Sensitivity of the Equatorial Undercurrent to Vertical Mixing

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Outline:

- **Comparison of the Equatorial Undercurrent at 0°, 140°W From ADCP Measurements and LLC4320 High-Resolution Global Ocean General Circulation Model** (Halpern, Zhang, et al., submitted to JTECH)

- Vertical mixing coefficient sensitivity experiments in LLC1080 (1/12°)

- Equatorial Undercurrent in LLC4320v2 (1/48 °)

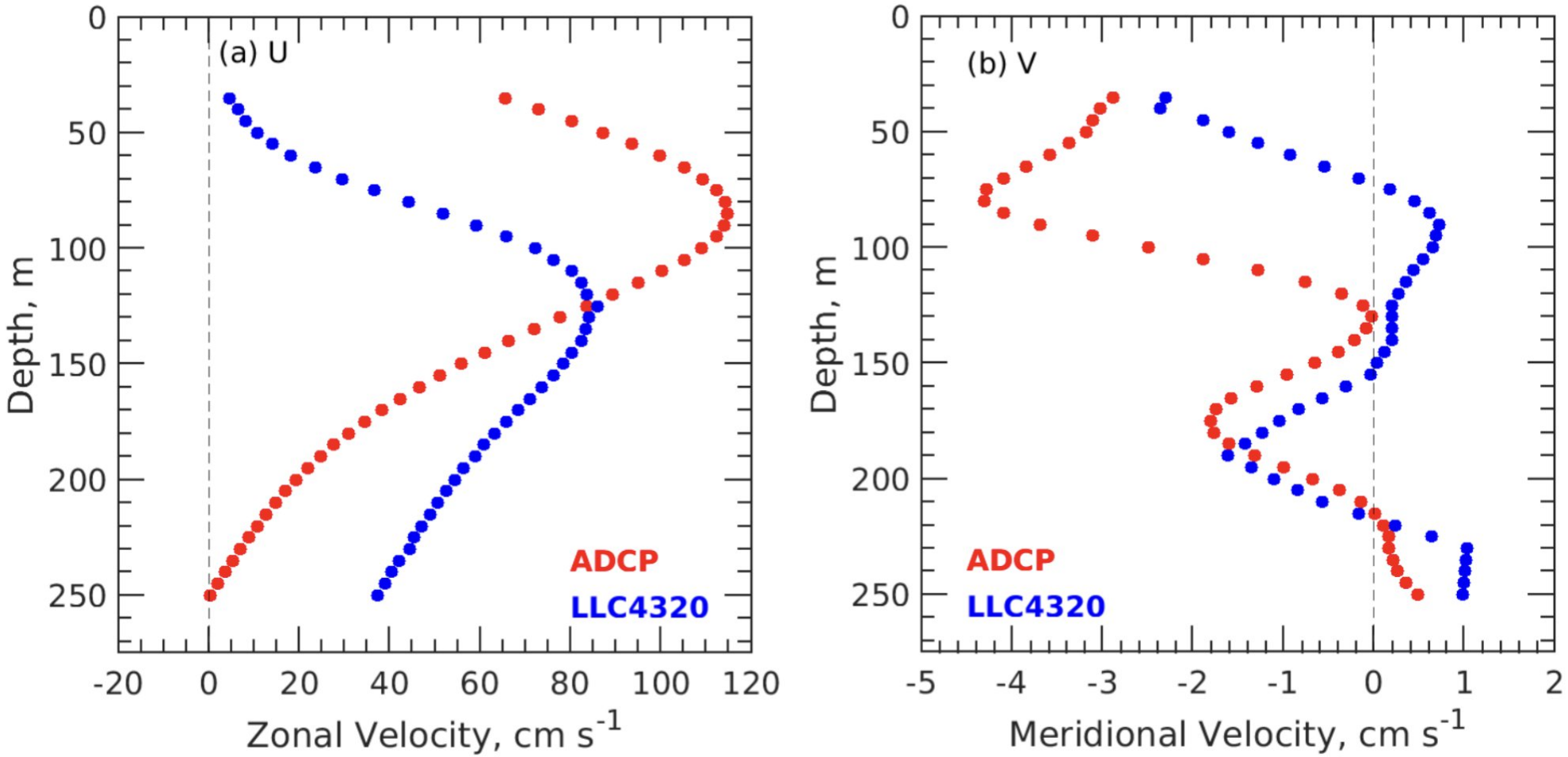

Figure 1. Vertical profiles of 1-year mean (a) zonal and (b) meridional currents at 0°, 140°W that were simulated with the LLC4320 global ocean general circulation model (blue dots) and measured with an acoustic Doppler current profiler (ADCP; red dots) for the time interval 1 November 2011 to 31 October 2012. In (a), zonal currents with positive values are directed towards the east. In (b), meridional currents with positive (negative) values are directed towards the north (south).

Halpern et al. (submitted to

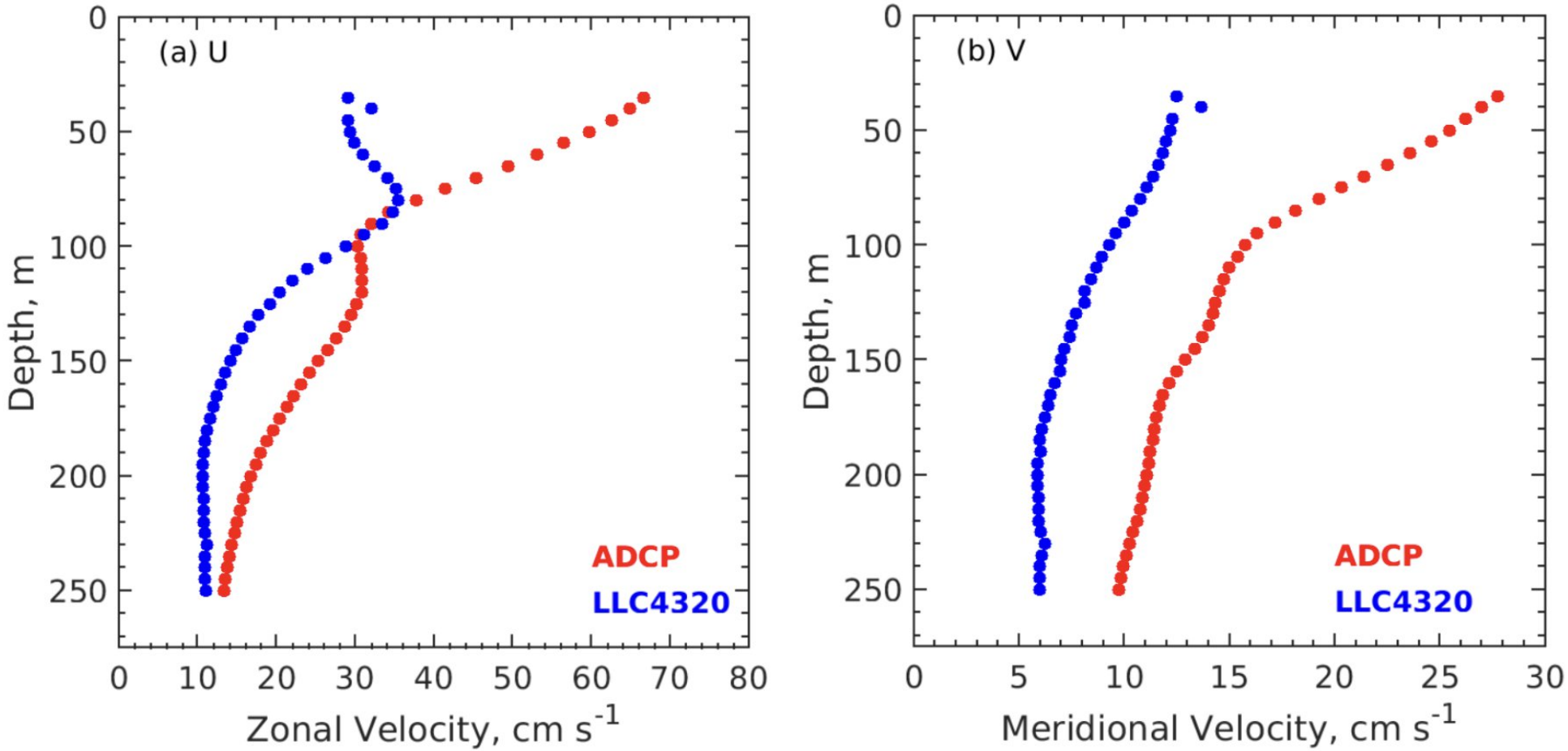

Figure 2. Vertical profiles of standard deviations of hourly (a) zonal and (b) meridional currents at 0°, 140°W that were simulated with the LLC4320 global ocean general circulation model (blue dots) and measured with an acoustic Doppler current profiler (ADCP; red dots) for the time interval 1 November 2011 to 31 October 2012.

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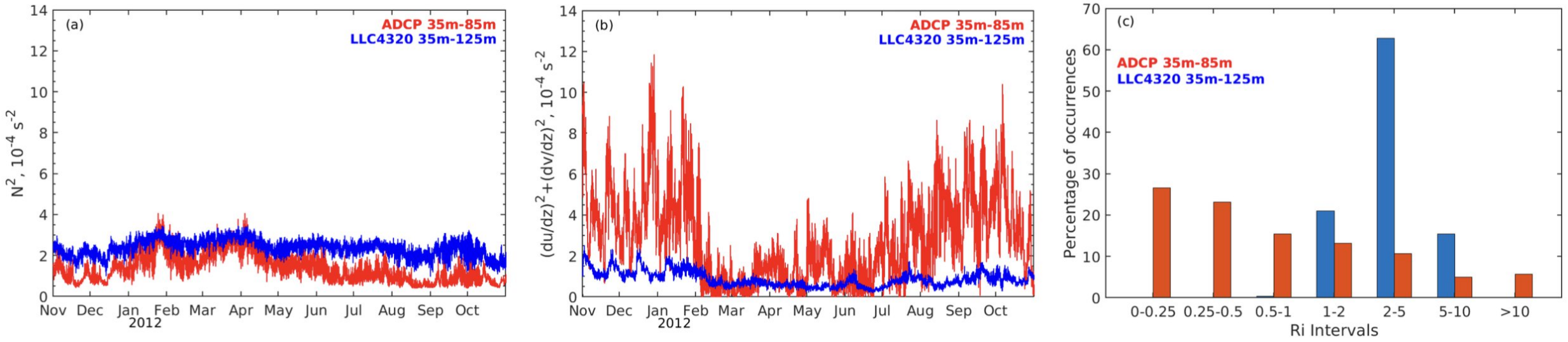

Figure 6. Time series of 8784 hourly values of the square of (a) the Brunt–Väisälä or buoyancy frequency and (b) square of the vector vertical shear. Vertical scales of both (a) and (b) are identical to ease visible comparison. Panel (c) displays LLC4320 and ADCP histograms of the frequency of occurrence of hourly Ri computed from datasets shown in panels (a) and (b). The arbitrary Ri intervals in (c) emphasize Ri < 1. Results for LLC4320 and ADCP datasets are colored blue and red, respectively.

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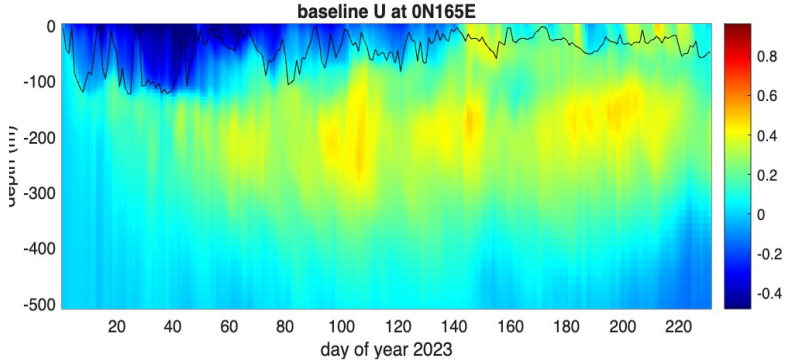
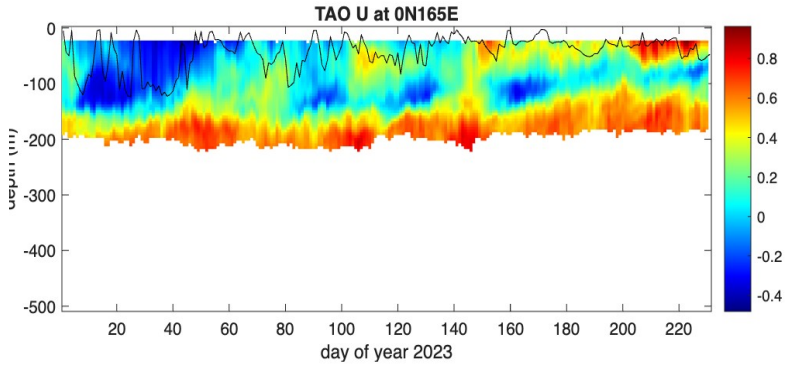
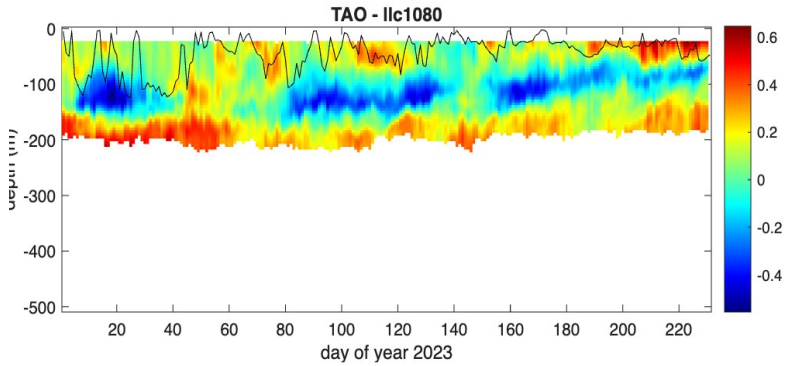
Adjustment of vertical mixing parameters

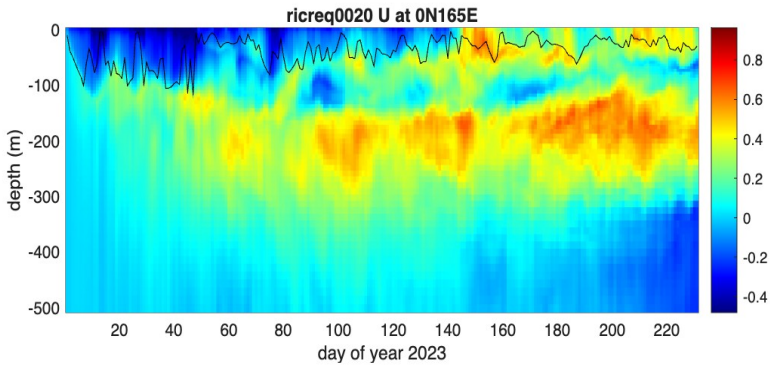
	Menemenlis et al 2005	Nguyen et al 2009	classic LLC4320					
	cs510, 18-km	cs510, 18-km	1/48-deg					
	50-level	50-level	90-level					
PARAMETERS	**global optimization**	**Arctic optimization**	**1. LPNB**	**0. Baseline**	**2. ricr0025**	**3. difst0025**	**4. prandtl10**	**5- ricreq0020**
bulk Ricr for KPPhbl computation	Ricr = 0.3559	Ricr = 0.3559	Ricr = 0.3559	Ricr = 0.3559	Ricr = 0.3559	Ricr = 0.3559	Ricr = 0.3559	Ricr = 0.3559
bulk Ricr for Equatorial KPPhbl comp.	RicrEq = 0.3559	RicrEq = 0.3559	RicrEq = 0.3559	RicrEq = 0.3559	RicrEq = 0.3559	RicrEq = 0.3559	RicrEq = 0.3559	RicrEq = 0.2
local critical gradient Ricr	Riinfty = 0.6998,	Riinfty = 0.6998,	Riinfty = 0.6998,	Riinfty = 0.6998,	Riinfty = 0.25,	Riinfty = 0.25,	Riinfty = 0.25,	Riinfty = 0.25,
viscosity for local gradient Ri < Ricr	difm0 = 5.e-3	difm0 = 5.e-3	difm0 = 5.e-3	difm0 = 5.e-3	difm0 = 5.e-3	difm0 = 5.e-3	difm0 = 5.e-3	difm0 = 5.e-3
S-diffusivity for local gradient Ri < Ricr	difs0 = 5.e-3	difs0 = 5.e-3	difs0 = 5.e-3	difs0 = 5.e-3	difs0 = 5.e-3	difs0 = 2.5e-3	difs0 = 5.e-3	difs0 = 2.5e-3
T-diffusivity for local gradient Ri < Ricr	difs0 = 5.e-3	difs0 = 5.e-3	difs0 = 5.e-3	difs0 = 5.e-3	difs0 = 5.e-3	difs0 = 2.5e-3	difs0 = 5.e-3	difs0 = 2.5e-3
background viscosity	viscAr= 5.6614e-4,	viscAr= 5.6614e-4,	viscAr= 5.6614e-4,	viscAr = 5.e-4,	viscAr = 5.e-4,	viscAr = 5.e-4,	viscAr = 1.e-4,	viscAr = 1.e-5,
background S-diffusivity	DIFFKR_2_20_1_lat6070_	diffKrS=5.44e-7,	diffKrS=5.44e-7,	diffKrS = 1.e-5,	diffKrS = 1.e-5,	diffKrS = 1.e-5,	diffKrS = 1.e-5,	diffKrS = 1.e-6,
background T-diffusivity	DIFFKR_2_20_1_lat6070_	diffKrT=5.44e-7,	diffKrT=5.44e-7,	diffKrT = 1.e-5,	diffKrT = 1.e-5,	diffKrT = 1.e-5,	diffKrT = 1.e-5,	diffKrT = 1.e-6,
Eq. undercurrent 110 W depth	**TAO: 65 m**		**65 m**	**65 m**	**60 m**	**60 m**	**60 m**	**55 m**
Eq. undercurrent 110 W mag	**TAO: 1.4 m/s**		**0.61 m/s**	**0.65 m/s**	**0.70 m/s**	**0.70 m/s**	**0.98 m/s**	**1.2 m/s**
Eq. undercurrent 170 W depth	**TAO: 145 m**		**150 m**	**150 m**	**145 m**	**140 m**	**140 m**	**140 m**
Eq. undercurrent 170 W mag	**TAO: 0.79 m/s**	C25	**0.52 m/s**	**0.54 m/s**	**0.58 m/s**	**0.58 m/s**	**0.69 m/s**	**0.76 m/s**

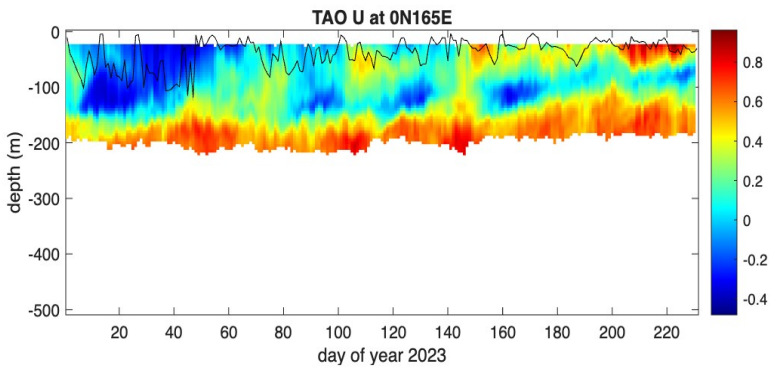
Allowed critical value of the bulk Ri number (Ricr) used for computation of KPP mixing depth (KPPhbl) to be latitude-dependent. In the equatorial region (5°S–5°N), Ricr=0.2; poleward of 20°S and 20°N, Ricr=0.36; with a smooth transition in between.

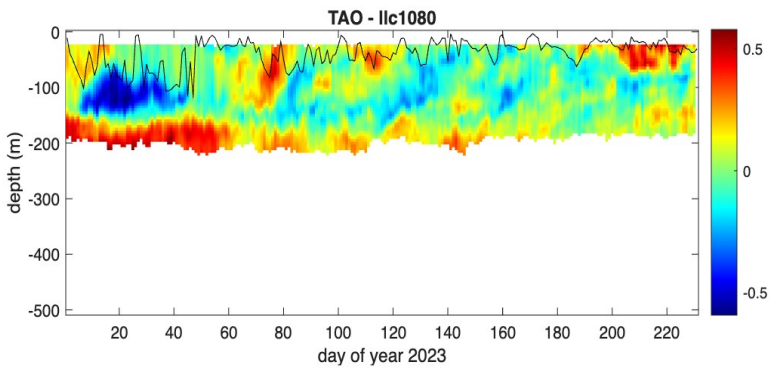


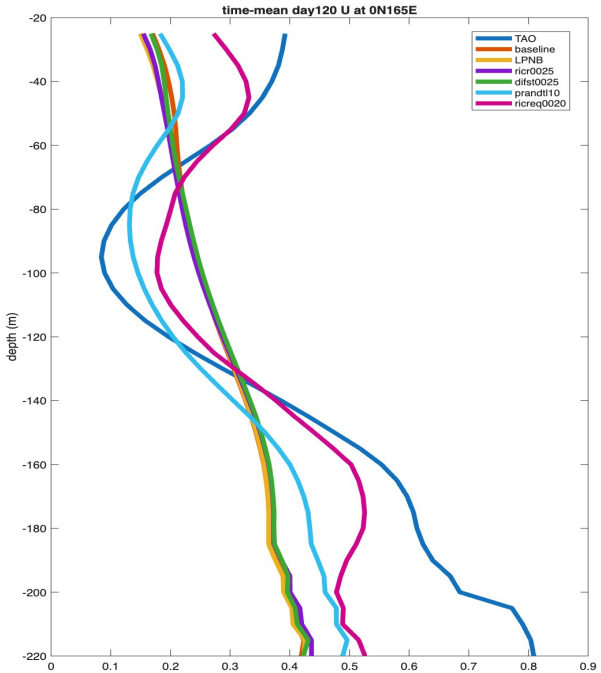




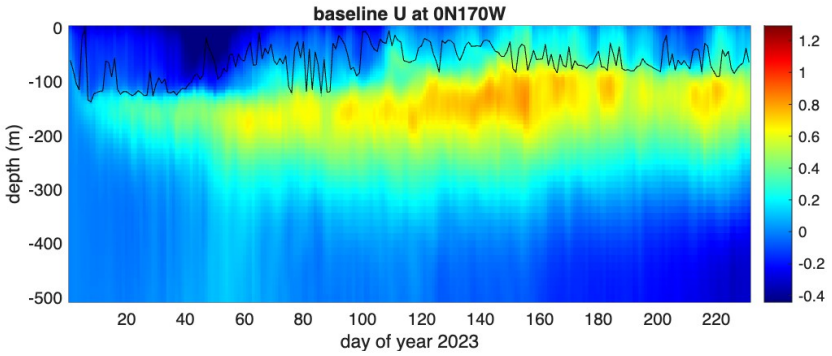


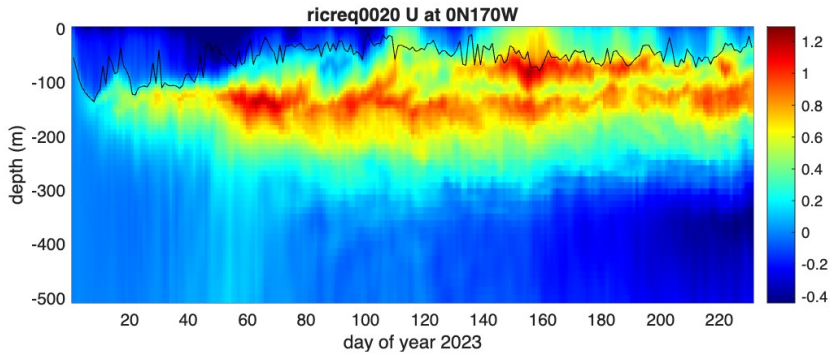


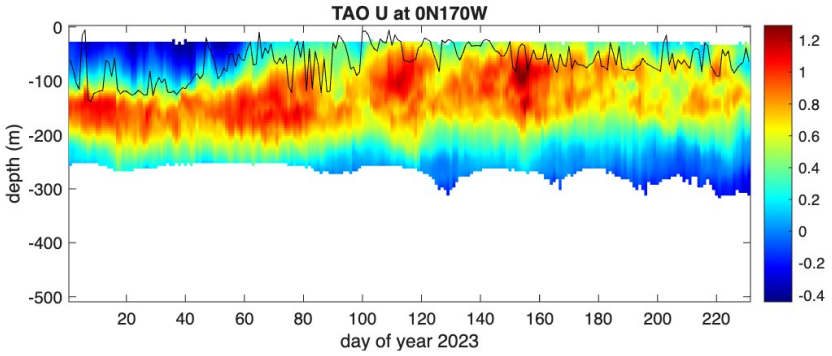


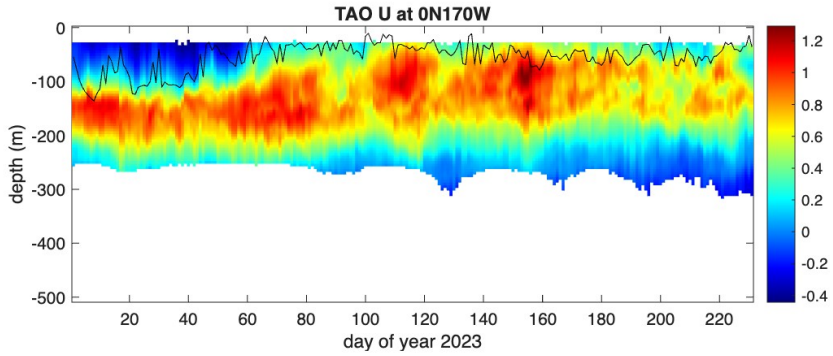


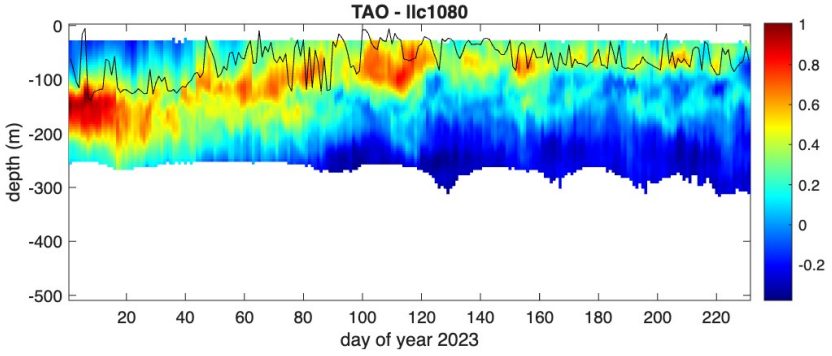
(simulations: Kayhan Momeni; analysis: Kate Q. Zhang

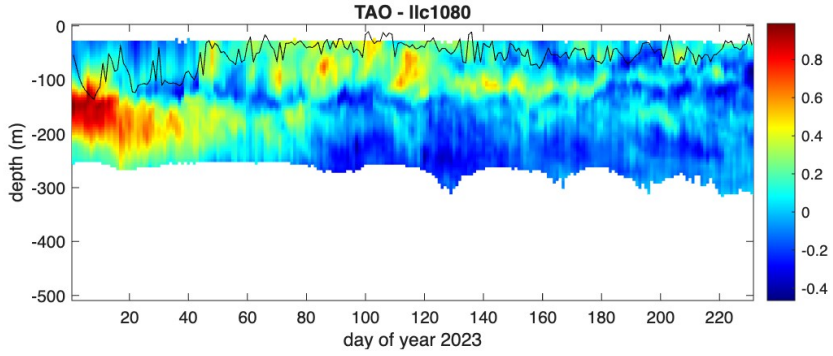


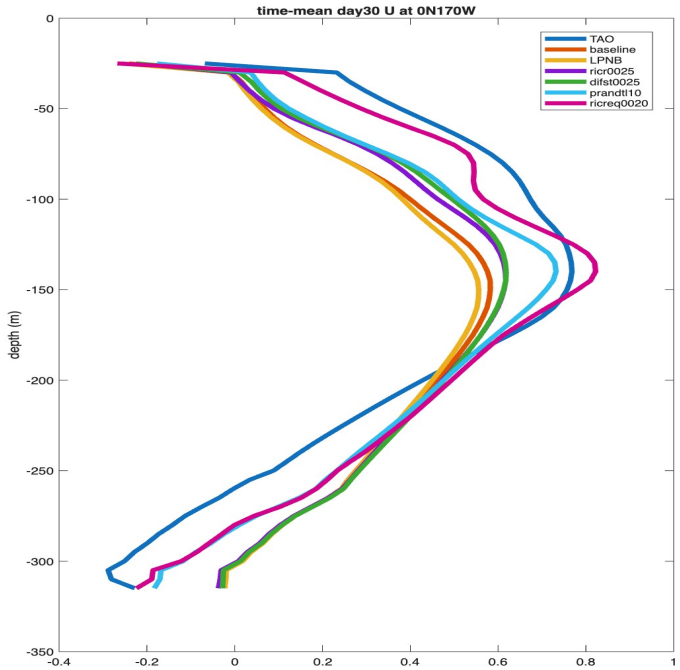












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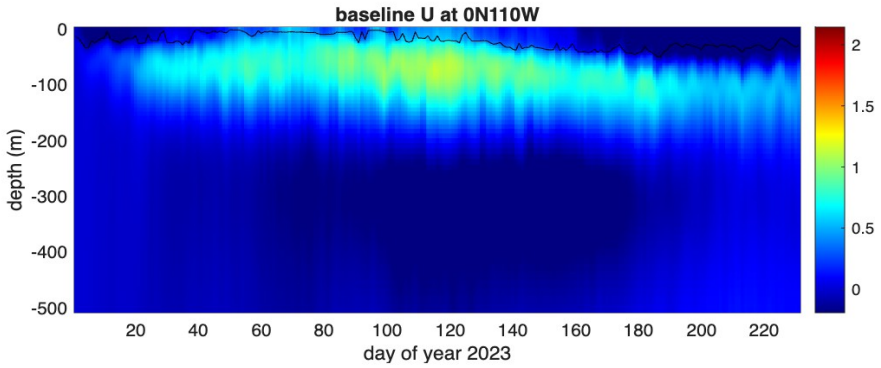

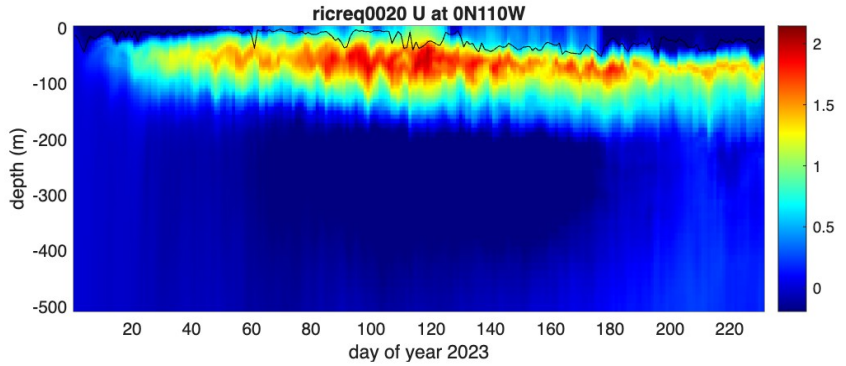

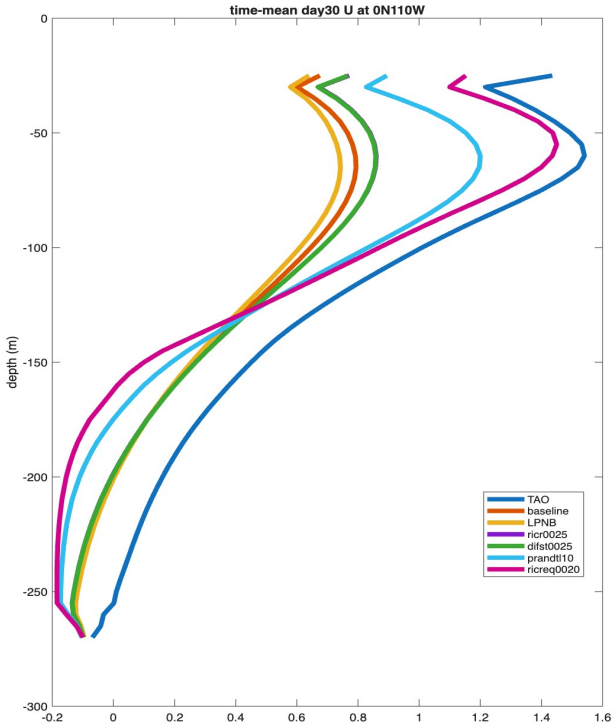

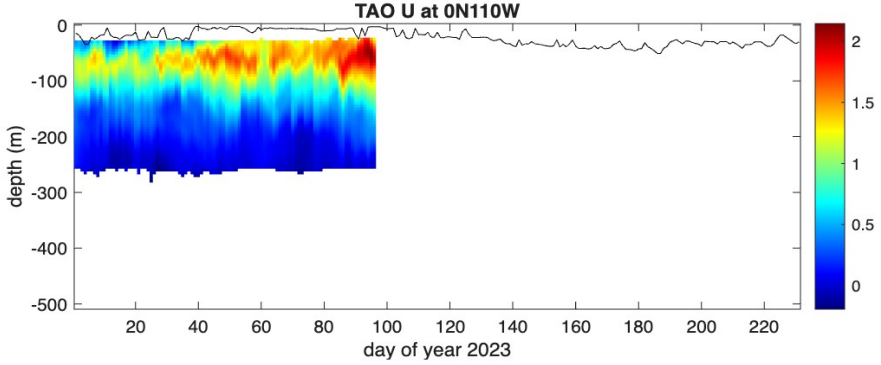

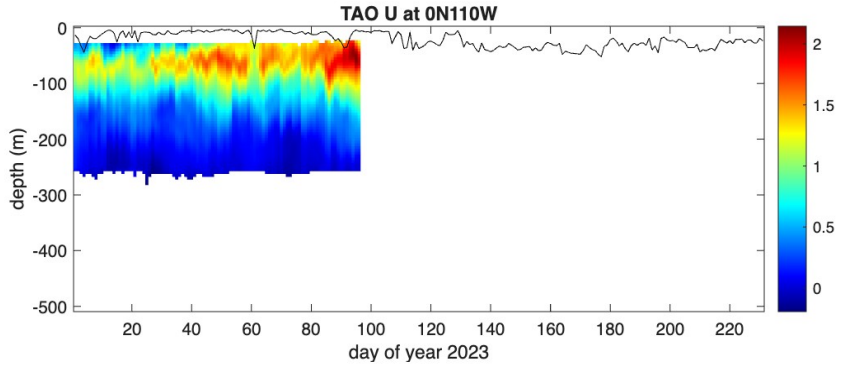

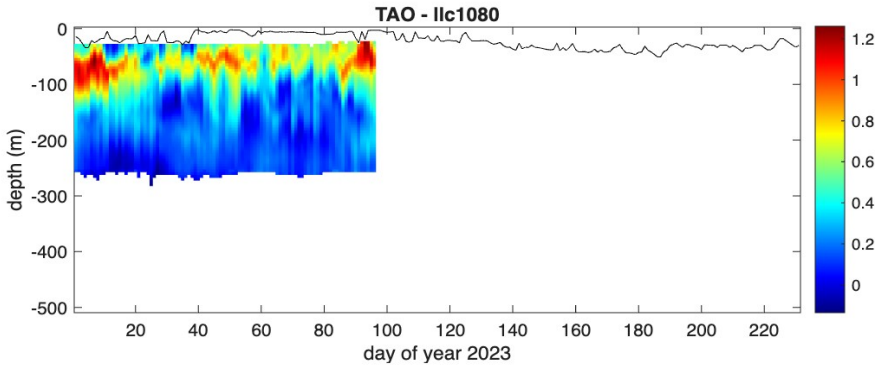

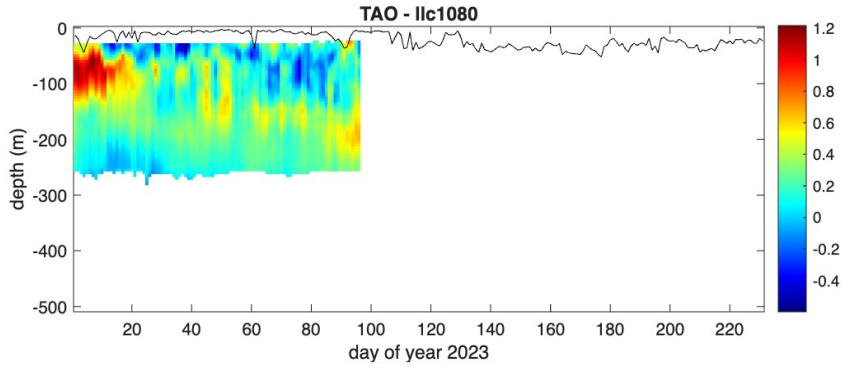

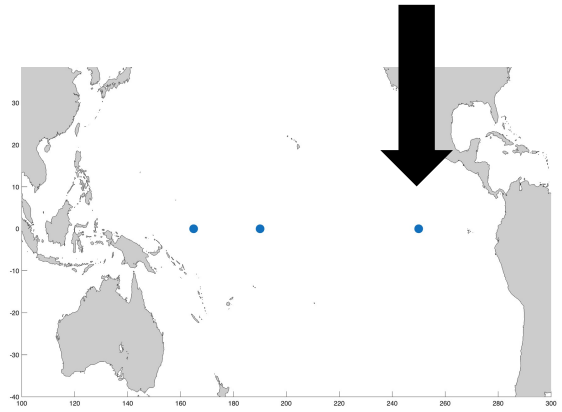

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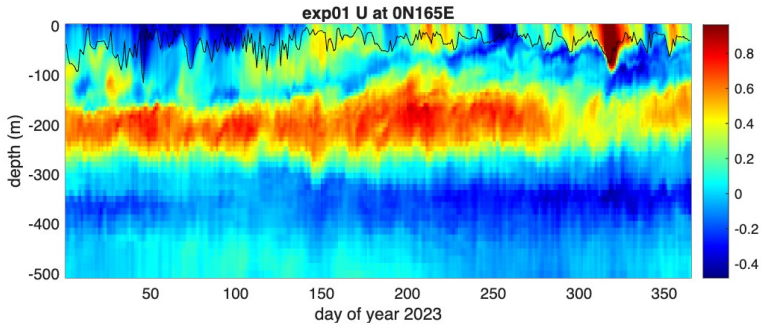

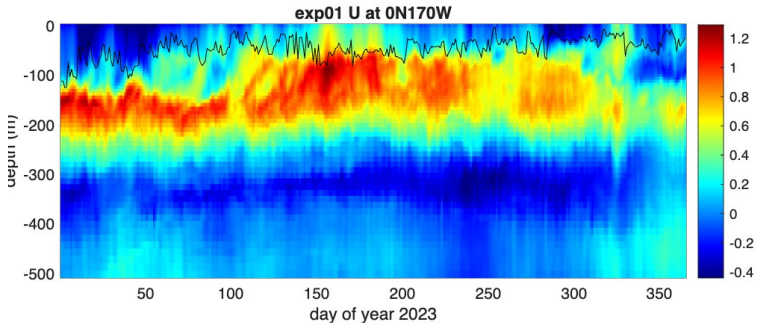

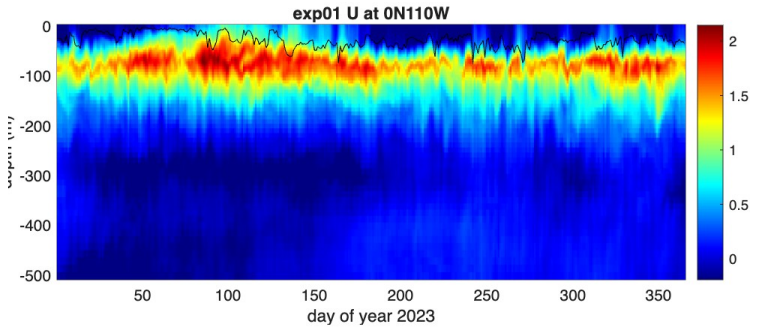

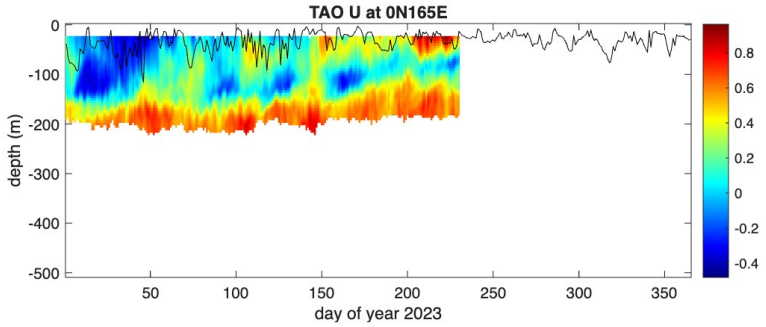

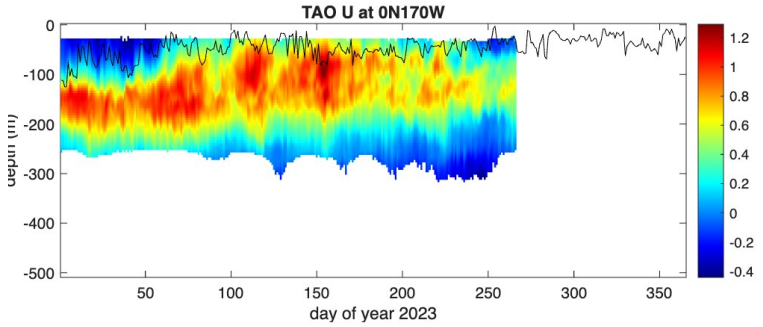

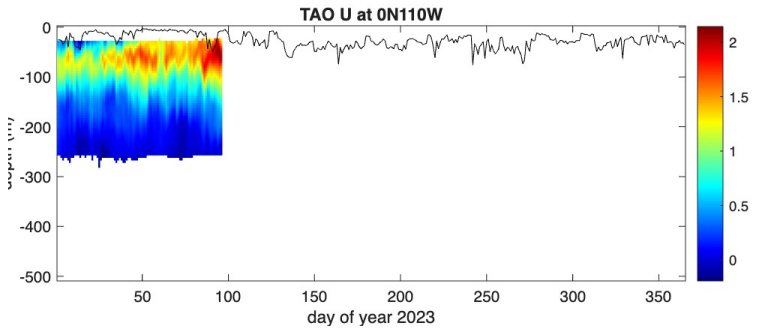

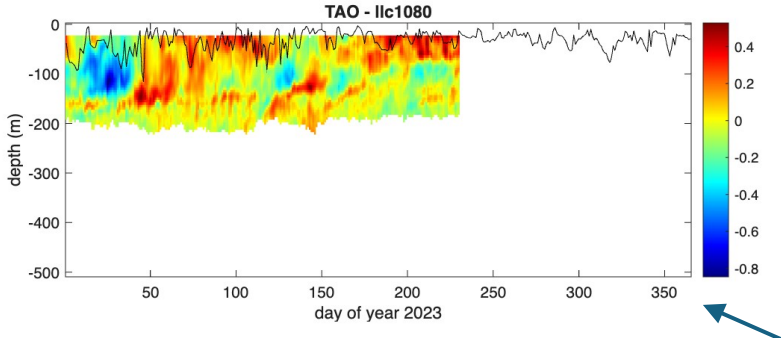

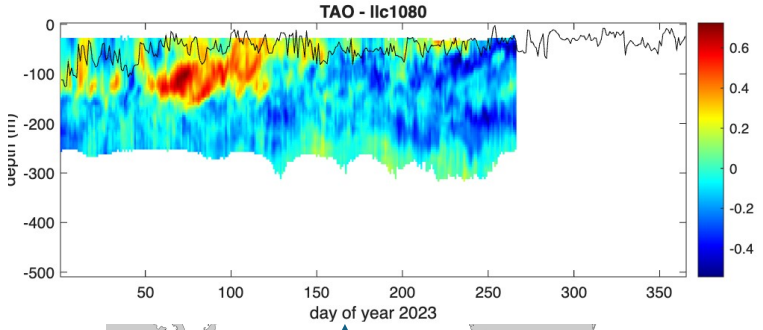

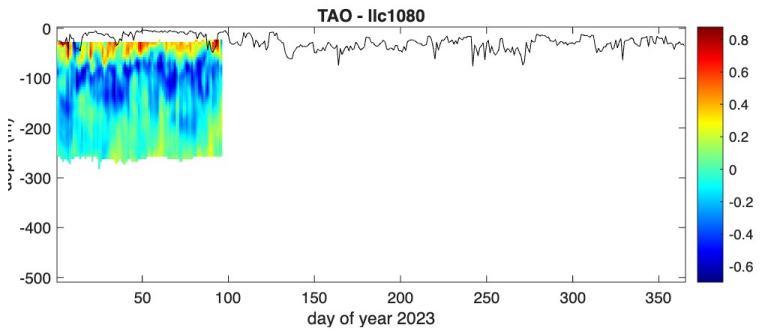

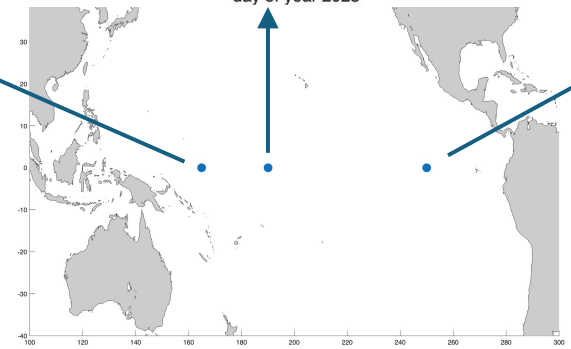

llc1080 simulation: Kayhan Momeni

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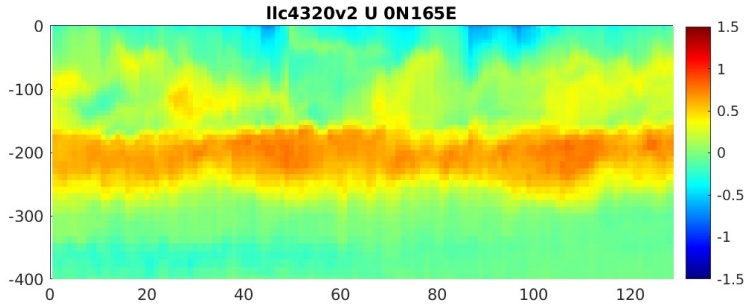

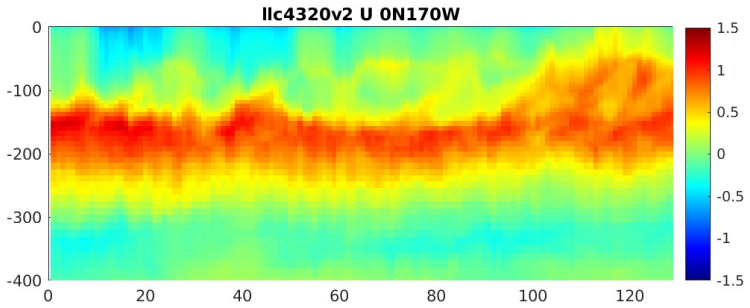

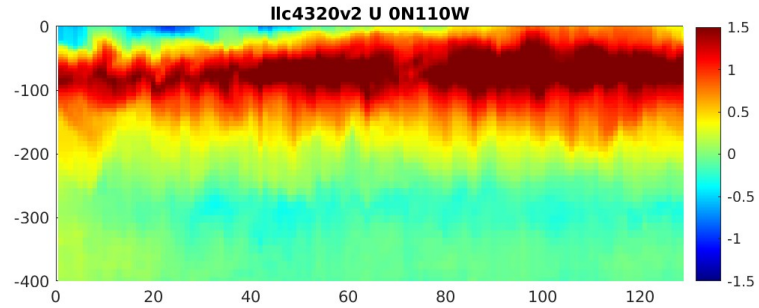

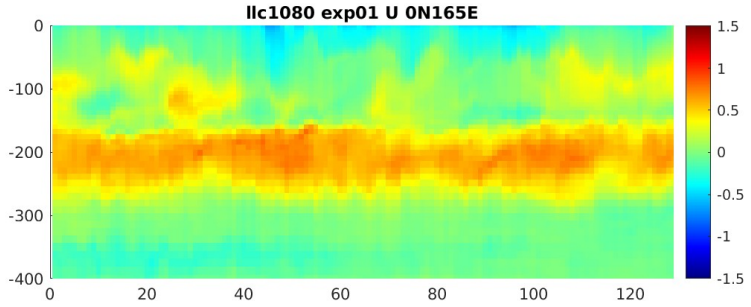

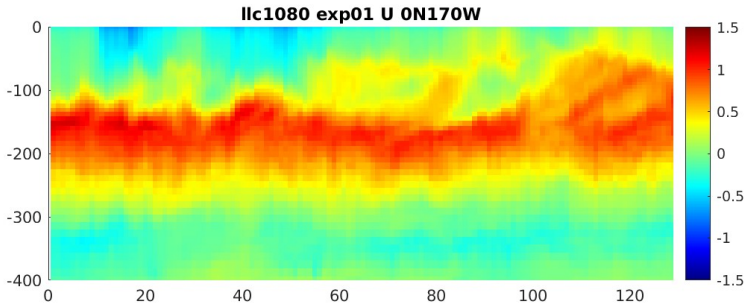

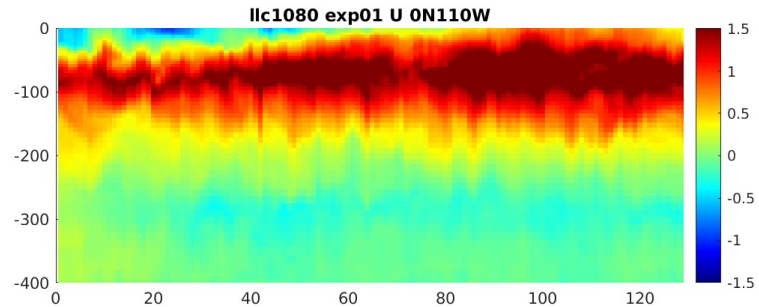

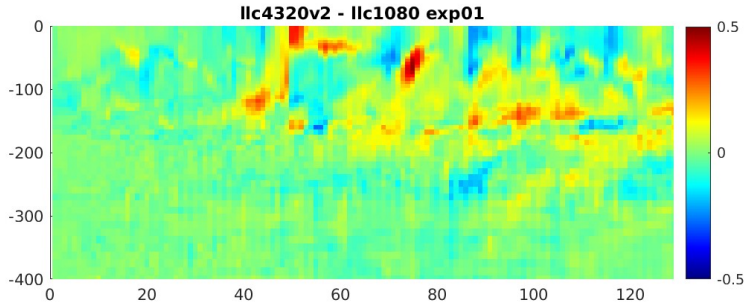

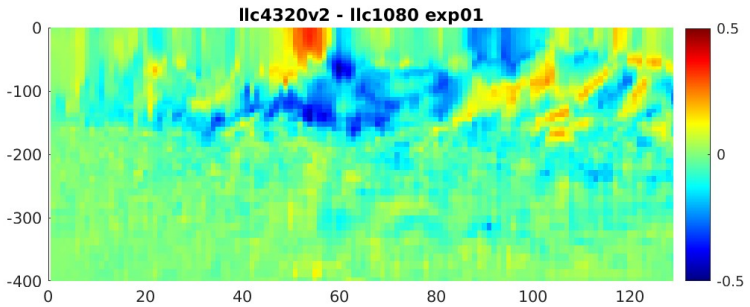

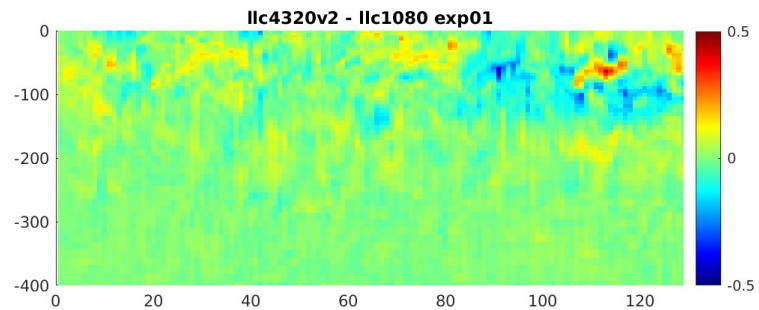

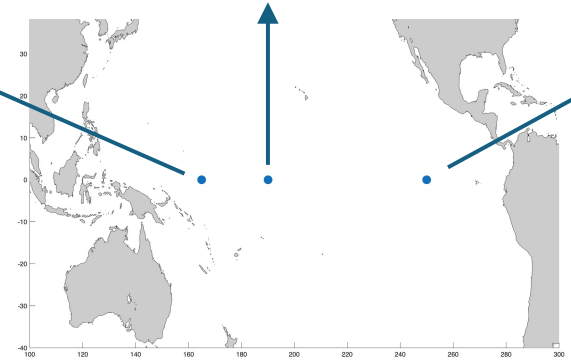

llc1080 simulation: Kayhan Momeni

llc4320 simulation: Dan Whitt

Conclusion:

- In classic llc4320, the Equatorial Undercurrent (EUC) was weaker, deeper, and with smaller variance than observed.
- This was caused by stronger stratification and smaller vertical shear than observed, leading to larger (more stable) Richardson (Ri) number.
- Sensitivity experiments to vertical mixing coefficients in llc1080 (1/12°) configuration confirm the key role of vertical mixing for more realistic representation of EUC.
- The adjusted mixing coefficients that help improve EUC at llc1080 (1/12°) have a similar impact for llc4320v2 (1/48°).