

Dr. Felix W. Landerer

Project Scientist – GRACE-FO

I am a Research Scientist in JPL's Sea Level and Ice Group. My field of study can be described as *Hydro-Geodesy*: I study the Earth's hydrosphere (e.g., the water cycle, sea level, ocean currents etc.) and its changes using observations like time-variable gravity and mass change (GRACE, GRACE Follow-On & geodetic satellites), satellite altimetry, in-situ measurements (tide gauges, GPS sensors, hydrographic floats). On Earth, the processes that couple water and energy are fundamental to today's most pressing climate science challenges. Tracking Earth's water movement and surface mass changes across the planet, monitoring changes in ice sheets and glaciers, near-surface and underground water storage, the amount of water in large lakes and rivers, as well as changes in sea level and ocean currents, provides an integrated global view of how Earth's water cycle and energy balance are evolving, with important applications for everyday life.

#### Research Interests

- Evaluating global and regional sea level variations from satellite and in-situ observations:
  - What are the contributions to global and regional sea level change from steric and non-steric sources, dynamic sea level adjustments, and so-called "sea level fingerprints"? How are these evolving over time?
- Tracking Earth's energy budget and ocean heat content from satellite gravimetry and altimetry
  - Where does the increasing ocean heat go? What role does the deep ocean (below 2000m) play?
- Earth's water cycle & associated surface mass redistributions:
  - How can we best utilize tools from *hydrogeodesy* to measure water availability (e.g., aquifer storage, drought monitoring, etc.) & develop applications of satellite observations to aid with water resources & coastal impacts management?
- Earth rotation and center of mass variations due to atmosphere-ocean-land interactions;
- Assessing observations & Earth System Model simulations: rates and patterns of sea level variability & trends and their drivers;

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#### Projects



##### [GRACE Follow-On](#)

GRACE Follow-On, the Gravity Recovery and Climate Experiment Follow-On, provides measurements of the Earth's month-to-month mass variations.



##### [MEaSURES](#)

NASA's Earth Science Program is dedicated to advancing Earth remote sensing and pioneering the scientific use of satellite measurements to improve human understanding of our home planet.



##### [SEA LEVEL CHANGE](#) [NASA Sea Level Change](#)

Observations from Space

NASA's Sea Level Change team was selected in 2014, 2017, and 2020, to focus on advancing NASA sea level science and forming new collaborations to tackle the interdisciplinary challenges in sea level research.

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## Education

- Ph.D., Oceanography, Max Planck Institute for Meteorology / University of Hamburg / Intl. Max Planck Research School on Earth System Modelling (2004-2007);
- Diploma (M.Sc.), Geophysics, University of Kiel (1998-2004);

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## Professional Experience

### Positions

- Jet Propulsion Laboratory / California Institute of Technology:
  - GRACE Follow-On Project Scientist (09/19 – present);
  - GRACE Follow-On Deputy Project Scientist (06/15 – 09/19);
  - Research Scientist (07/2010 - present);
  - NASA Postdoctoral Fellow (08/2008 - 06/2010);
- Max Planck Institute for Meteorology (Hamburg):
  - Research Assistant (07/2007 - 07/2008);

### Projects & Working Groups

- GRACE Follow-On (Project Scientist & JPL Science Data System Manager)
- NASA Sea Level Change Team (NSLCT, 2014 & 2017) Co-I
- Science Teams: GRACE / GRACE Follow-On (Satellite gravimetry) & OST (Satellite altimetry)
- US CLIVAR AMOC (Task Team 1)
- WCRP Working Group: Sea Level Budget
- MEaSUREs-2017 (PI): HOMAGE – Heat and Ocean Mass from Gravity ESDR
- MEaSUREs-2012 (PI): [Earth's surface mass changes](#)
- PI & Co-I (NASA Physical Oceanography)
- NASA-DOE obs4MIPs Working Group
- IPCC WGI AR6 Expert Panel [U.S. Government Review; 2020-21]
- IPCC-AR5 Contributing Author (2013, Chapter-09)
- National Climate Assessment (NCA) Report Contributing Author (2014)

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## Current Openings

For current openings (internships, summer opportunities, post-doctoral positions) please visit <https://www.jpl.nasa.gov/education> and search for 'Landerer', and/or 'GRACE', 'GRACE Follow-On'.

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## Selected Awards

- NASA Outstanding Public Leadership Medal (2020)
- JPL Voyager Award (2020, 2018)
- AGU's Outstanding Reviewers Award (2019)
- NASA Exceptional Achievement Medal (2018)

- JPL Ed Stone Award for Outstanding Research Publication (2017)
- NASA Early Career Public Achievement Medal (2016)
- Obs4MIPS - NASA Honor Award for Group Achievement (2015)
- Otto Hahn Medal of the Max Planck Society for outstanding scientific achievements (2008);
- NASA Postdoctoral Fellowship (2008);

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Publications (peer reviewed):

[Google Scholar](#)  
[Research Gate](#)

#### In Review / Preparation

1. Peidou, A., **Landerer, F.**, Wiese, D., et al. (2023). Error budget of GNSS vertical land displacement estimates for use in GNSS-GRACE joint inversion. In prep.
2. Johnson, G., Landerer, F., et al., (2023). Closure of Earth's Global Seasonal Cycle of Energy Storage, Surveys in Geophysics, *submitted*.

#### Published

3. von Schuckmann, K., Minière, A., Gues, F., Cuesta-Valero, F. J., Kirchengast, G., Adusumilli, S., Straneo, F., Ablain, M., Allan, R. P., Barker, P. M., Beltrami, H., Blazquez, A., Boyer, T., Cheng, L., Church, J., Desbruyeres, D., Dolman, H., Domingues, C. M., García-García, A., Giglio, D., Gilson, J. E., Gorfer, M., Haimberger, L., Hakuba, M. Z., Hendricks, S., Hosoda, S., Johnson, G. C., Killick, R., King, B., Kolodziejczyk, N., Korosov, A., Krinner, G., Kuusela, M., **Landerer, F. W.**, et al. (2023): Heat stored in the Earth system 1960–2020: where does the energy go?, *Earth Syst. Sci. Data*, 15, 1675–1709, <https://doi.org/10.5194/essd-15-1675-2023>.
4. Argus, D. F., Martens, H. R., Borsa, A., Knappe, E., Wiese, D. N., Alam, S., et al. (2022). Subsurface water flux in California's Central Valley and its source watershed from space geodesy. *Geophysical Research Letters*, 49, e2022GL099583. <https://doi.org/10.1029/2022GL099583>.
5. Delman, A., **Landerer, F.W.** (2022), Downscaling Satellite-Based Estimates of Ocean Bottom Pressure for Tracking Deep Ocean Mass Transport, *Remote Sens.*, 1, accepted.
6. Piecuch, C. G., Coats, S., Dangendorf, S., **Landerer, F. W.**, Reager, J. T., Thompson, P. R., & Wahl, T. (2022). High-tide floods and storm surges during atmospheric rivers on the US West Coast. *Geophysical Research Letters*, 49, e2021GL096820. <https://doi.org/10.1029/2021GL096820>.
7. Peidou, A., **Landerer, F.**, Wiese, D., et al. (2022). Spatiotemporal characterization of geophysical signal detection capabilities of GRACE-FO. *Geophysical Research Letters*, 49, e2021GL095157. <https://doi.org/10.1029/2021GL095157>.
8. Harvey, T.C., Hamlington, B.D., Frederikse, T. *et al.* Ocean mass, sterodynamic effects, and vertical land motion largely explain US coast relative sea level rise. *Commun Earth Environ* **2**, 233 (2021). <https://doi.org/10.1038/s43247-021-00300-w>.
9. Pie, N., Bettadpur, S. V., Tamisiea, M., Krichman, B., Save, H., Poole, S., et al. (2021). Time variable Earth gravity field models from the first spaceborne laser ranging interferometer. *Journal of Geophysical Research: Solid Earth*, 126, e2021JB022392. <https://doi.org/10.1029/2021JB022392>
10. Hakuba, M. Z., Frederikse, T., & **Landerer, F.W.** (2021). Earth's energy imbalance from the ocean perspective (2005–2019). *Geophysical Research Letters*, 48, e2021GL093624. <https://doi.org/10.1029/2021GL093624>
11. Frederikse, T., Adhikari, S., Daley, T. J., Dangendorf, S., Gehrels, R., **Landerer, F.W.**, et al. (2021). Constraining 20th-century sea-level rise in the South Atlantic Ocean. *JGR-O*, 126, e2020JC016970. <https://doi.org/10.1029/2020JC016970>.
12. Argus, D. F., Ratliff, B., DeMets, C., Borsa, A. A., Wiese, D. N., & Blewitt, G., Crowley, J.W., Martens, H.R., Kreemer, C., **Landerer, F.W.** (2020). Rise of Great Lakes surface water, sinking of

- the upper Midwest of the United States, and viscous collapse of the forebulge of the former Laurentide ice sheet. *JGR: Solid Earth*, 125, <https://doi.org/10.1029/2020JB019739>.
13. Frederikse, T., **Landerer, F.**, Caron, L. et al. (2020) The causes of sea-level rise since 1900. *Nature* 584, 393–397. <https://doi.org/10.1038/s41586-020-2591-3>.
  14. Sasgen I., Wouters, B., Gardner, A.S., King, M.D., Tedesco, M., **Landerer, F.W.**, Dahle, C., Save, H., Fettweis, X. (2020), Return to rapid ice loss in Greenland and record loss in 2019 1 detected by the GRACE-FO satellites, *Nature Communications Earth & Environment*.
  15. Ghobadi-Far, K., Han, S.-C., McCullough, C. M., Wiese, D. N., Yuan, D.-N., **Landerer, F. W.**, et al. (2020). GRACE Follow-On laser ranging interferometer measurements uniquely distinguish short-wavelength gravitational perturbations. *Geophysical Research Letters*, 47, e2020GL089445. <https://doi.org/10.1029/2020GL089445>.
  16. Hamlington, B. D. et al. (2020). Understanding of contemporary regional sea-level change and the implications for the future. *Reviews of Geophysics*, 58, e2019RG000672. <https://doi.org/10.1029/2019RG000672>.
  17. **Landerer, F. W.**, Flechtner, F. M., Save, H., Webb, F. H., Bandikova, T., Bertiger, W. I., et al. (2020). Extending the global mass change data record: GRACE Follow-On instrument and science data performance. *Geophysical Research Letters*, 47, e2020GL088306. <https://doi.org/10.1029/2020GL088306>
  18. Wu, X., Haines, B. J., Heflin, M. B., & **Landerer, F. W.** (2020). Improved global nonlinear surface mass variation estimates from geodetic displacements and reconciliation with GRACE data. *JGR: SolidEarth*,125, e2019JB018355. <https://doi.org/10.1029/2019JB018355>.
  19. Velicogna, I., Mohajerani, Y., A, G., **Landerer, F.**, Mouginit, J., Noel, B., et al. (2020). Continuity of ice sheet mass loss in Greenland and Antarctica from the GRACE and GRACE Follow-On missions. *Geophysical Research Letters*, 47, e2020GL087291. <https://doi.org/10.1029/2020GL087291>.
  20. Loomis, B. D., Rachlin, K. E., Wiese, D. N., **Landerer, F. W.**, & Luthcke, S. B. (2020). Replacing GRACE/GRACE-FO C30 with satellite laser ranging: Impacts on Antarctic Ice Sheet mass change. *Geophysical Research Letters*, 47, e2019GL085488. <https://doi.org/10.1029/2019GL085488>.
  21. Frederikse, **Landerer**, Caron (2019), The imprints of contemporary mass redistribution on regional sea level and vertical land motion observations, *Solid Earth*, 10, 1971–1987, <https://doi.org/10.5194/se-10-1971-2019>.
  22. Hamlington, B. D., Fasullo, J. T., Nerem, R. S., Kim, K. - Y., & **Landerer, F. W.** (2019). Uncovering the pattern of forced sea level rise in the satellite altimeter record. *Geophysical Research Letters*, 46, <https://doi.org/10.1029/2018GL081386>.
  23. Adhikari, Ivins, Frederikse, Landerer, Caron (2019), Sea-level fingerprints emergent from GRACE mission data, *Earth Sys Sci. Data*, 11, 629–646, <https://doi.org/10.5194/essd-11-629-2019>
  24. Meyssignac et al. (2019), Measuring Global Ocean Heat Content to estimate the Earth Energy Imbalance, *Frontiers in Marine Science*.
  25. Tapley, Watkins, Flechtner, Reigber, Bettadpur, Rodell, Sasgen, Famiglietti, **Landerer**, et al. (2019), Contributions of GRACE to understanding climate change, *Nature Climate Change*, 9, 358–369 (2019).
  26. Hamlington, B. D., Cheon, S. H., Piecuch, C. G., Karnauskas, K. B., Thompson, P. R., Kim, K. Y., et al. (2019). The dominant global modes of recent internal sea level variability. *Journal of Geophysical Research: Oceans*, 124 , 2750 – 2768. <https://doi.org/10.1029/2018JC014635>
  27. Gregory et al. (2019), Concepts and terminology for sea level - mean, variability and change, both local and global, *Surveys in Geophysics*, in press.
  28. Uebbing, B., Kusche, J., Rietbroek, R., & Landerer, F. W. (2019). Processing choices affect ocean mass estimates from GRACE. *Journal of Geophysical Research: Oceans*, 124. <https://doi.org/10.1029/2018JC014341>.
  29. Volkov, Baringer, Smeed, Johns, **Landerer** (2018): Teleconnection between the Atlantic Meridional Overturning Circulation and sea level in the Mediterranean Sea, *J Climate* 32 (3), 935-955.
  30. WCRP Global Sea Level Budget Group (2018); Global sea-level budget 1993–present, *Earth Syst. Sci. Data*, 10, 1551–1590, <https://doi.org/10.5194/essd-10-1551-2018>.

31. Piecuch, C.; Landerer, F.W.; Ponte, R. (2018); Tide Gauge Records Reveal Improved Processing of Gravity Recovery and Climate Experiment Time-Variable Mass Solutions over the Coastal Ocean. *Geophysical Journal International*, Volume 214, Issue 2, <https://doi.org/10.1093/gji/ggy207>.
32. Rodell M., J. S. Famiglietti, D. N. Wiese, J. T. Reager, H. K. Beaulieu, F. W. Landerer, M.-H. Lo (2018); Emerging trends in global freshwater availability. *Nature*, doi: 10.1038/s41586-018-0123-1.
33. Hamlington, B. D., Burgos, A., Thompson, P. R., Landerer, F. W., Piecuch, C. G., Adhikari, S., et al. (2018). Observation-driven estimation of the spatial variability of 20th century sea level rise. *JGR: Oceans*, 123, 2129–2140. <https://doi.org/10.1002/2017JC013486>.
34. Argus, D. F., Landerer, F. W., Wiese, D. N., Martens, H. R., Fu, Y., Famiglietti, J. S., Watkins, M. M. (2017). Sustained water loss in California's mountain ranges during severe drought from 2012 to 2015 inferred from GPS. *Journal of Geophysical Research: Solid Earth*, 122; <https://doi.org/10.1002/2017JB014424>.
35. Wu, Xiaoping, Jürgen Kusche, Felix W. Landerer (2017); A new unified approach to determine geocentre motion using space geodetic and GRACE gravity data, *Geophysical Journal International*, Volume 209, Issue 3, Pages 1398–1402, <https://doi.org/10.1093/gji/ggx086>.
36. Thomas, Famiglietti, Landerer, Wiese, Molotch, Argus (2017), California groundwater drought characterization using GRACE, *Remote Sensing of Environment* 198, 384-392, doi:10.1016/j.rse.2017.06.026
37. Talpe, M. J., R. S. Nerem, E. Forootan, M. Schmidt, F. G. Lemoine, E. M. Enderlin, & F. W. Landerer (2017), Ice mass change in Greenland and Antarctica between 1993 and 2014 from satellite gravity measurements. *J. Geod.* 91 (11), 1283-1298, doi: 10.1007/s00190-017-1025-y.
38. Volkov, D. L., S.-K. Lee, F. W. Landerer, and R. Lumpkin (2017), Decade-long deep-ocean warming detected in the subtropical South Pacific, *Geophys. Res. Lett.*, 44, doi:10.1002/2016GL071661.
39. Scanlon, B. R., Z. Zhang, H. Save, D. N. Wiese, F. W. Landerer, D. Long, L. Longuevergne, and J. Chen (2016), Global evaluation of new GRACE mascon products for hydrologic applications, *Water Resour. Res.*, 52, 9412–9429, doi:10.1002/2016WR019494.
40. Thompson, P. R., B. D. Hamlington, F. W. Landerer, and S. Adhikari (2016), Are long tide gauge records in the wrong place to measure global mean sea level rise?, *Geophys. Res. Lett.*, 43, doi:10.1002/2016GL070552.
41. Wiese, D. N., F. W. Landerer, and M. M. Watkins (2016), Quantifying and reducing leakage errors in the JPL RL05M GRACE mascon solution, *Water Resour. Res.*, 52, doi:10.1002/2016WR019344.
42. Peyser, C. E., J. Yin, F. W. Landerer, and J. E. Cole (2016), Pacific sea level rise patterns and global surface temperature variability, *Geophys. Res. Lett.*, 43, doi:10.1002/2016GL069401.
43. Thomas, B. F., F. W. Landerer, D. N. Wiese, and J. S. Famiglietti (2016), A comparison of watershed storage trends over the eastern and upper Midwestern regions of the United States, 2003–2015, *Water Resour. Res.*, 52, doi:10.1002/2016WR018617.
44. Landerer, F. W., D. N. Wiese, K. Bentel, C. Boening, and M. M. Watkins (2015), North Atlantic meridional overturning circulation variations from GRACE ocean bottom pressure anomalies, *Geophys. Res. Lett.*, 42, doi:10.1002/2015GL065730.
45. Bentel, K., Landerer, F.W., Boening, C. (2015), Monitoring Atlantic overturning circulation variability with GRACE-type ocean bottom pressure observations - a sensitivity study, *Ocean Sci. Discuss.*, 12, 1765-1791, doi:10.5194/osd-12-1765-2015.
46. Volkov, D.L., Landerer, F.W. (2015), Internal and external forcing of sea level variability in the Black Sea, *Clim. Dyn.* doi: 10.1007/s00382-015-2498-0.
47. Watkins, M. M., D. N. Wiese, D.-N. Yuan, C. Boening, F. W. Landerer (2015), Improved methods for observing Earth's time variable mass distribution with GRACE, *JGR Solid Earth*, 10.1002/2014JB011547.
48. Fu, Y., D. F. Argus, and F. W. Landerer (2015), GPS as an independent measurement to estimate terrestrial water storage variations in Washington and Oregon, *J. Geophys. Res. Solid Earth*, 120, 552–566, doi:10.1002/2014JB011415.
49. W. Llovel, J.K. Willis, F.W. Landerer and I. Fukumori (2014), Deep-ocean contribution to sea level and energy budget not detectable over the past decade, *Nature Climate Change*, 4, doi:

- 10.1038/NCLIMATE2387.
50. Durack, P., Gleckler, P.J., **Landerer, F.W.**, Taylor, K. (2014), Quantifying Underestimates of Long-term Upper-Ocean Warming, *Nature Climate Change*, 4, doi: 10.1038/NCLIMATE2389.
  51. Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, **F. Landerer**, T. Lenton, J. Kennedy, and R. Somerville (2014), Ch. 2: Our Changing Climate. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.
  52. Argus, D.F., Fu, Y., **F.W. Landerer** (2014), Seasonal variation in total water storage in California inferred from GPS observations of vertical land motion, *Geophys. Res. Lett.* 10.1002/2014GL059570
  53. Flato, G., J. Marotzke, B. Abiodun, P. Braconnot, S.C. Chou, W. Collins, P. Cox, F. Driouech, S. Emori, V. Eyring, C. Forest, P. Gleckler, E. Guilyardi, C. Jakob, V. Kattsov, C. Reason and M. Rummukainen + Contrib. Authors (2013), Evaluation of Climate Models. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
  54. Volkov, D. L.; **F.W. Landerer** (2013), Non-seasonal fluctuations of the Arctic Ocean mass observed by GRACE , *J. Geophys. Res.*, doi: 10.1002/2013JC009341.
  55. **Landerer, F.W.**; Gleckler, P. & Lee, T. (2013), Evaluation of CMIP5 dynamic sea surface height multi-model simulations against satellite observations *Climate Dynamics*, Springer Berlin Heidelberg, 1-13.
  56. Volkov, D. L.; **Landerer, F. W.** & Kirillov, S. A. (2013), The genesis of sea level variability in the Barents Sea, *Continental Shelf Research*, 66, 92 – 104.
  57. Fasullo, J. T., C. Boening, **F. W. Landerer**, and R. S. Nerem (2013), Australia's unique influence on global sea level in 2010–2011, *Geophys. Res. Lett.*, 40, 4368–4373, doi:10.1002/grl.50834.
  58. Ivins E. R. T. S. James, J. Wahr, E. J. O. Schrama, **F.W. Landerer**, K.M. Simon (2013): Antarctic Contribution to Sea-level Rise Observed by GRACE with Improved GIA Correction, *J. Geophys. Res. Solid Earth*, 118, doi:10.1002/jgrb.50208.
  59. Lee T., D.E. Waliser, J. Li, **F. W. Landerer**, and M. M. Gierach (2013): Evaluation of CMIP3 and CMIP5 Wind Stress Climatology Using Satellite Measurements and Atmospheric Reanalysis Products, *J. Climate* 26, 5810-5826, doi:10.1175/JCLI-D-12-00591.1.
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  65. Zlotnicki V., S. Bettadpur, **F. Landerer** and M. Watkins (2012): Remote Sensing of Earth's Gravity Field (GRACE). *Encyclopedia of Sustainability*, Springer.
  66. **Landerer, F. W.**, and S. C. Swenson (2012), Accuracy of scaled GRACE terrestrial water storage estimates, *Water Resour. Res.*, 48, W04531, doi:10.1029/2011WR011453.
  67. **Landerer, F. W.**, J. O. Dickey, and A. Guentner, 2010: Terrestrial water budget of the Eurasian pan-Arctic from GRACE satellite measurements during 2003–2009, *J. Geophys. Res.*, 115,

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69. **Landerer, F. W.**, Jungclaus, J. H., Marotzke, J., 2009: Long-term polar motion excited by ocean thermal expansion, *Geophys. Res. Lett.*, 36, L17603, doi:10.1029/2009GL039692.
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71. **Landerer, F. W.**, Jungclaus, J. H., Marotzke, J., 2007: Ocean Bottom Pressure Changes Lead to a Decreasing Length-of-Day in a Warming Climate, *Geophys. Res. Lett.*, 34, L06307, doi:10.1029/2006GL029106.
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Other publications:

**Landerer, F. W.** (2012), Gravity Recovery and Climate Experiment (GRACE) - Applications to the State of California in support of development of California Footprints, An EPA-AMI Project, Project Report - 1.1, Jet Propulsion Laboratory / California Institute of Technology.

**Landerer, F. W.** (2007) Sea level and hydrological mass redistribution in the Earth system: variability and anthropogenic change, Ph.D. thesis, Hamburg.