SLR-induced enhancement of the role of surges in coastal flooding in the Ebro delta.

R. Romero*, M. Sanuy & J.A. Jiménez*

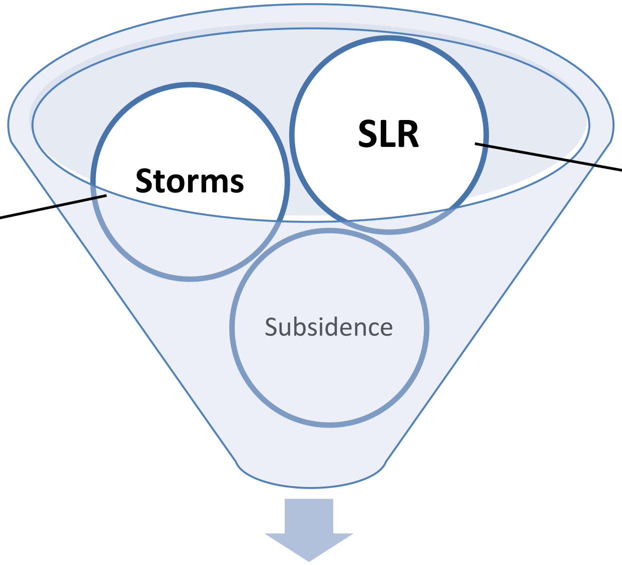
rut.romero@upc.edu

Laboratori d'Enginyeria Marítima
Universitat Politècnica de Catalunya·BarcelonaTech
Barcelona, Spain

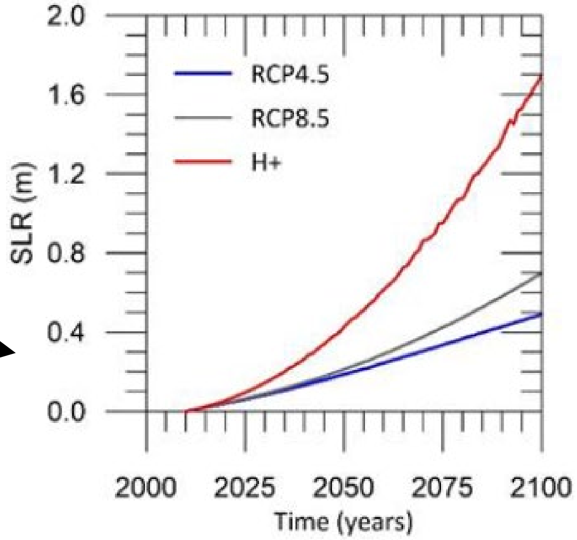
Introduction

Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

Inundation of the Ebro delta plain during the impact of Gloria storm (01/2020) (source: *El Periodico*)



↑ **Flooding** (frequency & intensity)
of low-lying deltaic areas



SLR projections (López-Doriga & Jiménez, 2020)

The **increasing flooding** (intensity & frequency) of low-lying coasts under the influence of **sea level rise** can be considered a **serious threat**, as it is a precursor to their permanent inundation and submergence (Nicholls, 2002).

One of the **most sensitive areas** to this impact are lowlands along the NW Mediterranean coasts, specially those **sheltered from wave action and subjected to low-magnitude storm surges** (max surges up to approx. 0.5 m) which are seldomly inundated except under the impact of extreme storms.

Under these conditions, small changes in mean water level may imply a drastic change in their inundation regime, and as a consequence, in their risk profile to flooding.

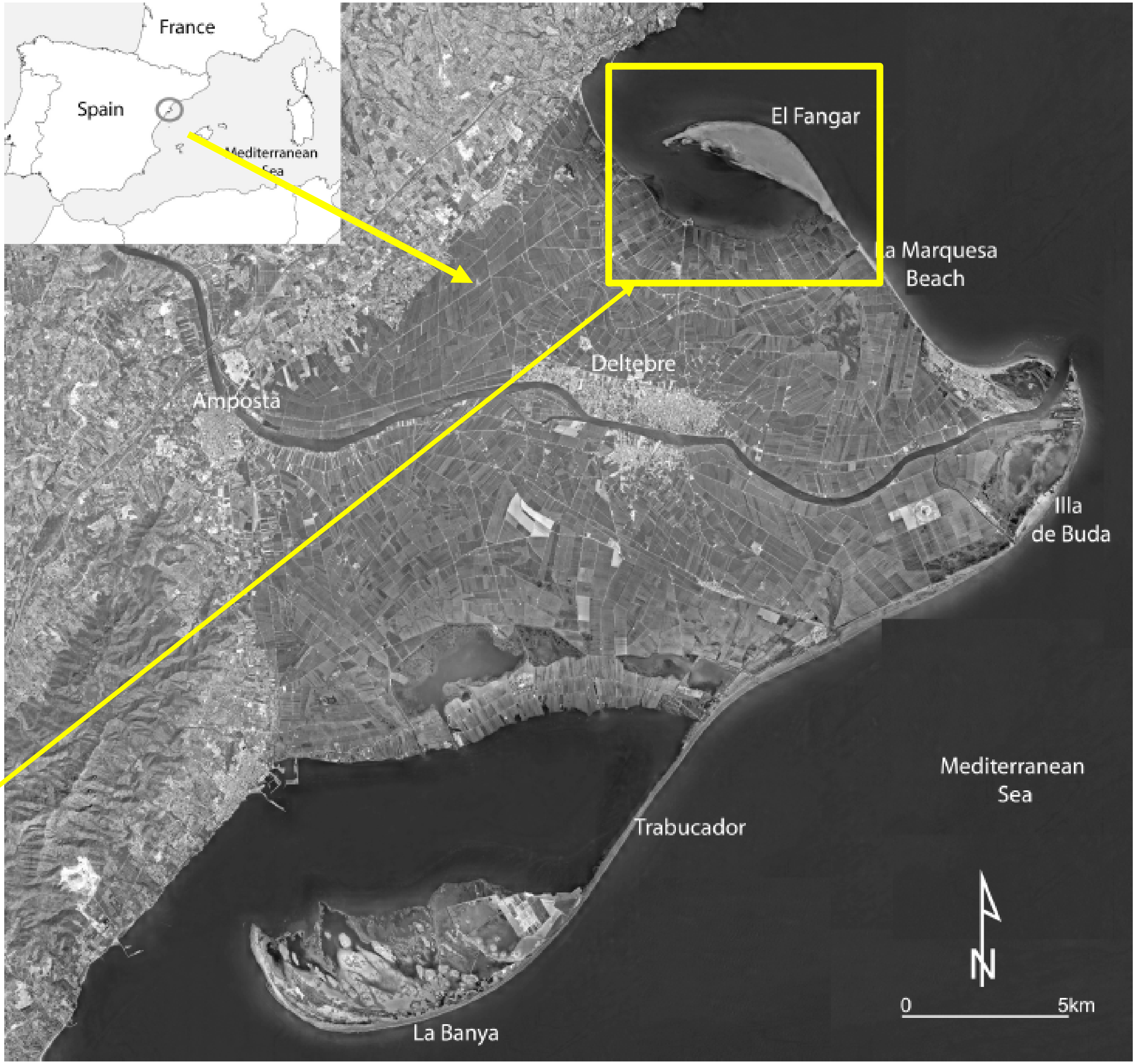
Objective

To assess the influence of sea level rise on the **storm surge-induced inundation regime (intensity)** in a **highly sensitive low-lying area** of the Mediterranean, the Ebro delta.

Study area

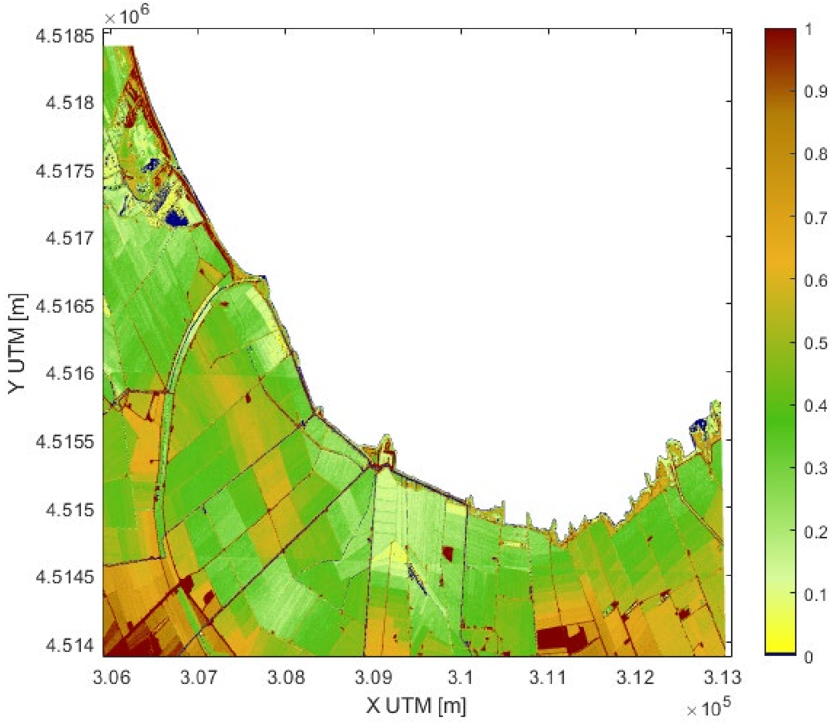
Ebro delta

- **NW Mediterranean**
- **Microtidal** range → 0.2 m
- **Low-lying** area → (about 50 % of the plain below + 0.5 m elevation)
- Main land use → 75% **agriculture (rice)**
- **Plain crisscrossed by channels and levees** for rice fields.
- Focus on **Fangar Bay** (passive shoreline) and sheltered from wave action.



Strategy

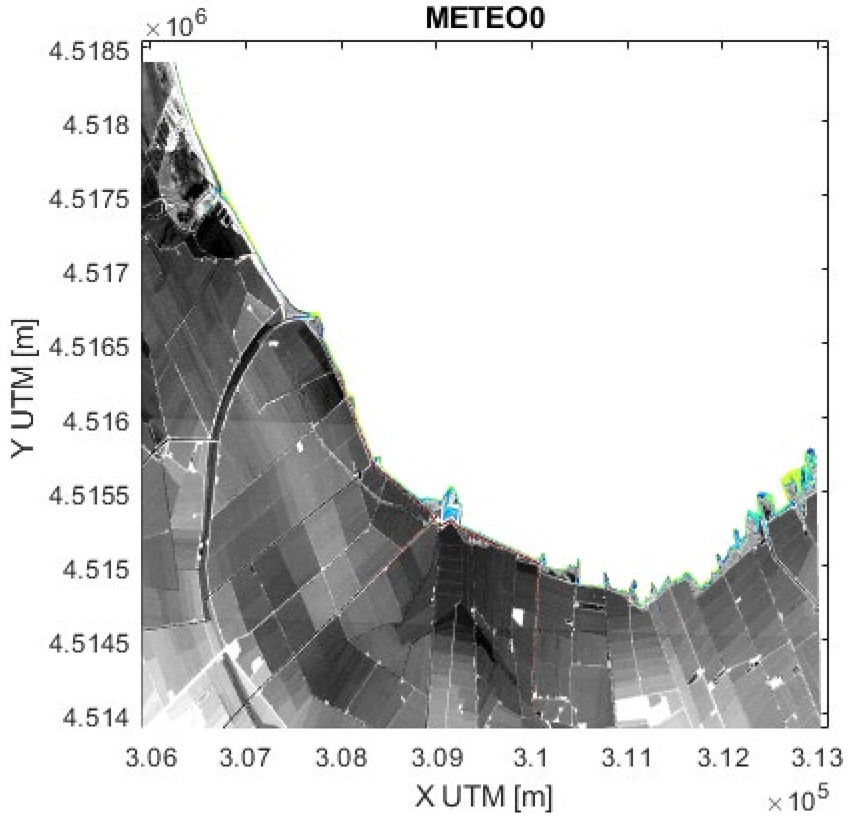
Inundation modelling of the **internal coast of the bay** under the impact of an **extreme storm solely by storm surge** under **current conditions** and under given **SLR scenarios**.



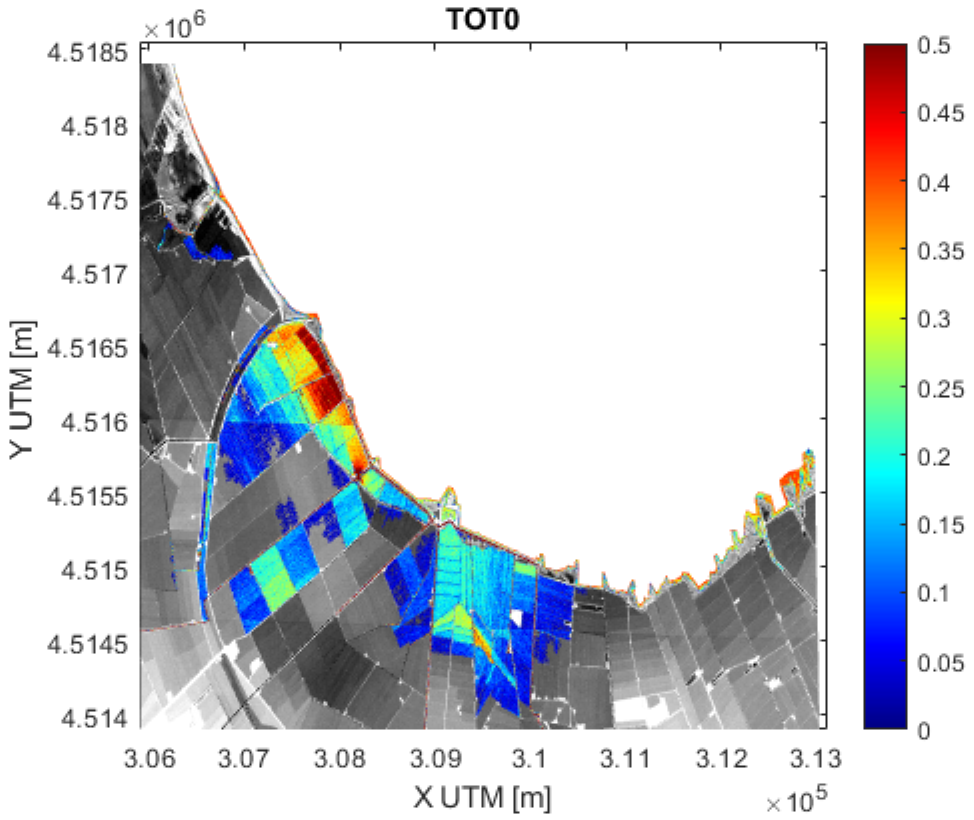
- **Topography: DTM 5 x 5** (ICGC)

- **LISFLOOD-FP** (Bates et al. 2005)
- **Acceleration** solver → convective acceleration negligible
- **Manning's** coefficient → arable soil
- Without **infiltration** (water saturated soil)
- **Storm boundary conditions** → complete time series of mean water level recorded during **Gloria storm** (96 h) (Puertos del Estado) (water level elevation record)
- Water level scenarios → **Storm surge/Total water level** + 0, 5, 10, 15, 20 cm (to test impact of relatively low SLR)

Current conditions

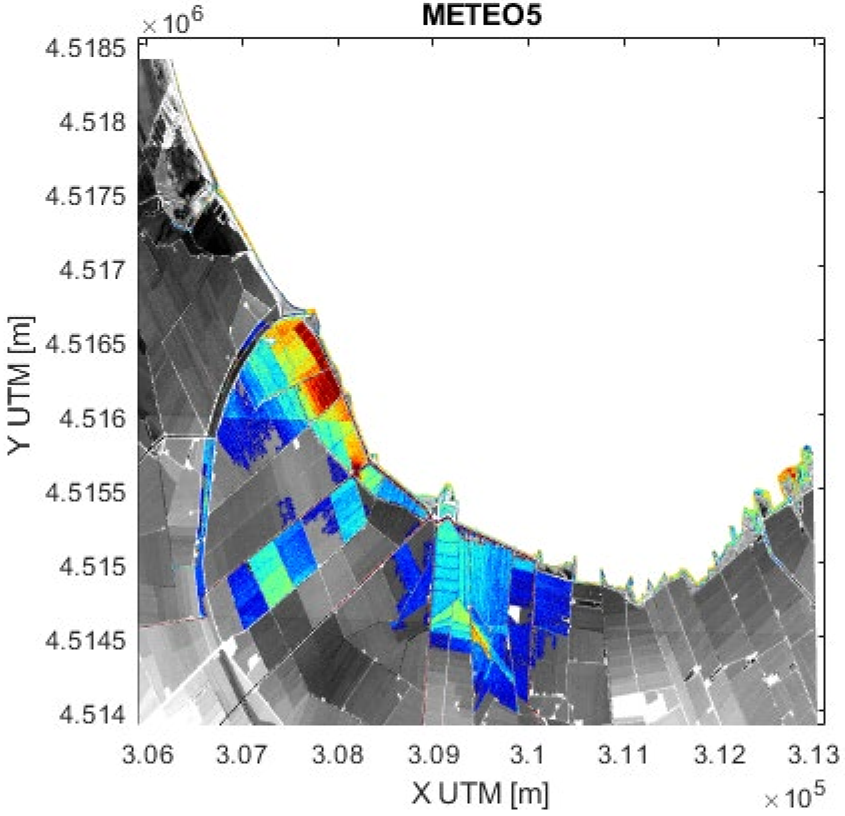


Storm surge

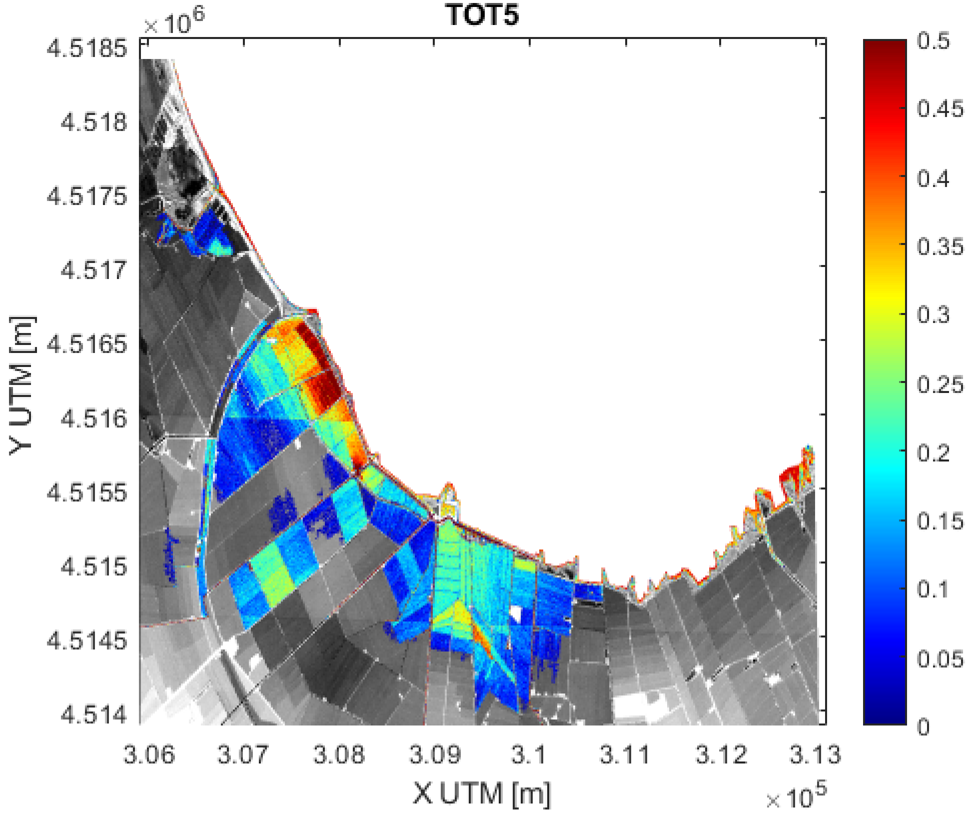


Total Water Level

SLR 5 cm

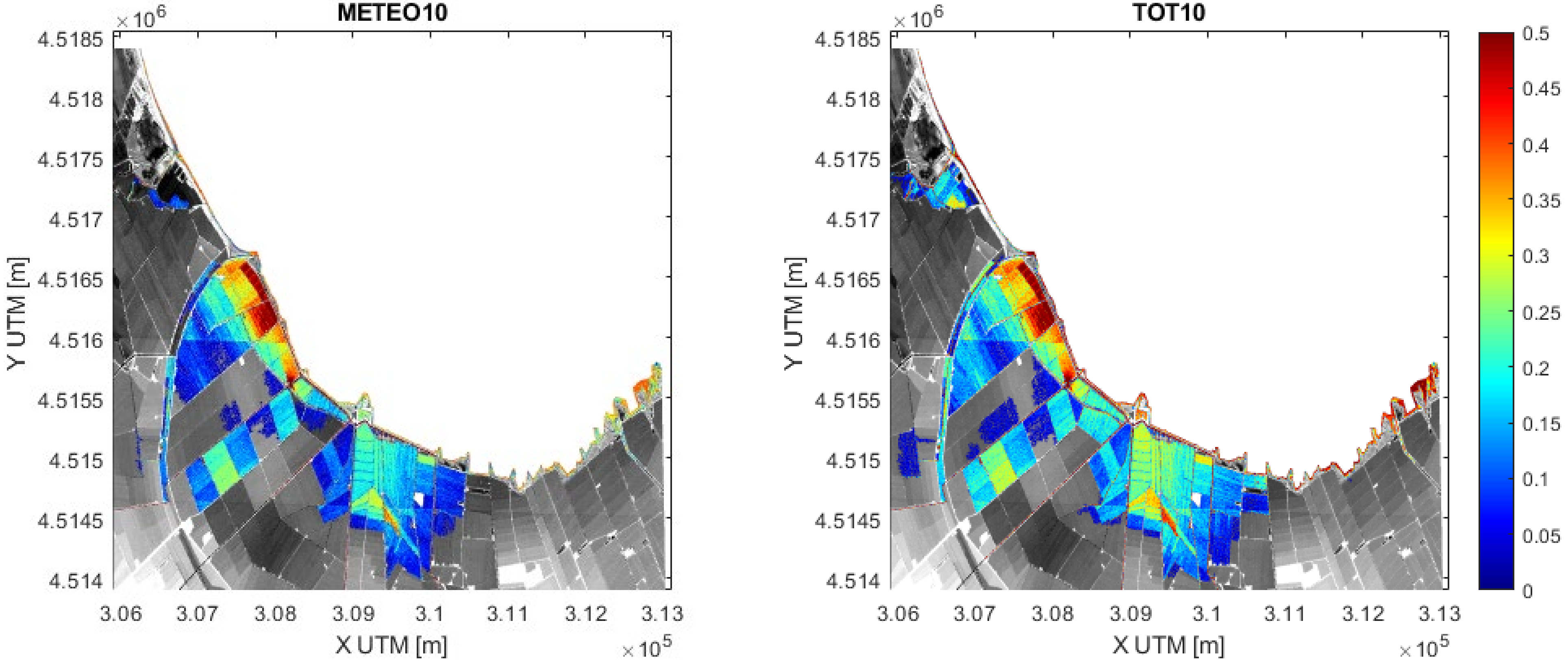


Storm surge



Total Water Level

SLR 10 cm

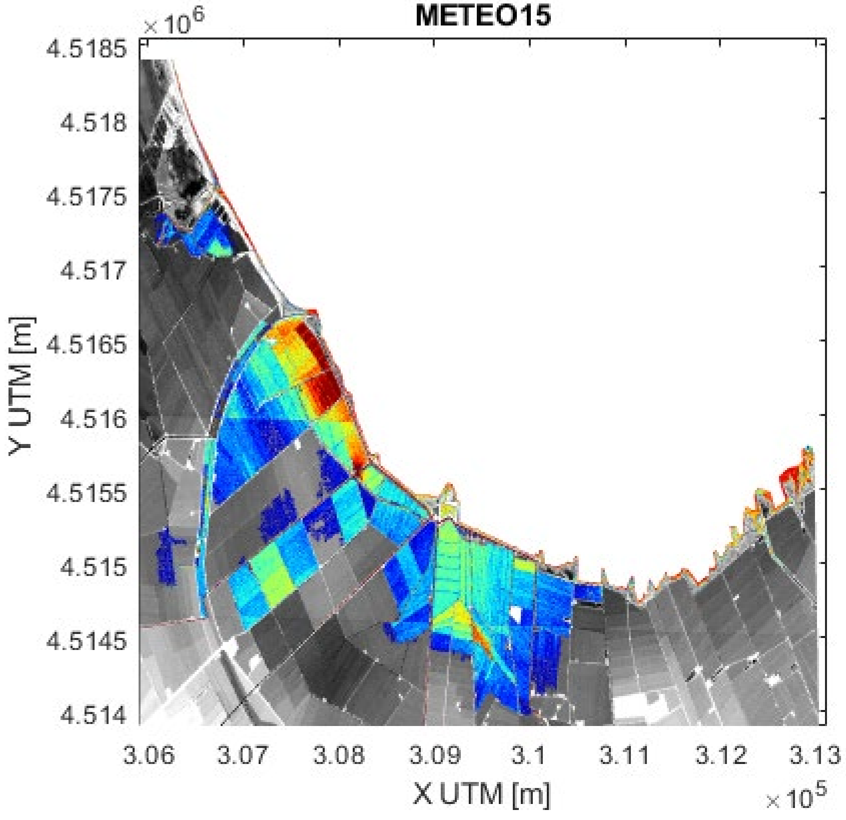


Storm surge

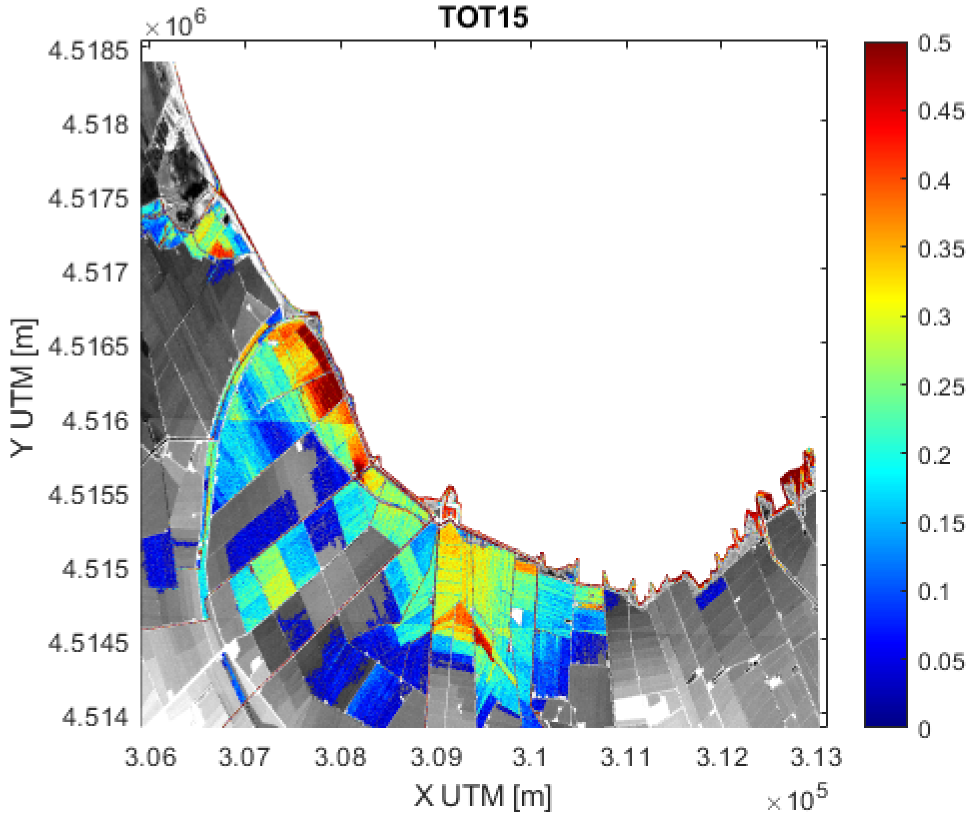
Total Water Level

Results

SLR 15 cm

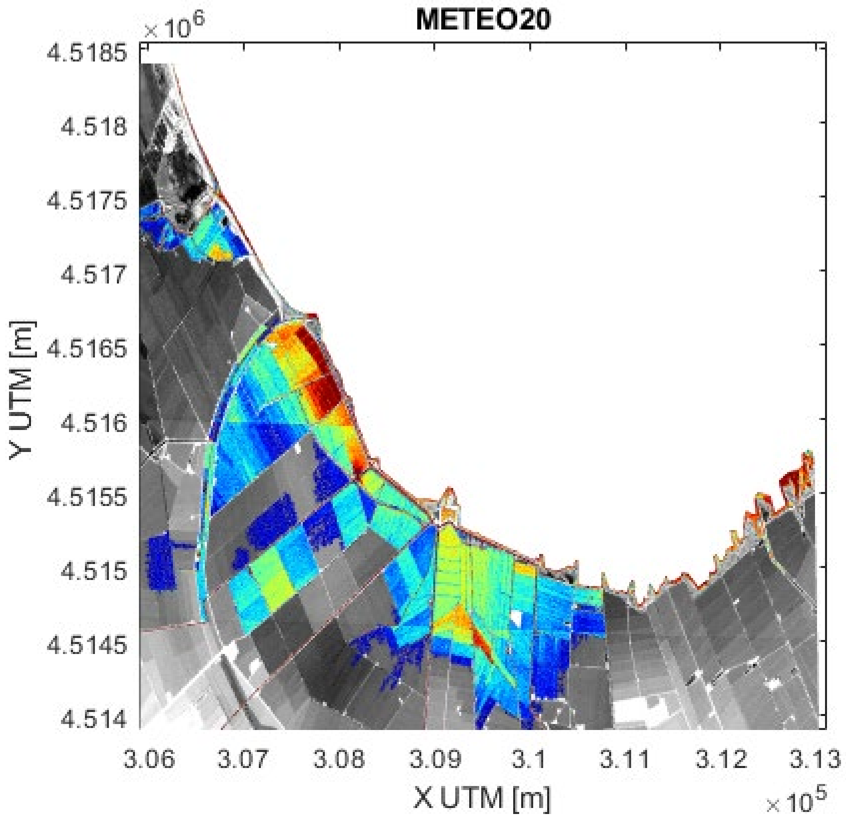


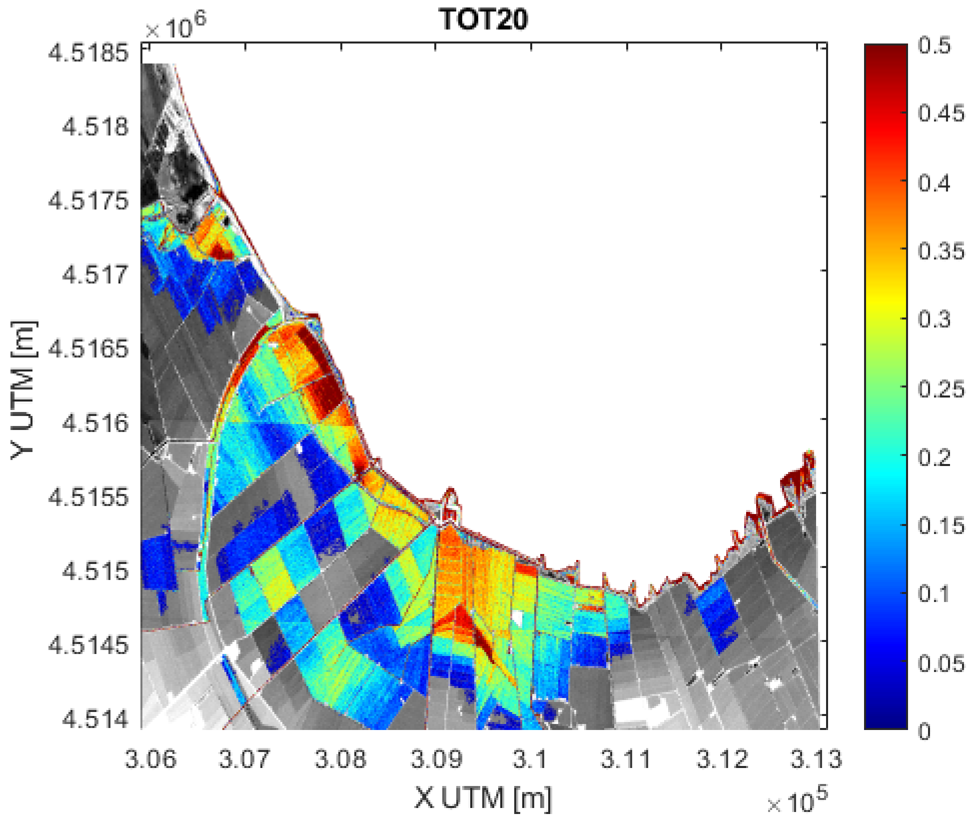
Storm surge



Total Water Level

SLR 20 cm

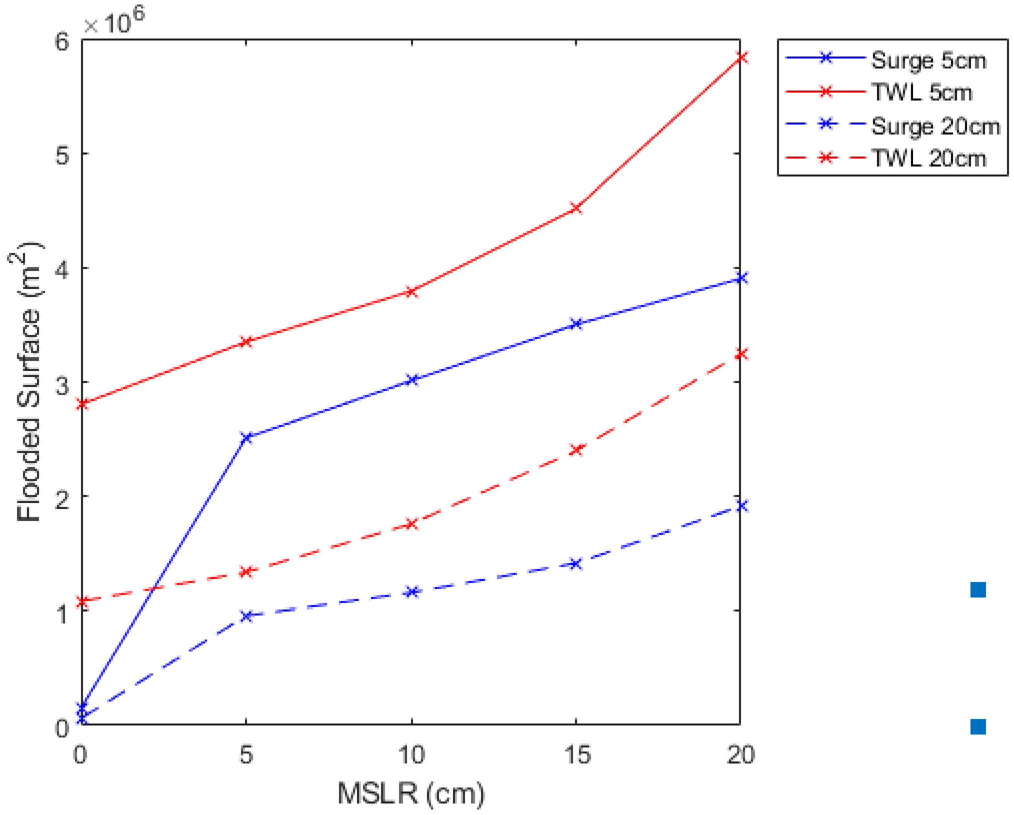




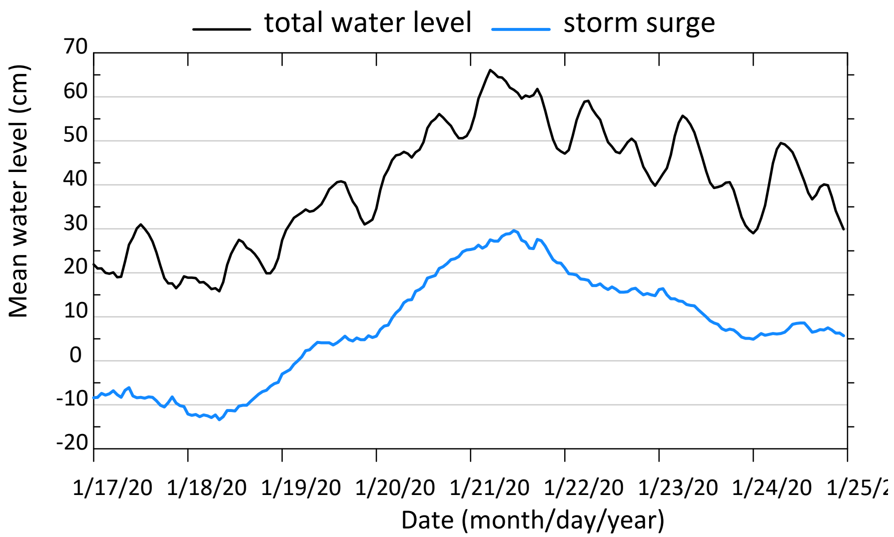
Storm surge **Total Water Level**

Laboratori d'Enginyeria Marítima
UNIVERSITAT POLITÈCNICA DE CATALUNYA

- Even though it is a microtidal environment, due to small magnitude of surges, the synergic action of astronomical tide and storm-surge is the driving force to flood the delta along the sheltered areas (without wave action).



Evolution of the surface flooded *by storm surge under different SLR scenarios.*



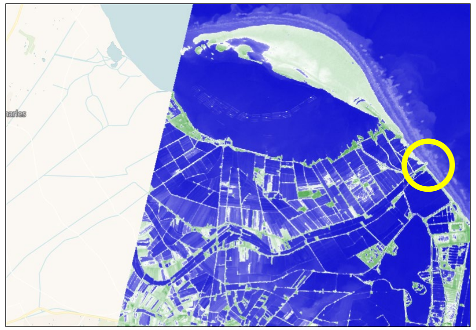
- Small variations in MWL induce significant increases of the flooded surface by storm surges. changes
- The increase in MWL of 20 cm **potentially doubles** the surface flooded in the area.

Results

(source: *El Pais*)

- The extension of the inundation in the deltaic plain **is conditioned by the existence of a dense network of canals and dikes/levees associated with the rice pads**, so that the extent of flooding is not necessarily proportional to the increase of water level →

  This is reflected in the results for cases of a SLR > 10 cm, where no proportional increase in flooded area is observed (faster increase).



(source: *ACN*)

- In addition to the storm-surge component analyzed here, under the impact of extreme storms, the wave-induced breaching and overtopping of a narrow and low-lying beach will contribute significantly to floodwater volumes entering the deltaic plain.

Conclusions

- Under current conditions, the inundation of the Ebro delta through **sheltered areas** such as inner bays during storms is mainly **restricted to very extreme conditions** where the **synergic action of a small astronomical tide and highest values of storm surges** contribute to total water levels exceeding the required threshold to inundate the area.

- When considering the effect of sea level rise, the **magnitude** of the storm-induced **flooding will significantly increase** even **under low SLR rates** (e.g. for tested conditions, the inundated surface will double under just a SLR of 20 cm). This is critical since the **inner shoreline along the bays is passive**, and will not react/adapt to SLR (as the outer coast will do). Thus, it is expected an increase of the importance of these type of events in the area at a relatively short time horizon.

- The existing network of channels and dikes segmenting the deltaic plain **modulates the extension of the inundation** as floodwater will be distributed through channels and/or confined within pads. This permits a rapid distribution of floodwater through the plain (reaching relative distant locations) but, at the same time, could be used to design "easy-to-implement" adaptation measures such as floodgates.

M-CostAdapt Project

http://mcostadapt.upc.edu

CTM2017-83655-C2-1-R

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

AGENCIA ESTATAL DE INVESTIGACIÓN

Unión Europea
Fondo Europeo de Desarrollo Regional
"Una manera de hacer Europa"

Data

Puertos del Estado
Institut Cartogràfic i Geològic de Catalunya