Does Ocean-Atmosphere coupling influence the properties of Tropical Instability Waves (TIW)?

O acoplamento Oceano-Atmosfera influencia as características das Ondas de Instabilidade Tropical (OIT)?

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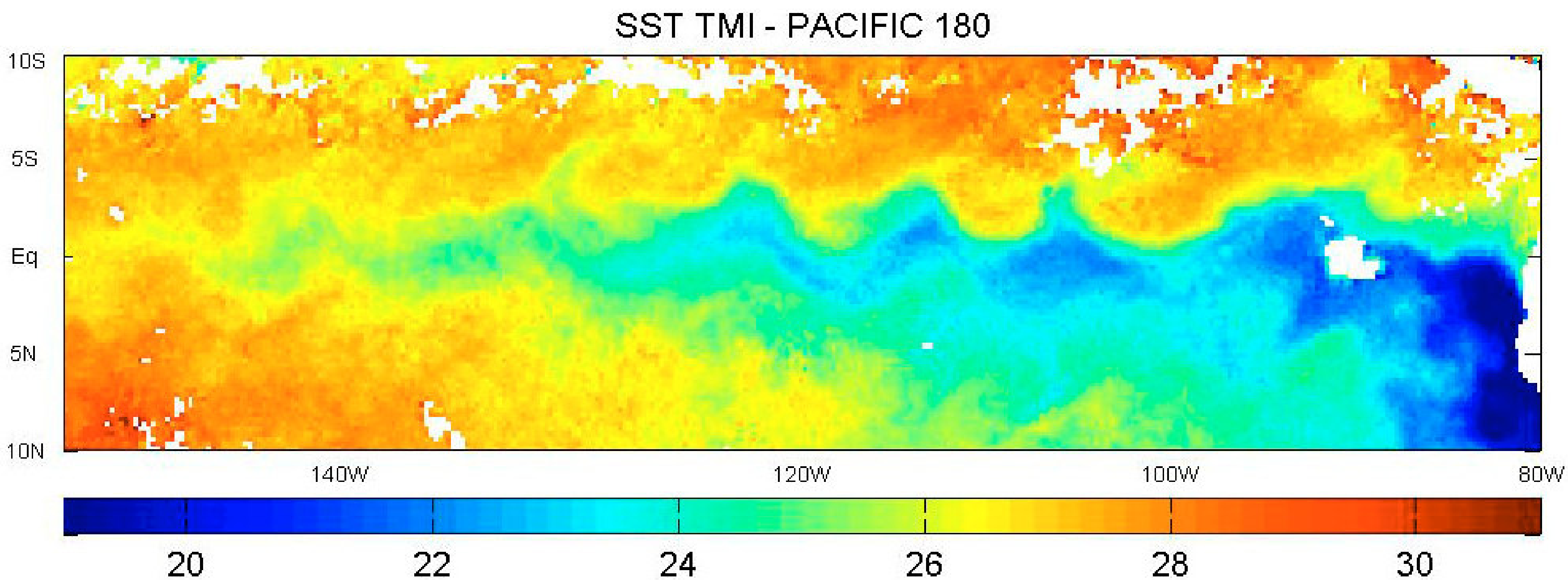
Tropical Instability Waves (TIW)

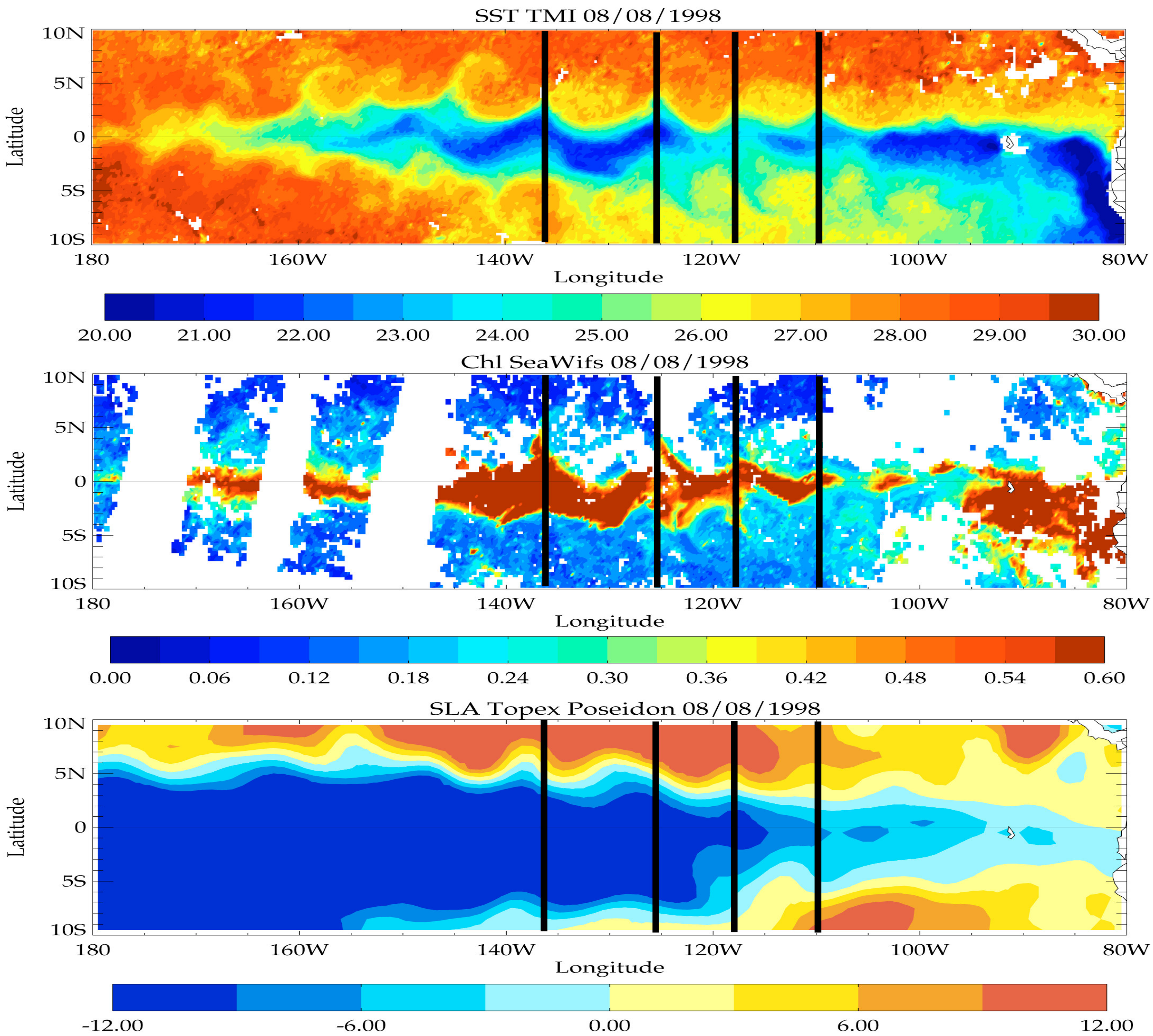


They can be seen as cusp shaped distortions of SST front.

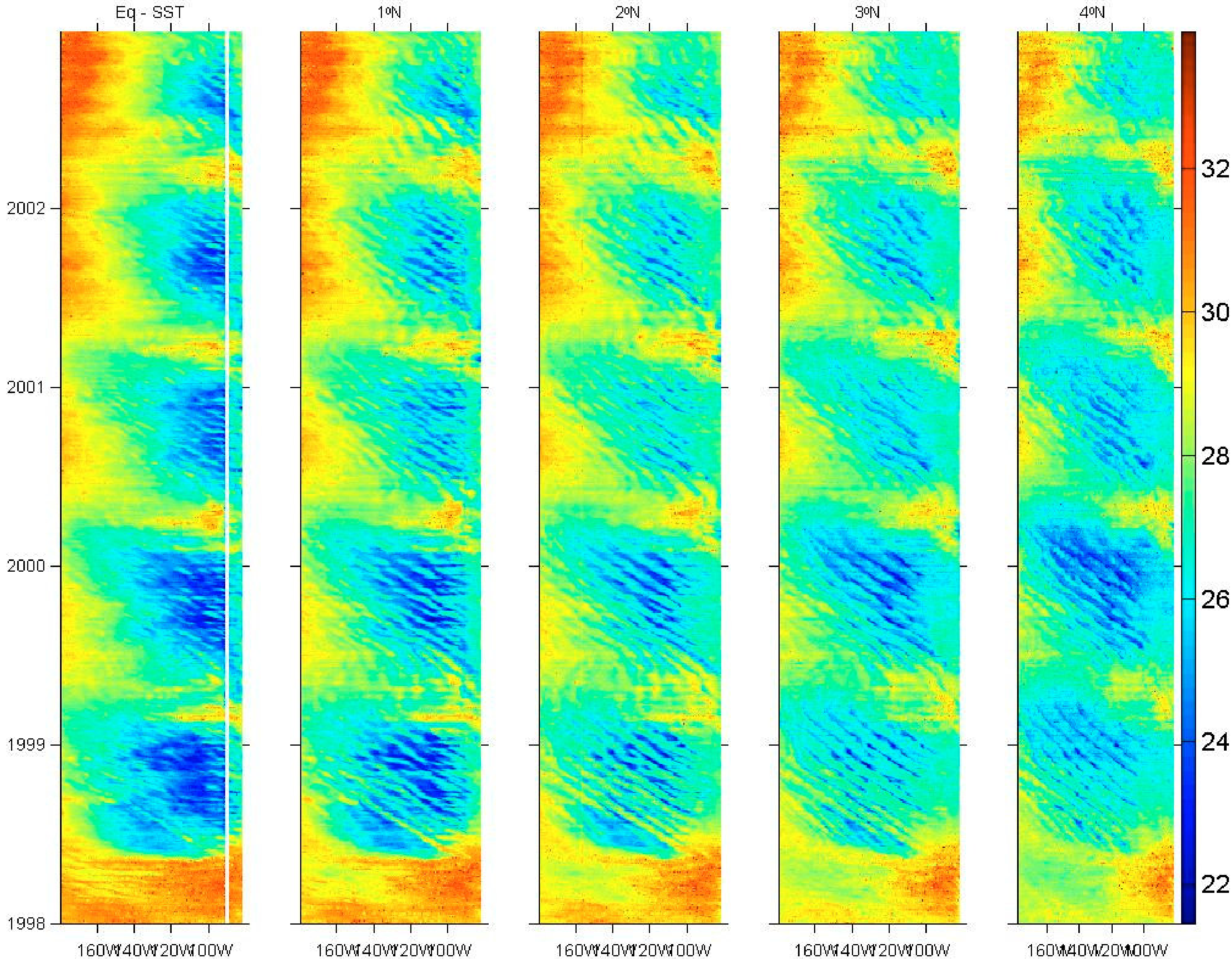
TIWs are mesoscale perturbations of currents and temperature in the upper eastern equatorial Pacific and Atlantic oceans and appear to play significant roles in the mean balances of momentum heat and energy.

TIWs three dimensional dynamics have a strong impact on biological ecosystems provoking unusual fronts and organism concentration off the equator.

TIWs Imprints

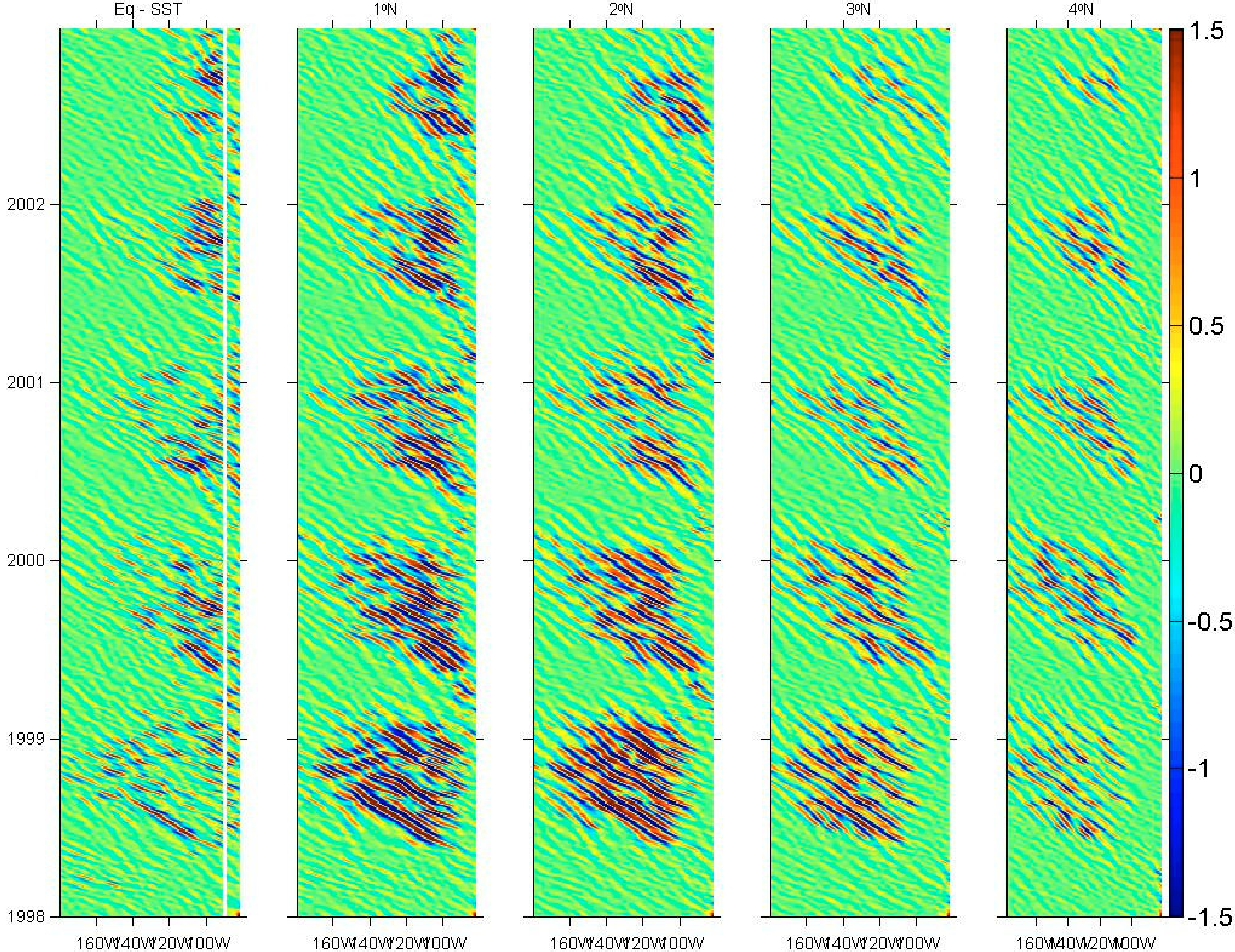


Raw data (TMI) TIWs Seasonality



Source: Pezzi (2003)

Filtered data (TMI) TIWs Seasonality



Source: Pezzi (2003)

TIW characteristics (Pacific ocean)

Wavelength: 700-2000 km (Legeckis, 1977), (Qiao and Weisberg, 1995, Chelton *et al* 2000)

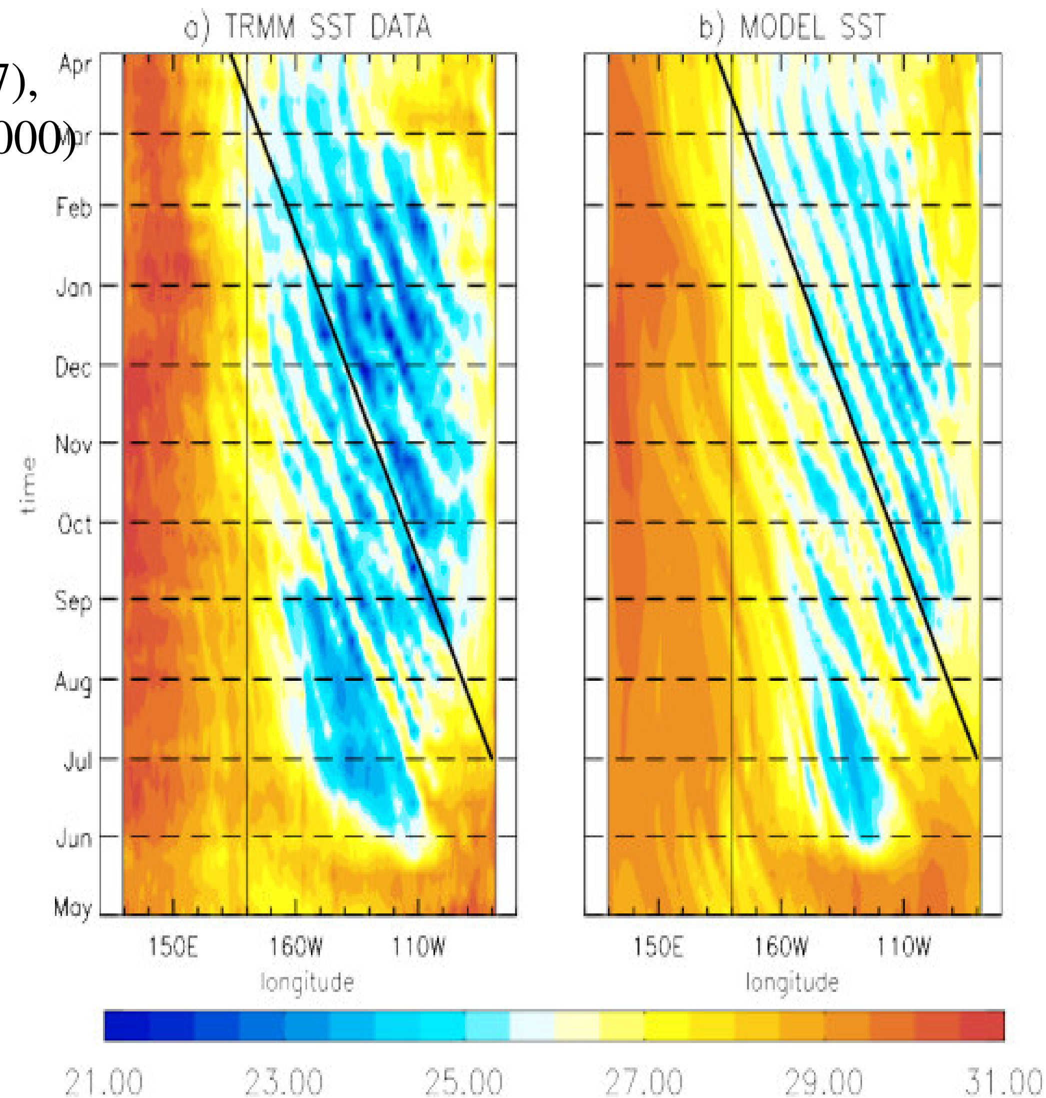
Period: 20-60 days

Phase speed: 30 to 60 cm/s (Chelton et al., 2001)

Season: ~ July to March

Origin: Current shear
(EUC-SEC, SEC-NECC)
Density (Temperature) gradient

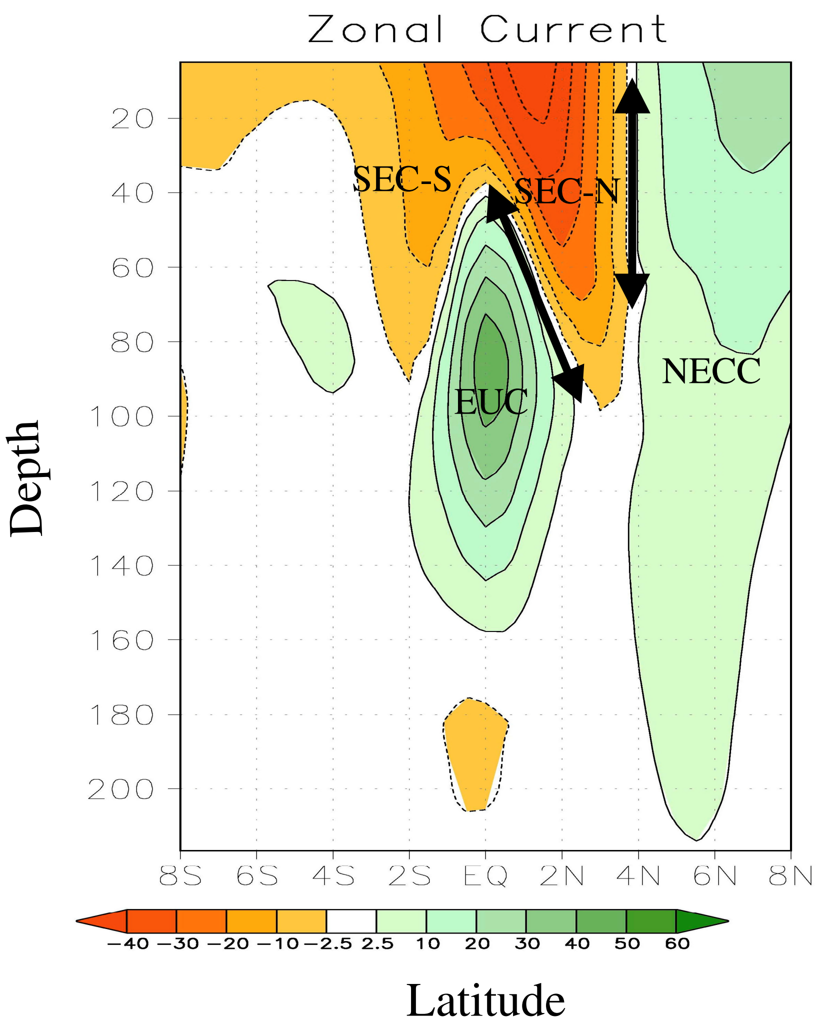
Energy Source: Barotropic and Baroclinic Instability; Masina *et al*.(1999ab)

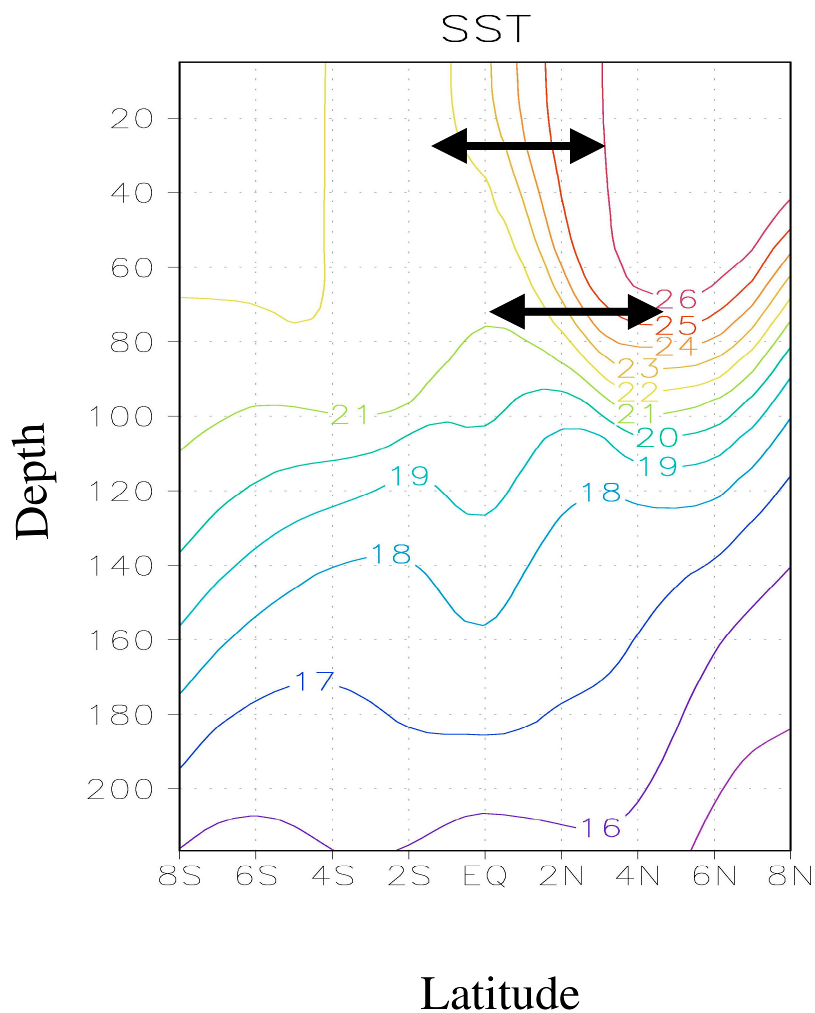


Source: Vialard *et al*. (2001)

TIWs - Energy Sources (triggering mechanism) :

Barotropic and Baroclinic
Instabilities





Motivation: TIW and Ocean-Atmosphere Interactions

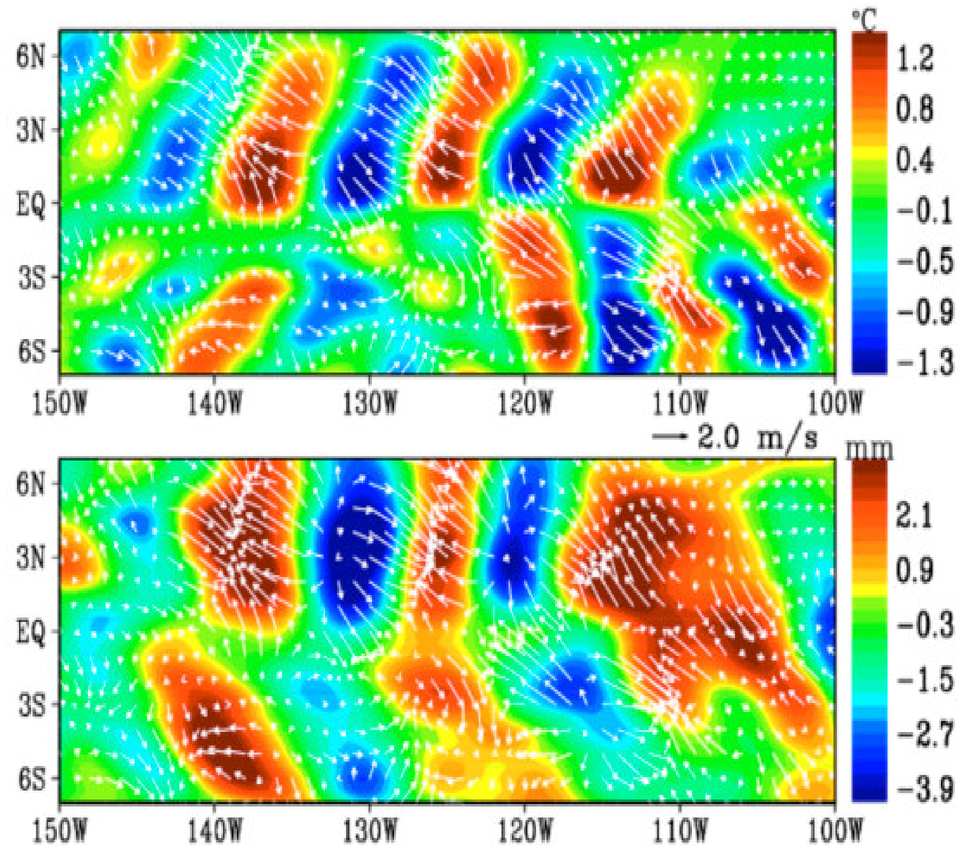
TIWs are an oceanic phenomena, however there is a signal of TIW activity within (Atmospheric) Planetary Boundary Layer (PBL).

TWO POSSIBLE MECHANISMS AFFECTING SURFACE WIND:

- Lindzen and Nigan (1987), Wallace *et al* (1989) - wind is affected by Sea Level Pressure (SLP) gradient.
- Hayes *et al* (1989) - wind is affected by PBL stability.

Liu *et al* (2000) and Chelton et al (2001) suggest 2nd mechanism in observational study.

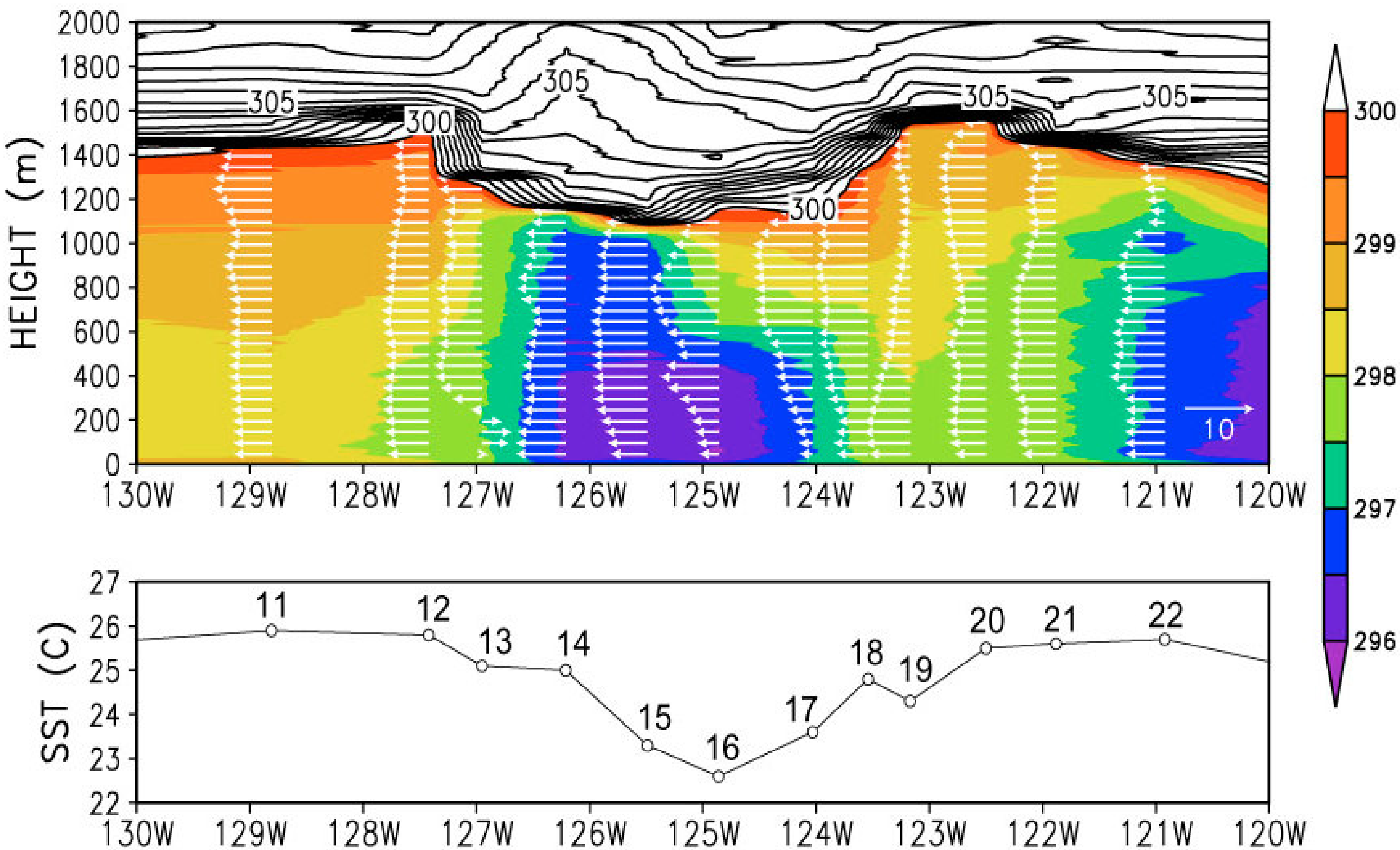
Wind vector anomalies superimposed on (a) SST and (b) Water Vapor anomalies



(Source: Liu *et al*. 2000)

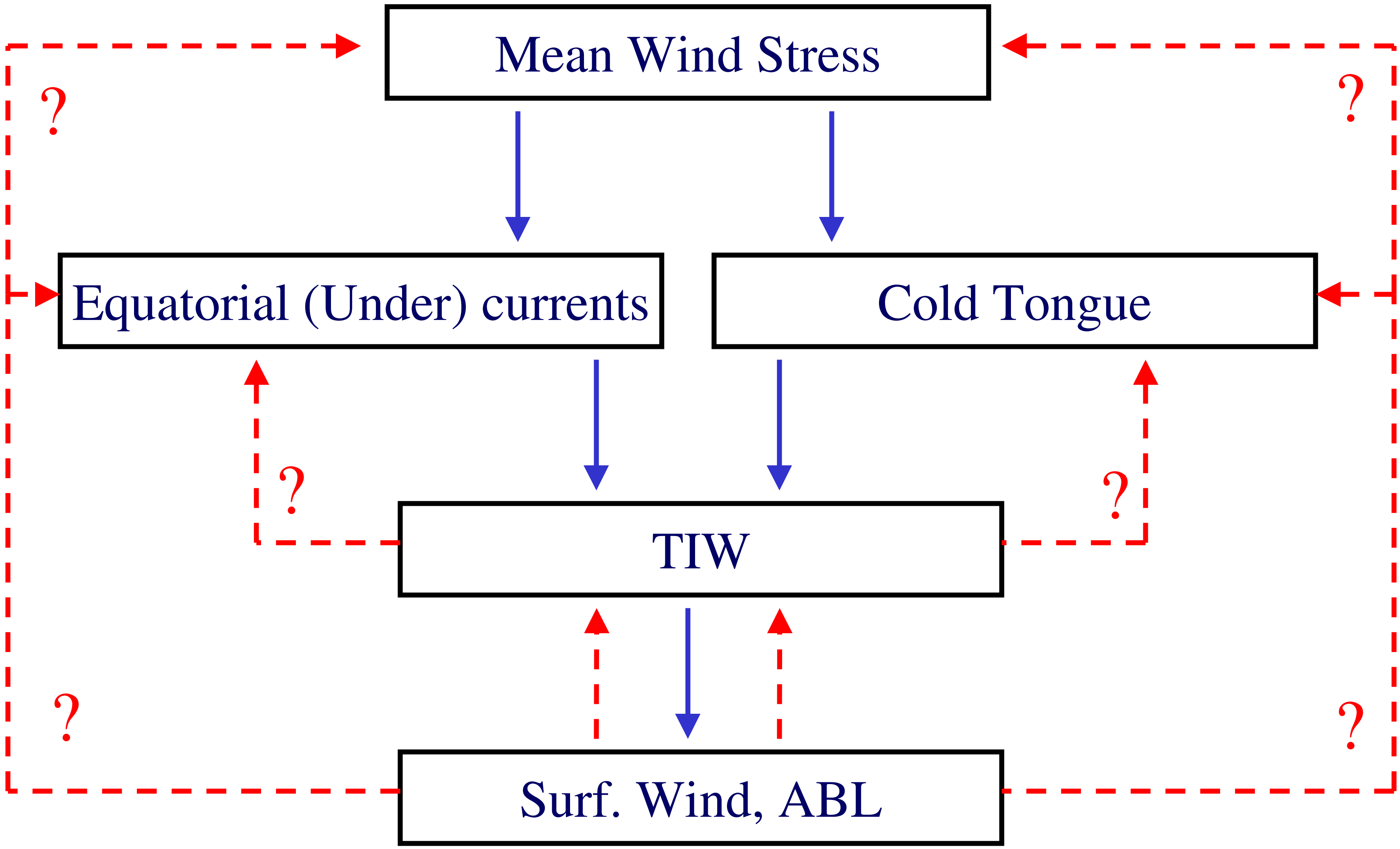
Hashisume et al (2002) , have confirmed using observed data the 2nd mechanism. Surface wind is affected by the PBL stability.

Cruise preiod from 16/09/1999 to 09/10/1999



What do we know up to now?

TIW Schematic feedback



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Objectives

- TIWs influence the ABL characteristics. Does this influence feedback on TIWs characteristics? (variability, amplitude, propagation speed, timescale)
- Does TIWs coupling influence the oceanic mean state?

Method

- Ocean general circulation model experiments, coupled with a simplified ABL parameterization

➡ First question: is it possible to reproduce the observed SST - wind stress coupling ?

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CTL Experiment Set-up:

TAO + ERS - daily wind climatology
1993-1996 (Vialard et al 2001)

Ocean Model:

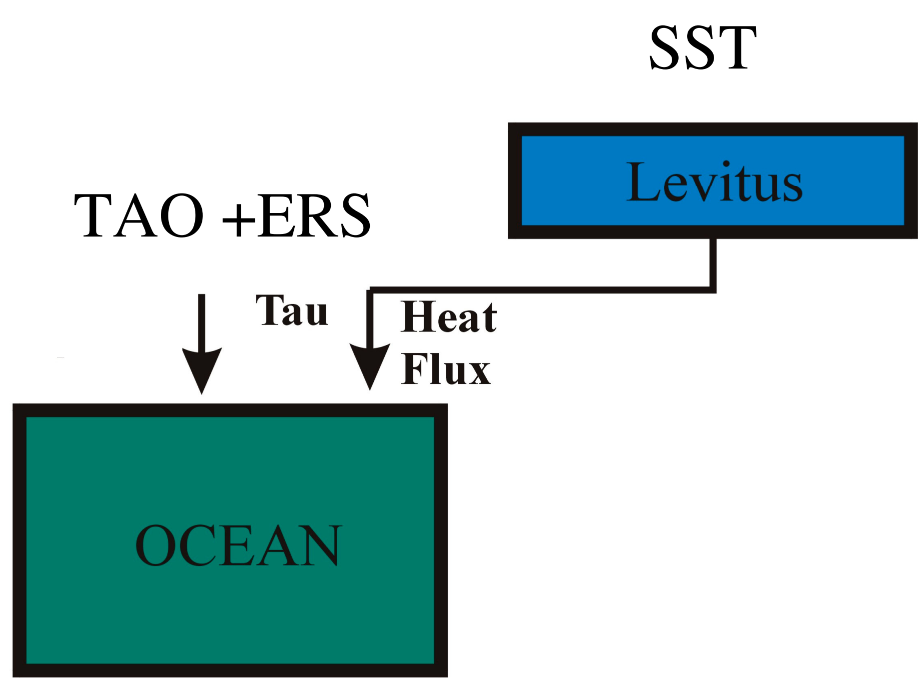
OPA 8.1-LODYC, Madec *et al* (1998)
Resolution:
0.5 ° Latitude – Equatorial Region
1.0 ° Longitude
Isopycnal lateral mixing
(Tracers + momentum)

Spin up:

-Starts from the rest and run for 60 years, constant forcing (October)

-2 additional years for analyses of Sensitivity

Non interactive case



Restart from CTL :

TAU function of SST

$$\vec{\tau} = \vec{\tau} + \begin{pmatrix} \alpha \, (SST - \overline{SST} \,) \\ \beta \, (SST - \overline{SST} \,) \end{pmatrix}$$

where

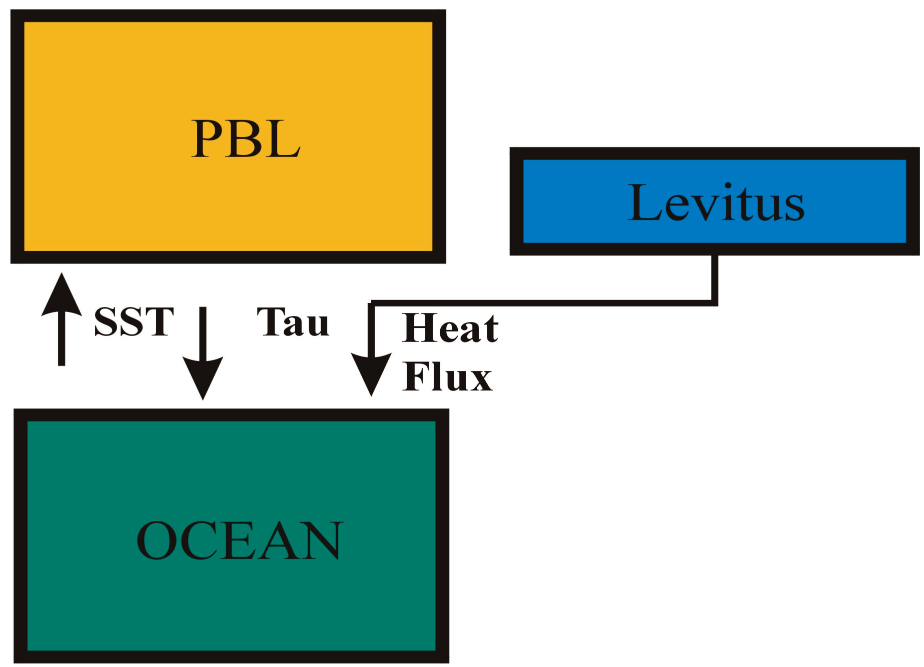
$$\begin{cases} \alpha \rightarrow Zonal \\ \beta \rightarrow Merid. \end{cases}$$ Coupling Coeffficients

$$SST' = SST - \overline{SST}$$

$\vec{\tau} =$ ERS + TAO Wind

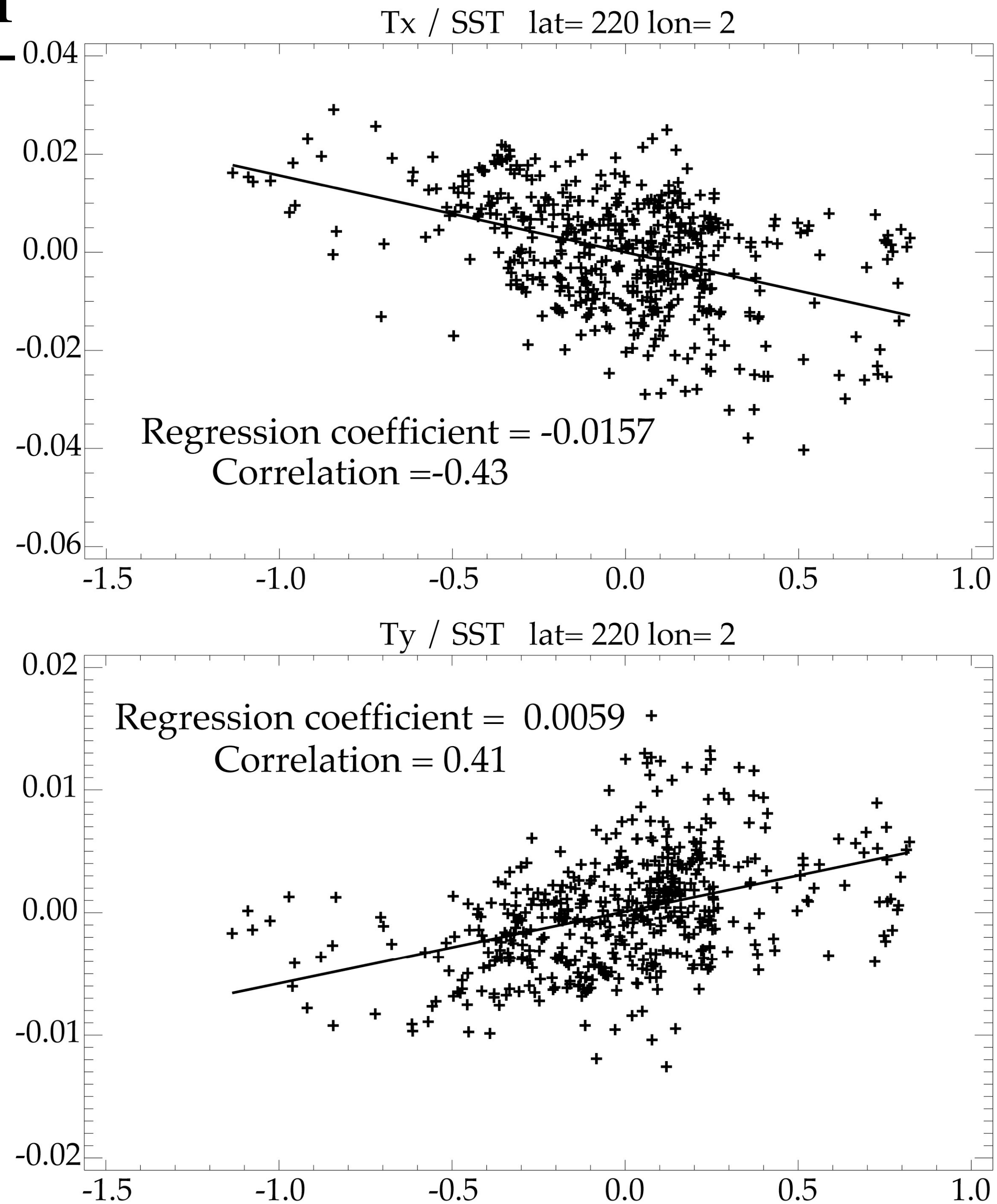
Interactive Case

TAO+ERS



Regression wind stress / SST

	Alpha	Beta
STD	-0.02	0.008
MID	-0.03	0.012
HIG	-0.05	0.02



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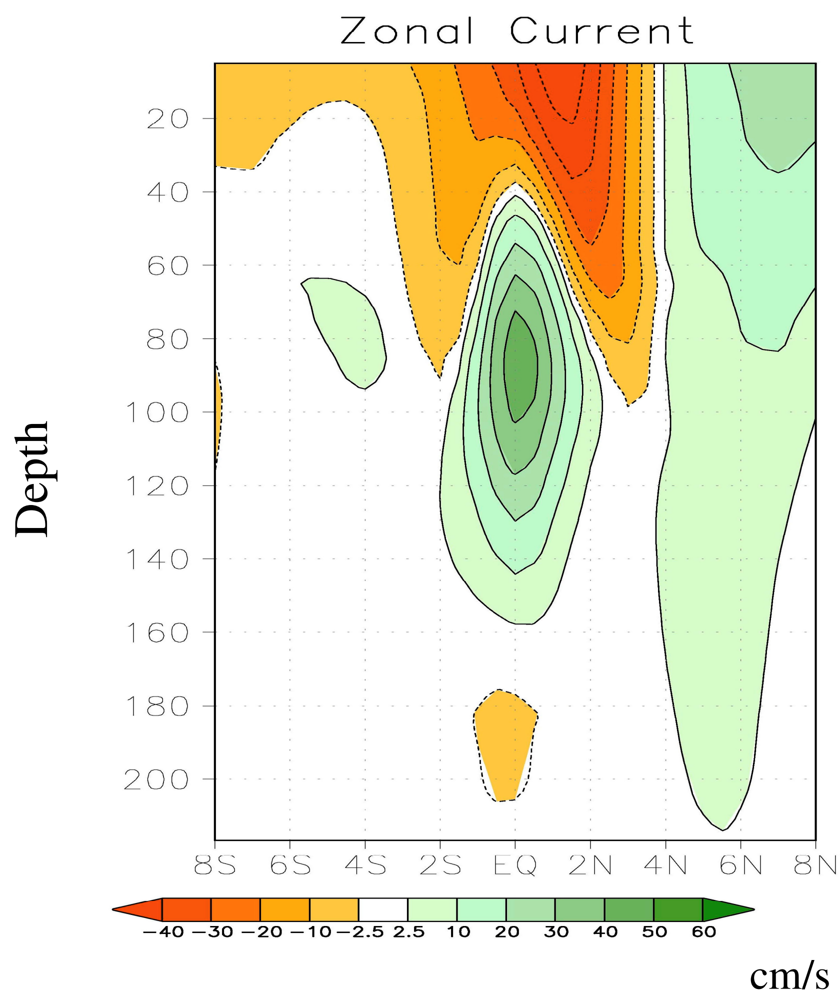
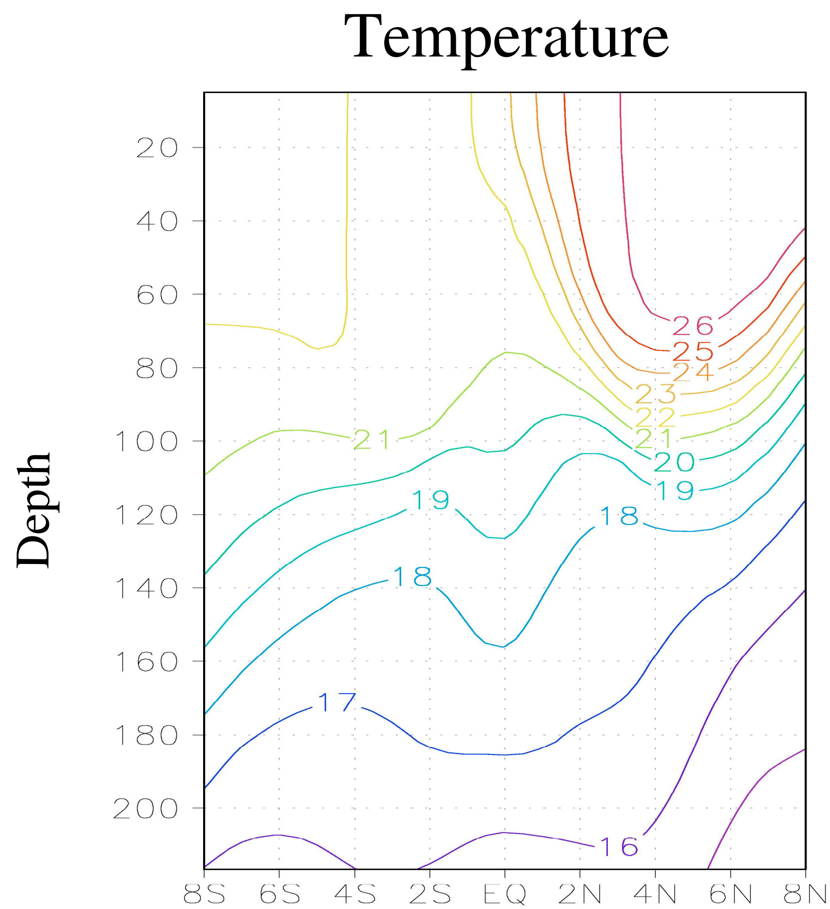
Mean State Analysis: Vertical Section at 100E - CTL Experiment

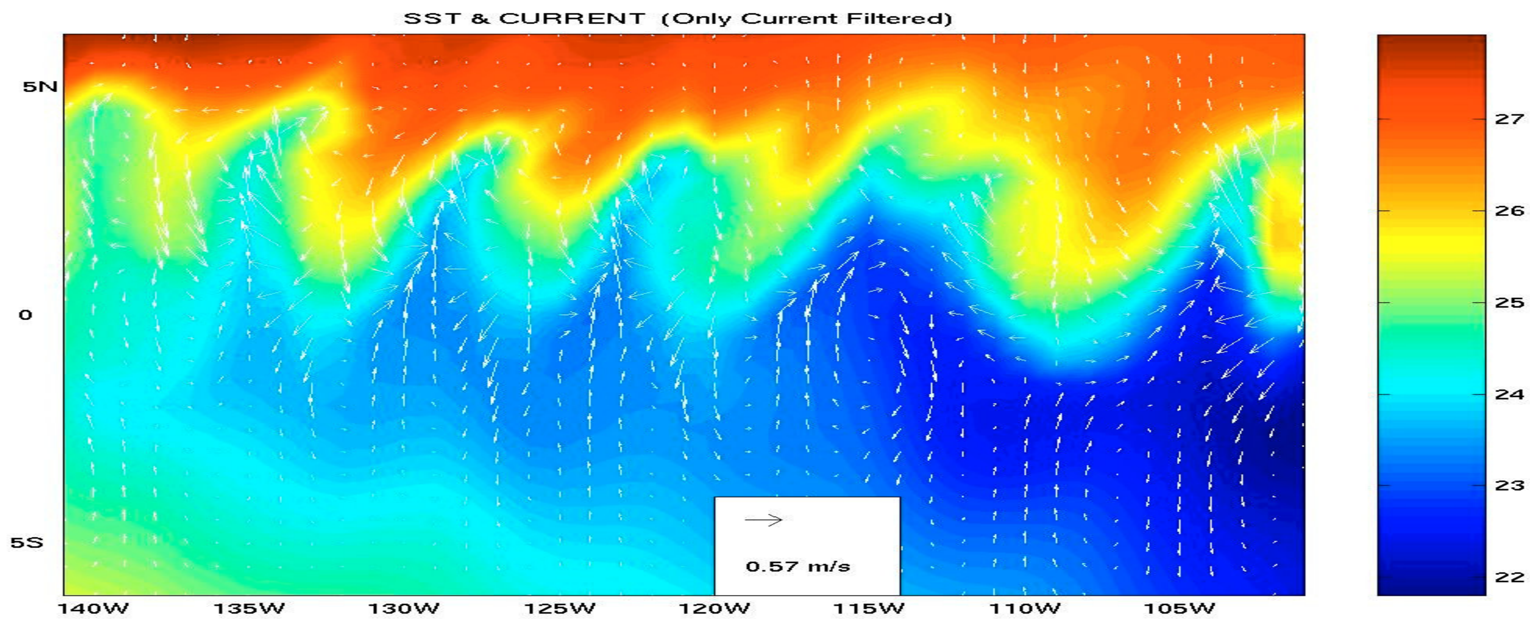
- •EUC, NECC
- •SEC (Northern and Southern) branches
- •Eastern upwelling region (cold tongue)



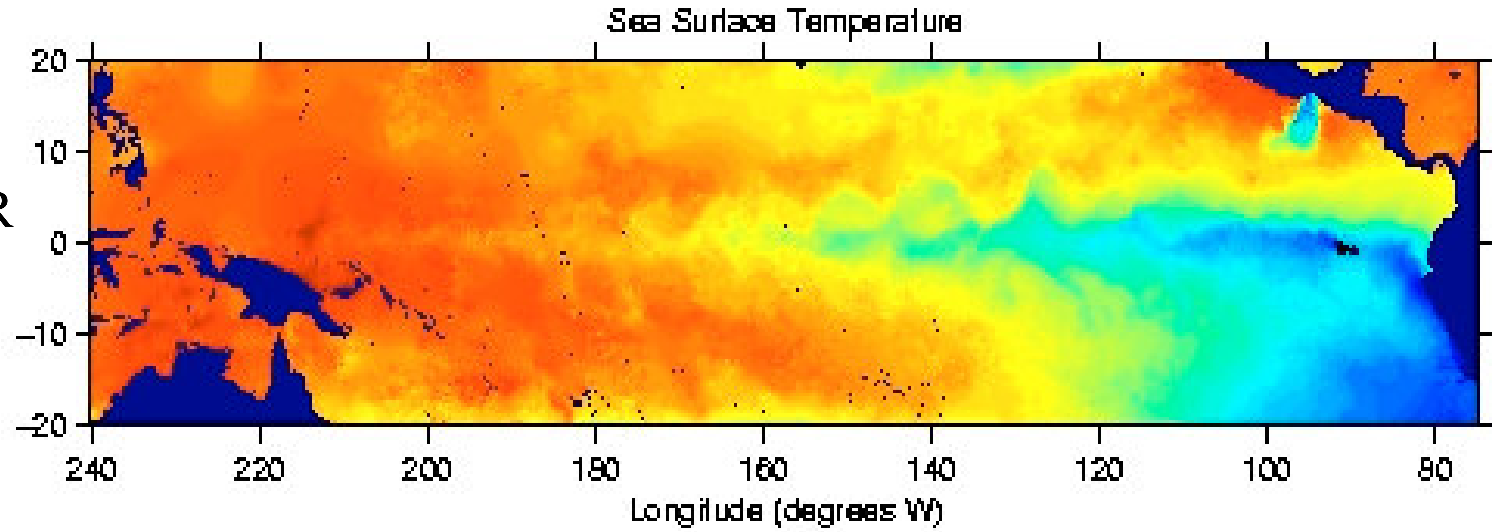


Tropical Instability Waves Results

Model

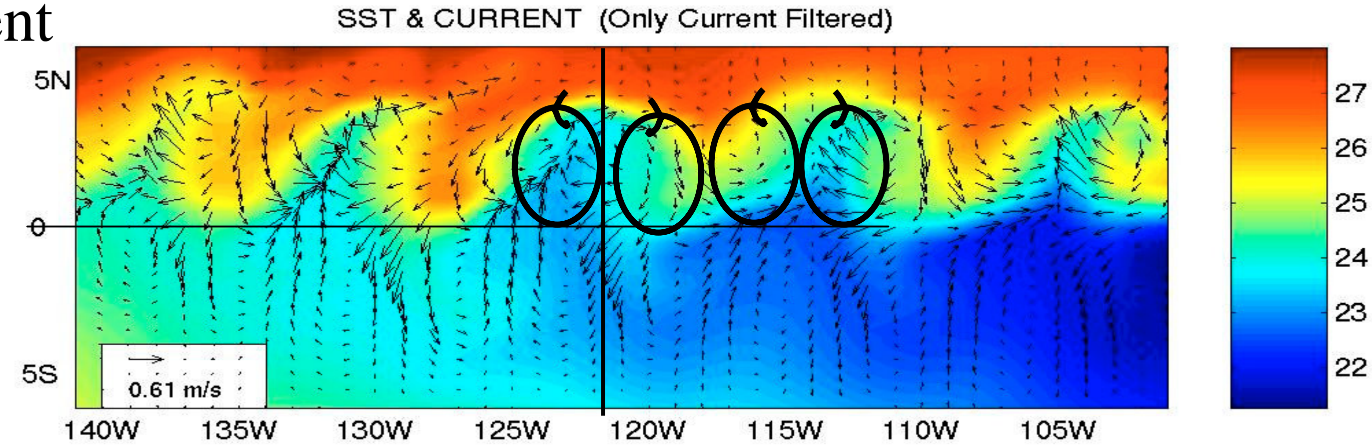


AVHRR

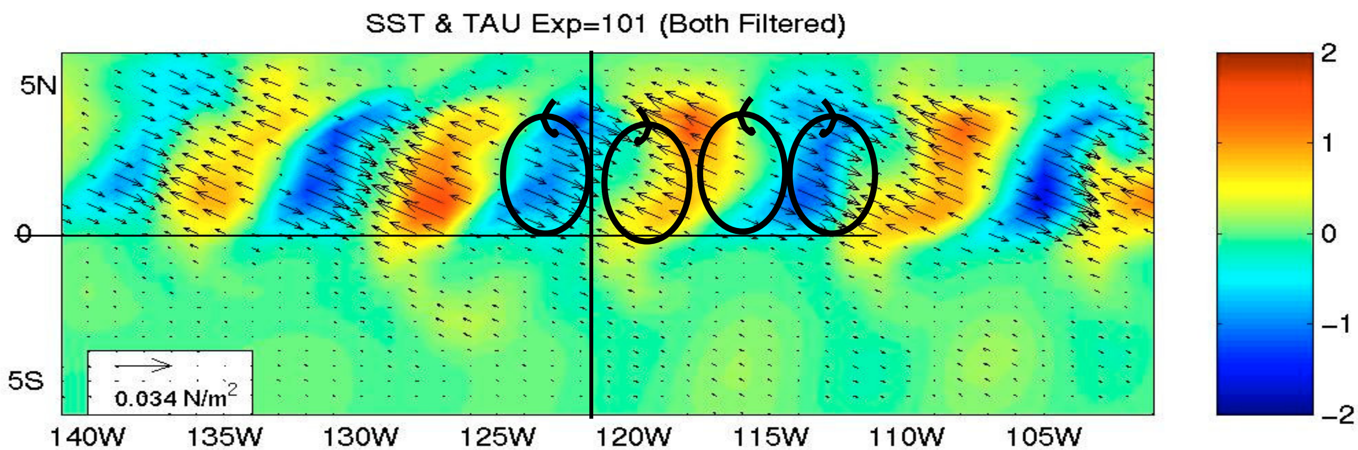


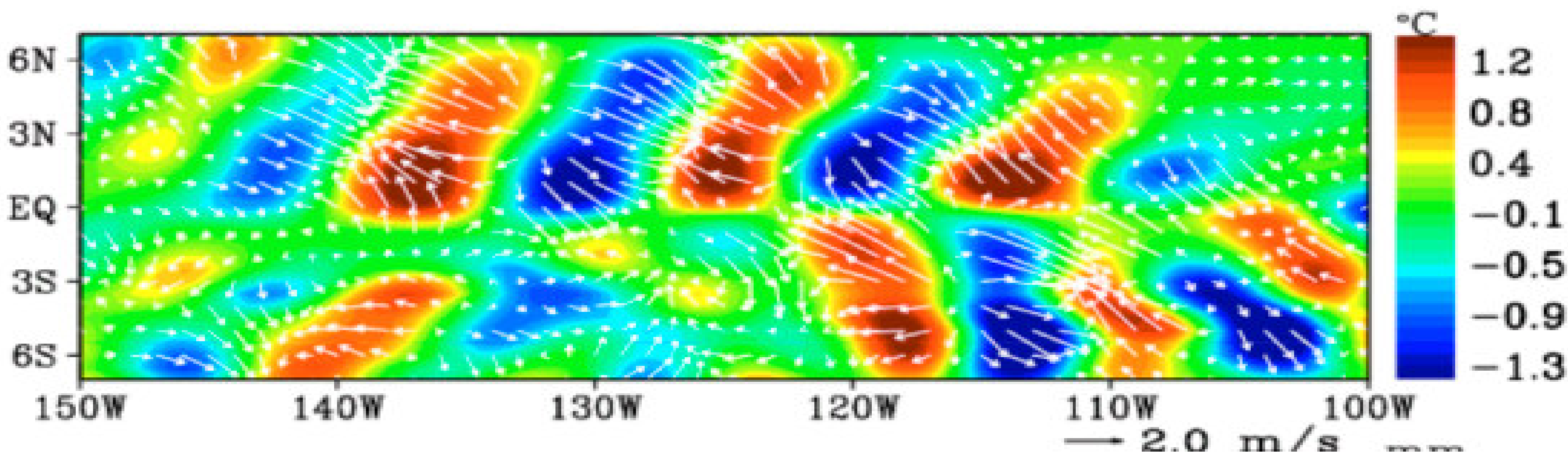
CTL Experiment

SST and filtered surface currents



SST and wind stress filtered

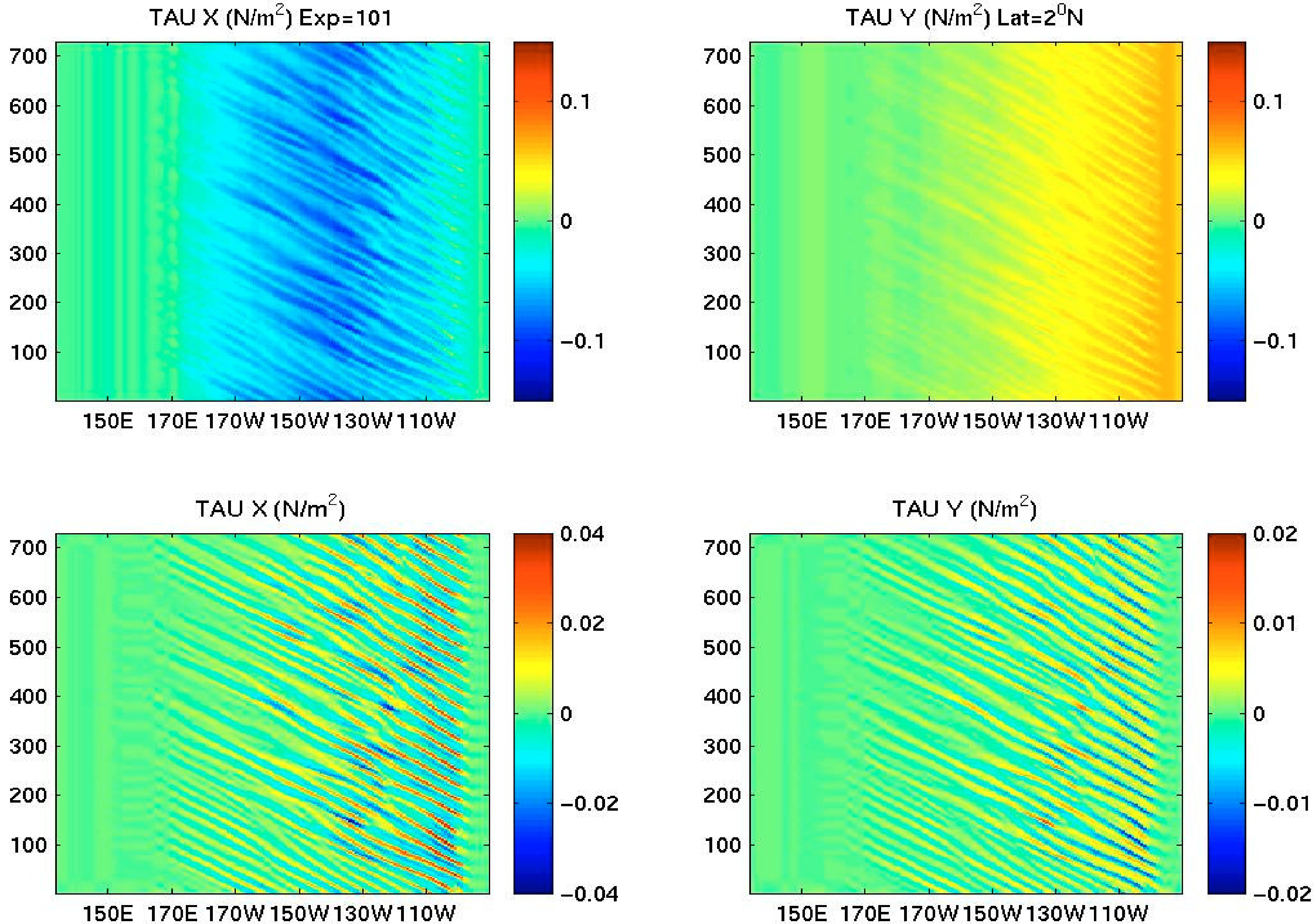


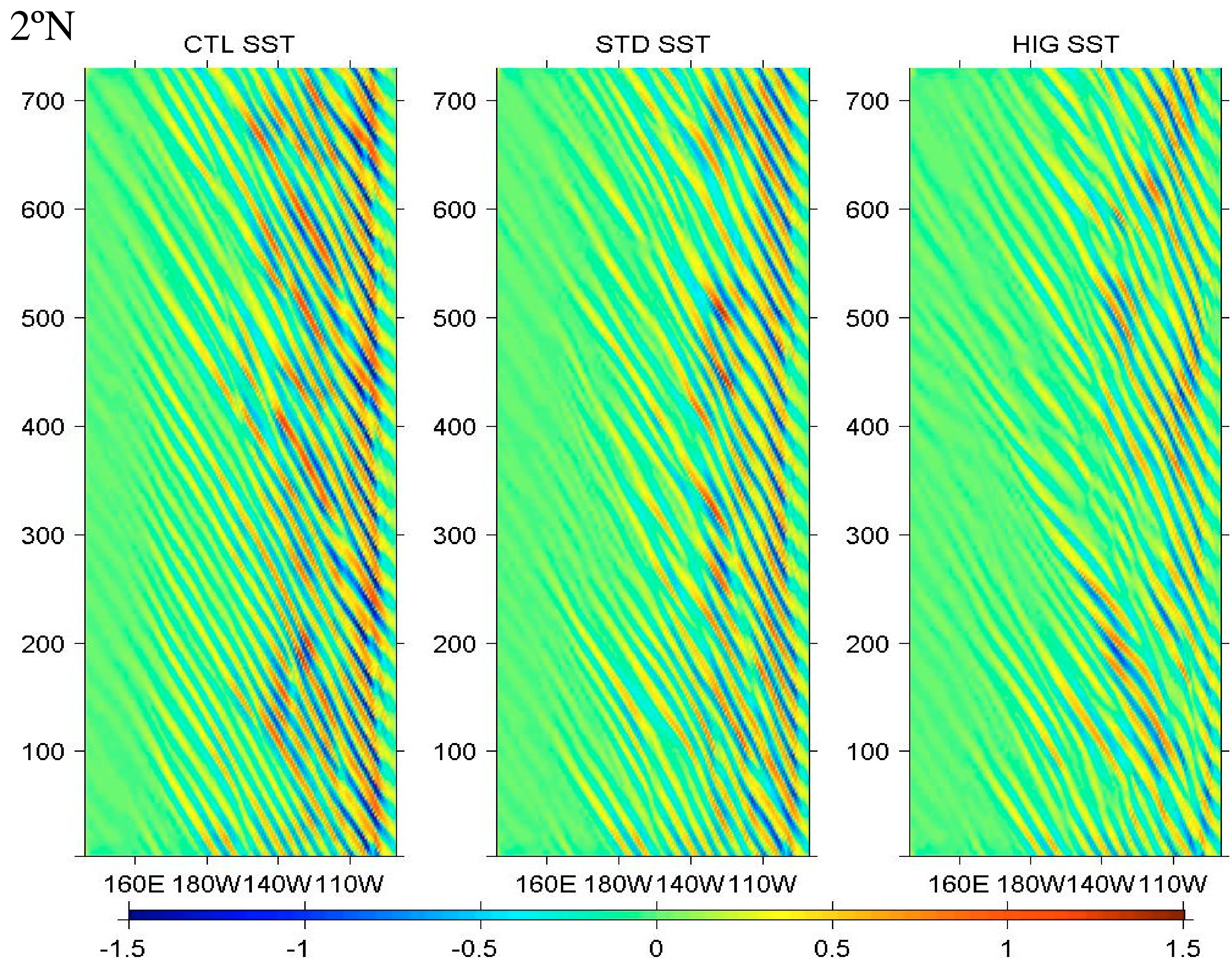


TIW Atmospheric imprint in the Wind fields

Raw

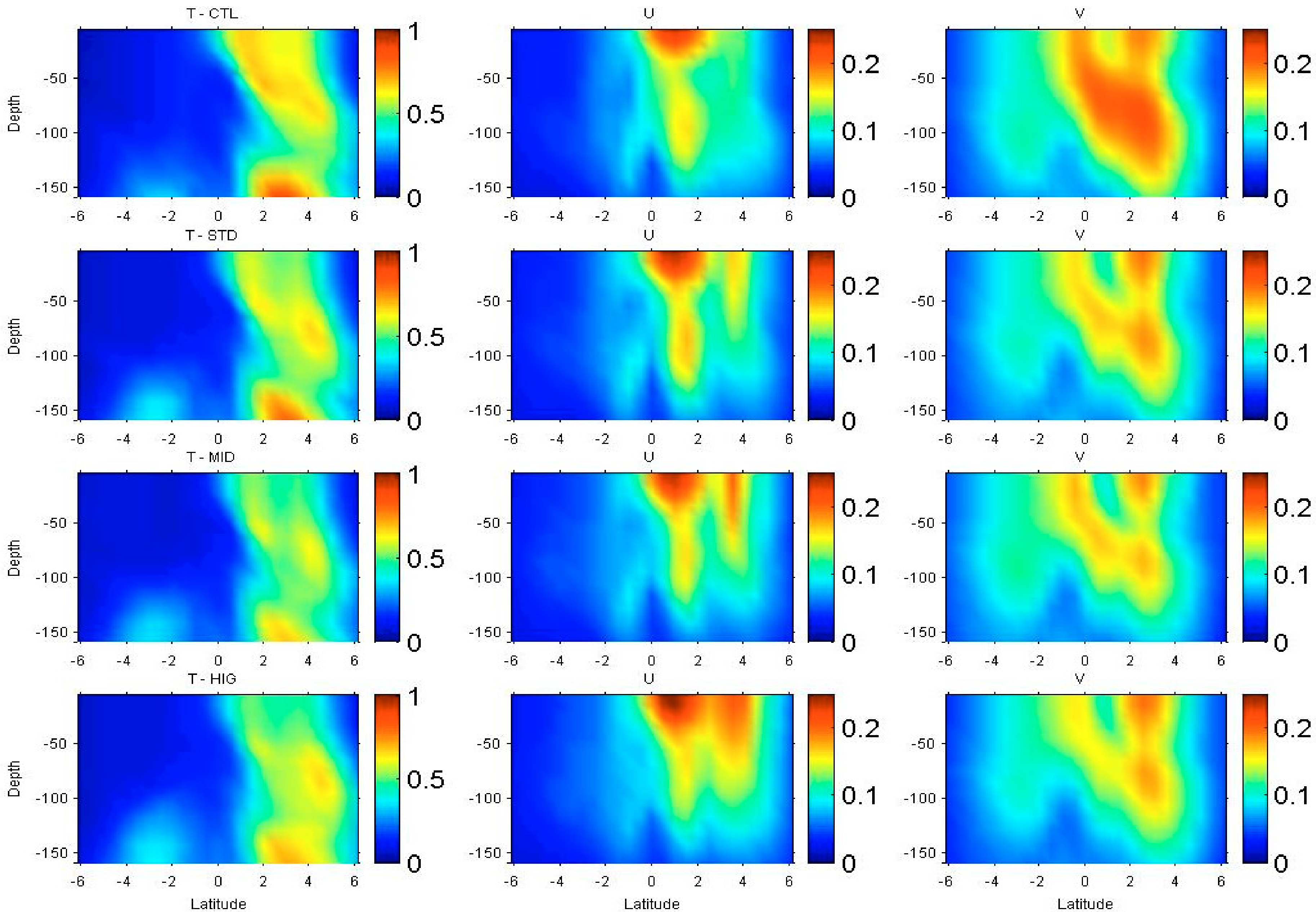
Filtered



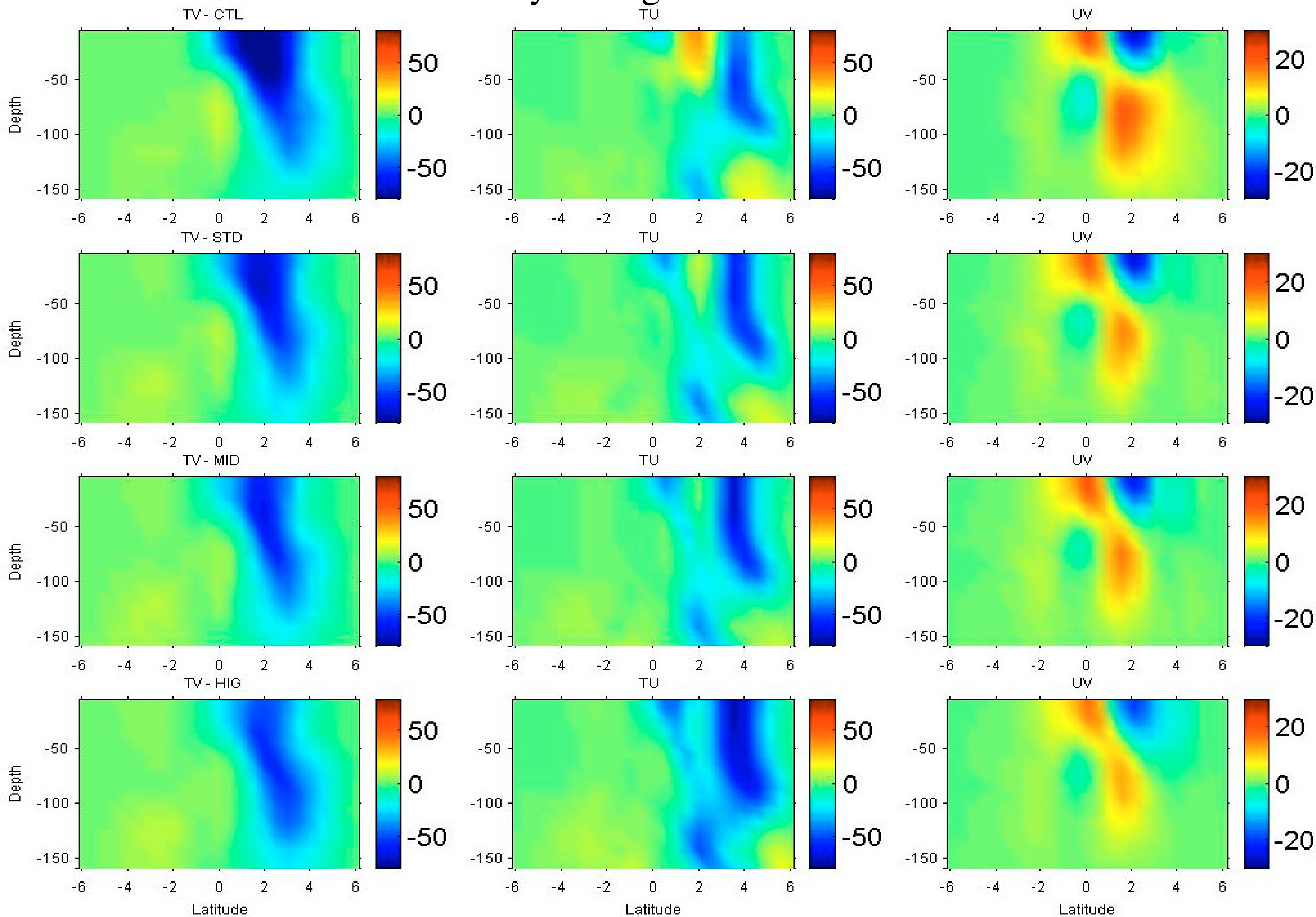


2ºN
CTL SST
STD SST
HIG SST
700
600
500
400
300
200
100
160E 180W 140W 110W
-1.5
-1
-0.5
0
0.5
1
1.5

Variability of T, U and V
Standard deviation zonally averaged 150ºW 90ºW



Heat (TU, TV) and momentum (UV) fluxes zonally averaged 150ºW 90ºW

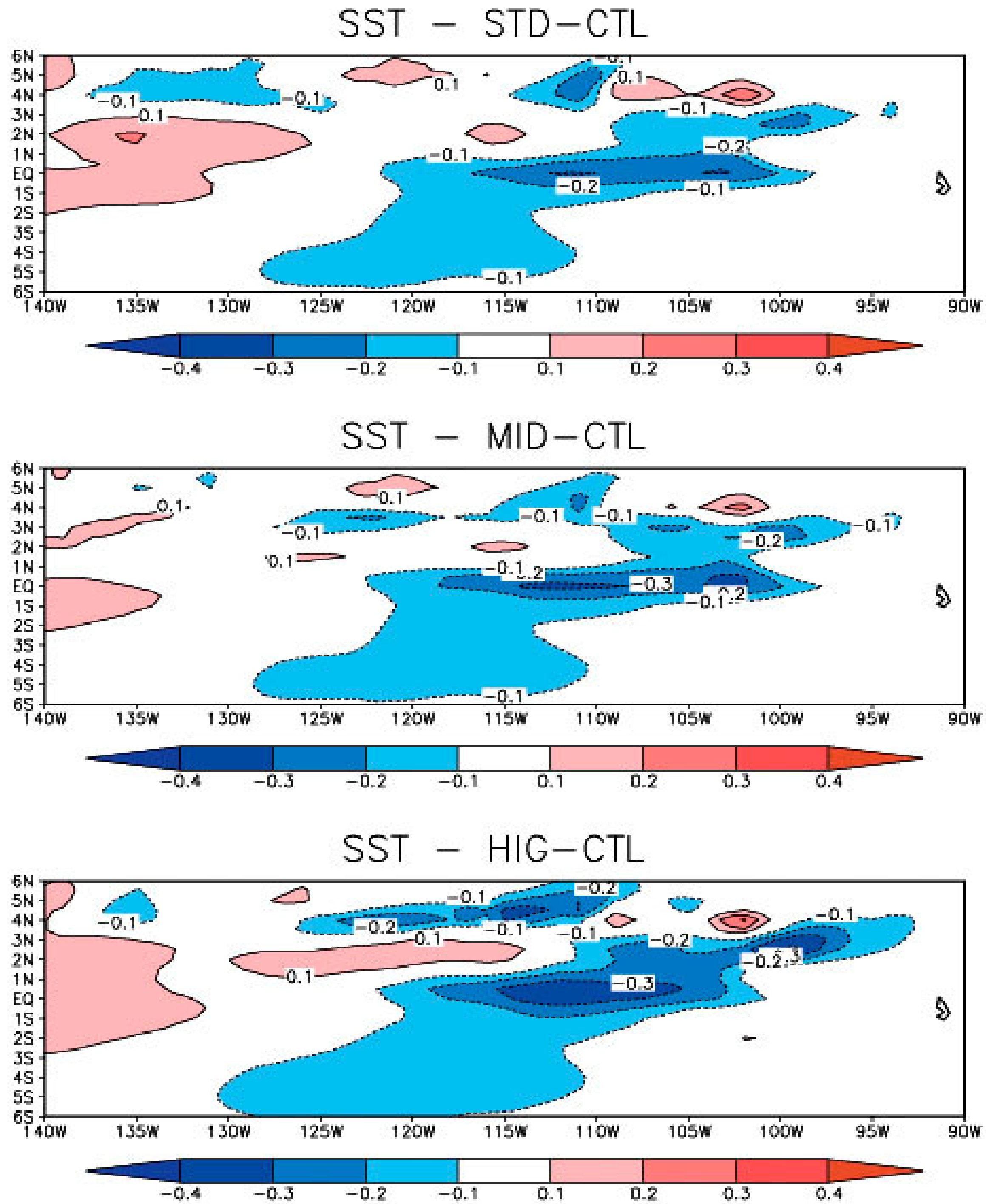


Coupling strenght leads to a SST cold tongue reduction.

Two competing effects:

- Upwelling reduction by 30% (would imply a warming)
- TIW has reduced equatorward heat flux (cooling CT)

TIW apparently are winning the battle!! being less efficient on warming CT.



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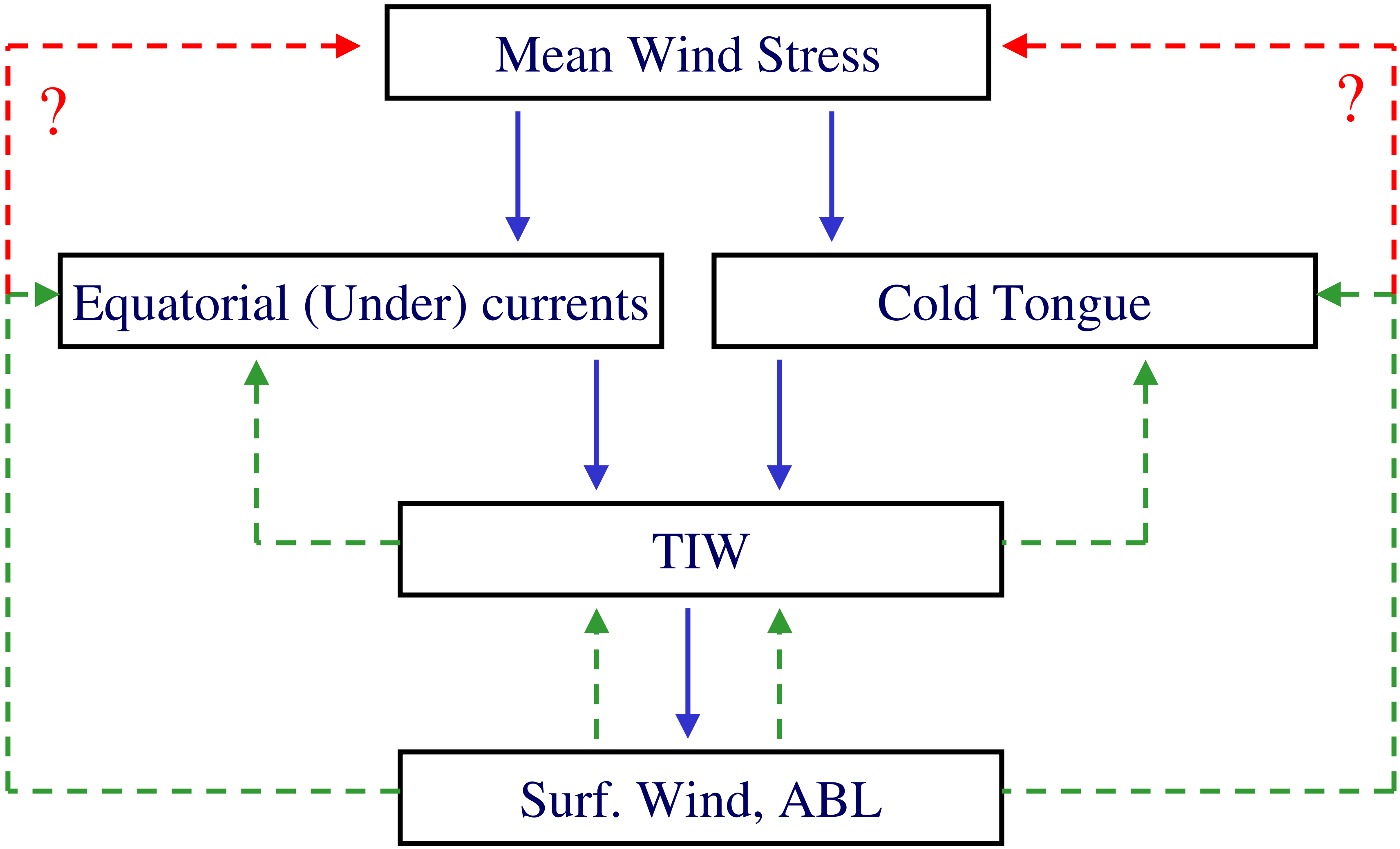
What do our results suggest?

TIW Schematic feedback



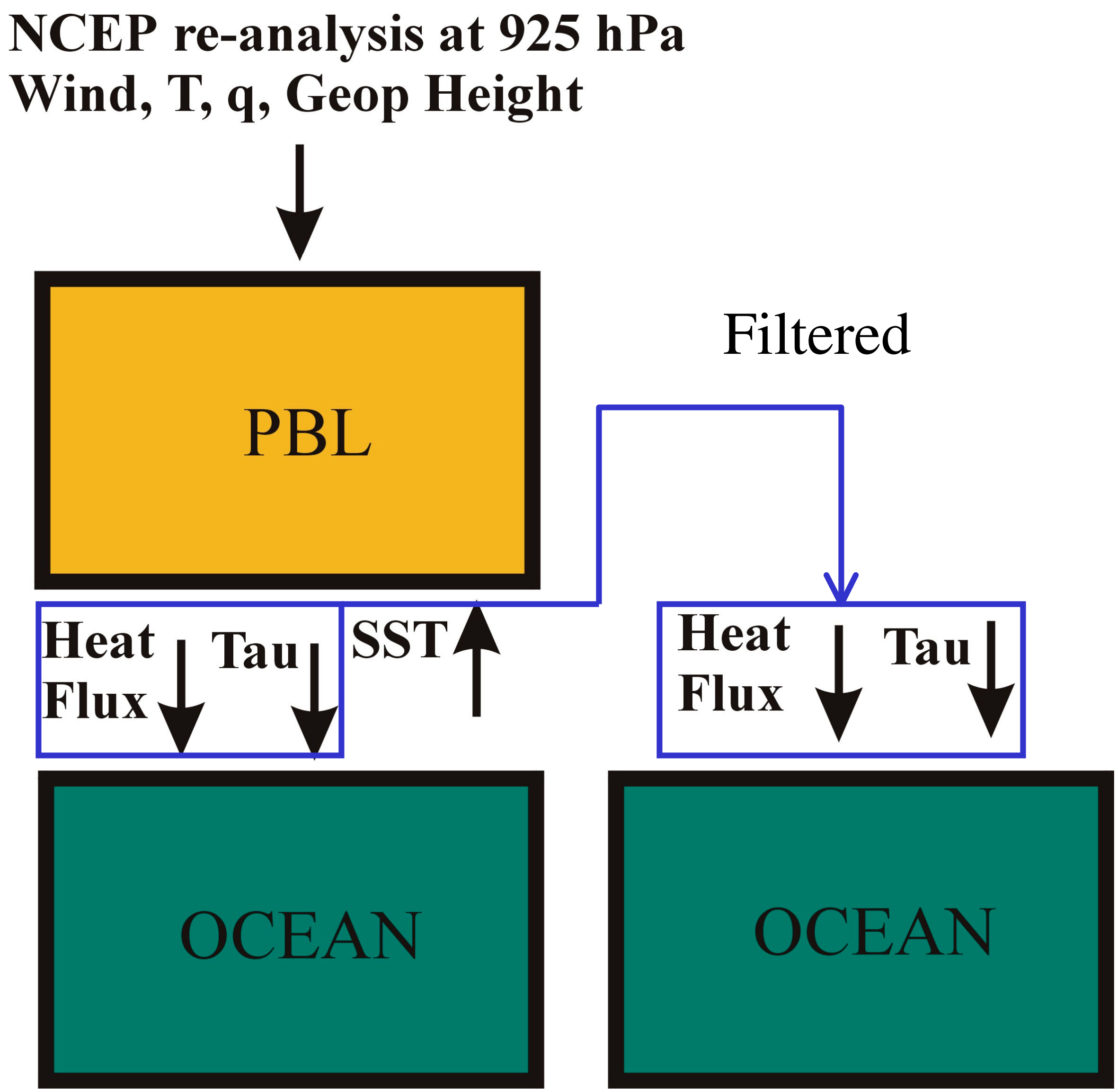
Summary of Major Findings:

- The (very!) simplified coupled system is able to simulate the PBL response to TIWs: the wind is speeded up over warm SST anomalies and slowed down over cold SST anomalies.
- Active coupling produces a *negative* feedback on TIWs, reducing their temperature and meridional current variability
- Some important atmospheric processes might be missing (such advection) and this work must be taken as a first step on TIWs-ABL interaction study.
- CGCMs have cold bias on the CT region. TIWs misrepresentation *might be collaborating*!!

Propositions for Future work:

- Examine the TIWs coupling feedbacks using a more sophisticated coupled model (ABL or AGCM).
- Undertand TIWs coupling on Atlantic, since we want good seasonal forecasts for this ocean

Future work: Experiments Fully Coupled



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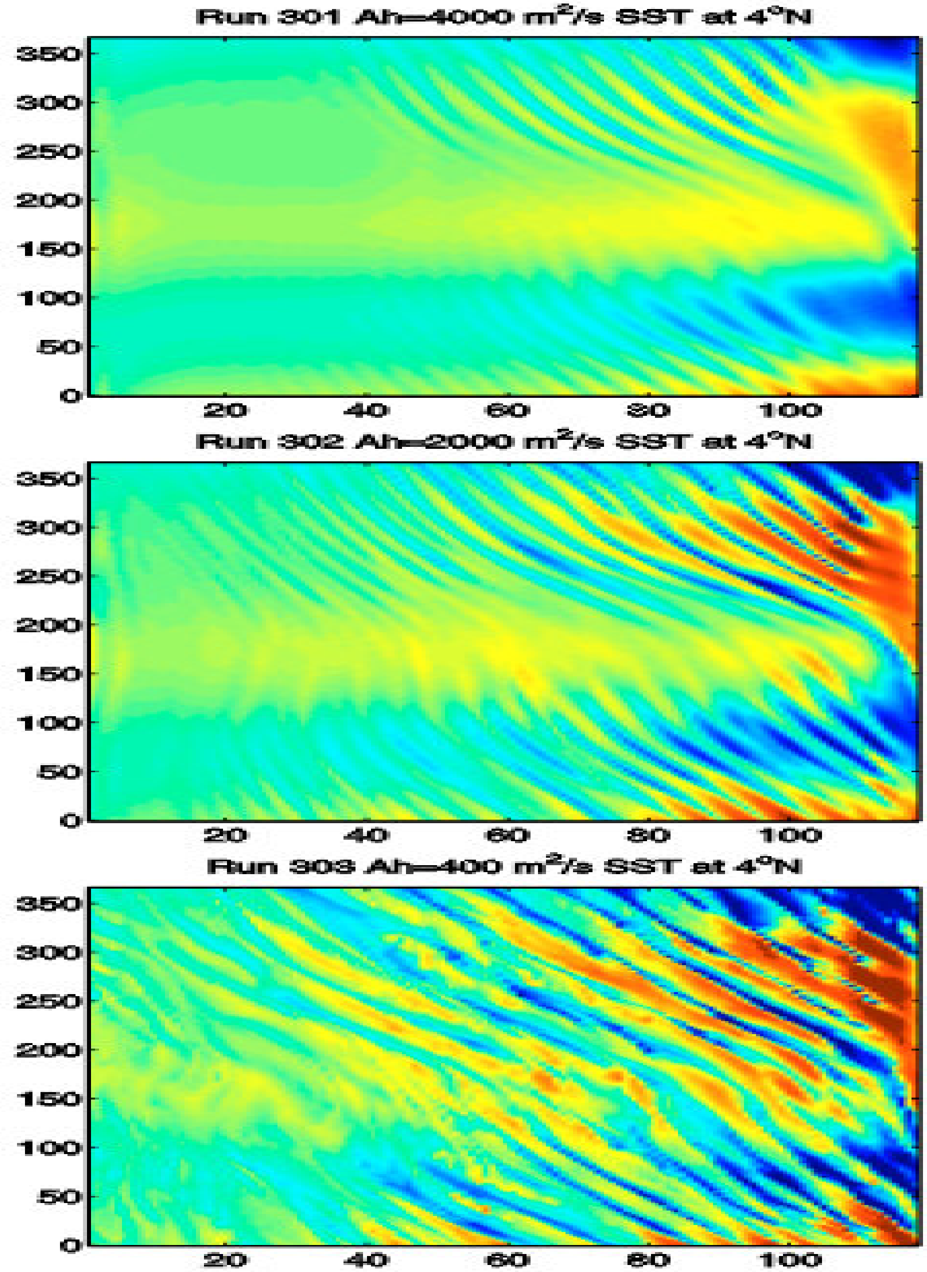
Fine Grid Resolution –TIWs – 5 Days averaged at 4°N

4000 m^2/s

2000 m^2/s

400 m^2/s



By decreasing lateral mixing the TIW Activities are largelly increased

Pezzi (2003)
and
Pezzi and Richards (2003)

Meridional Heat Transport - Pezzi and Richards (2003)