Observations, Ray-tracing, and Data Assimilation in the Assessment of Aerosols

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By tracing rays from natural (Sun, Moon, and other astronomical objects) and artificial (city) light sources and assessing how they are affected by the atmosphere, aerosols, and land / ocean surface, full-color visually realistic images of the environment can be created based on 3D Numerical Weather Prediction (NWP) analyses or model forecasts. Simulated Weather IMagery (SWIM) can be compared with observed images (camera or other photometric measurements) to (1) validate existing ray tracing and NWP analyses / forecast algorithms, or (2) assimilate observed images affected by atmospheric, aerosol, and surface variables into numerical analyses (NWP Data Assimilation, DA).

As for (1), in clear daytime skies, radiance patterns depend on the aerosol optical depth (AOD, see Fig. 1) and size distributions. The appearance of the sky during twilight, on the other hand, is most sensitive to the presence of stratospheric aerosols. Other relationships and observation platforms will be discussed in the presentation.

Since aerosols affect both simulated and observed weather images, we will use DA techniques to synthesize all aerosol related observational information into analysis states expanded by aerosol related "control" variables. AOD, scale height, single scattering albedo, and other aerosol parameters that are currently manually prescribed using a subjective estimation of visibility will be variationally estimated as 2- or 3D control variables, influenced by aerosol related observations (e.g., camera, photometer, LIDAR, AERONET, aerosonde, satellite) and a "first guess" forecast from an aerosol resolving numerical model such as GSD's WRF- or FIM-Chem.

Figures below show simulated (top) and observed (camera, bottom) weather images as seen from the top of the Boulder, CO DSRC building.

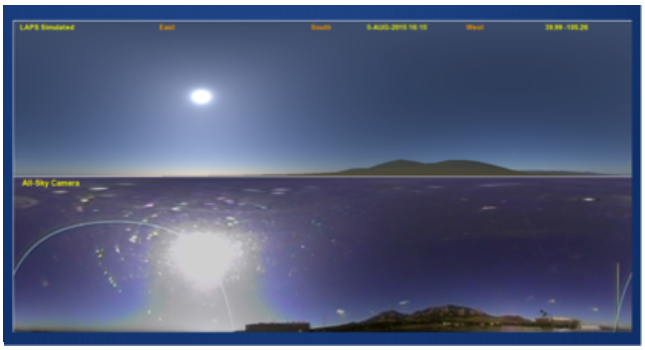

Figure 1. 16:15 UTC 5 Aug 2015 (AOD ~0.05).

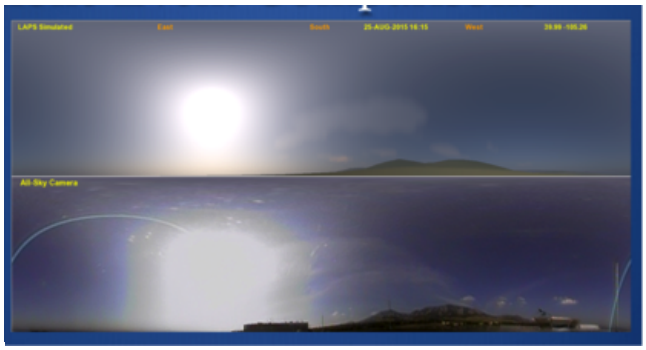

Figure 2. 25 Aug 2015 (right, AOD=0.23).