

# Effects of Wildfire Smoke on SIRS Shortwave and Longwave Irradiance

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## Abstract

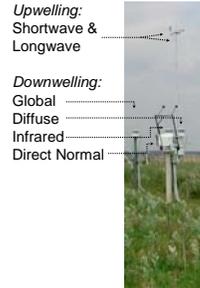
The tragic outbreak of wildfires in Oklahoma during the winter of 2005/2006 provided an opportunity to evaluate the smoke effects on broadband surface radiation fluxes. Media reports of the day tallied more than 1,000 fires since November, 2005 burning in excess of 411,000 acres by mid-January 2006.

We compare SIRS measurements of longwave and shortwave irradiances under cloudless conditions at Earlsboro, OK (EF-27) - unaffected by the fires - with data from Morris, OK (EF-18) which was downwind of a wildfire outbreak on 2 January 2006. Separated by 94 km (56 mi), both stations experienced prevailing winds averaging  $4.5 \text{ ms}^{-1}$  (10 mph) with gusts to  $13 \text{ ms}^{-1}$  (28 mph) that directed the smoke plumes as shown on the map below.

Before comparing the data from the two study sites, we established a baseline comparison of four SIRS sites using clear sky conditions (with no wildfires) on 24 January 2006. Radiometer measurement performance was found acceptable for our evaluations once we accounted for the slight differences in surface albedo at the two sites of interest.

Our results quantify the shortwave and longwave contributions to a  $40 \text{ Wm}^{-2}$  reduction in Net flux due to the heavy aerosol loading of the atmosphere.

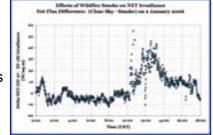
## Instrumentation



Solar & Infrared Station (SIRS) Radiometers

## Conclusions

- By comparing SIRS measurements from two sites on 2 January 2006 under cloudless sky conditions, one site effected by wildfire smoke, we find the Net Radiation flux was decreased by as much as  $40 \text{ Wm}^{-2}$  due to smoke (see chart).



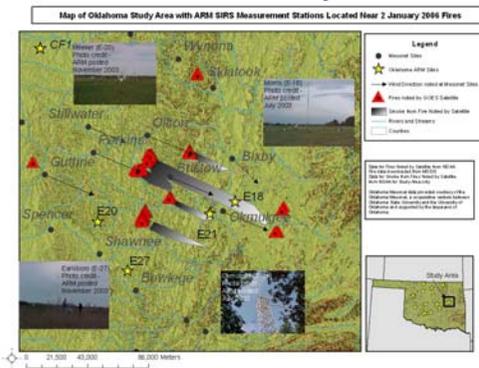
- Clear sky Direct Normal Irradiance was reduced by as much as 20%, comparable to effects of the 1991 Mt. Pinatubo volcanic eruption and 1989 Yellowstone fires on irradiance measurements taken by NREL in Golden, Colorado.<sup>1,2</sup>

- Global (downwelling total hemispheric shortwave) decreased by about  $30 \text{ Wm}^{-2}$  and Diffuse increased by about  $70 \text{ Wm}^{-2}$  due to the increased shortwave absorption and scattering at wavelengths below 3 microns.

- Decreased infrared fluxes, downwelling by  $10 \text{ Wm}^{-2}$  and upwelling by  $20 \text{ Wm}^{-2}$ , are consistent with observed estimated broadband aerosol optical depths 0.17 to 0.29 during the smoke event.

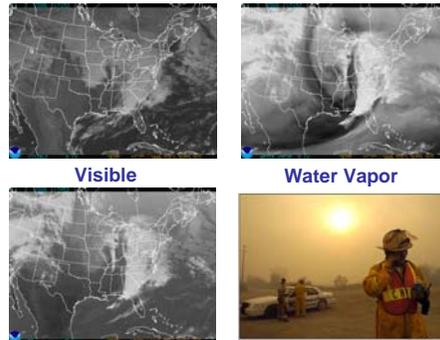
- Operational SIRS data randomly selected from four stations during a day with clear sky conditions agree to well within the estimated measurement uncertainties.

## Wildfires 2 January 2006



Locations of Fires, Smoke Trajectory & SIRS Stations

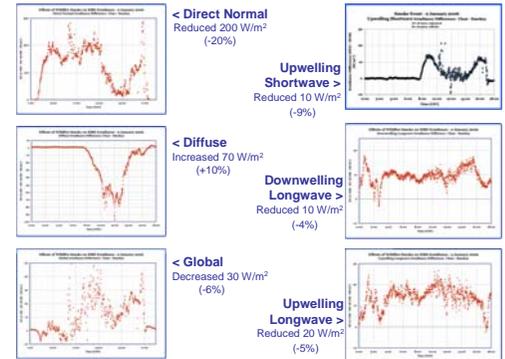
## Cloud Free Over Study Area GOES-E Images 2 January 2006 11:15 CST



Infrared

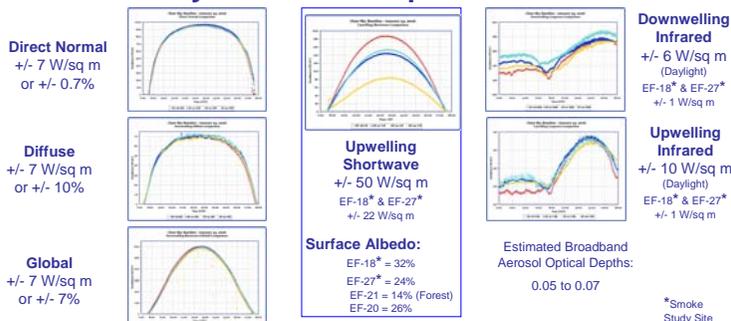
Typical Shortwave Scattering due to Smoke

## Smoke Cloud Forcing



Irradiance Differences (Clear - Smokey)

## Clear Sky Baseline Comparisons at 4 Stations

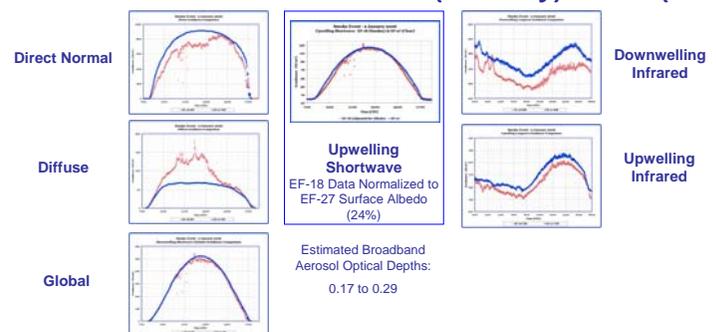


SIRS Measurements from 24 January 2006 in Agreement Except Upwelling Shortwave Irradiance Due to Surface Albedo Variations

## References

- Stoffel, T.; Nelson, D. (1993). Effects of the Mt. Pinatubo Volcanic Eruption on Solar Radiation Resources near Denver, Colorado - Some Preliminary Analyses. Burley, S. M.; Arden, M. E., eds. *Proceedings of the 1993 Annual Conference of the American Solar Energy Society*, 22-28 April 1993. Washington, DC: Boulder, CO: American Solar Energy Society pp. 489-494.
- Hulstrom, R. L.; Stoffel, T. L. (1990). Some Effects of Yellowstone Fire Smoke Cloud on Incident Solar Irradiance. *Journal of Climate*, Vol. 3, December 1990; pp. 1485-1490.

## Wildfire Smoke Event at EF-18 (Smokey) EF-27 (Clear)



SIRS Measurements from 2 January 2006

## Acknowledgments

Surface wind data from Oklahoma Mesonet. Fire Images from the *Abilene Reporter-News*, *Oklahoman*, & *Time*.