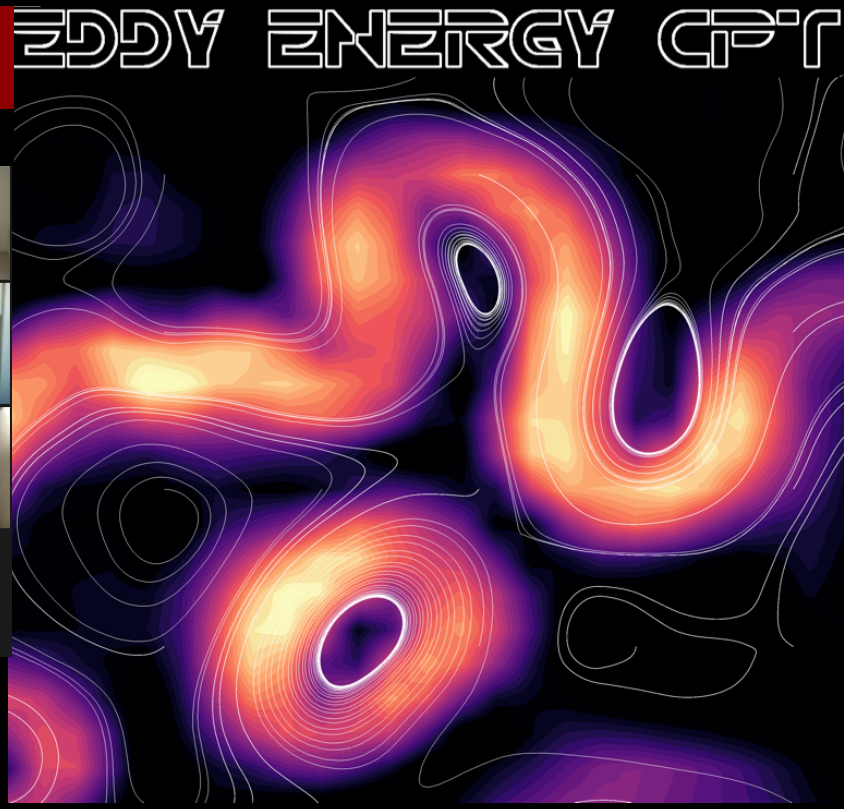
Ocean Transport & Eddy Energy Climate Process Team (CPT)

Laure Zanna, NYU

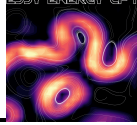


Thanks to

NOAA NSF US CLIVAR

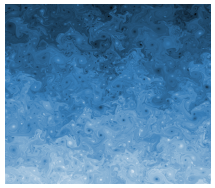
https://ocean-eddy-cpt.github.io/

Energy Cycle & Mesoscale Eddies

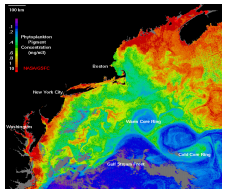


- Sources, sinks and transfer of energy across scales are key to maintain the circulation & transport in the ocean *(e.g., Wunsch & Ferrari 2004; Ferrari & Wunsch 2009)*

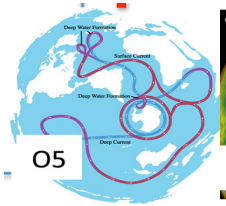
- **Mesoscale eddies are a major player in the energy cycle:**
  - ➡ extract energy from the mean flow
  - ➡ form the bulk of the kinetic energy in the ocean
  - ➡ transfer of kinetic energy across scales



Small Scale



Mesoscales (10-100 km)



Large Scale (1000's kms)

Wind + Buoyancy Work

Deformation Radius

Available Potential Energy

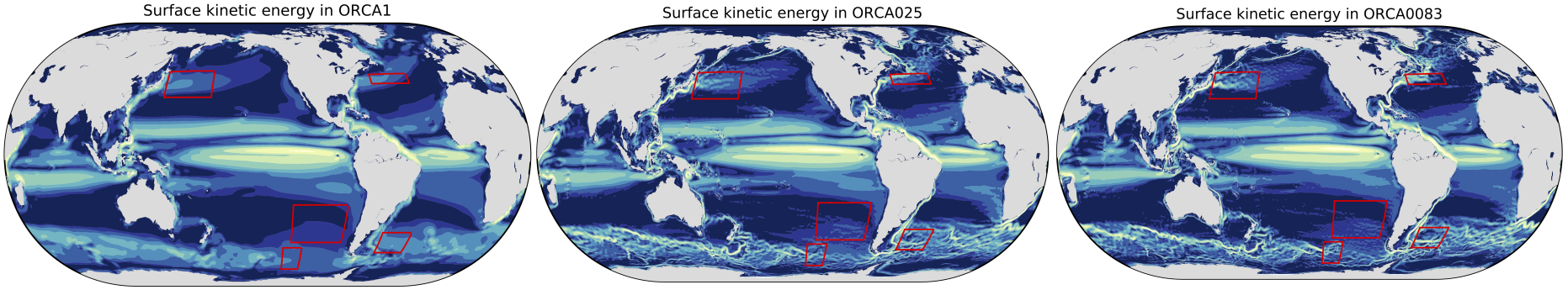
Baroclinic Instability

Kinetic Energy

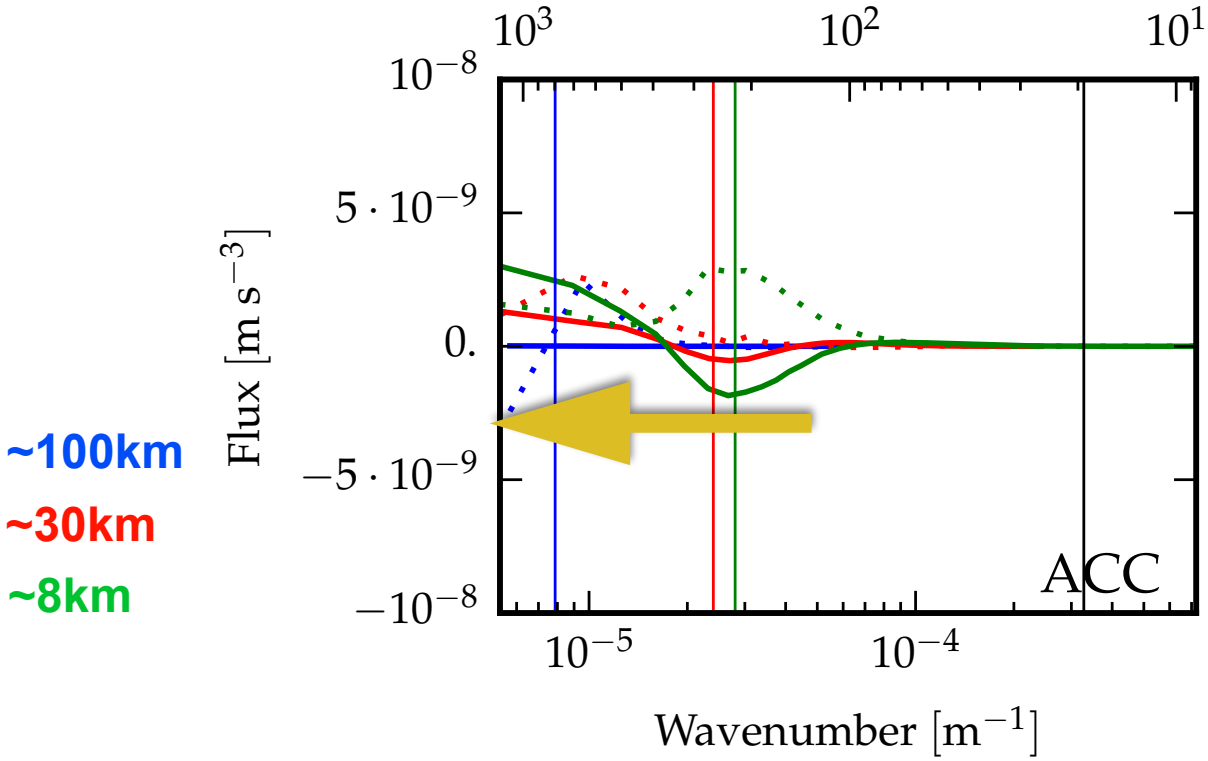
Inverse cascade/Backscatter

Zanna, Bachman, Jansen et al. 2020
adapted from Salmon, 1998 & Vallis, 2006

Symptoms of missing mesoscale eddy energy in GCMs



- Lack of kinetic energy at all scales
- Weak or inexistent flux of APE to KE & of KE from small to large scales



Kjellsson & Zanna, 2017

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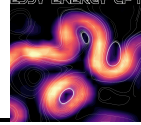
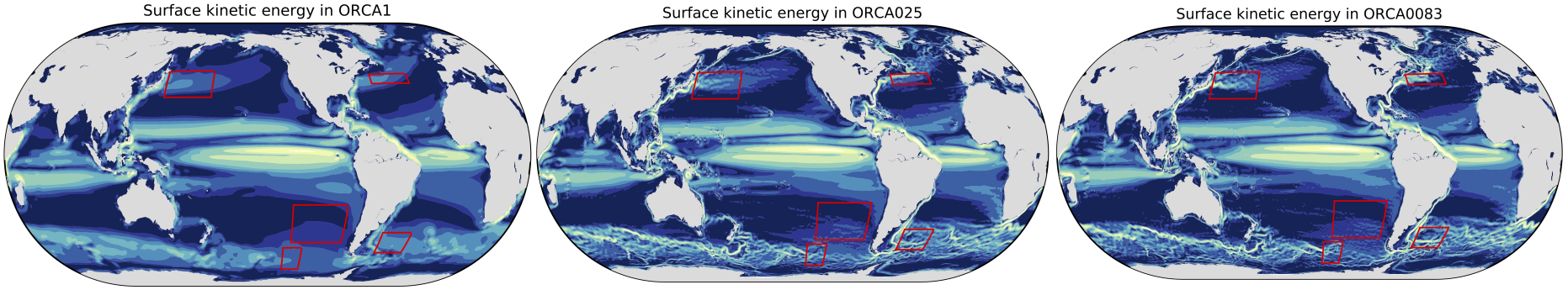
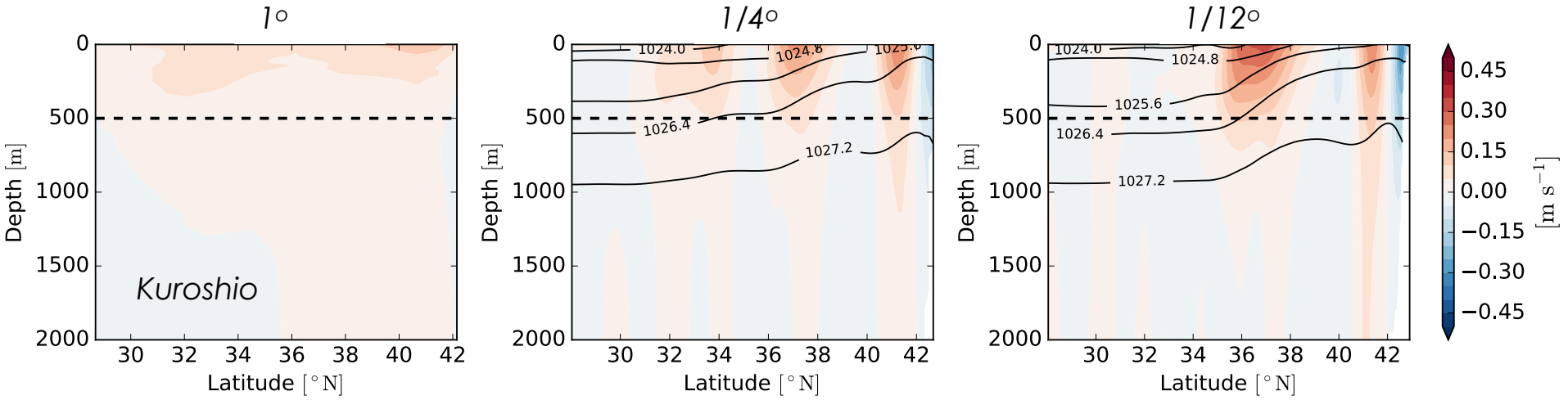




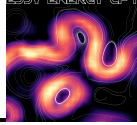
- Lack of kinetic energy at all scales + Weak or inexistent flux of APE to KE & of KE from small to large scales

= biases in horizontal & vertical transport in lower resolution GCMs



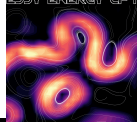
Kjellsson & Zanna, 2017

Aims of the Eddy Energy CPT



Increase the fidelity of the large-scale transport representation in IPCC-class models by unifying energetics & mesoscale eddy closures of buoyancy & momentum for a robust resolution-, scale- & flow-aware implementation

Aims of the Eddy Energy CPT



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- How:
  - Evaluate existing & future parameterizations of ocean mesoscale

Parameterization of ocean eddies: Potential vorticity mixing, energetics and Arnold's first stability theorem

David P. Marshall [a,*], Alistair J. Adcroft [b]

Energy budget-based backscatter in an eddy permitting primitive equation model

Malte F. Jansen [a,b,c,*], Isaac M. Held [b,c], Alistair Adcroft [b,c], Robert Hallberg [b,c]

Scale-aware deterministic and stochastic parametrizations of eddy-mean flow interaction

Laure Zanna [a,*], PierGianLuca Porta Mana [b], James Anstey [a], Tomos David [a], Thomas B

The GM+E closure: A framework for coupling backscatter with the Gent and McWilliams parameterization

Scott D. Bachman *

National Center for Atmospheric Research, Boulder, CO, USA

A scale-aware subgrid model for quasi-geostrophic turbulenc

Scott D. Bachman[1], Baylor Fox-Kemper[2], and Brodie Pearson[2]

Implementation of a Geometrically Informed and Energetically Constrained Mesoscale Eddy Parameterization in an Ocean Circulation Model

J. MAK

Effects of vertical variations of thickness diffusivity in an ocean general circulation model

Gokhan Danabasoglu [a,*], John Marshall [b]

Unified CPT-eddy energy parametrization (202?)

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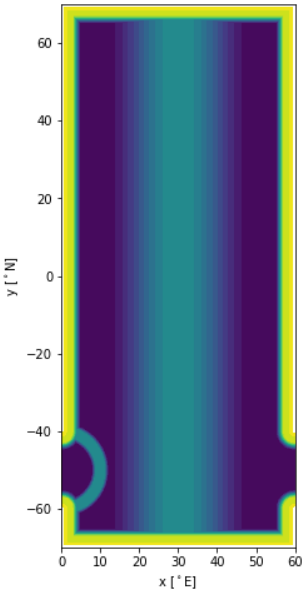
- How:
  - Evaluate existing & future parameterizations of ocean mesoscale in a new idealized configuration — NeverWorld 2 — & global models

Neeraja Bhamidipati

NeverWorld2



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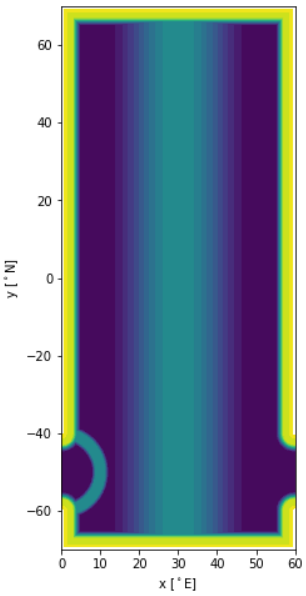
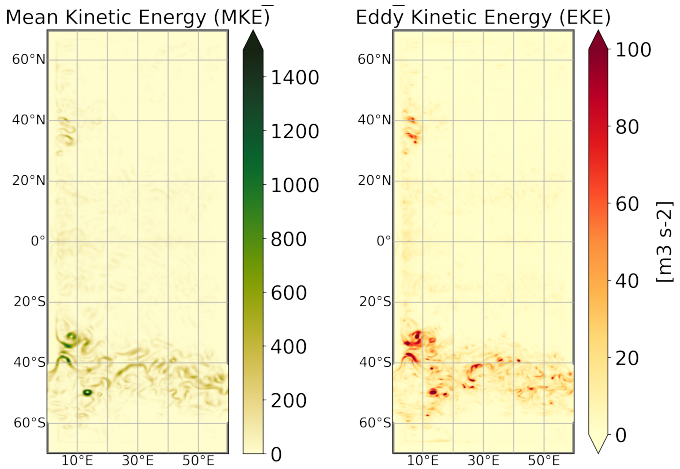
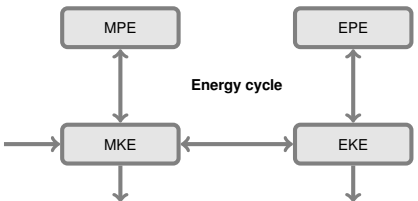


Nora Loose





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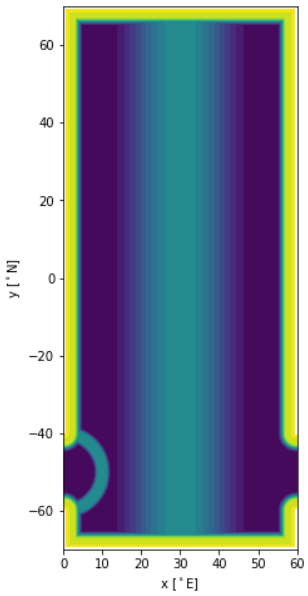

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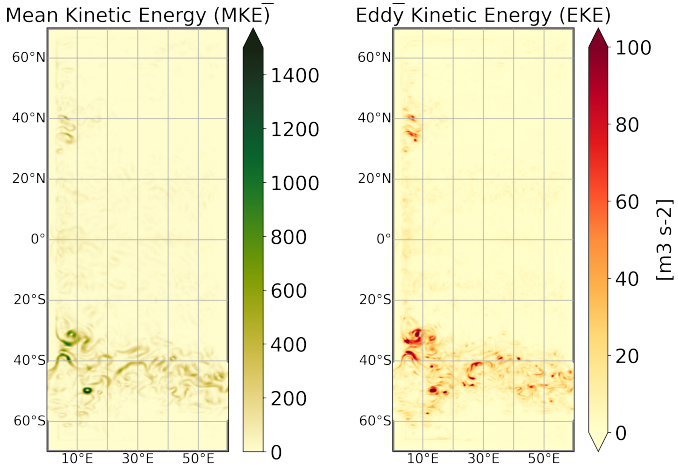
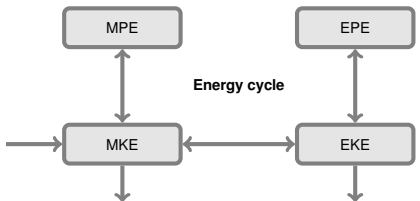
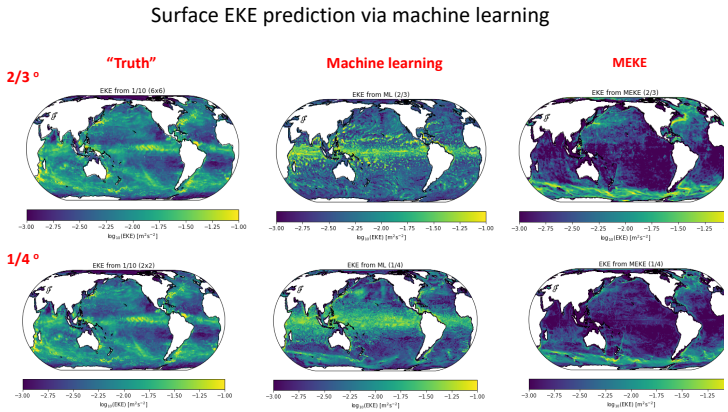




Gustavo Marques



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- How:
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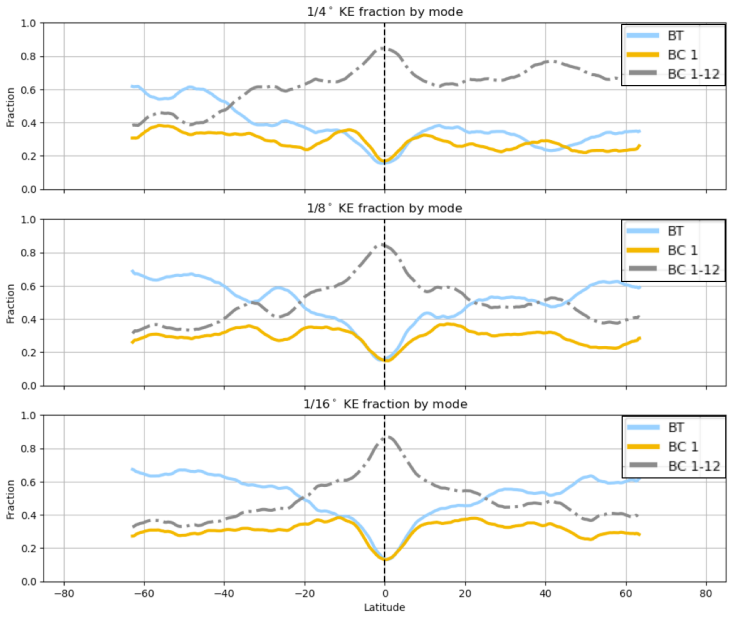
  - Unify closures of momentum & buoyancy through energy pathways

Elizabeth Yankovsky



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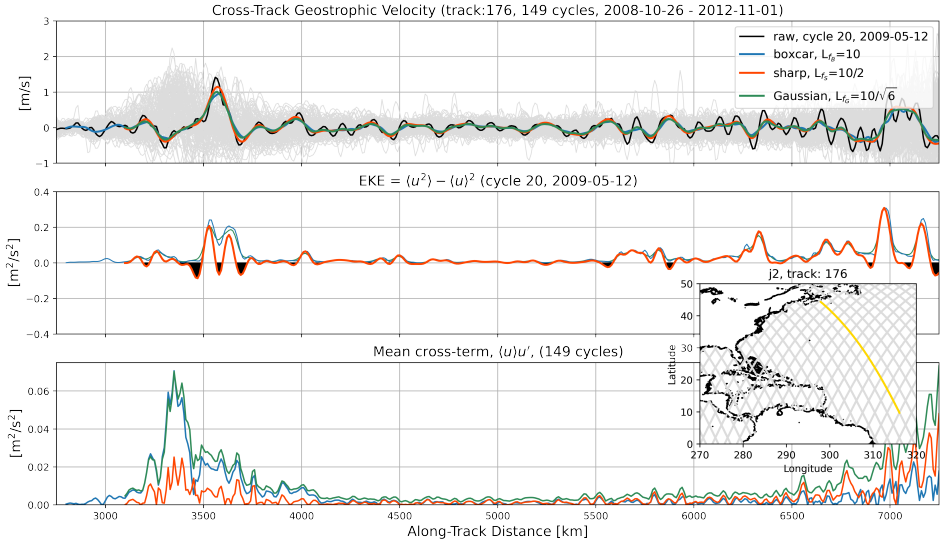
  - Unify closures of momentum & buoyancy through energy pathways
  - Curate observational diagnostics for model evaluations and constraining parameterizations

Jake Steinberg



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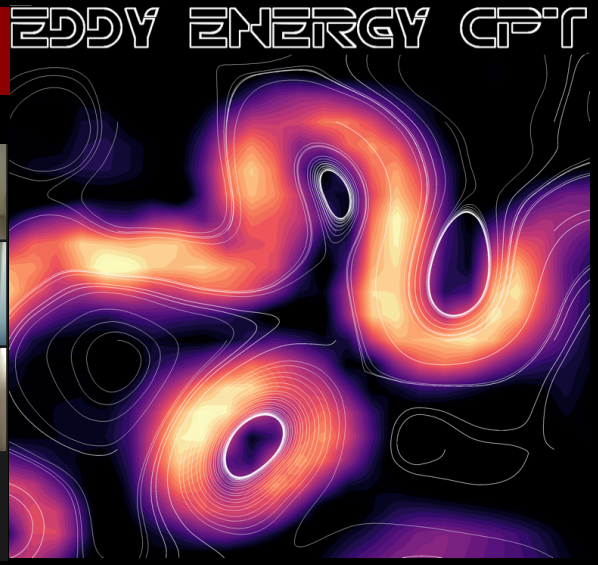

https://ocean-eddy-cpt.github.io/

This is possible thanks a great collaboration between observationalists and theoreticians at 8 institutions, and ocean modelers at GFDL, NCAR, LANL

Support from NOAA NSF US CLIVAR