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How to obtain atmospheric forcing fields for Surface Energy Balance models in climatic studies

Julia Hidalgo (1), Bruno Bueno (1,2), and Valéry Masson (1)

(1) Centre National de Recherches Météorologiques CNRM/Meteo-France, France (julia.hidalgo@ymail.com), (2) Massachusetts Institute of Technology, Cambridge, USA

At the local scale, topography and land use affect the spatial distribution of climate variables and generate (or modulate) atmospheric circulations at scales that are not explicitly described by Atmosphere/Ocean General or Regional Circulation Models. When local climate information is needed, for example in impact or adaptation studies, downscaling methods are thus needed to capture these effects. Often, statistical downscaling is performed using observational data from one or a group of surface stations, being the results strongly dependent on the region and criteria of comparison. Another option is to use a Surface Energy Balance model to perform a dynamical downscaling forced by the aforementioned climatic projections. These numerical modules need high temporal frequency (1 to 3 hours) atmospheric fields to be forced with. Future climate projections currently available for Europe have a daily frequency. This means that, for a grid point, only the daily mean or at the best the maximum and minimum values are available. The methodology presented here allows to obtain hourly frequency data from this type of daily databases based on past observations.

Observational data at hourly frequency is available from the operational network of surface stations. In a sufficiently long period, all the diversity of weather types affecting the site will be represented. It is then possible to classify the diurnal cycles to obtain a collection of clusters and to reconstruct the original observed sequence. Using for the classification only the mean, maximum and minimum daily data (the only one available for modelled future scenarios), a reconstructed sequence for the future projections at hourly frequency can be obtained.

The Chartres station close to Paris was used to perform a k-means cluster classification using hourly temperature, specific humidity, pressure, precipitation, wind force and wind speed for the 1998-2008 period. Twelve clusters were identified with sizes varying from 16.6 % to 1.1% of the days. The clusters represent well the diversity of the meteorological conditions, with dominant winds blowing from the NE and SW, and give a good representation of the daily temperature and humidity cycles. A validation analysis was performed for reconstructed series for the periods 1998-2008 and 1961-1990. In both cases, the standard deviation has a value over 0.97 for the mean, maximum and minimum temperatures. Reconstructed future projections at hourly frequency for different emission scenarios are obtained from the original Regional Climate Models database for the entire 21st century.

These reconstructed projections will be used in the framework of the MUSCADE (Urban Modelling and Climate Change adaptation to anticipate the energy demand) project were the Surface Energy Balance (SURFEX) model will be run in an offline mode for the entire 21st century. The Regional Climate Models do not use urban parameterizations, so urban climate features, such as the urban heat island, are not included in the original projections. Here, a set of 3-dimensional high-resolution numerical simulations with the non-hydrostatic Meso-NH atmospheric model, including the wind effects on the urban heat island intensity, is the strategy chosen to examine the external forcing impact in the urban heat island development. A “synthetic” urban heat island could be then combined with the reconstructed projections by means of a horizontal temperature scaling as developed for night-time by Lu et al. (1998) and for daytime by Hidalgo et al. (2010).