Suppression of Deep Convection by the Saharan Air Layer (SAL) over the Tropical North Atlantic

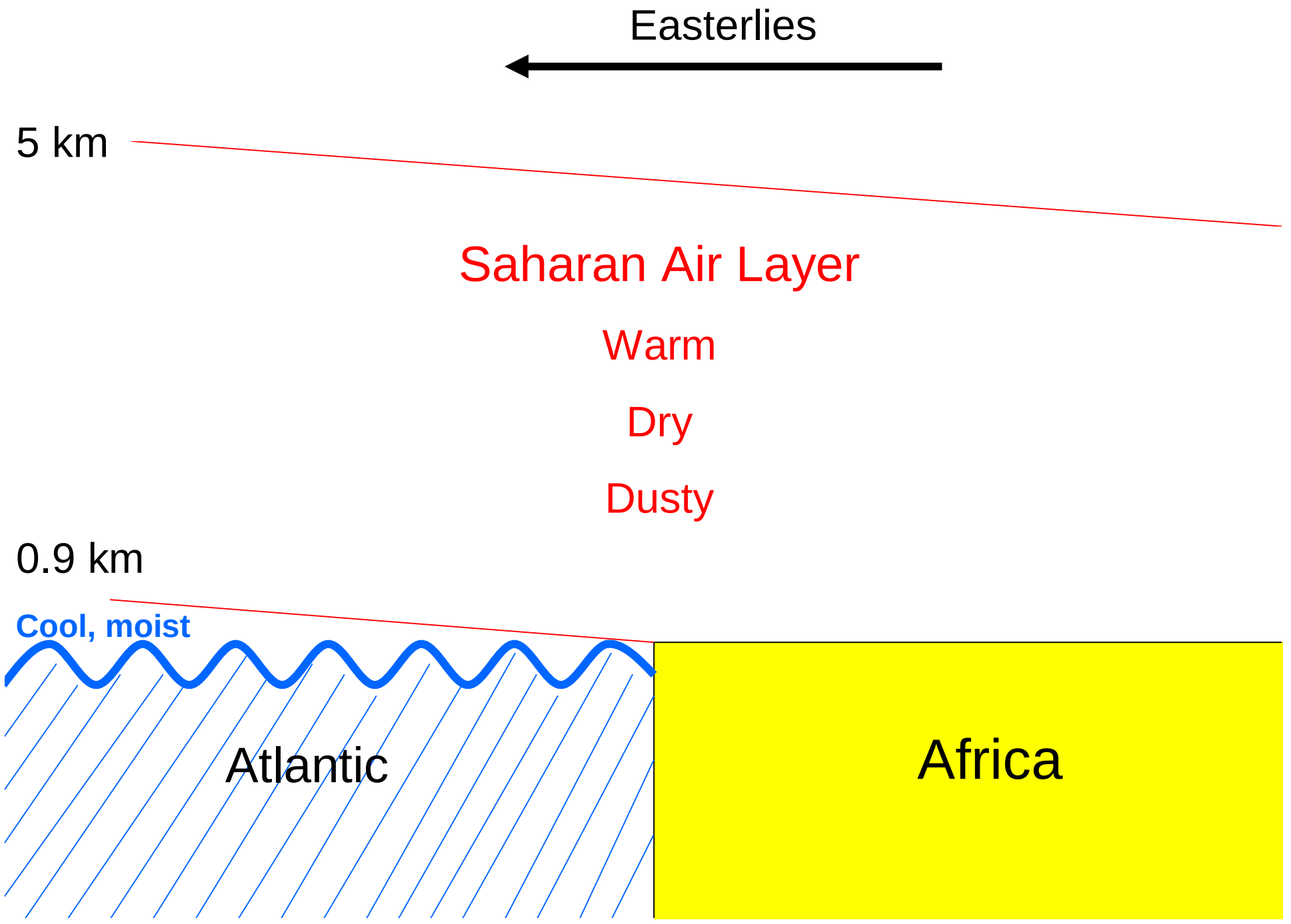
Sun Wong[1], Andrew E. Dessler[1], Peter Colarco[2]

[1]ESSIC, University of Maryland, College Park

[2]Goddard Space Flight Center, Maryland, Greenbelt

March 24, 2005

(MODIS Meeting)


Easterlies
5 km
Saharan Air Layer
Warm
Dry
Dusty
0.9 km
Cool, moist
Atlantic
Africa

Why does the SAL concern us?

- Evidence has shown linkage between the SAL and the tropical cyclone (TC) activity

- The SAL is associated with the transport and distribution of dust over Atlantic. Dust can cool the surface and warm the atmosphere (Global mean forcing at surface from dust: –0.96 Wm^{-2})

Purposes

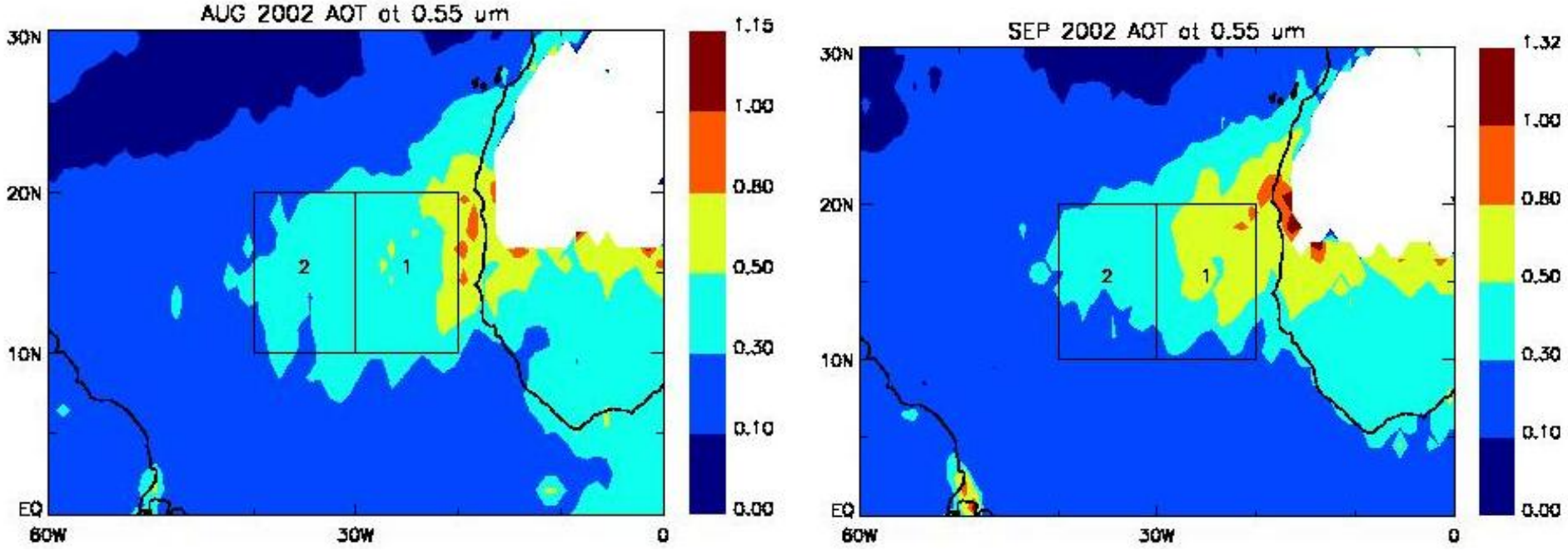
- Using NASA's satellite data (including MODIS) to study the thermodynamic structure of the SAL
- Evaluate simulation of the SAL by NASA's model (fvGCM) using the satellite data
- Understanding the detailed physics using the model

Data Resources

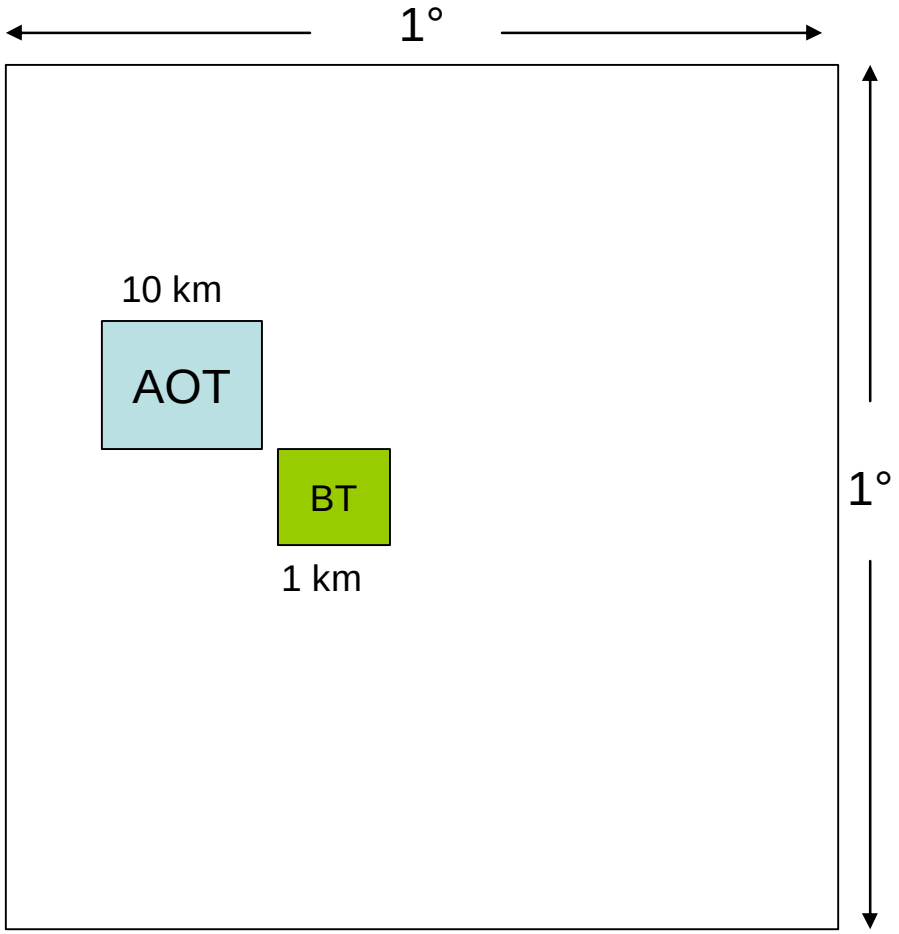
- MODerate resolution Imaging Spectroradiometer (MODIS) aerosol optical thickness (AOT,0.55 μm, MOD04 level-2 product from Terra)
- Brightness T (11 μm, MOD06 level-2 product)
- NCEP/NCAR Reanalysis T, RH (2.5°×2.5°)

- Time: Daily instantaneous samples at around noon for Aug-Sep 2002
- Region: 40°-20°W, 10°-20°N

Monthly Mean AOT



For each grid and each day in the region



- Grid-averaged AOT

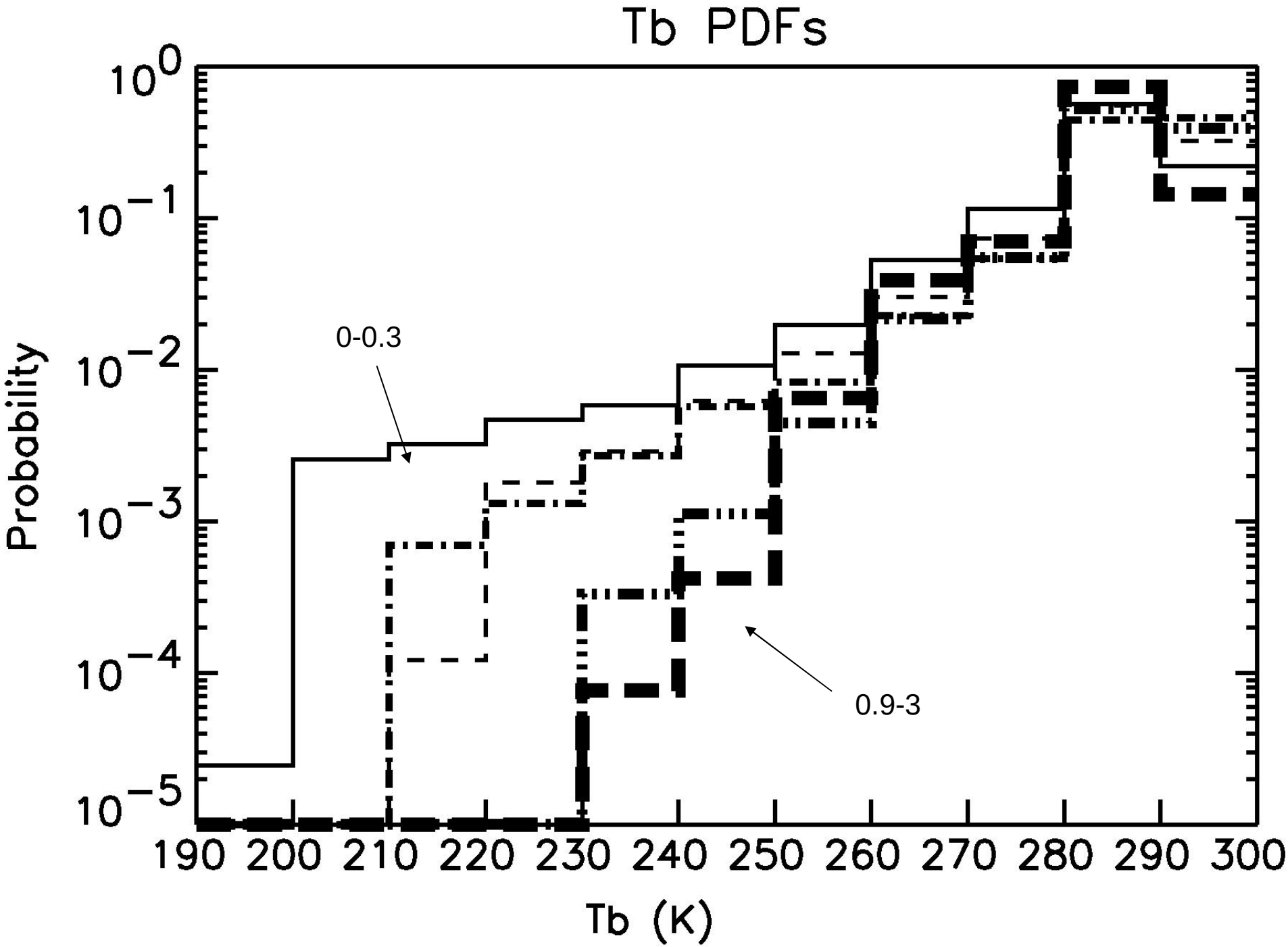
$$\sigma(AOT) < 0.2 \cdot \bar{\ }_{arsl}$$

- BT histogram

Total BT pixels no. > 100

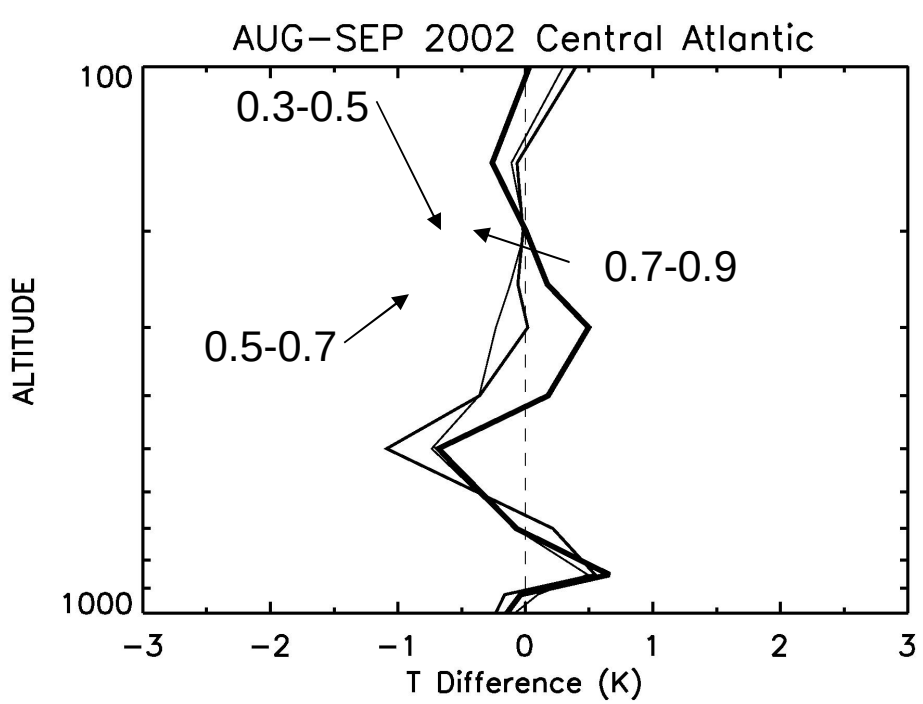
Range: 190-300 K

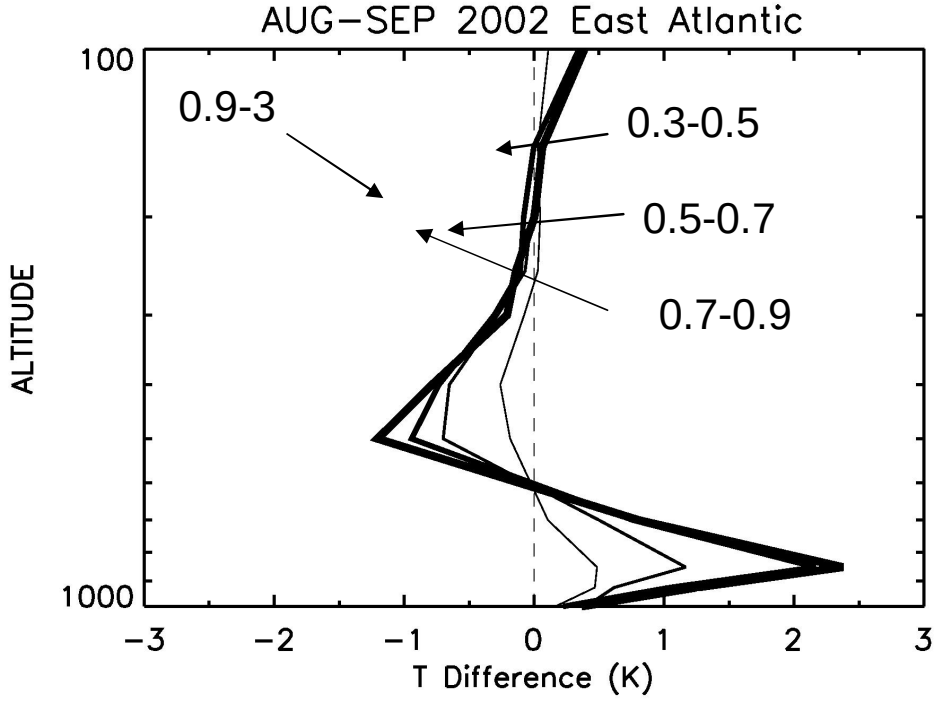
Bin width: 10 K


Tb PDFs
Probability
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0-0.3
0.9-3
190 200 210 220 230 240 250 260 270 280 290 300
Tb (K)

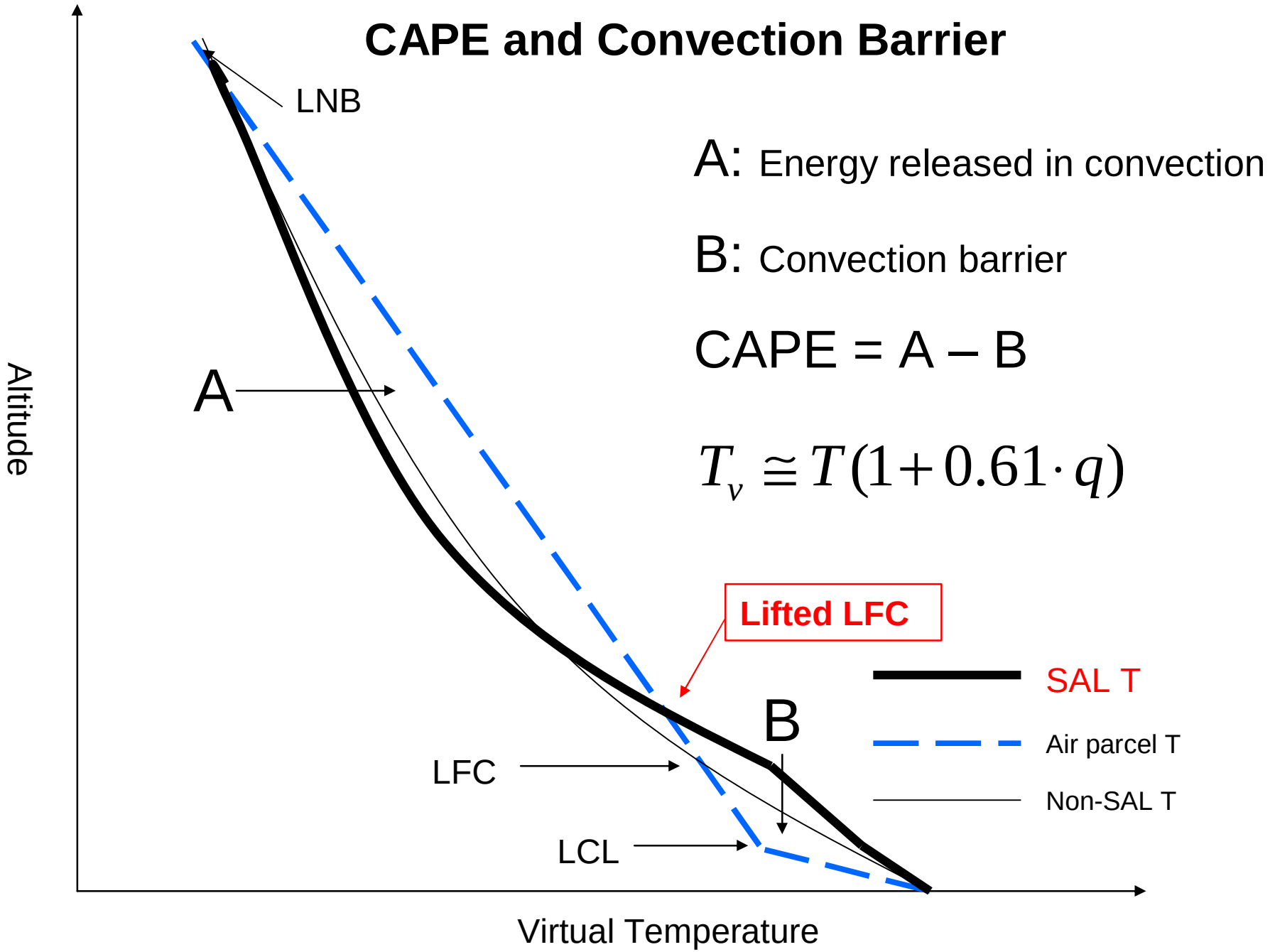
Composites of T Anomaly Profiles

$$T(a \le \bar{\ }_{arsl} < b) - T(0 \le \bar{\ }_{arsl} < 0.3)$$





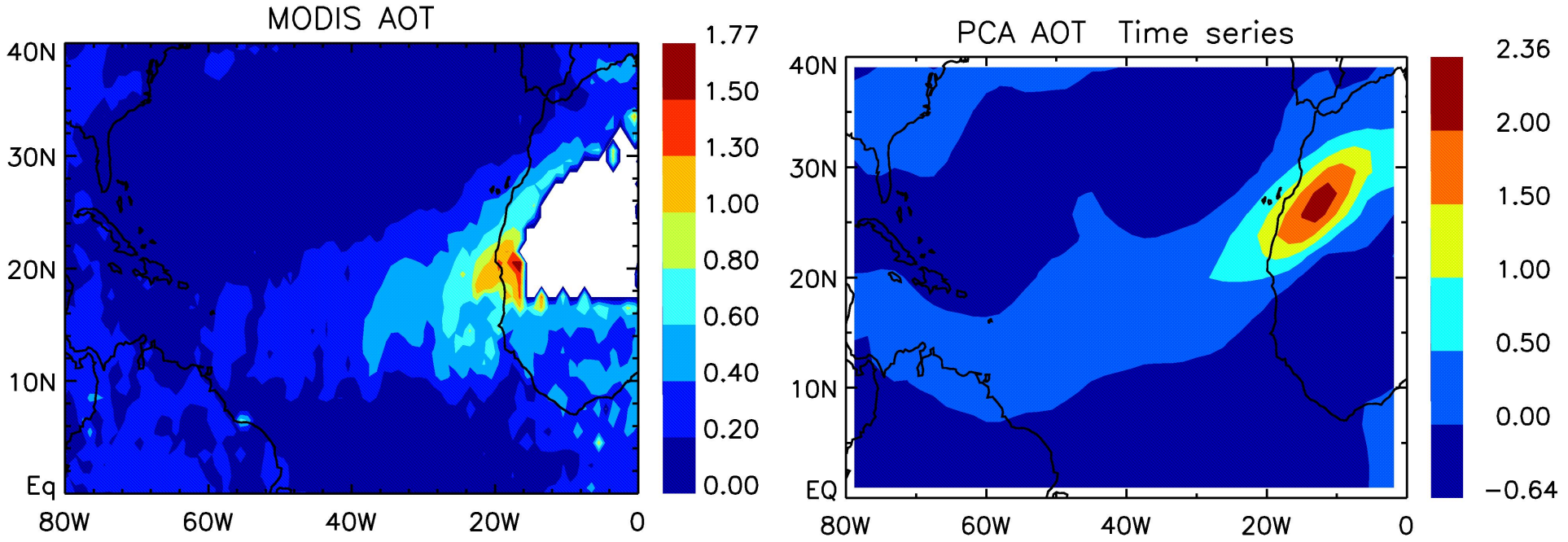
CAPE and Convection Barrier



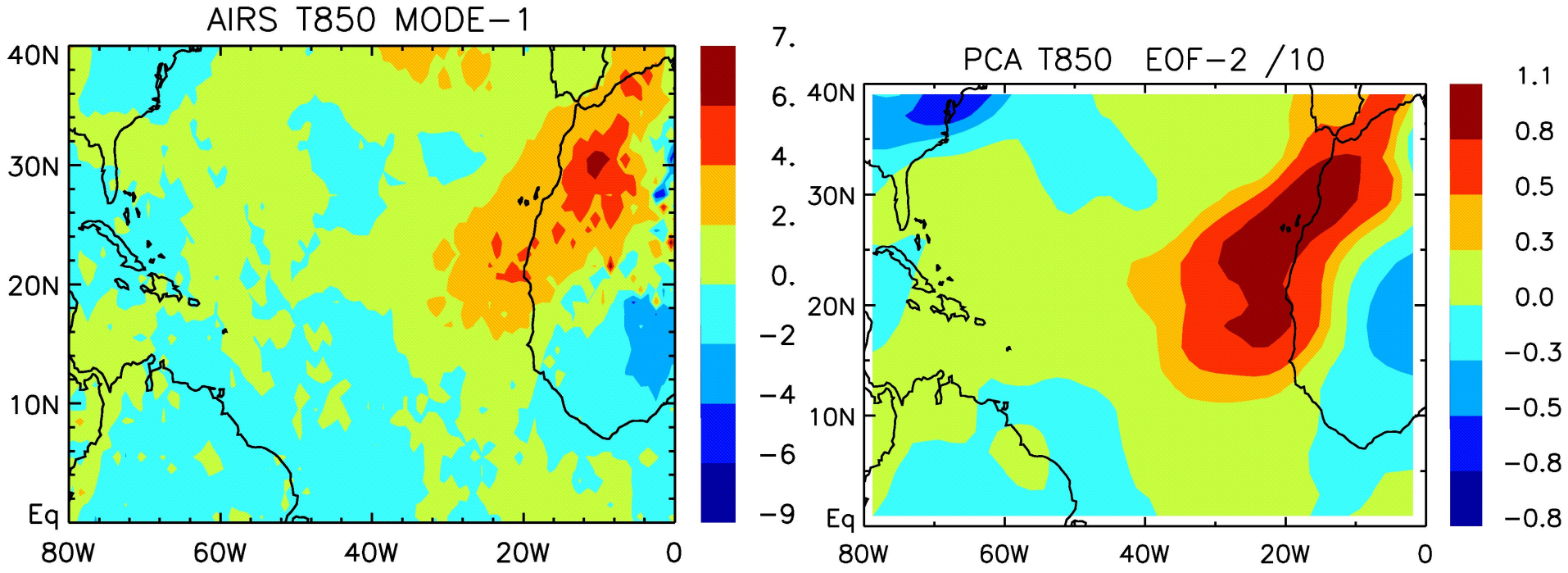
Summary for East Atlantic

AOT Range	Ave. AOT	Conv. Barrier (m^2/s^2)	P(BT<230 K) %	P(BT<250 K) %
0-0.3	0.21	6.65	1.05	2.70
0.3-0.5	0.41	16.10	0.19	1.10
0.5-0.7	0.60	27.84	0.20	1.04
0.7-0.9	0.79	37.63	0.00	0.15
0.9-3	1.21	54.27	0.00	0.05

AOT EOF-1


MODIS AOT
40N
30N
20N
10N
Eq
80W
60W
40W
20W
0
1.77
1.50
1.30
1.00
0.80
0.60
0.40
0.20
0.00
PCA AOT Time series
40N
30N
20N
10N
EQ
80W
60W
40W
20W
0
2.36
2.00
1.50
1.00
0.50
0.00
−0.64

T at 850 hPa EOF-1

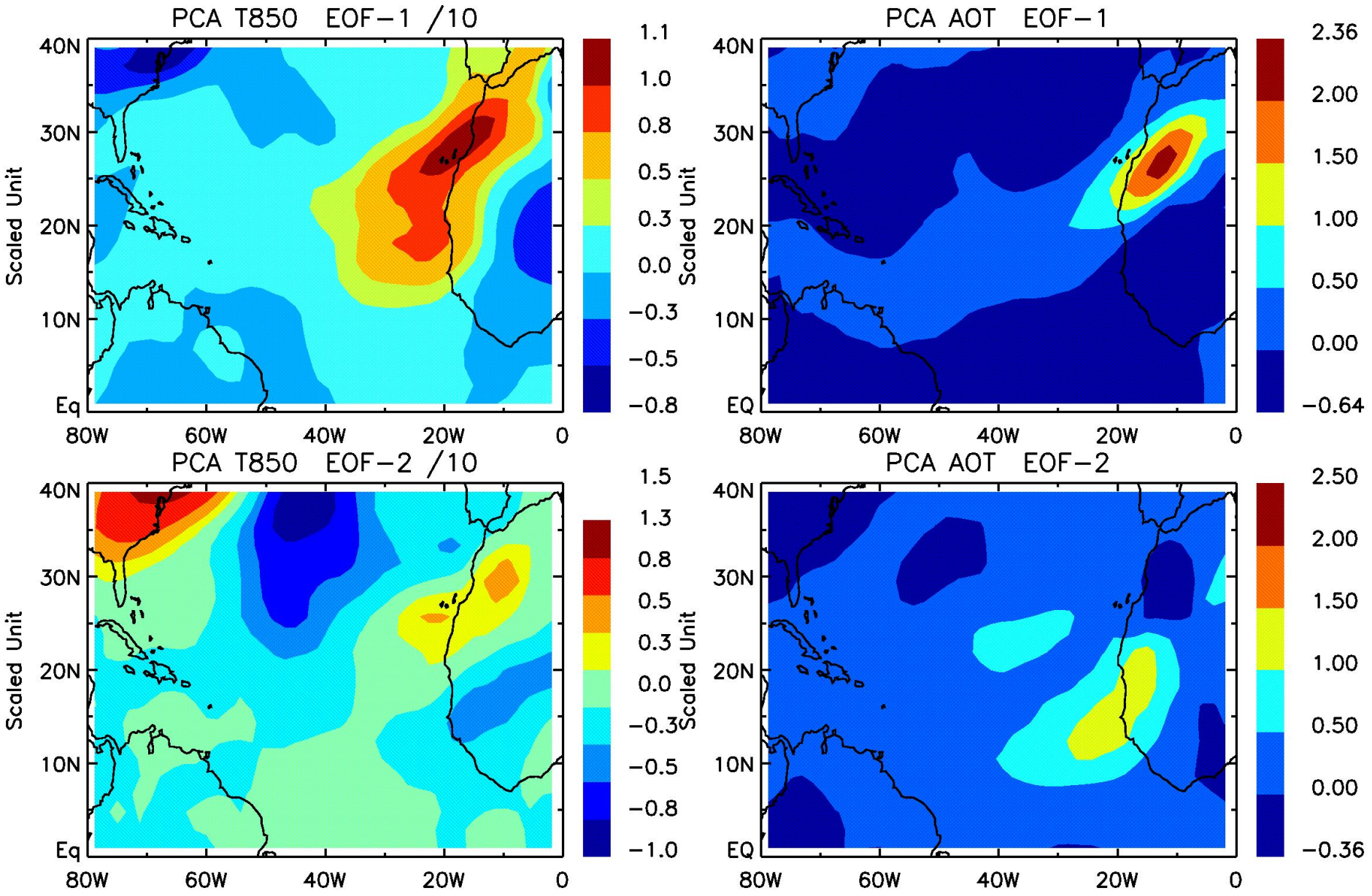


Conclusion

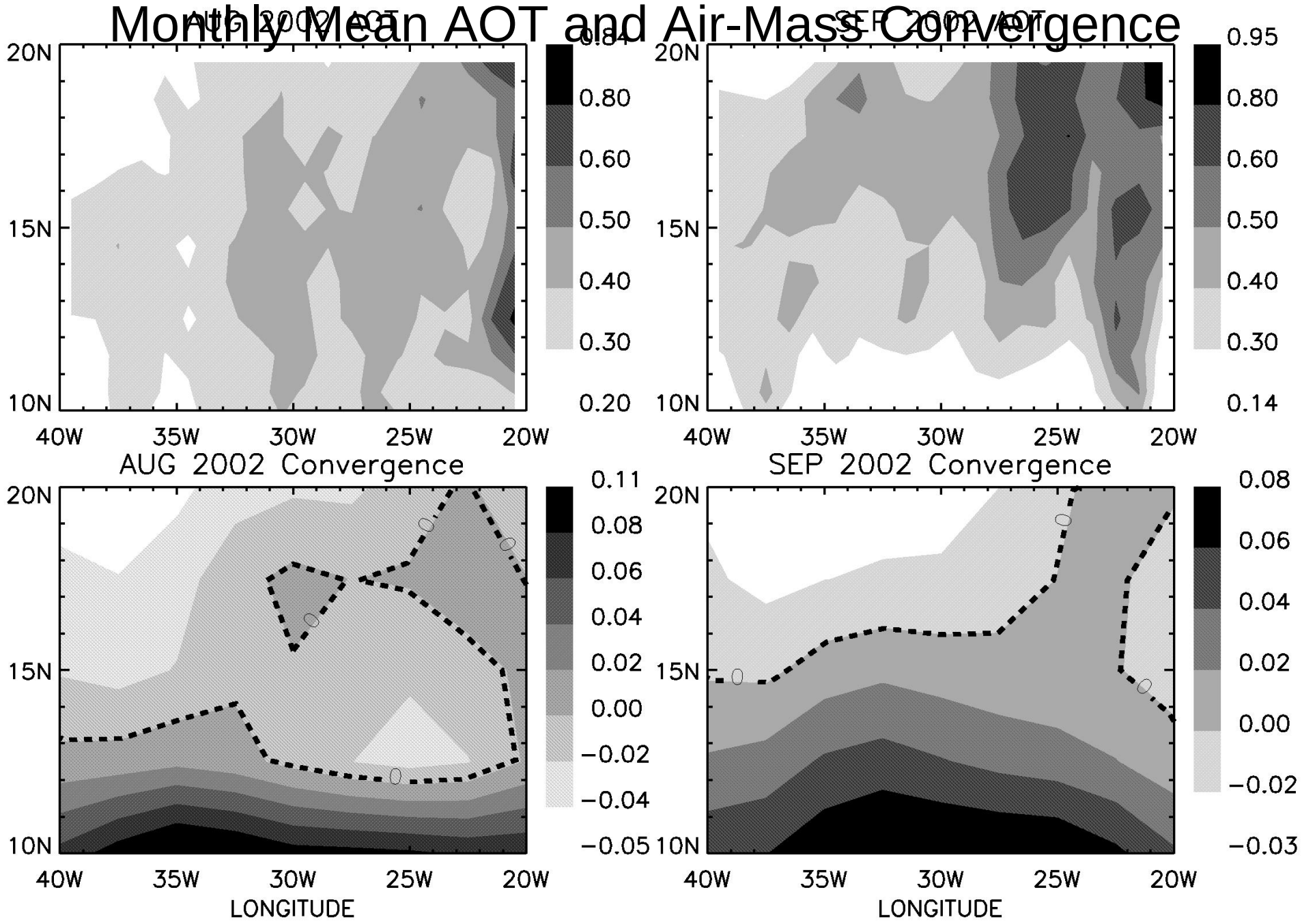
- The SAL is associated with a suppression of deep convection. Frequency of clouds with BT less than 250 K is largely reduced

- The SAL suppresses deep convection by lifting the LCL (less moisture), LFC (warmer temperature), and strengthening the convection barrier

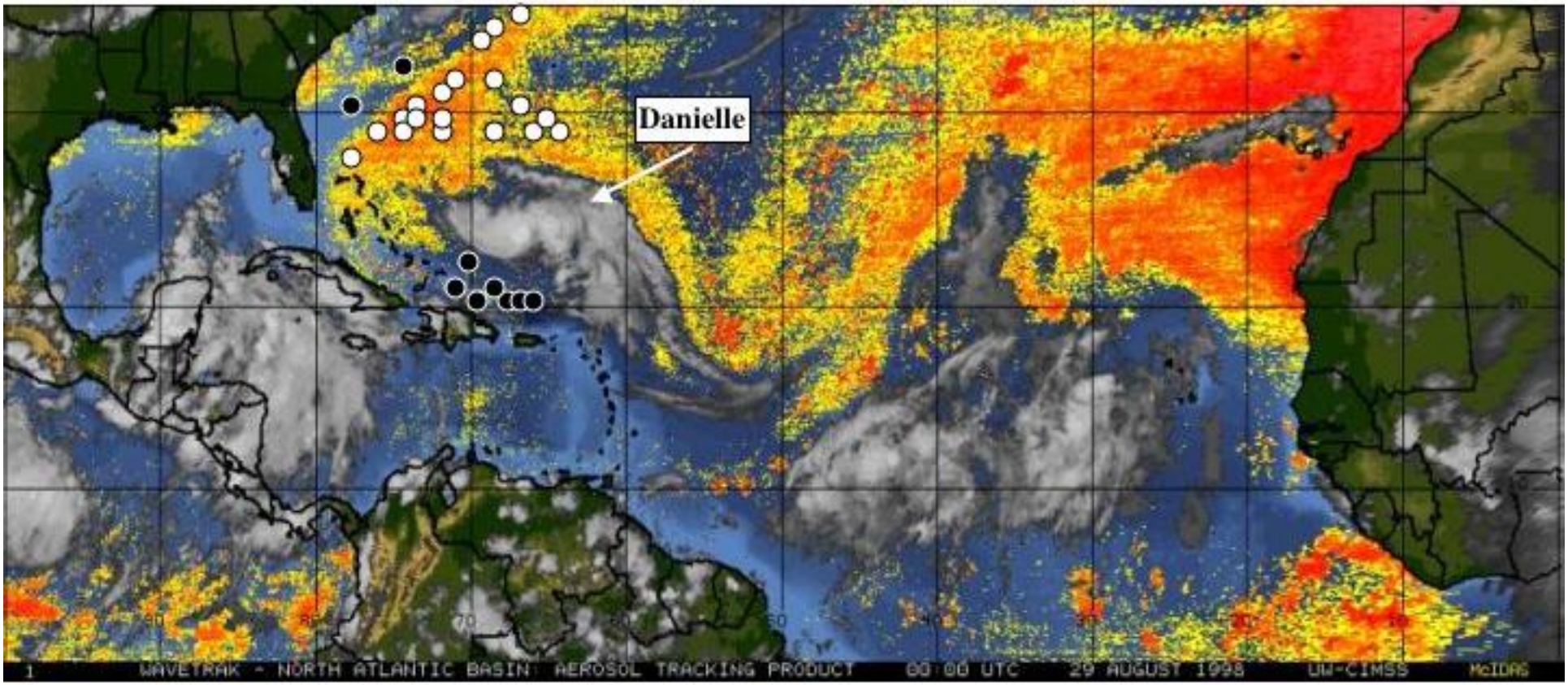
FVGCM + NCEP/NCAR + Peter Colarco



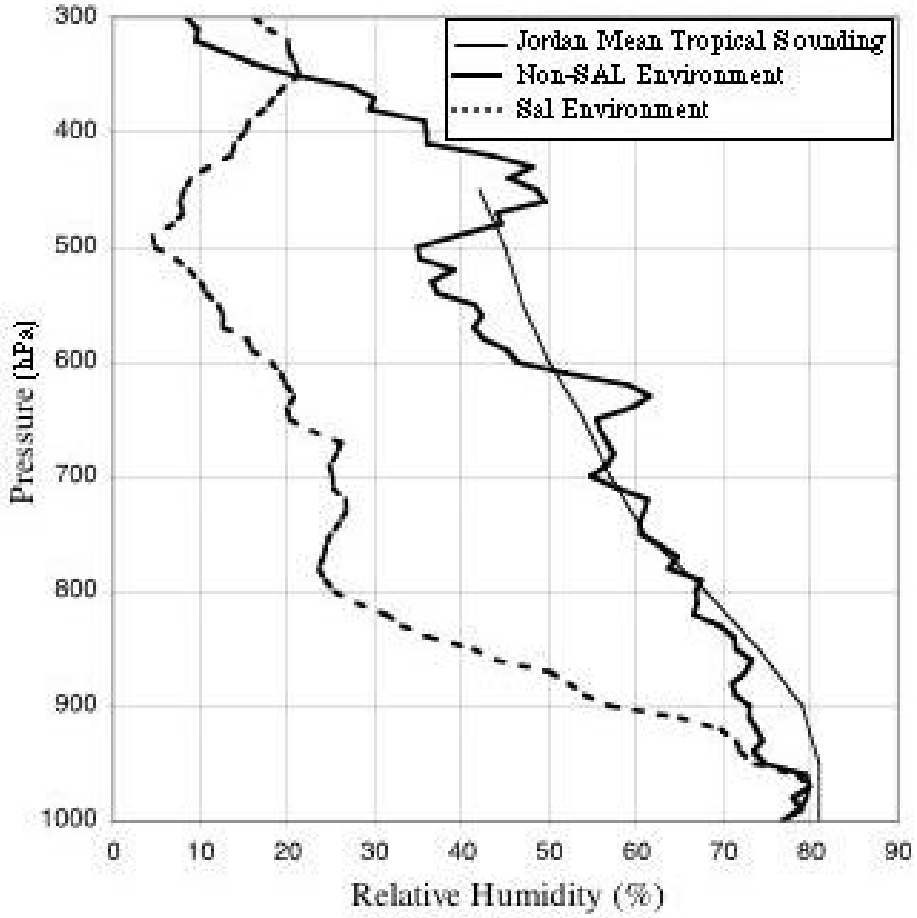
Monthly Mean AOT and Air-Mass Convergence

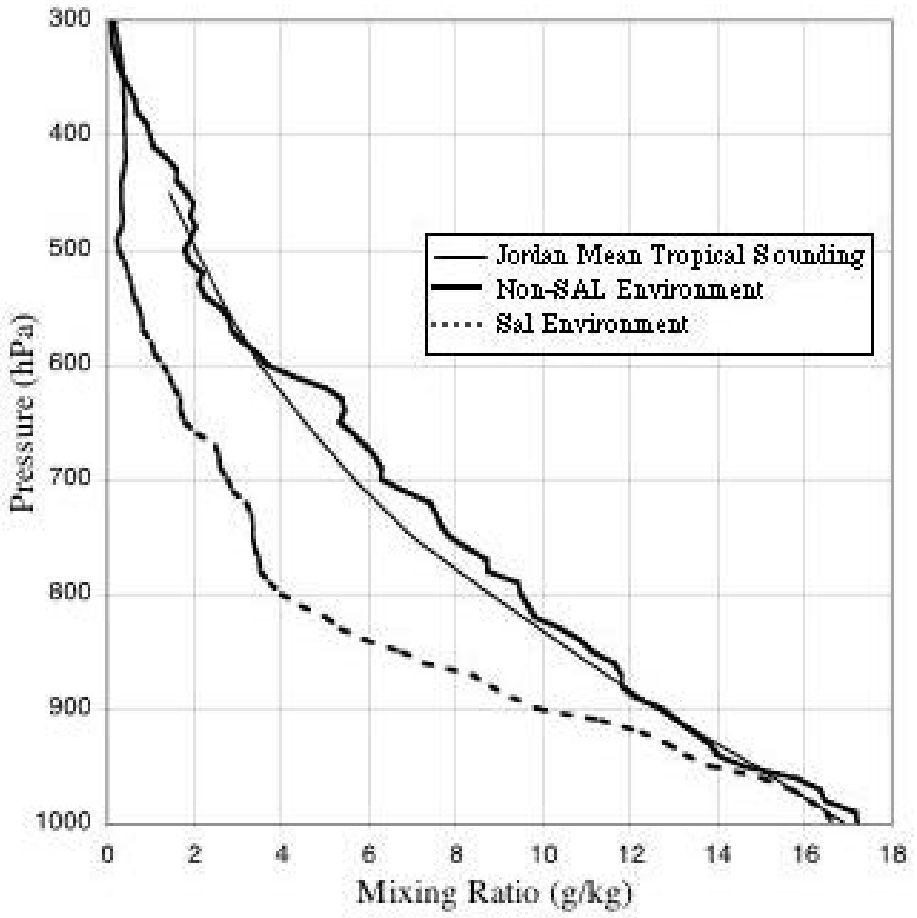


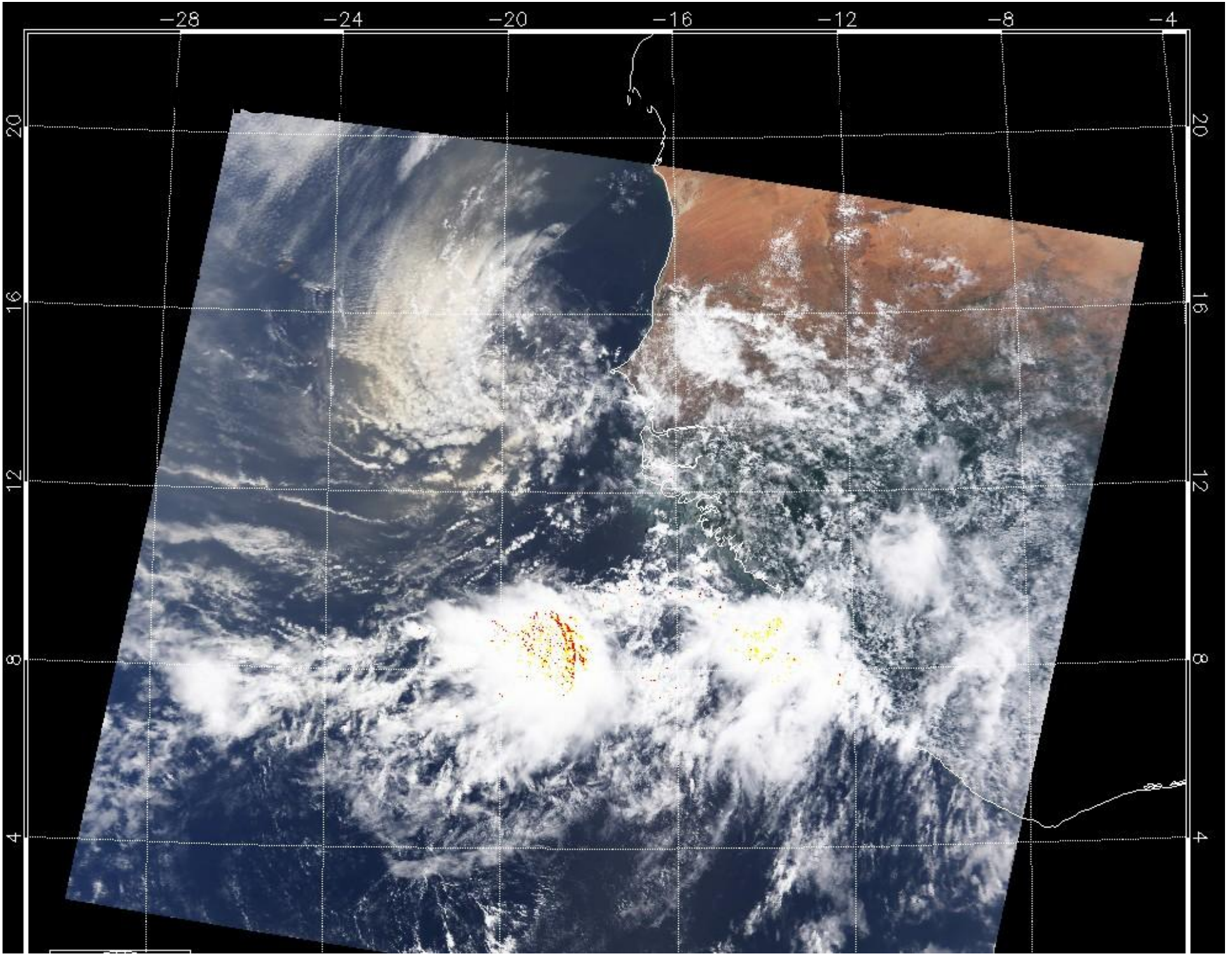
GOES SAL Tracking Imagery, BT11-BT12 (Dunion and Velden, 2004)



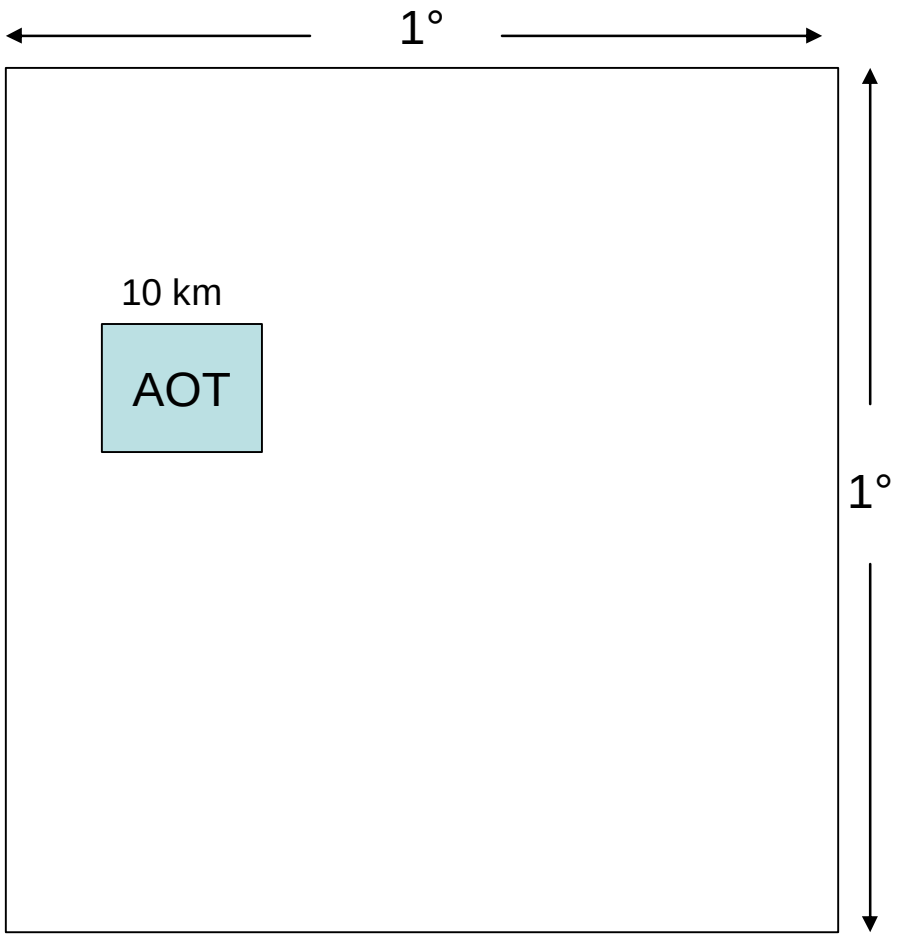
GPS Moisture Sounding Composites (Dunion and Velden, 2004)






−28
−24
−20
−16
−12
−8
−4
20
16
12
8
4

For each grid and each day in the region



- Grid-averaged AOT

$$\sigma(AOT) < 0.2 \cdot \bar{}_{arsl}$$

Regional Statistics for Aug-Sep 2002

East Atlantic (Region 1):

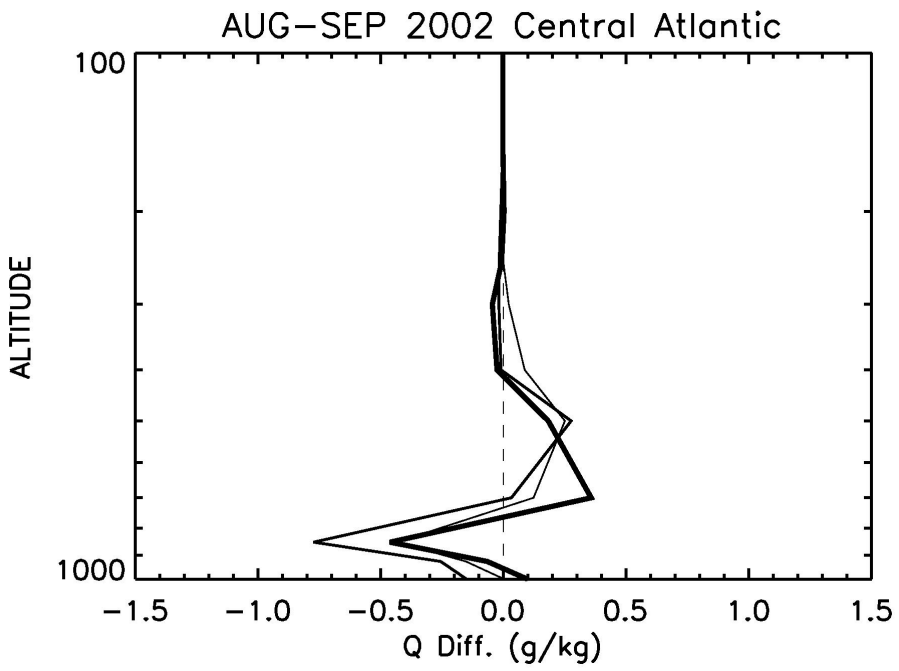
AOT	P(BT<230 K) in %
0-0.3	1.05
0.3-0.5	0.19
0.5-0.7	0.20
0.7-0.9	0.00
0.9-3.0	0.00

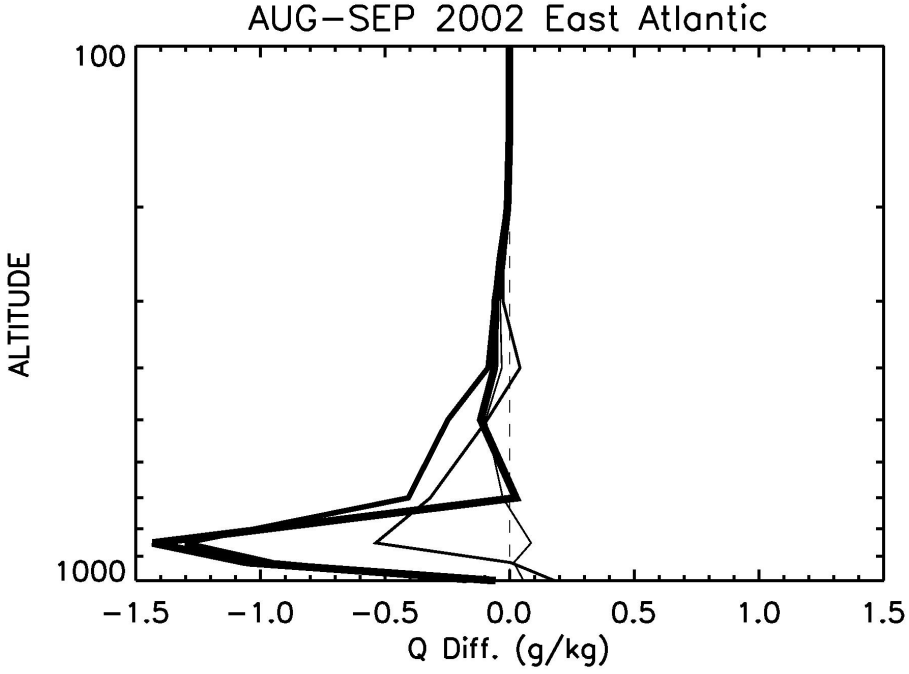
Summary for Central Atlantic

AOT Range	Ave. AOT	Conv. Barrier (m^2/s^2)	P(BT<230 K) %	P(BT<250 K) %
0-0.3	0.21	6.04	0.81	2.37
0.3-0.5	0.40	11.48	0.51	2.27
0.5-0.7	0.59	15.42	0.13	0.90
0.7-0.9	0.78	12.34	0.18	1.42
–	–	–	–	–

Composites of q Anomaly Profiles

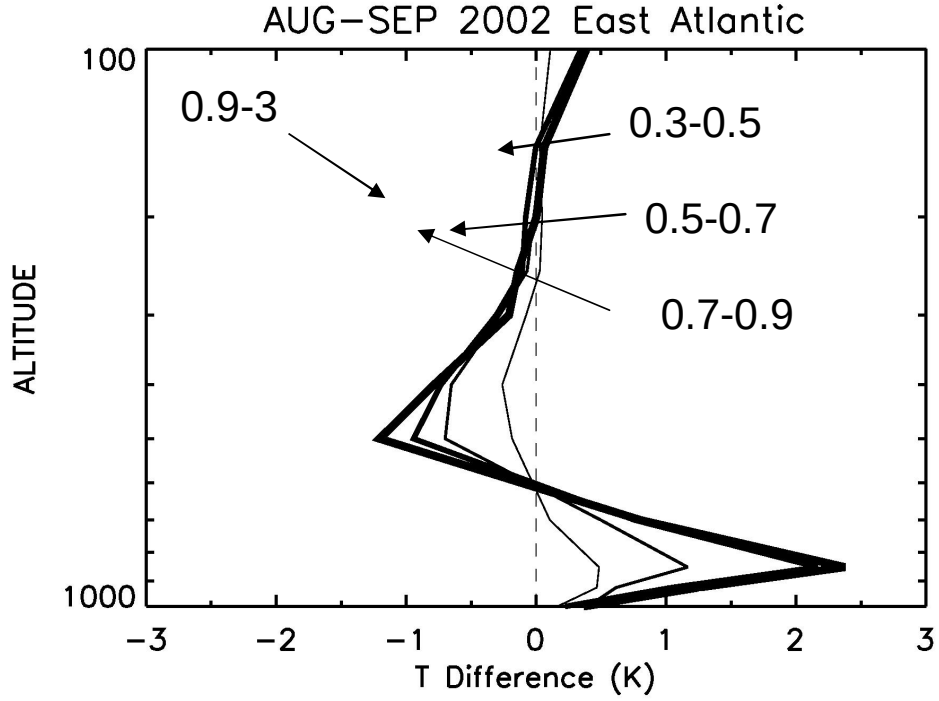
$$q(a \leq \bar{\ }_{arsl} < b) - q(0 \leq \bar{\ }_{arsl} < 0.3)$$



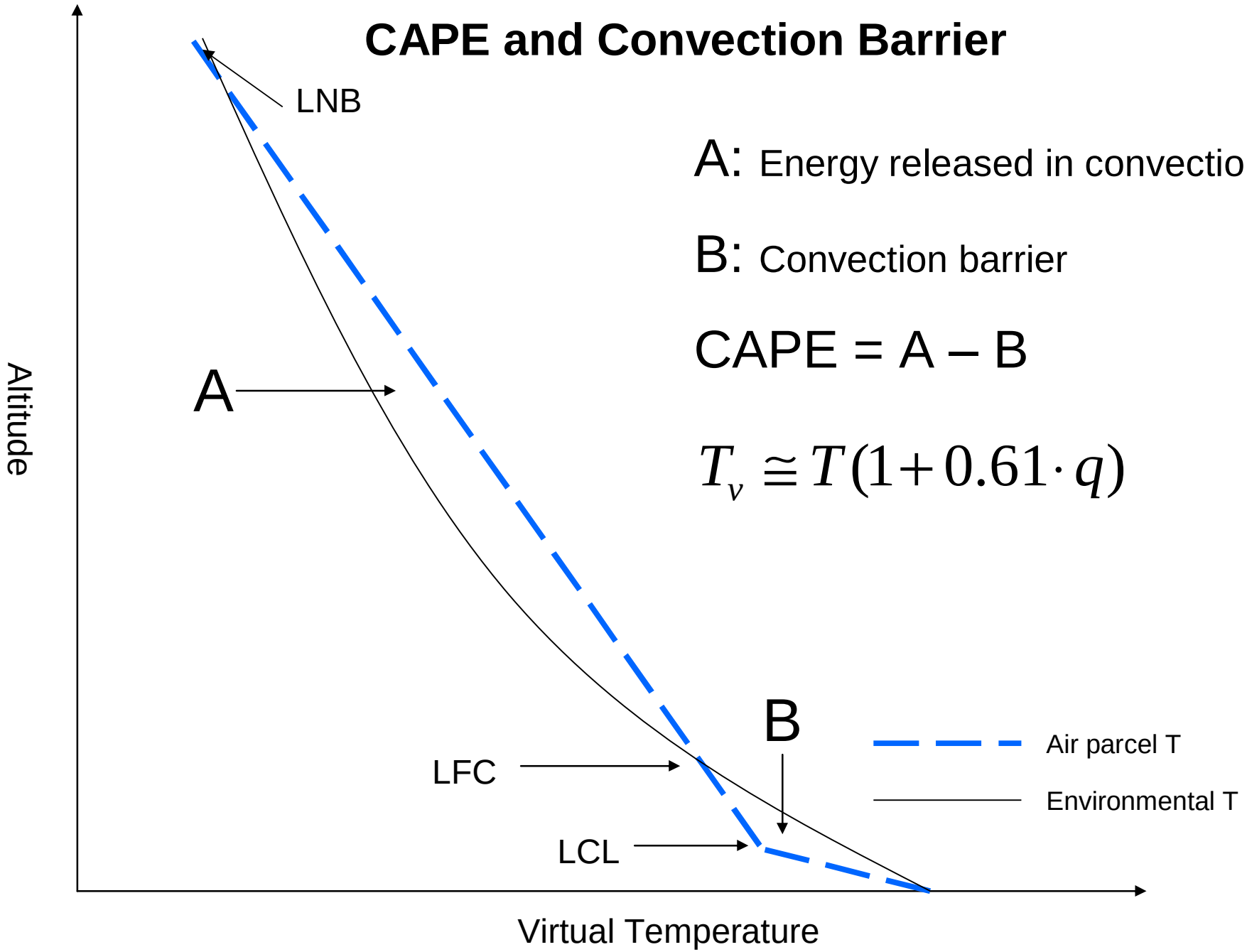


Composites of T Anomaly Profiles

$$T(a \leq \bar{}_{arsl} < b) - T(0 \leq \bar{}_{arsl} < 0.3)$$



CAPE and Convection Barrier



A: Energy released in convection

B: Convection barrier

CAPE = A – B

$$T_v \cong T(1+0.61 \cdot q)$$

Discussion and Future Direction

- How about the wind shear at the southern border of the SAL?
- Are dust and warm anomalies really advected coherently?
- The quality of NCEP/NCAR reanalysis? (Especially moisture!!!)