

# Contents

<b>Preface</b> . . . . .	xi
<b>List of figures and tables</b> . . . . .	xv
<b>List of charts</b> . . . . .	xxiii
<b>List of abbreviations</b> . . . . .	xxxix
<b>How to use this book</b> . . . . .	xxxv
 <b>1 Introduction: current knowledge and analysis of methods</b> . . . . .	 1
1.1 History of observations and research . . . . .	1
1.2 Our knowledge of factors and elements of climate . . . . .	3
1.3 Analysis of meteorological methods . . . . .	6
1.4 The approach of this book . . . . .	13
 <b>PART I Chorological factors</b> . . . . .	 21
 <b>2 Chorological factors</b> . . . . .	 23
2.1 Sea surface circulation and characteristics . . . . .	23
2.1.1 The Atlantic Ocean . . . . .	23
2.1.2 The Indian Ocean . . . . .	26
2.2 Effect on air temperature and atmospheric moisture . . . . .	27
2.2.1 Effect on coastal temperature and breezes . . . . .	27
2.2.2 Effect on coastal moisture . . . . .	30
2.2.3 Supply of precipitable water potential . . . . .	31
 <b>3 The orographical factor</b> . . . . .	 37
3.1 Main features of the relief of tropical Africa . . . . .	37
3.1.1 Chart 1: relief of tropical Africa . . . . .	37
3.1.2 Lowland (western and central) Africa . . . . .	38
3.1.3 Highland (southern and eastern) Africa . . . . .	40
3.2 Effect of relief on climatic parameters . . . . .	42
3.2.1 The effect of relief on temperature . . . . .	42
3.2.2 The effect of relief on pressure field and circulation . . . . .	45
3.2.3 The effect of relief on rainfall . . . . .	48

<b>4</b>	<b>Continental hydrology and vegetation</b> . . . . .	51
4.1	Hydrology and its local climatic effect. . . . .	51
4.1.1	Continental hydrology . . . . .	51
4.1.2	The local climatic effect of hydrology . . . . .	54
4.2	Vegetation and its local climatic effect. . . . .	58
4.2.1	The vegetation of tropical Africa . . . . .	58
4.2.2	The effect of vegetation on climate. . . . .	60
4.3	The water cycle over tropical Africa . . . . .	64
<b>PART II</b>	<b>Aerological factors</b> . . . . .	71
<b>5</b>	<b>Basic features of the troposphere and of tropical circulation</b> . . . . .	73
5.1	General circulation and the structure of the tropical troposphere . . . . .	73
5.1.1	The general circulation of the atmosphere . . . . .	73
5.1.2	The vertical structure of the tropical troposphere . . . . .	77
5.2	Tropical circulation: trade and monsoon winds . . . . .	79
5.2.1	The trade wind and the trades. . . . .	81
5.2.2	The monsoon and monsoons. . . . .	83
5.2.3	The stratified structure of the tropical troposphere . . . . .	85
5.3	Three-dimensional analysis of wind field: the structural method . . . . .	90
5.3.1	Logical continuity in charting the vertical space . . . . .	92
5.3.2	Analysis of synoptic charts . . . . .	94
<b>6</b>	<b>Pressure field, circulation and discontinuities over tropical Africa</b> . . . . .	103
6.1	Pressure field, circulation and discontinuities at surface and lower levels . . . . .	106
6.1.1	Mean monthly features (Charts 3–38) . . . . .	107
6.2	Pressure field, circulation and discontinuities in upper levels. . . . .	120
6.2.1	Mean monthly features (Charts 39–98) . . . . .	121
<b>7</b>	<b>Vertical structure of the African tropical troposphere</b> . . . . .	131
7.1	Mean vertical structure and annual evolution . . . . .	131
7.1.1	Mean monthly features (Charts 99–122) . . . . .	131
7.1.2	Annual evolution of the vertical structure (Charts 123–130) . . . . .	135
7.2	Aerological stratification over tropical Africa . . . . .	136
7.2.1	Air streams . . . . .	136
7.2.2	Discontinuities . . . . .	142
<b>PART III</b>	<b>Dynamics of circulation: disturbances</b> . . . . .	155
	Rainfall conditions (pluviogenesis) . . . . .	156
<b>8</b>	<b>Moving Polar Highs (MPHs) on African tropical margins</b> . . . . .	159
8.1	Polar influences: northern Africa . . . . .	160
8.1.1	Analysis of the situation on 21–23 January 1990. . . . .	162
8.1.2	Analysis of the situation on 29 and 30 November 1978 . . . . .	167

8.1.3	Climatic consequences . . . . .	173
8.2	Polar influences: southern Africa . . . . .	179
8.2.1	MPHs and the Great Escarpment . . . . .	180
8.2.2	Bergwinds . . . . .	182
8.2.3	Climatic outcomes: winter. . . . .	185
8.2.4	Climatic outcomes: summer. . . . .	186
9	<b>Pulses in trades and monsoons . . . . .</b>	<b>193</b>
9.1	Easterly wave or pulse line? . . . . .	194
9.2	Propagation of lower level pressure waves (pulse lines) in tropical fluxes . . . . .	205
9.3	Pulse lines and their climatic consequences . . . . .	211
9.3.1	The stable maritime trade in western coastal areas . . . .	212
9.3.2	The continental trade ( <i>harmattan</i> ) of northern Africa . . .	213
9.3.3	The maritime trade and the Atlantic monsoon . . . . .	217
9.3.4	The southern maritime trade and the Indian monsoon ( <i>kusi</i> ) . . . . .	220
9.3.5	The northern maritime trade ( <i>kaskasi</i> ) and the Madagascar monsoon . . . . .	226
10	<b>Inclined structures: the Inclined Meteorological Equator (IME) and Inter-Oceanic Confluence (IOC), and Squall Lines (SLs) . . . . .</b>	<b>229</b>
10.1	The Inclined Meteorological Equator (IME) . . . . .	229
10.1.1	From the Intertropical Front (ITF) to the Inclined Meteorological Equator (IME) . . . . .	229
10.1.2	The nature of inclined structures: Inclined Meteorological Equator (IME) and (IOC) . . . . .	232
10.2	Current understanding of the nature of squall lines . . . . .	234
10.2.1	Review of the literature on squall lines . . . . .	234
10.2.2	Our current knowledge. . . . .	237
10.3	Formation and evolution of squall lines. . . . .	238
10.3.1	Analysis of the situation of 2 and 3 August 1973 over West Africa. . . . .	238
10.3.2	Phases in the formation of squall lines . . . . .	243
10.4	Climatic consequences . . . . .	257
10.4.1	Weather associated with the passage of a squall line . . .	257
10.4.2	Precipitation associated with squall lines . . . . .	260
11	<b>The active Meteorological Equator (ME): the active Inclined Meteorological Equator (IME) and the Vertical Meteorological Equator (VME) . . . . .</b>	<b>267</b>
11.1	The active Inclined Meteorological Equator (IME). . . . .	267

11.2	Structure and characteristics of the Vertical Meteorological Equator. . . . .	269
11.2.1	Current understanding of the nature of the vertical structure of the Meteorological Equator . . . . .	270
11.2.2	The nature of the Vertical Meteorological Equator . . . . .	273
11.3	Climatic consequences of the VME. . . . .	286
<b>12</b>	<b>Tropical cyclones. . . . .</b>	<b>295</b>
12.1	Conditions for cyclogenesis . . . . .	295
12.2	Cyclogenesis in the south-west Indian Ocean. . . . .	298
12.3	Cyclones in Africa and their climatic consequences . . . . .	308
	<b>Disturbances in Africa: conclusion. . . . .</b>	<b>317</b>
<b>PART IV</b>	<b>Climates of tropical Africa . . . . .</b>	<b>319</b>
<b>13</b>	<b>Elements of climate: rainfall. . . . .</b>	<b>321</b>
13.1	The distribution of rainfall . . . . .	322
13.1.1	Monthly pluviometric patterns (Charts 131–169) . . . . .	322
13.1.2	Pluviometric regions of Africa . . . . .	330
13.2	Pluviometric regimes (Charts 170–175). . . . .	336
13.2.1	Unimodal pluviometric regimes . . . . .	337
13.2.2	Bimodal pluviometric regimes . . . . .	345
13.3	Dynamics of rainfall (Charts 176–187). . . . .	354
13.3.1	General pluviogenic conditions . . . . .	355
13.3.2	Monthly pluviogenic conditions and annual dynamics . . . . .	356
13.4	Conclusion on precipitation. . . . .	360
<b>14</b>	<b>Elements of climate: temperatures . . . . .</b>	<b>361</b>
14.1	Temperature distribution. . . . .	362
14.1.1	Monthly thermal patterns (Charts 188–237) . . . . .	362
14.1.2	Thermal regions of Africa. . . . .	367
14.2	Thermal regimes and the dynamics of temperature. . . . .	370
14.2.1	Thermal regimes (Charts 238–239) . . . . .	370
14.2.2	The dynamics of temperature (Charts 240–243). . . . .	380
14.3	Conclusion on temperatures. . . . .	383
<b>15</b>	<b>Climates of tropical Africa . . . . .</b>	<b>385</b>
15.1	Aerological criteria and climatic domains (Chart 244). . . . .	387
15.1.1	Domains of a single climatic tonality . . . . .	390
15.1.2	Domains of alternating climatic tonalities . . . . .	391
15.2	Chorological criteria: climatic domains and regions (Chart 245) . . . . .	394
15.2.1	The establishment of the climatic picture. . . . .	394
15.2.2	The climatic domains and regions of tropical Africa . . . . .	396
15.3	Climatic domains and regions of tropical Africa (Chart 246) . . . . .	407

<b>PART V Climate change in tropical Africa . . . . .</b>	<b>411</b>
<b>16 African palaeoenvironments since the Upper Pleistocene . . . . .</b>	<b>415</b>
16.1 African palaeoenvironments of the Last Glacial Maximum (LGM: 18–15 kyr BP) . . . . .	416
16.2 African palaeoenvironments of the Holocene Climatic Optimum (HCO: 9-6 kyr BP) . . . . .	422
16.3 Variations in insolation and palaeocirculations in Africa . . . . .	426
16.3.1 Some questions and explanations . . . . .	426
16.3.2 Variations in insolation in high latitudes and modes of circulation . . . . .	429
16.3.3 The influence of ice surfaces in the northern hemisphere . . . . .	435
16.3.4 Palaeocirculations over Africa during the LGM and the HCO . . . . .	438
16.4 Conclusion . . . . .	442
<b>17 Recent climate change in tropical Africa . . . . .</b>	<b>445</b>
17.1 The great Sahel drought . . . . .	445
17.1.1 A diagnosis too long in coming . . . . .	446
17.1.2 The supposed causes of the great drought . . . . .	450
17.2 Dynamics of climate change in tropical Africa . . . . .	457
17.2.1 The southward shift of pluviogenic structures . . . . .	458
17.2.2 The North Atlantic/European/Mediterranean/North African aerological space . . . . .	463
<b>18 General conclusion . . . . .</b>	<b>479</b>
<b>Appendix 1 Atlas: The aerological factors . . . . .</b>	<b>485</b>
<b>Appendix 2 Atlas: The elements of climates . . . . .</b>	<b>491</b>
<b>Appendix 3 Data of the Atlas . . . . .</b>	<b>CD</b>
<b>References and bibliography . . . . .</b>	<b>495</b>