BOTTOM GRAVITY CURRENTS AND STRATIFIED EXCHANGE FLOWS IN A ROTATING CHANNEL

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Abstract Large-scale laboratory experiments on bottom gravity currents and stratified exchange flows have been conducted. Both rotating and non-rotating experiments were performed in a trapezoidal cross section channel by varying both the upper fresh water volume fluxes and the channel rotation rates. Detailed velocity fields were measured in different vertical planes spanning the width of the channel. Results highlight the role that both ambient rotation and net-barotropic forcing have on the geostrophic adjustment of the dense outflow. As the rotation rate increases, the tilt of the interface between lower salty and upper fresh water flow increases, generating a meandering pattern within the salty layer.

Keywords: : Geophysical Flows, Rotation, Stratified flow.

Methods

Bottom gravity currents and **stratified exchange flows** were reproduced in a trapezoidal cross section in the **CNRS Coriolis Rotating Platform** a 13 m in diameter and 1.2 m deep circular tank, whose rotation was varied with four angular velocities **Ω**.

A constant saline water discharge $\mathbf{Q_2}$ =4.4 l/s at density $\boldsymbol{\rho_2}$, was fed into basin B to establish a stable, bottom gravity current along the trapezoidal channel.

Two water pumps were employed to provide a constant fresh water flux $\mathbf{Q_1}$ at density $\boldsymbol{\rho_1}$, to generate a stratified exchange flow.

Two-dimensional **Particle Image Velocimetry** (PIV) was used to obtain high temporal and spatial resolution velocity fields across the channel (Figure 1).

The velocity fields were acquired in 11 vertical sections (XZ).

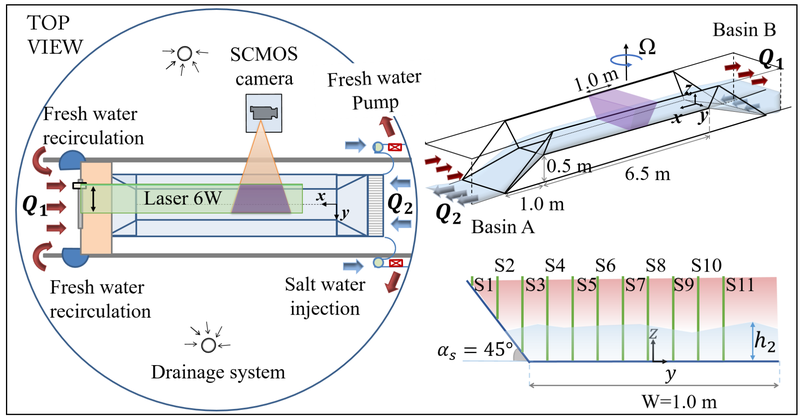

Figure 1: *Schematic representation of the experimental apparatus.*

Results

- For Ω=0, the increasing upper fresh water flow (i.e. q*) causes the **reduction** of the **lower layer thickness** (Figure 2a) defined as the zero-velocity interface.

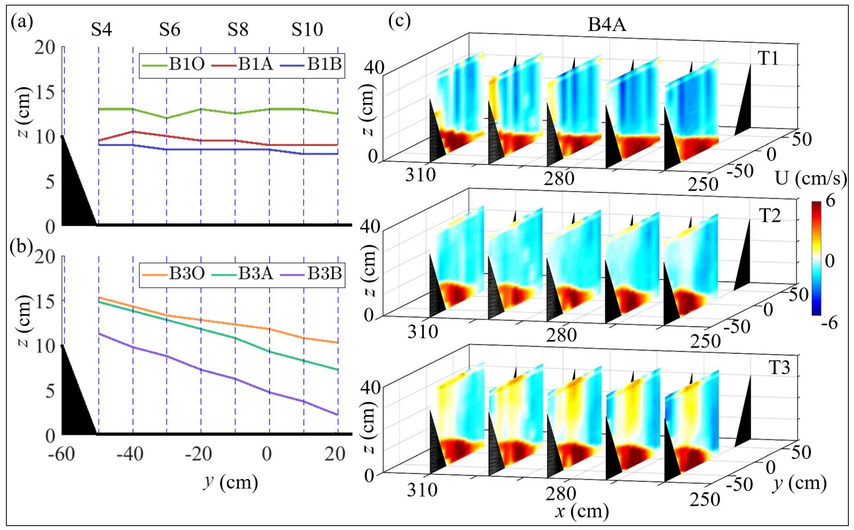

Figure 2: *Cross channel zero-velocity interface and colormaps of velocity fields*.

- When the angular rotation Ω plays a key role in the counter-flowing water masses (Fig.2b) **a tilt in the interface** is observed and is coupled with the effect of the increasing q*, causing a **significant deflection** of the saline outflow. When **Bu<0.5**, time and space variability in the velocity fields suggest the generation of a **baroclinic instability** within the dense lower layer.

Table 1: *Experimental parameters*

	f= 2Ω (rad/s)	$q^*=Q_1 / Q_2$ (O, A, B)			Bu
B1	0	0	1.8	4.5	-
B2	0.06	0	1.8	4.5	1.30 - 1.40
B3	0.1	0	1.8	4.5	0.76 - 0.79
B4	0.2	0	1.8	4.5	0.30 - 0.43

$$\mathbf{Bu}=\frac{\sqrt{g' h_2}}{f\,W}$$

$$g' = g \cdot \frac{\rho_2 - \rho_1}{\rho_1}$$

Conclusions

In conclusion, the rotation causes the deflection of the current to the right hand side of the trapezoidal channel and the exchange flows are geostrophically adjusted to the channel rotation. In the rotating stratified exchange flows, the coupled effect of an increase of both rotation and upper fresh water flow enhances the tilt of the interface up to generate a meandering pattern in the trapezoidal channel and baroclinic instability when Bu<0.5.

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