Recent developments in ARPEGE/AROME physics

Yann Seity, Salomé Antoine, Eric Bazile,Yves Bouteloup, Jonathan Guth, Rachel Honnert, Ingrid Etchevers, Adrien Marcel, Sébastien Riette, Benoît Vié ...

45th EWGLAM Meeting, September 2023

Outline :

- ARPEGE developments
  - CY48t1_op1 content

- AROME 1,3 km developments
  - radiation
  - PHYEX (turbulence,shallow convection,microphysics)
  - aerosols
  - diagnostics

cy48t1_op1 Arpege physics evolution

- New version of the IFS deep convection scheme (cy47r3) with a CAPE + moisture convergence closure
- Météo-France development to modulate closure to local resolution to avoid detrimental rainfall accumulation near the coast in the high-resolution area
- TKE production by deep convection
- EcRad radiation scheme with McIca solver
- Addition of a deposition rate within the microphysics scheme to reduce false fog alarms

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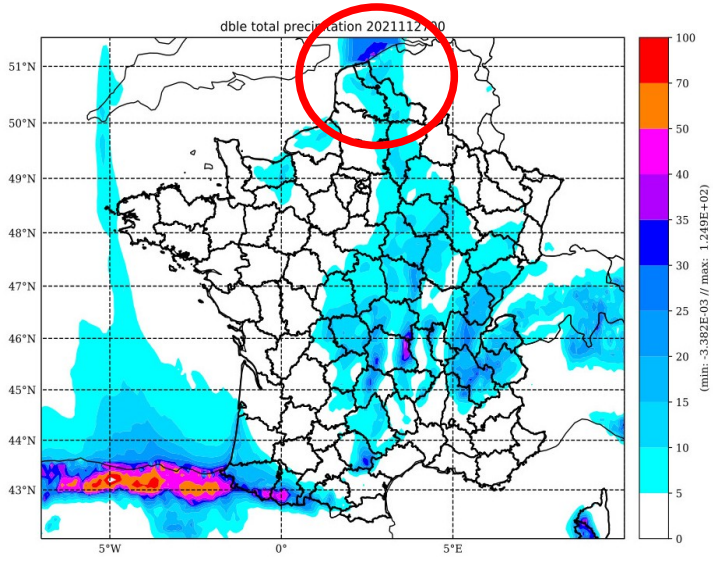
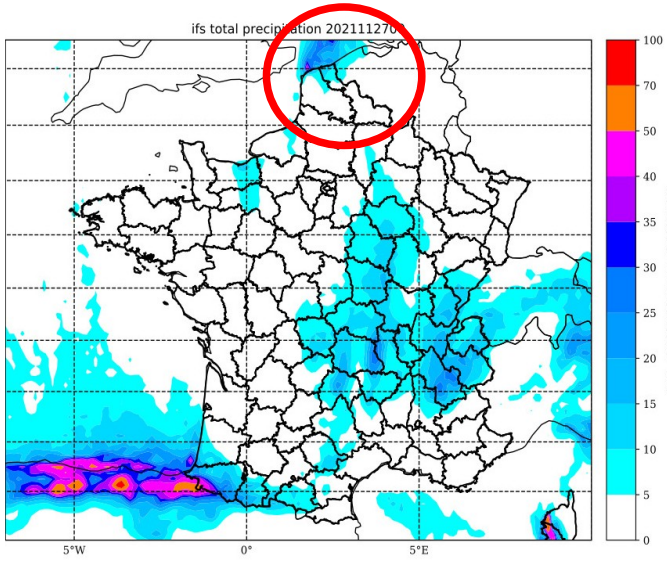
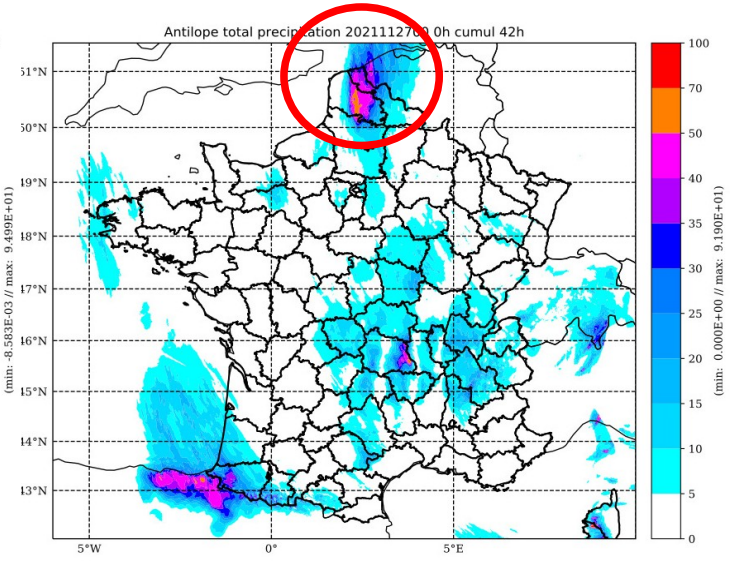
The 28 november 2021 case



Arpege cy46t1_op1

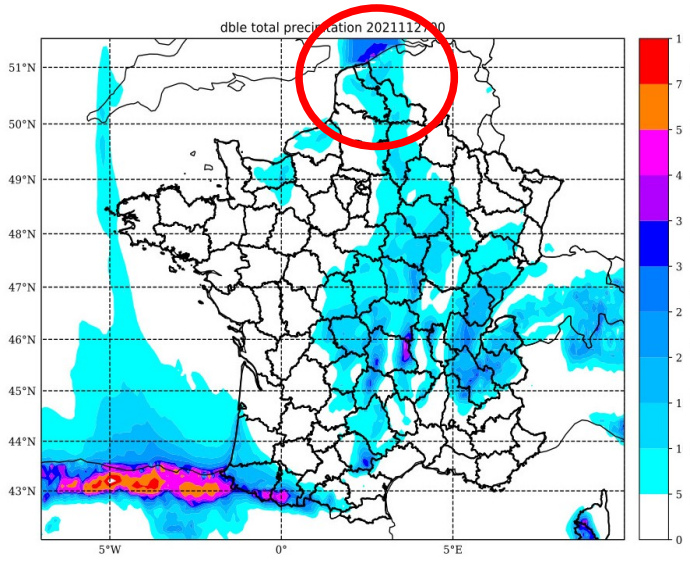


IFS

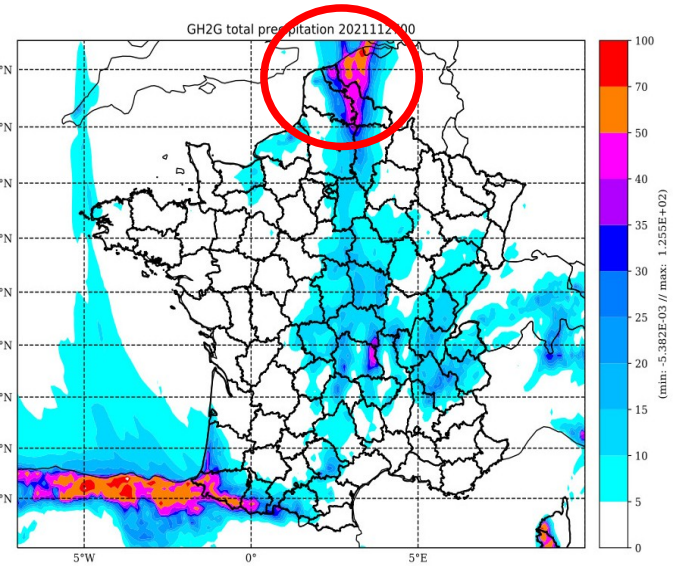


Antilope (observation)

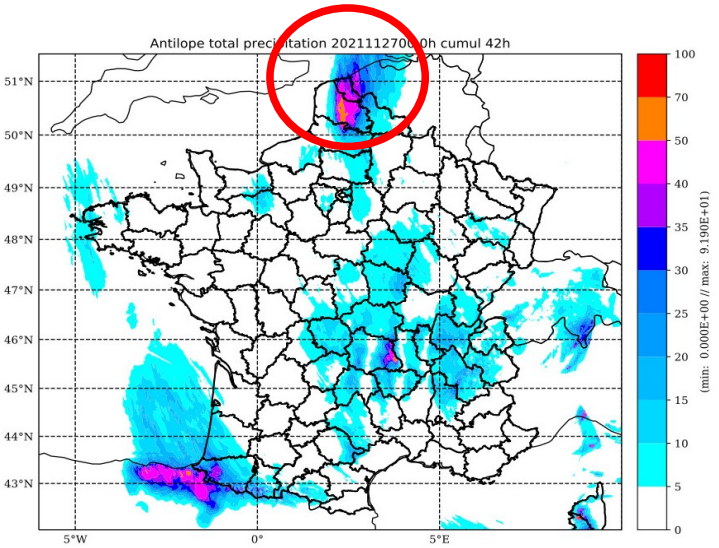
The 28 november 2021 case



Arpege cy46t1_op1



Arpege cy48t1_op1



Antilope (observation)

Status of radiation codes used in oper/e-suites

	OPER (CY46T1)			E-SUITE (CY48T1)		
	SW	LW	Aerosols	SW	LW	Aerosols
AROME	Fouquart-Morcrette	RRTM	Tegen 2D clims (6 var)	EcRad (SRTM)	EcRad (RRTM)	CAMS3D clims (12 var)
ARPEGE	SRTM					Tegen 2D clims (6 var)

→ 48T1_op will be oper in the begining of 2024

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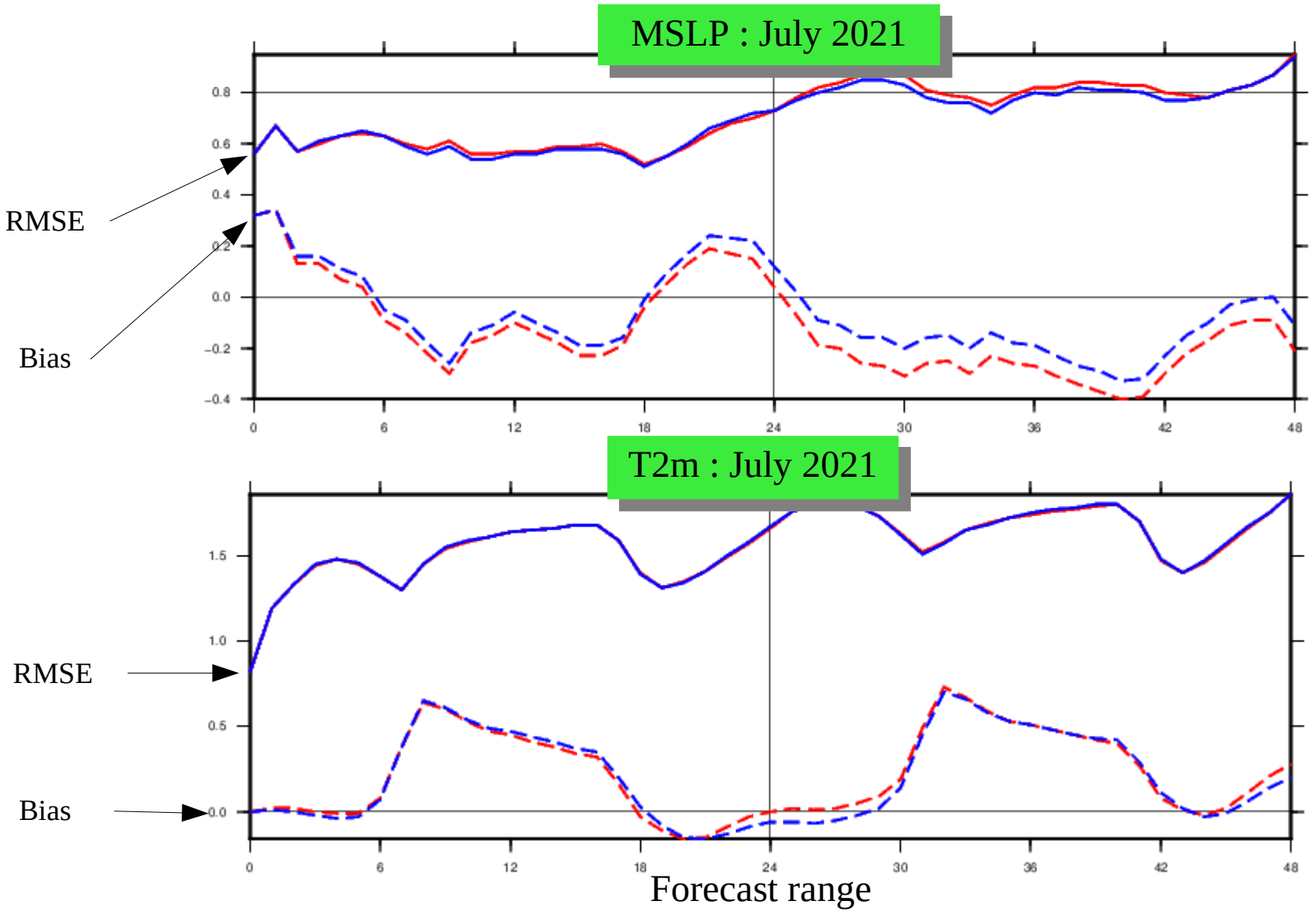
Aerosols : EcRad+CAMS(CLIM) versus EcRad+Tegen

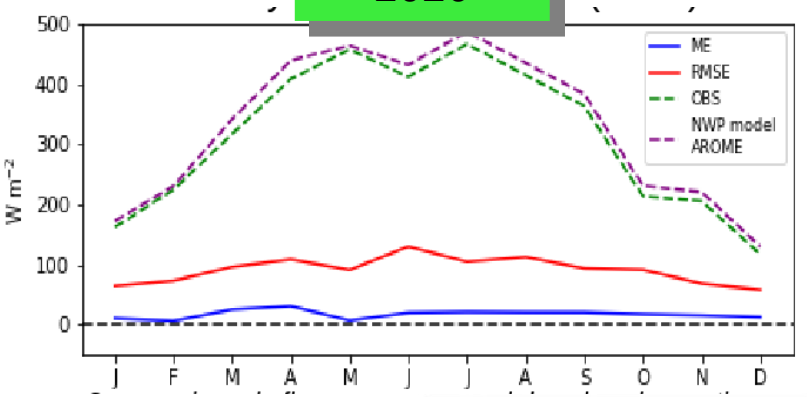


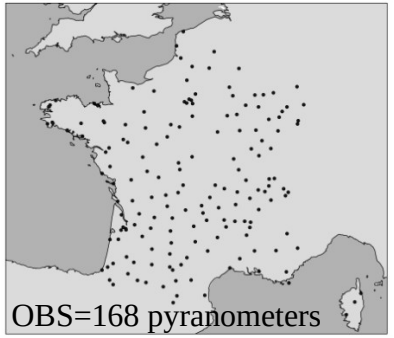
→ On July, improvements on surface pressure with CAMS Aerosols Clim

Evaluation of AROME surface hourly SW radiation :

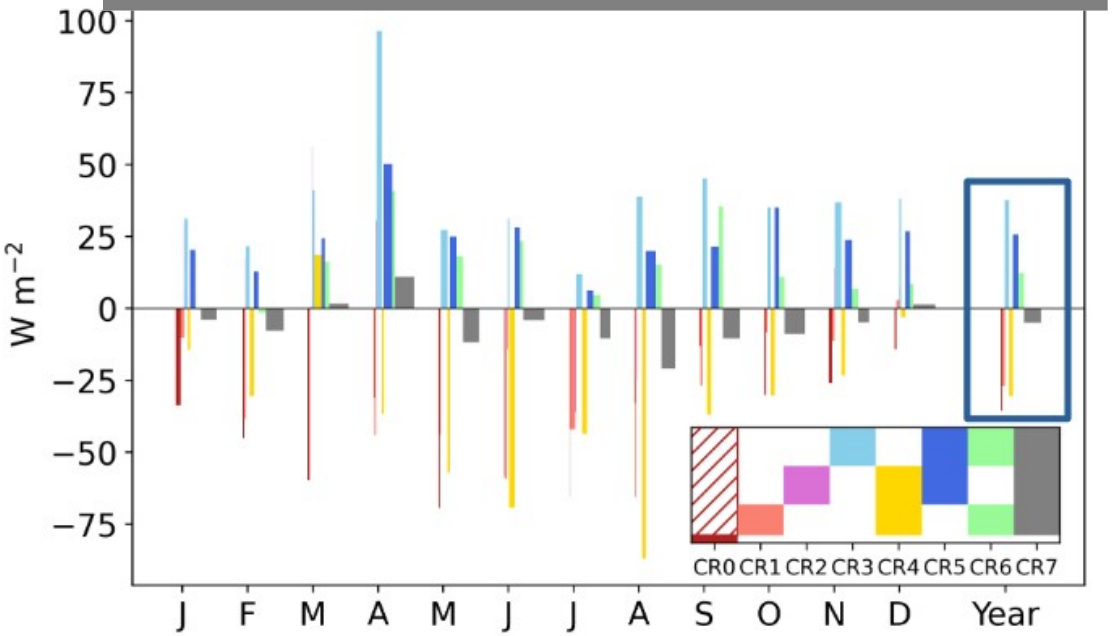
- Positive bias (+18W/m²), mainly when clouds are present in the model and in observations.
- Errors can come from cloud fractions, or optical depths computations

2020





Conditional bias (model cloud fraction > 95%)



- Mean bias when cloud fraction > 95 % is small (1W/m²), but due to compensating errors of positive bias for high clouds and negative one for low clouds

→ *From M-A Magnaldo PHD*

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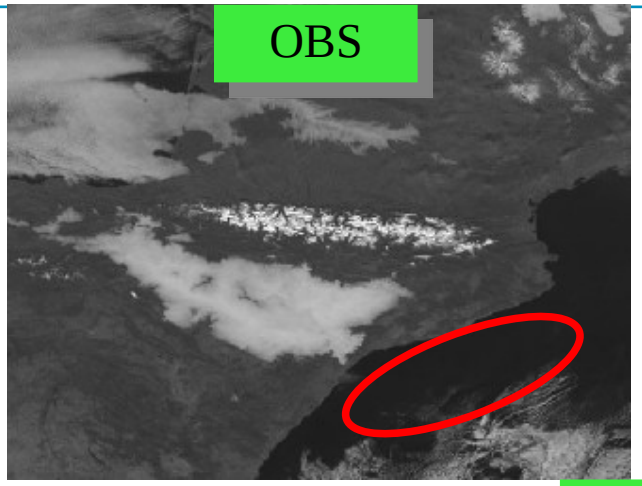
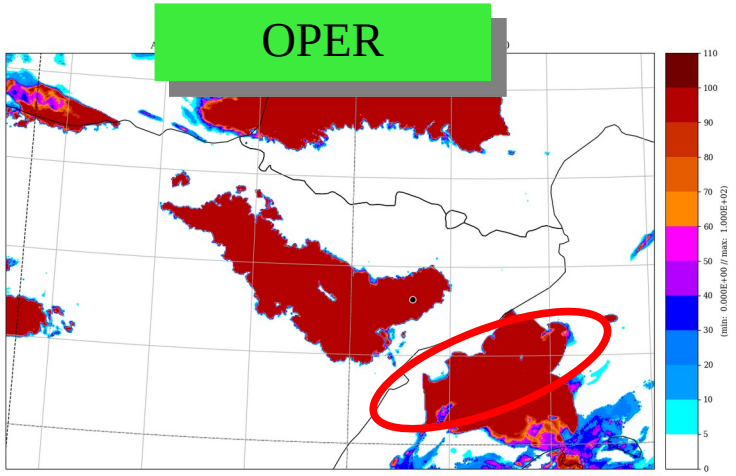
PHYEX=Externalised MesoNH Physics

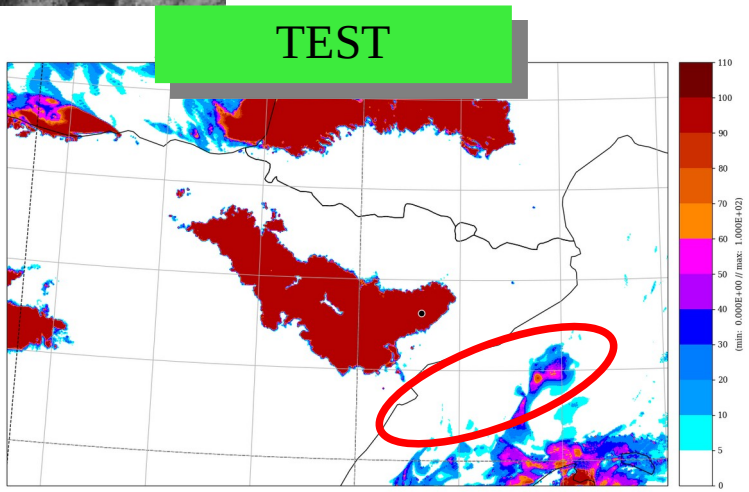
- PHYEX repository https://github.com/UMR-CNRM/PHYEX
  - turbulence, shallow convection (EDKF only), microphysics (ICE3, LIMA)
  - source code ready for GPU transformations
  - compatible with Meso-NH 5.6, AROME 49t1 and LMDZ. AROME setup modified to use the initialisation routines of Méso-NH (enabling all the options)
  - contains stand-alone programs (« dwarves ») for technical tests
  - python binding under development
- PhyexFortranTool repository https://github.com/SebastienRietteMTO/PHYEX-fortran-tool
  - python tool to transform the source code for GPUs (work in progress)
  - 

Turbulence : Modifications for low clouds over sea (in CY48T1_op) :

December 15th 2021 12TU :

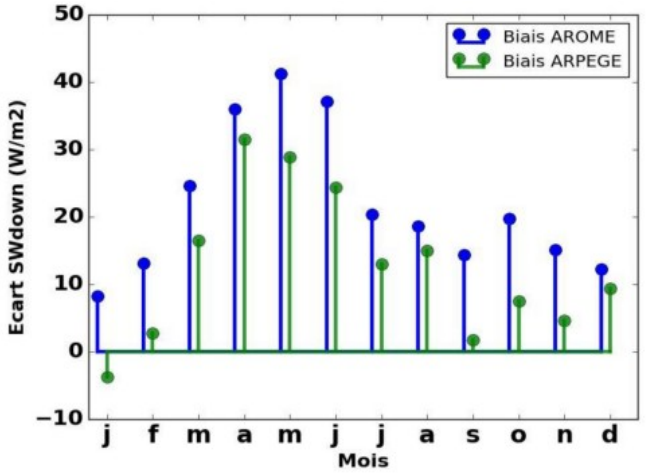






- In mixing length computation (bl89) :
  - → Corrected coefficients (bf from Pascal Marquet),
  - → Lup modified as in ARPEGE (more mixing in the top of clouds)
- Positive impact in that case (no impact on scores)

Improvements of EDKF/EDMF :

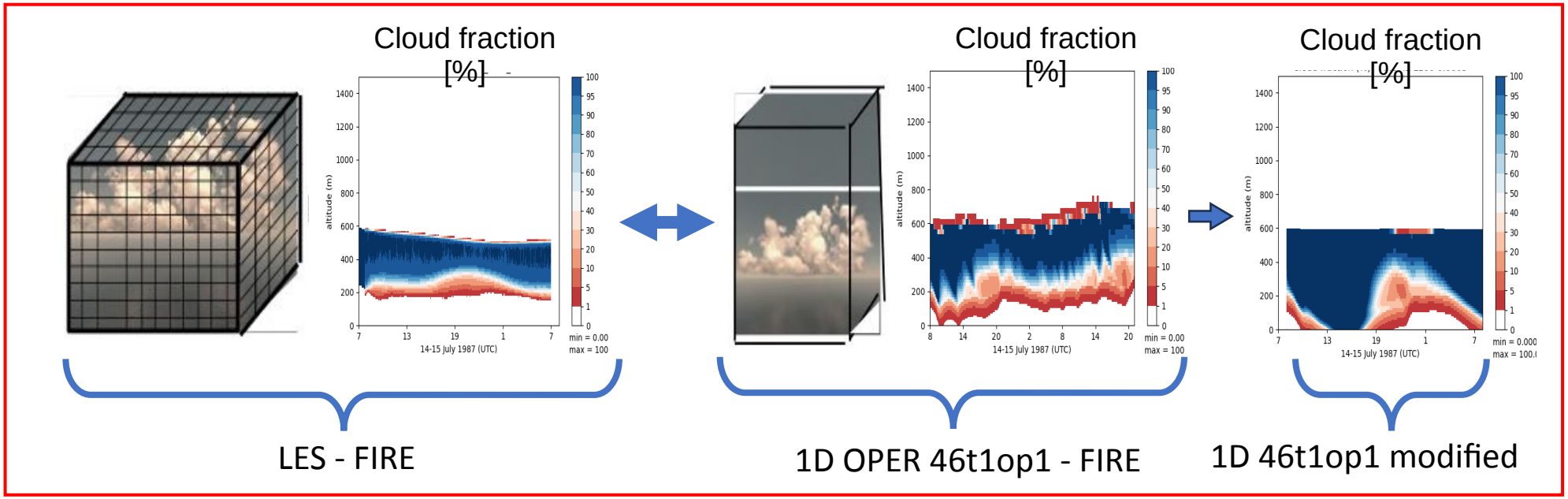


Important positive SW biases retrieved and assigned to low cloud deficit in PNT models (Météopole-flux, 2016).

Large amount of non-stratiform clouds maybe due to poor stratocumulus representation.

Improvements on shallow convection scheme in AROME and its interaction with turbulence, condensation and precipitating processes

AROME modifications tested in 1D experiments vs LES

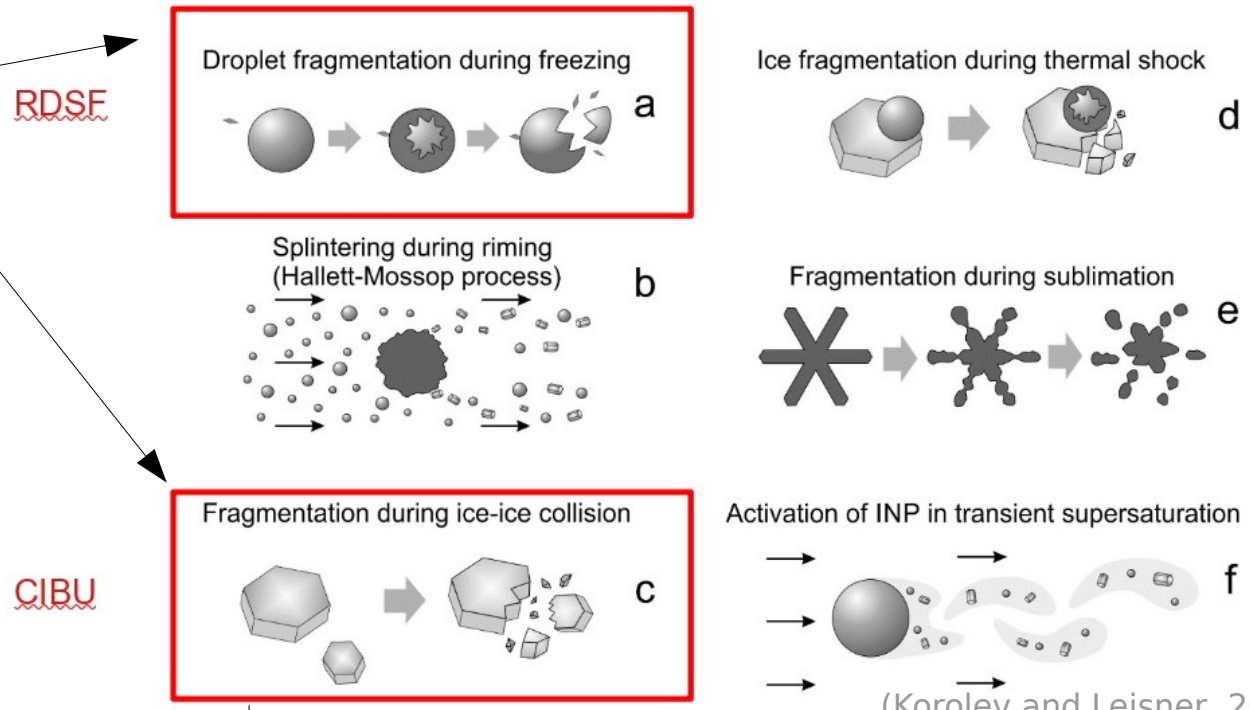


Some changes : detrainment / entrainment, vertical velocity equation, condensation PDF …

→ *From A. Marcel PHD*

Microphysics : LIMA news (available in PHYEX)

- 2 new secondary ice production mechanisms

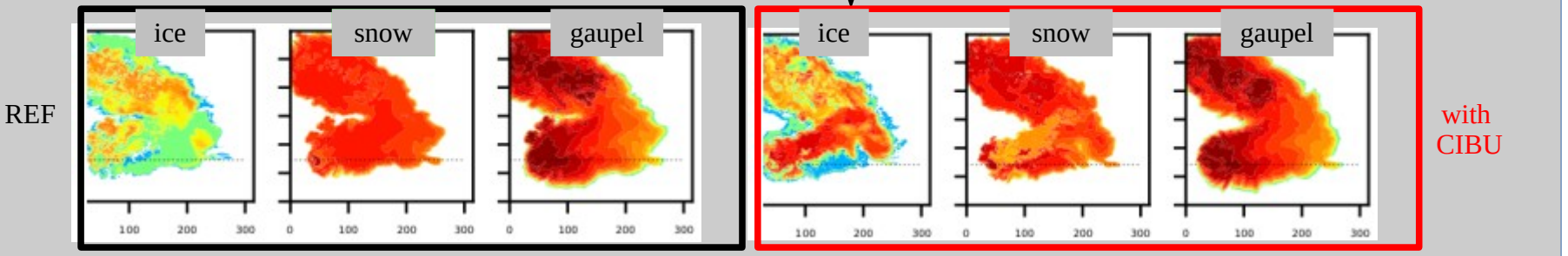


(Korolev and Leisner, 2020)

→ More ice

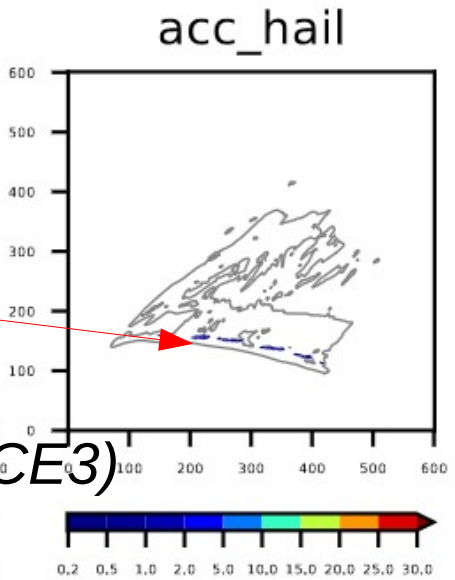
(MesoNH idealized supercell case)

t=140 min, level 65



Microphysics : LIMA news (available in PHYEX)

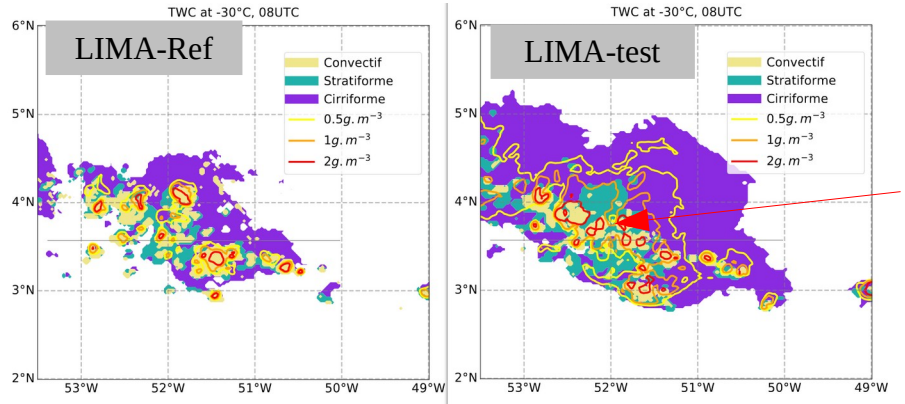
- More flexible choice for each variable (1 or 2-moments)



Full 2-moments with hail :
realistic hail along supercell track
(idealized supercell)

- New snow properties *(following J. Wurtz PHD work in ICE3)*

(HAIC test case)



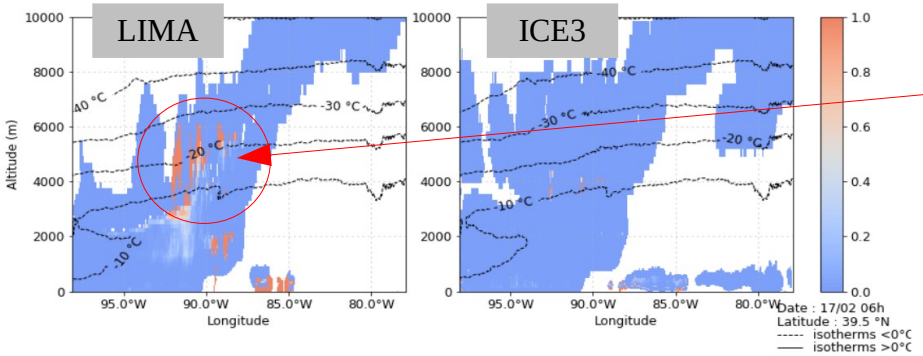
Much larger anvil and high ice water contents in the anvil

- Work on supercooled liquid water *(M. July-Wormit PHD)*

ICICLE (2019)

SENS4ICE (2023)

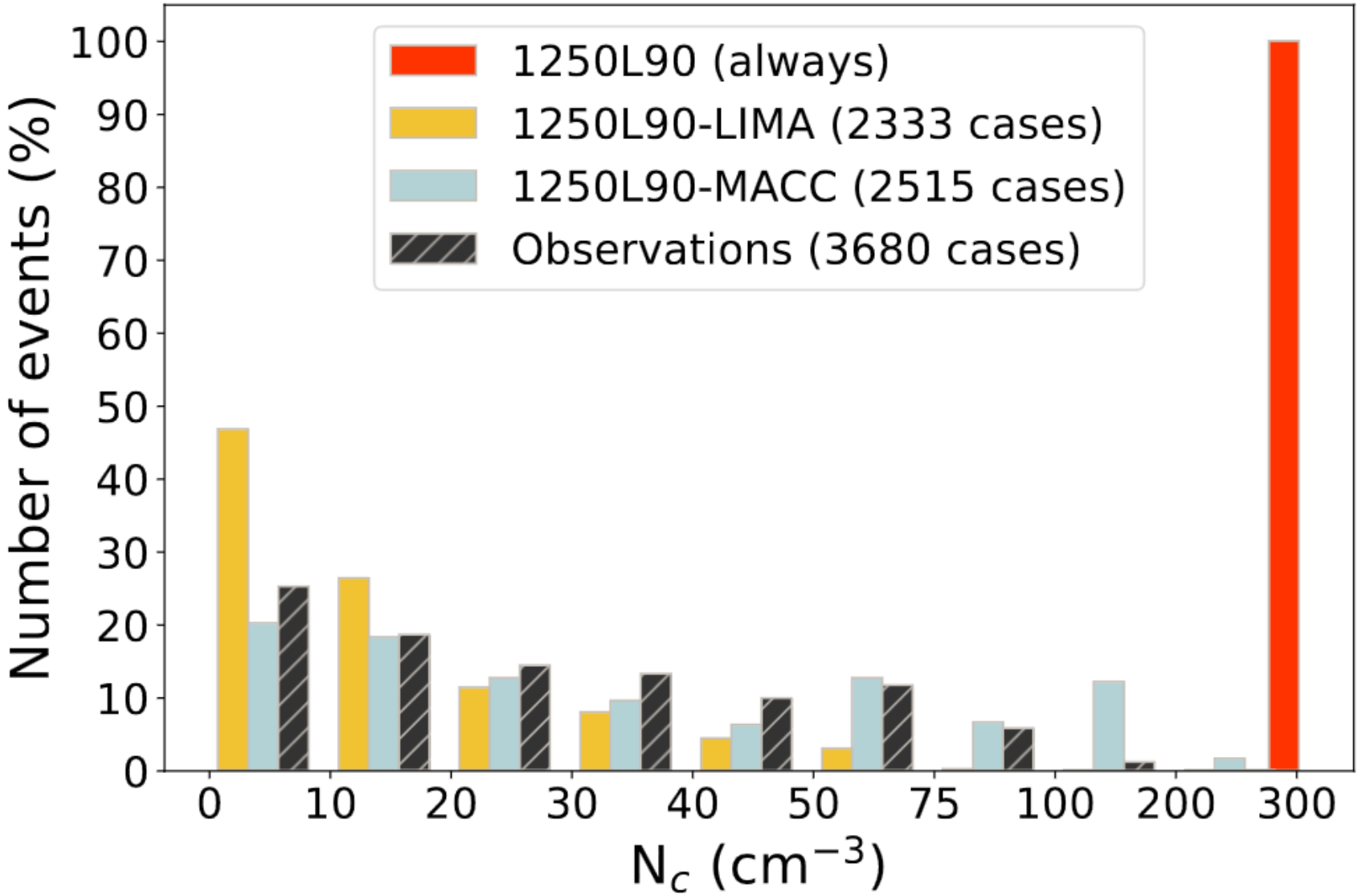
liq/ice ratio :



LIMA better than ICE3, but still too icy

➔ Investigating ice initiation,impact of aerosols,microphysical processes...

Aerosols/Microphysics link : CAMS Aerosols use in LIMA (SOFOG3D IOPs)



- **Significant improvment with the use of daily CAMS aerosols in LIMA**

→ *From S. Antoine PHD*

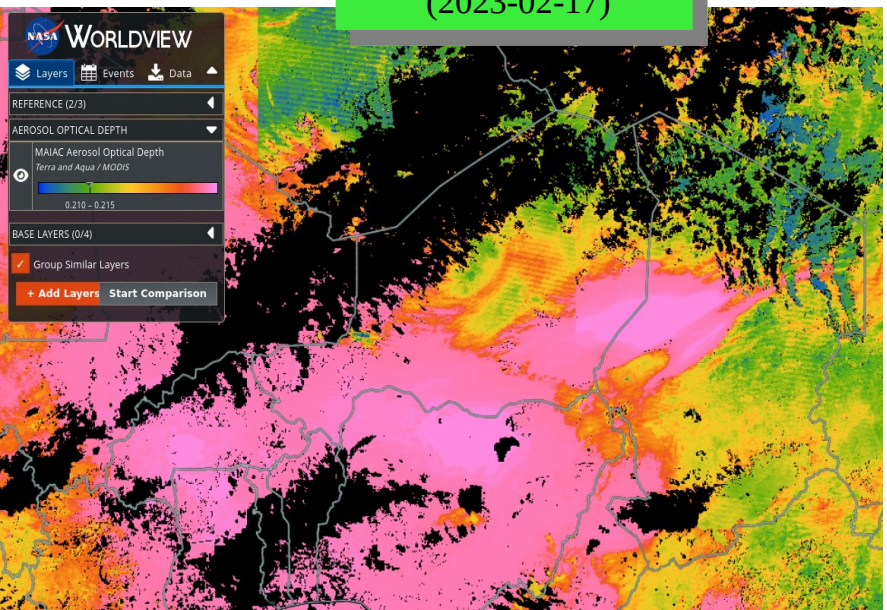
Towards oper AROME-Dust over the Sahel area

- Surface : As ALADIN-Dust emissions (M. Mokhtari) in SURFEX

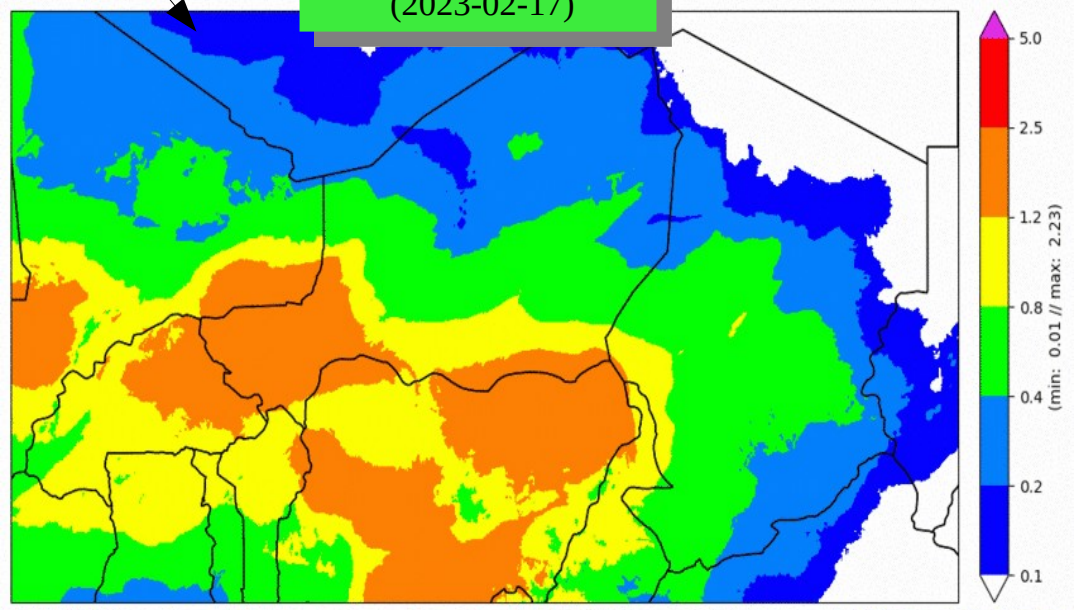
- Atmosphere : 3-moments Log-normal Dust distributions (ORILAM comming from Meso-NH-C)

- Work at Climate team (J. Guth and V. Guidard) since 2022 in order to setup an operational configuration (LBCs from MOCAGE) → daily runs currently available

OBS
(2023-02-17)

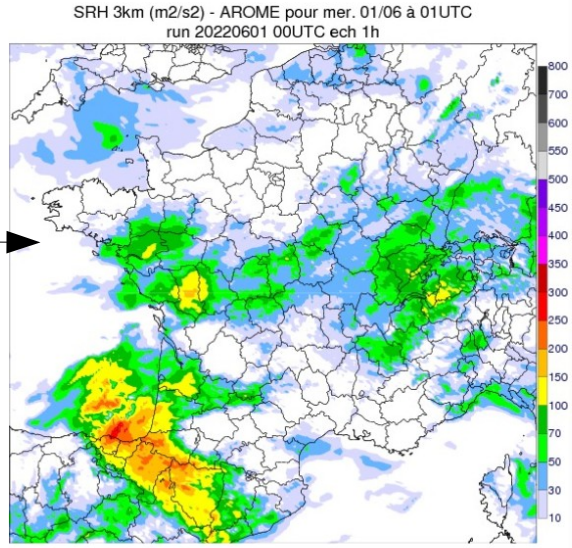


AROME-Dust AODs
(2023-02-17)



Modified/New diagnostics

- **Lightning diagnostic improvement**
- Precipitation type improvement
- New storm helicity diagnostic
- Pressure of the top and base of deep convection
- **Thermical vertical velocity (for gliding)**
- Snow depth diagnostic



Lightning diagnostic improvement

- Based on the McCaul (2009) parametrization, calibred by S. Radanovics in Arome (2021)
- Operationnal since summer 2022 (J-M. Piriou and Y. Seity)

But ….

- Overestimation during the winter 2022/2023

→ Take into account updraft size

- Multiplication by $(\min(zbase,1800)/1800)^2$

zbase : altitude of cloud base

More details : jean-marcel.piriou@meteo.fr

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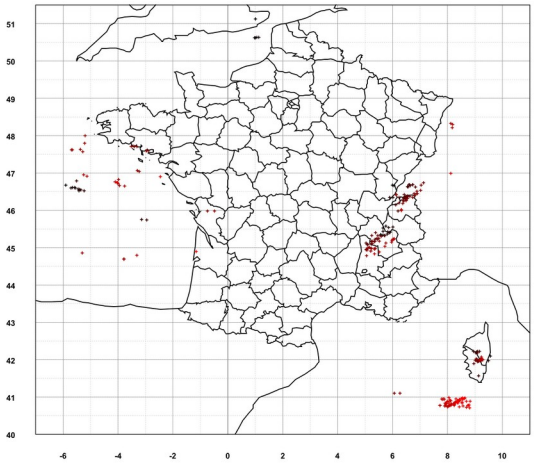
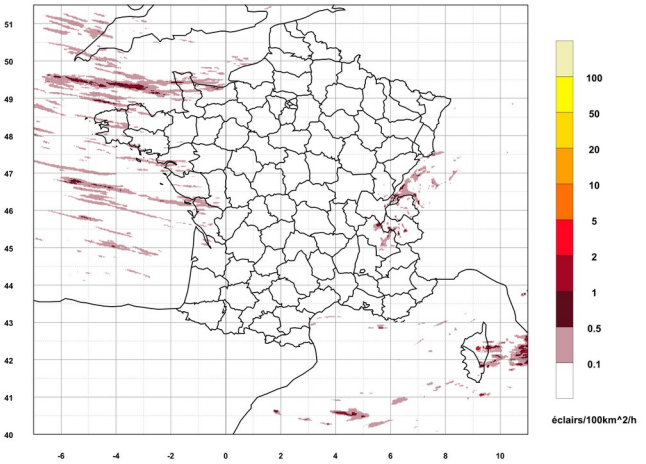
Lightning diagnostic improvement

- 9 January 2023 3TU, cumul. 0-3h
- Cumulative amounts decrease and are closer to observations

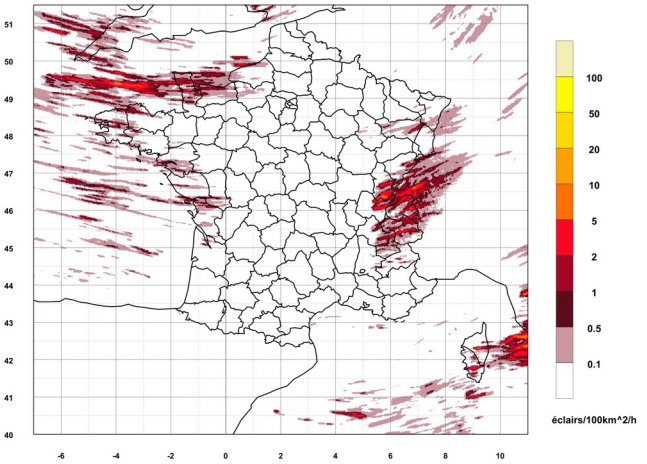
Observation



TEST



OPER



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Thermical vertical velocity

- Produced for gliding

$$V_z = \alpha (\beta Q_s H)^{1/3}$$ (adapted from J. W. Glendening formula)

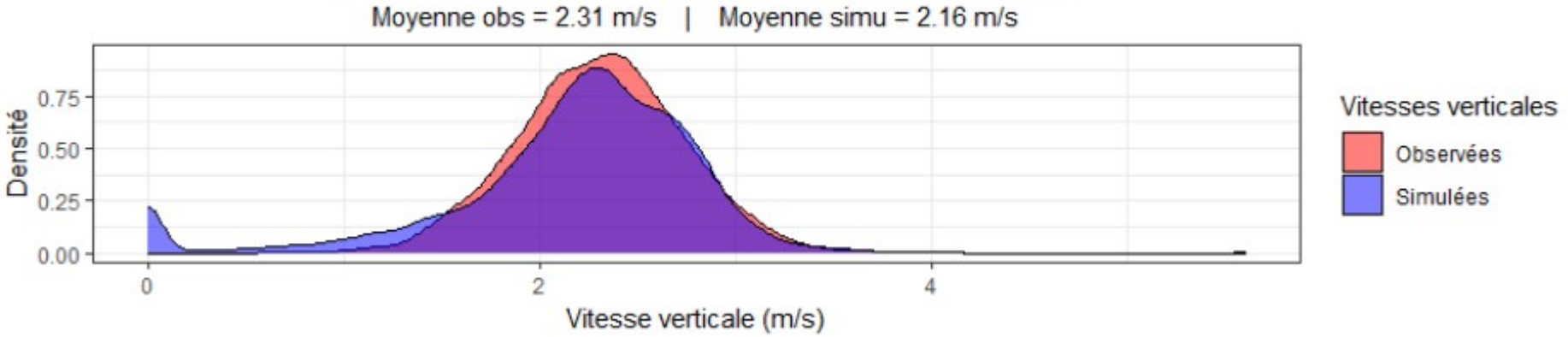
- V_z : Thermical vertical velocity
- α = 1.9 (tuned by V. Curat)
- β : Buoyancy constant = ratio of g (gravity)/ Ts (mean surface temperature)
- Q_s : Sensible heat flux
- H : Boudary Layer Height

More details : rachel.honnert@meteo.fr

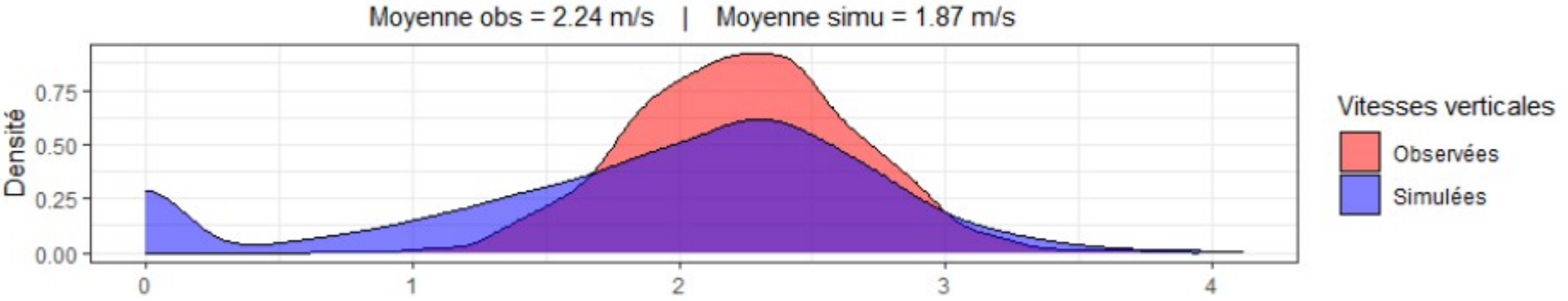
Thermical vertical velocity

Density of observed and simulated vertical velocities

During several flights



Only above complex terrain



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Next steps :

- Test new aerosols climatologies in ARPEGE
- Fast EcRad tests in AROME (ecckd)
- Towards oper use of daily aerosols for AROME (at least dusts for radiation) from CAMS or MOCAGE.
- Tests new LIMA options in AROME CY49T1

  (2-moments for liquid only, for fog, link with aerosols)
- EDKF modifications in real cases
- ARPEGE-NH with AROME physics, technicaly working, some science already started

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Thank you for your attention !
Questions ?

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