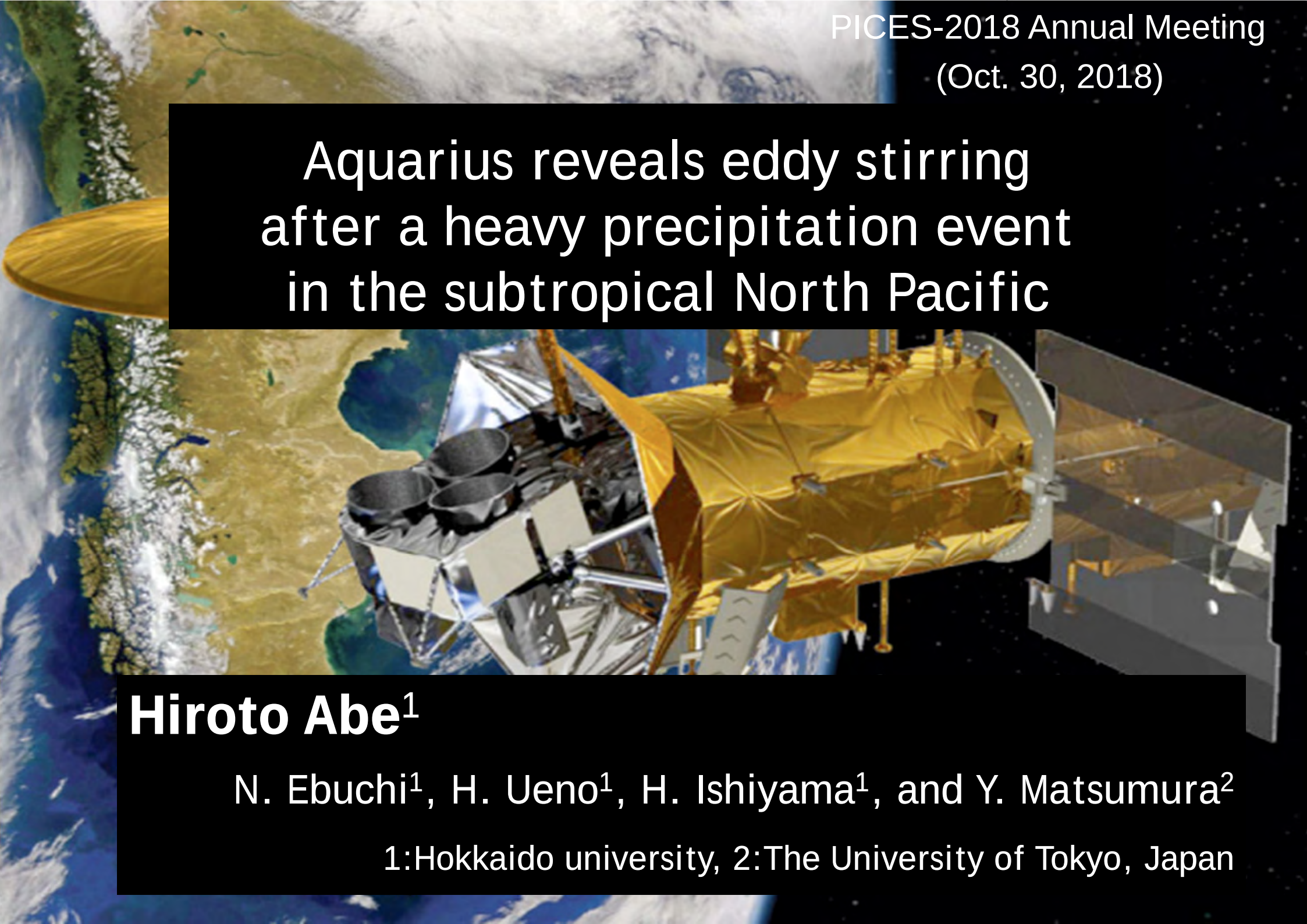
PICES-2018 Annual Meeting
(Oct. 30, 2018)

Aquarius reveals eddy stirring after a heavy precipitation event in the subtropical North Pacific



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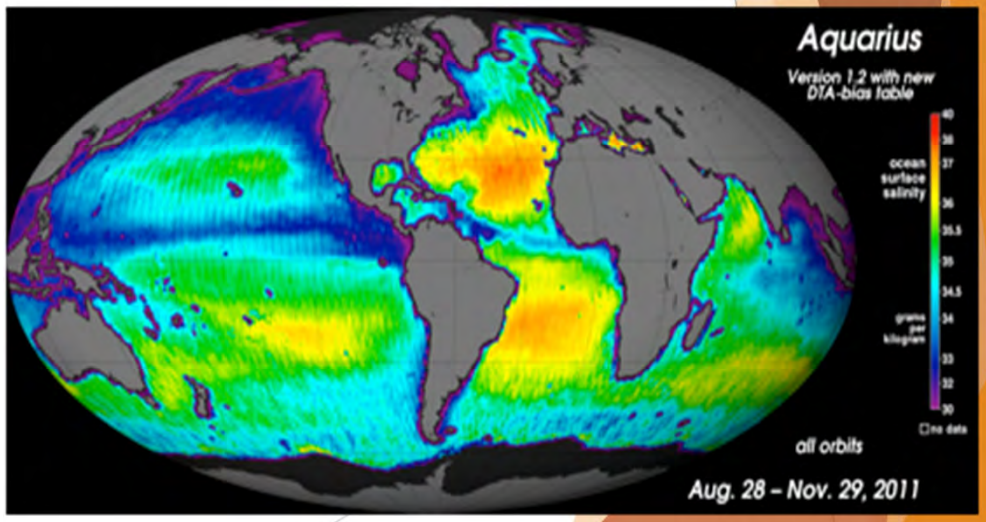
Introduction

A spaceborne salinity sensor developed by the NASA, Aquarius, onboard the Argentina's SAC-D spacecraft, was launched in June 2011.

This is the first mission with a primary target of measuring global sea surface salinity (SSS).

An accuracy of 0.2 psu over a spatial smoothing scale of 150 km on a monthly scale
(Lagerloef et al. 2008).



Aquarius Website (NASA)

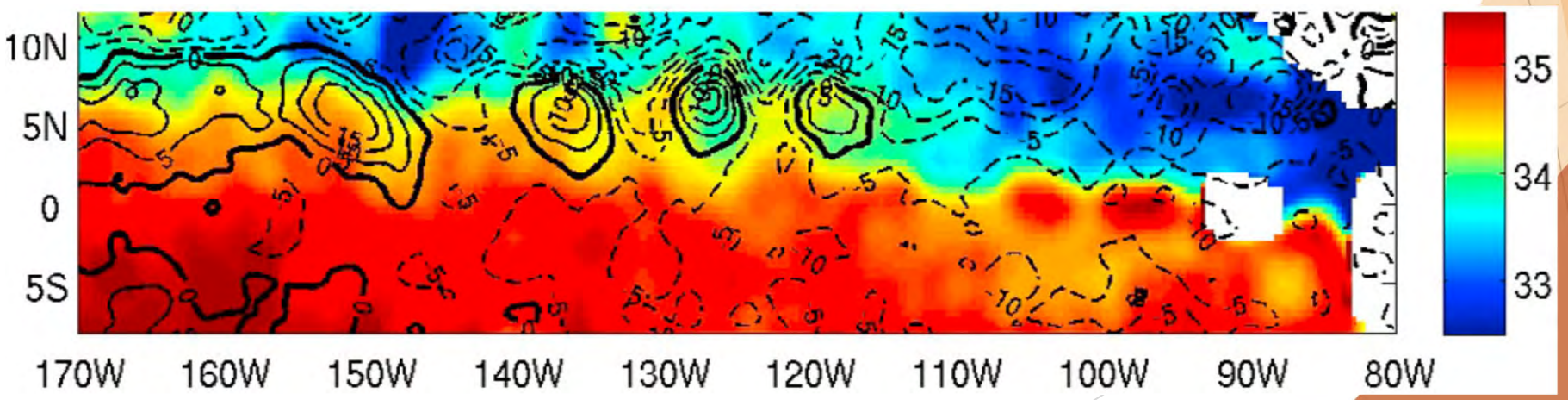
Introduction

The 1°× 1°snapshots of the Aquarius data revealed detailed pictures of the small-scale salinity signature.

Examples;

- Tropical instability waves (Lee et al. 2012)
- Mesoscale features (Melnichenko et al. 2017)
- River runoff into the ocean

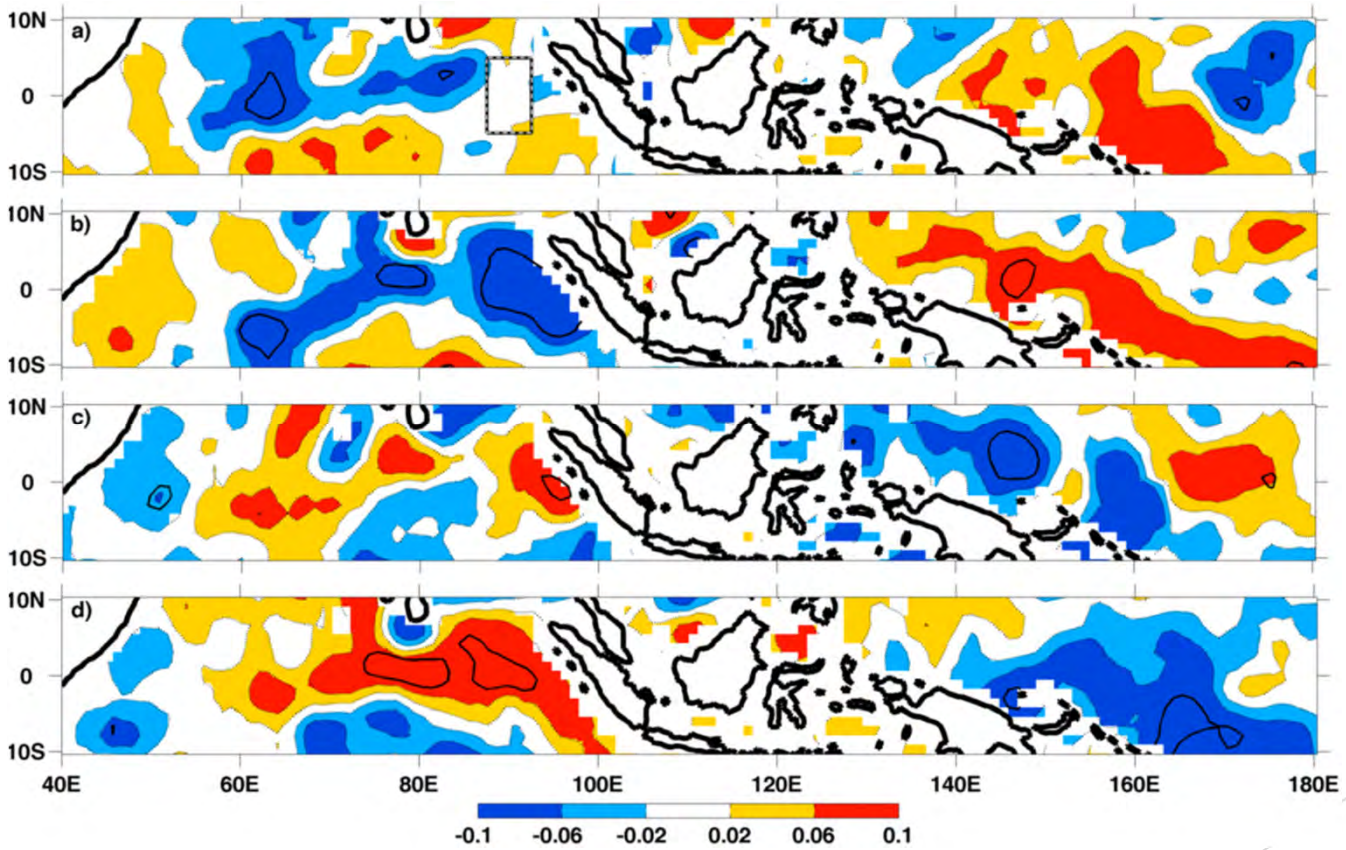
(Korosov et al. 2015; Gierach et al. 2013)



Tropical instability waves as seen in SSS field (Lee et al. 2012)

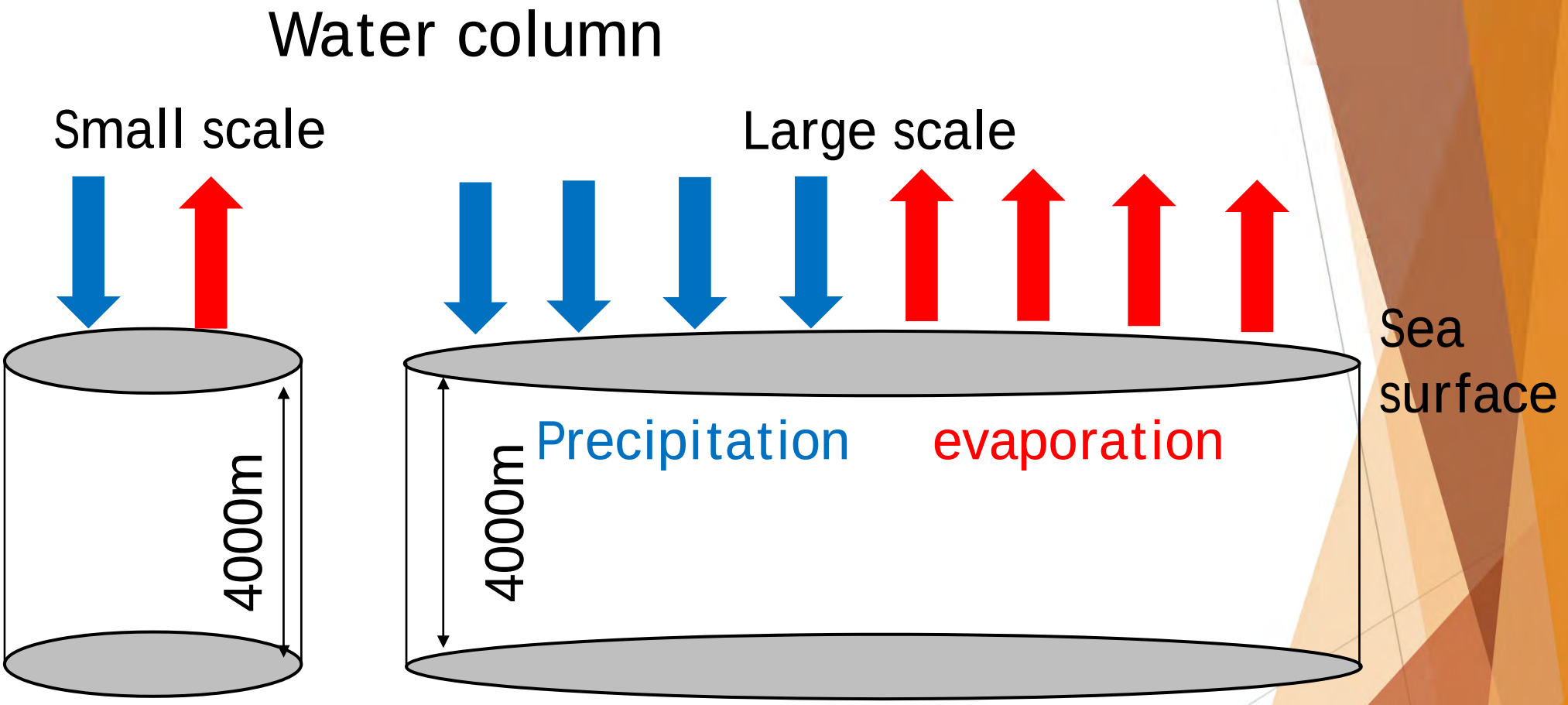
Introduction

On a synoptic scale (> 1000 km), precipitation and evaporation are dominant factors that regulate the SSS variability.



Eastward propagation of low SSS area following Madden Julian Oscillation (Grunseich et al. 2013)

Introduction



Because ocean depth is shallow for large scale water column, larger impact of fresh water flux on salinity change is expected.

Introduction

Mesoscale eddies play a significant role in ocean dynamics via the transportation of water masses and mixing.

My question:
How does the rain-induced fresh water behaves in the presence of mesoscale eddies?

Objective

To investigate behaviors of rain-induced fresh water with a focus on mesoscale eddies using Aquarius SSS.

※SSS : Sea Surface Salinity

Data

○Satellite data

① Weekly/monthly map of Aquarius SSS (1° x 1°)

② Weekly/monthly map of sea surface height anomaly (SSHA) by AVISO (1/3° x 1/3°)

③ Weekly map of GPCP※ precipitation data (1° x 1°)

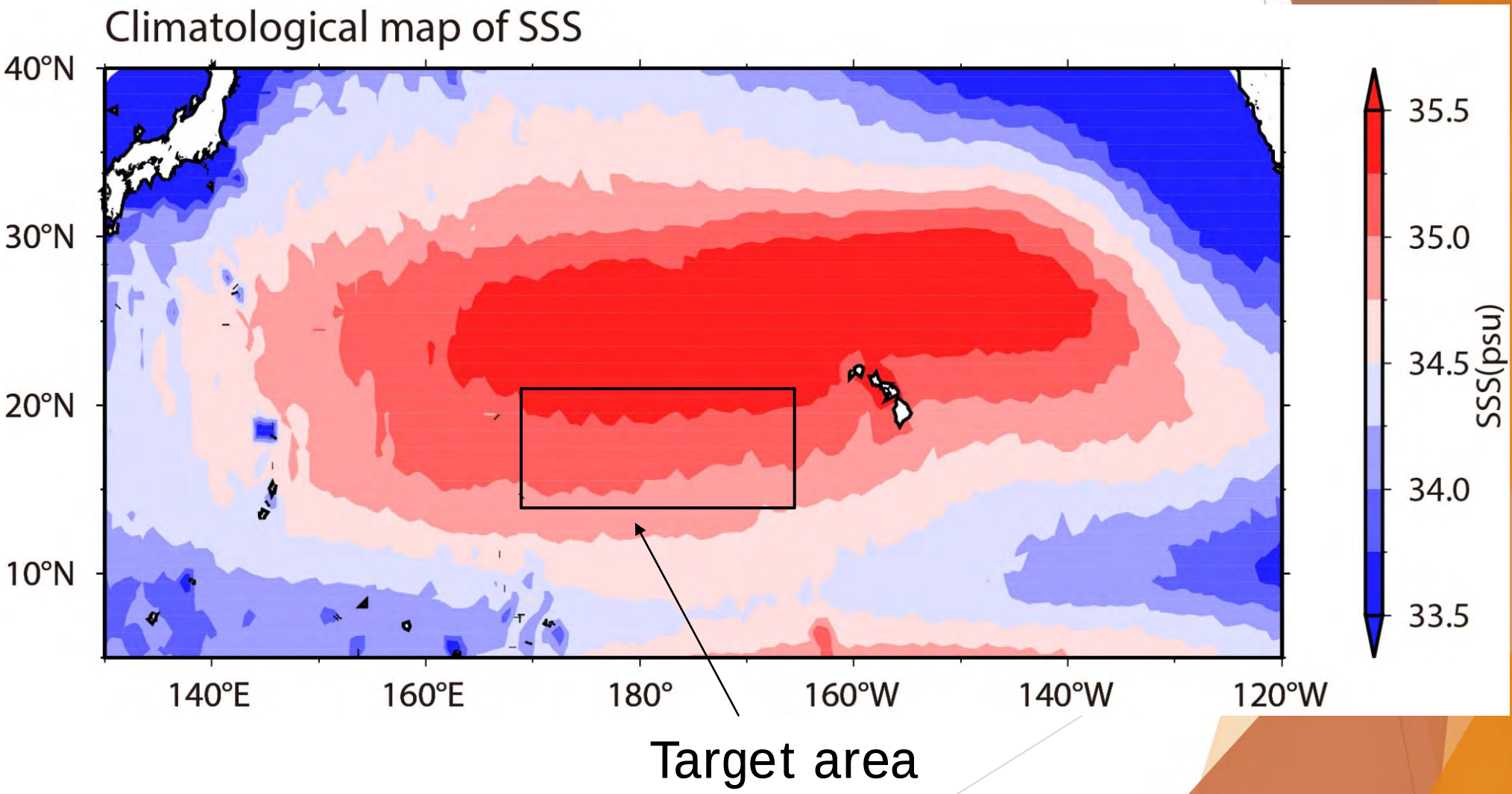
※Global Precipitation Climatology Project

○In-situ data

Salinity and temperature profiles recorded by Argo floats

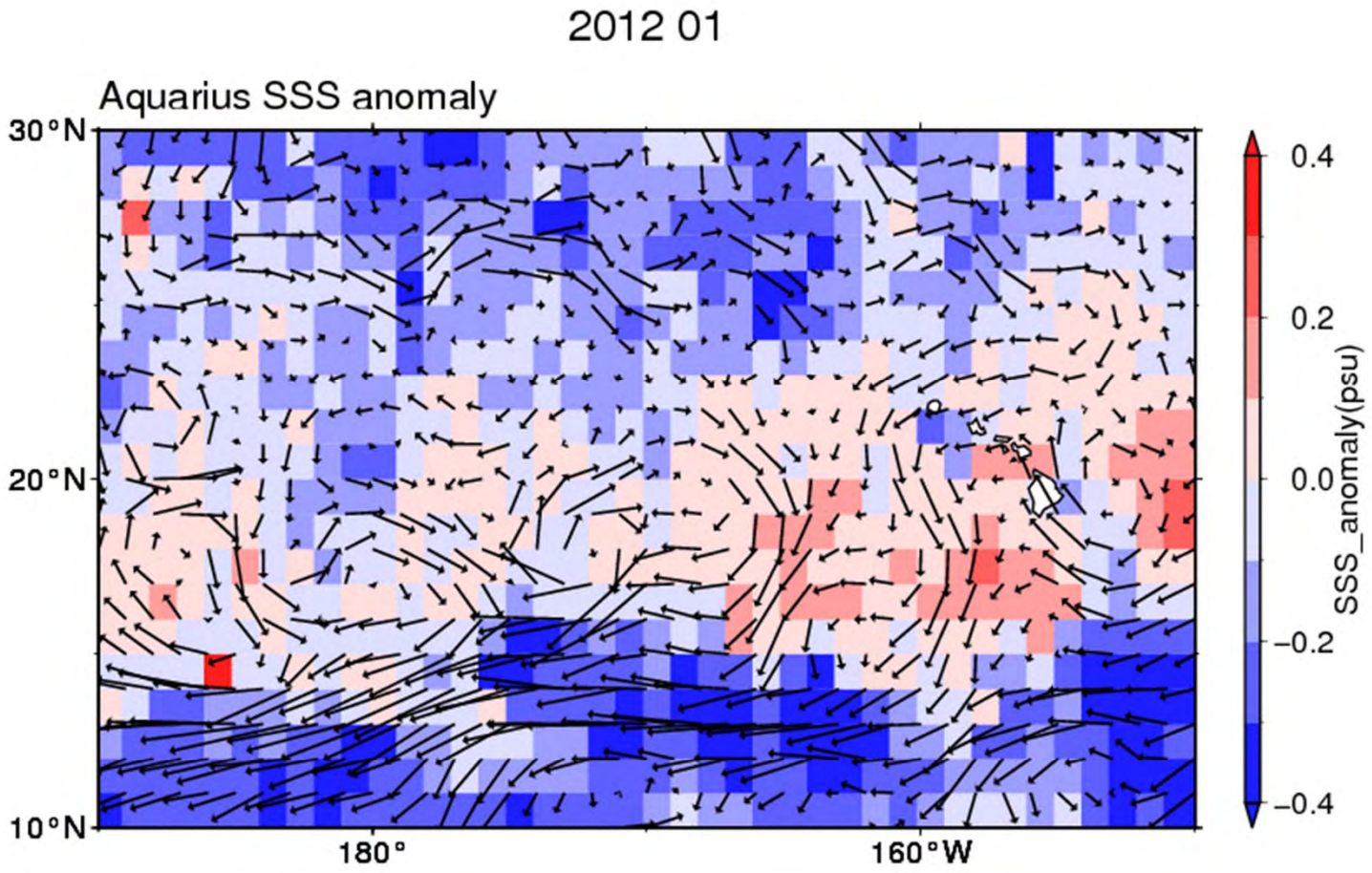
Analysis period : 2011 – 2015

Climatological field of Aquarius SSS (2011～2015)



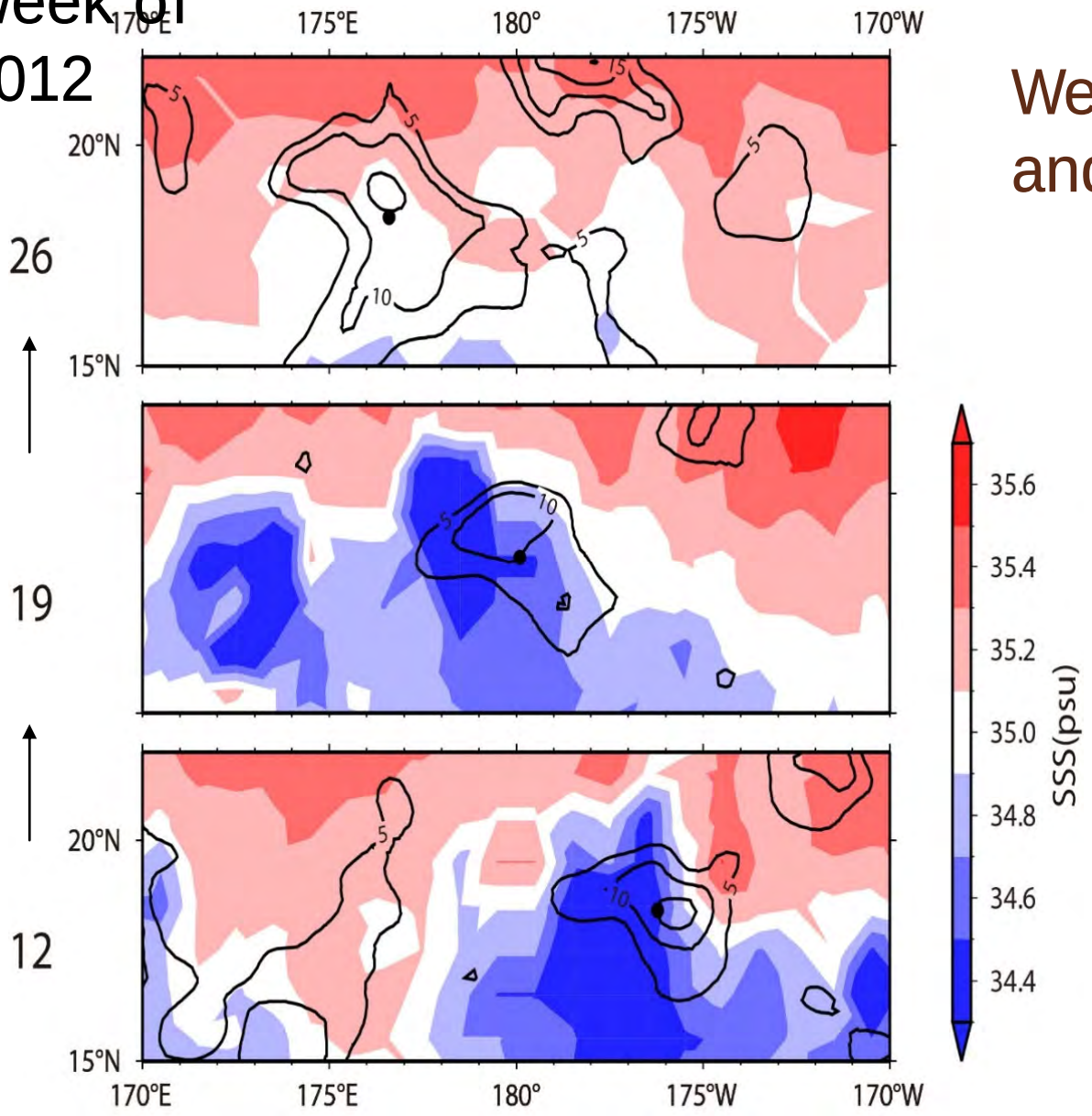
Fresh water and anticyclonic eddy

Temporal anomaly of monthly SSS from Jan - Dec 2012



Dominant low SSS pattern emerges which is in the shape of eddies.

Fresh water and anticyclonic eddy



Weekly map of SSS (color) and SSHA (contours) in 2012

Fresh water is formed, over which anticyclonic eddy propagates.

Interaction between fresh water and eddy is expected.

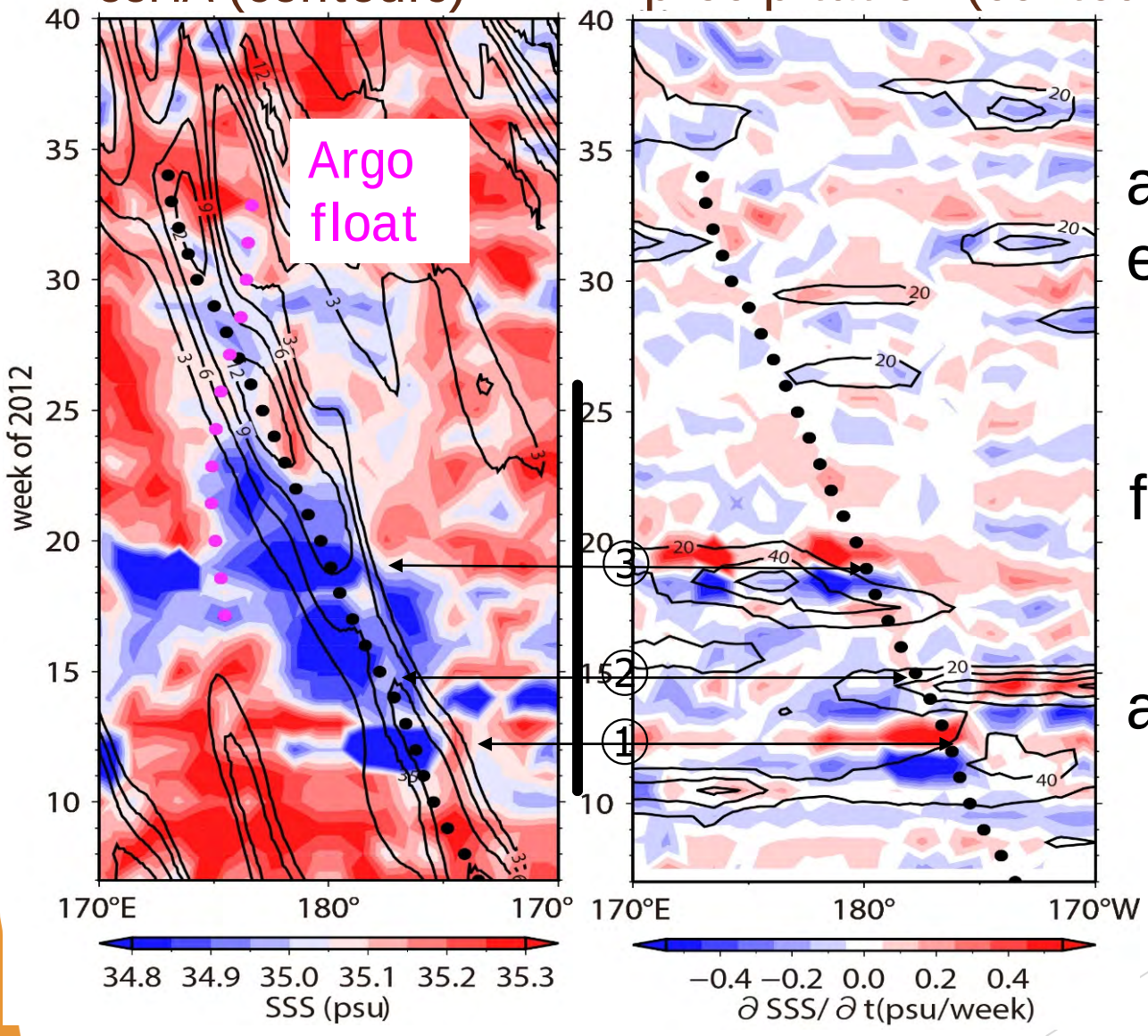
⇒ Hereafter we focus on this eddy

Westward propagation of fresh water

SSS (color) and SSHA (contours)

∂(SSS)/ ∂t (color) and precipitation (contours)

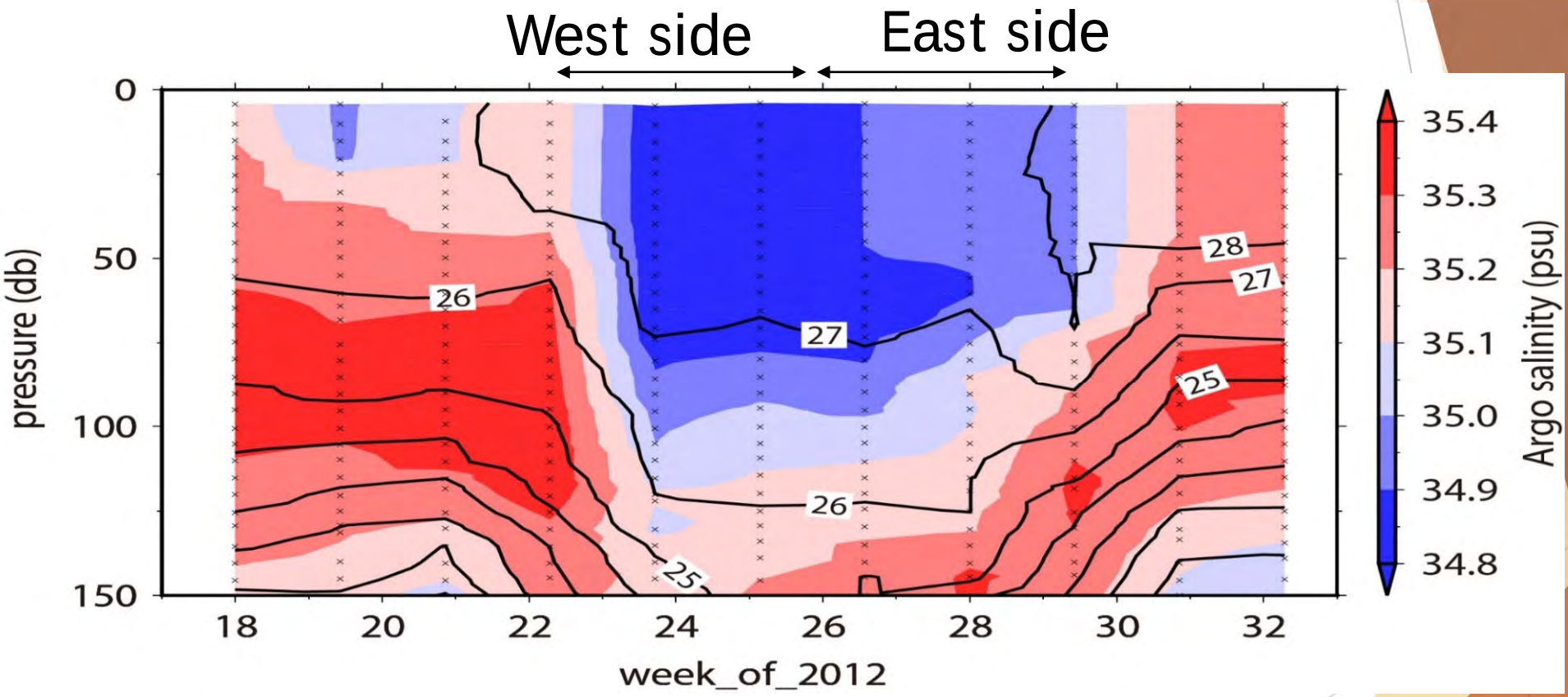
Longitude-time diagram of 17-20°



- Fresh water distributing along path of propagating eddy
- Three times of freshening by rainfall
- Argo float is monitoring at the same position.

Vertical structure of fresh water

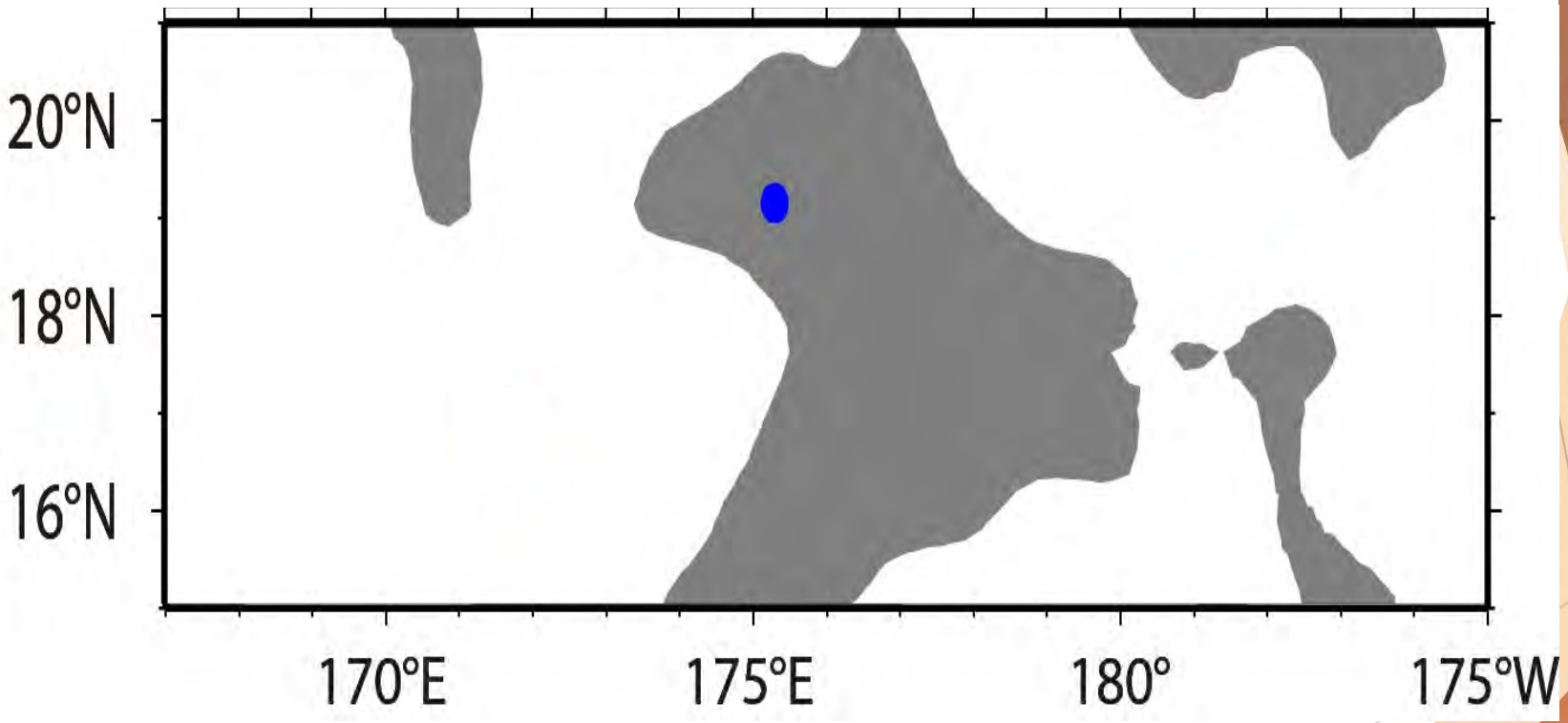
Salinity (color) and temperature profile (contours) of Argo float



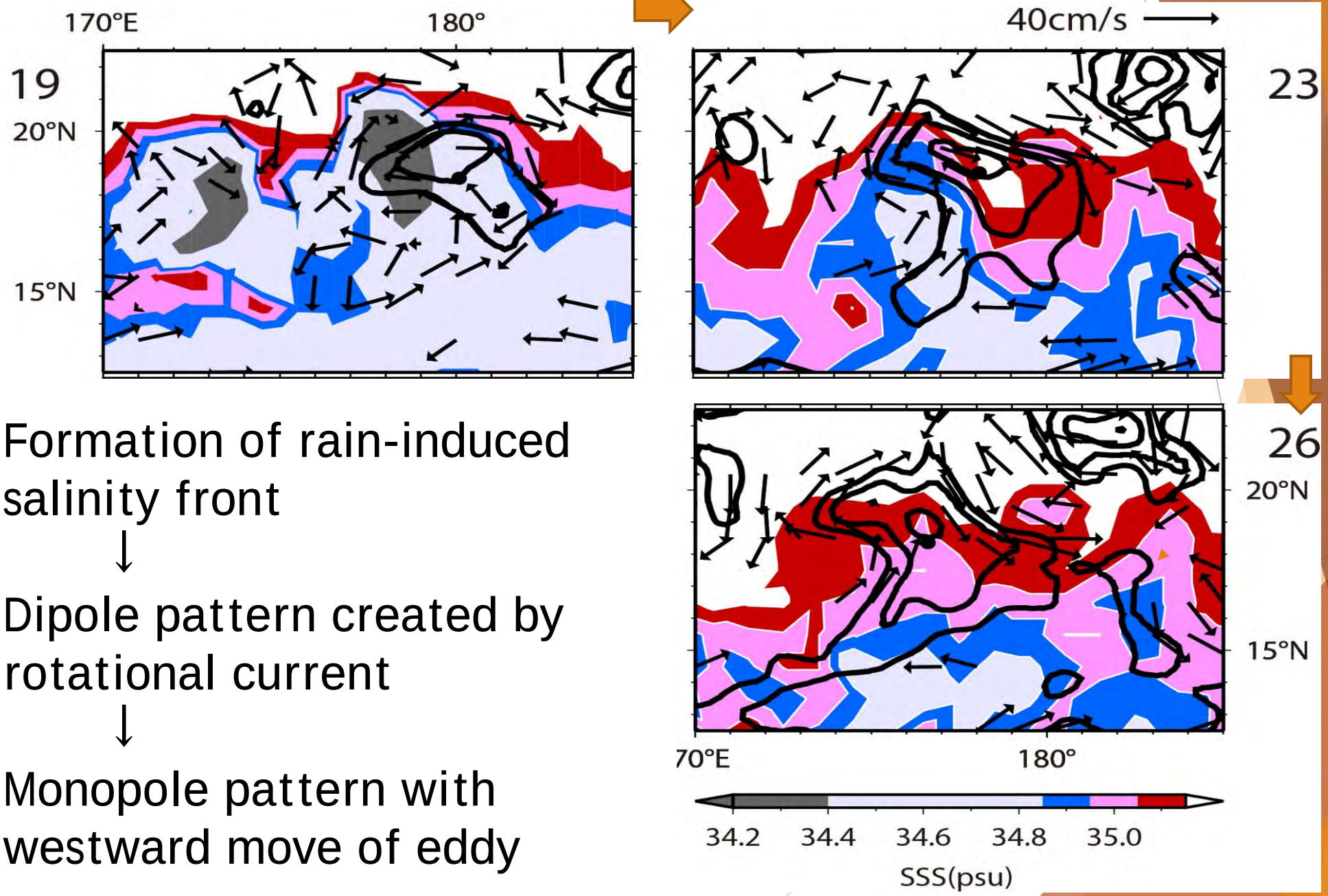
- Fresh water is deep in structure (70m)
- Fresher in the west side than east side

Vertical structure of fresh water

Location of Argo float (●) and eddy (●)



Eddy stirring



Formation of rain-induced salinity front

↓

Dipole pattern created by rotational current

↓

Monopole pattern with westward move of eddy

Discussion

What will happen next?

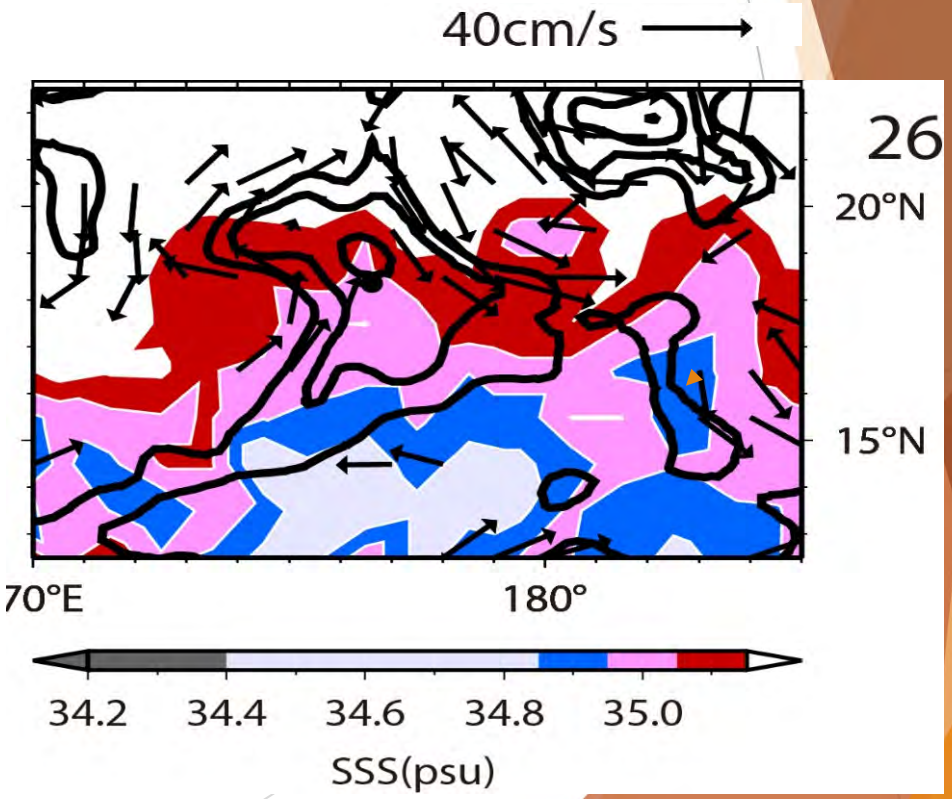
According to Chelton et al. (2011), “nonlinear eddy” can trap water parcel within the eddy interior as it propagates.

Nonlinear eddy : $U/c > 1$

- U : rotational fluid speed
- c : eddy propagation speed

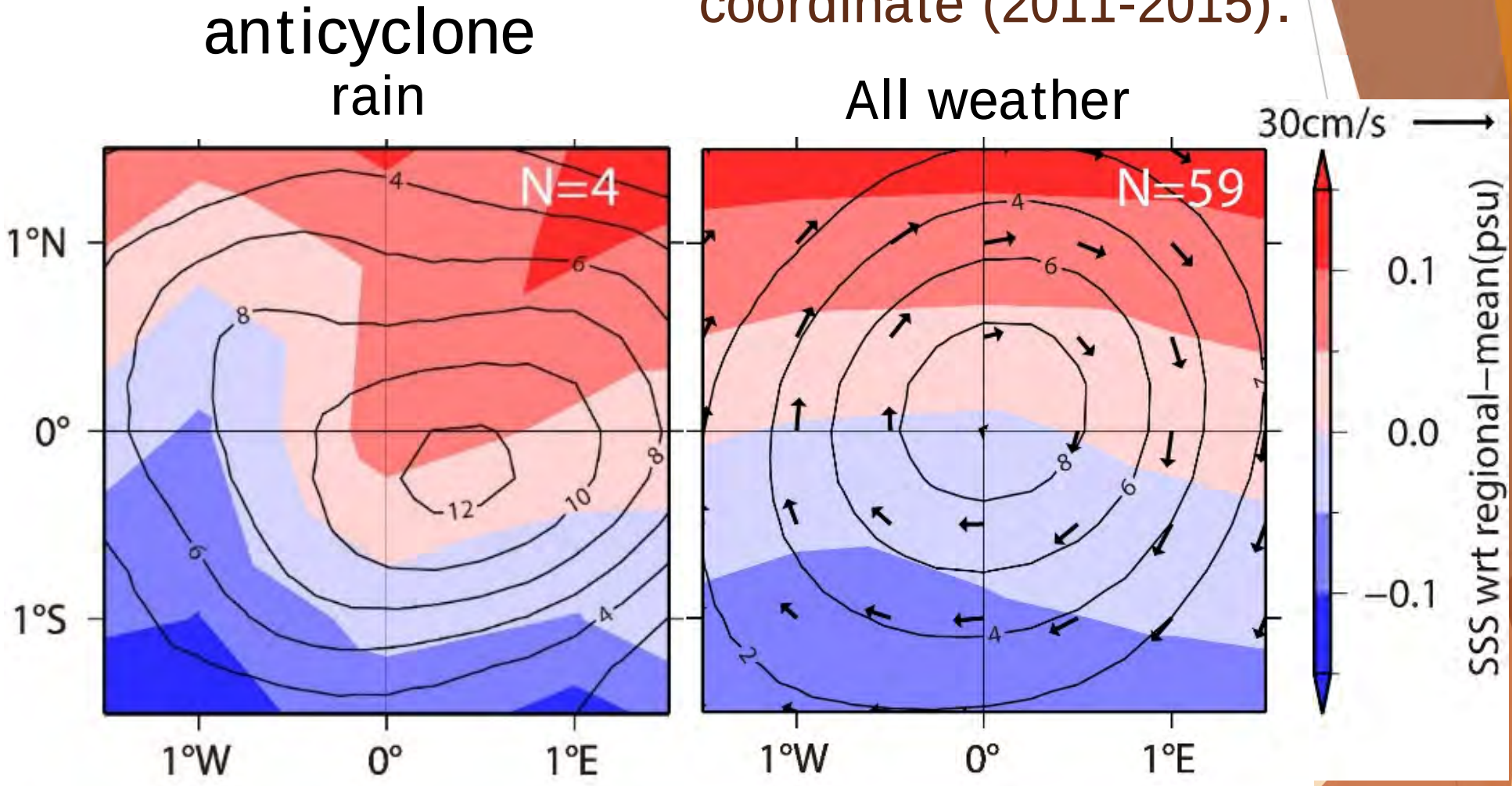
This is nonlinear eddy

(U = 20cm/s, c = 7cm/s)



Discussion

Composite map of SSS (color) and SSHA (contours) in the eddy coordinate (2011-2015).

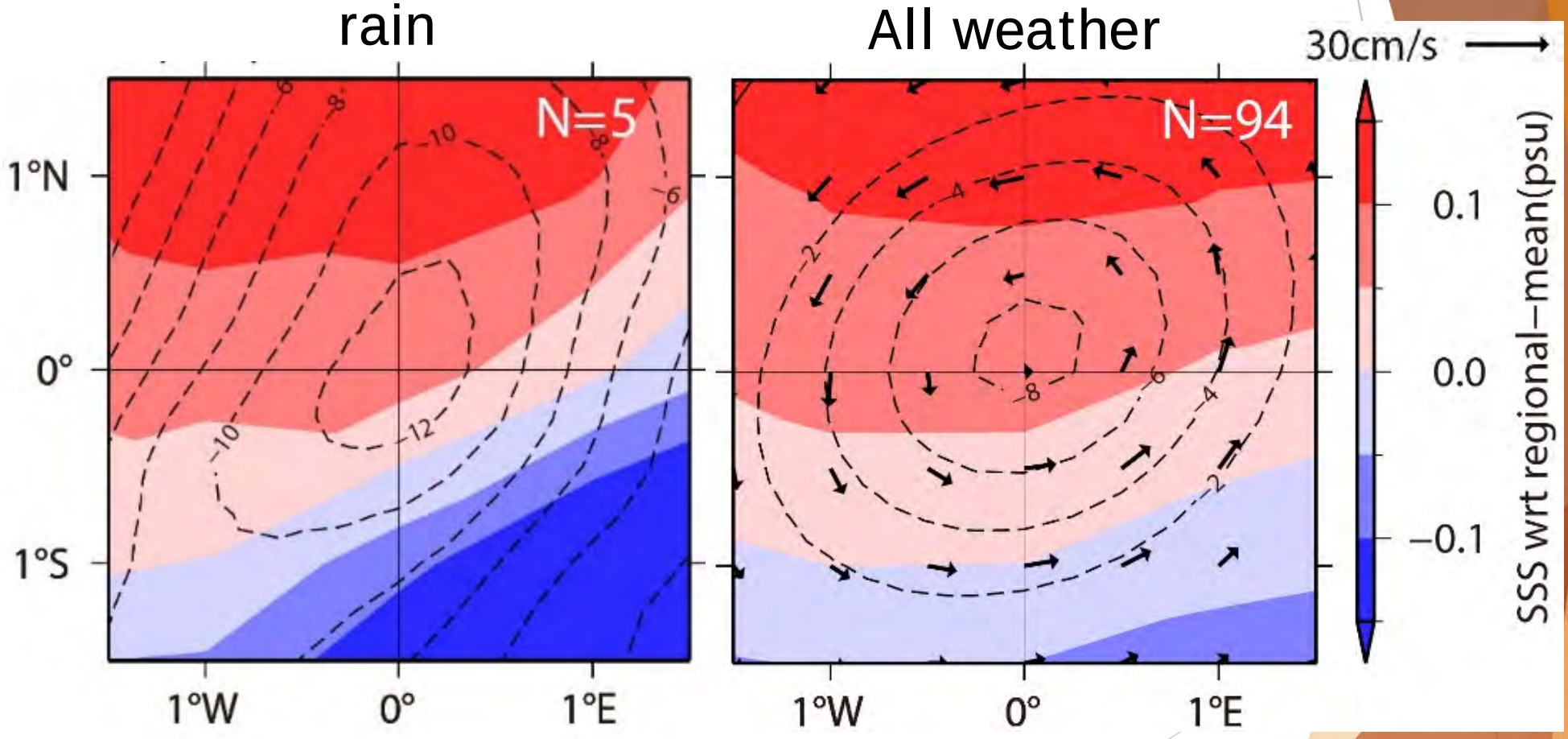


Eddy stirring is identified when rain not considered as well.

But clearer when rain considered.

Discussion

Composite map of SSS (color) and SSHA (contours) in the eddy coordinate (2011-2015).



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Summary

- Using 1° x 1° Aquarius SSS data, this study examined upper-ocean salinity responses to precipitation focusing on mesoscale eddies.
- SSS map reflected atmospheric pattern of precipitation just after this event.
- With the time progresses (3-5 weeks), oceanic dynamic structure associated with mesoscale eddies emerges.
- Dipole pattern of SSS was created by rotational flow (deep in structure (70m)).
- After monopole pattern formation, then eddy likely traps the fresh water as it propagates at 20°N.