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

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thanks to: David Docquier, Pasha Karami, Klaus Wyser, Klaus Zimmermann

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Knut och Alice Wallenbergs Stiftelse

EC-EARTH

Bolin Centre for Climate Research

Stockholm University

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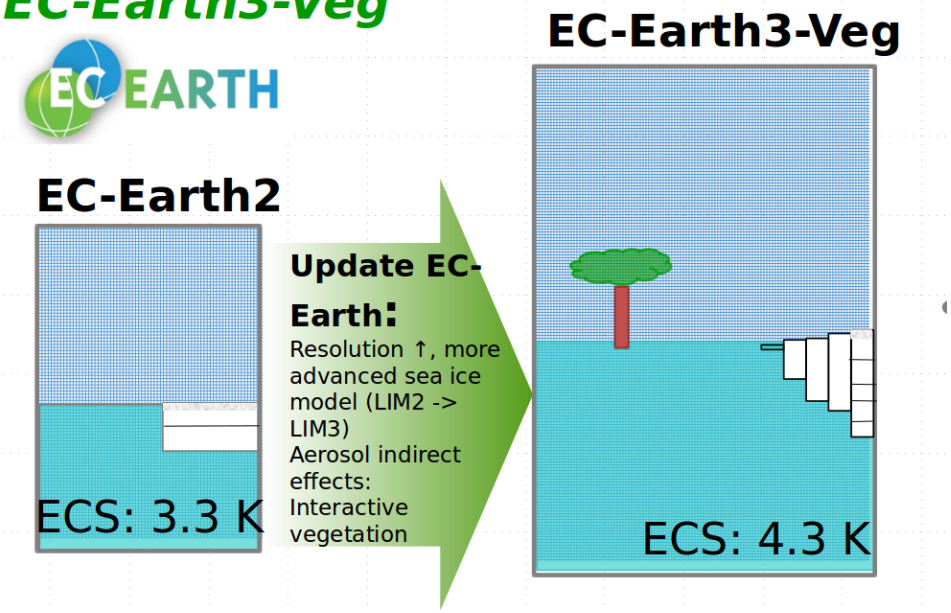
an upgrade of EC-Earth to CMIP6: EC-Earth3-Veg



Component	*EC-Earth2*	*EC-Earth3-Veg*
ocean	NEMO2 OPA9 ORCA1 42 levels	NEMO3.6 ORCA1 75 levels
Sea ice	LIM2 (1 ice category)	LIM3 (5 ice categories)
atmosphere	IFS cycle 31r1 T159 62 layers	IFS cycle 36r4 T255 91 layers
aerosols	CAM timeseries CMIP5 (prescribed)	TM5 + Abdul and Ghan (2000)
Dynamic vegetation	-	LPJ-GUESS

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).

Wyser, K., van Noije, T., Yang, S., von Hardenberg , J., O'Donnel, D., Doesscher, R. (2019): On the increased climate sensitivity in the EC-Earth model from CMIP5 to CMIP6, Geosci. Model Dev. Discuss.

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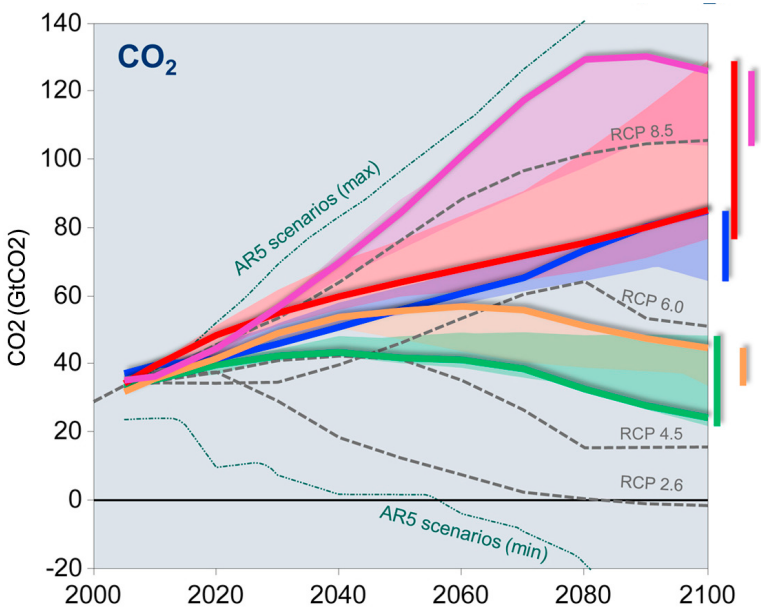
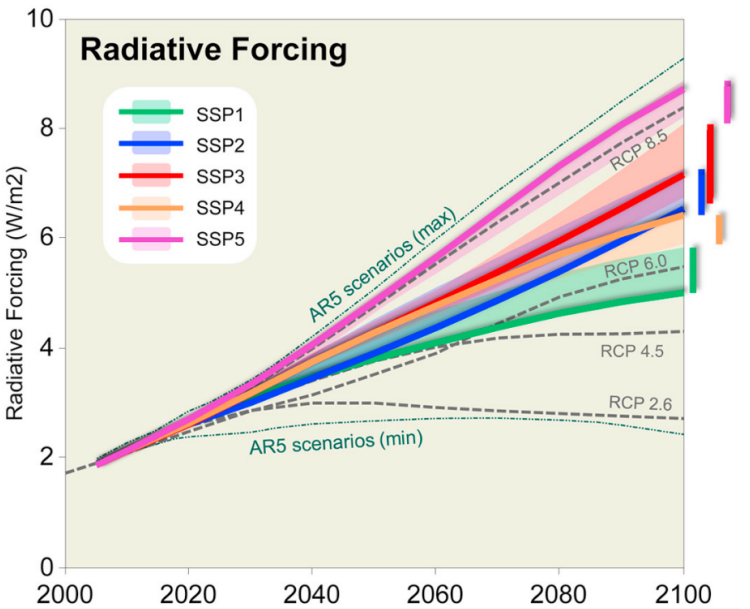
CMIP5 versus CMIP6 scenarios

RCP (representative concentration pathways → SSP shared socioeconomic pathways)

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

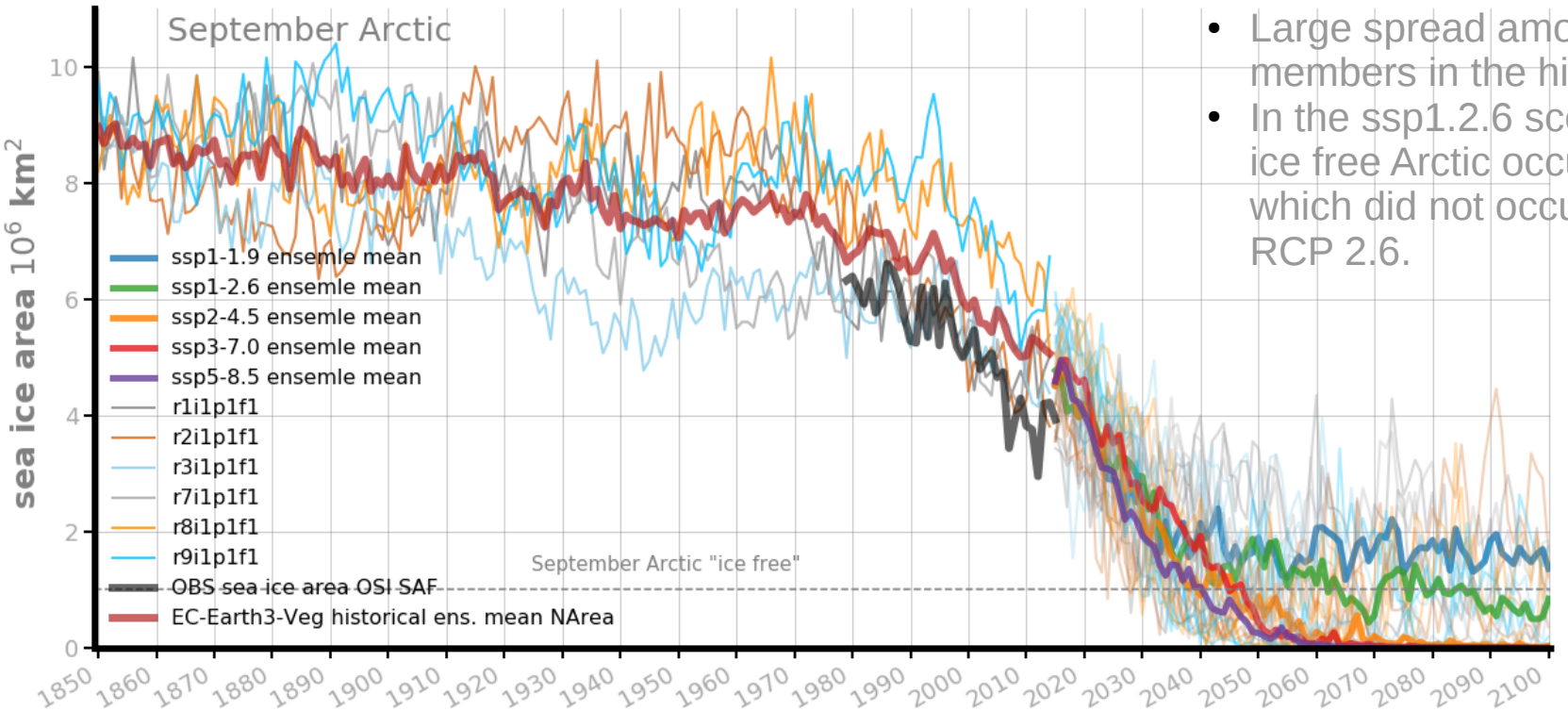
The radiative forcing in the SPP scenarios are all ending in a higher forcing than the CMIP5 scenarios





Riahi, K., Van Vuuren, D. P., Kriegler, E., Edmonds, J., O'neill, B. C., Fujimori, S., ... & Lutz, W. (2017). The shared socioeconomic pathways and their energy, land use, and greenhouse gas emissions implications: an overview. Global Environmental Change, 42, 153-168.

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.

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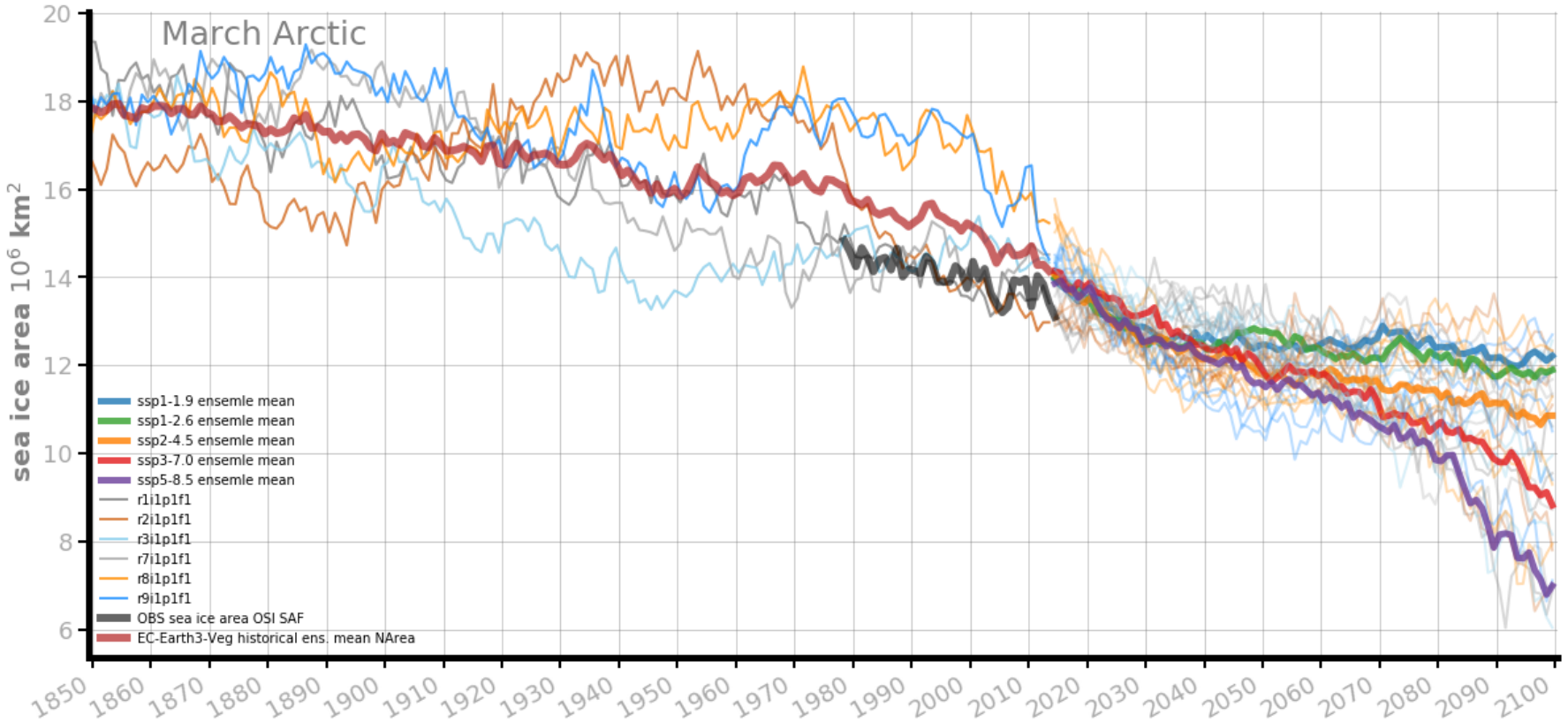
Historical & Future Arctic sea ice area



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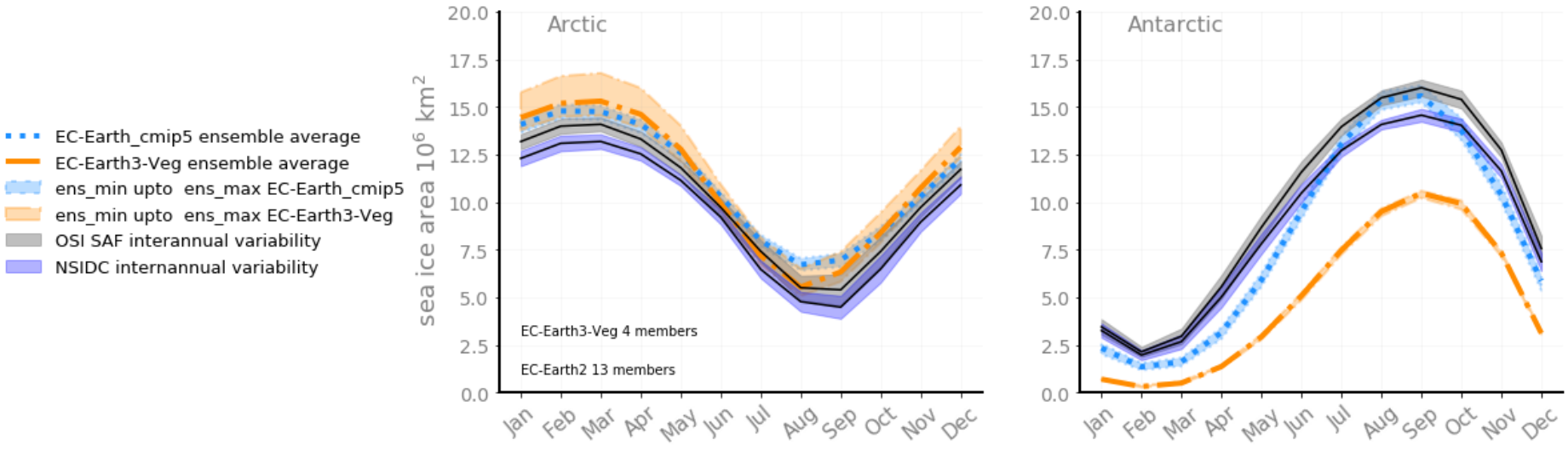
Seasonal Cycle

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 authumn 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 km^2 in September and by ~2 million km^2 in March, in line with the EC-Earth3-Veg warm bias in the Southern ocean.



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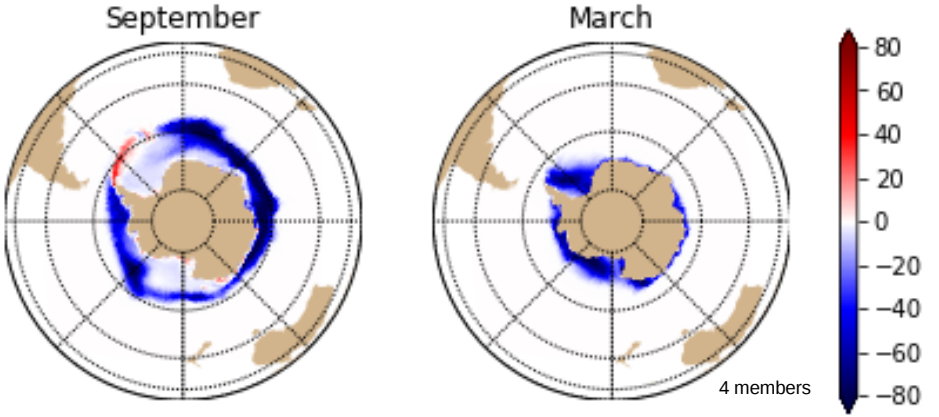
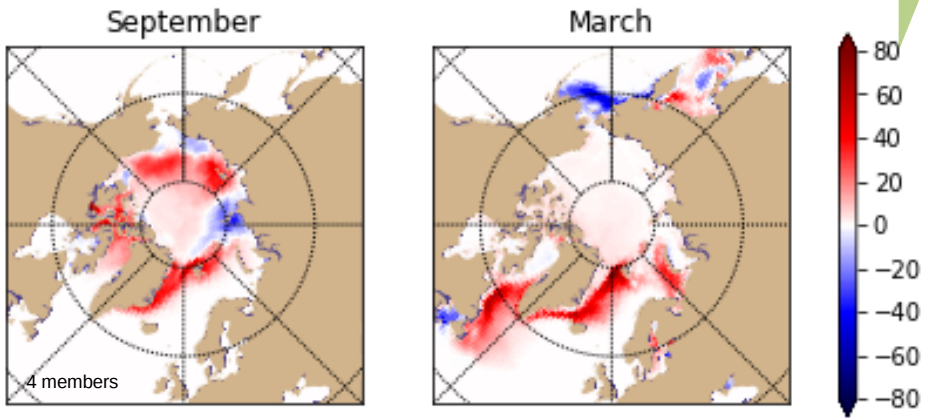
sea ice concentration

The amount of sea ice in the Southern Hemisphere is stongly under estimated, in line with the EC-Earth3-Veg Warm Southern Ocean bias.



Ensemble average of 1980-2010 averaged model minus remapped osi saf Antarctic sea ice concentration



Ensemble average of 1980-2010 averaged model minus remapped osi saf Arctic sea ice concentration

In March, EC-Earth3-Veg underestimates the concentration in sea 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.

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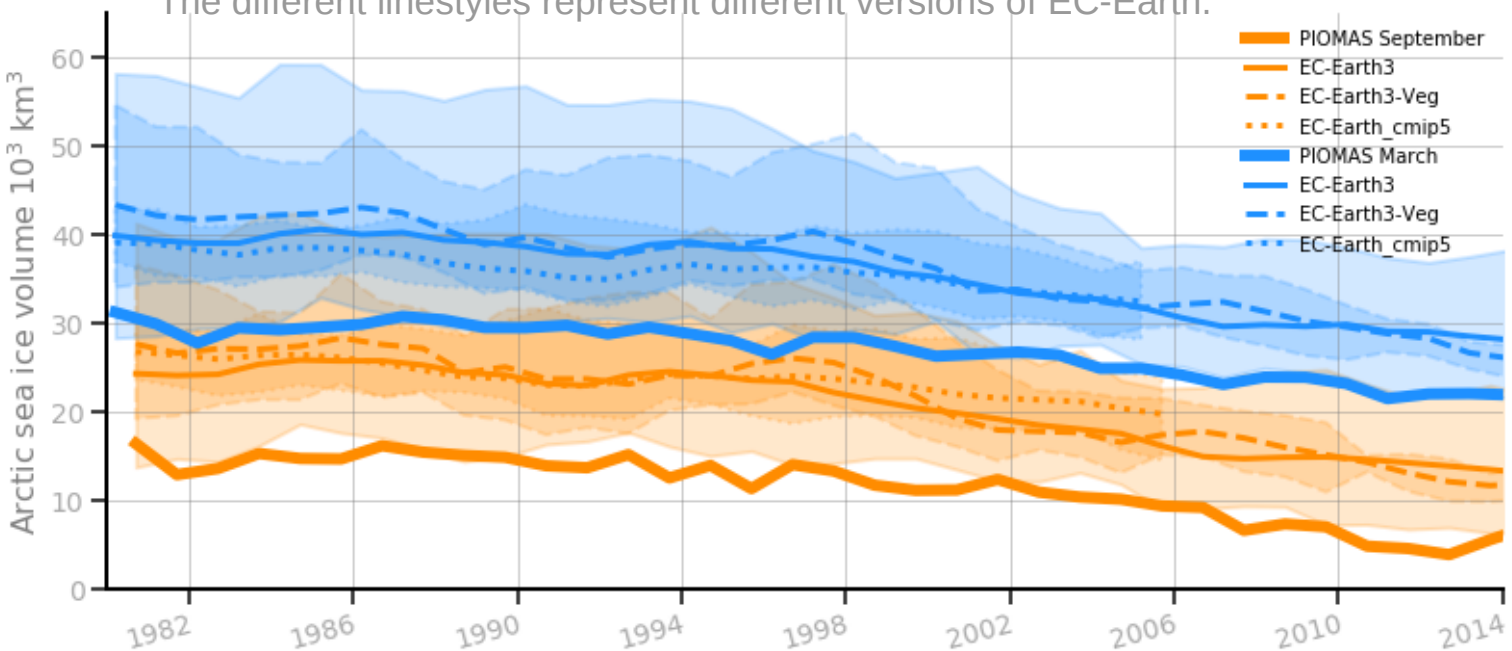
EC-Earth Arctic sea ice volume CMIP6 versus CMIP5

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.

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.



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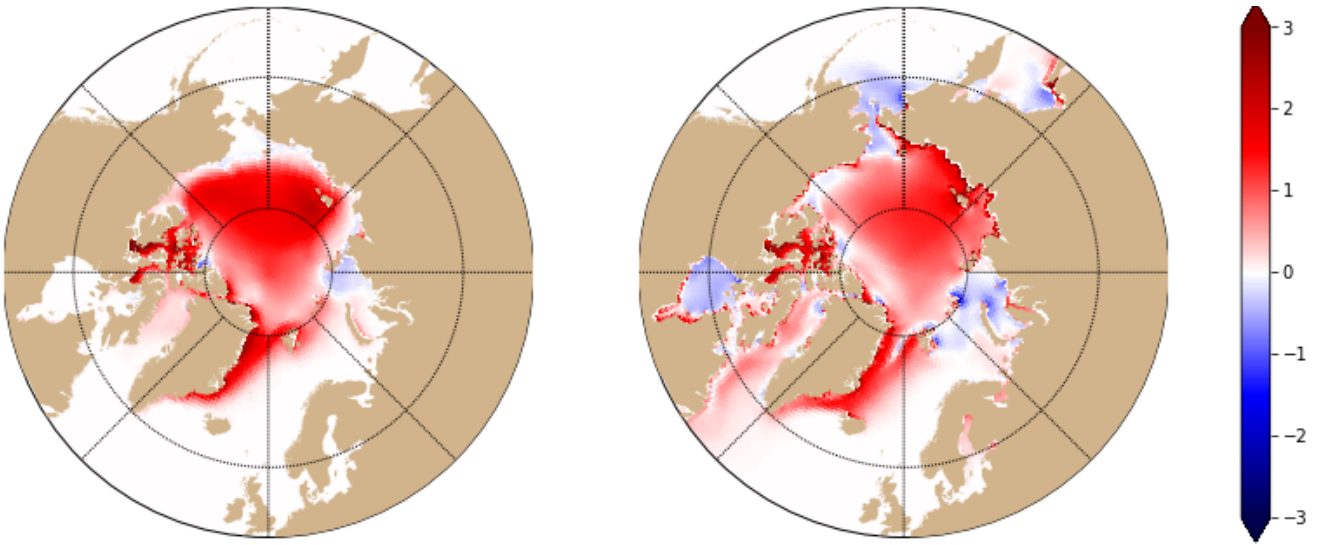
Average sea ice thickness difference with PIOMAS reanalyses

September

March



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

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)

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DATA:

EC-Earth Consortium (EC-Earth) (2019) EC-Eearth3-Veg model output prepared for CMIP6 ScenarioMIP. Version 20191118. Earth System Grid Federation

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

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

Wyser, K., van Noije, T., Yang, S., von Hardenberg , J., O'Donnel, D., Doesscher, R. (2019): ***On the increased climate sensitivity in the EC-Earth model from CMIP5 to CMIP6****, Geosci. Model Dev. Discuss.*

Notz, D., Dörr, J., Bailey, D. A., Blockley, E., Bushuk, M., Debernard, J. B., Dekker, E., DeRepentigny, P., Docquier, D., Neven. Fuckar, N.S., Fyfe, J. C., Jahn, A., Holland, M., Hunke, E., Doroteaciro, I., Khosravi, N., Mssonnet, F., Madec, G., O'Farrel, S., Petty, A., Rana, A., Roach, L., Rosenblum, E., Rousset, C., Semmler, T., Stroeve, J., Tremblay, B., Takahiro, T., Tsujino, H., Vancoppelle, M.: ***Arctic Sea Ice in CMIP6.*** *Geophysical Research Letters, e2019GL086749.*

Keen, A., Blockley, E., Bailey, D., Boldingh Debernard, J., Bushuk, M., Delhaye, S., Docquier, D., Feltham, D., Massonnet, F., O'Farrell, S., Ponsoni, L., Rodriguez, J. M., Schroeder, D., Swart, N., Toyoda, T., Tsujino, H., Vancoppenolle, M., and Wyser, K.: ***An inter-comparison of the mass budget of the Arctic sea ice in CMIP6 models****, The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-314, in review, 2020.*