Hydrology, Water Resources and Ecology in Headwaters

Edited by

K. KOVAR
National Institute of Public Health and the Environment (RIVM), PO Box 1, 3720 BA Bilthoven, The Netherlands

U. TAPPEINER
Institute of Botany, University of Innsbruck, Sternwartestraße 15, A-6020 Innsbruck, Austria, and European Academy Bozen/Bolzano, Weggensteinstraße 12/A, I-39100 Bozen/Bolzano, Italy

N. E. PETERS
US Geological Survey, 3039 Amwiler Road, Suite 130, Atlanta, Georgia 30360-2824, USA

R. G. CRAIG
Department of Geology, Kent State University, Kent, Ohio 44242, USA

Proceedings of the HeadWater'98 conference held in Meran/Merano, Italy, from 20 to 23 April 1998. This conference was jointly organized by:

the European Academy Bozen/Bolzano, Italy

the Standing Committee on Headwater Control (SCHC)

the International Association of Hydrological Sciences (IAHS)

the International Committee on Mountain Hydrology (ICMH)

The conference was sponsored and supported by: the European Union (DG XII), UNESCO (Division of Water Sciences), the FAO/European Forestry Commission (EFC) (Working Party on the Management of Mountain Watersheds), the International Association for Hydraulic Research (IAHR), the International Erosion Control Association (IECA), the International Union of Forest Research Organizations (IUFRO) (Working Group on Forest Hydrology), the World Association of Soil and Water Conservation (WASWC).

IAHS Publication no. 248
in the IAHS Series of Proceedings and Reports
Contents

Preface by Karel Kovar, Ulrike Tappeiner, Norman E. Peters & Rachael G. Craig

1 Meteorology and Climate

Sensitivity of groundwater/lake systems in the Upper Mississippi River basin, Wisconsin, USA, to possible effects of climate change Mary P. Anderson & Xiangxue Cheng 3

Measurement and simulation of runoff from Nepalese head watersheds Ludwig N. Braun, Christoph Hottelet, Markus Weber & Wolfgang Grabs 9

Changing climate and mountain streams—what do we need to know? (keynote paper) Rachael Craig 19

GEM (Generation of weather Elements for Multiple applications): its application in areas of complex terrain Clayton L. Hanson & Gregory L. Johnson 27

Precipitation interpolation in mountainous regions using multiple linear regression Lauren Hay, Roland Viger & Gregory McCabe 33

Impact of climate change on the seasonal distribution of runoff in mountainous basins in Slovakia Kamila Hlavčová & Juraj Čunderlík 39

On large-scale topographic control of the spatial distribution of extreme precipitation and floods in high mountain regions Herbert Lang & Dietmar Grebner 47

Topography effects on small-scale precipitation variability in the Swiss pre-Alps Boris Sevruk, Katarina Matokova-Sadlonova & Lubica Toskano 51

Using a Monte Carlo technique for modelling the natural variability of streamflow in headwaters of the Sierra Nevada, USA Marina Timofeyeva & Rachael Craig 59

2 Snow and Ice

Rainfall-induced high-magnitude runoff events in highly-glacierized Alpine basins David N. Collins 69

Glacier runoff in Alpine headwaters in a changing climate (keynote paper) Michael Kuhn & Nikolaus Batlogg 79

The role of snowpack in producing floods under heavy rainfall Pratap Singh, Gerhard Spitzbart, H. Hübl & H. W. Weinmeister 89

3 Soil–Plant–Water–Atmosphere Interactions

Simulation of effects of land-use changes on runoff and evapotranspiration J. Buchtele, A. Herrmann, F. Maraga & O. R. Bajracharya 99

Exchange of CO₂ and water vapour between a composite landscape and the atmosphere in the Alps Werner K. Graber, Rolf Siegwolf & Markus Furger 107

Spatial variation in evapotranspiration in Swiss Alpine regions Lucas Menzel & Herbert Lang 115
Grid-based mapping of long-term mean annual potential and actual evapotranspiration in Slovakia *Juraj Parajka & Jan Szolgay* 123

Effects of land-use changes in the Alps on exchange processes (CO$_2$, H$_2$O) in grassland ecosystems (keynote paper) *Ulrike Tappeiner & Alexander Cernusca* 131

4 Saturated and Unsaturated Zone

A detailed model to simulate heat and moisture transport in a frozen soil *Maria Laura DeAngelis & Eric F. Wood* 141

Karst springs, groundwater and surface runoff in the calcareous Alps: assessing quality and reliance of long-term water supply *Kurt Decker, Maria Heinrich, Peter Klein, Arden Kociu, Piotr Lipiarski, Herbert Pirkl, Dieter Rank & Harald Wimmer* 149

Hillslope–wetland hydrological linkages in the headwaters of a tussock grassland catchment at Glendhu, South Island, New Zealand *B. Fahey, W. B. Bowden, J. Smith & D. L. Murray* 157

Solute exchange between river water and groundwater in headwater environments (keynote paper) *Eduard Hoehn* 165

The role of near-stream riparian zones in the hydrology of steep upland catchments *Jeffrey J. McDonnell, Brian L. McGlynn, Kim Kendall, J. Shanley & C. Kendall* 173

Contribution of soil water and its flow path to stormflow generation in a forested headwater catchment in central Japan *Tadashi Tanaka & Takaya Ono* 181

5 Catchment and Streamflow Hydrology

Estimation of glacial runoff to the Tarim River, central Tien Shan *Vladimir B. Aizen & Elena M. Aizen* 191

Topographical and ecological controls of runoff generation and lateral flows in mountain catchments *Alfred Becker & Jeffrey J. McDonnell* 199

Physically-based hydrological modelling on the hillslope and micro-catchment scale: examples of capabilities and limitations *Axel Bronstert, Bernd Glüsing & Erich Plate* 207

Numerical hydrodynamic modelling of mountain streams for assessing instream habitat *Glenn Carter, Maurice Duncan & Barry Biggs* 217

A new approach for the estimation of extreme roughness in torrents by hydraulics and photogrammetry *Hanspeter Hodel, Thomas P. Kersten & Isidor Storchenegger* 225

Small-scale modelling of runoff components in an Alpine environment *Hubert Holzmann, Hans Peter Nachtnebel & Norbert Sereinig* 231

Observations on runoff generation mechanisms in small Alpine catchments *Robert Kirnbauer & Peter Haas* 239

Testing various constitutive equations for debris flow modelling *Thilo Koch* 249

The use of coupled atmospheric and hydrological models for water-resources management in headwater basins (keynote paper) *George Leavesley & Lauren Hay* 259

Baseline hillslope study prior to afforestation in the Umzimvubu headwaters of the North East Cape Province, South Africa *Simon Lorenz & Luke Esprey* 267
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nesting localized patch models and data</td>
<td>Paul Quinn, Francesc Gallart, Jerome Llatron &amp; Keith Russell</td>
<td>275</td>
</tr>
<tr>
<td>New results from sediment transport measurements in two Alpine torrents</td>
<td>Dieter Rickenmann, Vincenzo D'Agostino, Giancarlo Dalla Fontana, Mario Lenzi &amp; Lorenzo Marchi</td>
<td>283</td>
</tr>
<tr>
<td>Runoff generation process in a small limestone basin of the southern Eifel mountains</td>
<td>Wolfhard Symader &amp; Andreas Krein</td>
<td>291</td>
</tr>
<tr>
<td>Using a conceptual rainfall–runoff model on different scales by comparing a headwater with larger basins</td>
<td>Stefan Uhlenbrook, Johannes Holocher, Christian Leibundgut &amp; Jan Seibert</td>
<td>297</td>
</tr>
<tr>
<td>Modelling runoff in headwater areas using a runoff formation approach with distributed parameters</td>
<td>Tatyana A. Vinogradova</td>
<td>307</td>
</tr>
</tbody>
</table>

### 6 Tracers and Pathways

Tracer-based assessment of vulnerability in mountainous headwaters (keynote paper) | Chris Leibundgut | 317  |
Determination of the geomorphological instantaneous unit hydrograph using tracer experiments in a headwater basin | Jens Mehlhorn, Frank Armbruster, Stefan Uhlenbrook & Christian Leibundgut | 327  |
Resolving flow pathways and geochemistry in a headwater forested wetland with multiple tracers | Andrej Sirin, Stephan Köhler & Kevin Bishop | 337  |
Effect of subsurface flow on the isotopic composition of soil water in headwater basins | Maki Tsujimura, Tadashi Tanaka & Yuichi Onda | 343  |
Study of runoff generation on hillslopes using tracer experiments and a physically-based numerical hillslope model | Markus Weiler, Felix Naef & Christian Leibundgut | 353  |

### 7 Terrestrial Ecology and Limnology

Synergetic effects of organic pollution and river slope variability on the biotic continuum of the Adige River (south Tyrol, Italy) | Roberta Bottarin & Elisa Anna Fano | 363  |
Influence of surface and subsurface flow on distributions of particulate organic matter and inorganic fine particles in perialpine stream sediments | Matthias Brunke, Tom Gonser & Erwin Grieder | 371  |
Using spring biota of pristine mountain areas for long-term monitoring | Marco Cantonati & Karin Ortler | 379  |
High Alpine streams as models for ecological gradients | Leopold Füreder, Cornelia Schütz, Rainer Burger & Manfred Wallinger | 387  |
Chemistry of headwater lakes studied in the EU project “Acidification of mountain lakes: palaeolimnology and ecology (AL:PE)” (keynote paper) | Rosario Mosello, Angela Boggero, Aldo Marchetto, Bente Wathne & Leif Lien | 395  |
Measuring and modelling the dynamic response of remote mountain lake ecosystems to environmental change: an introduction to the MOLAR project | Simon Patrick, Richard W. Battarbee, Bente Wathne & Roland Psenner | 403  |
The influence of flow variation on the ability to evaluate the biological health of headwater streams Charles F. Rabeni & Gregory S. Wallace 411

The Val Roseg project: temporal and spatial patterns of benthic algae in an Alpine stream ecosystem influenced by glacier runoff Urs Uehlinger, Rainer Zah & Hansruedi Bürgi 419

The Val Roseg project: habitat heterogeneity and connectivity gradients in a glacial flood-plain system James V. Ward, Peter Burgherr, Mark O. Gessner, Florian Malard, Christopher T. Robinson, Klement Tockner, Urs Uehlinger & Rainer Zah 425

8 Water Quality

Trace element chemistry of glacial meltwaters in an Alpine headwater catchment Giles H. Brown & Ron Fuge 435

The nitrogen content of rivers in upland Britain: the significance of organic nitrogen P. J. Chapman, A. C. Edwards, B. Reynolds, M. S. Cresser & C. Neal 443

Riparian control of stream-water chemistry: Implications for hydrochemical basin models Richard P. Hooper, Brent T. Aulenbach, Douglas A. Burns, Jeffrey McDonnell, James Freer, Carol Kendall & Keith Beven 451

Predicting water chemistry from drainage basin characteristics in stream systems Martin Kernan & Timothy Allott 459

Neural network modelling of NO₃⁻ time series from small headwater catchments Gunnar Lischeid, Holger Lange & Michael Hauhs 467

Critical load of acidity for a forest ecosystem in the Black Forest, Germany Henning Meesenburg & Heidulf E. Müller 475

Tracing solute mobility at the Panola Mountain Research Watershed, Georgia, USA: variations in Na⁺, Cl⁻, and H₄SiO₄ concentrations (keynote paper) Norman E. Peters, Elizabeth B. Ratcliffe & Martyn Tranter 483

Response of discharge and water quality in headwater brooks on distinct hydroclimatic conditions in the Tyrolean Alps Hansjörg Thies, Ulrike Nickus & Roland Psenner 491

9 Socio-Economic Aspects and Management

A survey of running waters in the Venosta Valley (Alto Adige/South Tyrol, Italy) Vito Adami 501

Methodology for assessment of ecohydrological effects of dam construction in a headwater region Antje Giers, Elke Freistuhler & Gert A. Schultz 509

Comparison of the hydrology of two contrasting headwater catchments in Zimbabwe Matthew McCartney, John Butterworth, Patrick Moriarty & Richard Owen 515

Socio-economic factors in headwater land management (keynote paper) Erich Plate 523

Catchment hydrology and status of chum salmon in Washington State Robert C. Wissmar 535
10 Application of Geographical Information Systems

The definition of stream channel head location using digital elevation data
G. B. Bischetti, C. Gandolfi & M. J. Whelan  545

GIS indicators for sediment sources study in Alpine basins
Giancarlo Dalla Fontana & Lorenzo Marchi  553

Modelling high magnitude events in large arid catchments—a field based approach in Nahal Zin, Israel
Jens Lange, Christian Leibundgut, Noam Greenbaum & Asher P. Schick  561

Application of GIS for hydrological modelling in high mountain areas of the Austrian Alps
Andreas Schild, Pratap Singh & Johannes Hübl  569