Upper ocean heat budget in the southeast Pacific stratus cloud region using eddy-resolving HYCOM

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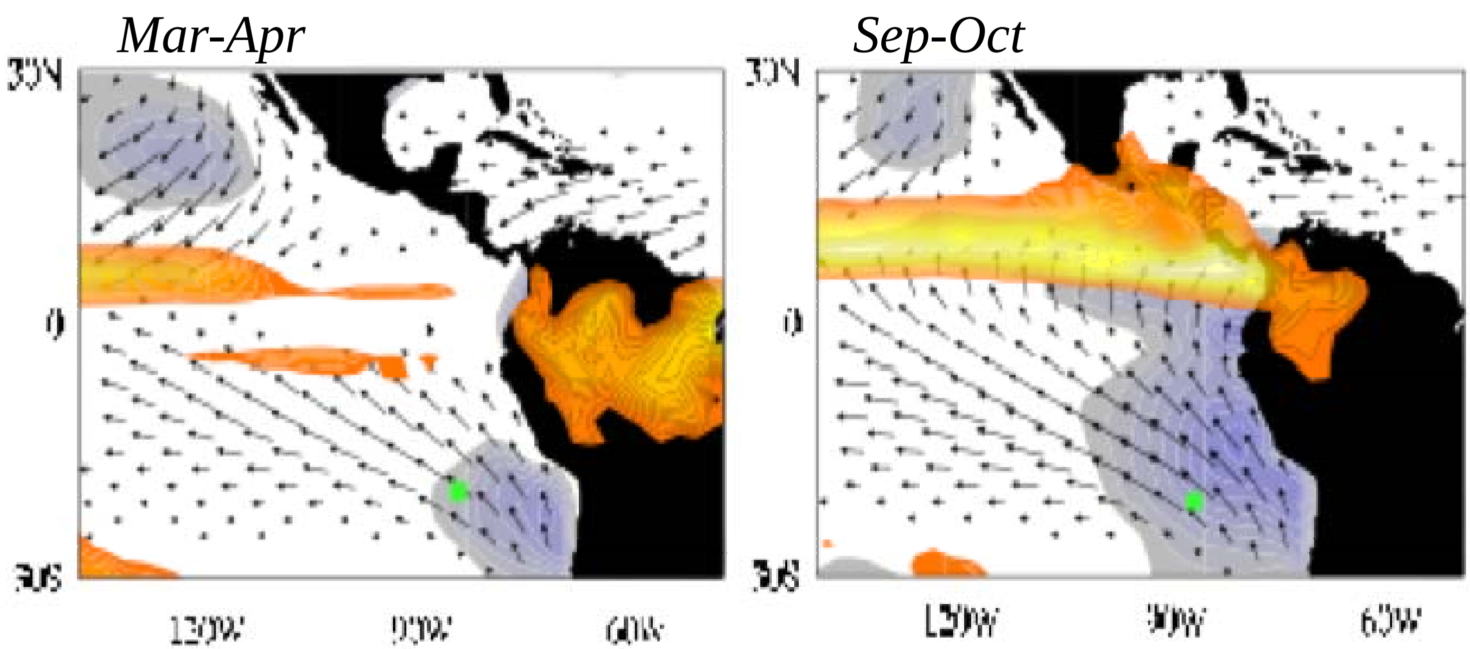


Stratus cloud decks ===> important role in regional and global climate

Most coupled GCMs have problems in producing realistic stratus clouds.

Upper ocean processes that control SST is crucial for simulating stratus clouds

Surface mooring measurements by WHOI since October 2000 (Colbo and Weller 2007)

New campaign: VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS)
Intensive Observations: VOCALS Regional Experiment (Oct. 2008)

Upper ocean heat balance (upper 250m) at the buoy site (Colbo and Weller, 2007)

Term	*Estimate (W/m2)*	*Data*
Surface heat flux	*44 (±5)*	*IMET buoy*
Horizontal heat advection by Ekman transport	*6 (± 4)*	*QuikSCAT winds* *Satellite SST*
Horizontal heat advection by geostrophic transport	*-20(± 5)*	*IMET velocity, temperature* *Historical temperature*
Ekman pumping	*2.5(± 5)*	*QuikSCAT winds* *IMET temperature*
Eddy flux divergence	*-30*	*Residual*
Vertical diffusion	*-3(± 2)*	*IMET temperature*

Hypothesis (Colbo and Weller 2007)

*"We postulate that the eddy flux divergence represents the effect of the cold coherent eddies formed near the coast…..
the upwelled water does influence the offshore structure, but through the fluctuating mesoscale flow not the mean transport."*

Issues

Upper ocean processes which balance the positive (warming) surface heat flux

Representativeness of the IMET site for the entire stratus cloud region

Role of eddies

Models

Global HYCOM

Horizontal resolution: 1/12 deg. X 1/12 deg.

Period: Jan. 2003-Apr. 2007

No data assimilation

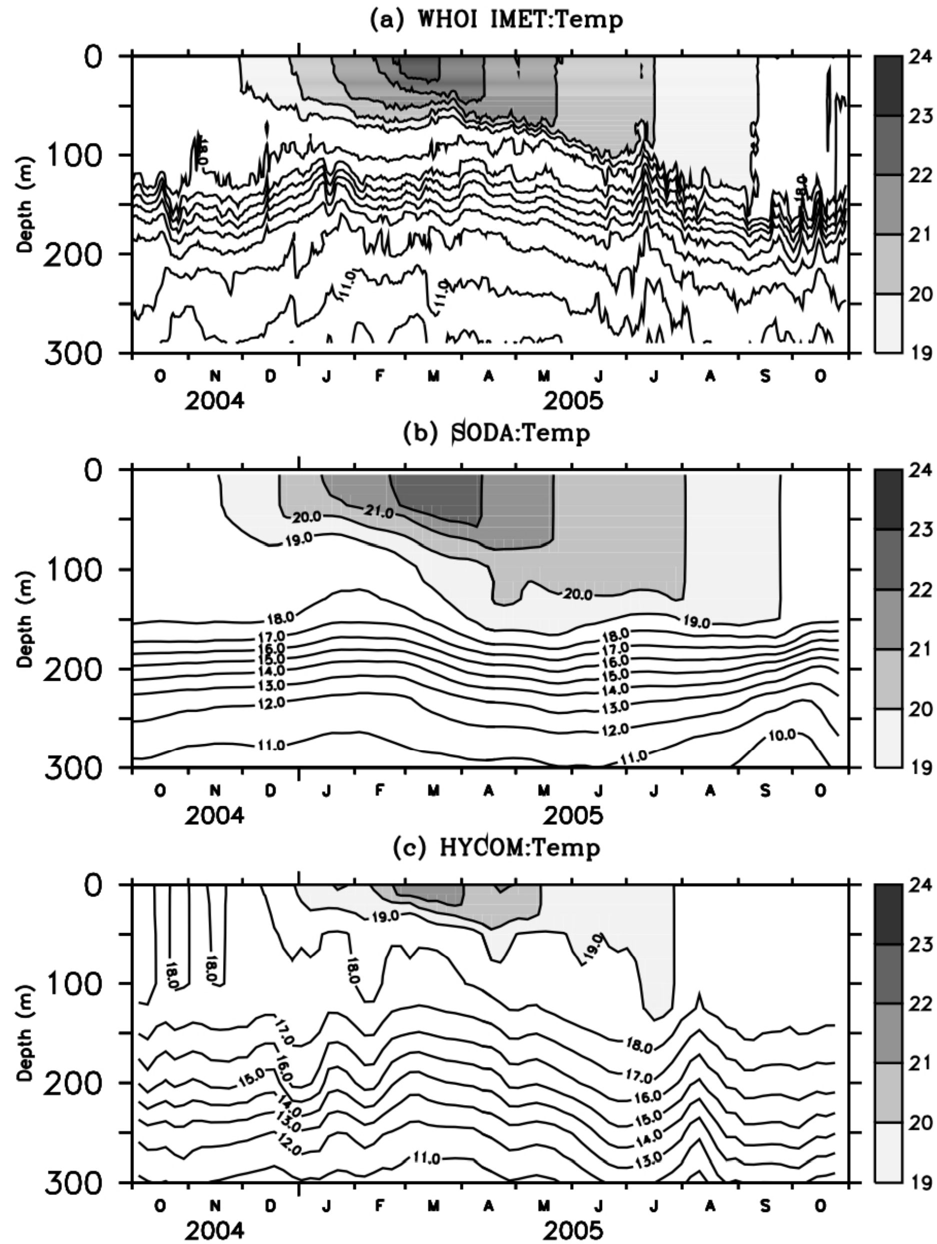
SODA

Horizontal resolution: 0.4 deg. (lon) X 0.25 deg.(lat)

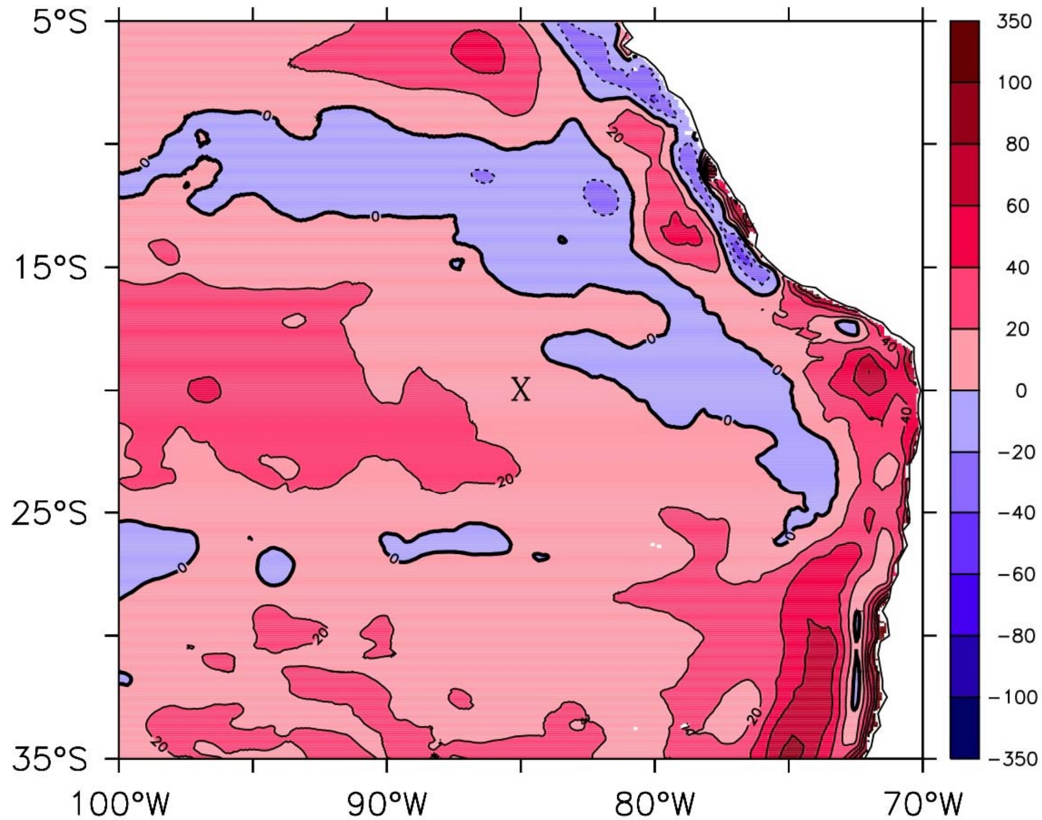
Period: 1980-2005

Data assimilation

Relative importance of horizontal advection and eddy flux divergence for the upper ocean heat balance


(a) WHOI IMET:Temp
Depth (m)
0
100
200
300
O N D J F M A M J J A S O
2004
2005
24
23
22
21
20
19
11.0
(b) SODA:Temp
Depth (m)
20.0
21.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
(c) HYCOM:Temp
Depth (m)
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0

HYCOM: Net Surface Heat Flux

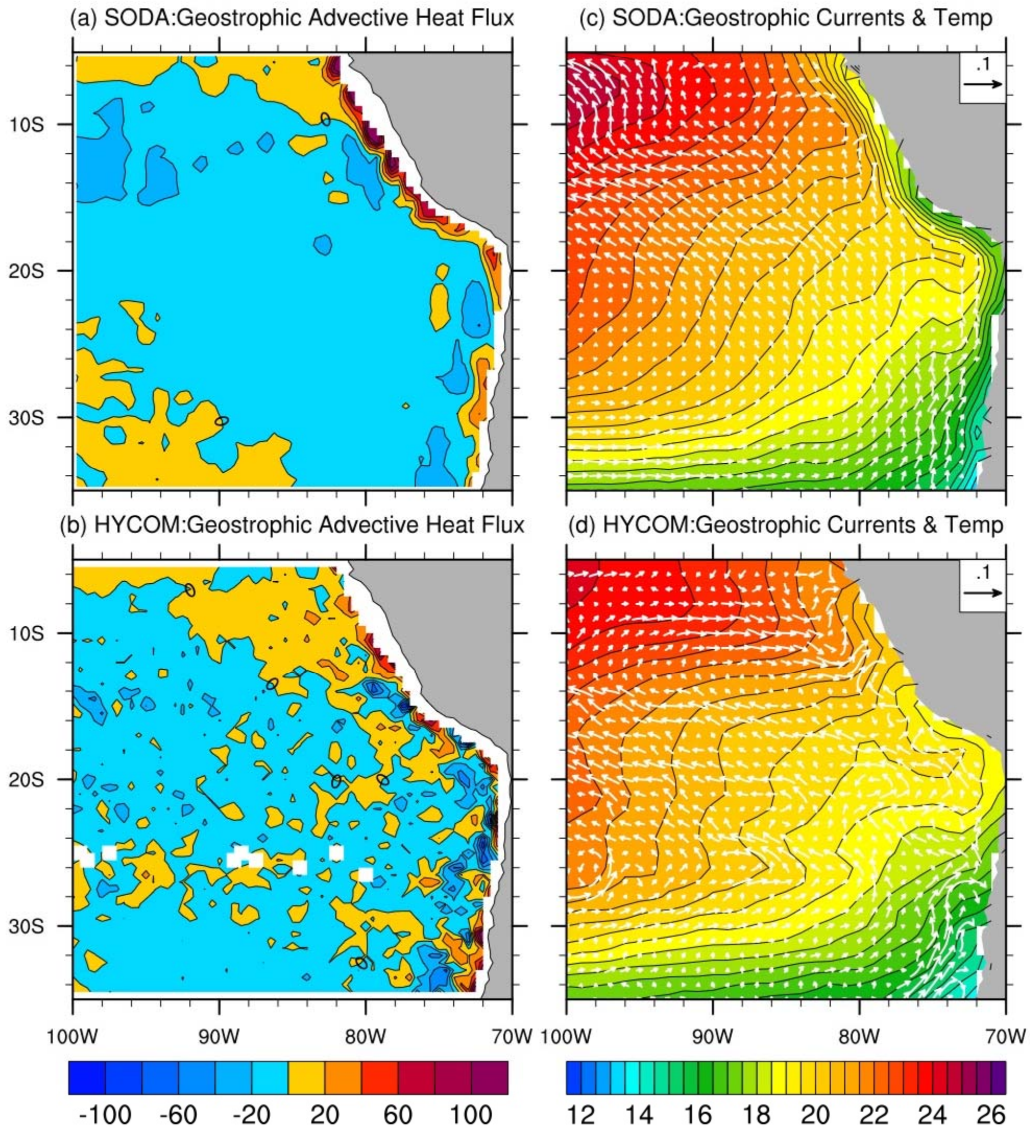


Comparison of heat budget at 85W, 20S

	Colbo and Weller (2007)	HYCOM	SODA
Surface heat fllux	44	18	
Geostrophic	-20	-45	-21
Ekman	6	-44	11
Eddy flux div.	-30	42	-19

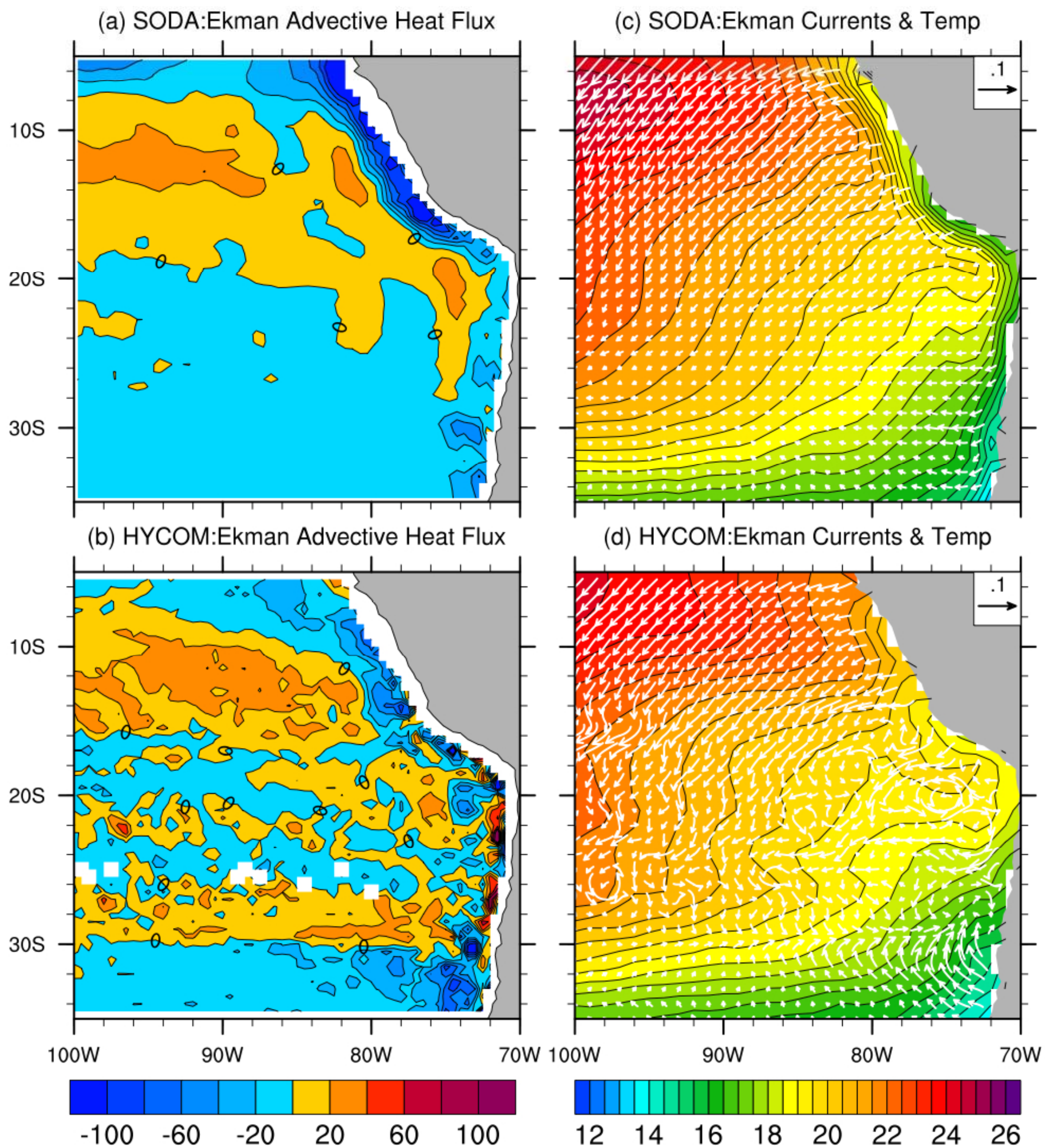
Ekman currents => total - geostrophic

Upper 50m

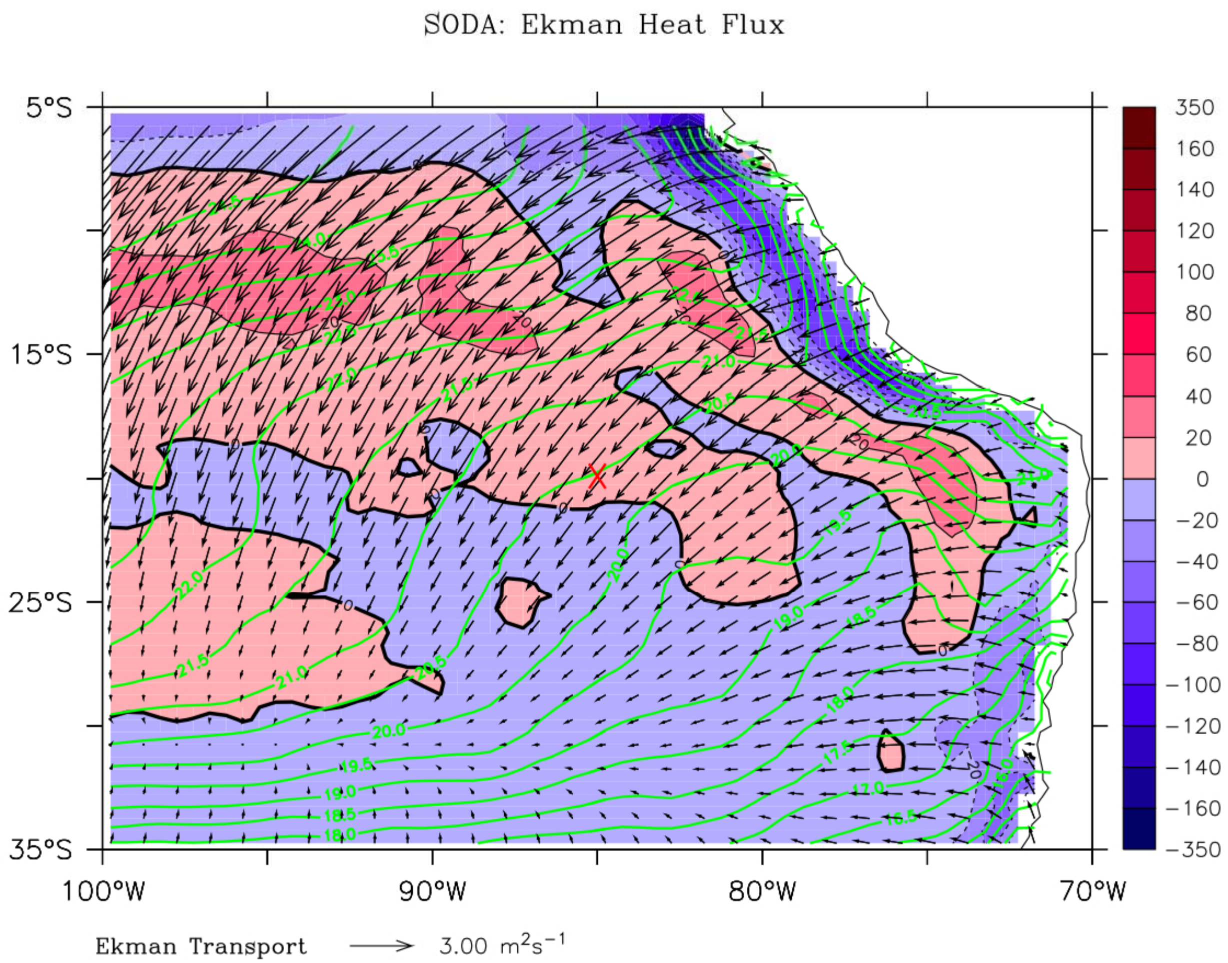


(a) SODA:Geostrophic Advective Heat Flux
(c) SODA:Geostrophic Currents & Temp
(b) HYCOM:Geostrophic Advective Heat Flux
(d) HYCOM:Geostrophic Currents & Temp
10S
20S
30S
100W
90W
80W
70W
.1
-100
-60
-20
20
60
100
12
14
16
18
20
22
24
26

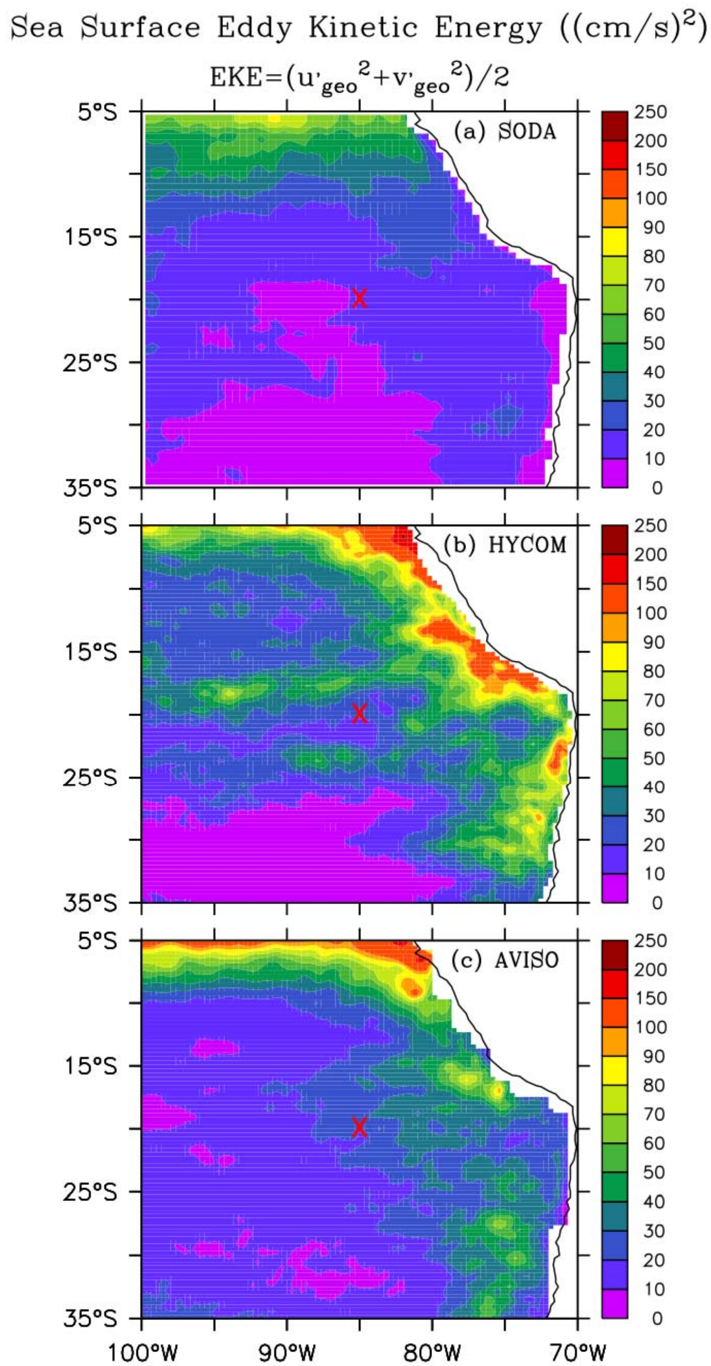
Upper 50m



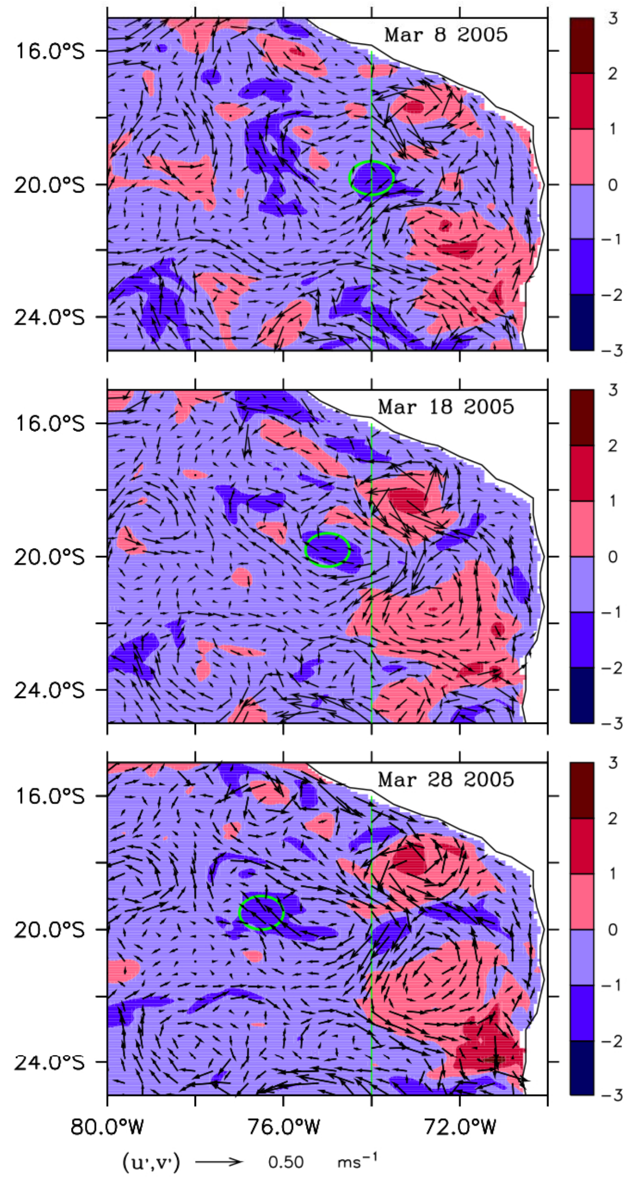
(a) SODA:Ekman Advective Heat Flux
(c) SODA:Ekman Currents & Temp
(b) HYCOM:Ekman Advective Heat Flux
(d) HYCOM:Ekman Currents & Temp
10S
20S
30S
100W
90W
80W
70W
.1
-100
-60
-20
20
60
100
12
14
16
18
20
22
24
26



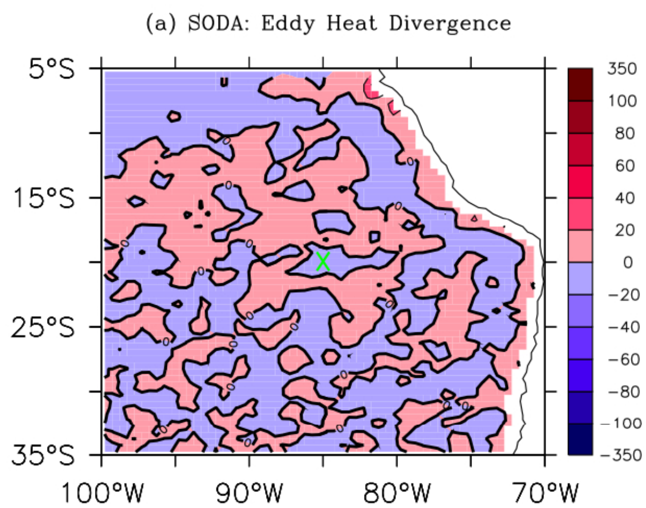
SODA: Ekman Heat Flux
5°S
15°S
25°S
35°S
100°W
90°W
80°W
70°W
350
160
140
120
100
80
60
40
20
0
−20
−40
−60
−80
−100
−120
−140
−160
−350
Ekman Transport
3.00 m²s⁻¹

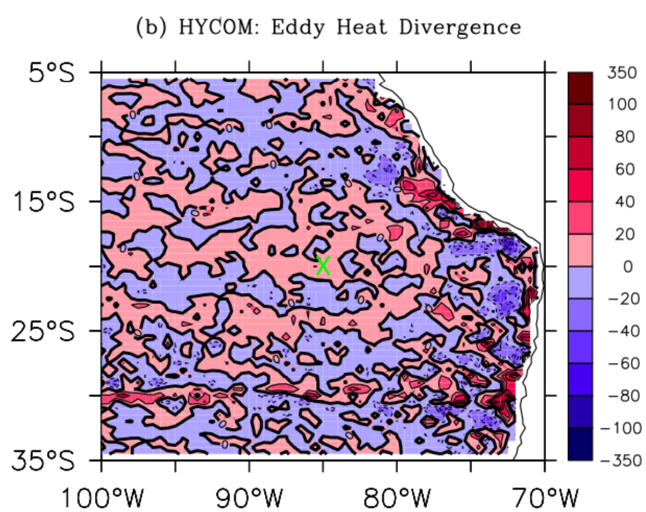


Sea Surface Eddy Kinetic Energy ((cm/s)^2)
EKE=(u'$_{geo}$^{2}+v'$_{geo}$^{2})/2
(a) SODA
(b) HYCOM
(c) AVISO
5°S
15°S
25°S
35°S
100°W
90°W
80°W
70°W
250
200
150
100
90
80
70
60
50
40
30
20
10
0



Mar 8 2005
Mar 18 2005
Mar 28 2005
16.0°S
20.0°S
24.0°S
80.0°W
76.0°W
72.0°W
3
2
1
0
−1
−2
−3
(u',v')
0.50
ms^{-1}


(a) SODA: Eddy Heat Divergence
5°S
15°S
25°S
35°S
100°W
90°W
80°W
70°W
350
100
80
60
40
20
0
−20
−40
−60
−80
−100
−350


(b) HYCOM: Eddy Heat Divergence
5°S
15°S
25°S
35°S
100°W
90°W
80°W
70°W
350
100
80
60
40
20
0
−20
−40
−60
−80
−100
−350

Heat budget in the upper 50m (100W-80W, 30S-10S)

	HYCOM	*SODA*
Surface heat flux	*11*	
Geostrophic	*-5*	*-9*
Ekman	*3*	*6*
Eddy flux div.	*0.1*	*-0.1*

Conclusions

Geostrophic transport in the upper 50m causes net cooling in most of the stratus cloud region

Ekman transport provides net warming north of the IMET site and net cooling south of the IMET site

The eddy heat flux divergence term can be comparable to other terms at a particular location such as the IMET site, but it is negligible for the entire stratus region when area averaged since it is not spatially coherent in the open ocean.

Surface buoy observations in locations both north and south of the IMET site would be useful.