Using AIRS to Quantify the Heating Effects of Dust in the Saharan Air Layer

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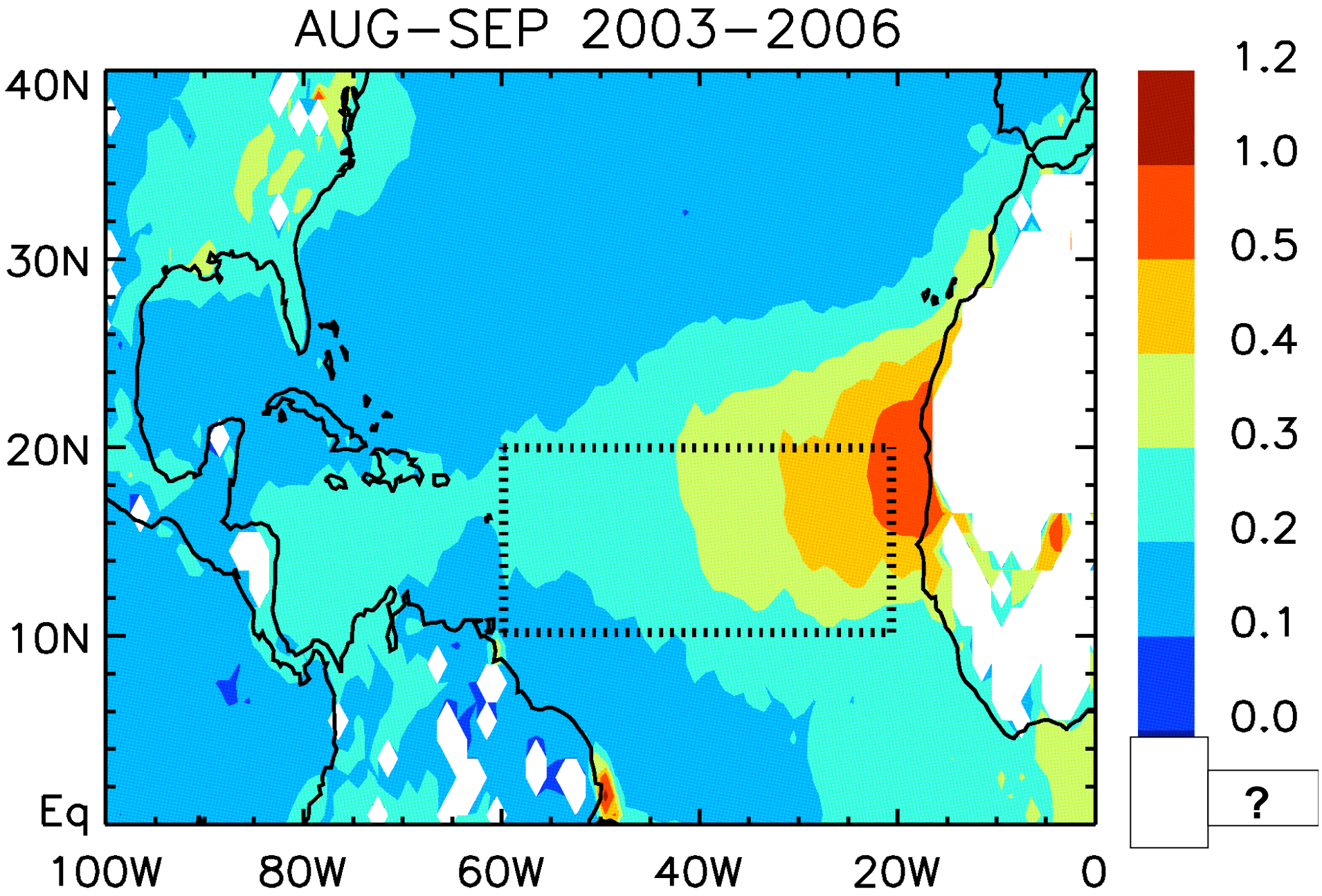
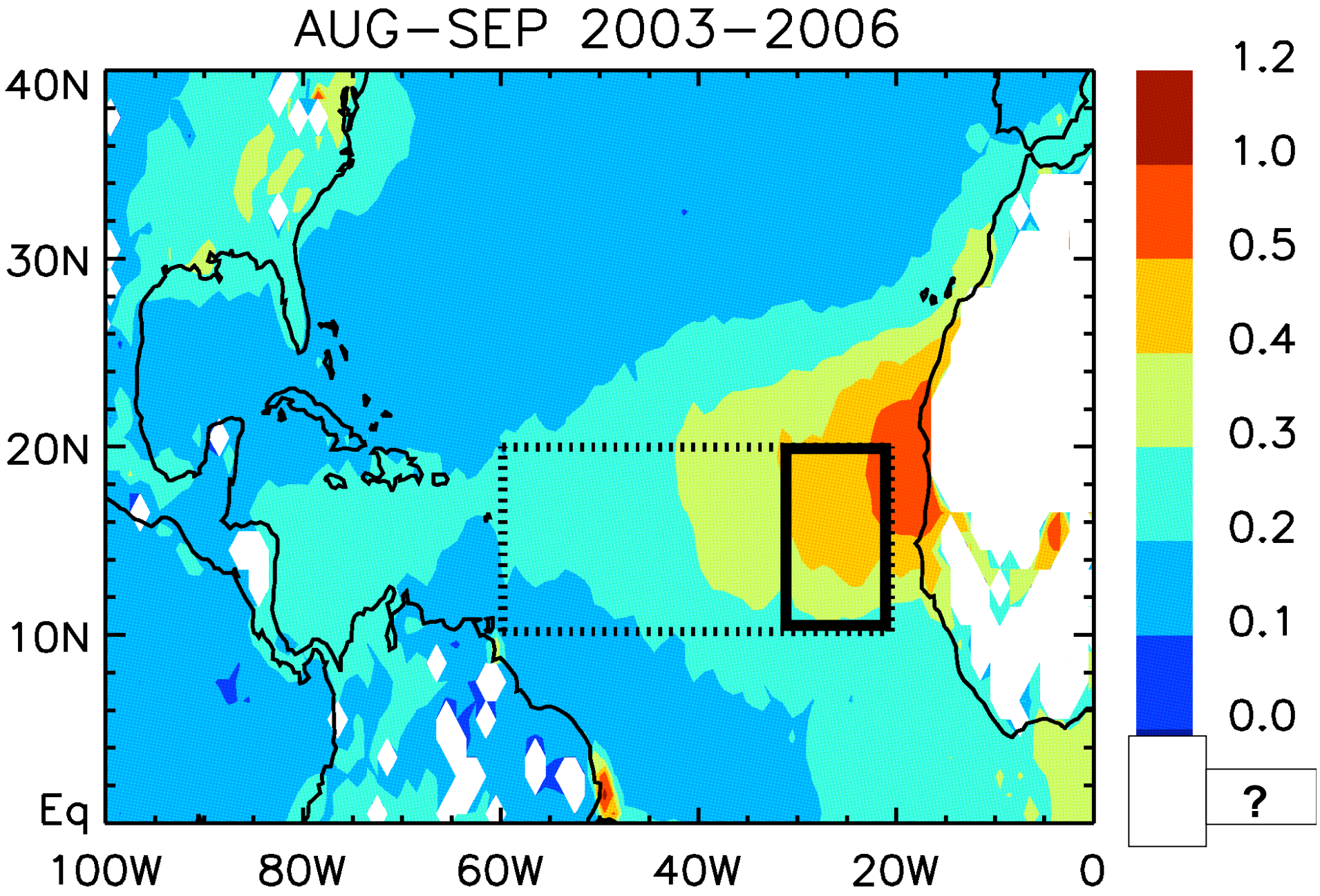
(AIRS STM 2008, Pasadena)

Aqua MODIS Aerosol Optical Thickness (AOT)

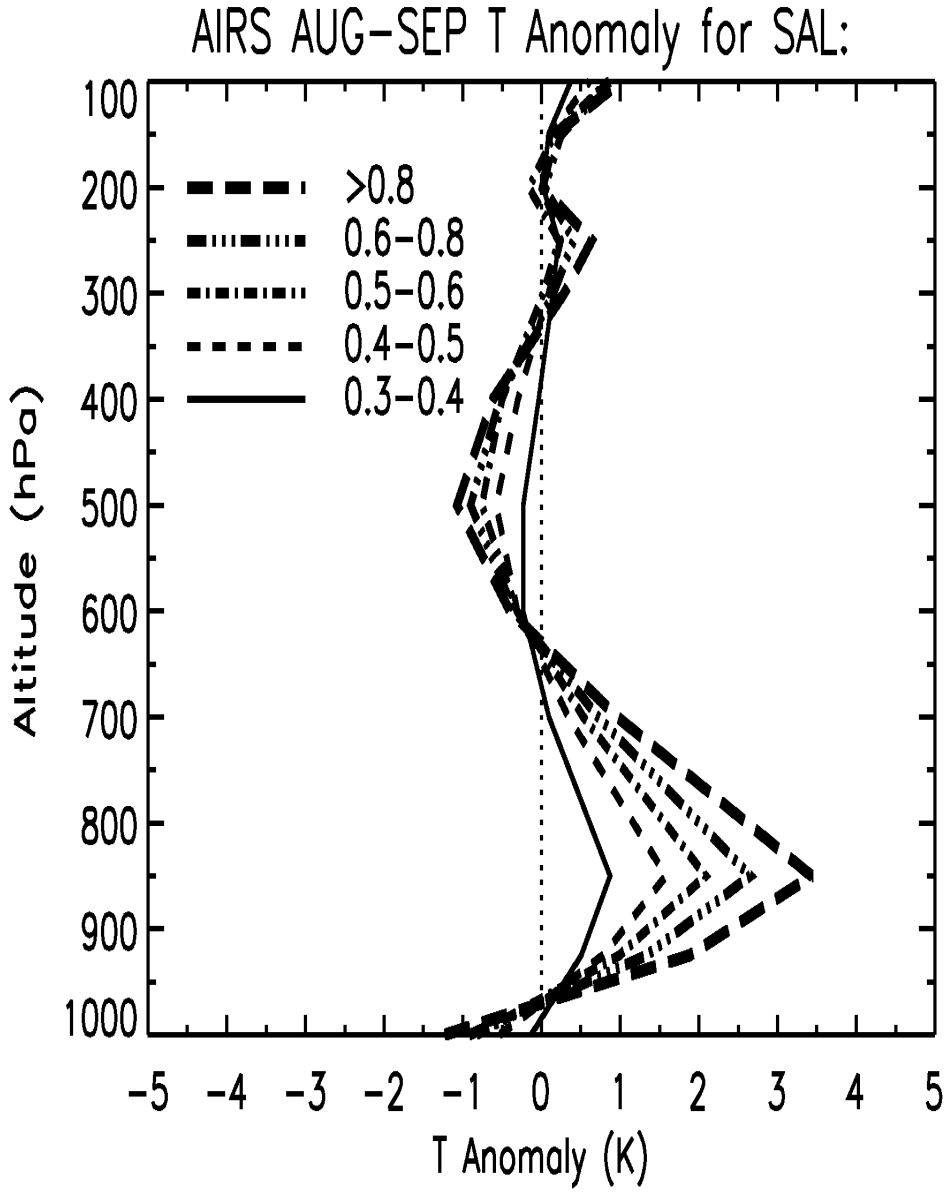


- How important is the Saharan dust in the radiative heating budget in the SAL?
- How important is the dry anomaly in the radiative heating budget in the SAL?
- Can the heating from dust maintain the warmness of the SAL?

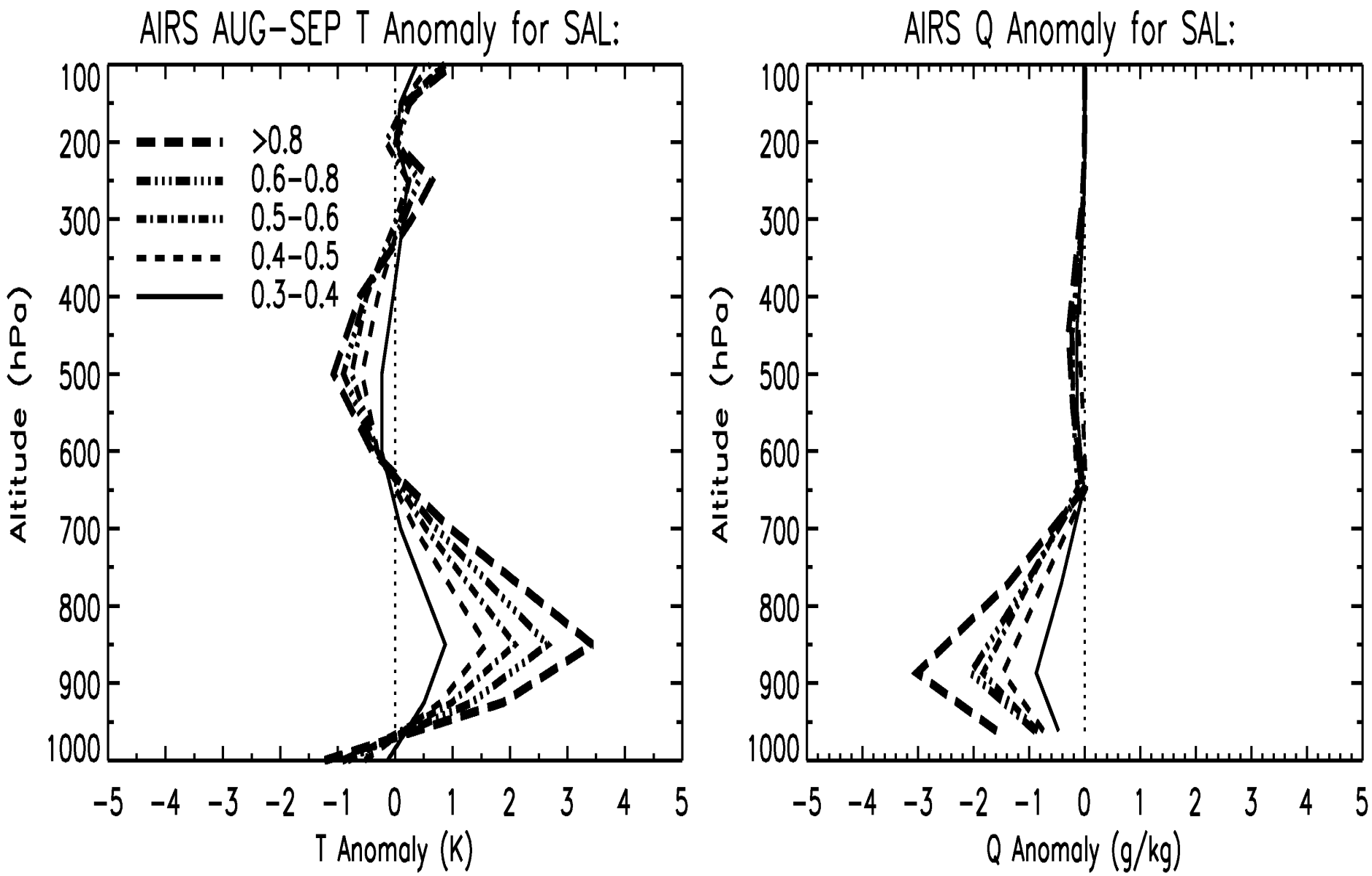
Aqua MODIS Aerosol Optical Thickness (AOT)



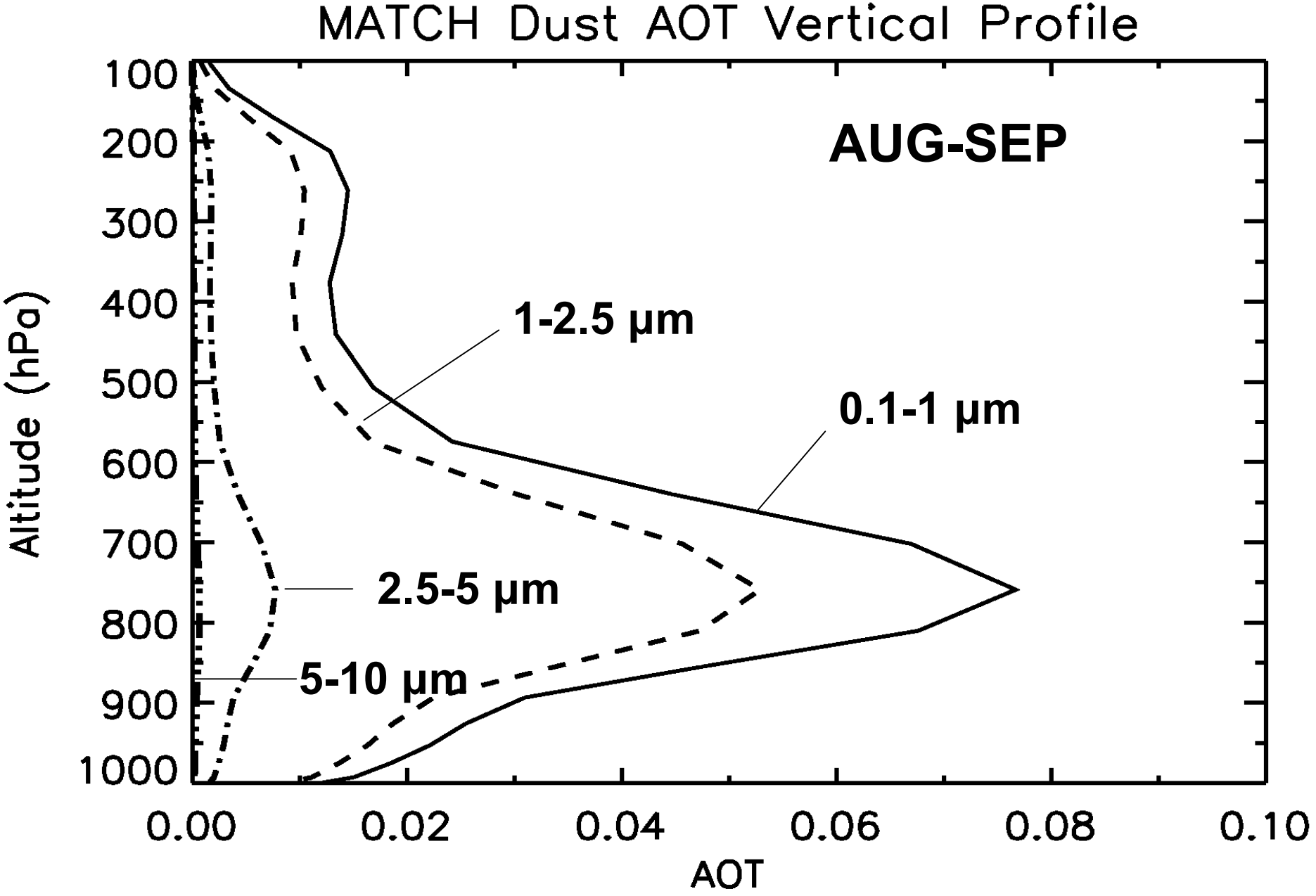
AIRS Saharan Air Layer (SAL)



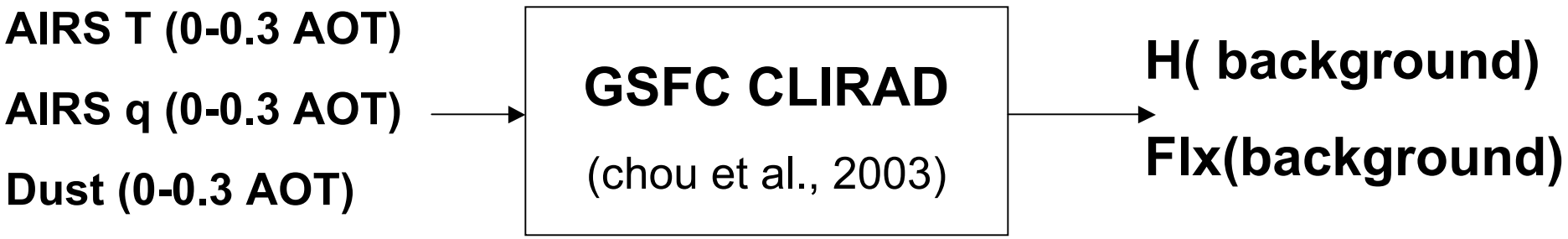
AIRS Saharan Air Layer (SAL)

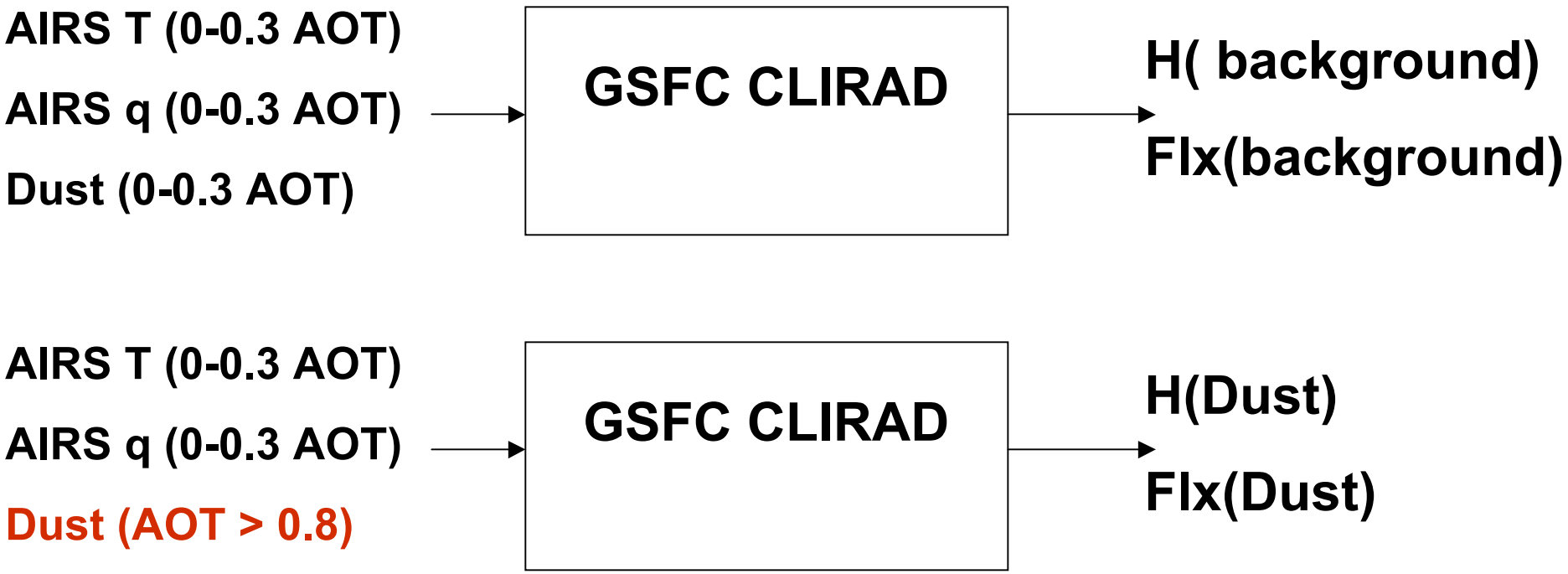


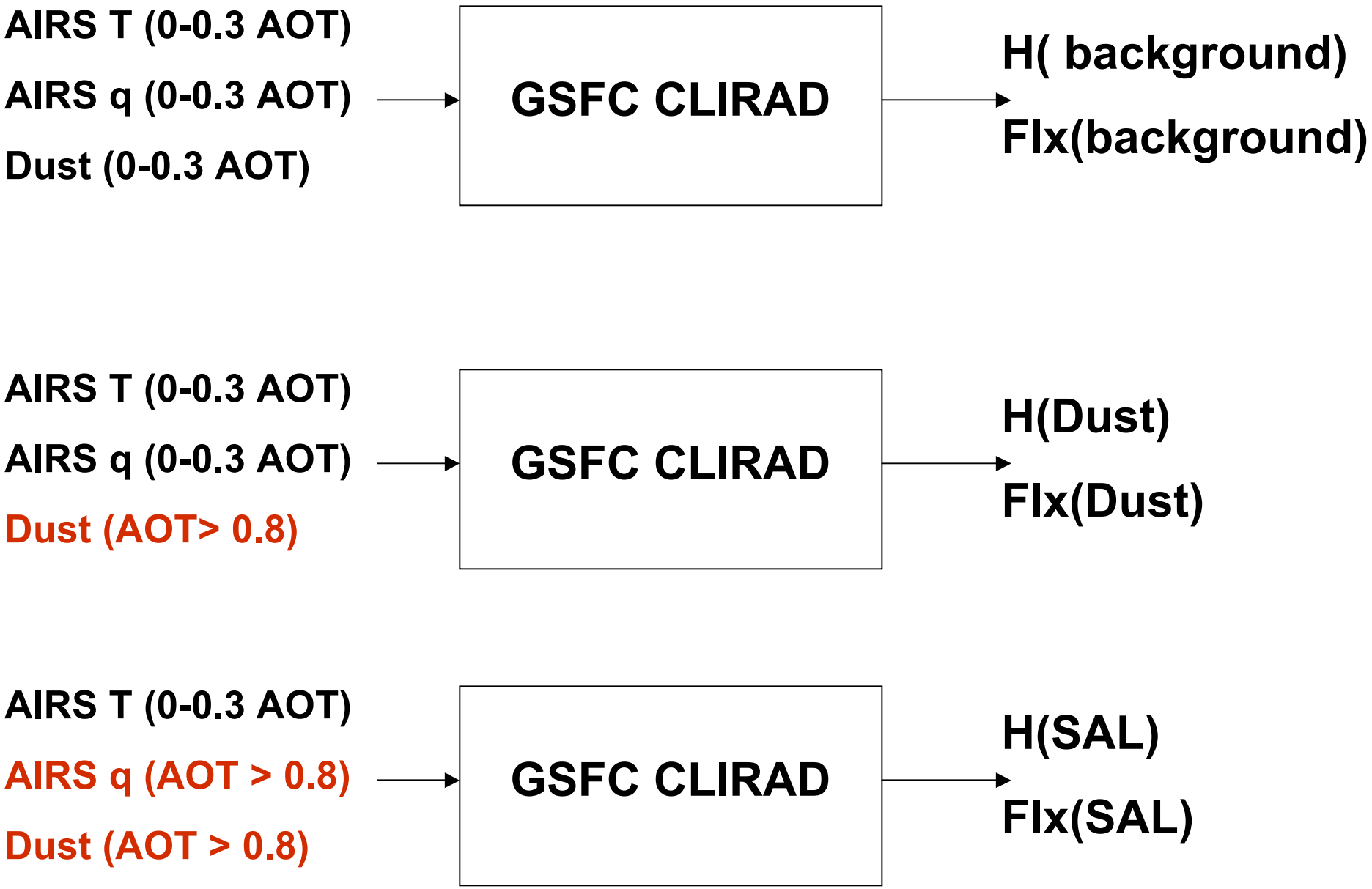
Dunion and Velden, BAMS 2004; Wong and Dessler, GRL, 2005

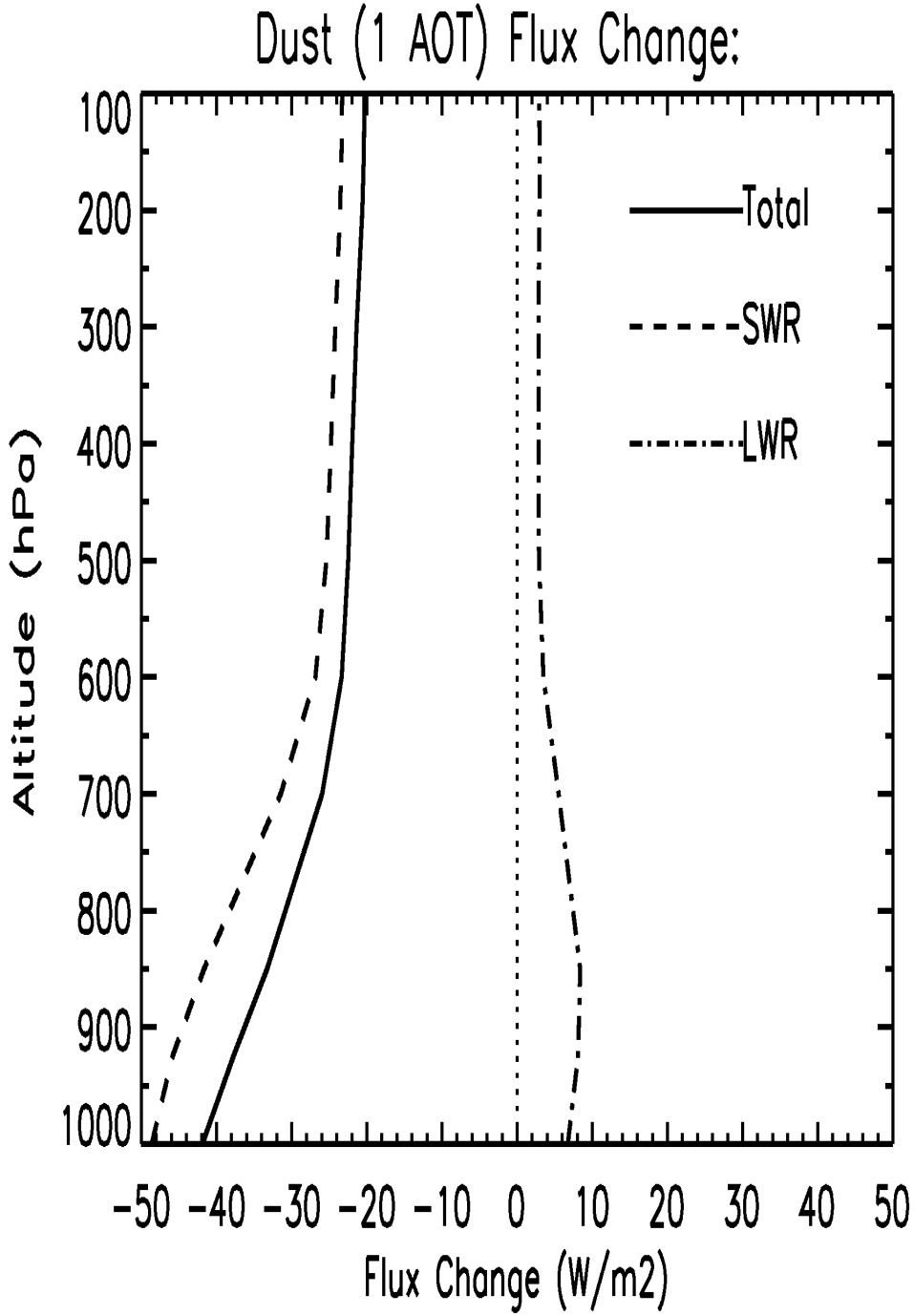


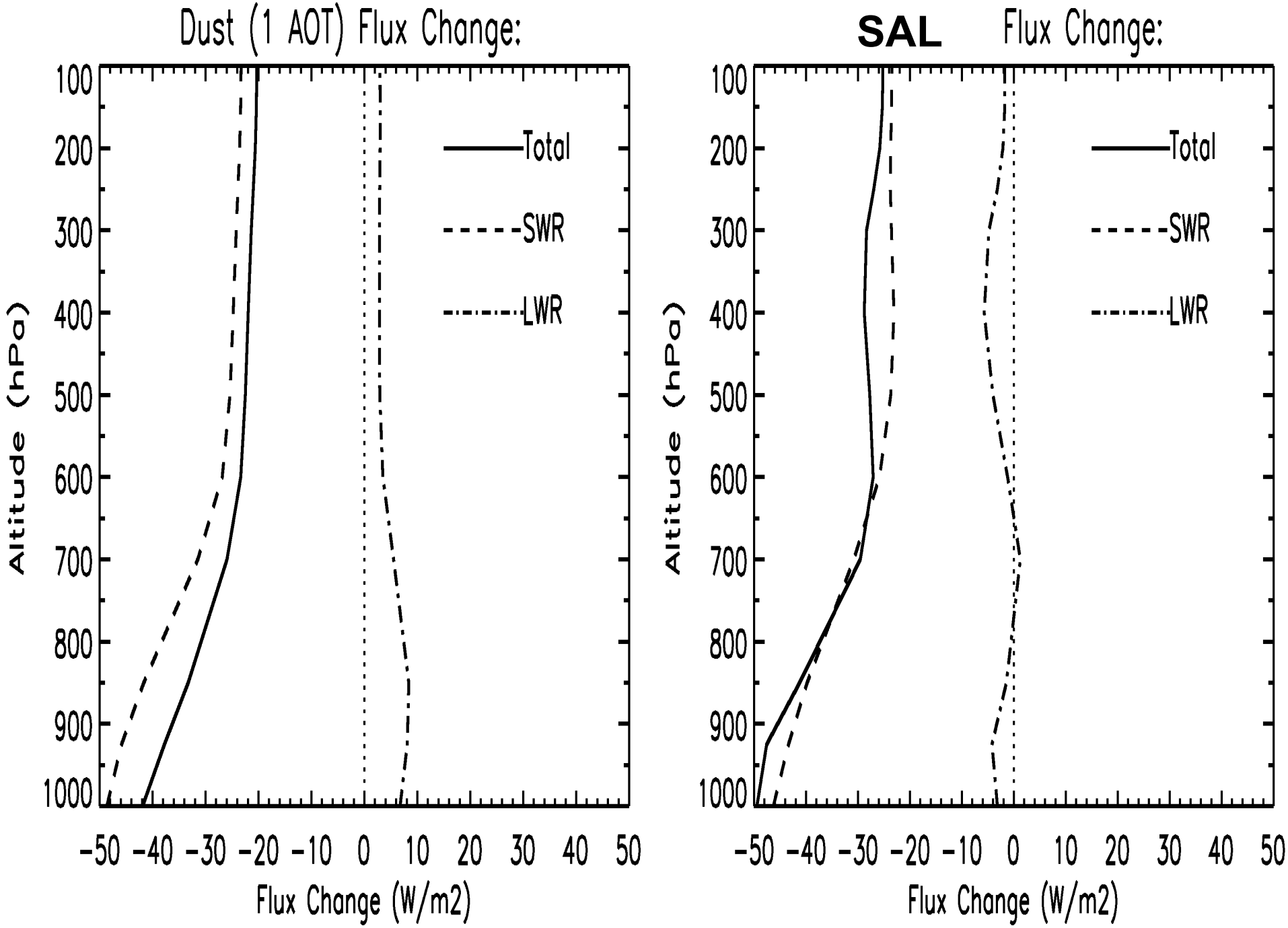
Mahowald et al., JGR 2003

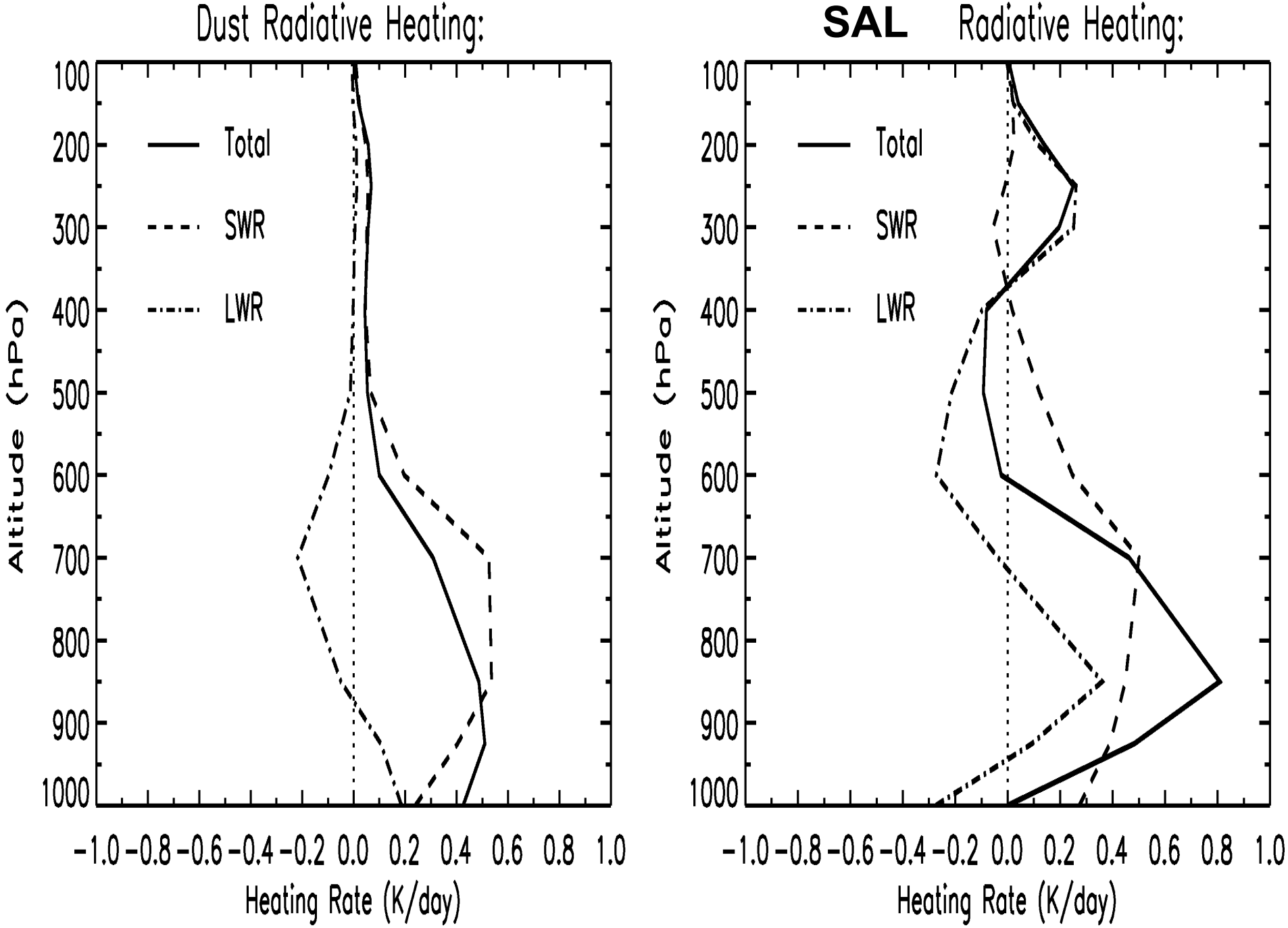

AIRS T (0-0.3 AOT)
AIRS q (0-0.3 AOT)
Dust (0-0.3 AOT)
GSFC CLIRAD
(chou et al., 2003)
H(background)
Flx(background)

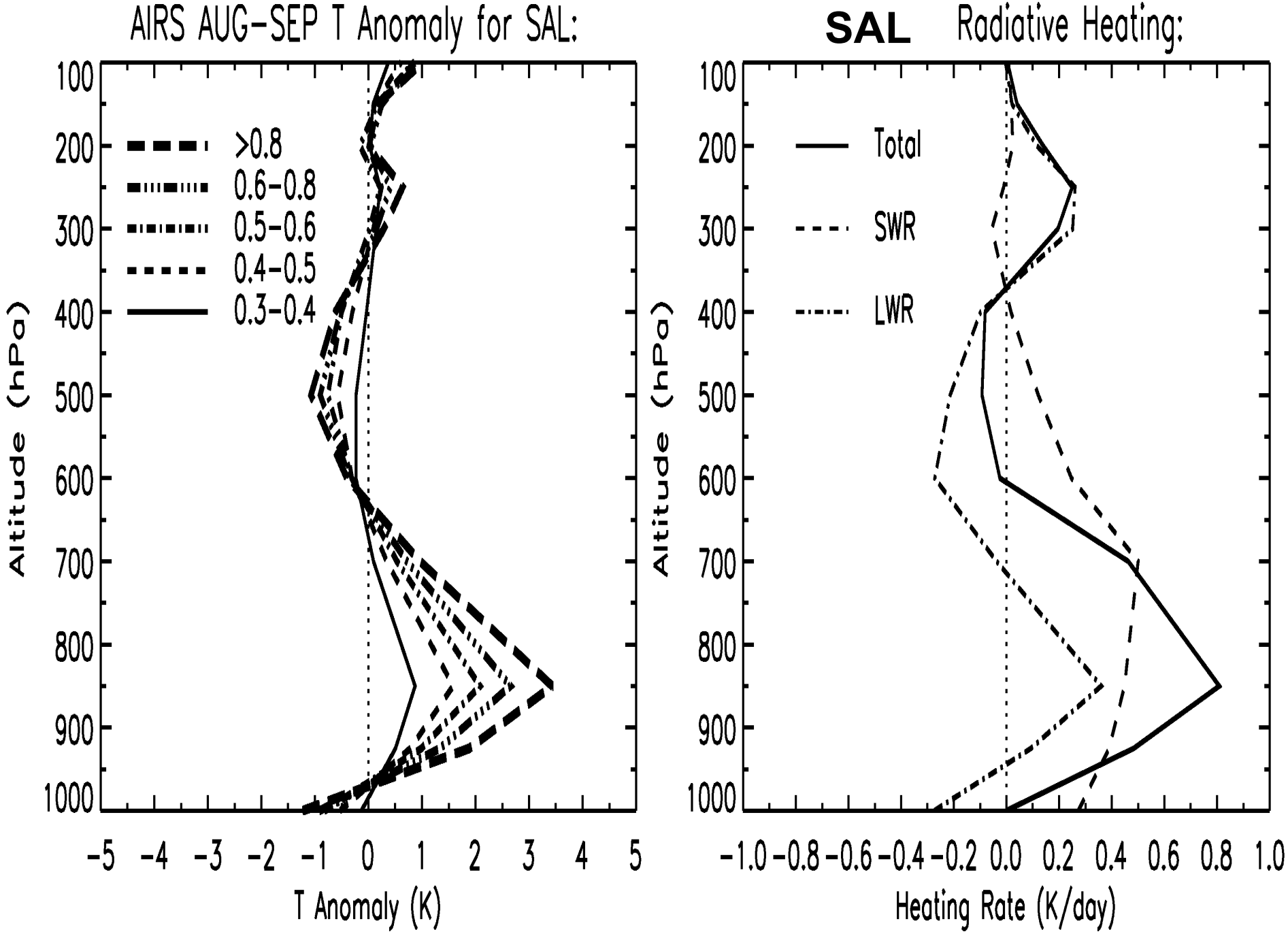

AIRS T (0-0.3 AOT)
AIRS q (0-0.3 AOT)
Dust (0-0.3 AOT)
GSFC CLIRAD
H(background)
Flx(background)
AIRS T (0-0.3 AOT)
AIRS q (0-0.3 AOT)
Dust (AOT > 0.8)
GSFC CLIRAD
H(Dust)
Flx(Dust)

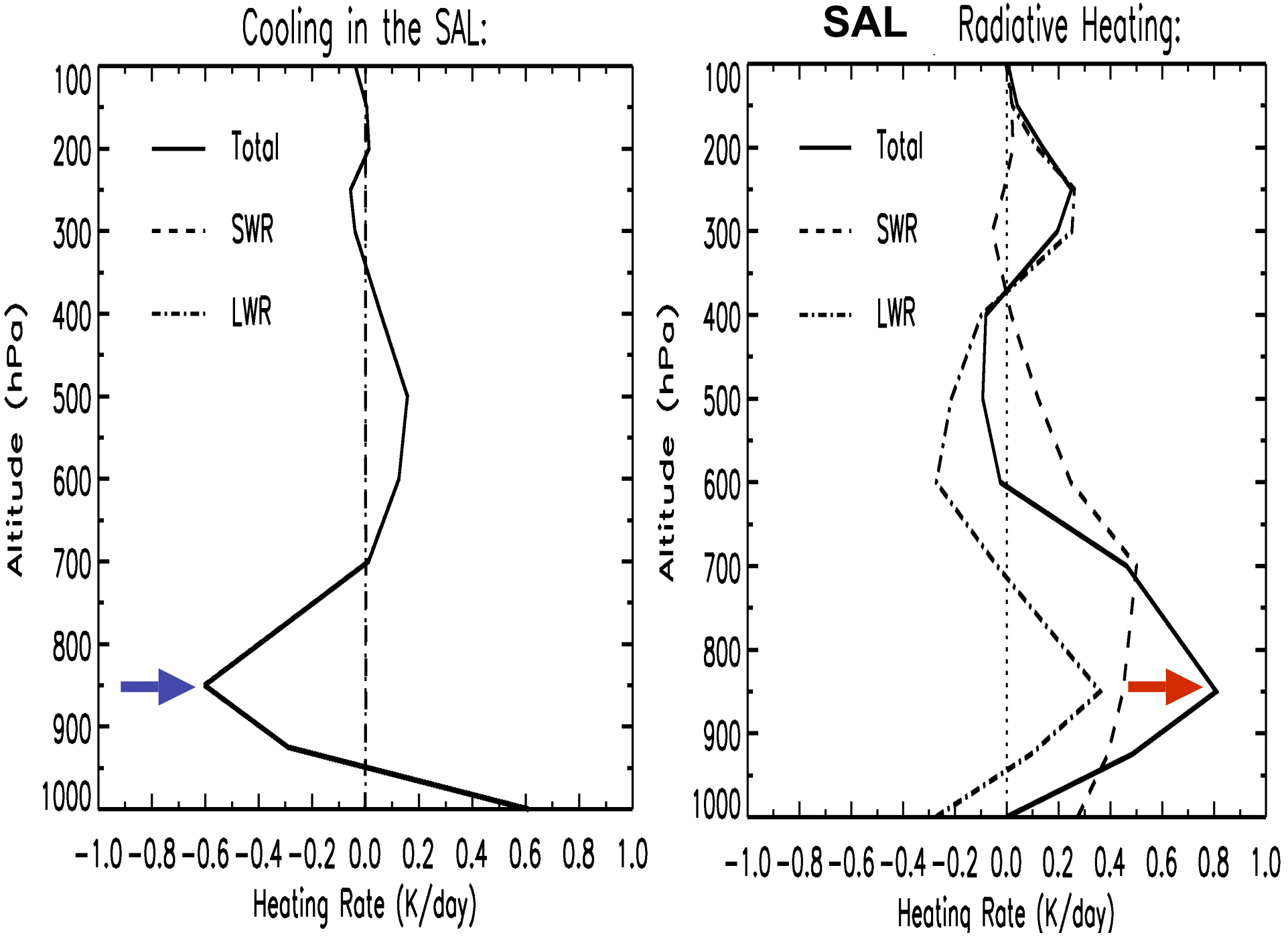

AIRS T (0-0.3 AOT)
AIRS q (0-0.3 AOT)
Dust (0-0.3 AOT)
GSFC CLIRAD
H(background)
Flx(background)
AIRS T (0-0.3 AOT)
AIRS q (0-0.3 AOT)
Dust (AOT> 0.8)
GSFC CLIRAD
H(Dust)
Flx(Dust)
AIRS T (0-0.3 AOT)
AIRS q (AOT > 0.8)
Dust (AOT > 0.8)
GSFC CLIRAD
H(SAL)
Flx(SAL)


Dust (1 AOT) Flux Change:
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
Total
SWR
LWR
-50 -40 -30 -20 -10 0 10 20 30 40 50
Flux Change (W/m2)

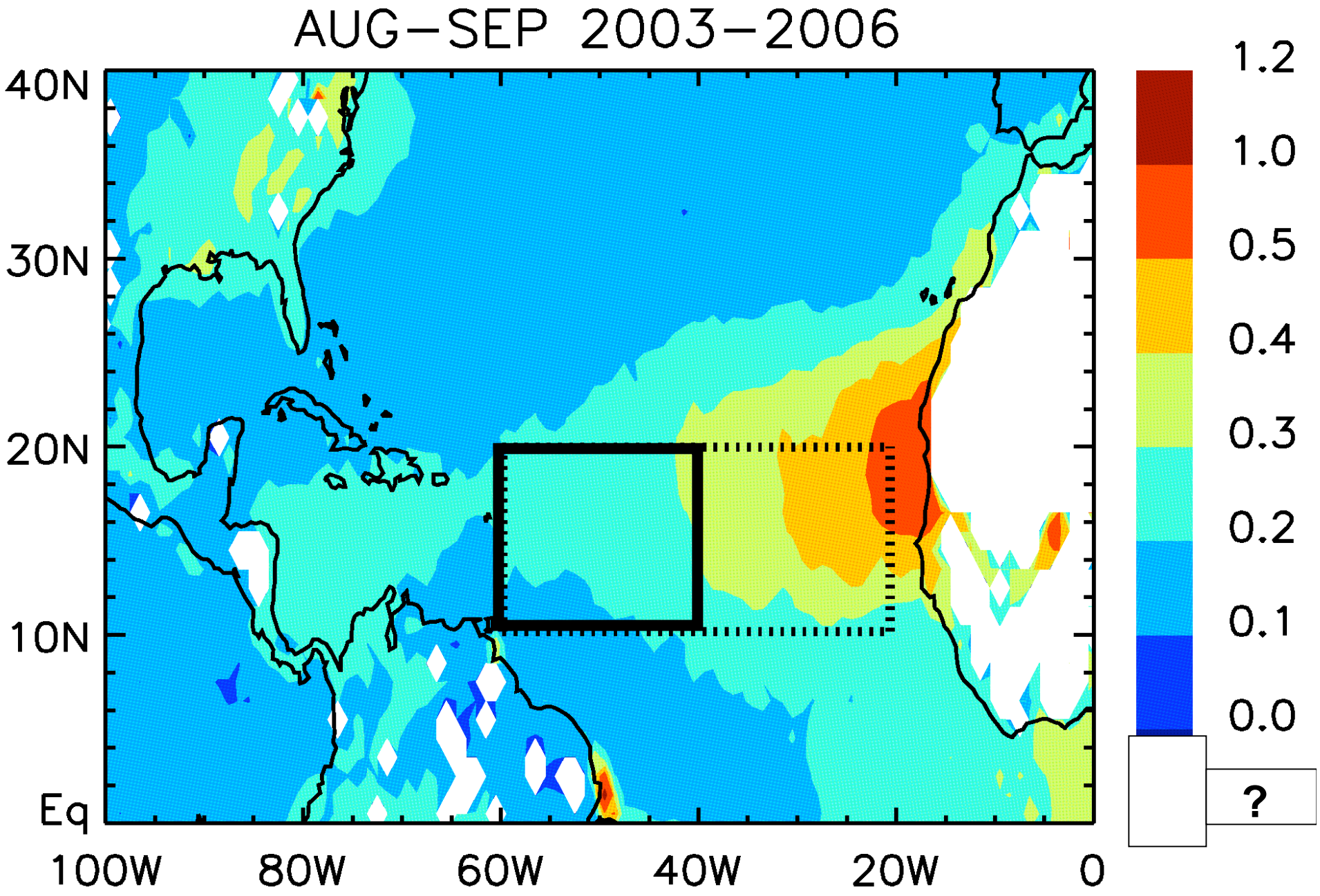

Dust (1 AOT) Flux Change:
SAL Flux Change:
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
Total
SWR
LWR
-50 -40 -30 -20 -10 0 10 20 30 40 50
Flux Change (W/m2)


Dust Radiative Heating:
SAL Radiative Heating:
Total
SWR
LWR
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
Heating Rate (K/day)


AIRS AUG-SEP T Anomaly for SAL:
>0.8
0.6-0.8
0.5-0.6
0.4-0.5
0.3-0.4
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
-5 -4 -3 -2 -1 0 1 2 3 4 5
T Anomaly (K)
SAL Radiative Heating:
Total
SWR
LWR
Altitude (hPa)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
Heating Rate (K/day)


Cooling in the SAL:
SAL Radiative Heating:
Total
SWR
LWR
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
Heating Rate (K/day)

Aqua MODIS Aerosol Optical Thickness (AOT)

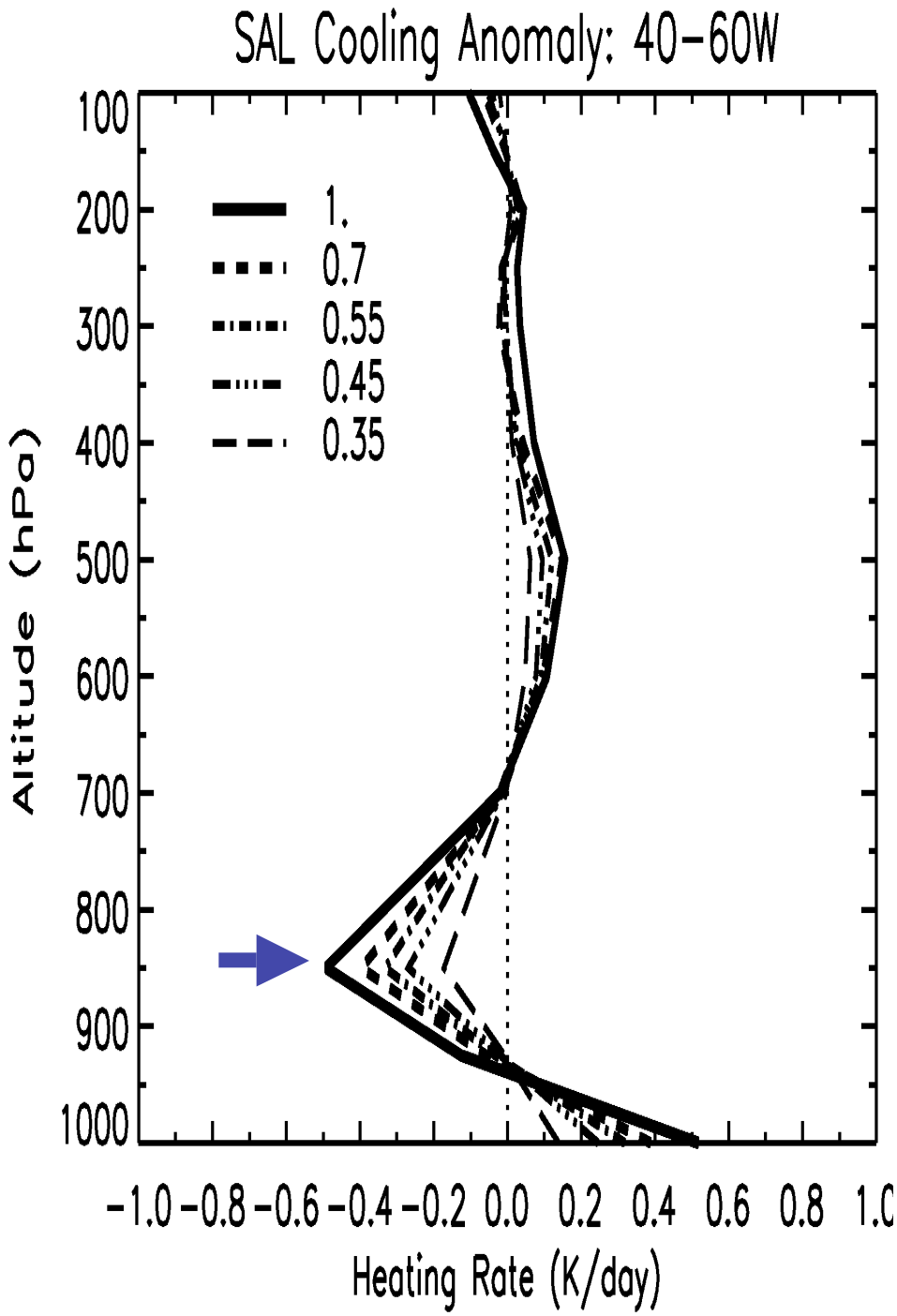


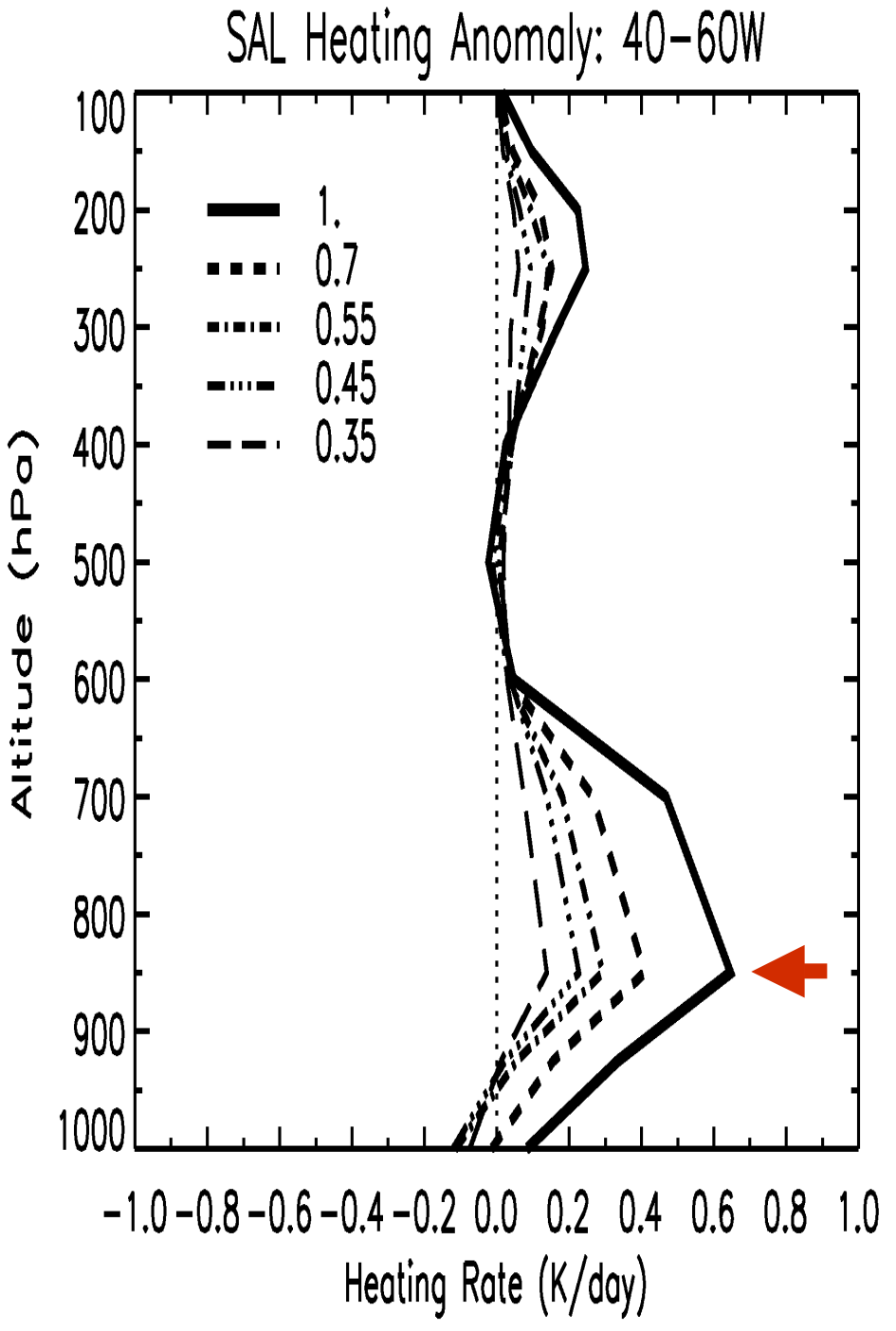
Heating Against Thermal Cooling at 850 hPa

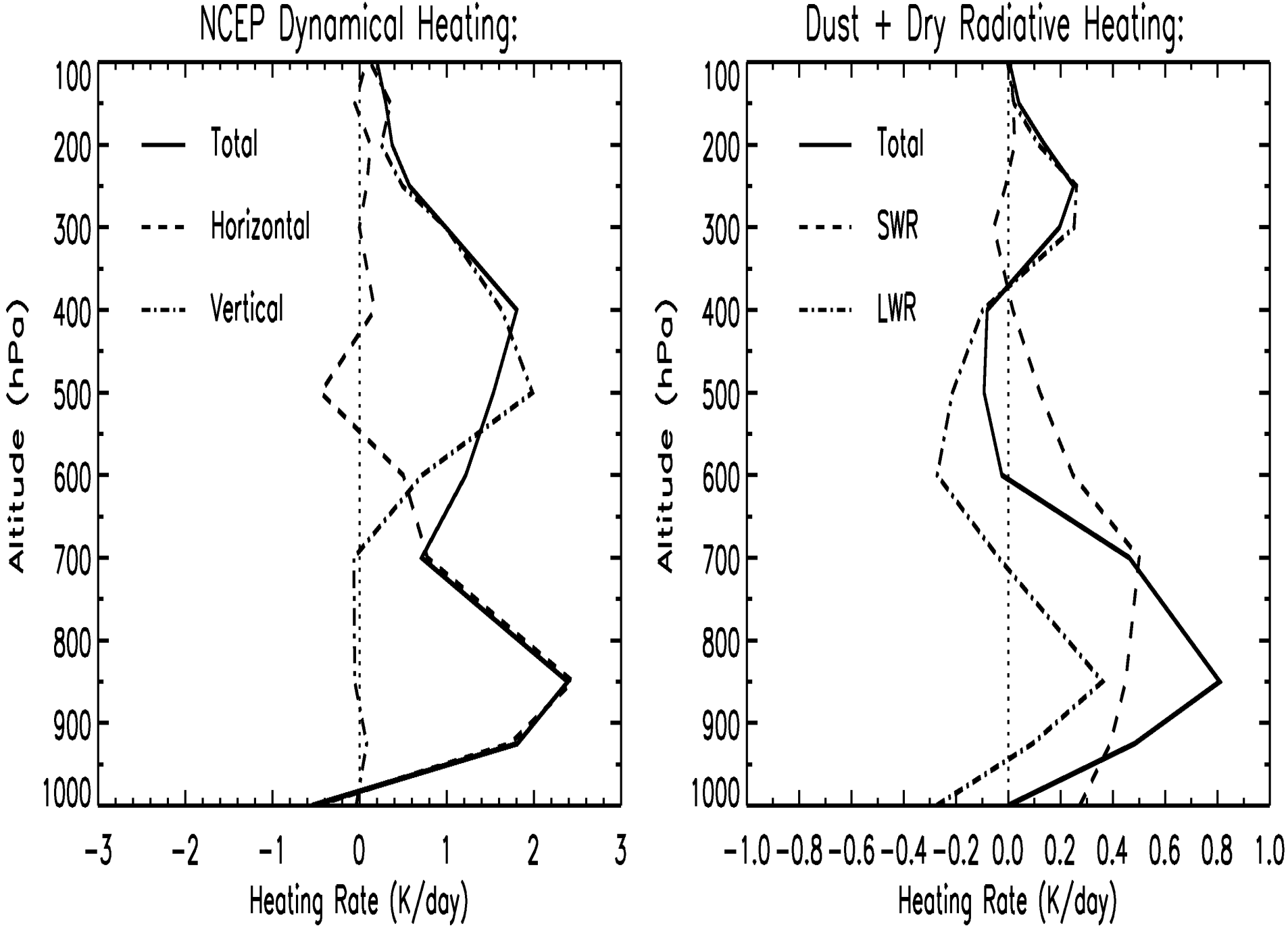
AOT	>0.8	0.6-0.8	0.5-0.6	0.4-0.5	0.3-0.4
20-30W	0.21	0.06	0.04	0.06	0.06
30-40W	0.30	0.11	0.08	0.03	0.04
40-60W	0.15	0.01	–0.04	–0.04	–0.03

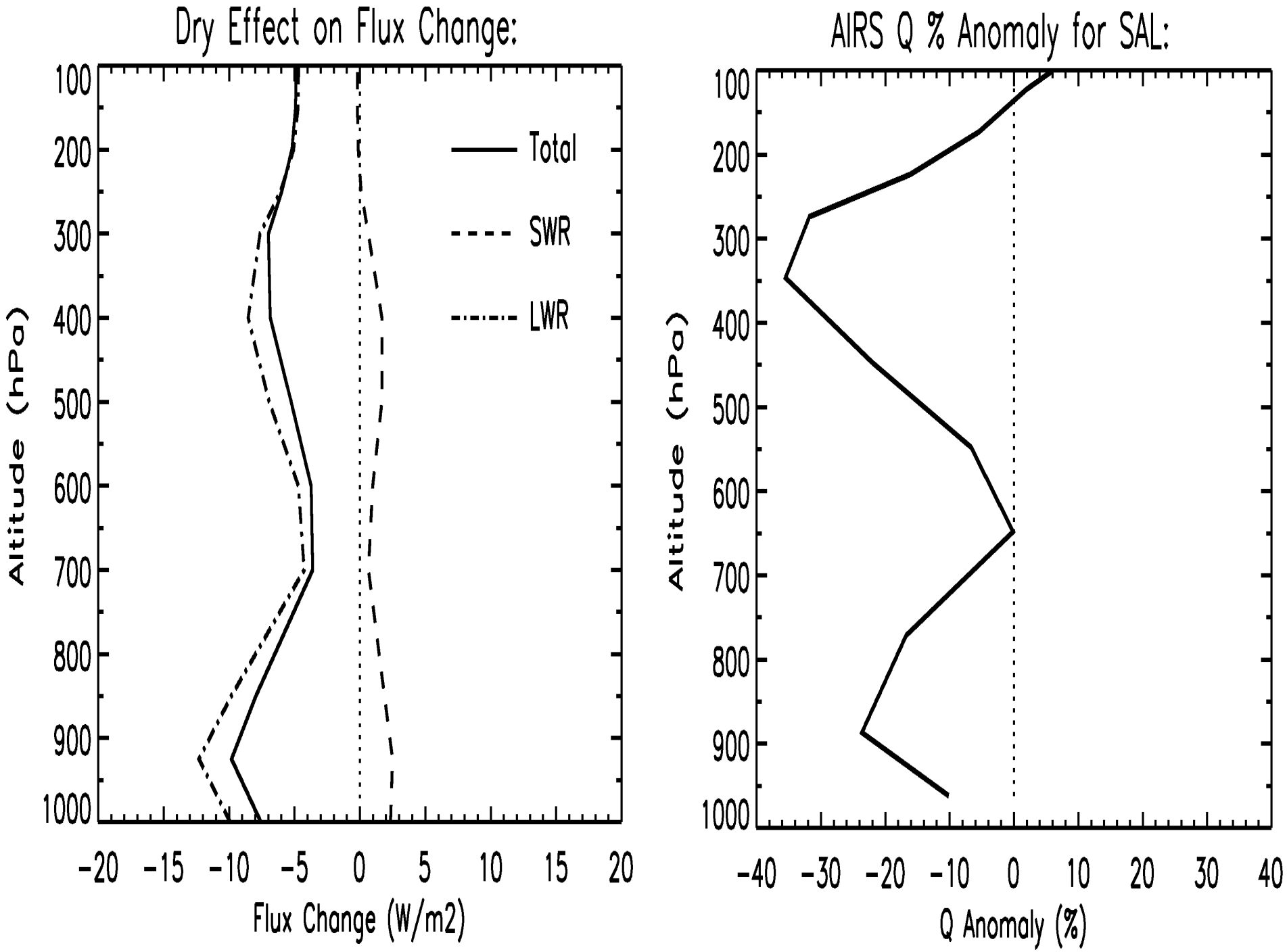
Conclusions:

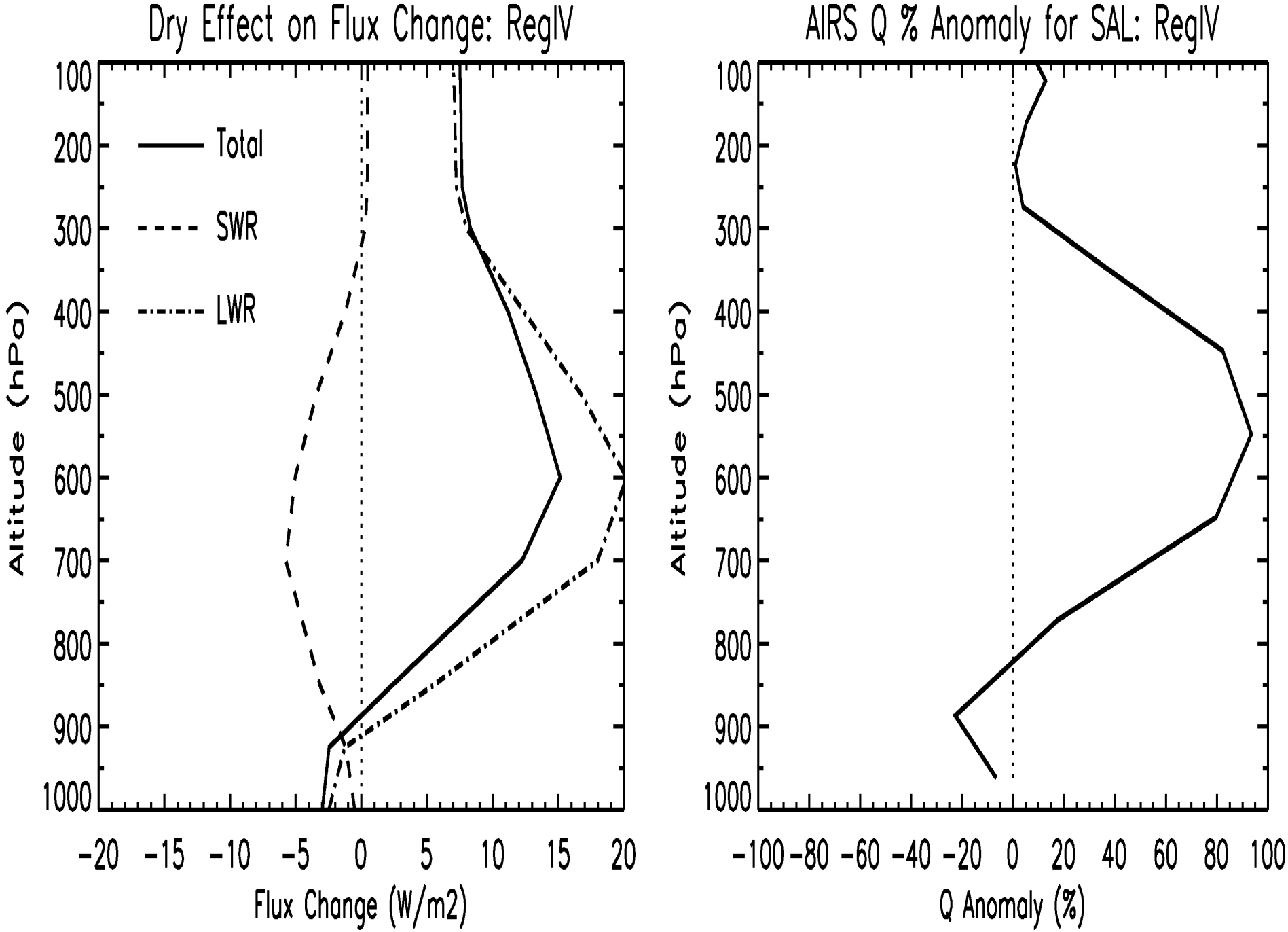
- Dust radiative heating ~ 50% of the SAL Heating
- SAL (dust + low H_2O) heating ~ T anomaly profiles
- (dust + low H_2O) maintains the T anomaly in the SAL. West of 50°W, SAL of AOT < 0.5 may lose the ability to maintain the T anomaly against thermal relaxation


SAL Cooling Anomaly: 40–60W
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
1.
0.7
0.55
0.45
0.35
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
Heating Rate (K/day)

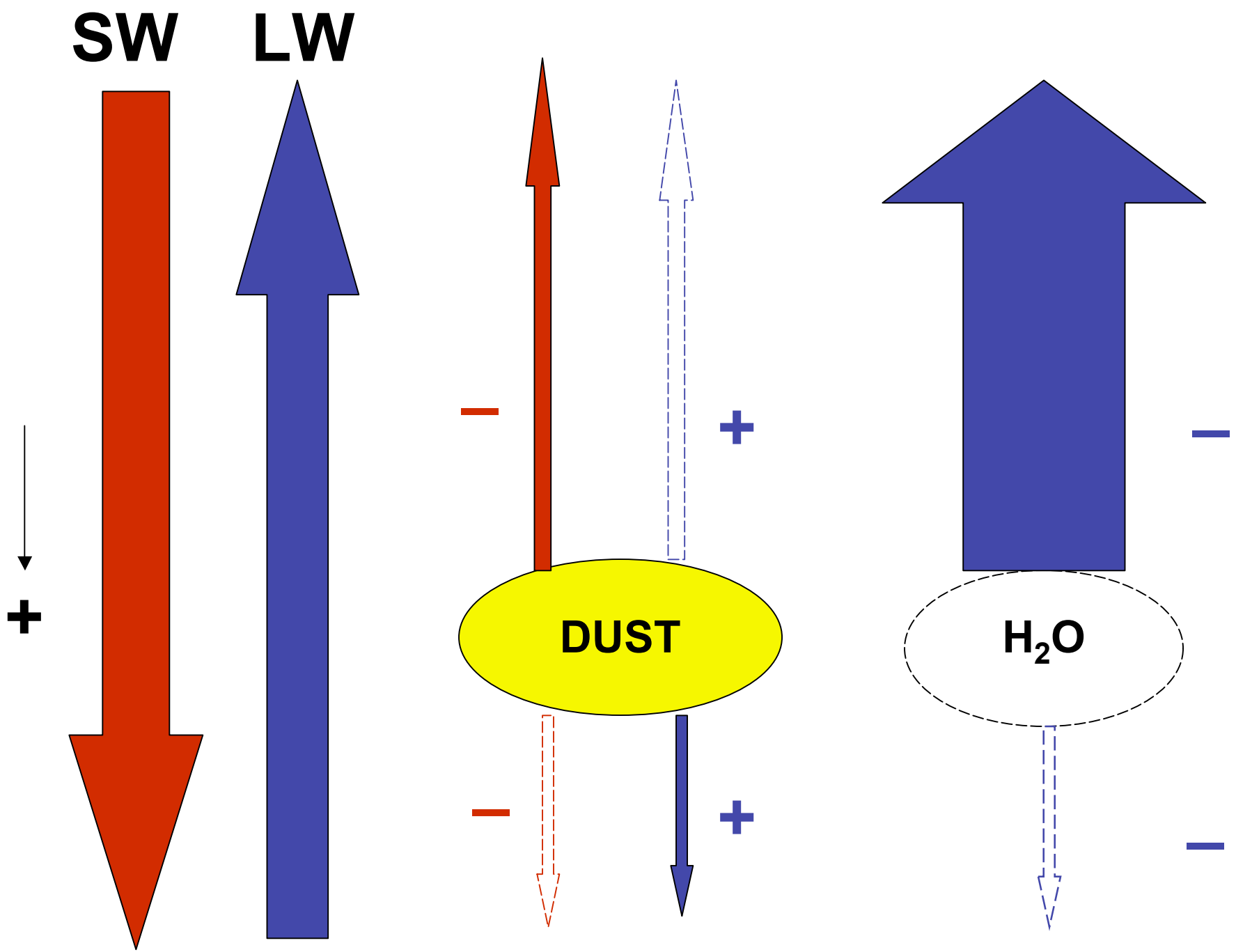

SAL Heating Anomaly: 40–60W
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
1.
0.7
0.55
0.45
0.35
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
Heating Rate (K/day)


NCEP Dynamical Heating:
Total
Horizontal
Vertical
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
-3
-2
-1
0
1
2
3
Heating Rate (K/day)
Dust + Dry Radiative Heating:
Total
SWR
LWR
Altitude (hPa)
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Heating Rate (K/day)


Dry Effect on Flux Change:
Total
SWR
LWR
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
-20
-15
-10
-5
0
5
10
15
20
Flux Change (W/m2)
AIRS Q % Anomaly for SAL:
Altitude (hPa)
-40
-30
-20
-10
0
10
20
30
40
Q Anomaly (%)


Dry Effect on Flux Change: RegIV
Total
SWR
LWR
Altitude (hPa)
100
200
300
400
500
600
700
800
900
1000
-20 -15 -10 -5 0 5 10 15 20
Flux Change (W/m2)
AIRS Q % Anomaly for SAL: RegIV
Altitude (hPa)
-100 -80 -60 -40 -20 0 20 40 60 80 100
Q Anomaly (%)

- Radiative (dust + dryness): GSFC CLIRAD (Chou et al., 2003)
- Dynamical: NCEP
  - Horizontal advection: $-v \cdot \nabla T$
  - Vertical advection + adiabatic: $-\omega \frac{\partial T}{\partial p} + \frac{\kappa \omega T}{p}$
- Latent Heat ???


SW
LW
+
−
+
DUST
−
+
−
H2O
−