

HAZARD ASSESSMENT OF STORM EVENTS IN THE CENTRAL REGION OF THE PORTUGUESE COAST

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Weaknesses and risk situations in the Portuguese coast

General background:

- Highly exposed to energetic sea actions;
- Many low areas without effective protections;
- Very degraded natural protection systems;
- Low amounts of sediment in transit;
- Inadequate or inefficient management.

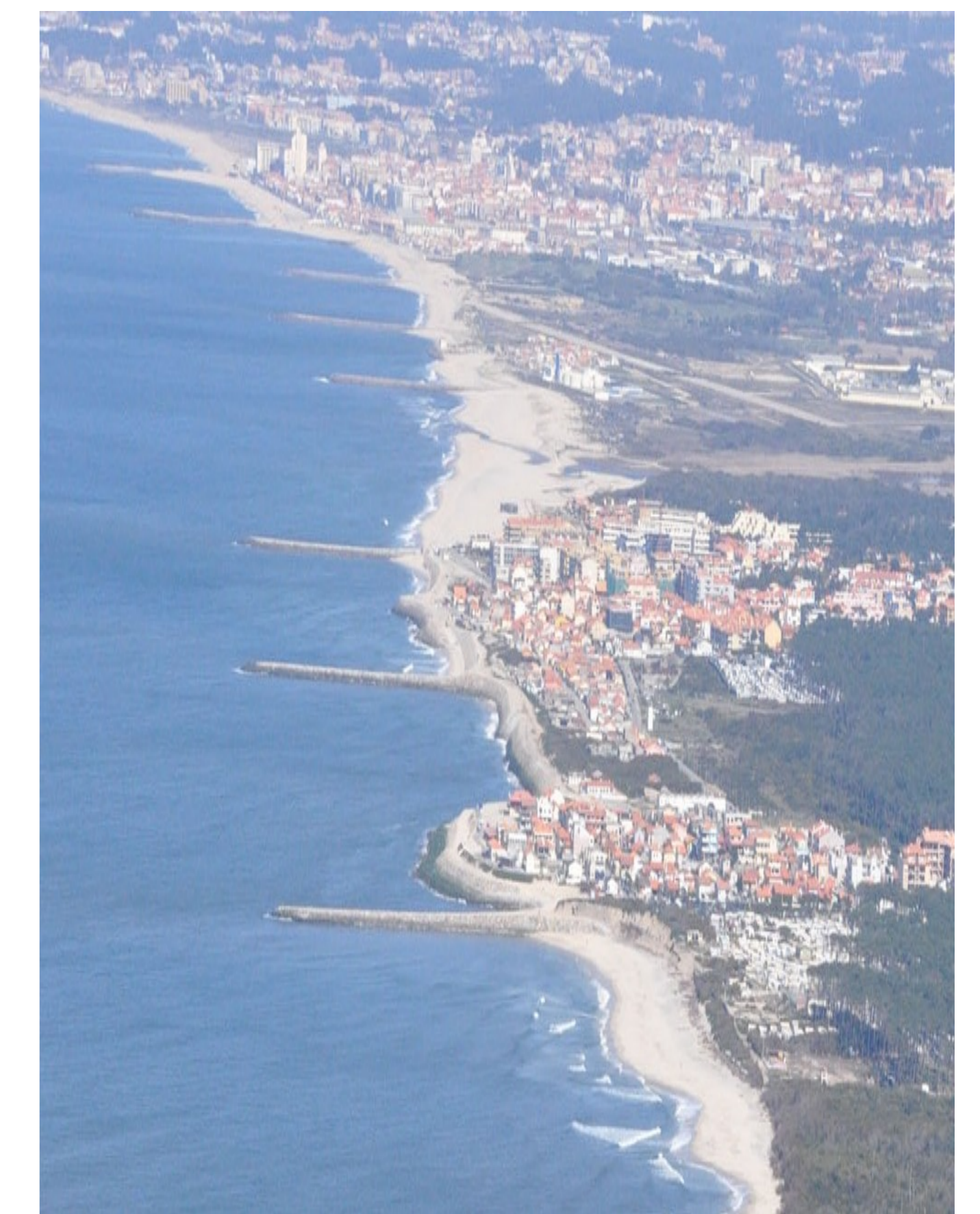


The increased demand and human occupation of the coast have greatly contributed to the existing weaknesses, due to:

- Buildings in hazardous areas;
- Increasing and improving accessibility;
- Great seasonal variation in demand;
- Pressure-generating activities;
- Intensive use of resources.

Main goals:

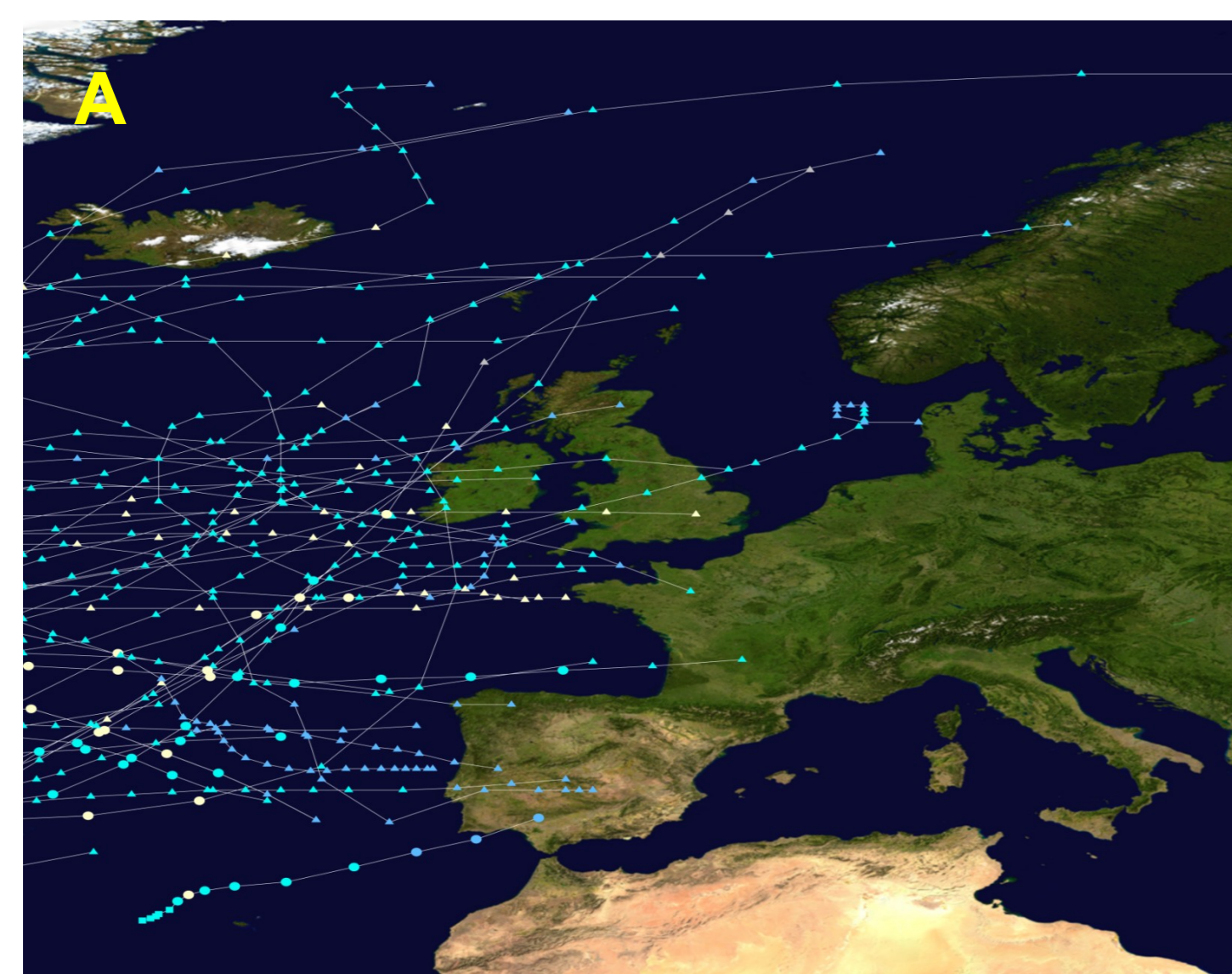
- Make a survey of the storms that have occurred in the North Atlantic, and that have affected the Portuguese coast, or that have passed next to it, since 1900 to the present.
- Simulate some historical storms and evaluate the possible heights reached along the coastal zone in order to support the planning and management of the Portuguese coast.



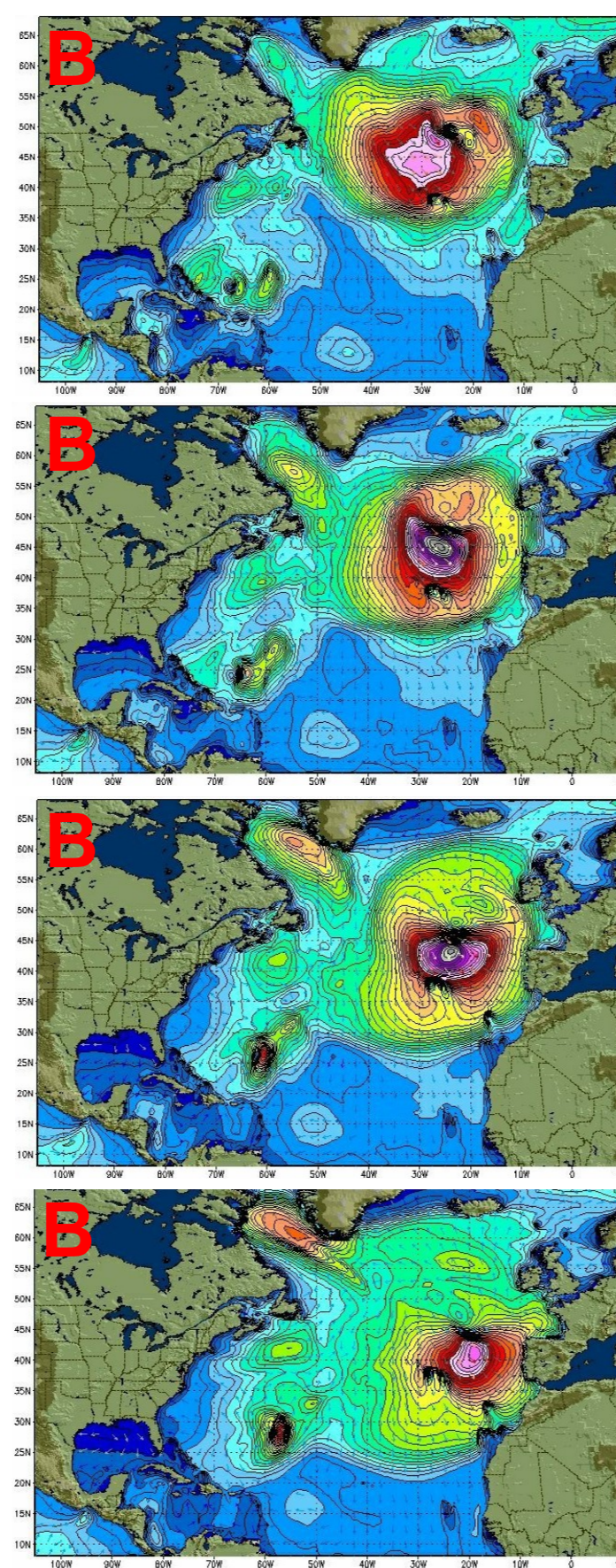
Some of the most recent storms that have affected the Portuguese coast

Storms recorded:

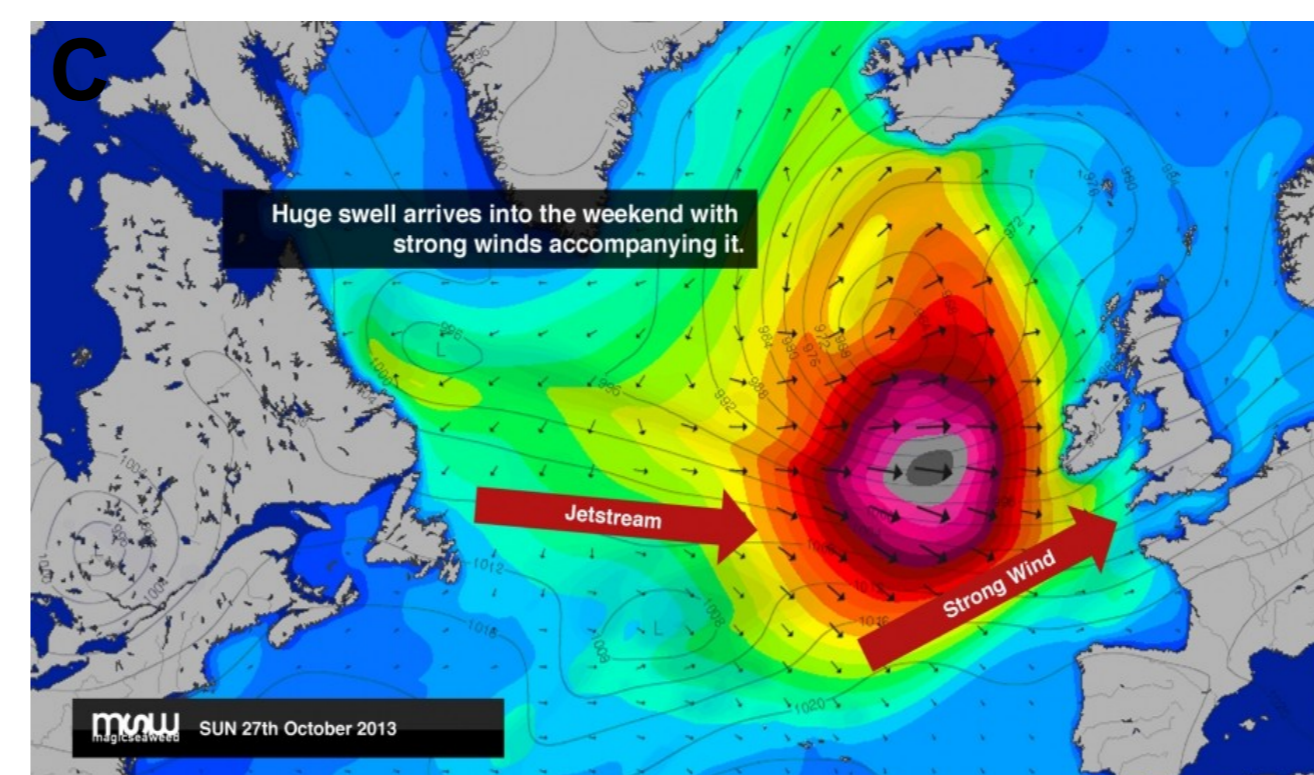
- **A** - Tracks of all cyclones that affected Europe since 1851.
- **B** - Hurricane OTTO, 8-10 October 2010.
- **C** - Extra-tropical cyclone St. JUDE, 26-28 October 2013.
- **D** - Tropical storm HERCULES, 6-8 January 2014.
- **E** - Hurricane STEPHANIE, 8-10 February 2014.



(http://en.wikipedia.org/wiki/Tropical_cyclone_effects_in_Europe)

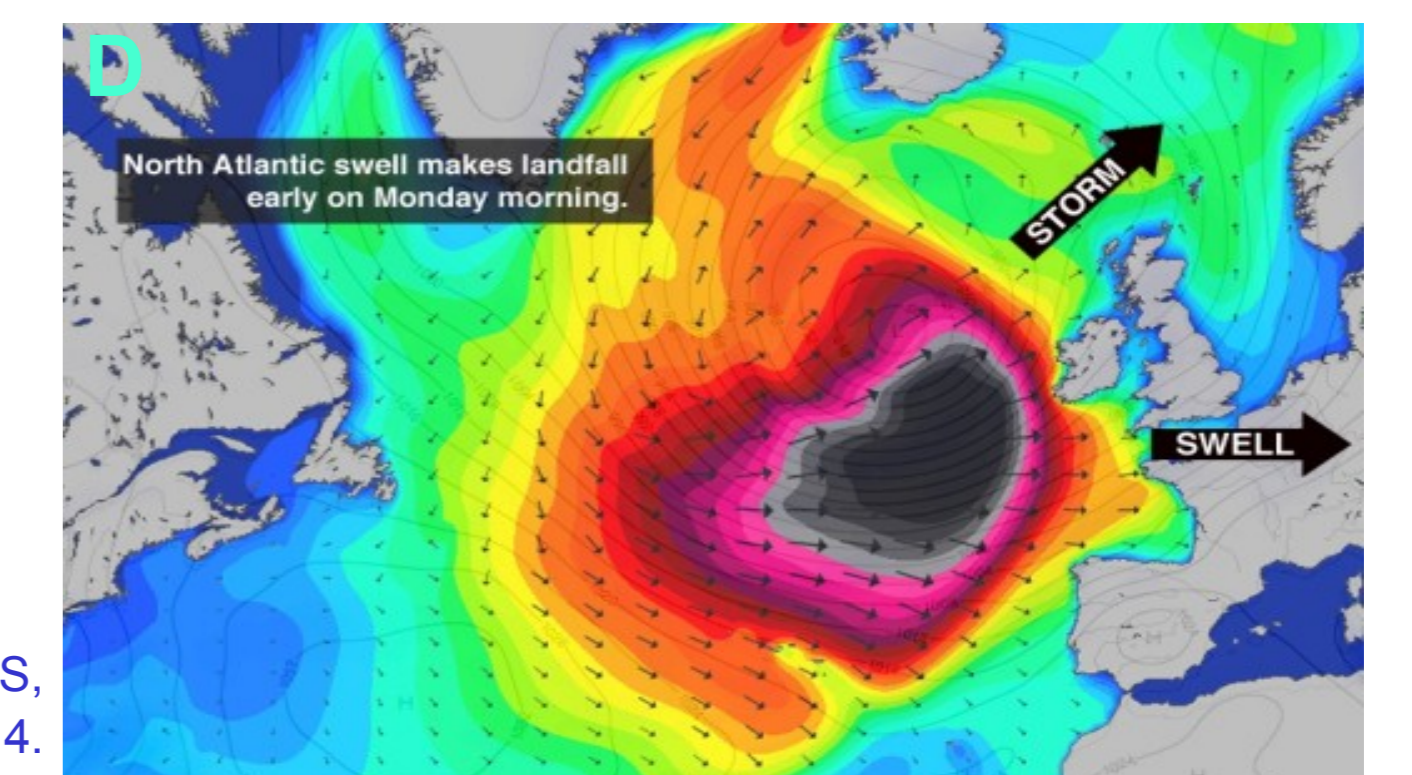


(<http://www.stormsurf.com/>)



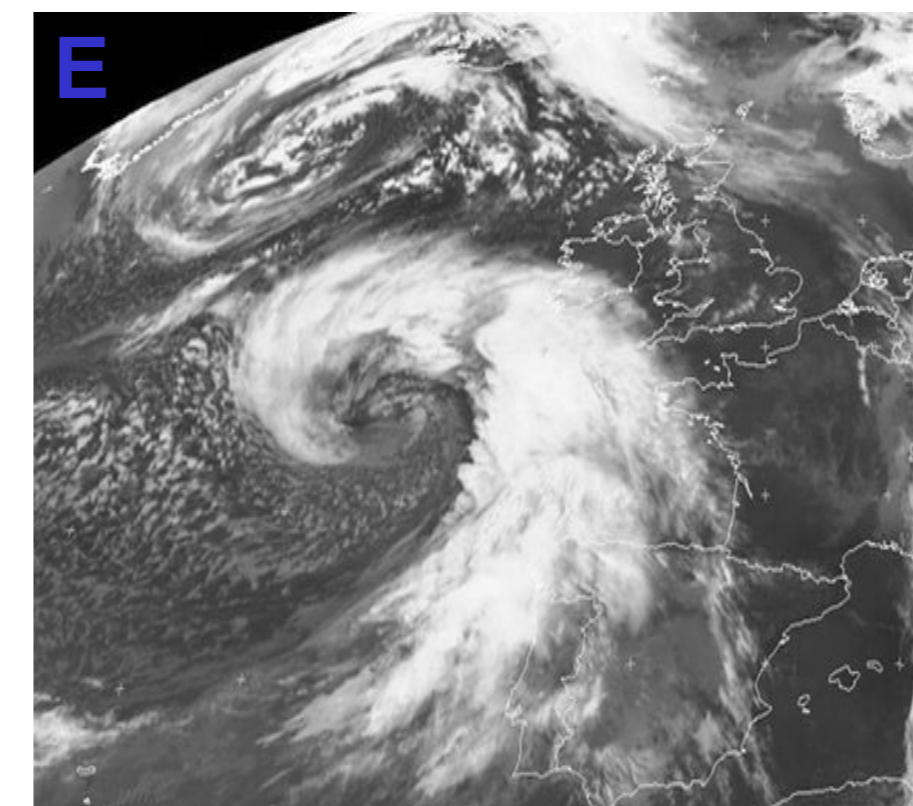
St. JUDE / CHRISTIAN
 26-28 October 2013.

(<http://magicseaweed.com/news/European-Storm-Call/5726/>)

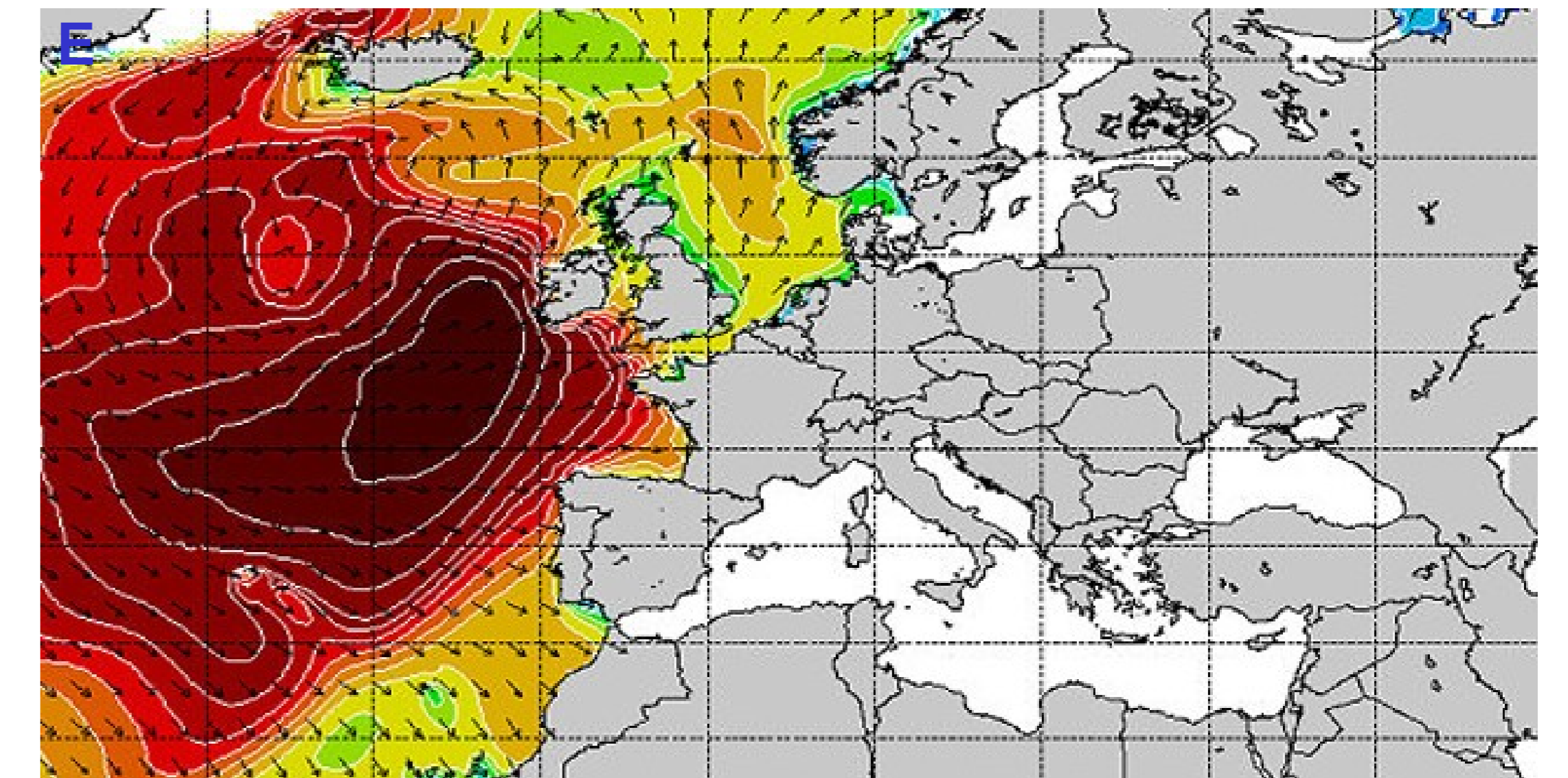


HERCULES,
 6-8 January 2014.

(<http://countdowntozero.com/2014/01/07/winter-storm-hercules-forecast-larger-than-perfect-storm-we-have-seen-nothing-like-it-atlantic-code-red-destructive-high-surf-evacuates-european-coast/>)



STEPHANIE, 8-10 February 2014.
 (http://en.wikipedia.org/wiki/2010_Atlantic_hurricane_season)



STEPHANIE, 8-10 February 2014.

Characteristics of the storms (1 mph ⇔ 1.609 m/h; 1 hPa = 1 mbar):

- ✓ OTTO storm (B), recorded at intervals of 12 hours: highest winds 140 km/h, lowest pressure 976 mbar
- ✓ St. JUDE or CHRISTIAN storm (C): highest winds 194 km/h, lowest pressure 965 mbar
- ✓ HERCULES storm (D): highest winds 120 km/h, lowest pressure 975 mbar
- ✓ STEPHANIE storm (E): highest winds 134 km/h, lowest pressure 981 mbar

D: Tropical Depression – wind speed less than 39 mph
 S: Tropical Storm – wind speed between 39 mph and 73 mph
 H: Hurricane – wind speed between 74 mph and 110 mph
 M: Major Hurricane – wind speed greater than 110 mph

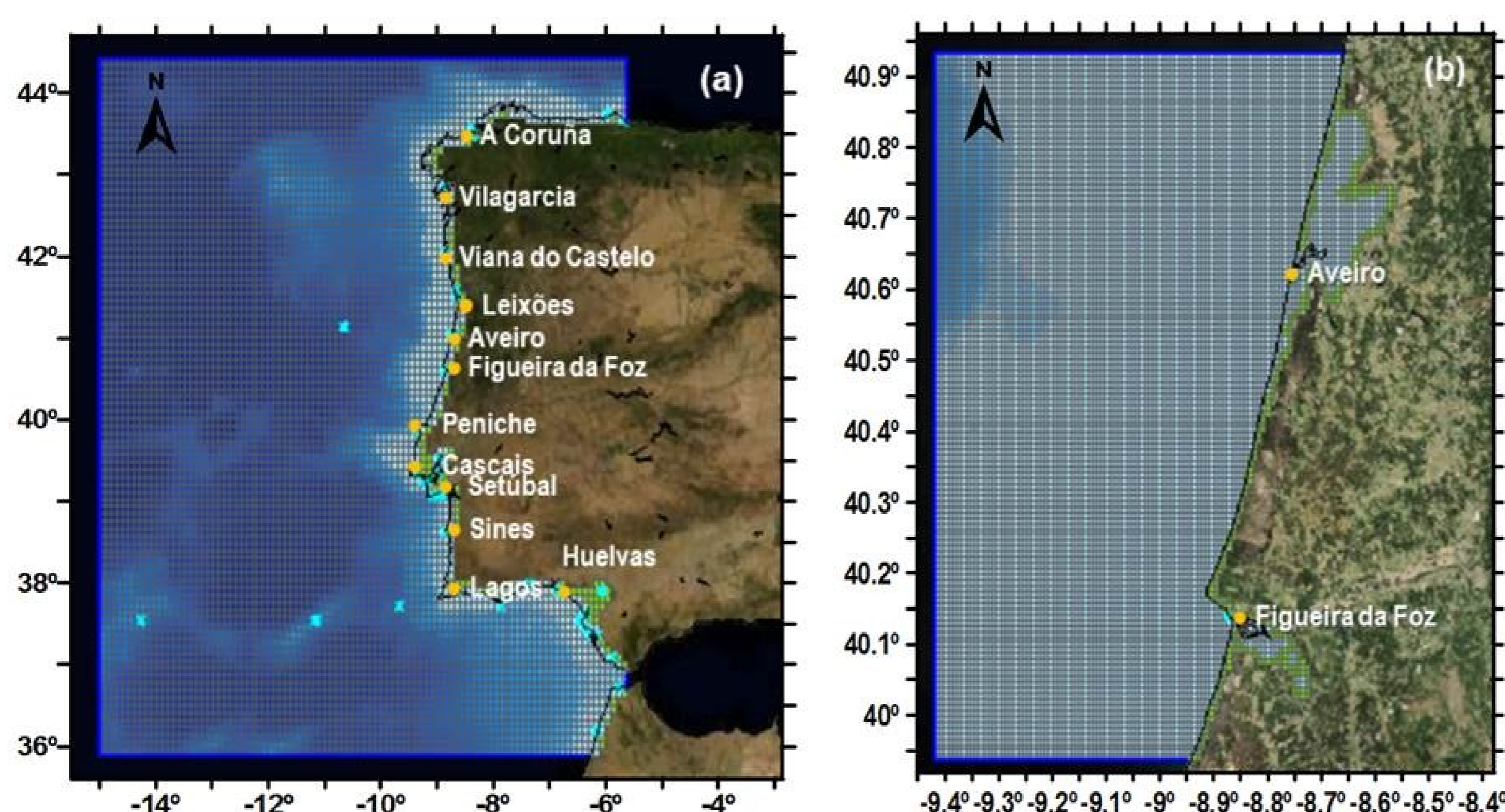
Contribution to support planning and management of the coastal zone

Spatial domains simulated with different grids:

- Iberian coastal domain (a), with a grid of dimensions 96x97 cells and a spacing of 10000 m in both directions.
- Central region domain (b), with a grid of higher spatial resolution (dimensions of 127x108 cells spaced about 1000 m).

Numerical tools (Deltares, 2011 and 2012):

- DelftDashboard for pre-processing tasks.
- Delft3D-FLOW for simulations.



Hydrodynamic domains generated, and several observation points (WGS 84 coordinate system):
 (a) Iberian domain; (b) Central region of Portugal domain.

Historical storms simulated:

- ✓ 3 Tropical depressions: S1 - Frances, 1992; S2 - Jeanne, 1998; S3 - Vince, 2005.
- ✓ 3 Tropical storms: S4 - Vince, 1842; S5 - Chloe, 1967; S6 - Irene, 1981.
- ✓ 2 Tropical cyclones: Not named, 1941; S7 - Xynthia, 2010.

Preliminary results:

MEOW (Maximum Envelope of Water) values in the central region domain (storm surge heights in meters).

Name	Year	F	P	G
<i>Tropical Depression</i>				
S1	1992	0.20	0.21	0.58
S2	1998	0.13	0.18	0.42
S3	2005	0.08	0.12	0.67
<i>Tropical Storm</i>				
S4	1842	0.56	0.66	2.04
S5	1967	0.28	0.55	1.22
S6	1981	0.65	0.95	1.61
<i>Tropical Cyclone</i>				
Not named	1941	1.74	2.98	3.63
S7	2010	2.58	2.13	2.87

MOM (Maximum of the MEOWs) values in the central region domain (storm surge heights in meters).

Category	F	P	G
Tropical depression	0.20	0.21	0.67
Tropical Storm	0.65	0.95	2.04
Tropical cyclone	2.58	2.98	3.63

F = Aveiro (north) P = Mira (center) G = Figueira da Foz

Preliminary conclusions:

- ✓ Coastal storms affecting the Portuguese territory were identified, based on historical data;
- ✓ Tropical storms are more frequent than tropical depressions and tropical cyclones;
- ✓ Results of the simulated coastal storms in an Iberian coastal domain for episodes of tropical depression and tropical storms showed that higher water levels occur at Vilagarcia, Huelva and Ayamonte;
- ✓ For historical tropical cyclones, Vilagarcia, Aveiro and Figueira da Foz showed the highest water heights;
- ✓ In the central region of Portugal, Figueira da Foz is the most vulnerable place to the various categories of storms, followed by Mira and, lastly, Aveiro;
- ✓ Figueira da Foz has the largest envelope of water levels, when compared to Aveiro, for categories of tropical storms and tropical cyclones.

Deltares, 2011. User Manual Delft3D-FLOW. Hydro-Morphodynamics, Version: 3.15, Netherlands.
 Deltares, 2012. DelftDashboard - OpenEarth - Deltares Public Wiki.
<http://publicwiki.deltares.nl/display/OET/DelftDashboard>