TABLE OF CONTENTS

page

ABSTRACT iii

ACKNOWLEDGMENTS iv

LIST OF TABLES x

LIST OF FIGURES xi

LIST OF ABBREVIATIONS xix

1 INTRODUCTION 1

2 BACKGROUND 6

2.1 Introduction 6

2.2 Stratospheric Aerosol 9

2.2.1 Aerosol Sources 10

2.2.2 Aerosol Microphysics 11

2.2.3 Climate Effects 14

2.3 Aerosol Measurements 15

2.3.1 In-situ Measurements 15

2.3.2 Occultation 16

2.3.3 Lidar 17

2.3.4 Limb Scatter 19

2.4 Radiative Transfer 22

2.4.1 Scalar Radiative Transfer 22

2.4.2 Vector Radiative Transfer 26

2.4.3 Rayleigh Scattering 28

2.4.4 Mie Scattering 28

2.4.5 SASKTRAN Radiative Transfer Model 31

2.5 Inversion Techniques 32

2.5.1 Optimal Estimation 33

2.5.2 Levenberg-Marquardt 34

2.5.3 Multiplicative Algebraic Reconstruction Technique 35

2.6 ALI Prototype Instrument and Stratospheric Balloon Flight 35

2.6.1 ALI Specifications 36

3 INSTRUMENT DESIGN 38

3.1 Introduction 38

3.2 AOTF Theory and Background 38

3.2.1 Solution to the Acoustic Equation 39

3.2.2 Diffraction Efficiency 44

3.2.3 Diffraction Angle 45

3.2.4 Tuning Curve 48

3.3 Optical Chain Development 50

3.3.1 AOTF Operation 51

3.3.2 Telecentric System Prototype 53

3.3.3 Telescopic System Prototype 60

3.3.4 ALI Optical Design 65

3.3.5 Correction to the Optical Design 70

3.4 Opto-Mechanical Design and Thermal Balancing 71

3.4.1 Opto-Mechanical Design 71

3.4.2 Baffle Design 75

3.4.3 Light Tight Case 80

3.4.4 Thermal Considerations 81

4 CALIBRATIONS AND CONTROL SOFTWARE 84

4.1 Introduction 84

4.2 Control Software 84

4.3 AOTF Calibration 88

4.3.1 Tuning Curve Analysis 88

4.3.2 Point Spread Function 91

4.3.3 Diffraction Efficiency 92

4.4 ALI Calibrations and System Test 93

4.4.1 Exposure Time Determination 93

4.4.2 DC Offset Removal 95

4.4.3 Dark Current Correction 97

4.4.4 Stray Light Calibration 98

4.4.5 Relative Flat-Fielding Correction 99

4.5 Integrated Testing 102

5 STRATOSPHERIC BALLOON FLIGHT AND AEROSOL RETRIVALS 104

5.1 Stratospheric Balloon Flight 104

5.1.1 Preflight Preparations 104

5.1.2 Balloon Flight 107

5.2 Limb Measurements 111

5.3 Aerosol Retrievals 118

5.3.1 Aerosol Extinction Retrieval Methodology 118

5.3.2 Particle Size Retrieval Methodology 123

5.3.3 Aerosol Extinction Retrievals 126

5.3.4 A Sample Particle Size Retrieval 131

6 THE SENSITIVITY TO POLARIZATION IN STRATOSPHERIC AEROSOL RETRIEVALS FROM LIMB SCATTERED MEASUREMENTS 133

6.1 Background and Forward Model 134

6.1.1 Polarized Scattered Sunlight and Stratospheric Aerosols 134

6.1.2 SASKTRAN-HR Model 138

6.1.3 Model Scenarios 139

6.2 Methodology 142

6.3 Analysis 146

6.3.1 Difference in Scalar Retrievals using a Scalar or Vector Model 146

6.3.2 Fraction of Limb Signal due to Aerosol 148

6.3.3 Potential for Retrieval Bias 153

6.3.4 Precision Analysis 155

6.4 Conclusions of the modelling study 159

7 CONCLUSION 161

7.1 Summary 161

7.2 Contributions of This Work 163

7.3 Outlook, Recommendations and Future Challenges 165

LIST OF REFERENCES 169

A ALI HARDWARE COMPONENTS 182

A.1 Optical Components 182

A.1.1 Optical Lenses 182

A.1.2 Polarizers 182

A.1.3 AOTF 183

A.2 Opto-Mechanical and Electrical Components 184

A.2.1 RF Driver 184

A.2.2 QSI CCD Camera 184

A.2.3 OCELOT Computer 184

A.2.4 Opto-Mechanical Pieces 185

B ALI SOFTWARE COMMANDS 186

B.1 List of Commands for ALI Software 186

B.1.1 EnableScience 187

B.1.2 DisableScience 187

B.1.3 EnableRF 187

B.1.4 DisableRF 188

B.1.5 EnableAutoSendStats 188

B.1.6 DisableAutoSendStats 188

B.1.7 SetScienceMode 188

B.1.8 ReloadConfig 189

B.1.9 LdCusCnf 189

B.1.10 LdCusExp 189

B.1.11 GetFile 190

B.1.12 EndCurrentScienceCycle 190

B.1.13 SetExposureScaleFactor 190

B.1.14 UpdateExposureTimeCurve 190

B.1.15 EnableCheckRfTemps 191

B.1.16 DisableCheckRfTemps 191

B.1.17 ResetHousekeeping 191

B.1.18 DumpConfig 191

B.1.19 SetBitsPerSecond 191

B.1.20 EnableAutomation 192

B.1.21 DisableAutomation 192

B.1.22 SetAutomationTimeout 192

B.1.23 EnableGps 192

B.1.24 DisableGps 192

B.1.25 EnablePulse 192

B.1.26 DisablePulse 192

B.2 List of ALI Science Modes 193

B.2.1 Invalid Mode 193

B.2.2 Calibration Mode 193

B.2.3 Aerosol Mode 194

B.2.4 H2O Mode 194

B.2.5 O2 Mode 195

B.2.6 Custom Mode 196

B.2.7 Aerosol Constant Exposure Time Mode 196

B.3 List of ALI Exposure Modes 196

B.3.1 Invalid Mode 196

B.3.2 Calibrated Exposure Mode 197

B.3.3 Custom Exposure Mode 197