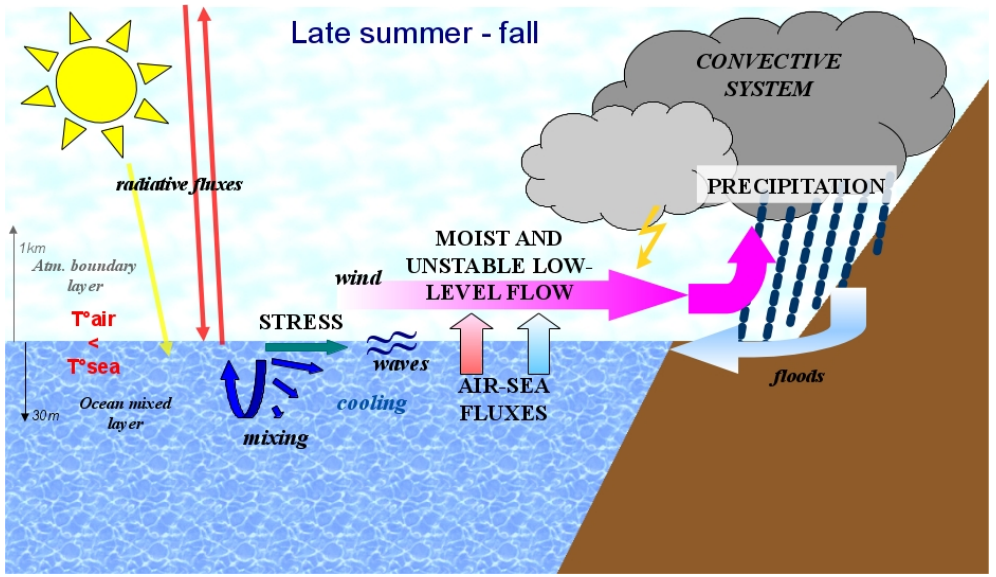
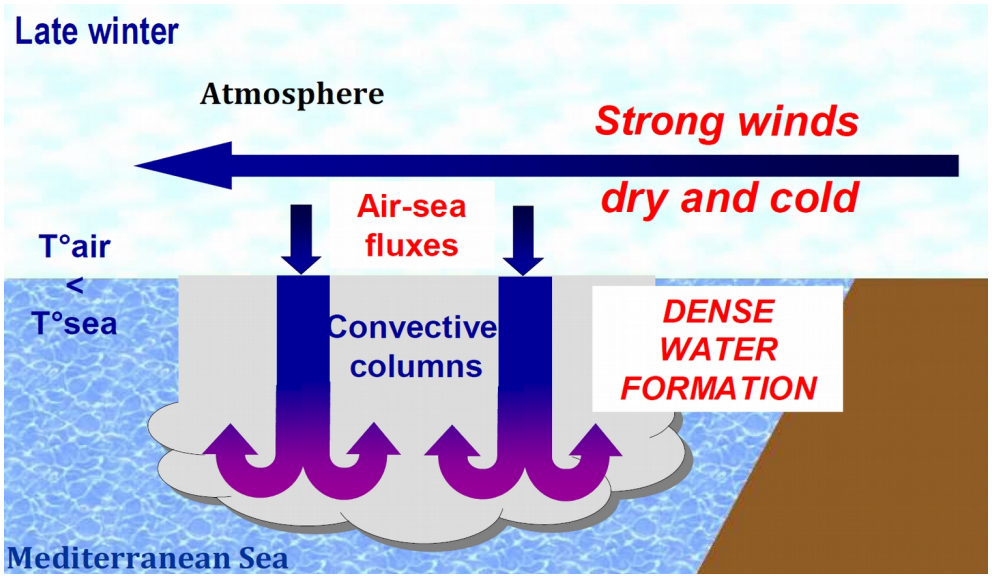
Coupling NEMO to AROME via the SURFEX-OASIS interface: Development and application to the HyMeX SOPs in the Western Mediterranean region

Cindy Lebeaupin Brossier,
Fabien Léger, Romain Rainaud, Véronique Ducrocq, Hervé Giordani, Marie-Noëlle Bouin, Nadia Fourrié, César Sauvage, Aurore Voldoire

Surfex Users Workshop, Toulouse, 28th February 2017

HyMeX field campaigns (SOPs)

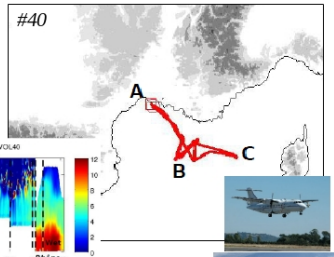


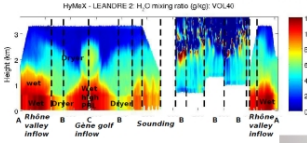


SOP1

Ducrocq et al. (2014)

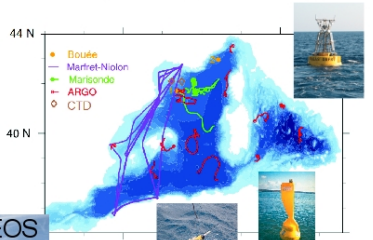
ATR42 & LEANDRE2 fligths

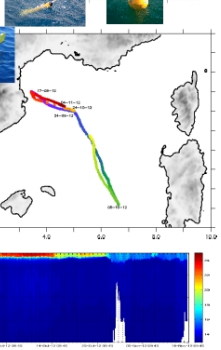




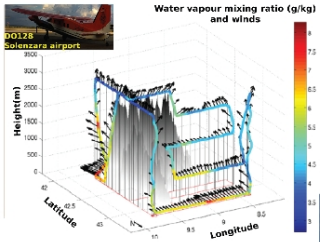
Ocean measurements

moored buoys, drifters, ships (TRANSMED, CTD), gliders

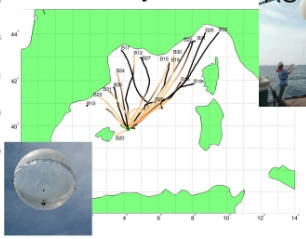




Do128 flights



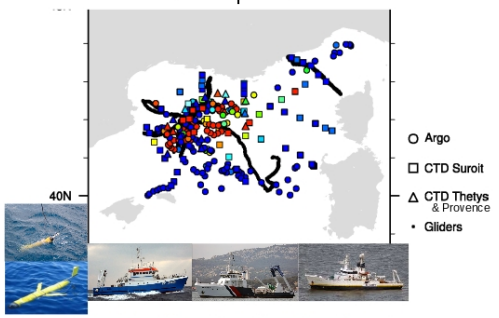
Balloon trajectories

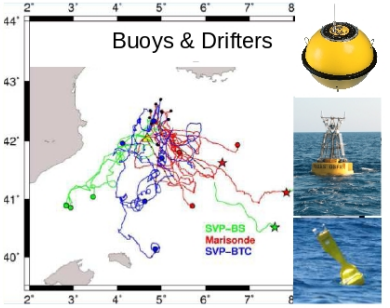


SOP2

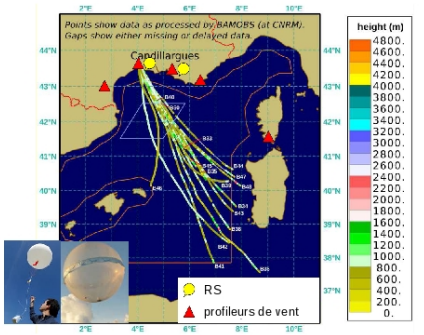
Estournel et al. (2016)

Ocean profiles

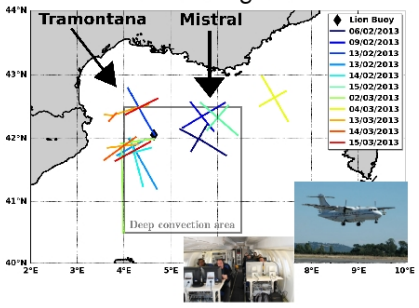




Balloons / RS / Wind profilers



ATR42 flights



Air-sea exchanges

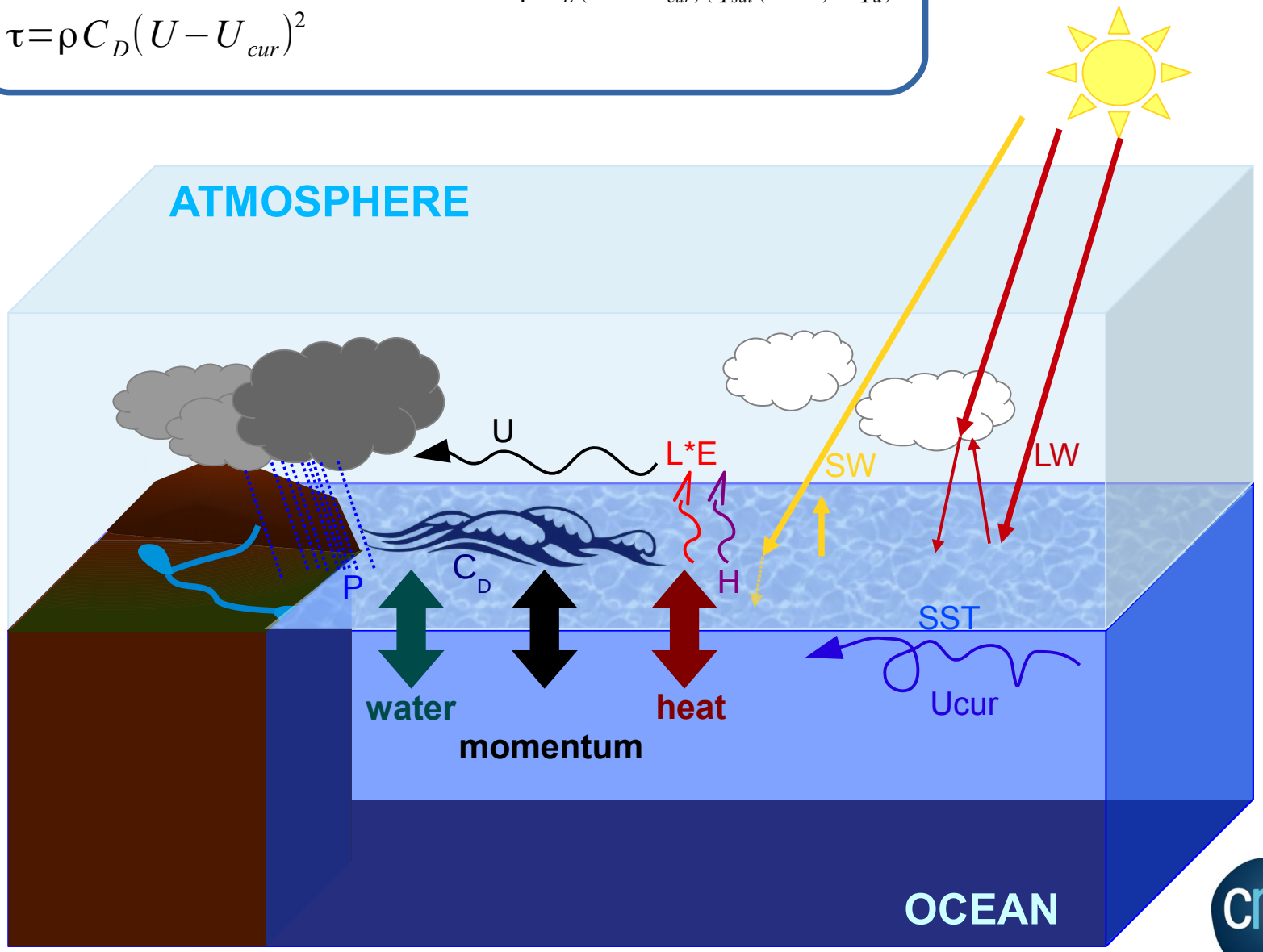
$$F_{wat} = P - E$$

$$Q = SW - LW - L*E - H$$

$$\tau = \rho C_D (U - U_{cur})^2$$

$$H = \rho C_H (U - U_{cur})(SST - T_a)$$

$$L*E = \rho C_E (U - U_{cur})(q_{sat}(SST) - q_a)$$



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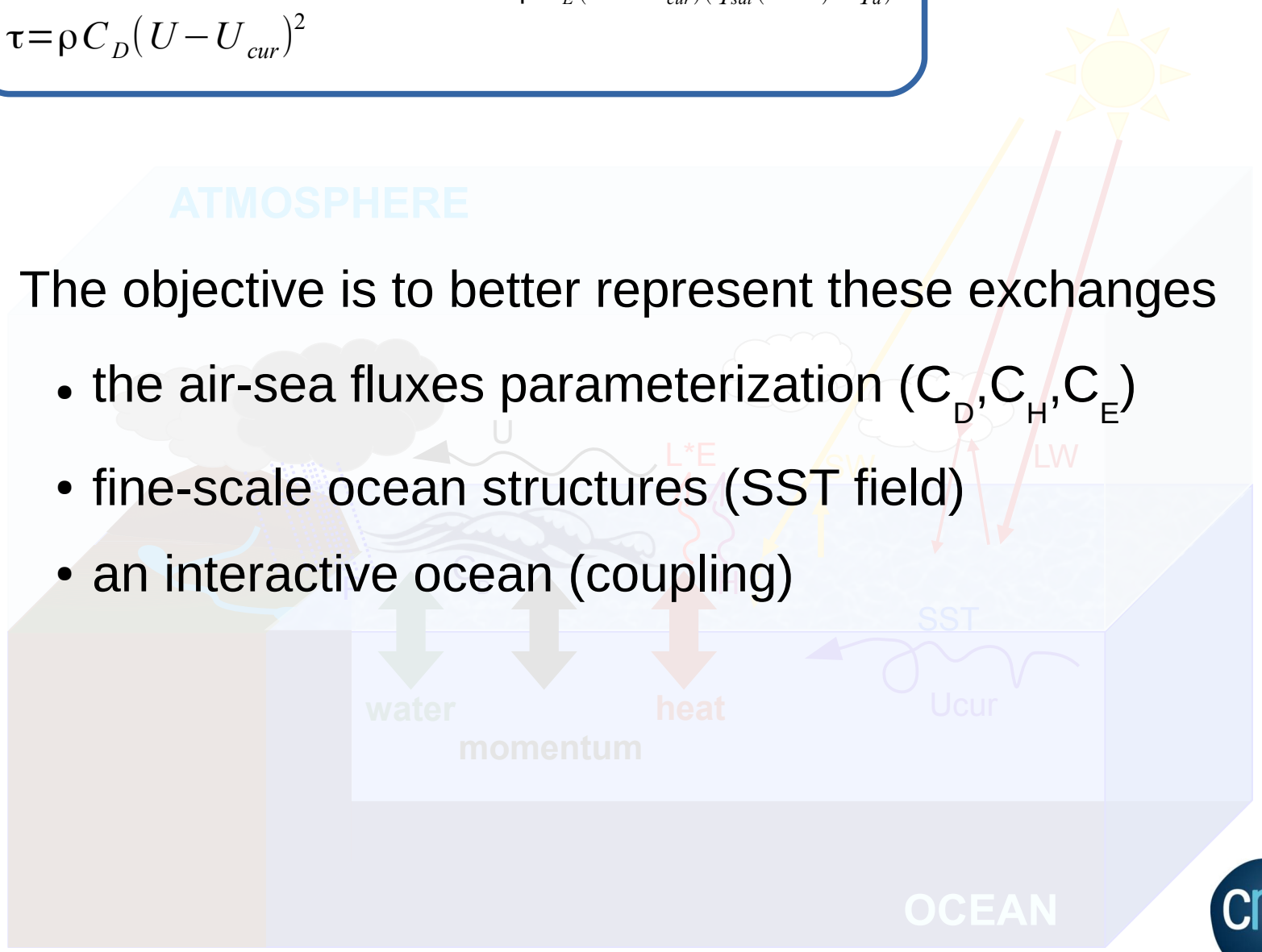

The objective is to better represent these exchanges

- the air-sea fluxes parameterization (C_D,C_H,C_E)
- fine-scale ocean structures (SST field)
- an interactive ocean (coupling)

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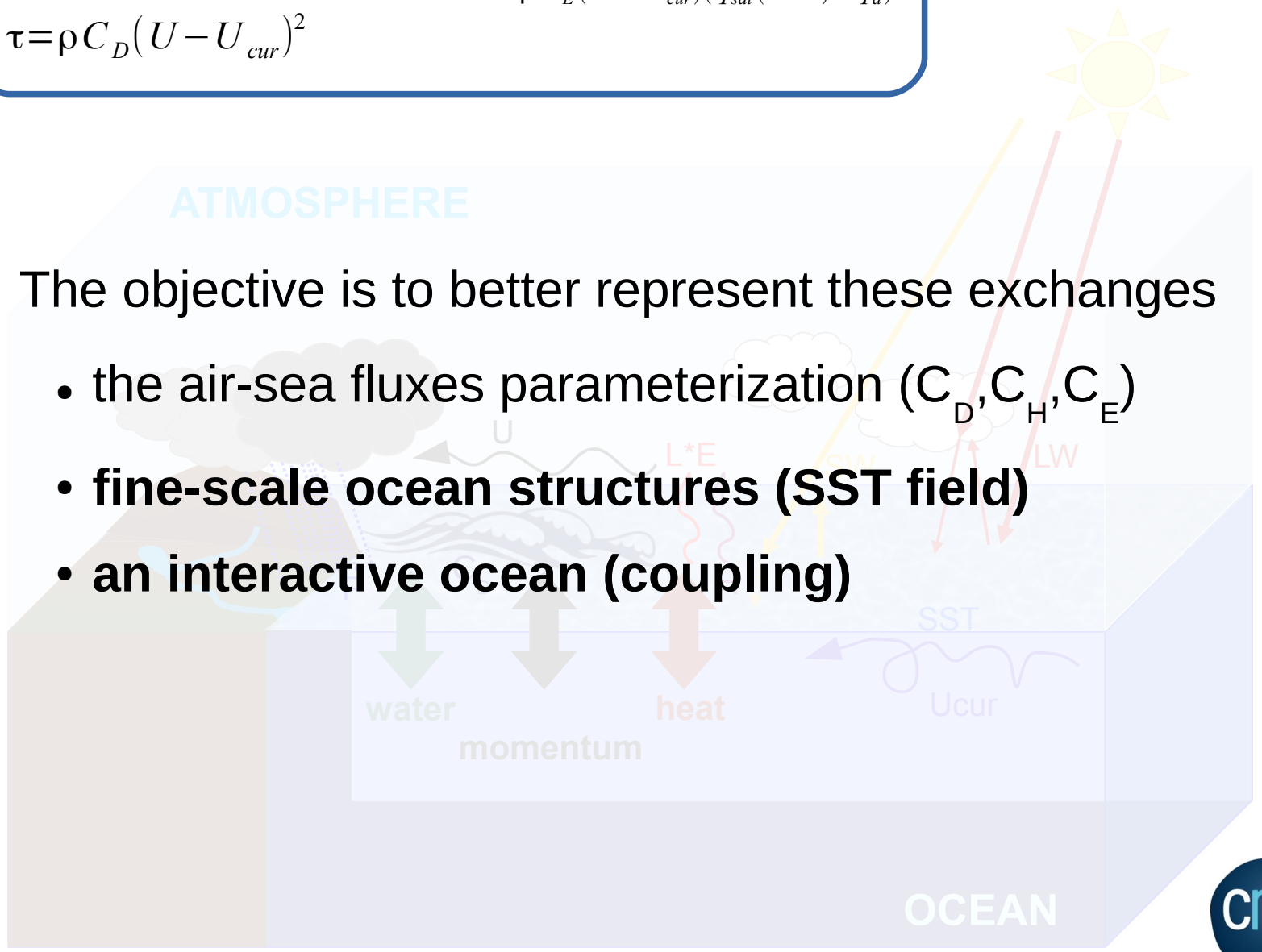

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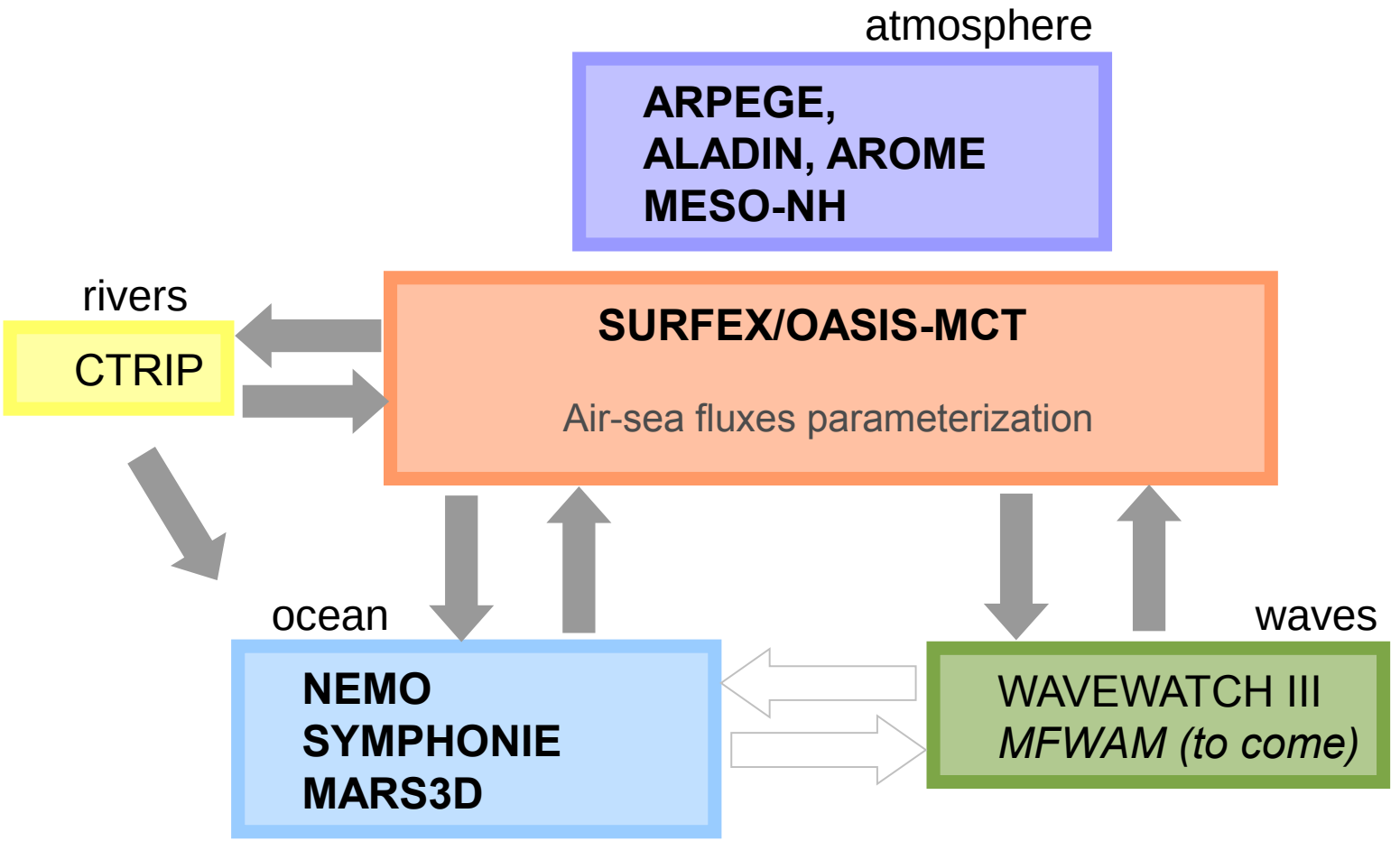
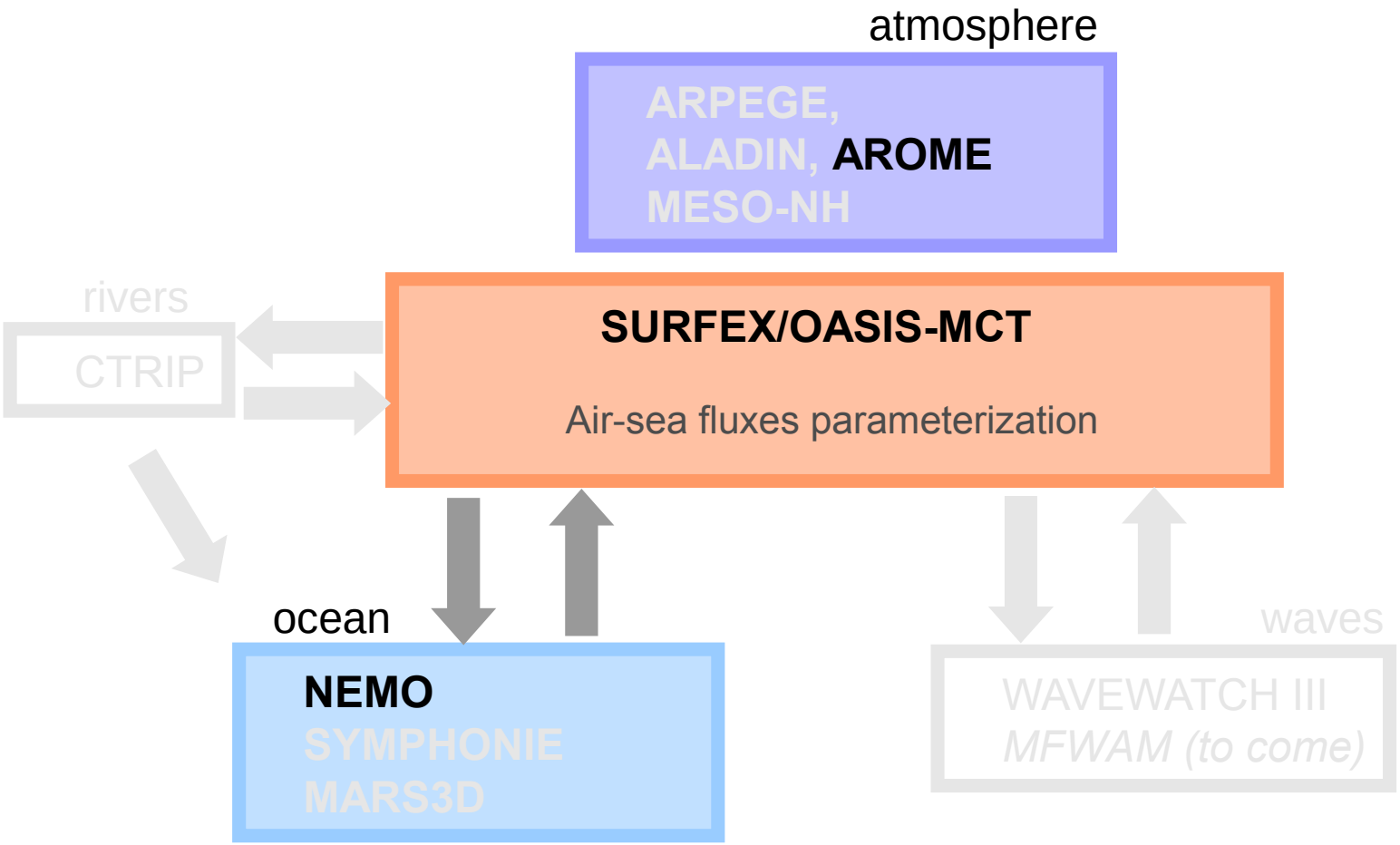
The SURFEX-OASIS coupling interface



Voldoire et al., in prep

A collaborative work from the Technichal Working Group
« O-A-W coupled systems using SURFEX-OASIS »
CNRM, Mercator Océan, LACY, LOPS, LA

The SURFEX-OASIS coupling interface



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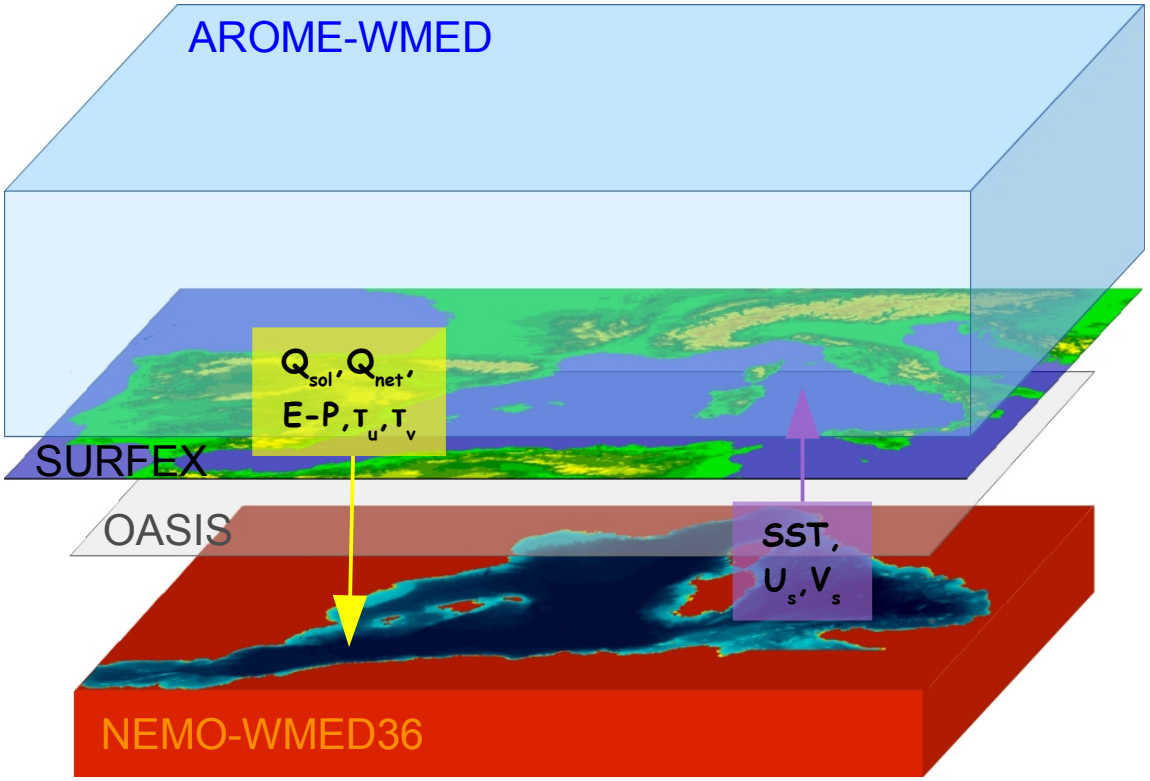
The AROME-NEMO WMED coupled system

AROME-WMED (Fourrié *et al*., 2015)
Based on AROME (Seity *et al*., 2011)
cy38t1 / no assimilation
Δt=60s
Δx=2.5km - grid: 960 x 640 x 60 η-levels
Radiatifve fluxes: scheme with 6 spectral bands for SW (Fouquart and Bonnel, 1980) ; RRTM for LW (Mlawer et al., 1997)

SURFEX (Masson *et al*., 2013)
v7_2
Bulk turbulent fluxes: COARE 3.0 (Fairall *et al*., 2003) or ECUME (Belamari, 2005)

OASIS3-MCT (Valcke *et al*., 2013)
Bilinear interpolation
Coupling frequency: 1h
Exchanged fields:
O→A : SST, U_s, V_s
A→O : Q_{net},Q_{sol}, E-P, τ_u, τ_v

NEMO-WMED36 (Lebeaupin Brossier *et al*., 2014)
code: NEMO v3_2 / SIMED
Δt=240s
Δx=1/36° (between 2.2 and 2.5km)
grid : 760 x 480 x 50 z-levels
Bathymetry: v10 Mercator-LEGOS
Runoff : monthly climatology (Beuvier *et al*., 2010)
2 open-boundaries: Alboran Sea and Sicily Channel

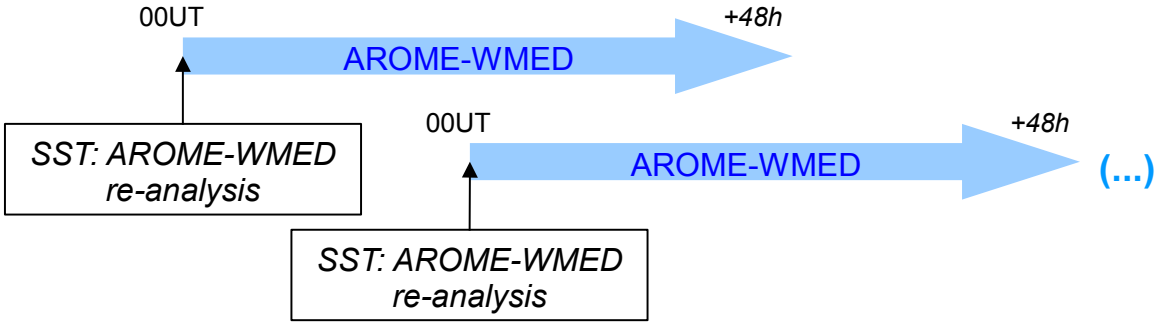


Application to HPEs during HyMeX SOP1

Simulations

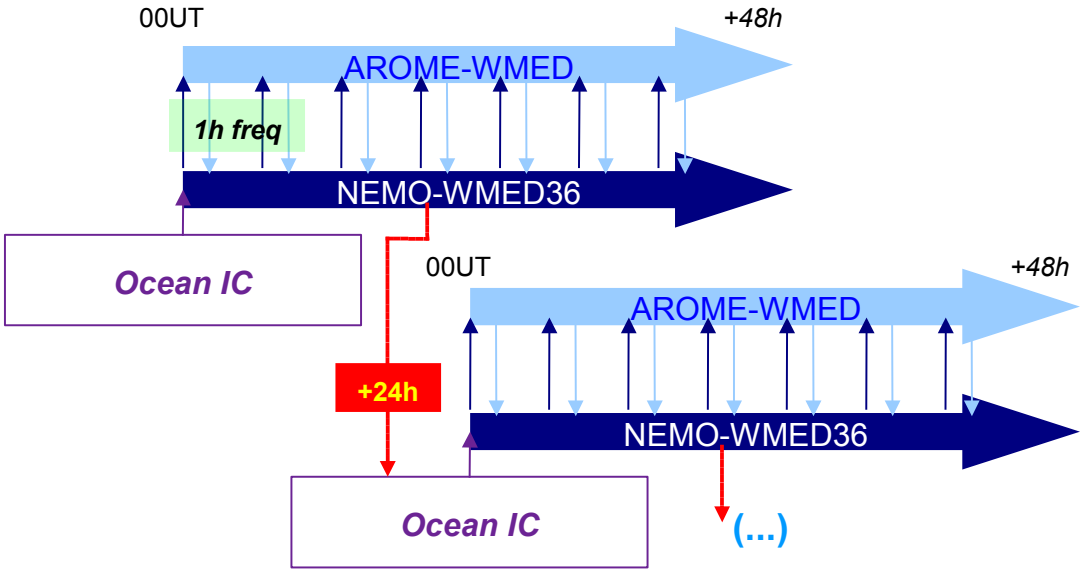
ARCO reference

- *AROME-WMED*
- *Bulk: COARE*
- *Initial SST: AROME-WMED re-analysis*
- *SST is constant in time*



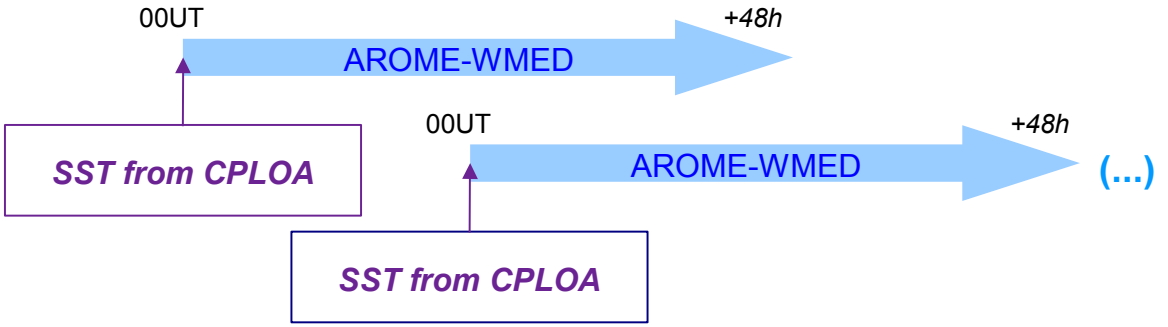
CPLOA coupled experiment

- **AROME-NEMO WMED**
- *Bulk: COARE*
- *SST: solved by NEMO-WMED36 and updated in SURFEX every hours by coupling*



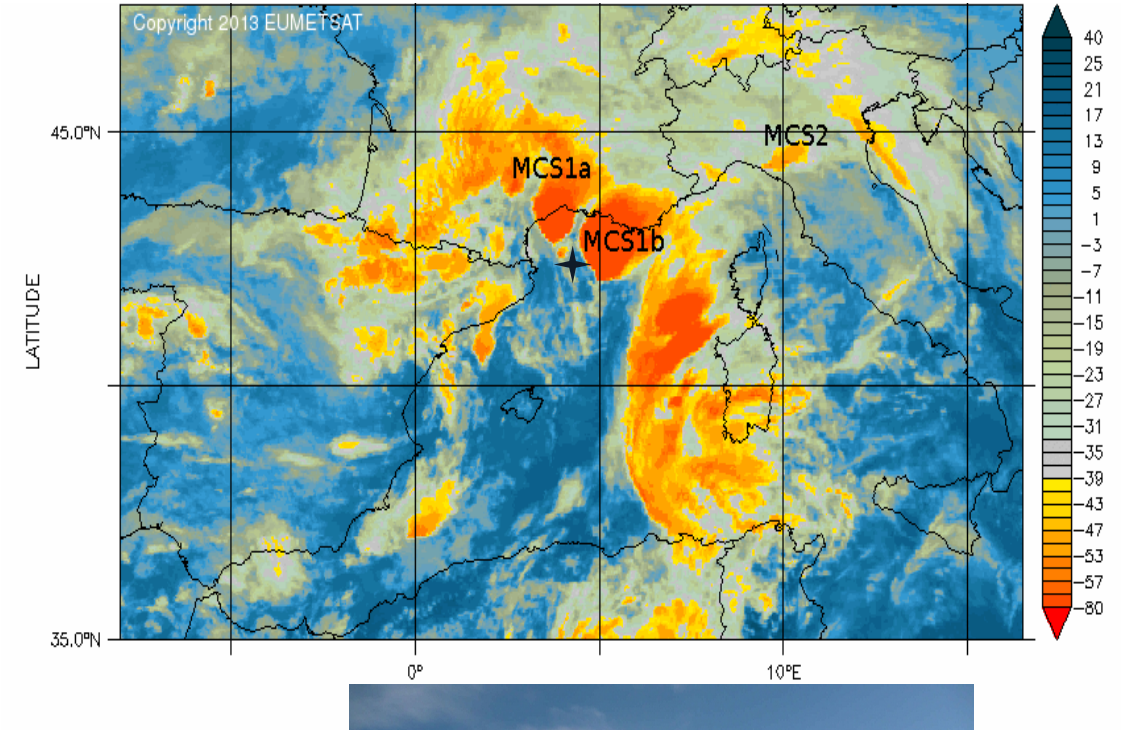
SSTHR Sensitivity to initial SST

- *AROME-WMED*
- *Bulk: COARE*
- *Initial SST: taken from CPLOA*
- *SST is constant in time*

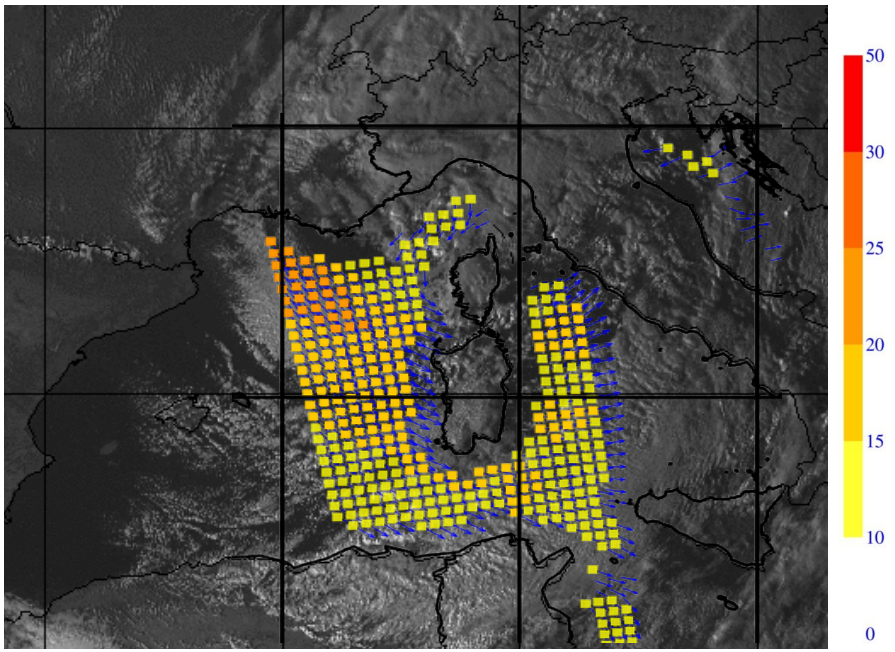


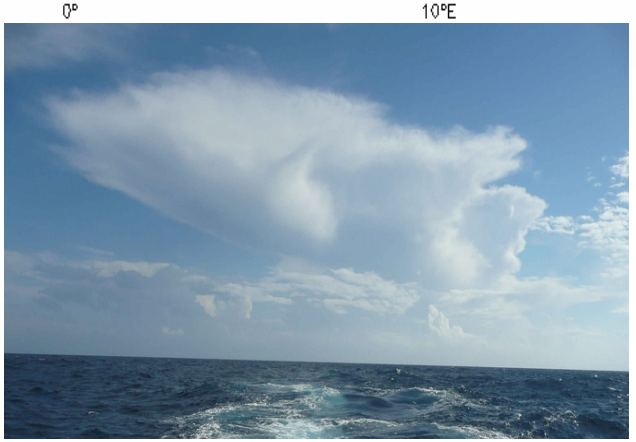
IOP16a/b

2012/10/26: Satellite IR image 09UTC
(IOP16a = several MCS with HP)



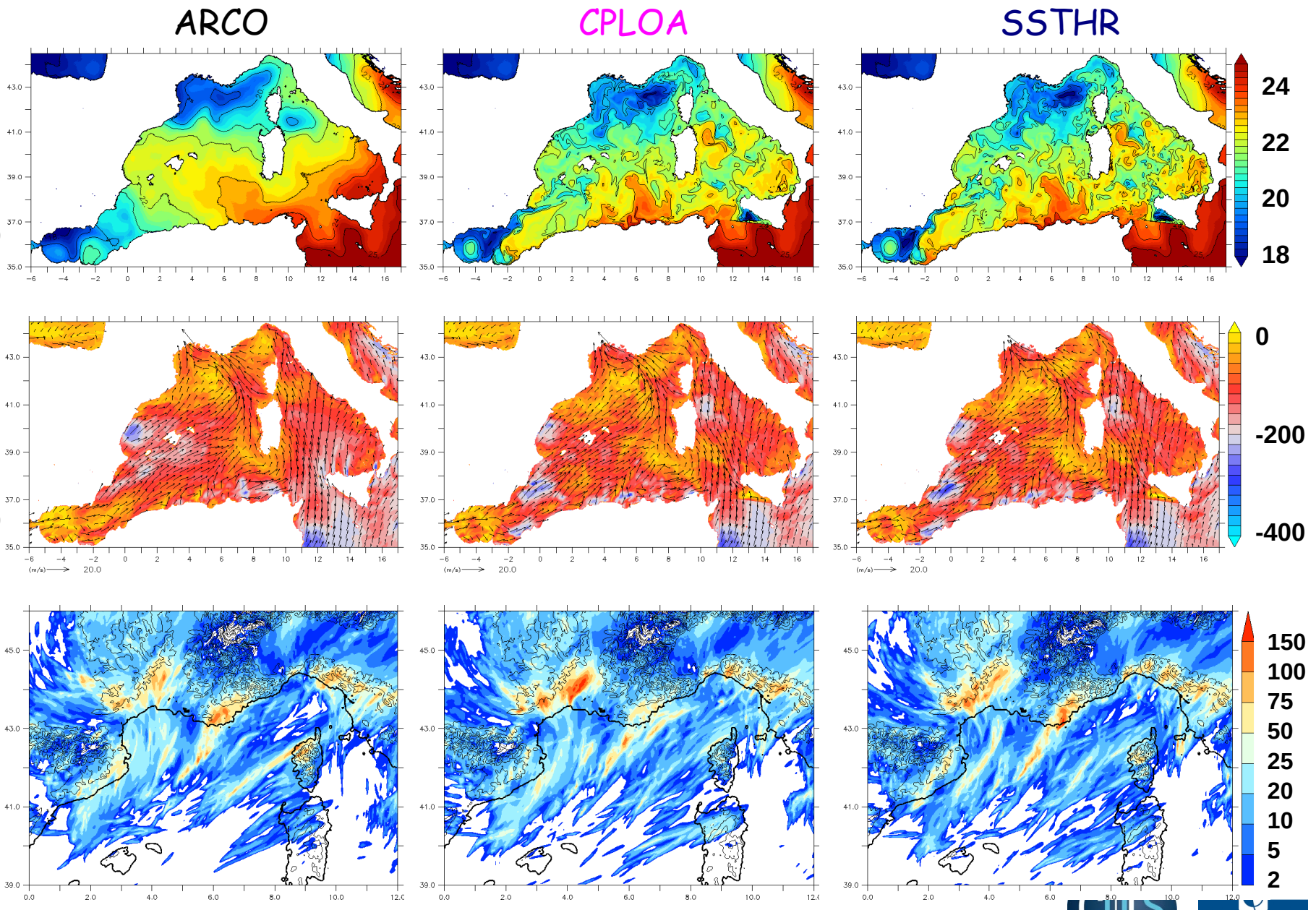
2012/10/28: Satellite visible image 15UTC + ASCATT wind (18-21UTC)
(IOP16b = severe mistral)





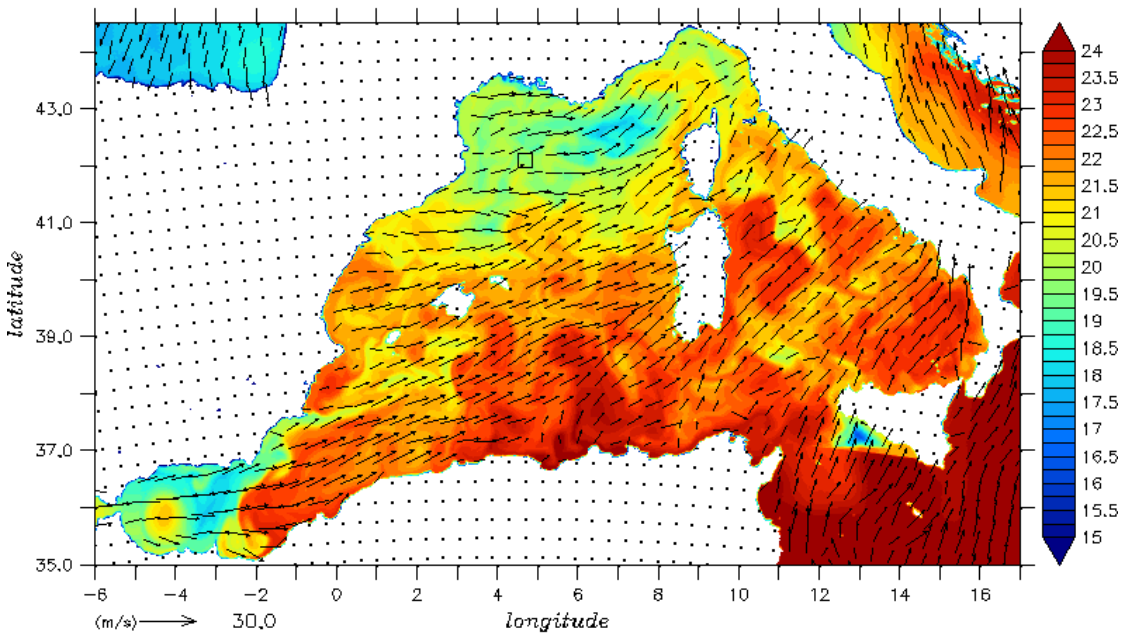
MCS1b picture taken from the B/T Provence

Coupling impacts

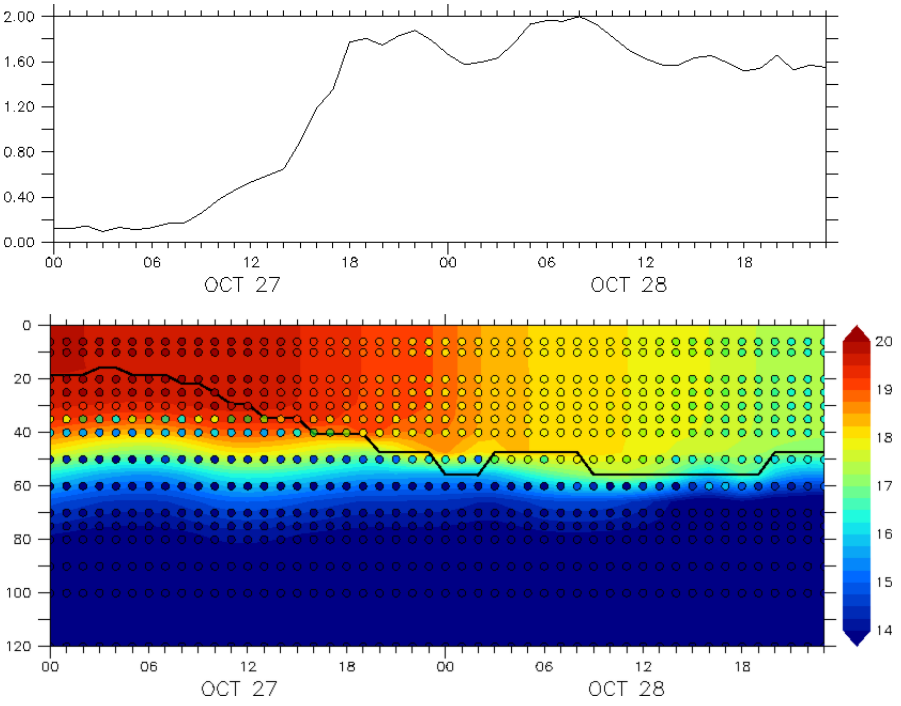


Ocean response to a severe mistral event

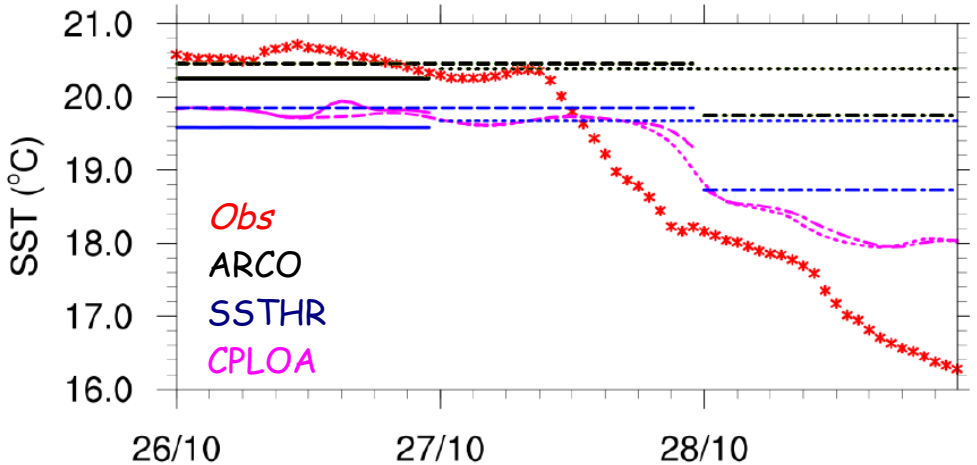
CPLOA : Wind at first level (~10m) and SST over 48h
(base 27/10/2012 00UTC)



CPLOA : Wind stress and temperature profile at Lion
(base 27/10/2012 00UTC)



Observed and forecasted SST at Lion

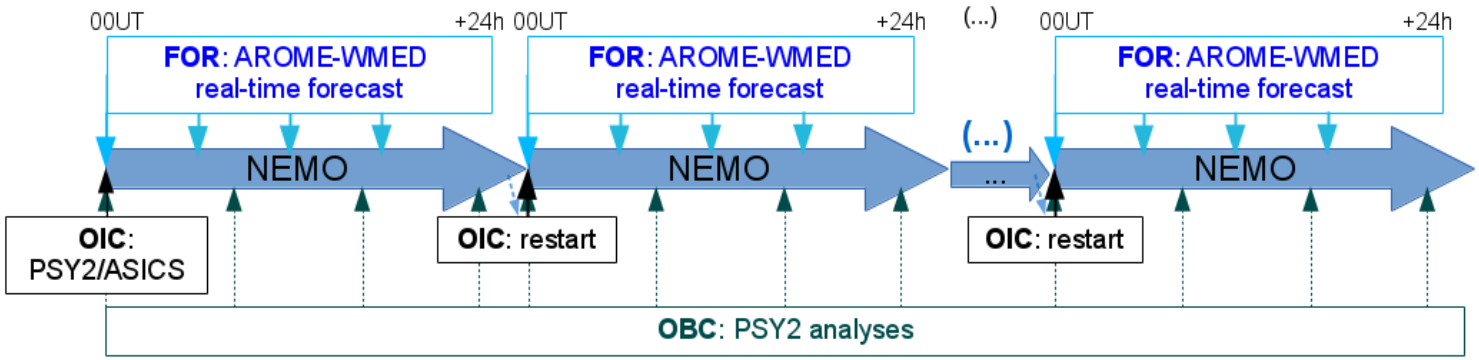


Application to DWF during HyMeX SOP2

Simulations

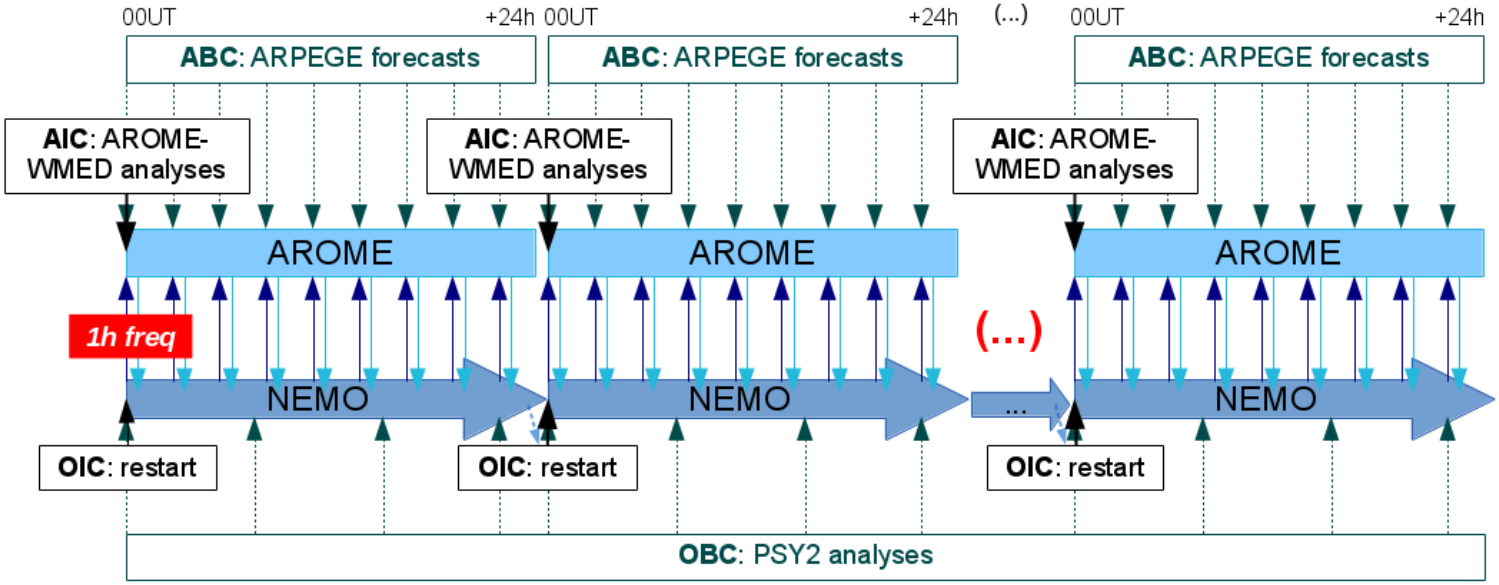
IMAP

- *NEMO-WMED36*
- *Forced by hourly fluxes from AROME-WMED real time forecasts*
- *From 1 Sep 2012 to 15 Mar 2013*
- *IC: ASICS (MOOSE) + PSY2 analysis*



CPL

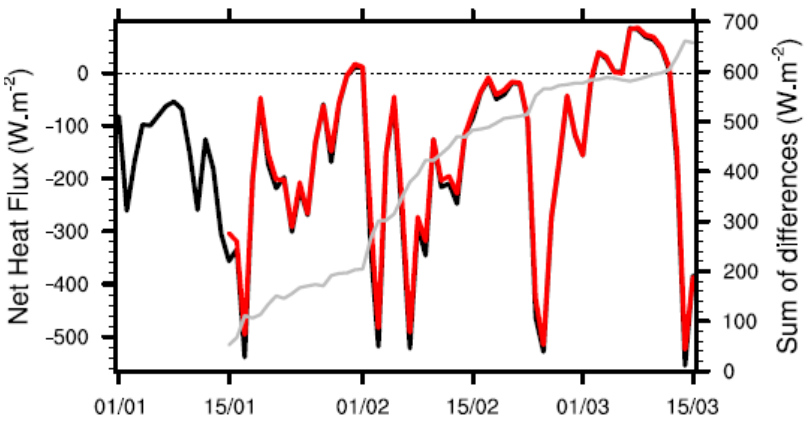
- *AROME-NEMO WMED*
- *Coupled (1h freq)*
- *From 15 Jan to 15 Mar 2013*
- *IC: restart from IMAP analysis*

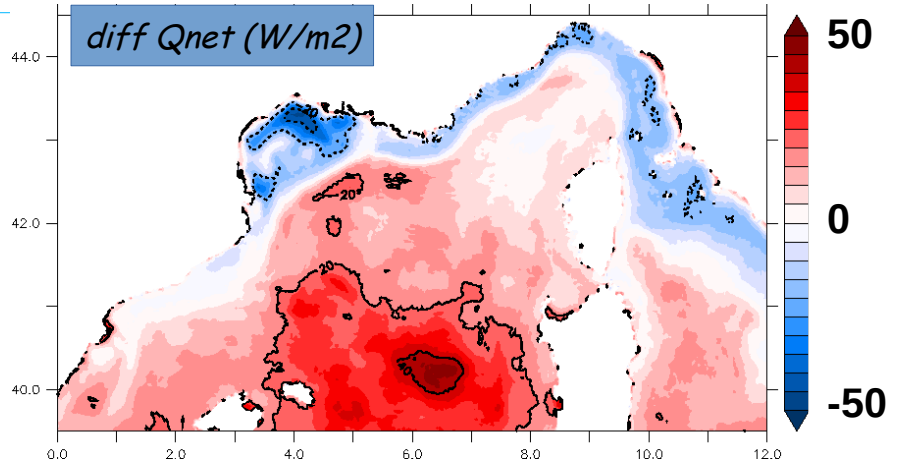


Surface fluxes

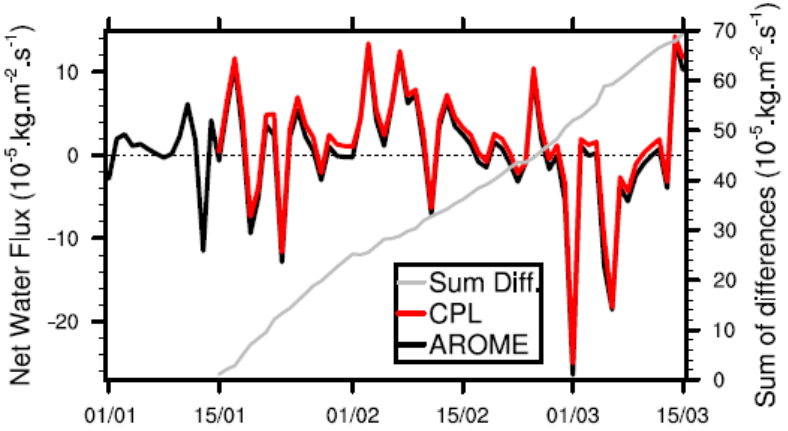
CPL - AROME

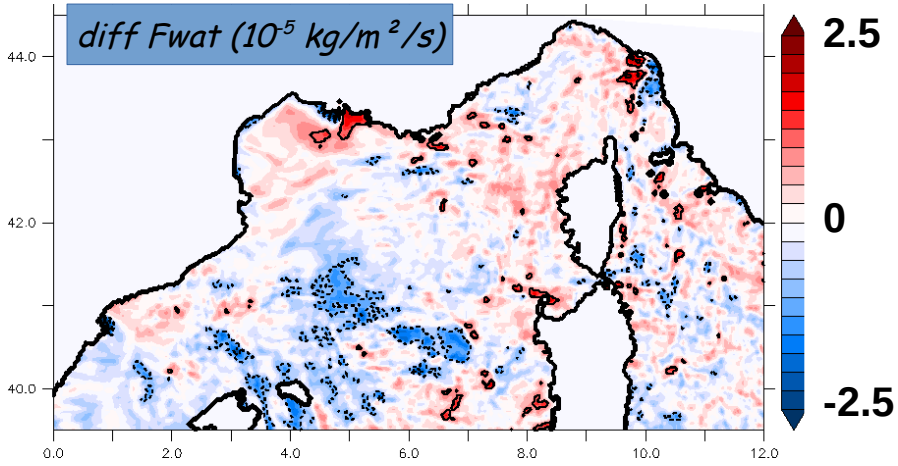
Qnet (W/m2)



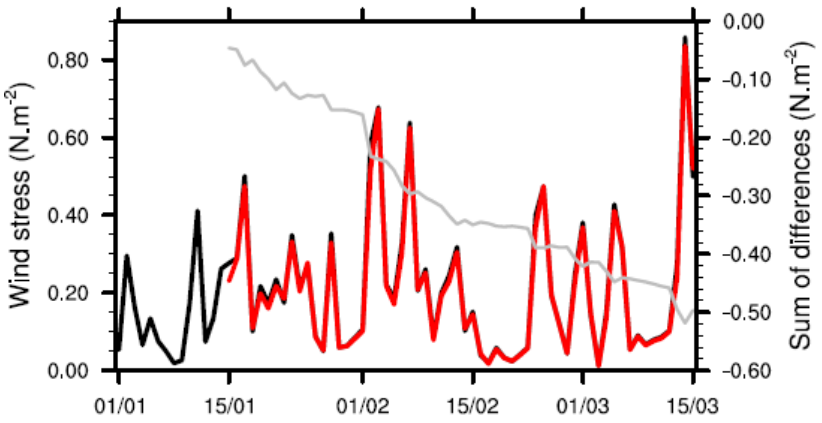


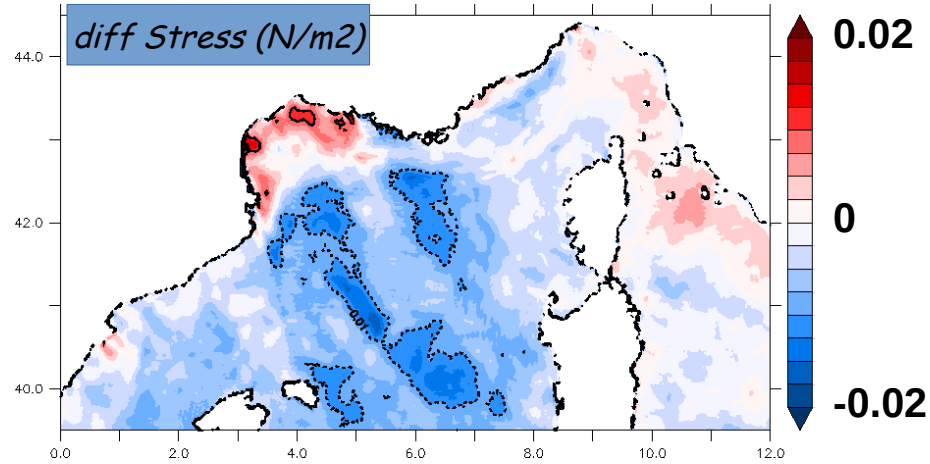
Fwat (10^{-5} kg/m²/s)





Stress (N/m2)





Surface fluxes

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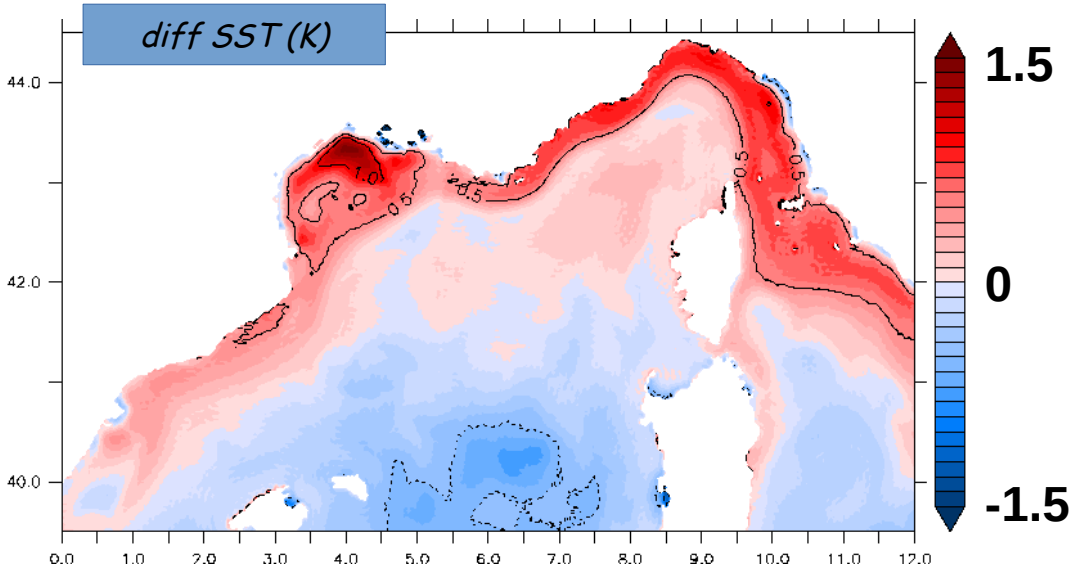
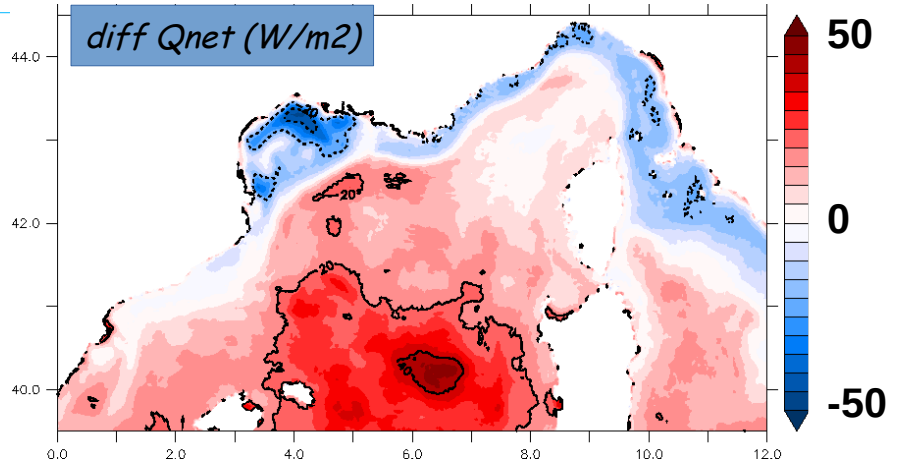
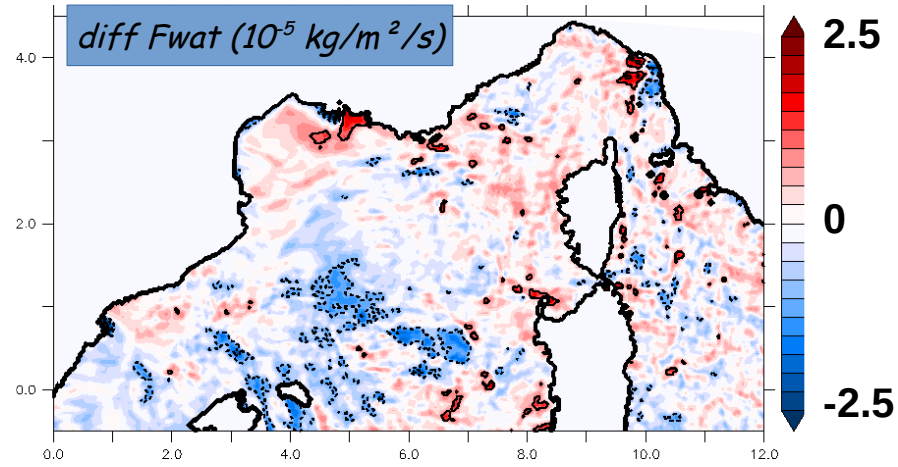
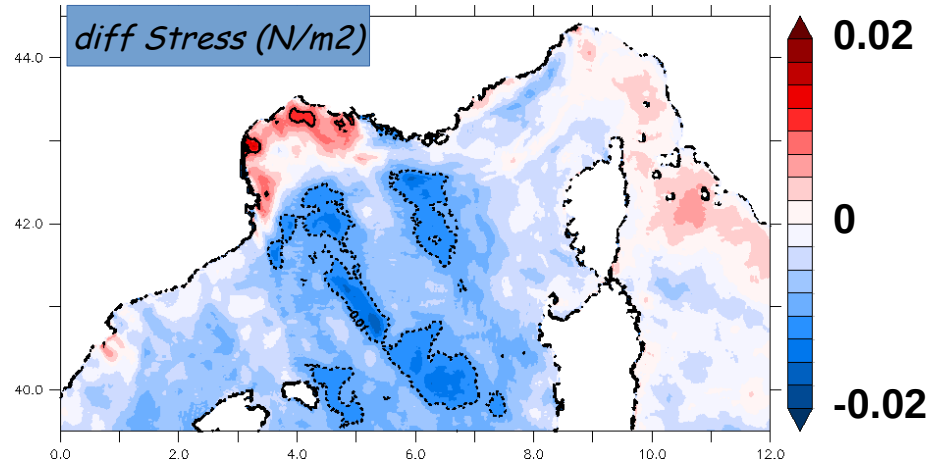


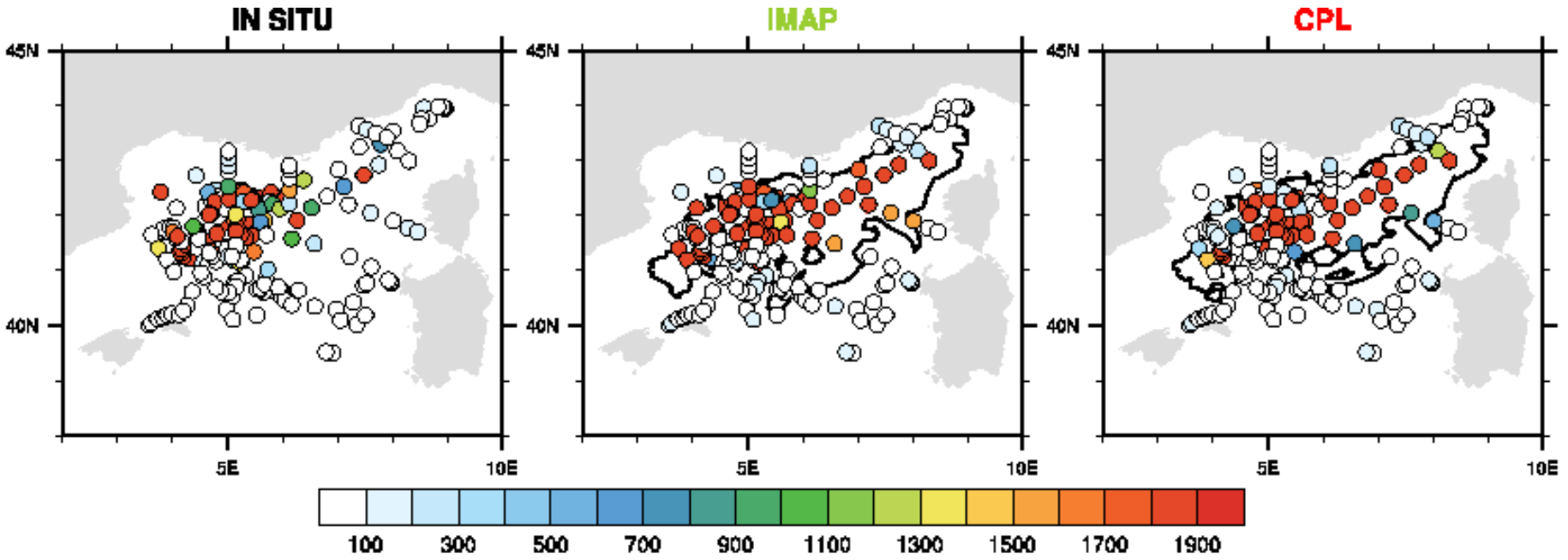
CPL - AROME





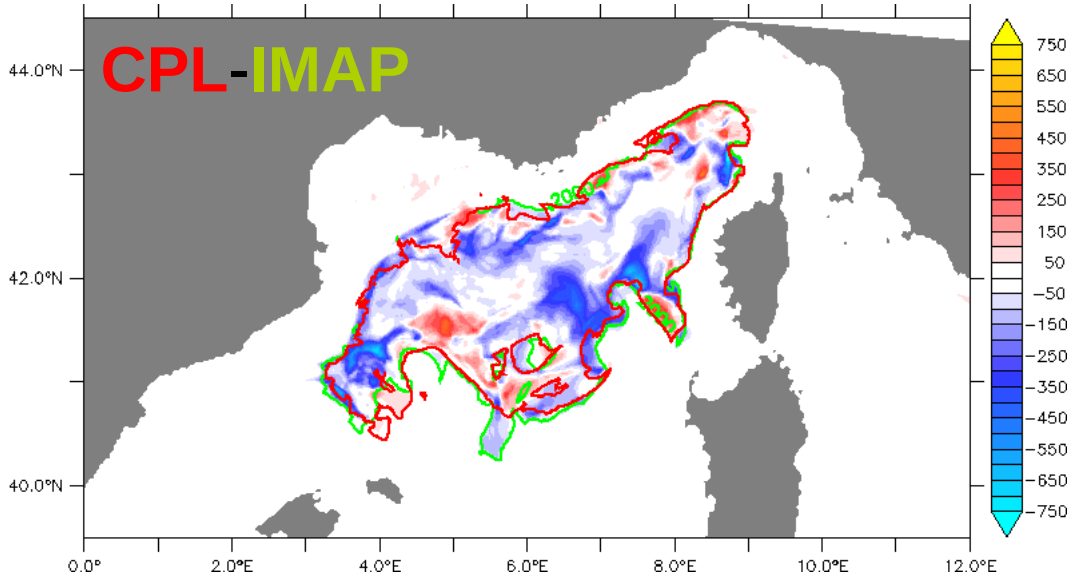


Mixed Layer Depth



MLD from CTD and ARGO profiles and co-localizedi n IMAP andCPL
Contour : maximum MLD below 2000m-depth

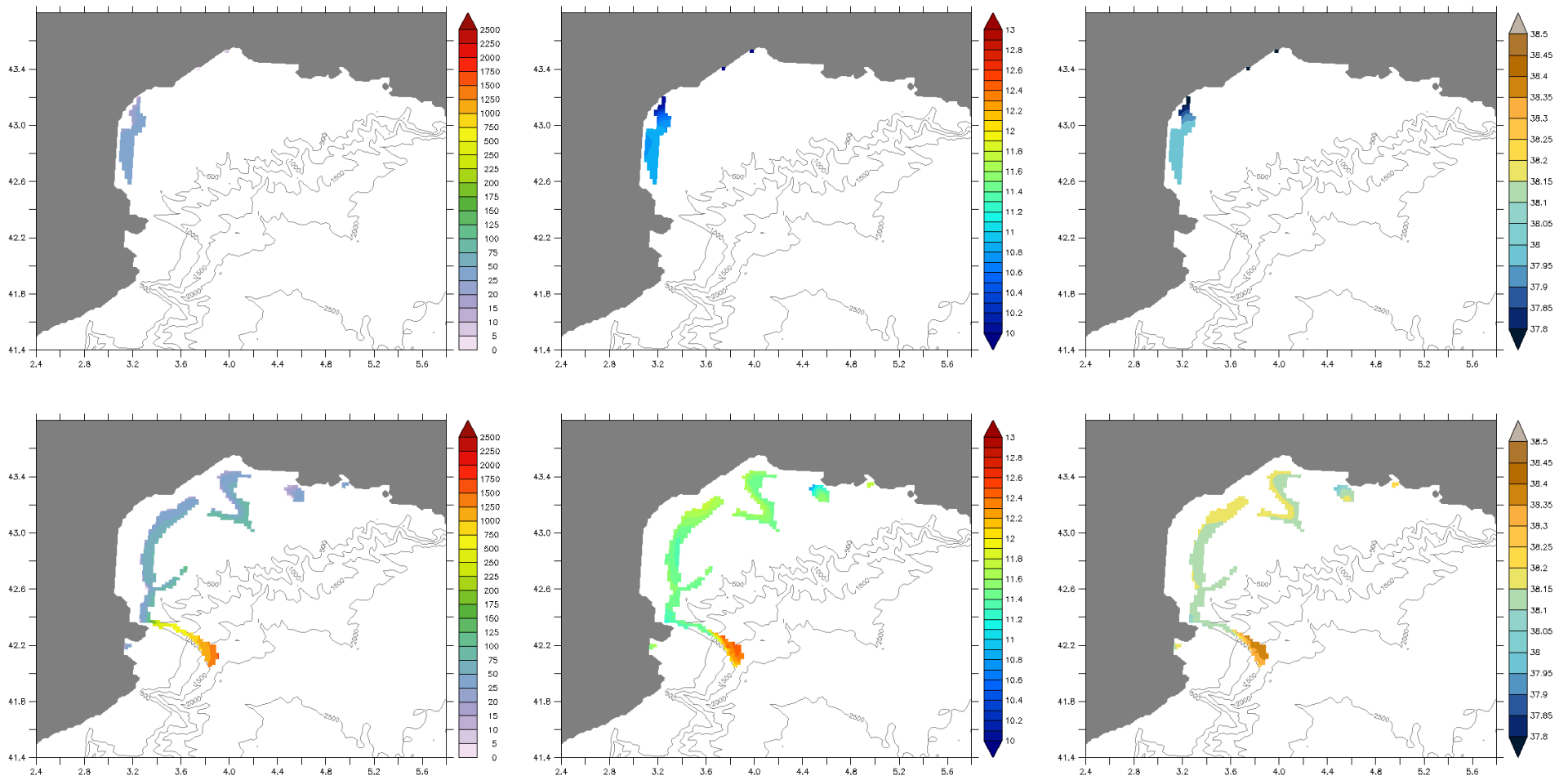
Difference in the mean MLD during SOP2 and maximum MLD below 2000m-depth (green for IMAP and red for CPL)



Dense water volumes

IMAP

CPL



Depth (m), potential temperature (°C) and salinity (psu) for the 29.13 kg/m ³ isopycnal surface simulated for 2 March 2013 in IMAP (top panels) and CPL (bottom panels)

Summary of the results

DWF and ocean circulation - SOP2: (Lebeaupin Brossier *et al*., JGR-Oceans, sub.)

- On average, the coupling produces small differences in terms of DWF (chronology, water characteristics and volumes)
- Looking more locally, we found that the offshore convection is reduced whereas the shelf dense water production is increased
- The most significant differences are found around the mixed patch where strong interactions between the wind and the ocean fronts occur

HPE and weather forecasts - SOP1: (Rainaud *et al*., QJRMS, rev.)

- Coupling has a significant impact on the location and the intensity of precipitation
- Interactive ocean (CPLOA vs. SSTHR) has an impact as important as a change in the initial SST field (SSTHR vs. ARCO)
- Other case studies are needed to verify the results, in particular using realistic initial ocean conditions (analyses) for the coupled system, improving the runoff inputs and including a wave model...

Thank you for your attention!

contact: cindy.lebeaupin-brossier@meteo.fr

How to?

SURFEX v8_0 sources contain the OASIS3-MCT subroutine calls with the following steps:

steps	subroutines
1. initialization and namelist reading	*sfx_oasis_init* *sfx_oasis_read_nam*
2. multi-process partition definition and listing	*sfx_oasis_define*
3. receiving/sending	*sfx_oasis_recv* *sfx_oasis_send*
4. finalization	*sfx_oasis_end*

Called by the atm. model when SURFEX is integrated, as it needs information about the domain and process partition

OASIS3-MCT should be downloaded at https://verc.enes.org/oasis/download
Once the OASIS3-MCT librairies obtained, they should be added during the model compilation.

For more technical information, contact: sophie.valcke@cerfacs.fr, aurore.voldoire@meteo.fr, cindy.lebeaupin-brossier@meteo.fr

Scheme of the subroutine calls in AROME (cy38t1)

master

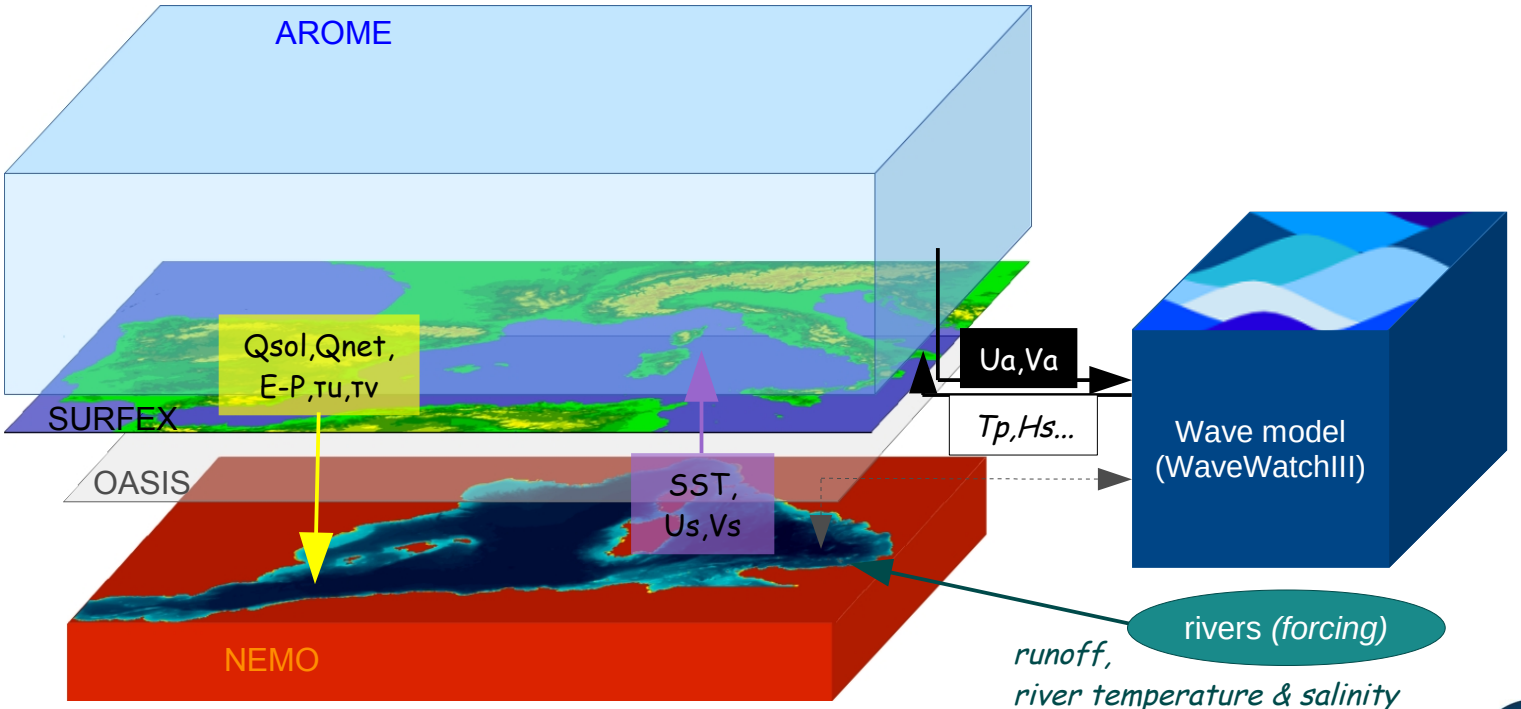
- → **ini_oasis_sfx**
  - → **sfx_oasis_init**
- → **...**
  - → **aroini_surf** *(in suphmse_surf)*
  - → **my_aroni_surfa** ***(****aroini_surfa****)***
    - → **sfx_oasis_read_nam**
  - → **aroni_surfb**
  - → **aroni_surfc**
  - → **sfx_oasis_define**
- → **...**
  - → **updtim**
  - → **send_oasis_sfx**
    - → **sfx_oasis_send**
  - → **update_sfx**
    - → **recv_oasis_sfx**
      - → **sfx_oasis_recv**
- → **sfx_oasis_end**

Perspectives and future work

César Sauvage's PhD thesis:

- Improvement of the runoff representation using real runoff data, with a higher frequency and taking into account of a vertical profile of discharge
- Taking the sea state into account in the bulk formulae, then developing of the interactive O / A / W coupling
- Development of a NEMO configuration to be coupled to AROME-France

→ *Application to more recent HPEs leading to floods and associated to rough sea*



Scheme of the target multi-component coupled system

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