The upgraded french operational coastal wave model with sea level and surface currents forcings

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13.09.2017
1st international workshop on waves, storm surges and coastal hazards

Outline

1. Configuration of WW3 at Meteo-France for coastal areas

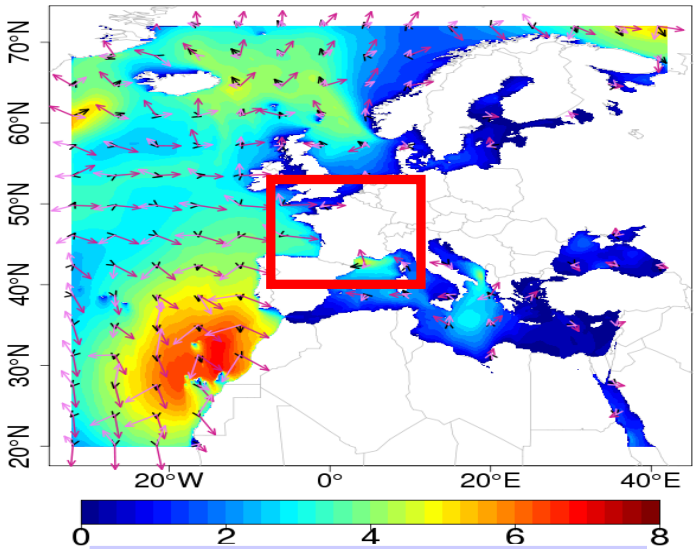
2. Validation of the sea level and currents forcing on Atlantic and Channel french coast

3. Comparison between two currents forcing

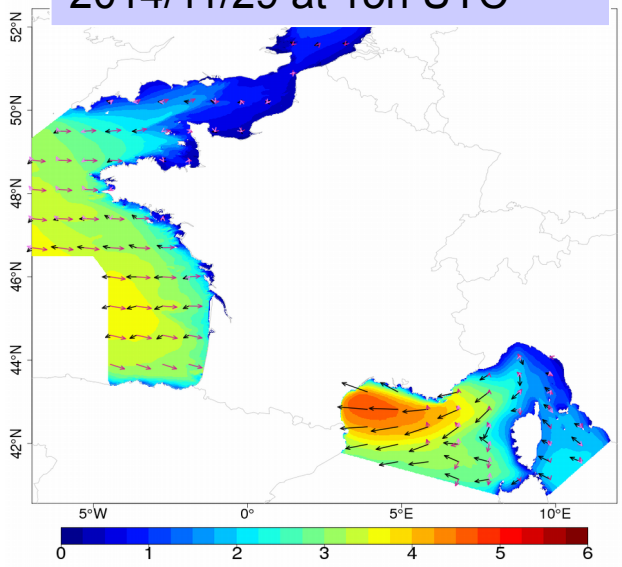
Île de Sein (Brittany) 05/02/2014

Configuration of WW3 at Meteo-France

Implementation in 2015 on metropolitan french coast by Meteo-France and SHOM in the frame work of the HOMONIM project (supported by the ministry of ecology and sustainable development)



Significant wave height (m)
2014/11/29 at 15h UTC



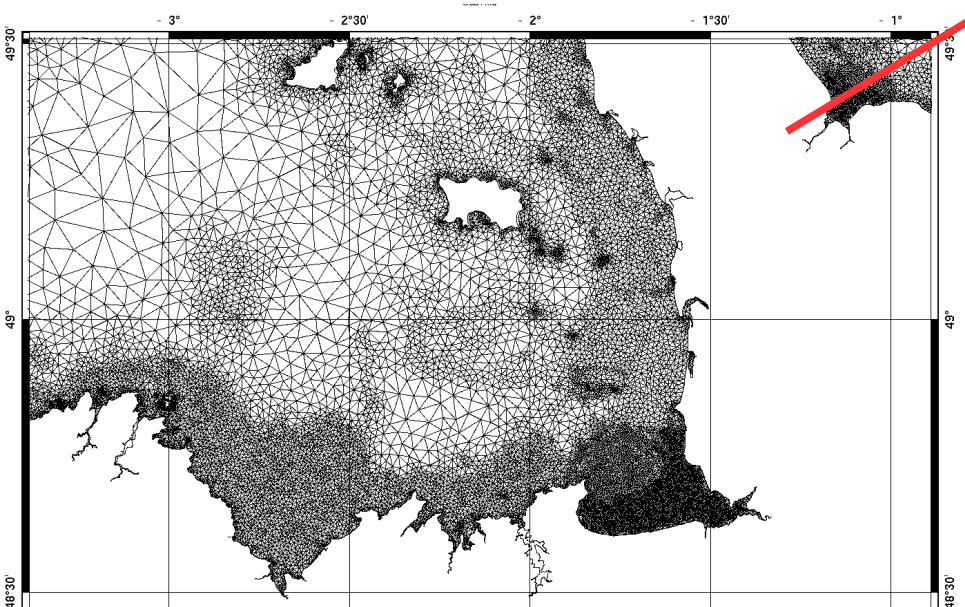
- Use of an irregular mesh up to a resolution of 200 m nearshore.
- Run in operational four times per day up to 72 hours.
- Nested in the wave model of Meteo-France, MFWAM, at 10 km
- Wind forcing :
  - Arpege (10 km)
  - IFS (12,5km)
  - Arome (2,5km)

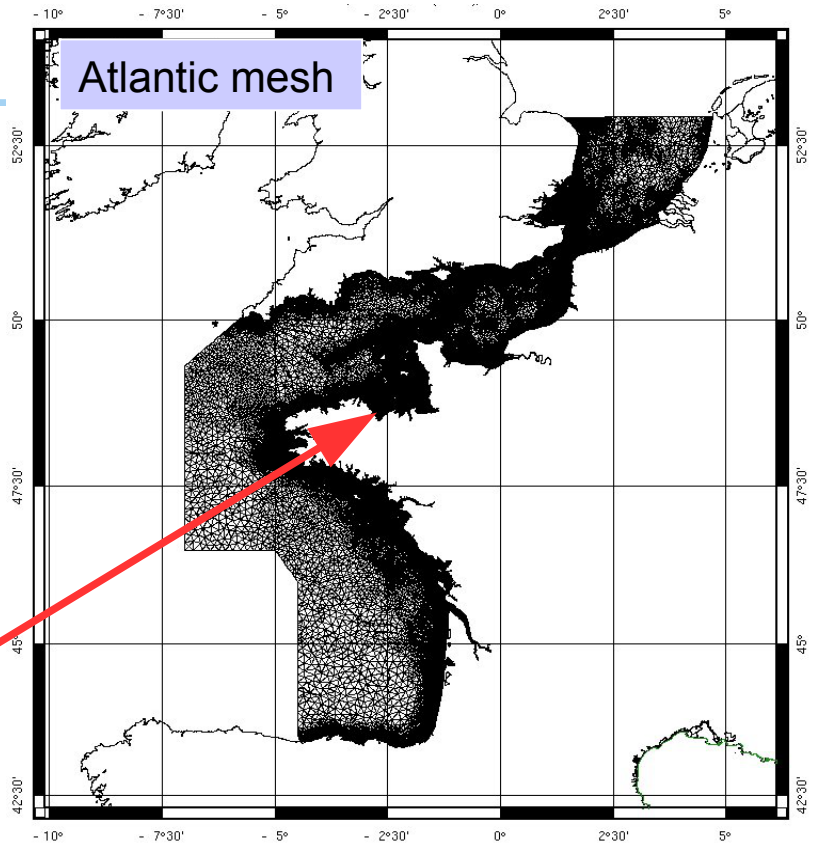
Configuration of WW3 at Meteo-France

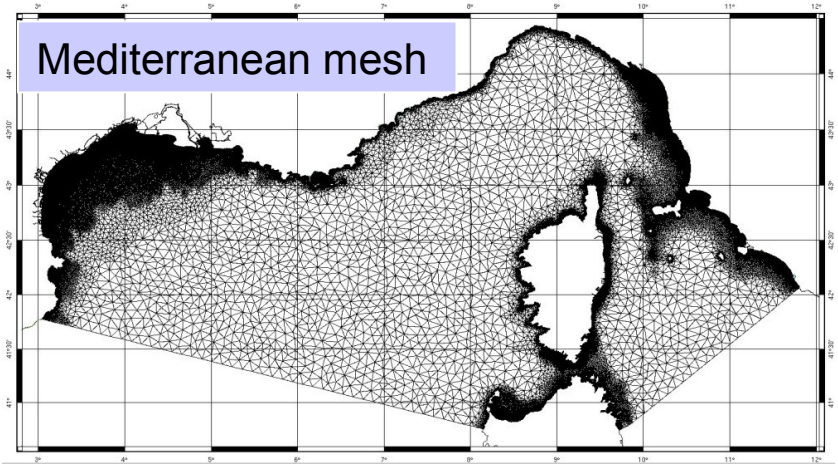
- Same parametrisation as MFWAM in deep water
  Dissipation developed by Ardhuin et al. (2010), ST4, and adjusted in the Mywave project (2014)

- Physical coastal processes implemented
  - Coast reflection
  - Refraction due to current and bathymetry
  - Bottom friction

- Irregular mesh adapted to geometry of coasts and bathymetry.





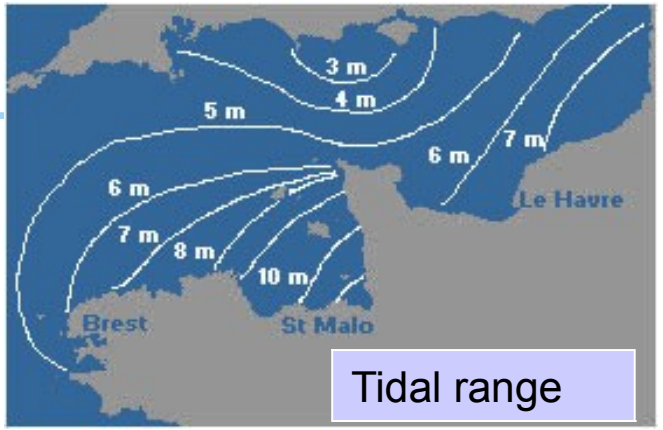


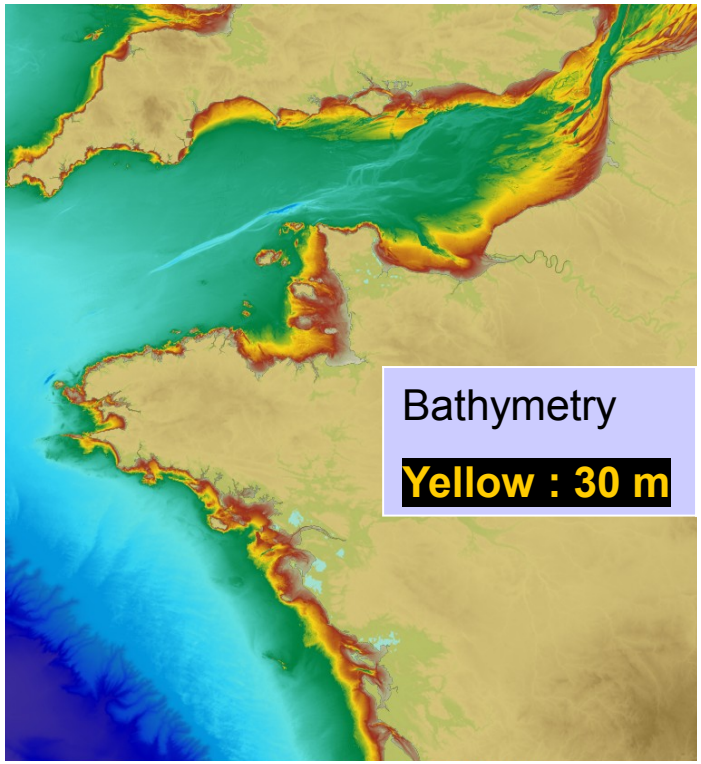
French Atlantic coasts : huge tides

- Relevance of tidal range on sea level : more than 5 m nearshore and in the Channel, up to 14 m in Mont Saint-Michel bay.

- large area of small depth : bays, Channel, nearshore areas on Atlantic coast

=> Need to update the sea level in the wave model



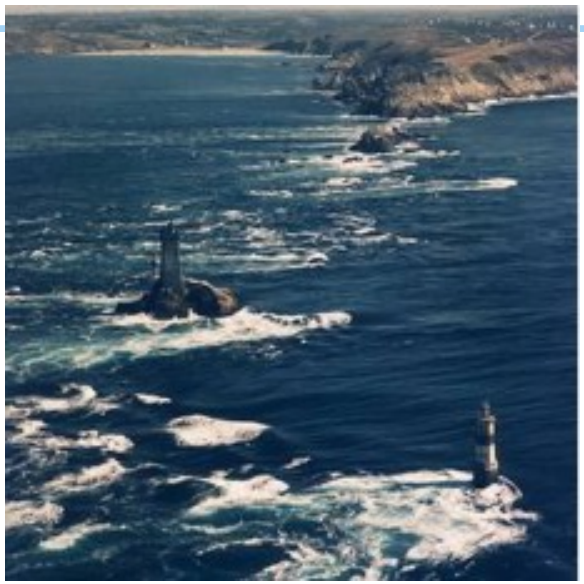


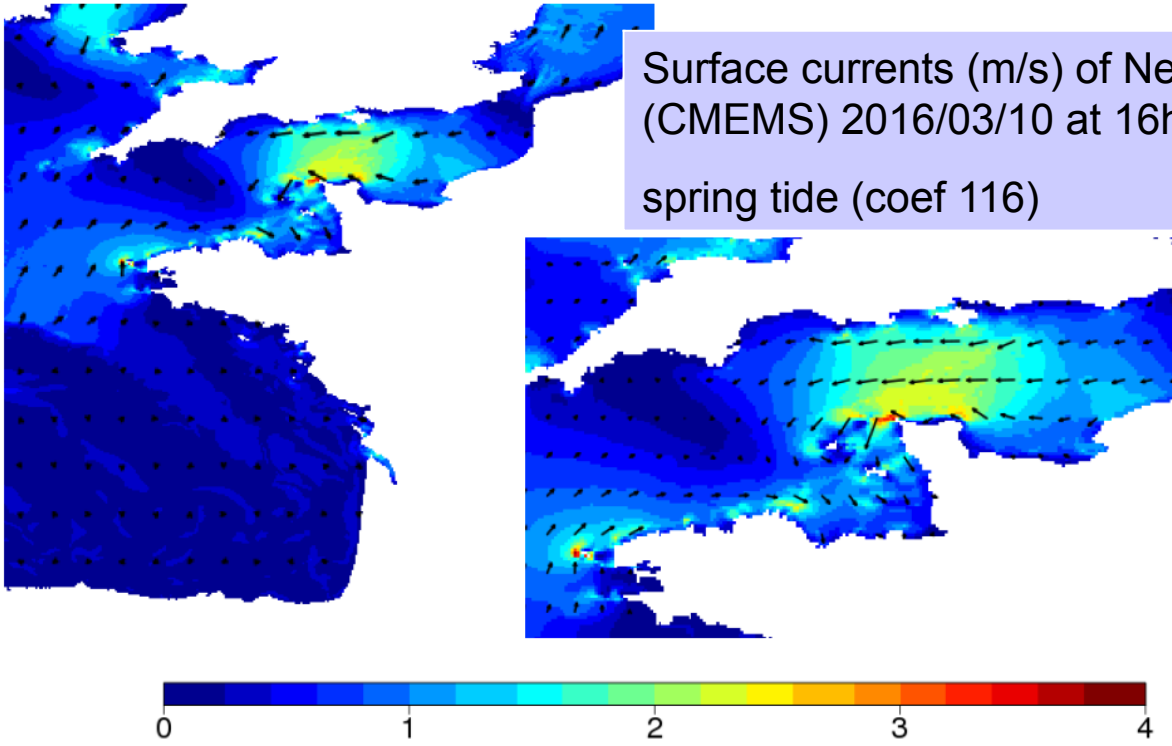
French Atlantic coasts : huges tides

- strong surface currents associated to the tides

- currents magnitude can reach every day 1 m/s in Brittany and Channel and 3 m/s in some areas during spring tides

=> Relevance to take surface currents into account





Surface currents (m/s) of Nemo IBI (CMEMS) 2016/03/10 at 16h UTC

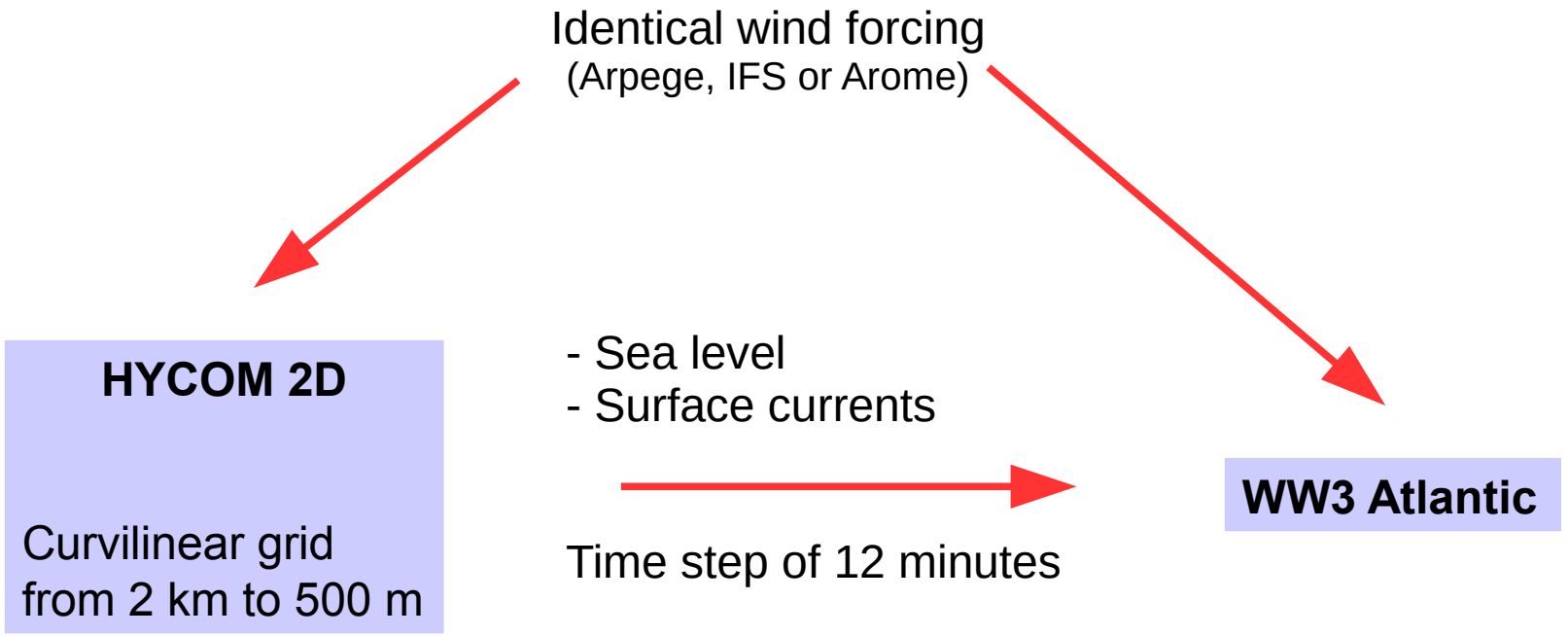
spring tide (coef 116)

Sea level and currents forcing on Atlantic coasts

- Sea level and currents forcing in operational since June 2017 for the Atlantic domain

- The forcings come from the barotropic model Hycom 2D (developed by SHOM)

→ Presentation of A.Pasquet (Tuesday)

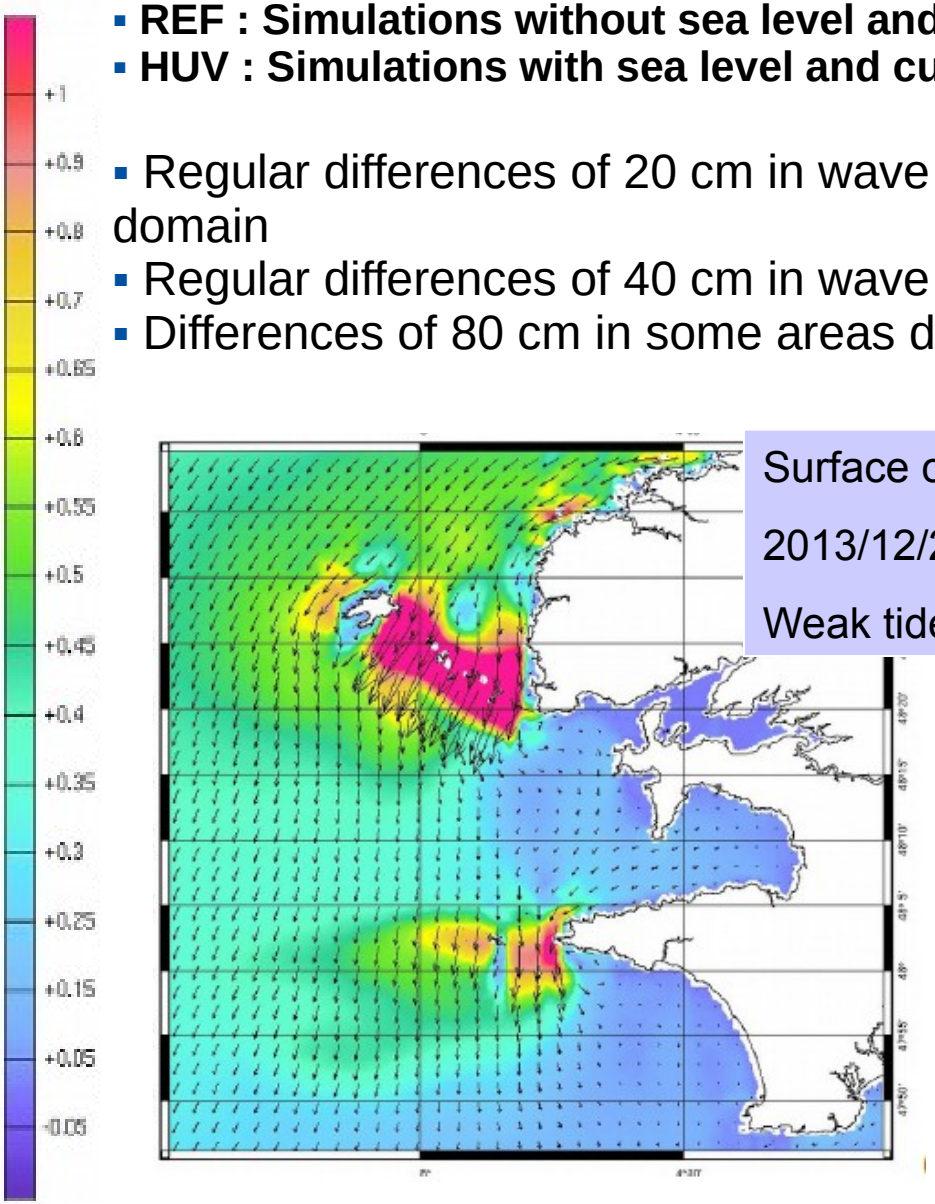


Validation of sea level and currents forcing on the winter 2013/2014

- **REF : Simulations without sea level and currents forcing**
- **HUV : Simulations with sea level and currents forcing**

- Regular differences of 20 cm in wave height between both simulations in the whole domain
- Regular differences of 40 cm in wave height in the Channel and in Brittany
- Differences of 80 cm in some areas during spring tide

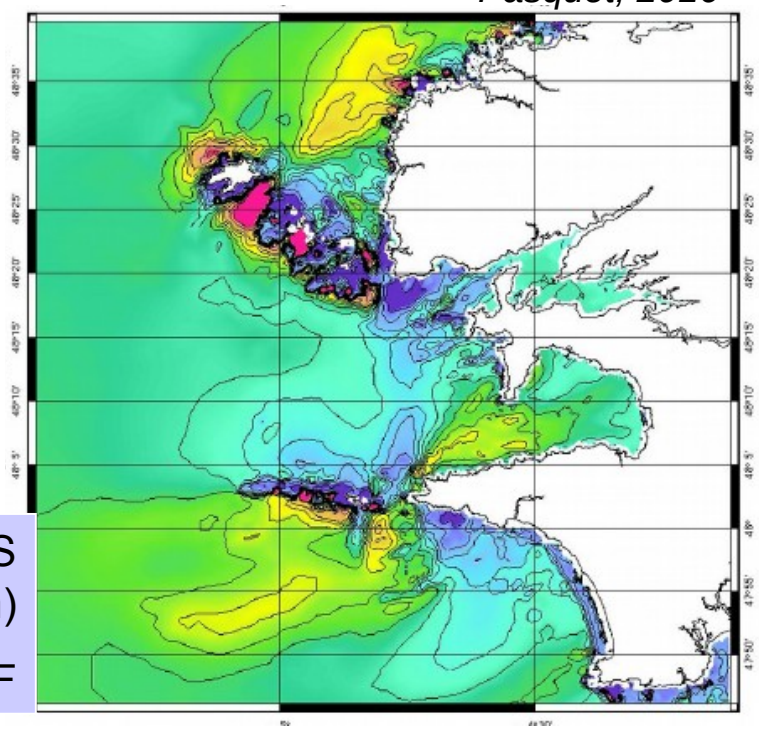
Michaud and Pasquet, 2016



Surface currents (m/s)

2013/12/24 0h

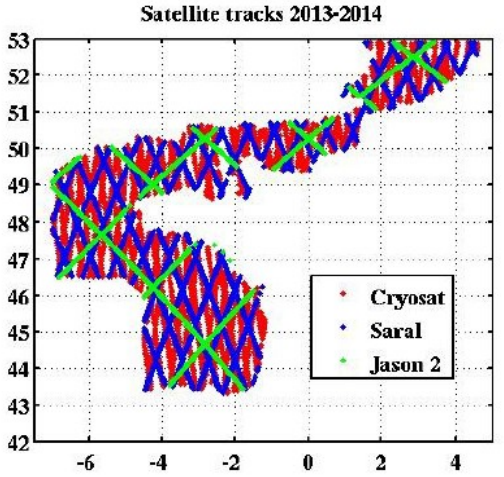
Weak tide (coef 55)



Difference of HS (m)

HUV - REF

Validation of sea level and currents forcing on the winter 2013/2014 with altimeters



- **REF : Simulations without sea level and currents forcing**
- **HUV : Simulations with sea level and currents forcing**

- Validation of wave height with altimeters (~2000 data)

- Improvement in dispersion. Scatter index (SI) is decreasing.

WW3 REF

Satellite	Biais (m)	RMSE	SI
SARAL	-0.07	0.354	0.118
JASON2	-0.11	0.372	0.114
CRYOSAT	-0.259	0.413	0.16

Mean of SI : **13,1 %**

WW3 HUV

Satellite	Biais (m)	RMSE	SI
SARAL	-0.08	0.338	0.114
JASON2	-0.117	0.358	0.11
CRYOSAT	-0.269	0.46	0.157

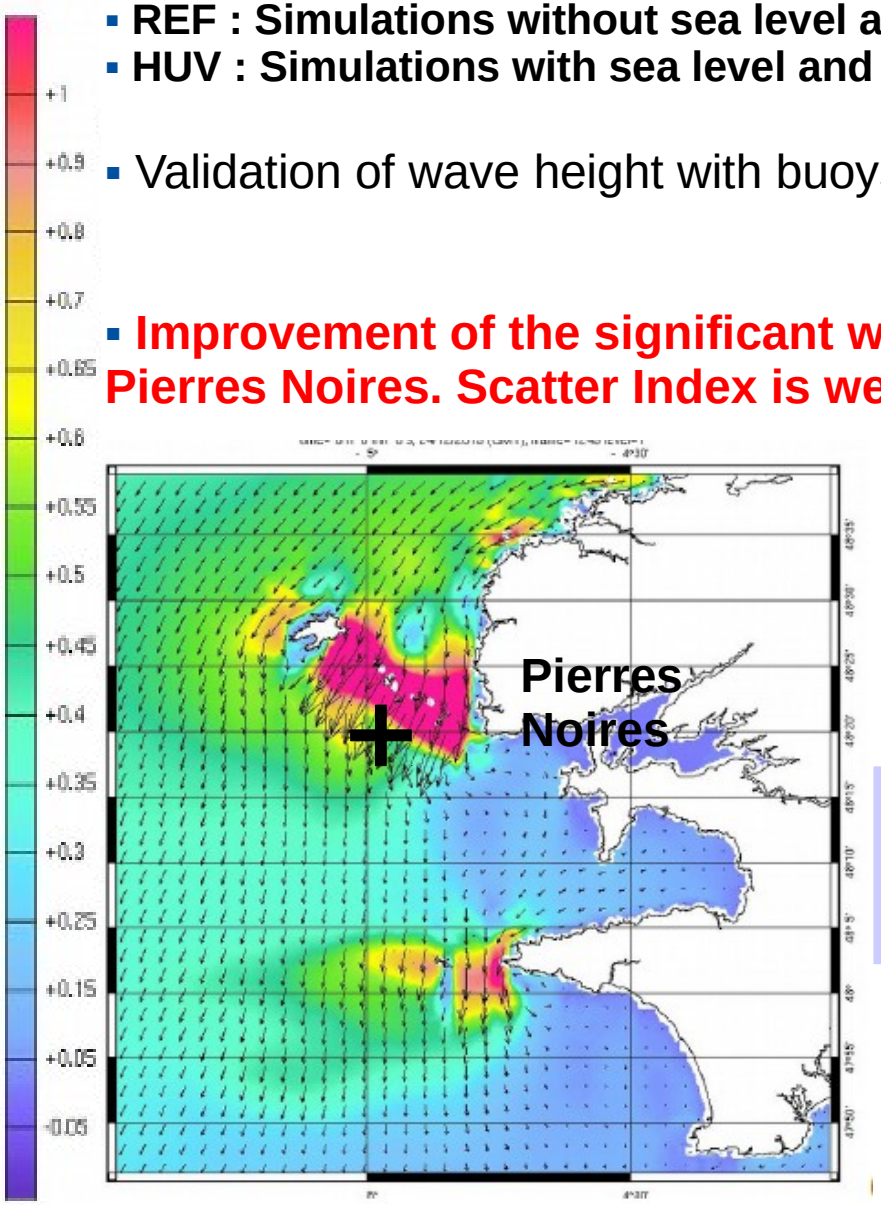
Mean of SI : **12,7 %**

Validation of sea level and currents forcing on the winter 2013/2014 with buoys

- **REF : Simulations without sea level and currents forcing**
- **HUV : Simulations with sea level and currents forcing**

- Validation of wave height with buoys

- **Improvement of the significant wave height at Pierres Noires. Scatter Index is well reduced.**



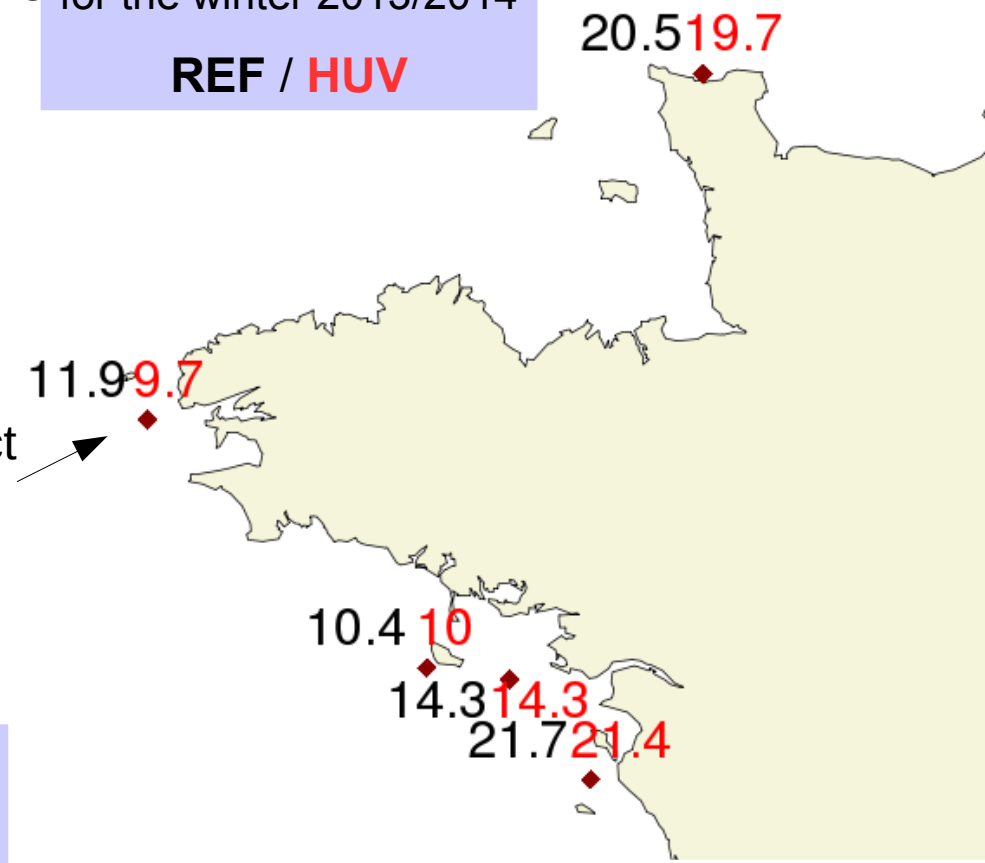
Important impact on Pierres Noires. Place of strong currents

Surface currents (m/s)

2013/12/24 0h

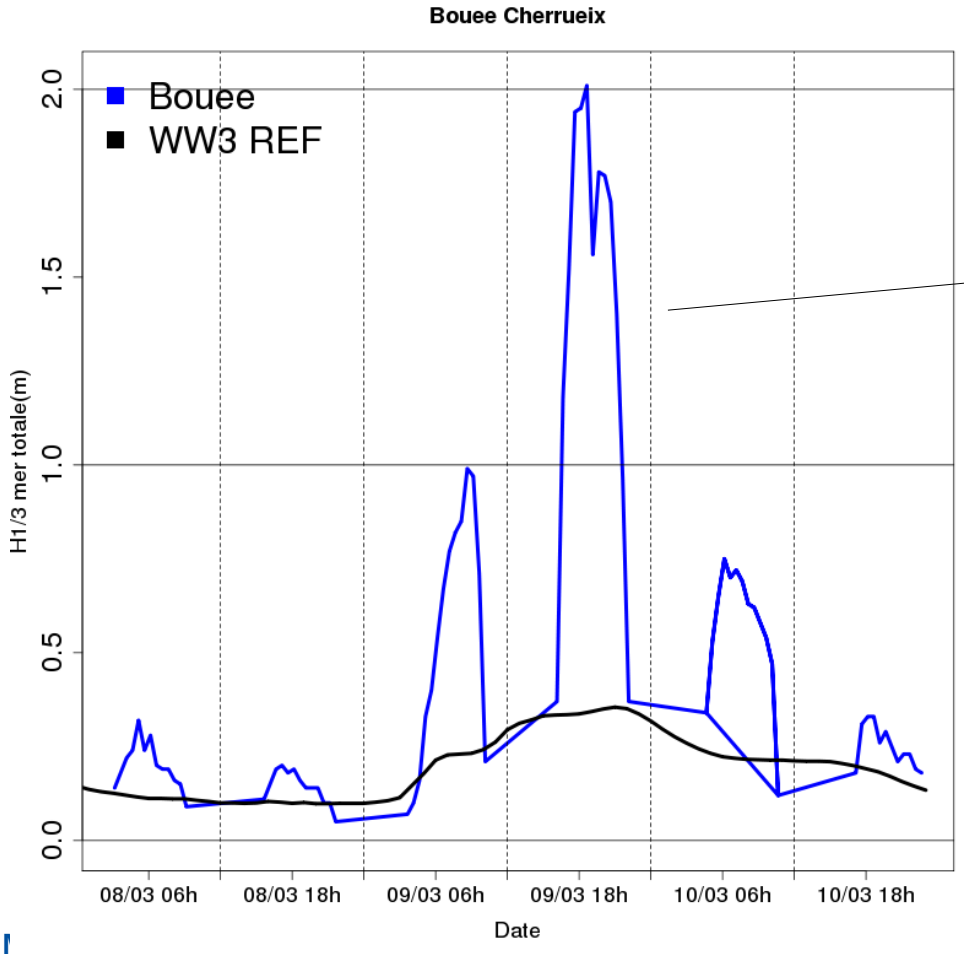
Scatter Index (%) of significant wave height for the winter 2013/2014

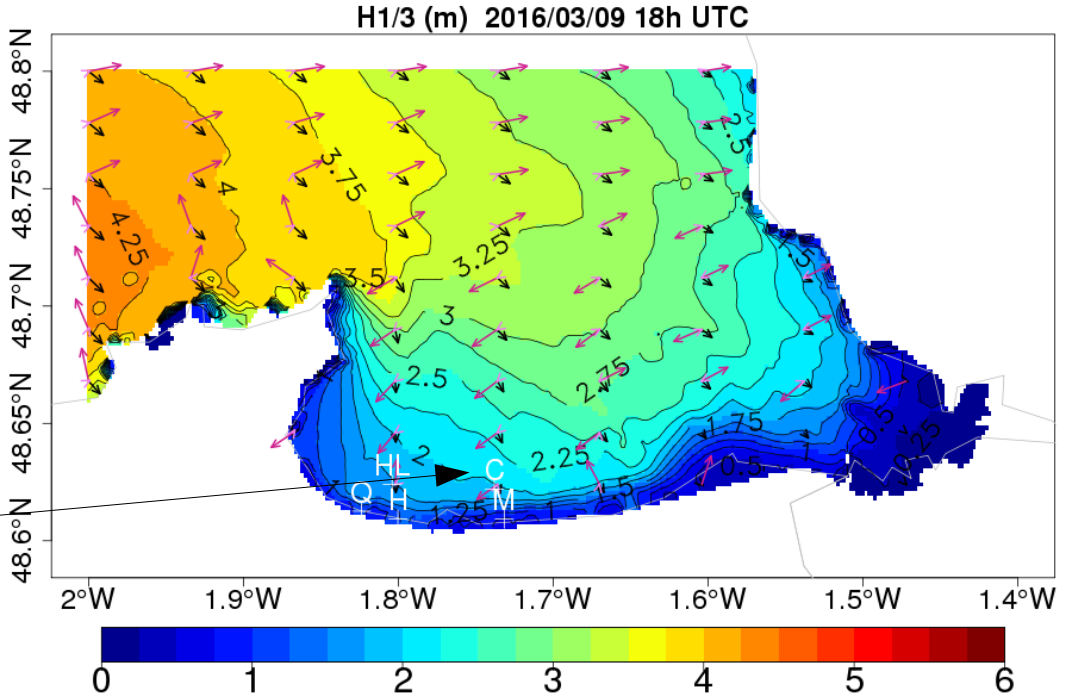
REF / **HUV**



Validation of sea level forcing at Mont Saint-Michel bay during Doris storm (09/03/2016)

- Measurement from the Dinard laboratory
- Occurence of a storm during a spring tide





- The buoys are on the sand during low tide

Significant wave height (m) 2016/03/09 at Cherrueix

Validation of sea level forcing at Mont Saint-Michel bay during Doris storm (09/03/2016)

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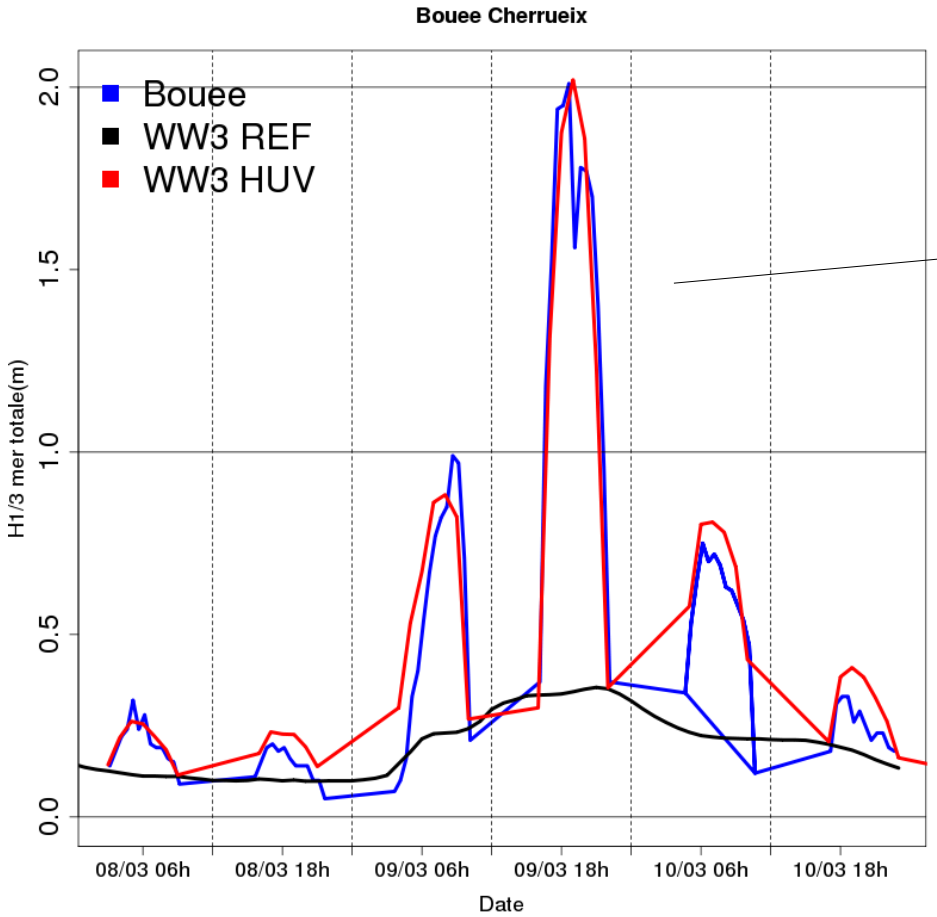

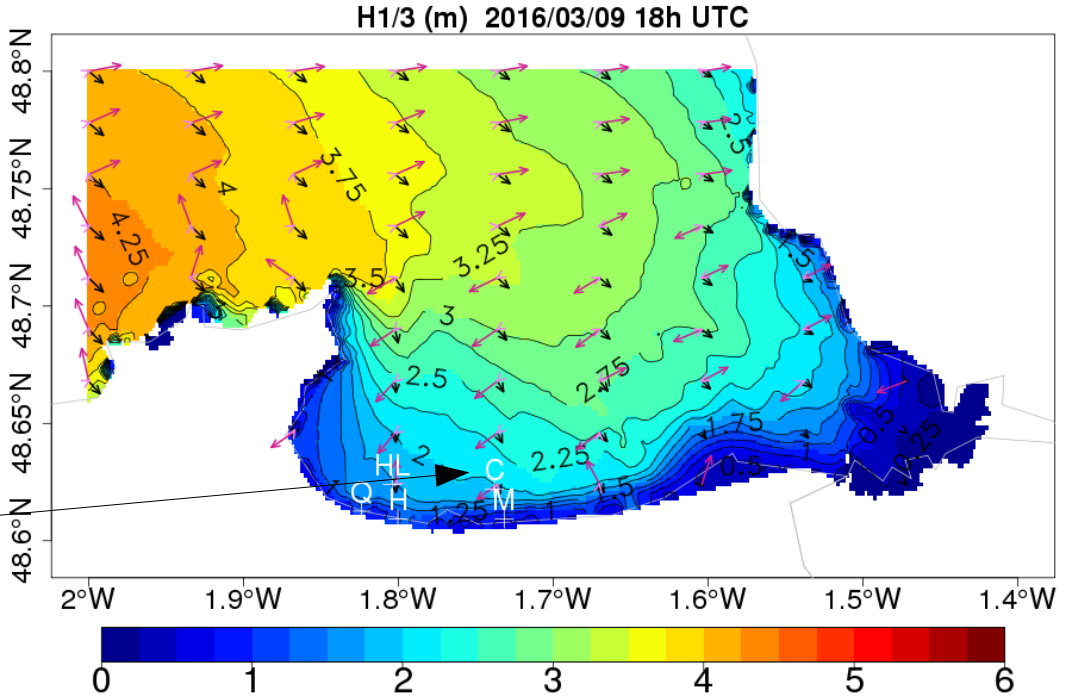

- The buoys are on the sand during low tide
- The height in high tide is well seen by WW3 thanks to sea level forcing

Significant wave height (m) 2016/03/09 at Cherrueix

Outline

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Île de Sein (Brittany) 05/02/2014

Impact study on surface currents forcing in WW3

- WW3 simulations on Atlantic domain without currents forcing, with Hycom currents and with NEMO IBI currents during January and February 2017

HYCOM 2D

- Barotropic model
- Resolution from 500 m to 2 km
- Time step of forcing data : 12 min

=> **good reference for the tide modelling**

NEMO IBI (CMEMS IBI)

- model in 3D including deep ocean dynamic
- Resolution of 1/36° (2,8 km)
- Time step of forcing data : 1 hour

=> **representation of currents coming from the dynamic of the ocean**

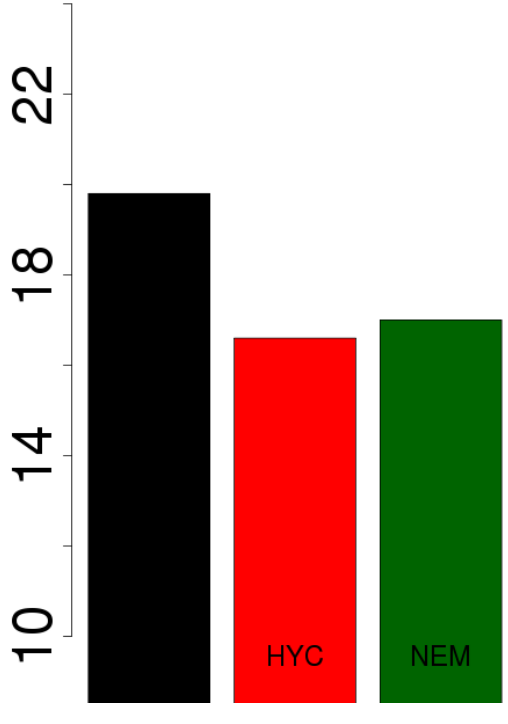
Comparison with buoys
SI in %

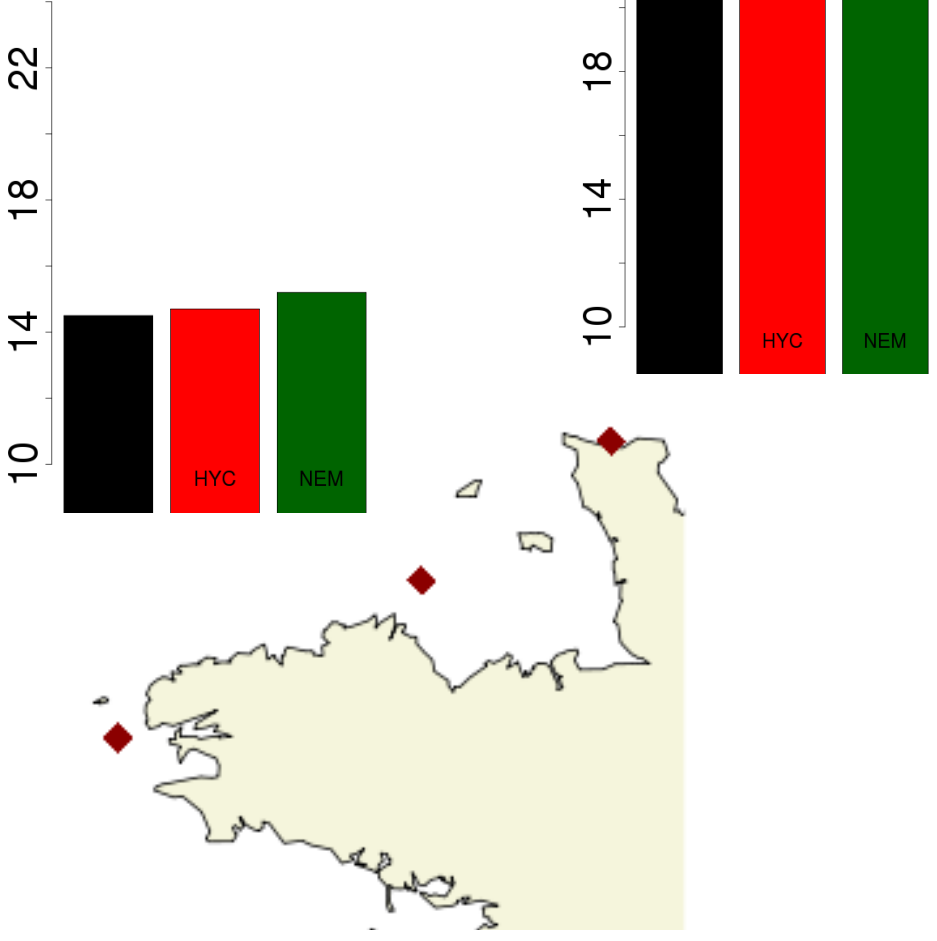
Scatter Index (%) of significant wave height for the winter 2013/2014

REF / HYC / NEM

- **REF : Simulations without sea level and currents forcing**
- **HYC : Simulations with Hycom currents forcing**
- **NEM: Simulations with Nemo currents forcing**

- **Improved scatter index for both models in Pierres Noires.**

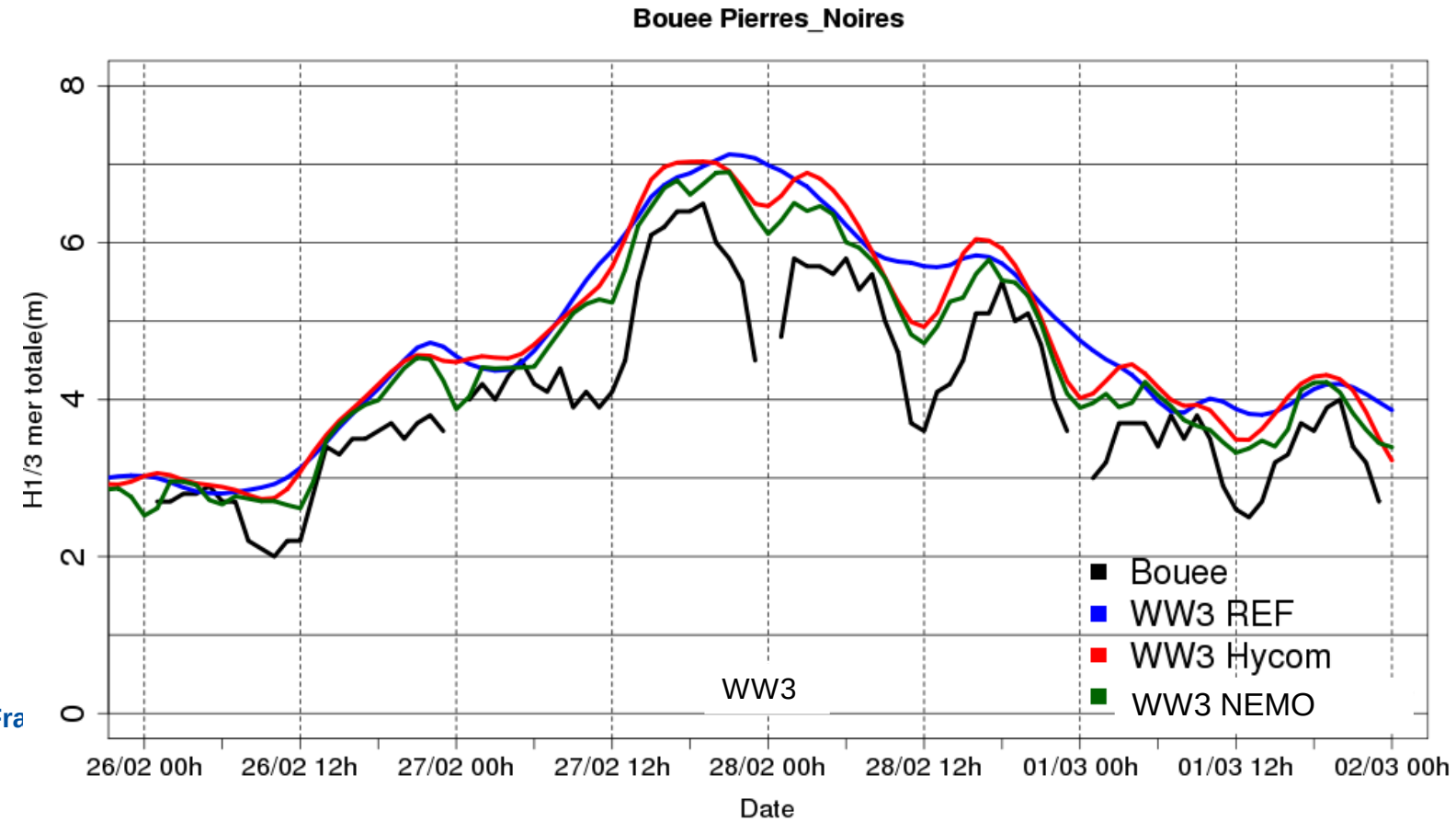




Comparison with buoys

- **REF : Simulations without sea level and currents forcing**
- **HYC : Simulations with Hycom currents forcing**
- **NEM: Simulations with Nemo currents forcing**

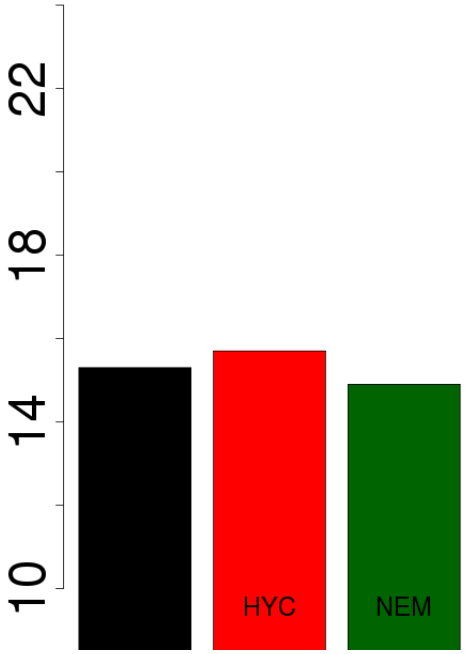
- With currents forcing, tidal cycle affecting significant wave height is well reproduced

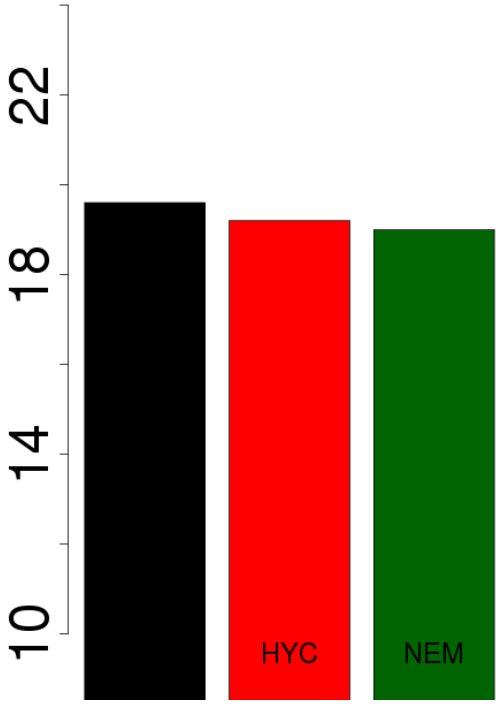


Comparison with buoys
SI in %

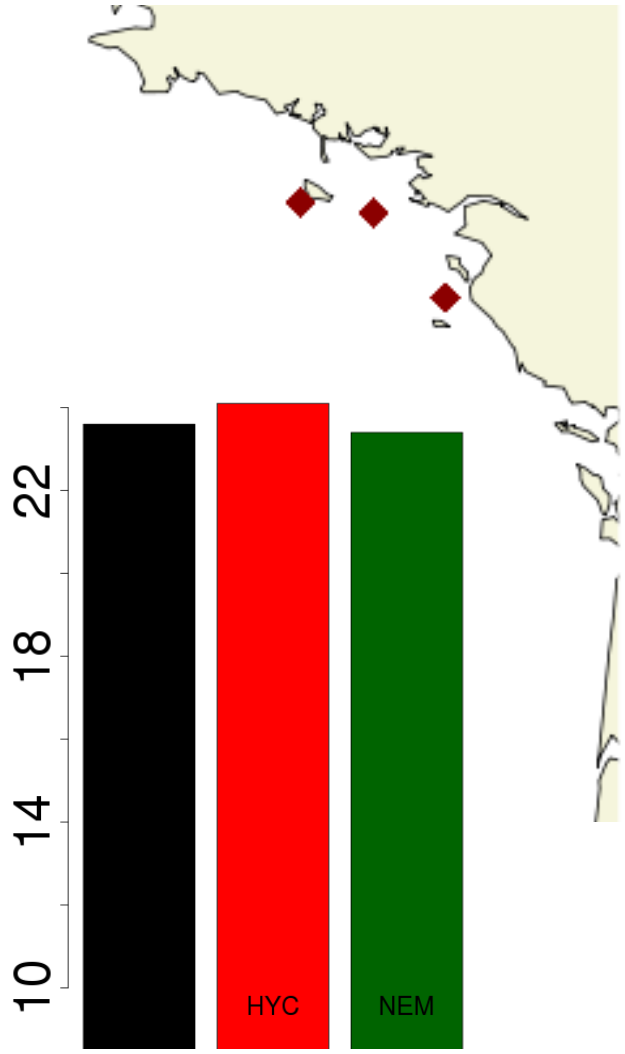
Scatter Index (%) of significant wave height for the winter 2013/2014

REF / HYC / NEM





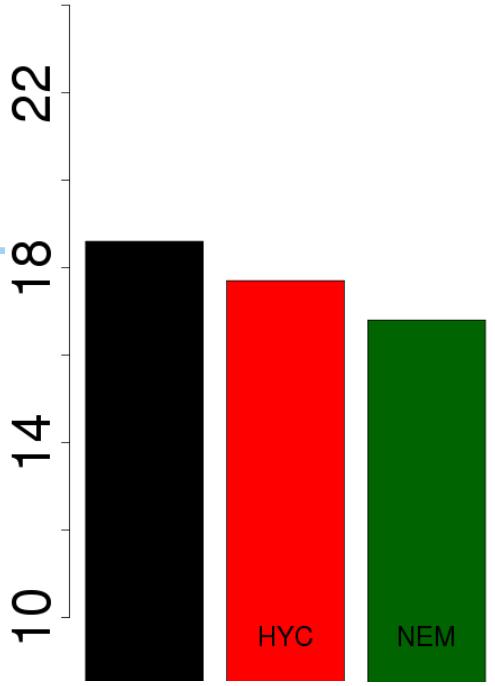
Scores similare to reference



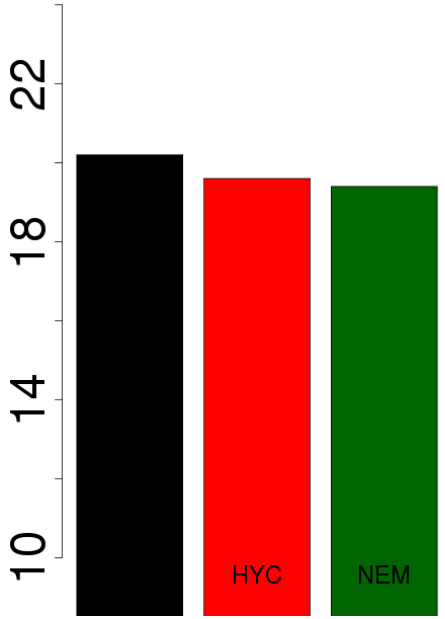
Comparison with buoys
SI in %

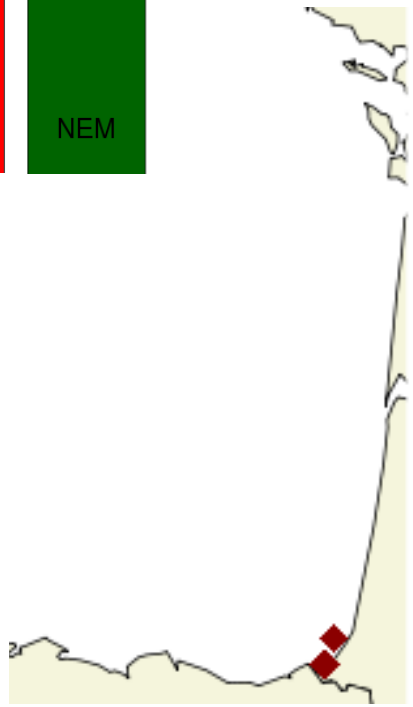
Scatter Index (%) of significant wave height for the winter 2013/2014

REF / HYC / NEM

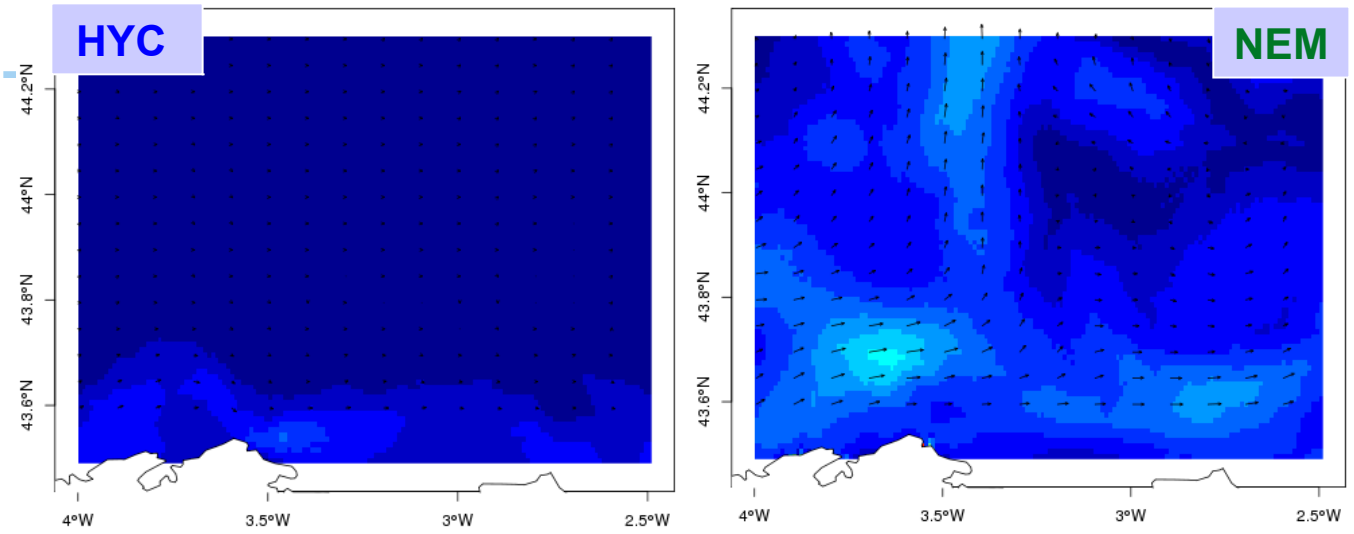


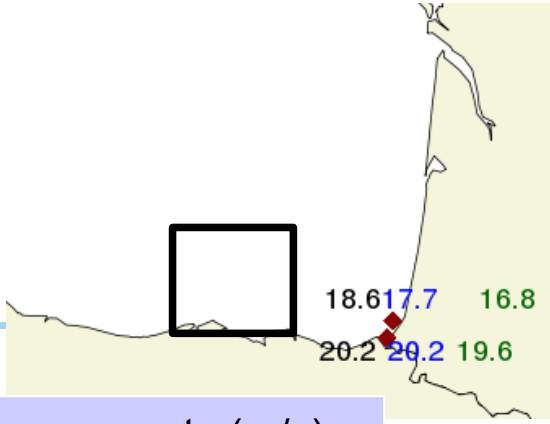
Improvement in Basque country for both simulations





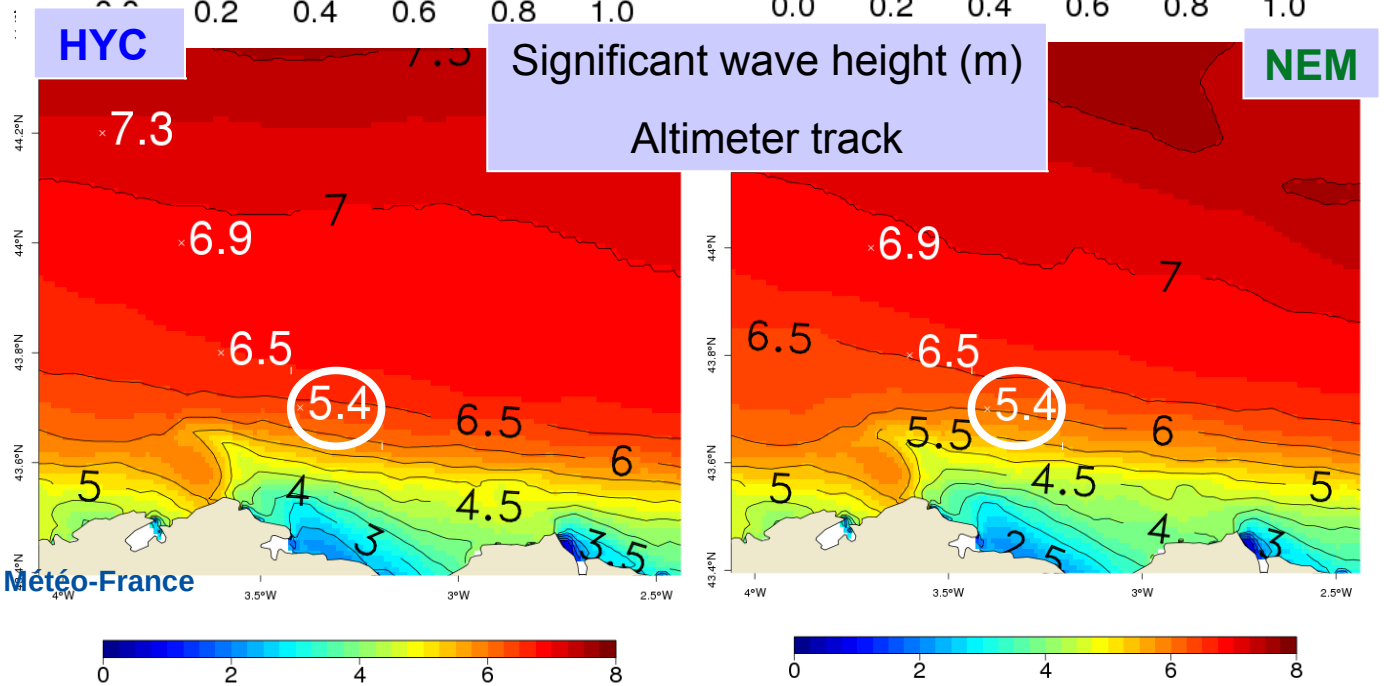
Currents in bay of Biscay





Surface currents (m/s)

2017/02/03 06h



- **Currents magnitude of 0,3 m/s given by NEMO IBI and not by Hycom 2D**
- **Slight improvement nearshore where currents go along the waves**

=> decrease of wave height of 50 cm on 6,5 m (-8%)

Conclusion

- Sea level and currents forcing from Hycom 2D in WW3 have been implemented in operations for Channel/ Atlantic area.

- Improvement has been clearly identified for the wave forecast in shallow water at the Channel, Brittany and nearshore areas on Atlantic : thanks to sea level update. Validation in Mont Saint-Michel Bay during a spring tide.

- Significant improvement thanks to currents forcing in area of important tide currents (Brittany, Channel,...). Validation in Pierres Noires buoy (-18 % of SI) and with the altimeters during winter 2013/2014.

- Comparison between currents forcing from Hycom 2D and NEMO IBI :
  - scores of tide currents of NEMO IBI are similar to those of Hycom 2D
  - currents are stronger in NEMO IBI in the Bay of Biscay than in Hycom 2D. But scores with altimeters didn’t show any consistant improvement.

- Future work :
  - Evaluation of Hycom and CMEMS-Glo currents in French Guyana
  - Implementation of WW3 unstructured grid in Indien Ocean french islands (end 2017), new Caledonia and Polynesia (in 2018)

Thank you for your attention