(also called a model) is used to represent the effects of the smallest-scale turbulence on the resolved scales.

- Direct Numerical Simulation (DNS) models capture all of the relevant scales of turbulent motion, so no parameterization is needed of the effects of unresolved scales. This is by far the most computationally demanding type of CFD modeling, and has limited use for complex processes.

The LES-type models are the ones most commonly used for research and practical applications in the atmospheric sciences. As an example of LES-model applications, an intercomparison of simulations of the stable boundary layer by eleven LES models was undertaken as part of the Global Energy and Water-cycle EXperiment (GEWEX) Atmospheric Boundary-Layer Study (GABLS). See Holtslag (2006) for a description of GABLS and Beare *et al.* (2006) for a summary of the LES models used in the study.

15.3 Scale distinctions between mesoscale models and LES models

Using the terminology of Wyngaard (2004), let Δ represent the scale of the spatial filter associated with the solution of the equations of motion and l be the scale of the energy-containing turbulence. Figure 15.1 shows a schematic of a turbulent-energy spectrum, as

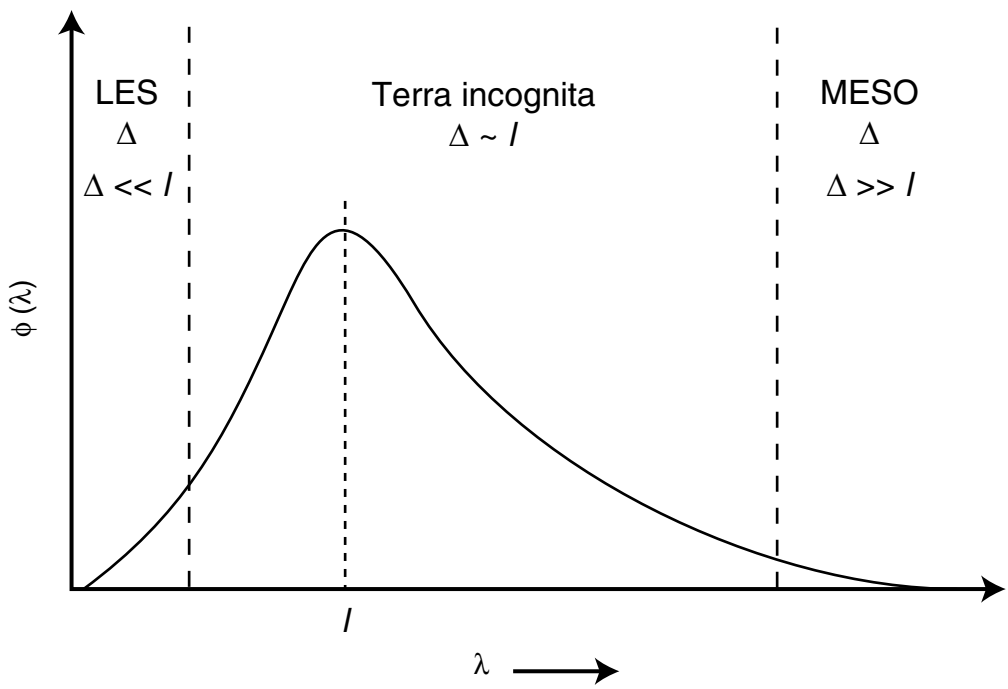

Fig. 15.1 Schematic of a turbulent-energy spectrum, as well as spatial-filter length scales (Δ) for LES and mesoscale (MESO) models. The variable l is the scale of the energy-containing turbulence, Φ is turbulent energy, and λ is wavelength. See the text for details. Adapted from Wyngaard (2004).