Note on roughness in HIRLAM

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A scale-dependent method for calculcation of orographic roughness was developed by Sattler (1999). This new roughness was used in experiments for implementation of a mesoscale orography (MSO) parametrization, see Sigg et al. (2001) and the report by Rontu and Sigg in this Newsletter.

The difference between the scale-dependent and reference HIRLAM roughness (Bringfelt et al. (1995) is significant. Fig. 1 shows the ratio between the new and old roughness in January over Europe in a grid with horizontal resolution of 44 km. As described in Sigg et al. (2001), the roughness used in HIRLAM is a combination of orographic and vegetation contributions. The new roughness is smaller along coastlines and over most of the Northern European flat areas. In Central Europe and around the mountain areas it is mostly greater than the old one though the maximum values over mountains have decreased. However, the picture is quite heterogeneous. As shown in the report by Rontu and Sigg in this Newsletter, these differences seem to have only a little influence in the HIRLAM model results.

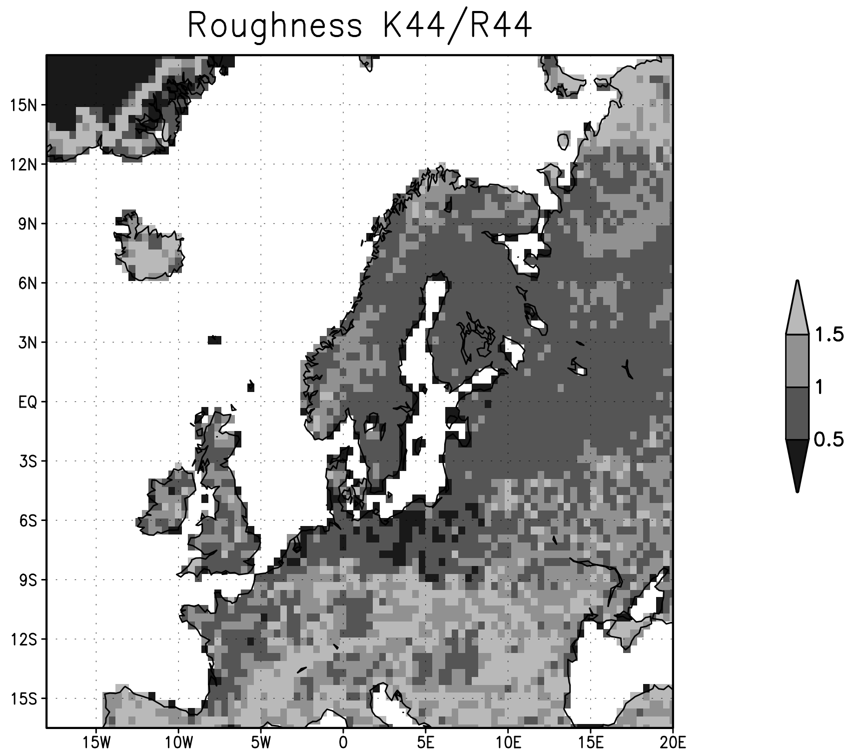

Figure 1: *Relation of the scale-dependent and reference HIRLAM roughness when the horizontal resolution is 44 km. Over the dark areas the new roughness is smaller, over the light areas larger than the old one.*

Fig. 2 shows an example of momentum fluxes in the surface layer calculated with the reference HIRLAM (subroutine SLFLUXO). A stable, unstable and neutral case were defined by the difference of potential temperatures at the surface and at the lowest model level (-1.5, 1.5 and 0 K, respectively). Momentum flux as a function of wind velocity and roughness length is shown. It can be seen, that roughness changes of the order of magnitude shown in Fig. 1 have a small influence on the momentum fluxes when the wind speed is moderate. The sensible and latent heat fluxes are somewhat more sensitive to the roughness changes in the unstable case (not shown).

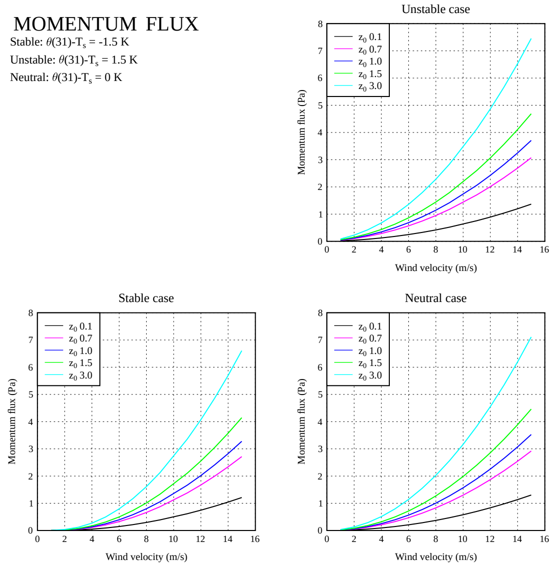

Figure 2: *Momentum flux calculated by the reference HIRLAM surface layer scheme (SLFLUXO) for stable, unstable and neutral case as a function of wind velocity and roughness length. The lowest lines depict the smallest roughness length of* $z_0 = 0.1m$*, the uppermost lines are related to* $z_0 = 3.0m$.

In practice roughness is used quite differently in different versions of the HIRLAM model. The reference system calculates the sum of orographic and vegetation roughness and uses this for momentum fluxes. For heat and moisture the same parameter is used but with a fixed upper limit of the order of 0.5 m. In the ISBA surface scheme heat and moisture flux calculations are based on vegetation roughness. In the modifications by the Rossby centre, which are used also for the BALTEX/Bridge data assimilation, the vegetation roughness (defined differently from the reference HIRLAM) alone is used for all fluxes.

Calculation of the orographic roughness length and the mesoscale orography variables are both essentially based on the orography variance. When calculating the parameters for the MSO parametrization scales of orography below a few kilometers and above the $2\Delta x$ are filtered out (Sigg et al. (2001)). When calculating the orographic roughness all scales smaller than the model's grid resolution are included. In principle, the horizontal scales where the MSO parametrization is active, should not contribute to roughness. This would mean that before calculation of the orographic roughness the basic orography should be filtered by a high-pass filter to include only features of the horizontal scale of 10km and below. In practice the influence of this kind of filtering might be small, also because of the empirical parameters used for scaling of the roughness.

It is concluded that the calculation and use of roughness in HIRLAM require attention when developing the turbulence and MSO parametrizations. The effects of this work on the forecast results are, however, expected to be not very large on average.

References

Bringfelt, B., N. Gustafsson, P. Vilmusenaho and S. Järvenoja, 1995. Updating of the HIRLAM physiography and climate data base. Hirlam Technical Report, **19**. Norrköping, June 1995, 42 pp.

Sattler, K., 1999: New high resolution physiographic data and climate generation for the HIRLAM forecasting system. *DMI Technical Report*, **99-11**, 1999, 41pp.

Sigg, R., L. Rontu and K. Sattler, 2001: Subgrid-scale orography parameterization for HIRLAM - first experiments. *Hirlam Newsletter*, **37**, 20-34.