Global warming effect on oceanic mesoscale eddy energetics

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Mesoscale eddies are **ubiquitous** in the global ocean, have a critical role in the mixing and transporting of heat, salt, and biogeochemical properties across the global oceans, and thus, **can regulate the regional and global climate**.

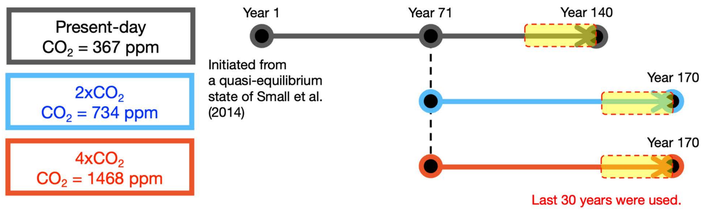
However, it remains unclear how greenhouse warming will alter ocean eddies due to the shortage of observational long-term records and model simulations with high spatiotemporal resolutions.

Questions.
- Will mesoscale eddy activity be enhanced or weakened under greenhouse warming?
- What is the key process underlying it?

Data

CESM 1.2.2 Ultra-high-resolution simulations (CESM-UHR)

- Fully-coupled (atmosphere, ocean, land, sea-ice, river-off) global climate simulations (Chu et al., 2020)
- Compset and resolution: B_2000_CAM5 (BC5), ne120_t12
- Atmospheric component: ~25km horizontal resolution and 30 vertical layers
- Oceanic component: ~10km horizontal resolution and 62 levels



Methodology

Oceanic mesoscale eddy energetics (Kang & Curchitser, 2015)

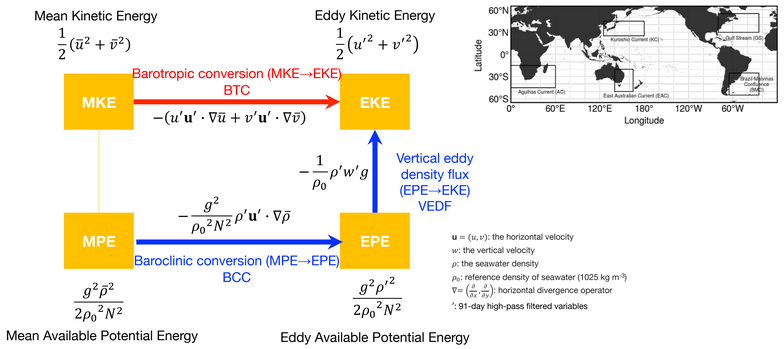
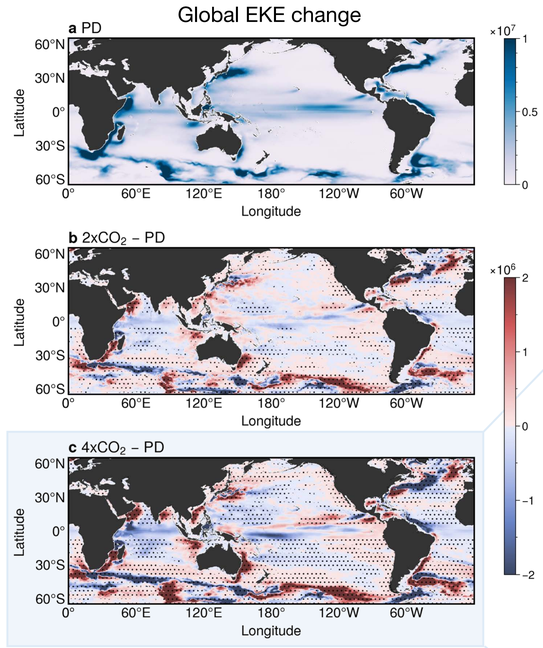
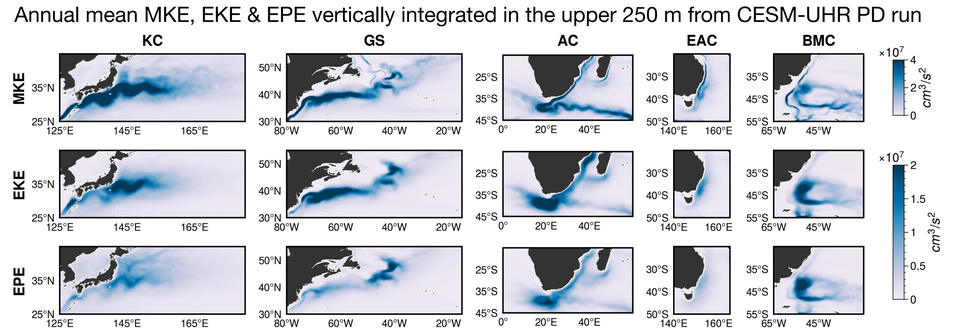


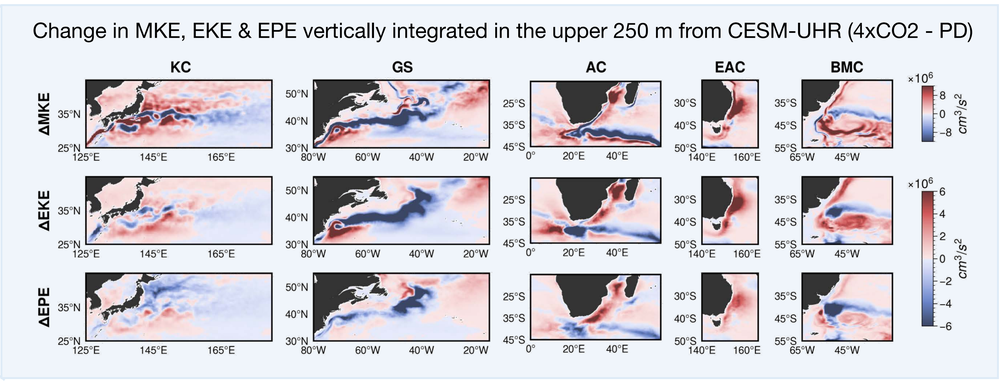
Figure. Schematic diagram of the energetics of eddy-mean flow interactions (Kang and Curchitser, 2015) and marks for western boundary currents

Results

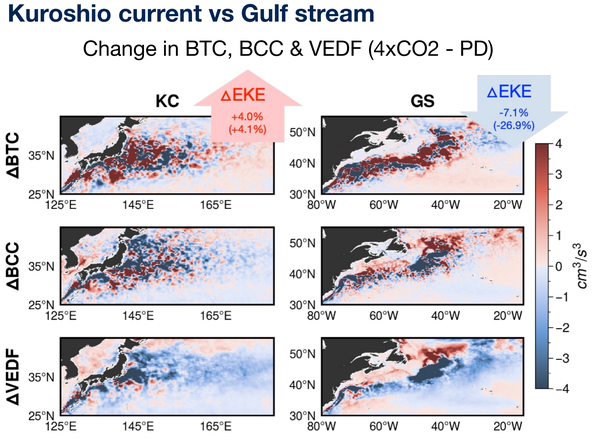
Global eddy energy change





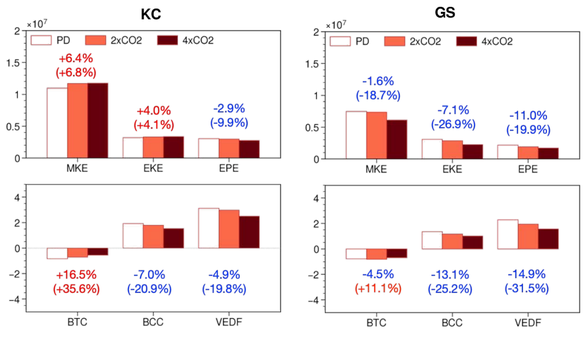


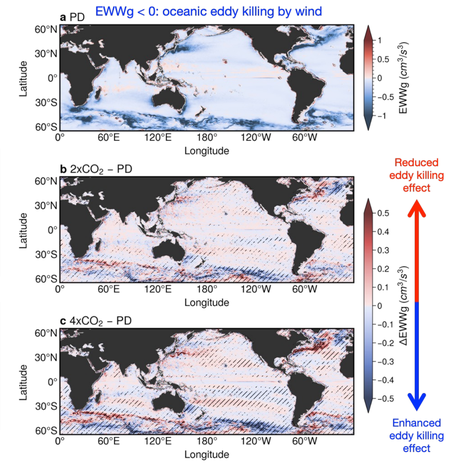
Kuroshio current vs Gulf stream



How did the effect of current feedback change under global warming?

ΔEKE vs ΔEWWg
: positive ΔEKE → enhanced eddy killing effects





Conclusions

- **CESM-UHR** projections revealed that CO2-induced global warming brings a complex EKE change across oceans:
  - KC: strong surface current => increase horizontal shear production => enhancing EKE
  - GS: weak AMOC => suppress vertical buoyancy flux => reducing EKE

Reference

Chu J-E, Lee SS, Timmermann A, Wengel C, Stuecker MF, Yamaguchi R. Reduced tropical cyclone densities and ocean effects due to anthropogenic greenhouse warming. *Sci. Adv*. 2020;6.
Kang D, Curchitser EN. Energetics of eddy-mean flow interactions in the gulf stream region. *Journal of physical oceanography*. 2015;45(4):1103-1120. doi: 10.1175/JPO-D-14-0200.1.