SENSITIVITY OF THE MEDITERRANEAN THERMOHALINE CIRCULATION TO THE ATMOSPHERIC HEAT AND FRESHWATER BUDGETS

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Abstract
Two simulations of the Mediterranean sea circulation are performed with the NEMO model forced by two atmospheric datasets, obtained performing a dynamical downscaling of the ERA-Interim reanalysis with the WRF model in a regional MED-CORDEX configuration. The first atmospheric simulation uses the RUC model for the land surface exchanges while the second one is coupled with the ORCHIDEE model. Both simulations use the same river routing scheme. The atmospheric run and routing scheme skills are investigated through heat and freshawter budgets over the Mediterranean Sea. Also, the thermohaline circulation is analyzed by looking at the temperature and salinity variations and at the winter convection characteristics during extreme transient events

Keywords: Circulation models, Heat budget, River input, Mediterranean Sea

The Mediterranean thermohaline circulation is characterized by a large interannual variability and events like the Eastern Mediterranean Transient (EMT) or the Western Mediterranean Transition (WMT). The winter convection, which occurs at several depths and in specific places, is largely triggered by the atmospheric forcing and air-sea interactions. The modelling of these processes is a hard challenge because of the complex circulation of the Mediterranean Sea. Also, a major contribution of the land surface models to the difference in the water budget of the Mediterranean sea comes through the riverine flux. In order to make projections, the use of coupled ocean-atmosphere-land models is needed. This work is a step towards the fully coupled model. Our analyses focus on the heat and freshwater budgets over the sea and on the the 3D long-term means of thermohaline characteristics.

1- Tools
ORCHIDEE model [1] includes a complex routing scheme (cf. Fig. 1), using HydroSHEDS data as input, which routes the water to the ocean and has been validated with in-situ observations. This scheme is also used to route the RUC [2] runoff and explore various scenario of the human impact on the river discharge. This spread in possible riverine inputs into the Mediterranean sea will serve to compare the sensitivity of the thermohaline circulation in the Mediterranean version of NEMO (damped toward ORAS4 hydrology in the Atlantic) [3, 4] to one obtained by with the atmospheric fluxes of the two WRF [5] dynamical downscaling of the ERA-I reanalysis [6] performed from January 1979 to December 2012**.**

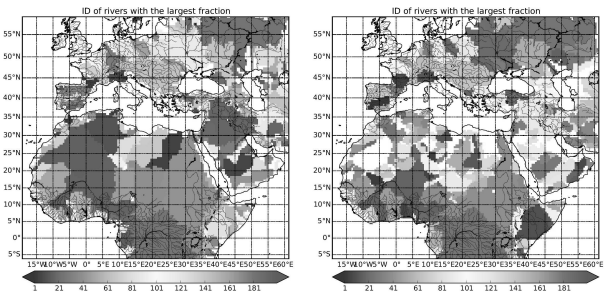

Fig. 1. Basin maps of the 200 controlled rivers by the ORCHIDEE using the old (left, 50km resolution) and the new (right, 1km resolution) river routing scheme.

2- Results
In average over the sea surface, the atmospheric fields show a good agreement with observations (satellite, in situ observations) for the sensible and net longwave heat fluxes. The net shortwave flux is warmer compared to observations with a shift is of the order of 15 $W.m^{-2}$. This shift is partly compensated by the latent heat flux which is larger than observations. Thus the 34-years budgets are around -2.5 $W.m^{-2}$ for the net heat flux and 0.9 $m.yr^{-1}$ for the evaporation minus precipitation. The two applied Mediterranean water (evaporation minus precipitation minus river runoff) and heat budgets slightly differ between the two companion atmospheric and routing simulations.

The ocean response is analyzed in terms of oceanic winter convection signatures, 3D temperature and salinity variations in four specific layers (surface, intermediate 150-600m, deep 600-1000m, and bottom). The winter convection is underestimated in the westerm Mediterranean while it is in agreement with observations in the eastern Mediterranean, but decadal variations of the temperature and salinity in each layer are well captured by the ocean model. The resulting timeseries show some drifts in the upper layer which is warmer than the EN4 observations [7], with a better agreement for the coupled WRF-ORCHIDEE model compared to the RUC scheme.

3- Conclusion
A 34-year ocean NEMO simulation of the Mediterranean Sea has been done for the 1979-2012 period forced by WRF simulation and two different land surface models using the same high resolution routing scheme. The integration of this model in the fully NEMO/WRF/ORCHIDEE coupled model will be achieved.

References
1 - Polcher, J., 2003. Les processus de surface à l'échelle globale et leurs interactions avec l'atmosphère, Habilitation à Diriger des Recherches, Université Paris VI.
2 - Smirnova, T. G. , Brown, J. M., Benjamin, S. G., Kim, D., 2000. Parameterization of cold season processes in the MAPS land-surface scheme, J. Geophys. Res., 105(D3), 4077-4086.
3 - Madec, G. 2014. NEMO ocean engine, IPSL technical report 27, 1288-1619.
4 - Beuvier J., Béranger K., Lebeaupin Brossier C. et al., 2012. Spreading of the Western Mediterranean Deep Water : Time scales and deep cyclone transport, J. Geophys. Res. 117(C07022), 10.1029/2011JC007679.
5 - Skamarock W.C., Klemp J. B., Dudhia J. et al., 2008. A description of the Advanced Research WRF Version 3, 125pp, NCAR Tech. Note NCAR/TN-475+STR.
6 - Simons A., Uppala S., Dee D., Kobayashi S, 2007. ERA-interim: New ECMWF re- analysis products from 1989 onwards, ECMWF Newsletter, Vol. 110, pp. 25-35.
7 - Good, S. A., M. J. Martin and N. A. Rayner, 2013. EN4: quality controlled ocean temperature and salinity profiles and monthly objective analyses with uncertainty estimates, Journal of Geophysical Research: Oceans, 118, 6704-6716, doi:10.1002/2013JC009067