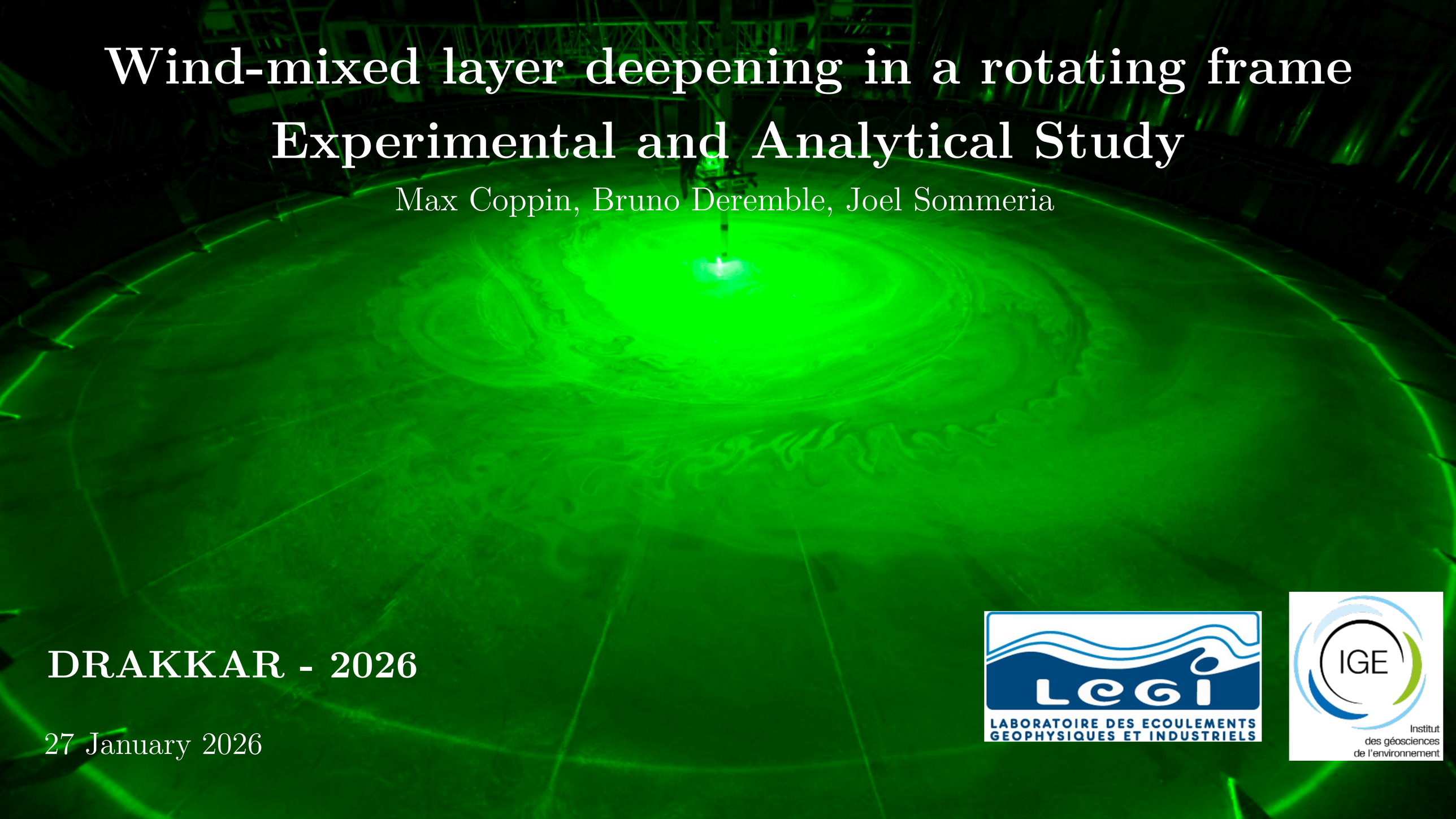
Wind-mixed layer deepening in a rotating frame
Experimental and Analytical Study

Max Coppin, Bruno Deremble, Joel Sommeria



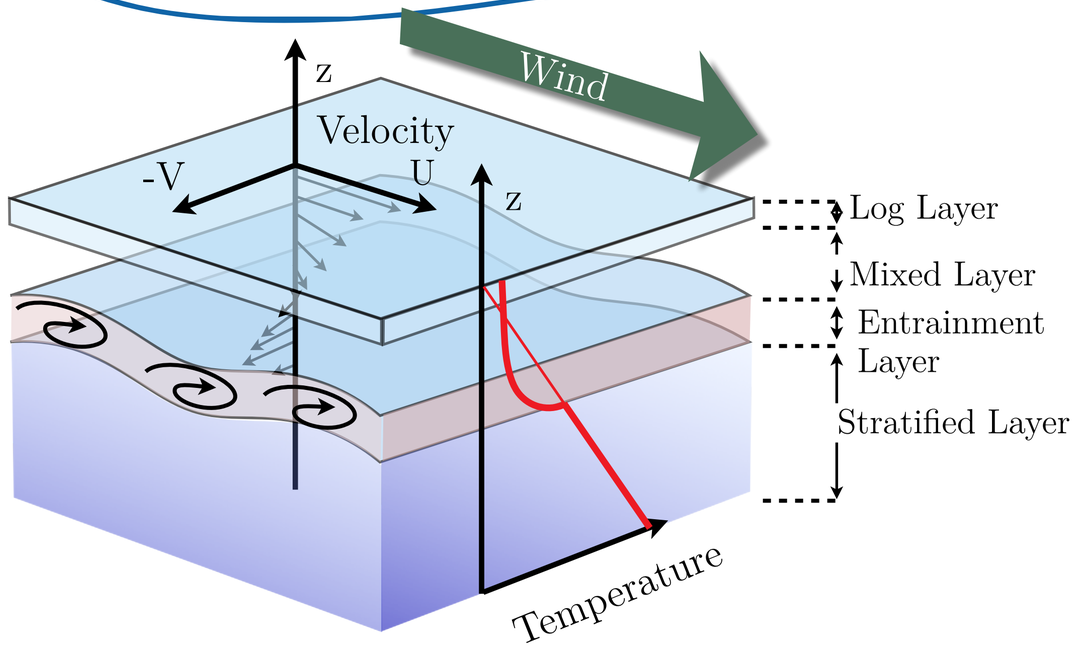
DRAKKAR - 2026

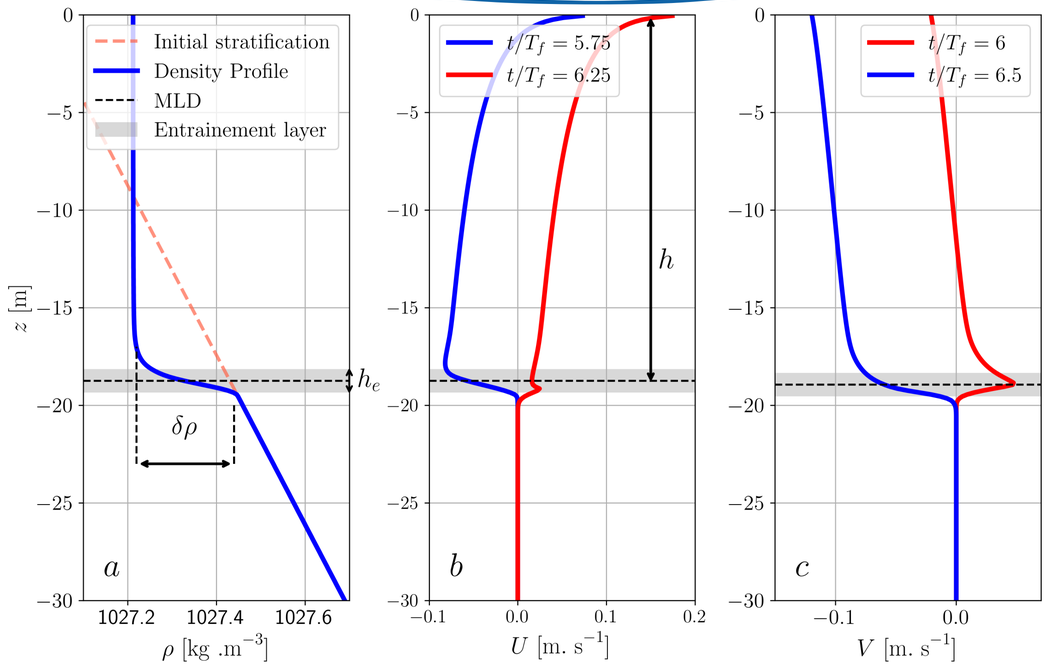
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Wind-Mixed Layer deepening





Motivation Accurate representation of MLD in Climate Model

Ocean heat uptake *(Senapati et al. 2024)*

Carbon cycle *(Gardner et al. 1999)*

Significant uncertainties in climate predictions and ocean circulation

(Sallée et et al. 2021, Treguier et al, 2023)

In rotating frame

Inertial oscillations triggered

Velocity profile → Ekman Spiral

Different deepening rate

Wind-driven Oceanic Convection: Scaling law

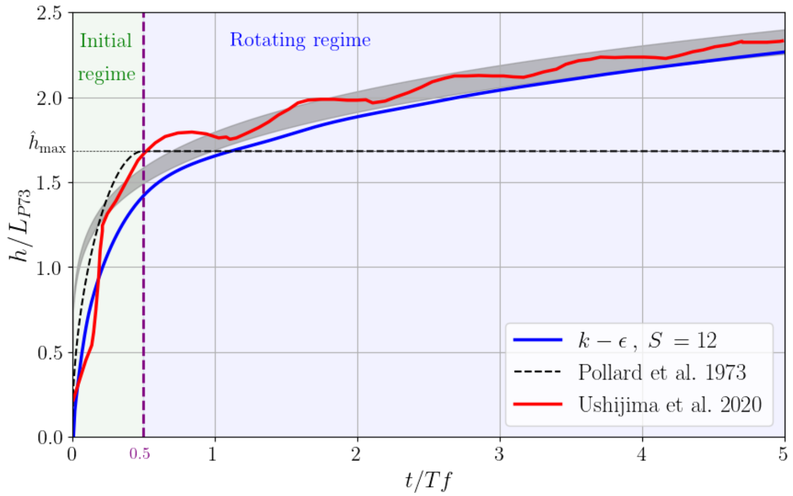
Pollard et al, 1973

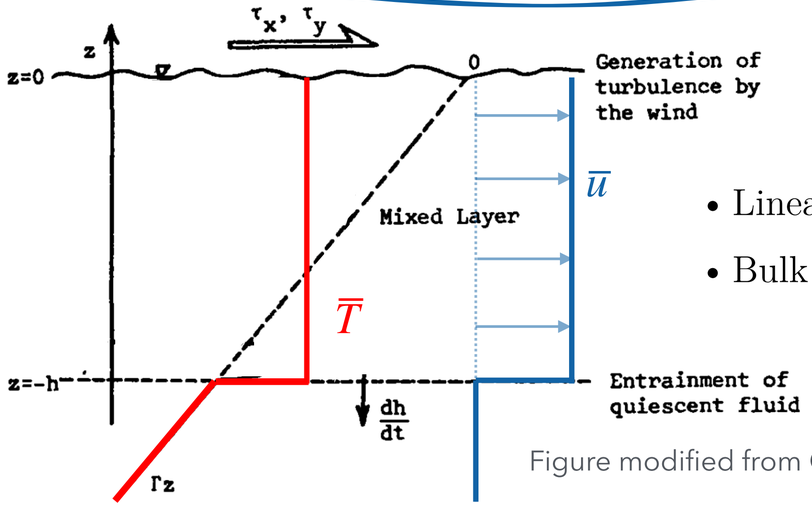
- Momentum of mixed Layer increase : $uh \propto u_*^2 t$
- Marginal stability state $\Rightarrow$ $Ri = \dfrac{h^2 N_0^2}{u^2} = Ri_c$

$$h_{(t)} \sim 2^{1/4} u_* \sqrt{\frac{t}{N_0}}$$

- Considering f $\Rightarrow$

$$h_{(t)} = \frac{u_*}{\sqrt{N_0 f}} \left[4(1-\cos(ft)\right]^{1/4}$$





- Linear stratification
- Bulk consideration

Figure modified from Cushman-Roisin, 1981

Long term deepening with rotation*

- Separation inertial oscillation / Ekman-type velocity
- Marginal stability within the *entrainement layer*

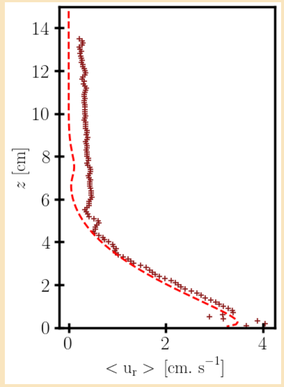
$\Rightarrow$ **Deepening rate in rotation** $h \propto \sqrt{\dfrac{u_*}{Nf}} (tf)^{1/4}$

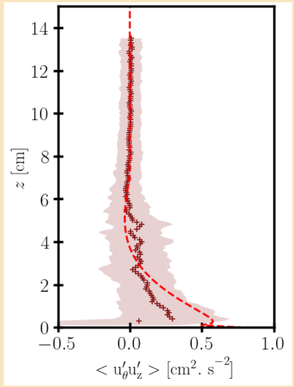
*Coppin, M., B. Deremble, and J. Sommeria (2025). "Wind-Mixed Layer Deepening in a Rotating Frame". *Geophys. Astro. Fluid.*

Experimental Ocean Mixed layer on Coriolis Plateform

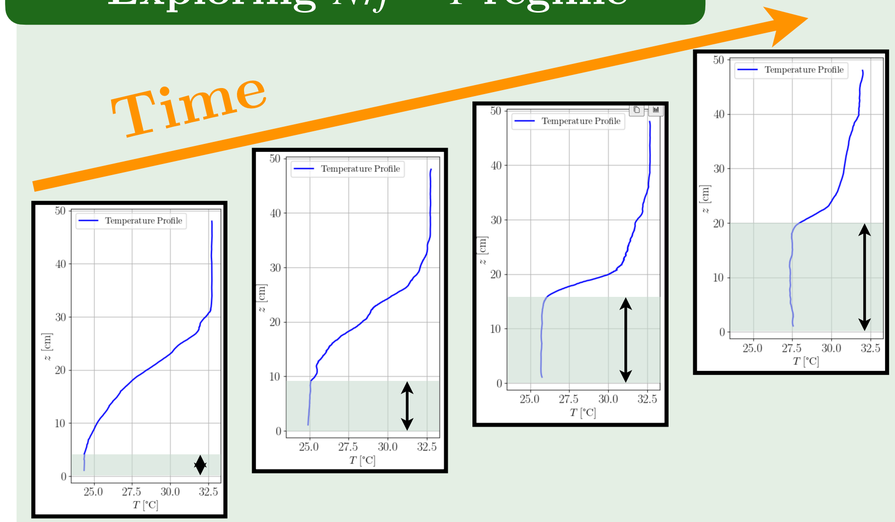
$k-\varepsilon$ closure in rotation

Shear stress effects are well modelled by k-epsilon model adapted to stratification (*Canuto et al. (2001), Burchard and Bolding (2001)*).





Exploring $N/f \sim 1$ regime

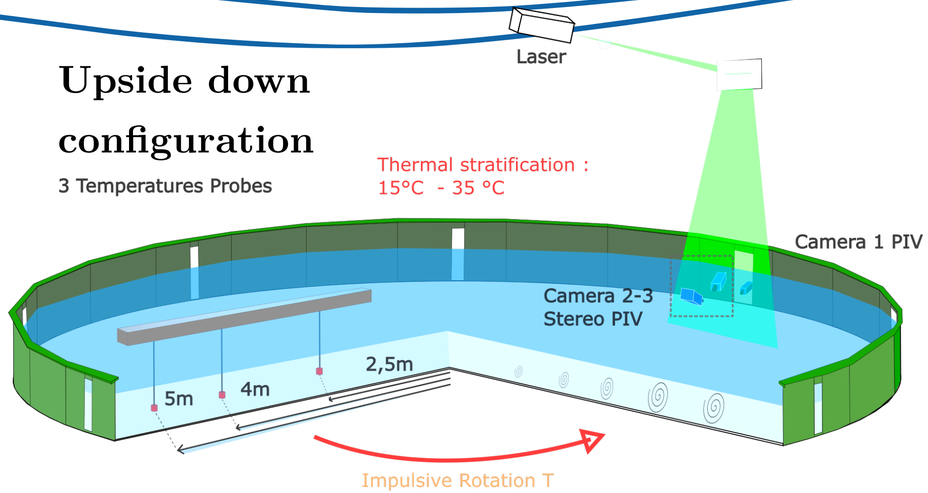


- Erosion of the stratification by turbulence
- Saturation by the rotation (Ekman-depth)

Upside down configuration

3 Temperatures Probes

Thermal stratification : 15°C - 35 °C



Shear generation by impulsive rotation:

- S-PIV (3 components)
- Thermal stratification
- Experiment with background rotation

