Recent progress in AROME physics

Yann Seity, Salomé Antoine, Rachel Honnert, Sébastien Riette, Benoît Vié , Yves Bouteloup, J-M Piriou, Adrien Napoly, Camille Birman...

Outline :

- For next e-suite (2021) :
  - Improve physics/dynamics consistency
  - Ecume v6 parametrisation
  - Lightning diagnostic

- For longer terms
  - Improve fog forecasts
  - Improve T< 0°C clouds
  - A step towards 3D turbulence
  - Surface diffusion scheme
  - Radiation

METEO FRANCE

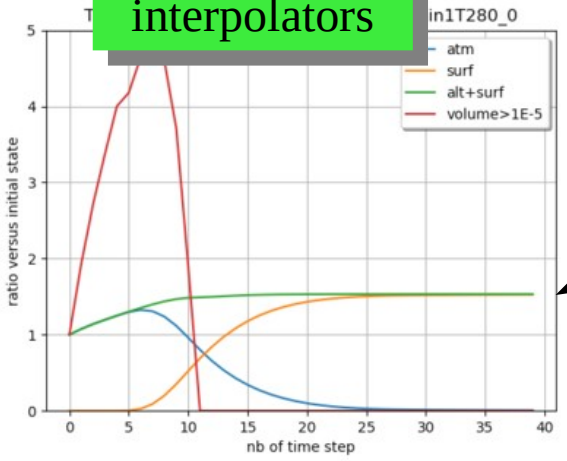
Semi-academic 3D AROME tests to verify mass conservation :

- 48x48x90 points @1250m, setup and coupled with AROME-oper
- Start with $q_c=q_i=q_r=q_s=q_g=0$ except in (24,24,2000m) : q_r=1g/kg
- Microphysics off except sédimentation.
- Turbulence and shallow convection off.
- Forecast term = 40 time steps (dt=50s)
- Flat domain (Z_s=0.)
- T=280K, U = V = 2 m/s
- Hydrostractic dynamics

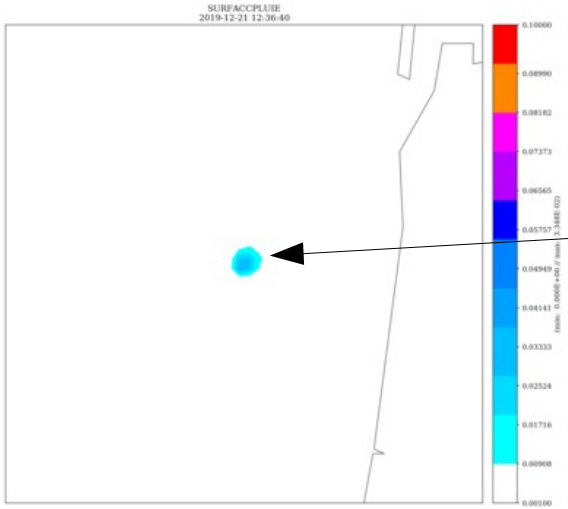
METEO FRANCE

Mass conservation test

QM SL interpolators



+50 %
(not so extreme if initialisation on N > 1 points, in real oper cases, partly compensated by numerical diffusion)



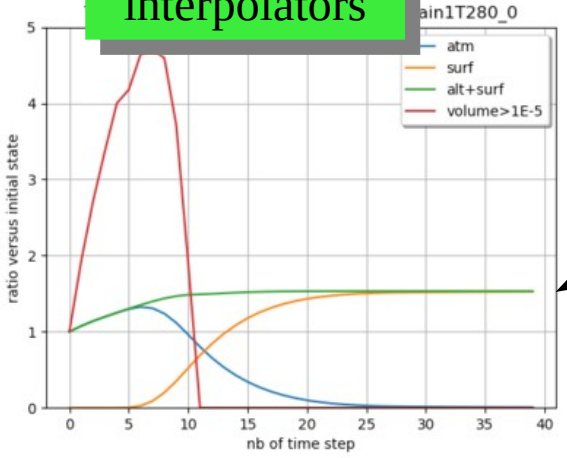
cumulated surface rain

METEO FRANCE

Mass conservation test

- Problem in mass conservation fixed by changing Semi-Lagrangian interpolators

QM SL interpolators



+50 %
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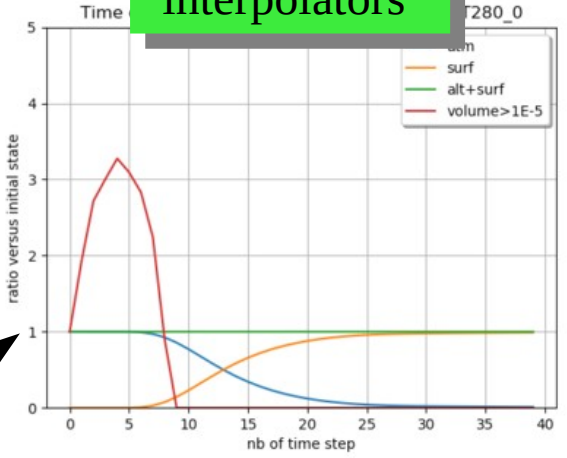
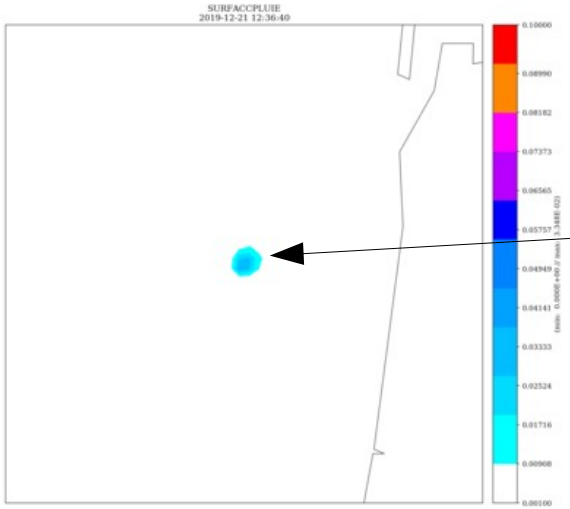
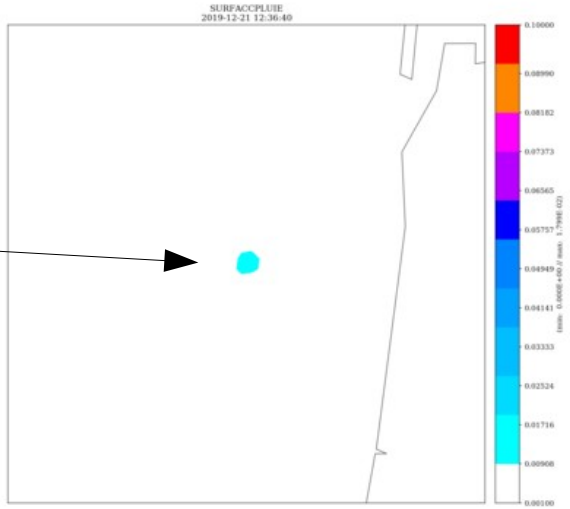
linear SL interpolators



mass conservation

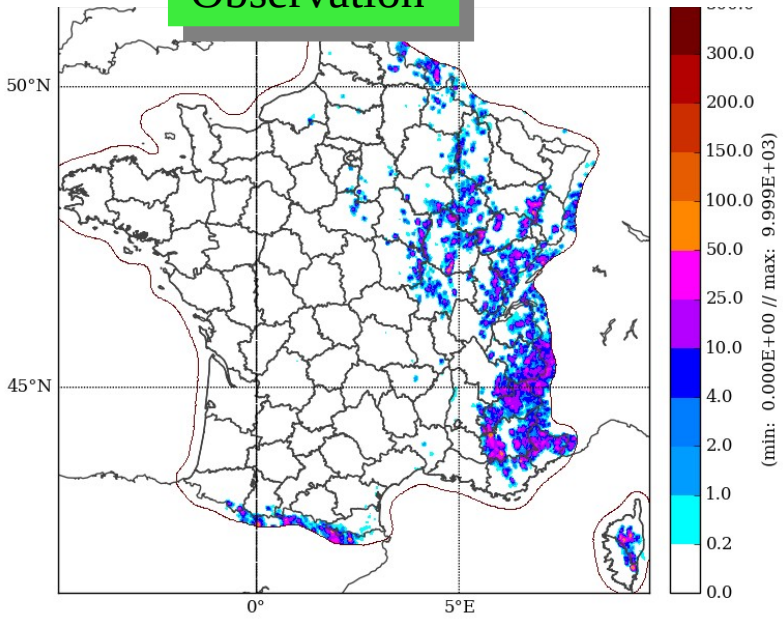


cumulated surface rain

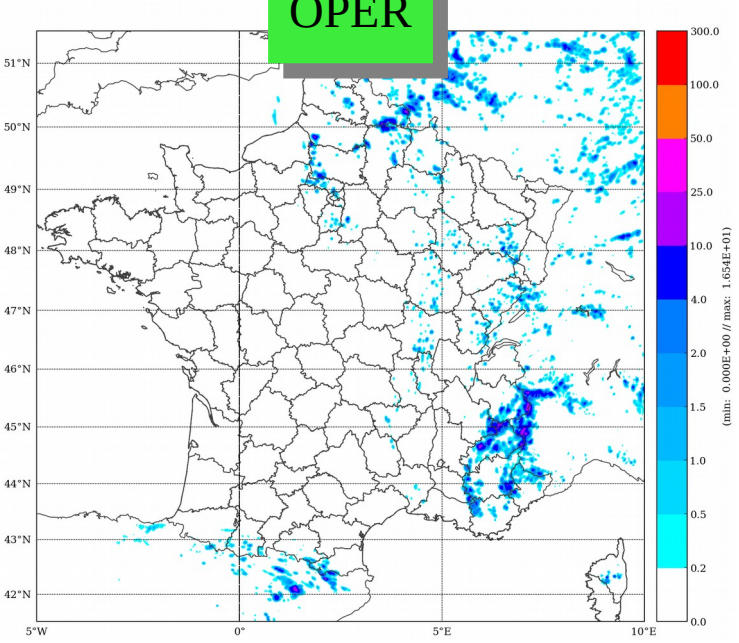


On real case : 25 July 2018 (RR24)

Observation



OPER



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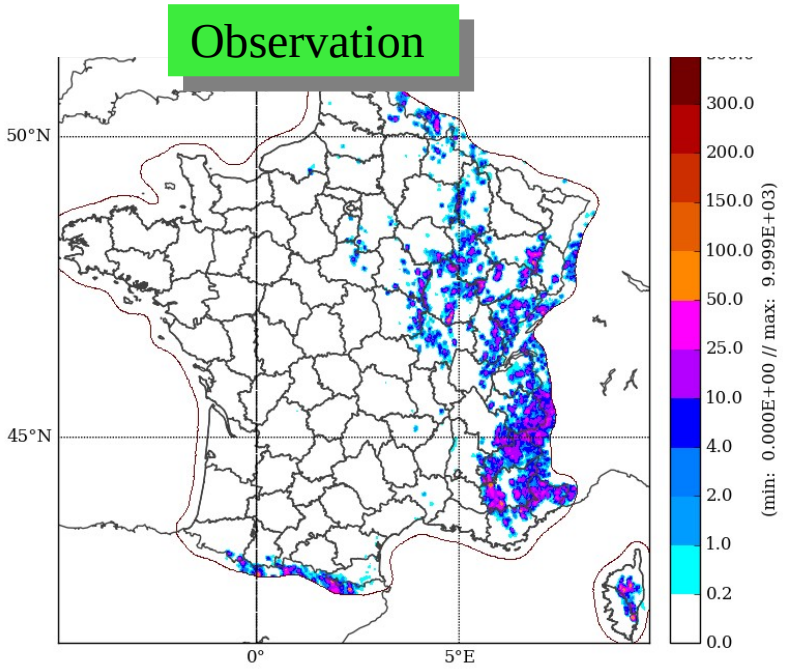
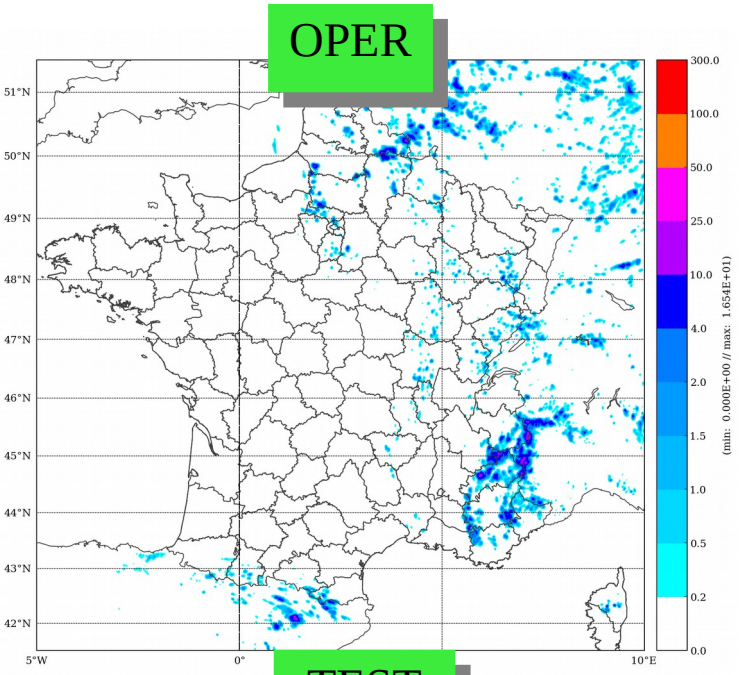
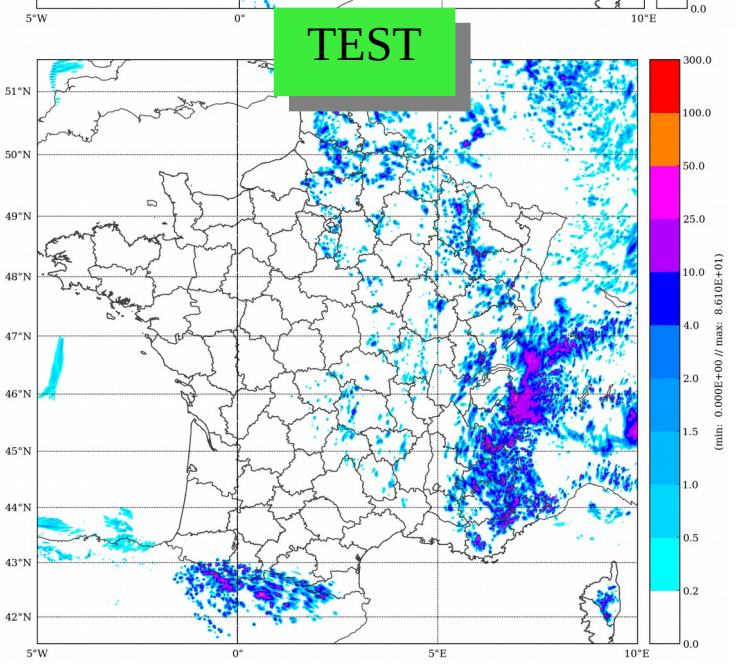






- Improve rain forecasts in diurnal convection cases

METEO FRANCE

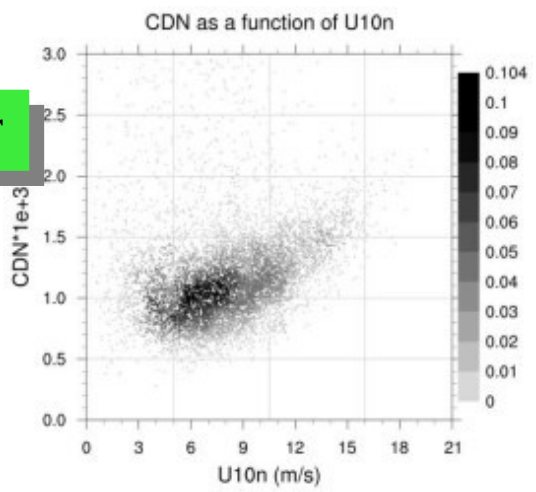
Sea surface fluxes : Ecume V6

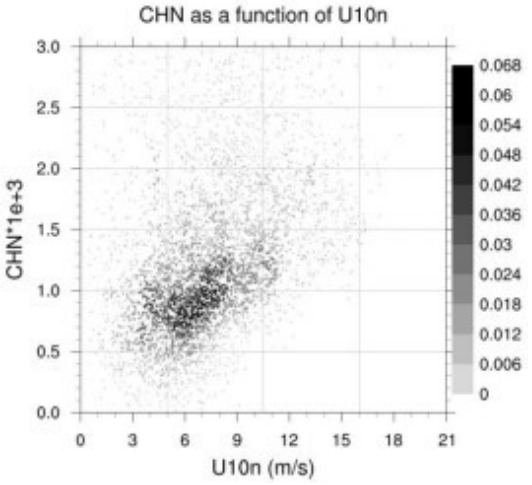
$$Param\_U = \left(\frac{C_{dn}}{\sqrt{C_{dn}}} \right) X \Delta U_{10m}$$

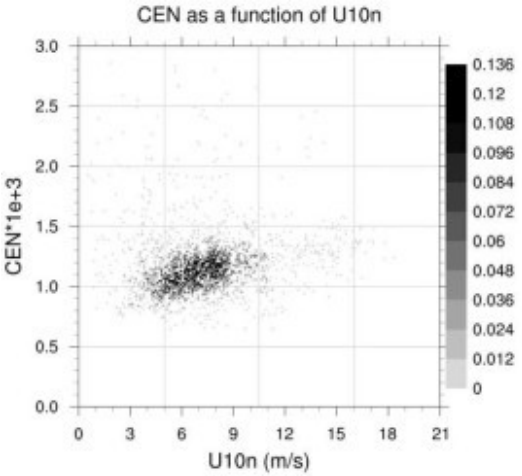
$$Param\_\theta = \left(\frac{C_{hn}}{\sqrt{C_{dn}}} \right) X \Delta U_{10m}$$

$$Param\_q = \left(\frac{C_{en}}{\sqrt{C_{dn}}} \right) X \Delta U_{10m}$$

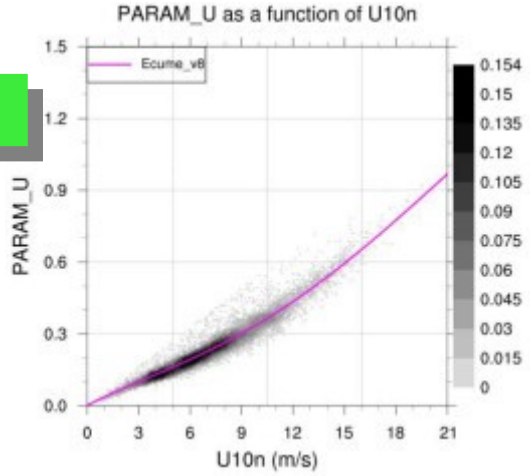
Oper

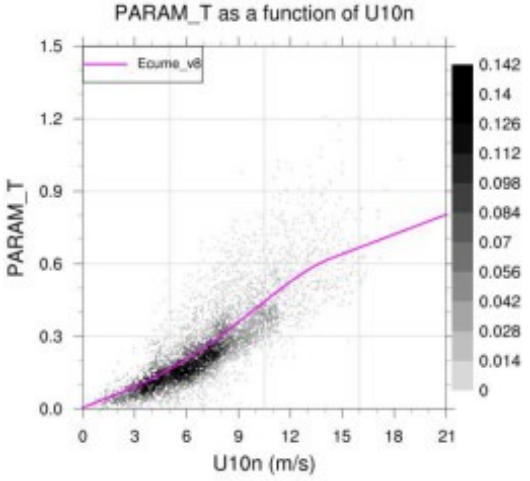


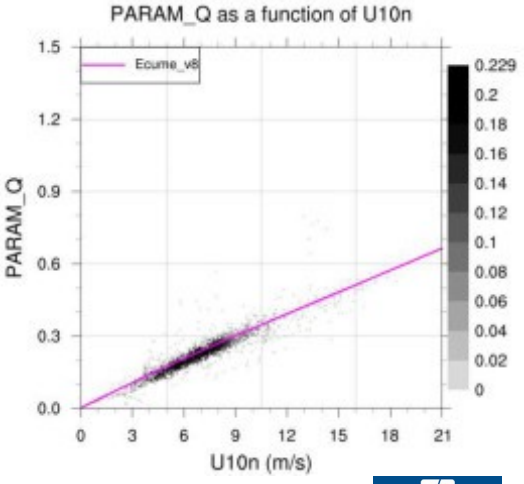




Test







From S. Belamari

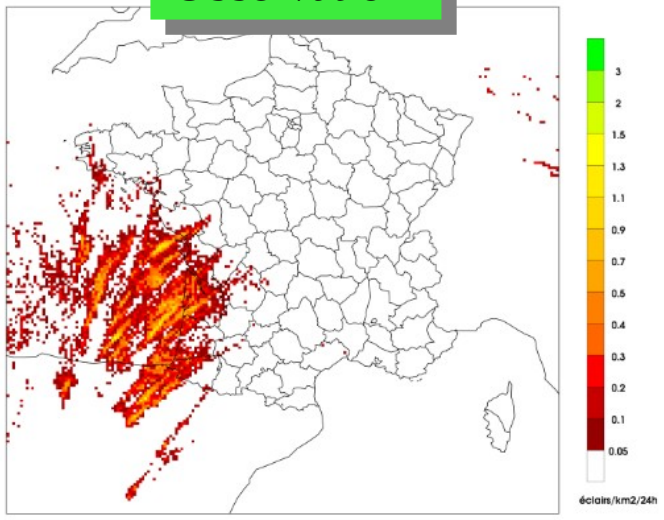
METEO FRANCE

Lightning diagnostic

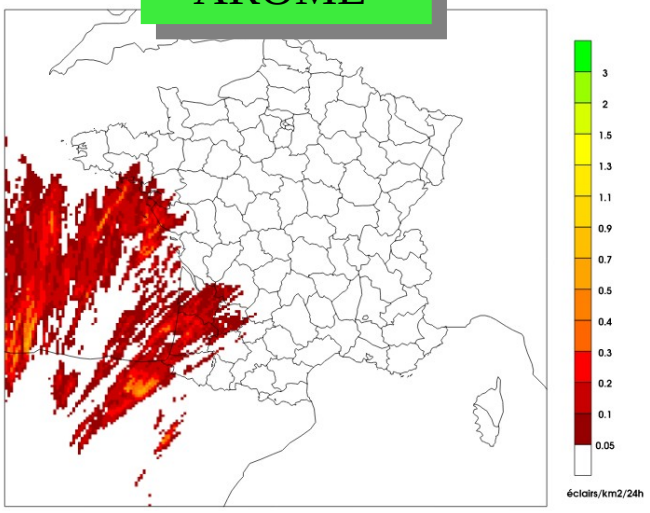
- Based on Mc Caul (2009)
- Related to gaupel flux at -15°C

- Example of May, 5th 2020, 24h cumulated :

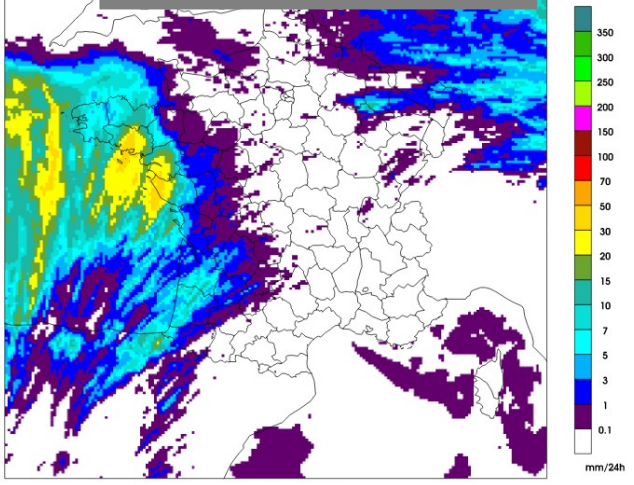
Observation



AROME



Cumulated rainall



METEO FRANCE

Outline :

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  - Improve ice/mixed phase clouds
  - A step towards 3D turbulence
  - Soil diffusion scheme
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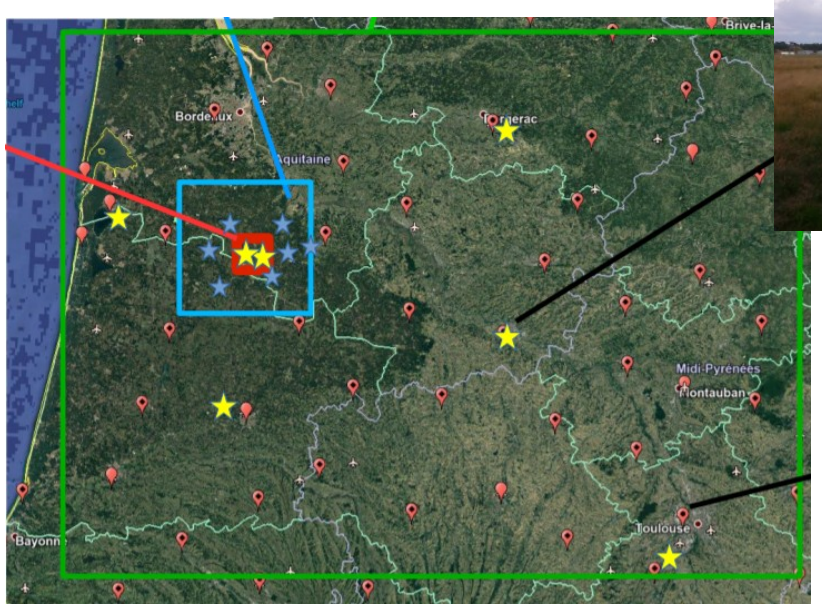
SOFOG 3D experiment

- October 2019 → March 2020 in SO of France
- Dedicated instruments : UAVs, tethered baloon (microphysics, turbulence), instrumented mast, radiometers, cloud radars...
- 15 IOPs



SOFOG 3D experiment : AROME forecasts

- 3 dedicated runs on SOFOG domain, without data assimilation, starting and coupled with oper :

  1) AROME 1,3 km L90 (as oper)

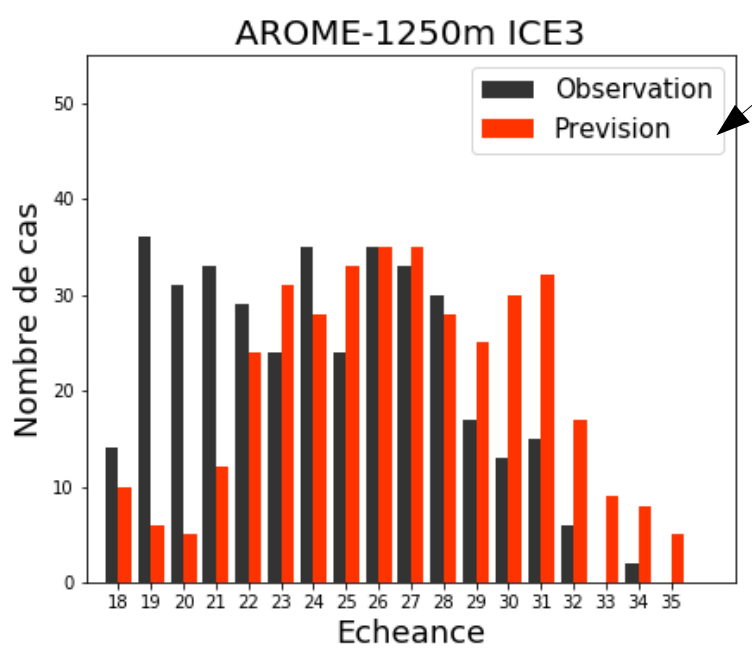
  2) AROME 500m L156 (Philip et al., 2016), 1st level at 1m

  3) AROME 500m L156 with LIMA microphysics (Vié et al., 2016)

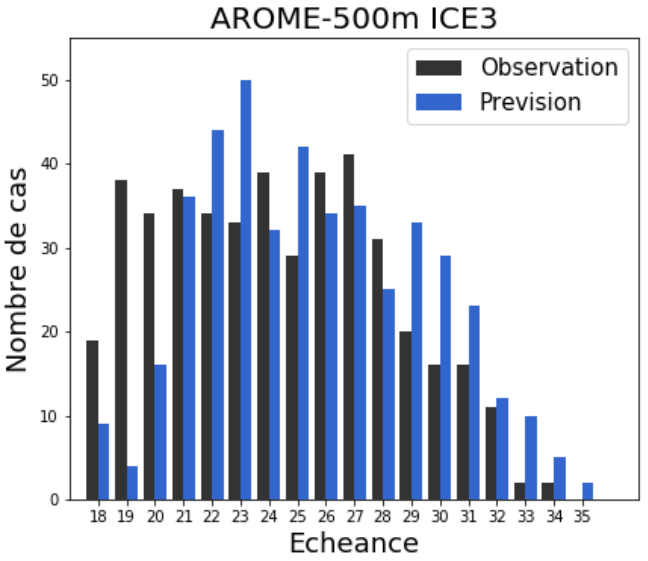
	Droplets	Drops	Ice	Snow	Graupel
mixing ratios →	q_c	q_r	q_i	q_s	q_g
concentration →	N_c	N_r	N_i		

First results (on 16 surface stations)

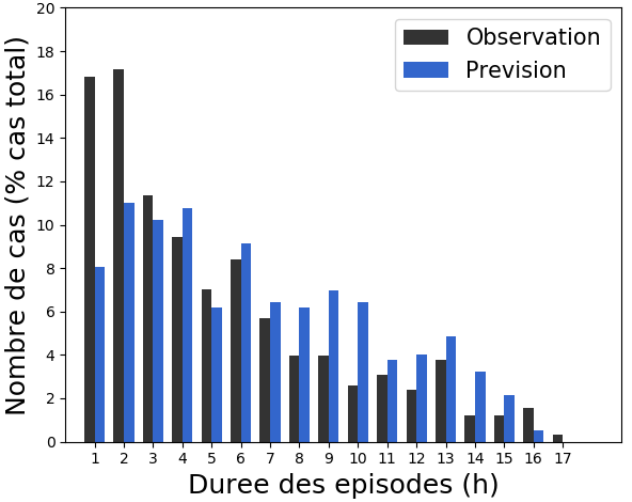
- More fog in 500m configuration, but also more false alarms
- Model delay in fog formation and dissipation
- Too long fog events in the model



Time of fog formation

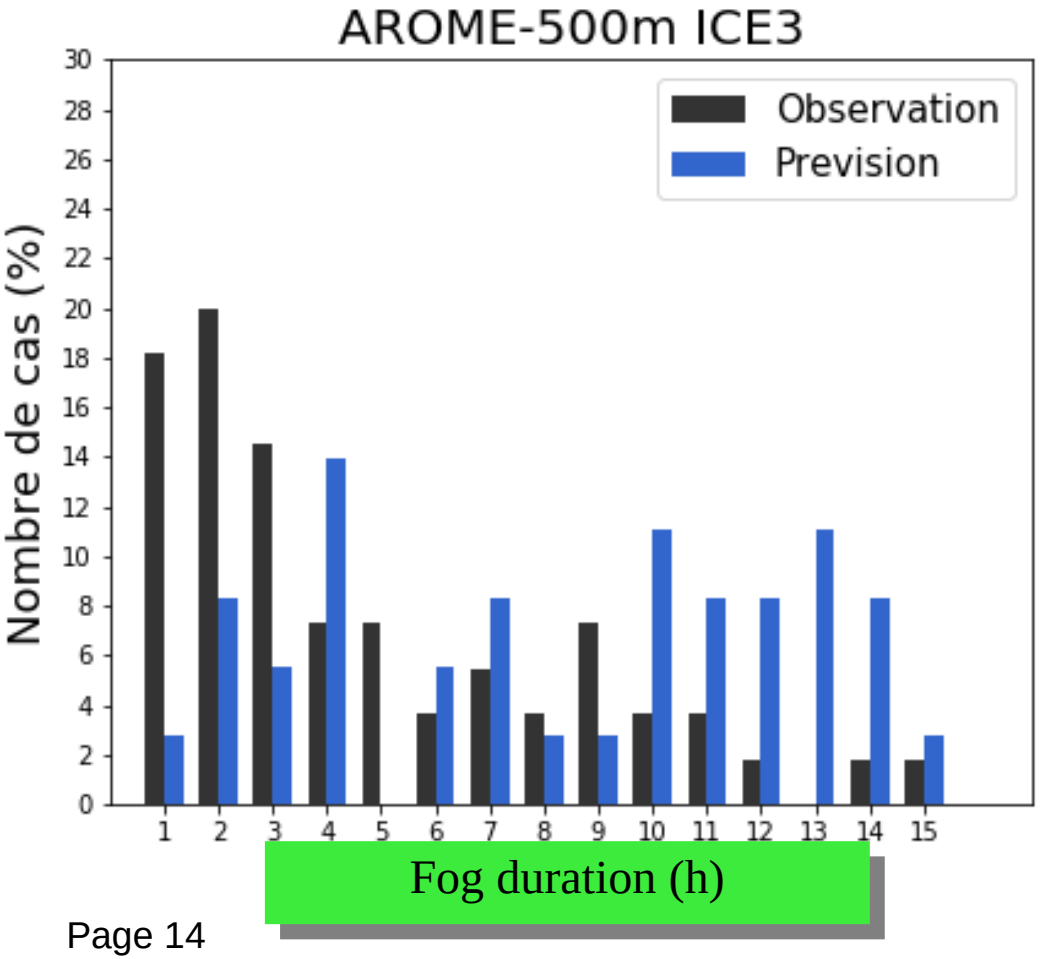


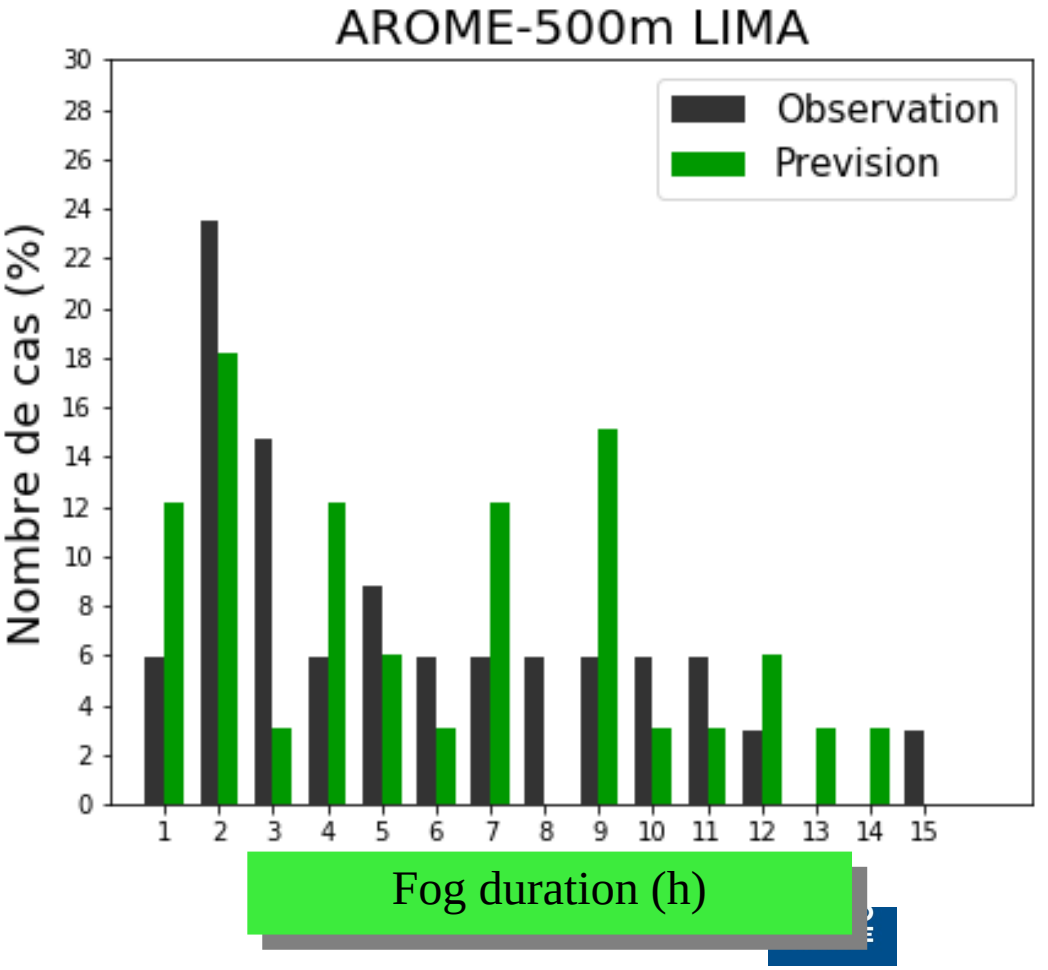
Fog duration



First results on the Super Site

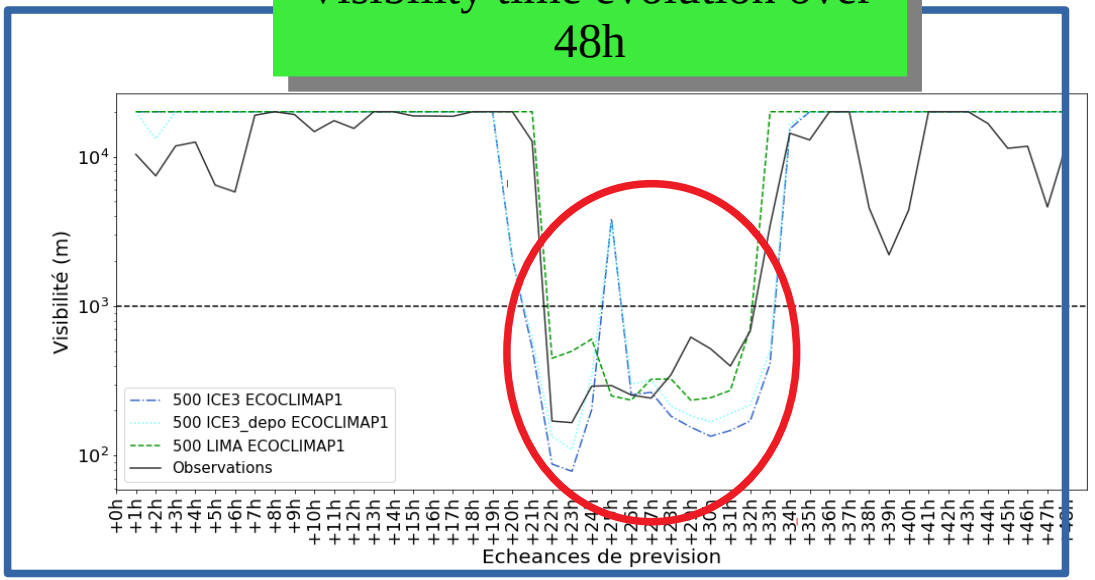
- LIMA forecast more short events that ICE3





IOP of 7 March 2020

Visibility time evolution over 48h



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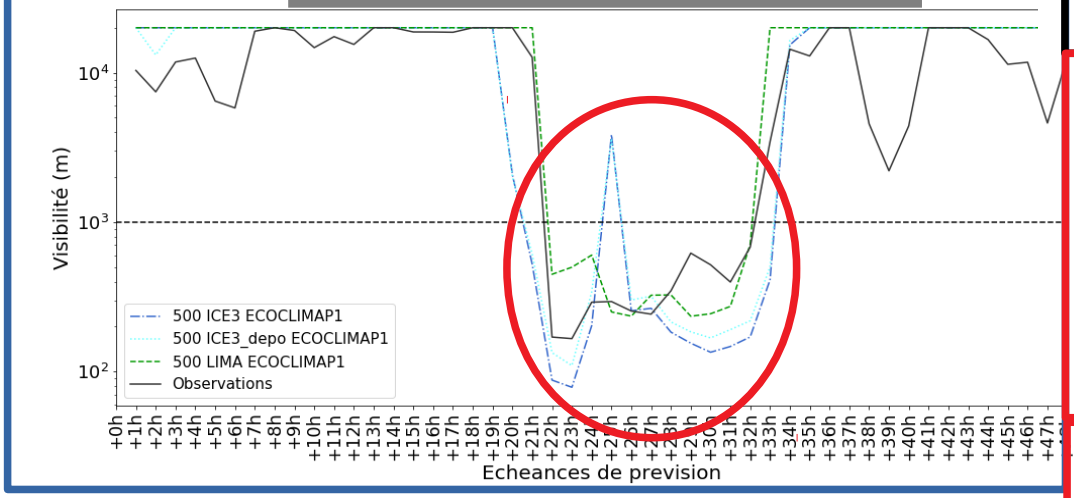
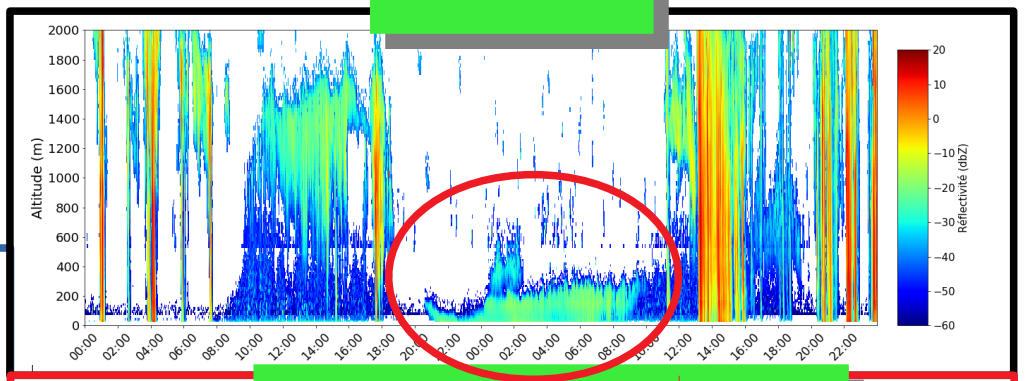
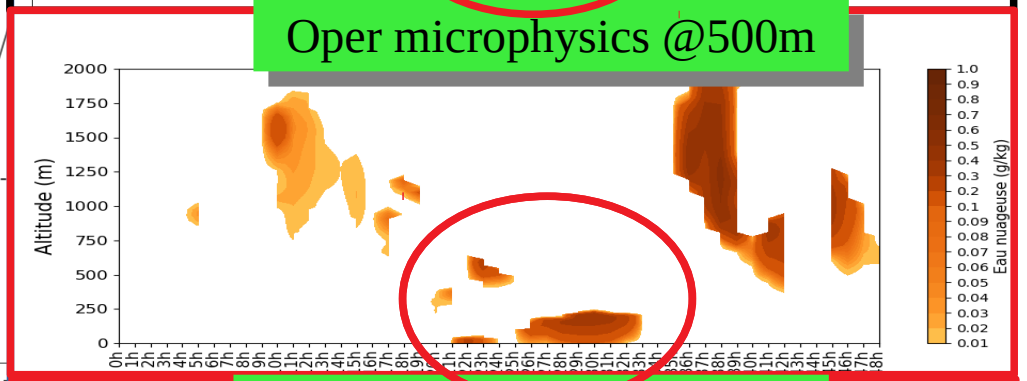


Cloud radar



Oper microphysics @500m



LIMA microphysics @500m

IOP of 7 March 2020

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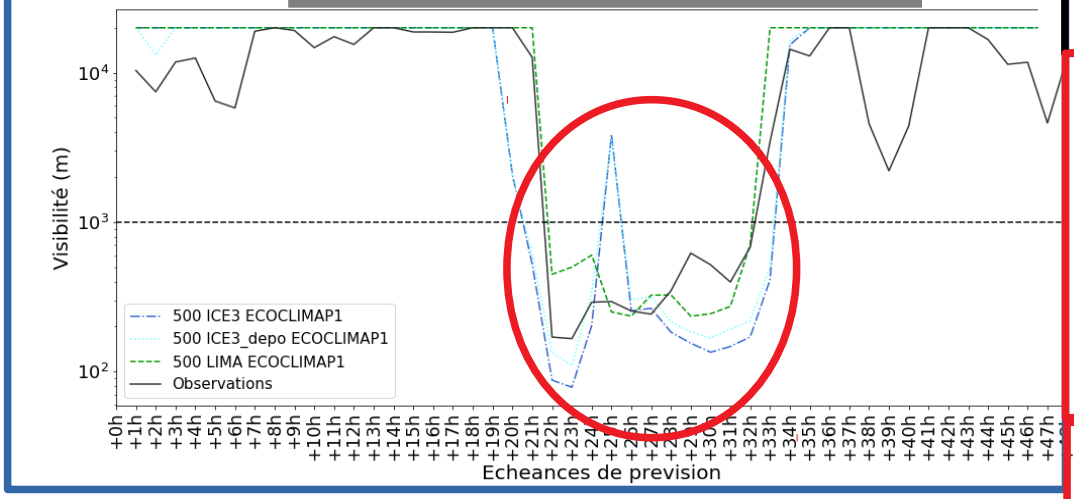
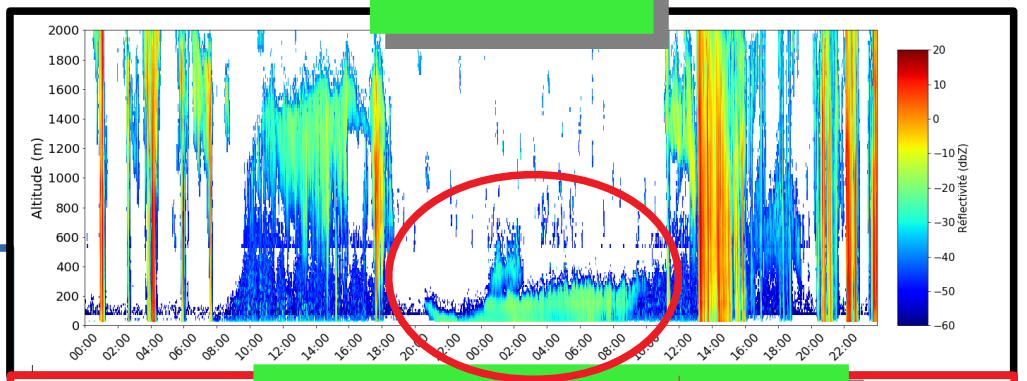
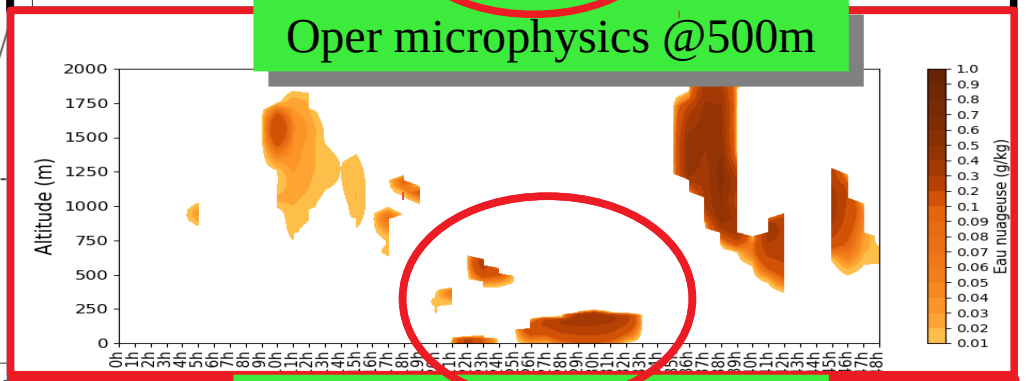


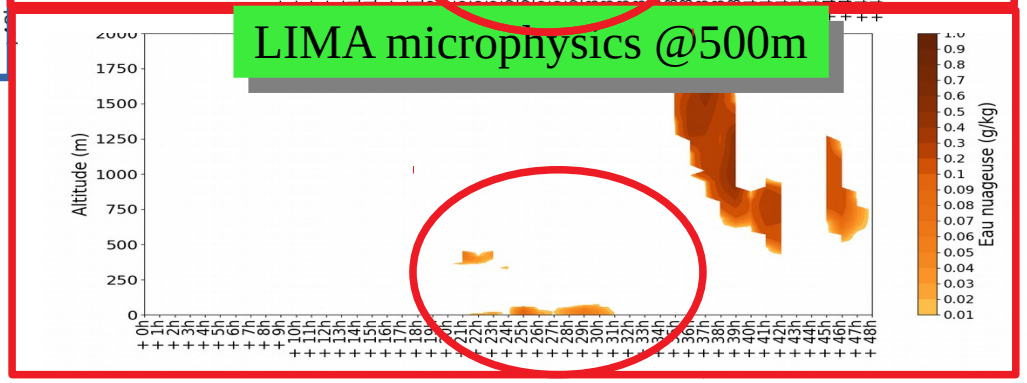
Cloud radar



Oper microphysics @500m



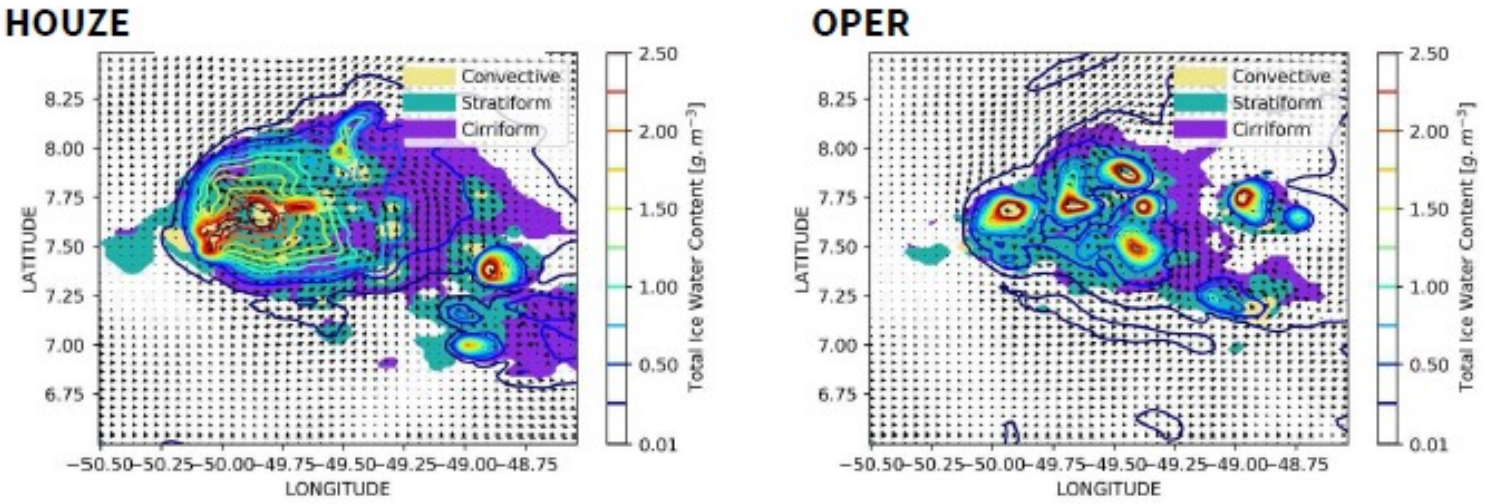
LIMA microphysics @500m



- LIMA well capture the timing of the fog, but not its depth...

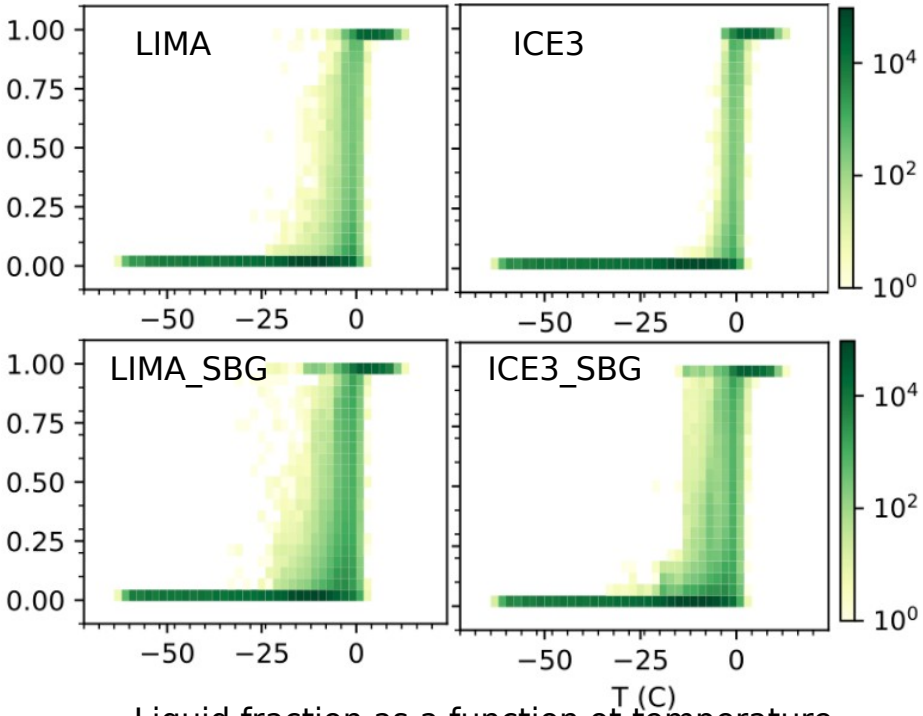
Improvments in the cold microphysics

- Work on the HAIC Campain data (Study high ice/snow concentration in tropical convective systems) : https://www.eol.ucar.edu/field_projects/haic-hiwc
- Modifications of snow Particle Size Distribution, based on observations → more snow in Cb anvils in AROME-Guyana (more realistic contents)

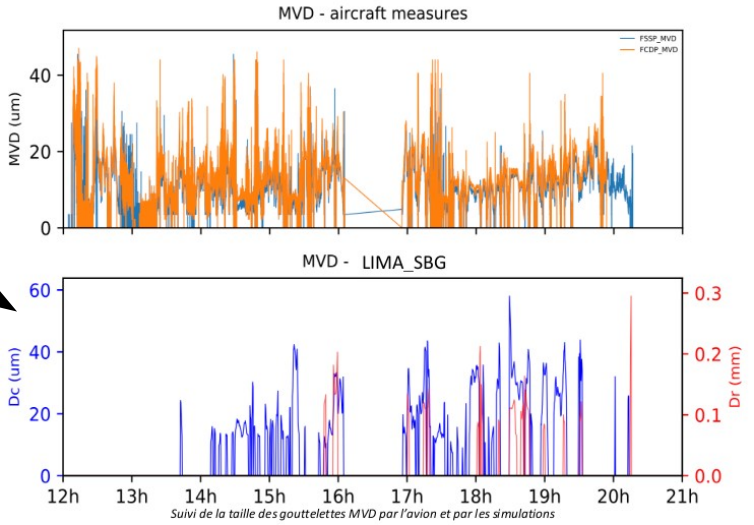


LIMA : ICICLE experiment

- Icing dedicated campain
- Meso-NH with ICE3 or LIMA :
  - More supercooled water in LIMA
  - Very sensitive to subgrid condensation
  - Cloud droplets diameters OK in LIMA



Liquid fraction as a function ot temperature



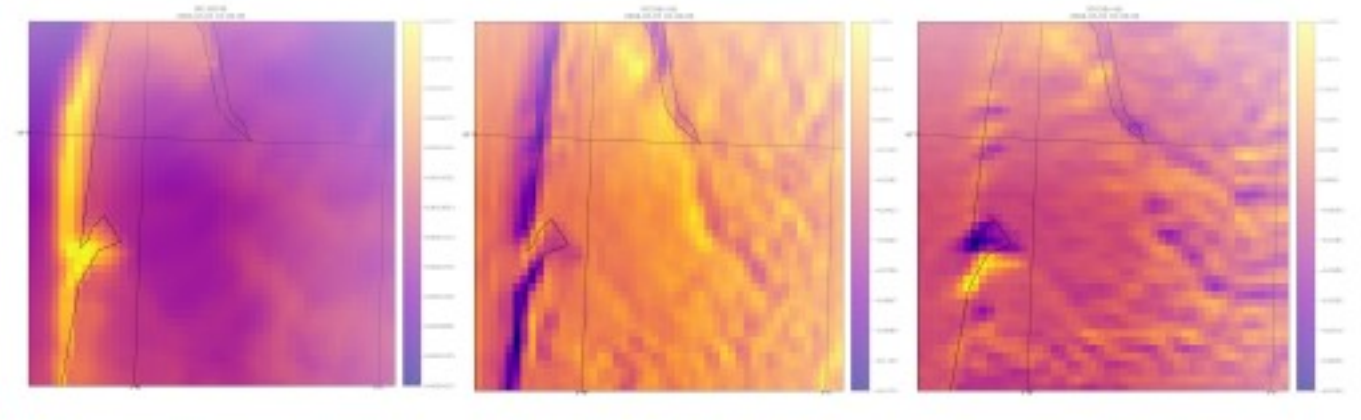
A step towards 3D physics...

- Thanks to technical work, horizontal gradients of 3D fields can now be available in the AROME physics :

  → D. Ricard will work on increasing the mixing into the cumulus deep clouds by adding turbulence terms from Moeng et al. (2010) Verrelle et al. (2015)

  → shear production term for TKE over orography (Arnold et al. 2014; Goger et al. 2018), could be implemented (TEAMx collaboration)

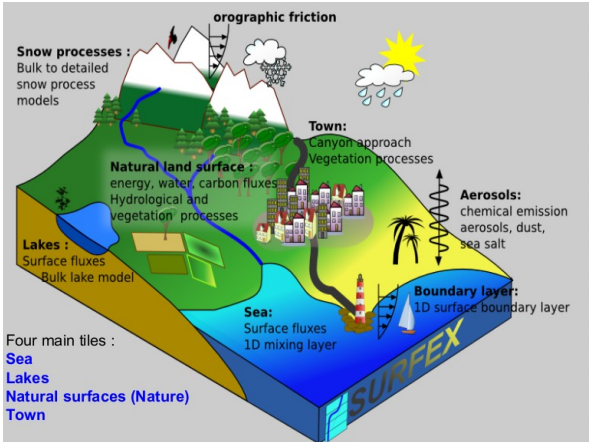
  → 3D scheme of MesoNH : additional technical work required in order to make mesoNH code more modular (manpower need)



qv d(qv)/dx d(qv)/dy

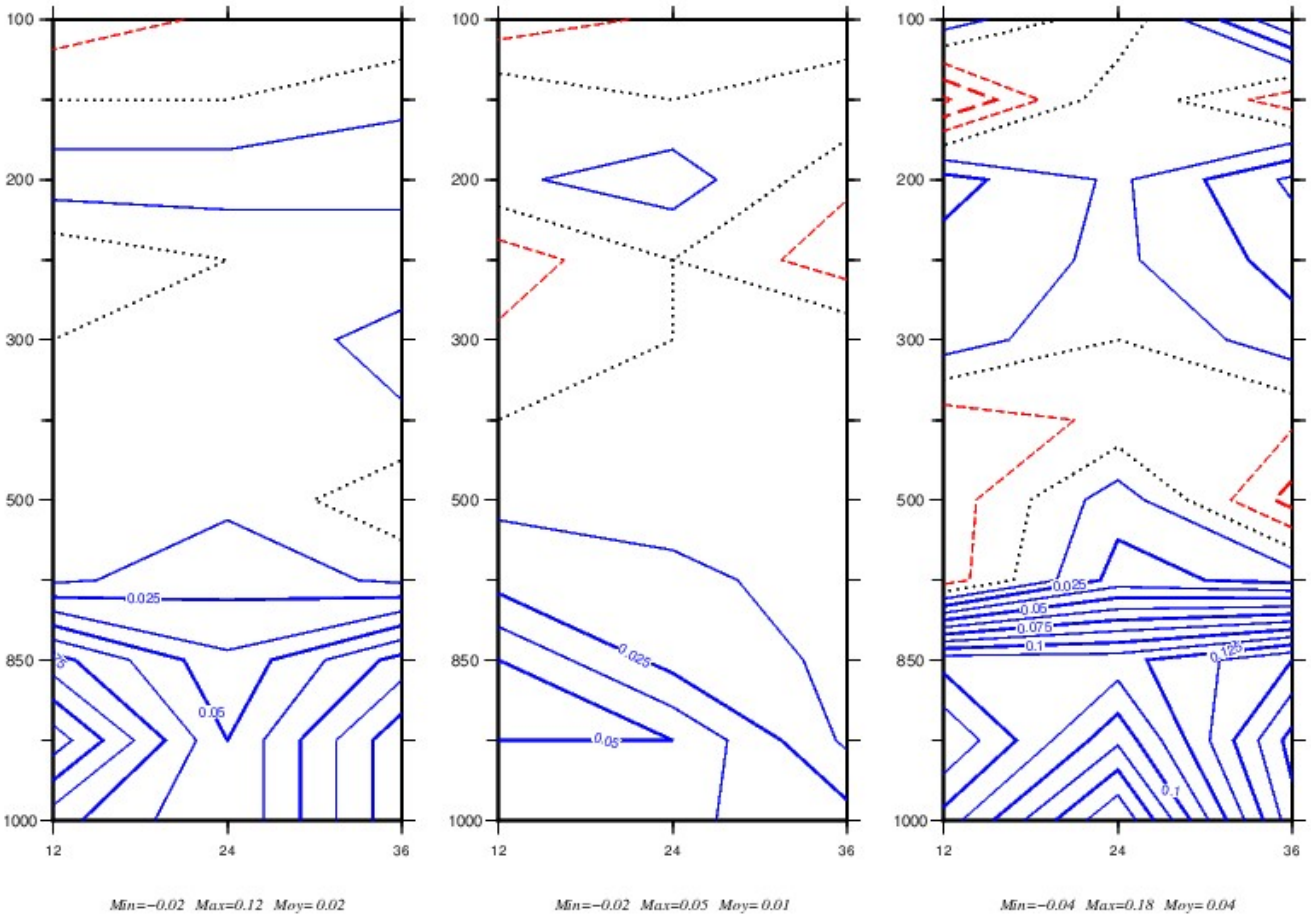
First tests in AROME 3DVAR with ISBA-Diff and multi-layer snow scheme

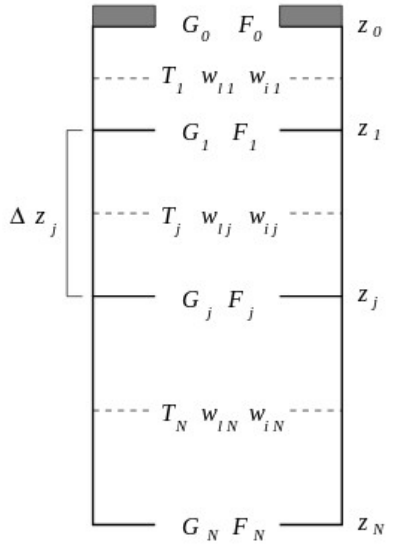
- First results promising !



Temperature profiles compared with RS between July 5 – August 6 2019

RMSE STD BIAS





Radiation :

- Test SRTM

  → neutral scores

- Toward EcRad Radiation scheme use

  → first tests in CY46T1, in ARPEGE and AROME but not in time to be ready for 2021 e-suite

- Use near real time aerosols for radiation and microphysics

Thank you for your attention !
Question ?