Snapshot of surface wind speed for January 27, 2018. From https://earth.nullschool.net

The Seasonal Cycle of Significant Wave Height in the Ocean: Local vs. Remote Forcing

Luke Colosi, Sarah T. Gille, Bia Villas Boas

Scripps Institution of Oceanography

Acknowledgements: Nasa, Remote Sensing Systems,Institut français de recherche pour l'exploitation de la mer

General Wave forecast in California and many other regions around the world

Spring Months

Punta Arenas, Chile:
Aia Produtura

Winter Months

Surfline: Newport Beach

General Wave forecast in California and many other regions around the world

Spring Months

Punta Arenas, Chile:
Aia Produtura

Why?

Winter Months

Surfline: Newport Beach

Local vs. Remote Forcing

Aia Produtura:Punta Arenas, Chile

Locally Forced Waves

- Short Period (high frequency)
- Short Wavelength
- Choppy Waves

Surfline: Newport Beach

Remotely Forced Waves

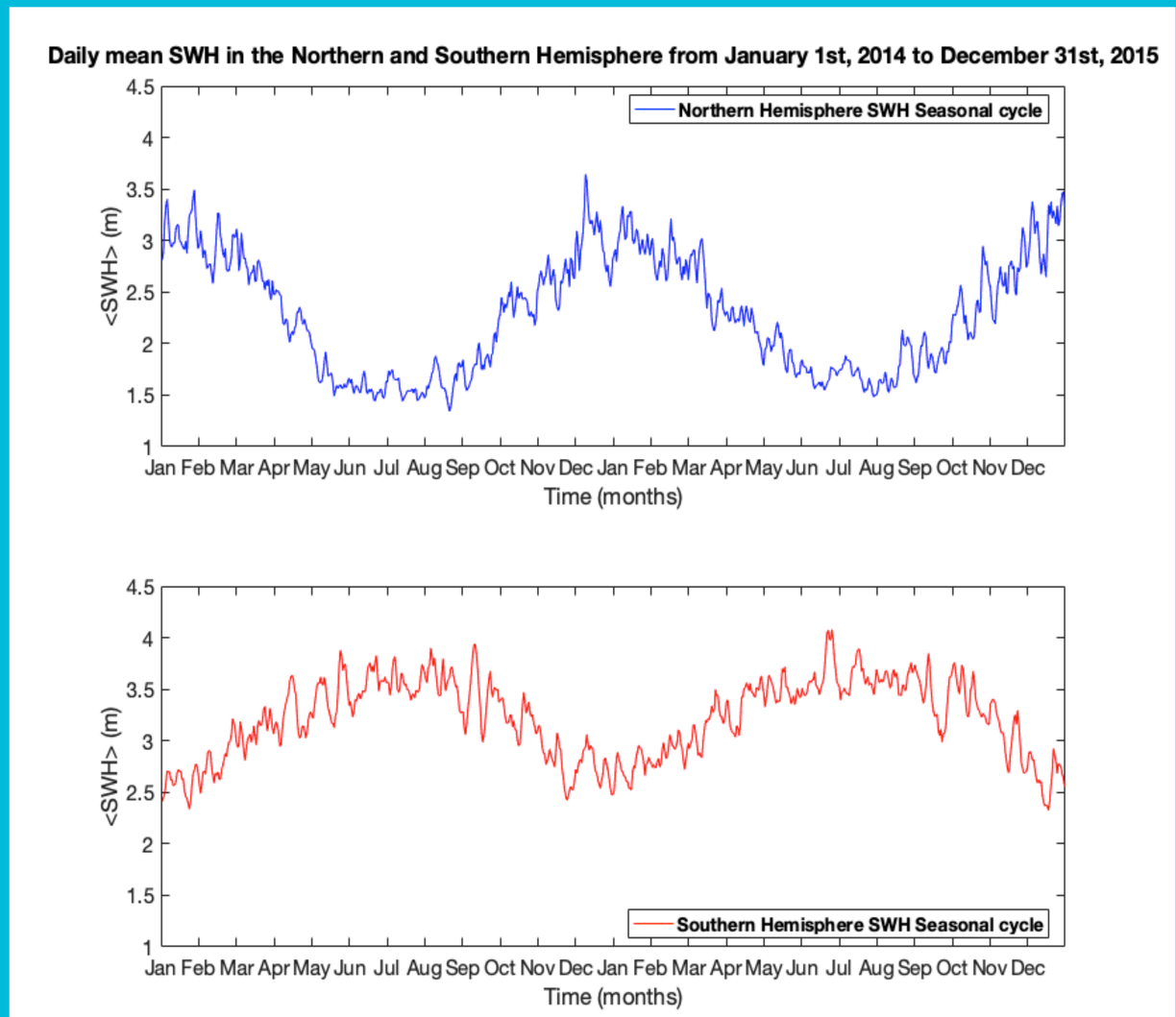
- Long Period (low frequency)
- Long Wavelength
- Well-sorted Swell

Significant Wave Height (SWH) Seasonal Cycle

General characteristics of SWH seasonal cycle:

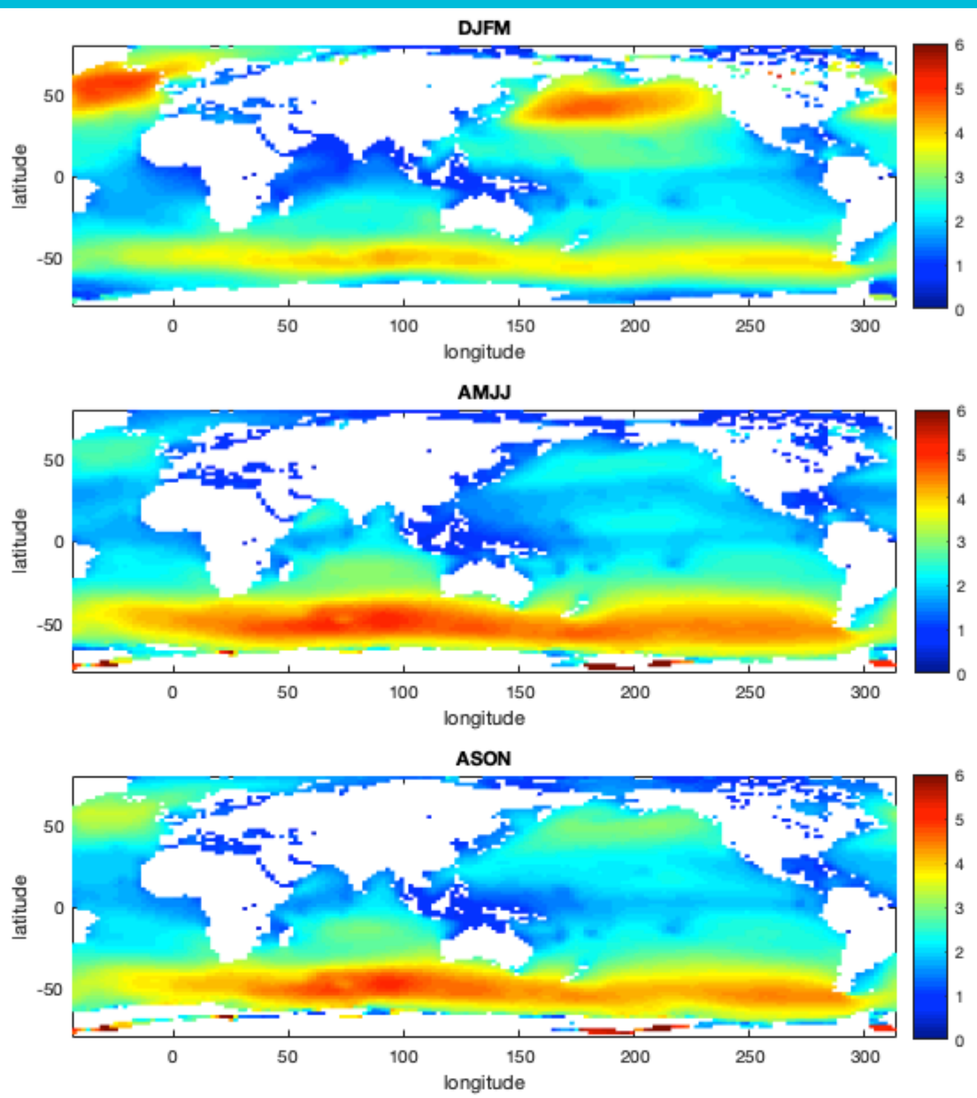
Phase SWH NH shifted by pi from the phase of the SH

Seasonal Cycle NH > Seasonal cycle SH
(signal strength)

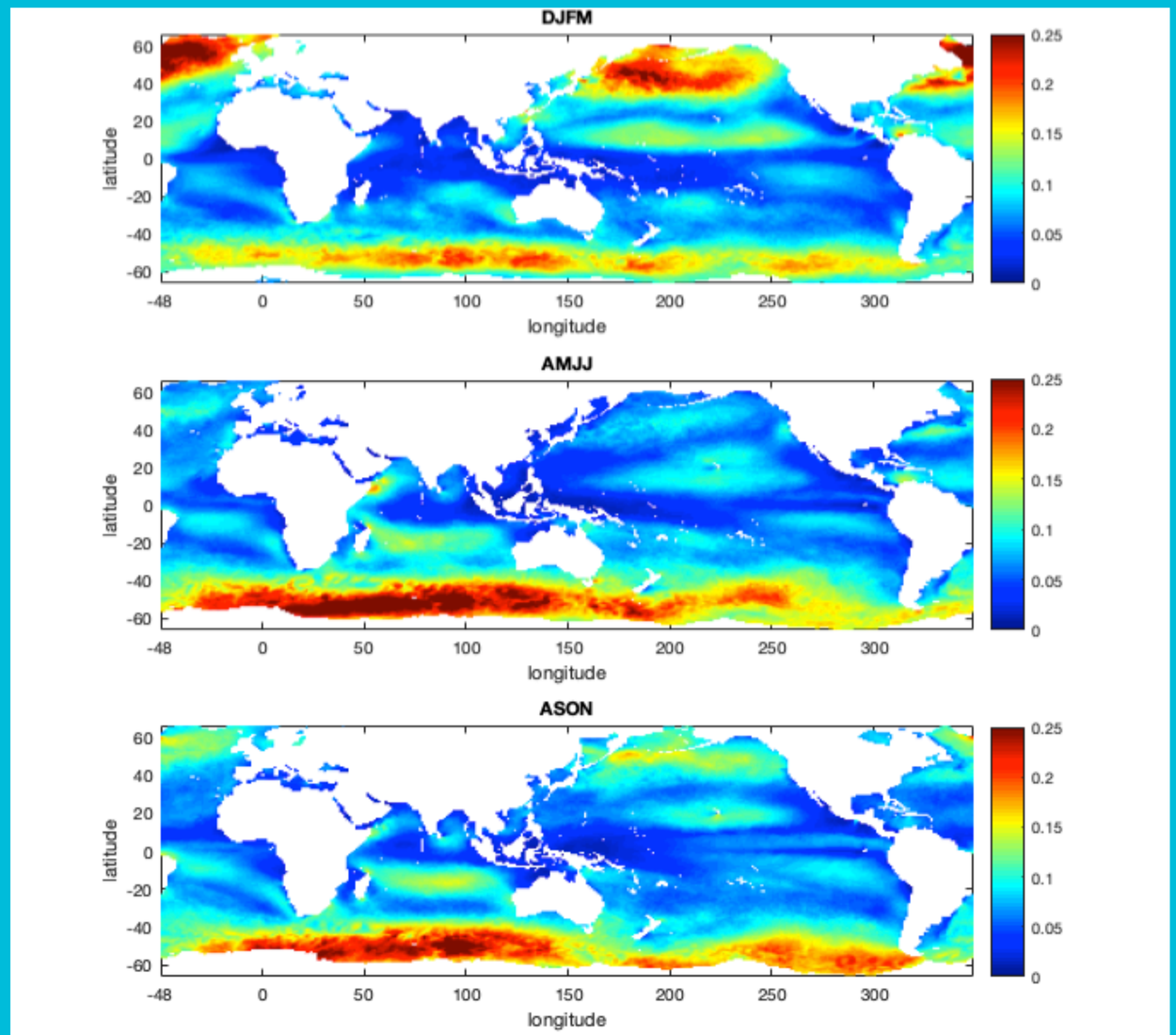


SWH undergoes an annual sinusoidal cycle in response to the seasonal changes in storm patterns

SWH

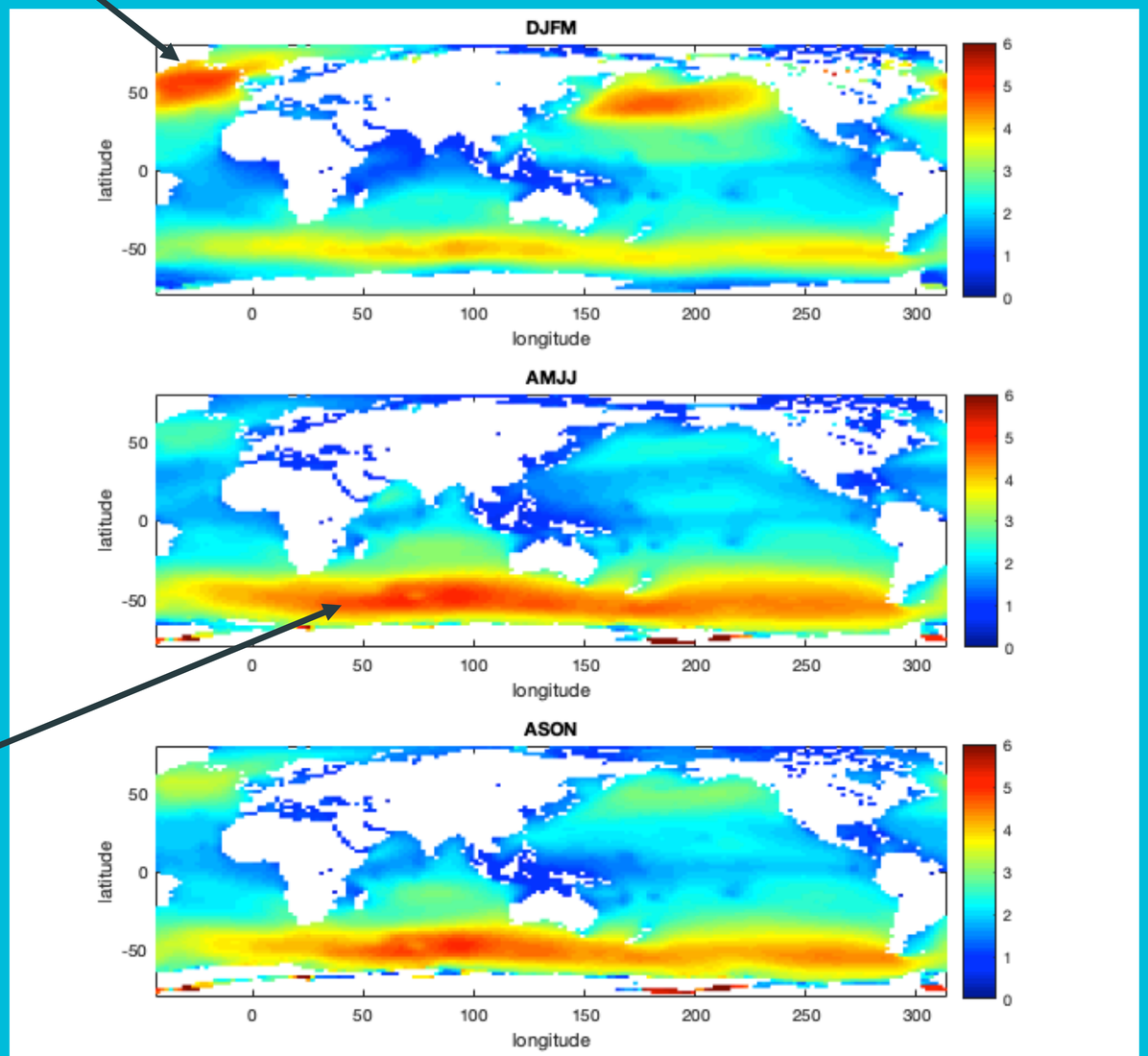


Wind Stress Magnitude

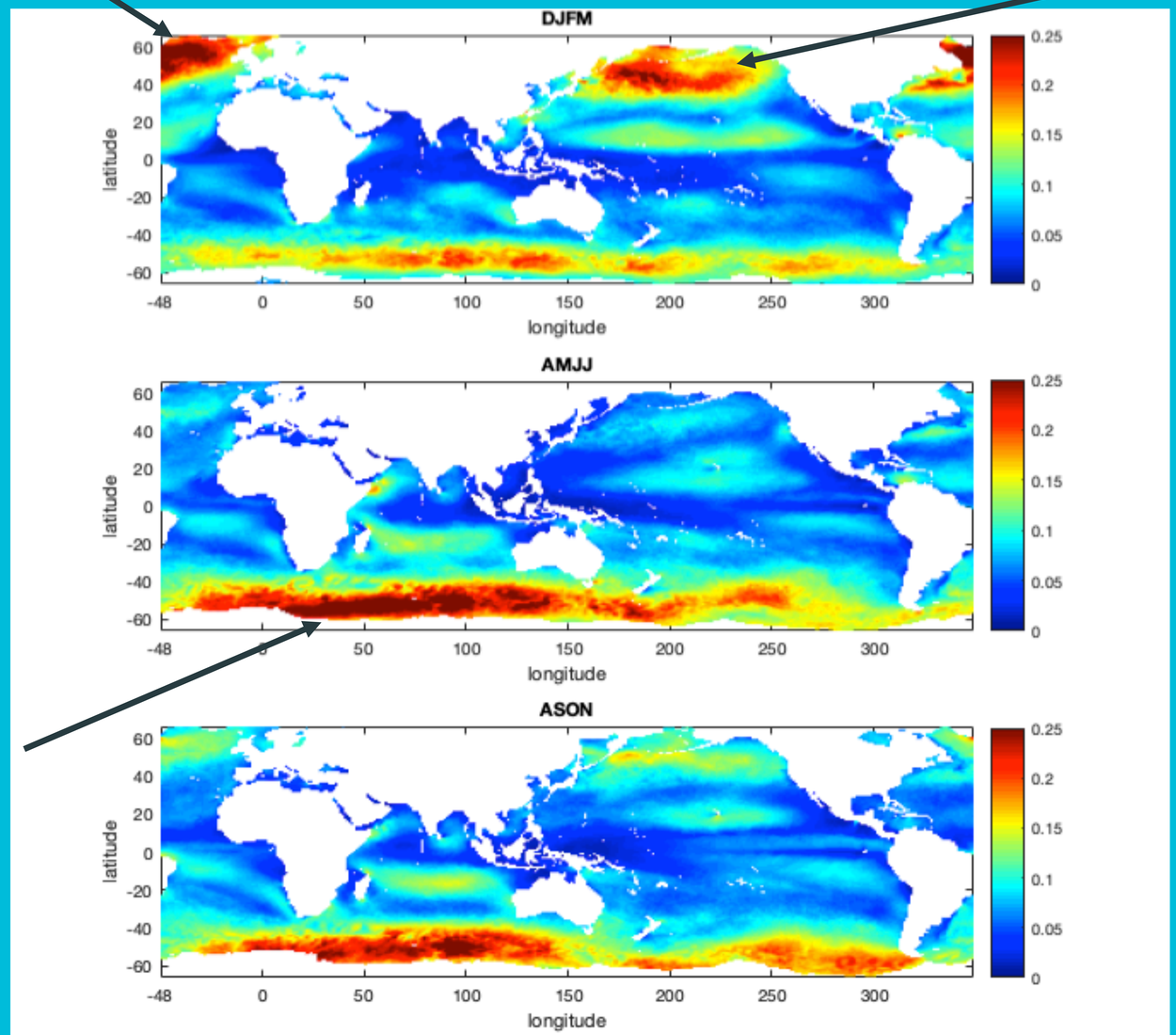


SWH undergoes an annual sinusoidal cycle in response to the seasonal changes in storm patterns

SWH

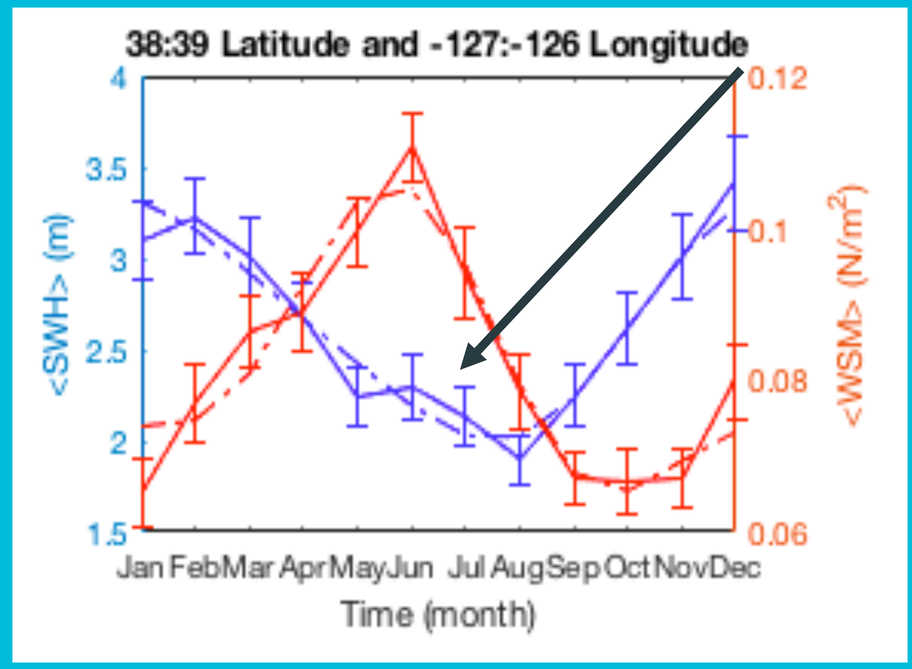


Wind Stress Magnitude

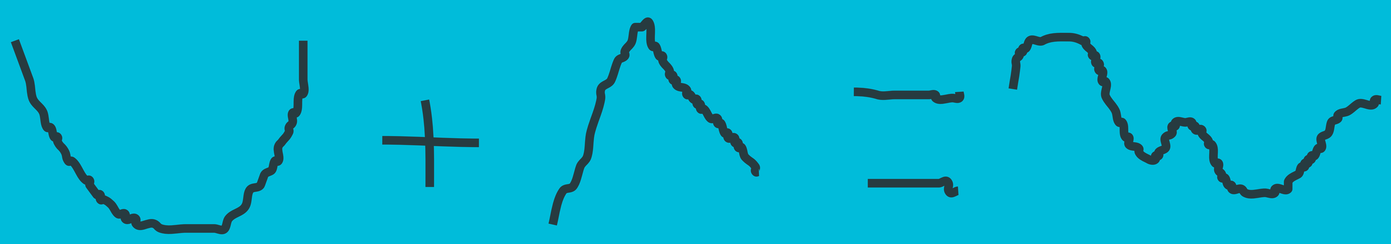


Deviations in the SWH Seasonal Cycle

Northern California 2°x2° Regional Climatology



- Intra-annual Variability in the swh seasonal cycle of the Coast of California during the spring and summer months due to local wind event (Villas Boas et al., 2017)
- Other regions around the world where similar wind events occur (Winant et al., 1988)



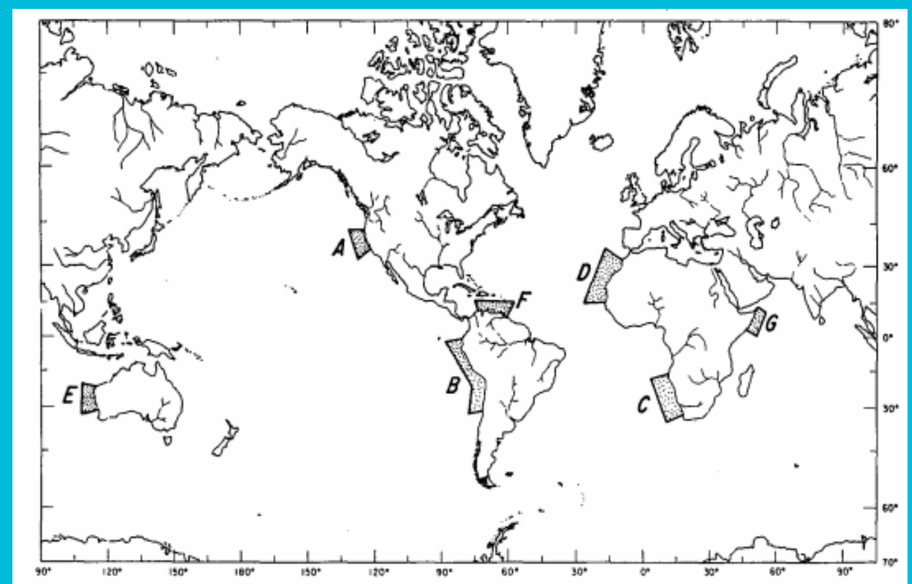


FIG. 14. Areas of the world where supercritical flow might be expected to occur in the marine layer.

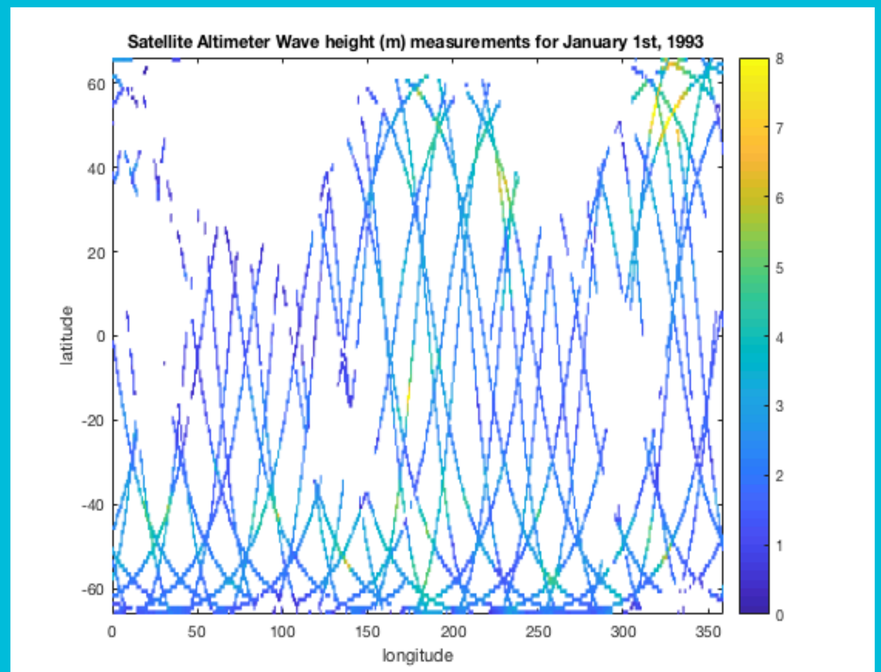
Research Question

1)Does a deviation in the SWH seasonal cycle extend to other eastern boundary regions in ocean basins around the globe?

2)What can the global structure of the SWH and wind stress magnitude seasonal cycles illustrate about the location of waves generation and its forcing mechanism?

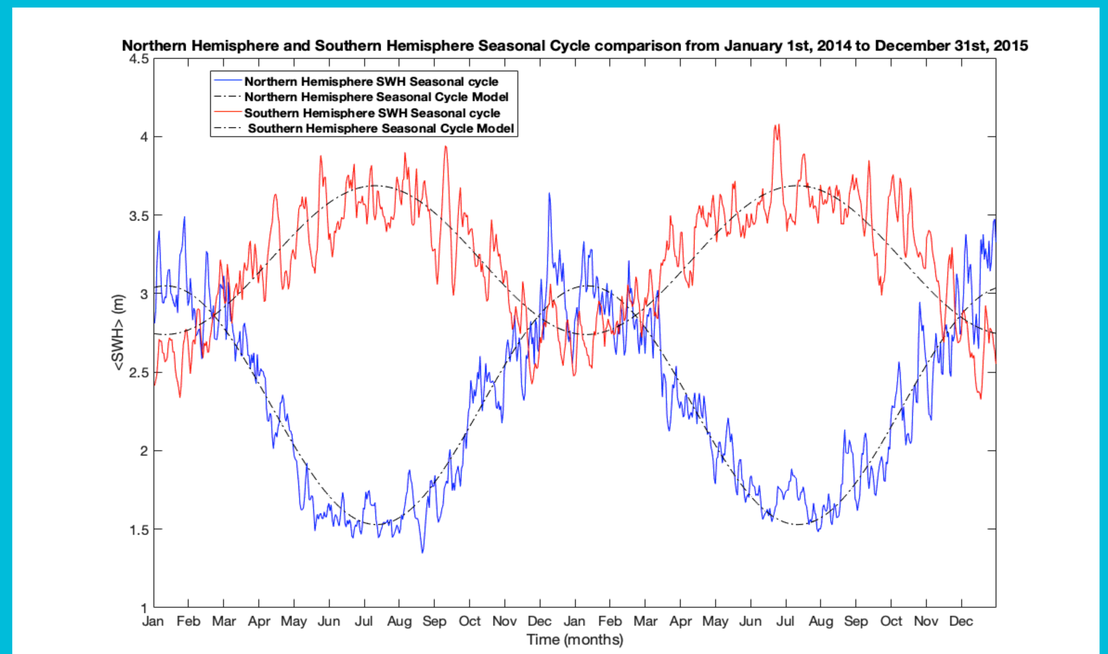
Data

- Cross Calibrated multi-platform satellite altimeter SWH measurements produced by the Institut français de recherche pour l'exploitation de la mer (Ifremer)
- Cross calibrated multi-platform wind vector analysis data produced by Remote Sensing Systems.



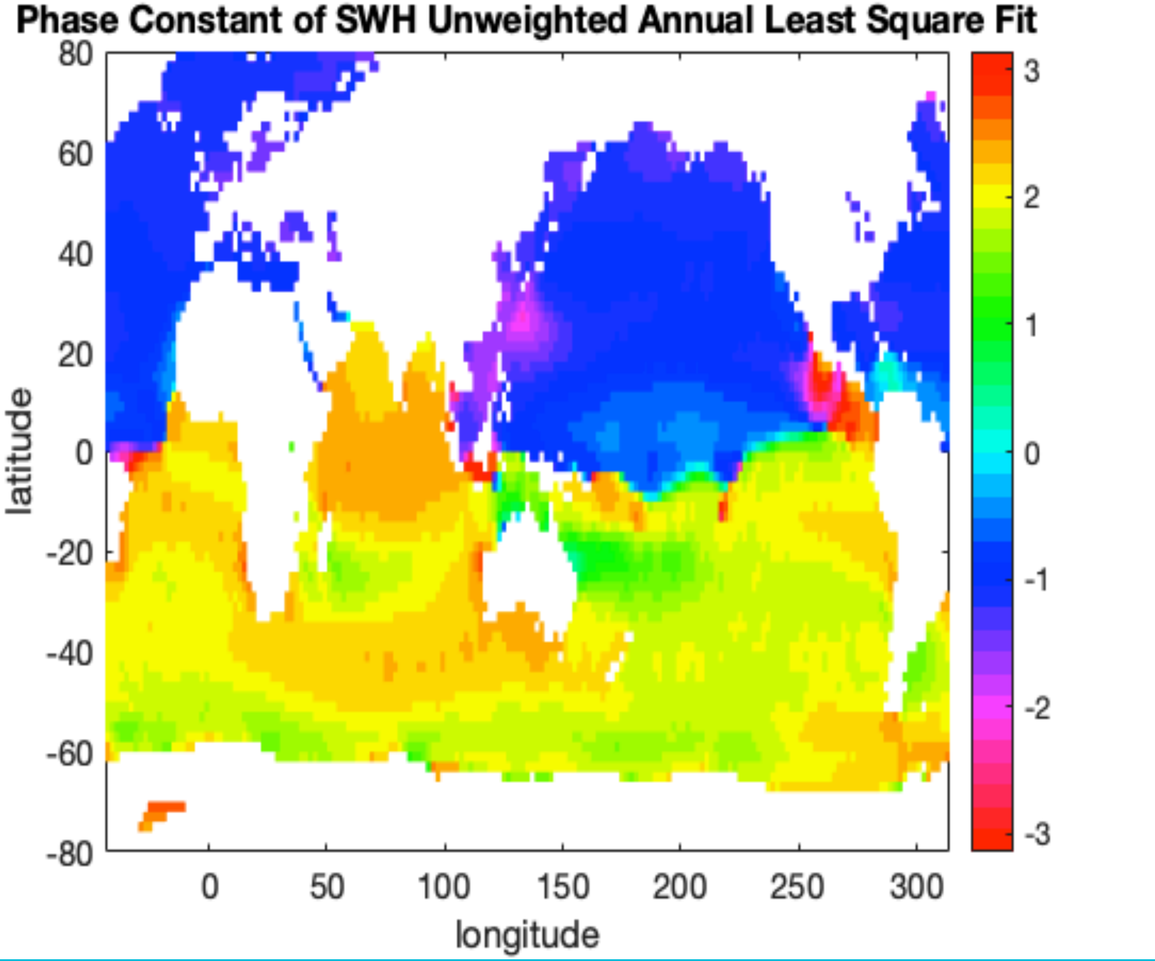
Methods

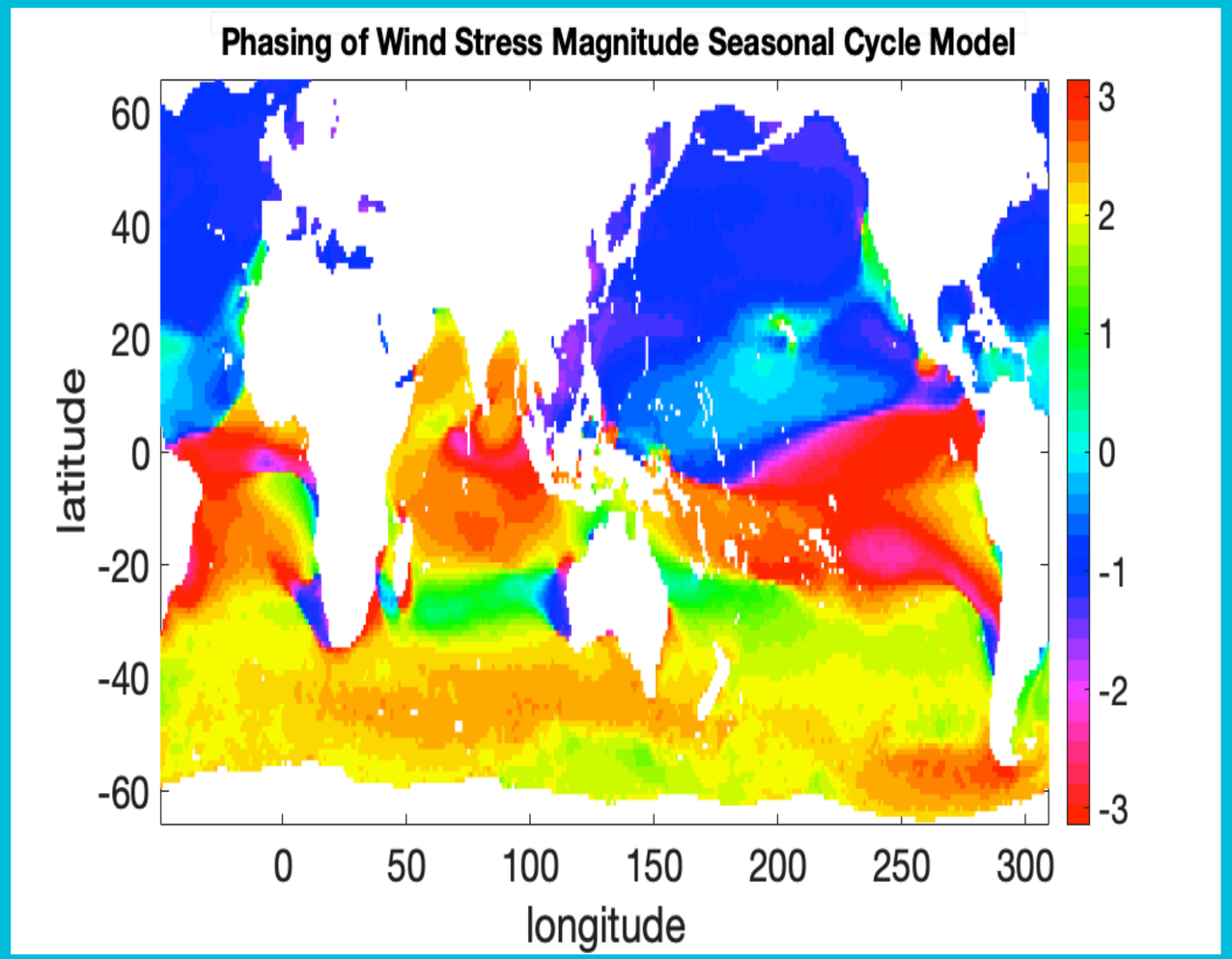
- Modeling of seasonal cycle: unweighted least square fit
- Characteristics of Seasonal Cycle:
  - Root mean square residual
  - Amplitude
  - Phase Constant
  - R^2 (Coeficient of Determination)



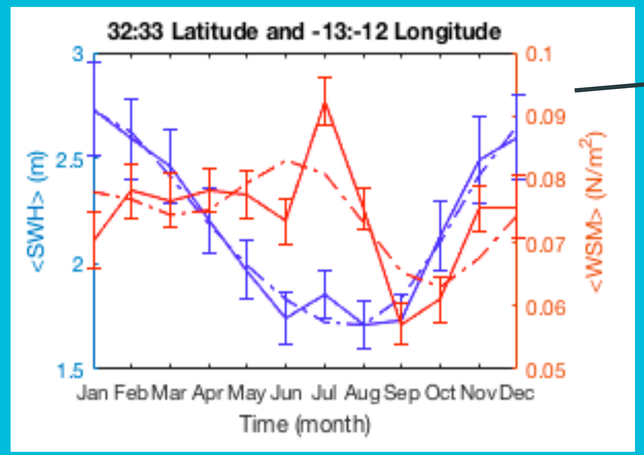
Results and Discussion

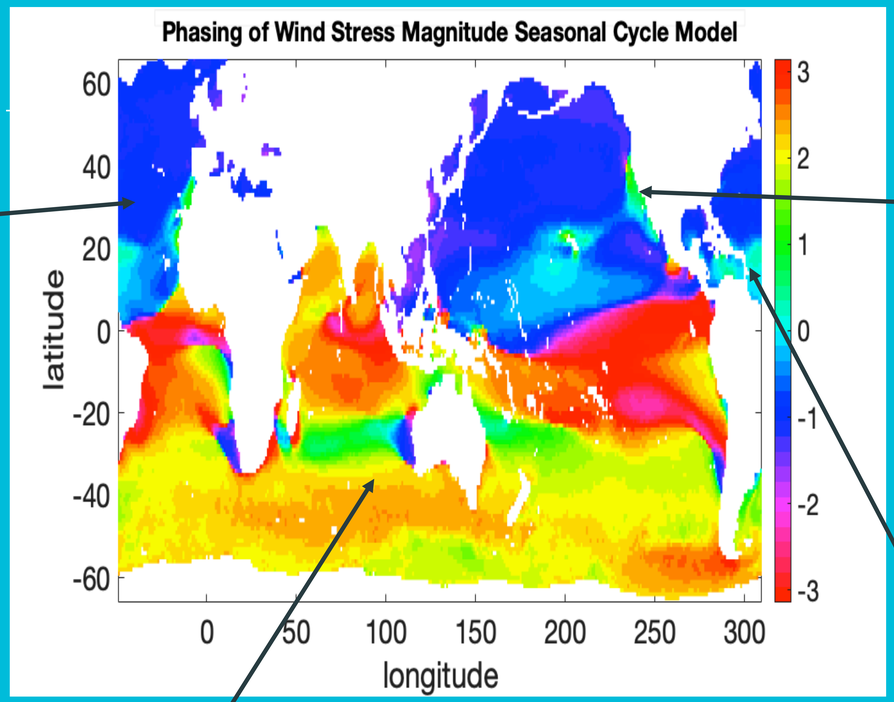
Global Phasing of Seasonal cycle for SWH and Wind Stress Magnitude

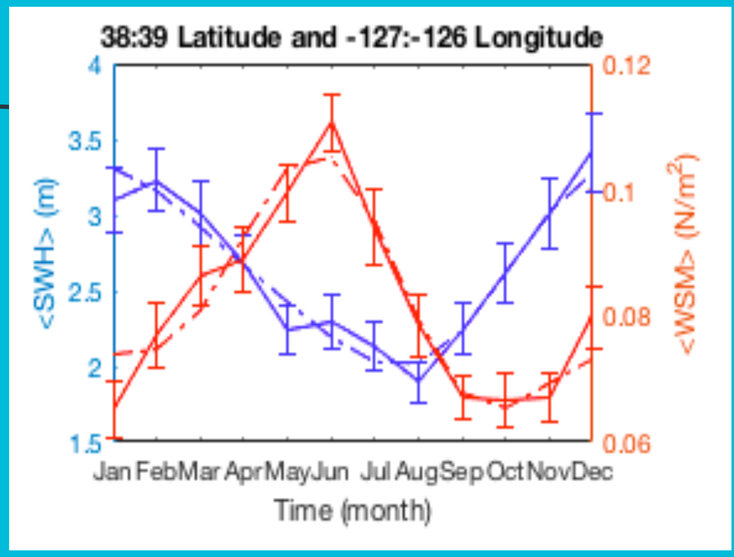


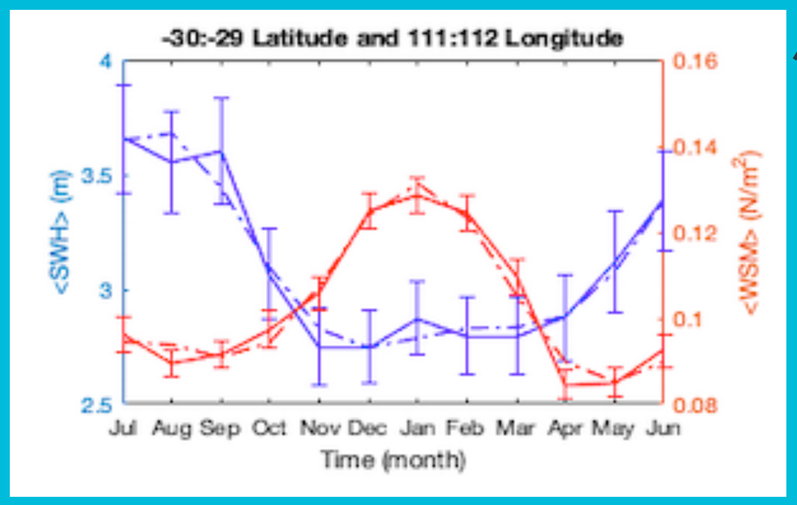


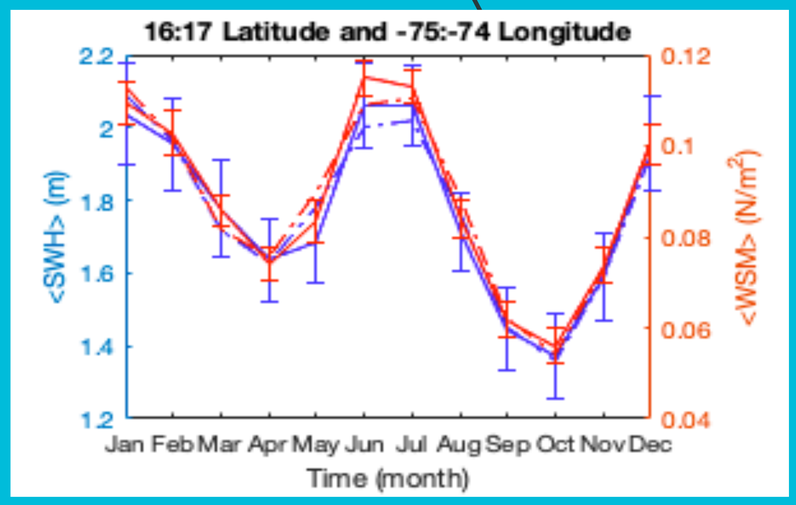
Regional Climatologies in Eastern Boundary Regions











Conclusion

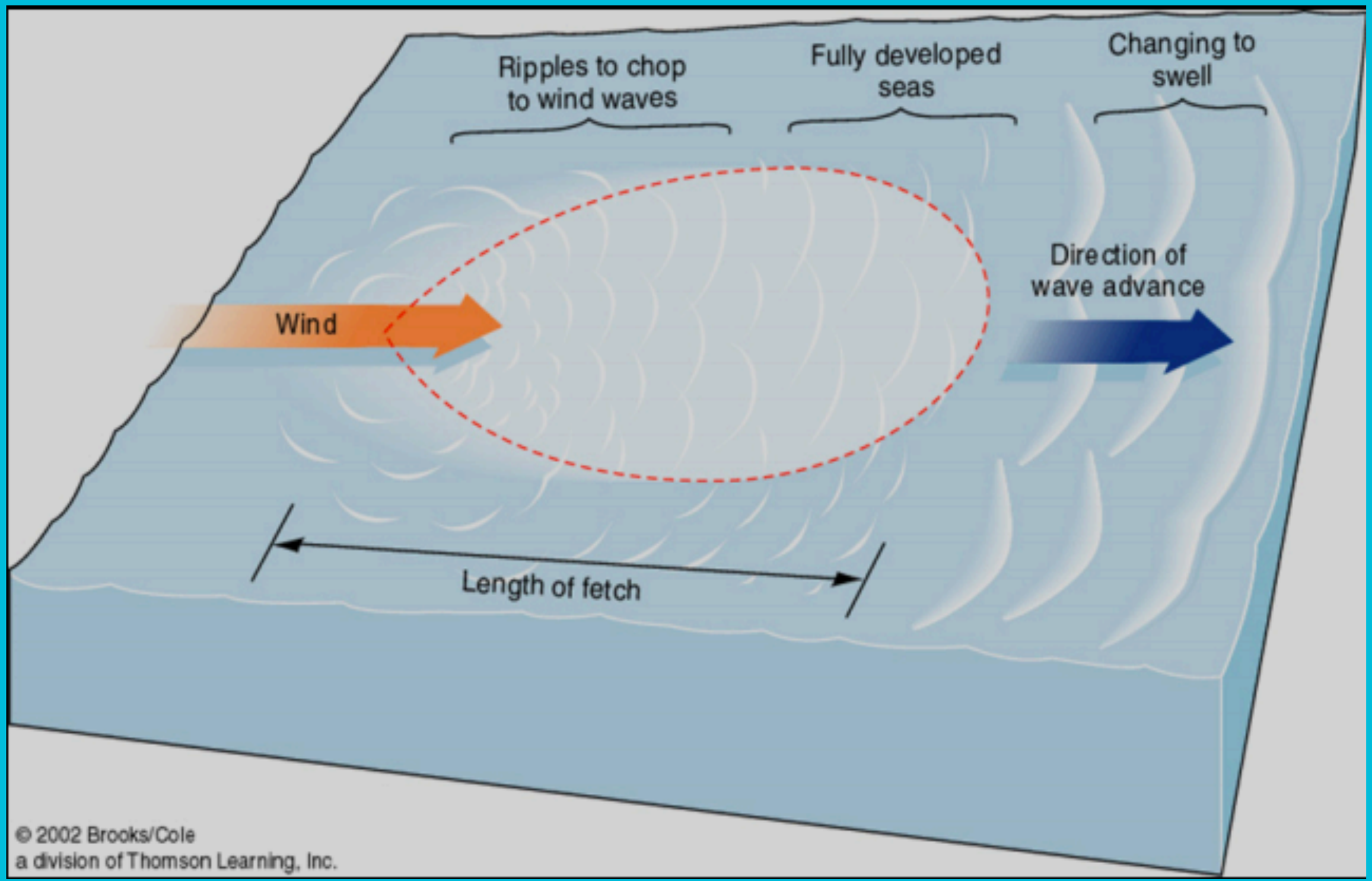
- Deviations in the SWH seasonal cycle can be observed in other regions
- Magnitude of SWH deviation from the seasonal cycle is determined/ modulated by local wave conditions

Therefore, we have a better idea of where and when to surf!!

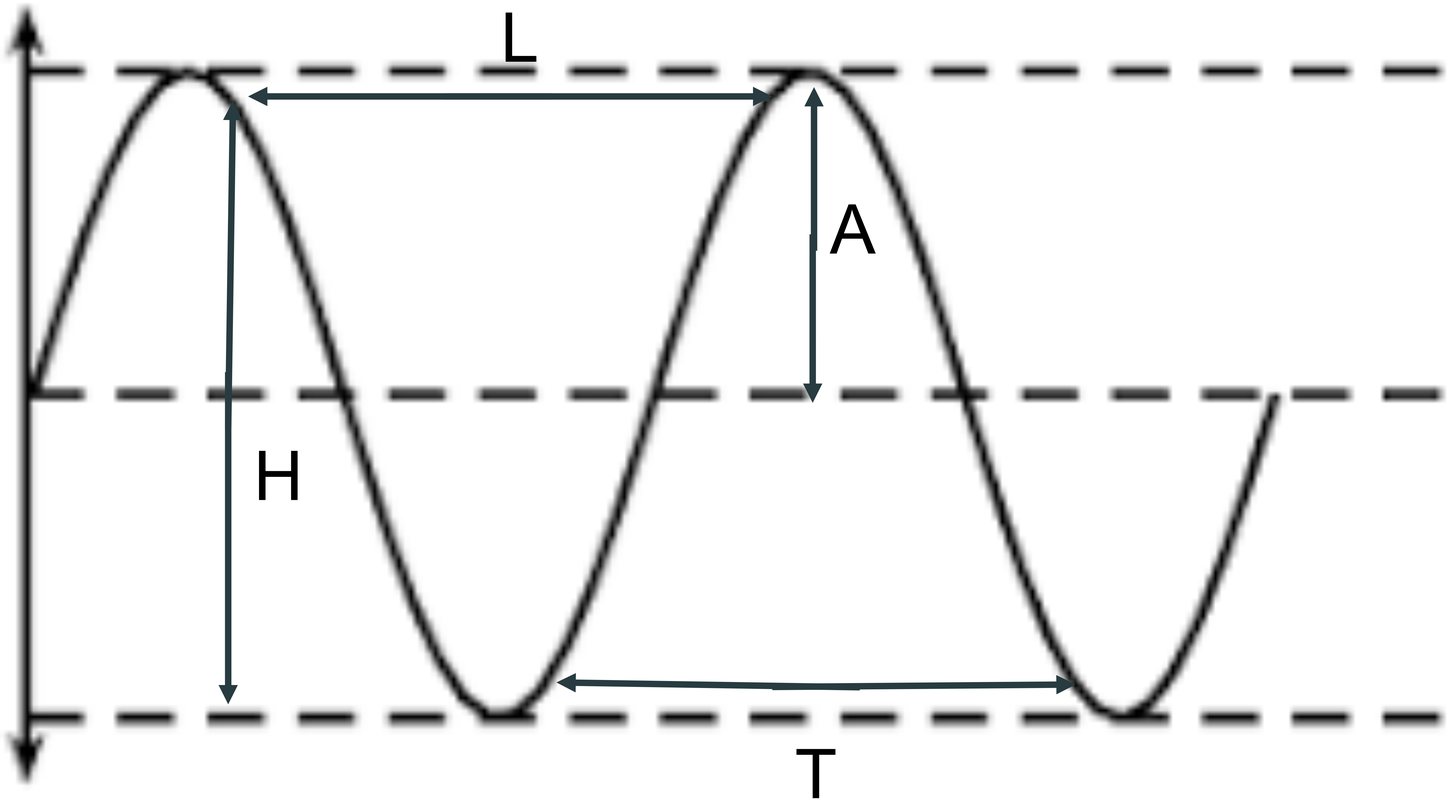
Trestles: Jeff Davis

Supplemental Slides

How are Waves formed?



How do we characterize waves?



Single frequency Parameters

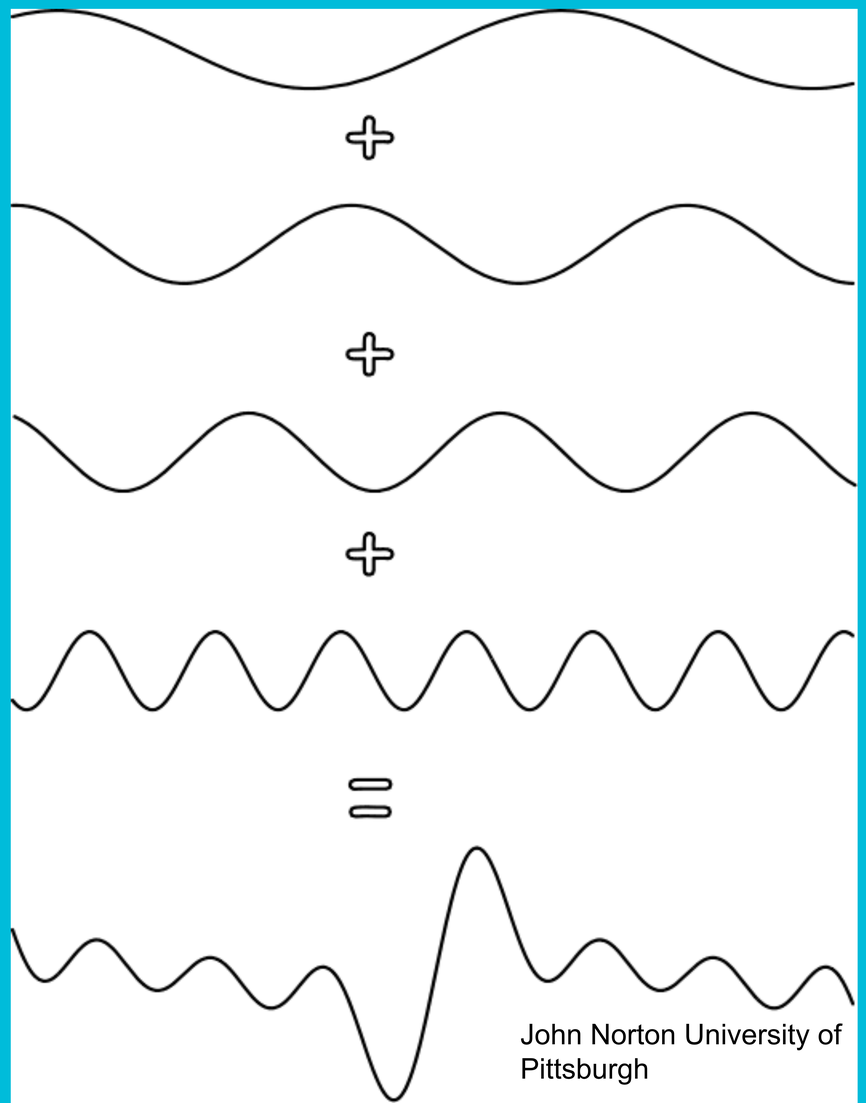
- T = Period
- H = Height
- A = Amplitude
- L = Wavelength

Local vs. Remote Forcing

The surface wave field in a given region results from the combined effect of both local and remote forcing

Locally Forced Waves

- Short Period (high frequency)
- Short Wavelength
- Choppy Waves



Remotely Forced Waves

- Long Period (low frequency)
- Long Wavelength
- Well-sorted Swell

Wave Age

The stage of development of waves is quantified by Wave Age:

$$A = \frac{C_p}{U_{10}}$$

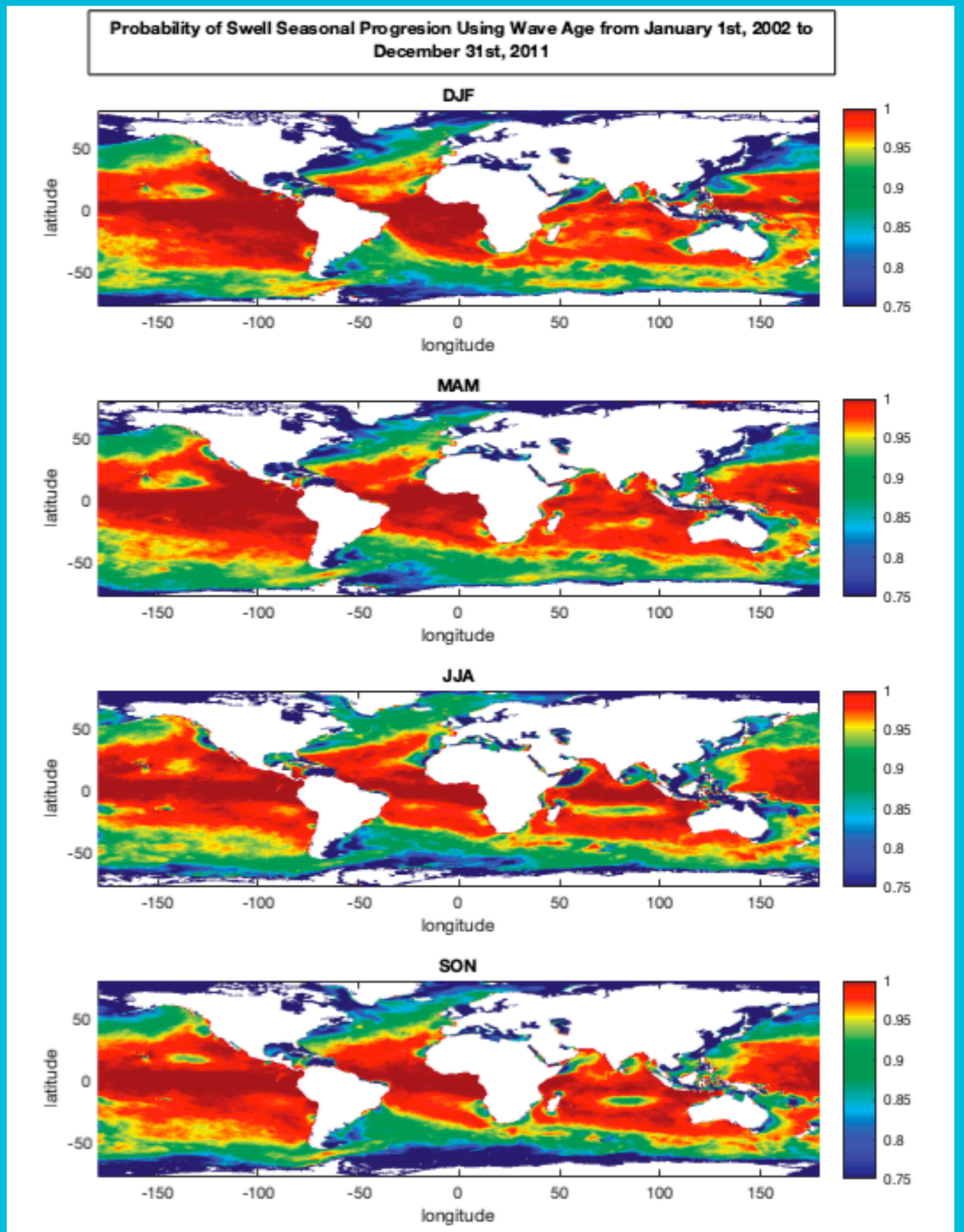
Where C_p = Phase Speed of the Wave

U_{10} = Wind Speed at 10m above the ocean surface

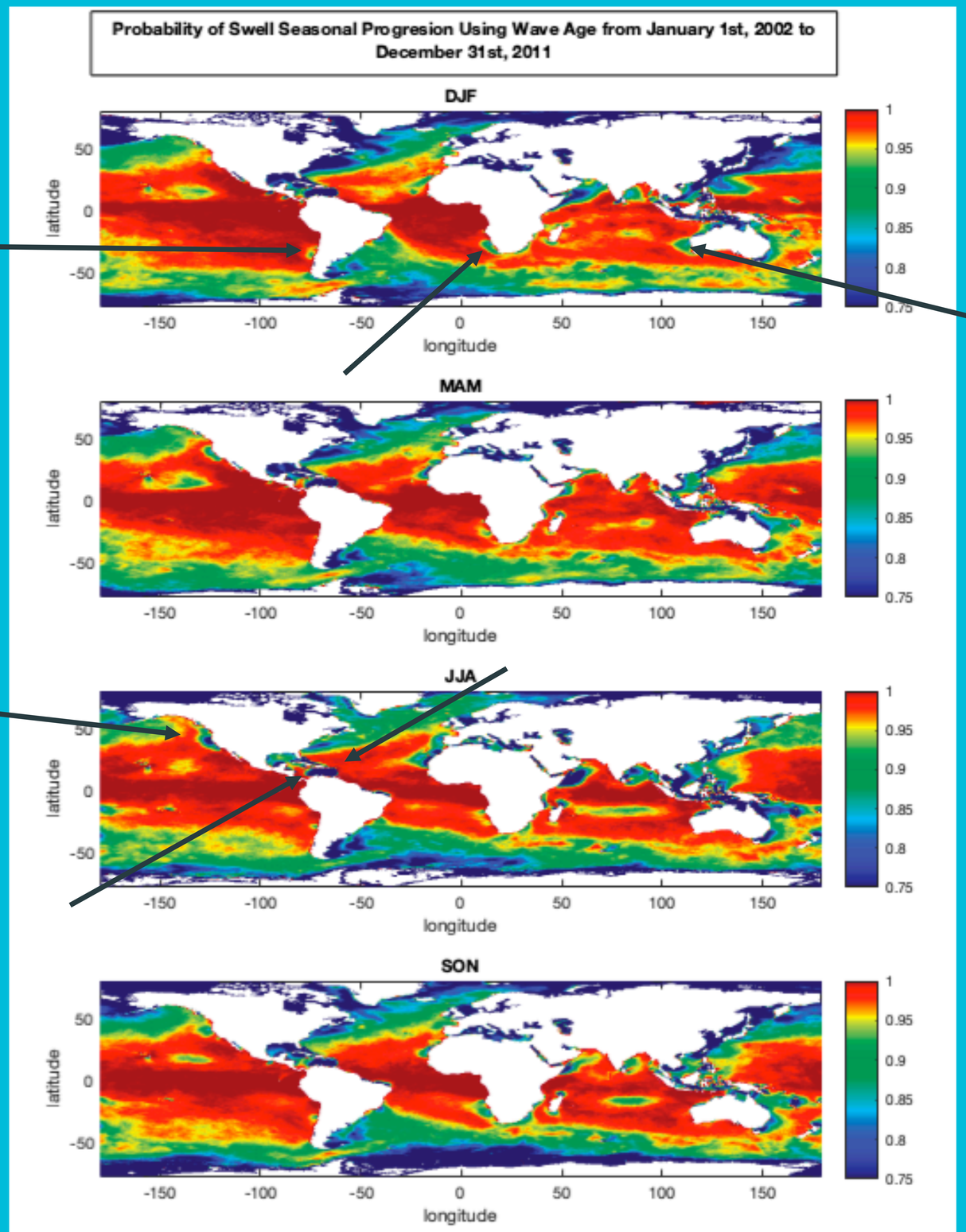
Wave age is used to separate wind seas from fully developed seas such that:

$C_p / U_{10} < 1.2$ Wind Seas $C_p / U_{10} >= 1.2$ Fully Developed Seas (Swell)

Second approach with Probability of Swell using Wave Age

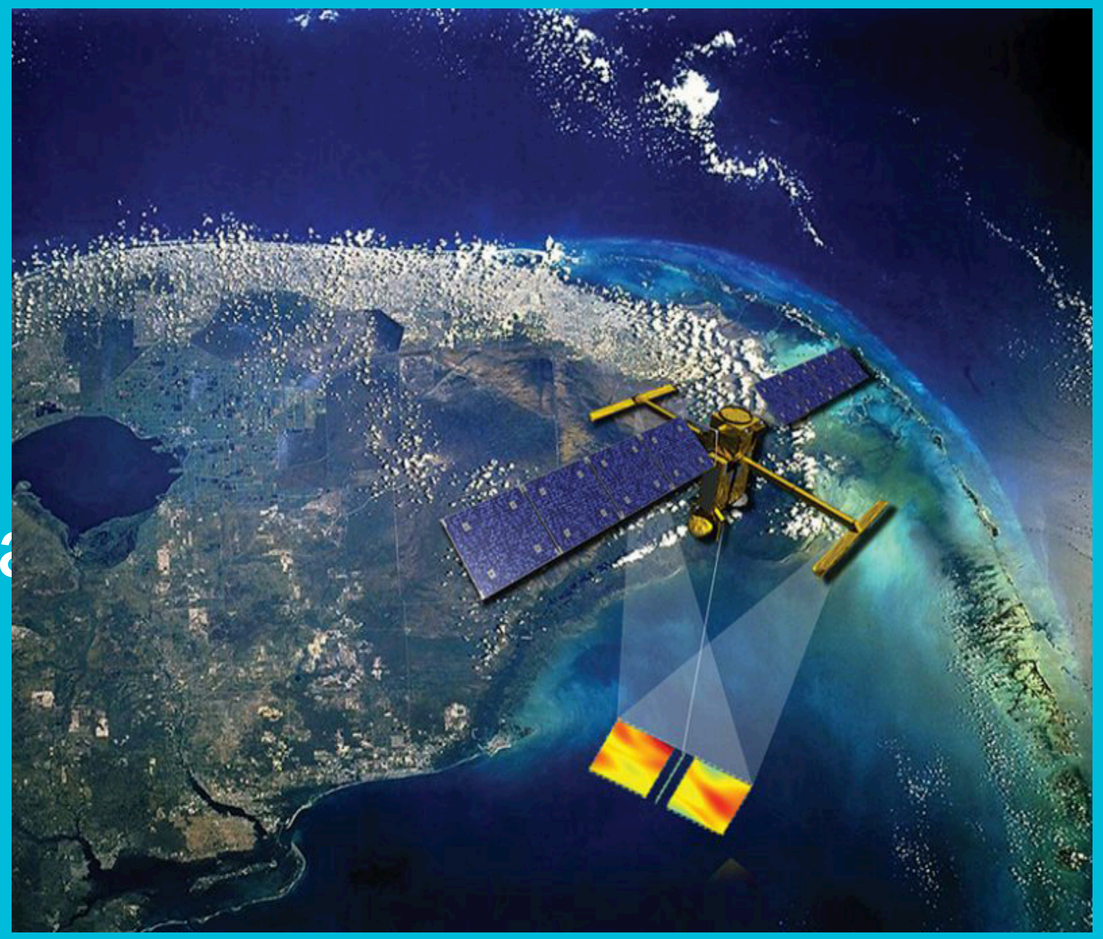


Second approach with Probability of Swell using Wave Age



Satellites

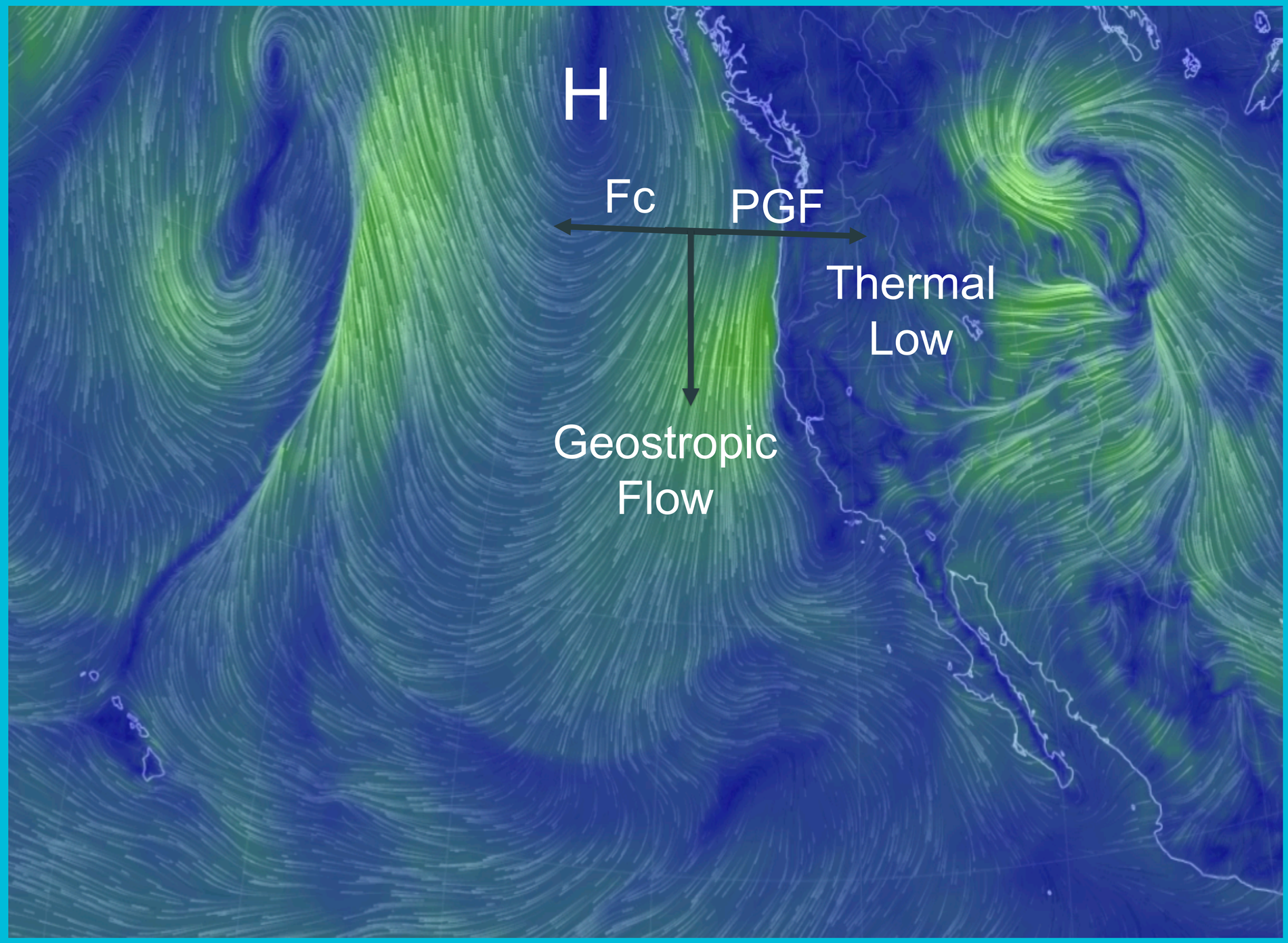
- Calibration of individual Satellite Altimeter measurements
- Inter-calibration between Satellite observations
- Limitations of Satellite altimetry data product prevalent to this project:
  - High frequency waves (short period)
  - Large amplitude waves (large SWH)



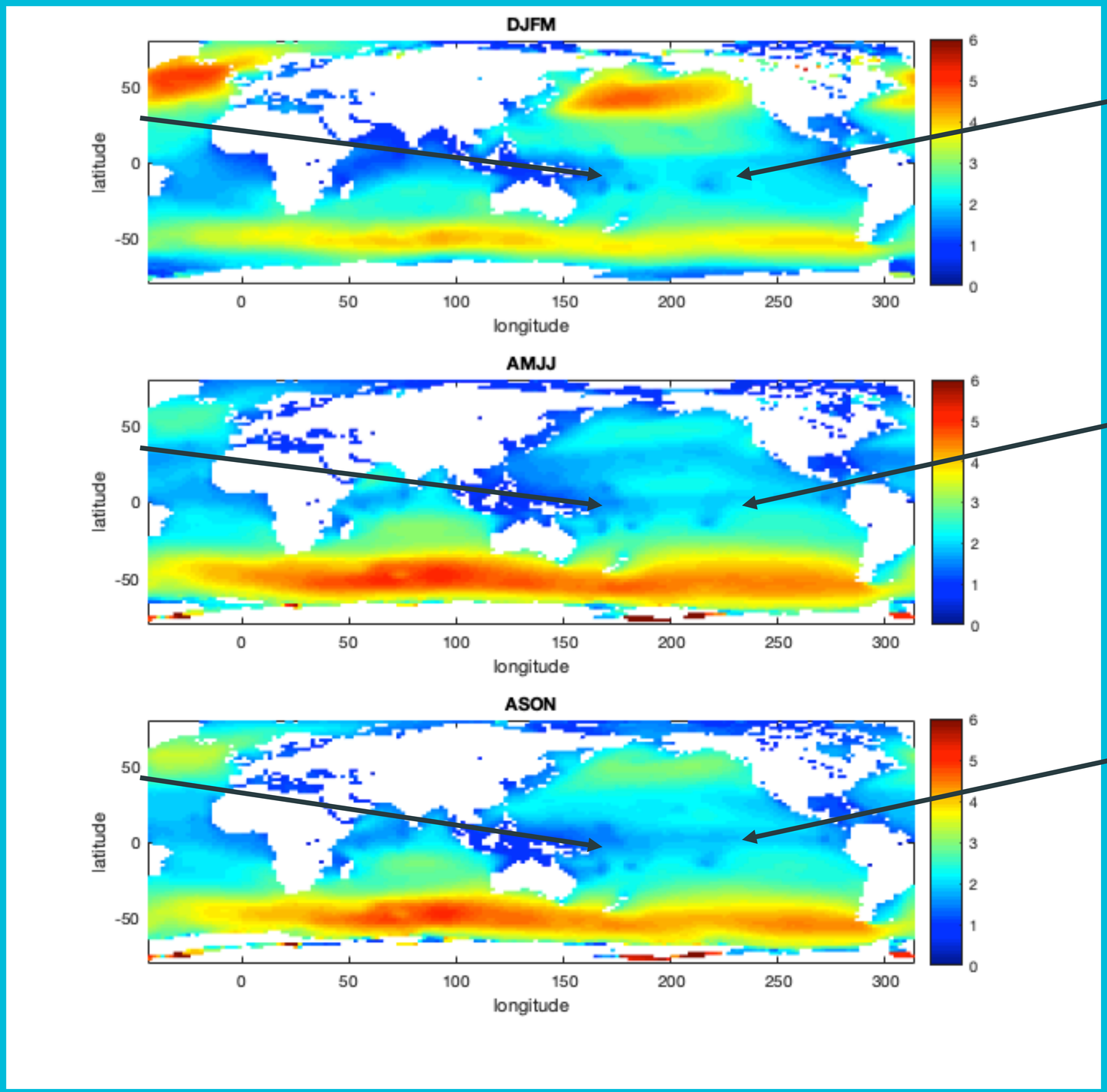
Mechanics causing Deviations

Coastal Topography

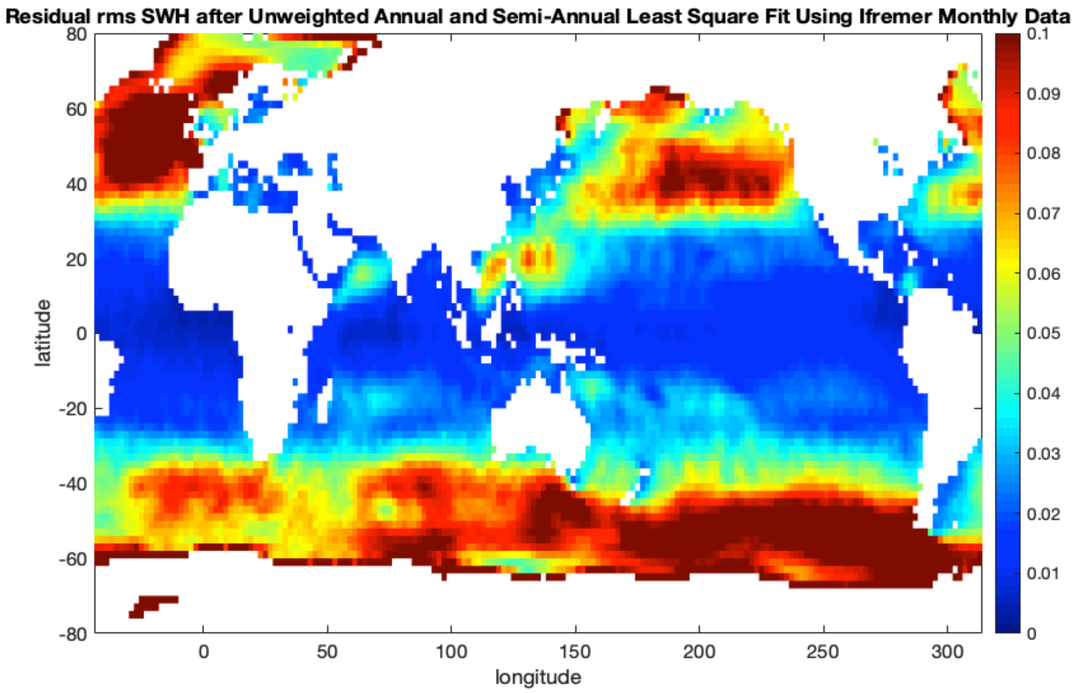
Inversion capping marine layer

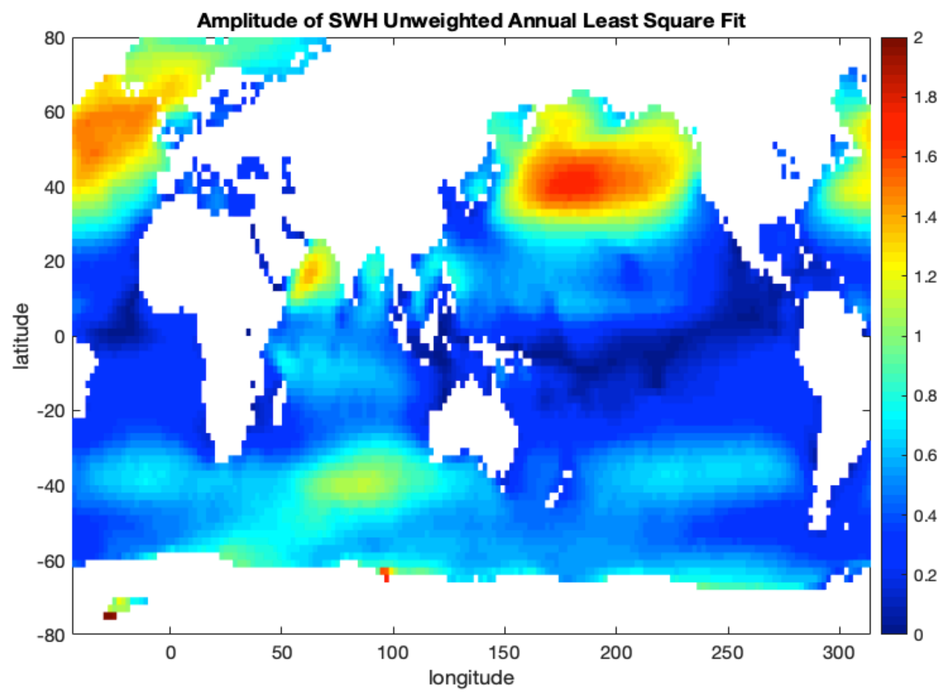


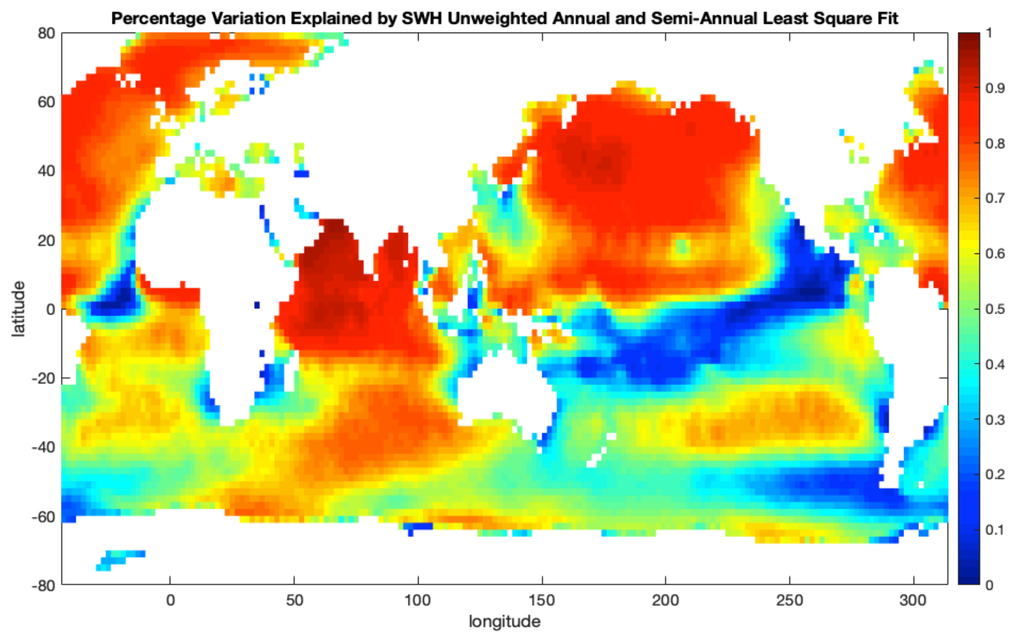
Island Shadowing in the Equatorial Region



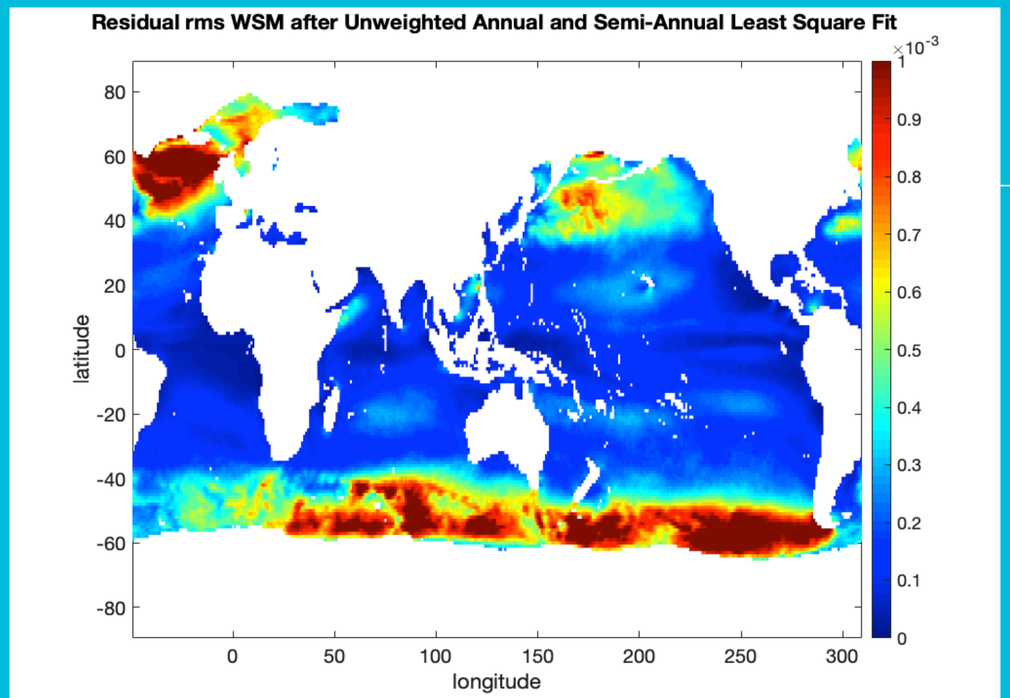
Other Characteristics of the SWH Annual Seasonal Cycle

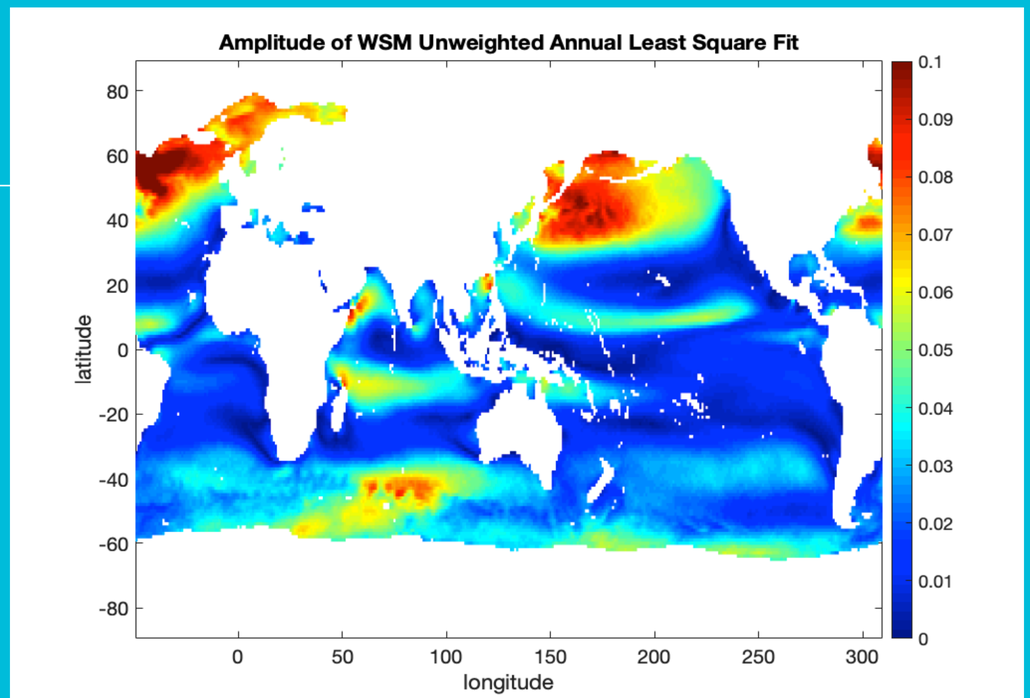


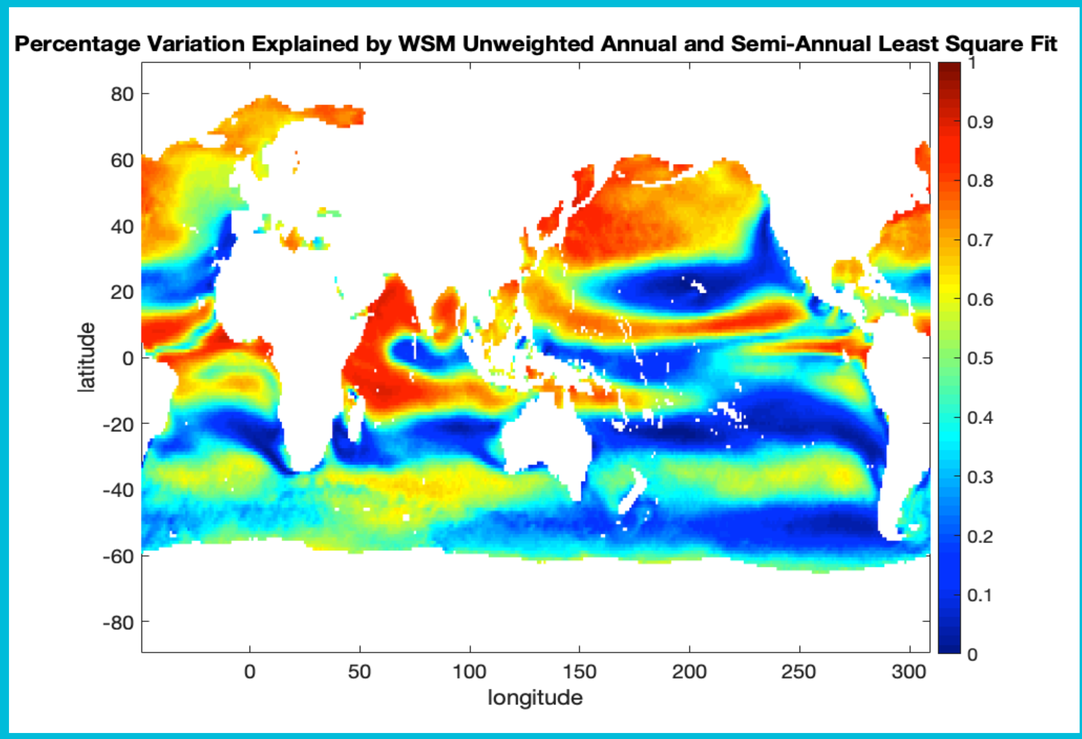




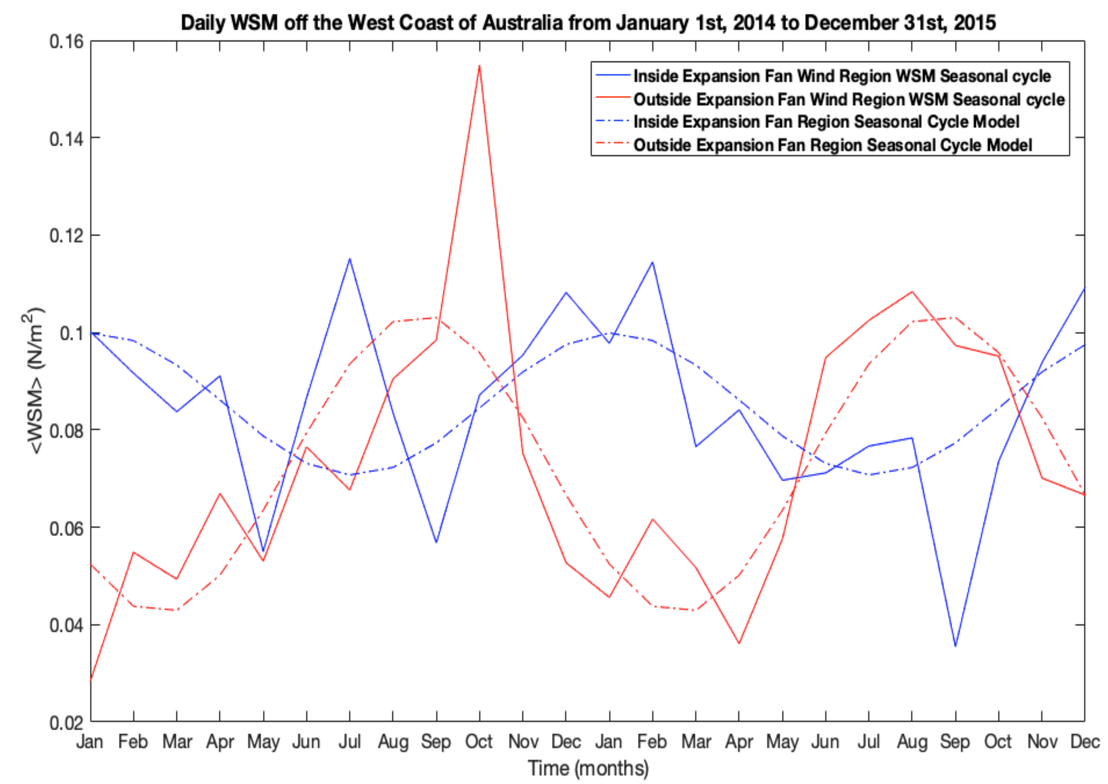
Other Characteristics of the WSM Annual Seasonal Cycle

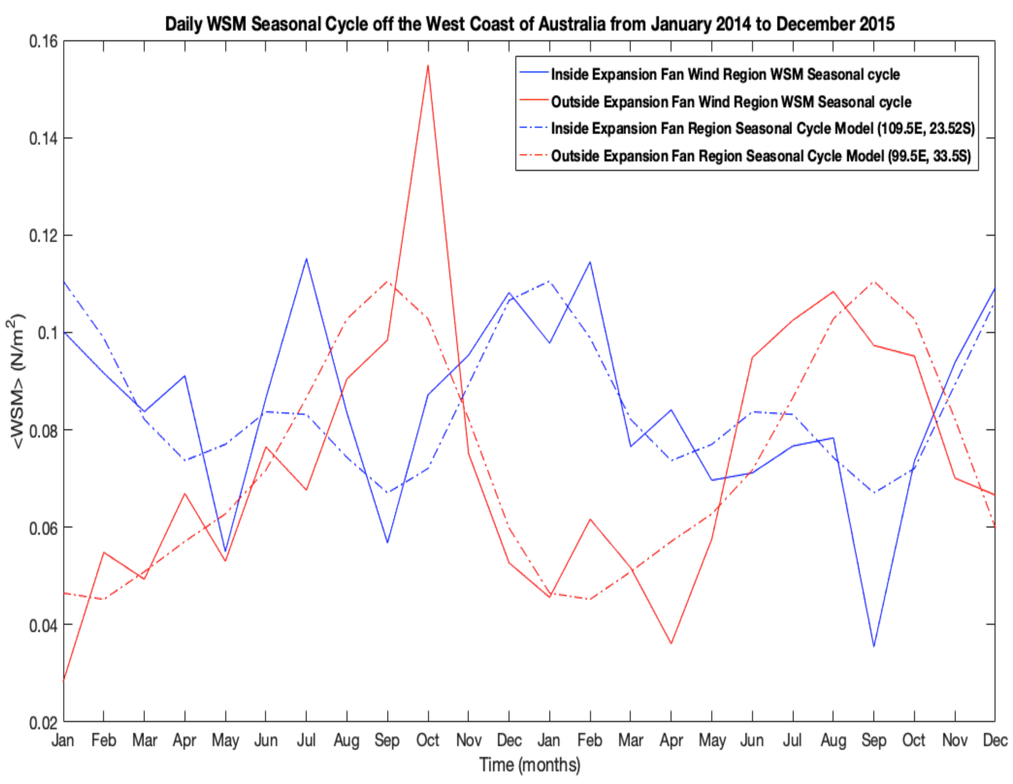






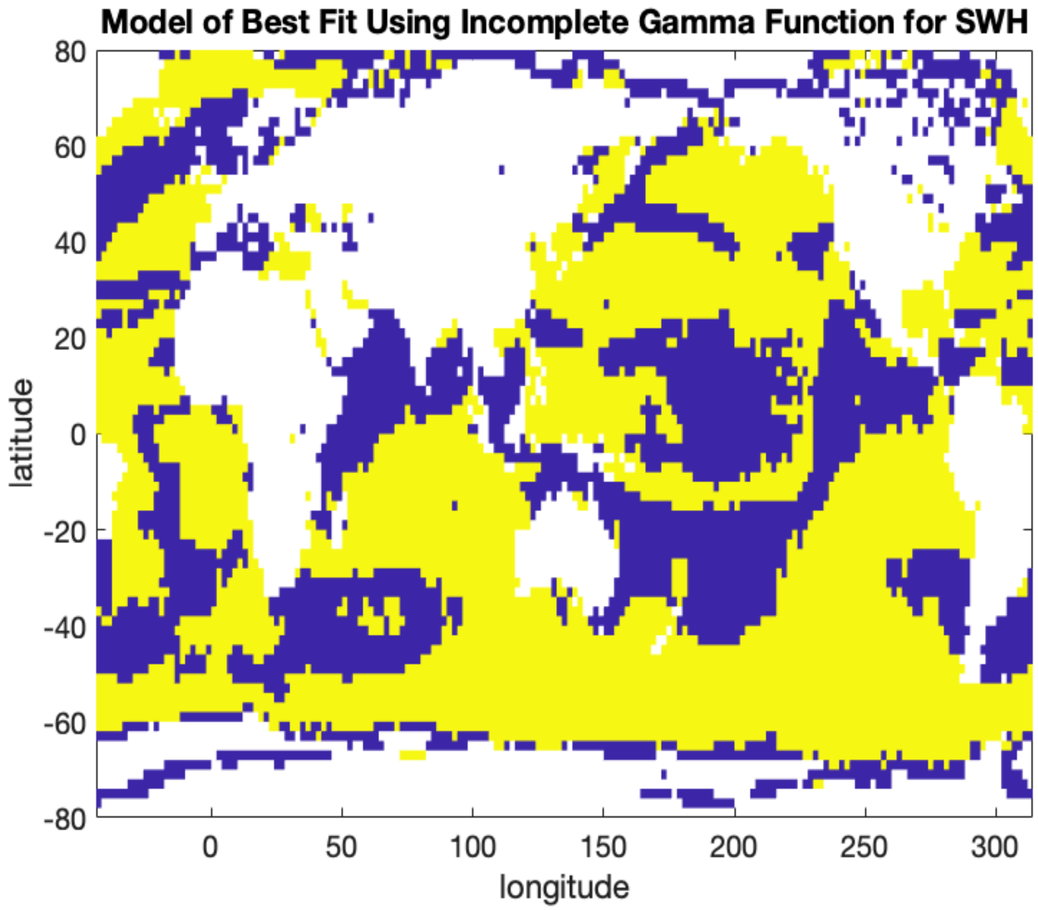
Close look at the phasing of wind stress magnitude for the annual seasonal cycle model and the annual and semiannual seasonal cycle model



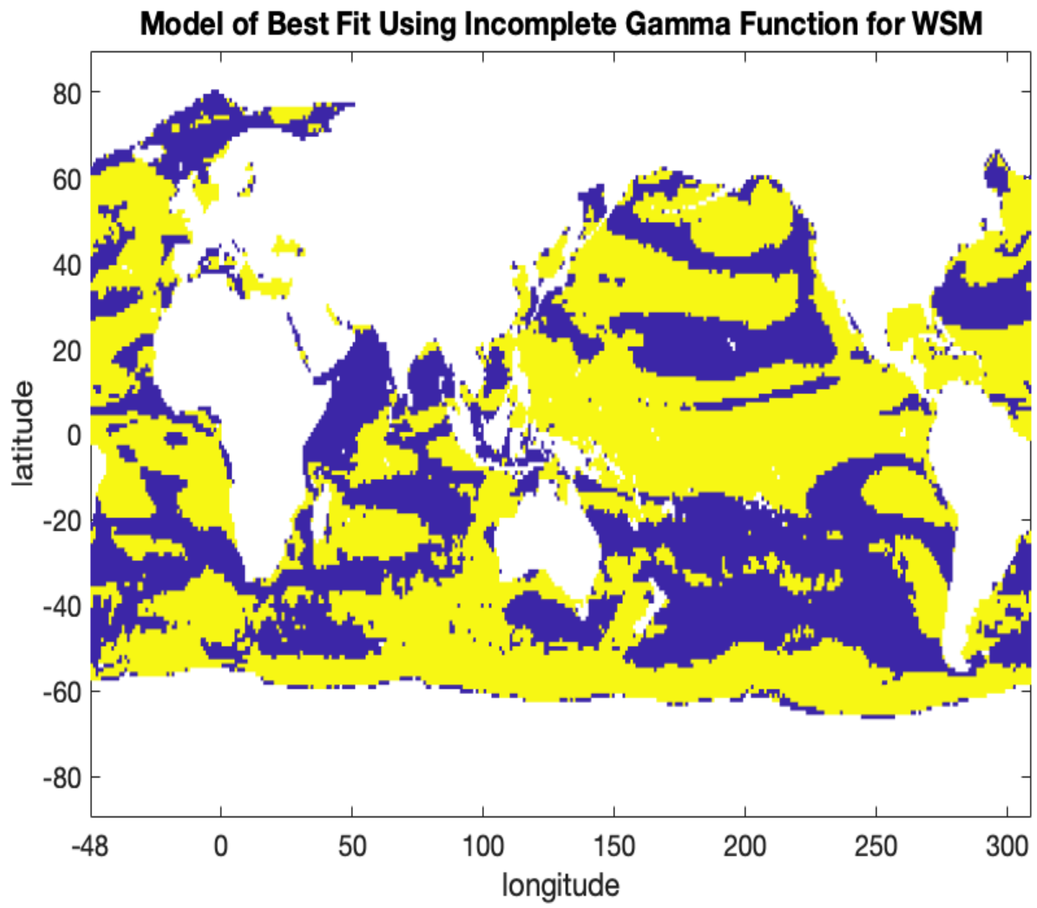


Determining the “best” fit model

SWH



Wind Stress Magnitude



Second approach with Probability of Swell using Wave Age