Interannual variation of cyclonic eddy in Amundsen Sea Polynya, Antarctica

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CTD Observation in Amundsen Sea

CTD observation stations from N. B. Palmer, J. C. Ross, Oden, and Araon after 2000
KOPRI Amundsen Project (Field Expeditions)

2010/2011
- Stations: 30 (CTD+LADCP)
- Moorings Deploy: 2

2011/2012
- Jan 31, 2012 – March 20, 2012
- Stations: 52 (CTD+LADCP)
- Moorings Deploy: 15
  Recovery: 6

2013/2014
- Jan 1, 2014 – Jan 16, 2014
- Stations: 35 (CTD+LADCP)
- Moorings Deploy: 8 (ARAON)
  Deploy: 5 (JCR)
  Recovery: 6 (ARAON)
  Recovery: 7 (JCR)

Moorings currently in the water

KOPRI: 6 moorings (Dotson trough, In front of Dotson Ice Shelf)
SWEDEN: 2 moorings (Dotson trough, Getz Ice Shelf)
BAS: 6 moorings (In front of Pine Island Glacier & trough)
Motivation: Why Amundsen?

- Mass loss/gain of ice sheet is strongly regional.
- The amount of glacier loss: In west Antarctica > In east Antarctica
- Amundsen/Bellingshausen Seas are the most rapidly melting region in the Southern Ocean.
- Ice melting is might depended on the intrusions of warm circumpolar deep water (CDW) onto the continental shelf.

Rignot, et al. (2008), Recent Antarctic ice mass loss from radar interferometry and regional climate modelling, Nature Geoscience, 1, 106–110.
CDW intrudes onto the shelf, delivering oceanic heat to ice shelves

Jacobs et al. (2011)

Hot issue in Amundsen Sea

- Temporal and spatial variation of ocean circulation in Amundsen Sea
- Mass/Meltwater and heat budget in front of ice shelf
- Effect of glacial meltwater on ocean circulation

Thurnherr et al. (2014)
Cyclonic eddy in Amundsen Sea Polynya (ASP)

- The existence of cyclonic eddy in ASP was confirmed from observed TS and Current data.
- Core of cyclonic eddy is located at 112°W and 73.5°S.
- Eddy is bounded on the south by the DIS.
- The boundary of eddy at the north is uncertain.

Horizontal distribution of vertical averaged velocity (50-250 m) and depth of 34.1 isohaline in 2011, 2012 and 2014.

Vertical distribution of potential temperature and salinity in 2012.
Vertical distribution of Current & TS

- Westward flow (In front of DIS)
- Eastward flow (Northern boundary of ASP)
- Maximum westward velocity in front of DIS
  - $21 \text{ cm/s at } 100 \text{ m depth}$.
- Maximum westward velocity in front of DIS
  - $40 \text{ cm/s at } 75 \text{ m depth}$.
- Maximum westward velocity in front of DIS
  - $13 \text{ cm/s at } 200 \text{ m depth}$.
Monthly mean sea surface circulation & sea ice concentration

The cyclonic eddy in ASP shows the interannual variation.

The east and southward flows are dominant at northern and eastern boundary of ASP, respectively.

The strong westward flows in front of DIS lead to formation of cyclonic eddy.
Summary of results

✓ The existence of cyclonic eddy in ASP was confirmed from observed TS and Current data.
✓ Eddy is bounded on the south by the Dotson Ice Shelf (westward velocity: 40 cm/s in 2012).
✓ From OSCAR data, the cyclonic eddy in ASP shows the interannual variation.
✓ The strong westward flows in front of DIS lead to formation of cyclonic eddy in ASP.

What forcing drive the cyclonic eddy in ASP

✓ Horizontal gradient of sea surface elevation.
✓ Horizontal variation of isopycnal by melting of sea ice and glacier.
✓ Ocean surface stress by wind and sea ice motion.
• TS diagram and end-member of CDW & WW at Amundsen continental shelf

• Horizontal distribution of vertical averaged meltwater fraction (0-300m)

• Horizontal distribution of density (10m)

In 2000, 2007, 2009 and 2011, the meltwater fraction was higher than 1.5% in front of DIS.

The meltwater fraction at center of ASP was relatively low.

The density at sea surface is relatively high in front of DIS and decreasing to the north due to sea ice melting.
Horizontal distribution of wind and SSHA

In front of DIS
- **Strong Wind** → 2007, 2009, 2011
- **Weak Wind** → 2000, 2012, 2014

Along DT
- **Negative gradient of SSHA** → 2007, 2012, 2014
- **Positive gradient of SSHA** → 2000, 2009, 2011
January, 2011
- Coriolis term: $15 \times 10^{-6} \text{ m/s}^2$
- Baroclinic pressure gradient: $3 \times 10^{-6} \text{ m/s}^2$
- Barotropic pressure gradient: $5 \times 10^{-6} \text{ m/s}^2$
- Vertical friction at surface: $-15 \times 10^{-6} \text{ m/s}^2$

February, 2012
- Coriolis term: $22 \times 10^{-6} \text{ m/s}^2$
- Baroclinic pressure gradient: $-5 \times 10^{-6} \text{ m/s}^2$
- Barotropic pressure gradient: $-4 \times 10^{-6} \text{ m/s}^2$
- Vertical friction at surface: $-3 \times 10^{-6} \text{ m/s}^2$

January, 2014
- Coriolis term: $7 \times 10^{-6} \text{ m/s}^2$
- Baroclinic pressure gradient: $-1 \times 10^{-6} \text{ m/s}^2$
- Barotropic pressure gradient: $-3 \times 10^{-6} \text{ m/s}^2$
- Vertical friction at surface: $-7 \times 10^{-6} \text{ m/s}^2$
Interannual variation of current velocity and effect of wind and SSH gradient in front of DIS

- Northwestward wind is dominant
- Westward flow in front of DIS depended on the SSH gradient in February.
Thank you!