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UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Departament de Física Aplicada

CLIMATE CHANGE IMPACT ON BEACHES

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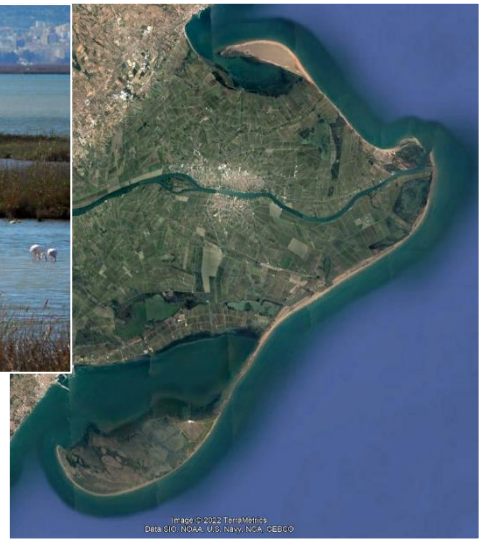
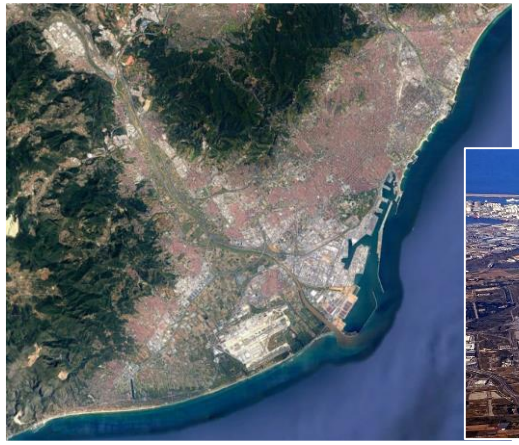




MOTIVATION

- **Inundation** during storms

Garraf beach, south of Barcelona

...inundation during a strong storm in Nov. 2001

MOTIVATION

- **Inundation** during storms
- **Erosion** produced by storms

Barcelona beaches

Common erosion problems

April 2016

Barcelona exige medidas que eviten la pérdida de arena en las playas

El Ayuntamiento denuncia que la de la Barceloneta ha perdido el 28 % de su superficie desde 2010

EFE

Barcelona - 8 ABR 2016 - 18:15 CEST

- **IPCC reports:** existing **inundation and erosion problems will worsen**

PRESENTATION TOPIC

What will be the impact of climate change on sandy beaches?

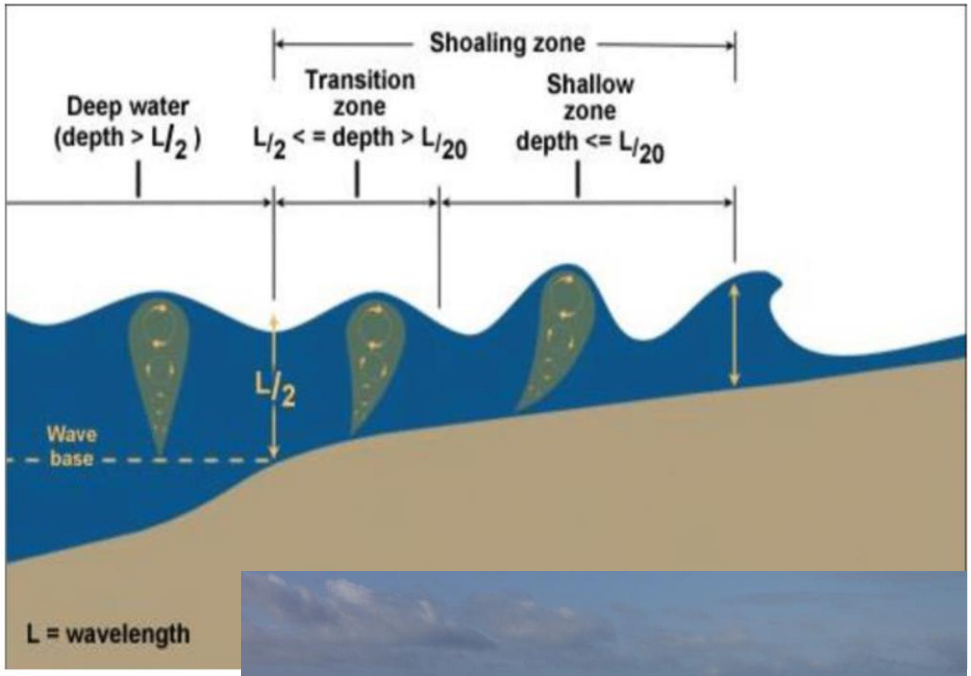
How do we model it? What are the associated uncertainties?

OUTLINE OF THE PRESENTATION

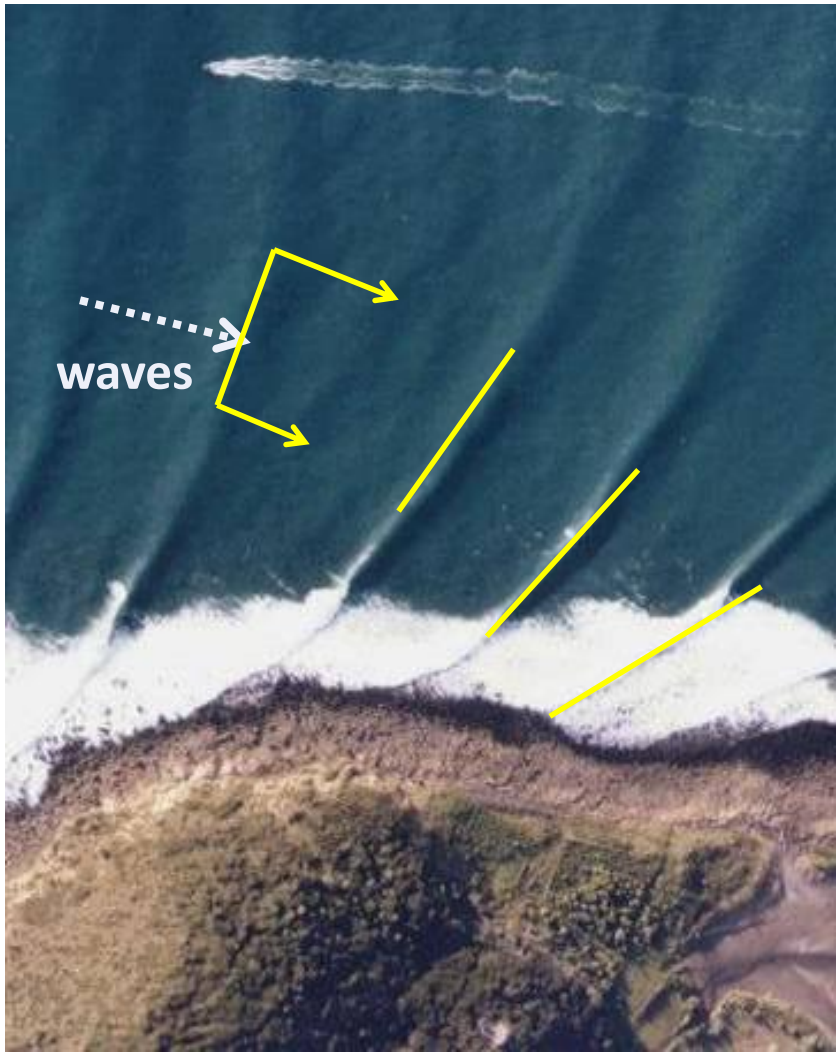
1. Motivation
2. Basic beach processes
3. Climate change effects on beaches
4. Unveiling the future of our beaches

SANDY BEACH MORPHODYNAMICS: BASIC PROCESSES

Wave shoaling and breaking



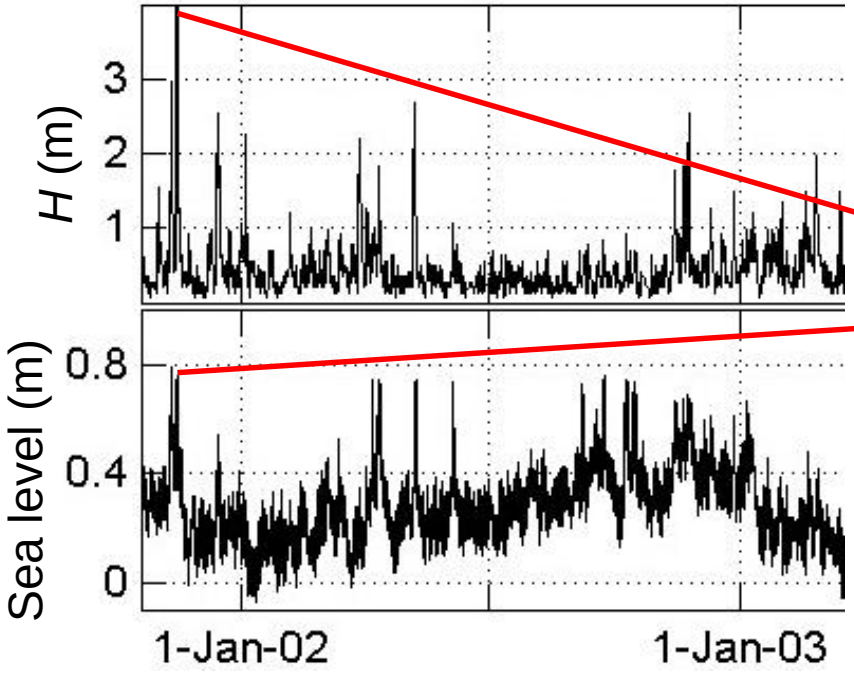
Wave refraction



SANDY BEACH MORPHODYNAMICS: BASIC PROCESSES

Mean sea level variations

- **Tides** → sea level changes from 20 cm (Catalonia) to 12 m (Canada)
- **Storm surges** → sea level over-elevation by low atmospheric pressure



Garraf beach, Nov. 2001

SANDY BEACH MORPHODYNAMICS: BASIC PROCESSES

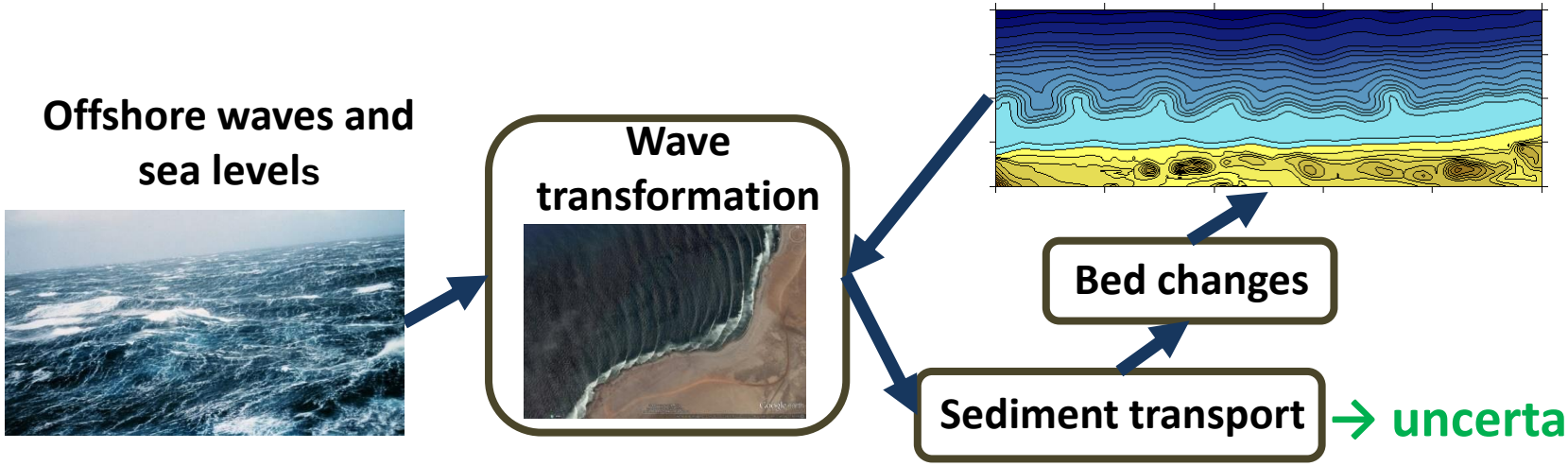
Sediment transport processes

- **Extremely complex:** still **many unknowns**

Amoudry and Souza, 2011

"…empirical formulas have nonnegligible uncertainty and are often only accurate within a factor of 5–10."

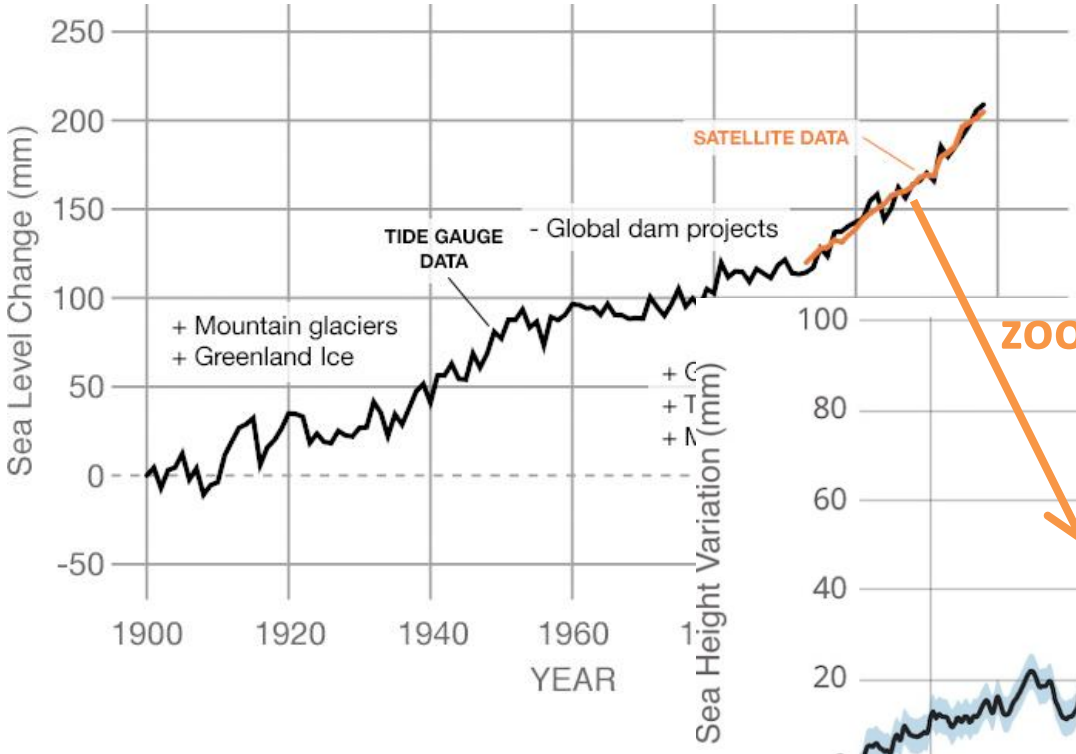
- Divergence of sediment transport produces **changes in beach bed level** that in turn affect wave transformation

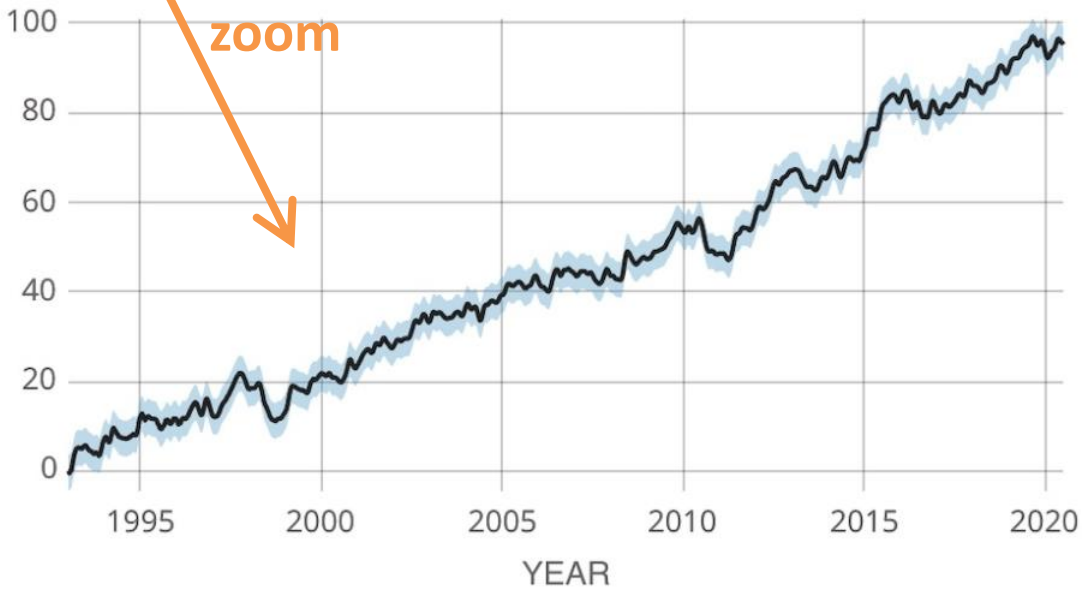


PHYSICAL EFFECTS OF CLIMATE CHANGE ON COASTS

- Well known effect of global warming → **Mean sea level rise (MSLR)**

https://climate.nasa.gov//





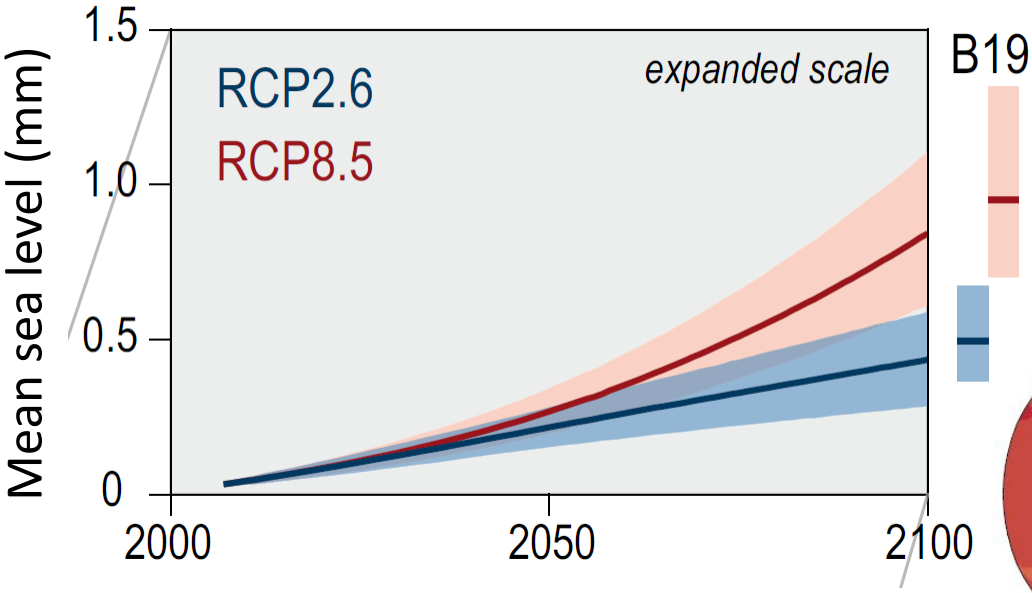
Cause 1: Glacier ice melting

Cause 2: Water dilatation due to ocean warming

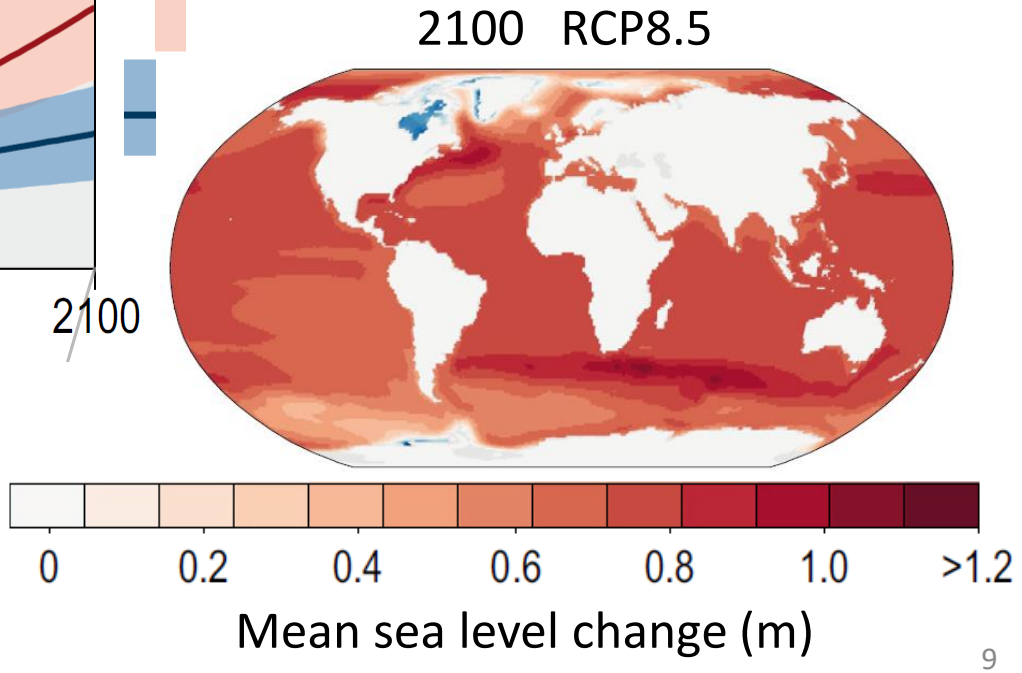
Frederiske et al., 2020

PHYSICAL EFFECTS OF CLIMATE CHANGE ON COASTS

- Well known effect of global warming → **Mean sea level rise (MSLR)**
- **Different future scenarios** as a function of CO2 emissions **(uncertainty!)**



Oppenheimer et al., 2019

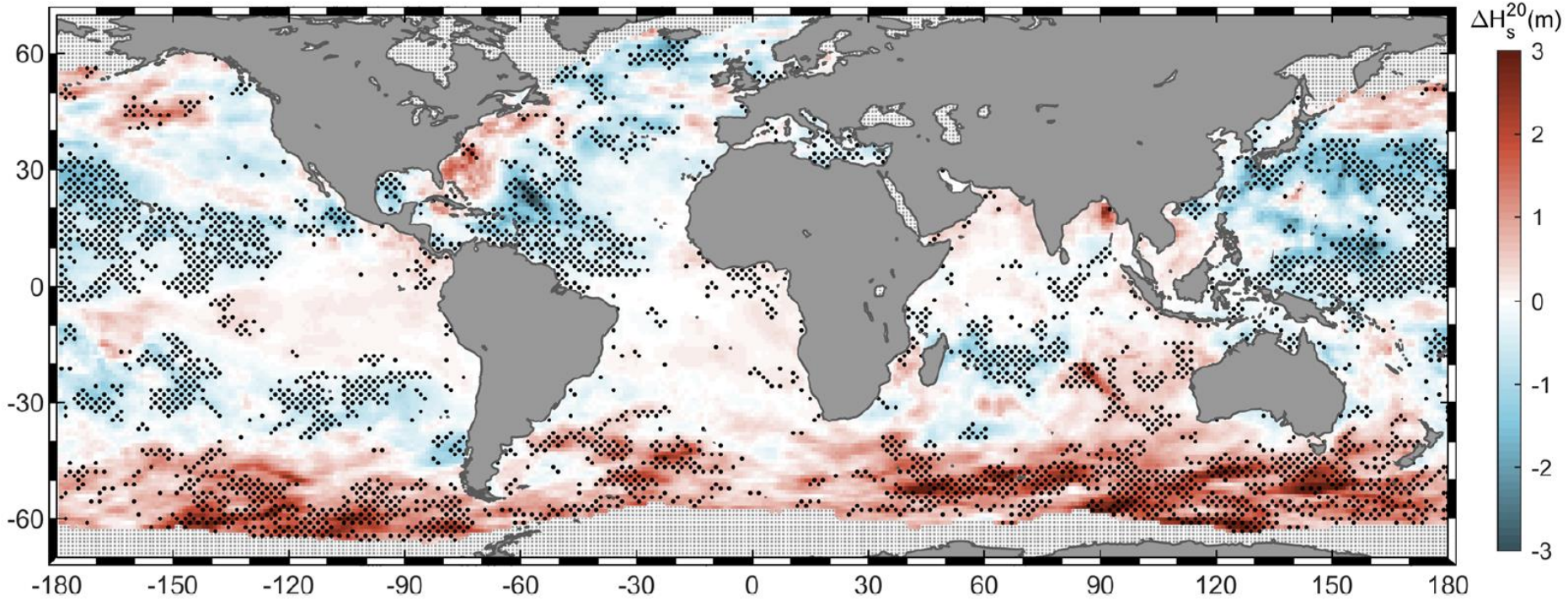


- It is a global phenomena
- Increase of 40-80 cm in 2100

PHYSICAL EFFECTS OF CLIMATE CHANGE ON COASTS

- **No** evidence of **increase in storminess** in Mediterranean Sea (past/future)
- Clear increases obtained in other areas like Antartic ocean

Wave height increase in 2100



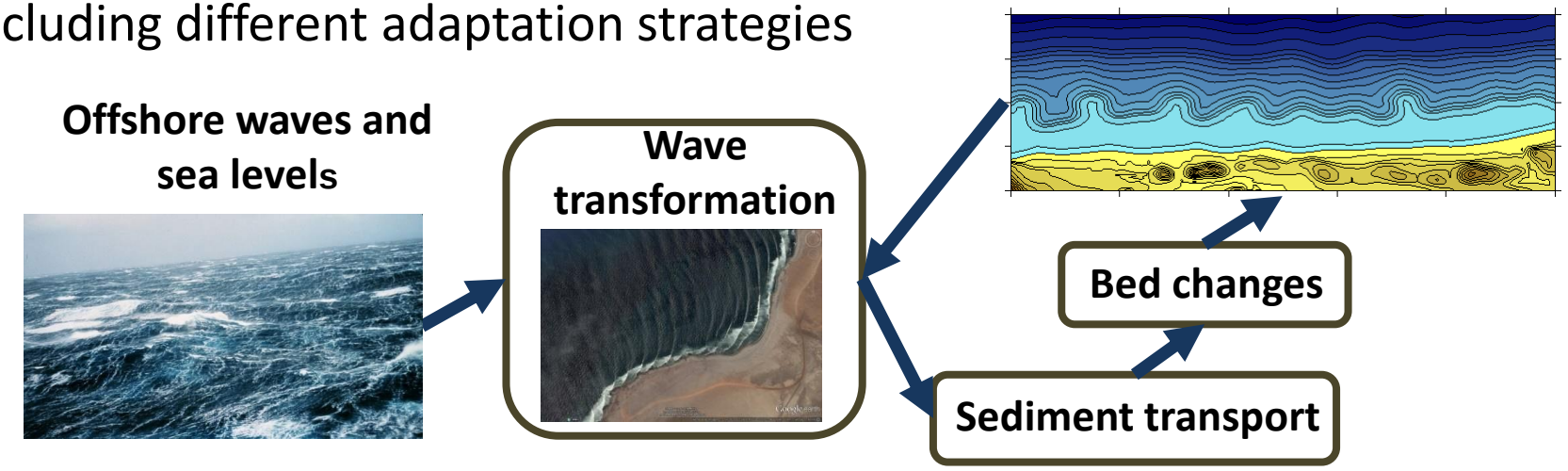
- **Storms** are **more dangerous** on **higher mean sea levels**

Lobeto et al., 2021

- Future storm **chronology** is **unknown (uncertainty!)**

HOW DO WE MODEL LONG-TERM BEACH EVOLUTION?

• **Morphodynamic models: useful tools** for long-term beach projections, including different adaptation strategies



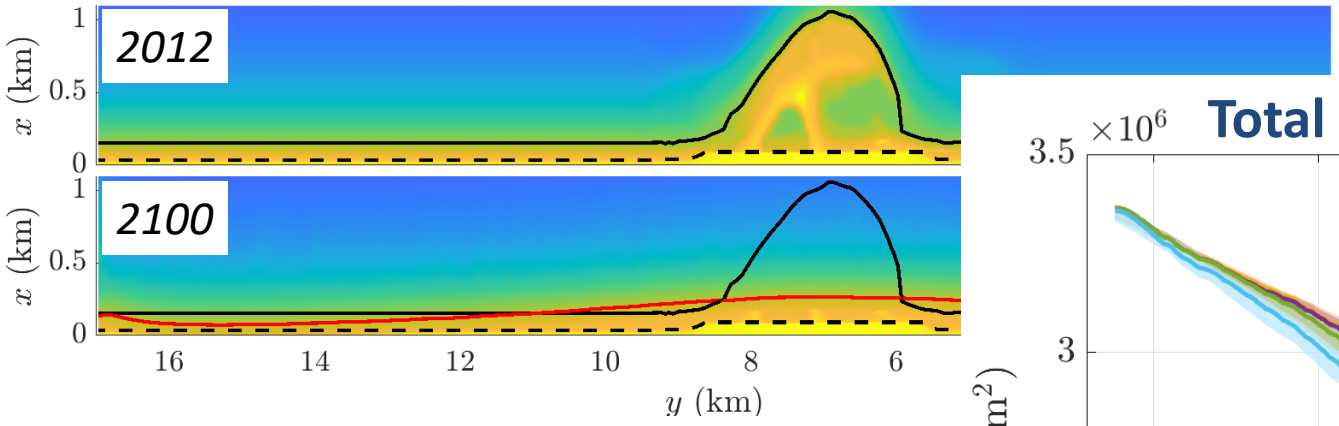
• **Beach morphodynamics** is **extremely complex** → Modelling response to storms and climate change is challenging

• There are many different **uncertainty sources**: **sea-level rise projections**, future **storm chronology**, unknowns on **sediment transport**

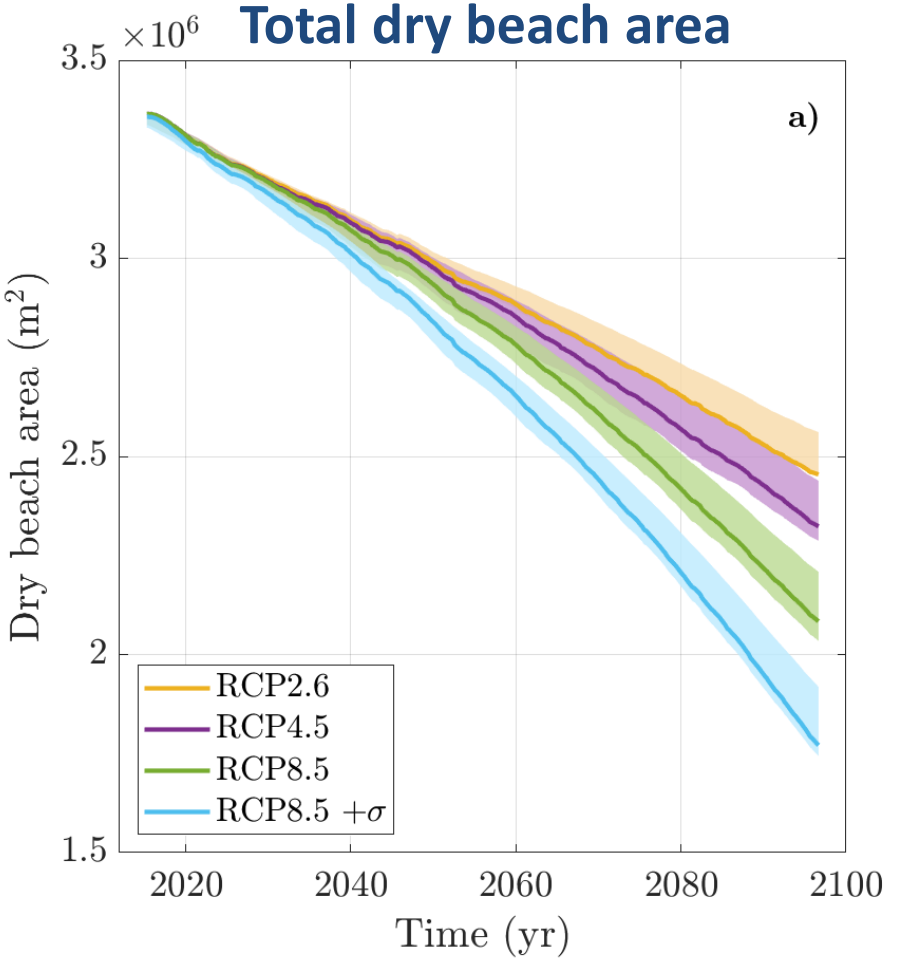
• **Data** is essential for **model forcing** and **model calibration and validation**

CASE STUDY 1: ZANDMOTOR MEGANOURISHMENT

Result for RCP8.5



Total dry beach area



- By 2100, **35% of area loss** (RCP8.5):
  - **50%** is **sediment erosion (seaward)**
  - **50%** is **pure MSLR inundation**
- Strongly **alongshore variable**
- Cross-shore and longshore transports
- **Uncertainty** also quantified

Ribas et al., under revision

PRESENT RESULTS ABOUT LONG-TERM BEACH EVOLUTION

- Climate change will produce mean **shoreline recession** (10-100 m)…
  - due to **pure MSLR inundation**: **relatively easy to model**
  - due to **sediment erosion**: **extremely hard to model**

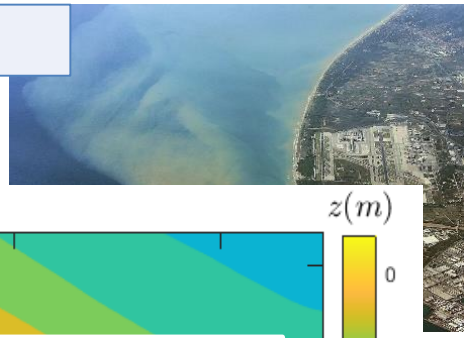
- **Complex models under development** with **promissing predictive capacity**
  - BUT lack of understanding of a few important processes
  - BUT **data at high spatio-temporal resolution** is **needed**

TAKE-HOME MESSAGES

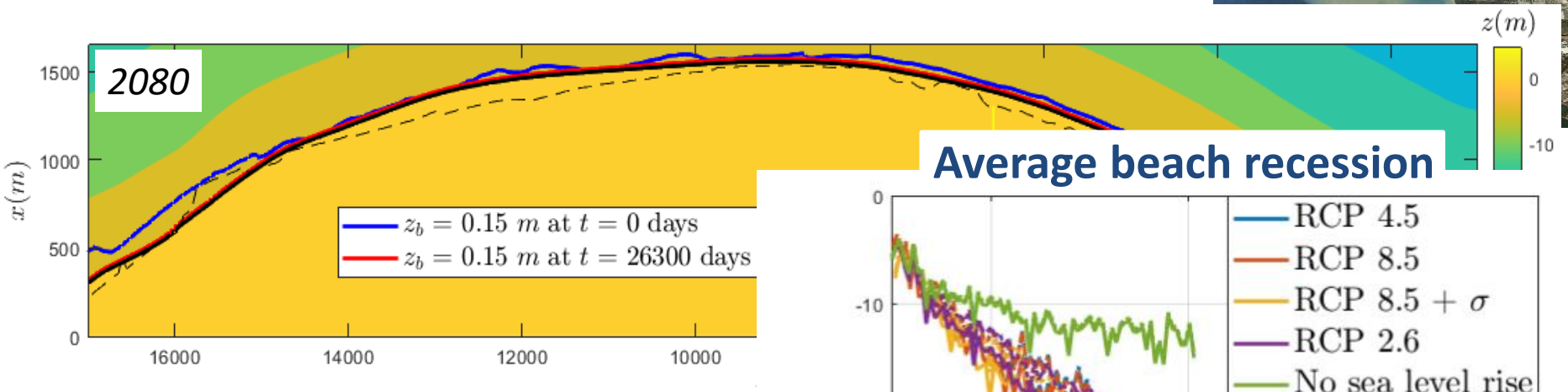
Climate change will increase erosion and inundation problems

Quantifying climate change impact on beaches and role of adaptation measures is feasible if we invest on science (data and models!) ☺

CASE STUDY 2: SOUTHERN HALF OF LLOBREGAT DELTA



Preliminary result for RCP8.5



- By 2080, **45% of area loss** (RCP8.5):
  - **75%** is **sediment erosion (seaward)**
  - **25%** is **pure MSLR inundation**
- Quite **alongshore variable**
- Cross-shore and longshore transports
- **More data** needed to improve model calibration

Average beach recession