

Table of Contents

Preface	11
Abstract	13
Chapter 1 - Origin and composition of the atmosphere	15
1.1 The atmosphere and the Earth	15
1.2 Impact of atmospheric composition on plants	20
1.3 Impact of plants on the composition of the atmosphere	22
Chapter 2 - Energy balance of the atmosphere	25
2.1 Shortwave and longwave radiation in the atmosphere	25
2.2 Energy balance	30
2.3 Impact of radiation on plants	33
2.4 Impact of plants on radiation	38
Chapter 3 - Soil and air temperature	41
3.1 Heat, thermal properties and temperature	41
3.2 Heating and cooling of the soil	43
3.3 Heating and cooling of the air	45
3.4 Impact of soil and air temperature on plants	47
3.5 Impact of vegetation on soil and air temperature	55
Chapter 4 - Air humidity	59
4.1 Quantifying air humidity	59
4.2 Processes following the water cycle	61
4.3 Atmospheric evaporation and condensation	63
4.4 Impact of air humidity on plants	65
4.5 Impact of plants on air humidity	69

Chapter 5 - Clouds and precipitation	75
5.1 Adiabatic processes and atmospheric stability	75
5.2 Clouds and their formation	78
5.2.1 Low clouds	80
5.2.2 Medium clouds	82
5.2.3 High clouds	83
5.3 Growth of water droplets in clouds	84
5.4 Hydrometeors	86
5.4.1 Precipitation	87
5.4.2 Hydrometeors consisting of a deposit of particles	90
5.4.3 Ensemble of particles raised by wind	92
5.5 Impact of clouds and precipitation on plants	93
5.6 Impact of plants on clouds and precipitation	97
Chapter 6 - Atmospheric circulations and winds	99
6.1 Forces governing atmospheric motion	99
6.2 Scales of atmospheric motion	101
6.2.1 Global winds	101
6.2.2 Synoptic scale winds	103
6.2.3 Local winds	104
6.2.4 Periodic winds	107
6.3 Impact of wind on plants	109
6.3.1 Windbreaks and shelter belts	109
6.4 Impact of plants on wind	111
Chapter 7 - Soil and water	115
7.1 The components of crop-soil water balance	115
7.2 Determining factors of water movement into and within the soil	120
7.2.1 Water-holding capacity of soils available to crops	120
7.3 Water extraction from the soil by plant roots	123
7.4 Soil evaporation and transpiration (evapotranspiration)	125
7.5 Approaches to basic soil-water balance calculations	127
Chapter 8 - Phenology	131
8.1 Introduction	131
8.2 Vegetation period and phenological phases	133
8.2.1 Phenophase classification	135
8.3 Pest and disease phenology	137
8.3.1 Calculating crop/pest development by phenological models	138
8.4 Low temperature effects on phenological phases	140
8.5 Crop phenology as an important information source for agricultural management	143
8.6 Phenology as an agroclimatic indicator	146

Chapter 9 - Extreme meteorological events	149
9.1 Drought	149
9.1.1 Agricultural drought	150
9.2 Heat	156
9.2.1 Protection methods against heat	159
9.3 Frost	161
9.4 Storm, hail and wind	165
9.4.1 Hail	165
9.4.2 Wind and storms	166
9.5 Floods and heavy precipitation	171
9.6 Early warning systems for agriculture	175
Chapter 10 - Risk management	183
10.1 Risk	184
10.2 Hazard, exposure and vulnerability: the three components of risk	185
10.2.1 Hazard	185
10.2.2 Exposure and vulnerability	185
10.3 Risk assessment and management	186
10.4 Adaptation and mitigation	188
10.5 Climate smart agriculture: a way to manage climate change	194
Chapter 11 - Agrometeorological models	197
11.1 Modelling approaches	197
11.2 Type of models	198
11.2.1 The model scaling problem	199
11.3 Model characteristics	200
11.3.1 Model structure	200
11.3.2 Model inputs and parameters	202
11.3.3 Simulation of production levels	204
11.4 Crop model calibration and validation	204
11.5 Crop model sensitivities to weather extremes and related uncertainties	206
11.6 Crop model applications	209
11.7 Pest and disease models or algorithms	210
11.8 Agroclimatic indices and algorithms	211
Chapter 12 - Climate, climate change and agriculture	215
12.1 Climate and climate change – an introduction	215
12.2 Climate classification and regionalization	216
12.3 Climate change	221
12.4 Impact of climate change on agriculture	228

12.5	Addressing uncertainties in climate change impact studies on agriculture	237
12.6	Expert assessments as an additional information source	238
12.7	Adaptation of agriculture to climate change	239
12.7.1	Optimizing farm technologies with respect to agricultural system	241
12.7.2	Adaptation options addressing water resources	243
12.7.3	Adaptation options addressing soil resources	244
12.7.4	Adaptation options addressing climate resources	246
12.7.5	Adaptation options addressing plant/crop genetic resources	247
12.7.6	Adaptation options for better crop management	248
12.8	Mitigation options in agriculture	250
Chapter 13 – Measurement methods in agrometeorology		255
13.1	Basic sensor technologies – introduction	255
13.2	Measurements methods	257
13.2.1	Scientific applications	257
13.2.2	Sensors and measurement methods and techniques for applied agrometeorology (practical applications)	259
13.2.3	Installation of an agrometeorological weather station	276
Chapter 14 – Remote sensing in agriculture		281
14.1	Introduction	281
14.2	Remote sensing for phenology and vegetation dynamics	284
14.3	Microwave satellites for soil moisture estimation	292
14.4	Application examples of remote sensing in agricultural practice	293
Numerical examples		297
E1	Origin and composition of the atmosphere	298
E1.1	Units	298
E2	Energy balance of the Atmosphere	300
E2.1	Units	300
E2.2	Transfer of measured solar radiation ($W\ m^{-2}$) in daily energy budget	301
E2.3	Atmospheric radiation	303
E2.4	Outgoing terrestrial radiation	304
E3	Soil and air temperature	304
E3.1	Units	304
E3.2	Daily, annual temperature, their variation and extremes	304

E3.3	Calculating Accumulated Degree Days	305
E3.4	Approximation of hourly temperatures	308
E3.5	Frost prediction	310
E4	Air humidity	313
E4.1	Units	313
E4.2	Air humidity quantification	313
E5	Clouds and precipitation	317
E5.1	Units	317
E5.2	Impact of cloudiness on energy balance	317
E5.3	Measurement of precipitation	317
E6	Atmospheric circulations and winds	318
E6.1	Units	318
E6.2	Wind rose	319
E6.3	Wind energy and power	320
E7	Soil and water	321
E7.1	Evapotranspiration	321
Appendix 1		323
Appendix 2		325
References		329
List of the authors and contributors		351