ICCE 2018
36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018
Baltimore, Maryland | July 30 – August 3, 2018

COMPREHENSIVE STUDY AND MONITORING PROGRAM FOR BEACHES AT VIÑA DEL MAR CHILE

August 3rd 2018

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PRDW
Consulting Port and Coastal Engineers

OUTLINE

1. Context and motivation
2. Objectives
3. Studies and main results
    - Hydrological study
    - Field measurements
    - Spectral wave propagation
    - Hydrodynamic modelling
    - Long-shore transport
    - Cross-shore erosion
4. Main findings
5. Conclusions

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N
Punta Cochoa
Playa Reñaca
Renaca
Playa Las Salinas
Playa Los Marineros
Achupallas
Playa Caleta Abarca
Viña del Mar
Punta Recreo
Playa Ancha
Población Vergara
El Salto
Placeres
5 km
Google Earth
Image © 2016 DigitalGlobe
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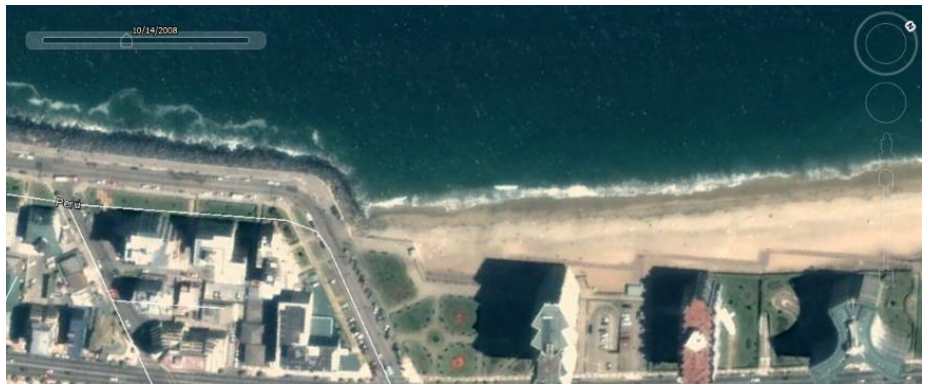
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

- Anecdotal fears of erosion
- Unclear current state or causes
  - Sediment deficit?
  - Sediment properties change?
  - Change in wave conditions?
  - Built environment?

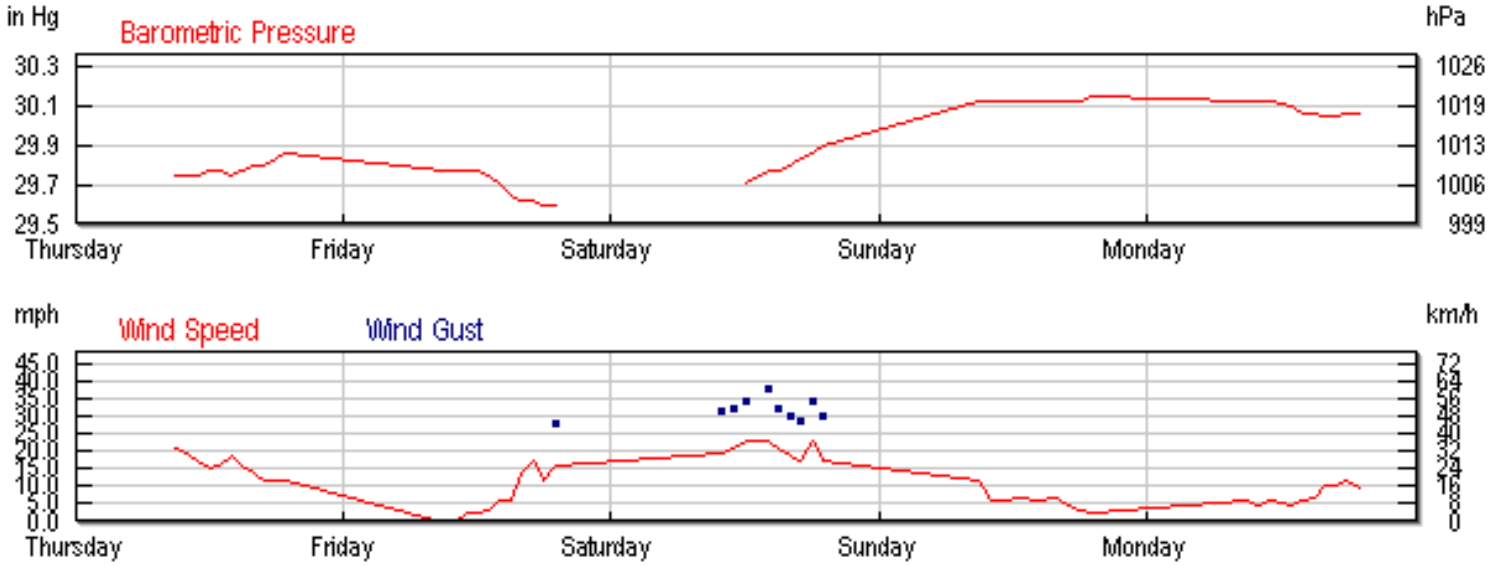
Miramar beach, Viña del Mar
~1930 - ~2010

- Anecdotal fears of erosion
- Unclear current state or causes
  - Sediment deficit?
  - Sediment properties change?
  - Change in wave conditions?
  - Built environment?
- **Permanent changes?**

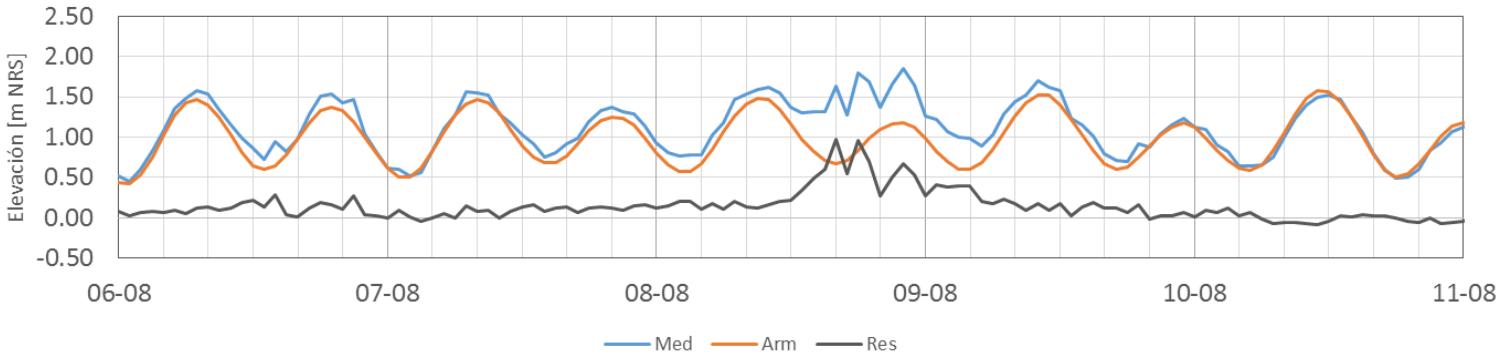


Playa Acapulco: 2003 – 2008 - 2017

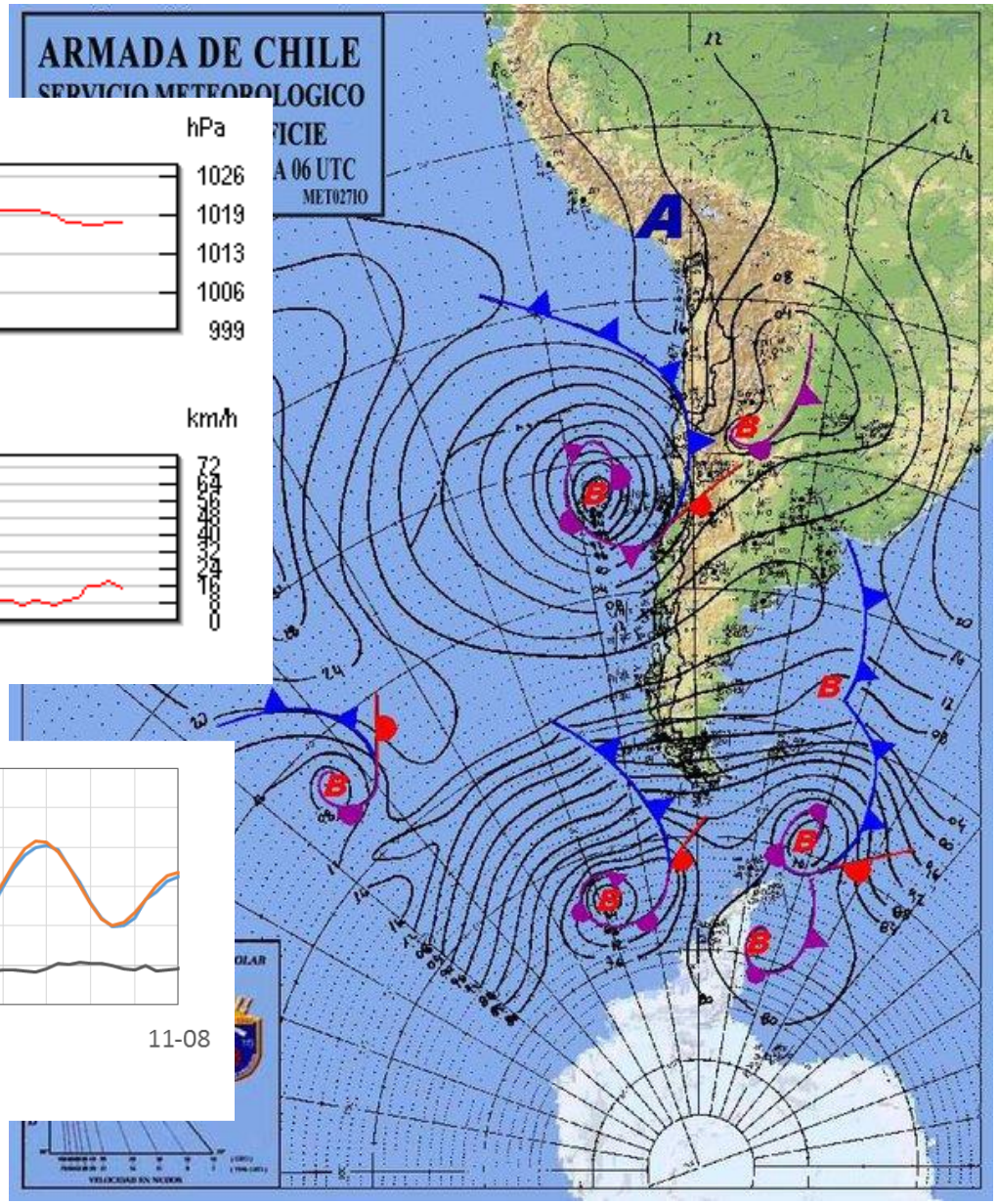
August 2015 storm



Rodelillos Airport (06/08/2015 – 10/08/2015)



IOC Valparaíso (06/08/2015 – 10/08/2015)



- 2015 storm impact
  - Huge erosion
  - Infrastructure loses
- Temporary changes
  - Seasonal wave variability
  - Seasonal beach profiles
  - Permanent change?
  - Recovery times?

El Sol beach, Viña del Mar
Agosto 2015

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- MOP (Ministry of Publics Works) asked PRDW for a comprehensive study

- General objectives:
  - Improve the knowledge on the morphological behavior of the Viña del Mar beaches

- Specific objectives:
  - Estimate storm expected impacts
  - Estimate recovery times after storms
  - **Determine the state of the beaches:**
    - **Structural erosion?**
    - **Eventual erosion?**
    - **Main drivers or causes?**

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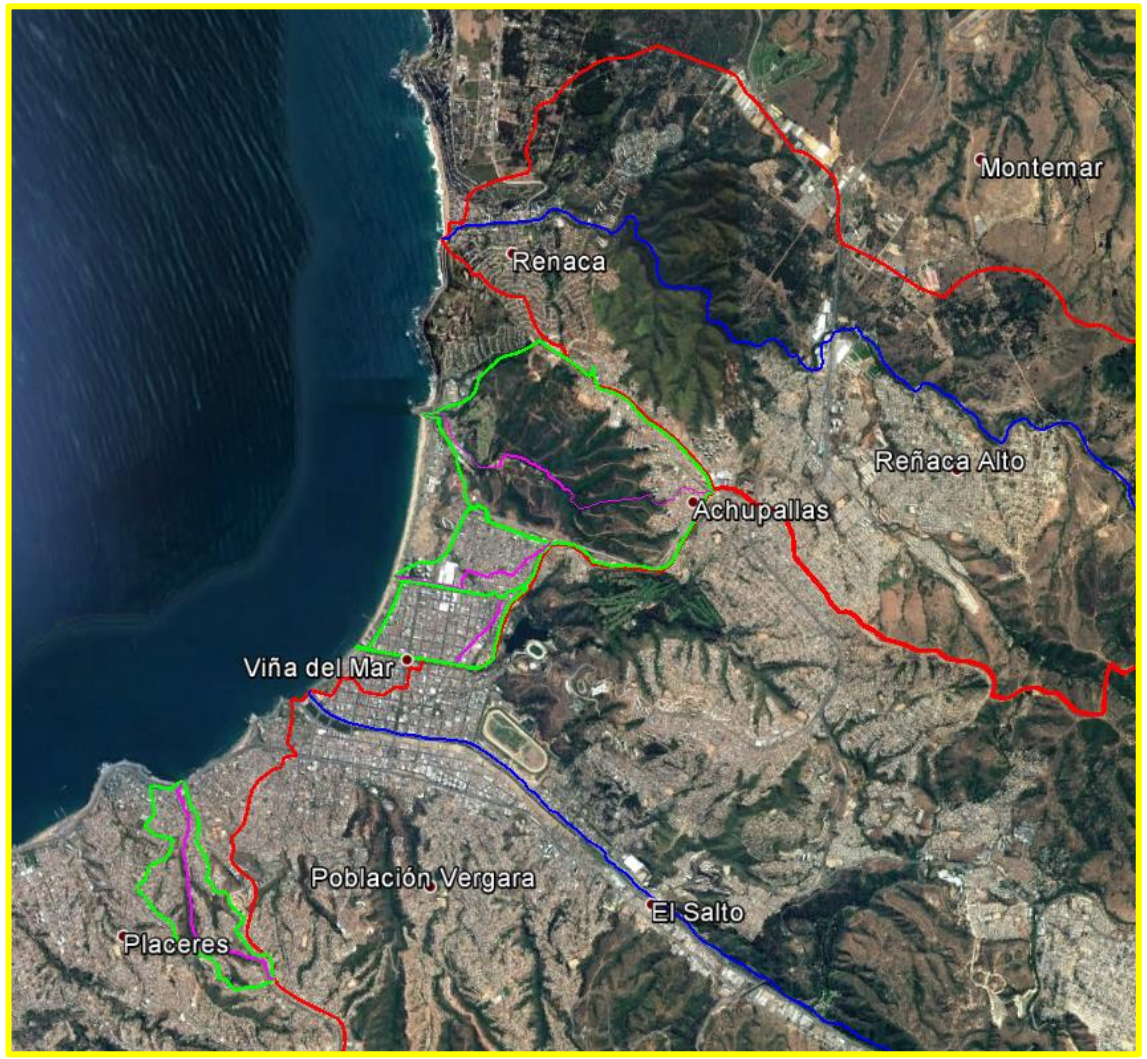
- Sediment discharge



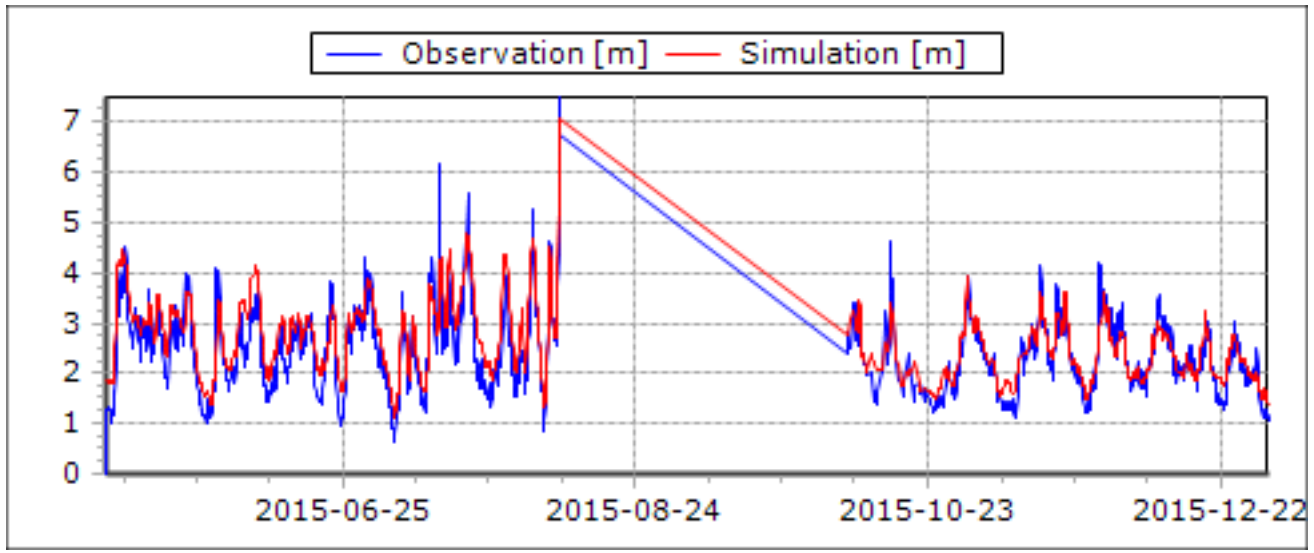
Basin	Mean yearly bed load transport [m^3/year]
Estero Marga-Marga	22,354
Estero Reñaca	2,914
Others	< 10%
Total	27,982

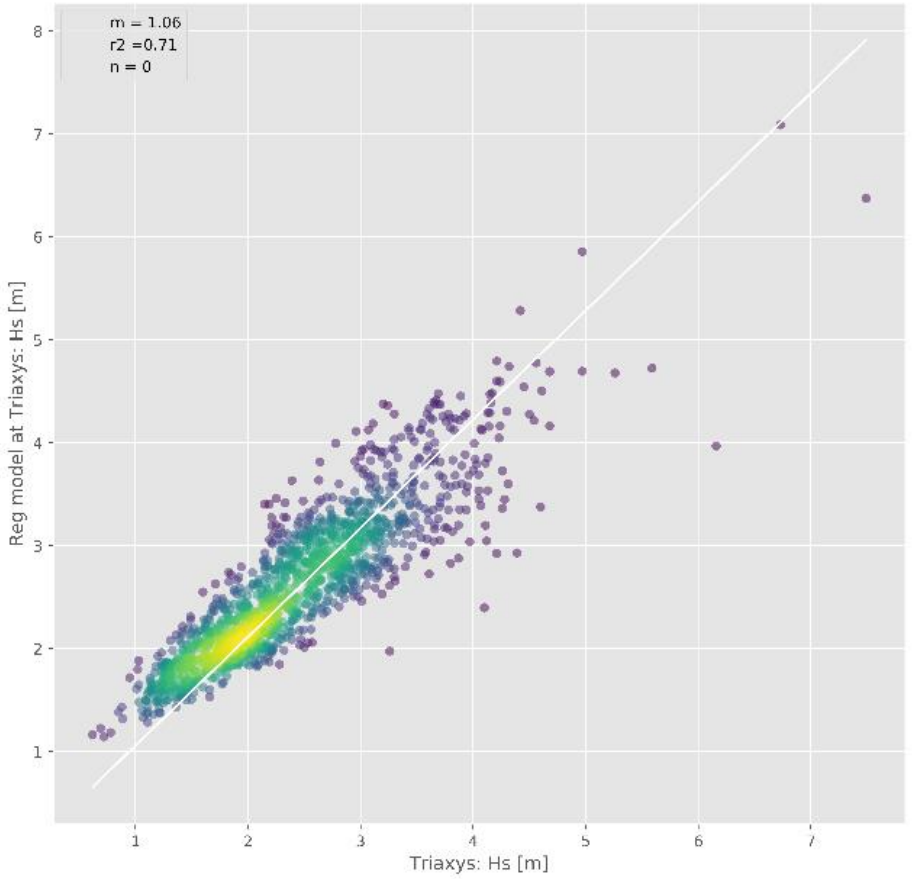
- Bathymetry
- Topography
- Water leves
- Currents (ADCP)
- Waves (ADCP)
- Sediment properties

- Beach monitoring

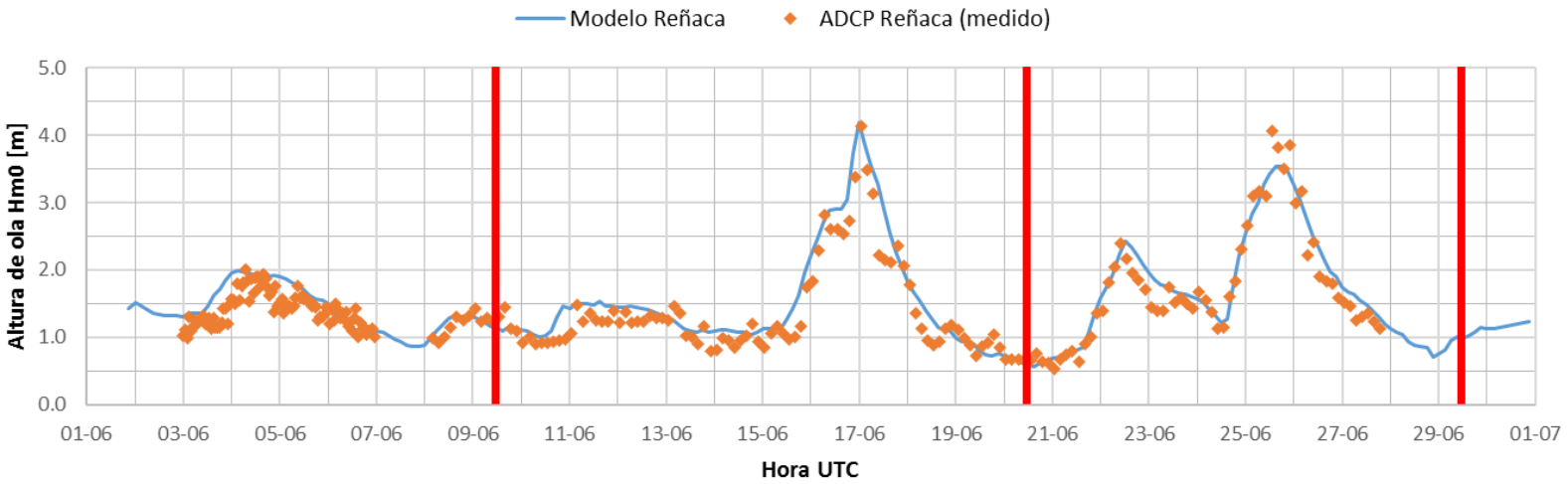
Date	Observation
2017-06-09	Pre storm
2017-06-20	Post storm 1
2017-06-29	Post storm 2
2017-07-31	Recovery month 1
2017-08-29	Recovery month 2
2017-10-03	Recovery month 3
2017-10-31	Recovery month 4

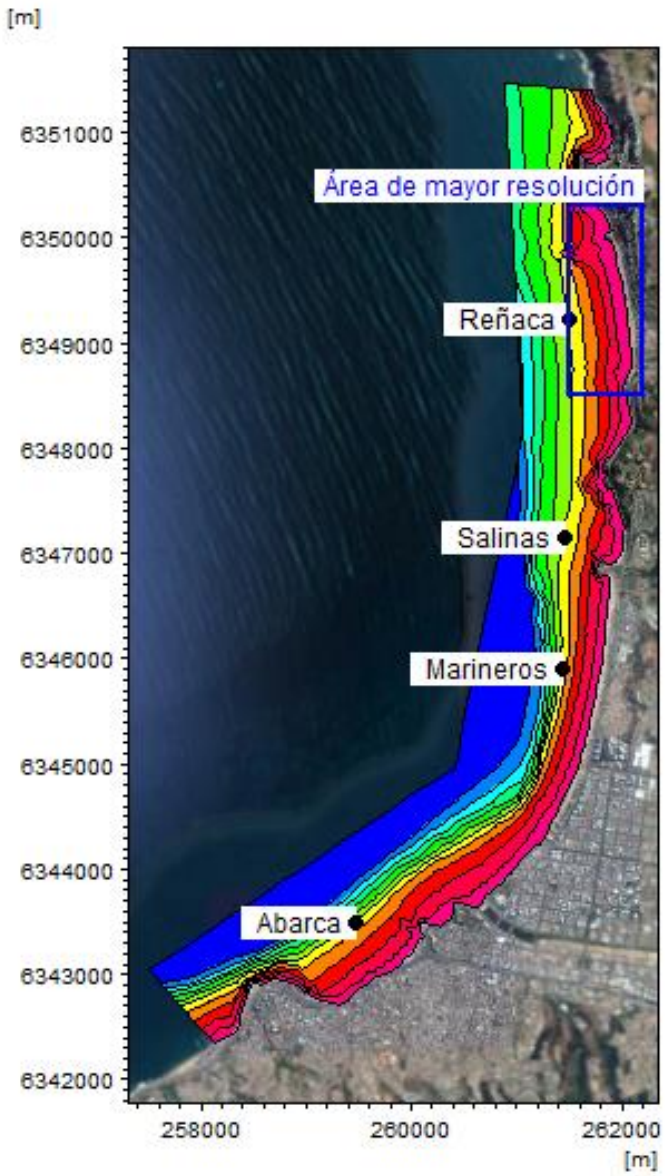
- Fully spectral, every sea state
- NCEP deep water recreated spectra
- Local seas generated by 2D wind field
- Deep water model:
  - Unsteady
  - Calibrated against deep water buoy





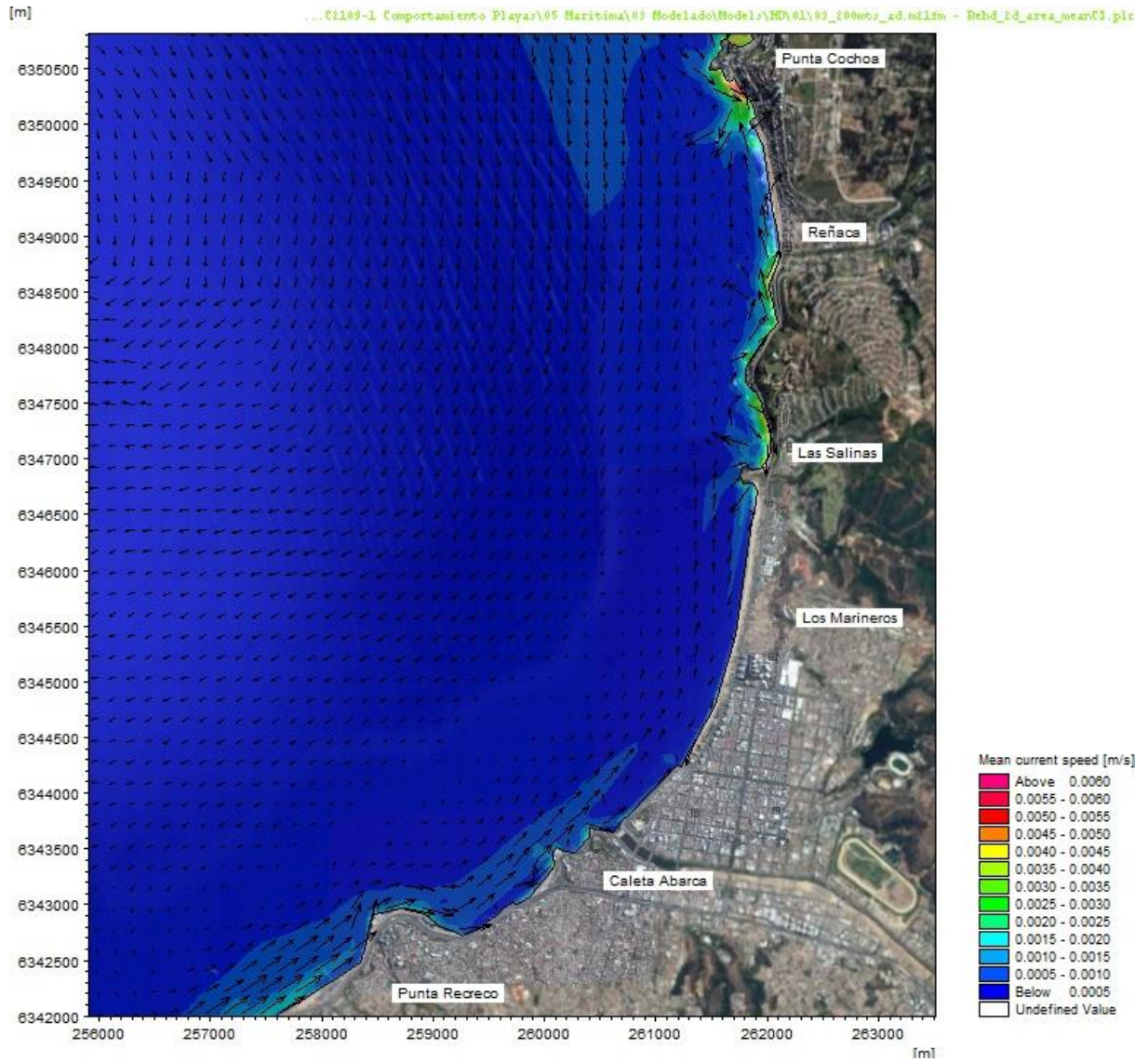
- Local model
  - fed by deep water model results
  - steady state
  - calibrated against ADCP data
- Main results
  - Local wave climate
  - Input for other models





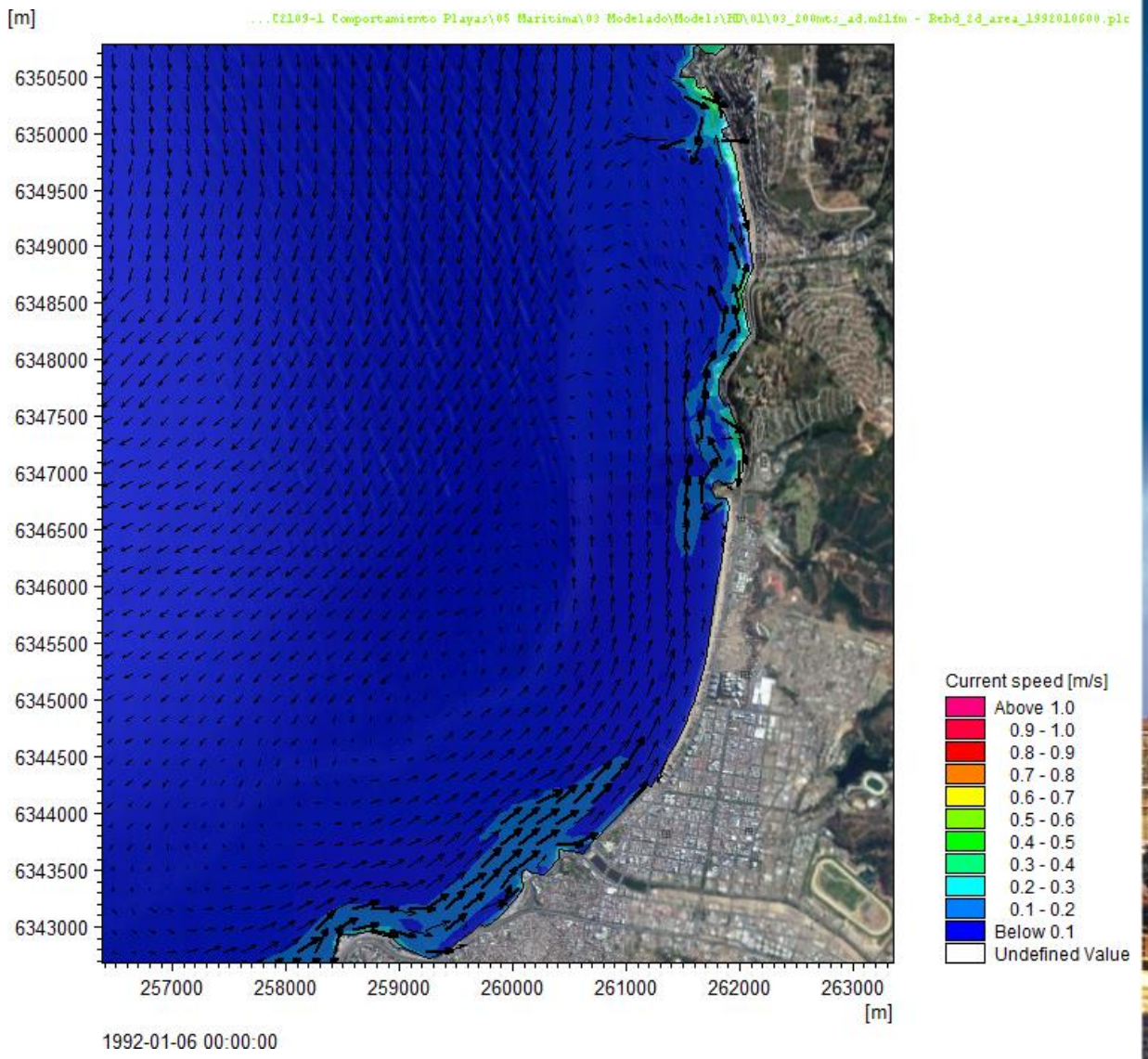
- Currents mainly induced by wave breaking
  - Tide and wind have minor effects

- Average current are weak



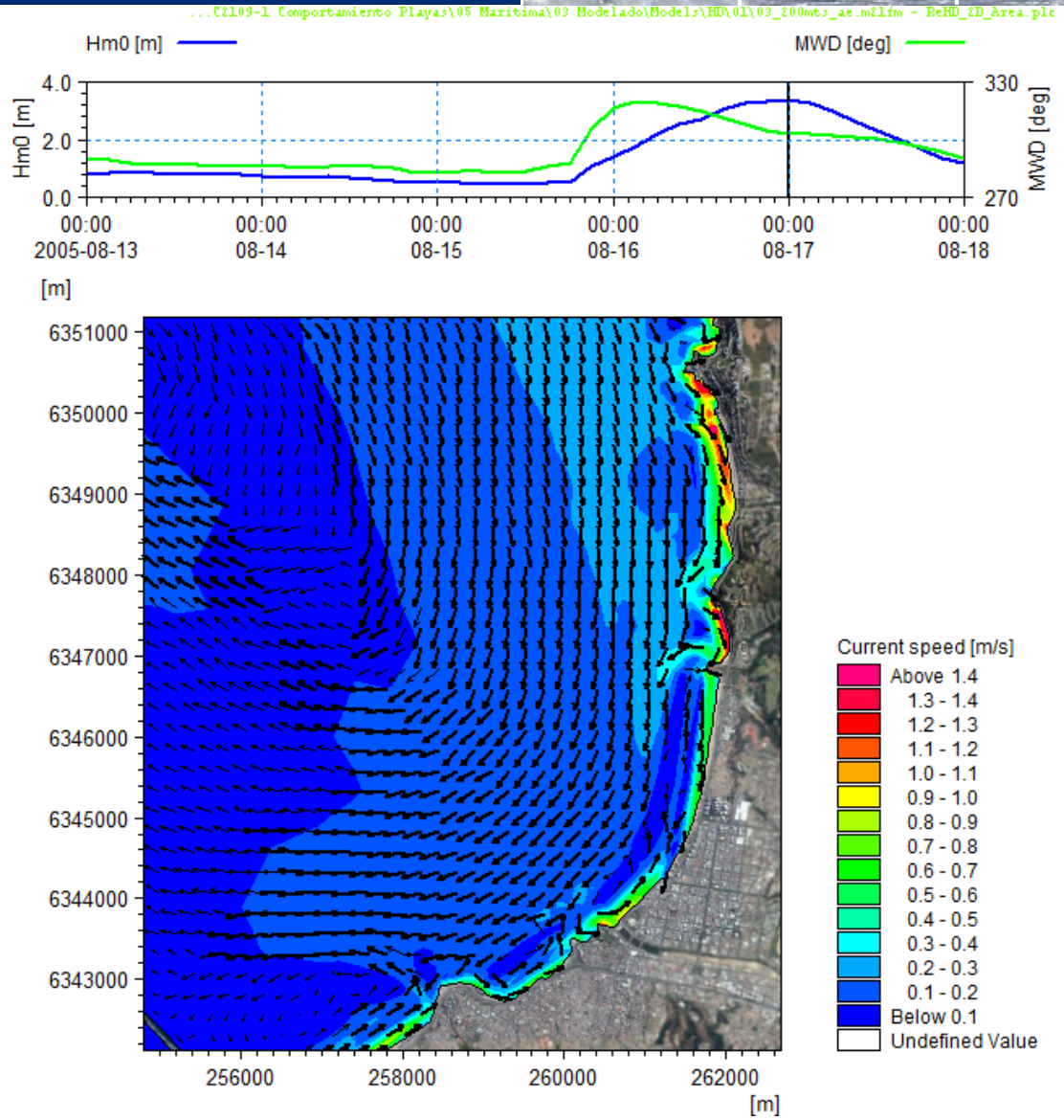
Average current conditions

- Currents mainly induced by wave breaking
  - Tide and wind have minor effects
- Average current are weak
- Mean wave induced currents mostly northwards



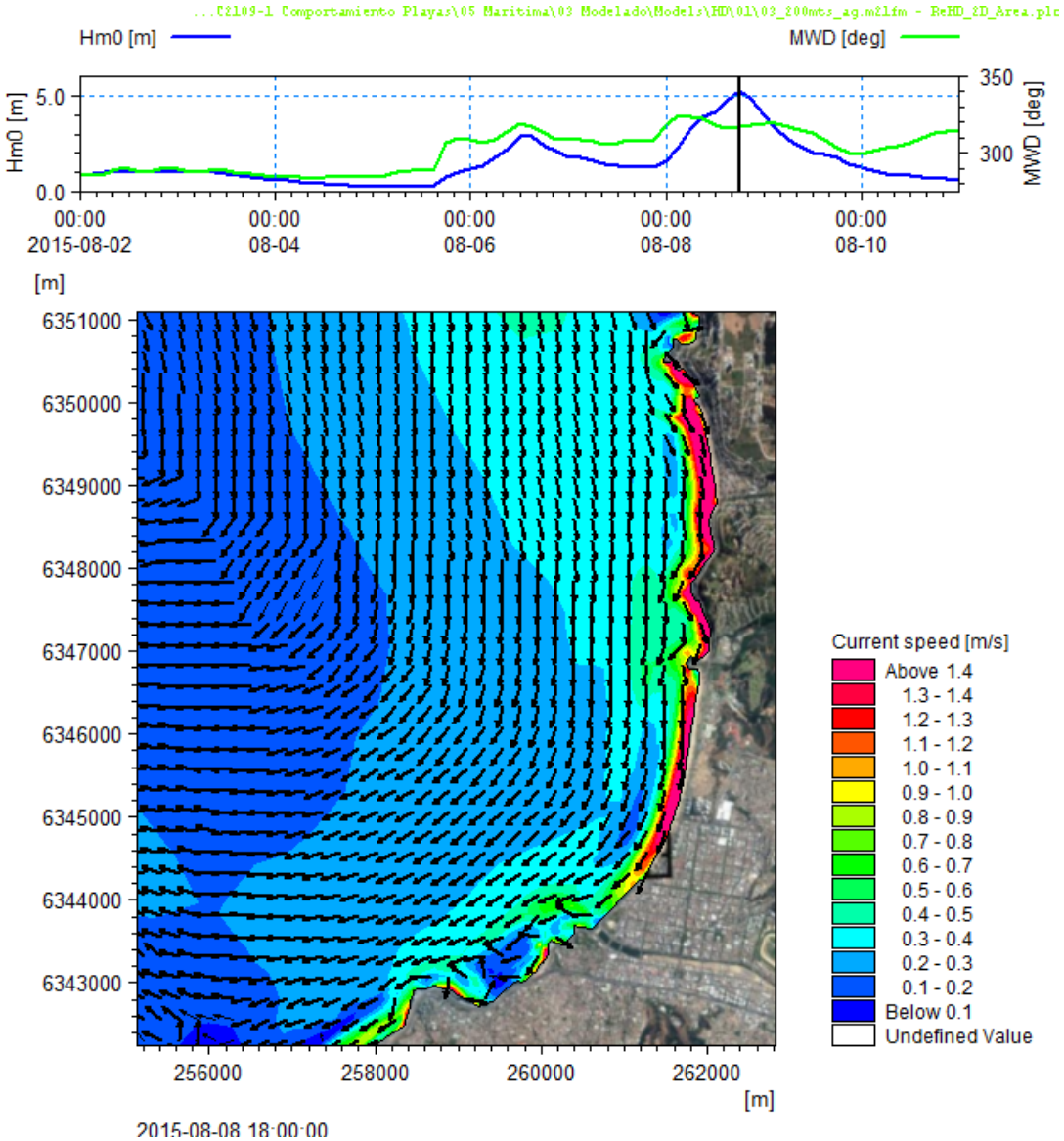
Mean wave conditions:
Hm0 = 2.5m, TP = 14s y MWD = 232°

- Currents mainly induced by wave breaking
  - Tide and wind have minor effects
- Average current are weak
- Mean wave induced currents mostly northwards
- Winter storm condition: mixed directions, mostly southward



Typical winter storm:
Hm0 = 5.0 m, Tp = 14s

- Currents mainly induced by wave breaking
  - Tide and wind have minor effects
- Average current are weak
- Mean wave induced currents mostly northwards
- Winter storm condition: mixed directions, mostly southward
- 2015 storm: large currents, all southward



August 2015 storm

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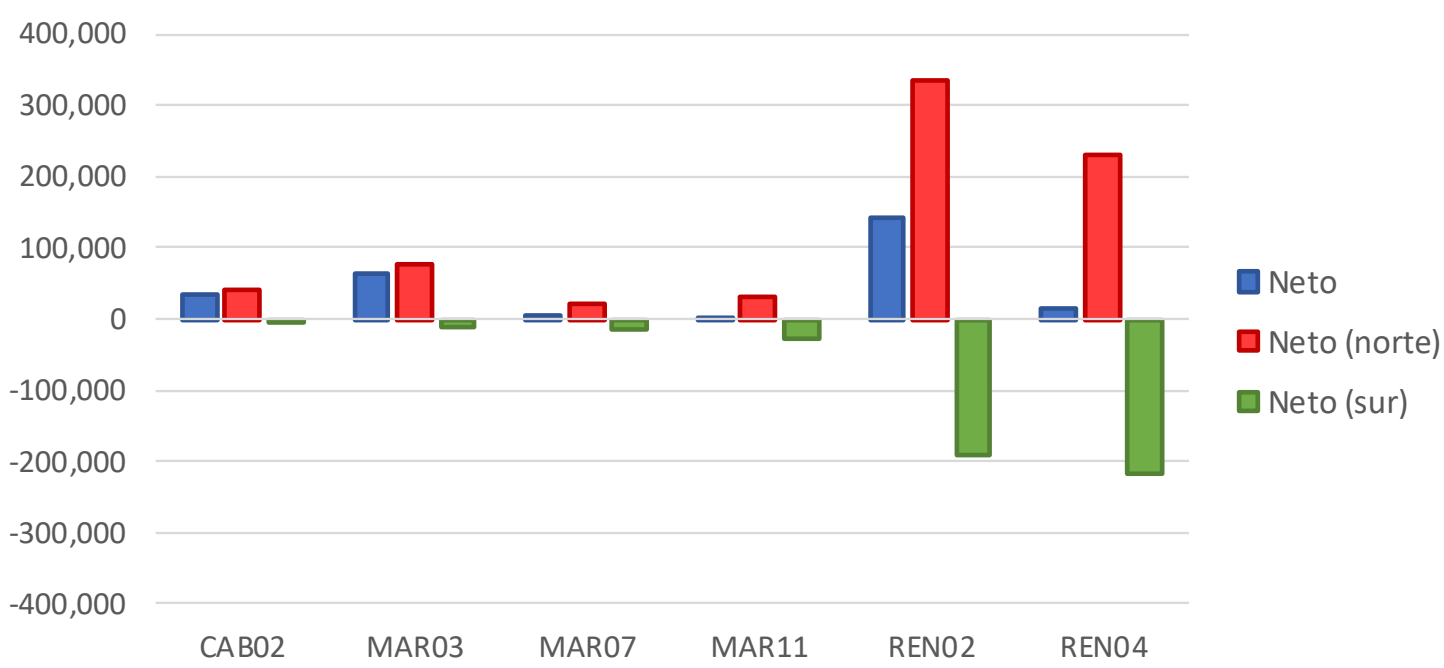
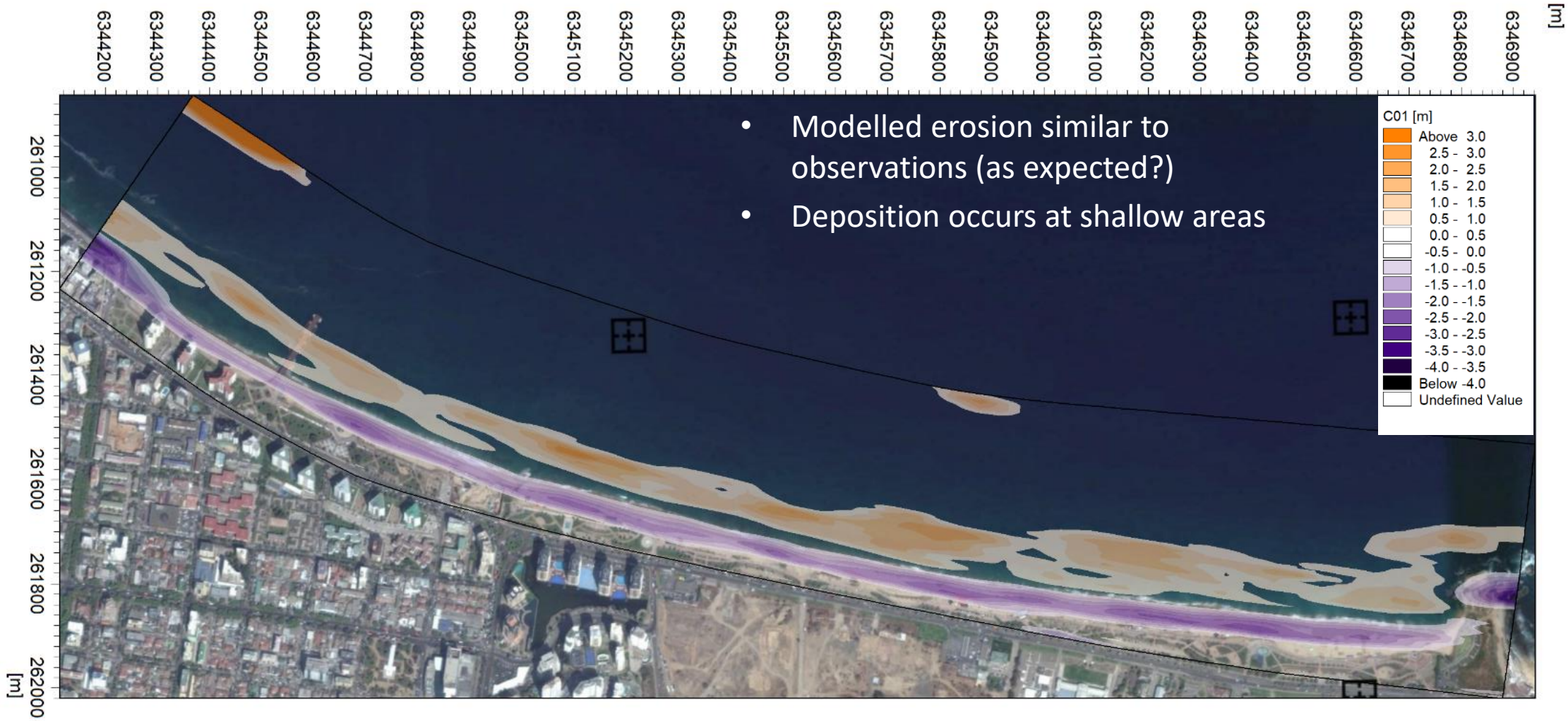
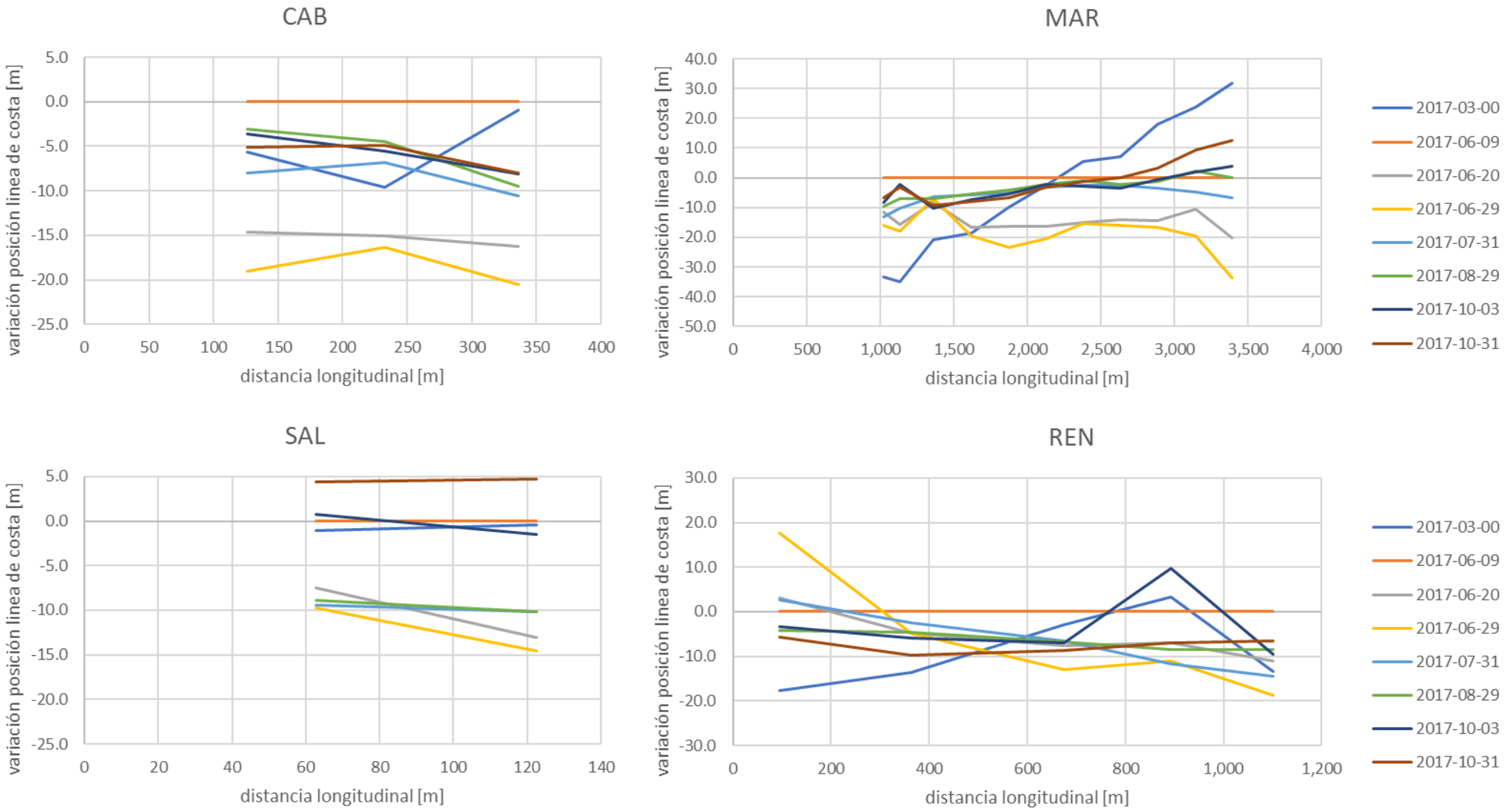
- Net transport close to zero
- Gross transport increases northward



- **CShore** profile erosion – **XBeach** erosion/deposition patterns



- Beach monitoring – coastline position



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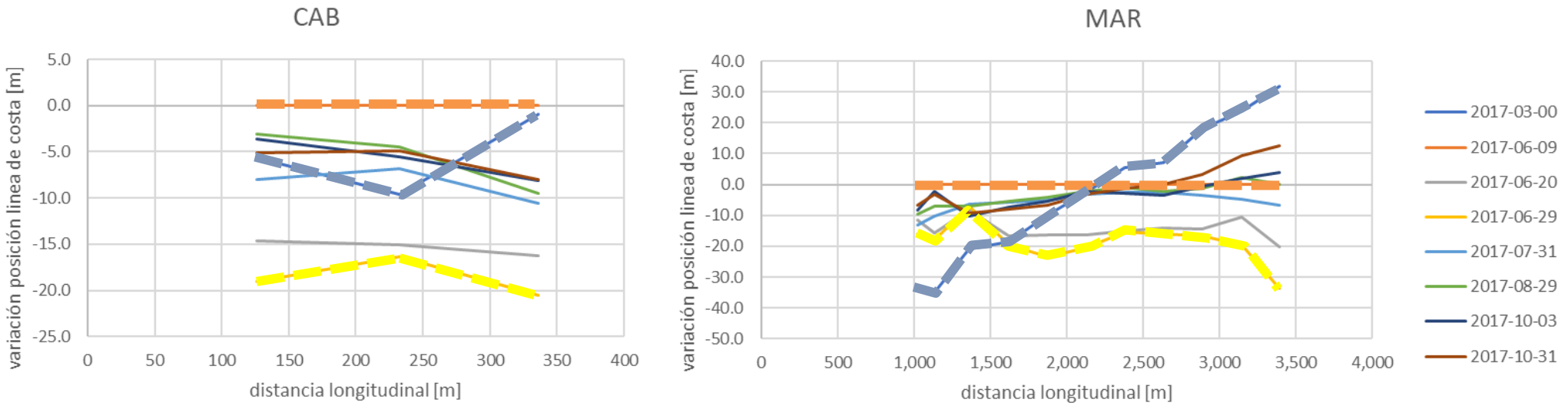

- Two groups of beaches
  - Confined/pockets beaches — Longer, tilting beaches
- Coastlines reacts to storms
  - Retreat — Retreat and tilt
- Berm volume slowly increases after storms

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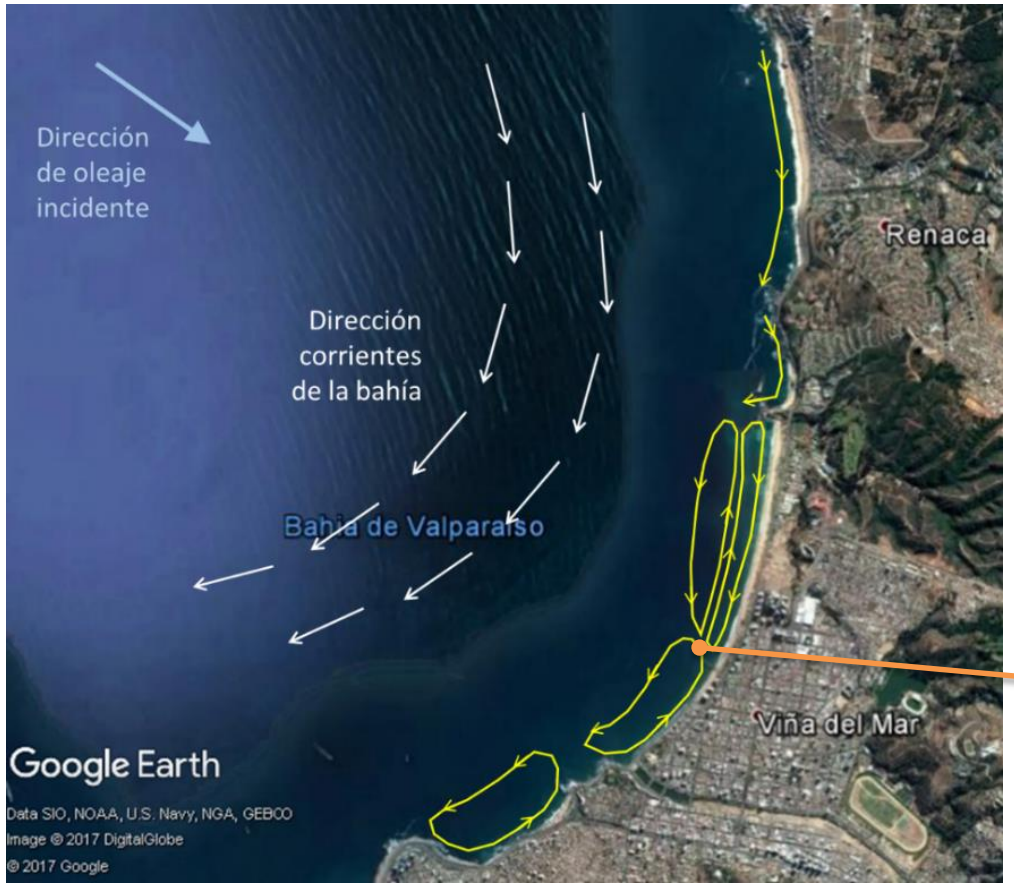
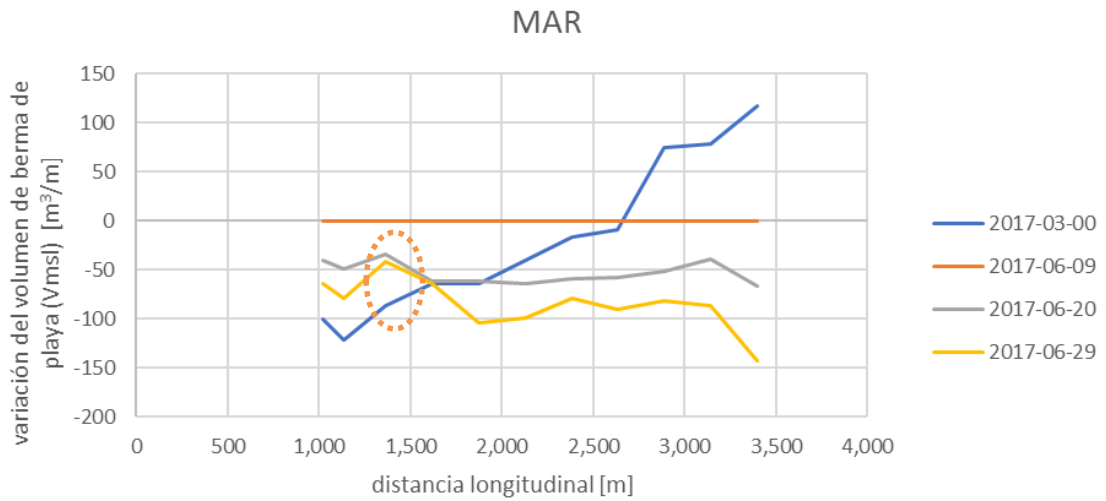
4. MAIN FINDINGS

Circulation cells





Convergence of currents
→ Expected sediment deposition

Debilitation of circulation might explain 2015 unusual erosion

- Northward transport
  - Small rates
  - Rather constant through the year
  - Associated to mean wave conditions
- Southward transport
  - Larger rates
  - Eventual
  - Associated to storm waves
- ~Relatively balanced

- **Beaches are mostly closed systems**
- Debilitation of circulation might explain 2015 unusual erosion

- Wave conditions rather constant in time

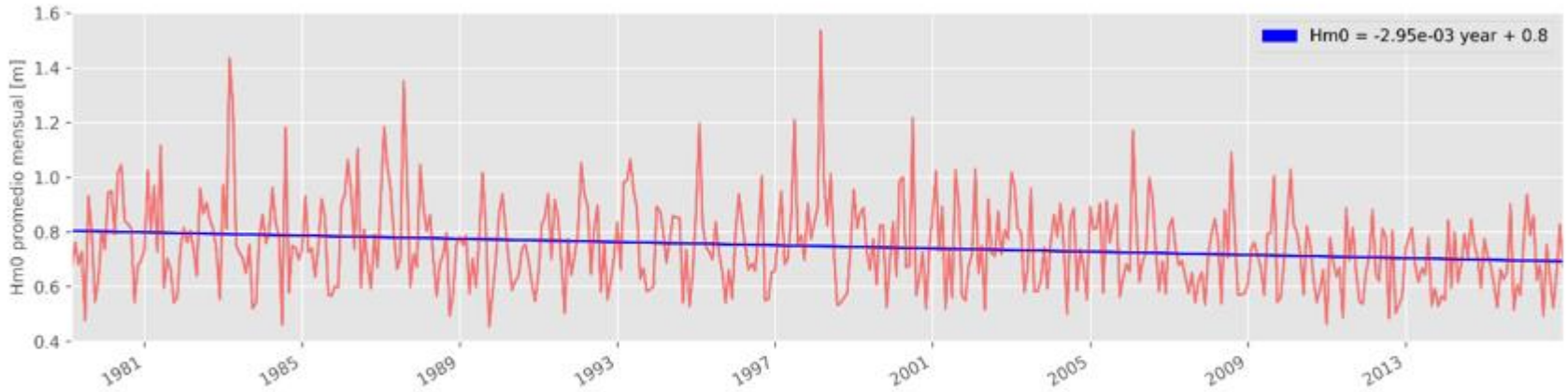


***Figura 3-11**: serie de altura de oleaje H_{m0} media mensual frente a Av. Perú.*

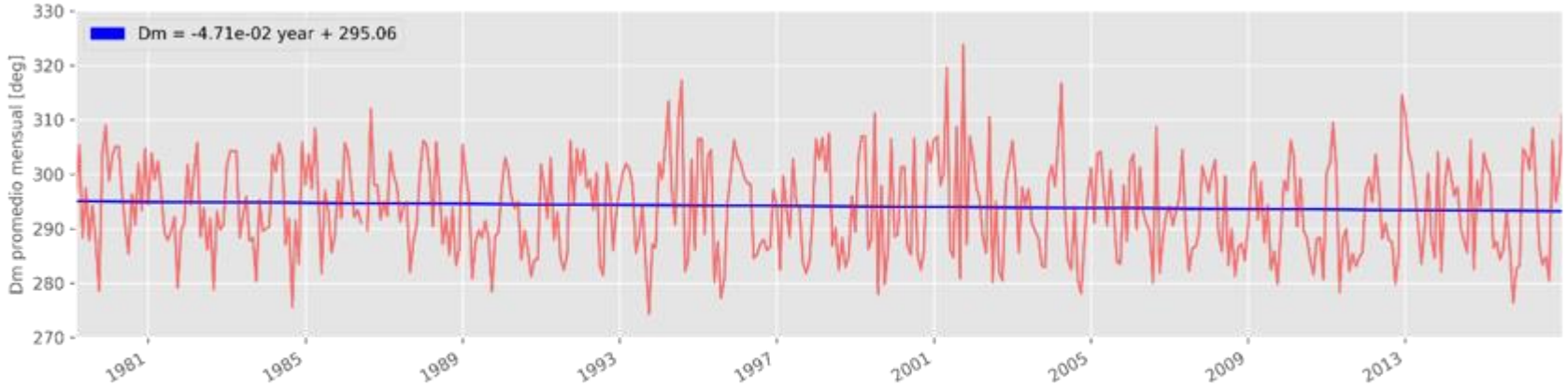


***Figura 3-13**: serie de dirección media de oleaje D_m media mensual frente a Av. Perú.*

- Wave conditions rather constant in time

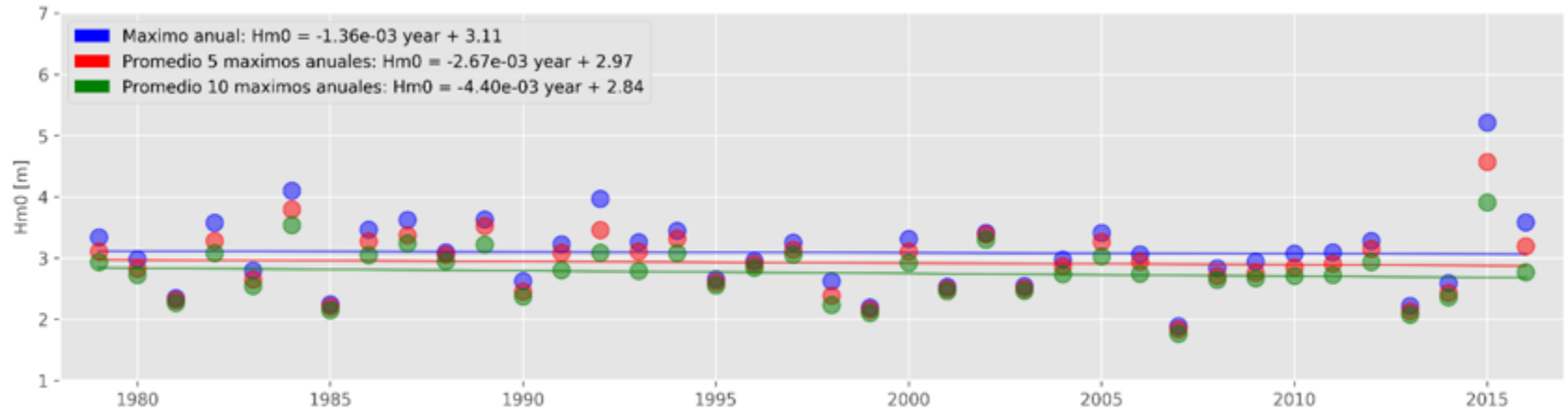


***Figura 3-16**: máximas alturas de oleaje por año frente a Av. Perú.*

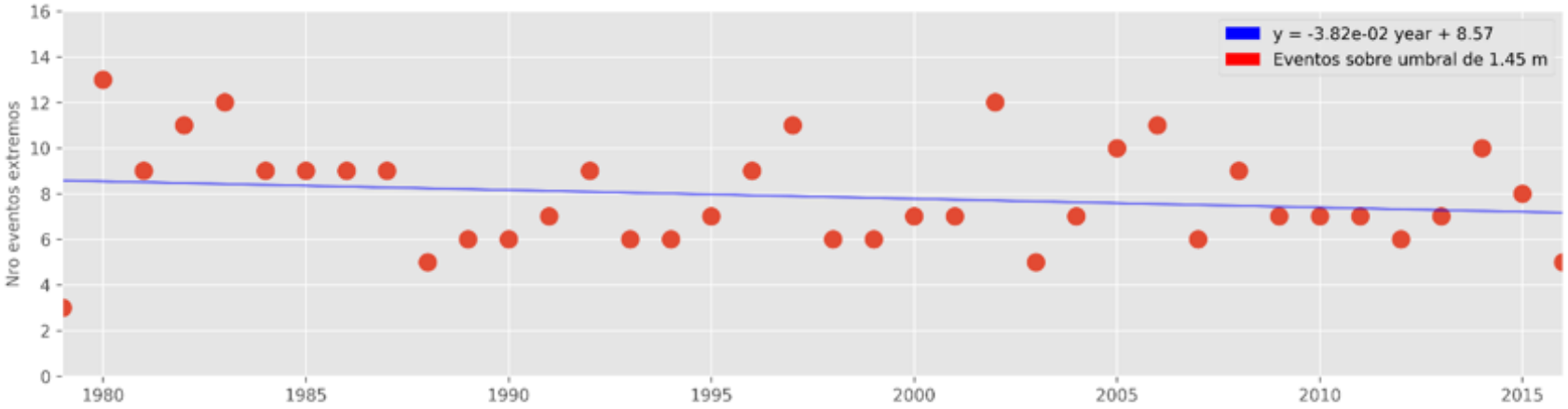


***Figura 3-18**: serie de tiempo del número de eventos extremos por año.*

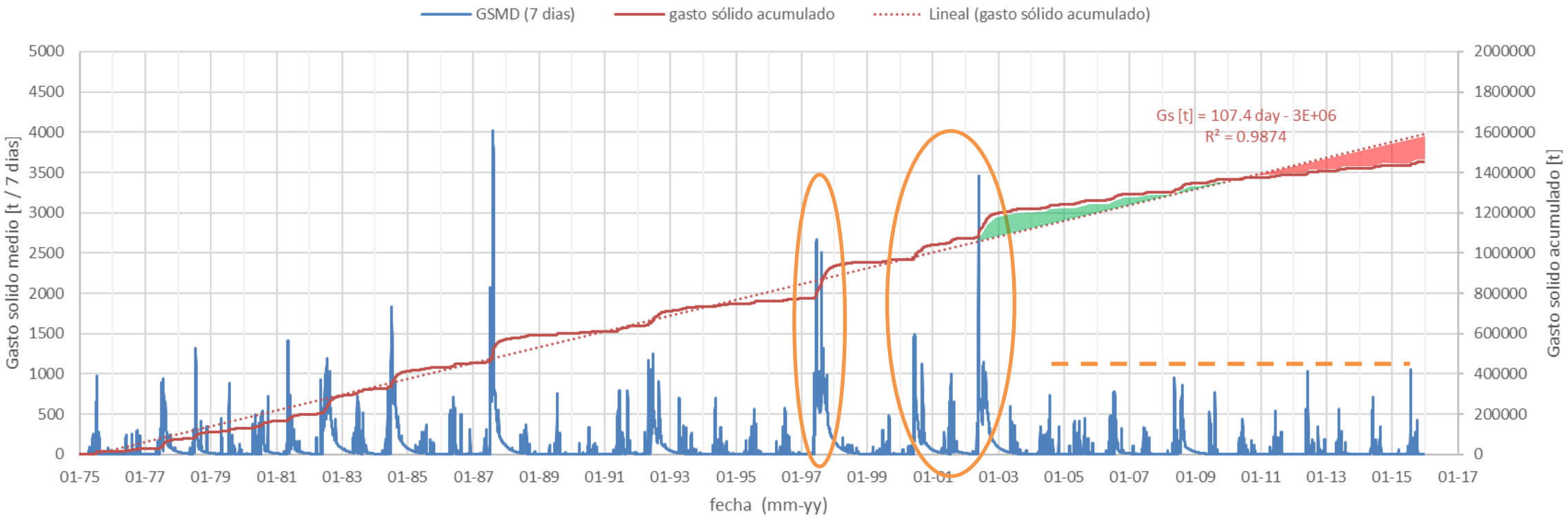
- So far, we have observed:
  - Average current field near zero
  - Each beach as closed system
  - Expected sediment supply consistent to longshore transport capacity
  - No long-term trends in wave forcing
  - (2018 beaches are fully recovered from 2015 event)

→ No structural erosion

Then why the beaches seem to be losing sand?

- Sediment supply from Marga Marga

Estimated sand supply from Marga Marga



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5. CONCLUSIONS

- Current are mostly wave-driven
  - Low persistent northward currents under normal conditions
  - Storms induce larger southward currents
  - Same trend for longshore transport
- Circulation cells are observed
  - Beaches are closed systems
- Cross-shore processes are dominant
  - Storm erosion moves sediment into offshore shallow water
  - Beach recovery occurs at longer time scales
- **No structural erosion is observed**
- Wave conditions don’t show a long-term rend
- Lack of sediment likely due to low discharges
  - Anthropogenic causes should be further investigated
  - Might imply future problems in longer time scales

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