CHAPTER 6

CONCLUSION

Measurements of aerosol have been used for decades from in-situ measurements through the use of balloons and sondes and globally through the use of satellites. These data sets have been used to determine radiative forcing changes on the earth such as have been used to infer the recent global warming hiatus. However, current generation instruments are aging and operating well beyond their lifetimes. New instrumentation to continue the long term global aerosol dataset is required to continue to monitor the climate changes of the earth. This work has been focused on developing a prototype instrument to capture images of polarized radiance from a limb scatter geometry in order to determine aerosol profiles in two dimensions. ALI is the proposed prototype instrument and was designed for an engineering test to be launch from a stratospheric balloon and to determine aerosol extinction and microphysics.

ALI was designed and developed using an AOTF to spectrally filter measured radiance in images from 650 to 950 nm with exposure times on the order of seconds. ALI was calibrated in the optics laboratory including stray light, flat fielding, and relative spectral calibrations among others. ALI was a simple linear three lens optical system using the telescoptic optical layout consisting of the telescope for the FEO and a focusing lens for the BEO to resolve the image on the CCD. The system had a large FOV of 6o to be able to image from a tangent point of the ground to float altitude (approximately 35 km). This resulted in significant aberrations being present in the last degree of the FOV, which was also partially outside of the acceptance angle of the AOTF. And from testing and simulations in Code V optical design software the optical resolution of the instrument was a nominal 210 m both vertical and horizontal direction.

With the completion of ALI a simulation study was underwent to determine the optimal geometry and polarization orientation for a limb scatter imaging polarized instrument. The study simulated the measured radiance profiles and used them to retrieved aerosol profiles assuming an incorrect particle size distribution. This simulated real retrievals algorithms where the particle size distribution is unknown and an a priori must be assumed. From this work the optimal geometry possible would be measuring a forward scatter radiance from a vertical polarization. This geometry results in the highest contribution of aerosol signal and high quality precision profiles. However, there are two downsides, first measuring the vertical polarization results in measuring less overall radiance than the horizontal polarization which may lead to long exposure times. Second, the vertically polarization aerosol scattering cross section is very sensitive to particle size distributions from SSA of 85 to 95o which can systematically bias the retrieved aerosol profiles and this bias is nonsignificant once the SSA is greater than 100o  or less than 80o. This region was considered acceptable for ALI and the vertical polarization was used for the test flight.

The test flight for ALI occurred from Timmins, Ontario from the CSA balloon launch facility. ALI was mounted on board the CNES CARMEN-2 gondola and the launch of the stratospheric balloon occurred at 05:35 UTC on September 19, 2014 and had a flight duration of 16 hours and 14 minutes. Float altitude was 36.5 km and ALI captures aerosol images for five hours resulting in 216 measurements. These image were used to computer one dimensional aerosol extinction profiles from the flight which agreed well to the nearest OSIRIS scans but had some disagreement in extinction values from 20-25 km. This may have been from unaccounted for systematics in the retrieval or the SSA close to 90o which is known to yield systematics in the retrieval. Overall, however the results are promising and work on a second iteration of the instrument have already begun. Furthermore, the particle size retrievals agrees with accepted values for the background stratospheric aerosol but since the wavelength range is limited a large error bar is associated. Even with this limitation ALI in its current state could notice large particle size trends in the stratosphere. A satellite version of ALI would be able to accurately model aerosol trends on a global basis and be able to continue the global aerosol dataset.

This first prototype ALI instrument has allowed for the measurement of stratospheric aerosol through polarized images and with the continuation of the ALI project some recommendations and future work are suggested. First, an azimuth scan occurred during the test flight to test the sensitivity of the measurement to aerosol to supply some verification of the simulation study. These measurements should be analyzed to better understand the correct orientation for the second generation of ALI. An orientation that was in the azimuth 45-60o from the sun would be preferable to be sure to stay out of the SSA of 80-100o range that can lead to aerosol biases in the retrievals to improve aerosol product quality.

During the mission, unknown stray light was noted in some of the images and a back end telescopic chain should be added to help further reduce in internal stray light from the rejected polarization. Furthermore, the addition of a shutter or masked pixels on the CCD would be useful to calibrate DC offset and dark current change during the flight due to temperature changes. Both of these improvements would help to improve the image quality of the next generation instrument.