EMS Annual Meeting Abstracts
Vol. 14, EMS2017-316, 2017

Quantification of fog liquid water budget from ground-based remote sensing and LES-modelling

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Background: Reduced visibility due to fog is a major concern for traffic safety, in particular on airports. However, the time of dissipation of fog layers is poorly predicted by present-day numerical weather forecast models. Our research aims to improve short-term forecasts of fog dissipation by applying detailed observations of the fog to infer the current state of physical processes that will affect the liquid water column (radiative budget, droplet deposition, turbulent mixing). We focus in particular on the use of a ground-based cloud radar, which can observe the fog vertical profile with high temporal and vertical resolution.

Methods: Our research is centred around the use of observations, but we also apply models in order to improve our understanding of the processes and how they can be related to the observed quantities. This study is based on observations from the SIRTA atmospheric observatory in Palaiseau (Paris) in the period 2014-2016. The microphysical properties of observed fog layers are estimated from the BASTA 95GHz FMCW cloud radar, supplemented by other ground-based instruments. To calculate the radiative budget, a single-column radiative transfer model is applied, using the retrieved microphysics as well as surface meteorology and radiosondes as input. To study dynamical processes in fog, we carry out large-eddy simulations of a number of the observed fog events using the DALES model. The simulated fogs are analysed in detail to quantify the contributions from turbulent mixing and from surface–atmosphere exchange of heat and moisture to the loss of fog liquid water that leads to the dissipation of the fog. We focus on the causes for variability in the different physical processes, and how this variability can be detected by ground-based observations. Comparisons between the modelled and observed fog events also allow for an evaluation of the ability of the DALES model to simulate the various aspects of the fog events.

Anticipated results:
– Quantification of the amount of liquid water that can be created by radiative cooling of fog layers and its variability due to various atmospheric conditions (fog thickness, clouds above the fog, temperature, humidity)
– Quantification of the loss of liquid water due to mixing with unsaturated air and water deposition on the surface, and how these sink terms vary due to atmospheric conditions (e.g. radiation, temperature, wind speed, moisture above fog)