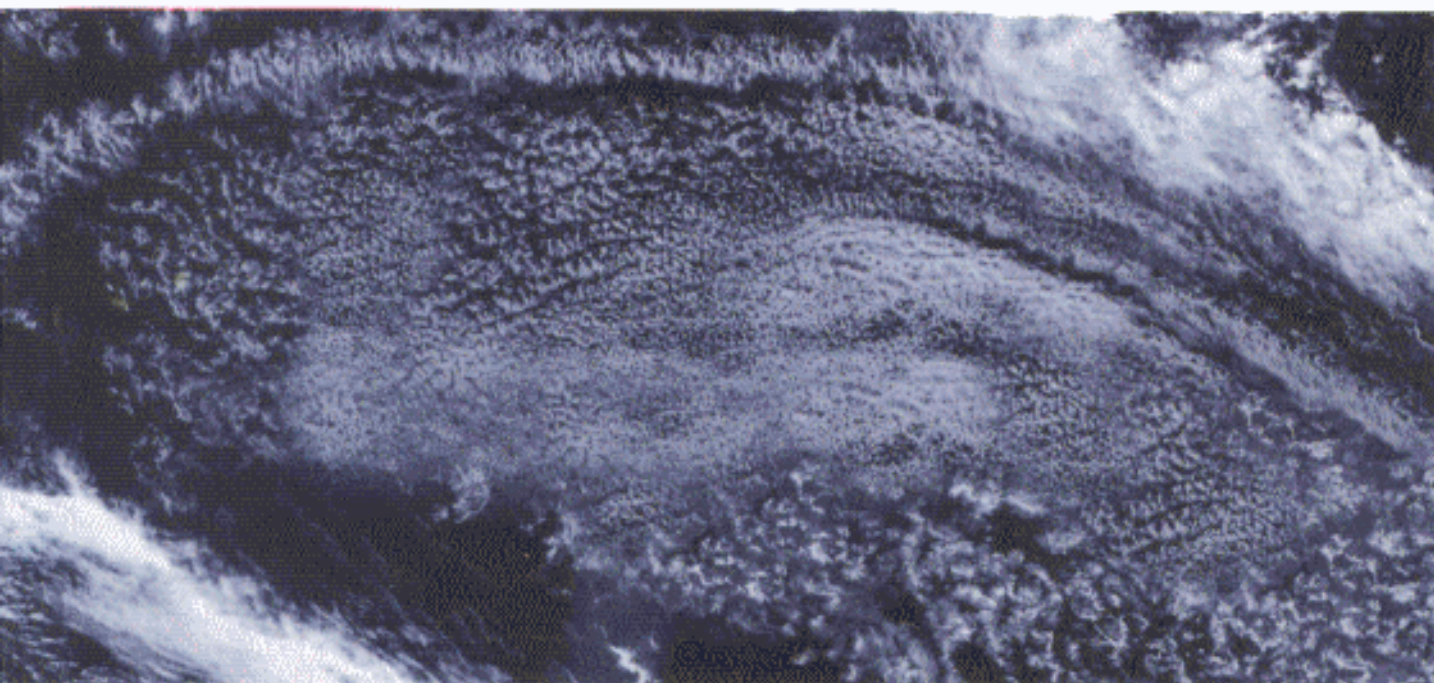


ATMOSPHERE, WEATHER AND CLIMATE

EIGHTH EDITION



ROGER G. BARRY AND RICHARD J. CHORLEY

Contents

<i>Preface to the eighth edition</i>	xi	4 Thermosphere	28
<i>Acknowledgements</i>	xiii	5 Exosphere and magnetosphere	28
1 Introduction and history of meteorology and climatology	1	3 Solar radiation and the global energy budget	32
A <i>The atmosphere</i>	1	A <i>Solar radiation</i>	32
B <i>Solar energy</i>	2	1 Solar output	32
C <i>Global circulation</i>	3	2 Distance from the sun	34
D <i>Climatology</i>	3	3 Altitude of the sun	36
E <i>Mid-latitude disturbances</i>	4	4 Length of day	37
F <i>Tropical weather</i>	5	B <i>Surface receipt of solar radiation and its effects</i>	37
G <i>Palaeoclimates</i>	6	1 Energy transfer within the earth–atmosphere system	37
H <i>The global climate system</i>	6	2 Effect of the atmosphere	38
2 Atmospheric composition, mass and structure	9	3 Effect of cloud cover	39
A <i>Composition of the atmosphere</i>	9	4 Effect of latitude	40
1 Primary gases	9	5 Effect of land and sea	41
2 Greenhouse gases	10	6 Effect of elevation and aspect	48
3 Reactive gas species	10	7 Variation of free-air temperature with height	48
4 Aerosols	12	C <i>Terrestrial infra-red radiation and the greenhouse effect</i>	51
5 Variations with height	13	D <i>Heat budget of the earth</i>	53
6 Variations with latitude and season	15	E <i>Atmospheric energy and horizontal heat transport</i>	57
7 Variations with time	16	1 The horizontal transport of heat	57
B <i>Mass of the atmosphere</i>	22	2 Spatial pattern of the heat budget components	59
1 Total pressure	22	4 Atmospheric moisture budget	64
2 Vapour pressure	24	A <i>The global hydrological cycle</i>	64
C <i>The layering of the atmosphere</i>	25	B <i>Humidity</i>	66
1 Troposphere	25		
2 Stratosphere	27		
3 Mesosphere	27		

1	Moisture content	66	B	Divergence, vertical motion and vorticity	118
2	Moisture transport	67	1	Divergence	118
C	Evaporation	69	2	Vertical motion	118
D	Condensation	73	3	Vorticity	118
E	Precipitation characteristics and measurement	74	C	Local winds	120
1	Forms of precipitation	74	1	Mountain and valley winds	120
2	Precipitation characteristics	75	2	Land and sea breezes	121
a	Rainfall intensity	75	3	Winds due to topographic barriers	122
b	Areal extent of a rainstorm	76	7	Planetary-scale motions in the atmosphere and ocean	127
c	Frequency of rainstorms	76	A	Variation of pressure and wind velocity with height	127
3	The world pattern of precipitation	79	1	The vertical variation of pressure systems	128
4	Regional variations in the altitudinal maximum of precipitation	80	2	Mean upper-air patterns	129
5	Drought	84	3	Upper wind conditions	131
5	Atmospheric instability, cloud formation and precipitation processes	89	4	Surface pressure conditions	133
A	Adiabatic temperature changes	89	B	The global wind belts	136
B	Condensation level	91	1	The trade winds	136
C	Air stability and instability	91	2	The equatorial westerlies	136
D	Cloud formation	95	3	The mid-latitude (Ferrel) westerlies	139
1	Condensation nuclei	95	4	The polar easterlies	139
2	Cloud types	96	C	The general circulation	139
3	Global cloud cover	99	1	Circulations in the vertical and horizontal planes	142
E	Formation of precipitation	99	2	Variations in the circulation of the northern hemisphere	146
1	Bergeron-Findeisen theory	100	a	Zonal index variations	146
2	Coalescence theories	102	b	North Atlantic Oscillation	147
3	Solid precipitation	102	D	Ocean structure and circulation	149
F	Precipitation types	103	1	Above the thermocline	149
1	'Convective type' precipitation	103	a	Vertical	149
2	'Cyclonic type' precipitation	103	b	Horizontal	151
3	Orographic precipitation	103	2	Deep ocean water interactions	155
G	Thunderstorms	106	a	Upwelling	155
1	Development	106	b	Deep ocean circulation	155
2	Cloud electrification and lightning	106	3	The oceans and atmospheric regulation	158
6	Atmospheric motion: principles	112	8	Numerical models of the general circulation, climate and weather prediction	162
A	Laws of horizontal motion	112	T.N. Chase and R.G. Barry		
1	The pressure-gradient force	113	A	Fundamentals of the GCM	162
2	The earth's rotational deflective (Coriolis) force	113	B	Model simulations	165
3	The geostrophic wind	114	1	GCMs	165
4	The centripetal acceleration	114	2	Simpler models	166
5	Frictional forces and the planetary boundary layer	116	3	Regional models	168

C Data sources for forecasting	168	3 British airflow patterns and their climatic characteristics	215
D Numerical weather prediction	170	4 Singularities and natural seasons	220
1 Short- and medium-range forecasting	170	5 Synoptic anomalies	221
2 'Nowcasting'	172	6 Topographic effects	222
3 Long-range outlooks	172		
9 Mid-latitude synoptic and mesoscale systems	177	B North America	225
A The airmass concept	177	1 Pressure systems	226
B Nature of the source area	177	2 The temperate west coast and Cordillera	229
1 Cold airmasses	178	3 Interior and eastern North America	231
2 Warm airmasses	180	<i>a Continental and oceanic influences</i>	231
		<i>b Warm and cold spells</i>	233
		<i>c Precipitation and the moisture balance</i>	234
C Airmass modification	181	C The subtropical margins	238
1 Mechanisms of modification	181	1 The semi-arid southwestern United States	238
<i>a Thermodynamic changes</i>	181	2 The interior southeastern United States	241
<i>b Dynamic changes</i>	182	3 The Mediterranean	241
2 The results of modification: secondary airmasses	182	4 North Africa	246
<i>a Cold air</i>	182	5 Australasia	247
<i>b Warm air</i>	182		
3 The age of the airmass	183	D High latitudes	249
D Frontogenesis	183	1 The southern westerlies	249
1 Frontal waves	184	2 The sub-Arctic	252
2 The frontal-wave depression	184	3 The polar regions	253
		<i>a The Arctic</i>	253
		<i>b Antarctica</i>	255
E Frontal characteristics	186	11 Tropical weather and climate	262
1 The warm front	187	A The intertropical convergence	263
2 The cold front	190	B Tropical disturbances	265
3 The occlusion	191	1 Wave disturbances	266
4 Frontal-wave families	191	2 Cyclones	269
		<i>a Hurricanes and typhoons</i>	269
F Zones of wave development and frontogenesis	193	<i>b Other tropical disturbances</i>	274
G Surface/upper-air relationships and the formation of frontal cyclones	196	3 Tropical cloud clusters	274
H Non-frontal depressions	199		
1 The lee cyclone	199	C The Asian monsoon	276
2 The thermal low	199	1 Winter	277
3 Polar air depressions	201	2 Spring	279
4 The cold low	201	3 Early summer	280
		4 Summer	281
I Mesoscale convective systems	201	5 Autumn	288
10 Weather and climate in middle and high latitudes	213	D East Asian and Australian summer monsoons	289
A Europe	213	E Central and southern Africa	292
1 Pressure and wind conditions	213	1 The African monsoon	292
2 Oceanicity and continentality	215	2 Southern Africa	297

F Amazonia	299	13 Climate change	353
G El Niño–Southern Oscillation (ENSO) events	302	A General considerations	353
1 The Pacific Ocean	302	B Climate forcings and feedbacks	354
2 Teleconnections	306	1 External forcing	356
H Other sources of climatic variations in the tropics	309	2 Short-term forcing and feedback	358
1 Cool ocean currents	309	C The climatic record	359
2 Topographic effects	309	1 The geological record	359
3 Diurnal variations	311	2 Late glacial and post-glacial conditions	361
I Forecasting tropical weather	312	3 The past 1000 years	362
1 Short- and extended-range forecasts	312	D Possible causes of recent climatic change	368
2 Long-range forecasts	313	1 Circulation changes	368
12 Boundary layer climates	321	2 Energy budgets	368
A Surface energy budgets	322	3 Anthropogenic factors	370
B Non-vegetated natural surfaces	323	E Model strategies for the prediction of climate change	374
1 Rock and sand	323	F The IPCC models	376
2 Water	324	G Other environmental impacts of climate change	378
3 Snow and ice	324	1 Sea-level	378
C Vegetated surfaces	325	2 Snow and ice	382
1 Short green crops	325	3 Hydrology	384
2 Forests	327	4 Vegetation	384
<i>a Modification of energy transfers</i>	328	H Postscript	385
<i>b Modification of airflow</i>	329		
<i>c Modification of the humidity environment</i>	330	APPENDICES	
<i>d Modification of the thermal environment</i>	332	I Climate classification	391
D Urban surfaces	333	A Generic classifications related to plant growth or vegetation	391
1 Modification of atmospheric composition	333	B Energy and moisture budget classifications	392
<i>a Aerosols</i>	334	C Genetic classifications	395
<i>b Gases</i>	337	D Classifications of climatic comfort	396
<i>c Pollution distribution and impacts</i>	338	2 Système International (SI) units	399
2 Modification of the heat budget	339	3 Synoptic weather maps	401
<i>a Atmospheric composition</i>	340	4 Data sources	404
<i>b Urban surfaces</i>	341	A Daily weather maps and data	404
<i>c Human heat production</i>	341	B Satellite data	404
<i>d Heat islands</i>	341	C Climatic data	404
3 Modification of surface characteristics	344	D Selected sources of information on the World Wide Web	405
<i>a Airflow</i>	344		
<i>b Moisture</i>	345	Notes	406
4 Tropical urban climates	346	Bibliography	409
		Index	412