# Air-Sea Interactions and Coupling in Mediterranean torrential rainfall events

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## INTRODUCTION

The Mediterranean Sea is an important source of heat and moisture for Mediterranean heavy precipitating events. Within the CYPRIM project framework, we examine the sensitivity of high-resolution atmospheric forecasts to the sea surface temperature and to the turbulent fluxes parameterization on three cases of heavy precipitation that occured in the South-East of France: The **Aude** (12-13 Nov. 1999), **Gard** (8-9 Sept. 2002) and **Hérault** (3 Dec. 2003) cases.

An air-sea coupling with a 1D oceanic model (Gaspar et al., 1990) is also presently developed to evaluate the impact of torrential rain events on the oceanic mixed layer.

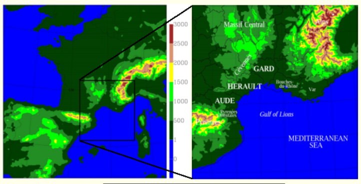
## EXPERIMENTAL DESIGN

Sensitivity tests were carried out with the non-hydrostatic **Meso-NH** model in a configuration of two-way interactive nested grids:

•outer domain: Δx=9.5km, *parameterized convection*

•inner domain: Δx=2.4km, *explicit convection*

Initial conditions are provided by large scale ARPEGE analysis. SST is kept time-constant during the run.




Orography of the Meso-NH domains.

Experiments:

→ Various SST: from ARPEGE in-situ data analysis, from satellite data, or ±3°C and ±1.5°C increased/decreased SST.

→ Different sea surface fluxes parameterizations introduced and used in the surface scheme of the Meso-NH model (SURFEX).

### *SENSITIVITY TO THE INITIAL SST*

| EXPERIMENTS WITH DIFFERENT INITIAL SST | AUDE 12-13 Nov. 1999 Start: 12 Nov. 1999 12UTC Duration 18h | GARD 8-9 Sep. 2002 Start: 8 Sep. 2002 12UTC Duration 24h | HERAULT 3 Dec. 2003 Start: 3 Dec. 2003 00UTC Duration 24h |
|---|---|---|---|
| ARPEGE analysis SST *(IO données bouées et bateaux)* | **ARP12** | **ARP12** | **ARP00** |
| Satellite SST (AVHRR) | NOA12 | NOA12 | NOA00 |
| ARPEGE SST increased +3°C | STAP3 | STAP3 | STAP3 |
| ARPEGE SST increased +1.5°C | STAP1.5 | | |
| ARPEGE SST decreased –1.5°C | STAM1.5 | | |
| ARPEGE SST decreased –3°C | STAM3 | STAM3 | STAM3 |

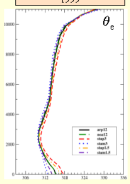
The initial SST tends to modulate the convective system intensity and location. Warmer sea surface:

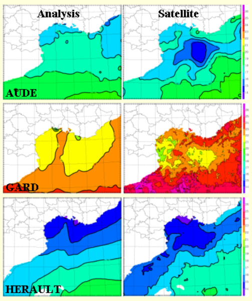
⇒ larger air-sea heat fluxes which destabilize the atmospheric low levels

⇒ convection more intense

⇒ larger amount of surface rainfall (and vice versa).

Aude case: Mean $\theta_e$ profiles averaged over the sea domain at 03 UTC, 13 Nov. 1999



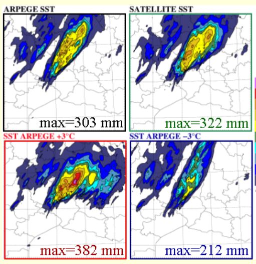




Analysed (ARPEGE) and satellite (AVHRR) SST for the three studied cases

The averaged SST value over the western Mediterranean basin influences significantly the heavy precipitating systems.

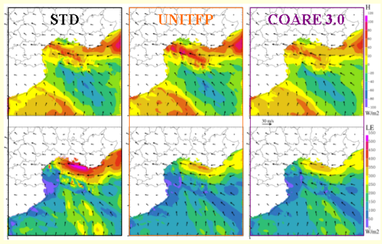
The fine-scale structures in satellite SST fields seems only to affect the convection by their integrated spatial value under the low- level jet.

Gard case: 24h-accumulated rainfall (mm)




### *SENSITIVITY TO THE SEA SURFACE FLUXES PARAMETERIZATION*

| EXPERIMENTS WITH DIFFERENT SEA SURFACE FLUXES PARAMETERIZATION | AUDE 12-13 Nov. 1999 Start: 12 Nov. 1999 12UTC Duration 18h | GARD 8-9 Sep. 2002 Start: 8 Sep. 2002 12UTC Duration 24h | HERAULT 3 Dec. 2003 Start: 3 Dec. 2003 00UTC Duration 24h |
|---|---|---|---|
| **Standard** Meso-NH parameterization (Louis, 1979) | **STD** | **STD** | **STD** |
| Bulk iterative **Unified turbulent fluxes parameterization** *with a multi-campain calibration of the exchange coefficients* ($C_{D10N}$, $C_{H10N}$, $C_{E10N}$) (Belamari, 2005) | UniTFP | UniTFP | UniTFP |
| Simplified **COARE 3.0 iterative bulk algorithm** (Fairall et al., 2003) | COARE3.0 | COARE3.0 | COARE3.0 |

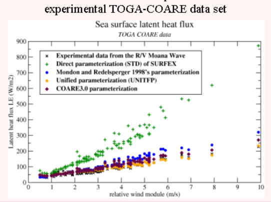



Sensible and latent heat fluxes simulated with different parameterizations for the Aude case at 06 UTC, 13 Nov. 1999

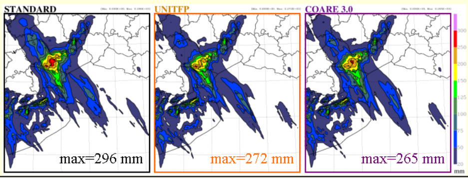
Strong decrease of the latent heat fluxes with UNITFP and COARE3.0 compared to STD.

⇒Less unstable environment; weaker convection; smaller amount of precipitation

Offline validation of sea surface parameterizations on experimental TOGA-COARE data set




Aude case: 18h-accumulated rainfall simulated.




## OCEAN-ATMOSPHERE COUPLING

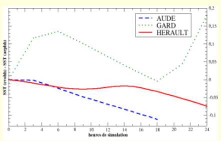
### *OD COUPLING (PROGNOSTIC SST)*

A slab ocean-atmosphere coupling (0D) has been implemented with a prognostic SST that evolves according to the simple equation here.

$$\frac{\partial SST}{\partial t} = \frac{R_N - H - LE}{\rho c_p h}$$

$R_N$ is the net radiation, H is the sensible heat flux, LE is the latent heat flux. h is the oceanic mixed layer depth choosen from the Levitus, 1982's climatology.

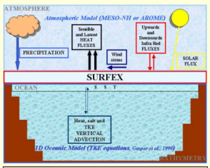
Mean SST evolutions for the three studied cases




Weak impacts on the simulation of the convection and on the amount of precipitation

However, SST changes are expected to be significant on the oceanic mixed layer.

### *1D COUPLING*




Insights the future coupled modelling.

The 1D oceanic model from Gaspar et al., 1990 was updated to be coupled with the surface scheme (SURFEX) of Meso-NH. The development includes :

•Initialization of the bathymetry from topographical data at 2 km-spatial resolution and considering its effects in the oceanic model.

•Initialization of the oceanic model variables from the MERCATOR analysis

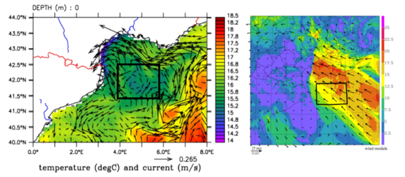
***Offline forcing of the 1D model*** **: Hérault case** (3 Dec. 2003)

For some points located in a cold zone in surface in the Gulf of Lion, 24h-forcing with stress and heat fluxes constant is applied to the 1D oceanic model.

➢**Atmospheric** data from a Meso-NH simulation

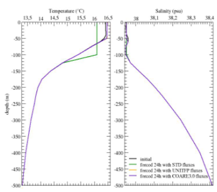
➢**Oceanic** data from a MERCATOR analysis

➢**Interface fluxes** computed offline from several parameterizations




Sea surface temperature and current from MERCATOR analysis and 10m-wind simulated by Meso-NH at 12 UTC, 3 Dec. 2003

Temperature and salinity profiles initial and obtained after 24h forcing, 3 Dec. 2003



Intense cooling and deepening of the oceanic mixed layer when **STD** parameterization is used.

Weak mixing within the oceanic boundary layer when the **UniTFP** and **COARE3.0** parameterizations are used

## CONCLUSION

Results of the sensitivity tests to the Mediterranean Sea on three heavy precipitating cases show the significant impact of the mean SST value over the basin. The influence of a sea surface fluxes parameterization change for high-resolution short range atmospheric forecasts has been also examined and can be significant under the low-level jets that prevail in these situations.

The first results when the 1D oceanic model is forced offline show the impact of the simulated fluxes values for an air-sea coupling simulation. A two-way coupling will enable us to study the impact of the heavy precipitation events on the oceanic mixed layer, and also its feedbacks on the low-level jet and heavy precipitating systems.

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