



# Radiative Forcing Efficiencies and Heating Rates of Forest Fire Smoke During SEAC4RS

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(photo credit: Barbara Barletta)

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# Motivation, Objectives, Procedure

## Motivation:

**Boreal forest fire smoke** can:

- reduce surface solar rad => cooling
- increase surface IR rad => warming
- **heat atmospheric layer:**
  - increase stability of atmosphere
  - suppress cloud formation

## Objectives:

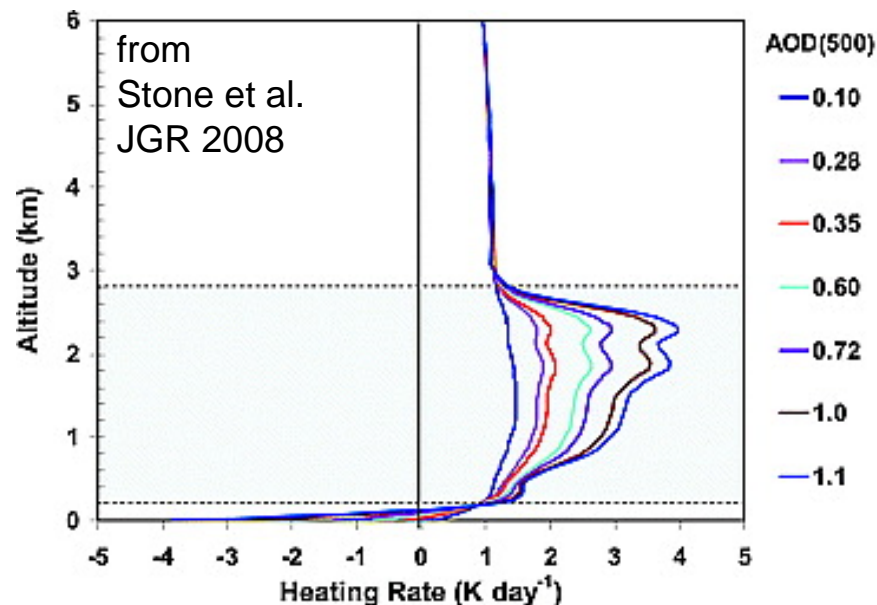
For smoke from Yosemite Rim fire:

1. Characterize **radiative forcing efficiencies**
2. Characterize **radiative heating rates**

## Procedure:

Two case studies downwind of Yosemite fires:

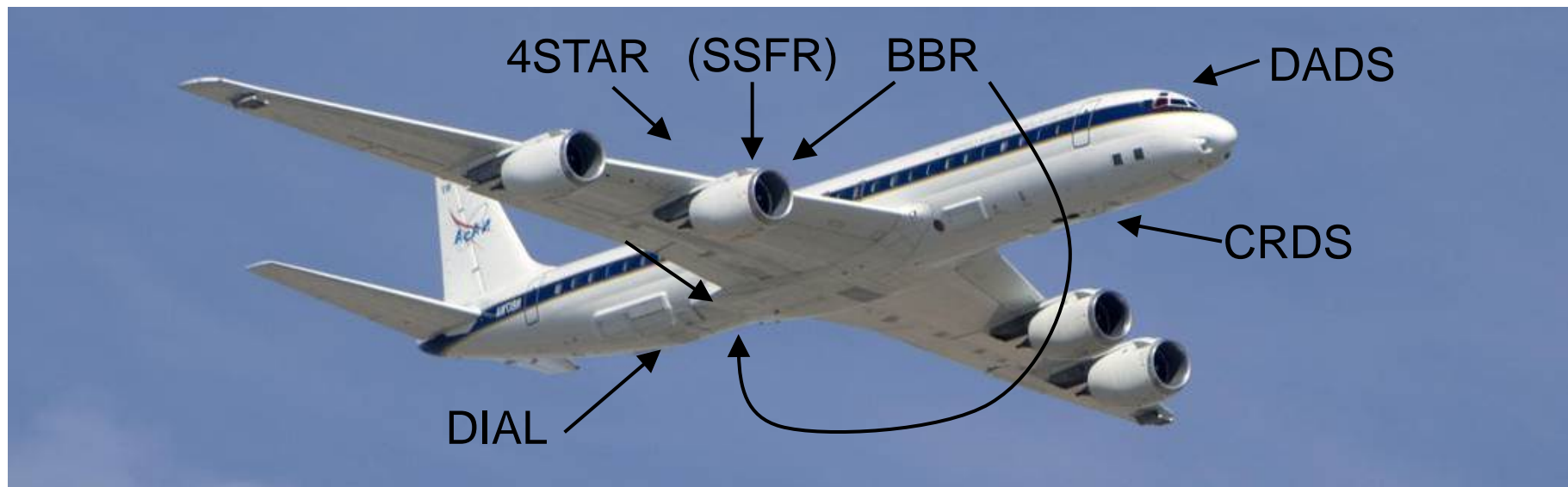
1. **“Wall 1”** - north of Reno, NV  
Stacked legs perpendicular to plume  
Measured **gradient** in AOD & net rad fluxes  
=> **forcing efficiencies**
2. **“Wall 2”** – near Boise, ID  
Stacked Legs - **homogeneous** smoke  
Measured net radiative flux profile  
=> **heating rates**



(Photo credit: Barbara Barletta)



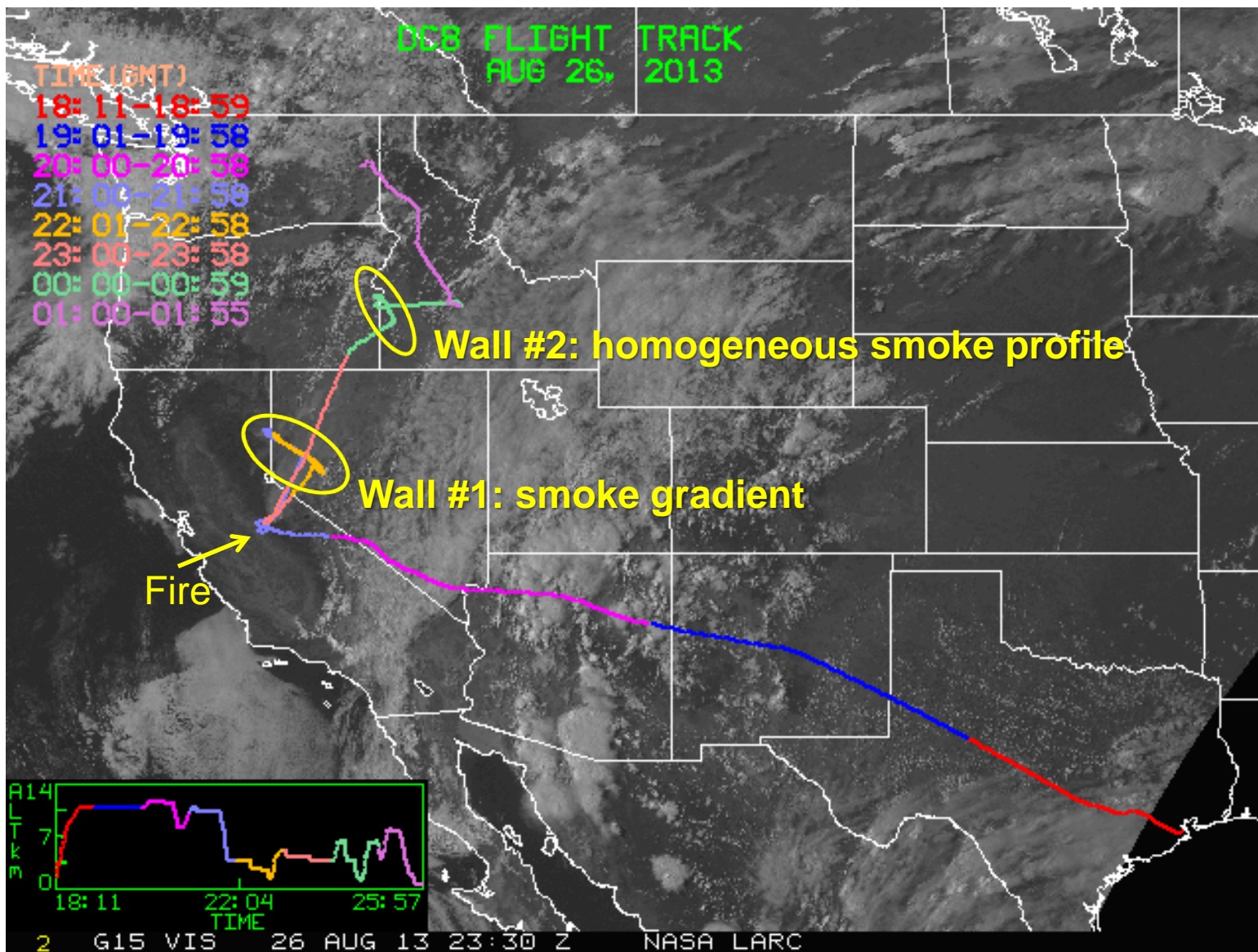
# Instrumentation Used On NASA DC-8 Aircraft



- BBR (Broad Band Radiometers) – Down and Up Solar and IR Irradiance
- 4STAR (Spectrometers, Sky-Scanning, Sun Tracking Atmospheric Research) – AOD
- SSFR (Solar Spectral Flux Radiometer) – Down and Up Spectral Solar Irradiance
- DADS (DC8 Data System) – Temp, Pres, RH, Nav Data
- DIAL (Differential Absorption Lidar) – Aerosol profiles
- CRDS (Cavity Ringdown Extinction Spectrometer) – Aerosol Extinction Coefficient

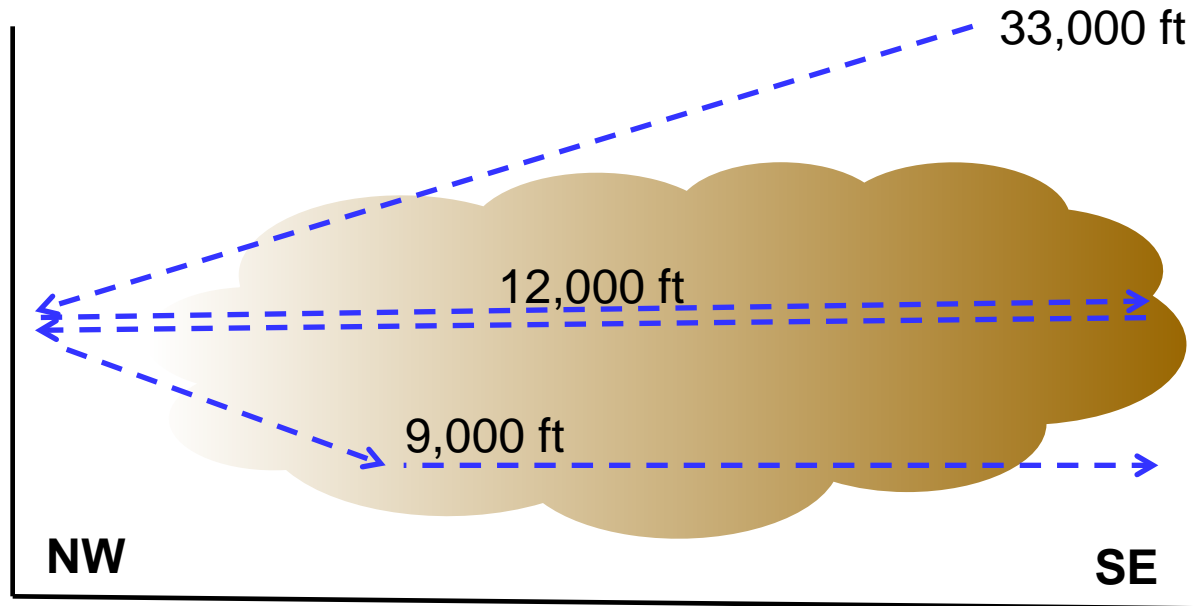
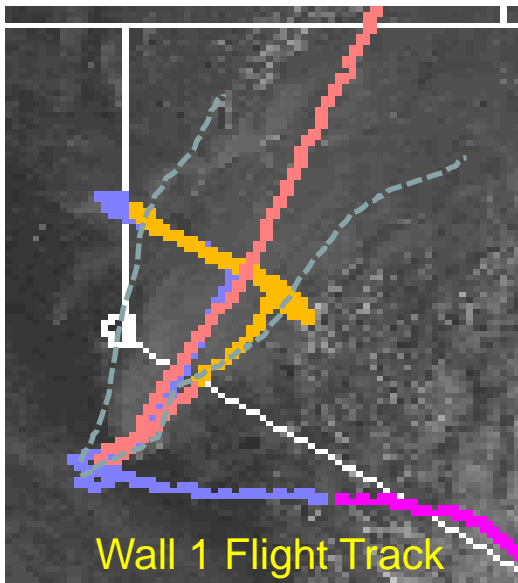


# Location of Downwind "Wall" Flight Patterns 26 Aug 2013 DC8 Flight – Yosemite Rim Fire





# Wall 1: Perpendicular to smoke plume axis



DC8 forward camera on descent leg from 33,000 ft

Ideal conditions to measure:

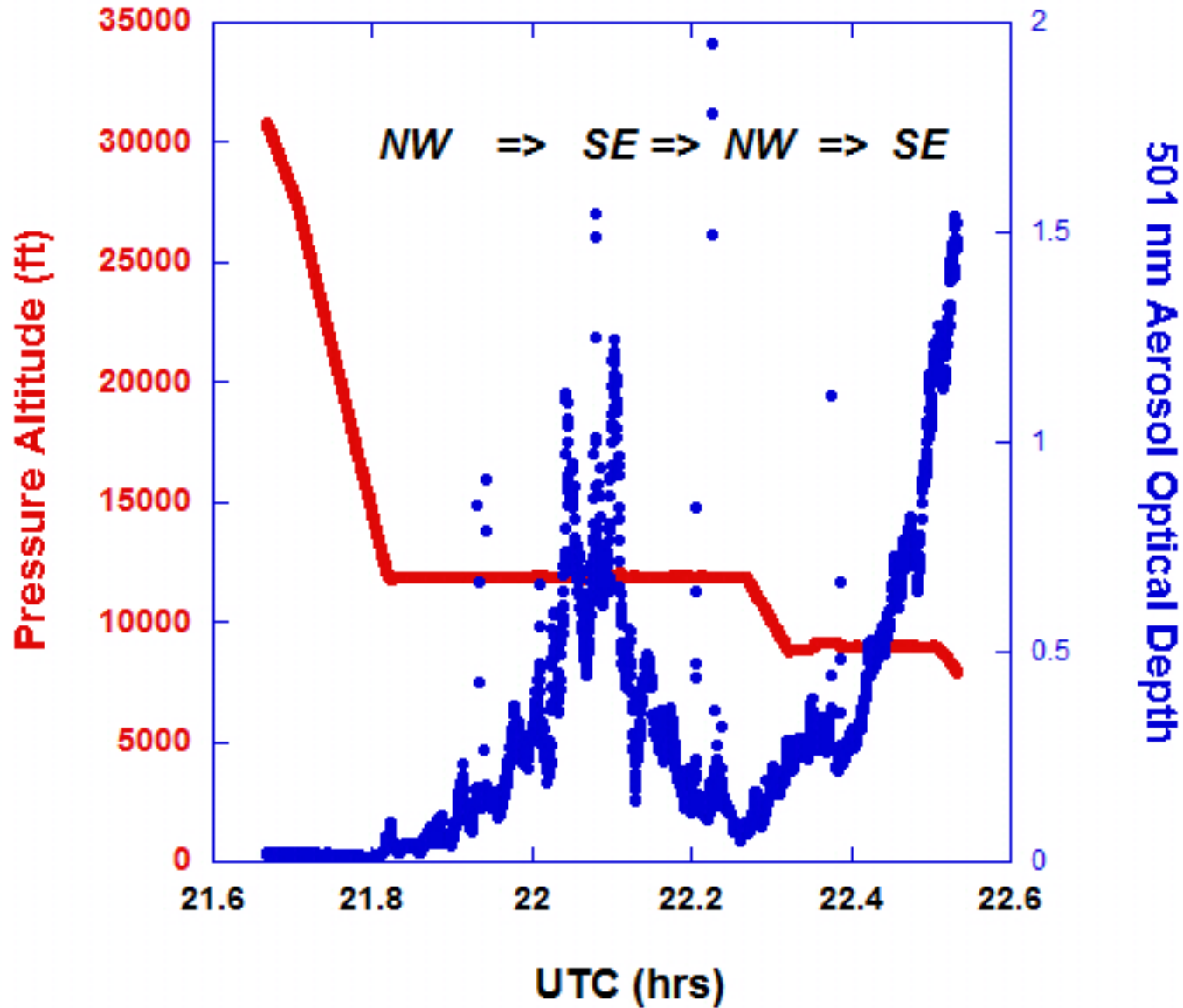
**Forcing Efficiency ( $F_E$ )**

= **slope of Net Flux vs AOD**

= in effect, a measure of the radiative forcing '**sensitivity**' of the smoke

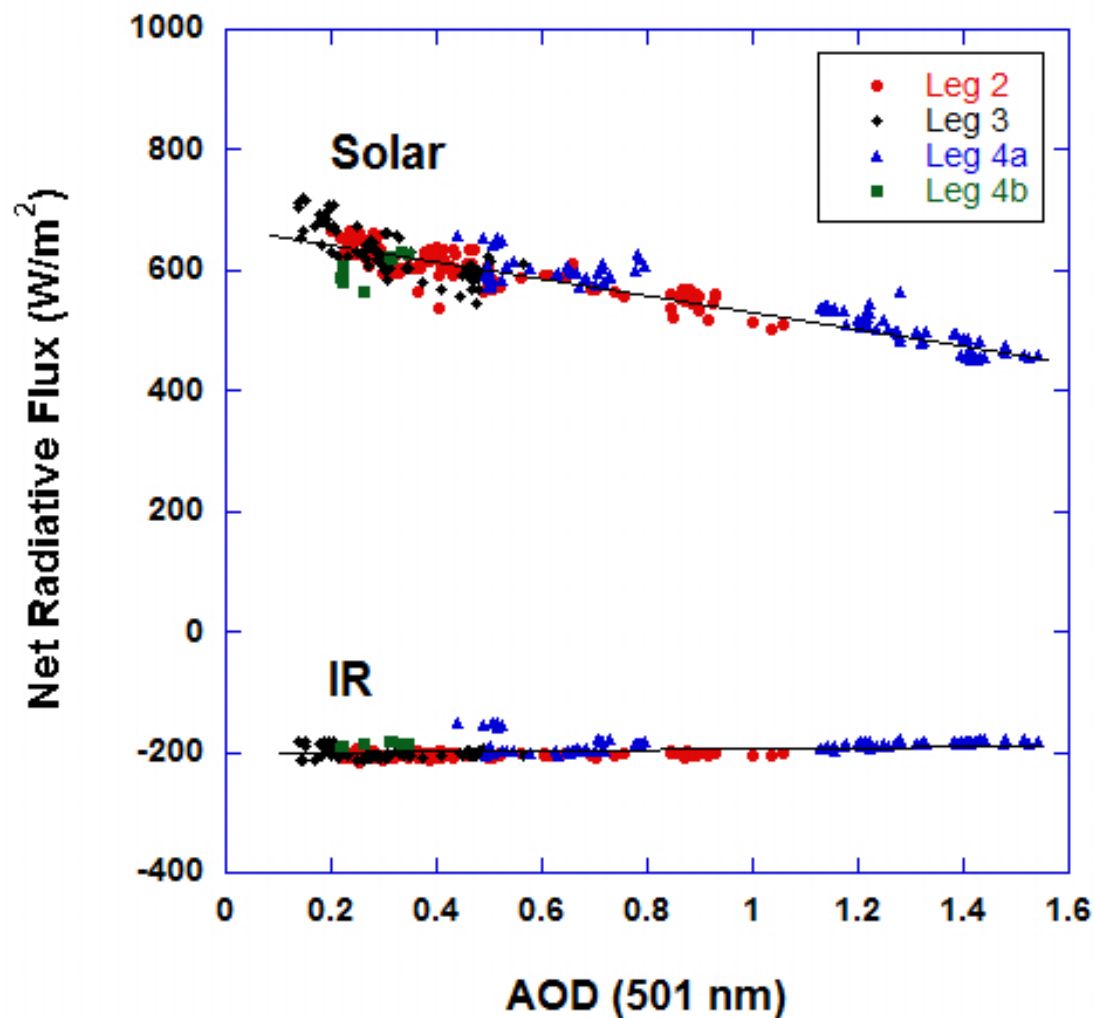
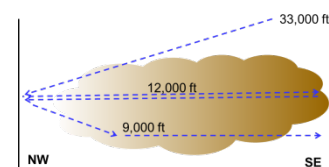


# AOD Gradient Wall 1 Smoke





# Forcing Efficiencies Wall 1 - Smoke



$$F_{E,\text{solar}} = -139.77 \text{ W}/\text{m}^2/\text{AOD}$$



$$F_{E,\text{Net}} = -124.35 \text{ W}/\text{m}^2/\text{AOD}$$

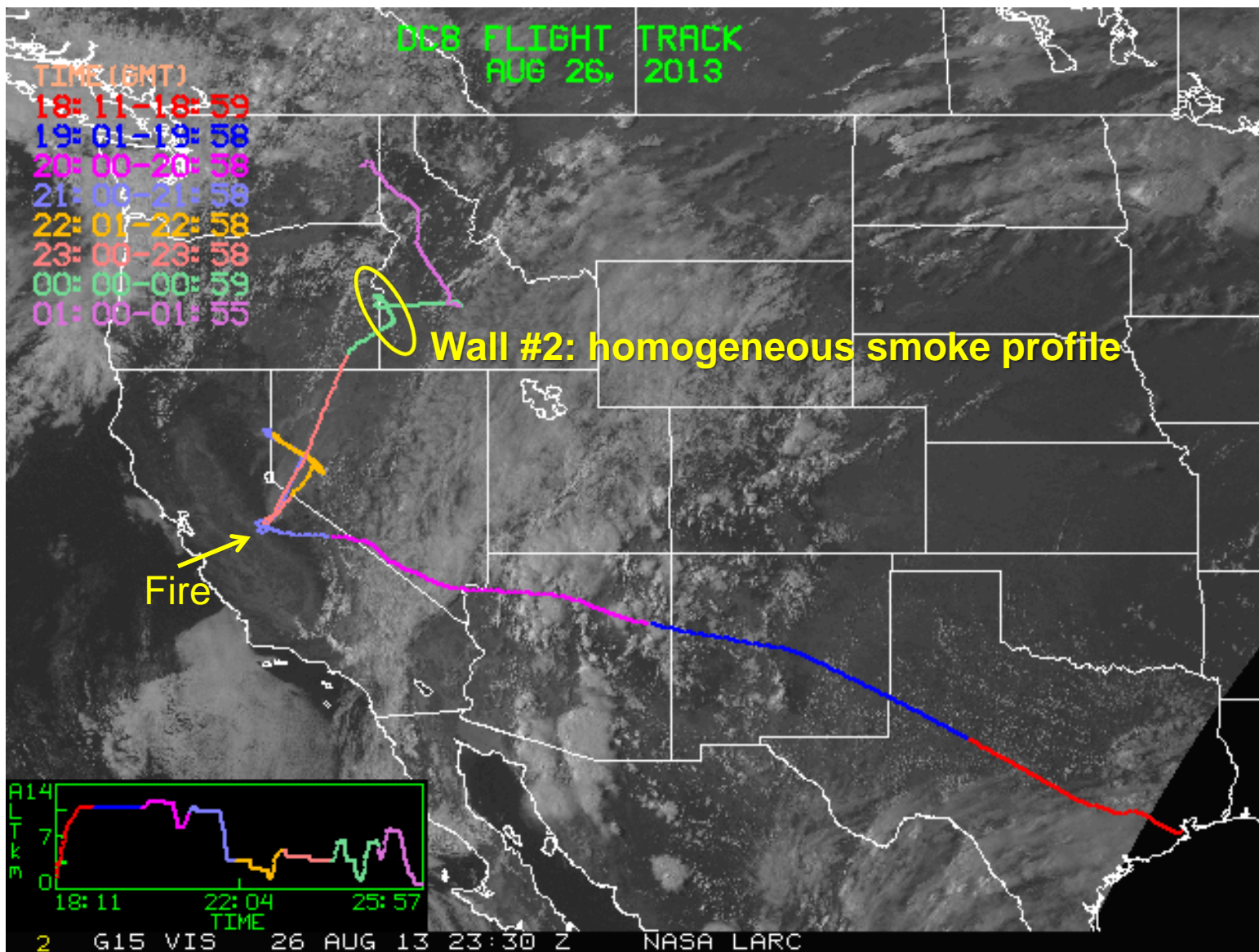


$$F_{E,\text{IR}} = +15.42 \text{ W}/\text{m}^2/\text{AOD}$$

- Significant forcing
- Consistent with previous model and ground-based estimates from other fires



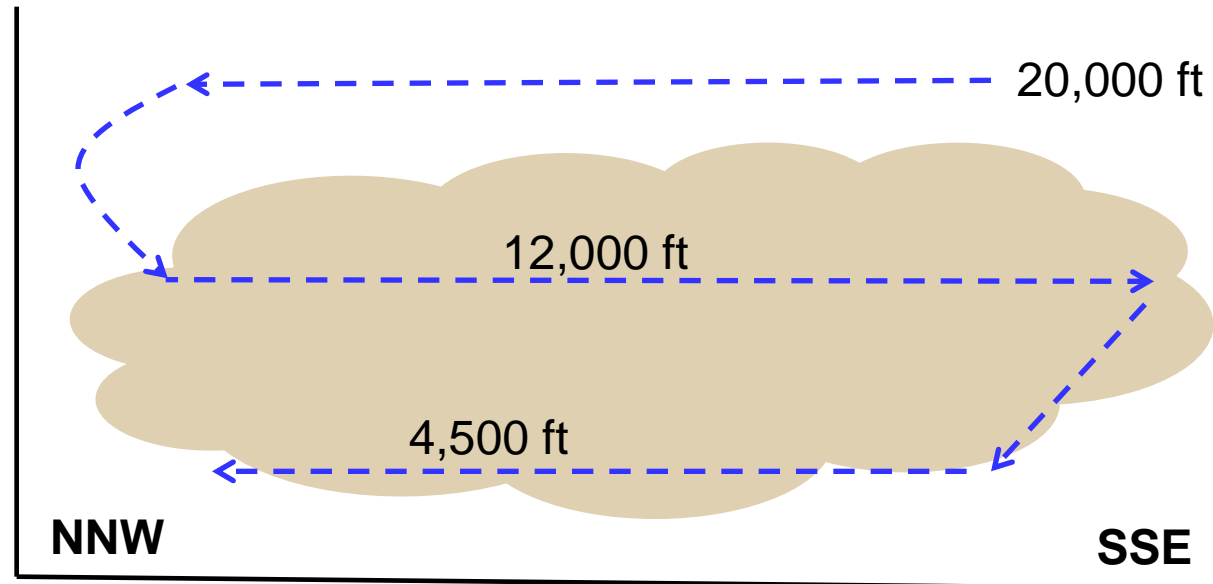
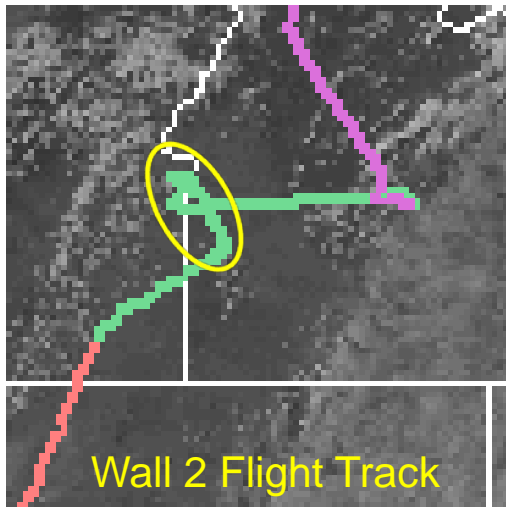
# Location of Downwind "Wall 2" Flight Pattern 26 Aug 2013 DC8 Flight – Yosemite Rim Fire







# Wall 2: Stacked Legs Through Homogeneous Smoke



DC8 forward camera on 20,000 ft leg

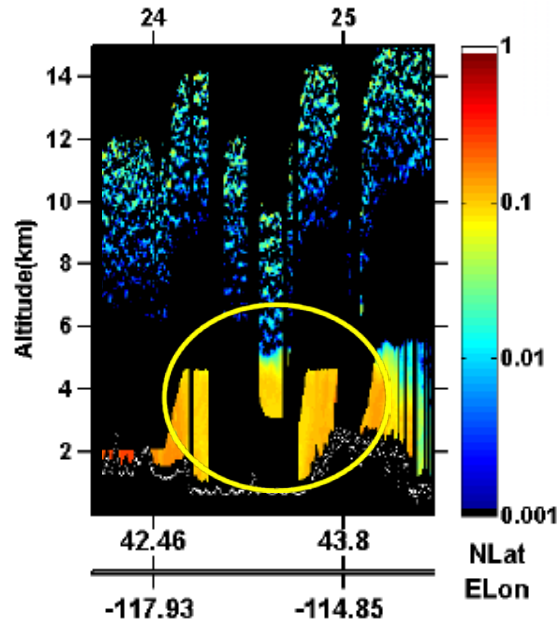
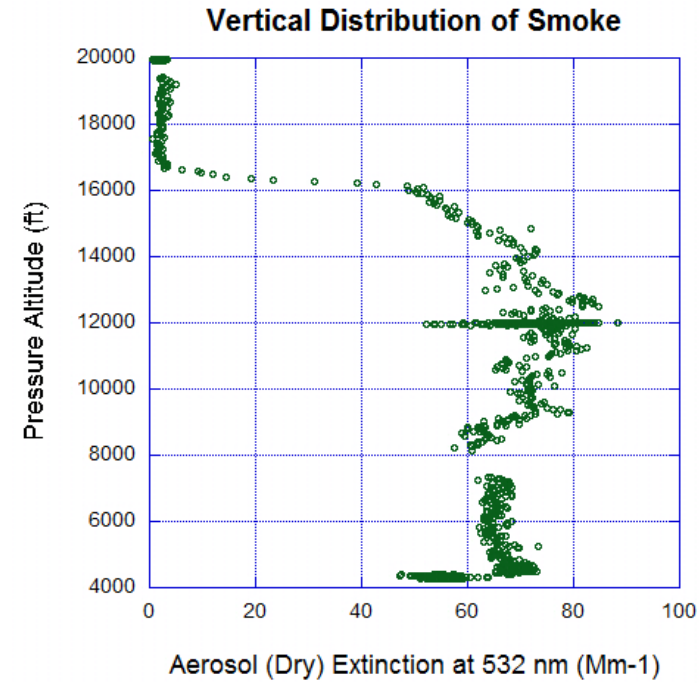
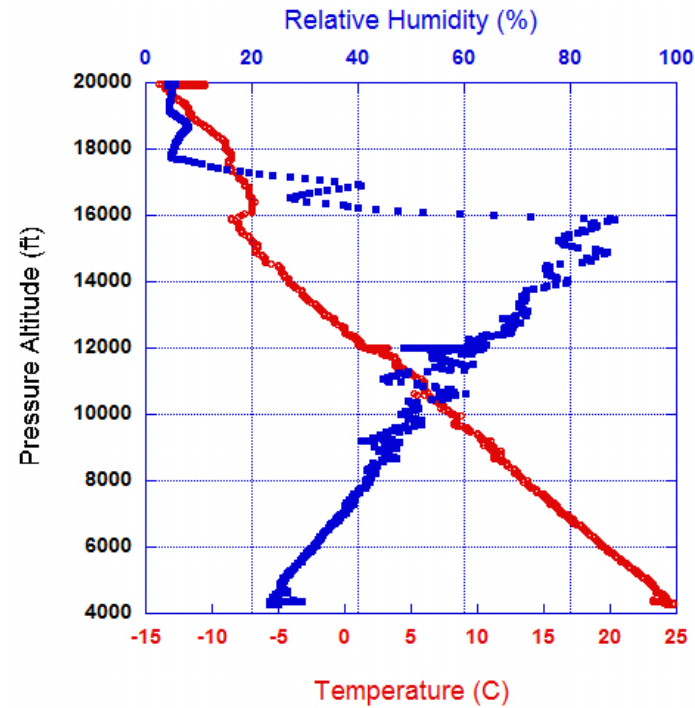
Ideal conditions to measure:

**Solar/IR Heating/Cooling Rates**

$$\propto \left( \frac{\text{change in net radiative flux}}{\text{change in altitude}} \right)$$



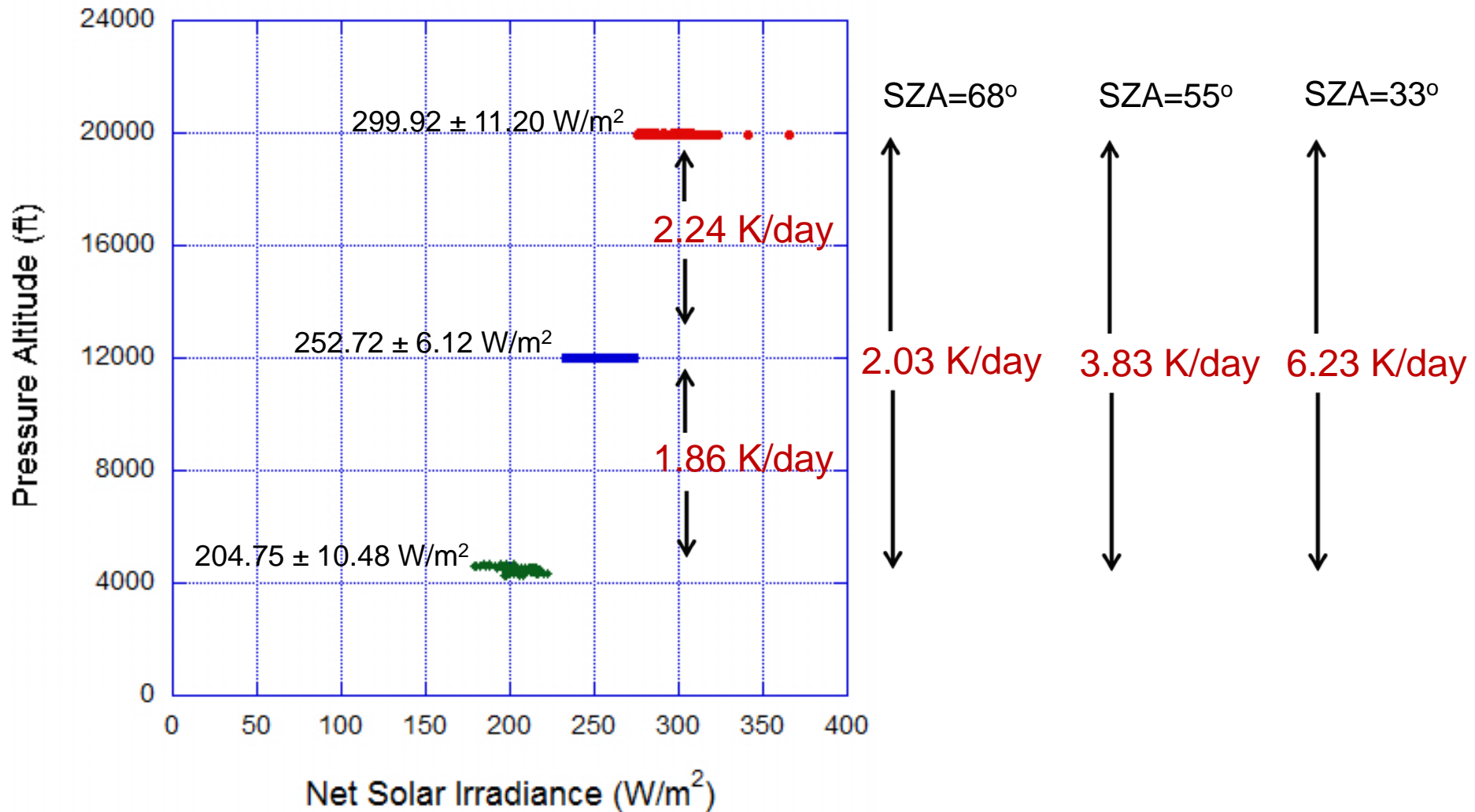
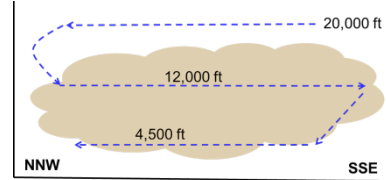
# Wall 2 Smoke Very Homogeneous



AOD of smoke  
~ 0.43 +/- 0.06

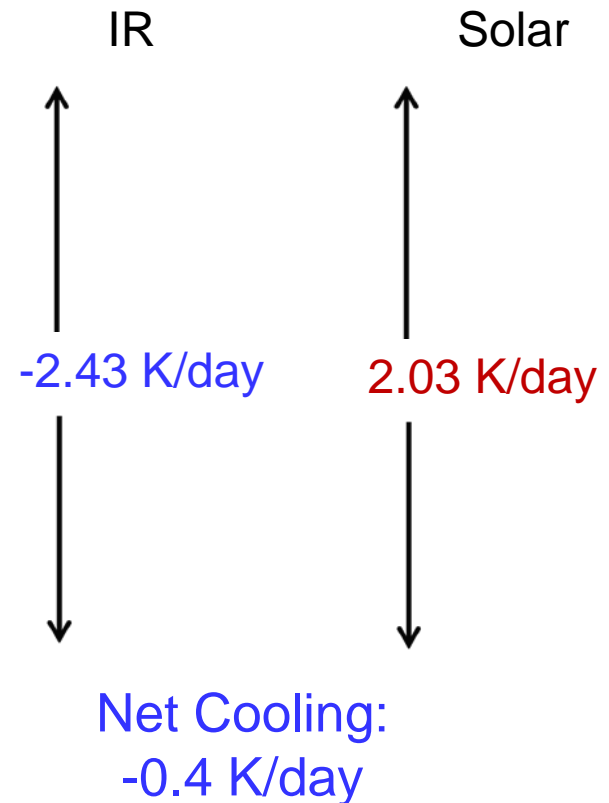
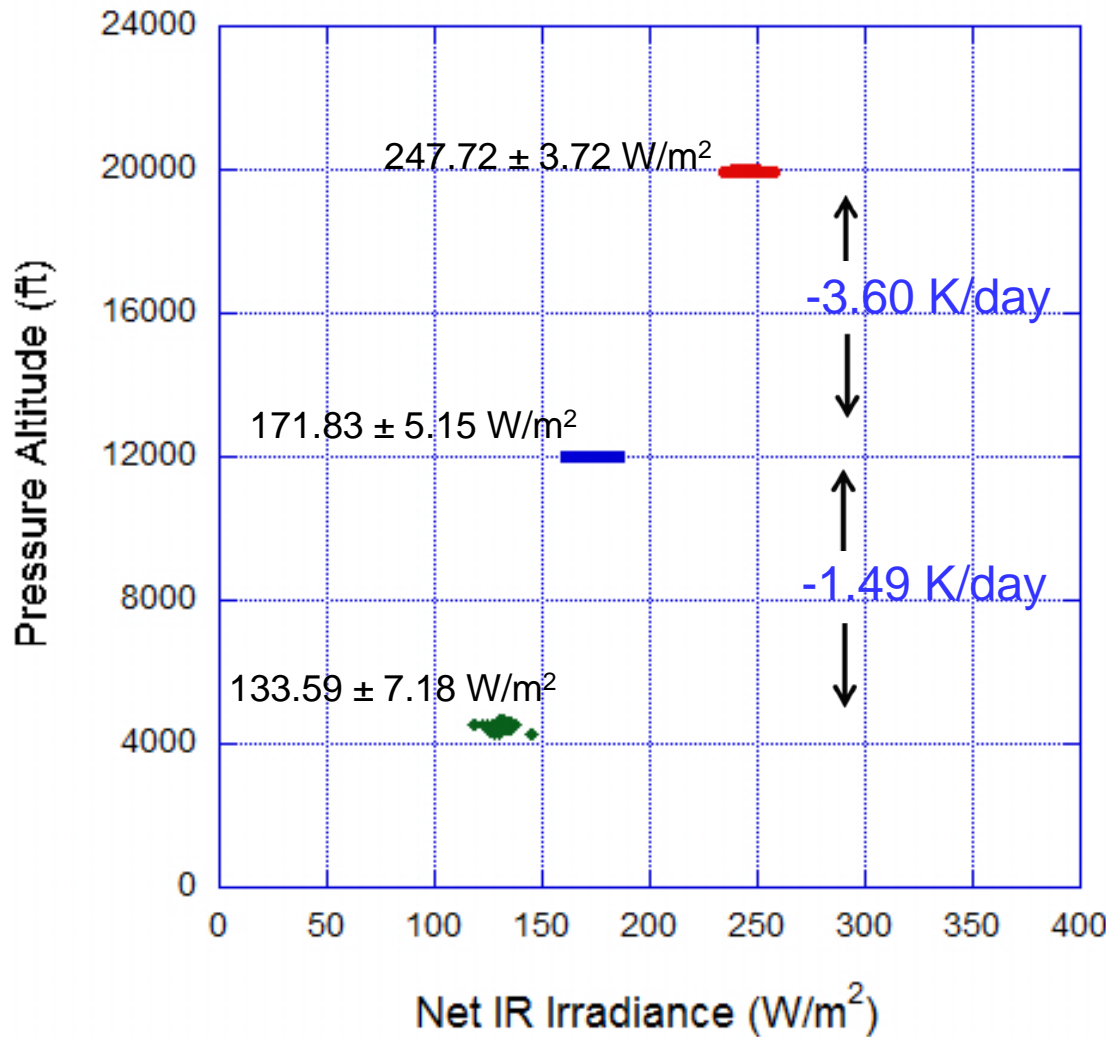
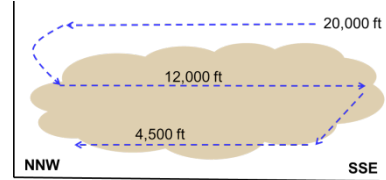


# Solar Heating Rates Wall 2 Smoke





# IR Cooling Rates Wall 2 Smoke





# Summary and Future Work

## Summary:

- **26Aug2013** DC8 Flight '**Golden Day**' for measuring smoke radiative effects
- Smoke just downwind of Yosemite fires (Wall 1) had significant solar radiative forcing efficiency => consistent with previous model estimates and ground based measurements for other fires
- Directly measured solar and IR heating rates of boreal forest fire smoke farther downwind of fires (Wall 2) can still be significant (depending on time of day)
- Measured heating rates are also consistent with previous modeling, measurement studies
- **Radiation "Wall" flight patterns work!**

## Future Work:

- Exploit other remote sensing measurements on DC8 more fully: SSFR, DIAL
- Correlate with in situ microphysical and chemical measurements



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Questions?

