

Contents

Preface	VII
James Dooge — Curriculum vitae	IX
James Dooge — List of publications	XI
List of contributors	XXIII

PART A. HYDROLOGICAL PROCESSES

Chapter 1. Linear theory of open channel flow by Jarosław J. Napiórkowski	3
Abstract	3
1. Introduction	3
2. Linearization of the St. Venant equations	4
3. Solution for finite channel reach	6
4. The generalized linear channel response	10
4.1. Cumulants of generalized channel response	10
4.2. Amplitude and phase characteristics	12
5. Simplified forms of St. Venant equations	13
6. Conclusions	14
References	14
Chapter 2. Analytical and numerical modelling of unsaturated flow by Q.J. Wang	17
Abstract	17
1. Introduction	17
2. Physics of soil moisture flow	18
3. Reduced form of Richards' equation	19
4. Closed form solutions for constant D and linear K^* model	20
5. Effect of assumptions on D and K^* functions	23
6. A proposed hybrid solution scheme for future research	24
References	25
Chapter 3. The hydrology of milled peat production by J. Philip O'Kane	27
Abstract	27
1. Introduction	27
2. The peat–water system	28

2.1. Peat as a fuel	28
2.2. The peat–air–water system	29
2.3. Water content and heating value	30
3. Water movement in a peat column	31
3.1. Equations of motion and of continuity	31
3.2. Potential energy and the phase-partitioning of water	32
3.3. Liquid and vapour conductivities	33
4. Boundary conditions at the pedon scale	34
4.1. The drainage boundary condition at the bottom	34
4.2. Surface boundary condition for infiltration of rain	35
4.3. Surface boundary condition for isothermal evaporation	36
5. The drying of a layer of milled peat	37
5.1. Modelling milling and harrowing	37
5.2. Numerical treatment	38
5.3. The two phases of evaporation	39
5.4. The role of harrowing	41
6. Conclusions	43
Acknowledgements	44
References	45

Chapter 4. Role of active–passive scalar relationships in evaporation from vegetated surfaces

by Gordon A. McBean	47
Abstract	47
1. Introduction	47
2. Efficiency of evaporation	48
3. Concept of active and passive scalars	50
4. Impact of K_E/K_H ratio on traditional methods of estimating evaporation from vegetated surfaces	53
5. Concluding remarks	55
References	56

Chapter 5. On the weights of precipitation stations

by M. Sugawara	59
Abstract	59
1. The Thiessen polygon method is illogical	59
2. Weights should be determined considering the reliability of observed data	61
3. Weights of precipitation stations should be determined to obtain good results in discharge calculation or flood forecasting	62
4. How to determine the weights of precipitation stations	63
5. The problem	65
6. The singular matrix (A_{ij})	66
7. The method of principal axis transformation	67
8. Factor analysis	69
9. Orthogonal expansion of the runoff	70

10. The precipitation weights	72
11. The determination of the cut-off point k'	74
References	74

Chapter 6. A Neyman-Scott shot noise model for the generation of daily stream-flow time series

by P.S.P. Cowpertwait and P.E. O'Connell	75
Abstract	75
1. Introduction	75
2. Definition of a second order Neyman-Scott shot noise (NSSN) model	76
3. Some moments of the Neyman-Scott shot noise model	78
4. Some special cases	81
5. Fitting the NSSN model to historical daily flows	81
6. Model validation	86
7. Discussion and epilogue	91
Acknowledgements	93
References	94

PART B. LARGE-SCALE HYDROLOGY

Chapter 7. Criteria for a hydrologically sound structuring of large scale land surface process models

by Alfred Becker	97
Abstract	97
1. Introduction	97
2. Scales in hydrology and related categories of hydrological models	98
3. Critical concepts in macroscale hydrological modelling at land surfaces	100
4. Hydrologically sound structuring of macroscale models	102
5. Basic types of areal heterogeneity at land surfaces and assessment of landscape patchiness	105
6. Hierarchy in the areal discretization of land surfaces for modelling	108
7. Criteria to delineate zones of uniform climate forcing	109
References	110

Chapter 8. The construction of continental scale models of the terrestrial hydrological cycle: an analysis of the state-of-the-art and future prospects

by L.S. Kuchment	113
Abstract	113
1. Introduction	113
2. Time-space scales and main research directions	114
3. Continental scale hydrological models with present-day space resolution of GCMs (100–300 km)	117
4. Modelling of the terrestrial hydrological cycle for a horizontal scale of 30–100 km ..	122
4.1. Basin schematisation	123

4.2. Input to finite elements	123
4.3. Soil moisture transfer and point evapotranspiration	124
4.4. Rainfall excess	124
4.5. Average surface depression interception for each finite element	124
4.6. Surface overland flow	125
5. Opportunities for developing parameterisations of the hydrological cycle for horizontal resolutions of less than 30 km	125
Acknowledgements	126
References	127

Chapter 9. A rainfall-runoff scheme for use in the Hamburg climate model

by L. Dümenil and E. Tóðini

Abstract	129
1. Introduction	129
2. Runoff in the context of general circulation models	130
2.1. Motivation	130
2.2. The ECHAM Model	132
3. Description of the Arno scheme	133
3.1. Derivation of the equations	133
3.2. Modifications for use in the OAGCM	137
4. The simulated hydrological cycle	139
4.1. Precipitation	140
4.2. Local runoff	144
4.3. Soil water	146
4.4. River gauge data	147
5. Conclusions	155
Acknowledgement	155
References	156

Chapter 10. Transient response of a coupled ocean–atmosphere–land surface model to increasing atmospheric carbon dioxide

by S. Manabe, R.J. Stouffer, M.J. Spelman and K. Bryan

Abstract	159
1. Introduction	160
2. Model structure	160
3. Numerical experiments	161
4. Temperature change	162
4.1. Annual mean response	162
4.2. Seasonal dependence	163
5. Hydrologic change	166
5.1 Annual mean response	166
5.2. Seasonal dependence	168
6. Summary and concluding remarks	169
References	171

PART C. THE PAST AND THE FUTURE

Chapter 11. Quantitative hydrology in Scandinavia in the 18th century

by Lars Gottschalk	177
Abstract	177
1. Introduction	177
2. Hydrometeorological observations	178
2.1. Observations of temperature and precipitation	178
2.2. Evaporation experiments	179
3. Water balance studies	180
4. The origin of springs	182
4.1. Rain or “underground channels”?	183
4.2. “Disappearance of water”	185
5. Conclusions	186
References	187

Chapter 12. Hydrology and hydrologists — reflections

by J.E. Nash	191
Abstract	191
1. Introduction	191
2. The alleged failure of engineering hydrology	192
3. Science or technology	193
4. Empirical hydrology	194
5. The two pillars of hydrology	194
6. The real failure of engineering hydrology	195
7. The future for hydrology	196
8. The education and training of hydrologists	196
9. Environmental awareness	198
References	199

Chapter 13. Hydrology and the real world

by J.R. Philip	201
Abstract	201
1. Introduction	201
2. Hydrology and non-linearity	201
3. Natural science and trans-science	202
4. Scientific hydrology and professional practice	203
5. Hydrology and the real world	205
6. Hydrology and faith	205
Acknowledgments	206
References	206

Chapter 14. Water and soil: circulation and risks of pollution

by George Vachaud and Michel Vauclin	209
Abstract	209

1. Introduction	209
2. Presentation of the problem	210
3. Circulation of water in the soil	211
3.1. The microscopic scale of the pore	211
3.2. The macroscopic scale: the laboratory column	211
3.3. Megascopic scale: the landscape	213
4. Transport of dissolved substances	214
5. Conclusion	217
References	217

Chapter 15. Global change, a catalyst for the development of hydrologic science

by Peter S. Eagleson

Abstract	219
1. Introduction	220
2. Historical development of hydrologic science	221
3. The geophysical basis of hydrologic science	223
4. The biogeochemical basis of hydrologic science	225
5. Some global change issues in hydrologic science	226
5.1. How do we aggregate the dynamics at various space–time scales in the presence of great heterogeneity?	227
5.2. What are the feedback sensitivities of atmospheric dynamics and climate to changes in landsurface hydrology?	228
5.3. What are the sensitivities of the methane productivity of wetlands to climate change?	229
5.4. What is the physical basis for the observed geographical distribution of the major vegetation types on earth's continents?	230
5.5. Can the dynamics of multistable nonlinear systems suggest new physical insights into the patterns of annual rainfall time series?	231
6. Hydrologic science is a distinct geoscience	233
7. Needed actions	234
Acknowledgements	235
References	235

Chapter 16. The theory of the hydrologic model, or: the struggle for the soul of hydrology

by M.B. Abbott

Abstract	237
1. Introduction: maintaining continuity in thinking through a discontinuity in thought	237
2. Navigating through a world of models: the function of the sign	238
3. Understanding through the ordering of signs	241
4. Hydrological rhetoric and its ordering in grammar	244
5. The struggle for the soul of hydrology	247
6. Does the future hold out any hope at all?	251
References	252