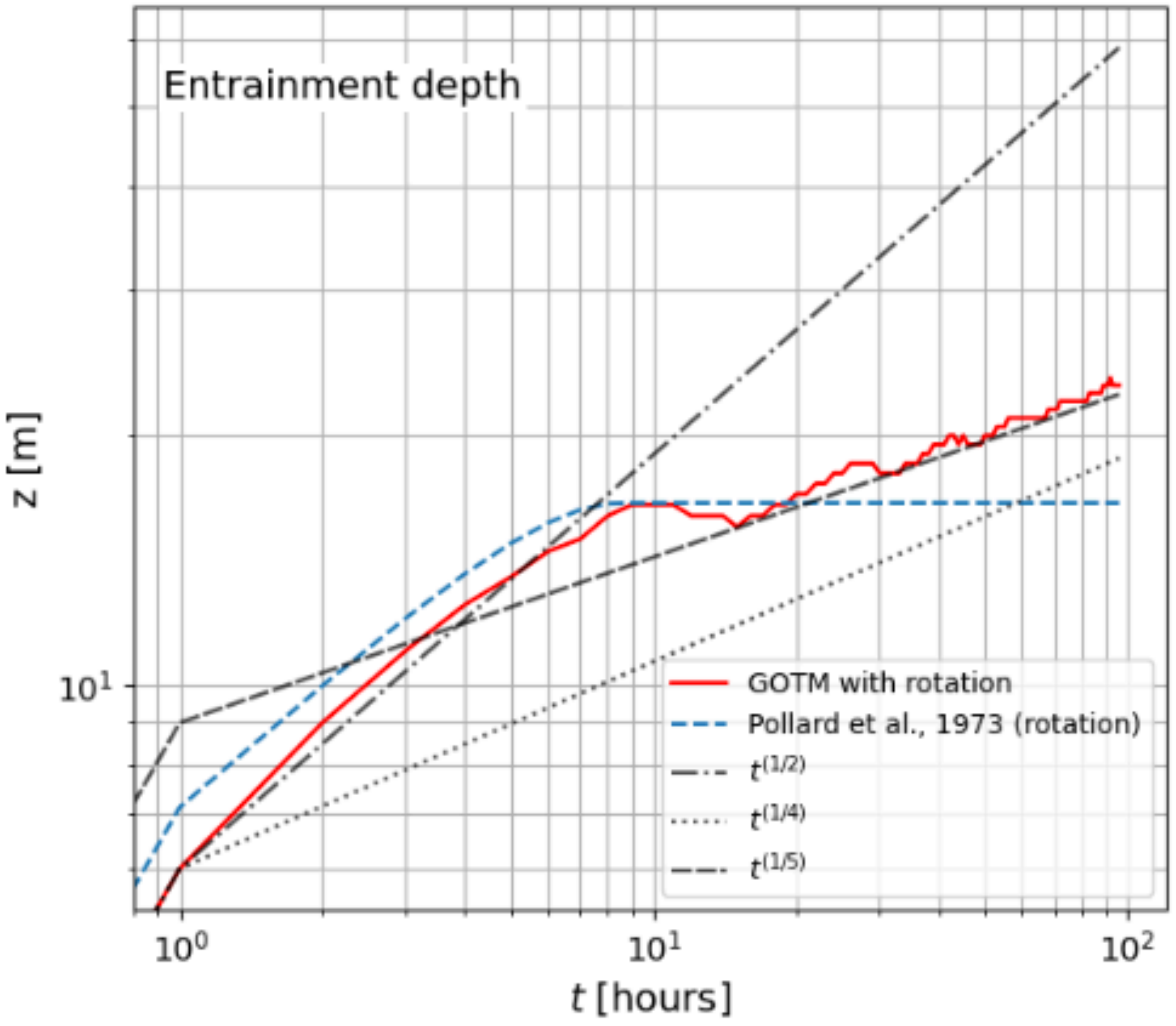
Scaling - Mixed layer depth forced by wind shear stress in rotation

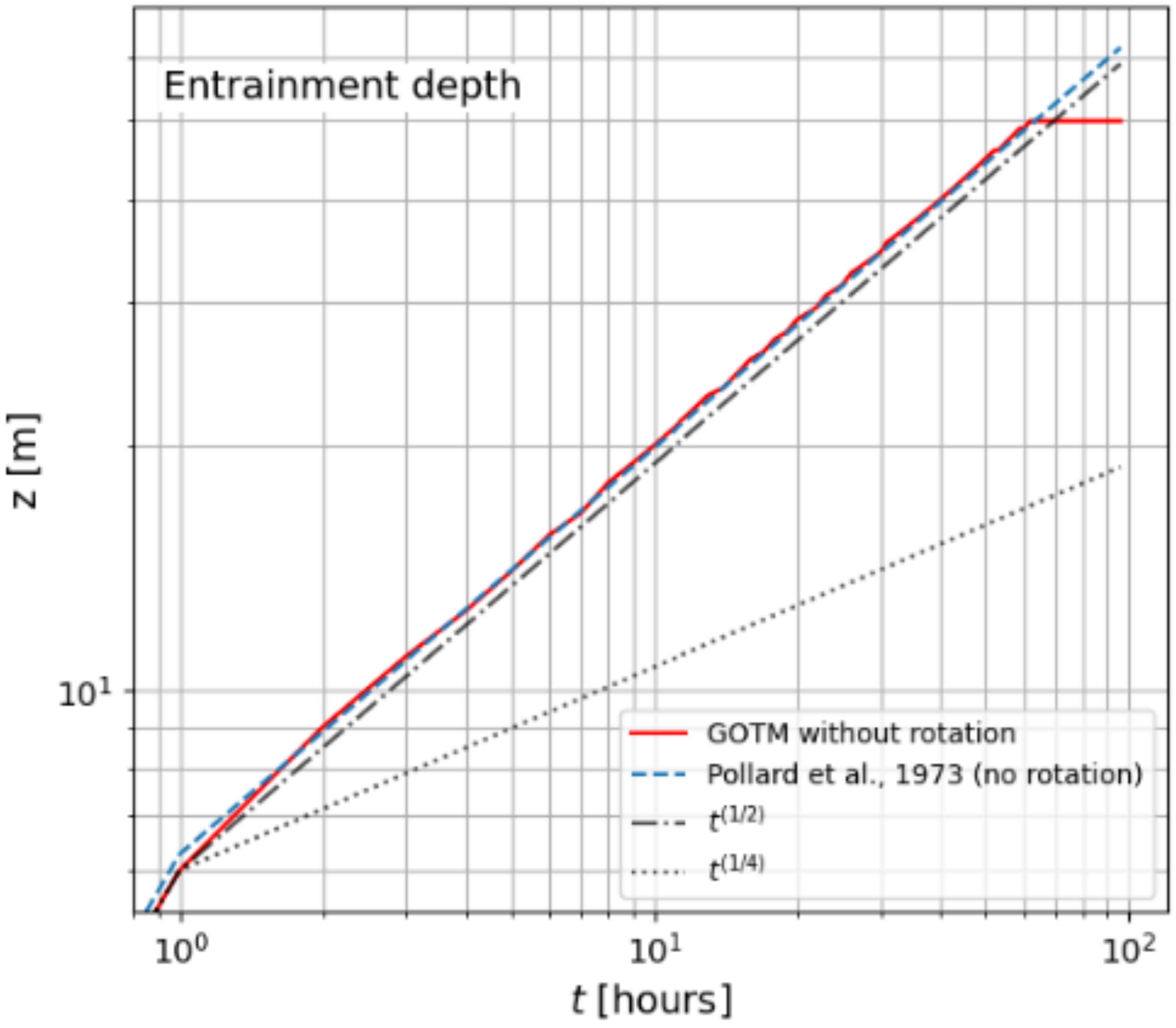
Reunion LEGI - 5/12/2023

Context

Il existe une loi d’échelle qui prédit l’approfondissement sans rotation (Pollard)

Avec rotation: La loi d’échelle prévoit une épaisseur constante au de la période inertiel





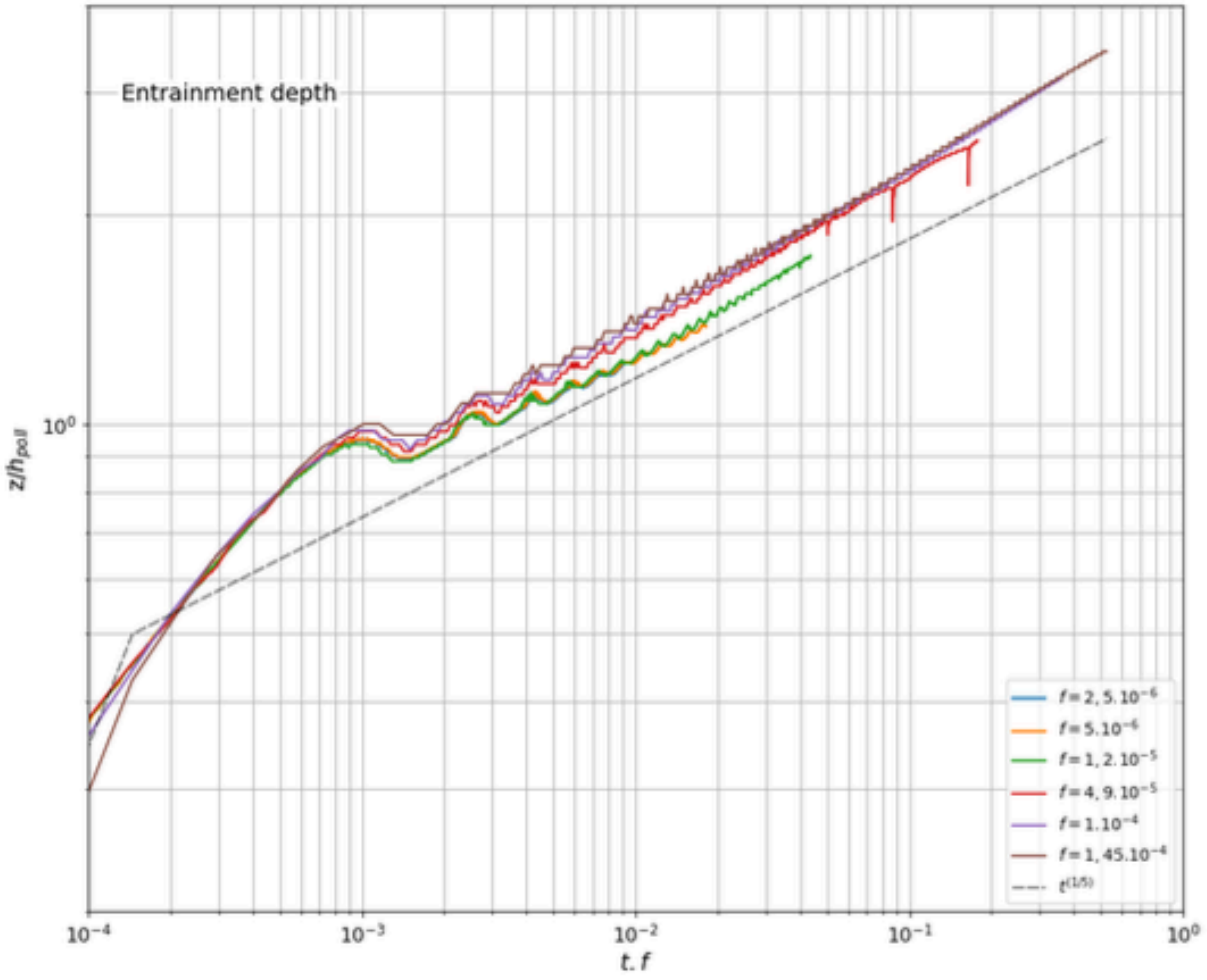
Loi d’échelle au-delà de période inertielle :

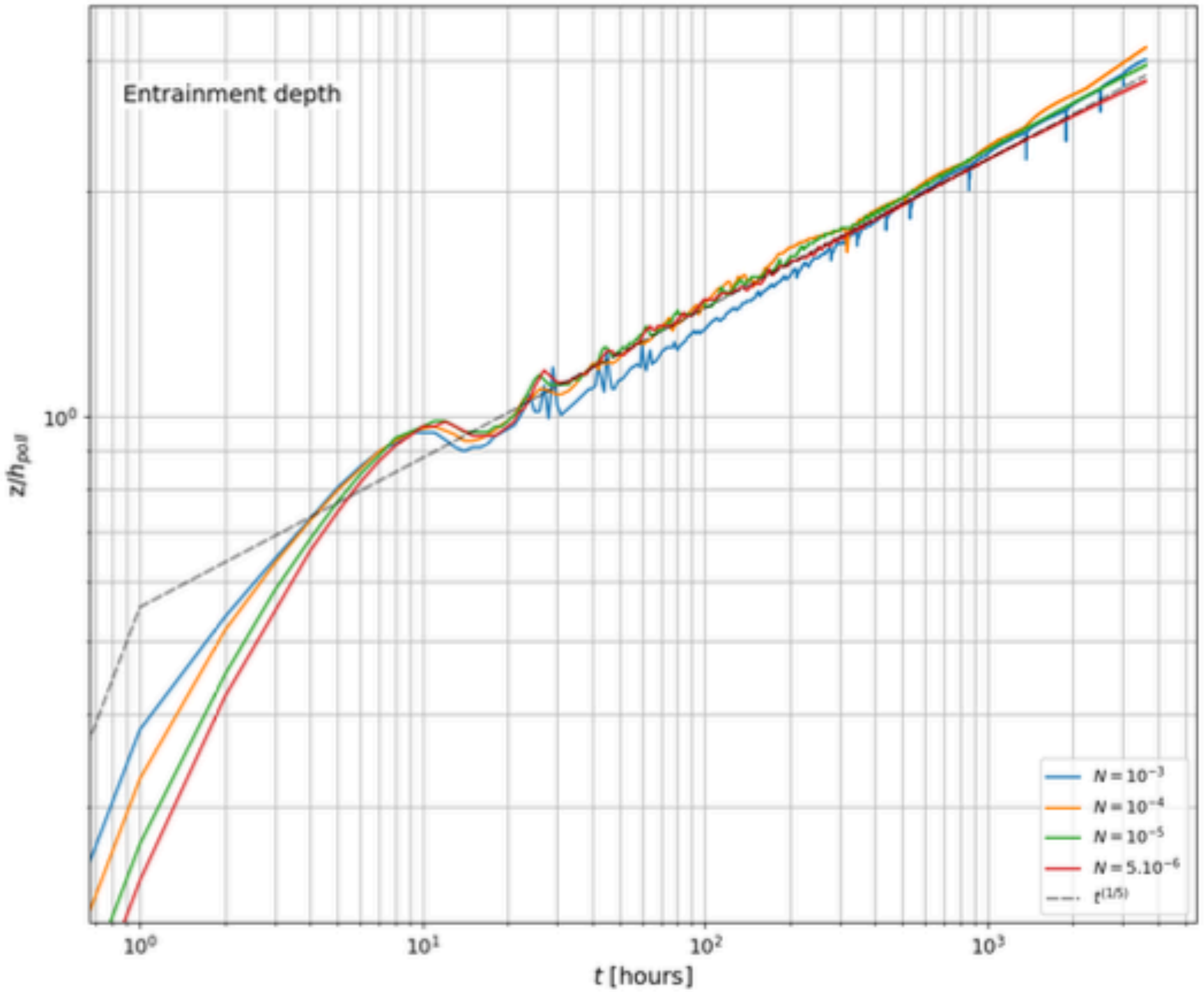
- Pollard [1972] $$h(t) = h_{max} = 1.7 \left(\frac{u_*}{\sqrt{Nf}} \right) \qquad \text{Pour } t > \pi f$$

- Ushijima et al [2020] $$h = 1.5 L_{p73} \left(\frac{f}{N} \right)^{-2.2\times10^{-2}} \left(\frac{t}{T_f} \right)^{0.18}$$

Cette étude -> LES => n’avance pas d’argument physique

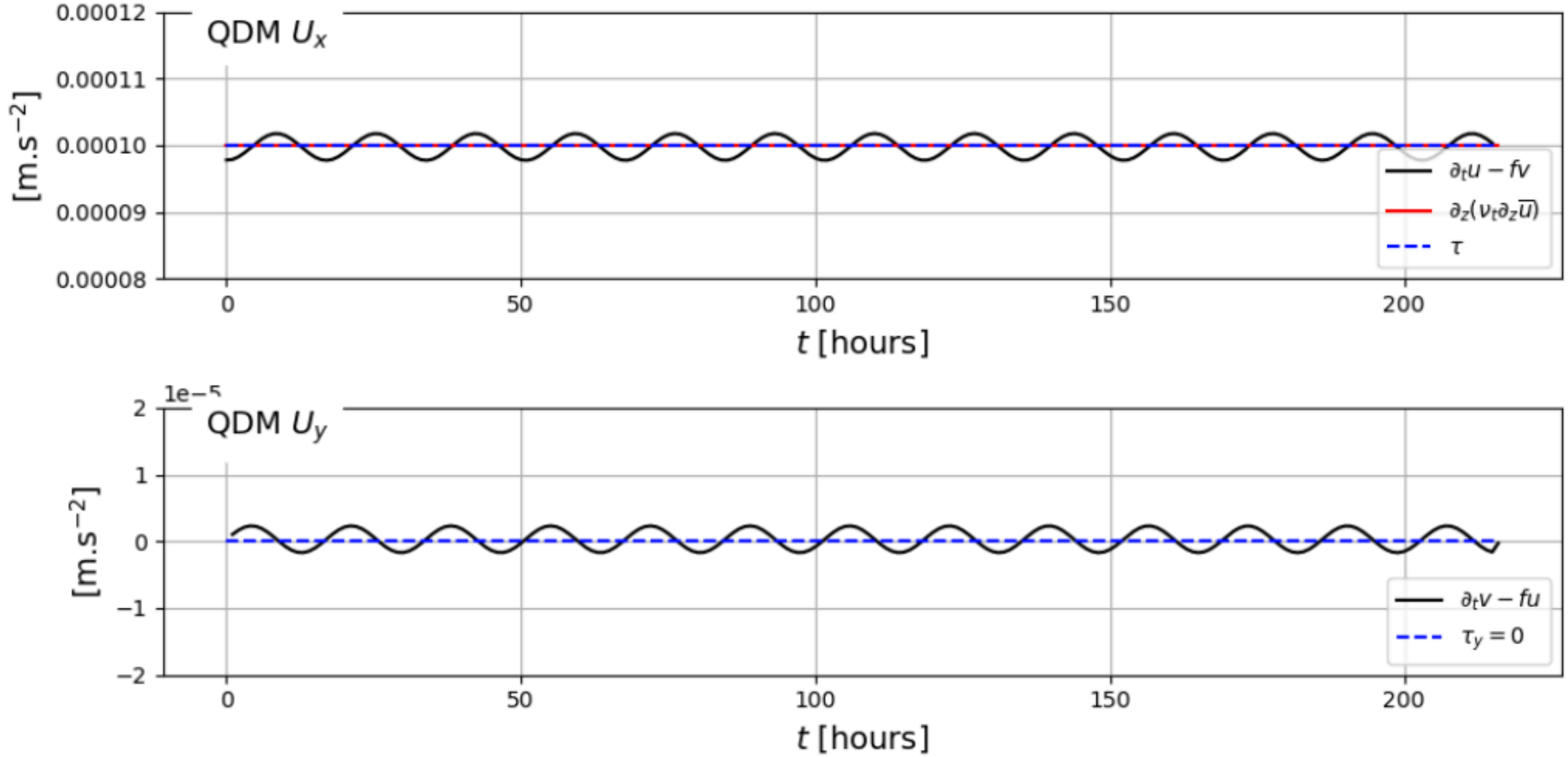
On cherche une loi en t^1/5





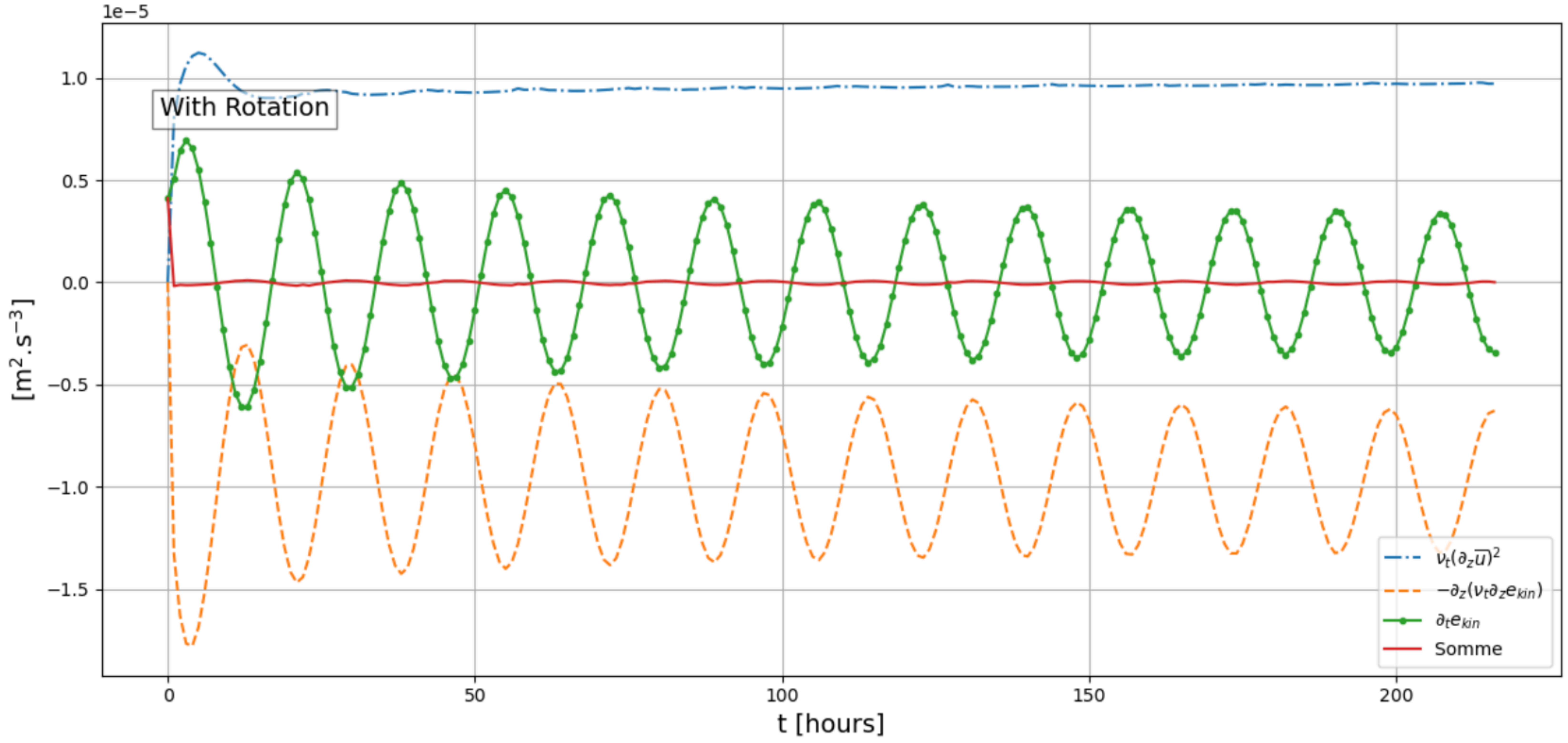
Bilan de QDM

$$\begin{cases} \dfrac{\partial \overline{u}}{\partial t} - f\overline{v} = \dfrac{\partial}{\partial z}\left(\nu_t \dfrac{\partial \overline{u}}{\partial z}\right) \\ \dfrac{\partial \overline{v}}{\partial t} + f\overline{u} = \dfrac{\partial}{\partial z}\left(\nu_t \dfrac{\partial \overline{v}}{\partial z}\right) \end{cases}$$



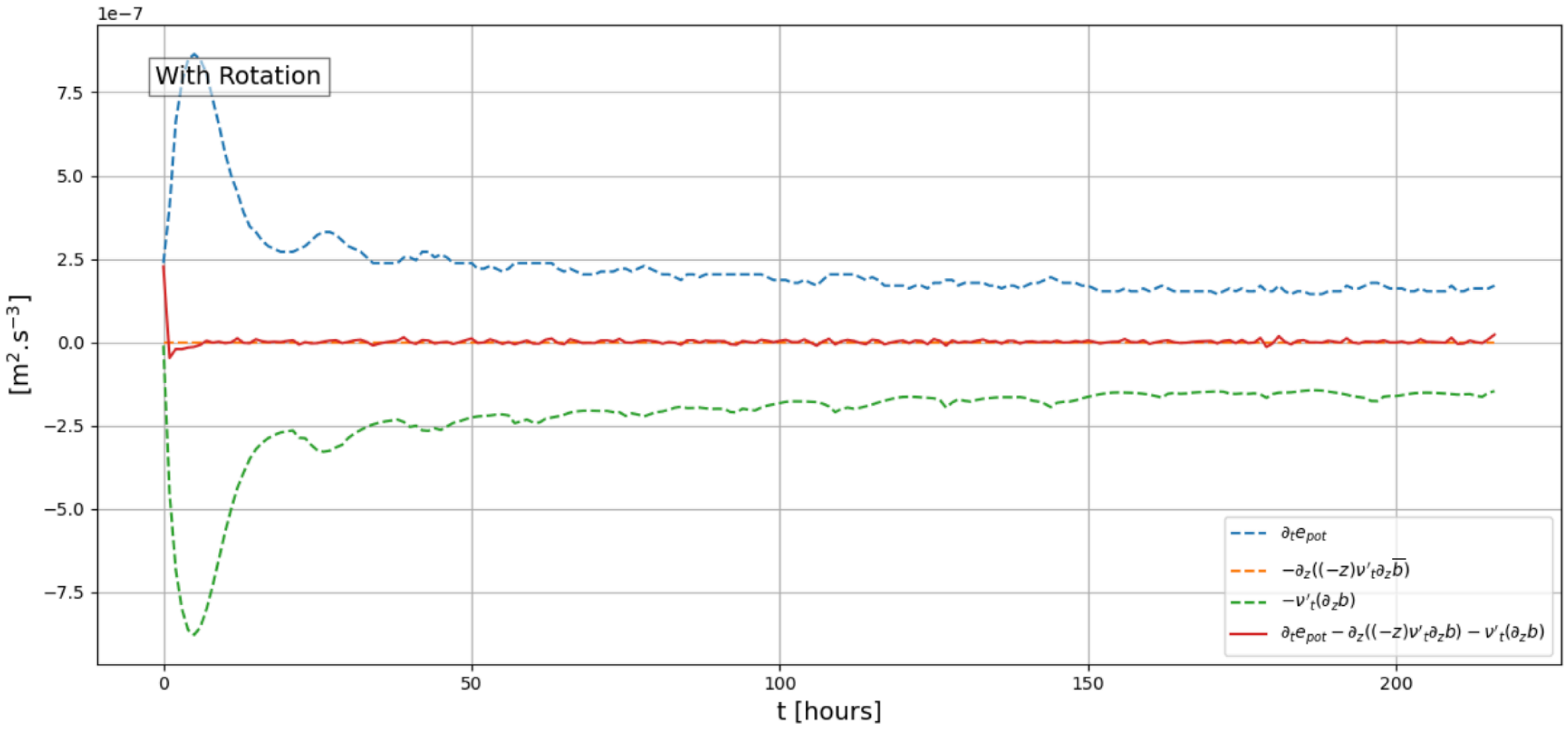
Bilan d’énergie cinétique

$$\begin{cases} \frac{\partial}{\partial t}(\frac{1}{2}u^2) - fuv - \frac{\partial}{\partial z}\left(\nu_t u \frac{\partial u}{\partial z}\right) = \nu_t(\frac{\partial u}{\partial z})^2 \\ \frac{\partial}{\partial t}(\frac{1}{2}v^2) + fuv - \frac{\partial}{\partial z}\left(\nu_t v \frac{\partial v}{\partial z}\right) = \nu_t(\frac{\partial v}{\partial z})^2 \end{cases} \Rightarrow \boxed{\frac{\partial}{\partial t}(E_{kin}) - \langle \mathbf{U_{surf}}.\tau \rangle = -P}$$



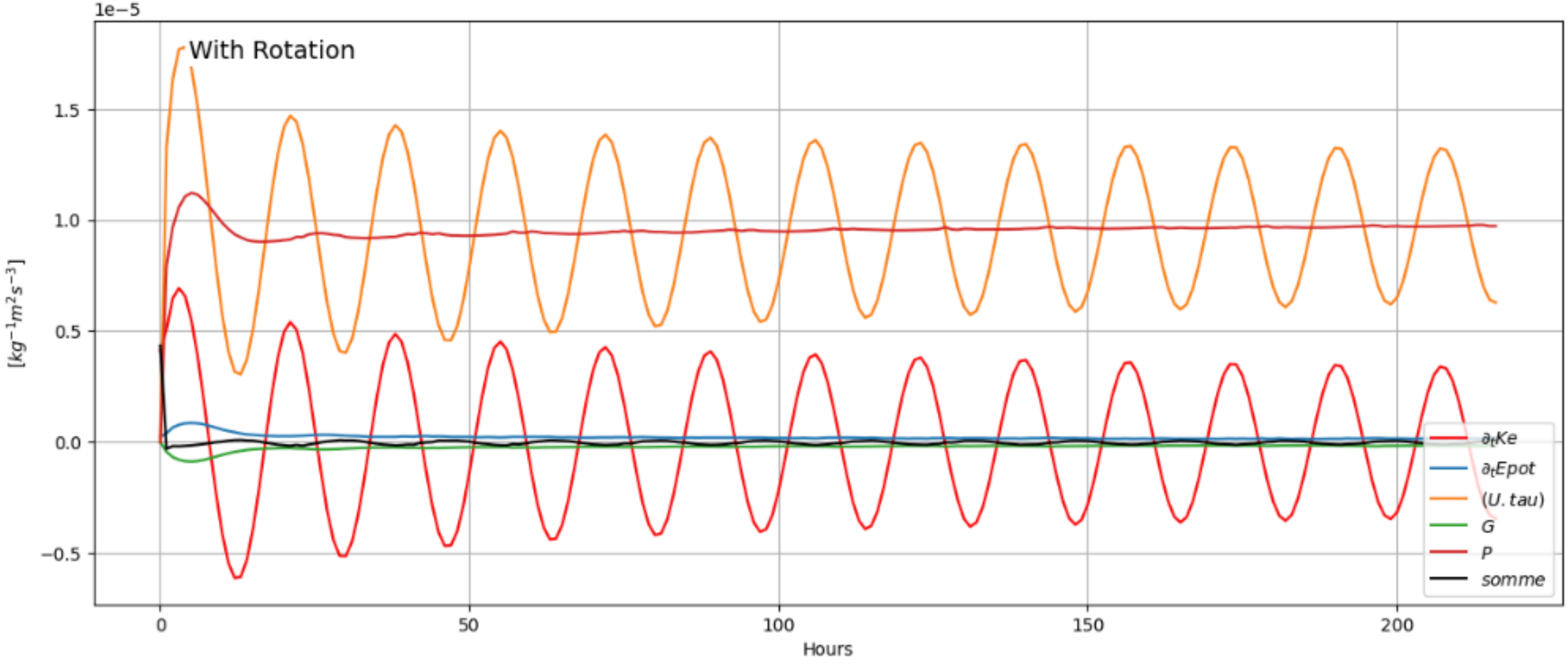
Bilan d'énergie Potentiel

$$\frac{\partial E_{pot}}{\partial t} - \int_{-H}^{0} d\left((-z)\nu_t' \frac{\partial b}{\partial z}\right) = \int_{-H}^{0} \nu_t' \frac{\partial b}{\partial z} dz = -B \quad \Rightarrow \quad \boxed{\frac{\partial}{\partial t}(E_{pot}) = -B}$$



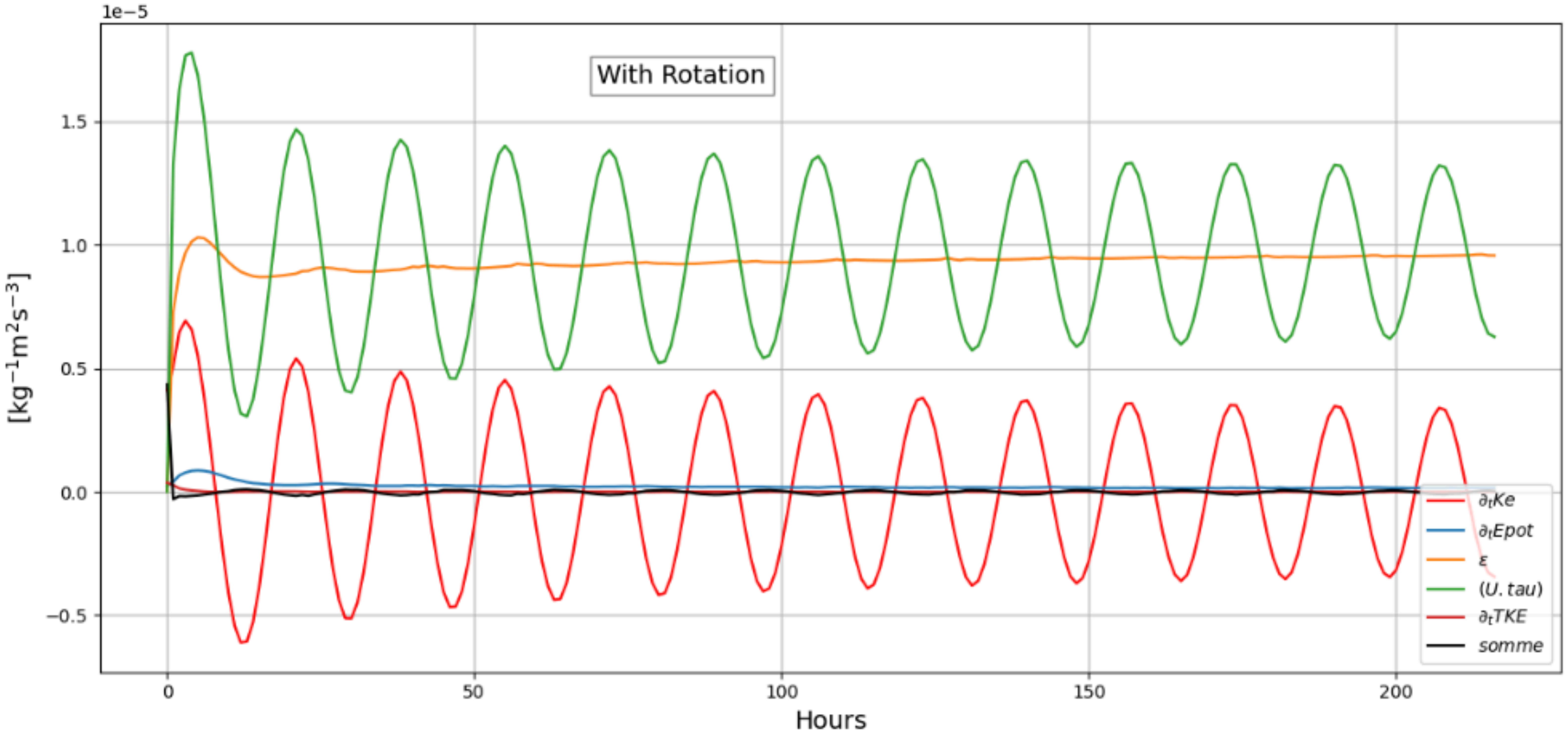
Bilan TKE

$$\frac{\partial}{\partial t}(TKE) = P + B - \int_{-H}^{0} \epsilon dz$$



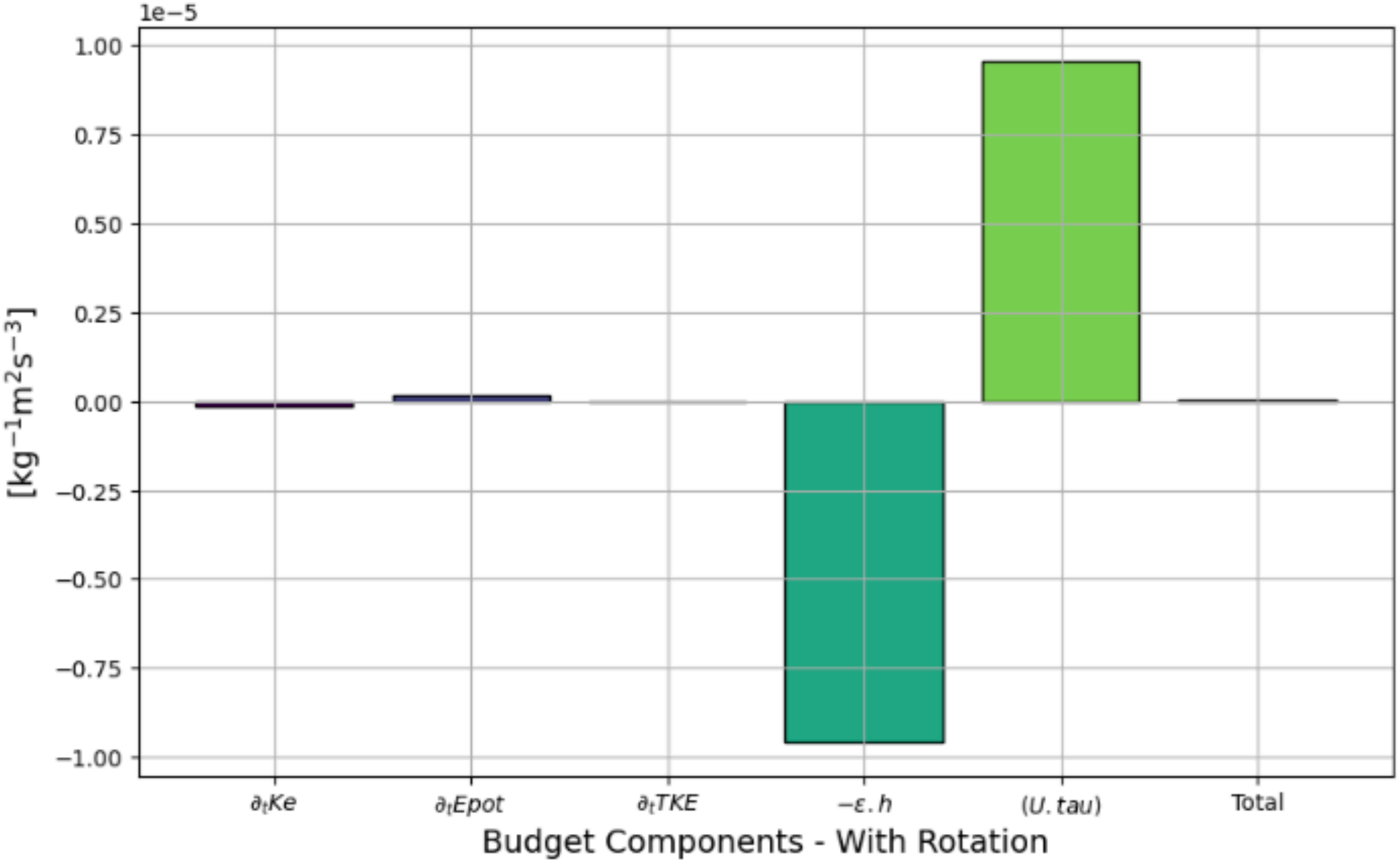
Bilan d’énergie

$$\boxed{\frac{\partial}{\partial t}(E_{kin}) + \frac{\partial}{\partial t}(E_{pot}) + \frac{\partial}{\partial t}(TKE) = +\langle \mathbf{U_{surf}}.\tau \rangle - \int_{-H}^{0} \epsilon dz}$$



Bilan d'énergie

$$\boxed{\frac{\partial}{\partial t}(E_{kin}) + \frac{\partial}{\partial t}(E_{pot}) + \frac{\partial}{\partial t}(TKE) = +\langle \mathbf{U_{surf}}.\tau \rangle - \int_{-H}^{0} \epsilon dz}$$



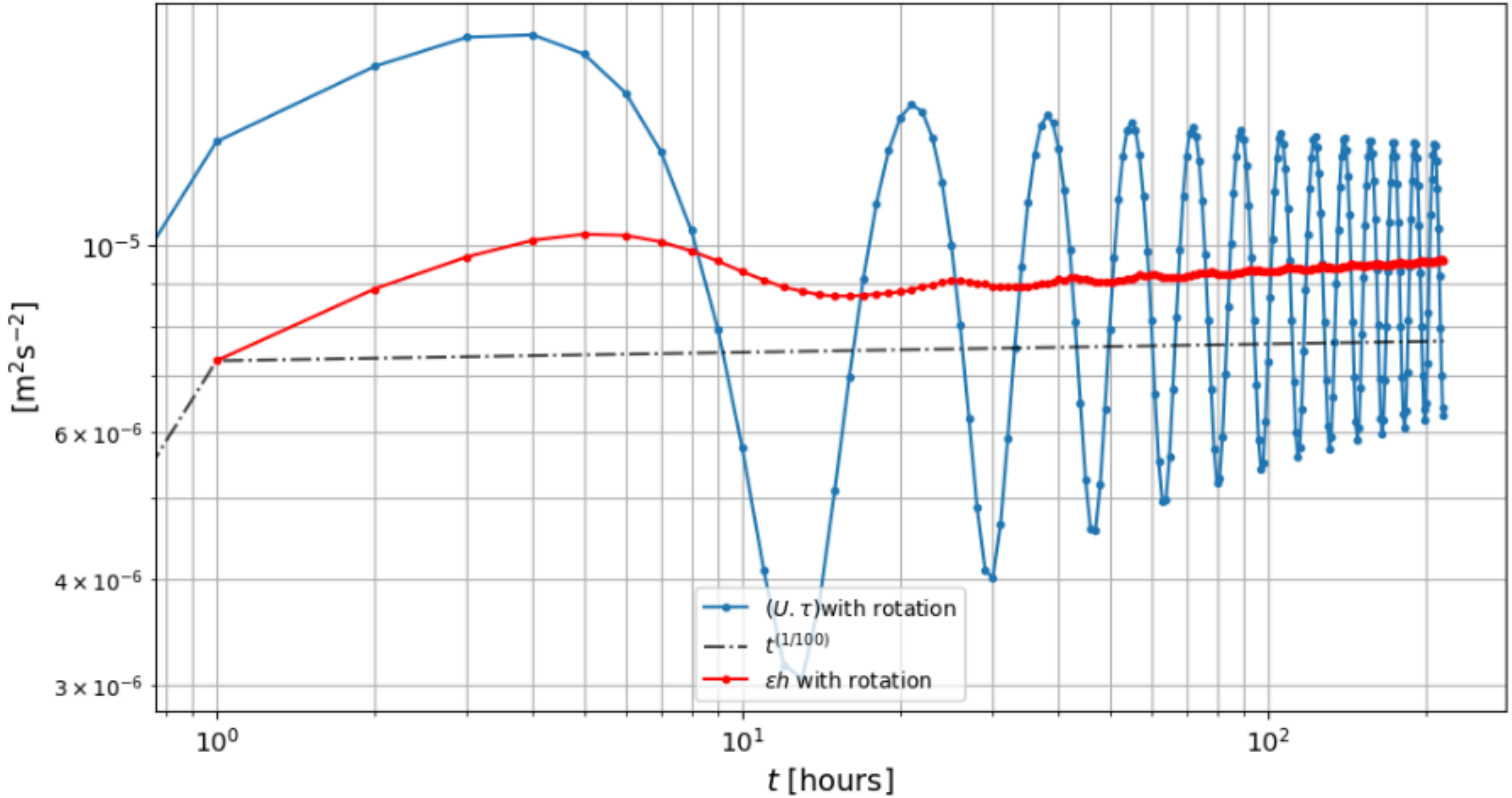
3 hypothese

$$\textbf{Hypothèse 1 :} \; \langle U.u_*^2 \rangle \propto \epsilon h = c$$

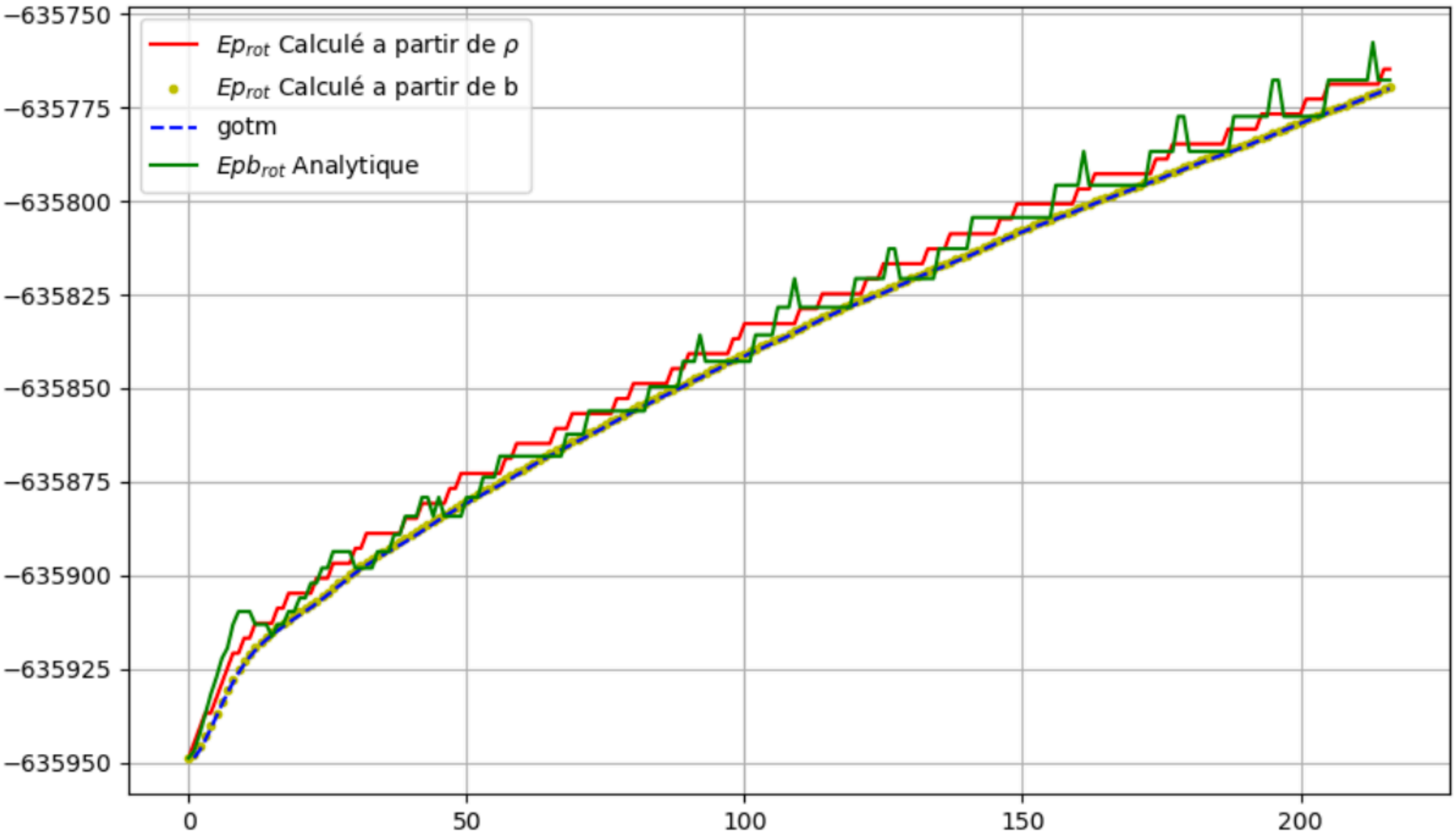
$$\textbf{Hypothèse 2 :} \; Ep_b \propto h^3 N^2$$

$$\textbf{Hypothèse 3 :} \; \frac{dEpb}{dt} = \Gamma \epsilon_{interface} h$$

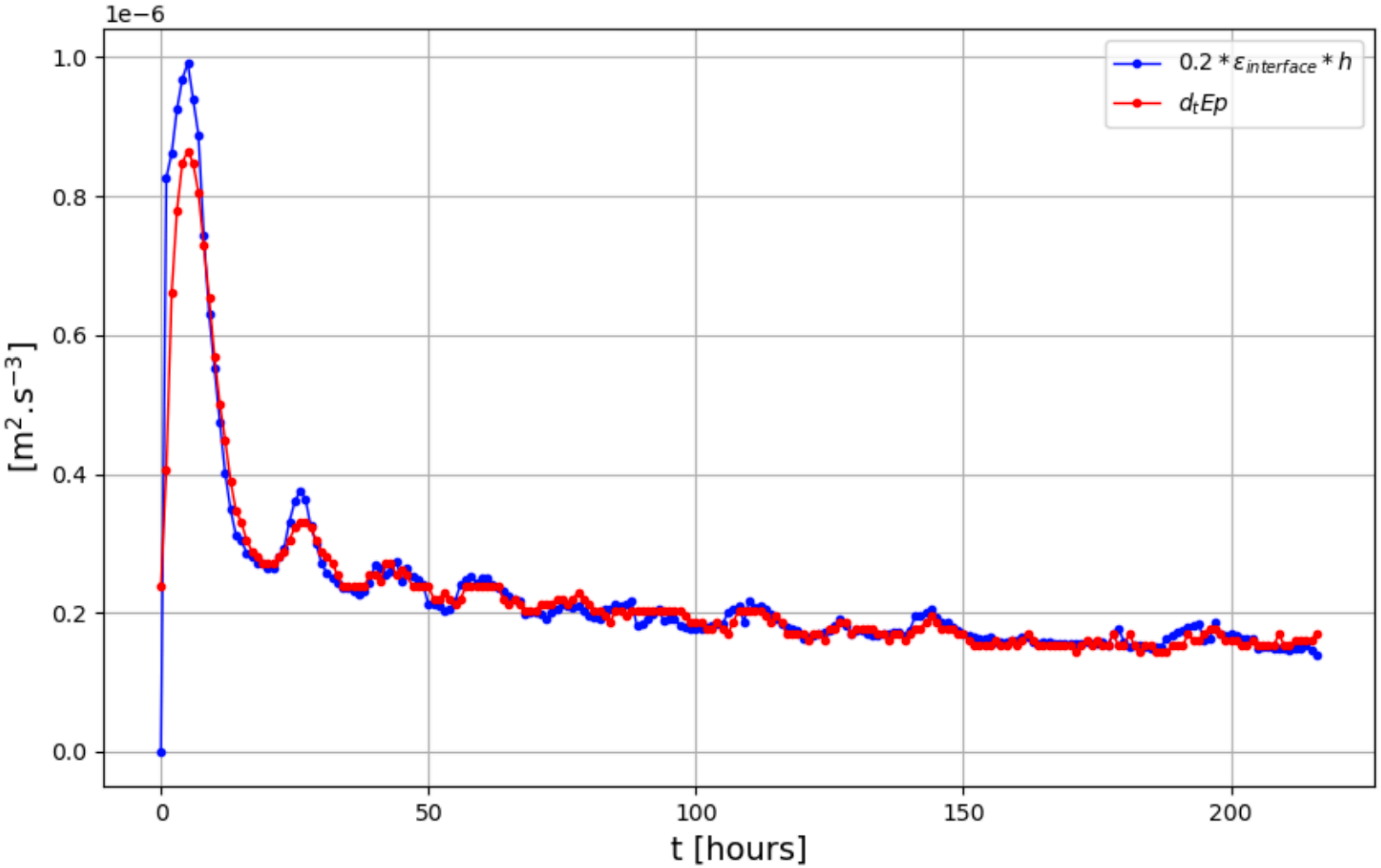
Hypothèse 1 : $\langle U.u_*^2 \rangle \propto \epsilon h = c$



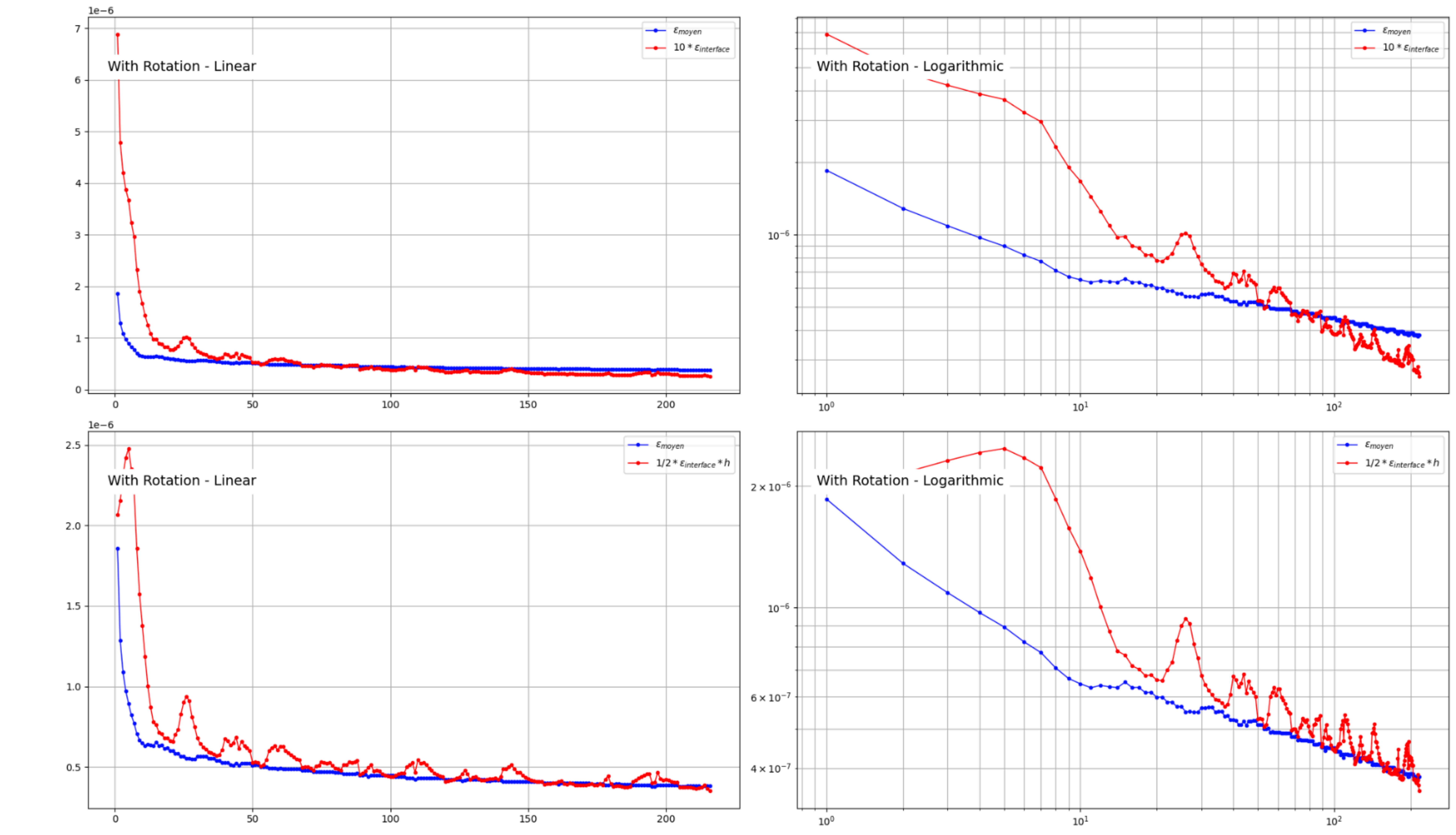
Hypothèse 2 : $Ep_b \propto h^3 N^2$



Hypothèse 3 : $\frac{dEpb}{dt} = \Gamma \epsilon_{interface} h$



Relation qui relie εinterface et εmoyen



Scaling à rediscuter

$$
\begin{aligned}
\epsilon h = c \Leftrightarrow \Gamma\epsilon &= \Gamma c h^{-1} \\
&\Leftrightarrow \frac{dEp_b}{dt} = \Gamma c h^{-1} \\
&\Leftrightarrow \frac{dh^3}{dt} = \frac{4}{\rho_0 N^2}\Gamma c h^{-1} \\
&\Leftrightarrow \frac{dh^4}{dt} = \frac{16}{\rho_0 N^2}\Gamma c \\
&\Leftrightarrow h = \left(\frac{16}{\rho_0 N^2}\Gamma c\right)^{1/4} t^{1/4}
\end{aligned}
$$