National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

EGU2016-15636-1

Arctic Pacific water dynamics from model intercomparison and observations

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1. Introduction

- Pacific Water brings heat and fresh water from the Northern Pacific into the Arctic Ocean and can impact Arctic sea ice [1]
- Pathways and circulation of the Pacific Water in the Arctic Ocean are not fully known due to lack of observations [2].

3. Results

- In the Beaufort Gyre wind stress curl is anti-cyclonic during the negative or neutral Arctic Oscillation (AO-) periods (1997-2007) vs. the cyclonic positive AO+ periods (1989-1996). The Ekman downwelling is stronger (Fig. 2), resulting in freshwater accumulation in the gyre during the negative / neutral AO- (Fig. 3).
- Stronger Ekman downwelling deepens the Pacific Water in the gyre, increases lateral density gradients and baroclinic response
- This leads to a stronger vertical shear in the relative vorticity, thinning of the halocline and Pacific Water divergence (Fig.4-6)
- Stronger Ekman downwelling in the Beaufort Gyre during the AO- results in Pacific water being 'pushed' out of the centre of the gyre towards the Siberian shelves (Fig. 7).

4. Discussion and Summary

- We analyse Pacific Water tracer releases in the models from the Forum for Arctic Ocean Modeling project (FAMOS)
- Schematic for the Pacific water accumulation and release in the Beaufort Gyre is proposed as follows (Fig. 8)
- Changes in winds from the cyclonic AO+ to anti-cyclonic AO- periods increase Ekman downwelling in the gyre and pushes down halocline and Pacific Water
- A stronger density gradient creates divergence of the Pacific Water towards the Beaufort Gyre periphery
- Anti-cyclonic winds reduce Pacific Water content in the gyre.

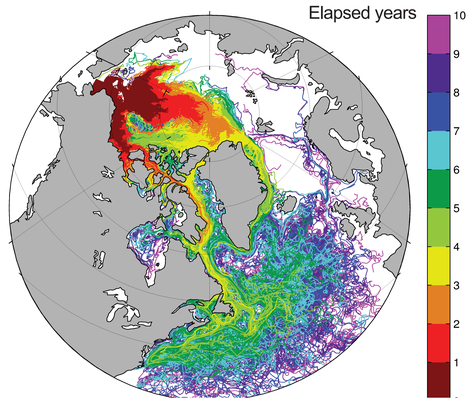

Fig. 1. Pacific water tracer release experiments in an eddy resolving/admitting NEMO 1/12°global model. The color shows the elapsed years since the tracer release. The simulations show anti-cyclonic circulation of the Pacific Water in the Beaufort Gyre and flow towards Fram Strait.

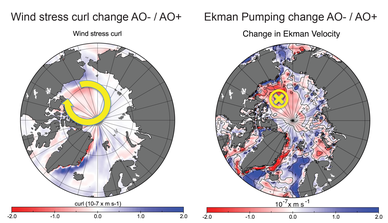

Fig. 2. Changes in wind stress curl between cyclonic AO+ and anticyclonic AO-. Ekman downwelling in the Beaufort Sea is stronger.

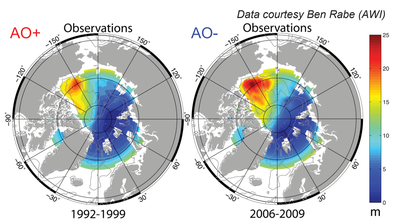

Fig. 3. Observed oceanic freshwater content in the top 500 m during the positive AO+ (1992-1999) and negative/neutral AO- (2006-2009) periods.

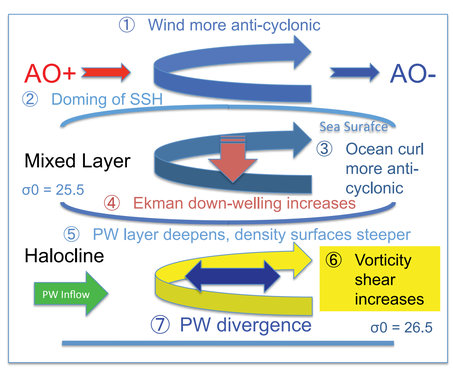

Fig. 8. Schematic of a possible wind-driven mechanism for the Pacific Water accumulation and release in the Beaufort Gyre.

2. Methods

- We analyse ocean models COCO, ECCO2, ICMMG, NAOSIM, NEMO-1°, 1/4° and 1/12° and OCCAM from the Forum for Arctic Ocean Modeling and Observational Synthesis (FAMOS) [2]
- We release Pacific tracer in Bering Strait in 1989-2007 (Fig.1)
- We investigate changes in Pacific Water due to changes in wind, oceanic potential vorticity and Montgomery potential [3,4].

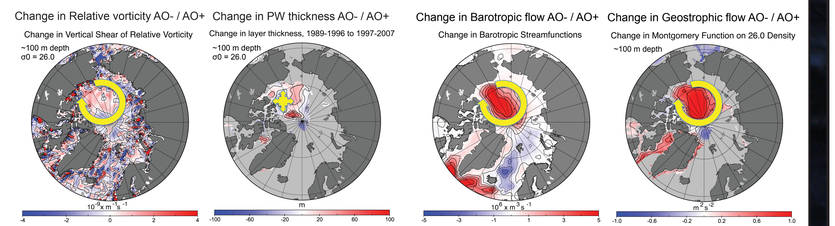

Fig. 4. Changes in voritcity vertical shear and Pacific layer thickness between cyclonic AO+ (1989-1996) and anticyclonic AO- (1997-2007).

Fig. 5. Changes in barotropic and geostrophic circulation between cyclonic AO+ (1989-1996) and anticyclonic AO- (1997-2007).

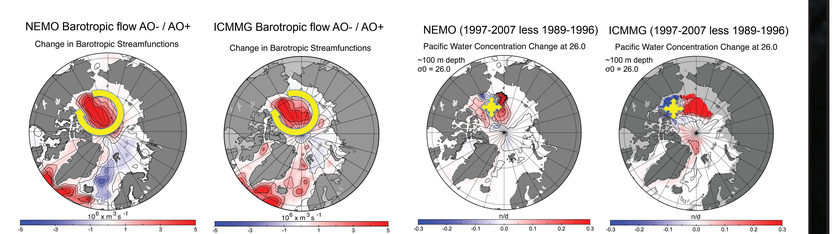

Fig. 6. Changes in barotropic circulation between cyclonic AO+ (1989-1996) and anticyclonic AO- (1997-2007) in NEMO and ICMMG models.

Fig. 7. Changes in Pacific Water between cyclonic AO+ (1989-1996) and anticyclonic AO- (1997-2007) in NEMO and ICMMG models.

References

[1] Woodgate et al., Geophys.Res. Lett., 39, 2012.
[2] Timmermans et al., J. Geophys. Res., 119, 2014.
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