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A role of ocean gyre related to an extended ocean boundary via retreat of a Pine Island Glacier ice front

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Abstract Text:

The ocean gyre within the Pine Island Bay (PIB) in front of the Pine Island Glacier (PIG) plays a crucial role in distributing of heat toward the sub-ice-shelf by controlling the amount of Circumpolar Deep Water incursion. The strength of gyre in the PIB is modified under the influence of oceanic and atmospheric forcing, but its spatial variability and effect of PIG ice front retreat on its location have not been addressed. Hydrographic measurements have been successfully conducted in the PIB from January to March 2020 via two cruises as part of LIONESS-TG (January–February 2020) and ITGC-TARSAN/THOR (February–March 2020). Here, we present the results of hydrographic data analysis to demonstrate an anti-cyclonic gyre (Left cell) that was dominant in the PIB center during the period of February 2020 in contrast to the case of February 2009 when a cyclonic gyre prevailed in the area. In February 2020, a cyclonic gyre (Right cell; 17 km) was centered in the location closer to the recently retreated ice front of PIG due to a reduction in circulation cell size accompanied by a decrease in ocean heat content (3.4 GJ) and weakening of negative (cyclonic) wind stress curl (3.9×10^{-7} N/m^3; ERA5) in this area compared to the case of February 2009 (25 km, 3.7 GJ, and 4.5×10^{-7} N/m^3). The existence of counter-rotating gyres (double-cell) is newly identified from the 2020 observations, which is distinct from the single gyre in 2009. A cyclonic gyre would effectively deliver heat into an ice shelf cavity in this region, which leads us to anticipate a high basal melting rate in 2020 comparable to that in 2009. However, the estimated melt rate is much lower than expected, which is attributed to the formation of the anti-cyclonic gyre in the middle of the PIB (Left cell) — away from the ice front — that likely blocks heat transport to the Right cell. Our results highlight the important roles of the PIB gyres in relation to the ice front migration on heat transport into the sub-ice-shelf and basal melting rates that would help to improve model parameterization of ice shelf-ocean interaction.

Session Selection:
C011. *Ongoing evolution of the climate-ice-ocean system on the Amundsen Sea - West Antarctic coast*

Submitter's E-mail Address:
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Abstract Title:

A role of ocean gyre related to an extended ocean boundary via retreat of a Pine Island Glacier ice front

Requested Presentation Type:
Assigned by Program Committee (Oral, eLightning, or Poster)

Previously Published?:
No

AGU On-Demand:
Yes

Abstract Payment:
Paid (agu-fm20-718243-5743-9992-7390-7912)

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