TOPOGRAPHICAL BOUNDARY LAYER MODEL FOR ROAD WEATHER PREDICTION

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ABSTRACT

This paper describes a boundary layer model for the localization of synoptic model predictions. The local area-elevation distribution of topography and its soil characteristics are considered, convection is calculated explicitely, and the cloud effect on diurnal and nocturnal radiation transfer is treated in detail. Model forcing with local measurements is useful and the prediction range covers day and night with any atmospheric stability. Predictions of road surface temperatures and local fog formation and dissipation can be expected from such a model.

1 INTRODUCTION

The localization of meteorological predictions from the synoptic scale down to particular sites like roads, bridges, and airports remains a challenging task for the weather community (Chapman and Thornes, 2002; Bogren and Gustavsson, 2002; Sass, 2002). Atmospheric processes of sub-synoptic scale must be considered and local topography is of crucial importance. Heating and cooling is controlled by radiation and thus affected by clouds, soil characteristics, and local topography. A successful technique developped for the prediction of regional convection in aviation meteorology has the potential to improve predictions for local road and airport weather.

2 LOCAL WEATHER PREDICTION WITH A BOUNDARY LAYER MODEL

Nested synoptic models (SM) take care of predicting atmospheric processes on a global and national scale. Locally a SM can provide the advection of weather. Boundary layer processes like convection, turbulence and pooling of cooled air can not be calculated explicitely in synoptic models if they are to be used for predictions.

For local weather phenomena the boundary layer processes must be considered and the local topography taken into account. Localized boundary layer models (BM) can focus on the vertical dimension. This allows the detailed calculation of convective mixing as a cloud formation and dissipation process. The horizontal dimension of a localized BM can be very close to zero, as long as areas with horizontally homogeneous atmospheric conditions are to be looked at.

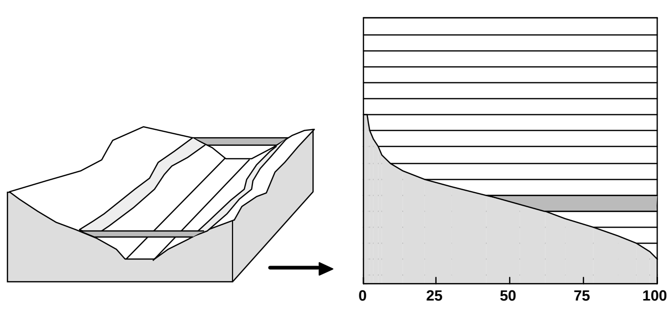

Fig. 1 Area-elevation distribution in complex topography

The local area-elevation distribution (Steinacker, 1984) of complex topography, however, is a key element to localization and should therefore be considered for local weather prediction with a BM. A BM with such a representation of topography shall be denoted as a **tBM**. Surface heating and cooling in a tBM will occur at the correct altitudes and the atmospheric mass will depend correctly on altitude (Figure 1). The volume effect will be present in such a model (Liechti *et al*, 1994). By retaining the topographical area-elevation distribution the nocturnal formation of cold air pools in basins can be treated with a tBM.

The horizontal extension of the model area depends on the requested horizontal homogeneity. An area of e.g. 7x7 km^2 – corresponding to a single grid-point of a routinely used synoptic model – may have an area-elevation distribution that differs significantly from a flat surface. Soil characteristics like albedo, evaporation, and ground heat flux may then vary with altitude.

A tBM coupled to a SM for advection has been in operational use at several national weather services since 1995 and produces diurnal convection predictions for soaring (Liechti, 2002). The obtained quality is sufficient to offer meteorological flight planning (Liechti *et al*, 2003) to glider pilots based on these regional forecasts. Region size in this application is on the order of 5000 km^2 with smaller regions in alpine topography.

A further tBM has been developed in order to simulate the nocturnal cooling over complex topography. The infrared radiation processes in a cloudy boundary layer were implemented and the vertical resolution refined to 10 m in order to apply it to areas on the order of 100 km^2 (Figure 2). Nocturnal cooling with and without fog can be simulated for complex terrain on a local scale.

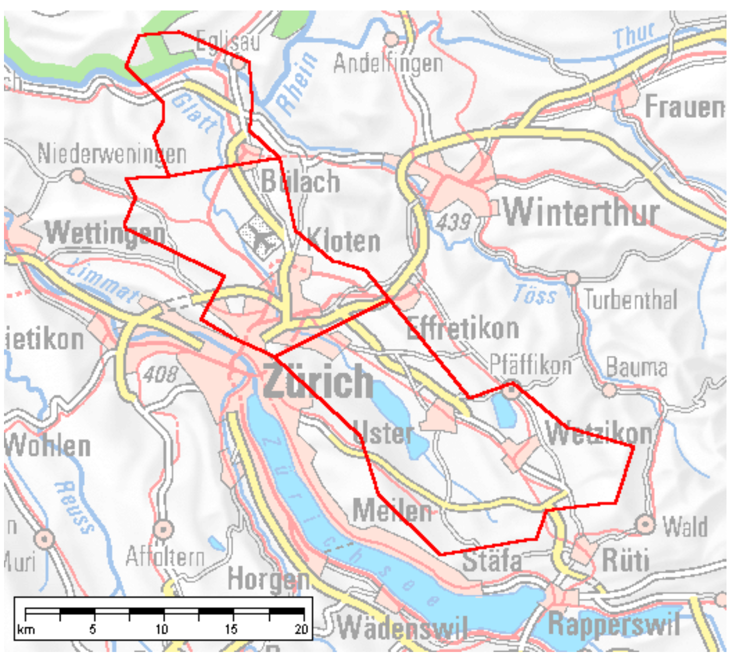

Fig. 2 Scale for local predictions with a tBM

Coupling this tBM to a synoptic model for advection and forcing it with observed meteorological data will allow its application for local road and airport weather predictions. In addition to predictions of road surface temperatures the formation and dissipation of fog should be in the scope of this tBM. Operational application will show its potential for local predictions.

3 CONCLUSION

Nocturnal cooling and diurnal heating in complex terrain can be calculated with a topographical boundary layer model. Air temperature and humidity predictions can be localized to scales useful for road and airport operations. Significant improvements can be expected from such a meteorological model for predictions of local fog, visibility, and road surface temperature.

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