Dynamical downscaling inter-comparison for high resolution climate reconstruction

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1. Introduction

An evaluation of various methods of dynamic downscaling is presented. The methods evaluated range from the classic method of nesting a regional model results in a global model, in this case the ECMWF reanalysis, to more recently proposed methods, which consist in using Newtonian relaxation methods in order to nudge the results of the regional model to the reanalysis. The method with better results involves using a system of variational data assimilation to incorporate observational data with results from the regional model. The climatology of a simulation of 5 years using this method is tested against observations on mainland Portugal and the ocean in the area of the Portuguese Continental Shelf, which shows that the method developed is suitable for the reconstruction of high resolution climate over continental Portugal.

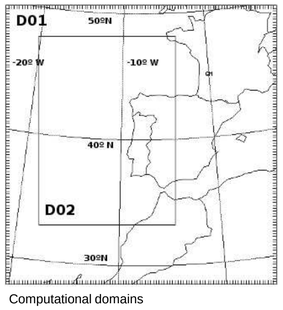
2. Methodology

Several downscaling methods were applied through the year 2004, using atmospheric fields of the ECMWF Era Interim reanalysis for initial and boundary conditions to a regional application of the WRF model (see Figure below).

Main physical options used in the several tests:
- Microphysics: WRF Single-Moment 6-class scheme.
- SW radiation scheme: Dudhia.
- LW radiation scheme: Rapid Radiative Transfer Model (RRTM).
- Surface boundary layer: MM5 similarity surface layer.
- Planetary boundary layer: Yonsei University (YSU) planetary boundary layer.
- Soil model: Noah Land Surface Model.
- Cumulus parameterization: Grell-Dévényi ensemble convective.

Table 1 – Nudging experiments

	Reinitialization Frequency	Simulation Length	Grid Nudging	3DVAR
Run2	29 days	30 days	No	No
Run4	29 days	30 days	Yes	No
Run8	6 hours	12 hours	No	Yes
Run12	6 hours	12 hours	Yes	Yes
Run14	6 hours	12 hours	No	No



Computational domains

Experiments Run2 and Run4 are simulations with 30 days length and reinitialized every 29 days, in which the first 24 hours are considered as spin up time, and to the former an analysis grid nudging technique is applied. The remaining three simulations, Run8, Run12 and Run14, consists of 12 hours simulations, reinitialized every 6 hours, where the firsts 6 hours are considered as spin up time and are not included in the results analysis. In experiments Run8 e Run12, the initial condition of each re-initialization is obtained from assimilating data through the use of 3DVAR assimilation, having as first guess the last instant from a former simulation with the same valid time as the analysis time. The difference between Run8 and Run12 is the use of analysis grid nudging to the former experiment.

The observations used in this study are datasets ds351.0 (upper air data) and ds461.0 (surface data) from http://dss.ucar.edu. This observations are used in the data assimilation process and in to evaluate the performance of each experiment of Table 1.

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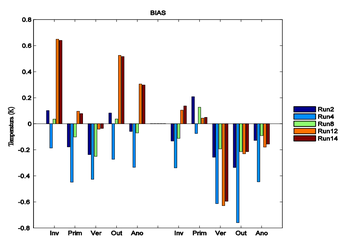
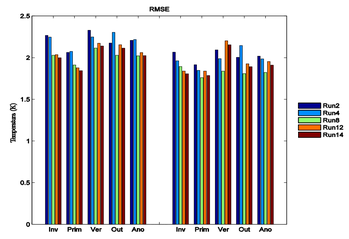
3. Results

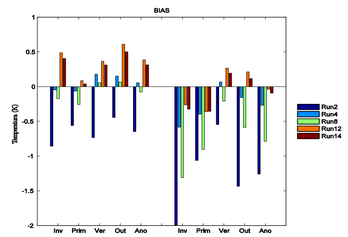
In the following figures it is shown computations of BIAS and RMSE of each of the experiments presented in Table 1, for data collected at surface, over land (columns in the left) and over the ocean (columns in the right).



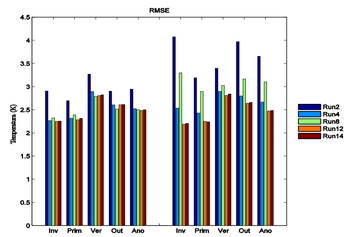
BIAS – 2 m temperature.



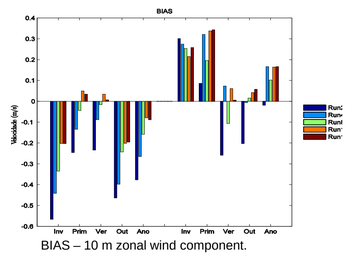
RMSE – 2 m temperature.



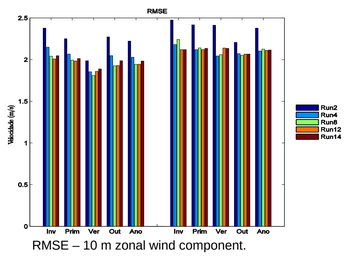
BIAS – 2 m dew point temperature.



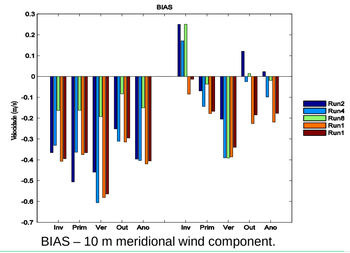
RMSE – 2 m dew point temperature.



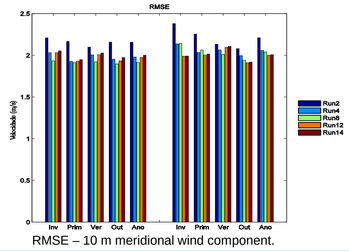
BIAS – 10 m zonal wind component.



RMSE – 10 m zonal wind component.



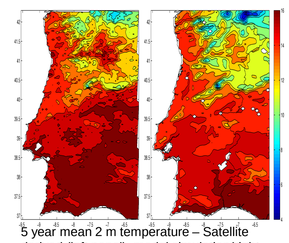
BIAS – 10 m meridional wind component.

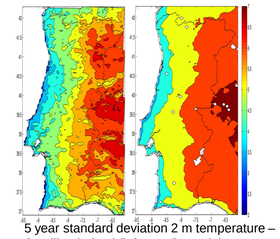


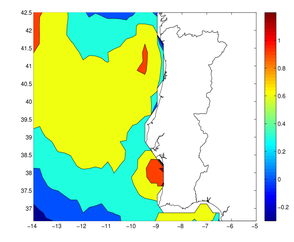
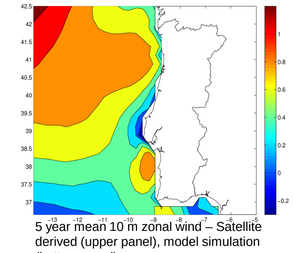
RMSE – 10 m meridional wind component.

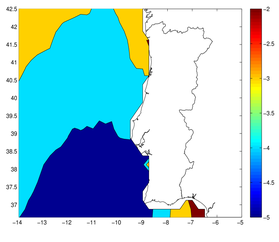
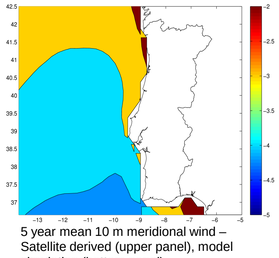
4. Results

Comparisons of model results with satellite derived data of 2 m temperature (data from Benali *et al.* (2011)) and 10 meter sea wind (QuikScat data).


5 year mean 2 m temperature – Satellite derived (left panel), model simulation(right panel)


5 year standard deviation 2 m temperature – Satellite derived (left panel), model simulation(right panel)



5 year mean 10 m zonal wind – Satellite derived (upper panel), model simulation (bottom panel)



5 year mean 10 m meridional wind – Satellite derived (upper panel), model simulation (bottom panel)

5. Discussion

Several dynamical downscaling techniques were tested, revealing that the choice process is not straightforward. Only one experiment, Run2, is ruled out as being constantly worst, in comparison with the remaining experiments. Performance of experiments Run4 to Run14 is very variable, depending of the meteorological parameter in study and the area where the model is being applied. Besides, practical aspects of the downscaling technique should be taken into consideration, once a very complex application of the method may carry out little advantage in model accuracy.

The Run12 dynamical downscaling method was applied for a 5 year period. Comparisons with satellite derived data reveals a fairly good agreement between the spatial patterns of the simulation and those derived from satellite observations.

References:Benali, A., Nunes, J. P., Carvalho, A. C., Carvalhais, N., Santos, A., 2011. Estimating air surface temperature in Portugal using modis lst data. Accepted with minor revisions at Remote Sensing of Environment, 52 pp.