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Future Arctic Primary Productivity from CMIP5 Simulations: Uncertain Outcome, but Consistent Mechanisms

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Net primary production (PP) in the Arctic should increase over this century, due to sea ice retreat, inducing an increase in available light, but could decrease if nitrate renewal is insufficient. Here, simulations performed with 11 Earth System Models from the CMIP5 exercise, covering 1900-2100, are analyzed using Arctic PP, surface nitrate and sea ice concentrations. Whereas the mean model well simulates Arctic-integrated PP at 511 TgC/yr for 1998-2005 and projects a 58 TgC/yr increase by 2080-2099, models neither agree on what limits PP today, nor on the sign of future PP change. However, the same mechanisms operate in all models. First, both sea ice and nitrate decrease over the 21^{st} century. Depending on the model, the strengthening nitrate stress is sufficient to overcome the effect of light increase. The inter-model spread stems from present nitrate stocks, poorly constrained by observations and characterized by an inter-model uncertainty of $>$50% of the mean. Second, virtually all models agree in the open ocean zones on more spatially-integrated PP and less PP per unit area. Where models disagree is the sea ice zone, where a subtle balance between light and nutrient limitations determines the change in productivity. Hence, it is argued that reducing uncertainty on present Arctic nitrate would render Arctic PP projections much more consistent. That is definitely required to understand the impact of climate change on the Arctic food webs and carbon cycle.