Parametrization of mountain-related effects in fine-scale HIRLAM - items for discussion

Laura Rontu (FMI)

During the work with a mesoscale orography (MSO) parametrization intendend for coarse resolution HIRLAM (see a report by Rontu and Sattler in this Newsletter) questions of orography-related parametrizations in fine-scale (non-hydrostatic) model arose. Usually we expect that model dynamics is able to handle generation of mountain waves and blocking or stable air without parametrizations when model's resolution is sufficiently fine. However, there are indications that the high-resolution models may have specific problems in handling the orography-related effects. E.g., results from the second COMPARE experiment, (**?**), indicated that models with a horizontal resolution of 10 km were not able to describe correctly the wave and blocking processes over a mesoscale mountain system. The resolved wave intensity tended to be overestimated and upstream blocking and related effects underestimated by the models. In their model comparison experiment related to the orography effects due to the Pyrenean mountains, these authors found that models with enhanced surface friction, i.e. with large values of orographic roughness, gave the best results in describing the mountain wave and blocking of the low level flow.

Some questions deserving further study include

- Do we see in HIRLAM the problems discussed by (**?**)?
- What could be the possible reasons of these problems: insufficient resolution, some processes missing in the model dynamics, formulation of the lower boundary condition?
- What would be sufficient horizontal and vertical resolutions for a model to handle mountain waves and blocking effects without separate parametrizations?
- At which scales of orography features should possible parametrizations of mesoscale orography, on the other hand, and of the orographic turbulence, on the other hand, be based on?
- Are the present day parametrization methods for mesoscale orography effects and orographic turbulence applicable in fine-scale models even in principle?
- How should the relationship and interaction between the MSO and turbulence parametrizations change when model's resolution increase? E.g., does the turbulence scheme automatically take care of breaking of the resolved mountain waves?
- Would it be possible to construct a simpler than the effective roughness method parametrization for the orographic turbulence? A direct parametrization for turbulent momentum fluxes due to orography is proposed by (Wood et al., 2001; Brown and Wood, 2001)?
- If an enhancement of the resolved blocking is needed, simple parametrization could possibly be based on resolved orography. Including of directional effects is important and needs additional study.

A possible scenario for further development of orography-related parametrizations in HIRLAM could include different approach for coarse and fine resolution models.

Orography parametrizations for HIRLAM-M (Medium size, around 10-50 km)

- Surface layer turbulent fluxes based on effective orographic rougness lenght and reasonable stability-dependent functions
- Mesoscale orography parametrization according to the MF MSO scheme
- Turbulence parametrizations in whole atmosphere according to the CBR scheme

Orography parametrizations for HIRLAM-XS (Extra small size, below 10 km)

- Surface layer turbulent momentum fluxes by direct parametrization and reasonable stability-dependent functions
- Enhancement of resolved blocking using resolved orography
- Turbulence scheme (CBR) for dissipation of resolved waves and handling of PBL turbulence

References

Brown, A. R., and N. Wood, 2001: Turbulent form drag on anisotropic three-dimensional orography. *Bound. Lay. Met.*, **101**, 229–241.

Wood, N., A. R. Brown, and F. E. Hewer, 2001: Parametrizing the effects of orography on the boundary layer: An alternative to effective roughness lengths. *Quart. J. Roy. Met. Soc.*, **127**, 759–777.