Impact of Forcing/Coupling on Atmospheric and Oceanic Forecasts

herve.giordani@meteo.fr

GAME/CNRM (Météo-France/CNRS),Toulouse, France

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Toujours un temps d'avance

Oceanic state in atmospheric models: **SST**

Tropical cyclones (Emanuel, 2005)

Middle latitude Storms (Doyle et Warner 1993; Giordani & Planton 2001; Ren et al., 2004; Pullen et al., 2006)

MABL circulations induced by oceanic fronts (Hyodae Seo, 2005; Giordani & Planton 1998)

Heavy precipitating events in the Mediterranean basin (Millan et al., 1995; Romero et al., 1997; Pastor et al., 2001; Homar et al., 2003)

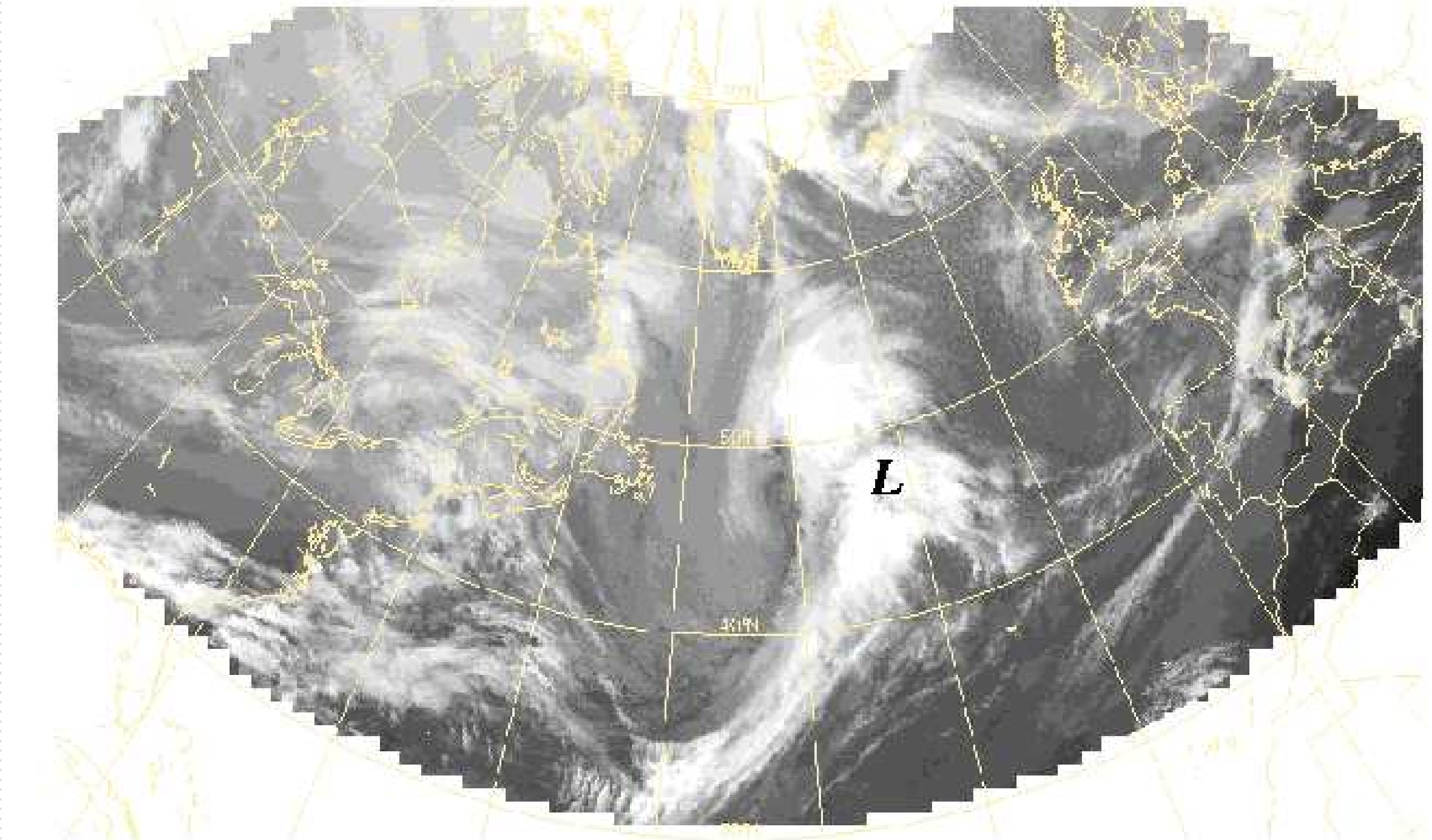
Sensitivity of **Mesoscale Convective Systems** to:

- **SST**
- **Surface flux parameterization**
- **Coupled ocean mixed-layer model** (heat content)

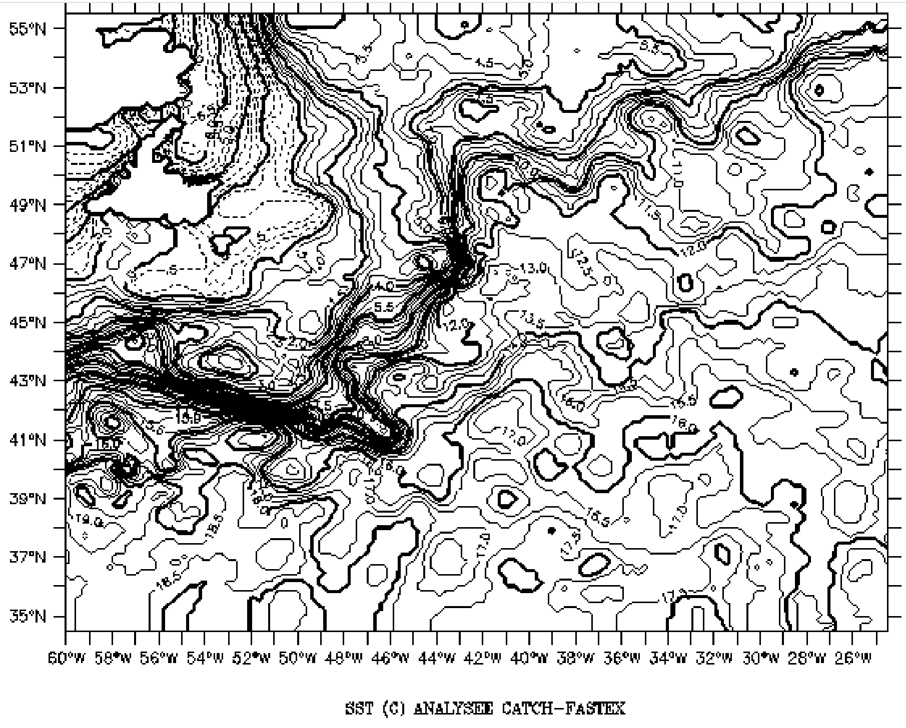
Sensitivity of the **Mixed-Layer** to:

- **surface heat & mass fluxes**

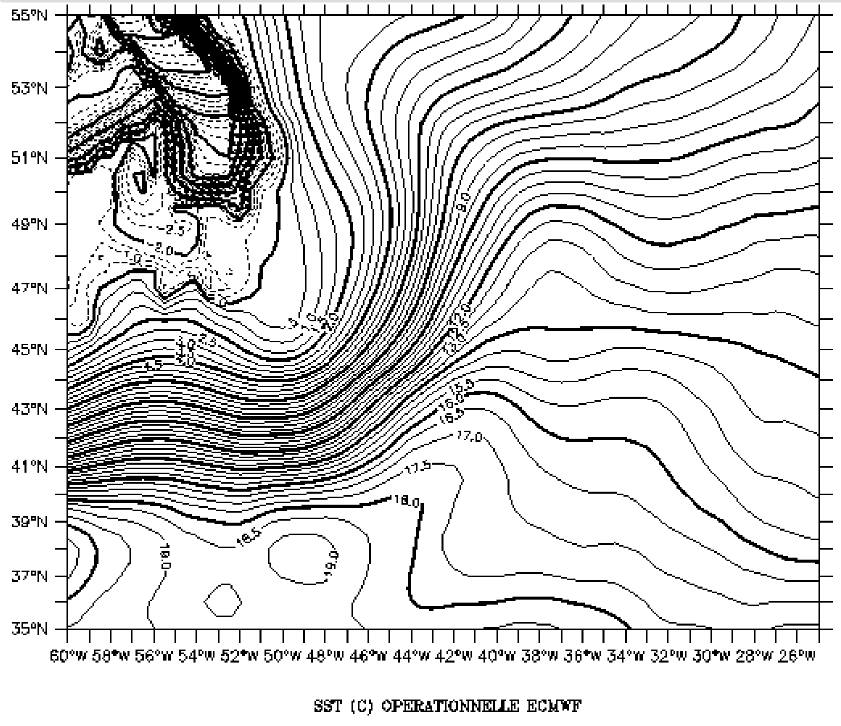
FASTEX-CATCH - IOP15



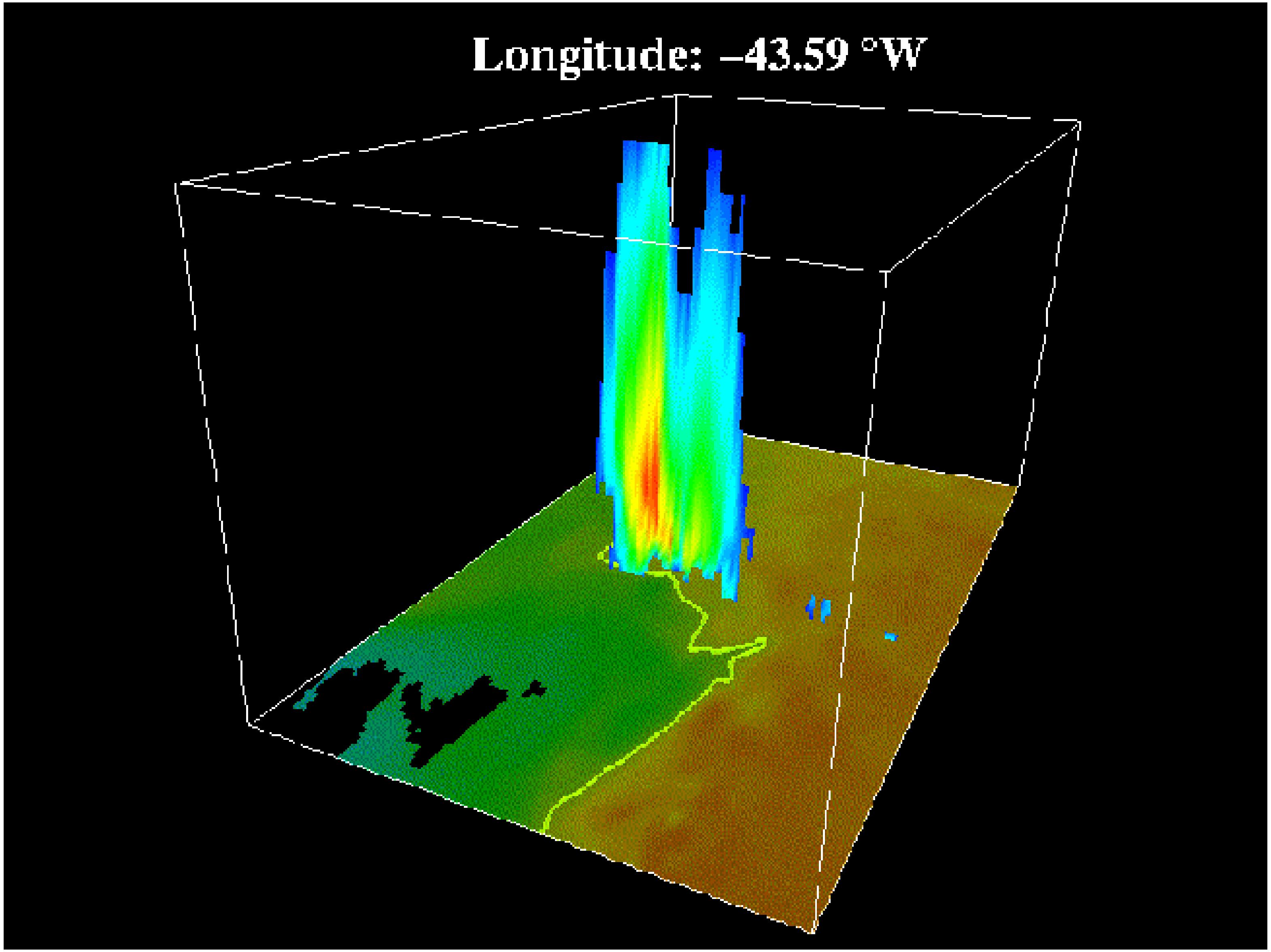
CATCH-FASTEX- IOP15



SST Reanalysis

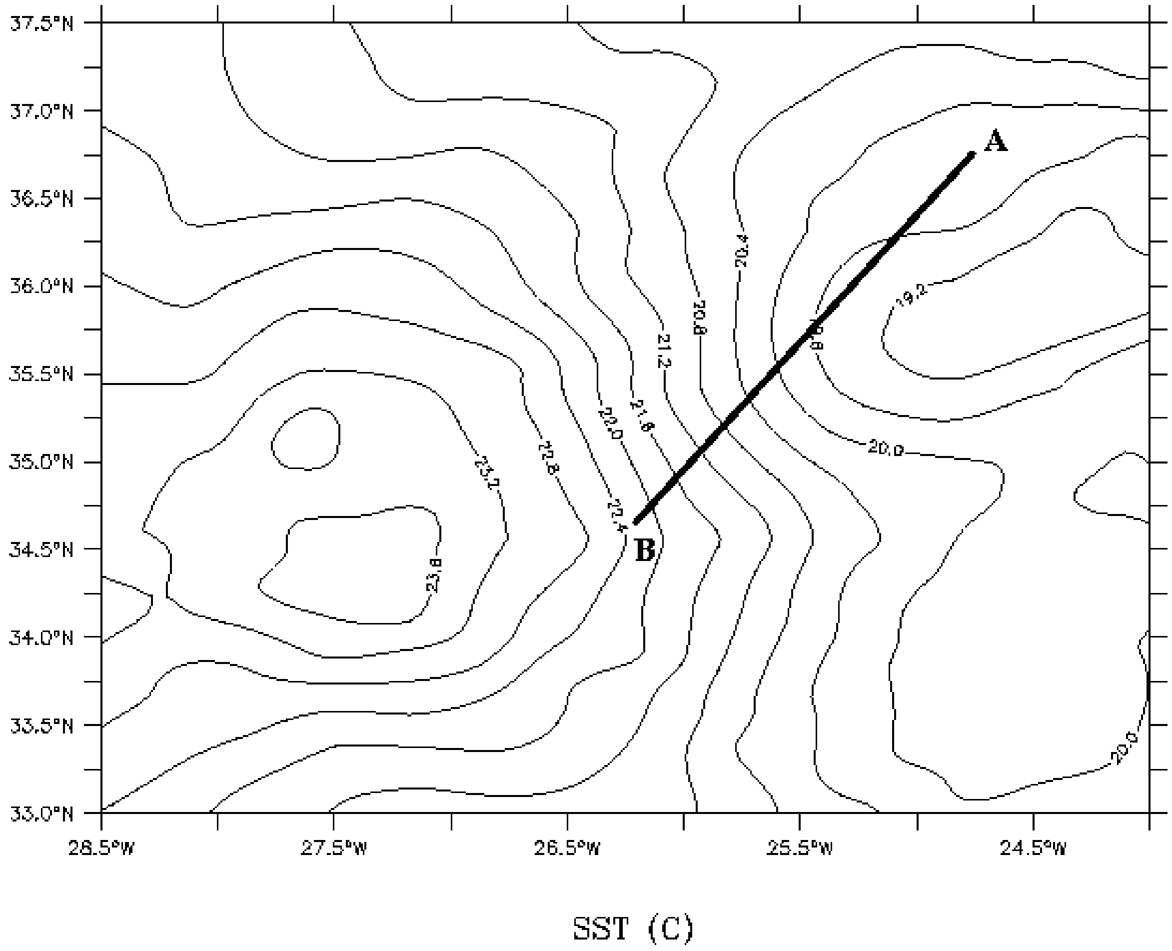


ECMWF SST Analysis



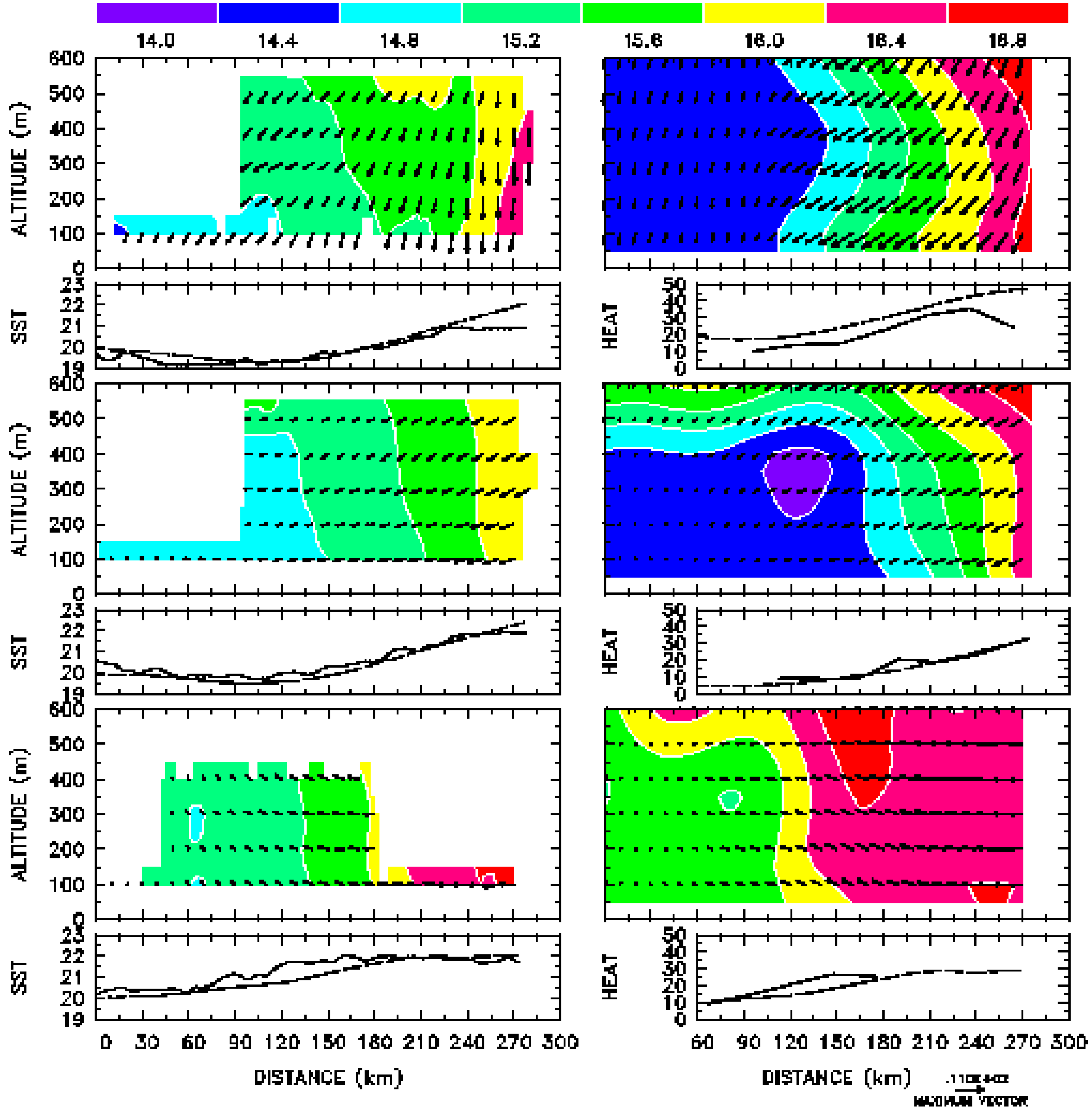
Giordani et al., 2001

SEMAPHORE Experiment, 1993
Eymard et al., 1995



Giordani et al., 1997

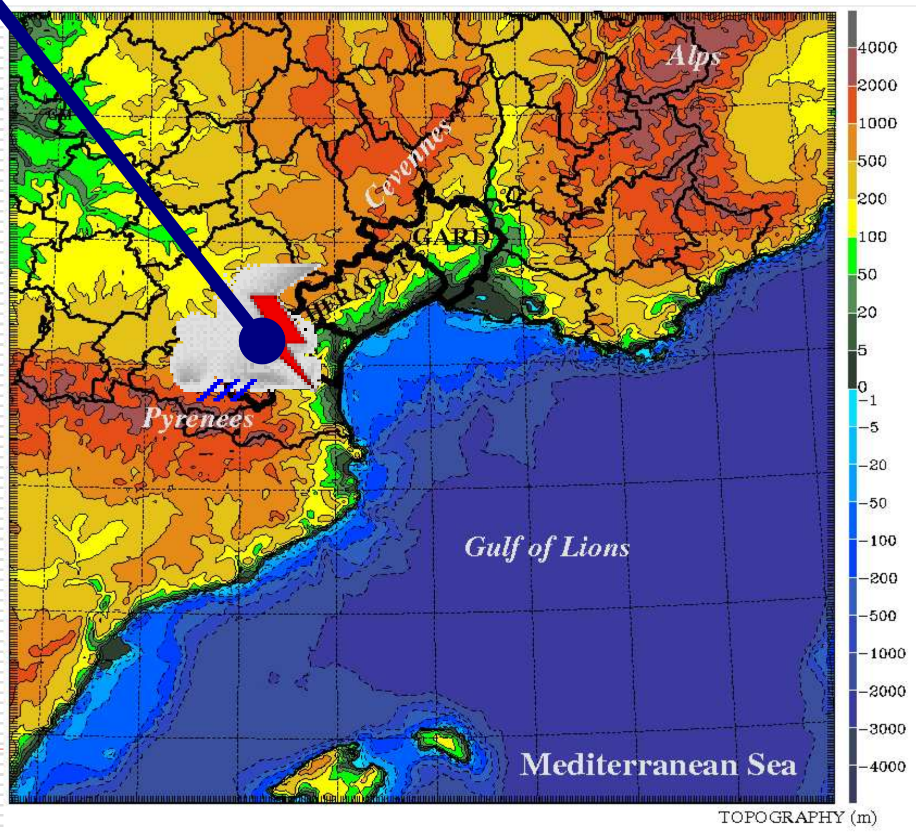
SEMAPHORE

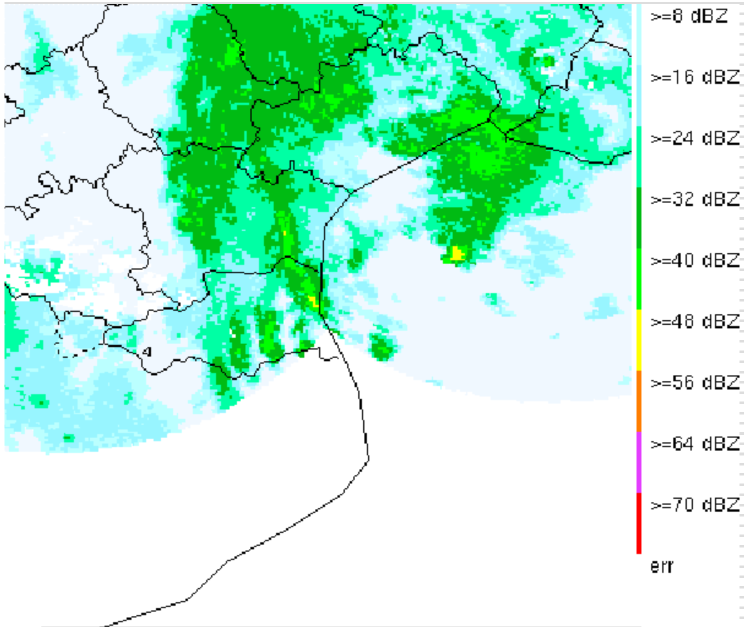


Giordani et al., 1997

Aude Case

Flash flood in the ***AUDE*** *department* ***12-13 November 1999***
MCS quasi-stationnary; 551 mm in 24h;
More than 30 deceases.
(Ducrocq et al. 2003)

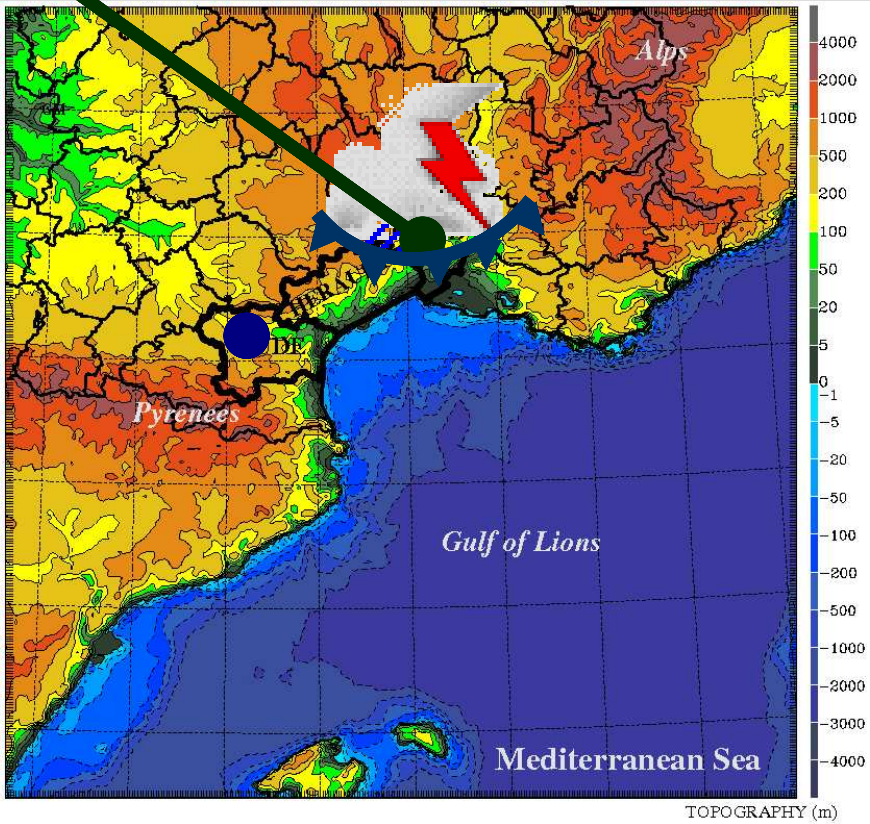


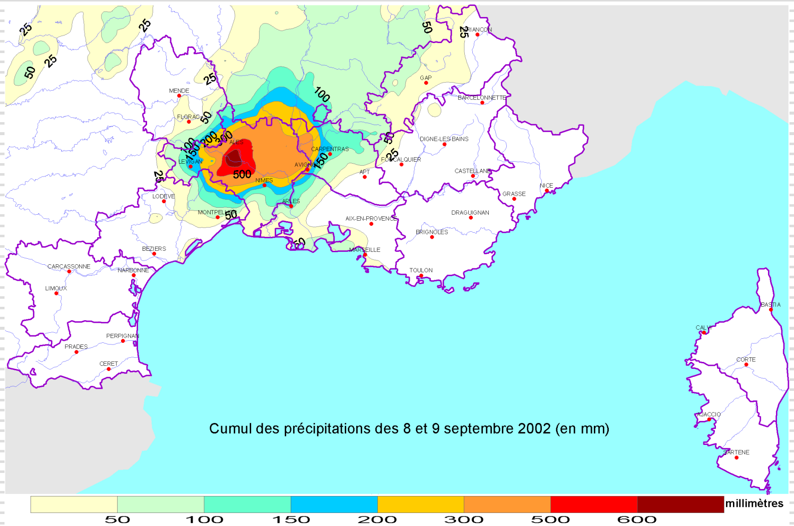


AUDE : Radar reflectivity (dBz)

Gard Case

*Flash flood in the **GARD** **department 8-9 September 2002***
MCS quasi-stationnary; 691 mm in 24h;
24 deceases
(Delrieu et al. 2005)





GARD : Observed 24h-accumulated precipitation (mm)

Hérault Case

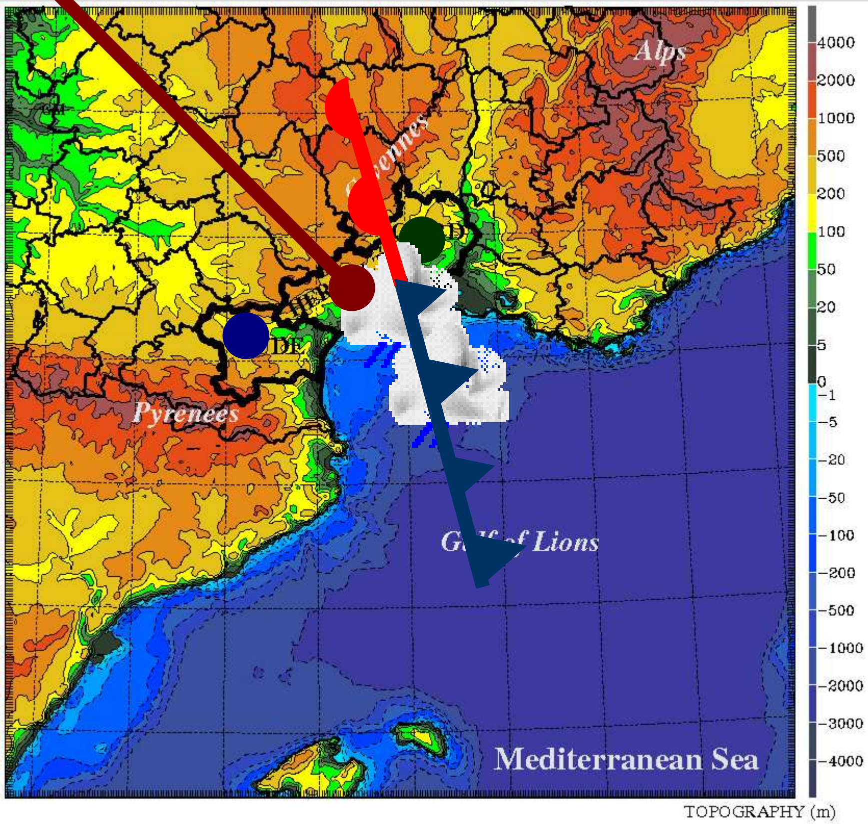
Rhône flood, *December 2003*

(HÉRAULT department, ***3 December 2003****)*

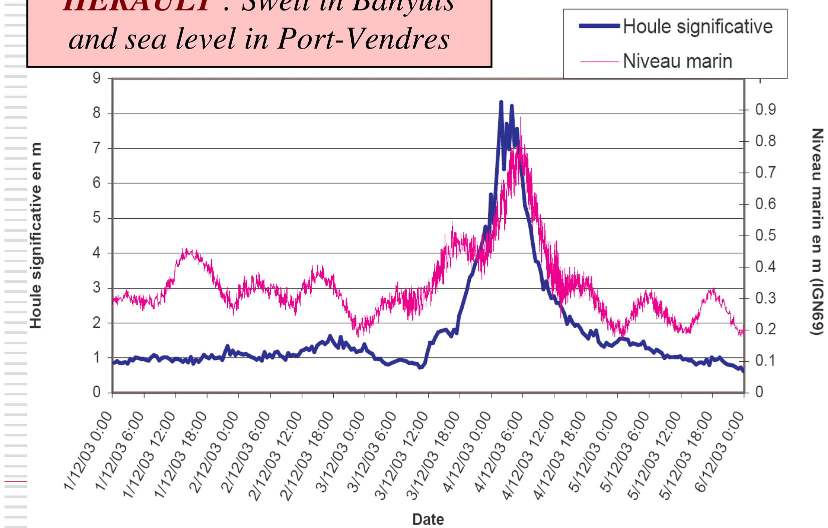
Quasi stationary frontal system; 198 mm in en 24h;

7 deceases

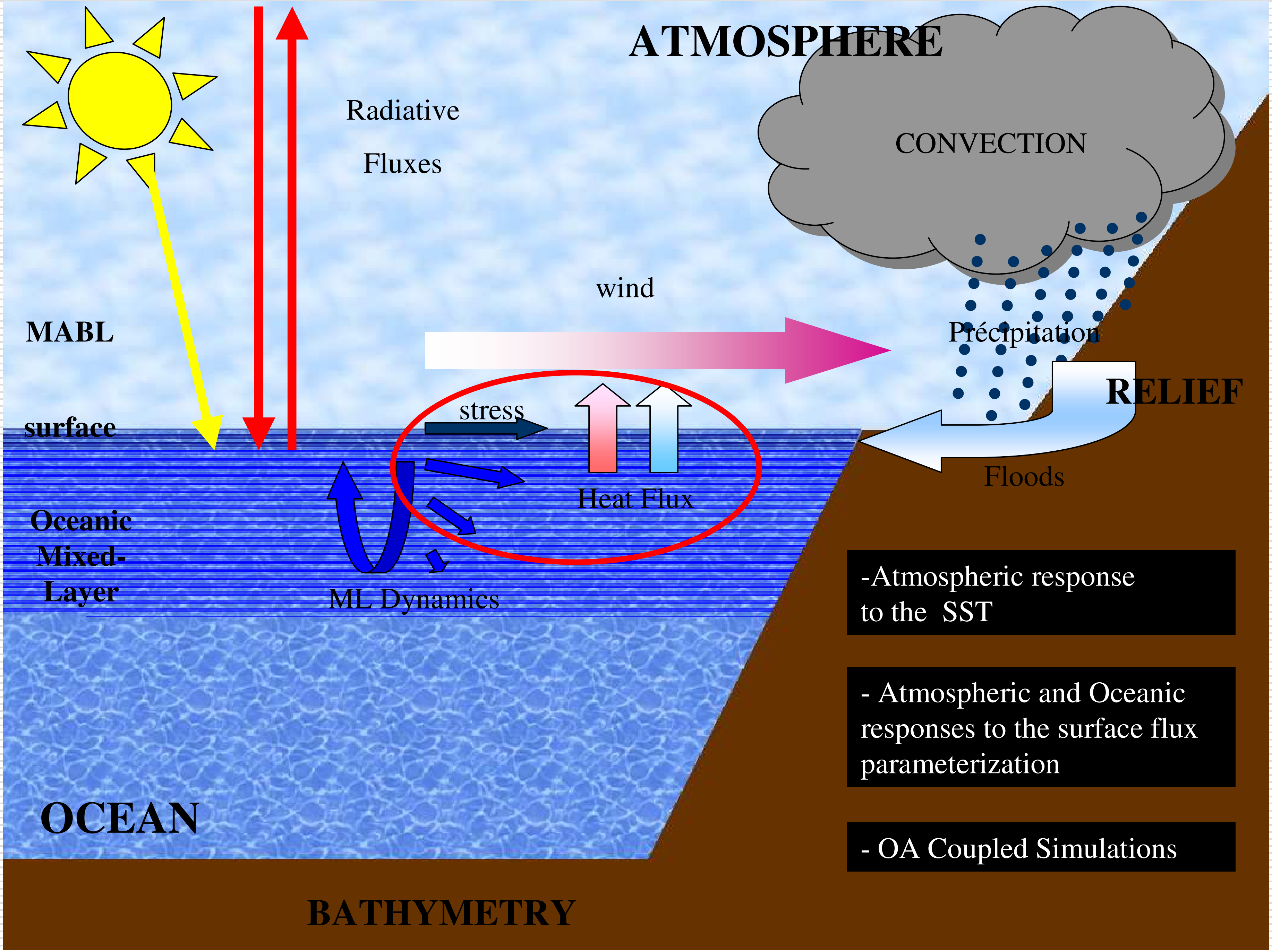
(Hontarrède et al. 2004)



HERAULT : Swell in Banyuls and sea level in Port-Vendres



METHODOLOGY



-Atmospheric response to the SST

- Atmospheric and Oceanic responses to the surface flux parameterization

- OA Coupled Simulations

Atmospheric Model

Atmospheric Model : MESO-NH (Lafore et al. 1998)

Mesoscale Non-Hydrostatic Model

microphysique scheme : Pinty et Jabouille (1998)

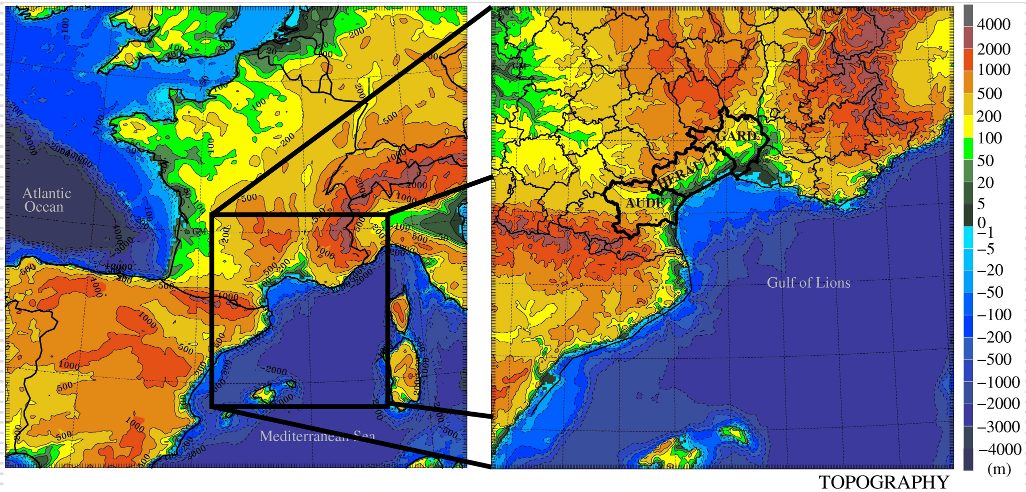
turbulence scheme : Cuxart *et al.* (2000)

radiative scheme : RTTM (Mlawer *et al.* 1997)

Grid Nesting :

Large domain Δx= **9.5km**
⇒ parameterized convection
(Kain et Fritsch 1990;
Bechtold *et al.* 2001)

Small domain Δx=**2.4km**
⇒ explicit convection



Initialisation with ARPEGE analyses.

Oceanic Model

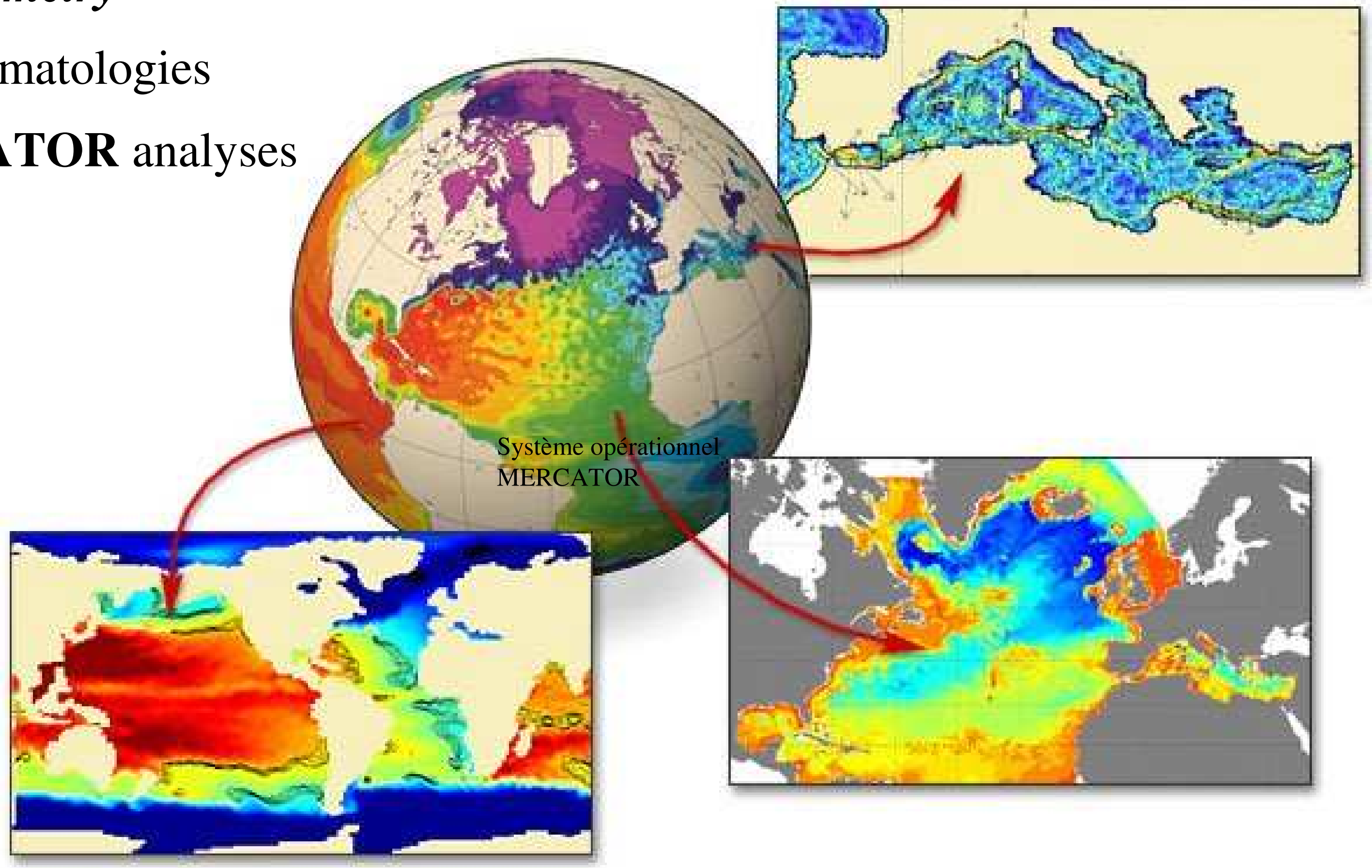
Oceanic Model : Column mixed-layer model (Gaspar et al. 1990)

pronostic variables : Turbulent Kinetic Energy (TKE), T, S, u, v.

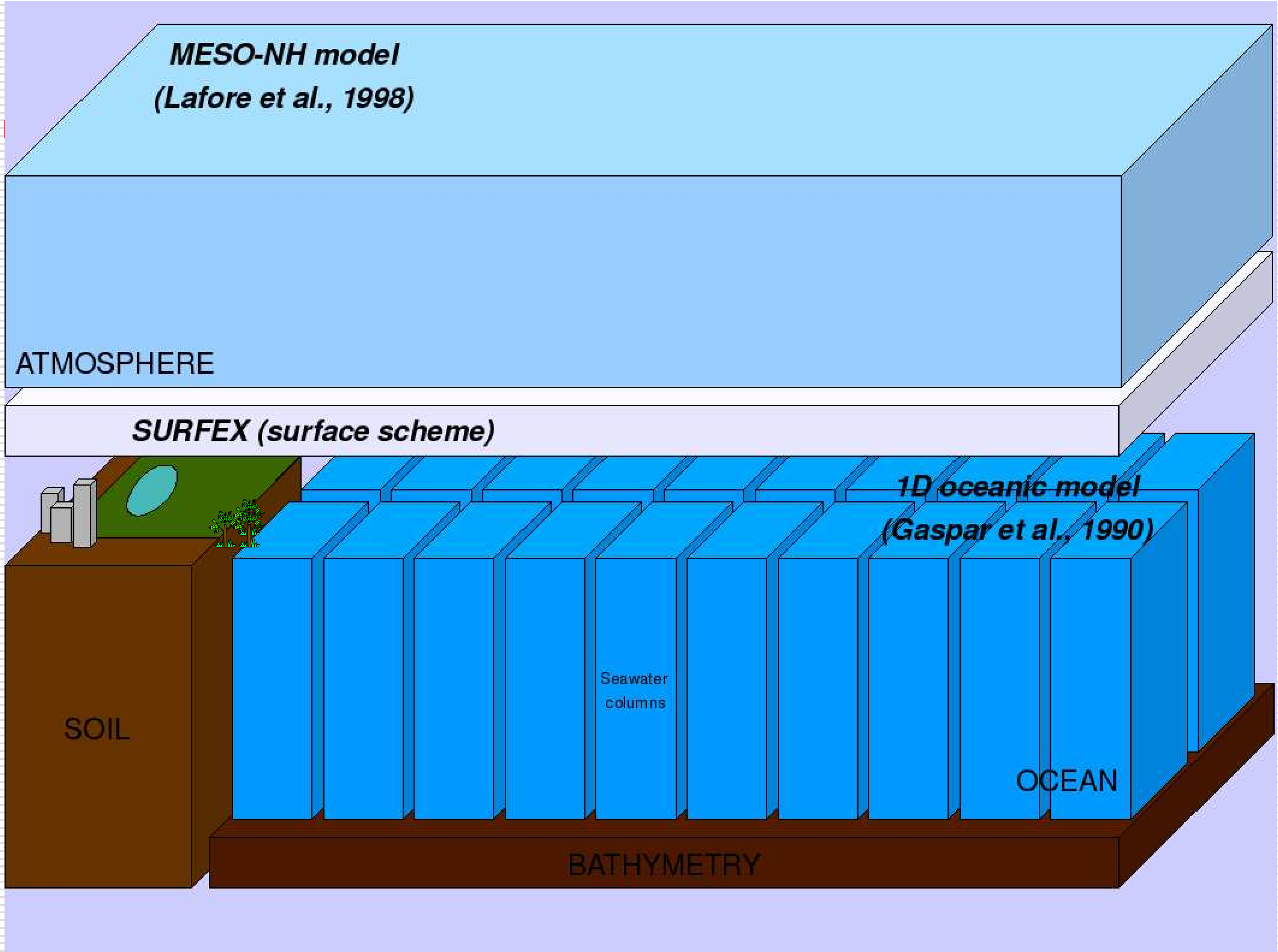
Adapted to the bathymetry

Initialisation with climatologies

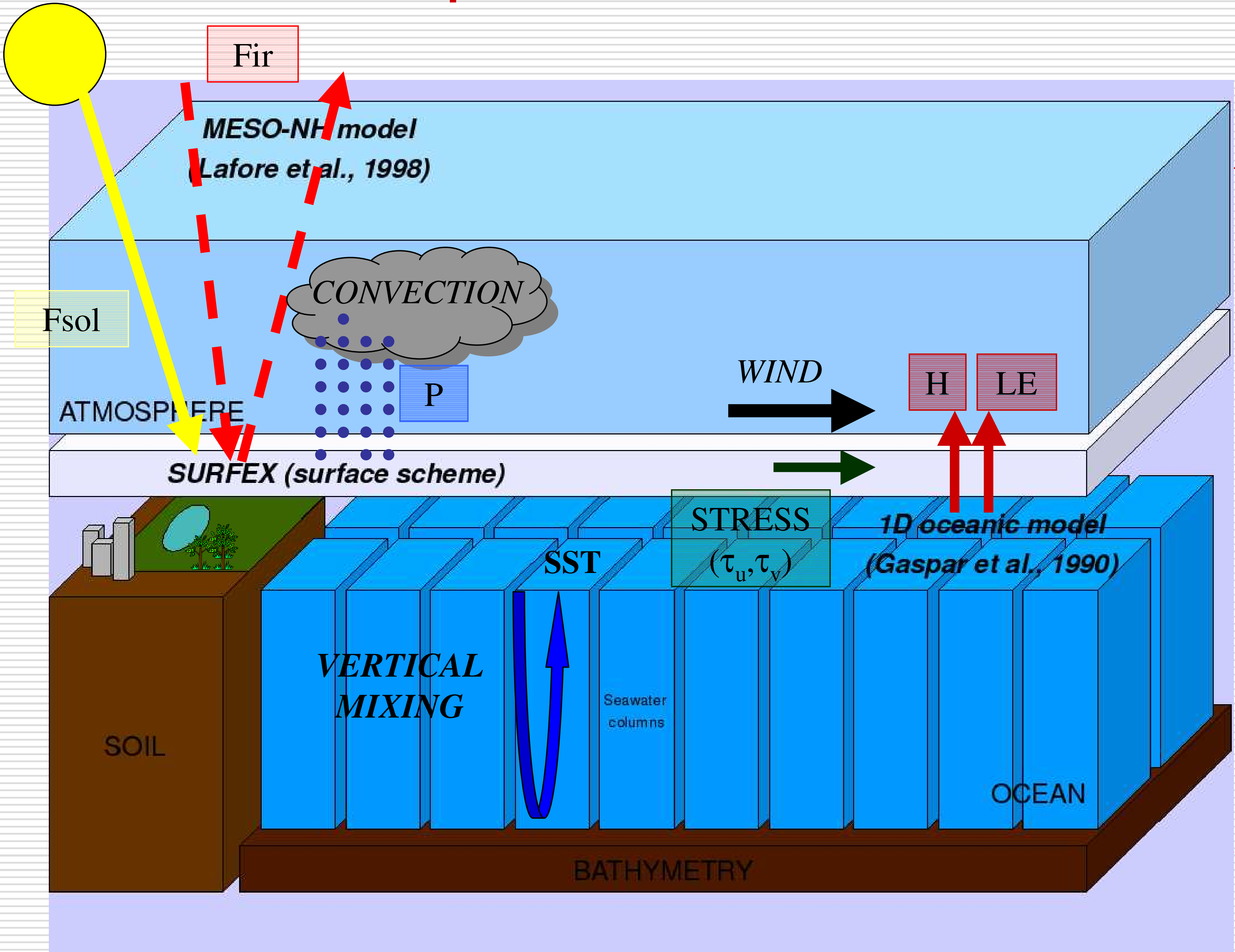
or **MERCATOR** analyses



The Mesoscale OA Coupled Model



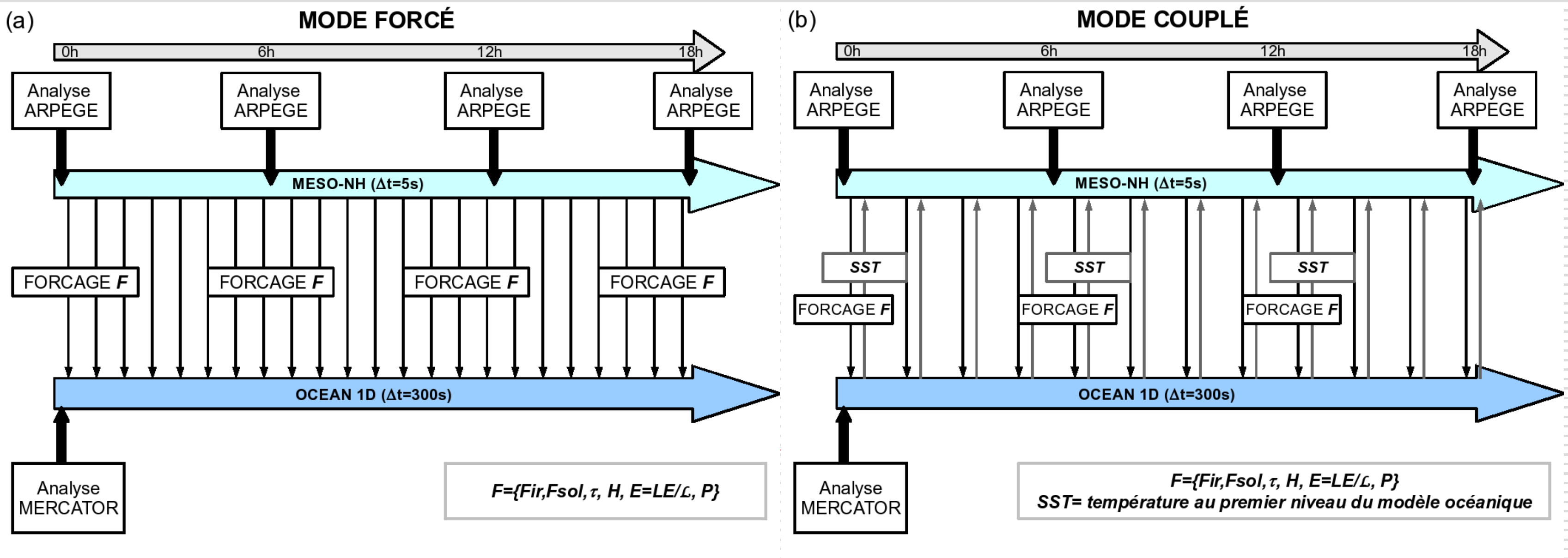
The Mesoscale OA Coupled Model



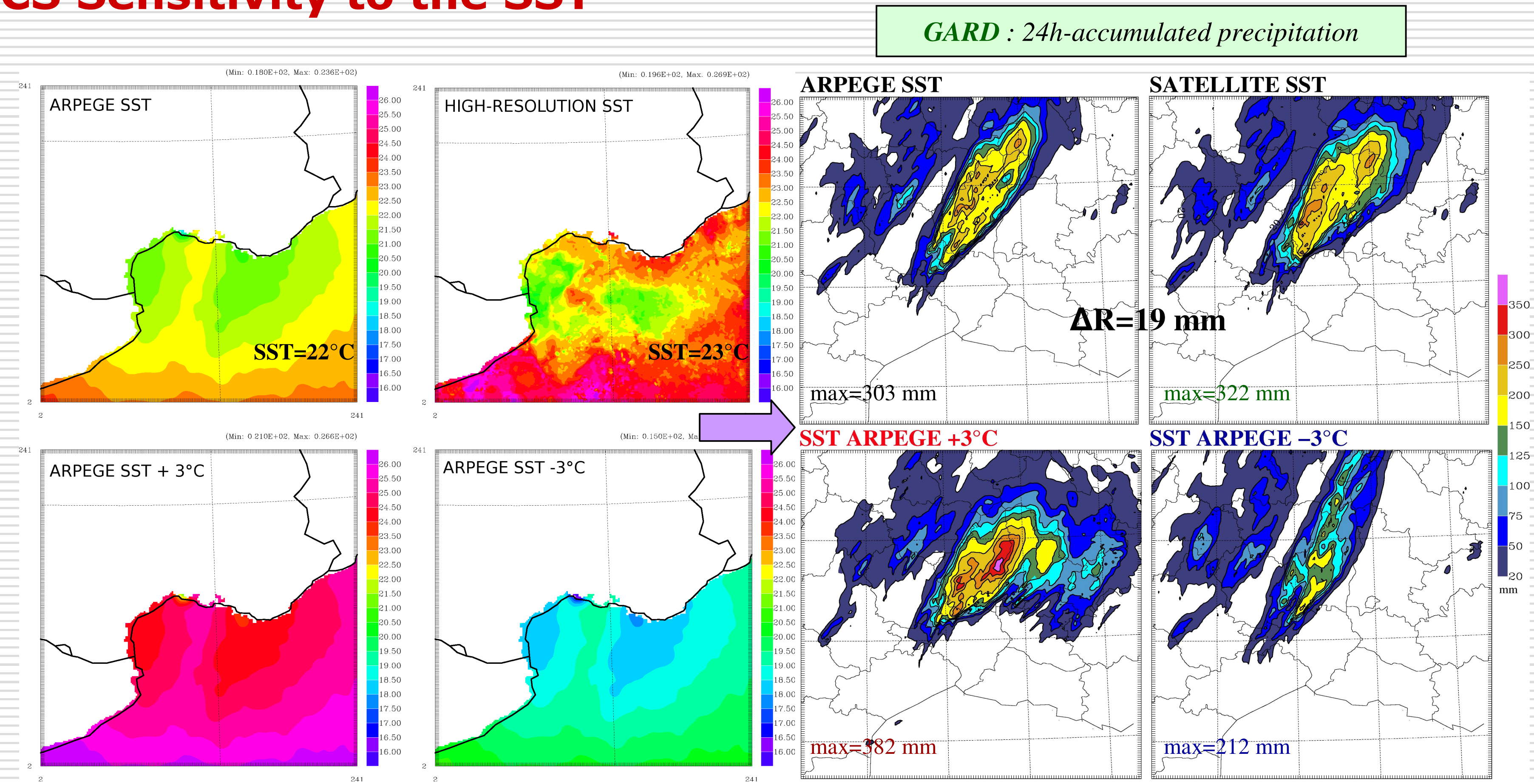
The Mesoscale OA Coupled Model

Experiences:

	MESO-NH *Oceanic Forcing*	**SURFEX** *Flux Parameterisation*	**1D OCEANIC MODEL** *Atmospheric Forcing*
Control Simulation	Forced Mode (initial SST)	COARE 3.0 +gustiness + corrections H_p, τ_p	Presribed Fluxes
Coupled Simulation	**Interactive Coupling (Simulated SST)**	COARE 3.0 +gustiness + corrections H_p, τ_p	Interactive Fluxes



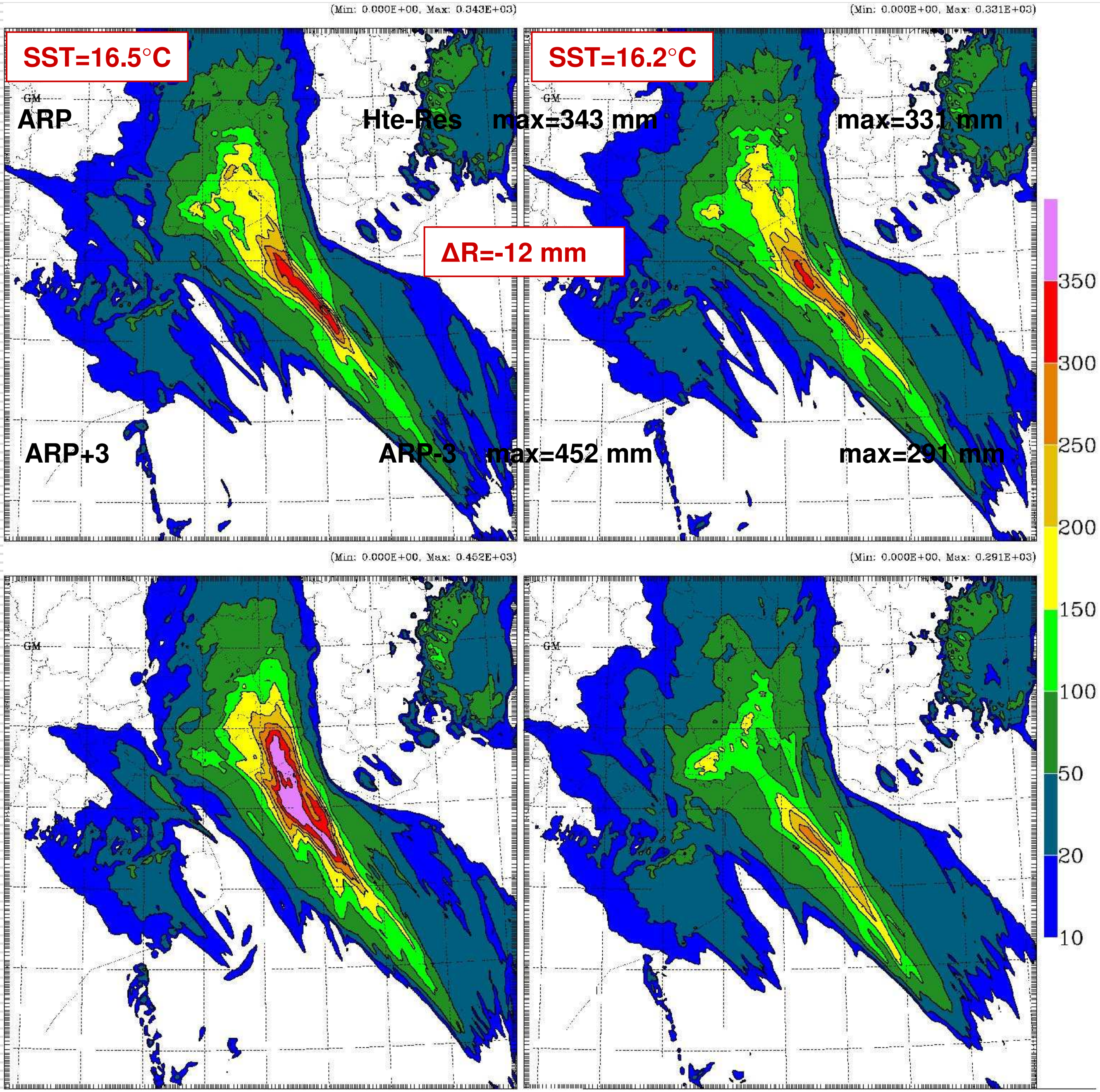
MCS Sensitivity to the SST



Lebeaupin *et al.*, 2006

MCS Sensitivity to the SST

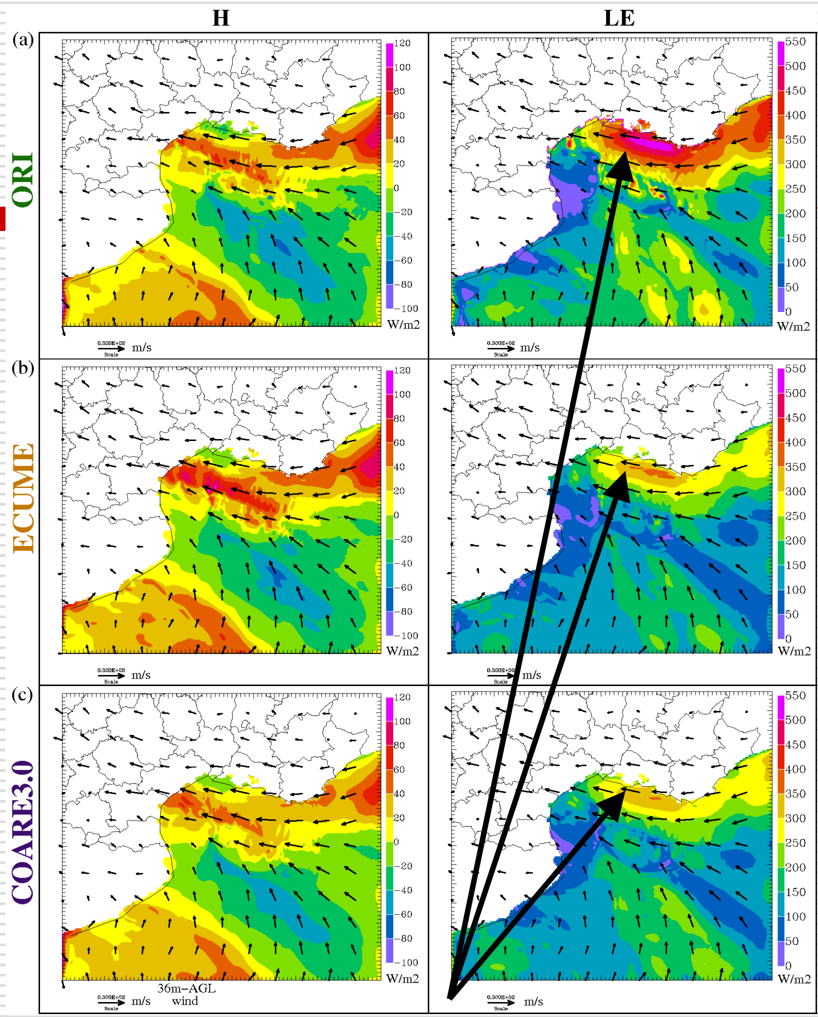
HERAULT : 24h-accumulated precipitation



Lebeaupin *et al.*, 2006

MCS Sensitivity to the Surface Flux Parameterization

AUDE : *Heat flux* (W/m^2) *and surface wind (m/s) with* ***ORI***, ***ECUME*** *and* ***COARE3.0*** **on** *Nov. 13 1999 06 UTC*



Louis, 1979

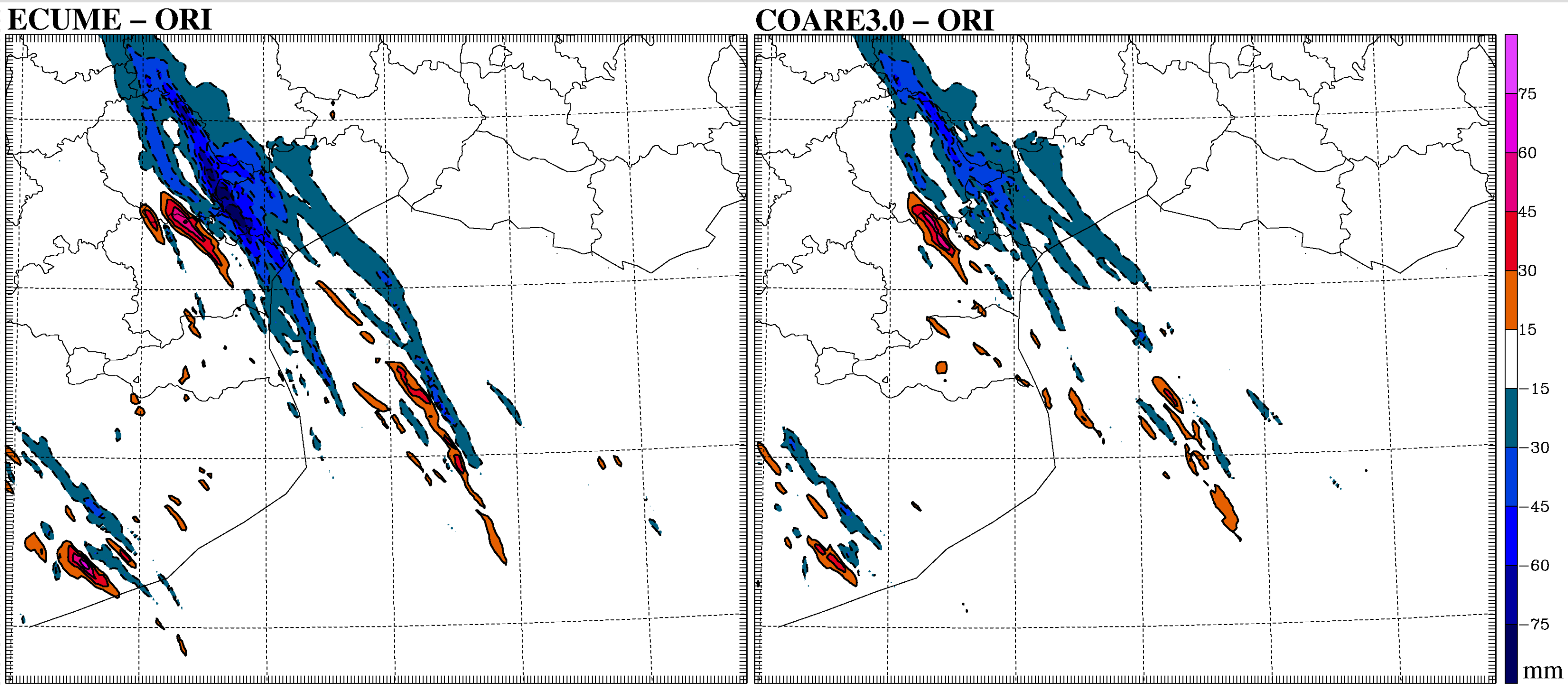
Weill *et al.*, 2003

Fairall *et al.*, 2003

Latent Heat Flux LE decreased by150 to 200W/m² under the LLJ (≈30m/s)

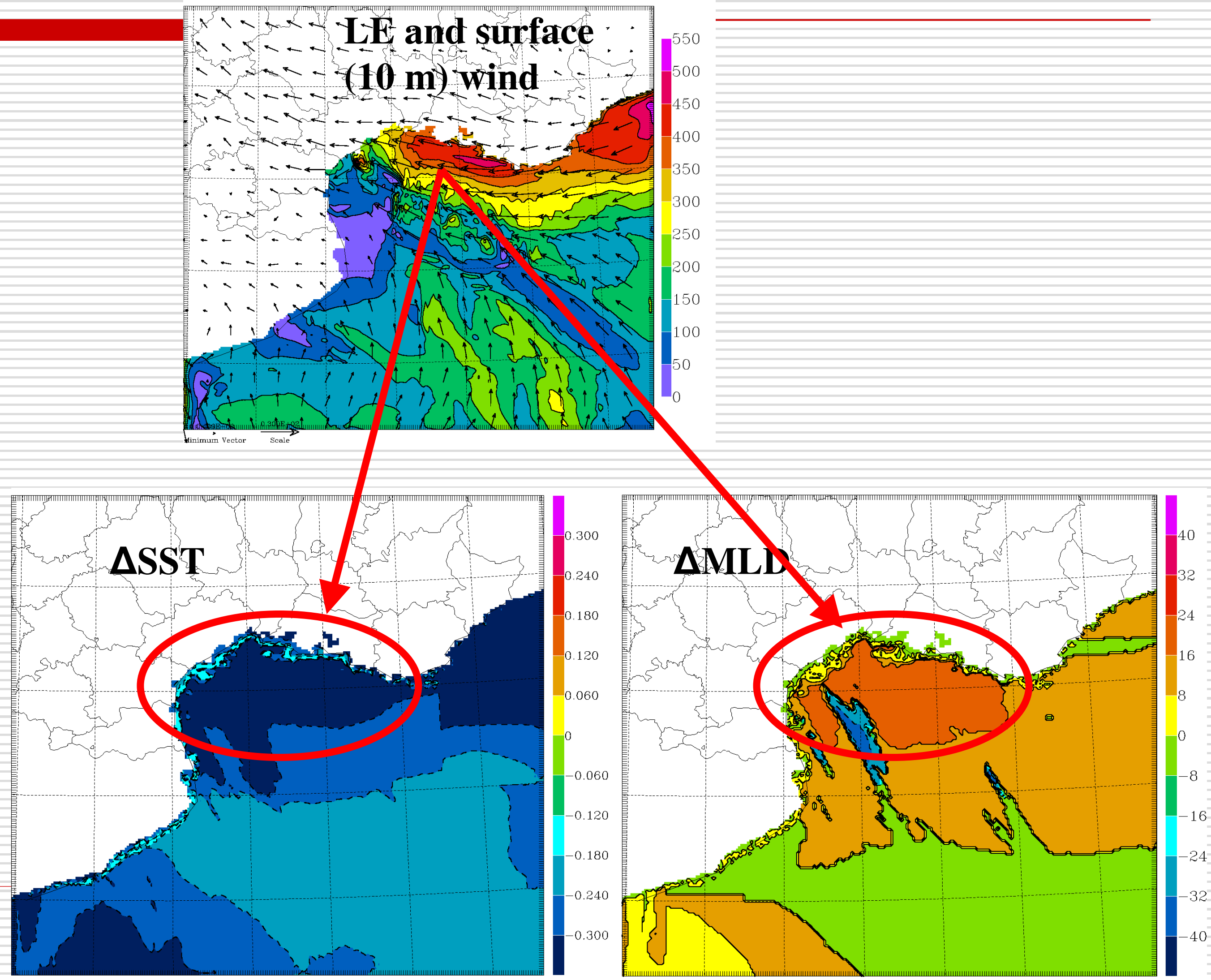
Lebeaupin *et al.*, 2006

MCS Sensitivity to the Surface Flux parameterization



Aude : differences in the 18h-accumulated precipitation (mm)

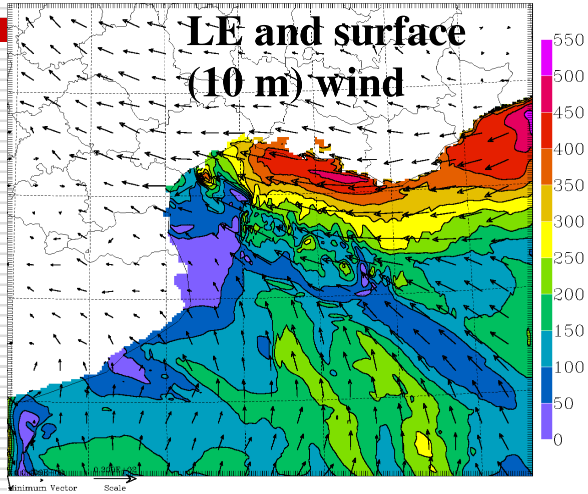
Forced Oceanic Simulation: Aude

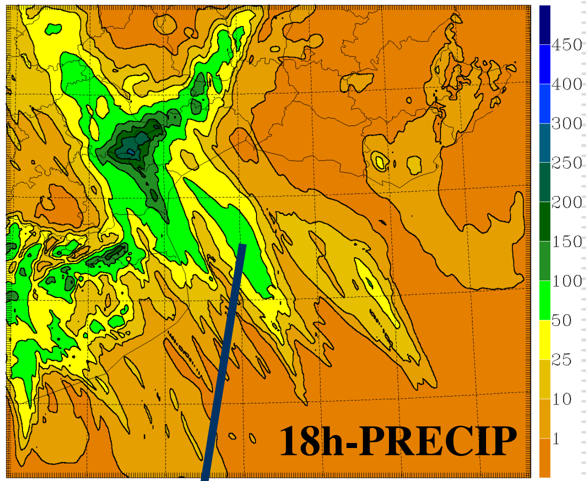


AUDE: SST & MLD differences between the final (18 h simulation) and the initial state.

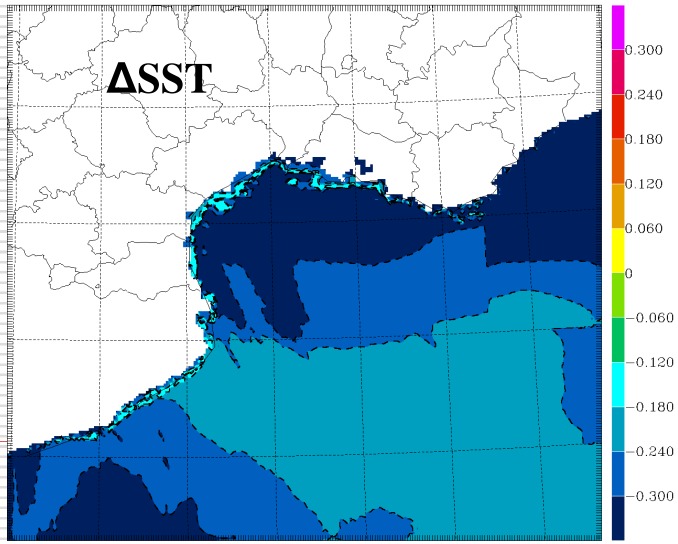
Forced Oceanic Simulation: Aude

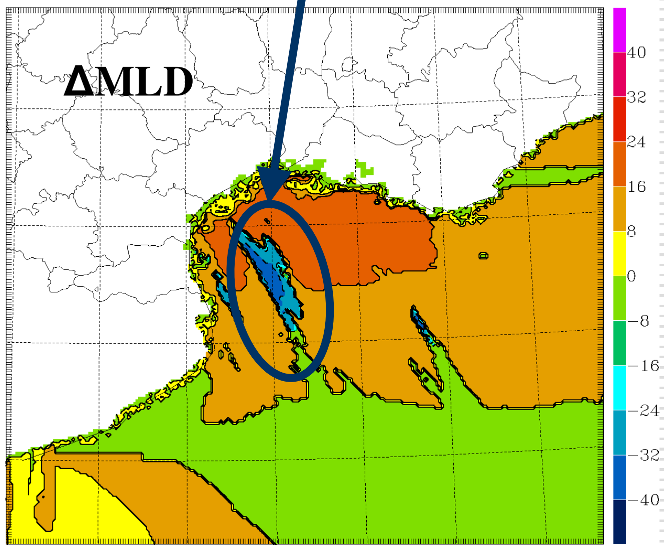
AUDE: 18h-accumulated précipitation





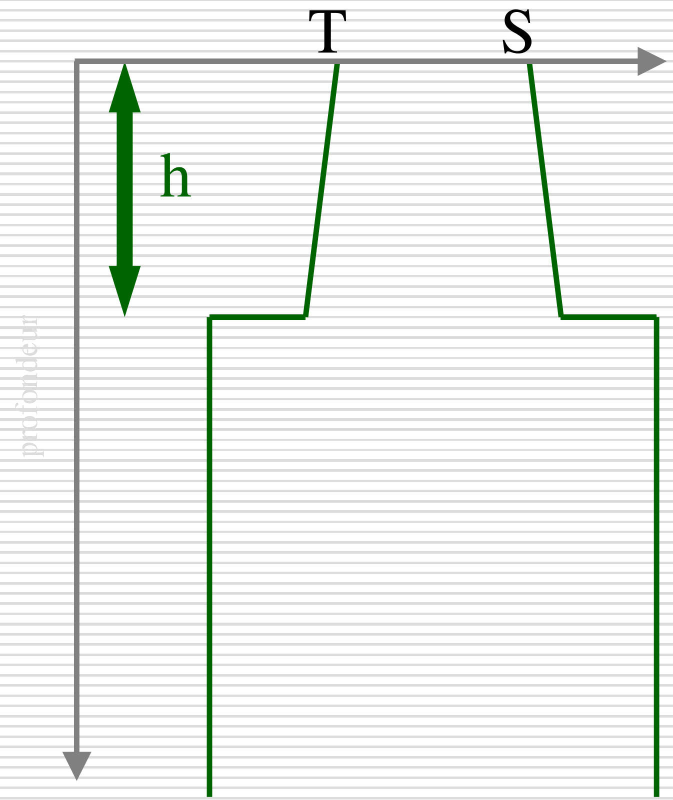
AUDE: SST & MLD differences between the final (18h simulation) and the initial state

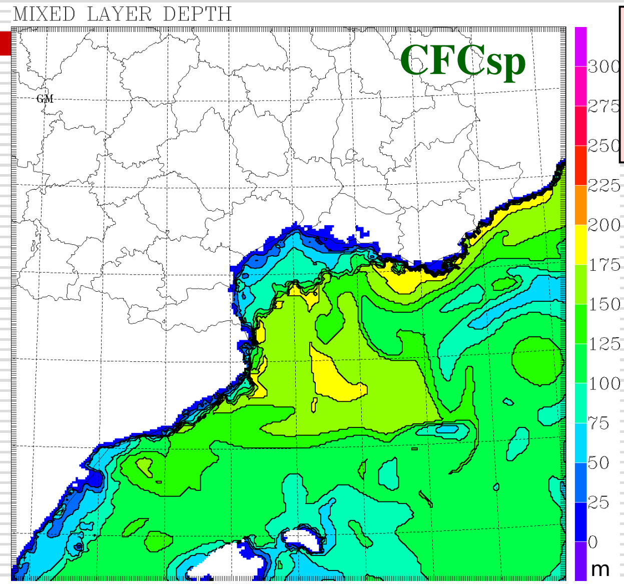




Forced Oceanic Simulation: Hérault

Impact of Heavy Precipitation on the Mixed-Layer



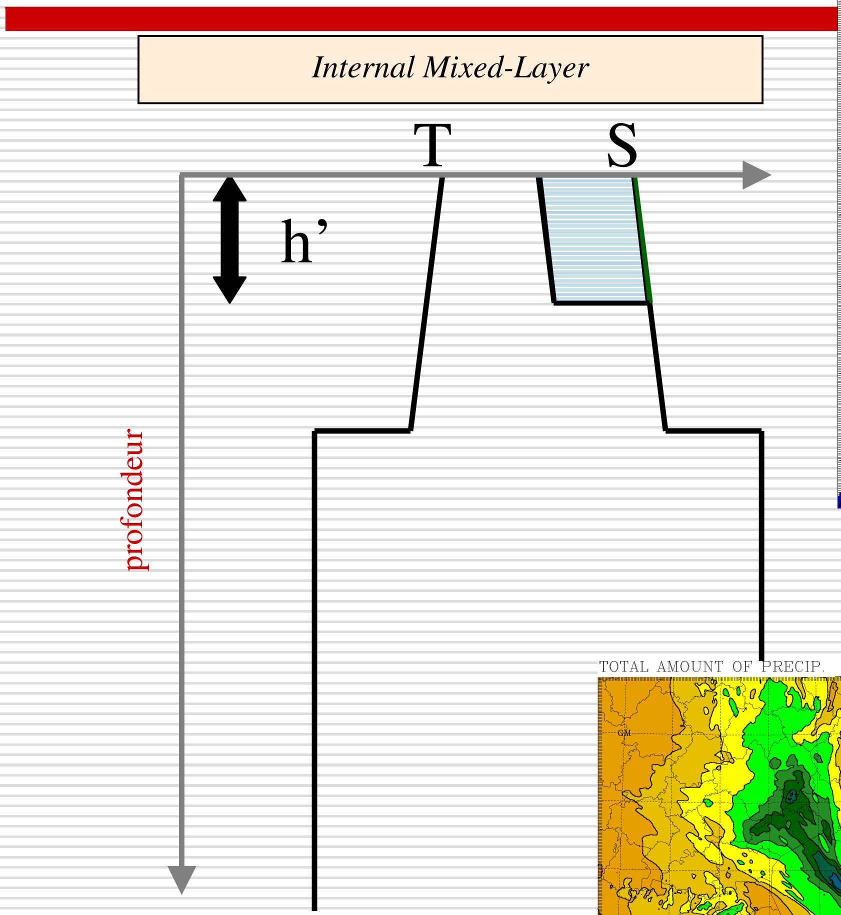


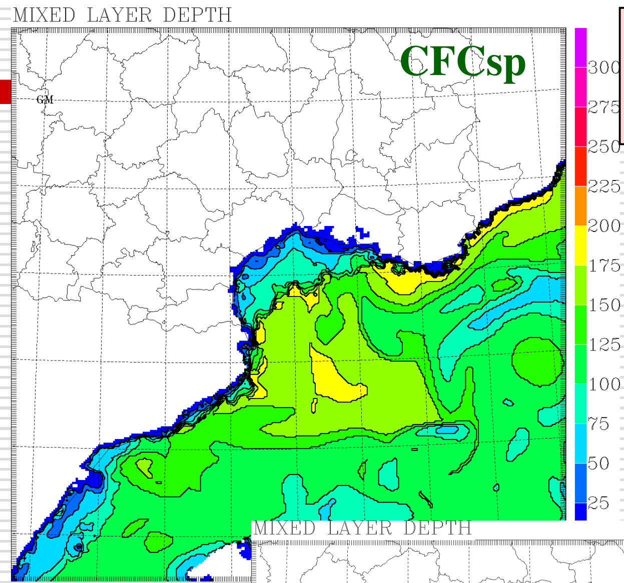
***HERAULT* :**

Simulated MLD (m) after 24h

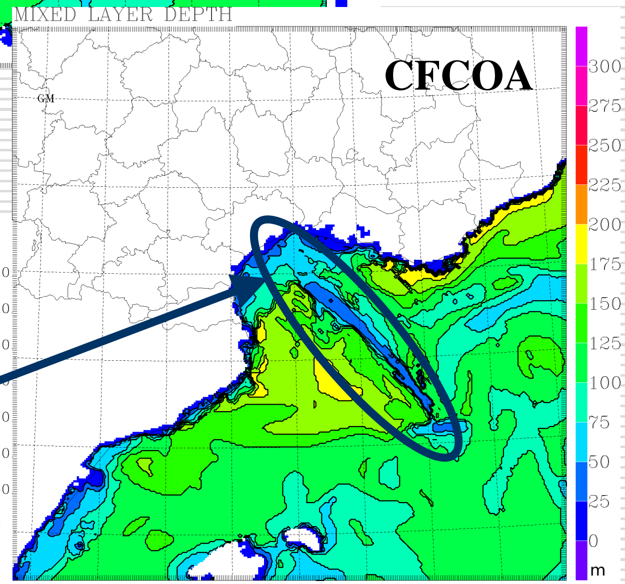
Forced Oceanic Simulation: Hérault

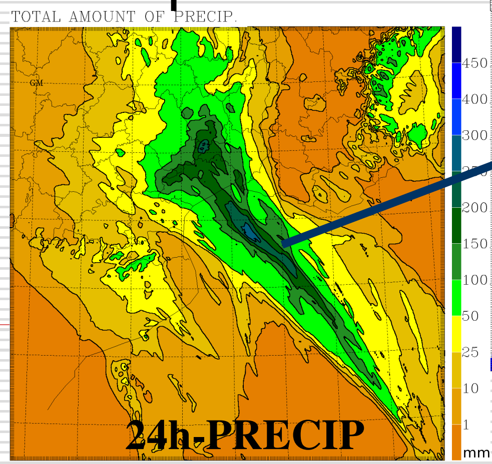
Impact of Heavy Precipitation on the Mixed-Layer





HERAULT : Simulated MLD (m) after 24h

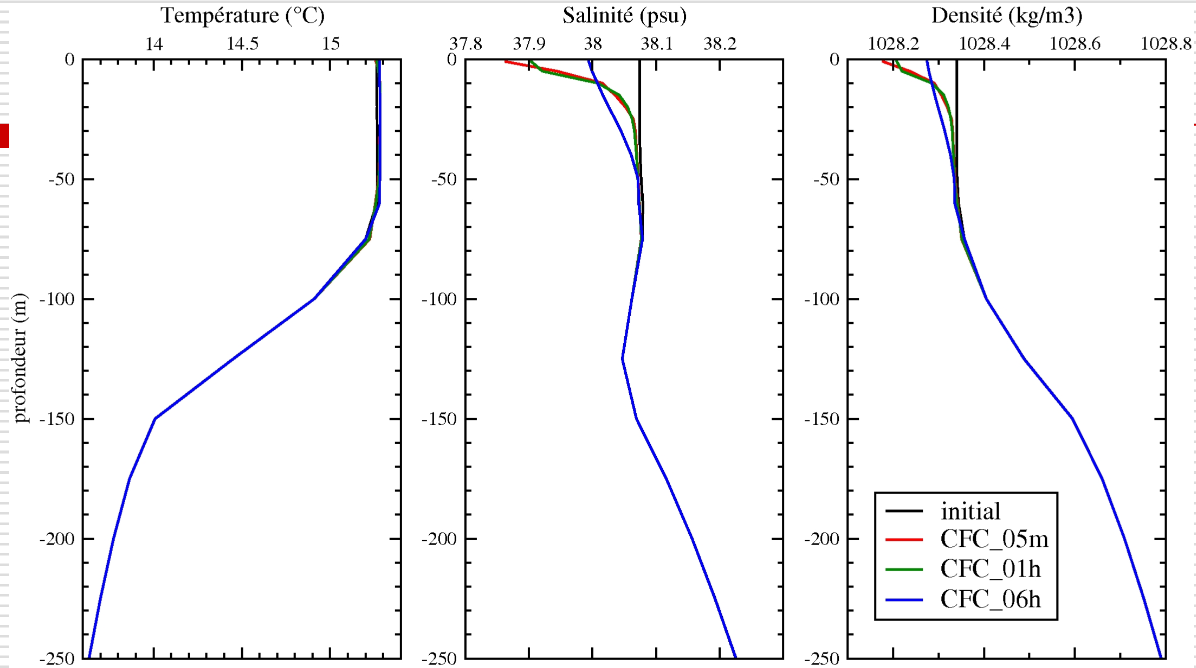


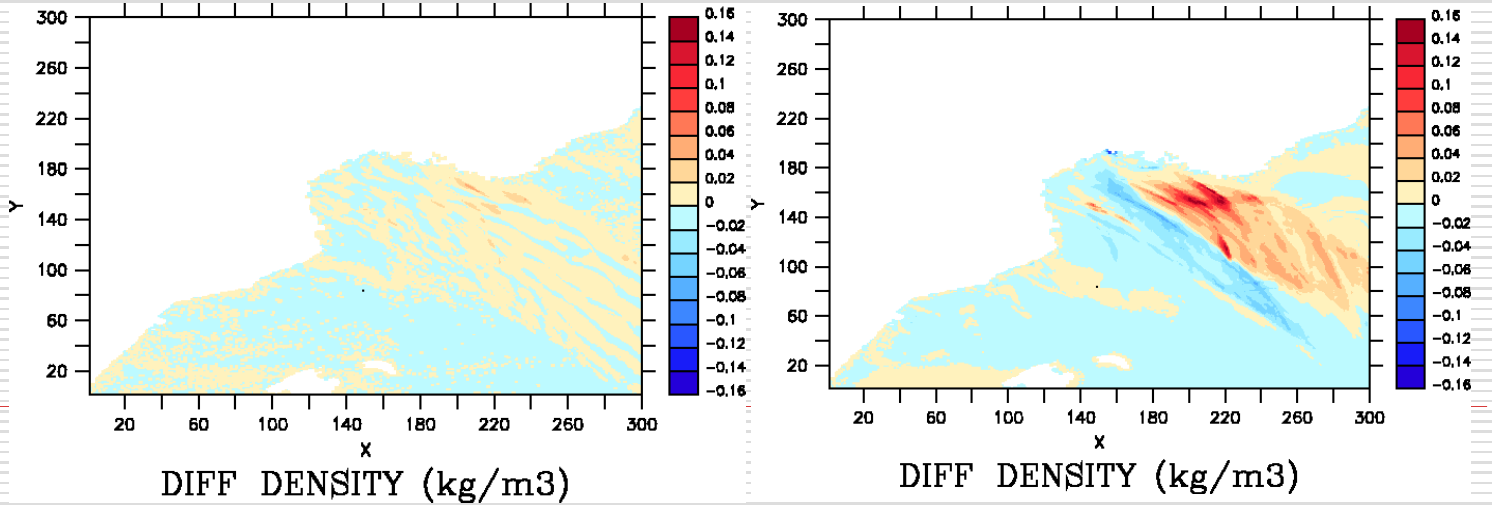


HERAULT : 24h-accumulated precipitation

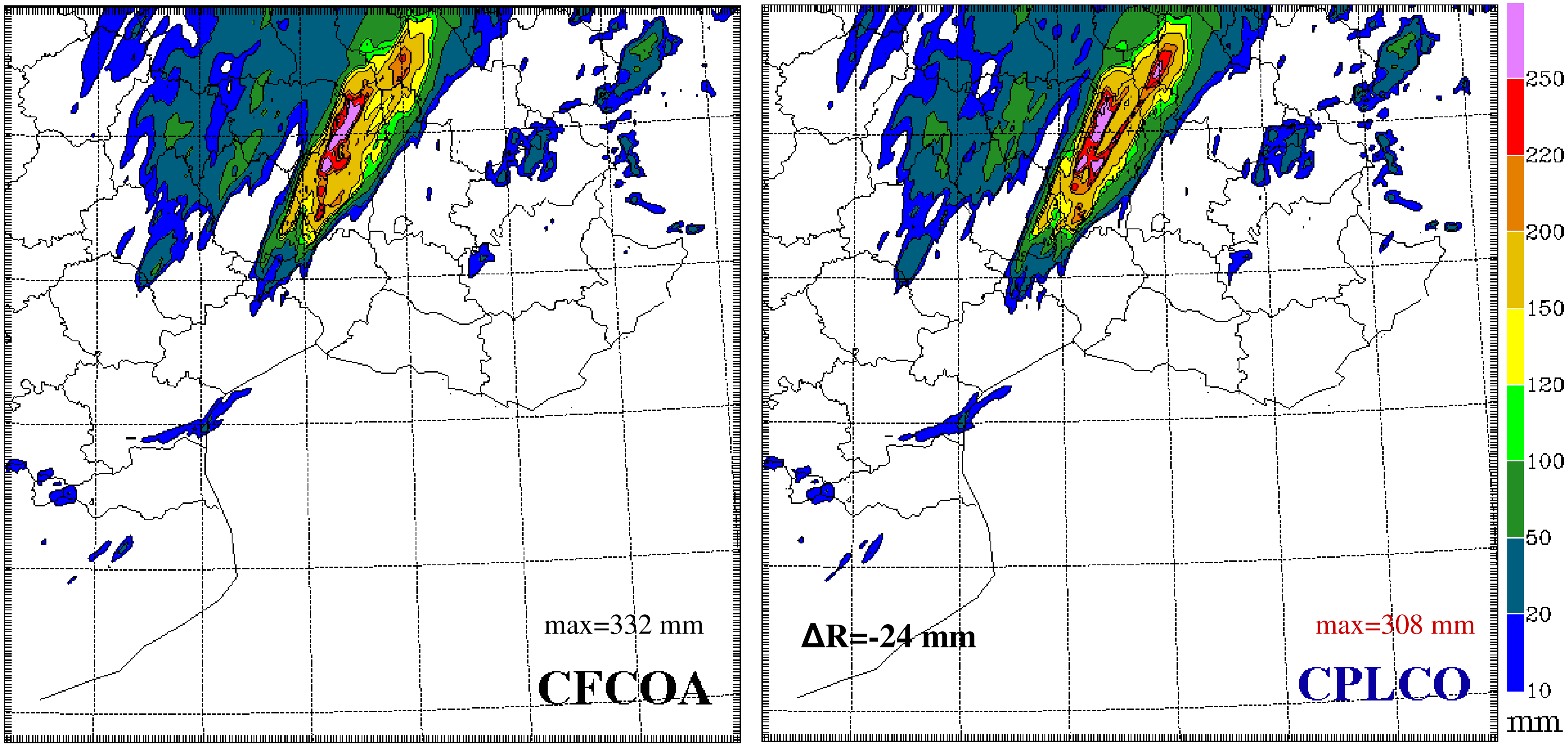
Forced oceanic Simulation: Hérault

Impact of the forcing frequency on the Mixed-Layer response





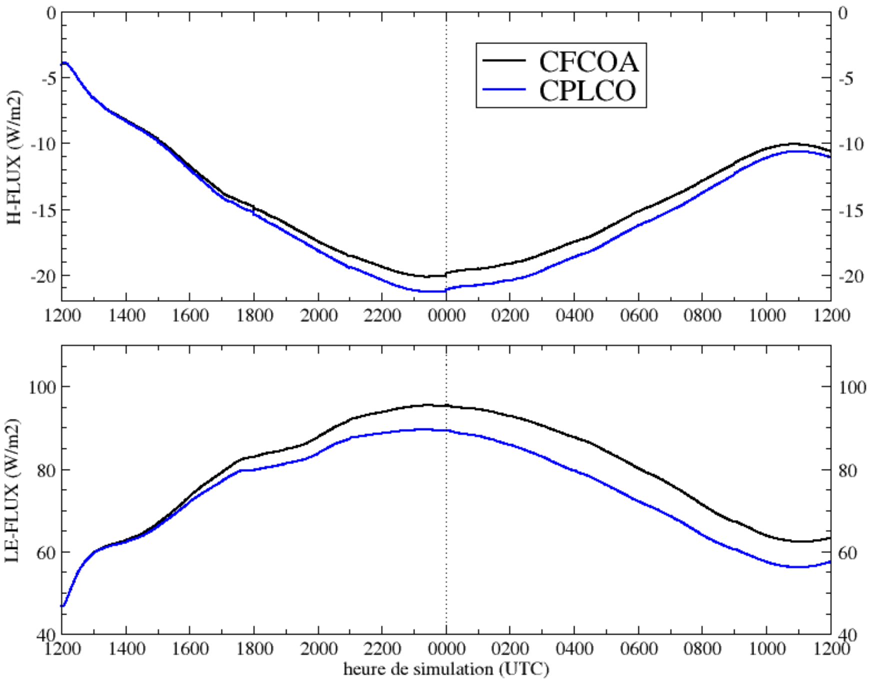
Comparison Forced/Coupled Model



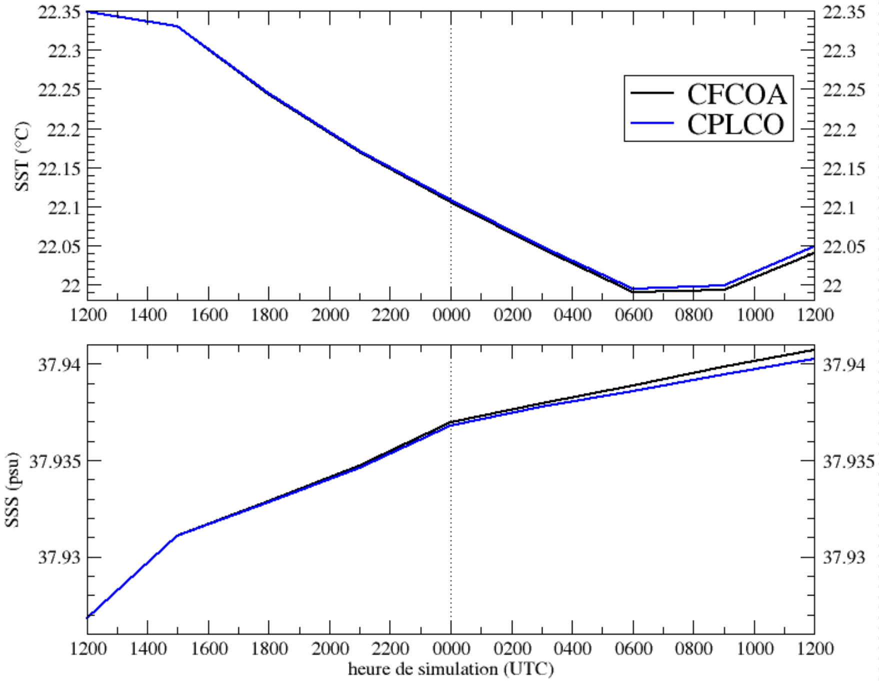
GARD : 24 h-Accumulated precipitation

Coupled OA Model

Comparison Forced/Coupled Model



GARD : Surface Fluxes Evolution



GARD : Evolution of the averaged SST and SSS

Synthesis

- The spatial averaged SST is a relevant parameter for MCS forecasts. The LLJ plays the role of an integrator of the SST small scale structures.

- Great dispersion in the surface flux (parameterization) > impact on the precipitation similar as a change of 1℃ in SST.

- The coupling attenuates the oceanic and atmospheric responses. The coupling decreases the accumulated precipitation similarly as a decrease of ~1℃ in SST.

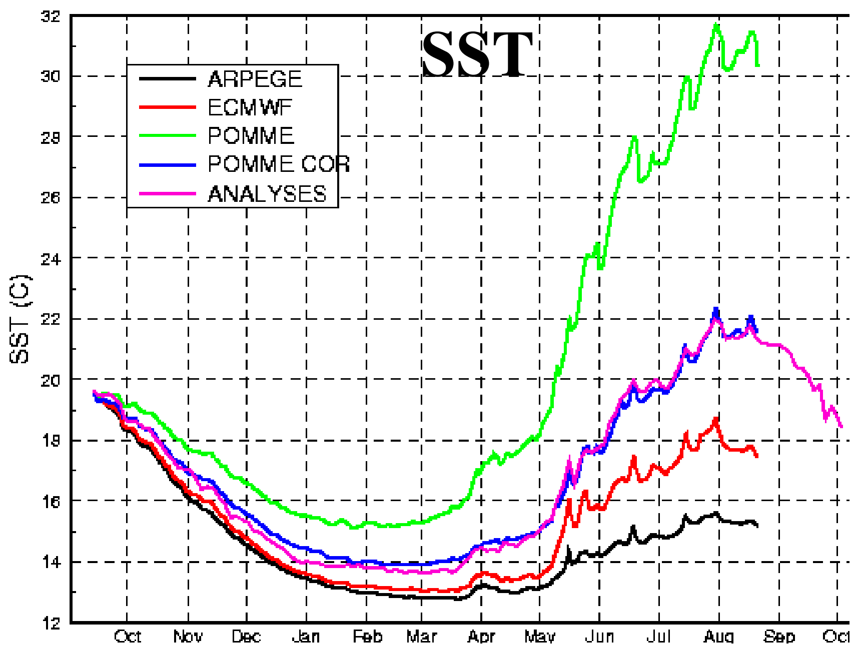
- The oceanic mixed-layer response to high-resolution atmospheric forcing.
    - LLJs > flux > Mixed-Layer cooling and deepening.
    - Precipitation > fresh internal boundary layers > collapse the mixing.
    - Strong sensitivity to the surface forcing frequency.
    - Wind-stress > strong currents which contributes to enhance floods.

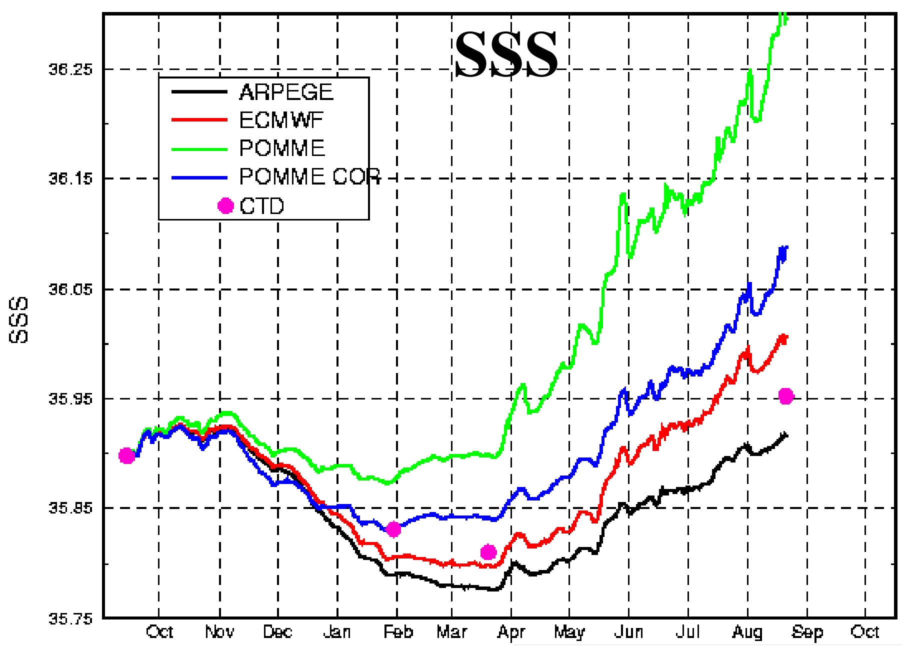
Major Issues

Key points for coupled OA models

- Usefulness of high resolution SST fields ?
- What are the best surface fluxes for a coupled system ?
- What is the optimal coupling frequency ?
- What mixing parameterizations (diffusion/convection) for the ocean ?
- …

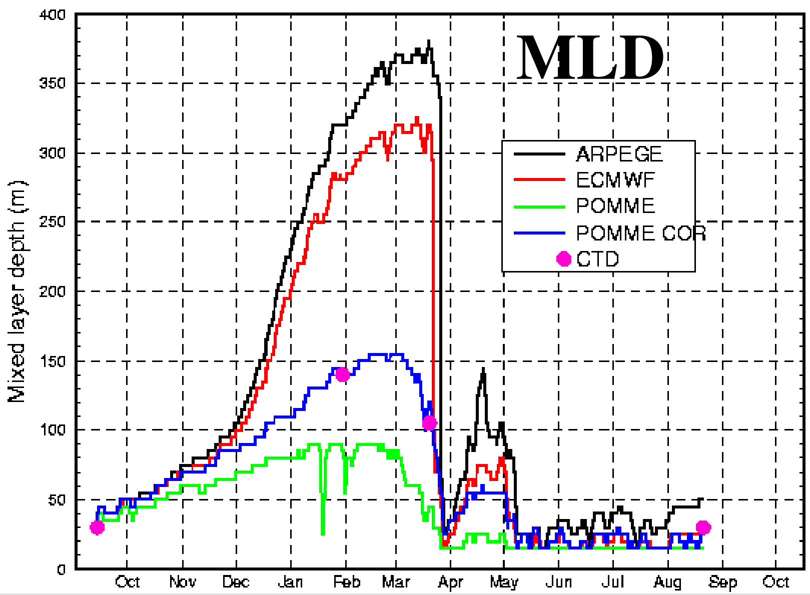
What Surface Fluxes for Ocean Models ?





POMME Experiment, 2001

Mémery et al., 2005



Caniaux et al., 2005
Giordani et al., 2005

An Intermediate Coupled Model. What for?

- High resolution processes studies: tropical cyclones, African monsoon (AMMA-EGEE), coastal breezes/fog, SST front, gust wind (mistral, tramontane), ...

- **Towards an operational simplified coupled OA system: Ocean Mixed-Layer coupled to AROME. Good strategy ?**

SST and mixed-layer heat content more realistic and coherent with the atmosphere evolution. Sequential initialization with the MERCATOR analyses.

- Mesoscale operational applications: full 3D coupled OA model ?