




The MedCORDEX Flagship Pilot Study on air-sea interactions.



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Main Achievements

- ➔ **23 different modelling groups** (ENEA, CNRM, LMD, MPI, IPSL, UCLM, ENSTA, MERCATOR, INSTM, GUF, ICTP, CMCC, Puertos de l'Estado, Univ. of Athens, Univ. Belgrade, UPM, KIT, ITU, UAH, Eotvos Lorand U, IC3, BSC, JRC) from **9 countries** (France, Italy, Spain, Serbia, Greece, Turkey, Tunisia, Germany, Hungary) in **Europe, Middle-East** and **North-Africa**
- ➔ **87 individual members** in the Med-CORDEX Science Team
- ➔ 9 atmosphere RCMs (minimal resol. 50 km), 4 atmosphere RCMs running at 12 km, 10 ocean models (min. resol. 25 km), 5 surface models and **12 fully-coupled RCSMs** (3 including river coupling) and a total of **106 climate simulations**. Historical and scenario runs use **6 different GCMs from CMIP5**
- ➔ Database : Upload : 116.000 files, 4.4 To / **Download: 412.000 files, 13.5 To** by **125 users** (incl. 39 HyMeX users)
- ➔ **Ruti et al. 2015** (BAMS) + **43 published articles** in since 2011 + **28 articles submitted to a special issue in Clim. Dyn.** (France, Italy, Germany, Spain, Tunisia, Greece, Croatia)

Med-CORDEX is **the largest coordinated multi-model effort ever for Mediterranean** climate simulations

Med-CORDEX is the largest coordinated effort using **coupled regional climate models**

Med-CORDEX provides for the first time long-term regional **ocean** simulations in a standardized and open way

Ruti et al., 2015

Common baseline runs and targeted Flagship Pilot Studies (FPS)

Baseline runs :

Characterization of the Regional climate variability and future change , of the relevant Mediterranean climate phenomena and of the Mediterranean climate impacts

FPS1:

Role of the natural and anthropogenic aerosols in the Mediterranean region

FPS2:

Convection phenomena at high-resolution over Europe and the Mediterranean

FPS3:

Role of the air-sea coupling and small-scale ocean processes on regional climate

SIMED

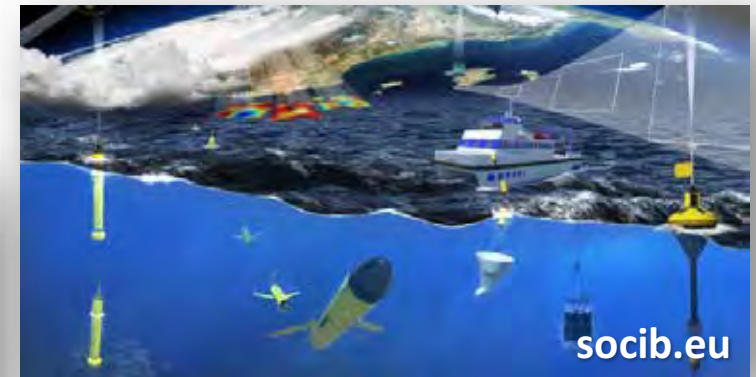
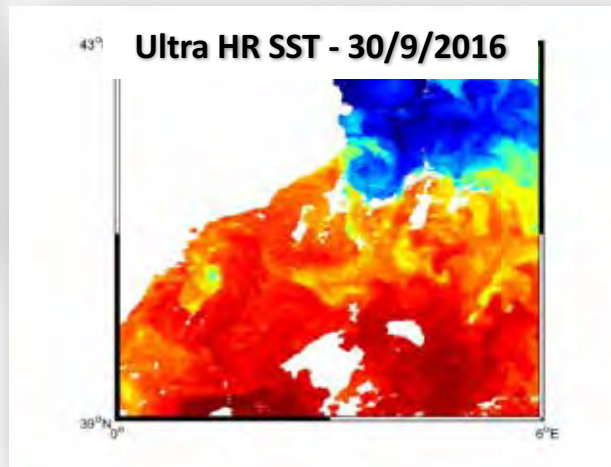
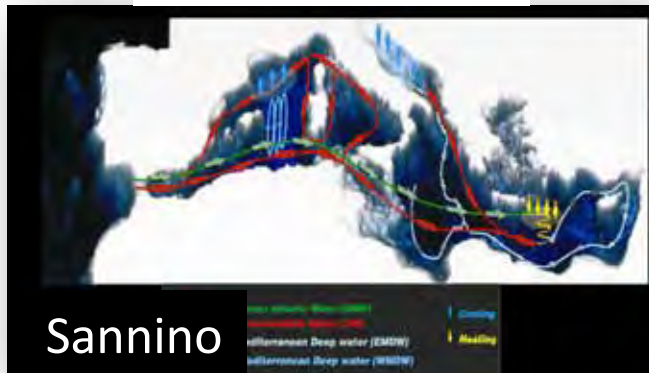


The Mediterranean, an appealing case

The Mediterranean Sea is one of the few places in the world where **water masses are formed** and an **overturning thermohaline circulation** appears. Also the deformation radius is small (from 2-20 km) and presents a very **active mesoscale and submesoscale field** which plays a key role in the air-sea interactions

The Mediterranean area is **one of the best observed oceanic regions** in the world and the MedCORDEX community gathers an active group of modelling teams that run **atmosphere-ocean coupled models**

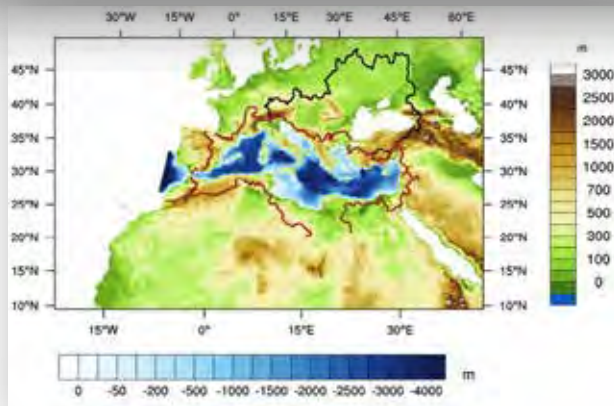
Mediterranean THC



- Investigate the **benefits of simulating realistic air-sea interactions** on the modelling of past and future regional climate.
- **Determine the role of small scale oceanic processes** on the evolution of regional climate including regional heat budgets
- **Provide a consistent and reliable database** of regional atmospheric and oceanic projections to be used by stakeholders (including marine applications).

Modelling systems in the FPS

Atmosphere	Ocean	Land Surface	Waves	Ocean Biogeochemistry	Teams
					6
					4
					1
					4
					1
					1

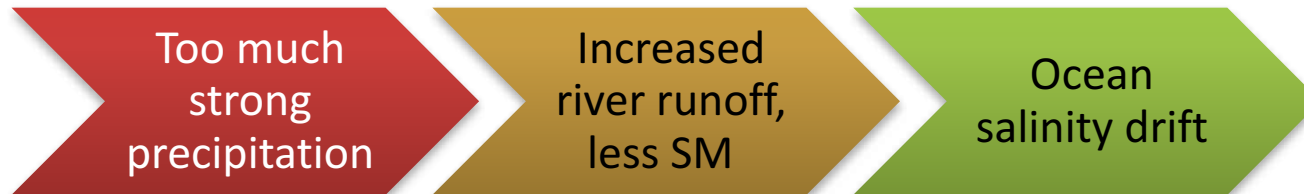


Atmosphere Resolution : 12-50 km
Ocean Resolution: 3- 25 km

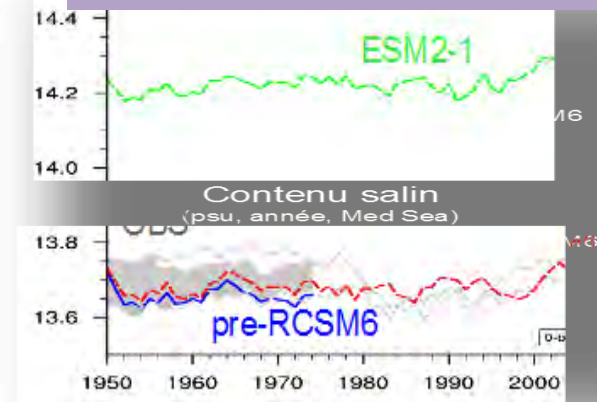
The increase in model complexity implies an extra effort in technical aspects.

Example – salinity drift due to overestimation of intense precipitation in CNRM-RCSM6

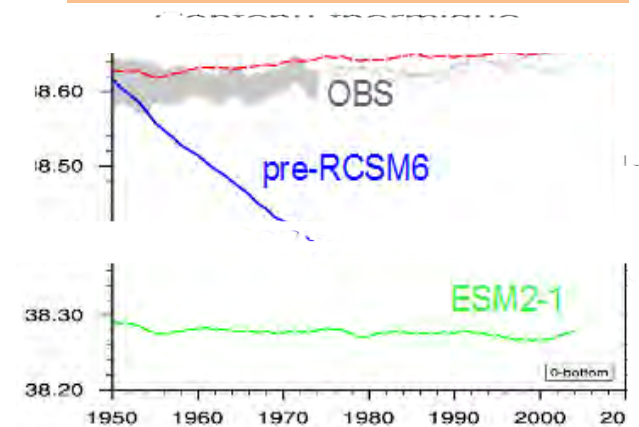
Somot et al., 2019, pers. Comm.



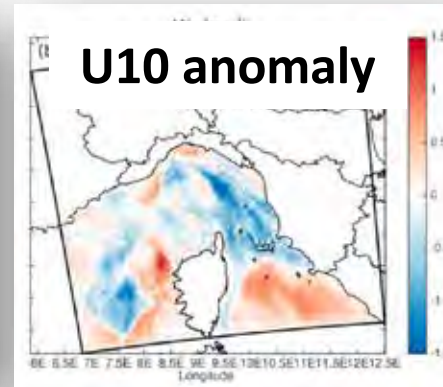
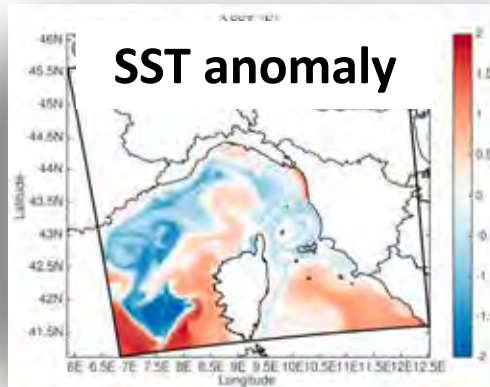
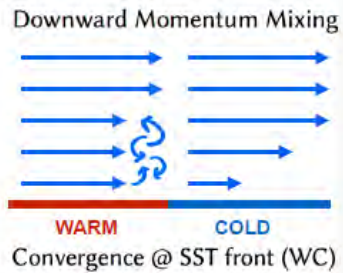
Med Heat Content



MedSalt Content



Impact of HR SST on wind convergence

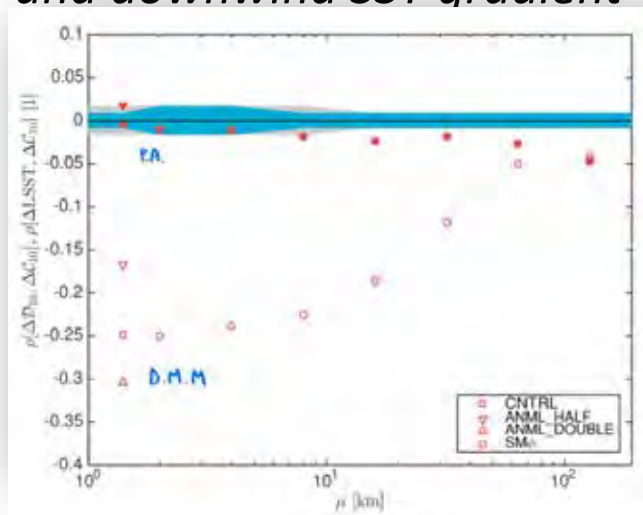


SST structures of the order O(km) significantly affect the surface wind field

The higher the SST resolution, the higher the impact

The wind is accelerated (decelerated) over warmer (colder) sea areas in O(h) time scales

Correlation between wind convergence and downwind SST gradient

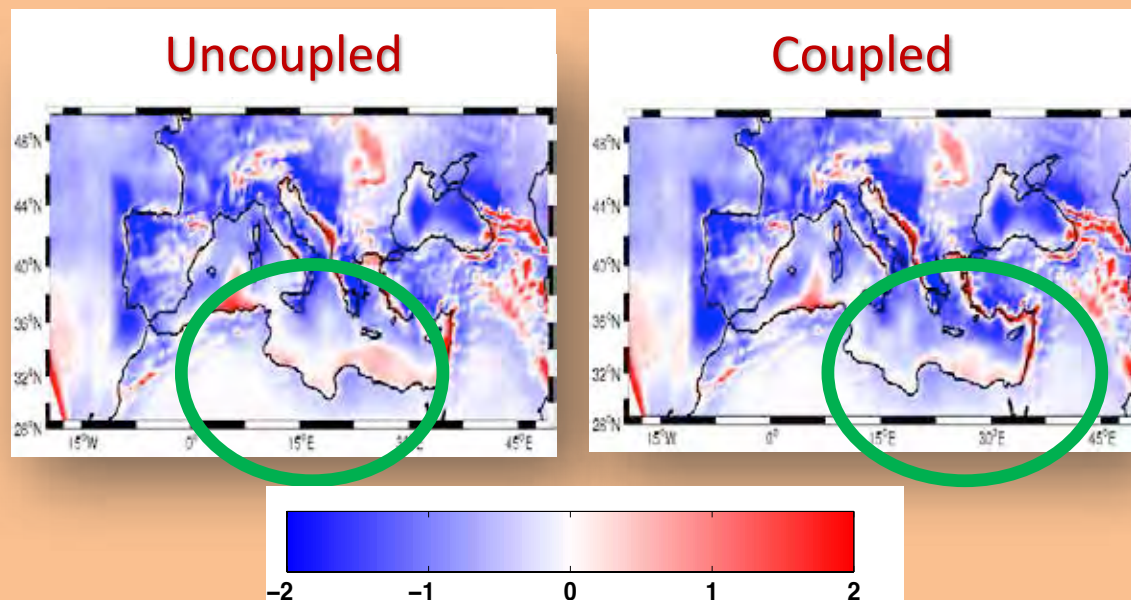


Pasquero, Meroni et al., 2019

Impact of air-sea coupling

The **air-sea coupling has a significant although moderate impact** on atmospheric variables both for single events, present climate and projections

However, some results suggest **that higher resolution in coupled models will translate into higher impacts** (*Cabos, pers. Comm.; Pasquero, pers comm.*)

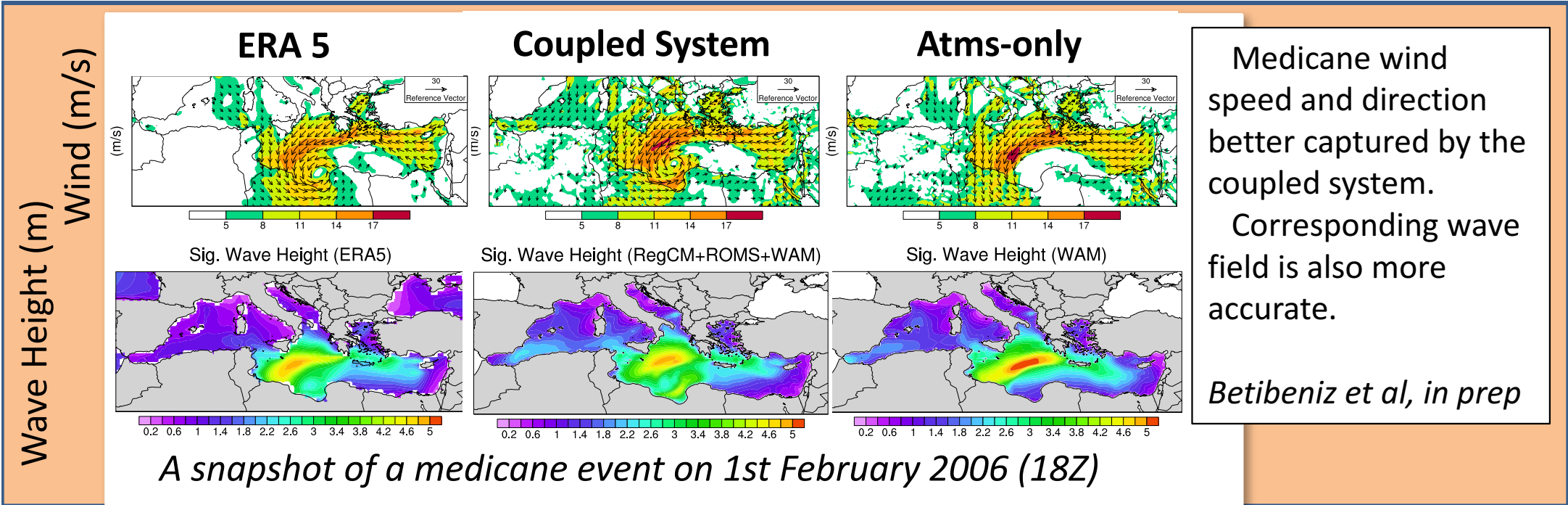


Error in the mean OND
precipitation (in mm)

Reale et al., subm. 2019

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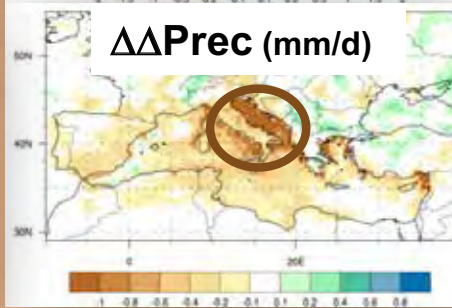
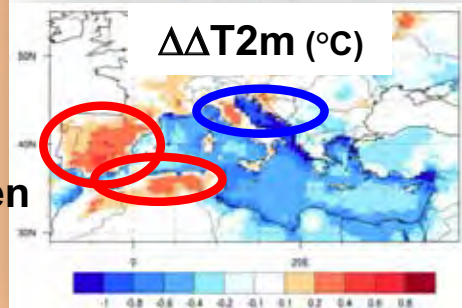
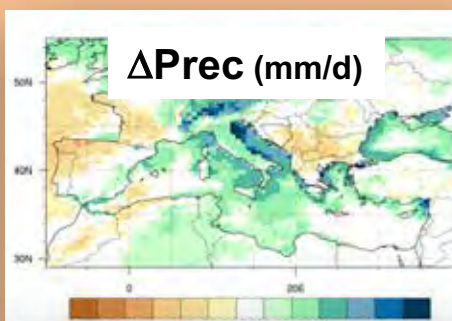
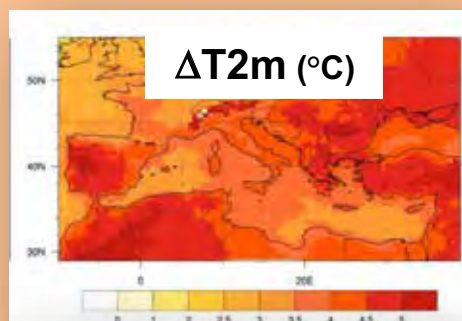
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Climate change signal in Summer

(RCP8.5, 2071-2100 vs 1976-2005, JJA)

Difference of climate change signal between HR-SST and CORDEX



T2m climate change signal is modified over sea and surrounding lands

Enhanced drying over sea and surrounding lands in HR-SST

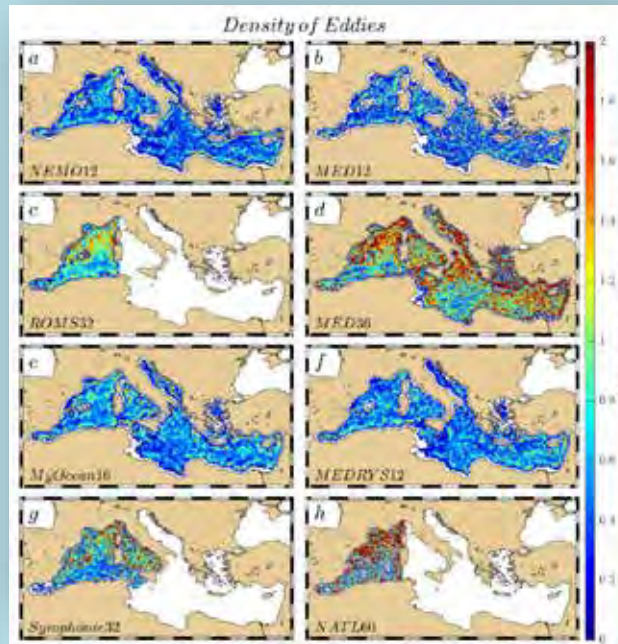
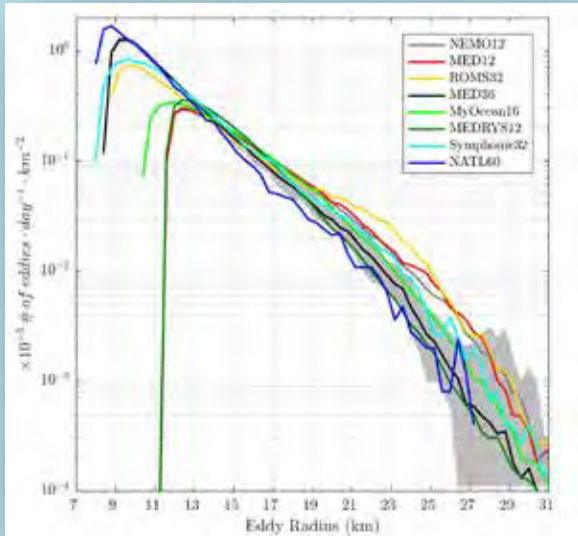
Land-sea contrast and dynamical modifications explain the West Europe signal

S. Somot, pers. comm

The **modelling of small scale ocean processes** at those scales that may affect air-sea interactions is challenging (o(1 km))

ORCMs show a clear added value wrt to OGCM. The **representation of ocean processes at climate scales** is satisfactory for the temperature in the upper layers while circulation and salinity variability is more dubious

Density of ocean eddies in different ocean simulations



The number and characteristics of ocean eddies largely depend on the model resolution, but not only!

There are severe difficulties to obtain suitable observational records to calibrate/validate simulations.

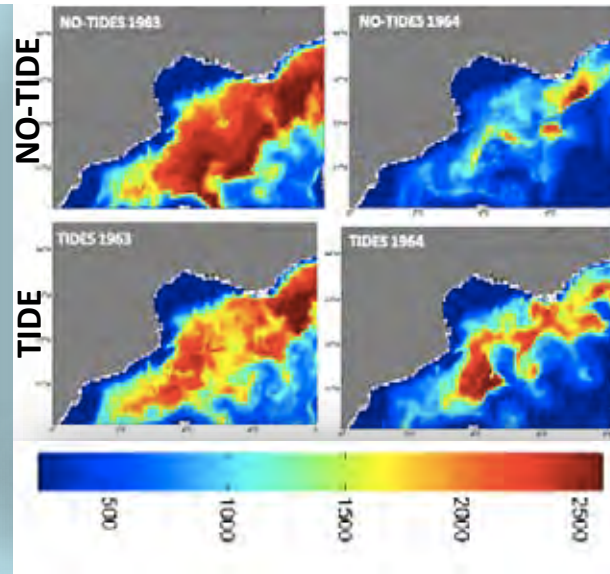
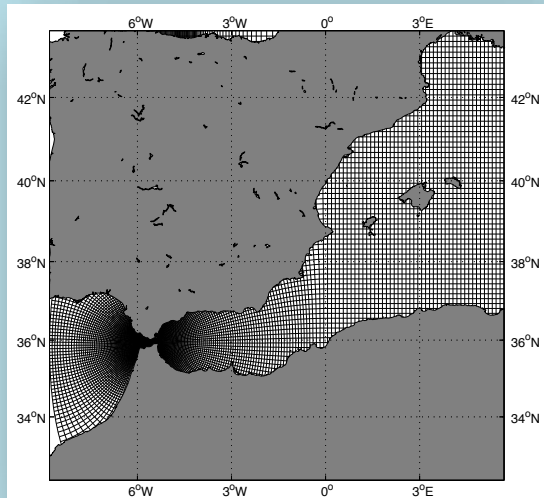
Amores et al., in prep.

Small scale ocean processes

The **modelling of small scale ocean processes** at those scales that may affect air-sea interactions is challenging ($\text{o}(1 \text{ km})$)

ORCMs show a clear added value wrt to OGCM. The **representation of ocean processes at climate scales** is satisfactory for the temperature in the upper layers while circulation and salinity variability is more dubious

Intensity of the Convection (MLDmax depth (m))



The representation of the processes occurring at the Strait of Gibraltar requires very high-resolution ($\text{o}(500\text{m})$) and the inclusion of tides.

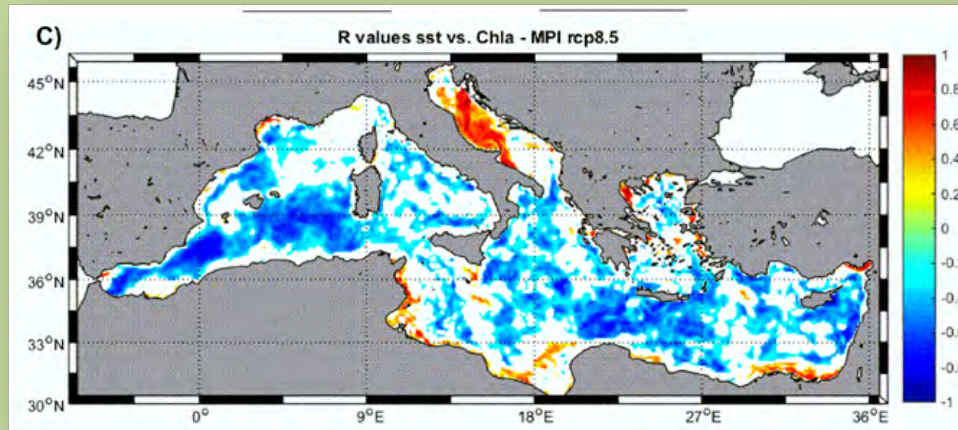
What happens at the « gate » of the Mediterranean modify the evolution of the THC and convective processes

Naranjo et al., 2014

A growing interest is developing for **marine impacts** as well as for **marine-related climate services** (e.g. related to beach erosion, coastal ecosystems, fisheries management).

Coupling waves and biogeochemical models help to answer those aspects. Often the interests focus on the short-term predictions/projections (i.e. 2030-2050)

Correlation between SST and surface Chla – JRC-MPI rcp8.5



In the open ocean higher stratification reduces the phytoplankton biomass due to the reduction of fertilization by mixing.

In coastal areas, higher temperatures favours the biomass increase due to the physiological control of growth rates by temperature

Macías et al. 2018

The **Mediterranean Sea** is an appealing region to investigate the air-sea interactions and how the coupling can modify the regional climate. The **MedCORDEX Flagship Pilot Study on the air-sea coupling and small-scale ocean processes** aims to tackle those issues.

- The **air-sea coupling has a significant although moderate impact** on atmospheric variables both for single events, present climate and projections, but some results suggest **that higher resolution in coupled models will translate into higher impacts**
- The **modelling of small scale ocean processes** at those scales that may affect air-sea interactions is challenging. The lack of suitable data increases the difficulties.
- A growing interest is developing for **marine impacts** as well as for **marine-related climate services** (e.g. related to beach erosion, coastal ecosystems, fisheries management).



Thanks for your attention



The MedCORDEX Flagship Pilot Study
on air-sea interactions.

<https://www.medcordex.eu>

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