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
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: $0.2 \pm 0.01$ m/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.

<table>
<thead>
<tr>
<th>Location</th>
<th>Jorda et al. 2017</th>
<th>RegIPSL</th>
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</thead>
<tbody>
<tr>
<td>Gibraltar</td>
<td>0.8±0.4</td>
<td>0.69 (9.0 inflow &amp; 8.3 outflow)</td>
</tr>
<tr>
<td>Dardanelles</td>
<td>0.1±0.02</td>
<td>0.12</td>
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- 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 correspond 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 ocean/atmosphere exchanges. The average flux is $-2\text{W/m}^2$ which is in the range proposed by Jorda et al. 2017: $-3.0\pm8\text{W/m}^2$

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:
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.