Contents

Preface page xi

Acknowledgements xii

List of Abbreviations xiii

1 The evolution of knowledge about the Arctic and its climate 1
   1.1 Historical exploration 4
   1.2 The beginning of systematic observations 10
   1.3 The modern era 12

2 Physical characteristics and basic climatic features 17
   2.1 The Arctic ocean 19
   2.2 The Arctic lands 30
   2.3 Basic climatic elements 37

3 The basic atmospheric heat budget 55
   3.1 The Arctic and the global heat budget 56
   3.2 The basic Arctic heat budget 60
   3.3 Further analysis of $F_{\text{walt}}$ 69

4 The atmospheric circulation 74
   4.1 Historical perspective 75
   4.2 The stratospheric circulation 79
   4.3 The Arctic tropopause 90
   4.4 The mid-tropospheric circulation 92
Contents

4.5 Surface and near-surface circulation 94
4.6 Polar Lows 106

5 The surface energy budget 110
5.1 The energy balance equations 111
5.2 The downward solar radiation flux 115
5.3 Surface albedo 120
5.4 Longwave radiation fluxes 125
5.5 Distribution of net radiation 127
5.6 Cloud radiative forcing 128
5.7 Radiation fluxes from surface observations: examples from SHEBA 131
5.8 Partitioning of net radiation 131
5.9 Skin temperature, SAT and vertical structure 137
5.10 Radiation–climate feedbacks 143

6 Precipitation, net precipitation and river discharge 147
6.1 Precipitation 148
6.2 Evapo-transpiration and net precipitation 156
6.3 Mean annual cycles for the major terrestrial drainages 162
6.4 River discharge and runoff 166

7 Arctic ocean–sea ice–climate interactions 177
7.1 Sea ice formation, growth and melt 179
7.2 Mean circulation, ice zones and concentration 183
7.3 Sea ice motion 190
7.4 Examples of large-scale ocean–sea ice–climate interactions 197
7.5 The Fram Strait outflow and the thermohaline circulation 204

8 Climate regimes of the Arctic 208
8.1 The Greenland Ice Sheet 209
8.2 Polar desert 217
8.3 Maritime Arctic 220
8.4 Central Arctic Ocean 223
8.5 Mountains and uplands 226
8.6 Urban modifications of local climate 228

9 Modeling the Arctic climate system 229
9.1 General model types 230
9.2 Single-column models 232
9.3 Land surface models 237
9.4 Sea ice and ice–ocean models 240
9.5 Global climate models 245
9.6 Regional climate models 252
9.7 Numerical weather prediction models 255
9.8 Ecosystem models 258
9.9 Summary of model errors 260

10 Arctic paleoclimates 262
10.1 The distant past 263
10.2 Paleoclimate records for the Quaternary 266
10.3 Features of the Quaternary 269
10.4 Rapid climate shifts 276
10.5 Regional aspects of the LGM 279
10.6 Deglaciation 283
10.7 The Holocene 287

11 Recent climate variability, trends and the future 291
11.1 Setting the stage 292
11.2 Summary of observed variability and change 295
11.3 The NAO and AO 306
11.4 The NAO/AO framework: merits and shortcomings 312
11.5 Related multiyear climate variability 324
11.6 The future 326

References 335
List of selected websites 377
Index 378

The plates will be found between pages 174 and 175