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Salinity and water cycle: Salinity trends indicate a rapid intensification of the global water cycle

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Models project an intensification of the water cycle at a rate of about 2% per ^{o}C of warming, well below the Clausius-Clapeyron thermodynamic rate of 7%/^{o}C. This is termed a "robust response" of the climate system by Held and Soden (2006) and ascribed to weaker winds and a longer residence time for water vapor in the atmosphere. Terrestrial data on the water cycle shows variability but no clear trends in water fluxes (Huntington, 2006; Dai et al, 2009). However, the terrestrial water cycle is a small portion of the global water cycle; the total discharge of all rivers is less than 10% of the global evaporation from the surface of the ocean (Schanze, Schmitt and Yu, 2011). The strong preponderance of marine water fluxes over terrestrial fluxes suggests that it is the oceanic salinity field where we should expect to detect evidence for a changing water cycle. Durack and Wijffels (2010) and others have identified strong 50-year trends in surface salinity that closely resemble the mean salinity distribution; salty areas are getting saltier, fresh areas have gotten fresher. Similar patterns are found in sub-surface water masses. The rate of intensification is at least as strong as Clausius-Clapeyron. Strong trends in precipitable water and precipitation have been found by Wentz et al (2007). Increases in oceanic evaporation have been identified by Yu and Weller (2007) and ascribed in part to increasing winds. Salinity records allow us to use the ocean as a rain gauge, though an understanding of the ocean's circulation and mixing processes is required for quantitative interpretation. The strong intensification of the water cycle found in the data indicates that serious flaws remain with its representation in the current generation of climate models.