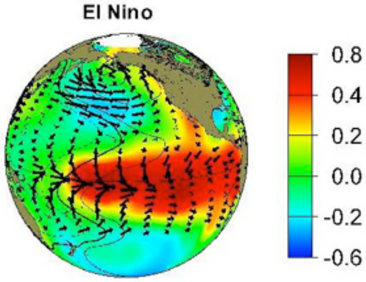
ENSO modulated by Lunar cycles

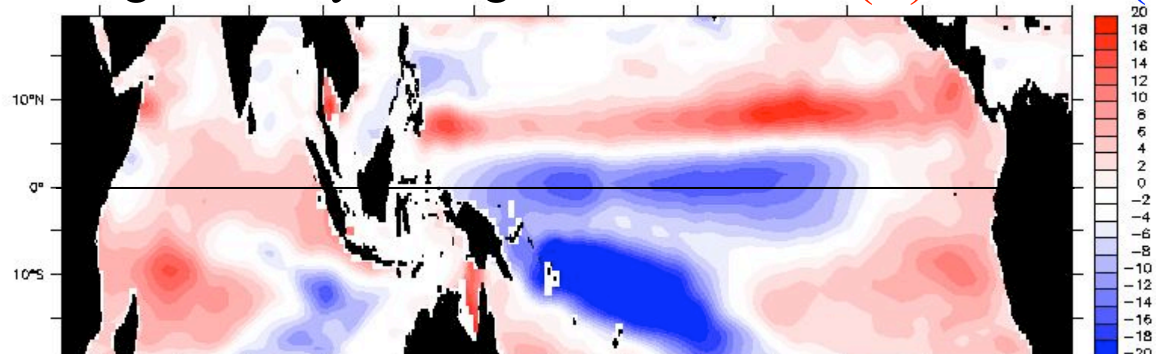


Claire Perigaud

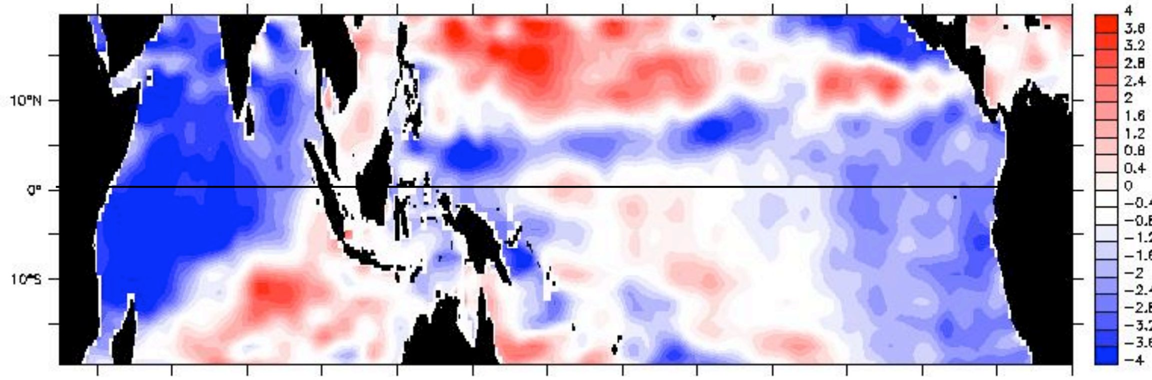
Jet Propulsion Laboratory

OSTST, 22-24 June 2009

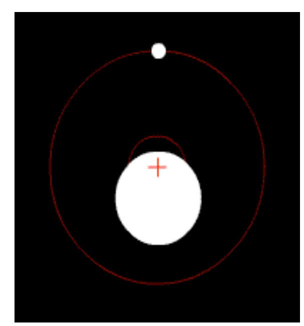
ENSO recharge: zonally averaged SLA North (+) South (-) and Equator(-)



Sea **L**evel **A**nomalies: **SLA** from TOPEX/Poseidon [Oct97-to-Aug98] - [Jan93-to-Jan96]

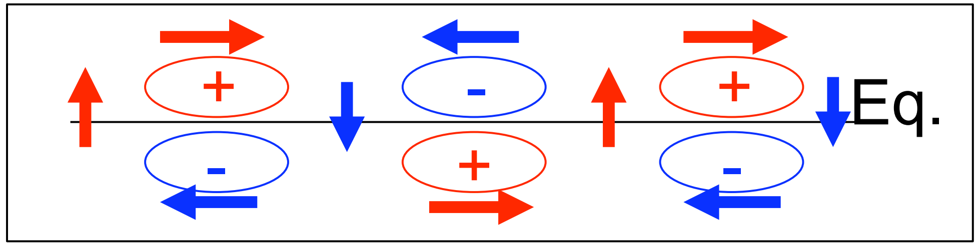


[2001-2004] - [1993-1996] “decadal” change from TP-Jason.



Introductory Summary

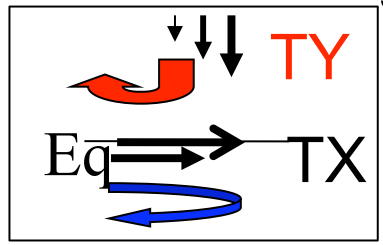
1. Ocean/Atmos data & Ocean models give evidence for Tropical Instability Waves (TIW) modulated by biweekly Lunar cycles.



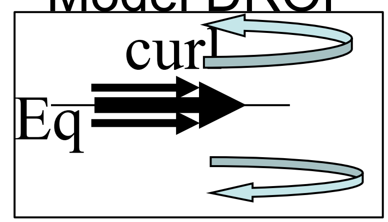
2. Conversely to ENSO-SST-TX and the Delayed Recharge Oscillator Paradigm (DROP), altimetry monitors a level of recharge with opposite signs in the North and South.

Coupled O/A models simulate symmetric DROP because they fail to reproduce the observed meridional circulation TY.

Observed Recharge



Model DROP



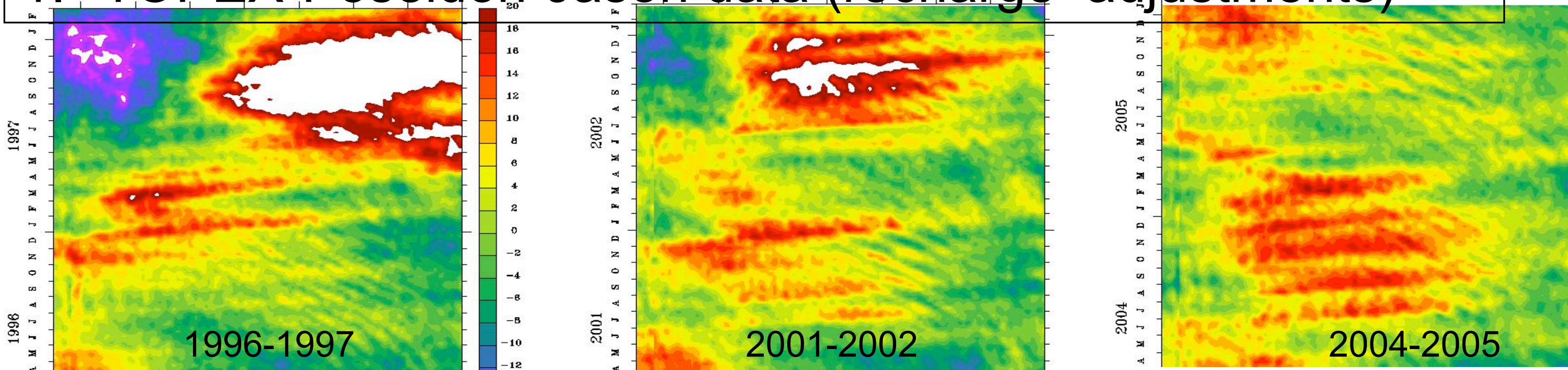
TX

3. ENSO-TIW modulations are consistent with 1997 min and 2006 max Lunar Inclination extrema (18.6yr cycle).

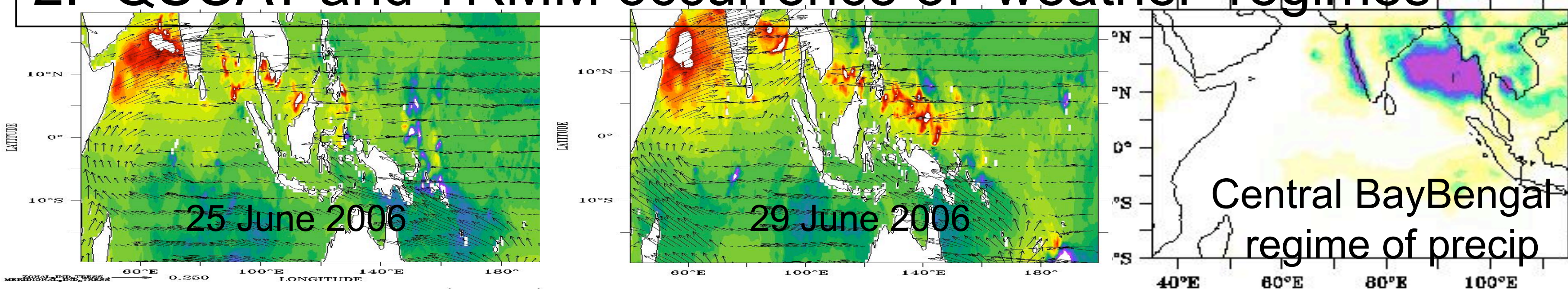
4. Lunar- added to solar-forcing of climate models may allow to simulate antisymmetric recharge and explain some paleoclimate puzzles.

ENSO forecasts initialized with:

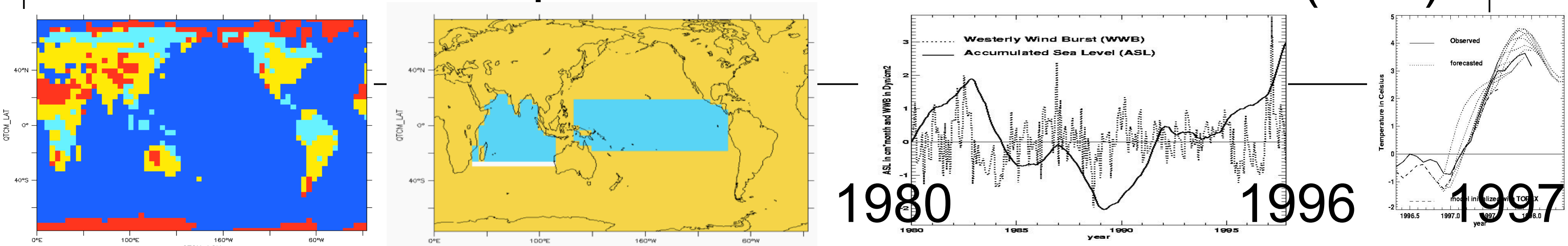
1. TOPEX-Poseidon-Jason data (recharge adjustments)



2. QSCAT and TRMM occurrence of weather regimes



3. Intermediate Coupled Ocean-Atmos/land Model (ICM)



Climate Change in the Tropics induced by Indian Weather events

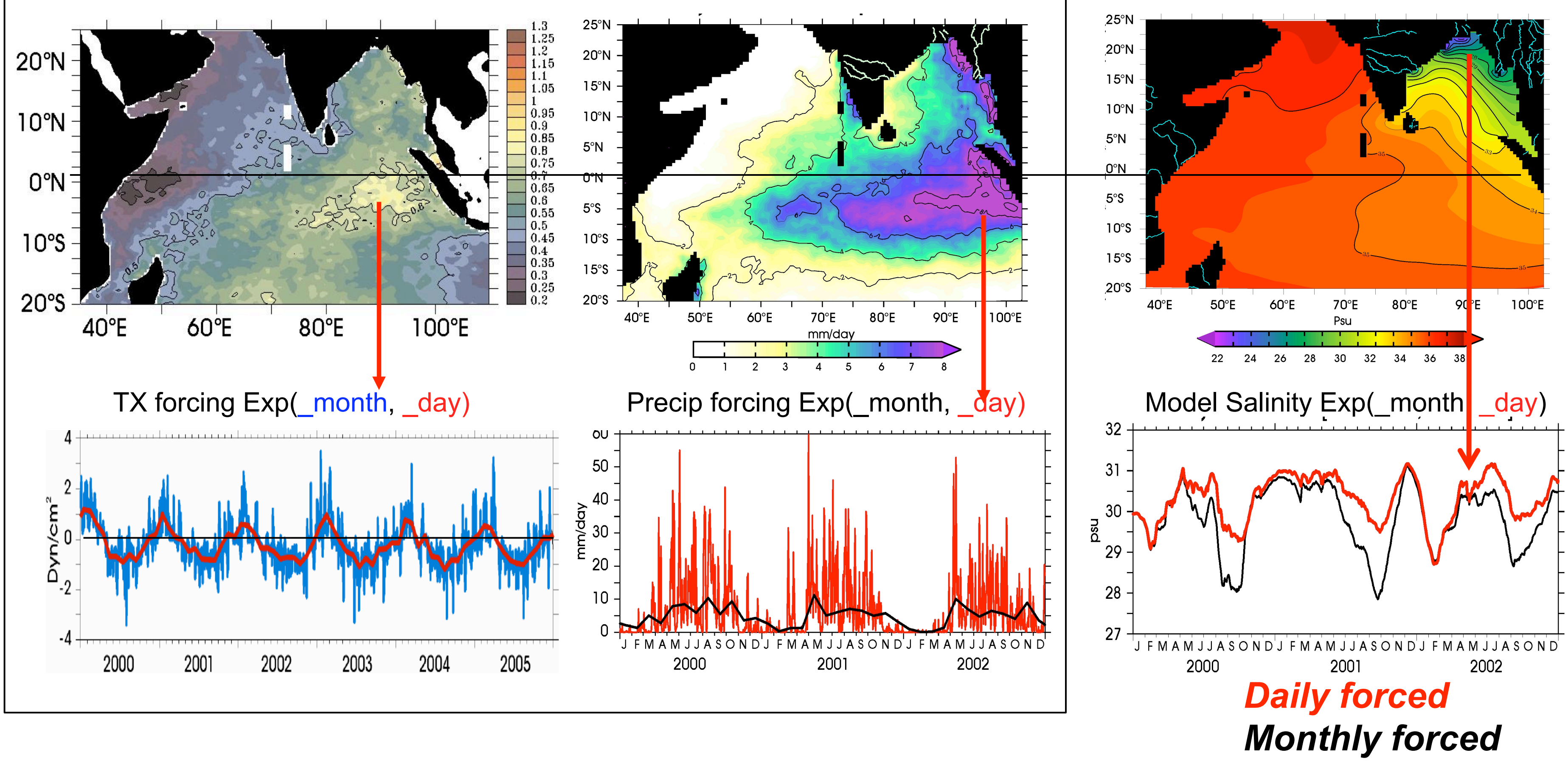
Monthly or daily averaged forcings:

Model response

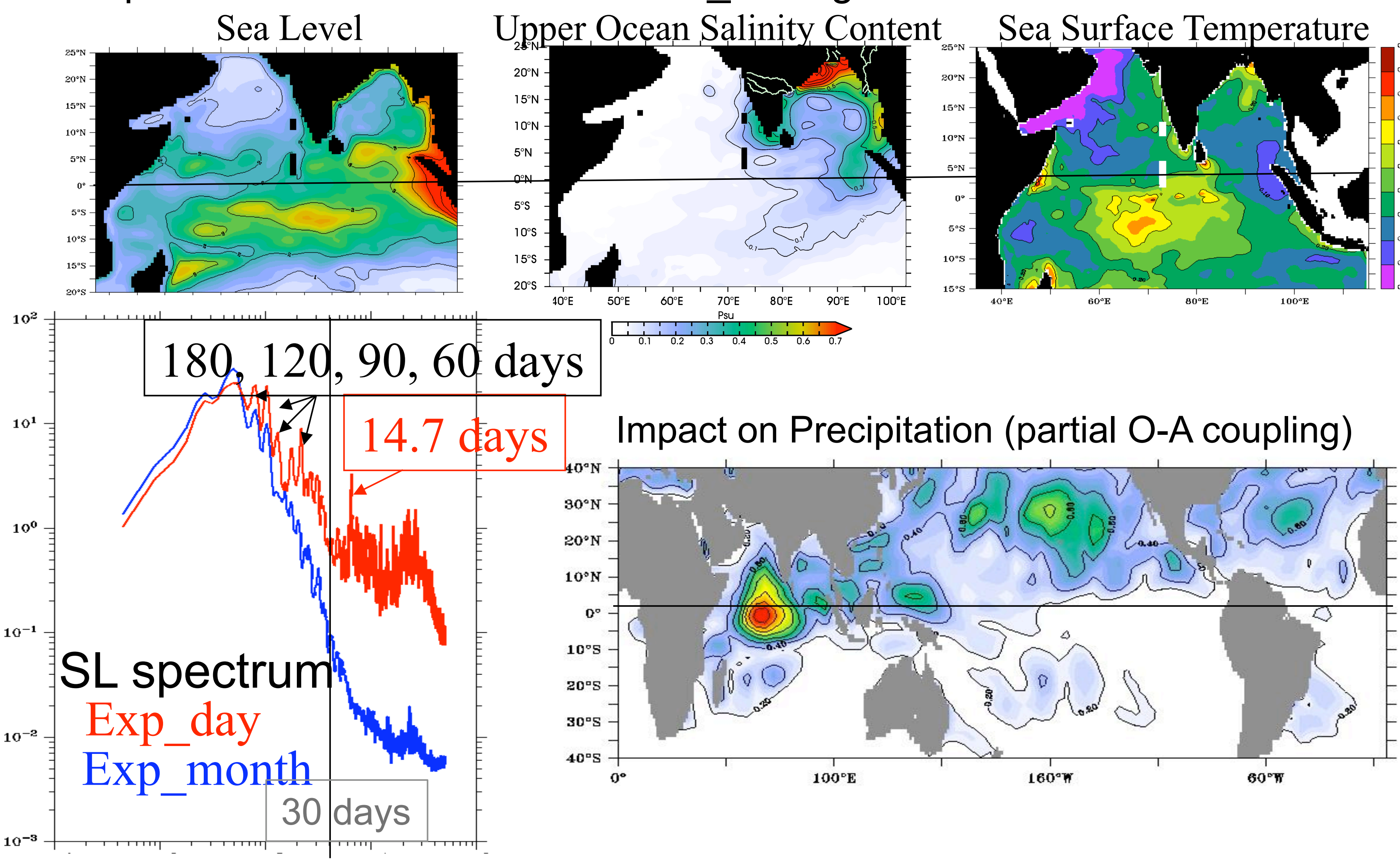
QSCAT data

TRMM data

in Salinity

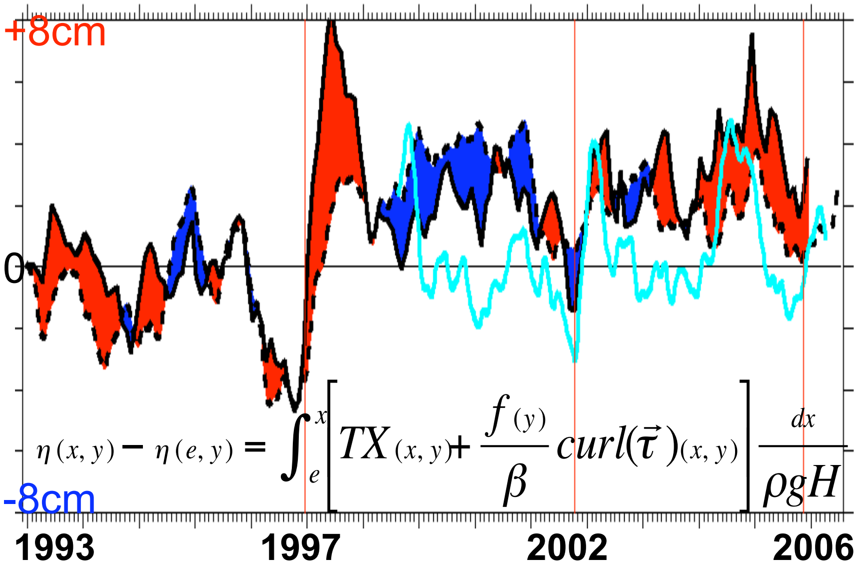


Impact of QSCAT+TRMM weather_forcing onto Climate variations of

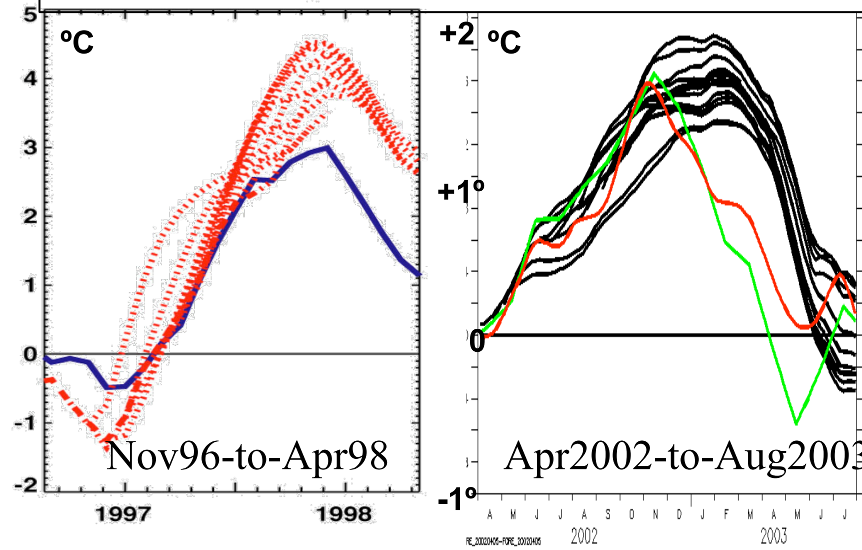


Indian oceanic resonance at 180days and harmonics (Kelvin+Rossby) and at biweekly MRGW are excited by weather regimes. Impact Salt in the BB in Oct, SST in the South in Dec-Jan and the atmosphere in the tropics + North.

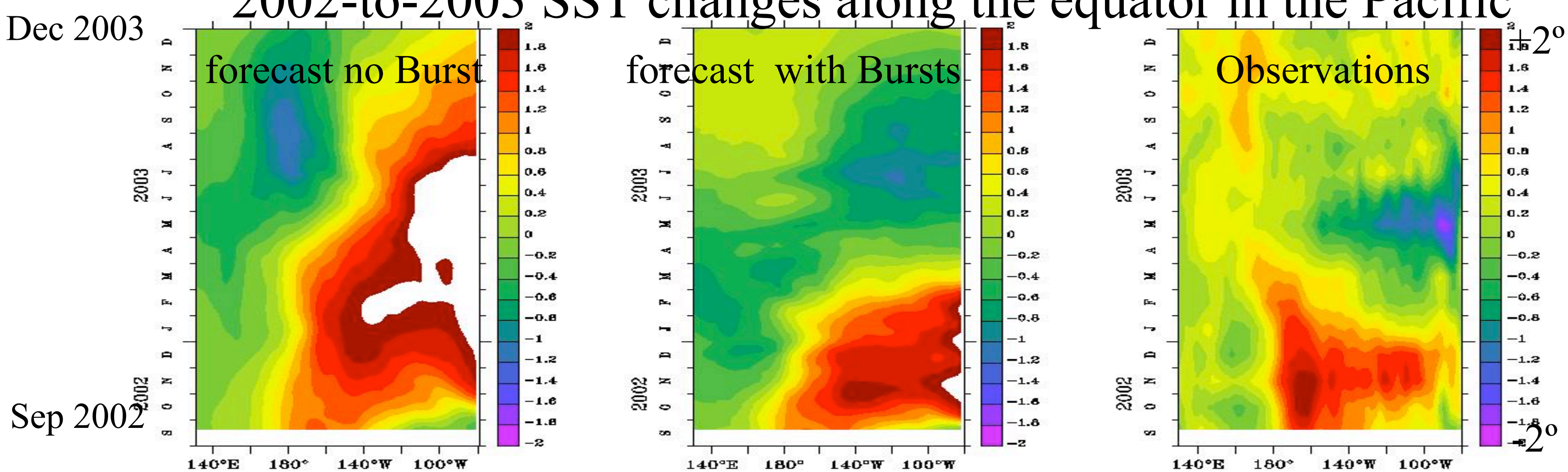
IndoPacific recharge



Forecasts of Nino3 index

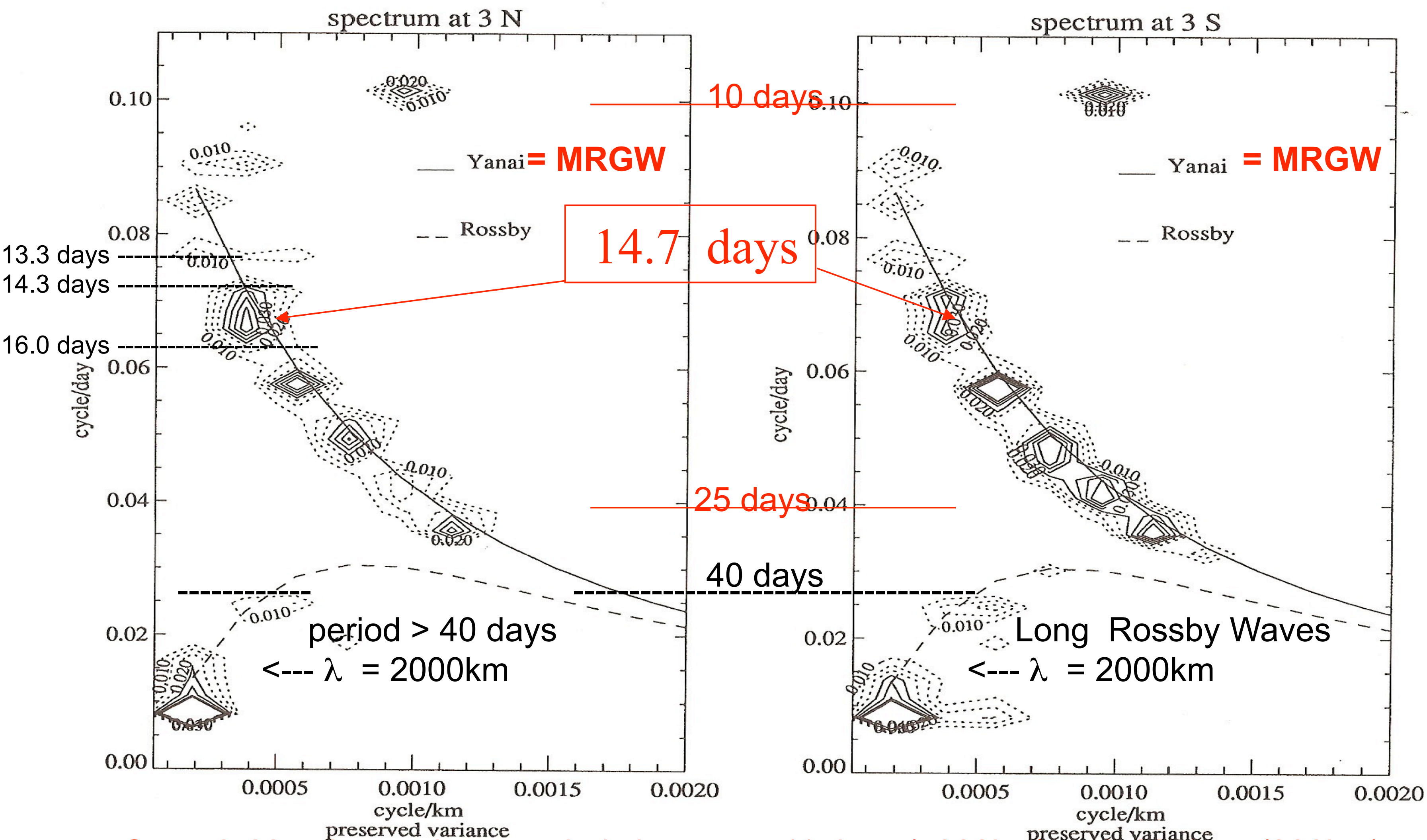


2002-to-2003 SST changes along the equator in the Pacific



ENSO, Indo-Pacific recharge (TPJ), and weather bursts (QSCAT&TRMM).

SL dispersion diagram obtained by Kalman Filtering Geosat



Oceanic Yanai wave have periods between 11 days (5000km) and 28 days (900km).

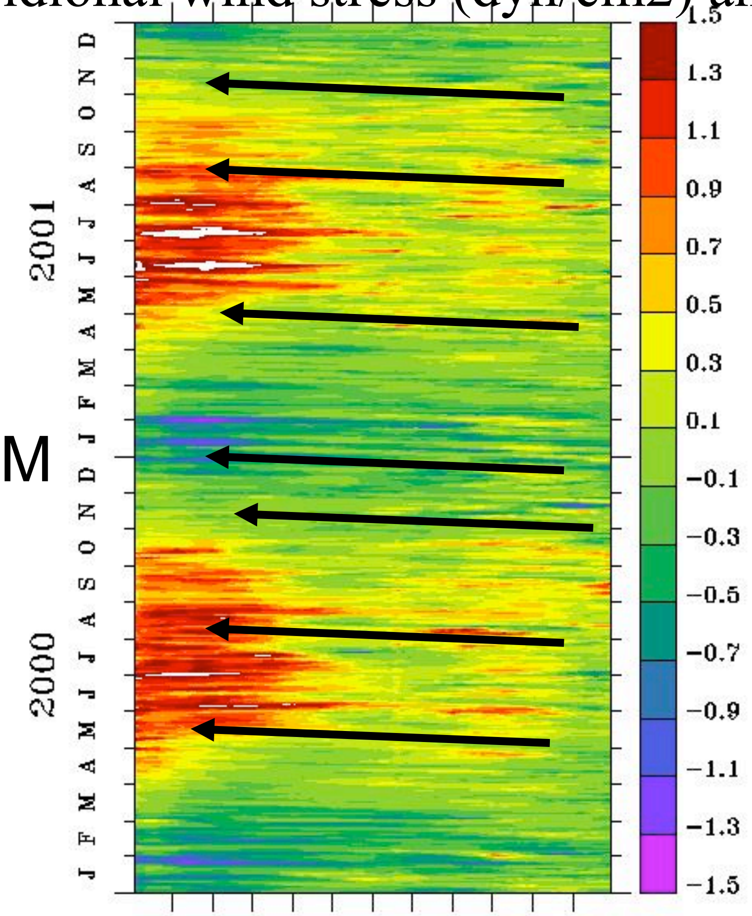
Notice the peak at 14.7 days.

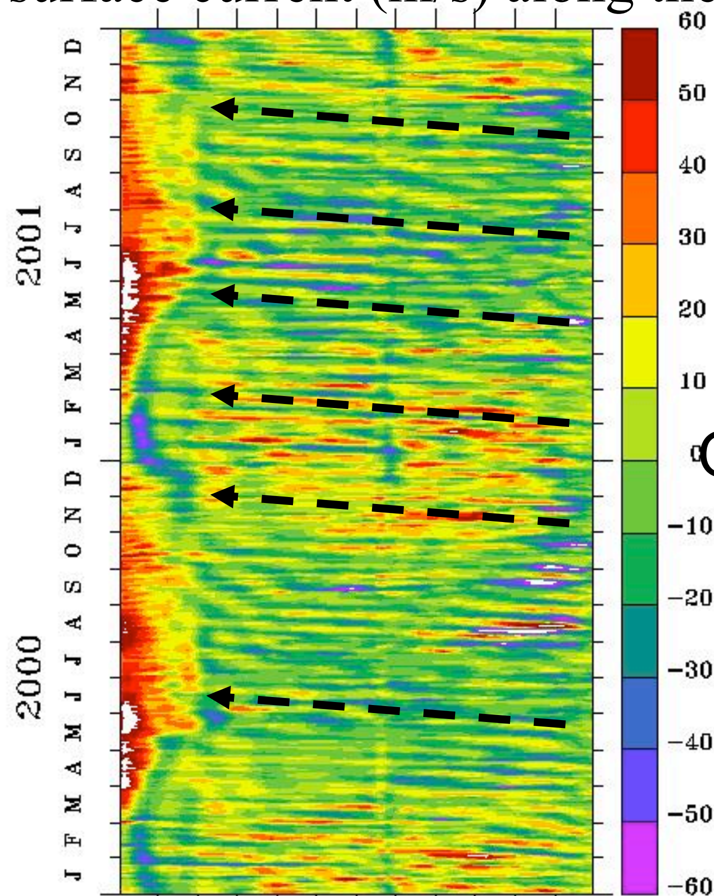
* see Fu et al. (1990) extended to the filtering of **M**ixed **R**ossby **G**ravity **W**aves in Indian Ocean.

TIW forced by QuikSCAT in Indian ICM

Meridional wind stress (dyn/cm2) and surface current (m/s) along the equator

ATM



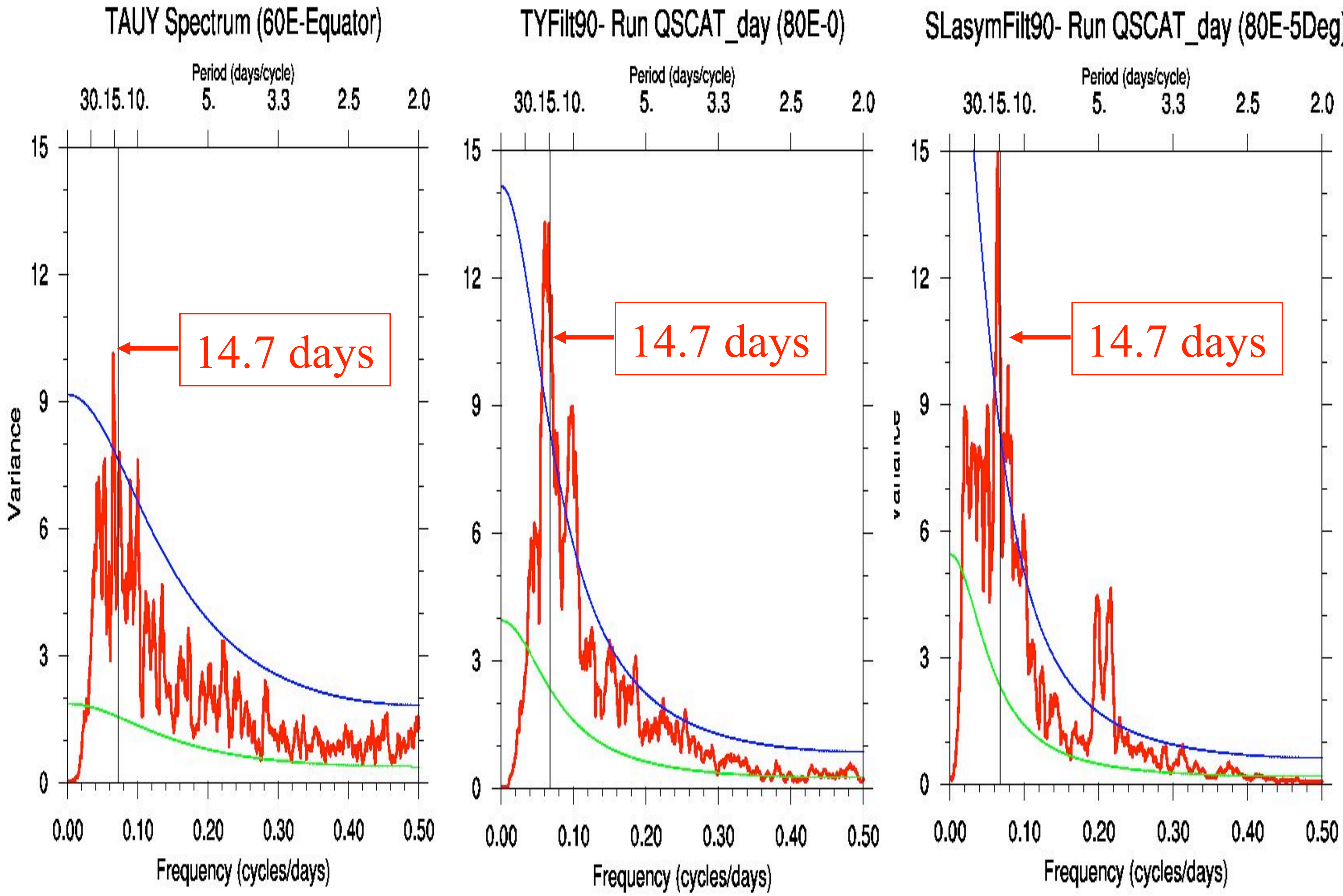


OCEAN

~15 day reversals are present in QSCAT all throughout the year, stronger than in other winds ➔ model TIWs are dominated by ~15 days.

Wind reversals LEAD the Ocean TIWs (Ogata et al., 2007), but this is in the case of ocean experiments FORCED by Atmos.

Biweekly TIWs in TY and SL forced by QSCAT



QSCAT vorticity TIW Pacific

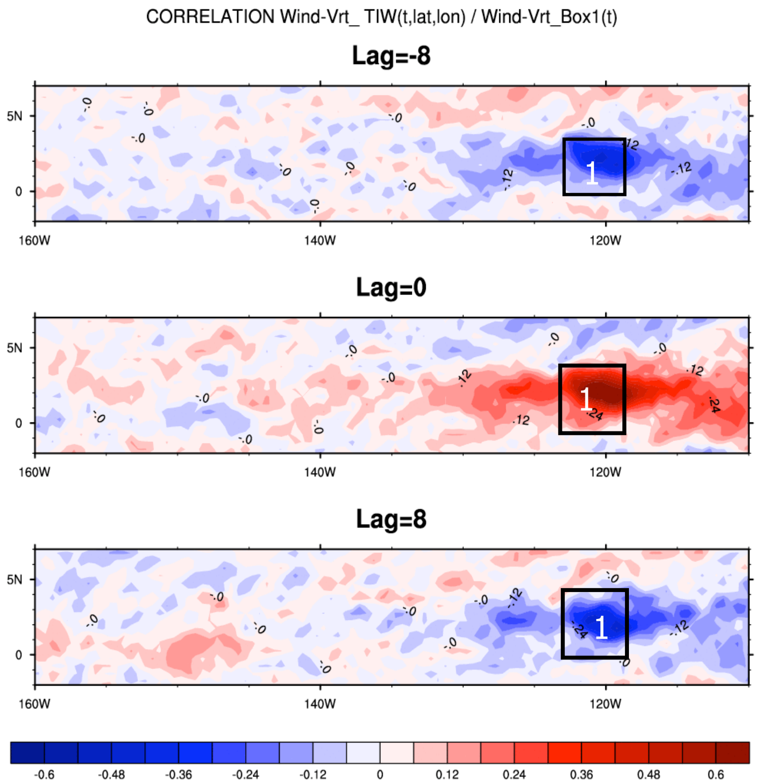
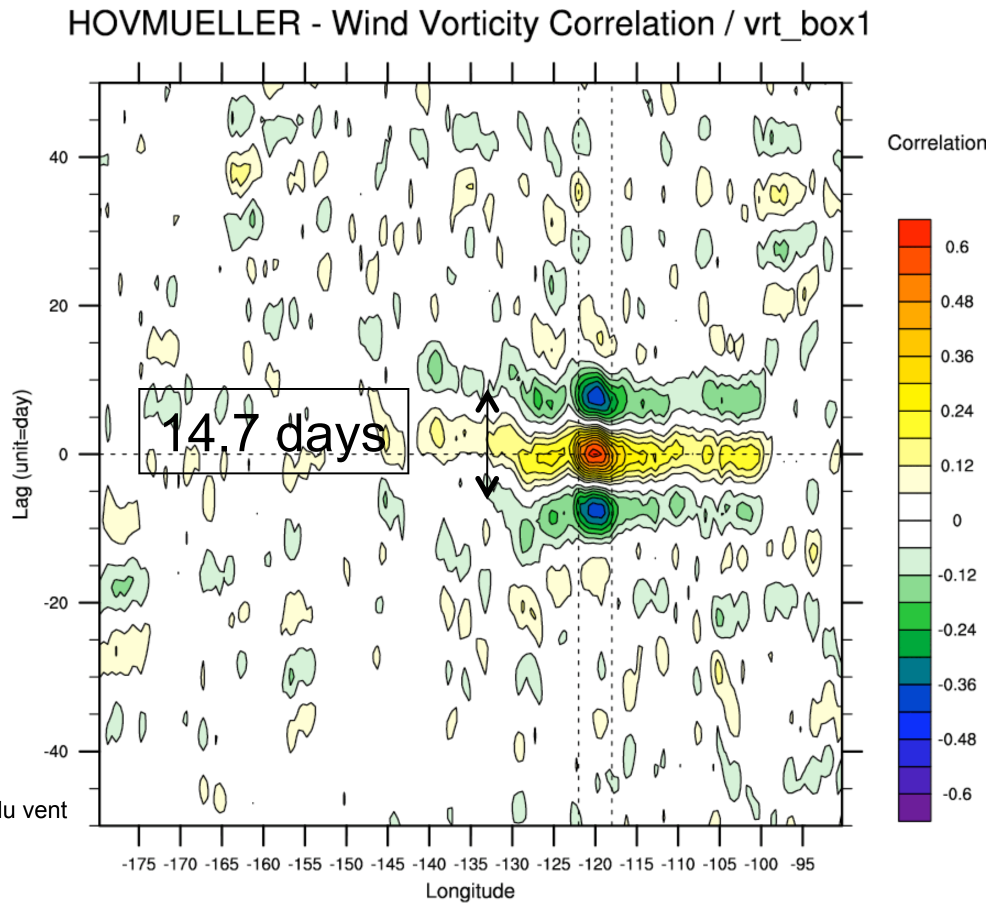
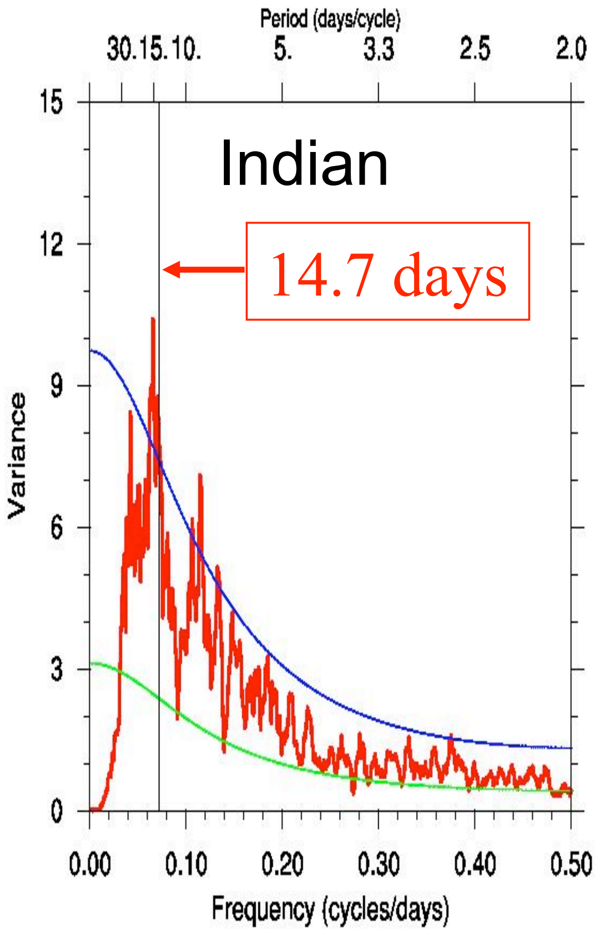


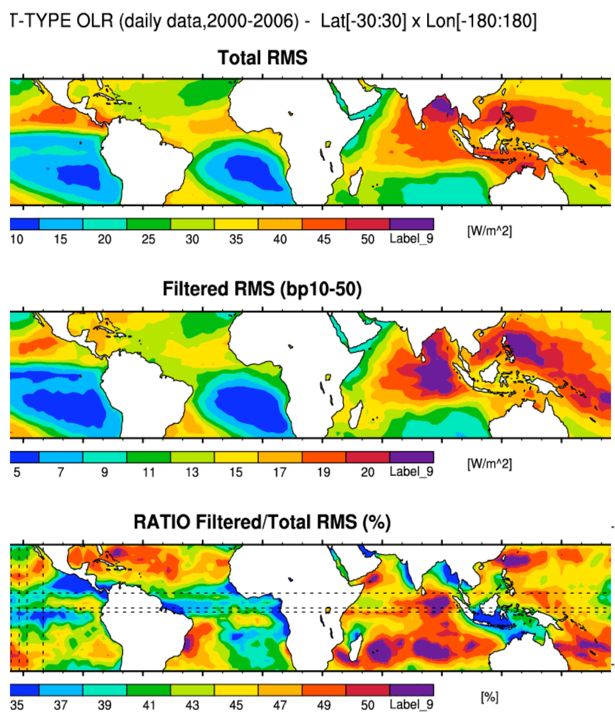
FIG : Graphe d'Hovmüeller pour la vorticité du vent

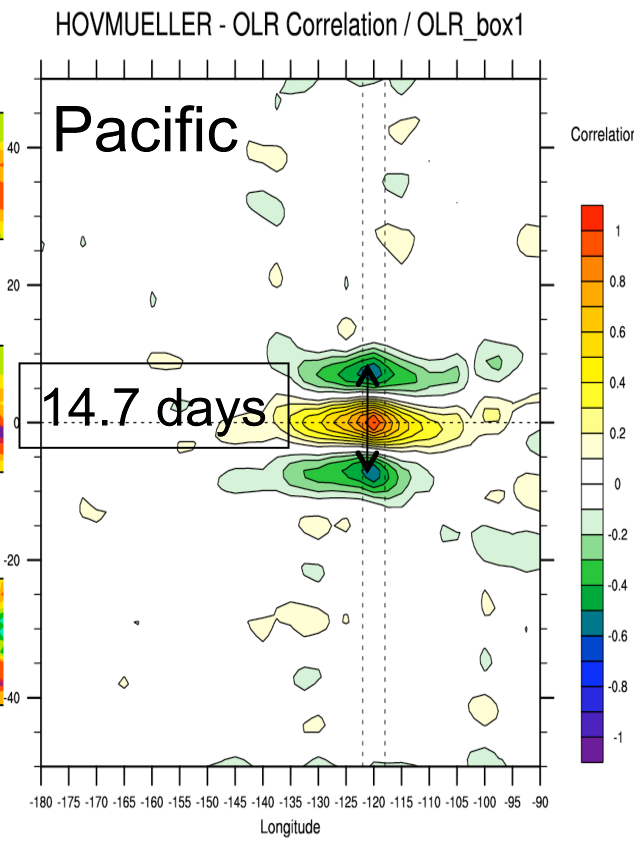


Correlates with biweekly OLR and leads SST

OLR biweekly signal in all tropics



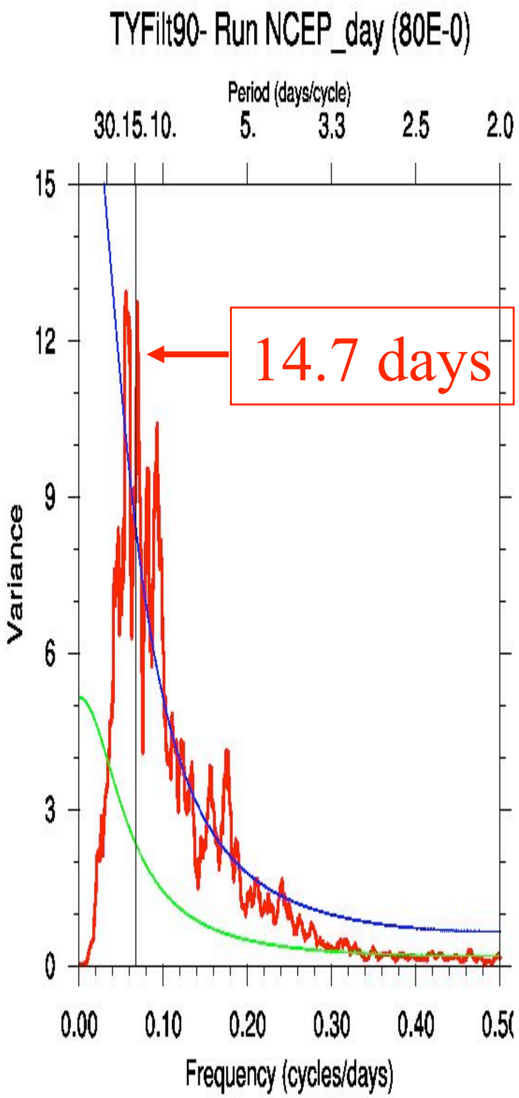


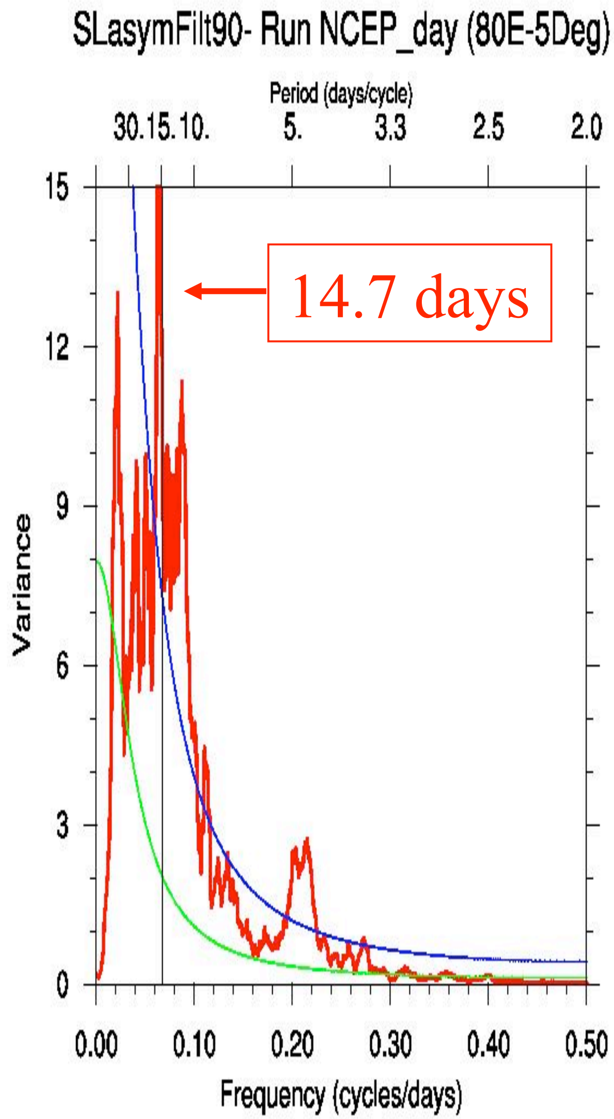


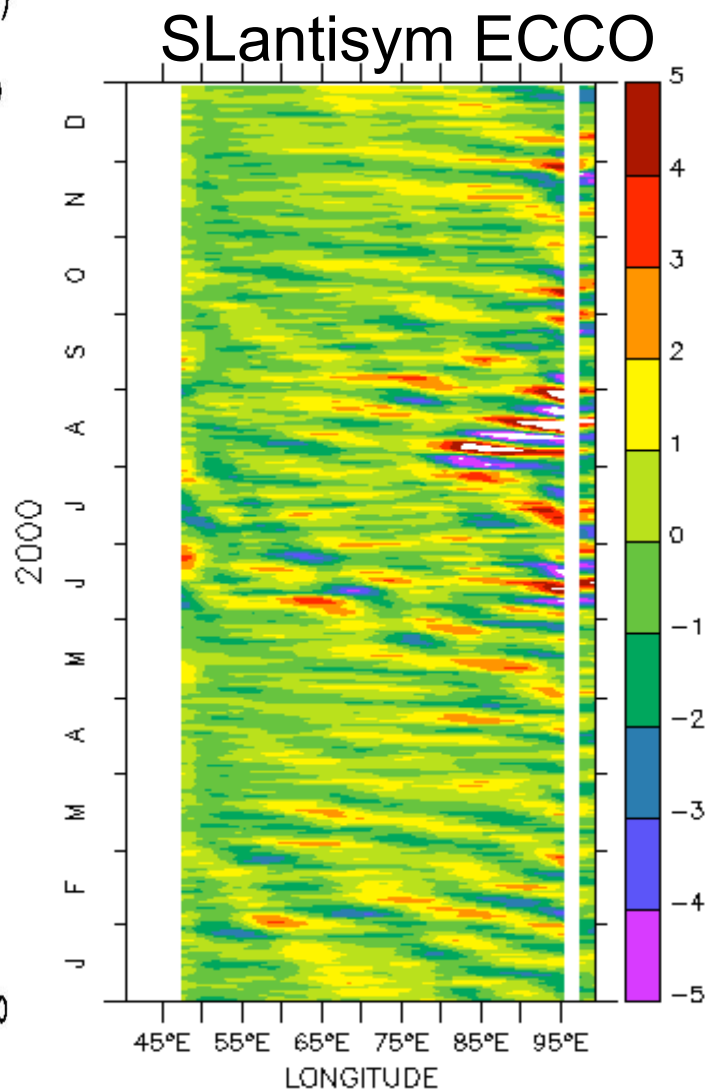
E-242E]

Biweekly OLR signals are in the tropical Indian and Pacific TIW zone too.

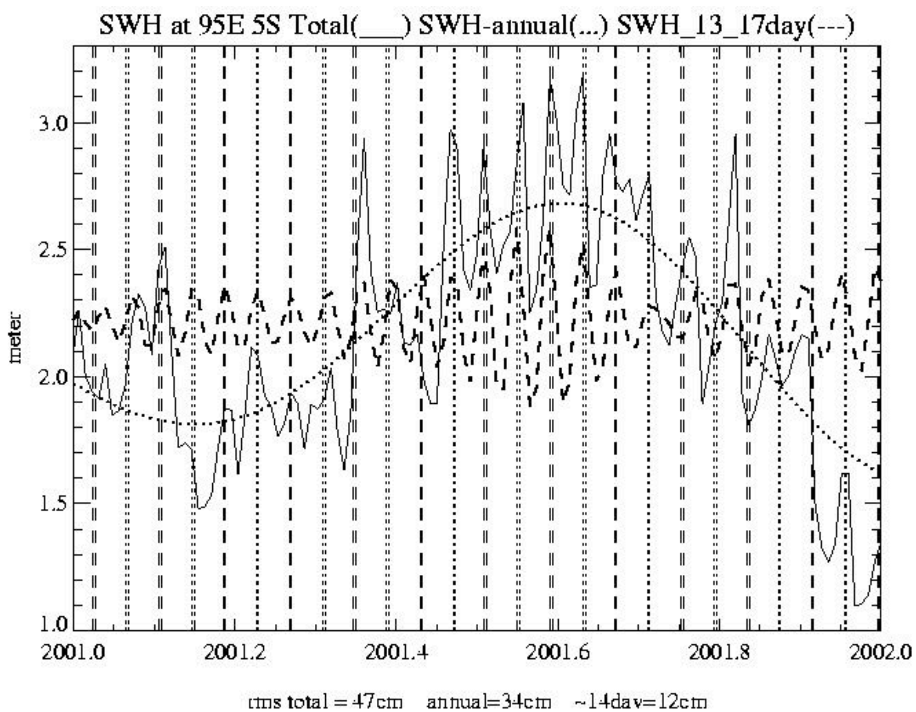
TY and SL NCEP or ECCO

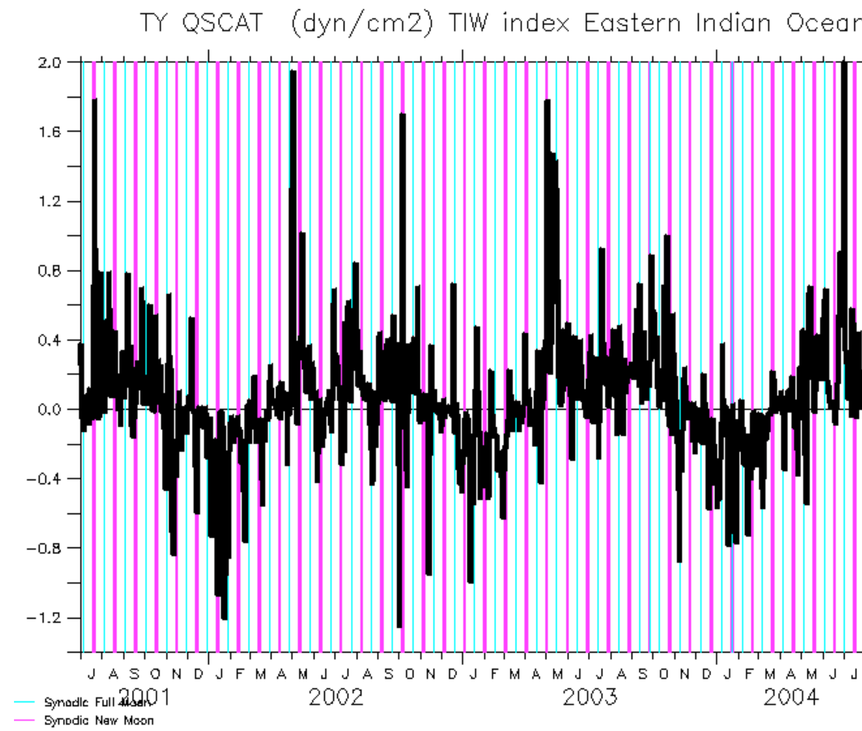




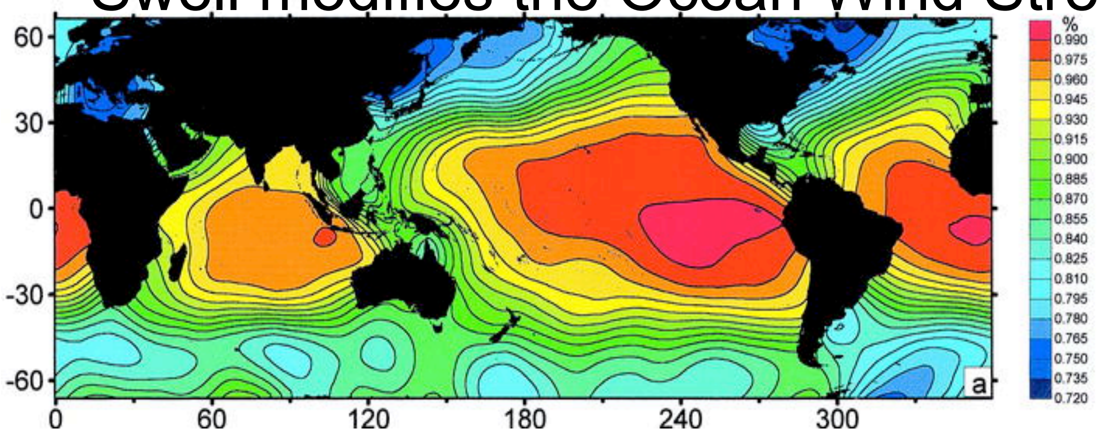


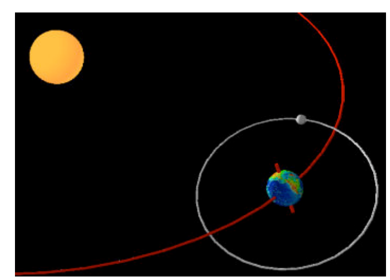
Biweekly SWH in the tropical swell pools



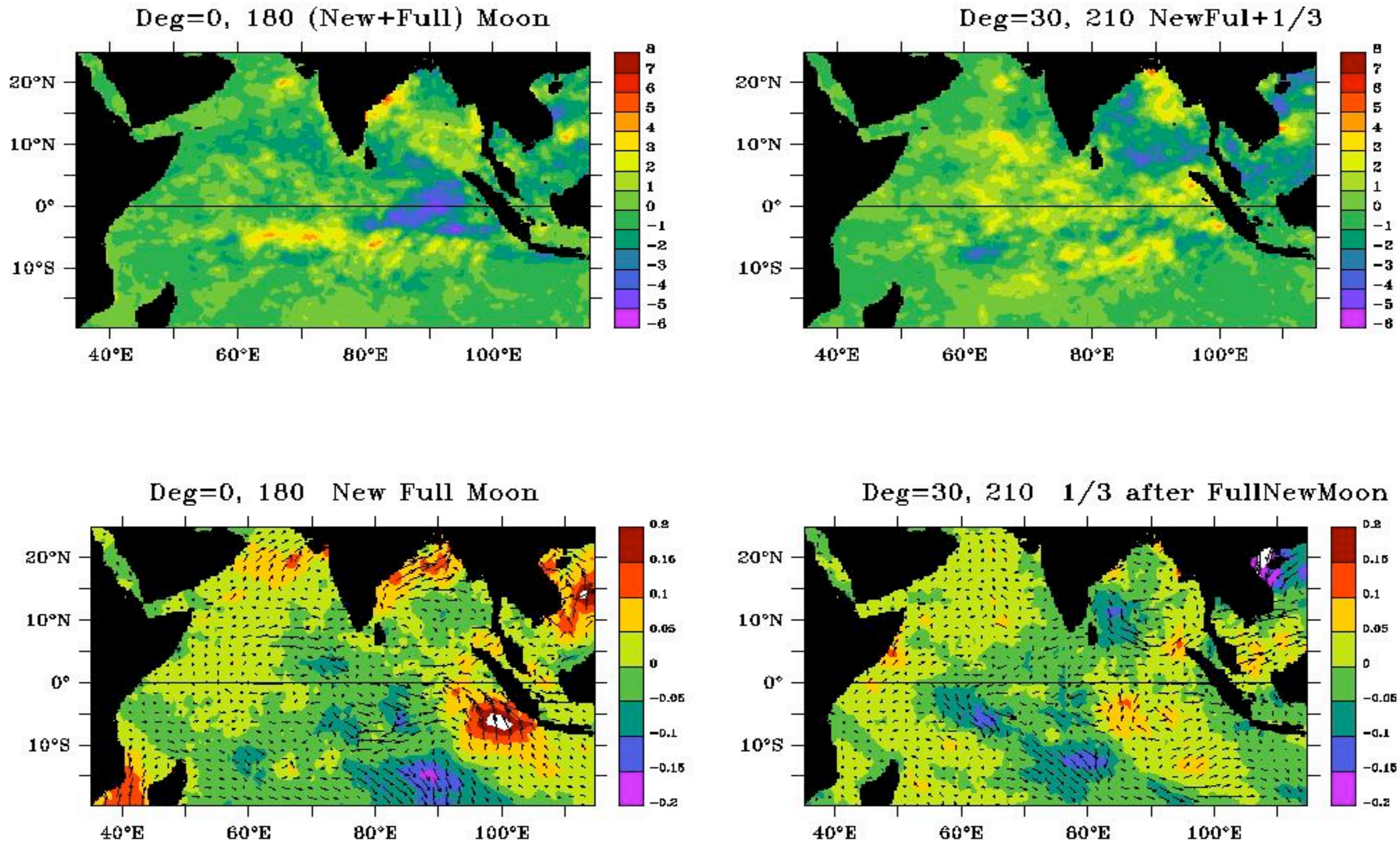


Swell modifies the Ocean Wind Stress Work Vector directions

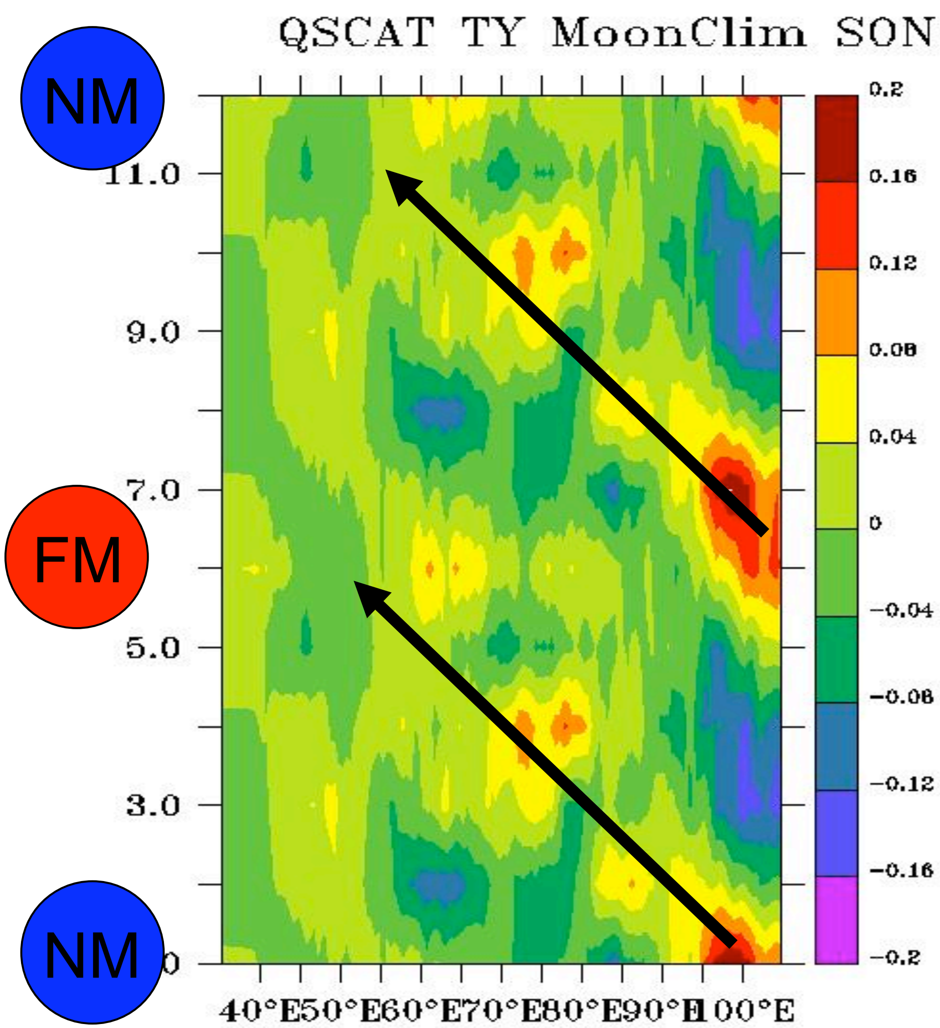


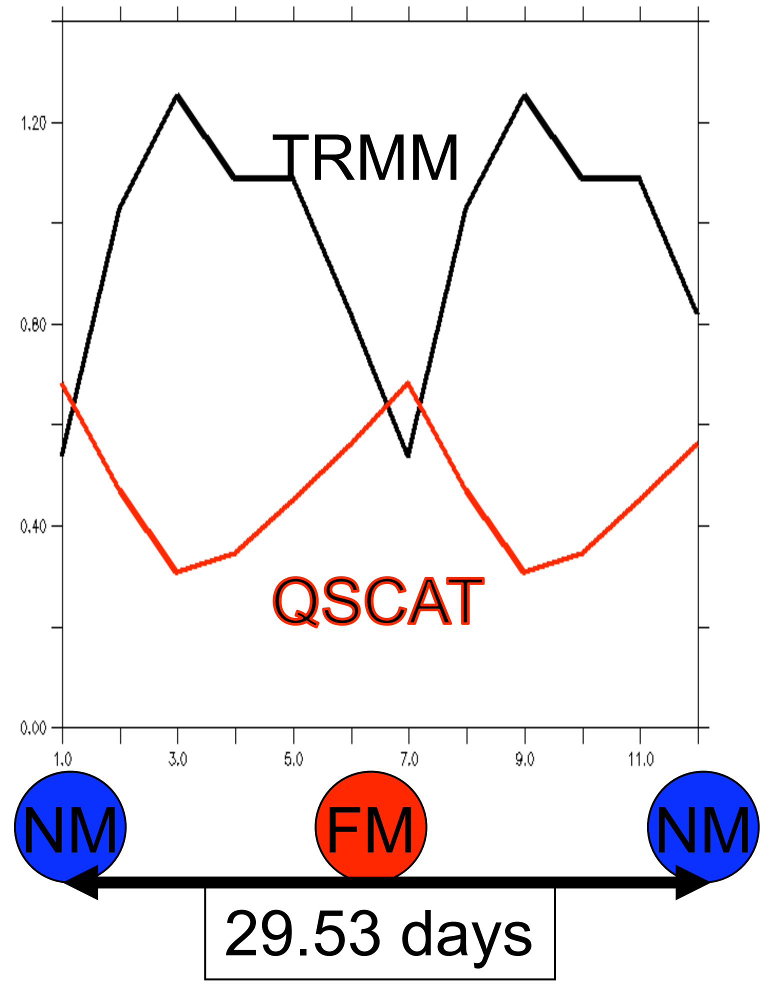


Moon Climatology of TRMM rain and QSCATstress vectors



Moon Climatology of QSCAT and TRMM





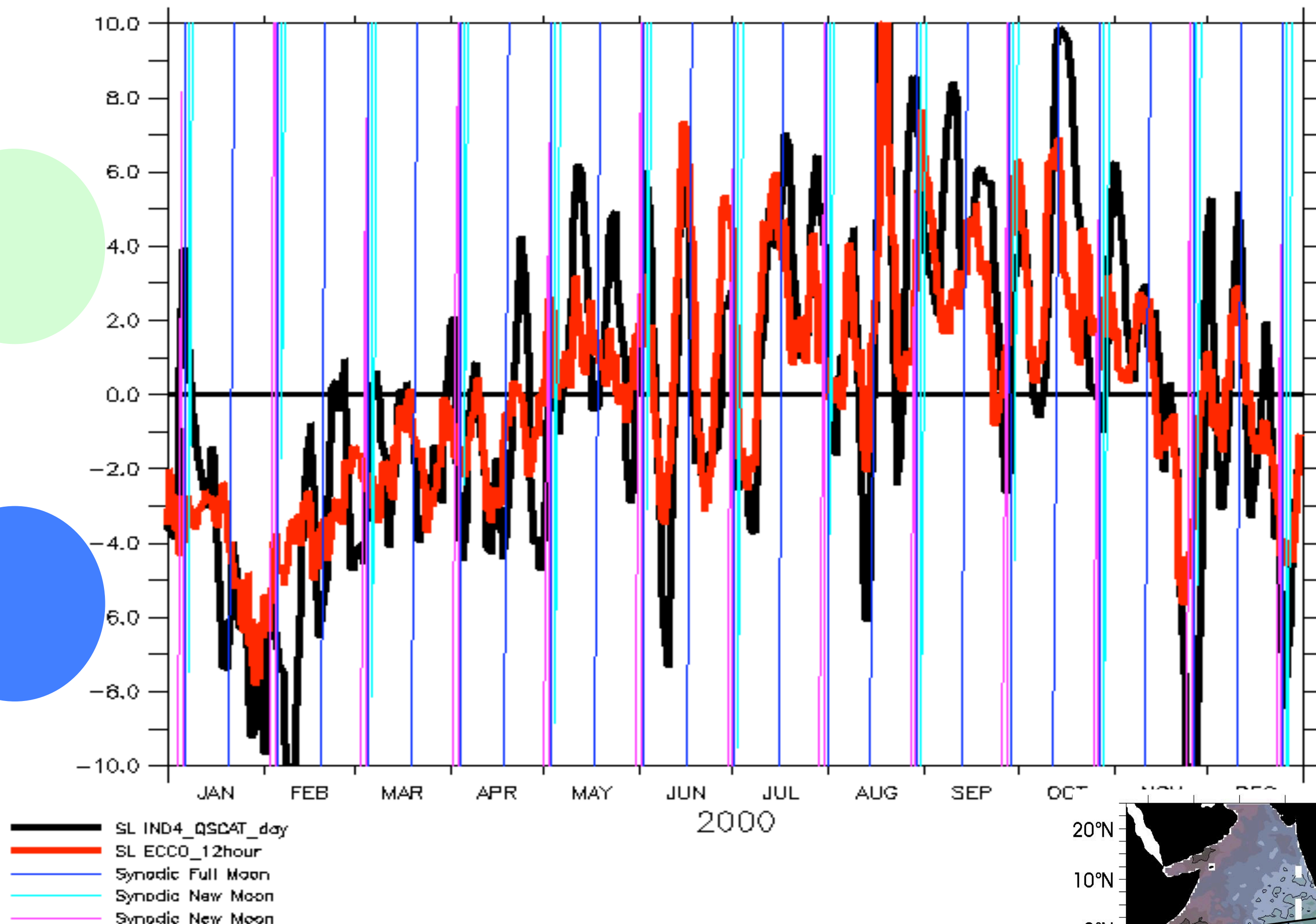
Units of time (1 to 12) are “Moon-Clim-month”:

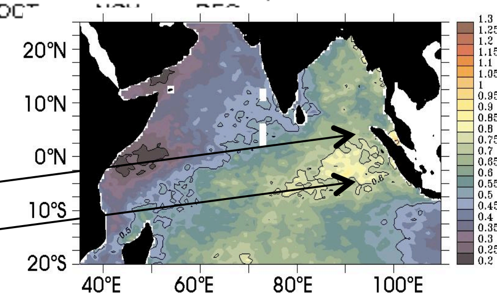
12 “MC-months” = 29.53 days→ each ”MC-month” = 2.46 days

TIW from ECCO and Ind_QSCAT+TRMM

full

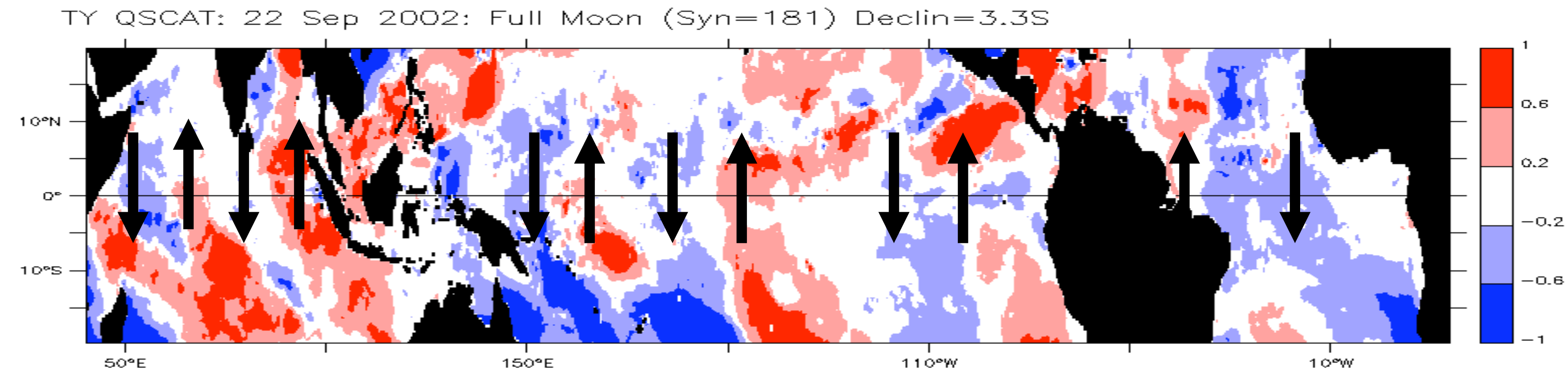
new



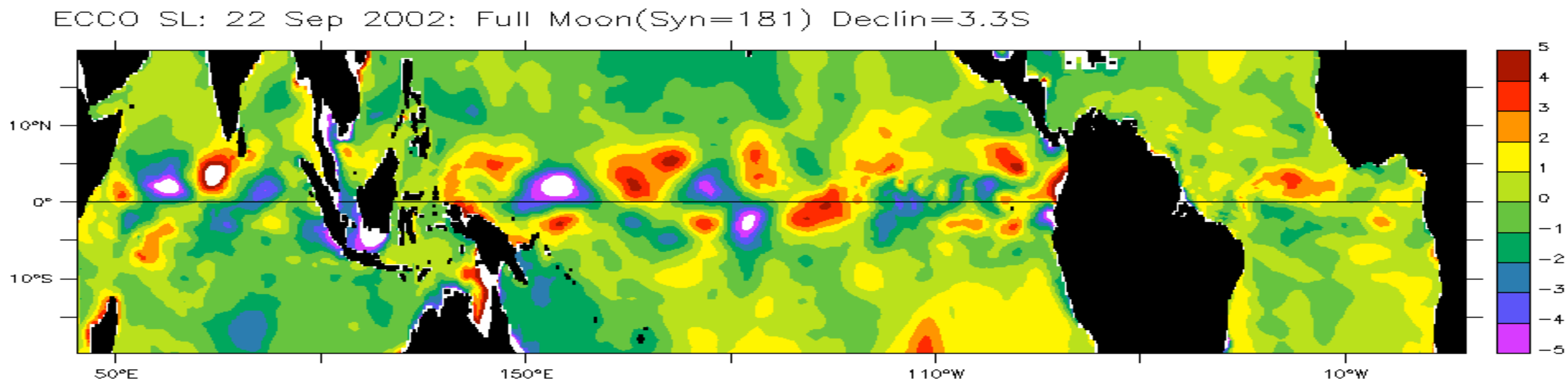


Index = Sea Level averaged (North – South)

Exple: TY and SL on day= 22 Sep 2002
relative to mean { (day+7) and (day-7) }



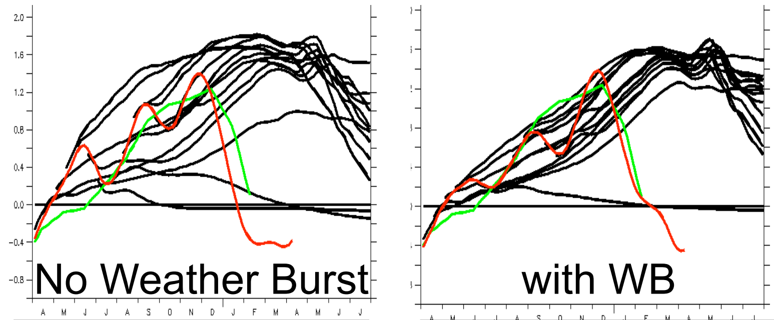
Meridional Wind stress TY from QuikSCAT



Sea Level from ECCO Exp.kf066b

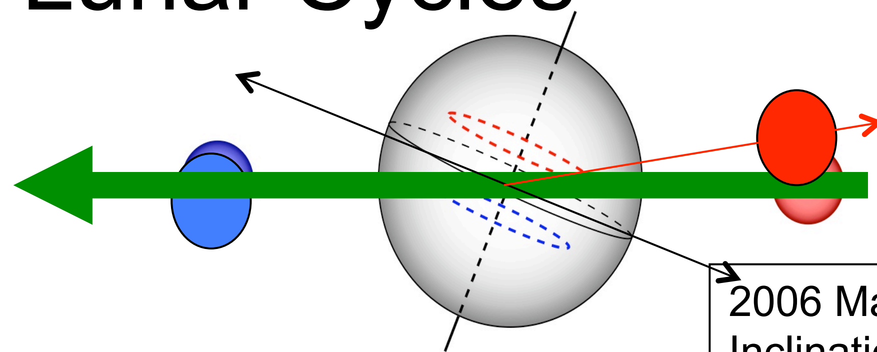
ENSO and Lunar Cycles

Forecasts of 2006-2007 warm event

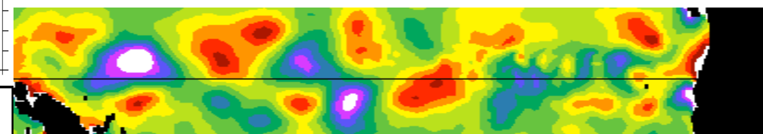


Apr06…...Nov07

Apr06…...Nov07



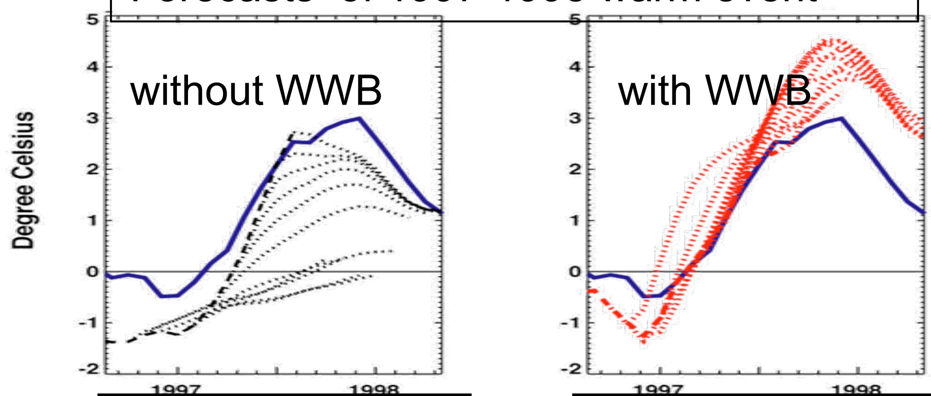
2006 Max Inclination of the Moon



TIW index stronger in 2006 during Max Lunar inclination than in 1996/97 during Lunar minimum. Event collapsed in Jan 2007 because of strong cooling TIW activity during Lunar max.

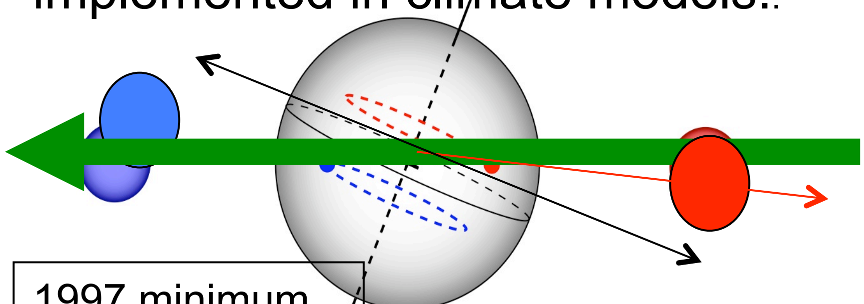
Biweekly Lunar forcing to be implemented in climate models..

Forecasts of 1997-1998 warm event



Nov96…….Jul98

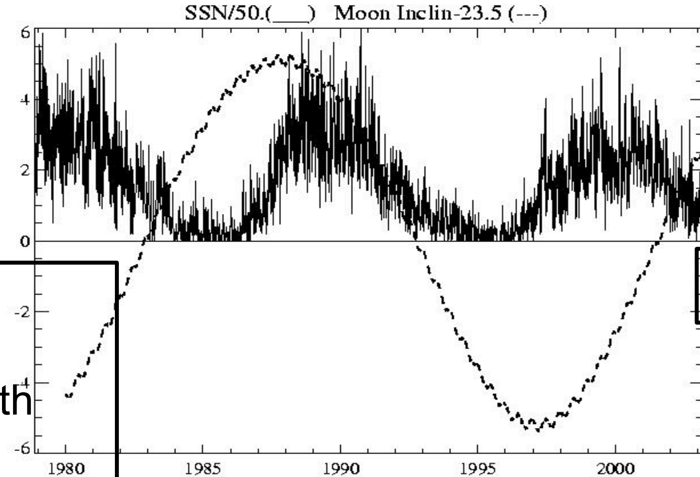
Nov96…….Jul98



1997 minimum Lunar Inclination

1900-2000 observed SST, Lunar and Solar Cycles

18.6yr --> 3.6, **2.2yr**



11yr --> **3.6yr, 2.2yr**

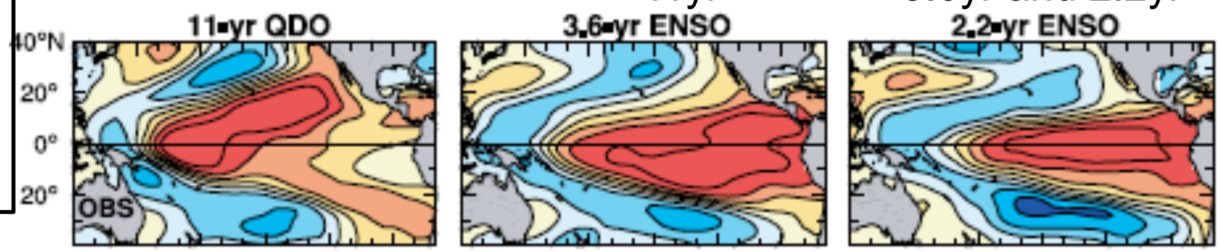
Solar White and Liu, 2008

h(T,S)<->TX+ f/β dTY/dx
dT/dt <-> TX
dTY/dx <-> h(SST,SSS) with

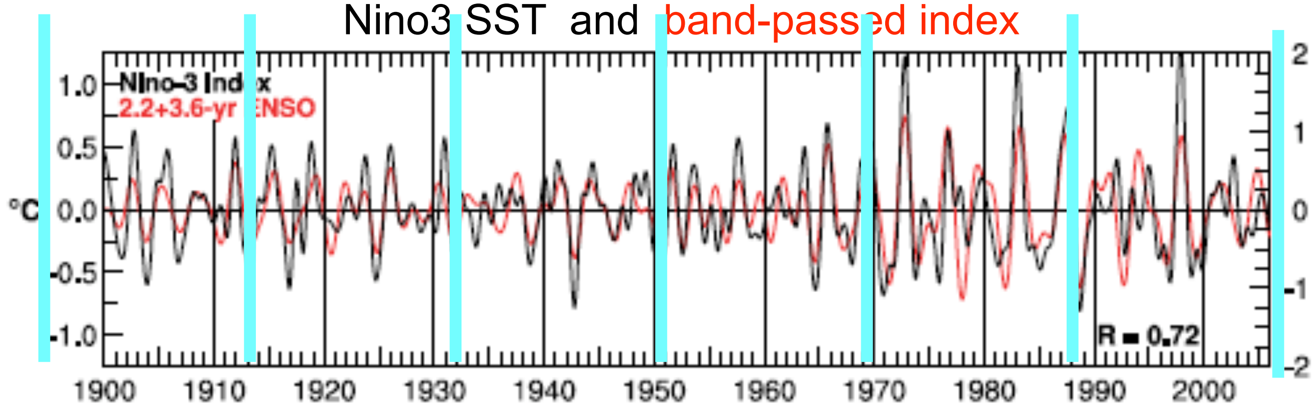
(h+bh^5)
needs 5th and 7th harmonics of
~18.6yr ===> 3.6yr and 2.2yr

DROP (SST<->TX<-> curl <-> h)

h+bh^3
needs 3rd and 5th harmonics of
~11yr ===> 3.6yr and 2.2yr



Nino3 SST and band-passed index

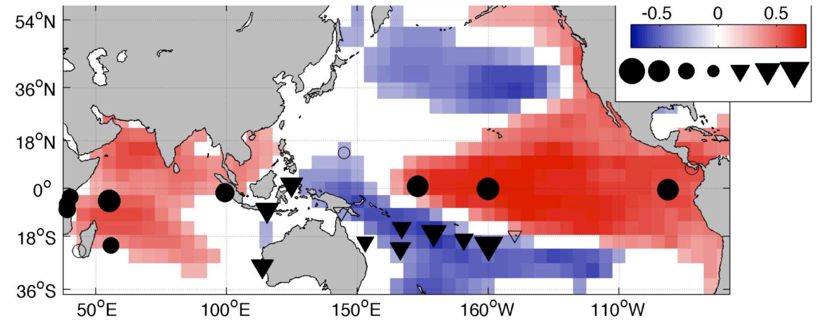


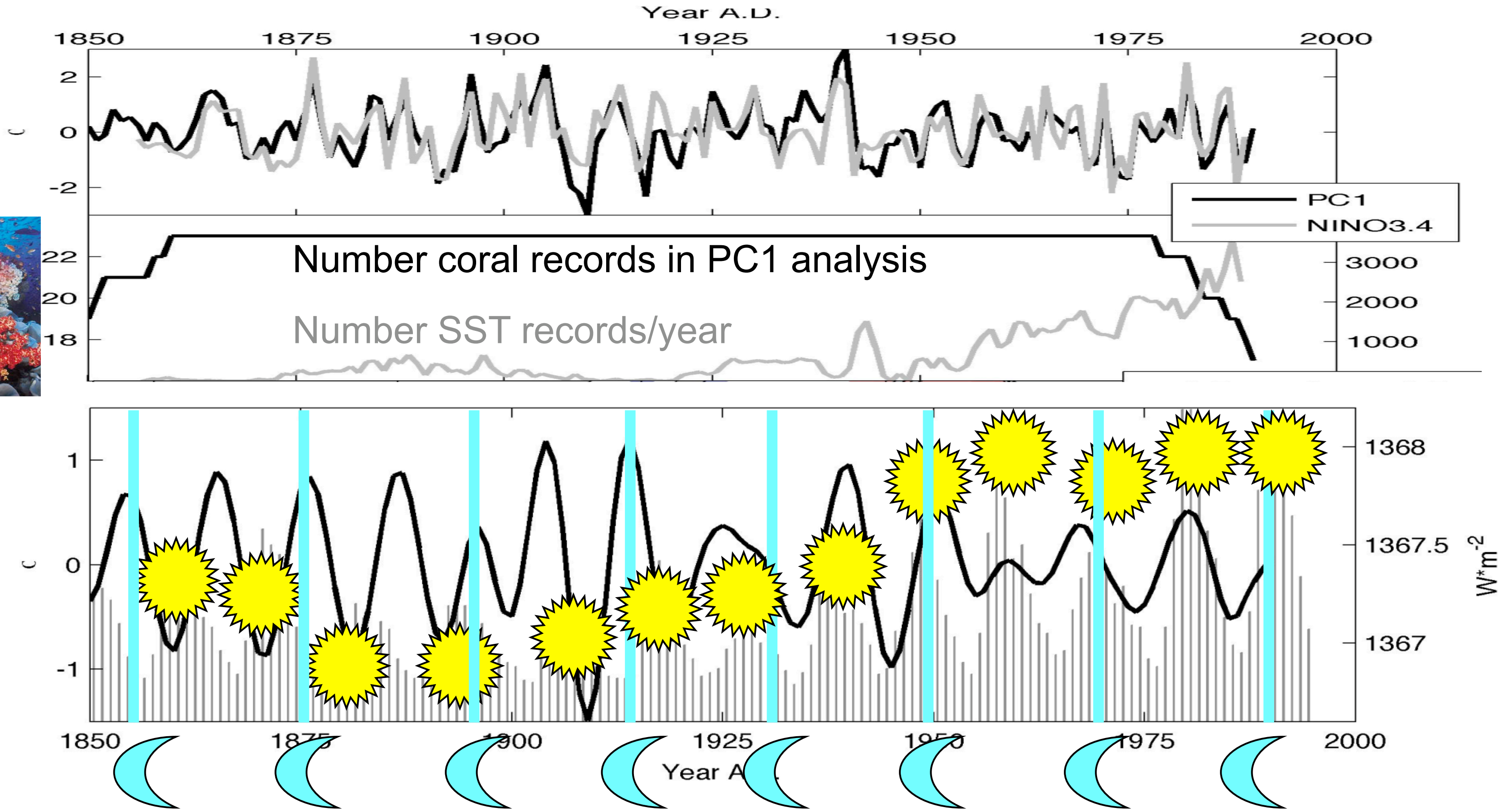
Sum of 2.2yr and 3.6yr band-passed index explains 52% of interannual variance.

Coral reefs, ENSO, and Solar cycles…..

from Ault et al., GRL, 2009

"No correl with ~11yr solar cycles
Cold events <-> min SSN in 1850-1910
Warm events <-> max SSN in 1930-2000"





Conclusion and Perspectives

- Biweekly TIWs found in cross-equatorial winds, currents, OLR, rain, SWH, Sea Level λ ~3000 km, 200cm/s to the W, source = ocean (MRGW).
- Role in interhemispheric exchanges (climate, TC).
- Active (Indian, Atlantic resonant basin geometry) all year around in the 3 oceans (West Pac: TC, East Pac: ENSO).
- Luni-Solar gravitational triggering of TIW.
- COUPLED models fail to reproduce TIWs and are overwhelmed by symmetric patterns.
- Let's add the Luni-Solar gravitational forcing in CGCMs.