Contents

A. Overview of Geodetic Refraction Studies
F.K. BRUNNER (With 1 Figure)

1. Introduction 1
2. The Challenge 2
3. Organisation 4
References 6

B. Two Wavelength Angular Refraction Measurement
D.C. WILLIAMS and H. KAHMEN (With 11 Figures)

1. Introduction 7
2. Theory of the Method 8
   2.1 The Refraction Integral 9
   2.2 Refraction Magnitudes 10
   2.3 The Two Wavelength Relationship 12
   2.4 Consideration of Water Vapour 13
3. Instrumental Methods 15
   3.1 Instrumental Approaches 16
   3.2 Khvostikov 16
   3.3 Tengström 17
   3.4 Vshivkov and Shilkin 19
   3.5 Startsev and Tukh 20
   3.6 Brein and Glissmann 21
   3.7 Dyson and Williams 22
   3.8 Astheimer and McHenry 23
   3.9 Mikhailov 24
4. Concluding Discussion 26
   4.1 Future Prospects 26
   4.2 Refraction Elimination 27
Appendix: Notation 27
References 28

C. Effects of Atmospheric Turbulence on Geodetic
Interference Measurements: Methods of its Reduction
M.T. PRILEPIN and A.S. MEDOVIKOV (With 2 Figures)

1. Introduction 33
2. Signal-to-Noise Ratio 33
   2.1 General Remarks 33
   2.2 Symmetrical Interferometer with Similar and
       Completely Correlated Fluctuations in Both Beams .. 35
   2.3 Symmetrical Interferometer with Similar but
       Partially Correlated Fluctuations 35

2.4 Interferometers with the Reference Arm without Fluctuations 36
2.5 Discussion 36
3. Angle-of-Arrival Fluctuation: Estimation of the Effect 37
4. Linear Interference Measurements: Fluctuation Effect and its Reduction 39
Appendix: Notation 42
References 43

D. Multiple Wavelength Electromagnetic Distance Measurement
J. LEVINE (With 1 Figure)

1. Introduction 45
2. Instrument Design - General Principles 46
3. Instrument Design - Engineering Tradeoffs 47
4. Proposed Instrument Design 50
5. Current Instrument 50
References 51

E. Water Vapor Radiometry in Geodetic Applications
G.M. RESCH (With 14 Figures)

1. Introduction 53
2. The Problem 53
3. Formulation of the Algorithm 55
4. Determination of "Constants" in the Algorithm 59
5. Instrumentation 67
6. Vapor Effects on Baseline Determination 73
7. Summary and Conclusions 80
Appendix A: Notation 81
References 82

F. Temperature and Humidity Structure in the Lower Atmosphere
E.K. WEBB (With 18 Figures)

1. Introduction 85
2. Broad Considerations 86
3. The Atmospheric Surface Layer 87
3.1 Turbulent Transfer Relationships 87
3.2 Diabatic Mean Profile Forms 93
3.3 Features of Temperature and Humidity Fluctuations 100
3.4 Magnitude of Temperature and Humidity Fluctuations 104
3.5 Spectrum and Structure Function 105
4. The Atmospheric Boundary Layer 116
4.1 Broad Character 116
4.2 Convective Boundary Layer 116
4.3 Stable Boundary Layer 124
5. Surface Complexities 129
5.1 Introduction 129
5.2 Small-Scale Adjustment or "Local Advection" 129
5.3 Sea Breeze 129
5.4 Hill-Valley Effects 130
Notation 131
References 132

G. Modelling of Atmospheric Effects on Terrestrial Geodetic Measurements
F.K. BRUNNER (With 3 Figures)

1. Introduction 143
2. Concept of Modelling 145
3. The Atmospheric Turbulence Model 147
4. Integral Models for $\tilde{r}$ 150
4.1 Overview 150
4.2 Rectification Model 152
4.3 Operational Model 155
4.4 Discussion 156
5. Model Evaluation 156
6. Conclusion 158
Appendix A: Notation 159
References 160

H. Refraction in Geodetic Levelling
P.V. ANGUS-LEPPAN (With 1 Figure)

1. Introduction 163
2. Investigations of Refraction by Kukkamäki 164
3. General Equation for Levelling Refraction 167
4. Temperature Gradient in the Atmospheric Boundary Layer 168
5. The Holdahl Model for Levelling 169
6. National Geodetic Survey Tests 170
7. Investigations using Angus-Leppan Equations 171
8. Statistical Analysis 173
9. Systematic and Random Effects 176
10. Conclusions 176
Appendix: Notation 178
Bibliography 179

I. Atmospheric Refraction Effects in Time and Latitude Observations Using Classical Techniques
I. NAITO and C. SUGAWA

1. Introduction 181
2. Expressions for Astronomical Refraction 182
3. Refraction Problems in VZT, PZT and Astrolabe Observations 183
4. Actual Atmospheric Structure 184
5. Refraction Effects and Meteorological Improvements for Their Corrections 186
6. Concluding Remarks 187
References 187

J. The Equations of Electromagnetic Wave Propagation in a Refractive Medium Corotating with the Earth
E.W. GRAFAREND

1. Introduction 189
2. The Variational Problem 189
2.1 Euler-Lagrange Equations 189
2.2 The Hamiltonian Complex 190
2.3 Invariant Postulates 191
2.4 Examples 192

3. The Variational Principle of the Wave Equations in an Electromagnetic Medium 195
3.1 The Faraday-Maxwell Tensors 195
3.2 Linear Constitutive Equations 197
3.3 The Variational Principles of the Wave Equation ... 198
4. A Discussion of the Wave Equation in an Earth-Fixed Frame 199
4.1 The Set of Wave Equations in a Medium at Rest in an Inertial Frame 199
4.2 The Set of Wave Equations in a Medium Corotating with the Earth 201
4.3 Examples 204
Appendix A: Notation 205
Appendix B: The Formal Structure of Electromagnetism 207
References 208

Subject Index 209