Hydroclimatology provides a systematic structure for analyzing how the climate system causes time and space variations (both global and local) in the hydrologic cycle. Changes in the relationship between the climate system and the hydrologic cycle underlie floods, drought, and possible future influences of global warming on water resources. Land-based data, satellite data, and computer models contribute to our understanding of the complex time and space variations of physical processes shared by the climate system and the hydrologic cycle.

Blending key information from the fields of climatology and hydrology—which are not often found in a single volume—this is an ideal textbook for students in atmospheric science, hydrology, Earth and environmental science, geography, and environmental engineering. It is also a useful reference for academic researchers in these fields.

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Hydroclimatolgy

Perspectives and Applications

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University of California, Davis, USA
CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi
Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK
Published in the United States of America by Cambridge University Press, New York
www.cambridge.org
Information on this title: www.cambridge.org/9780521848886

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First published 2009

Printed in the United Kingdom at the University Press, Cambridge

A catalog record for this publication is available from the British Library

Library of Congress Cataloging in Publication data
Shelton, Marlyn L.
p. cm.
Includes bibliographical references.
ISBN 978-0-521-84888-6
1. Hydrologic cycle. 2. Climatology. 3. Hydrometeorology. I. Title.
GB848.S54 2009
551.48–dc22
2008040772

ISBN 978-0-521-84888-6 hardback

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Contents

Preface  page ix

1  The realm of hydroclimatology  1
   1.1  Water as a unifying concept  1
   1.2  The global hydrologic cycle  5
   1.3  Hydroclimatology defined  6
   1.4  Emergence of the hydrologic cycle  8
   1.5  Two climates for two hydrologic cycles  14
   1.6  Hydroclimatic data  21
   1.7  Data quality  21
       Review questions  23

2  The climate system and the hydrologic cycle  24
   2.1  Climate and water  24
   2.2  Scale considerations  25
   2.3  Dynamic climate  26
   2.4  The climate system  27
   2.5  The atmospheric subsystem  30
   2.6  Feedbacks  31
   2.7  The hydrologic cycle  32
   2.8  The radiation balance  34
   2.9  Selective atmospheric response to solar radiation  39
   2.10  Terrestrial radiation and the greenhouse effect  43
   2.11  Global radiation balance  45
   2.12  Surface radiation balance  47
   2.13  Planetary energy balance  48
   2.14  The water balance  49
       Review questions  54
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3.1</td>
<td>An atmospheric focus</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>3.2</td>
<td>Surface data</td>
<td>56</td>
</tr>
<tr>
<td>3</td>
<td>3.3</td>
<td>Radiation</td>
<td>57</td>
</tr>
<tr>
<td>3</td>
<td>3.4</td>
<td>Temperature</td>
<td>61</td>
</tr>
<tr>
<td>3</td>
<td>3.5</td>
<td>Atmospheric pressure</td>
<td>63</td>
</tr>
<tr>
<td>3</td>
<td>3.6</td>
<td>Humidity</td>
<td>66</td>
</tr>
<tr>
<td>3</td>
<td>3.7</td>
<td>Radiosonde upper-air measurements</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Review questions</td>
<td>73</td>
</tr>
<tr>
<td>4</td>
<td>4.1</td>
<td>A terrestrial focus</td>
<td>74</td>
</tr>
<tr>
<td>4</td>
<td>4.2</td>
<td>Terrestrial hydroclimatic data</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>4.3</td>
<td>Precipitation formation</td>
<td>76</td>
</tr>
<tr>
<td>4</td>
<td>4.4</td>
<td>Rainfall</td>
<td>78</td>
</tr>
<tr>
<td>4</td>
<td>4.5</td>
<td>Snowfall</td>
<td>80</td>
</tr>
<tr>
<td>4</td>
<td>4.6</td>
<td>Wind</td>
<td>86</td>
</tr>
<tr>
<td>4</td>
<td>4.7</td>
<td>Soil moisture</td>
<td>88</td>
</tr>
<tr>
<td>4</td>
<td>4.8</td>
<td>Evaporation and evapotranspiration</td>
<td>102</td>
</tr>
<tr>
<td>4</td>
<td>4.9</td>
<td>Streamflow</td>
<td>117</td>
</tr>
<tr>
<td>4</td>
<td>4.10</td>
<td>Estimating areal hydroclimatic data</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Review questions</td>
<td>125</td>
</tr>
<tr>
<td>5</td>
<td>5.1</td>
<td>Remote sensing data</td>
<td>126</td>
</tr>
<tr>
<td>5</td>
<td>5.2</td>
<td>Satellites</td>
<td>128</td>
</tr>
<tr>
<td>5</td>
<td>5.3</td>
<td>Radiation data from satellites</td>
<td>140</td>
</tr>
<tr>
<td>5</td>
<td>5.4</td>
<td>Remotely sensed temperature</td>
<td>142</td>
</tr>
<tr>
<td>5</td>
<td>5.5</td>
<td>Derived pressure from satellite data</td>
<td>144</td>
</tr>
<tr>
<td>5</td>
<td>5.6</td>
<td>Atmospheric humidity from satellites</td>
<td>145</td>
</tr>
<tr>
<td>5</td>
<td>5.7</td>
<td>Rainfall remote sensing</td>
<td>146</td>
</tr>
<tr>
<td>5</td>
<td>5.8</td>
<td>Snow remote sensing</td>
<td>153</td>
</tr>
<tr>
<td>5</td>
<td>5.9</td>
<td>Surface wind remote sensing</td>
<td>159</td>
</tr>
<tr>
<td>5</td>
<td>5.10</td>
<td>Soil moisture remote sensing</td>
<td>160</td>
</tr>
<tr>
<td>5</td>
<td>5.11</td>
<td>Evapotranspiration remote sensing</td>
<td>162</td>
</tr>
<tr>
<td>5</td>
<td>5.12</td>
<td>Runoff remote sensing</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Review questions</td>
<td>164</td>
</tr>
<tr>
<td>6</td>
<td>6.1</td>
<td>Transforming precipitation into runoff</td>
<td>165</td>
</tr>
<tr>
<td>6</td>
<td>6.2</td>
<td>Factors affecting runoff</td>
<td>165</td>
</tr>
<tr>
<td>6</td>
<td>6.3</td>
<td>Precipitation input</td>
<td>168</td>
</tr>
<tr>
<td>6</td>
<td>6.4</td>
<td>Interception</td>
<td>169</td>
</tr>
<tr>
<td>6</td>
<td>6.5</td>
<td>Infiltration</td>
<td>172</td>
</tr>
</tbody>
</table>
### 6 Hydrologic Processes

- **6.6 Overland flow** 174
- **6.7 Throughflow or interflow** 174
- **6.8 Groundwater** 176
- **6.9 The hydrograph** 177
- **6.10 Rainfall runoff** 181
- **6.11 Snow and runoff** 190
- **6.12 Lakes as surface storage** 200
- **6.13 Wetlands and runoff** 203
- **6.14 Reservoirs and streamflow** 204
- **6.15 Watershed models** 207
- **Review questions** 210

### 7 Hydroclimate Spatial Variations

- **7.1 Spatial scale** 212
- **7.2 Global atmospheric hydroclimate** 213
- **7.3 The radiation balance** 214
- **7.4 Temperature** 218
- **7.5 Atmospheric humidity** 219
- **7.6 Atmospheric pressure** 223
- **7.7 Atmospheric circulation** 230
- **7.8 Global terrestrial hydroclimate** 235
- **7.9 Precipitation** 235
- **7.10 Evapotranspiration** 242
- **7.11 Soil moisture** 243
- **7.12 Runoff** 244
- **7.13 Regional hydroclimate** 248
- **7.14 Local hydroclimate** 256
- **Review questions** 260

### 8 Hydroclimate Temporal Variations

- **8.1 Temporal scale** 262
- **8.2 Earth’s climate in perspective** 264
- **8.3 Tree-ring reconstructions** 269
- **8.4 Ocean–atmosphere influences on hydroclimate** 272
- **8.5 Madden–Julian Oscillation** 273
- **8.6 El Niño, La Niña, and the Southern Oscillation** 275
- **8.7 North Atlantic Oscillation** 282
- **8.8 Pacific–North American teleconnection pattern** 284
- **8.9 Pacific Decadal Oscillation** 286
- **8.10 Recent temperature trends** 289
- **8.11 Recent precipitation trends** 293
- **8.12 Recent streamflow trends** 296
- **8.13 Recent lake level trends** 300
- **Review questions** 304
# Contents

9 Floods: the hydroclimatic extreme of excessive moisture 305

9.1 Hydroclimatic extreme events 305
9.2 Flood hydroclimatology 307
9.3 Flash floods 310
9.4 Mediterranean Europe flash floods 311
9.5 United States flash floods 315
9.6 General floods 325
9.7 The 2002 central Europe flood 326
9.8 The 1993 Midwestern United States flood 331
Review questions 343

10 Drought: the hydroclimatic extreme of deficient moisture 344

10.1 Negative moisture anomalies 344
10.2 Drought hydroclimatology 346
10.3 Drought indices 347
10.4 Proxy evidence of drought 352
10.5 Drought causes 354
10.6 West Africa Sahel drought 356
10.7 Western United States drought 361
10.8 Midwestern United States 1988 drought 364
10.9 Summer 2003 European drought 368
10.10 Drought and wildfires 373
10.11 Looking ahead 379
Review questions 382

References 383
Index 418
Preface

Droughts, floods, heatwaves, and other extreme weather events often have disastrous consequences for society and for the infrastructure that provides our goods and services. An increasing global population with an increasing population occupying areas subject to extreme weather events has heightened awareness of the potential impact of climate and weather and extreme events on our daily lives. This new awareness is occurring at a time when a consensus in the scientific community supports the idea of climate change and that at least a part of the change in recent decades is due to human activity. Against this backdrop we have advances in satellite and computer technology that permit us to examine natural processes in ways that were not possible in the recent past. Hydroclimatology is an area that benefits from these advances as it endeavors to improve understanding of the linkages between the climate system and the hydrologic cycle.

A global view provides a sense of the immensity and complexity of the Earth’s climate system and the hydrologic cycle. An important suite of climatic processes involves atmospheric moisture, atmospheric energy storage in the form of latent heat, and energy transport by the atmosphere. The heating and cooling of the atmosphere and atmospheric motion define a climatic perspective easily related to the atmospheric branch of the hydrologic cycle that is dominated by moisture transport accomplished by the mobile atmosphere. At regional and local scales, additional processes are introduced into the climatic and hydrologic cycle perspectives as land surface differences exert strong influences on the exchanges of energy and mass between the Earth’s surface and the atmosphere. Climate-related fluxes at the Earth’s surface are vertically oriented, and hydrologic processes are altered by the character of soil and vegetation. The perspectives of climate and the hydrologic cycle at the Earth’s surface have separate sets of variables that complement atmospheric processes but require different observational data.
Hydroclimate incorporates the atmosphere, the oceans, and the land surface and how these realms are coupled by exchanges of energy, mass, and momentum. A comprehensive treatment of the physical processes involved in linking the atmosphere, oceans, and land surface is complicated by our incomplete understanding of many of the natural processes and their variable nature at different time and space scales. Since many earth science sub-disciplines are involved, choices must be made to keep the topic manageable. Consequently, an effort is made in this book to provide a sense of the complexity and interconnectedness of hydroclimatic processes without going into excessive detail in any one area.

This book is intended for students studying atmospheric science and/or climatology and those specializing in hydrology. Chapters 1 and 2 set the conceptual structure of hydroclimatology. Two climate paradigms are introduced to complement the recognized atmospheric and terrestrial branches of the hydrologic cycle and their links with the climate system. Measurement and estimation of hydroclimatic variables are addressed in Chapters 3, 4, and 5. Atmospheric data in Chapter 3 are familiar to atmospheric science students, while data measurements at the Earth’s surface covered in Chapter 4 are familiar to hydrology students. Remote sensing in Chapter 5 focuses on satellite and radar data specifically relevant to hydroclimatic analysis. Chapter 6 addresses the runoff process and is intended to provide background in hydrology for atmospheric science students. Hydrology students will benefit most from the spatial and temporal variability of atmospheric phenomena and the interaction of surface and atmospheric events emphasized in Chapters 7 and 8. Floods and drought, Chapters 9 and 10, respectively, provide opportunities for all students to examine the circumstances surrounding the occurrence of extreme weather events and the role played by complex atmospheric circulation features and distant climatic circumstances that influence these events.

The goal of this book is to promote understanding of hydroclimatic diversity, the link between climate and the water resource, and the possible influence of climate change on the future hydroclimate and water resource. Recent hydroclimatic studies utilize contemporary data observation methodologies and improved estimation techniques to achieve expressions of relevant variables. Complex scientific questions arise in efforts to understand the relationships between the climate system and the hydrologic cycle. The impacts of natural climate variability and human-induced change contribute to the complexity. Floods, drought, desertification, agriculture and food production, municipal and industrial water supplies, and water quality are some of the areas requiring carefully formulated plans for sustaining future development. Floods and drought addressed in Chapters 9 and 10 illustrate the character of the complex
problems. Faced with such challenges, hydroclimate provides a structure for systematic analysis of atmospheric, hydrologic, and biologic variables related to these areas of human concern.

The analytical perspective employed in this book is based on principles that portray hydroclimate as the relationship between flows or exchanges of energy and moisture between the atmosphere and the Earth’s surface. The water balance provides the operational framework for characterizing hydroclimate, the spatial and temporal variations of hydroclimate, and hydroclimate resulting from altered future conditions. Real-world hydrologic events occur within the context of a history of climatic variations in magnitude and frequency. These events have the best chance of being understood when analyzed within the spatial framework of regional and global networks of changing atmospheric circulation patterns and land surfaces processes.

The late Professor Douglas B. Carter shared his vision of climate expression with me, and his vision became the foundation for the dual-climate paradigm developed in this book. The book concepts evolved from 10 years of teaching undergraduate and graduate students in ATM 115 and ATM 215 at the University of California, Davis. I profited greatly from student comments and from discussions with my colleagues at UC Davis for which I am grateful. I am indebted to David Jones who applied his professional skills in extracting data from many digital data archives and converting the data into attractive and informative global and regional maps. The competence, courtesy, and patience of Matt Lloyd and the other staff of the Cambridge University Press were invaluable in the preparation of this book.

This book is dedicated to my family. I am especially indebted to my wife, Sue, whose love, encouragement, understanding, and assistance were constant during the book’s lengthy preparation. My son, Kirk, daughter-in-law, Rachel, and my grandchildren, Scott and Emma, are the promise that the continuing search for understanding of God’s magnificent world is in good hands.