Examining processes setting the sea surface salinity pattern under anthropogenic forcing and relationships to sea surface temperature

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Introduction

- Surface salinity pattern change affects ocean heat uptake, and thus climate sensitivity [1]
- Surface salinity [2] and temperature fields, are affected both by atmospheric fluxes and by ocean transport

Research questions

1. **How do freshwater fluxes and ocean transport affect the ocean surface salinity pattern?**
2. **Are changes in the surface salinity pattern correlated to changes in the surface temperature pattern?**

Key Points

- Change in freshwater fluxes results in the freshest surface regions getting fresher and the saltiest regions getting saltier
- Heat flux forcing results in change in ocean transport such that the saltiest regions get saltier
- The change in the SST field is largely due to heat flux forcing
- With a heat flux forcing, there is correlation between change in the SST and SSS patterns which may suggest some covariability of the fields due to change in ocean transport [3]

References

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2. J. D. Zika *et al.*, *Environmental Research Letters* **13**, (`http://iopscience.iop.org/article/10.1088/1748-9326/10/9/094021/meta`) (July 2018).
3. S. Kido, M. Nonaka, Y. Tanimoto, *Geophysical Research Letters* **48**, ISSN: 19448007 (Dec. 2021).
4. J. M. Gregory *et al.*, *Geosci. Model Dev* **9**, 3993–4017, (`www.geosci-model-dev.net/9/3993/2016/`) (2016).
5. A. Todd *et al.*, *Journal of Advances in Modeling Earth Systems* **12**, ISSN: 1942-2466, (`https://onlinelibrary.wiley.com/doi/10.1029/2019MS002027`) (Aug. 2020).

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Characterizing the surface salinity pattern

- Categorize salinity pattern by applying a Gaussian Mixture Model (GMM) to the surface salinity distribution in control experiment
- Each mixture making up the surface salinity distribution represents salinities in a particular range which can be collocated to regions (Figure 2)
- Examine change in surface salinity to separate heat flux, freshwater flux, and wind stress step forcings in identified mixtures using data from the ocean only Flux-Anomaly-Forced Model Intercomparison Project (FAFMIP) which applies forcings extracted from 1% CMIP5 experiments at the time of doubling [4, 5]

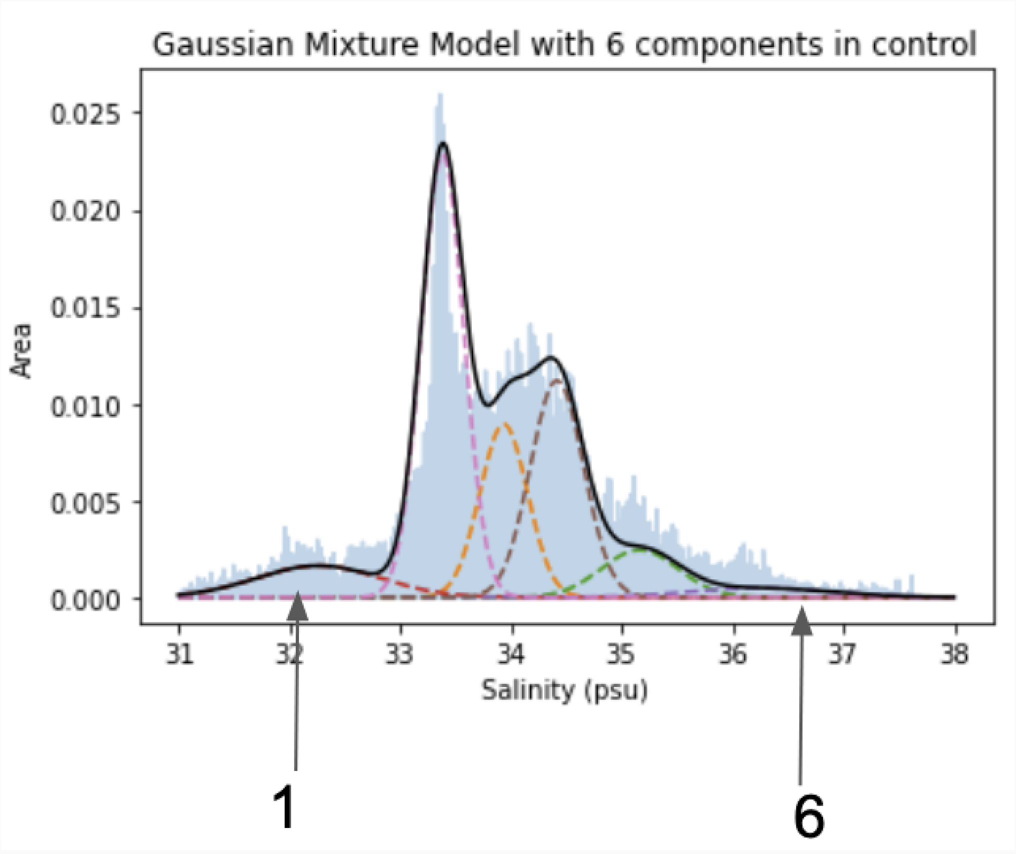

Figure 1. Distribution of surface salinity in control run of HadOM3. A Gaussian Mixture Model (GMM) with 6 components is fit to the distribution. The mixtures are numbered 1 (freshest) to 6 (saltiest).

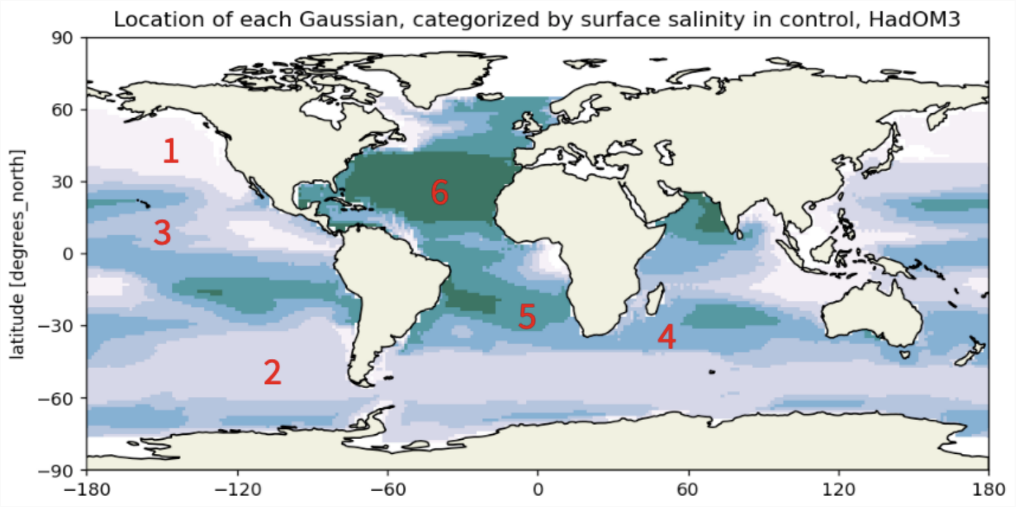

Figure 2. Map of locations of mixtures identified through GMM fit to surface salinity distribution in a control run in HadOM3. The numbers on the map correspond to the mixture numbering shown in Figure 1.

Response of surface salinity

- Mean surface salinity difference between end of FAFMIP forced experiments and control in mixtures found from control distribution GMM (Figures 1 and 2)
- **Freshwater flux forcing:** freshest regions get fresher and saltiest regions get saltier
- **Heat flux forcing:** largest changes in salinity are in saltiest regions (subtropics) where the magnitude of change is the same as for freshwater flux forcing
- **Wind stress forcing:** minimal change in salinity pattern

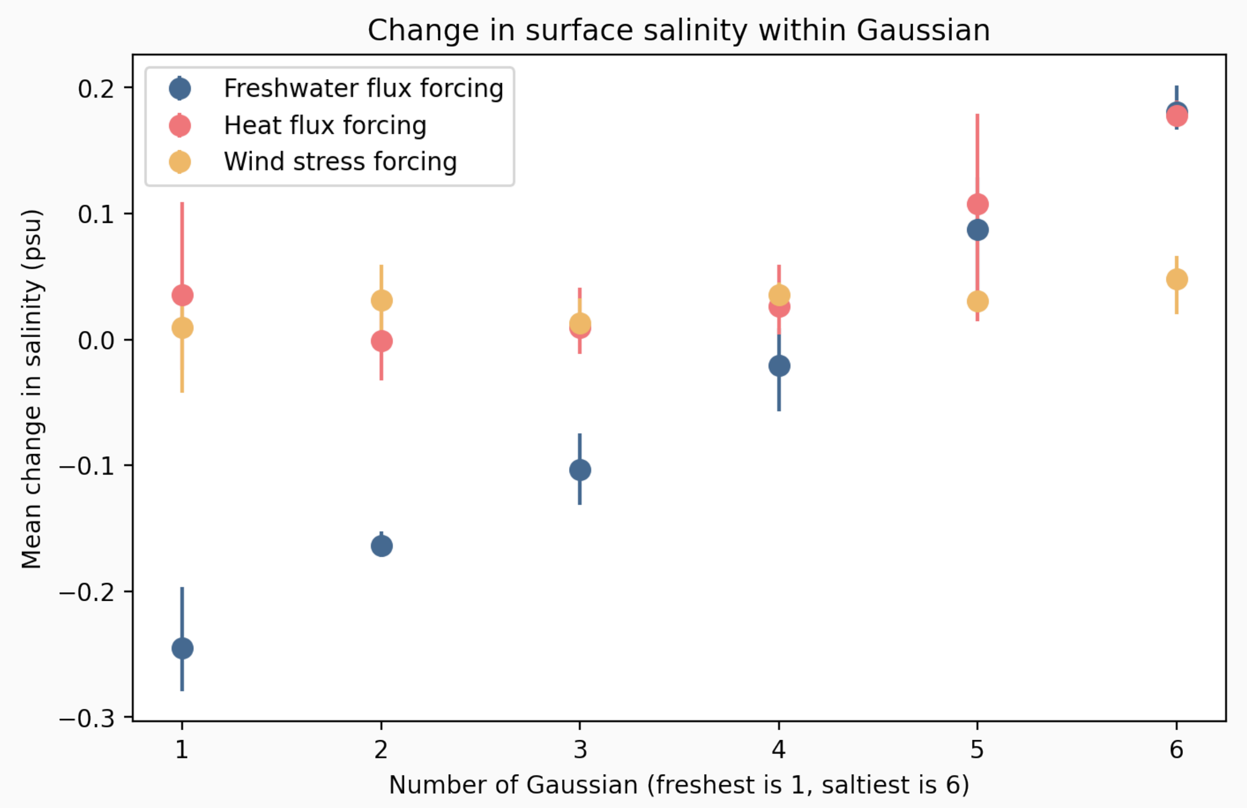

Figure 3. Mean change in surface salinity in the last decade of the forced experiment compared to the last decade of the control experiment in each region.

Relationship to change in surface temperature

- Mean surface temperature difference between end of FAFMIP forced experiments and control in mixtures found from control salinity distribution GMM (Figures 1 and 2)
- Changes in SST are mostly due to heat flux forcing with small effects from freshwater flux and wind stress change
- Pattern of SST change due to heat flux correlates with pattern of SSS change due to heat flux shown in Figure 3

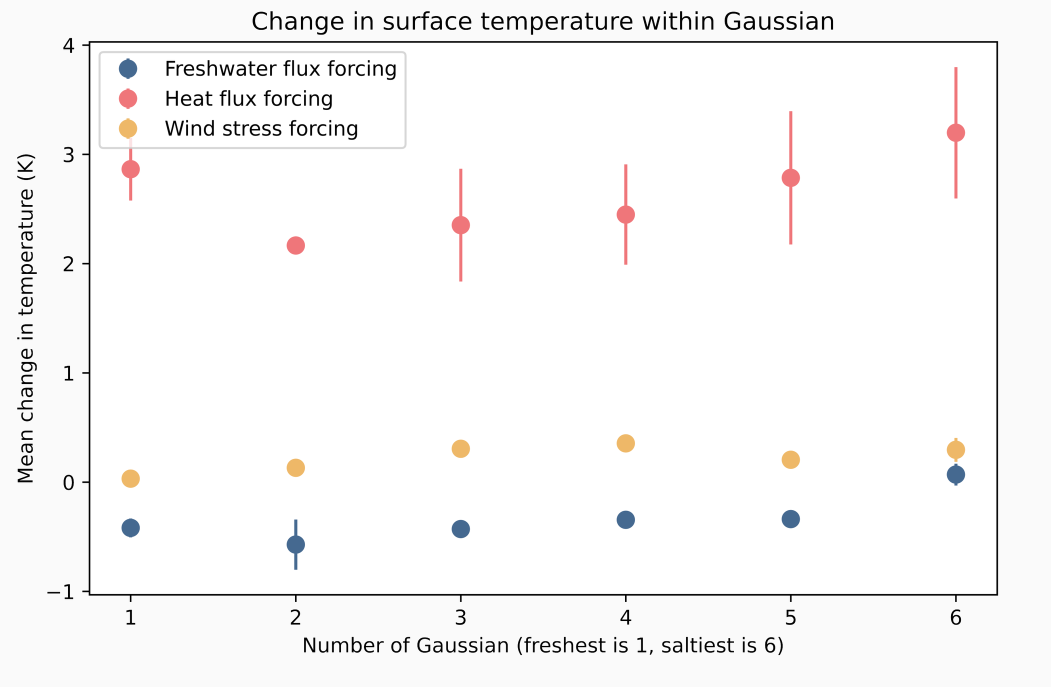

Figure 4. Mean change in surface temperature in the last decade of the forced experiment compared to the last decade of the control experiment in each region.

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