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# Evaluation of a surface temperature simulation over Tunisia using the WRF model

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## 1. Introduction

According to a recent World Bank study (Verner 2013), Tunisia is and will continue be impacted by climate variability and change mainly through the adverse effects resulting from increasing temperatures, sea level rise, reduced and variable precipitation. Meteorological records and observations show that mean annual temperatures rose by about 1.4°C in the twentieth century.

In this context, the need for climate information at the regional scale by using regional climate models (RCMs) seems to be so necessary in order to examine Tunisian present climate and prepare illustrative scenarios for the future.

In this study, we aim to evaluate the Weather Research and Forecasting (WRF) model for regional climate application over Tunisia, focusing in simulated surface temperature.

## 2. Methods and data

The model used in this study is the Weather Research and Forecasting/Advanced Research WRF (ARW) model, version 3.4 (WRF here- after, Skamarock et al. 2008). WRF simulation was setup with two nested domains, one at 60 km and a second at 12 km horizontal grid spacing. The coarse grid (120 x 60 grid points) extends over the Mediterranean basin (Southern Europe and North Africa) while the high-resolution nest (46 x 71 grid points) covers Tunisia (Figure 1), both grids have 28 vertical levels.

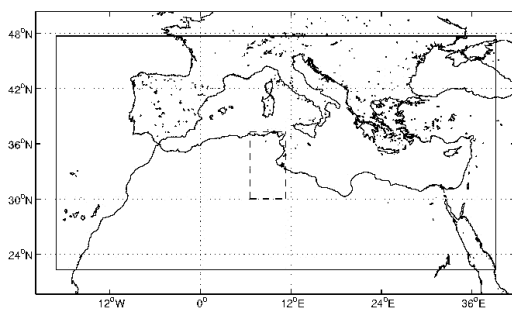


Figure 1. Model domains (continuous line for the parent domain and dashed line for the fine nest)

Initial and lateral boundary conditions for the outermost domain are provided at 6h interval by ECMWF ERA-interim (ERA-I) reanalysis (Dee et al. 2011). SST for both grids are also provided every 24 h, at monthly resolution, from ERA-I. Surface data are derived from the 20-category MODIS-based land use data with inland water bodies (Friedl et al. 2002). WRF physics options include the WRF Single-Moment 6-class (WSM6) for

cloud microphysics, the Yonsei University (YSU) parameterization of the planetary boundary layer, the Rapid Radiative Transfer Model (RRTM) scheme for long wave radiations and Dudhia scheme for short wave radiations. Over the continent, WRF is coupled with Noah LSM 4-layer soil temperature, soil and canopy moistures model (Chen and Dudhia, 2001). The WRF run started at 0000 UTC 1 January 1991 and ended at 2400 UTC 31 December 2011. The first year was considered as model spin-up.

To assess the accuracy of our simulation, WRF surface (2m) temperature is compared (using the nearest grid point of the model to the observations) against an observational dataset belonging to the Tunisian National Institute of Meteorology. Available observations were checked for continuity, retaining 18 surface temperature stations. A variety of statistical verification techniques (Bias, Root Mean Square (RMSE), correlation coefficient (R) and Standard Deviation of the difference (SD)) are also used to evaluate the model. Comparisons are carried out at annual and seasonal time scales

## 3. Results

Long term means (1992-2011) of annual and seasonal simulated surface temperatures are given by figures 2 and 3. Spatial pattern of temperature is heterogeneous and significantly superimposed with regional topographic features. Indeed, the minimum of temperature is observed along the Tunisian Saharan Atlas while the maximum is obtained in the Tunisian salt depressions : "Chott el Djerid", "Chott El Gharsa" (particularly visible during SON season, see frame in figure 3D).

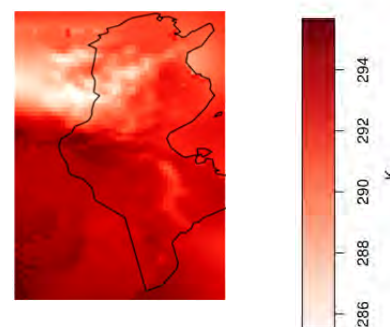


Figure 2. The 20-years mean annual simulated temperature

Spatial distributions of averaged annual and seasonal temperature biases are showed in figures 4 and 5. WRF underestimates mean annual temperature and only few (1 to 2) stations show hot seasonal biases. The south stations always record the highest values of bias. Error

measures computed by pooling together all the weather stations are summarized in table 1. The best correlation (0.92) between the simulated and observed temperatures is obtained during spring (MAM). Time averaged biases are cold and always inferior to  $-1^{\circ}\text{C}$ .

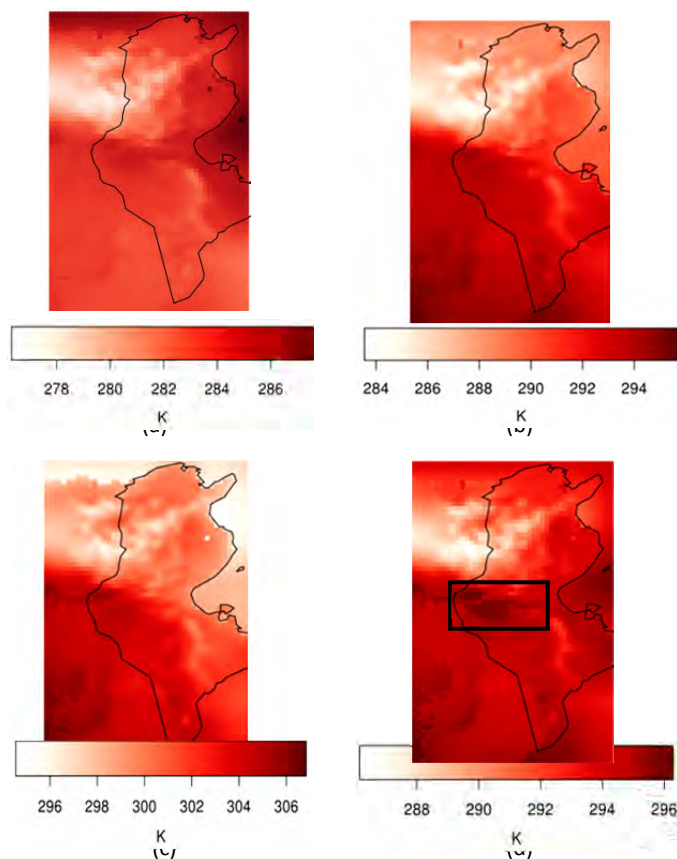


Figure 3. The 20-years mean seasonal simulated temperature (a: DJF, b: MAM, c: JJA and d: SON)

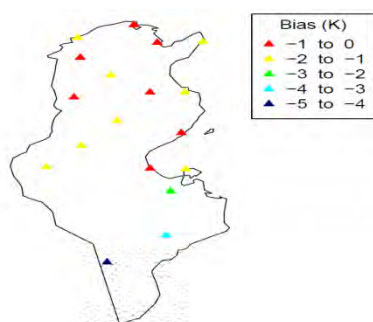


Figure 4. Spatial distribution of 20-years biases of annual temperature

### 3. Conclusion

WRF temperature simulation shows significant topographic signatures as the model uses finer surface parameters and more elaborated parameterization schemes allowing good representation of local processes. Simulated temperature is colder than the observations, especially in the south of the country where the model underestimates temperature higher than other regions. Although the systematic cold bias, WRF reproduces well the interannual variability and annual cycle (not shown) of Tunisian temperatures. Unlike results for the first

domain (not shown) where simulations were compared to some observational gridded datasets, the few number of available stations cannot allow a robust evaluation of the model in addition to the lack of similar regional climate application performed over the country and allowing comparisons.

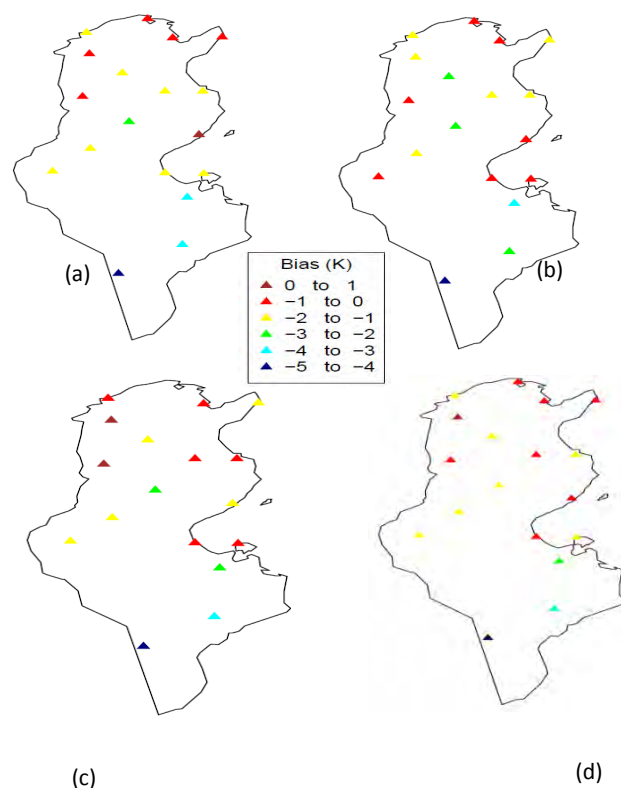


Figure 5. Spatial distribution of 20-years biases of seasonal temperatures (a :DJF, b: MAM, c: JJA and d : SON)

Table 1. Annual and seasonal temperature errors

	BIAS ( $^{\circ}\text{C}$ )	RMSE ( $^{\circ}\text{C}$ )	SD ( $^{\circ}\text{C}$ )	R
<b>Annual</b>	-1,5	1,84	1,10	0,88
<b>DJF</b>	-1,6	1,93	1,09	0,80
<b>MAM</b>	-1,6	1,92	1,08	0,92
<b>JJA</b>	-1,3	1,90	1,40	0,89
<b>SON</b>	-1,4	1,83	1,22	0,85

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