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The Norwegian Earth System Model, NorESM1-M – Part 2: Climate response and scenario projections

T. Iversen[1,2,*], M. Bentsen[3,4], I. Bethke[3,4], J. B. Debernard[1], A. Kirkevåg[1], Ø. Seland[1], H. Drange[4,5], J. E. Kristjansson[2], I. Medhaug[4,5], M. Sand[2], and I. A. Seierstad[1]
[1]Norwegian Meteorological Institute, P.O. Box 43, Blindern, 0313 Oslo, Norway
[2]Department of Geosciences, University of Oslo, P.O. Box 1047, Blindern, 0315 Oslo, Norway
[3]Uni Bjerknes Centre, Uni Research AS, P.O. Box 7810, 5020 Bergen, Norway
[4]Bjerknes Centre for Climate Research, P.O. Box 7810, 5020 Bergen Norway
[5]Geophysical Institute, University of Bergen, P.O. Box 7803, 5020 Bergen, Norway
[*]currently at: ECMWF, Shinfield Park, Reading, RG2 9AX, UK

Abstract. NorESM is a generic name of the Norwegian earth system model. The first version is named NorESM1, and has been applied with medium spatial resolution to provide results for CMIP5 (http://cmip-pcmdi.llnl.gov/cmip5/index.html) without (NorESM1-M) and with (NorESM1-ME) interactive carbon-cycling. Together with the accompanying paper by Bentsen et al. (2012), this paper documents that the core version NorESM1-M is a valuable global climate model for research and for providing complementary results to the evaluation of possible anthropogenic climate change. NorESM1-M is based on the model CCSM4 operated at NCAR, but the ocean model is replaced by a modified version of MICOM and the atmospheric model is extended with online calculations of aerosols, their direct effect and their indirect effect on warm clouds. Model validation is presented in the companion paper (Bentsen et al., 2012). NorESM1-M is estimated to have equilibrium climate sensitivity of ca. 2.9 K and a transient climate response of ca. 1.4 K. This sensitivity is in the lower range amongst the models contributing to CMIP5. Cloud feedbacks dampen the response, and a strong AMOC reduces the heat fraction available for increasing near-surface temperatures, for evaporation and for melting ice. The future projections based on RCP scenarios yield a global surface air temperature increase of almost one standard deviation lower than a 15-model average. Summer sea-ice is projected to decrease considerably by 2100 and disappear completely for RCP8.5. The AMOC is projected to decrease by 12%, 15–17%, and 32% for the RCP2.6, 4.5, 6.0, and 8.5, respectively. Precipitation is projected to increase in the tropics, decrease in the subtropics and in southern parts of the northern extra-tropics during summer, and otherwise increase in most of the extra-tropics. Changes in the atmospheric water cycle indicate that precipitation events over continents will become more intense and dry spells more frequent. Extra-tropical storminess in the Northern Hemisphere is projected to shift northwards. There are indications of more frequent occurrence of spring and summer blocking in the Euro-Atlantic sector, while the amplitude of ENSO events weakens although they tend to appear more frequently. These indications are uncertain because of biases in the model's representation of present-day conditions. Positive phase PNA and negative phase NAO both appear less frequently under the RCP8.5 scenario, but also this result is considered uncertain. Single-forcing experiments indicate that aerosols and greenhouse gases produce similar geographical patterns of response for near-surface temperature and precipitation. These patterns tend to have opposite signs, although with important exceptions for precipitation at low latitudes. The asymmetric aerosol effects between the two hemispheres lead to a southward displacement of ITCZ. Both forcing agents, thus, tend to reduce Northern Hemispheric subtropical precipitation.

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