Geophysical Research Abstracts
Vol. 14, EGU2012-2525-1, 2012
EGU General Assembly 2012

Detection of the Length-of-Day Response to a Sub-Monthly Fluctuation of the Antarctic Circumpolar Current in November 2009

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At seasonal and shorter periods the solid Earth and its overlying geophysical fluids form a closed dynamical system, which (except for the effect of tides) conserves its total angular momentum. While atmospheric effects dominate changes in the Earth's rate of rotation and hence length-of-day (LOD) on these time scales, the addition of oceanic angular momentum (OAM) estimates has been shown to improve closure of the LOD budget in a statistical sense. In this study we demonstrate, for the first time, the signature of a specific, sub-monthly ocean current fluctuation on the Earth's rotation rate. In late 2009 highly anomalous conditions prevailed in the Southern Ocean, involving in particular record monthly sea surface temperature (SST – Lee et al., GRL 2010) and ocean bottom pressure (OBP – Boening et al., GRL 2011) in the southeast Pacific. Here we show that these conditions were accompanied by a sharp (14-day) drop and subsequent recovery in the strength of the Antarctic Circumpolar Current (ACC), leading to an unprecedented short-period anomaly in global OAM as reconstructed from the last decade of an altimeter-assimilating run (KF080) of the Consortium for Estimating the Circulation and Climate of the Ocean (ECCO) model. The resulting LOD change was large enough to be detected in geodetic data from the Jet Propulsion Laboratory (JPL) Kalman Earth Orientation Filter (KEOF), following removal of atmospheric effects computed from the NASA Global Modeling and Assimilation Office (GMAO) Modern Era Retrospective Analysis for Research and Applications (MERRA). The OAM fluctuation comprised nearly equal and simultaneous contributions from changes in ocean current and mass fields, with the modeled Drake Passage transport showing negative anomalies at all latitudes for a ten-day period coinciding with the LOD anomaly. In situ observational confirmation was provided by tide-corrected OBP data from the South Drake bottom pressure recorder (BPR) maintained by the Antarctic Circumpolar Current Levels by Altimetry and Island Measurements (ACCLAIM) project, which showed a large positive fluctuation coinciding with the Earth rotation signal. Departures in OBP from climatological norms in the southeast Pacific (Boening et al.) and the ACC region (as shown in our results) may be expected during late 2009 when some of the initial retrievals from the Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) campaign were conducted. The possible connection of these anomalies with enhanced poleward heat transport in the Southern Ocean, as suggested by the subsequent appearance of record high SSTs in the Bellingshausen Sea (Lee et al.), remains to be explored.