Recent SMART-COMMIT Observations of Smoke# and Dust@ Aerosols

Si-Chee Tsay and SMART-COMMIT Team*

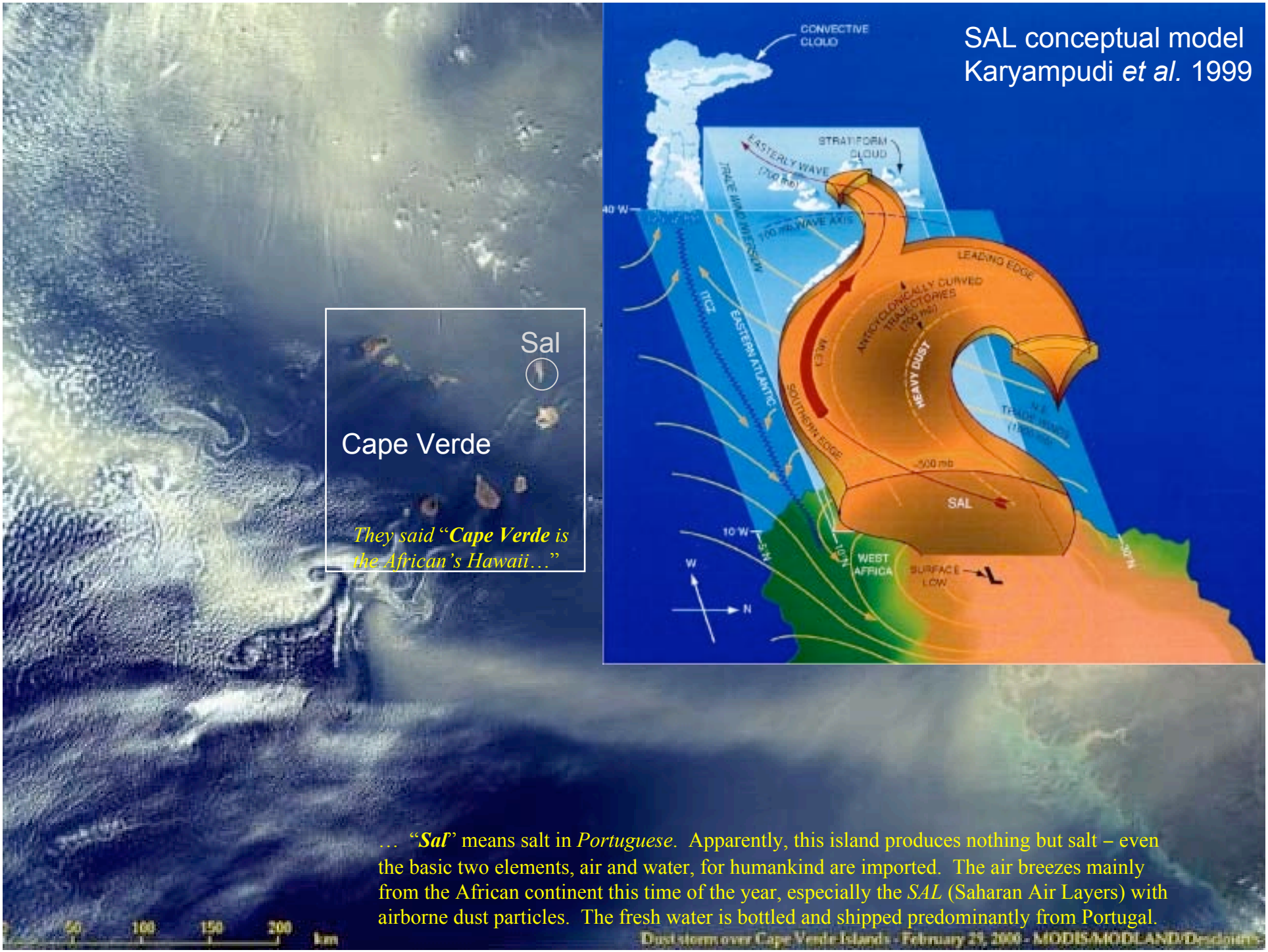
NASA Goddard Space Flight Center

#http://climate.gsfc.nasa.gov; Image of the week, June archive

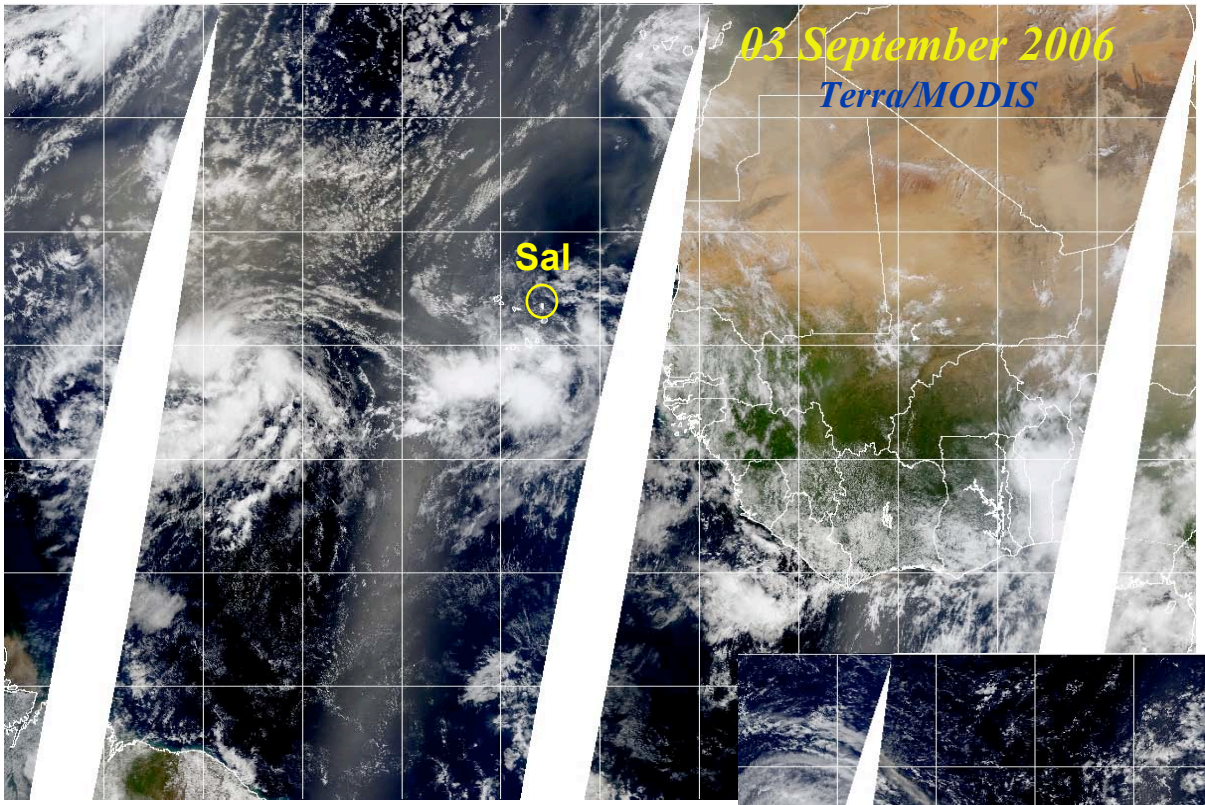
@Special thanks to U.S. Air Force Reserve for FREE C-5 contributions

($22 K/hr x 16 hr = $352 K)

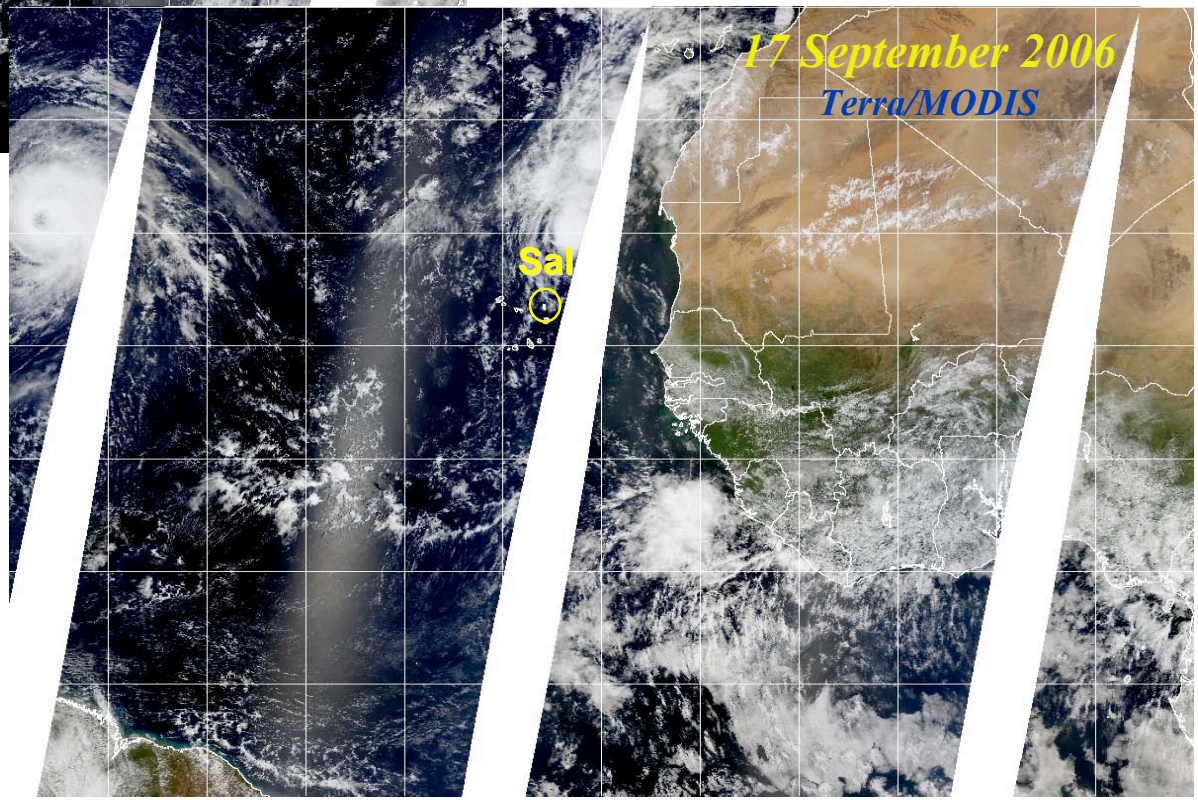
***Q. Jack Ji, M-J. Jeong, Richard A. Hansell**


SAL conceptual model
Karyampudi *et al.* 1999
CONVECTIVE CLOUD
STRATIFORM CLOUD
EASTERLY WAVE
TRADE WIND INVERSION
700 mb WAVE AXIS
40 W
LEADING EDGE
ANTICYCLONICALLY CURVED TRAJECTORIES
ITCZ
EASTERN ATLANTIC
HEAVY DUST
SOUTHERN EDGE
500 mb
SAL
10 W
5 N
10 N
WEST AFRICA
SURFACE LOW
W
N
Sal
Cape Verde
*They said "**Cape Verde** is the African's Hawaii…"*
… "***Sal***" means salt in *Portuguese*. Apparently, this island produces nothing but salt – even the basic two elements, air and water, for humankind are imported. The air breezes mainly from the African continent this time of the year, especially the *SAL* (Saharan Air Layers) with airborne dust particles. The fresh water is bottled and shipped predominantly from Portugal.
50
100
150
200
km
Dust storm over Cape Verde Islands - February 23, 2000 - MODIS/MODLAND/Dr. Joel Gill

Rationale



- ***Saharan Air Layer:***
  - occurs during the late spring through early fall
  - convergence induced by heat lows over the Sahara
  - hot, dry, dust laden of well mixed layer up to 500mb, westward propagation with African Easterly Waves

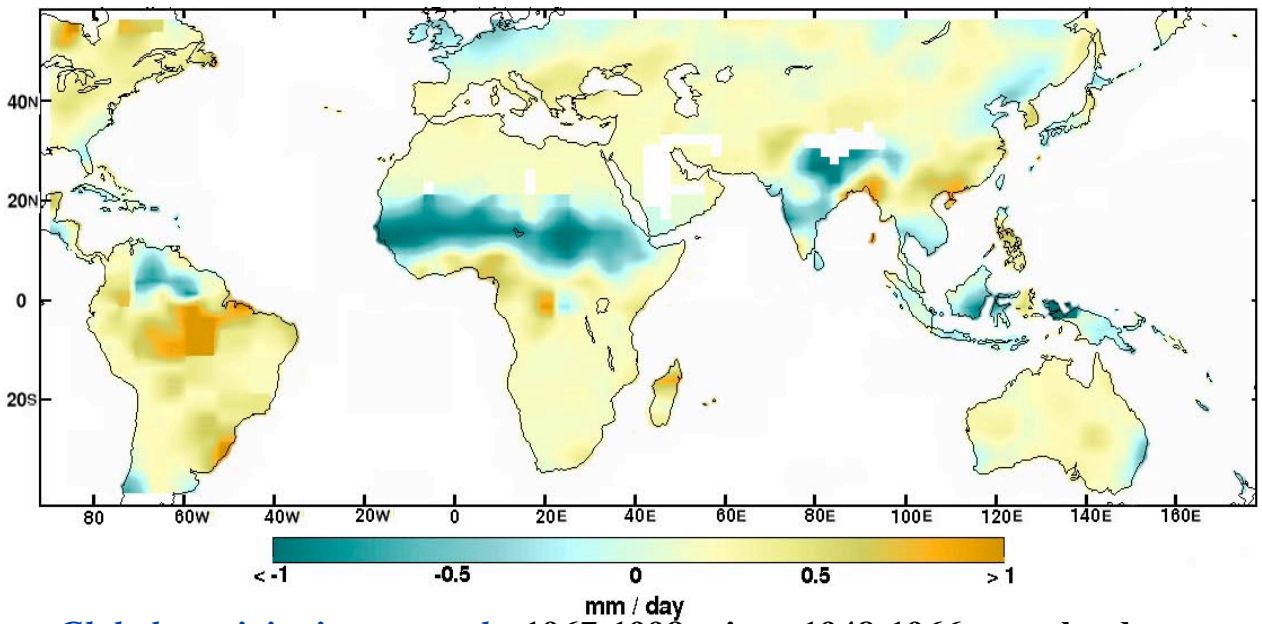


- ***SAL-Tropical Cyclogenesis:***
  - may stabilize the lower atmosphere due to *solar absorption* by dust particles;
  - may regulate the *strength* and *structure* of Mid-Level Easterly Jet (MLEJ);
  - impact remains *inconclusive*!

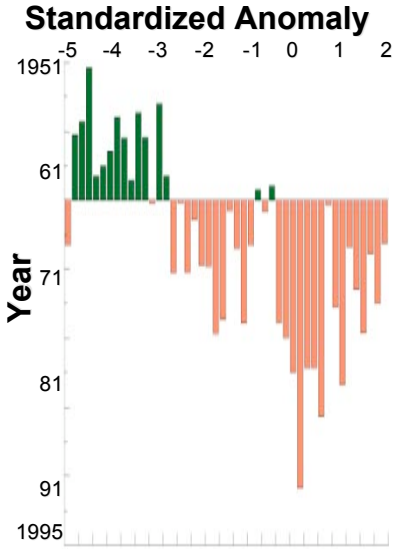
(e.g., Karyampudi & Pierce, MWR, 2002)

Si-Chee Tsay, Deputy
EOS/Terra Project Scientist

NAMMA: NASA African Monsoon Multidisciplinary Activities (8/15-9/15, 2006)

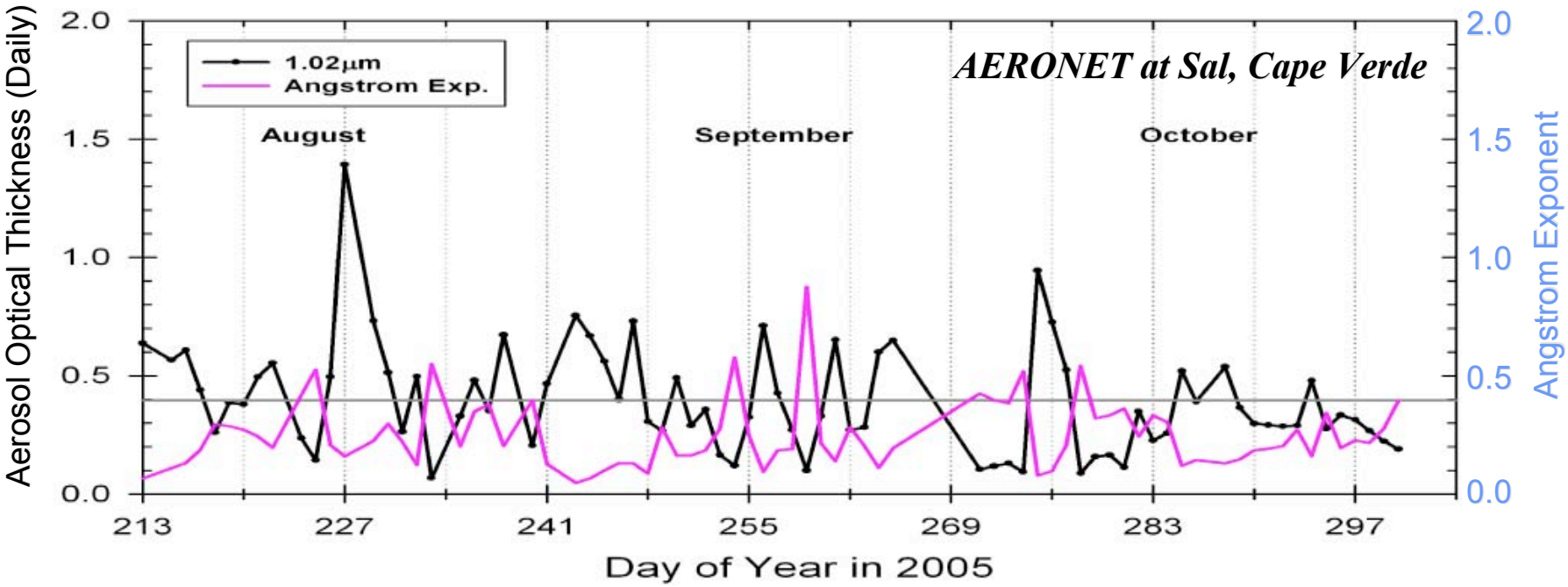


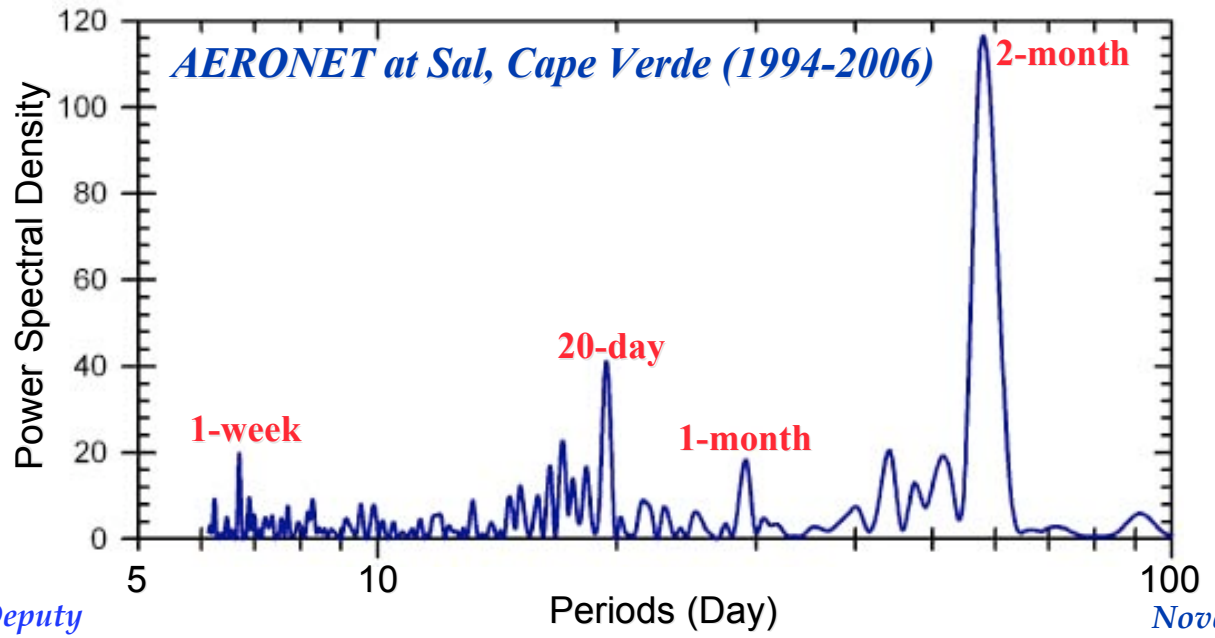
Global precipitation anomaly, 1967-1998 minus 1948-1966, over land for the peak-summer months of July-August (after Hulme *et al.*, 1998).



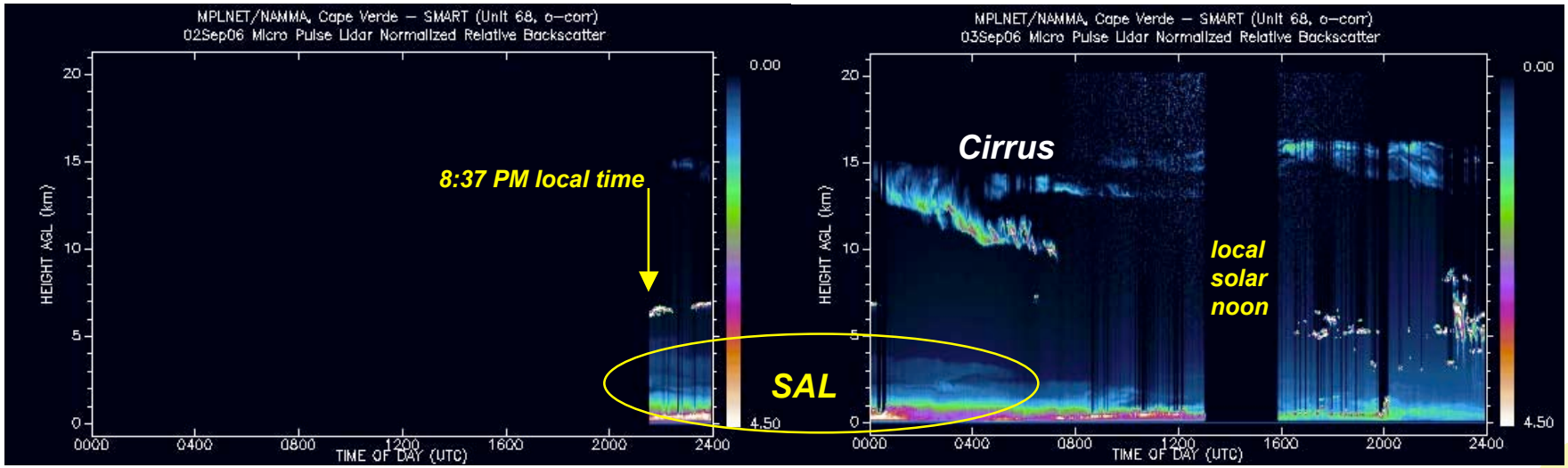
West African precipitation anomaly, based on 1951-1980 mean for the Sahel (after Jenkins *et al.*, 2000).

- *Earth Observing Satellites: Terra, A-Train, etc. (e.g., Deep-Blue)*
- *DC-8 high-altitude research aircraft (based at Sal)*
- *NPOL polarimetric weather research radar (based at Dakar)*
- *TOGA C-band Doppler weather radar (based at Praia)*
- *SMART-COMMIT ground-based mobile observatory (based at Sal)*

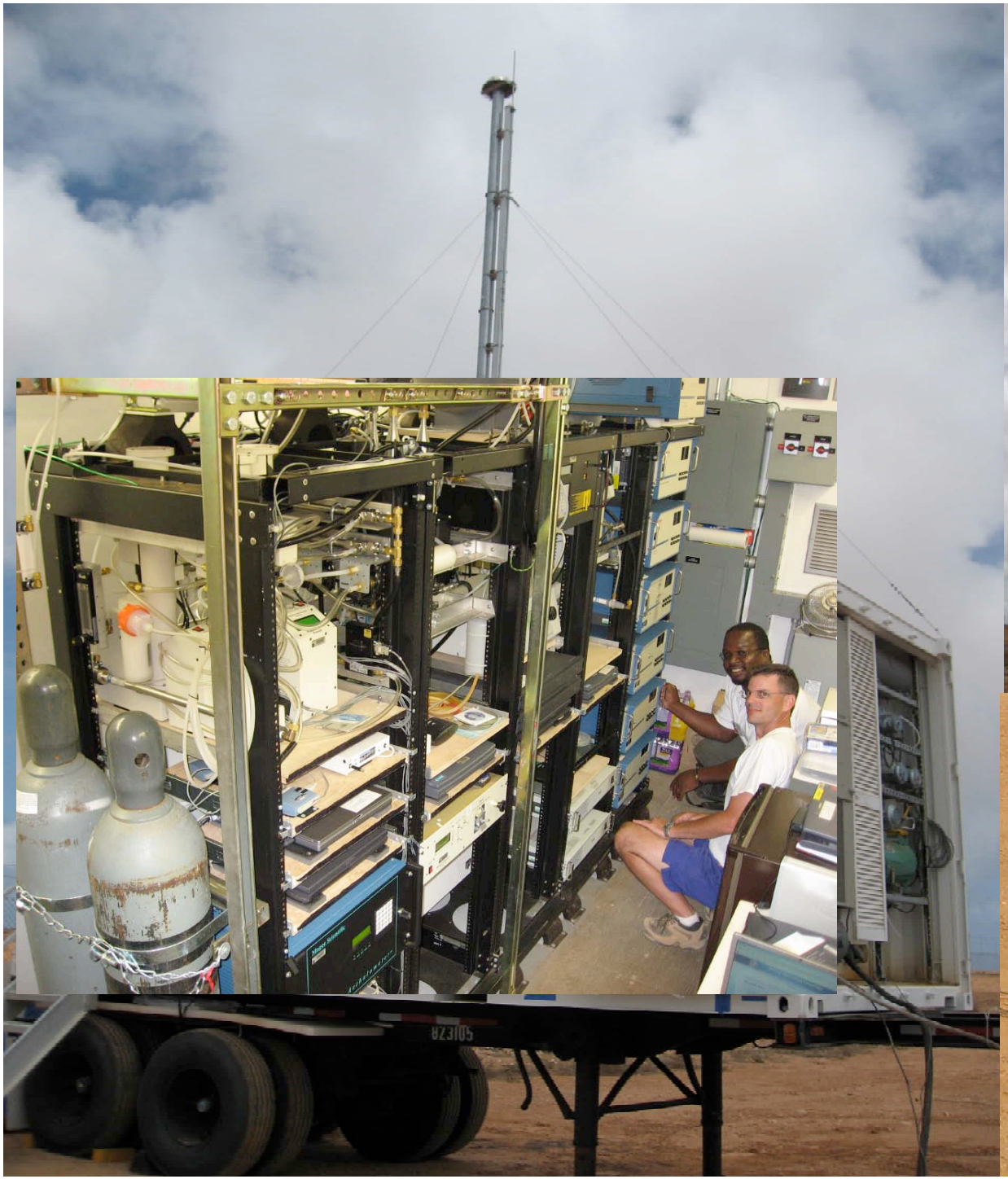

AERONET at Sal, Cape Verde
1.02μm
Angstrom Exp.
August
September
October
Aerosol Optical Thickness (Daily)
Angstrom Exponent
Day of Year in 2005
2.0
1.5
1.0
0.5
0.0
213
227
241
255
269
283
297


AERONET at Sal, Cape Verde (1994-2006)
2-month
20-day
1-week
1-month
Power Spectral Density
Periods (Day)
120
100
80
60
40
20
0
5
10
100

SMART-COMMIT Deployment at Sal, CV



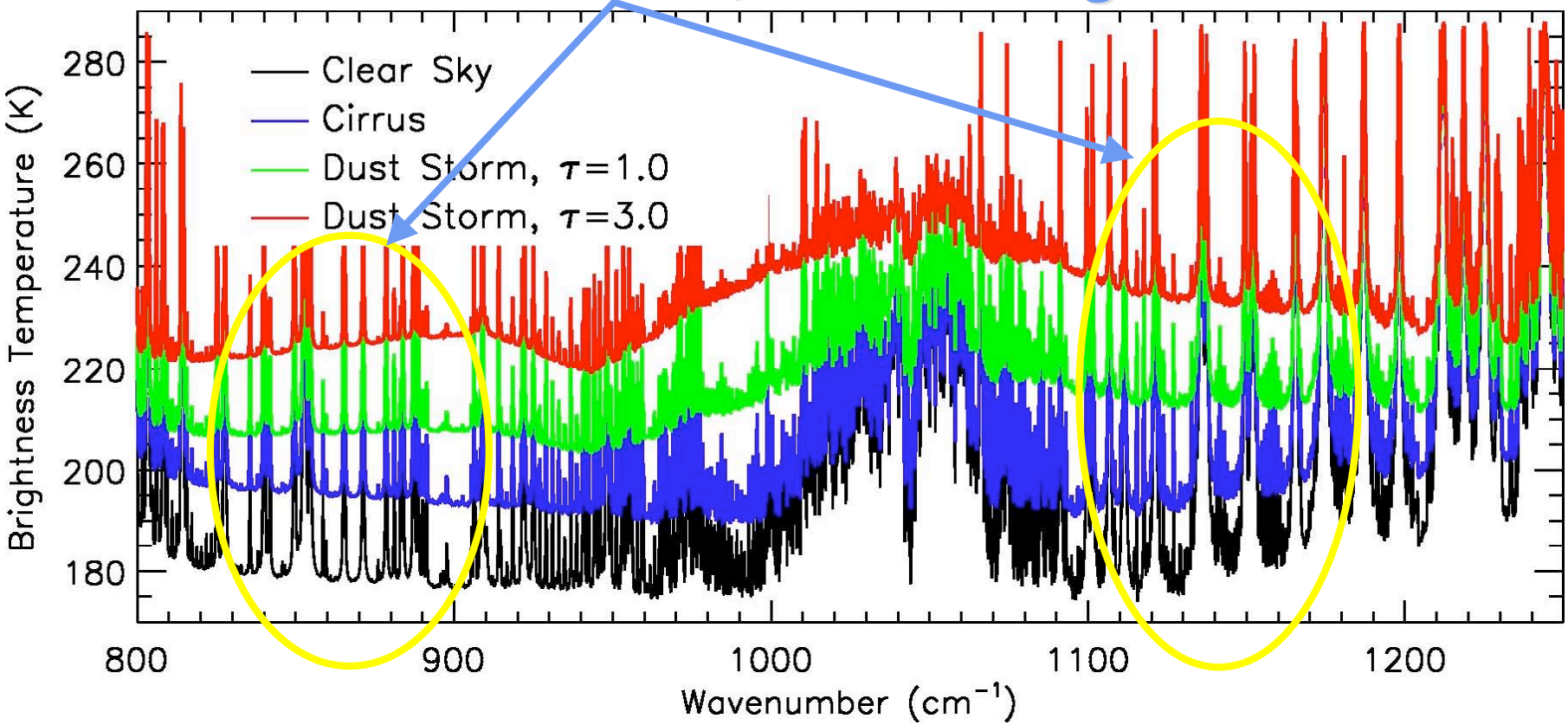

CAUTION



SMART-COMMIT Goals for NAMMA

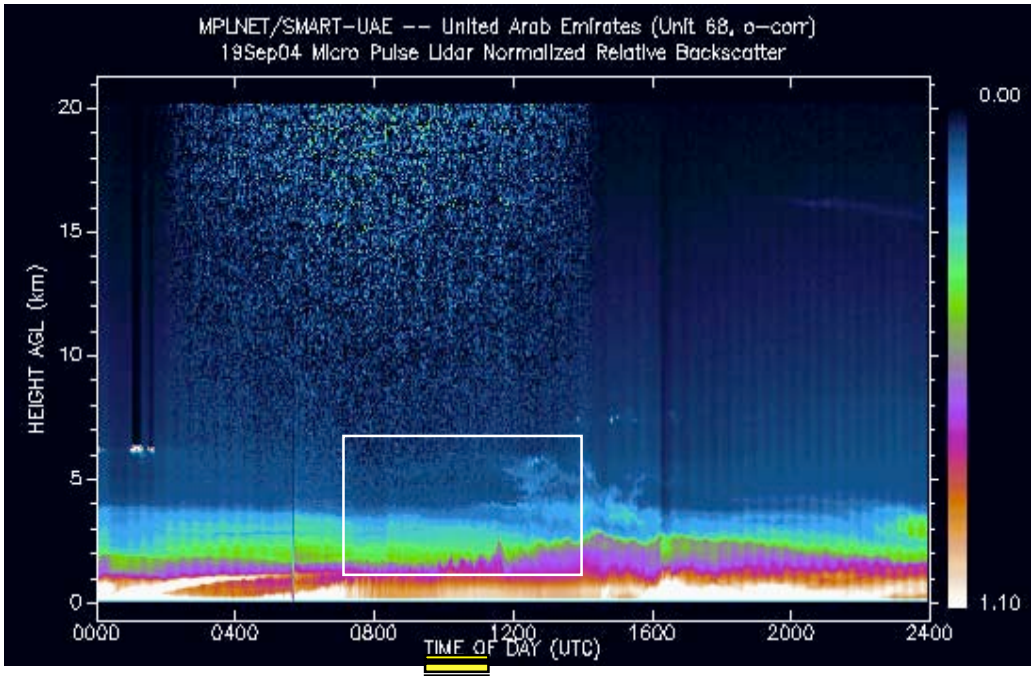
- ***Remote sensing:***
  - **detecting/retrieving *Dust* (in SAL) and *Cirrus* (aloft) properties from atmospheric emitted, as well as transmitted, radiance fields.**
- ***In-situ:***
  - **measuring surface *aerosol* (& *precursor*) *properties* and *boundary-layer atmospheric parameters* for *mixing/transport* modeling.**
- ***Surface energetics :***
  - **developing *radiative forcing* approximations for measurements of coexisting *aerosol-cloud*.**

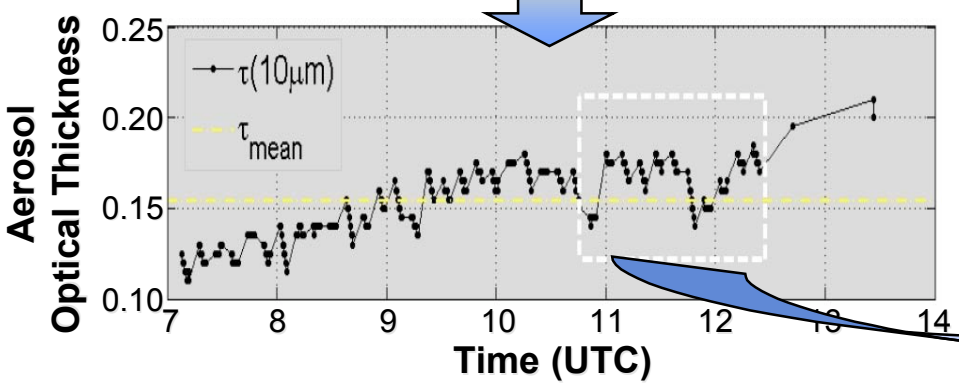
$\partial I / \partial \lambda$, contrasting each other

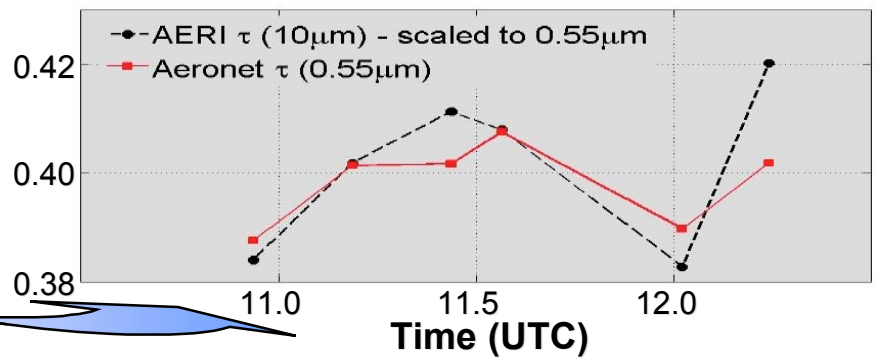


Simulated nadir up-looking spectral brightness temperatures at the surface as a function of wavenumber for different dust loadings (τ = 0.5, 1.0, and 3.0; 0-5 km), in conjunction with effective particle radius of 2.0 μm. The cirrus cloud, located at 10 km, has an effective particle size of 15 μm and an optical thickness τ = 0.5.

- ***Retrievals of Dust Properties***
  - **forward radiative transfer calculations of dust models as function of *wavelength*, *size*, *shape*, *and composition*;**
  - **χ^2 statistical optimization;**
- ***Comparisons***
  - **collocated *AERONET***
  - **wavelength scaling factor as *extinction coefficient ratio*;**
  - **good results depending on choice of *dust compositions*.**





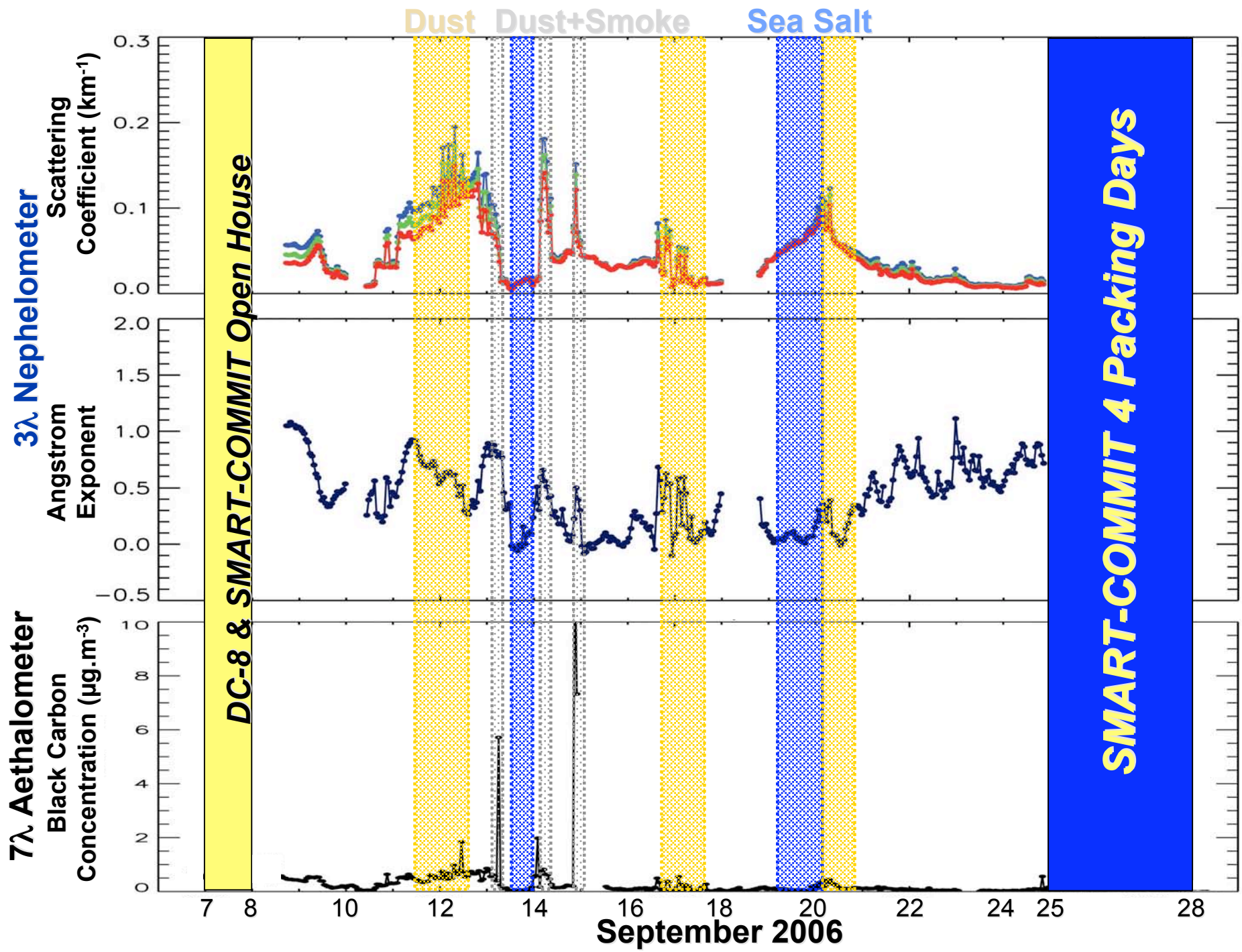


Tropospheric Aerosols:

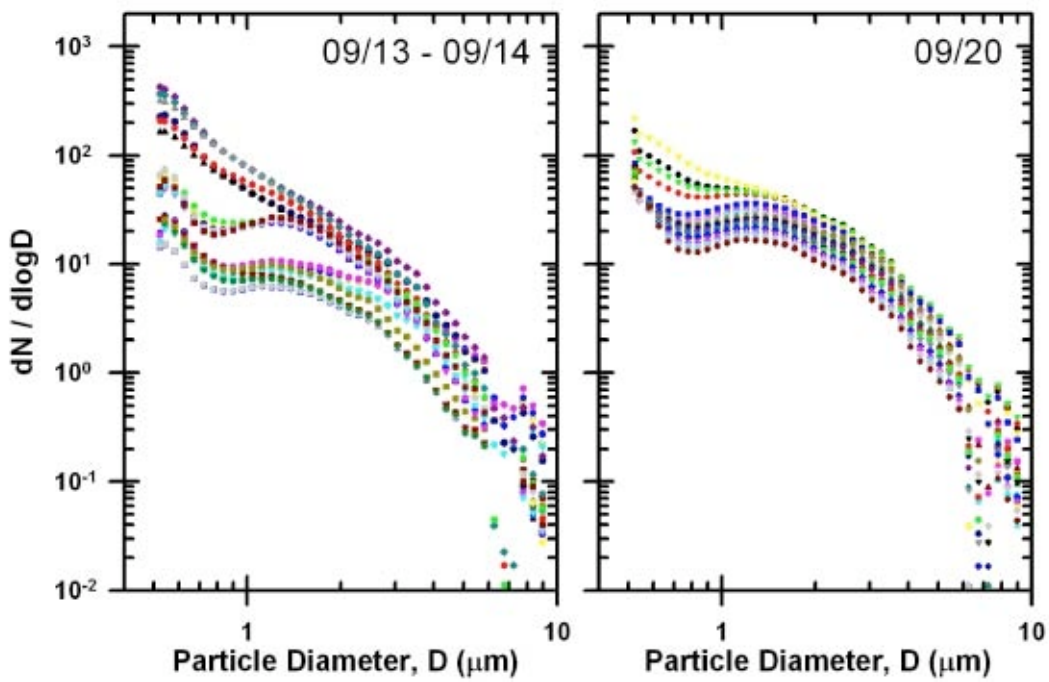
- ***Originate by activities at/near Surface***
  - ***Dust, Smoke, Air Pollution, Sea Salt, etc.***
  - ***Chemical, Physical, & Optical properties measurable***

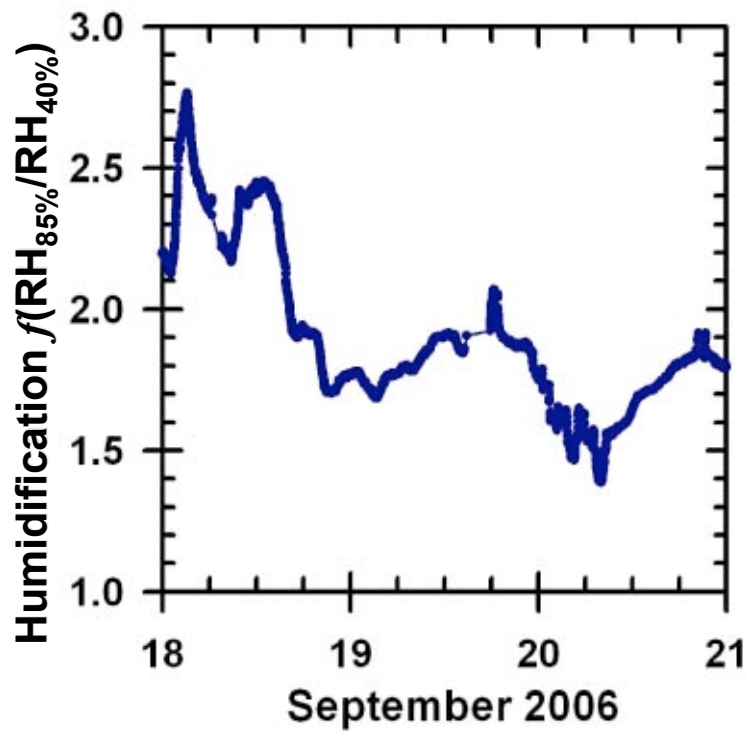
- ***Evolve in Planetary Boundary Layer***
  - ***Diffusing, Mixing, Transport, etc. Processes***
  - ***Chemical, Dynamical & Physical models available***

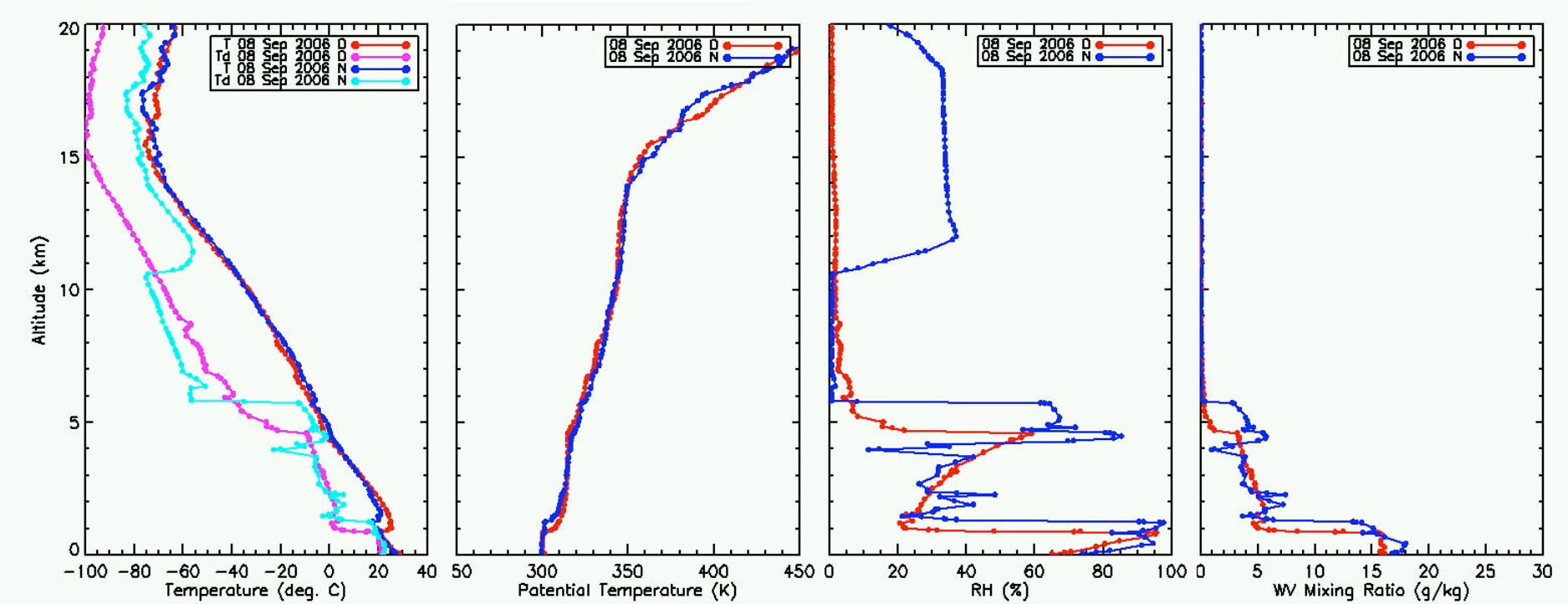
- ***Signify within Free Troposphere***
  - ***Diabatic Heating/Cooling, Microstructure Effects, etc.***
  - ***Satellite, Surface/Aircraft, Modeling synergy***

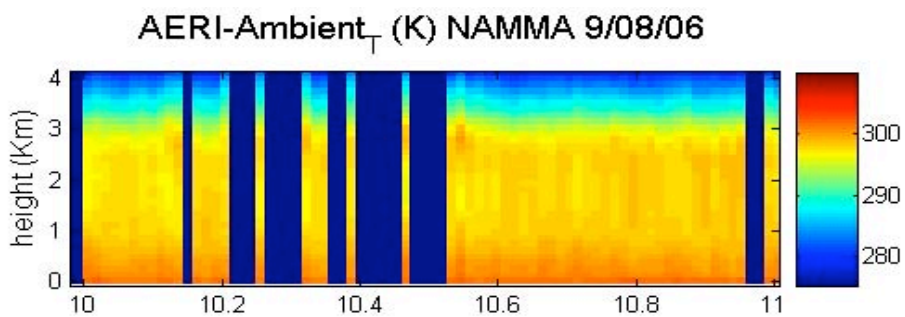

Dust
Dust+Smoke
Sea Salt
3λ Nephelometer
Scattering Coefficient (km-1)
0.3
0.2
0.1
0.0
Angstrom Exponent
2.0
1.5
1.0
0.5
0.0
−0.5
7λ Aethalometer
Black Carbon Concentration (µg.m-3)
10
8
6
4
2
0
DC-8 & SMART-COMMIT Open House
SMART-COMMIT 4 Packing Days
7
8
10
12
14
16
18
20
22
24
25
28
September 2006

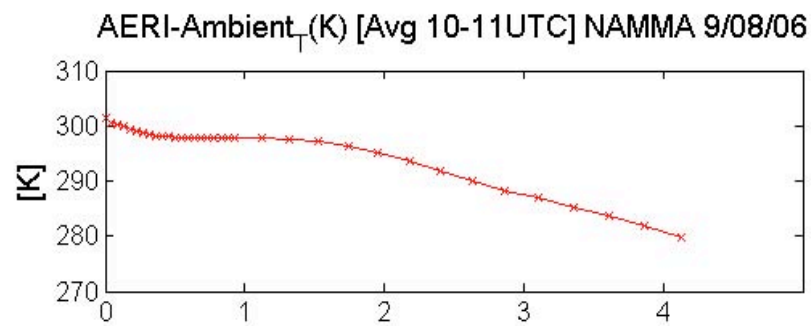
- ***Aerosol Types:***
  - Angstrom Exponent
  - Filter Color
  - Size Distribution
  - Hygroscopicity
  - Others

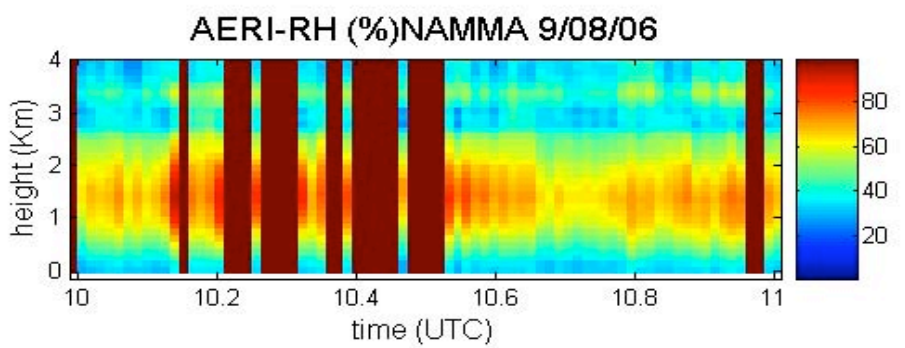


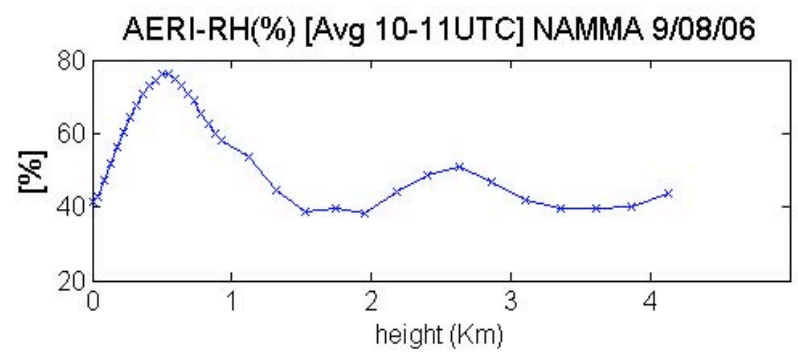



T 08 Sep 2006 D
Td 08 Sep 2006 D
T 08 Sep 2006 N
Td 08 Sep 2006 N
08 Sep 2006 D
08 Sep 2006 N
Altitude (km)
Temperature (deg. C)
Potential Temperature (K)
RH (%)
WV Mixing Ratio (g/kg)


AERI-Ambient$_T$ (K) NAMMA 9/08/06
height (Km)

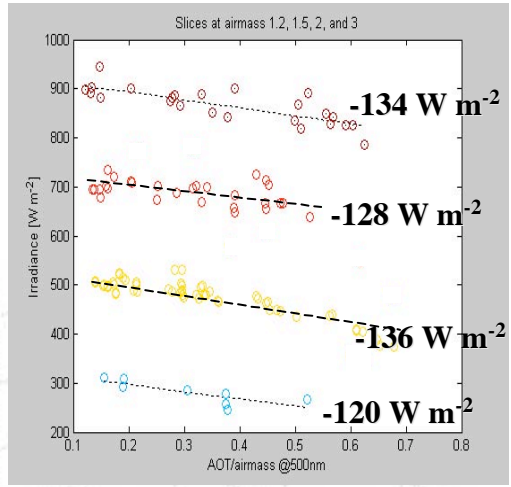

AERI-Ambient$_T$(K) [Avg 10-11UTC] NAMMA 9/08/06
[K]

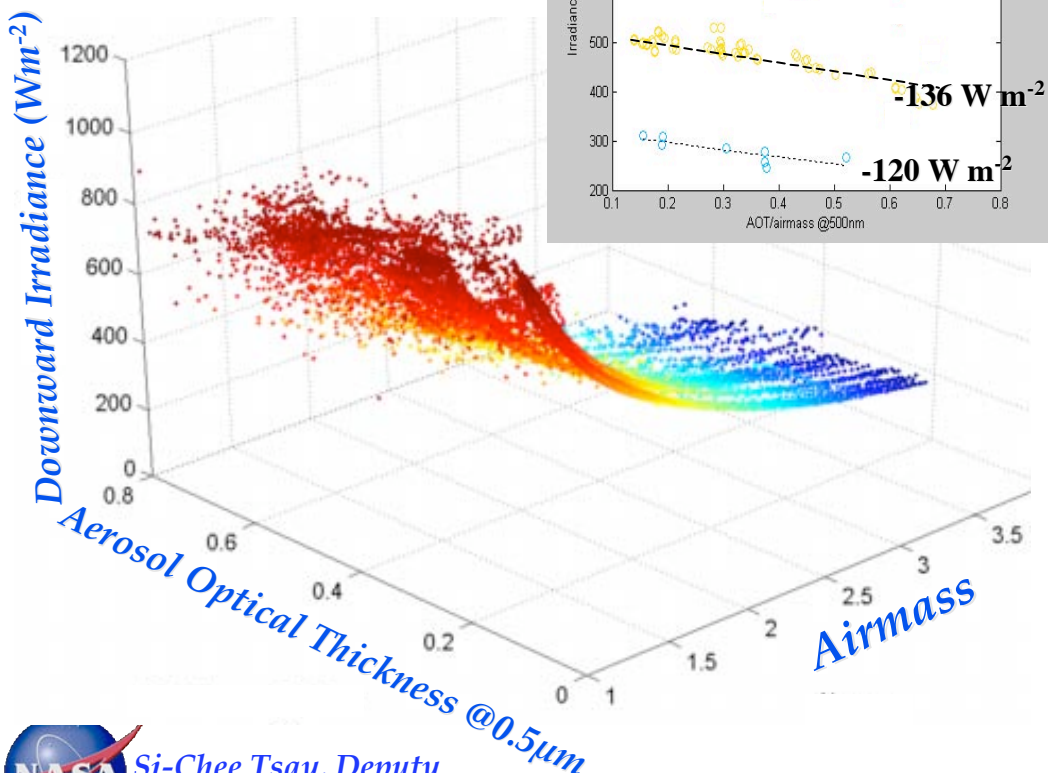

AERI-RH (%)NAMMA 9/08/06
height (Km)
time (UTC)


AERI-RH(%) [Avg 10-11UTC] NAMMA 9/08/06
[%]
height (Km)

Aerosol Direct Radiative Forcing

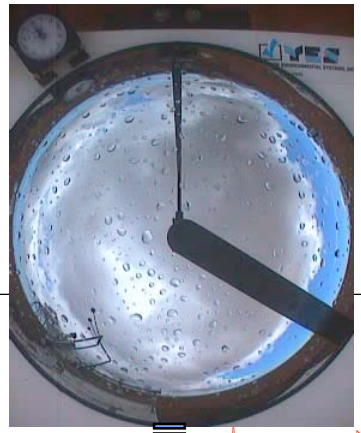
$$F_{ARF} = F_{Asl} - F_{Cln}$$ **or** $$\frac{\Delta T}{\Delta t} = -\frac{1}{C_p \rho}\frac{\Delta F}{\Delta z} \propto \frac{\Delta F}{\Delta \tau}$$



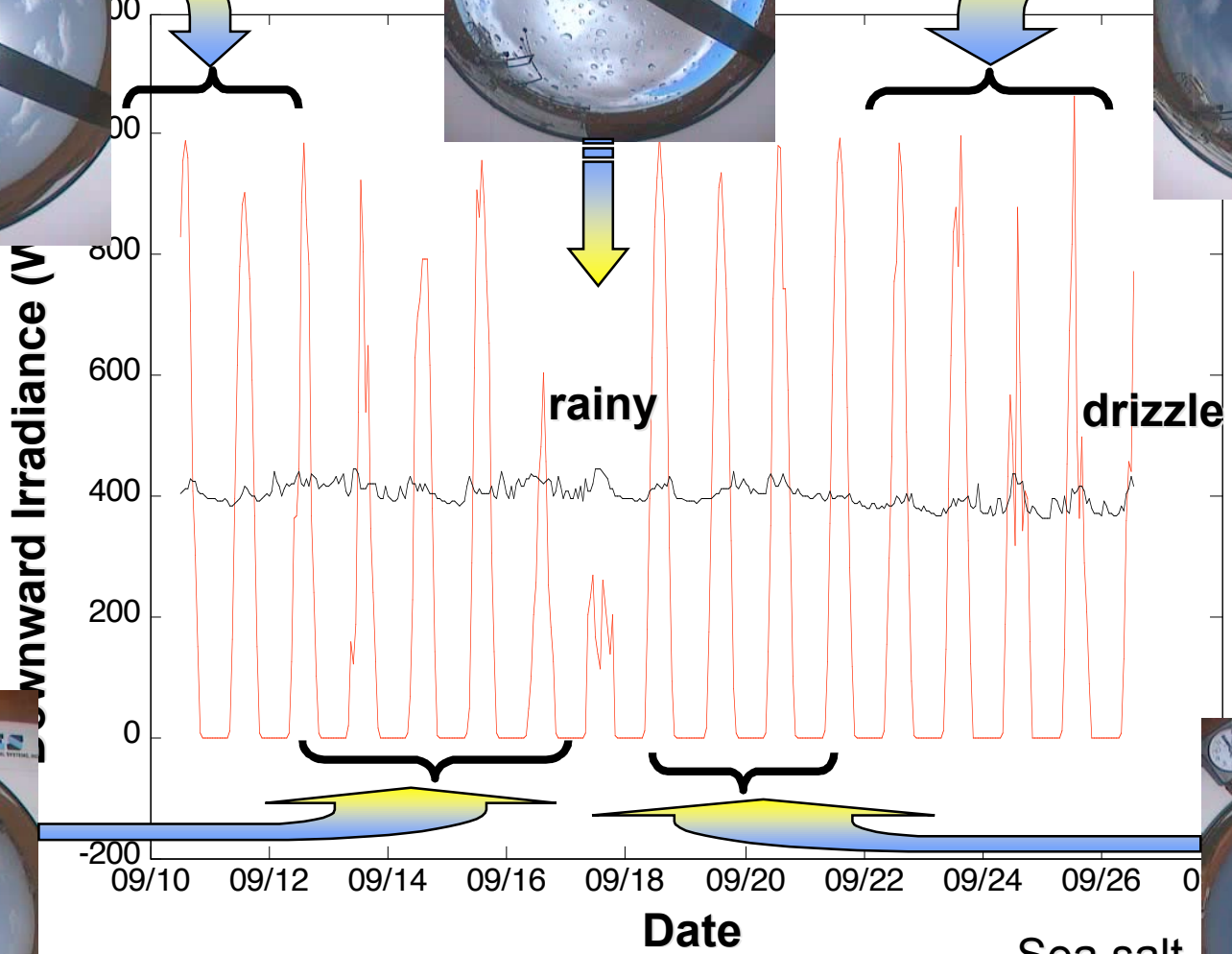


- *Hypothetical, not co-existed*
- *Surrogate:*
  - Monthly mean, e.g., ERBE (Ramanathan *et al.*, 1989)
  - Reference min., e.g., INDOEX (Conant, 2000)
  - Hybrid approach
- *Water vapor interactions*
- *Langley-like approach*

Dust-hazy
low clouds
thin cirrus



Light haze
low & high
clouds



Hazy, low &
high clouds

Sea salt
patchy clouds