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Current and future medicane risk based on the generation of synthetic storms

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Medicanes are warm-core, surface flux-driven extreme windstorms potentially threatening the islands and coastal areas of the Mediterranean countries that have captured the attention of the research community. With an average frequency of only 1-2 events per year and given the lack of systematic, multidecadal databases, an objective evaluation of the long-term risk of medicane-induced winds is impractical with standard methods. A statistical-deterministic approach was developed by the second author in the context of the tropical cyclone risk over the great ocean basins. This approach entails the generation of thousands of synthetic storms with low computational cost, thus enabling a statistically robust assessment of the risk (e. g. calculation of return periods for extreme winds at fixed locations). By using GCM transient climate simulations instead of reanalyses as input data, the capabilities of this technique can be expanded to account for the expected effects of global warming. This work presents an adaptation of the statistical-deterministic approach to the Mediterranean region with the aim of assessing the medicane risk under current and future climate conditions. These climates are represented by ERA-40 reanalysis (1981-2000) and four different GCMs under the SRESA2 emission scenario (2081-2100).

First, the spatial variability in 10-day synoptic evolutions of key ingredients for the environmental control of these storms (potential intensity, mid-tropospheric temperature and humidity, and winds in the low and upper troposphere) is converted via principal component analysis (PCA) into a new space represented by the resulting independent PCs. In a random sequence, states are selected from the new space, slightly perturbed in each PC, and then converted back into physical space. By construction, this is tantamount to generating 10-day sequences of spatiotemporal coherent fields which also respect the mutual covariances among the environmental ingredients. Thousands of climate realizations generated in this way are then scrutinised for the potential incubation of medicanes based on the presence of high values of an empirical index of genesis that have been shown to accompany the development of real events. Finally, tracks for all candidate storms are produced using the Beta and Advection Model and numerically simulated using a simple but accurate deterministic tropical cyclone intensity model, involving both atmospheric and oceanic elements. By this means, synthetic time series of storm intensity, including the radial distribution of wind, are produced with an adequate population number and spatial coverage.

With this statistical-deterministic approach we attained unprecedented wind risk maps for the Mediterranean region, generally consistent with what can be inferred about the medicane phenomenology from the few documented real cases. In addition, GCMs tend to project fewer medicanes at the end of the century compared to present but a higher number of violent storms, suggesting an increased probability of major economic and social impacts as the century progresses.