Short abstract

The Arctic Ocean is particularly sensitive to Climate Change with a warming more than two times faster than in temperate regions. The most striking illustration is the reduction by ∼50% of the sea-ice volume during the last four decades. This loss of sea-ice has been responsible for increasing light availability and therefore stimulating the net primary production (NPP) by phytoplankton which forms the base of a unique and fragile ecosystem. However, climate projections are suggesting the appearance of a summer ice-free Arctic Ocean by ∼2050. In this context, the ’new Arctic’ might move from a light-limited (ice-covered) to a nutrient-limited (open ocean) system. But the nutrient dynamics are also rapidly changing due to a complex interplay of physical and biogeochemical processes. On the one hand, the amount of nutrients laterally advected are decreasing and the increase in stratification in most part of the Arctic inhibits vertical mixing. On the other hand, more nutrient are expected from increasing inputs from turbulent mixing, upwelling (due to stronger atmospheric forcing in the absence of sea-ice), land (river runoff, permafrost thaw and erosion) and remineralization (enhanced bacterial metabolic activity in a warmer Ocean). Ocean biogeochemical models are particularly relevant to identify key climate-change-mediated environmental changes that can act as multiple drivers. Previous CMIP5 projections estimated that NPP will increase until 2050 and then decrease due to nutrient limitation. But those modelling studies are neglecting terrigenous nutrient inputs which is particularly problematic given that the Arctic Ocean is surrounded by thawing permafrost lands and receives 11% of the global river discharge. CMIP6 simulations have evolved to fill this gap but they are currently largely using climatological data. As a result, most models are largely underestimating NPP on the russian shelves compared with 1 V1.4-2023/06/16 satellite observations. Here, we propose to disentangle those processes identifying the present and future NPP levels and detect ’tipping points’ in their evolution towards the ’new Arctic’. We will use the most complete in situ pan-Arctic database for terrigenous nutrient and carbon inputs from rivers and erosion that will be dynamically coupled with FESOM2.1. We will perform a sequence of ’next generation’ biogeochemical coupled experiments (hindcast and forecasts, FESOM2.1-REcoM3) with the finest horizontal resolution at present time for studies of the Arctic Ocean in global biogeochemical models (4.5 km). The Finite VolumE Element Sea Ice-Ocean Model (FESOM2.1), the successor of FESOM1.4, provides improved mixing schemes, ’Arctic-optimized’ configuration and up to five times speedup. FESOM2.1 is coupled with REcoM3 (the Regulated Ecosystem Model, version 3).