First tests with AROME 1.3 km: technical note and scale effect on the short term rainfall forecast.

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Abstract

AROME is a convective-scale numerical weather prediction system developed by Meteo France in close collaboration with national and international institutes so as to benefit from the latest research in atmospheric modeling. Today, this system is used by some fifteen countries already, for both operational and research purpose. This short paper aims to (i) define some technical notes about the AROME system and its operational use at Météo Algérie in Algeria, (ii) explain the scientific and the technical approach of reducing the horizontal resolution from $3.0\,\mathrm{km}$ to $1.3\,\mathrm{km}$, (iii) show the first results obtained by the new configuration AROME $1.3\,\mathrm{km}$ on a small domain (North-center) and compare it to the operational configuration AROME $3.0\,\mathrm{km}$.

Keywords:

AROME — Convective Event — High-Resolution Model

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1. Introduction

The AROME forecasting system (Seity et al. (2011)) is a blend of the best components from the Méso-NH model, the ALADIN model, and the IFS/Arpège data assimilation software (Bouttier and Roulet (2008)). AROME is a convective-scale numerical weather prediction system developed by Meteo France, its physical parameterizations comes mostly from the research Meso-NH model whereas the dynamic core is the Non-Hydrostatic ALADIN one.

AROME has been running operationally at Météo Algérie since February 2014, one year after the acquisition of a new HPC system. The current configuration of AROME Algeria covers only the Northern part of the country with an horizontal resolution of $3.0\,\mathrm{km}$. This area restriction is caused by the high computational costs needed to run the model over the full domain. This did not prevent us to prepare a configuration covering the whole country (Ambar and Mokhtari (2016)) in the soon perspective to acquire a new HPC system with more resources (the procedure of purchase is in progress). The results obtained by fine mesh model AROME are quite encouraging; it has improve notably the very localized phenomena forecasts, especially in convective situations, for forecasts ranging from 3 hours to 48 hours, compared to ones of the ALADIN model with $8.0\,\mathrm{km}$ horizontal resolution. Thereby, improving the resolution of the AROME model from $3.0\,\mathrm{km}$ et $1.3\,\mathrm{km}$ is one of the priorities for the NWP service at the Meteo Algérie. The main objective is to allow forecasters to progress in the anticipation and localization of severe weather phenomena. The challenges are multiple: the safety of people and property when it comes to alerting the public authorities and the population on the arrival of a major weather risk, the economic prevention when a company needs very fine meteorological information to organize its activities.

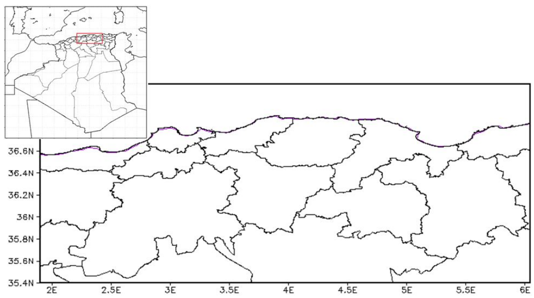

Figure 1. New configuration AROME-$1.3\,\mathrm{km}$ domain.

2. Scientific and technical approach

It uses a non-hydrostatic dynamical core that was developed by Bénard et al. (2010). Physical parameterizations of the model are inherited from the French research community model Meso-NH (Lafore et al. (1997)) whereas the dynamic part is an adaptation for the fine scale of the ALADIN dynamic.

It uses the so-called ICE3 scheme for microphysics (Pinty and Jabouille (1998)) with five prognostic hydrometeor types (cloud water, cloud ice, rain, snow, and graupel) and a 1D prognostic TKE scheme based on Cuxart et al. (2000). Deep convection is assumed to be explicitly resolved by the model's dynamics. The shallow convection requires a parameterization of subgrid effect for which the Pergaud et al. (2009) (hereafter PMMC09) scheme is used. The surface scheme employs the three-layer "Surface Externalized" (SURFEX, Masson and Seity (2009)).

The AROME model implemented operationally at Meteo Algérie is running on a $3.0\,\mathrm{km}$ horizontal grid resolution using 60 levels in the vertical. The model is run two times per day up to lead time of $48\,\mathrm{h}$. The lateral boundary conditions are provided by the ALADIN model ($8.0\,\mathrm{km}$), running locally in ALGERIA.

In order to set up an AROME-$1.3\,\mathrm{km}$ configuration, first of all we have prepared the CLIM files on a small domain that covers only the north-central part of the country (figure-1).

The choice of this area was made to meet the needs of a Master topic focused on intense precipitations over North-central Algeria. The prepared domain is characterized by a field that contains 500×500 points (further details in the table 1) .

Table 1. New configuration AROME-1.3 km characteristics.

Model	AROME
Cycle	43T2
Resolution	1.3 km
Levels	60
Grid	500×500
Area	[35.4 °N – 37.2 °N] [1.8 °W – 6.1 °E]
Initial/Boundaries conditions	ALADIN
Starting time	0 h
Cycle interval	1 h

3. Test case : January, 23rd and 24th 2017

We have performed two simulations using the operational configuration AROME 3.0 km (figure-2) and the new configuration AROME 1.3 km (figure-3), in order to predict the 24 hours total precipitations for January 23rd and 24th, 2017. The choice of this situation was made based on its high convective activity which can be taken as a typical case study for the convective scale of the AROME model. Also, this situation has caused considerable human damage, with 6 deaths during the whole episode (DGPC report, 2017).

First of all, the comparison between the results obtained by the two configurations showed the ability of the AROME model to predict severe rainstorm situations like the chosen one (23rd, 24th January). The model predicts the triggering of the situation on the North-central region of the country for January 23rd, and then its intensification during the next 24 hours. However, the results obtained by AROME 1.3 km gave more accuracy and more details on rainfall amounts and spatial distributions.

During January, 23rd, we note that AROME 3.0 km does not provide significant precipitations amounts in the region of Boumerdes and Blida, while AROME 1.3 km gave amounts that exceeded 30 mm in 24 h for those two regions, which are closer to the observations (60 mm and 40 mm in 24 hours were recorded on Boumerdes and Blida respectively based on ANRH network).

For January, 24th, the intensification of the situation could be seen for both configurations, but it is more accurate on the fields provided by AROME 1.3 km , especially in the region of Tizi Ouzou. Indeed, the red color on the map (which means rainfall above 80mm) obtained by AROME 3.0 km, covers almost all the Kabylie region while the observations recorded less than 40 mm. On the other side, AROME 1.3 km gave more realistic amounts with less than 60 mm in this region. For the other regions, we note that AROME 1.3 km overestimated the rains amounts in Bejaia with amounts that exceed 50mm/24h, whereas in reality this region had not recorded more than 10mm/24h. Even though the AROME 1.3 km configuration follows the trend of the operational configuration, either by overestimating or underestimating the rainfall amounts, it reduces the error margin by giving only 28mm / 24h.

During this extreme situation, we notice that AROME, with its two configurations (3.0 km and 1.3 km), follow the same trend as the observations. However, the comparison between the two configurations reveals that AROME 1.3 km reduces notably the error between simulated and observed precipitations compared to AROME 3.0 km .

Switching from the 3.0 km configuration to the one of 1.3 km has improved the rainfall prediction and has allowed a better geographical localisation of the extreme values.

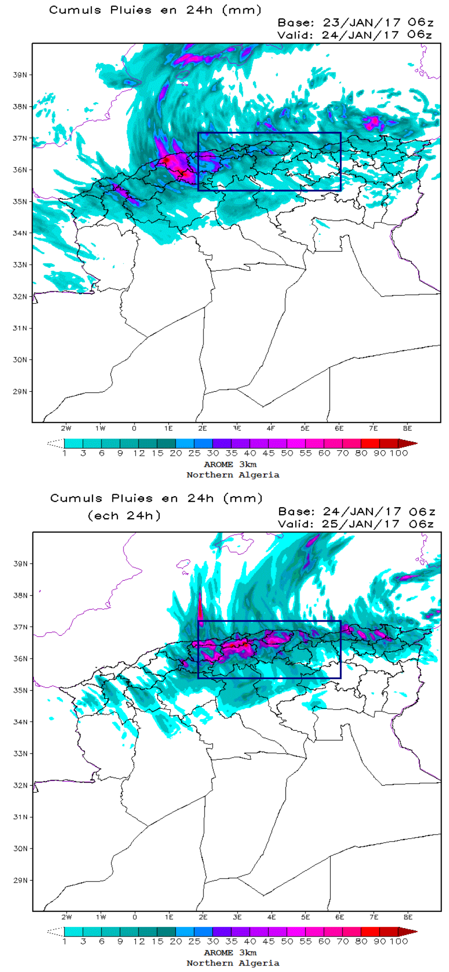

Figure 2. 24h total rainfall predicted by AROME 3.0 km on January, 23rd and 24th 2018

4. Conclusion

This work aimed to show the relative benefit of reducing the horizontal resolution of the convective scale model AROME, particularly in case of heavy rain situations. Indeed, going from 3.0 km to 1.3 km of horizontal resolution in AROME allowed a better physical realism, which can be mainly attributed to its mesoscale physics-dynamics at fine scale. AROME 1.3 km seems to be more accurate than AROME 3.0 km in predicting precipitation caused by convective processes. Nevertheless, this first version needs to be improved, especially by doing sensitivity tests on the impact of the physical parameterization at fine scale, trying to ensure a better numerical stability for long time steps (it caused crashes in a few cases) and maybe introducing some observations in its data assimilation cycle.

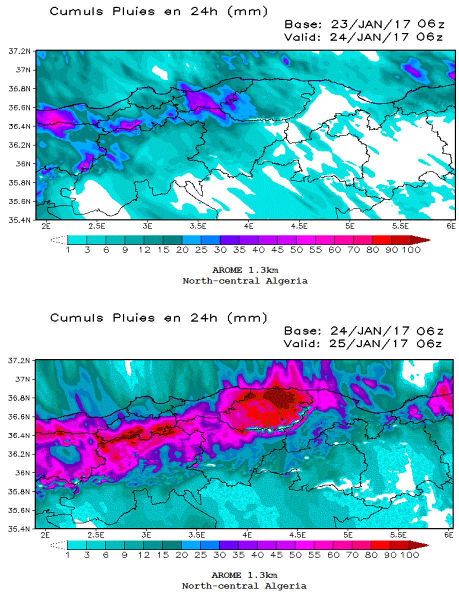

Figure 3. 24h total rainfall predicted by AROME 1.3 km on January, 23rd and 24th 2018.

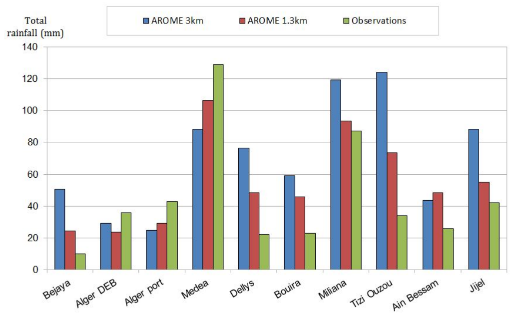

Figure 4. 48h total rainfall predicted by AROME 3.0 km in blue, by AROME 1.3 km in red and recorded (in green) on January, 23rd and 24th 2018, at different stations of the North-central Algeria.

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