Regeneration of an ocean anticyclone: from warm to cold

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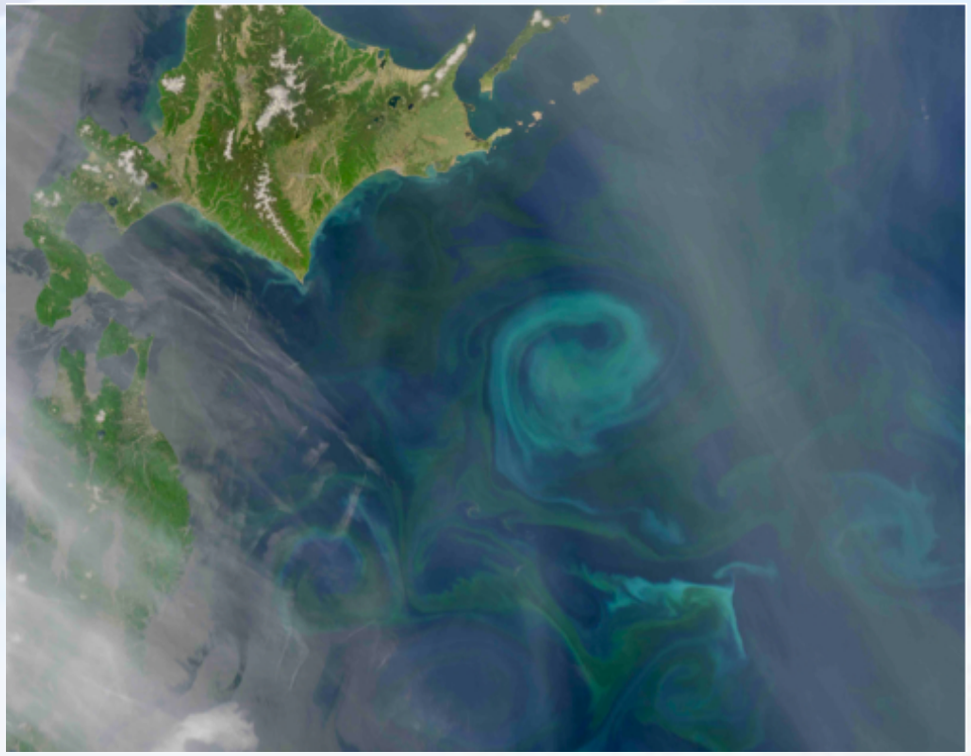
Reference: Itoh et al. (2014, J. Oceanogr.)

Mesoscale Eddies in the ocean

Ocean

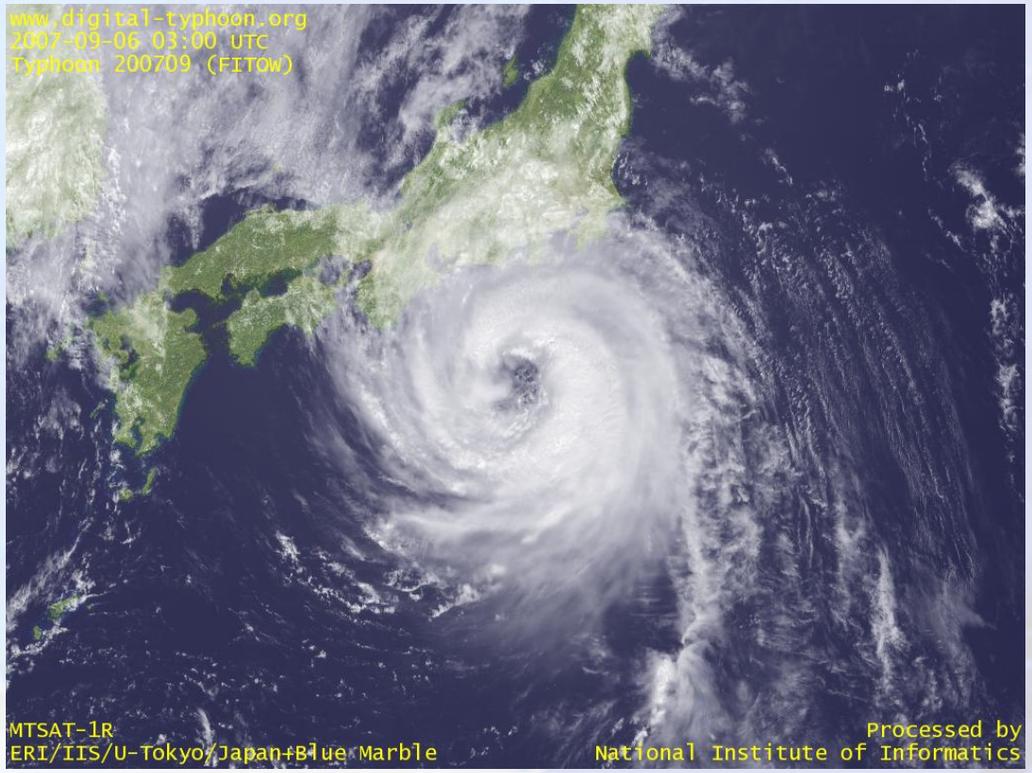
Mesoscale eddies
(e.g. Anticyclonic ring)



Elevated surface (high pressure) and anticyclonic circulation

Atmosphere

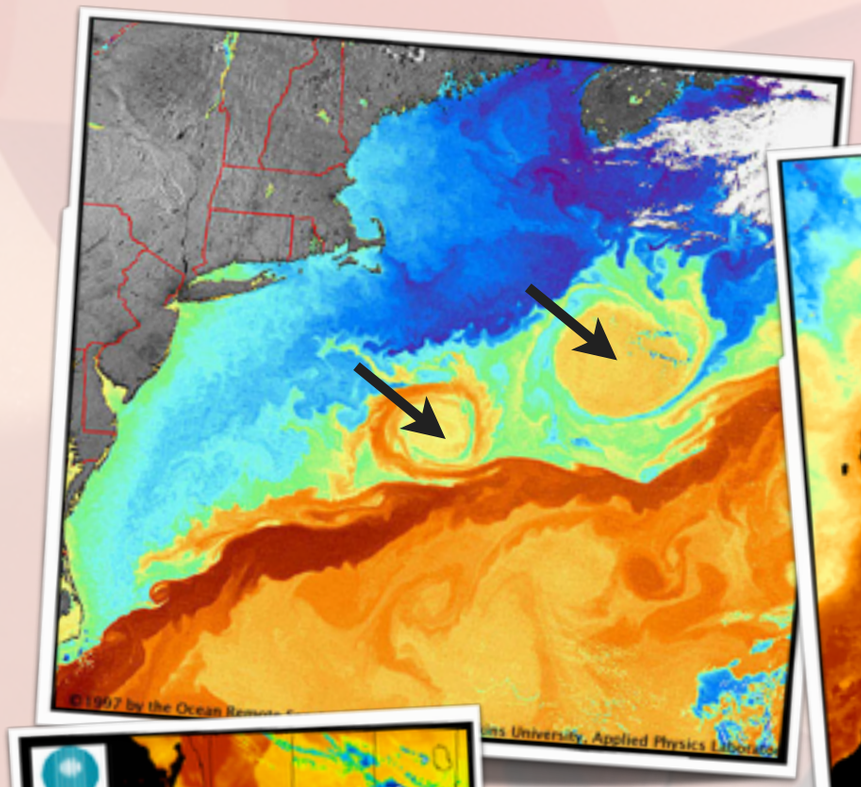
Cyclone/anticyclone
(e.g., Typhoon)



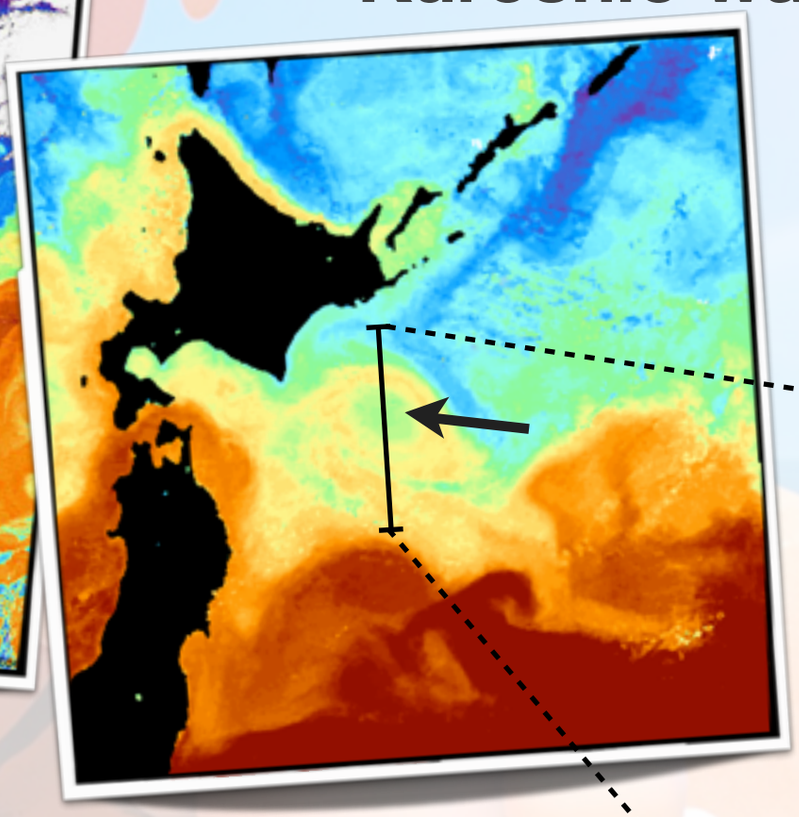
Low pressure and cyclonic circulation (anticyclonic for highs)

Warm-core Rings (warm anticyclonic

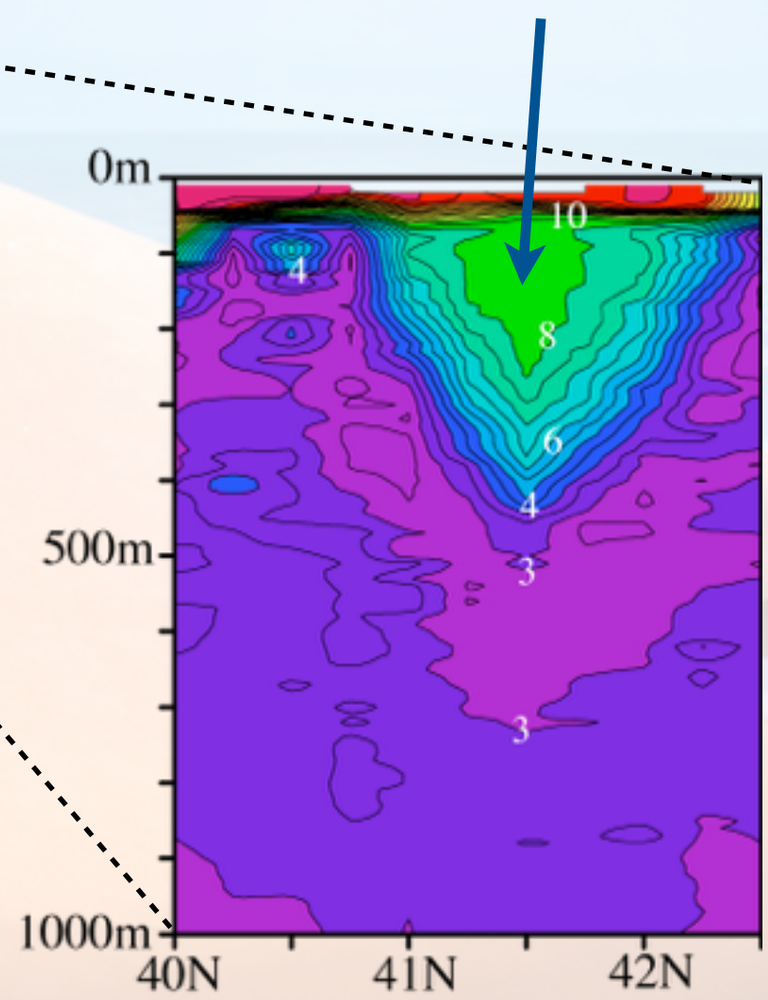
Gulf Stream warm-core rings[1]



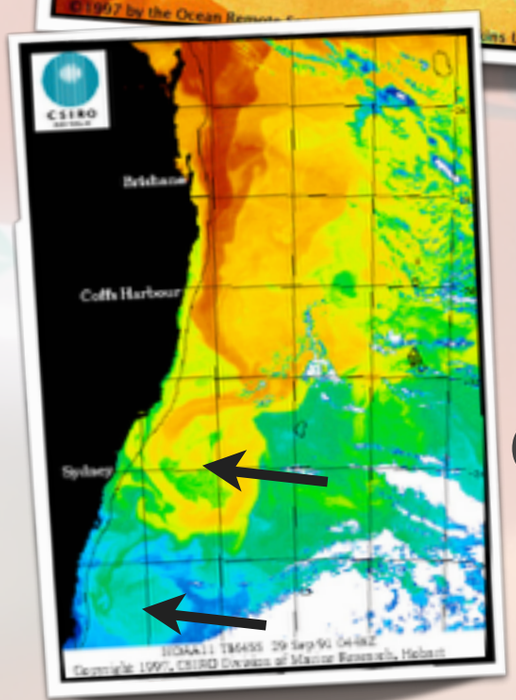
Kuroshio warm-core rings



Warm (and saline) core water



East Australian Current eddies[2]



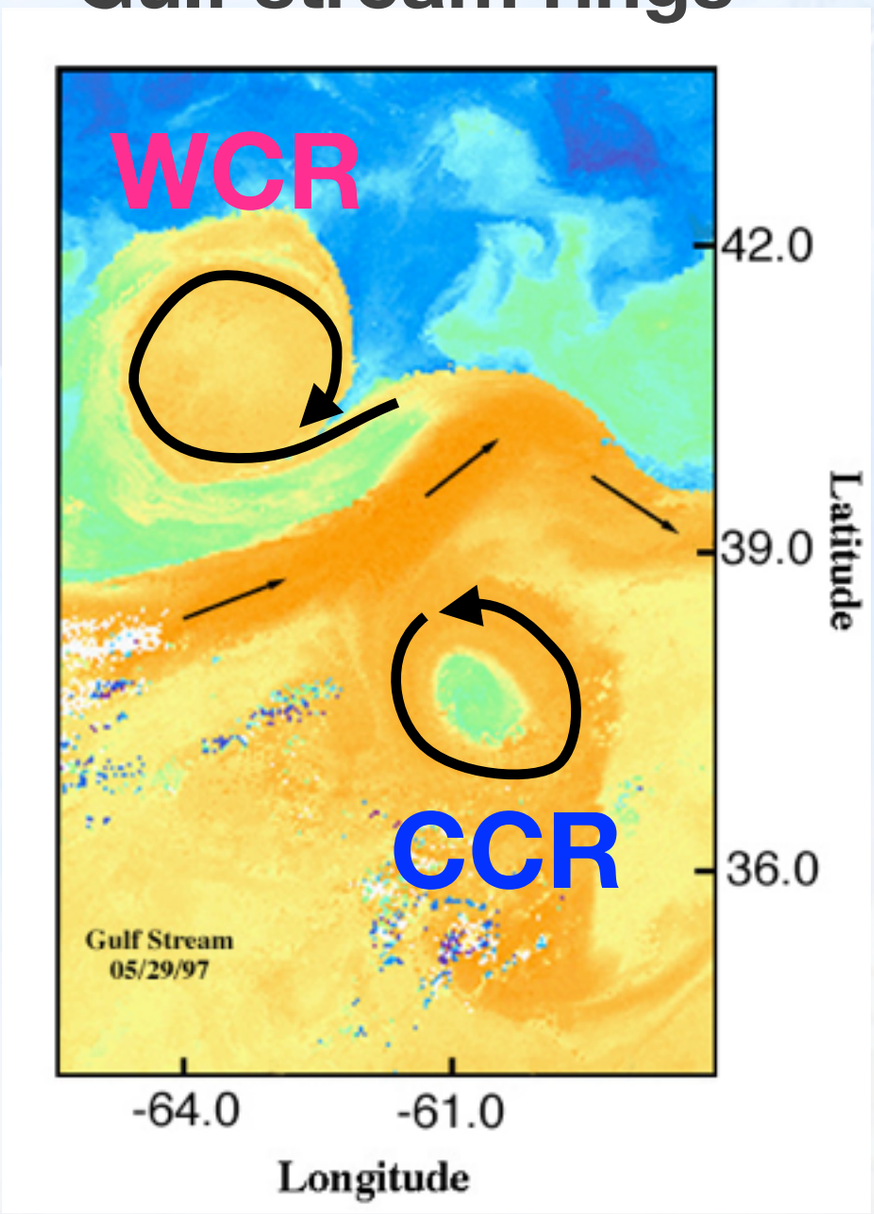
[2]Ridgway & Hill (2009)

[1]http://pages.jh.edu/~dwaugh1/gallery_ocean.html

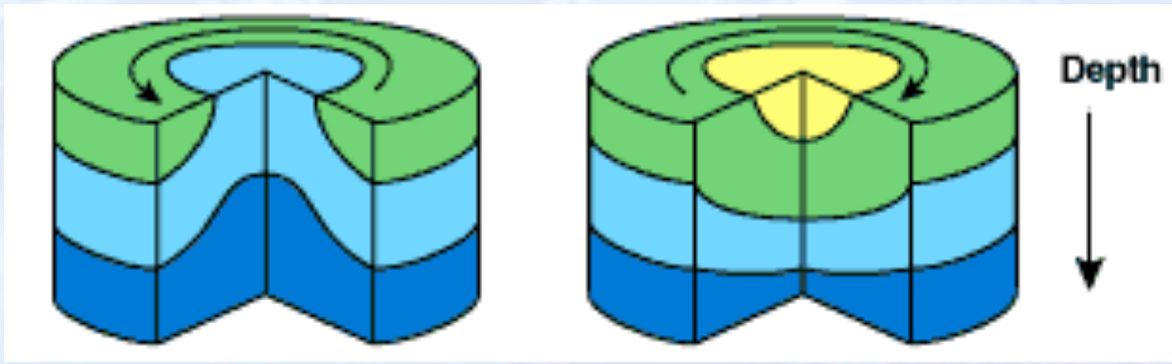
Cold-core Rings

around subtropical western boundary currents

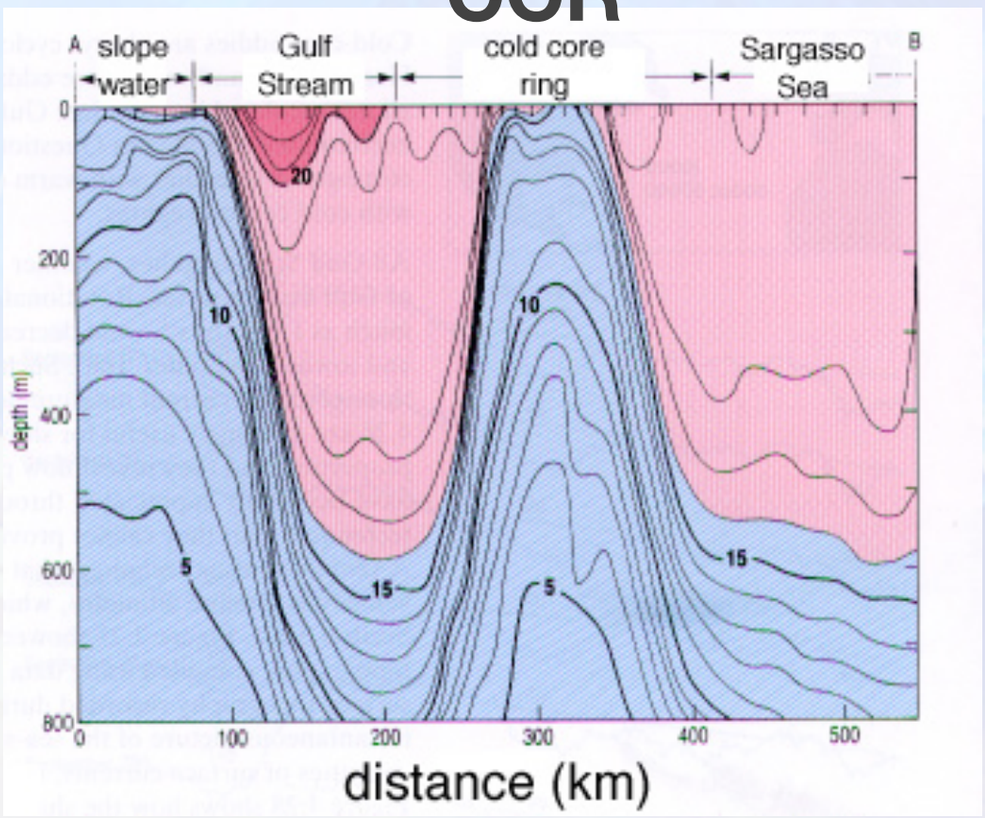
Warm and cold Gulf stream rings



CCR **WCR**



CCR

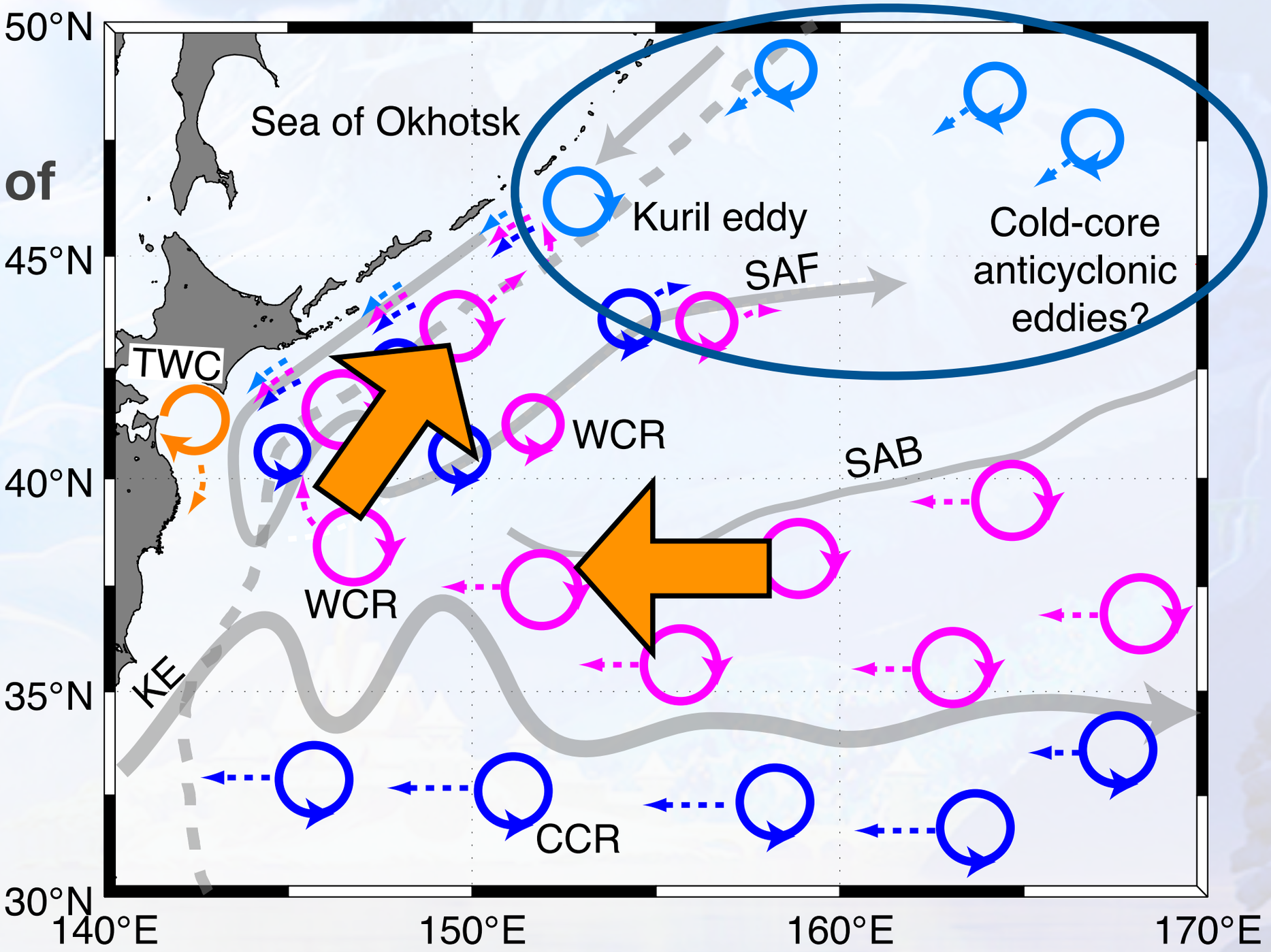


http://marine.coastal.edu/gulfstream/

Itoh & Yasuda (2010JPO)

Mesoscale EDDIES EAst of Japan

Transport of heat, materials and biota



Question

- **What happens after the northward propagation?**

Broken into small patches?

Cooled down by the atmosphere?

Mixed up with subarctic water ?

Information was limited for disappearance processes of the Kuroshio warm-core rings within the subarctic gyre

Purpose

To examine the fate of the aged rings in the subarctic gyre

Profiling Float Observations

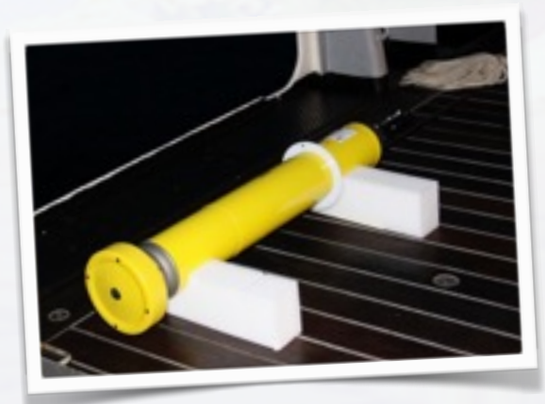
R/V Hakuho maru

- Three profiling floats into a WCR off Hokkaido

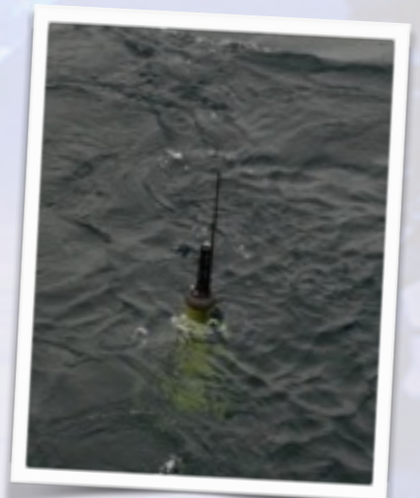
  - The main float was deployed aboard *R/V Hakuho maru*
  - Parking at 500/1000 m, profiling temperature and salinity and transmitting the data every 5 days

Configuration

Deployment



Diving



Satellite Images

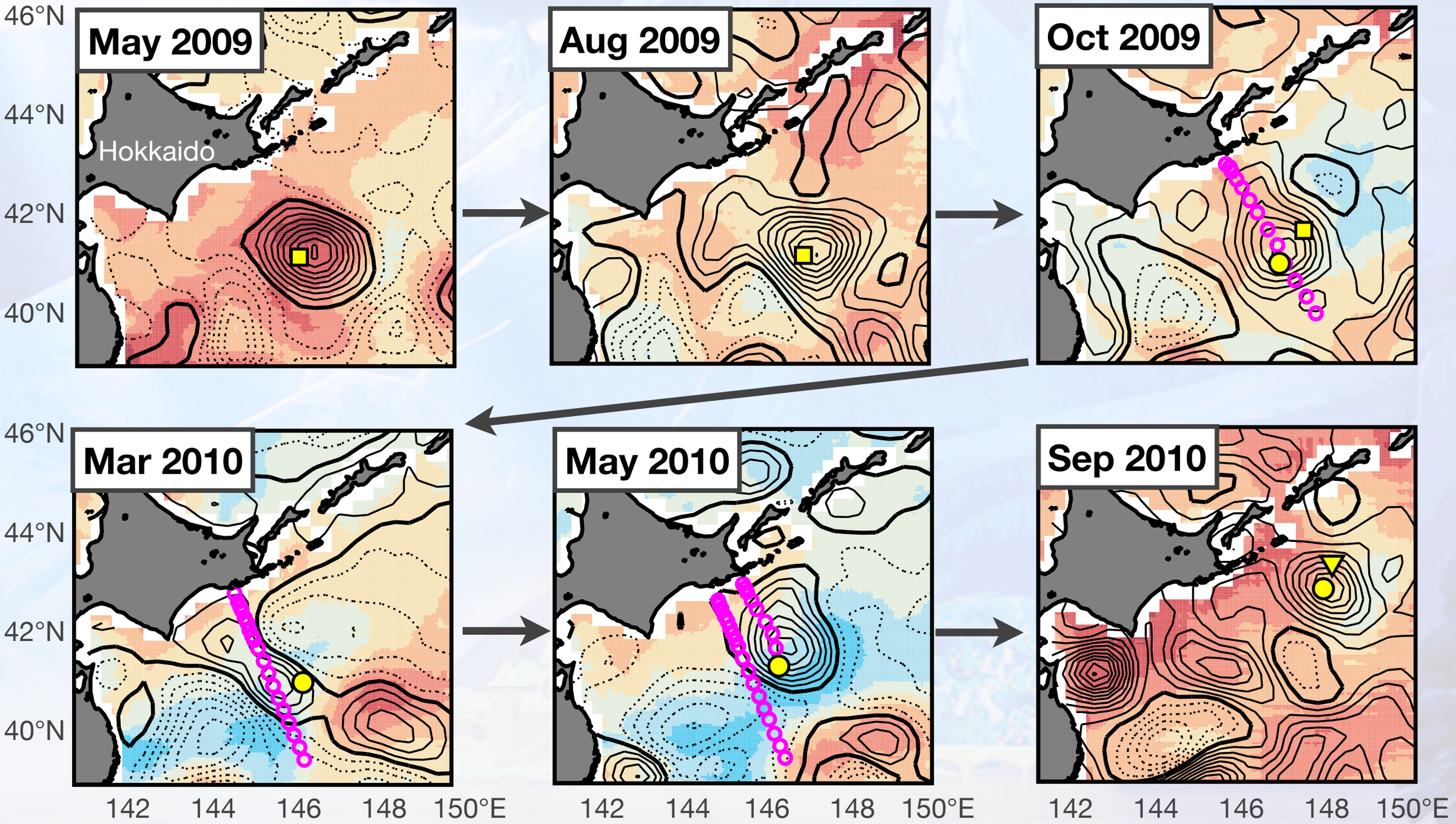
Float position

Shipboard observations

Contour: SSHA

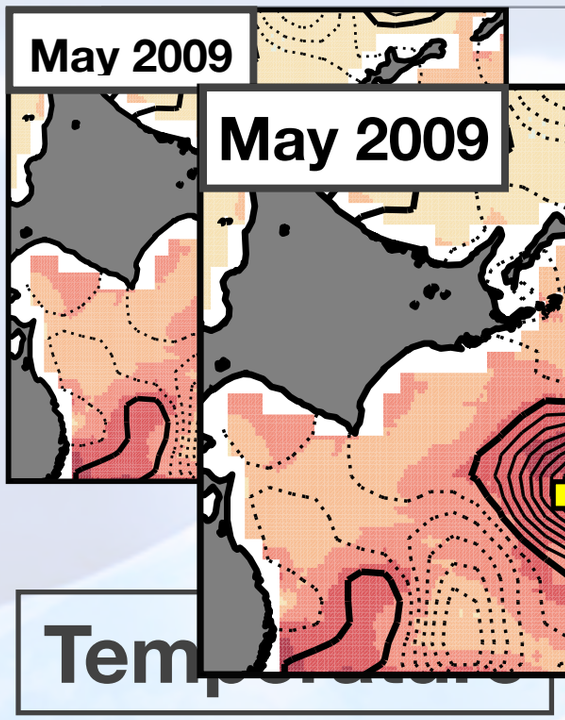
Color: SSTA

–5 0°C +5



Temperature and

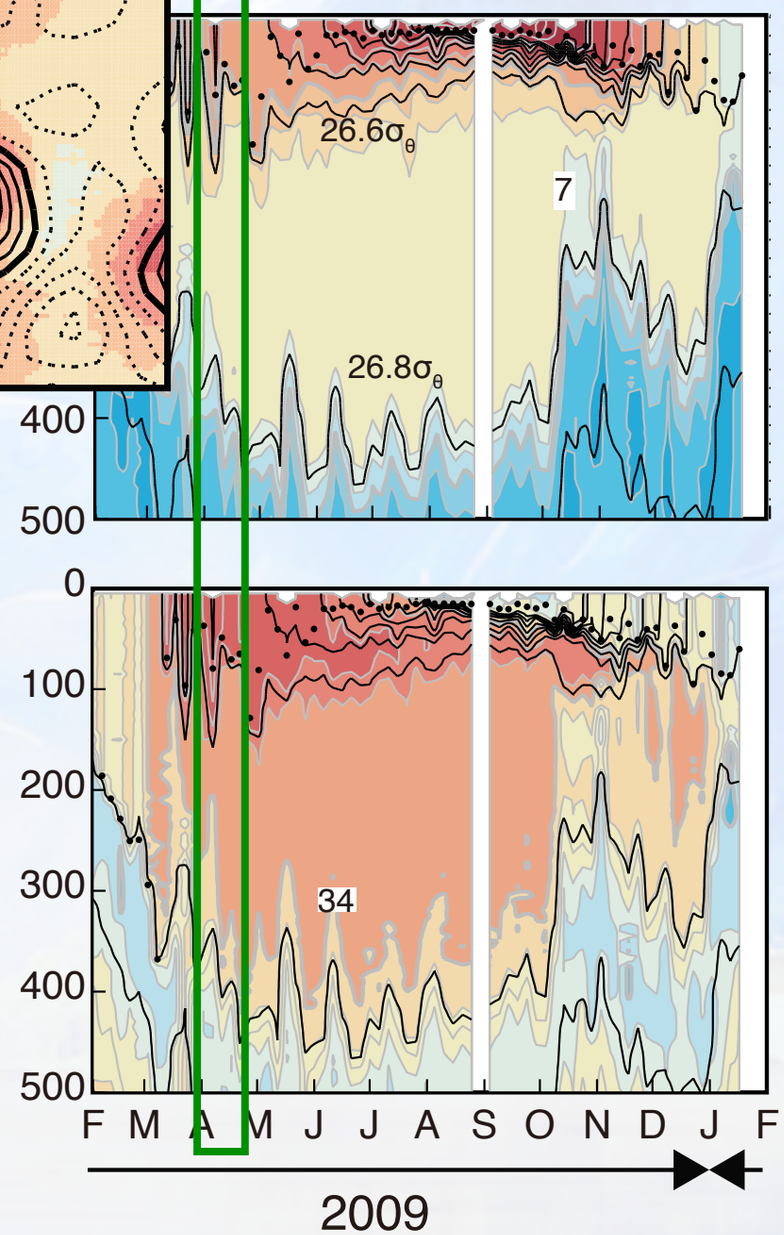
Cooled (Freshened)

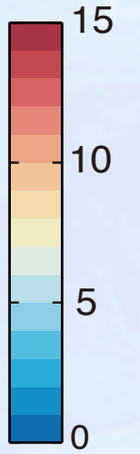


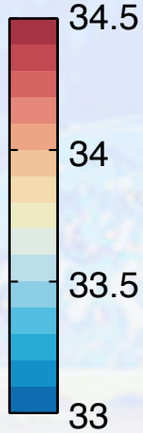
Temperature

Salinity

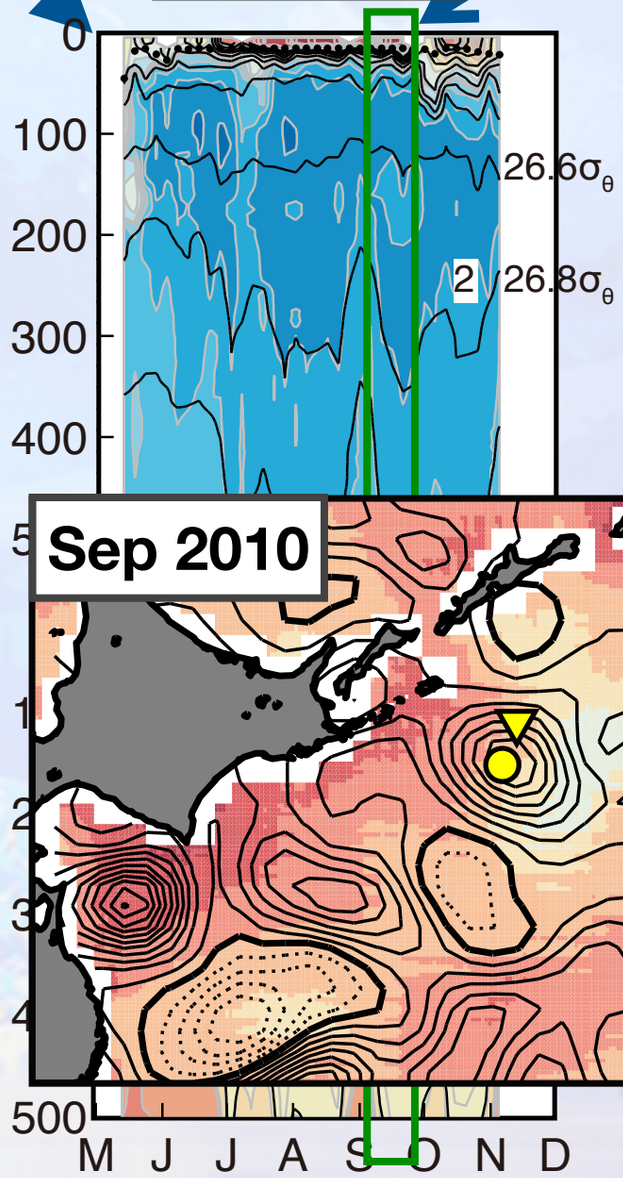
Float A

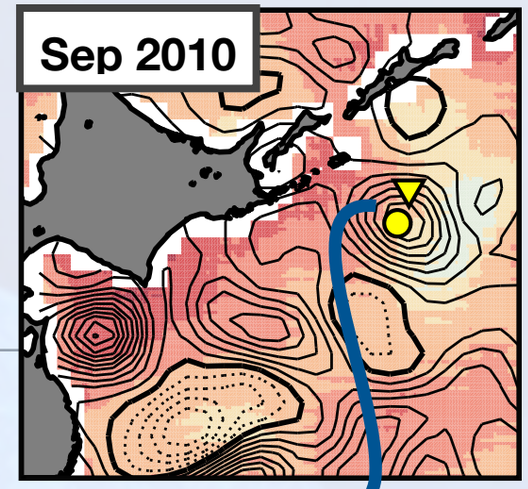




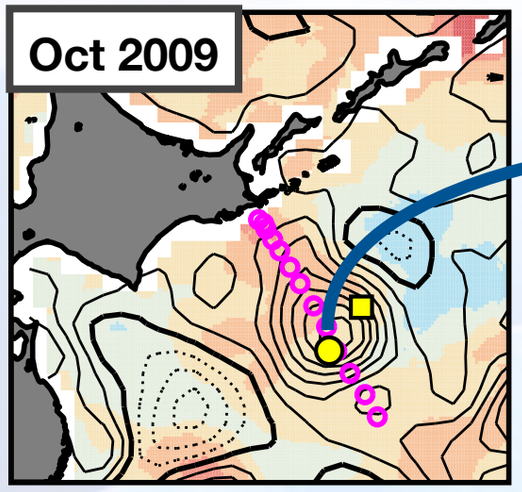


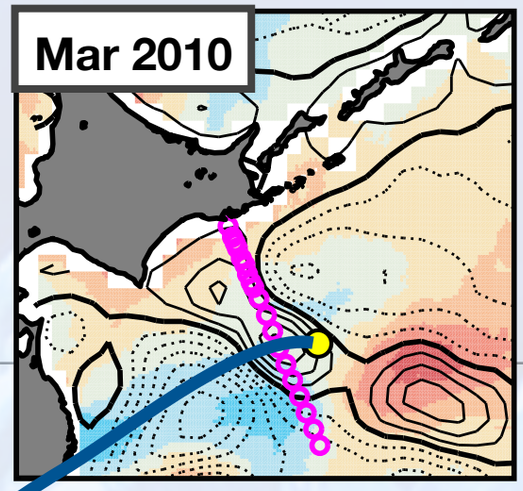
Float C

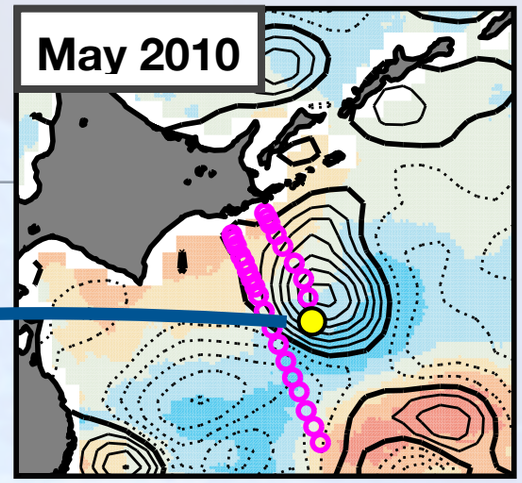




Temperature and



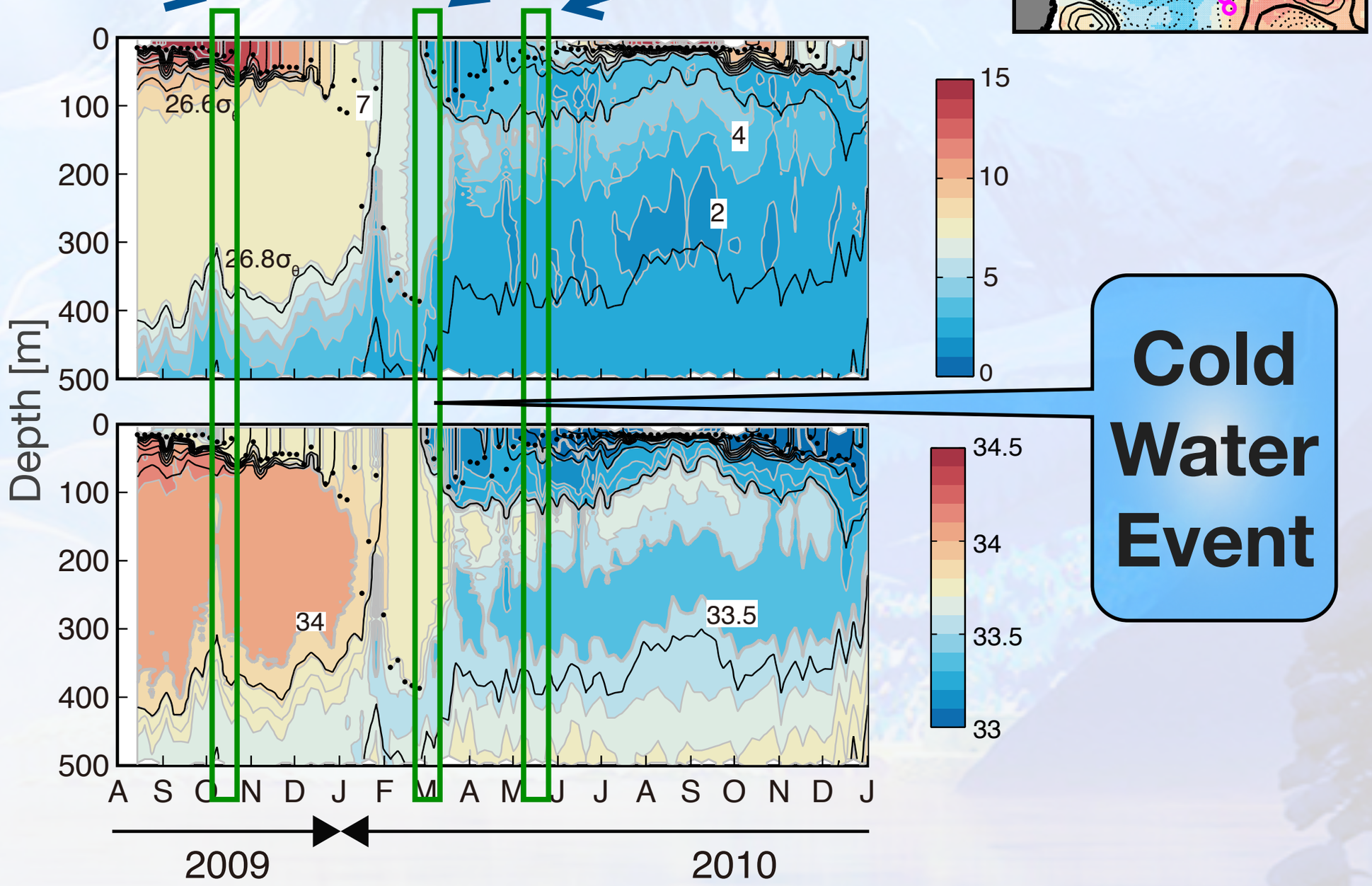




Float B

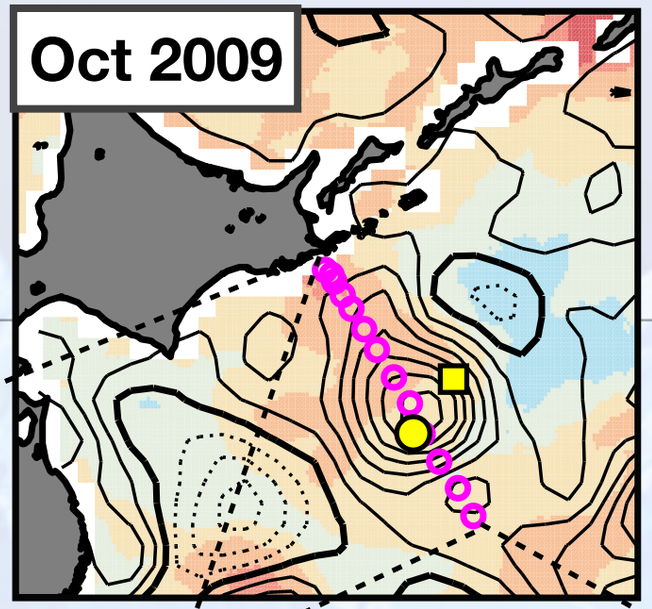
Temperature

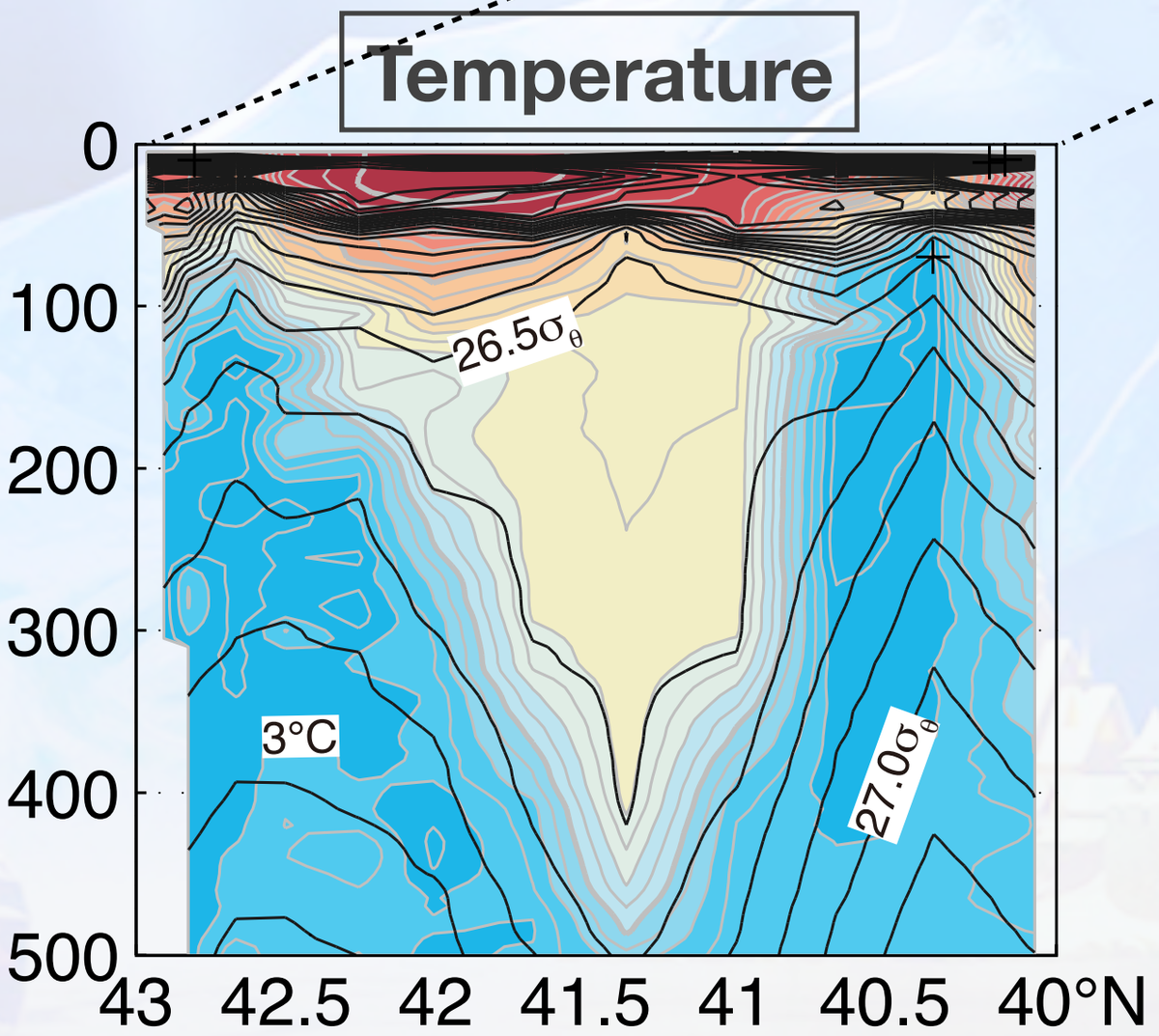
Salinity

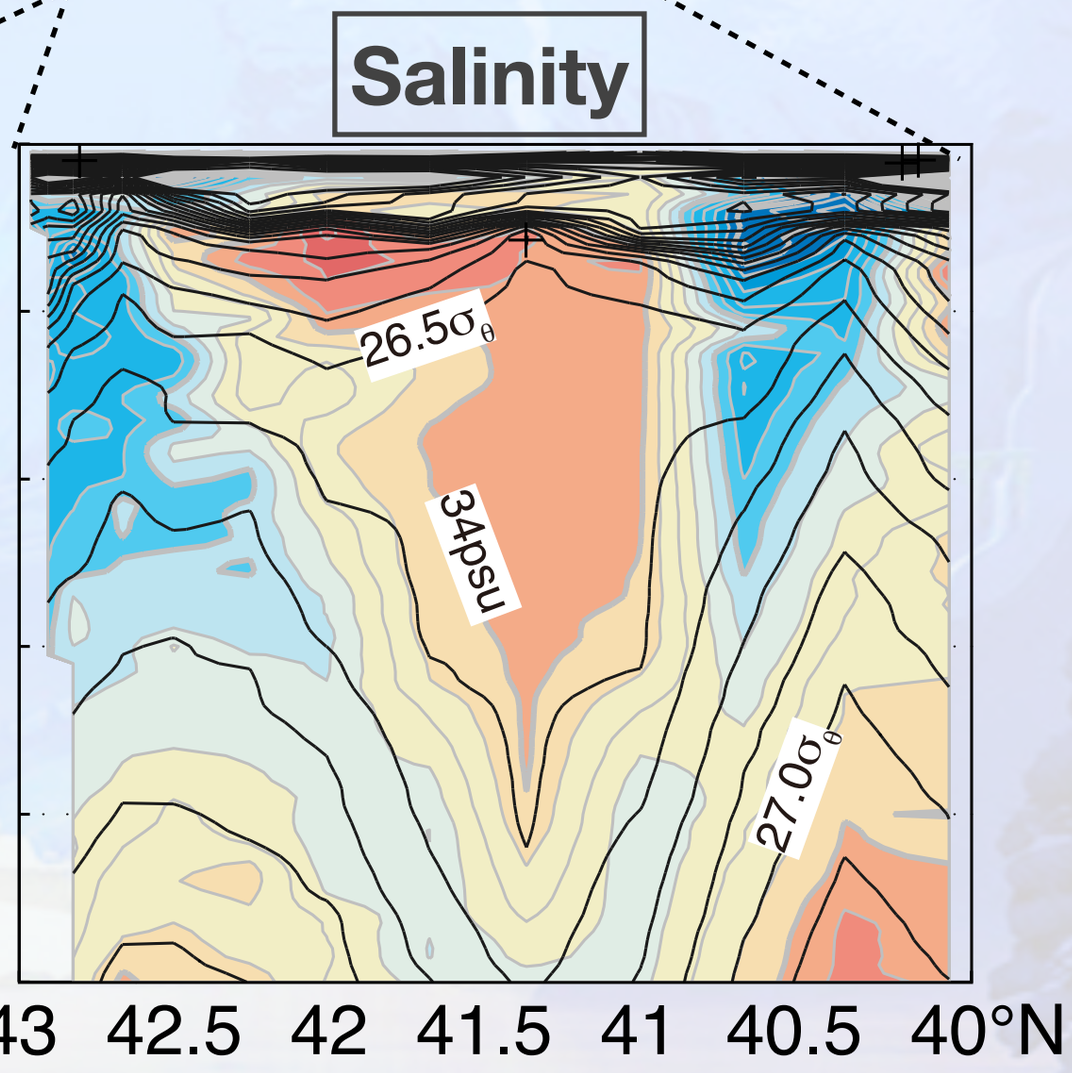


Cold Water Event

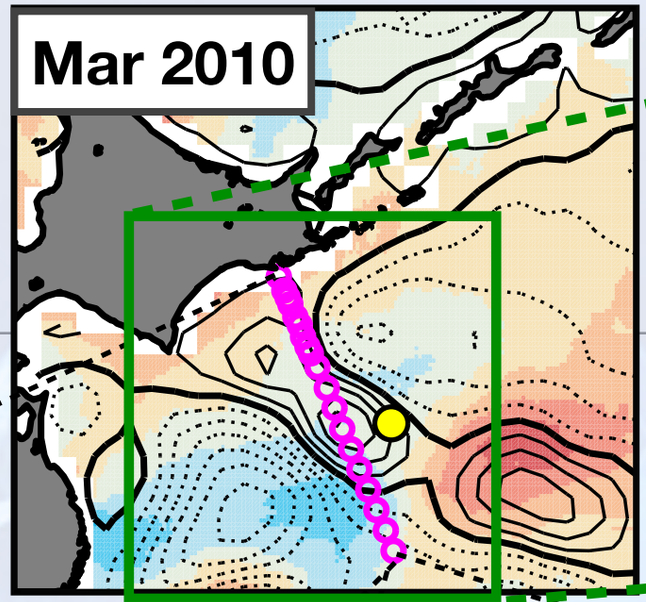
Transect before



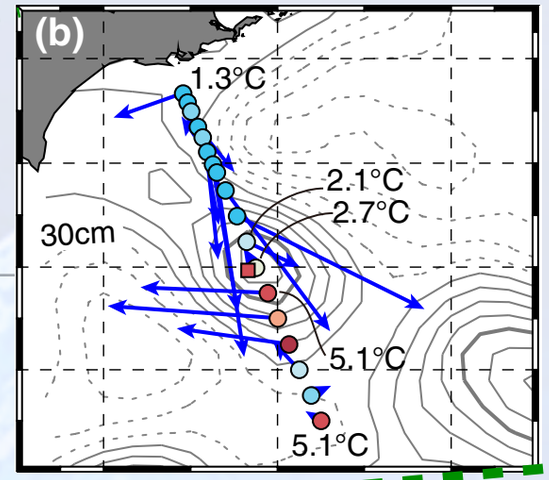




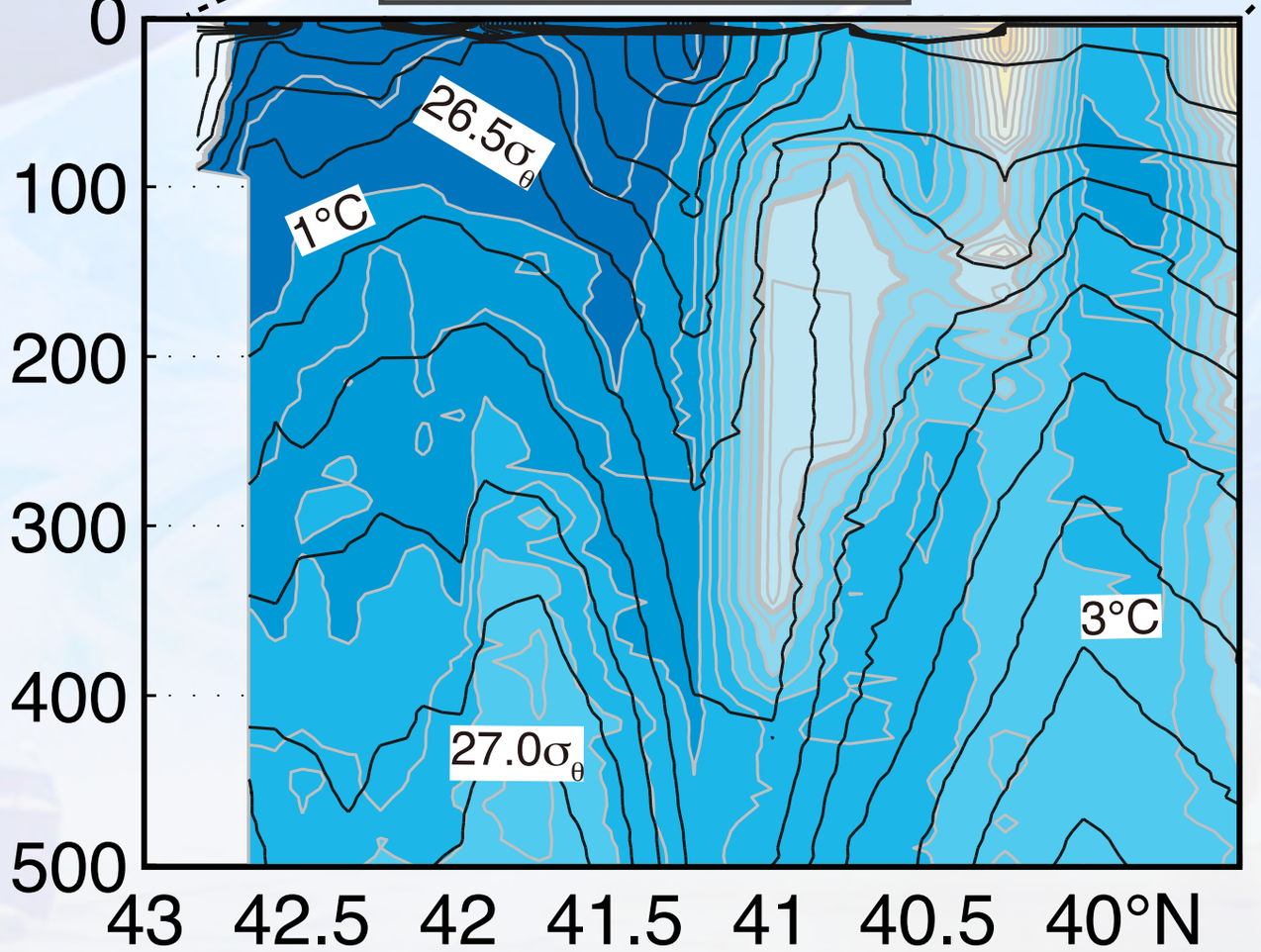
Transect during



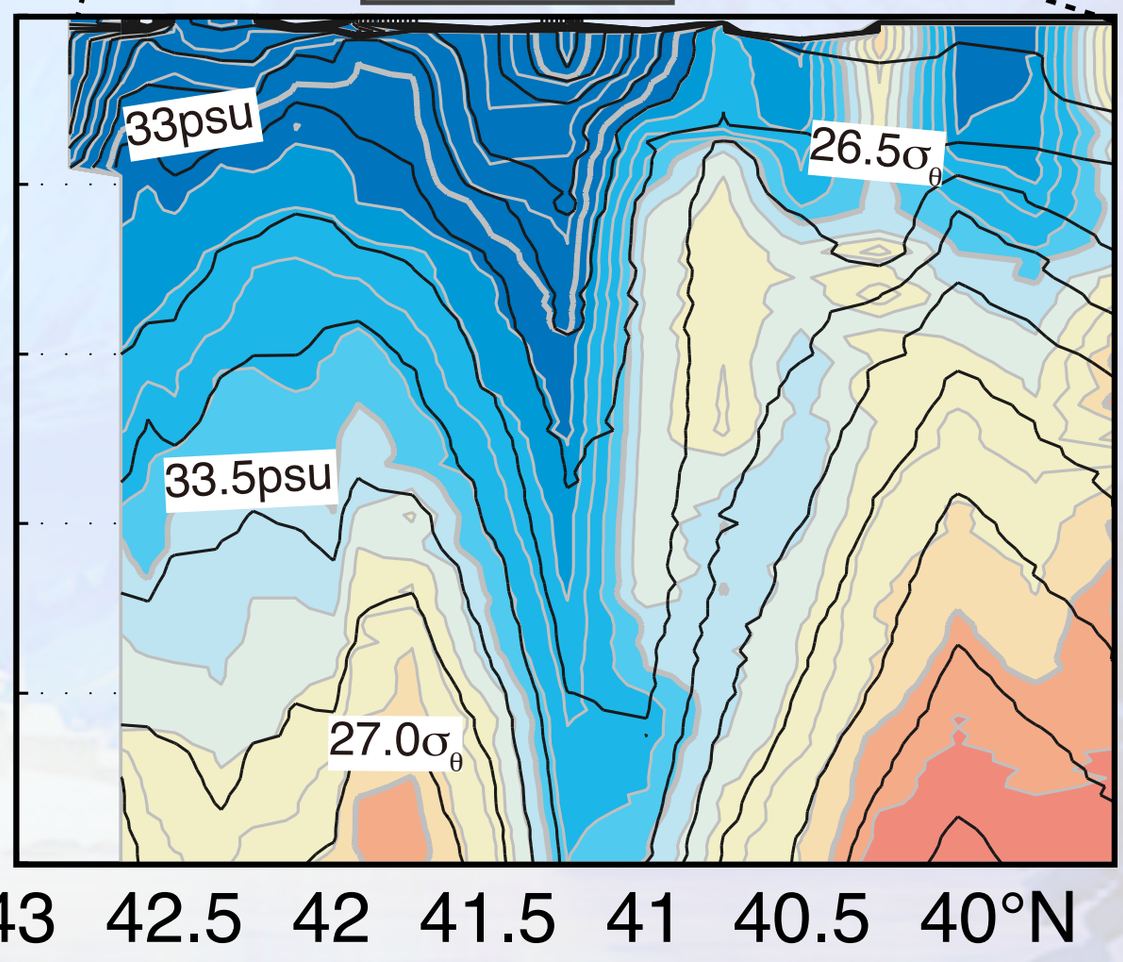
Velocity @26.6–26.7σ_θ



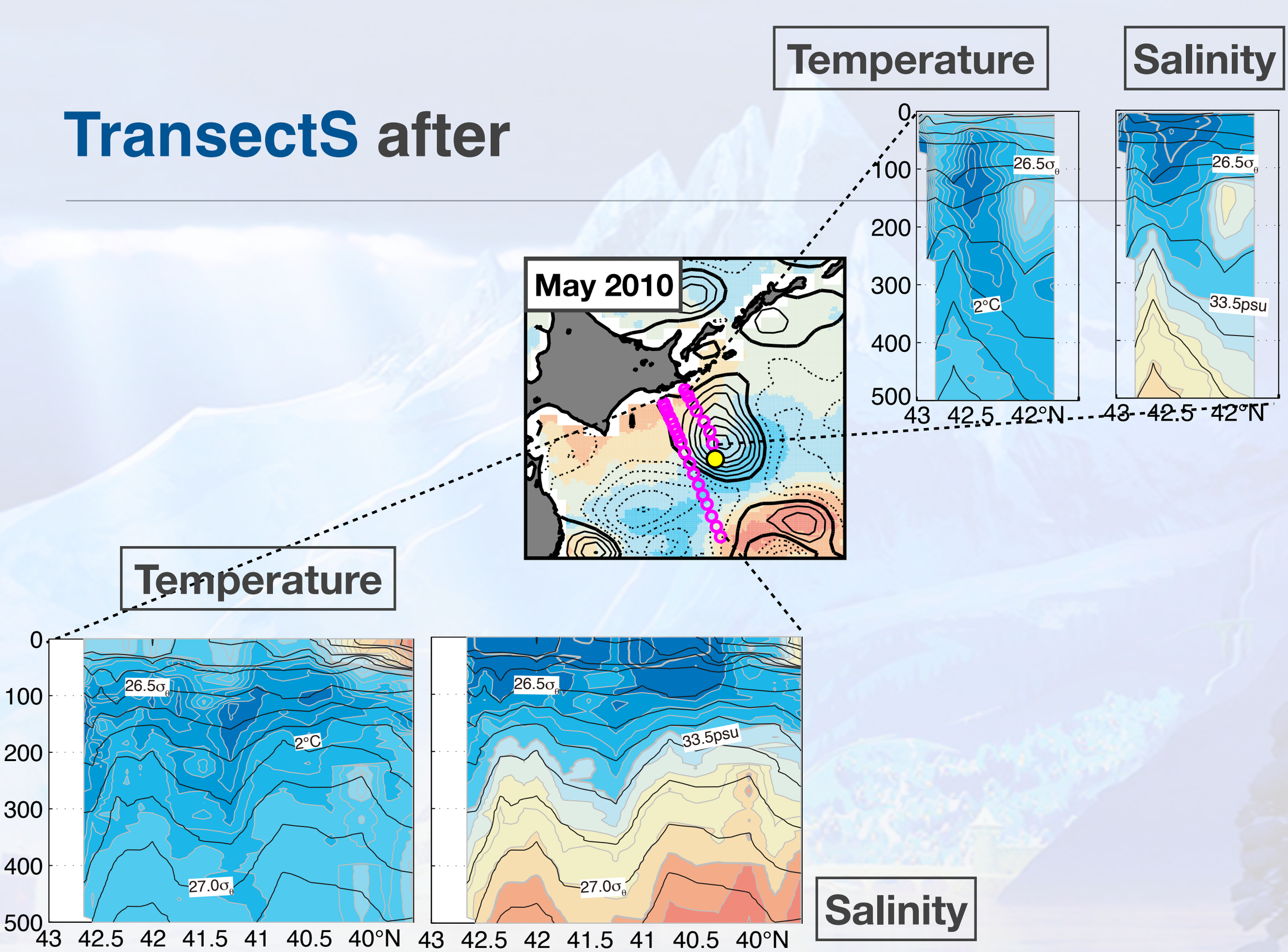
Temperature



Salinity

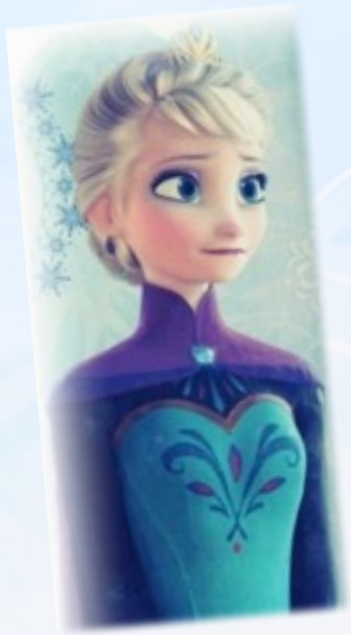


TransectS after

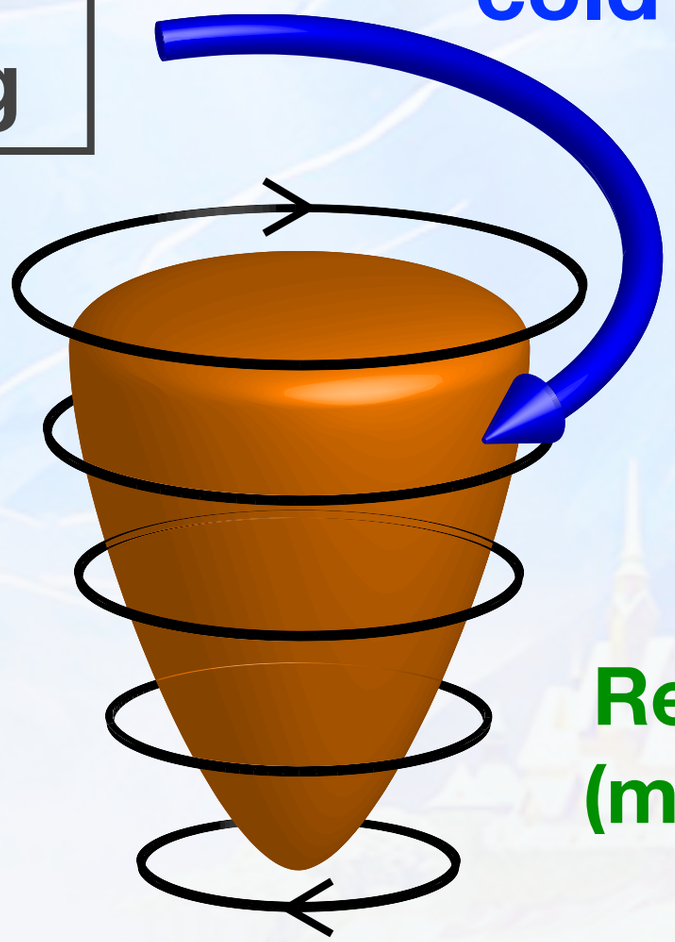


Regeneration from warm to cold

Warm-core ring

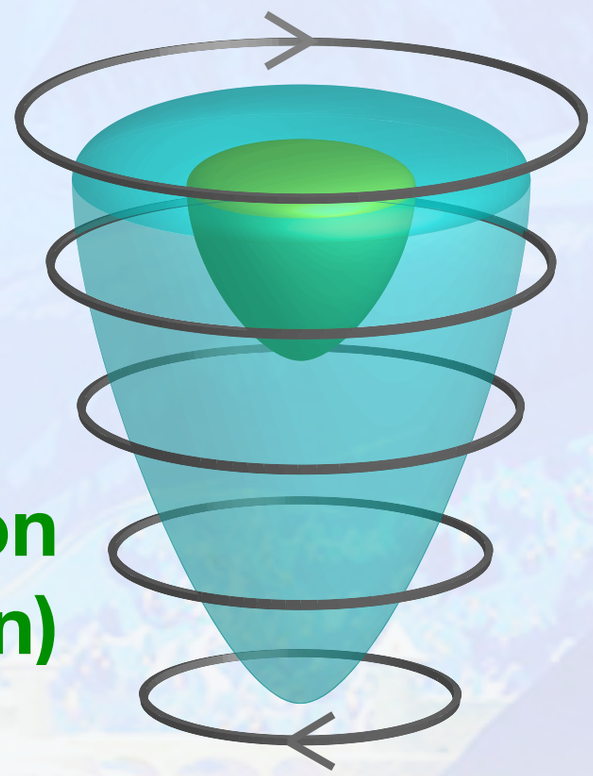


Encounter cold water

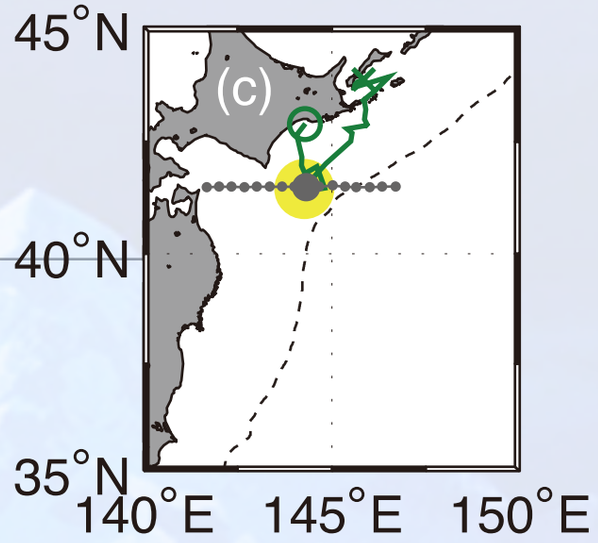


Regeneration (modification)

Cold-core ring (with a small warm-core)



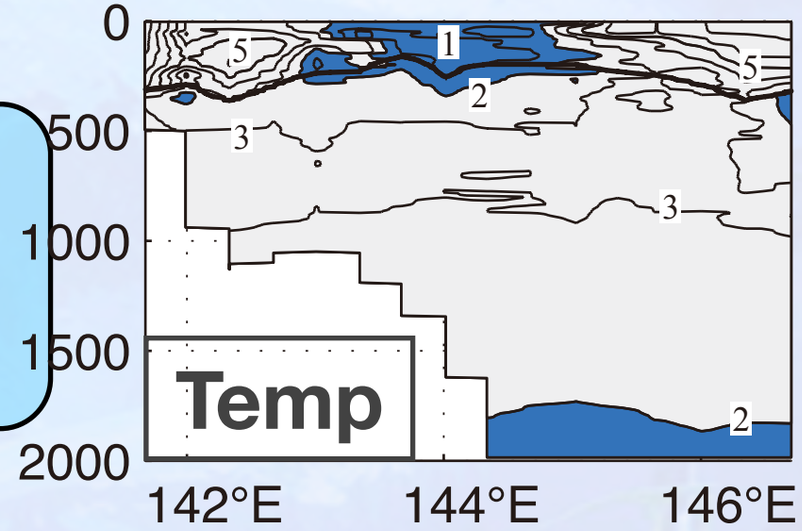
cold, fresh and Low-pv water



Why the warm anticyclone could become an anticyclone even after the cold water intrusion?

Maybe because the cold water had low potential vorticity

Like partial merger of like-signed vortices !

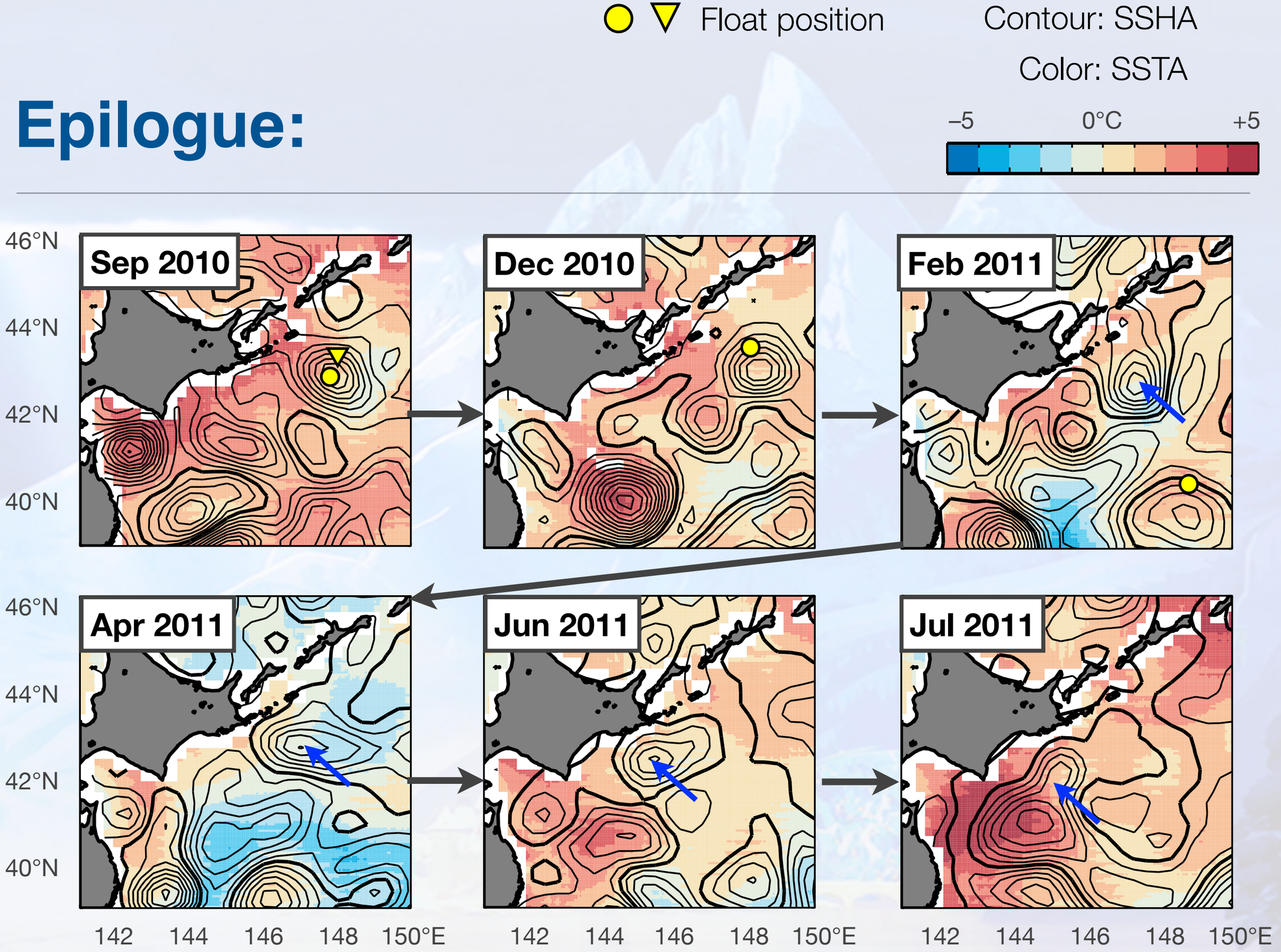


Cold anticyclonic ring

originating from the Sea of Okhotsk

(Itoh & Yasuda, 2010JPOb)

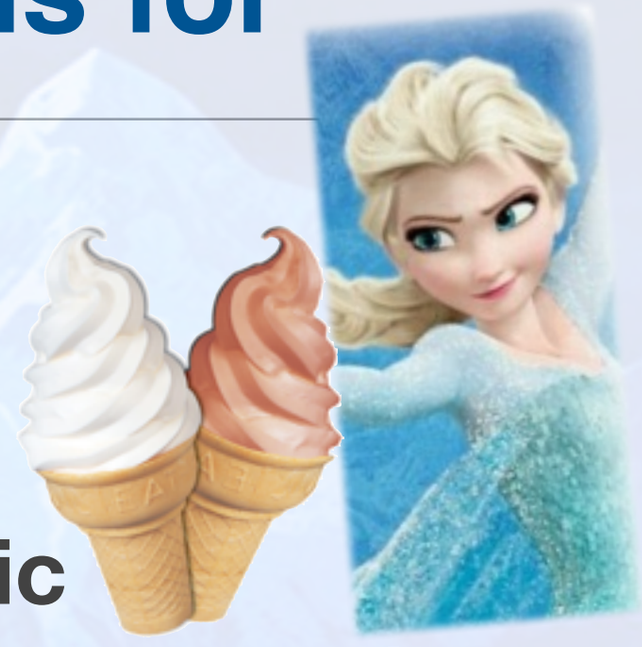
Epilogue:


Float position
Contour: SSHA
Color: SSTA
–5
0°C
+5
Sep 2010
Dec 2010
Feb 2011
Apr 2011
Jun 2011
Jul 2011
46°N
44°N
42°N
40°N
142
144
146
148
150°E

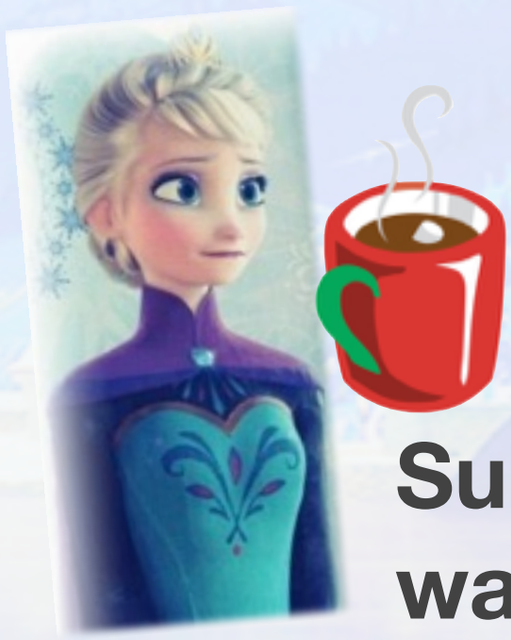
Fate of the ring and Implications for

A possible cycle of anticyclones in the Kuroshio-Oyashio transition area

1. propagate northward,
2. become a cold anticyclone,
3. propagate southward,
   and then,
4. merge to newly generated
   warm anticyclone (s)



Subarctic water (not frozen)



Subtropical water

Effective water exchange via meridional propagation and regenerations of anticyclones