

Maike Sonnewald, Ph.D.

Atmospheric and Oceanic Sciences Program
Princeton University
300 Forrester Rd, Princeton, NJ 08540

maikes@princeton.edu
msonnewald.com
+1 413-406-9121

Current position

2/2020–present	Princeton University, NJ Associate Research Scholar
2/2020–present	NOAA Geophysical Fluid Dynamics Laboratory (GFDL), NJ Research Affiliate
12/2019–present	University of Washington, WA Visiting scientist

Education

2011–2016	University of Southampton, UK. Ph.D. Complex Systems Simulation. Joint: National Oceanography Center and School of Computer Science. Dissertation: Ocean model utility dependence on horizontal resolution
2011	University of Southampton, UK. M. Sci. <i>magna cum laude</i> , complex systems simulation
2006–2010	University of Southampton, UK. M. Sci. <i>magna cum laude</i> , physical oceanography

Academic positions

10/2015–2/2020	Massachusetts Institute of Technology (MIT) , Earth, Atmosphere and Planetary Sciences (EAPS) <ul style="list-style-type: none">• Postdoctoral Associate. Collaborator: Carl Wunsch, Patrick Heimbach & Stephanie Dutkiewicz
2/2017–10/2019	Harvard University , Earth and Planetary Science (EPS) <ul style="list-style-type: none">• Visiting scientist. Collaborator: Carl Wunsch
12/2018–1/2019	Grenoble Les Alpes , Lab. des Ecouls. Geophysiques et Industriels (Fr) <ul style="list-style-type: none">• Visiting scientist. Collaborator: Thierry Penduff & Nicolas Le Bihan
10/2018–10/2017 & 10/2016–2/2017	University of Texas (UT) at Austin , Inst. for Computational Engineering and Sciences (ICES) <ul style="list-style-type: none">• Visiting scientist. Collaborator: Patrick Heimbach
2/2014–4/2014	MIT , EAPS <ul style="list-style-type: none">• Visiting Graduate Research Assistant. Host: Raffaele Ferrari
7/2008–8/2008	GEOMAR , Helmholtz Centre for Ocean Research Kiel (GER) <ul style="list-style-type: none">• Research Assistant. Host: Johannes Karstensen & Martin Visbeck

Review articles

Sonnewald, M., Brajard, J., Duben, P., Lguensat, R. and Balaji, V., *Bridging theory, simulation, and observations of the global ocean using Machine Learning*, 2021, **Environmental Research Letters**.

Irrgang, C., Boers, N., Sonnewald, M., Elizabeth A. Barnes, Christopher Kadow, Staneva, J., and Saynisch-Wagner, J. *Towards neural Earth system modelling by integrating artificial intelligence in Earth system science*, 2021, *Nature Machine*

Peer reviewed publications¹

Sonnewald, M., and Lguensat, R. *Revealing the impact of global warming on climate modes using transparent machine learning*, 2021, **Journal of Advances in Modeling Earth Systems**. Available: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2021MS002496>. Featured on cover, and separately in the “Machine Learning Application to Earth System Modeling” edition.

Sonnewald, M., and Lguensat, R. , Radhakrishnan, A., Sayibou, Z., Wittenberg, A.T. and Balaji, V. *Revealing the impact of global heating on North Atlantic circulation using transparent machine learning*, 2021, **International Conference on Machine Learning: Spotlight paper at ClimateChangeAI Workshop**. Available: <https://www.climatechange.ai/papers/icml2021/13>

Sonnewald, M., Dutkiewicz, S., Hill, C. and Forget, G. *Elucidating Ecological Complexity: Unsupervised Learning determines global marine eco-provinces*, 2020, **Science Advances**. DOI: 10.1126/sciadv.aay4740. Featured on: [EOS science news](#) by AGU, [MIT News](#), [Hakai Magazine](#), [ECCO story map](#), [The Batch](#), [SciTechDaily](#), [Yahoo! Finance](#), [Dailyhunt](#), [Firstpost](#), [Scienceblog](#).

Le Bras, I., **Sonnewald, M.**, and Toole, J.M. *A bulk Potential Vorticity budget for the western North Atlantic based on observations*, 2019, **Journal of Physical Oceanography**. DOI: 10.1175/JPO-D-19-0111.1.

Sonnewald, M., Wunsch, C. and Heimbach, P. *Unsupervised Learning Reveals Geography of Global Ocean Dynamical Regions*, 2019, **Journal of Earth and Space Science** edition “Geoscience paper of the future”. 6. <https://doi.org/10.1029/2018EA000519>. Featured on: [MIT News](#), [Artificial Intelligence Research](#), [Physics.org](#), [ECN magazine](#).

Sonnewald, M., C. Wunsch, and P. Heimbach, *Linear Predictability: A Sea Surface Height Case Study*, 2018, **Journal of Climate**, 31, 2599–2611, DOI.org/10.1175/JCLI-D-17-0142.1

Bulczak, A.I., Bacon, S., Naveira Garabato, A.C., Ridout, A., **Sonnewald, M.**, and Laxon, S.W. *Seasonal Variability of Sea Surface Height in the Coastal Waters and Deep Basins of the Nordic Seas*, 2014, **Geophysical Research Letters** (42) (DOI:10.1002/2014GL061796).

Sonnewald, M., Hirschi, J.J.-M., Marsh, R., McDonagh, E.L. and King, B.A. *Atlantic meridional ocean heat transport at 26N: impact on subtropical ocean heat content variability*, 2013, **Ocean Science**, 9, (6), 1057-1069. DOI:10.5194/os-9-1057-2013.

In review: J. Krasting, M. De Palma, J. Dunne, J. John, and **Sonnewald, M.** *Regional Sensitivity Patterns of Arctic Ocean Acidification Revealed With Machine Learning*. Major revisions, **Nature Communications Earth & Environment**.

In review: Kaiser, B., Saenz, J.A., **Sonnewald, M.** and Livescu, D., *Objective discovery of dominant dynamical processes with machine learning*. In review **Nature**.

Submitted: **Sonnewald, M.**, Lguensat, R., A. Adcroft, V. Balaji and A. Radhakrishna *A supergyre modulates the global overturning through upwelling in the Southern Ocean*. Submitted, **Geophysical Research Letters**.

In revision: **Sonnewald, M.**, Hirschi, J.J.-M., Nurser, A.G., Firing, Y., Coward, A. and Hyder, P. *Increasing ocean model resolution reveals impact of tuning eddy permitting models*. In revision. **Journal of Advances in Modeling Earth Systems**.

In revision: Bingham, R. and **Sonnewald, M.** *Stable Atlantic overturning circulation revealed by a dynamically-proximate reconstruction*. In revision, **Geophysical Research Letters**.

¹Manuscripts in preparation and in revision available at co-authors’ discretion.

Upcoming: **Sonnwald, M.**, Lguensat, R., A. Adcroft, V. Balaji and A. Radhakrishna *How Southern Ocean wind gyre circulation buffers global heating in climate models*. In preparation.

Upcoming: **Sonnwald, M.**, Sayibou, Z., Wittenberg, A.T., Lguensat, R., A. Adcroft, V. Balaji and A. Radhakrishna *Tracking the equatorial undercurrent to understand the El Niño Southern Oscillation mean state in climate models*. In preparation.

Upcoming: Jones, D., **Sonnwald, M.**, Rosso, I., Zhou, S., and Boehme, L., Unsupervised classification identifies coherent thermohaline structures in the Weddell Gyre. In preparation.

Other publications

The ECCO Consortium. *A Twenty-Year Dynamical Oceanic Climatology: 1994-2013. Part 1: Active Scalar Fields: Temperature, Salinity, Dynamic Topography, Mixed-Layer Depth, Bottom Pressure*, 2017, MIT DSpace: <https://dspace.mit.edu/handle/1721.1/107613>.

The ECCO Consortium. *A Twenty-Year Dynamical Oceanic Climatology: 1994-2013. Part 2: Velocities and Property Transports*, 2017, MIT DSpace: <https://dspace.mit.edu/handle/1721.1/109847>.

Gille, S., Abernathey, A., Chereskin, T., Cornuelle, B., Heimbach, P., Mazloff, M., Menemenlis, D., Rocha, C., Soares, S., **Maike Sonnwald**, Villas Boas, B., and Wang, J. *Open Code Policy for NASA Space Science: A perspective from NASA-supported ocean modeling and ocean data analysis*, 2018, **NASA White Paper**, Available: <https://tinyurl.com/NASA-WhitePaper>

Upcoming: Abernathy, R., ... **Sonnwald, M.**, et al., *OpenOceanCloud*. **UN Ocean Decade White Paper**.

Awards and honours

Active	Principal Investigator: <i>Revealing trophic dynamic provinces in the sea: using unsupervised machine learning to map energy and material fluxes from nutrients to fisheries production</i> . To NOAA Climate Program Office to fund a postdoctoral associate. \$426,301.
2021	University of California, Santa Barbara, Kavli Institute for Theoretical Physics (KITP). Core member. “Machine Learning and the Physics of Climate” activity.
2021	NOAA AI strategy 2021-2025 , work featured.
2020	Collaborator/Amazon Sustainability Data Initiative (ASDI). \$48,595
2020-2021	Co-Investigator/Proposal in progress, ASDI. \$31,032.
2018-2020	Visiting Scientist Grant, Data Institute Univ Grenoble Alpes. €1700.
2021	Work featured on cover of JAMES.
2021	Paper received spotlight at ICML.
2017	Award from the Kaufman Teaching Certificate Program (KTCP) , MIT.
2016	Physical Oceanography Dissertation Symposium grant, University of Hawaii at Manoa, USA. \$1500.
2015	International Council for the Exploration of the Sea’s North Pacific Marine Science Organization 3rd Climate Change Symposium grant. \$600
2014	Awarded grant to lead NOCS Software Carpentry workshop for Ph.D. students.
2014	ICSS grant to visit MIT. £4500
2013	International Association for the Physical Sciences of the Oceans 2013 conference grant. £500.
2010	Graduate Scholarship. Full tuition and stipend, Engineering and Physical Sciences Research Council (EPSRC, UK).
2006–2010	Undergraduate Scholarship. Full tuition and stipend, Norwegian Lanekassen.
2005–2006	Undergraduate Scholarship. Full tuition and stipend, Danish Statens Uddannelsesstøtte.

Languages

Native speaker	Norwegian, Danish and German
Excellent	English
Proficient	French

Invited conference panels

- 2021 **Virtual Summit: Incorporating Data Science and Open Science in Aquatic Research.** Virtual, 624 participants.
- 2020 **AGU, Challenges and opportunities of applying AI, ML and DL to problems in the environmental and geosciences.** Virtual, 1200 participants.
- 2020 **NOAA Workshop, Second NOAA Workshop on Leveraging AI in the Environmental Sciences.** Virtual, 60+ named participants.

Selected invited talks (total: 50)

- 2022- Current upcoming: 5
- Mar 2022 **SIAM**, Geosciences Webinar, TBA.
- Mar 2022 **University of Cambridge**, Environmental Data Science Group, TBA.
- Jan 2022 **Max Planck Institute**, Hamburg, TBA.
- 2021 Talks total: 14
- Dec 2021 **AGU**, Revealing the impact of climate change on North Atlantic circulation using transparent machine learning.
- 2021 **Dept of Energy workshop**, initiative focused on Artificial Intelligence for Earth System Prediction (AI4ESP), Ocean “grand challenges”: Using AI/ML to push the frontiers of knowledge.
- 2021 **University of Washington**, Revealing the Impact of Global Heating on the Meridional Overturning Circulation. Virtual.
- 2021 **Climate Change AI**, A robust blueprint for trustworthy AI for climate analysis.
- 2021 **Scripps Institute of Oceanography**, CAPSO, Revealing the Impact of Global Heating on the Meridional Overturning Circulation. Virtual.
- 2021 **NOAA AI, 3rd workshop**, Revealing the impact of global warming on climate modes using transparent machine learning and a suite of climate models. Virtual.
- 2021 **University of Chicago**, Department of Statistics, Elucidating Ecological Complexity: Unsupervised Learning determines global marine eco-provinces. Keynote speaker for workshop/institute launch *Verification, Validation, and Uncertainty Quantification Across Disciplines*.
- 2021 **GEOMAR Helmholtz Centre for Ocean Research**, Revealing the impact of global heating on North Atlantic circulation using transparent machine learning, Ocean Circulation and Climate Dynamics Colloquium, Kiel, Germany. Virtual.
- 2020 Talks total: 7
- 2020 **NOAA Senior Management Meeting**, Oceanic and Atmospheric Research, *Building geographies of ocean dynamical regimes*. Virtual.
- 2020 **Los Alamos National Laboratory**, *Living on the Manifold: A geography of ocean dynamical regimes from eddy to global scale*. Los Alamos, USA.
- 2020 **University of Washington**, Department of Ocean Sciences, *Living on the Manifold: A geography of ocean dynamical regimes from eddy to global scale*. Seattle, USA.
- 2019 Talks total: 7
- 2019 **AGU**, *The case for machine learning in geoscience*. San Francisco, USA.
- 2019 **Princeton University**, *Ocean exploration with machine learning: An Antidote to Chaos?* Princeton, USA.
- 2019 **WHOI**, *Ocean exploration with machine learning: An Antidote to Chaos?* Woods Hole, USA.
- 2018-2012 Total talks: 17
- 2018 **WHOI**, *Unsupervised learning classifies global ocean dynamical regions*. Woods Hole, USA.
- 2017 **Columbia University, Lamont-Doherty Earth Observatory**, *Linear predictability: A sea surface height case study*, Palisades, USA.
- 2017 **Yale University**, *Ocean model utility dependence on horizontal resolution*. Yale, USA.
- 2015 **MIT**, *Ocean model utility dependence on horizontal resolution*. Cambridge, USA.
- 2015 **NOCS**, *Resolution dependence and Southern Ocean zonal asymmetries in mixed layer depth variability in the NEMO GCM*. Southampton, UK.

Selected conference contributions (total: 34) ²

<u>2021</u>	<u>Contributions total: 4</u>
Dec 2021	AGU2021 , <i>Elucidating ecological complexity: Unsupervised learning determines global marine eco-provinces</i> . Talk .
2021	EGU 2021 , <i>Revealing mechanisms of change in the Atlantic Meridional Overturning Circulation under global heating</i> . Vienna/virtual. Highlighted vPICO .
<u>2020</u>	<u>Contributions total: 3</u>
2020	Climate Informatics 2020 , <i>Elucidating Ecological Complexity: Unsupervised Learning determines global marine eco-provinces</i> . Oxford/virtual. Talk .
<u>2019-2011</u>	<u>Contributions total: 27</u>
2019	EGU , <i>Unsupervised Learning Reveals Geography of Global Ocean Dynamical Regions</i> , Vienna, Austria.
2018	AGU , <i>Unsupervised Learning Reveals Geography of Global Ocean Dynamical Regions</i> . Washington, USA.
2018	Ocean Science Meeting , <i>Vorticity budgets and the North Atlantic gyre overturning</i> . Portland, OR, USA. Poster .
2017	World Climate Research Programme (WCRP), Intergovernmental Oceanographic Commission of UNESCO (IOC) Sea Level , <i>Linear predictability: A sea surface height case study</i> . NYC, USA. Poster .
2017	EGU , <i>Linear predictability: A sea surface height case study</i> . Vienna, Austria. Talk .
2016	Ocean Sciences , <i>How do Ocean Heat Fluxes Depend on Bottom Pressure Torque?</i> New Orleans, USA. Talk .
2015	EGU , <i>How do heat fluxes in the Southern Ocean depend on bottom pressure torque?</i> Vienna, Austria. Talk .
2013	International Association for the Physical Sciences of the Oceans (IAPSO) , <i>Atlantic ocean meridional heat transport at 26N: Impact on subtropical ocean heat content variability</i> . Gothenburg, Sweden. Talk .

Mentoring and advising

Upcoming	Advising: Lapenta Internship (NOAA). Currently advertising.
2021-	Committee member: Jacob Cohen, University of Washington.
2021	Advising: Mariana Clare, Imperial College London, on French National Centre for Scientific Research (CNRS) grant.
2021-	Committee member: Yvonne Jenniges, Alfred Wegener Institute (DE), first year Ph.D. Title: Using machine learning to define and characterize 3D ocean regions.
2021 Summer	Advising: Zouberou Sayibou, Bronx Community College. Princeton University CIMES Scholar, targeted at minorities. Graduate level, 9 weeks. Resulted in ICML and AGU contribution and EEO student letter highlight. Now Junior at Stanford.
2019-	Mentoring: Catherine Wilka, was graduate student at MIT, now postdoc at Stanford.
2016-	Informal graduate student mentoring.

²Only first author presentations

Teaching experience

Upcoming	Lecture: Princeton University: “Deep learning in geophysical fluid dynamics”, graduate level.
2021	Tutorial/workshop: Society for Industrial and Applied Mathematics (SIAM): Conference on Mathematical and Computational Issues in the Geosciences. Milan, Italy, graduate and undergraduate level. <i>Participants 60, developed material, taught.</i>
2020	Lecture: Oceanhackweek 2020, <i>class size 20, developed material, taught.</i>
2020	Lecture: GFDL Holling, CIMES and Lapenta interns, undergraduate level: “Machine learning for the geosciences”, undergraduate and graduate level. <i>Class size 6, developed material, taught.</i>
2019	Lecture: Harvard University EPS: “Machine Learning in Geoscience”, graduate level. <i>Class size 10, developed material, taught</i>
2019	Lecture: Harvard University Data Science Club: “The good, the bad and the ugly of applied unsupervised learning”, graduate and undergraduate level. <i>class size 60, developed material, taught</i>
2019	Tutorial/workshop (3 day course), Princeton University & GFDL workshop for graduate students: “Machine learning and climate modeling”, graduate level. <i>Class size 20-30, developed material, taught</i>
2016	Lecture: UT (ICES) “Vertical Mixing Schemes: Why we need them & what they do”, graduate level. <i>Class size 5, developed material, taught.</i>
2014	Tutorial/workshop: Student Conference on Complex Systems (SCCS), “Finite differences methods”. <i>Class size 40+, developed material, taught.</i>
2014	Tutorial/workshop: SCCS “Importance of model validation”. <i>Class size 40+, developed material, taught.</i>
2013	Teaching Assistant: NOCS, “Physical Oceanography II”, undergraduate level. <i>Class size 50, held lab sessions.</i>
2012	Teaching Assistant: NOCS, “MSc Fieldwork Boat Week”, undergraduate level. <i>Class size weather dependent (5-9), instrument deployment (CTD, secchi disk and acoustic Doppler current profiler) on the Research Vessel Callista).</i>
2012	Teaching Assistant: NOCS, “Physical Oceanography I”, undergraduate level. <i>Class size 50, held lab sessions.</i>

Service

Review duties

Journals	Nature, Journal of Advances in Modeling Earth Systems, Geophysical Research Letters, Ocean Modelling, Journal of Geophysical Research, Journal of Physical Oceanography, Data Science, Frontiers in Marine Science.
Review Panel	NASA review panel 2017

Conference, workshop and seminar organization

2022	EGU, <i>Machine learning for Earth system modelling</i>
2021	Conference on Neural Information Processing Systems (NeurIPS), <i>Climate Change AI’s workshop on “Tackling Climate Change with Machine Learning</i> , Program Committee.
2021	EGU, <i>ITS4.4/AS4.1: Machine learning for Earth system modelling.</i>
2020	AGU, <i>OS014: Innovation and exploration in observed and model oceanographic data using interpretable machine learning</i> , oral and poster, head-convener.
2020	AGU, <i>A084: Machine Learning for Weather and Climate Modeling</i> , oral and poster, co-convener.
2020	The 2nd NOAA Workshop on Leveraging AI in Environmental Sciences “Exploiting Space- and Ground-Based Observations and Enhancing Earth System Prediction”. Session chair.
2020	EGU, <i>ITS4.3/AS5.2: Machine learning for Earth System modelling</i> , oral and poster, co-convener.
2019	OceanObs’19, breakout session, <i>Open Source Software Revolution</i> , co-convener.
2019	AGU, <i>GC33C - Innovation and Exploration of Observations and Earth System Models Using Machine Learning and Big Data Analysis</i> , oral and poster, head convener.
2015–2016	MIT Sack Lunch, seminar, organizing member.
2014	SCCS, conference, web-design, organizing member.

2014	SCCS, conference, Earth System Complexity session, head-convener .
2014	SCCS, workshop on “The importance of model validation”, organized with Martin Wood .
2014	SCCS, Workshop on “Finite differences methods” organized with Martin Wood .
2014	NOCS Software Carpentry, workshop, single organizer .
2014	Polar Network Workshop: Science and Society, workshop, organizing member .
2014–2015	POETS Corner, seminars organizing member .
2013–2015	Dynamical discussions series, seminars, organizing member .
2012–2013	Complex earth system modelling and physical Understanding, seminars, organizer .
2012	SCCS, conference, ICSS representative .
2012	SCCS, conference, ICSS representative .
2011–2013	Rhubarb series, seminars organizing member .
2011	SCCS, conference, organizing member .
2011	SCCS, conference, Physical Systems Chair, convener .

Diversity, equity and inclusion activities

2021-present	<i>POD member</i> , Unlearning racism in Geoscience (URGE) . Program to develop anti-racist policies and strategies at Princeton University, POD member.
2021	<i>Advising</i> : CIMES internship.
2020	<i>Speaker at</i> , Bronx Community College , NYC, USA. Effort by the Bronx Community College STEM Advisory Board to encourage students to consider STEM careers.
2017	<i>Leader</i> , Massachusetts Institute of Technology Outing Club . Organization aimed at enabling students and MIT associates of varied cultural and financial backgrounds to access the outdoors by providing leadership expertise and access to gear (such as skies).

Public engagement and outreach

2020	<i>Taught</i> “Climate change 101”, Virtual “Summer Climate Camp” by SynergyEd . Class size 10, ages 11-13 years, developed material, taught.
2019	<i>Helper</i> : <i>Nautical day at the MIT museum</i> , MIT Museum , USA.
2018	<i>Attendee</i> , US Software Sustainability Institute NSF workshop , Berkeley, USA.
2016	<i>Copezilla team</i> , Red Bull Flugtag , Boston, USA. MIT EAPS outreach activity .
2013	<i>Speaker</i> : <i>Ocean Model fidelity and resolution</i> , ICSS Open Day , Southampton, UK.
2012	<i>Speaker</i> : <i>Impact of resolution in ocean models</i> , ICSS Industrial and International Advisory Board meeting , Southampton, UK. Invited talk .
2012	<i>Speaker</i> : <i>Ocean Model fidelity and resolution</i> , ICSS Open Day , Southampton, UK.
2009	<i>Information tent scientist helper for</i> “Climate Change”, United Nations Climate Change Conference (COP 15) , Copenhagen, Denmark.

Seagoing experience

July 2016	RV NORSEMAN II , Mooring recovery in the Bering Strait and high resolution synoptic survey of the Strait and Chukchi Sea area. Chukchi Sea glider deployment.
August 2010	RV Callista , Falmouth Bay data collection.

Professional memberships

2010–present	European Geosciences Union
2016–present	American Geosciences Union