Assessing the water cycle in the MED-CORDEX simulations of the IPSL regional Earth system model

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- The configuration of the model
- The water fluxes between the land, ocean and atmosphere
- The energy exchanges with the atmosphere
- Simulated ocean processes.
- Extreme events : Droughts

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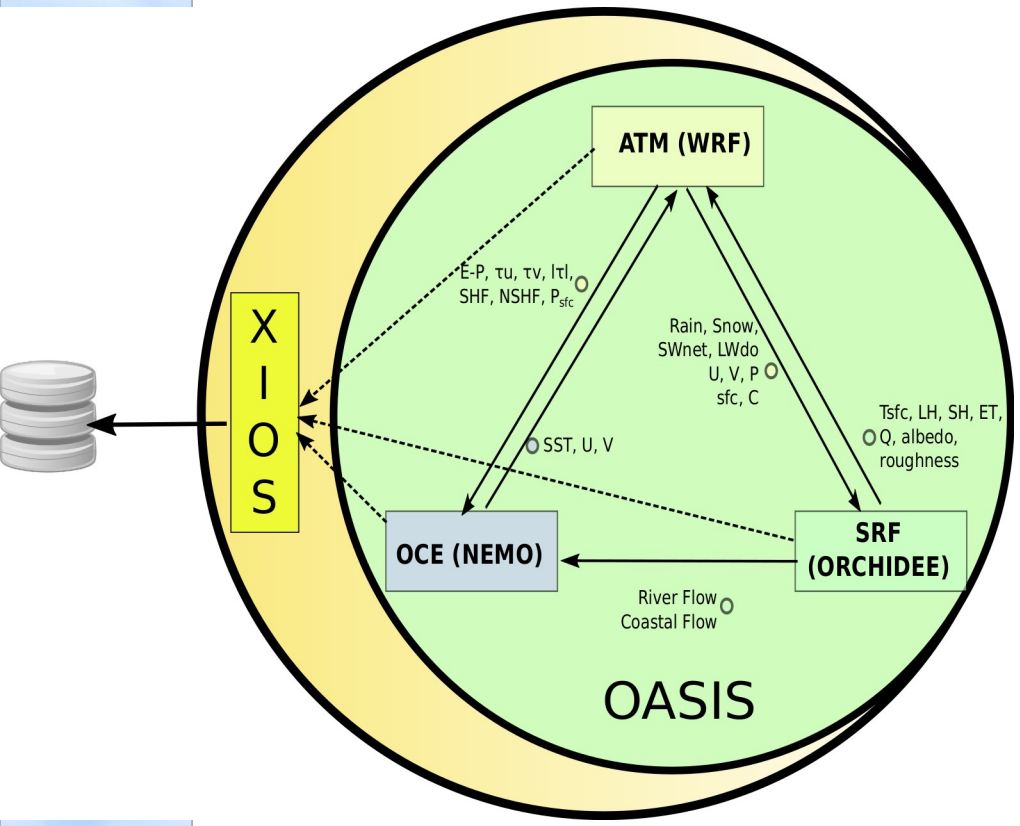
The coupling strategy for RegIPSL



- IPSL components of the global Earth system model are used regionally.
- For the atmosphere WRF is used while a new model is under development.
- All couplings are performed with OASIS.
- All models output with XIOS.
- The same workflow as the global ESM is used.

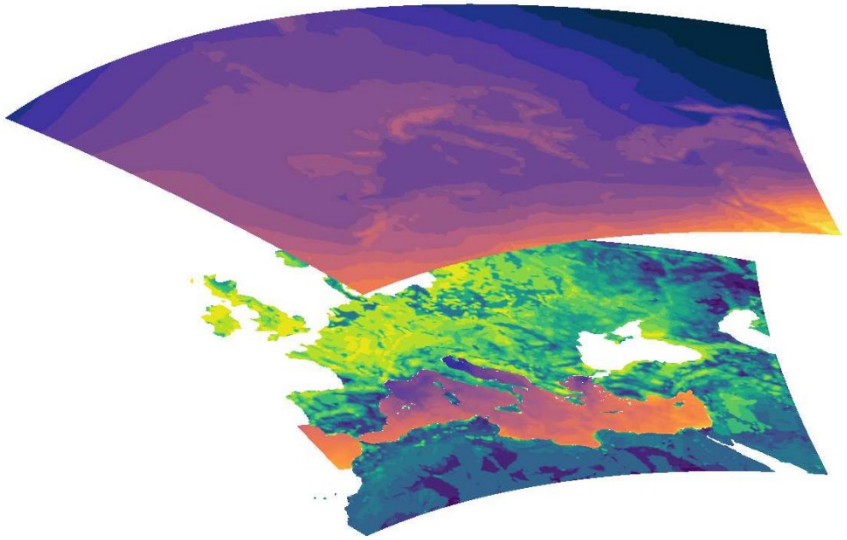
Original features :

- The land surface model is not part of the atmosphere
- Communicates with the atmosphere and ocean through OASIS
- The high resolution information of river flow is directly transmitted to the ocean.

RegIPSL-MED configuration

Ocean : NEMO-MED12

- 1/12° resolution, 75 levels
- Atlantic buffer zone
- Black Sea only provides the water balance



Atmosphere : WRF 3.7.1

- 20km resolution, 46 levels
- Microphysics WSM5 / PBL MYNN2.5 / spectral nudging / Tegen
- New T2/Q2 parametrization

Land : ORCHIDEE

- Same grid as atmosphere
- 13 PFTs
- 11 layer soil thermodynamics and hydrology
- 36 HTU routing scheme
- Interactive vegetation

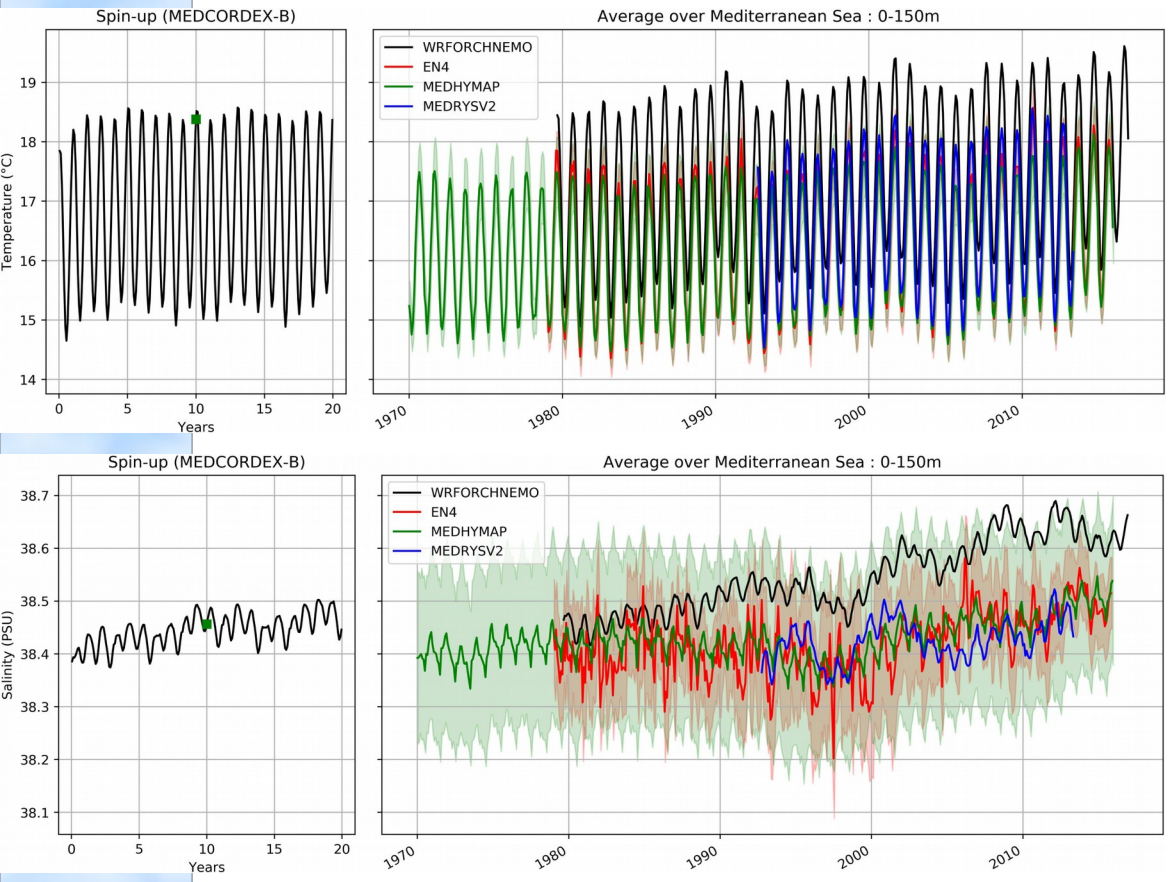
Simulations presented :

WRFORCHNEMO : ERA-I hindcast 1979-2016

WRFORCH : as above but imposed SST

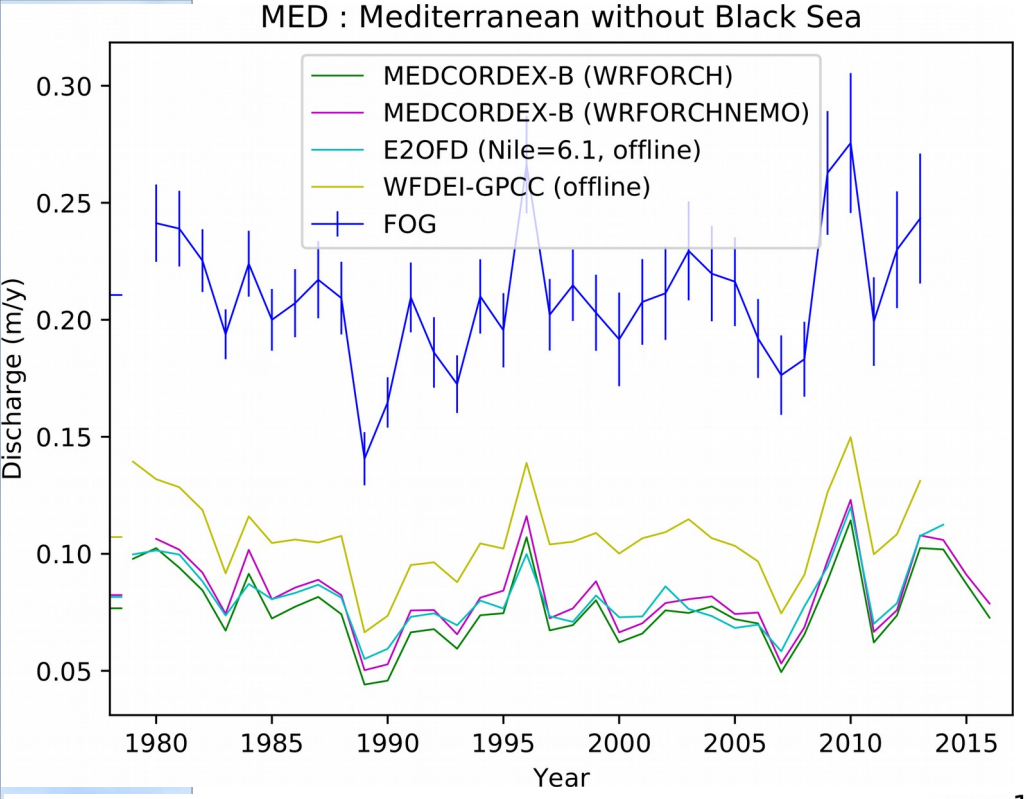
ORCHIDEE off-line simulations (WFDEI & E2OFD)

The spin-up of the model



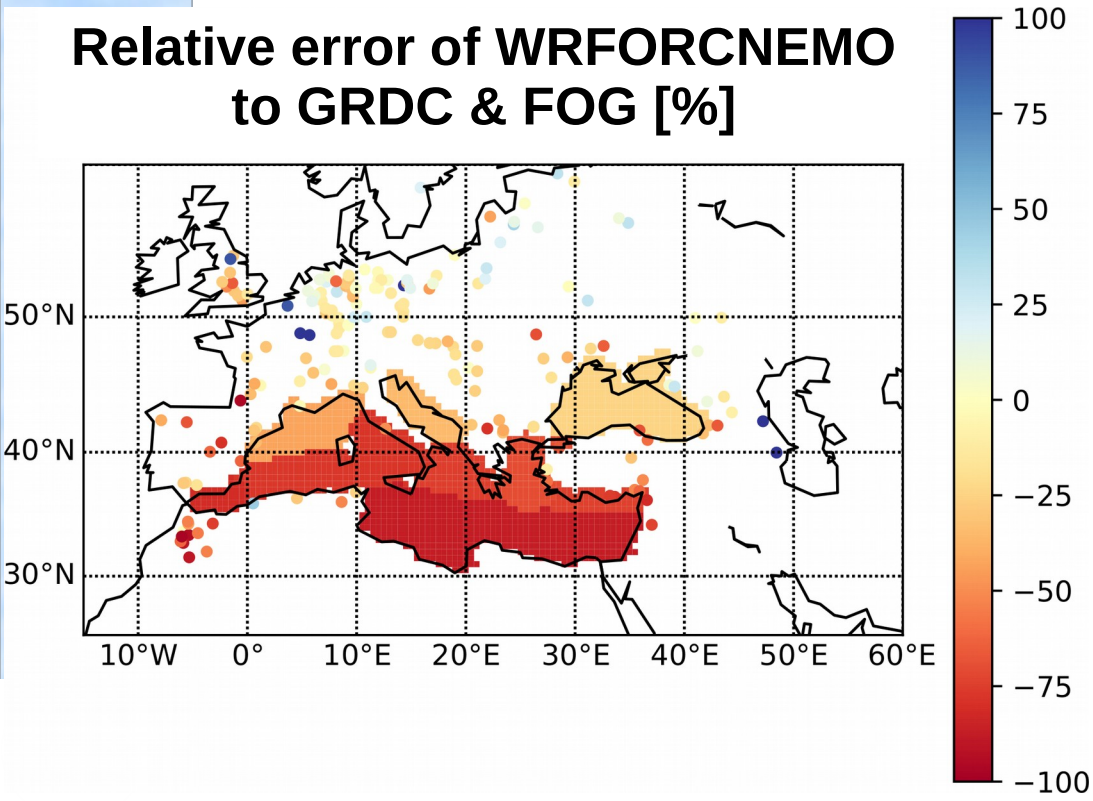
- The ocean has been spun-up with a random choice of years between 1979 and 1985.
- The forcing is taken from the WRFORCH simulation.
- The deep layers (> 600) spin-up was not achieved in temperature or salinity.

- ORCHIDEE is spun-up with a long off-line simulation. This is particularly important for the rivers.

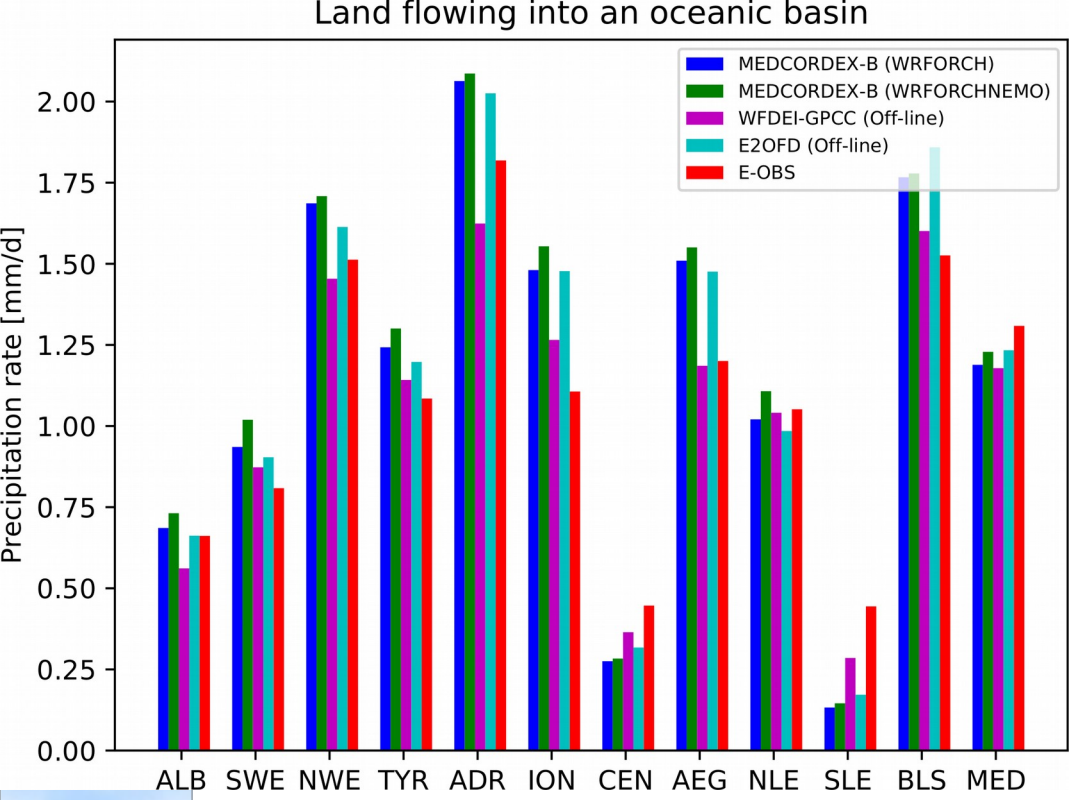


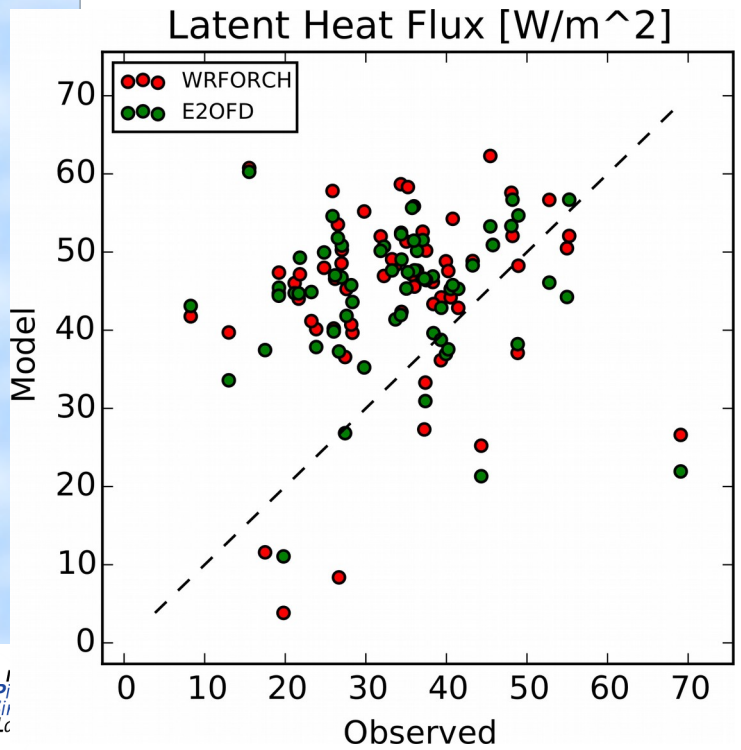
Continents/ocean freshwater exchanges

- Comparison to the FOG product (Wang & Polcher 2019)
- Evaluation against GRDC gauging stations
- Comparison to *Jorda et al. 2017* : 0.2±0.01m/y



The continental water cycle produces too low river discharge : lack of rainfall or too much evaporation ?

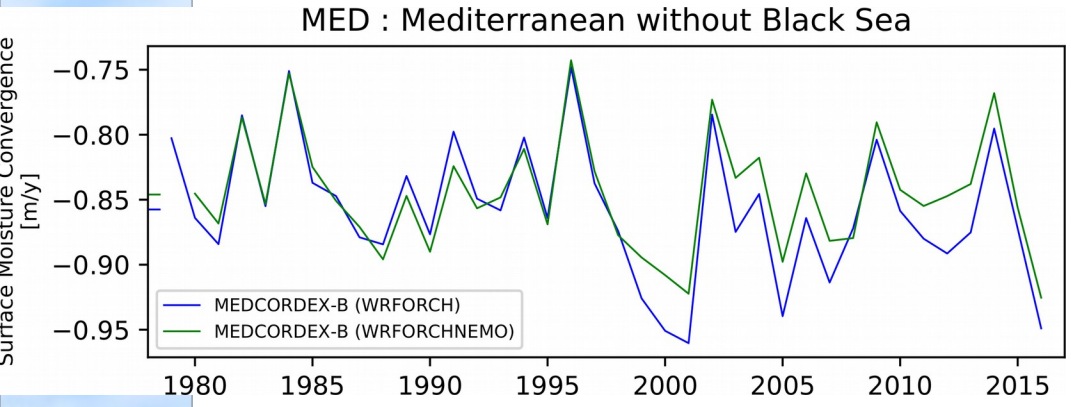


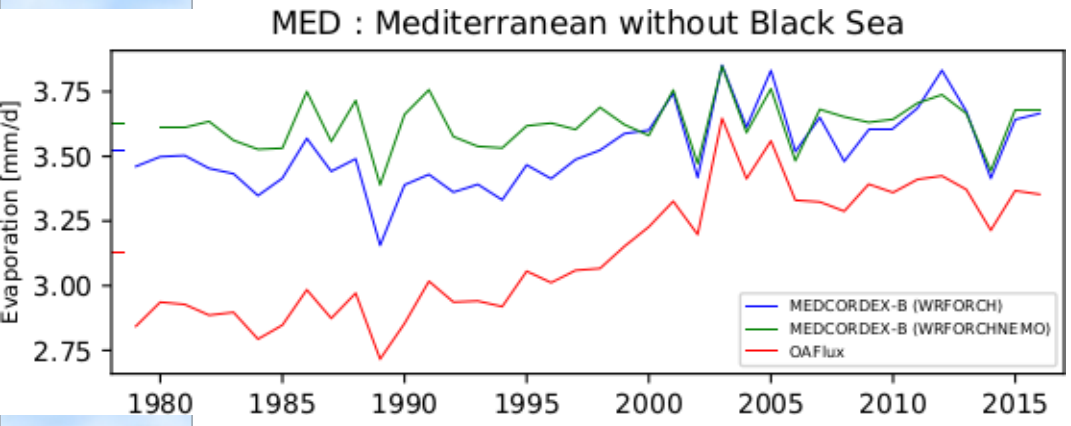


Land/Atmosphere freshwater exchange

- Diverse results for rainfall over the catchments of the MED.
- On the northern basin WRFORCH has too much rainfall.
- Comparison with 72 FluxNet station in the domain indicate that evaporation is too high.
- A bias which also exists with ORCHIDEE off-line.

Atm./Ocean freshwater exchanges



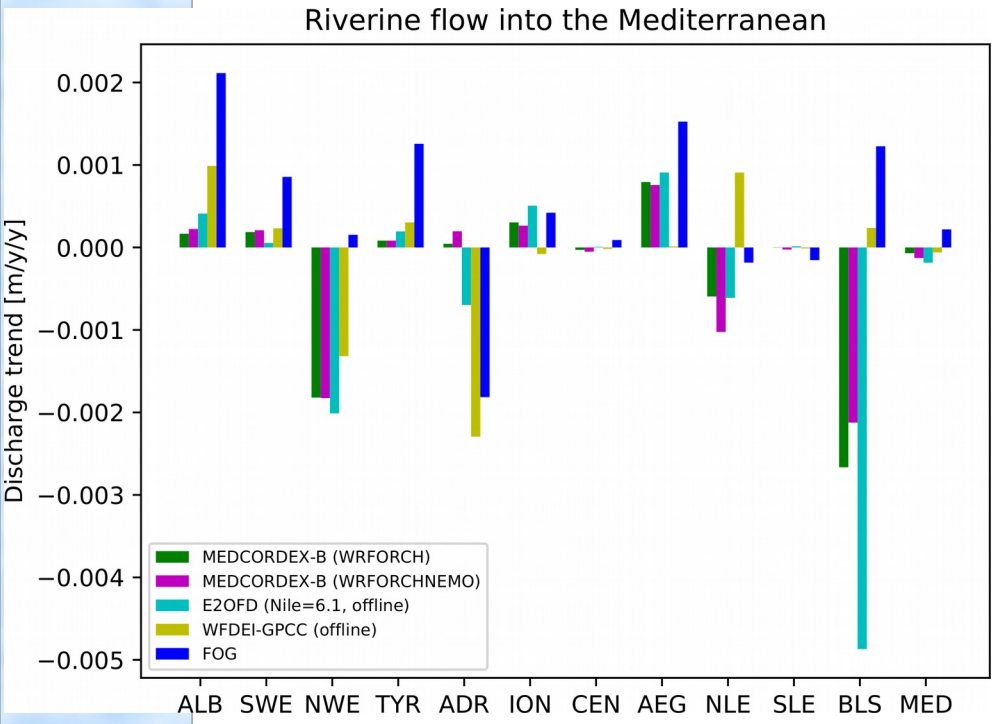


- Moisture convergence over the oceans matches *Jorda et al. 2017* estimates : -0.8±0.2m/y
- But when compared to the OAFlux product (Yu et al. 2008), the model seems to have too much evaporation.

	Jorda et al. 2017	RegIPSL
Gibraltar	0.8±0.4	0.69 (9.0 inflow & 8.3 outflow)
Dardanelles	0.1±0.02	0.12

- The lateral exchanges of the ocean also seem realistic.

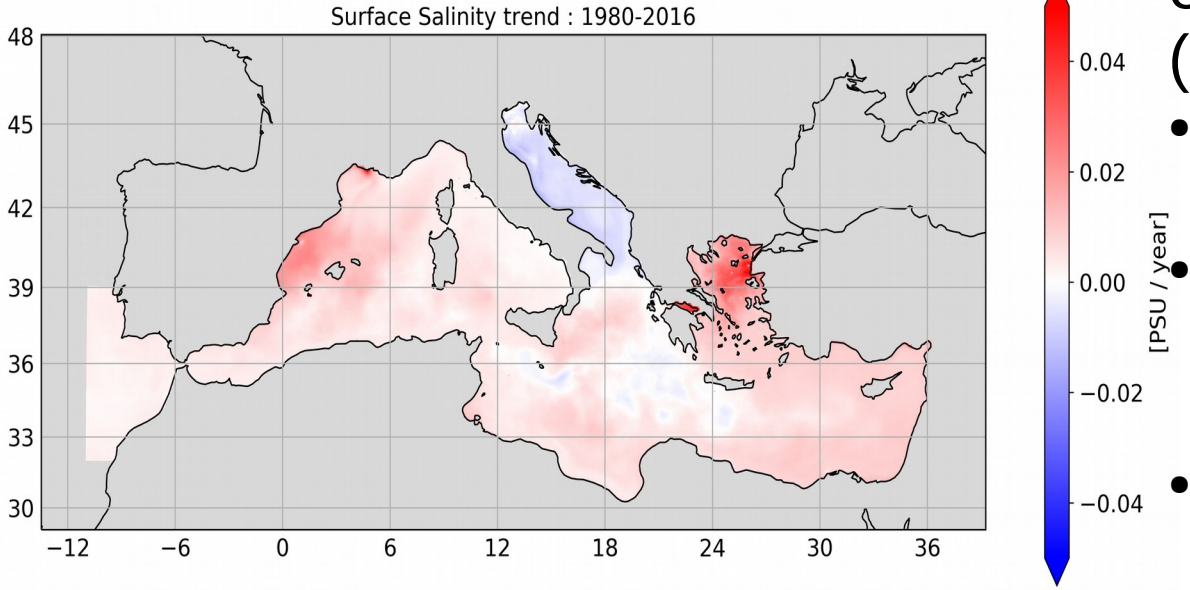
Trends in the water cycle



The model produces trends in river discharge :

- NWE+BLS+NLE : reducing freshwater flows
- AEG : increasing flows
- ADR : no trend

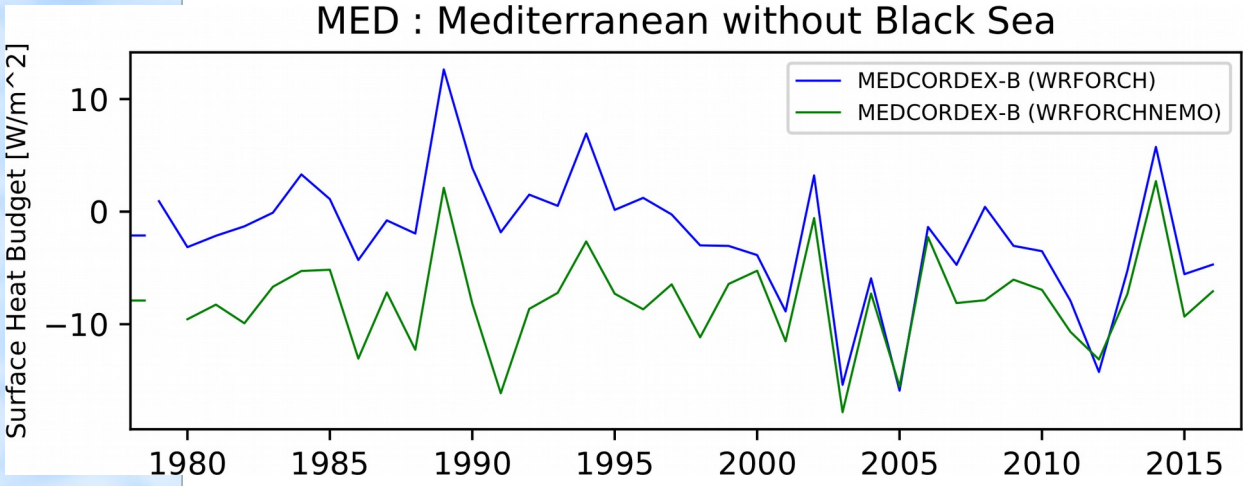
Only in the case of AEG does it corresponds to the trend in FOG.

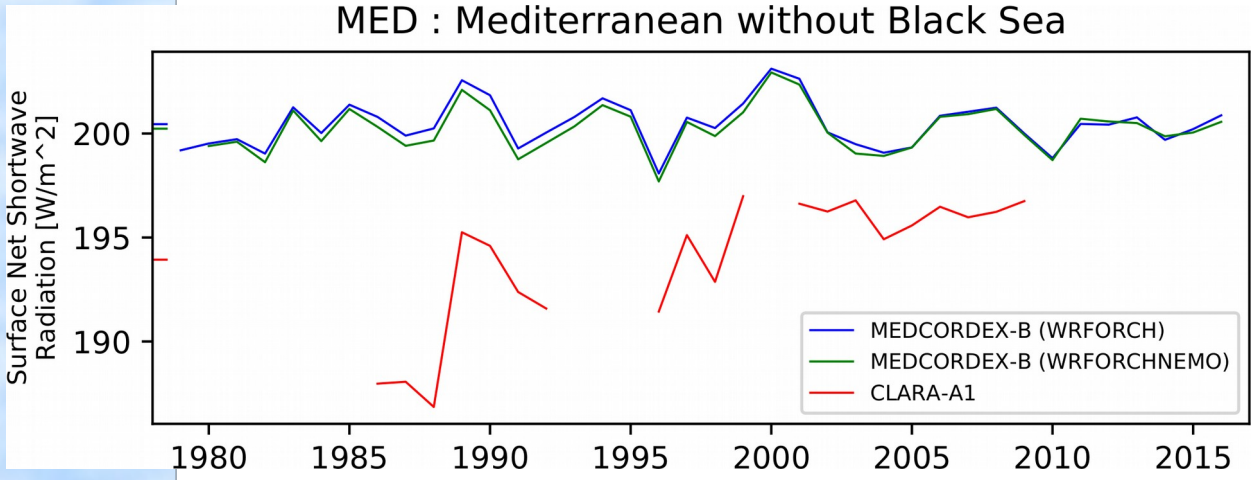


These trends impact the evolution of the surface salinity (SSS) :

- NWE : Salinity has a positive trend.
- AEG : SSS becomes more saline. Not driven by rivers but the Dardanelles trend.
- ADR : The SSS increases, not explained by rivers.

Atm./Ocean energy exchange





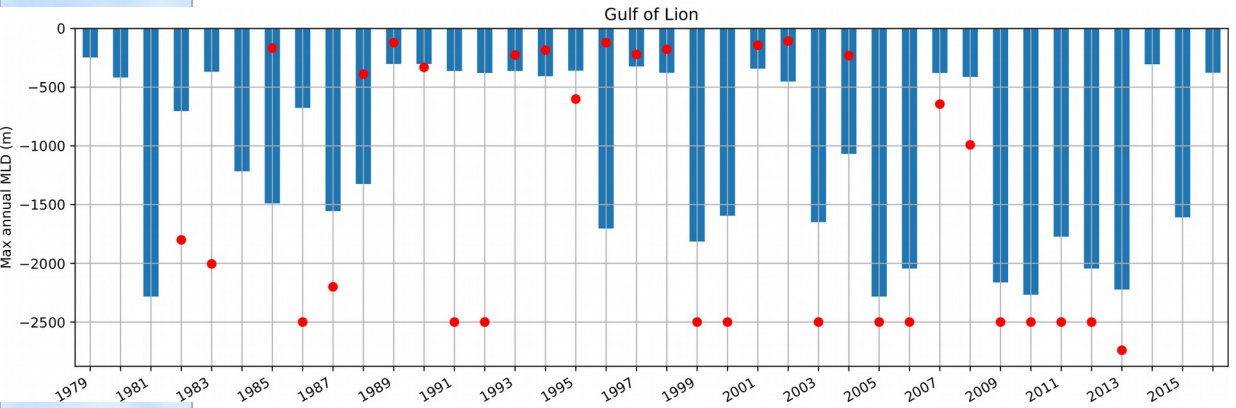
- The coupling changes the oce/atm exchanges.
- The average flux is -2W/m² which is in the range proposed by *Jorda et al. 2017* : -3.0±8W/m²

This result is only due to a compensation of errors :

- Too much solar radiation arrives at the sea surface
- Too much longwave radiation is lost to the atmosphere.

The oceanic circulation

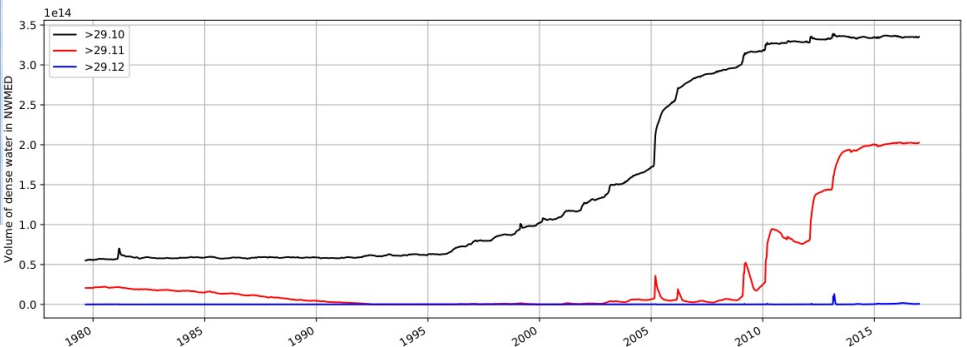
Focus on the deep water masses in the Golf of Lyon (NWE)

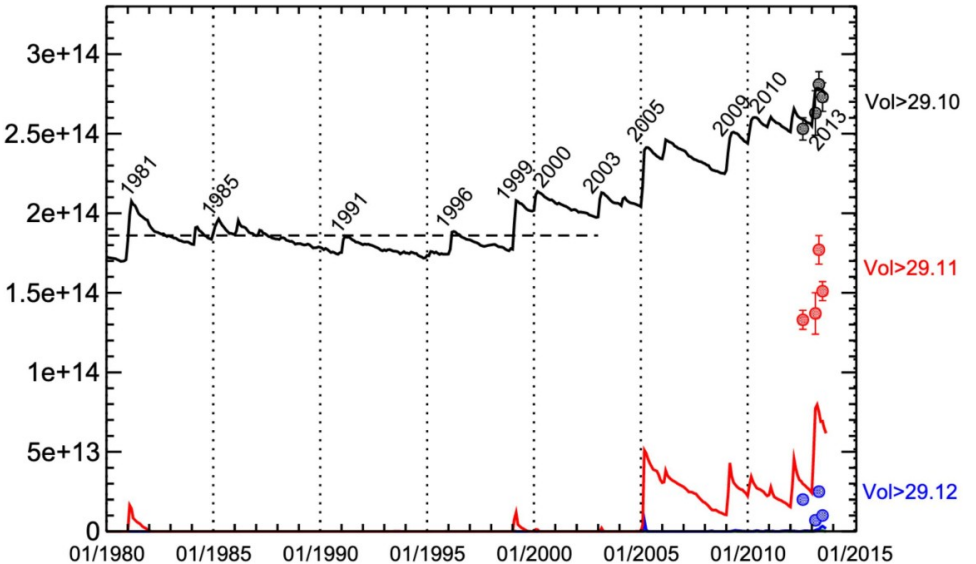


- The simulation mixed layer depth shows a realistic inter-annual variability.

- The water mass formation shows the increase of the last decades.
- The increase is too strong in the model.
- The deep layer drift is still visible.

Somo et al. 2016

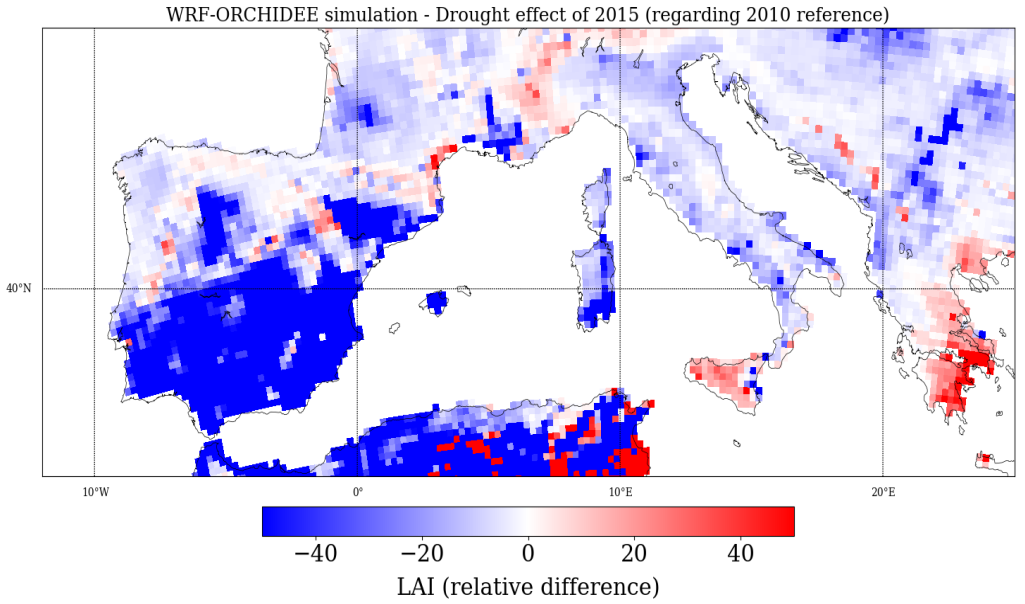




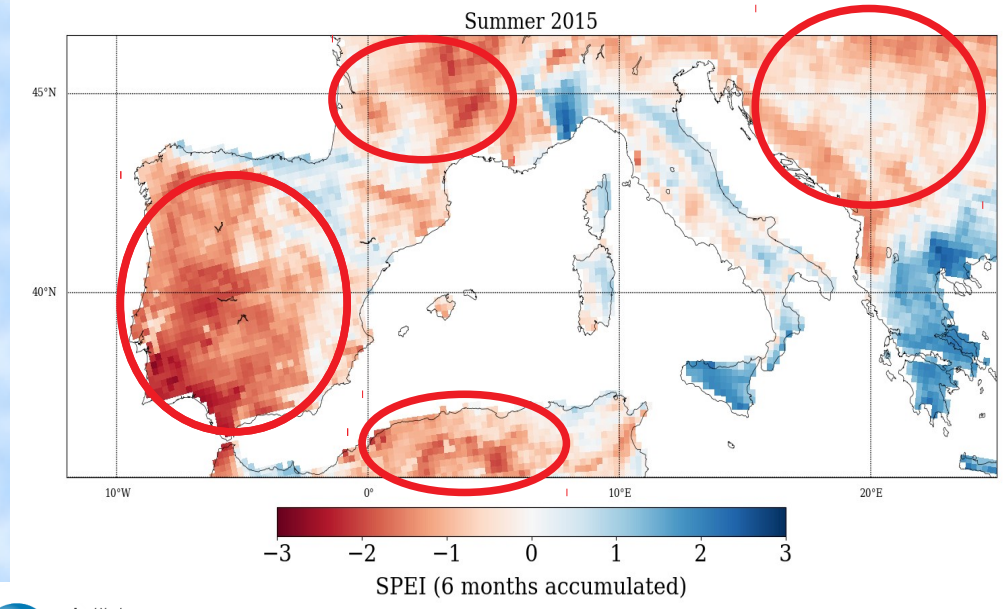
Impact of droughts on vegetation

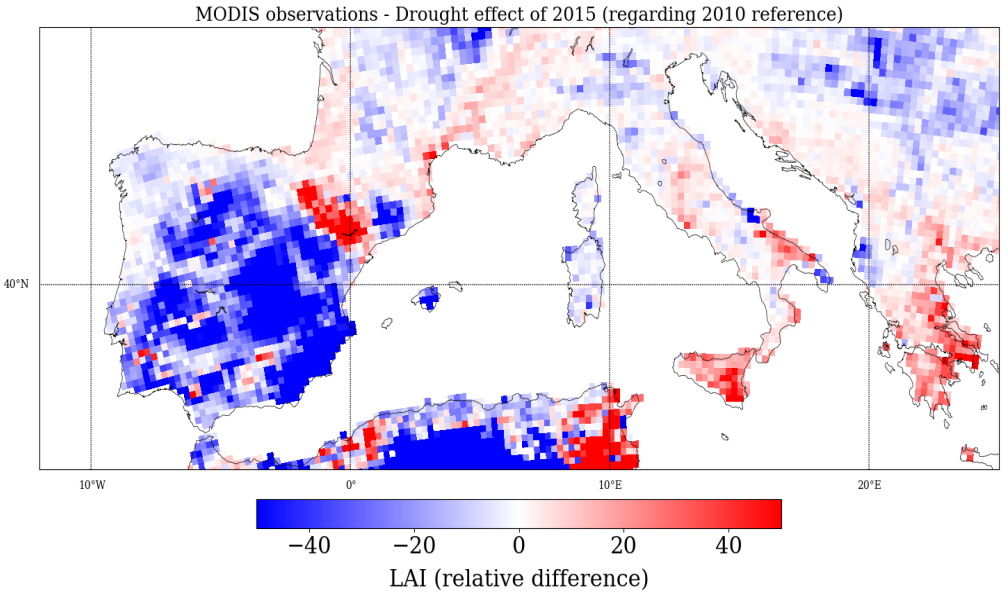
Relative difference of LAI between a summer drought (2015) and a non-drought (2010)

- from MEDCORDEX simulation
- from MODIS observation



Areas of severe droughts according to SPEI from model:





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Conclusion

- RegIPSL is now an operational regional Earth system model at IPSL.
- The value of coupling ORCHIDEE and NEMO to a constrained atmosphere allows to examine in detail surface and ocean processes.
- Biases in the continental water cycle affects the ocean processes. This is an undervalued coupling which needs more attention.
- Extreme events linked to the water cycle are well represented. The model represents the impact on the vegetation.
- The observational estimates are an insufficient constraint for models. This is a call for a more thorough assessment of the regional water and energy cycle.