Geophysical Research Abstracts
Vol. 18, EGU2016-11387, 2016
EGU General Assembly 2016

Drivers of long-term ocean salinity changes

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Previous work has highlighted near-surface salinity pattern amplification (PA) and depth-integrated halosteric (salinity-driven) sea-level changes in long-term change estimates from observations and climate model simulations. These suggest that fresh ocean regions are becoming fresher, and salty regions saltier in part to a response to evaporation minus precipitation (E-P; water cycle) changes driven by a warming Earth.

While near-surface salinity changes relate to the climatological mean (fresh becoming fresher, salty becoming saltier), subsurface salinity changes have also been recorded. Similar to the near-surface, these changes represent a complex three-dimensional structure that is different in each ocean basin. Like near-surface changes, subsurface salinity changes also share a strong correspondence with the subsurface climatological mean. When integrated through the depth of observed data coverage (0-2000 m), these show a clear basin halosteric contrast – a freshening Pacific and an enhancing Atlantic salinity a fingerprint of change that has been successfully attributed to anthropogenic climate change in previous studies.

As long-term observational insights are limited, model simulations provide a novel method to assess and validate observed change estimates, and attribute the drivers of long-term change. Using the CMIP (Coupled Model Intercomparison Project phase 3 & 5) 20C3M/historical (20th century), SRES/RCP (future 21st century) and pre-industrial (piControl; unforced) simulations, these basin salinity change contrasts are investigated and their relationship to simulated E-P (water cycle) changes is diagnosed. The intrinsic variability of both modelled salinity and E-P change fields is investigated to ascertain an envelope of unforced (piControl) climate variability, an estimate currently unavailable for long-term observational estimates due to poor measurement coverage. These unforced distributions are compared to those of weakly- (20C3M/historical) and strong-forced (SRES/RCP) simulations to assess for the emergence of an anthropogenic-forced fingerprint from intrinsic variability as defined by the models.

Using the forced-signal versus variability assessments from models, estimates of observed salinity change are revisited, and the significance of resolved changes over 1950-present are investigated.