

ICHIRO FUKUMORI

PERSONAL INFORMATION:

Address: Jet Propulsion Laboratory, Mail Stop 300-323
4800 Oak Grove Drive, Pasadena, CA 91109 U.S.A.
Phone: +1-818-354-6965 e-mail: fukumori@jpl.nasa.gov
ORCID: 0000-0002-0882-6400 ResearcherID: [AA-9005-2020](#)

RESEARCH INTERESTS:

Climate variability; Sea level change; General circulation of the ocean; State estimation; Data assimilation; Numerical modeling; Adjoint modeling; Satellite remote sensing

EDUCATION:

1989: Ph.D. (Physical Oceanography), Joint Program in Oceanography, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution
1983: B.S. (Geophysics), University of Tokyo, Japan

PROFESSIONAL EXPERIENCE:

2005-2015: Supervisor, Ocean Circulation Group, Jet Propulsion Laboratory, California Institute of Technology.
2003-present: Principal Scientist, Jet Propulsion Laboratory, California Institute of Technology.
1999-2005: Team Leader, Ocean Data Assimilation, Jet Propulsion Laboratory.
1992-2003: Research Scientist, Jet Propulsion Laboratory, California Institute of Technology.
1990-1992: Resident Research Associate, National Research Council, at Jet Propulsion Laboratory, California Institute of Technology.
1989-1990: Postdoctoral Associate, Massachusetts Institute of Technology.
1983-1989: Research Assistant, Massachusetts Institute of Technology.
1983: Research Assistant, Woods Hole Oceanographic Institution.

PROFESSIONAL ACTIVITIES:

ECCO Summer School, May 2019
NASA Oceans Melting Greenland Science Team, 2015-2021
NASA Sea Level Change Team, 2014-2017
Japan Marine Science Foundation Data Assimilation Summer School, August 2016
NASA Ocean Surface Topography Science Team, 2013-2016
Ecole de Physique des Houches, International Summer School, June 2012
NASA GRACE and GRACE-FO Science Team, 2011-present
NASA Ocean Salinity Science Team, 2009-2015
U.S. CLIVAR Working Group on Decadal Prediction, 2009-2011
GODAE Summer School, September 2004
U.S. CLIVAR Pacific Implementation Panel, 2004
U.S. Argo Science Panel 2001-2013
WOCE Young Investigator Workshop, June 2000
U.S. Global Ocean Data Assimilation Experiment Steering Team, 1999-2003
Consortium for Estimating the Circulation and Climate of the Ocean (ECCO), 1998-present
Japan Marine Science Foundation Data Assimilation Summer School, August 1998
International Global Ocean Data Assimilation Experiment Steering Team, 1997-2003
NASA Jason-1 Science Working Team, 1997-2008

PROFESSIONAL AFFILIATIONS:

American Geophysical Union, American Meteorological Society, The Oceanography Society, Institute of Electrical and Electronics Engineers

POSTDOCS ADVISED:

William Llovel, Zhengqing Ye, Peng Yu, Joshua K. Willis, Sophie Ricci, Ou Wang, Seungbum Kim, Mototaka Nakamura, Naoki Hirose

HONORS AND AWARDS:

NASA Group Achievement Award, ECCO and PO.DAAC (2022)

NASA Exceptional Public Achievement Medal (2017)

NASA Group Achievement Award, Oceans Melting Greenland Team (2017, 2019)

NASA Exceptional Scientific Achievement Medal (2005)

National Research Council Postdoctoral Fellowship (1990-1992)

REFEREED PUBLICATIONS:

- 86) Chandanpurkar, H. A., and Coauthors, 2022: Influence of Nonseasonal River Discharge on Sea Surface Salinity and Height. *J. Adv. Model. Earth Syst.*, **14**, e2021MS002715, <https://doi.org/https://doi.org/10.1029/2021MS002715>.
- 85) **Fukumori, I.**, O. Wang, and I. Fenty, 2021: Causal Mechanisms of Sea-level and Freshwater Content Change in the Beaufort Sea. *J. Phys. Oceanogr.*, **51**, 3217-3234, <https://doi.org/10.1175/JPO-D-21-0069.1>.
- 84) Picuch, C. G., **I. Fukumori**, and R. M. Ponte, 2021: Intraseasonal Sea-Level Variability in the Persian Gulf, *J. Phys. Oceanogr.*, **51**, 1687-1704, <https://doi.org/10.1175/JPO-D-20-0296.1>.
- 83) Fournier, S., T. Lee, X. Wang, T. W. K. Armitage, O. Wang, **I. Fukumori**, and R. Kwok, 2020: Sea Surface Salinity as a Proxy for Arctic Ocean Freshwater Changes. *J. Geophys. Res. Ocean.*, **125**, e2020JC016110, <https://doi.org/https://doi.org/10.1029/2020JC016110>.
- 82) Ponte, R. M., and Coauthors, 2019: Towards comprehensive observing and modeling systems for monitoring and predicting regional to coastal sea level. *Frontiers in Marine Science*, **6**, doi: 10.3389/fmars.2019.00437.
- 81) Hughes, C. W., **I. Fukumori**, and Coauthors, 2019: Sea level and the role of coastal trapped waves in mediating the influence of the open ocean on the coast, *Surveys in Geophysics*, **40**, 1467-1492, doi:10.1007/s10712-019-09535-x.
- 80) Gregory, J. M., and Coauthors, 2019: Concepts and Terminology for Sea Level: Mean, Variability and Change, Both Local and Global, *Surveys in Geophysics*, **40**, 1251-1289, doi: 10.1007/s10712-019-09525-z
- 79) Khazendar, A., and Coauthors, 2019: Interruption of two decades of Jakobshavn Isbrae acceleration and thinning as regional ocean cools. *Nat Geosci*, **12**, 277-283, doi:10.1038/s41561-019-0329-3
- 78) Heimbach, P., **I. Fukumori**, and Coauthors, 2019: Putting It All Together: Adding Value to the Global Ocean and Climate Observing Systems With Complete Self-Consistent Ocean State and Parameter Estimates. *Frontiers in Marine Science*, **6**, doi: 10.3389/fmars.2019.00055
- 77) Qu, T., **I. Fukumori**, and R. A. Fine, 2019: Spin-Up of the Southern Hemisphere Super Gyre. *J Geophys Res-Oceans*, **124**, 154-170, doi: 10.1029/2018jc014391.
- 76) Quinn, K. J., R. M. Ponte, P. Heimbach, **I. Fukumori**, and J. M. Campin, 2019: Ocean angular momentum from a recent global state estimate, with assessment of uncertainties, *Geophysical Journal International*, **216**(1), 584-597, doi: 10.1093/gji/ggy452.

- 75) Ferster, B. S., B. Subrahmanyam, **I. Fukumori**, and E. S. Nyadjro, 2018: Variability of Southern Ocean Transports, *J Phys Oceanogr*, **48**(11), 2667-2688, doi: 10.1175/jpo-d-18-0055.1.
- 74) **Fukumori, I.**, P. Heimbach, R. M. Ponte, and C. Wunsch, 2018: A Dynamically Consistent, Multi-Variable Ocean Climatology, *B Am Meteorol Soc*, **99**(10), 2107-2128, doi:10.1175/bams-d-17-0213.1.
- 73) Piecuch, C. G., R. M. Ponte, C. M. Little, M. W. Buckley, and **I. Fukumori**, 2017: Mechanisms underlying recent decadal changes in subpolar North Atlantic Ocean heat content, *Journal of Geophysical Research: Oceans*, **122**(9), 7181-7197, doi:10.1002/2017JC012845.
- 72) Toyoda, T., et al. 2017: Interannual-decadal variability of wintertime mixed layer depths in the North Pacific detected by an ensemble of ocean syntheses, *Clim Dynam*, **49**(3), 891-907, doi:10.1007/s00382-015-2762-3.
- 71) Toyoda, T., et al. 2017: Intercomparison and validation of the mixed layer depth fields of global ocean syntheses, *Clim Dynam*, **49**(3), 753-773, doi:10.1007/s00382-015-2637-7.
- 70) Storto, A., et al. 2017: Steric sea level variability (1993–2010) in an ensemble of ocean reanalyses and objective analyses, *Clim Dynam*, **49**(3), 709-729, doi:10.1007/s00382-015-2554-9.
- 69) **Fukumori, I.**, 2017: Kamifusen no kagaku: Tsukuto fukuramu shikumi no kousatsu, *Kagaku*, **87** (4), 309-312. (in Japanese)
- 68) **Fukumori, I.**, 2017: Kamifusen, the self-inflating Japanese paper balloon, *Physics Today*, **70**(1), 78-79, doi:10.1063/pt.3.3437.
- 67) Fenty, I., et al. 2016: OCEANS MELTING GREENLAND Early Results from NASA's Ocean-Ice Mission in Greenland, *Oceanography*, **29**(4), 72-83, doi:10.5670/oceanog.2016.100.
- 66) **Fukumori, I.**, O. Wang, W. Llovel, I. Fenty, and G. Forget, 2015: A near-uniform fluctuation of ocean bottom pressure and sea level across the deep ocean basins of the Arctic Ocean and the Nordic Seas, *Prog. Oceanogr.*, **134**, 152-172, doi:10.1016/j.pocean.2015.01.013.
- 65) Piecuch, C. G., **I. Fukumori**, R. M. Ponte, and O. Wang, 2015: Vertical structure of ocean pressure variations with application to satellite-gravimetric observations, *J. Atmos. Oceanic. Tech.*, **32**(3), 603-613, doi:10.1175/JTECH-D-14-00156.
- 64) **Fukumori, I.**, 2015: Combining models and data in large-scale oceanography: Examples from the Consortium for Estimating the Circulation and Climate of the Ocean (ECCO), in "Advanced Data Assimilation for Geosciences: Lecture Notes of the Les Houches School of Physics: Special Issue, June 2012", E. Blayo, M. Bocquet, E. Cosme, and L. F. Cugliandolo Eds., Oxford University Press, Oxford, UK, 608pp, doi: 10.1093/acprof:oso/9780198723844.003.0023.
- 63) Llovel, W., 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**(11), 1031-1035, doi:10.1038/nclimate2387.
- 62) Vinogradova, N. T., R. M. Ponte, **I. Fukumori**, O. Wang, 2014: Estimating satellite salinity errors for assimilation of Aquarius and SMOS data into climate models, *J Geophys Res-Oceans*, **119**(8), 4732-4744, doi:10.1002/2014jc009906.
- 61) Qu, T., S. Gao, and **I. Fukumori**, 2013: Formation of salinity maximum water and its contribution to the overturning circulation in the North Atlantic as revealed by a global GCM, *Journal of Geophysical Research: Oceans*, **118**(4), 1982-1994, doi:10.1002/jgrc.20152.
- 60) **Fukumori, I.**, and O. Wang, 2013: Origins of heat and freshwater anomalies underlying regional decadal sea level trends, *Geophys. Res. Lett.*, **40** (3), 563-567, doi: 10.1002/grl.50164.

- 59) Llovel, W., **I. Fukumori**, and B. Meyssignac, 2013: Depth-dependent temperature change contributions to global mean thermosteric sea level rise from 1960 to 2010, *Global and Planetary Change*, **101**, 113-118, doi:10.1016/j.gloplacha.2012.12.011.
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- 57) Marcus, S. L., J. O. Dickey, **I. Fukumori**, and O. de Viron, 2012: Detection of the Earth rotation response to a rapid fluctuation of Southern Ocean circulation in November 2009, *Geophys. Res. Lett.*, **39**, doi:10.1029/2011GL050671.
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- 55) Wu, X., X. Collilieux, Z. Altamimi, B. L. A. Vermeersen, R. S. Gross, and **I. Fukumori**, 2011: Accuracy of the International Terrestrial Reference Frame origin and Earth expansion, *Geophys. Res. Lett.*, **38**, L13304, doi:10.1029/2011GL047450.
- 54) Qu, T., S. Gao, and **I. Fukumori**, 2011: What governs the North Atlantic salinity maximum in a global GCM?, *Geophys. Res. Lett.*, **38**, L07602, doi:10.1029/2011GL046757.
- 53) Solomon, A., et al., 2011: Distinguishing the roles of natural and anthropogenically forced decadal climate variability, Implications for Prediction, *Bull. Amer. Met. Soc.*, **92**, 141-156, doi:10.1175/2010bams2962.1.
- 52) Gao, S., T. Qu, and **I. Fukumori**, 2011: Effects of mixing on the subduction of South Pacific waters identified by a simulated passive tracer and its adjoint, *Dyn. Atmos. Oceans.*, **54**, 45-54, doi:10.1016/J.Dynatmoce.2010.10.002.
- 51) Qu, T., S. Gao, **I. Fukumori**, R. A. Fine, and E. J. Lindstrom, 2010: The obduction of Equatorial 13°C Water in the Pacific identified by a simulated passive tracer, *J. Phys. Oceanogr.*, **40**, 2282-2297, doi:10.1175/2010jpo4358.1.
- 50) Lee, T., W. R. Hobbs, J. K. Willis, D. Halkides, **I. Fukumori**, E. M. Armstrong, A. K. Hayashi, W. T. Liu, W. Patzert, and O. Wang, 2010: Record warming in the South Pacific and western Antarctica associated with the strong central-Pacific El Niño in 2009-10, 2010: *Geophys. Res. Lett.*, **37**, L19704, doi:10.1029/2010GL044865.
- 49) Lee, T., T. Awaji, M. Balmaseda, N. Ferry, Y. Fujii, **I. Fukumori**, B. Giese, P. Heimbach, A. Kohl, S. Masina, E. Remy, A. Rosati, M. Schodlock, D. Stammer, and A. Weaver, 2010: Consistency and fidelity of Indonesian-throughflow total volume transport estimated by 14 ocean data assimilation products, *Dyn. Atmos. Oceans.*, **50** (2), 201-223, doi:10.1016/J.Dynatmoce.2009.12.004.
- 48) Cummings, J., L. Bertino, P. Brasseur, **I. Fukumori**, M. Kamachi, M. J. Martin, K. Mogensen, P. Oke, C. E. Testut, J. Verron, and A. Weaver, 2009: Ocean data assimilation systems for GODAE, *Oceanography*, **22** (3), 96-109, doi:10.5670/oceanog.2009.69.
- 47) Qu, T., S. Gao, **I. Fukumori**, R. A. Fine, and E. J. Lindstrom, 2009: Origin and pathway of Equatorial 13°C Water in the Pacific identified by a simulated passive tracer and its adjoint, *J. Phys. Oceanogr.*, **39**, 1836-1853, doi:10.1175/2009jpo4045.1.
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- 43) Qu, T., S. Gao, **I. Fukumori**, R. A. Fine, and E. J. Lindstrom, 2008: Subduction of South Pacific waters, *Geophys. Res. Lett.*, **35**, L02610, doi:10.1029/2007GL032605.

- 42) Fenoglio-Marc, L., J. Kusche, M. Becker, and **I. Fukumori**, 2007: Comment on “On the steric and mass-induced contributions to the annual sea level variations in the Mediterranean Sea” by David Garcia et al., *J. Geophys. Res.*, **112**, C1208, doi:10.1029/2007JC004196.
- 41) Kim, S.-B., T. Lee, and **I. Fukumori**, 2007: Mechanisms controlling the interannual variation of mixed layer temperature averaged over the NINO3 region, *J. Climate*, **20**, 3822-3843, doi:10.1175/Jcli4206.1.
- 40) Zlotnicki, V., J. Wahr, **I. Fukumori**, and Y. T. Song, 2007: Antarctic circumpolar current transport variability during 2003-05 from GRACE, *J. Phys. Oceanogr.*, **37** (2), 230-244, doi:10.1175/Jpo3009.1.
- 39) Menemenlis, M., **I. Fukumori**, and T. Lee, 2007: Atlantic to Mediterranean sea level difference driven by winds near Gibraltar Strait, *J. Phys. Oceanogr.*, **37**, 359-376, doi:10.1175/Jpo3015.1.
- 38) **Fukumori, I.**, D. Menemenlis, and T. Lee, 2007: A near-uniform basin-wide sea level fluctuation of the Mediterranean Sea, *J. Phys. Oceanogr.*, **37**, 338-358, doi:10.1175/Jpo3016.1.
- 37) Wu, X., M. B. Heflin, E. R. Ivins, and **I. Fukumori**, 2006: Seasonal and interannual global surface mass variations from multisatellite geodetic data, *J. Geophys. Res.*, **111**, B09401, doi:10.1029/2005JB004100.
- 36) Kim, S.-B., **I. Fukumori**, and T. Lee, 2006: The closure of ocean mixed layer temperature budget using level-coordinate model fields, *J. Atmos. Oceanic. Tech.*, **23** (6), 840-853, doi:10.1175/Jtech1883.1.
- 35) **Fukumori, I.**, 2006: What is data assimilation really solving, and how is the calculation actually done?, in “*Ocean Weather Forecasting: An Integrated View of Oceanography*”, E. P. Chassignet and J. Verron, Eds., Springer, 578pp, doi:10.1007/1-4020-4028-8_11.
- 34) Hirose, N., **I. Fukumori**, C. H. Kim, J.-H. Yoon, 2005: Numerical simulation and satellite altimeter data assimilation of the Japan Sea circulation, *Deep-Sea Research, Part II*, **52**, 1443-1463, doi:10.1016/J.Dsr2.2004.09.034.
- 33) Gross, R. S., **I. Fukumori**, and D. Menemenlis, 2005: Atmospheric and oceanic excitation of decadal-scale Earth orientation variations, *J. Geophys. Res.*, **110** (B9), B09405, doi:10.1029/2004jb003565.
- 32) Menemenlis, D., **I. Fukumori**, and T. Lee, 2005: Using Green functions to calibrate an ocean general circulation model, *Mon. Weather Rev.*, **133** (5), 1224-1240, doi:10.1175/Mwr2912.1.
- 31) Menemenlis, D., C. Hill, A. Adcroft, J. Campin, B. Cheng, B. Ciotti, **I. Fukumori**, P. Heimbach, C. Henze, A. Koehl, T. Lee, D. Stammer, J. Taft, J. Zhang, 2005: NASA Supercomputer Improves Prospects for Ocean Climate Research, *EOS, Transactions, American Geophysical Union*, **86**, 89, 95-96, doi:10.1029/2005EO090002.
- 30) Kim, S.-B., T. Lee, and **I. Fukumori**, 2004: The 1997-99 abrupt change of the upper ocean temperature in the Northcentral Pacific, *Geophys. Res. Lett.*, **31** (22), L22304, doi:10.1029/2004GL021142.
- 29) Wang, O., **I. Fukumori**, T. Lee, and B. Cheng, 2004: On the cause of eastern equatorial Pacific Ocean T-S variations associated with El Niño, *Geophys. Res. Lett.*, **31**, L15309, doi:10.1029/2004GL020188.
- 28) Lee, T., **I. Fukumori**, and B. Tang, 2004: Temperature advection: Internal versus external processes, *J. Phys. Oceanogr.*, **34** (8), 1936-1944, doi:10.1175/1520-0485(2004)034<1936:Taivep>2.0.Co;2.
- 27) **Fukumori, I.**, T. Lee, B. Cheng, and D. Menemenlis, 2004: The origin, pathway, and destination of Niño3 water estimated by a simulated passive tracer and its adjoint, *J. Phys. Oceanogr.*, **34**, 582-604, doi:10.1175/2515.1.

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- 24) Lee, T. and **I. Fukumori**, 2003: Interannual to decadal variation of tropical-subtropical exchange in the Pacific Ocean: boundary versus interior pycnocline transports, *J. Climate*, **16**, 4022-4042, doi:10.1175/1520-0442(2003)016<4022:Ivotet>2.0.Co;2.
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- 21) Dickey, J. O., S. L. Marcus, O. de Viron, and **I. Fukumori**, 2002: Recent Earth oblateness variations: Unraveling climate and postglacial rebound effects, *Science*, **298**, 1975-1977, doi:10.1126/Science.1077777.
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- 18) **Fukumori, I.**, 2002: A partitioned Kalman filter and smoother, *Monthly Weather Review*, **130**, 1370-1383, doi:10.1175/1520-0493(2002)130<1370:Apkfas>2.0.Co;2.
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- 15) Talley, L. D., D. Stammer, and **I. Fukumori**, 2001: Towards a WOCE Synthesis, in "Ocean Circulation and Climate", G. Siedler, J. Church, and J. Gould, editors, Academic Press, 715pp, doi:10.1016/S0074-6142(01)80137-6.
- 14) **Fukumori, I.**, 2001: Data Assimilation by Models, in "Satellite Altimetry and Earth Sciences", L.-L. Fu and A. Cazenave, editors, Academic
- 13) Hirose, N., **I. Fukumori**, and J.-H. Yoon, 1999: Assimilation of TOPEX/POSEIDON altimeter data with a reduced gravity model of the Japan Sea, *Journal of Oceanography*, **55**, 53-64, doi:10.1023/A:1007707405711.
- 12) **Fukumori, I.**, R. Raghunath, L. Fu, and Y. Chao, 1999: Assimilation of TOPEX/POSEIDON data into a global ocean circulation model: How good are the results?, *Journal of Geophysical Research*, **104**, 25,647-25,665, doi:10.1029/1999jc900193.
- 11) **Fukumori, I.**, R. Raghunath, and L. Fu, 1998: Nature of global large-scale sea level variability in relation to atmospheric forcing: A modeling study, *Journal of Geophysical Research*, **103**, 5493-5512, doi:10.1029/97jc02907.
- 10) Fu, L.-L., and **I. Fukumori**, 1996: A case study of the effects of errors in satellite altimetry on data assimilation, in "Modern Approaches to Data Assimilation in Ocean Modeling", P. Malanotte-Rizzoli editor, Elsevier, 77-96, doi:10.1016/S0422-9894(96)80006-7.

- 9) Malanotte-Rizzoli, P., **I. Fukumori**, and R. E. Young, 1996: A methodology for the construction of a hierarchy of Kalman filters for nonlinear primitive equation models, in "Modern Approaches to Data Assimilation in Ocean Modeling", P. Malanotte-Rizzoli editor, Elsevier, 297-317, doi:10.1016/S0422-9894(96)80014-6.
- 8) **Fukumori, I.**, 1995: Assimilation of TOPEX sea level measurements with a reduced-gravity shallow water model of the tropical Pacific Ocean, *Journal of Geophysical Research*, **100**, 25,027-25,039, doi:10.1029/95jc02083.
- 7) **Fukumori, I.**, and P. Malanotte-Rizzoli, 1995: An approximate Kalman filter for ocean data assimilation; An example with an idealized Gulf Stream model, *Journal of Geophysical Research*, **100**, 6777-6793, doi:10.1029/94jc03084.
- 6) Fu, L.-L., **I. Fukumori**, and R. N. Miller, 1993: Fitting dynamic models to the Geosat sea level observations in the tropical Pacific Ocean. Part II: A linear wind-driven model, *Journal of Physical Oceanography*, **23**, 2162-2181, doi:10.1175/1520-0485(1993)023<2162:Fdmmtg>2.0.Co;2.
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- 1) **Fukumori, I.**, 1991: Circulation about the Mediterranean Tongue: An analysis of an EOF-based model ocean, *Progress in Oceanography*, **27**, 197-224, doi:10.1016/0079-6611(91)90016-F.

NON-REFEREED PUBLICATION:

Fukumori, I., 2022: "Adjoint Modeling" A Brief Introduction, *Zenodo*.

<https://doi.org/10.5281/zenodo.5794446>

Fukumori, I., 2017: What does data assimilation actually solve?, *Kaiyo Monthly*, **59**, 37-49. (in Japanese).