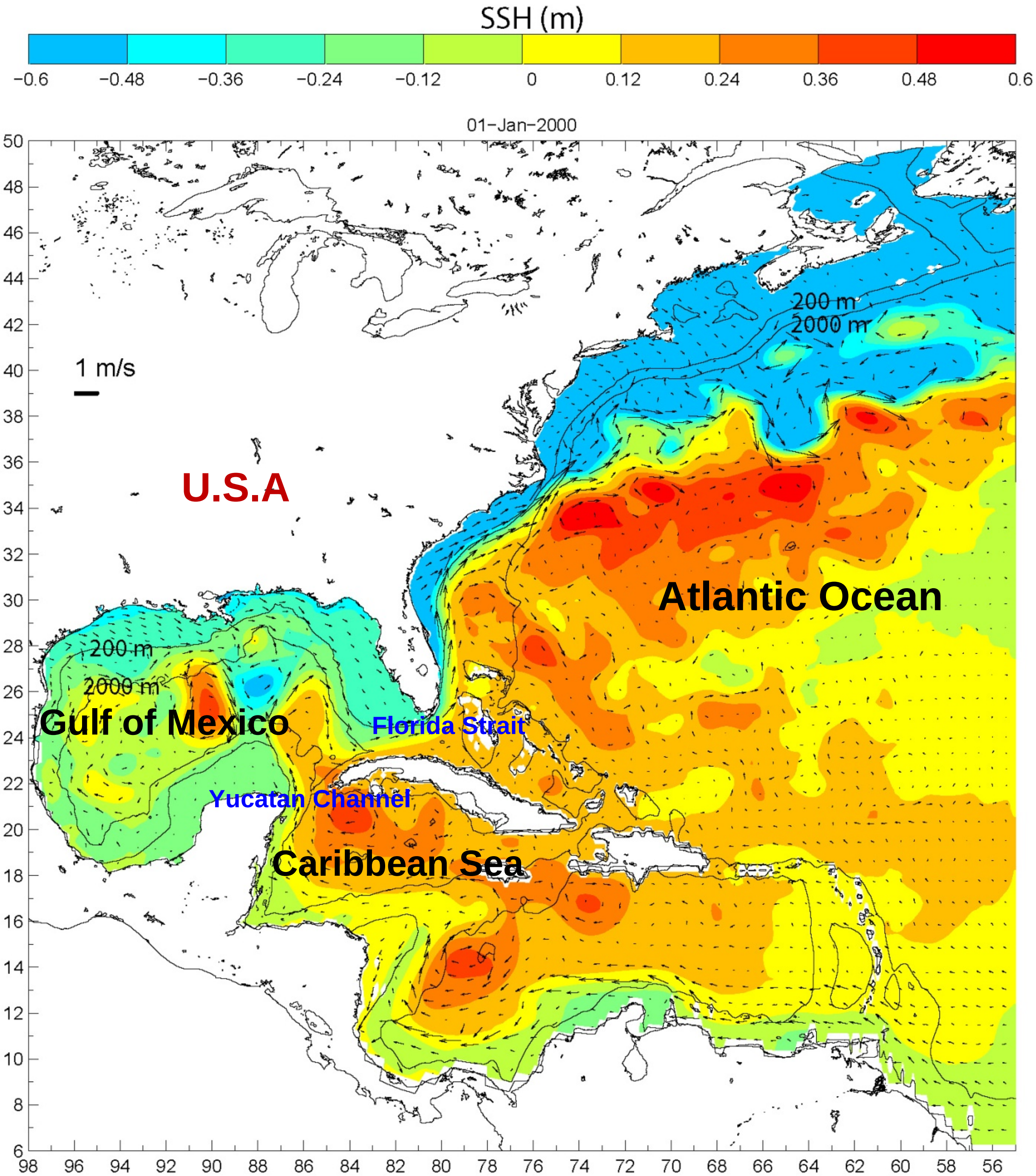
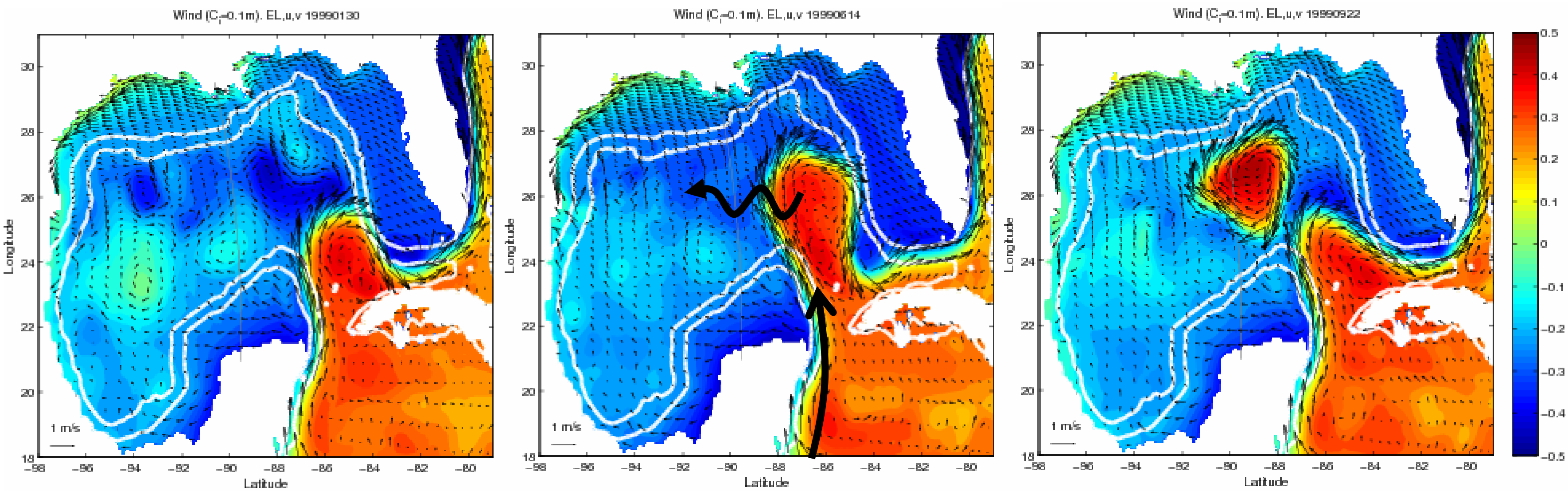
Why can wind delay the shedding of Loop Current eddies?

Yu-Lin Eda Chang[1,2] **and Lie-Yauw Oey**[1]

1. *Program in Atmospheric and Oceanic Sciences, Princeton University, USA*
2. *Dept. of Earth Sciences, National Taiwan Normal University, Taiwan.*



SSH (m)
−0.6
−0.48
−0.36
−0.24
−0.12
0
0.12
0.24
0.36
0.48
0.6
01−Jan−2000
1 m/s
U.S.A
Atlantic Ocean
Gulf of Mexico
Florida Strait
Yucatan Channel
Caribbean Sea
200 m
2000 m
200 m
2000 m
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
98
96
94
92
90
88
86
84
82
80
78
76
74
72
70
68
66
64
62
60
58
56



Period :2 ~20months

Westward speed (~ $-\beta R_d^2$) > growth rate

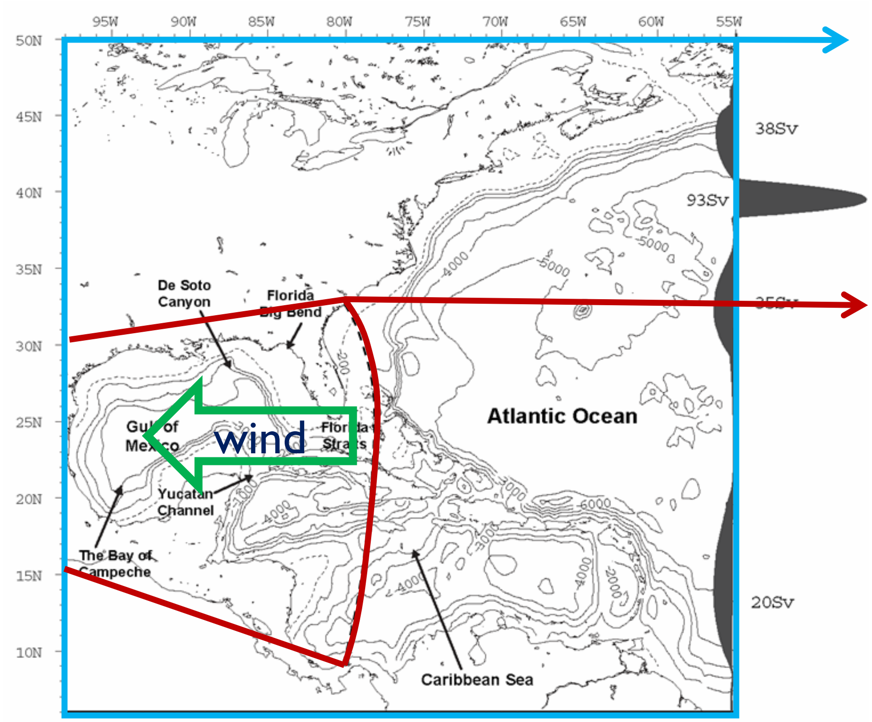
Nof [2005,JPO]

What I will show and explain:

- Shedding is delayed by wind
- Why it is delayed?

- The dynamics are closely connected to LC and ring sizes; it is also related to the way mass is redistributed within the Gulf → which leads to different mass exchanges

Princeton Ocean Model

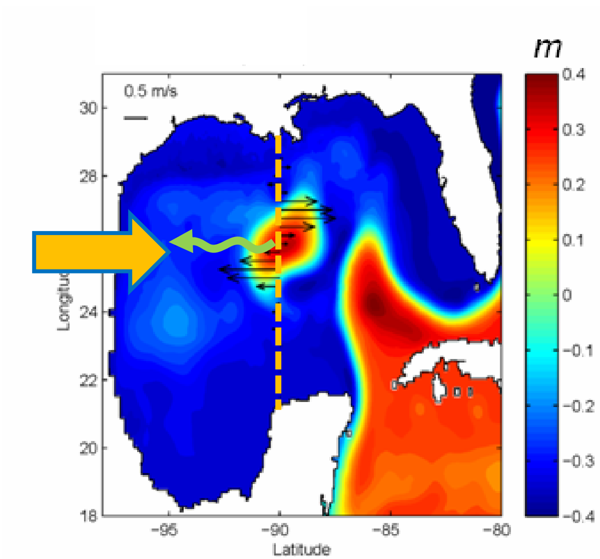


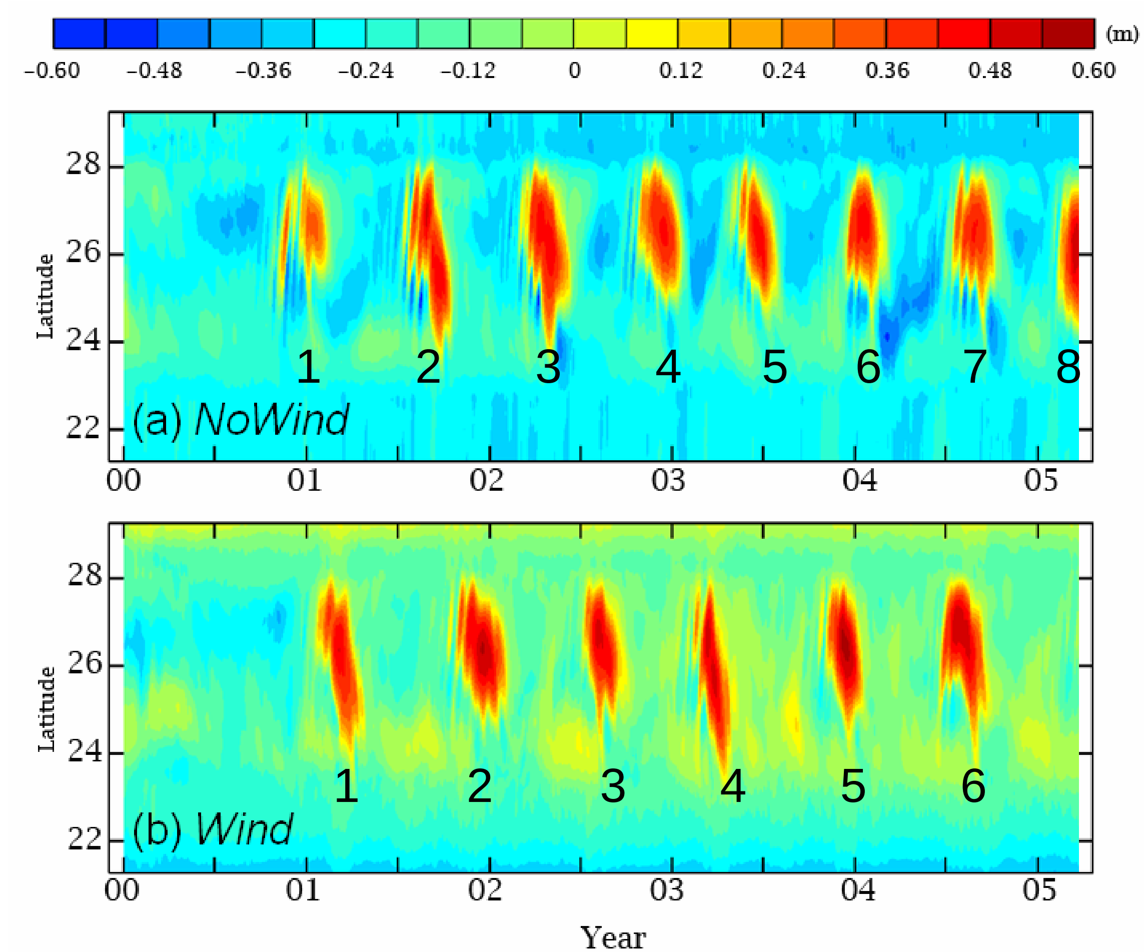
Northwest Atlantic Ocean model	
Resolution	~10km, 25 σ levels
Simulation time	20 years
B.C: climatology, τ=0	

Nesting finer grid model	
Resolution	~5km, 25 σ levels
Simulation time	10 years

Exp	NOWIND	WIND
τ_o^x	0	-0.1N/m^2
Heat flux	0	
Time	5 years	

Growing eddy and delay shedding



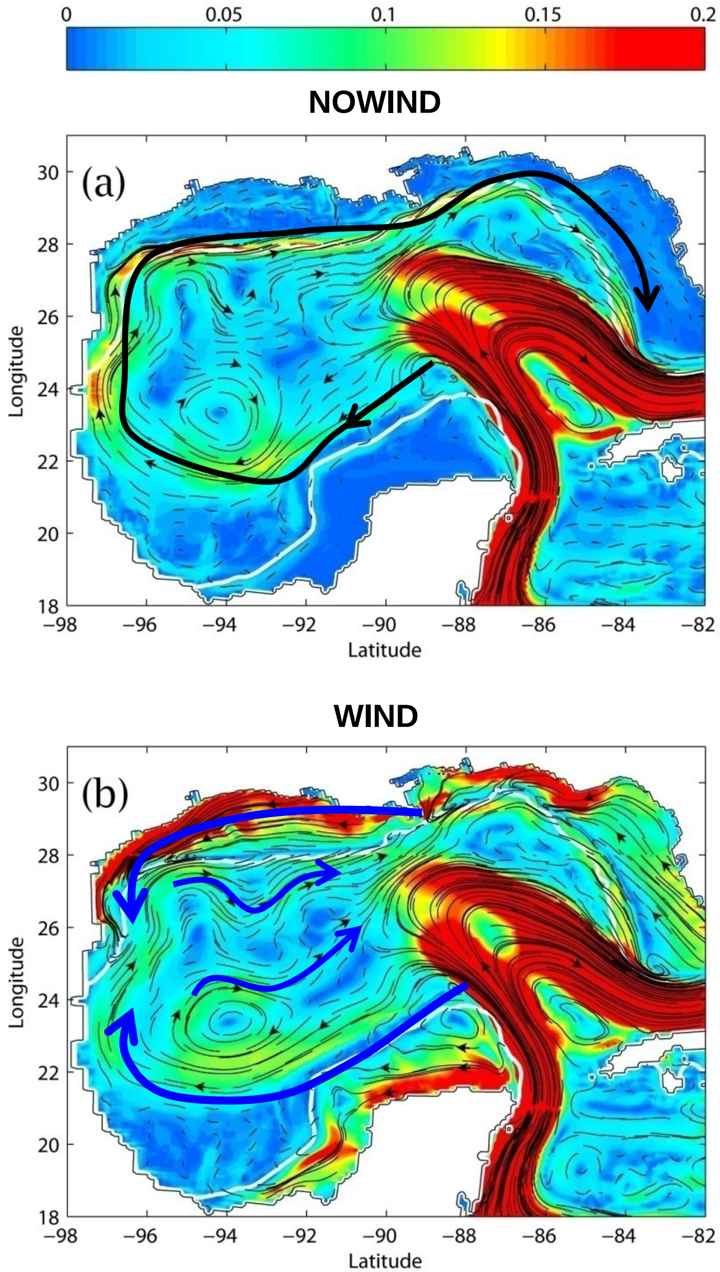


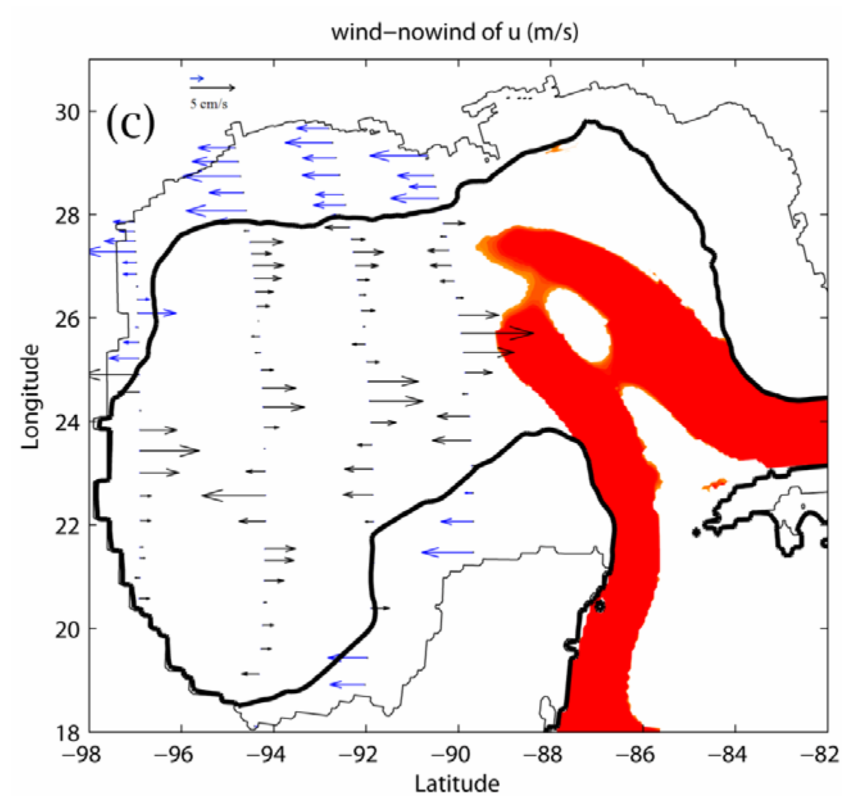
$P_{nowind} \sim 215$ days

$P_{wind} \sim 260$ days

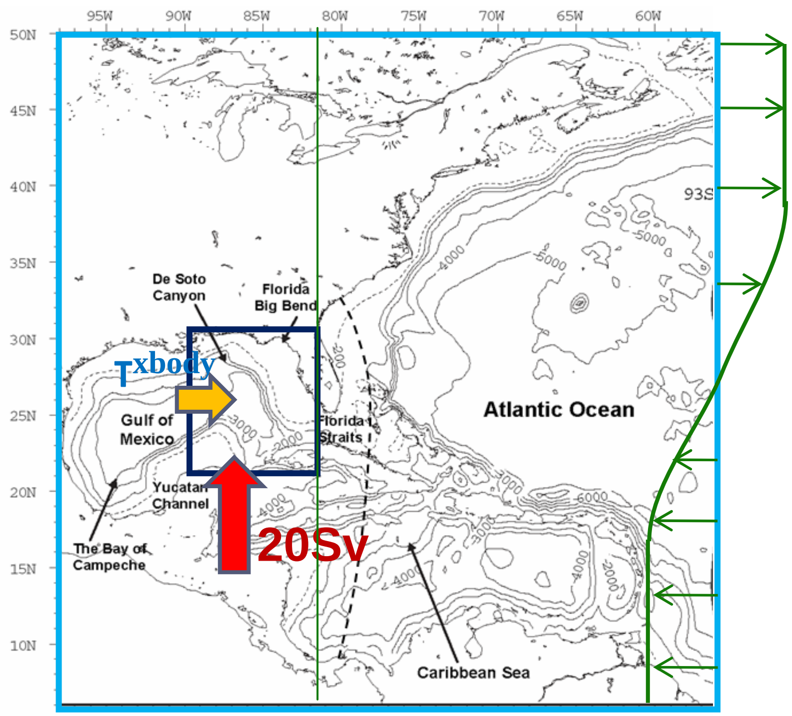
Circulation

5 years, upper 200m average





Reduced gravity Experiments



RGExp	τ^{xbody} ($m^2\ s^{-2}$)	P_{shed}(days)
1	0	260
2	2×10^{-4}	280
3	8×10^{-4}	360
4	-2×10^{-4}	245

- Specify wind stress to drive a gyre
- No topography, no shelf current:

Specified τ^{xbody} as return momentum flux

- Following Pichevin and Nof [1997,Tellus]

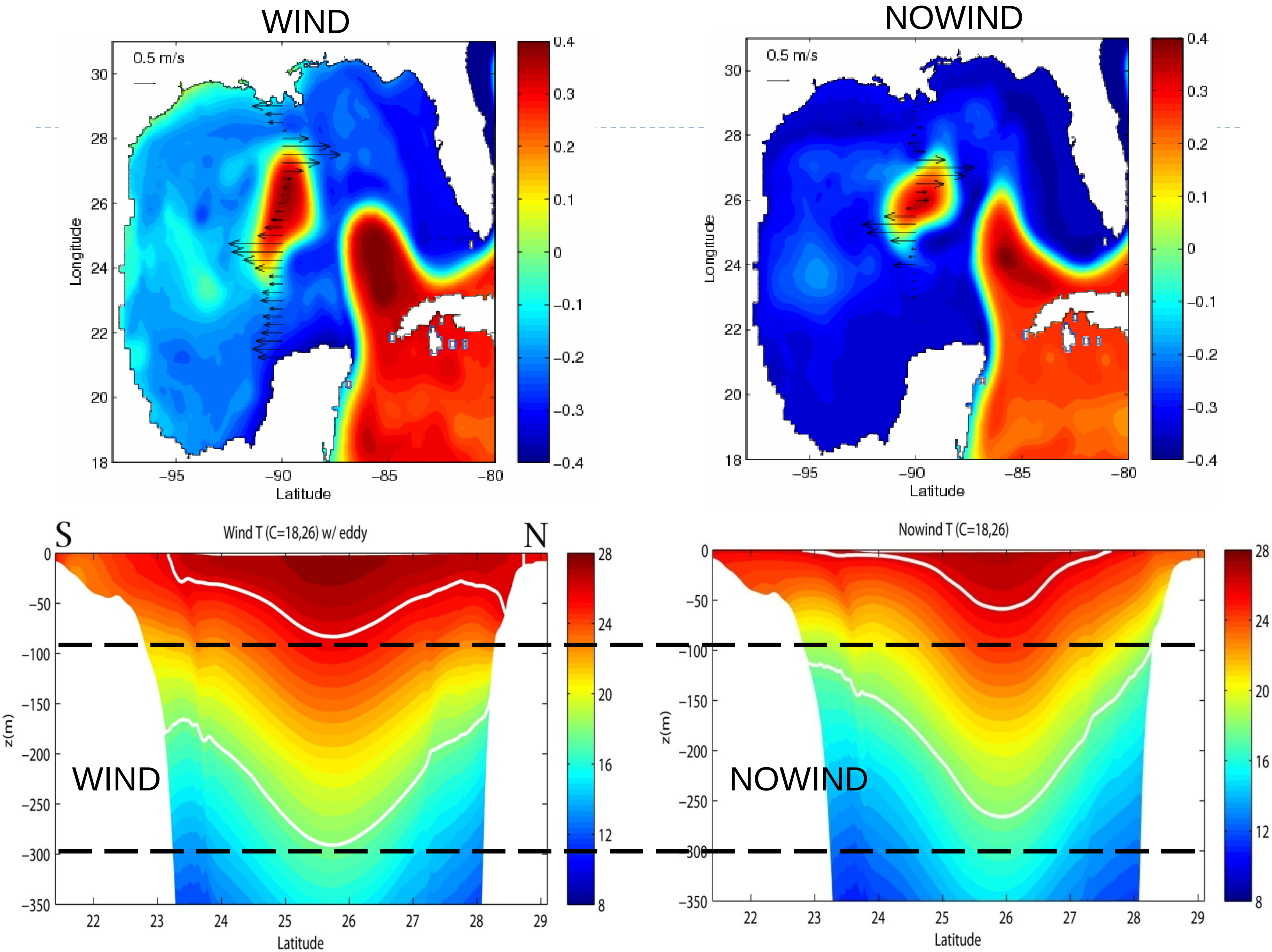
(steady state, inviscid, x-momentum eq.)

$$\cancel{\int_{Florida} hu^2 dy = 0}$$

$$\frac{\partial}{\partial t}(\ldots) = \int_{Florida} hu^2 dy$$

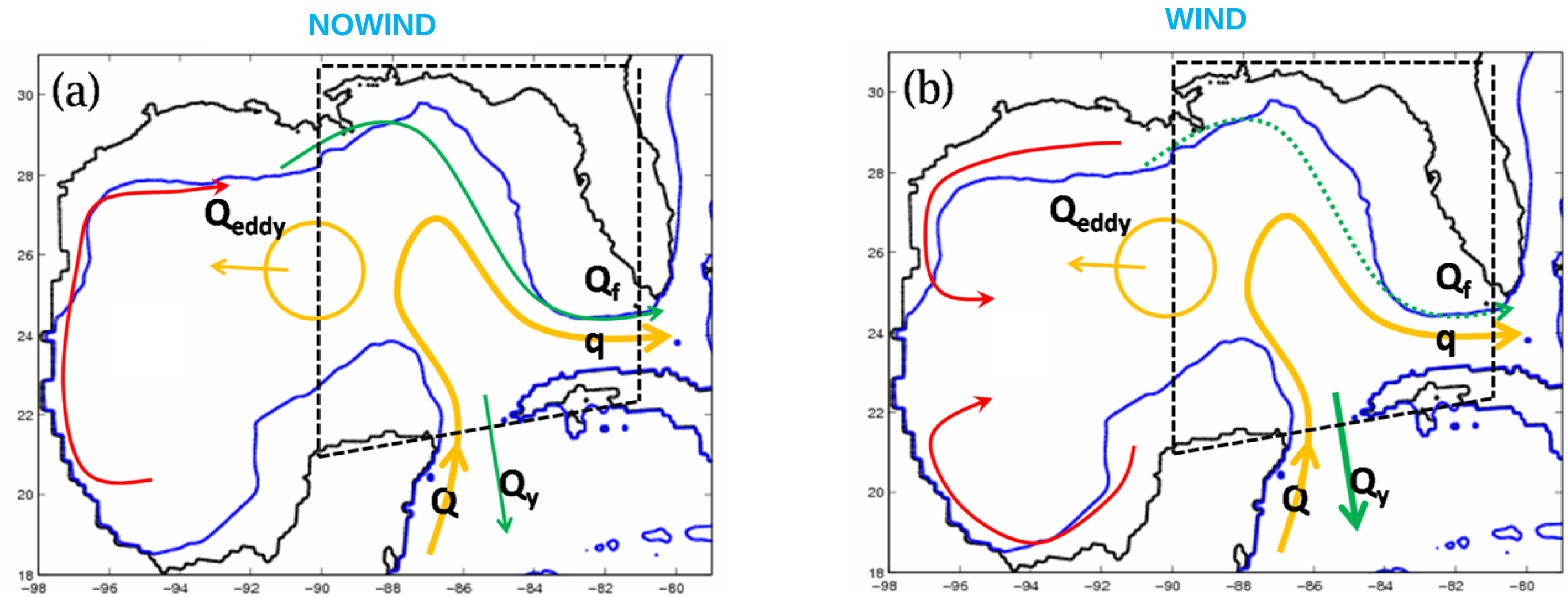
$$\frac{\partial}{\partial t}(\ldots) = \int_{Florida} hu^2 dy - \iint_{S_{EG}} \tau^{xbody} dS_{EG}$$

- Run for 15 years, g'=0.01m/s^2, H=600m



WIND
0.5 m/s
Longitude
Latitude
NOWIND
0.5 m/s
Longitude
Latitude
S
Wind T (C=18,26) w/ eddy
N
z(m)
WIND
Latitude
Nowind T (C=18,26)
z(m)
NOWIND
Latitude

Mass balance



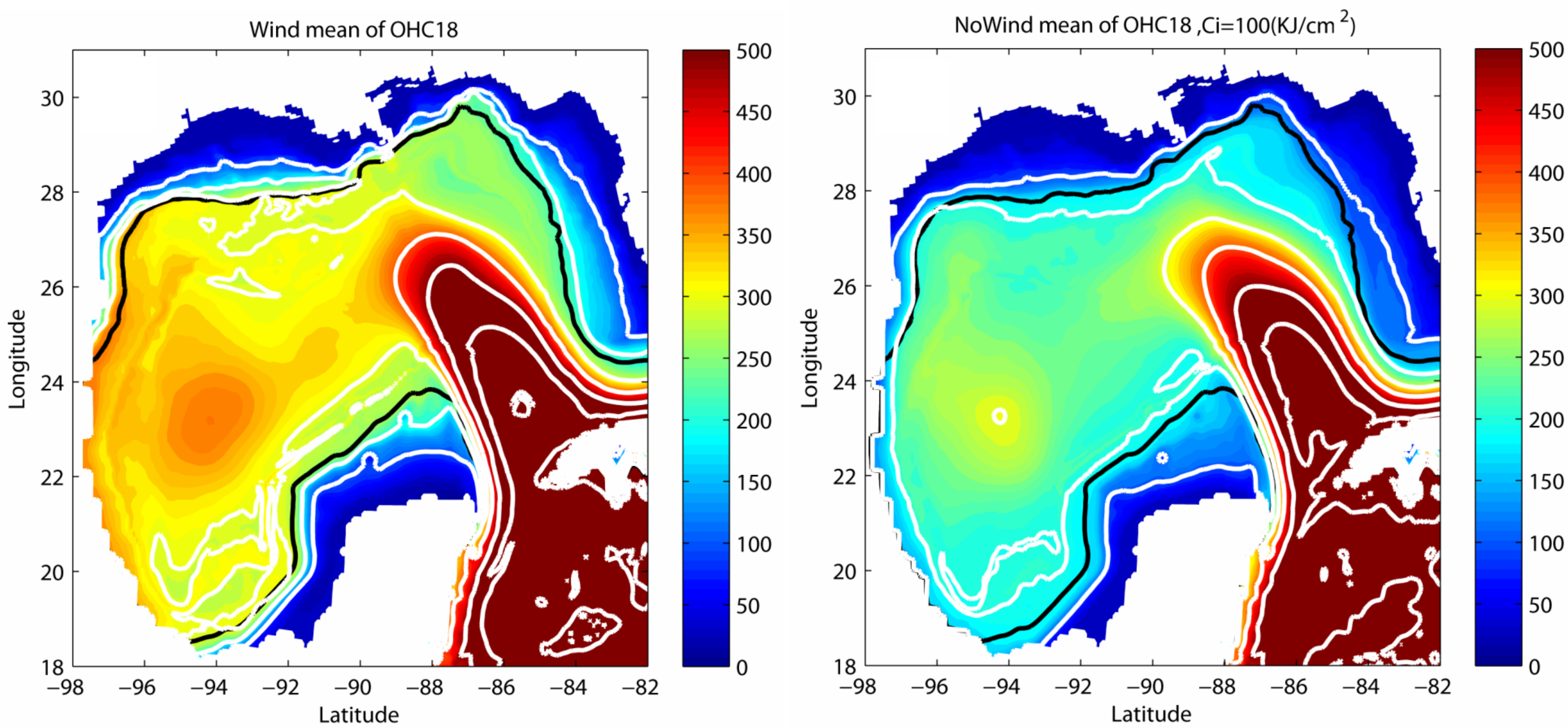
$Q\text{-}Q_y = q + Q_f$

$Q_{eddy} = Q\text{-}q = Q_y + Q_f$

Transports (Sv)	No Wind	Wind
Yucatan Inflow Q	30.6	33.2
Yucatan Outflow Q_y	6.9	9.2
Westward Eddy Q_{eddy}	13.1	13.2
Florida Outflow $q = Q - Q_{eddy}$	17.5	20.0
Florida Eddy Outflow $Q_f = Q_{eddy} - Q_y$	6.2	4.0

Discussion

$$OHC = \rho_r c_p \int_{z18}^{\eta} (T - 18) dz$$



Conclusions

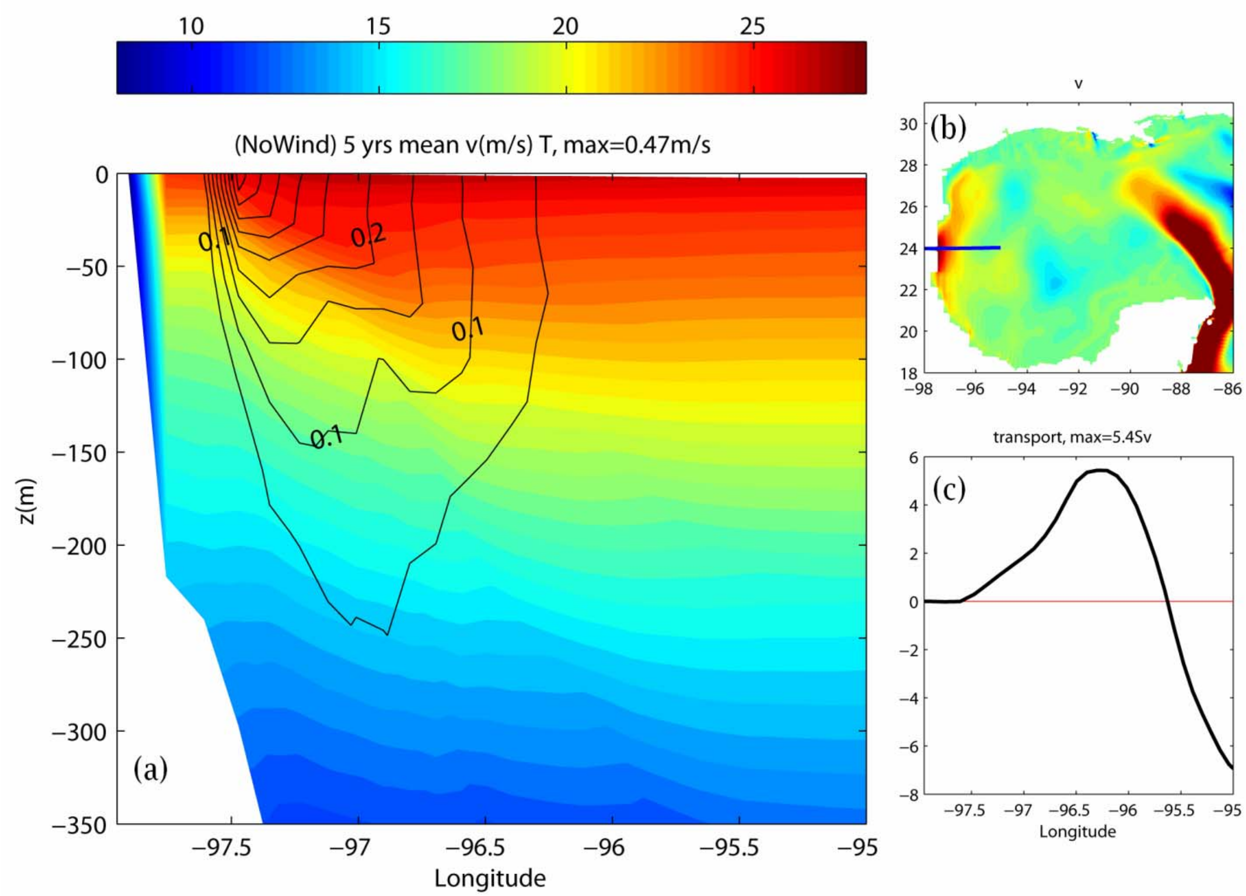
- Wind produces westward transport over the shelves, and a returned flow in central basin towards the Loop Current.

- The returned flow constitutes a zonal momentum flux, delaying eddy shedding; this finding is confirmed by reduced gravity experiments, and it is *general*.

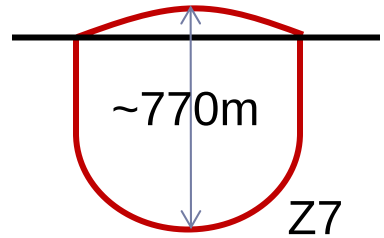
- Returned flow forces larger and stronger Loop & rings

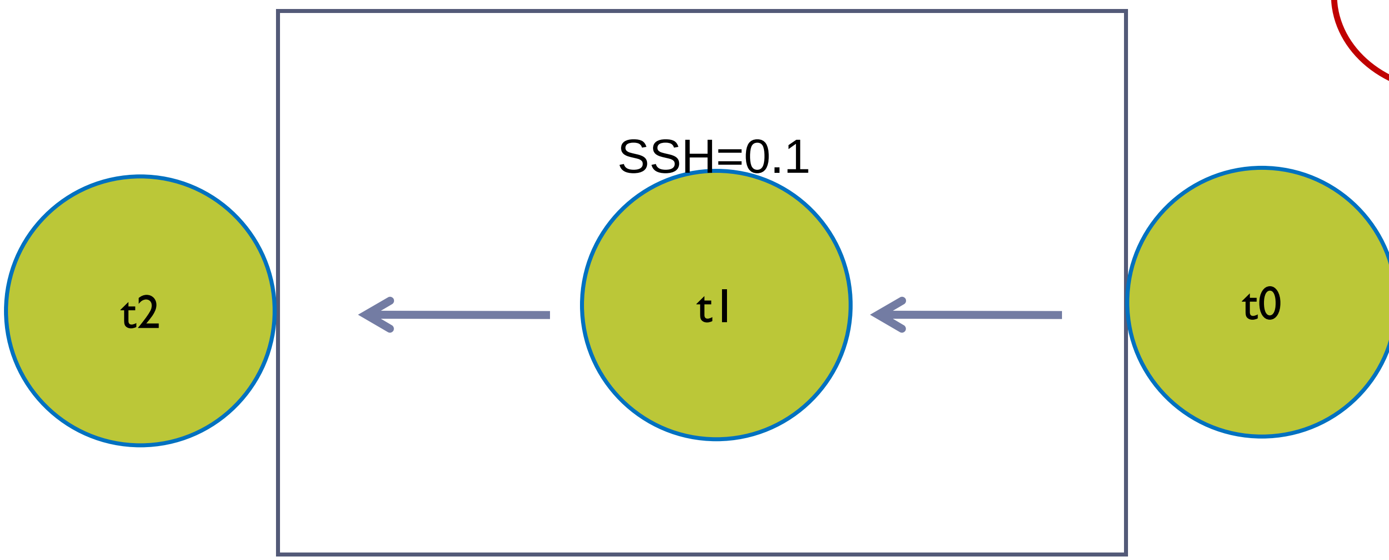
- Winds increase the Yucatan-Caribbean Sea exchange

Thank you!



10
15
20
25
(NoWind) 5 yrs mean v(m/s) T, max=0.47m/s
0
−50
−100
−150
−200
−250
−300
−350
z(m)
0.1
0.2
0.1
0.1
(a)
−97.5
−97
−96.5
−96
−95.5
−95
Longitude
v
(b)
30
28
26
24
22
20
18
−98
−96
−94
−92
−90
−88
−86
transport, max=5.4Sv
(c)
6
4
2
0
−2
−4
−6
−8
−97.5
−97
−96.5
−96
−95.5
−95
Longitude

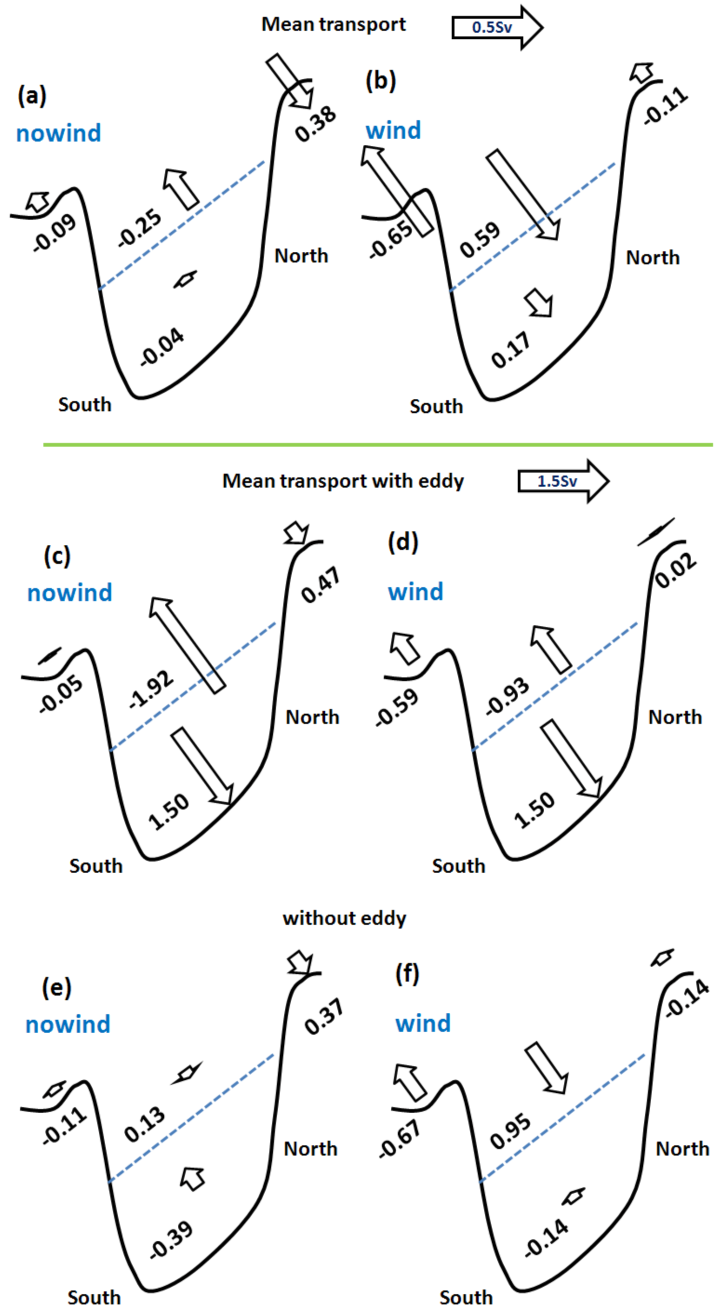




Distance/passing time=speed

Width*depth*speed=Q_{eddy}

Wind:235km*770m*7.3cm/s
Nowind:195km*770m*8.7cm/s


Mean transport
0.5Sv
(a)
nowind
-0.09
-0.25
-0.04
0.38
North
South
(b)
wind
-0.65
0.59
0.17
-0.11
North
South
Mean transport with eddy
1.5Sv
(c)
nowind
-0.05
-1.92
1.50
0.47
North
South
(d)
wind
-0.59
-0.93
1.50
0.02
North
South
without eddy
(e)
nowind
-0.11
0.13
-0.39
0.37
North
South
(f)
wind
-0.67
0.95
-0.14
-0.14
North
South