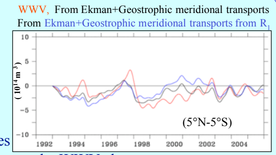
Equatorial waves and Warm Water Volume Changes in the Equatorial Pacific Ocean

Christelle BOSC and Thierry DELCROIX
Legos, Toulouse, France
Contacts : Christelle.Bosc@legos.obs-mip.fr, Thierry.Delcroix@legos.obs-mip.fr

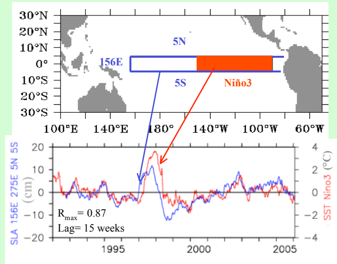
Abstract

- Study of Warm Water Volume (WWV) changes in the Equatorial Pacific to improve the understanding of ENSO
- WWV changes during 1992-2005 analyzed in terms of Geostrophic and Ekman transports
- Geostrophic transports computed from geostrophic surface currents (derived from altimetry) and statistical vertical profiles
- The first meridional mode equatorial Rossby waves (R1) influence the WWV changes.



2. Data

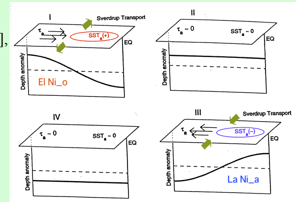
- Sea Level Anomalies (SLA, η) : Topex Poseidon and Jason [11]
- Winds (τ): ERS1/2 and Quikscat [12]
- For η and τ : dx, dy, dt = 1° long., 0.5° lat, 1 week. Period : 1992-2005
- In situ currents (U,V) : TAO TRITON moorings [13] and cruises [14]
- Mean thermocline depth (Z_{20}) from [15].



1. Introduction

- 4 major theories for ENSO : the delayed oscillator [1,2], the advective reflective oscillator [3], the Western Pacific Oscillator [4,5] and the **Recharge Discharge Oscillator** [6].
- Specificity of the Recharge Discharge oscillator :
  - Valid at both interannual and decadal time scales [6,7]
  - Predictive abilities: WWV leads NINO3 SST [8],[9]
  - The only one theory not explicitely considering equatorial waves

Question : What is the role, if any, of equatorial waves in changing WWV in the equatorial band (156°E-70°W-5°N-5°S).



Schematic diagram of the Recharge Discharge Oscillator. Adapted from [10].

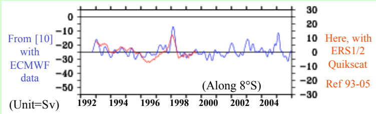
3. WWV, geostrophic and Ekman transports from η and τ

3.1. WWV changes

WWV is estimated using the approximation of the 1.5 ocean layer with $\frac{\rho}{\Delta\rho} = 200$ [16].

$$\frac{dWWV}{dt} = \frac{\rho}{\Delta\rho}\frac{d}{dt}\iint_{x,y}\eta\, dxdy$$

3.2. Ekman flows (Sv)



3.3. Geostrophic flows

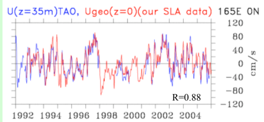
- **Methods :** Zonal flow : $\int_{y=8S}^{8N}\int_{z=0}^{H} u_{geo}(y,z)dydz$ Meridional flow : $\int_{x=156E}^{265E}\int_{z=0}^{H} v_{geo}(x,z)dxdz$ where $H = \bar{Z}_{20} + \frac{\rho}{\Delta\rho}\eta$

❑ From SLA to geostrophic surface currents [17]

Off equator : usual $v_{geo}(z=0)$ and $u_{geo}(z=0)$

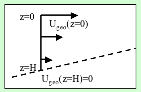
At the equator : $u_{geo}(z=0) = -\frac{g}{\beta}\frac{\partial^2\eta}{\partial y^2}$

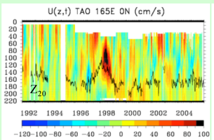
It compares well with TAO surface currents.

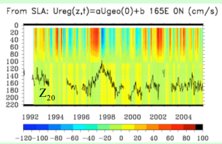


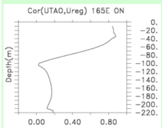
❑ From $v_{geo}(z=0)$ and $u_{geo}(z=0)$ to $v_{geo}(z)$ and $u_{geo}(z)$: test of 2 different vertical structures for the currents

- Linear profile
- Statistical approach based on in situ current data obtained during cruises [14]

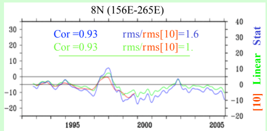


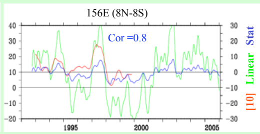






- **Comparison between our method and in situ [10] measurements**

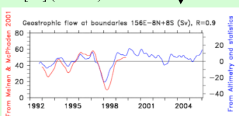




Choice of vertical profiles :
8°N and 8°S: linear profile
156°E : linear regression.

With such profiles :

Geostrophic flows (in Sv) across the 8°N and 156°E boundaries estimated with 2 different methods: linear profile (green line), statistical approach (blue line) and in situ measurements [10] (red line).



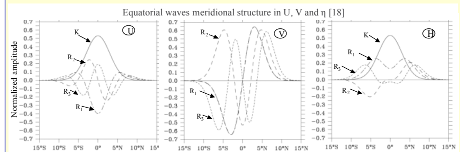
Comparison between the geostrophic transport (Sv) entering the (8°N-8°S, 156°E-265°E) box, as estimated from in situ measurements [10] versus altimetry and statistics.

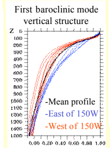
4. Equatorial waves and 5°N-5°S WWV changes

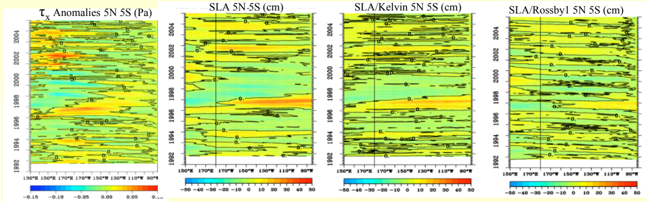
4.1. Decomposition in equatorial waves (first baroclinic mode)

U = U/Kelvin + U/Rossby + ε [18]

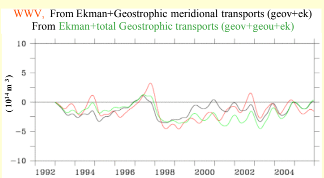
η = η/Kelvin + η/Rossby + ε [18]

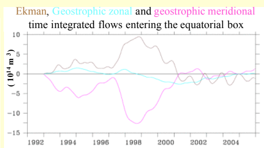






4.2. WWV and meridional transports





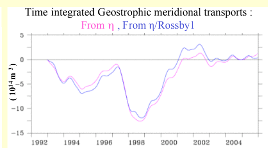
Comparison between 5°N-5°S WWV and time-integrated Geostrophic + Ekman transports

Cor(WWV,geov+ek) = 0.53 rms/rms=0.7

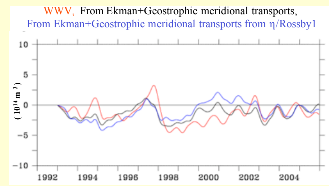
Cor(WWV,geov+geou+ek)= 0.66 rms/rms=0.9

Meridional transports can account for a major part of the WWV changes in the 5N-5S equatorial band (156E-70W)

4.3. WWV and equatorial waves



Cor(geov,geov(R1)) = 0.96 rms/rms=0.9



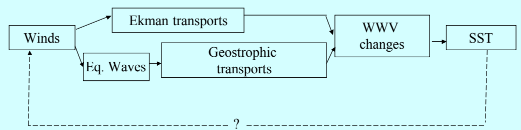
Comparison between 5°N-5°S WWV and time-integrated Geostrophic + Ekman transports where the geostrophic meridional transports are estimated from

$v_{geo}(\eta)$ Cor(WWV,geov+ek) = 0.53 rms/rms=0.7

$v_{geo}(\eta/_{R1})$ Cor(WWV,geov(R_1)+ek)= 0.21 rms/rms=0.9

The first meridional mode Rossby waves explains a major part of the meridional geostrophic transports

5. Conclusions and perspectives



Conclusions :

- Good estimation of geostrophic transports from altimetry.
- The first meridional mode Rossby waves influence the evolution of WWV in the equatorial Pacific via geostrophic meridional transports .

Perspectives :

- Detailed analysis of WWV changes and equatorial waves (chronology, reflected/forced waves, coupled processes)
- WWV changes in the whole tropical Pacific
- Analyzing the possible role of the third meridional mode Rossby waves.

References

[1] Suarez and Schopf, 1988.
[2] Battisti and Hirst, JAS, 1989.
[3] Picaut et al., Science, 1997.
[4] Weisberg and Wang, GRL, 1997.
[5] Wang et al., JGR, 1999.
[6] Jin, JAS, 1997.
[7] Hasegawa and Hanawa, GRL, 2003.
[8] Meinen, JPO, 2005.
[9] Kessler, GRL, 2002.
[10] Meinen and McPhaden, JPO, 2001.
[11] AVISO/Altimetry, 1996.
[12] Bentamy et al., 1999.
[13] McPhaden, M. J., 1995.
[14] Delcroix T. and G. Eldin, 1995.
[15] Durand and Delcroix, JPO, 2000.
[16] Rebert et al., JGR,1985.
[17] Picaut and Tournier, 1991.
[18] Delcroix et al., JGR, 1994.