INSTITUTO DE INGENIERÍA UNAM

LIPC LABORATORIO DE INGENIERÍA Y PROCESOS COSTEROS UNAM

Laboratorio Nacional de Resiliencia Costera

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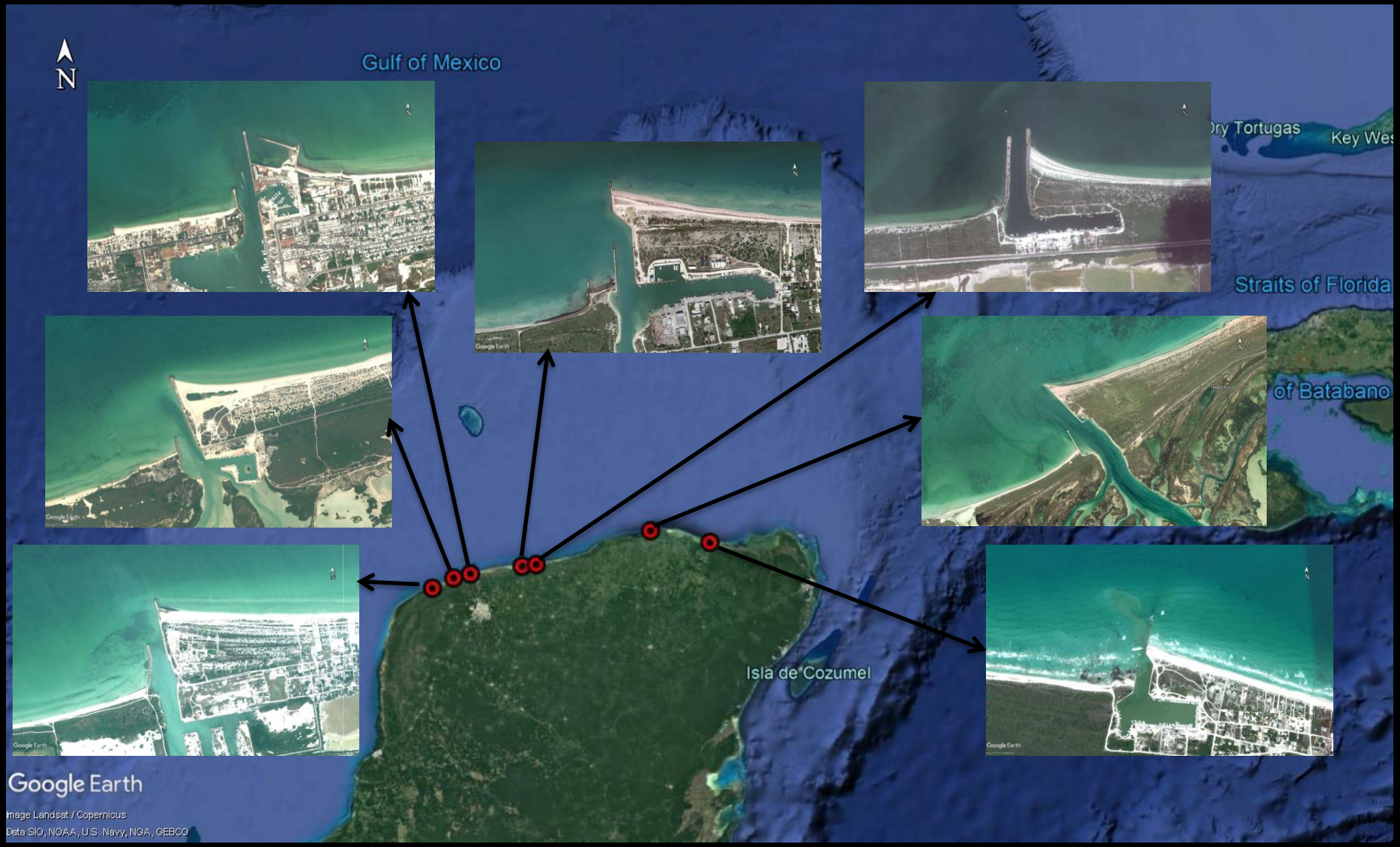
Seasonal beach variability on a sea-breeze dominated beach

Gabriela Medellín & Alec Torres-Freyermuth

1. Motivation

Beach erosion along the Yucatan coast

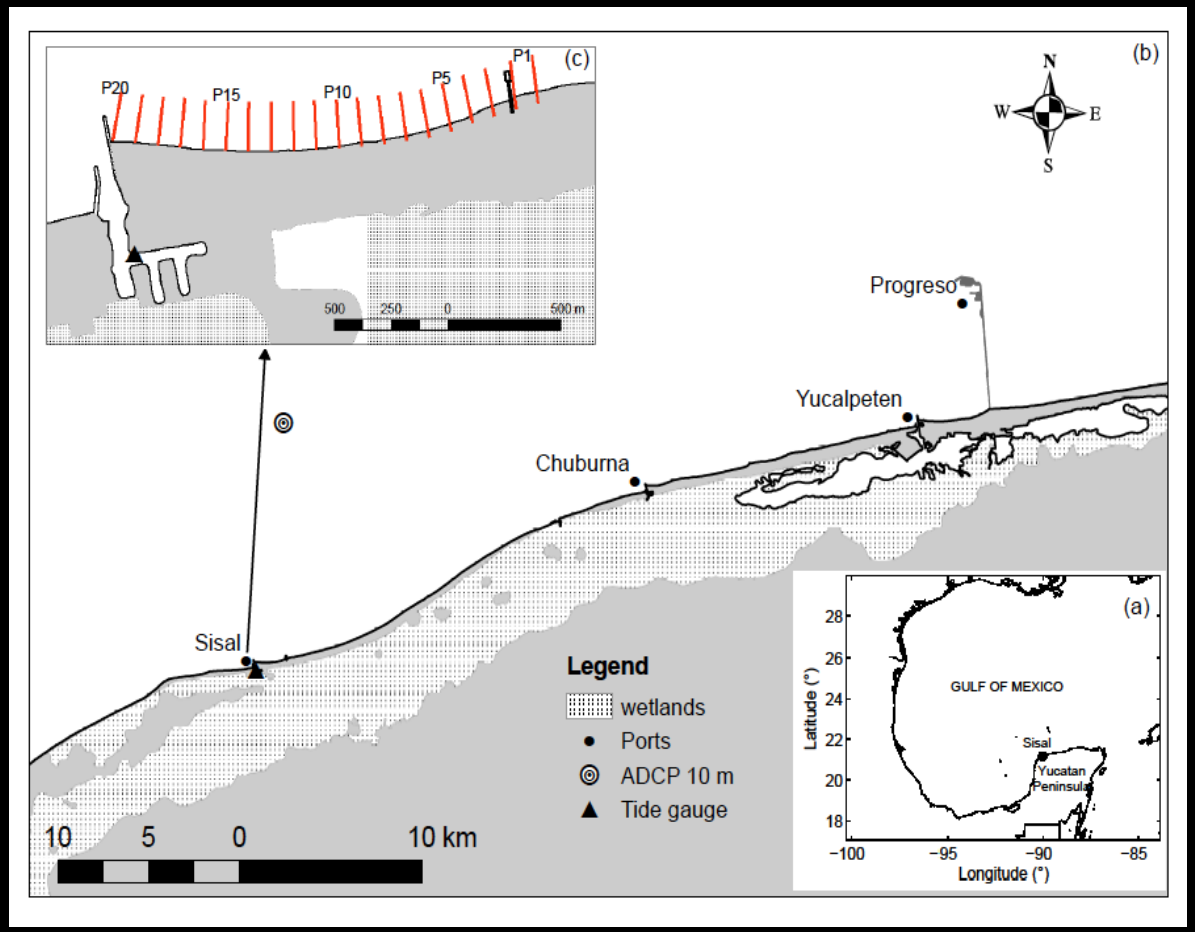


Beach erosion along the Yucatan coast

2. Study Area

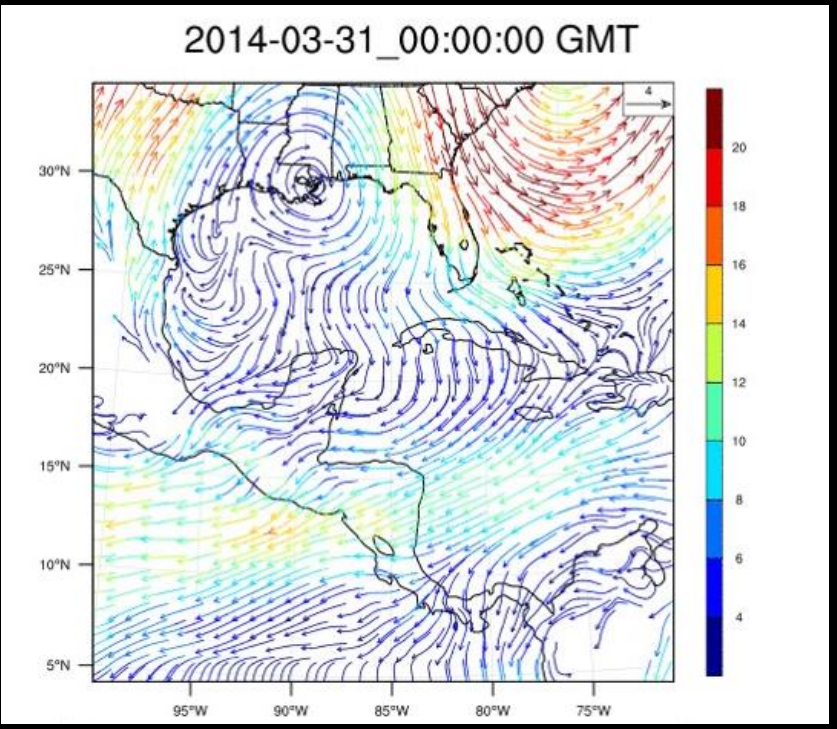
Site location: Sisal Beach, Yucatán

- Located on a barrier island.
- Vicinity of the port's Jetty and the Sisal Pier.
- E-W coastline orientation.
- Winds: NE sea breeze, SE land breeze, and northern winter storms



Synoptic scale: Central American Cold Surge (CACS)

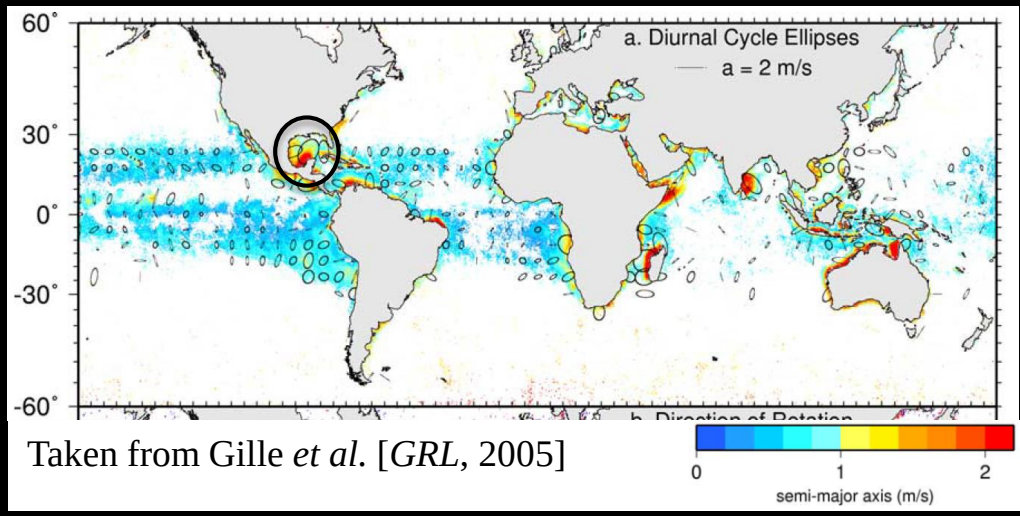
- Synoptic scale disturbances from mid-latitudes characterized by a cold front passage



- CACS usually occur September through April
- Their effects may last from 2 to 6 days.

Local scale: Sea-breeze

- Characterized by a reversal of the wind on a daily basis.

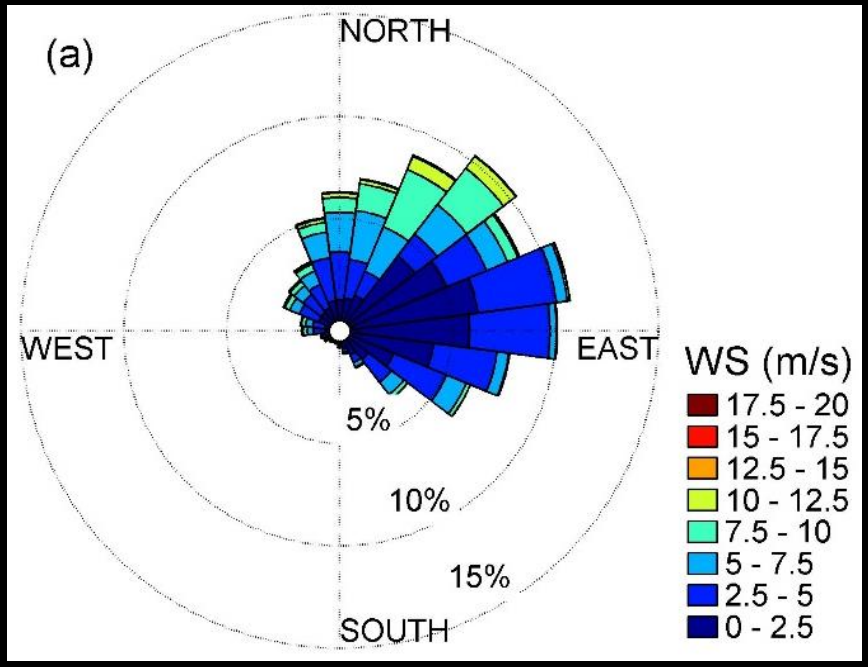


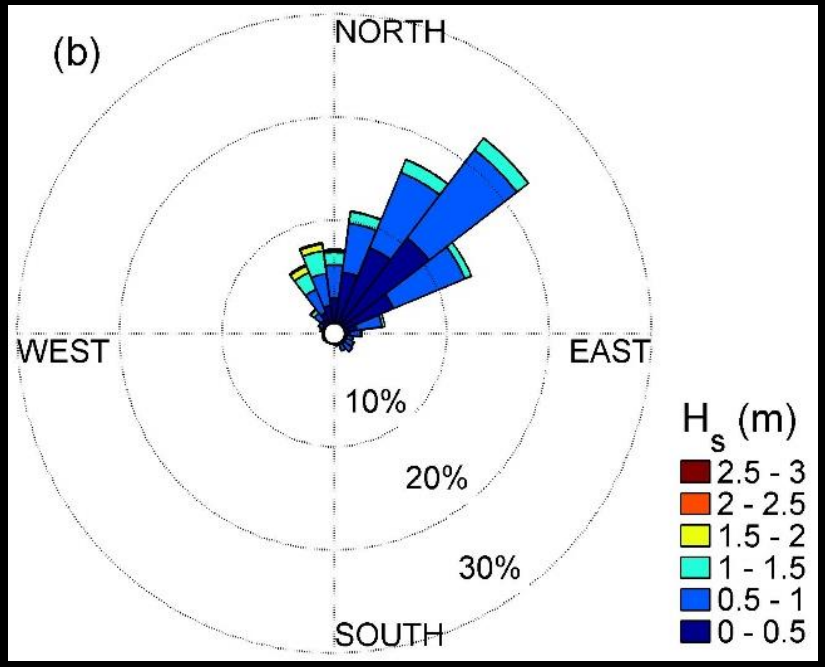
Taken from Gille *et al.* [*GRL*, 2005]

Figure. Strength of diurnal wind cycle in locations where it is statistically significant.

- Wind observations (QuikSCAT and ADEOS-II) used to study land/sea breeze circulation.

Field observations: Wind and waves

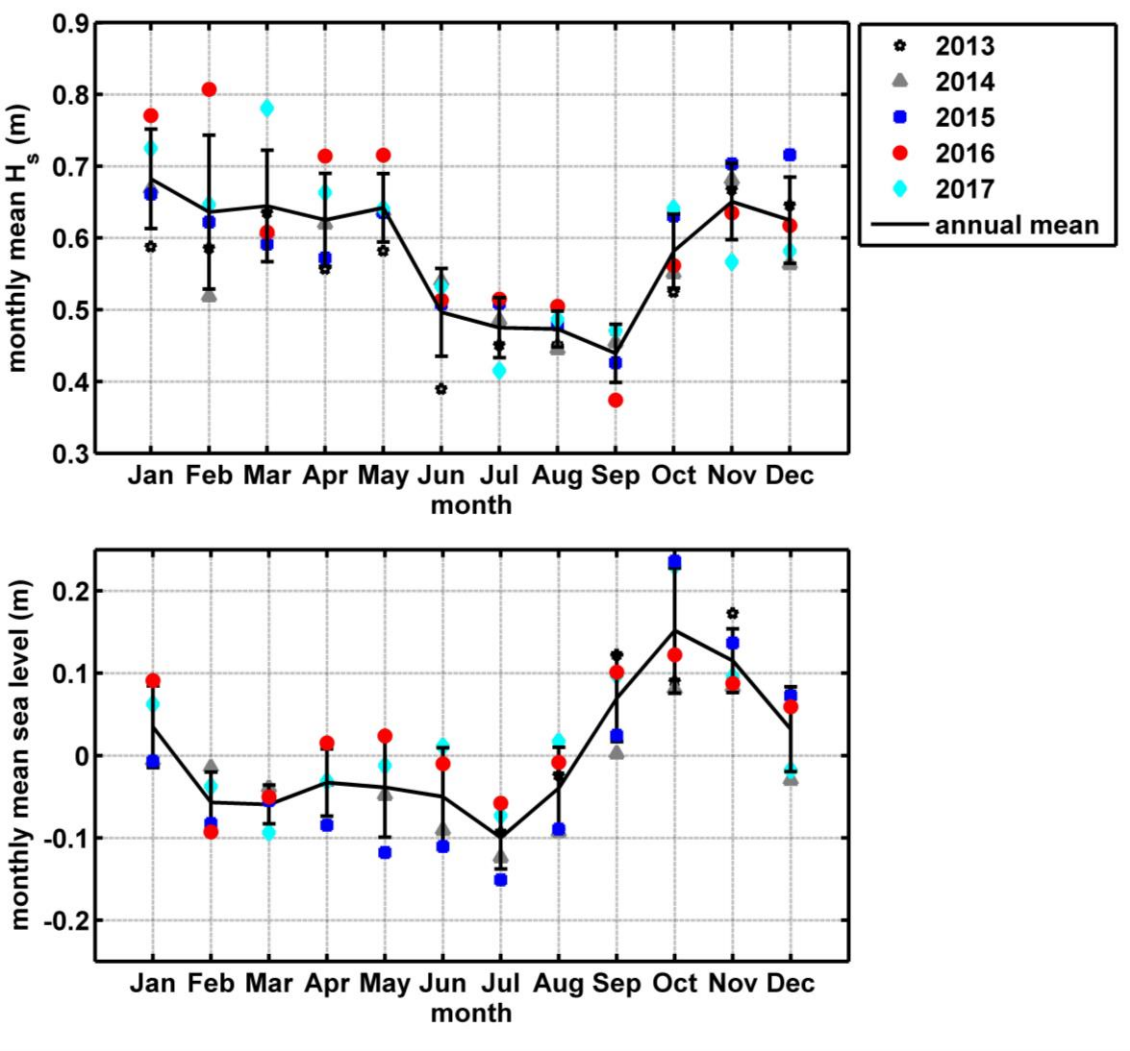




(a) Wind data (www.weather underground.com, 01/01/2009-06/17/2016)

(b) Wave data (ADCP @ 10 m depth in front of Sisal, 12/10/2013-4/20/2016).

Field observations: Waves and tides



➢ **Hs:**

- Higher energy Oct-Mar (CACS) and Apr-May (intense sea-breeze)
- Low energy during summer
- 2015-2016 Winter – higher energy

➢ **Mean sea level:**

- Minimum in July
- Maximum in October
- Mean difference ~ 25 cm
- Difference in 2015 ~ 40 cm

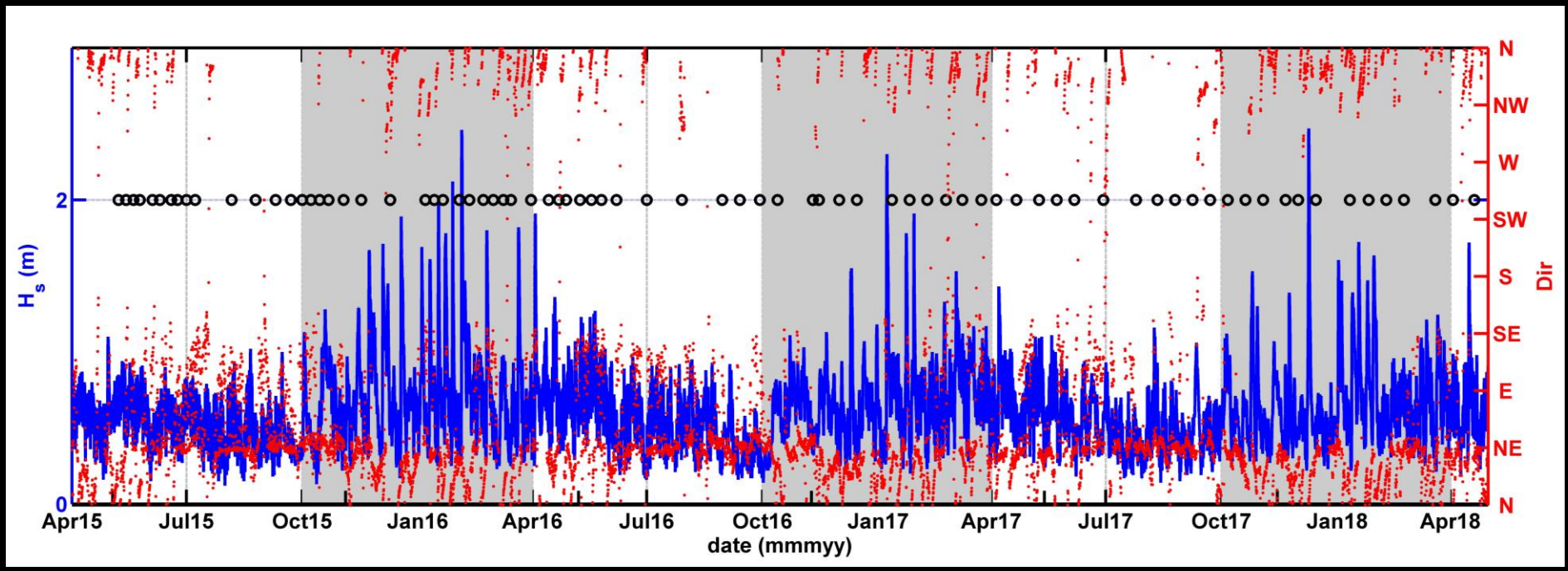
www.mareografico.unam.mx/

3. Methods

Beach surveys

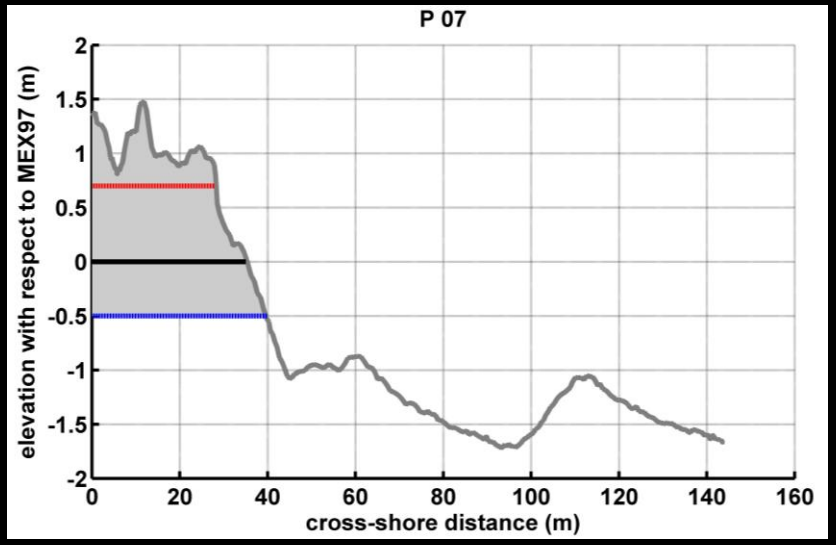
- RTK-DGPS measurments
- Period: May 2015 - date
- Spatial resolution: 20 transects @ 100 m

- Temporal resolution: 7 to 15 days (>80 beach surveys)

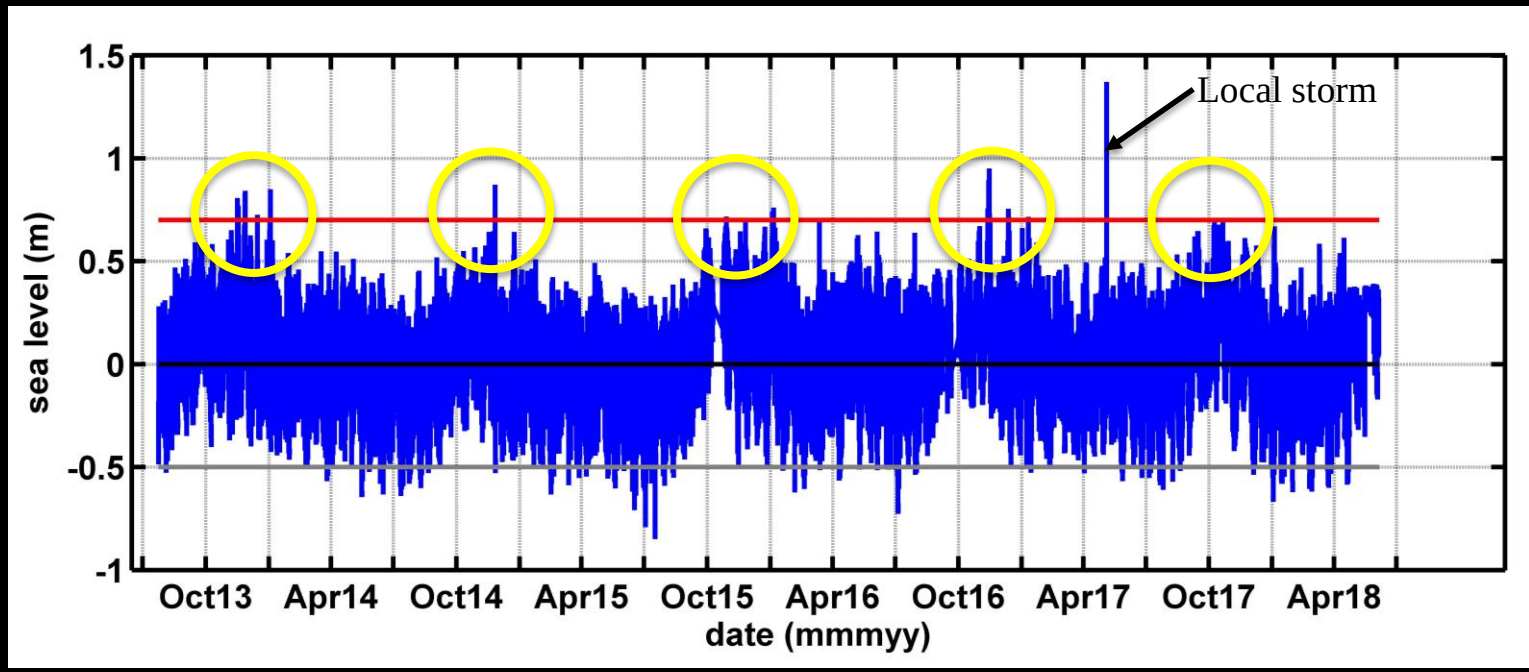


http://polar.ncep.noaa.gov/waves/hindcasts/

Methods: Time series of beach morphology features



- Shoreline (z = 0 m)
- High water level contour (z = 0.7 m)
- Subaerial and intertidal beach volume (z >= -0.5m)



Methods: Data analysis of beach morphology features

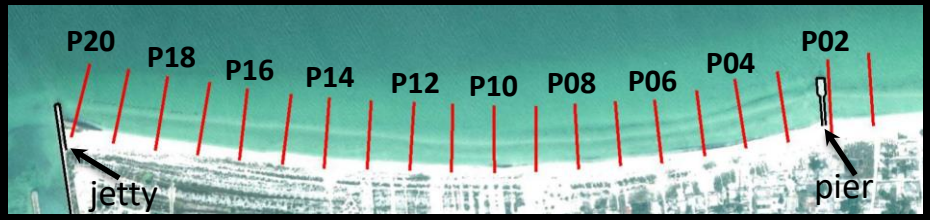
- Empirical Orthogonal Function (EOF) analysis:

$$x(y,t) = \sum_{n=1}^{N} e_n(y) C_n(t)$$

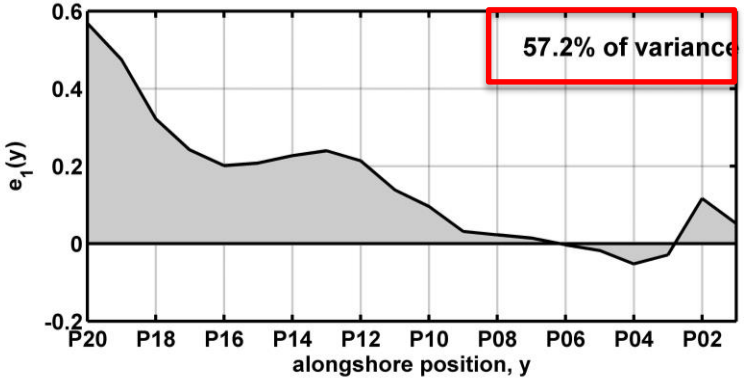
- Cross correlation: Forcing vs beach response, $C_n(t)$

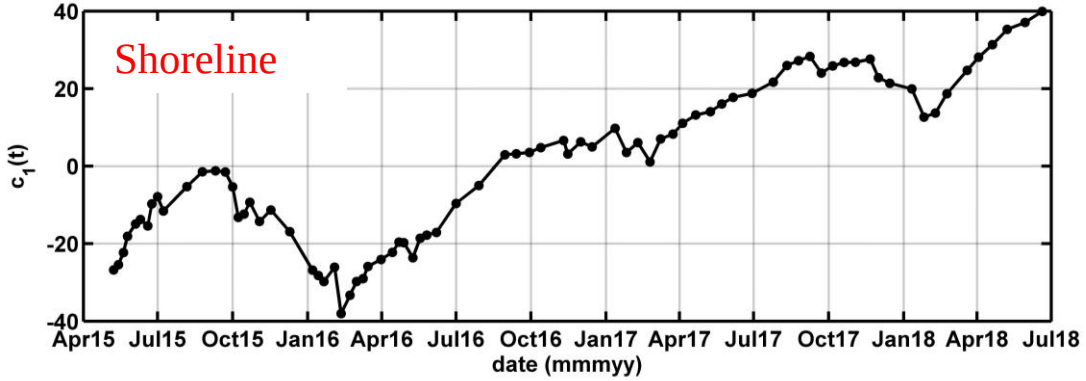
$$r_{xy} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{s_x s_y} \quad -1 \leq r_{xy} \leq 1$$

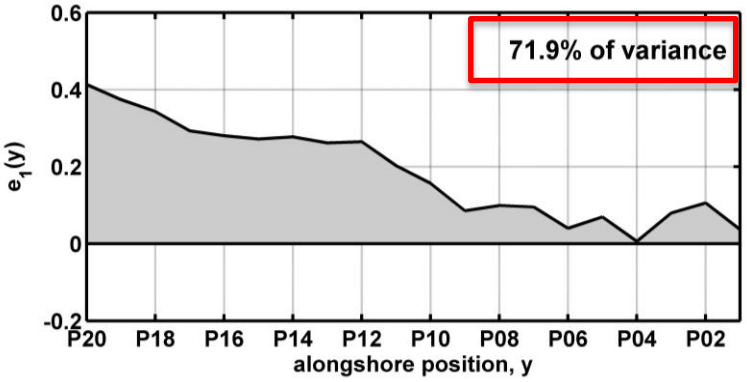
4. Results

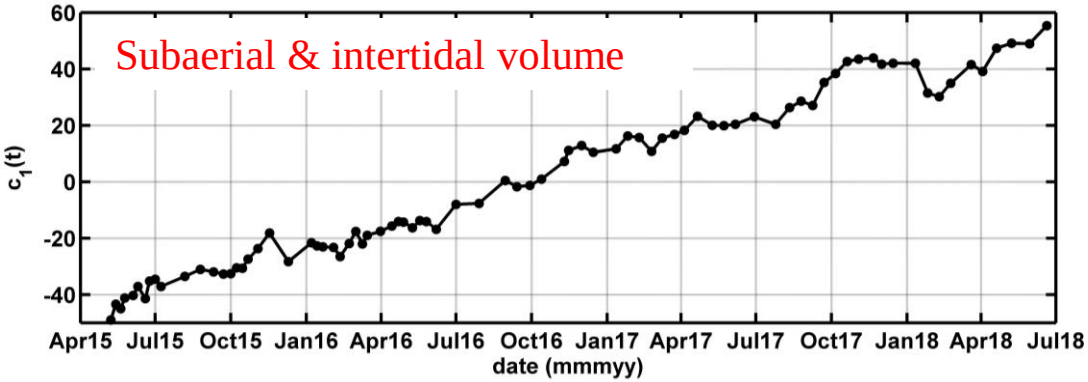


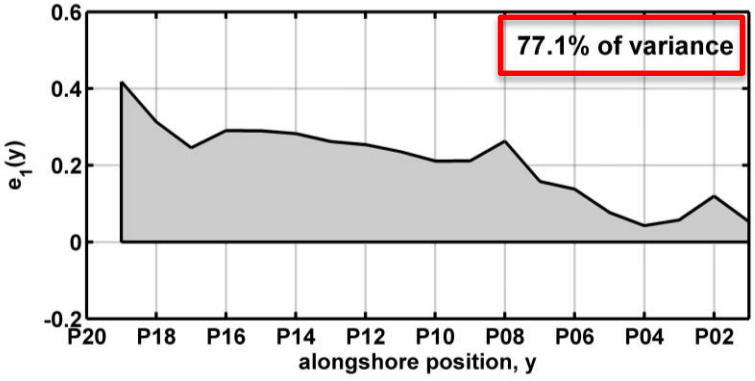
EOF Analysis: 1st mode (net increase/advance)

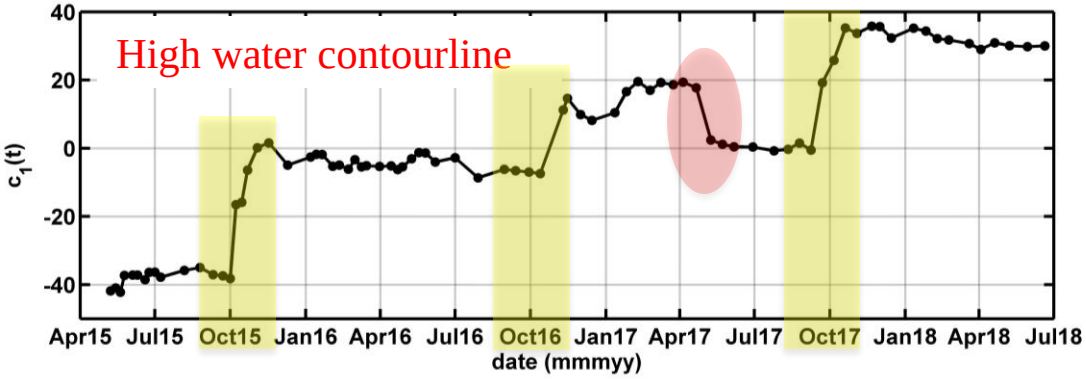


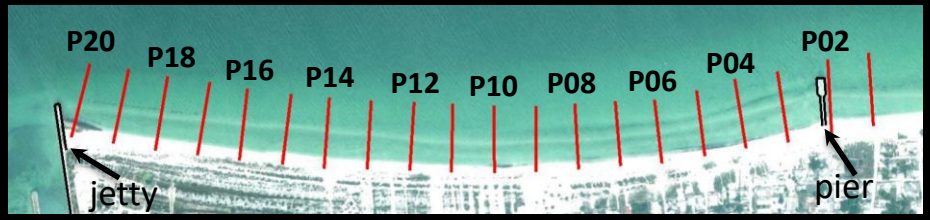




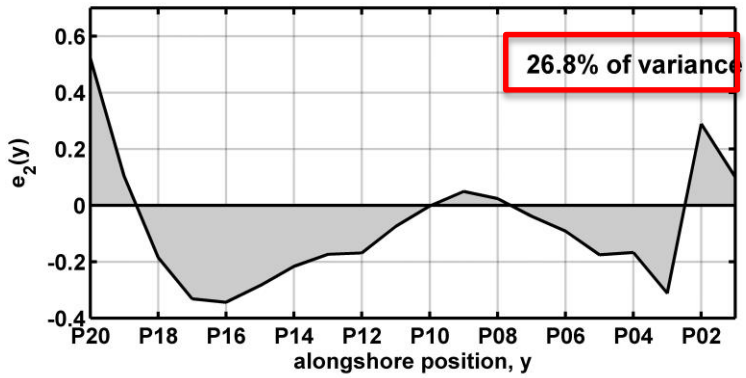


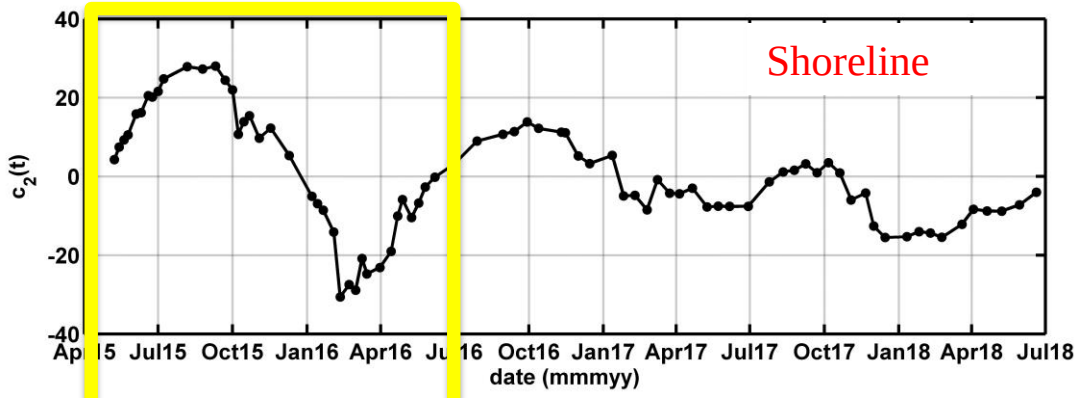


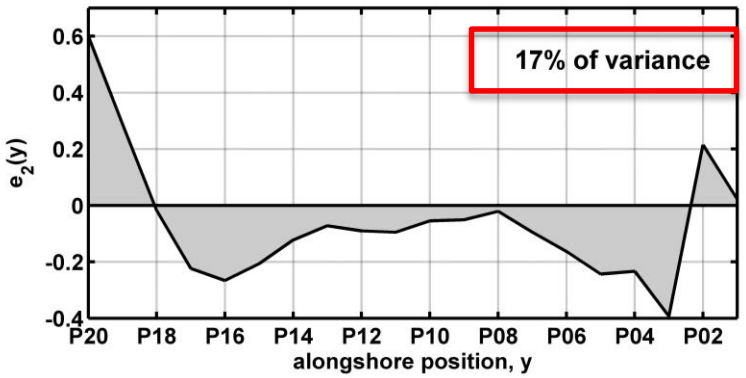


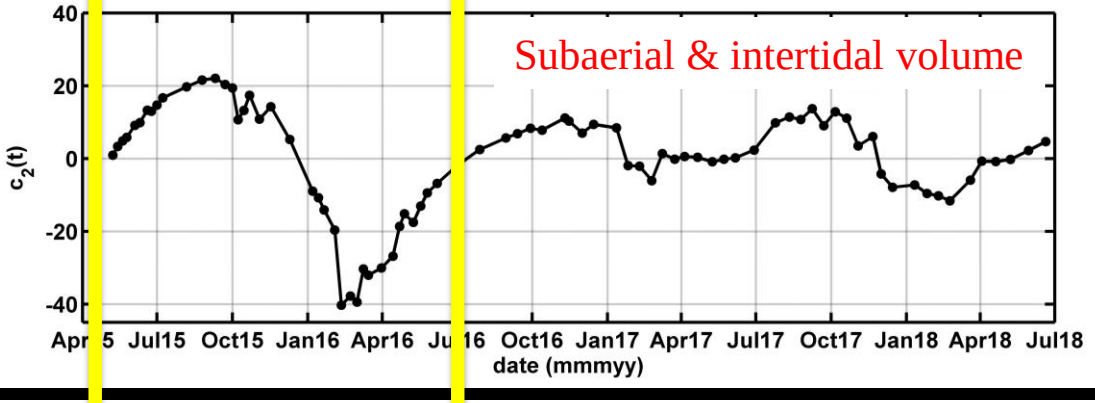


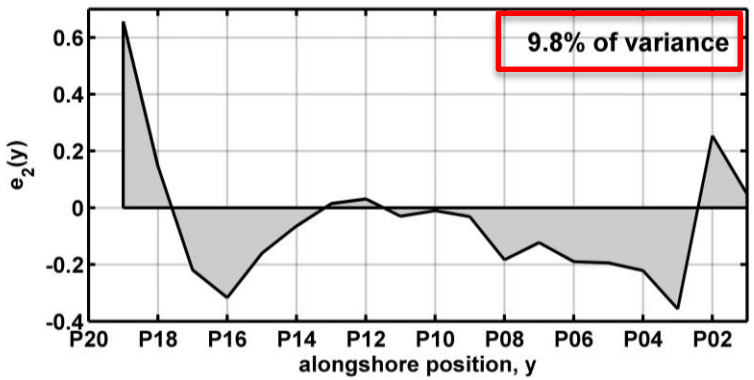
EOF Analysis: 2nd mode (beach rotation)

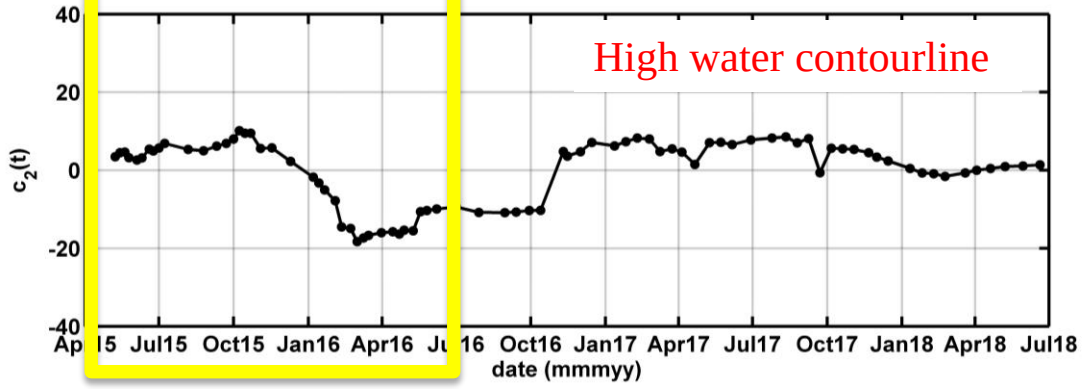










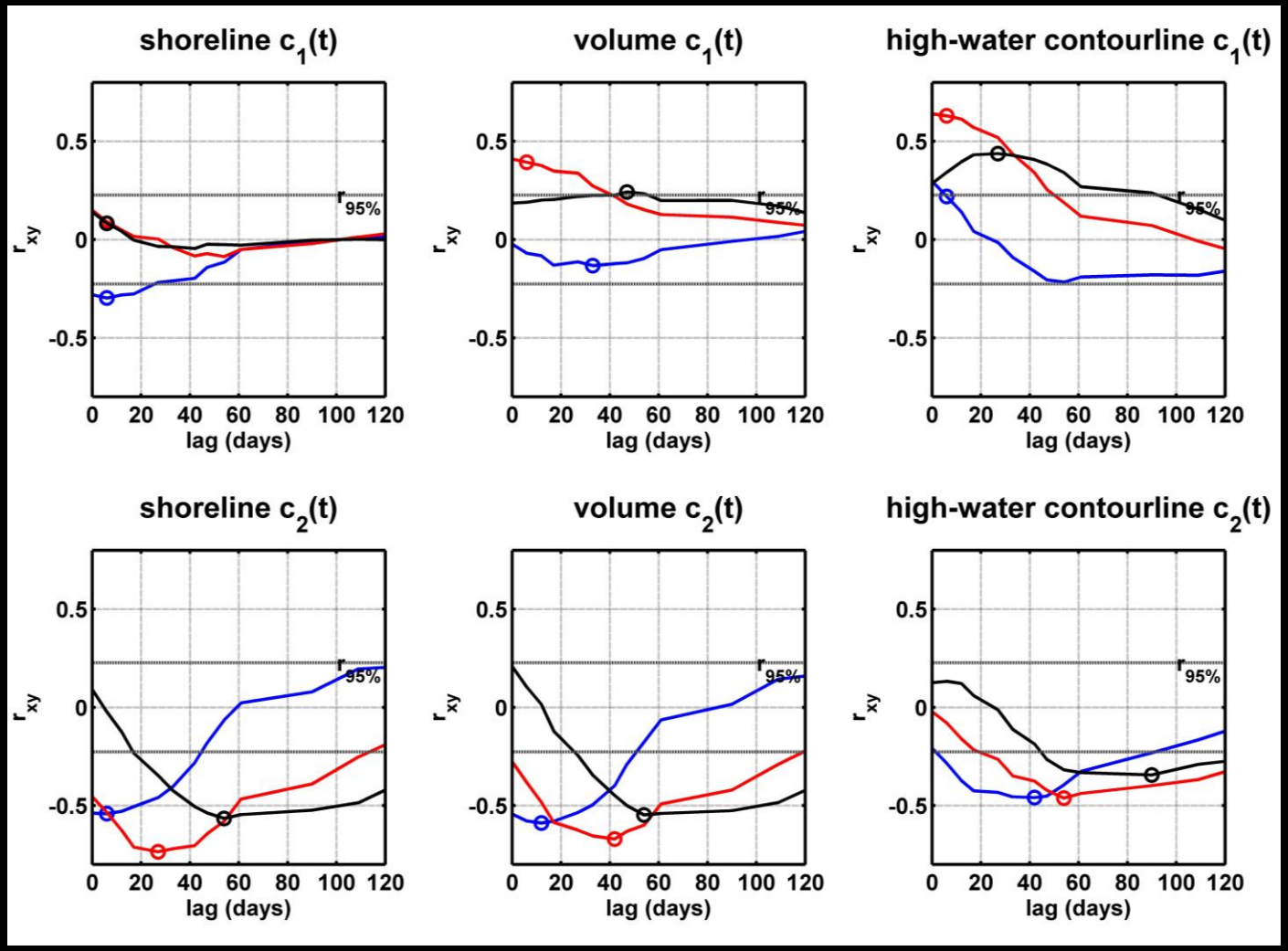


Cross-Correlation: temporal EOFs and forcing conditions

Shoreline EOFs | Volume EOFs | High-water contourline EOFs

1st EOF

2nd EOF

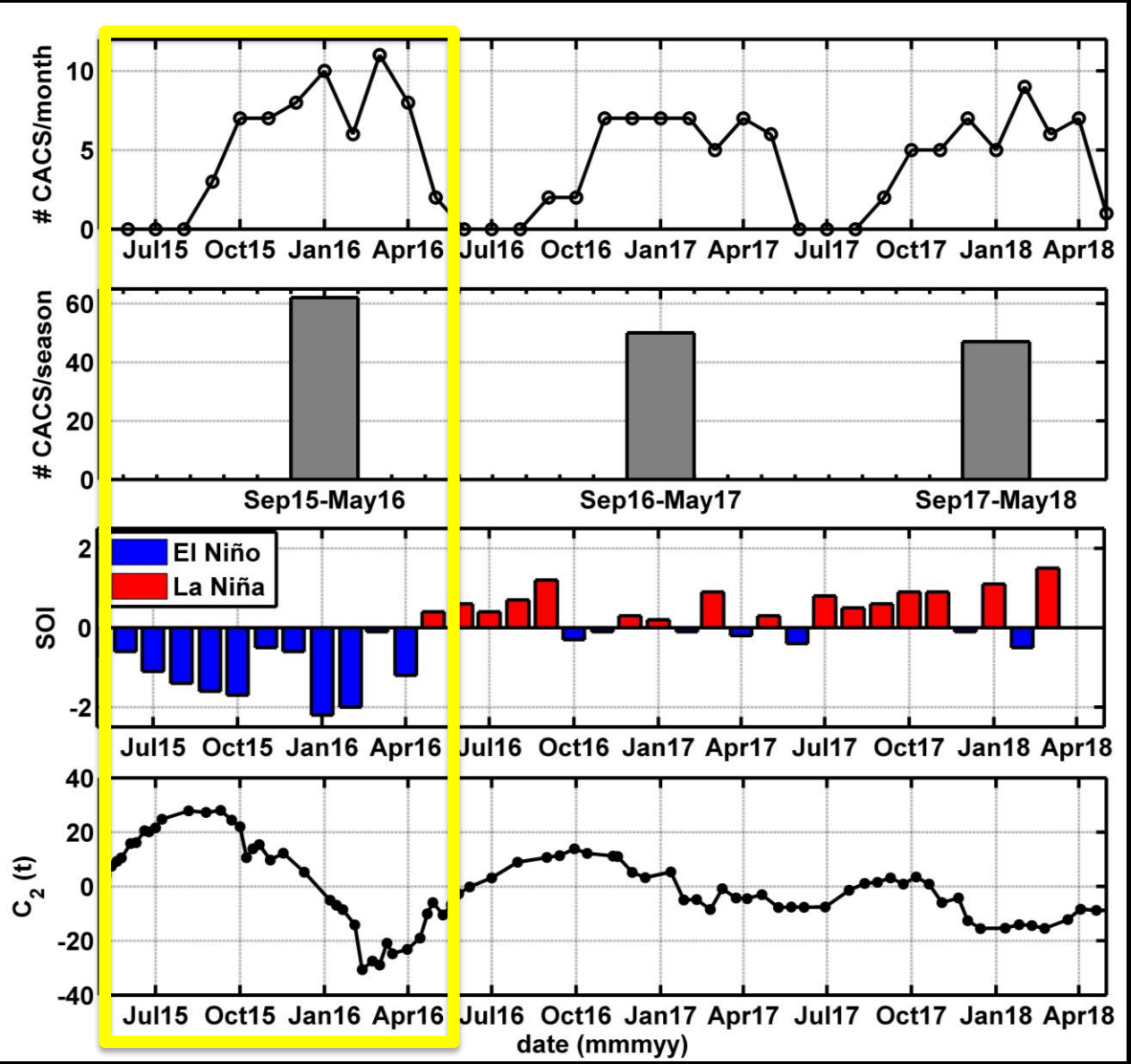


H_s

T_p

η

Frequency of Central American Cold Surge Events



- Substantial interannual variability in cold surge activity, mainly in relation to El Niño/Southern Oscillation (ENSO) (Magaña et al.,2003)
- Peaks in CACS frequency correspond to El Niño (Reding ,1992)

Data: Servicio Meteorológico Nacional

5. Concluding remarks

Concluding remarks

- The EOF analysis of beach morphology features shows a net increase on beach width, beach elevation, and volume during the three-year period.

- The staircase mode of variability of the high water level contour shows a high positive correlation with wave period and mean sea level.

- The seasonal variability of beach features shows a strong negative correlation with wave height and period.

- Beach rotation is enhanced during El Niño conditions due to an increase of CACS events.

Acknowledgements