Geophysical Research Abstracts
Vol. 17, EGU2015-6373, 2015
EGU General Assembly 2015

Projected climate change impacts to the North Sea marine system

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Future climate change impacts to the North Sea marine system are driven by a combination of changes induced by the globally forced oceanic boundary conditions and the regional atmospheric and terrestrial changes. We reviewed the recent progress and the projected future change of the North Sea marine system as part of the North Sea Climate Change Assessment (NOSCCA) and focussed on three major aspects, namely the change of (i) sea level, the (ii) hydrographic and circulation changes of the North Sea and the (iii) changes in lower trophic level dynamics, biogeochemistry and ocean acidification. In recent years more and more regional climate change assessments became available for the North Sea and new developments contributed important understanding on regional processes mediating climate change impacts in the North Sea. Important new knowledge on regional future sea level change was gained by improved understanding of processes contributing to global sea level rise during the last decade. Assessment of climate change impacts to hydrography, circulation and biogeochemistry has benefited from new and advanced downscaling methods. The large number of regional studies enables now a critical review of the current knowledge on climate change impacts on the North Sea and allows the identification of challenges, robust changes, uncertainties and specific recommendations for future research.

The long term trends in the climate conditions are superposed on the natural modes of variability and separating these to give a clear anthropogenic climate change signal is one of the ‘grand challenges’ of climate change impact studies in marine regions and of particular relevance for North Sea. The impact of natural variability on future annual average steric sea level, sea surface temperature and ocean acidification is less dominant compared to the climate change signal and their projected changes for the North Sea, namely rising future sea level, increasing surface temperature and substantial decrease in ocean pH, which are robust results from regional model ensemble projections reviewed here. However, the precise amounts of these changes remain uncertain and are highly dependent on the choice of the parent global model. The choice of the regional model, bias correction methods and downscaling strategies further contribute uncertainties on regional and smaller scales. Near the coast terrestrial impacts are becoming more important and the projections suffer from lacking terrestrial coupling and missing information on river load and alkalinity changes. Uncertainties in regional projections diagnosed from regional multi-model ensembles remain large for offshore oceanic nutrient and salt fluxes. Projected changes in primary production remain therefore still uncertain for the North Sea and multi-model ensembles driven by global Earth System models are required in future to assess uncertainty ranges and inter-model variations.