Radiative Forcing Efficiency of the Fourmile Canyon Fire Smoke Plume - A Near-Perfect Ad Hoc Experiment

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On 6 Sep 2010 a wildfire in the foothills west of Boulder, CO grew explosively and sent a plume of smoke eastward. Fortunately, observations were made under and around the plume that were ideal for determining its radiative forcing efficiency (RFE), i.e., the change in net surface irradiance per unit aerosol optical depth at 500 nm (AOD_{500}) [Stone et al. 2011]. Observations included two operational surface radiation budget (SRB) stations (Table Mountain and Boulder Atmospheric Observatory), four GPS water vapor sites, and three Weather Underground stations. Multiple channel Aerosol Optical Depth (AOD) was measured at the SRB sites and at the David Skaggs Research Center (DSRC) in Boulder, where air samples were also collected and analyzed for the aerosol's optical properties. The ideal nature of this situation was enhanced by clear skies that permitted unrestrained AOD and RFE calculations over a continuum of solar zenith angles (SZA). Our primary result was the documentation of RFE for shortwave (SW) and longwave (LW) irradiance over a wide range of SZA (35°–73°) for a surface albedo of 0.15. RFE_{sw} varied from –194±10 $Wm^{-2}AOD_{500}^{-1}$ at high sun to –81±9 $Wm^{-2}AOD_{500}^{-1}$ at 73° SZA, while RFE_{lw} was diurnally stable at +10±7 $Wm^{-2}AOD_{500}^{-1}$. Diurnally integrated RFE for SW, LW and all-wave net were –61.5, +10.0, and –51.5 $Wm^{-2}AOD_{500}^{-1}$, respectively. The net loss of incoming energy resulted in significant daytime cooling; observed air temperature anomalies under the plume were as much as –5°C. Published assessments of RFE are rare and often include a mix of limited ground-based data, error prone satellite retrievals, and model simulations that require assumptions on the optical properties of the aerosol. Our results were achieved entirely from highly accurate measurements and may be useful for refining model parameterizations and for improving assessments pertaining to smoke from northern wildfires.

Stone, R.S., J.A. Augustine, E.G. Dutton, N.T. O'Neil, and A. Saha (2011), Empirical determinations of the longwave and shortwave radiative forcing efficiencies of wildfire smoke, J. Geophys. Res., (in press).

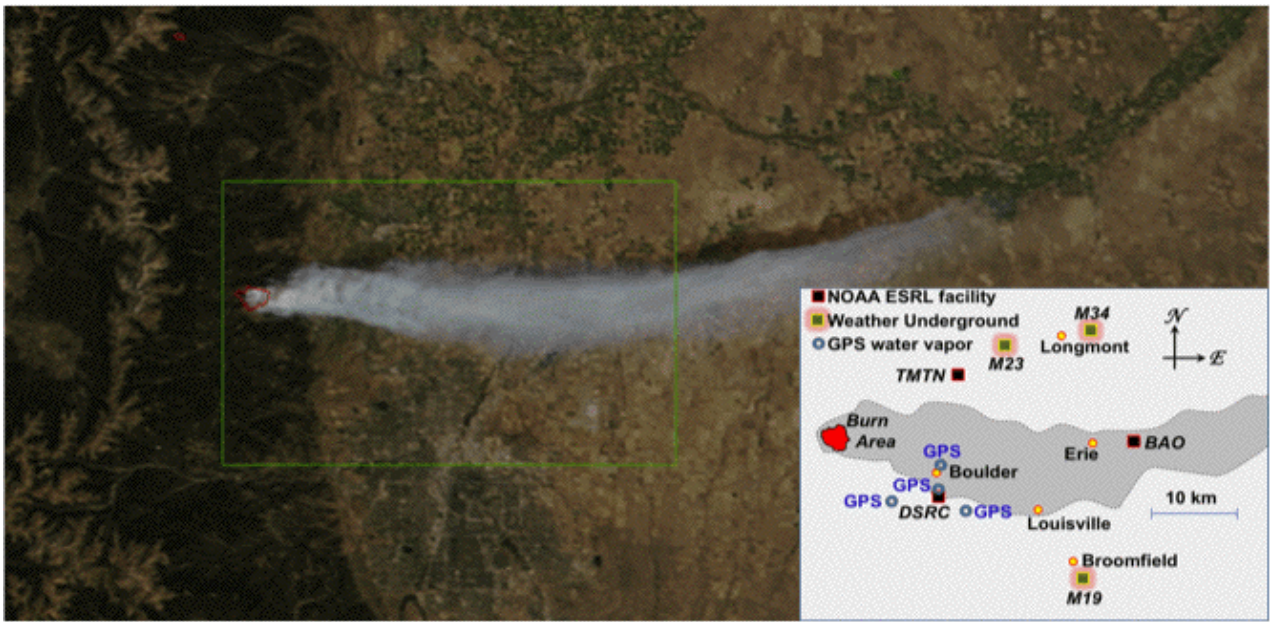

Figure 1. NASA MODIS image of the Fourmile Canyon wildfire smoke plume at 12:15 LDT, 6 Sep 2010. Insert corresponds approximately to the green rectangle.