Desert dust modeling in AROME: Contribution of physical parametrization at convective scale.

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ABSTRACT

This study is dedicated to the modeling of desert dust in the convective scale model AROME (Application of Research to Operational at Mesoscale) coupleled with the ALADIN model (Aire Limité Adaptation dynamique International) operational at Algerian meteorological office. For this purpose, we carried out simulations with AROME Dust model (resolution of 3km and 60 level) in order to investigate the contribution of the physical parameters of this model to the quality of desert dust cycle prediction. The selected dust event corresponds to the one which occurred on 1st April 2017. It was marked by a sandstorm of an exceptional intensity which affected several localities in the Southern Algeria, sweeping in particular the departments of Ouargla, Ghadaria and Tamanrasset. North-South traffic and vice versa were paralyzed due to sand deposition over the roadway at several locations.

1. Desert dust prediction in Algeria

The interest of modeling the cycle of desert aerosols in Algeria is important because the Sahara covers more than 75% of the country’s surface area. This interest is reinforced by the fact that desert dust has a direct impact on the environment, the economy and public health.

Since February 2014, the prediction of atmospheric cycle desert dust at the ONM (Office National de la Météorologie – ALGERIA) is based on the operational model ALADIN_Dust with 14 km of horizontal resolution (Mokhtari et al., 2012). An AROME_Dust configuration based on cycle 40 was updated (Mokhtari and A.Alharthi, 2016) in order to investigate the contribution of physical scheme impled in the convective-scale model AROME. We carried out meteorological simulations of a particular event (sandstorm in southern Algeria, 1st April 2016). AROME_Dust outputs are compared with those of ALADIN_Dust (operational) and with observations.

2. AROME model and dust Modules

The AROME convective scale model (Seyfi et al., 2011) is operational at the National Center of Meteorological Forecasts (Algeria) since April 2014, covering the northern part of the country (Latitude: 29°N-40°N, Longitude: 3°W-9°E). An AROME covering all the country was configured basing on cycle 40 in order to simulate dust aerosol cycle (Tab 1).

Physical parametrizations of the model are inherited from the Mesoscale models dynamique (MODEX) model (Grini et al., 2006). The transport, deposition and leaching processes are managed by the ORIUM dust deposition (Grini et al., 2005).

Initially, desert dust modules were activated in the AROME configuration (cycle 36 and 38) (Mokhtari et al., 2012, Mokhtari et al., 2015) and AROME (cycle 33) (Koiba, 2011) in order to provide predictions of dust events during the FEMENI project (Chabaneu et al., 2016). For more technical details about the activation of dust modules in AROME, see the following link: http://www.antwerp.in/tulet/AROME-perspectives/AROME_Dust/southernAlgeria.htm.

Since we don’t have measurements of dust concentrations, we applied an empirical equation (1) relating desert dust concentrations and horizontal visibility (Bertrand, 1976). We can then use observations of the visibility available on various meteorological stations in Algerian Sahara and compare it to the model outputs.

\[ V = \frac{C}{10^3} \]

• Dust plume is well predicted by AROME_Dust (Fig 3) comparing to MOD-SEVIRI satellite images and to the operational model ALADIN_Dust, with a better consideration of extreme values.
• The net solar radiation at surface (Fig 4) decreases significantly during sand-spraying episodes.
• Temperature differences fields (at 2 meters) reveals that the presence of desert dust particles could reduce the temperature up to 7°C (Fig 5) during high sand-spraying events.
• The calculated visibility based on AROME concentration outputs is nearest to the observation comparing to that calculated based on ALADIN concentration outputs, but it remains overestimated. Generally speaking, the visibility prediction is well because it had the same fluctuation as the observation, with an exception for Tamanrasset station. Indeed, the Tamanrasset region is a very rocky area, while in reality it contains important dust deposit areas surrounding mountains including the Hoggar and Tassili, which can be subsequently reactivated by the wind.

3. Results and discussion

4. Conclusion

The physical scheme impled in AROME showed an important contribution by improving the cycle dust forecast in terms of horizontal visibility and dust concentration.

The convective scale model AROME (3km) compared to ALADIN_Dust (14km) allowed to better grasp the spatial extent of desert plumes and extreme values.

The presence of desert aerosols leads to a significant reduction in the Surface temperature (up to 5°C), and a radiative forcing which can reach 150W/m².

References

Bertrand, J.: The influence of sand storms on Algeria. La météorologie, VI, 6, 201-211, 1976.