

Contents

<i>Preface</i>	<i>page vii</i>
1. The Atmospheric Mesoscale	1
1.1 Introduction	1
1.2 Historical Perspectives	3
1.3 Atmospheric-Scale Classification Schemes	6
1.4 Mesoscale-Convective Processes	7
2. Theoretical Foundations	11
2.1 Fundamental Set of Equations	11
2.2 Atmospheric Waves and Oscillations	22
2.3 Instabilities	30
2.4 Density Currents	38
3. Observations and Mesoscale Data Analysis	43
3.1 Introduction	43
3.2 In-Situ Observations	45
3.3 Report-Based Observations of Hazardous Convective Weather	51
3.4 Remotely Sensed Observations	53
3.5 Observation Networks	72
3.6 Data Analysis and Synthesis	78
4. Mesoscale Numerical Modeling	88
4.1 Introduction	88
4.2 Equations and Numerical Approximations	89
4.3 Parameterizations	96
4.4 Model Design and Implementation	112
5. The Initiation of Deep Convective Clouds	121
5.1 Parcel Theory	121
5.2 Synoptic-Scale Conditioning of the Convective Environment	126
5.3 Mechanisms of Local or Near-Field Mesoscale Lift	131

vi	<i>Contents</i>	
	5.4 Mesoscale Baroclinic Circulations	138
	5.5 Lifting Mechanisms from Nonlocal Sources	149
	6. Elemental Convective Processes	162
	6.1 Overview of the Convective Storm Spectrum	162
	6.2 Components: Updrafts and Downdrafts	163
	6.3 Convective Outflow	182
	6.4 Unicellular Convective Storms	188
	6.5 Multicellular Convective Storms	190
	7. Supercells: A Special Class of Long-Lived Rotating Convective Storms	195
	7.1 Characteristics of Supercell Thunderstorms: An Overview	195
	7.2 Midlevel Mesocyclogenesis in an Early-Stage Supercell	199
	7.3 Supercell Dynamics	203
	7.4 Interaction of Wind Field and Precipitation	217
	7.5 Low-Level Mesocyclogenesis	219
	7.6 Tornadogenesis	223
	7.7 Supercell Environment Quantification	228
	7.8 Analogues in Tropical Convection: Vortical Hot Towers	229
	8. Mesoscale Convective Systems	233
	8.1 Overview of MCS Characteristics and Morphology	233
	8.2 Dynamical Explanations for MCS Evolution	239
	8.3 Weather Hazards Associated with MCSs	251
	8.4 Mesoscale Convective Complex	263
	8.5 Environments	265
	9. Interactions and Feedbacks	270
	9.1 Introduction	270
	9.2 Boundaries	271
	9.3 Mesoscale-Convective Vortices	273
	9.4 Interaction between Deep Moist Convection and Synoptic-Scale Dynamics	277
	9.5 Land–Atmosphere Feedbacks	281
	9.6 Convective Processes and the Global Climate	288
	10. Mesoscale Predictability and Prediction	295
	10.1 Introduction	295
	10.2 On Predictability and Its Theoretical Limits	296
	10.3 Probabilistic Forecasts and Ensemble Prediction Systems	303
	10.4 Forecast Evaluation	305
	10.5 Forecast Strategies with Mesoscale Numerical Models	312
	10.6 Long-Range Prediction	315
	<i>References</i>	323
	<i>Index</i>	343
	<i>Color plates appear after page 120.</i>	