



# Exchange Processes at the Land Surface for a Range of Space and Time Scales

Edited by

**H.-J. BOLLE**

*Institut für Meteorologie, Freie Universität Berlin,  
Carl-Heinrich-Becker-Weg 6-10, 1000 Berlin 41, Germany*

**R. A. FEDDES**

*Department of Water Resources, Agricultural University, Nieuwe  
Kanaal 11, 6709 PA Wageningen, The Netherlands*

**J. D. KALMA**

*CSIRO Division of Water Resources, Canberra Laboratories, GPO  
Box 1666, Canberra City, ACT 2601, Australia*



Proceedings of an international symposium held in Yokohama, Japan, 13-16 July 1993. The Symposium was jointly organized by the International Association of Hydrological Sciences (IAHS) and the International Association of Meteorology and Atmospheric Physics (IAMAP) and co-sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO).

6984

IAHS Publication No. 212

## Contents

Preface by H.-J. Bolle, R. A. Feddes, J. D. Kalma & M. Tani

v

### General Introduction

Scientific goals of the IGBP Core Project "Biospheric Aspects of the Hydrological Cycle" <i>Hans-Jürgen Bolle</i>	3
Goals and implementation of the UNESCO/IHP Project H-1-1 "Review of the scientific aspects of the interface processes of water transport through the atmosphere-vegetation-soil system at elementary plot, catchment and large grid-size scales" <i>Jetse D. Kalma &amp; Reinder A. Feddes</i>	13

### 1 Evaporation from Homogeneous Vegetation Stands

Estimation of evapotranspiration from a Castanopsis cuspidata forest using the eddy correlation method <i>K. Mizutani &amp; T. Ikeda</i>	21
Comparison of transpiration rate measured by heat pulse method and water uptake rate in single trees of Chamaecyparis obtusa and Pinus densiflora <i>Y. Kominami &amp; M. Susuki</i>	27
Experimental determination of the dependence of transpiration rate on the stage of plant growth <i>O. Ye. Busarova, L. Ya. Dzhogan, E. A. Lozinskaya &amp; O. N. Nasonova</i>	35
Estimating seasonal variations of canopy resistance for the mapping of evapotranspiration at a forested watershed <i>Nobuhiro Ebisu &amp; Shigeru Ogawa</i>	41
The factor analysis of research data from the Beskydy experimental basins <i>A. Chlebek &amp; M. Jarabac</i>	49
Estimation of the water storage capacity of forest soils in Tsukuba Forest Experimental Basin, Japan <i>Y. Ohnuki, S. Yoshinaga &amp; S. Noguchi</i>	55
Apportionment of evapotranspiration of a deciduous broad-leaved forest in the Yamashiro catchment <i>K. Tamai &amp; S. Hattori</i>	61

### 2 Evaporation from Inhomogeneous Terrain

Method of LAI information convolution for estimating heat and vapor fluxes over non-homogeneous land surface <i>L. Ya Dzhogan &amp; E. A. Lozinskaya</i>	69
Evaporation from a complex land-use surface – How to estimate average evaporation <i>Y. Kuzuha, S. Ikebuchi &amp; K. Tanaka</i>	73
Heat and water transfer in surface soil layers of forest <i>I. Hosoda, Y. Tsuboyama &amp; S. Noguchi</i>	81
Estimation of soil, lake and catchment evaporation by either physical or climatic approach methods <i>Guo Sheng Lian</i>	89
A climatic method for estimating water resources based on the principles of water and heat balance <i>Liu Chunzhen &amp; Pei Buxiang</i>	97

### 3 Fluxes from Inhomogeneous Areas

Modelling terrestrial water and energy balances at local ( $1 \text{ km}^2$ ) scales <i>R. Silberstein &amp; M. Sivapalan</i>	105
Linking hydrologic parameterizations across a range of scales: hillslope to catchment to region <i>Murugesu Sivapalan</i>	115
Upscaling of Richards' equation for soil moisture dynamics to be utilized in mesoscale atmospheric models <i>Zhi-Qiang Chen, M. L. Kavvas &amp; R. S. Govindaraju</i>	125
Mapping of scale-representative fluxes in inhomogeneous areas <i>A. N. Zolotokrylin &amp; N. N. Samarina</i>	133
Estimation model of single tree transpiration based upon heat pulse velocity and micrometeorological data <i>M. Hashino &amp; H. Yoshida</i>	137

### 4 Regional and Local Effects on Fluxes

The effect of the temperature gradient on the evaporation from bare soils with dry surfaces <i>Tetsuo Kobayashi</i>	147
A comparison between measured local scale suburban and areally-averaged urban heat and water vapour fluxes <i>H. A. Cleugh &amp; C. S. B. Grimmond</i>	155
The role of "rural" in comparisons of observed suburban-rural flux differences <i>C. S. B. Grimmond, T. R. Oke &amp; H. A. Cleugh</i>	165
Thermally induced local wind passing a mountain ridge <i>Fujio Kimura &amp; Tsuneo Kuwagata</i>	175
Heating of paved ground and its effects on the near surface atmosphere <i>Takashi Asaeda, Vu Thanh Ca &amp; Akio Wake</i>	181
Boundary layer structure and heat budget of sea breeze circulation <i>T. Kuwagata, J. Kondo &amp; M. Sumioka</i>	189
On the estimation of the exchange parameters and turbulence intensities and their variability at a coastal terrain <i>R. Ramachandran, K. Sen Gupta, K. Narayanan Nair, P. K. Kunhikrishnan &amp; J. Winston Jeeva Prakash</i>	195

### 5 Heat, Water and Salt Transport in Soils

Modelling heat transport from the earth's surface through aquifers to springs: theoretical examples and case studies <i>J. Bundschuh</i>	205
Hierarchically structured hydrological process studies to regionalize interflow in a loess covered catchment near Heidelberg, Germany <i>W.-A. Flügel</i>	215
Field techniques for estimation of recharge using a soil water balance approach <i>P. N. J. Lane, S. Theiveyanathan, R. A. Vertessy &amp; E. M. O'Loughlin</i>	225
Characteristics of pipe flow in forested slopes <i>Hikaru Kitahara</i>	235
Water and salt transport in a sandy soil-soybean root system <i>K. Momii, J. Nozaka &amp; T. Yano</i>	243
Water exchange processes at the land surface <i>Liu Suxia &amp; Mo Xingguo</i>	249

Water exchange processes at the land surface <i>Liu Suxia &amp; Mo Xingguo</i>	249
Changes in soil physical properties due to surface crust formation under simulated rainfall <i>T. Nishimura, M. Nakano &amp; T. Miyazaki</i>	253
The role of climate, soil properties and vegetation in controlling soil moisture in the Sudano-Sahelian zone of Nigeria <i>Lekan Oyebande &amp; Idowu Balogun</i>	259
Unsaturated flow in an evaporative regime and cation exchange in soils <i>R. T. Raju, K. Jinno &amp; S.-I. Wada</i>	263

## 6 Modelling and Estimation of Hydrological Balance Parameters

Characterization and parameterization of the physical and hydrological processes of the Niger Delta wetland soils <i>I. Balogun &amp; L. Oyebande</i>	273
Watershed evapotranspiration prediction using hydrologic modelling approach <i>S. Susanto</i>	281
A study of scale effects on the estimation of maximum direct runoff rates using a catchment model <i>K. Sunada</i>	289
Le rôle des mares dans le bilan hydrologique d'une région sahélienne <i>J. C. Desconnets, J. D. Taupin &amp; T. Lebel</i>	299

## 7 Scaling of Land Surface Processes

A method to bridge the gap between microscale land-surface processes and land-atmosphere interactions at regional and continental scales <i>R. Avissar &amp; F. Chen</i>	315
Aggregation of surface fluxes from partially wet mesoscale areas <i>E. M. Blyth, A. J. Dolman &amp; J. Noilhan</i>	325
Mesoscale parameterization of heat fluxes due to landscape variability for use in general circulation models <i>R. A. Pielke, G. A. Dalu, T. J. Lee, H. Rodriguez, J. Eastman &amp; T. G. F. Kittel</i>	331
The averaging of surface flux densities in heterogeneous landscapes <i>M. R. Raupach</i>	343
A large scale study of land-atmosphere interactions in the semiarid tropics (HAPEX-Sahel) <i>J.-P. Goutorbe, T. Lebel, A. Tinga, P. Bessemoulin, J. Brouwer, A. J. Dolman, E. T. Engman, J. H. C. Gash, M. Hoepffner, P. Kabat, Y. H. Kerr, B. Monteney, S. Prince, F. Said, P. Sellers &amp; J. Wallace</i>	357

## 8 Mesoscale Experiments

Components of the energy and water balance at the HAPEX-Sahel southern super-site <i>J. S. Wallace, S. J. Allen, J. H. C. Gash, C. J. Holwill &amp; C. R. Lloyd</i>	365
Evaporation and energy fluxes during EFEDA: horizontal variability and area averaging <i>A. M. Jochum</i>	373
Measurements and estimates of evaporation at a range of scales <i>Cor Hofstee, Jetse D. Kalma, Helen A. Cleugh &amp; Jorg M. Hacker</i>	381
IGBP/BAHC field experiment to address scale problems in land-surface parameterization <i>M. Sugita, I. Kayane &amp; T. Hiyama</i>	389

An overview of the HEIFE experiment in the People's Republic of China  
*Wang Jeimin, Gao Youxi, Hu Yingqiao, Shen Zhibao, Yasushi Mitsuta & Ken Sahasi*

397

## **9 Use of Remote Sensing Data for Estimating Energy and Water Vapour Fluxes**

Analysis of land-surface exchange processes in two agricultural regions in Spain using Thematic Mapper Simulator data <i>W. G. M. Bastiaanssen &amp; R. A. Roebeling</i>	407
Use of Landsat-5 TM data for the estimation of evapotranspiration for a Scottish basin <i>S. K. Ghosh &amp; G. Fleming</i>	417
Area integration of process related land-surface properties with the aid of observations from space <i>Hans-Jürgen Bolle</i>	427
Estimates of convective fluxes over sparse canopy from infrared temperature <i>J. P. Lhomme &amp; B. Monteny</i>	437

## **10 Hydrological Processes and Climate**

The atmospheric heating over snow-covered forested areas and snowmelt <i>T. Yamazaki &amp; J. Kondo</i>	447
Measurement method and main characteristics of the glacier mass balance in Asia <i>Xie Zichu &amp; Liu Chaohai</i>	453
Catchment hydrological responses to climate changes calculated from incomplete climatological data <i>Dionysia Panagoulia</i>	461
Influence of climate change on the discharge of the River Rhine – a model for the lowland area <i>B. W. A. H. Parmet &amp; M. A. M. Mann</i>	469
Estimation of impact of climate change on the peak discharge probability of the river Rhine <i>Jaap Kwadijk &amp; Hans Middelkoop</i>	479

## **11 Land Surface Processes and Climate**

Sensitivity of the global water cycle to the water-holding capacity of soils <i>P. C. D. Milly</i>	495
Moving between scales in surface hydrology: the need to reformulate physics <i>D. L. Short, P. F. Crapper &amp; J. D. Kalma</i>	503
Climate simulations of the Sahel: a comparison with surface energy balance observations <i>A. J. Dolman, S. J. Allen &amp; J. Lean</i>	513
The response of seasonal snow cover of Xinjiang Uygur Autonomy in western China to climate change <i>Cao Meisheng</i>	521
The microclimatic role of agricultural land use in moderating the thermal environment <i>H. Oue, H. Tagashira, K. Otsuki &amp; T. Maruyama</i>	527
Effects of climate change on the regional hydrological cycle in Japan <i>H. Tanakamaru, &amp; M. Kadoya</i>	535

**12 Parameterization of Land Surface Processes**

The ECHAM rainfall runoff model combined with variable soil water holding capacities <i>Lydia Dümenil &amp; Ezio Todini</i>	545
Land-surface parameterizations for climate models: a new method for composite fluxes <i>Z. L. Yang &amp; A. J. Pitman</i>	551
Parameterization of land surface evaporation by means of location dependent potential evaporation and surface temperature range <i>M. Menenti &amp; B. J. Choudhury</i>	561
Parameterization scheme of the land hydrology considering the orography at different spatial scales <i>A. B. Shmakin, A. Yu. Mikhailov &amp; S. A. Bulanov</i>	569
Dynamic framework of the coupled model of vegetation-land-surface processes <i>Ouyang Bing</i>	577
Implementing an advanced land-surface scheme into an AGCM: methodology and results <i>Z. L. Yang, A. J. Pitman &amp; A. Henderson-Sellers</i>	583

**13 Spatial Variability of Precipitation and Evaporation**

Small scale spatial variability of the annual rainfall in the Sahel <i>J. D. Taupin, A. Amani &amp; T. Lebel</i>	593
Spatial interpolation: getting a realistic estimate of general circulation model precipitation <i>W. C. Skelly</i>	603
Predicting spatially distributed evaporation using terrain, soil and land cover information <i>L. Guerra, I. D. Moore, J. D. Kalma &amp; C. Hofstee</i>	611
A method for predicting spatial distribution of evaporation using simple meteorological data <i>M. J. Varley, K. J. Beven &amp; H. R. Oliver</i>	619