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Temporal scales of variability in the Mediterranean Sea ecosystem: insights from a multi-decadal 1/12° MITgcm-BFM simulation

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We used a 3D hydrodynamic-biogeochemical model of the Mediterranean Sea to investigate the temporal scales of variability of the marine ecosystem, from inter-annual to sub-weekly periods. The modeling system is based on the online coupling between the MIT General Circulation Model (MITgcm) and the Biogeochemical Flux Model (BFM). A hindcast simulation at 1/12° horizontal resolution, featuring 75 vertical levels and with a daily frequency output was carried out for the period 1994-2012.
The validation showed that the coupled MITgcm-BFM model is able to reproduce the main physical and biogeochemical processes characterising the Mediterranean Sea, from basin-wide to mesoscale. In particular, good performances were achieved in simulating the mean temperature, salinity, nutrients concentration and primary production across the basin. Furthermore, the model properly reproduced the seasonal cycle of mixed layer depth and phytoplankton chlorophyll concentration at surface and along vertical sections.
We designed and computed statistical metrics of temporal variability at the sub-basin scales for the surface temperature, nitrate, phosphate and chlorophyll. We found a positive inter-annual trend for the surface temperature, in agreement with satellite data. Conversely, we did not observe significant trends for the biogeochemical variables.
The seasonal variability is the most relevant term among all the temporal scales investigated. Nevertheless, the high-frequency (i.e. sub-weekly) variability is not negligible and is approximately equal to the inter-annual modulation of the seasonal variability. Moreover, the high-frequency variability of the biogeochemical variables displays a decreasing southward gradient over the Mediterranean Sea, like the seasonal variability.
A further analysis, based on the wavelet method and performed at different Mediterranean sites, highlighted a significant power associated to the sub-weekly periods (in addition to annual and semi-annual patterns), confirming the importance of the high-frequency scale of variability in the biogeochemistry of the basin.