Part II
Water Flow and Solute Transport Models at the Catchment Scale

The aim of this, second part of the book, is to demonstrate: (1) how elemental processes as presented in the first part of the book can manifest at the mezzo-(regional) scale, and (2) how rational approaches from the elementary theory of the overland flow dynamics can be meaningfully applied to analyzing mezzo-scale hydrological processes. Although these issues are related to the global upscaling problem, the latter is not particularly relevant to the present analysis.

The emphasize will be put on the lumped-conceptual approach, explicitly or implicitly. According to that the catchment (watershed) is considered as a single homogeneous unit (e.g., a whole river basin) considering as a time-invariant system with a limited number of average/effective parameters, i.e. spatial variability in physical properties is ignored. Also the rainfall is considered to be spatially uniform over the catchment. In other word, a catchment is considered here as a control volume which is characterized by a well-defined hydrological structure (Chap. 5). It is worth mentioning that, as noted earlier, the terms catchment and watershed are used interchangeably without defining the distinctions between them to refer to a drainage area (basin) characterized by all runoff being conveyed to the same outlet.

According to viewpoints of some authors, errors in runoff predictions that are based on lumped hydrological models are not due to neglecting the special variability of hydrological parameters and input data within a particular catchment, but mostly result from errors related to a selection of model structure. It was shown that if the structure of a lumped model is adequate to describe the catchment nature and a model is properly calibrated, it can produce predictions that are almost identical to those generated by a distributed model (Das et al. 2008; Kling and Gupta 2009). Lumped-parameter models can be simply validated with the available hydrological data and global tracer concentration measurements (Maloszewski et al. 2000).

Finally, such lumped-concept may provide a basis for semi-distributed (spatially lumped continuous) models (Karnieli et al. 1994; Sheffer et al. 2010), where the catchment area is considered as a series of isolated or interconnected cell units/subcatchments (each cell produces the surface runoff, evapotranspiration and seepage losses as a response to rainfall input based on simple infiltration or saturation excess concept). The lateral flow component between the spatially lumped cells is ignored.

The lumped-parameter formulation of the water budget and flow problems significantly simplifies the solving of solute transport problem and makes practically possible the long-range prediction of chemical component distributions between the near-surface domains relying on a restricted number of hydrogeological parameters (Chap. 6).

Physically based, distributed-parameter models that are based on rigorous mathematical formulations of physical laws governing the coupled surface and subsurface flow and solute transport will be introduced as well, and practical application of a numerical simulator from this software family will be given in the conclusion Chap. 7 of the book.

References

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