



# CONTENTS

FOREWORD .....	xi
PREFACE .....	xiii

## Part I. Historical Introduction

### Global Scale Circulations—A Review

A. C. WIIN-NIELSEN

1. Introduction .....	3
2. The Distant Past .....	3
3. The Near Past .....	8
4. Blocking as a Structural Entity .....	15
5. Some General Considerations .....	24
6. A Concluding Remark .....	25
References .....	26

## Part II. Observations

### The Life Cycles of Persistent Anomalies and Blocking over the North Pacific

RANDALL M. DOLE

1. Introduction .....	31
2. Data .....	32
3. Procedure .....	33
4. Development of 500-mbar Height Anomaly Patterns .....	34
5. Vertical and Thermal Evolutions during Development .....	50
6. Synoptic Characteristics of Development .....	54
7. Breakdown .....	59
8. Discussion .....	64
9. Conclusions .....	66
References .....	68

### On Atmospheric Blocking Types and Blocking Numbers

HEINZ-DIETER SCHILLING

1. Introduction .....	71
2. Energy Parameters and Data .....	72
3. Blocking Numbers .....	77
4. Kinetic Energy Budget and Blocking Numbers .....	80

5. Relevant Energy Fluxes . . . . .	85
6. Types of Blocking . . . . .	89
7. Conclusions . . . . .	94
Appendix A . . . . .	96
Appendix B . . . . .	97
Appendix C . . . . .	98
References . . . . .	99

**Observational Characteristics of Atmospheric Planetary Waves  
with Bimodal Amplitude Distributions**

ANTHONY R. HANSEN

1. Introduction . . . . .	101
2. Frequency Distribution of the Planetary-Wave Amplitude Indicator . . . . .	103
3. Wave Structure of the Two Modes . . . . .	105
4. Energetics and Enstrophy Budgets for the Two Modes . . . . .	113
5. Role of Cyclone Waves in Blocking . . . . .	127
6. Conclusion . . . . .	131
References . . . . .	132

**A Case Study of Eddy Forcing  
during an Atlantic Blocking Episode**

G. J. SHUTTS

1. Introduction . . . . .	135
2. The Eddy Straining Mechanism . . . . .	136
3. Data Manipulation and the Synoptic Situation . . . . .	139
4. E Vectors and the Sense of Momentum Forcing . . . . .	142
5. Eddy Vorticity Flux Divergence Patterns . . . . .	145
6. Ertel Potential Vorticity Analysis . . . . .	147
7. Summary and Discussion . . . . .	158
References . . . . .	161

**Part III. Theory**

**The Effect of Local Baroclinic Instability on  
Zonal Inhomogeneities of Vorticity and Temperature**

R. T. PIERREHUMBERT

1. Introduction . . . . .	165
2. Eddy Fluxes in the Two-Layer Model . . . . .	167
3. Fluxes and Tendencies Associated with Local Baroclinic Instability . . . . .	169

4. Conclusions .....	180
References .....	182

**Forcing of Planetary-Scale Blocking Anticyclones  
by Synoptic-Scale Eddies**

J. EGGER, W. METZ, AND G. MÜLLER

1. Introduction .....	183
2. Stochastically Forced Planetary Modes .....	184
3. Results .....	186
References .....	197

**Deterministic and Statistical Properties of Northern Hemisphere,  
Middle Latitude Circulation: Minimal Theoretical Models**

A. SPERANZA

1. Introduction .....	199
2. A Reexamination of CDV .....	200
3. Modification of the CDV Wave Equation .....	209
4. Baroclinic Energetics .....	215
5. Resonance Bending in a Baroclinic Model Atmosphere .....	219
6. Summary and Conclusions .....	223
References .....	224

**Probability Density Distribution of Large-Scale Atmospheric Flow**

ALFONSO SUTERA

1. Introduction .....	227
2. Theoretical Background .....	228
3. The Data .....	230
4. Nonparametric Probability Density Estimation .....	231
5. Results .....	233
6. Connection with Patterns of the 500-mbar Geopotential Height .....	235
7. Discussion .....	243
8. The Zonal Wind .....	246
9. Conclusions .....	247
References .....	248

**Stationary Planetary Waves, Blocking, and Interannual Variability**

R. S. LINDZEN

1. Introduction .....	251
2. How Persistent Are Anomalies? .....	253

3. Multiple Equilibria? . . . . .	255
4. Teleconnections—The Tropical Connection? . . . . .	259
5. Linearized Response to Stationary Forcing . . . . .	262
6. Free Rossby Waves and the Meaning of Persistence . . . . .	269
7. Concluding Remarks . . . . .	271
References . . . . .	272

#### Part IV. Numerical Experiments

##### Instability Theory and Nonlinear Evolution of Blocks and Mature Anomalies

J. S. FREDERIKSEN

1. Introduction . . . . .	277
2. Three-Dimensional Instability Theory . . . . .	278
3. Time Evolution of Observed Mature Anomalies . . . . .	289
4. Nonlinear Simulation . . . . .	291
References . . . . .	301

##### Numerical Prediction: Some Results from Operational Forecasting at ECMWF

A. J. SIMMONS

1. Introduction . . . . .	305
2. The ECMWF Forecasting System . . . . .	306
3. Methods of Assessment . . . . .	308
4. The Accuracy of Forecasts in the Medium Range . . . . .	310
5. The Prediction of Blocking and Cutoff Lows . . . . .	318
6. Developments in Predictive Skill . . . . .	323
7. The Representation of Monthly-Mean Anomalies . . . . .	328
8. Systematic Model Errors . . . . .	333
9. Concluding Remarks . . . . .	335
References . . . . .	336

##### Envelope Orography and Maintenance of the Quasi-Stationary Circulation in the ECMWF Global Models

STEFANO TIBALDI

1. Introduction . . . . .	339
2. Orographic Forcing and the Systematic Error of the ECMWF Gridpoint Model: The Envelope Orography . . . . .	340
3. The January 1981 Set of Experiments . . . . .	343
4. The Experiments with the Blended Orographies . . . . .	355

5. Mountain Torque and Zonal Flow . . . . .	359
6. The Effects of the Envelope Orography in the Tropical Regions . . . . .	363
7. Summary and Conclusions . . . . .	370
References . . . . .	372

**Numerical Forecasts of Tropospheric and Stratospheric Events  
during the Winter of 1979: Sensitivity to the  
Model's Horizontal Resolution and Vertical Extent**

CARLOS R. MECHOSO, MAX J. SUAREZ, KOJI YAMAZAKI, AKIO KITO, AND  
AKIO ARAKAWA

1. Introduction . . . . .	375
2. Selected Features of the Atmospheric Circulation during the Northern Hemisphere Winter of 1979 . . . . .	377
3. Description of the Model. . . . .	380
4. Tropospheric Forecasts . . . . .	381
5. Stratospheric Forecasts . . . . .	392
6. Impact of the Upper Boundary on Tropospheric Forecasts . . . . .	398
7. Conclusions . . . . .	411
References . . . . .	413

**Mechanistic Experiments to Determine the Origin of  
Short-Scale Southern Hemisphere Stationary Rossby Waves**

EUGENIA KALNAY AND KINGTSE C. MO

1. Introduction . . . . .	415
2. Analysis and Control Experiments . . . . .	417
3. "No Andes" Experiment . . . . .	427
4. "Reduced Tropical Heating" Experiment . . . . .	429
5. "Suppressed Regional Heating" Experiments . . . . .	435
6. "Easterly Deceleration" Experiment. . . . .	437
7. Summary and Conclusions . . . . .	439
References . . . . .	441

**SST Anomalies and Blocking**

J. SHUKLA

1. Introduction . . . . .	443
2. Influence of Tropical SST Anomalies on Extratropical Circulation . . . . .	445
3. Influence of Extratropical SST Anomalies on Extratropical Circulation . . . . .	449
References . . . . .	451

INDEX . . . . .	453
-----------------	-----