4TH INTERNATIONAL WORKSHOP ON WAVES, STORM SURGES, AND COASTAL HAZARDS
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AN ENSEMBLE-BASED EARLY-WARNING INDEX FOR COASTAL FLOODING ALERTS IN LOW-LYING LITTORAL AREAS

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Prototype of marine natural hazard early-warning system based on ensemble forecasting

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NextGenerationEU

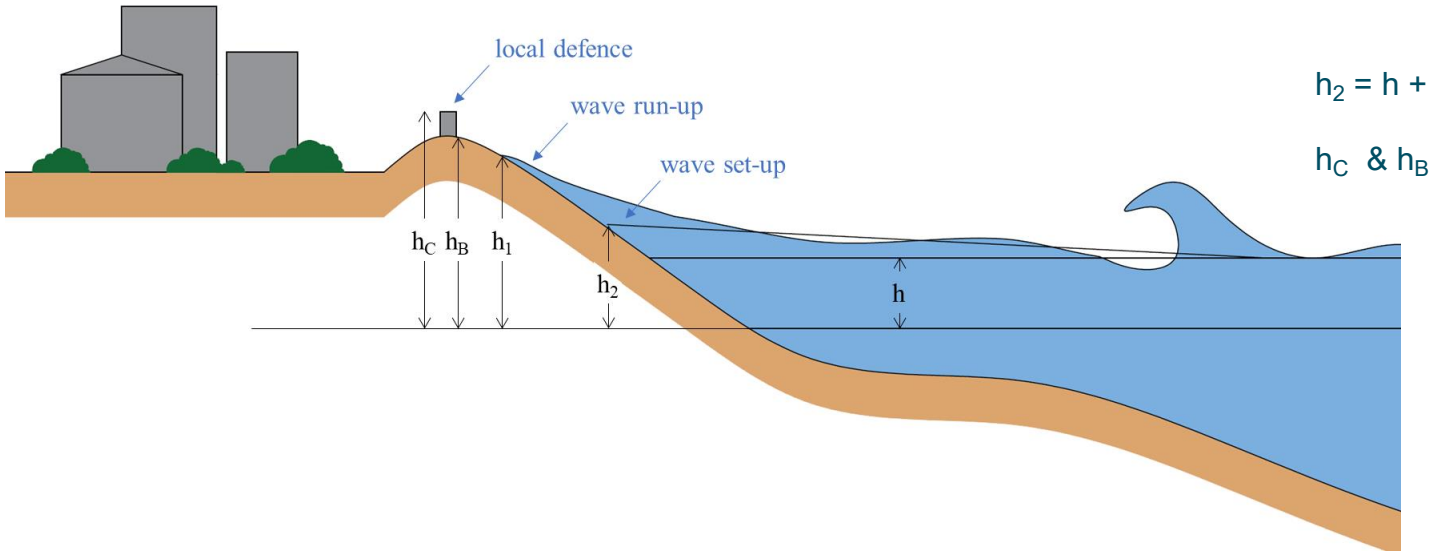
Motivation & Aim

Coastal hazards have the potential to cause significant damage to coastal communities, especially in low-lying coastal areas characterized by high population density and/or significant environmental and economic value

Set-up an **ensemble-based Early-Warning Index** for **coastal flooding**, beneficial for civil protection operations prior to the occurrence of extreme marine events

COASTAL FLOODING EARLY-WARNING INDEX

The proposed Coastal Flooding Early Warning Index (CF-EWI) **compares the total water level at the beach (sea level and wave contributions) to the characteristics of the existing coastal defenses**



$h_1 = h + R_{up}2\%$ = sum of sea level (astronomical tide, meteorological tide, mean sea level) and wave run-up (wave set-up, swash uprush)

$h_2 = h + \langle h_W \rangle$ = sum of sea level and set-up

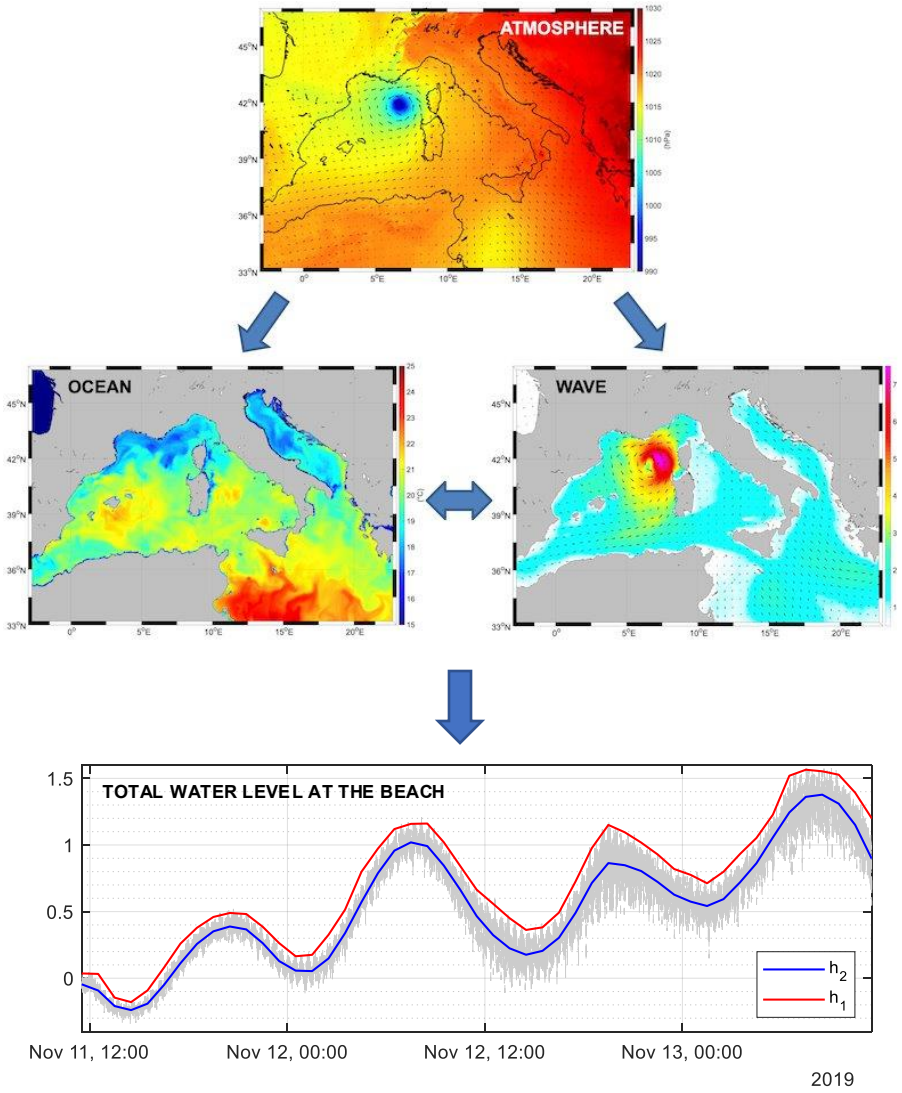
h_C & h_B = coastal defence crest and berm heights

CF-EWI

- **Case 1:** $h_1 > h_B$ → **flooding of the emerged beach**
- **Case 2:** $h_1 > h_C$ → **limited inland flooding due to wave overtopping**
- **Case 3:** $h_2 > h_C$ → **inland flooding due to overflow**

WEATHER AND MARINE MODELING SYSTEM

The EWI takes advantage of a short-range (2 days) **ensemble** numerical predictions of a modeling chain



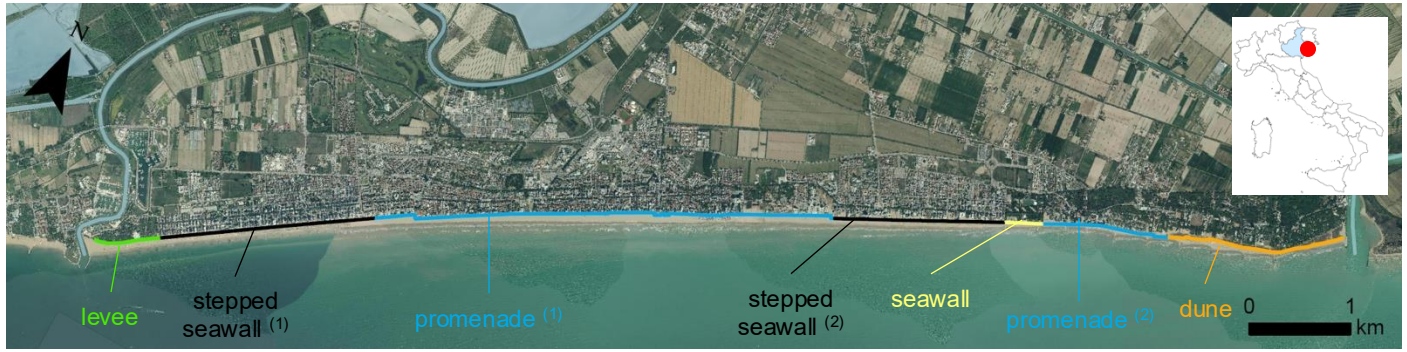
WRF-ARW simulations: dynamical downscaling of the ECMWF ensemble members down to the convection-permitting resolution (3 km) over the Italian Seas

Coupled SHYFEM and WW3 simulations: Mediterranean Sea mesh composed of triangular elements of variable form and size, up to 500 m

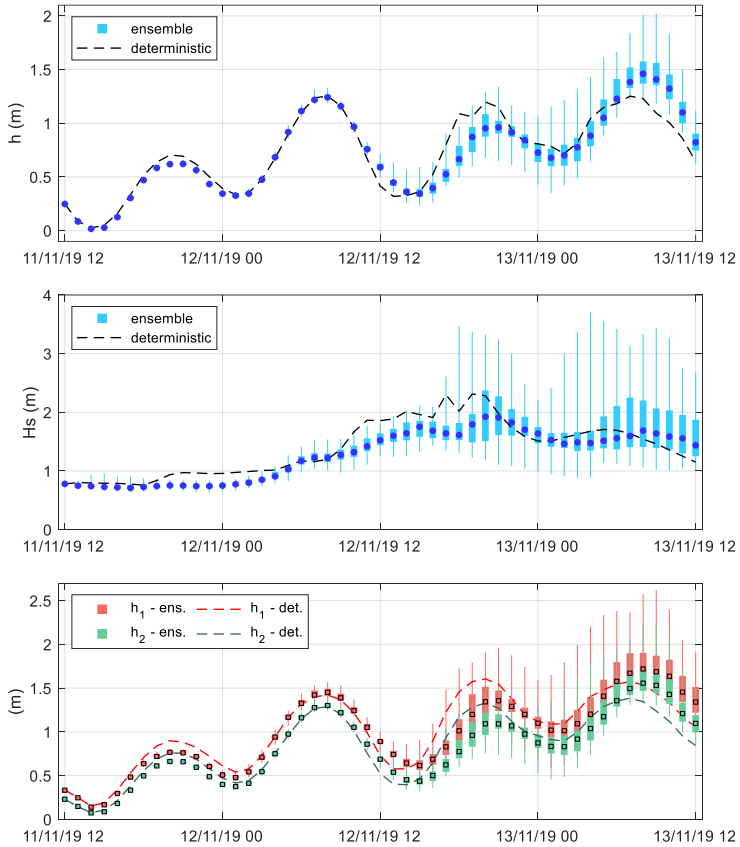
XBeach simulations**:** horizontal one-dimensional domain, resolution varies from 0.5 m in the swash region to 10 m at the offshore boundary -10 m

PILOT CASE: JESOLO (ITALY)

Jesolo (Venice, IT): high volume of tourism, intense urban expansion in the immediate vicinity of the beach (loss of the pre-existing dune system), shoreline stabilized by permeable groins, coastal flooding defence delegated to a fragmented system (seawalls, promenade, etc.)



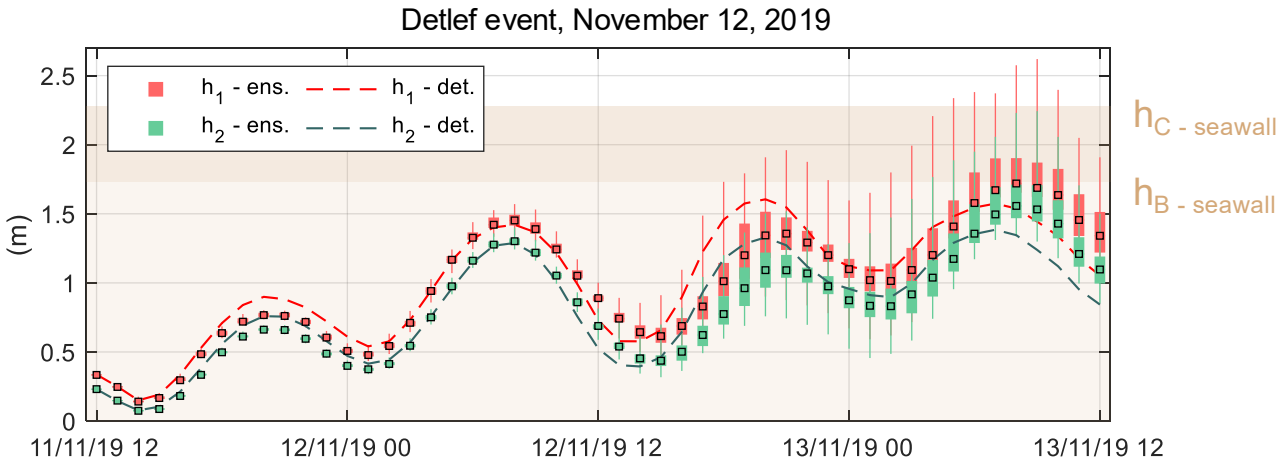
Detlef event, November 12, 2019



Coastal defence	Deterministic forecast	Ensemble % No Flood	Ensemble % Case 1	Ensemble % Case 2	Ensemble % Case 3
Levee	No flood	49%	51%	0%	0%
Stepped seawall (1)	No flood	65%	35%	0%	0%
Promenade (1)	Case 1	0%	100%	0%	0%
Stepped seawall (2)	No flood	49%	51%	0%	0%
Seawall	No flood	43%	53%	4%	0%
Promenade(2)	No flood	69%	31%	0%	0%
Dune	Case 1	2%	98%	0%	0%

No flood
Case 1: flooding of the emerged beach
Case 2: limited inland flooding due to wave overtopping
Case 3: inland flooding due to overflow

PILOT CASE: JESOLO (ITALY) - SEAWALL



Seawall: **Deterministic forecast** CF-EWI during the storm

No flood

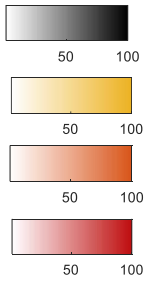
Seawall: **Ensemble CF-EWI probability** of case forecasts (%) during the storm

No flood 43%

Case 1: 53%

Case 2: 4%

Case 3: 0%



A deterministic forecast is just one possible outcome from an infinite number of possibilities. An **ensemble forecast** provides a **probability**

The Ensemble Coastal Flooding Early Warning System can help to **effectively forecast and communicate hazardous events**