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Modeling the spatial and temporal variability of fog in the Namib desert with COSMO-PAFOG

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Fog is a typical feature in the Namib desert. The hyper-arid Namib desert located next to the cold Benguela Current of the southeast Atlantic Ocean is one of the most arid places on earth. In this dry region, fog deposition is an important source of water for ecosystems and water harvesting has a great potential to alleviate water shortage for human settlements. Thus, the knowledge of the spatial and temporal patterns of fog in the Namib-region is of great ecological and socio-economic interest.

The central aim of our study is to understand processes controlling the spatial and temporal development of coastal desert fog in the Namib by means of numerical simulations. The complex topography of the Namib-region with steep slopes in combination with the Benguela Current leads to complex interactions of meso-scale circulation systems like mountain-valley-breeze and land-sea-breeze. These meso-scale circulations yield different types of fog influenced by advection processes requiring three-dimensional numerical modeling and a detailed description of microphysical processes. Numerical simulations are performed with an extension of a three-dimensional meso-scale weather prediction model. The nonhydrostatic meso-scale weather prediction model COSMO (COnsortium for Small-scale MOdeling) developed and maintained by the German Meteorological Service is adapted for the application in the Namib region. To account for microphysical processes involved in fog formation, the microphysical parametrization of the one-dimensional fog forecast model PAFOG (PArameterized FOG) has been implemented into COSMO. The resulting fog forecast model COSMO-PAFOG is run with kilometer-scale horizontal resolution. Results of model configurations with different vertical grid spacings and microphysical parametrizations are compared to satellite observations.
Various fog events are presented revealing that the model captures well the local meso-scale circulations and their forcing. The spatial extent of the fog and stratus is often underestimated, especially in the daytime, when the stratus dissolves almost completely in contrast to observations. Reasons for this underestimation of low stratus over the southeast Atlantic in the model simulations are analyzed. An increase in vertical grid spacing in the atmospheric boundary layer and fine-tuning of model parameters slightly improve the representation of strong inversions and moist layers which are crucial for the formation and persistence of the stratus.