Gyre Turbulence

Interfaces dans le système climatique, 27/05/2024

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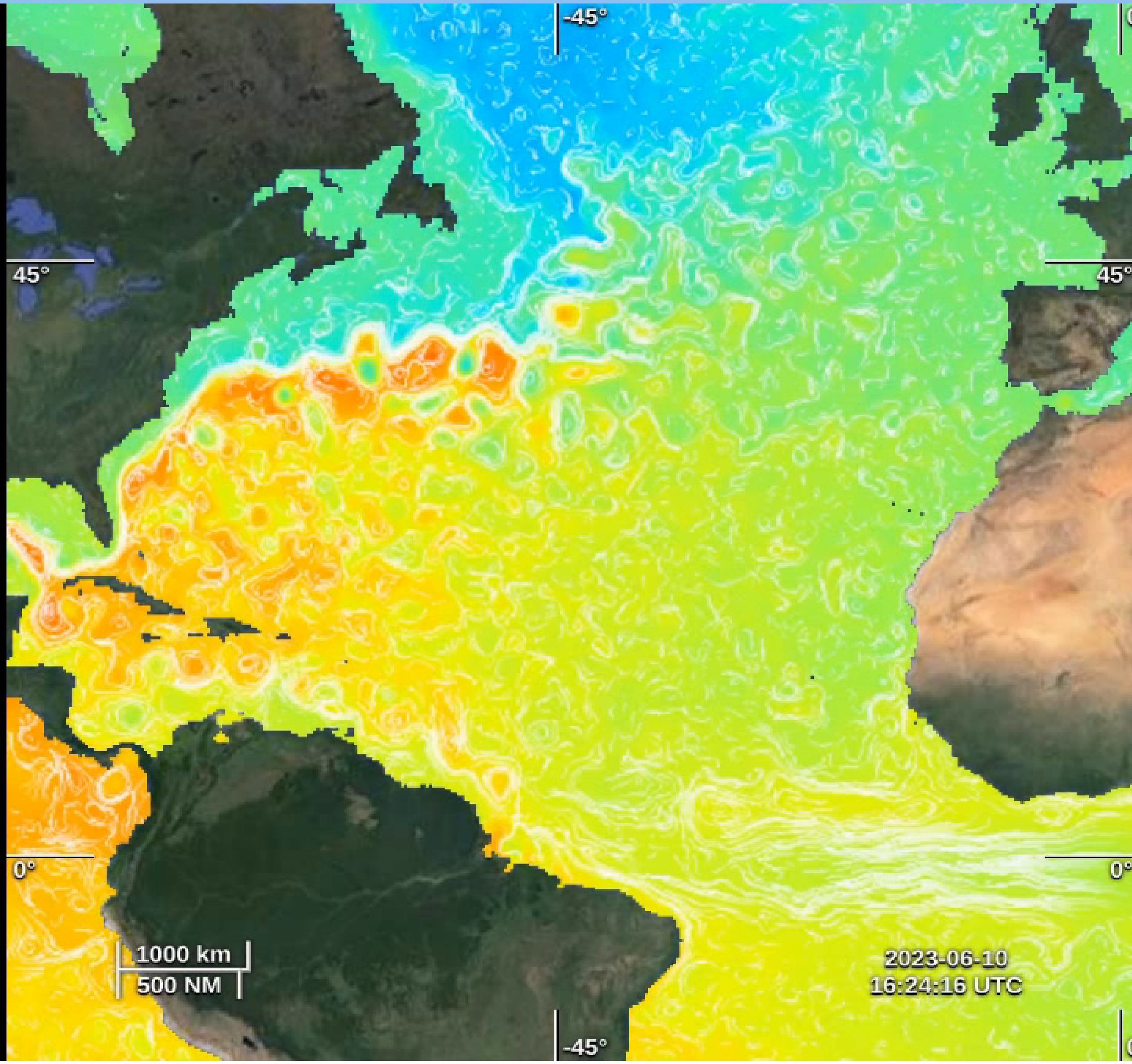
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45°
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2023-06-10
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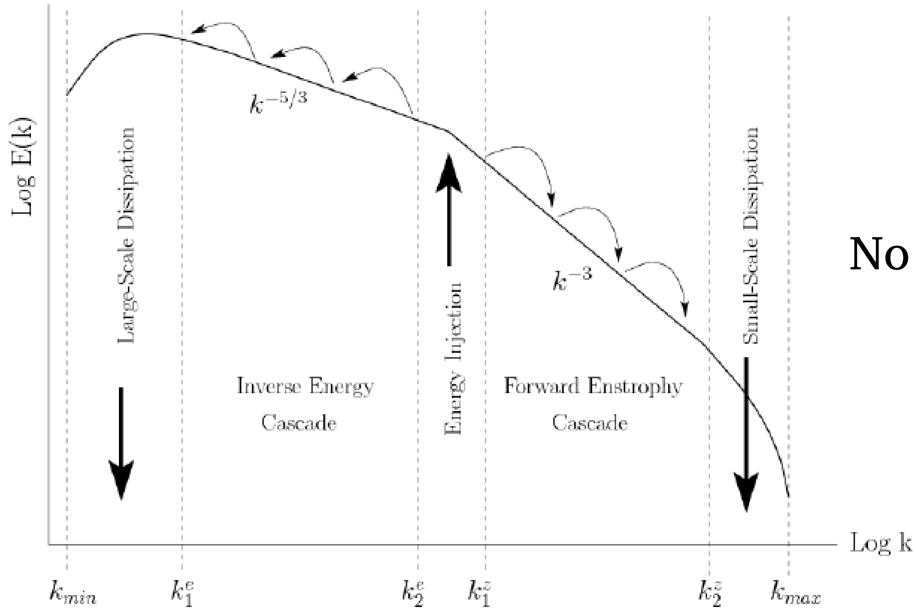
2D Oceanic Turbulence – Theory

Energy Transfer in **unbounded** 2D turbulence

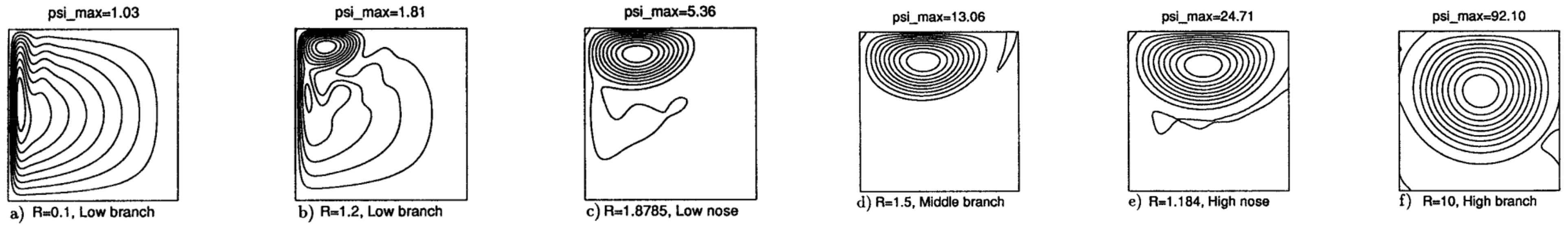


Farazmand et al. 2011

No dissipation when $\nu \to 0$

Aim of PhD: **Can coasts lead to efficient dissipation?**

Early Gyre Studies



Sverdrup Gyres
direct "β cascade" wins

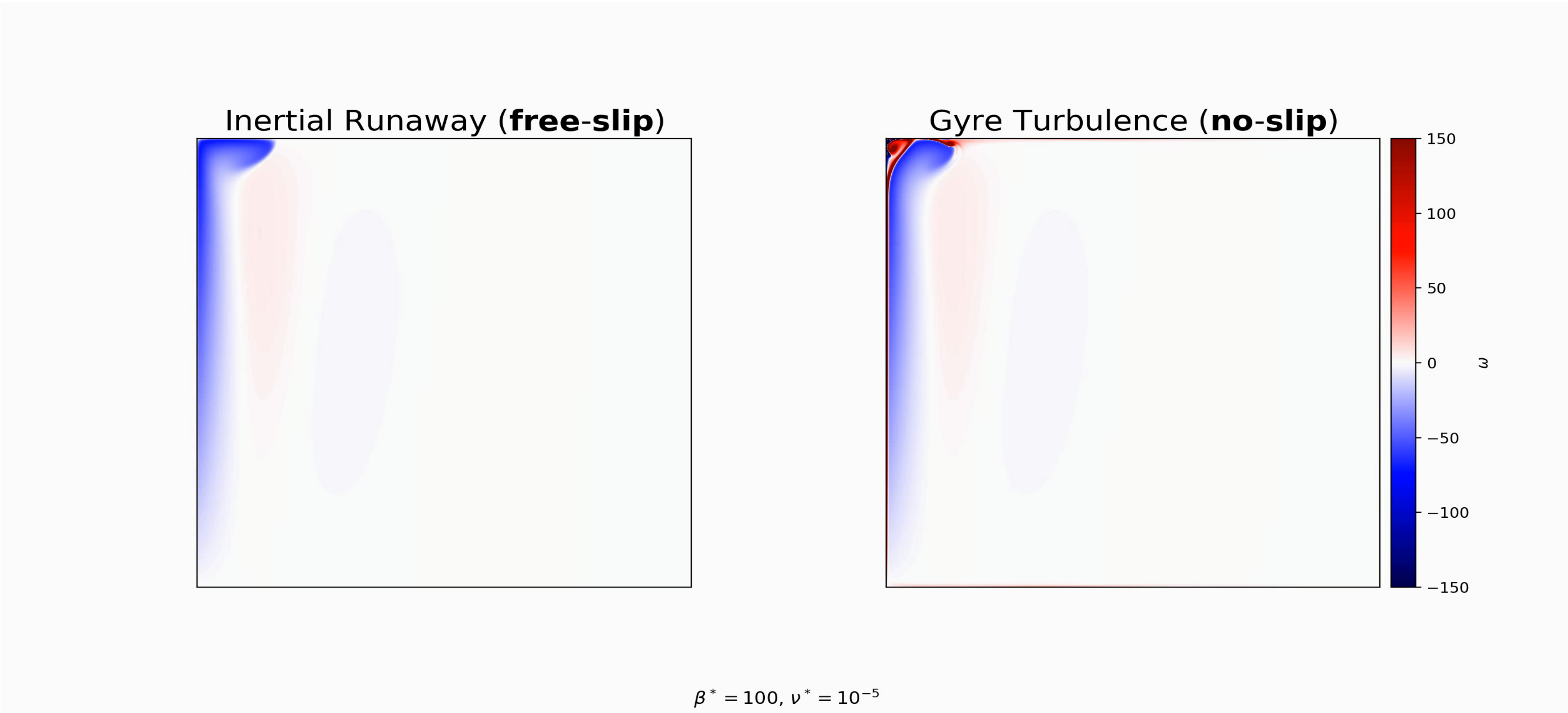
decrease ν →

Inertial Runaway
Inverse cascade wins

" ... the circulation does not, nor should it, saturate in the limit of vanishing lateral viscosity ... Barotropic instability alone, we argue, is insufficient to retard the increase in recirculation beyond realistic values. "

Sheremet et. al, 1997

Boundary Conditions!



Gyre Turbulence

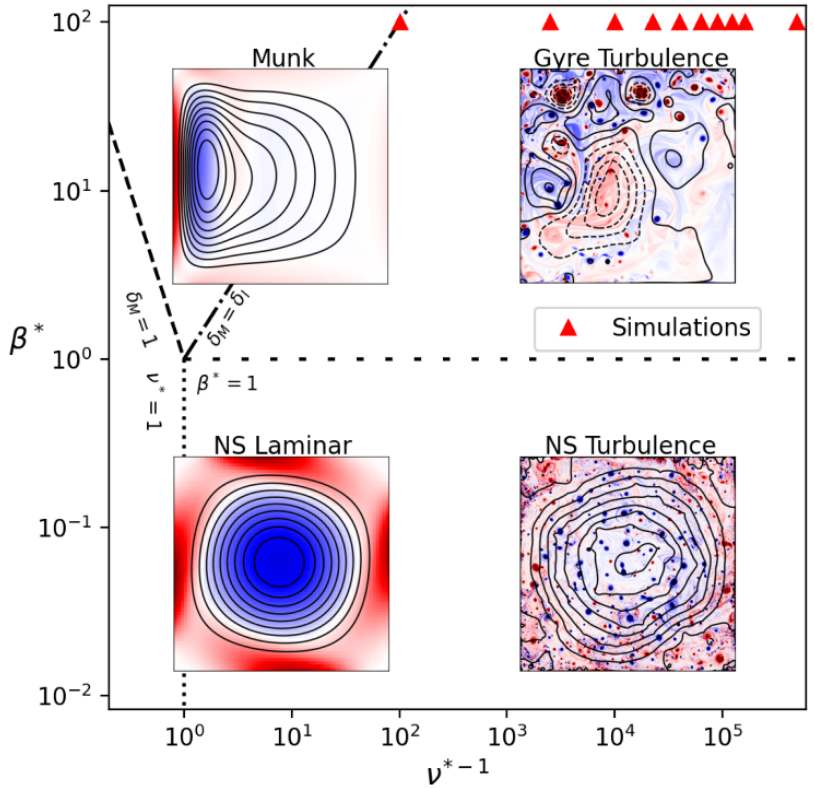
Governing Equation:

$$\frac{\partial \omega}{\partial t} + u.\nabla\omega + \beta v = \nu\nabla^2\omega - \frac{\tau}{L}\pi sin\left(\frac{\pi y}{L}\right)$$

Non-dimensional Parameters:

$$\nu^* = \frac{\nu}{\sqrt{\tau_0 L^3}}, \qquad \beta^* = \beta\sqrt{\frac{L^3}{\tau_0}}$$

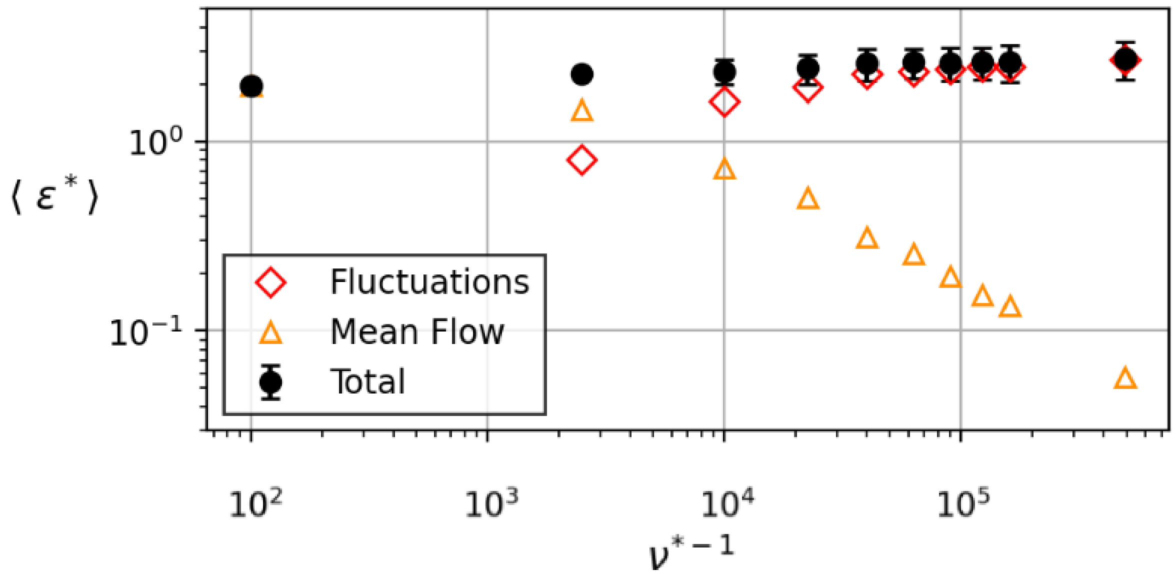
No-slip Boundary Conditions



Aim of the study: Explore limit of $\beta^* > 1$, $\nu^* \rightarrow 0$ **(Gyre Turbulence)**

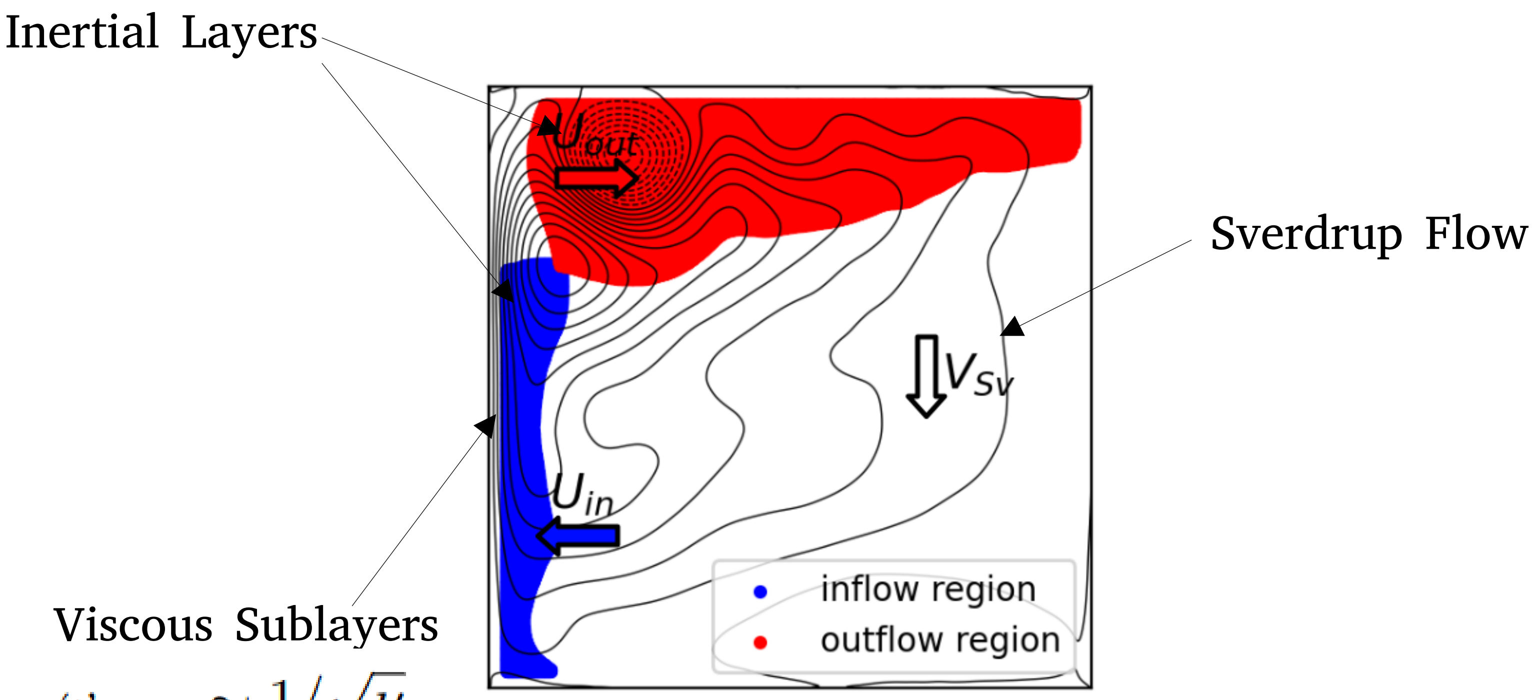
A 2D finite-dissipation limit

$$\varepsilon = \nu \int \omega^2 dA \quad = \nu \int \overline{\omega}^2 + \overline{\omega'^2} \, dA$$



“Anomalous Dissipation”

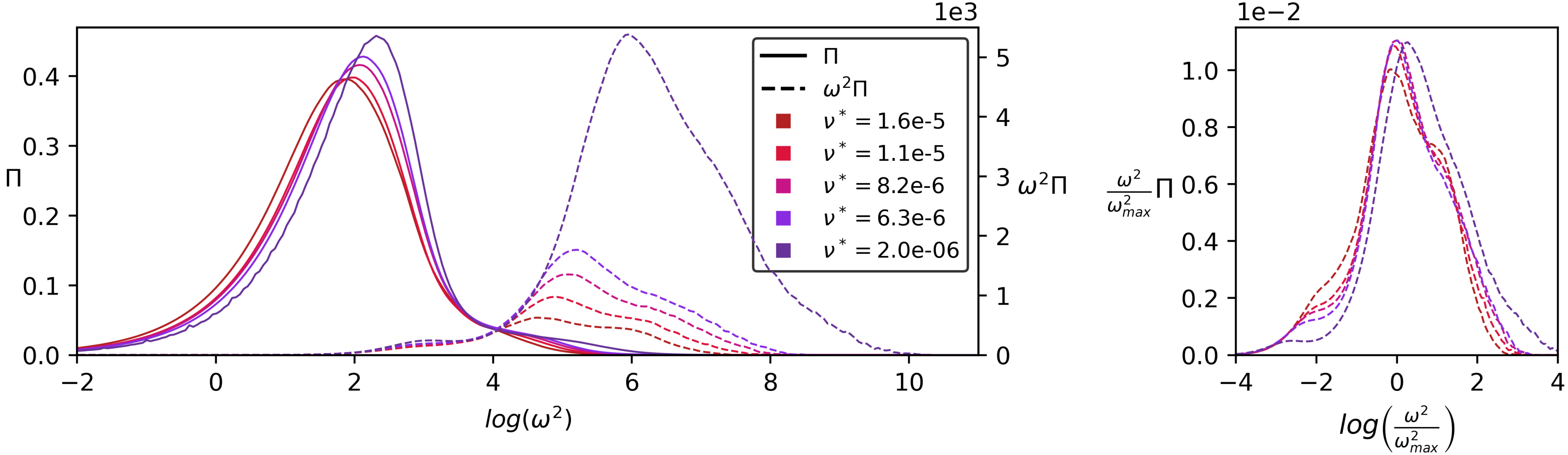
Mean Flow



$\omega_{max} \sim 1/\sqrt{\nu}$

Vorticity Statistics

$$\varepsilon = \nu \int \omega^2 dA = \nu \int \omega^2 \Pi \left(\log(\omega^2)\right) d\log\left(\omega^2\right)$$



Collapse onto unity

→ ω_{max} sets vortex maxima

Summary

- **Gyre Turbulence** is an inviscid regime with **finite dissipation rate**

- **No-slip** boundary conditions and **strong β-effect** are critical

- A barotropic model can contain a **finite inviscid energy cycle**