# Insight into the structure of the Wyville Thomson Ridge overflaw

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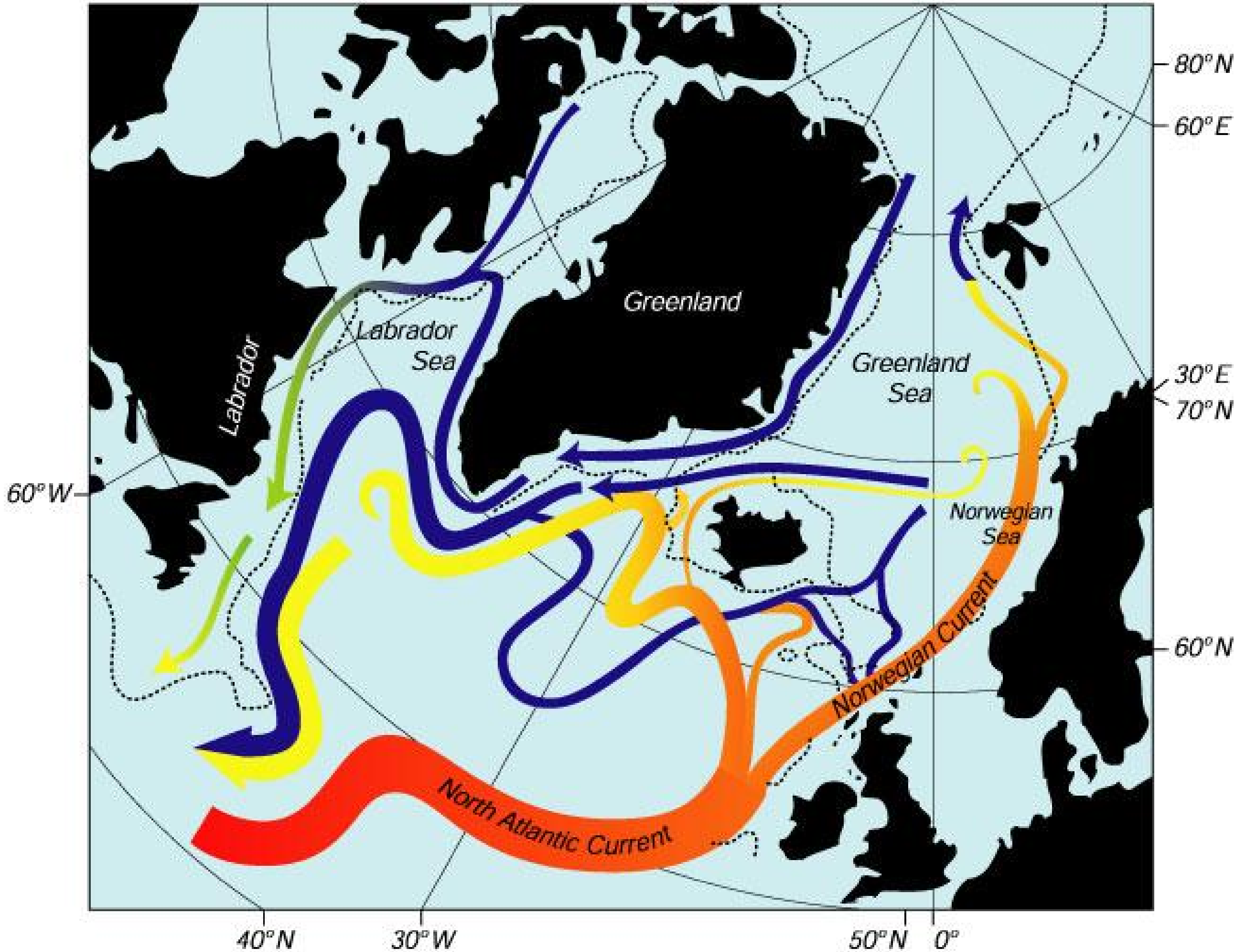
# The area




(from Stewart, 2005).

**AREA:** The buoyancy-driven exchange of water between the Nordic Seas and the North Atlantic Ocean forms part of the Meridional Overturning Circulation (MOC). One of its main deep water outflow pathways is via the Faroe-Shetland Channel (FSC) and Wyville Thomson Basin (WTB), through the Faroe Bank Channel (FBC) and over the Wyville Thomson Ridge (WTR) (see Fig. 1). The WTR overflow accounts for nearly 1/10$^{th}$ of the total Norwegian Sea Deep water (NSDW) discharged through the Faroese channels.

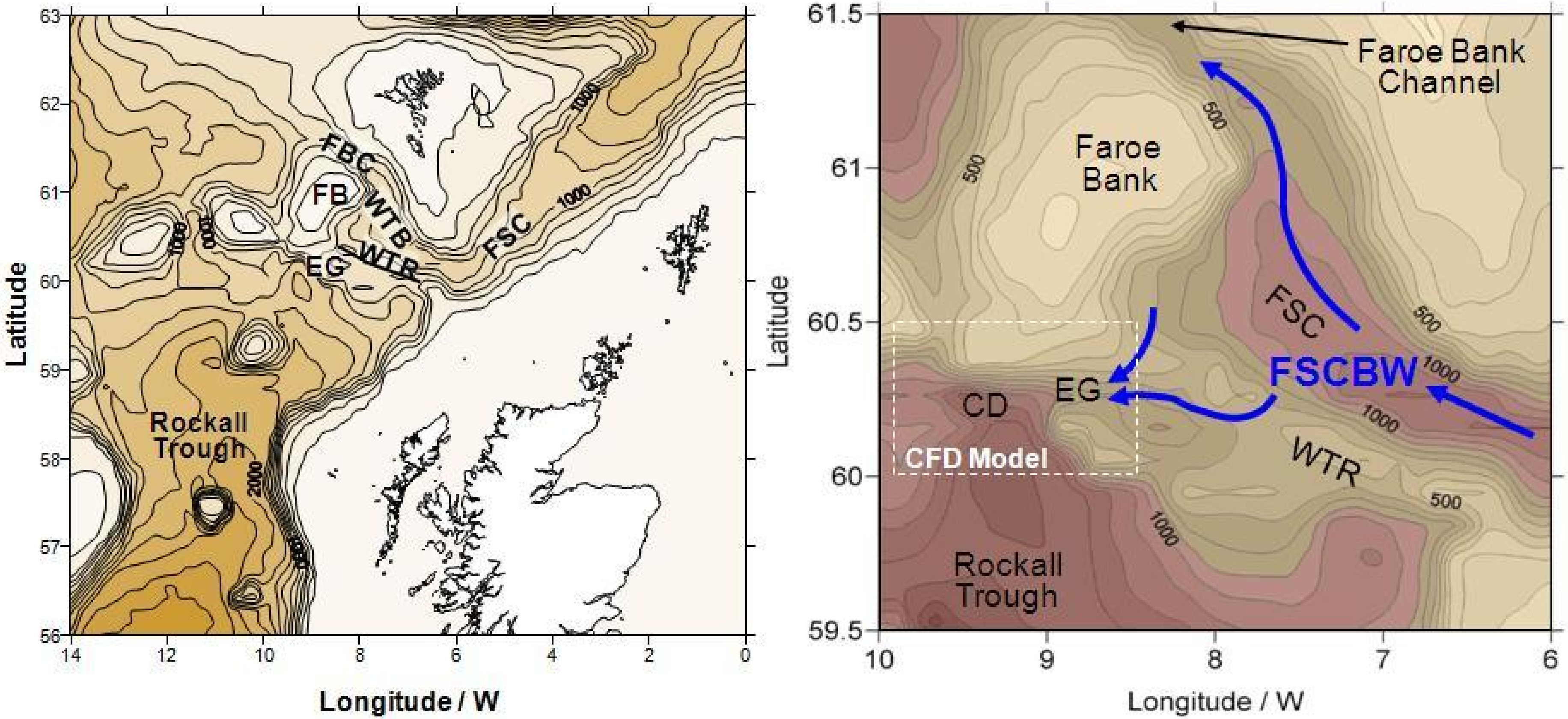



Fig. 1: (a) Principal topographic features of Faroese Channels; (b) WTR outflow pathways through Ellett Gully (EG) to Cirolana Deep (CD).

## Field Monitoring Studies

Moored ADCPs at Stations 1 & 2 in the Ellett Gully (EG) [Fig. 2(a)] recorded 5-day average transports of Faroe-Shetland Channel Bottom Waters (FSCBW) across the WTR. Comparisons with 5-day average FBC sill transports [Fig. 2(b)] show that (i) WTR transport increases with FBC transport [with no WTR overflow when FBC transport < 1.2 Sv], (ii) more WTR overflow is captured in the lower parts of the EG [sta. 2, Fig. 2(b)]. Seasonality of the 10-year record of FBC transport (larger overflows in summer) implies that WTR overflows will also be seasonal. 3-day average transports at EG [Fig 2c)] show much greater variability at sta. 1 (winter, mean total = 0.57 Sv, std. dev. = 0.38 Sv) than at sta. 2 (summer, mean total = 0.96 Sv, std. dev. = 0.24 Sv).

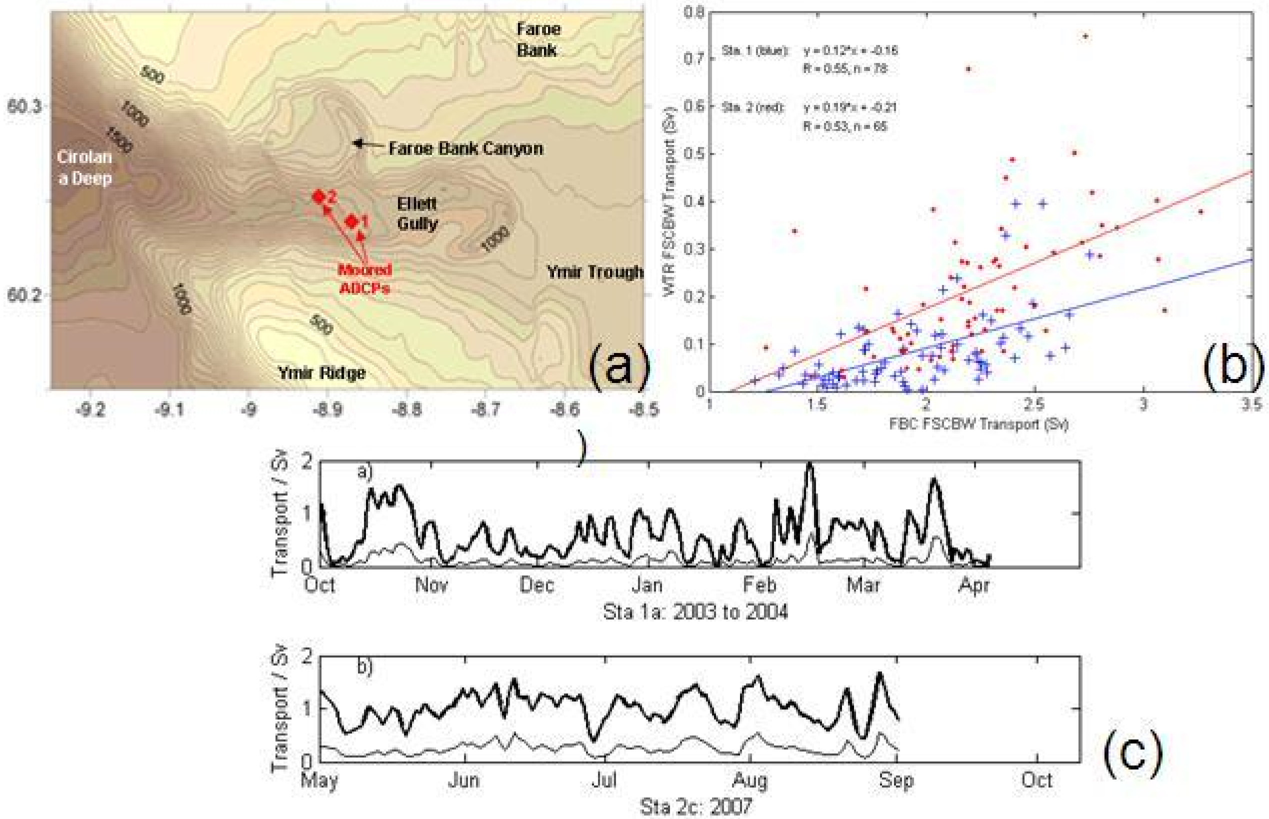
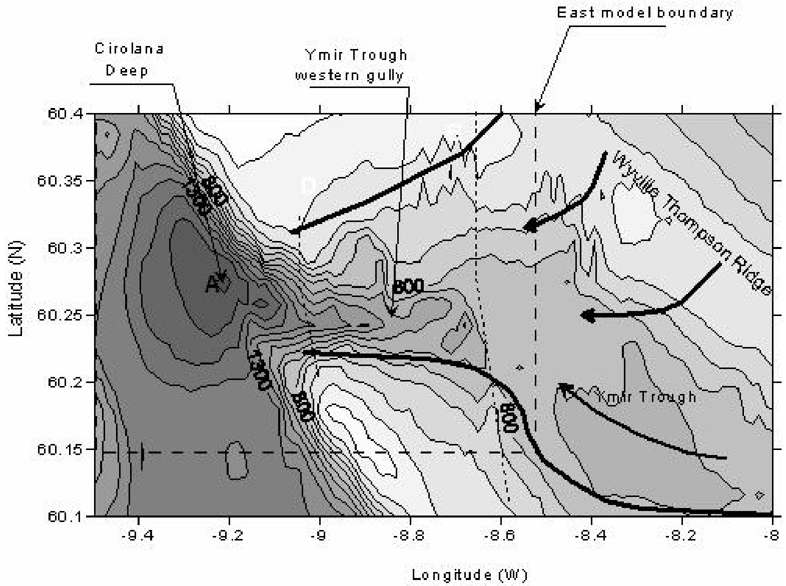
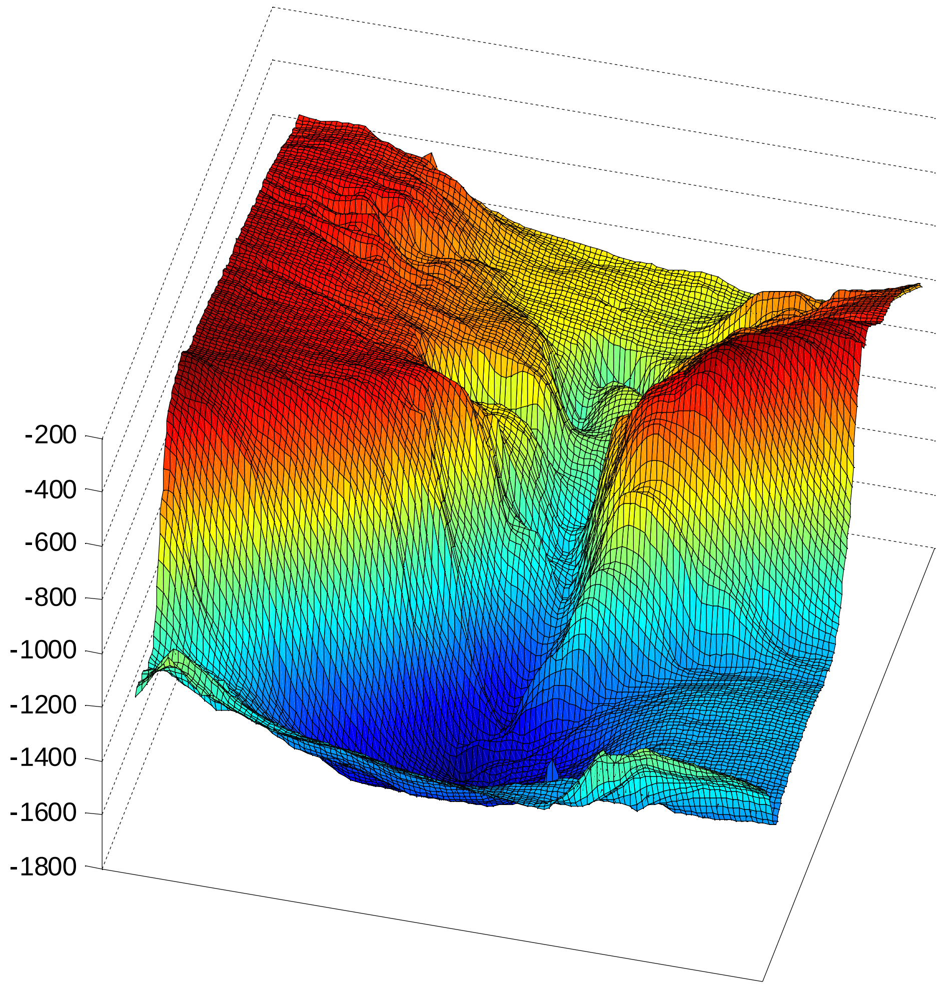


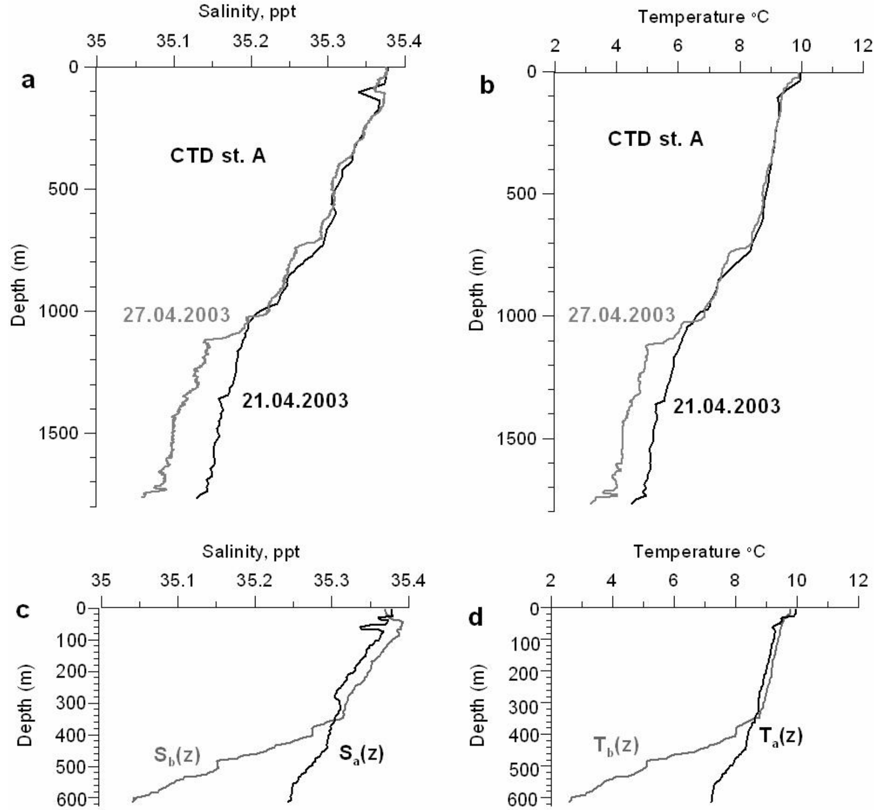

Fig. 2: (a) Complex topography of the Ellett Gully (EG) with moored ADCP positions (sta. 1 & 2); (b) direct comparison of measured WTR transport (sta. 1 & 2) with FBC sill transport; (c) time series of 3-day average WTR transports measured at sta. 1 & 2 (thick line – total transport; thin line – FSCBW only)

# Modelling

The MIT general circulation model (MITgcm) is used to model the WTR overflow pathways through EG into the Cirolana Deep (CD). Initial domain and boundary conditions are set from appropriate field measurements. The model is forced by density gradients between the ambient waters and the WTR dense overflow waters, and an incoming flux velocity (0.15 $m.s^{-1}$) set in the bottom 200 m layer at the eastern model boundary.



## Modelling of significant overflow event in April 2003

**AIM:** The work was motivated by an intention to find a reasonable set of model parameters in order to describe the WTR overflow and to achieve the best fit of the model output to the observational data reported by Sherwin and Turrell, 2005.

The particular novelty of these experiments in comparison with similar studies is that the model resolution (in both horizontal and vertical directions) has been made sufficiently fine that the details of the interaction between the overlying ambient and overflowing water masses can be investigated.

Model domain: 54.4x24.8 km$^2$

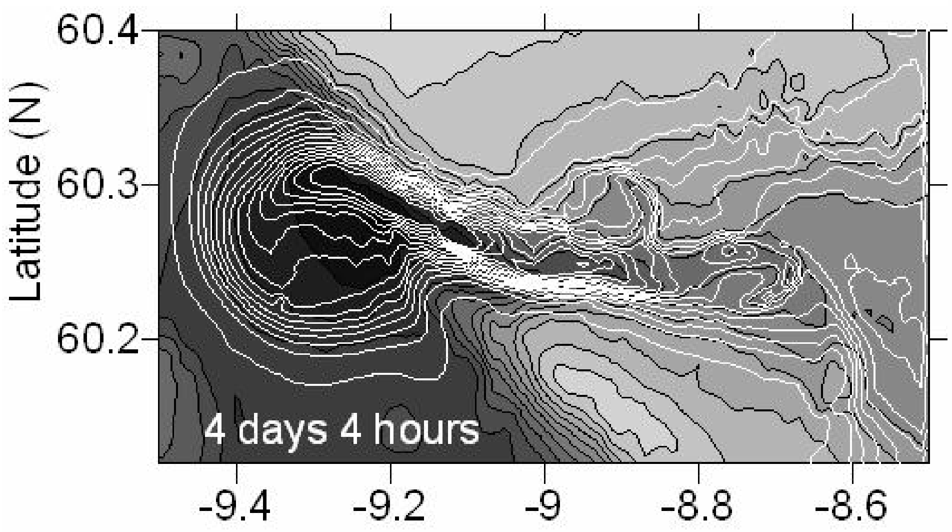
**Resolution:**

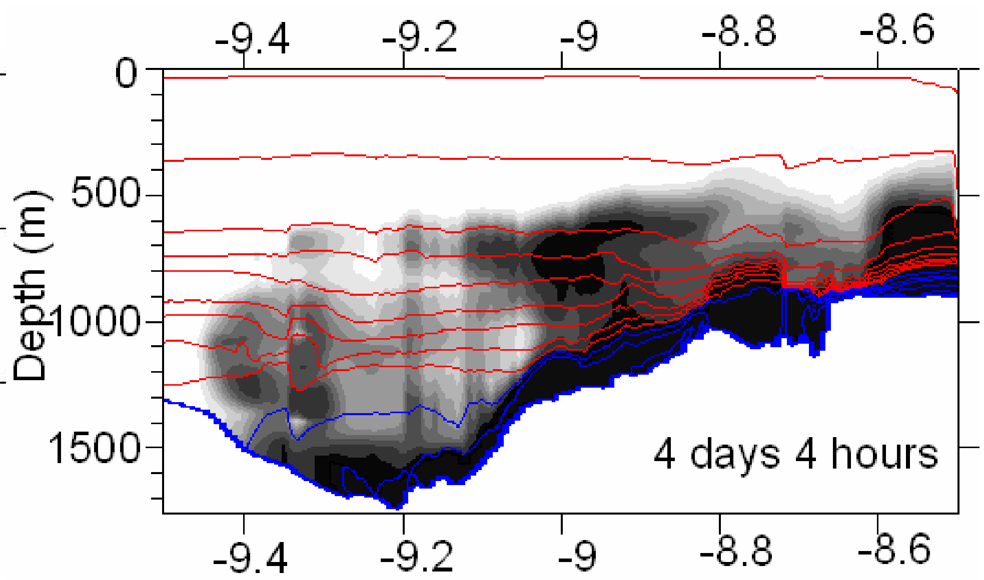
$$Horizontal \quad : \Delta x = \Delta y = 250 \ \text{m},$$

$$Vertical \quad : 293 \ \text{layers with} \ \Delta z = 10 \ \text{m}, \ \text{below} \ 600\text{m} \ \Delta z = 5 \ \text{m}$$

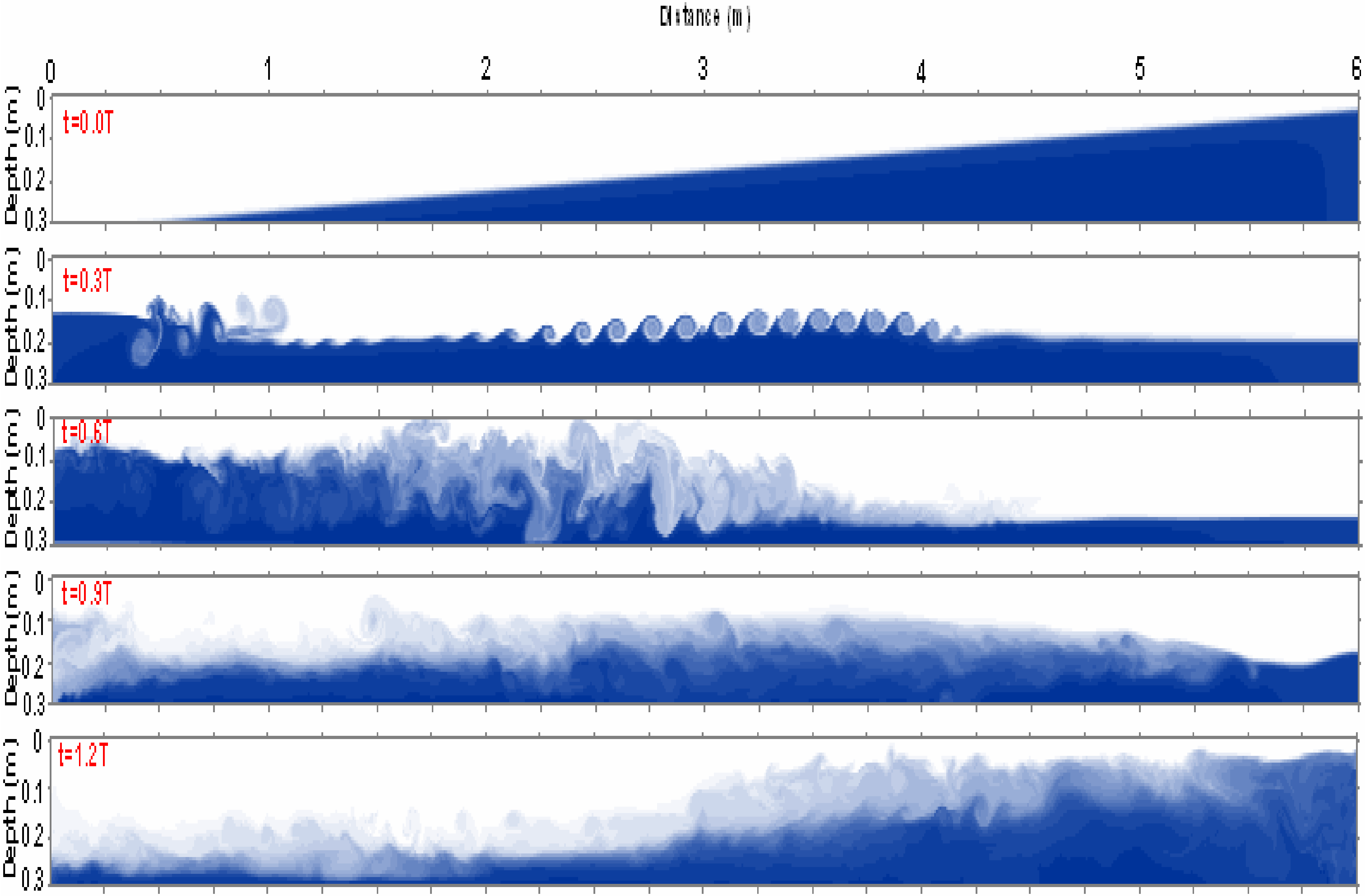
Plan views of depth integrated tracer evolution
overlaid with topography.

Cross-sections of temperature and tracer along the gully thalweg

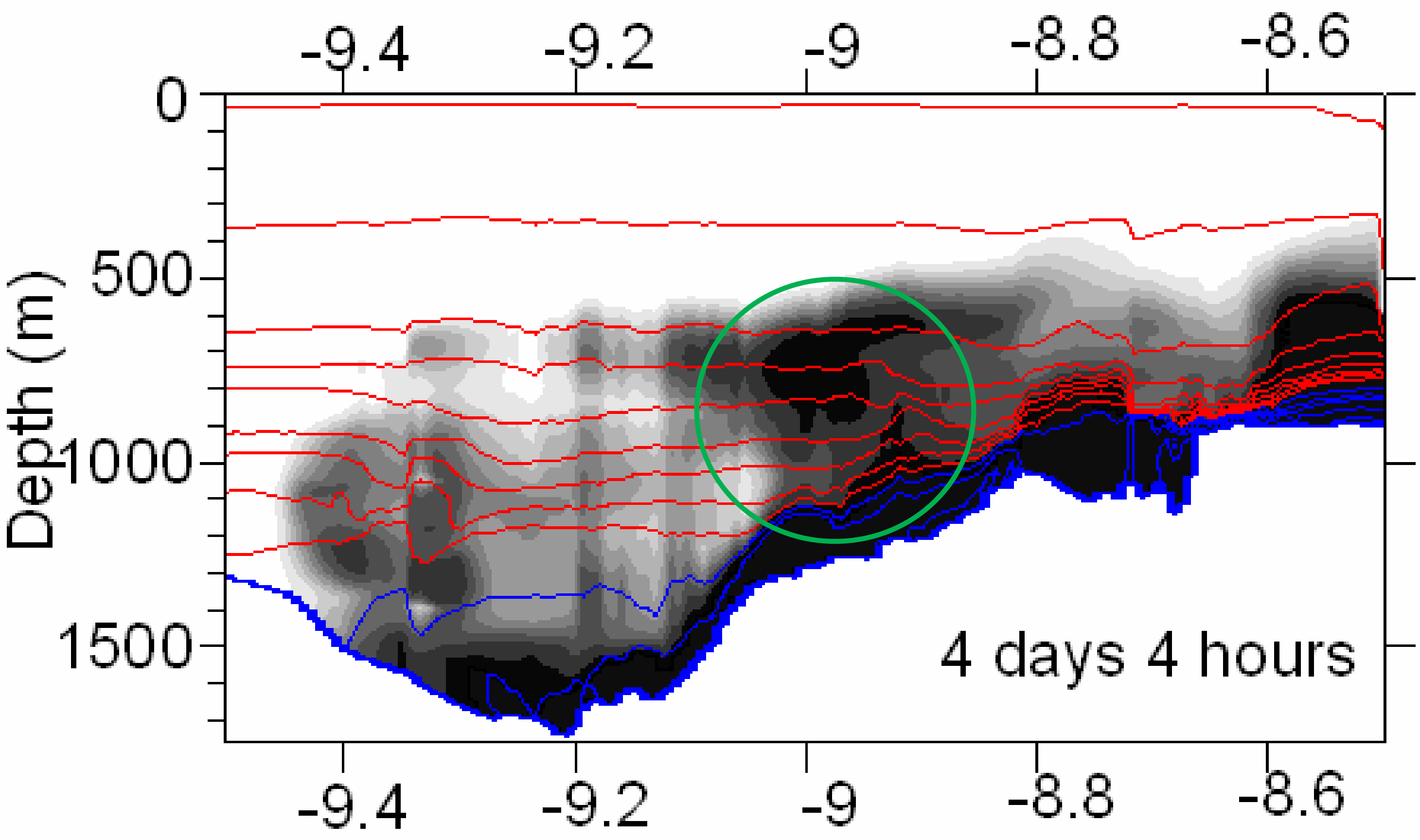


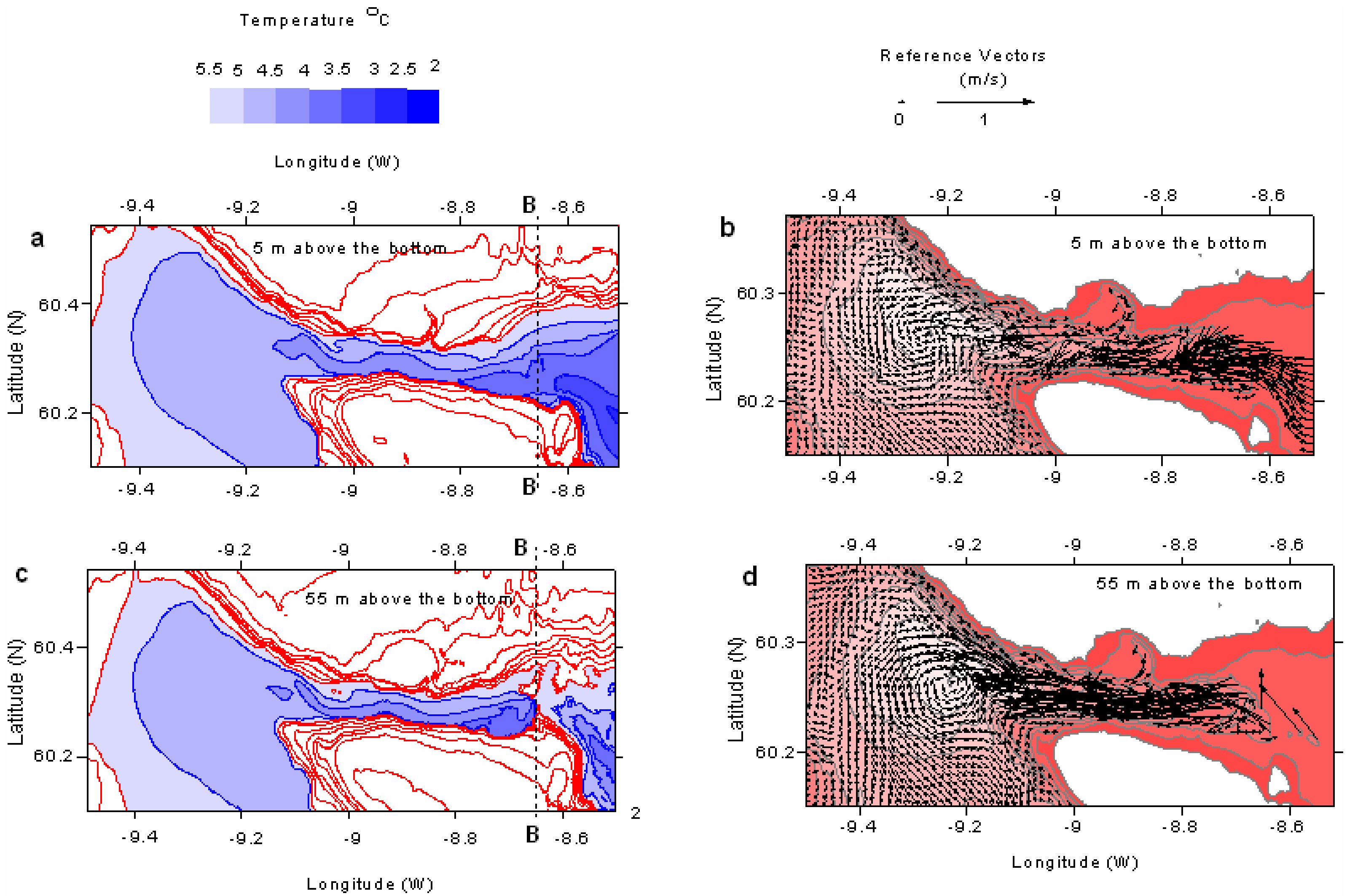
The breakdown of a density interface in a shear flow produced by tilting the containing tube.



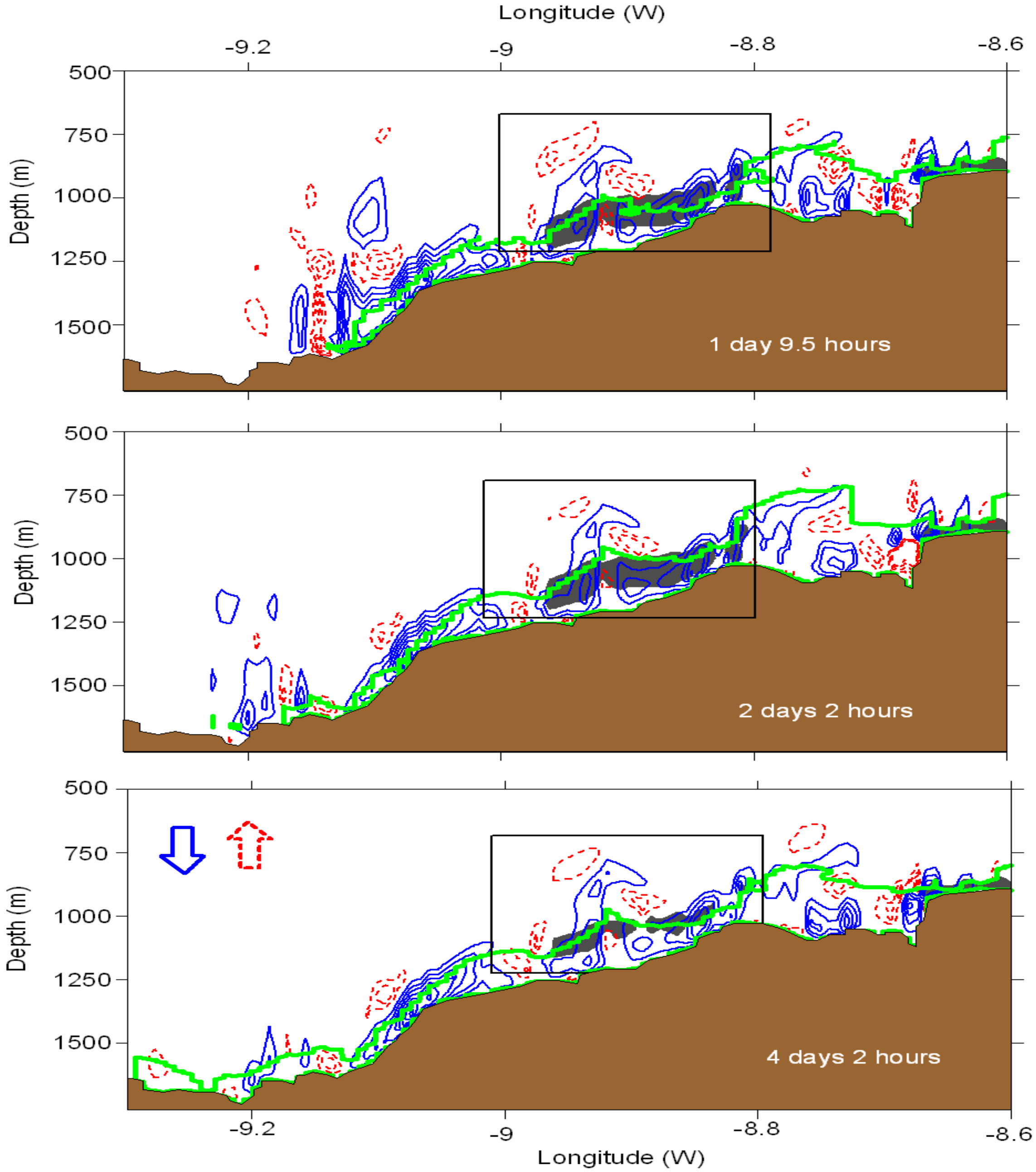
# Entrainment or detrainment?



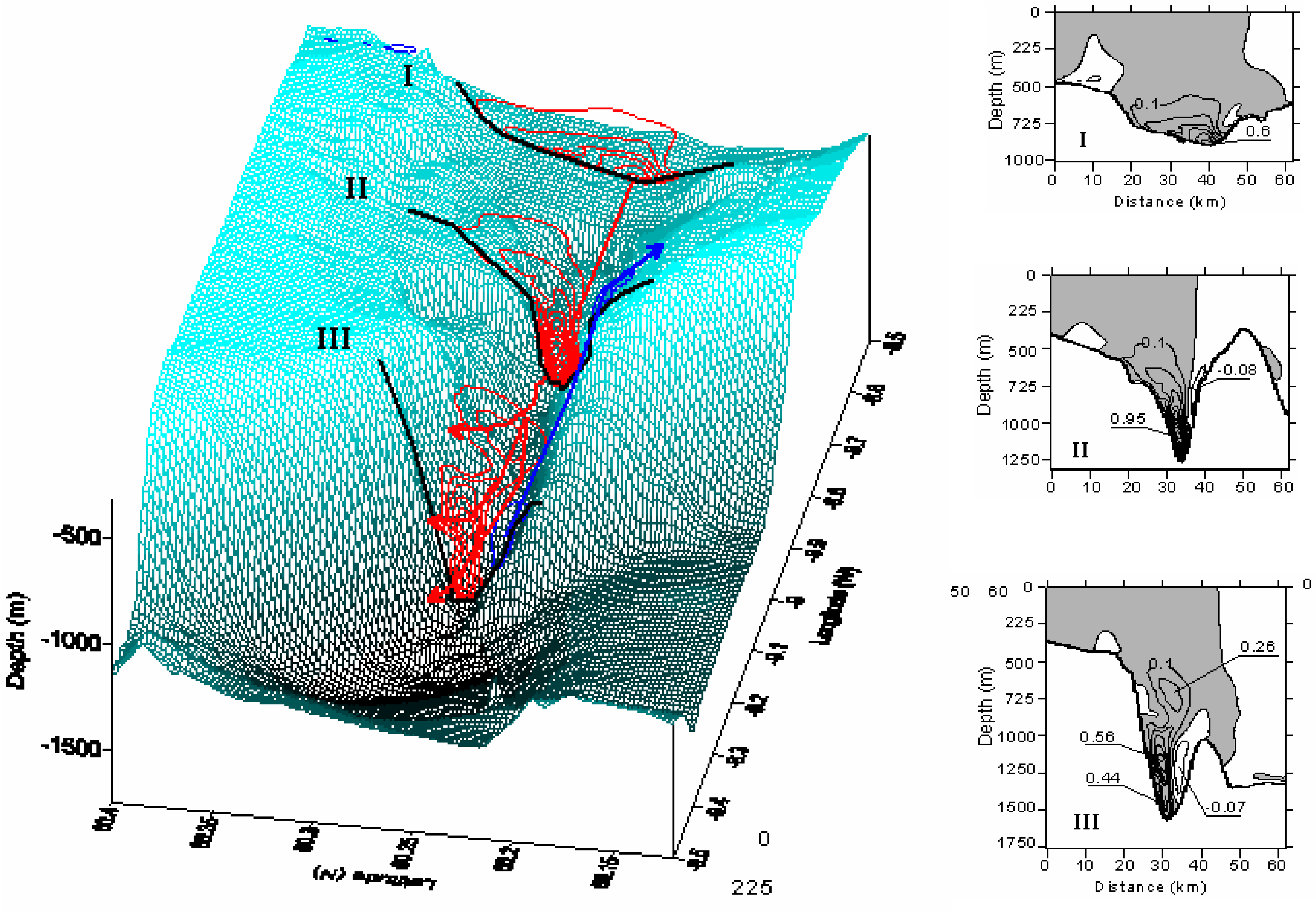
Temperature and velocity vectors at heights of 5 m and 55 m above bottom after 7.5 days of overflow



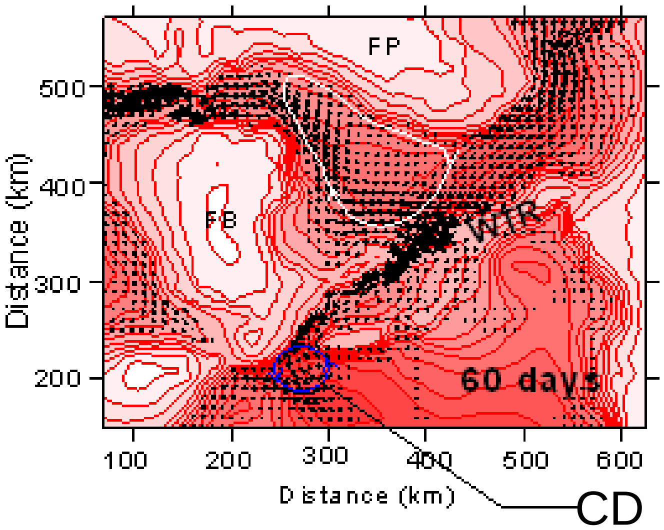
Froude number (Fr≥1) overlaid with vertical velocity and tracer concentration along the gally.

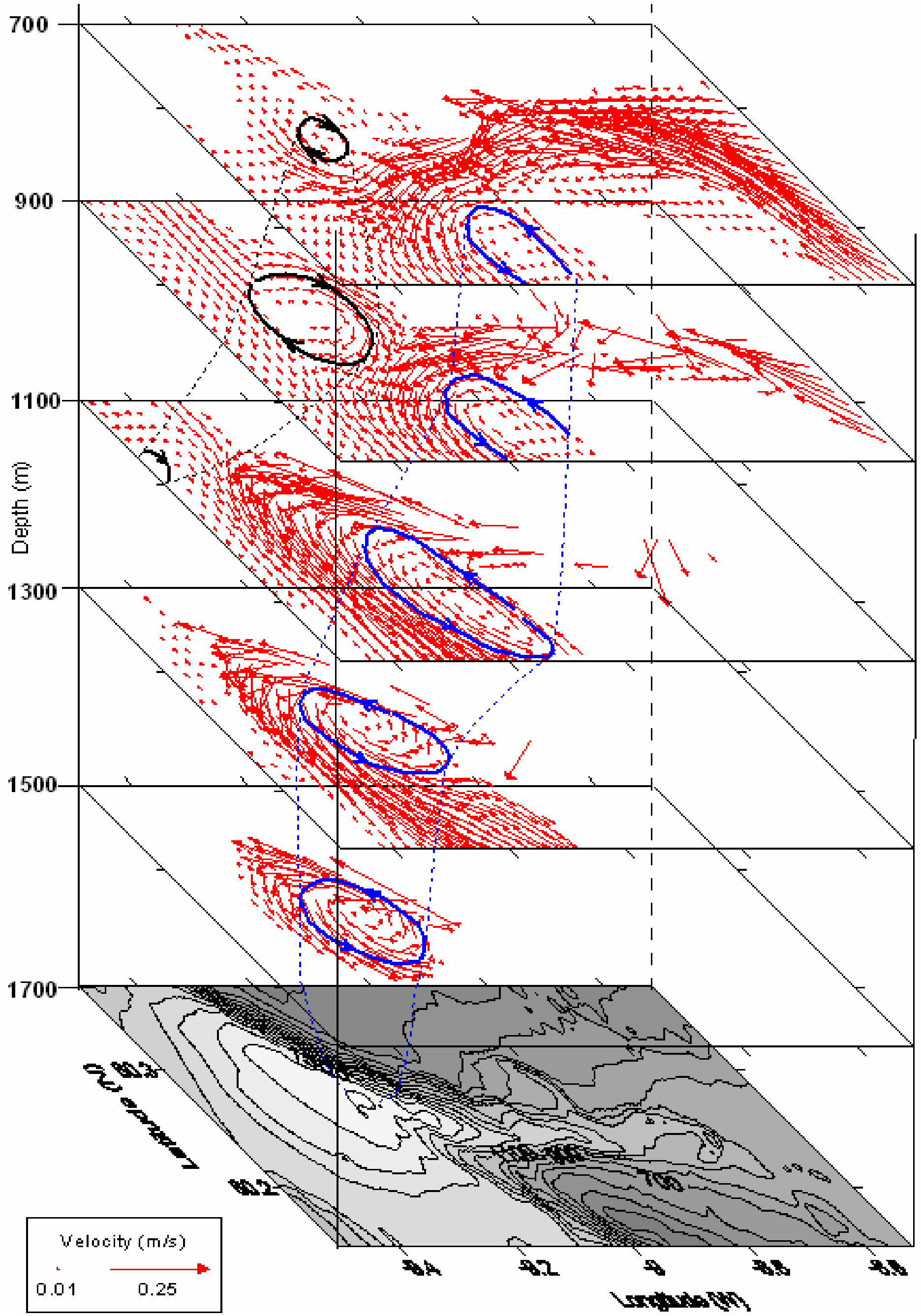


# The three-dimensional structure of the gravity current in the canyon.

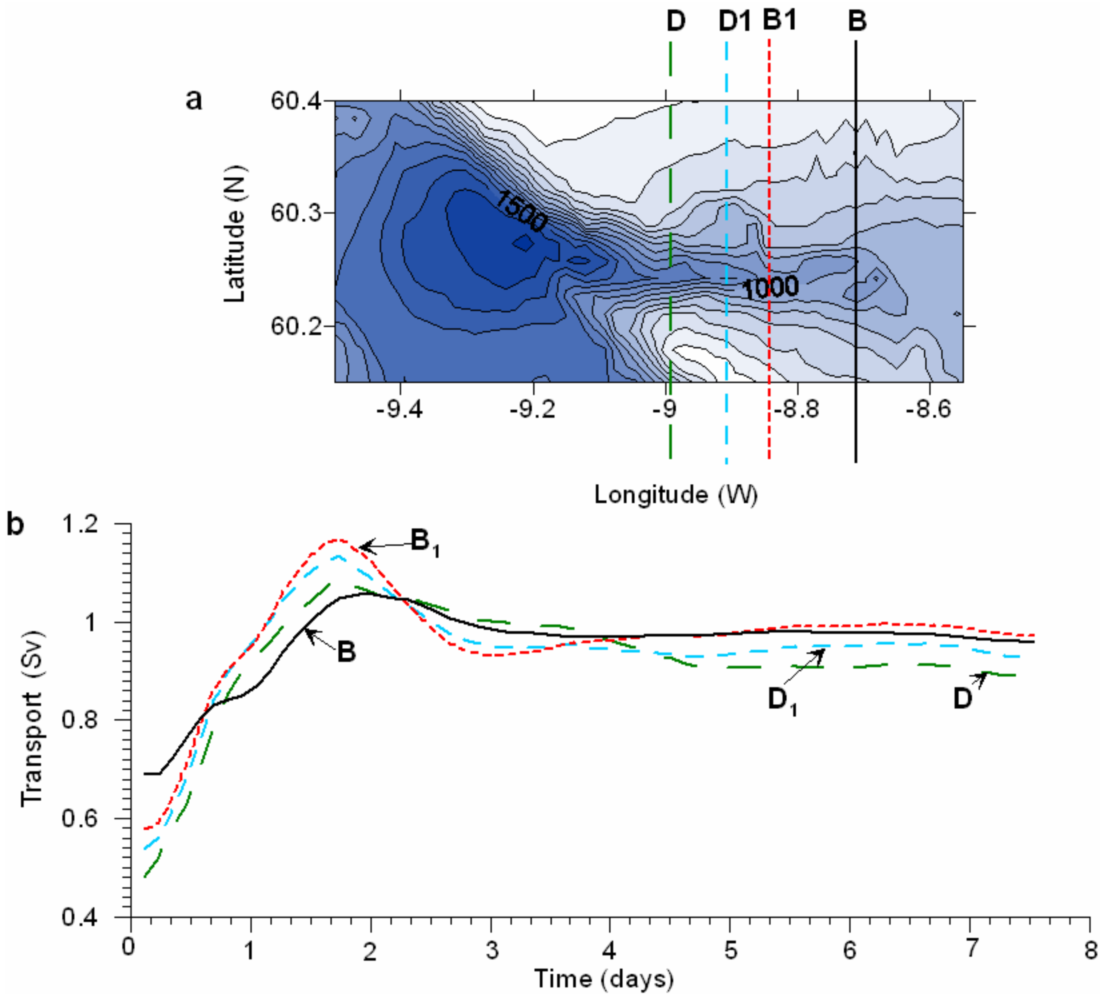


Flow along the Ellett Gully and and in the Cirolana Deep demonstrating the formation of anticyclonic (black) and cyclonic (blue) eddies.



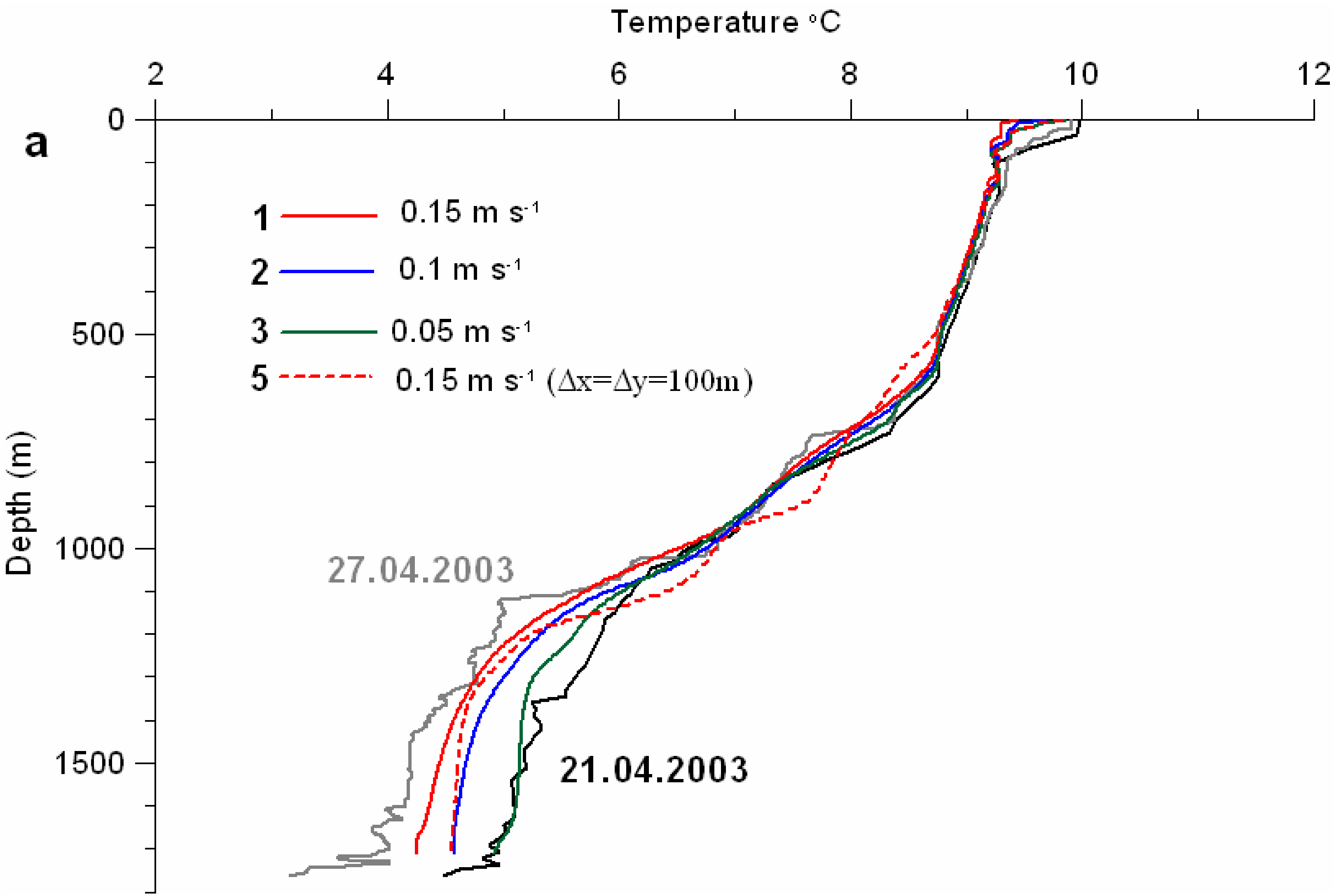



Predicted volume transports of the WTR overflow at sections B, B1, D and D1.

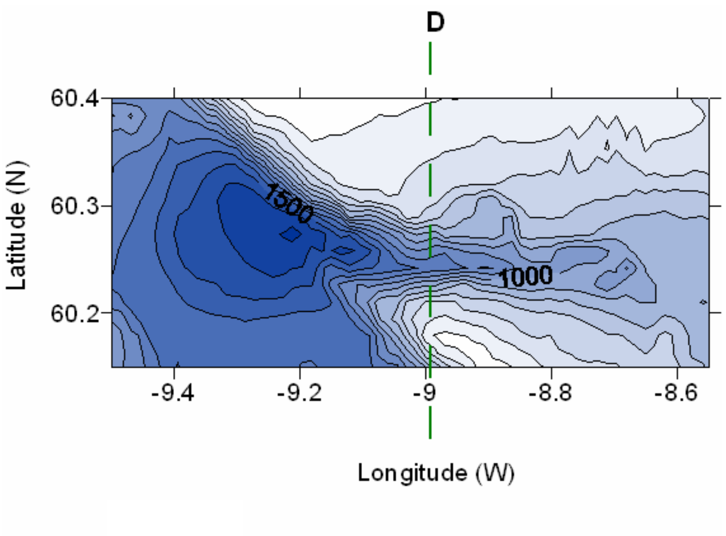


Vertical profile of the temperature at the deepest point of the Cirolana Deep .

Black and gray lines show the observed temperature distributions on 21 and 27 April, 2003, respectively. The color lines show the model predicted profiles, T(z).

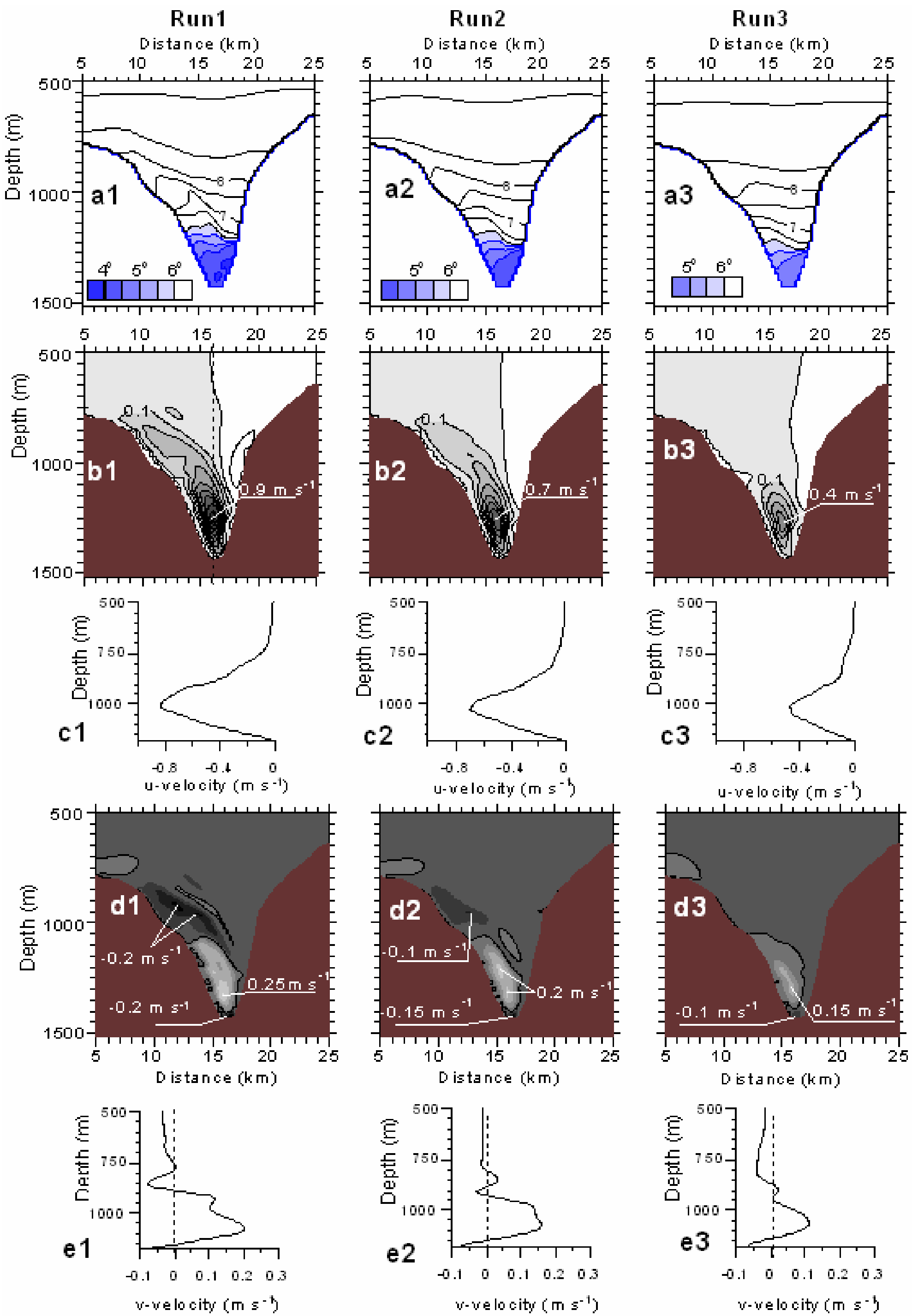


Cross-sections of temperature, along-channel, cross-channel velocities after 7.5 days of WTR overflow in section D.

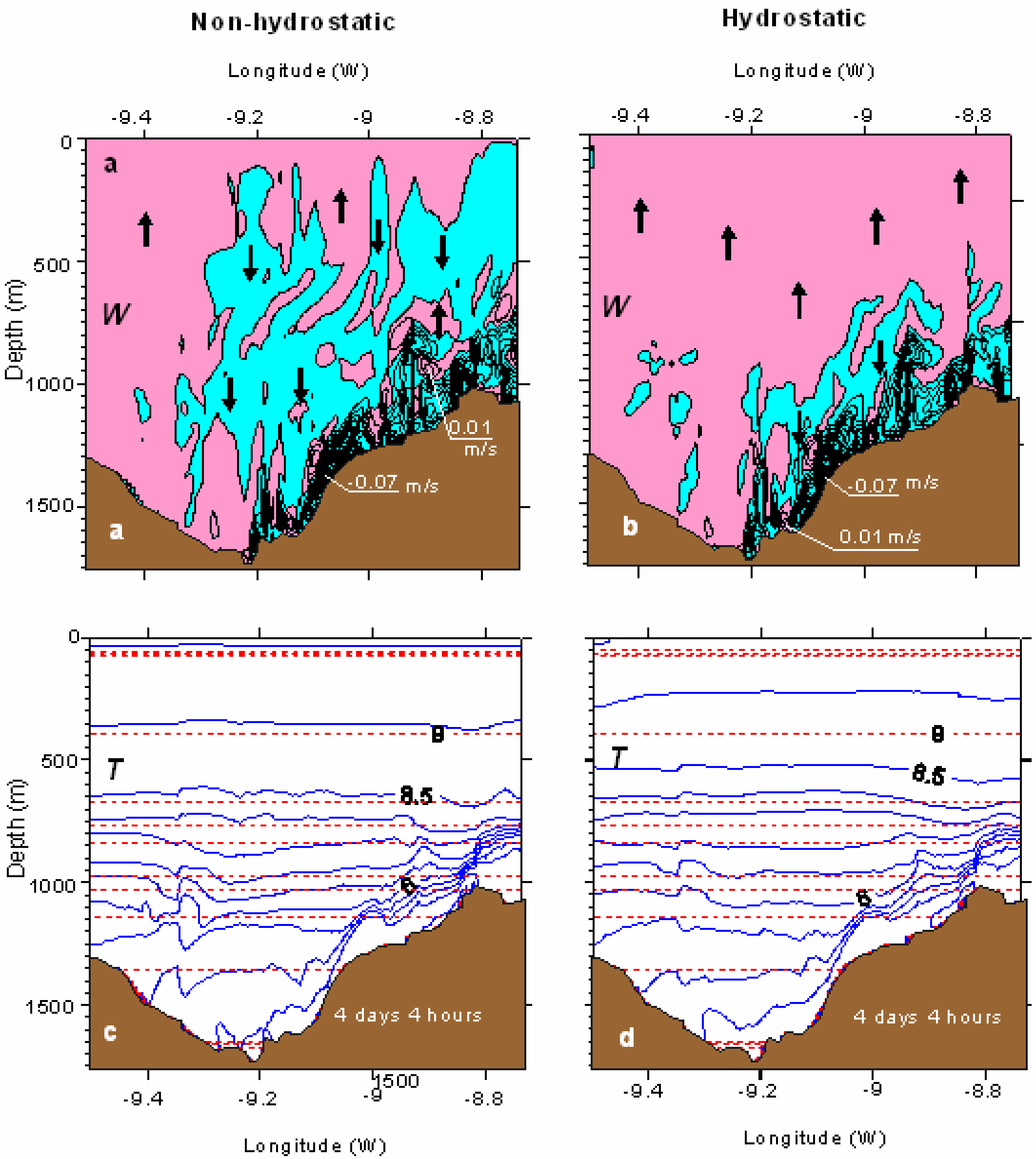



Velocity at eastern boundary in (m/s)

| run1 | run2 | run3 |
|---|---|---|
| 0.15 | 0.1 | 0.05 |



Cross –sections of vertical velocity and temperature along the gully for non-hydrostatic and hydrostatic cases.



# CONCLUSIONS

- **DETRAINMENT:** The density gradient between ambient and overflowing waters can be so small that it allows intruding water to uplift and detrain into the ambient waters.

- **HORIZONTAL STIRRING: HG** is initiated by the joint effect of the rotation and complex bottom topography. The main body of sinking water is steered anti-cyclonically along the contours of constant f/H within the Deep. However, any excess of incoming water from the gully forms a cyclonic eddy that stirs water in the opposite direction.

- **NONHYDROSTATIC EFFECTS:** In the non-hydrostatic case the vertical dynamics is characterized by two-way motions that produce mixing and result in a more realistic temperature distribution.