

Cold and Fresh Biases of the Arctic Atlantic Water Layer in CMIP6 Models; Potential Origin and Implications

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The content of this contribution is part of the manuscript: Khosravi, Koldunov, Wang, Danilov, Hinrichs, Semmler and Jung (2019) *Temperature and Salinity Biases of the Arctic Ocean Atlantic Water Layer in CMIP6 Models* submitted to the Journal of Geophysical Research Letters (under review)

- Saline and warm Atlantic Water is the main source of oceanic heat entering the Arctic Ocean.
- Atlantic Water flows into the Arctic Ocean through two Branches, among which the Fram Strait is the major point of entry of warm water.
- One of the three broad scientific questions that CMIP6 seeks to answer is the origins and consequences of systematic model biases [1].
- To investigate the biases of the Atlantic Water inflow, we examined the model biases in temperature and salinity.

- Multi-Model-Mean (MMM) temperature (T) and salinity (S) at 400 m depth [2] are calculated for 1979-2005 using nine CMIP6 models (Table)
- Climate Signals (CS) are defined as the difference between the average over the last 30 years of the SSP experiment and the average over the last 30 years of the corresponding historical experiment
- For the sake of comparison, MMM sea-surface height (SSH) and sea-level pressure (SLP) are calculated for 1979-2005 and can be seen together with temperature and salinity in Figure 1.
- The climatological means of the observed data are provided by:
 - ocean temperature: PHC3.0 database
 - SLP: ERA5
 - SSH: DTU10MDT altimetry data

No	Model name	Institute	Grid Res.
1	AWI-CM-1-1-MR	AWI	~ 25 km
2	BCC-CSM2-MR	BCC	360×232
3	CESM2	NCAR	320×384
4	CESM2-WACCM	NCAR	360×180
5	EC-Earth3	EC-Earth-Consortium	362×292
6	EC-Earth3-Veg	EC-Earth-Consortium	362×292
7	IPSL-CM6A-LR	IPSL	363×332
8	MIROC6	MIROC	360×256
9	NESM3	NUIST	362×292

The models for which data was made available for both historical and scenario experiments (SSP245 and SSP585)

Results and Discussion

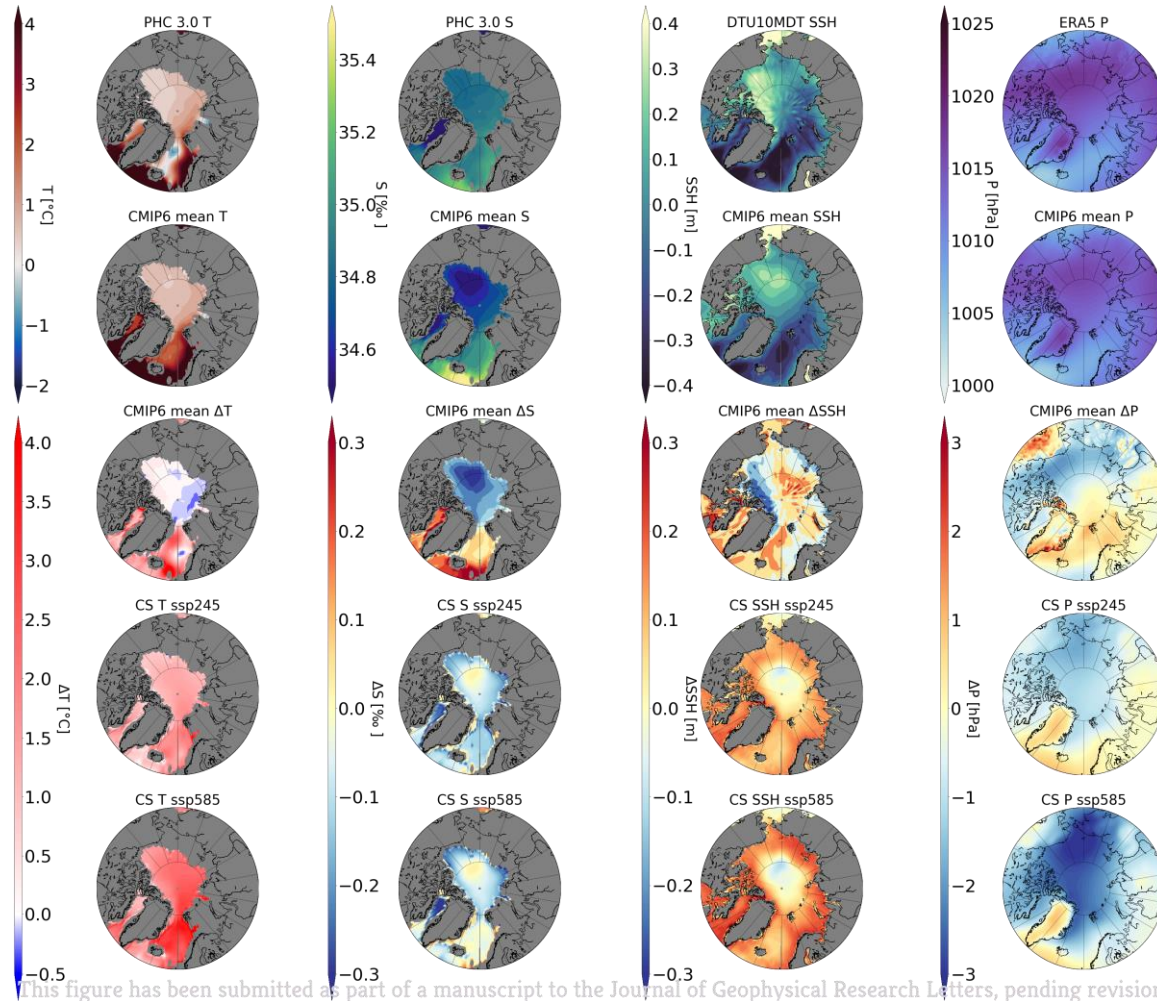


Figure 1 From top to bottom: Climatology from observations or reanalysis, multi-model means (MMM) of CMIP6 models averaged from 1979 to 2005 in their historical runs, MMM biases with respect to the observations or reanalysis, MMM climate signal (CS) for SSP245.

Results and Discussion



- The MMM sea water potential temperature and salinity fields have a warm bias in the west Spitsbergen current and Greenland Sea and a cold bias within the Arctic Ocean.
- The MMM salinity has a strong fresh bias in the Canadian Basin.
- The fresh and cold biases are due to an **insufficient Atlantic Water inflow** from the Fram Strait.
- It has been shown that the strength of the cyclonic gyre circulation in the Nordic Seas is strongly correlated with the strength of the cyclonic atmospheric circulation over the Nordic Seas [3].
- CMIP6 models on average produce a weaker cyclonic gyre circulation, which has been shown to be linked to too weak Fram Strait inflow, ergo the cold biases inside the Arctic Ocean.
- The identified biases are **not negligible** compared to the Climate signals for SSP245 and SSP585.



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2. Ilıcak, M., Drange, H., Wang, Q., Gerdes, R., Aksenov, Y., Bailey, D., ... others (2016). An assessment of the arctic ocean in a suite of interannual core-ii simulations. part iii: Hydrography and fluxes. *Ocean Modelling*, 100, 141–161
3. Wang, Q., Wang, X., Wekerle, C., Danilov, S., Jung, T., Koldunov, N., ... Sidorenko, D. (2019). Ocean heat transport into the Barents sea: Distinct controls on the upward trend and inter-annual variability. *Geophysical Research Letters*

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