About
View Issues
Subscribe
Order Back Issues
Author Guidelines
Permissions
Advertising
Change of Address
Contact Us
Magazine Home
TOS Home

2011, *Oceanography* 24(2):122–129, http://dx.doi.org/10.5670/oceanog.2011.32

Balancing the Sea Level Budget

Authors | Abstract | Full Article | Citation | References

Authors

Eric W. Leuliette | Laboratory for Satellite Altimetry, National Oceanic and Atmospheric Administration, Silver Spring, MD, USA

Josh K. Willis | Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Top

Abstract

Sea level rise is both a powerful impact of and indicator for global warming and climate change. Observing sea level change, as well as its causes, is therefore a top priority for scientists and society at large. By measuring the ocean's temperature, salinity, mass, and surface height, the relative sources of recent sea level rise can be discerned. With these observations, sea level change is determined in terms of total sea level and its two major components, ocean mass and steric (density-related) sea level. The sea level budget is closed when the sum of the independent components agrees with measurements of total sea level, indicating that the observations can be used to interpret the causes of sea level change. While nearly global monitoring of sea level from space-based radar altimeters has been available since the early 1990s, satellite gravity missions capable of weighing changes in ocean mass have been available for less than 10 years. Even more recently, the Argo array of profiling floats achieved a level of coverage that now allows assessment of global sea level change due to temperature and salinity in the upper 2,000 m of the ocean. Only during the overlapping period of all three observing systems can the sea level budget be directly addressed by observations.

Top

Full Article

Download 1 MB pdf.

Top

Citation

Leuliette, E.W., and J.K. Willis. 2011. Balancing the sea level budget. *Oceanography* 24(2):122–129, http://dx.doi.org/10.5670/oceanog.2011.32.

Top

References

Beckley, B., N. Zelensky, S. Holmes, F. Lemoine, R. Ray, G. Mitchum, S. Desai, and S. Brown. 2010. Assessment of the Jason-2 extension to the TOPEX/Poseidon, Jason-1 sea-surface height time series for global mean sea level monitoring. *Marine Geodesy* 33(1):447–471. [CrossRef]

Bindoff, N., J. Willebrand, V. Artale, A. Cazenave, J. Gregory, S. Gulev, K. Hanawa, C. Le Quéré, S. Levitus, Y. Nojiri, and others. 2007. Observations: Oceanic climate change and sea level. Pp 385–432 in *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, eds, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Cazenave, A., and W. Llovel. 2010. Contemporary sea level rise. *Annual Review of Marine Science* 2(1):145–173. [CrossRef]

Cazenave, A., K. Dominh, S. Guinehut, E. Berthier, W. Llovel, G. Ramillien, M. Ablain, and G. Larnicol. 2009. Sea level budget over 2003–2008: A reevaluation from GRACE space gravimetry, satellite altimetry and Argo. *Global and Planetary Change* 65(1–2):83–88. [CrossRef]

Chambers, D. 2006. Observing seasonal steric sea level variations with GRACE and satellite altimetry. *Journal of Geophysical Research* 111(3):C03010, http://dx.doi.org/10.1029/2005JC002914. [CrossRef]

Chambers, D.P., and J.K. Willis. 2009. Low-frequency exchange of mass between ocean basins. *Journal of Geophysical Research* 114(C11), C11008. [CrossRef]

Chambers, D.P., and J.K. Willis. 2010. A global evaluation of ocean bottom pressure from GRACE, OMCT, and steric-corrected altimetry. *Journal of Atmospheric and Oceanic Technology* 27(8):1,395–1,402. [CrossRef]

Chambers, D.P., J. Wahr, and R.S. Nerem. 2004. Preliminary observations of global ocean mass variations with GRACE. *Geophysical Research Letters* 31, L13310. [CrossRef]

Chambers, D.P., J. Wahr, M.E. Tamisiea, and R.S. Nerem. 2010. Ocean mass from GRACE and glacial isostatic adjustment. *Journal of Geophysical Research* 115(B11), B11415. [CrossRef]

Chang, Y.-S., A.J. Rosati, and G.A. Vecchi. 2010. Basin patterns of global sea level changes for 2004–2007. *Journal of Marine Systems* 80(1–2):115–124. [CrossRef]

Church, J.A., J.M. Gregory, N.J. White, S.M. Platten, and J.X. Mitrovica. 2011. Understanding and projecting sea level change. *Oceanography* 24(2):130–143. [CrossRef]

Church, J.A., and N.J. White. 2006. A 20th century acceleration in global sea-level rise. *Geophysical Research Letters* 33, L01602. [CrossRef]

Collilieux, X., and G. Wöppelmann. 2011. Global sea-level rise and its relation to the terrestrial reference frame. *Journal of Geodesy* 85(1):9–22. [CrossRef]

Domingues, C.M., J. Church, N. White, P. Gleckler, S. Wijffels, P. Barker, and J. Dunn. 2008. Improved estimates of upper-ocean warming and multi-decadal sea-level rise. *Nature* 453(7198):1,090–1,093. [CrossRef]

Douglas, B., and W. Peltier. 2002. The puzzle of global sea-level rise. *Physics Today* 55(3):35–40. [CrossRef]

Gouretski, V., and F. Reseghetti. 2010. On depth and temperature biases in bathythermograph data: Development of a new correction scheme based on analysis of a global ocean database. *Deep-Sea Research Part I* 57(6):812–833. [CrossRef]

Han, W., G.A. Meehl, B. Rajagopalan, J.T. Fasullo, A. Hu, J. Lin, W.G. Large, J. Wang, X.-W. Quan, L.L. Trenary, and others. 2010. Patterns of Indian Ocean sea-level change in a warming climate. *Nature Geoscience* 3:546–550. [CrossRef]

Hu, A., G.A. Meehl, W. Han, and J. Yin. 2009. Transient response of the MOC and climate to potential melting of the Greenland Ice Sheet in the 21st century. *Geophysical Research Letters* 36, L10707. [CrossRef]

Ishii, M., and M. Kimoto. 2009. Reevaluation of historical ocean heat content variations with time-varying XBT and MBT depth bias corrections. *Journal of Oceanography* 65(3):287–299. [CrossRef]

Leuliette, E.W., and L. Miller. 2009. Closing the sea level rise budget with altimetry, Argo, and GRACE. *Geophysical Research Letters* 36, L04608. [CrossRef]

Leuliette, E.W., and L. Miller. 2010. The budget of recent global sea level rise, January 2004–March 2010. http://ibis.grdl.noaa.gov/SAT/SeaLevelRise/documents/NOAA_NESDIS_Sea_Level_Rise_Budget_Report_2010.pdf (accessed April 29, 2010).

Leuliette, E.W., and R. Scharroo. 2010. Integrating Jason-2 into a Multiple-Altimeter Climate Data Record. *Marine Geodesy* 33(1):504–517. [CrossRef]

Levitus, S., J.I. Antonov, T.P Boyer, R.A. Locarnini, H.E. Garcia, and A.V. Mishonov. 2009. Global ocean heat content 1955–2008 in light of recently revealed instrumentation problems. *Geophysical Research Letters* 36(7):L07608. [CrossRef]

Llovel, W., S. Guinehut, and A. Cazenave. 2010. Regional and interannual variability in sea level over 2002–2009 based on satellite altimetry, Argo float data and GRACE ocean mass. *Ocean Dynamics* 60(5):1,193–1,204. [CrossRef]

Lyman, J.M., and G. Johnson. 2008. Estimating annual global upper ocean heat content anomalies despite irregular in situ ocean sampling. *Journal of Climate* 21(21):5,629–5,641. [CrossRef]

Milne, G.A., W.R. Gehrels, C.W. Hughes, and M.E. Tamisiea. 2009. Identifying the causes of sea-level change. *Nature Geosciences* 2(7):471–478. [CrossRef]

Mitchum, G. 2000. An improved calibration of satellite altimetric heights using tide gauge sea levels with adjustment for land motion. *Marine Geodesy* 23(3):145–166. [CrossRef]

Nicholls, R.J. 2011. Planning for the impacts of sea level rise. *Oceanography* 24(2):144–157. [CrossRef]

Nerem, R., D. Chambers, E. Leuliette, G. Mitchum, and B. Giese. 1999. Variations in global mean sea level associated with the 1997–1998 ENSO event: Implications for measuring long-term sea level change. *Geophysical Research Letters* 26(19):3,005–3,008. [CrossRef]

Nerem, R., D. Chambers, C. Choe, and G. Mitchum. 2010. Estimating mean sea level change from the TOPEX and Jason altimeter missions. *Marine Geodesy* 33(1):435–446. [CrossRef]

Paulson, A., S. Zhong, and J. Wahr. 2007. Inference of mantle viscosity from GRACE and relative sea level data. *Geophysical Journal International* 171 (2):497-508. [CrossRef]

Peltier, W.R. 2009. Closure of the budget of global sea level rise over the GRACE era: The importance and magnitudes of the required corrections for global glacial isostatic adjustment. *Quaternary Science Reviews* 28(17–18):1,658–1,674. [CrossRef]

Pfeffer, W.T. 2011. Land ice and sea level rise: A thirty-year perspective. *Oceanography* 24(2):94–111. [CrossRef]

Prandi, P., A. Cazenave, and M. Becker. 2009. Is coastal mean sea level rising faster than the global mean? A comparison between tide gauges and satellite altimetry over 1993–2007. *Geophysical Research Letters* 36, L05602. [CrossRef]

Purkey, S.G., and G.C. Johnson. 2010. Warming of global abyssal and deep Southern Ocean waters between the 1990s and 2000s: Contributions to global heat and sea level rise budgets. *Journal of Climate* 23(23):6,336–6,351. [CrossRef]

Tamisiea, M.E., and J.X. Mitrovica. 2011. The moving boundaries of sea level change: Understanding the origins of geographic variability. *Oceanography* 24(2):24–39. [CrossRef]

Trenberth, K.E., and J.T. Fasullo. 2010. Tracking Earth's energy. *Science* 328:316–317. [CrossRef]

Willis, J.K., D.P. Chambers, and R.S. Nerem. 2008. Assessing the globally averaged sea level budget on seasonal to interannual timescales. *Journal of Geophysical Research* 113(C6), C06015. [CrossRef]

Woodworth, P.L., W.R. Gehrels, and R.S. Nerem. 2011. Nineteenth and twentieth century changes in sea level. *Oceanography* 24(2):80–93, http://dx.doi.org/10.5670/oceanog.2011.29. [CrossRef]

Top

Oceanography Magazine, The Oceanography Society, P.O. Box 1931, Rockville, MD 20849-1931, USA
Tel: (1) 301-251-7708, Fax: (1) 301-251-7709, E-mail: **magazine@tos.org**
Send comments about this site to **webmaster@tos.org**