



# CONTENTS

LIST OF CONTRIBUTORS .....	v
FOREWORD.....	vii

## Airborne Geophysical Methods

PETER HOOD and S. H. WARD

1. Introduction.....	2
2. Aeromagnetic Methods.....	4
3. Low-Frequency Airborne Electromagnetic Methods.....	41
4. Airborne Radiometric Methods.....	79
5. Airborne Gravity Methods.....	88
6. Other Airborne Remote-Sensing Methods.....	102

## Lidar

R. T. H. COLLIS

1. Introduction.....	113
2. The Basic Lidar Technique .....	114
3. Atmospheric Optical Parameters .....	117
4. The Significance of Lidar-Measured Optical Parameters.....	122
5. Application of Lidar Observations to Meteorological Problems and Atmospheric Studies.....	125
6. Lidar Contributions to Atmospheric Studies and Meteorological Problems.....	133
7. Future Developments.....	135
Appendix .....	136
List of Symbols.....	137
References .....	138

## Structure of Ball Lightning

JAMES R. POWELL and DAVID FINKELSTEIN

1. Introduction.....	141
2. Earlier Observations and Theories .....	144
3. Experimental Evidence .....	152

4. New Analysis of the Problem .....	167
5. Summary and Conclusions.....	185
List of Symbols.....	186
References .....	188

### Energetics of the Middle Atmosphere

CONWAY LEOVY

1. Introduction.....	191
2. The Ozone Distribution .....	193
3. The Water Vapor Distribution .....	202
4. Infrared Radiative Transfer .....	204
5. Heat Sources and Sinks above 80 kM .....	214
List of Symbols.....	216
References .....	217

### The Nature and Properties of Gaseous Ions Encountered in Atmospheric Studies

LEONARD B. LOEB

Introduction .....	223
1. Forces Influencing Ionic Behavior .....	224
2. Mobility Theory and Equations .....	225
3. Cluster Ions .....	227
4. Reactions between Ions and Molecules .....	229
5. Ion Mobility and Ion Identification.....	233
6. Accuracy of Mobility Determinations as Diagnostic Tools.....	234
7. Summary of Influences Affecting the Presence of Ion Species.....	235
8. Normal Ions in the Atmosphere.....	236
9. Reaction Rates of Ions.....	243
10. Langevin and Intermediate Ions.....	244
References .....	252

AUTHOR INDEX.....	257
SUBJECT INDEX.....	265

# AIRBORNE GEOPHYSICAL METHODS

Peter Hood\*

Geological Survey of Canada, Ottawa, Ontario, Canada

and

S. H. Ward\*

Department of Mineral Technology, University of California, Berkeley, California

	<i>Page</i>
1. Introduction.....	2
1.1. Methods and Applications.....	3
2. Aeromagnetic Methods .....	4
2.1. General.....	4
2.2. The Geomagnetic Field .....	4
2.3. Airborne Magnetometers .....	6
2.4. Aeromagnetic Survey Techniques .....	31
2.5. Aeromagnetic Data Compilation .....	34
2.6. Gradiometers .....	37
References .....	39
3. Low-Frequency Airborne Electromagnetic Methods.....	41
3.1. Introduction.....	41
3.2. The Basic Principle of Inductive AEM Systems .....	42
3.3. Types of AEM Systems.....	46
3.4. The Design of AEM Systems .....	49
3.5. Interpretation.....	68
3.6. Survey Procedures .....	73
3.7. Possible Future Developments.....	74
3.8. Conclusion .....	75
List of Symbols .....	75
References .....	76
4. Airborne Radiometric Methods.....	79
4.1. Introduction .....	79
4.2. Airborne Scintillation Counters .....	80
4.3. Airborne Scintillation Spectrometers .....	81
4.4. Airborne Radiometric Survey Techniques .....	84
References .....	86
5. Airborne Gravity Methods .....	88
5.1. General .....	88
5.2. Airborne Gravimeters .....	91
5.3. Airborne Gravity Gradiometers .....	97
References .....	100
6. Other Airborne Remote-Sensing Methods .....	102
6.1. General .....	102
6.2. Aerial Photography .....	104

\* Peter Hood is the author of Sections, 1, 2, and 4–6. S. H. Ward is the author of Section 3.

6.3. Ultraviolet Methods .....	104
6.4. Infrared Methods .....	105
6.5. Microwave Radiometers .....	107
6.6. Radar Methods .....	108
References .....	109
List of Symbols .....	111





# LIDAR

R. T. H. Collis

Aerophysics Laboratory, Stanford Research Institute, Menlo Park, California

	<i>Page</i>
1. Introduction . . . . .	113
2. The Basic Lidar Technique . . . . .	114
3. Atmospheric Optical Parameters . . . . .	117
3.1. General . . . . .	117
3.2. Rayleigh Scattering . . . . .	117
3.3. Mie Scattering . . . . .	118
3.4. Backscattering by Atmospheric Turbulence . . . . .	121
3.5. Absorption . . . . .	122
4. The Significance of Lidar-Measured Optical Parameters . . . . .	122
4.1. Meteorological Significance . . . . .	122
4.2. The Evaluation of Lidar-Measured Optical Parameters . . . . .	123
5. Application of Lidar Observations to Meteorological Problems and Atmospheric Studies . . . . .	125
5.1. General . . . . .	125
5.2. Illustrative Examples . . . . .	125
6. Lidar Contributions to Atmospheric Studies and Meteorological Problems . . . . .	133
7. Future Developments . . . . .	135
Appendix . . . . .	136
List of Symbols . . . . .	137
References . . . . .	138





# STRUCTURE OF BALL LIGHTNING\*†

James R. Powell

Brookhaven National Laboratory, Upton, New York

and

David Finkelstein

Belfer Graduate School of Science, New York

and

Brookhaven National Laboratory, Upton, New York

	<i>Page</i>
1. Introduction .....	141
2. Earlier Observations and Theories.....	143
2.1. Observations of Ball Lightning .....	143
2.2. Thunderstorm Conditions .....	148
2.3. Critique of Ball Lightning Theories .....	149
3. Experimental Evidence .....	152
3.1. Experiments with Persistent Atmospheric Luminosities .....	152
3.2. Convective Mixing Experiments .....	166
4. New Analysis of Problem .....	167
4.1. A Model of Ball Lightning .....	167
4.2. Energy Input to Ball .....	168
4.3. Townsend Multiplication in Ball .....	174
4.4. Spatial and Temporal Variation of Currents in Ball .....	181
4.5. Electrohydrodynamic Forces .....	183
4.6. Stability of the Ball .....	184
5. Summary and Conclusions .....	185
List of Symbols .....	186
References .....	188



# ENERGETICS OF THE MIDDLE ATMOSPHERE\*†

Conway Leovy

The RAND Corporation, Santa Monica, California

	<i>Page</i>
1. Introduction .....	191
2. The Ozone Distribution .....	193
2.1. Observations of the Ozone Distribution .....	193
2.2. Photochemical Theories of the Ozone Distribution.....	196
2.3. Ozone and Atmospheric Dynamics.....	200
3. The Water Vapor Distribution .....	202
4. Infrared Radiative Transfer .....	204
4.1. Curtis' Method for Calculation of Heating Rates .....	205
4.2. Influence of Line Shape and Line Spacing .....	207
4.3. Vibrational Relaxation .....	208
4.4. Heating Rate Caused by Infrared Transfer .....	211
4.5. Infrared Radiative Exchange and Atmospheric Dynamics .....	212
5. Heat Sources and Sinks above 80 km .....	214
List of Symbols .....	216
References .....	217



# THE NATURE AND PROPERTIES OF GASEOUS IONS ENCOUNTERED IN ATMOSPHERIC STUDIES\*

Leonard B. Loeb

Department of Physics, University of California, Berkeley, California

Introduction .....	223
1. Forces Influencing Ionic Behavior .....	224
2. Mobility Theory and Equations .....	225
3. Cluster Ions .....	227
4. Reactions between Ions and Molecules .....	229
4.1. Positive Ion Generation .....	229
4.2. Negative Ion Generation .....	231
4.3. Charge Exchange Reactions .....	231
4.4. Chemical Reactions .....	232
5. Ion Mobility and Ion Identification .....	233
6. Accuracy of Mobility Determinations as Diagnostic Tools .....	234
7. Summary of Influences Affecting the Presence of Ion Species .....	235
8. Normal Ions in the Atmosphere .....	236
9. Reaction Rates of Ions .....	243
10. Langevin and Intermediate Ions .....	244
References .....	252