Radiative Forcing of a Small-scale Wildfire Smoke Plume at the Surface, Atmosphere, and Top of Atmosphere (TOA) from Surface and Satellite Observations

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Circumstances converged on 6 Sep 2010 over northeastern Colorado that permitted documentation of the radiative impact of a small-scale forest fire smoke plume at the surface, TOA, and within the atmosphere. The plume drifted over two surface radiation budget sites where the radiative forcing of the smoke was computed throughout the day. For TOA, narrow-to-broadband conversion methods, one for ShortWave (SW) (see below), and one for LongWave (LW), were applied to high spatial resolution spectral MODIS data for two satellite passes that were an hour and 40 minutes apart. Results showed negative SW forcing by the smoke at both TOA and the surface, indicating cooling, but the magnitude of the cooling was two to four times greater at the surface. LW forcing warmed both TOA and the surface, but the magnitude of the LW warming was 4 to 10 times less than the SW cooling at both levels. Thus, the net effect of the plume was to cool the surface and TOA, but with a greater impact at the surface. This differential cooling resulted in instantaneous atmospheric warming rates of 2° to 9° C per day. These heating rates were a third to a half less than those computed from SW forcing alone, indicating the importance of including LW in calculations of smoke induced atmospheric heating. MODIS water vapor imagery clearly demonstrated that the burning biomass injected measureable water vapor into the atmosphere. Integrated water vapor within the plume area increased by 20 to 40% due to combustion alone during the period between the two satellite passes, and absolute increases were on the order of 0.1 to 0.2 cm.

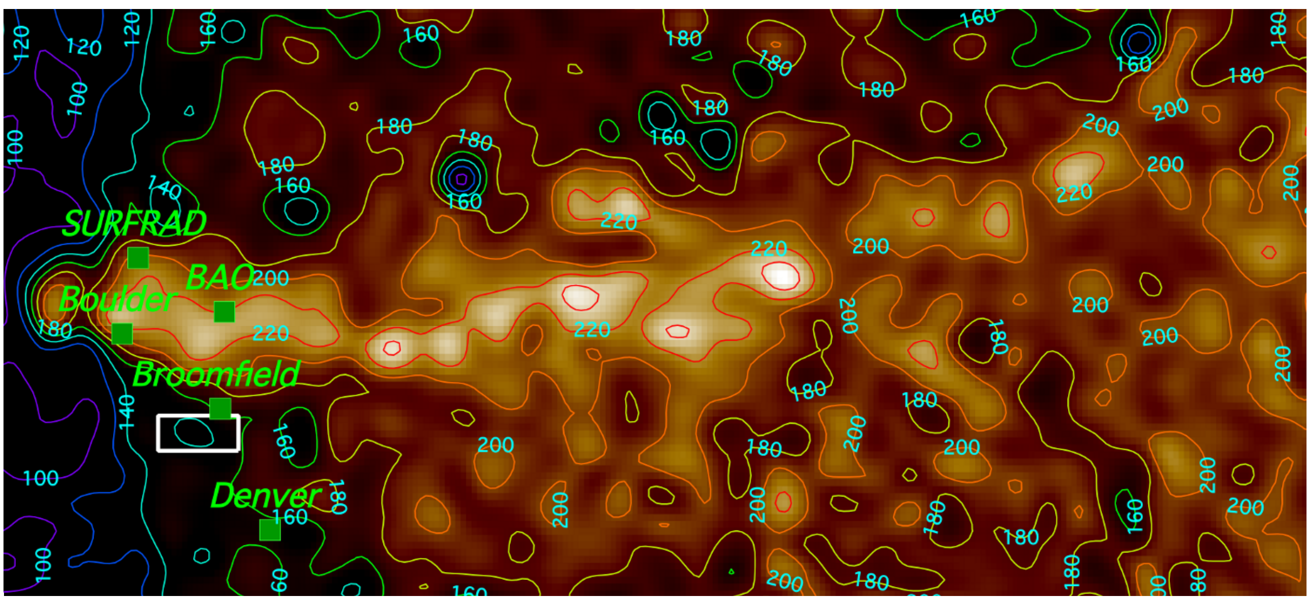

Figure 1. Upwelling broadband shortwave flux at TOA in Wm-2 computed from MODIS spectral imagery for 2000 UTC on 6 Sep 2010. Greater fluxes reflected from the smoke plume show up as white and lighter shades of brown. CERES data was too coarse to resolve the plume.