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A new technique for measuring aerosols with moonlight observations and a sky background model

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There have been an ample number of studies on aerosols in urban, daylight conditions, but few for remote, nocturnal aerosols. We have developed a new technique for investigating such aerosols using our sky background model and astronomical observations. With a dedicated observing proposal we have successfully tested this technique for nocturnal, remote aerosol studies.

This technique relies on three requirements: (a) sky background model, (b) observations taken with scattered moonlight, and (c) spectrophotometric standard star observations for flux calibrations. The sky background model was developed for the European Southern Observatory and is optimized for the Very Large Telescope at Cerro Paranal in the Atacama desert in Chile. This is a remote location with almost no urban aerosols. It is well suited for studying remote background aerosols that are normally difficult to detect. Our sky background model has an uncertainty of around 20 percent and the scattered moonlight portion is even more accurate. The last two requirements are having astronomical observations with moonlight and of standard stars at different airmasses, all during the same night. We had a dedicated observing proposal at Cerro Paranal with the instrument X-Shooter to use as a case study for this method. X-Shooter is a medium resolution, echelle spectrograph which covers the wavelengths from 0.3 to 2.5 micrometers. We observed plain sky at six different distances (7, 13, 20, 45, 90, and 110 degrees) to the Moon for three different Moon phases (between full and half). Also direct observations of spectrophotometric standard stars were taken at two different airmasses for each night to measure the extinction curve via the Langley method. This is an ideal data set for testing this technique.

The underlying assumption is that all components, other than the atmospheric conditions (specifically aerosols and airglow), can be calculated with the model for the given observing parameters. The scattered moonlight model is designed for the average atmospheric conditions at Cerro Paranal. The Mie scattering is calculated for the average distribution of aerosol particles, but this input can be modified. We can avoid the airglow emission lines, and near full Moon the airglow continuum can be ignored. In the case study, by comparing the scattered moonlight for the various angles and wavelengths along with the extinction curve from the standard stars, we can iteratively find the optimal aerosol size distribution for the time of observation. We will present this new technique, the results from this case study, and how it can be implemented for investigating aerosols using the X-Shooter archive and other astronomical archives.