Contents

Foreword ..... (iii)

Preface ..... (v)

Chapter 1

Basic Governing Equations

1.1 Introduction 1
1.2 Equation of Motion 1
1.3 Continuity Equation 3
1.4 Equation of State 4
1.5 First Law of Thermodynamics 4
1.6 Co-ordinate Systems 6
1.7 Spherical Polar Co-ordinates 8
1.8 Pressure Co-ordinates 10
1.9 Natural Co-ordinates 11
1.10 Gradient Wind 13
1.11 Thermal Wind-Variation of Wind in the Vertical 14
1.12 Vorticity and Divergence 15
1.13 Vorticity Equation 17
1.14 Humidity 19
1.15 Hydrostatic Stability 21

Chapter 2

Energetics of the Atmosphere

2.1 Introduction 25
2.2 Energy Equations 26
2.3 Physical Explanation of the Energy Conversion Processes 28
2.4 Total Potential Energy (TPE) 28
2.5 Available Potential Energy (APE) 30
2.6 Zonal and Eddy Forms of Energy 31
2.7 Energy Conversions in the Atmosphere 33

Chapter 3

Atmospheric General Circulation

3.1 Introduction and General Considerations 35
3.2 Angular Momentum Balance in the Atmosphere 40
3.3 Three Dimensional Structure of the General Circulation 43

Chapter 4

Waves in the Atmosphere

4.1 Introduction 63
4.2 Speed of Rossby Waves 64
4.3 Equatorial Waves 68

Chapter 5

Large Scale Atmospheric Modeling

5.1 Introduction 71
5.2 Vorticity Equation 72
5.3 Divergence Equation 74
5.4 Hierarchy of Models 75
5.4.1 Non Divergent Barotropic Model 75
5.4.2 Quasi-geostrophic Model 76
5.5 Other Filtered Models 80
5.6 Numerical Methods 81
5.7 Subgrid Scale Processes 82
5.8 Simulation of the Atmospheric General Circulation 84

Chapter 6

Hydrodynamic Instability

6.1 Introduction 91
6.2 Barotropic Instability 91
6.3 Baroclinic Instability 93
6.4 Sources of Energy for Atmospheric Disturbances 94

Appendices

Appendix 1 – Pressure Gradient Force 117
Appendix 2 – Equation of Motion in Rotating Co-ordinates 118
Appendix 3 – Equation of State for Air (a mixture of gases) 122
Appendix 4 – Rossby Number 123
Appendix 5 – Dry Adiabatic Lapse Rate (DALR) 125
Appendix 6 – Energy Equations – Derivation 126

List of Symbols used 129

References 133

Bibliography 136

Colour Plates 137