Biweekly Oceanic and Atmospheric Tropical Instability Waves

Claire Perigaud, JPL, OVWST May2009

1. Are the Oceanic TIWs forced by the surface wind stress vectors?

2. Are the O-TIWs forcing the atmosphere?

3. Could the Moon be the trigger?

Oceanic TIWs

- TIWs in the 3 tropical oceans have been observed long ago as (10-to-40day) cross-equatorial current reversals.

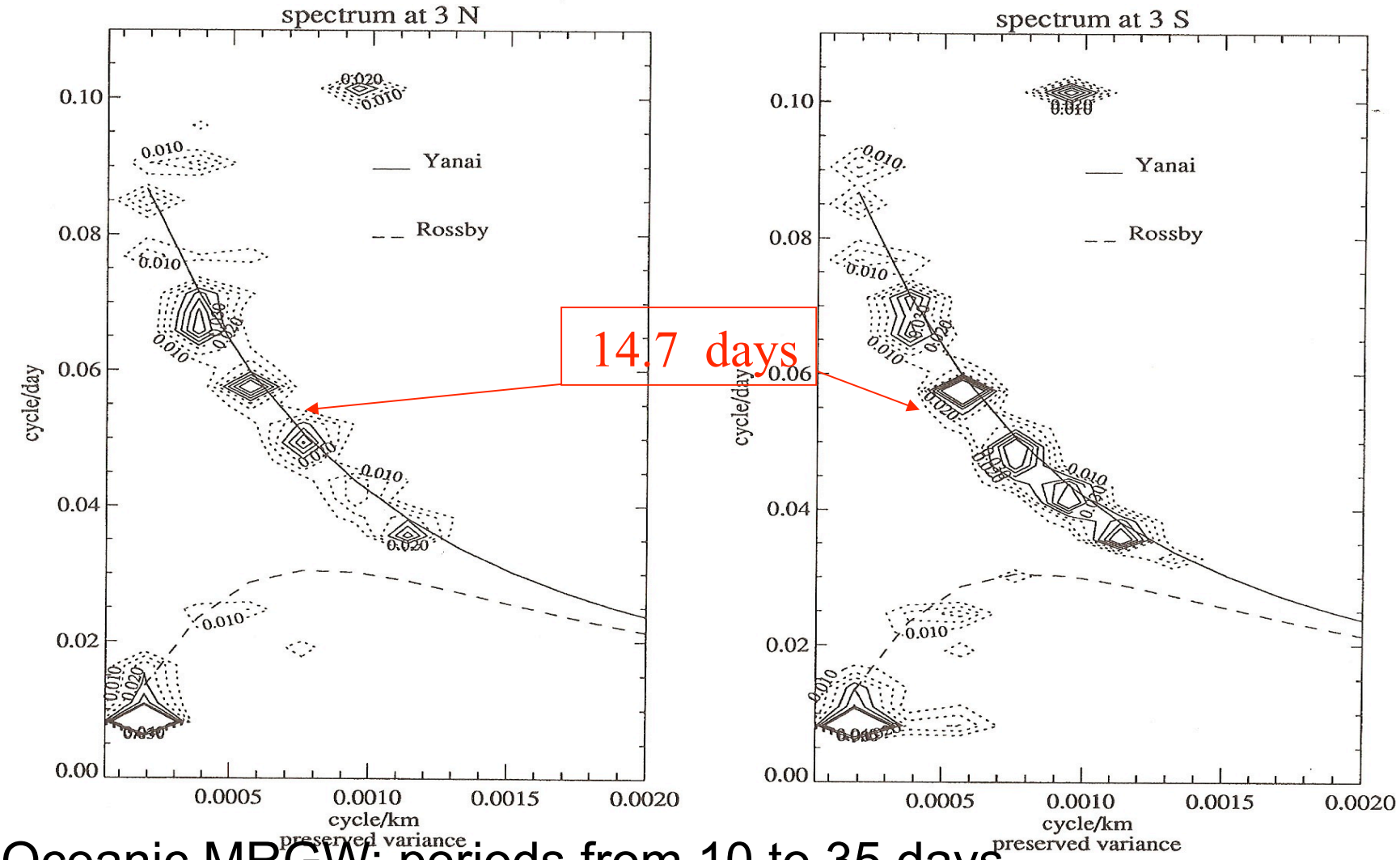
- As early as Seasat and Geosat, TIWs were identified as Mixed-Rossby-Gravity-Waves (MRGW).

- TIWs and MRGWs are simulated by all Primitive Equation ocean models, regardless of the wind stress forcing.

See experiments forced by climatology.

TIW characteristics in models are however very sensitive to the wind stress forcing. See 1993-to-2006 experiments forced by ERA (Mercator), NCEP+TPJ (ECCO), 1999-to-2006 Intermediate Coupled Model forced by (TRMM+QSCAT) daily variability (ICM).

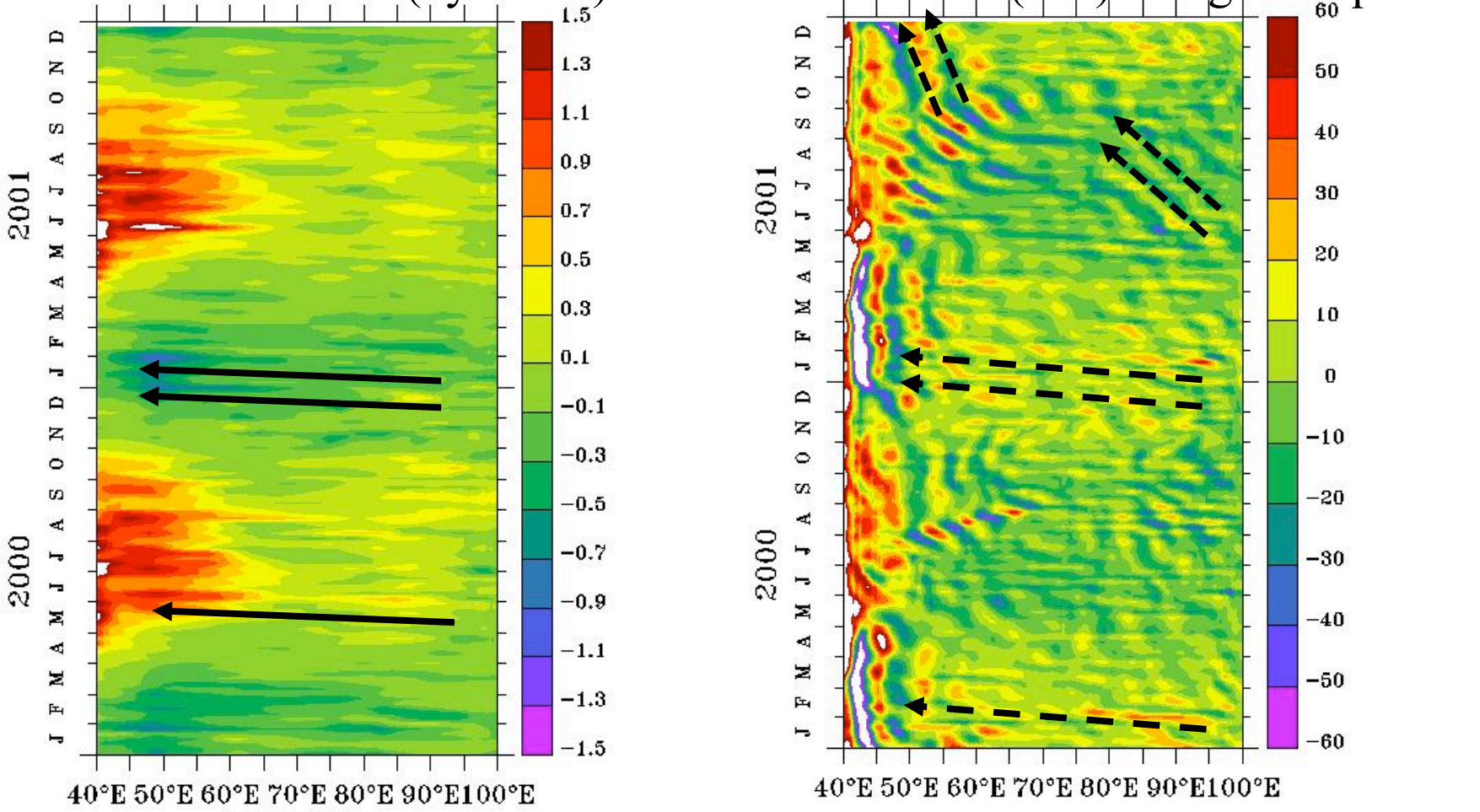
SL dispersion diagram from altimetry



Oceanic MRGW: periods from 10 to 35 days,
phase speed propagation to the West,
group velocity to the East.

TIW forced by ERA in Indian Ocean (Mercator)

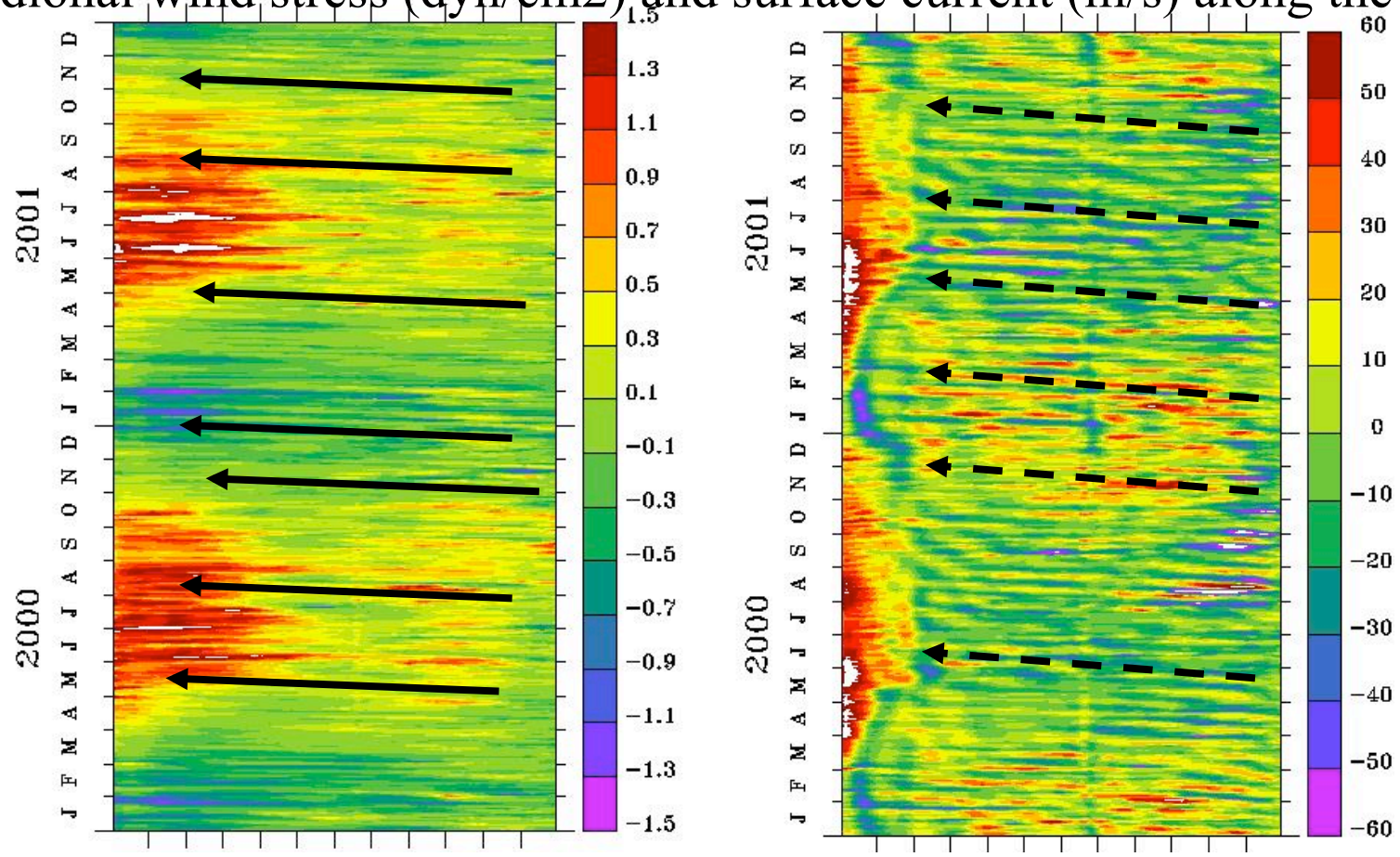
meridional wind stress (dyn/cm2) and surface current (m/s) along the equator



On top of 20-to-40 day cross-equatorial current reversals propagating at 30-to-50 cm/s, ~15 day reversals propagate much faster at ~200 cm/s. ~15 day reversals are also in ERA, propagating slightly faster.

TIW forced by QuikSCAT in Indian ICM

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

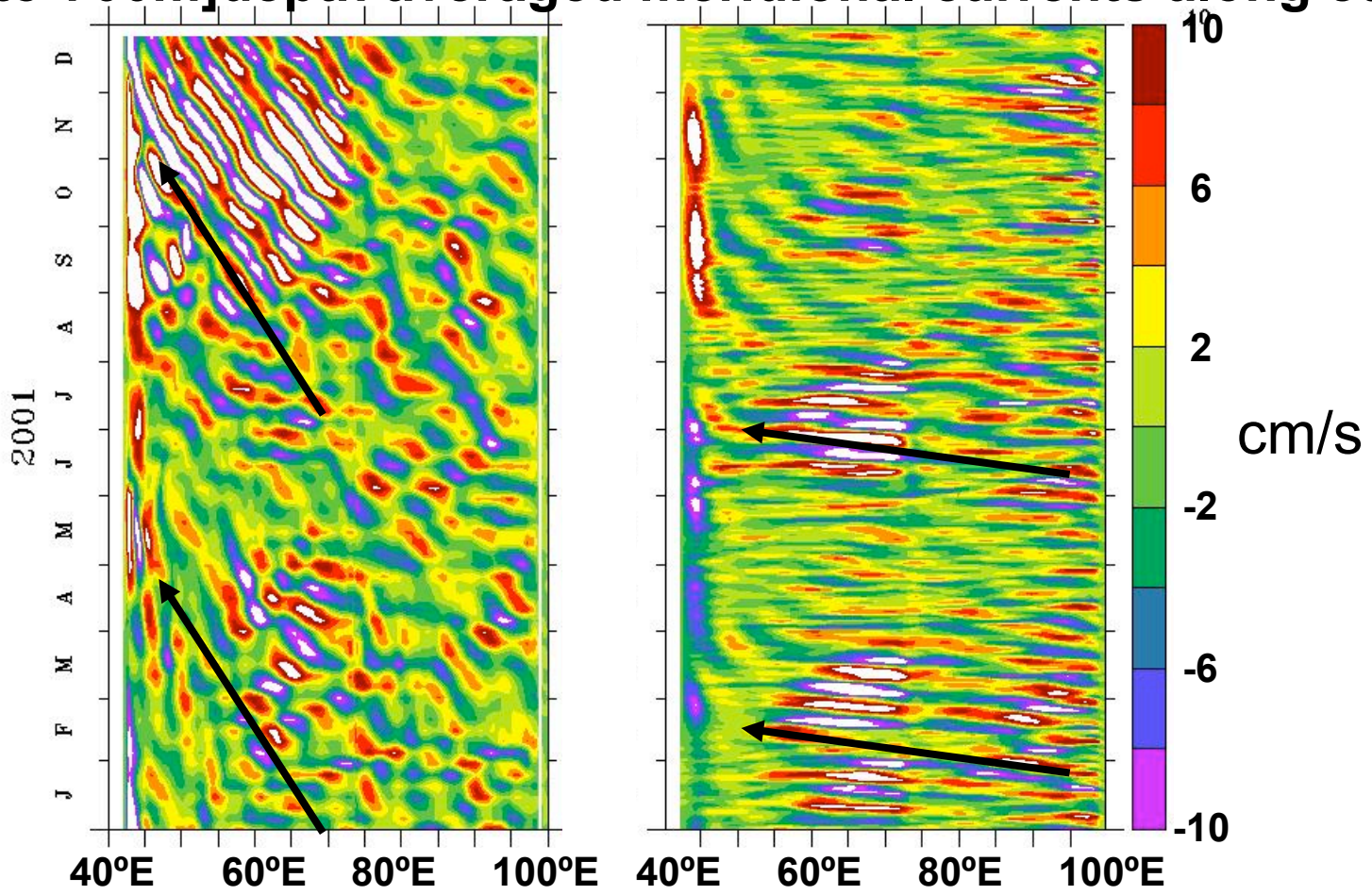


~15 day reversals are present in QSCAT all throughout the year, stronger than in other winds ➔ model TIWs dominated by ~15 days.

Wind reversals trigger and lead the MRGWs in wind FORCED ocean experiments.

TIW subsurface currents: comparison

[300-to-700m]depth averaged meridional currents along equator

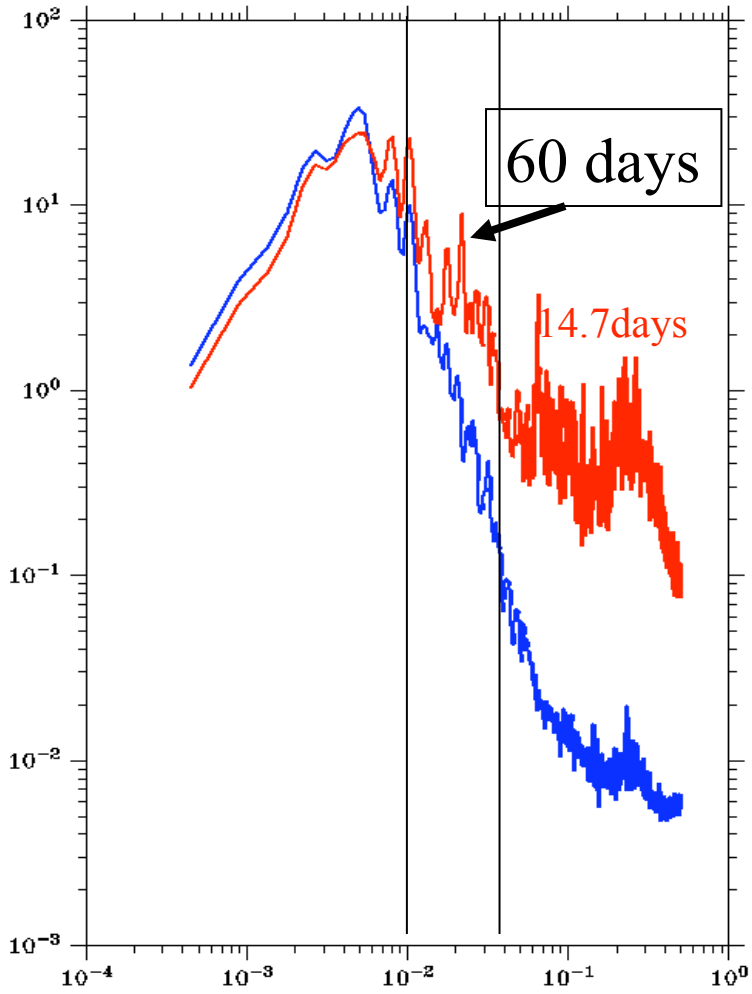


Forced by ERA **Forced by Qscat**

~15 day peak propagating at 200cm/s dominate at depth for QSCAT expt

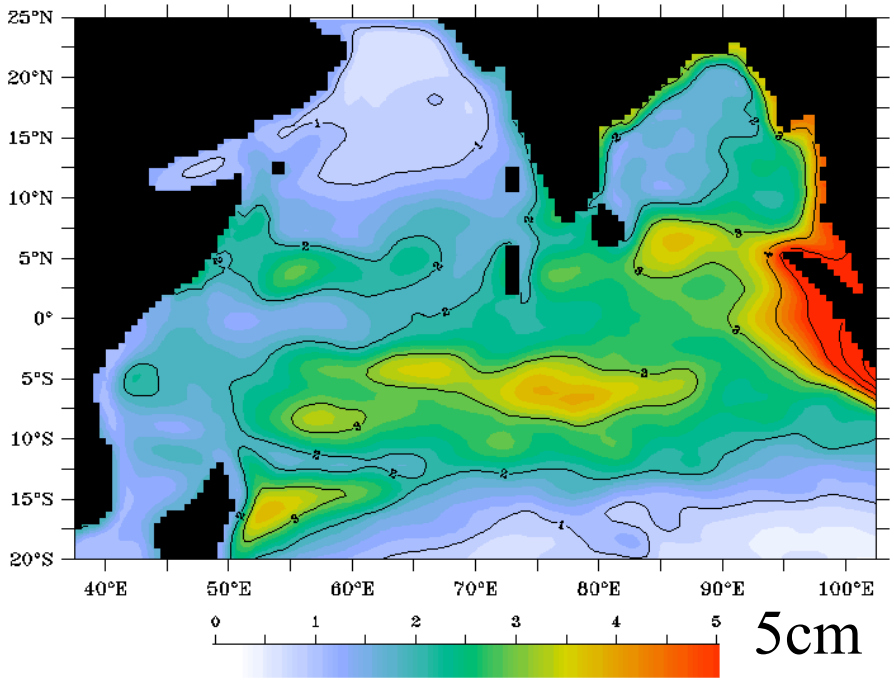
~ 30 day peak propagating at 30 cm/s "" ERA expt.

Model Sea Level



Indian ICM forced by
monthly averaged or daily averaged
QuikSCAT stress vectors.
Impact on sea level

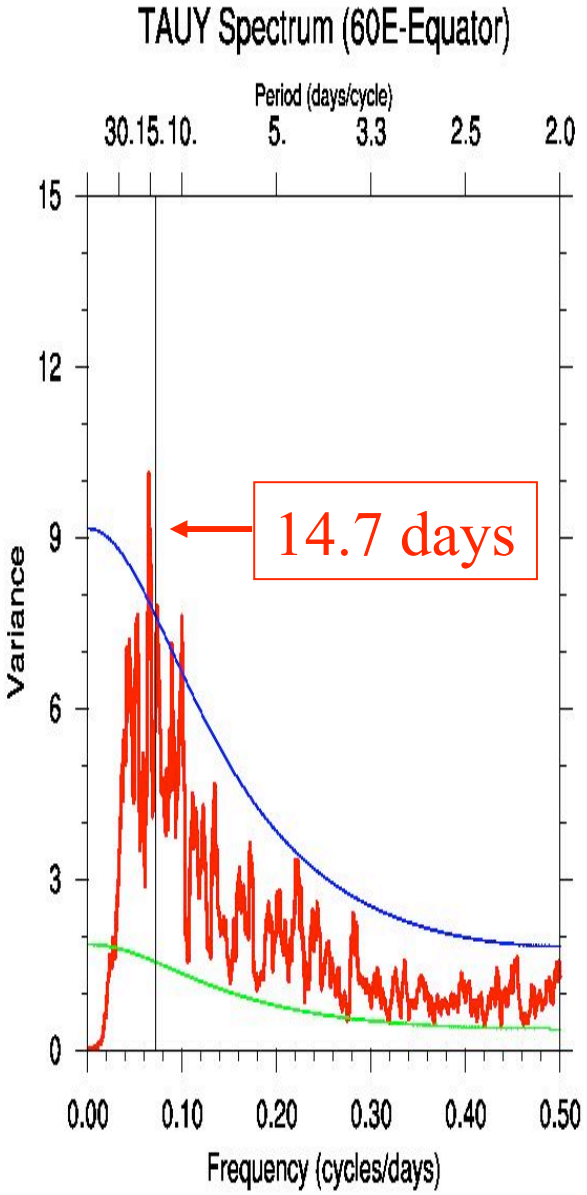
Rms Diff Sea Level



Run QSCAT_day has 25 % energy in the intraseasonal band with a peak at 60 days and at 14.7 days because of resonance due to the size of the basin.

Run QSCAT_month: 7% in the intraseasonal band (2-to-90 days).

Biweekly TIWs in TY and SL forced by QSCAT



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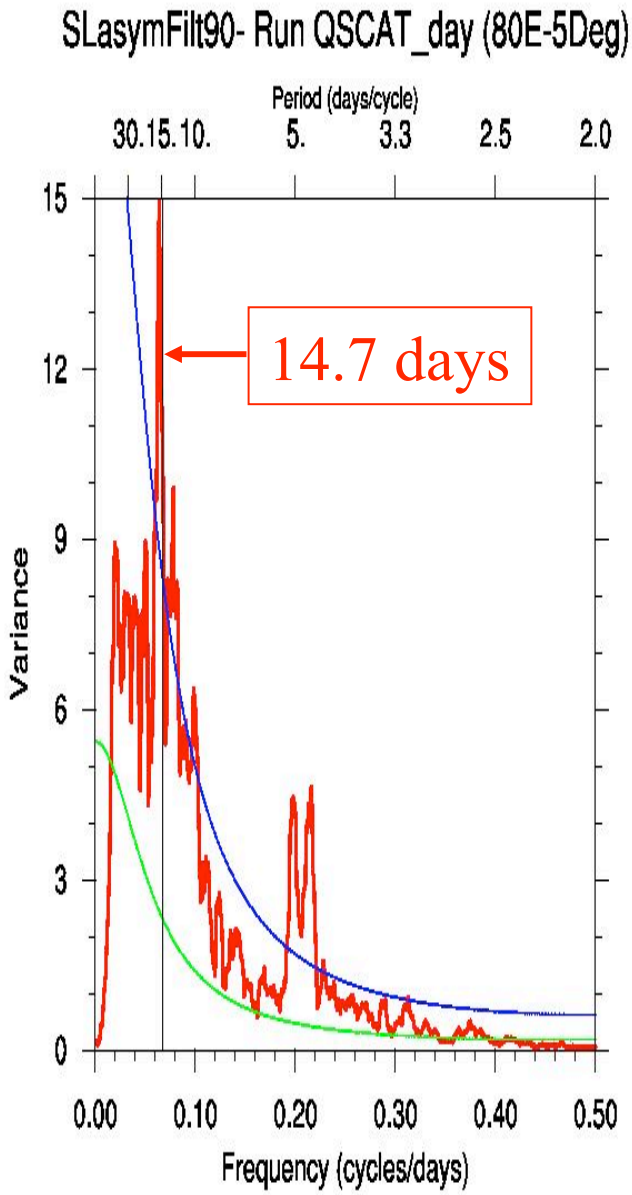
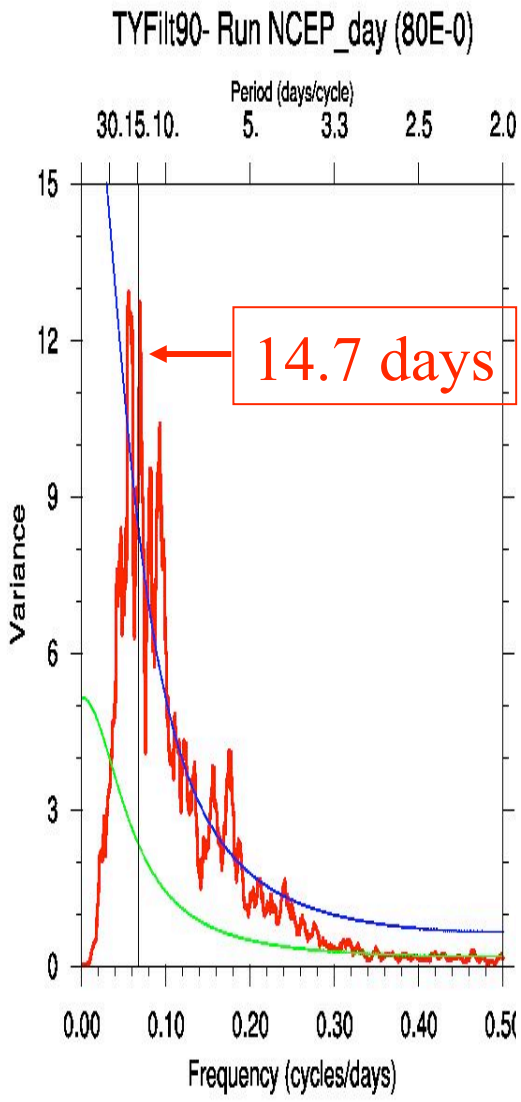
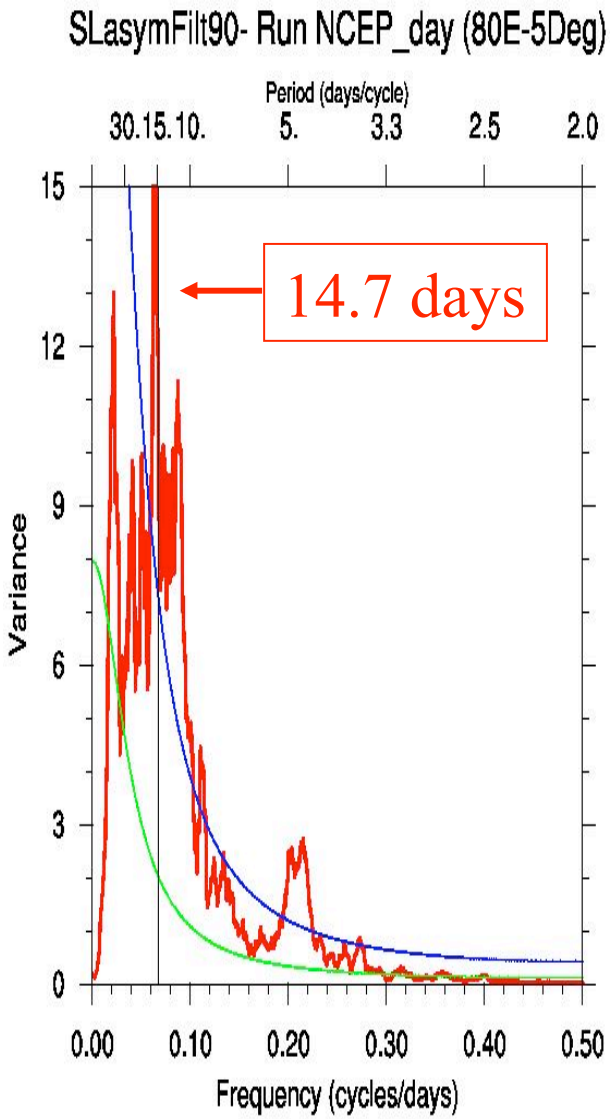
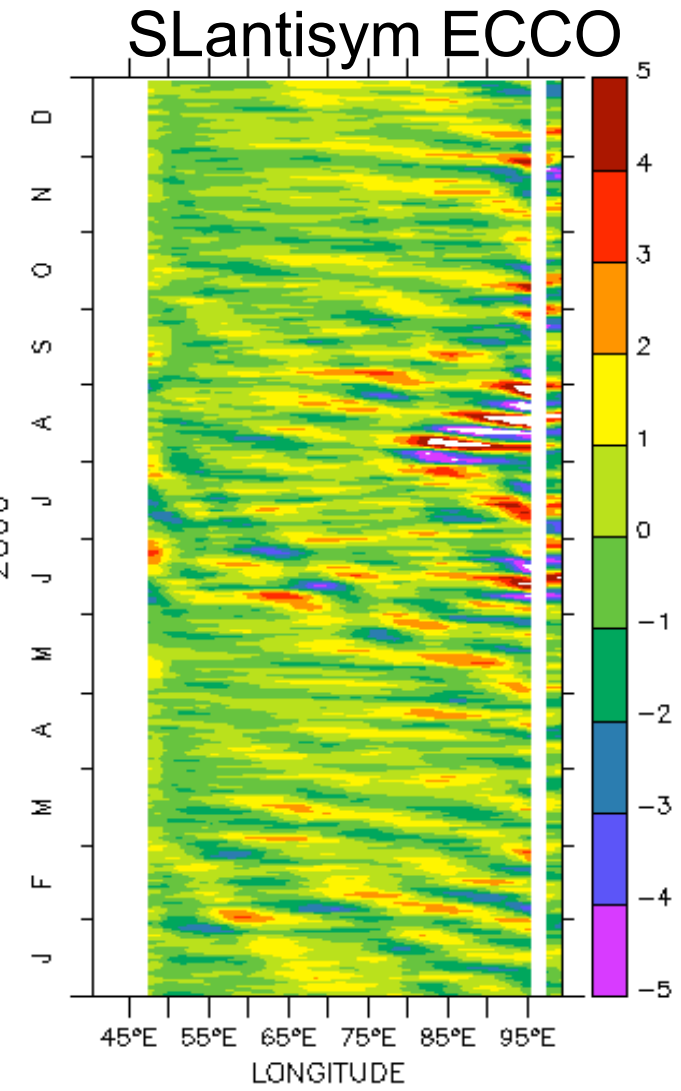


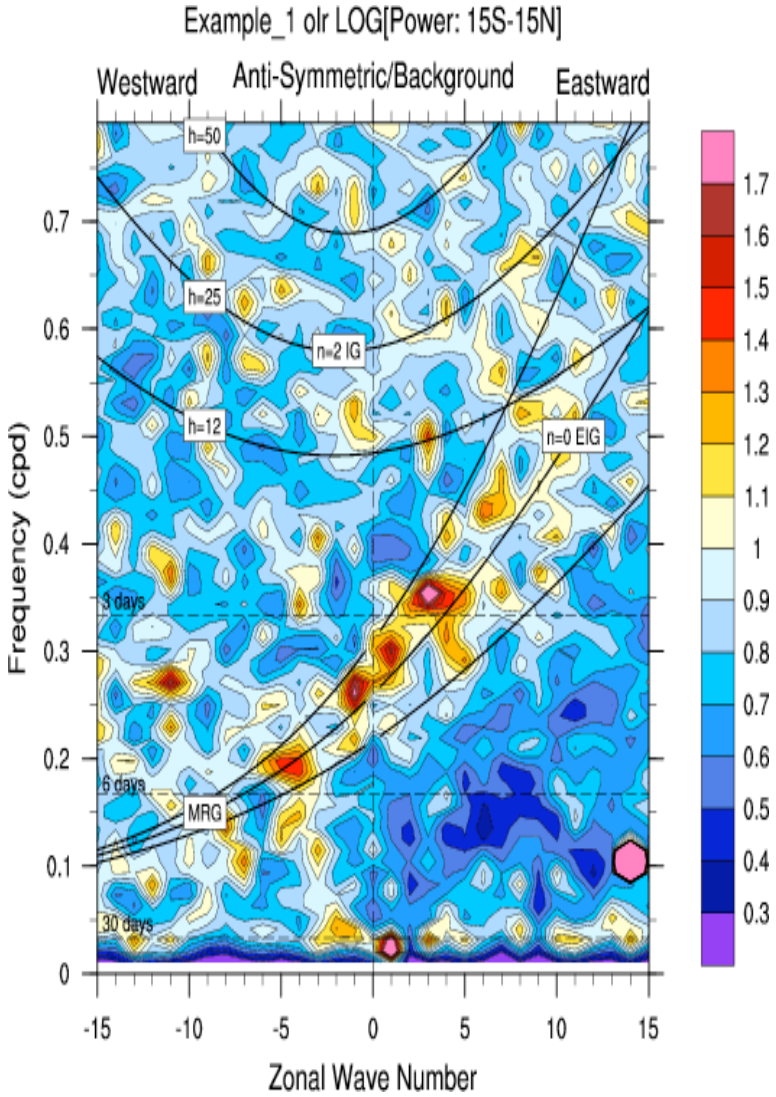
TY and SL NCEP or ECCO

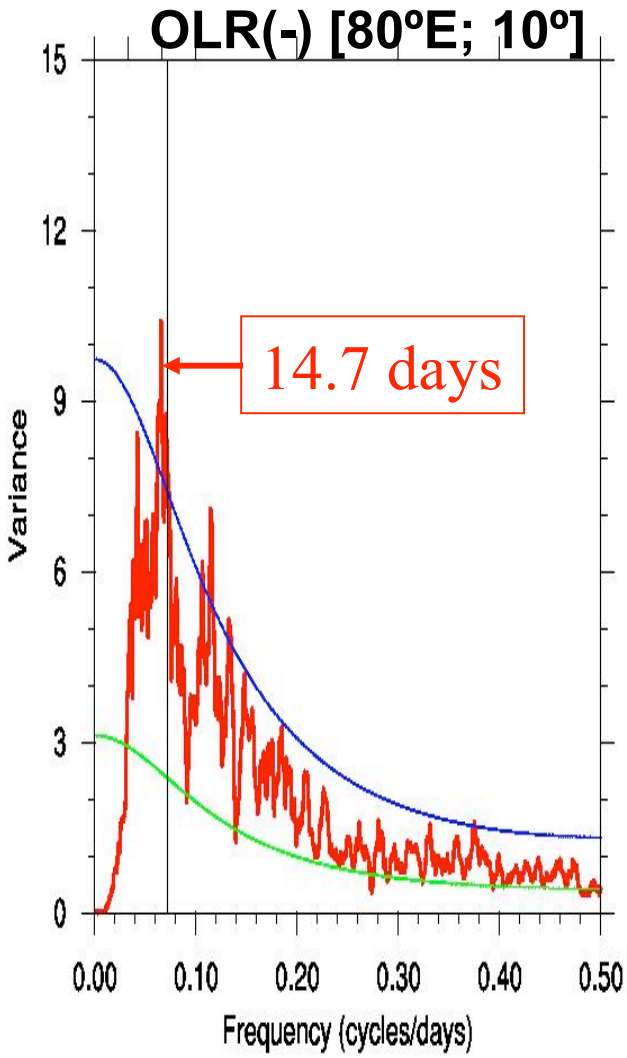






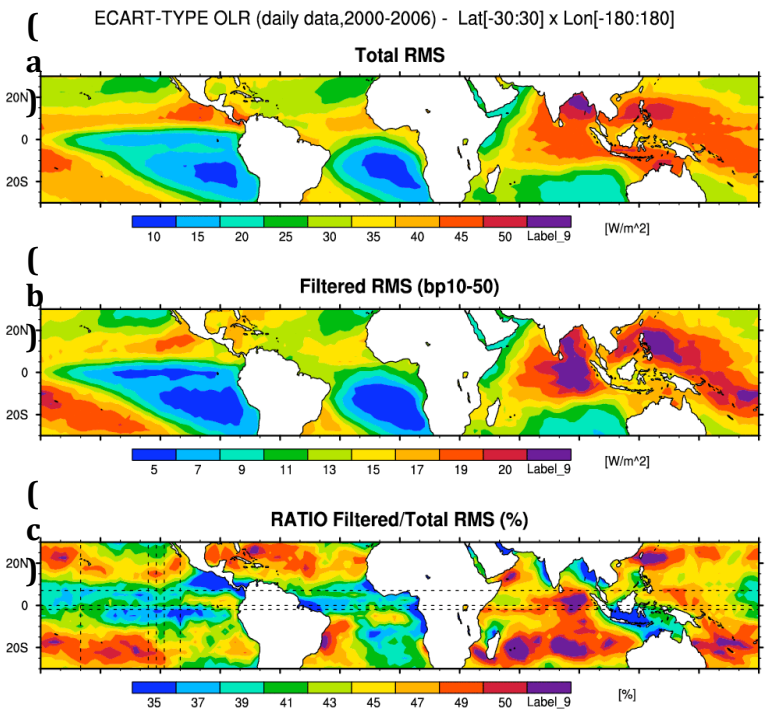
Biweekly Atmospheric MRGW



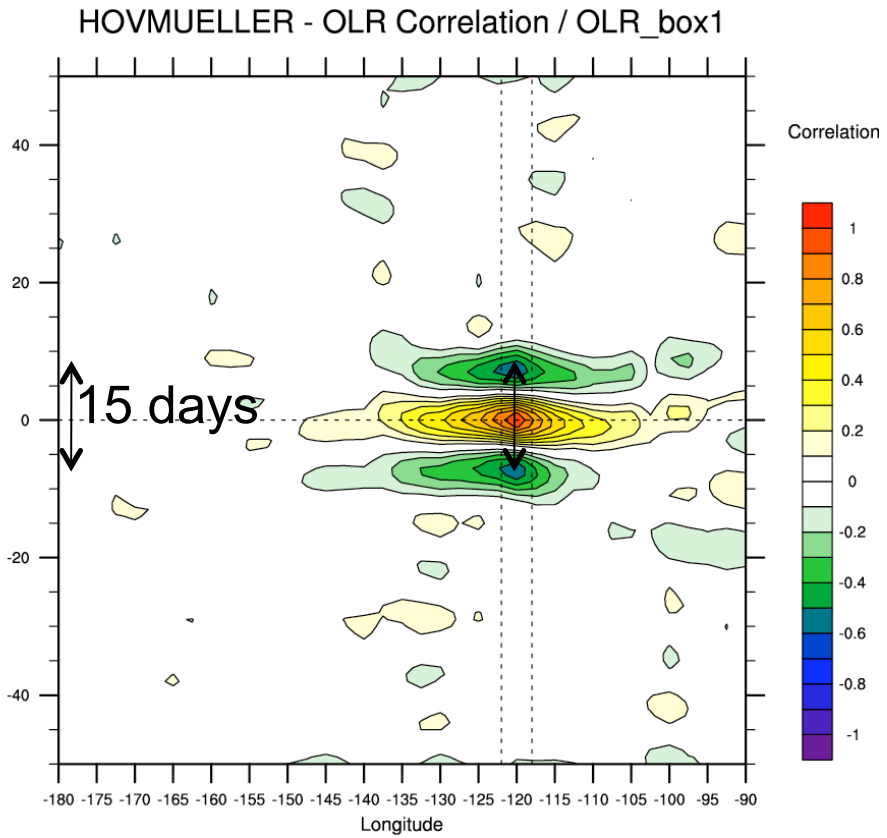


From Wheeler and Kiladis:
Westward MRGW are known in the 2 to 10 day band. Actually OLR data also have a 14.7 day peak

OLR biweekly signal in all tropics

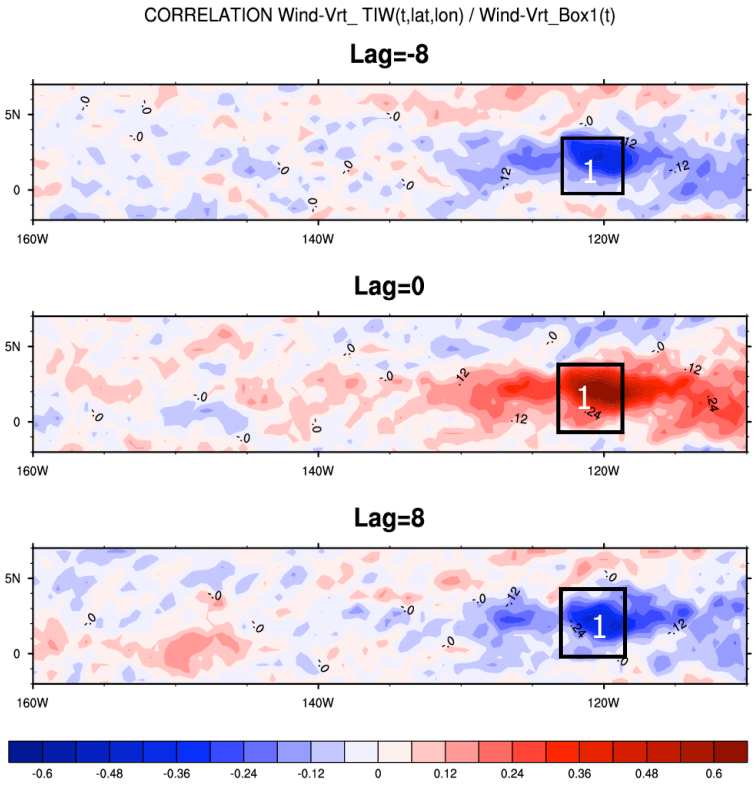


6 hourly OLR data from 1999 to 2006.
Rms total and filtered [10-to-50 day]
And ratio.
Box 1 for Pacific TIW index = [1N-3N, 238E-242E]



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

QSCAT vorticity



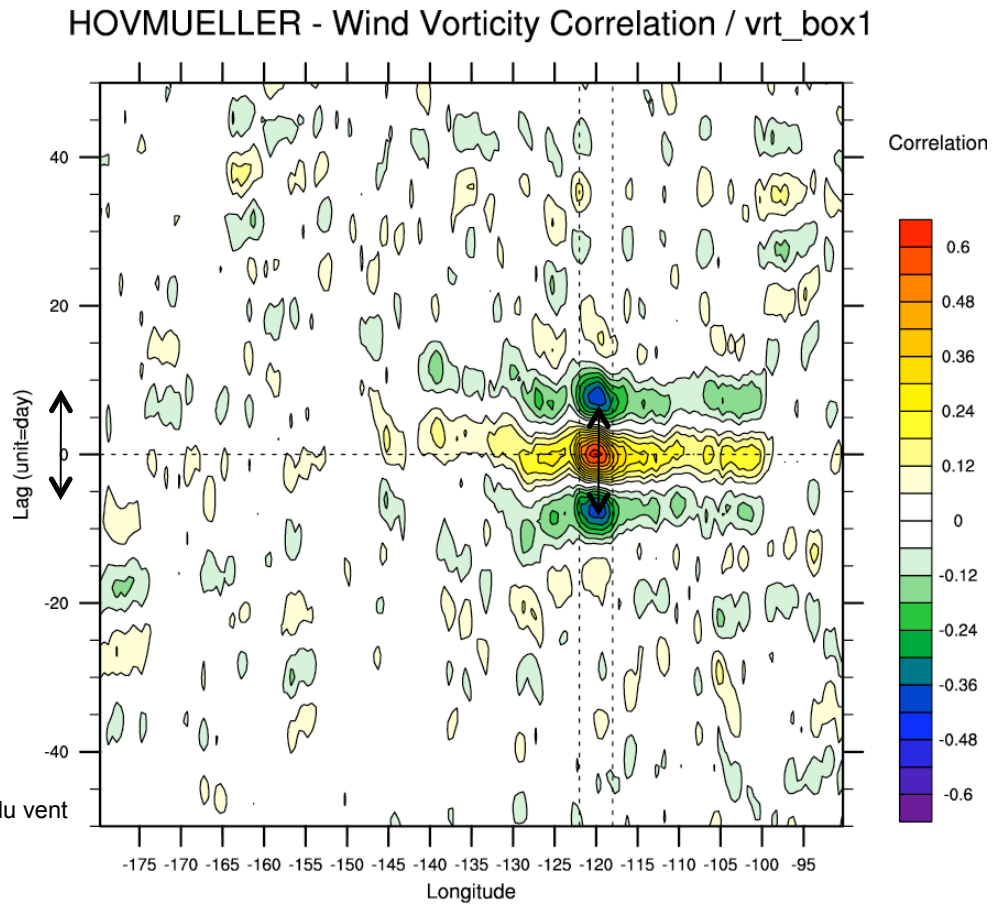
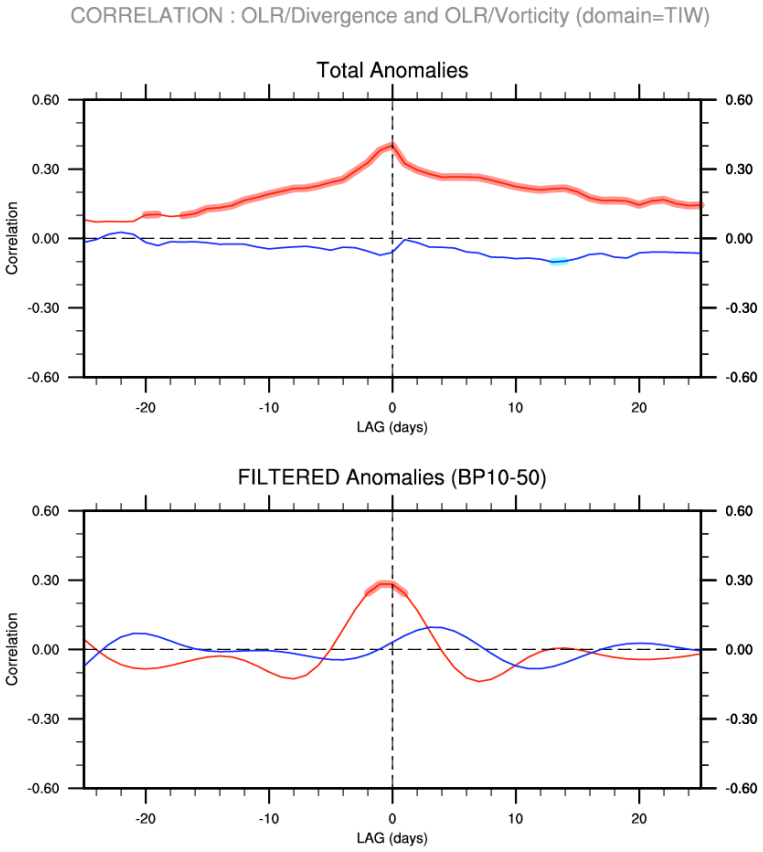


FIG : Graphe d'Hovmüeller pour la vorticité du vent

The 15 day peak of Pacific TIW is in QSCAT vorticity like in OLR.

Correlation (QSCAT, OLR)



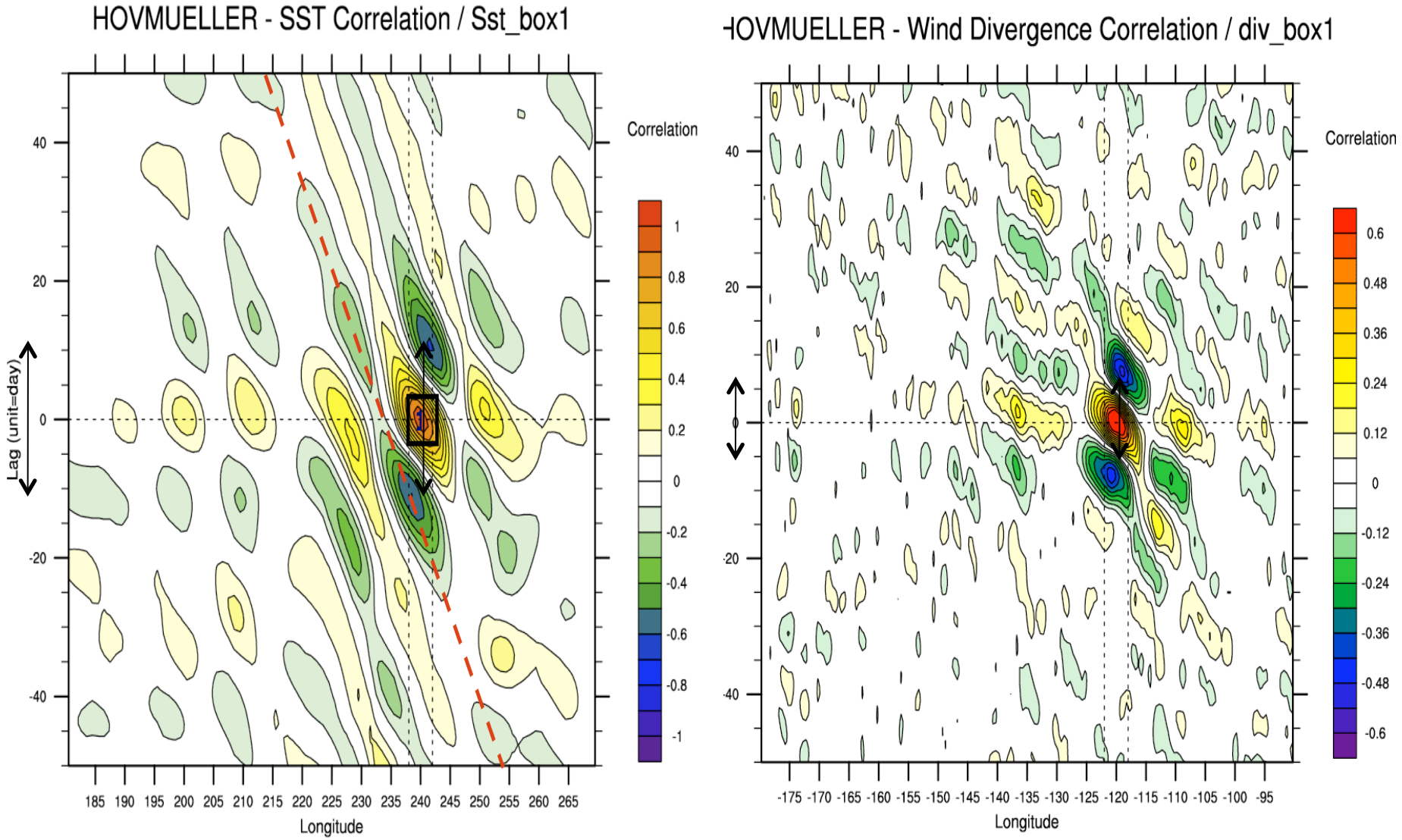
In the Eastern Pacific TIW

Correlation between OLR and divergence is significative and maximum at lag = 0:

Correl= +0.4 (total)
Correl= + 0.3 (filtered)

(OLR,divergence) in red
(OLR,curl) in blue
significant level >95%: highlighted

TIW in the Eastern Pacific from SST



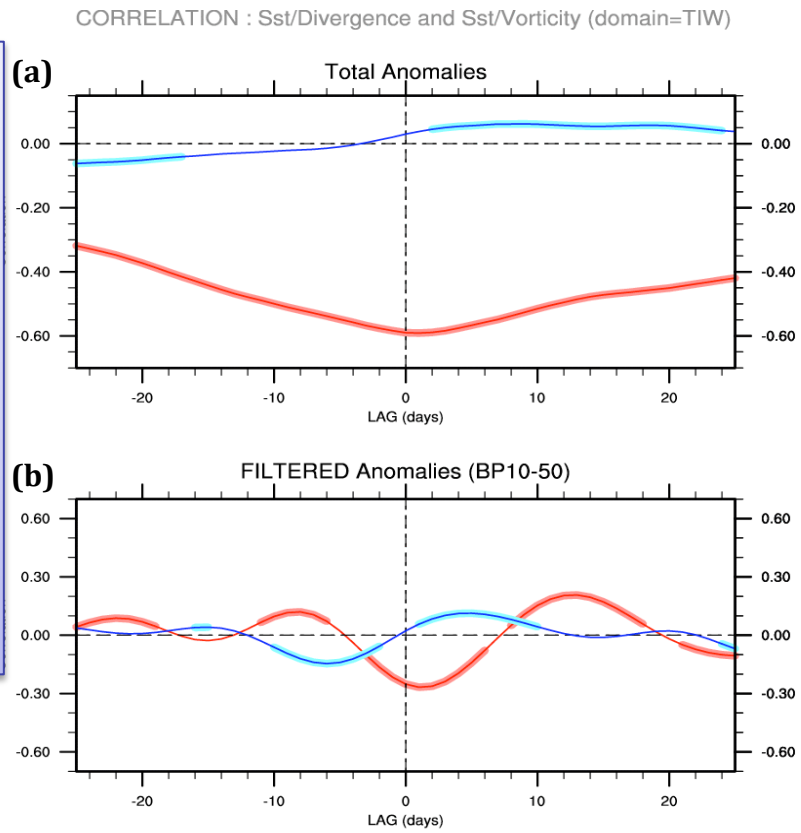
SST fluctuations have a longer period: 20 days.

QSCAT divergence (15 day period) propagate westward.

Correlation (SST, QSCAT)

Correlation between SST and divergence is significative.
It is maximum at lag= 2 day lead for SST:

Correl= - 0.6 (total)
Correl= - 0.3 (filtered)



(SST,divergence) in red
(SST,curl) in blue
significant level >95%: highlighted

TIW Forced? Coupled? Or Conditionned by the Moon?

Sidereal period = 27.322 days --- > 13.66 days

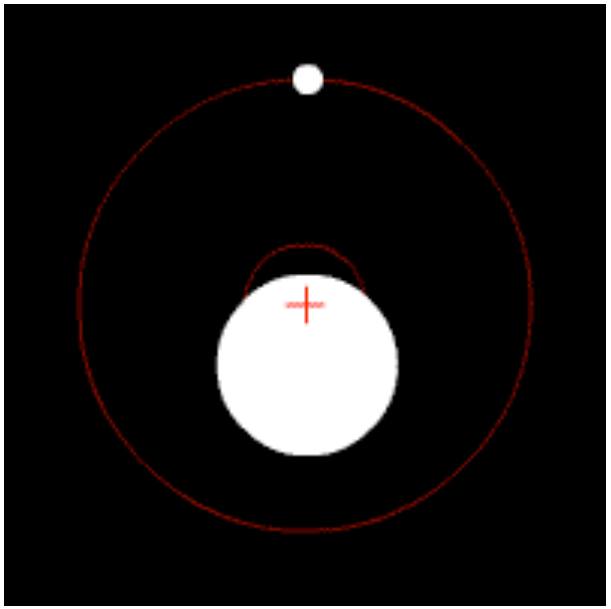
Nodical period = 27.212 days

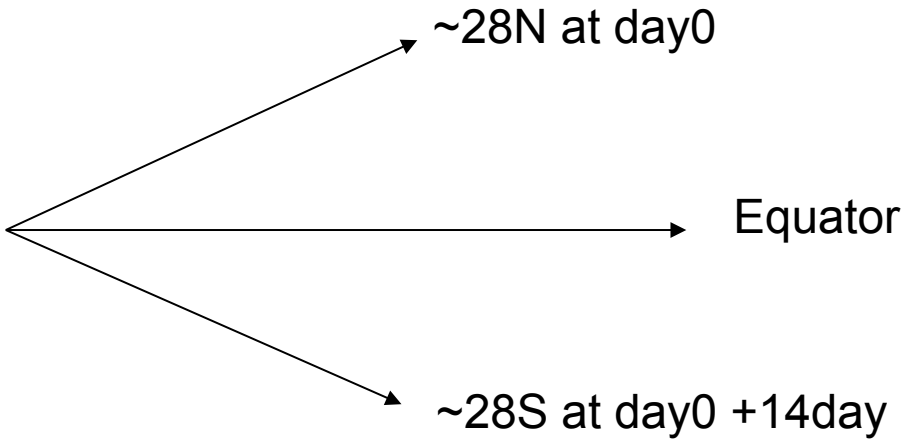
Anomalistic period = 27.555 days

Synodic period = 29.5306 days ---> 14.77 days

Lunar Nodal precession period is 18.6 yrs

(Moon-Earth) center of mass travels North/South

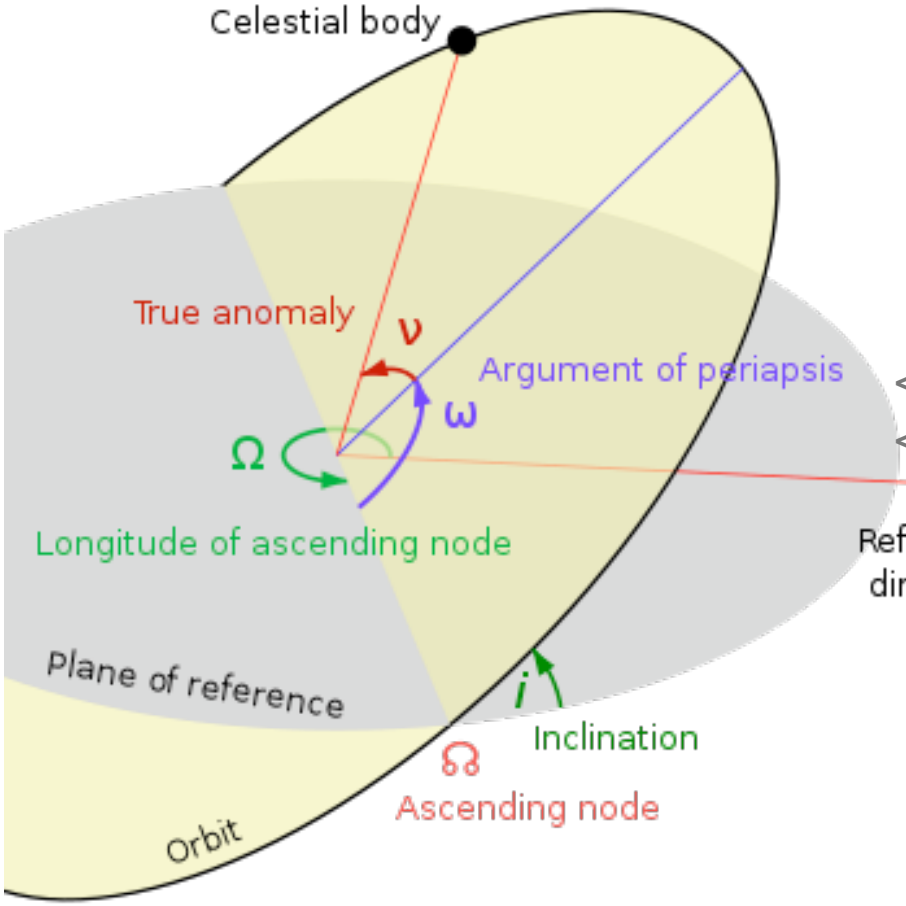




The center of mass is ~4700km away from the Earth center.

Because the Earth axis is so tilted, the mass center moves from South to North in ~14 days (from ~28S to ~28N in years of max standstill like in 2006) and back from ~28N to ~28S during the following ~14 days.

Orbit Parameters



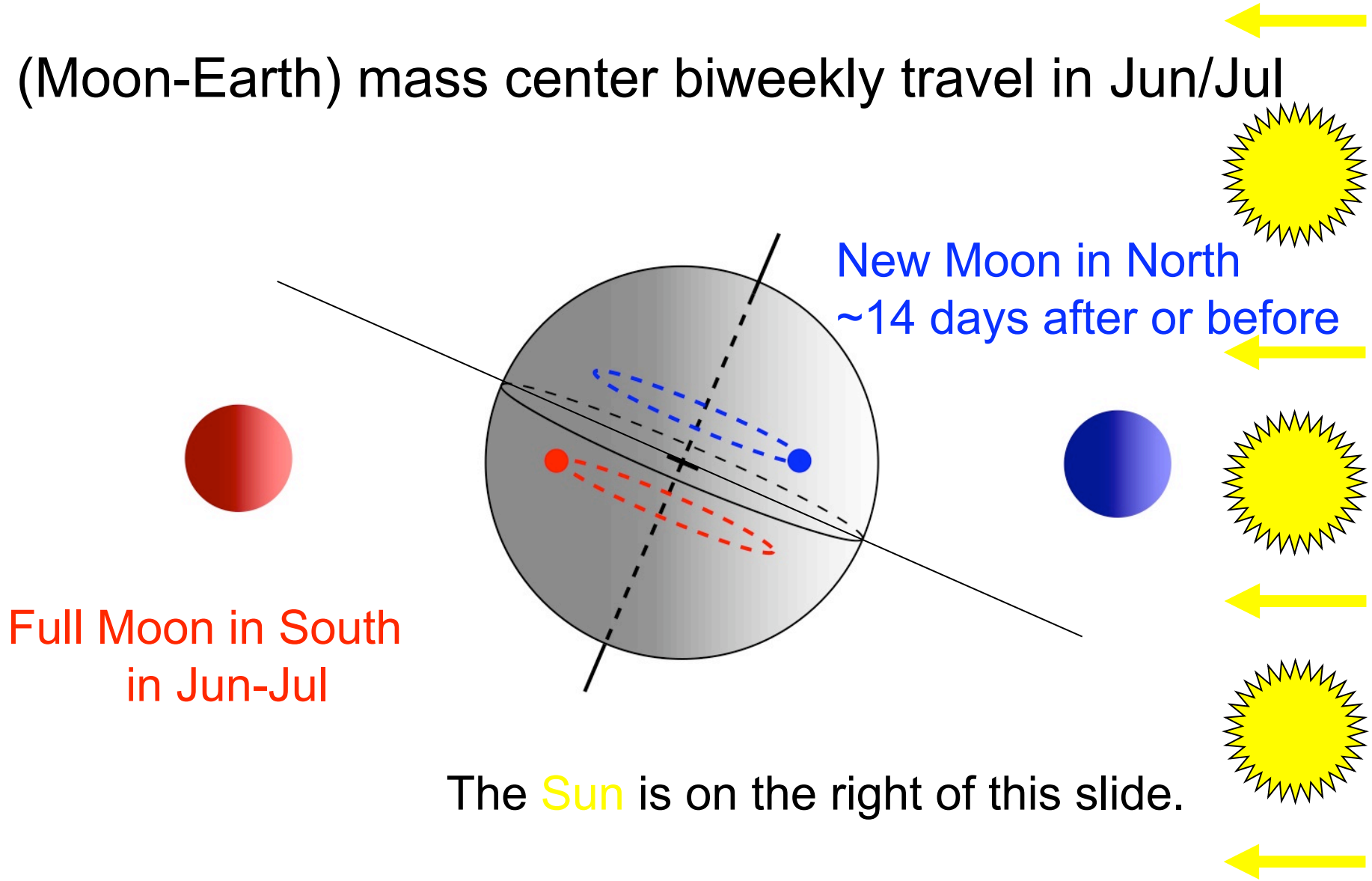
Reference plane for:
<- Earth around Sun= ecliptic plane
<- Moon around Earth=equatorial plane

♈ Reference direction

Fixed stars

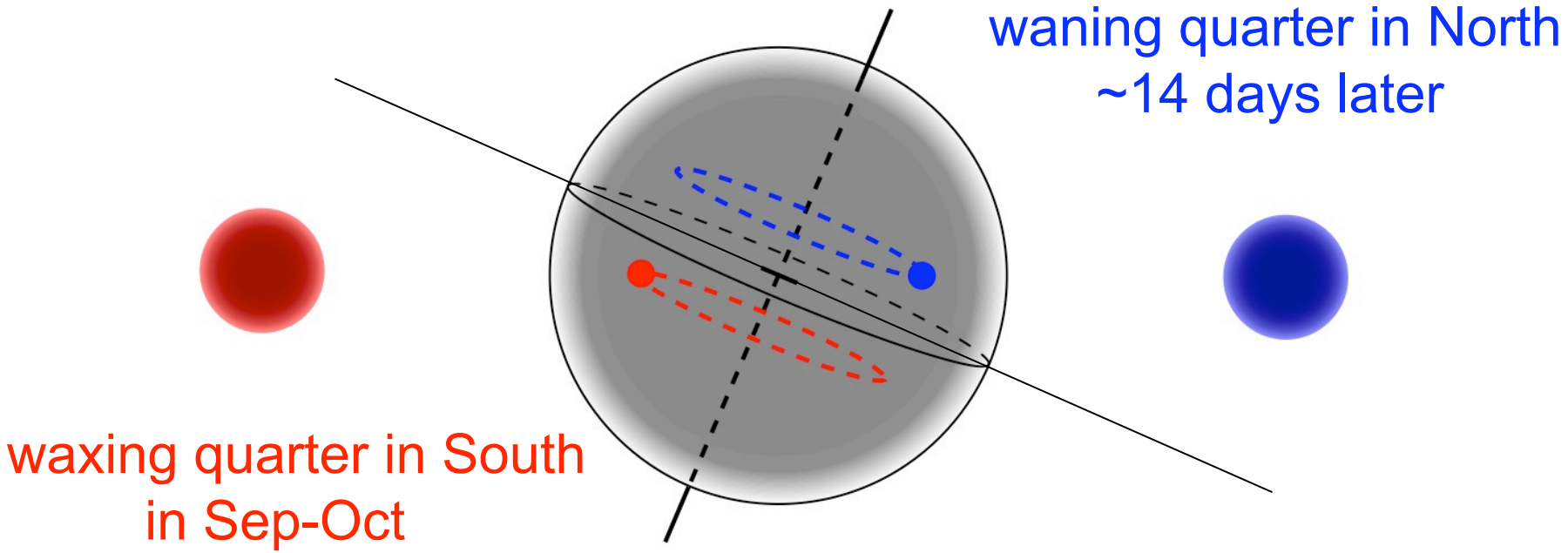
The Orbital plane intersects the Reference plane.
along lone of nodes ---> 3 angles: Ω=longitude of Asc node,
ω=argument of perigee, ν=true anomaly.

(Moon-Earth) mass center biweekly travel in Jun/Jul



Displacement on orbit around the Sun is towards us.

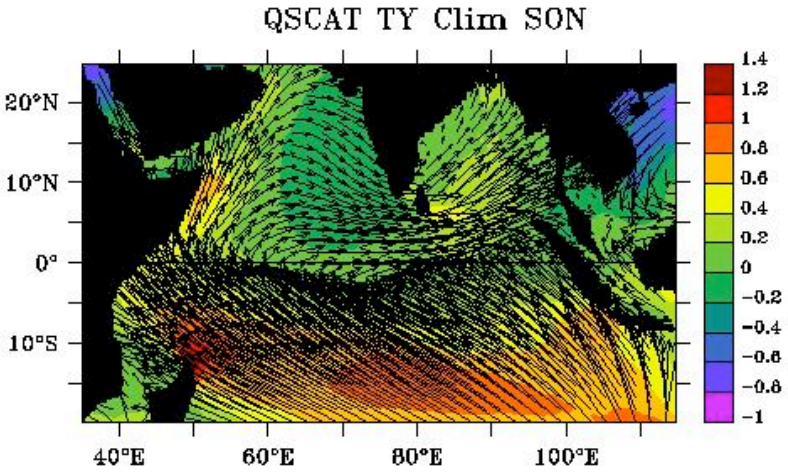
(Moon-Earth) mass center biweekly travel in Fall

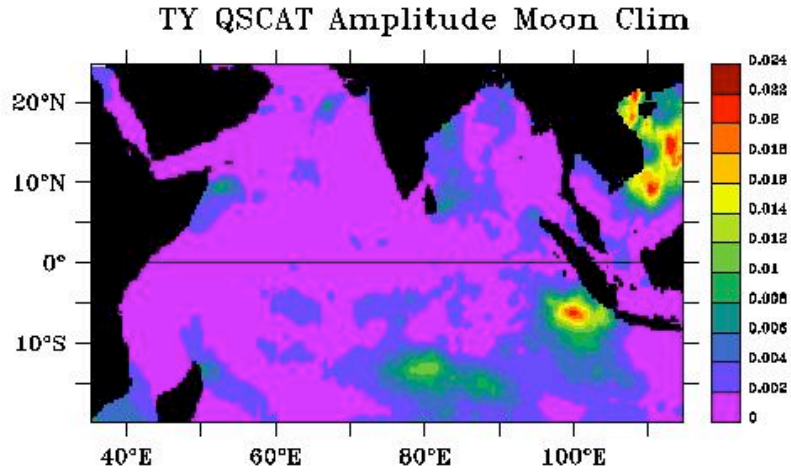


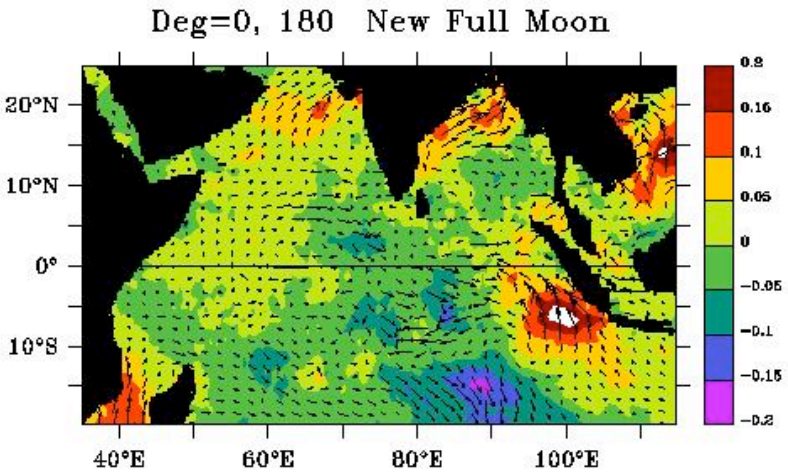
The Sun is in the back of this slide.

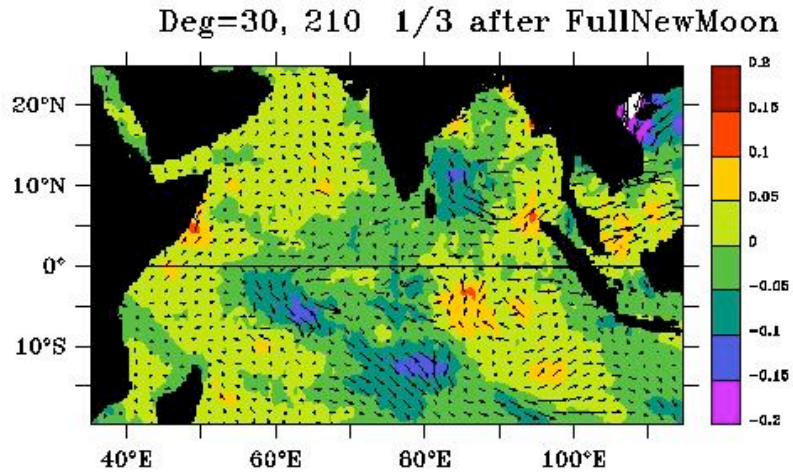
Direction of (Moon-Earth) displacement on orbit around Sun

Moon Climatology of QSCAT

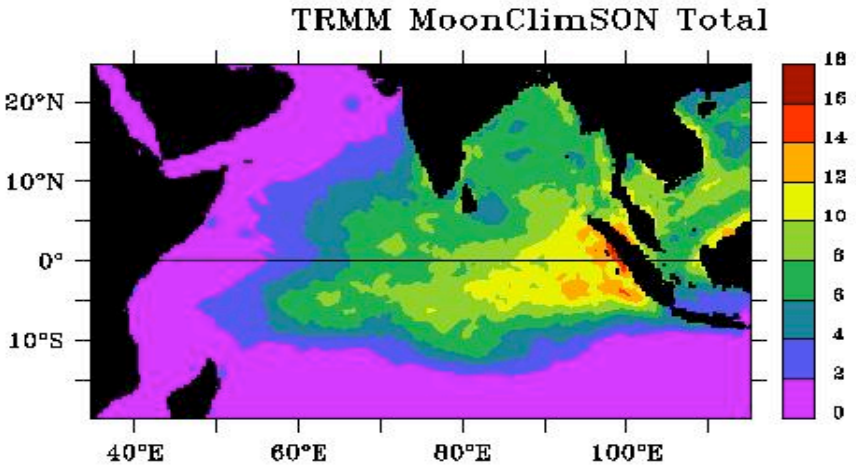


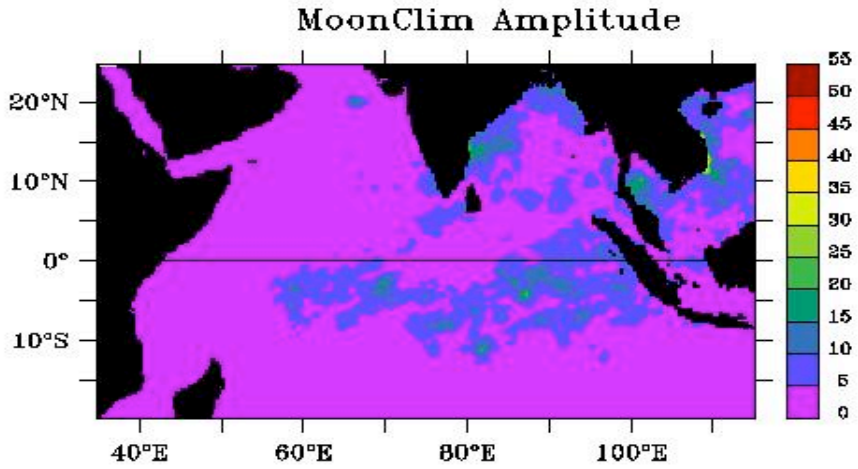


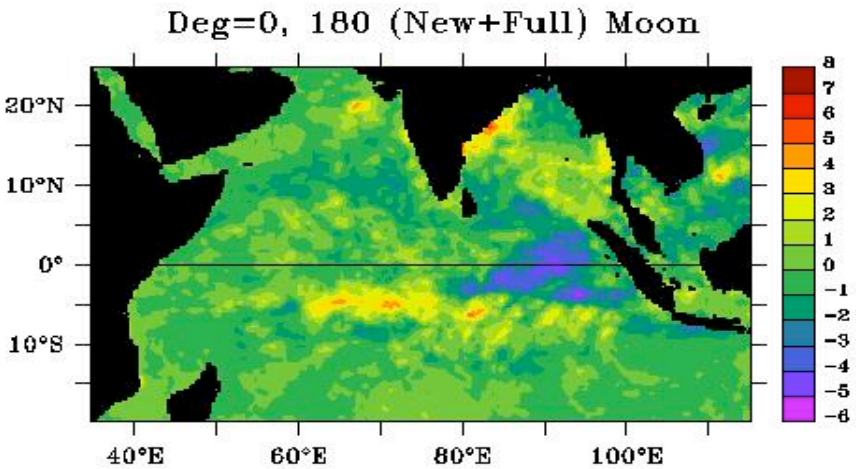


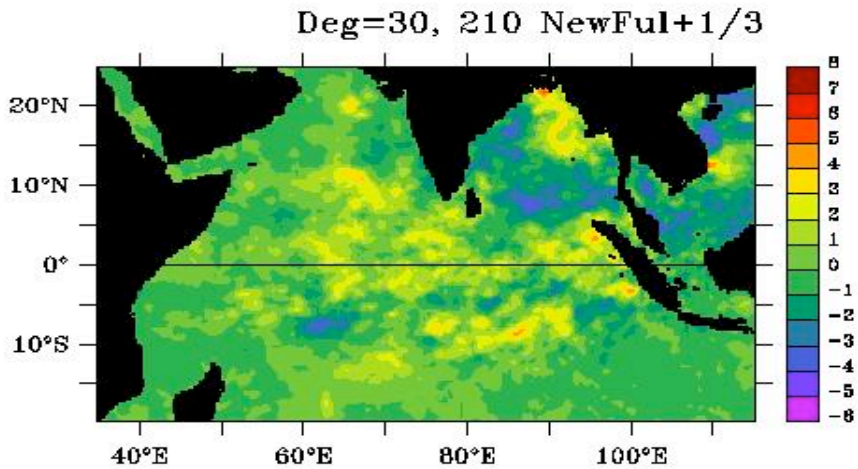


Moon Climatology of TRMM

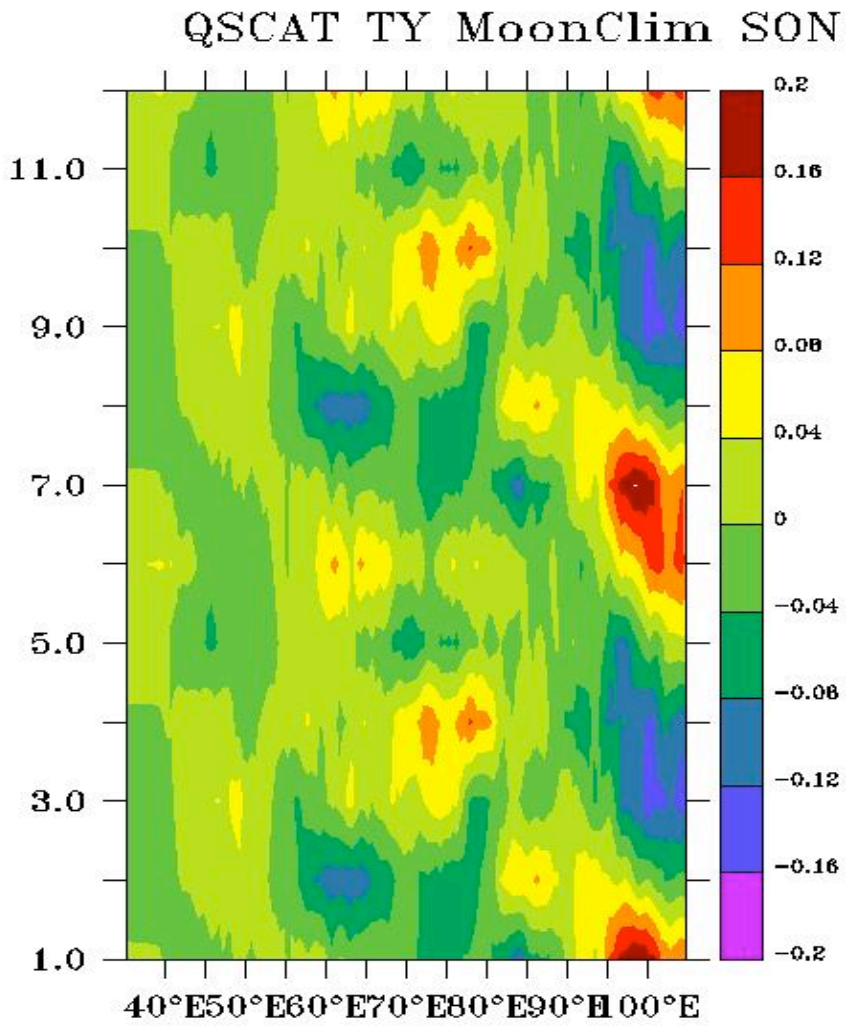


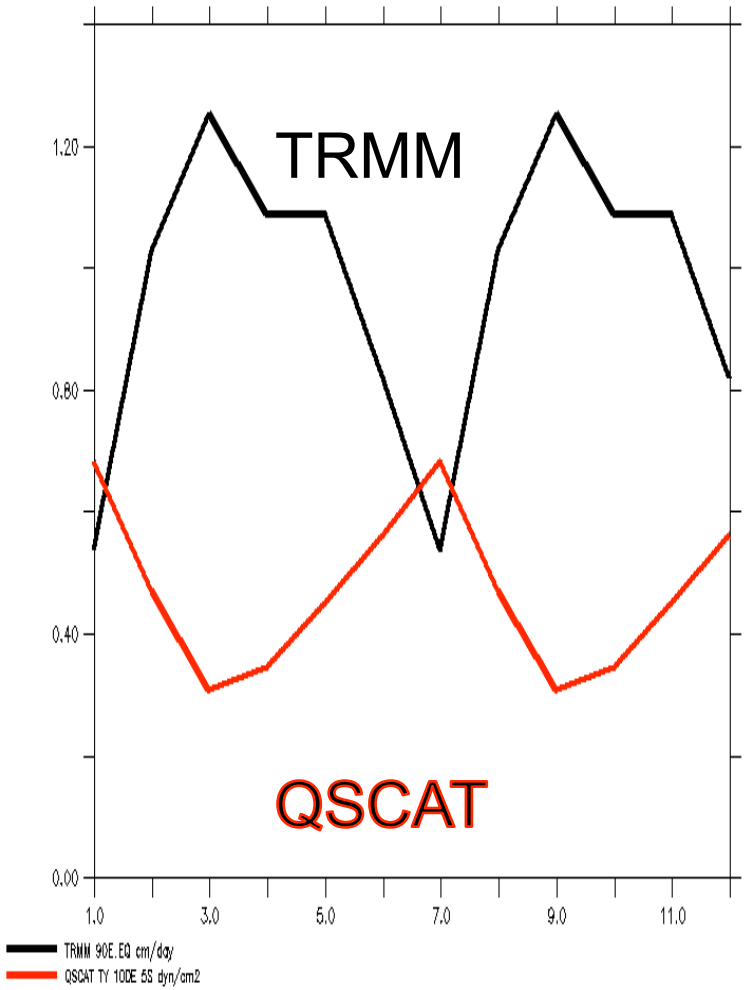




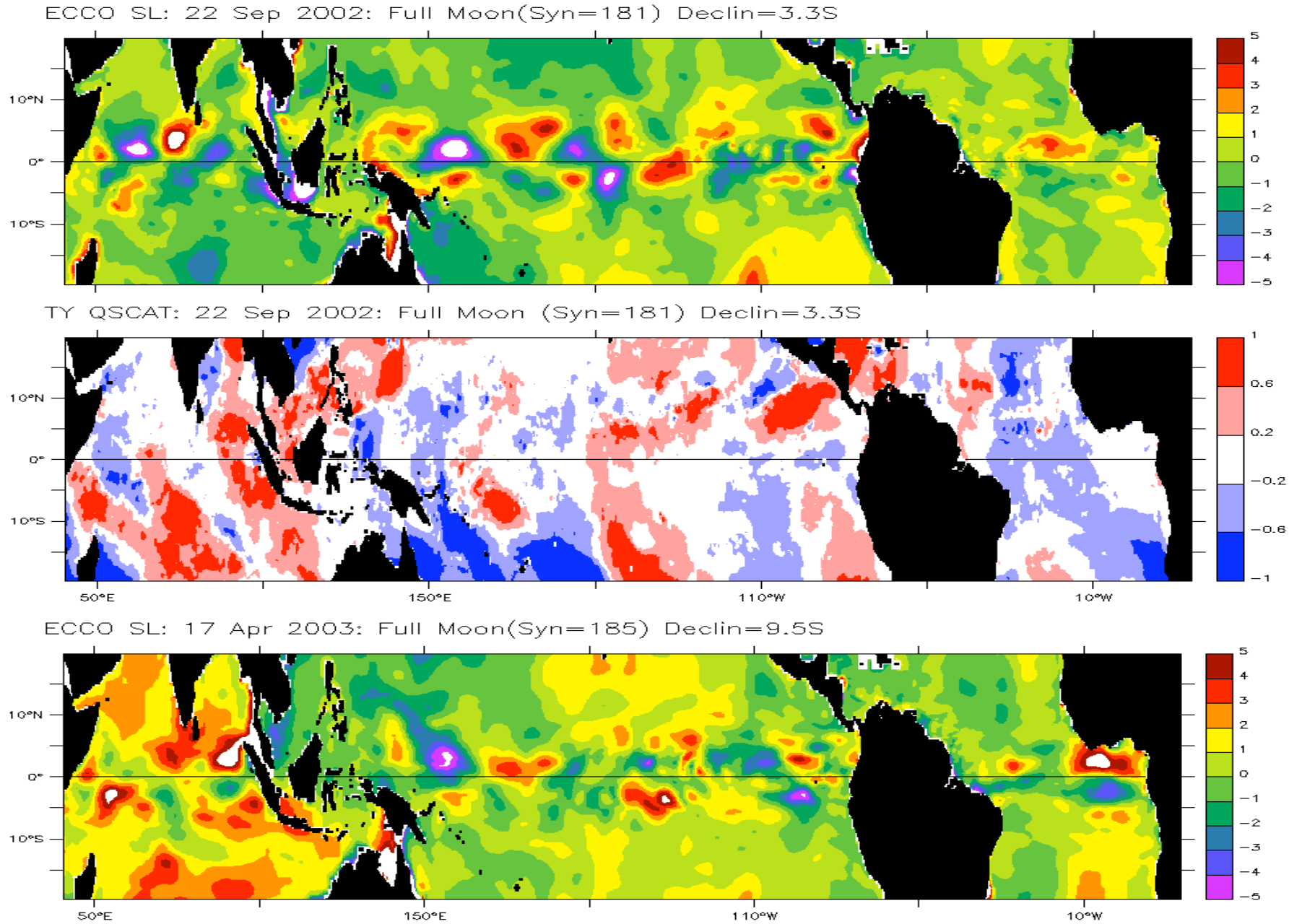


Moon Climatology of QSCAT and TRMM





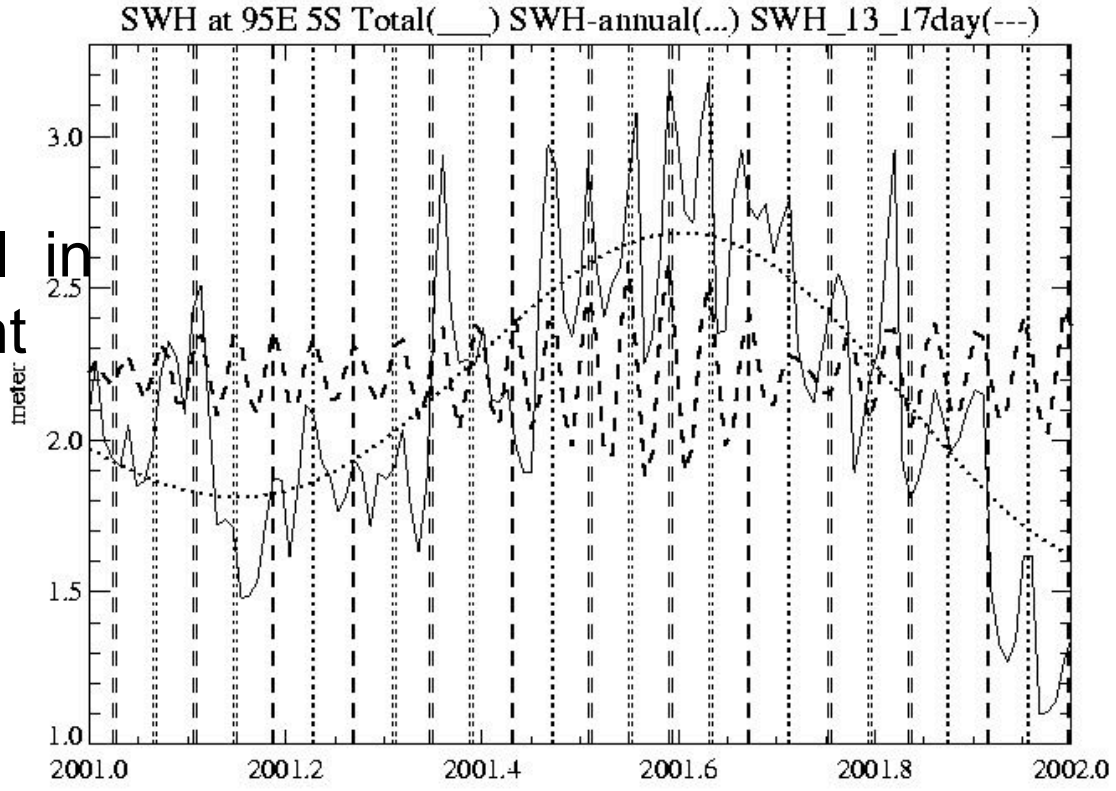
Units of time (1 to 12) are “month-of-Moon-Clim”, meaning 12 months in 29.53 days→ each”month” = 2.46 days

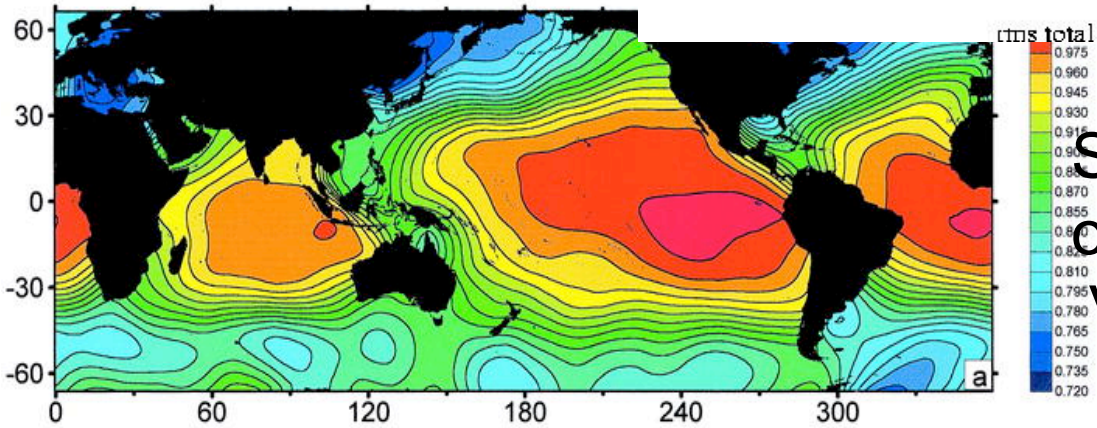

ECCO SL: 22 Sep 2002: Full Moon(Syn=181) Declin=3.3S
10°N
0°
10°S
5
4
3
2
1
0
−1
−2
−3
−4
−5
TY QSCAT: 22 Sep 2002: Full Moon (Syn=181) Declin=3.3S
10°N
0°
10°S
50°E
150°E
110°W
10°W
1
0.6
0.2
−0.2
−0.6
−1
ECCO SL: 17 Apr 2003: Full Moon(Syn=185) Declin=9.5S
10°N
0°
10°S
50°E
150°E
110°W
10°W
5
4
3
2
1
0
−1
−2
−3
−4
−5

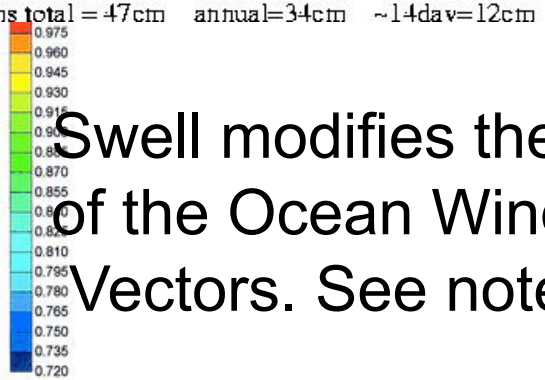
SWELL POOLS in the tropics

There is a biweekly signal in the significant wave height monitored by TPJ.

---- New Moon phase
…. Full Moon phase.







Swell modifies the direction of the Ocean Wind Stress Vectors. See note.

Conclusion and Perspectives

- Biweekly signals are found in QSCAT, TMI, TRMM, OLR, Significant Wave Height, and sea level with MRGW characteristics.
- Possible Luni-Solar gravitational triggering of TIWs

- COUPLED models fail to reproduce observed characteristics of TIWs. Should we add the biweekly Luni-Solar gravitational forcing?

- Are the strong biweekly swell variations introducing larger scale momentum in the Ocean-Wind stress important for climate?