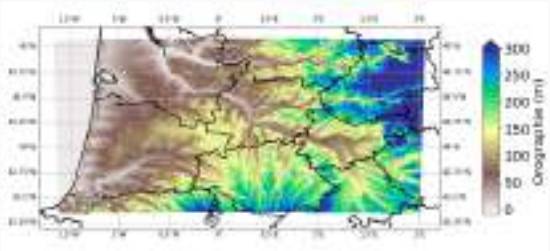
Modeling data - AROME (Brousseau et al. 2016, Seity et al. 2011)

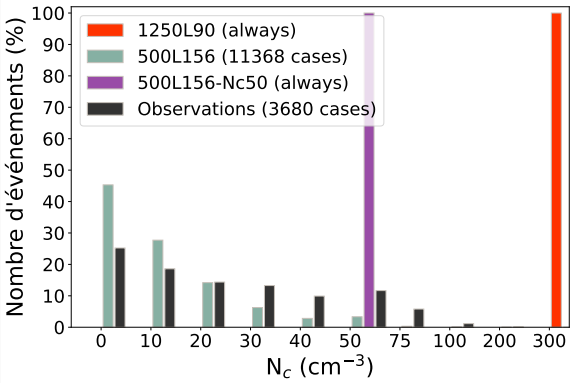
Configurations	1250L90 Reference (≈ AROME-France)	500L156 Adapted to fog	500L156-Nc50
Horizontal resolution	1250 m	500 m	500 m
Number of vertical levels	90	156	156
First level height	5 m	1 m	1 m
Initialisation and coupling	AROME-France forecasts		
Micophysical scheme	ICE3	LIMA	ICE3
Droplet deposition	No	Yes	Yes
ICE3 droplet concentration	300 cm^{-3}	-	50 cm^{-3}
LIMA CCNF [1] initialisation	-	Constant field	-



Operational AROME-France domain



Reduced domain in South-West of France



Droplet concentration in fogs observed by CDP and forecast at Charbonnière

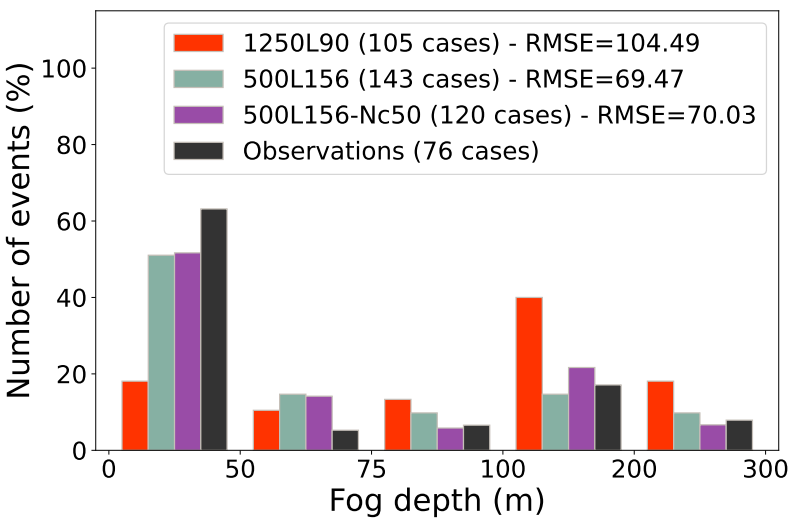
1. CCNF - Free Cloud Condensation Nuclei

Contents

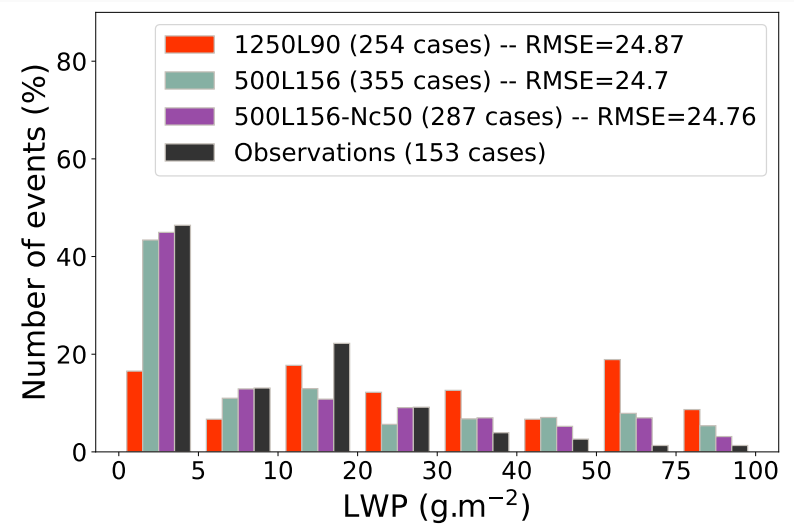
- **Statistical evaluation of the AROME configuration adapted to fog forecasts over the whole campaign**
- Overestimated fogs due to low-level clouds
- Overestimated fogs linked to low-level jet

Improvement of fog characteristics with 500L156

Fog top height



LWP in fog events



500L156 Vs 1250L90

+ More fogs with low LWP [a] (less than 20 g.m^{-2}) and with low top height (less than 50 m)
+ Less fogs with high LWP (more than 30 g.m^{-2}) and with top height upper than 100 m

a. Liquid Water Path

500L156-Nc50 Vs 500L156

- Similar distributions
- Improvement allowed by 500L156 linked to droplet concentration values
- The 2-moment approach with LIMA would be better adapted to the large variety of droplet concentrations during the fog life cycle and over France (not only the South-West)

Statistical evaluation of 500L156 configuration

General improvement in fog forecasts

+ Improved detection
+ Reduced fog formation delay, mainly at the beginning of the night (from 1800 UTC to 0000 UTC)
+ Reduced fog dissipation delay, mainly at the end of the night and in the morning (after 0600 UTC)

Persistent problems

− More false alarms
− Fog dissipation still too late

More details in the previous SOFOG3D workshops presentations and soon in the paper (accepted with minor revisions) :

Antoine S., Honnert R., Seity Y, Vié B., Burnet F. and Martinet P. Evaluation of an improved AROME configuration for fog forecasts during SoFog3D campaign. *Weather and Forecasting*

False alarms and overestimated fogs during SOFOG3D IOPs

overall impression during IOPs of SOFOG3D by observers

False alarms / overestimated fogs in model occurred in 2 types of observed meteorological situations

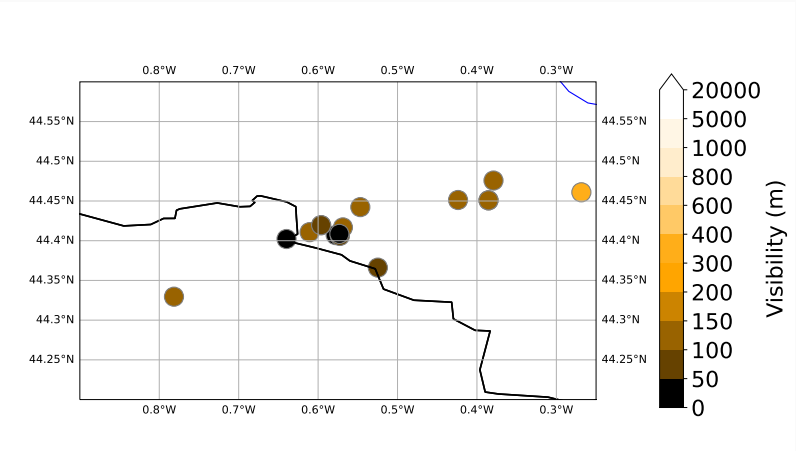
(1) **low-level clouds** (stratus or stratocumulus) above the site

(2) **low-level jet**

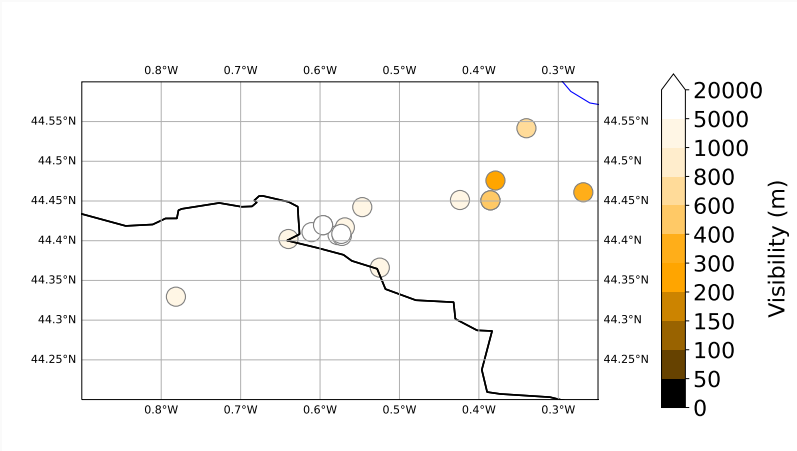
Contents

- Statistical evaluation
- **Overestimated fogs due to low-level clouds**
- Overestimated fogs linked to low-level jet

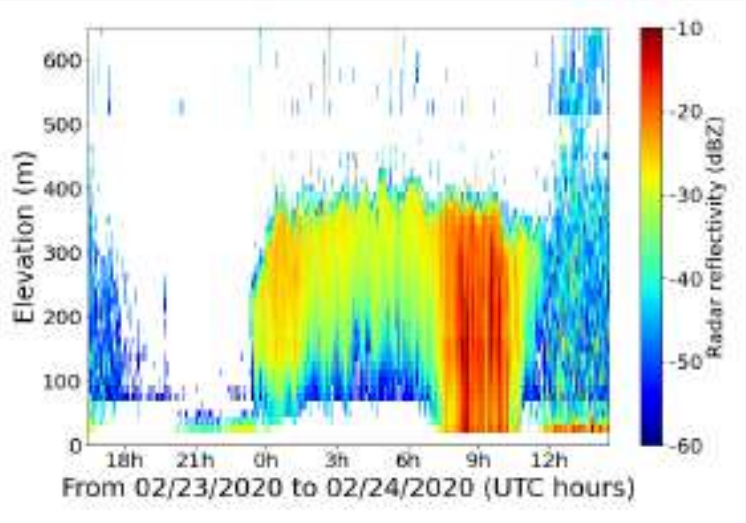
IOP-13.2 – Night of February 23-24, 2020 – Observations



Minimum visibility observed between 1800 UTC on 02/23/2020 and 0000 UTC on 02/24/2020



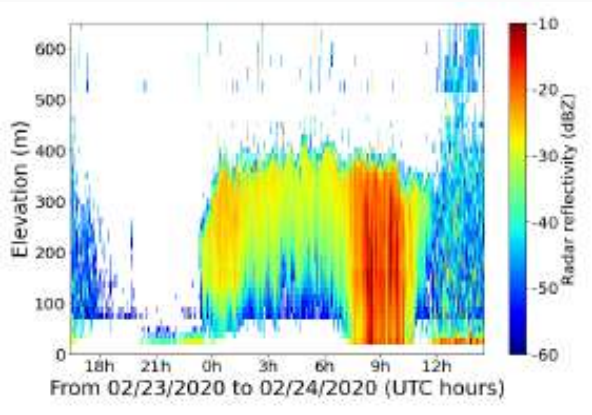
Minimum visibility observed between 0200 UTC and 0600 UTC on 02/24/2020



Reflectivity (cloud radar at Super-site)

- Fog observed at the beginning of the night
- Low cloud advected in the area from 0000 UTC on 02/24/2020
- Fog dissipation after 0200 UTC on 02/24/2020

IOP-13.2 – Night of February 23-24, 2020 – Forecasts



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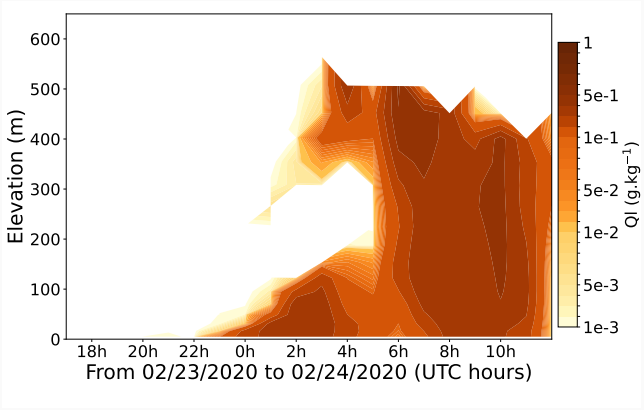
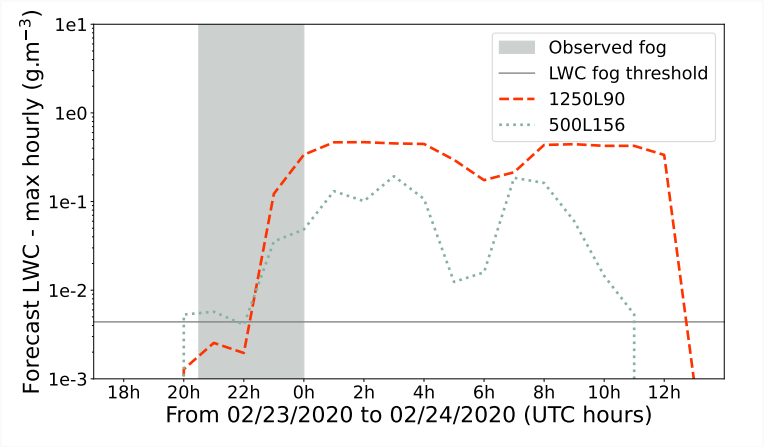
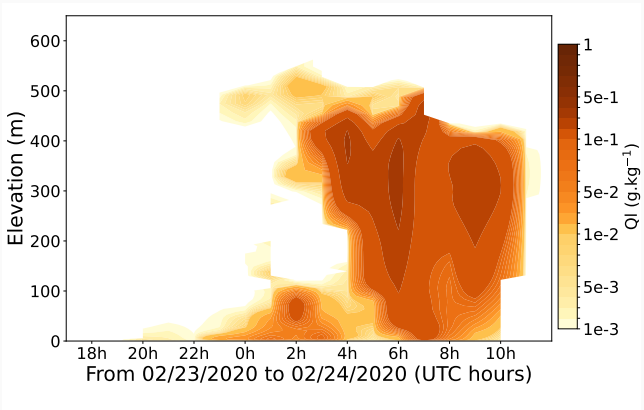


Forecast cloud water content at Super-site **1250L90** of 02/23/2020 R00



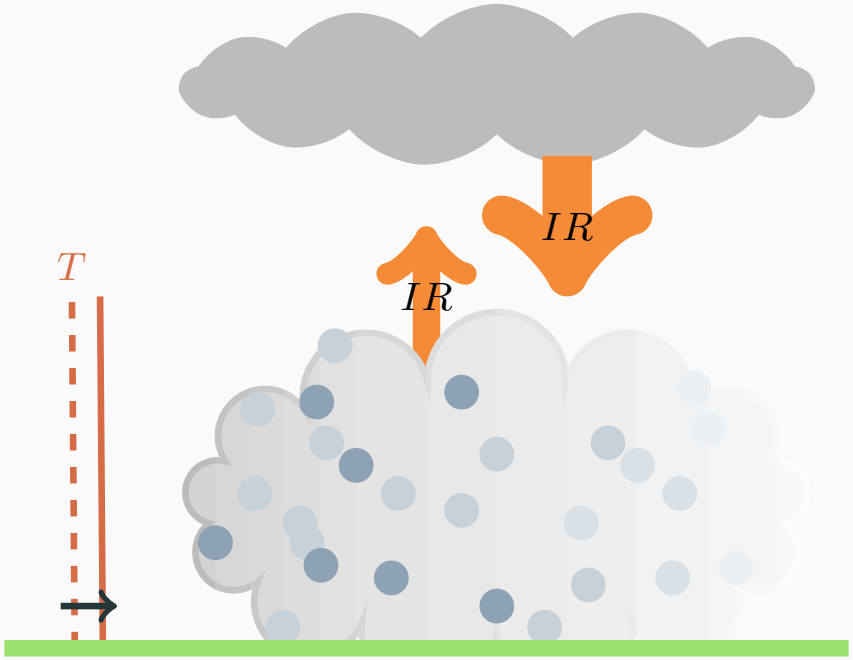
Observed and forecast fog occurrences at the Super-site



Forecast cloud water content at Super-site **500L156** of 02/23/2020 R00

- Fog forecast at the beginning of the night
- Low cloud in the model
- **But the fog dissipates far too late in the model !**

Fog and stratus/stratocumulus – Theory



Presence of a cloud (Roach et al. 1976)

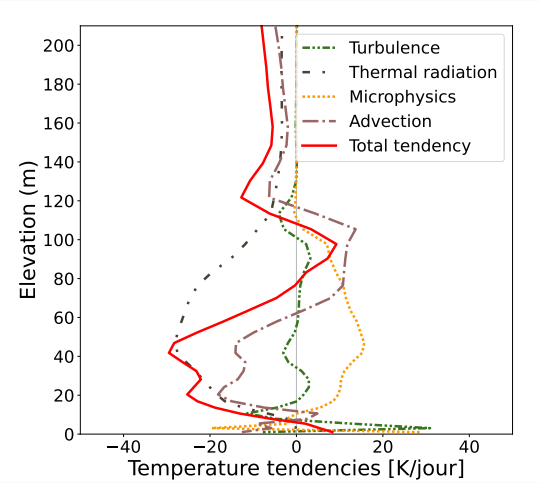
- Stop radiative cooling (surface or summit)
- Air mass warming
- Reduced water content
- The lower and optically thicker the cloud, the greater its impact.

Taking the cloud into account in the model

What physical processes affect the evolution of temperature and cloud water in fog before and after cloud arrival ?

Before the cloud came over the fog

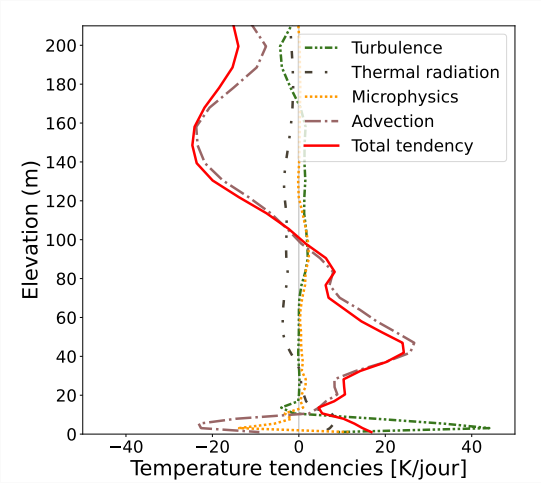
Temperature



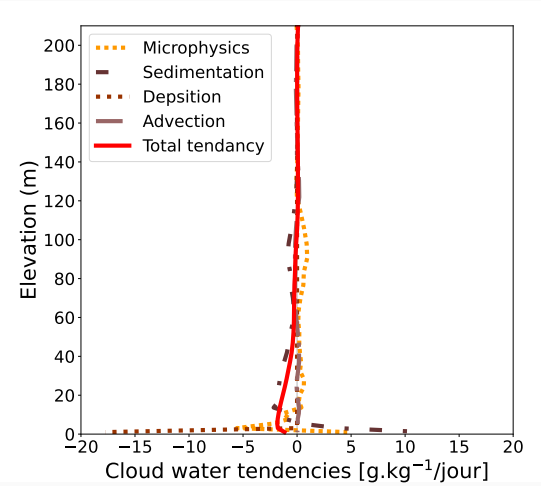
Between 0200 and 0300 UTC the 02/24/2020
500L156 of 02/23/2020 R00

After the cloud came over the fog

Temperature



Cloud water



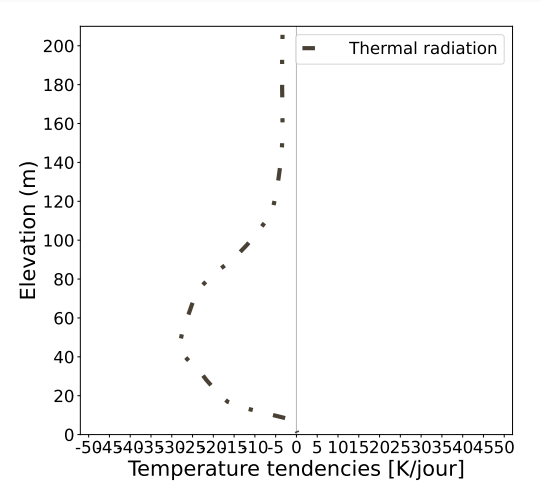
Between 0300 and 0400 UTC the 02/24/2020
500L156 of 02/23/2020 R00

Taking the cloud into account in the model

- Reduced radiative cooling of fog $\Longrightarrow$ YES
- Reduced cloud water content in fog $\Longrightarrow$ YES

Before the cloud came over the fog

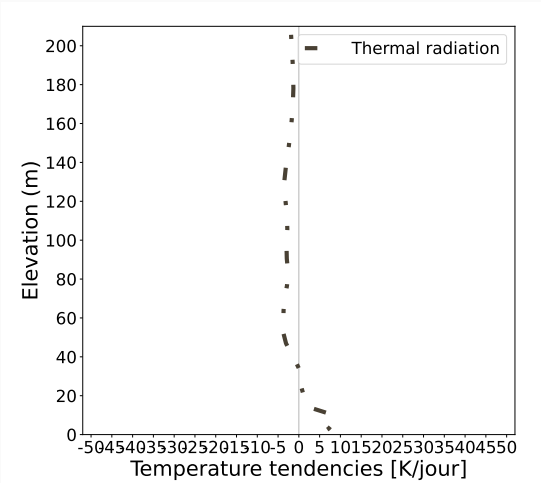
Temperature



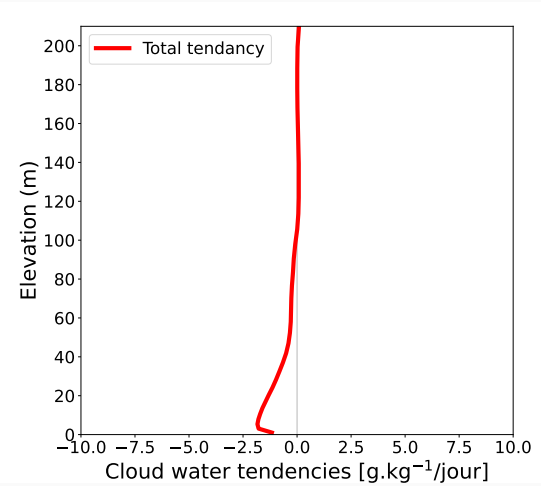
Between 0200 and 0300 UTC the 02/24/2020
500L156 of 02/23/2020 R00

After the cloud came over the fog

Temperature

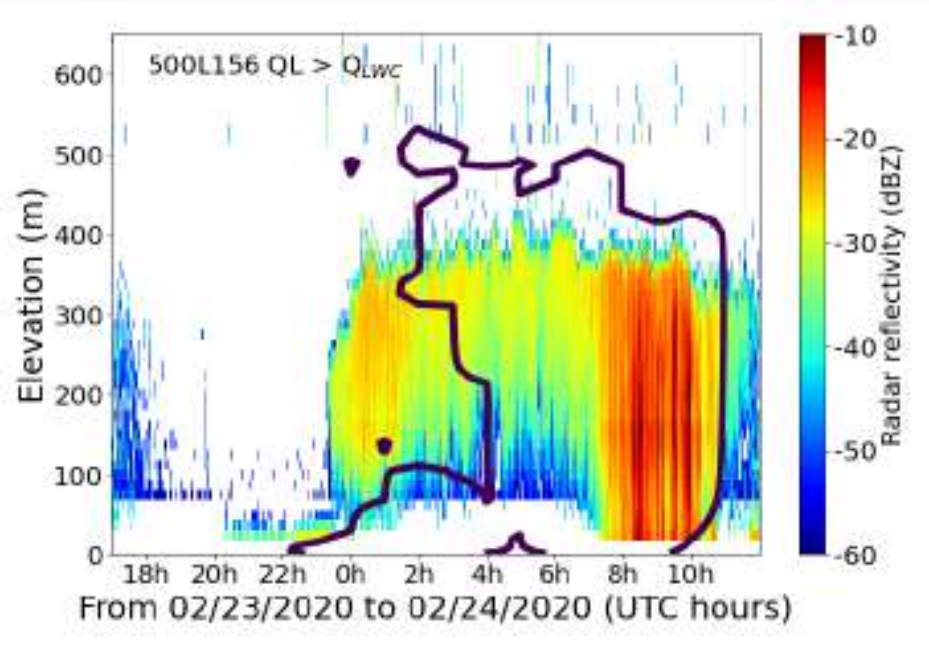


Cloud water



Between 0300 and 0400 UTC the 02/24/2020
500L156 of 02/23/2020 R00

Overdeveloped fog

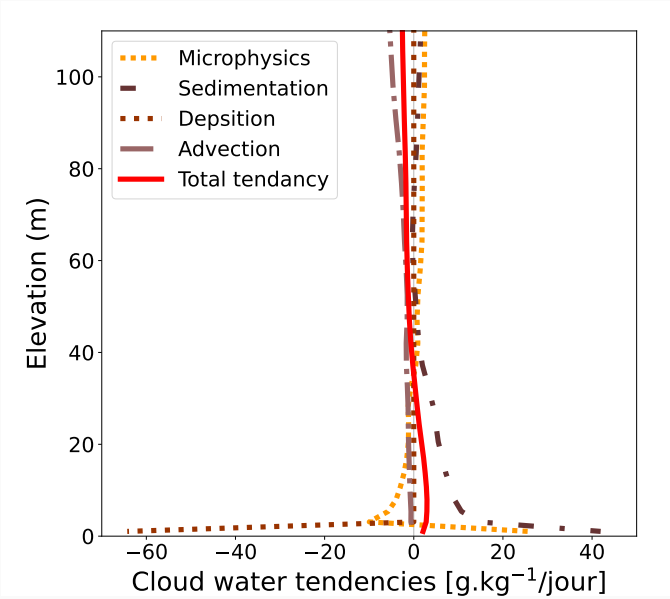


Radar reflectivity measured at Super-site Cloud water content forecast at the super-site greater than Q_{LWC} (**500L156** of 02/23/2020 R00)

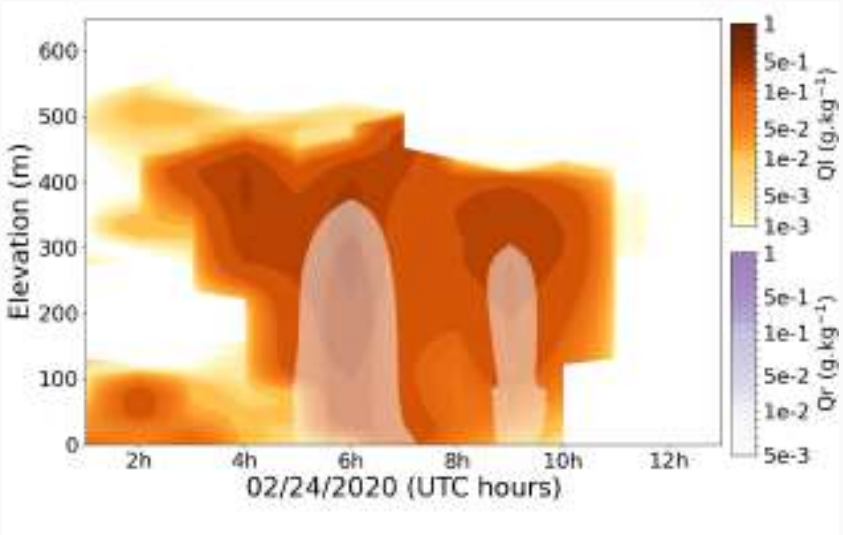
Forecasts compared to observations

- The cloud arrives 2/3 h late
- The fog has time to develop
- And therefore takes longer time to dissipate
- But that can't be the only explanation...

Droplet sedimentation and rain formation



Processes impacting the evolution of cloud water at Super-site
Between 0600 and 0700 UTC on 02/24/2020
500L156 of 02/23/2020 R00



Liquid water content (orange range) and rainy water contents (violet range) forecast for Super-site **500L156** of 02/23/2020 R00

- Sedimentation of cloud water contained in the cloud
- Raindrop formation + sedimentation and evaporation

→ Maintains high humidity in the lower layers

→ The fog can't dissipate

A usual situation in the model forecast

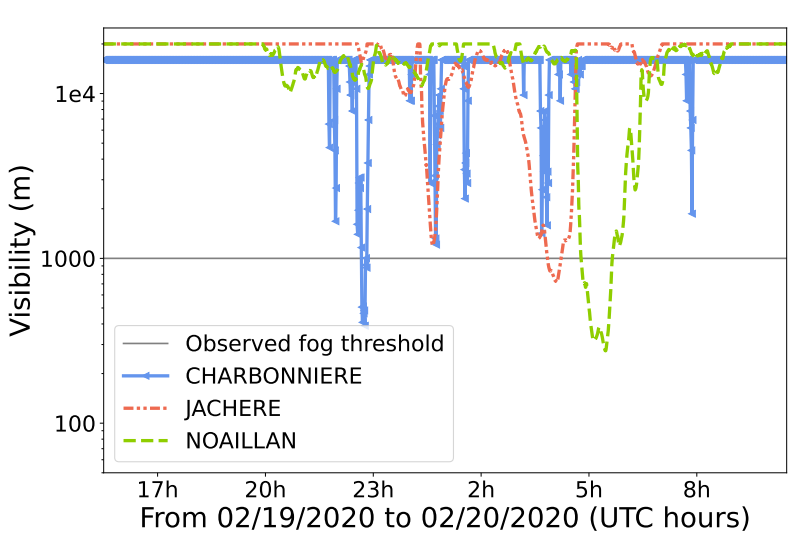
Analysis of other IOPs from the SOFOG3D campaign (5 in all) led to similar results :

- A bad large-scale forecast inevitably has an impact on the fog forecast.
- The processes involved in dissipation mechanisms are represented in the model.
- Over-developed fogs (too thick, too extensive, with too high water content, etc.) take longer time to dissipate.
- Stratus/stratocumulus clouds sediment, keeping moisture in the lower layers and preventing fog from dissipating.

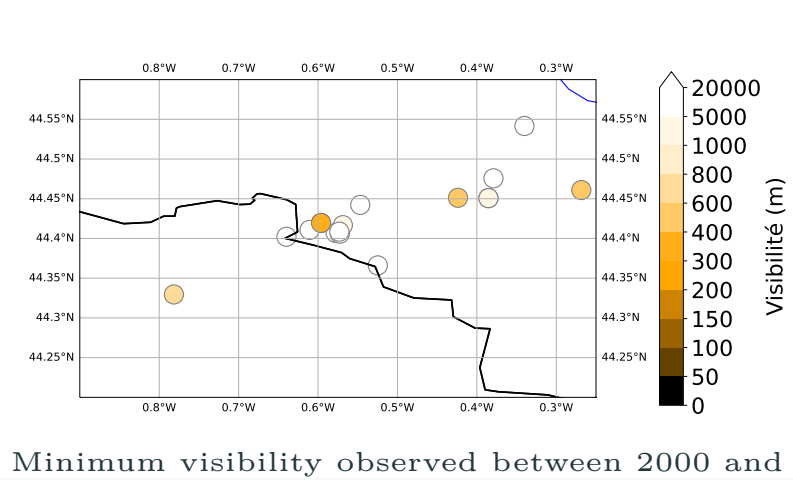
Contents

- Statistical evaluation
- Overestimated fogs due to low-level clouds
- **Overestimated fogs linked to low-level jet**

IOP-12 – Night of February 19-20, 2020 – Observations

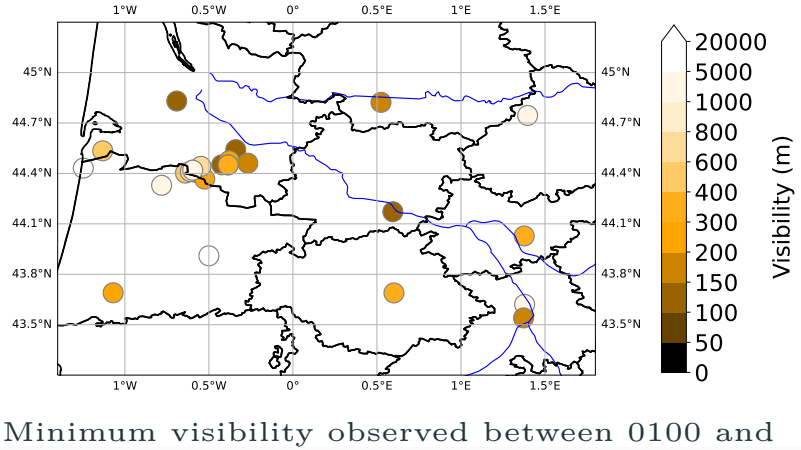


Observed visibility



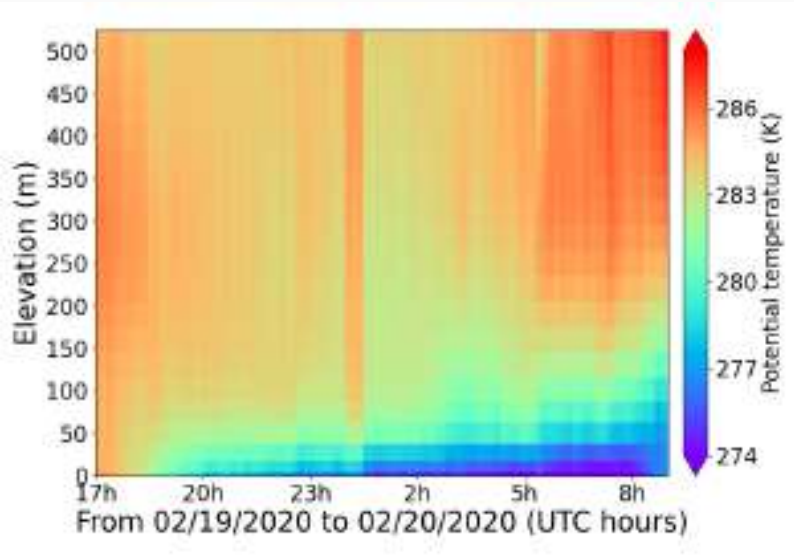
Minimum visibility observed between 2000 and 2400 the 02/19/2023

- Low density fog near super site before 0000 UTC the 02/19/2020
- Deep fog around the southwest between 0100 and 0700 UTC the 02/20/2020
- But no fog at the super site between 0100 and 0700 UTC the 02/20/2020

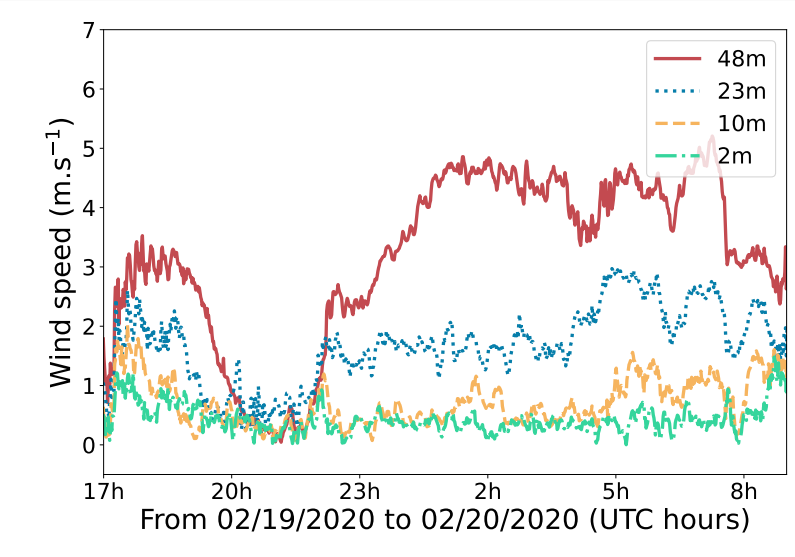


Minimum visibility observed between 0100 and 0700 the 02/20/2023

IOP-12 – Between 2000 and 2400 UTC the 02/19/2023 - Observations

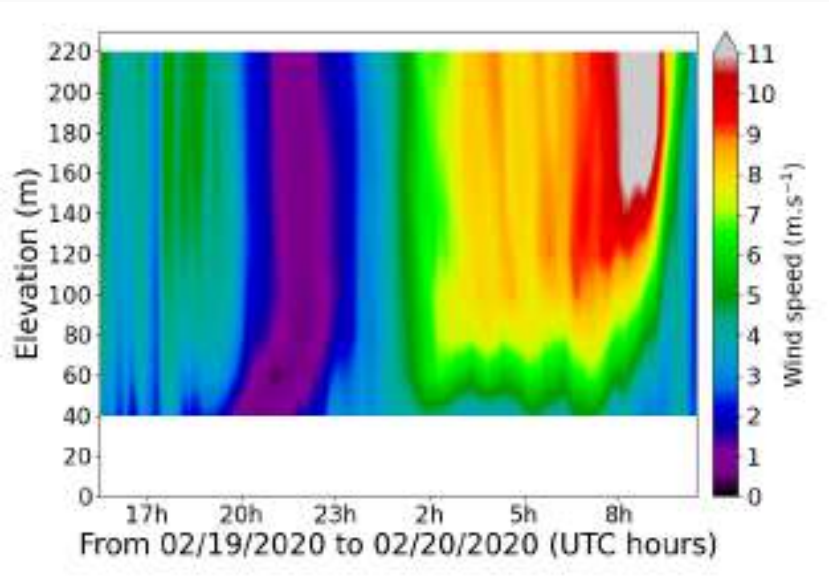


Potential temperature observed with radiometer at Charbonnière



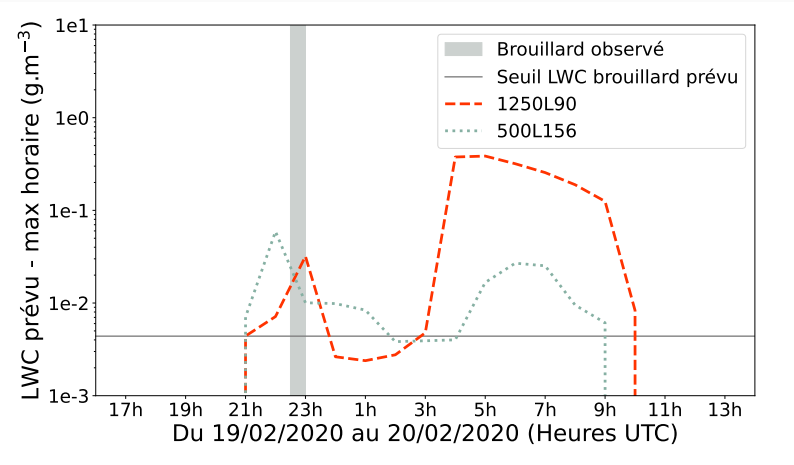
Wind speed observed at "Le Couye"

- Radiative cooling of air above the ground : radiative fog
- Fog onset when the wind gets stronger (near 2200/2300 UTC)
- Fog dissipation when low level jet get too developed

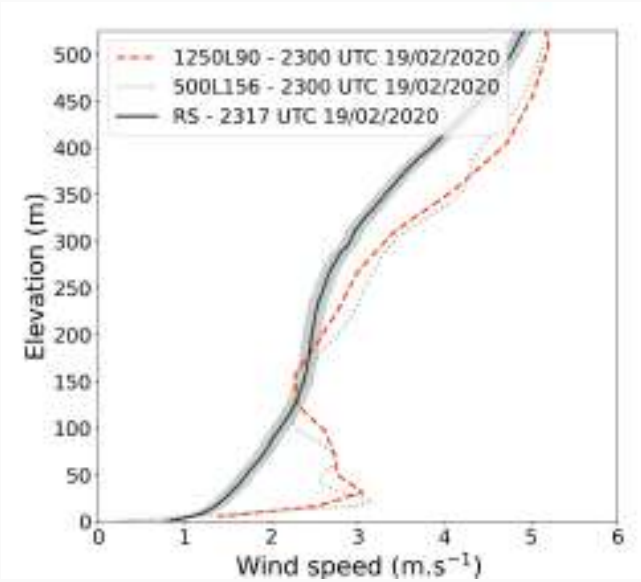


Wind speed observed by LIDAR at Charbonnière

IOP-12 – Between 2000 and 2400 UTC the 02/19/2023 - Forecast

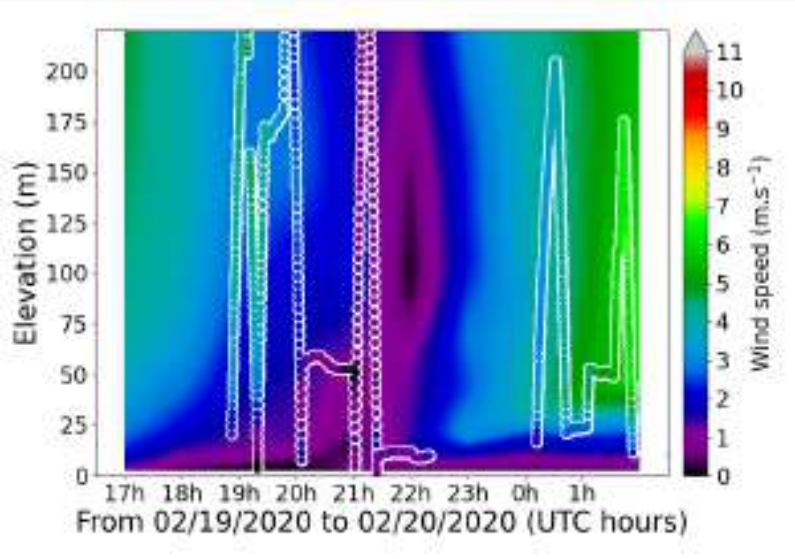


Observed and forecast fog occurrences at the Super-site



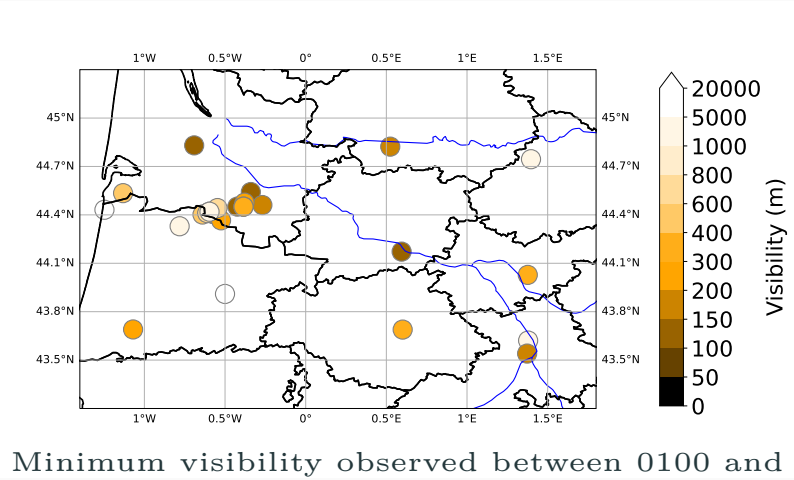
RS at Charbonnière - 2300 UTC 02/19/2020

- Thin radiative fog at the beginning of the night in forecast
- Wind strengthens earlier in the forecasts : earlier fog onset
- Fog dissipation link to low-level jet, but less efficient process

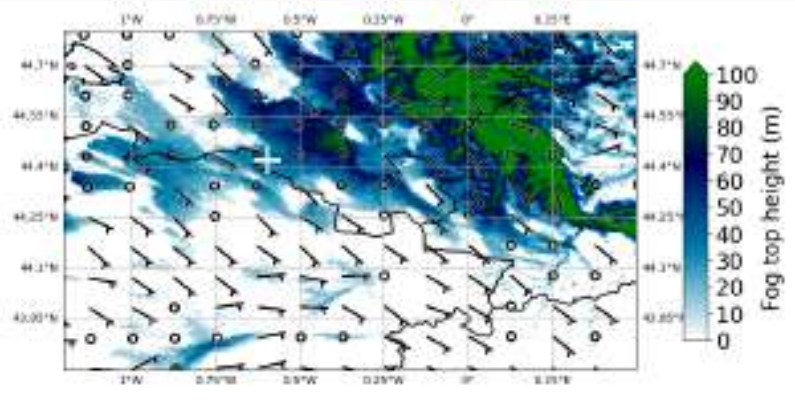


Wind speed observed with tethered balloon and forecast by **500L156** 02/19/2020 R00

IOP-12 – Between 0100 and 0700 UTC the 02/20/2023



Minimum visibility observed between 0100 and 0700 the 02/20/2023



Fog thickness and wind at 20m at 0500 UTC forecast by **500L156** 02/19/2020 R00

- No fog at Charbonnière
- But fog at other stations
- Advective fog from Southeast
- Good forecast of this fog episode
- Heterogeneity in fog forecast by 500L156 around Charbonnière

- Dissipation due to sunrise
- Faster dissipation with 500L156 than 1250L90
- 500L156 fogs thinner and less homogeneous

IOP-12 – Night of February 19-20, 2020 – Conclusions

- A generally good fog forecast for this IOP

- At the beginning of the night, fog forms when the wind strengthens and dissipates when the low-level jet becomes too intense.

- In the second part of the night the fog is an advection fog, the super site is an exception in the zone (fog heterogeneity).

- The fog in the model is also an advection fog, thicker and more homogeneous in 1250L90 than 500L156 -> fog closer to observations in 500L156

Conclusions

Statistical evaluation of AROME new configuration

- General improvement in fog forecasts with our new AROME configuration (improved vertical and horizontal grids, LIMA microphysics scheme, deposition taken into account).
- Persistent problems : false alarms or excessive fog

Overestimated fogs due to low-level clouds (5 IOP)

- Very important : large-scale situation
- Processes involved are represented in the model
- Thicker fogs take longer time to dissipate
- Lower layers are too wet for fog evaporation

Overestimated fogs linked to low-level jet (IOP-12)

- Processes involved are represented in the model
- During this IOP advection fog was well forecast by the model.
- Improvement link to AROME new configuration : more heterogeneous, more realistic fog compared with reference.

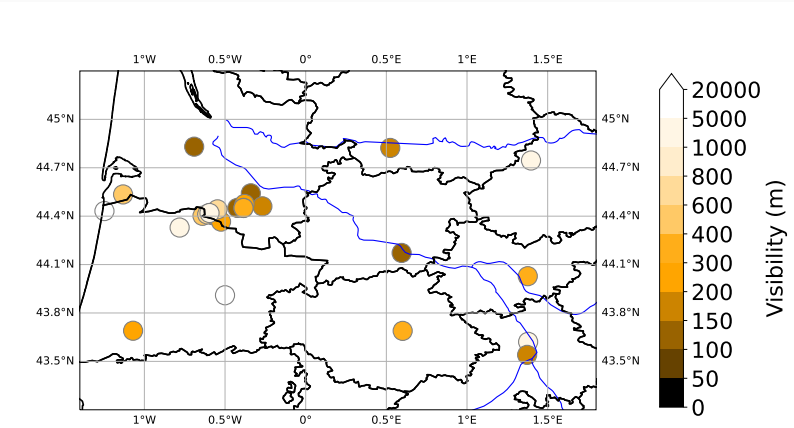
Outlook

Outlook

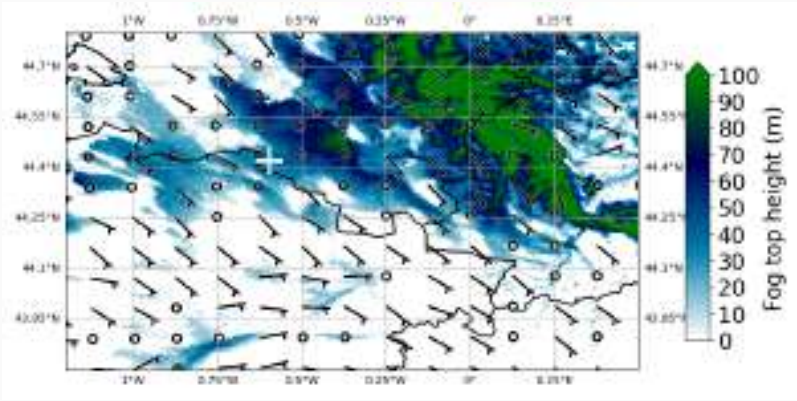
- Publish these case study results
- Test new modifications : Using more realistic fields to initialize CCNF fields in LIMA simulations (CAMS)
- Test the new configuration around Paris
- AROME 500 m operational over Paris and South East of France as soon as 2024 (Olympic games)


Thank you for your attention
Any questions ?

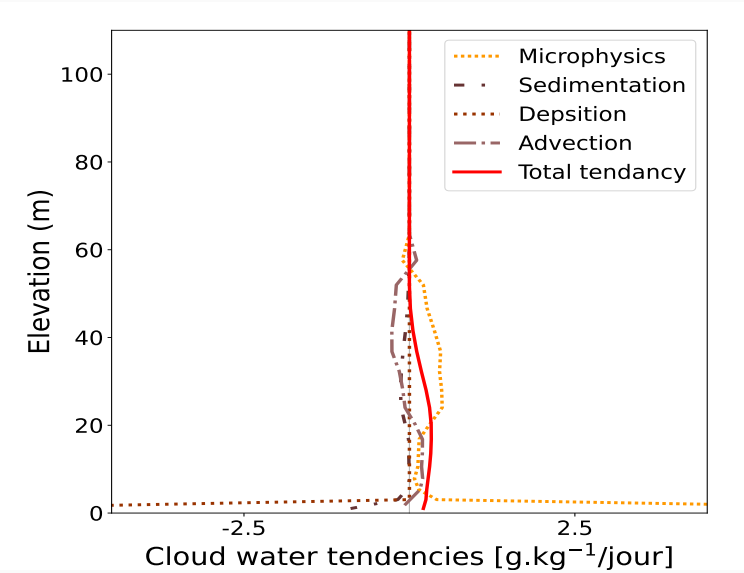
IOP-12 – Between 0100 and 0700 UTC the 02/20/2023



Minimum visibility observed between 0100 and 0700 the 02/20/2023



Fog thickness and wind at 20m at 0500 UTC forecast by **500L156** 02/19/2020 R00



Processes involved in LWC evolution between 0400 and 0500 UTC the 02/20/2020 forecast by **500L156** 02/19/2020 R00

- No fog at Charbonnière
- But fog at other stations
- Advective fog from Southeast
- Good forecast of this fog episode
- Heterogeneity in fog forecast by 500L156 around Charbonnière

- Dissipation due to sunrise
- Faster dissipation with 500L156 than 1250L90
- 500L156 fogs thinner and less homogeneous

Bibliographie I

P. Brousseau, Y. Seity, D. Ricard, and J. Léger. Improvement of the forecast of convective activity from the AROME-France system. Quarterly Journal of the Royal Meteorological Society, 142 (699) :2231–2243, 2016. doi : 10.1002/qj.2822.

W. Roach, R. Brown, S. Caughey, J. Garland, and C. Readings. The physics of radiation fog : I–a field study. Quarterly Journal of the Royal Meteorological Society, 102(432) :313 – 333, 1976. doi : 10.1002/qj.49710243204.

Y. Seity, P. Brousseau, S. Malardel, G. Hello, P. Bénard, F. Bouttier, C. Lac, and V. Masson. The AROME-France Convective-Scale Operational Model. Monthly Weather Review, 139(3) :976–991, 2011. doi : 10.1175/2010MWR3425.1.