Interannual variability of deep convection in the Gulf of Lion in an AORCM for the Mediterranean area.

B. L'Hévéder[1], L. Li[1], S. Somot[2]

1- LMD, Paris; 2- CNRM, Toulouse

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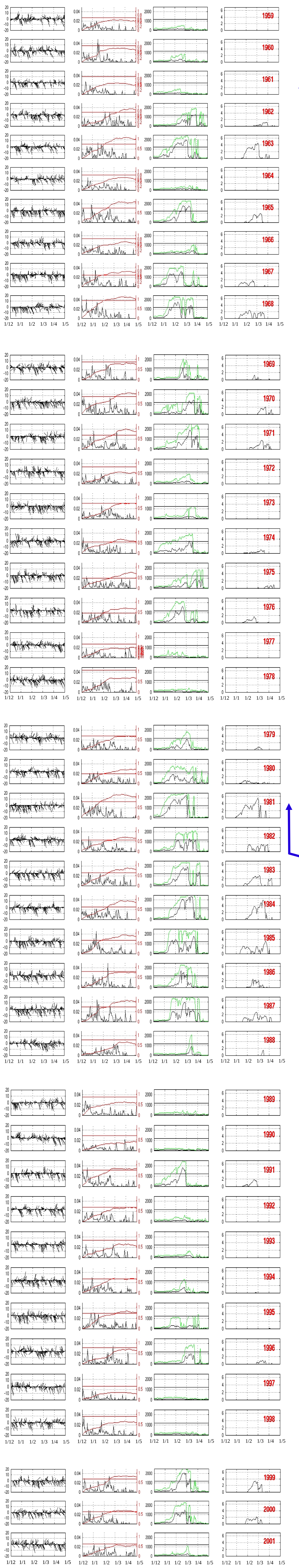
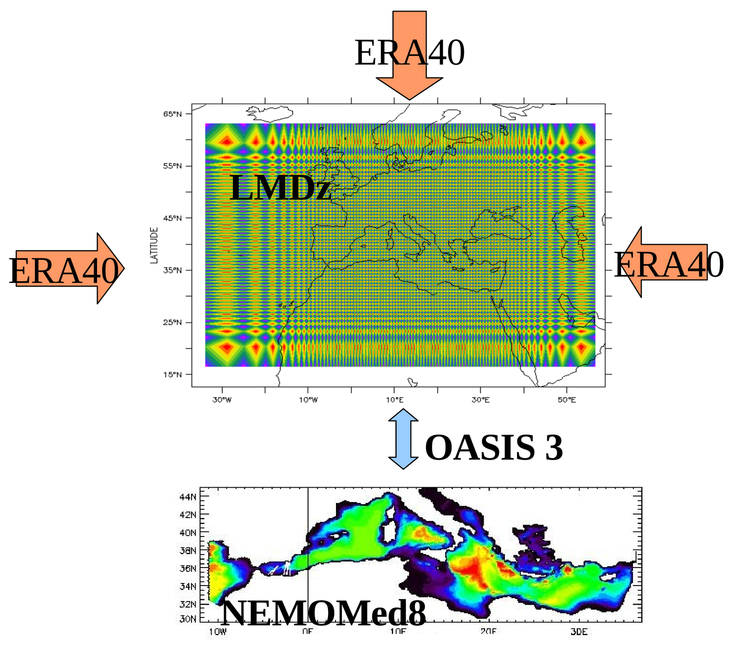


LMDz-NEMO-MED



LMDz (~35 km) - NEMOMED8 (~12 km) simulation of 1958-2001, driven by ERA40 reanalysis

44-year hindcast experiment with the LMDz-NEMO-Med AORCM for the Mediterranean region, using ERA40 reanalysis as lateral boundary conditions.

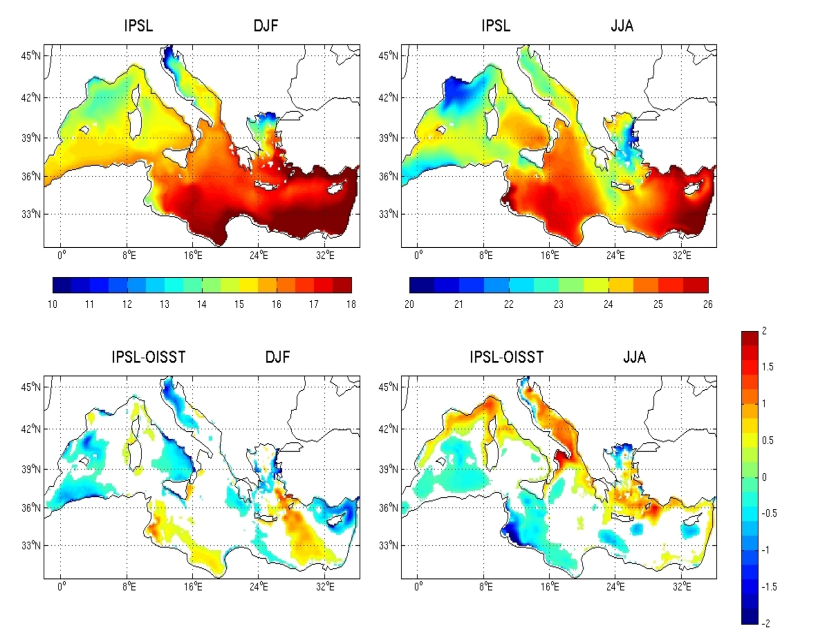
Simulated atmospheric and oceanic surface fields in good agreement with the observational datasets :

- small global cold bias of the **SST** in winter (Fig. 1).
- salty bias of the **SSS** in the Adriatic Sea, due to the absence of runoff coupling (Fig. 2).
- surface circulation well represented, only sub-mesoscales eddies are missing (Fig. 4).
- spatial structures not enough localized, with an underestimation of the **wind speed** (Fig. 3 bottom part) .
- traditionally convection regions : Gulf of Lion, Adriatic Sea and Aegean Sea emerge with particularly strong heat loss (Fig. 3 up right).

Surface conditions required to allow deep convection are satisfied.

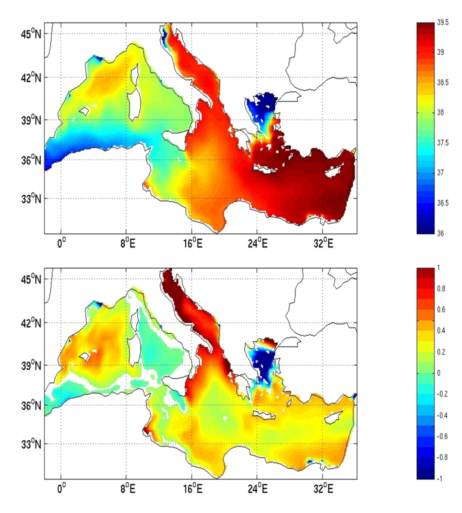
Mean state of the ocean surface simulation over 1958-2001

Mean winter and summer **SST** (°C) over 1958-2001 Fig. 1



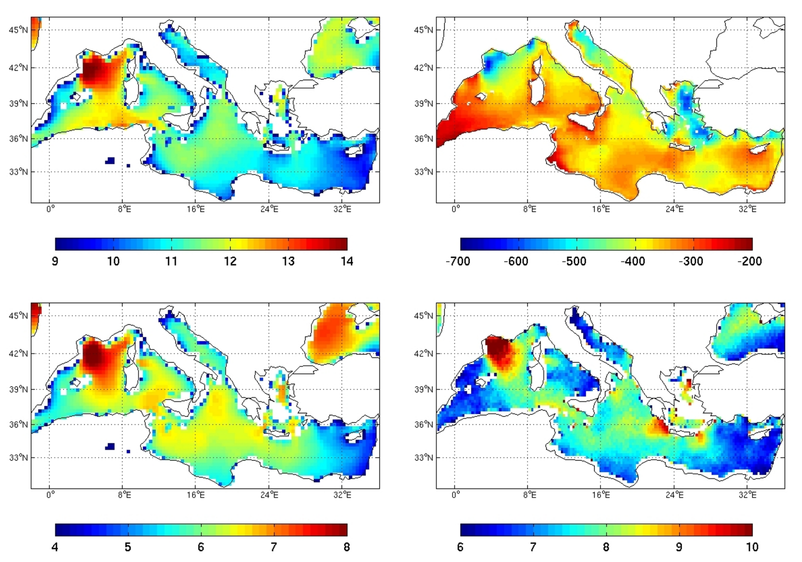
Mean seasonal **SST** anomalies IPSL/OISST over 1985-2001

Annual-mean **SSS** (psu) over 1958-2001 Fig. 2



Annual-mean **SSS** anomalies IPSL/MEDATLAS

95[th] perc. of daily winter **wind speed** (left, m/s) and **heat flux** (right, W/m²) over 1958-01 Fig. 3



Mean winter **wind speed** in IPSL(left), in QuickSCAT(right) over 2000-01

Mean **SSH** (m) and **35m-depth currents** (m/s) over 1958-01

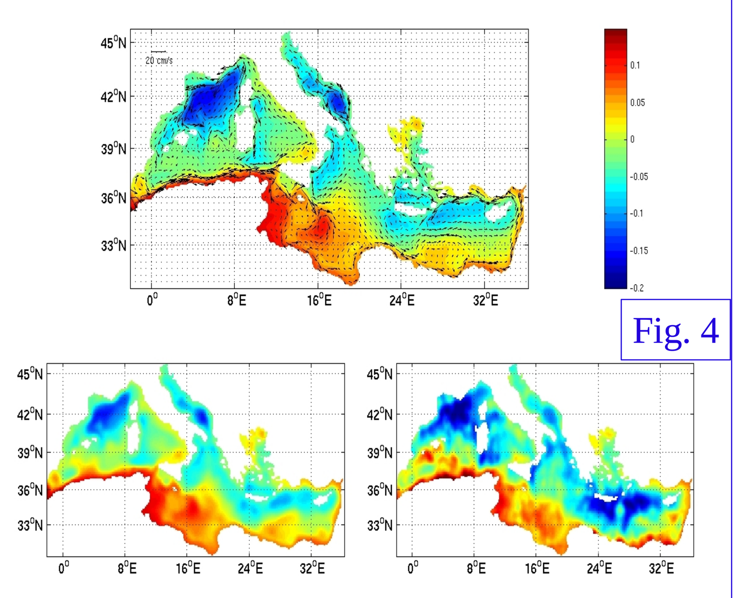


Fig. 4

Mean **SSH** in IPSL(left), in AVISO(right) over 1993-2001

Interannual variability of deep convection in the Gulf of Lion

1965 : days of DC and mean winter SSH

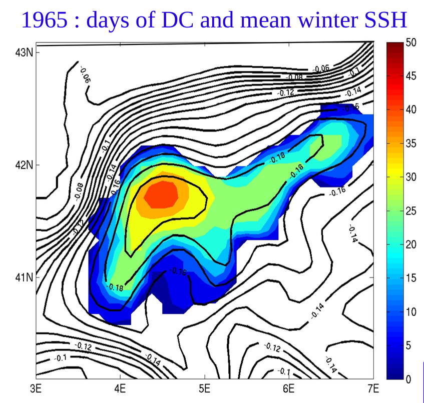


Fig. 5

- strong relationship between SSH and deep convection (DC) in winter 1965 (Fig. 5).
- mean spatial correlation of **0.78** between SSH and number of DC days over the 43 winters of the simulation.

- determination of a yearly **"cyclonic gyre area"**
- interannual variability of the "cyclonic gyre area" location and extent (Fig. 6).

Cyclonic gyre area for different years

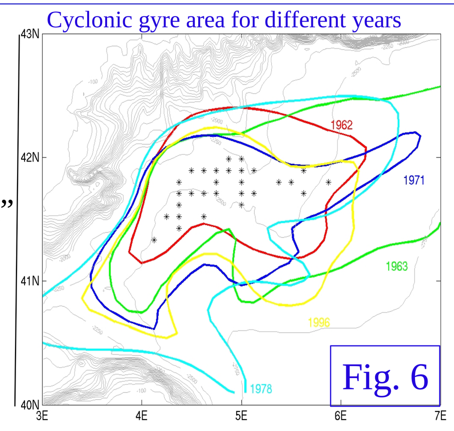
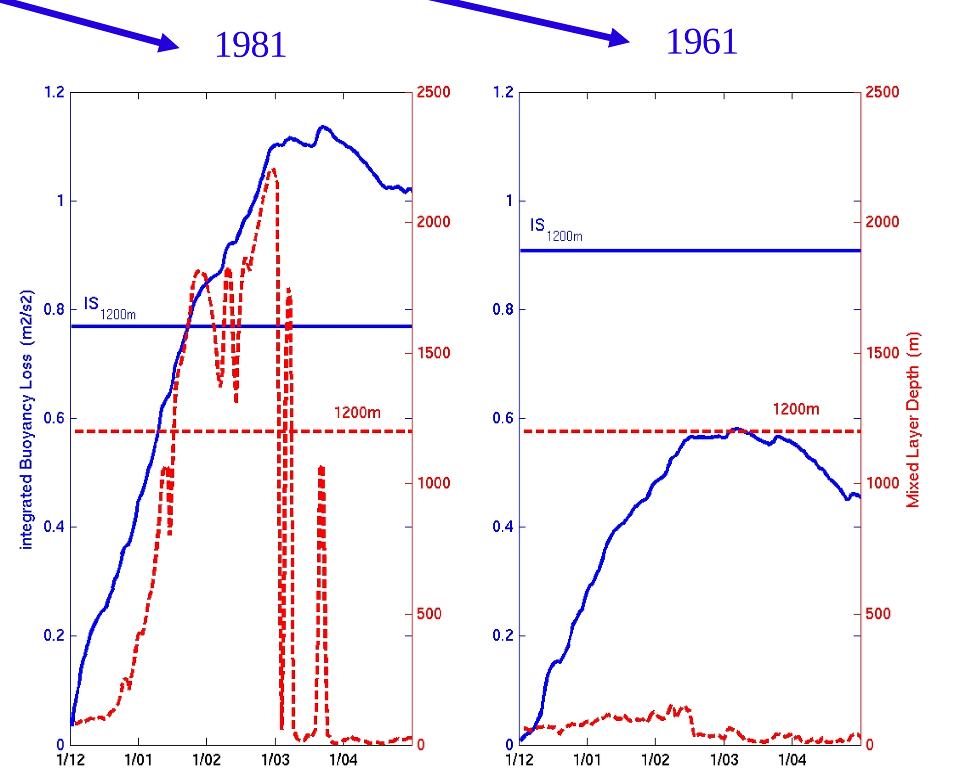


Fig. 6



convective winter non-convective winter Fig. 7

Deep convection criterion : $BL_{int} > IS_{1200m}$

- BL_{int}, the time integrated surface buoyancy loss, since early December, averaged over the "cyclonic gyre area".
- IS_{1200m}, the buoyancy loss required to mix the initially (early December) stratified water column down to the convective threshold depth of 1200 m, averaged over the "cyclonic gyre area".

Spatially averaged inside the yearly "cyclonic gyre area", deep convection is reduced to a 1D process during which 100% of the surface buoyancy flux is used to deepen the mixed layer. Lateral buoyancy fluxes are neglected (Herrmann et al. 2008).

Winter 1981 : strong deep convection beginning in January (Fig. 7 left)

Winter 1961 : the combination of a stronger stratification of the water column and of much weaker surface buoyancy fluxes leads to an absence of deep convection (Fig. 7 right).

Deep convection criterion along 1958-01 in LMDz-NEMO-Med

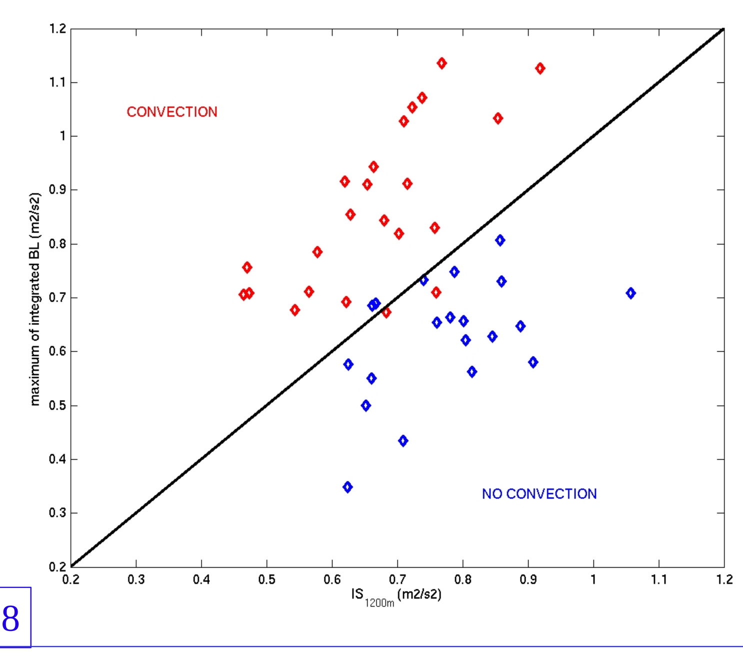


Fig. 8

In the diagram (Fig. 8) linking the maximum of the integrated BL to the initially stratification index at 1200m, for the 43 winters of the simulation, the deep convection criterion is validated if :

-convective winter ◆ <=> $\max(BL_{int}) > IS_{1200m}$

-non-convective winter ◆ <=> $\max(BL_{int}) < IS_{1200m}$

in 93% of the winters, the criterion is verified in the LMDz-NEMO-Med simulation.

To the first order, the deep convection criterion is efficient to determine the occurence of deep convection.

Conclusion

- LMDz-NEMO-Med is in the state-of-the-art of the recent AORCM's of the Mediterranean region.
- High interannual variability of deep convection is simulated, with 53% of convective winters, representative of the present climate state.
- The yearly **"cyclonic gyre area"**, determined from the SSH, gives the mean state of the region in terms of dynamics. It is a useful tool for process study on the deep convection.
- The deep convection criterion provides a **prognostic probability** (in early December) to foresee the occurence of convection during the winter season.