Many methods for dealing with the coordinate problem have been published in the past decades.

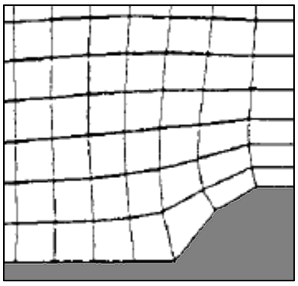

Fig. 4: Computer generated general curvilinear coordinates (Satomura 1989).

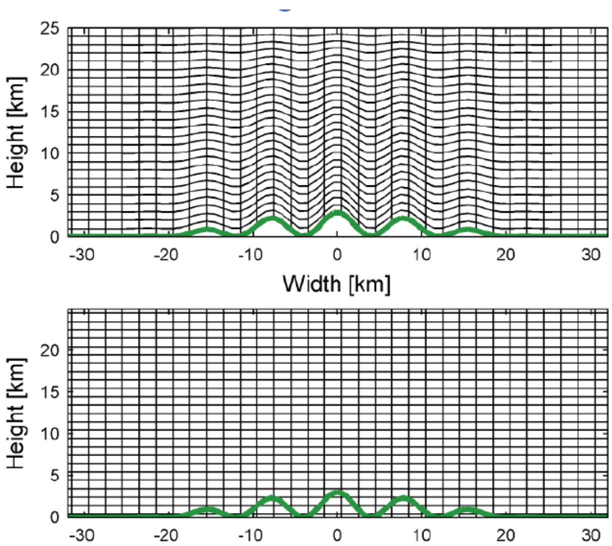

Fig. 5: Comparison of the usual sigma coordinates (above) and the immersed boundary method (below), from Lundquist et al 2008).

It is clear that the key limitation for terrain-following coordinate systems is high resolution over complex terrain with very steep slopes. Thus, models designed for this specialised application would possibly have to move to other coordinate systems in the future. Coordinate systems used in models are

– terrain-following pressure ("sigma", Figure 15) or height coordinates,
– boundary-fitting curvilinear (Figure 14), or
– Cartesian height (e.g., "immersed boundary method", IBM, Figure 15).

. Among these options, a height-based Cartesian coordinates system appears to be an attractive choice, due to the simple form that the governing equations assume. However, handling computational cells completely or partially filled by the topography is not a trivial task. In the Cartesian coordinates systems, there still exist several choices depending on how to avoid the small cell problem: an immersed boundary method (IBM, e.g., Walko et al., 2008), a cut cell (Figure 16) model with a thin-wall approximation (e.g., Steppeler et al., 2002), or a cut cell model with a cell merging method (Yamazaki and Satomura 2010, 2012, Figure 17). We are worried that the immersed boundary method and the cut cell model with the thin-wall approximation possibly obscure the lower boundary of the model (the position and the shape of the terrain). This type of coordinate system can also make only limited use of non-uniform vertical grid resolution.