Evaluation of ECCOv4r4 Currents in the Pacific Equatorial Undercurrent

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1. Methodology

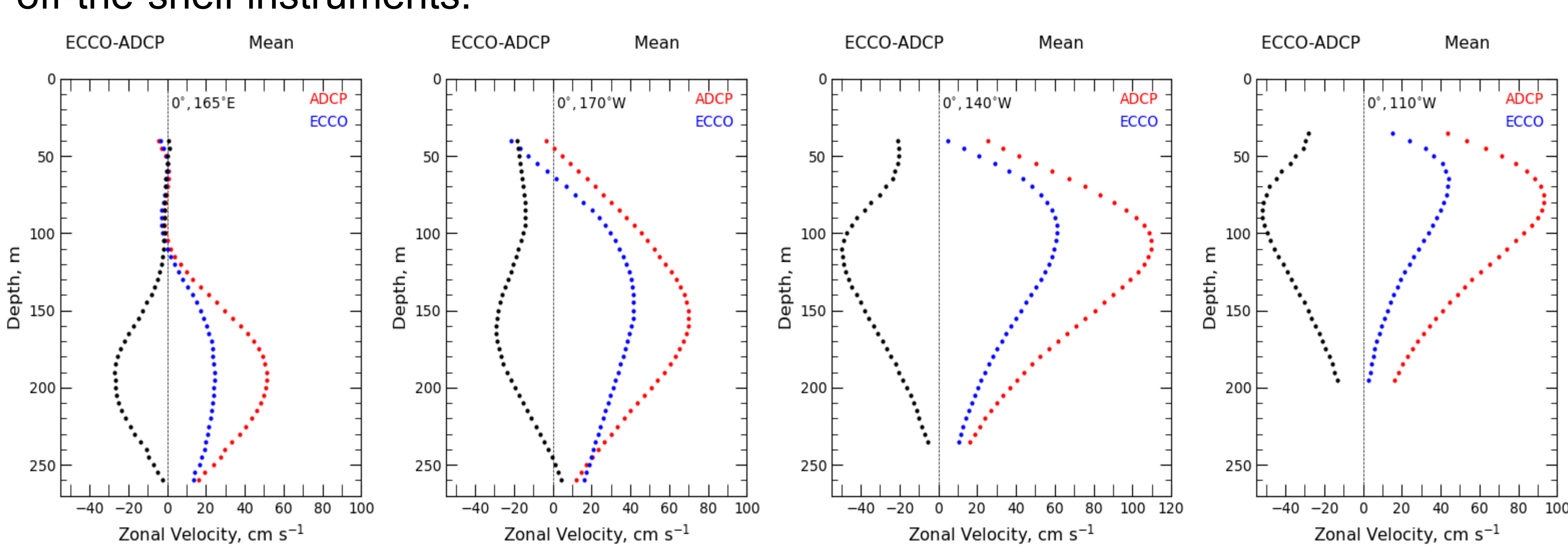
ECCOv4r4. T. Smith produced 1-hour averaged horizontal velocity components at selected geographical grid cells by running the combined global model and data assimilation system of the Consortium for Estimating the Circulation and Climate of the Ocean (ECCO) Central Production Version 4 Release 4 (ECCOv4r4) (doi:10.5281/zenodo.3765929). Data are available at doi.org/10.6084/m9.figshare.16557387.v1. Latitudinal and longitudinal grid dimensions for ECCOv4r4 currents at the equator were 45 and 111 km, respectively.

ADCP Observations. We use 1-hour averaged acoustic Doppler current profiler (ADCP) in-situ measurements recorded at the equator and 165°E, 170°W, 140°W and 110°W. Data were extracted from https://www.pmel.noaa.gov/gtmba/pmel-theme/pacific-ocean-tao. The ADCP did not measure currents above about 25 m.

Data Processing. Evaluation time periods were 1996-2005, 1995-2005, 1997-2010 and 1996-2005 at 165°E, 170°W, 140°W and 110°W, respectively. The eastward transport per unit width (TPUW) is equal to $\int u\,dz$ where u is the zonal component and is integrated vertically for u(z) greater than 0.2 m s^{-1}. A Richardson Number (Ri) less than 0.25 represents the tendency for sheared flow in a density-stratified fluid to develop vertical mixing. We calculated hourly depth-averaged values of Ri between the depth of the core speed and the upper depth where u(z) = 0.2 m s^{-1}. $Ri = N^2/[(du/dz)^2 + (dv/dz)^2]$, where N is the Brunt-Väisälä frequency and v is the north-south current component. Climatological mean-monthly values of density were obtained from the World Ocean Atlas 2018.

2. Results

Mean Zonal Current (Figure 1). ECCOv4r4 produced a substantially smaller current compared to observations: at or near the depth of the EUC core speed and typically over a large depth interval, ECCOv4r4 currents were about half as large as observations. ECCOv4r4 and ADCP EUC thicknesses and upward slopes of the EUC from 165°E to 110°W were similar. Maximum mean biases occurring at or near the depth of the EUC core speed were significant, i.e., values readily measured with off-the-shelf instruments.



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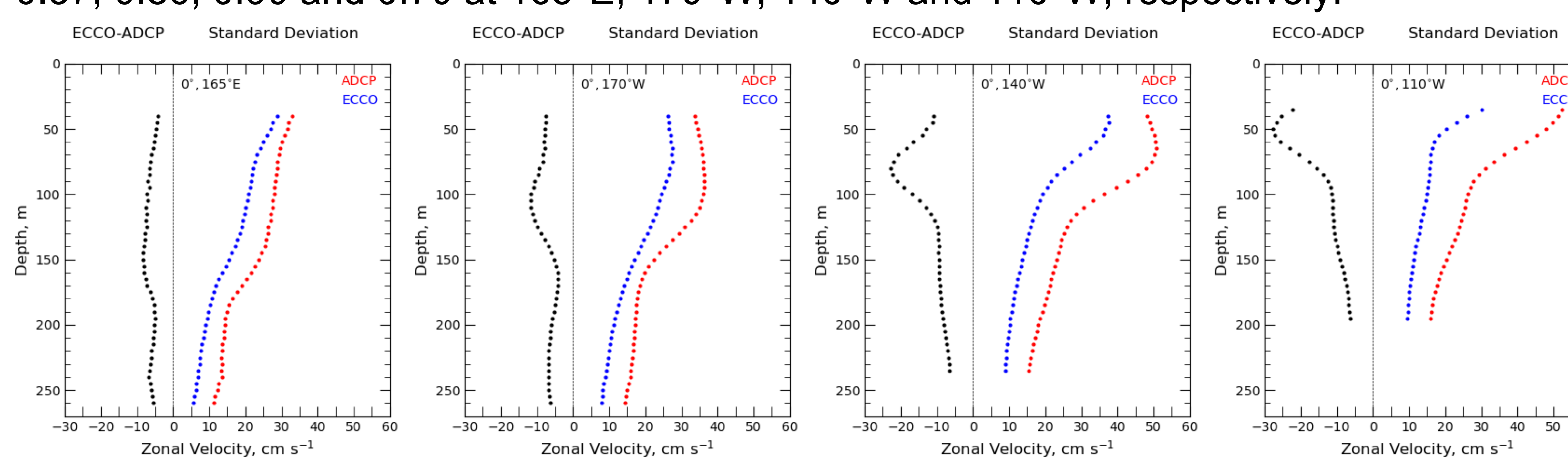
TPUW (Table 1). The ECCOv4r4 representation of TPUWs was one-third to two-thirds less than those computed with ADCP measurements. Both datasets had minimum and maximum TPUW at 165°E and 140°W, respectively. As the EUC moved eastward from 165°E to 140°W, its strength increased with inflows from below and from the south and north. From 165°E to 170°W, the ECCOv4r4 and ADCP TPUW increased 1.4 and 1.7 m^2 s^{-1} per degree of longitude, respectively, which was a 20% difference. However, from 170°W to 140°W, the difference increased to one-third. ECCOv4r4 did not represent an EUC that was rapidly increasing mass compared to ADCP data. From 140°W to 110°W, both ECCOv4r4 and ADCP showed the same mass loss, although at 110°W the ECCOv4r4 EUC strength was about one-third that determined with ADCP.

TPUW (m^2 s^{-1})	165°E	170°W	140°W	110°W
ECCO	17.1	52.8	67.7	31.4
ADCP	45.7	88.8	130.6	95.1

Time Variations (Figure 2, 1-h data). ECCOv4r4 standard deviations were consistently less than ADCP values. The maximum difference, nearly 0.3 m s^{-1}, occurred at 50-m depth at 110°W. The root-mean-square differences between monthly-mean ECCOv4r4 and ADCP TPUWs were 0.30, 0.40, 0.63 and 0.66 m s^{-1}, respectively, at 165°E, 170°W, 140°W and 110°W. At each site, monthly-mean TPUWs were significantly correlated at 95% confidence level with correlation coefficients of 0.74, 0.91. 0.93 and 0.71, respectively, at 165°E, 170°W, 140°W and 110°W. ECCOv4r4 and ADCP representations of monthly-mean EUC core speeds were 95% significantly with correlations coefficients of 0.57, 0.86, 0.90 and 0.70 at 165°E, 170°W, 140°W and 110°W, respectively.



Richardson Number (Table 2). The smaller core speeds associated with ECCOv4r4 and, consequently, a smaller vertical shear produced larger Ri compared to ADCP. ECCOv4r4 had larger amplitude time fluctuations than ADCP. Time intervals when Ri < 0.25 will be investigated. Mean, standard deviation (SD) and minimum (Min) Ri are:

	165°E		170°W		140°W		110°W	
	ECCO	ADCP	ECCO	ADCP	ECCO	ADCP	ECCO	ADCP
Mean	153.6	8.1	31.0	12.2	9.0	1.3	86.7	2.9
SD	988.5	9.8	230.4	1632.6	106.7	6.6	2489.9	19.1
Min	1.25	0.05	0.08	0.04	0.04	0.04	0.10	0.04

3. Summary

(1) A point measurement at the equator is expected to have larger values than ECCOv4r4 with its 45-km latitudinal cells. (2) ECCOv4r4 produced substantially less EUC transport. (3). ECCOv4r4 produced substantially smaller temporal fluctuations. (4) Much smaller ECCOv4r4 Ri suggests that vertical mixing parameterization should be re-evaluated.