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Current position

7/2023–present	Assistant Professor: University of California Davis, CA
7/2023–present	Visiting Scholar: Princeton University, NJ
1/2022–present	Affiliate Assistant Professor: University of Washington, WA
2/2020–present	Affiliate Researcher: NOAA Geophysical Fluid Dynamics Laboratory (GFDL), NJ
8/2022–present	Associate Editor: Journal of Artificial Intelligence for the Earth Systems (American Meteorological Society)

Education

2011-2016	University of Southampton, UK. Ph.D. Complex Systems Simulation through the National Oceanography Center Dissertation: Ocean model utility dependence on horizontal resolution Advisors: George Nurser, Joel J.-M. Hirschi, James Dyke
2006-2011	University of Southampton, UK. M. Sci. <i>magna cum laude</i> , complex systems simulation, 2011 M. Sci. <i>magna cum laude</i> , physical oceanography, 2010

Academic positions

2/2020–6/2023	Princeton University, NJ , Associate Research Scholar
2/2019–1/2022	Visiting Scientist: University of Washington , School of Oceanography, Visiting Scientist. Host: L. Thompson
10/2015–2/2020	Postdoctoral Associate: Massachusetts Institute of Technology (MIT) , Earth, Atmosphere and Planetary Sciences. Advisor.: C. Wunsch, P. Heimbach & S. Dutkiewicz
2/2017–10/2019	Visiting Scientist: Harvard University , Earth and Planetary Science, Visiting Scientist. Host: C. Wunsch
12/2018–1/2019	Visiting Scientist: Grenoble Les Alpes , Lab. des Ecouls. Geophysiques et Industriels (Fr), Visiting Scientist. Host: T. Penduff & N. Le Bihan
10/2016–2/2017 & 10/2017–10/2018	Visiting Scientist: University of Texas at Austin , Inst. for Computational Engineering and Sciences, Visiting Scientist. Host: P. Heimbach

Review articles (total: 2, 1 in review)

[1] **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**.

[2] 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 Intelligence**. DOI: 10.1038/s42256-021-00374-3 <https://arxiv.org/abs/2101.09126>. Featured on: [Carbonbrief](#), [Helmholtz Association of German Research Centers press release](#), [Physics.org](#), [enggtalks](#) and [Newsbreak](#).

[3] Bronner, U., **Sonnewald, M.** and Wisbeck, M., 2023, *Marine modelling as the key to sustainable use and protection of the marine environment*. Invited contribution to the centennial edition of **The International Hydrographic Review**.

Peer reviewed publications (total: 13)¹

4 in review/revision, ‘*’ indicates student advised and press coverage in [blue](#)

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

- [4] **Sonnewald, M.**, Reeve, K., Lguensat, R. *A supergyre modulates the global overturning through upwelling in the Southern Ocean*. 2023, **Nature Commun. Earth Environ.**
- [5] Jones, D., **Sonnewald, M.**, Rosso, I., Zhou, S., and Boehme, L., *Unsupervised classification identifies coherent thermal-haline structures in the Weddell Gyre*. 2023, **Ocean Science**.
- [6] Clare, M.*, **Sonnewald, M.**, Lguensat, R., Deshayes, J. and Balaji, V., *Explainable Artificial Intelligence for Bayesian Neural Networks: Towards trustworthy predictions of ocean dynamics*. 2022, **Journal of Advances in Modeling Earth Systems**.
- [7] Kaiser, B., Saenz, J.A., **Sonnewald, M.** and Livescu, D., *Automated identification of dominant physical processes*, 2022, **Engineering Applications of Artificial Intelligence**. Available: ArXiv
- [8] J. Krasting, M. De Palma, J. Dunne, J. John, and **Sonnewald, M.** *Regional Sensitivity Patterns of Arctic Ocean Acidification Revealed With Machine Learning*, 2022, **Nature Commun. Earth Environ.** <https://doi.org/10.1038/s43247-022-00419-4>.
- [9] **Sonnewald, M.**, and Lguensat, R. *Revealing the impact of global heating on North Atlantic circulation 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.
- [10] **Sonnewald, M.**, and Lguensat, R. , Radhakrishnan, A., Sayibou, Z.*, Wittenberg, A.T. and Balaji, V. *Revealing the impact of global warming on climate modes using transparent machine learning and a suite of climate models*, 2021, **International Conference on Machine Learning: Spotlight paper at ClimateChangeAI Workshop**. Available: <https://www.climatechange.ai/papers/icml2021/13>
- [11] **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](#) and [Scienceblog](#).
- [12] 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.
- [13] **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](#) and [ECN magazine](#).
- [14] **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
- [15] 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.
- [16] **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.
- [17] In review: **Sonnewald, M.**, *A hierarchical ensemble manifold methodology for new knowledge: An application to ocean physics*, in review, **JAMES**.
- [18] In review: Navarra, G.G*, **Sonnewald, M.**, Deng, Y., Liguori, G. and Di Lorenzo, E. *Using Deep Learning to forecast marine fishery indicators in the North Pacific*. In review **Nature Communications Biology**.
- [19] In review: Khatri. H., Griffies, S.M., Storer, B.A., Buzzicotti, M., Aluie, H., **Sonnewald, M.**, Dussin, R. and Shao, A., *A scale-dependent analysis of the barotropic vorticity1budget in a global ocean simulation*. **JAMES**.
- [20] In review: Kaiser, B. and **Sonnewald, M.** *Build AI with scientific definitions of interpretability and explainability*. In review. **Nature Machine Intelligence**.
- [21] Submitted: **Sonnewald, M.** *A hierarchical ensemble manifold methodology for new knowledge on spatial data: An application to ocean physics*. Submitted. **JAMES**.

- [22] In revision: **Sonnevald, M.**, Hirschi, J.J.-M., Nurser, A.G., Firing, Y., Coward, A. and Hyder, P. *Increasing ocean model resolution reveals viscosity tuning bias*. In revision, **JAMES**.
- [23] In revision: Bingham, R. and **Sonnevald, M.** *Stable Atlantic overturning circulation revealed by a dynamically-proximate reconstruction*. In revision, **Geophysical Research Letters**.
- [-] Upcoming: **Sonnevald, 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: **Sonnevald, M.**, Sayibou, Z., Wittenberg, A.T., Lguensat, R., Balaji, V. and A. Radhakrishna *Tracking the equatorial undercurrent to understand the El Niño Southern Oscillation in future climate*. In preparation.

Other publications (total: 3)

- [24] **The ECCO Consortium**. *A Twenty-Year Dynamical Oceanic Climatology: 1994-2013. Part 1: Active Scalar Fields*, 2017, **MIT DSpace**: <https://dspace.mit.edu/handle/1721.1/107613>.
- [25] **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>.
- [26] Gille, S., Abernathey, A., Chereskin, T., Cornuelle, B., Heimbach, P., Mazloff, M., Menemenlis, D., Rocha, C., Soares, S., **Maike Sonnevald**, Villas Boas, B., and Wang, J. *Open Code Policy for NASA Space Science: A perspective from ocean modeling and ocean data analysis*, 2018, **NASA White Paper**, Available: <https://tinyurl.com/NASA-WhitePaper>
- [-]Upcoming: Abernathy, R., ... **Sonnevald, M.**, et al., *OpenOceanCloud*. **UN Ocean Decade White Paper**.

Selected awards and honours

Honour	Elected a UC Davis Faculty Scholar of the Center for the Advancement of Multicultural Perspectives on Science (CAMPOS).
In review	Principal Investigator: <i>Climate modes determined with Responsible AI for Knowledge, model Evaluation, and observatioN (CRAKEN)</i> . European Research Council Starting Grant €1.6 million .
Funded	Principal Investigator: <i>Improving coastal sea level predictions with ocean process insight guided by machine learning</i> . To NOAA Climate Program Office \$510,000 .
Pending	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> . NOAA Climate Program Office \$426,301 .
2023	Podcast feature: AGU “Third pod from the sun” and “Carry the two” collaboration.
2023	Grant Collaborator: <i>Bridging theory to reality in projections of the Asian and West African monsoons (BRIDGE)</i> . National Environmental Research Council (UK). £958,000 .
2022	Policy impact/advisory role: “Climate and Ocean - Variability, Predictability, and Change” program, a core part of the World Climate Research Program by UNESCO and the International Science Council . Invited panel speaker.
2022	Invited working group: Nucleus European Model of the Ocean (NEMO) on machine learning and uncertainty quantification.
2021	Core member: University of California, Santa Barbara, Kavli Institute for Theoretical Physics (KITP) , “Machine Learning and the Physics of Climate”.
2021	Work featured on cover of JAMES .
2021	Policy impact/advisory role: Dept of Energy AI workshop, requested overview talk on ‘Ocean Grand Challenges’.
2021	Spotlight paper: International Conference on Machine Learning (ICML).
2021	Grant: French National Centre for Scientific Research (CNRS) laboratory collaboration, Mariana Clare. £2000 .
2021	Policy impact/work featured: NOAA artificial intelligence strategy 2021-2025 . Agency wide recommendations.
2020-2021	Grant: Amazon Sustainability Data Initiative (ASDI), \$31,032.
2020	Grant: ASDI, \$48,595

2020	Policy impact: Work contributed to science basis for New Zealand’s Marine Protected Area legislation.
2018-2020	Grant: Visiting Scientist, Data Institute Univ Grenoble Alpes. €1700.
2017	Award from the Kaufman Teaching Certificate Program (KTCP), MIT.
2016	Physical Oceanography Dissertation Symposium grant, University of Hawaii at Manoa, USA. \$1500.
2014	Awarded grant to lead NOCS Software Carpentry workshop for Ph.D. students.
2010	Graduate Scholarship. Engineering and Physical Sciences Research Council (EPSRC, UK).

Scientific cruises

2016	NORSEMAN II, Bering Strait mooring recovery and high resolution synoptic survey including Chukchi Sea.
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Invited conference panels

2021	Incorporating Data Science and Open Science in Aquatic Research Summit. 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, Leveraging AI in the Environmental Sciences. Virtual, 60+ participants.

Selected keynotes and invited talks (total: 61)

Upcoming	European Laboratory for Learning and Intelligent Systems (ELLIS) AI4Good talk, Sorbonne University (June).
<u>2023</u>	<u>total: 14</u>
-	University of Toronto Nobel Seminar Series.
-	University of Liege 54th international Liege colloquium on ocean dynamica.
<u>2022</u>	<u>total: 14</u>
-	CLIVAR Physical Oceanography review panel.
-	NOAA GFDL HQ site review , Discovering and using ocean regimes at GFDL.
-	Climate Informatics , Asking how the Southern Ocean responds to global heating and understanding why the answer emerged.
-	SIAM Geoscience , Understanding the ocean’s response in a future climate.
-	U. Cambridge , Environmental Data Science Group, Intelligent solutions to monitor ocean health.
Others	SIAM DS, U. Wisconsin-Madison, Max Planck Institute for Meteorology, UC Berkeley, MIT for EAPS and Mechanical Engineering, U. Rhode Island (Nov.), IMSI, U. Chicago.
<u>2021</u>	<u>Talks total: 14</u>
-	AGU , Revealing the impact of climate change on North Atlantic circulation using ML.
-	Dept of Energy workshop, Requested topic: Ocean Grand Challenges: Using AI/ML to push the frontiers.
-	Climate Change AI , A robust blueprint for trustworthy AI for climate analysis.
-	NOAA , workshop, Revealing the impact of global warming on climate modes using transparent machine learning and a suite of climate models. Virtual.
Others	KITP, Scripps Institute of Oceanography, U. Washington, U. Chicago, International Conference on Machine Learning, Summit: Incorporating Data Science and Open Science in Aquatic Research, University Corporation for Atmospheric Research (UCAR), U. California, Santa Cruz, GEOMAR Helmholtz Centre for Ocean Research, Technical U. Munich, Potsdam Institute for Climate Impact.
<u>2020</u>	<u>Talks total: 7</u>
-	NOAA Senior Management Meeting, Oceanic and Atmospheric Research. Building geographies of ocean dynamical regimes.
Others	Los Alamos National Laboratory, U. Washington (engineering), U. Washington (phys. oceanography), U. British Columbia, NOAA, workshop, U. Washington (bio. oceanography).
<u>2019</u>	<u>Talks total: 7</u>
-	AGU, The case for machine learning in geoscience. San Francisco, USA.
-	Norway-US bilateral AI workshop, Elucidating Ecological Complexity. Austin, USA.
Others	Princeton University, Norway-US bilateral AI workshop (on dynamical regimes), WHOI, U. Tromsø, U. Bergen.

2012-2018	<u>Total talks: 17</u>
-	WHOI , <i>Unsupervised learning classifies global ocean dynamical regions</i> .
-	Columbia University, LDEO , <i>Linear predictability: A sea surface height case study</i> .
-	Yale University , <i>Ocean model utility dependence on horizontal resolution</i> .
Others	MIT (2018 & 2015), Stony Brook University , U. Texas at Austin , U. Washington , Oregon State University , U. Oxford , MIT (Two invited student talks), U. Bristol , NOCS (2015, 2014 & 2013) and MONCACO meeting .

Selected conference contributions (12 posters and 23 talks) ²

2023	<u>Contributions total: 1</u>
-	EGU , The Southern Ocean supergyre: a unifying dynamical framework identified by ML. Talk .
2021	<u>Contributions total: 5</u>
-	AGU , Elucidating ecological complexity. Talk .
-	EGU , <i>Mechanisms of change in the AMOC under global heating</i> . Highlighted vPICO .
Others	Ocean Science , ICML and Knowledge Guided Machine Learning (KGML) .
2020	<u>Contributions total: 3</u>
	Climate Informatics , <i>Elucidating Ecological Complexity</i> . Oxford/virtual. Talk .
Others	Climate Informatics and AGU .
2011-2019	<u>Contributions total: 27</u>
-	EGU , <i>Unsupervised Learning Reveals Geography of Global Ocean Dynamical Regions</i> . Talk .
-	AGU , <i>Unsupervised Learning Reveals Geography of Global Ocean Dynamical Regions</i> . Poster
-	World Climate Research Programme (WCRP) , Intergovernmental Oceanographic Commission of UNESCO (IOC) Sea Level , <i>Linear predictability: An SSH case study</i> . Poster .
-	Int. Ass. for the Physical Sciences of the Oceans (IAPSO) . Talk , grant recipient.
Others	European Geosciences Union (EGU) (2019, 2017, 2015x2, 2012x2), AGU , ECCO meeting (2018, 2017x2), Ocean Science Meeting (2016, 2018), Society of Engineering Science , Physical Oceanography Dissertation Symposium (PODS) , SIAM (2015, 2014), Student Conference on Complex Systems (SCCS) (2014, 2013, 2012, 2011), Graduate Climate Conference , ICSS , Ocean Modeling Group and Challenger Conference .

Mentoring and advising³

Upcoming	Advising: William Yik, Harvey-Mud, Holling Scholar (NOAA). Undergraduate.
2021-	Committee member: Jacob Cohen, University of Washington. Ph.D. student.
2021-	Committee member: Yvonne Jenniges, Alfred Wegener Institute (DE), Ph.D. student.
2021	Advising: Mariana Clare, Imperial College London, National Centre for Scientific Research (CNRS, Fr), Ph.D. student, now researcher at European Center for Medium Range Weather Forecasting.
2021-2022	Advising: Giangiacomo Navarra, Georgia Tech. Ph.D. student, now postdoc at Princeton.
2021	Advising: Zouberou Sayibou, Bronx Community College, undergraduate, now Junior at Stanford.
2019-	Mentoring: Catherine Wilka, now postdoc at Stanford.

Teaching experience

2023	Lecture: ECMWF Massive Open Online Course: “Unsupervised learning to understand the ocean”, open to public. <i>Registered: 9000, developed material, taught</i> .
2022	Lecture: University of Washington: “Uses and misuses of machine learning for geoscience”, undergraduate. <i>Participants 20, developed material, taught</i> .
2021	Lecture: Princeton University: “Deep learning in geophysical fluid dynamics”, graduate. <i>Participants 10, developed material, taught</i> .
2021	Tutorial/workshop: Society for Industrial and Applied Mathematics (SIAM): Conference on Mathematical and Computational Issues in the Geosciences. Milan, Italy, graduate and undergraduate. <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” <i>Class size 6, developed material, taught</i> .

²Only first author presentations

³Only formal mentoring and advising listed

2019	Lecture: Harvard University EPS: “Machine Learning in Geoscience”, graduate. <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. <i>class size 60, developed material, taught.</i>
2019	Tutorial/workshop (3 day) , Princeton University & GFDL workshop at graduate level: “Machine learning and climate modeling”, graduate. <i>Class size 20-30, developed material, taught</i>
2016	Lecture: University of Texas at Austin: “Vertical Mixing Schemes: Why we need them & what they do”, graduate. <i>Class size 5, developed material, taught.</i>
2014	Tutorial: SCCS, “Finite differences methods”. <i>Class size 40+, developed material, taught.</i>
2014	Tutorial: SCCS “Importance of model validation”. <i>Class size 40+, developed material, taught.</i>
2013	Teaching Assistant: NOCS, “Physical Oceanography II”, undergraduate. <i>Class size 50, held labs.</i>
2012	Teaching Assistant: NOCS, “MSc Fieldwork Boat Week”.
2012	Teaching Assistant: NOCS, “Physical Oceanography I”, undergraduate. <i>Class size 50, held labs.</i>

Service

Review duties

Journals	Nature, JAMES, Geophysical Research Letters, Ocean Modelling, Journal of Geophysical Research, Journal of Physical Oceanography, Data Science and others.
Review Panel	NASA review panel 2017

Conference, workshop and seminar organization

2023	Climate Informatics , <i>12th International Conference on Climate Informatics</i> , Program Committee .
2023	EGU , <i>Machine learning for Earth System modeling</i> , convener .
2022	AGU , <i>Interpretable Machine Learning for Marine Sciences</i> , convener .
2022	EGU , <i>Machine learning for Earth system modelling</i> , convener .
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>Machine learning for Earth system modelling</i> , convener .
2020	AGU , <i>Exploration in observed and model oceanographic data using interpretable ML</i> , oral and poster, head-convener .
2020	AGU , <i>Machine Learning for Weather and Climate Modeling</i> , oral and poster, 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>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>Exploration of Observations and Models Using ML</i> , oral and poster, head convener .
2015–2016	MIT Sack Lunch , seminar, organizing member .
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 .
2012–2013	Complex earth system modelling and physical Understanding , seminars, organizer .
2011–2013	Rhubarb series , seminars organizing member .
2011– 2014	SCCS , conference, organizing member and session convener .

Selected diversity, equity and inclusion activities

2021-present	POD member , 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 skis).

Selected public engagement and outreach

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