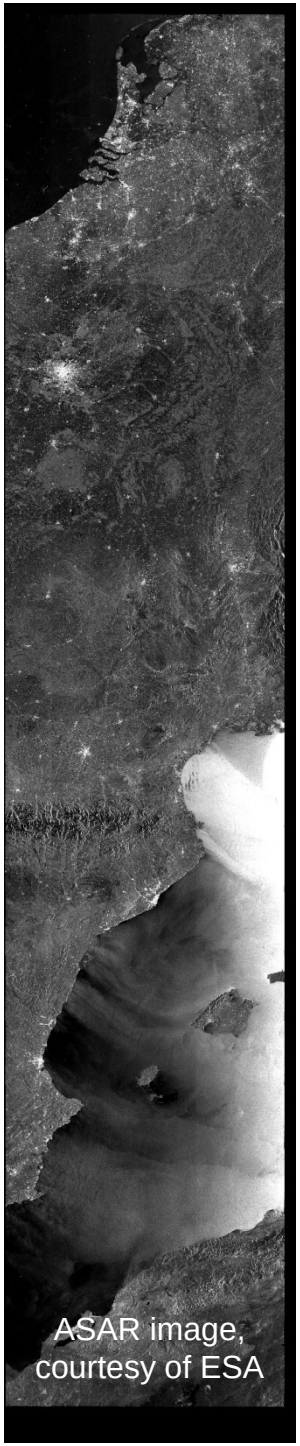
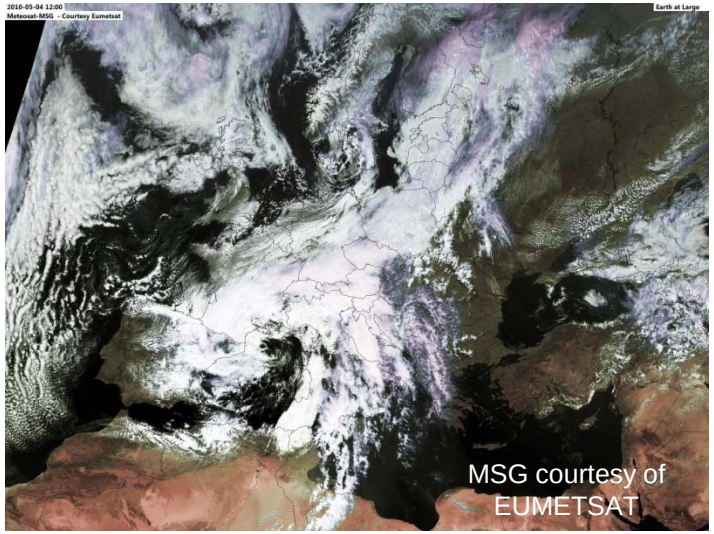


Ocean-atmosphere-wave coupling: extreme event analysis, forecast and effects in the Mediterranean Sea in May 2010



L. Renault[1], *J. Chiggiato*[2] , G. Vizoso[3], M. Gomez[4], J. Tintoré[1,3]and J. C. Warner[5]

[1] Balearic Islands Coastal Observing and Forecasting System (SOCIB), Palma de Mallorca, Spain;
[2] NATO Undersea Research Centre (NURC), La Spezia, Italy;
[3] Mediterranean Institute for Advanced Studies (IMEDEA), Palma de Mallorca, Spain;
[4] Puertos del Estado, Madrid, Spain;
[5] United States Geological Survey (USGS), Woods Hole, MA, USA.

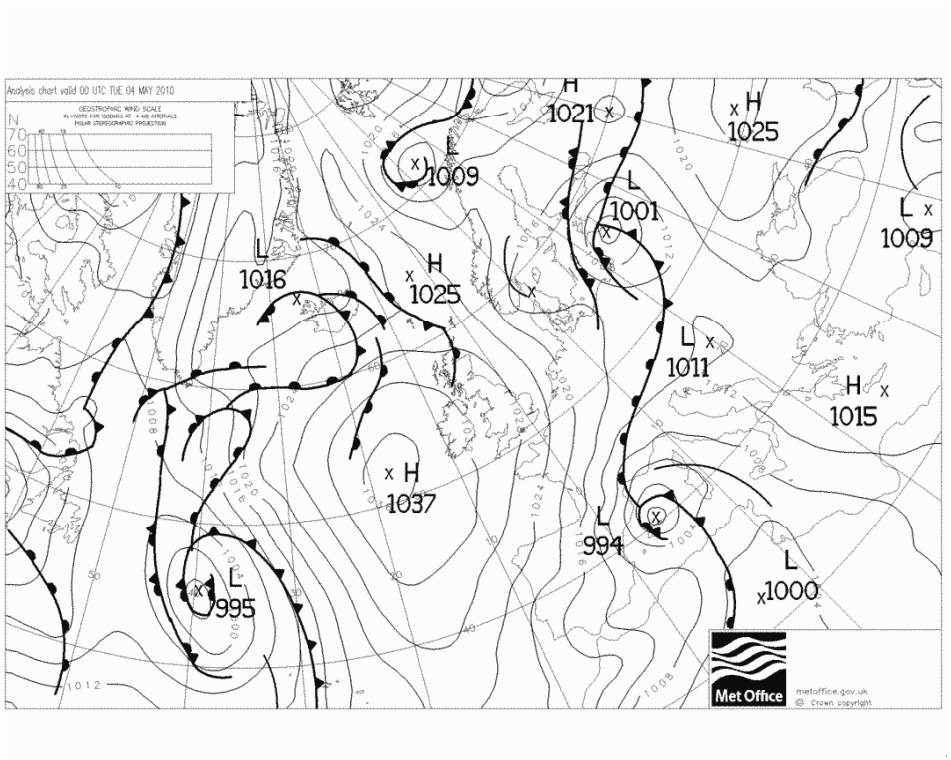
Motivations

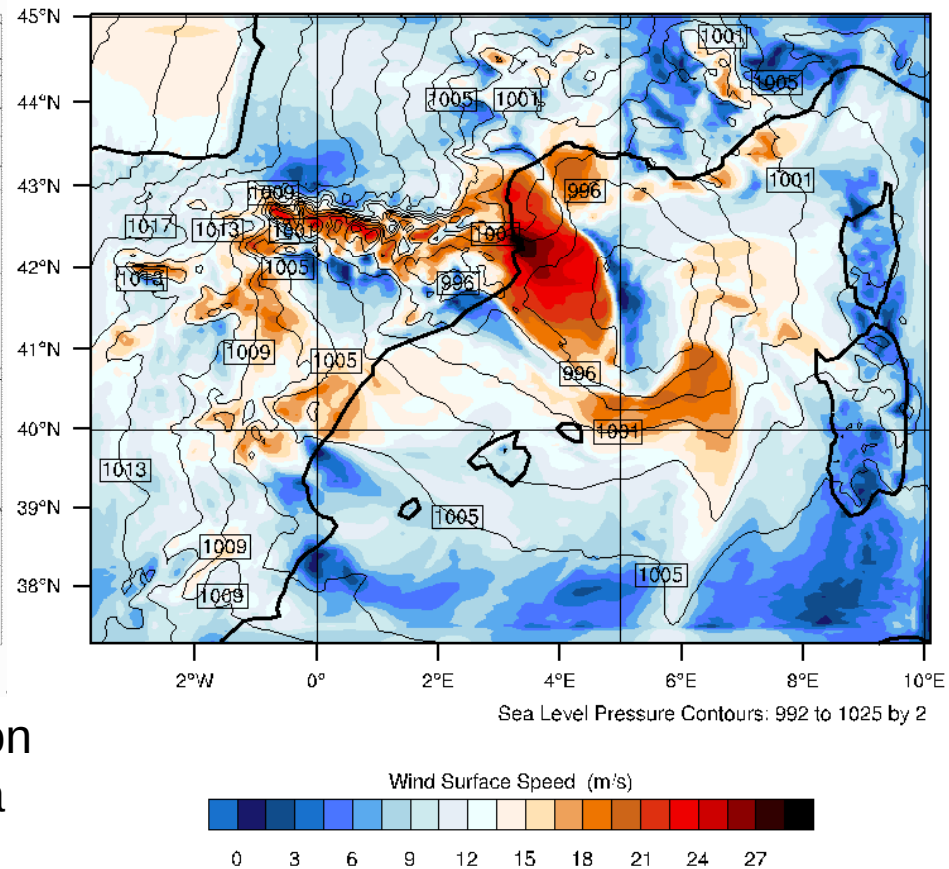
•Testing the system: it is still under development -and it is meant to be that way for long-;

•Better understanding of the role of key quantities in the storm evolution;

•Is the coupling providing better picture?

Case Study: Storm on May 3-5 2010

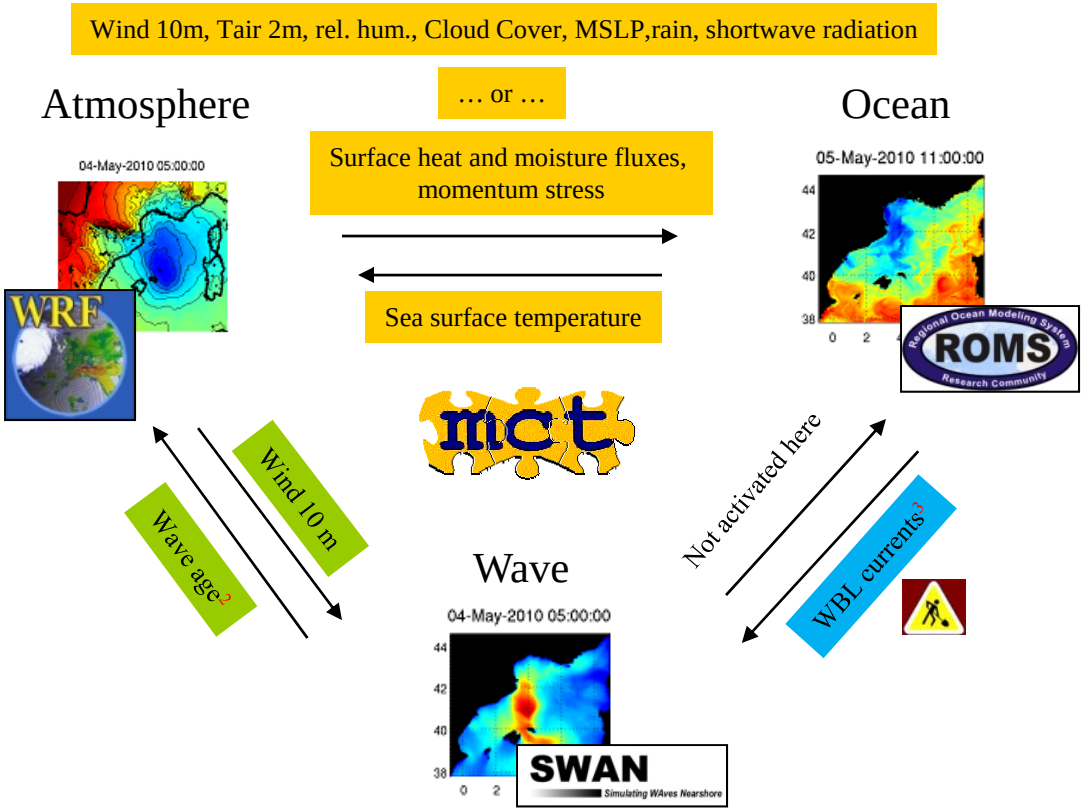




- Cyclogenesis Catalan Sea/Gulf of Lion
- 20 mbar decrease in 24 hrs (almost a meteorological bomb)
- Gale-force winds in the Gulf of Lion
- SST decrease 2+ degC

Coupled Ocean Atmosphere Wave Sediment Transport (COAWST) Model[1]

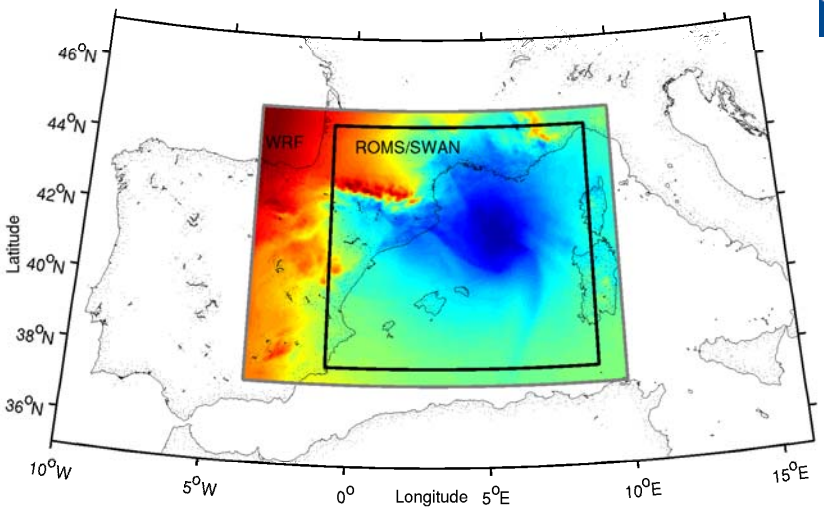
Balearic Sea Application



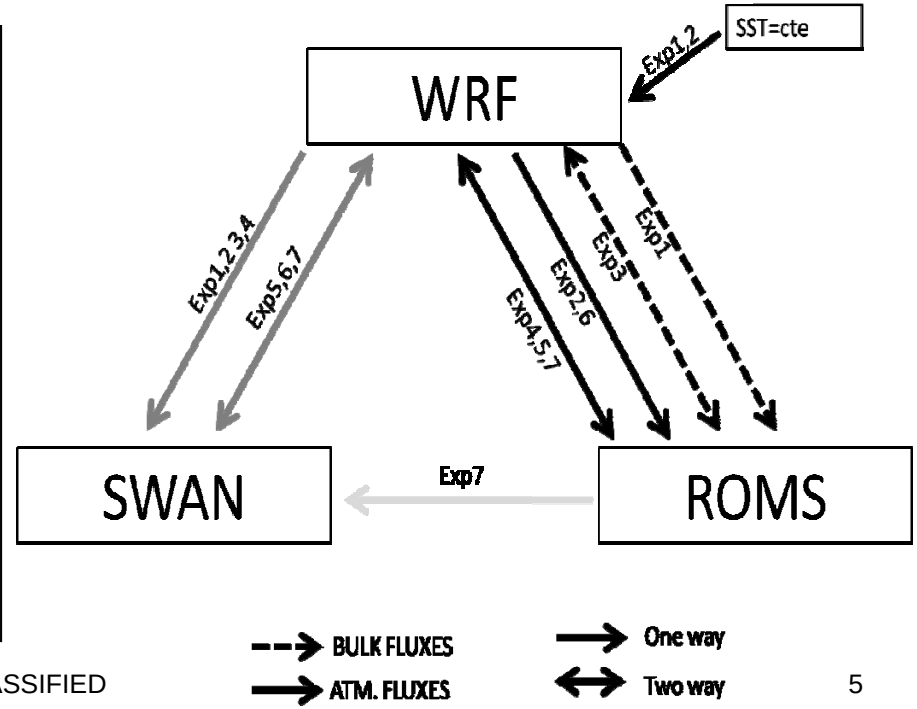
[1]Warner, J. C., B. Armstrong, R. He and J. B. Zambon, 2010, Development of a Coupled Ocean–Atmosphere–Wave–Sediment Transport (COAWST) Modeling System. Ocean Modelling, 35, 230-244.
[2]Drennan, W. M., H. C. Graber, D. Hauser, and C. Quentin, 2003: On the wave age dependence of wind stress over pure wind seas. J. Geophys. Res., 108, 8062, doi:10.1029/2000JC000715.
[3]Kirby J.T., and Chen T.-M., 1989. Surface Waves on Vertically Sheared Flows: Approximate dispersion relations J. Geophys. Res., 94 (C1), 1013-1027.

COAWST Configuration

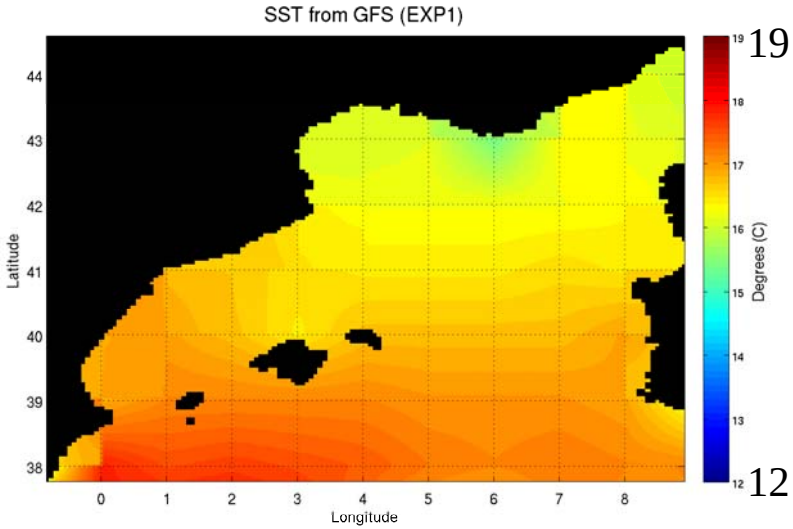
- WRF : 6 km res, 47 levels. OBC from WRF 30km (nested in GFS): transtioning to WRF30km->WRF10km->WRF3.3 km
- ROMS : ~1.8km, OBC from MFS
- SWAN : ~1.8km, OBC from WAM

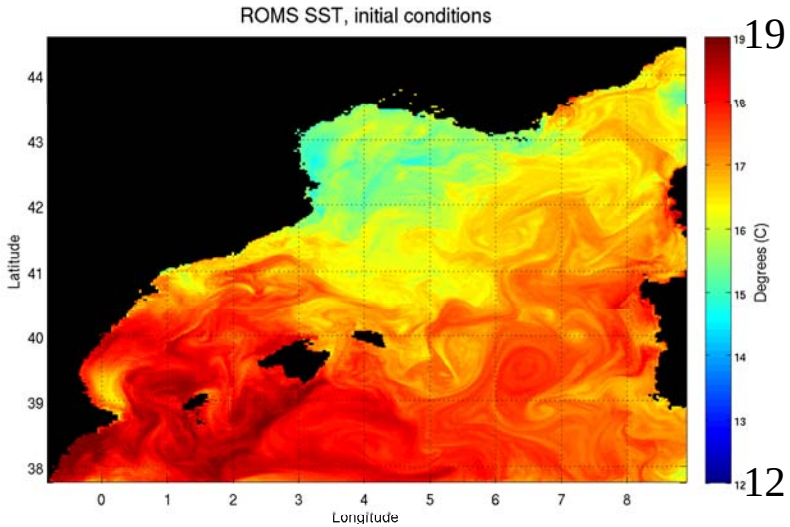


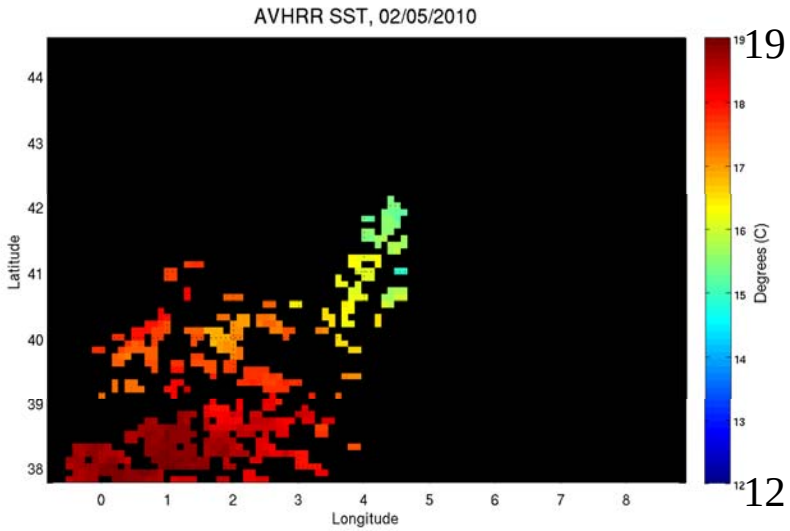
- Exp 1: ROMS ←WRF →SWAN, BULK_FLUXES
- Exp 2 : Exp1 with ATM_FLUXES
- Exp 3 : ROMS←→WRF→SWAN, BULK_FLUXES
- Exp 4 : Exp3 with ATM_FLUXES
- Exp 5 : ROMS←→WRF←→SWAN with ATM_FLUXES
- Exp 6 : ROMS←WRF←→SWAN with ATM_FLUXES
- Exp 7 : ROMS←→WRF←→SWAN & ROMS→SWAN



SST Initial conditions

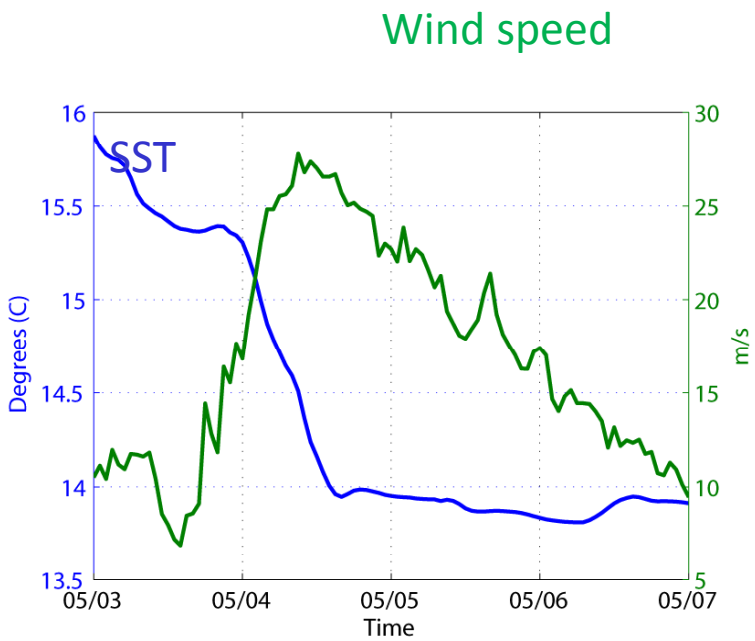


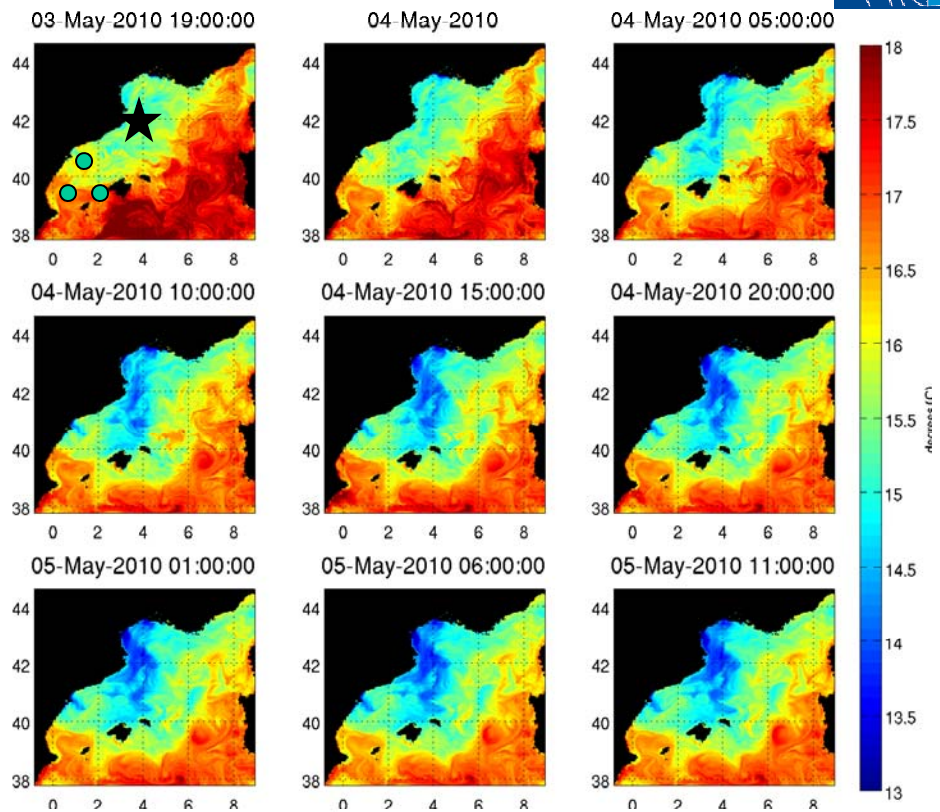


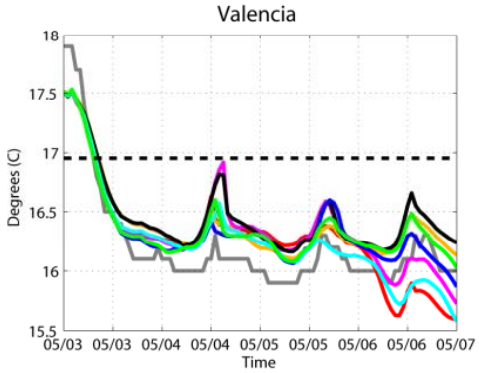


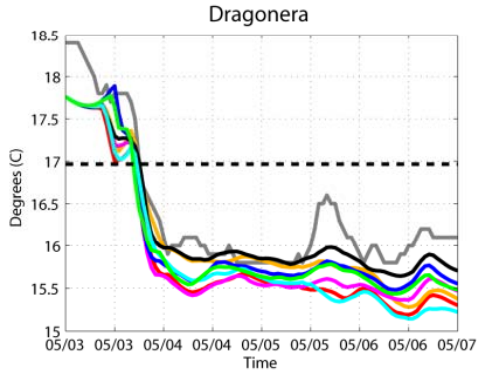
The AVHRR SST is almost overcast the 02/05/2010, but we have some indication of the realism of the simulation comparing with the ROMS SST the same day (end of the ROMS spin up)

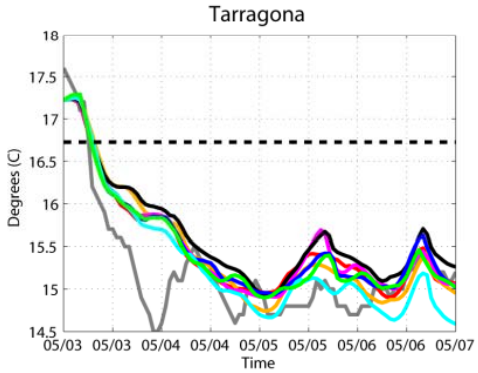
Sea Surface Temperature



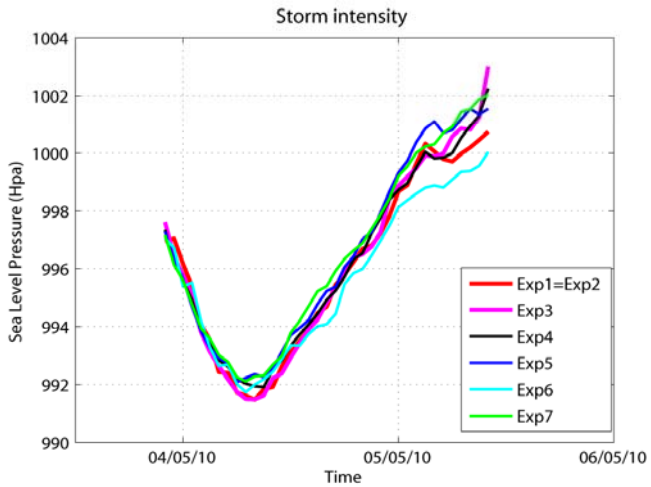


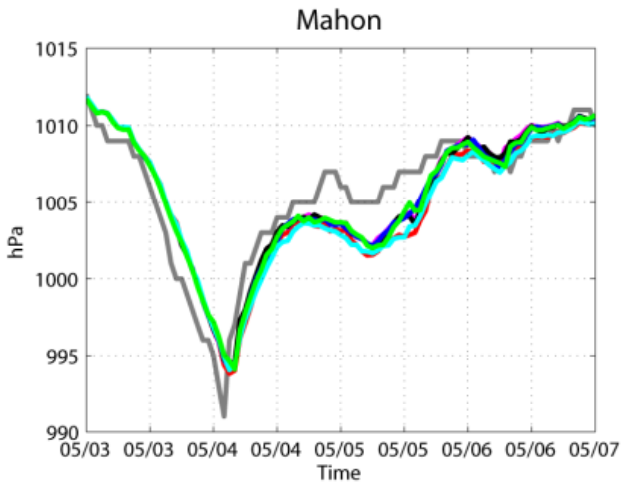


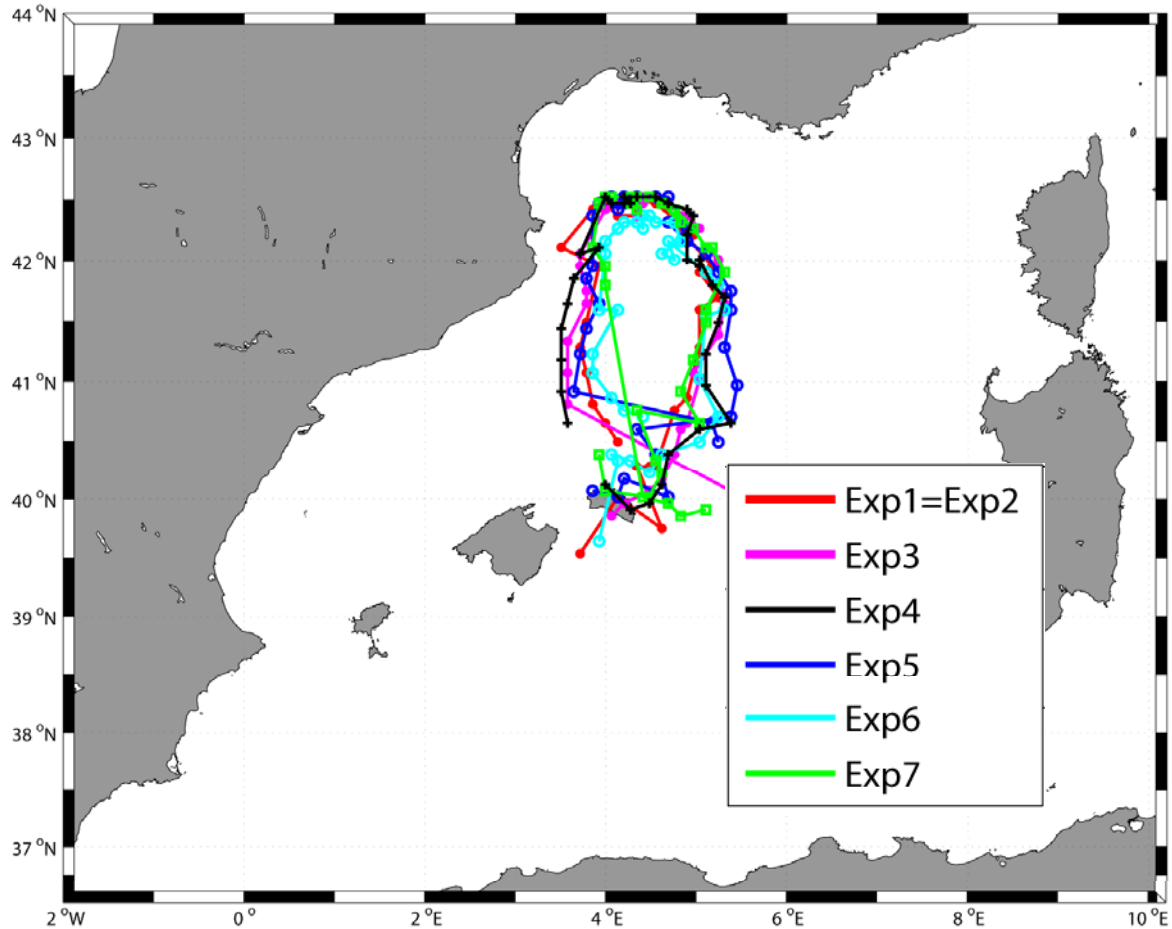




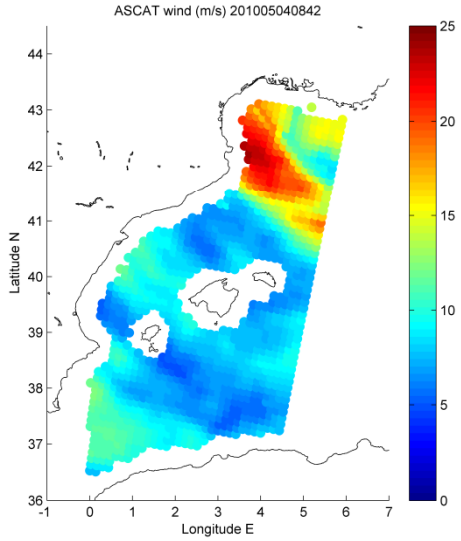
Storm track

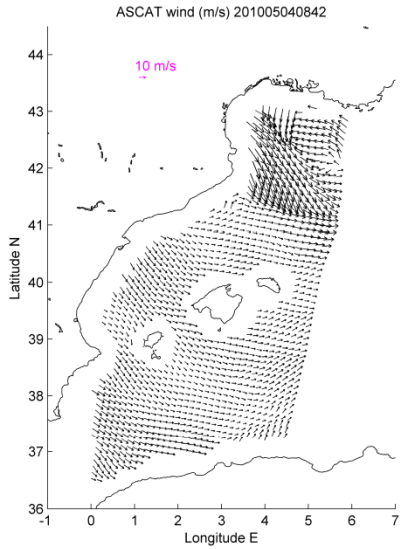

Storm intensity
Sea Level Pressure (Hpa)
1004
1002
1000
998
996
994
992
990
04/05/10
05/05/10
06/05/10
Time
Exp1=Exp2
Exp3
Exp4
Exp5
Exp6
Exp7

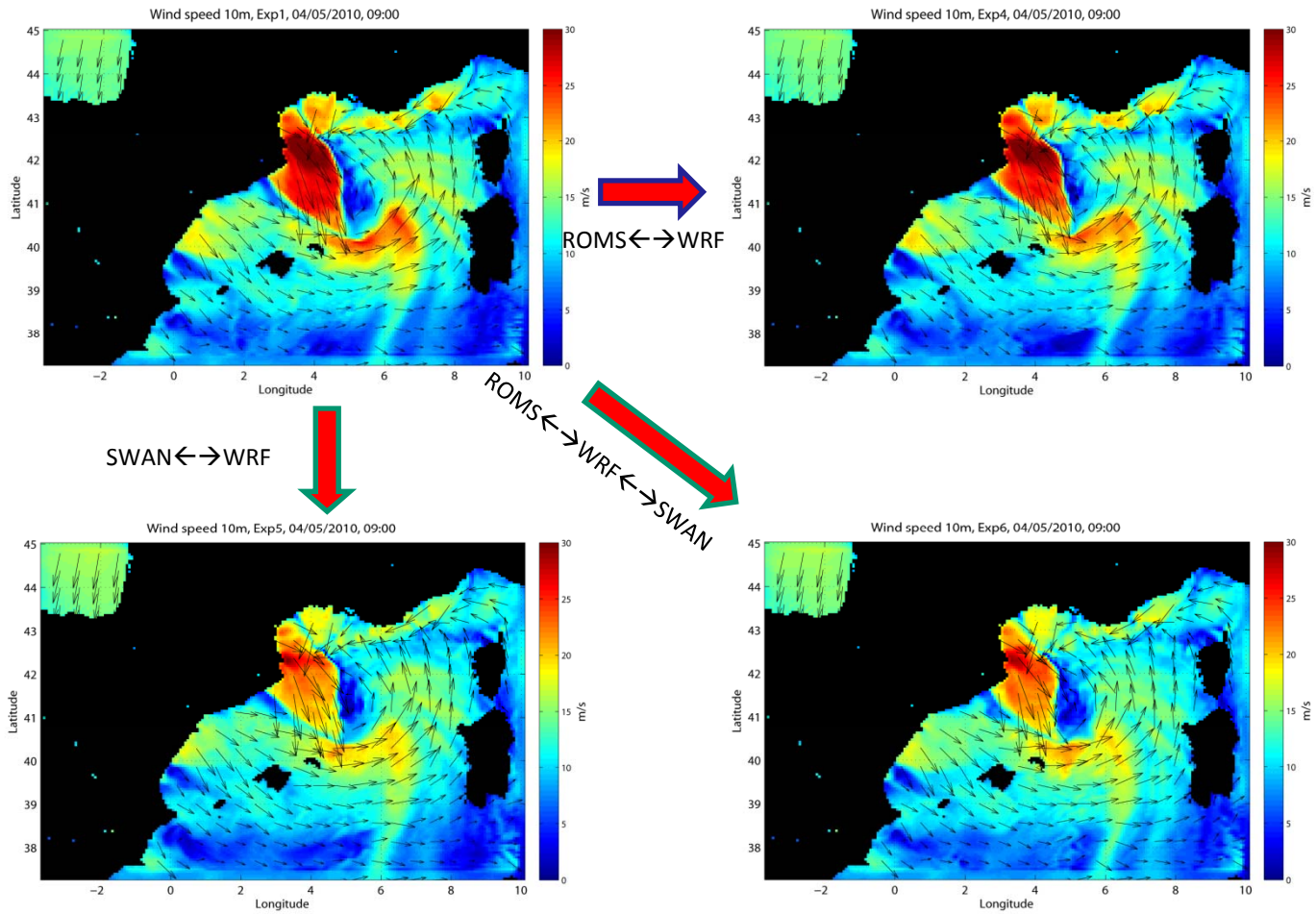

Mahon
hPa
1015
1010
1005
1000
995
990
05/03
05/03
05/04
05/04
05/05
05/05
05/06
05/06
05/07
Time


44 °N
43 °N
42 °N
41 °N
40 °N
39 °N
38 °N
37 °N
2 °W
0 °
2 °E
4 °E
6 °E
8 °E
10 °E
Exp1=Exp2
Exp3
Exp4
Exp5
Exp6
Exp7

Comparison with ASCAT







Good agreement with ASCAT but overestimation of the maximum wind speed

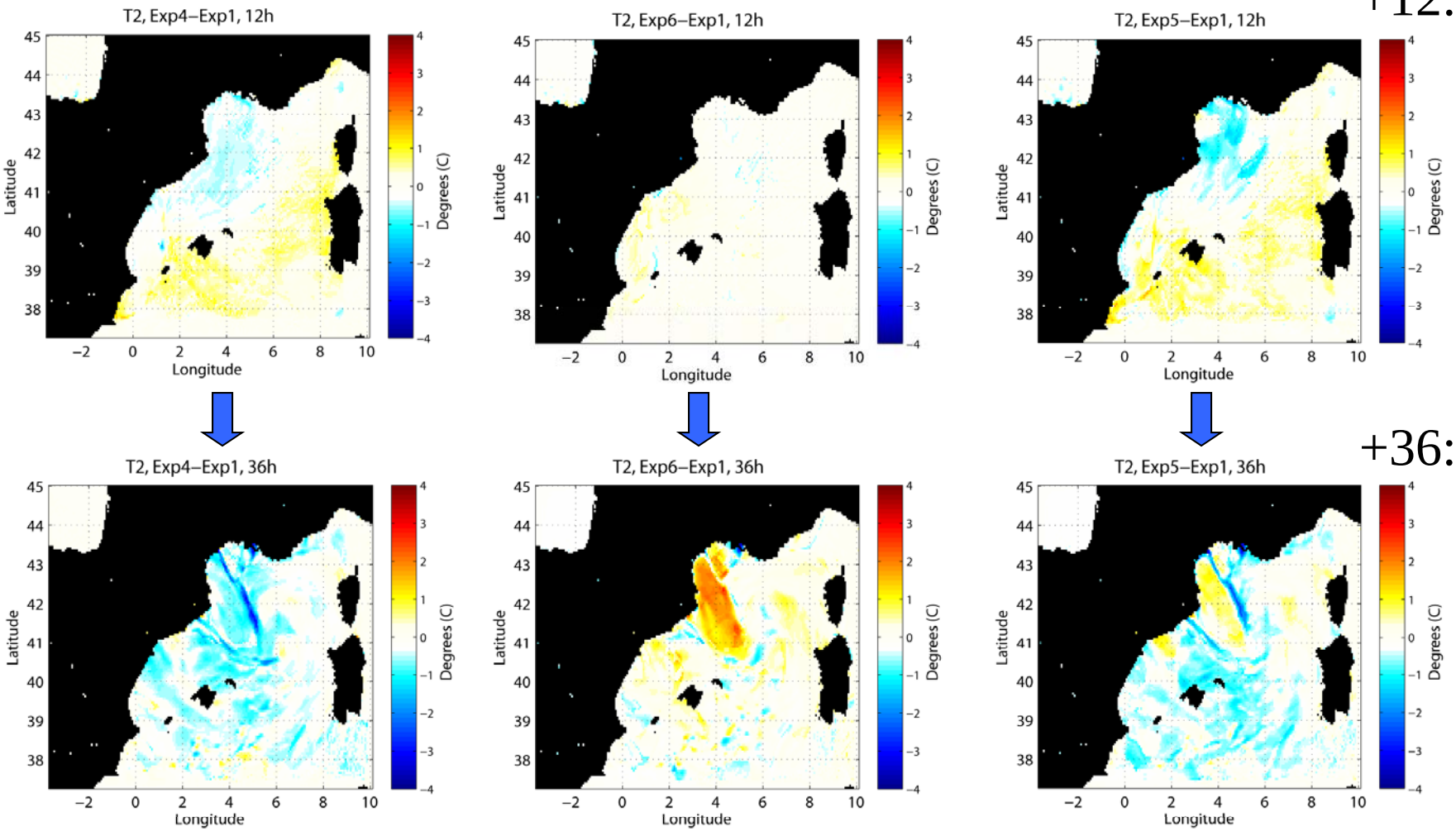
EXP4 vs. EXP1 : SST cooler → slight decrease of the max. wind speed

EXP 5 and EXP6 : wind decrease due to the roughness and position of the core

2 meter air temperature

ROMS←→WRF WRF←→SWAN ROMS←→WRF←→SWAN

+12:00



+36:00

Opposite effects … later (+60:00) the SST cooling due to the coupling prevails (also because the Hs decreases)

Hs sensitivity, 05/05/2010, 11:00

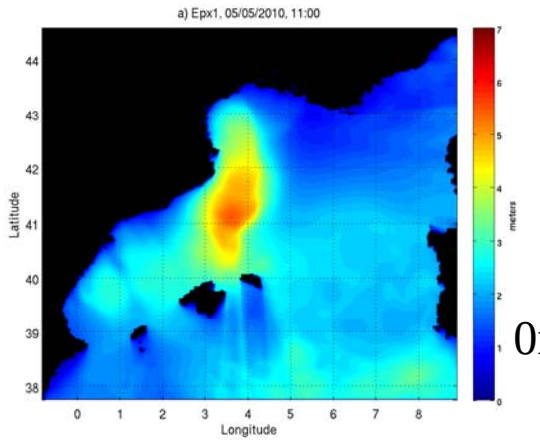
- Exp1 overestimated the wave heigth due to an overestimation of the wind.

- Updating the SST (cooling) leads to a weakening of the wind and so on a weakening of the Hsig and more again of we used the atmosphere wave coupling

- Overestimation of the wave in the Exp7 due to the wave-current interactions.

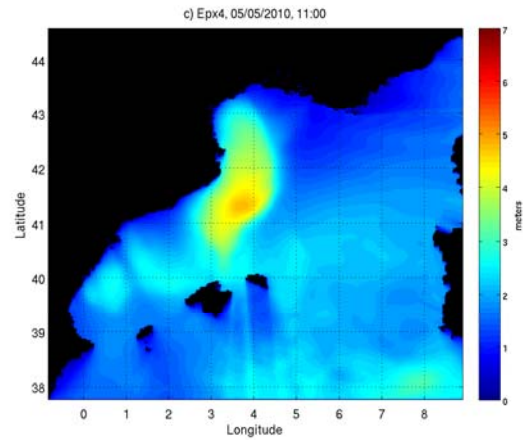
WRF → SWAN

7m

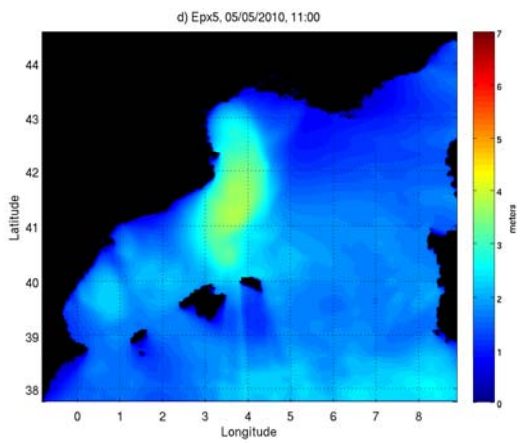


0m

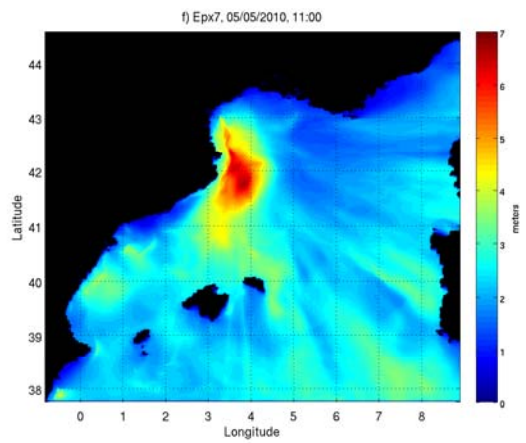
WRF → SWAN
WRF ←→ ROMS



WRF ←→ SWAN



WRF ←→ SWAN
ROMS ←→ SWAN

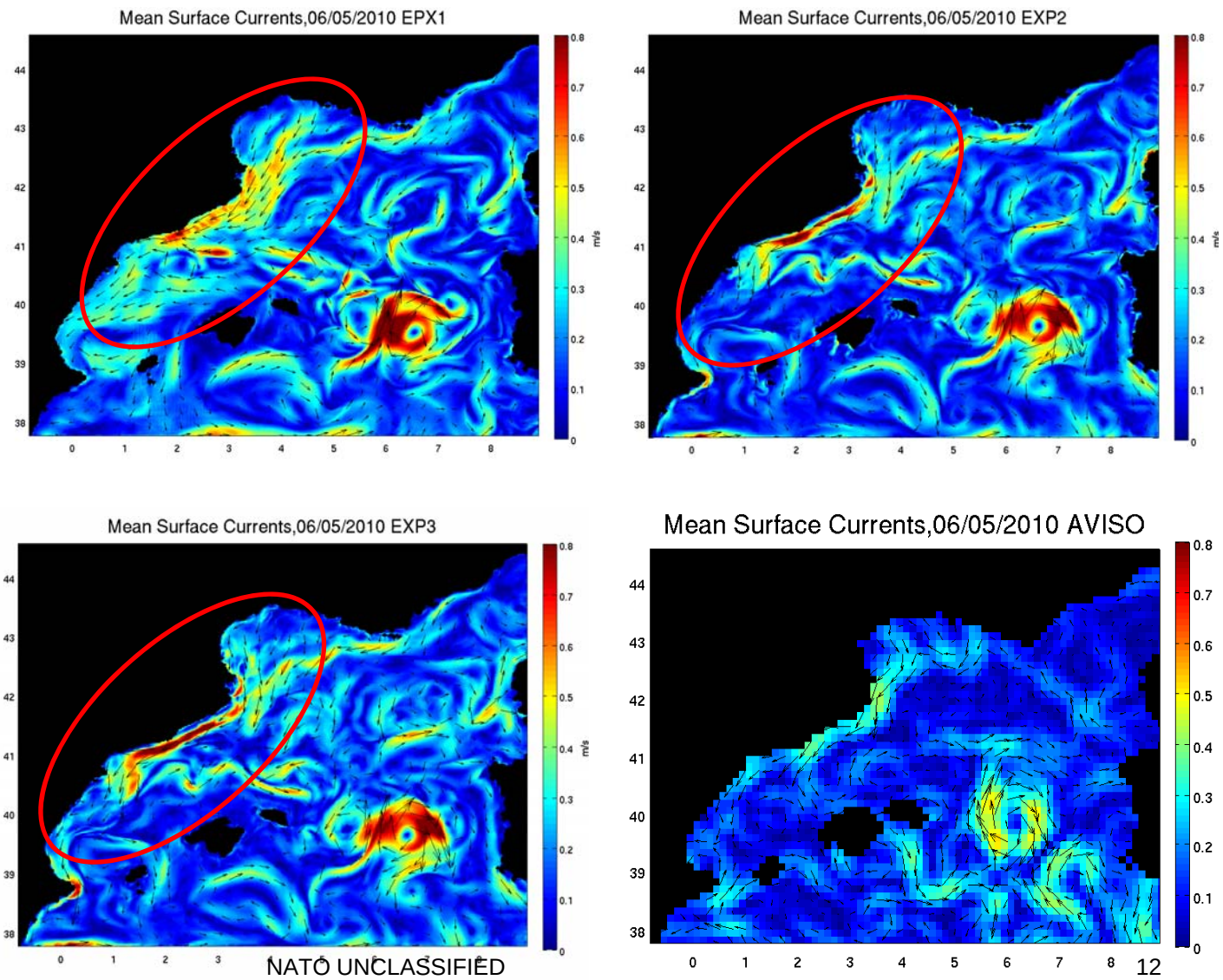


Sea surface current at the end of the storm

Using the ATM_BULK →intensification of the north current and also a confinement in a thinner fringe along the coast

→ Using the SST coupling <u>and</u> the BULK_FLUXES leads to similar results

→ role of the surface schemes used to compute fluxes rather than coupling



Conclusions?

… not yet!

Ongoing activities

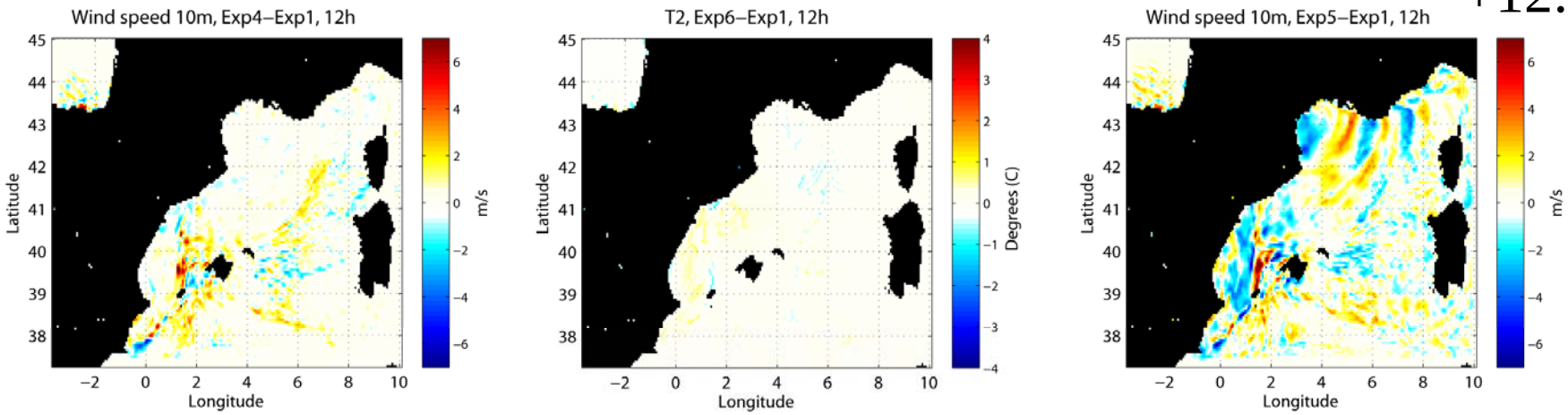
•Transition to a higher resolution WRF nesting cascade (30km, 10km, 3.3 km)
•Collection and exploitation of sea-truth datasets for validation
•Additional in-depth analyses (e.g., heat budget)
•Statistical assessment

Thanks

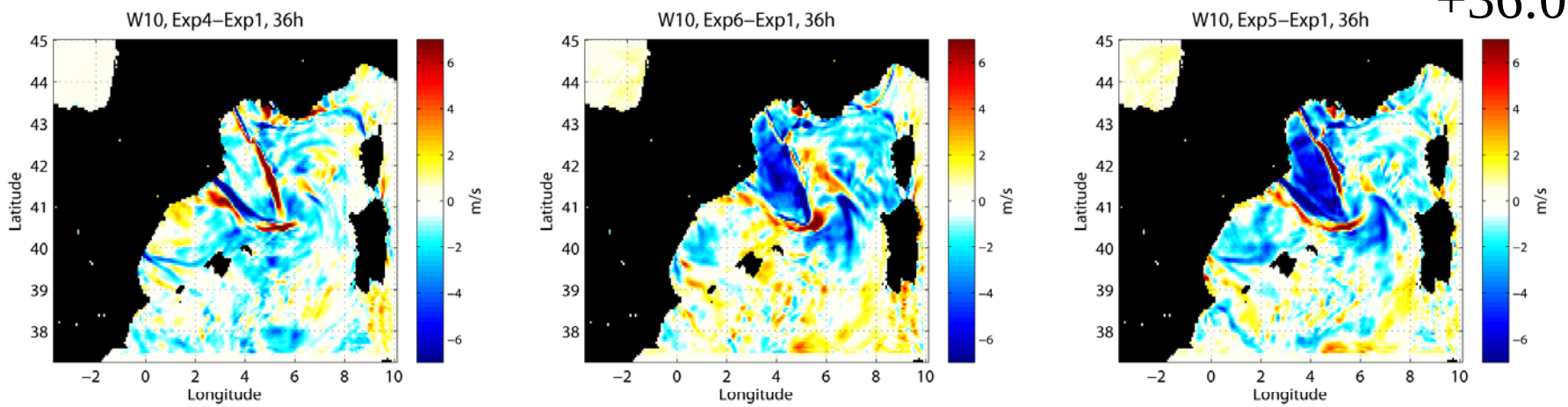
10 meter wind speed

ROMS←→WRF WRF←→SWAN ROMS←→WRF←→SWA

+12:00



+36:00



The SST coupling has a strong influence on the wind core position (translation to the north east) whereas the wave coupling leads to a decrease of the wind speed (roughness)