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Historical changes in fresh water transport from sub-tropical to sub-polar oceans

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Warming-induced global water cycle changes pose a significant threat to biodiversity and humanity. The atmosphere transports freshwater from the sub-tropical ocean to the tropics and poles in two distinct branches. The resulting air-sea fluxes of fresh water and river run-off imprint on ocean salinity (S) at different temperatures (T), creating a characteristic `T-S curve' of mean salinity as a function of temperature. Using a novel tracer-percentile framework, we quantify changes in the observed T-S curve from 1970 to 2014. The warming ocean has been characterised by freshening tropical and sub-polar oceans and salinifying sub-tropical oceans. Over the 44 year period investigated, a net poleward freshwater transport out of the sub-tropical ocean is quantified, implying an amplification of the net poleward atmospheric freshwater transport. Historical reconstructions from the 6th Climate Model Intercomparison Project (CMIP6) exhibit a different response, underestimating the peak salinification of the ocean by a factor of 4, and showing a weak freshwater transport *into* the sub-polar ocean. Results indicate this discrepancy between the observations and models may be attributed to consistently biased representations of evaporation and precipitation patterns, which lead to the the weaker amplification seen in CMIP6 models.