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Frictionally Driven Convection

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A series of Spin-up experiments were carried out in the 13 m diameter Coriolis rotating tank in Grenoble, France, to investigate stress induced entrainment in a stratified fluid. A global flow rotation is produced by an initial change in the tank rotation speed. The velocity is measured in a vertical plane by Particle Imaging Velocimetry (PIV) simultaneously by two cameras (Stereoscopic PIV), giving the three components.

Key words: Entrainement; Mixed Layer; Forced Convection; Stratified Fluid; Shear flow Turbulence; Spin-Up

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1. Introduction

Context; MLD; Forced convection;

Introduire notion de mélange; Stirring VS mixing; Entrainment

Ocean captation Carbon/Chaleur

Application de l'entrainement Turbulent au ecoulement Geophysiques : Turner 1986

1.1. *Description of previous model*

Commencer avec model Theorique :
- Pollard 1973 (Theorie MLD)
- Philips 1971 (Théorie entrainement)

puis avec les experiences:

focus sur Kato Philips (KP) (experience historique) (essayer de trouver si les parametrisation issue du model KP sont encore utilisé)
Kantha Phillips Azard (KP-A) 1976
Wyatt 1977 : Mechanisme d'entrainement (selon exp de KP-A)
Price 1978
Deardoff and Willis 1980
Ellison et Turner 1959
Turner 1968
Narimousa et al, 1985
Moor et Long 1971

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Si on utilise des models Num :
Lignères, Califano et Mangeney 1997 **Parler des simulation LES**
Wang 2003
Shonker, Reeuwijk,Sulivan et Patton 2013

2. Experimental Apparatus

Experiments were carried out in a 13 m diameter rotating platform which can be filled with water to a depth H of up to 1 m. These experiment consist to produce an Azimuthal flow in the platform frame (referential frame) by an impulsive change in its rotation speed. Such procedure are refereed as Spin-up when the rotation speed increases and Spin Down when it reduces.

2.1. *Stereoscopic Particle Image Velocimetry and Images Processing*

Two PCO cameras (2048×2048 pixels, B&W, 16bit) are positioned on both sides of the vertical laser sheet so as to observe the same plane from two different perspectives.

Simultaneous images of Neutral buoyant particles were illuminated by a laser sheet in a vertical plane are captured in short burst of 3 images at 100Hz, fives times at each second.

2.2. *Thermal Acquisition*

Acquisition des sondes:
Filtrage des données,
Interpolation des données de température sur une grille (Temps, Vretical)

3. Parameter of control

3.1. *Vertical stratification*

A stable stratification in temperature is created by a progressive filling carried out by the bottom with the help of filling nozzle located at the bottom of the platform as shown fig. The injected water is a composition of water heated preliminary in tanks annexed to the platform (until a temperature 40°C) and fresh water resulting from the network of the laboratory (approximately 17°C). Filling starts with 100% of heated water and ends with 100% of fresh water.

As the air temperature in the laboratory is 25°C, heat loss and convective mixing are inevitable in the upper layers. On the other hand, the filling must not be too rapid to avoid turbulent mixing. A compromise was therefore found for a filling time of 4 h for a height of 50 cm ($66 m^3$).

The temperature profiles obtained, shown as an example in figure ...present a linear gradient over the first 25-30 cm and then a homogeneous layer above. The interest of this study is to investigate the erosion of the stratification by a background friction and therefore this homogeneous layer does not impact significantly on our results.

3.2. *dimensionless Parameter*

Ekman:

$$Ek = \frac{\nu}{2\Omega H^2} \tag{3.1}$$

Rossby:

$$Ro = \frac{U}{fR} \tag{3.2}$$

u_*
$\Delta\Omega$
Re
f
N
Ro
Fr

Table 1: External parameters for the Main experiment

Froud:

$$Ro = \frac{U}{fR} \tag{3.3}$$

Ekman spin-down time scale:

$$\tau_{Ek} = \frac{H}{\sqrt{\nu\Omega}} \tag{3.4}$$

Tables des parametre
u*, f, N, Ro, (Q), Fr

4. Characterisation of stress forcing

4.1. *Evaluation of the friction Velocity*

4.1.1. *Turbulent momentum fluxes*

Cf papier Smith et al, 2021 (https://doi.org/10.1017/jfm.2021.736)

$$u'w'$$

4.1.2. *Decay of friction law*

Cf Papier Sous et al, 2013

$$U(t) = f(u_*, t)$$

4.2. *Turbulent diffusion*

Obtenire la diffusion turbulente à partir de la concentration de colorant

$$w'C' \approx w'T'$$

4.3. *Self-similar solution*

Es-ce que toutes les quantités sont auto-similaire dans la couche de mélage ?

4.4. *Estimation of lateral boundaries effects*

Estimation des effets de bords (Cf papiers de Jan-Bert)

5. Mixed Layer Evolution

5.1. *Deepening Rate*

Retrouve-t-on les lois données par pollard/ KP

5.2. *Interface Layer*

Y-a-t-il une relation entre la taille de la couche de mélange et la couche d'interface d'entrainement.

Transition vers la partie entrainement

6. Structure and Dynamics of the Entrainement

6.1. *Qualitatives description*

6.2. *Developement of the entrainement Layer*

- Observe t-on différent régimes (couche de Boldvald/ Karman)
- Il y a t-il un blocage qui apparait par l'effet de la rotation

6.3. *Low Ri Number*

on se situe a des nombres de richardson tres faible, car des stratifications assez faibles. - es-ce la cas dans les régions de forte convection (mer d'Irminger, etc) , (justification de l'interêt d'une telle stratification/ Faire un lien avec les valeures en convection oceanique (valeur de vents, rotation (ou pas) et stratification)

- qu'es ce que cela implique pour nos résultat : (approche du régime de scalaire passife)

6.4. *Structure de l'entrainement*

-Peut on identifier/Quantifier des structures coherentes d'entrainement
si oui, peut on relier des longueur /temps caracteristiques avec les parametre de l'experience.

7. Energetics of Forced convection

7.1. *Estimation des flux radiaux*

Reprendre les Résultat de Lorenzo p16 -18 de son rapport

7.2. *Internal wave Generation*

- Quelle est la part d'energie dissipé/transporté par ondes internes Source Linden 1973

8. Discussion

-Quelle est la pertinence d'un model 1D pour ce problems : (Divergence avec model Gotm)

9. Conclusion

10. Citations and references

Supplementary data. Supplementary material and movies are available at
https://doi.org/10.1017/jfm.2019...

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Appendix A.