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Studying Aerosol Properties from Astronomical Observations Using a Scattered Moonlight Model

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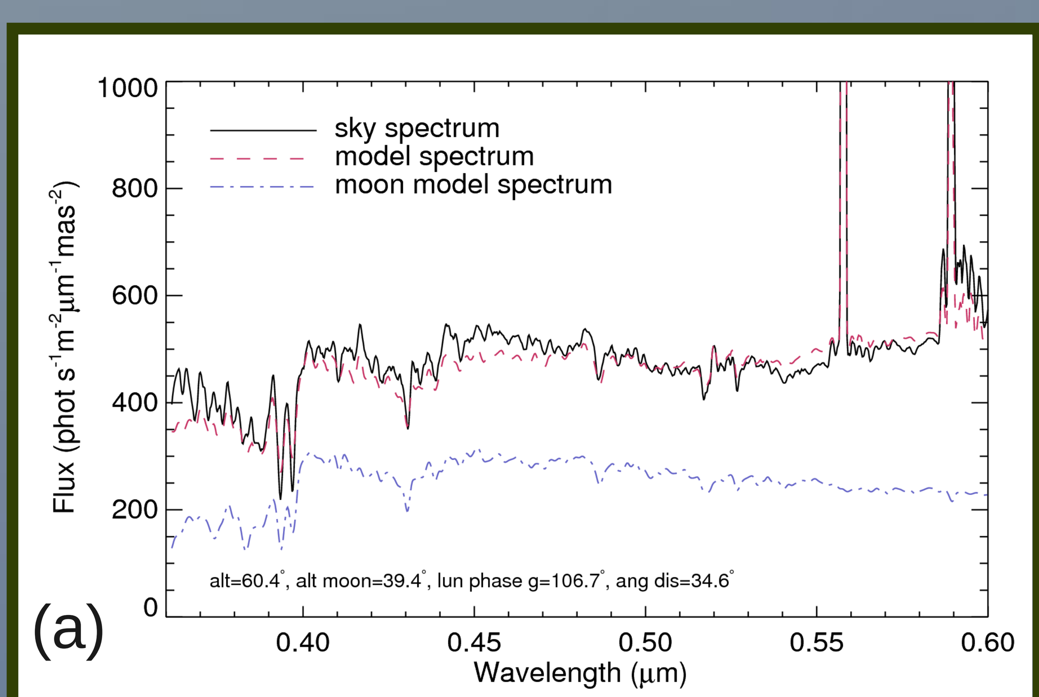
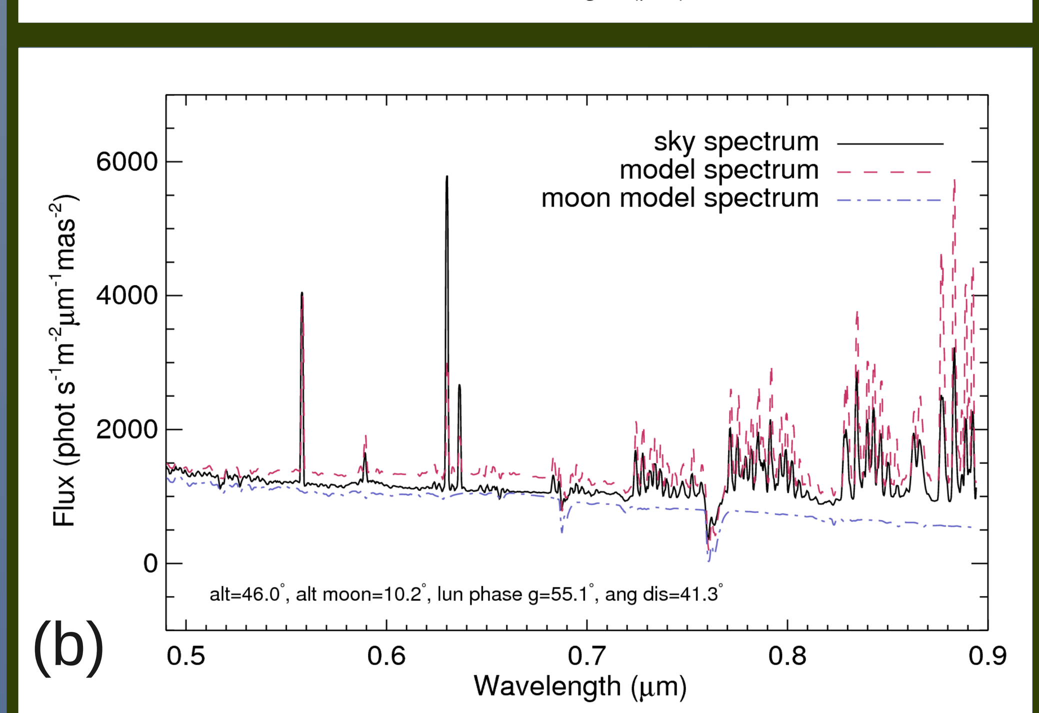
We are developing a new technique for monitoring the atmosphere with astronomical observations and our scattered moonlight model. This model is more physical than previous works in astronomy, which were almost completely empirical [1]. It can be used to determine the size distributions and amounts of various aerosol particles. By taking the Moon as an illuminating source in sky observations, it is possible to iteratively find aerosol properties for a given time and location. There is a wealth of astronomical data over the last decade taken at Cerro Paranal in Chile where this technique can be applied.
This method, coupled with the location and height of the observatory, uniquely allows the investigation of nocturnal background aerosols.

(1)

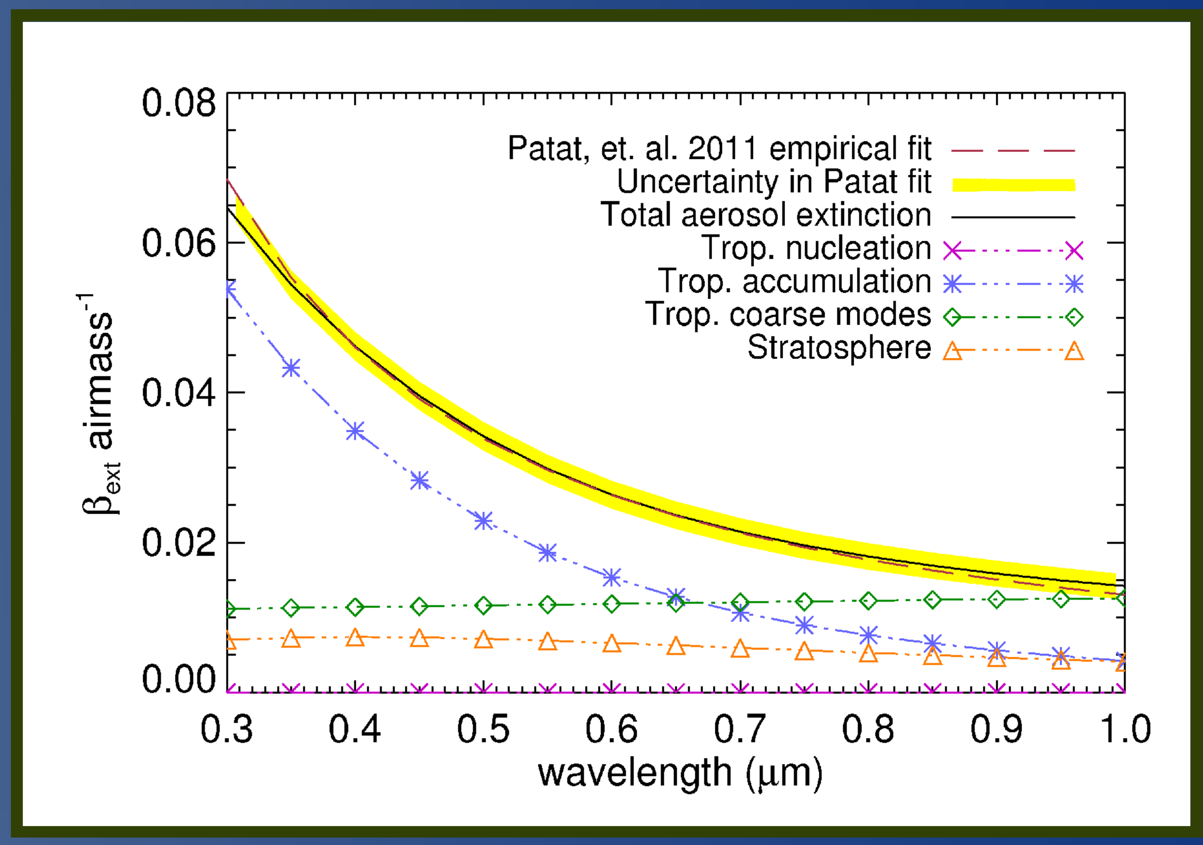




Our advanced scattered moonlight model is part of a sky radiance and transmission model developed for the Very Large Telescope of the European Southern Observatory [2]. The Moon model can calculate the amount of scattered moonlight present in a given astronomical observation based on the positions of the Moon and target, lunar phase, and atmospheric properties.

Fig 1: Typical FORS1 spectrum [3] with moderate (a) and strong (b) moonlight. The full sky background model and scattered moonlight model are overlaid.

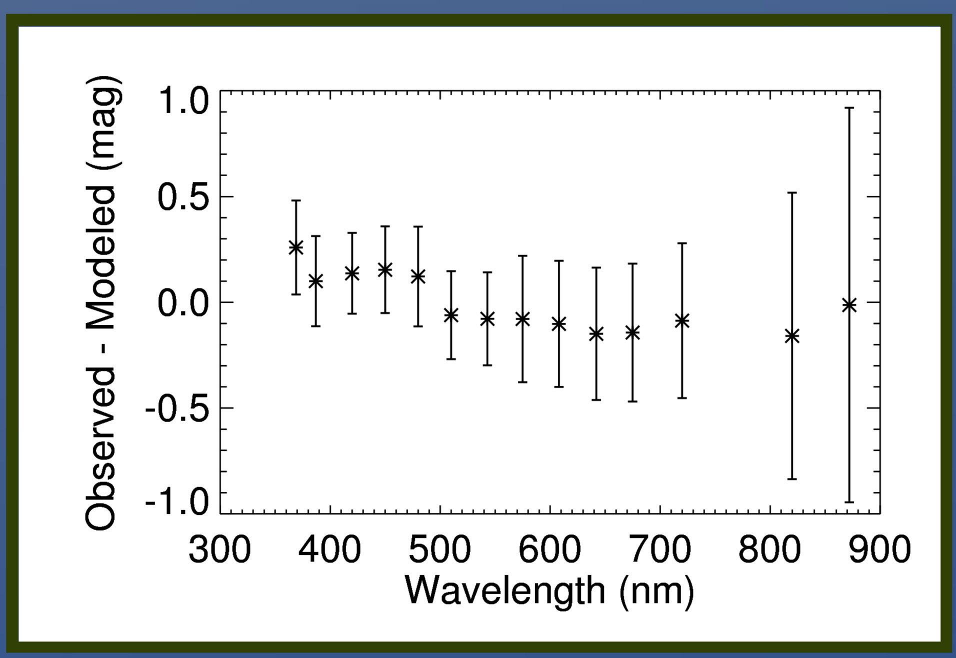
(3)



The scattered moonlight model uses typical size distributions of remote continental tropospheric and stratospheric aerosols [4] for Mie scattering that is then scaled to the extinction curve derived at Cerro Paranal [5]. **Fig 3** shows the optical depths of the aerosol distributions and the total derived extinction curve. Because the model incorporates the properties of the aerosols, in principle we can use this model with sky background observations to iteratively find the aerosol composition. The sky observations would first need to be analyzed with our full sky model to calculate the other sky background components, along with a derived extinction curve from flux standard star observations.

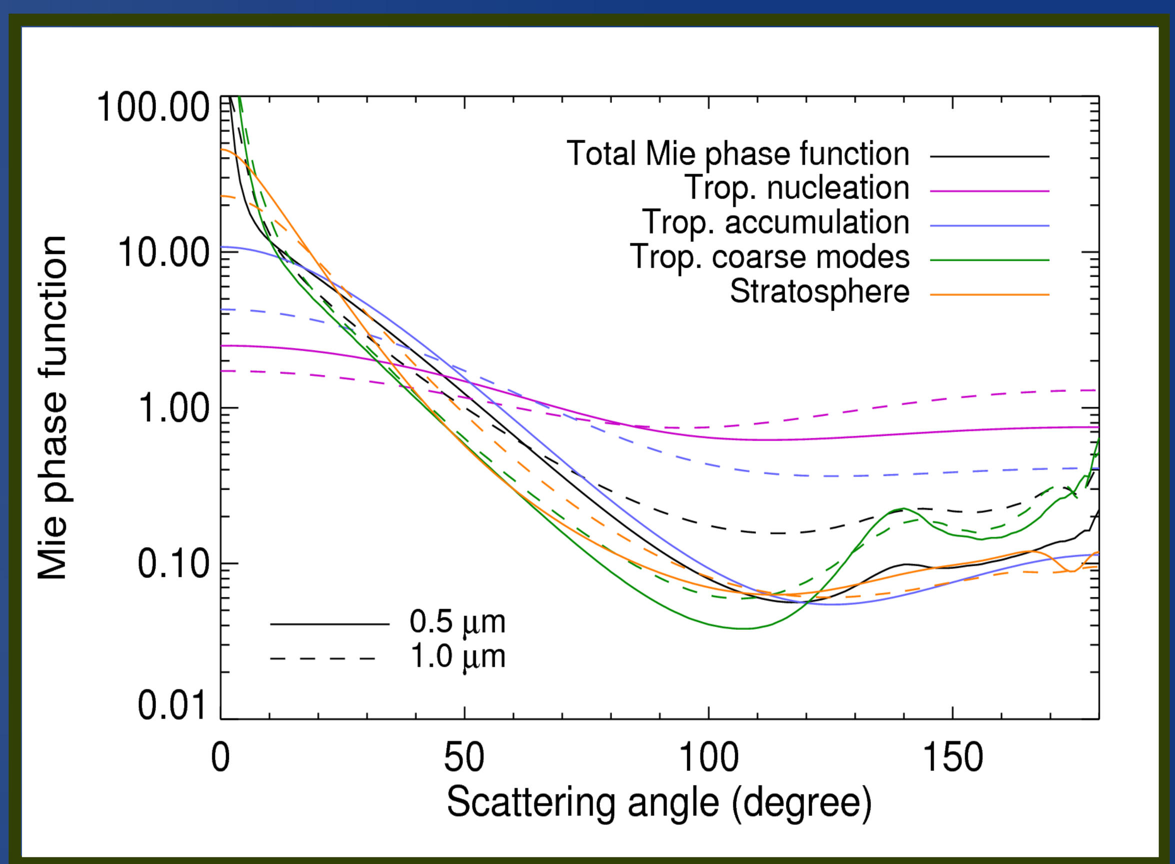
(2)

Fig 2: The mean of the difference between the observed [3] and modeled spectra at several continuum windows for data with significant moonlight and good weather conditions. The error bars are the one sigma spread. The uncertainty in the flux calibration of the spectra for the different filters can be seen by the jump at 500 nm.



(4)

Fig 4 shows the Mie phase functions of the various distributions [4] at two different wavelengths and the total phase function. The Mie phase functions are calculated using the aerosol properties from the decomposed extinction curve [6].



This technique for studying aerosol properties would provide data from a new perspective. Most current methods use the Sun as the illuminating source to study the aerosols and so with this new nocturnal data set one could compare the two types. Additionally, the aerosols near the observatory are not dominated by local pollution sources and the background aerosols can be better studied. Finally, the observatory has been operational for over a decade, and the aerosol data set could be extended into the past, as well as the model can be modified so the technique could be applied to other observatories around the globe.
This new method for determining aerosol properties from astronomical observations with our scattered moonlight model could be a promising tool for atmospheric science.

www.twanight.org, Tamas Ladanyi

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