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Seasonality comparison between simulated and measured wind field: case study of Tunisian arid areas

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ABSTRACT: *The absence of pre-established input meteorological database is one of constraint to apply modeling tools to simulate the desert emissions on a continental scale. Different meteorological models are used to provide the surface wind fields. The purpose of this work is the simulation at finer spatial and temporal scales, from a meteorological model "Regional Atmospheric Modeling System (RAMS)", the surface wind speed in Tunisian arid zones. To evaluate the consistency of wind field simulated by RAMS in southern Tunisia, we compared the wind speeds at 10 meters simulated by RAMS and measured by 2 meteorological stations located in the study area which are Djerba (costal station) and Tozeur (inland). A very good correlation between measured and calculated wind fields was found. In addition, a very good agreement is observed, in particular with respect the seasonality of wind speeds, with a maximum recorded in spring and a minimum marked in summer.*

Keywords: *Field wind, RAMS model, meteorological stations, southern Tunisia*.

1. INTRODUCTION

In the models developed to simulate desert emissions to various scales, the reference level at which is measured or calculated wind speed should be as close as possible to the surface. For the meteorological model, the minimum level at which the wind speed is provided is generally 10 meters above the surface. Therefore, this level represents the connection point of two vertical profiles of wind speed. One representative wind speed variations simulated by the meteorological model, between 10 meters and the top of the Atmospheric Boundary Layer (CLA) and integrating relief effects; one taking into account only the local effects of small roughness elements and characterized by aerodynamic roughness height [1].

On a continental scale, the wind fields to 10 meters are provided by different meteorological models, the most commonly used are those issued by the European Center for Medium-range Weather Forecasts, ECMWF, and the "National Center for Environmental Prediction" (NCEP). Using the wind fields of NCEP, [2] showed that the simulations seem to underestimate by a factor of 2 the wind of panache movement near source areas such as depression Bodélé. Moreover, although the application of ECMWF surface wind fields also have a slight bias in this region [3], their use at the continental scale can simulate emissions [1].

Moreover, there are regional meteorological mesoscale models which can provide meteorological fields spatially resolved a few kilometers. the Regional Atmospheric Modeling System (RAMS) meteorological model

[4] has recently been used with success, coupled with the DPM MB95 (Dust Production Model, [5]) by [6] to simulate dust emissions in the area of depression Bodélé (Chad).

Considering these simulation results through experiments conducted in an area considered to be the primary source of the world's mineral aerosols emissions, the RAMS model was chosen to achieve simulations of wind field at 10 meters regional scale in southern Tunisia. The objective of this study was to evaluate the consistency of the wind field simulated by RAMS for Tunisian arid areas by comparing wind speeds at 10 meters simulated by RAMS and measured by meteorological stations located in the study area. This paper aims also to test the capability of mesoscale model to reproduce the seasonality of measured wind fields at finer spatial and temporal scales in 2 meteorological stations located in Djerba (coastal station) and Tozeur (inland).

2. MATERIAL AND METHODES

2.1. Regional Atmospheric Modeling System (RAMS) model

In this study, a mesoscale model, the Regional Atmospheric Modeling System version 6.0 paralleled was used. The RAMS model is an Eulerian, non-hydrostatic meteorological model featuring powerful facilities such as 4-Dimentional Data Assimilation, interactive two-way nesting (up to 8 girds), bulk or detailed microphysics, and a comprehensive surface model. The model is initialized and laterally nudged by the reanalysis European Center for Meduim-Range Weather Forcasts (ECMWF) fields [6].

Version 6 of the RAMS model includes a detailed soil model (Land Ecosystem-Atmosphere feedback, LEAF, [7]; [8]) which allows a better description of the surface boundary layer. A total of 11 soil levels is considered by RAMS ranging from 1 centimeter to 1 meter (1 m; 0.70 m; 0.50 m; 0.35 m; 0.25 m; 0.16 m; 0 12 m, 0.09 m, 0.06 m, 0.03 m and 0.01 m).

The vegetation is represented by the Normalized Difference Vegetation Index (NDVI). The NDVI used in the RAMS model are global monthly data produced by the United States Geophysical Survey (USGS) at a resolution of 30". Finally, soil texture data used in RAMS have a resolution of 2', about 4 km, and are taken from the Food and Agriculture Organization (FAO) of the United Nations.

The heat flow, momentum and the water vapor in the surface layer are calculated with the scheme of [9]. The turbulence scheme used is the closure deformation-K scheme of [10] with modifications of stability made by [11] and [12].

The surface temperatures of the sea used in RAMS are temperatures from global monthly climate data at 1° resolution (about 100 km). The radiation scheme is the code of [13] (visible and infrared) which takes into account the cloud processes, condensed water in liquid water. The convective parameterization used is a simplification of the scheme of Kuo-Tremback [14]. The cloud model is the microphysics scheme at a momentum (mixing ratio) of [15].

The topography used in the RAMS model is derived from the USGS database to 30", about 1 km resolution. The same for land use data: USGS database comes from data to 1 km from the Advanced Very High Resolution Radiometer (AVHRR) for the period April 1992 to March 1993.

To determine the surface wind speed modules $(u^2 + v^2)^{1/2}$, we used the instantaneous values calculated every 10 minutes of the two horizontal components (u and v) to 10 meters wind speed.

2.2. Meteorological stations

The model domain is composed of one grid centred on (32.2°N; 9.75°E). Inside this area, to assess the consistency of the wind field simulated by RAMS for Tunisian arid regions, we have compared wind speeds at 10 meters simulated by RAMS and measured by meteorological stations located in Djerba (33°48’33’’N ; 10°50’40’’E) and Tozeur (33°55’01’’N ; 8°07’59’’E) for the whole year every three hours.

3. RESULTS AND DISCUSSIONS

To ensure that the RAMS model simulates correctly the wind field at 10 meters, we compared the simulated wind speeds to those observed in the 2 meteorological stations in southern Tunisia. Specifically, these comparisons were conducted between simulated wind speeds every three hours and observations at meteorological stations, the same day and the same hour, when data were available.

Fig .1 shows, for two stations, wind speed at 10 meters modules simulated and observed every 3 hours as well as the daily average. A very good agreement is observed, in particular with respect the seasonality of wind speeds, with a maximum recorded in spring and a minimum marked in summer but with different intensities for both stations. In addition, the correlation coefficients are highly significant (0.66 and 0.68 respectively for Djerba and Tozeur) and slopes of close to 1 regressions (0.87 and 1 respectively for Djerba and Tozeur).

4. CONCLUSION

With the aim to apply a mesoscale meteorological model to simulate 10 meters wind fields in southern Tunisia, a meteorological database provided by the Regional Atmospheric Modeling System (RAMS) model was used. In this study, a comparison, which at least should assess the coherence of measurements, between RAMS’s wind field with measurements in two meteorological stations were also conducted. The results of this analysis show a very good correlation between the measured and calculated wind field, in particular as regards the seasonality of wind speeds.

Moreover, given the character "imperfect" of each of these types of data (models, measurements of meteorological stations ...), their use in a complementary manner is the only way to reach a certain level of quantification simulations.

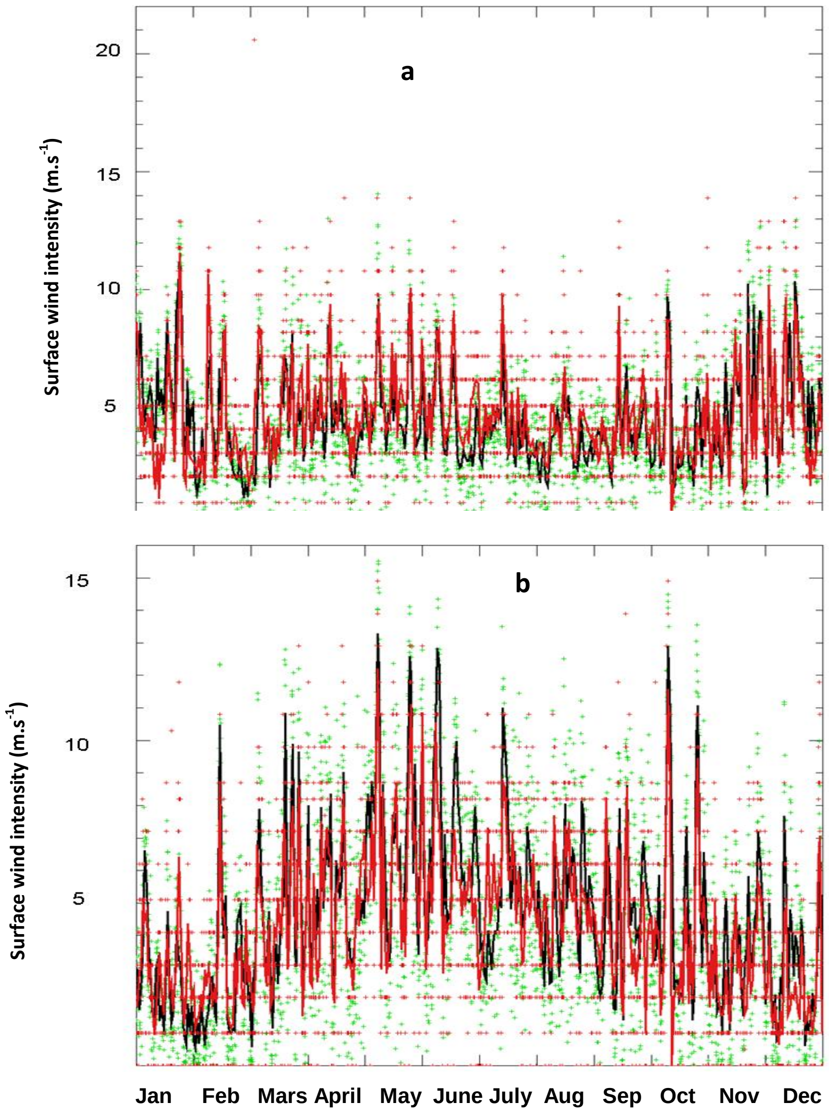

Figure 1: (a) Comparison between wind speed measured in Djerba station (*red dots : data every 3 hours , red curve : daily average*) and wind speed modeled by RAMS (*green dots : data every 3 hours , black curve : daily averages*), (b) comparison between wind speed measured in Tozeur station (*red dots : data every 3 hours , red curve : daily average*) and wind speed modeled by RAMS (*green dots : data every 3 hours , black curve : daily averages*)

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