# Wind waves variability in the Atlantic and Caribbean Sea.

**13th International Workshop on Wave Hindcasting & Forecasting and 4th Coastal Hazards Symposium.**

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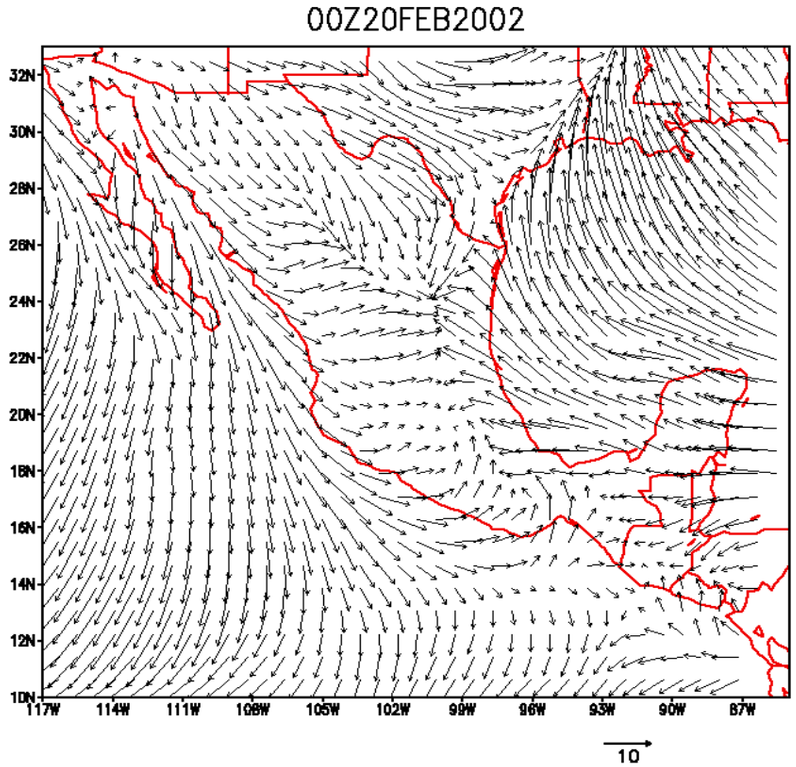
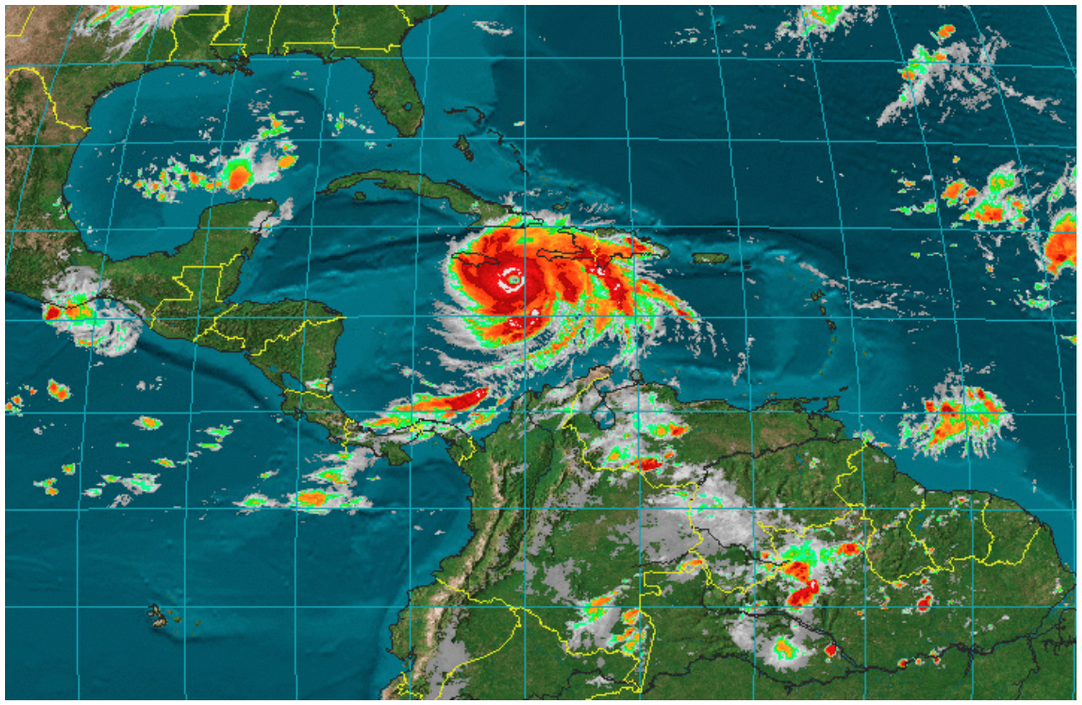
**October 2013.**

# Motivation

•Mexico has more than 11,000 km. of coastline, which are affected by extreme waves throughout the year.




Wind associated to a cold front



Example of hurricane trajectory

•In winter, in the Gulf of Mexico and Caribbean Sea, are observed wind waves associated with cold fronts, while in summer and autumn by a low level jet, easterly waves and hurricanes.

# Methodology

Reanalysis data (winds). 1°  1960-2009

WAM model

Significant wave height

$\Delta t = 1\ day$

Winter and Sumer

25° N-35°N, 20°W-70°W
9°N-18°N,70°W-82°W
9°N-18°N,17°W-60°W

Extremes values

Wavelet analysis

EOF's

10th and 90th percentile

Studied years 1962,1976,1995 and 2009

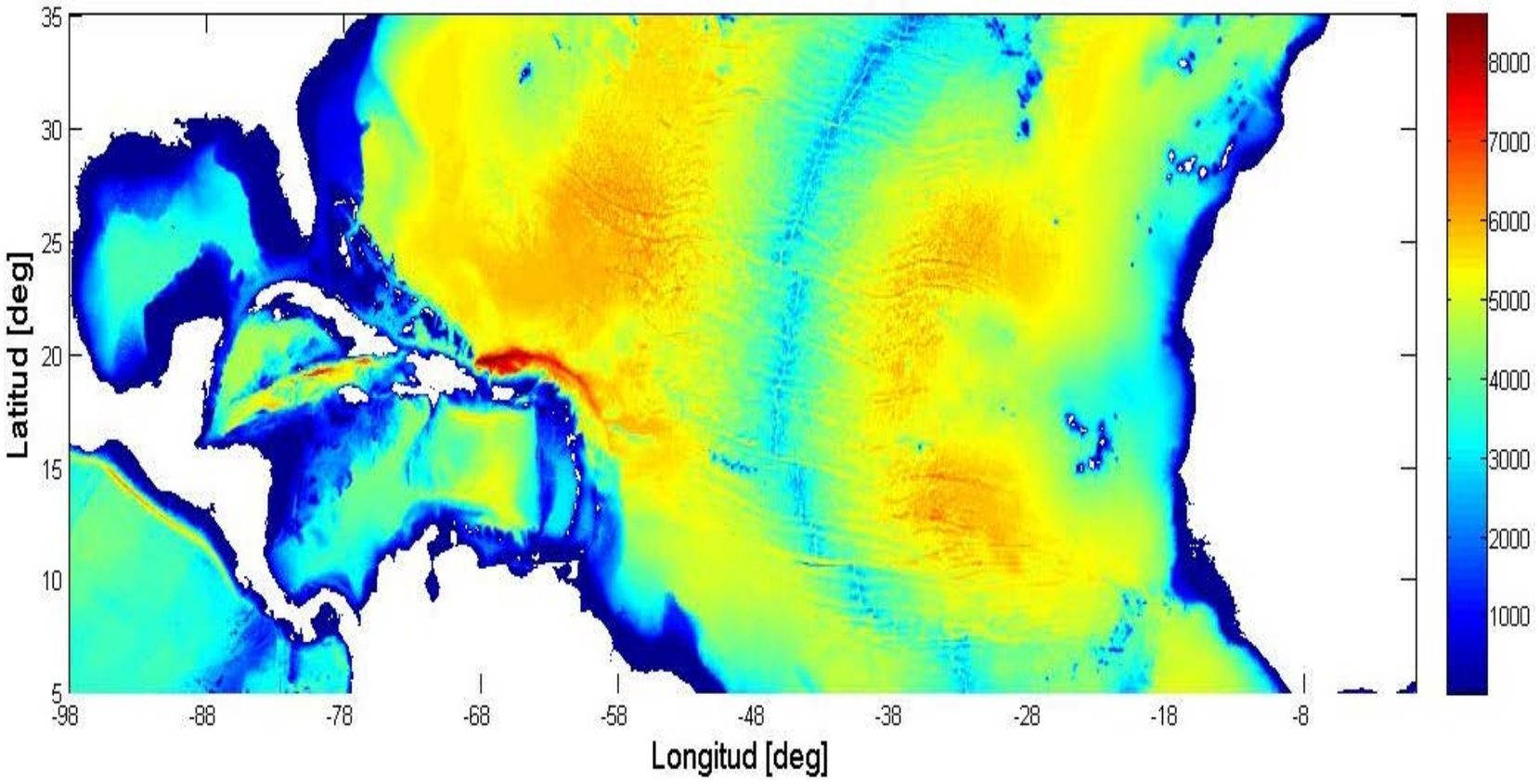
Daily, monthly, annual

Mean (1960-2009)

# Methodology
# The WAM model

## The action balance equation

$$\frac{\partial N}{\partial t}+\frac{\partial}{\partial x}\left(c_x N\right)+\frac{\partial}{\partial y}\left(c_y N\right)+\frac{\partial}{\partial \sigma}\left(c_\sigma N\right)+\frac{\partial}{\partial \theta}\left(c_\theta N\right)=\frac{S_{tot}}{\sigma}$$



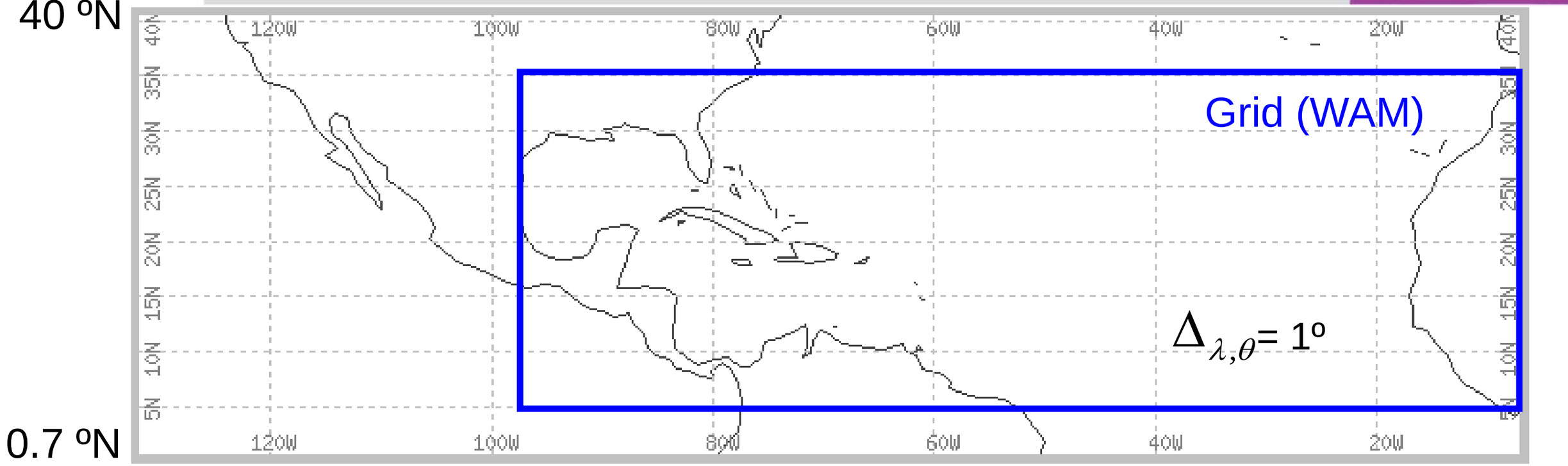
# Summary and conclusions

The wind waves in the tropical Atlantic have different behavior as the extra-tropical area, for the former, four atmospheric processes was identified: trade winds, a low-level jet in the Caribbean Sea (CLLJ), easterly waves (EW), hurricanes and cold fronts (CF).

In the seasonal mean, significant wave height values are clearly influenced by low frequencies (CLLJ and the trade winds)

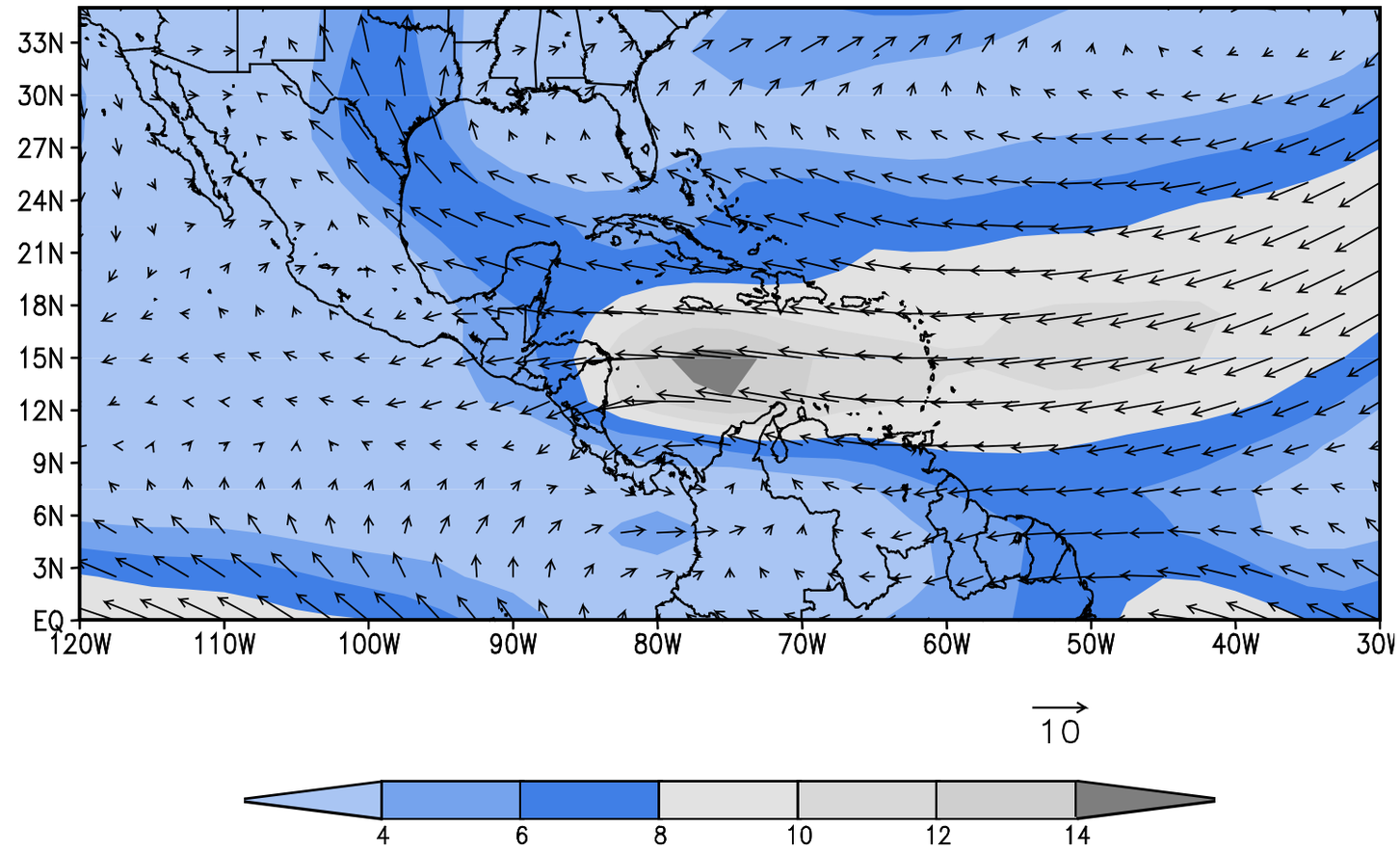
In a wavelet analysis the impacts in the selected years, the atmospheric perturbations was identified, as cold fronts and easterly waves, which have an inverse relationship with the mean flow (CLLJ) as several authors have reported.

# Grid characteristics



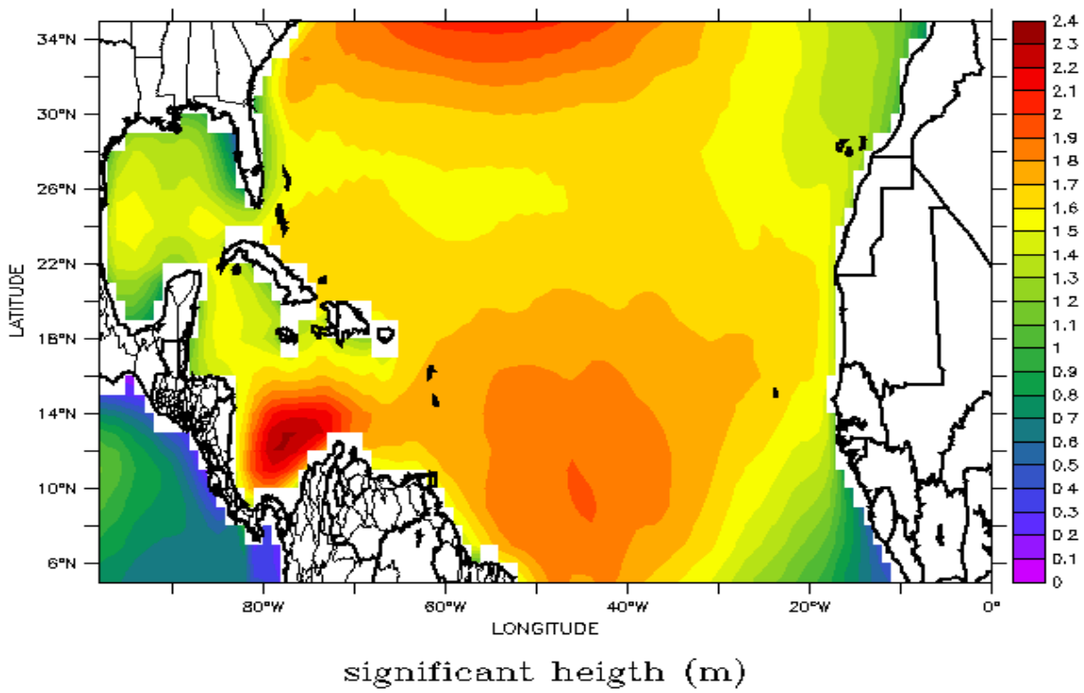

| Parameters | **Spectral domains** | Value |
|---|---|---|
| $f_{low}$ $f_{high}$ [s$^{-1}$] | | 0.0412, 0.4060 |
| $nf$ $\Delta f$ | | 24, 0.1xf |
| $nf$ $\Delta\theta$ | | 36, 10º |

# The atmospheric component

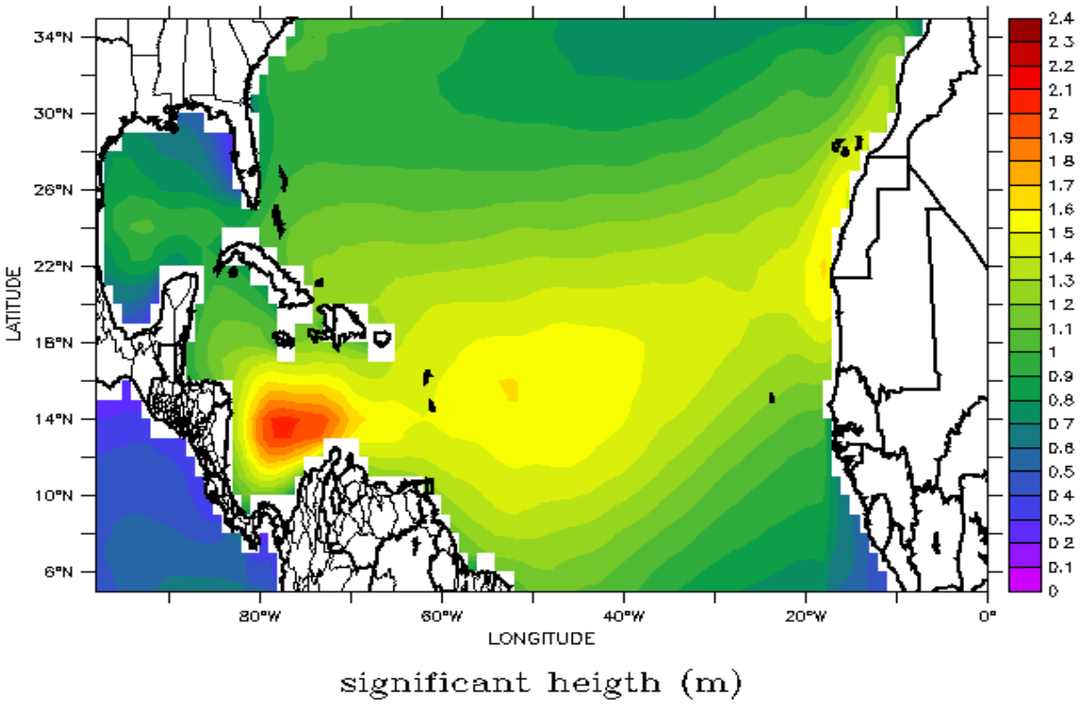



Mean wind (m.) at 925 hPa. (July 1960-2009).

# Mean waves



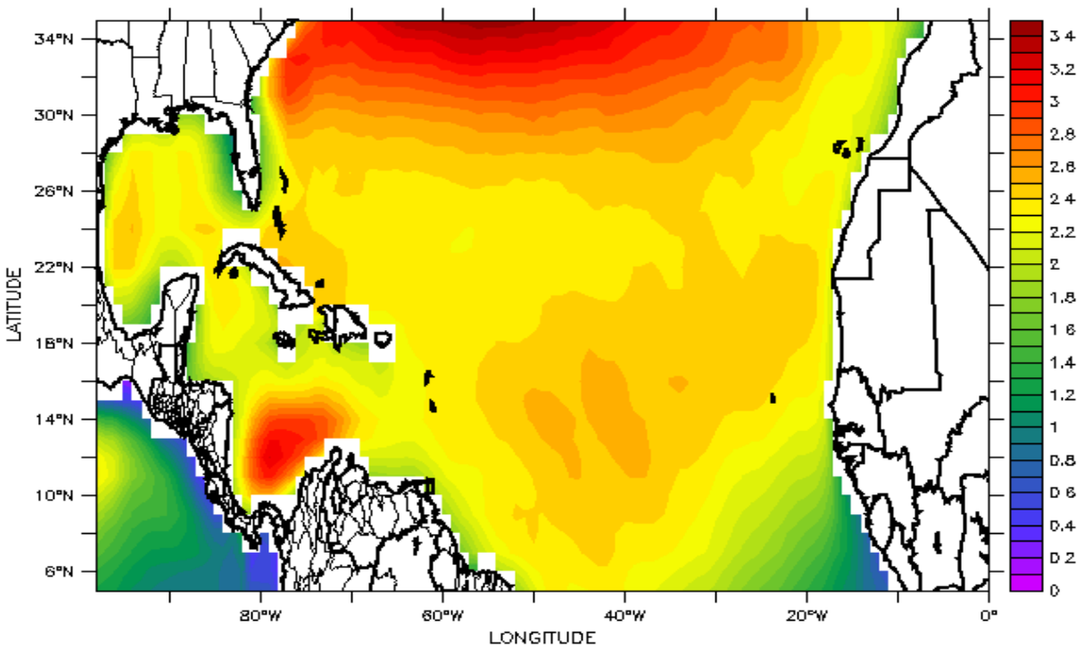

significant heigth (m)

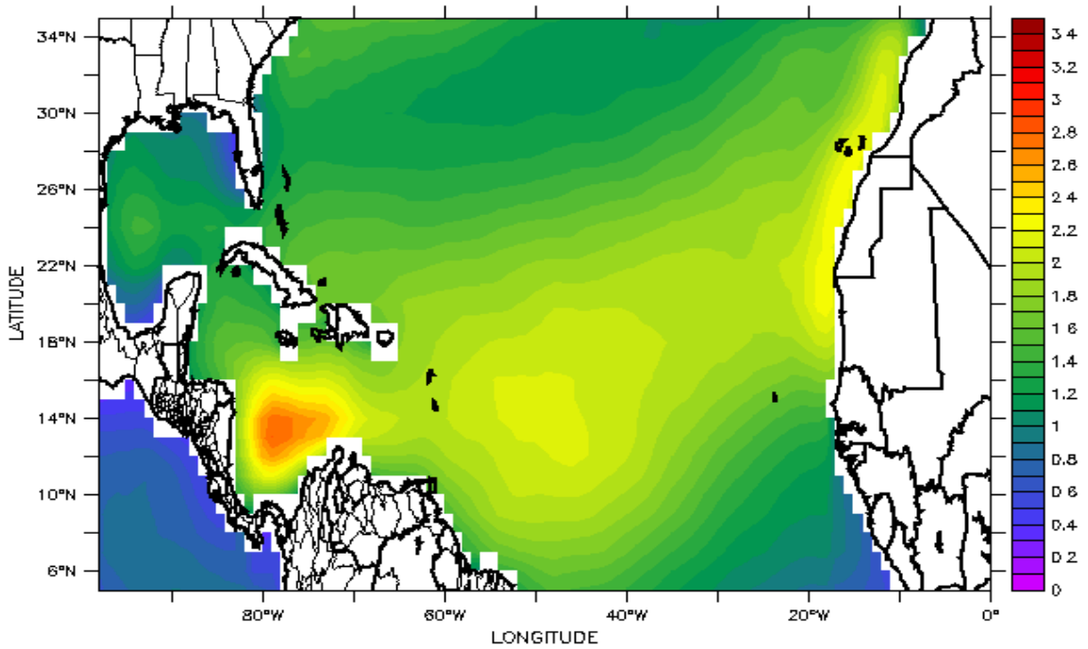


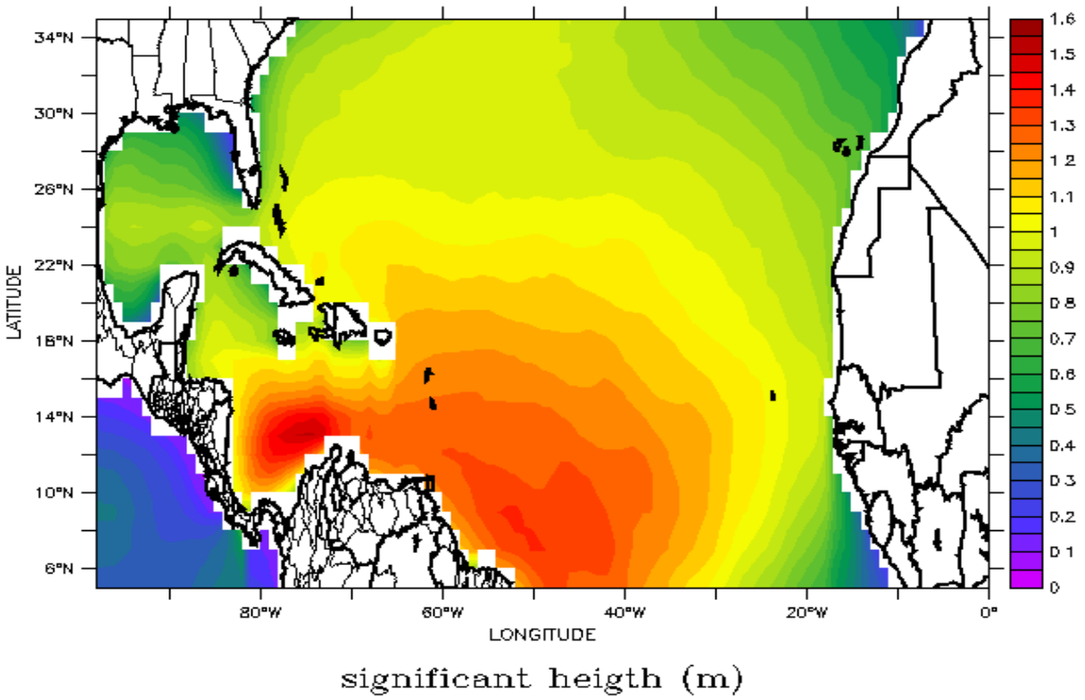

significant heigth (m)

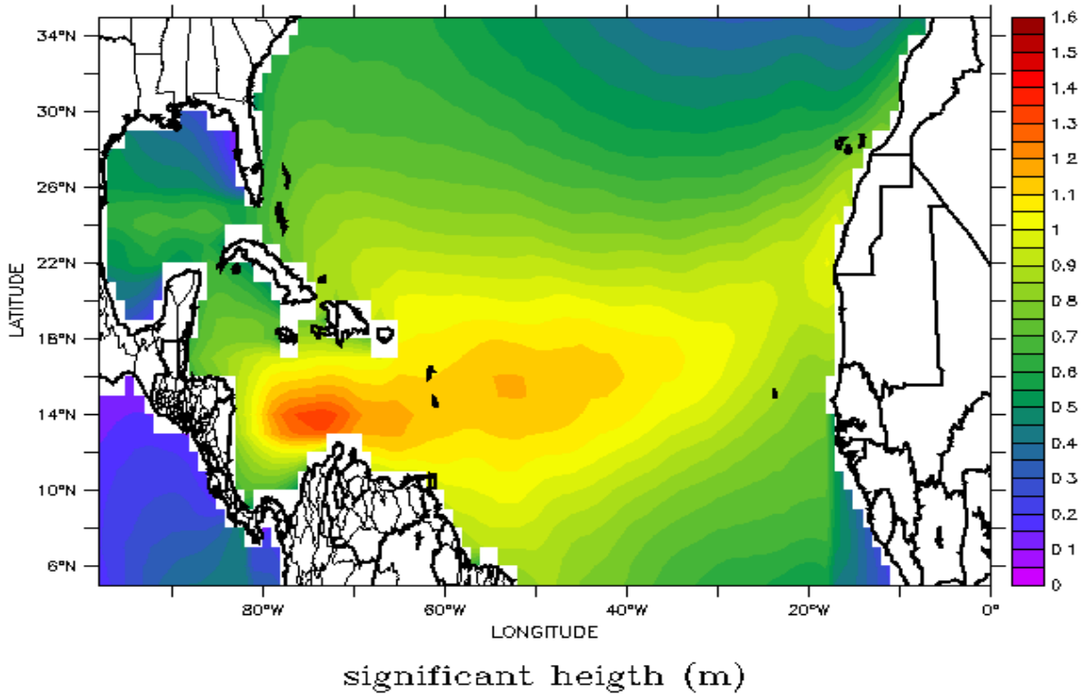
Wind waves (m.) simulated for winter (left) and summer (right) (1960-2009).

# Extreme waves



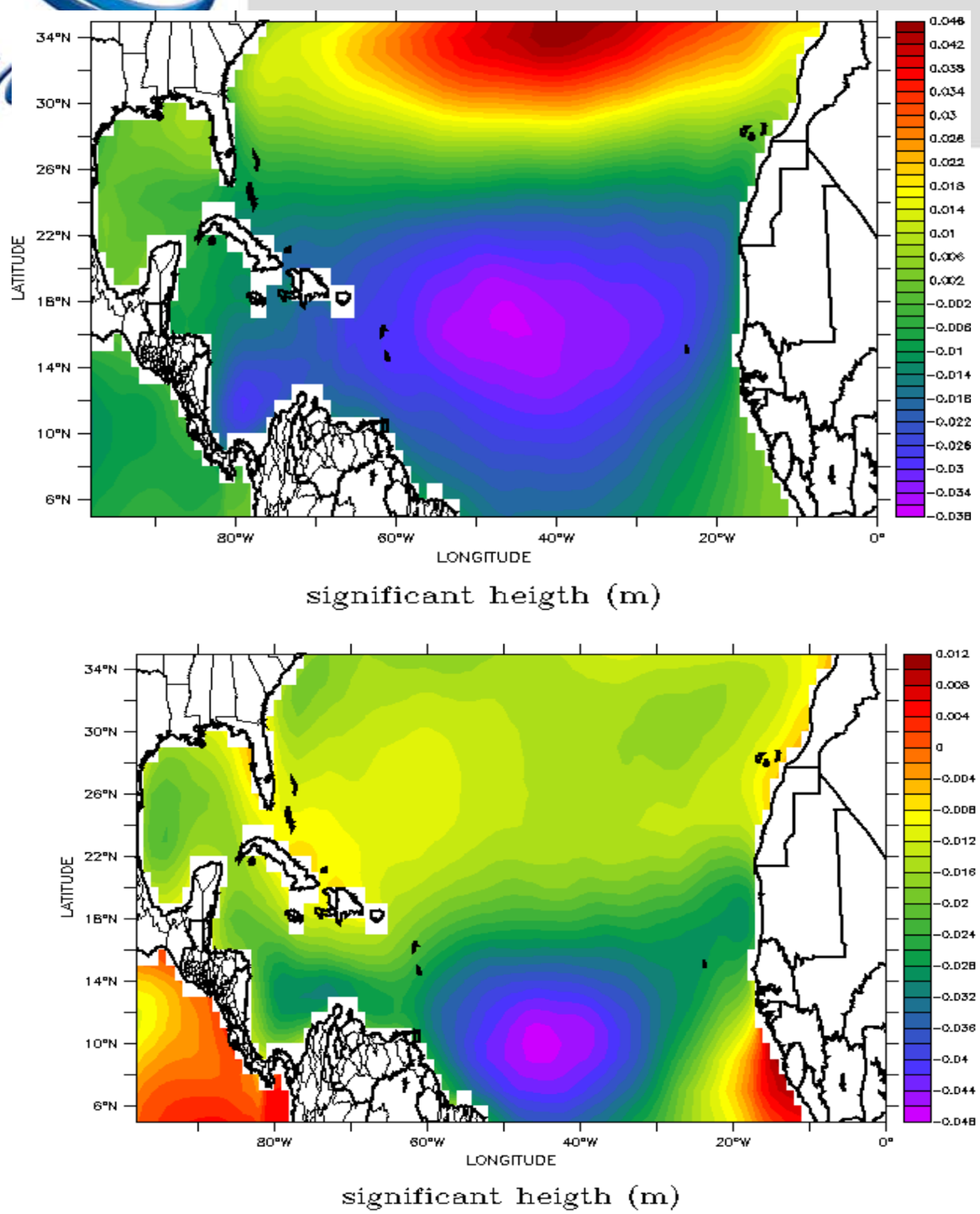



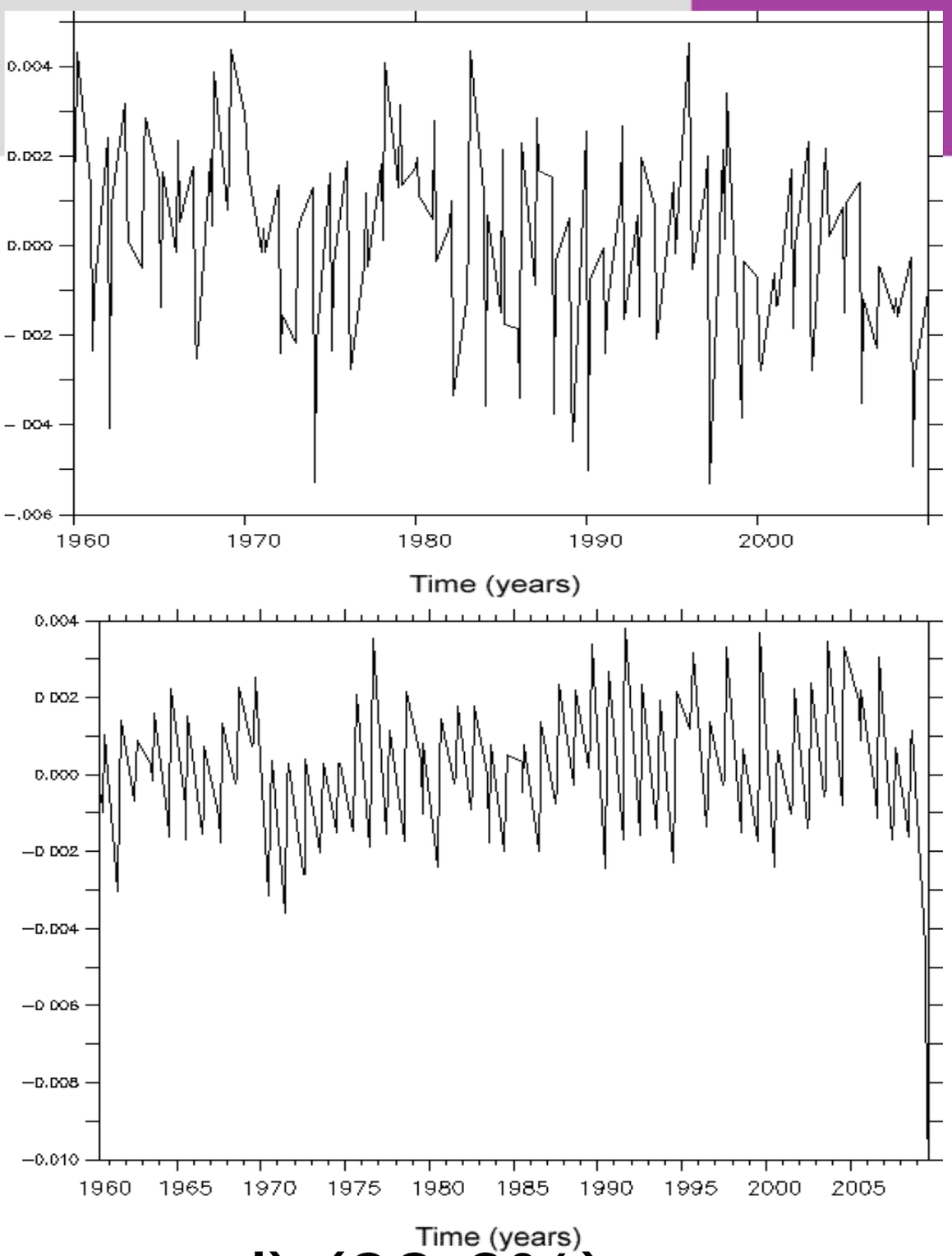




90$^{th}$ percentile (upper panel), 10$^{th}$ percentile (lower panel) for winter (left) and summer (right) (1960-2009).

# Main modes

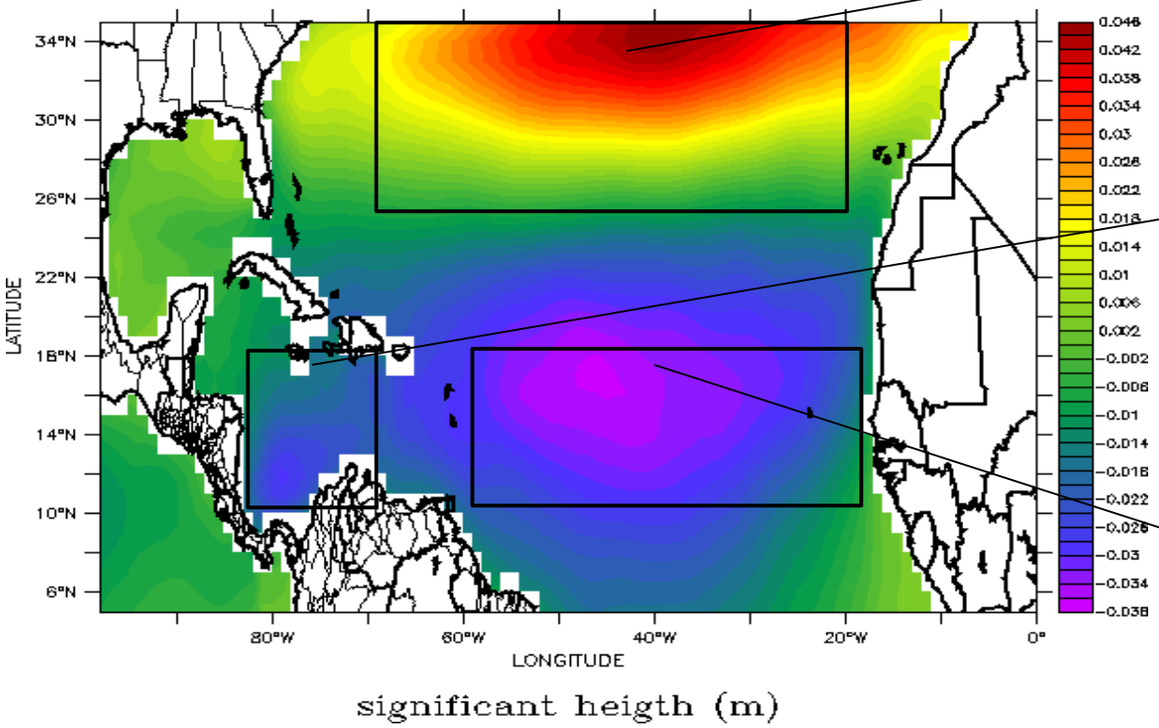


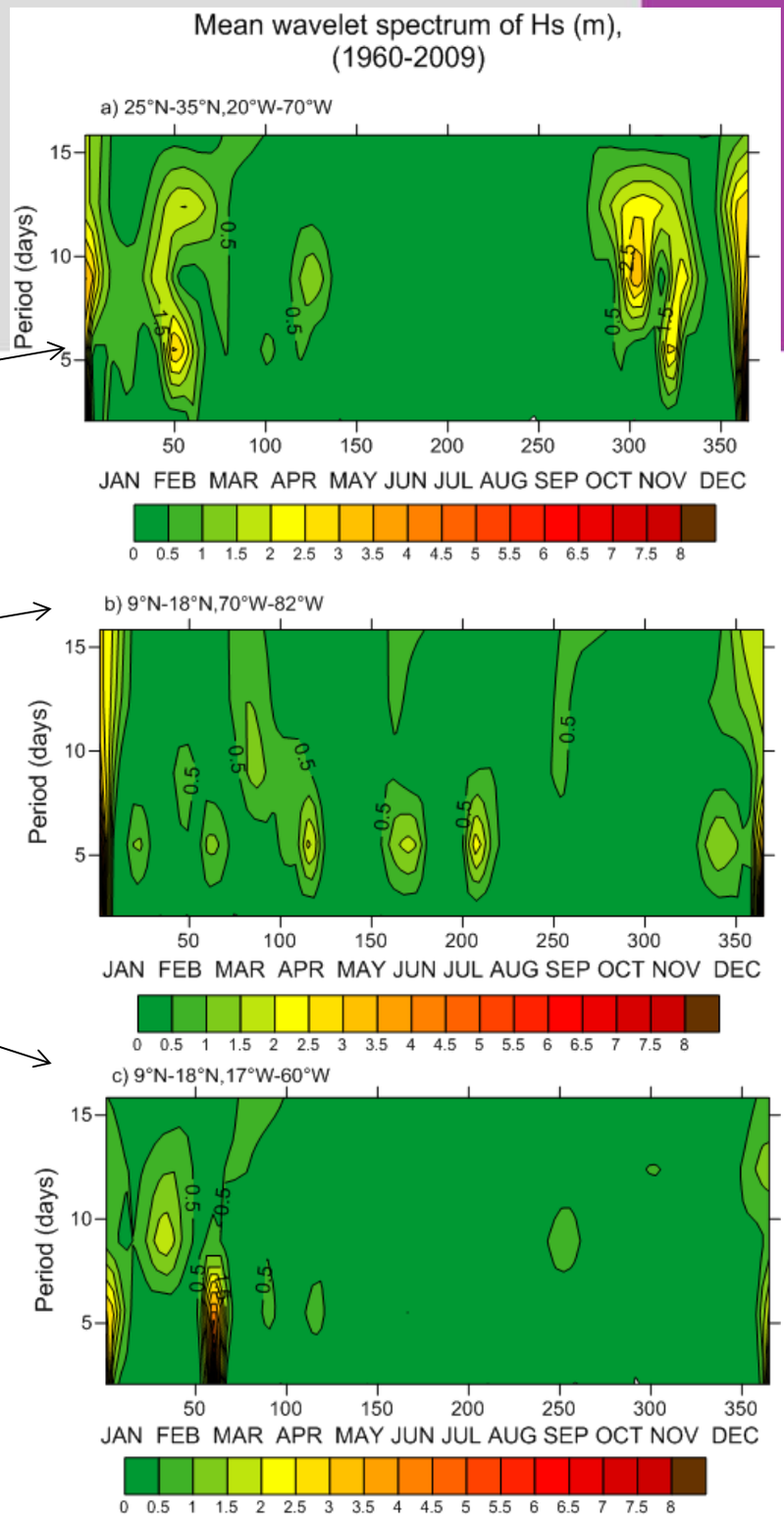

EOF1 winter (upper panel) (99.6%).

EOF1 summer (lower panel) (62%). 1960- 2009.

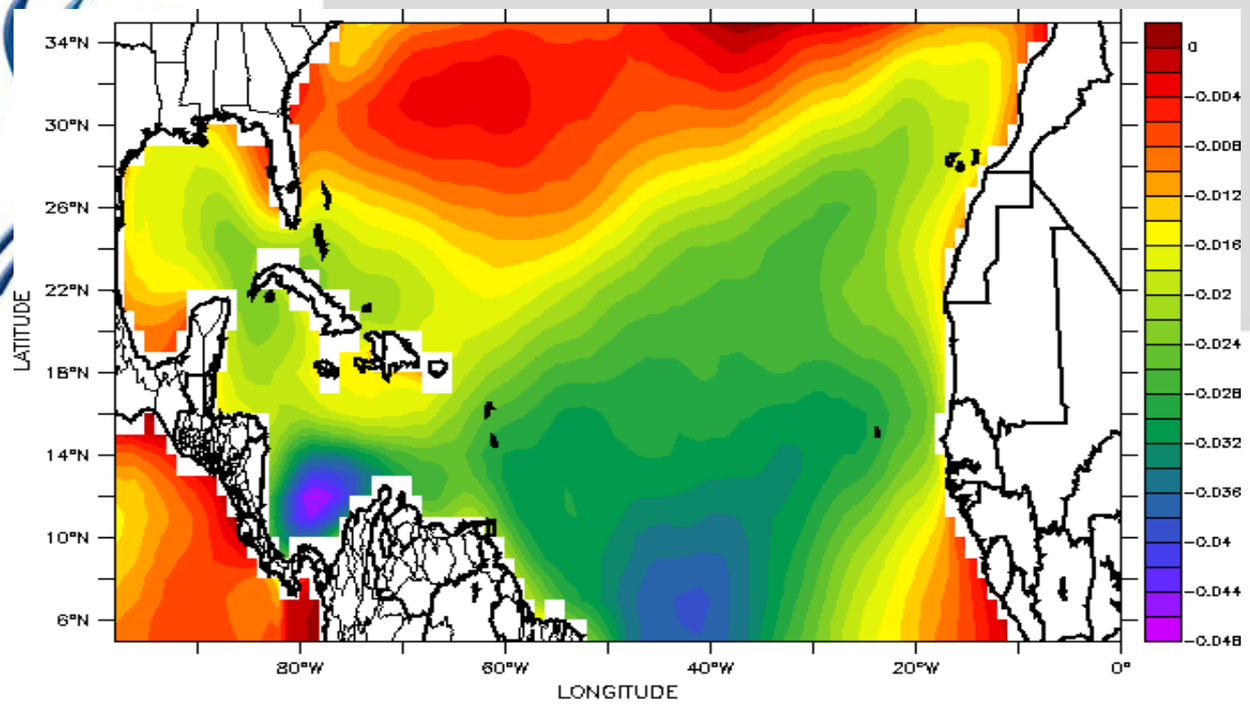
# Regional analysis



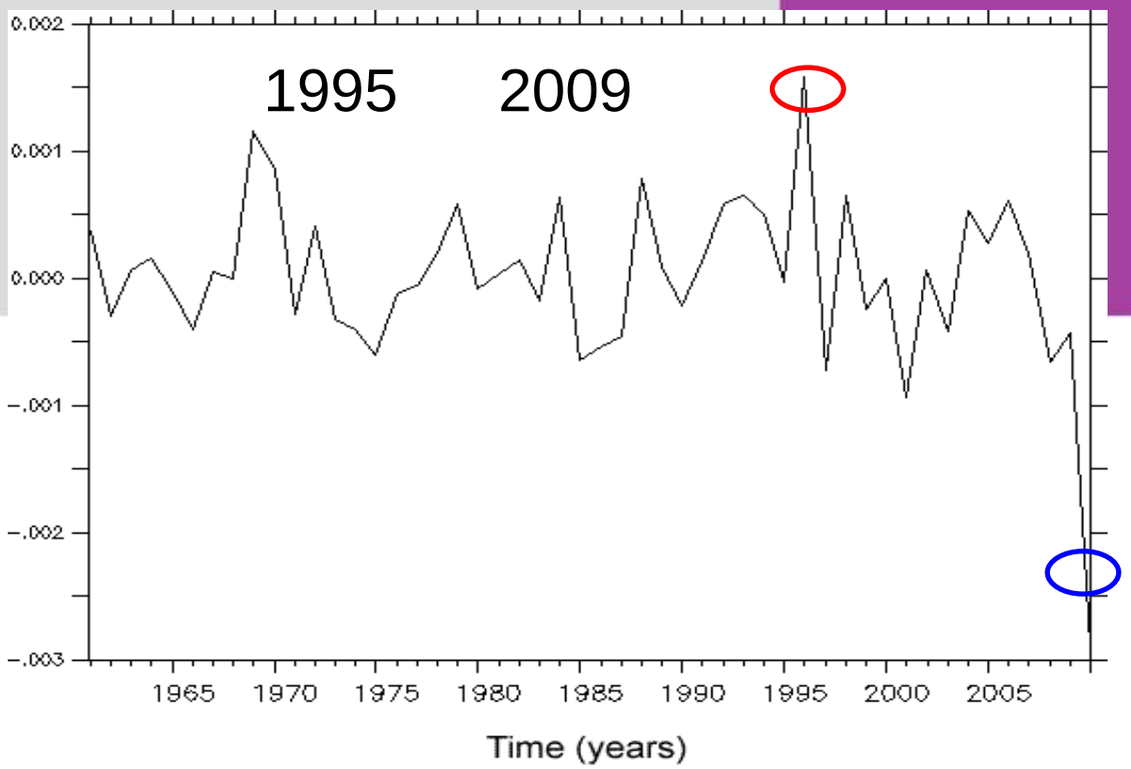

significant heigth (m)

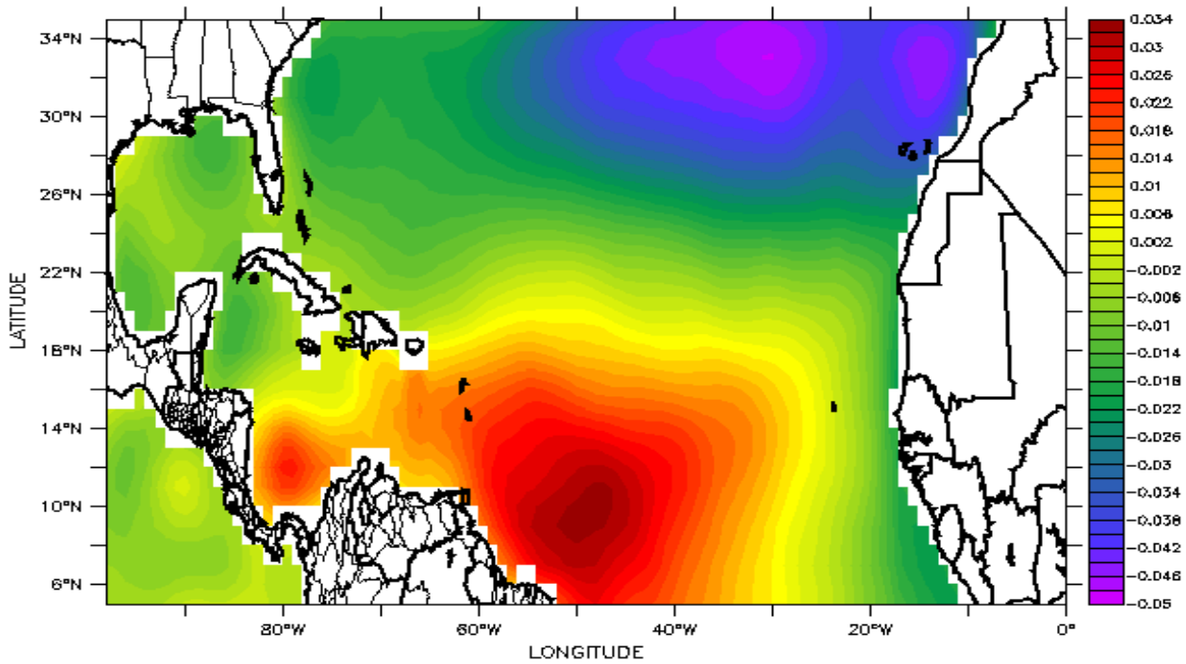



Mean wavelet spectrum for Hs: a) North Atlantic, b) Caribbean Sea. and c) Center Atlantic (1969 to 2009).

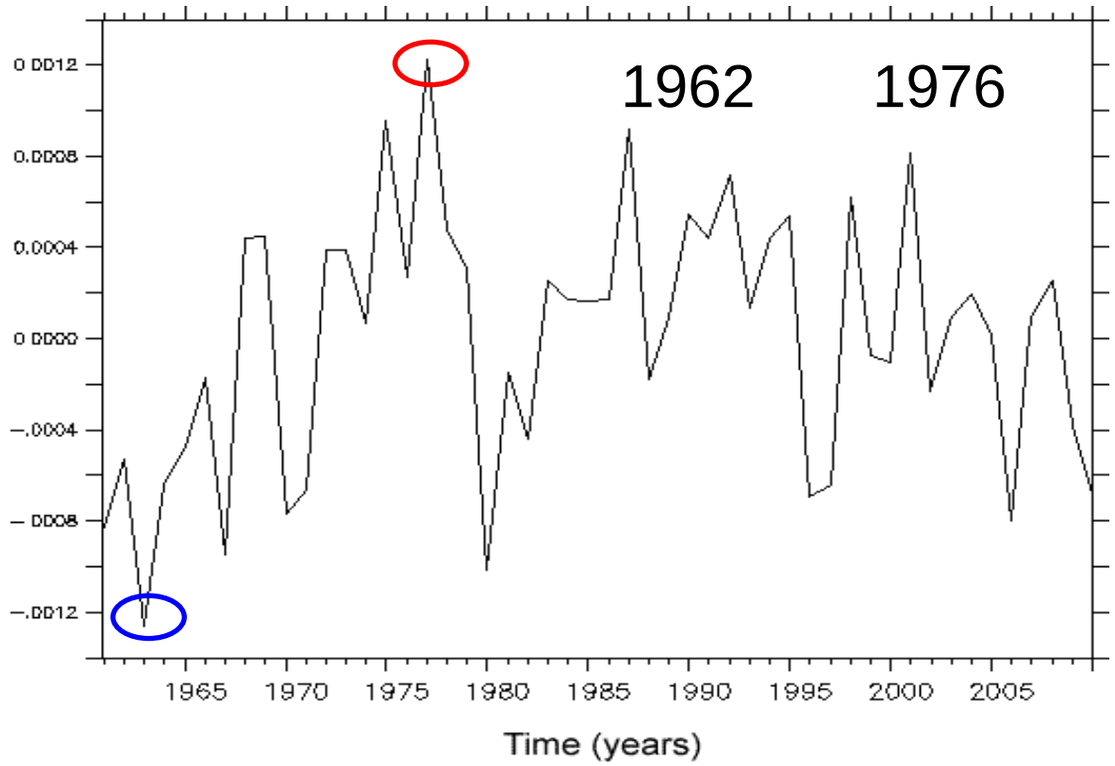



significant heigth (m)

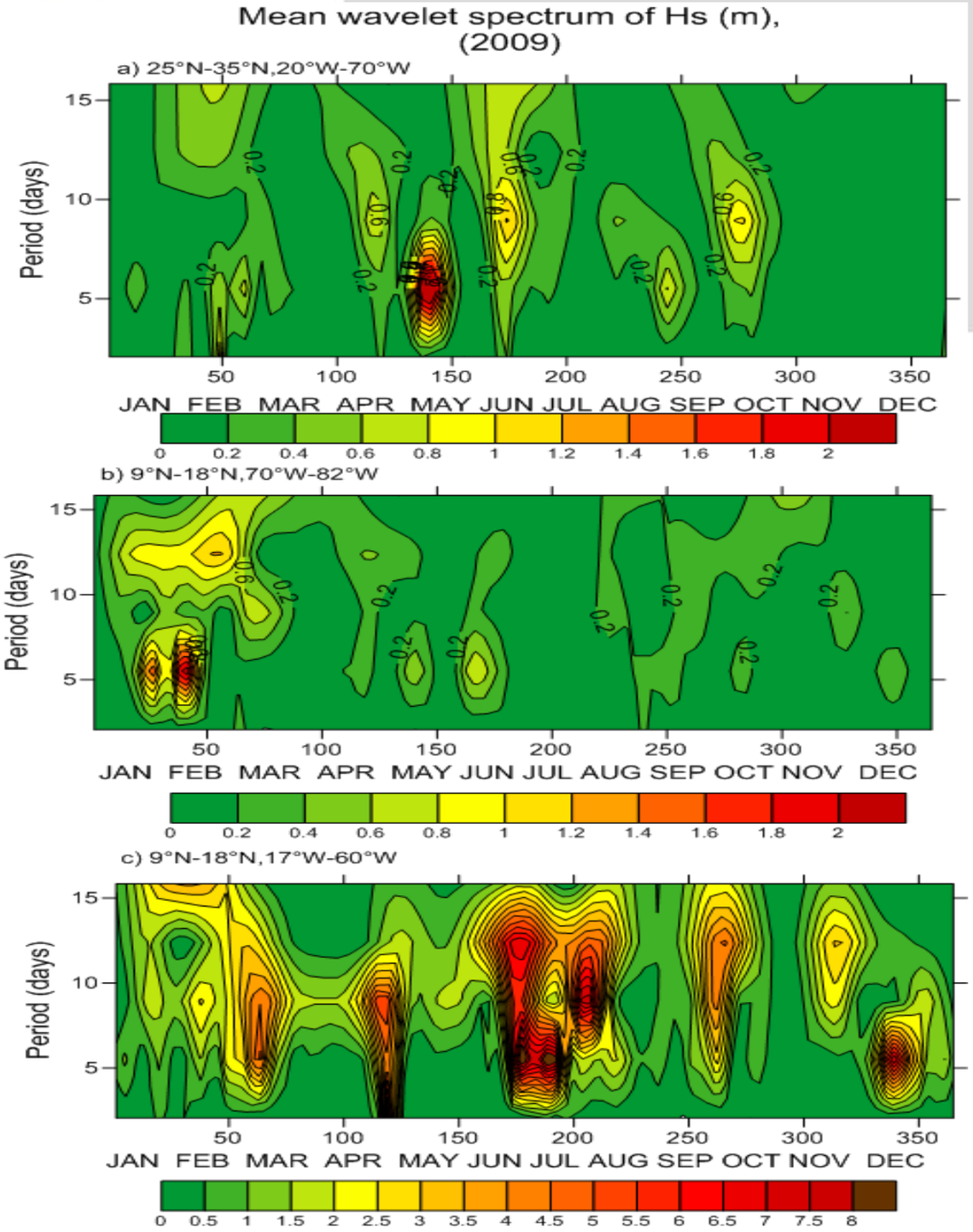


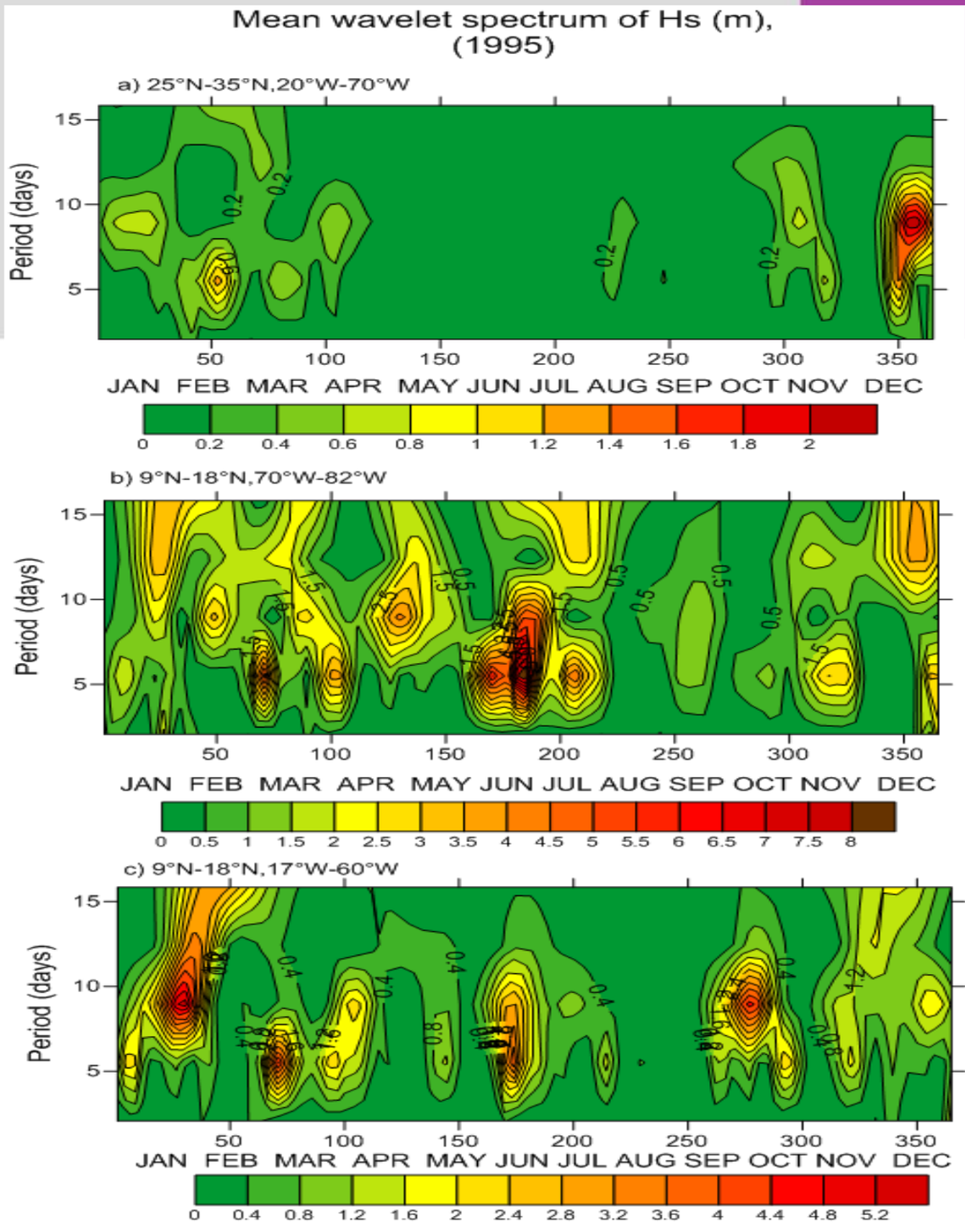




significant heigth (m)

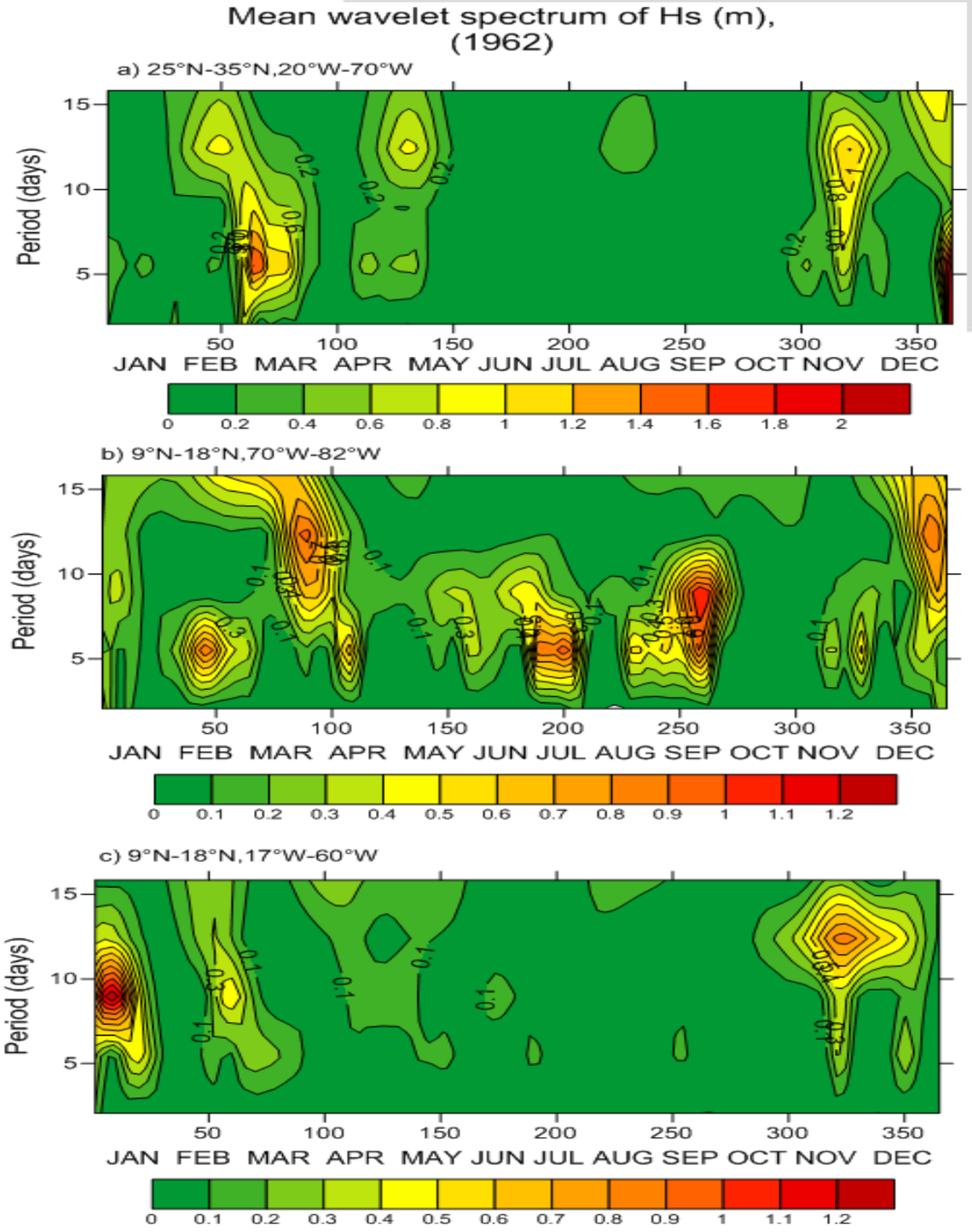



Annual EOF1, upper panel (72%). Annual EOF2 lower panel (24%). 1960- 2009




Mean wavelet spectrum for Hs: a) North Atlantic, b) Caribbean Sea. and c) Center Atlantic (EOF1. inactive year: 2009 active year: 1995).




Mean wavelet spectrum for Hs: a) North Atlantic, b) Caribbean Sea and c) Center Atlantic. (EOF2. inactive year: 1962 active year: 1976).

# Concluding remarks.

There is an inverse relationship between the high frequencies activity and the seasonal activity (low frequencies).
Because of it persistence, perturbations (3-9 days) and low level jet (seasonal activity) contribute to the active (inactive) years.