Interannual variation of cyclonic eddy in Amundsen Sea Polynya, Antarctica

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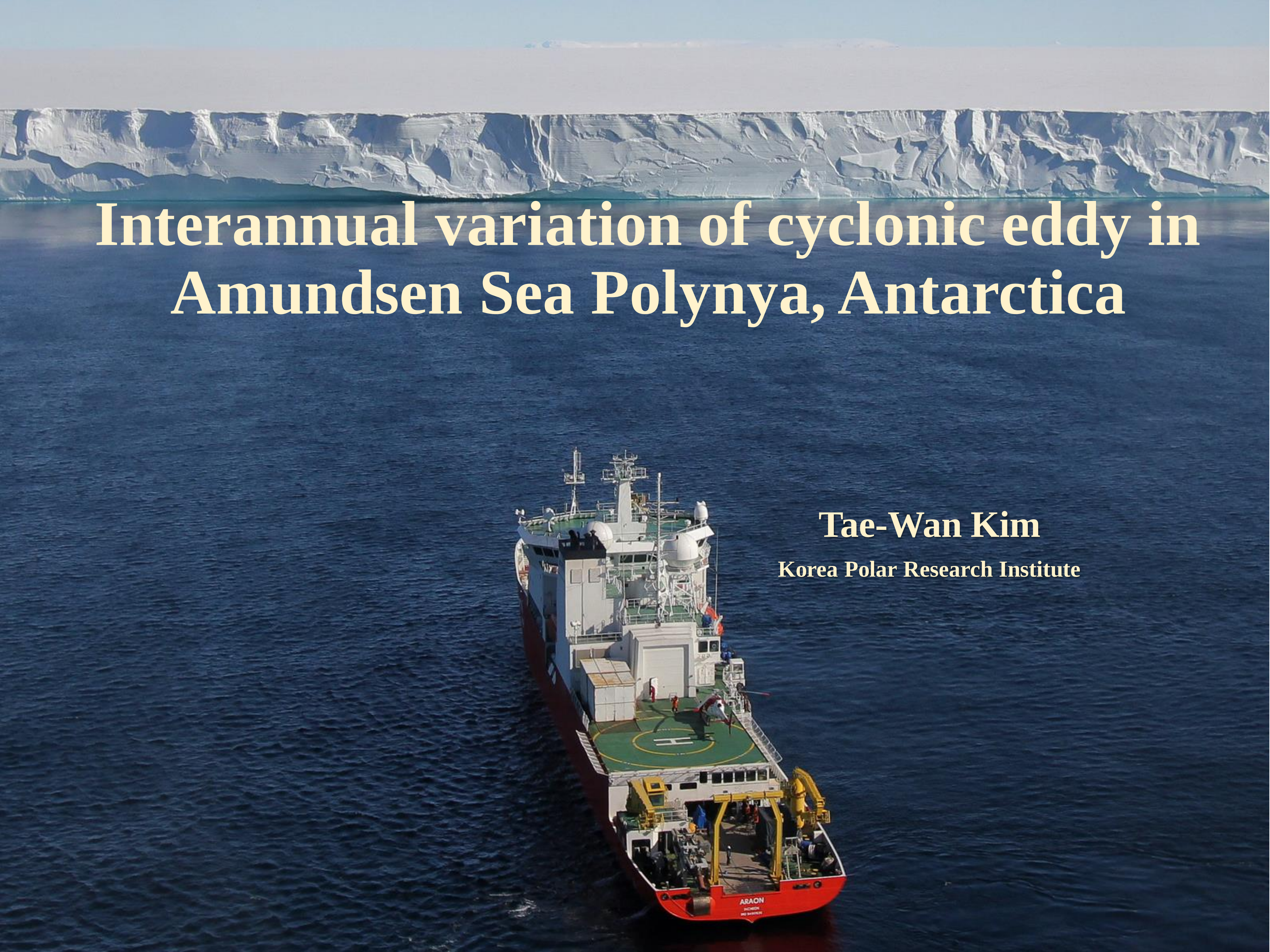
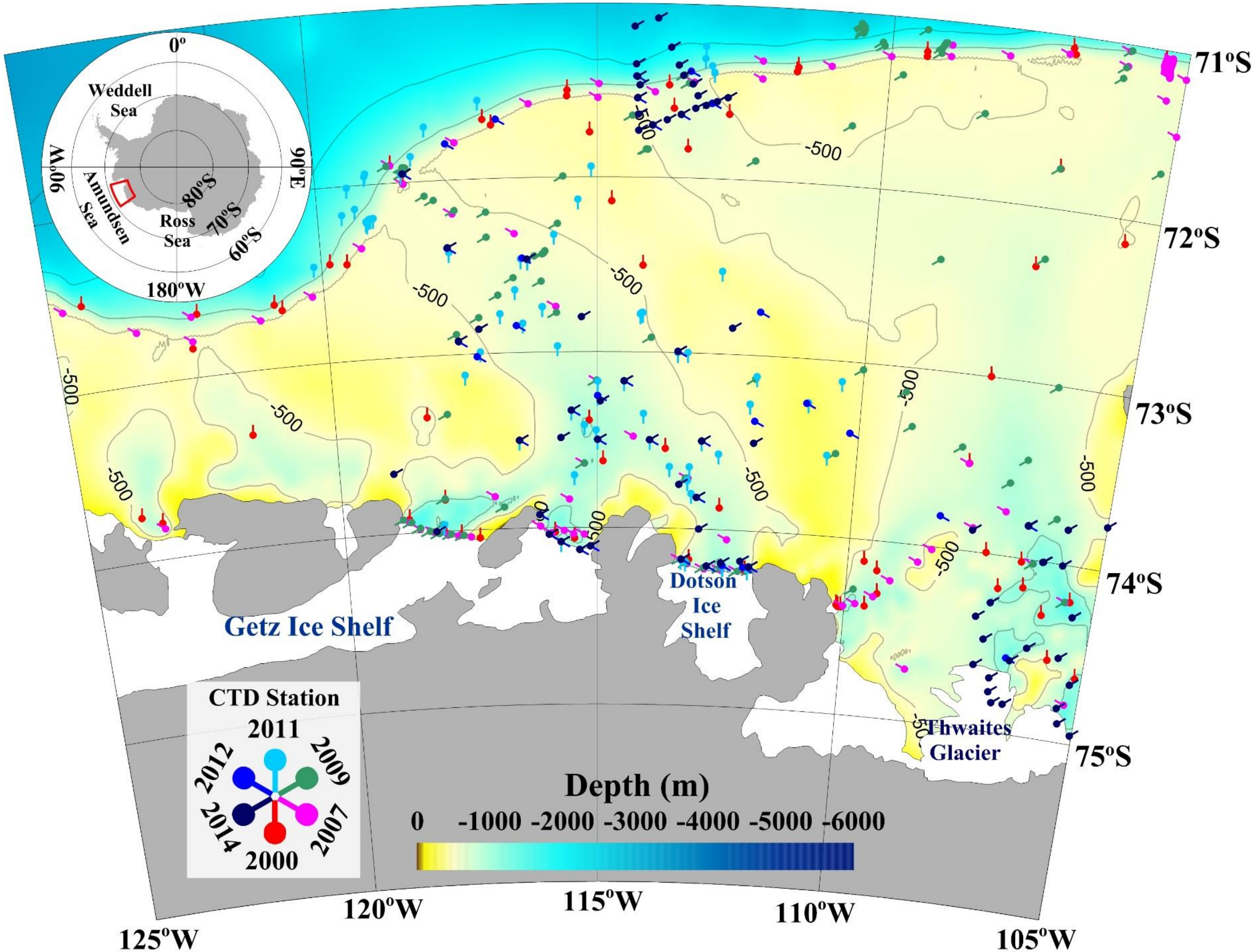
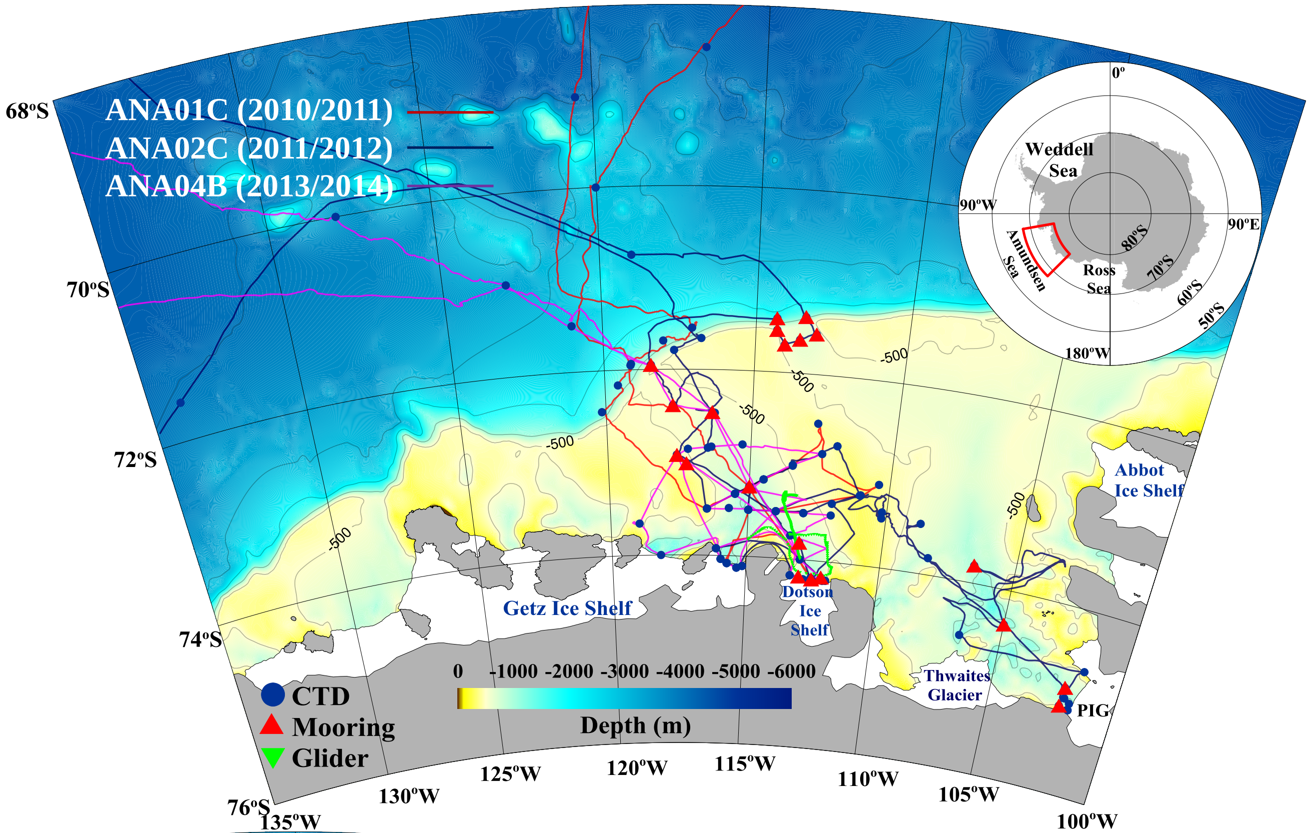


CTD Observation in Amundsen Sea



CTD observation stations from N. B. Palmer, J. C. Ross, Oden, and Araon after 2000

KOPRI Amundsen Project (Field Expeditions)



2010/2011

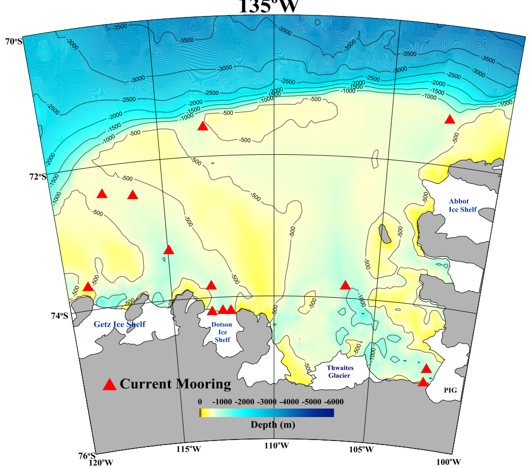
- Dec 21, 2010 – Jan. 23, 2011
- Stations: 30 (CTD+LADCP)
- Moorings Deploy: 2

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)



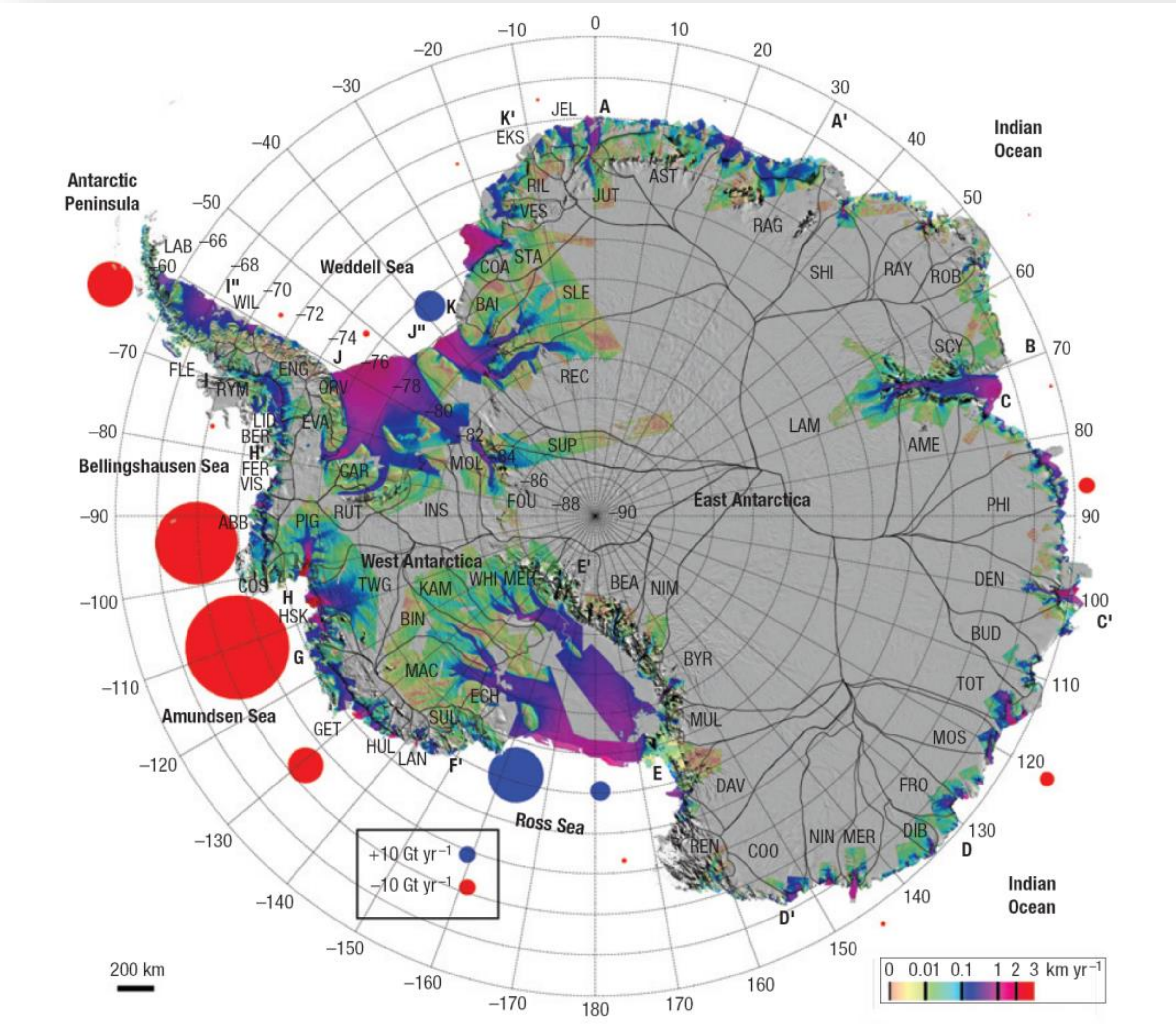
Moorings currently in the water

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)

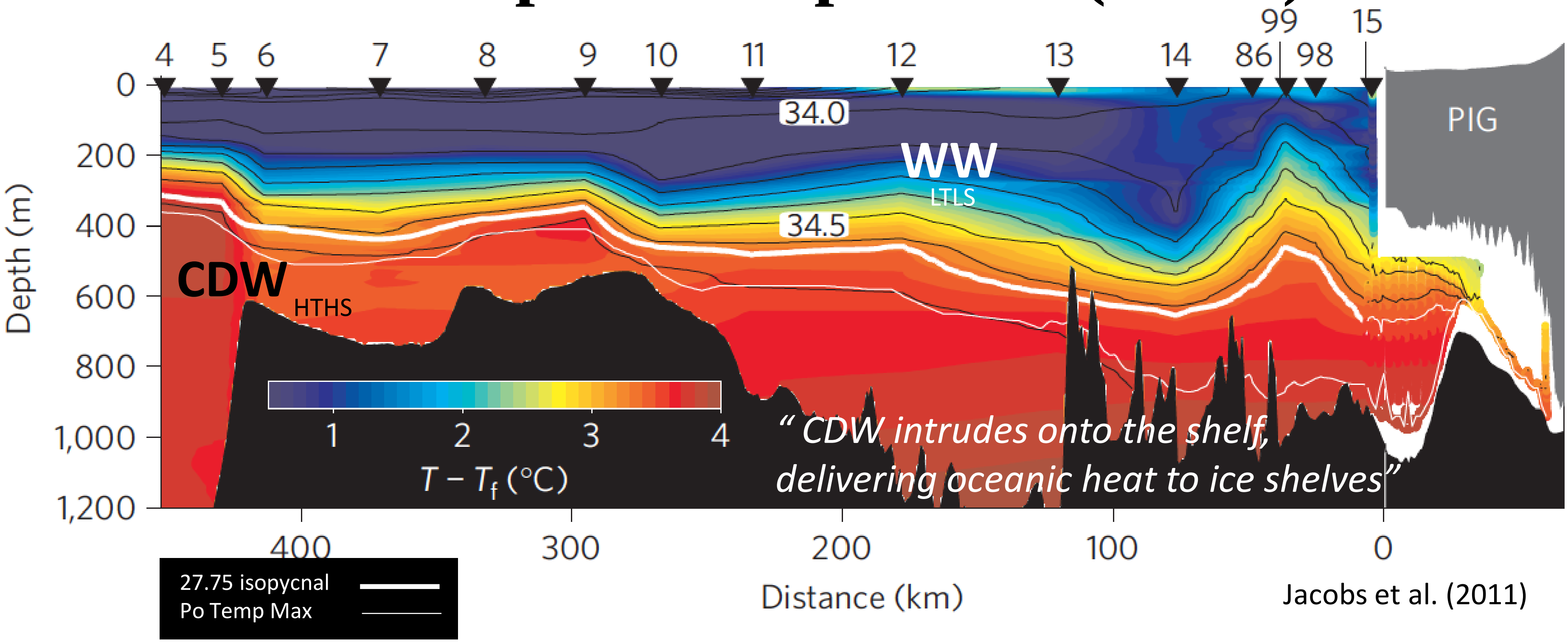
Motivation: Why Amundsen?



Rignot, et al. (2008), **Recent Antarctic ice mass loss from radar interferometry and regional climate modelling**, *Nature Geoscience*, 1, 106– 110.

- 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.

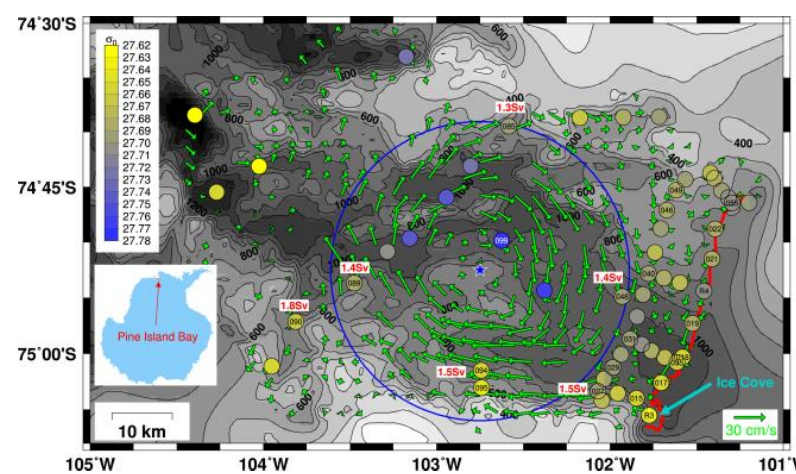
Circumpolar Deep Water (CDW)



Jacobs et al. (2011)

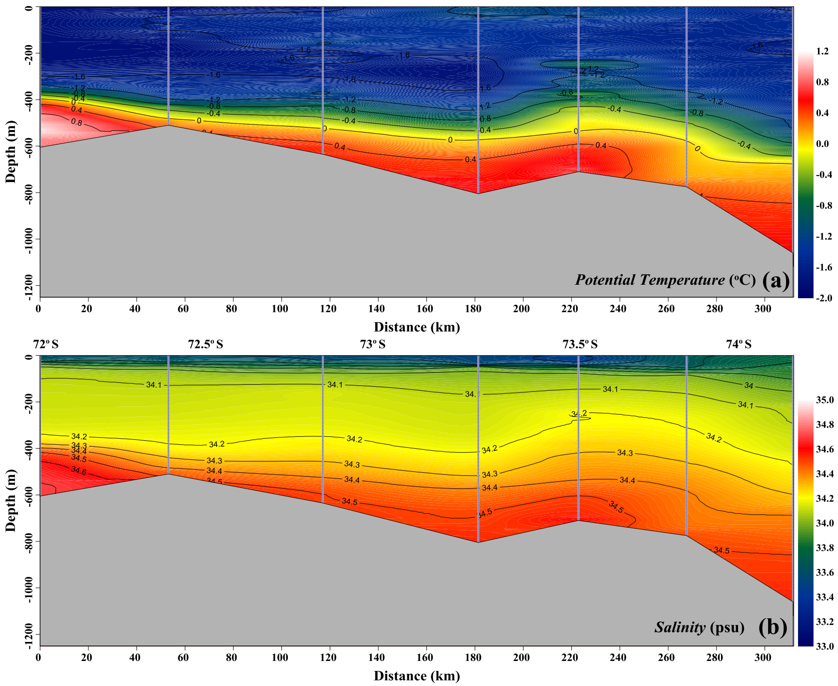
Hot issue in Amundsen Sea

- ✓ 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



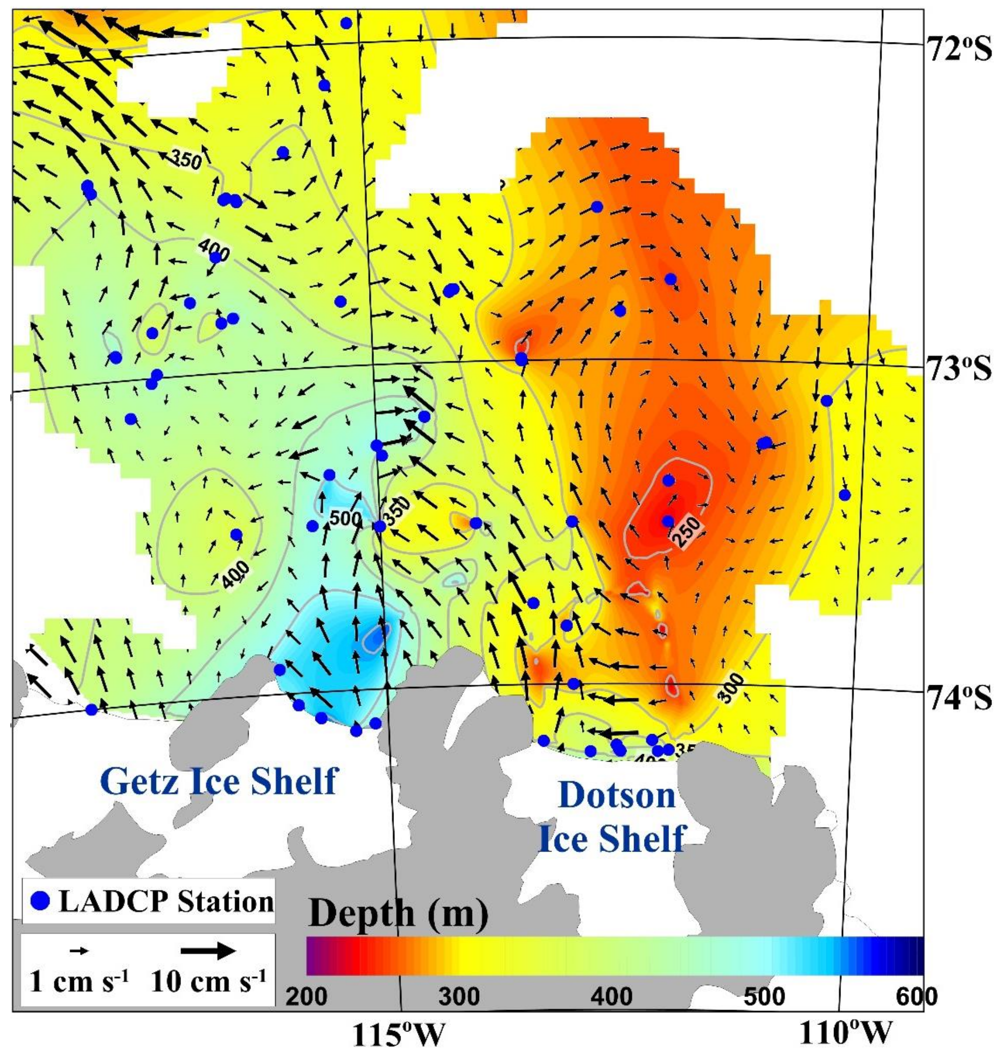
Thurnherr et al. (2014)

Cyclonic eddy in Amundsen Sea Polynya (ASP)



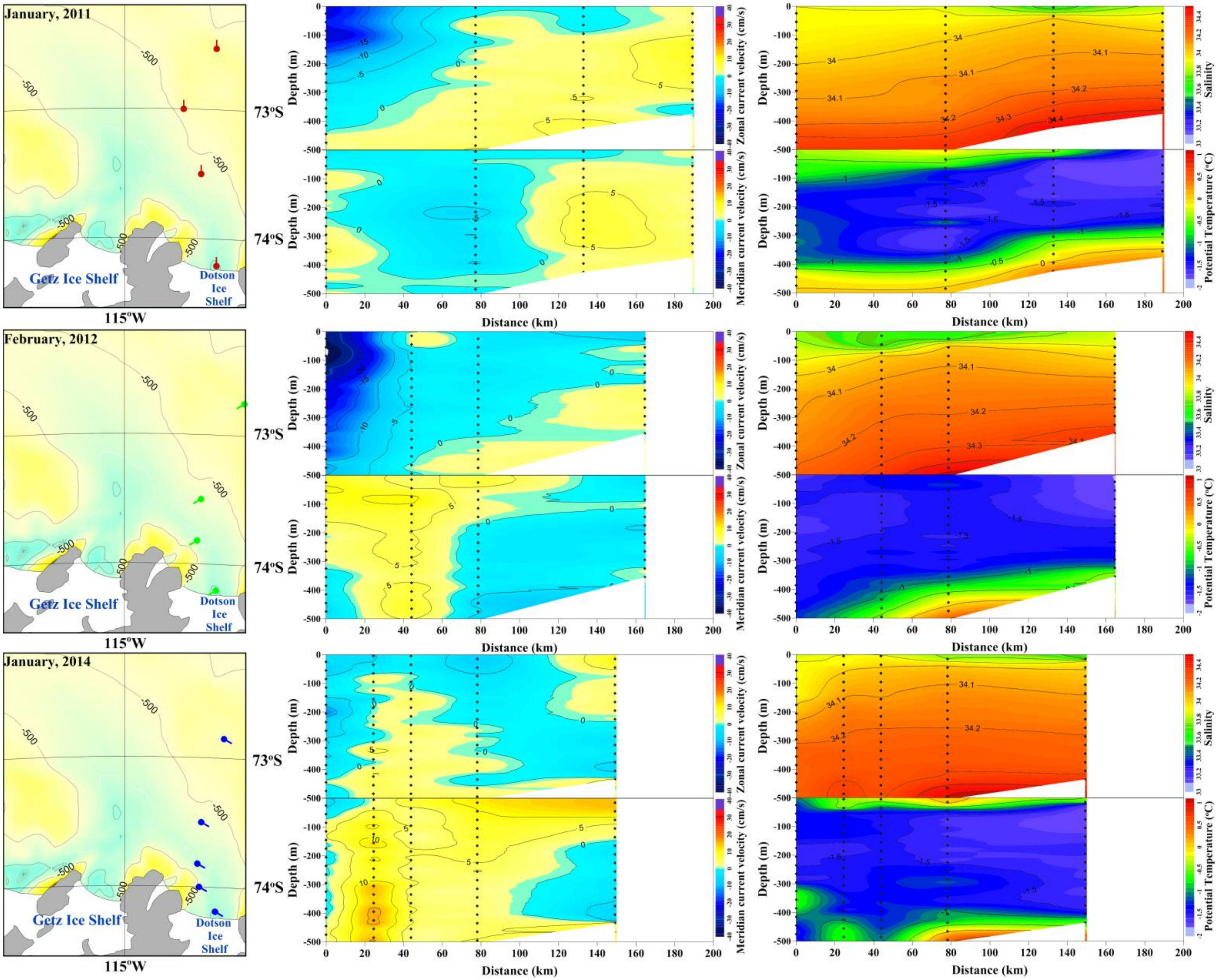
Vertical distribution of potential temperature and salinity in 2012.

- ✓ **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 Current & TS



- ✓ **Westward flow (In front of DIS)**
- ✓ **Eastward flow (Northern boundary of ASP)**
- ✓ **Maximum westward velocity in front of DIS**

  → 21 cm/s at 100 m depth.

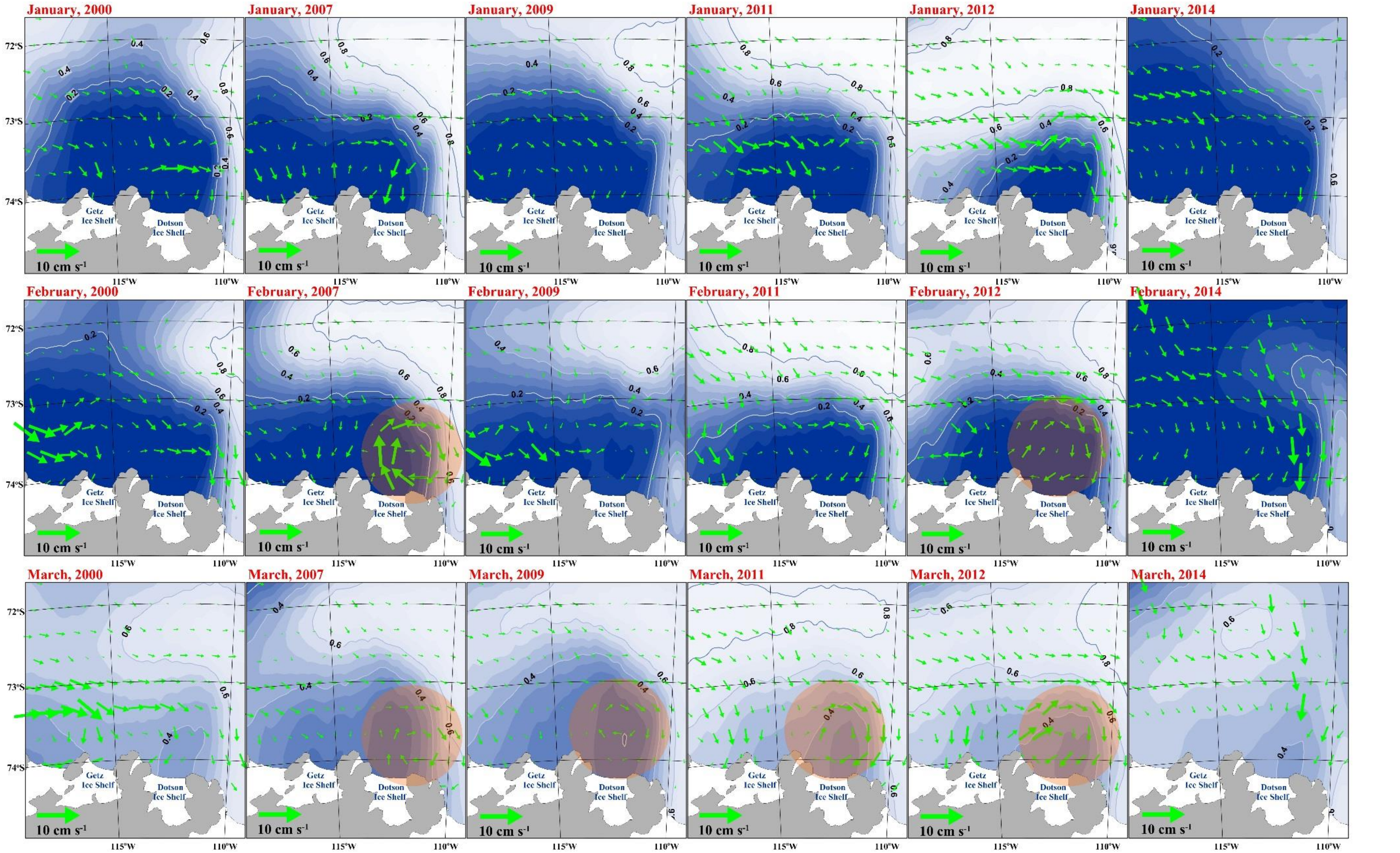
- ✓ **Maximum westward velocity in front of DIS**

  → 40 cm/s at 75 m depth.

- ✓ **Maximum westward velocity in front of DIS**

  → 13 cm/s at 200 m depth.

Monthly mean sea surface circulation & sea ice concentration



OSCAR (*Ocean Surface Current Analysis – Real time*): calculated from quasi-linear and steady flow momentum equations using **SSH**, **SST** and **Wind** obtained from satellites.

- ✓ **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.**

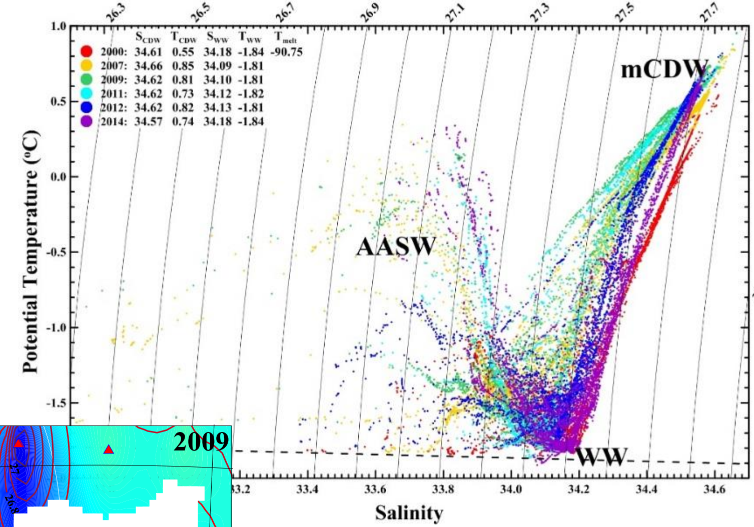
Summary of results

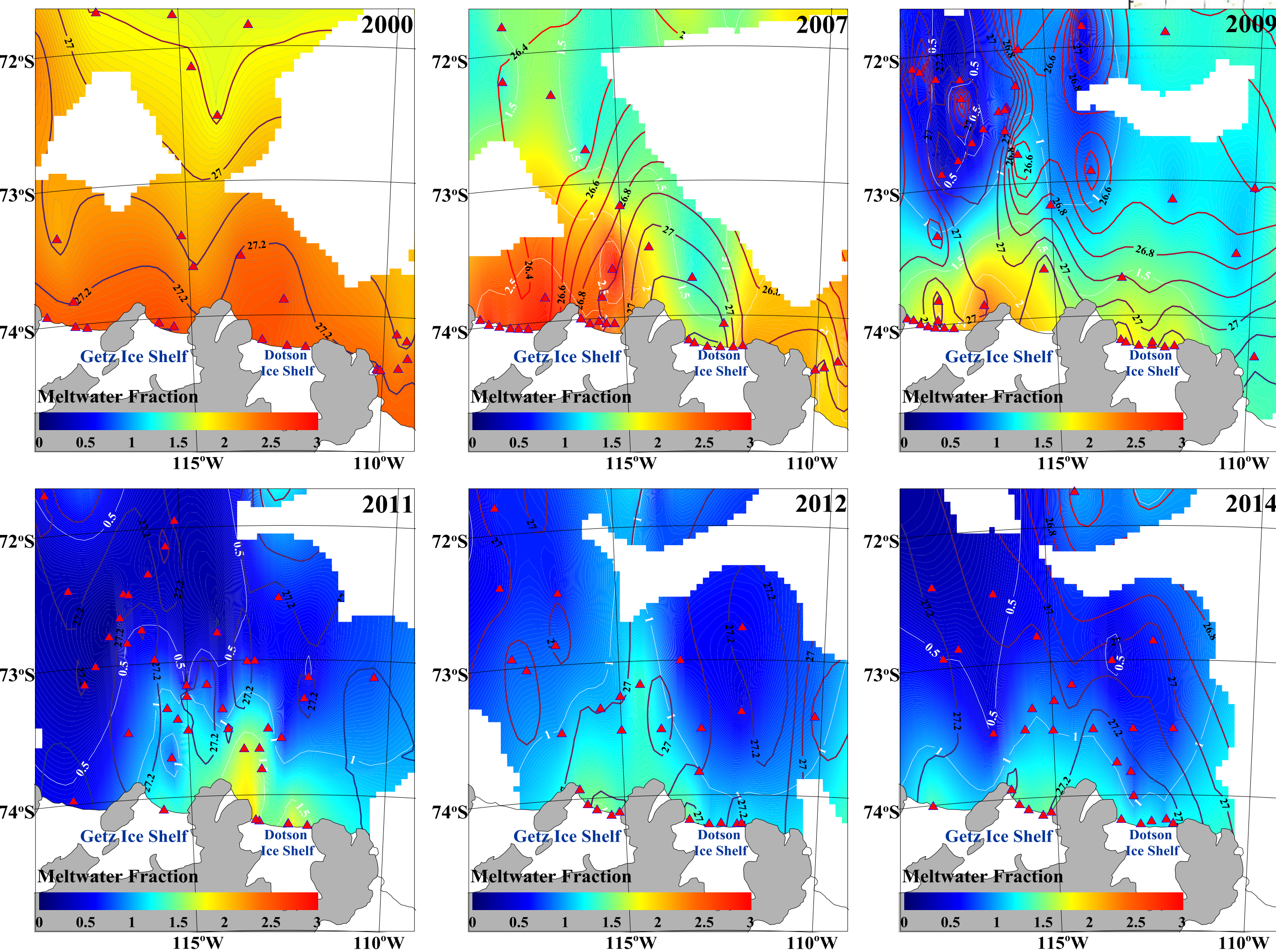
- ✓ The existence of cyclonic eddy in ASP was confirmed from observed TS and Current data.
- ✓ Eddy is bounded on the south by the Dotson Ice Shelf (westward velocity: 40 cm/s in 2012).
- ✓ From OSCAR data, the cyclonic eddy in ASP shows the interannual variation.
- ✓ The strong westward flows in front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



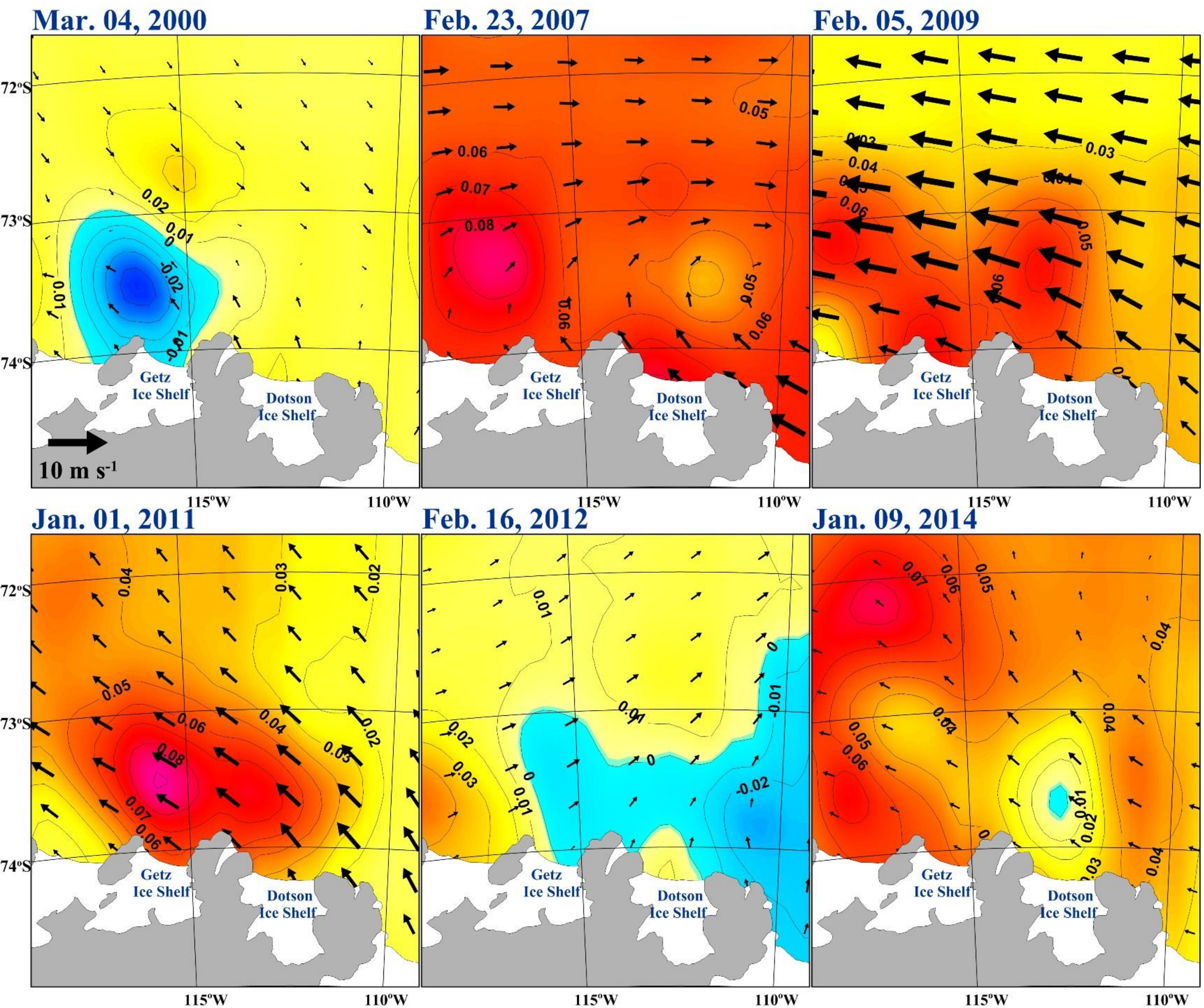


✓ **In 2000, 2007, 2009 and 2011, the meltwater fraction was higher than 1.5 % in front of DIS.**

✓ **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



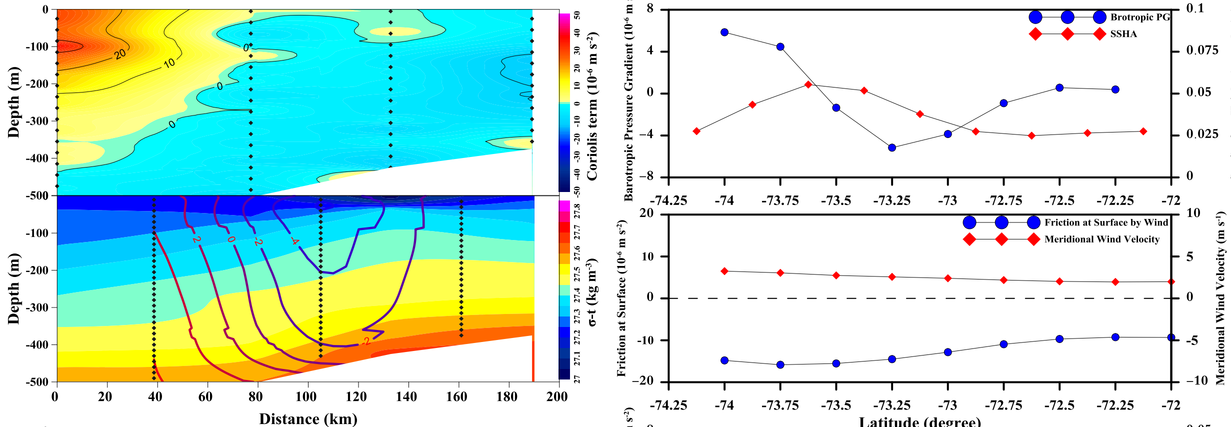
In front of DIS

- **Strong Wind**
  → **2007, 2009, 2011**
- **Weak Wind**
  → **2000, 2012, 2014**

Along DT

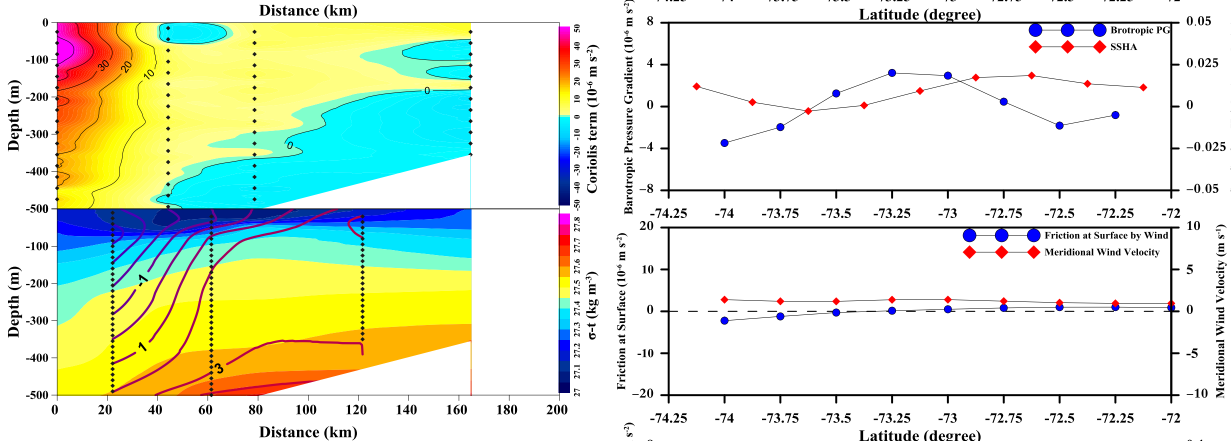
- **Negative gradient of SSHA**
  → **2007, 2012, 2014**
- **Positive gradient of SSHA**
  → **2000, 2009, 2011**

Momentum Balance



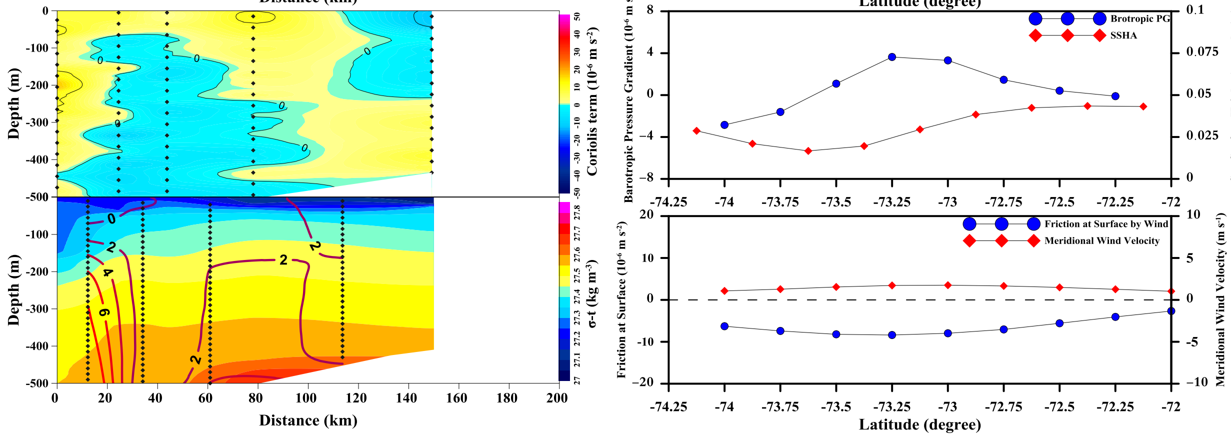
January, 2011

- Coriolis term: 15×10^{-6} m/s^2
- Baroclinic pressure gradient: 3×10^{-6} m/s^2
- Barotropic pressure gradient: 5×10^{-6} m/s^2
- Vertical friction at surface: -15×10^{-6} m/s^2



February, 2012

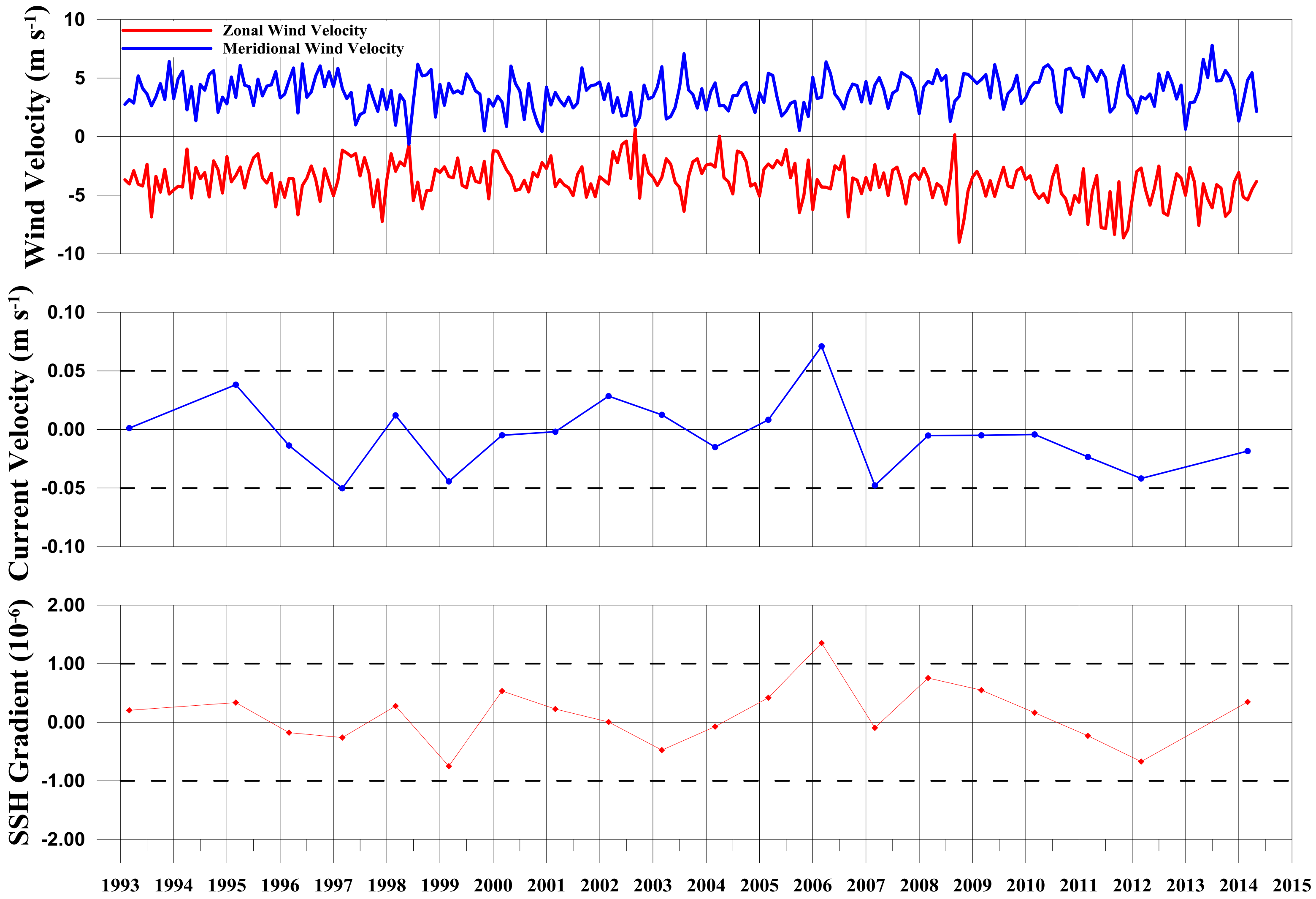
- Coriolis term: 22×10^{-6} m/s^2
- Baroclinic pressure gradient: -5×10^{-6} m/s^2
- Barotropic pressure gradient: -4×10^{-6} m/s^2
- Vertical friction at surface: -3×10^{-6} m/s^2



January, 2014

- Coriolis term: 7×10^{-6} m/s^2
- Baroclinic pressure gradient: -1×10^{-6} m/s^2
- Barotropic pressure gradient: -3×10^{-6} m/s^2
- Vertical friction at surface: -7×10^{-6} 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!

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