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Impact of regionally increased CO2 concentrations in coupled model simulations

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Abstract

In which direction is the influence larger: from the Arctic to the mid-latitudes or into the other direction? To answer this question, the CO2 has been regionally quadrupled in different areas in the Arctic as well as outside the Arctic and globally in a series of 150 year coupled model experiments with the AWI-CM 1.1, one of the CMIP6 models. CO2 increase applied only in the Arctic is very efficient in melting the Arctic sea ice while the influence outside the Arctic is rather limited although in the 30 years immediately after switching on the CO2 forcing some robust circulation changes with impact on the surface temperature including local cooling of up to more than 1 K in parts of North America are simulated. Further into the simulation, circulation and surface temperature changes become less robust and smaller. Due to the reduced meridional temperature gradient the synoptic activity is decreased in the mid-latitudes, a feature that is strongest in the 30 years after regionally quadrupling CO2 and gradually becomes less pronounced. When switching on CO2 forcing outside the Arctic, northward atmospheric heat transport melts about half of the Arctic sea ice volume in the first 15 years. In the remaining 135 years a further sixth of the Arctic sea ice volume is melted mainly from ocean heat transport. In most of the seasons, except for summer, Arctic Amplification is accomplished by purely increasing CO2 south of 60°N, i.e. without any forcing in the Arctic. This is a strong indication that the influence of a warming extra-Arctic on the Arctic is strong while forcing applied in the Arctic mainly materializes in a warming Arctic.