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Impact of sea-level change on the paleo Primary Productivity record in the NW African coastal upwelling area

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A sea level decrease of 120 m at the Last Glacial Maximum (LGM) drastically modifies the shelf morphology of the North West African coastal upwelling area. Using a regional coupled circulation-ecosystem model subject to a set of boundary conditions that reflect Present Day (PD) and LGM conditions, we aim to quantify how changes in shelf morphology, as well as changes in sub-surface nutrient concentrations or local climatic conditions, influence the biological productivity and its record in the sediments.

The oceanic circulation is simulated by the Regional Ocean Modelling System (ROMS), taking advantage of the AGRIF (Adaptive Grid Refinement in Fortran) technique to set-up an embedded grid structure. A high-resolution grid (1/10°) is centred on our study area, and is nested in a larger, coarser grid (1/2°) over the Atlantic domain. Boundary and initial conditions for PD and LGM are provided by global simulations performed with the University of Victoria Earth System-Climate Model (UVic ESCM). We used NPZD (Nutrient, Phytoplankton, Zooplankton and Detritus) biogeochemical models.

We have identified the following issues in interpreting a sedimentary record at a fixed core location as an indicator of the total upwelling productivity:
- Changes in the shelf morphology due to sea-level change appeared to have an impact on the productivity of the upwelling itself, but also to displace the high-productivity zone.
- Comparing the Primary Production (PP) between PD and LGM at a given geographical location, or comparing the zonal mean of the PP, can show opposite results. The comparison at geographical locations assumes a direct connection between the production in the surface ocean and the underlying sediments. The comparison of the zonal mean of PP or sediment flux assumes that lateral advection of particulates and sediment transport are significant processes in producing the sedimentary signal at a given location.

We illustrate the various situations, with or without lateral integration of the PP, by a comparison of sedimentary data with the different modelling scenarios. While core data north of 23°N show an increase of organic carbon flux to the sediments at LGM compared to PD, our standard LGM simulation yielded a decrease. We attribute this decrease to the nutrient depletion of subsurface waters. Model results showed an increase in PP in an experiment where the wind stress was doubled over the NW Africa area. All simulations showed the same decoupling between PP at a geographical location and zonal mean PP.