Stochastic variability of oceanic flows above topography anomalies

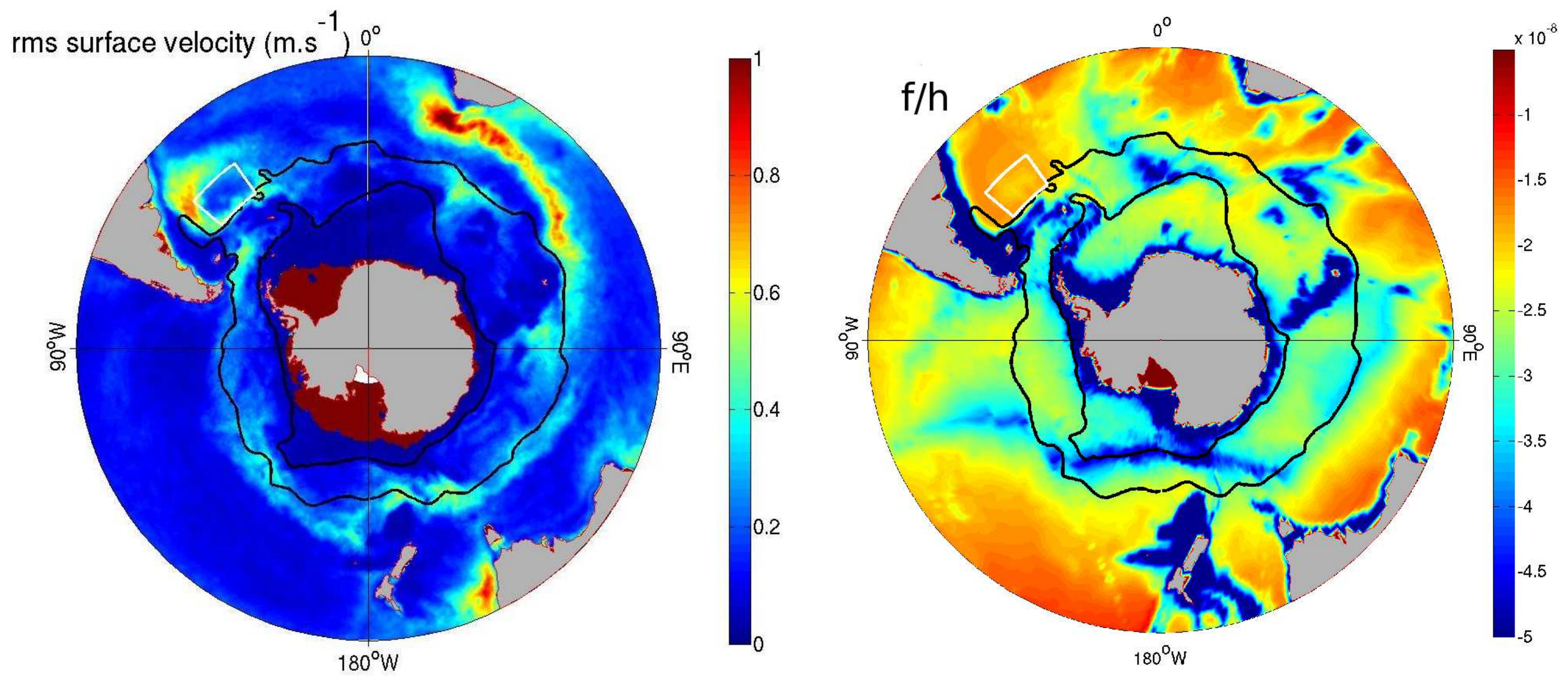
Antoine VENAILLE, Julien LE SOMMER, Bernard BARNIER

LEGI/CNRS, Grenoble France (current affiliation of AV: AOS-GFDL, Princeton.)

Contacts: venaille@princeton.edu

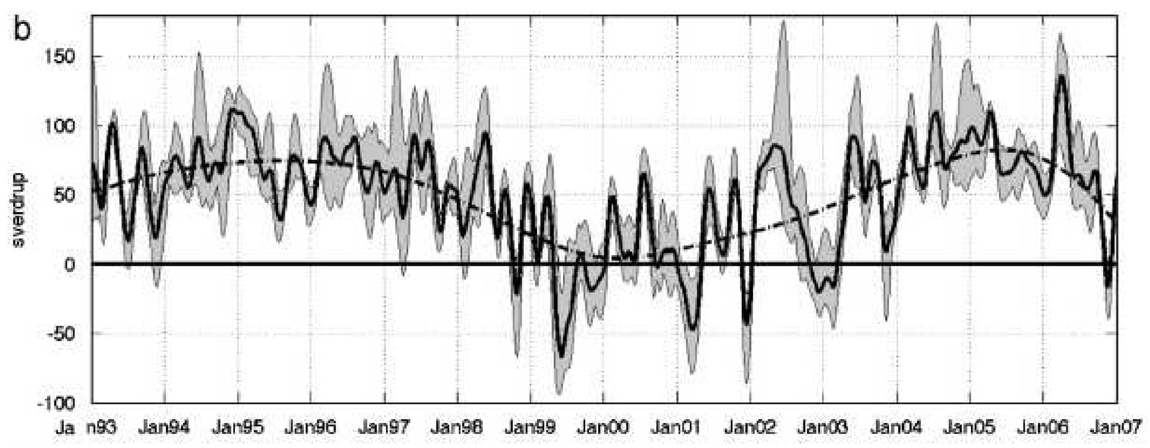
A pulsating vortex in the Argentine basin

Existence of a robust anticyclone above the zapiola rise



- The local minimum of EKE (from TOPEX-Poseidon 1992-2002) in the white box of the left panel corresponds to the **Zapiola anticyclone**.
- This is a robust vortex taking place above a sedimentary bump, the Zapiola rise (see the closed f/h contours of the right panel).
- Its transport ($\sim 100\ Sv$) is as large as other major oceanic currents.
- Formation of stationary eddy-driven flow above topography *Dewar JMR 98*

Previous altimetry observations of a vigorous variability

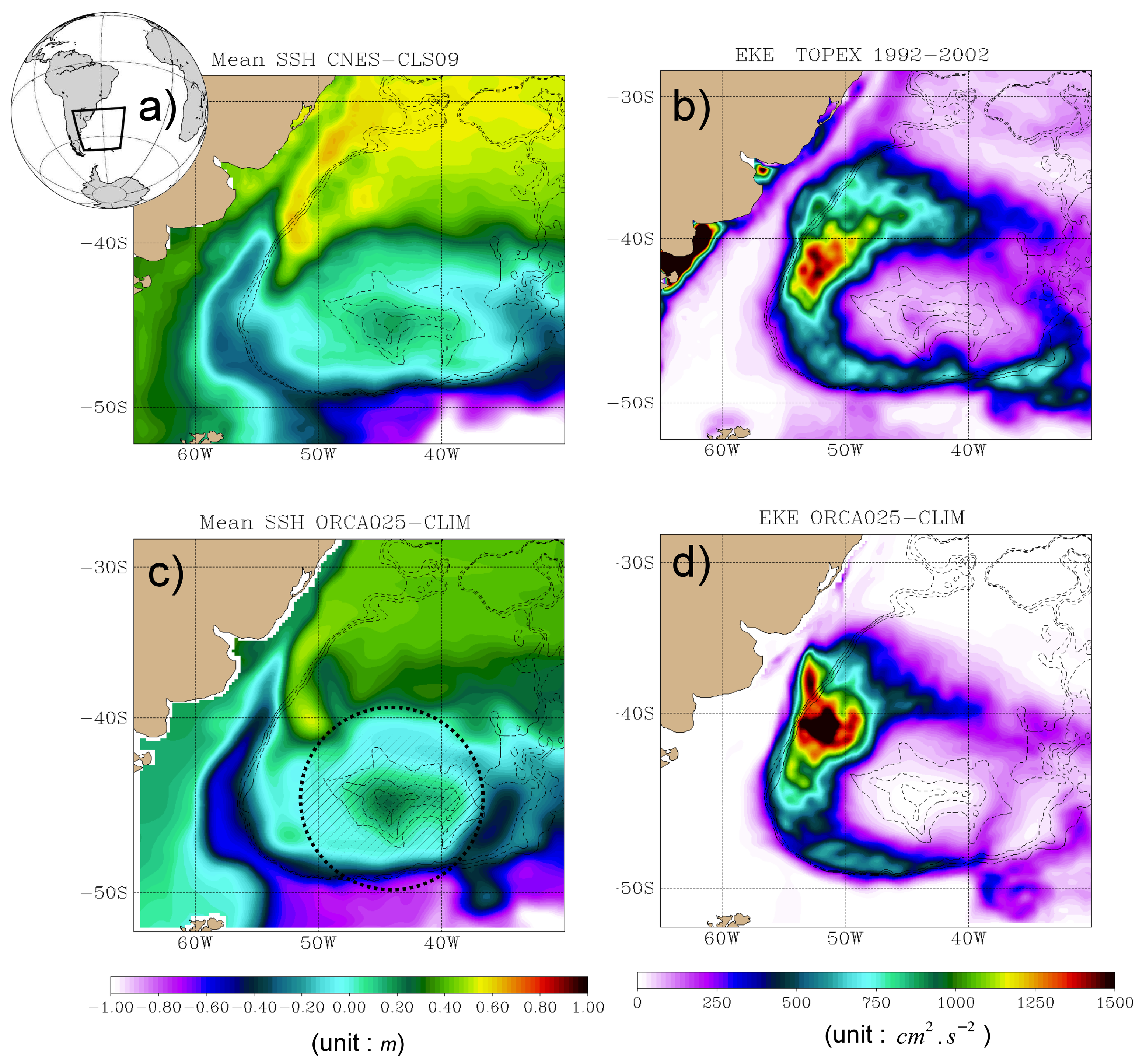


- From *Saraceno et al Deep Sea Res. 09*: previous studies using altimetry measurements have shown that **the transport of the anticyclone is as large as the transport itself**.
- Variability reported in idealized QG simulations *Bigorre & Dewar Ocean Modeling 10*
- Only small impact of wind stress on these fluctuations, see *Volkov & Fu, JGR 08*.

To which extent is this variability intrinsic to the ocean dynamics?

Mean State of the Zapiola anticyclone

Horizontal structure: comparison model-observations



- Good agreement between observed dynamic topography and SSH from the model
- SSH proportional (and opposite) to the transport streamfunction ψ

Model configurations

- DRAKKAR Project, **1/4th degree resolution**, **300 years run**.
- z-coordinates with 46 levels and a partial step representation of bottom topography
- **Repeated-year forcing** built by computing a daily climatology during 50 years.
- For a barotropic flow of about $0.1\mathrm{m.s}^{-1}$, **the bottom friction time-scale** ω_b^{-1} **is about** 14 **months.**

A mechanism for internal, stochastic variability

Eddy-driven Taylor Columns

Simple case of axisymmetric f/h contours, for a barotropic flow.

$$\frac{\partial}{\partial t}\overline{u} = -\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\overline{u'v'}\right) - \omega_b \overline{u}$$

Where $\overline{u}$ is averaged over a f/h contour.

$$\frac{d\mathcal{T}}{dt} = C_{eddy} + \eta_{eddy}(t) - \omega_b \mathcal{T}$$

Transport:

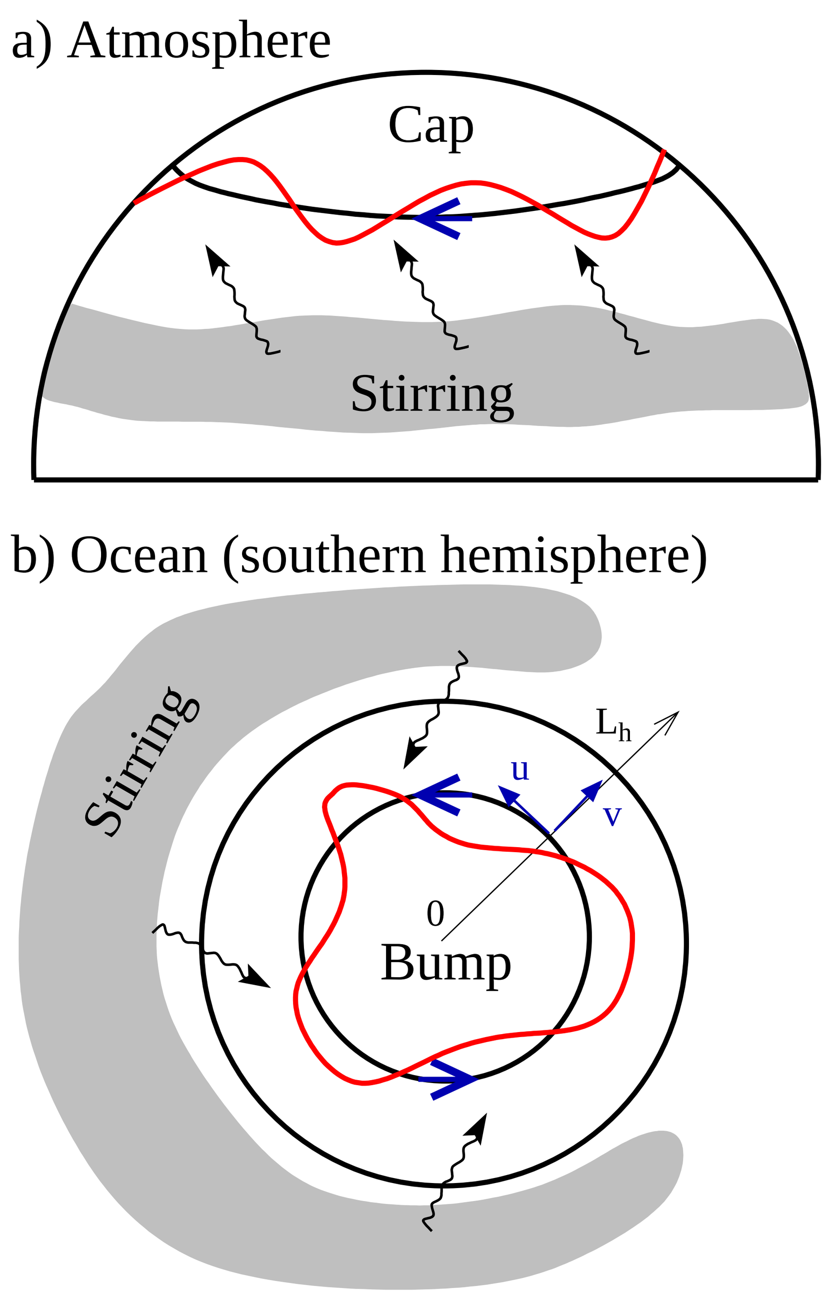
$$\mathcal{T} = \int_0^{L_h} \mathrm{d}r\ h\overline{u}$$

Eddy momentum flux:

$$C_{eddy} + \eta_{eddy}(t) \approx -h\,\overline{v'u'}|_{r=L_h}$$

Mean transport: $<\mathcal{T}> = \dfrac{C_{eddy}}{\omega_b}$

Spectrum: $|\widetilde{\mathcal{T}}(\omega)|^2 = \dfrac{|\widetilde{\eta}_{eddy}|^2}{(\omega^2 + \omega_b^2)}$



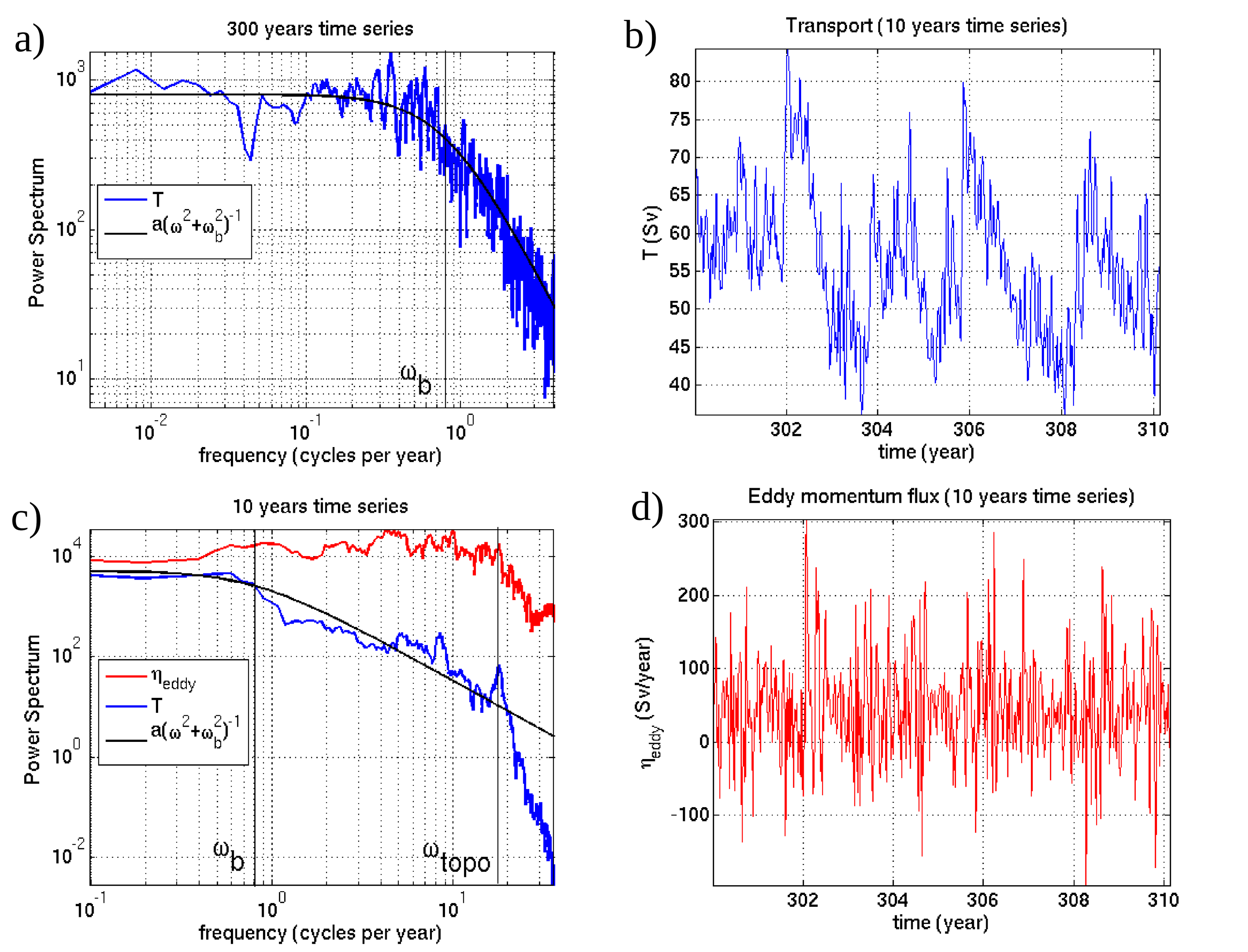
Transport fluctuations modelled with an AR(1) process

If η_{eddy} is a white noise process then the transport is a red noise process for frequency larger than ω_b.

The key ingredients are

- **Source: eddying PV fluxes**
- **Sink: bottom friction**
- **Closed isolines of** f/h

Variability of the Zapiola anticyclone



The frequency cut-off is close to bottom friction coefficient used in the model.

Take home message

Internal, stochastic low frequency variability reported in an eddy permitting numerical ocean model

A mechanism has been proposed: i) one needs eddies and closed f/h **contours ii) and bottom friction plays a key role.**