Evaluation of visibility with LIMA

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ABSTRACT :

This study presents the incorporation of the double moment LIMA scheme into visibility calculations for foggy conditions, in addition to the existing acvisih scheme in AROME. Traditional visibility calculations rely on the Koschmieder formula, but research by Gultepe et al. (2007) suggests that considering both liquid water content (*LWC*) and droplet number concentration (N_d) can enhance visibility predictions. By utilizing the LIMA scheme and advancements in microphysical modeling, significant improvements in visibility forecasting, especially for warm fog, can be achieved.

To assess this contribution, a selected fog event occurring between January 1st and January 3rd, 2022, is examined. This event was characterized by exceptional and persistent fog along the coastal regions from the Northwest to the North-central areas of Algeria.

1. Background & Motivation

AROME with ICE3 successfully forecasts low cloud fog, as demonstrated in a study published in the ACCORD Newsletter No.1.[(1)] :

Tab. 01: Scores of AROME With ICE3

	AROME 0.5	AROME 1.3
	All period	
PC	77,29	79,02
POD	0,53	0,47
FAR	0,55	0,54
	December	
PC	79,55	81,19
POD	0,38	0,29
FAR	0,64	0,65
	May	
PC	72,43	74,35
POD	0,71	0,69
FAR	0,46	0,44

However, there's potential to enhance its accuracy. This research explores the LIMA scheme, which considers both liquid water content and concentration. Current methods based on the Koschmieder formula have limitations. Previous research (Gultepe et al , 2007)[(2)]. suggests that including both LWC (Liquid Water Content) and N_d (Droplet number concentration) can significantly improve visibility predictions up to 20 –50% , especially for warm fog :

$$vis = \frac{1{,}13}{(Nd * LWC)^{0.51}} \quad \cdots\cdots\cdots \quad 01)$$

2. AROME Configurations & Pre-Processing

Tab.02: AROME Characteristics

Characteristics	AROME	
Cycle	CY48T1	
Initial conditions	ARPÉGE	
Coupling frequency	3H	
Horizontal resolution	1.3 km	
levels	90 levels	
First level from ground	5 meters	
Time-step	45 s	
Grid	C+I	720 x 440
	C+I+E	740 x 480

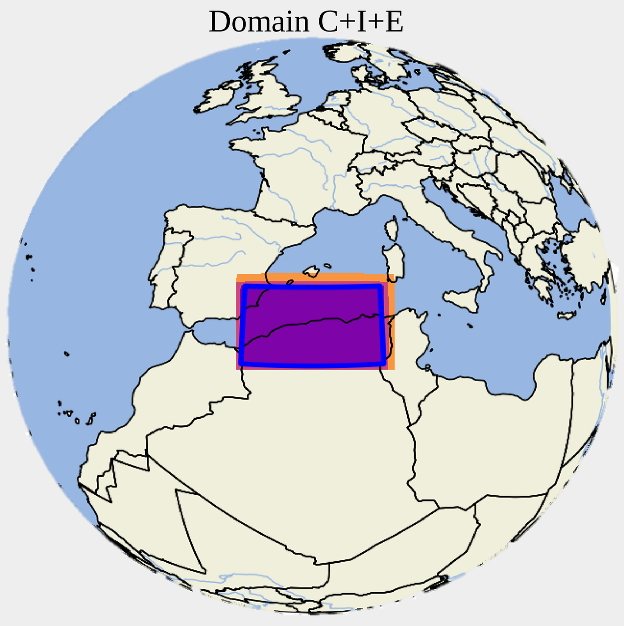

Fig .1: AROME Domain

- Three distinct configurations were prepared for the purpose of comparison :

1. **AROME_ICE3 :** No Aerosols Initialization + ICE3 Scheme + Default formula .
2. **AROME_LIMA :** No Aerosols Initialization + LIMA scheme + Default formula
3. **AROME_INIT :** Aerosols Initialization using CAMS + LIMA scheme + New Formula (01)

- From CAMS , we **identify 11 types of aerosols** that can be grouped into **five major modes between CCN and IFN**. (The characteristics of each group have been extracted from old works of: Y.Seity, B.Vié , D.Martin , and M.Mokhtari) :

Cams Aerosols	LIMA Name	Rho	md	sigma
Sea Salt {0,03-20} um	CCN_F1	2160	0,8	1,89
Sulphate	CCN_F2	2000	0,5	1,6
Hydrophobic Organic Matter	CCN_F3	1750	0,2	1,6
Hydrophobic Black Carbon				
Dust {0,03 – 20} um	IFN_F1	2300	0,8	1,9
Hydrophilic Organic Matter	IFN_F2	1700	0,2	1,6
Hydrophilic Black Carbon				

3. First Results

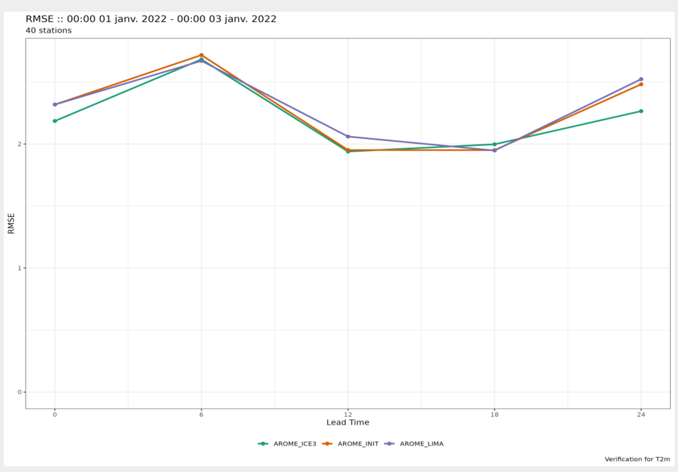

Fig. 2: RMSE T2m

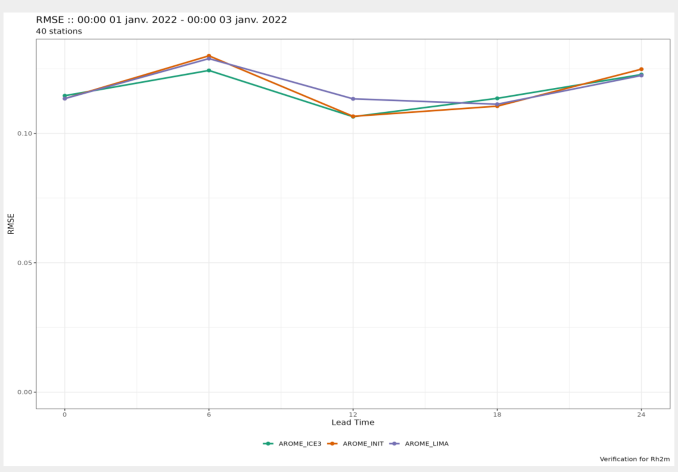

Fig. 3: RMSE Rh2m

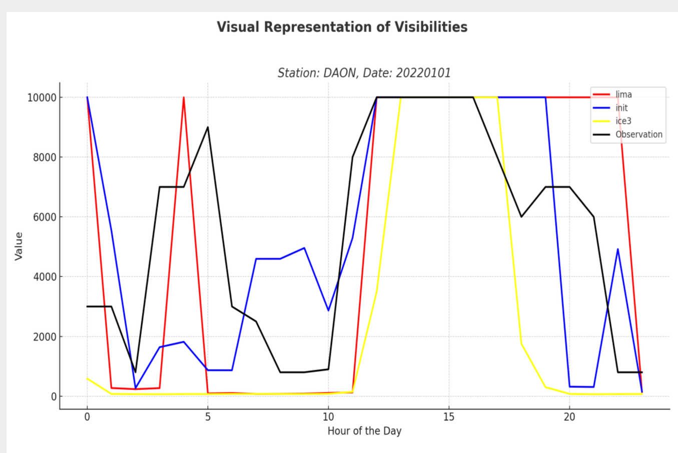

Fig. 4: Representation of Vis with 3 configurations

Tab. 03 Contingency tables

Category	Visibility
Very Bad	< 1000 m
Bad	[1000m–5000m[
Good	> 5000 m

AROME_LIMA

Observations	Good	Bad	V.Bad	Total
Good	14	0	0	*14*
Bad	42	0	20	*62*
V.Bad	37	0	31	*68*
Total	*93*	*0*	*51*	*144*

AROME_INIT

Observations	Good	Bad	V.Bad	Total
Good	22	1	0	*23*
Bad	46	6	5	*57*
V.Bad	35	13	16	*64*
Total	*103*	*20*	*21*	*144*

AROME_ICE3

Observations	Good	Bad	V.Bad	Total
Good	11	3	0	*14*
Bad	29	1	32	*62*
V.Bad	12	2	54	*68*
Total	*52*	*6*	*68*	*144*

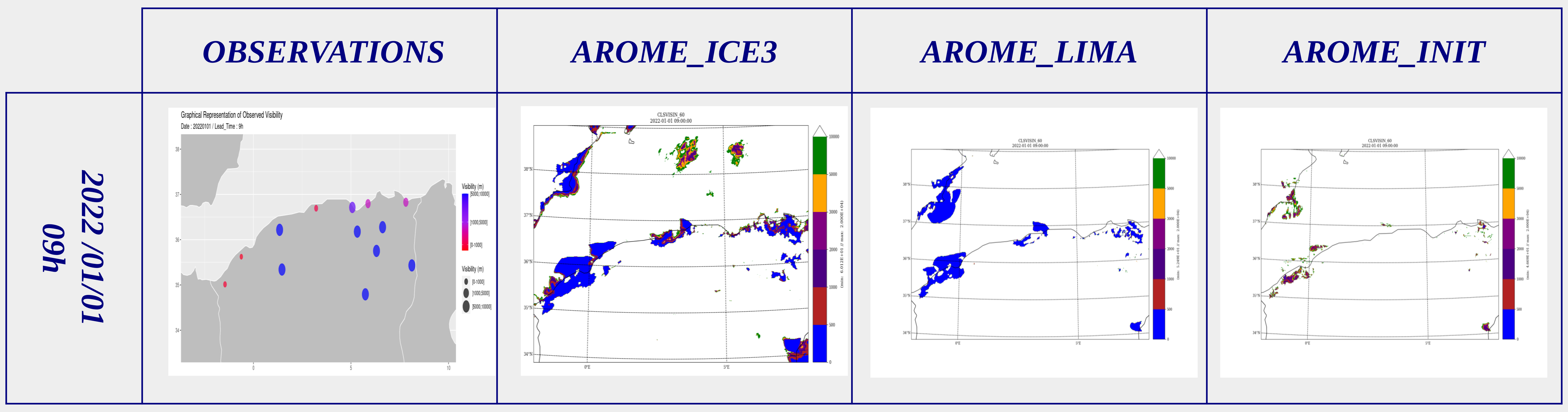

Fig. 5: Visual comparison of Visibility for the 3 configurations

4.Conclusions & Perspectives

The results for the selected scenario show :

- Visibility values lower at all forecast times compared to visibilities simulated by the ICE3 or LIMA schemes without aerosol initialization.
- Despite foggy conditions, the activated CCN remains low.
- The scores of T2m and Rh2m for the LIMA_INIT configuration demonstrates a fluctuation and even behavior similar to the other two configurations.

Further work is planned :

- Extended the validation period and over different seasons, including LWC, T2m, Rh2m and visibilities.
- Investigate physical processes in the LIMA to improve fog forecasting.
- Implement direct LWC calculated by the LIMA scheme.

References

1. CHIKHI,W et al ; (2021) . Testing visibility diagnostics in AROME at high resolution , ACCORD Newsletter N°1 .
2. Gultepe, I., & Milbrandt, J. A. (2007). Microphysical Observations and Mesoscale Model Simulation of a Warm Fog Case during FRAM Project. Pure and Applied Geophysics.

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