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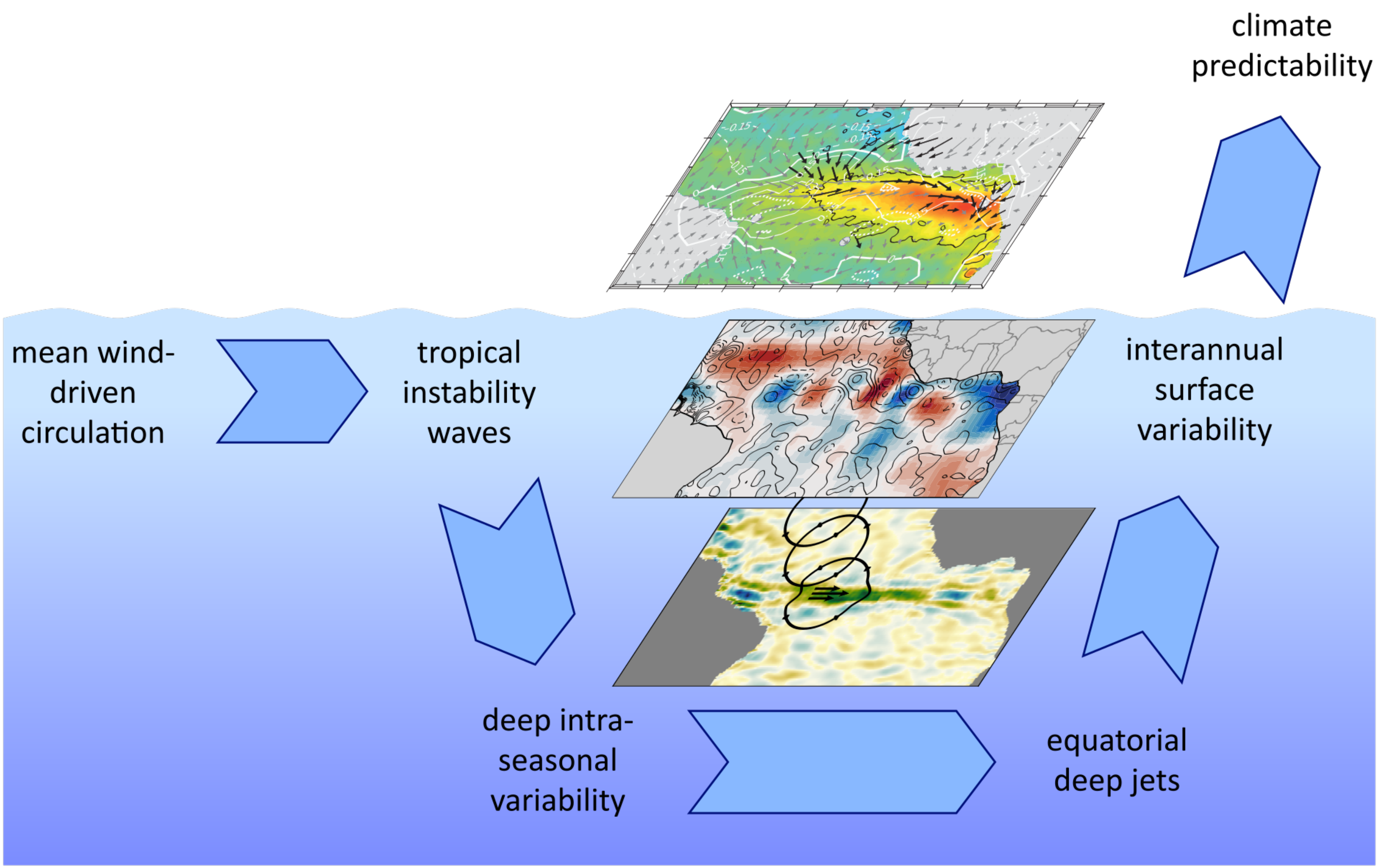
An oceanic mechanism for the generation of interannual climate variability in the tropical Atlantic

M. Claus, R. Greatbatch, P. Brandt, F. Tuchen, J.-D. Matthießen

GEOMAR

Interannual mode of climate variability

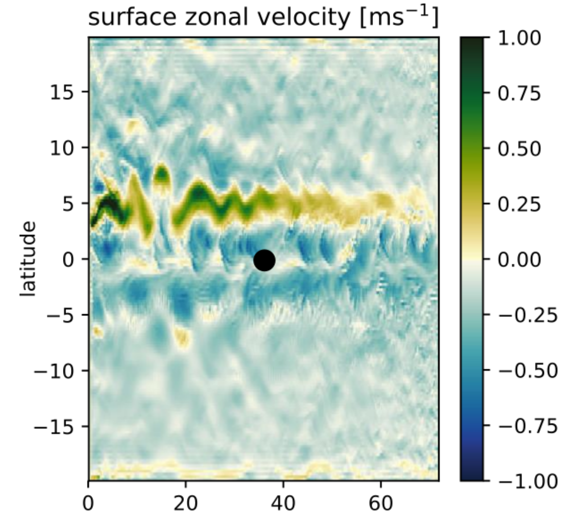


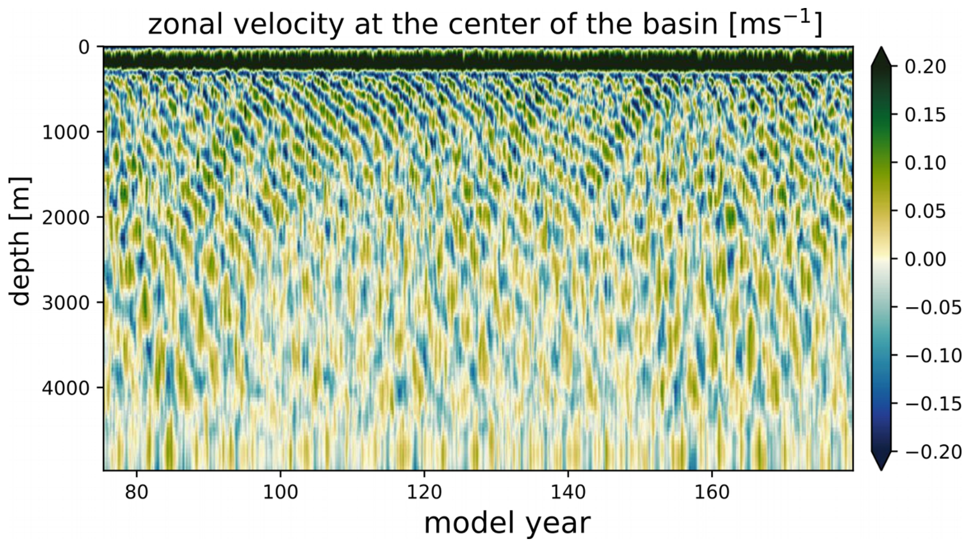
Model setup

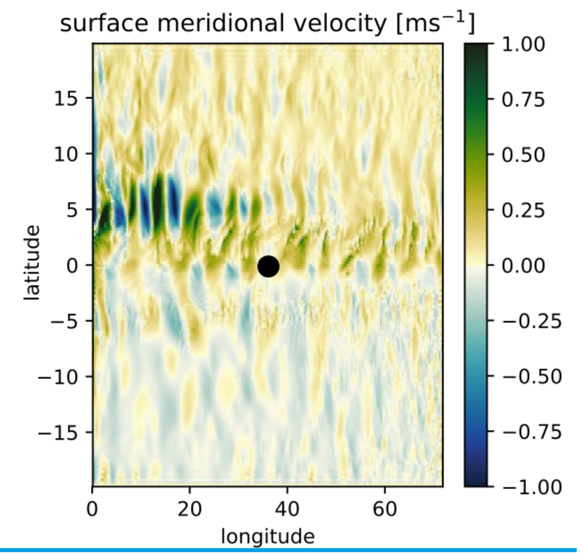
- MITgcm, z-coordinate
- 1/4° x 1/4°, 200 level
- Uniform salinity, linear EOS
- flat bottom, free-slip BBC, no-slip LBC
- Vertical mixing: Pacanowski and Philander (1981)
- Driven by zonally uniform **steady wind stress**

- Velocity decomposition with 70-day cut-off

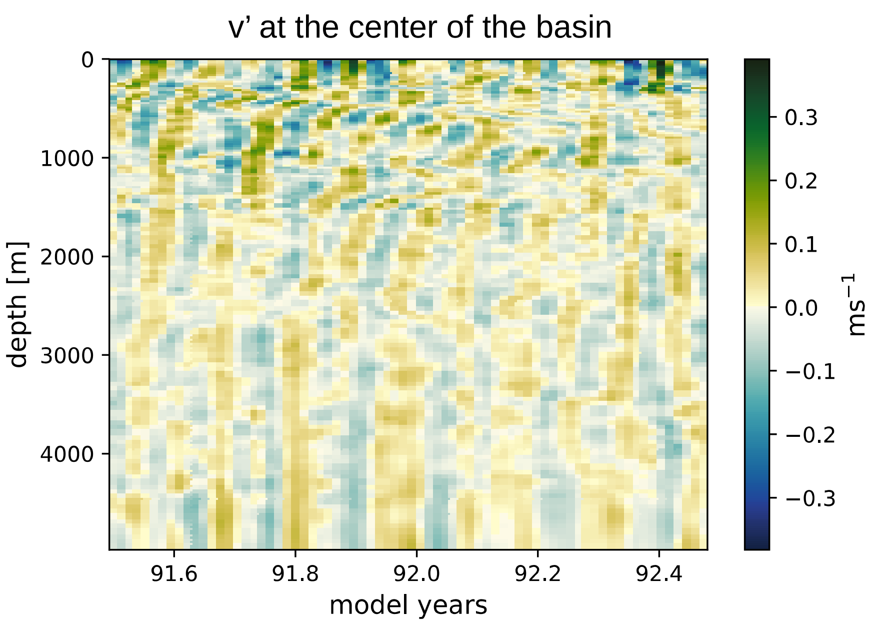
$$u = u_0 + \overline{u} + u'$$

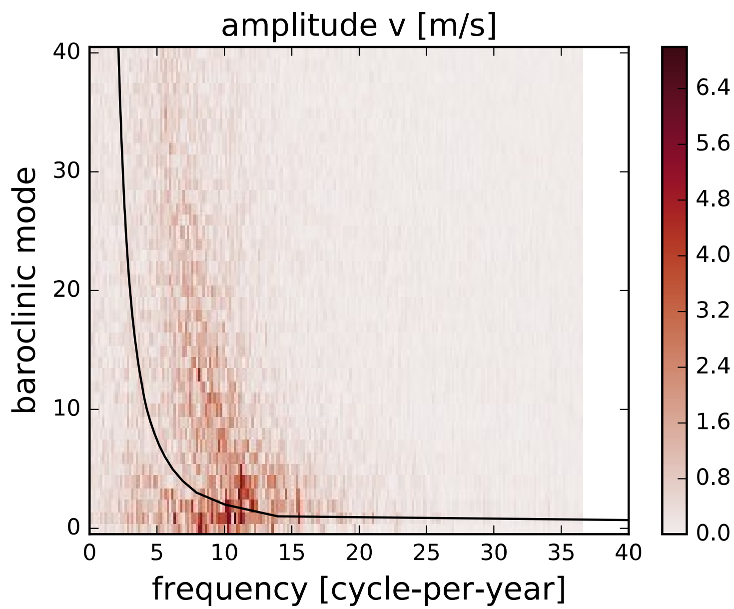






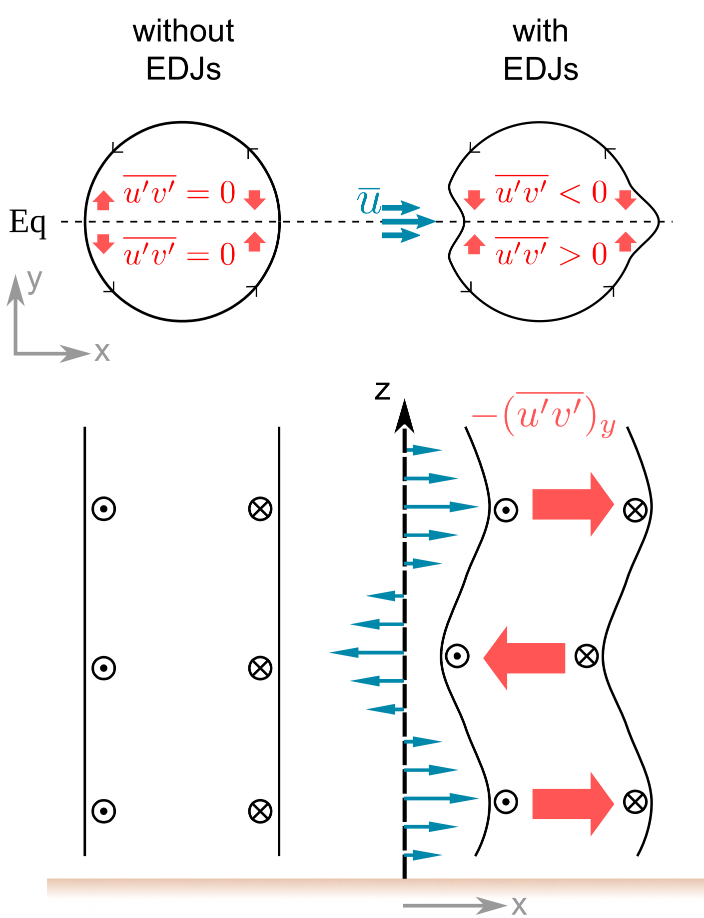
Intraseasonal variability





- Pronounced intraseasonal variability of large vertical scale
- Spectrum is similar to observations

Momentum flux from intraseasonal to interannual time scales



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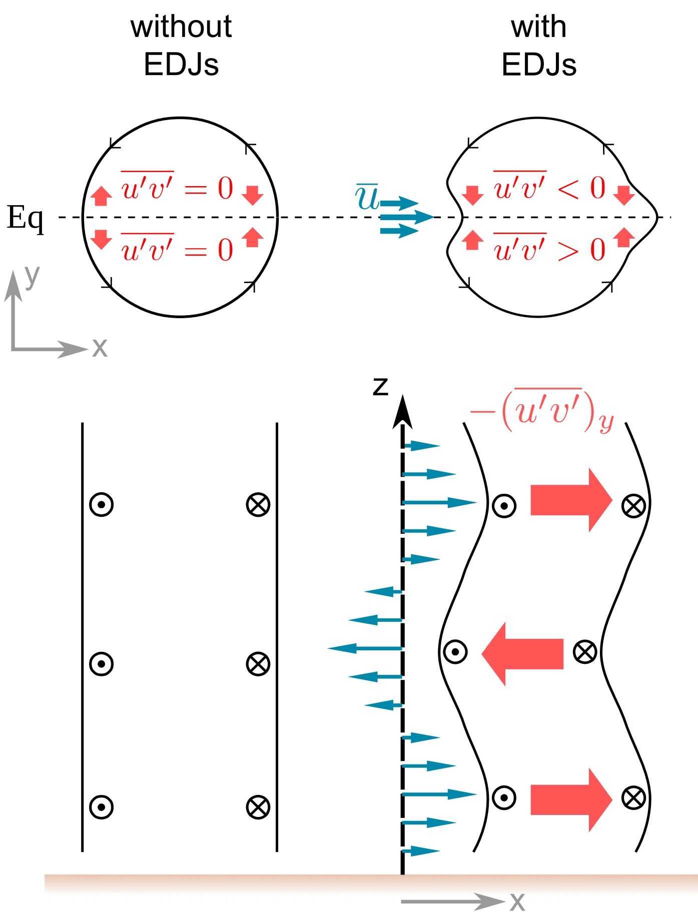
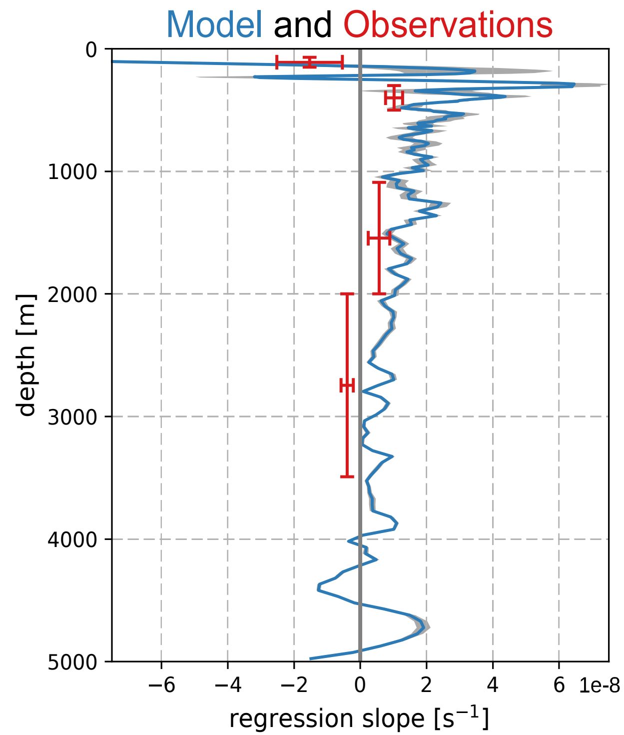
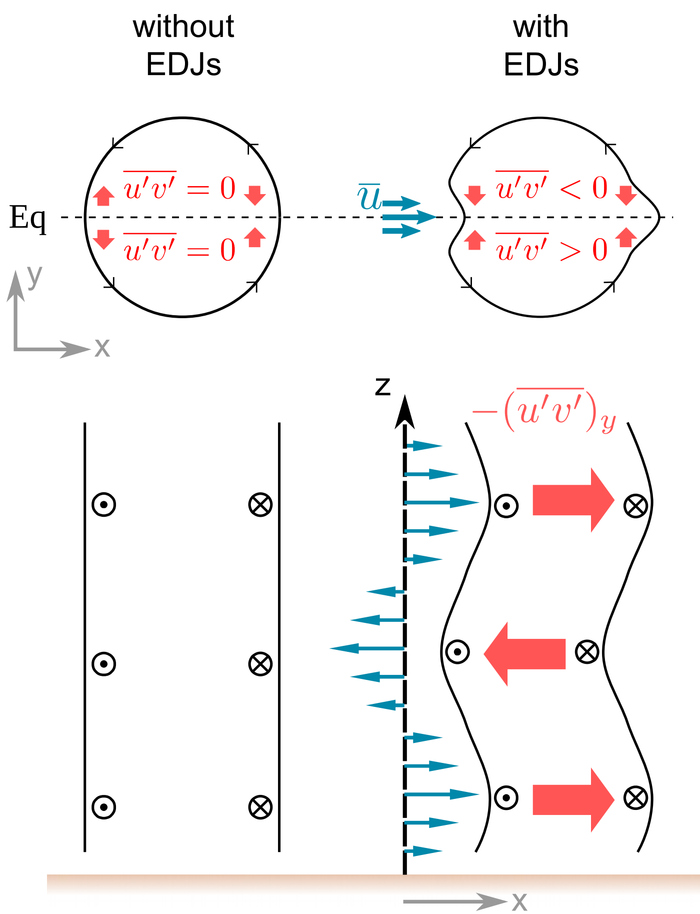


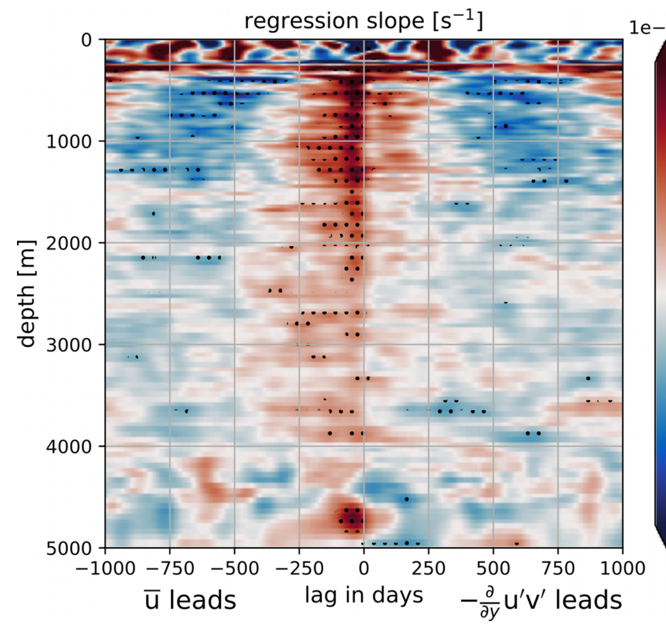


→ Equatorial deep jets are maintained by the convergence of intra-seasonal momentum flux

Greatbatch et al., in prep.

Momentum flux from intraseasonal to interannual time scales

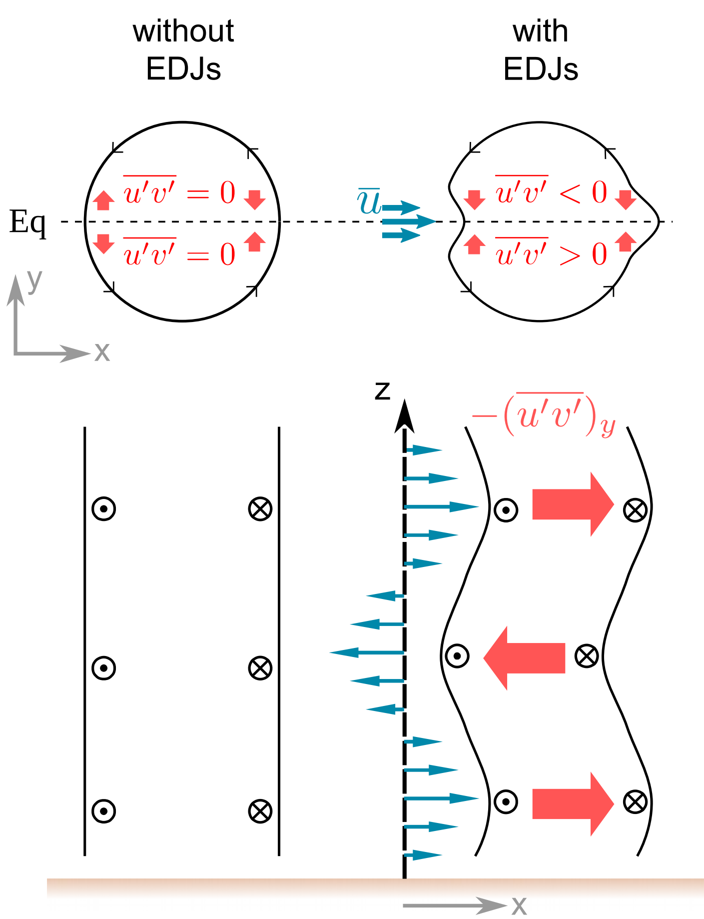


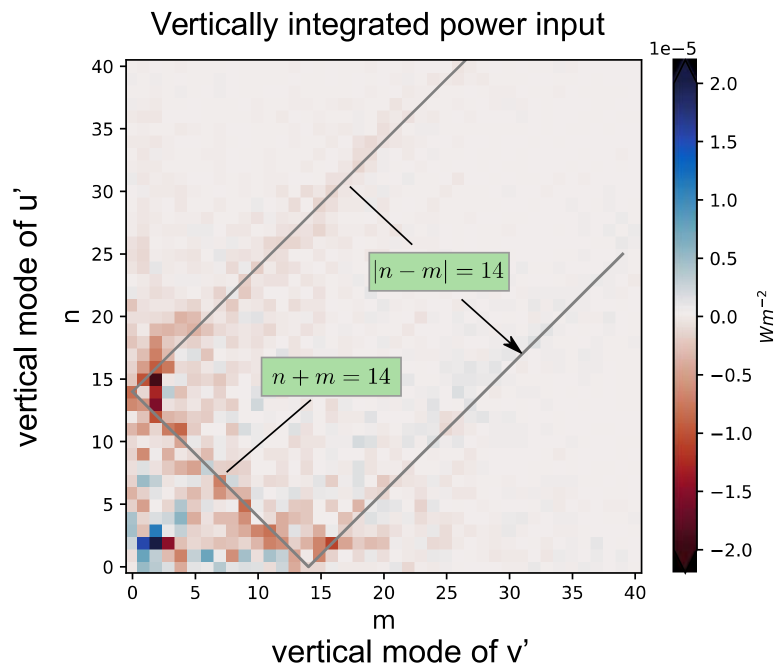


➔ Low frequency zonal flow variability leads momentum flux convergence

Greatbatch et al., in prep.

Momentum flux from intraseasonal to interannual time scales

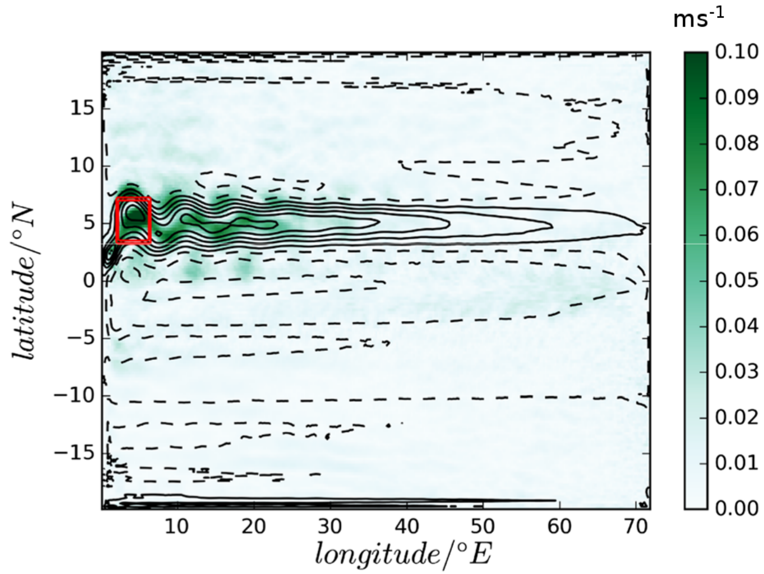


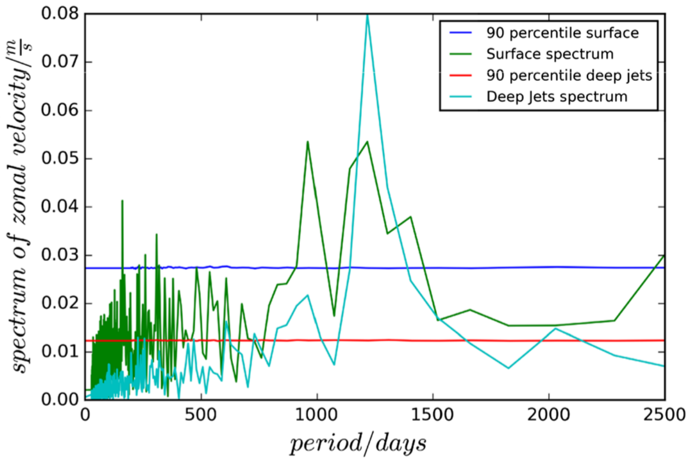


→ The combination of small vertical scale u' and large vertical scale v' maintain the EDJs

Greatbatch et al., in prep.

Surface signature and vertical energy propagation

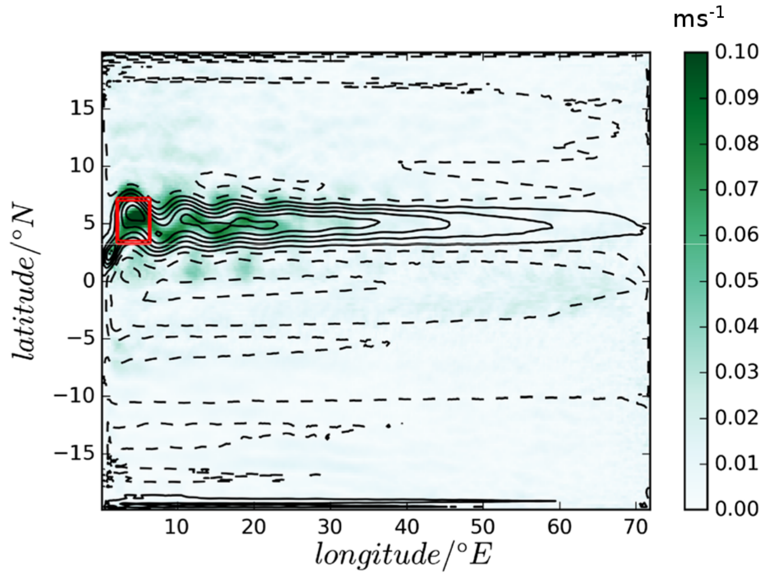


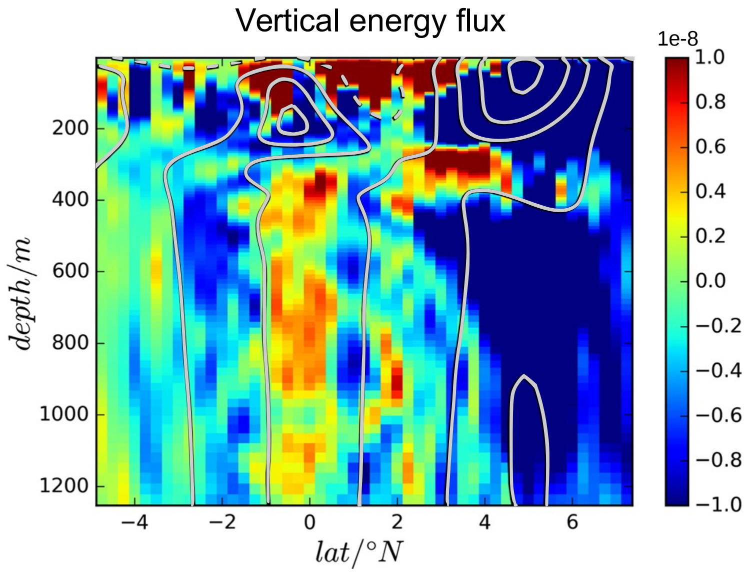


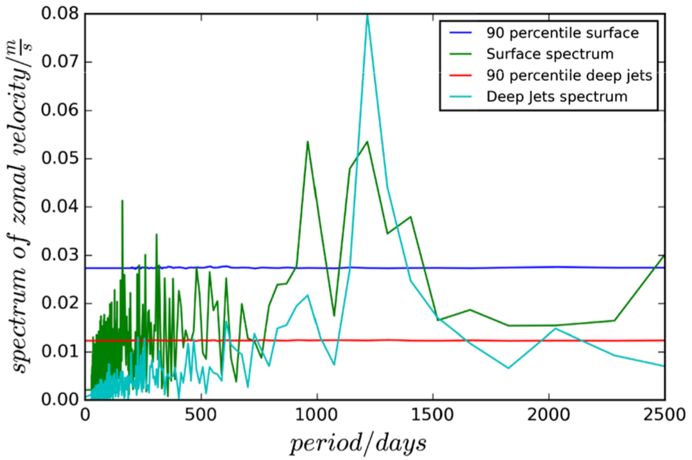
- Interannual variability of NECC is linked to EDJs

Matthießen et al., 2015, OD

Surface signature and vertical energy propagation







- Interannual variability of NECC is linked to EDJs
- Energy of EDJs is propagating upwards

Matthießen et al., 2015, OD

Summary and discussion

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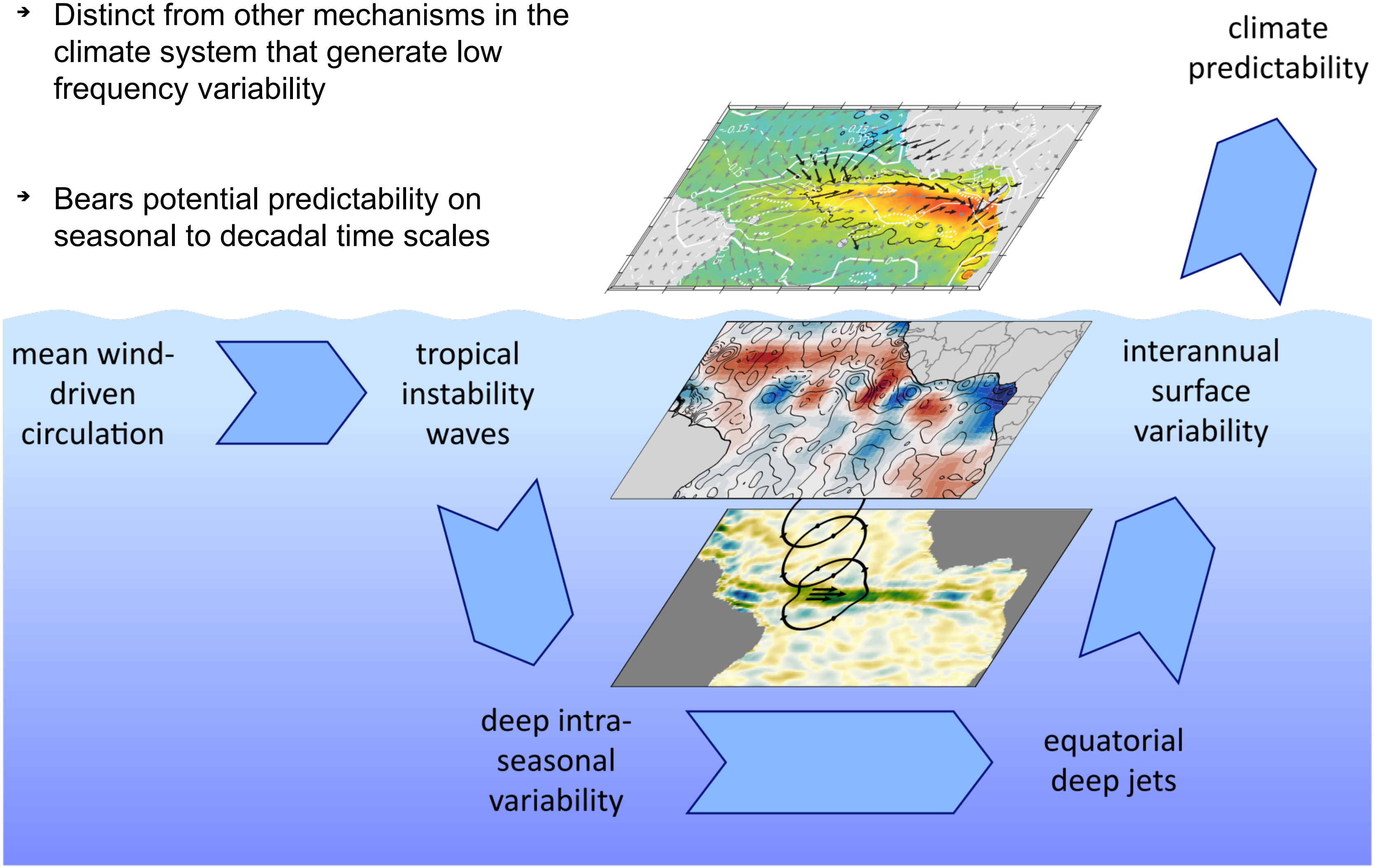
- Distinct from other mechanisms in the climate system that generate low frequency variability
- Bears potential predictability on seasonal to decadal time scales



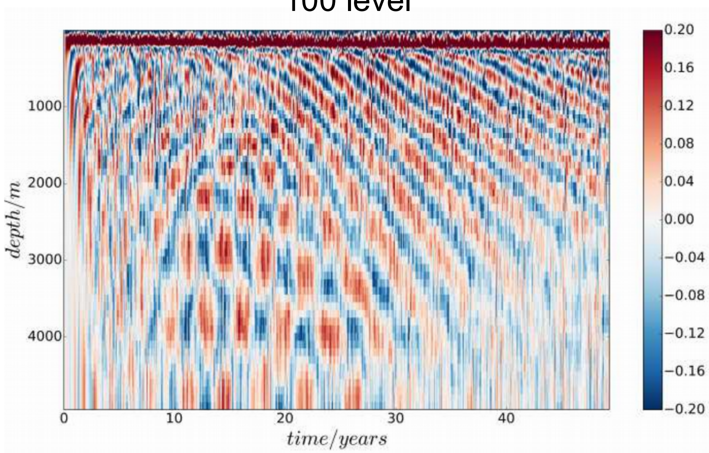
Summary and discussion

- What sets the vertical scale of the EDJs?
  - Large amplitude, short intraseasonal Yanai waves are subject to barotropic shear instability which produces stacked zonal jets (Hua et al., 2008, JFM; Gill, 1974, GFD)
  - More stable Yanai waves flux momentum to low frequency small vertical scale motion through resonant triad interaction (see Appendix of Hua et al., 2008, JFM)

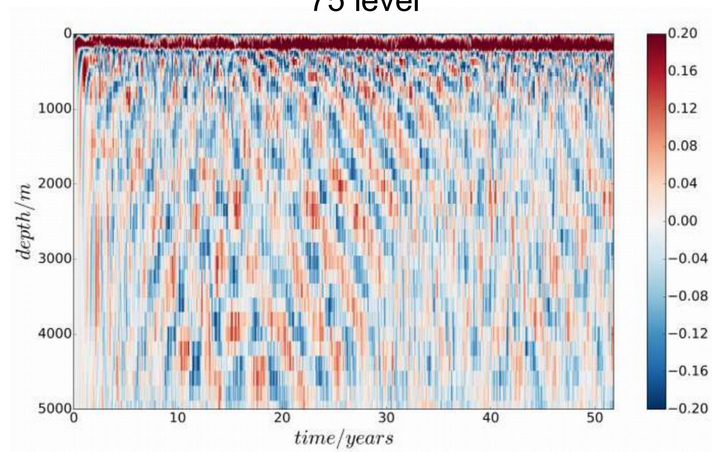
- Why are most ocean models unable to generate EDJs?
  - Vertical resolution?
  - Presence of coastline?
  - Wind stress variability?
  - Topography?

Summary and discussion

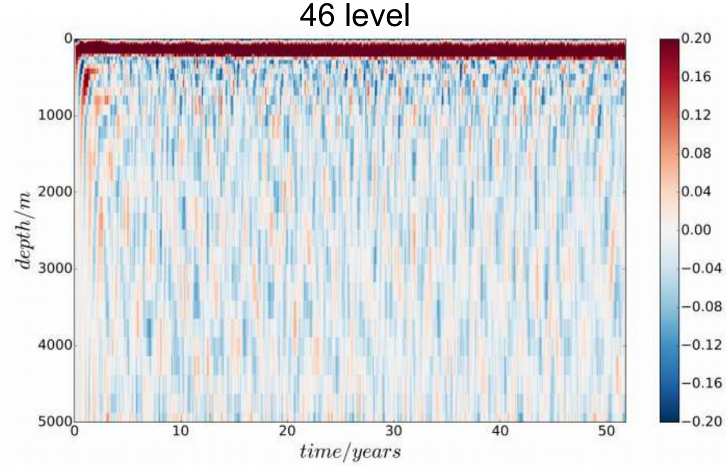
100 level



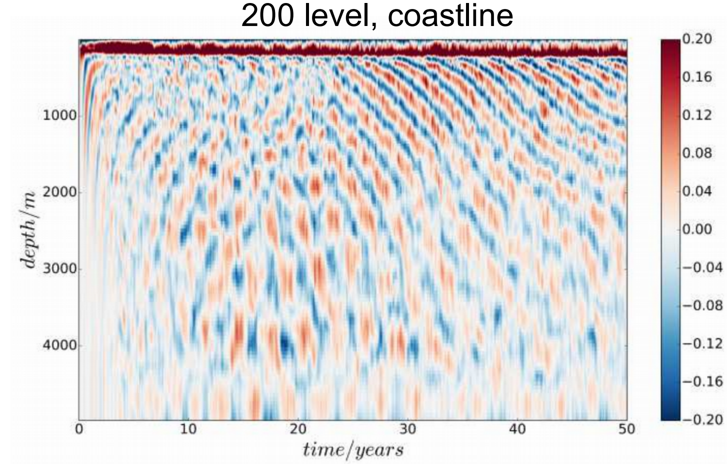
75 level



46 level



200 level, coastline



Summary and discussion

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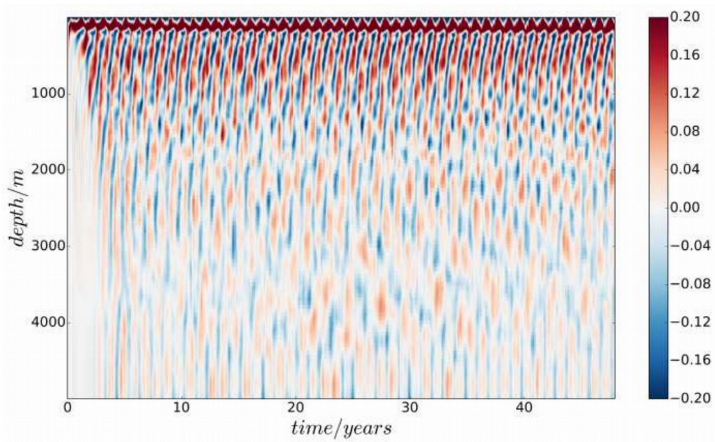
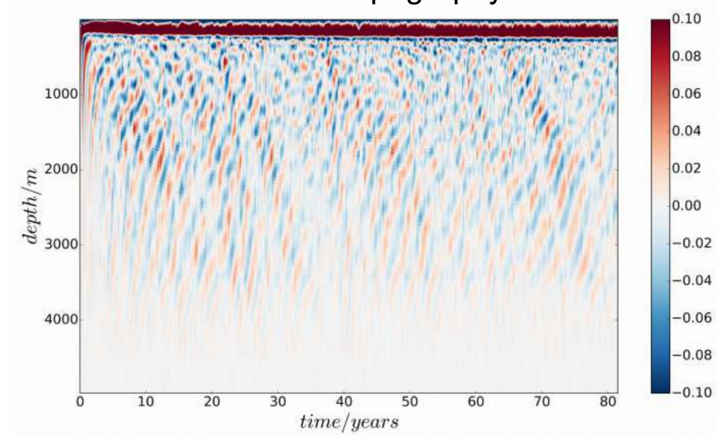
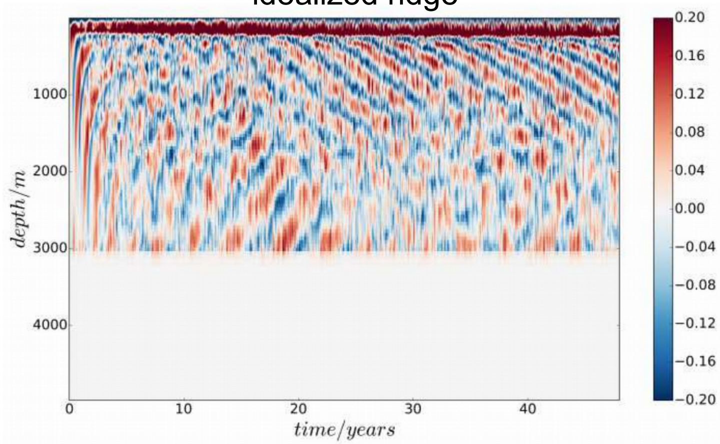
Climatological wind stress



realistic topography



idealized ridge



➔ Why are most ocean models unable to generate EDJs?

- ✔ Vertical resolution
- ✗ Presence of coastline
- ✗ Wind stress variability
- ✔ Topography

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