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Uncertainties in freshwater and MOC predictions in the North Atlantic region

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Future changes in the Atlantic meridional overturning circulation (MOC) will result from processes both internal and external to the climate system. Global warming leads to an amplified hydrological cycle, which affects the vertical salinity and temperature profiles. The meridional changes in the ocean-atmosphere interaction diminish the meridional oceanic density contrast. In the North Atlantic sinking regions, these changes are strongly related to salinity anomalies at the surface. Most climate models predict a weakening of the North Atlantic meridional overturning circulation (MOC) during the twenty-first century when forced by increasing levels of greenhouse gas concentrations. However, large uncertainty exists in comparing different climate model predictions, even under identical forcing. Individual studies suggest that multidecadal changes in the MOC are strongly related to large-scale salinity anomalies and therefore probably to changes in the surface freshwater fluxes and freshwater transport. We derived the general relationship between the MOC and freshwater budget of the Northern Hemisphere analyzing the CMIP3 20th century simulations and the A1B scenario prediction. A quantification of the different sources of uncertainty (external, internal and model uncertainties) indicates the model error as the largest component. The internal variability is significant during the first decades, while scenario uncertainty is almost negligible. The different contributions to model uncertainty like surface wind and density, salinity versus temperature has been analyzed additionally. Overall, the strongest MOC changes have been predicted in the models around 40°N, whereas the strongest signal-to-noise ratio is located south of 40°N. Uncertainties in meridional ocean density profiles are dominated by model uncertainties in the salinity distribution. The local signal-to-noise ratio of the ocean freshwater flux is low in the arctic and subpolar region. First analyses of the CMIP5 historical simulations and the RCP45 scenario runs show still large model variability for the freshwater fluxes as well as for the meridional overturning.