



# About the use of aerosols in AROME

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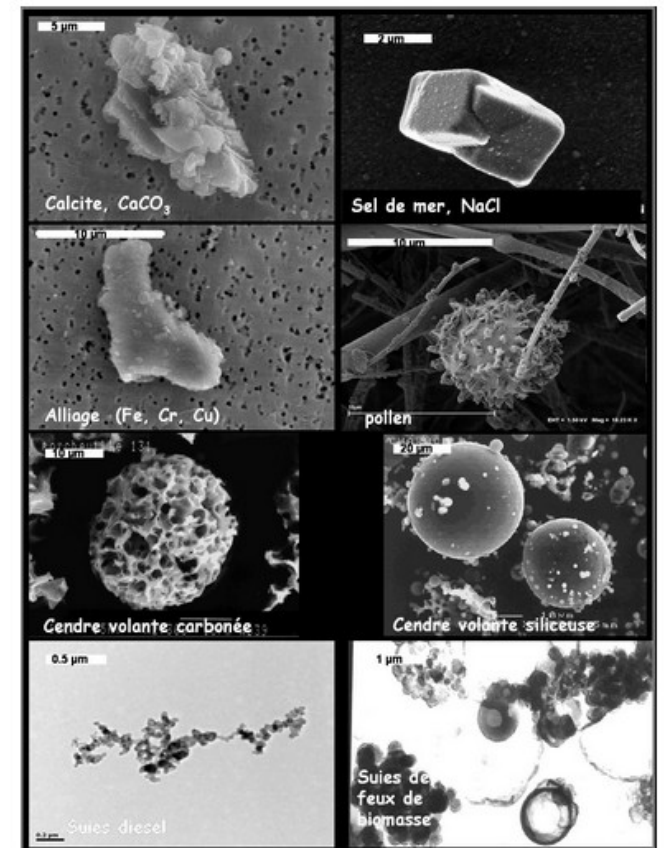
*Yann Seity, Abdenour Ambar, Vincent Guidard, Jonathan Guth,  
Bergson Kuete-Lafouet, Quentin Libois. Mohamed Mokthari*

*ACCORD ASM, Tallinn, March 2023*

# Outline

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- (1) Aerosols in radiation (monthly climats/near real time/prognostic)
- (2) Aerosols in microphysics (with LIMA)
- (1)+(2) in AROME-Dust

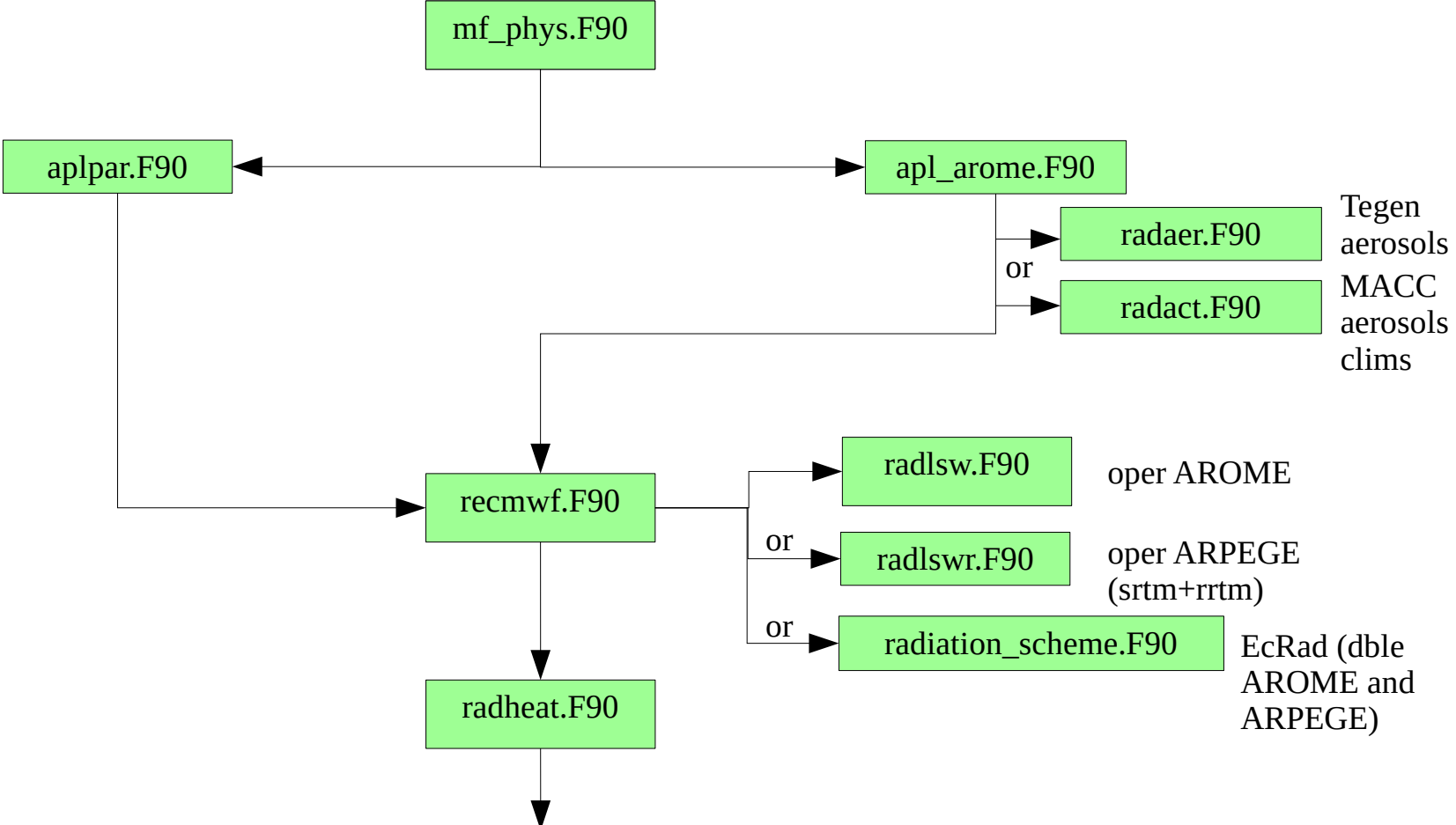


various aerosols ( from LISA)

# 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 clim (6 var)	EcRad (SRTM)	EcRad (RRTM)	CAMS3D clim (12 var)
ARPEGE	SRTM					Tegen 2D clim (6 var)

# Radiation call in (AROME/ARPEGE) 48t1\_op forecasts

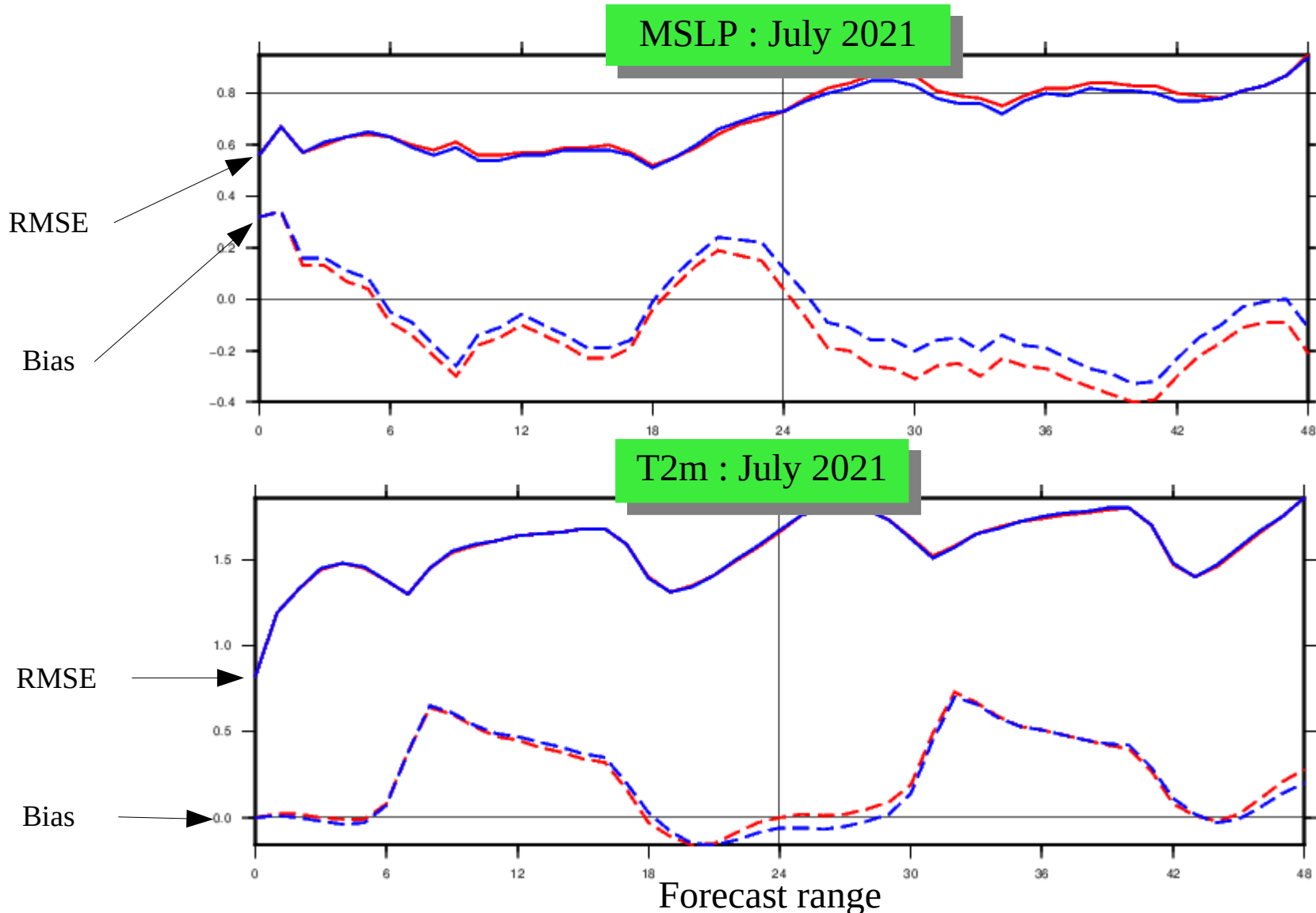


recmwf called every 15' in AROME (1h in ARPEGE), radheat every time step



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

- In EcRad : new aerosols climatologies available based on CAMS (in CY46T1 : 2D, in CY48T1 : 3D)



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

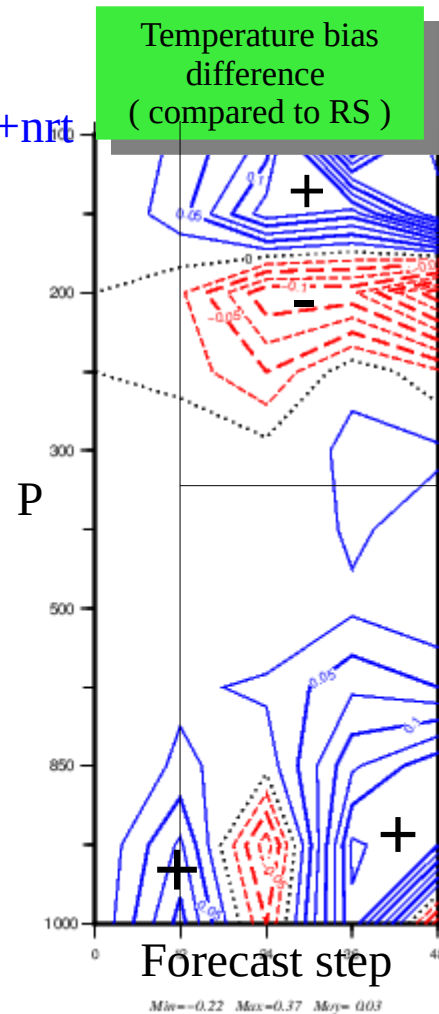
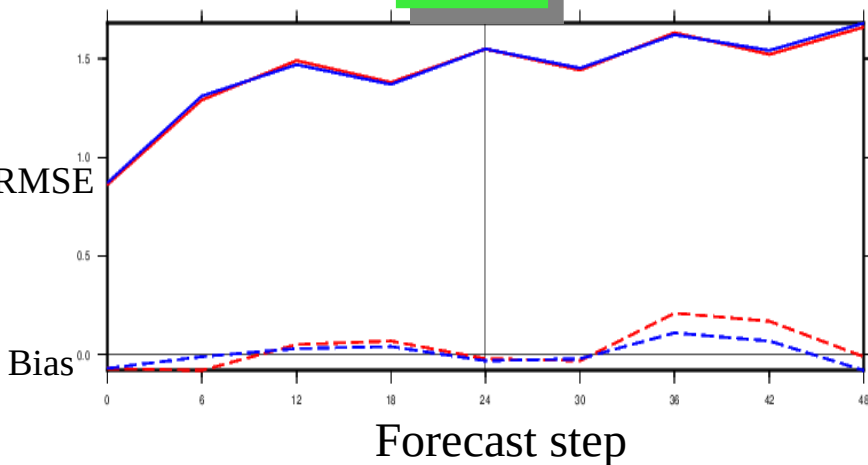
# Impact of the use of near real time CAMS aerosols

- Fields preparation done with gl, can also be done now with e903 configuration (thanks Ryad !)
- 11 aerosols taken from CAMS forecasts, added in model initial file and provided to EcRad.
- Fields are advected by SL with no significant extra cost (linear interpolators)
- Only radiative effect, no interaction with microphysics

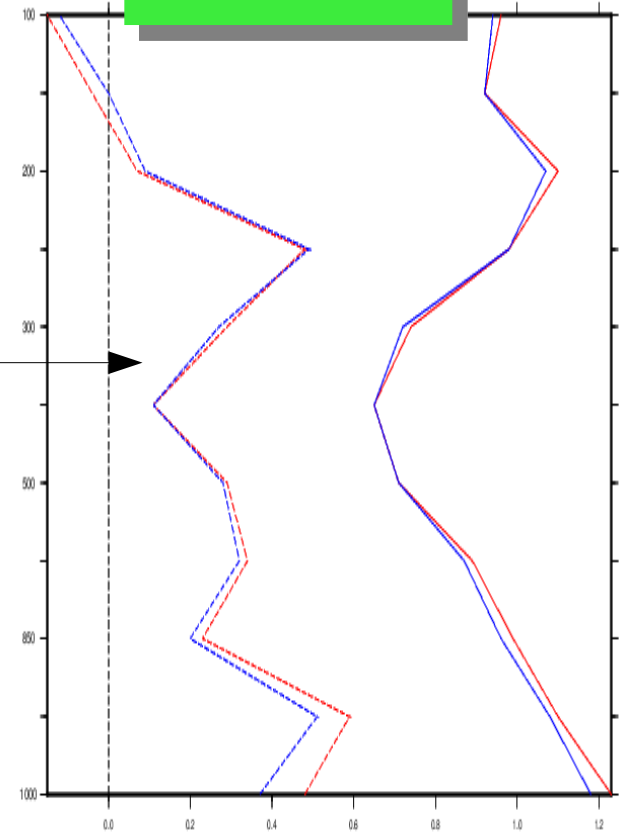
24-07 to 31-08-2021 :

EcRad / EcRad+nrt  
CAMS

T2m

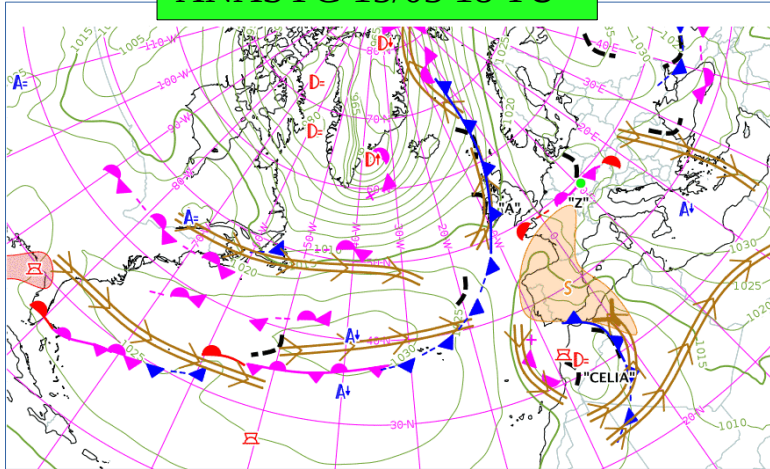


Temperature at +12

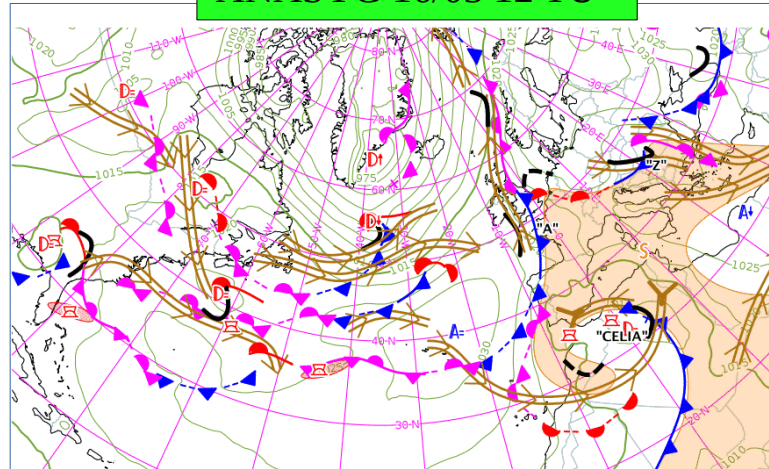


# A significant saharian dust event over France (15 - 17 March 2022)

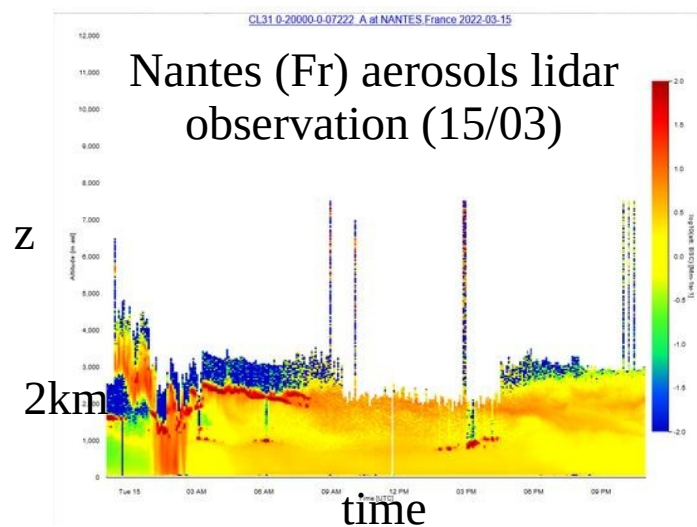
ANASYG 15/03 18 TU



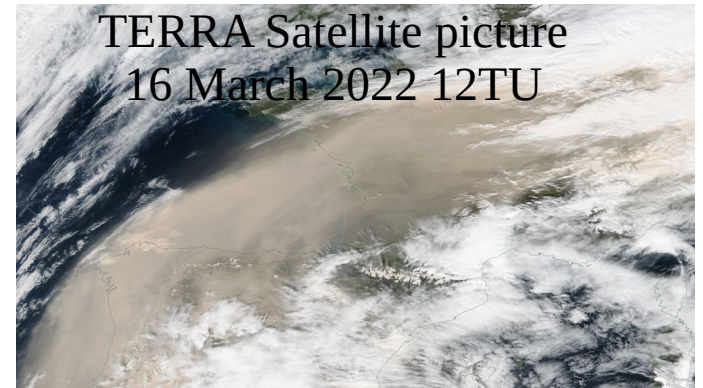
ANASYG 16/03 12 TU



Piau ski-resort  
webcam (Pyrenies)



TERRA Satellite picture  
16 March 2022 12TU



- Large errors in T2M by our operational models (→ pb for energy sector, as electricity for instance)

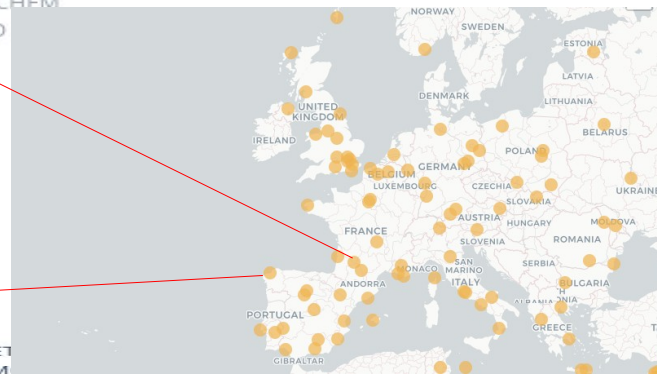


# Observed Aerosol Optical Depth (AOD)

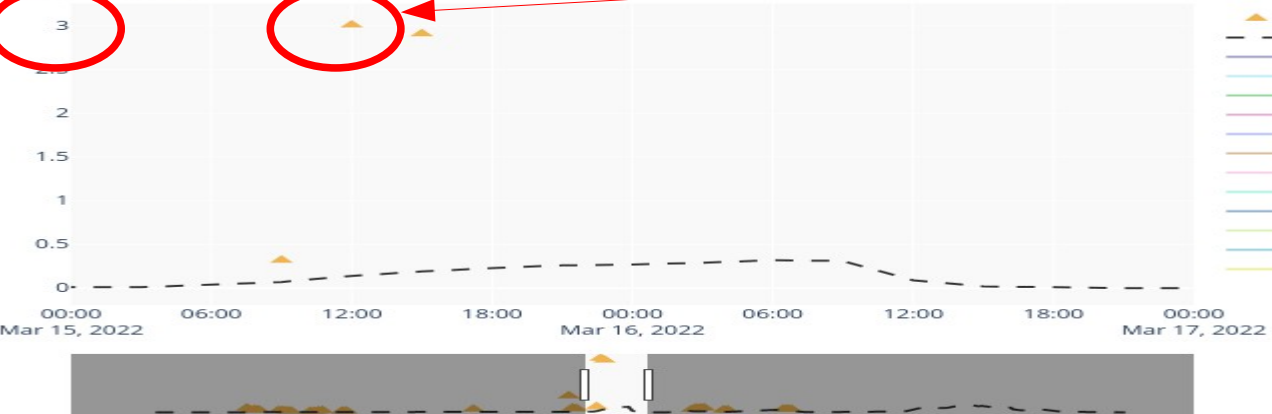
all 2w 7d Dust Optical Depth @ Agen\_Palissy (lat = 44.20, lon = 0.62)



- AERONET
- MULTI-MODEL
- MONARCH
- CAMS-IFS
- DREAM8-CAMS
- NASA-GEOS
- MetOffice-UM
- NCEP-GEFS
- EMA-RegCM4
- SILAM
- LOTOS-EUROS
- NOA-WRF-CHEM
- WRF-NEMO
- ALADIN



all 2w 7d Dust Optical Depth @ Coruna (lat = 43.36, lon = -8.42)

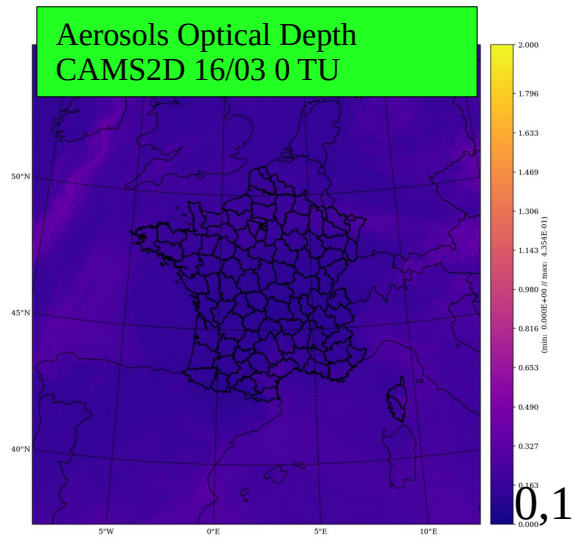


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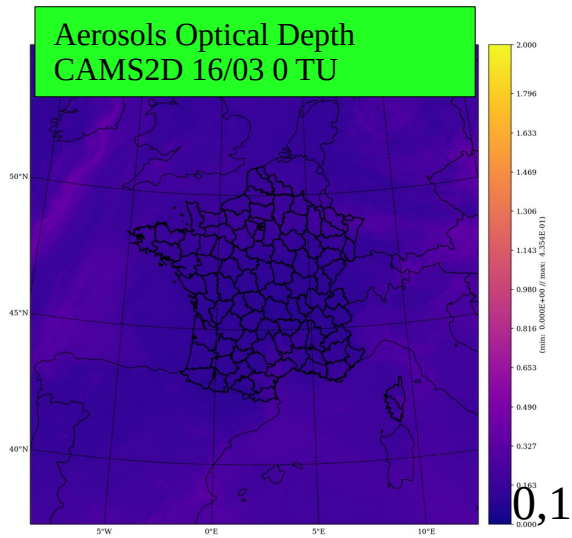
# About aerosols :

- CAMS 2D climatologies :

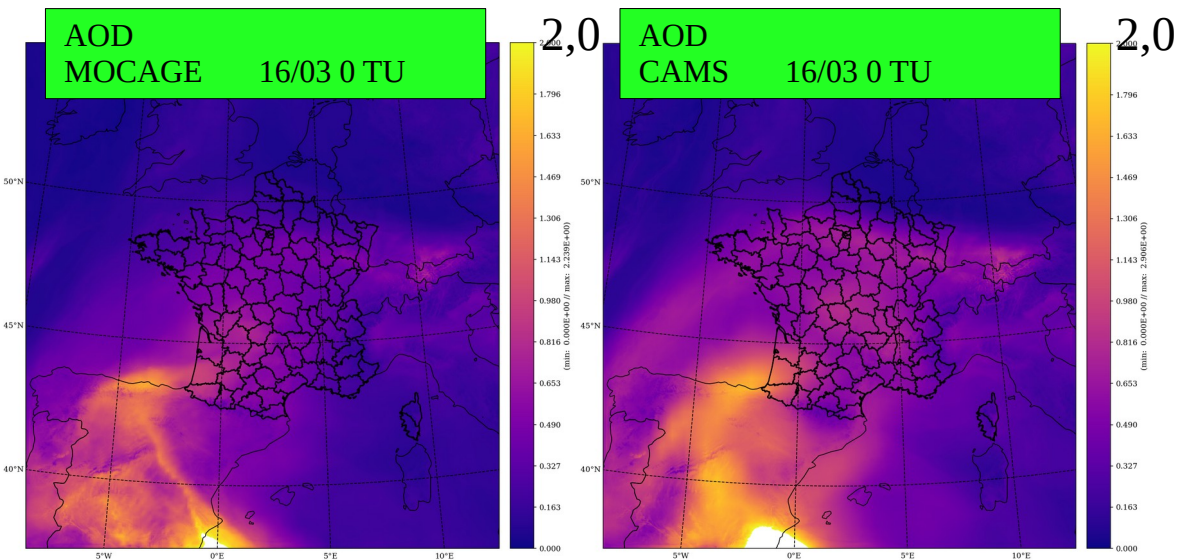


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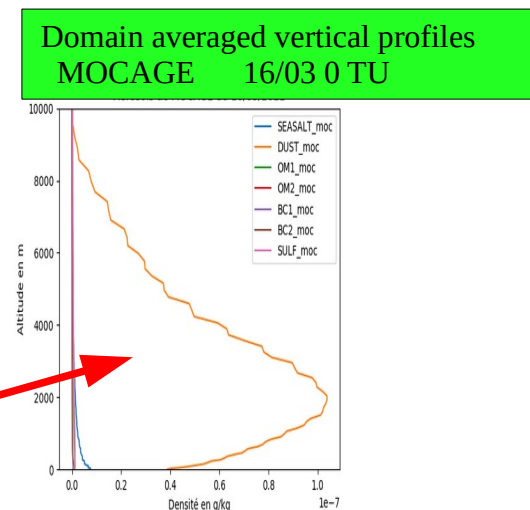
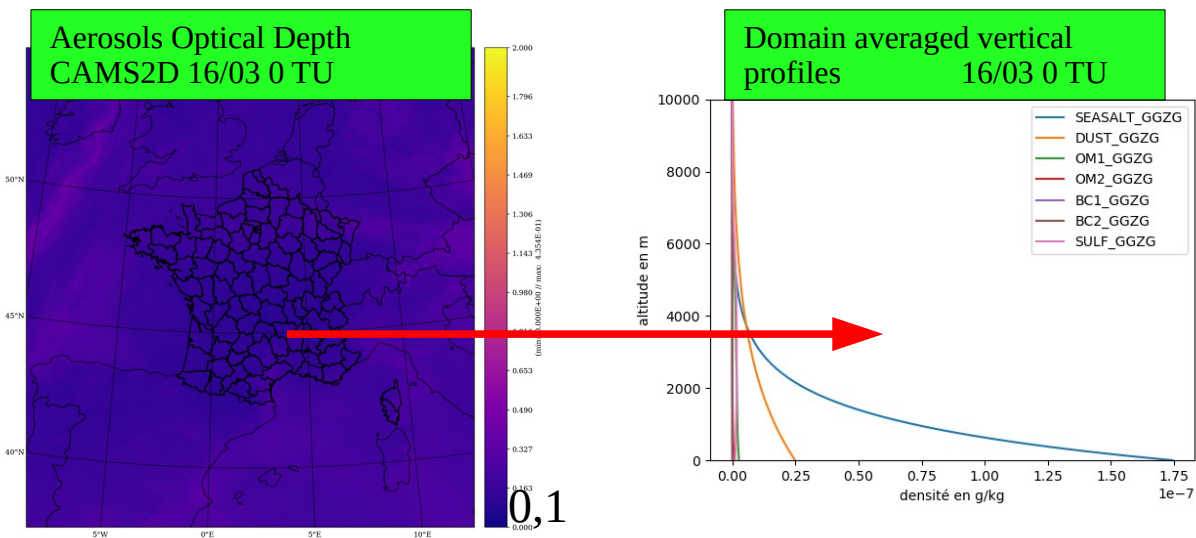


- Near real time aerosols :

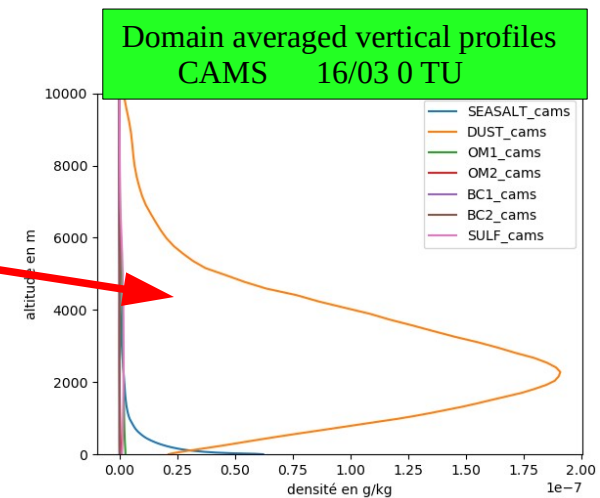
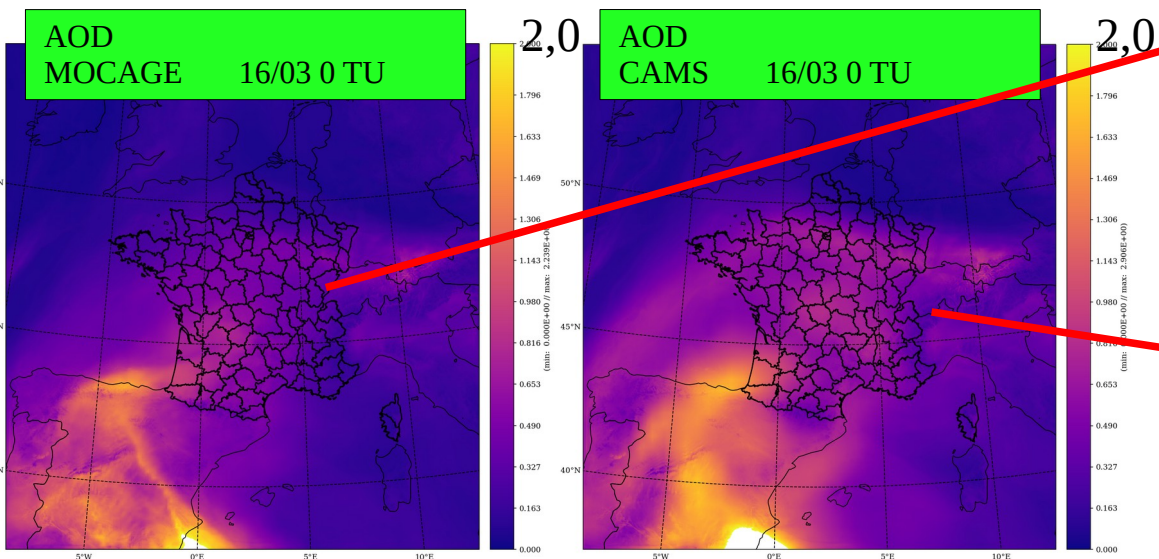


# About aerosols :

## ■ CAMS 3D climatologies :



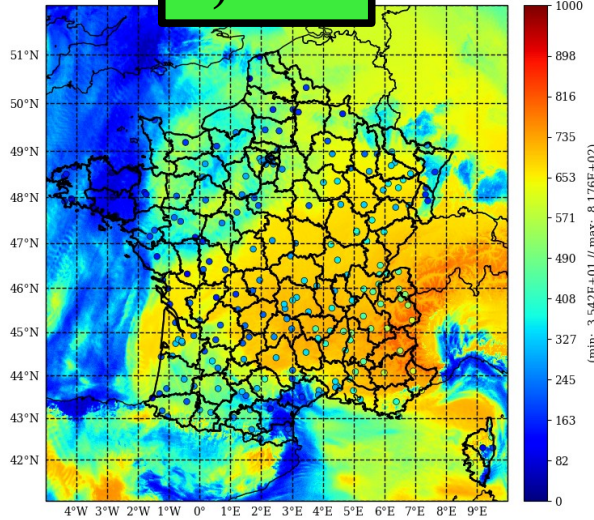
## ■ Near real time aerosols :



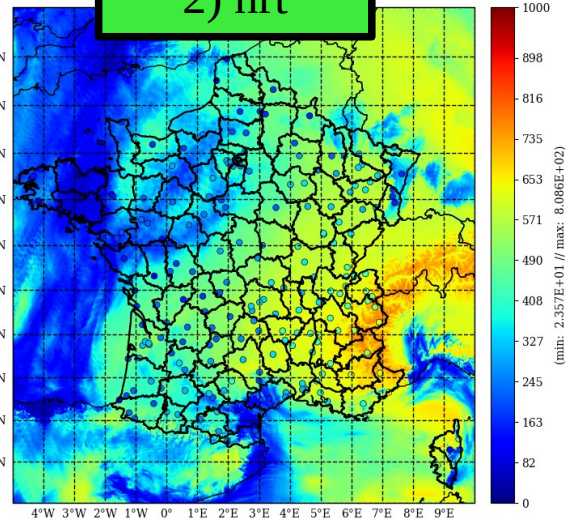
# Radiative impact of near real time aerosols :

Mean downward SW between 11 and 12 TU :

1) clim



2) nrt

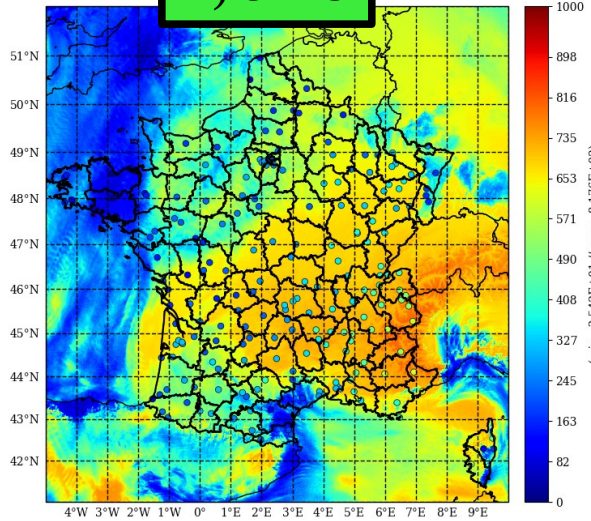




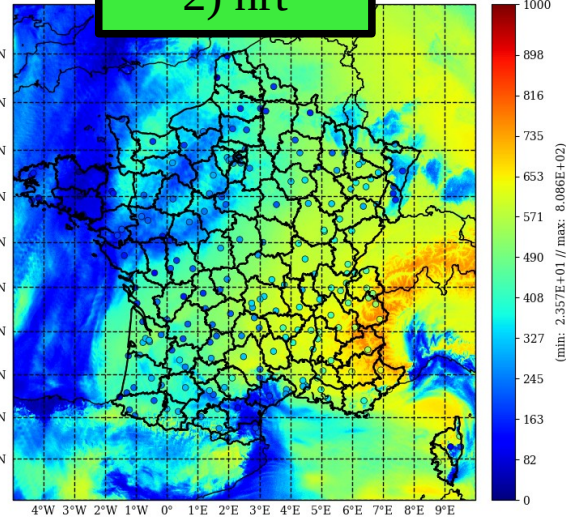
# Radiative impact of near real time aerosols :

Mean downward SW between 11 and 12 TU :

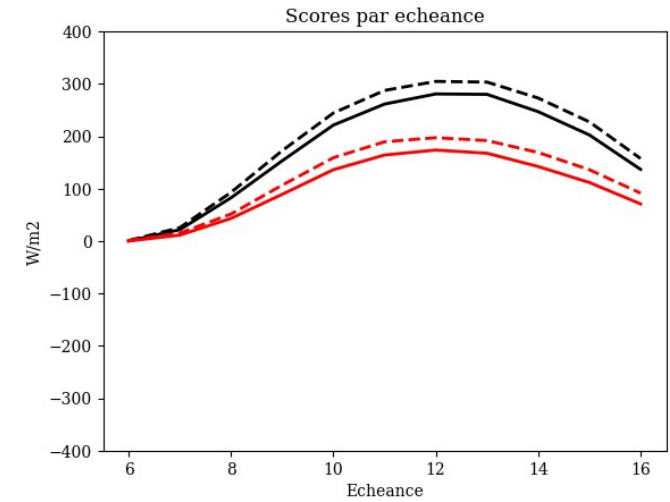
1) clim



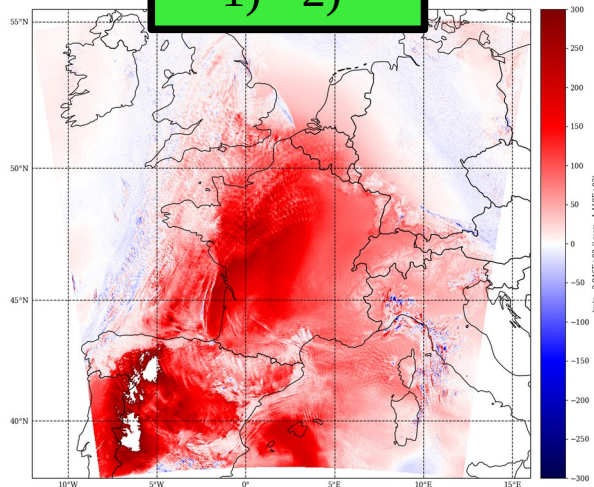
2) nrt



— Biais clim de CAMS 2D      — Biais aerosols de CAMS du jour  
- - Rms clim de CAMS 2D      - - Rms aerosols de CAMS du jour



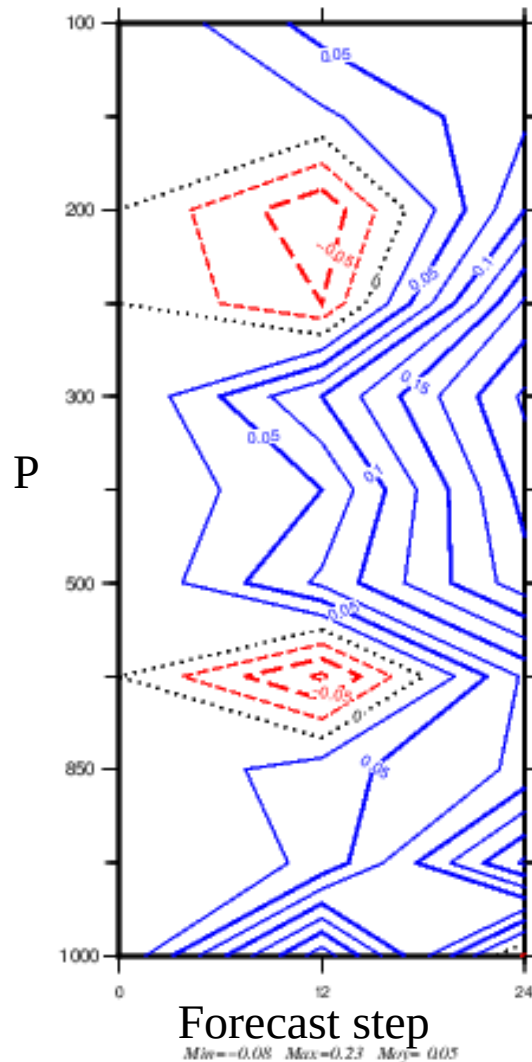
1) - 2)



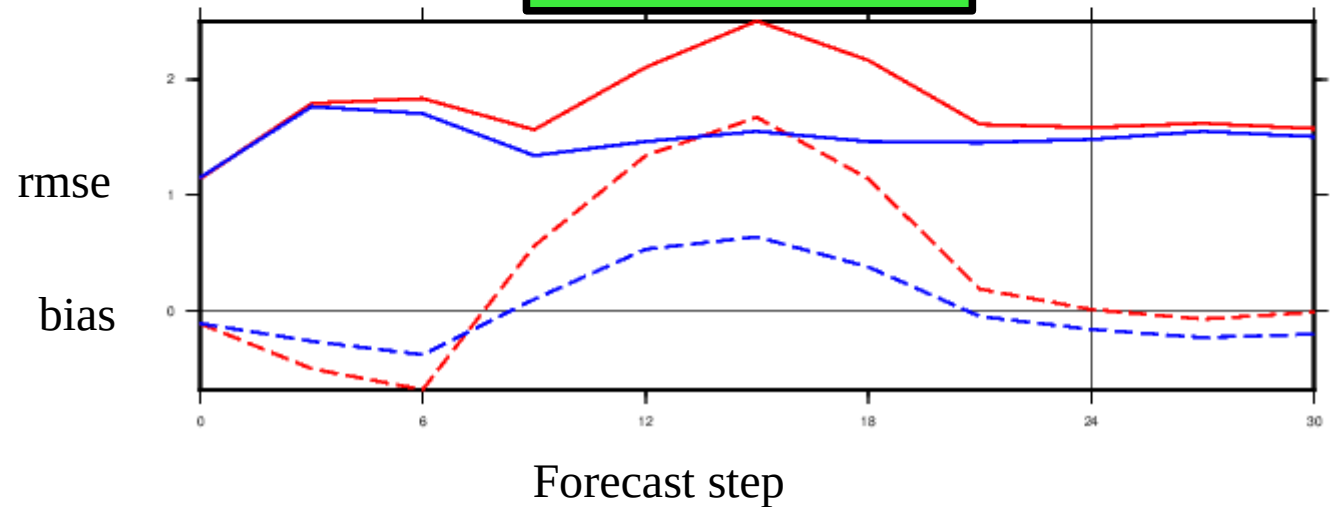
→ Correction of half of the SW bias (~ -120 W/m²)

# Model T bias significantly reduced by the use of nrt aerosols in EcRad

Temperature : Exp -  
Ref bias compared  
to RS



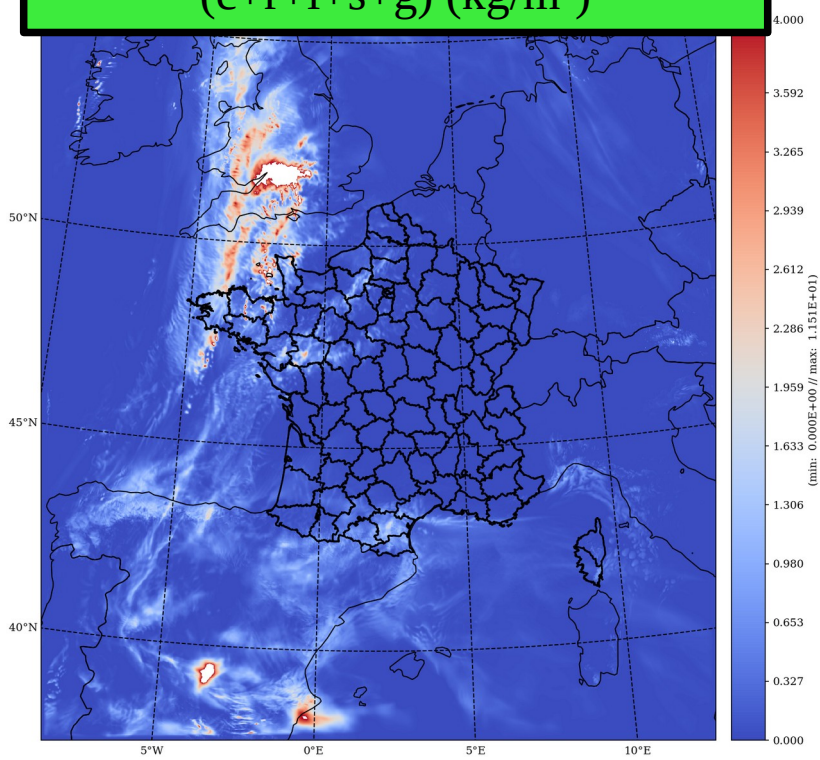
T2m : Exp / Ref



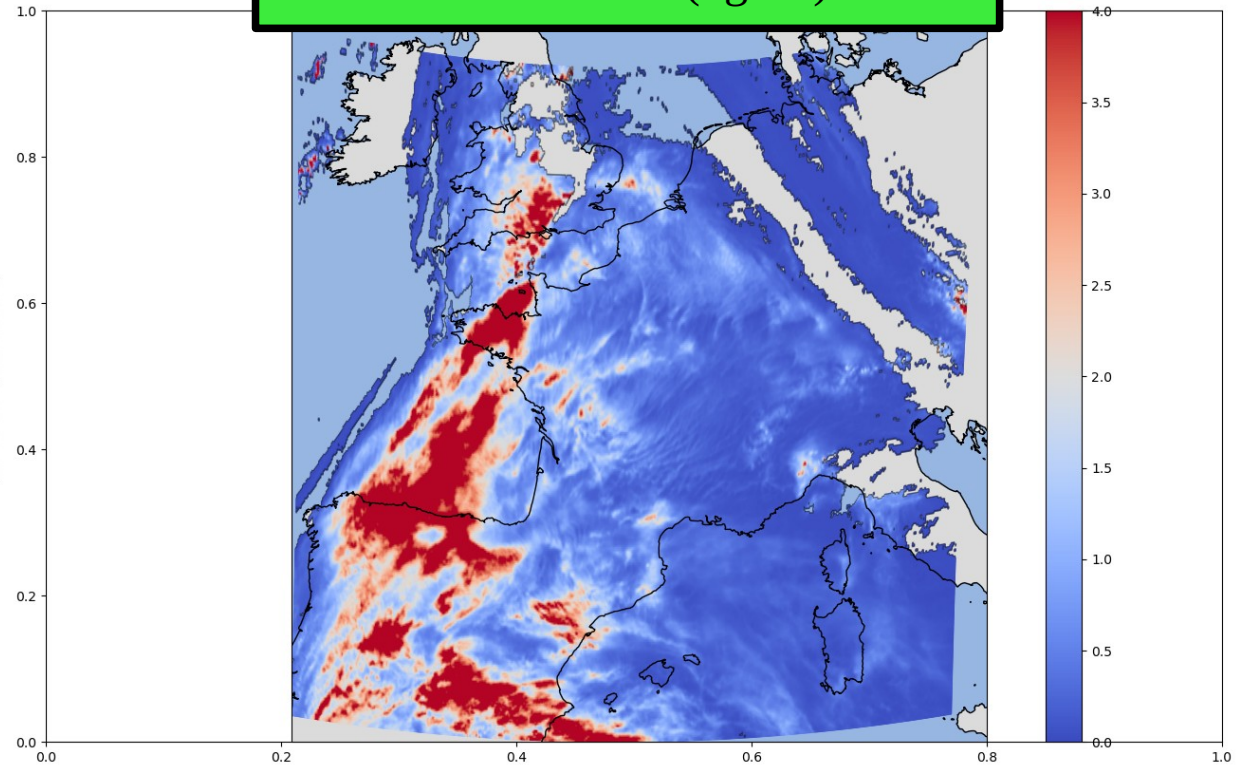
- half of the T2M bias fixed ( $\sim -1^{\circ}\text{C}$ )
- Improvements also on T profiles, increasing with forecast step

# Residual biases probably due to model clouds underestimation (2022-03-16 12TU)

Vertically integrated cloud content  
(c+r+i+s+g) (kg/m<sup>2</sup>)



Satellite Obs (kg/m<sup>2</sup>)

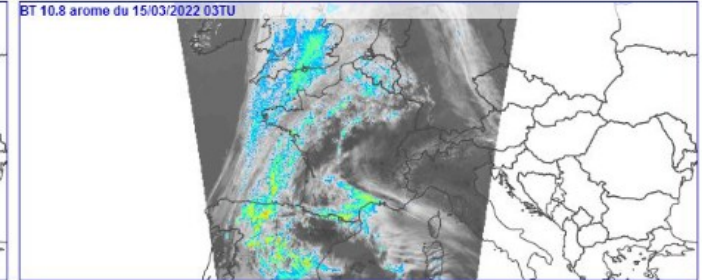
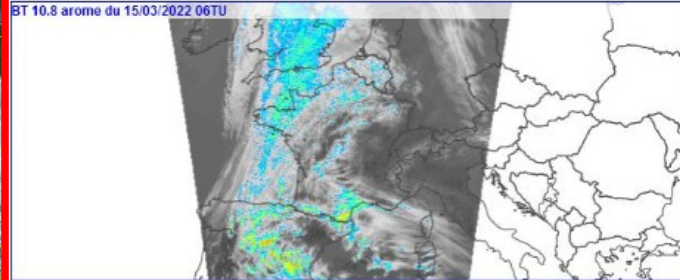
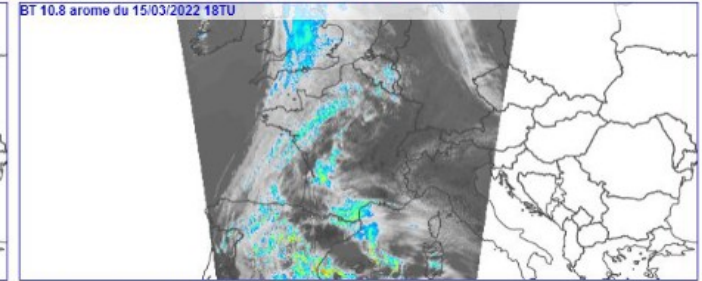
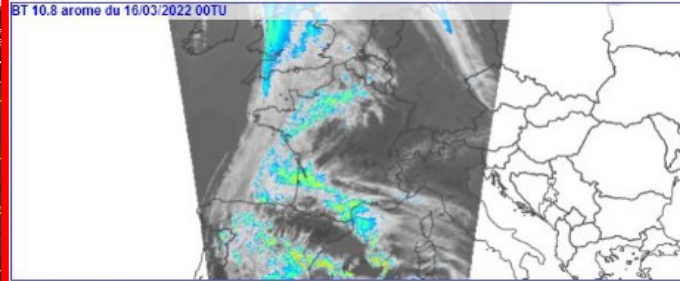
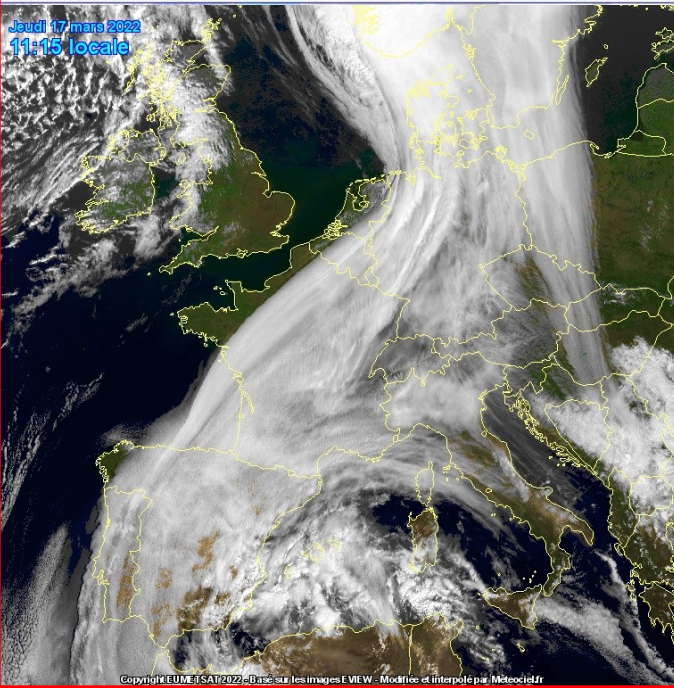
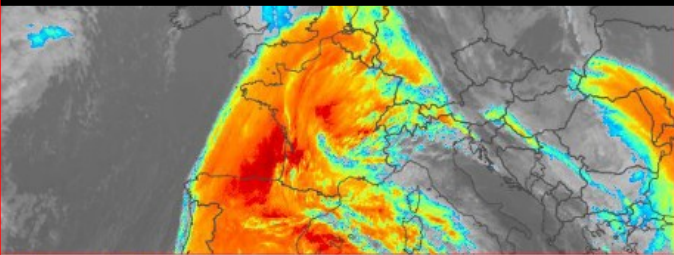




# Residual biais probably due to model clouds underestimation (2022-03-16 12TU)

Satellite IR Obs (K)

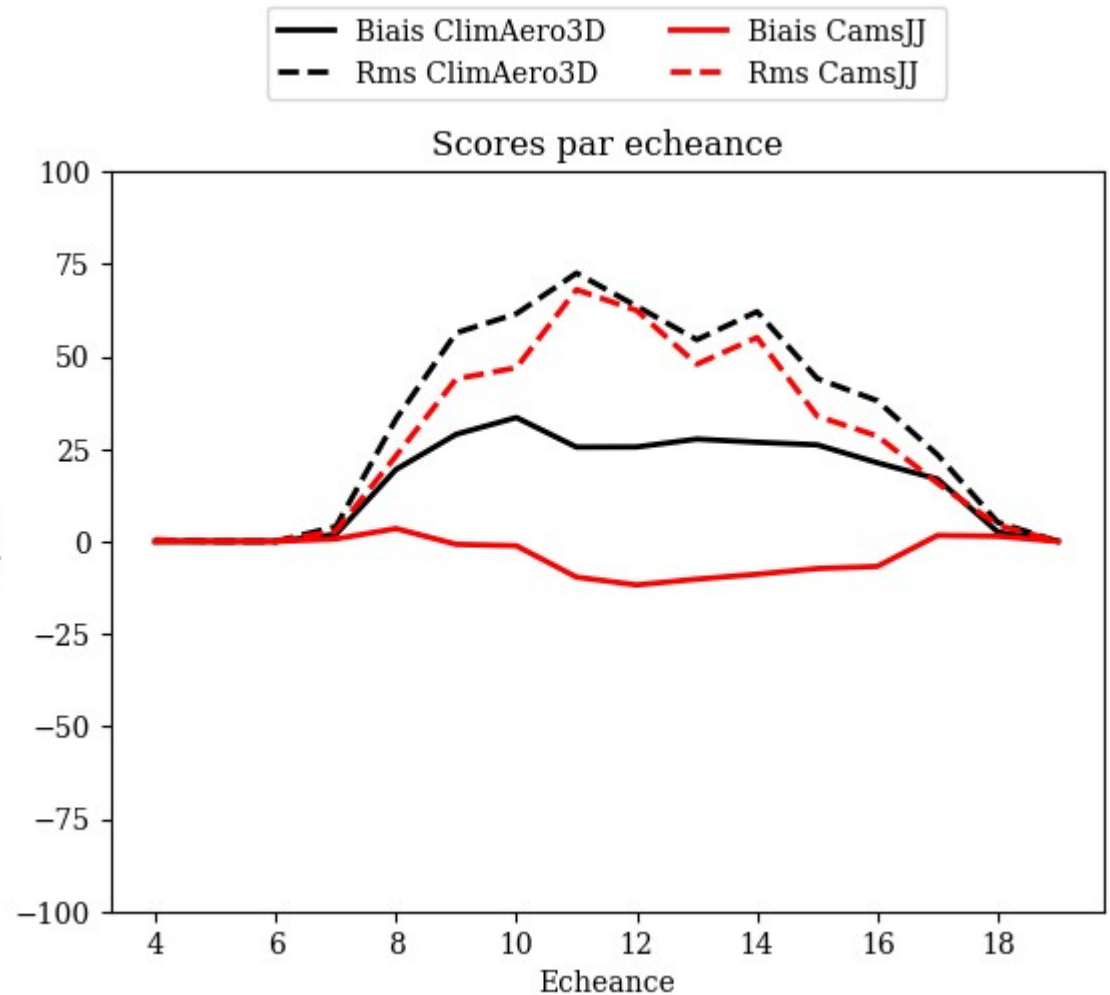
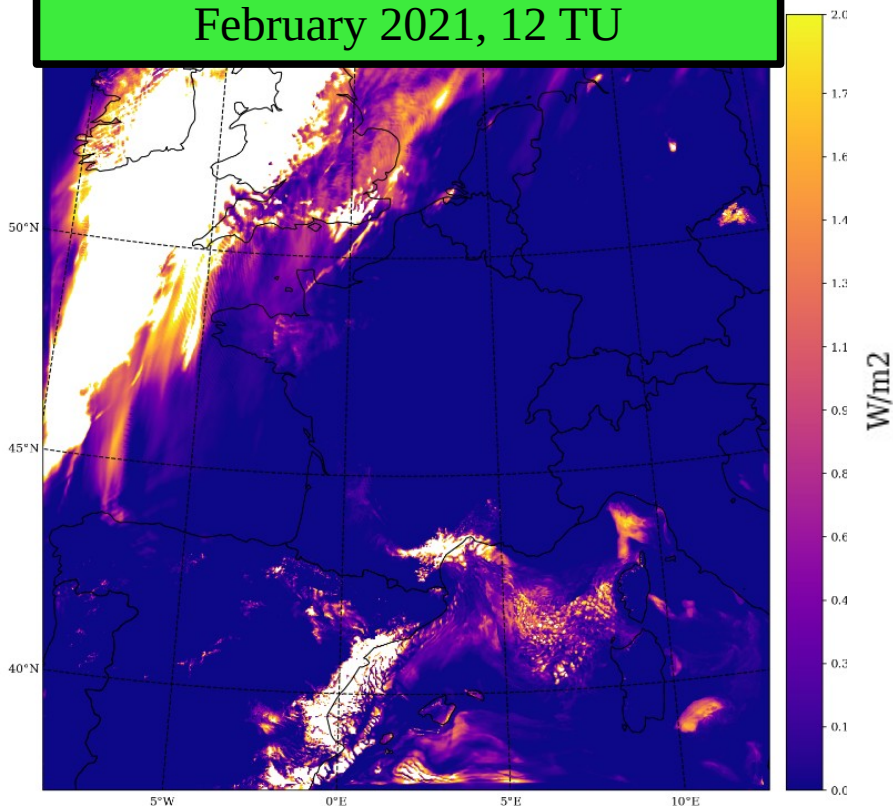
AROME IR ( model starting at various steps )



# An other case...

→ On an other date with less dusts but no significant clouds, SW bias fixed with nrt aerosols (CamsJJ)

AROME Cloud Optical Depth : 24  
February 2021, 12 TU



# AROME-Dust experiment ( J. Guth)

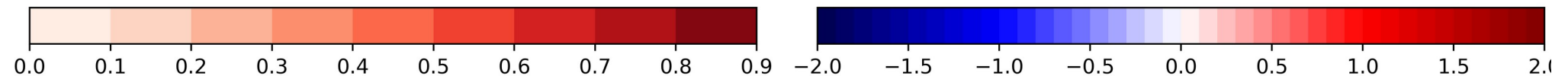
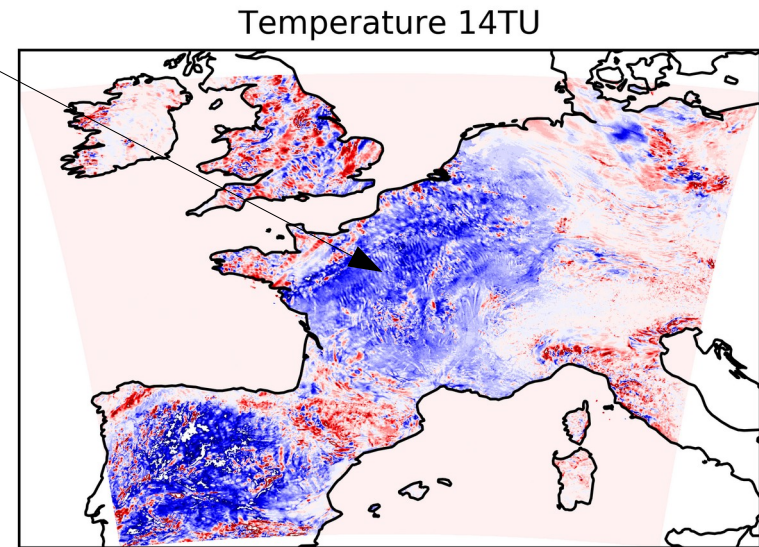
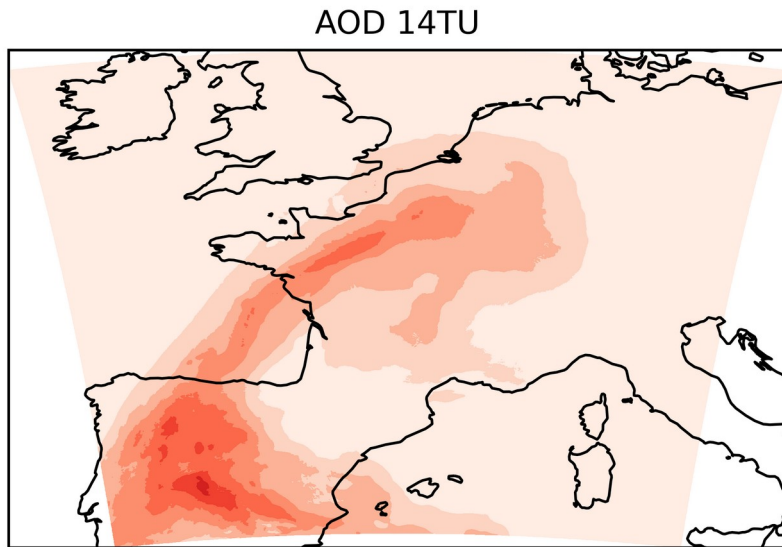
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- AROME-Dust : 3 prognostic desertic dust modes : thin, medium, coarse  
(→ 9 GFL\_EXT = 3x3 variables by separating Clear sky, Cloudy, Rainy parts)
- Handle emissions (in Surfex), transport by Semi-Lagrangian, and wet deposition by clouds/rain.
- Initialisation with MOCAGE dusts 10<sup>th</sup> March 2022  
Without EcRad (→ need code modification) → old radiation scheme used  
(But AOD provided to radiation code)  
Cycled Dusts P24h from 10 to 20 March.  
LBC from ARPEGE except for dusts (MOCAGE)



# Impact on T2m 16 March 2022 14TU

→ Cooling of about  $-1^{\circ}\text{C}$  under dust area

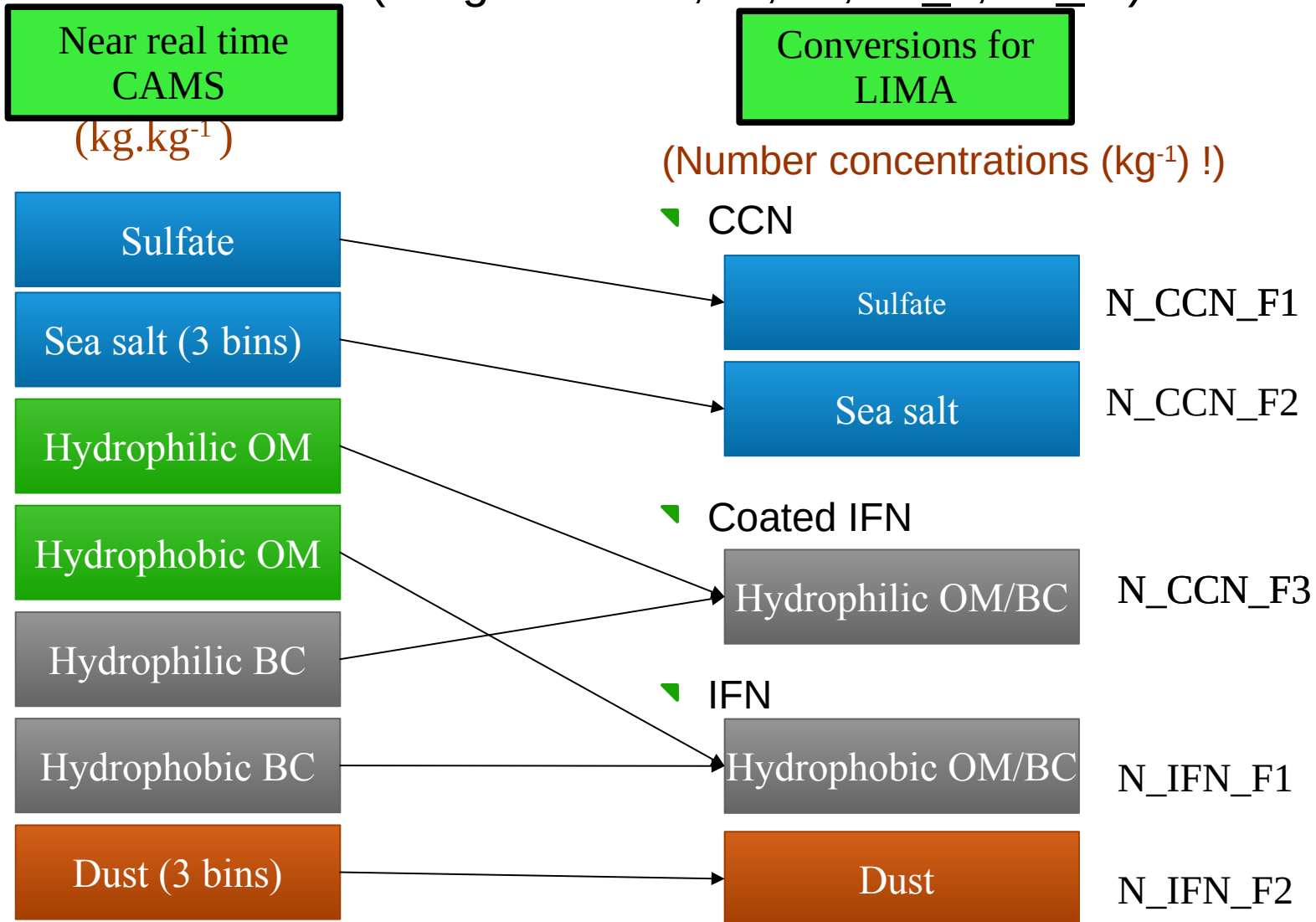


→ Less impact than with CAMS (AOD MOCAGE < AOD CAMS)

→ Wet deposition / washing out in AROME-Dust reduce dust contents seen by radiation

# Aérosols in microphysics with LIMA

Liquid Ice Multiple Aerosols : 2-moments Microphysics scheme  
(Prognostic  $N_c$ ,  $N_i$ ,  $N_r$ ,  $N^*_F$ ,  $N^*_A$ )



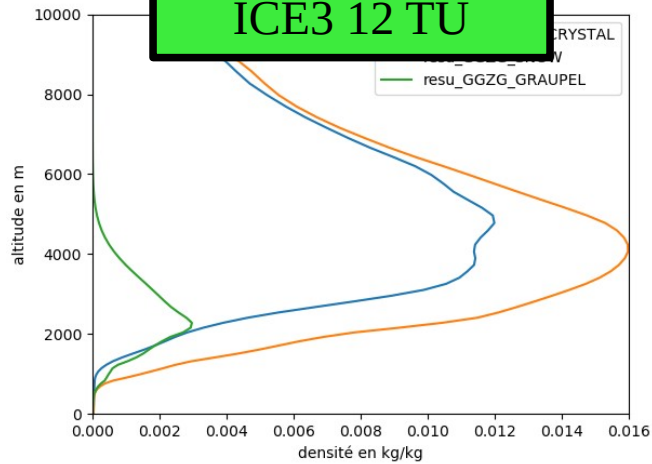
# Microphysics impact of the use of dusts (2022/03/16)

ICE\_CRYSTALS

SNOW

GRAUPEL

Mean vertical profiles  
ICE3 12 TU



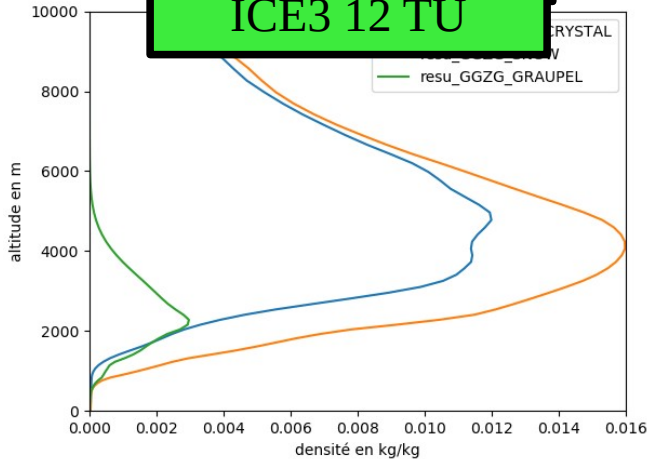
# Impact of the use of dusts as IFN (2022/03/16)

ICE\_CRYSTALS

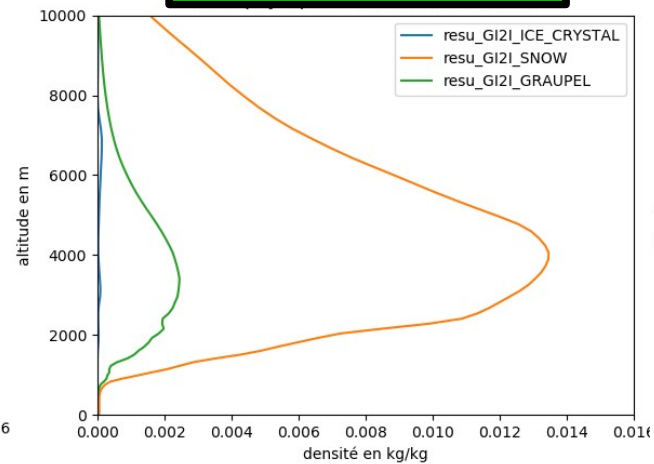
SNOW

GRAUPEL

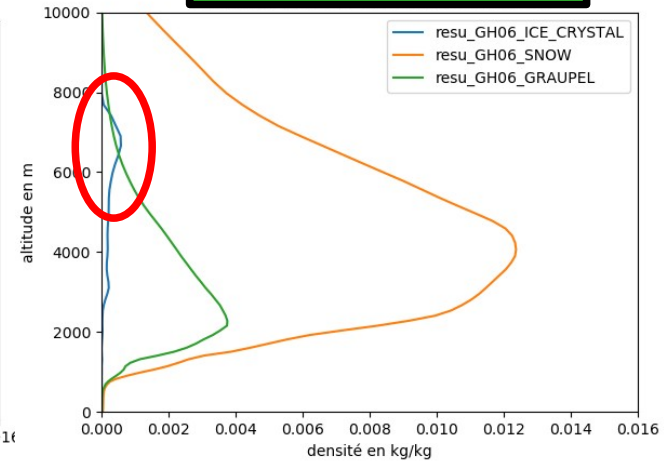
Mean vertical profiles  
ICE3 12 TU



LIMA référence  
12 TU



LIMA with nrt  
CAMS  
12 TU



- The altitude of main dust plume is lower than main ice altitude in the model
- Nevertheless, a little more ice in LIMA nrt CAMS / Ref LIMA (→ but radiative impact small)
- But ICE+SNOW in LIMA < ICE+SNOW in ICE3 (→ SW surface fluxes and T2m are better with ICE3 on that case)
- Ice is converted to snow too quickly (known pb in LIMA)



# Prognostic aerosols (AROME-Dust) + LIMA

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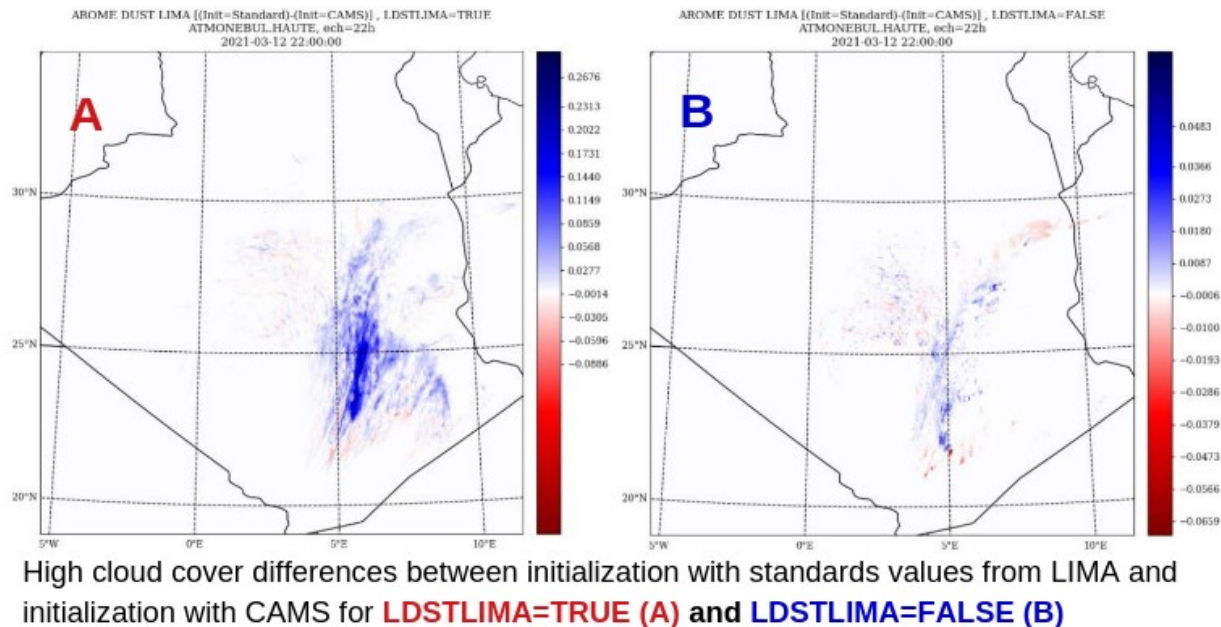
→ Thanks to recent work by Abdenour and Mohamed (based on CY48T1 and CY48T3), we are able at the same time in AROME-DUST to :

- Use prognostic Dusts in LIMA (as IFN) under new switch (LDSTLIMA)
- Compute turbulent transport of both dusts and LIMA variables.

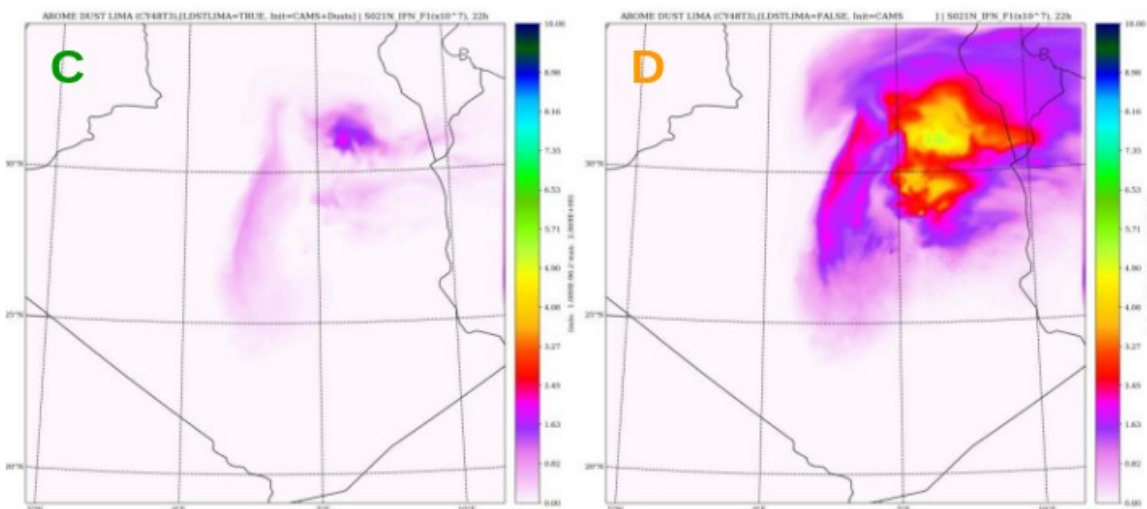
# A test case over Algeria : 2021-03-12

Several tests performed :

Tests	LMICRO	LRDUST	LDSTLIMA	INIT	Status
Exp1	ICE3	FALSE	-	-	OK
Exp2	ICE3	TRUE	-	-	OK
Exp3	LIMA	FALSE	-	Standard	OK
Exp4	LIMA	FALSE	-	CAMS	Crashed at 23h
Exp5	LIMA	TRUE	TRUE	CAMS	OK
Exp6	LIMA	TRUE	TRUE	Standard	OK
Exp7	LIMA	TRUE	FALSE	CAMS	Crashed at 22h
Exp8	LIMA	TRUE	FALSE	Standard	OK



High cloud cover differences between initialization with standards values from LIMA and initialization with CAMS for **LDSTLIMA=TRUE (A)** and **LDSTLIMA=FALSE (B)**

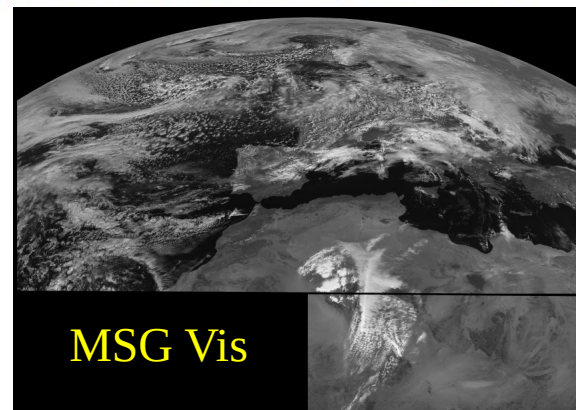


Ice Freezing nuclei (N\_IFN) for :

**(C) LDSTLIMA=TRUE, Initialization by aerosols from CAMS + Dusts from AROME**

**(D) LDSTLIMA=FALSE, Initialization by aerosols from CAMS**

→ Less high clouds with LDSTLIMA=T in that case, in link with less IFNs



# Conclusions and next steps

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- New aerosols monthly climatologies (CAM3 3D) in AROME 48T1\_op
- Work towards an operational use of near real time aerosols in AROME (in CY49T1\_op ?) for radiation.
- AROME-Dust, daily runs in CY48T1 on research mode + EcRad ( by the end of 2023)
- Ongoing work on the use of nrt aerosols in LIMA for fog (not shown here, Salomé Antoine PhD, paper under revision)
- Ongoing work in LIMA in order to keep more ice\_crystals (modified snow mass-diameter function for instance as proposed by Wurtz et al. (2022), modified thresholds, new processes...)
- Work will continue in link with ACCALMIE project at Météo-France (on-line chemistry/aerosols libraries)

# ACCALMIE

**A**pproche **C**oordonnée pour la **C**himie et les **A**érosols dans **L**es **M**odèles du CNRM, **I**ncore et **o**ffline

Objective is to build a common framework for gaseous chemistry and aerosol modelling in NWP, climate and Chemistry models used and/or developed at CNRM:

- ARPEGE, ALADIN, AROME (PNT + climat), Meso-NH, MOCAGE, IFS(chimie)

Surface fluxes (emissions and depositions) will be coded in SURFEX

A common library for aerosols – chemistry will gather all schemes used at CNRM

Interfaces in host models will be coded / adapted to call the library  
and allow interactions with meteorological processes (radiation, microphysics)

Prototype should be delivered first semester 2024.

Operational applications to be identified and planned.



**Thank you for your attention !**

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*ACCORD ASM, Tallinn, March 2023*