# Covariability of Wind and Sea Surface Height in the Tropical Pacific: Part 2

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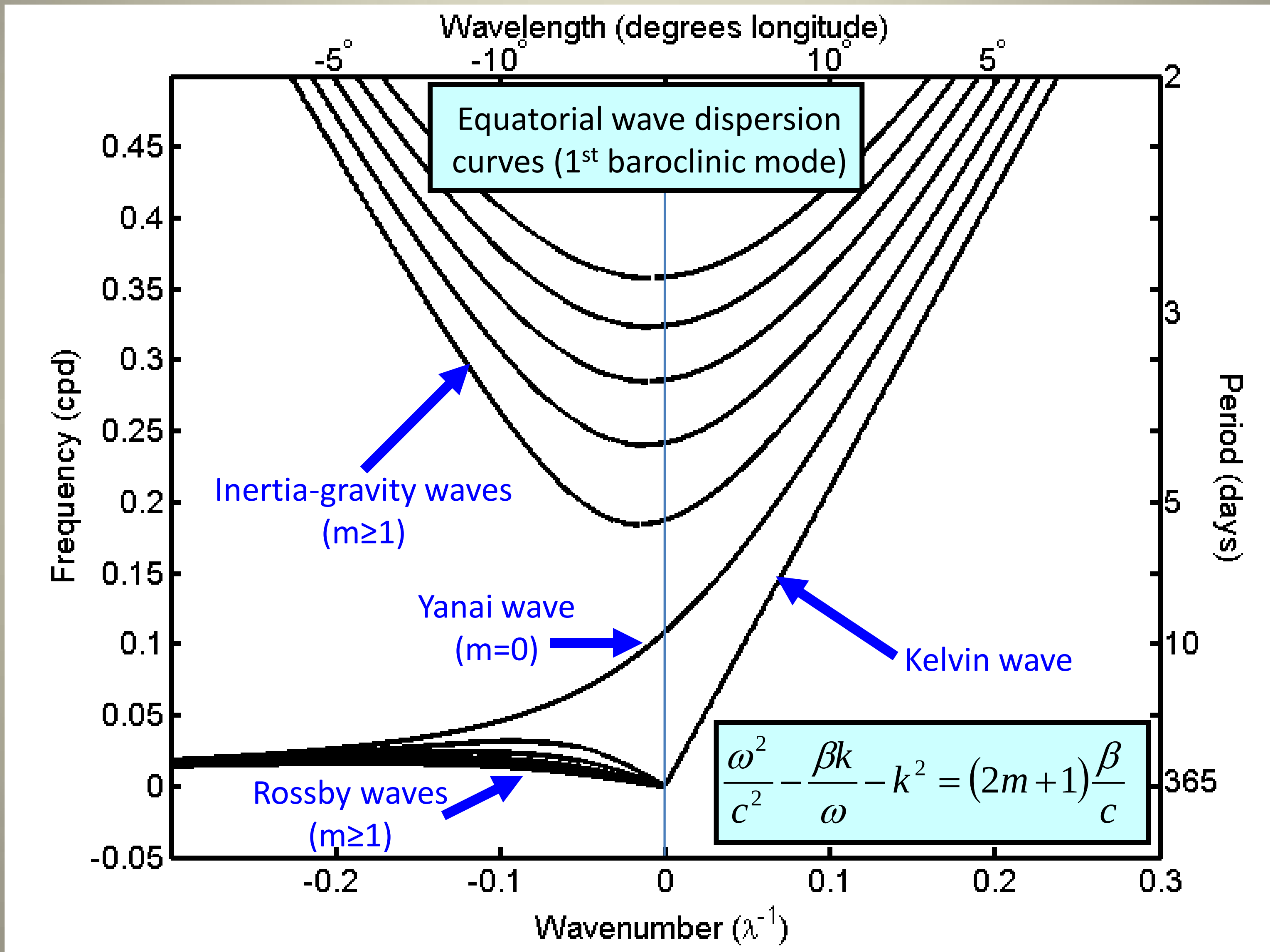
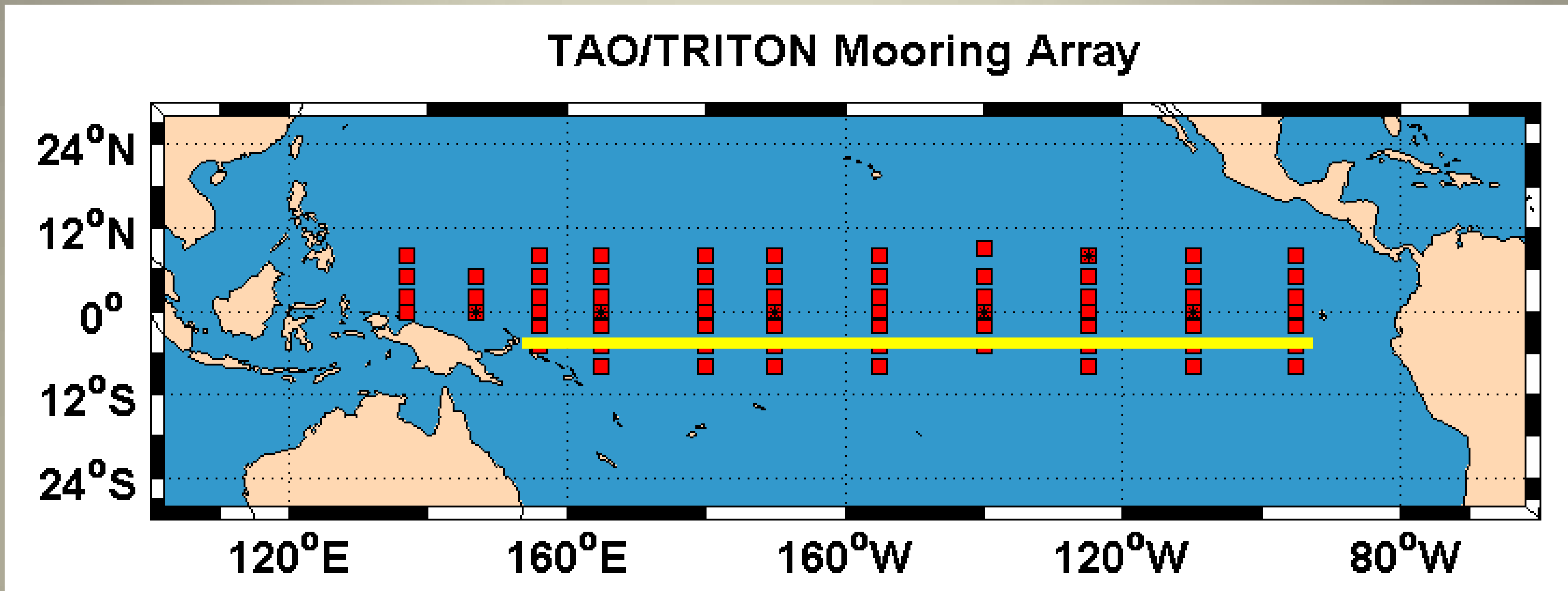
A plot like this is in almost every physical oceanography textbook. What is not in the textbooks is an analogous plot from observations.




Westward propagation ← → Eastward propagation

# Equatorial waves in the zonal-wavenumber/frequency domain

→Estimating wavenumber-frequency spectra of the wind forcing and ocean response



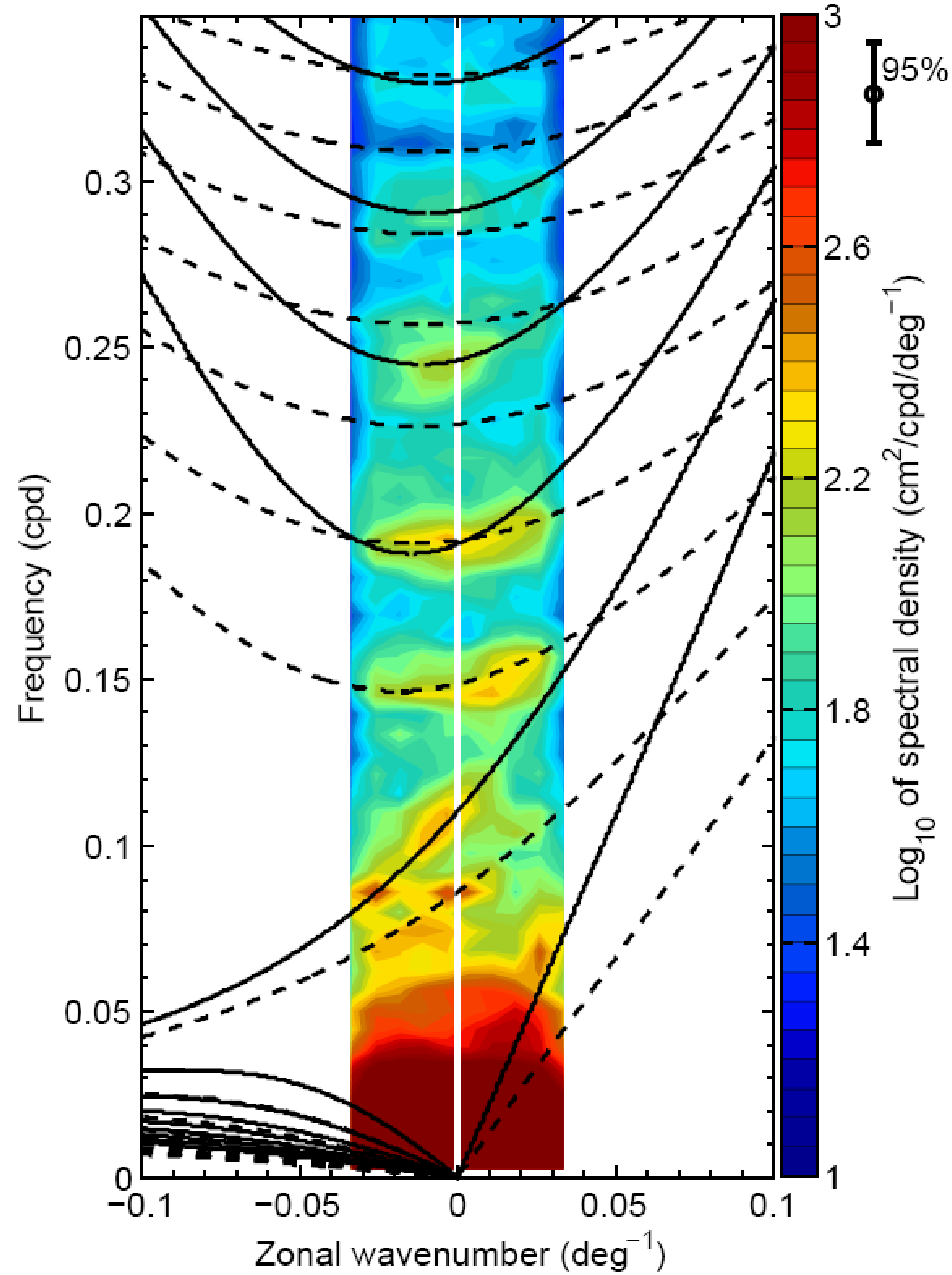

General approach: (e.g., Farrar, 2008, 2011, Farrar and Durland, accepted)

→ At each latitude, estimate the 2D Fourier transform of time-longitude sections

→ Form estimates of zonal-wavenumber/frequency spectra and average these spectra over a band of latitudes near the equator

→ Note that this approach mimics the standard theoretical approach to equatorial waves and instabilities

# Zonal-wavenumber/ frequency spectrum of dynamic height from the TAO/TRITON mooring array (average over 5°S-5°N) (12 years of data)



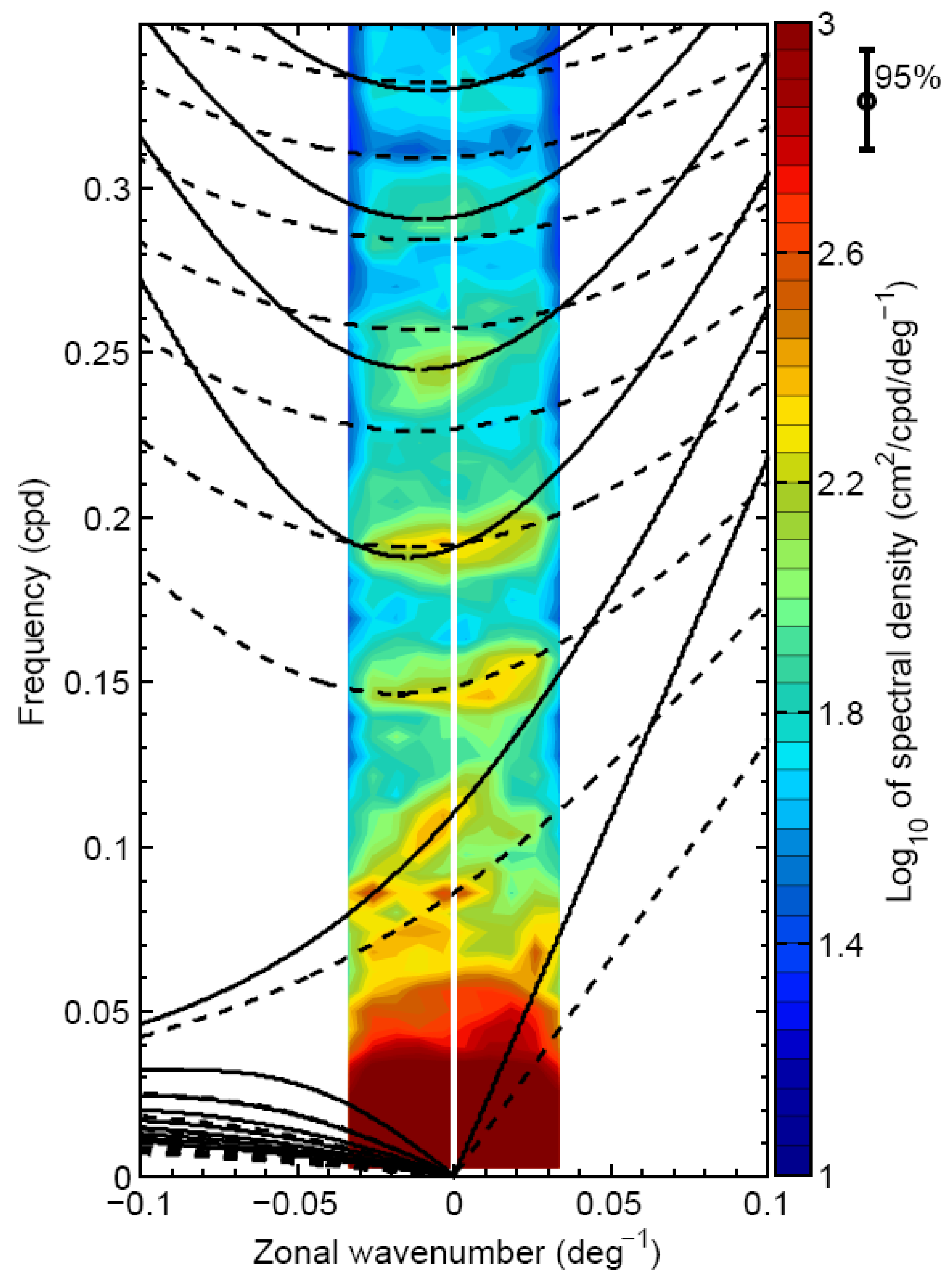

1st baroclinic mode (solid black lines)

2nd baroclinic mode (dashed black lines)

Farrar and Durland (*J. Phys. Oceanogr.*, accepted)
Durland and Farrar (*J. Phys. Oceanogr.*, accepted)

# Zonal-wavenumber/ frequency spectrum of dynamic height from the TAO/TRITON mooring array (average over 5°S-5°N) (12 years of data)

Note that the spectral peaks at high frequencies are all confined to low wavenumbers (wavelengths>30°)




Farrar and Durland (*J. Phys. Oceanogr.*, accepted)
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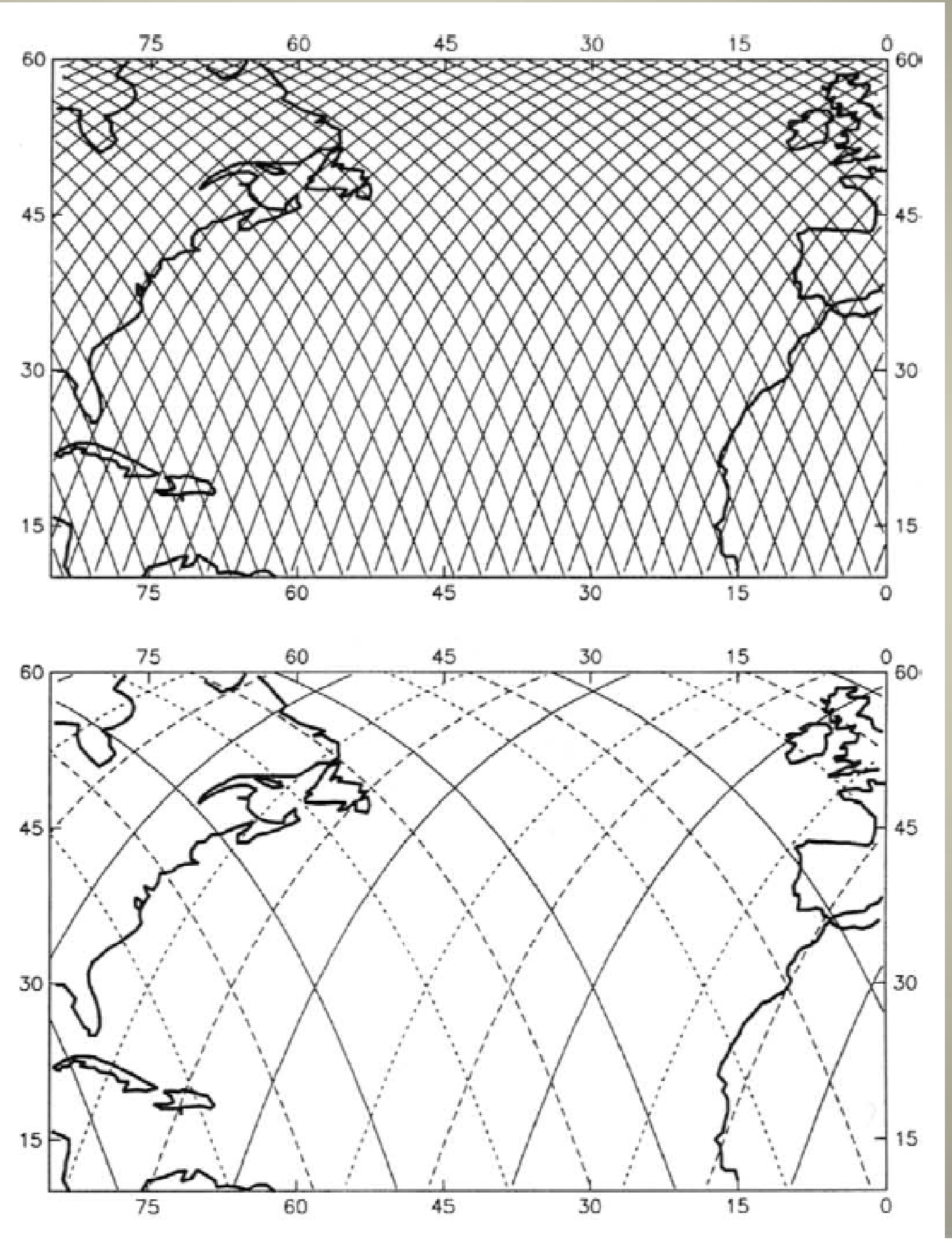
# Sampling by satellite altimeters

Ground tracks of the 10-day repeat orbit of TOPEX/Poseidon and Jason-series altimeters



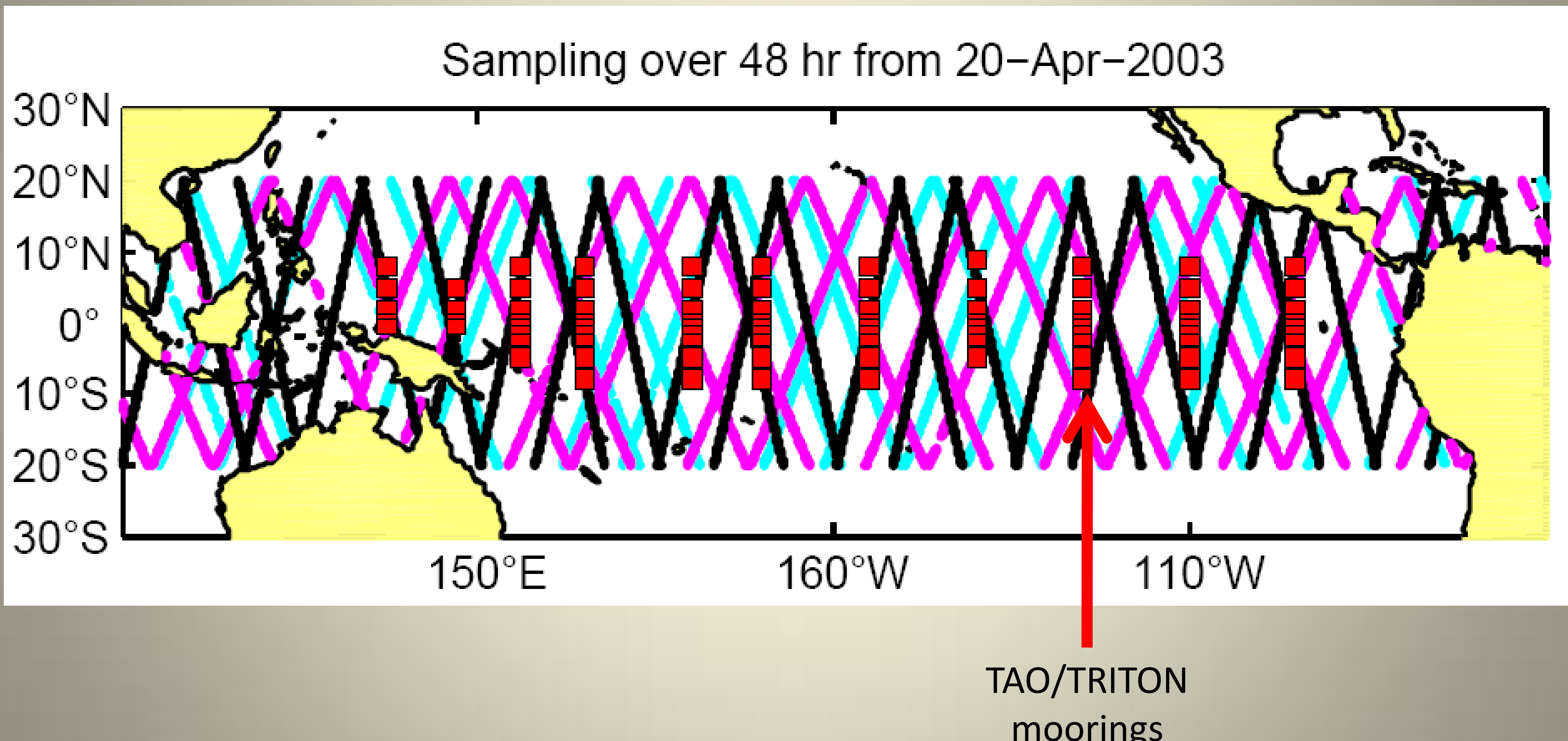

From Chelton et al., (2001)

3 days worth of sampling:

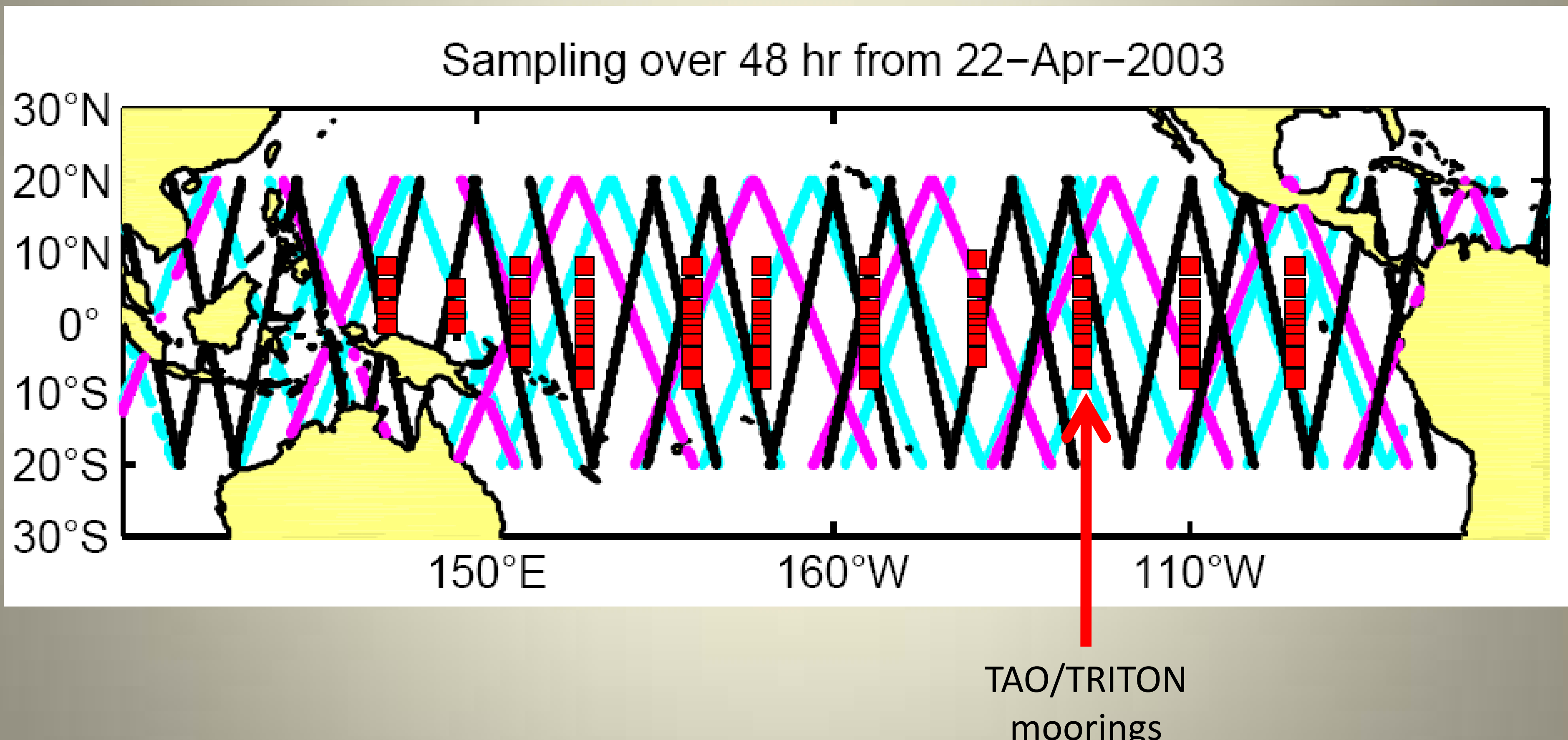
We do not need a full repeat cycle to get information on the largest spatial scales

(Gilbert and Mitchum, 2001)

# Two days of altimetry sampling

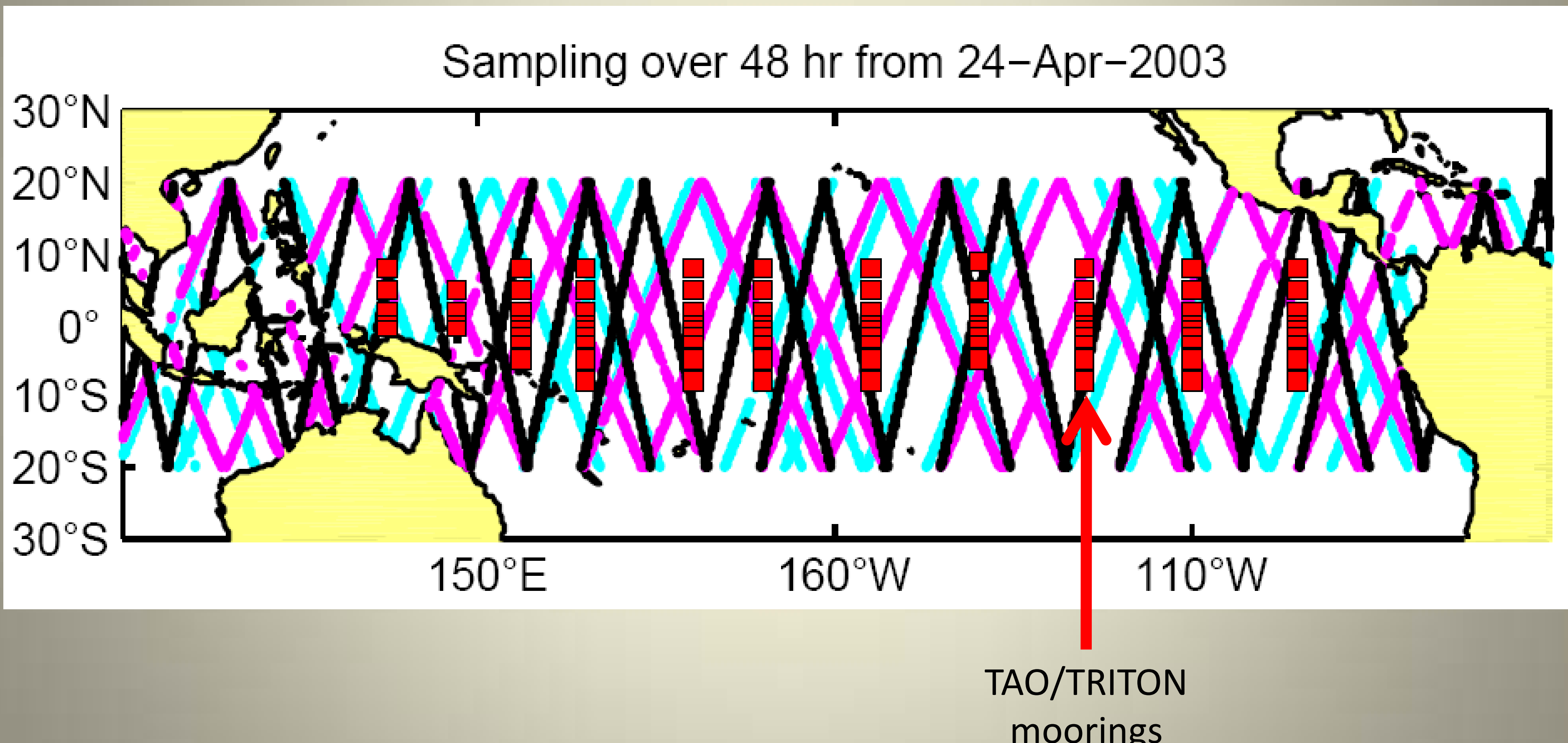


# The next two days of altimetry sampling



And the next two days…

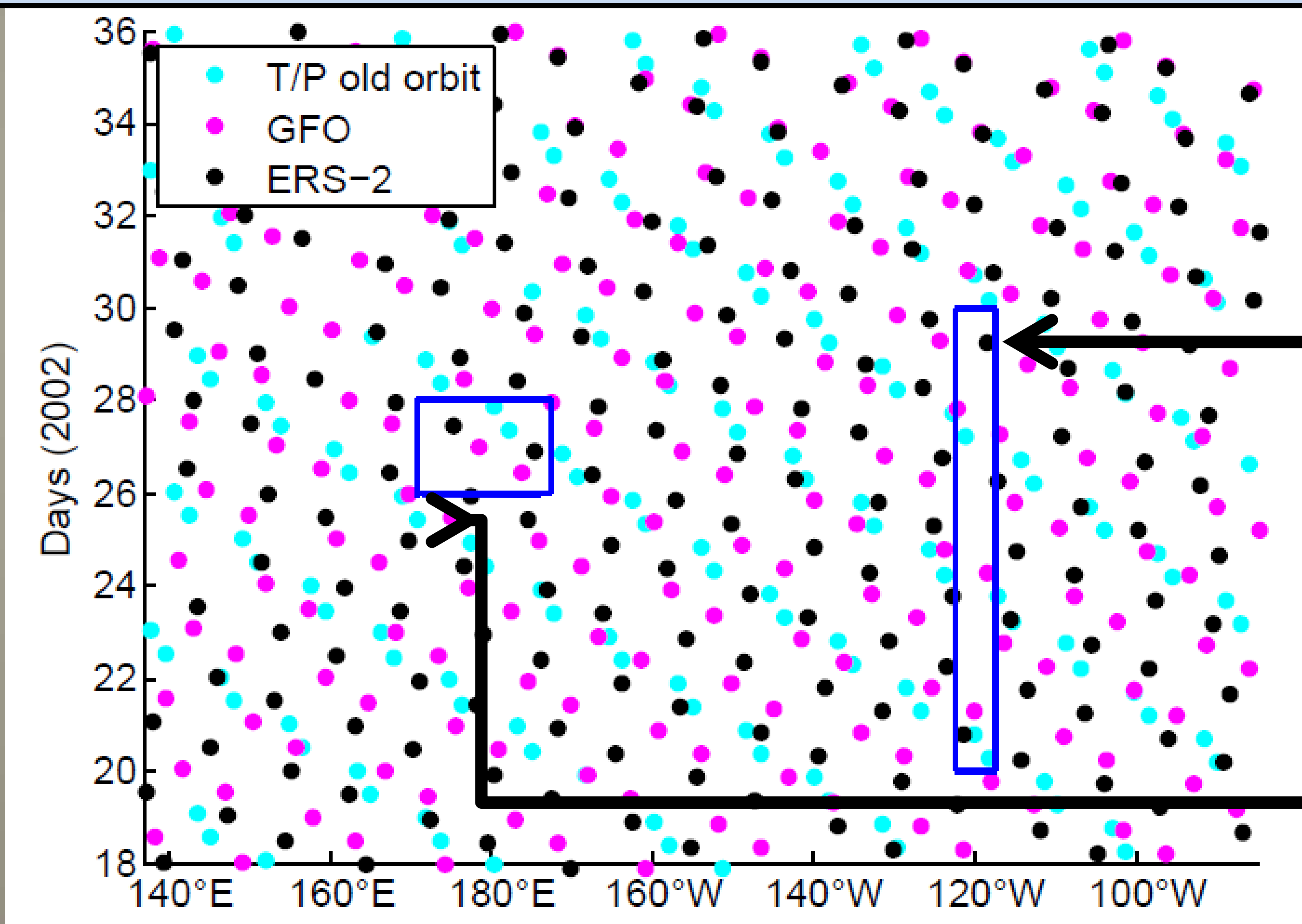
→For large-scale waves of four-day periods and longer, the space-time coverage of altimetry rivals that of the TAO/TRITON mooring array (and is in some ways better)



# Longitude-time altimetry sampling (using 3.5°N as an example)

Approach:
→ At each latitude on 6°S-6°N, estimate the 2D Fourier transform of time-longitude sections by fitting sinusoids to 6 years of data (2000-2005).
→ Form spectra and average over latitude (6°S-6°N).

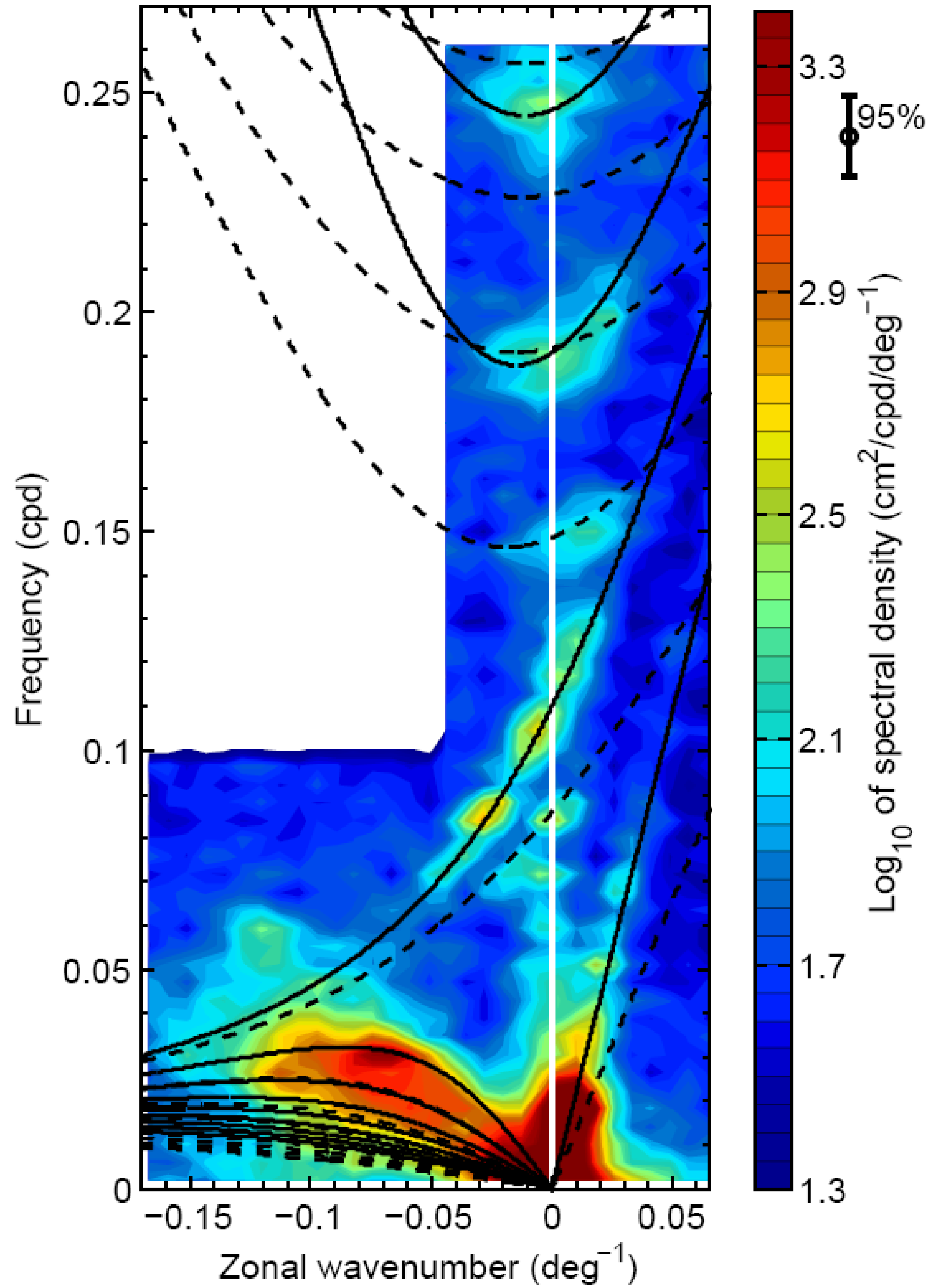
Data: Along-track data from ERS-2, Envisat, Topex/Poseidon, Jason-1, GFO, with standard corrections and AVISO crossover corrections (~1 step before input to AVISO gridding)




5° by 10 days (similar to scales represented in AVISO gridded products)

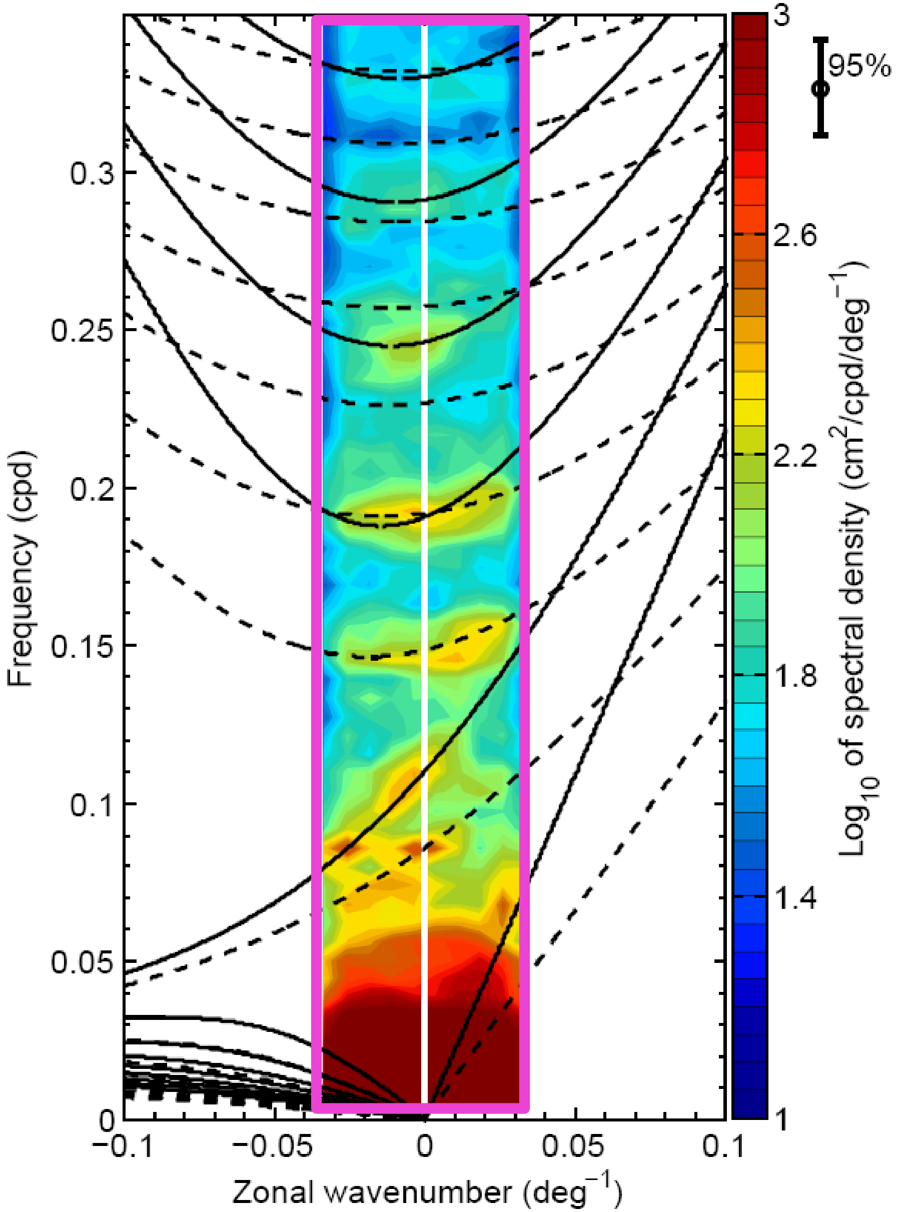
15° by 2 days (scales needed to study equatorial inertia-gravity waves)

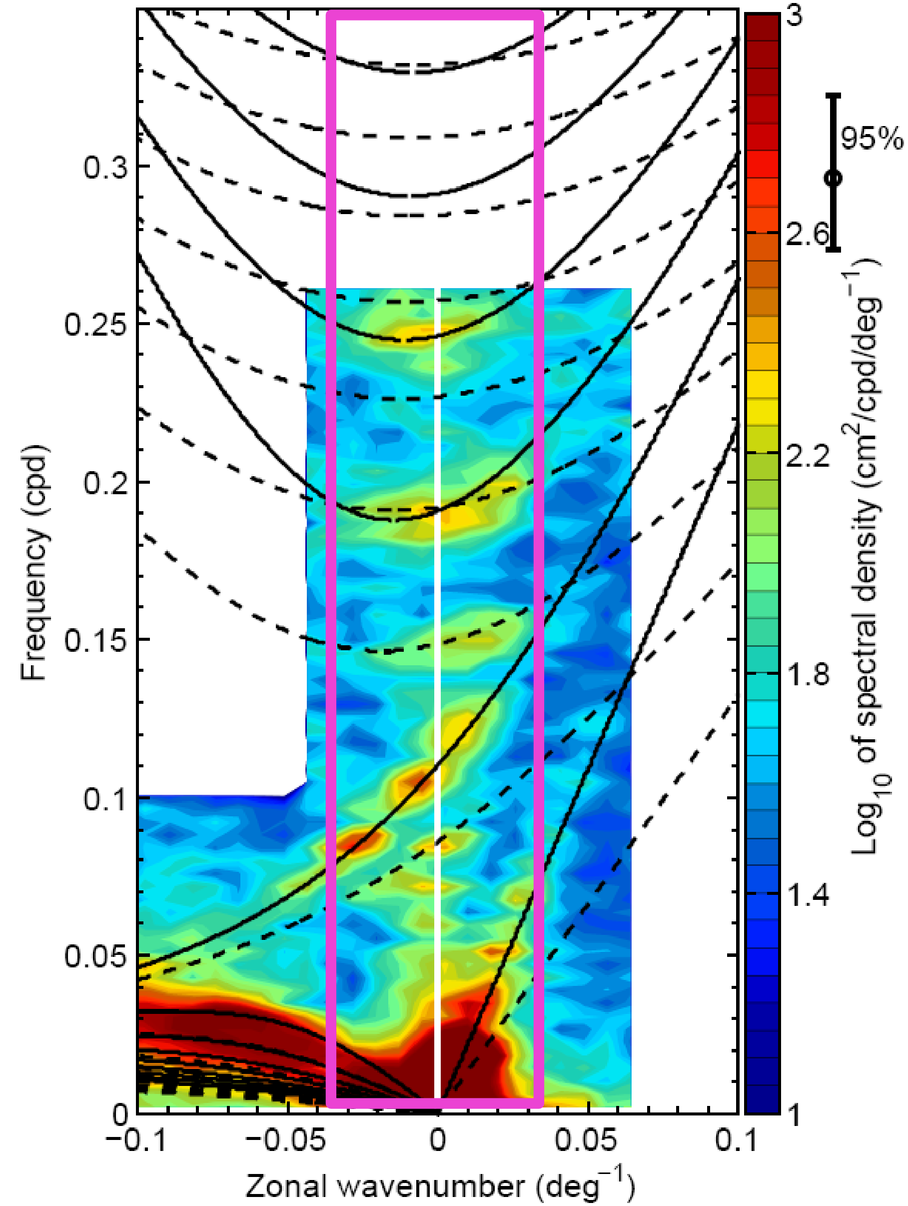
Zonal-wavenumber/ frequency spectrum of SSH from fit to along-track altimeter data (average over 6°S-6°N) (2000-2005; 6 years)



Dynamic height rel. to 500m (TAO; 1997-2008)

SSH spectrum (altimetry; 2000-2005)

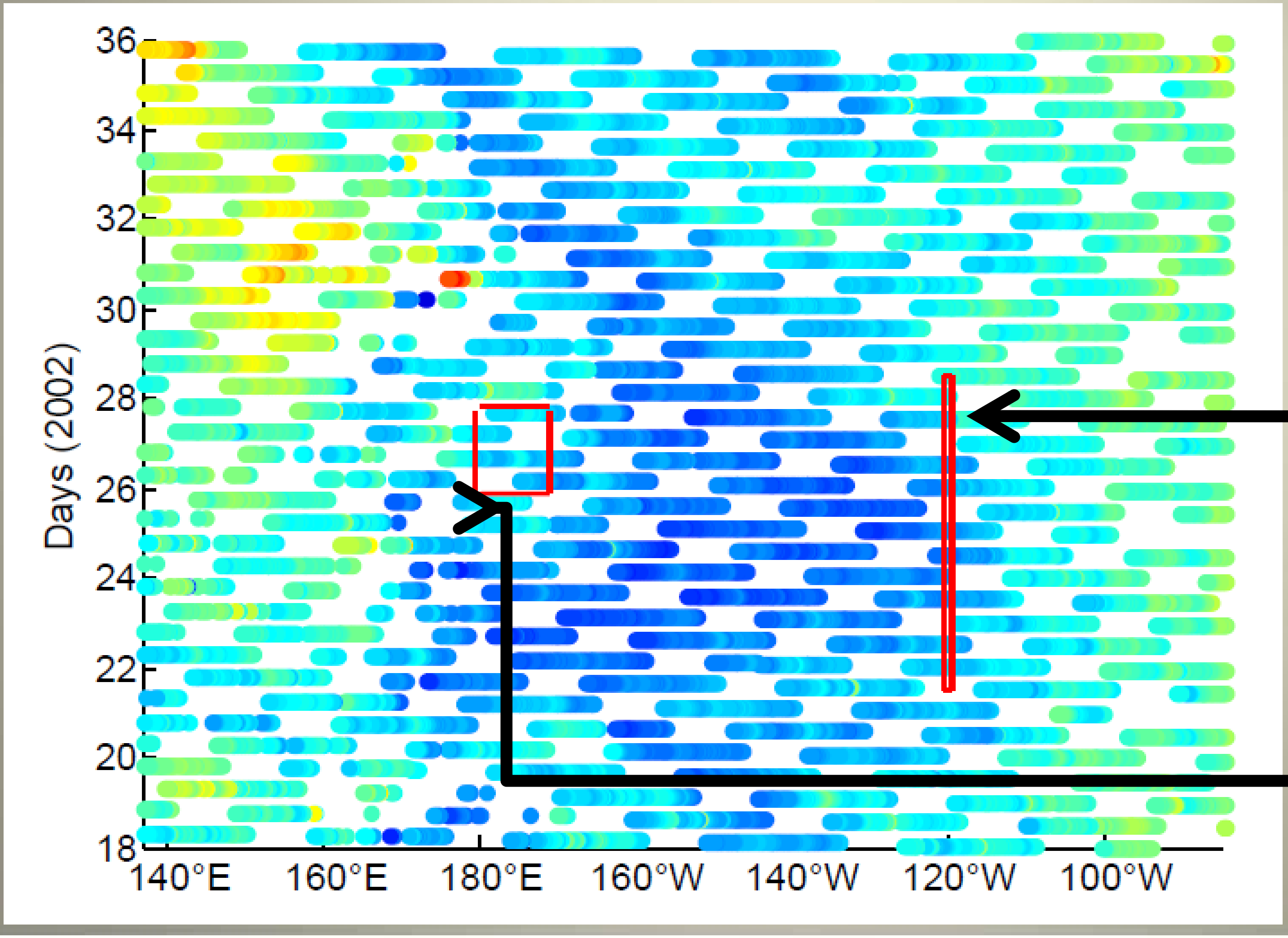



1st baroclinic should be stronger in SSH; 2nd baroclinic should be weaker in SSH

# Longitude-time QuikSCAT sampling (using 3.5°N as an example)

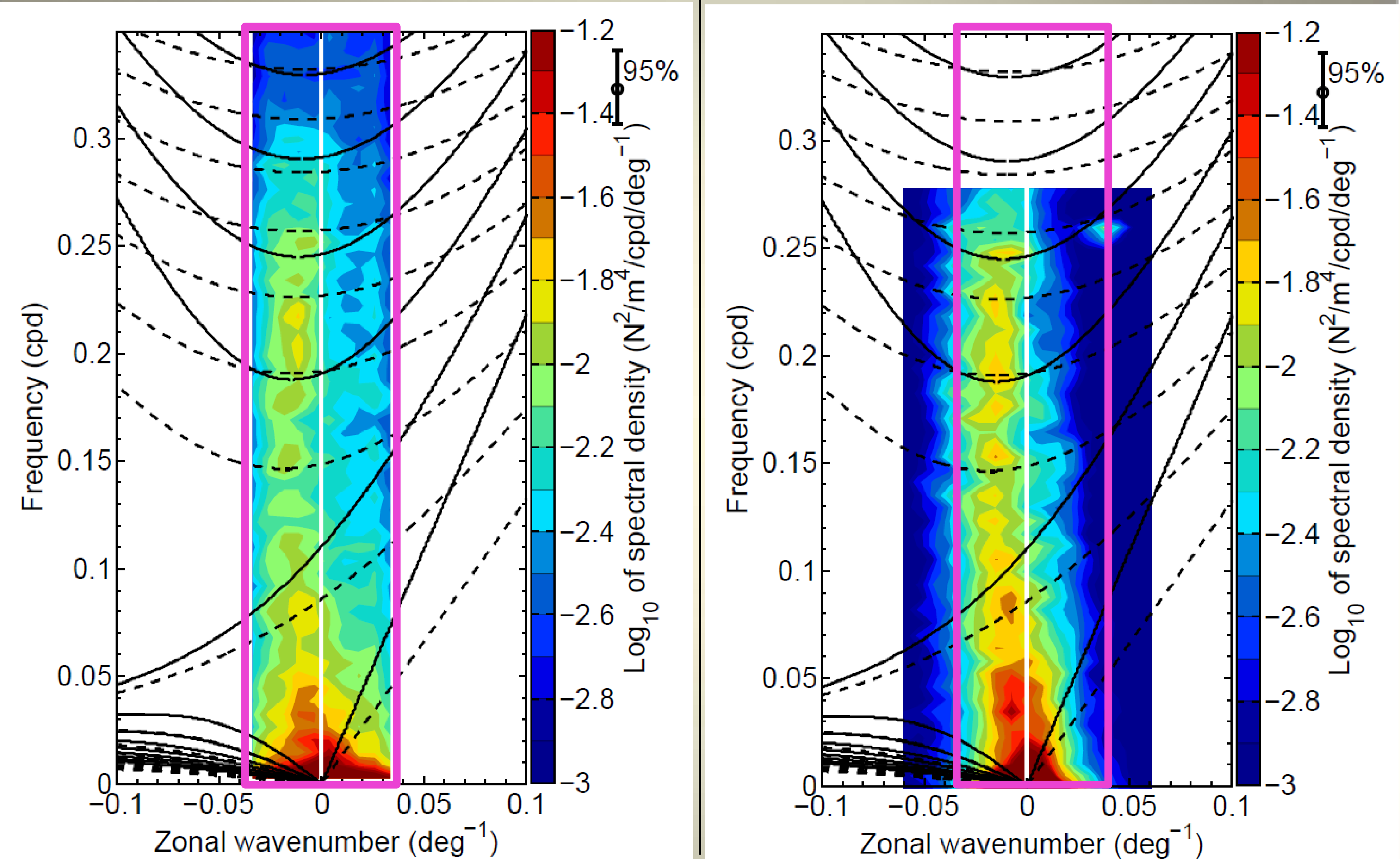
Approach:
→ Grid the data in time-longitude using loess smoother; then estimate Fourier transform by FFT using 6 years of data (2000-2005).
→ Form spectra and average over latitude (8°S-8°N).
Data: Ascending/descending pass QuikSCAT winds from Remote Sensing Systems (Ku-2011 GMF)




0.25° by 7 days (similar to weekly average of QuikSCAT data)

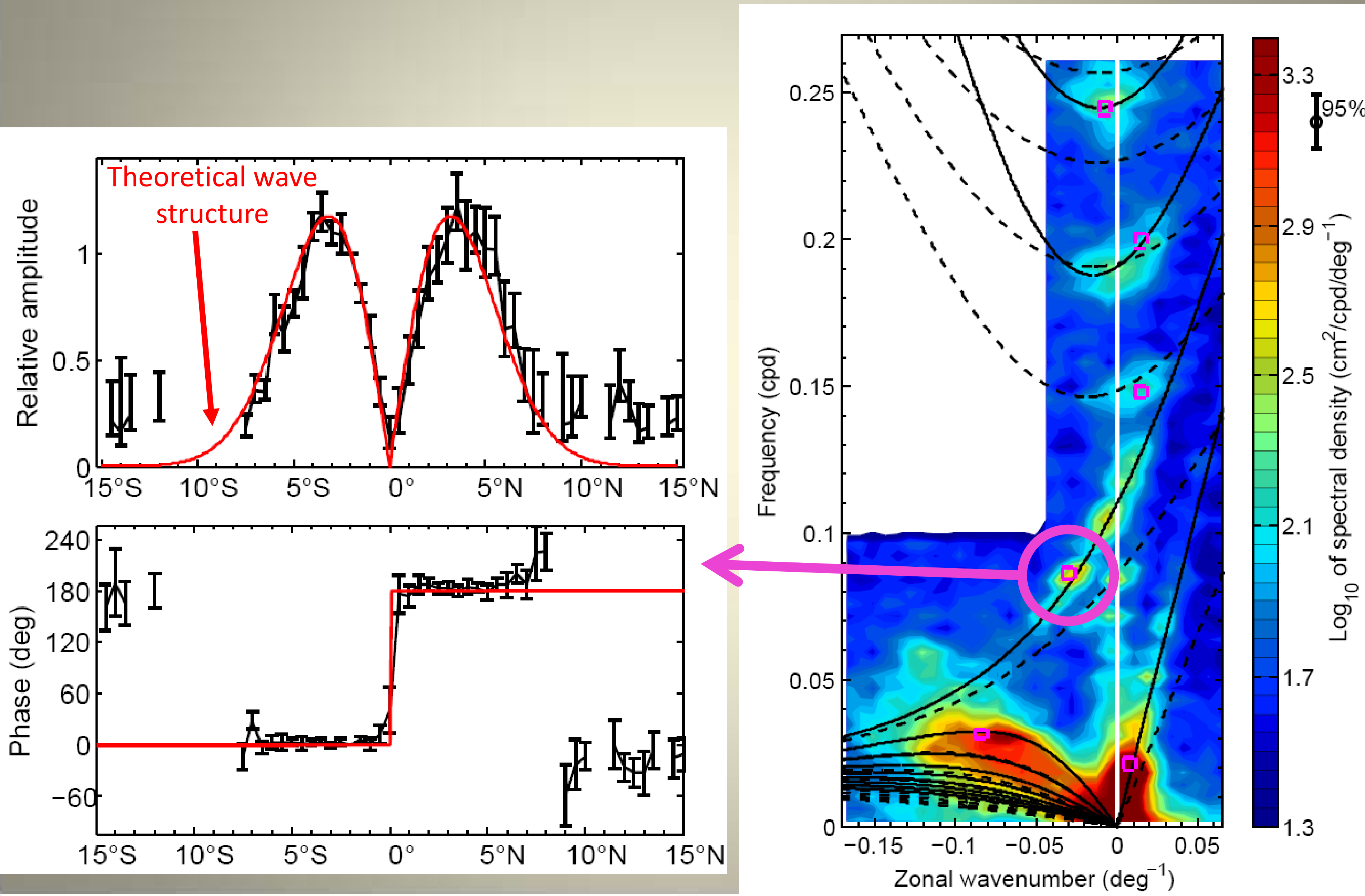
8° by 2 days (scales desired for study of equatorial waves)

Meridional wind stress from TAO (1997-2008) | Meridional wind stress from QuikSCAT (2000-2005)

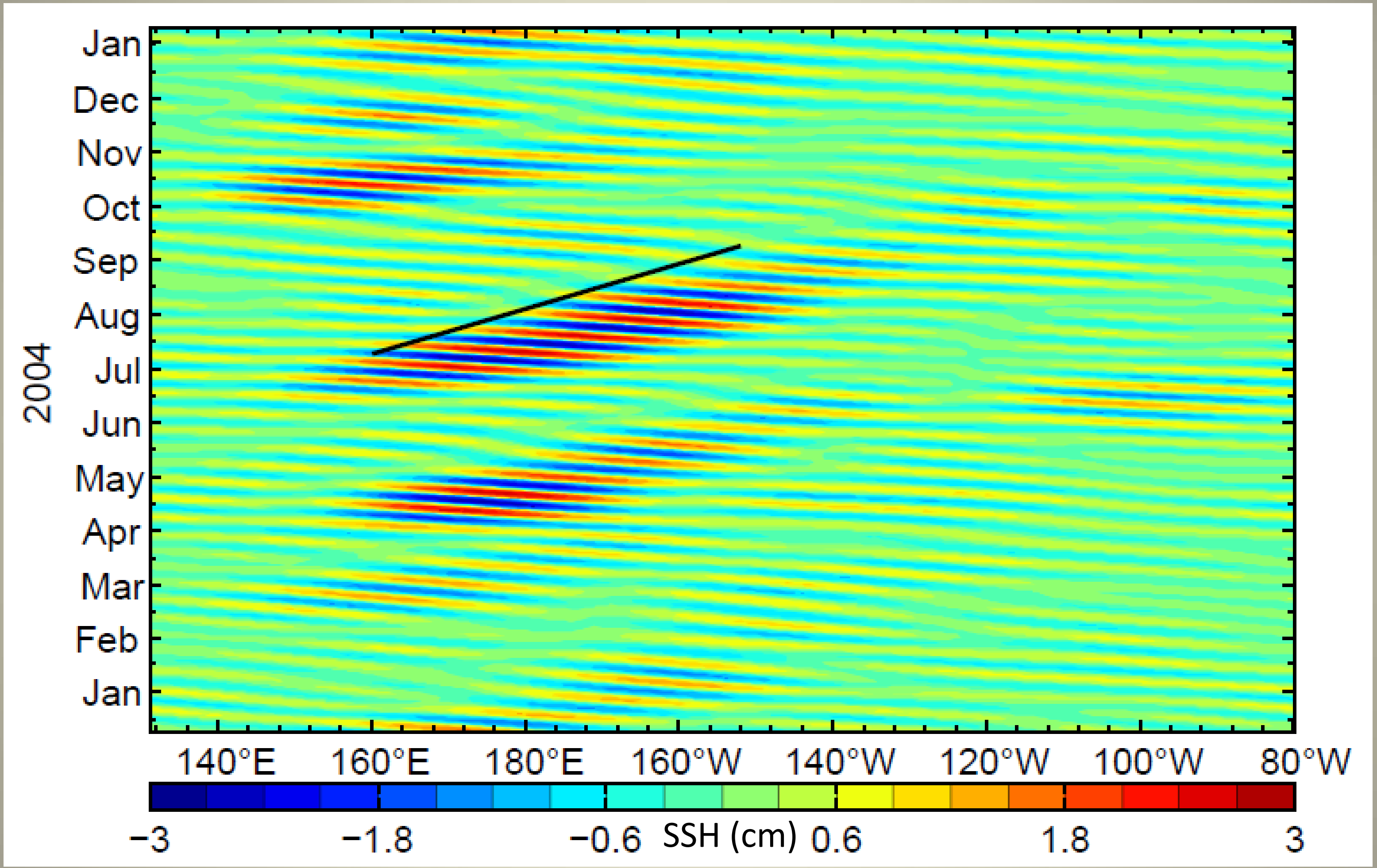



Note: TAO stress was estimated with neutral drag coefficient, which should cause low bias

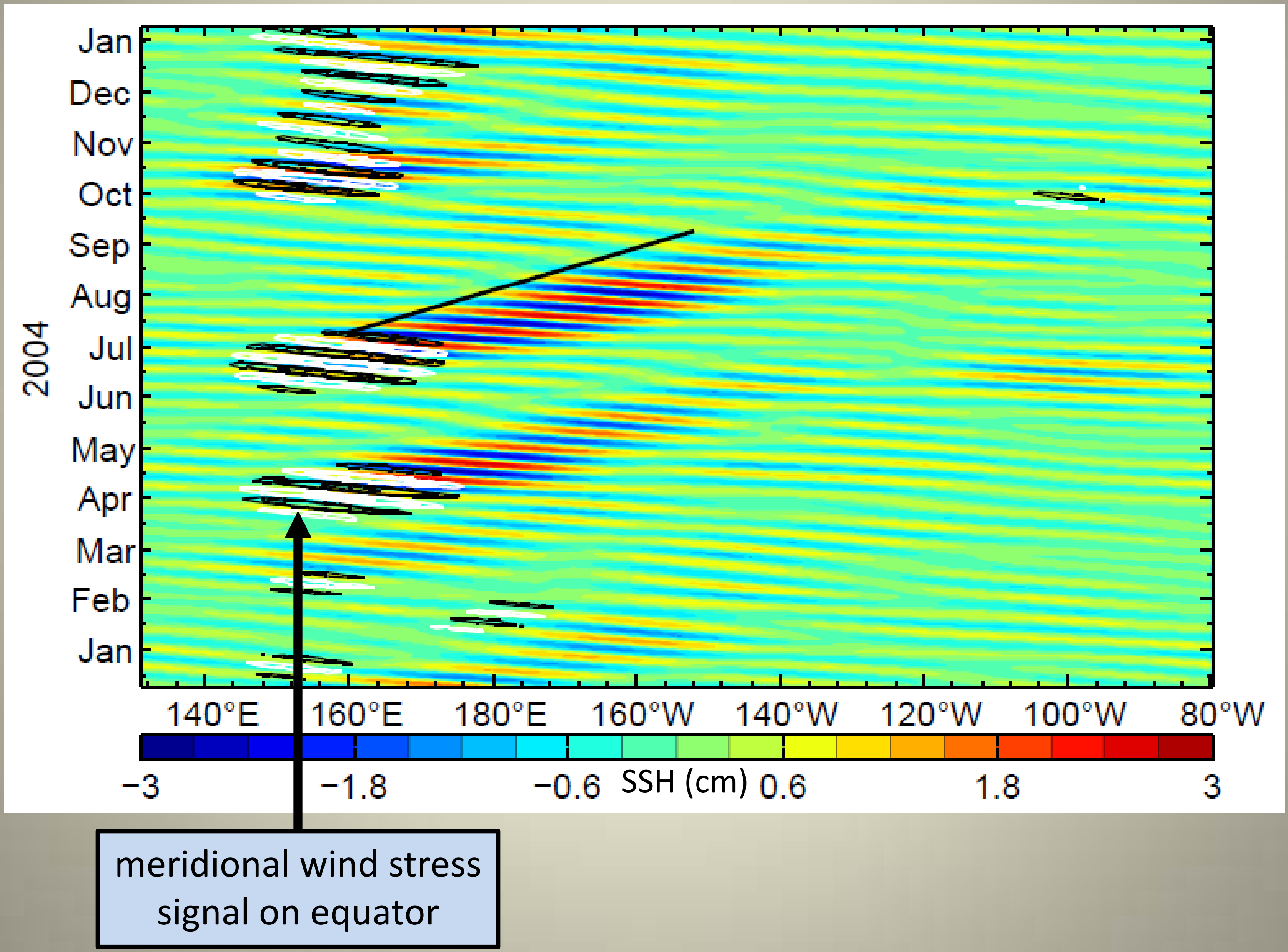
# Example: 11-day, 33° Yanai wave (1st baroclinic mode)



# Longitude-time slice on 4°N
(bandpass filtered for the 11-day, 33°-wavelength Yanai wave)



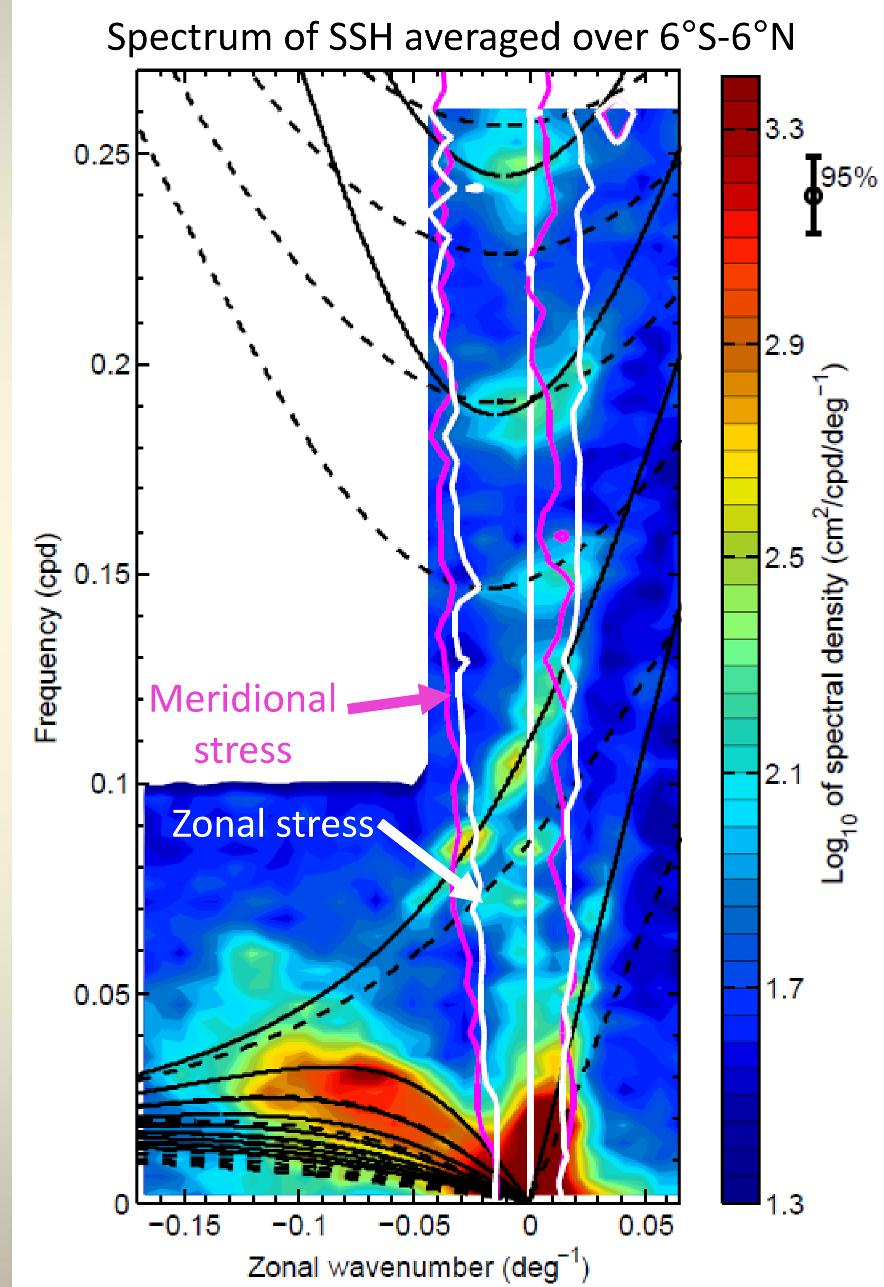
# Longitude-time slice on 4°N
(bandpass filtered for the 11-day, 33°-wavelength Yanai wave)



# Conclusions

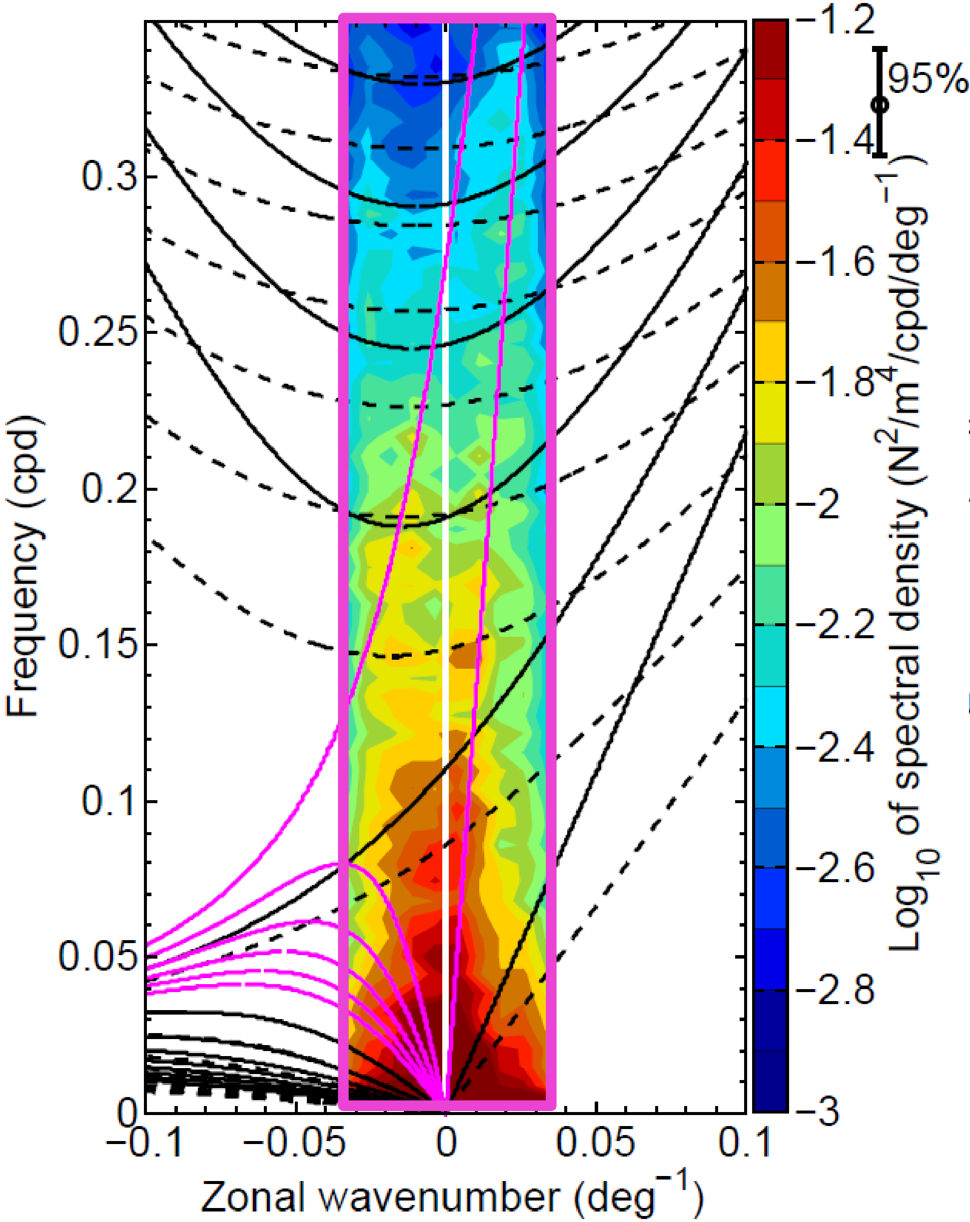
→The QuikSCAT and multimission-altimetry records allow a new and detailed view of large-scale equatorial waves and the wind forcing at periods of days

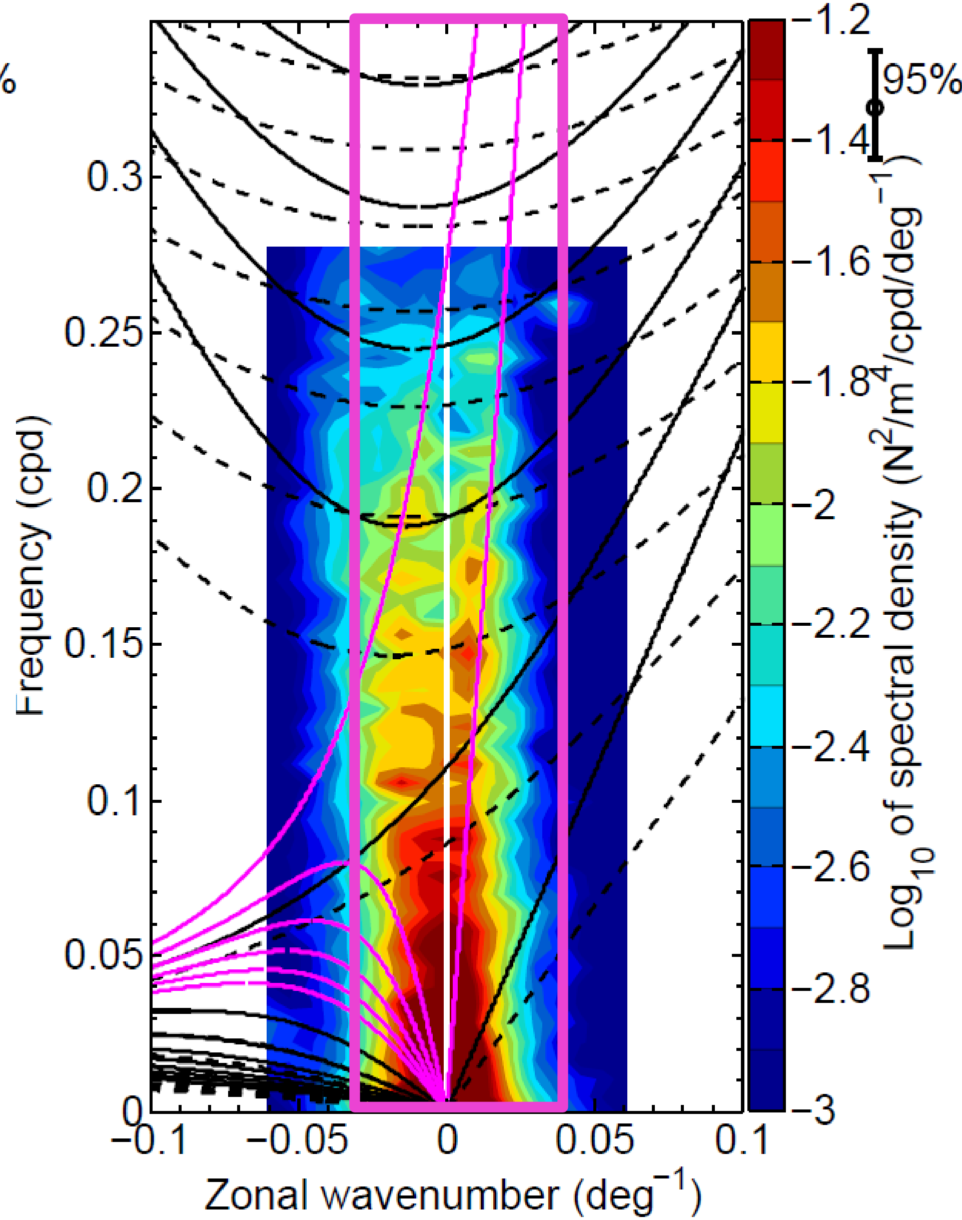
→We plan to use this information to
  (1) estimate the transfer function from wind forcing to ocean response
  (2) examine the relationship of wind forcing and ocean response in time and space



Zonal wind stress from TAO

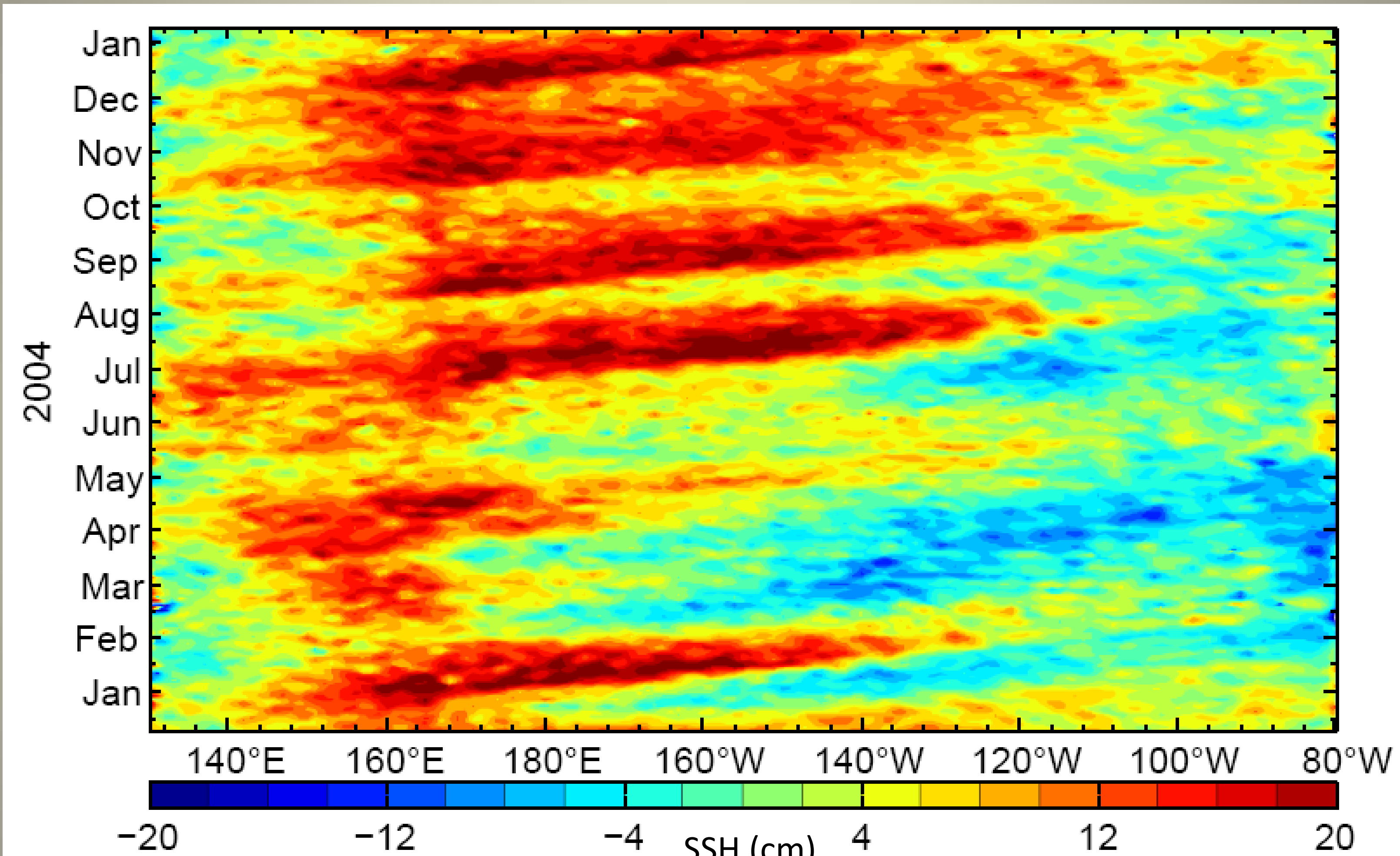
Zonal wind stress from QuikSCAT




Note: TAO stress was estimated with neutral drag coefficient, which should cause low bias

# Longitude-time slice on equator (no filtering)
# → The intraseasonal Kelvin wave



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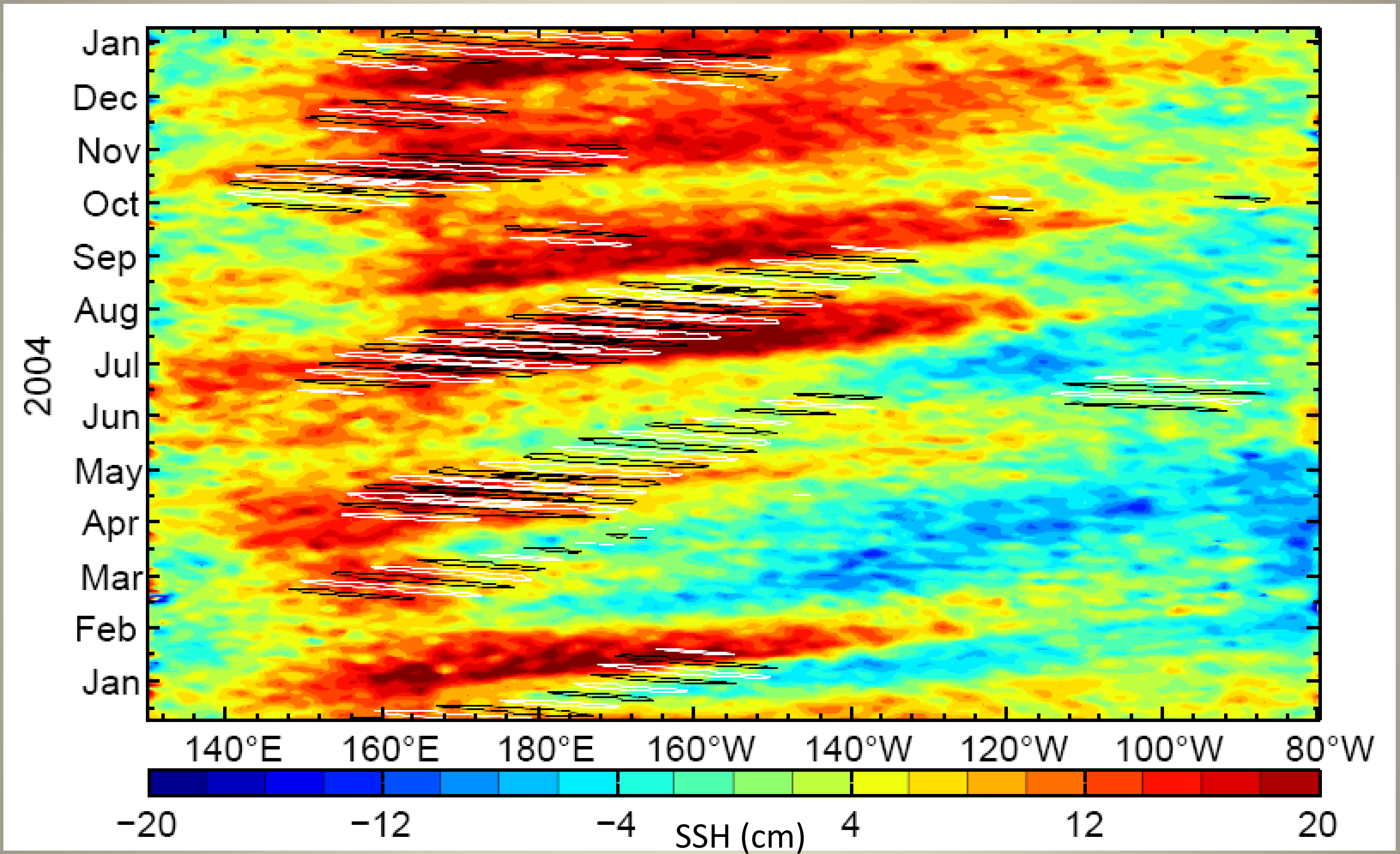
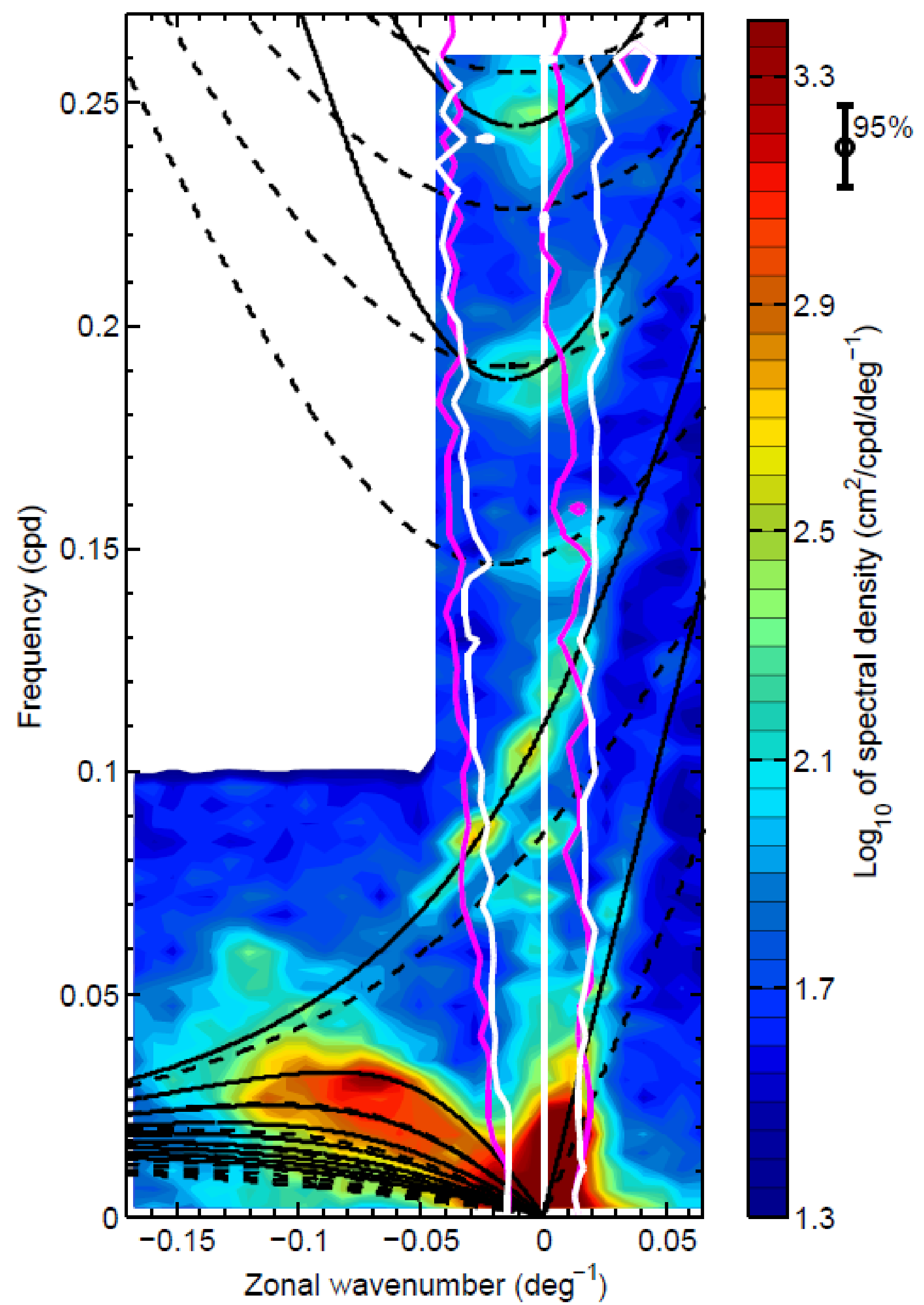


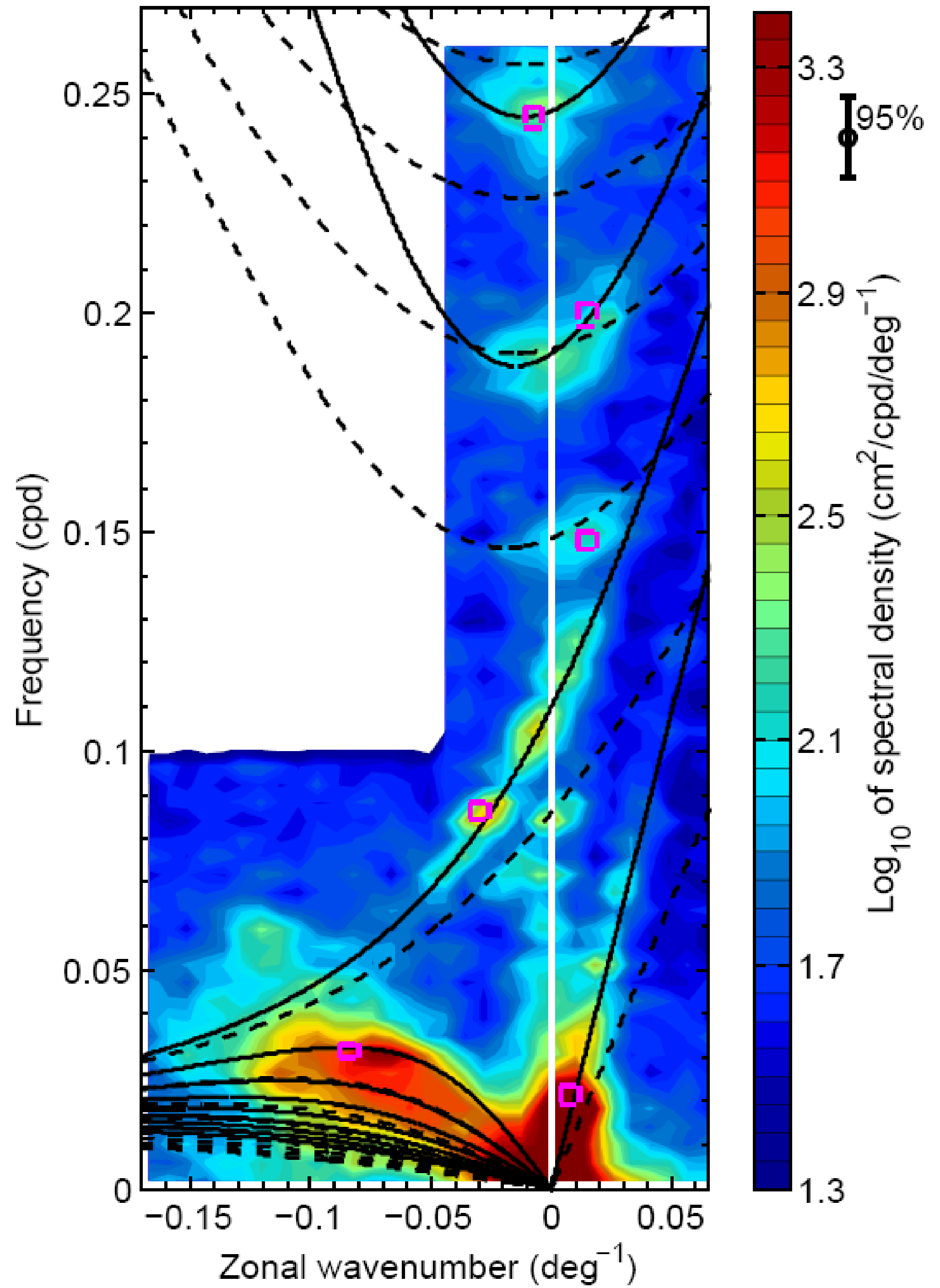

Black and white contours are Yanai wave signal at 4°N



0.25
0.2
0.15
0.1
0.05
0
Frequency (cpd)
-0.15
-0.1
-0.05
0
0.05
Zonal wavenumber ($deg^{-1}$)
3.3
2.9
2.5
2.1
1.7
1.3
$Log_{10}$ of spectral density ($cm^2/cpd/deg^{-1}$)
95%

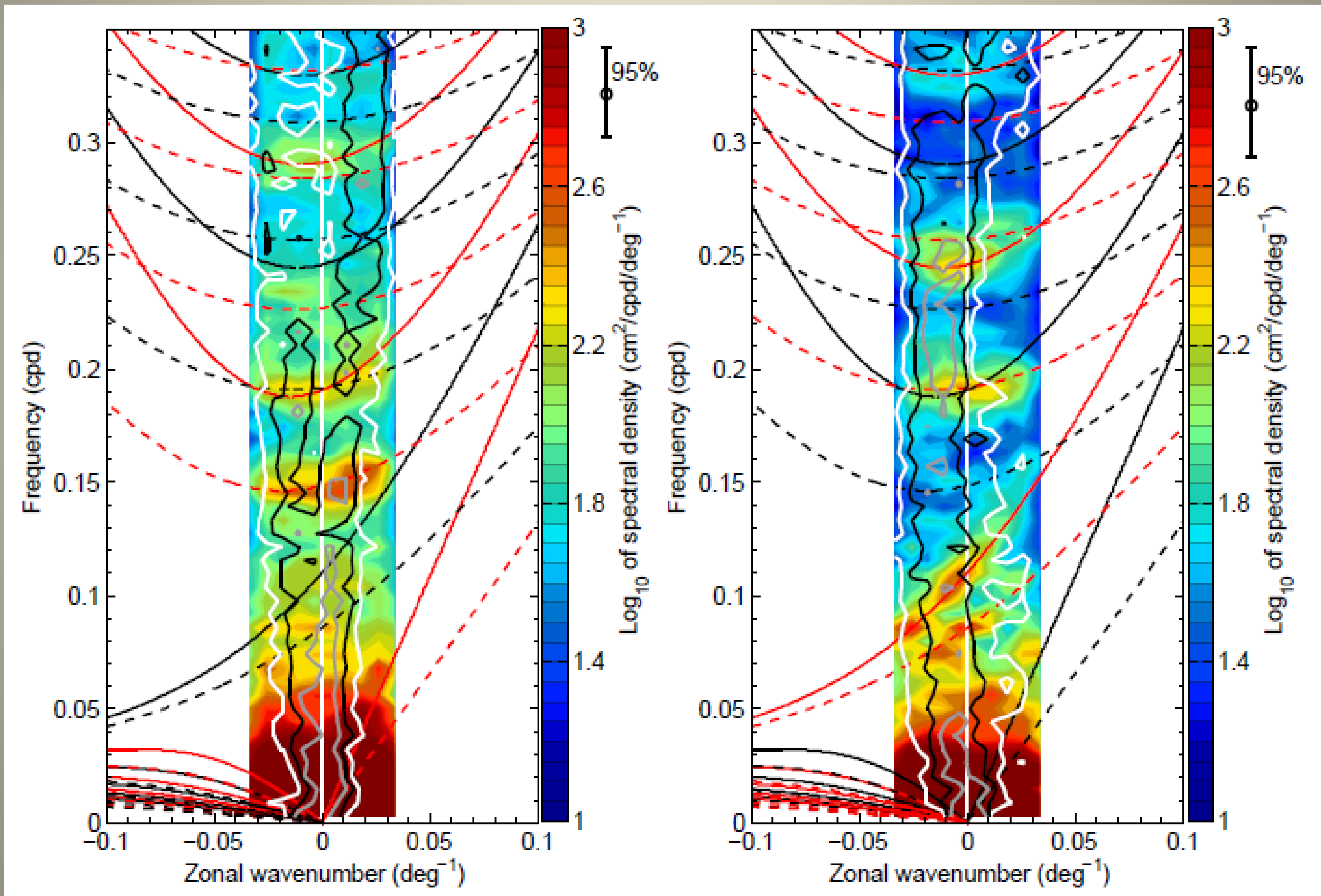
# Zonal-wavenumber/ frequency spectrum of SSH from fit to along-track altimeter data (average over 6°S-6°N) (2000-2005; 6 years)

The satellite data allow us to examine the meridional structure of these waves and their forcing in detail, without any assumptions about their meridional structure.

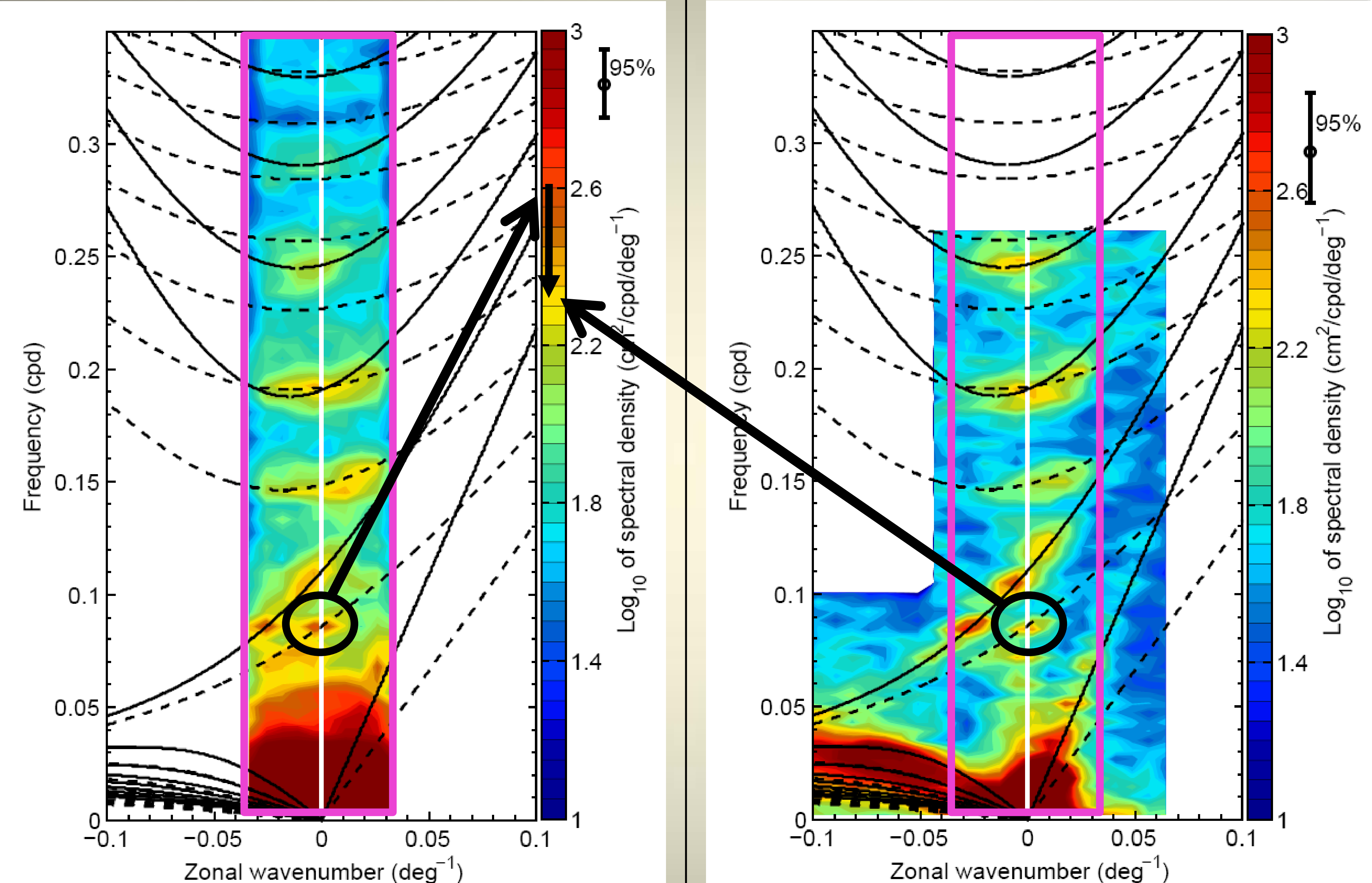


Symmetric dynamic height spectrum (colors) with symmetric zonal wind stress (line contours)

Antisymmetric dynamic height spectrum (colors) with symmetric meridional wind stress (line contours)



Dynamic height rel. to 500m (TAO; 1997-2008) | SSH spectrum (altimetry; 2000-2005)




1[st] baroclinic should be ~5 contours larger in SSH; 2[nd] baroclinic should be ~6 contours smaller