Upper-Atmosphere Signature of Midlatitude Ocean Fronts

1. Satellite Revelation and Controversy
2. Latest GCM Results
3. ECMWF analysis

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Permenant Meanders of Ocean Fronts

Kuroshio and Agulhas Extensions

- Ocean has slow and small-scale processes.

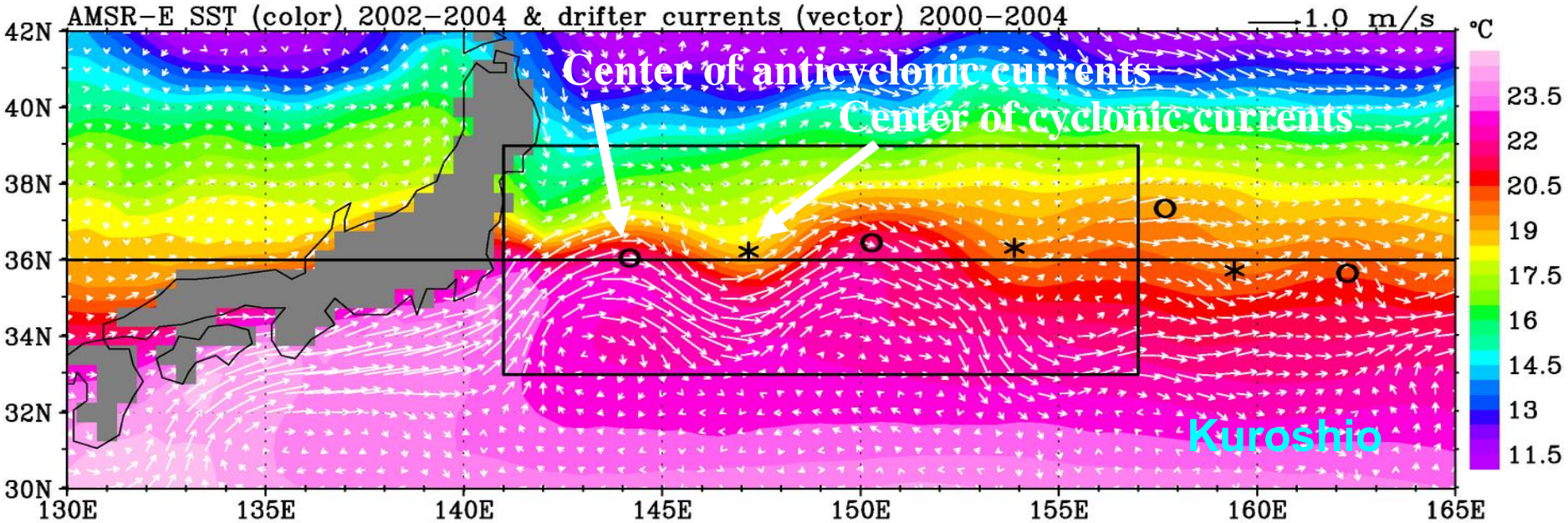
  Atmosphere has fast and large-scale processes.

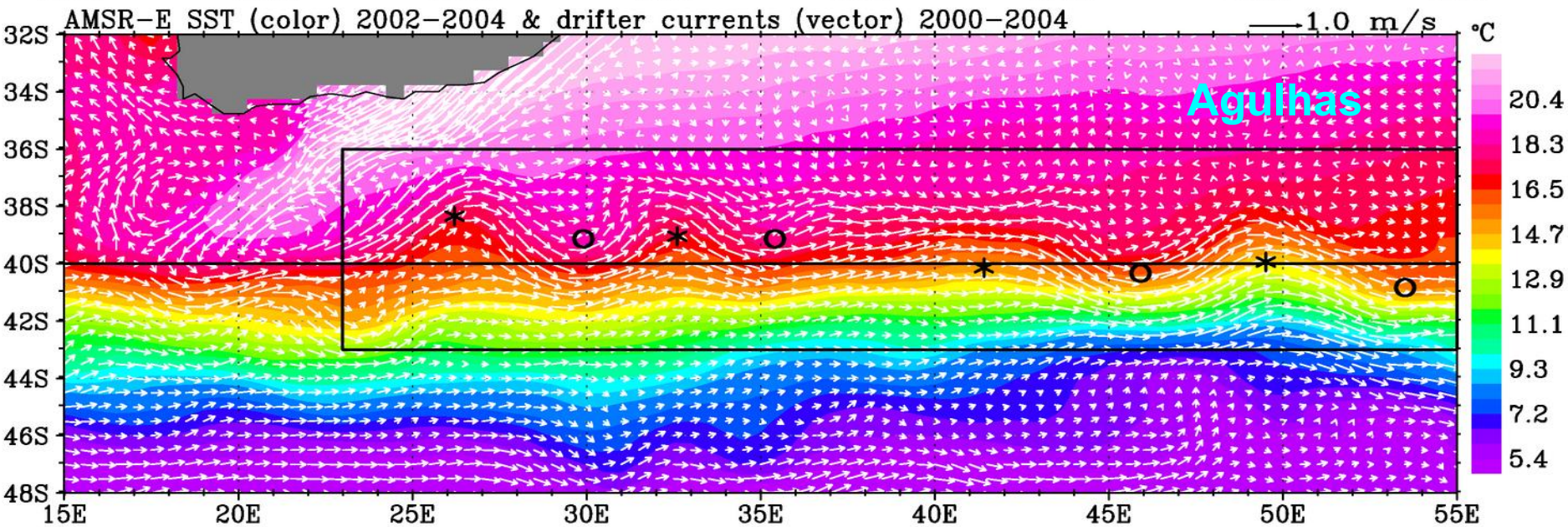
  Coupling in mid-latitudes at long time period is controversial.

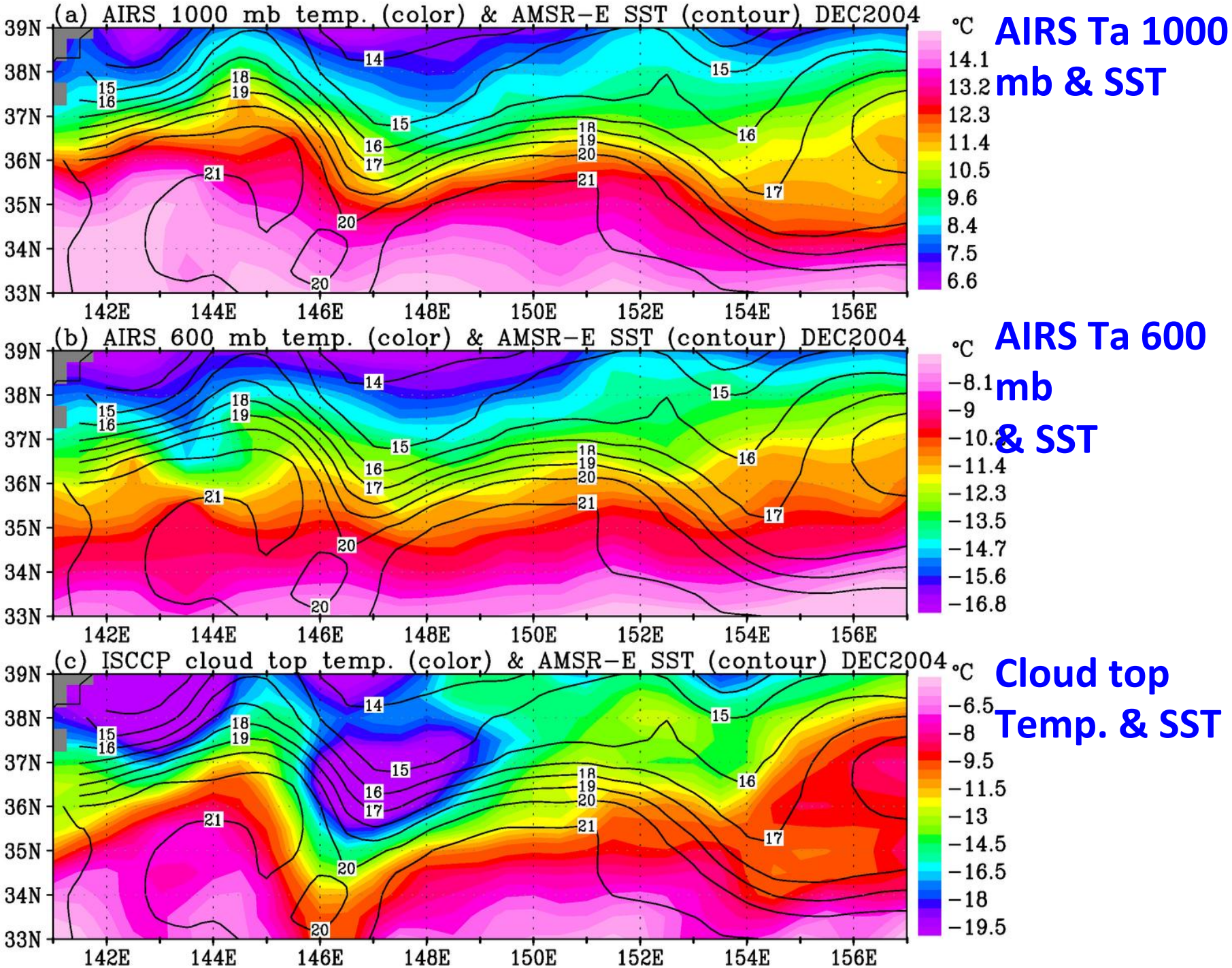
- GCM fails to generate systematic response to prescribed midlatitude SST anomalies.

  Lapse rate is believe to be too weak to generate deep convection.

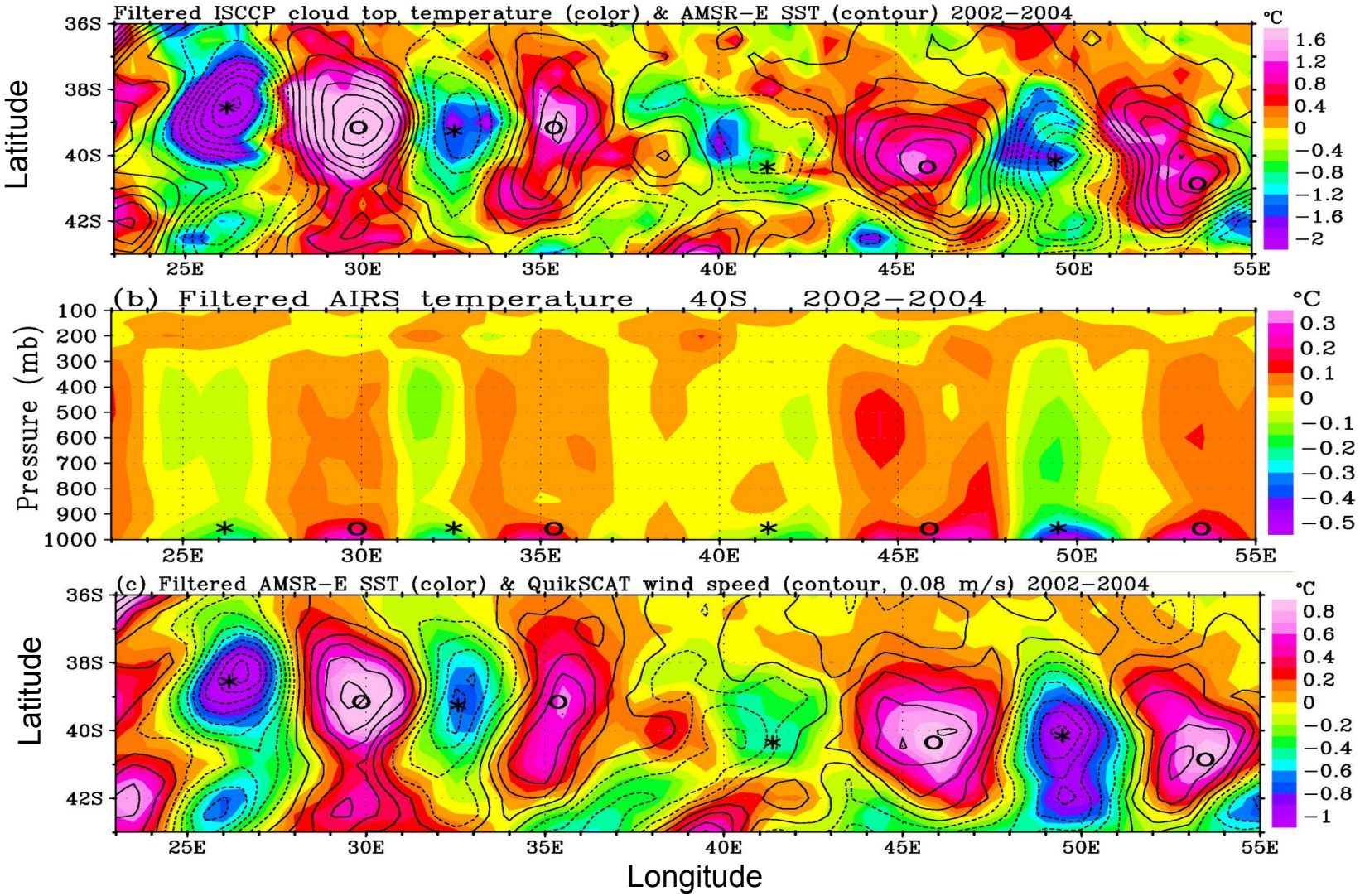
Strong Temperature Gradient & Current Shear at Ocean Front





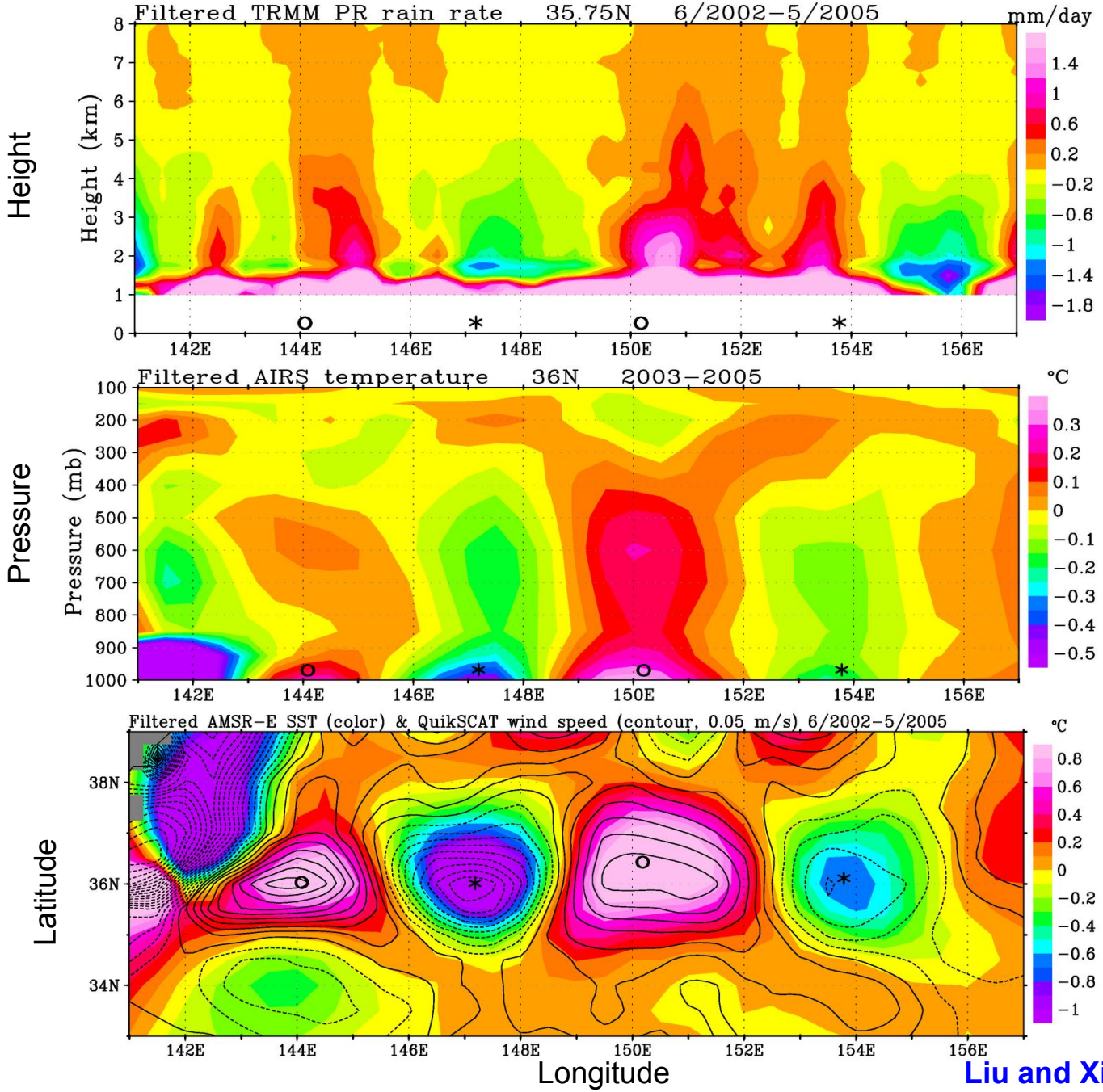

(a) AIRS 1000 mb temp. (color) & AMSR-E SST (contour) DEC2004
°C
14.1
13.2
12.3
11.4
10.5
9.6
8.4
7.5
6.6
AIRS Ta 1000 mb & SST
(b) AIRS 600 mb temp. (color) & AMSR-E SST (contour) DEC2004
°C
−8.1
−9
−10.8
−11.4
−12.3
−13.5
−14.7
−15.6
−16.8
AIRS Ta 600 mb & SST
(c) ISCCP cloud top temp. (color) & AMSR-E SST (contour) DEC2004
°C
−6.5
−8
−9.5
−11.5
−13
−14.5
−16.5
−18
−19.5
Cloud top Temp. & SST
39N
38N
37N
36N
35N
34N
33N
142E
144E
146E
148E
150E
152E
154E
156E

Cloud Radiative Feedback on Ocean Fronts - Agulhas



Coincident long-term mean ocean surface temperature (AMSR-E) and wind stress (QuikSCAT) anomalies over the Agulhas Current Extension (lower panel) have effects that penetrate high above the atmospheric boundary layer, as shown in the temperature profile by AIRS (middle panel). The effects are also evident in the cloud top temperature (upper panel) and cloud optical thickness (not shown) provided by ISCCP. (Liu, Xie, and Niiler, 2007: J. Clim.)

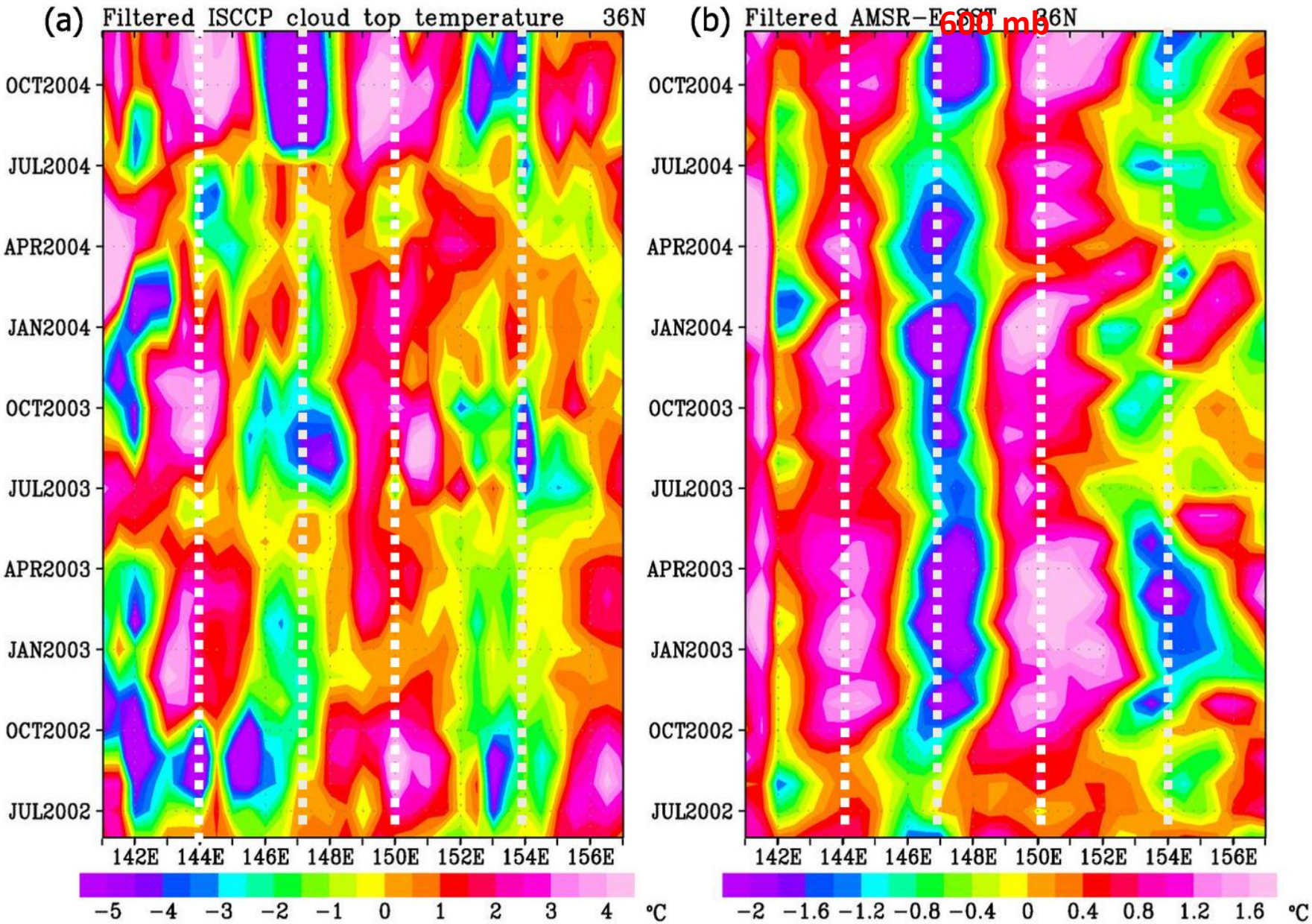
Long-term Penetrating Effect at Ocean Fronts – Kuroshio



Liu and Xie (2008, JO)

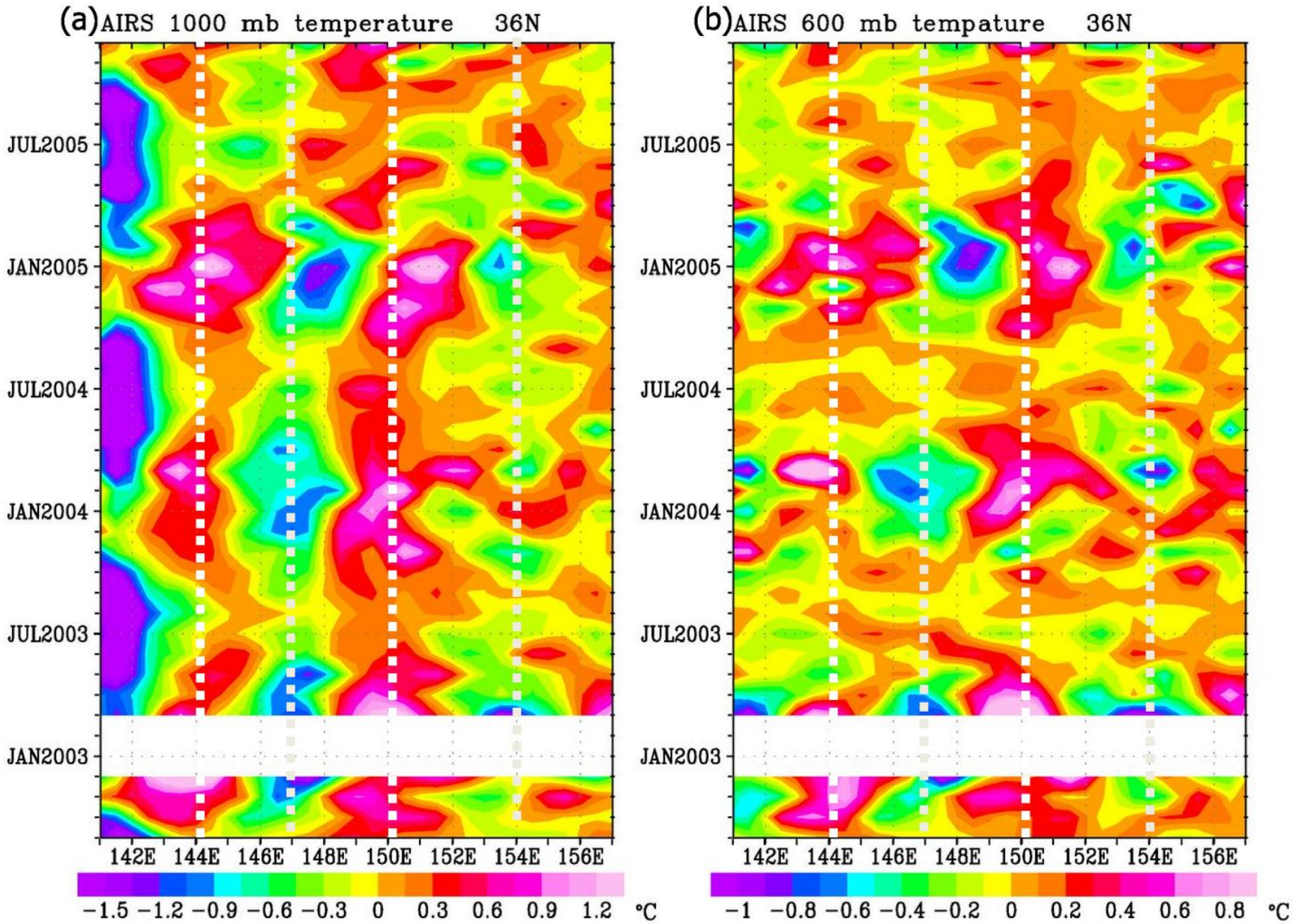
ISCCP cloud top temperature AMSR sea surface temperature

Kuroshio Extension, 36N,



AIRS temperature, Kuroshio Extension, 36N,

1000 mb 600 mb



- AIRS, TRMM, and ISCCP reveal signature of SST way above the atmospheric boundary layer at low frequencies.
- Present GCM or operational NWP data, do not show vertical propagation of ocean SST effect beyond atmospheric boundary layer.
- The observations present a challenge to modeling community in improving model dynamics and spatial versus temporal scales parameterization.
- Skeptics of the coupling could not simulated results through mesoscale models and blamed AIR data retrieval dependence on SST

Alexander et al. 2004

NCAR Community Atmosphere Model CAM5

Six month simulation 1 Nov-31 Mar

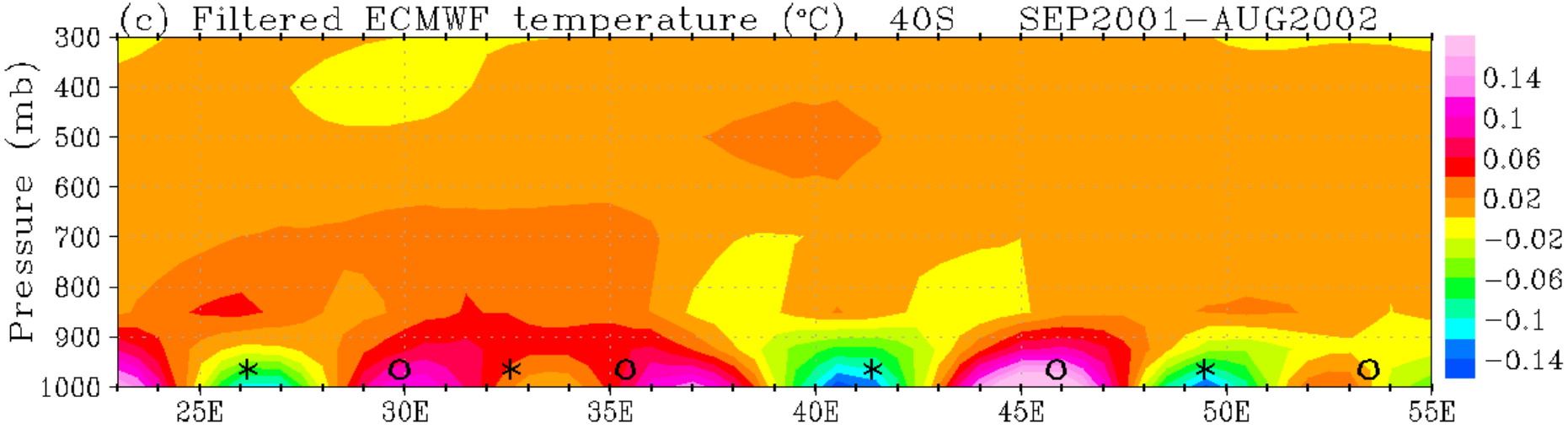
High Resolution HR -0.25 °

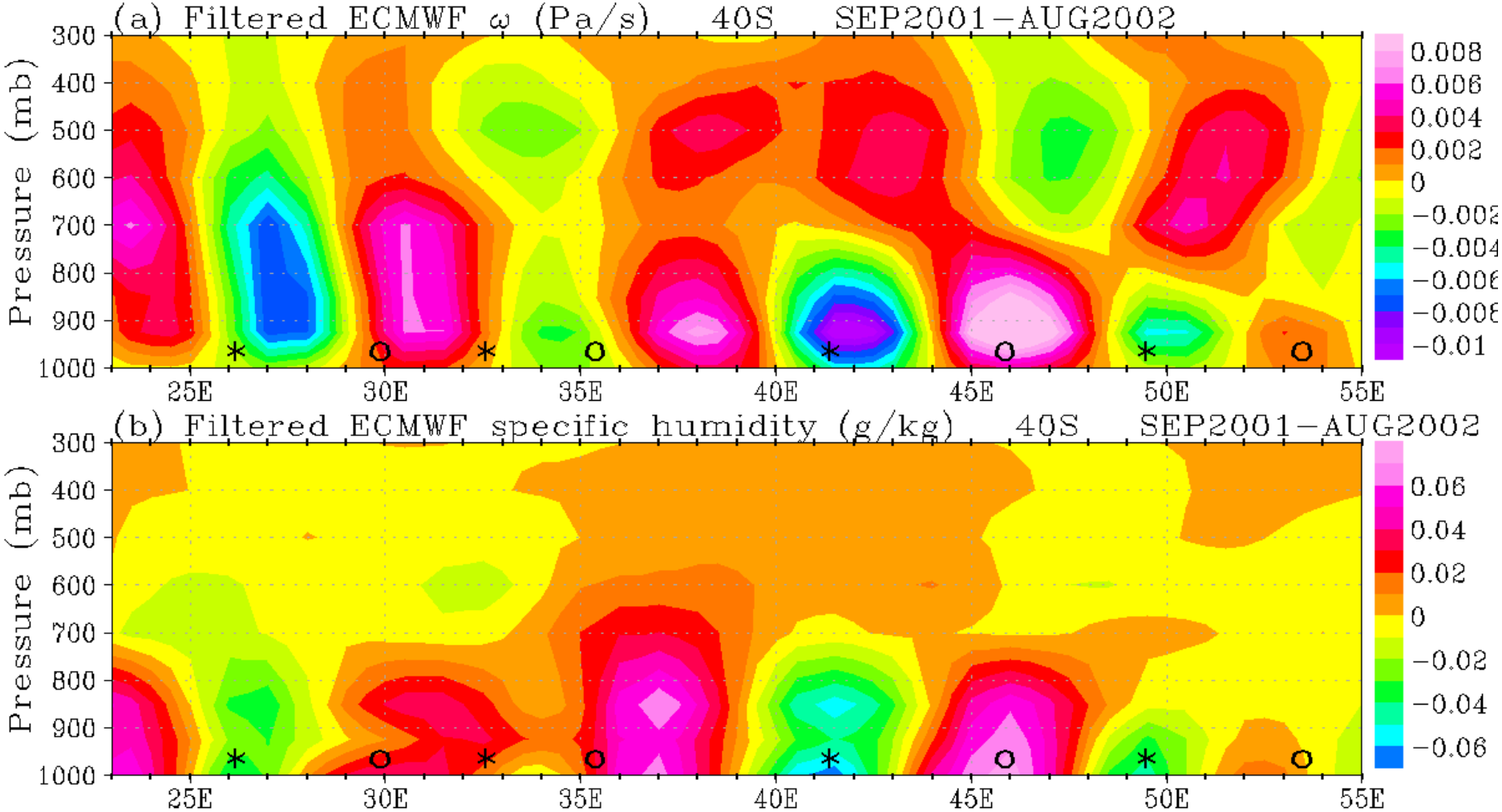
Low Resolution LR – 1.0°

For low resolution, surface heating causes horizontal advection near surface

For high resolution, it causes vertical advection up in the atmosphere

- ERA-Interim reanalysis data
- 1.125 degrees, 6 hourly, 60 vertical pressure levels, created at NCAR


(c) Filtered ECMWF temperature (°C) 40S SEP2001–AUG2002
Pressure (mb)
300
400
500
600
700
800
900
1000
25E
30E
35E
40E
45E
50E
55E
0.14
0.1
0.06
0.02
−0.02
−0.06
−0.1
−0.14


(a) Filtered ECMWF ω (Pa/s) 40S SEP2001–AUG2002
Pressure (mb)
300
400
500
600
700
800
900
1000
25E
30E
35E
40E
45E
50E
55E
0.008
0.006
0.004
0.002
0
−0.002
−0.004
−0.006
−0.008
−0.01
(b) Filtered ECMWF specific humidity (g/kg) 40S SEP2001–AUG2002
Pressure (mb)
300
400
500
600
700
800
900
1000
25E
30E
35E
40E
45E
50E
55E
0.06
0.04
0.02
0
−0.02
−0.04
−0.06

Backup