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High frequency wind events and vertical mixing in the South China Sea

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High frequency wind events and vertical mixing in the South China Sea

Yuley Cardona
and
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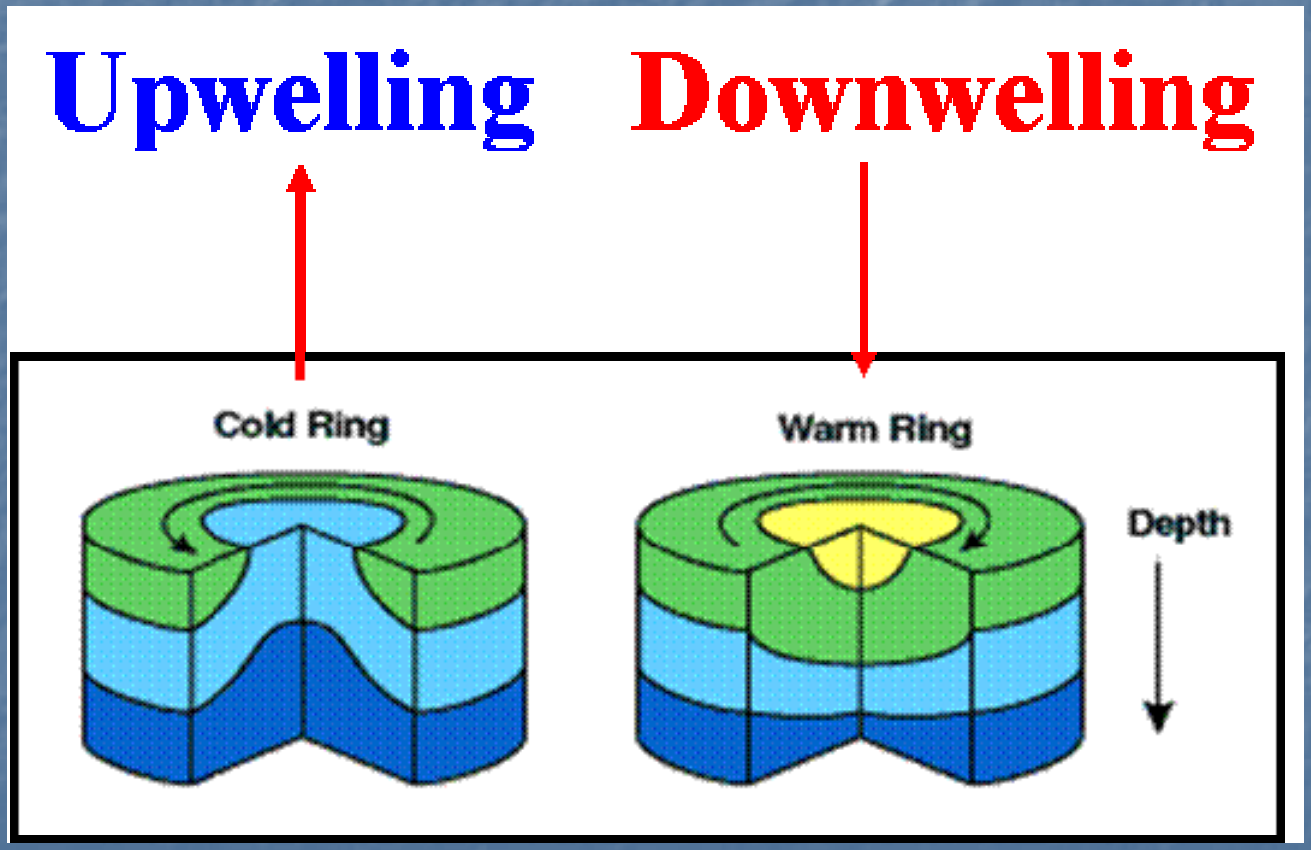
EAS – Georgia Tech

with Inga Koszalka,
Un. of Oslo

personal view on open questions in PO

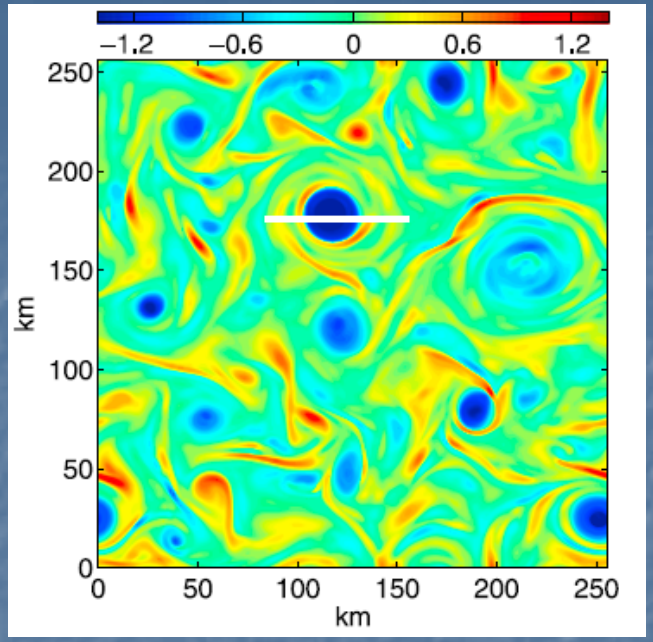
- Vertical mixing: role of unbalanced motions.
- Vertical mixing and impact on biology
- Oceanic energy budget

Traditional view: geostrophic (balanced) flow



Koszalka, Bracco, McWilliams, Provenzale JGR 2009

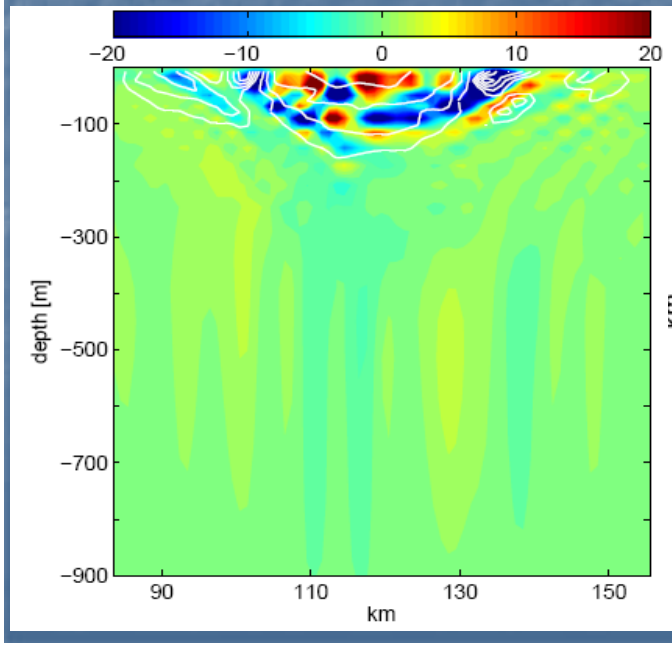
Vorticity Field, ζ/f →

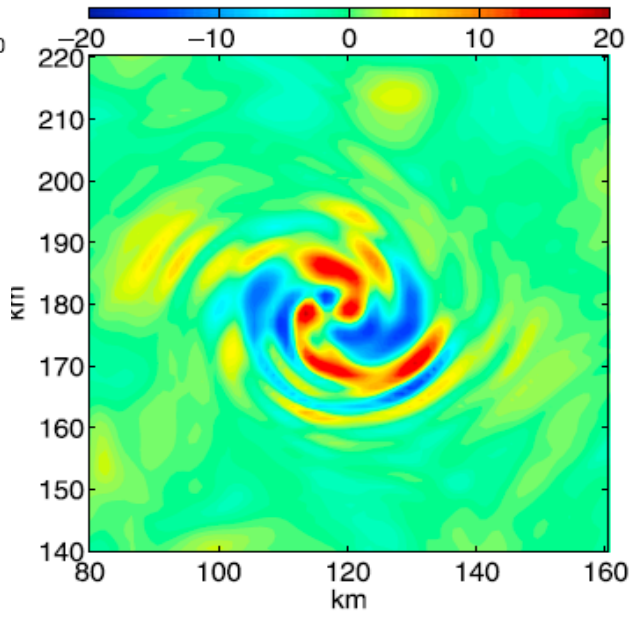


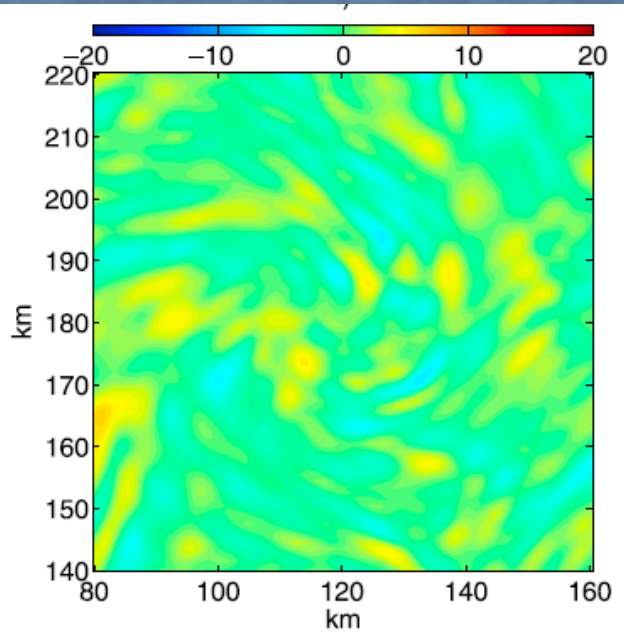
How does the vertical velocity field associated with a vortex look like?

Daily averaged Vertical velocity field

Vertical Section horizontal section at 78m and at 350m (m/day)





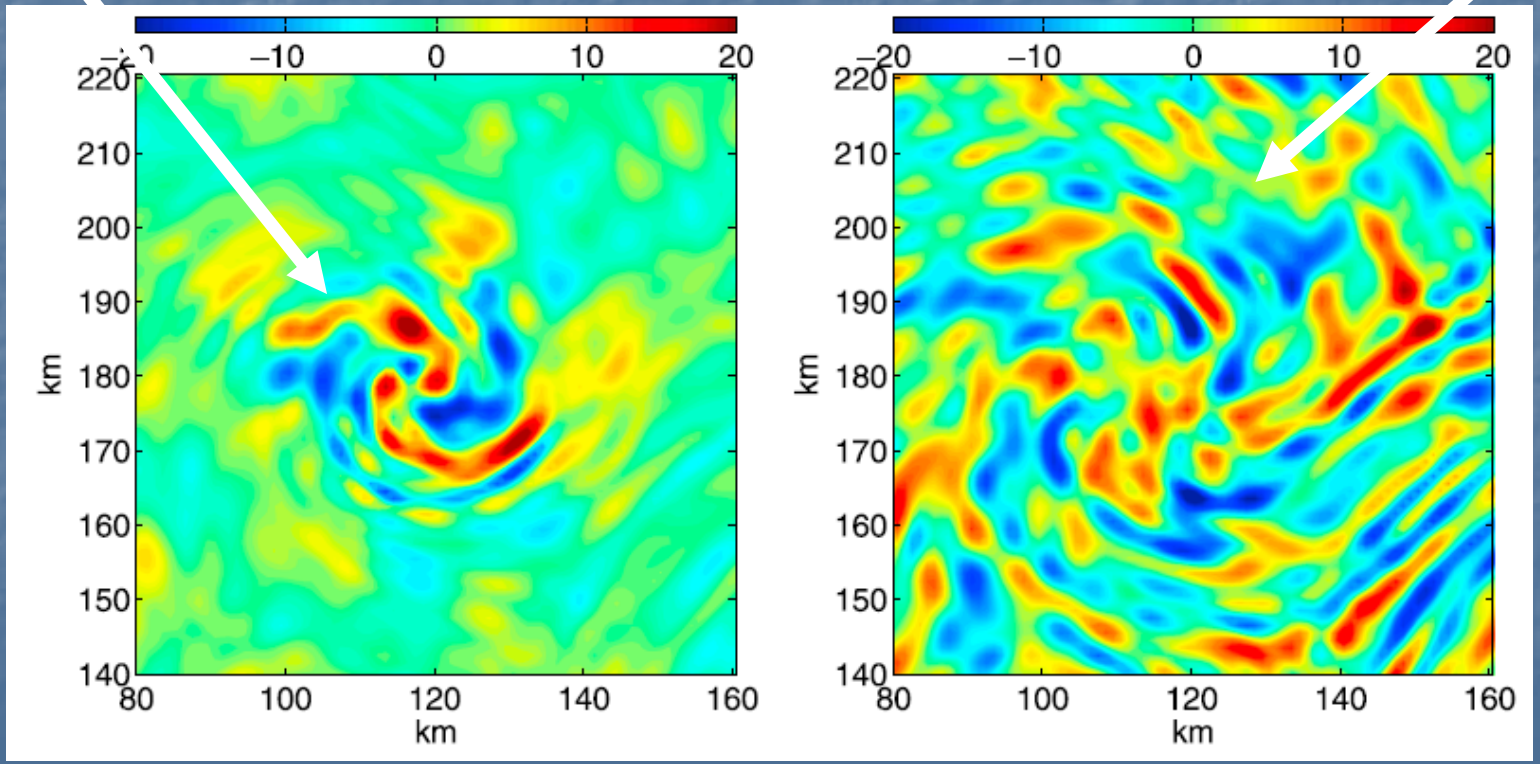


Looks even more complicated if we do not average over 1 day…

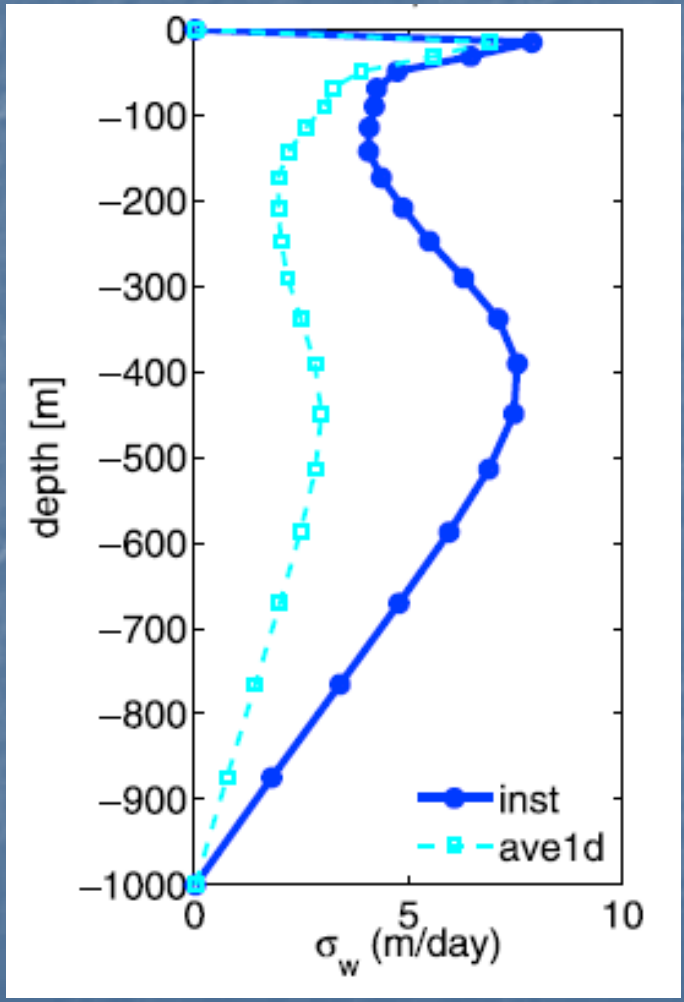
Vortex Rossby waves

again 78 and 350m, in m/day

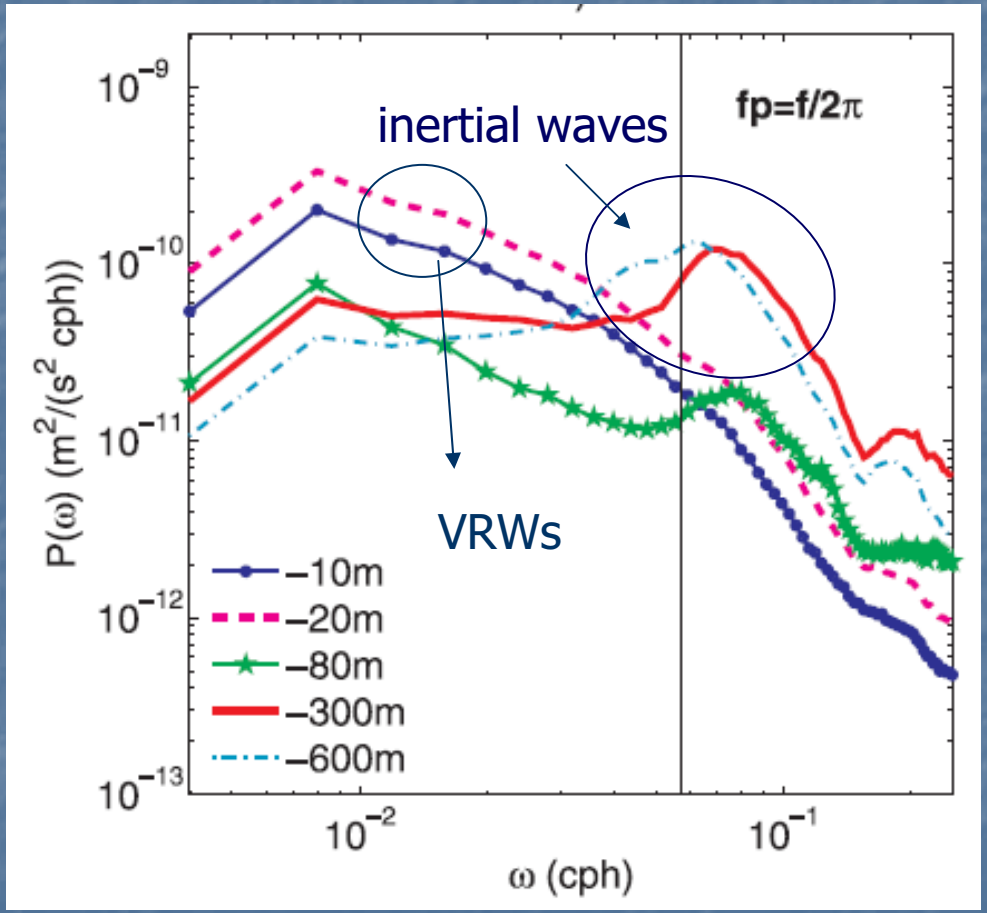
near-inertial waves



standard deviation
vertical velocity field



frequency spectra



what about realistic configurations?

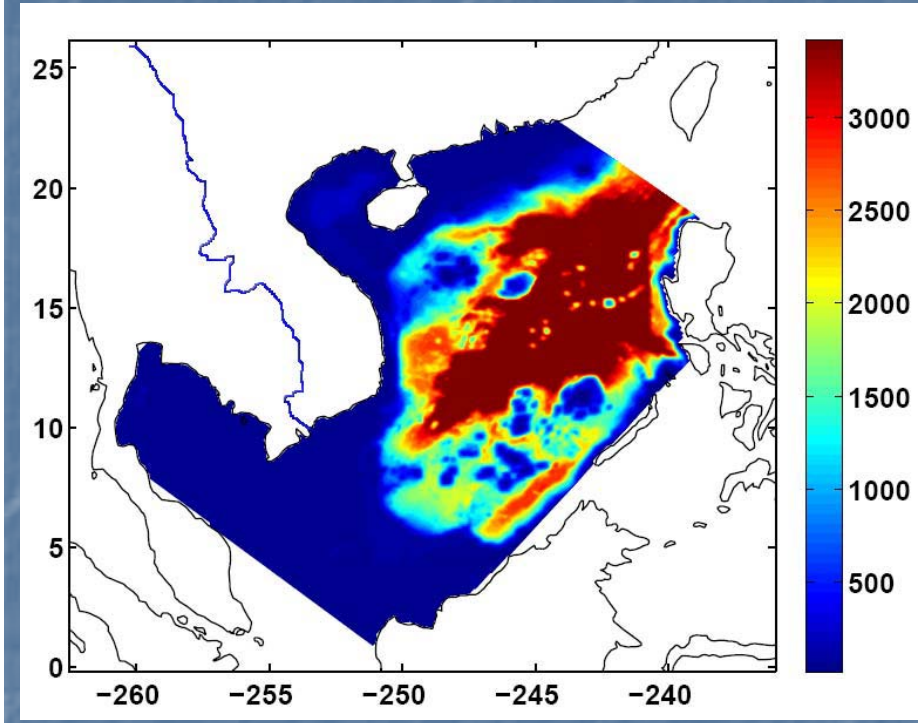
(see also Zhai et al., 2007)

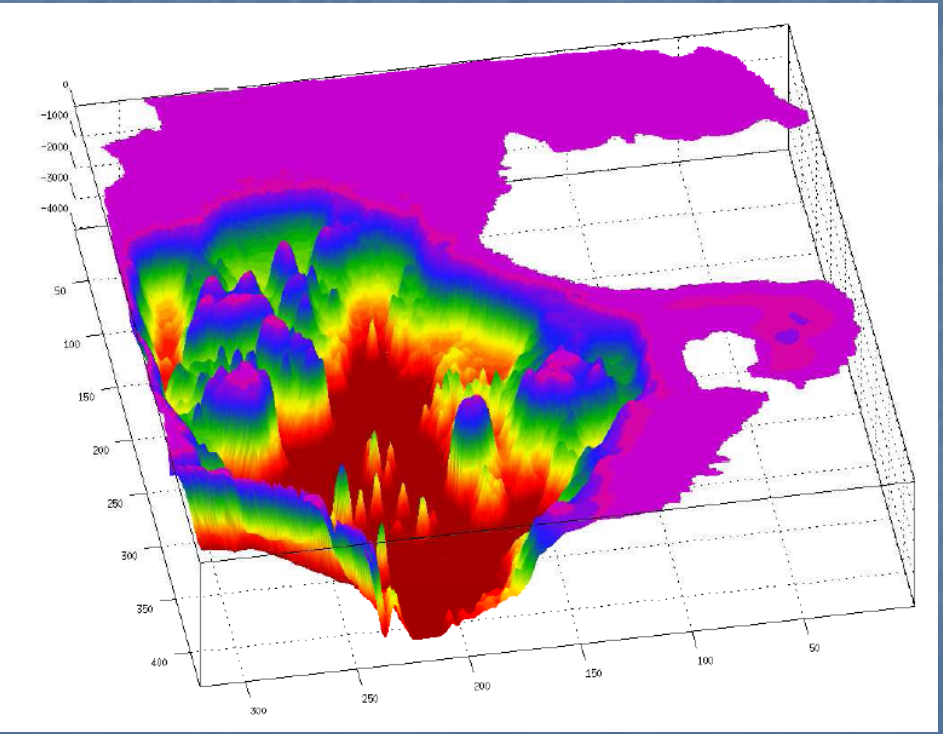
The eddies need to "ring", i.e. the frequency of the Vortex Rossby waves and of the near-inertial oscillations have to excited (Klein et al., 2004)

High frequency winds may do the job

The South China Sea

Cardona and Bracco (in prepar.)

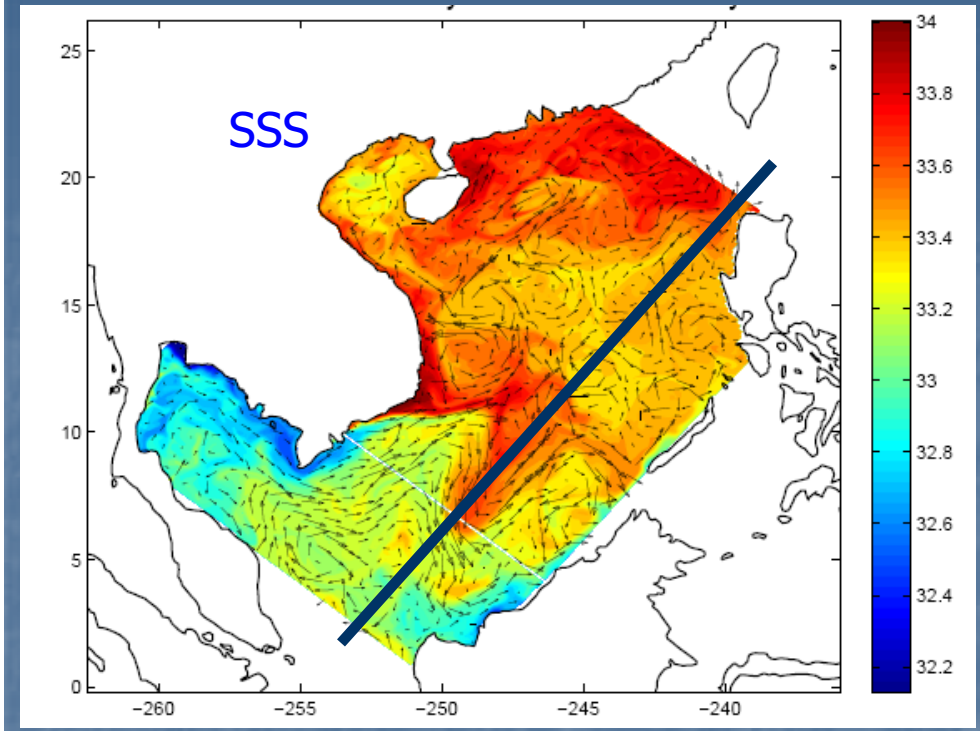




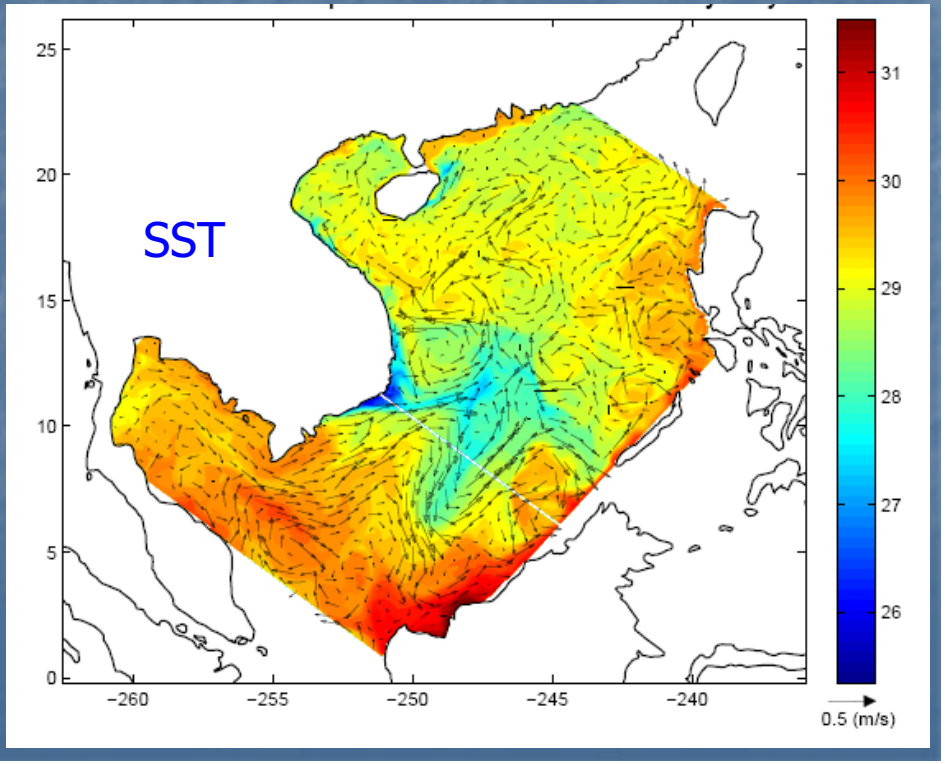
complicated bathymetry

3 sets of runs:

- monthly NCEP-NCAR winds (QuickScat blended)
- daily NCEP-NCAR winds (QuickScat blended)
- 6-hours NCEP-NCAR winds (QuickScat blended)

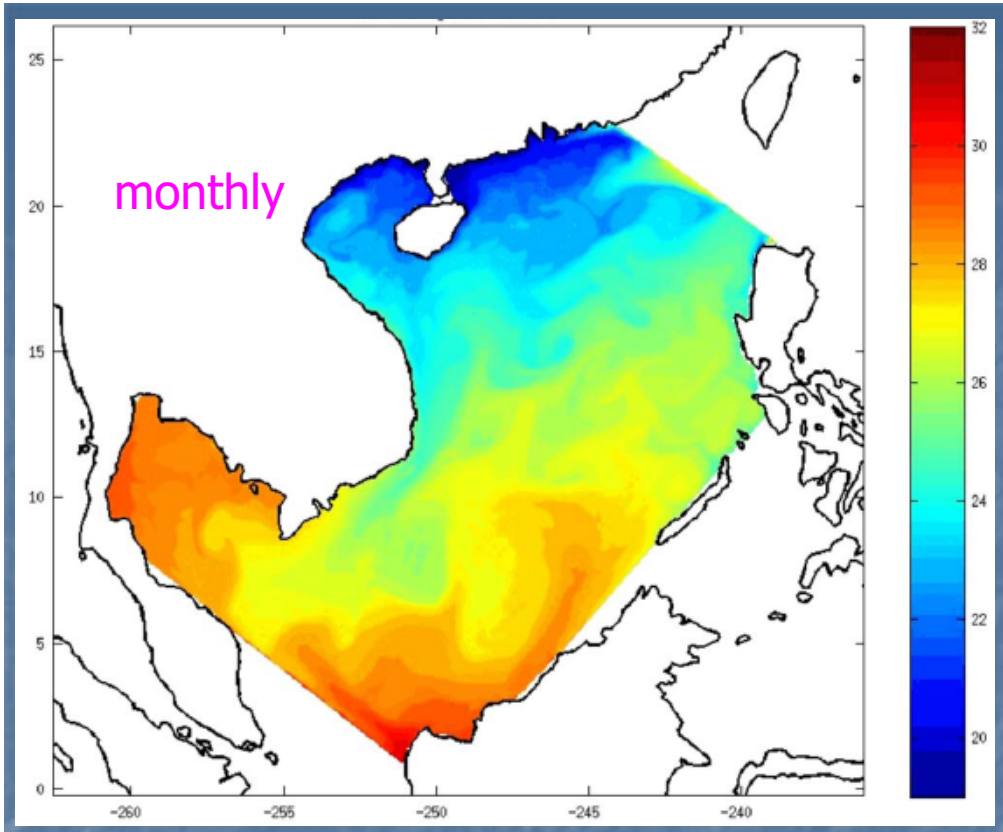


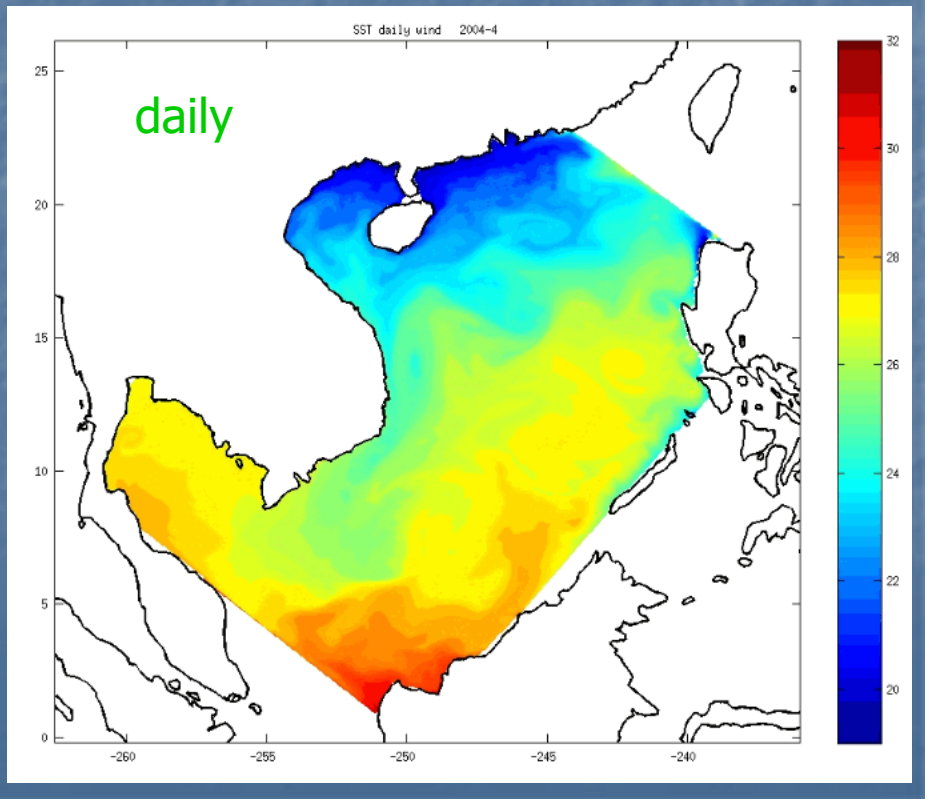
ROMS
5km horizontal resolution

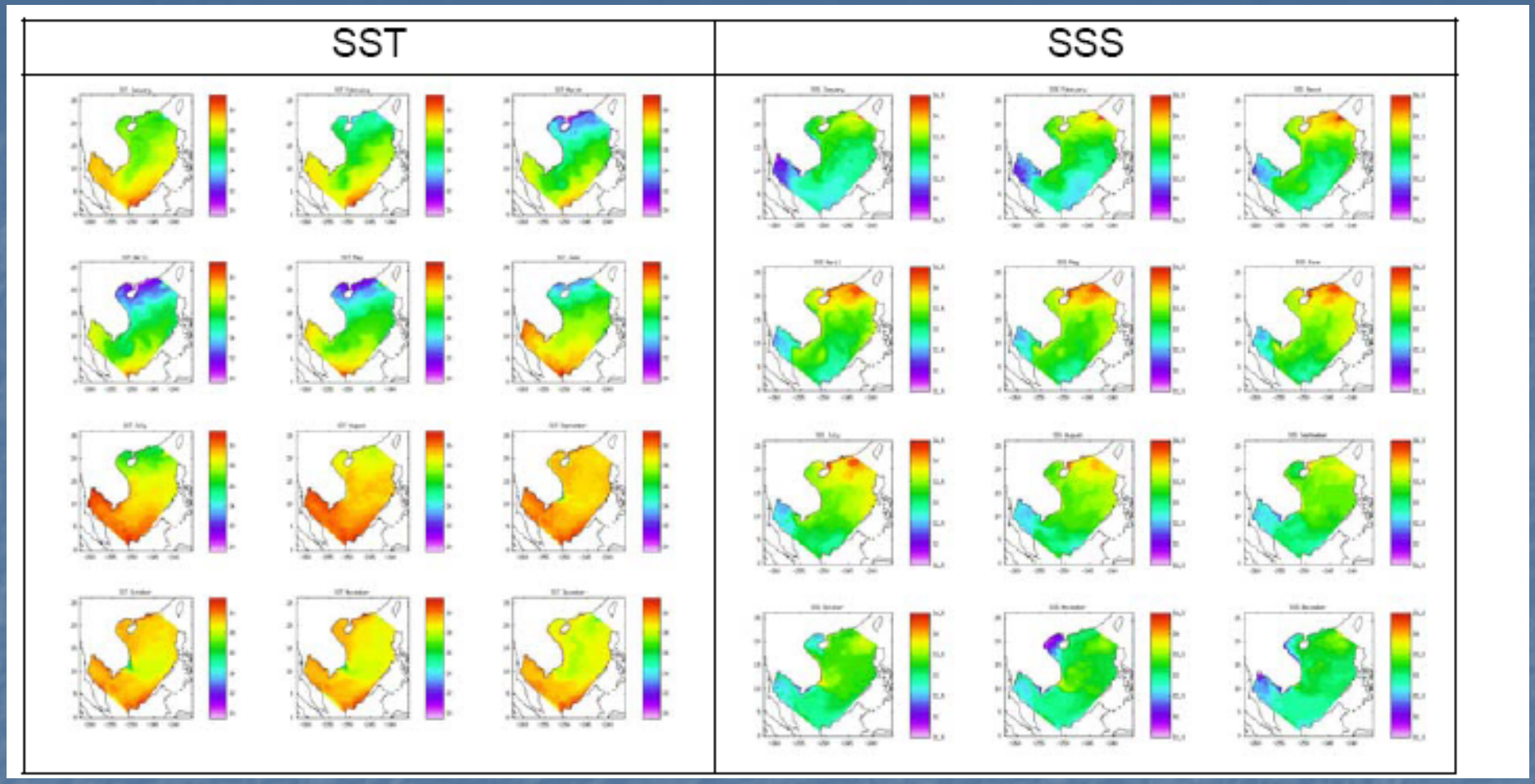


complex mesoscale activity

SST / SSS + surface hor. velocity on July 16, 2000


monthly
25
20
15
10
5
0
-260
-255
-250
-245
-240
32
30
28
26
24
22
20

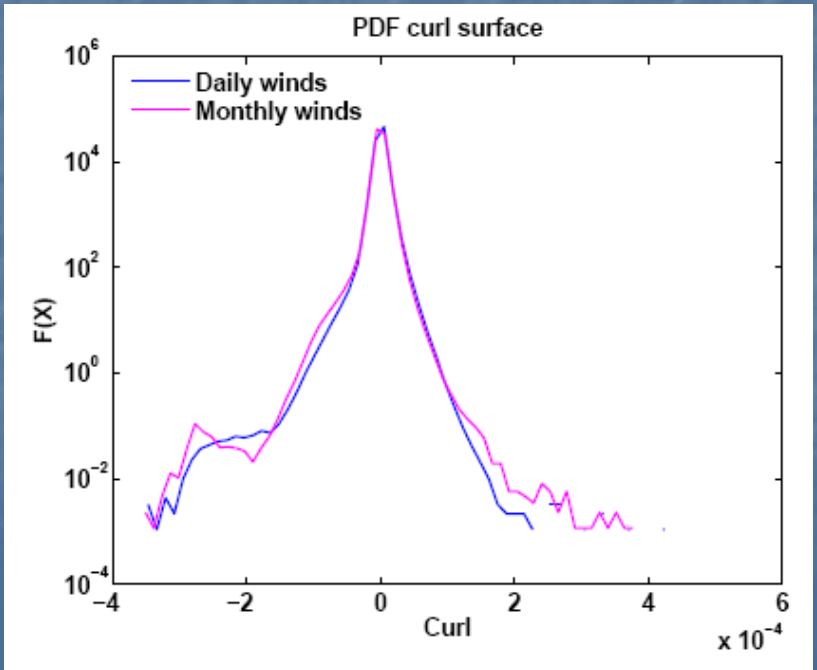

SST daily wind 2004-4
daily
25
20
15
10
5
0
-260
-255
-250
-245
-240
32
30
28
26
24
22
20

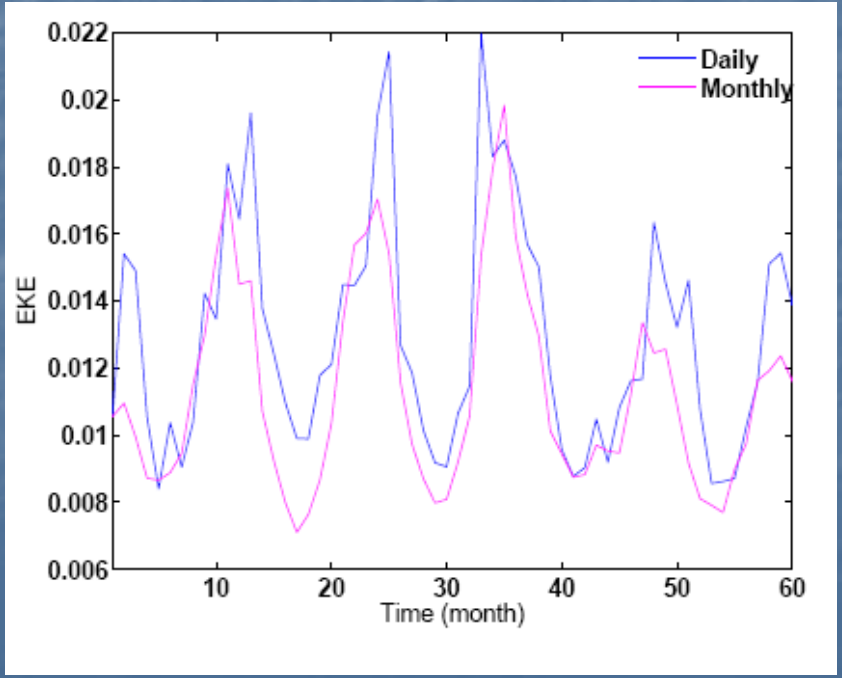


seasonal cycle in SST and SSS

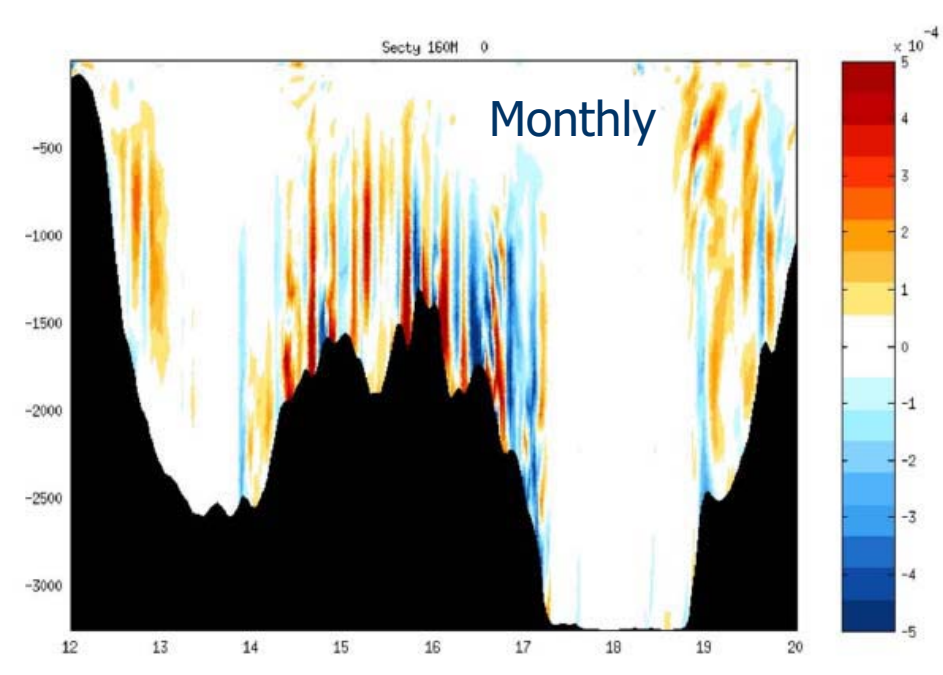
Monthly, daily or hourly winds? Does it make a difference?

- Vorticity distribution at the surface… no
- Surface EKE… a bit, but not much

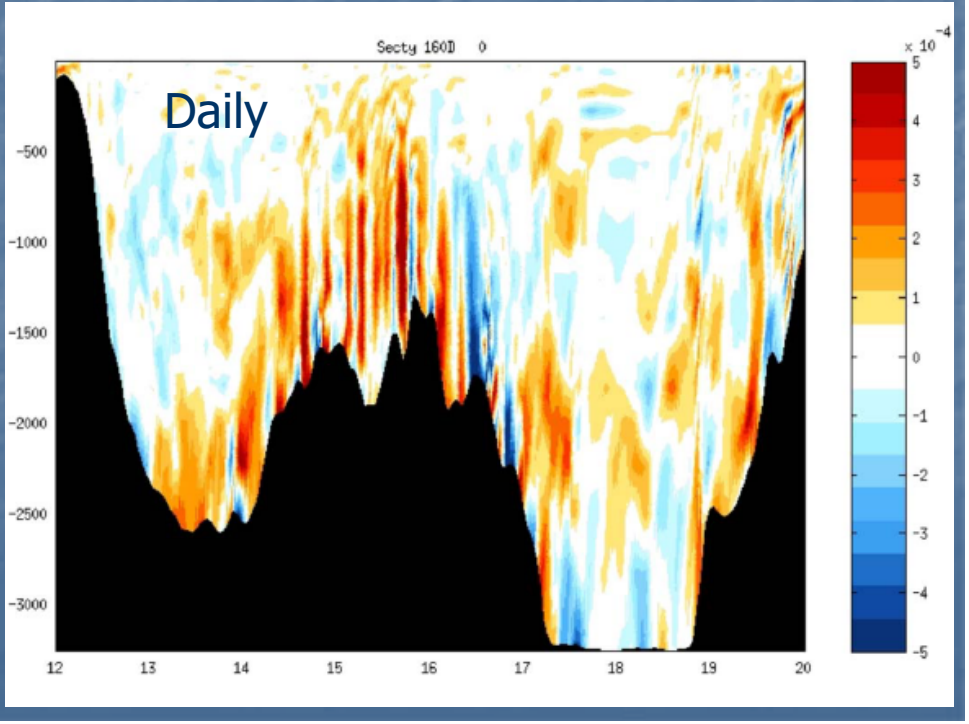


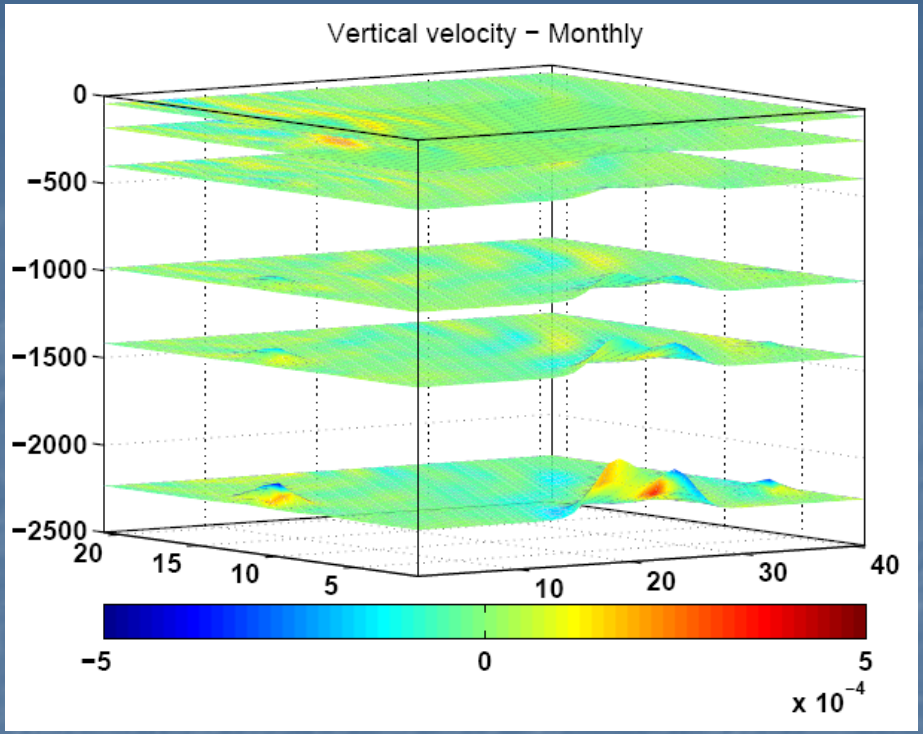


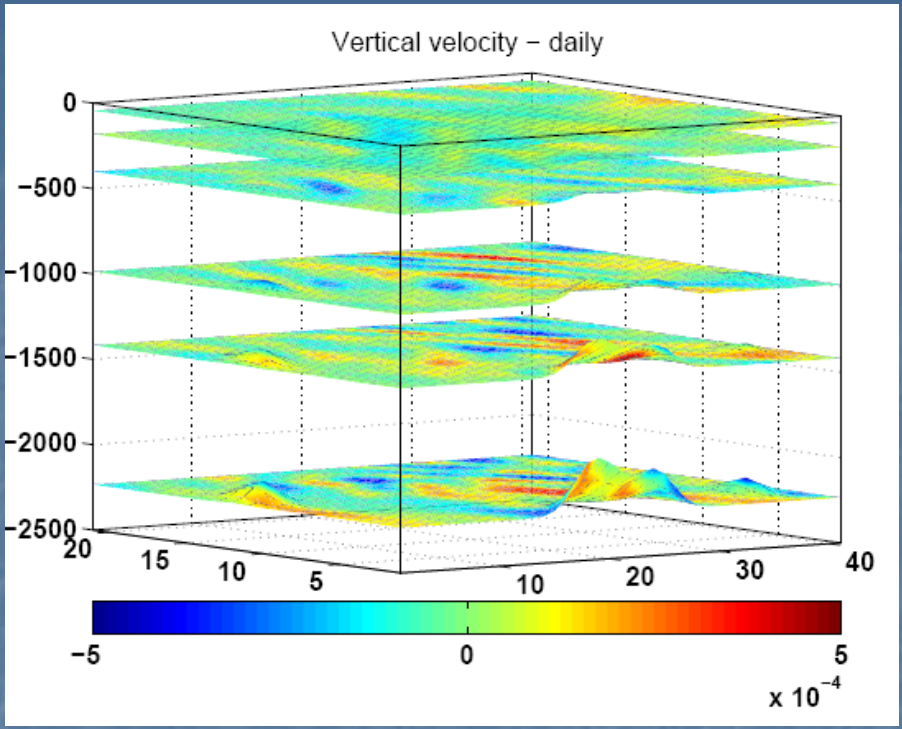
but the vertical velocities…

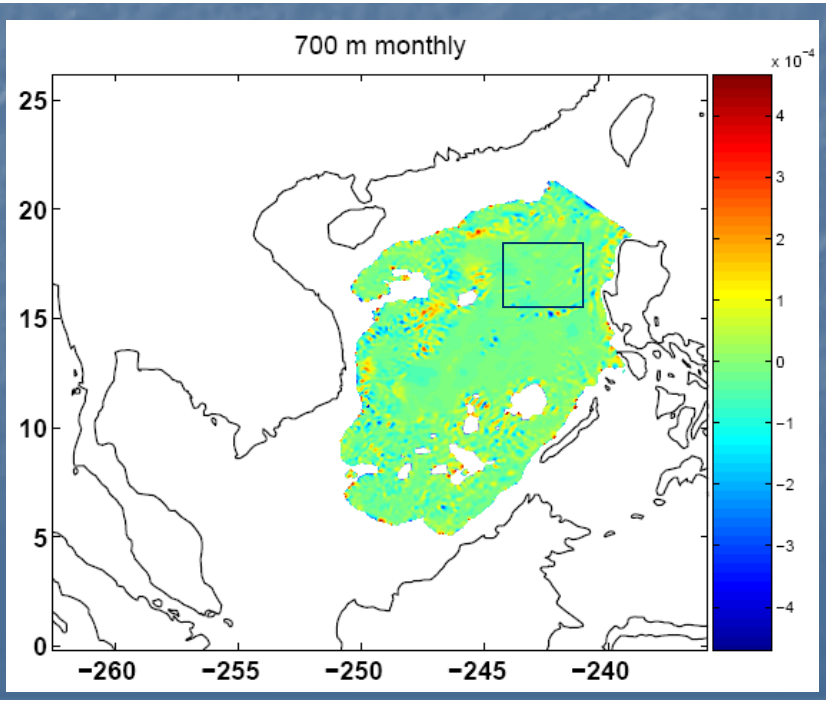


m/s

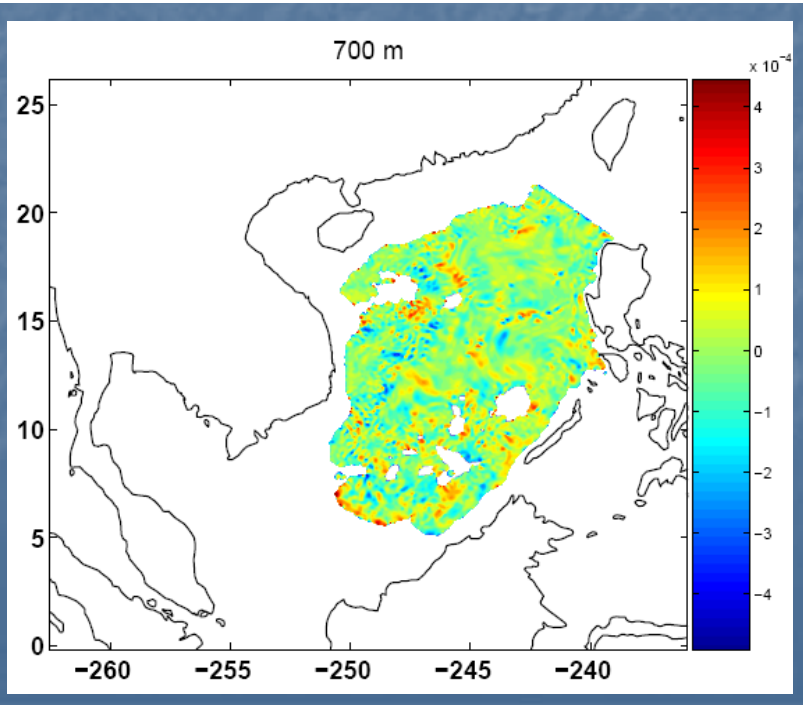


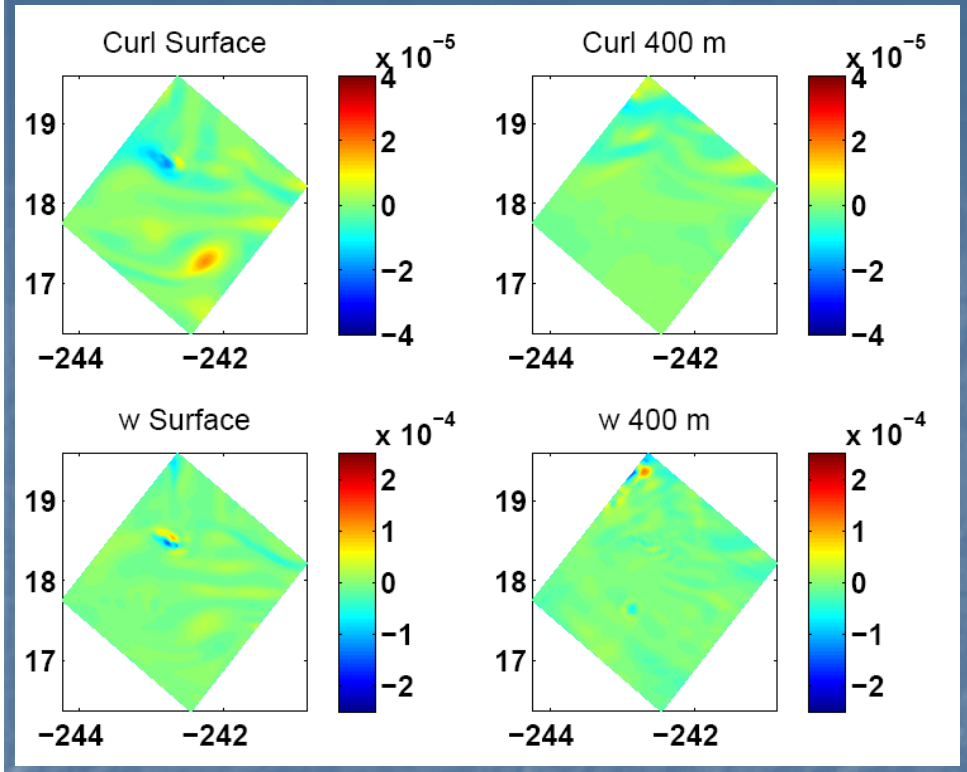

Vertical velocity − Monthly
0
−500
−1000
−1500
−2000
−2500
20
15
10
5
10
20
30
40
−5
0
5
x 10^−4

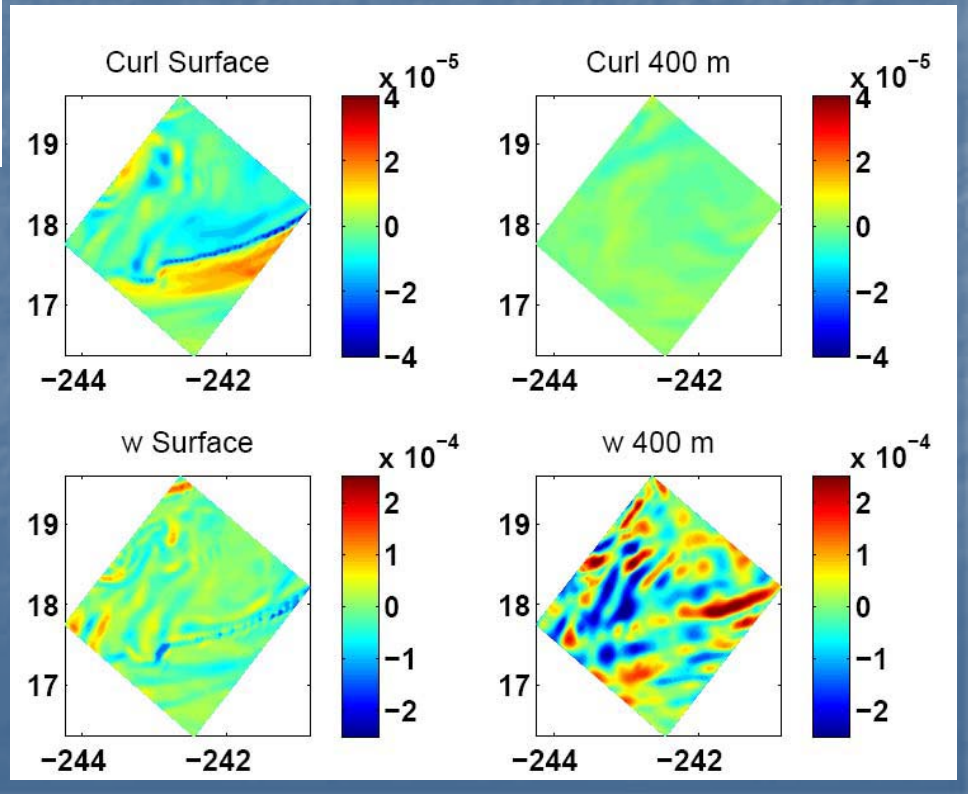

Vertical velocity − daily
0
−500
−1000
−1500
−2000
−2500
20
15
10
5
10
20
30
40
−5
0
5
x 10^−4


700 m monthly
x 10^−4
25
20
15
10
5
0
−260
−255
−250
−245
−240
4
3
2
1
0
−1
−2
−3
−4

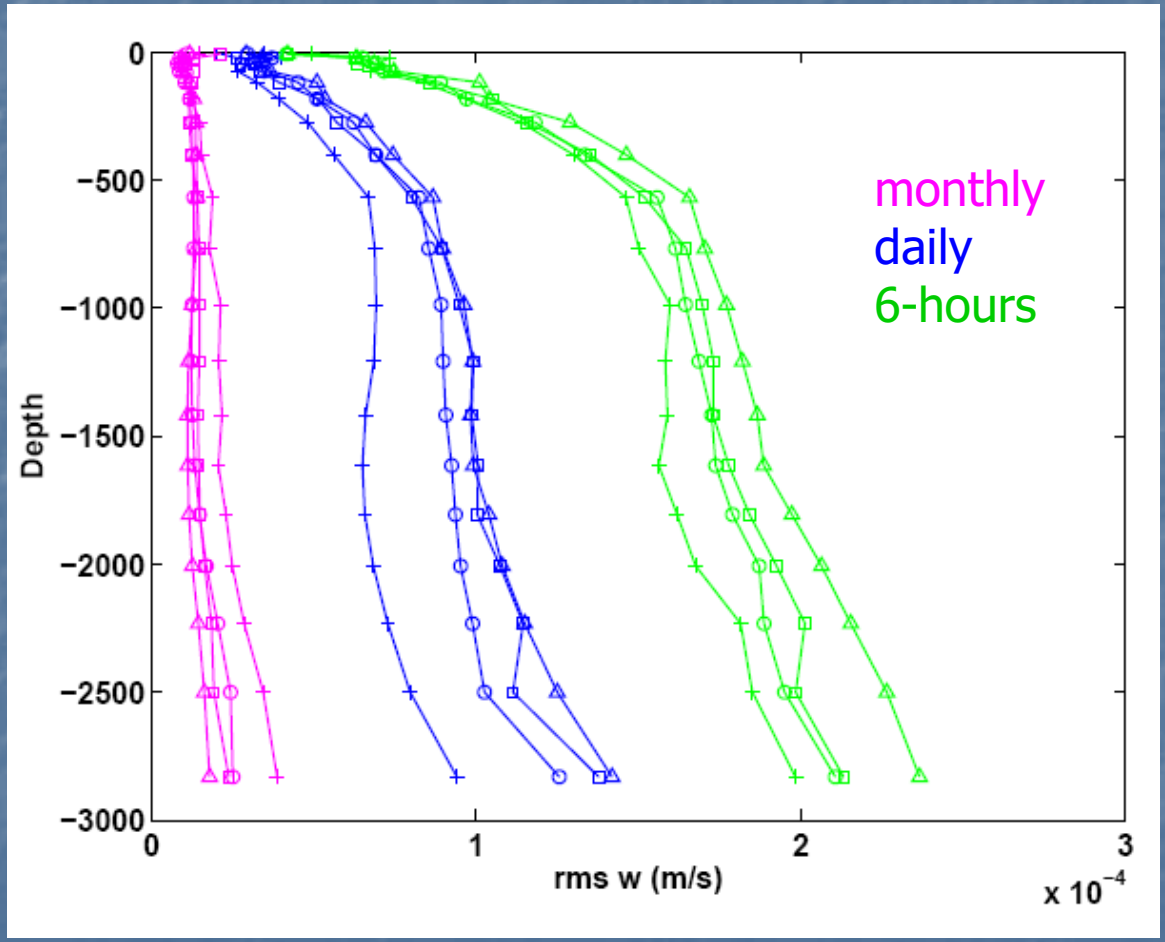
m/s

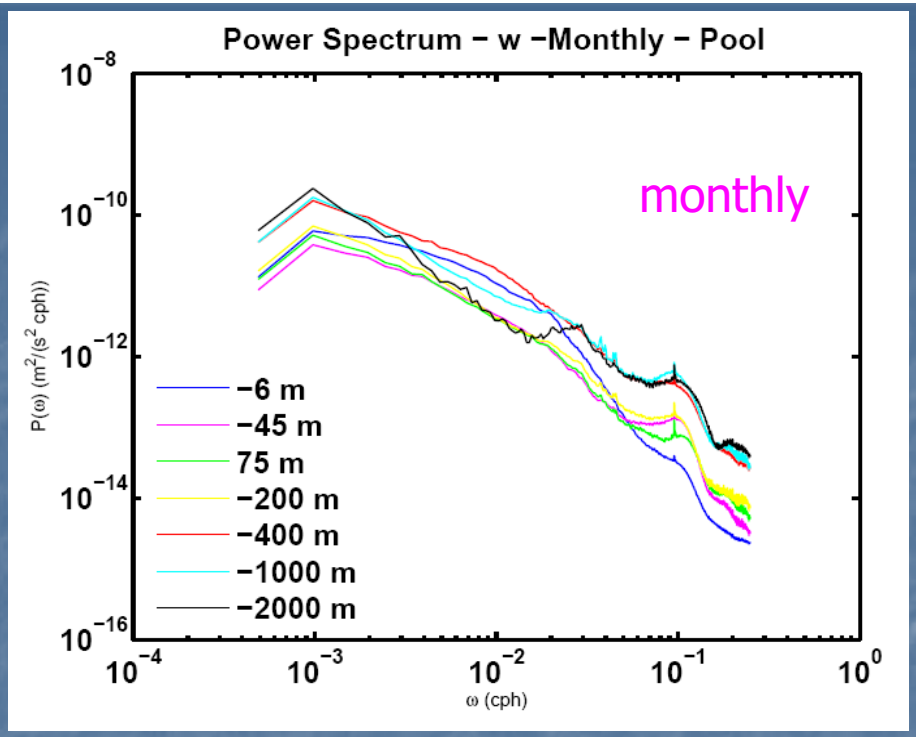

700 m
x 10^−4
25
20
15
10
5
0
−260
−255
−250
−245
−240
4
3
2
1
0
−1
−2
−3
−4

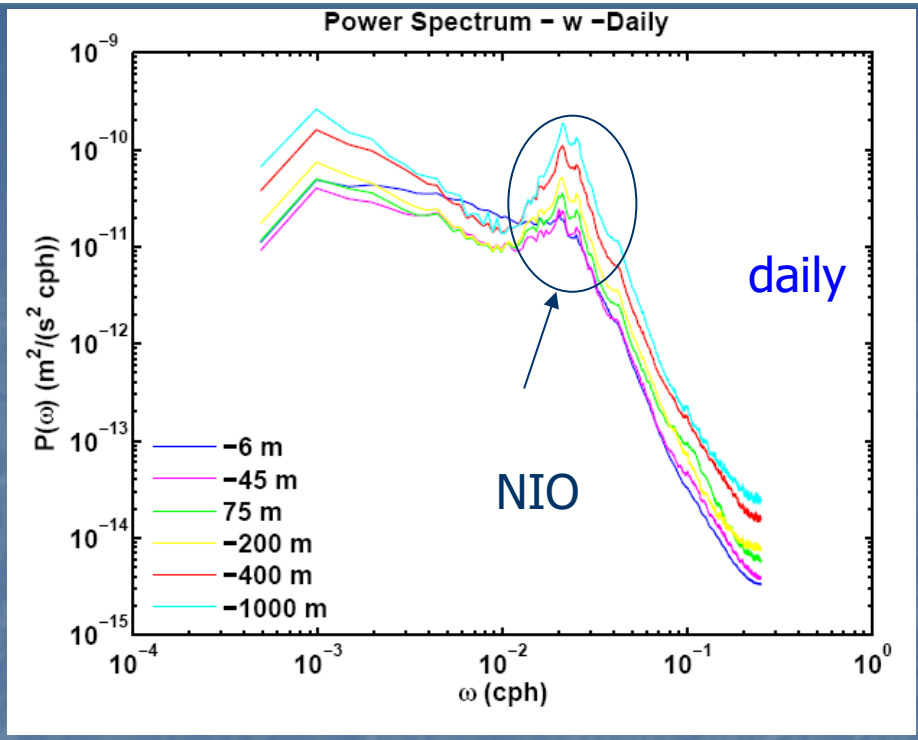

Curl Surface
x 10^-5
4
2
0
−2
−4
19
18
17
−244
−242
Curl 400 m
x 10^-5
4
2
0
−2
−4
19
18
17
−244
−242
w Surface
x 10^-4
2
1
0
−1
−2
19
18
17
−244
−242
w 400 m
x 10^-4
2
1
0
−1
−2
19
18
17
−244
−242

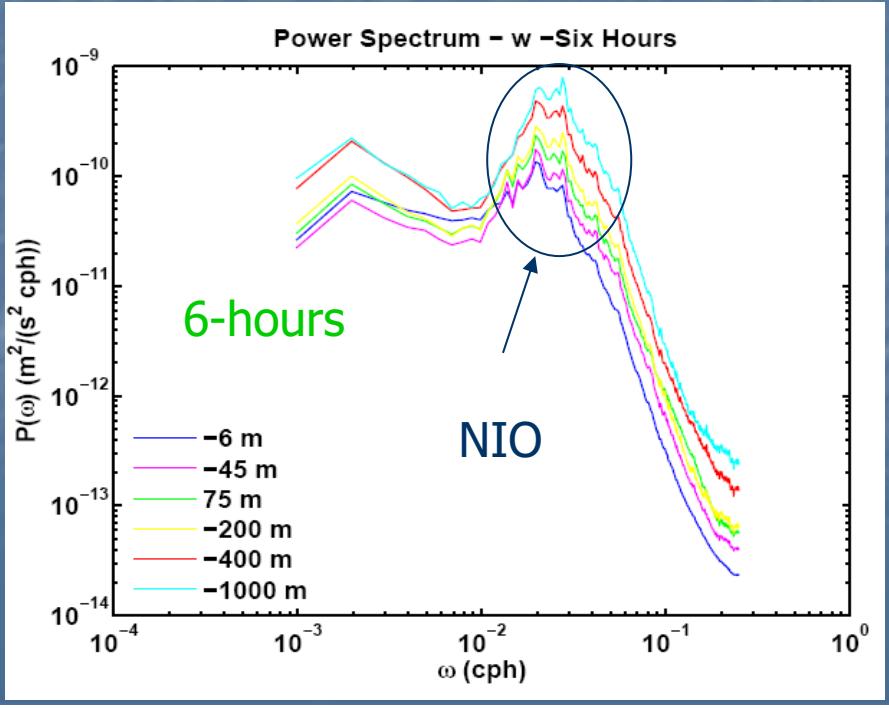

Curl Surface
x 10^-5
4
2
0
−2
−4
19
18
17
−244
−242
Curl 400 m
x 10^-5
4
2
0
−2
−4
19
18
17
−244
−242
w Surface
x 10^-4
2
1
0
−1
−2
19
18
17
−244
−242
w 400 m
x 10^-4
2
1
0
−1
−2
19
18
17
−244
−242

Quantifying differences in vertical velocities

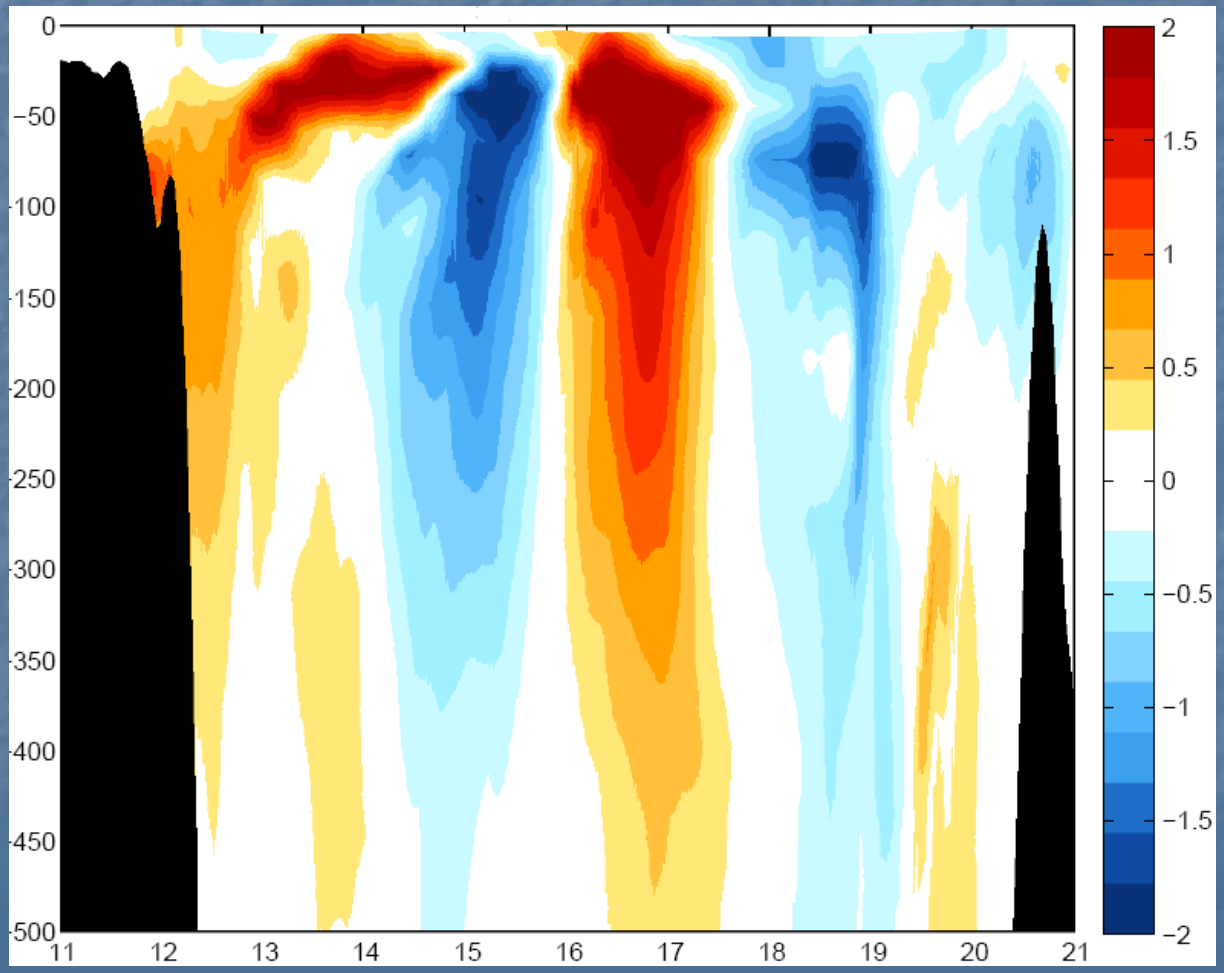



Power Spectrum – w –Monthly – Pool
monthly
P(ω) (m²/(s² cph))
ω (cph)
–6 m
–45 m
75 m
–200 m
–400 m
–1000 m
–2000 m


Power Spectrum – w –Daily
daily
NIO
P(ω) (m²/(s² cph))
ω (cph)
–6 m
–45 m
75 m
–200 m
–400 m
–1000 m

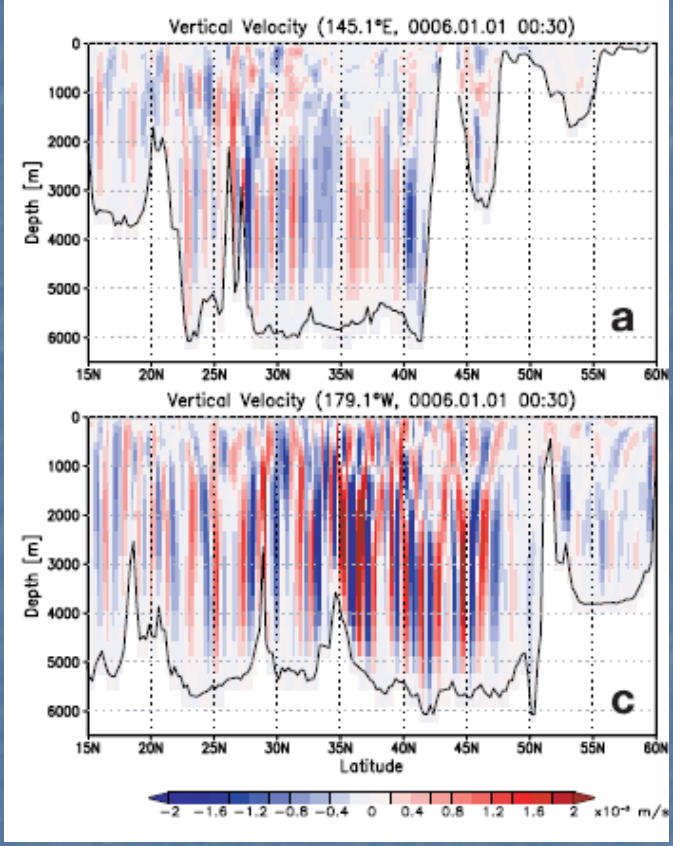

Power Spectrum – w –Six Hours
6-hours
NIO
P(ω) (m²/(s² cph))
ω (cph)
–6 m
–45 m
75 m
–200 m
–400 m
–1000 m

Difference in Temp daily-monthly Jan 2004



GEOPHYSICAL RESEARCH LETTERS, VOL. 35, L04610, doi:10.1029/2007GL032807, 2008

Komori et al., 2008



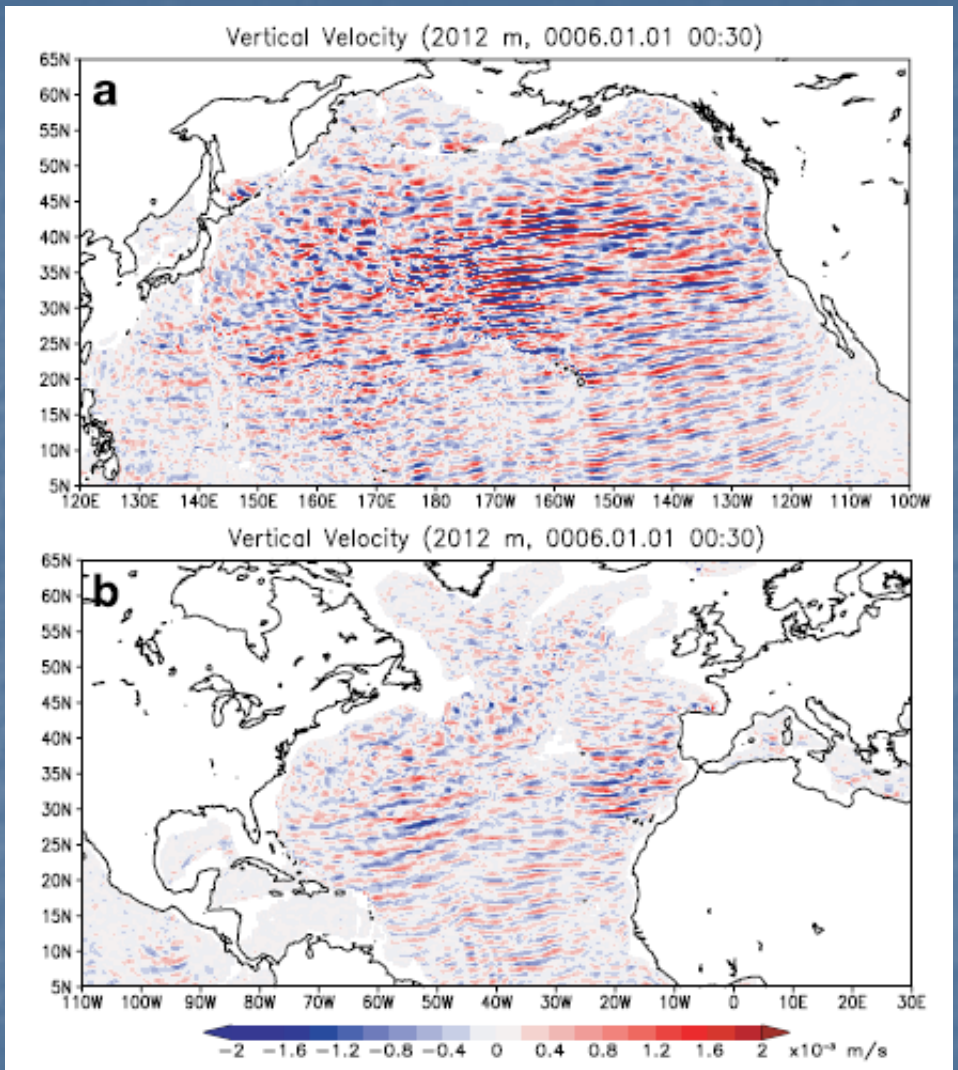


Figure 1. Snapshots of vertical velocity at 2012-m depth (a) in the North Pacific and (b) in the North Atlantic. Unit in color bar is 10^{-3} m s^{-1}.

conclusions

- NIOs and VRWs associated with mesoscale vortices represent an important mechanism to mix the ocean. We need to quantify their contribution. Implications for biology!
- Measurements!!! We need them pretty desperately at this point
- High frequency winds are indispensable for ocean models. Likely needed every 3 hours