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On the role of nudging and the initialisation of RCM simulations for medicanes

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Medicanes are small-scale cyclones that develop in the Mediterranean Sea and exhibit tropical features, such as barotropic structure and the presence of a warm core. Although they are rare, medicanes have great potential to cause important economic costs caused by severe winds and flash floods in coastal regions. Given the small-scale features of these events, whose simulation requires high-resolution Regional Climate Models (RCM), as well as the lack of a systematic network of observations over the sea, these situations remain poorly investigated. Transient RCM simulations driven by reanalysis products can be used in principle to identify and study these storms, allowing their climate characterization, and therefore its projection under climate change conditions. Further, RCMs ability to include the explicit formation of marine aerosol are important to capture the aerosol-heat release feedbacks.

Unfortunately, the simulation of small-scale dynamical phenomena such as medicanes is very sensitive to the initial conditions, therefore becoming susceptible to internal variability within the model domain. This is problematic, as the initial condition is “forgotten” in transient simulations. Consequently, this unavoidable factor in RCM simulations can modify or even completely preclude the formation of a medicane, despite the fact that the large-scale drivers of the phenomenon are continuously introduced through the model boundaries. This source of model uncertainty can be constrained through the so-called nudging techniques. With this nesting approach, the model is not left free to deviate from the driving dataset, but forced to closely follow it, so minimising the freedom of internal variability within the RCM domain. Several variants, e.g. 3D nudging, spectral nudging, reforecast, etc., have been proposed as a mean of constraining this source of uncertainty.

Here we perform a number of sensitivity experiments to find the optimal setup of initial conditions and nudging for the simulation of a case study (the Rölf medicane, in Nov 2011) with WRF and WRF-CHEM run at spatial resolution of 12 km and driven by ERA Interim. We perform a battery of test to characterize the temporal window at which the formation of the medicane becomes affected. Then, we test different nudging techniques to try to constrain the internal variability of the model, so that the storm dynamics remain independent on the initialisation of the RCM. Results indicate that initializing the model 5 to 7 days before the event without nudging affects its formation, whereas spectral nudging is able to reduce this uncertainty, at the same time that does not preclude the simulation of the local physical mechanisms that characterize these phenomena. Hence, nudging techniques become necessary for the suitable simulation of historical medicane events in transient RCM simulations.