ECCO2 Meridional Heat Transports in the Ocean

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Outline

- **Motivation**
- **Part 1:** Total Time-Mean Heat Transport
- **Part 2:** Eddy Heat Transport
- **Summary**

Motivation

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Meridional Heat Transport:

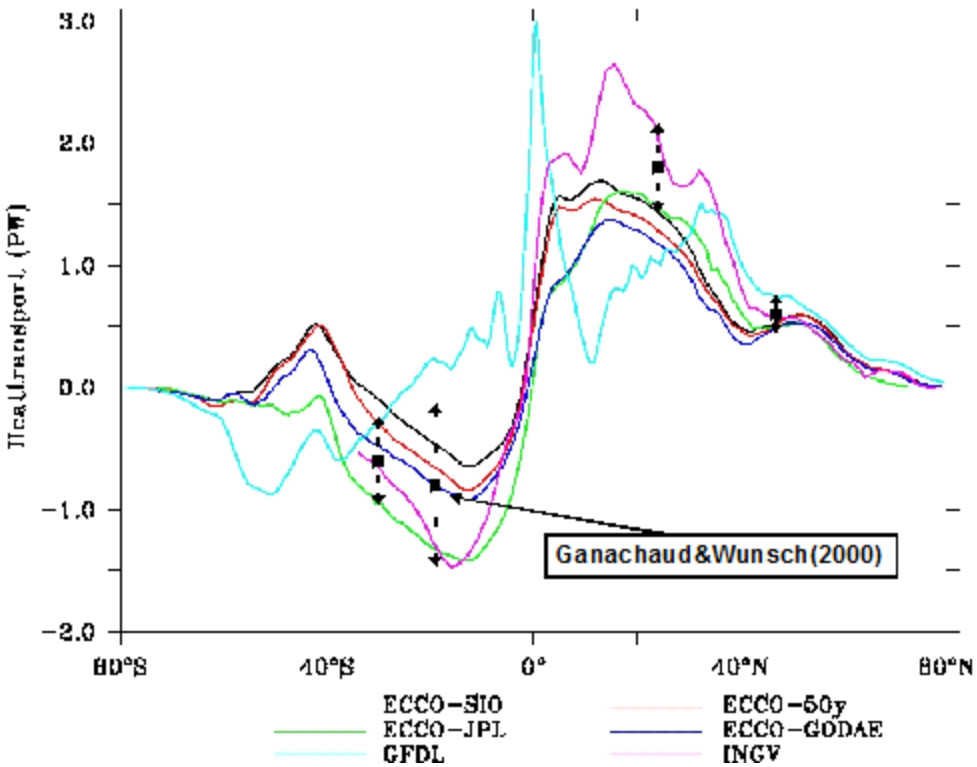
$$Q(y,t) = \iint \rho C_p \theta(x,y,z,t) V(x,y,z,t)\, dx\, dz$$

- MHT at **24°N** ~
1.5±0.3 PW [Macdonald & Wunch, 1996]
1.8±0.3 PW [Ganachaud & Wunch, 2000; Ganachaud & Wunch, 2003]

- Heat is transported poleward by both the overturning (zonally integrated) and the horizontal (gyre transport) circulations

Objective 1:
Estimate the relative contribution of the **overturning** and **horizontal** circulations to the meridional heat transport?

Global Oceanic Heat Transport



by Armin Koehl; www.clivar.org

Motivation

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- **Part 1:** Total Time-Mean Heat Transport
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Eddy Heat Transport:

$$Q_{eddy}(y,z) = \iint \rho C_p \theta V dxdz - \iint \rho C_p \langle\theta\rangle\langle V\rangle dxdz$$

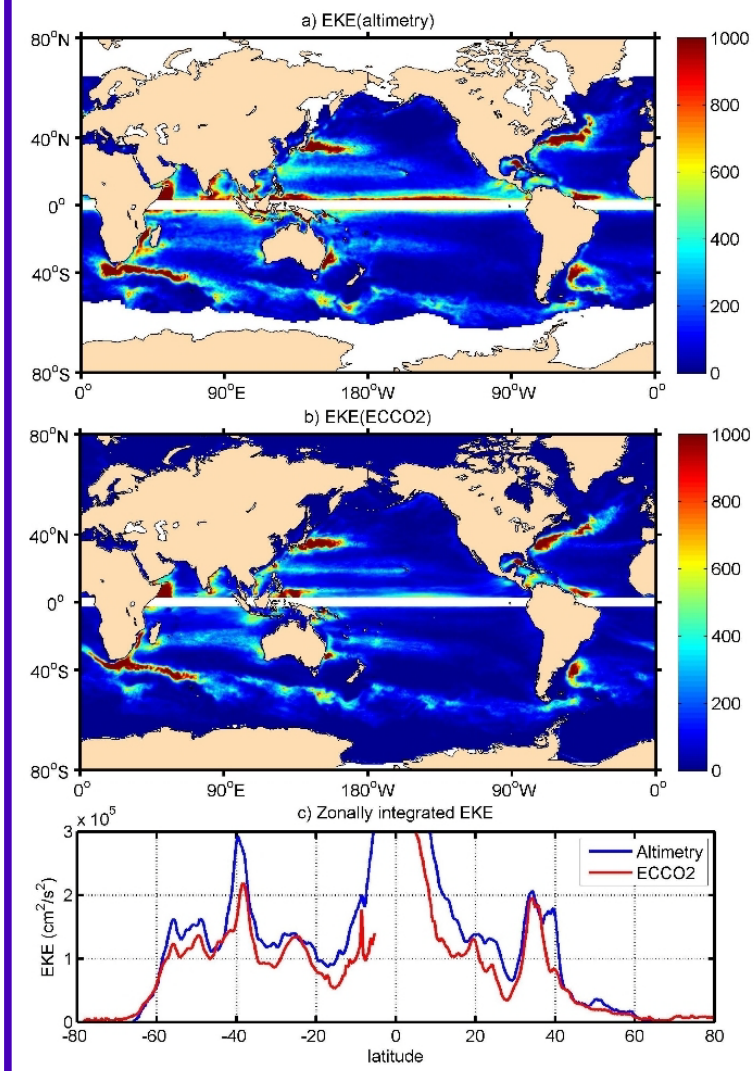
Earlier estimates of the EHT
[e.g. Jayne & Marotzke, 2002]:

- were based on coarser resolution GCM (model EKE much less than altimetry EKE)
- included variability on all time scales
- considered only the time-mean EHT

Objective 2:
Estimate the time-dependent EHT

- benefiting from eddy permitting resolution of ECCO2
- using 3-month averages of θ and V
- assessing the contribution of eddies to the variability of the MHT

EKE: Altimetry vs ECCO2



Part 1

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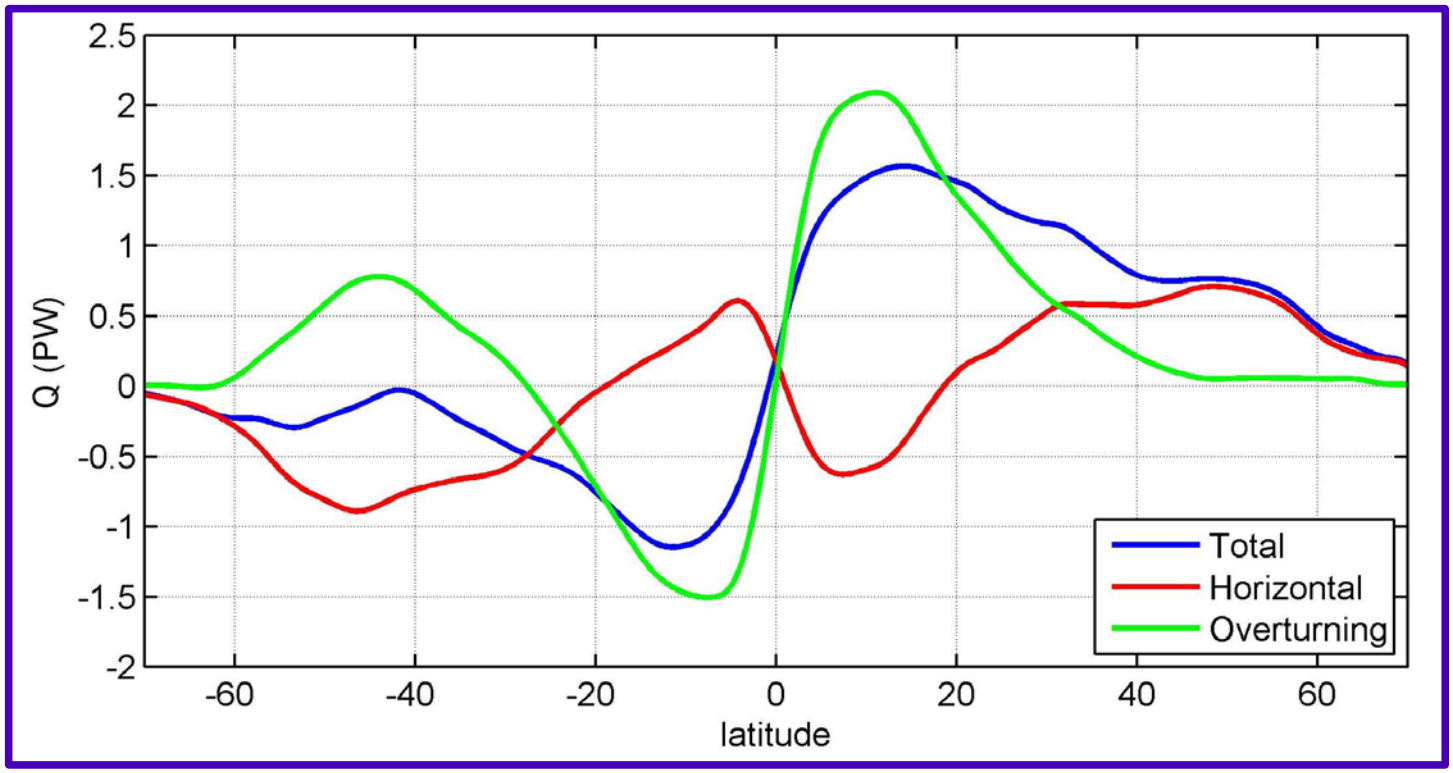
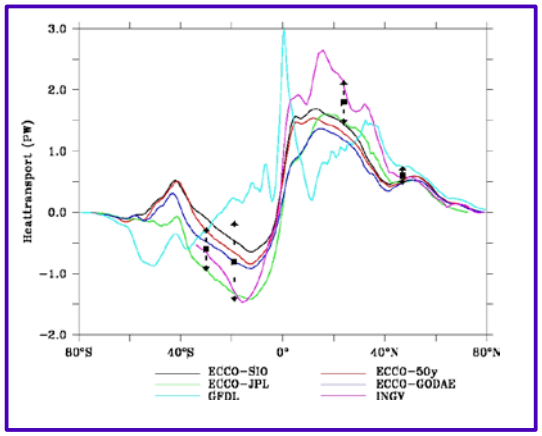
Eddy Heat Transport:

$$Q(y,t) = \iint \rho C_p \theta V dxdz = \rho C_p \left(\underbrace{\iint \theta \langle V \rangle dxdz}_{\text{overturning}} + \underbrace{\iint \theta V' dxdz}_{\text{horizontal}} \right)$$

$V = \langle V \rangle + V'$ where <V> is the zonally averaged meridional velocity



World Ocean



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Eddy Heat Transport:

$$Q(y,t) = \iint \rho C_p \theta V dxdz = \rho C_p \left(\underbrace{\iint \theta \langle V \rangle dxdz}_{\text{overturning}} + \underbrace{\iint \theta V' dxdz}_{\text{horizontal}} \right)$$

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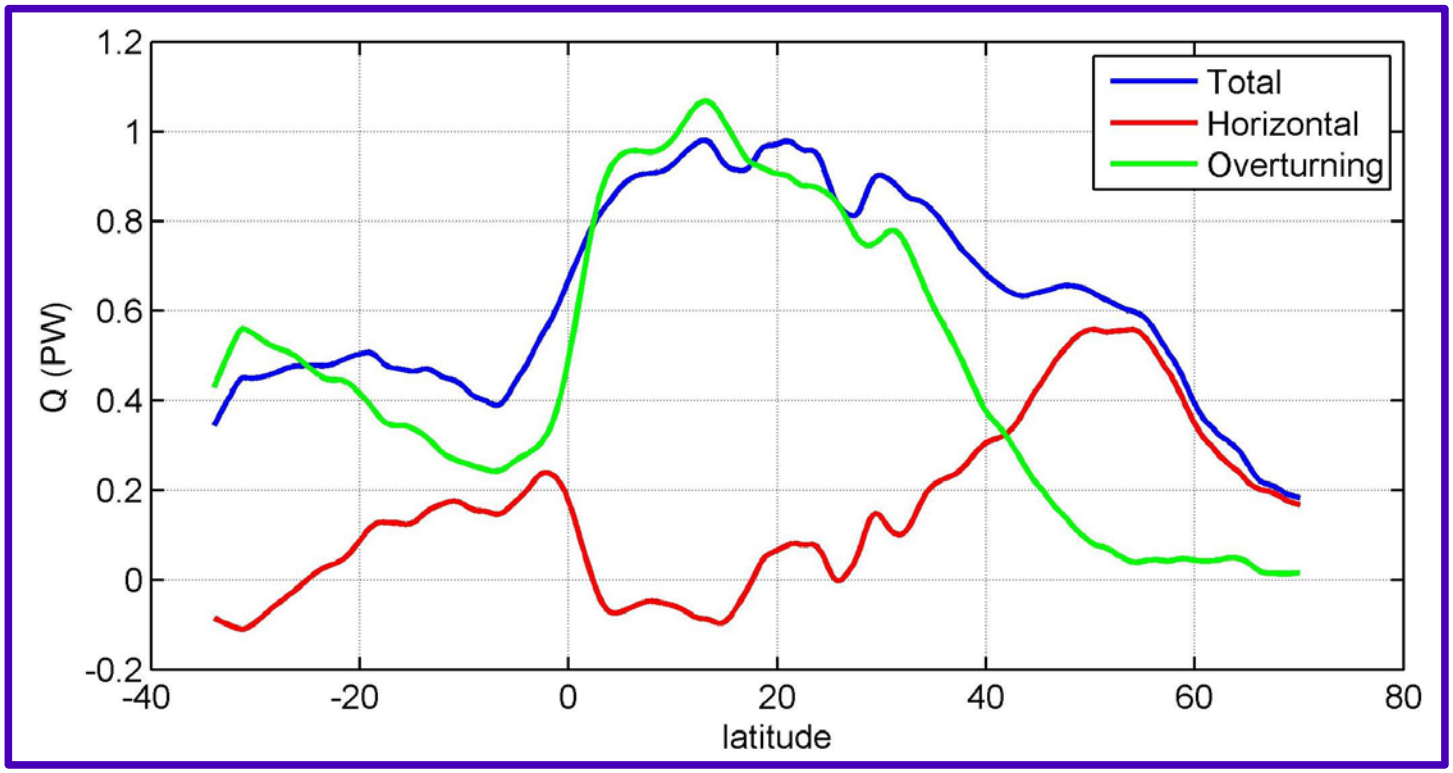

Atlantic Ocean

Part 1

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Eddy Heat Transport:

$$Q(y,t) = \iint \rho C_p \theta V dxdz = \rho C_p \left(\underbrace{\iint \theta \langle V \rangle dxdz}_{\text{overturning}} + \underbrace{\iint \theta V' dxdz}_{\text{horizontal}} \right)$$

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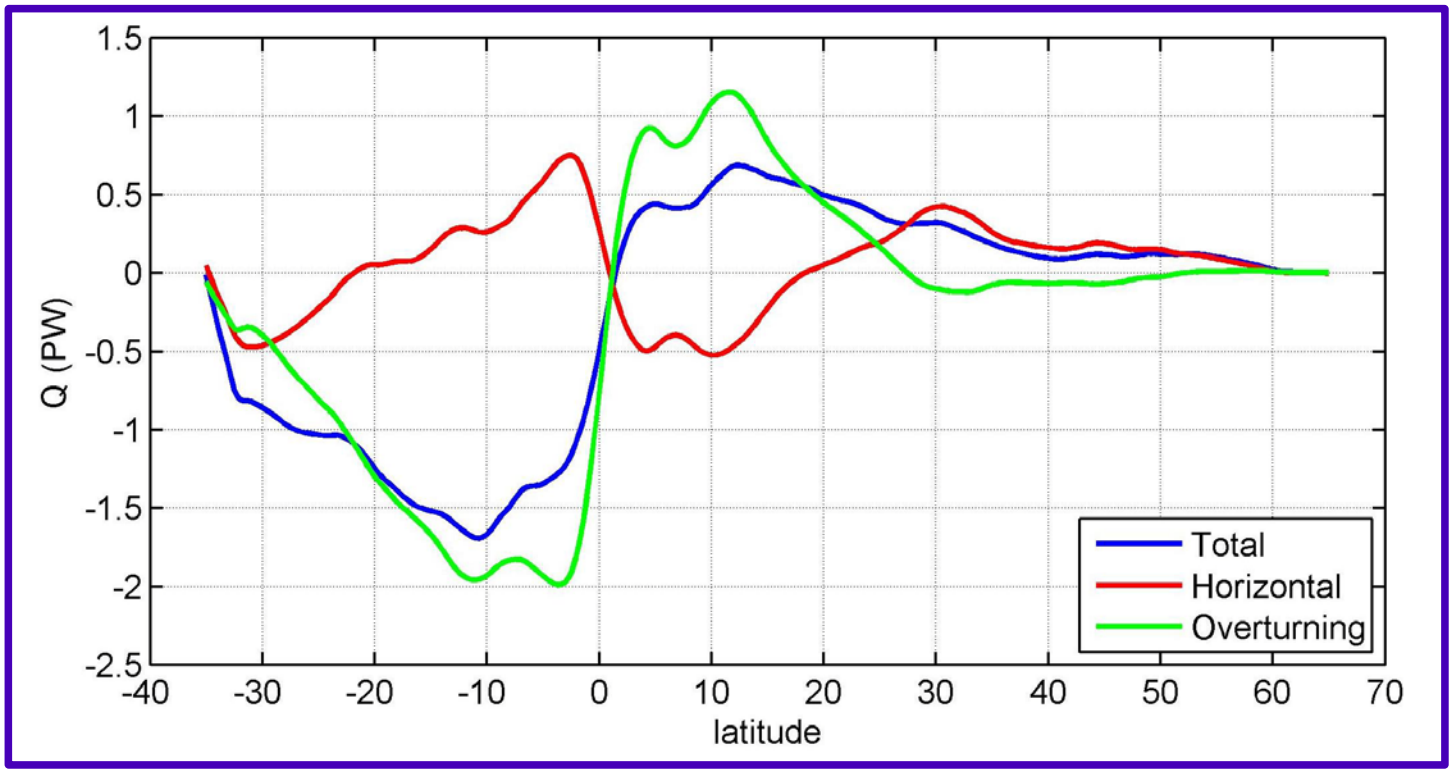

Indo-Pacific

Part 2

- Motivation
- **Part 1:** Total Time-Mean Heat Transport
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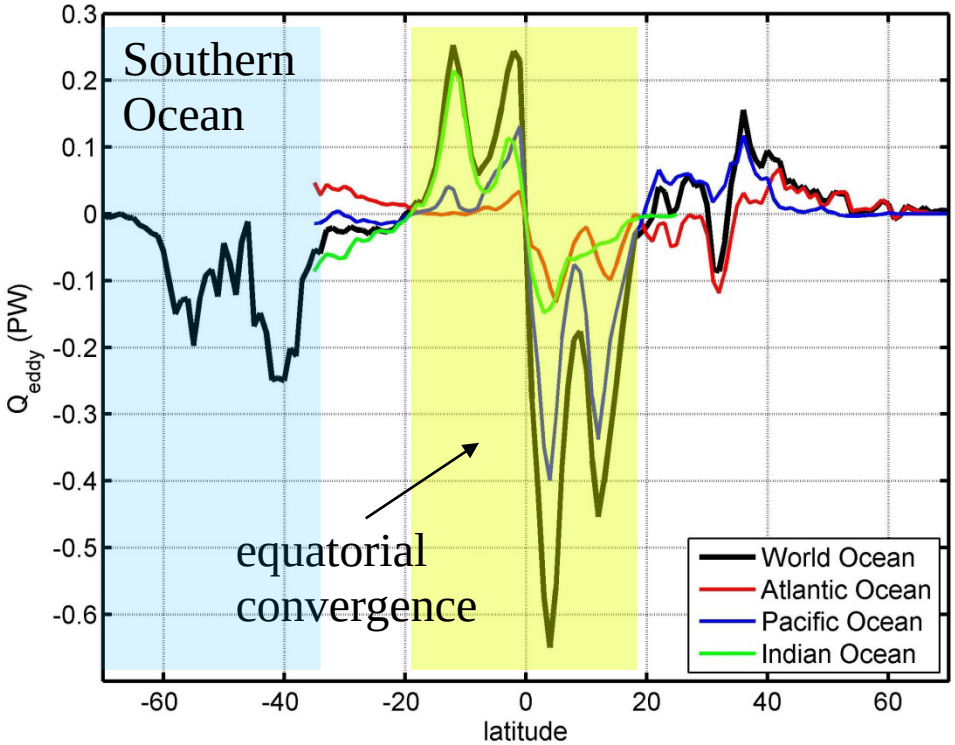
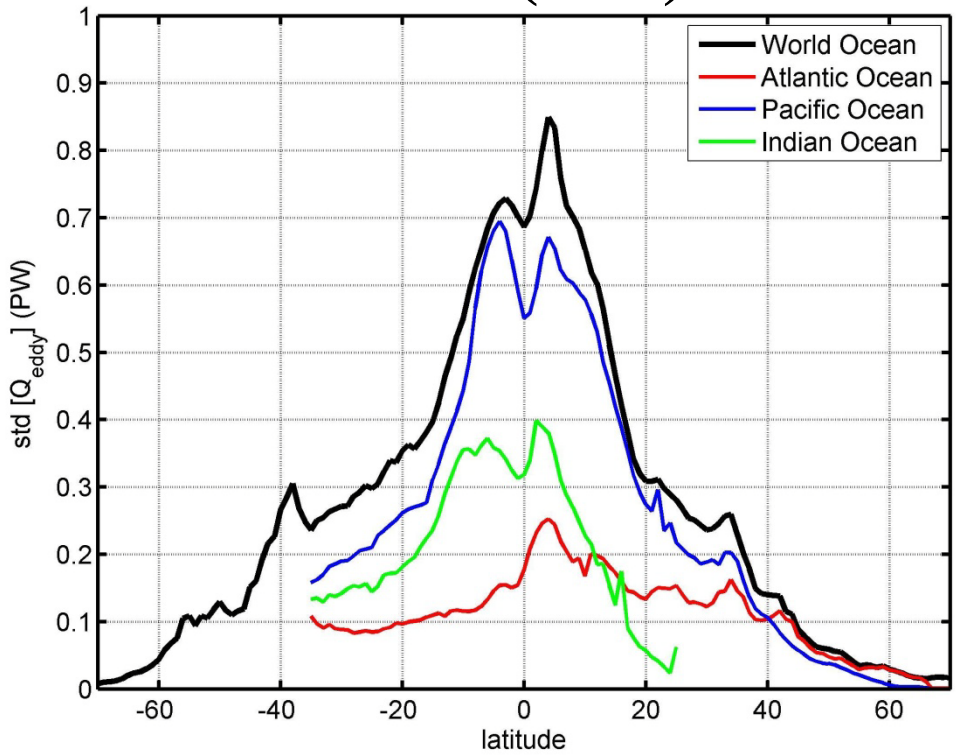
Eddy Heat Transport: $$Q_{eddy}(y,z) = \iint \rho C_p \theta V dxdz - \iint \rho C_p \langle \theta \rangle_{3months} \langle V \rangle_{3months} dxdz$$

Time-mean EHT



STD (EHT)



In the tropics away from equator, in the Southern Ocean, and in the Kuroshio Current EHT significantly contributes to the time-mean total MHT

Part 2

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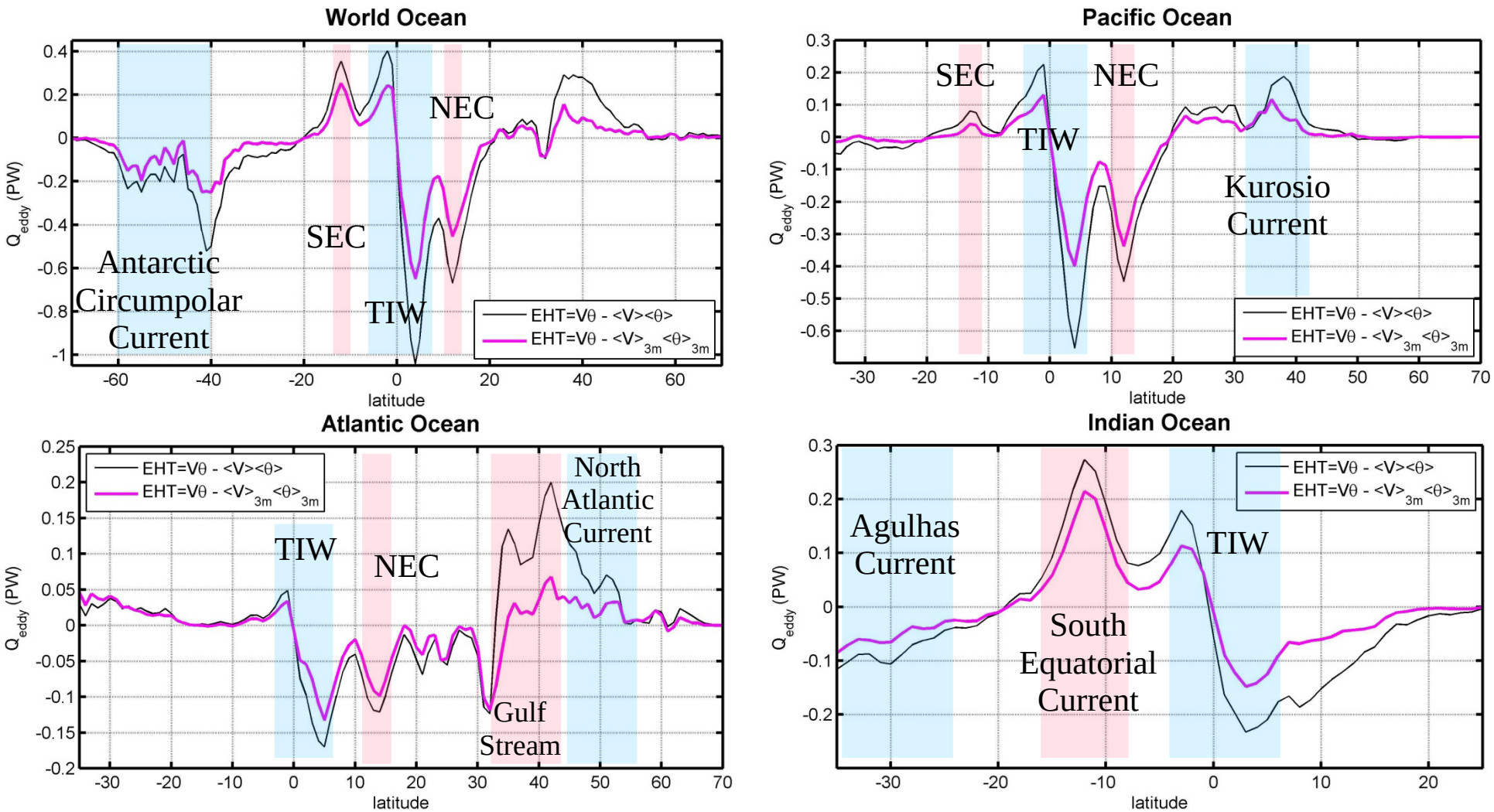
The impact of the EHT definition:

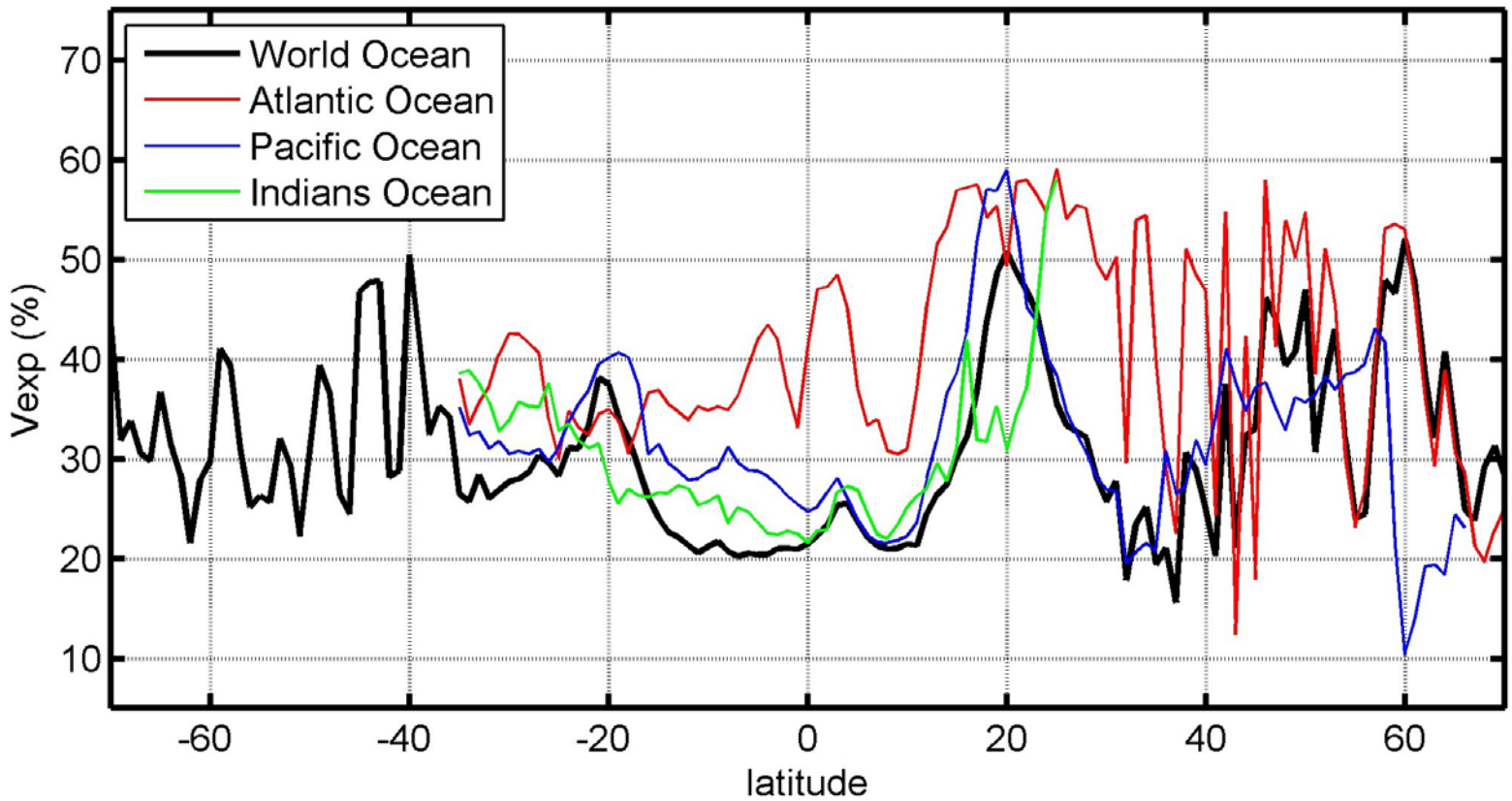
$$Q_{eddy}(y,z) = \iint \rho C_p \theta V dxdz - \iint \rho C_p \langle\theta\rangle\langle V\rangle dxdz$$



Part 2

➢ What is the contribution of the EHT to the time-dependent MHT?

Portion of the total MHT variance (%) explained by the EHT



Globally the EHT explains ~1/3 of the MHT variance

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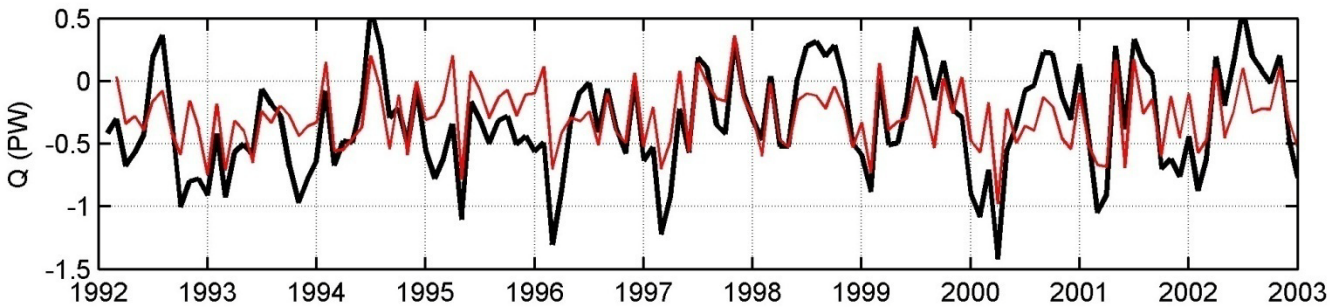
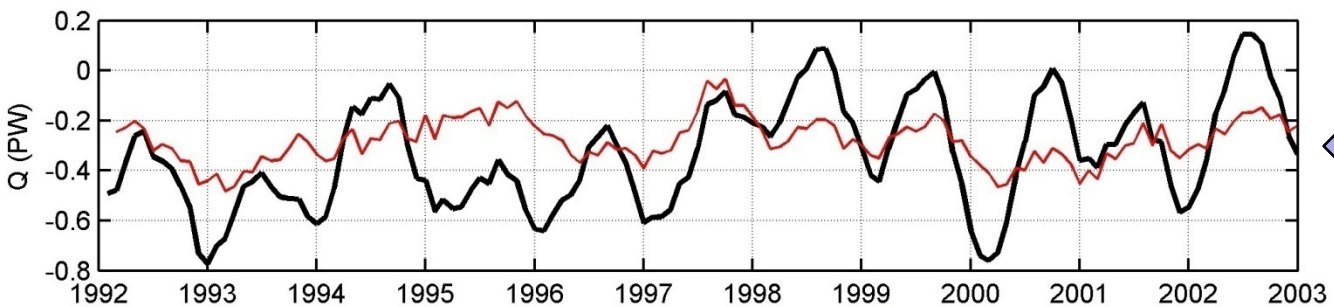
➢ How much of the seasonal-interannual MHT variance is due to eddies?

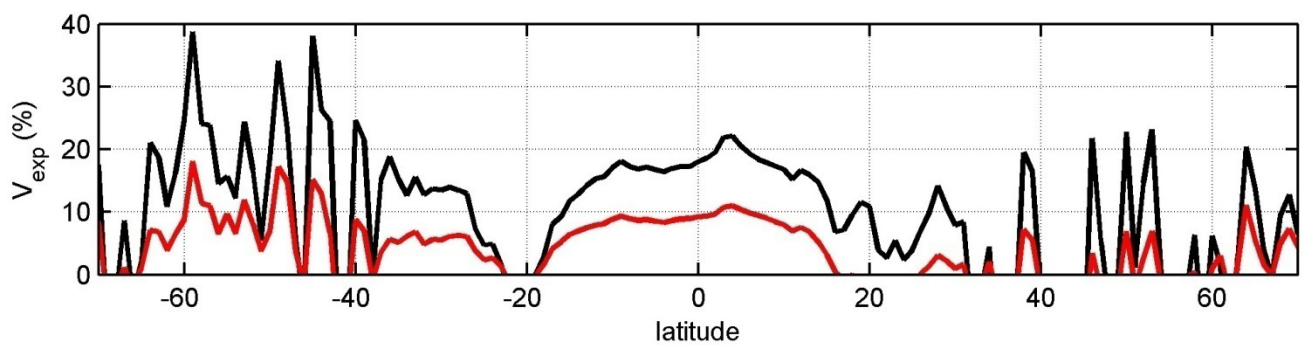


MHT

EHT



low-pass filtered with a 7-month running mean



The portion of the seasonal-interannual (**black curve**) and the total (**red curve**) MHT variance explained by the seasonal-interannual EHT

Summary

- In the subpolar oceans most of heat is transported poleward by the horizontal circulation; the overturning circulation is dominant in the subtropical gyres

- This research demonstrates the importance of increasing the spatial resolution of models and a proper separation of the eddy signal from lower frequency variability

- The eddy heat transport has a significant contribution to the time-mean heat transport in the tropics, in the Southern Ocean, and in the Kuroshio Current

- Eddies represent a significant contributor to the variability of the total heat transport