The impact of air-sea interaction on wind stress and ocean circulation

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Wind Stress in Global HYCOM

$$\tau = c_d(T_N, U_{10})|U_{10}|(U_{10})$$

- Traditionally used in HYCOM
- Function of atmospheric winds only

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This approach appears to be incomplete …

- Chelton (2004) – impact of SST resolution on wind stress accuracy
- Cornillon and Park (2001), Kelly et al. (2001) – Impact of ocean currents on wind stress
- Anderson et al. (2011), McClean et al. (2011) – simulation improvements via the inclusion of ocean/atmosphere shear

What are the impacts of wind-current shear and the finer spatial/temporal resolution model SST in the wind stress used to force global HYCOM?

Investigate using .08° Global HYCOM

$$\tau_{classical} = c_d(T_{SH}, U_{10})|U_{10}|(U_{10})$$

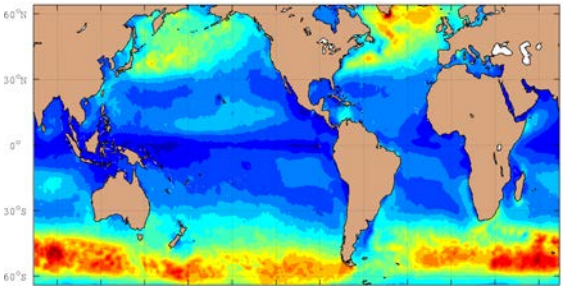
$$\tau_{mbl} = c_d(T_H, U_{10})|U_{10}|(U_{10})$$

$$\tau_{mbl+shear} = c_d(T_H, U_{10} - U_H)|U_{10} - U_H|(U_{10} - U_H)$$

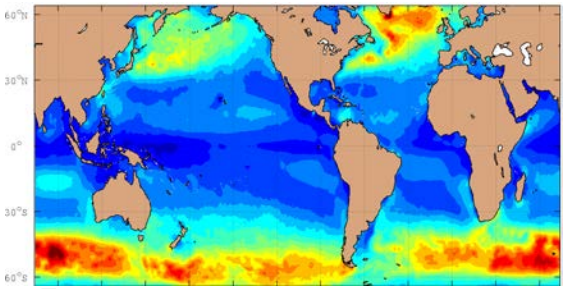
mbl - modified boundary layer stability
T_H - HYCOM SST
T_{SH} - smoothed HYCOM SST
U_{10} - 10m wind
U_H – HYCOM surface current

Impact of including high-res SST and current-wind shear – stress magnitude

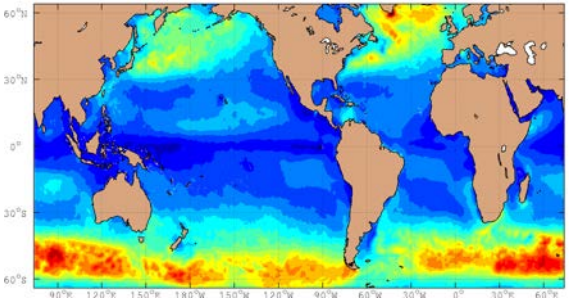
$\tau_{classical}$

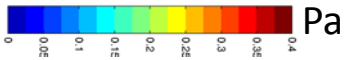


τ_{mbl}

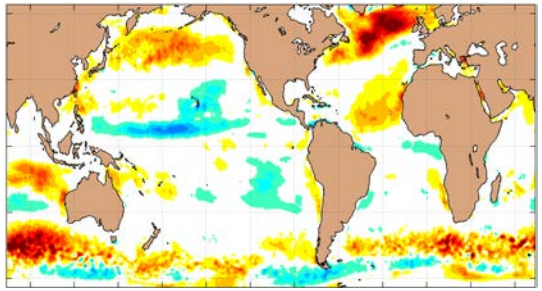


$\tau_{mbl+shear}$

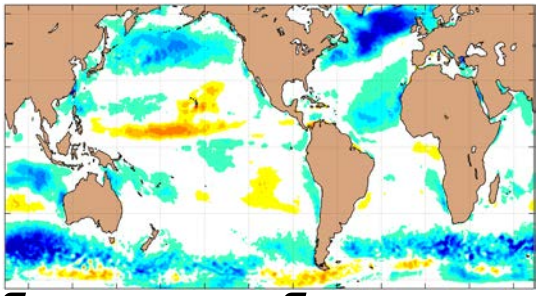




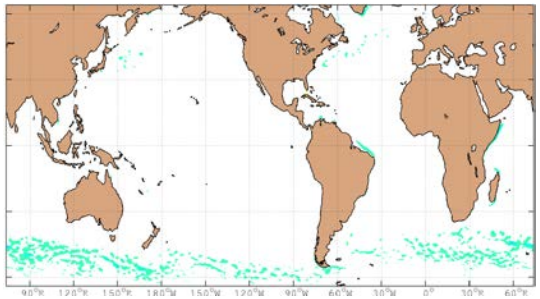
τ_{mbl} - $\tau_{classical}$

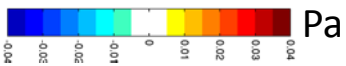


$\tau_{mbl+shear}$ - τ_{mbl}



$\tau_{mbl+shear}$ - $\tau_{classical}$





(impact of high-res SST)

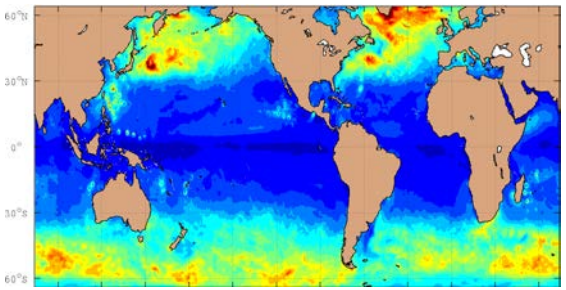
(impact of ocean-atm shear)

(impact of high-res SST + shear)

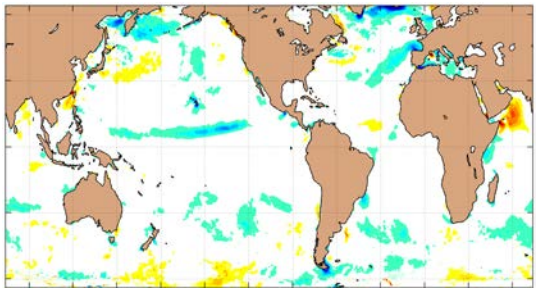
1 year mean - July 2012 – June 2013

Impact of including high-res SST and current-wind shear – variability

$\tau_{classical}$

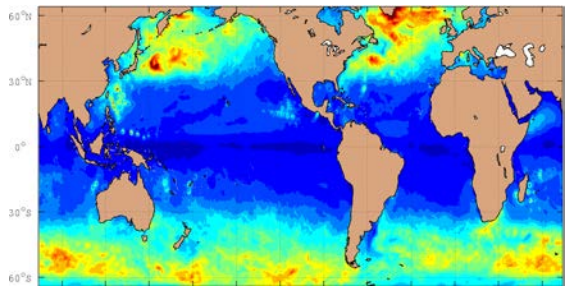


τ_{mbl} - $\tau_{classical}$

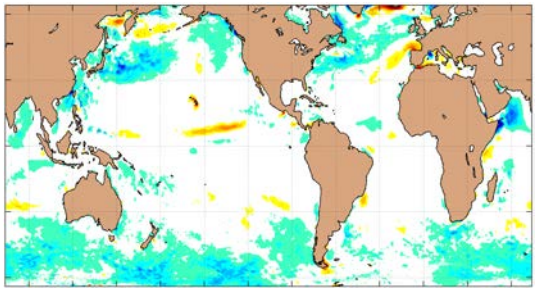


(impact of high-res SST)

τ_{mbl}

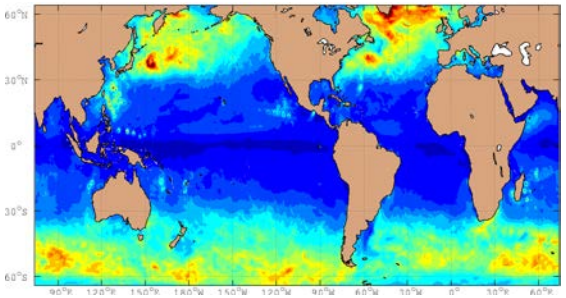


$\tau_{mbl+shear}$ - τ_{mbl}

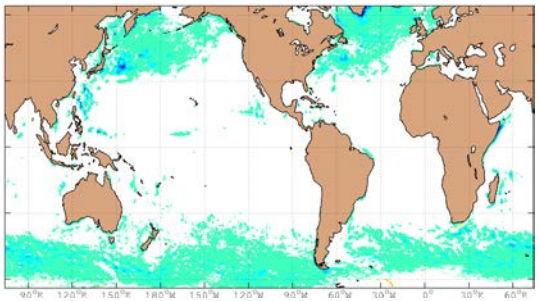


(impact of ocean-atm shear)

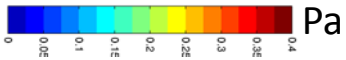
$\tau_{mbl+shear}$

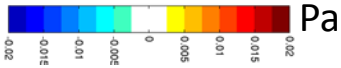


$\tau_{mbl+shear}$ - $\tau_{classical}$



(impact of high-res SST + shear)





1 year RMS variability July 2012 – June 2013

What impact does the change in stress formulation have on the properties of eddies?

We identified and tracked eddies using a technique based upon the Okubo-Weiss parameter which is a measure of the difference between the deformation and vorticity of the velocity field (Okubo, 1970; Weiss, 1991; Isern-Fontanet et al., 2003; Douglass and Richman, 2014).

We first examine the number of eddies and their lifetime, radius and rotational speed for the years 2003-2007.

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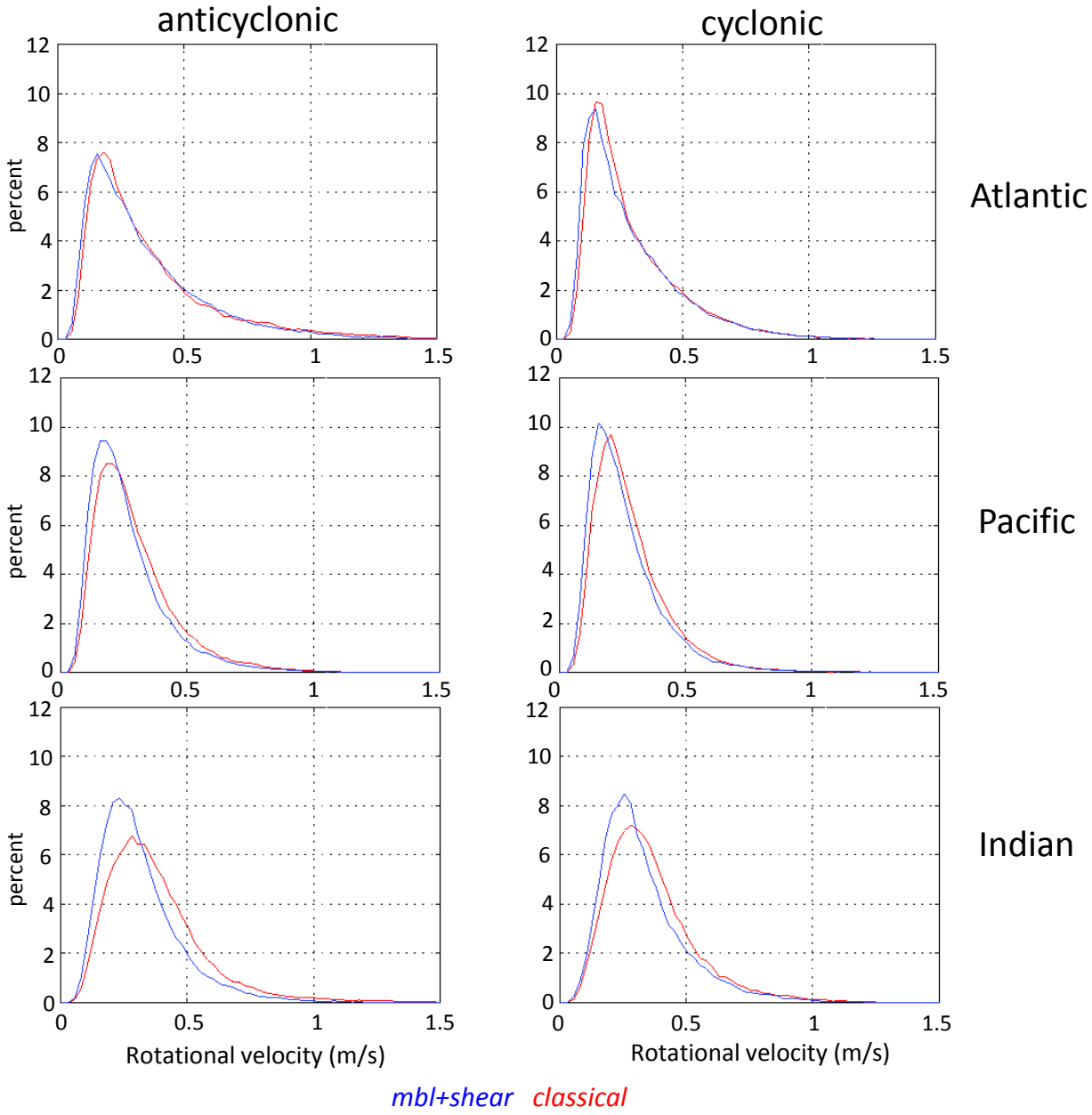
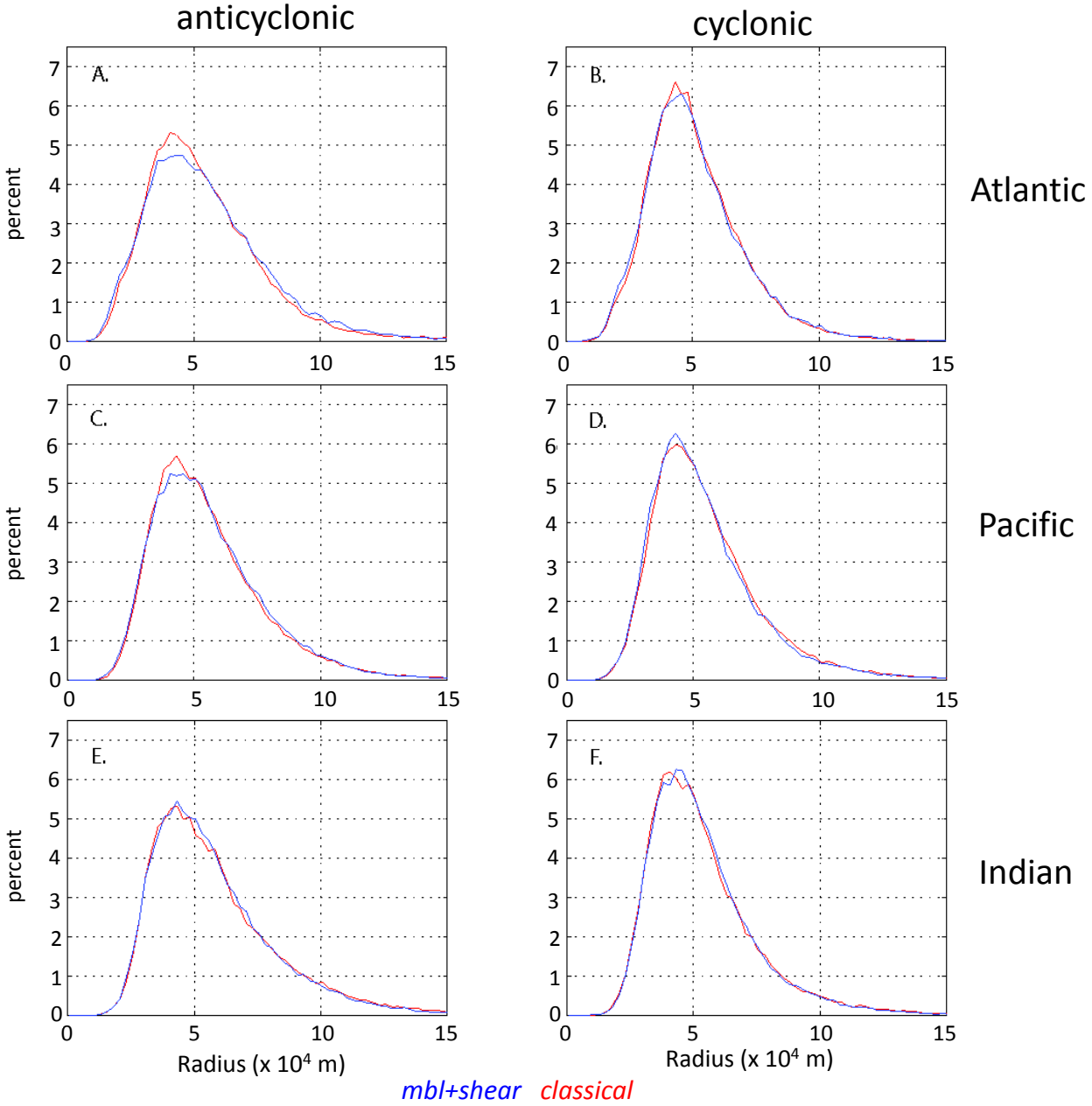
Total number of eddies reduced by 28% (anticyclonic) and 24% (cyclonic)

What is the impact on the strength of eddies as characterized by rotational velocity?



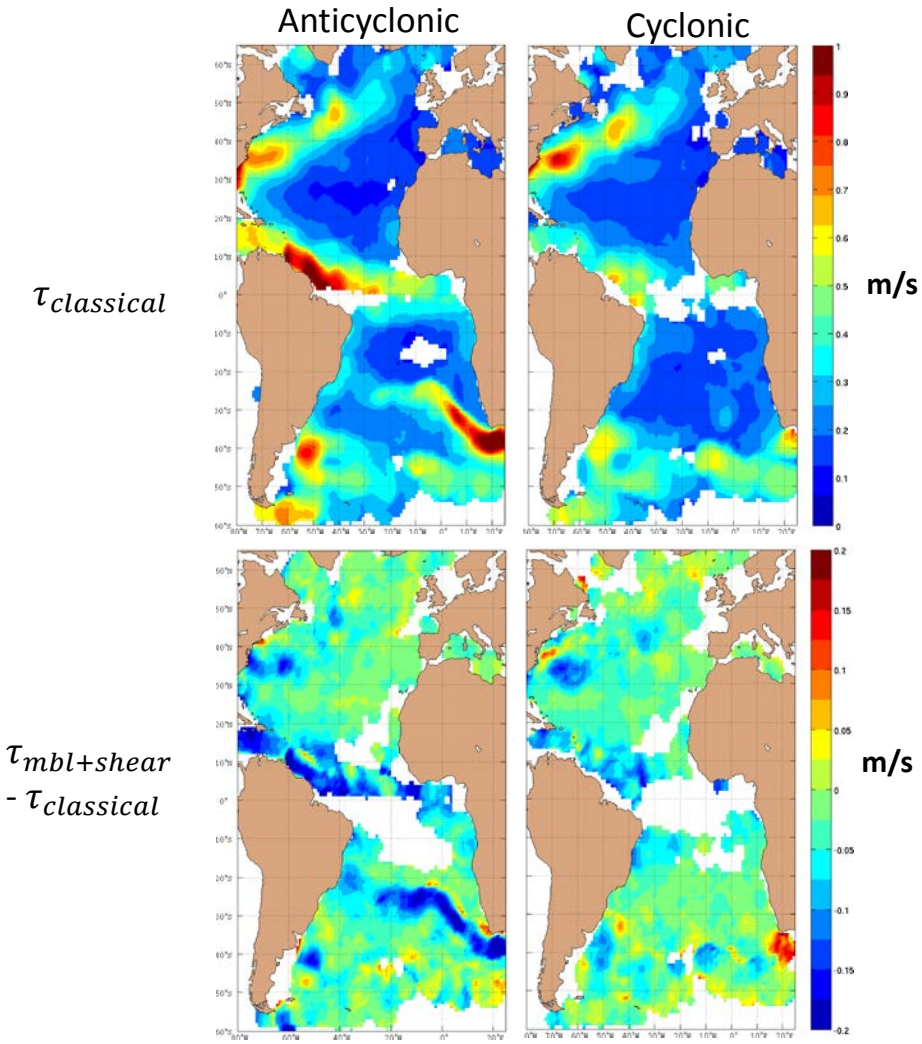
- Pdfs from a 2003-2007 eddy census (Douglass and Richman, 2014)

Changes in eddy radius as a function of wind stress



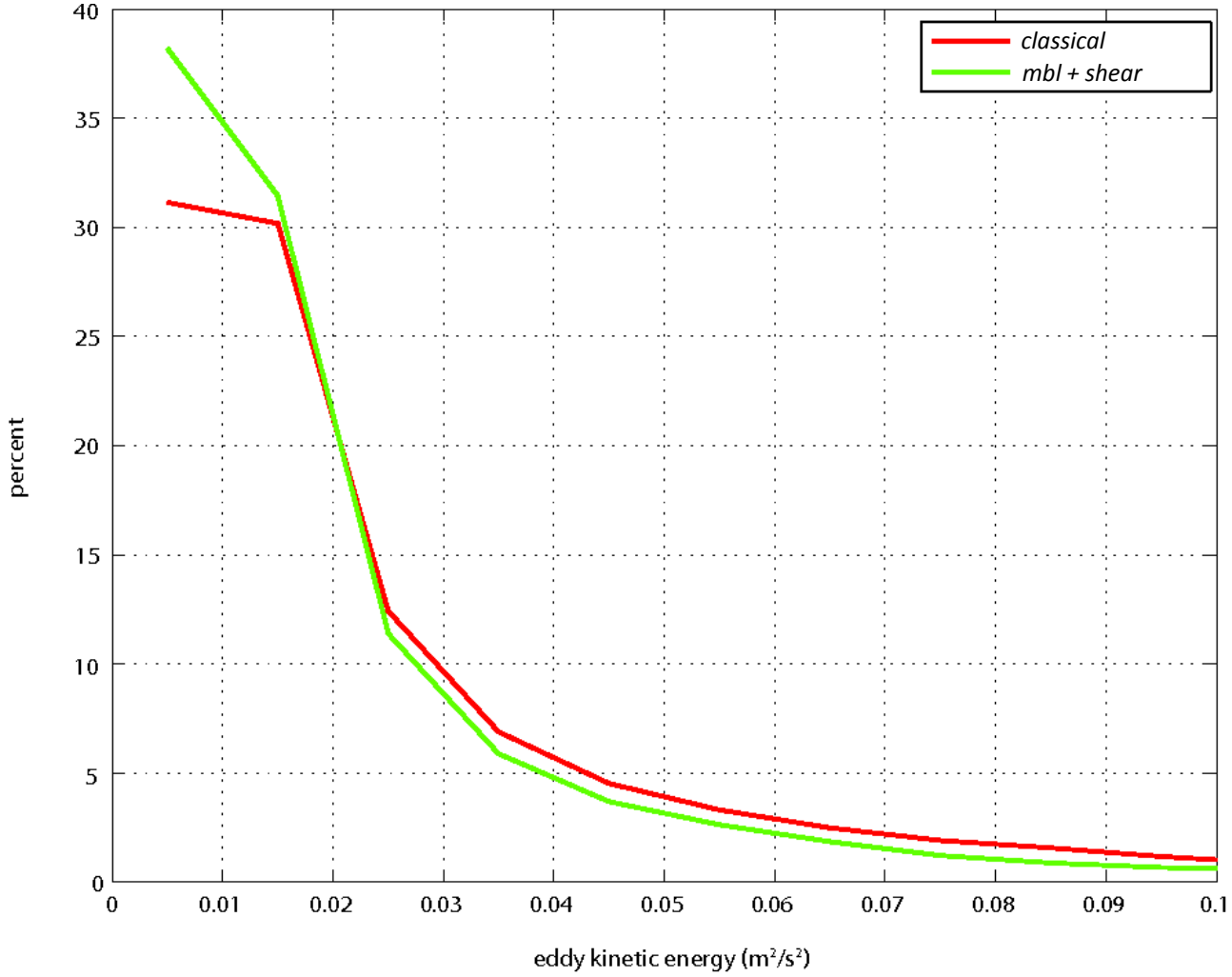
- Pdfs from a 2003-2007 eddy census (Douglass and Richman, 2014)

Changes in eddy rotational velocity



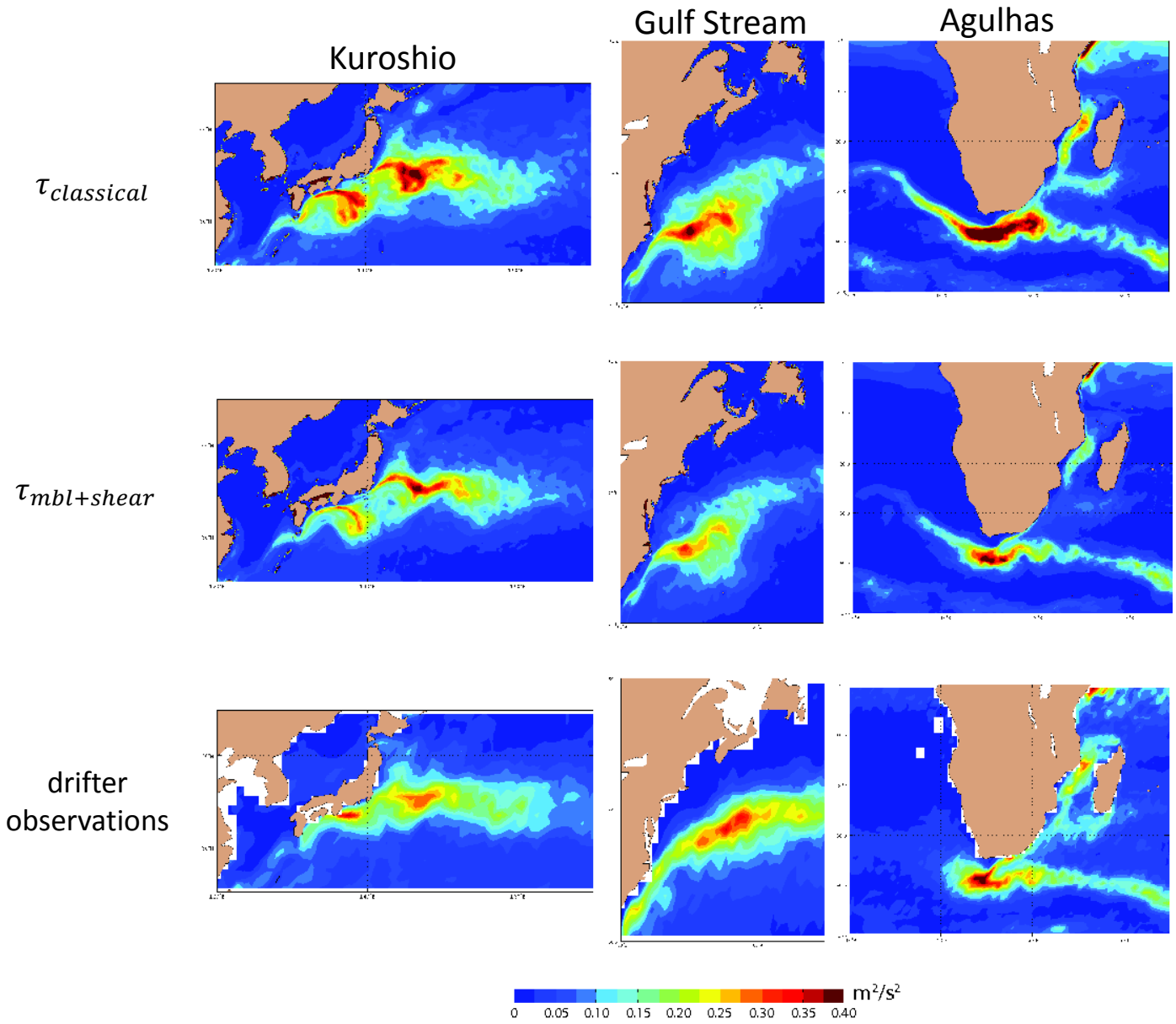
- Rotational velocities of all eddies interpolated to a 1x1 grid
- White areas < 5 eddies

Changes in EKE as a function of wind stress



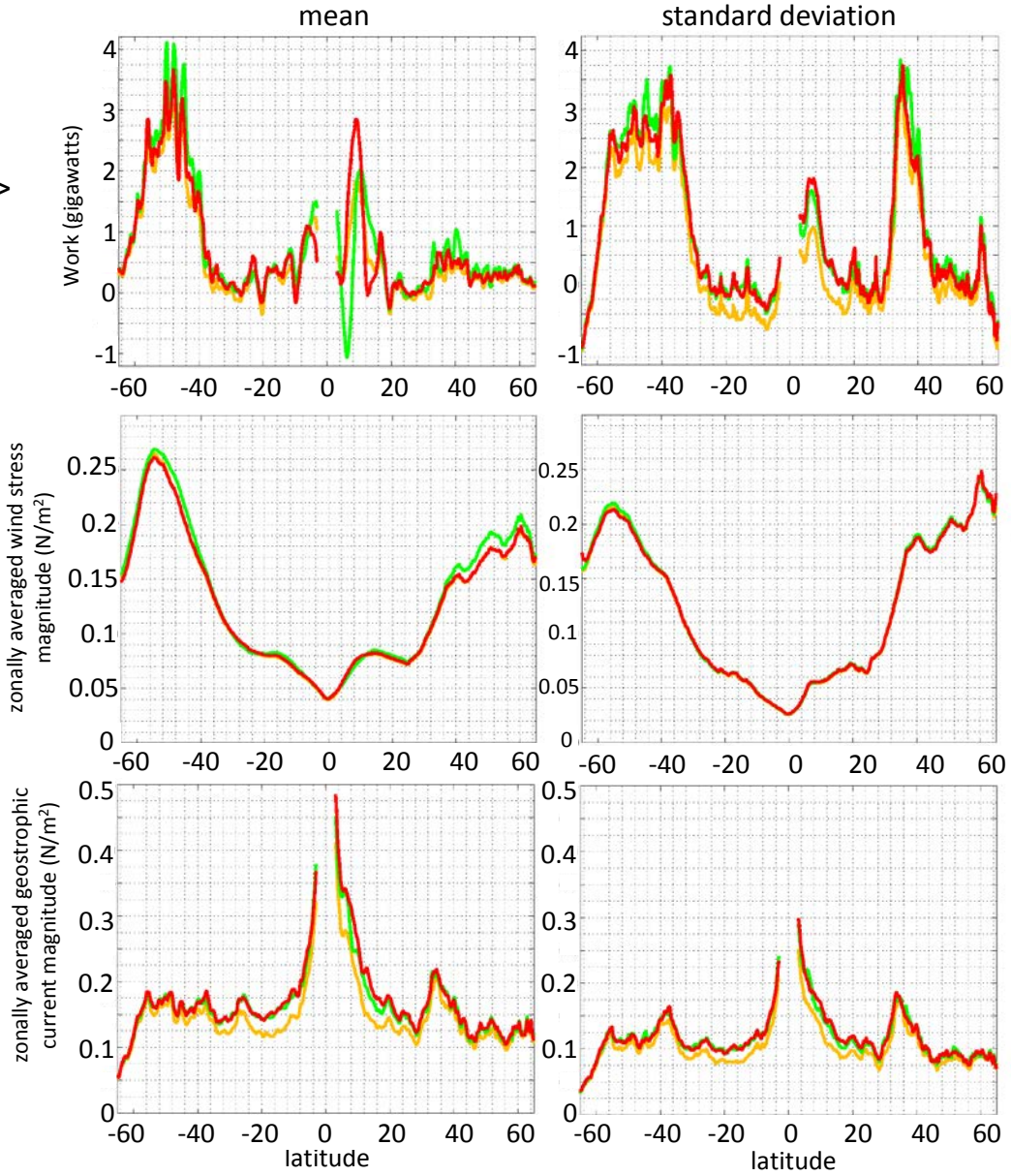
- Global average decreases 28% for mbl+shear vs classical

2003-2007 surface EKE (per unit mass)



Zonally integrated wind work/averaged wind stress magnitude and surface current magnitude

work = $< \tau \cdot u_g >$



classical mbl mbl+shear

What is the impact on the wind work on the geostrophic ocean circulation?

work = $< \tau \cdot u_g >$

Classical	1.20 TW
MBL	1.33 TW
MBL+Shear	1.02 TW

Wunsch (1998)	.88 TW
Scott and Xu (2009)	.85 – 1.0 TW

Conclusions

- The inclusion of high resolution SST acts to increase stress magnitude, changes due to the inclusion of ocean-atmosphere shear changes are nearly equal and opposite in sign

- Other impacts due to the inclusion of high resolution SST and ocean-atmosphere shear
  - Stress variability is reduced in high latitudes
  - The number of eddies and their rotational velocities are reduced
  - Global average EKE is reduced
  - Global wind work is reduced

Questions?