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Statistical downscaling of WRF mesoscale simulations using an artificial neural network to forecast winds at local, unresolved scale

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In regions of complex topography, the local flows (i.e. at the sub-kilometer scale) are difficult to forecast on a routine basis because of the too coarse resolution of operational models. The worst performance is obtained for stable stratifications, which are yet the most dangerous ones regarding the accumulation of pollutants accidentally or chronically released. In the SE of France, the Cadarache site features such a complex topography. Furthermore, the region is also characterized by a high occurrence of clear skies leading to stable boundary layers during nighttime periods.

Since February 2015, the Weather Research and Forecasting (WRF) model has been run daily to forecast the weather in this region with a horizontal resolution of 3 km. These simulations cannot resolve all the details of the topography and particularly the narrow Cadarache valley, where local wind patterns are therefore not accessible, especially when the boundary layer is stratified. However, other variables, less dependent on the sub-grid topography, are satisfactorily forecasted.

Duine et al., (2016) built a successful nowcasting method to determine the presence of the Cadarache down-valley wind, based on the observation of the temperature difference between two levels. Here, we elaborated a new method whereby the 3-km WRF forecasts are used as the input of an artificial neural network (ANN). The goal is to go from nowcasting to forecasting of winds in the Cadarache valley.

Using the vertical gradient of temperature and the horizontal wind as ANN input parameters, this method allows improving the forecast of the low level wind direction. The Directional Accuracy (DACC), which represents the fraction of wind directions which do not depart from the observations by more than 45°, thus jumps from 0.55 for WRF simulations to 0.75 for ANN output, and the Proportion Correct (PC), which represents the fraction of data that are well classified regarding the different ranges of wind direction, increases from 0.50 for WRF to 0.72 for the ANN.