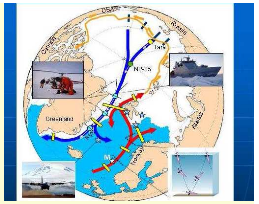
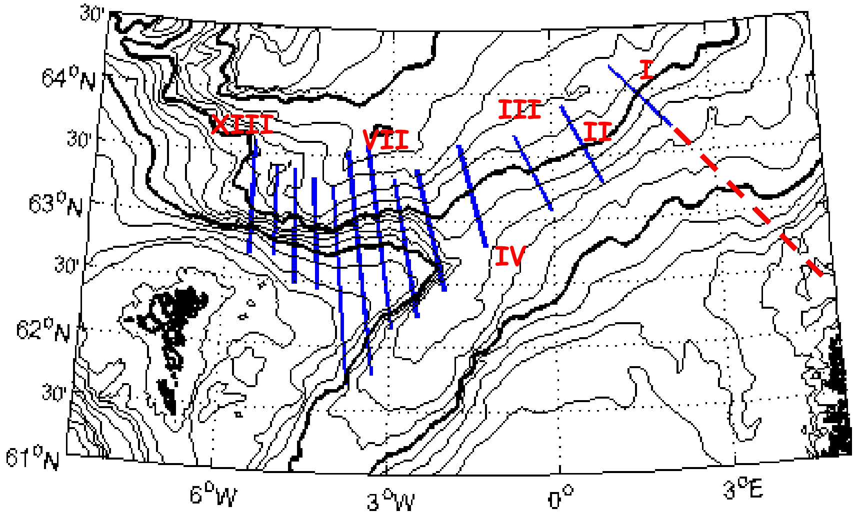
Submesoscale features in the western branch

Yoshie Kasajima
Geophysical Institute, University of Bergen



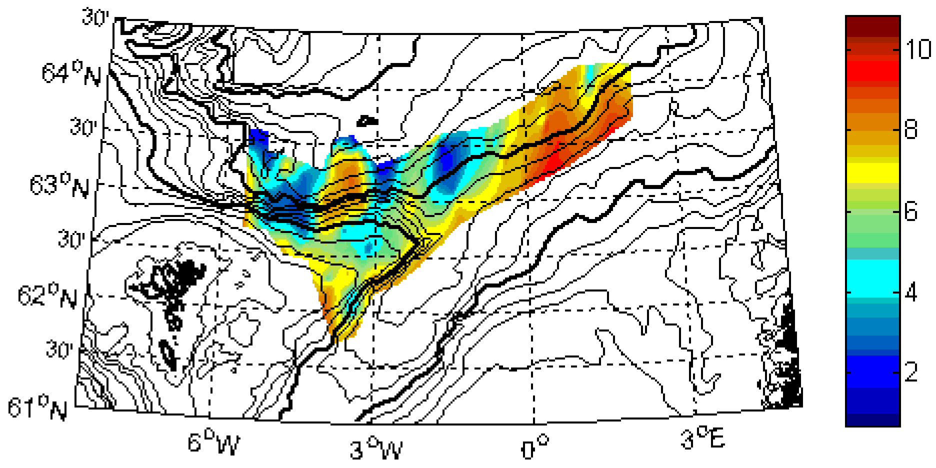


iAOOS task :
Understanding the western branch of the Atlantic inflow

Data (timeseries of hydrography) has not been transferred successfully.

Towed CTD
Vessel-mounted ADCP
in summer 2002

Temperature at 150 m depth



ADCP, CTD data ~400 m

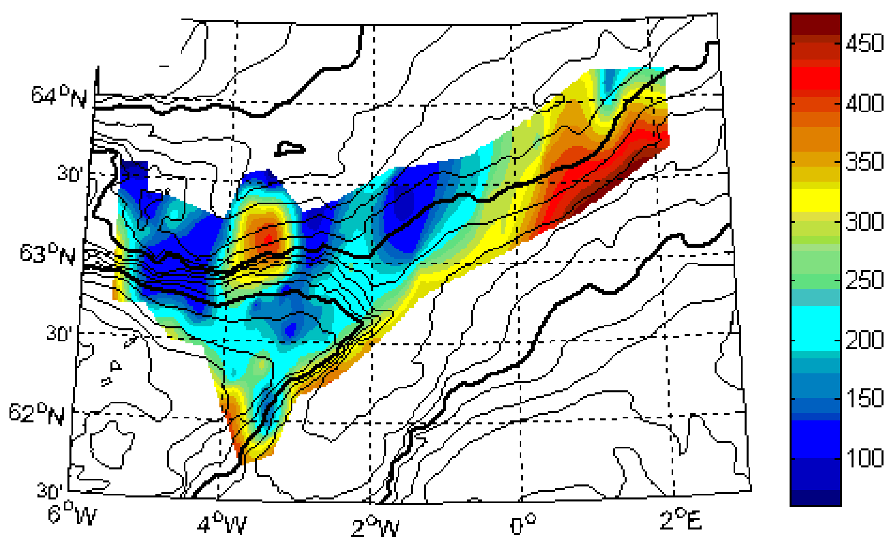
Horizontal resolusion along sections ~600 m

Atlantic Water definition
S >= 35

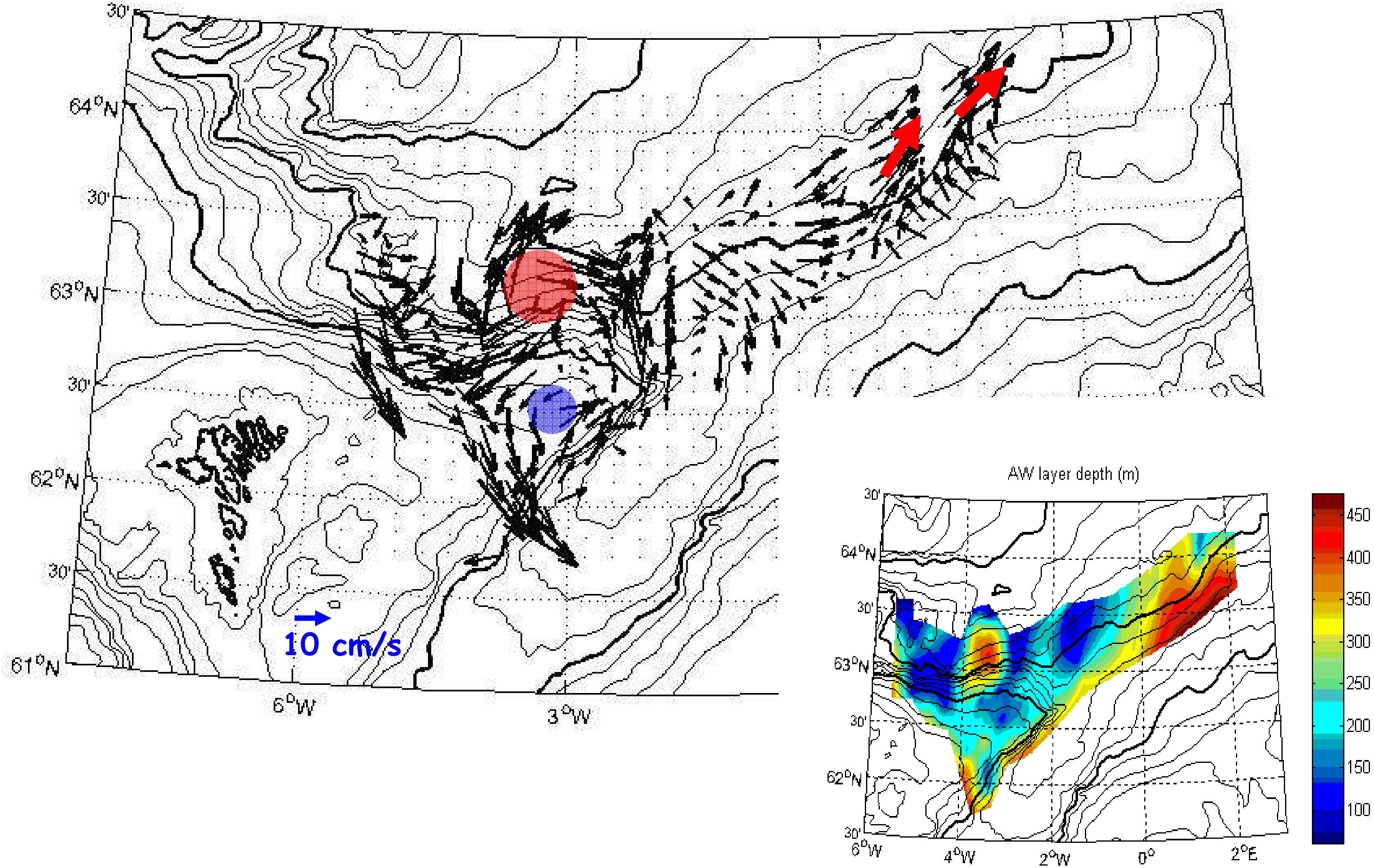
↕

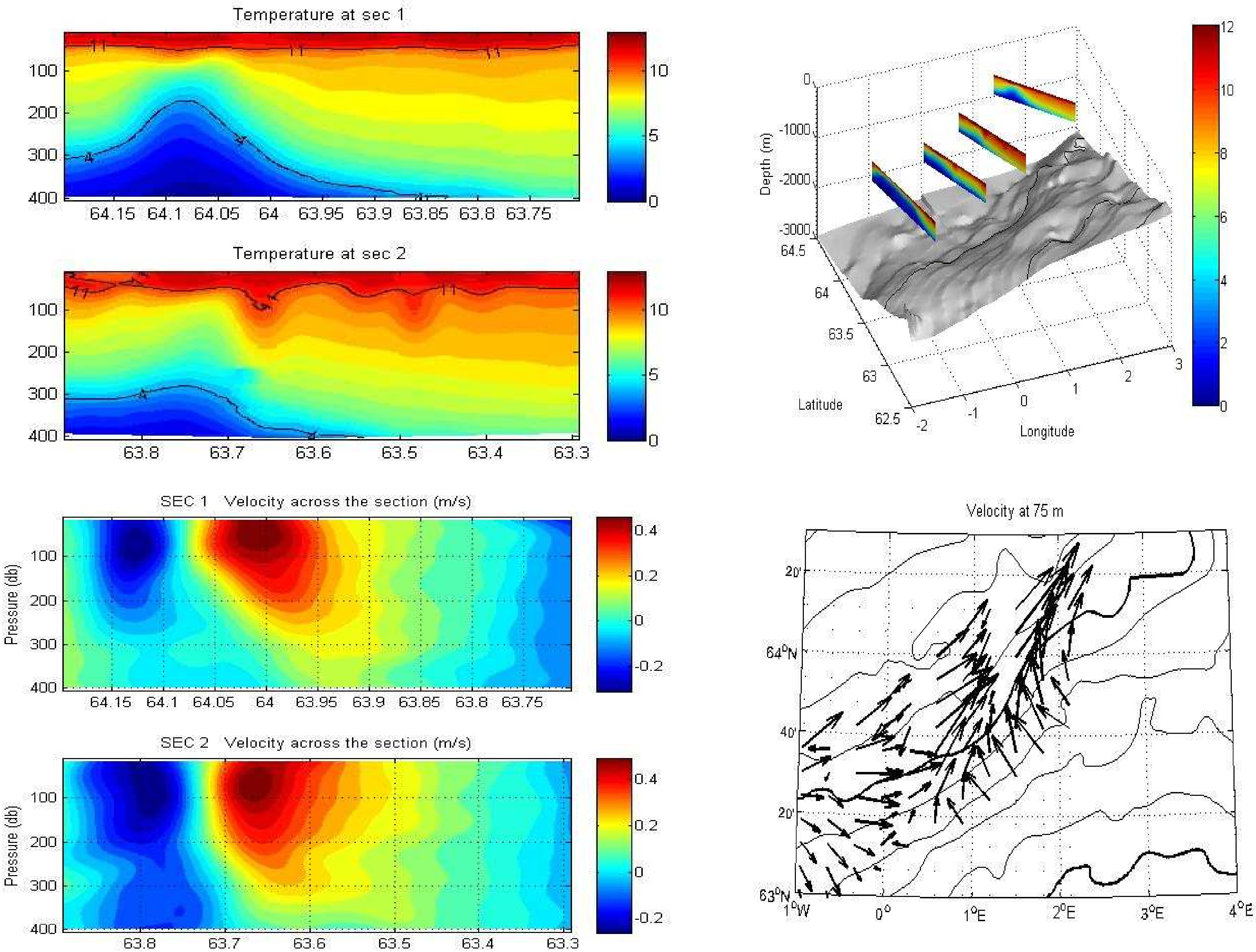
Temperature 4 C < T

AW layer depth (m)



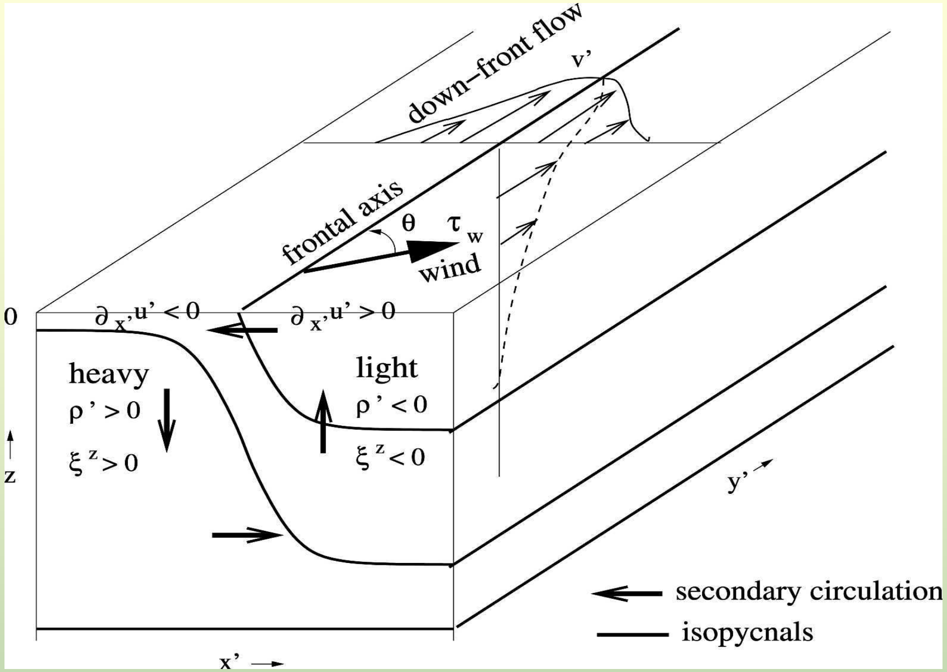
Velocity at 150 m





Temperature at sec 1
Temperature at sec 2
SEC 1 Velocity across the section (m/s)
SEC 2 Velocity across the section (m/s)
Pressure (db)
Depth (m)
Latitude
Longitude
Velocity at 75 m
64°N
63°N
1°W
0°
1°E
2°E
3°E
4°E

Front dynamics



(Capet et al. 2008)

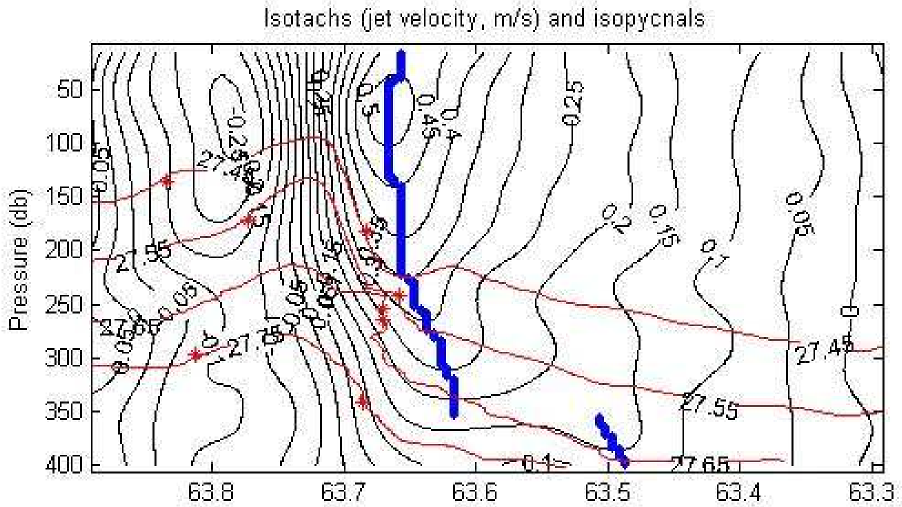
Down-front flow ~ geostrophic

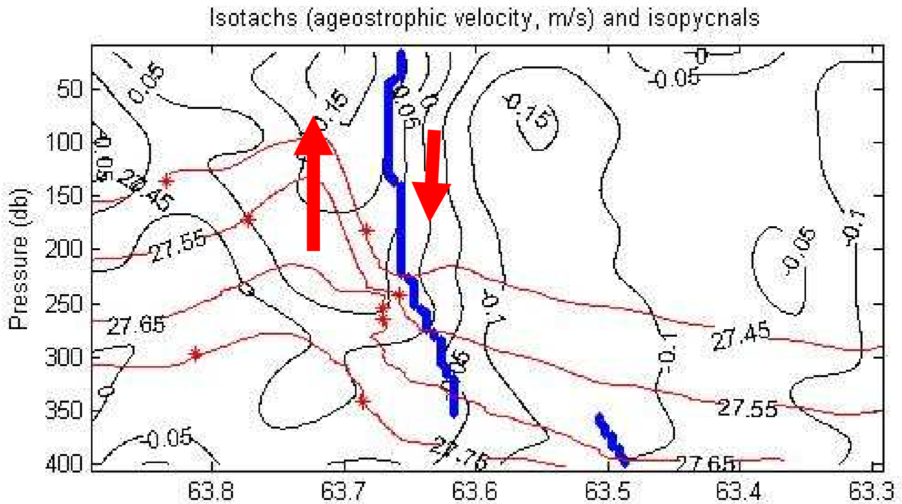
→ baroclinicity = the slope of isopycnals ~ speed of the jet

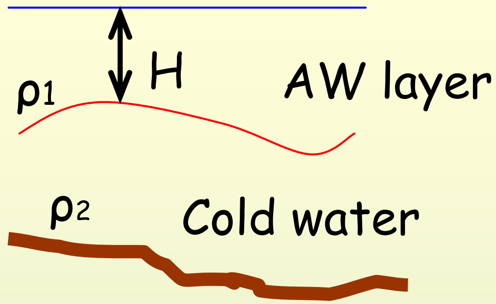
Horizontal shear creates vorticities

K.E + A.P.E = constant

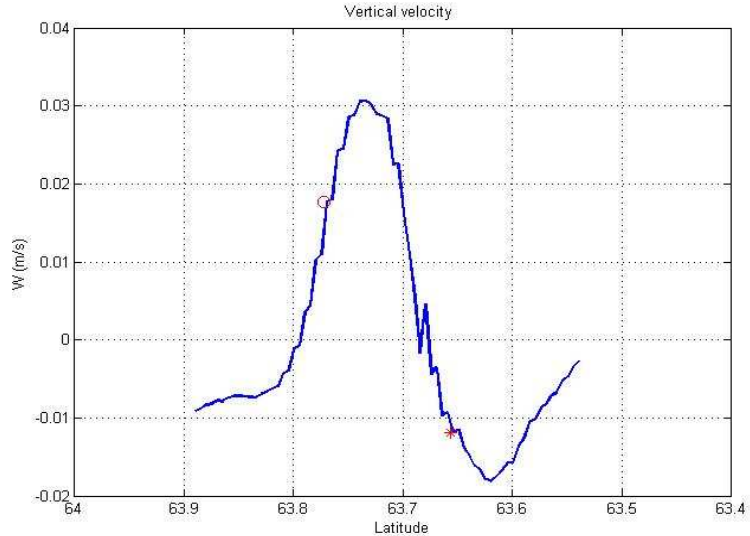
Section II



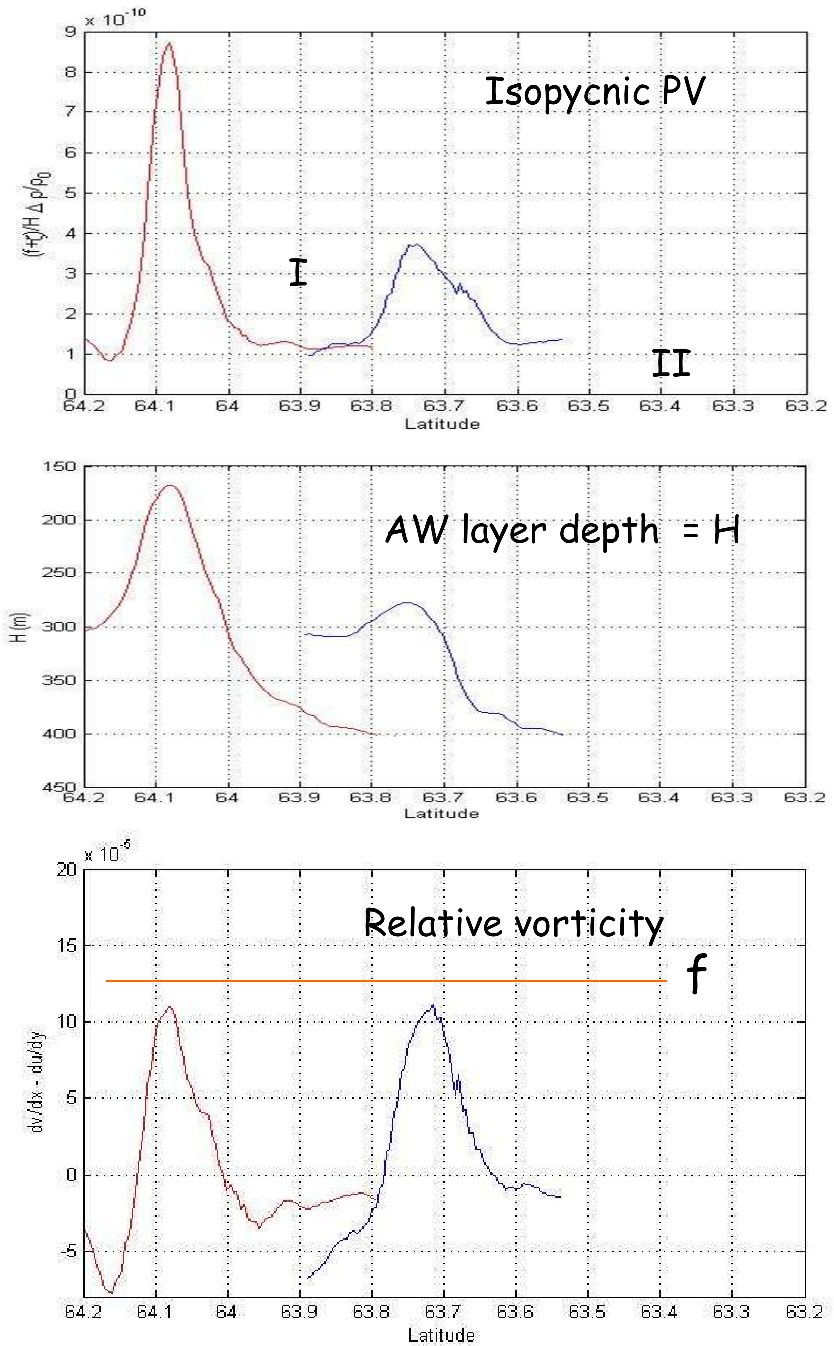




$$w = -\int_0^H \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right) dz$$



The direction of the secondary flow does not agree to the front dynamics.



Isopycnic potential vorticity

$$q = \frac{f + \zeta}{H} \frac{\Delta \rho}{\rho_0}$$

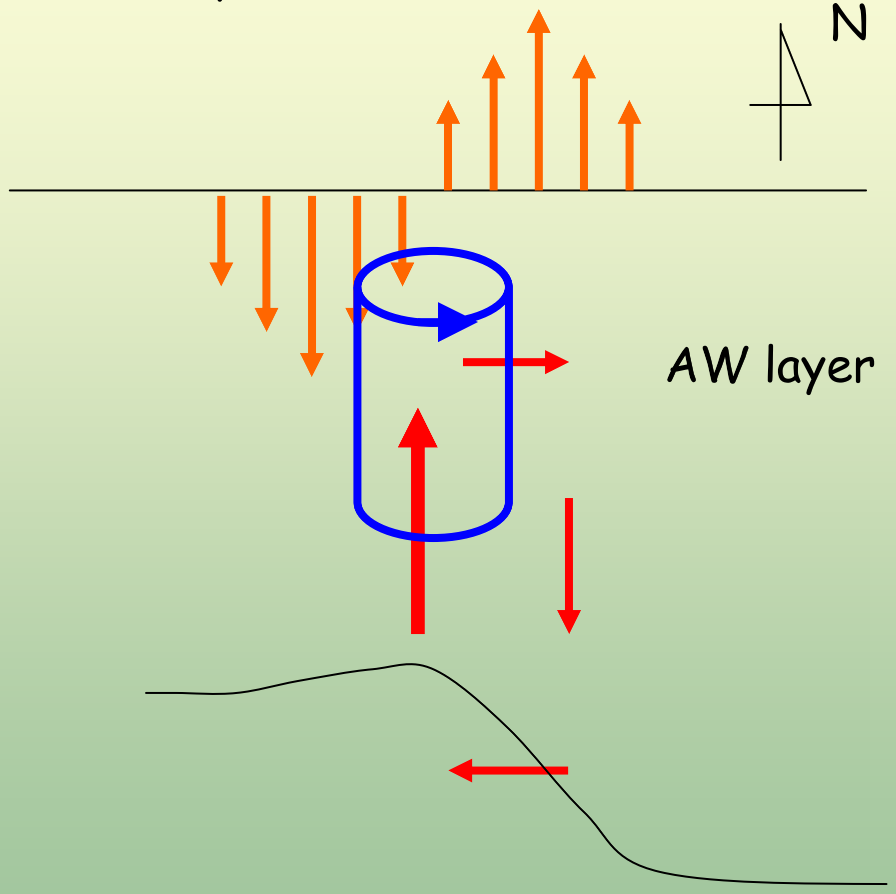
In quasi-geostrophic regime

q ~ f/H

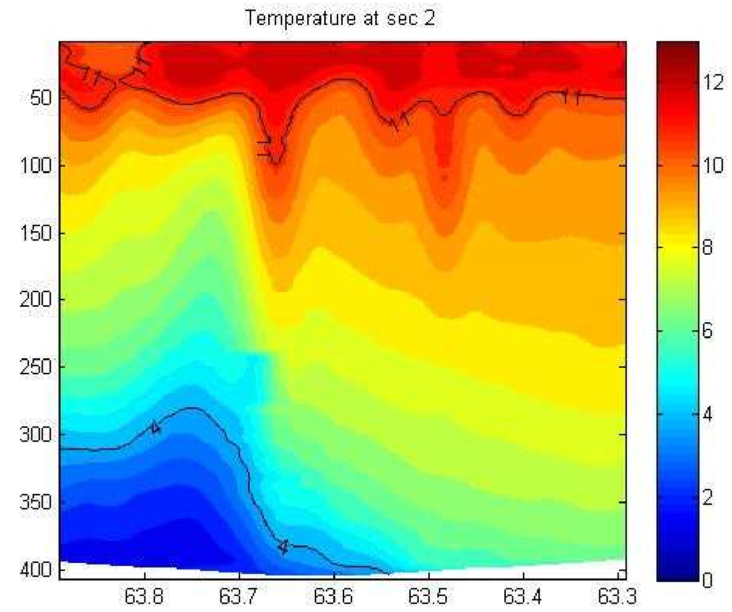
Change in the sign of PV gradient indicates instability.

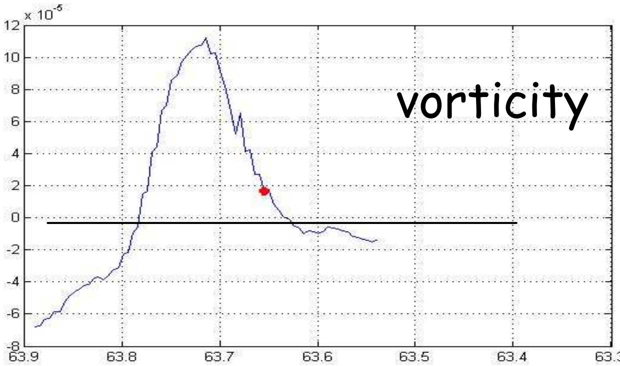
High relative vortcity at the front
→ high Rossby number ~ O(1)

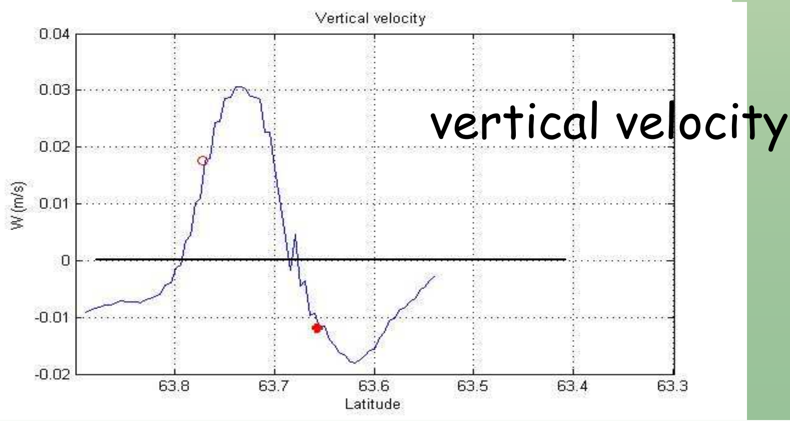
The southward flow intensifies the cyclonic vorticity



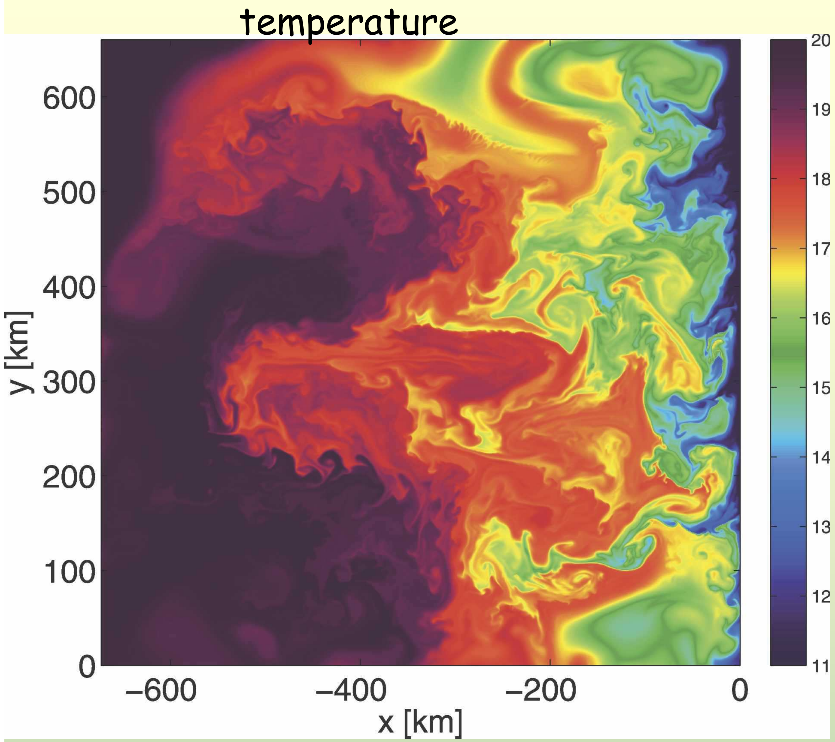
Upwelling at the cyclonic vorticity
~ 'unbalanced velocity field'

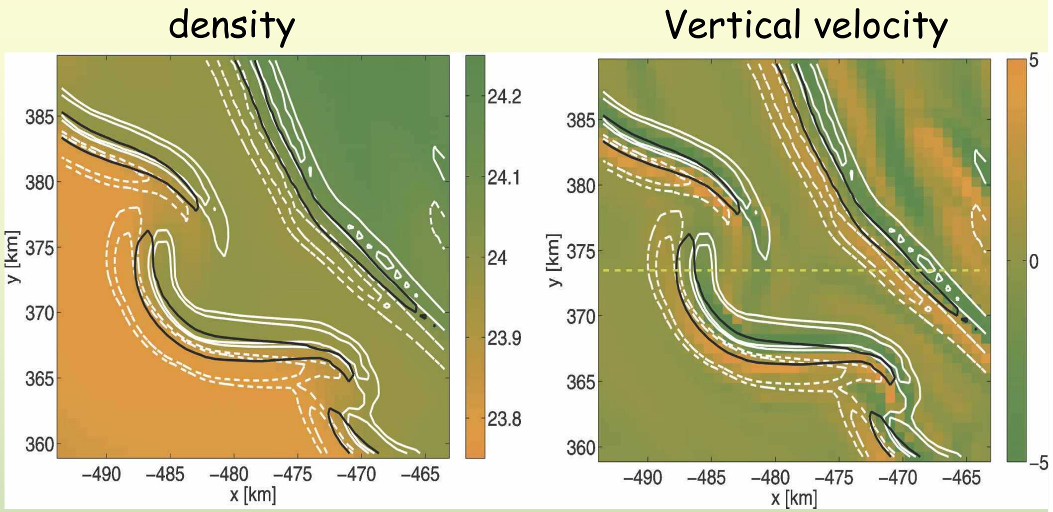






Submesoscale features (capet et al. 2008)

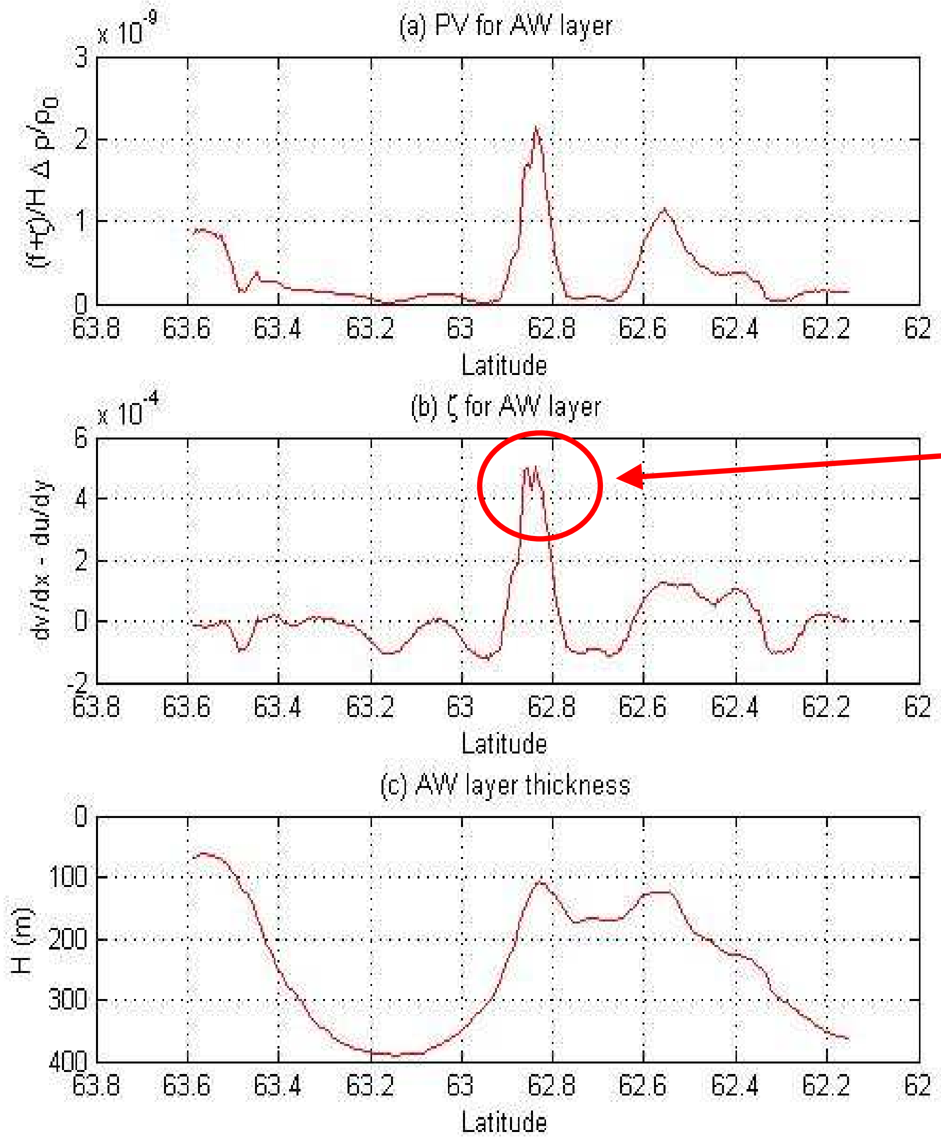


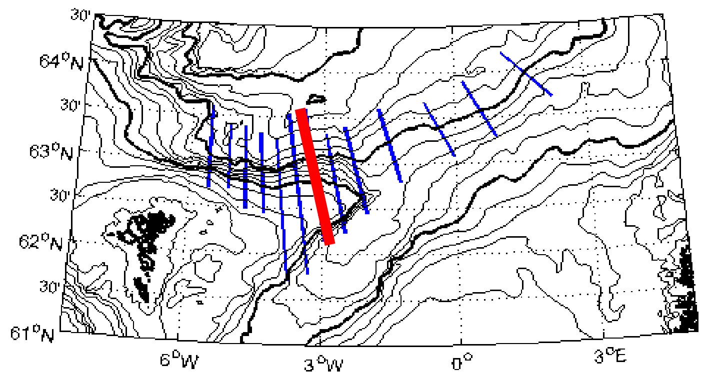


Additional structural complexity emerges at smaller scales permitted by increases in the grid resolution.

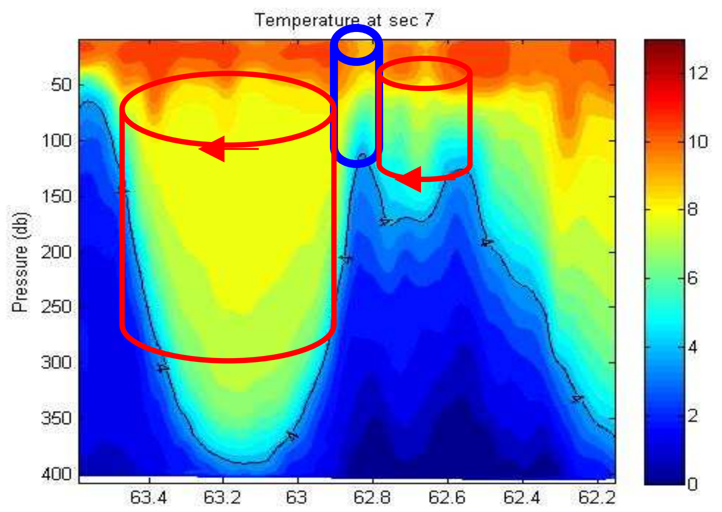
The submesoscale vorticity structures are characterized by O(1) Rossby numbers ($\zeta \geq f$) that occur principally on the periphery of the mesoscale eddies. In the centre of the mesoscale eddies the submesoscale structures are sparser.

Section VII (eddy section)





High vorticity between mesoscale eddies



Summary

The 'bell-shaped' isopycnals induces a northward jet and a southward flow.

→ it is not observed in Orvik et al. (2001). Is it a warm core eddy?!

The presence of the southward flow intensifies cyclonic vorticity close to the front axis and causes significant vertical velocity. PV maximum appears at the cyclonic vorticity.

→ upwelling at the cyclonic vorticity ?!?!

The scale of the intensified cyclonic vorticity is small (~ 5km), though the associated (?) vertical velocity is significant, which would be the source of instability. A frontal breakup between section I and II would be due to submesoscale instability.

→ it is not revealed in the time-average data. . . .

The submesoscale features would not be important for the heat/volume flux calculations, however, they are the cause of high variability of the western branch.