Preface

Point of departure

In 1966 the first colloquium on 'Water in the unsaturated zone' at Wageningen was organized by UNESCO in co-operation with the International Association of Scientific Hydrology (IAHS). Since then continuous activities have evolved on measurement and modeling of soil water flow, hysteresis, root water uptake, preferential flow in swelling and shrinking clay soils as well as in water-repellent non-structured soils, transport of solutes including nutrients and pesticides, application of agrohydrological models to regional scales, inverse modeling to estimate effective soil hydraulic parameters, and remote sensing to estimate regional evapotranspiration and soil moisture.

Objectives

The overall purpose of the present symposium was to discuss history and assumptions that have been made and applications that have been performed for a number of different research areas in unsaturated-zone hydrology, finally leading to a research agenda for the future. This volume is a reflection of these discussions. A synthesis will be made of Strengths, Weaknesses, Opportunities and Threats for each of the four research themes and of the three application areas; this synthesis will be published as a separate paper in a scientific journal.

Unsaturated zone

The unsaturated zone comprises the section of the hydrological cycle that through its soil – water – vegetation system connects the atmosphere with the groundwater system by converting the infiltrating rainfall into groundwater recharge and the evaporative demand into uptake of groundwater. As a consequence, biogeochemical reactions in the unsaturated zone are intense and diverse. Hence, the unsaturated zone has a paramount effect on the chemical composition of the soil water solution. The description of *water flow and solute movement* in soils is strongly affected by irregular flows in structured soil and preferential flow in soils with unstable wetting fronts. Heterogeneity of soil properties further limits our capability of prediction. Also practical and reliable transfer from plot to regional scale, without losing the actual physical behavior of the system, has not been made so far. This has serious implications for the analysis, validity and consequences of policy measures. *Soil – vegetation – atmosphere interactions* determine to a large extent the regional climate and the behavior of the hydrological cycle. Soil moisture content is the most important state variable in the continental hydrological cycle, as it controls the partitioning of available energy into latent heat (evapotranspiration) and sensible heat. As such, soil moisture controls climate variability in continental climates to a large extent. Previous land-surface parameterization schemes that were applied in regional atmospheric climate models failed, because of deficiencies in the description of the soil hydraulic properties and the rooting depth and because of improper handling of the lower boundary condition. Recently a considerable amount of energy has been put into the characterization of the *interaction between the unsaturated and saturated zone*. Due to the different concepts of the models, the interaction between both zones

has led to different approaches. Therefore more attention should be paid to characterization of the concepts used to couple the saturated and unsaturated zone, the scales in space and time that are appropriate for the coupling, and the ways of parameterization considering the scales used in the modeling. *Remote sensing* can be applied to unsaturated-zone hydrology in various ways and on various scales. Because of the spatial characteristics of remotely-sensed applications, the scale on which one can effectively apply these tools begins at field scale and is by nature at least two-dimensional. Thus far the potential of space measurements to study land surface processes has been demonstrated, but a complex variable such as evapotranspiration cannot be measured directly from space. One of the main questions with respect to remote-sensing measurements and hydrological models to be solved is: "How do we achieve consistency of what we measure with what we try to model?". Mankind uses at present more than half of all accessible fresh water, and underground water resources are being depleted rapidly in many areas. Accelerating demand is exceeding the finite resources over widening regions of the globe. The rising threat from floods and droughts, erosion, pollution, salinization and climate change is imminent. We therefore need to *manage and develop our water resources in a scientifically better way* in order to meet current human needs while preserving the environment and natural resources.

Research areas and applications considered

- Concepts and dimensionality in modeling unsaturated water flow and solute transport
- Parameterization of the soil – water – atmosphere transfer through vegetations
- Unsaturated – saturated water flow and solute transport and relation to surface water: regional scale
- Observing the soil – vegetation system: measurements and models
- Applications :
    - Irrigation, drainage and salt management
    - Soil moisture and natural vegetation
    - Soil moisture, pesticide and nutrient dynamics

Acknowledgments

We are very grateful to J.P.M. Witte, P. Droogers, M. Menenti, W.G.M. Bastiaanssen, P. Kabat and J.G. Kroes for their contribution to the scientific co-ordination of the symposium, to a large number of external reviewers for their critical and constructive comments, to R.J. Bogers (Frontis) for critically reading the manuscripts, to P. van Vredendaal (Wageningen UR Library) for the technical editing and to P.M.E. van Boetzelaer (Frontis) for the pleasant way she organized the symposium.

Scientific editors,

R.A. Feddes, G.H. de Rooij and J.C. van Dam

Wageningen, August 2004