

Contents

Preface	<i>page xv</i>
I Introduction	1
1.1 Ecological climatology – concepts	1
1.2 Ecological climatology – applications	5
1.3 Overview of the book	8
1.4 Review questions	9
1.5 References	9
Part I The Earth System	13
2 Components of the Earth system	15
2.1 Chapter summary	15
2.2 Atmosphere	15
2.3 Hydrosphere	16
2.4 Cryosphere	18
2.5 Biosphere	18
2.6 Pedosphere	19
2.7 Humans	20
2.8 The Earth system	25
2.9 Review questions	25
2.10 References	26
3 Global cycles	28
3.1 Chapter summary	28
3.2 Scientific units	28
3.3 Energy fluxes	28
3.4 Hydrologic cycle	31
3.5 Biogeochemical cycles	34
3.6 Review questions	37
3.7 References	37
Part II Global Physical Climatology	39
4 Atmospheric radiation	41
4.1 Chapter summary	41
4.2 Solar geometry	41
4.3 Top of the atmosphere solar radiation	45

4.4	Atmospheric attenuation	46
4.5	Annual global mean energy budget	47
4.6	Planetary energy balance model	49
4.7	Review questions	49
4.8	References	50
5	Atmospheric general circulation and climate	51
5.1	Chapter summary	51
5.2	Air pressure	51
5.3	Wind	52
5.4	Large-scale atmospheric circulations	56
5.5	Continents	57
5.6	Oceans	60
5.7	Seasons	62
5.8	Review questions	67
5.9	References	67
6	Earth's climates	68
6.1	Chapter summary	68
6.2	Global climate zones	68
6.3	Regional climates	71
6.4	Forests and clearings	83
6.5	Review questions	86
6.6	References	86
7	Climate variability	88
7.1	Chapter summary	88
7.2	Floods, droughts, and heat waves	88
7.3	El Niño/Southern Oscillation	89
7.4	North Atlantic Oscillation	98
7.5	Review questions	101
7.6	References	104
8	Climate change	105
8.1	Chapter summary	105
8.2	Climate history of the last 250 000 years	105
8.3	Mechanisms of climate change	107
8.4	Climate of the twentieth century	119
8.5	Climate of the twenty-first century	122
8.6	Climate feedbacks	123
8.7	Review questions	124
8.8	References	125
Part III	Soil Processes	129
9	Soil physics	131
9.1	Chapter summary	131
9.2	Soil texture and structure	131
9.3	Soil temperature	132
9.4	Soil water	135

9.5	Review questions	140
9.6	References	140
10	Soil biogeochemistry	141
10.1	Chapter summary	141
10.2	Weathering	141
10.3	Decomposition and mineralization	144
10.4	Soil solution	146
10.5	Soil profile	148
10.6	Soil formation	149
10.7	Review questions	152
10.8	References	152
Part IV	Hydrometeorology	153
11	Water balance	155
11.1	Chapter summary	155
11.2	Cycling of water on land	155
11.3	Interception and throughfall	157
11.4	Evapotranspiration	158
11.5	Infiltration	160
11.6	Overland flow	163
11.7	Soil water	164
11.8	Water balance model	166
11.9	Review questions	167
11.10	References	168
12	Watershed hydrology	170
12.1	Chapter summary	170
12.2	Watersheds	170
12.3	Watershed studies	170
12.4	Runoff processes	173
12.5	Catchment runoff	173
12.6	Riverflow	184
12.7	Global drainage basins	184
12.8	Review questions	187
12.9	References	188
13	Surface energy fluxes	192
13.1	Chapter summary	192
13.2	Surface energy budget	192
13.3	Energy balance of Earth's surface	193
13.4	Annual cycle	195
13.5	Diurnal cycle	196
13.6	Energy balance model	199
13.7	Penman–Monteith equation	202
13.8	Soil microclimates	203
13.9	Review questions	203
13.10	References	204

14 Turbulent fluxes	205
14.1 Chapter summary	205
14.2 Turbulence	205
14.3 The statistics of turbulence	206
14.4 Eddy covariance	207
14.5 Logarithmic wind profiles	207
14.6 Monin–Obukhov similarity theory	208
14.7 Bulk transfer equations	211
14.8 Review questions	212
14.9 References	213
15 Soil moisture and the atmospheric boundary layer	214
15.1 Chapter summary	214
15.2 Boundary layer characteristics	214
15.3 Diurnal cycle	215
15.4 Soil moisture and surface fluxes	217
15.5 Surface heterogeneity and mesoscale circulations	222
15.6 Review questions	224
15.7 References	224
Part V Biometeorology	227
16 Leaf energy fluxes	229
16.1 Chapter summary	229
16.2 Leaf energy budget	229
16.3 Leaf resistances	229
16.4 Leaf fluxes and temperature	232
16.5 Leaf–air coupling	232
16.6 Leaf size and shape	234
16.7 Review questions	235
16.8 References	236
17 Leaf photosynthesis	237
17.1 Chapter summary	237
17.2 Overview	237
17.3 Light reactions	237
17.4 Dark reactions	238
17.5 Stomata	240
17.6 Net photosynthesis	241
17.7 Photosynthesis–transpiration compromise	244
17.8 A photosynthesis–stomatal conductance model	245
17.9 Coordinated leaf traits	247
17.10 Review questions	249
17.11 References	250
18 Plant canopies	253
18.1 Chapter summary	253
18.2 Leaf area index	253
18.3 Radiative transfer	253
18.4 Canopy photosynthesis	257

18.5	Canopy conductance	259
18.6	Turbulent transfer in forest canopies	262
18.7	“Big leaf” canopy models	263
18.8	Multi-layer canopy–soil models	266
18.9	Environmental controls of canopy fluxes	267
18.10	Review questions	269
18.11	References	270
Part VI Terrestrial Plant Ecology		273
19	Plant strategies	275
19.1	Chapter summary	275
19.2	Carbon balance of plants	275
19.3	Seasonality of growth and development	276
19.4	Allocation	278
19.5	Life history patterns	281
19.6	Plant functional types	287
19.7	Review questions	289
19.8	References	289
20	Populations and communities	292
20.1	Chapter summary	292
20.2	Niche and species abundance	292
20.3	Environmental gradients and communities	296
20.4	Plants in a changing environment	299
20.5	Review questions	301
20.6	References	302
21	Ecosystems	303
21.1	Chapter summary	303
21.2	The ecosystem concept	303
21.3	Ecosystem structure and function	304
21.4	Environmental controls of net primary production	307
21.5	Biogeochemical cycles	311
21.6	Forest production and nutrient cycling	314
21.7	Net ecosystem production	319
21.8	Review questions	321
21.9	References	323
22	Vegetation dynamics	326
22.1	Chapter summary	326
22.2	Population dynamics	326
22.3	Succession	329
22.4	Mechanisms of succession	338
22.5	Review questions	343
22.6	References	344
23	Disturbances and landscapes	347
23.1	Chapter summary	347
23.2	Pattern and process in plant communities	347

23.3	Forest gap dynamics	347
23.4	Fire	350
23.5	Land use	352
23.6	Review questions	360
23.7	References	361
24	Global biogeography	364
24.1	Chapter summary	364
24.2	Biogeography	364
24.3	Net primary production and plant biomass	368
24.4	Litterfall and soil carbon	373
24.5	Climate change	373
24.6	Global terrestrial ecosystem models	379
24.7	Review questions	386
24.8	References	386
Part VII Terrestrial Forcings and Feedbacks		393
25	Land surface processes in climate models	395
25.1	Chapter summary	395
25.2	Hydrometeorological models	395
25.3	Satellite land data products	401
25.4	Model validation	402
25.5	Land–atmosphere coupling experiments	408
25.6	Coupled climate–ecosystem models	409
25.7	Review questions	410
25.8	References	411
26	Seasonal-to-interannual variability	418
26.1	Chapter summary	418
26.2	Soil water	418
26.3	Snow	422
26.4	Leaf phenology	424
26.5	Review questions	427
26.6	References	427
27	Land use and land-cover change	432
27.1	Chapter summary	432
27.2	Biogeophysical processes	432
27.3	Green planet/desert planet	434
27.4	Dryland overgrazing	436
27.5	Australia	441
27.6	Tropical deforestation	445
27.7	European deforestation	449
27.8	Land clearing in the United States	450
27.9	Irrigation	456
27.10	Wetland drainage	457
27.11	Land use as a climate forcing	458
27.12	Review questions	461
27.13	References	461

28 Coupled climate–vegetation dynamics	470
28.1 Chapter summary	470
28.2 Ecosystem feedbacks on climate	470
28.3 Daisyworld	470
28.4 Northern Africa	472
28.5 Boreal forest–tundra ecotone	476
28.6 Vegetation feedback with increased atmospheric CO ₂	481
28.7 Review questions	483
28.8 References	484
29 Carbon cycle–climate feedbacks	489
29.1 Chapter summary	489
29.2 Global carbon cycle	489
29.3 Carbon storage on land	492
29.4 Carbon and climate change	500
29.5 Coupled carbon cycle–climate models	502
29.6 Mineral aerosols	507
29.7 Integrated biogeochemical and biogeophysical studies	508
29.8 Review questions	511
29.9 References	512
30 Urbanization	520
30.1 Chapter summary	520
30.2 Urban morphology	520
30.3 The urban heat island	521
30.4 Urban energy fluxes	526
30.5 Urban canyons and radiation	527
30.6 The urban canopy layer	530
30.7 Urban parks	531
30.8 Urban energy balance models	534
30.9 Rainfall and other climate influences	535
30.10 Urban hydrology	537
30.11 Review questions	539
30.12 References	541
Index	545
Color Plates between pages 272 and 273	