Fog and Frost Predictions

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An operational chain of nested numerical weather prediction models has been extended with a two dimensional boundary layer model in order to produce short-term and local predictions of frost and fog. For an experimental period of six months the topographical boundary layer model TGM has been coupled to the operational COSMO-2 model of MeteoSwiss for the hydrological catchment of the Glatt river (ZH, Switzerland). The three hourly COSMO-2 runs have been completed by one hourly runs of the boundary layer model TGM which assimilates local observations.

In the topographical boundary layer model the subscale processes governing the nocturnal cooling have been tuned for a five day period with a variety of weather and visibility conditions. Simulations of other nights with reduced visibility have been verified with visibility, radiation, and air and surface temperature observed at Zurich airport. The verifications documented a remarkable quality and level of sophistication in the simulations of nocturnal boundary layers for a variety of visibility reductions by radiative mist and fog. The relevant subscale processes are included in the topographical boundary layer model and have been tuned for practical application.

Nights after days with well mixed convective boundary layers have been simulated most precisely and consistently. Cases of marked low-level inversions with stratus, either persisting or hardly dissipating during the day, have been simulated less consistently. A sensitivity of the simulations to the external forcing and the assimilated local observations has been demonstrated and shows a need for refining both the coupling to the external model and the assimilation procedure in order to obtain more stable sequences of model runs in particular cases. The transmission of short wave radiation by low stratus, fog, and mist needs to be implemented in the topographical boundary layer model, as the dissipation of fog occurred systematically too rapidly when using the transmission of the COSMO-2 model.

Verifications of the threshold forecasts for frost and ground frost over the experimental period show that the forecasts of the air temperature are better than the ones of the surface temperature. The assimilation of local observations by TGM improves the air temperature forecasts during several hours – particularly for the end of the night period. The surface temperature prediction by TGM is better than by COSMO-2 during the entire forecast range of 22 hours although this parameter is not assimilated.

The quality of the obtained nocturnal boundary layer simulations is remarkable. With the mentioned refinements the topographical boundary layer model TGM can be suggested for local predictions of reduced visibility and frost for airports and roads.

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