Radiative Forcing Efficiency of a Forest Fire Smoke Plume at the Surface and Top Of the Atmosphere (TOA)

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On 6 Sept. 2010, at about 10:00 AM LST a forest fire developed northwest of Boulder, Colorado. The smoke plume was carried eastward through a dry cloudless sky and drifted over several sets of instruments that were ideal for computing the surface radiative forcing efficiency (RFE) of the aerosol [*Stone et al*. 2011]. Persistent clear skies permitted unrestrained Aerosol Optical Depth (AOD) calculations throughout the day. Surface-measured AOD_{500nm} ranged from background values (0.045 prior to the event) to a peak of ~3.5. Surface RFE was documented over a wide range of solar zenith angles (SZA) for a surface albedo of 0.15. Surface RFE_{sw} varied from -194±10 at high sun (35° SZA) to -81±9 $Wm^{-2}AOD_{500}^{-1}$ at low sun (73° SZA), while RFE_{lw} was stable at +10±7 $Wm^{-2}AOD_{500}^{-1}$ throughout the day and night. Diurnally averaged RFE for Shortwave (SW), Longwave (LW) and all-wave net radiation at the surface were -61.5, +10.0, and -51.5 $Wm^{2}AOD_{500}^{-1}$, respectively. Computation of the plume's radiative effect at the TOA and the subsequently inferred total atmospheric heating induced by the plume requires space-borne measurements of outgoing SW and LW irradiance. NASA/CERES broadband measurements aboard its EOS satellites would be best for this task, but the plume was too small compared to the CERES footprint. The higher resolution (500 m) MODIS satellite imager did sample the smoke plume about three hours after the fire started at about 1300 LST. However, MODIS does not provide a broadband TOA irradiance product but samples spectrally at several solar wavelengths. We will estimate the total broadband SW radiative effect of the smoke plume at TOA using MODIS data and the Fu-Liou radiative transfer model. First, we will convert the MODIS spectral sampling to broadband SW using empirical methods, and then analyze the MODIS-derived broadband irradiance from the plume and clear areas outside of the plume to infer the RFE_{sw} at TOA. Our empirical results will be compared to radiative transfer model calculations.

R. S. Stone, J. A. Augustine, E. G. Dutton, N. T. O'Neill, and A. Saha (2011), Empirical determinations of the longwave and shortwave radiative forcing efficiencies of wildfire smoke, *J. Geophys. Res.*, 116, D12207, doi:10.1029/2010JD015471.

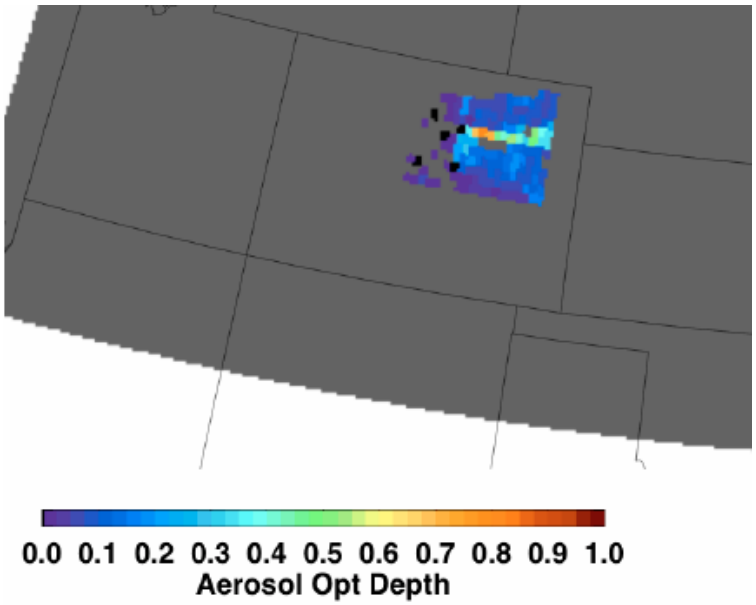

Figure 1. NASA MODIS processed AOD image of the Fourmile Canyon wildfire smoke plume at 1300 LST, 6 Sept. 2010.