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Towards an improved representation of fog and low stratus in high-resolution numerical weather prediction models

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Context
Predicting the extent of fog and low stratus (FLS) is increasingly important. For example, airport authorities require accurate forecasts of visibility to optimise operations and in the energy sector knowledge about future low cloud cover is required to estimate the short-term solar energy yield. Despite the many improvements in recent years high-resolution numerical weather prediction (NWP) models still show unsatisfactory performance regarding FLS forecasts.

Aim
Our goal is to improve FLS forecasts with COSMO-1, a deterministic 1-km resolution NWP-model employed operationally at MeteoSwiss, the Swiss national weather service.

Methods
To enable an objective intercomparison of different model versions and configurations, we developed a verification method for FLS forecasts based on infrared satellite imagery. In order to identify the key processes that are responsible for the insufficient representation of FLS in NWP models we conducted sensitivity experiments addressing the microphysics parameterisation, subgrid-scale turbulence parameterisation, model resolution and model topography for a series of case studies. In this presentation, we focus on a case in December 2017 where the modelled FLS clouds had dissipated after only a few hours, whereas in reality they had persisted throughout the entire day.

Results
A novel algorithm based on three infrared channels allowed us to objectively quantify the quality of the modelled spatial extent of FLS. We could show that COSMO-1 underpredicts FLS already at the beginning of the model forecast, indicating deficiencies in the data assimilation scheme. Furthermore, the modelled FLS generally dissipates too fast with increasing leadtime. Changes in the model parameterisations have shown limited improvements only: Adopting a two-moment microphysics scheme for cloud water does not significantly affect the FLS extent. Reducing the minimum turbulent diffusion coefficients for momentum and heat slightly reduces the warm temperature bias close to the ground but the FLS dissipation remains too early. The model showed improved performance when decreasing the horizontal grid spacing from 2km to 1km to 500m. However, even at 500m resolution, the modelled life cycle remains unsatisfactory.

Conclusions
A novel validation procedure based on satellite imagery confirms that the NWP-model COSMO-1 generally underestimates the extent of FLS clouds and dissipates them too fast. Adaptations to the model resolution show the most promising results so far. We will conclude the presentation with an overview of future directions in order to improve FLS forecasts.