



MétéoAlgérie

الديوان الوطني للأرصاد الجوية
Office National de la Météorologie

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Evaluation of AROME-DUST-CY46 configuration over Southern Algeria

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Summary

- Introduction
 - Motivation
 - Overview of AROME/ALADIN Dust configurations
- Algerian NWP current Dust system
 - Feedback after 10 years of using Aladin_Dust
- Desert dust modeling in NWP
 - AROME Dust Configuration over the Sahara
 - Sensitivity Tests: The Tamanrasset Case
- Perspectives.

Motivation

The interest for studying desert dust lies in its significant effects on air quality, climate, and public health. Understanding and predicting dust events can help mitigate their adverse effects. However, modeling these phenomena presents challenges, including data scarcity and the complex interactions within the atmosphere.

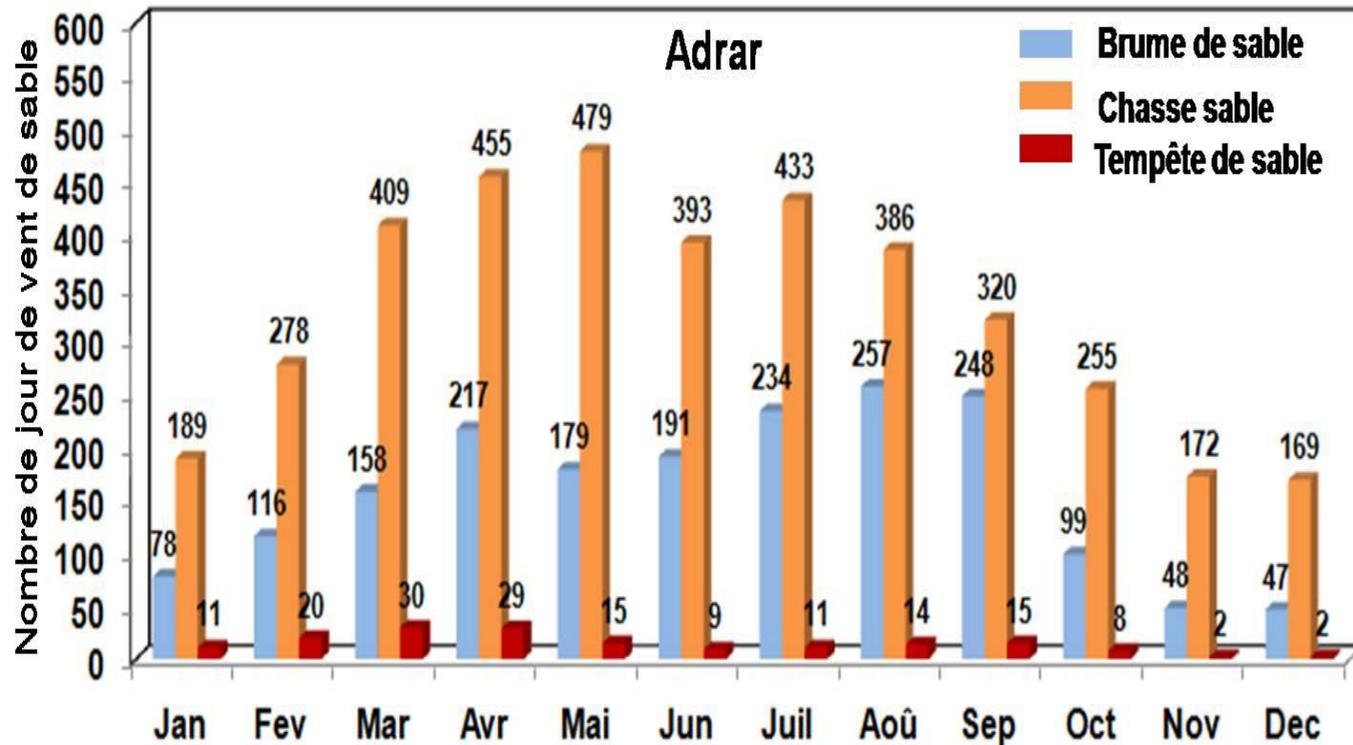


Fig1. Monthly variation in the frequency of lithometeor occurrences by type for the Adrar station, during the period 1984-2015. (Houari Benmoussa - DRM-SO Bechar)

Adrar: 217 days/year

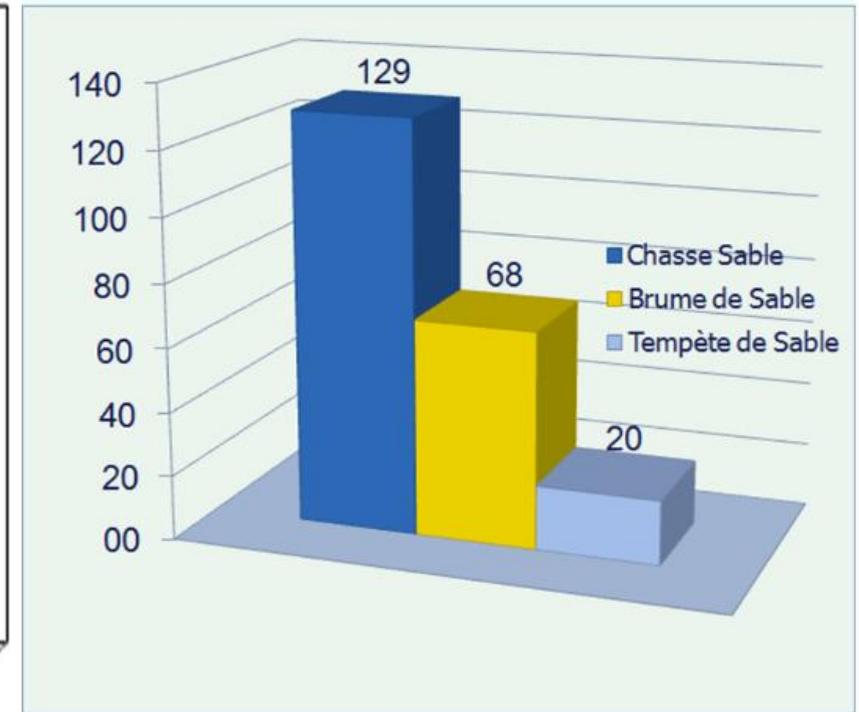


Fig2. Number of dusty / sandy days per year in Adrar

Overview of AROME/ALADIN Dust configurations

- 2007: first use of AROME_DUST configurations in research and development mode (Kocha et al., 2011).
- 2008-2012: Integration of dust cycle in ALADIN (Mokhtari et al. 2012)
- 2011: Use of both configurations during the Fennec campaign (June 2011) in the Sahara to plan flight operations. (Chaboureau et al.2016)
- 2014: Exploitation of the ALADIN-DUST configuration in operational use at ONM-Algeria.
- Since 2016: ONM-Algeria and Météo-France have been developing, maintaining, and updating the two configurations ALADIN_DUST and AROME-DUST.
- Now: AROME_DUST can operate with the LIMA microphysical scheme + ECRAD radiative scheme in interactive mode in cycle Cy49.

Operational Sand Forecasting Models at ONM

ALADIN-Dust

- Operational since : **Avril 2014**
- Resolution **14 x 14 km**
- Grid points : **250*250**
- Levels : **70 Lev**
- Forecast range : **72 h**
- Coupling files : **ARPEGE**
- Initialisation : **24h previous forecast**

Same Fields as ALADIN plus :

- Visibility
- Optical thickness
- Surface flux
- Dust concentration at the levels 700hPa, 850hPa, 1000hPa



Feedback after 10 years of using Aladin_Dust

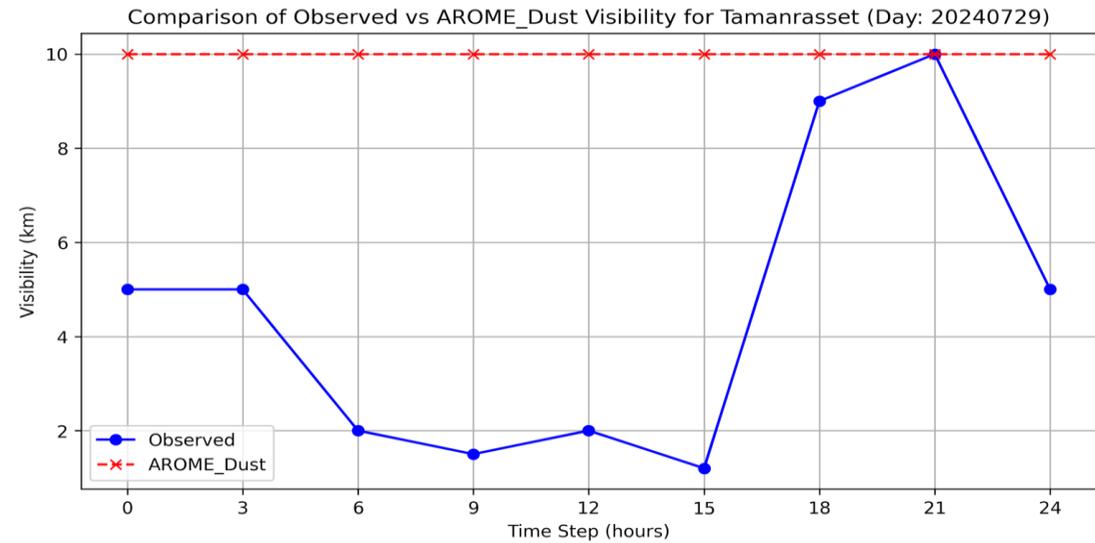
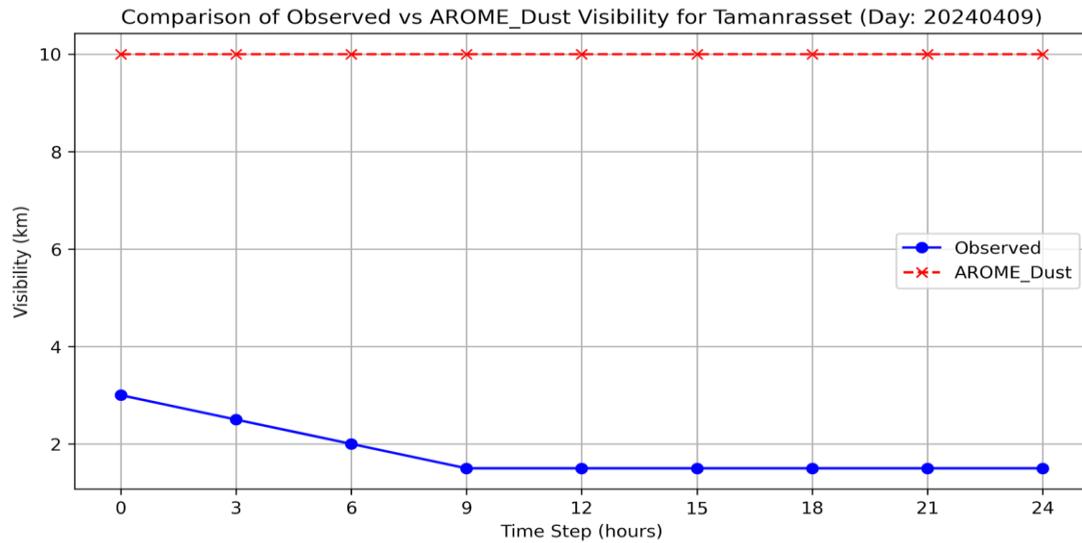
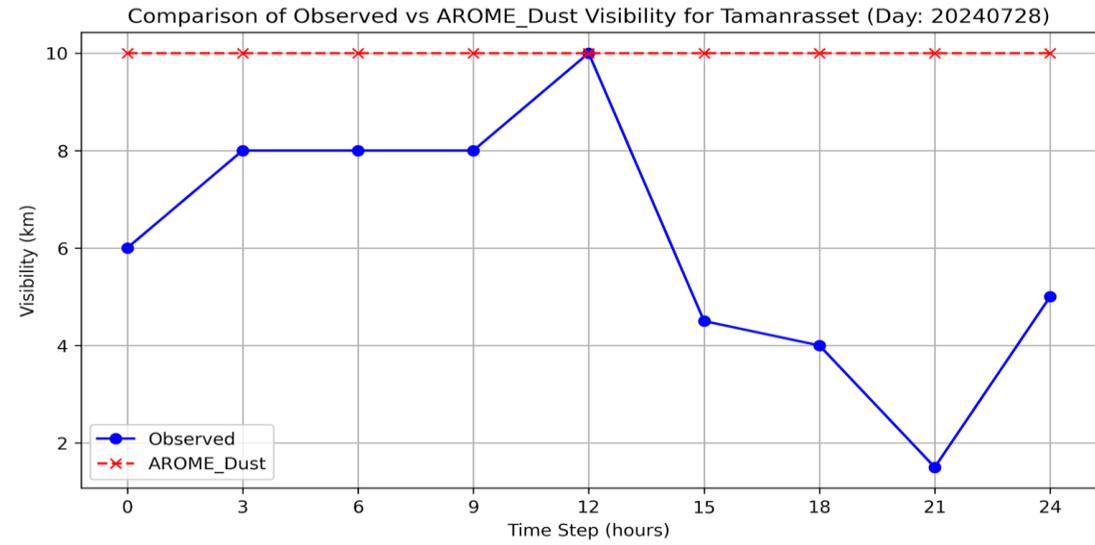
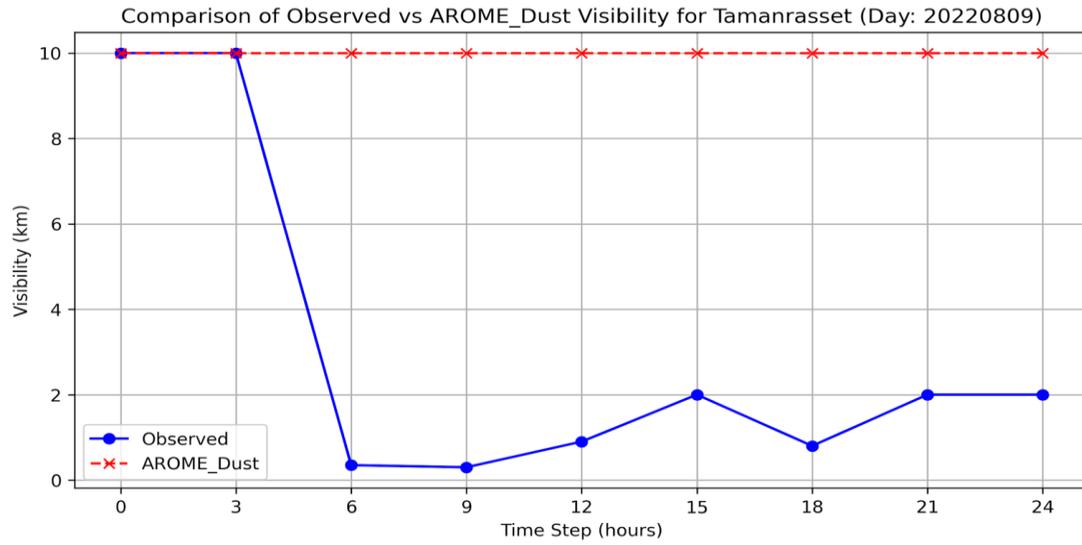


Fig. Observed visibility vs AROME_Dust visibility for Tamanrasset



Feedback after 10 years of using Aladin_Dust

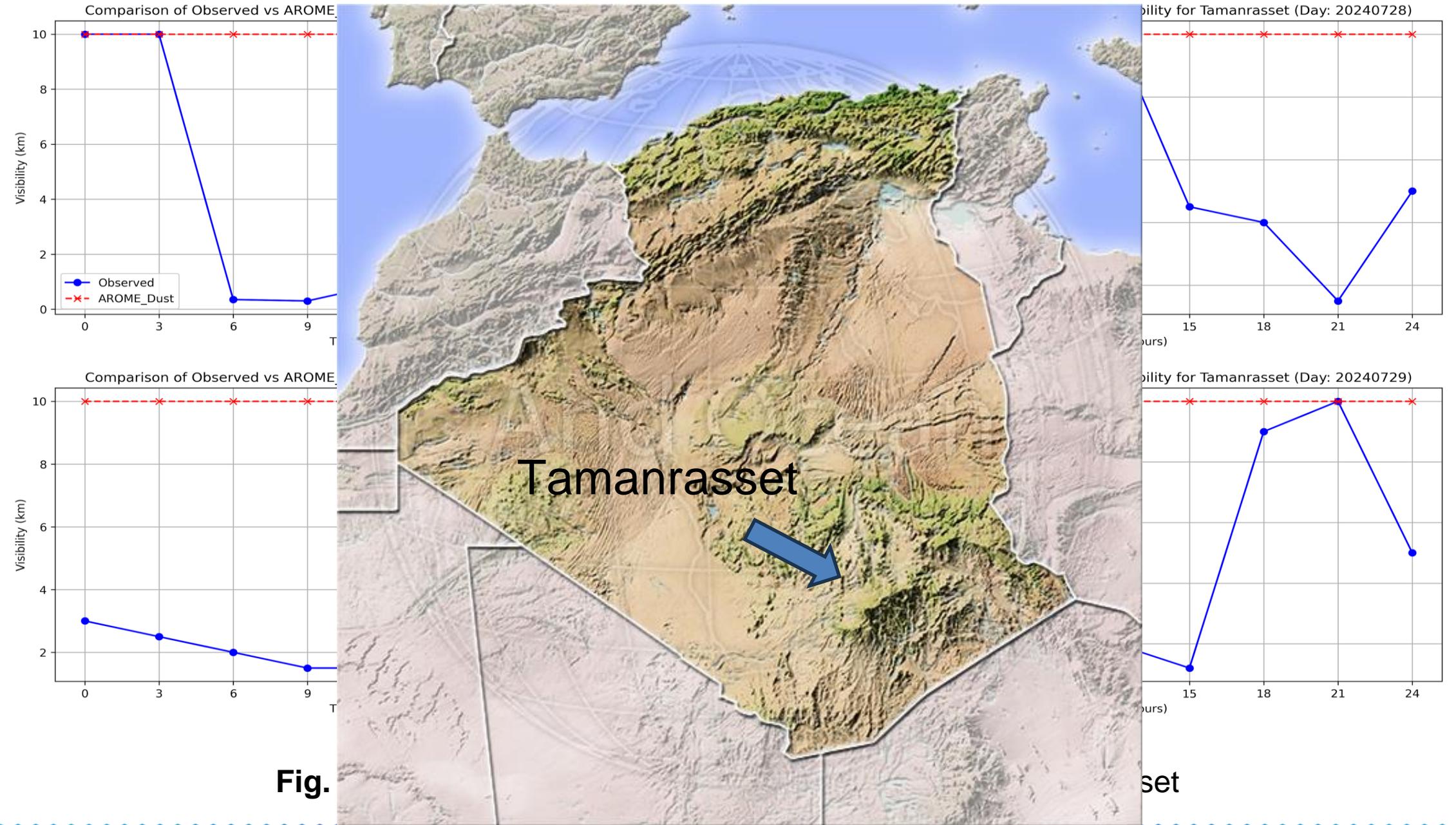


Fig.

set

Modeling the Atmospheric Cycle of Desert Dust

➤ Emissions

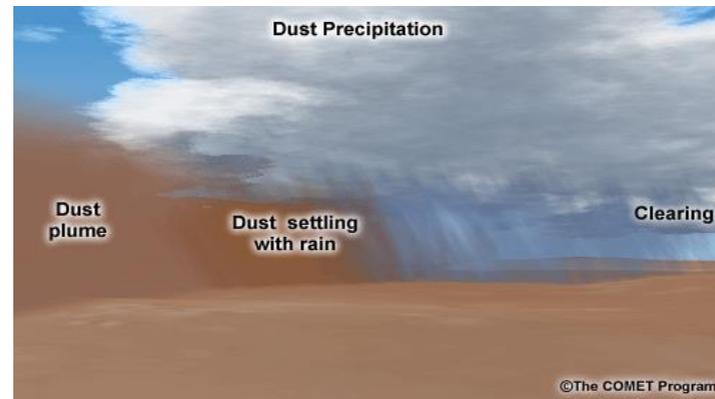
- ✓ friction velocity
- ✓ surface characteristics
- ✓ soil conditions

➤ Transport

- ✓ wind and turbulence

➤ Deposition:

- ✓ wet deposition
- ✓ Dry deposition



Movie from the COMET program at <http://meted.ucar.edu/> of the University Corporation for Atmospheric Research (UCAR)

Modeling the Atmospheric Cycle of Desert Dust

Equation of the concentration :

$$\frac{\partial C_k}{\partial t} = -u \frac{\partial C_k}{\partial x} - v \frac{\partial C_k}{\partial y} - w \frac{\partial C_k}{\partial z} - \nabla(K_H \nabla C_k) - \frac{\partial(K_Z \partial C_k / \partial z)}{\partial z} + \left(\frac{\partial C_k}{\partial t} \right)_{source} - \left(\frac{\partial C_k}{\partial t} \right)_{puits}$$

The diagram shows the concentration equation with six terms in boxes. Orange arrows point from labels below to each term:

- Horizontal advection** points to $-u \frac{\partial C_k}{\partial x} - v \frac{\partial C_k}{\partial y}$
- Vertical advection** points to $-w \frac{\partial C_k}{\partial z}$
- Horizontal diffusion** points to $-\nabla(K_H \nabla C_k)$
- Vertical diffusion** points to $-\frac{\partial(K_Z \partial C_k / \partial z)}{\partial z}$
- Source (emission)** points to $+\left(\frac{\partial C_k}{\partial t} \right)_{source}$
- Dry and wet deposition** points to $-\left(\frac{\partial C_k}{\partial t} \right)_{puits}$

Modeling the Atmospheric Cycle of Desert Dust

The surface fluxes is calculated through the DEAD scheme (Dust Entrainment And Deposition) (Zender et al.2003)

DEAD is called in surfex for the Cover004 and the Cover005 related to bare and rocky soils respectively

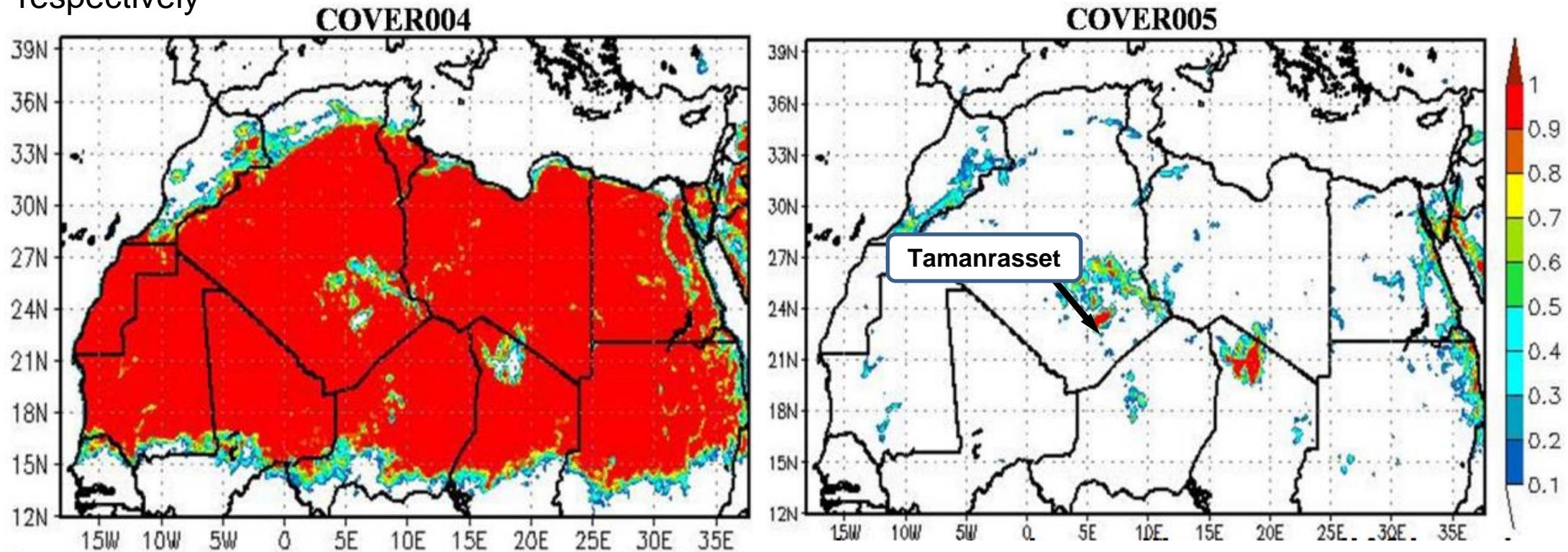
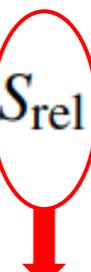


Fig. Maps of cover004 and cover005 related, respectively, to smooth bare soils (cover004) and rocky soils (cover005).

Improving Forecasts: The Tamanrasset Case

The total horizontal saltating mass flux G is calculated following MaB95: (Marticorena and Bergametti, 1995)

$$G = a.E.c.\frac{\rho}{g}.u_*^3 \left(1 + \frac{u_{*t}}{u_*}\right) \left(1 - \frac{u_{*t}^2}{u_*^2}\right) \int_{D_{bin}} dS_{rel}(D_{bin}) dD_{bin}$$


Default Particules intensity factor in AROME_Dust	
caly size $D_p < 2 \mu\text{m}$	0.005
small silt size $2 \mu\text{m} < D_p < 10 \mu\text{m}$	0.006
large silt size $10 \mu\text{m} < D_p < 60 \mu\text{m}$	0.1
sand size $D_p > 60 \mu\text{m}$	0.10

Tab. Default Particules intensity factor in AROME_Dust

Modeling the Atmospheric Cycle of Desert Dust

The total dust source emission

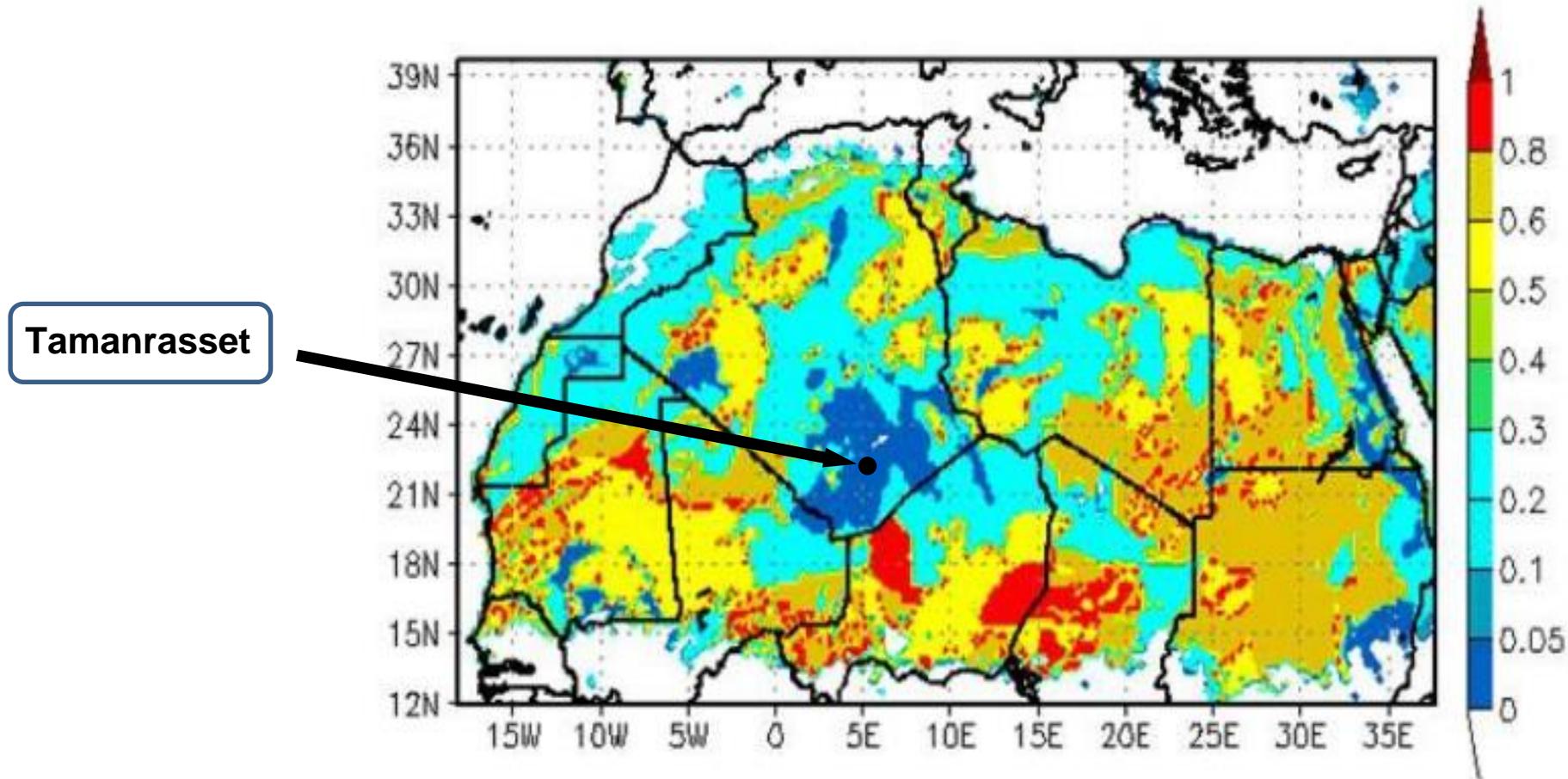


Fig. Total average relative surface for the four populations of particles over northern Africa (Mokhtari et al. 2012)

AROME Dust Configuration over the Sahara

AROME Dust:

Research & Development Configuration

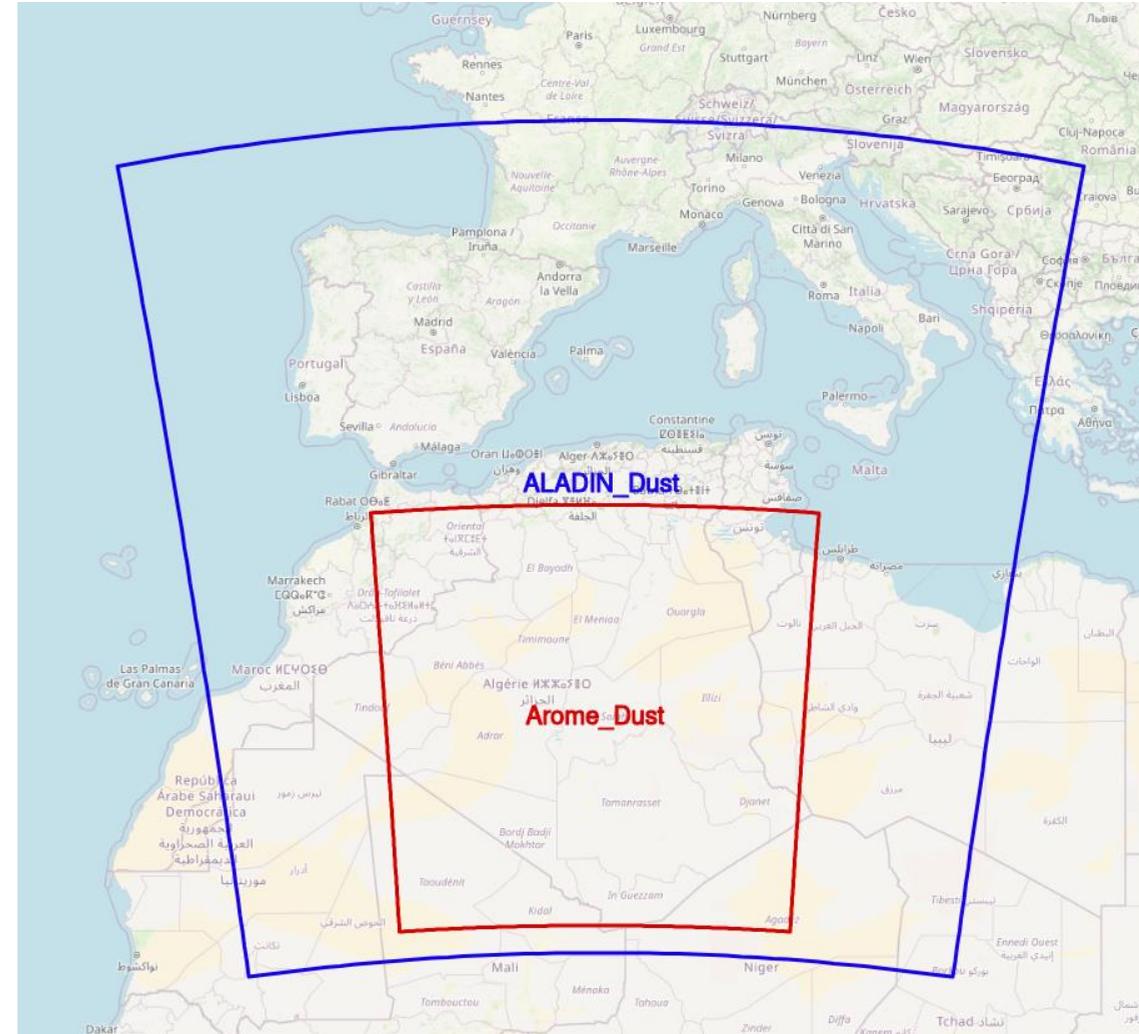
Resolution **2.5 km**

Grid **621*521**

Levels **41 Levels**

Forecast range **48h**

Coupling and initialisation **ALADIN_Dust(14km)**



Sensitivity Tests: The Tamanrasset Case

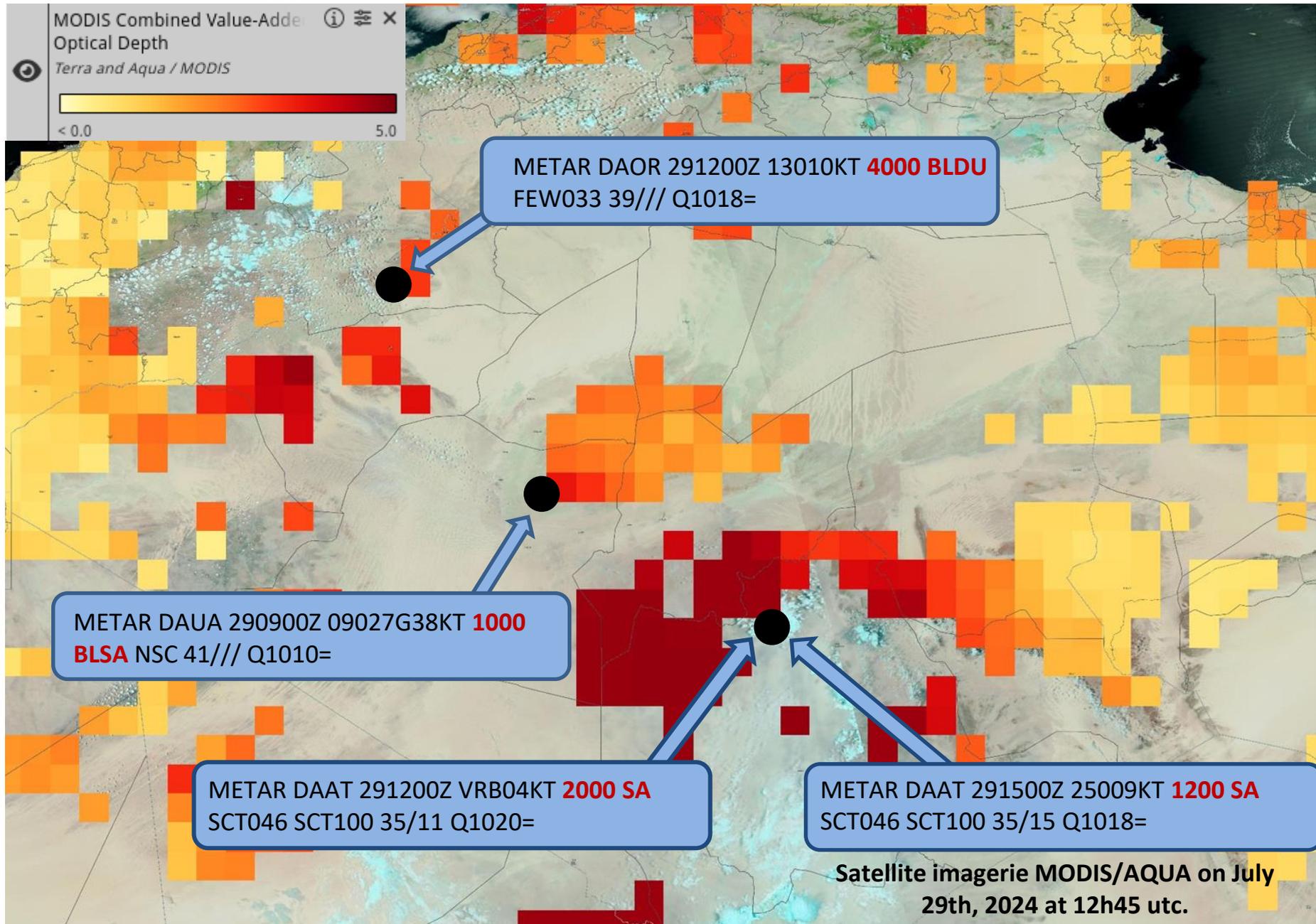
We performed four distinct sensitivity tests by varying the particles intensity factors randomly, as shown in the table.

By altering these factors, we were able to observe how each test influenced the model's accuracy in predicting dust concentration/visibility.

Exp		Mod	Mod2	Mod3	Mod4
Particules intensity factors	caly size	1	0.5	0.5	0.5
	small silt	1	0.6	0.5	0.5
	large silt size	1	0.1	0.5	1
	sand size	1	0.105	0.5	1

Tab. Table of modifications made in AROME_Dust

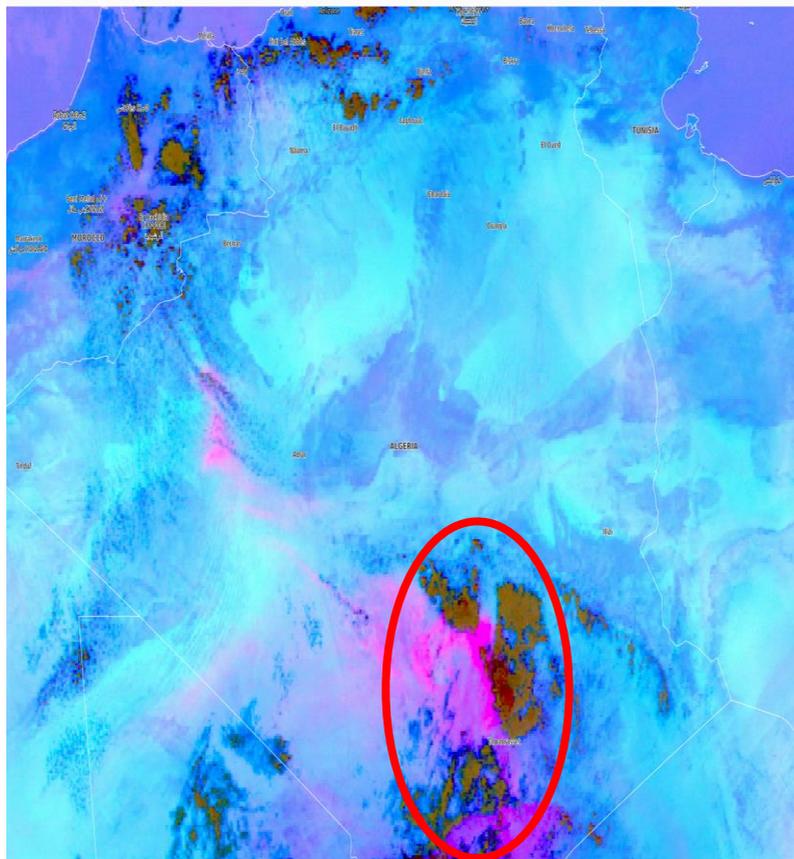
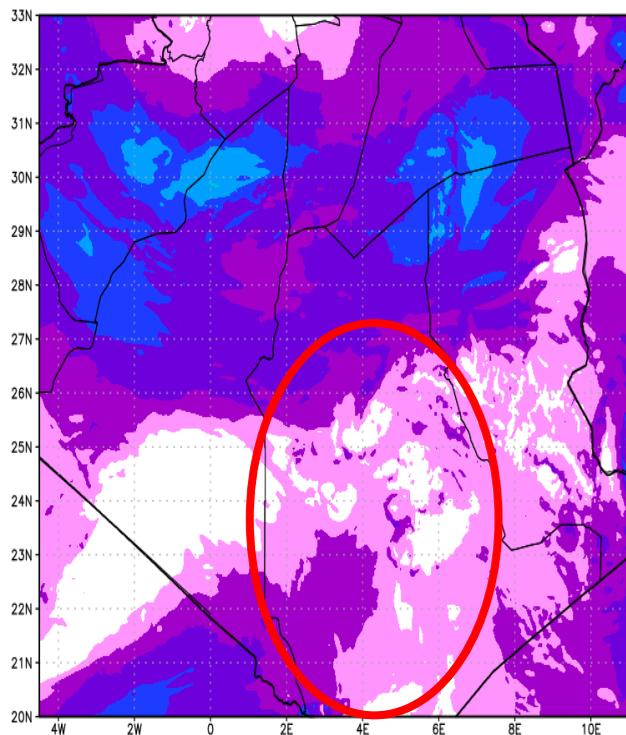
Sensitivity Tests: The Tamanrasset Case



Sensitivity Tests: The Tamanrasset Case

Dust Concentration 29 July 2024 at 15h

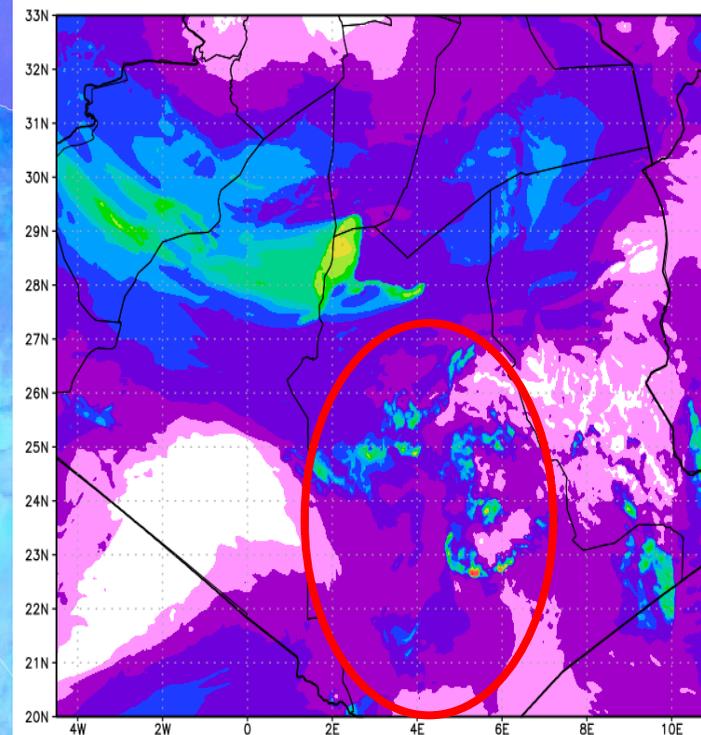
Dust concentration (mg/m³) en 03h
(ech 39h) Base: 28/JUL/24 00z
Valid: 29/JUL/24 15z



EUMETSAT 气象行 Japan Meteorological Agency

2024-07-29 15:00:00 UTC

Dust concentration (mg/m³) en 03h
(ech 39h) Base: 28/JUL/24 00z
Valid: 29/JUL/24 15z



Arome Dust/Algerie (en mg)
0.05 0.1 0.2 0.4 0.6 0.8 1 1.5 2 2.5 3 4 5 10 20

AROME Dust (Control)

Image Sat MSG-SEVIRI

AROME Dust "Mod"

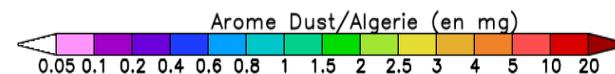
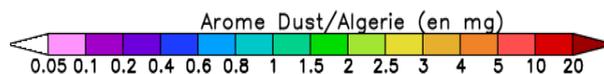
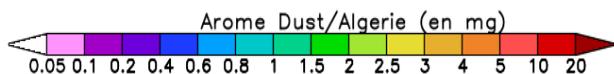
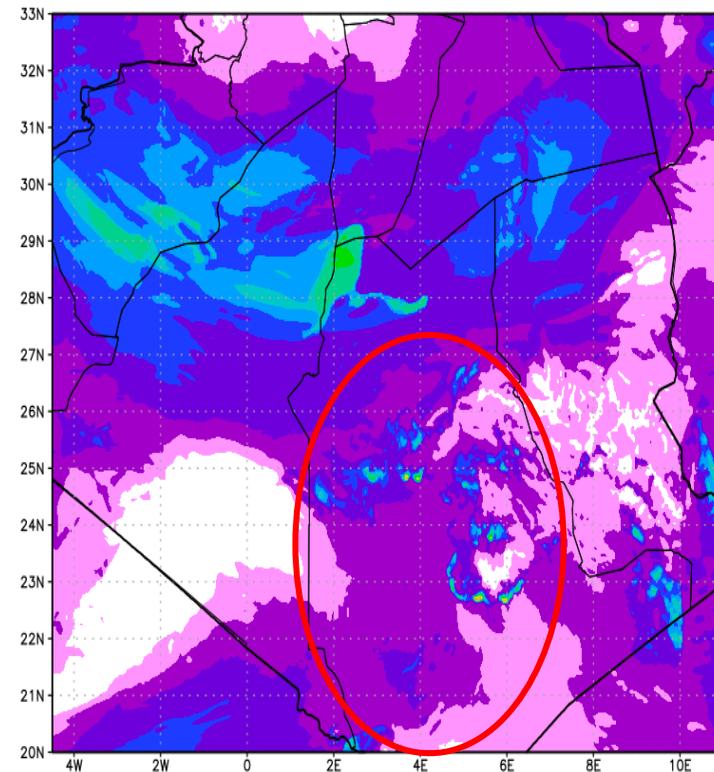
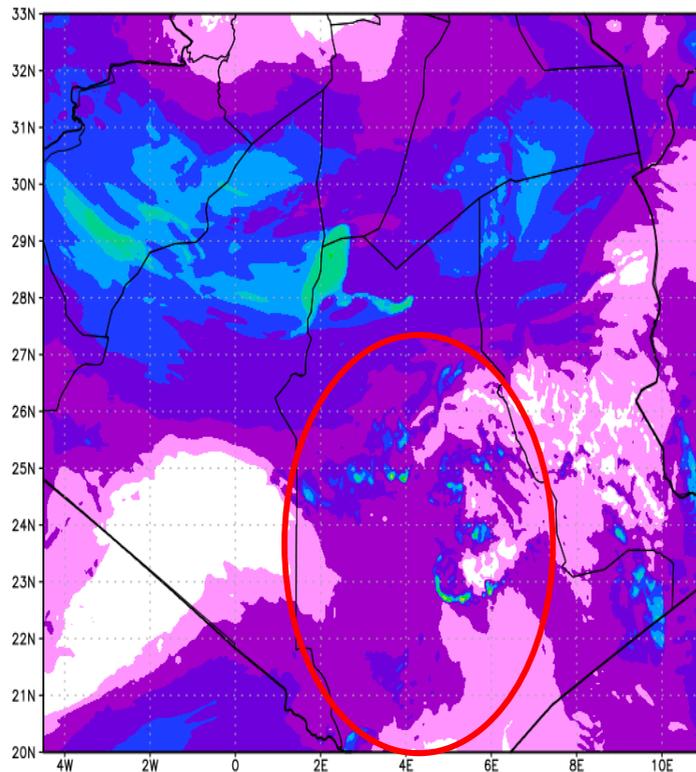
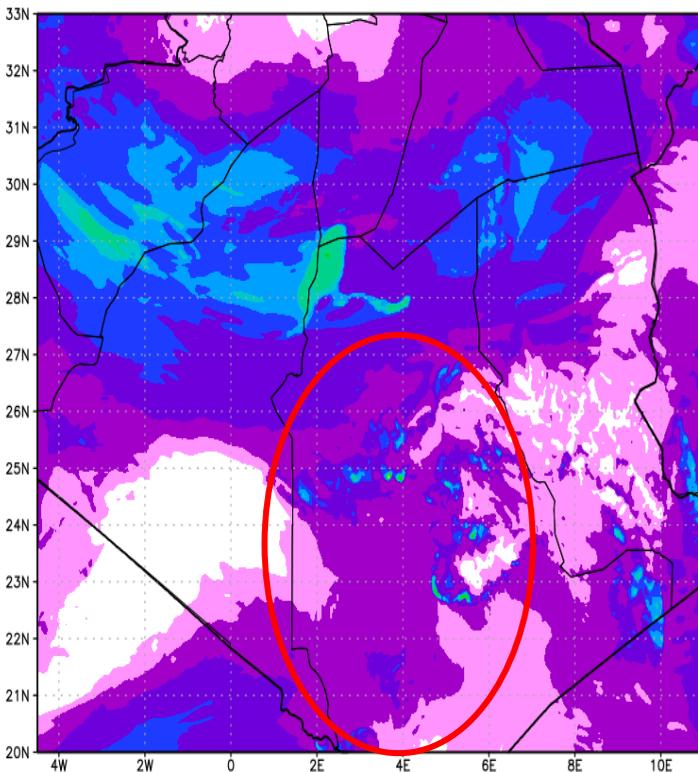
Sensitivity Tests: The Tamanrasset Case

Dust Concentration 29 July 2024 at 15h

Dust concentration (mg/m³) en 03h
(ech 39h)
Base: 28/JUL/24 00z
Valid: 29/JUL/24 15z

Dust concentration (mg/m³) en 03h
(ech 39h)
Base: 28/JUL/24 00z
Valid: 29/JUL/24 15z

Dust concentration (mg/m³) en 03h
(ech 39h)
Base: 28/JUL/24 00z
Valid: 29/JUL/24 15z



AROME_Dust (Mod2)

AROME_Dust (Mod3)

AROME_Dust (Mod4)

Sensitivity Tests: The Tamanrasset Case

Visibility in Km 29 July 2024 à 15h

Visibilité en km
(ech 39h)

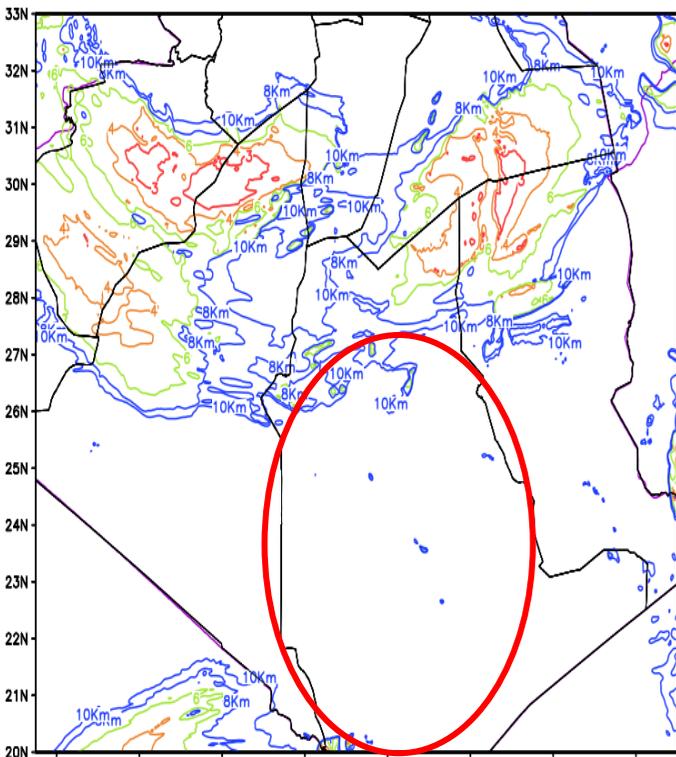
Base: 28/JUL/24 00z
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Visibilité en km
(ech 39h)

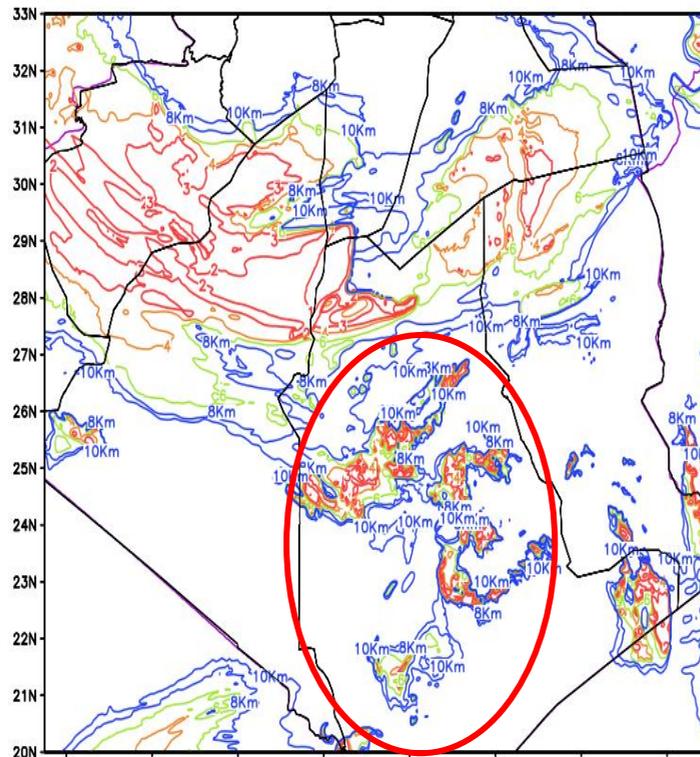
Base: 28/JUL/24 00z
Valid: 29/JUL/24 15z

Visibilité en km
(ech 39h)

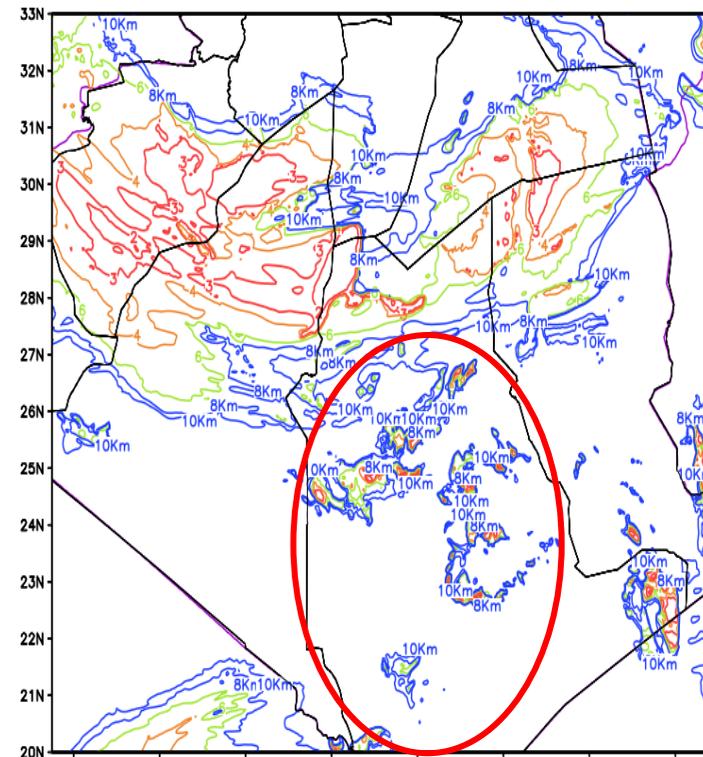
Base: 28/JUL/24 00z
Valid: 29/JUL/24 15z



Arome_Dust/Algerie



Arome_Dust/Algerie



Arome_Dust/Algerie

AROME_Dust (Control)

AROME_Dust (Mod)

AROME_Dust (Mod2)

Sensitivity Tests: The Tamanrasset Case

Comparison between observed visibilities and those simulated by AROME Dust and AROME Dust with modifications at the Sahara stations on July 29, 2024.

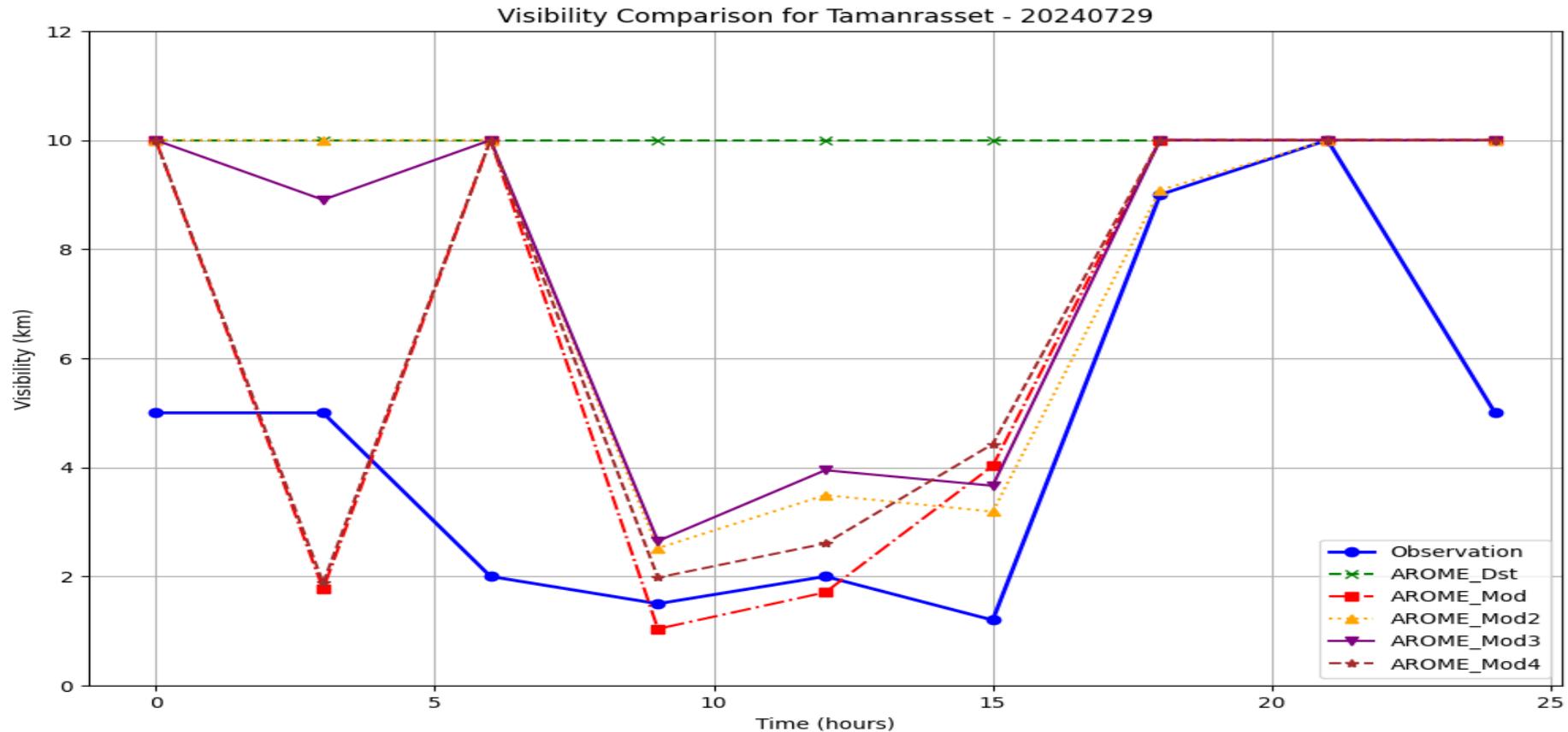
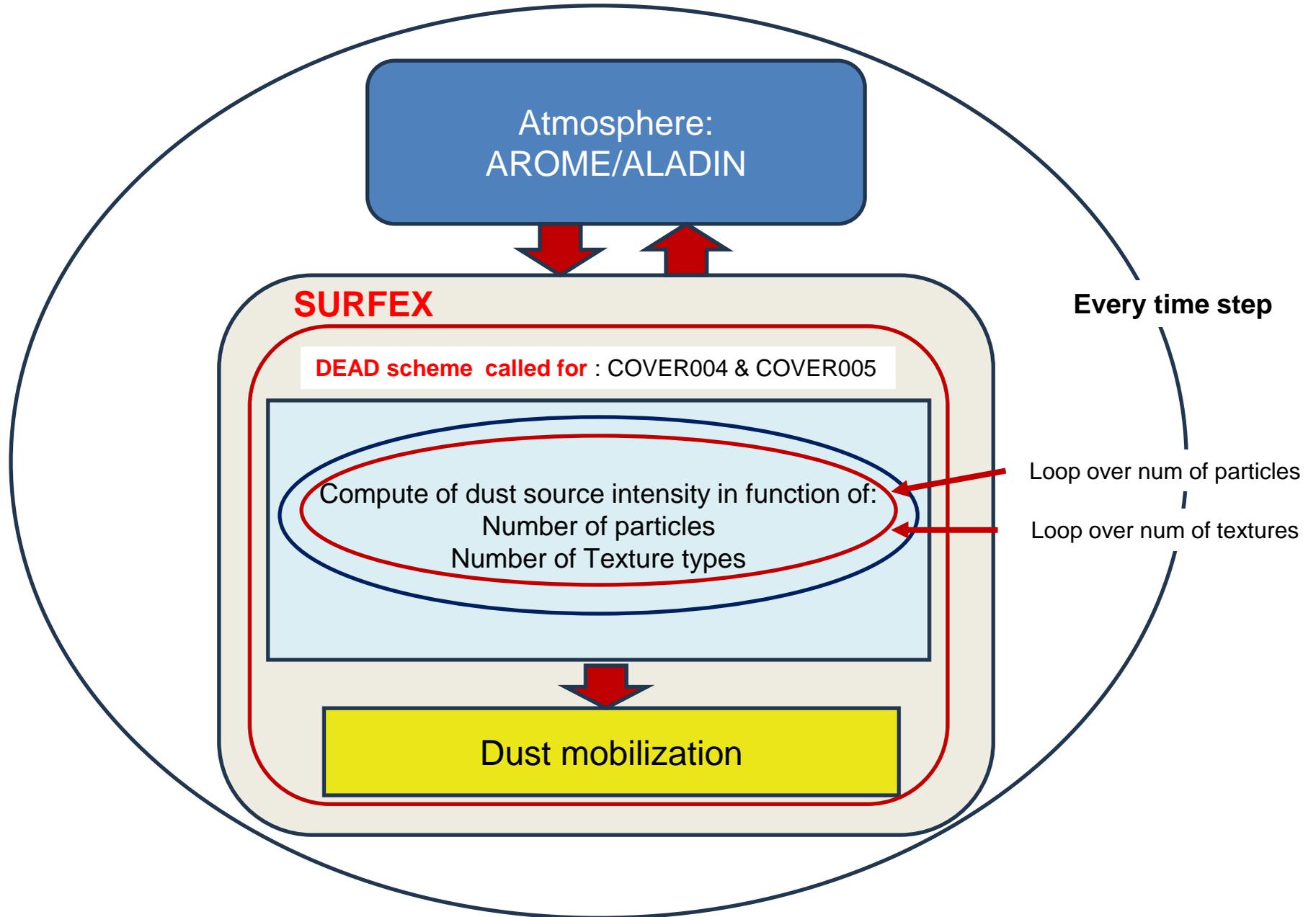


Fig. Comparison plot between obs and simulated visibility by AROME Dust

Perspectives



Atmosphere:
AROME/ALADIN

SURFEX

DEAD scheme called for : COVER004 & COVER005

Compute of dust source intensity in function of:
Number of particles
Number of Texture types

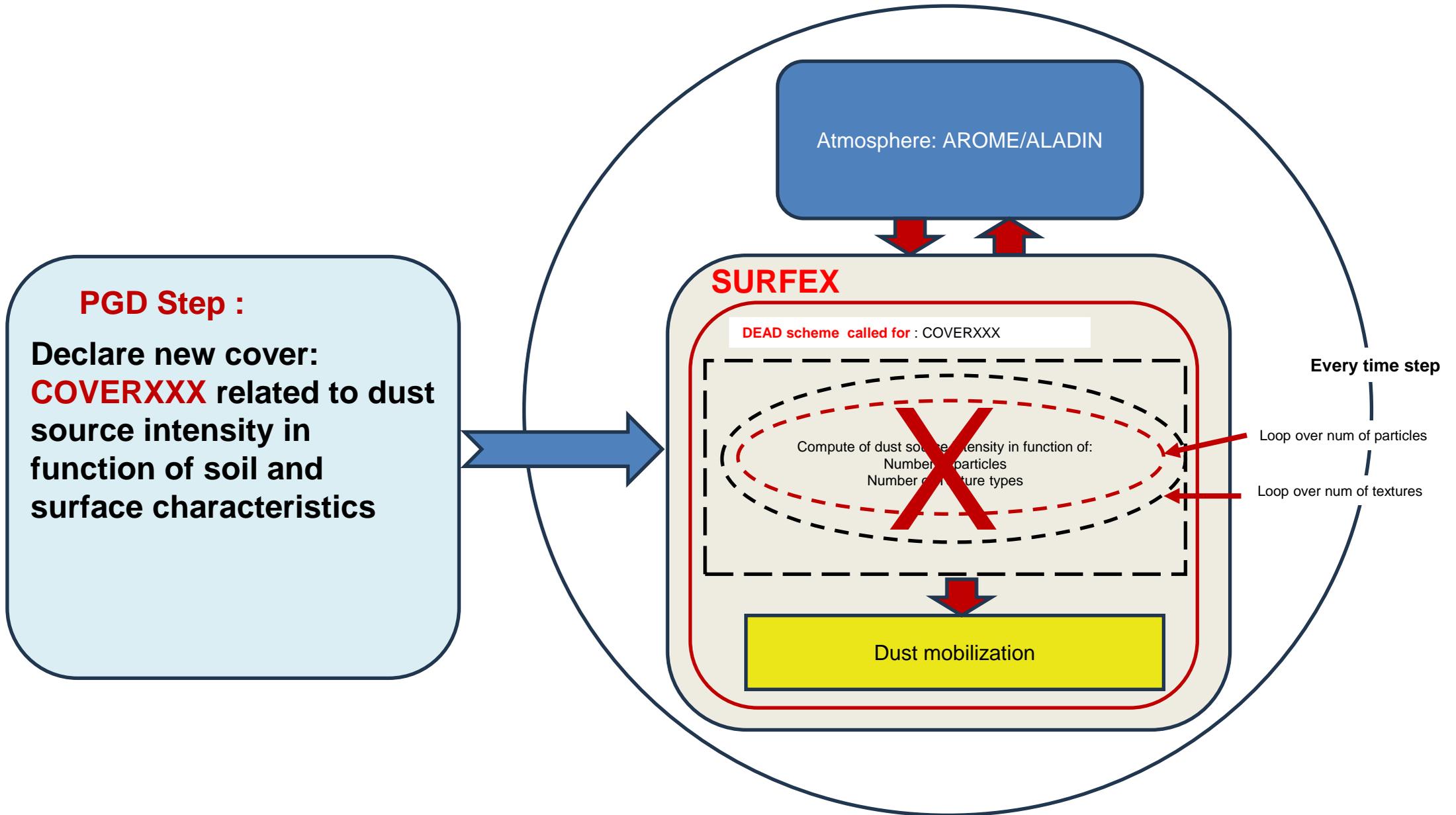
Dust mobilization

Every time step

Loop over num of particles

Loop over num of textures

Perspectives



Thank you for your attention

