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 4

2.1 Introduction 4

2.2 Stratospheric Aerosol 7

2.2.1 Aerosol Sources and Microphysics 8

2.2.2 Climate Effects 11

2.3 Aerosol Measurements 12

2.3.1 In-Situ Measurements 12

2.3.2 Occultation 13

2.3.3 Lidar 15

2.3.4 Limb Scatter 16

2.4 Radiative Transfer 19

2.4.1 Scalar Radiative Transfer 19

2.4.2 Vector Radiative Transfer 23

2.4.3 Rayleigh Scattering 24

2.4.4 Mie Scattering 25

2.4.5 SASKTRAN Radiative Transfer Model 27

2.5 ALI Prototype and Stratospheric Balloon Flight 28

3 OPTICAL DESIGN AND CALIBRATIONS 31

3.1 AOTF Theory and Background 31

3.1.1 Solution to the Acoustic Equation 31

3.1.2 Diffraction Efficiency 35

3.1.3 Diffraction Angle 36

3.1.4 Tuning Curve 39

3.2 AOTF Calibration and Operation 41

3.2.1 Operation 41

3.2.2 Tuning Curve Analysis 43

3.2.3 Point Spread Function 46

3.2.4 Diffraction Efficiency 47

3.3 Optical Chain Development 47

3.3.1 Telecentric System Prototype 48

3.3.2 Telescopic System Prototype 55

3.3.3 ALI Optical Design 60

3.3.4 Correction to the Optical Design 65

3.4 Opto-Mechanical Design and Thermal Balancing 66

3.4.1 Opto-Mechanical Design 66

3.4.2 Baffle Design 72

3.4.3 Light Tight Case 77

3.4.4 Thermal Considerations 78

3.5 Control Software 80

3.6 ALI Calibrations and System Test 84

3.6.1 Exposure Time Determination 84

3.6.2 DC Offset Removal 86

3.6.3 Dark Current Correction 87

3.6.4 Stray Light Calibration 88

3.6.5 Relative Flat-Fielding Correction 90

3.6.6 Integrated Testing 93

4 AEROSOL SENSITIVITY TO POLARIZATION 95

4.1 Introduction 95

4.2 Model, Scenarios, and Methodology 96

4.2.1 Polarized Scattered Sunlight 96

4.2.2 Model 98

4.2.3 Aerosol Scenarios 98

4.2.4 Methodology 100

4.3 Analysis 103

4.3.1 Aerosol Sensitivity 103

4.3.2 Retrievals 108

4.3.3 Precision analysis 111

4.4 Conclusions 115

5 STRATOSPHERIC BALLOON FLIGHT AND AEROSOL RETRIVALS 117

5.1 Stratospheric Balloon Flight 117

5.1.1 Preflight Preparations 117

5.1.2 Balloon Flight 121

5.2 Limb Measurements 125

5.3 Aerosol Retrievals 131

5.3.1 Aerosol Extinction Retrieval Methodology 132

5.3.2 Aerosol Extinction Retrievals 136

5.3.3 Particle Size Retrieval Methodology 141

5.3.4 A Sample Particle Size Retrieval 145

5.4 Results and Future Improvements 147

6 CONCLUSION 150

LIST OF REFERENCES 153

A ALI HARDWARE COMPONENTS 164

A.1 Optical Components 164

A.1.1 Optical Lenses 164

A.1.2 Polarizers 164

A.1.3 AOTF 165

A.2 Opto-Mechanical and Electrical Components 166

A.2.1 RF Driver 166

A.2.2 QSI CCD Camera 166

A.2.3 OCELOT Computer 166

A.2.4 Opto-Mechanical Pieces 167

B ALI SOFTWARE COMMANDS 168

B.1 List of Commands for ALI Software 168

B.1.1 EnableScience 169

B.1.2 DisableScience 169

B.1.3 EnableRF 169

B.1.4 DisableRF 170

B.1.5 EnableAutoSendStats 170

B.1.6 DisableAutoSendStats 170

B.1.7 SetScienceMode 170

B.1.8 ReloadConfig 171

B.1.9 LdCusCnf 171

B.1.10 LdCusExp 171

B.1.11 GetFile 172

B.1.12 EndCurrentScienceCycle 172

B.1.13 SetExposureScaleFactor 172

B.1.14 UpdateExposureTimeCurve 172

B.1.15 EnableCheckRfTemps 173

B.1.16 DisableCheckRfTemps 173

B.1.17 ResetHousekeeping 173

B.1.18 DumpConfig 173

B.1.19 SetBitsPerSecond 173

B.1.20 EnableAutomation 174

B.1.21 DisableAutomation 174

B.1.22 SetAutomationTimeout 174

B.1.23 EnableGps 174

B.1.24 DisableGps 174

B.1.25 EnablePulse 174

B.1.26 DisablePulse 174

B.2 List of ALI Science Modes 175

B.2.1 Invalid Mode 175

B.2.2 Calibration Mode 175

B.2.3 Aerosol Mode 176

B.2.4 H2O Mode 176

B.2.5 O2 Mode 177

B.2.6 Custom Mode 178

B.2.7 Aerosol Constant Exposure Time Mode 178

B.3 List of ALI Exposure Modes 178

B.3.1 Invalid Mode 178

B.3.2 Calibrated Exposure Mode 179

B.3.3 Custom Exposure Mode 179