Sea ice representation in CMIP6: from EC-Earth2.3 to: EC-Earth3-Veg

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The aerosol indirect effects (through cloud microphysics) were diagnosed as the main contribution to raise EC-Earth climate sensitivity by 1 degree (from 3.3 to 4.3) from EC-Earth2 to EC-Earth3-Veg. (Wyser et al 2019).

CMIP5 versus CMIP6 scenarios
RCP (representative concentration pathways → SSP shared socioeconomic pathways)

The time evolution of the SSP scenarios follows a slightly different curve

The radiative forcing in the SSP scenarios are all ending in a higher forcing than the CMIP5 scenarios

Historical & Future Arctic sea ice area

- Large spread among these 6 members in the historical period
- In the ssp1.2.6 scenario an almost ice free Arctic occurs around 2050, which did not occur in the CMIP5 RCP 2.6.
Historical & Future Arctic sea ice area
Seasonal Cycle

EC-Earth3-Veg exhibits a stronger Arctic sea ice seasonal cycle than EC-Earth2, likely related to the upgrade of the sea ice model from LIM2 → LIM3.

Especially the minimum sea ice area in autumn is closer to observations. Note that the minimum in EC-Earth3-Veg occurs in August, which is a common feature in several coupled GCMs with NEMO-LIM as ocean component (Keen et al. 2020).

Antarctic sea ice area is underestimated by ~5 million km² in September and by ~2 million km² in March, in line with the EC-Earth3-Veg warm bias in the Southern ocean.
The amount of sea ice in the Southern Hemisphere is strongly underestimated, in line with the EC-Earth3-Veg Warm Southern Ocean bias.

In March, EC-Earth3-Veg underestimates the concentration in the Bering Sea. On the Atlantic side, the concentration is overestimated.

In September, EC-Earth3-Veg underestimates the concentration in the Kara Seas, while otherwise, the amount of sea ice is too high.
EC-Earth Arctic sea ice volume
CMIP6 versus CMIP5

EC-Earth3-Veg is the CMIP6 version of EC-Earth which has interactive vegetation. There is also the EC-Earth3 version, which uses the vegetation output of EC-Earth3-Veg as input and is not interactive. More ensemble are available for EC-Earth3 and the ensemble mean results are very similar to EC-Earth3-Veg. The different linestyles represent different versions of EC-Earth.

The ensemble min and max value are shows by the bands. Note that different ensemble sizes were available. Sea ice ensemble spread in area en volume is larger in CMIP6 than in CMIP5. Even though here only 4 members of EC-Earth3-Veg are shown, the ensemble spread of EC-Earth3-Veg is larger than that of EC-Earth2 (14 members). EC-Earth3 here shows 19 members.
Average sea ice thickness difference with PIOMAS reanalyses

Grid cell mean thickness, red means more ice in ECE3-Veg than in PIOMASS

Based on an average of 4 EC-Earth3-Veg members (similar to 19 EC-Earth3 members)

Ensemble average of 1980-2010 averaged model minus remapped PIOMAS sea ice thickness
DATA:

esgf-node.gov/search/cmip6
Cmip6-data@ecearth.org

Selection of papers that used EC-Earth3-Veg data:

