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Dynamics and forcing of interannual regional steric sea level variability

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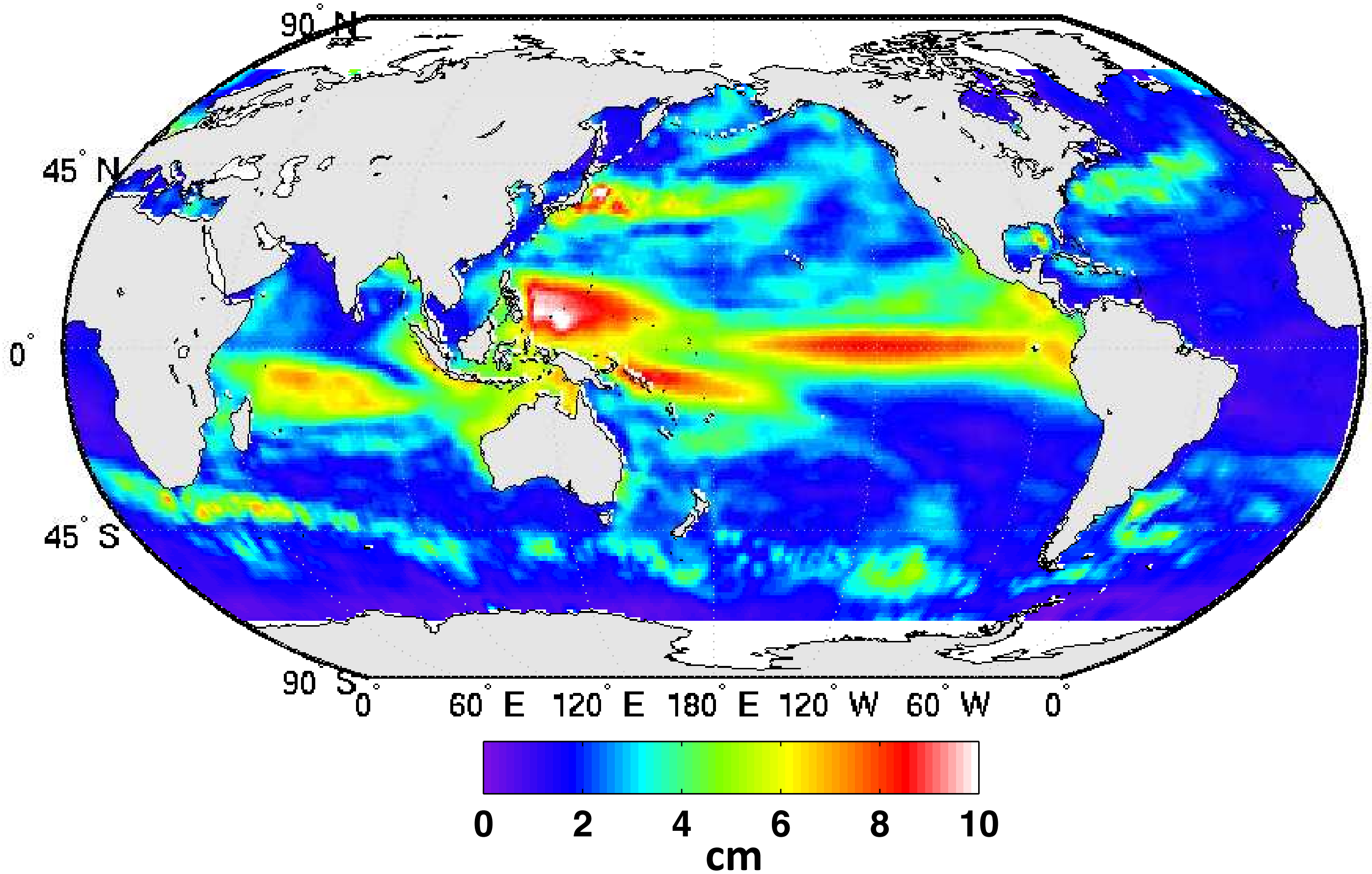
Interannual RMS variability from altimetry*



…what processes underlie these patterns?

*Merged TOPEX/Poseidon/*Jason* data '93-'04, smoothed in space (5°) and time (1 yr)

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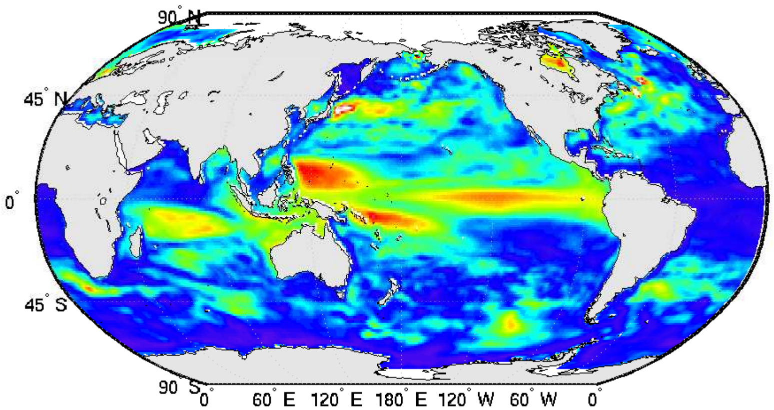
- **Mechanisms of sea level variability**
  - Forcing: external atmospheric driving (i.e., winds and buoyancy) and intrinsic ocean processes.
  - Dynamics: density advection, wave propagation, local Ekman pumping, mixing, etc.
- **An ocean state estimate**
  - ECCO-GODAE v2.216 (1993-2004)*
  - MITgcm, 80°S-80°N; 1°×1° grid; 23 vertical layers
  - Fit to altimetry, hydrography and other datasets
  - Satisfies governing thermo/dynamics and conservation laws (momentum, energy, etc.)

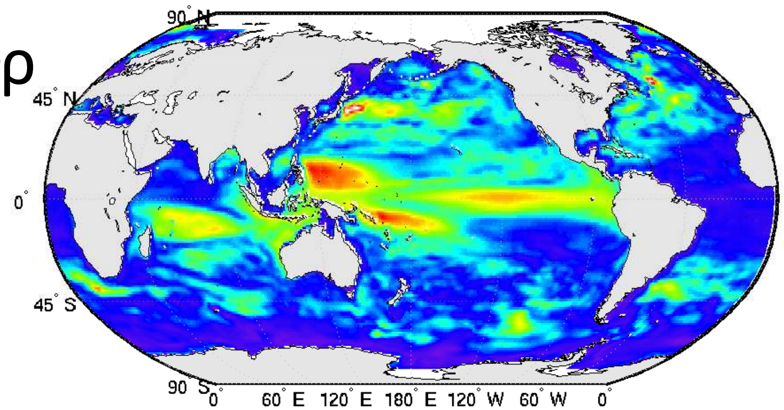
*Wunsch, Ponte & Heimbach (2007) J. Climate **20**

Interannual RMS variability (ECCO)

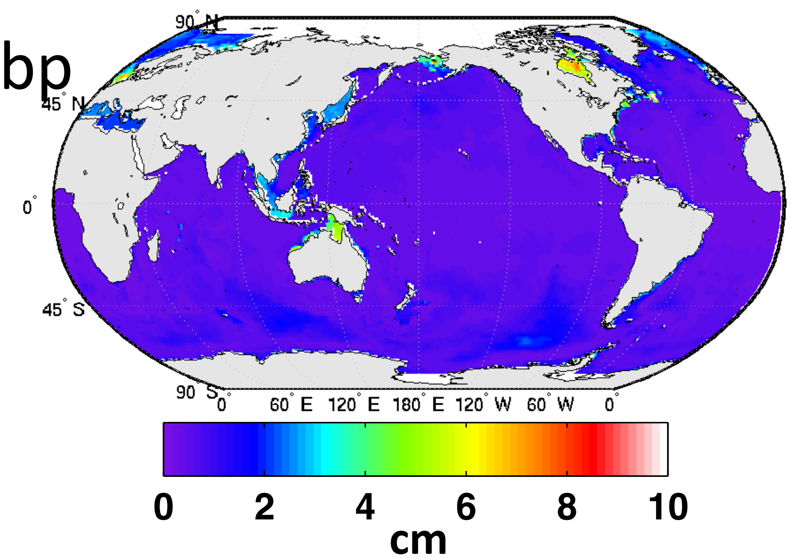
ζ



ζ_ρ



ζ_{bp}



<u>Hydrostatic condition:</u>

$$\zeta = \zeta_\rho + \zeta_{bp}$$

…what governs the steric changes?

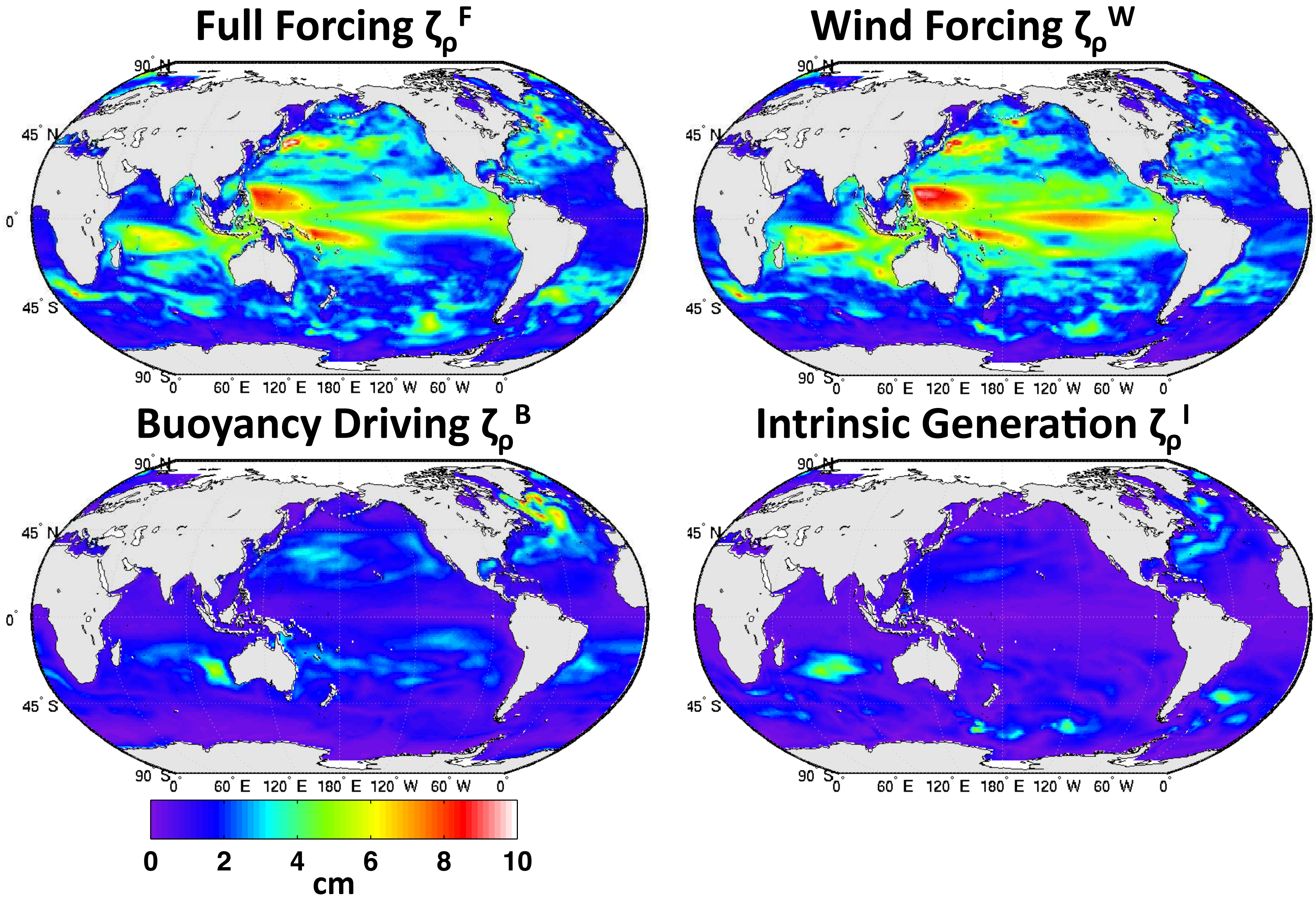
Forcing experiments*

		Buoyancy forcing	
		Fully Variable	*Climatological*
Wind forcing	*Fully Variable*	**I. VWVB**	**II. VWCB**
	Climatological	**III. CWVB**	**IV. CWCB**

- Influence of interannual forcing mechanisms:
  - Full: $\zeta^{F} = \zeta^{VWVB}$
  - Wind: $\zeta^{W} = \zeta^{VWCB} - \zeta^{CWCB}$
  - Buoy.: $\zeta^{B} = \zeta^{CWVB} - \zeta^{CWCB}$
  - Intr.: $\zeta^{I} = \zeta^{CWCB}$
- Assume linearity:
  - $\zeta^{F} = \zeta^{W} + \zeta^{B} + \zeta^{I}$

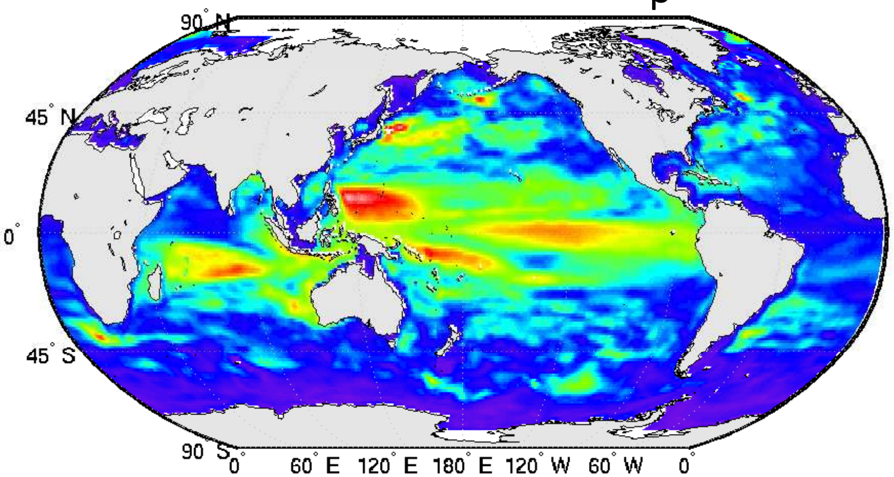
*Forcing represents NCEP/NCAR fields adjusted *via* ECCO optimization

Forcing of steric variability



Wind-forced variability

Total Variability ζ_ρ^W

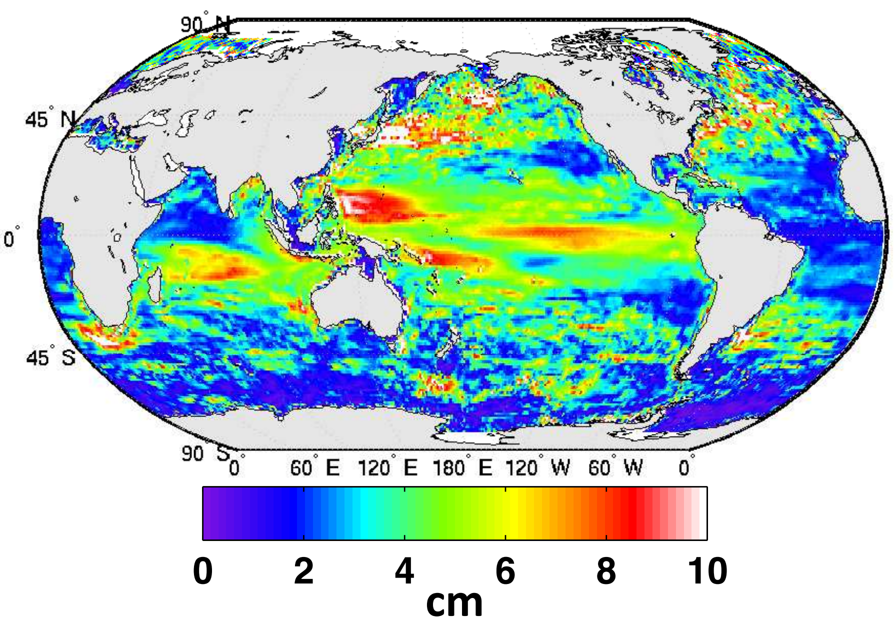


Steric height budget:

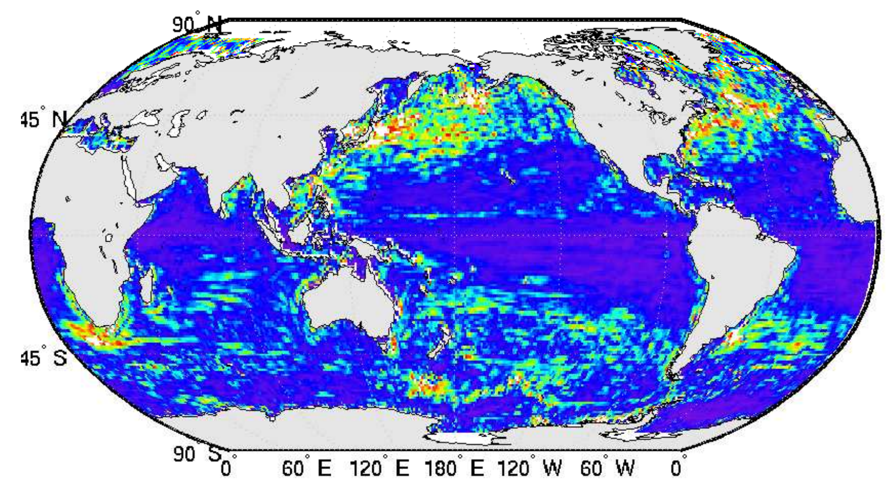
$$\zeta_\rho = A + M + F$$

Piecuch & Ponte (2011) GRL **38**

Advective Transport A^W



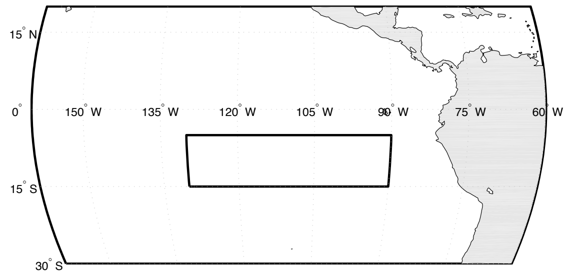
Diffusive Transport M^W

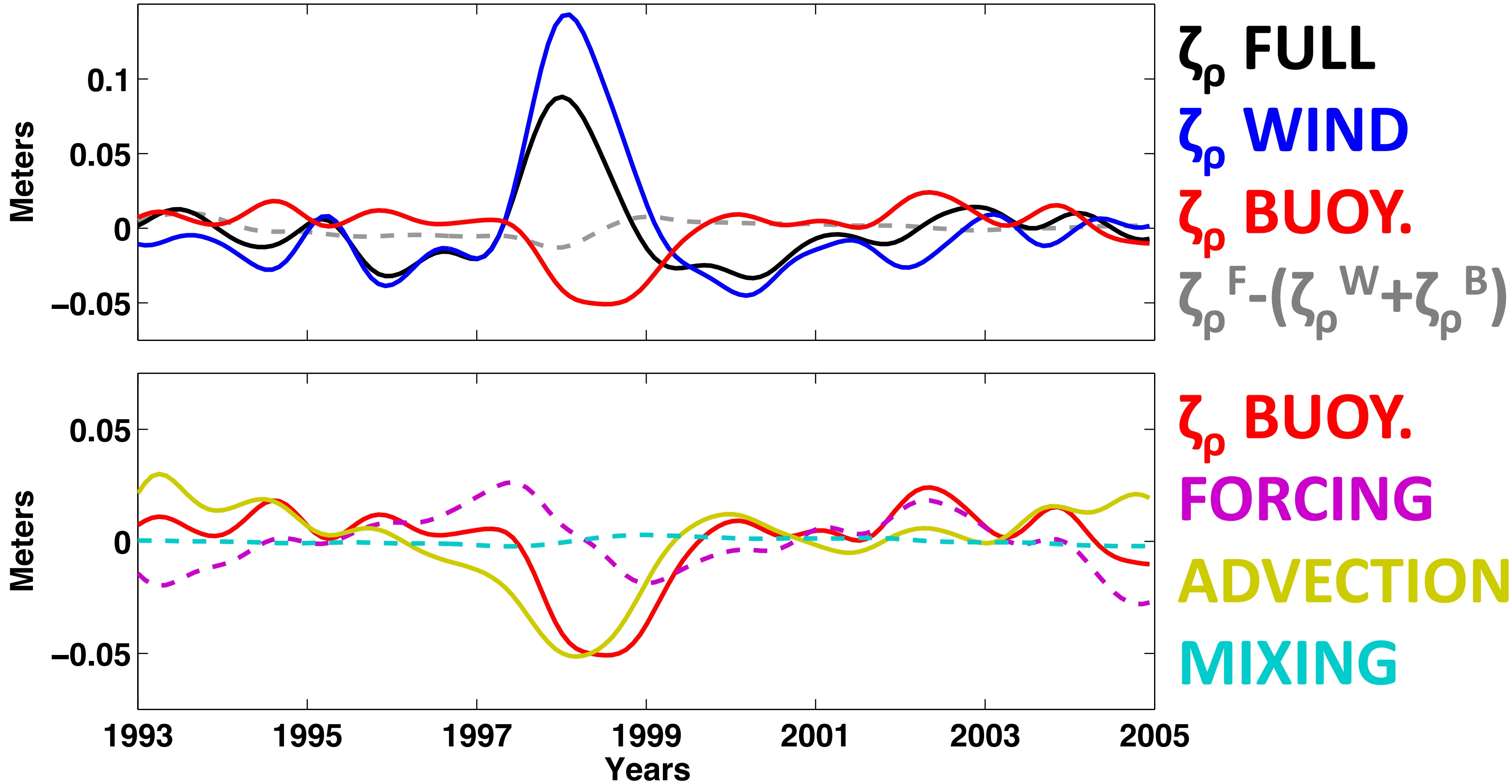


Research and Development Division – Oceanography Group

Tropical Pacific

15°S-5°S; 130°W-90°W





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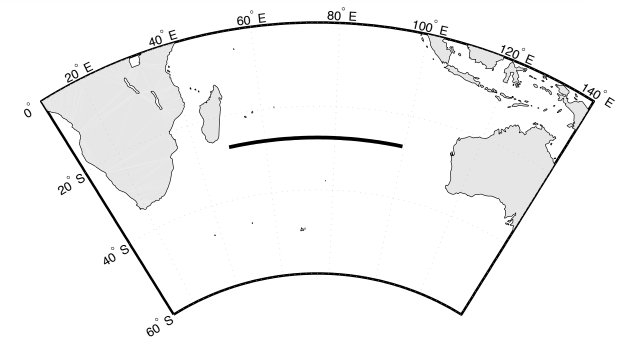
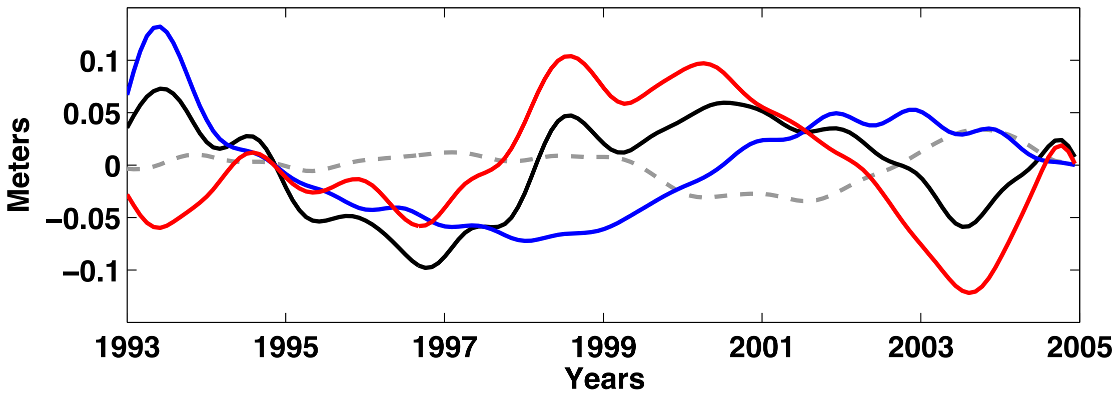
Subtropical Indian intrinsic variability



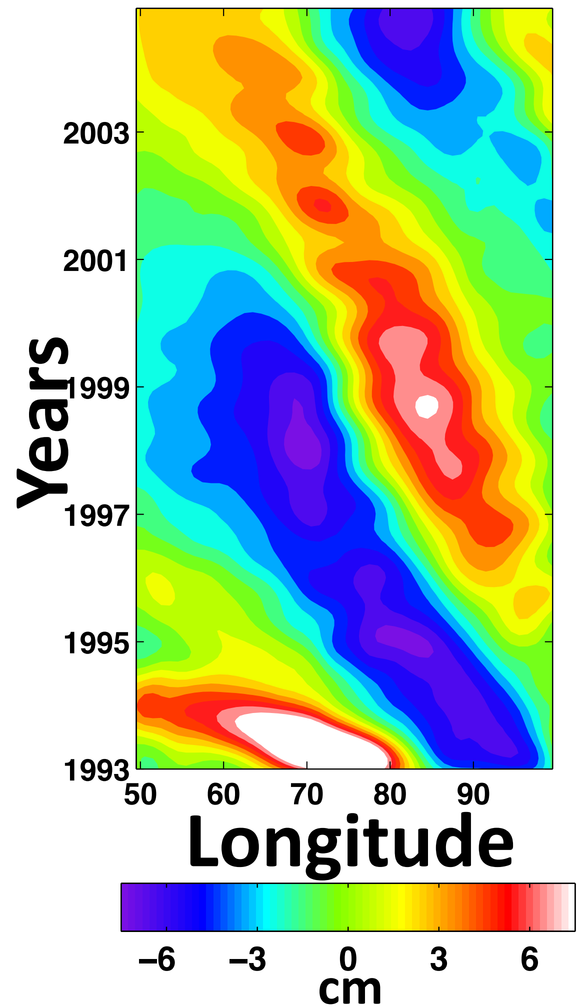
Time series @ 27.5°S, 69.5°E



ζ_ρ FULL ζ_ρ INTRINSIC

ζ_ρ BUOYANCY+ ζ_ρ WIND

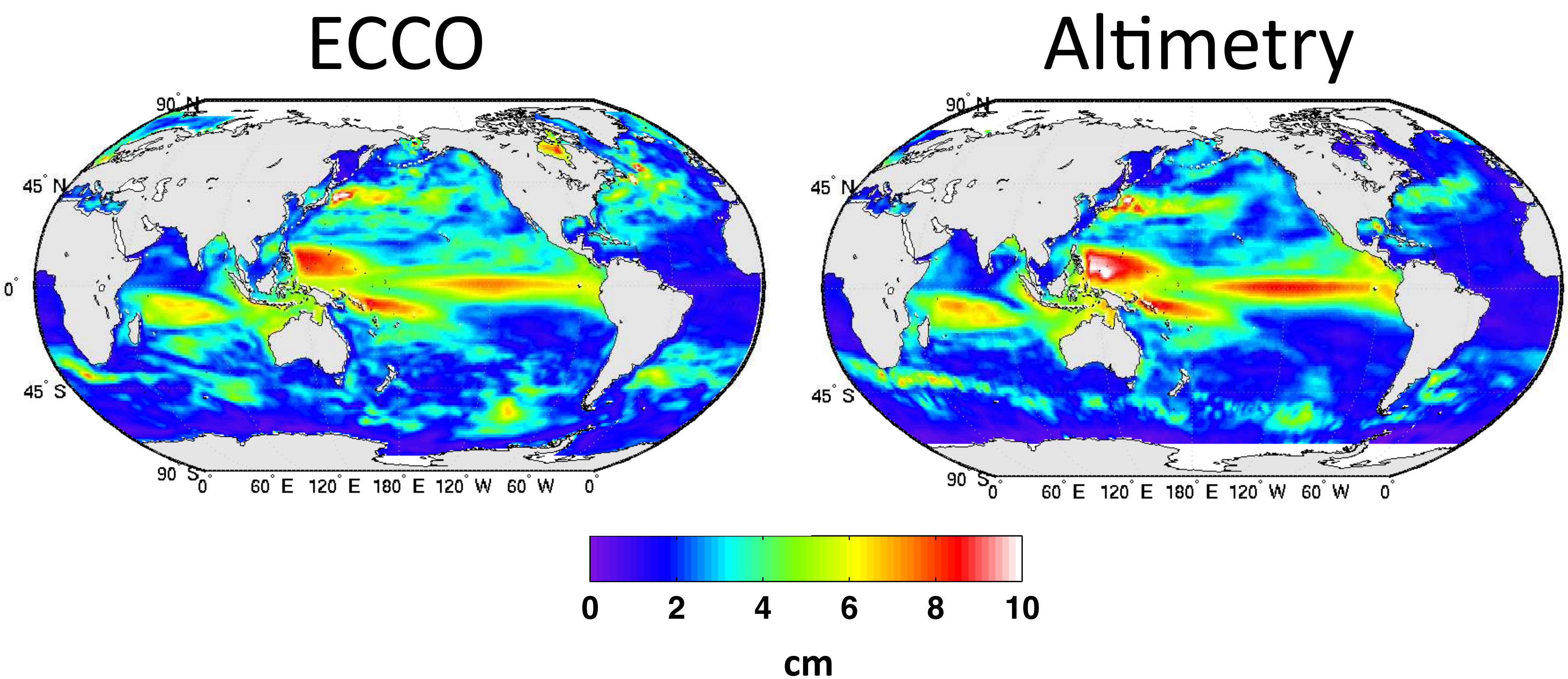
ζ_ρ RESIDUAL



Summary

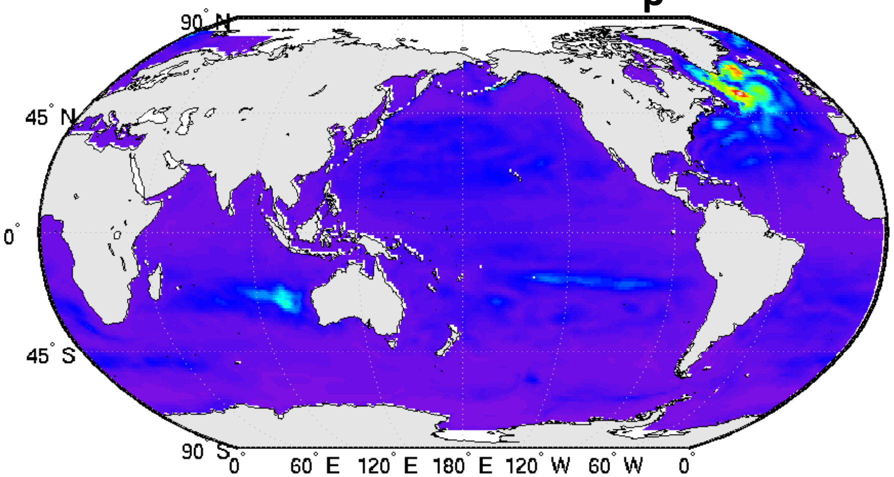
- Interannual ζ variability mostly represents steric changes resulting from wind variations and associated large-scale advection patterns
- However, other forcing mechanisms and dynamics can be important regionally
  - Local and remote buoyancy signals in tropics/subtropics
  - Parameterized sub-grid-scale fluxes in extratropics
  - Intrinsic variability in subtropics
- Need better understanding and accurate modeling of all these processes to simulate and project low frequency changes in regional sea level
  - Errors incurred if buoyancy forcing is assumed to have no remote or dynamical effect
  - Realism of parameterized sub-grid-scale mixing in coarse resolution models

Comparison interannual RMS variability

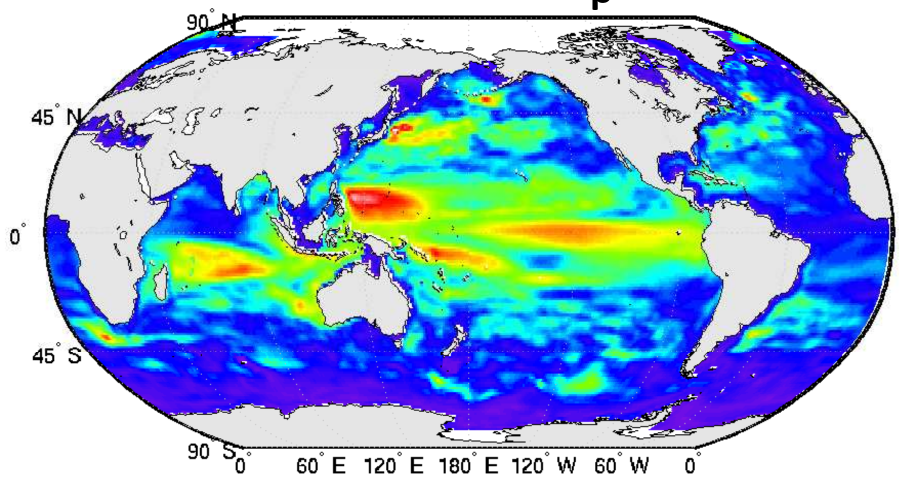


Checking decomposition

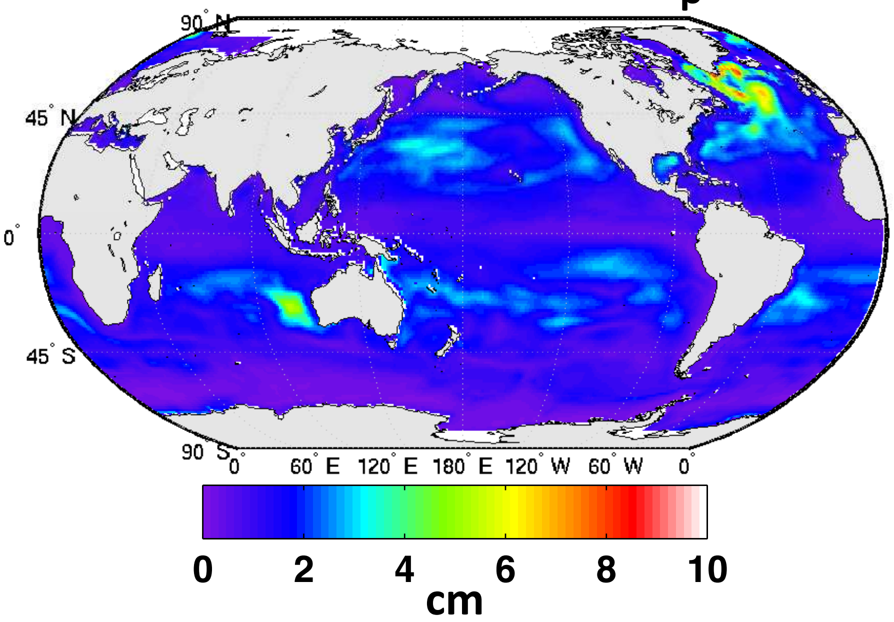
Residual RMS ζ_ρ



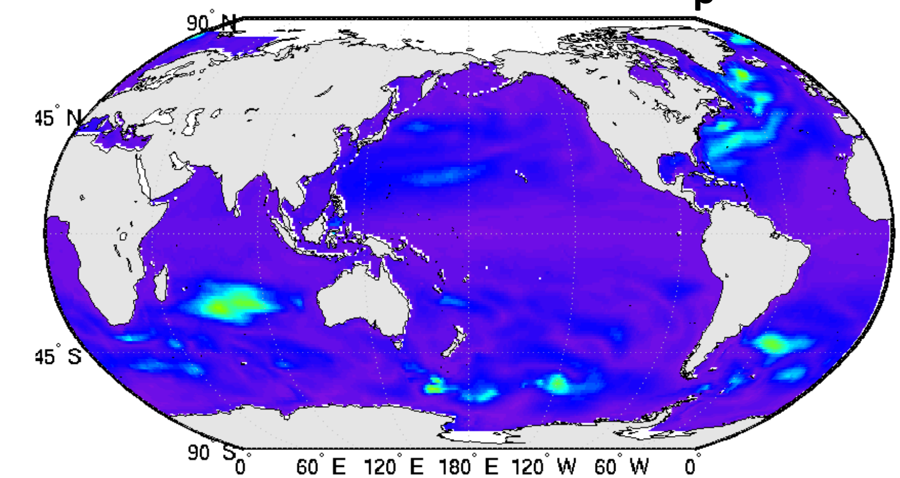
Wind Forcing ζ_ρ^W



Buoyancy Driving ζ_ρ^B

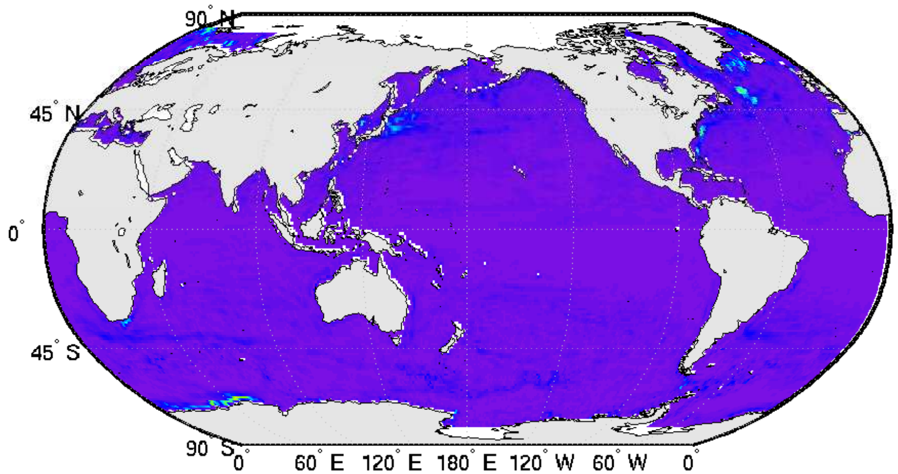


Intrinsic Generation ζ_ρ^I



Mixing Components

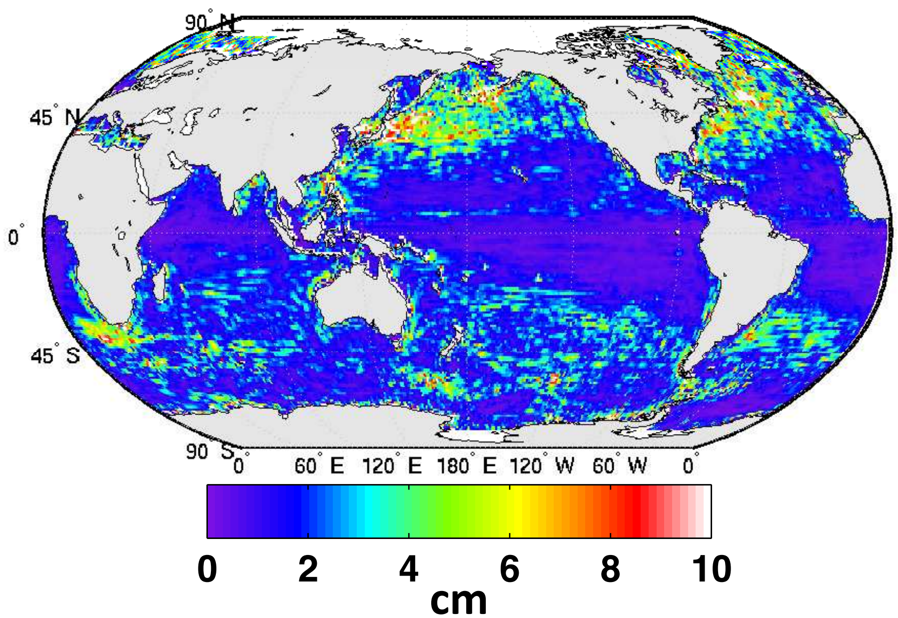
Laplacian Diffusion (LAP)



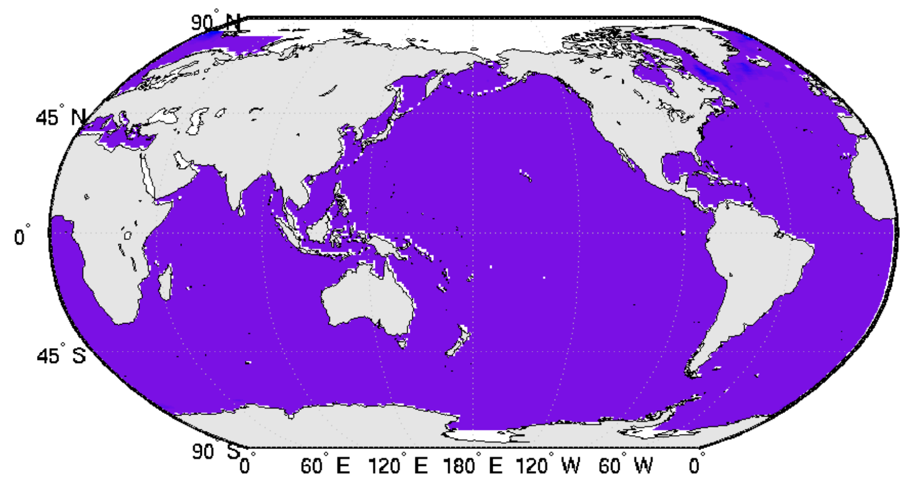
Mixing terms:

$$M = LAP + GMR + KPP$$

Gent-McWilliams/Redi (GMR)

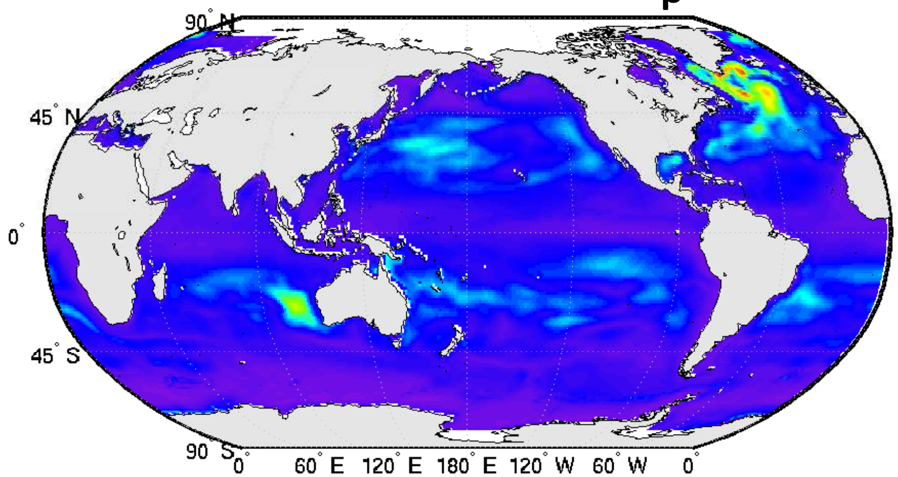


Nonlocal K profile (KPP)

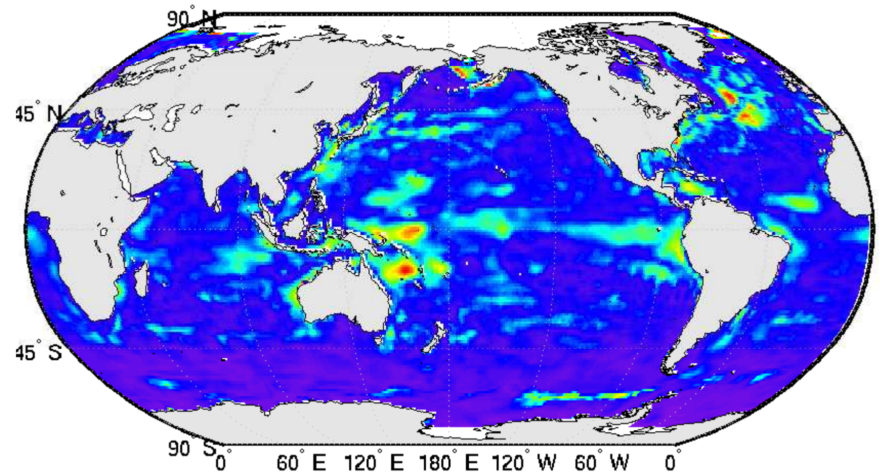


Buoyancy-driven changes

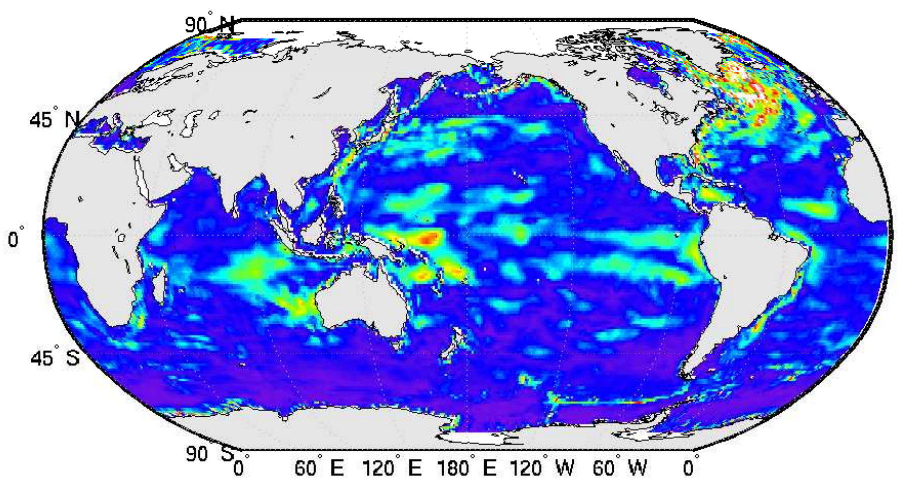
Total Variability ζ_ρ^B

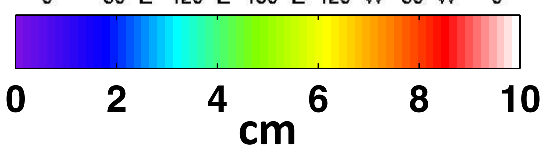


Surface Buoyancy Exchange F^B

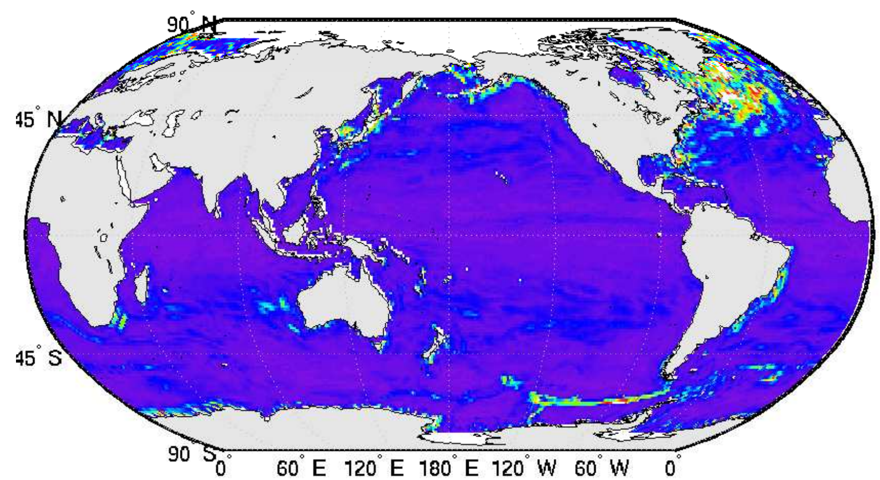


Advective Transport A^B





Diffusive Transport M^B



Tropical Atlantic
20°S-5°N; 30°W-10°E