Propagation of Antarctic Bottom Water through abyssal channels in the Atlantic Ocean

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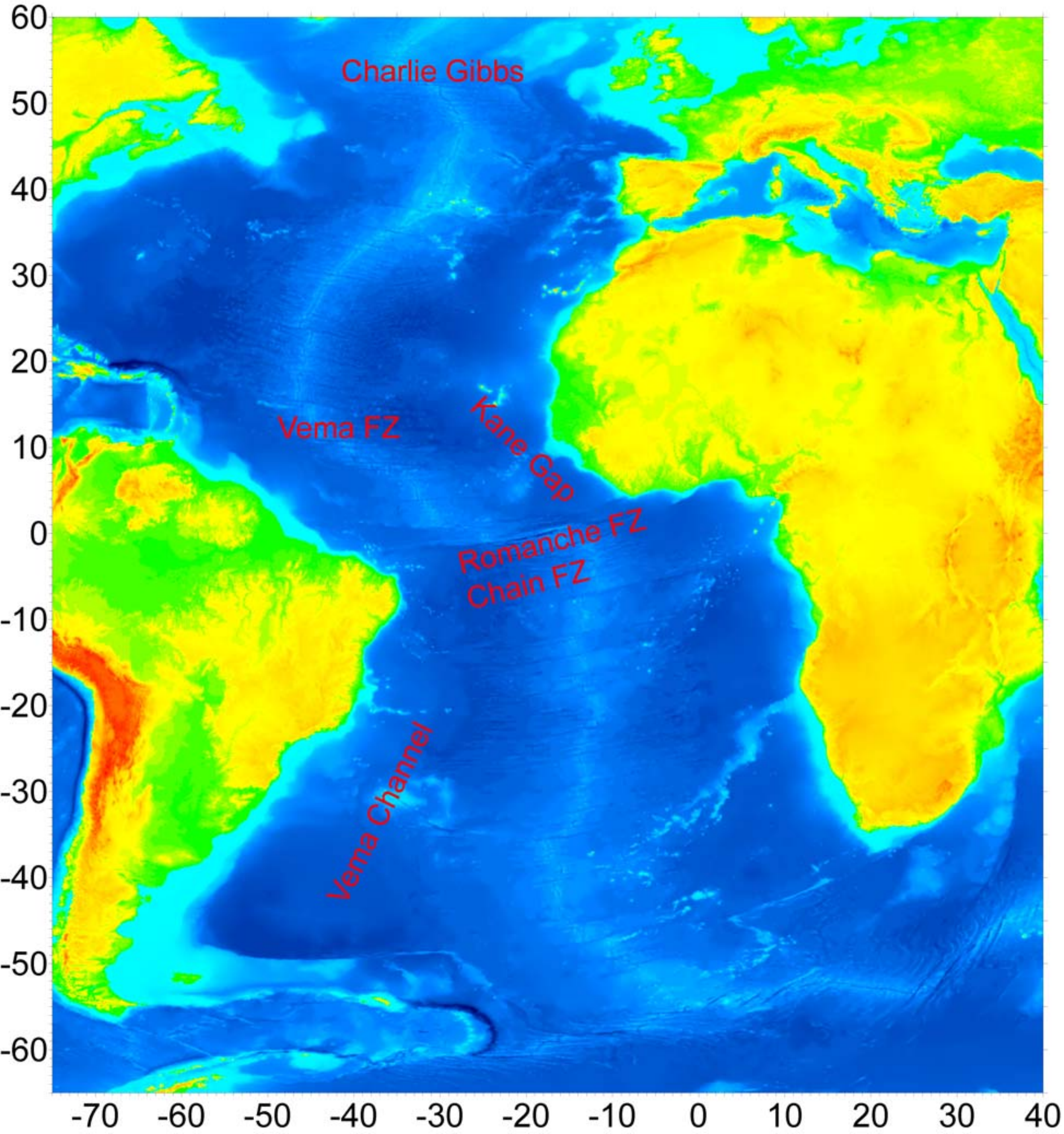
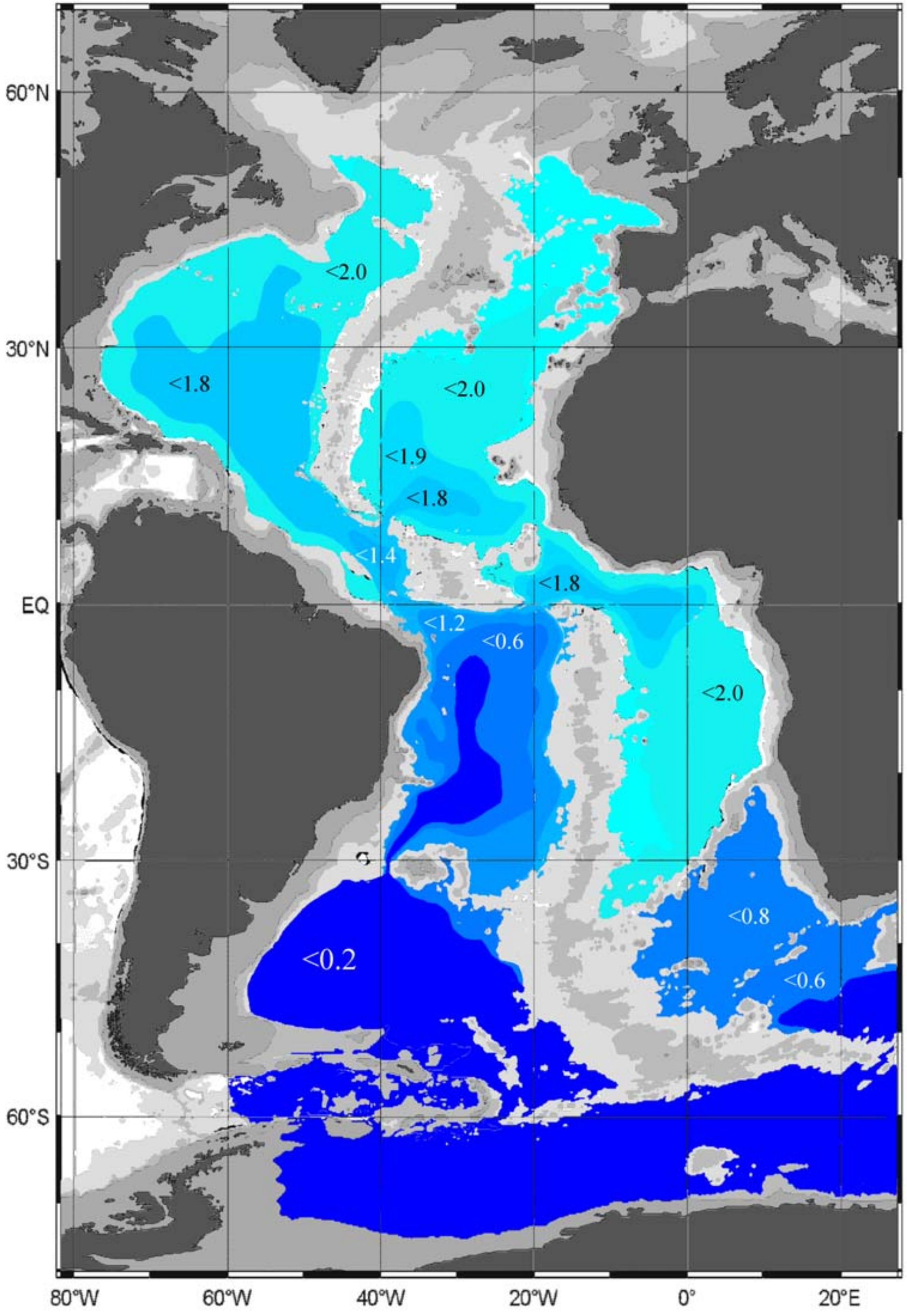


Main Atlantic abyssal channels studied in 2001-2009



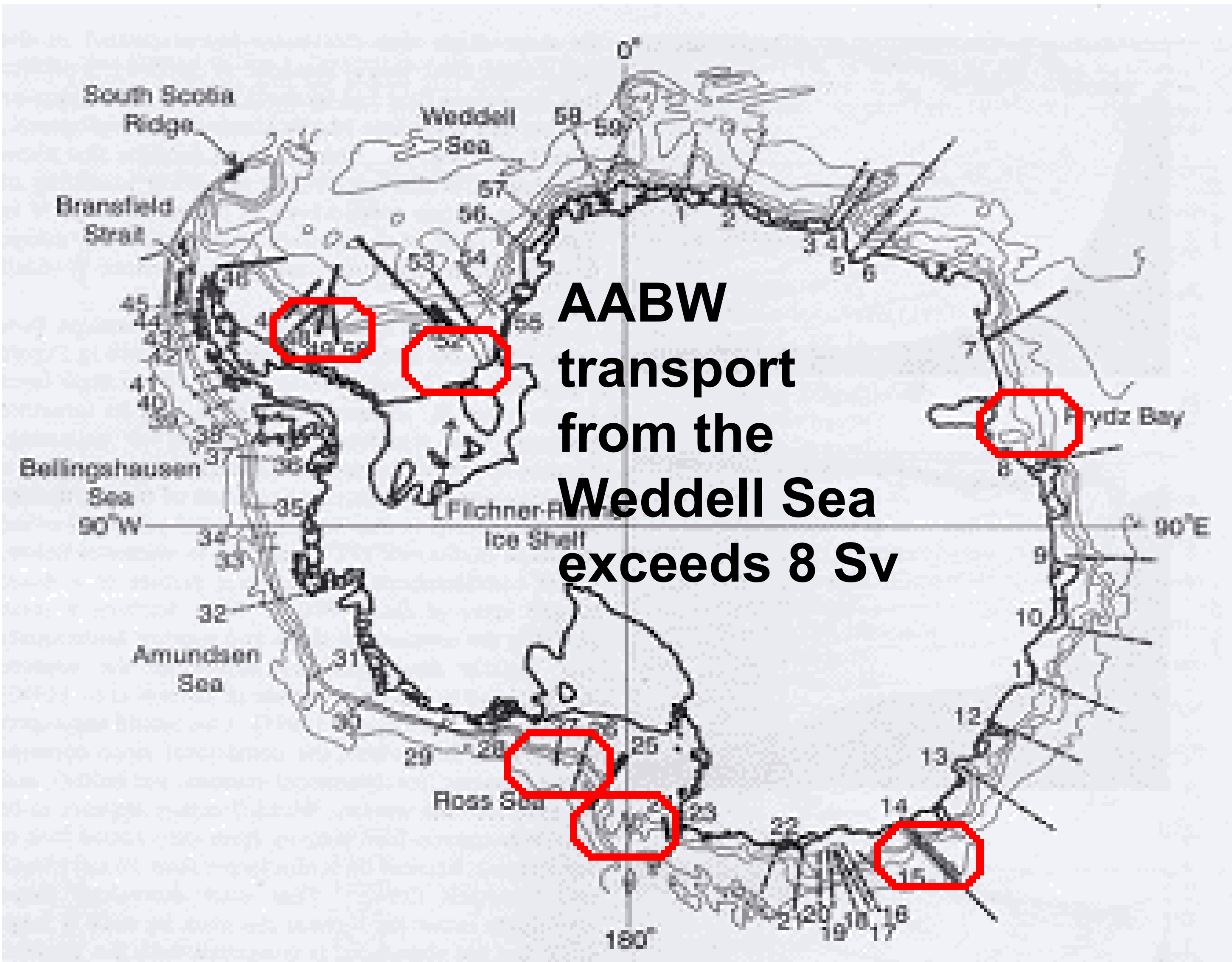
Spreading of Antarctic Bottom Water

Chart of potential temperature at the bottom

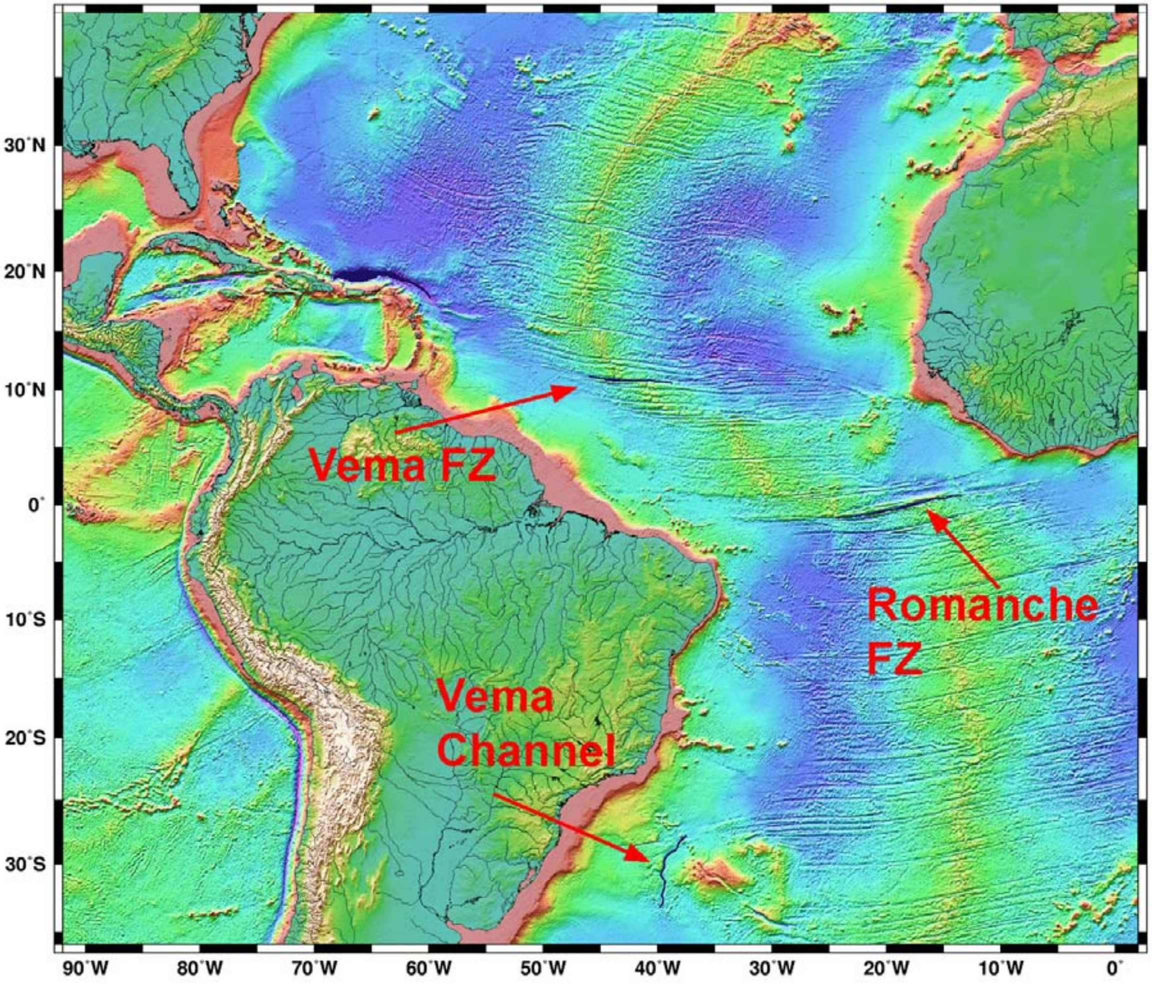
Antarctic Bottom Water (AABW) is formed due to strong cooling over the Antarctic shelf and slowly flows to the north over the ocean bottom

The total amount of AABW formation is 25 Sv
1 Sverdrup = million cubic meters per second

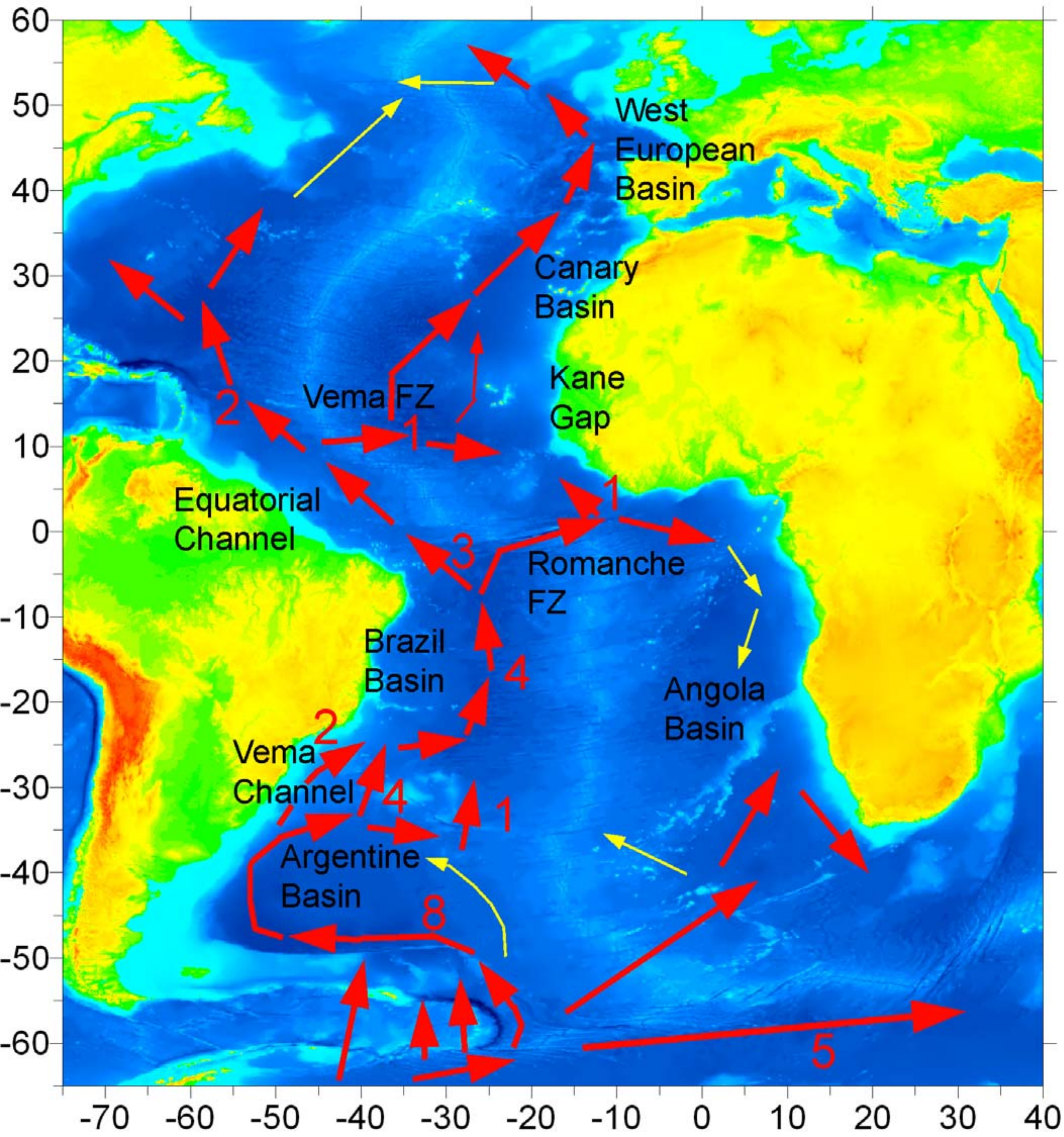
Regions of intense Antarctic Bottom Water formation



Key points on the pathway of Antarctic Bottom Water spreading



Transport of Antarctic Bottom Water



Arrows show directions of bottom currents

Numerals indicate water transport in Sverdrups

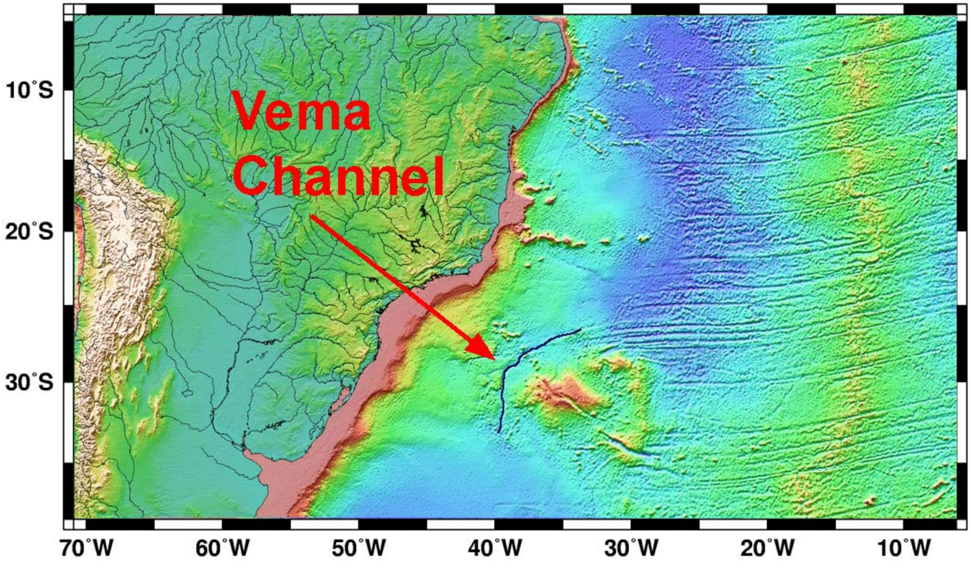
1 Sv = million cubic meters per second

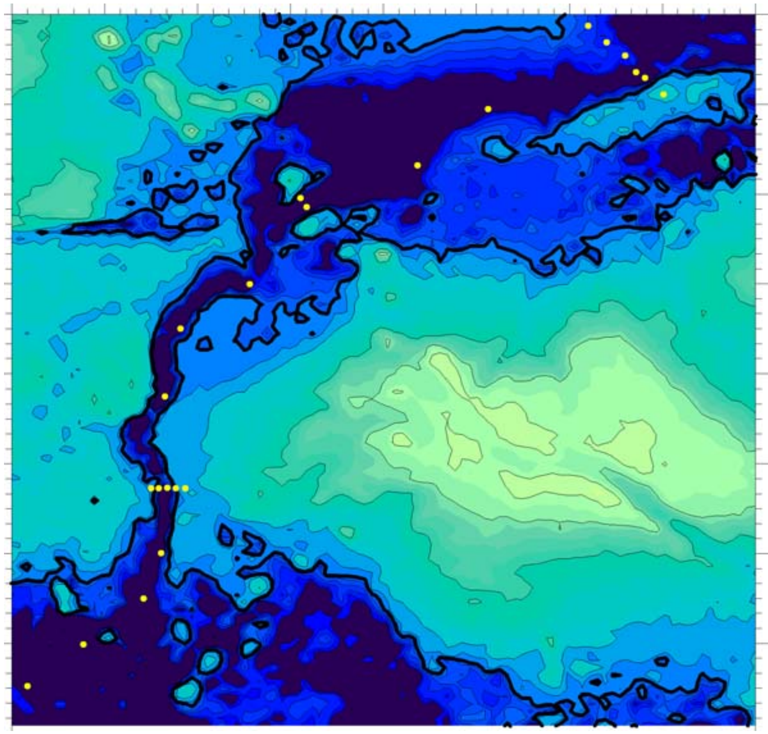
Deep water Vema Channel

The Vema Channel is a deep passage (4700 m) in the Rio Grande Rise (4200 m deep plateau)

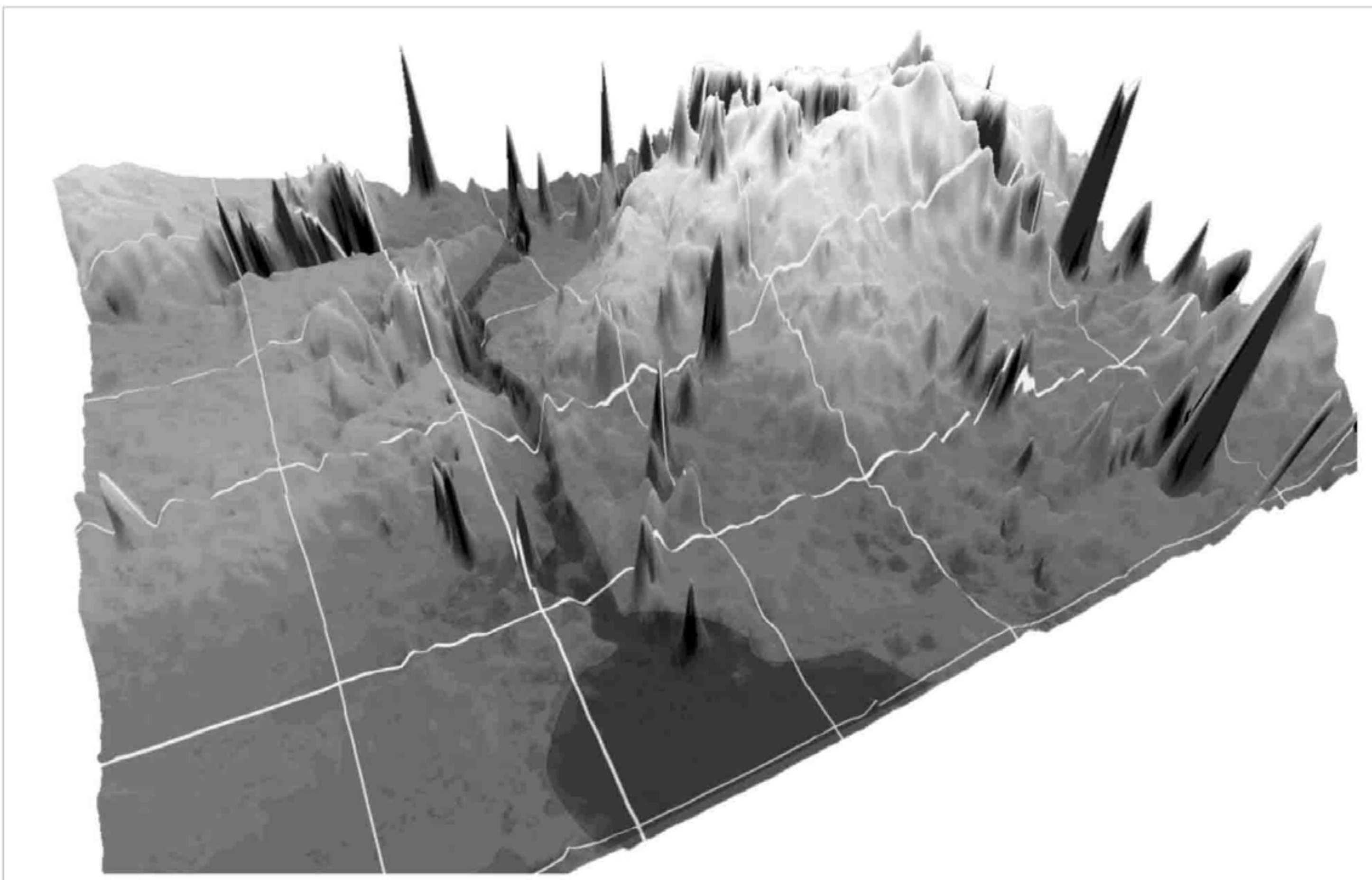
The transport of AABW in the Vema Channel is estimated as 4 Sv.

Mean velocities are 30 cm/s;
Maximum velocities reach 60 cm/s



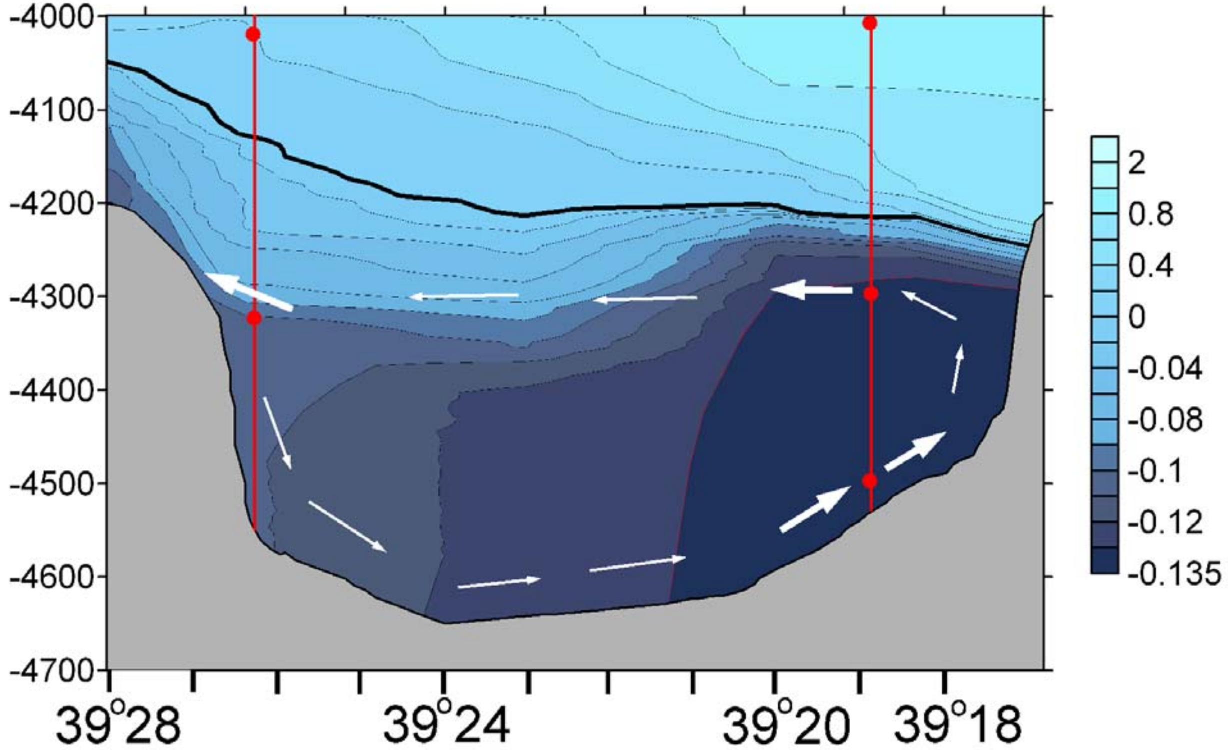


A 3D view of the Vema Channel
A view from the south
The channel was visited 21 times from 1979 to 2009 by oceanographic expeditions



Potential temperature section across the Vema Channel

Potential temperature is temperature corrected for adiabatic compression

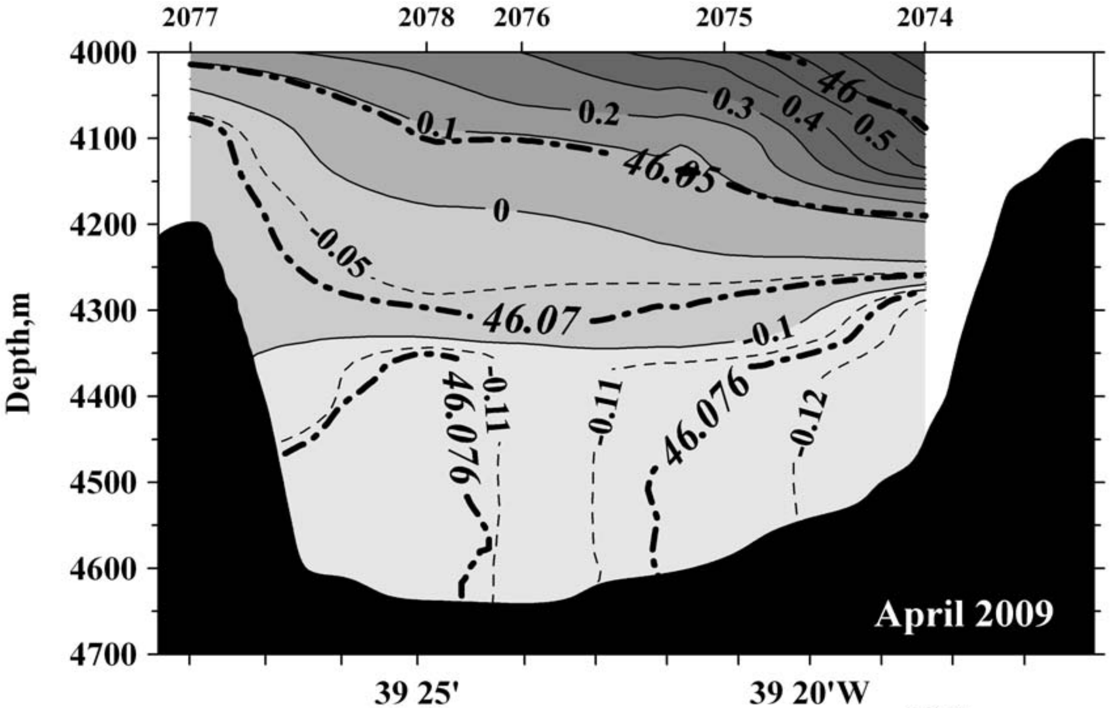


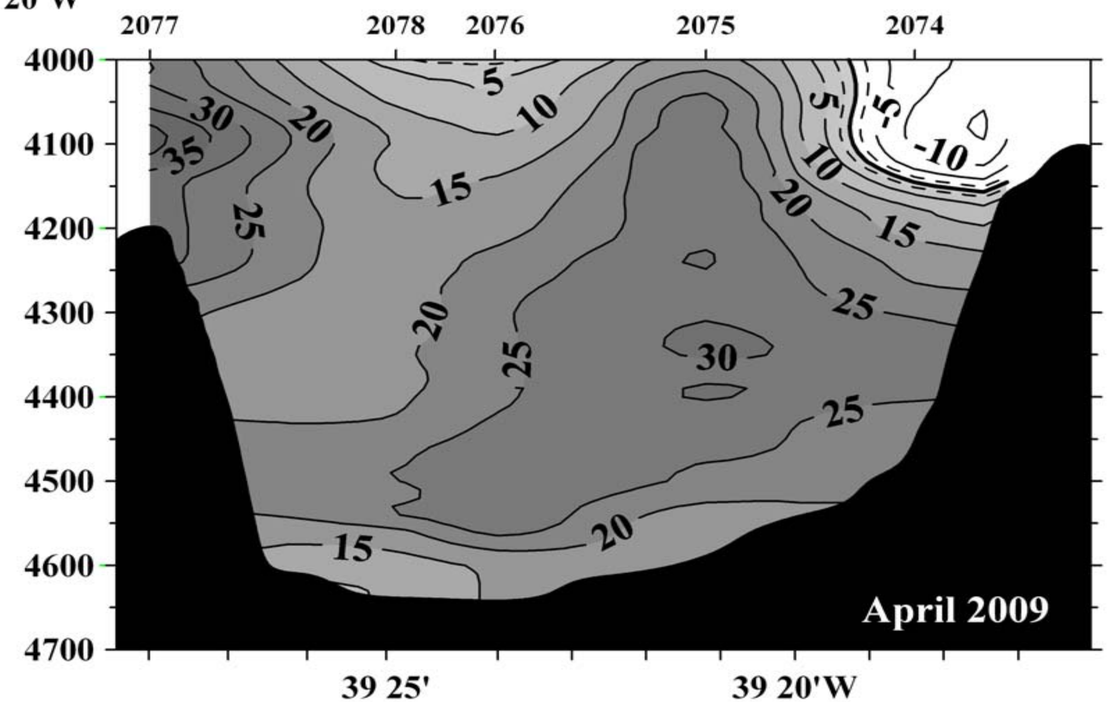
The flow is strongly mixed.

The coldest water is displaced to the eastern wall of the channel due to the Ekman friction

Standard section in 2009.

Potential temperature and currents





Bottom water transport in the Vema Channel

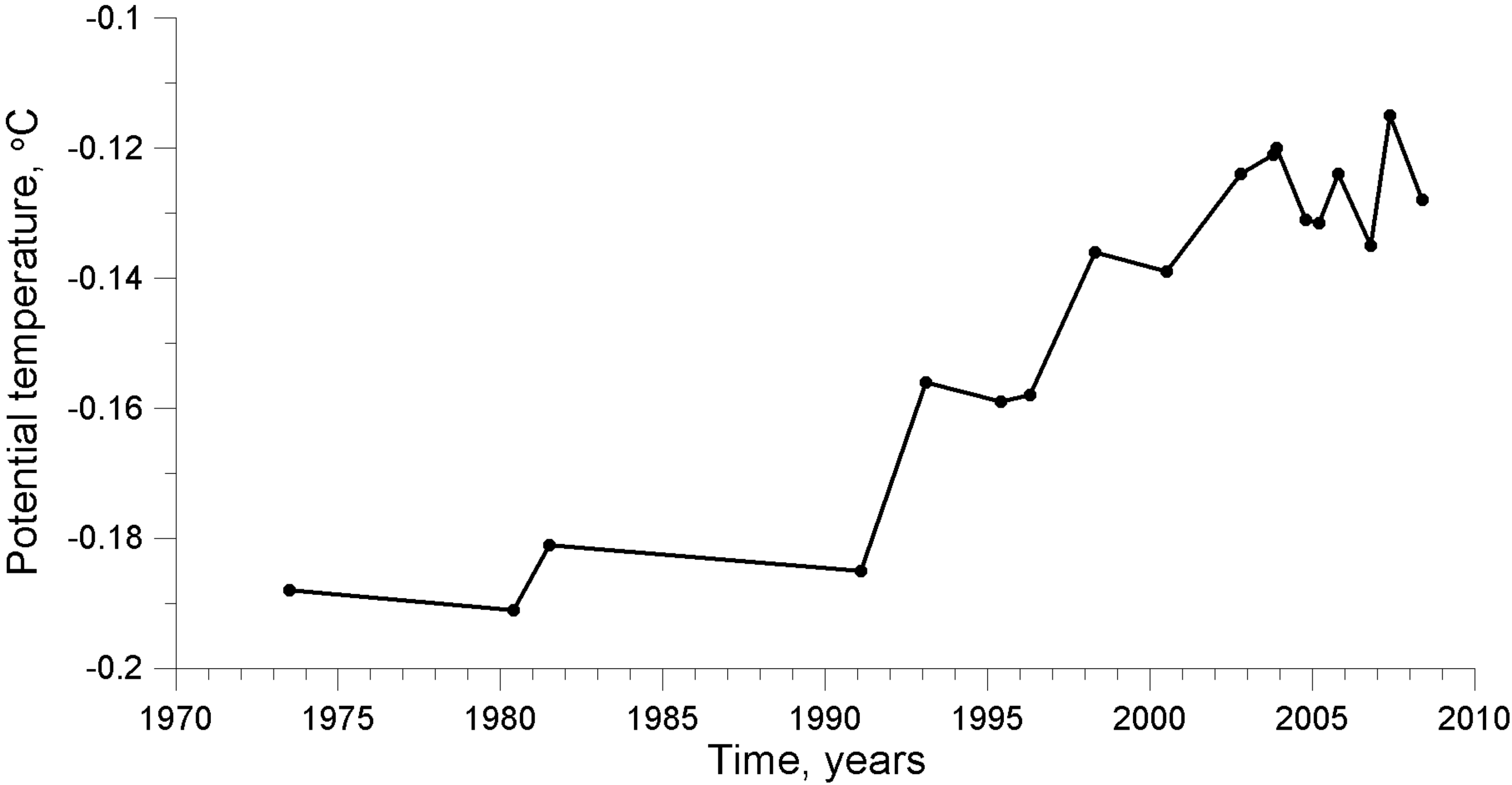
Maximum transport based on moored measurements reached 4 Sv ($4 \cdot 10^6$ m^3/s).
This is gained when velocities are as high as 60 cm/s.

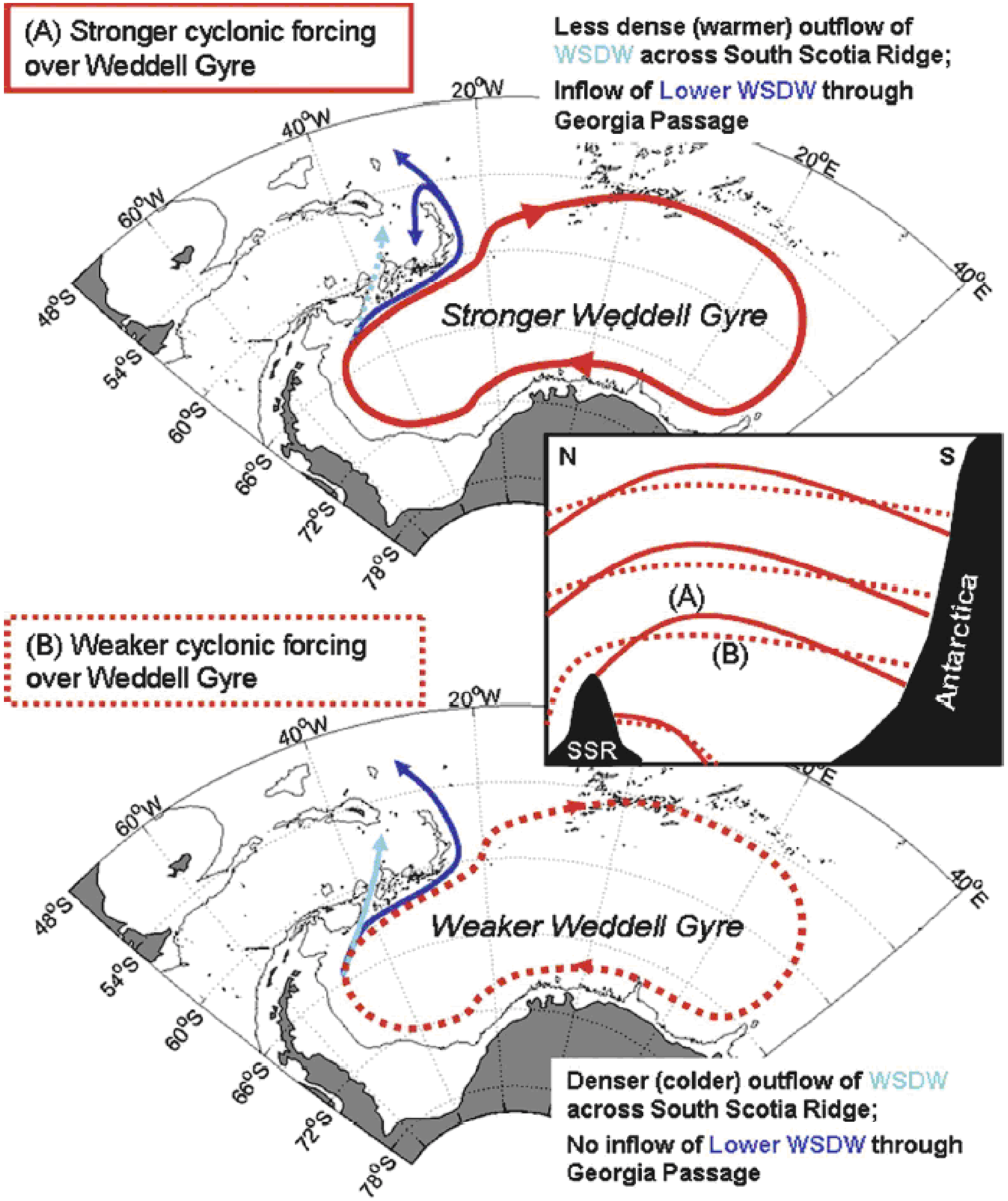
Usually, velocities are approximately 30 cm/s, and the transport fluctuates near 2 Sv.

Measurements in 2009 show that maximum velocities are 35 cm/s and a countercurrent exists in the upper layer of the channel that decreases northerly transport.

Transport estimate in 2009 is 1.6 Sv.

Time variation of potential temperature from 1973 to 2009 in the cold jet of the Vema Channel at 31°12'S



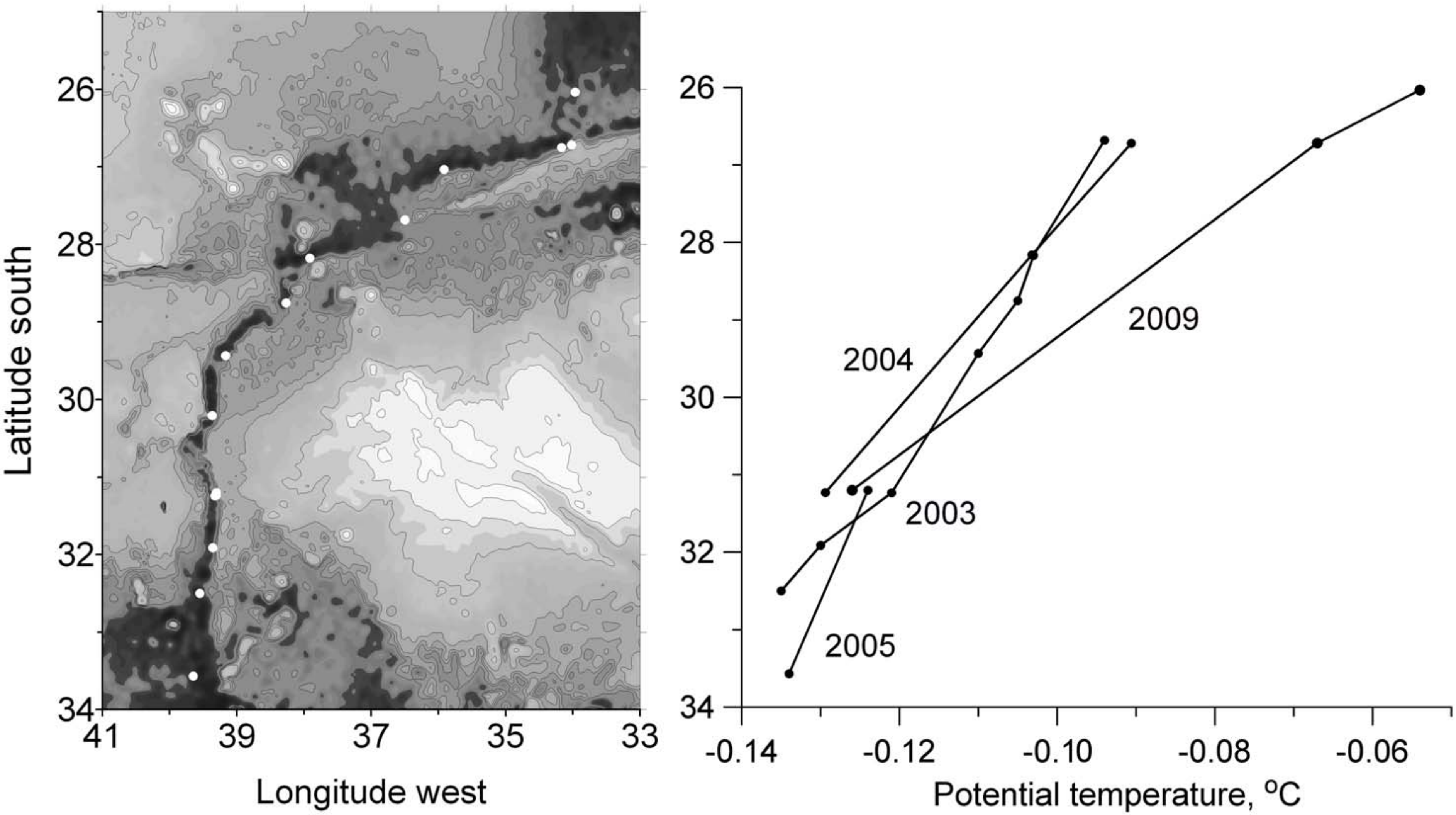


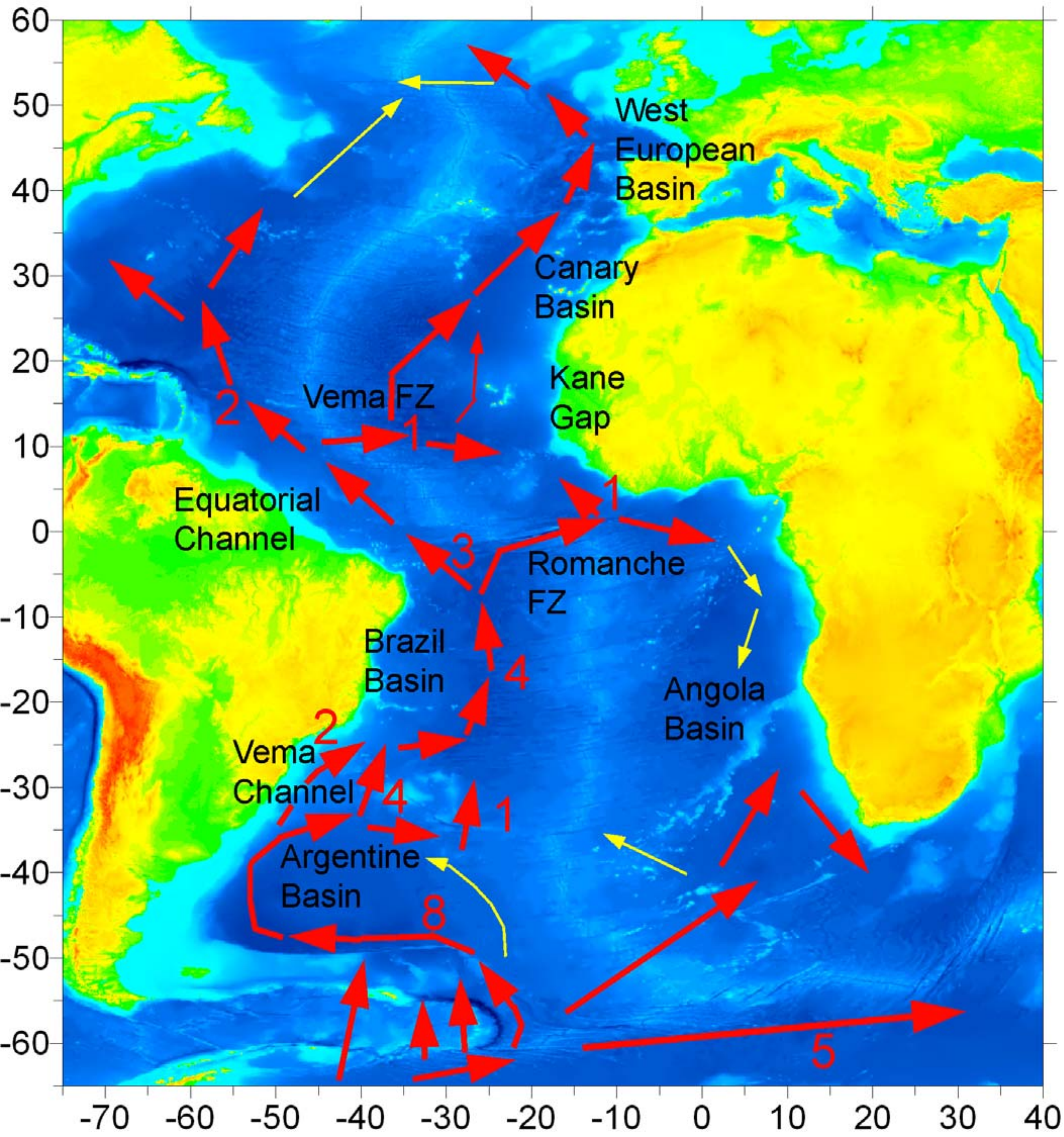
Dome of Antarctic Bottom water in the Weddell Gyre

[Coles, 1996;

Meredith, et al., 2008]

Warming of the cold jet from south to north

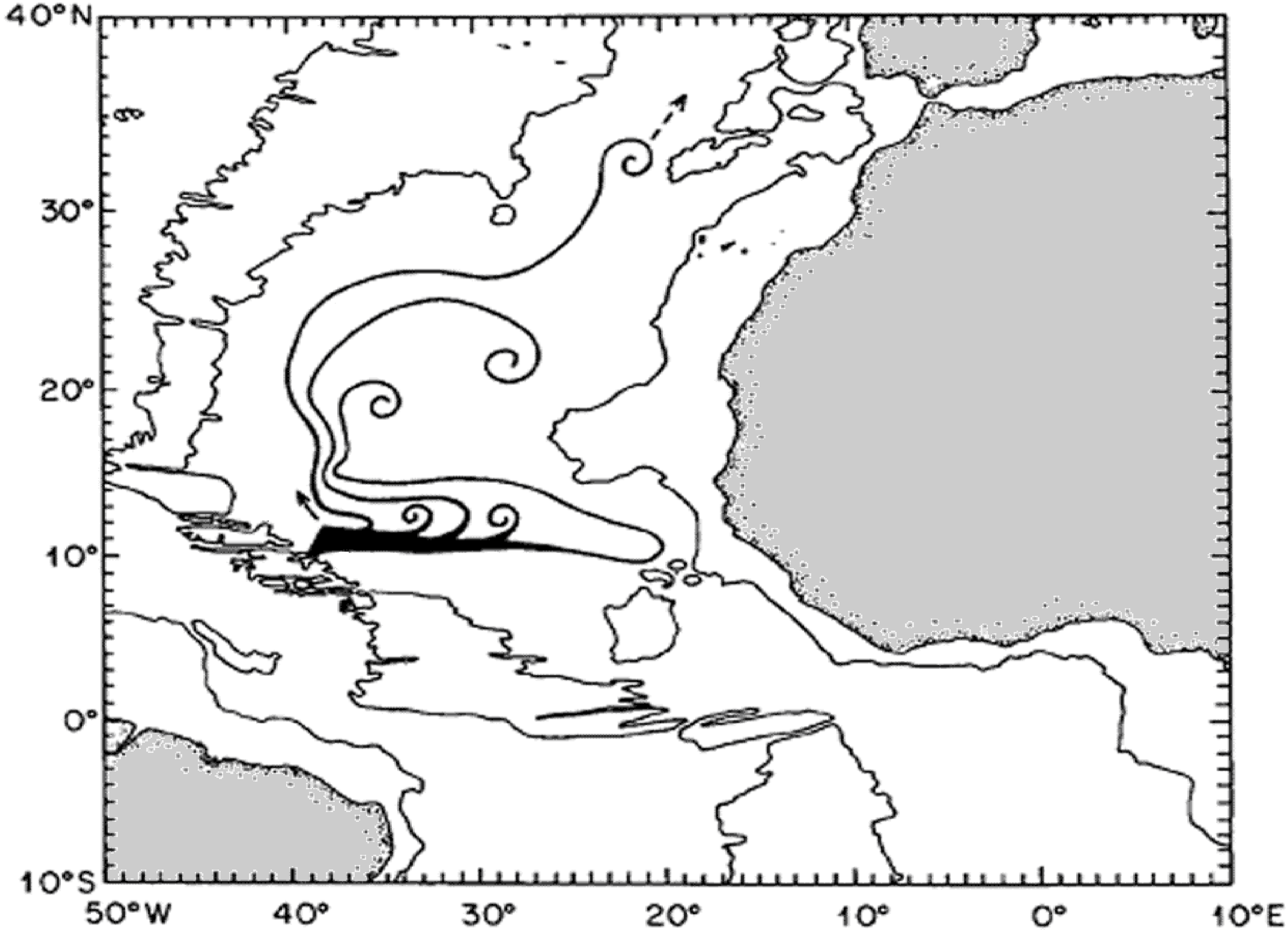




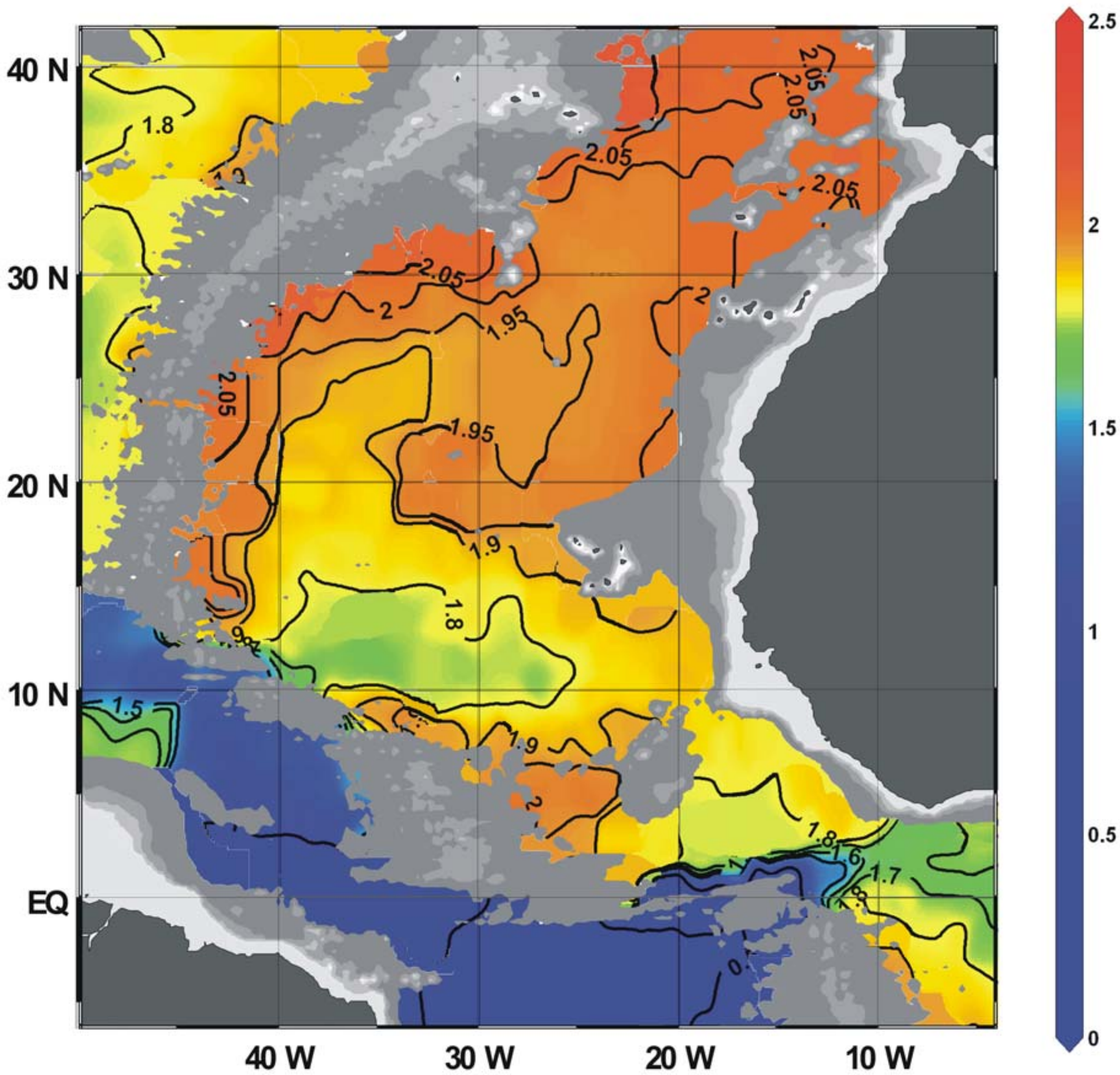
The goal of this presentation is to show the further propagation of Antarctic Bottom Water after it passes the Vema Channel

Bottom water circulation in the East Atlantic

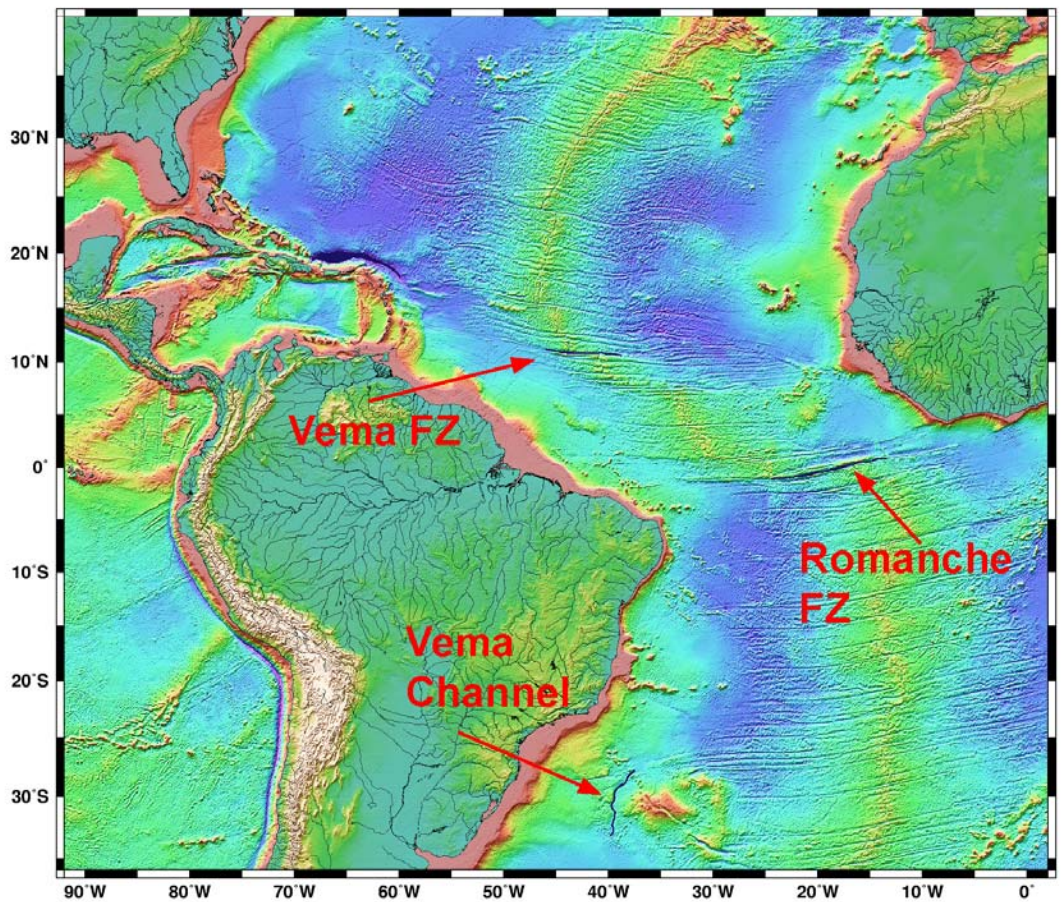
McCartney, Bennet, Woodgate, JPO, 1991



Contour lines of potential temperature in the latest data

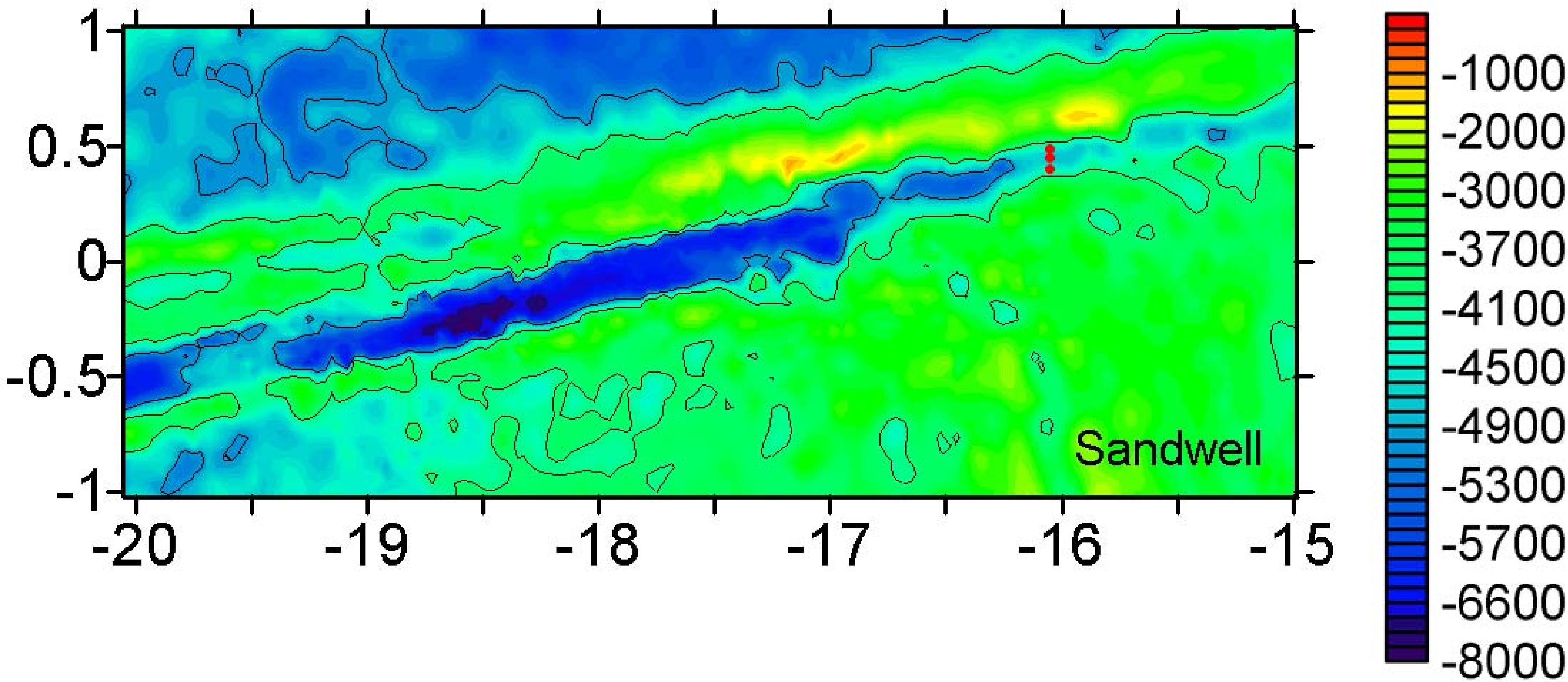


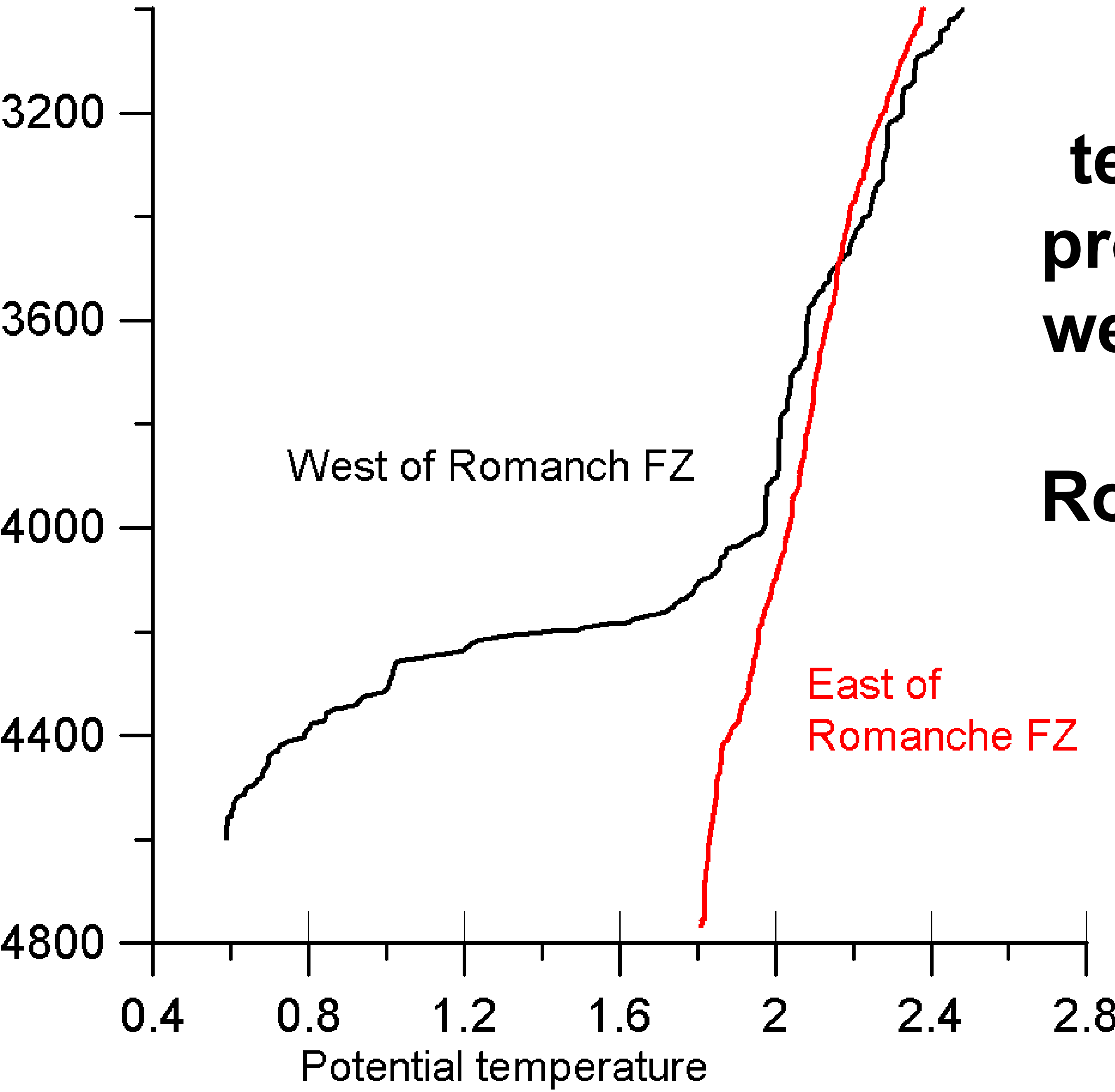
Key problem of this presentation



Why Northeast Atlantic is filled with AABW through the Vema FZ, but not through the Romanche FZ?

A CTD-section across the Romanche Fracture Zone was occupied in 2005





Potential temperature profiles to the west and east of the Romanche FZ

Velocity measurements in the Romanche FZ in 2005 in AABW layer

Velocities measured in the layer of AABW using LADCP instrument were approximately equal to 10 cm/s.

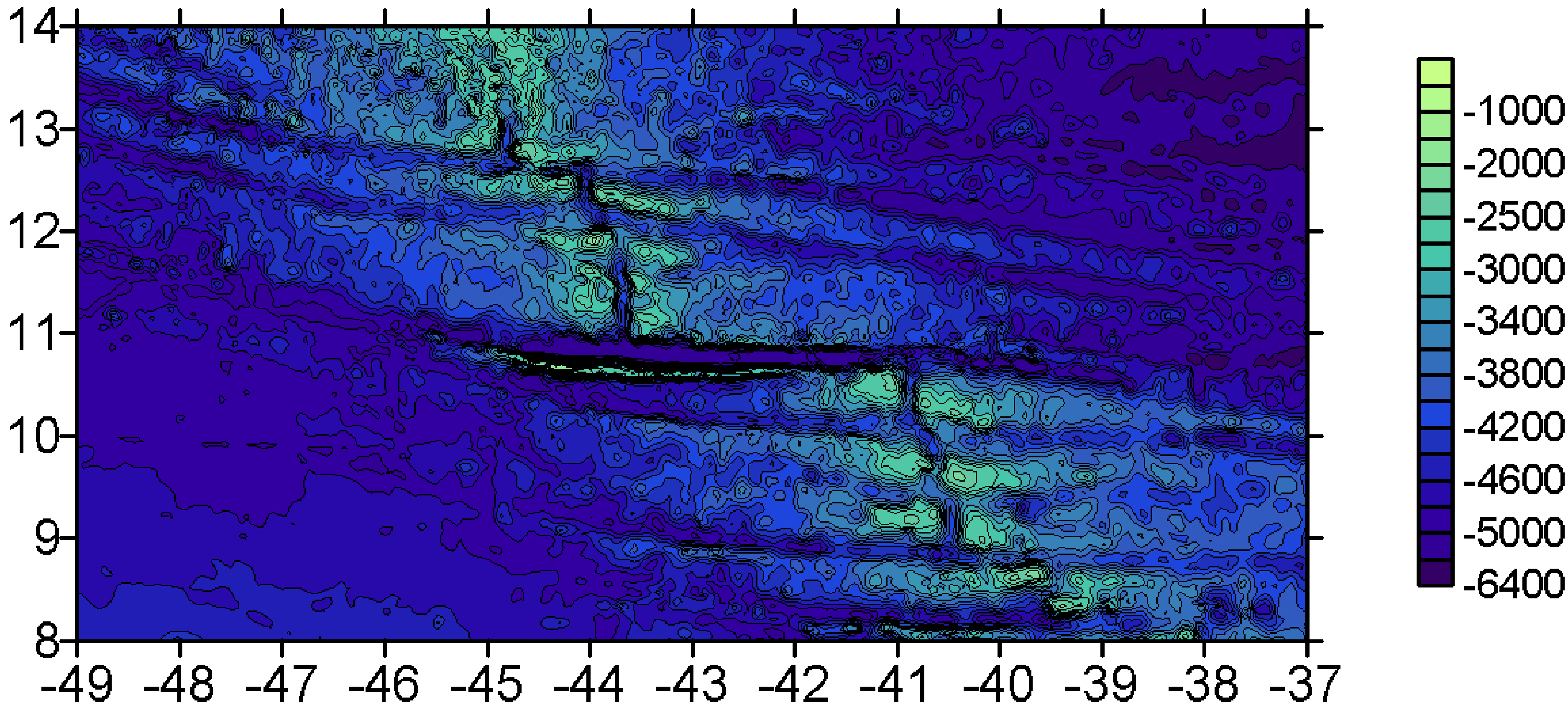
Width of the channel is 7 km;

Thickness of the AABW layer is 800 m.

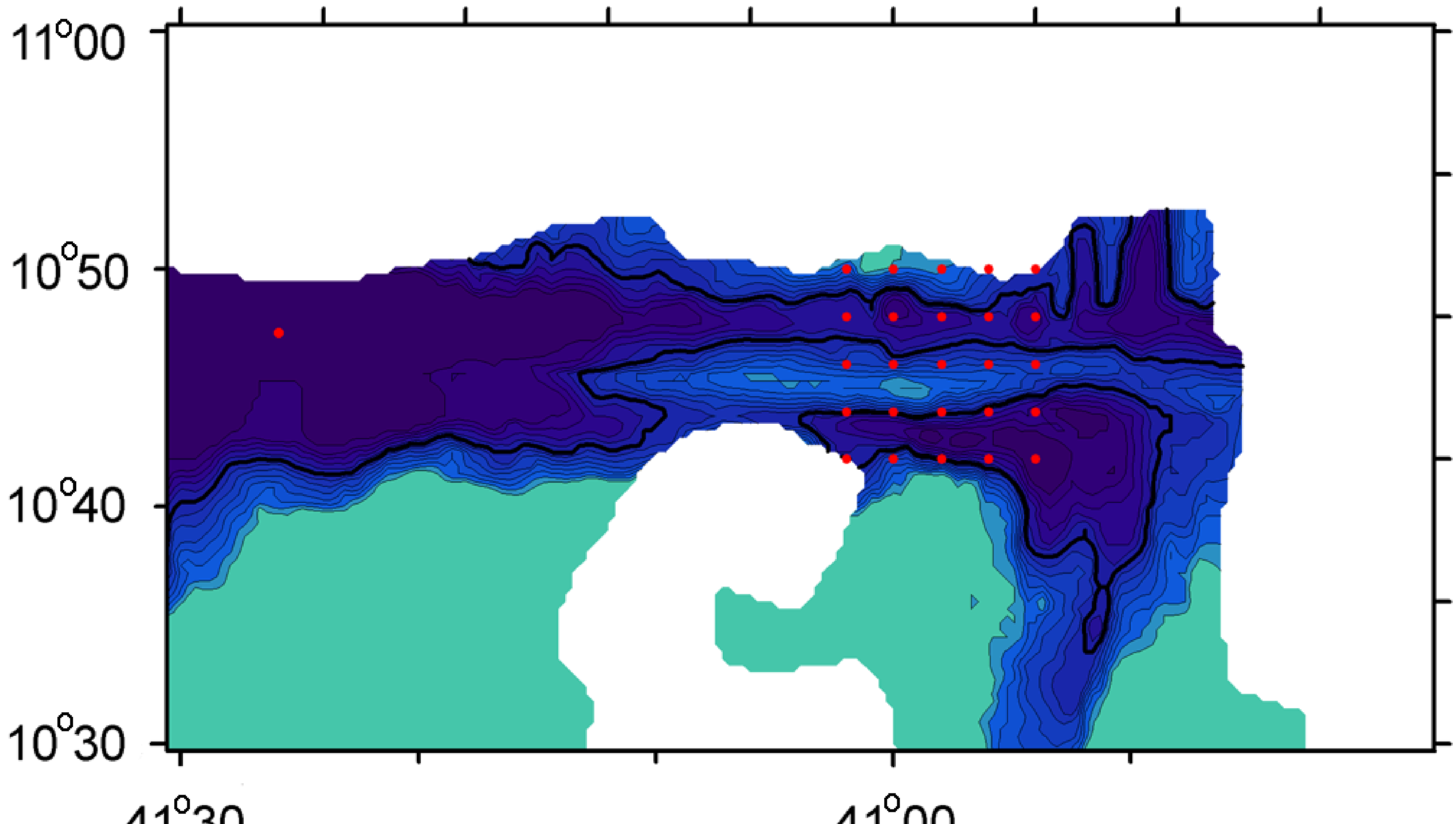
This gives a total easterly transport of AABW approximately equal to 0.5 Sv.

Earlier estimates ranged between 0.5 and 2 Sv.

Vema Fracture Zone at 11° N



Bottom topography and stations in 2006



Velocity measurements in the Vema FZ in 2006 in AABW layer

Mean velocities measured in the layer of AABW using LADCP instrument were equal to 10 cm/s.

Maximal velocities reach 30 cm/s

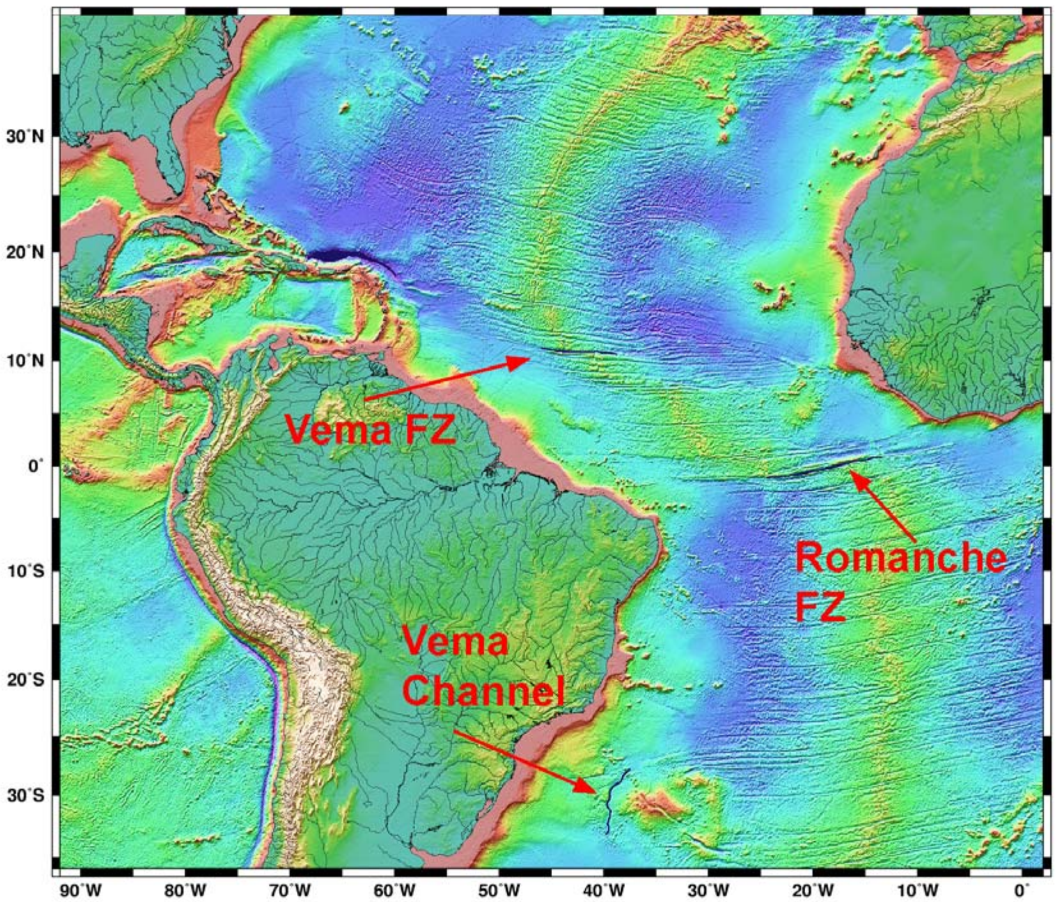
Width of the channel is 8 km;

Thickness of the AABW layer is 600 m.

This gives a total easterly transport of AABW approximately equal to 0.5 Sv.

Earlier estimates ranged between 0.5 and 2 Sv.

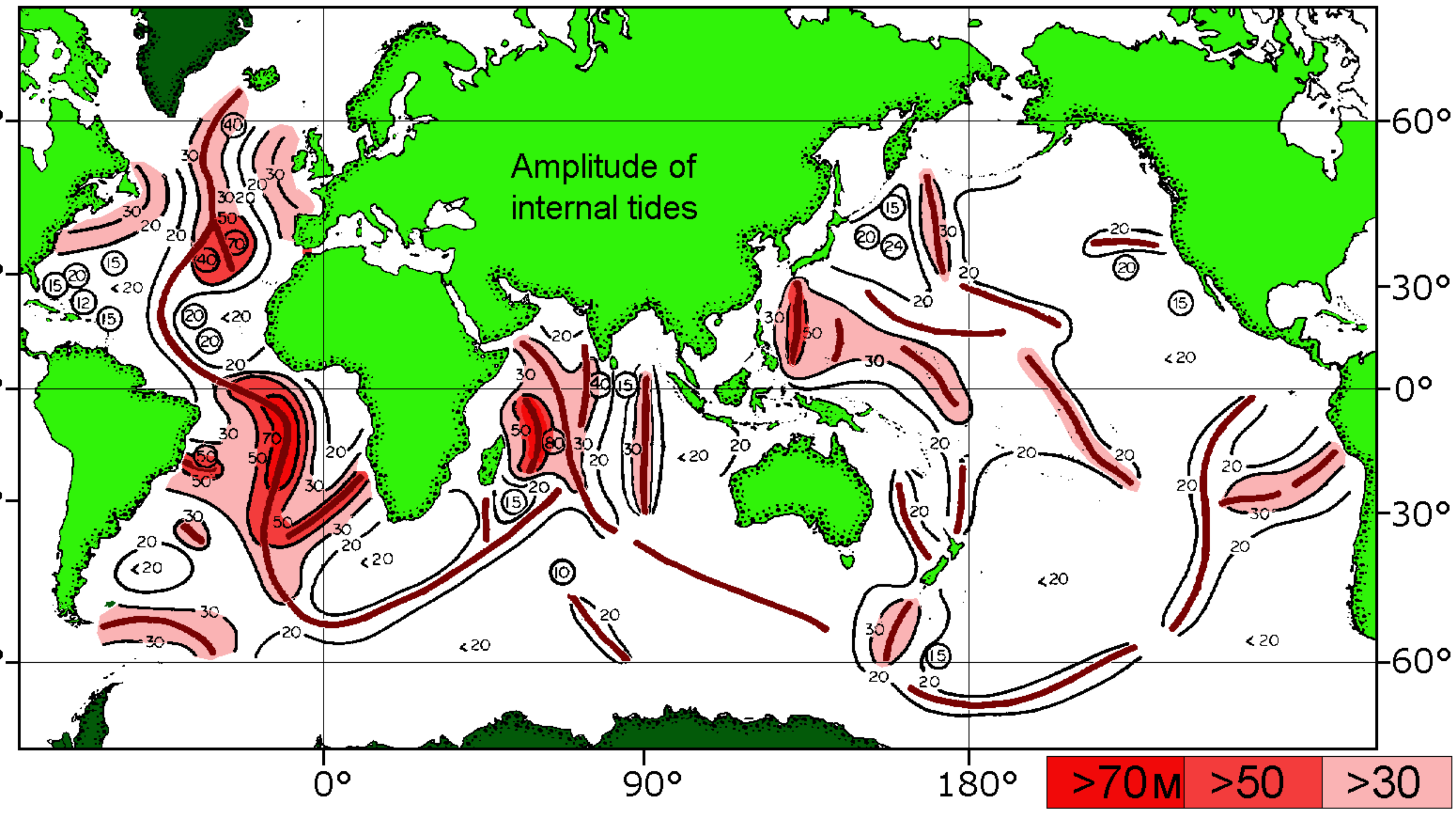
Key problem of this presentation



Why Northeast Atlantic is filled with AABW through the Vema FZ, but not through the Romanche FZ?

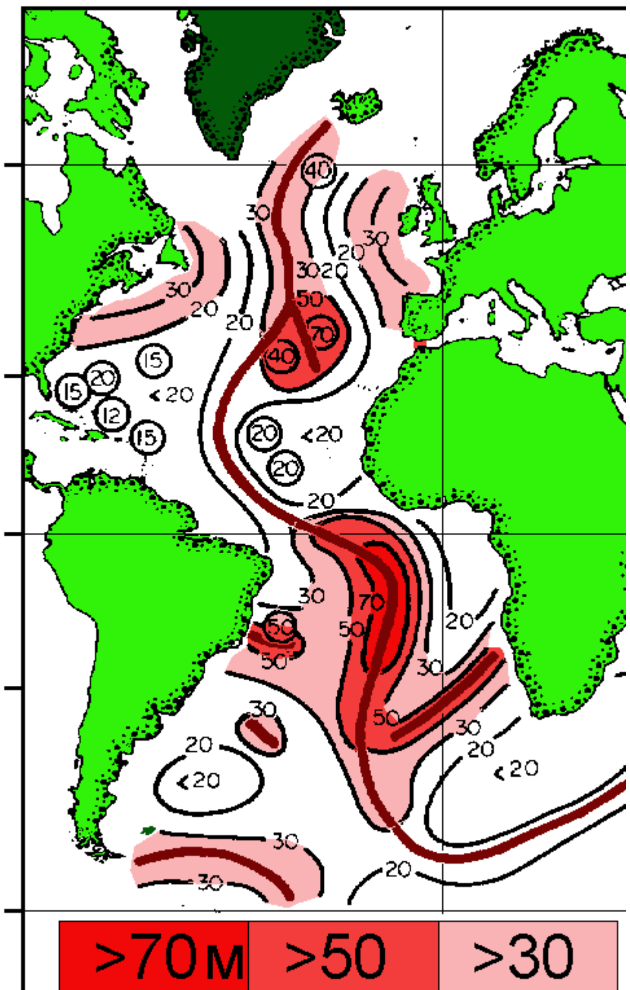
The water transports through both channels are approximately the same.

E. Morozov "Global Internal Wave Field", Deep-Sea Res. 1995.

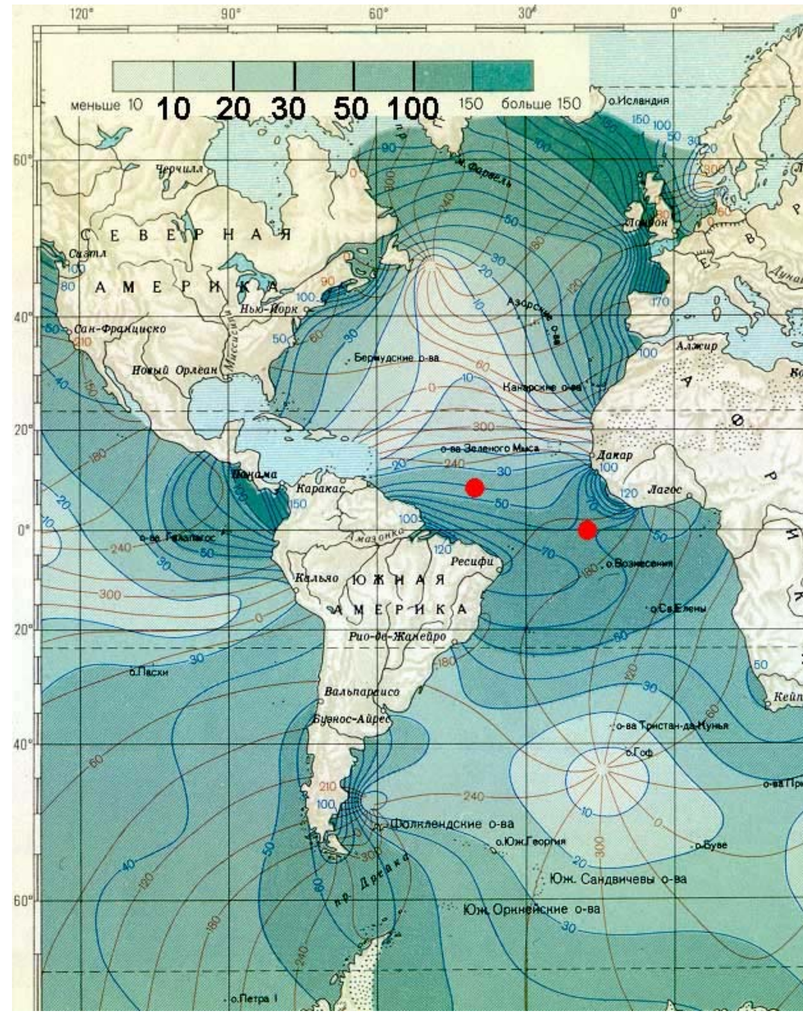


Mixing by internal tides in the region of Romanche FZ is stronger than in the region of Vema FZ

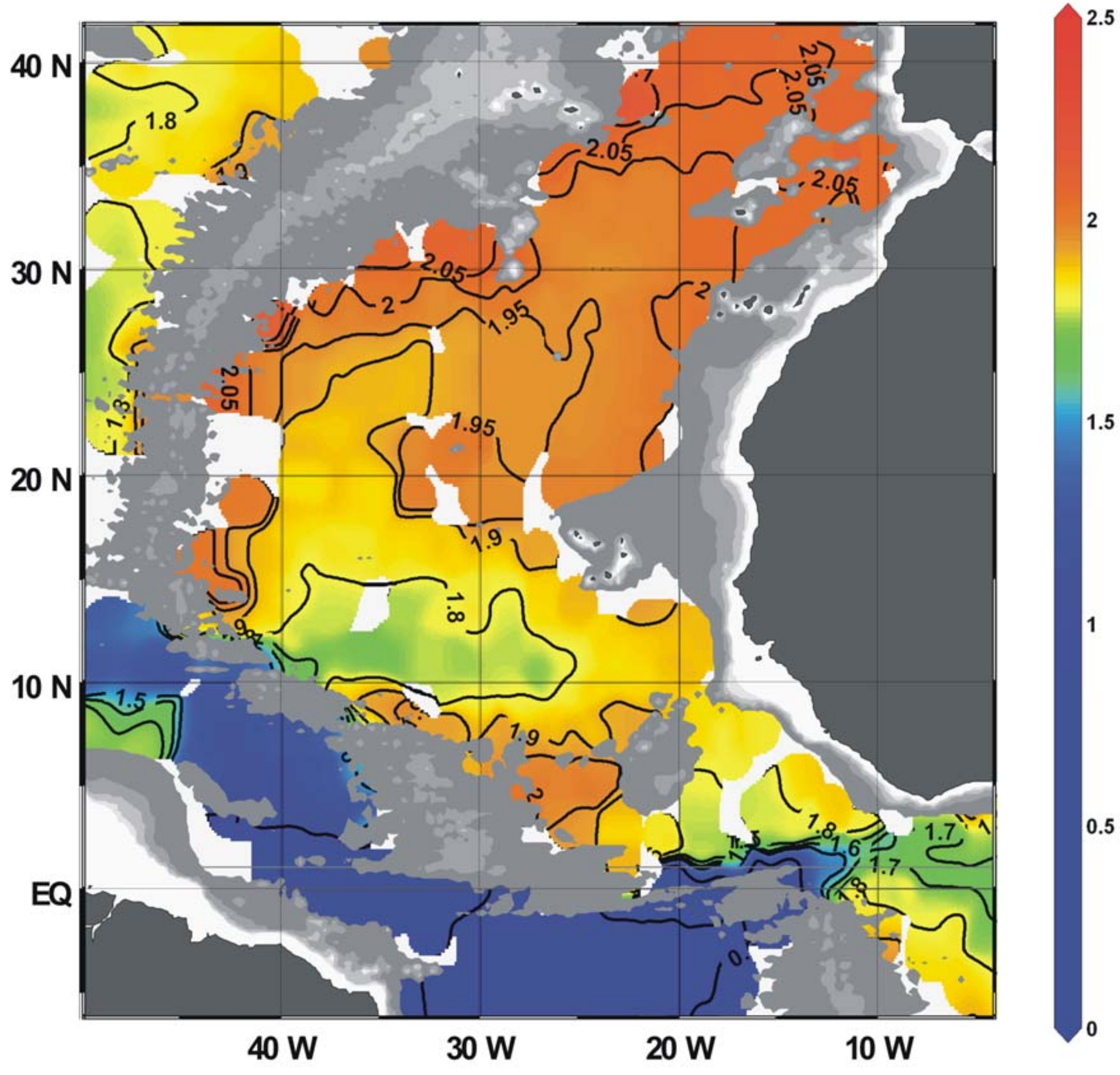
Amplitude of internal tide in meters

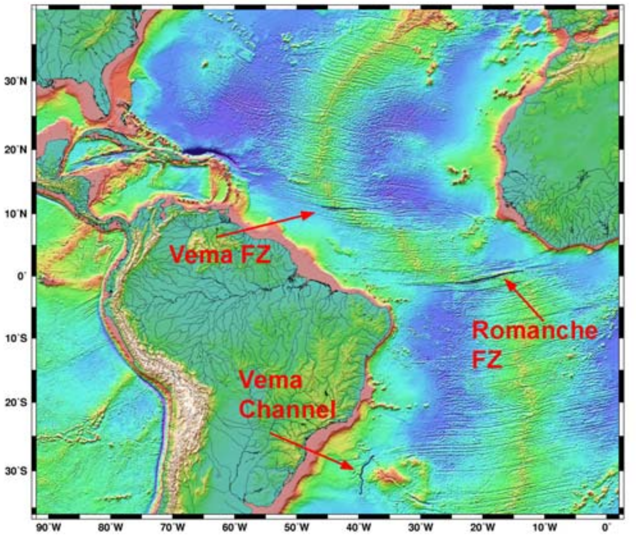


Amplitude of surface tide in centimeters



Northeastern Atlantic is filled with AABW through the Vema FZ





Due to stronger mixing in the Romanche region, the coldest AABW cannot pass through the Kane Gap.

The NE Atlantic is filled with AABW flowing through the Vema FZ. The flow is 0.5 Sv.

Vema

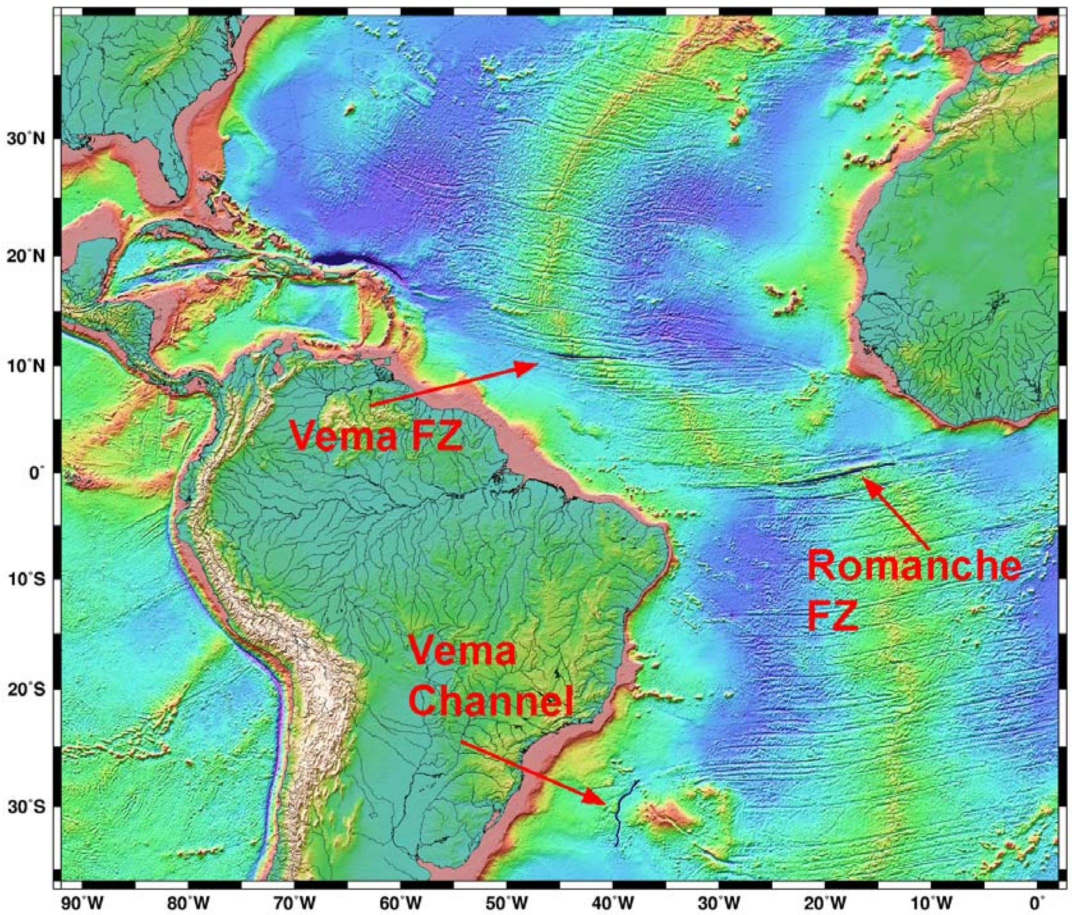
$N=0.80 \cdot 10^{-3}\ s^{-1}$

$K_z=1.2 \cdot 10^{-4}\ m^2/s$

Romanche

$N=0.14 \cdot 10^{-3}\ s^{-1}$

$K_z=7.1 \cdot 10^{-4}\ m^2/s$



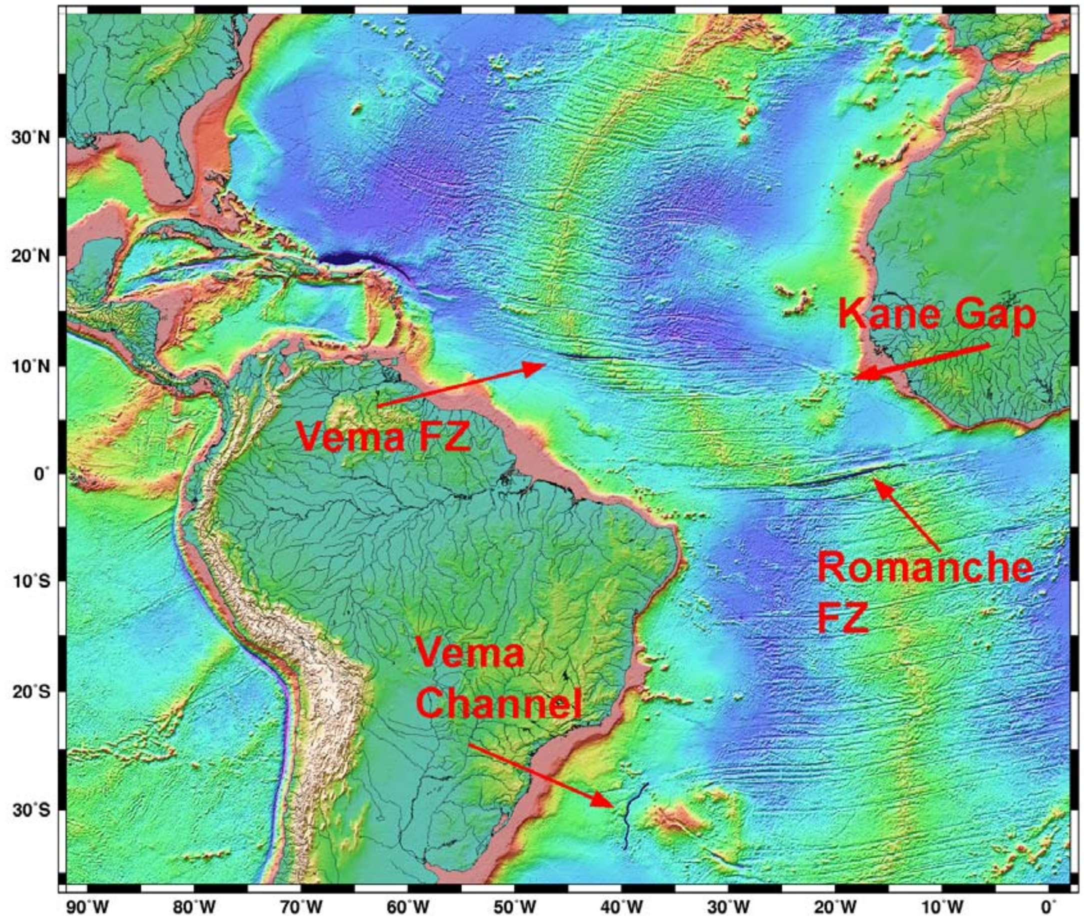
Mixing in the Romanche FZ is greater than in the Vema FZ

Diffusivity k_z

Brunt-Vaisala frequency N

$$k_Z = \frac{10^{-7} m^2/s^2}{N(z)}$$

Important question:
What happens in the Kane Gap?

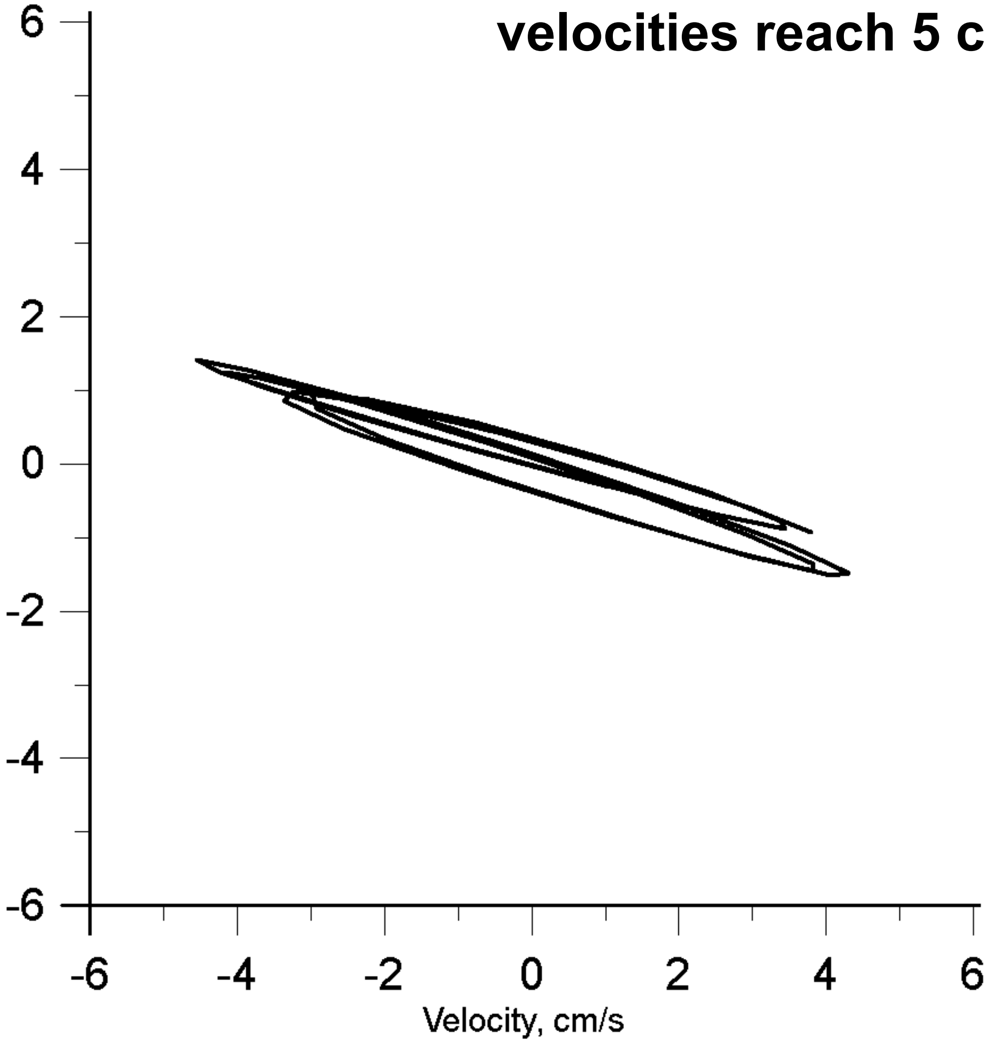


Measurements on May 1, 2009 showed that the flow is directed to the south transporting 0.2 Sv

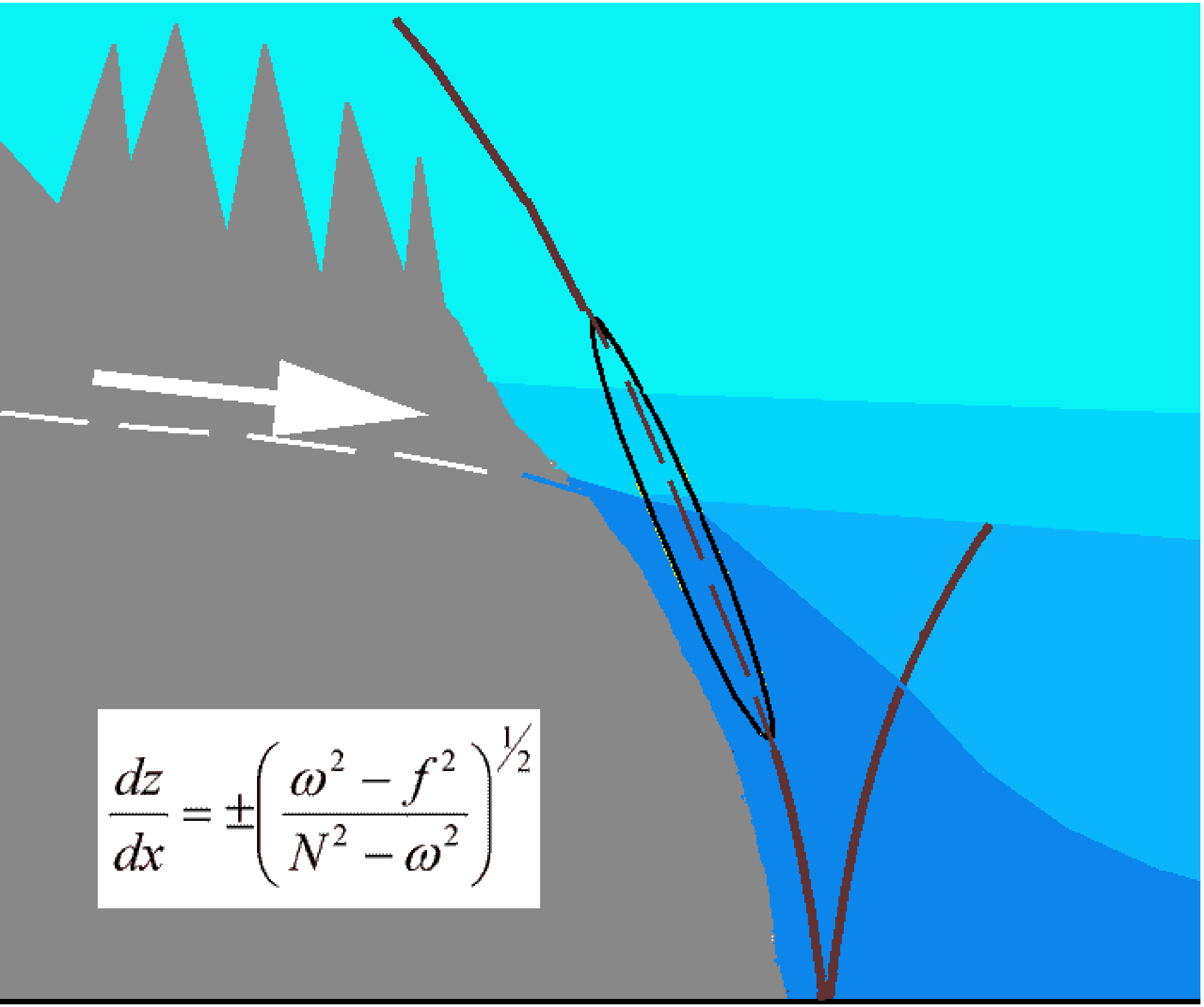
0.2 Sv = Amazon River

Tidal ellipses near the Chain Fracture Zone (main sill) based on satellite TOPEX/POSEIDON

velocities reach 5 cm/s

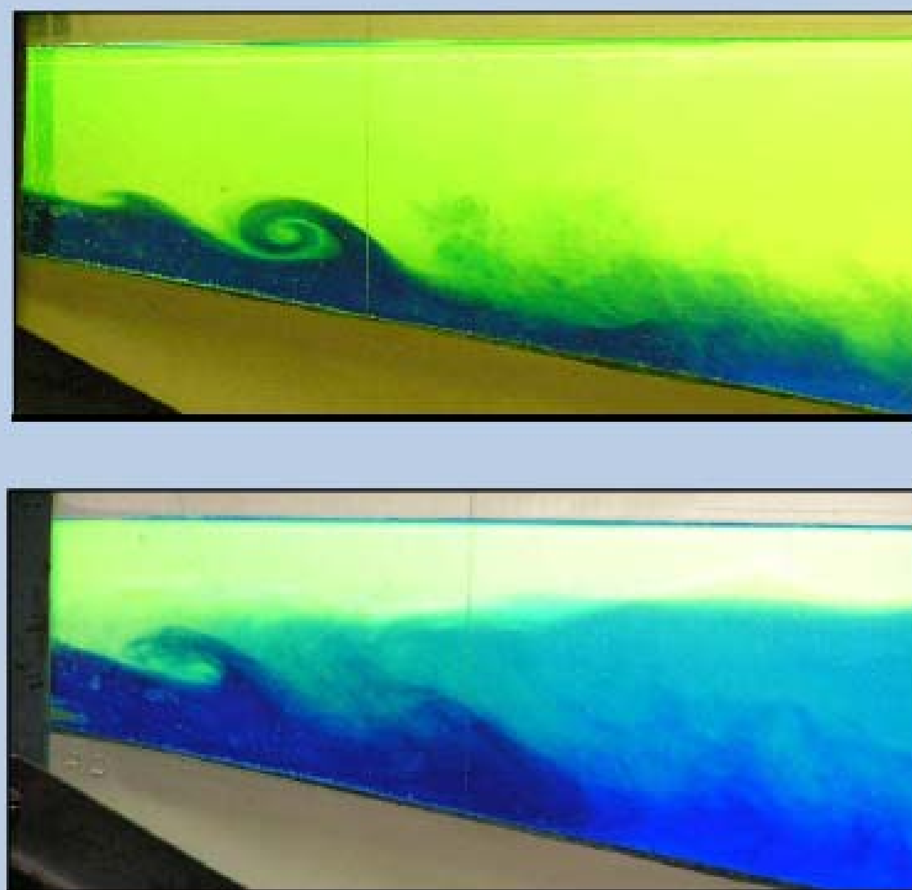


Flow east of the Mid-Atlantic Ridge after the Chain Fracture Zone



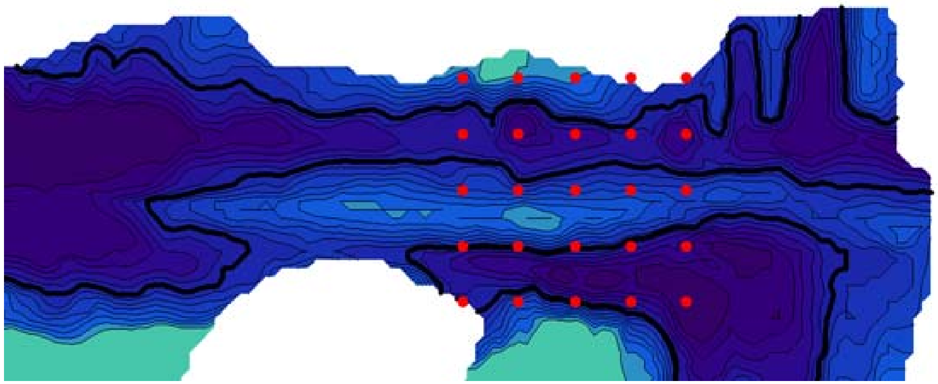
$$\frac{dz}{dx} = \pm\left(\frac{\omega^2 - f^2}{N^2 - \omega^2}\right)^{1/2}$$

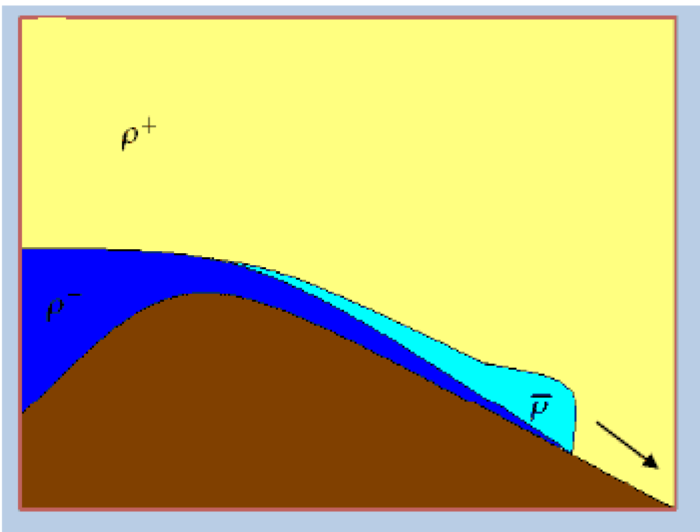
Laboratory experiments by Liapidevsky

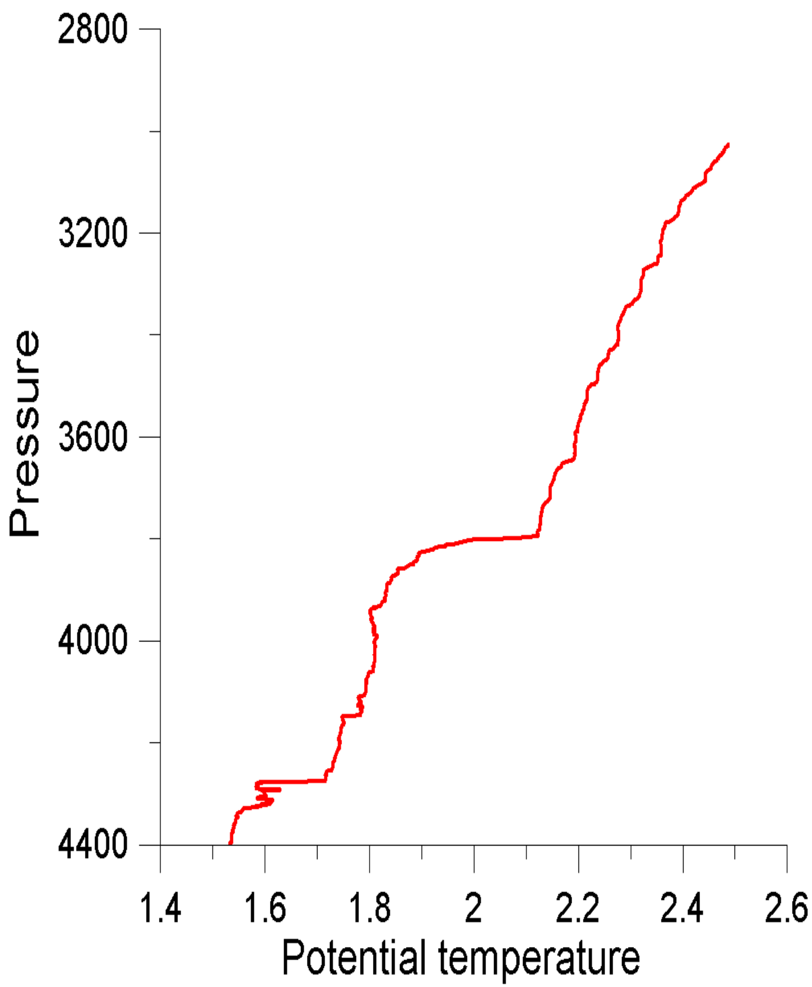


Siberian Institute of Hydrodynamics

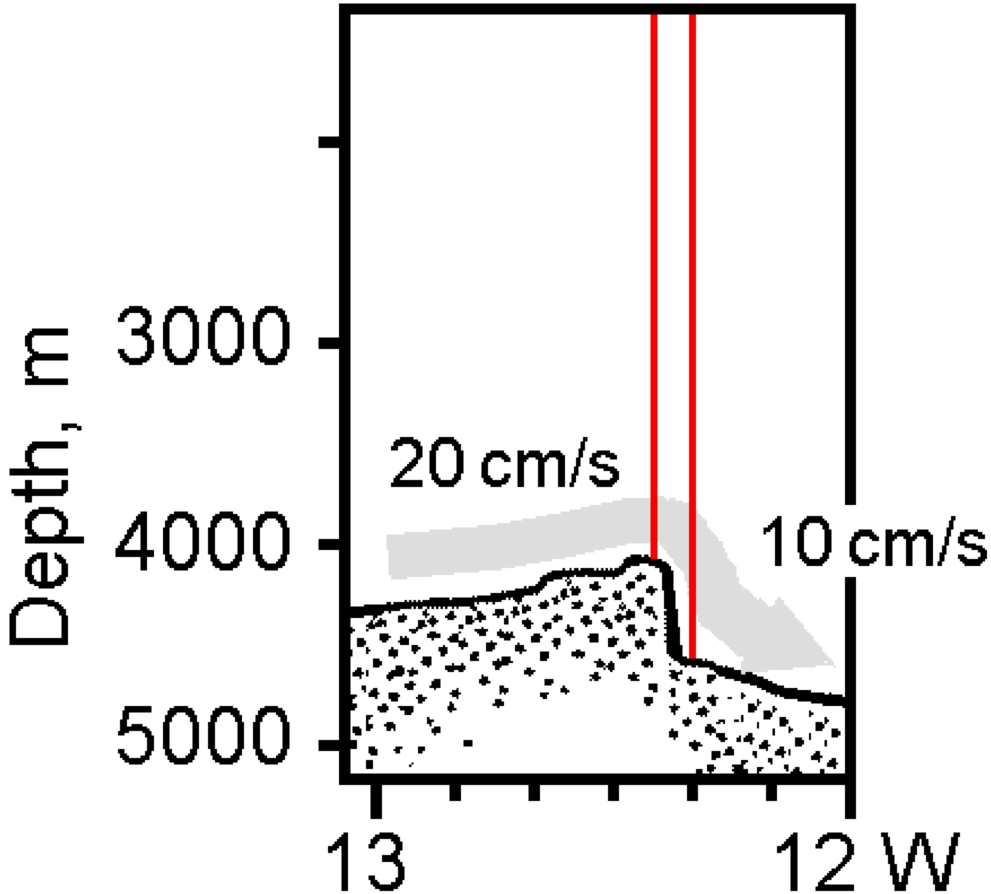
Measurements in the Vema Fracture Zone at 11° N



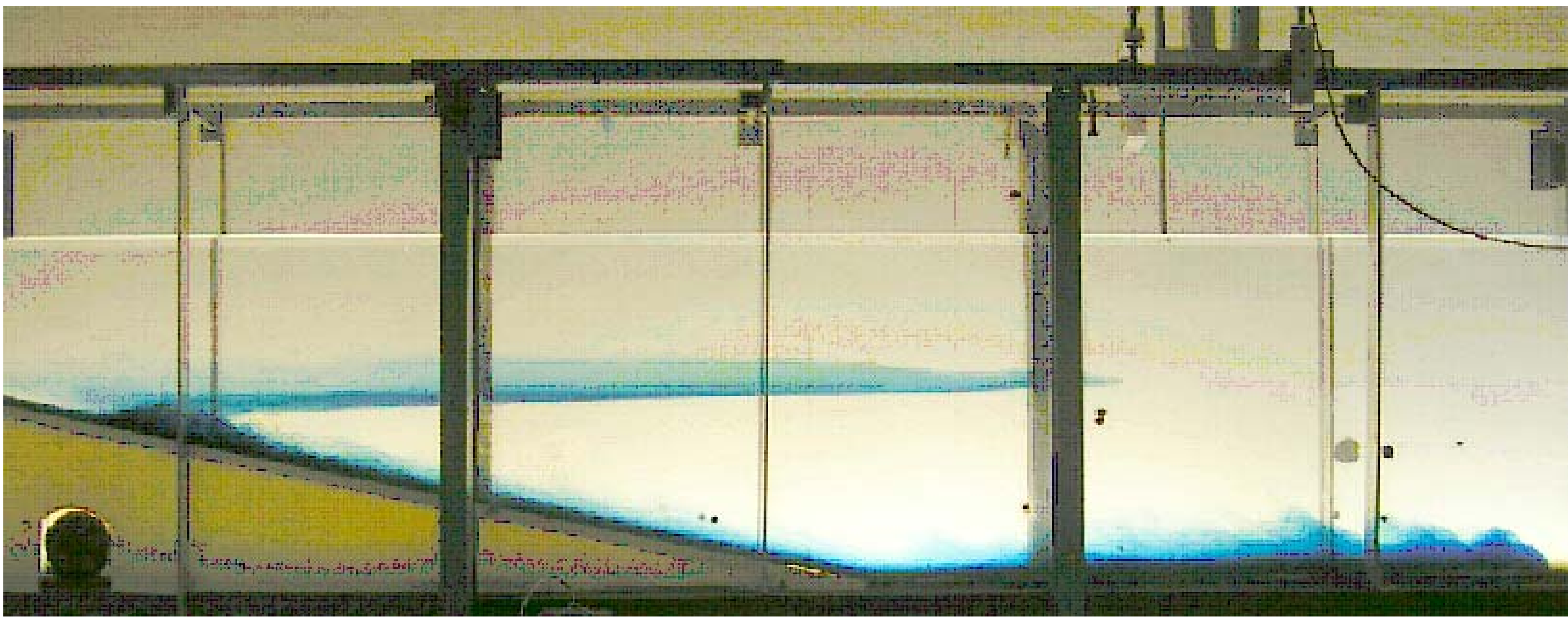




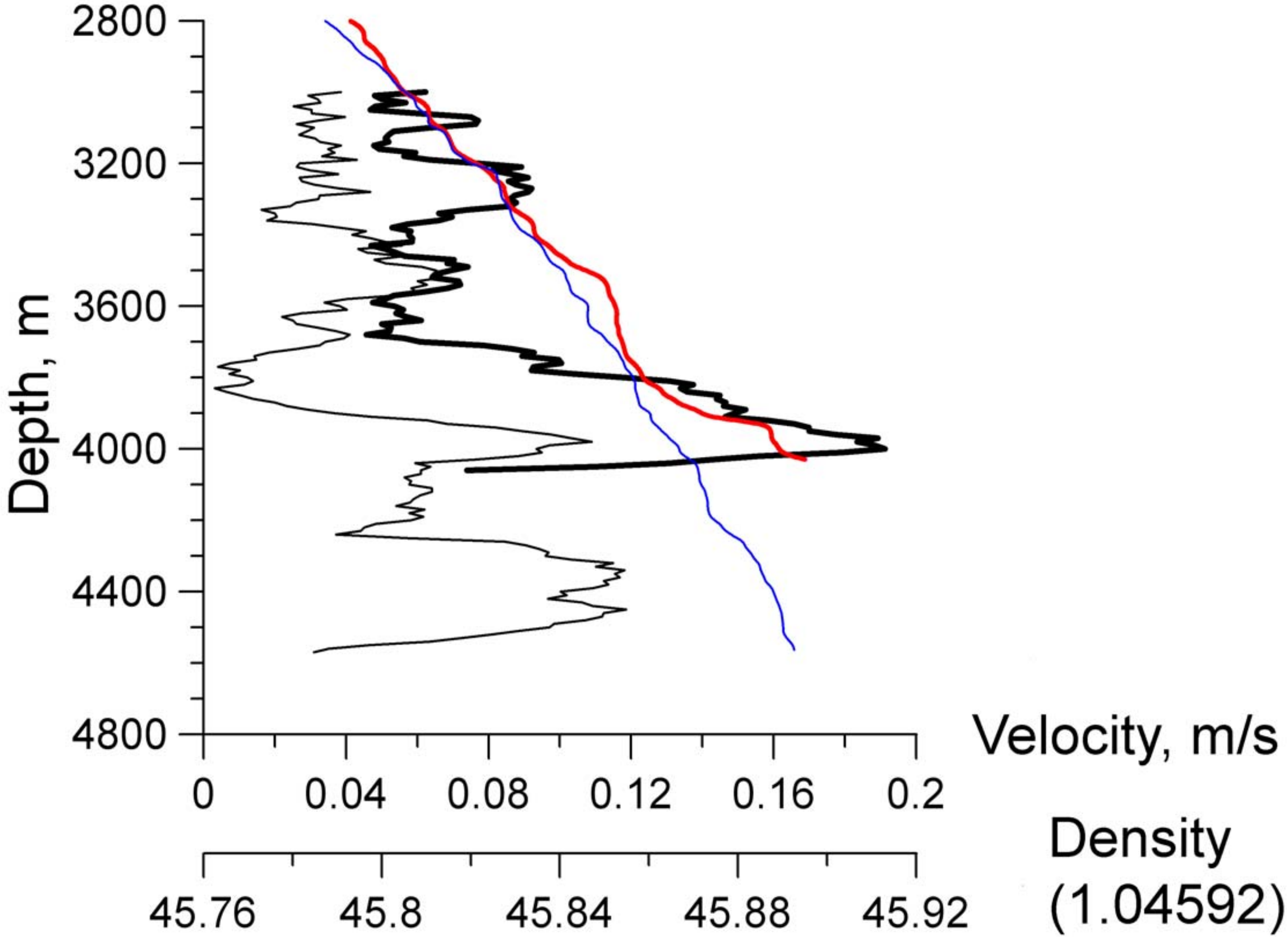
Flow over the main sill



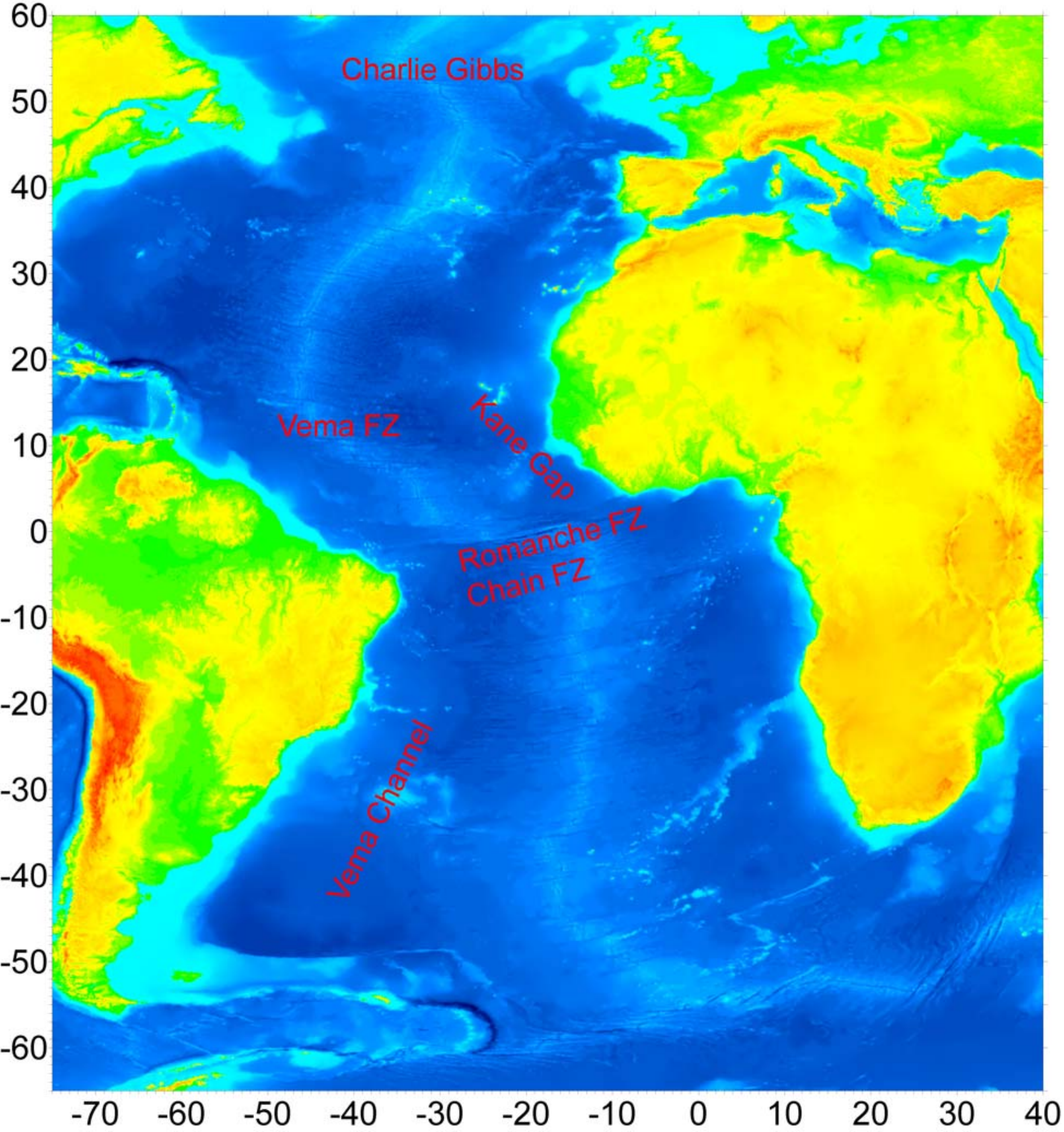
Laboratory experiments by Liapidevsky
(Siberian Institute of Hydrodynamics**)**



Profiles of currents near the main sill of the Chain Fracture Zone



Expedition and instrument



Grand Slam of studies in the most important abyssal channels of the Atlantic Ocean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