Numerical study of the general circulation in the Japan/East Sea with simple assimilation of temperature and salinity data

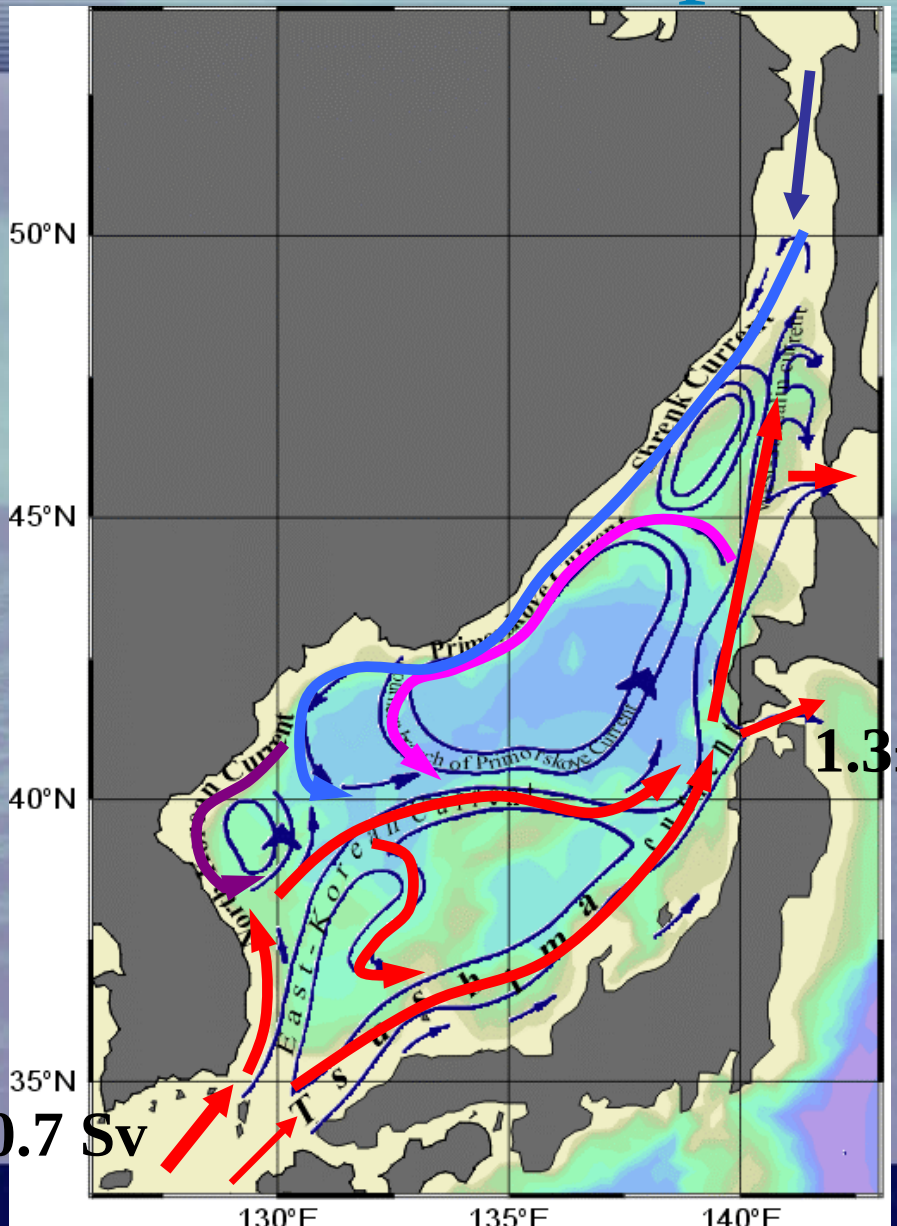
Gennady A. Platov[1], Elena N. Golubeva[1], Young Jae Ro[2] and John F. Middleton[3]

1. *Ins. of Comp. Mathematics and Mathematical Geophysics,Novosibirsk,Russia*
2. *Chungnam National Uni., Teajon,Korea*
3. *Uni. Of New South Wales, Sydney, Australia*

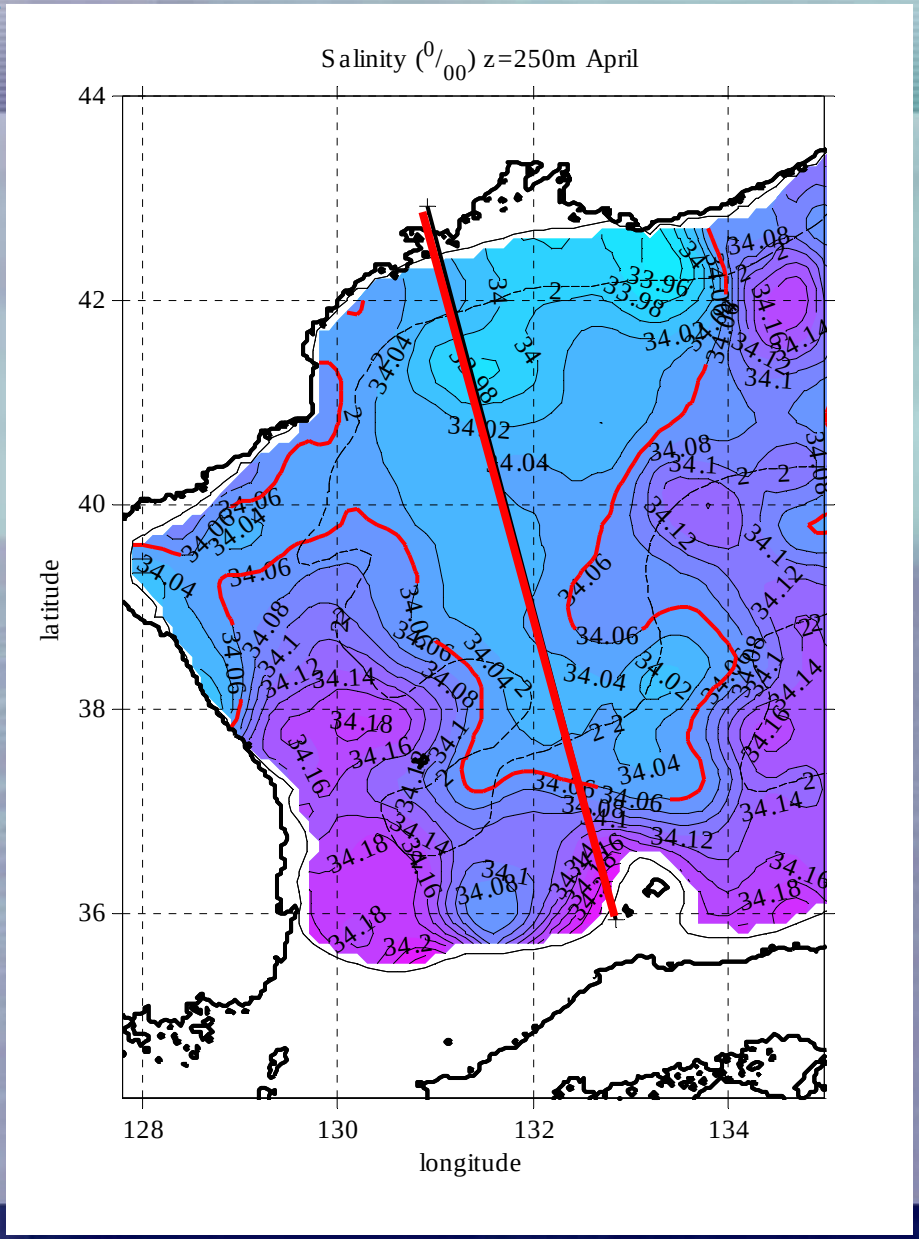
Topics

- Regional circulation pattern
- Intermediate water formation. Data analysis
- Model parameters. Assimilation technique
- External forcing
- Numerical results
- Discussion

Regional circulation pattern



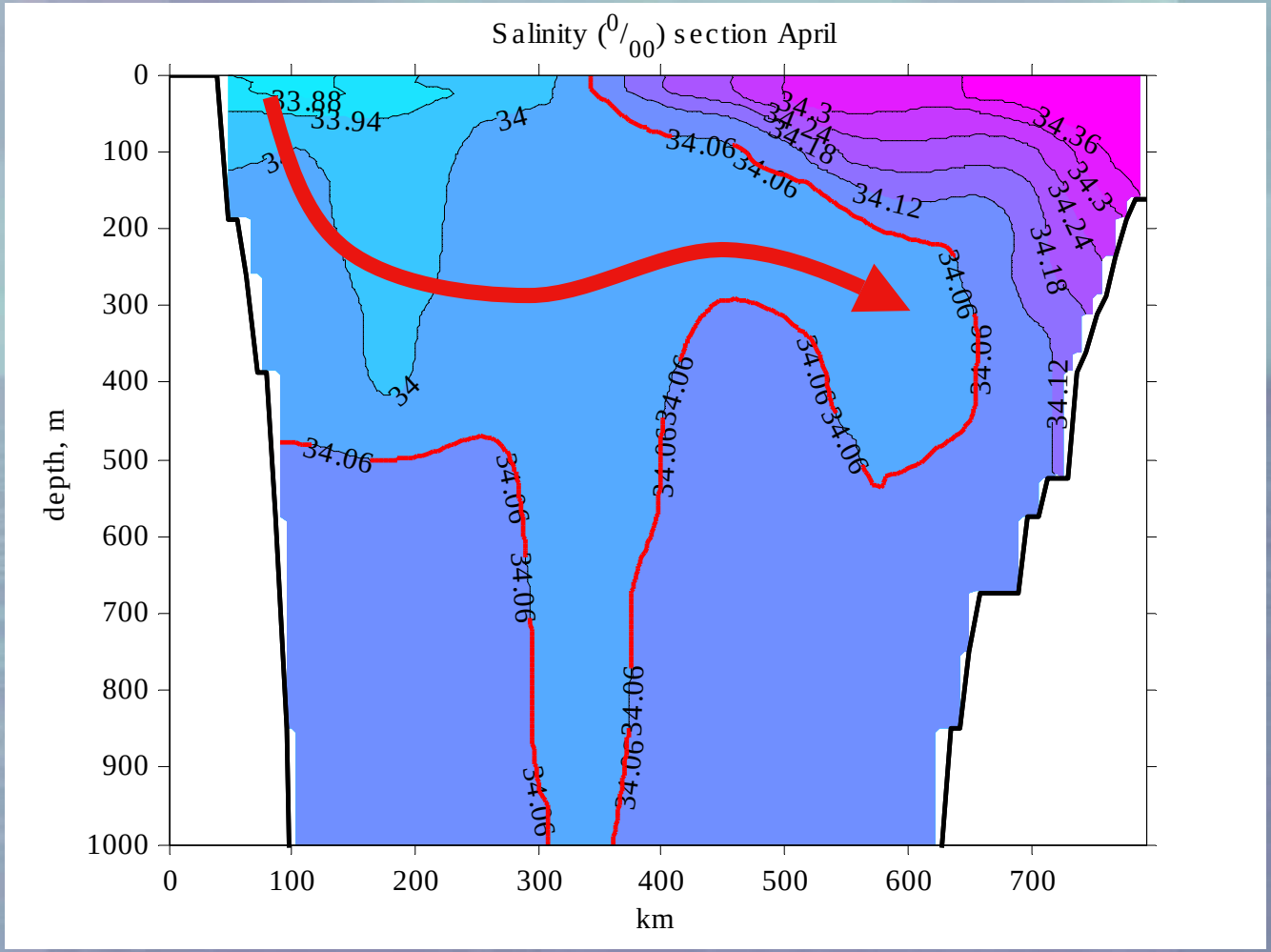
Japan Sea Intermediate Water (JSIW)



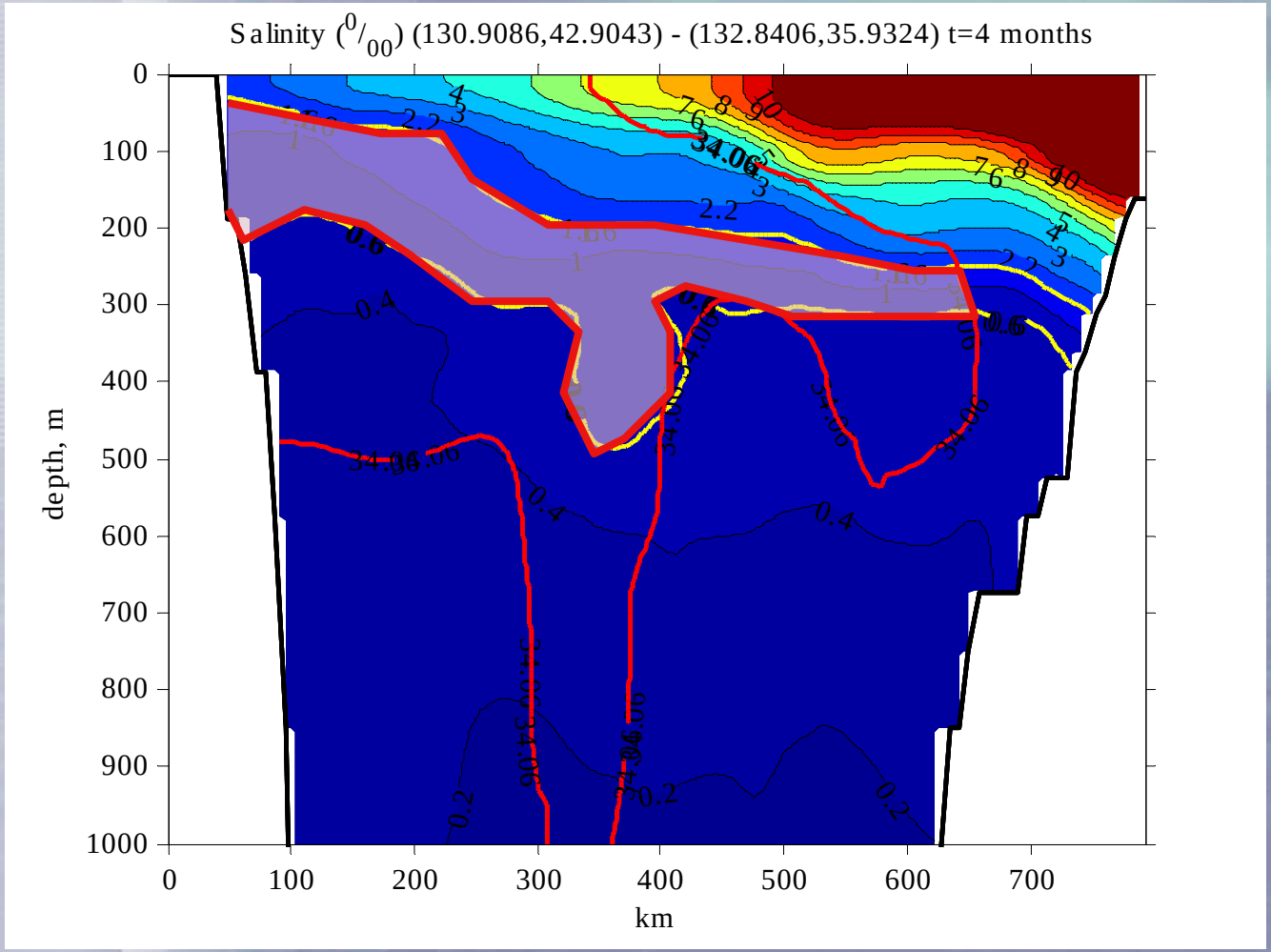
Sudo, 1986

Senjyu and Sudo, 1993

Salinity section

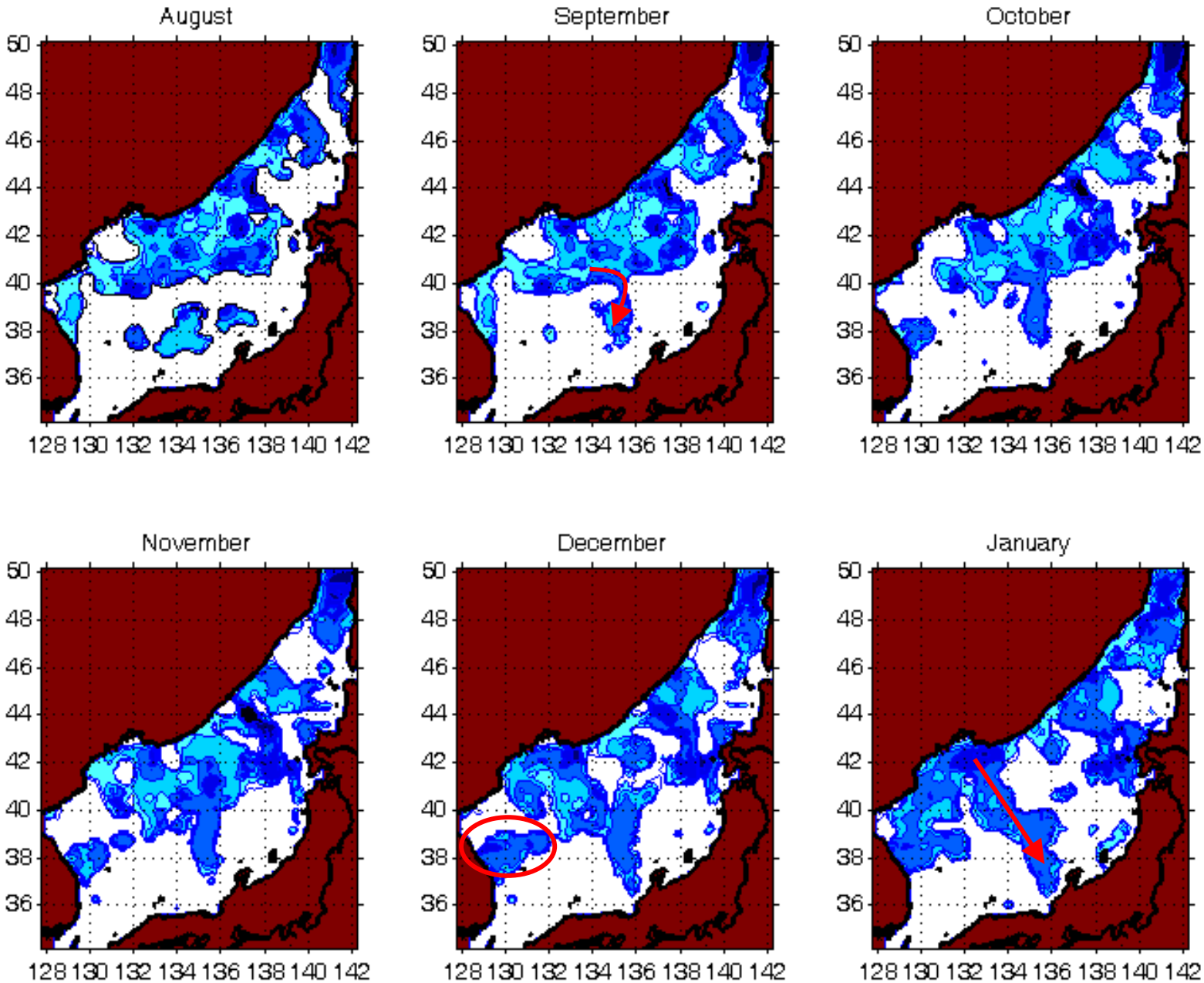


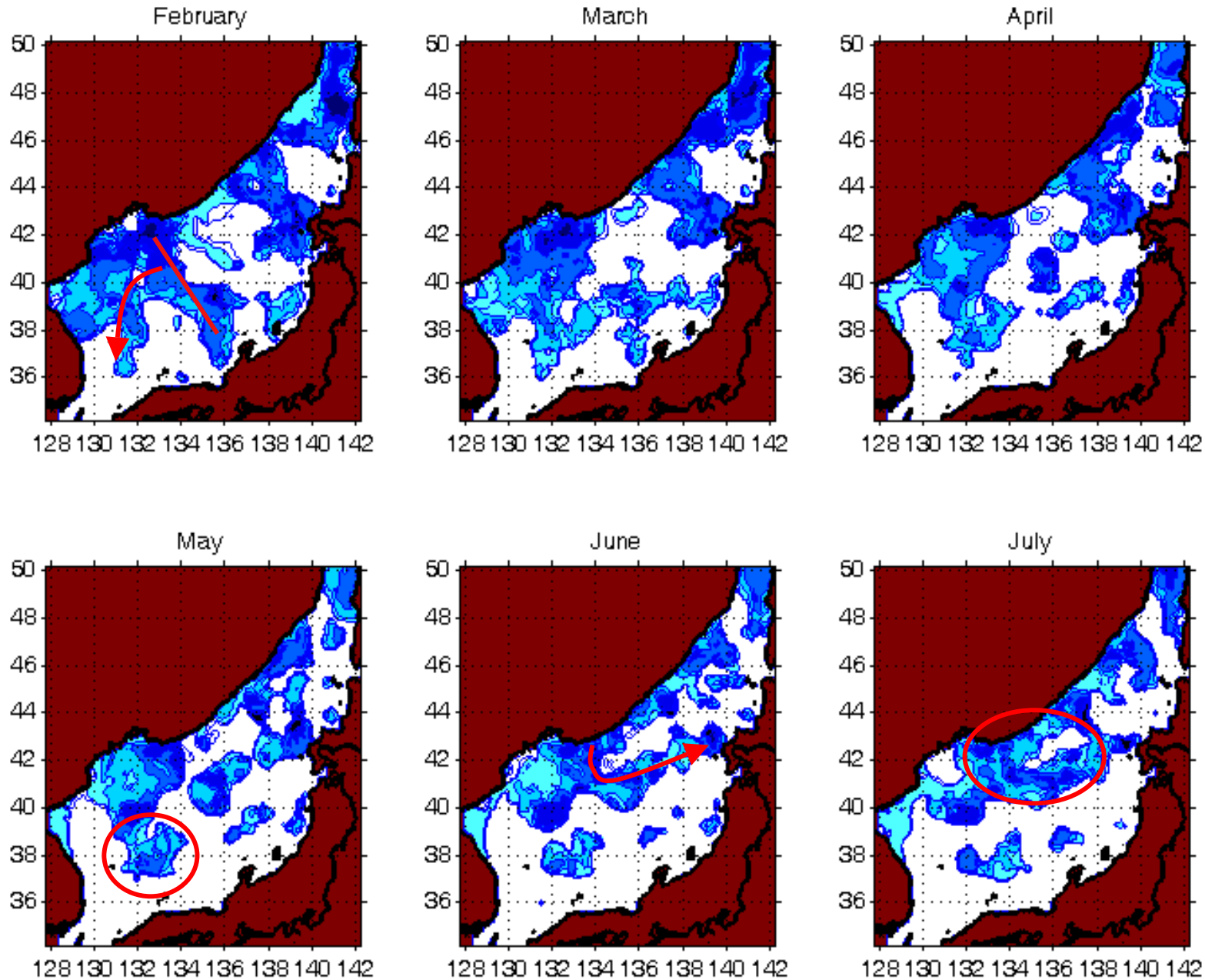
JSIW type definition



$S < 34.06$ ‰

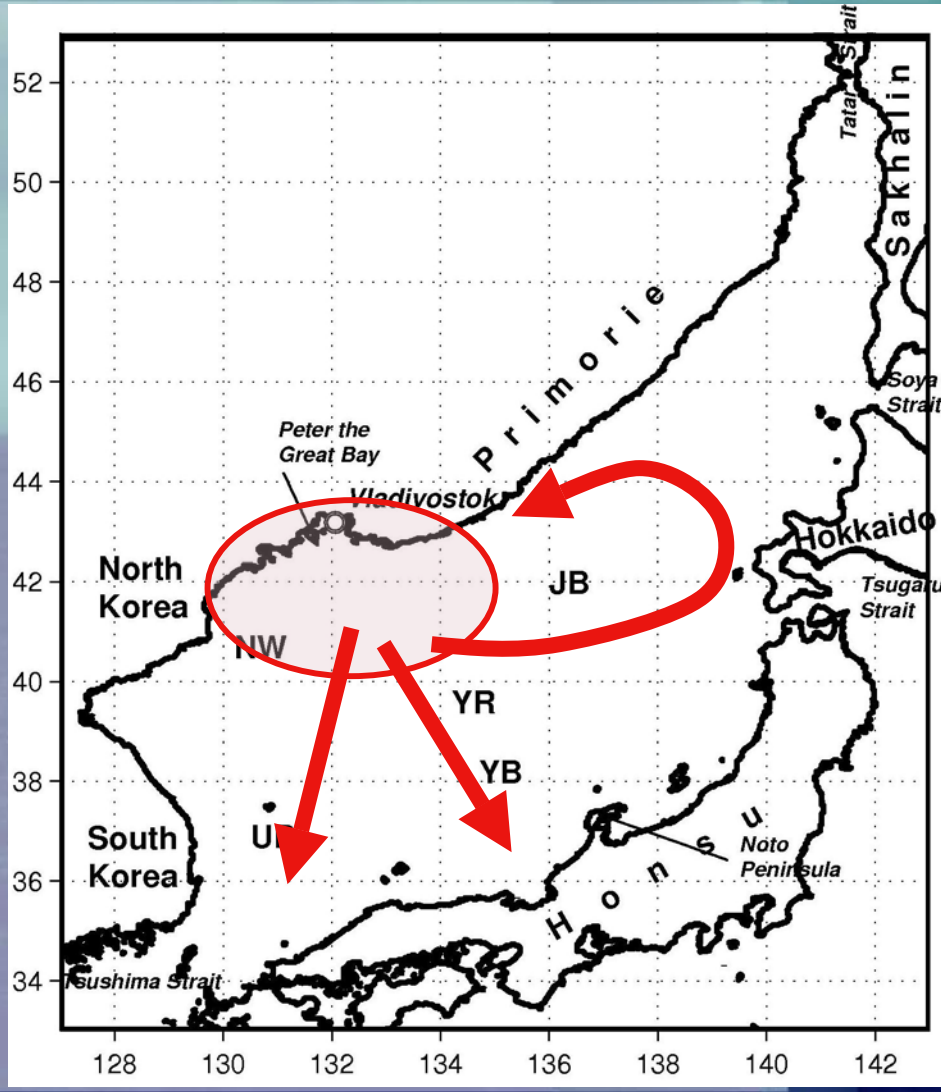
$0.6^0 < T < 1.6^0$


August
September
October
November
December
January
50
48
46
44
42
40
38
36
128 130 132 134 136 138 140 142


February
March
April
May
June
July
50
48
46
44
42
40
38
36
128 130 132 134 136 138 140 142

Seasonal JSIW dynamics and circulation

- The area of JSIW origin is the area adjacent to Peter the Great Bay, where it could be formed and deepened by 1) seasonal convection, 2) alongslope downwelling, 3) convection, caused by mixture of different water types with more dense water production
- Almost half of the year (September-March) this area supplies JSIW to the Yamato Basin
- In February-May period JSIW occupies the Ulleung Basin
- In summer it propagates eastward, so that by the August it is locked in northern part of the JES only



ICMMG model (parameters)

- Horizontal resolution 0.05^{o}x0.05^{o}
- Time step 40 min
- Vertical resolution:
  - 0, 10, 20, 30, 40, 50, 65, 80, 100, 125,150, 200, 250, 300, 400, 500, 600, 700, 800, 1000, 1250, 1500, 1750, 2000, 2500, 3000, 3500 m
- Max inflow 2.4Sv in November, Min inflow 1.2Sv in May
- Smagorinsky parameterization of horizontal viscosity with minimum value 1 m^2/s
- Vertical diffusion coefficient parameterization:

$$A_z = (ch)^2 \sqrt{\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2 - \frac{g}{\rho}\frac{\partial \rho}{\partial z}}$$

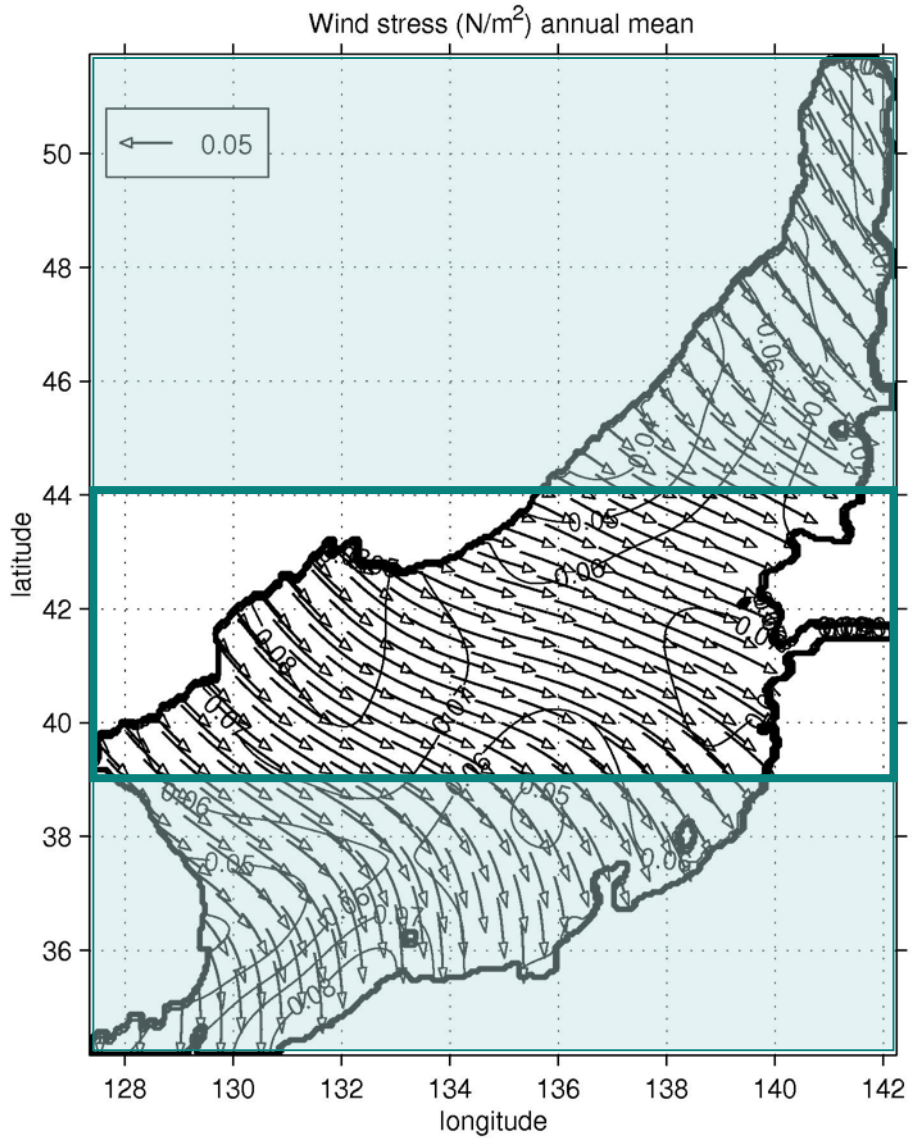
Data assimilation scheme

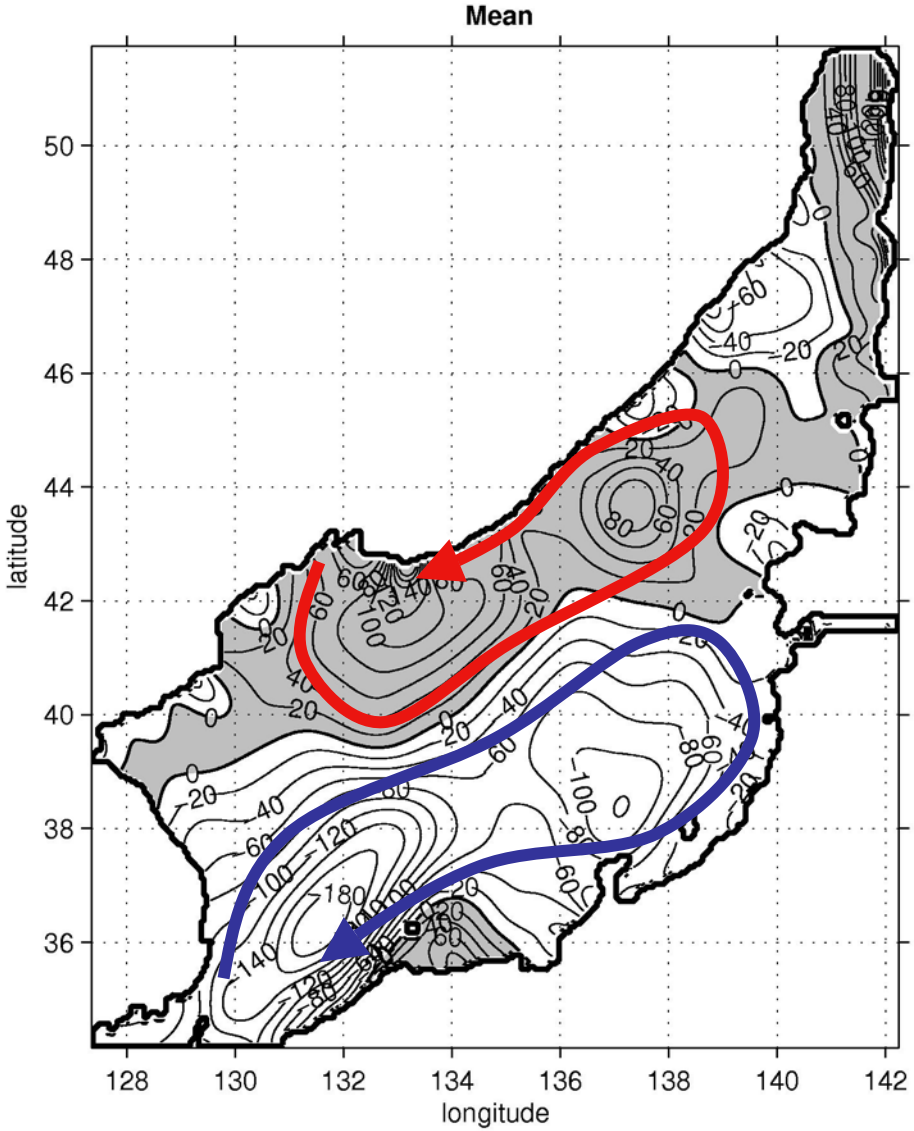
$$\left(\frac{\partial T}{\partial t}\right)_{\text{nudging}} = \begin{cases} \frac{1}{\tau}\left(T^*(t-\tau) - T\right) & \text{if } z > -500\text{ m} \\ 0 & \text{otherwise} \end{cases}$$

where $T^*(t) = \overline{T_{\text{GDEM}}}^{t} + r\left(T_{\text{GDEM}}(t) - \overline{T_{\text{GDEM}}}^{t}\right)$

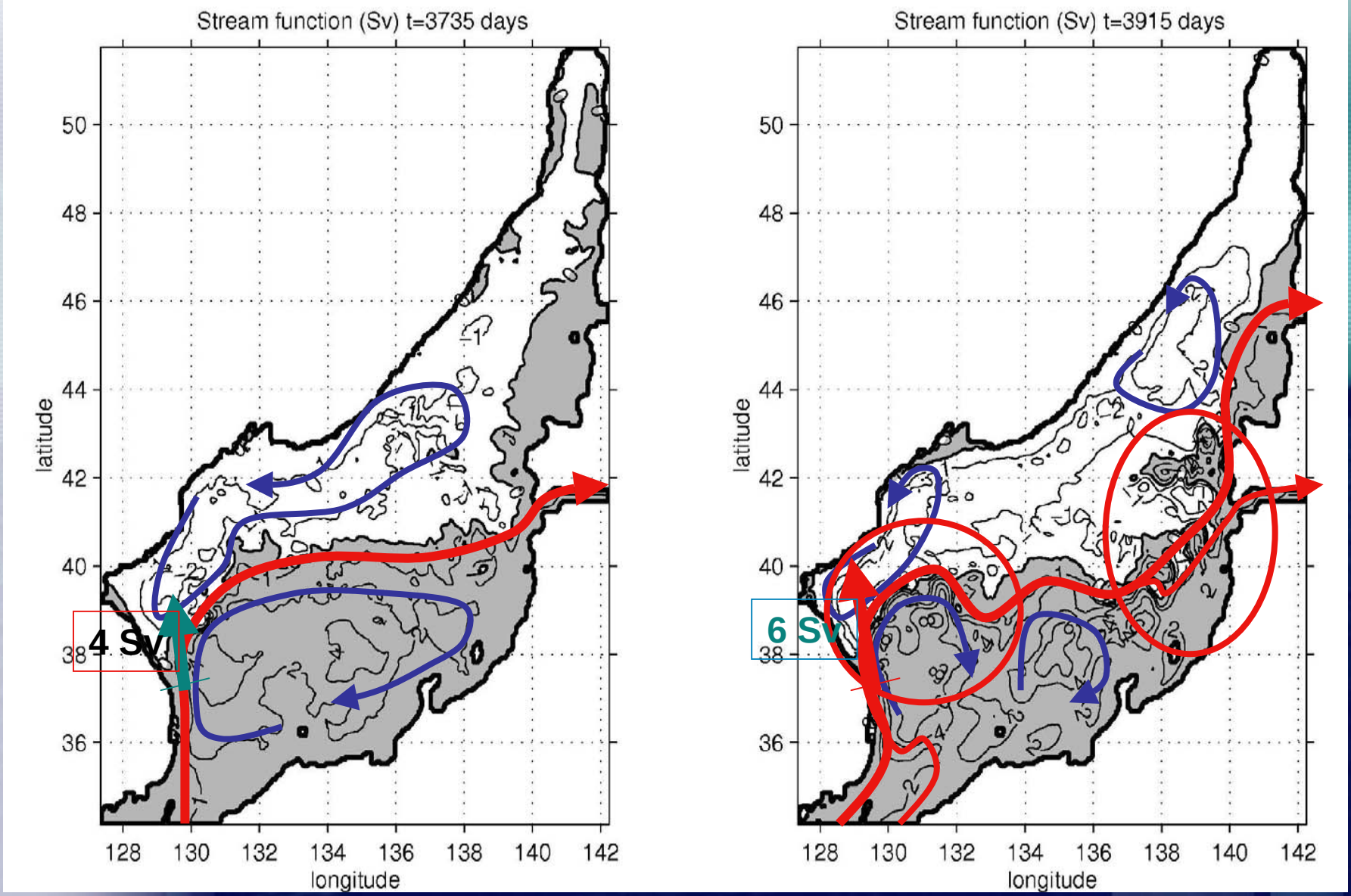
and τ = 37 days, r = 1.25

Wind stress – wind stress curl (Na and Seo, 1992)



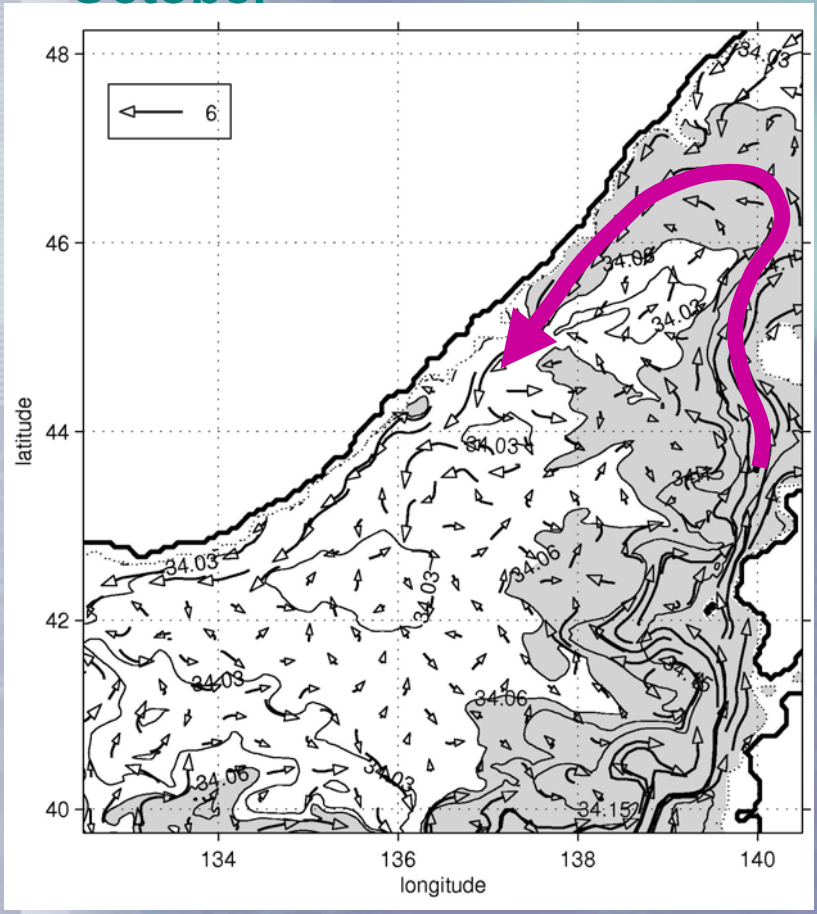


Seasonal variation of stream function

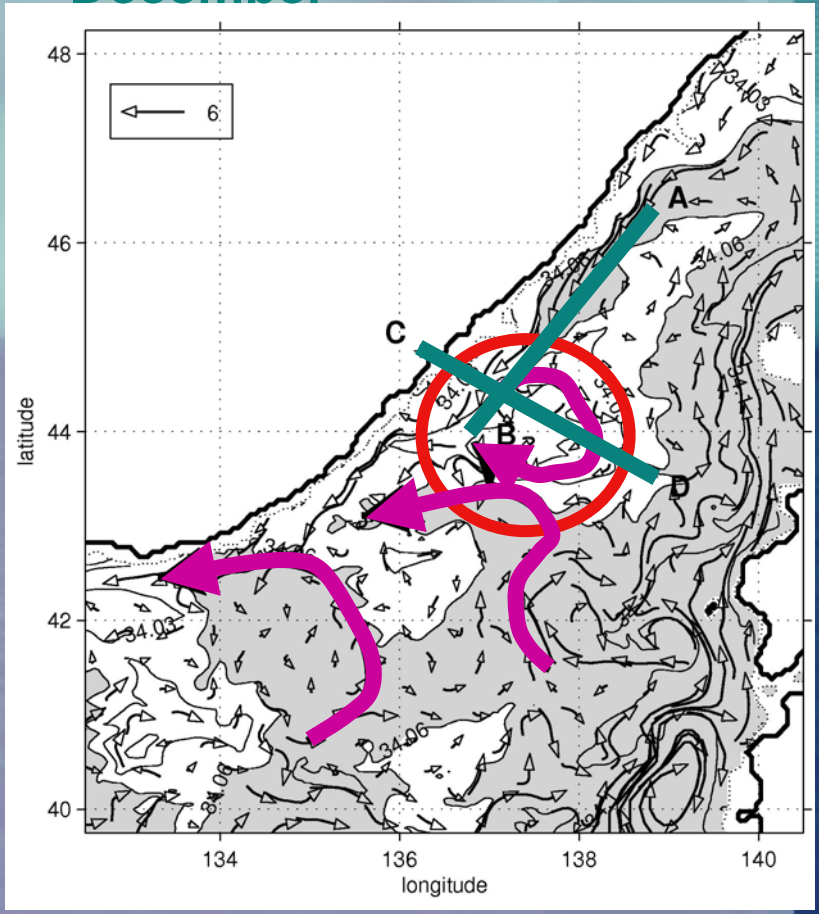


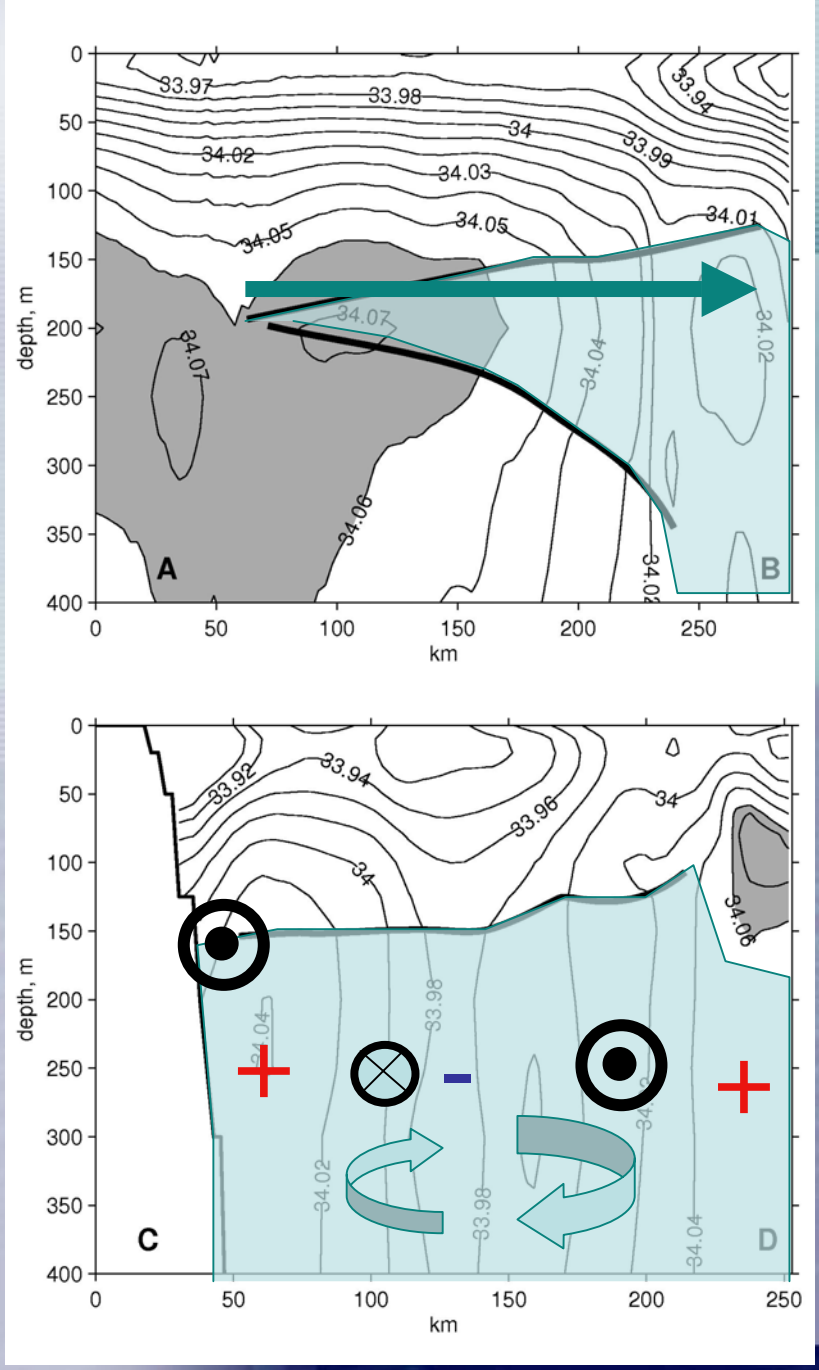
Salinity belt – salt water intrusion

October



December

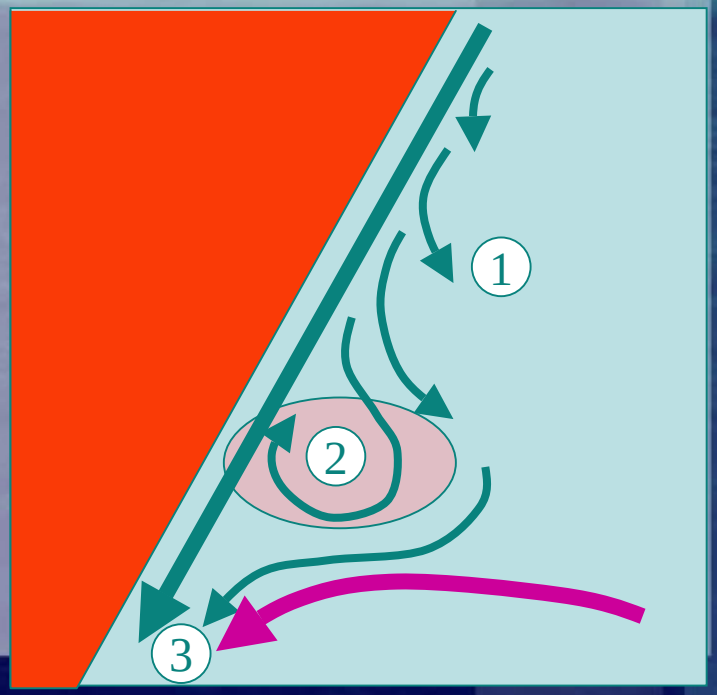




SWI transformations

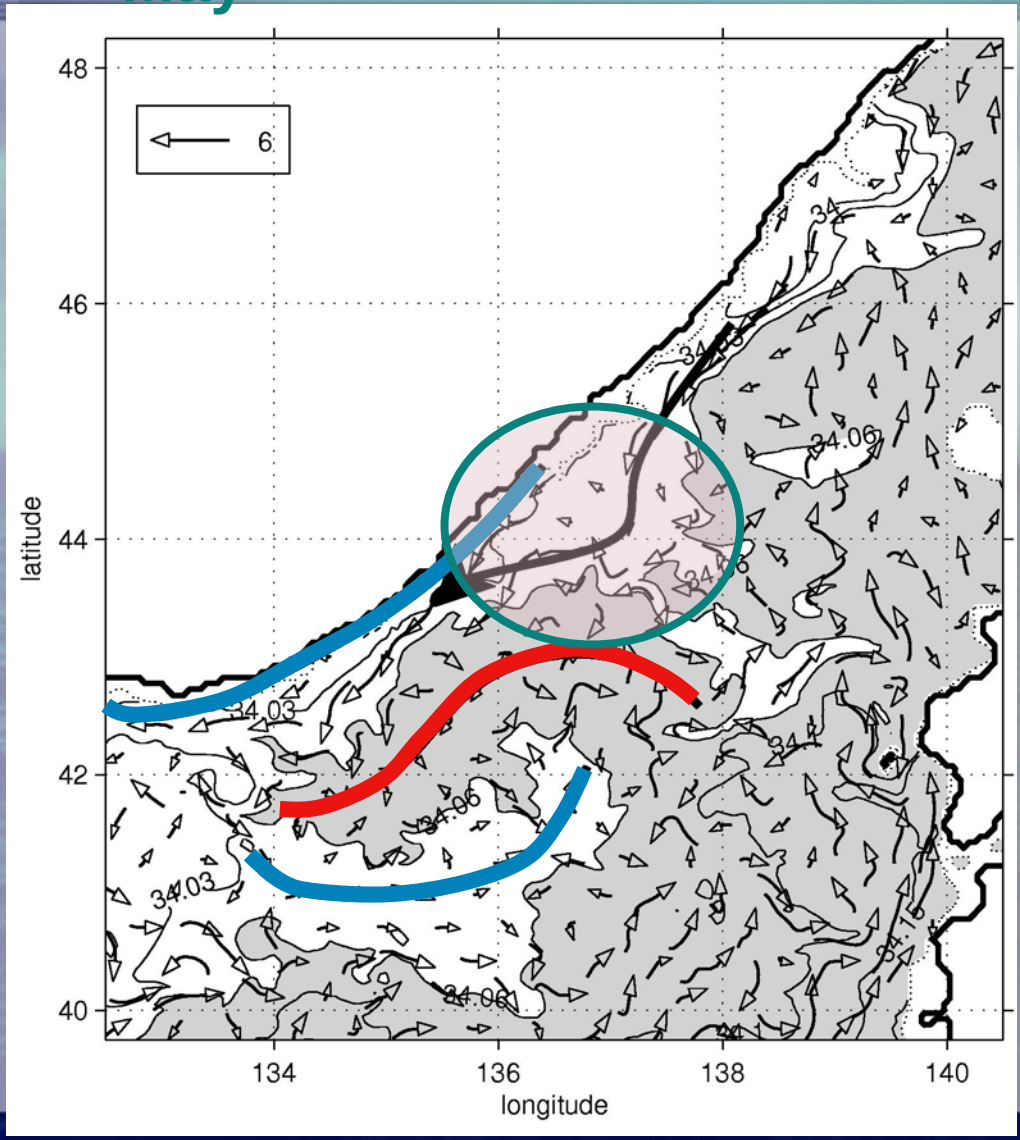
$$\frac{\zeta + f}{H} = \text{const}$$

1. As mixed layer thickness is growing, it makes the water column to stretch, thus according to the above expression ζ must also increase to become positive (cyclonic). It makes the stream line to decline in the offshore direction
2. The small shallow area down the stream lowers the depth, so that overall vorticity ζ becomes negative (anticyclonic). It produces an anticyclonic eddy.
3. Following the stream line, the depth starts to increase again and ζ becomes positive making the flow to follow the coast line.



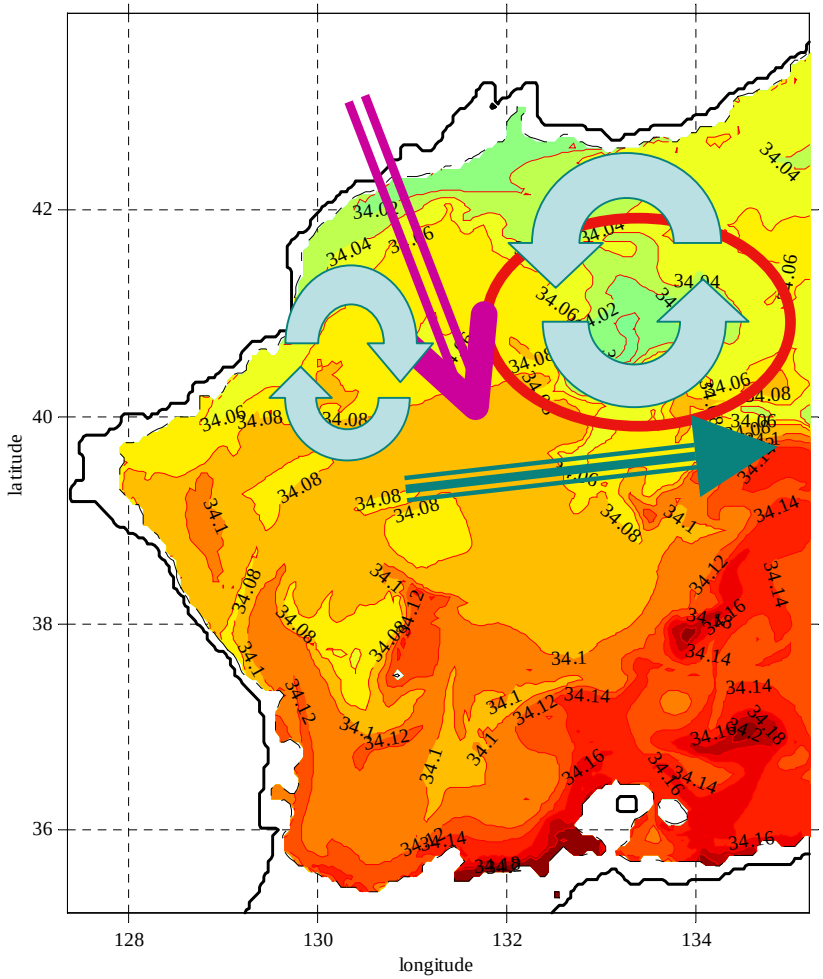
Salinity belts

May

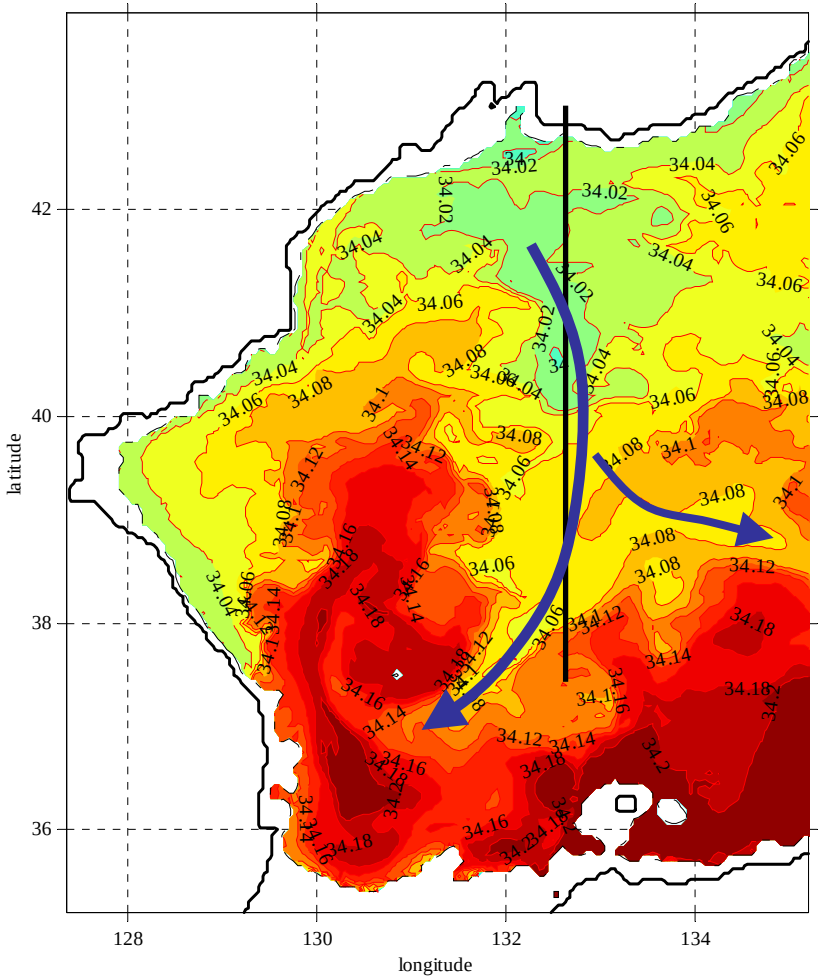


Ulleung Basin

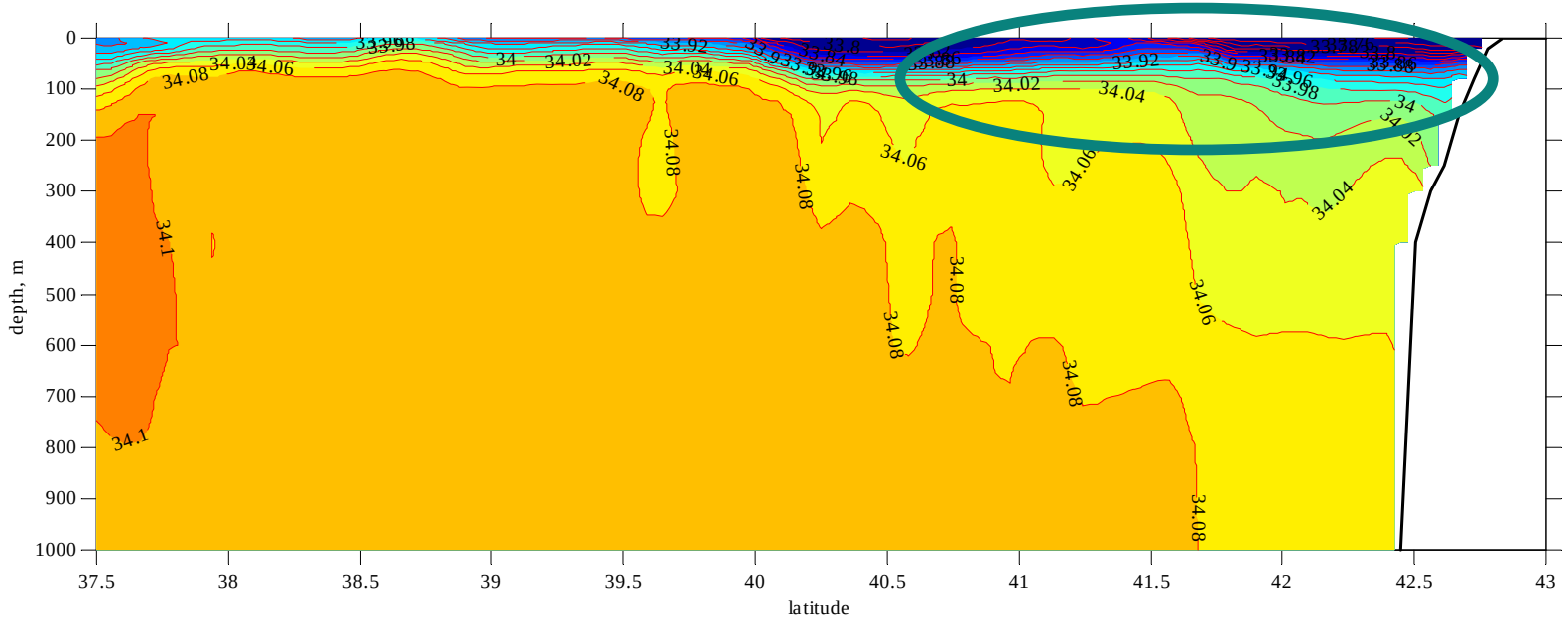
December

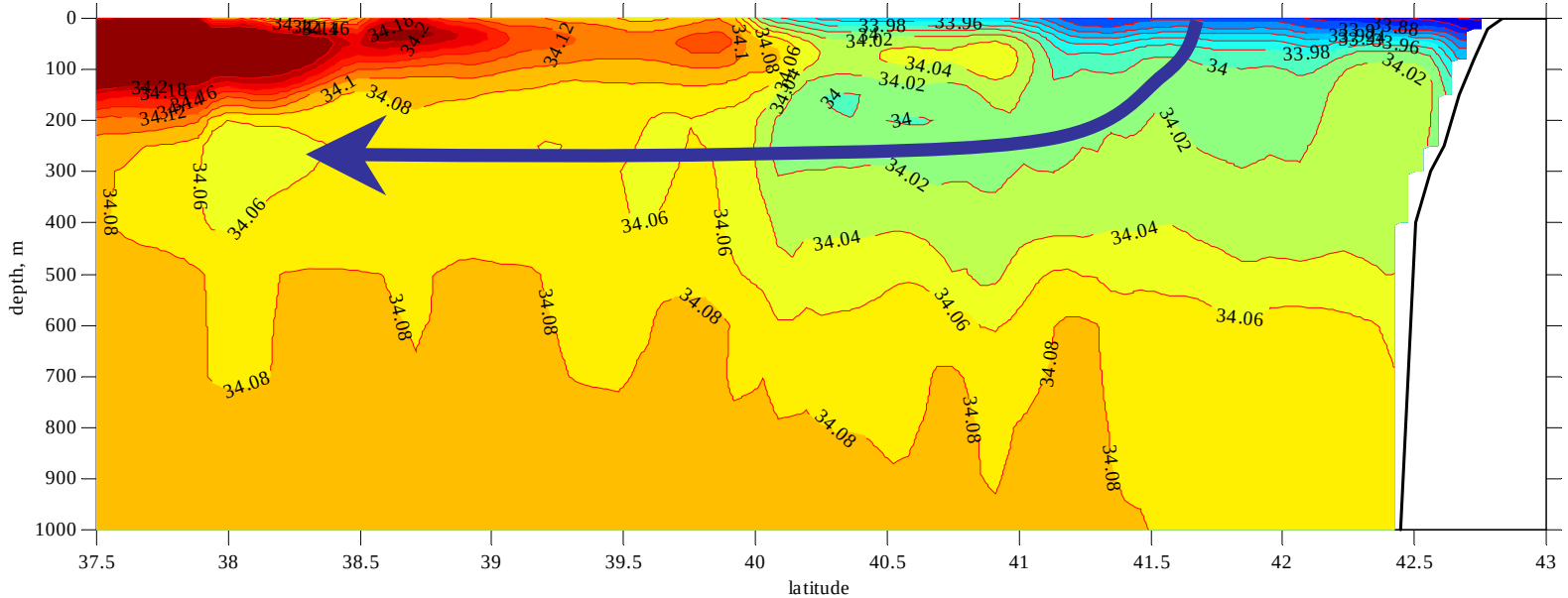


April

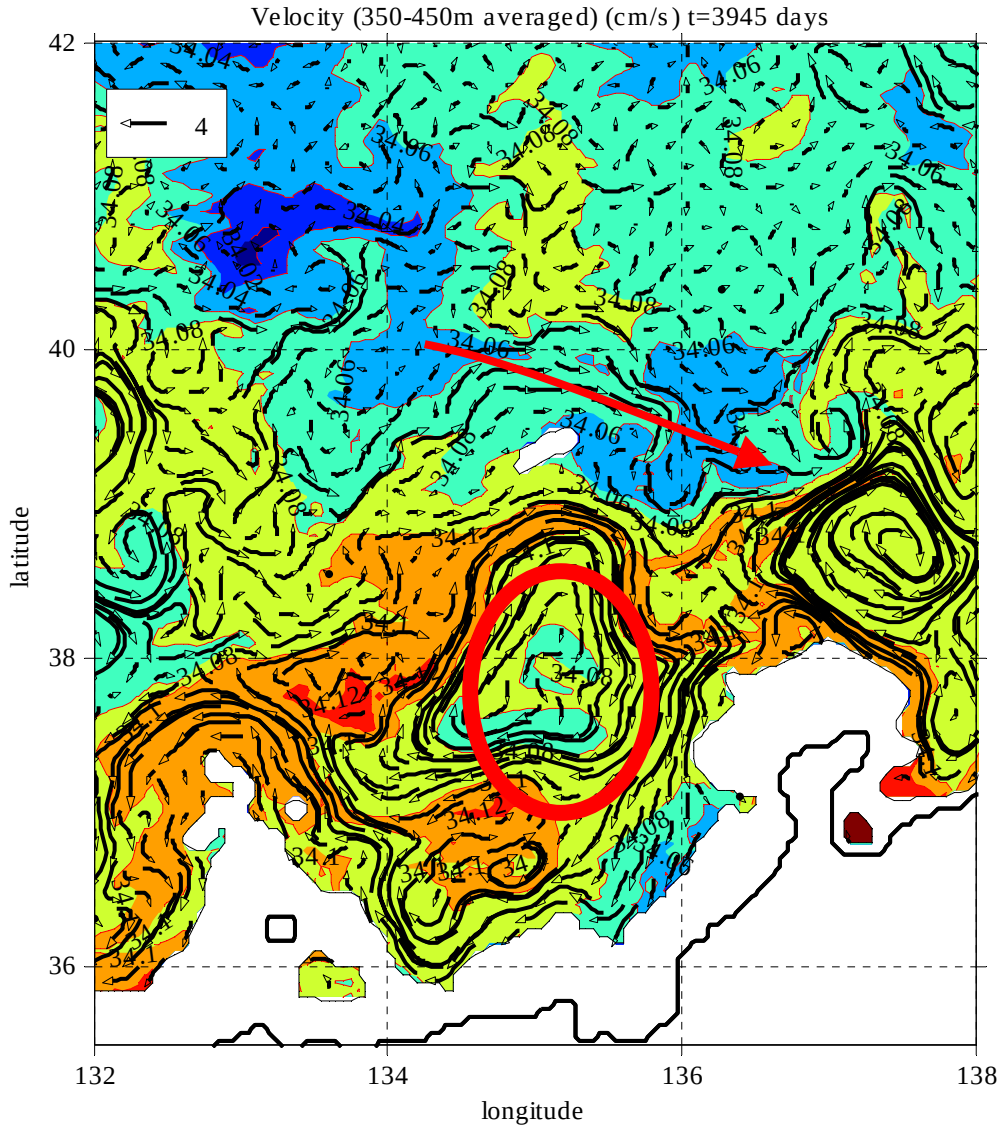


Salinity section along 132.5E

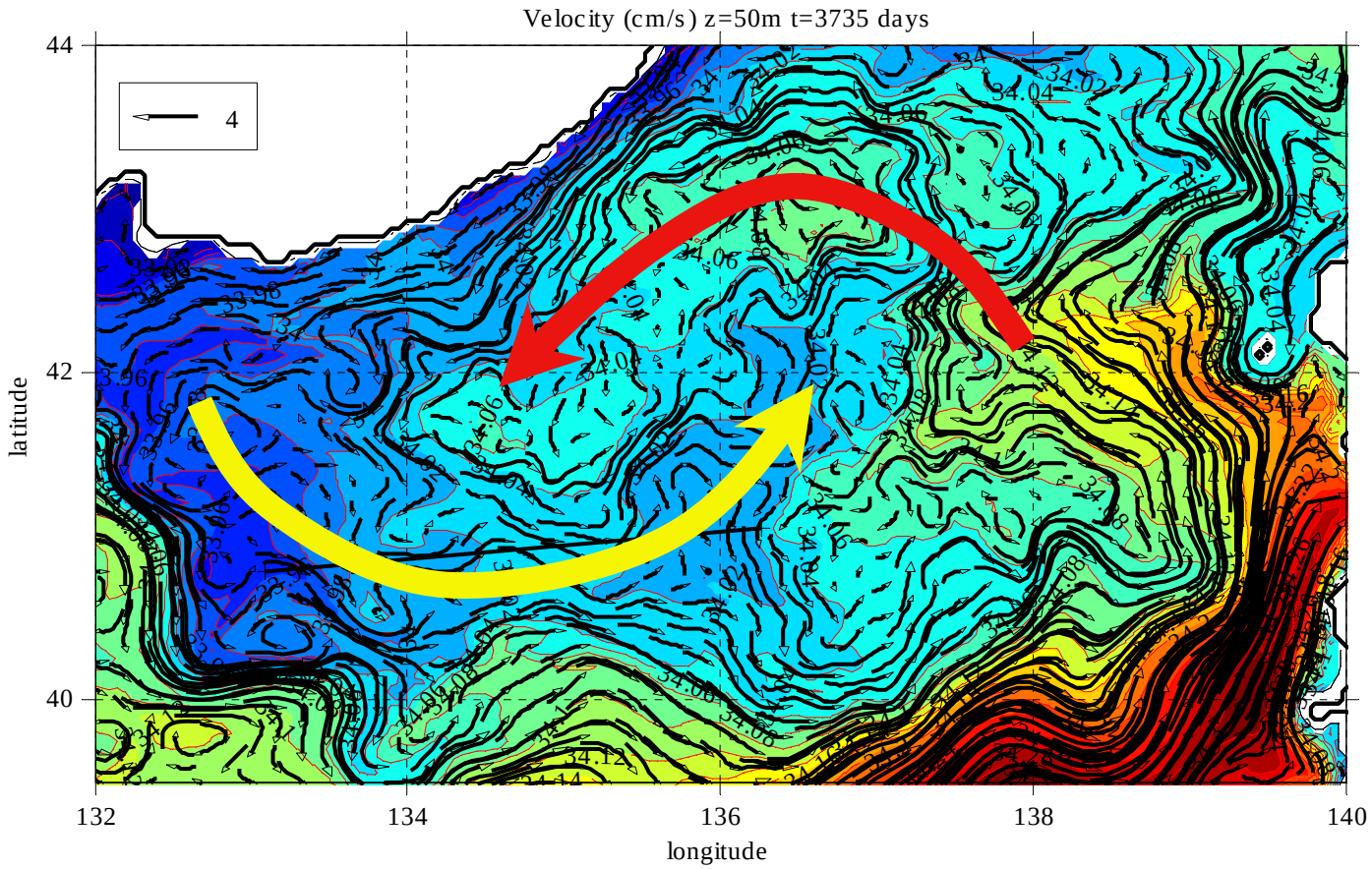




Yamato Basin circulation at 400m



Japan Basin


Velocity (cm/s) z=50m t=3735 days
4
44
42
40
latitude
132
134
136
138
140
longitude

Concluding remarks

- Due to changes in inflow-outflow transport balance, ***more saline and warm water propagates northward*** toward the Soya Strait and becomes involved into northern gyre.
- The salinity belt structure is a transitional form of this water development before it gets completely mixed with cold northern water type
- The water type produced as a result of this mixing is ***driven by Liman current*** and gathers in front of Peter the Great Bay. Because it is a mixture of different water types, it is ***more dense***
- This water type is ***locked in front of Peter the Great Bay*** in early winter by strong SPF current and winter monsoon circulation cell
- As the two above factors get weaker in the end of the winter, this water ***propagates southward at 200-300m*** and fills the Ulleung Basin
- The origin of the JSIW type in Yamato Basin is still unclear, whether they are formed locally due to vertical convection, or advected from northern regions. The latter is ***not supported by our study***
- The presented JES model seams to be capable to reproduce well the most prominent dynamic features, and the ***correct position of EKWC separation*** is one of those features.