CO2 Uptake of the Ocean: Research Challenges and Recent Results

Malte Prieß
Christian-Albrechts-University in Kiel

Abstract: Understanding the oceanic CO2 uptake is of central importance for projections of climate change and oceanic ecosystems. Simulating ocean circulation and biogeochemistry has become a key tool for understanding the ocean carbon cycle and its variability. The underlying models are governed by coupled systems of parabolic partial differential equations for ocean circulation and transport of biogeochemical tracers. The coupling relations between the tracers are more or less empirical, i.e., it is not very clear how the coupling terms look like mathematically, and, moreover, how many tracers have to be taken into account. Many model parameters are used which are chosen such that the model results remain feasible and that given measurement data is matched by the model output. The overall aim is to minimize a least-squares type cost functional, measuring the misfit between the model output and given data. The optimization variables are the unknown parameters in the nonlinear coupling terms in the tracer transport equations.

To a substantial degree the resulting problems belong to mathematical disciplines of Optimization, Optimal Control and Inverse Problems. These problems as a main topic of our research group are very complex in the field of mathematical analysis, numerical transformation and algorithmic realization. Important research areas are:
- Algorithmic sensitivity and gradient calculations (automatic differentiation)
- Nonlinear optimization methods
- Analysis and numerical mathematics of nonlinear transport equations and equations of the ocean circulation (Navier-Stokes-equations)
- Analysis of optimization problems with partial differential equations

The talk will give an overview of the research on C02 uptake conducted in Junior Research Group A3 at the Christian-Albrechts-University in Kiel.

Author's bio: Malte Prieß was born in Germany, Berlin, in 1981. He received his diploma degree (with distinction) in Physics with foucs on theoretical physics, mathematics and computer science from the Leipniz Universität Hannover, Germany, in 2007. He is currently a Ph.D. student in the junior research group Algorithmic Optimal Control - CO2 Uptake of the Ocean (headed by Prof. Thomas Slawig) at the department of Computer Science, Christian-Albrechts-Universität zu Kiel.

The research group is part of a huge cluster of excellence, The Future Ocean, which is a unique research group in Germany made up of more than 140 scientists from six faculties of the Christian-Albrechts-University of Kiel (CAU), the Leibniz Institute of Marine Sciences (IFM-GEOMAR), the Institute for World economy (IfW) and the Muthesius University of Fine Arts. The target of these inter-disciplinary groups comprising marine scientists, earth scientists and economists, as well as medical scientists, mathematicians, lawyers and sociologists is to jointly investigate climate and ocean change, to re-evaluate the opportunities and risks of global change for the oceans and develop a sustainable system of resource management of the world's oceans and marine resources.

The research interests of Malte Prieß include Surrogate-Based optimization, model reduction, algorithms of nonlinear optimization, optimal control, numerical analysis and ocean and ecosystem modeling.