EGU21-4429, updated on 06 Dec 2022
https://doi.org/10.5194/egusphere-egu21-4429
EGU General Assembly 2021

A new vertical coordinate formulation to improve forecasts of fog and low stratus in high-resolution numerical weather prediction models

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Fog and low stratus pose a major challenge for numerical weather prediction (NWP) models. Despite high resolution in the horizontal (~1 km) and vertical (~20 m), operational NWP models often fail to accurately predict fog and low stratus. This is a major issue at airports which require visibility predictions, or for energy agencies estimating day-ahead input into the electrical grid from photovoltaic power.

Most studies dedicated to fog and low stratus forecasts have focused on the physical parameterisations or grid resolutions. We illustrate how horizontal advection at the cloud top of fog and low stratus in a grid with sloping vertical coordinates leads to spurious numerical diffusion and subsequent erroneous dissipation of the clouds. This cannot be prevented by employing a higher-order advection scheme. After all, the formulation of the terrain-following vertical coordinate plays a crucial role in regions which do not exhibit perfectly flat orography. We suggest a new vertical coordinate formulation which allows for a faster decay of the orographic signal with altitude and present its positive impact on fog and low stratus forecasts. Our experiments indicate that smoothing of the vertical coordinates at low altitudes is a crucial measure to prevent premature dissipation of fog and low stratus in high-resolution NWP models.