Cloud feedback depends on Southern Ocean salinity

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1 Introduction

Background

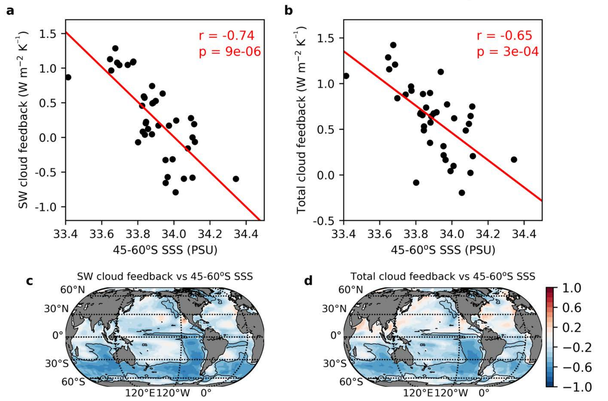
- It has been well established that at the heart of the inter-model spread in equilibrium (or effective) climate sensitivity is cloud feedback primarily attributed to shortwave (SW) cloud feedback.
- The spread in SW cloud feedback has been thought to largely originate from models' difference in cloud parameterizations.

New proposal and work

- We proposed that, besides cloud parameterizations, salinity-dominated Southern Ocean heat uptake also plays an important role in models' spread in SW cloud feedback.
- We explored a suite of 40 CMIP6 coupled climate models to examine the salinity impact on OHU and SW cloud feedback and underlying physical mechanisms.

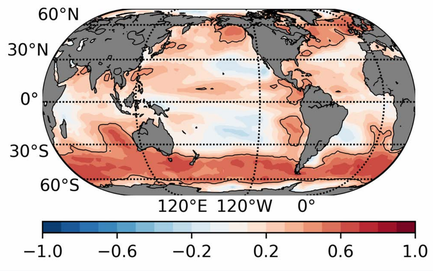
2 Statistical link between Southern Ocean salinity and cloud feedback

Correlation: 45-60S SSS and SW cloud feedback



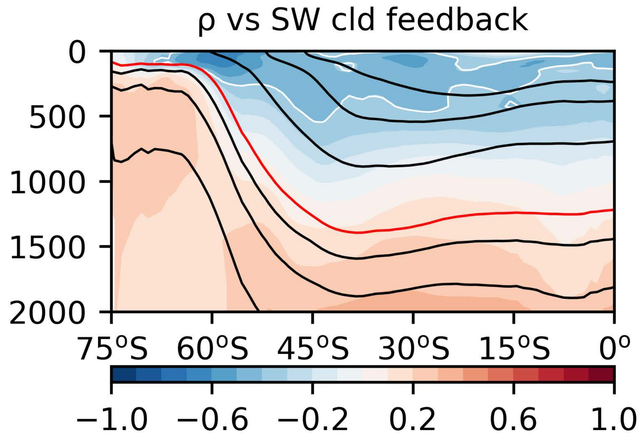
- 45-60S sea surface salinity (SSS) statistically account for more than half of the variance of SW cloud feedback from CMIP6 climate models.
- There is a slight drop in terms of cloud feedback, partially due to the canceling effect arising from the positive correlation between 45-60S SSS and Southern Ocean longwave (LW) cloud feedback, see below.

Correlation: 45-60S SSS and LW cloud feedback

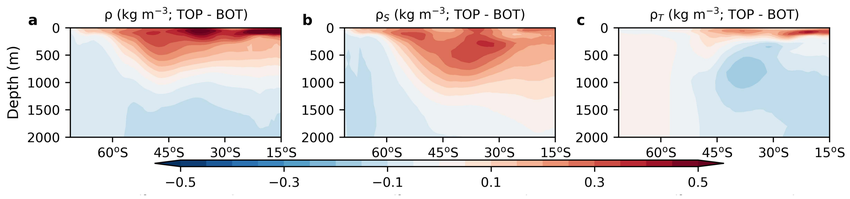


3 Salinity impact on Southern Ocean heat uptake

Correlation: global-mean SW cloud feedback and zonal-integral ocean density

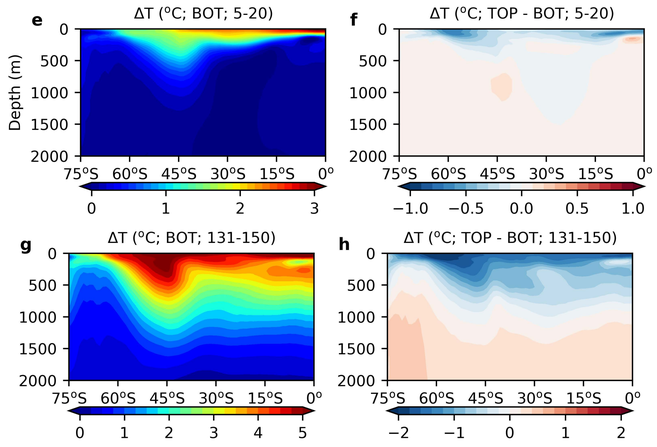


Ocean density difference between TOP and BOT 45-60S salinity models and its contribution from salinity and temperature



- Models' difference in Southern Ocean density is dominated by salinity rather than temperature.

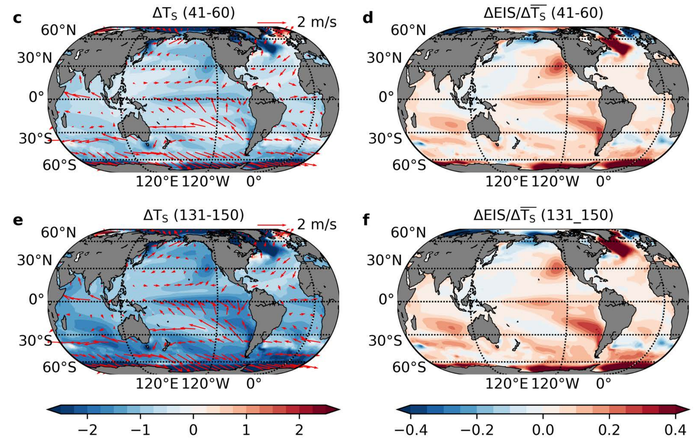
Difference in ocean temperature response between TOP and BOT 45-60S salinity models



- Salinity-dominated ocean stratification difference leads to deeper ocean warming in the top salinity models: less warming in the upper ocean and more warming in relatively deep ocean.

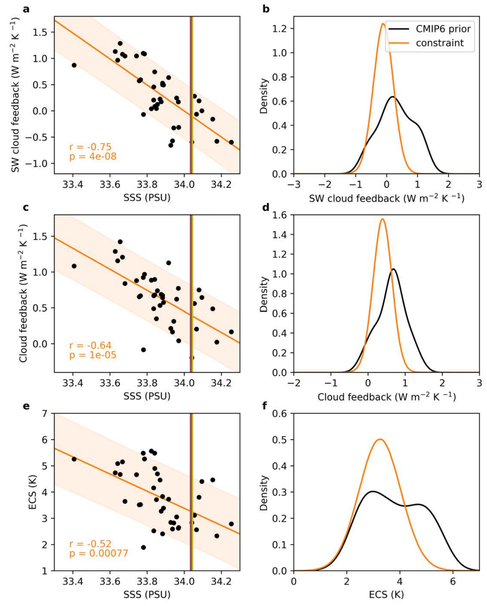
4 The physical link between OHU, sea surface warming and cloud feedback

TOP minus BOT: surface temperature and normalized estimated inversion strength response



- The deeper warming in top salinity models leads to reduced surface warming in both local oceans and remote tropical and subtropical oceans, arising from northward advection of surface waters due to enhanced trade winds.
- Models' difference in surface warming pattern further influences their difference in lower tropospheric stability represented by estimated inversion strength.
- Both surface warming and inversion strength contribute to models' spread in SW cloud feedback seen in Section 2.

5 Emergent constraint on cloud feedback and climate sensitivity using 45-60S SSS



- The emergent constraint reduces models' spread in cloud feedback and effective climate sensitivity.
- The constraint argues against high cloud feedback and high climate sensitivity models.