2018-0334

# 서남극 아문젠해 남극순환심층수 경년변동성: 아라온 관측 및 해양모델

박태욱, 김태완, 조경호, 이상훈
극지연구소
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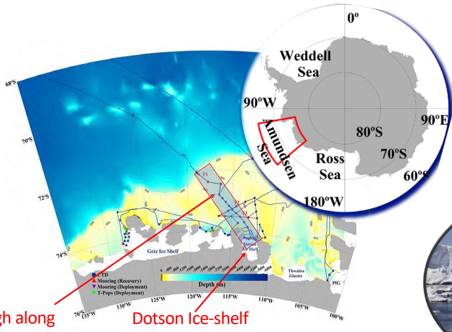
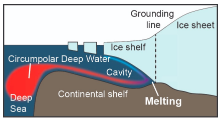
Outlet glaciers of the Amundsen Sea in the west Antarctica have thinned over recent decades. Circumpolar Deep Water (CDW) originated from Antarctic Circumpolar Current is responsible for the thinning due to basal melting beneath ice shelves. Observations based on mooring stations as well as hydrographic survey have shown that CDW intrusion and behaviors in the Amundsen Sea show year-to-year variations. In this study, we analyzed model data (2001-2016) of a high-resolution MITgcm ocean model that allows ocean-ice shelf interaction, by comparing with observational data including a recent ARAON expedition. We find that different hydrographic structure in 2012 and 2014 attribute to wind stress curl and its relevant up- and downwelling processes in the oceanic interior.




Map of the Amundsen Sea study area. Blue dots denote the CTD stations visited during ARAON expedition. A transects is selected along the Dotson Trough.

Underwater melting of Antarctic ice far greater than thought **"The base of the ice around the south pole shrank by 1,463 km² between 2010 and 2016" (Konrad, 2018)**

Diagram illustrating how **Circumpolar Deep Water (CDW)** flows onto the continental shelf and drives high melt rates at the grounding line of glaciers in the Amundsen Sea Embayment (www.AntarcticGlaciers.org)




## 1. Hydrographic characteristics in 2012 and 2014 (Observation and Model)

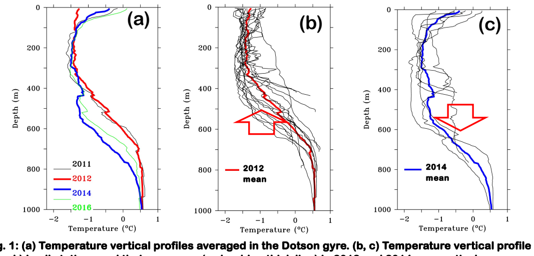



**Fig. 1: (a) Temperature vertical profiles averaged in the Dotson gyre. (b, c) Temperature vertical profile (black) in all stations and their averages (red or blue thick line) in 2012 and 2014, respectively.**

**OBSERVATION (Temperature)**

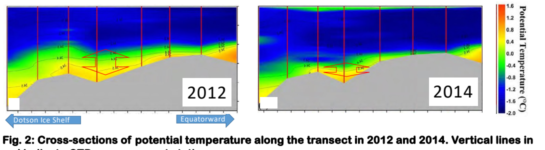



**Fig. 2: Cross-sections of potential temperature along the transect in 2012 and 2014. Vertical lines in red indicate CTD measurement stations.**

**Ocean model (MITgcm) simulation**

- Regional Amundsen and Bellingshausen Seas simulation from 2001-2016 (Nakayama and Menemenlis)
- This is improved version of Nakayama et al 2018 with 70 vertical layers.

**MODEL (Temperature)**

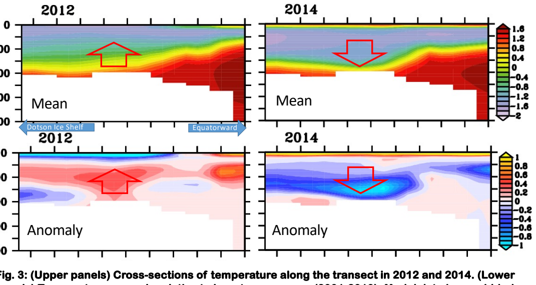



**Fig. 3: (Upper panels) Cross-sections of temperature along the transect in 2012 and 2014. (Lower panels) Temperature anomaly relative to long-term average (2001-2010). Model data is re-gridded on 0.25$^{o}$ Gaussian grid.**

➢ Observed vertical profiles show that CDW layer in 2012 is thicker than that in 2014 in a south of 72.5°S along the Dotson Trough (Figs. 1, 2). The observed structures are demonstrated in the model simulation (Fig. 3) .

## 2. Oceanic responses to wind stress curl in Dotson cyclonic gyre

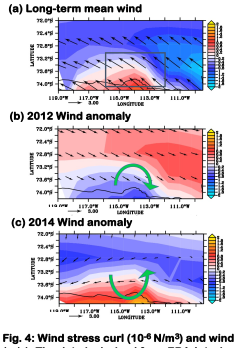



**Fig. 4: Wind stress curl ($10^{-6}$ N/m³) and wind vector (m/s). The data is derived from ERA-Interim dataset.**

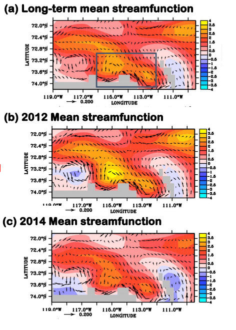



**Fig. 5: Simulated streamfunction (color; mSV) and ocean current (arrows; m/s).**

➢ Dotson cyclonic gyre is stronger in 2012 and weaker in 2014 (Fig. 5). The wind stress curl (Fig. 4) has a strong negative correlation with oceanic streamfunction (Fig. 6), indicating warming (cooling) in the ocean interior under cyclonic (anticyclonic) wind anomaly condition (Fig. 7).

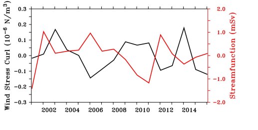



**Fig. 6: Anomalies of wind stress curl with oceanic streamfunction. All the variables are calculated in the cyclonic circulation area of the box in Fig. 4a. Streamfunction is extracted from the model and wind data is from ERA-Interim.**

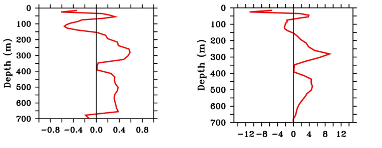



**Fig. 7: (a) Correlation and (b) regression coefficient of wind stress curl on the vertical advection term, $-w\partial T/\partial z$ in a heat budget in the model simulation (2001-2016).**

## Conclusion

➢ ARAON observations and ocean model data show that the Circumpolar Deep Water (CDW) layer near the Dotson ice-shelf has year-to-year variations.

➢ Stronger cyclonic wind stress curl in 2012 compared that in 2014 strengthens the Dotson cyclonic gyre, thereby warming in the ocean interior due to upwelled thermocline, and surface cooling due to upwelled subsurface winter water.

➢ We suggest that local wind stress curl and its relevant Ekman up- and downwelling process contributes to CDW thickness and temperature structures in the Dotson cyclonic gyre at an interannual timescale.