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MORPHOLOGICAL IMPACTS AND COASTAL RISKS INDUCED BY EXTREME STORM EVENTS

Morphological Impacts and Coastal Risks induced by extreme storm events – the MICORE Project (2008-2011)

Balouin Y., Ciavola, P and the MICORE group

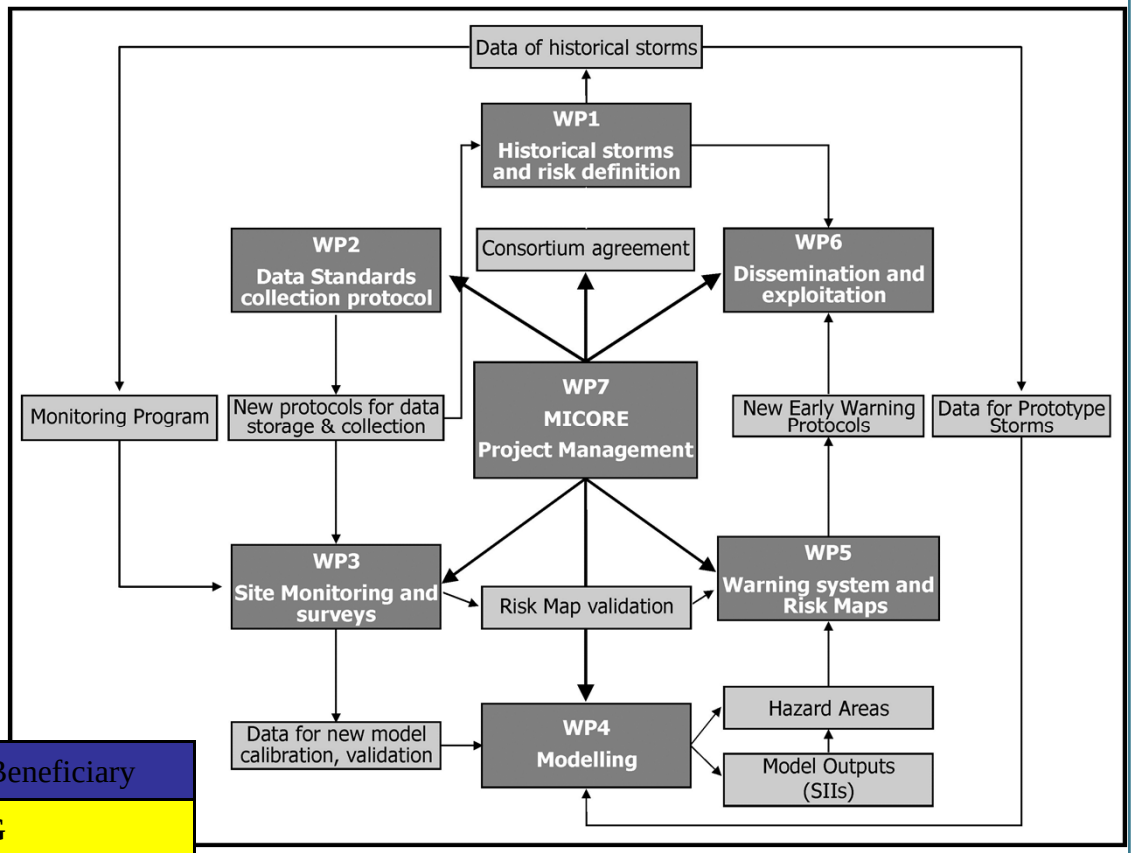
Grant agreement n° 202798

E-URAL Workshop–Nov. 22-23, 2010, Barnaul

Research objectives:

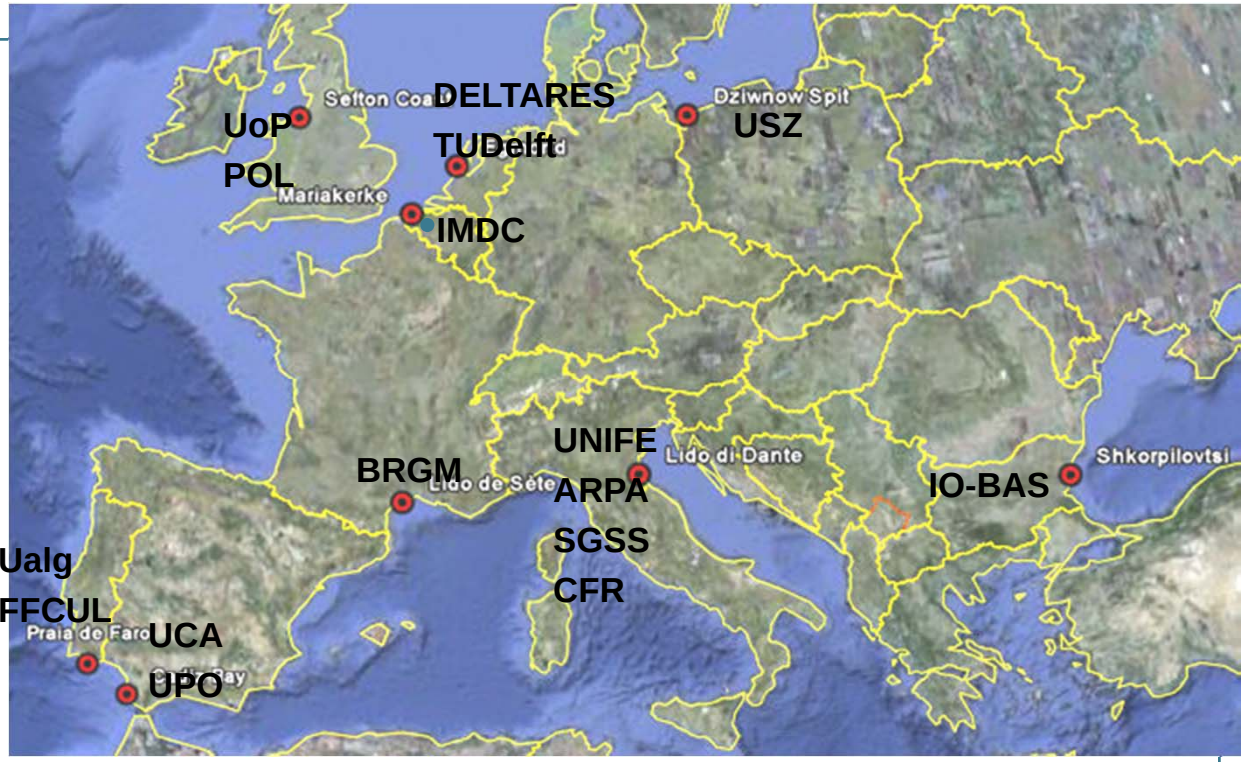
- Past European Marine Storms (homogeneous database, socio-economic damages)
- Change in dangerous storm occurrence
- Map storm related risks: intensity, spatial extent, duration, hazard interaction. Special attention is devoted to the morphological impact
- Early warning and information system
- Multiple risks (e.g. tide+surge+wave action)
- Timely relief operations

MICORE Organisation



Workpackage	Lead Beneficiary
1. Historical Storms	**UALG**
2. Data Standards	**TUD**
3. Site Monitoring	**BRGM**
4. Modelling	**WLD**
5. Warning System Development	**IMCD**
6. Dissemination and Exploitation	**SGSS**
7. Project Management	**CFR-Ufe**

MICORE Consortium



University of Ferrara
Consorzio Ferrara Ricerche
Ufe-CFR
Coordinator
WP7 Leader

University of Algarve
UALG
WP1 Leader

Technical University of Delft
TUD
WP2 Leader

France Geological Survey
BRGM
WP3 Leader

Deltares
WLD
WP4 Leader

International Marine Dredging Consultants
IMDC
WP5 Leader

Emilia Romagna Geological Survey
SGSS
WP6 Leader

University of Lisbon
FFCUL

Emilia Romagna Meteo Service
ARPA

University of Cadiz
UCA

University of Plymouth
UoP

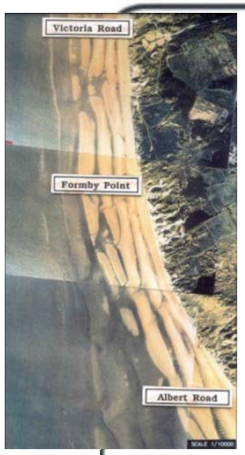
University of Szczecin
USZ

Institute of Oceanology - Bulgarian Academy of Sciences
IO-BAS

Proudman Oceanographic Laboratory
POL

University Pablo de Olavide
UPO

Regional coastlines and case studies



Are European Coastlines vulnerable to exceptional storms?

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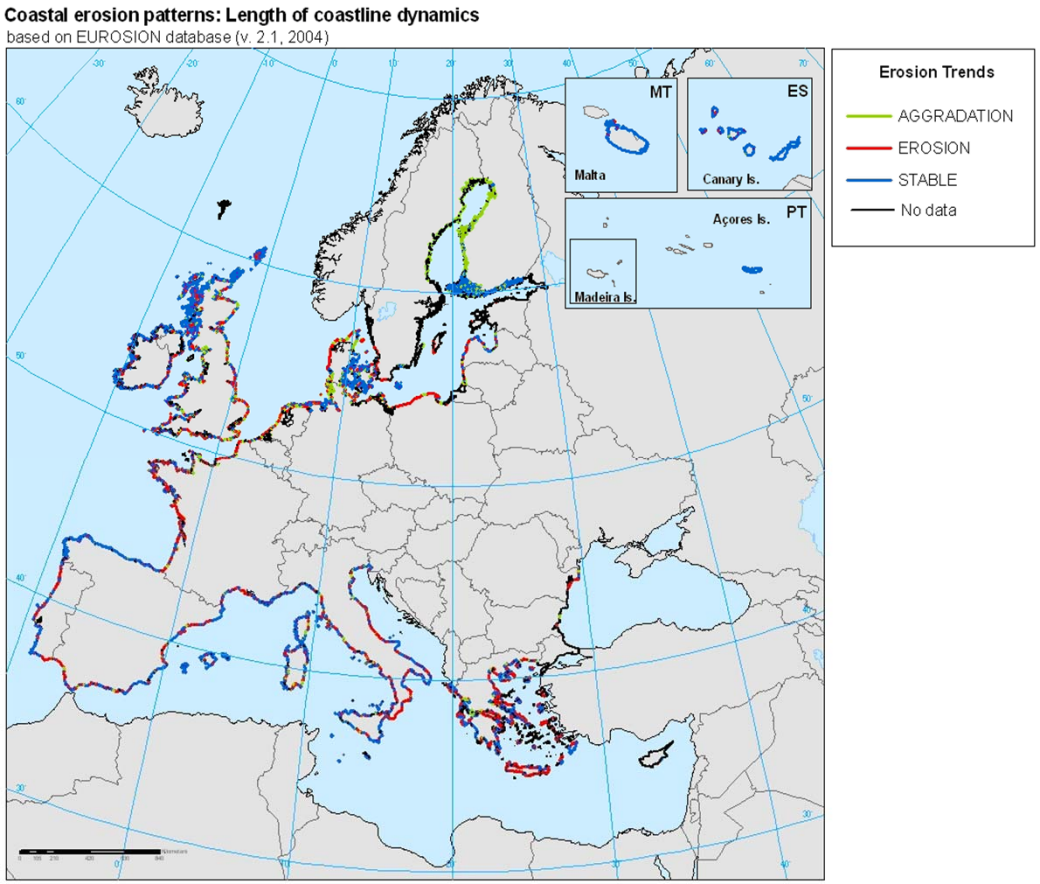
Vulnerability of coastal systems in the EU



Eurosion: annual sediment deficit of European coasts 100 Mt

JRC: 19% of total EU-25 population (86 million inhabitants) live in 0-10 km coastal zone

EEA: 12% of all EU coastal zones is lying below 5 m elevation and are potentially vulnerable for sea level rise and related inundations

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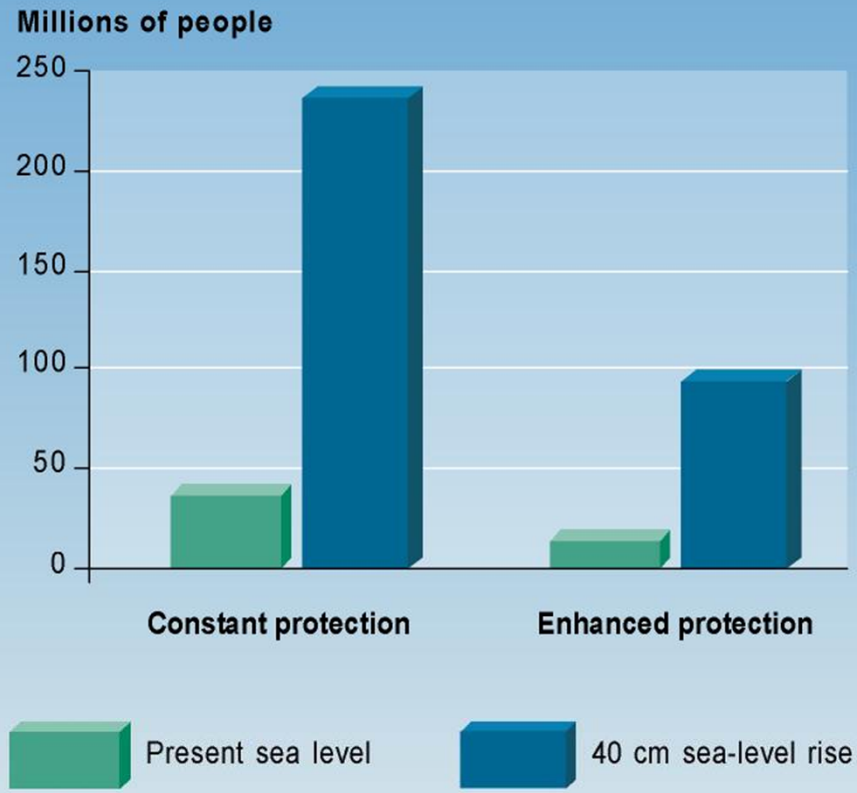
Adaptation and average annual number of people flooded by coastal storm surges, projection for 2080s



SYR - FIGURE 3-6

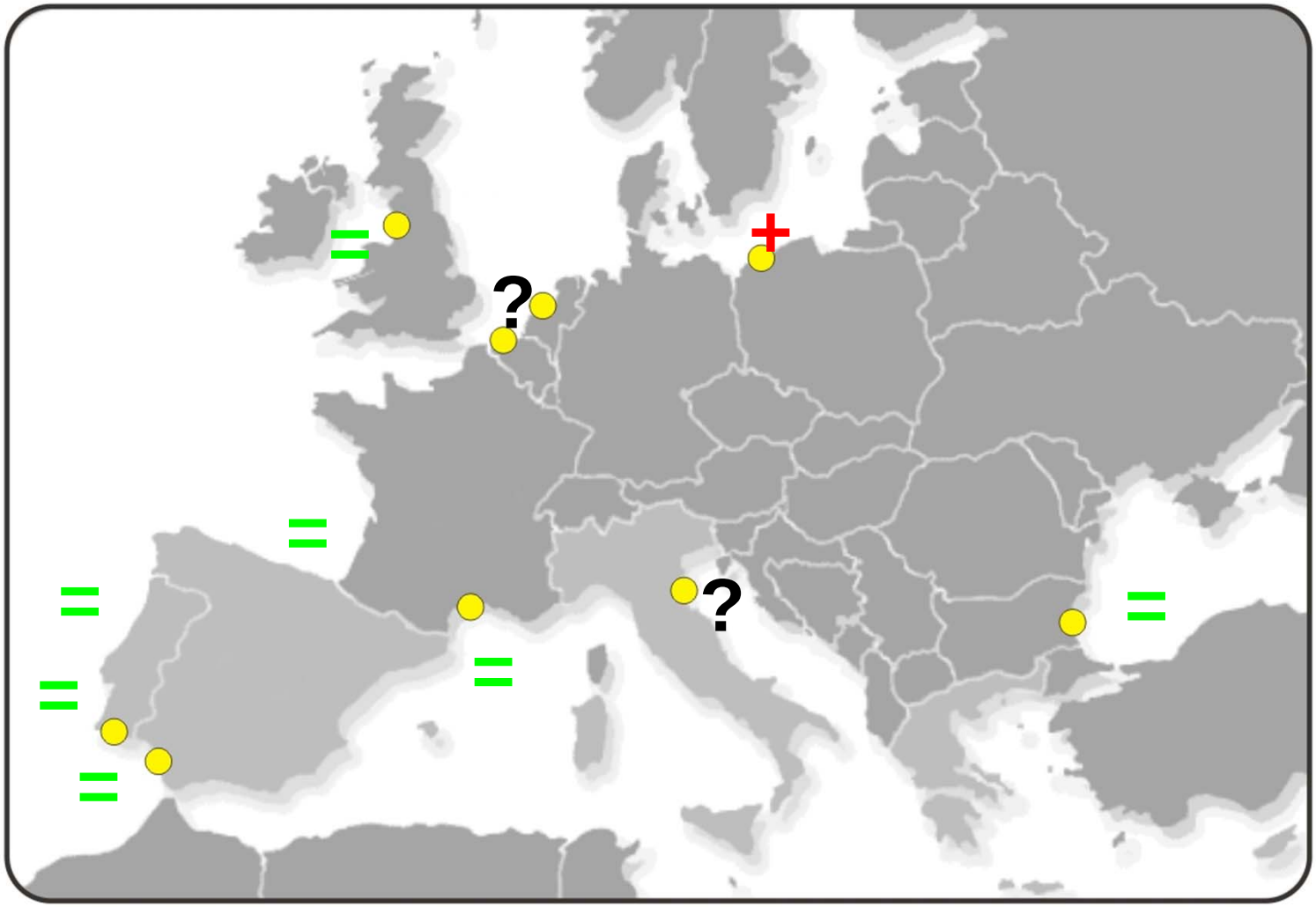
IPCC
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

WP1
Historical Marine Storm Analysis: effect of climate change on storminess?

- Datasets range from 30 to 100 years
- Only events above a locally defined storm threshold
- Proxies for storm identification vary locally according to availability: wind, waves, surges
- Validation against damage reports
- MICORE Open-access report D1.4 available of project's website

Variability: Storm duration



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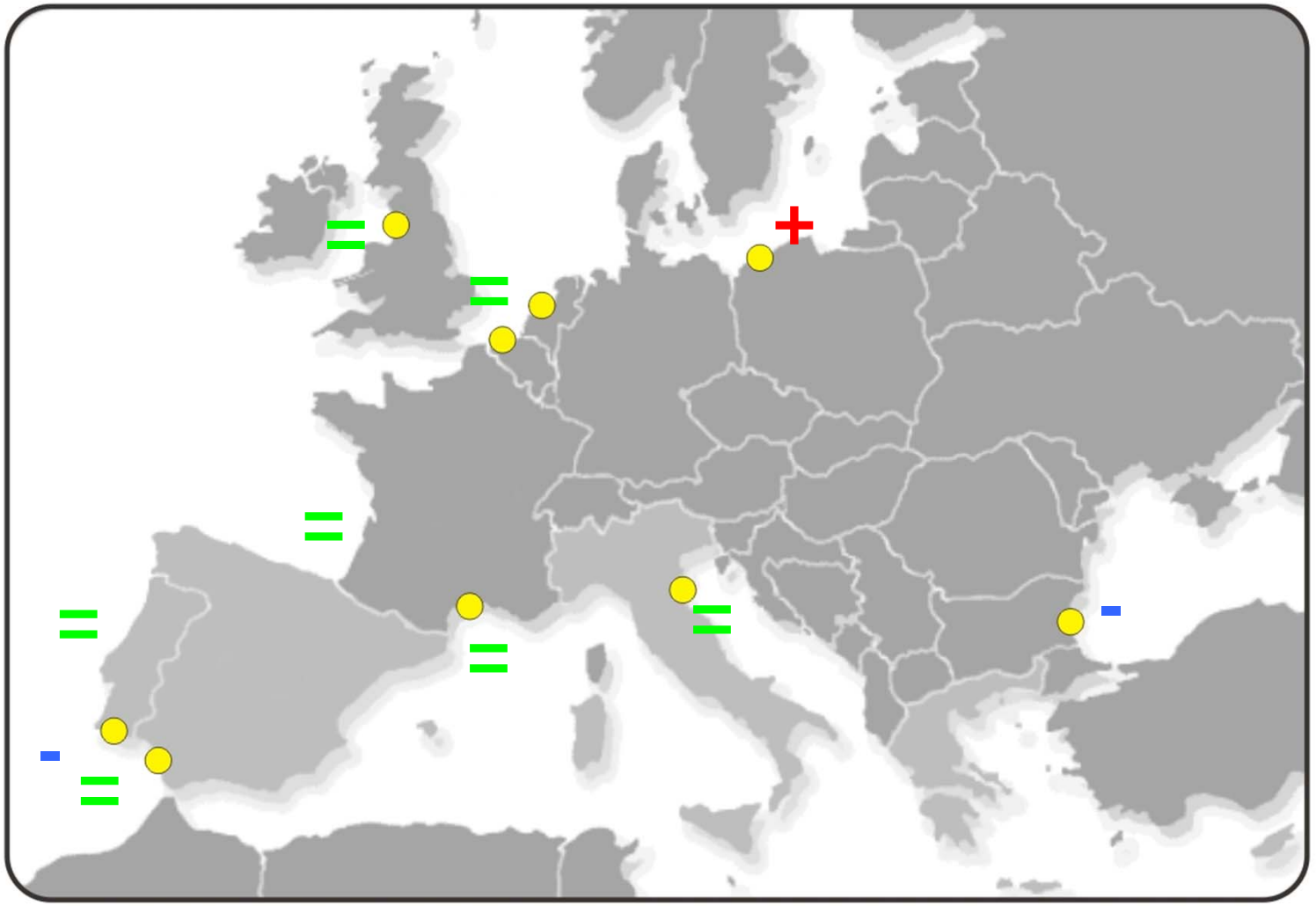
Variability: Storm Intensity



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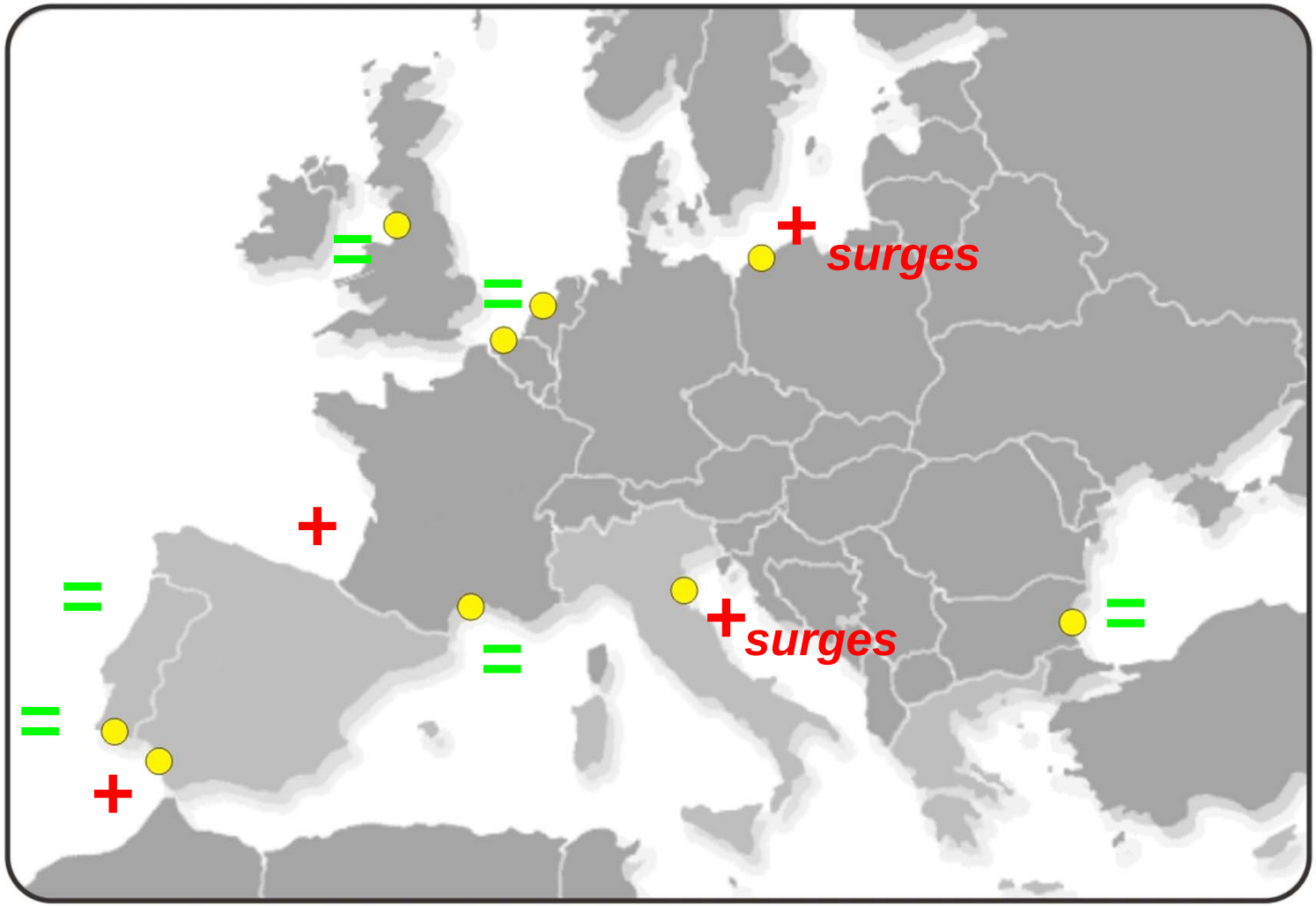
Variability: Storm frequency



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Do we have a common strategic/operational approach in EU countries regarding risks from marine storm erosion?

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Strategic vs. operational aims

Strategic (long time to prepare, current practice):

- prevention: strong enough sea defenses
- adaptation: town planning, zoning
- mitigation: means to decrease effects

Operational (short time to prepare, not done yet):

- emergency response
  - evacuation of coastal towns;
  - dike patrol;
  - adhoc strenghtening of defenses
- Question of end-users: where, when, how much wave height, inundation, wind, (physical parameters), etc.?

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Do we have operational warning systems in place for coastal storms?

- It requires to correctly define the storm risk, using thresholds for morphological change
- Probabilistic scenarios require datasets of forcing factors
- It requires reliable numerical models for morphological change validated using high energy datasets

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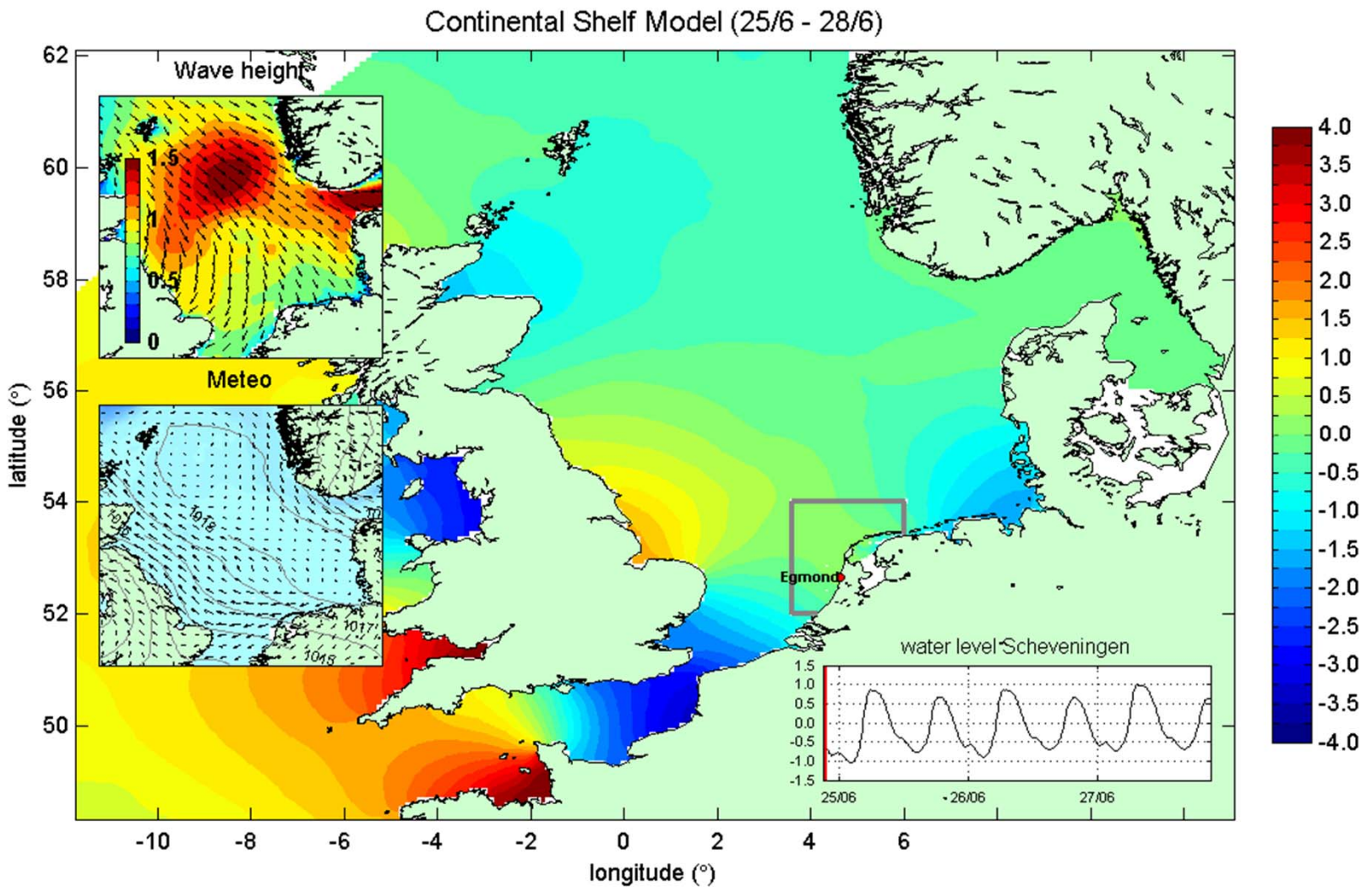
Forecast of forcing factors (waterlevel, wind and waves)



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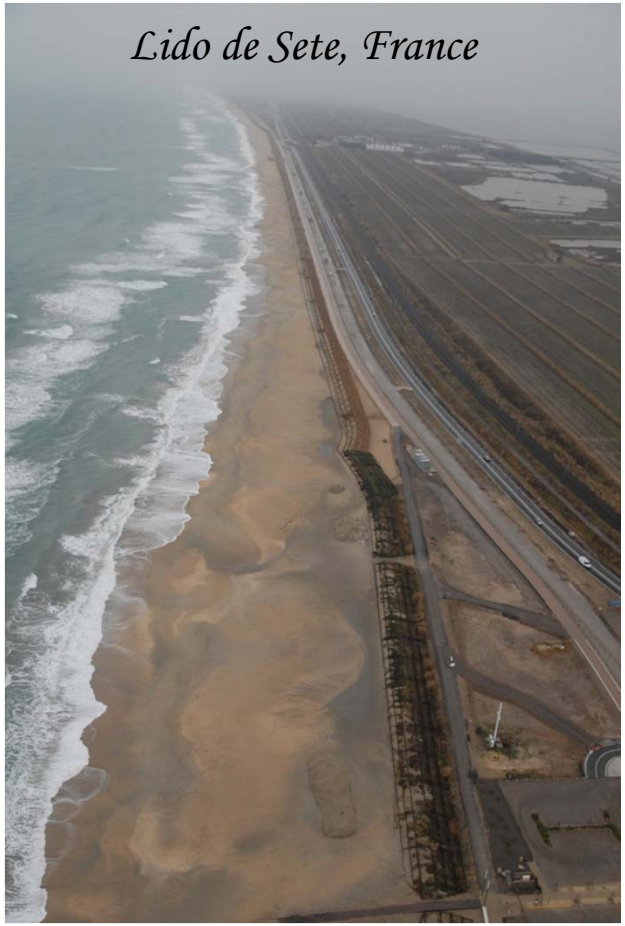
What are the morphological impacts of exceptional storms ?

- Dune breaching and overwashing
- Beach erosion
- Damage to ecosystems
- Increased vulnerability to hinterland flooding



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Sète, 2003
DRE-LR


Coup de mer sur la Côte Vermeille
2008
Le désastre
C'est la vague de 19 h, vendredi soir, qui a causé le plus de dégâts à Cerbère où tout le front de mer a été dévasté ainsi que d'autres rues du village.
La digue de Cerbère a cédé. Le port a été détruit. D'énormes dégâts sont constatés dans la commune.
A Banyuls, sept bateaux ont coulé. Toute la Côte Vermeille a été touchée à des degrés divers.
Le préfet appuie la demande de classement en catastrophe naturelle pour les communes sinistrées.


Argelès, déc 1997
DRE-LR

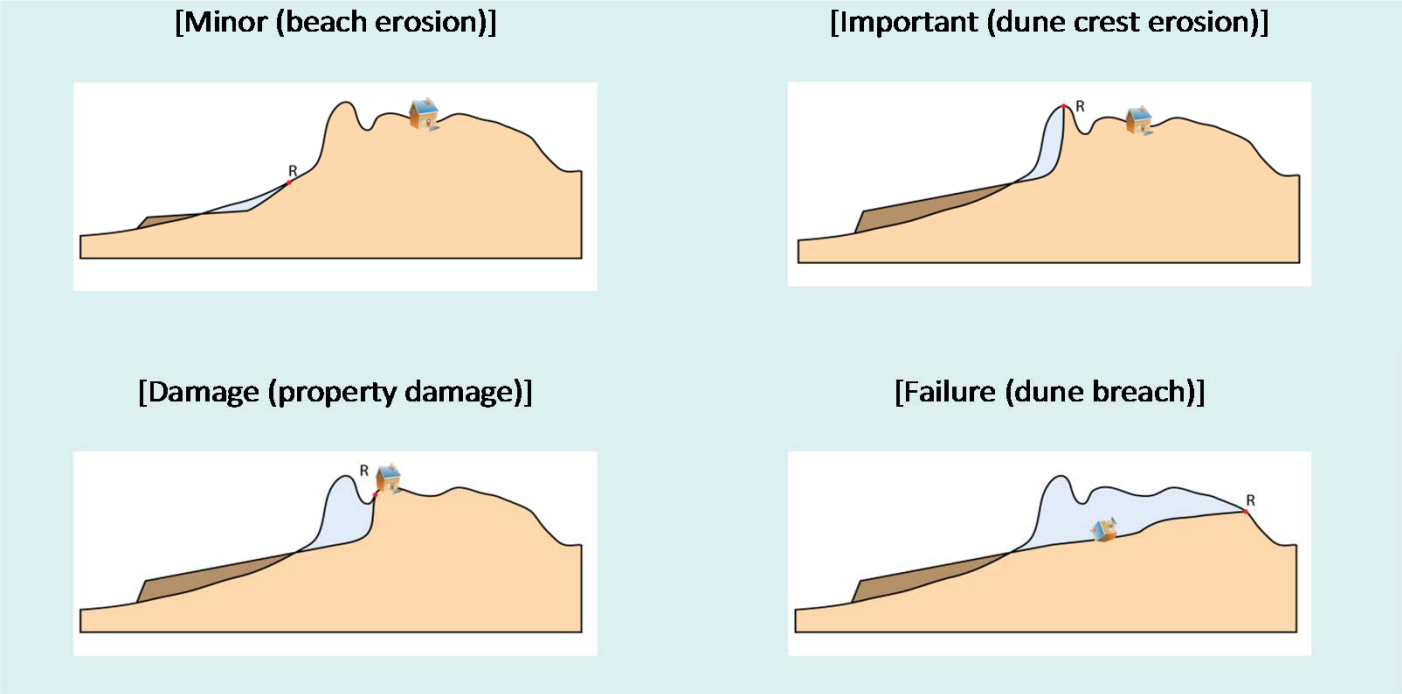

Sète, 1982
Urbanis


Frontignan, 2003.
DRE-LR


Météo Des vagues gigantesques ont frappé Banyuls et Cerbère
TEMPÊTE
2008
Sept bateaux de plaisance ont sombré dans le port de Banyuls-sur-Mer. Photo L'Indépendant

Storm thresholds and how to simulate morphological impacts ?

> Storm thresholds were defined for each coastal region using historical databases and storm-specific field datasets



Example of different thresholds of morphological change (Netherlands)

> Morphodynamic modelling: X-beach

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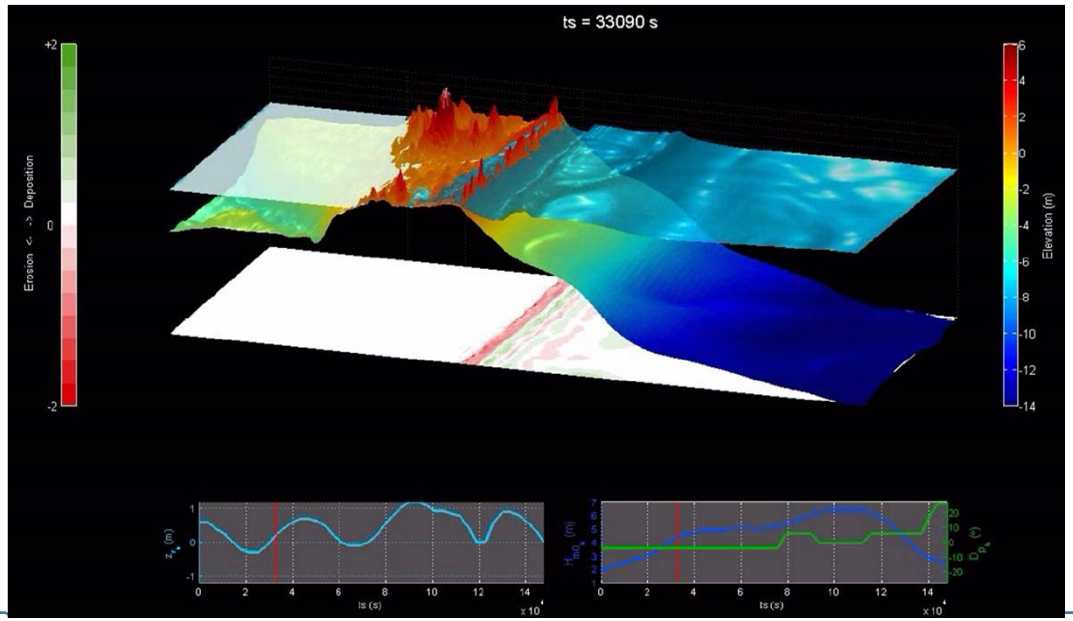
X-Beach model

UNESCO-IHE Institute For Water Education | Deltares | TU Delft

- open source code available for free on internet (xbeach.org)
- easy to use

- Short-wave averaged but long-wave resolving modeling of waves, flow and morphology change in time-domain
- Swash and overwashmotions
- Dune erosion, overwashing, breaching and full inundation
- Domain from outside surf zone to backbarrier
- Driven by boundary conditions from surge and spectral wave models



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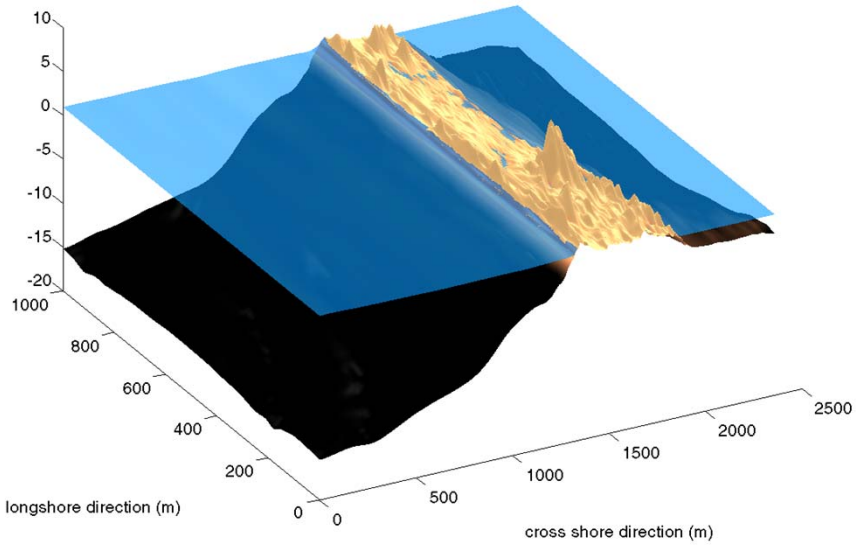
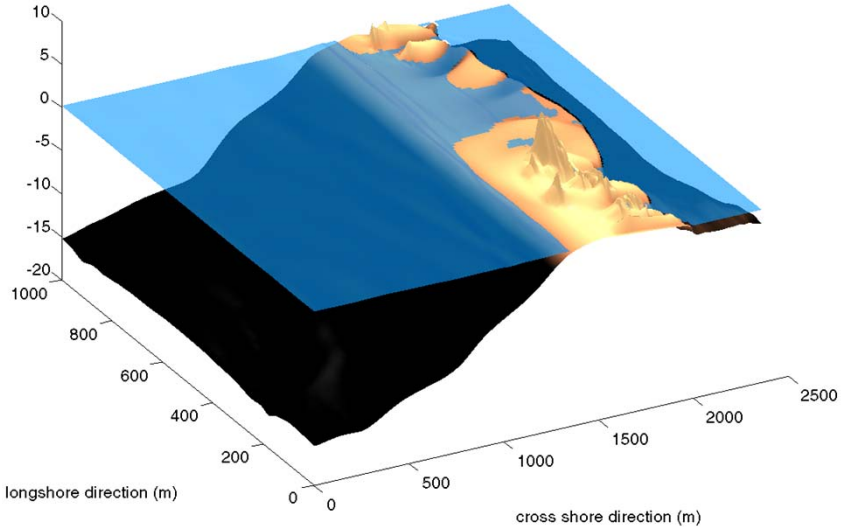
Example of storm induced coastal flooding

Pre-storm



Post-storm



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Hurricane IVAN (2004), Santa Rosa Island, Mexico Gulf

Model calibration with field data *WP3*

Country	Field site	
Italy	Lido di Dante- Classe	
Portugal	Ria Formosa, praia de Faro	
Spain	Cadiz Bay, Cortadura, camposoto	
France	Lido of Sète to Marseillan	
UK	Sefton coast	
NL	Egmond	
Poland	Dziwnow Spit	
Belgium	Mariakerke	
Bulagaria	Kamchia - Shkorpilovtsi beach	

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Variability of coastal environments

Tidal conditions

No tide: Dziwnow, Shkorpilovsti

Micro-tidal range: Lido di Dante, Lido de Sète

Meso-tidal range: Praia de Faro, Cadiz Bay, Egmond

Macro-tidal range: Sefton coast, Mariakerke

Wave exposure

Low to high wave energy

Geomorphology

Barriers: Lido de Sète, Praia de Faro, Dziwznow, camposoto

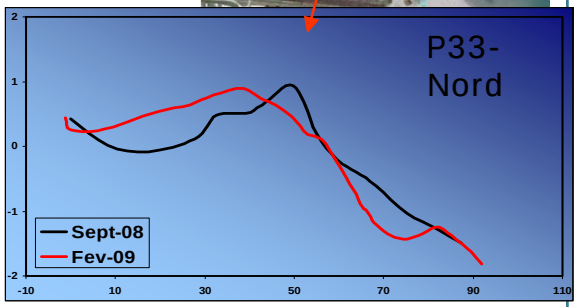
Open beaches: Lido di Dante, Egmond, Mariakerke, Shkorpilovtsi

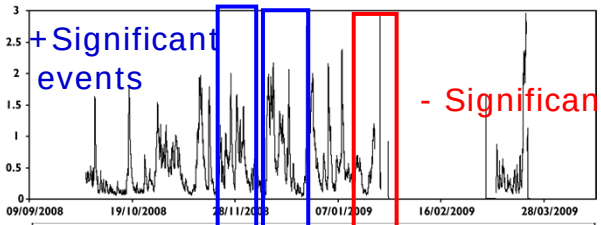
Estuarine beach: Sefton coast

Model calibration with field data — WP3

Field campaigns to obtain storm-specific datasets

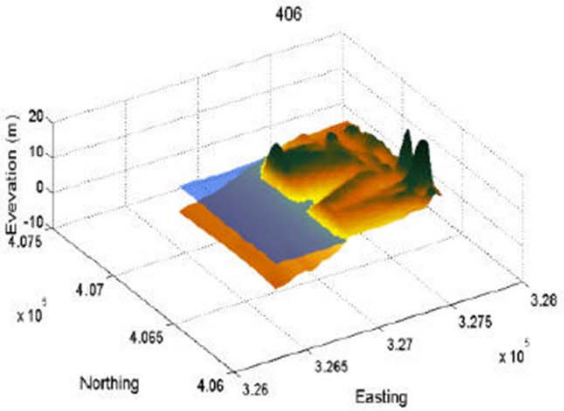
- To monitor field sites with pre and post-storm surveys
- To provide supporting measurement for model calibration
- To monitor shoreline and deploy instrumentation during storms
- To undertake aerial photos, Lidar and Video measurements
- To undertake intensive field campaigns after major storm events
- To collect socio-economic information on impacts

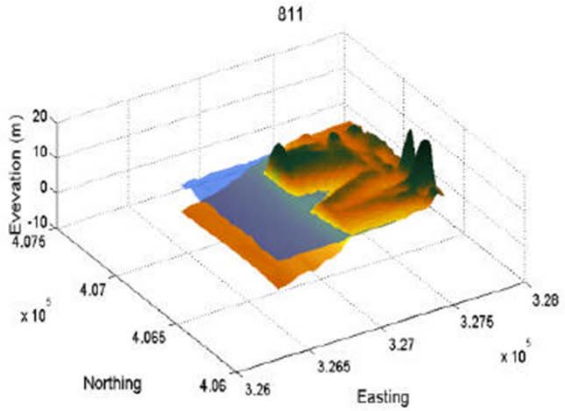


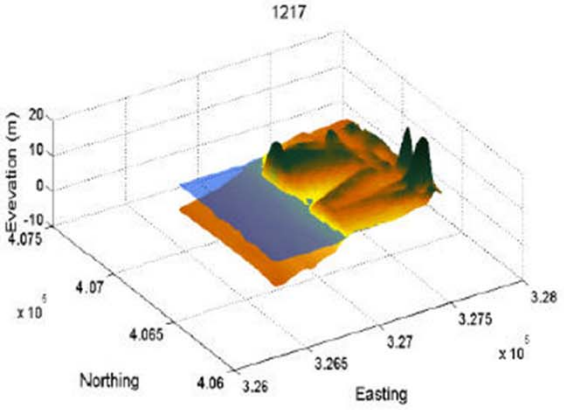


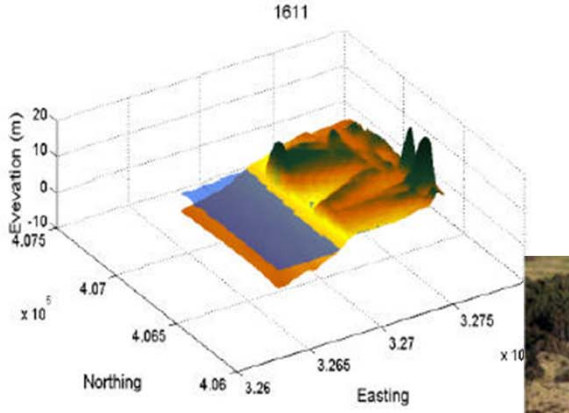
Overwash of Bevano spit

Calibration and validation of morphological modelling









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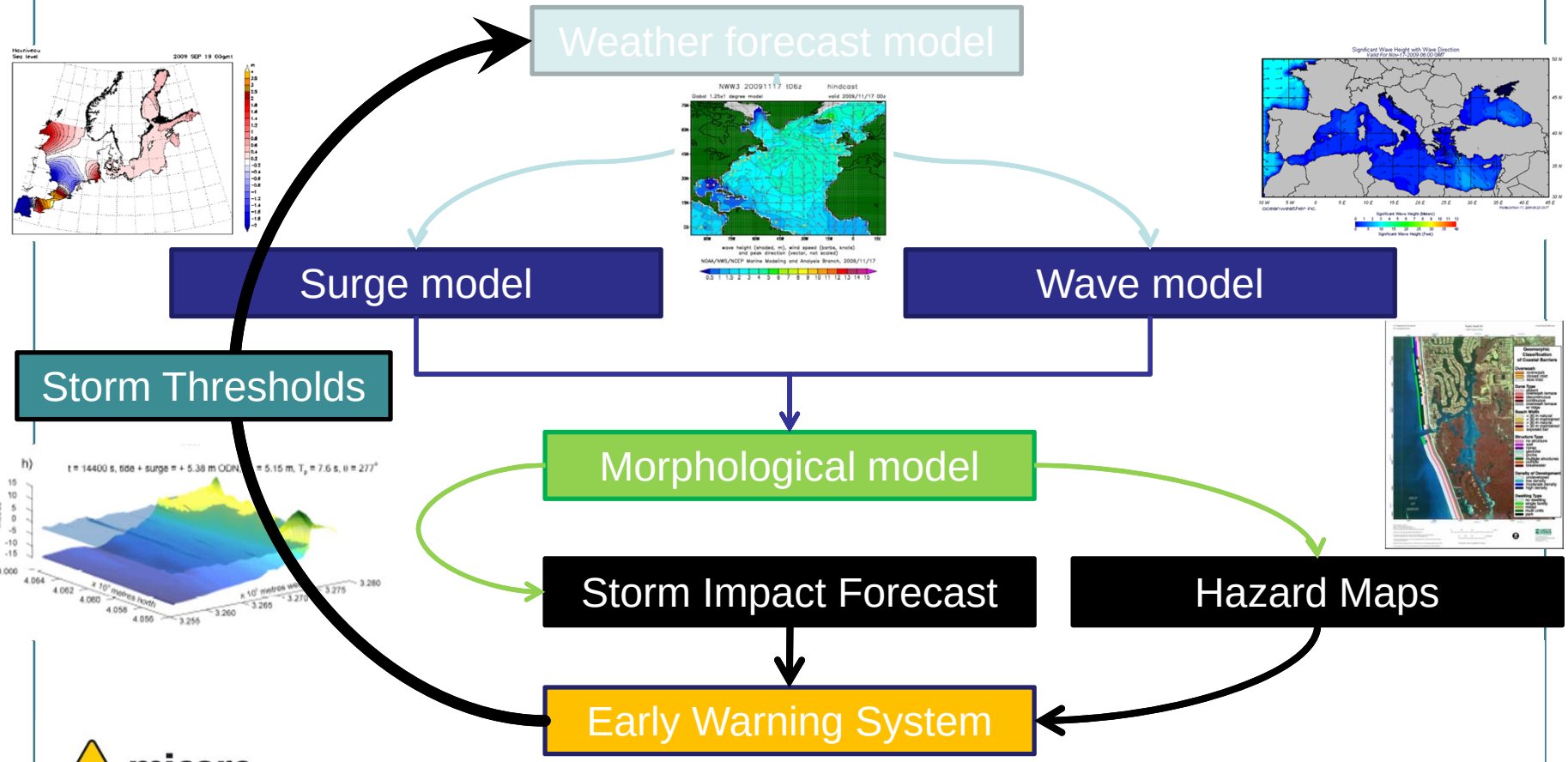
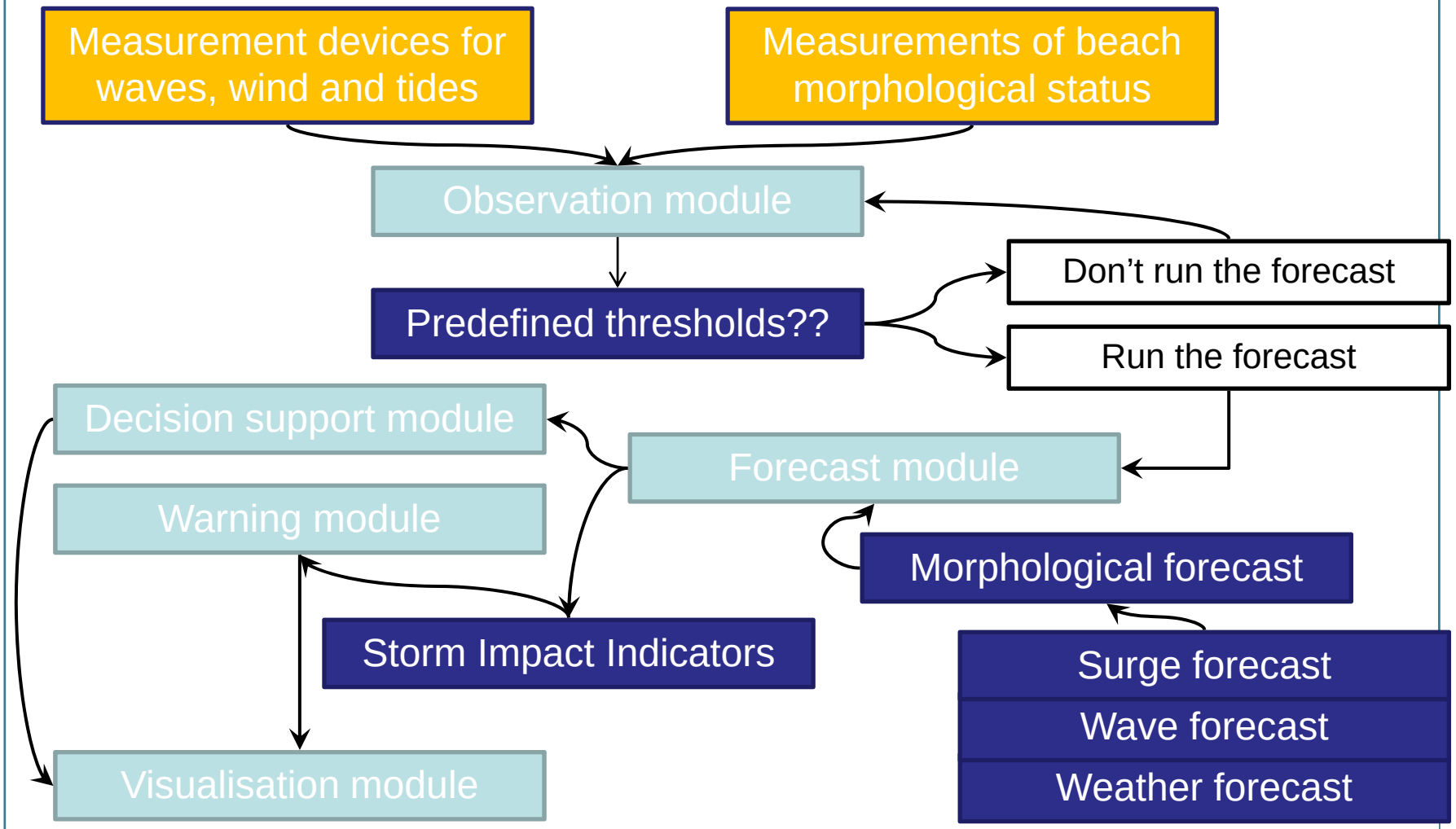
WP5 – Early Warning system

> **Elements of a generic concept of the Early Warning System:**




Measurement devices for waves, wind and tides
Measurements of beach morphological status
Observation module
Predefined thresholds??
Don't run the forecast
Run the forecast
Decision support module
Warning module
Forecast module
Morphological forecast
Storm Impact Indicators
Surge forecast
Wave forecast
Weather forecast
Visualisation module
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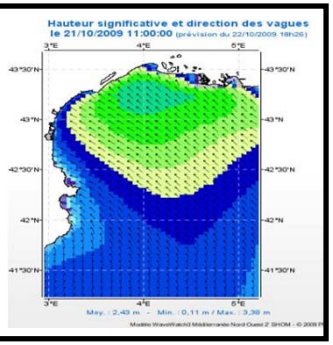
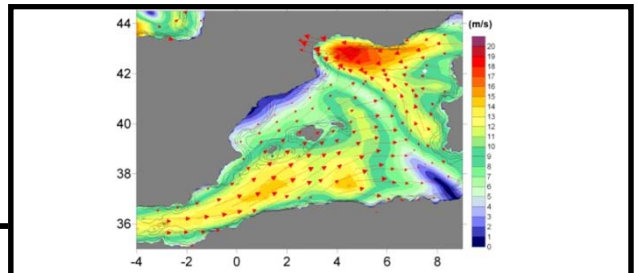
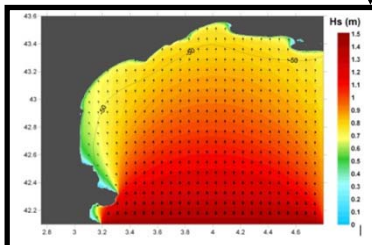
Wave model WW3



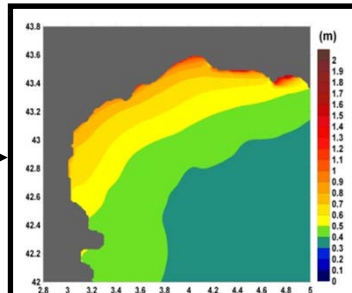


Weather forecast model GFS

Wave threshold

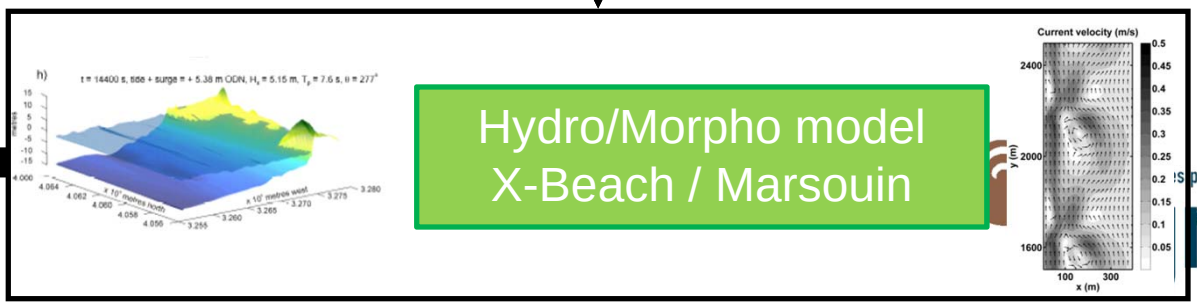


Wave model SWAN



Surge/Tide model MARS

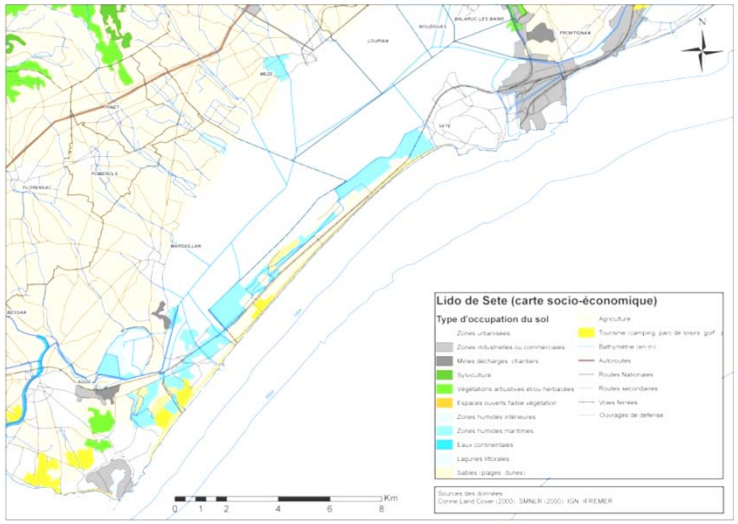
Results: Hs, WL, DTM, currents, …



Hydro/Morpho model X-Beach / Marsouin

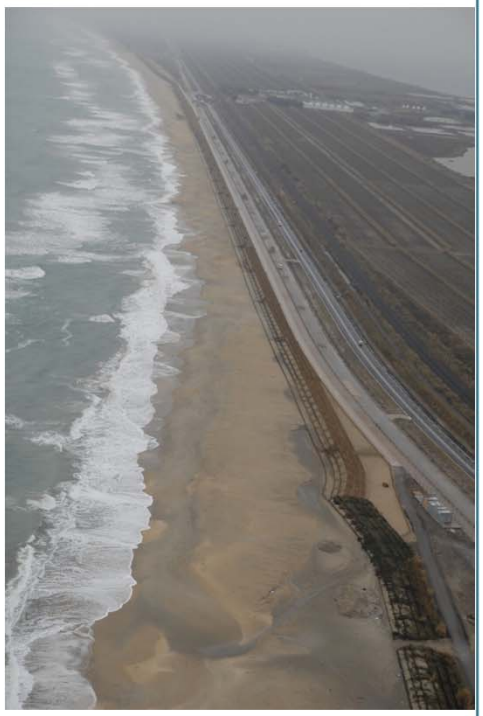
Storm Impact indicator - Example

- Evacuation preparation
- Coastal safety –road and railways



Strategic objective	Operational objective	QSC	Benchmarking desired state	Benchmarking current state	Intervention procedure	Evaluation procedure
Guarantee a minimum threat to human life in coastal areas during major storms (beach, campings, …)	Minimize the number of people in hazard zones	Maps safe/ unsafe	No hazard in hazardous areas (w>x m and C>y m/s)	Hazard maps / recreational/residential areas	Evacuation	Inhabitants, tourists are safe when critical waterlevel reached
Guaranty sustainable safety on the transport infrastructures (road/railways)	Minimize the risk of accident and anticipate closure of potential evacuation roads	Inundation maps	Overtopping discharge Q< x l/m/s or water level < x m	Inundation maps	Closure of the road / railways	Check if people using infrastructures were safe; Check if evacuation procedure were modified

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