Dr. Karin F. Kvale

Scientific Programmer, Biogeochemical Modelling, GEOMAR
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Education

PhD Climate Science (2014), University of New South Wales, Australia

MSc Atmospheric Science (2009), University of Victoria, British Columbia, Canada

BSc Environmental Science (2005), Indiana University, U.S.A., with minors in Geology, Mathematics and Geography

Nationalities

United States of America, birthright citizen

Commonwealth of Australia, naturalized citizen

Refereed Publications

Kvale KF, Meissner KJ, Keller DP (2015). Potential increasing dominance of heterotrophy in the global ocean. *Environmental Research Letters.*

Kvale KF, Meissner KJ, Keller DP, Eby M, Schmittner A (2015). Explicit planktic calcifiers in the University of Victoria Earth System Climate Model version 2.9. *Atmosphere-Ocean.*

Kvale KF, Zickfeld K, Meissner KJ, Tanaka K, Bruckner T, Weaver A (2012). Carbon dioxide emission pathways avoiding dangerous ocean impacts. *Weather, Climate and Society*, 4(3).

Kvale KF, Pryor SC (2006). Precipitation composition in the Ohio River Valley: Spatial variability and temporal trends. *Water, Air and Soil Pollution*, 170.

Renshaw CE, Johnson GD, **Kvale KF**. (2000). A laboratory exercise to determine dinosaur speeds using dimensional analysis. *Journal of Geoscience Education*, 48.

Other Publications

Kvale KF (2014). *Representations of biological calcification in two climate models*, PhD Dissertation, University of New South Wales, Sydney, Australia.

Kvale KF, Meissner KJ, d'Orgeville M, Matear R, McNeil B, England MH (2011). The combined

impact of CO2-dependent parameterizations of Redfield and rain ratios on ocean carbonate saturation. *Biogeosciences Discussions*.

Kvale KF (2008). *Carbon Dioxide Emission Pathways Avoiding Dangerous Ocean Impacts*. Masters Dissertation, University of Victoria.

http://dspace.library.uvic.ca:8080/bitstream/handle/1828/1334/thesis_Kvale_FINAL.pdf

Awards and Honors

Awarded `Best Poster' at the SOLAS Summer School, Corsica, France 08/2011

University International Postgraduate Award (UNSW Graduate School), 2009

Tuition Fee Remission Scholarship for international postgraduates (UNSW Graduate School), 2009

Awarded 'Best Talk' at the UVic Graduate Student Workshop, 2008

Charles Deiss Scholarship (IU Department of Geological Sciences), 2003

Edward L Hutton International Experiences Program Grant (IU Honors College)

Professional Experiences Internship Grant (IU Honors College)

Undergraduate Research and Creative Activity Partnership Grant (IU Graduate School)

Presentations

Khatiwala S, Muglia J, Schmittner AS, **Kvale KF** (2016). Exploring the controls on glacial-interglacial variations in atmospheric CO_2 in an observationally-constrained ocean circulation-biogeochemical model. International Conference on Paleoceanography, Utrecht, Netherlands.

Khatiwala S, Muglia J, **Kvale KF**, Schmittner AS (2016). Simulation of glacial ocean biogeochemical tracer and isotope distributions based on the PMIP3 suite of climate models, European Geophysical Union Meeting, Vienna, Austria.

Kvale KF, Meissner KJ, Keller DP (2016). Potential increasing dominance of heterotrophy in the global ocean, American Geophysical Union Ocean Sciences Meeting, New Orleans, USA.

Kvale KF, Meissner KJ, Keller DP, Schmittner A (2012). Explicit planktic calcifiers in the UVic ESCM, American Geophysical Union Ocean Sciences Meeting, Salt Lake City, USA.

Kvale KF and Meissner KJ (2011). Adding calcifiers to the UVic model, SOLAS Summer School, Corsica, France.

Kvale KF, Meissner KJ, Matear R, McNeil B (2011). The combined impact of CO2-dependent parameterizations of Redfield and rain ratios on ocean carbon chemistry, American Society of

Limnology and Oceanography Aquatic Sciences Meeting, San Juan, Puerto Rico.

Kvale KF, Zickfeld K, Meissner, KJ, Weaver A, Tanaka K, Bruckner T (2008). Balancing oceans and emissions: A cost-effective analysis, Canadian Meteorological and Oceanographic Society (CMOS) Annual Conference, Kelowna, BC, Canada.

Kvale KF, Zickfeld K, Meissner KJ, Weaver A, Tanaka K, Bruckner T (2007). Avoiding dangerous anthropogenic climate change, Graduate Climate Conference, Pack Forest Conference Center, University of Washington, WA, USA.

Kvale KF and Pryor SC (2005). Precipitation composition in the Ohio River Valley: Spatial variability and temporal trends, Indiana University Undergraduate Research Conference, Indianapolis, IN, USA.

Teaching Experience

Introduction to the Marine Environment (MSCI0501, UNSW):

- Course Coordinator, S2 2009- S1 2011
- Botany Bay Field Trip Leader/Lecturer S1 2010- S1 2011
- Sydney Aquarium Field Trip Leader S1 2010- S1 2011

Coral Reefs: Ecology and Environment (MSCI2051, UNSW):

- Lady Eliott Island Field Trip Lecturer 02/2010

Introduction to the Earth System (EOS110, Univ. of Victoria):

- Lab Teaching Assistant 09/2007-12/2007

Research Experience

GEOMAR Helmholtz-Zentrum für Ozeanforschung, Prof. Andreas Oschlies, 2014-2017

I am implementing transport matrix extraction and interface schema in the University of Victoria Earth System Climate Model (UVic ESCM) in collaboration with Samar Khatiwala at the University of Oxford, UK. This will allow for efficient offline testing of the biogeochemical and sediment submodels. Secondary projects include implementing a new phytoplankton functional type, diatoms, as well as a prognostic silica cycle into the model and coordinating an update of the UVic ESCM biogeochemistry for the next release. My collaborators include researchers at the University of Victoria in Canada and Oregon State University in the US. Furthermore I am supervising research by a masters student into the marine ecological tipping point identified in Kvale et al. (2015).

University of New South Wales, Dr. Katrin Meissner, Prof. Matthew England, and Dr. Andreas Schmittner (Oregon State University, USA), 2009-2014

I implemented a new phytoplankton functional group, calcifying phytoplankton, in the University of Victoria Earth System Climate Model. I also revised the ocean surface-to-deep ocean carbon export scheme to make the ocean carbon cycle mechanistically more realistic. A high carbon emissions scenario applied to the new model as a transient simulation revealed transition into a microbe-dominated ocean occurring between 2 and 4 degrees C of sea surface temperature change, depending upon model structure.

University of Victoria, Drs. Kirsten Zickfeld (now at Simon Fraser University), Katrin Meissner (now at UNSW), Andrew Weaver (curent leader of the Green Party and MLA in British Columbia, Canada) 2007-2009

My masters thesis used a global annual mean, coupled economy-climate model to calculate optimal carbon emissions pathways and emissions corridors using least-cost analysis and the tolerable windows approach. These pathways and corridors are recommended for avoiding dangerous levels of anthropogenic interference with the climate system, specifically socially intolerable increases in temperature, sea level, and ocean acidification. To find these pathways and corridors, I coupled two models (ACC2 and DICE) and updated the sea level calculation in ACC2.

Indiana University, Dr. Sara Pryor (now at Cornell University, USA), 2002-2005

During the last two years of my undergraduate degree at IU I used meteorological data collected from regional weather stations over recent decades to look for a changing climate signature with statistical techniques.

Work Experience

Scientific Programmer, 09/2014-09/2017

GEOMAR Helmholtz-Zentrum für Ozeanforschung, Biogeochemical Modelling Division, Kiel, Germany
        Working both independently and collaboratively on climate model development as well as
        conducting and supervising scientific research.

Resource Assessment Analyst, 8/2008-11/2008

3Tier Environmental Consulting, 2001 6th Ave, Suite 2100, Seattle, WA, 98121, USA

Worked within a group writing reports detailing wind generating potential for prospective wind farms.

Field Technician, 7/2005

Indiana Geological Survey, 611 N. Walnut Grove Bloomington, IN, 47405, USA

Contributed to an ongoing project monitoring water quality around the Lake Michigan shore. Collected data from data loggers at monitoring wells, and water samples from a constructed wetland.

Extended Absences from Work

Full-time maternity leave, 07/2012-03/2013

Part-time (50%) maternity leave, 03/2013-08/2014

Full-time maternity leave, 07/2015 - 03/2016

Part-time (50%) maternity leave, 03/2016 - 11/2016

Volunteer Experience

UNSW Academic Board, 2009-2011. I represented the interests of postgraduate research students at the university level in various capacities. Please see the Professional Memberships section for details.

UVic Common Energy, 2007-2009. Common Energy is a student organization at the University of Victoria and University of British Columbia that works to make both universities more sustainable. I worked with the food systems focus group, writing a proposal to reactivate an existing but unmaintained orchard on campus.

Hoosier Hikers Council, 2002-2006. The Hoosier Hikers Council is a non-profit in Indiana, USA that advocates for hikers' interests at the state level. I attended State and National Forest planning meetings as a representative of the interests of pedestrians in these forests, and worked with a range of stakeholders (private landowners and public management) to develop a long-distance hiking trail network within the state.

Computer Language and Model Fluency

Matlab

GAMS- ACC2 and DICE

Fortran- Mk3L and UVic ESCM

Professional Memberships

Future Ocean Cluster of Excellence Member (from 2014)

Integrated Marine Postdoc Network (IMAP) Member (from 2014)

UNSW Academic Board Student Representative from Electorate B (2009-2010)

Research Committee Student Member, UNSW Academic Board (2009-2010)

Higher Degree Research Committee Student Member, UNSW Academic Board (2010-2011)

Academic Services Committee Student Member, UNSW Academic Board (2009)

List of Publications by Karin F. Kvale

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Kvale KF, Meissner KJ, Keller DP (2015). Potential increasing dominance of heterotrophy in the global ocean. *Environmental Research Letters.*

Kvale KF, Meissner KJ, Keller DP, Eby M, Schmittner A (2015). Explicit planktic calcifiers in the University of Victoria Earth System Climate Model version 2.9. *Atmosphere-Ocean.*

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Professional References

Associate Professor Dr. Katrin Meissner

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Level 4 Mathews Building

Sydney, N.S.W. Australia 2052

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Assistant Professor Dr. Kirsten Zickfeld

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Professor Dr. Andrew Weaver

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Ocean, Earth & Atmospheric Sciences Building

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Victoria, B.C. Canada V8W 3V6

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Research Statement by Karin F. Kvale

Global biological and biogeochemical cycle representations in earth system climate models are becoming increasingly complex as our mechanistic understanding of their connections improves. Ocean models often now contain multiple plankton types classified according to biogeochemical role, linked to global cycles through physiology and ecology. The non-linear biogeochemical response from their ecological and physiological adjustments to climate change presents an exciting area of research in modelling.

My Ph.D. dissertation examines representations of the ocean inorganic carbon cycle in the University of Victoria Earth System Climate Model (UVic ESCM) and the CSIRO-Mk3L model. The CSIRO-Mk3L ocean carbon model is structurally simple, and was used to quantify the non-linear response of global seawater carbonate saturation state under the dual forcing of increasing seawater CO_2 (a phytoplankton fertiliser) and acidity (a calcification inhibitor). The strong sensitivity of carbonate saturation state to these dual pressures reveals a mechanism for radically altering ocean biogeochemistry without also requiring changes in ocean circulation, and might at least partly explain how ocean calcification remained depressed for long time intervals following high-carbon atmospheric events in the geologic past.

The UVic ESCM uses a more complex ocean carbon cycle, and I have implemented a new phytoplankton class to distinguish calcifying from non-calcifying phytoplankton, and calcifying zooplankton. These new calcifiers interact with the ocean inorganic carbon cycle through a new prognostic calcite tracer. This new inorganic carbon representation (in combination with the existing ocean sediment model) will position the UVic ESCM as an ideal model for examining earth system sensitivity to changes in biological calcite production over long periods of time. Over the remainder of my Ph.D. tenure I will experiment with the ballast model, compare output to the modern ocean, and apply it to future transient carbon scenarios. Time permitting I will also apply it to the Last Glacial Maximum to see how well the model recreates global sediment patterns.

After three years of developing and testing my addition to the UVic ESCM I would like to have an opportunity to use it, and to share it with other researchers who might use it. As a post-doctoral researcher my hope is to continue using this tool to explore ocean biogeochemical sensitivity to this (and possibly other) representations of the ocean inorganic carbon cycle. The global biogeochemical impact of multiple physiological responses of calcifiers to changes in ocean carbonate saturation state is one line of research I would like to test. Recent sediment surveys reveal some planktic calcifiers have a higher tolerance for low carbonate saturation state than is

often assumed in models. This feature potentially provides an ecological advantage in an acidifying ocean that has not been explored within a climate model.

A similar line of research I would be interested to pursue is the use of non-Redfield stoichiometric parameterisations for nutrient utilisation by ocean phytoplankton, since ocean biogeochemistry has recently been shown to be very sensitive to these (frequently static) ratios.

A key asset of the UVic ESCM is the sediment model, which I would like to use to compare model output from climatologically important eras with real-world sediment deposits as a means of validation. This may require the addition of a full or approximated diatom phytoplankton class (many paleo sediments are reported as percentage diatom composition). Adding diatoms as a phytoplankton class would be relatively simple for me, having just included calcifiers. Adding a silicate cycle would be more work but could be more simply approximated using a silicate ocean mask. Comparisons of model sediment assemblages with real ones can provide insight into how well the model reproduces marine phytoplankton communities, nutrient availability, and physical circulation.

More generally, I am interested in pushing climate modelling into new applications. My master's thesis examined economically optimal CO_2 emissions pathways that avoided dangerous climate thresholds. The analysis used cost-effectiveness optimisation software to couple simple climate and economic models under several IPCC non-CO_2 greenhouse gas emissions scenarios. The analysis showed that the two degree Celsius climate guardrail is impossible to respect, provided non-CO_2 greenhouse gases are not mitigated and economically tolerable rates of de-carbonisation are not exceeded. A one meter sea level rise guardrail is also likely already committed to if recent estimates of equilibrium sea level sensitivity are applied. A global average drop of 0.1 units of ocean pH was the one guardrail I tested that proved to be physically avoidable under economically tolerable rates of de-carbonisation. I enjoyed working on a problem that was both physical as well as economic and would be open to a similar interdisciplinary collaboration in the future.