

Enhanced warming over the global subtropical western boundary currents

Lixin Wu¹, Wenju Cai², Liping Zhang¹, Hisashi Nakamura³, Axel Timmermann⁴,
Terry Joyce⁵, Michael J. McPhaden⁶, Michael Alexander⁷,
Bo Qiu⁴, Martin Visbeck⁸, Ping Chang⁹, and Benjamin Giese⁹

¹ Physical Oceanography Laboratory, Ocean University of China, Qingdao, China

² CSIRO Marine and Atmosphere Research, Australia

³ Department of Earth, Planetary Science, University of Tokyo, Japan

⁴ International Pacific Research Center, University of Hawaii, USA

⁵ Physical Oceanography Department, Woods Hole Oceanographic Institution, USA

⁶ NOAA/Pacific Marine Environmental Laboratory, Seattle, Washington, USA

⁷ NOAA/Earth System Research Laboratory, Boulder, Colorado, USA

⁸ Leibniz-Institut für Meereswissenschaften, IFM-GEOMAR, Kiel, Germany

⁹ Department of Oceanography, Texas A&M University, USA

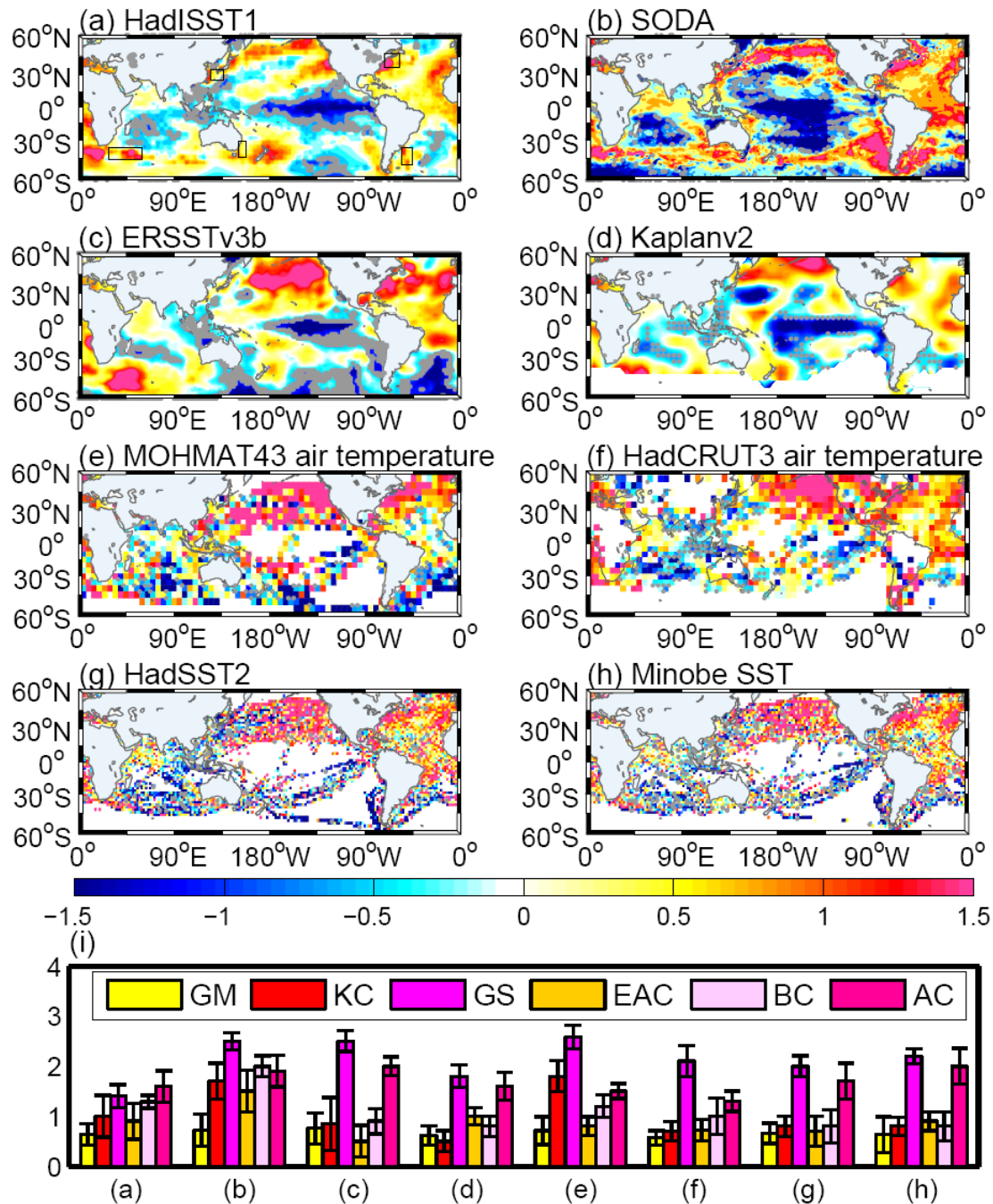


Figure S1: Global SST trends over the 1900-1950 period. (a-h) SST trends for various datasets. The corresponding global mean SST trend has been subtracted. White grid boxes denote insufficient data, and grey boxes indicate trends that are not statistically significant at the 95% confidence level. (i) SST trends averaged over the midlatitude extensions of the subtropical western boundary currents in each dataset (labels (a)-(h) stand for different dataset). Black error bar denotes the 95% confidence interval. Boundary current regions include the Kuroshio Current (KC) (25°E-150°E, 25°N-38°N), the Gulf Stream (GS) (75°W-45°W, 38°N-48°N), the Eastern Australian Current (EAC) (150°E-165°E, 44°S-34°S), the Brazil Current (BC) (58°W-35°W, 48°S-35°S) and the Agulhas Current (AC) (25°E-60°E, 45°S-35°S) (denoted by black rectangles in Fig.S1a). The unit for SST trends is °C per century. GM stands for global mean.

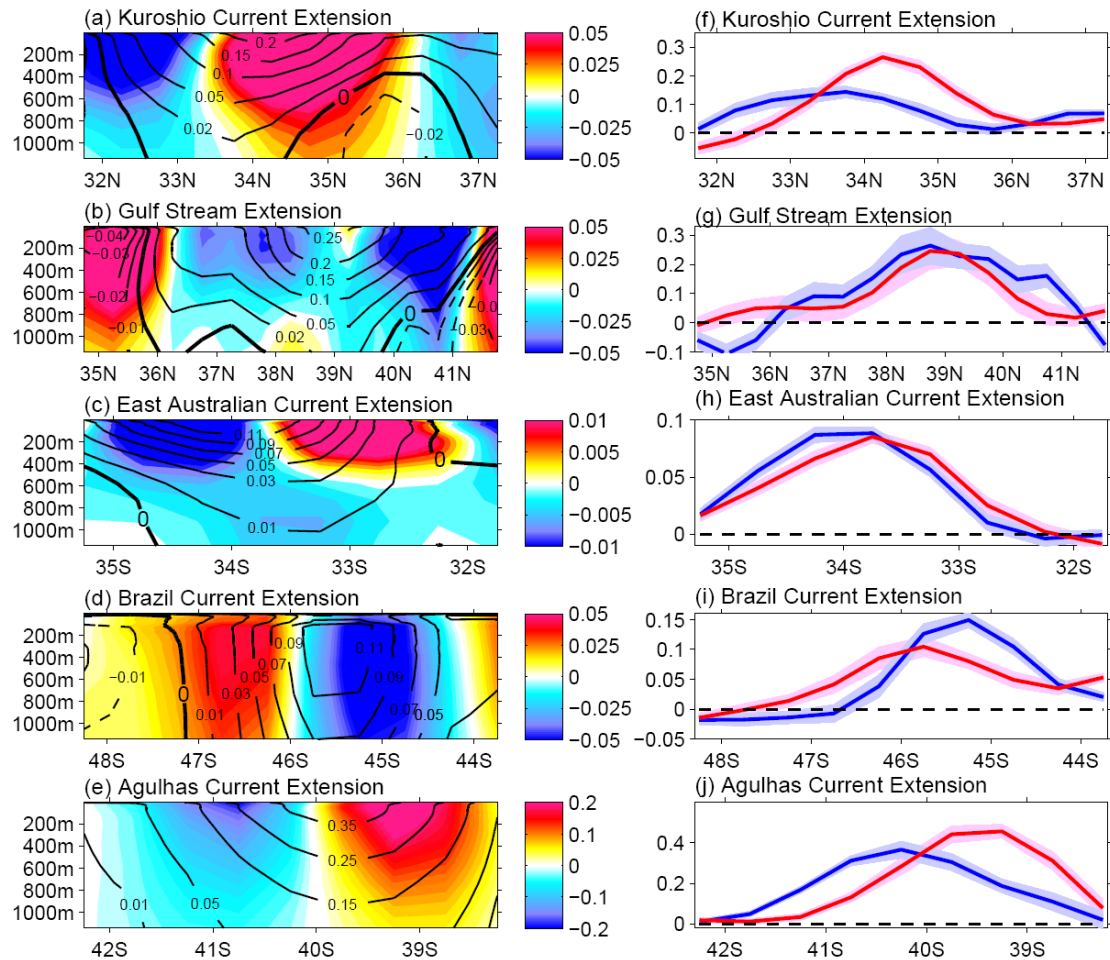


Figure S2: Trends of eastward velocity across the extensions of the subtropical western boundary currents from SODA (1900-1950). Left panel: Depth-latitude profile of mean (contours) and trend (color, multiplied by the length of data used for trend analysis). Units for mean and trend are m s^{-1} . Right panel: Latitudinal distribution of depth-weighted average eastward velocity in upper 500-m. Red and blue curves denote mean \pm trend $\times N/2$ (N is the length of data used for trend analysis), respectively. Shading indicates the 95% confidence interval of the trend. If the shading around the red and blue curves overlaps, the trend is not significant. The eastward velocity is zonally averaged over the Kuroshio Current (140°E - 180°E), the Gulf Stream (290°E - 320°E), the East Australian Current (150°E - 160°E), the Brazil Current (295°E - 320°E), and the Agulhas Current (21.25°E - 40°E), respectively.

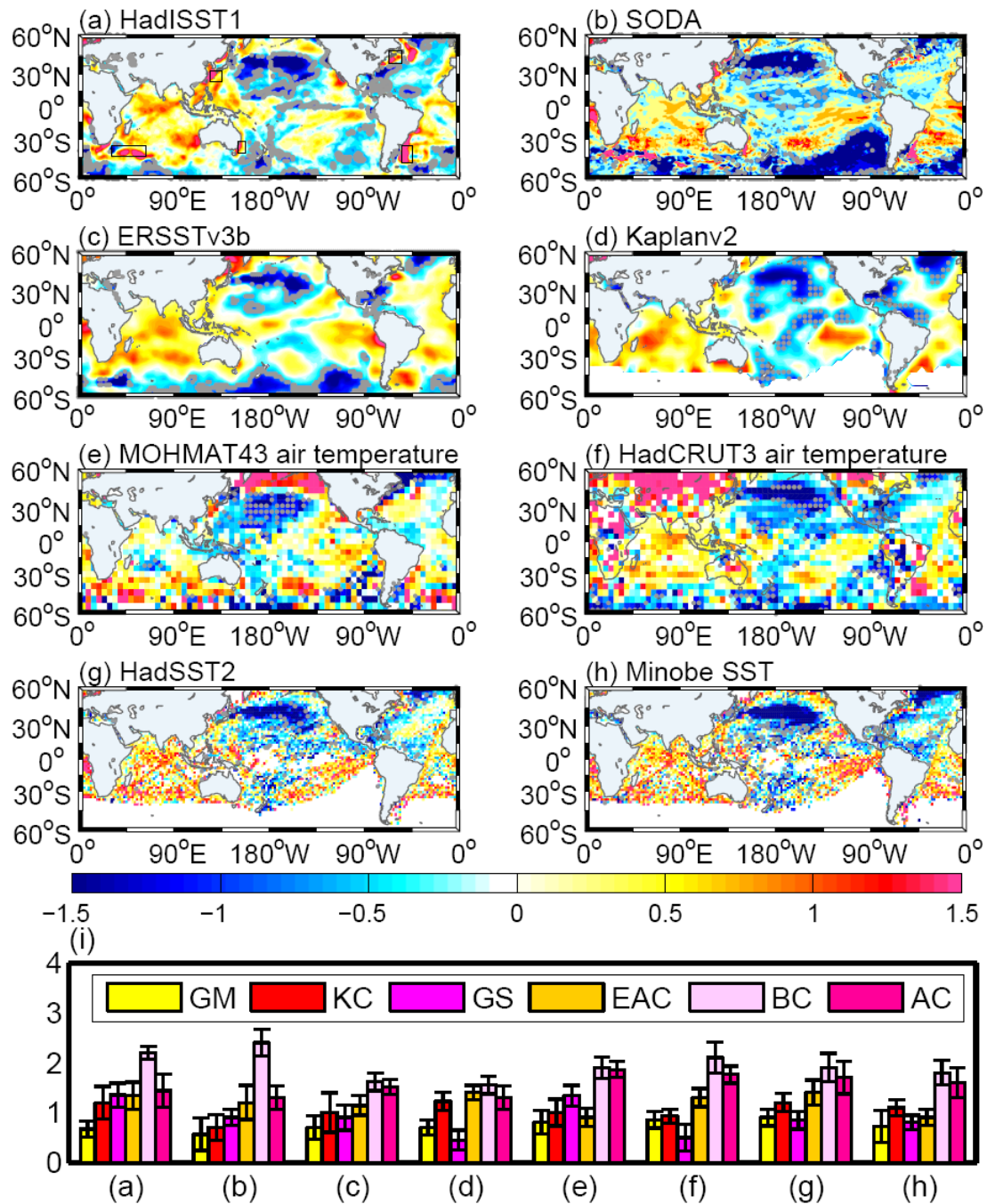


Figure S3: Same as Figure S1 but for 1950-2008.

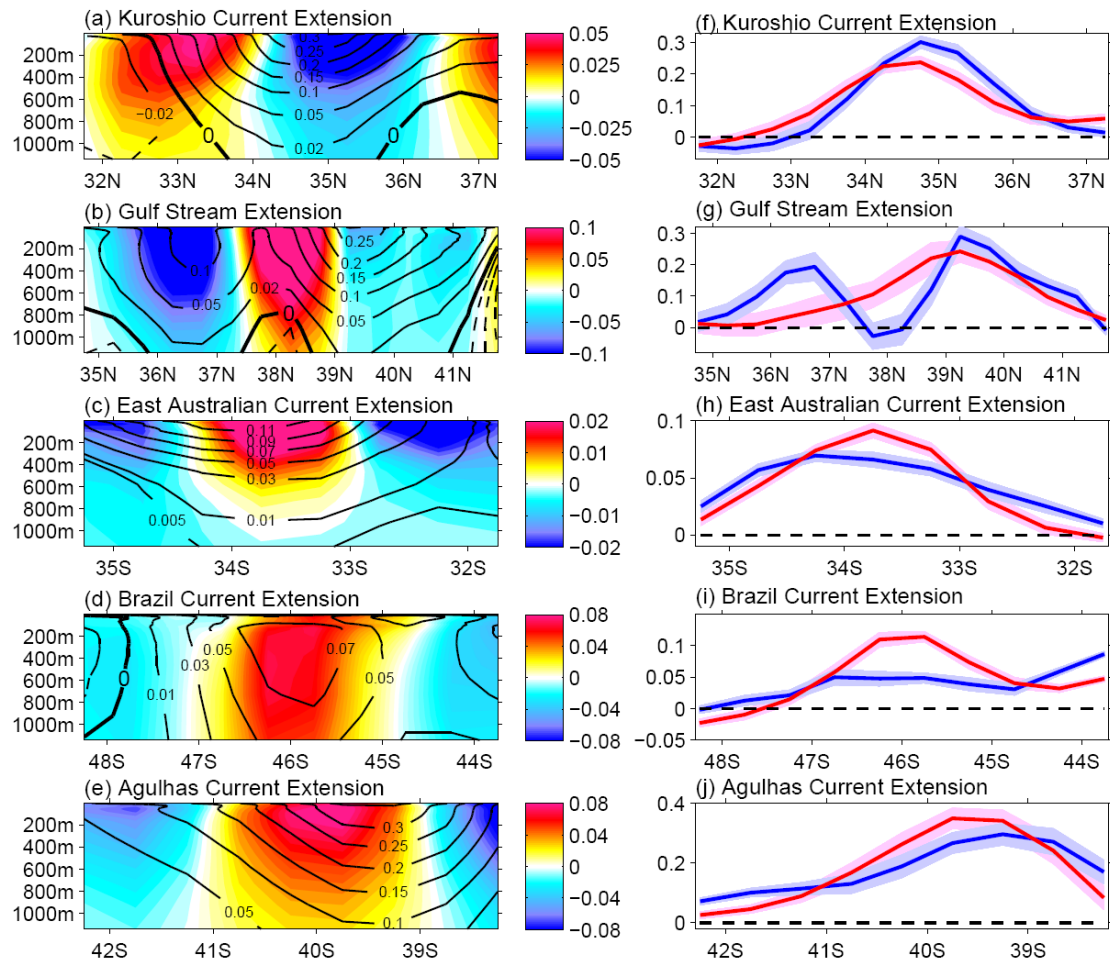


Figure S4: Same as Figure S2 but for 1950-2008, but with different contour intervals.

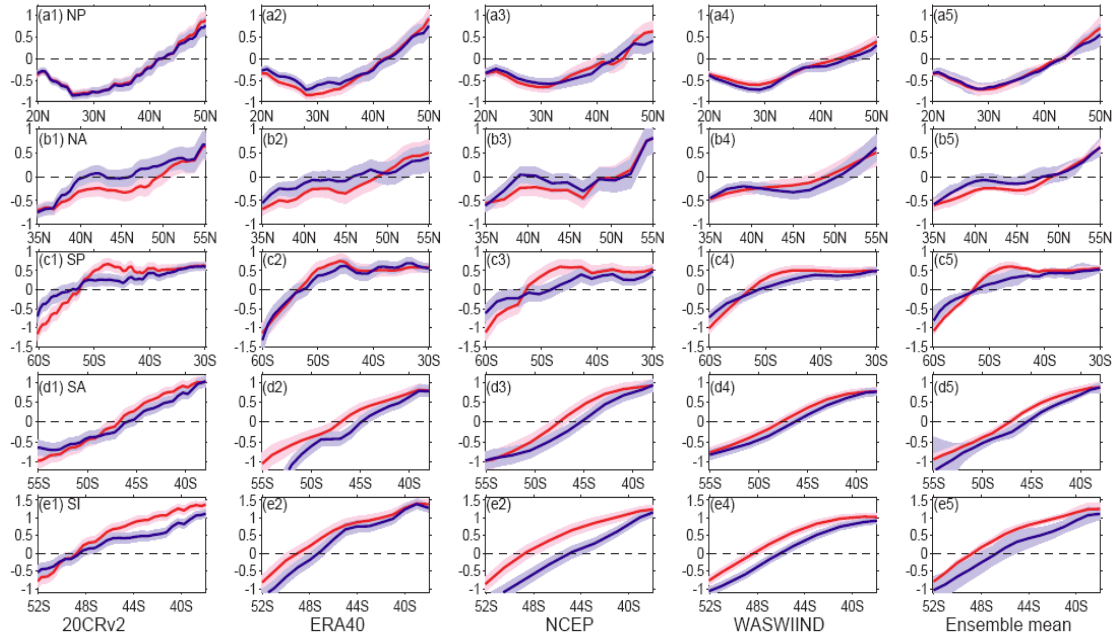


Figure S5: (a1-e4) Wind stress curl zonally averaged over each ocean basin for various datasets. Red and blue curves denote mean \pm trend \cdot N/2 (N is the length of data used for trend analysis) in the North Pacific, the North Atlantic, the South Pacific, the South Atlantic Ocean and the South Indian Ocean, respectively. The unit is 10^{-7} N m^{-3} . Gray shading indicates the 95% confidence interval determined by a Student's-t test. If the shading around the red and blue curves overlaps, the trend is not significant. Panels from left to right represent 20CRv2, ERA40, NCEP/NCAR, WASWIND data, respectively. Right panel (a5-e5): Ensemble mean and standard deviation of trends from four datasets.

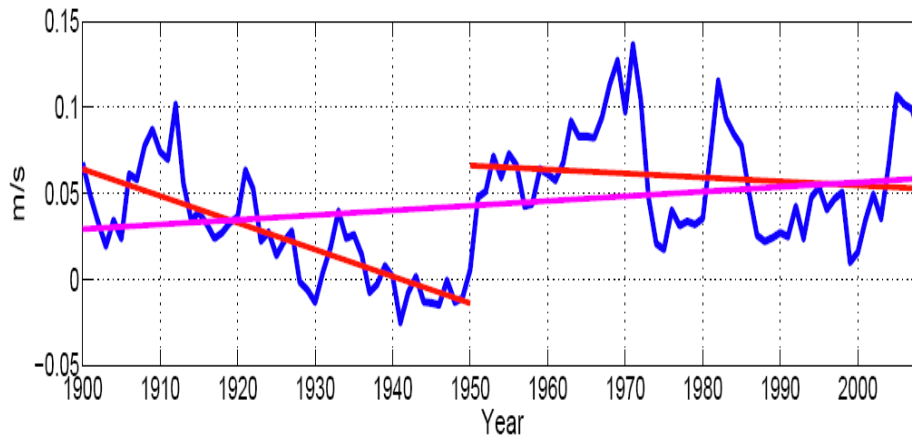


Figure S6: Time series of zonal velocity of the Agulhas Current at 41°S from SODA (1900-2008). The velocity is zonally averaged over (21.25°E-40 °E) in upper 400-m. Two red lines represent the linear trends of the zonal velocity in 1900-1950 and 1950-2008, respectively. The pink line represents the long-term trend from 1900-2008. The significant trend can be only found in 1900-1950, while the trends in 1950-2008 and 1900-2008 are less significant.

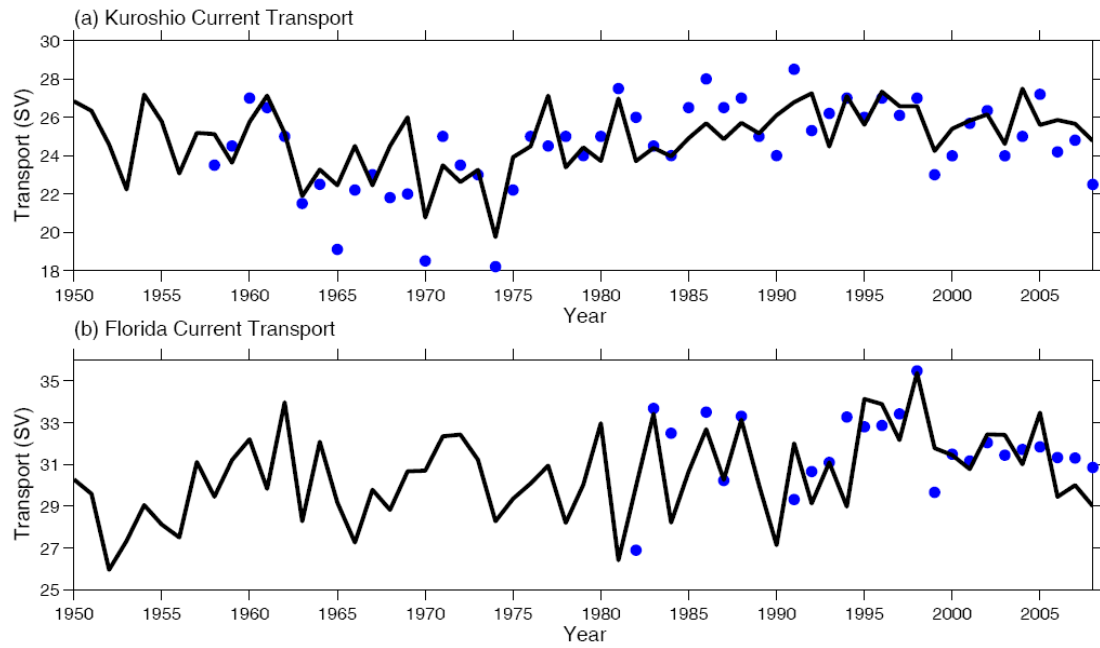


Figure S7: The transports of (a) the Kuroshio Current across the Pollution Nagasaki (PN) line and (b) the Florida Current are superimposed over these from SODA. Transport of subtropical western boundary currents in SODA (black curve) and observations (blue dots).