Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

RISES-AM- EU Research Project

# NATURAL ACCRETION MECHANISMS IN DELTAIC SUSTAINABILITY. EBRE DELTA CASE

RESPONSES TO COASTAL CLIMATE CHANGE: INNOVATIVE STRATEGIES FOR HIGH END SCENARIOS –ADAPTATION AND MITIGATION–
**RISES –AM –**

**A. Sanchez-Arcilla, C. Ibañez, J. Jimenez, N. Caiola**

European Contract No. 603396

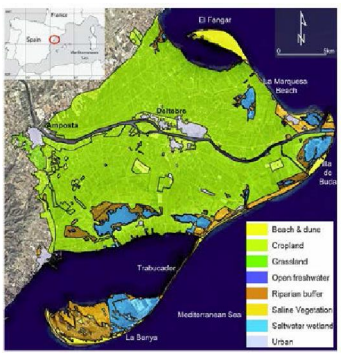
IRTA RECERCA I TECNOLOGIA AGROALIMENTÀRIES

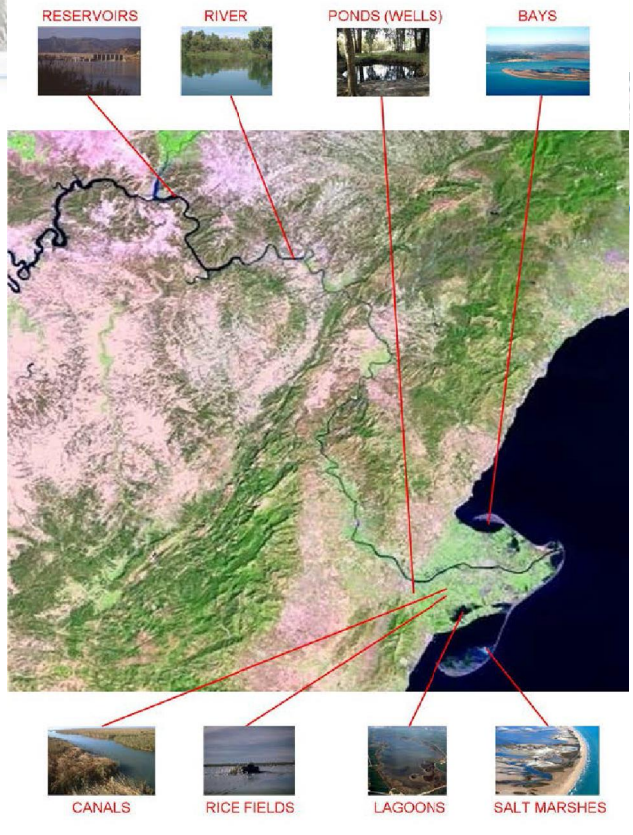
DELTAS IN TIMES OF CLIMATE CHANGE II
OPPORTUNITIES FOR PEOPLE, SCIENCE, CITIES AND BUSINESS

Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

## Contents

- Deltaic sustainability. Ebre delta
- Vertical / horizontal dynamics
- Future evolution
- Natural accretion mechanisms
- Conclusions




IRTA RECERCA I TECNOLOGIA AGROALIMENTÀRIES

DELTAS IN TIMES OF CLIMATE CHANGE II
OPPORTUNITIES FOR PEOPLE, SCIENCE, CITIES AND BUSINESS

Deltaic sustainability – Common perception
- ✓ No land loss, no flooding
- ✓ Maintain **present** uses
- ✓ **Short term** solutions (policy, costs)

180 dams + climate change for Ebre delta
- ✓ Subsidence
- ✓ Erosion

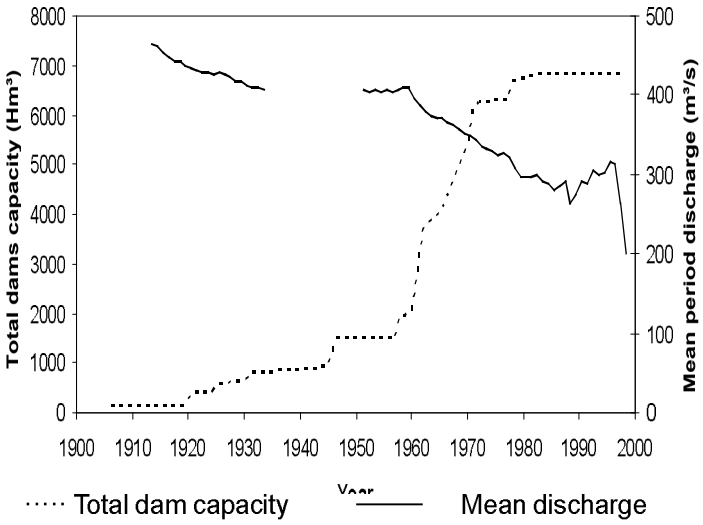

IRTA
RECERCA I TECNOLOGIA AGROALIMENTÀRIES

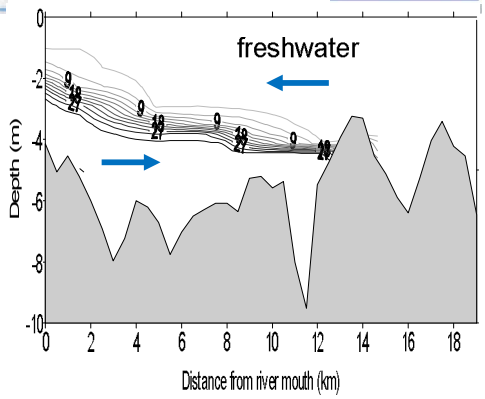
Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

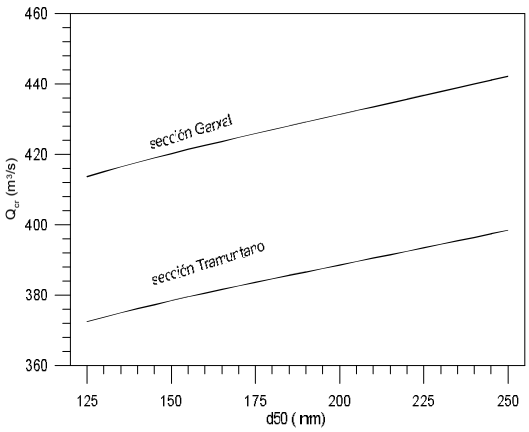
Deltaic sustainability
Ebre delta

RISES-AM- EU Research Project

Deltaic sustainability – Integrated river basin analysis
- ✓ Dam capacity and river regulation (water uses)
- ✓ Reduction of river floods (solid discharge)
- ✓ Increasing salinization



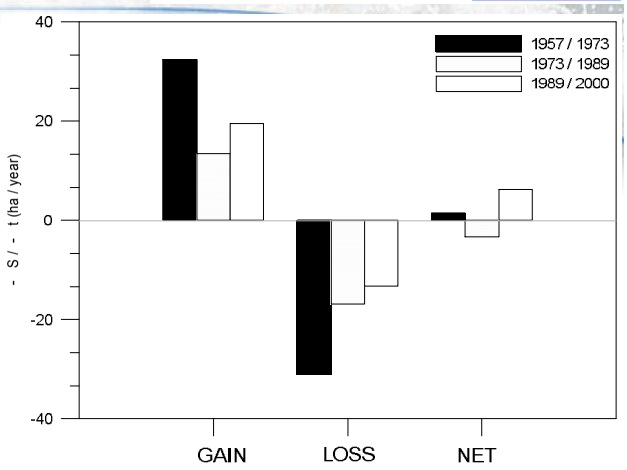

Threshold for sand transport

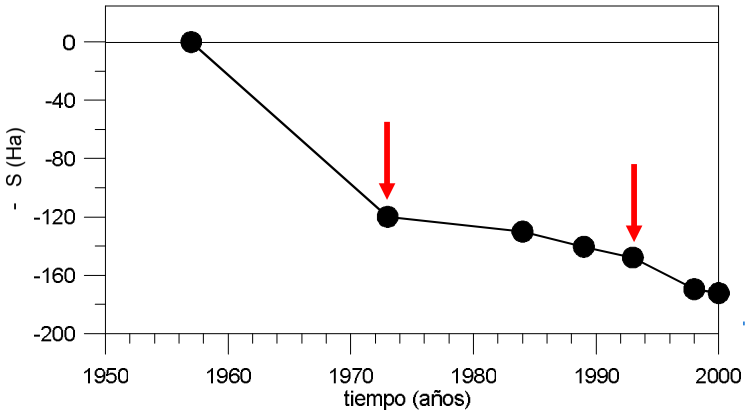
## Horizontal dynamics



Horizontal dynamics

- ✓ Erosion > accretion (total / local)
- ✓ Stabilization due to reshaping
- ✓ No longer pristine coast (starvation)



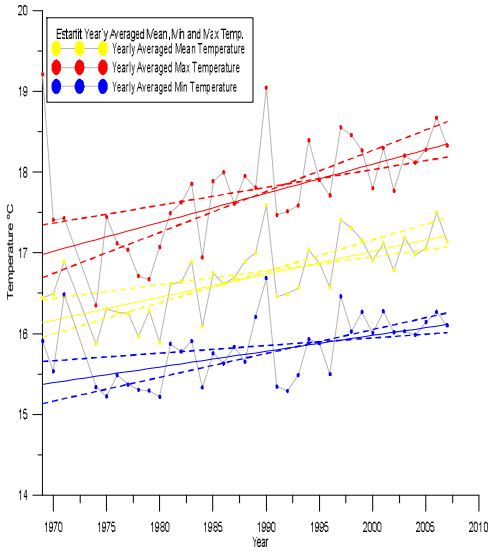



## Vertical dynamics

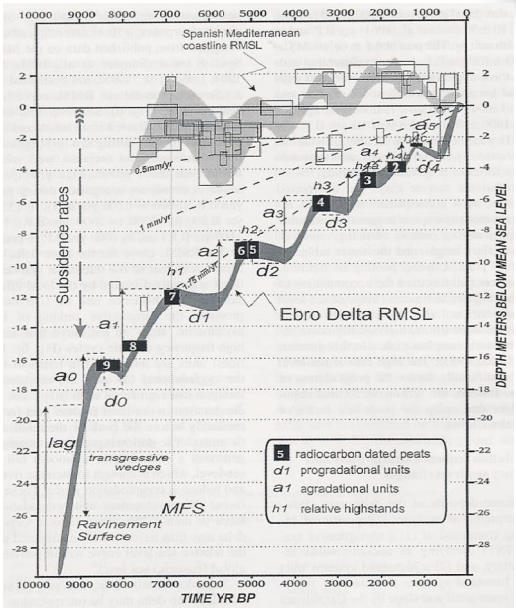
Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA
RISES-AM- EU Research Project

Vertical dynamics

- ✓ Affected by average SLR (regional) and surges
- ✓ Affected by organic and inorganic deposition
- ✓ Affected by subsidence

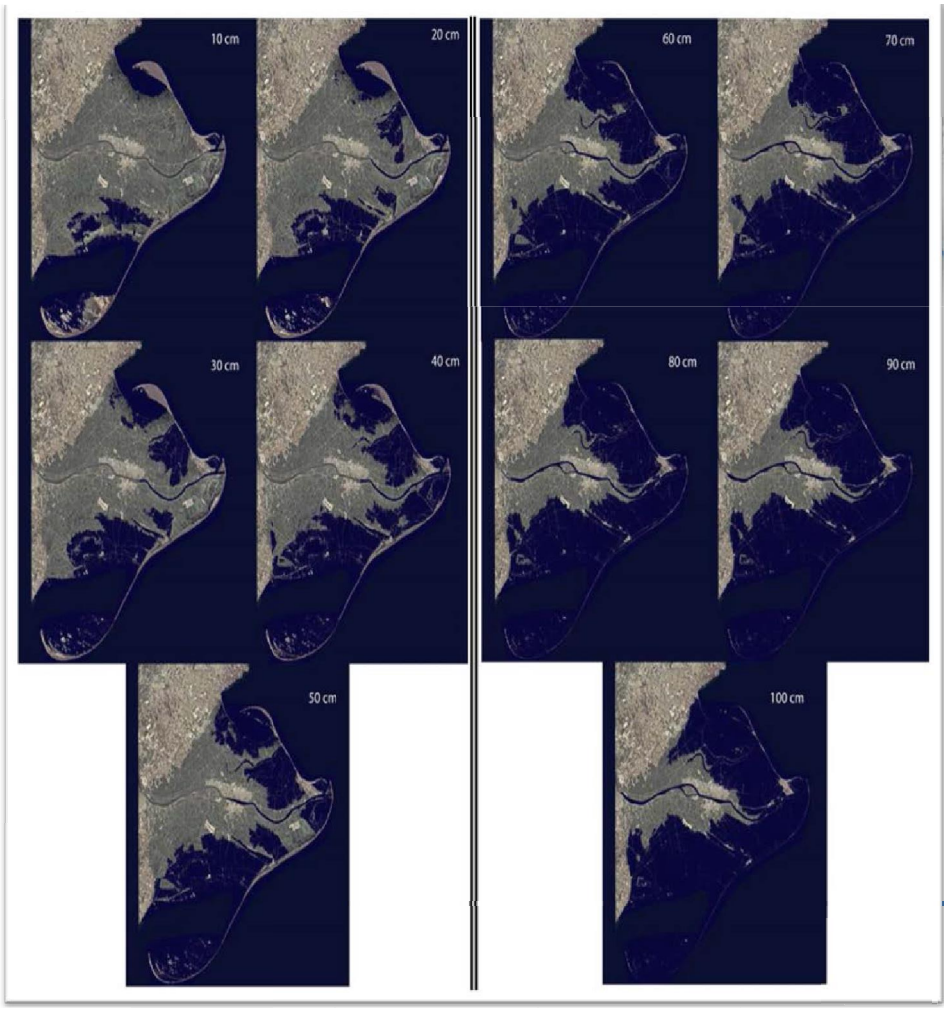



Holocene subsidence rates (Somoza et al 1998)



Natural deltaic response (SLR)

- ✓ Feed-back: **SLR-sedimentation-vertical accretion** (marshes & full delta)
- ✓ Pulsing events (**wave storms/river floods**) supply large sediment volumes naturally (deltaic resilience to CC)
- ✓ These **natural mechanisms** can be **enhanced** by human action (dam releases, controlled flooding…)




Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

Future evolution Waves

RISES-AM- EU Research Project

Coast **out of wave "equilibrium"** due to changes in wave direction in winter (5 GCM-RCM sets for SRES)

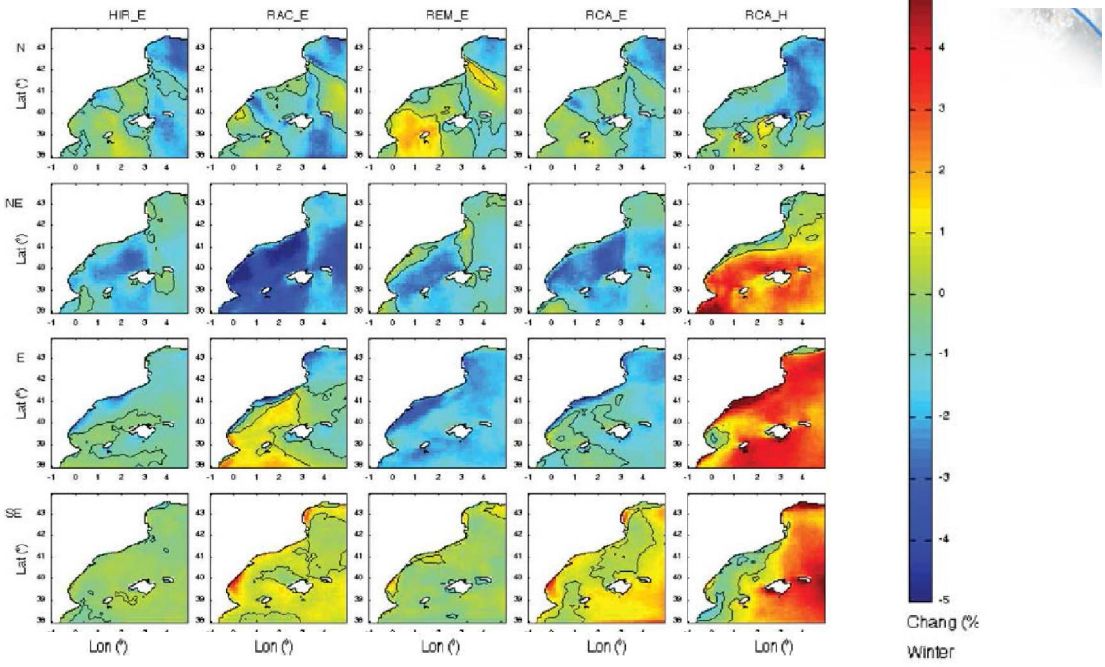
Directions

N (less freq)

NE

E

SE (more freq)




Projected changes in absolute value (relative values are higher, exceeding in some cases 100%)

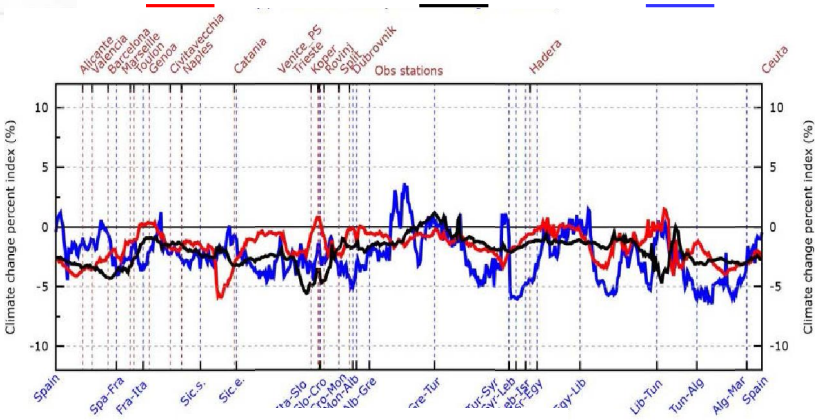
IRTA RECERCA I TECNOLOGIA AGROALIMENTÀRIES

Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

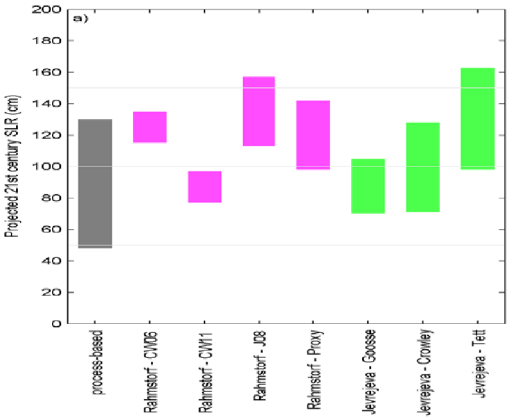
# Future evolution: SLR + storm surges + waves

Positive surges  Negative surges  Waves

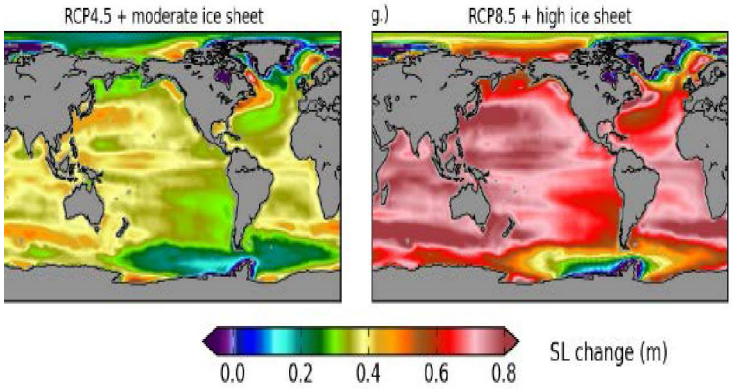
Projection of future conditions
- ✓ Downscaled scenarios
- ✓ Physical and socio-economic
- ✓ CC % index for surges (+/-)
- ✓ CC % index for waves
- ✓ Regional SLR




Conte and Lionello et al 2013




95% or "max" (Moore et al 2013)



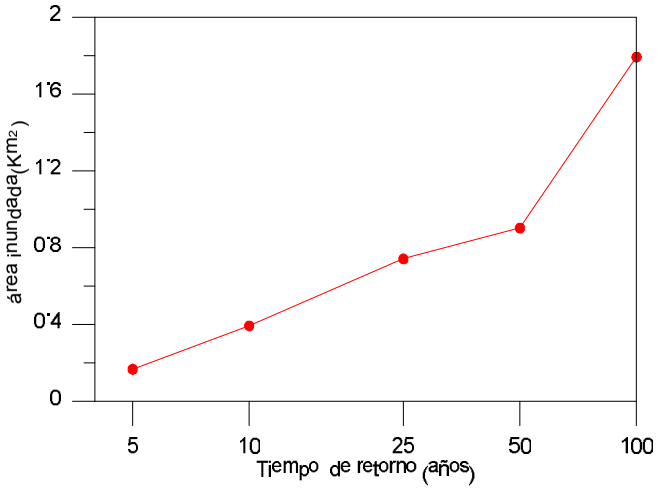

Combining regional MSL components (median projections)

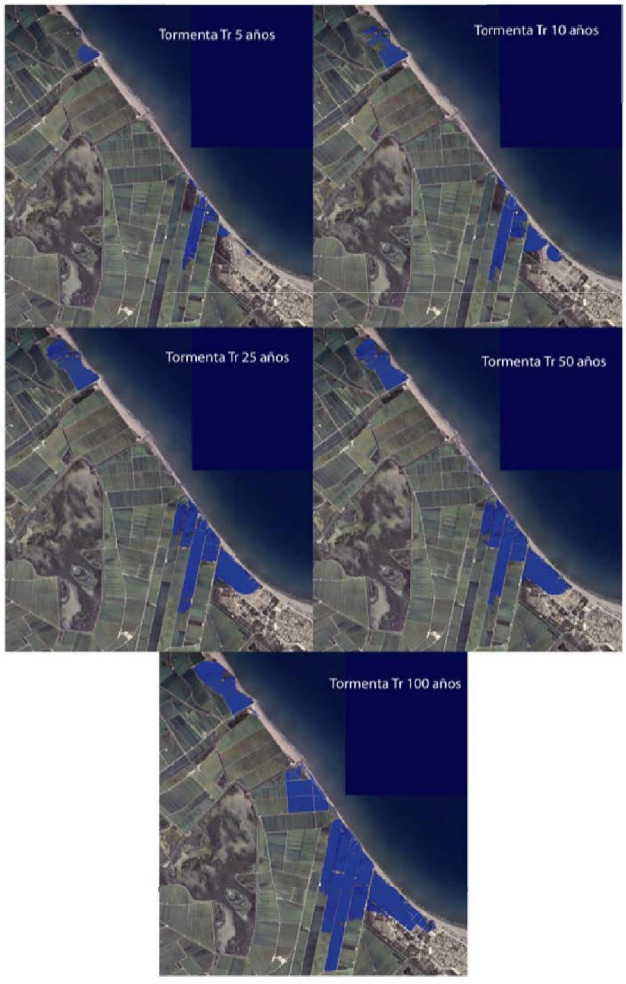
Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

# Future evolution

Projection of future conditions
Episodic scale (storms)

- ✓ Increased **flooding** (area vs Tr)
- ✓ Enhanced **erosion** (**accumulation**)




IRTA
RECERCA I TECNOLOGIA AGROALIMENTÀRIES

Sustainability (present and mainly future) → working with Natural processes (~~against~~)

- ✓ Reduced cost and risk (economic sustainability)
- ✓ Reduced impact (environmental sustainability)
- ✓ Reduced sediment volumes (energetic sustainability)

Based on enhancing **natural accretion**

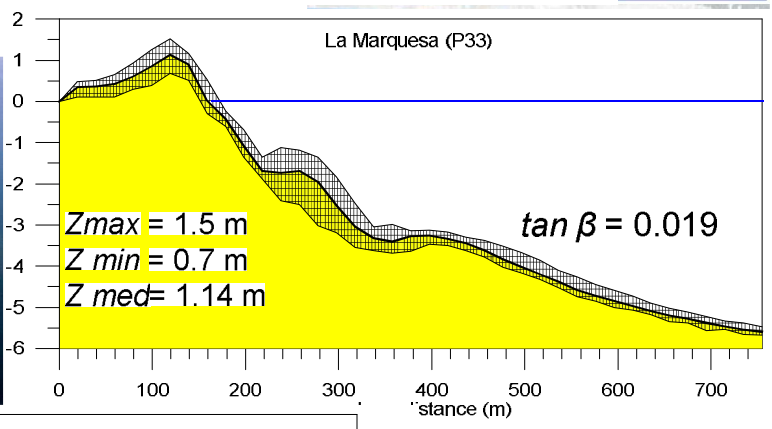
Novel interventions:

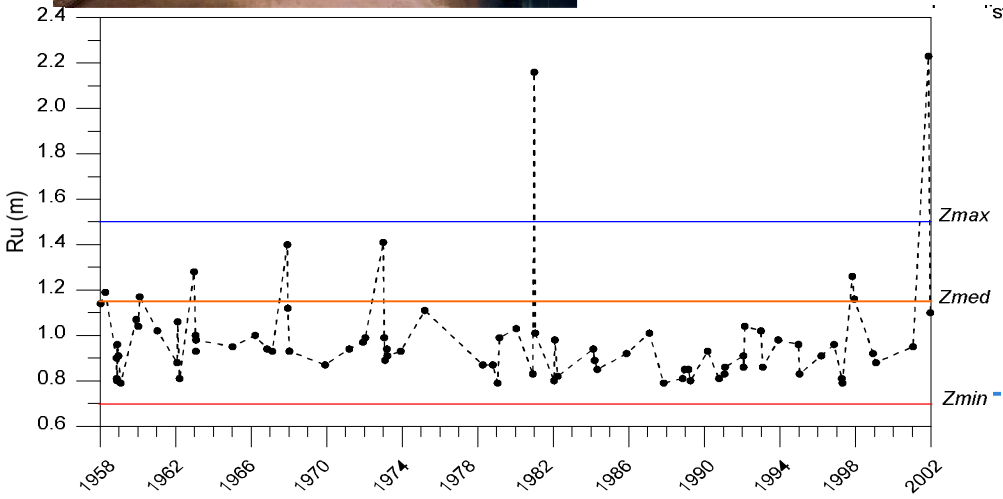
- ○ Promote vertical accretion
- ○ Flooding offsetting subsidence

IRTA RECERCA I TECNOLOGIA AGROALIMENTÀRIES

Natural accretion - I
RISES-AM- EU Research Project

**La Marquesa beach**




**Ru time series For storm events**

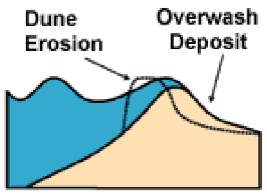
- ▪81 storm events (ave 1.84 events/year)
- ▪44 years (Stockdon model)
- ▪ Shown overwash events (*Ru* > *Zbeach*) for evolving profiles

## Overwash transport

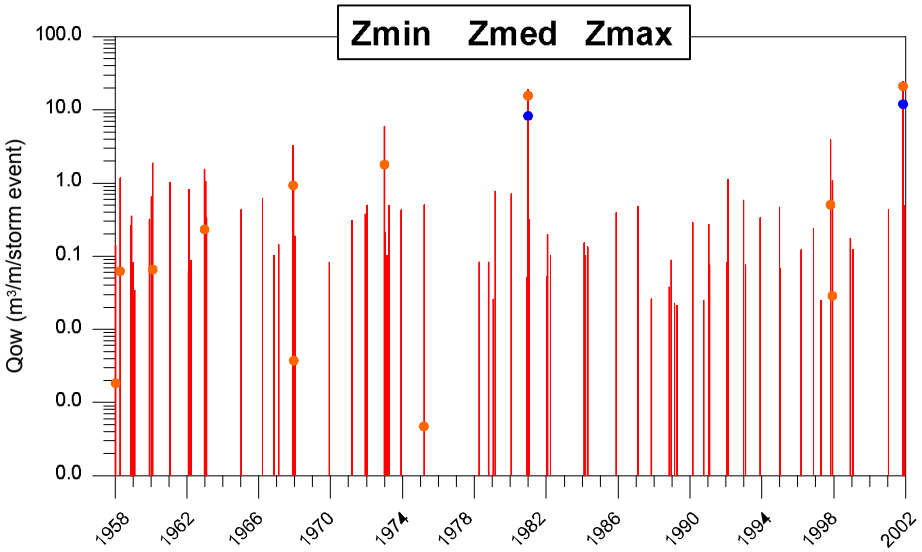
- Landward transport when Ru > beach berm height/dune (calibrated locally)
- Values integrated over storm duration ($m^3/m/storm$) with Nguyen et al 2006 model

$$Q = 0.0011 \frac{H_c}{R} \frac{t_D}{T} (R - H_c)^2$$

$H_c$: Beach/dune height
$R$: Runup
$t_D$: storm duration (above Hc)
$T$: wave period




overwash



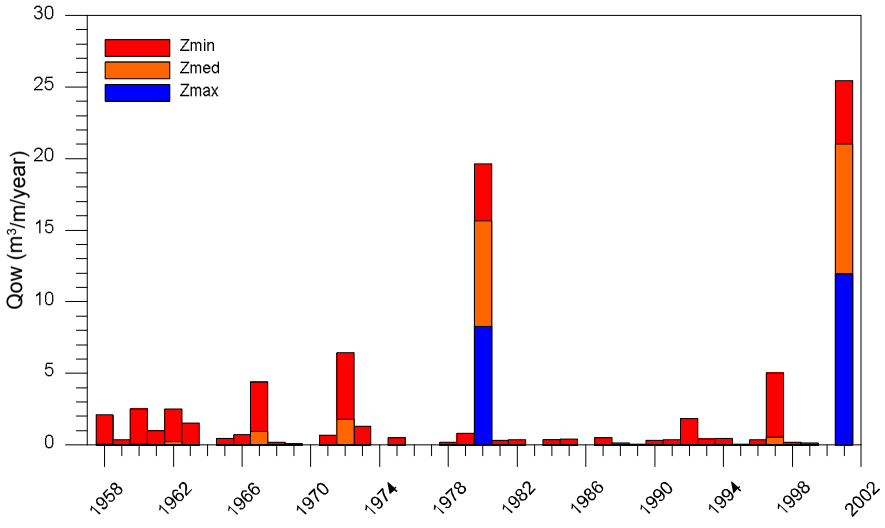

Estimations for storm events exceeding beach berm height for evolving profiles

Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA
Natural accretion - I
RISES-AM- EU Research Project

## Overwash transport

- Yearly integrated overwash transport ($m^3/m/year$) for evolving beach profiles

**Zmin Zmed Zmax**



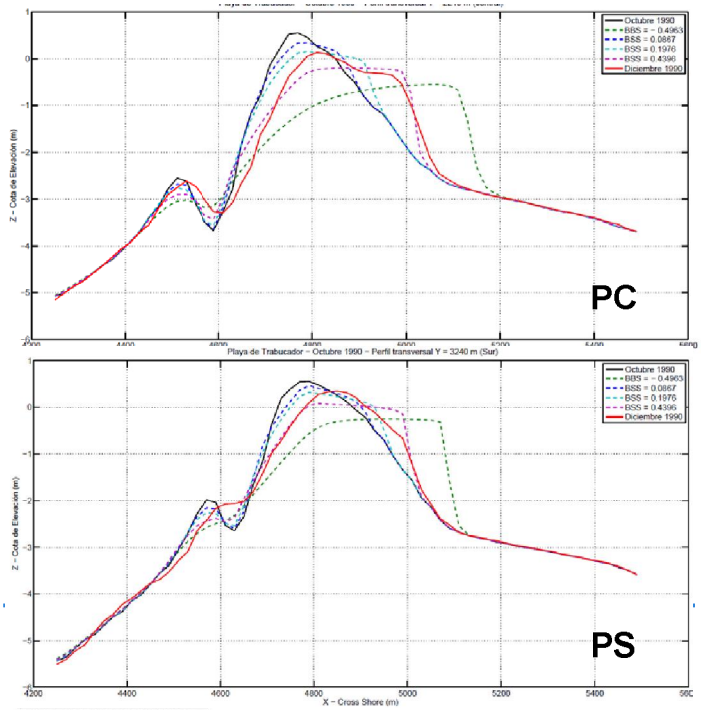

| | Q_av | Q_mx |
|---|---|---|
| Zmin | 1.86 | 25.4 |
| Zmed | 0.91 | 21 |
| Zmax | 0.64 | 20.2 |

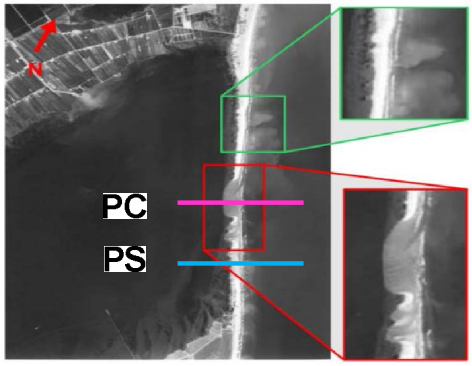
Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

## Natural accretion - II

Accretion by overwash and rollover → Natural process

- ✓ Related to bar rotation and migration
- ✓ Source for lagoons (plain)
- ✓ Sink for coastal fringe




PREMOS model
Calibrated for Oct 1990 storm (Tr=5y)
$BSS_{ave}$ = 0.44 (acceptable)

Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

## Natural accretion - III
## Sediment trapping by vegetation

Plant canopy effect reduces bed mobility → Natural processes

- ✓ Reduced near bed velocities and erosion
- ✓ Increased sediment trapping
- ✓ Quantified in Nature and by large scale flume tests (e.g. CIEM in Barcelona)

- **Deltas** are **vulnerable** to climatic factors but can have **greater resilience** than other coasts if **natural accretion** mechanisms are enhanced
- **Pulsing events** provide large amounts of natural energy and can be "used" to enhance *morphodynamic resilience* (**marine + riverine** flooding)
- **Rising grounds** (+ rising dikes) may prove to be the most **efficient** solution under future **high end conditions** (otherwise only retreat will be possible)
- Past practice (**siltation from irrigation**, accretion rates of 0.5 cm/y with 5% of Ebre river flow) show an **adaptive pathway** for *deltas under climate change*

IRTA
RECERCA I TECNOLOGIA AGROALIMENTÀRIES

Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA
Conclusions
RISES-AM-
EU Research Project
Deltas are vulnerable to climatic factors but can have greater resilience than other coasts if natural accretion mechanisms are enhanced
Pulsing events provide large amounts of natural energy and can be "used" to enhance morphodynamic resilience (marine + riverine flooding)
Rising grounds (+ rising dikes) may prove to be the most efficient solution under future high end conditions (otherwise only retreat will be possible)
Past practice (siltation from irrigation, accretion rates of 0.5 cm/y with 5% of Ebre river flow) show an adaptive pathway for deltas under climate change

THANKS!

IRTA
RECERCA I TECNOLOGIA AGROALIMENTÀRIES