Tests of a Z-Coordinate Nonhydrostatic Model Including Physical Processes

J. Steppeler, S. Janjic**, H. W. Bitzer***, P. Prohl*, U. Schättler**
*DWD , **NCEP,***AWGeophys
Offenbach, Frankfurterstr. 135

Z-Coordinate numerical models of the atmosphere have the advantage of representing the atmosphere at rest properly and therefore justify the expectation of improved forecasts of orographically induced winds. An example for such a Z-coordinate model is the etamodel, which is based on the step orography. The step approach does not allow for a proper representation of the meso-scale flow over smooth and well resolved mountains. This problem was pointed out by Gallus and Klemp (2000). Steppeler et al (2002a) showed that the problem can be solved by formulating lower boundaries using a representation of the mountains by linear splines rather than the step approach. On this basis a Z-coordiante version of the model LM (see Steppeler et al. (2002b)) was developed and tested extensively in idealised situations using bell shaped mountains and the orography of Scandinavia.

A physical parameterisation package was created by using the parameterization package for the terrain following model LM and developing an interface between the z-levels and the terrain following levels. The tendencies of the physics routine in the terrain following grid are interpolated by cubic splines to the z-representation.

A number of idealised tests were done. A bell shaped mountain of height 2000 m was used with an atmosphere being initially at rest. Different circulations developed at night and day, corresponding to mountain and valley winds. In comparison, the model version using terrain following coordinates produced a mountain wind even without radiation being switched on. When a homogeneous velocity field of 10 m/sec is used with the same mountain, a warming or cooling is produced in the wake of the mountain, leading to a rotational motion perpendicular to the axis of the main motion. With radiation switched off the temperature in the wake of the mountain is unchanged.

Fig. 1 shows a test where the step type z-coordinates had a disadvantage as compared to terrain coordinate models. A shallow mountain of 400 m height is used with a homogeneous velocity field of 10 m/sec. The cloud water field in a vertical cross section through the centre of the mountain and the precipitation field is shown. Due to the proper treatment of the gravitational wave, these results come out in the expected way.

References:

Gallus, W. and J. Klemp, 2000: Behaviour of flow over step orography. *Mon. Wea. Rev.* ***128****, 1153-1164.*

Steppeler, J. , H. W. Bitzer, M. Minotte, L. Bonaventura, 2002a: Nonhydrostatic Atmospheric Modelling Using a z-Coordinate Representation. *Mon. Wea. Rev* ***130****, 2143-2149.*

Steppeler, J., G. Doms, U. Schättler, H. W. Bitzer, A. Gassmann, U. Damrath, G. Gregoric, 2002b: Meso-gamma scale forecasts using the nonhydrostatic model LM, *MAP* ***82****, 75-96.*

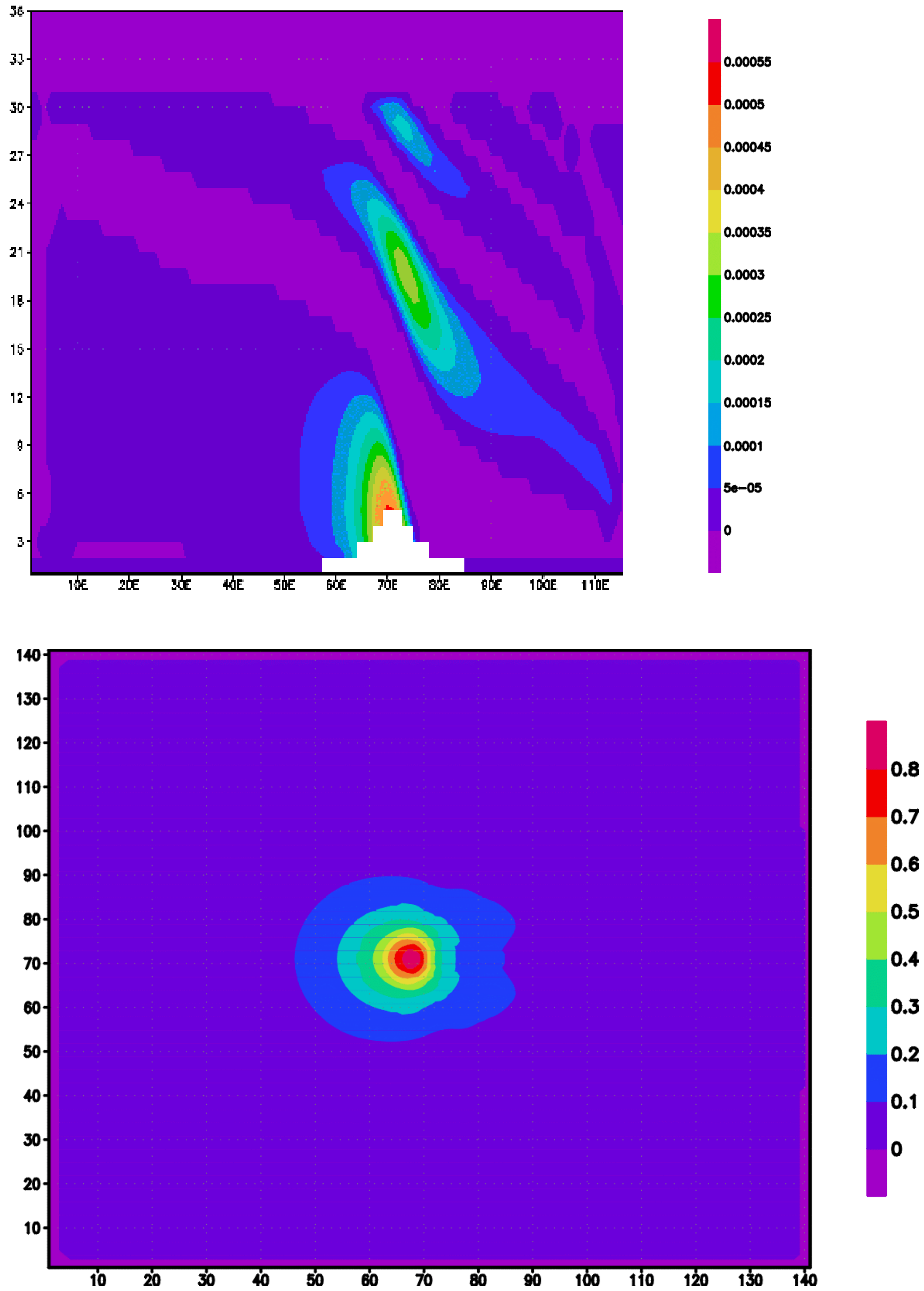

Fig. 1: Cloud water (kg/kg) on a cross section through the centre of the mountain (top) and precipitation (mm) for the bell shaped mountain of height 400 m in a homogeneous velocity field.