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OLD DOMINION UNIVERSITY

Center for Coastal Physical Oceanography

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Leading the Way Toward Better Projections of Regional Sea Level Rise

Dr. Ben Hamlington

Although sea level rise is a global phenomenon, the impacts are local, and are happening now. Changes in sea level are impacting communities – like ours in Hampton Roads – on an almost daily basis through increased erosion, greater saltwater intrusion, more frequent “nuisance” flooding, and higher storm surge. Projections of future sea level rise point to far more dramatic impacts, with even moderate estimates leading to the potential displacement of millions of people currently living along the world’s coastlines. While most are familiar with the projections of global sea level rise that are heavily discussed in documents like the most recent IPCC report, from a planning perspective, the pertinent and needed information is how sea level will change at the local level. Sea level does not rise like a bathtub. When ice melts in Greenland and flows into the ocean, for example, it does not raise the height of the ocean the same amount everywhere. Although, the sources leading to regional sea level rise are generally known, the relative contributions of many of these sources are still not well constrained. Spatial variations in sea level rise can result from a wide range of influences including shifts in ocean currents and global gravitational effects. Many of the processes involved are difficult to observe and operate on vastly different timescales. Furthermore, the “whole climate” nature of sea level change also requires an

interdisciplinary approach involving scientists and engineers with a broad range of expertise.

Having highlighted some of the challenges we face in projecting future sea level rise, let’s discuss what is being done to address these issues. Three years ago, NASA formed the NASA Sea Level Change Science Team (N-SLCT). While perhaps not what it is traditionally known for, NASA has become a leader in sea level science. Satellite records provide important observations of many of the contributors to sea level rise. Importantly, many of these satellites provide near global coverage on regular intervals, sampling the whole climate system in a way that in situ measurements never could. Proposals were solicited to serve on this team, and a group of roughly 50 scientists and engineers from academic institutions and government agencies across the country were brought together to tackle some of the outstanding issues in the broad study of sea level. The goal was to form an interdisciplinary team that would collaborate, share data and techniques, and ultimately make progress towards improving regional sea level projections. While this may seem like a common sense approach to many, it involved bringing together groups that are often in competition for funding and publishing the latest and greatest in sea level science.

“...NASA has become a leader in sea level science. Satellite records provide important observations of many of the contributors to sea level rise.”

Letter from the Director

Dr. John Klinck



We all hope that the science questions that we address and resolve are important to someone. Many times, those who care about our work are other scientists. However, Ben Hamlington provides an example of a research topic with local and personal impacts: local sea level rise and flooding. Everyone living in Hampton Roads, Virginia is aware of the increased frequency of flooding from wind events of various kinds. While the general public may not be aware of the subtleties of water level in response to the melting of far-away glaciers, we are all aware of the consequences: water on streets and in houses and businesses.

Ben's leadership of the NASA Sea Level Climate team certainly provides a local information source for regional planners as well as a focus for continued research into the processes responsible for changing local water levels. This activity at CCPO provides national visibility for ODU and should attract students who wish to study here. This leadership role for Ben also provides him with a clear path to extend his efforts and continue the important work that he is doing.

Over the course of the three-year project (2014-2017), this first iteration of the N-SLCT demonstrated the potential of such an approach, with new working relationships formed as a result and the foundation laid for actually getting to the end-goal of producing a new and improved set of regional sea level projections. I served on this team first as a Co-Investigator on a project led by the University of Colorado at Boulder. Dr. Steve Nerem, a member of my dissertation committee when I was a student in Colorado, served as the Principal Investigator of this specific project, and also served as the Team Leader for the broader science team. He was tasked with organizing team interactions - including annual team meetings - and ensuring progress towards the goals of the team.

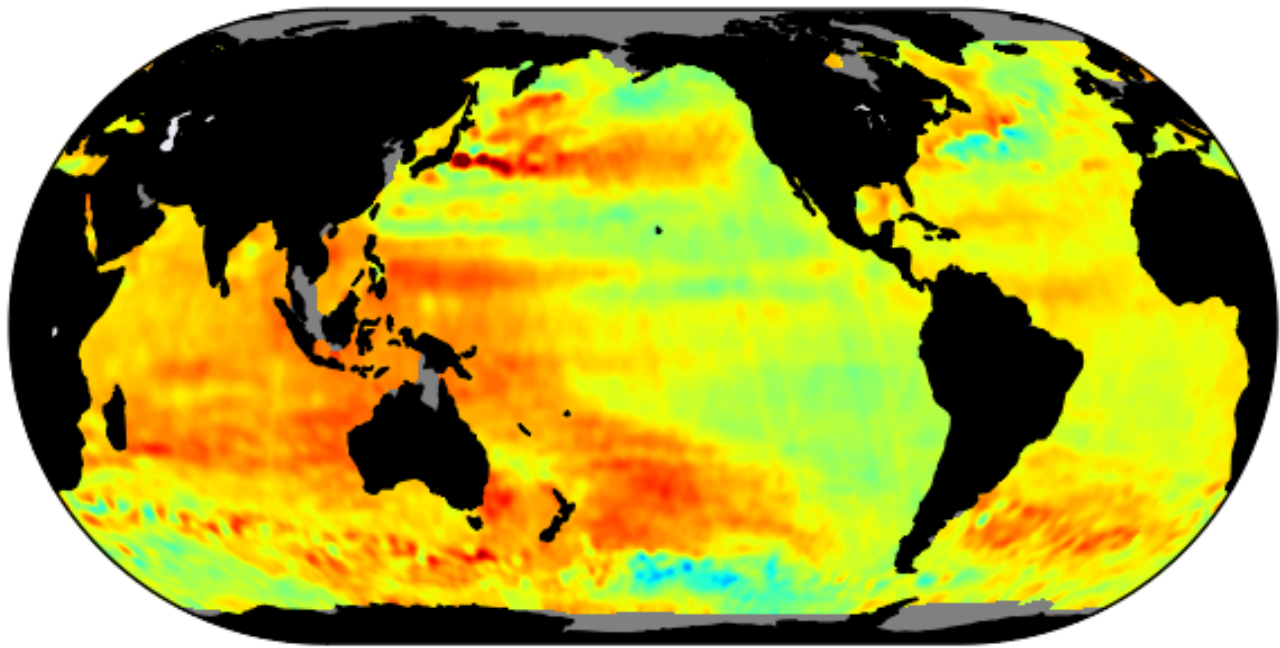
The last team meeting was held in Norfolk at the Slover Library in September 2016. I served as the

local host and organized a special session - separate from the scientific discussions of the team - between local officials and the N-SLCT. This meeting gave the members of the team the opportunity to visit a location already being impacted by sea level rise, and hear first-hand from some of the decision-makers

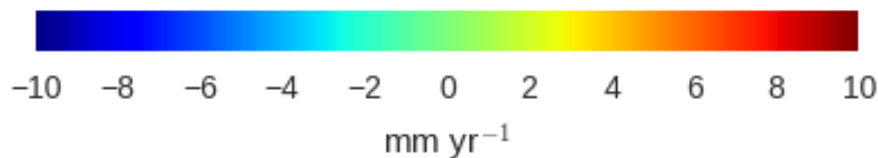
and planners in the region about what is being done to deal with present and future sea level rise. As scientists, it is important that we understand what information is needed for planning and how that information is being used.

Last year, NASA again solicited proposals to form the next iteration of N-SLCT, beginning a new three-year cycle. When selections were announced this July, I found out I would serve as both a Principal Investigator and the new Team Leader.

"...As a member and the lead of the N-SLCR, we have an increased opportunity to leverage the connection to Hampton Roads..."



University of Colorado 2016_rel4



The regional pattern of sea level rise as measured by satellite altimeters from 1993 to present. Regional sea level trends can be significantly larger or smaller than the global trend. You can find more information on this dataset at www.sealevel.colorado.edu.

While initial excitement faded quickly with the realization of the amount of work this would entail, I view this as an excellent opportunity for a number of reasons. From a personal perspective, it provides the chance to highlight the work already being done at Old Dominion University to tackle sea level rise, and will allow us to further establish ourselves as a leader in the field of sea level science. This will also lead to new opportunities for graduate students to interact with leading experts across the country. Additionally, as a member and the lead of the N-SLCT, we have an increased opportunity to leverage the connection to Hampton Roads and increase the role of the decision-maker in informing the activities of the team. The final product from the team should be designed to meet the needs of the planners.

My responsibilities as Team Lead have begun. A large portion of my time going forward will be spent on organizing meetings and teleconferences, and ensuring that the team is interacting. In my view, however, my most important task is to get the team to coalesce around a single goal that we can all work towards. As of right now, this “goal” is in the form of a final product, specifically a set of regional sea level projections across a range of timescales hosted by NASA and leveraging as much of NASA’s observation system and capabilities as possible. Regardless of the ultimate success of the team and the extent to which we meet this target, this will be a personal learning experience and an opportunity to build upon what we currently do at ODU and CCPO.

The Summer 2017 REU Program

Shannon Cofield

This summer, OEAS hosted nine undergraduates from across the country as part of the Research Experience for Undergraduates (REU) program. The students came from a wide variety of backgrounds and levels of research experience. As the Projector Coordinator, I worked hand-in-hand with Dr. Rodger Harvey, Program Director, and Ryan Glaubke, Near-Peer Mentor. Together we selected the REU students, suggested student-mentor matches, and oversaw the logistics of research presentations and papers.



2017 ODU Ocean, Earth & Atmospheric Sciences REU Program Participants

Student research projects were developed with their mentor or within their lab groups. Projects spanned all four disciplines of oceanography, as well as all three components of our department: ocean, earth, and atmosphere. As the students dove into their research, they were encouraged to work as a scientific cohort by sharing data and helping each other with data collection. One of our favorite outings was collecting juvenile crabs at First Landing State Park (sorry, no crab dinners for the students).

Outreach activities were an important component to introduce the students to sea level rise issues in our local coastal community. We organized field trips and guest speakers that covered a variety of topics including paleo sea level rise changes, local organizations focused on addressing community issues from sea level rise and flooding, awareness of voices against climate change, and trips to the Norfolk Zoo and Virginia Beach Aquarium. We also held some energetic workshops to help students continue to refine their public speaking skills and scientific writing methods.

The students' energy and willingness to dive into new research made the summer a great experience for myself, as well as the students. As undergraduates, they developed and completed an accelerated research project in the short time span of 10 weeks. A number of the students came from universities with no active research, so this was their first experience with research and the pressure that comes with rapid-paced projects. Their ability to handle pressure and stay focused on their end goal was incredible.

We had plenty of time for extra-curricular activities outside of research. The graduate students held weekly volleyball matches against the REU students. Some students visited Washington D.C., ventured out on hikes in the Blue Ridge, made a point to visit all of our delicious local coffee shops, and spent many weekends at the beach. Overall, our goal for this experience was not only to develop research projects and learn about the local impacts of sea level rise, but it was to incorporate a balance of research, personal development, and, of course, fun!

Ocean Modeling Course in China

Dr. Tal Ezer

I spent this past summer in China, teaching and providing training in ocean modeling. The two-week long summer training course was focused on the development of coupled regional ocean models and included both lectures and practical training with various analysis tools and computer model codes. Forty-five trainees were selected from mostly developing countries in four continents (Africa, Asia, Europe and South America) and the lecturers that were invited to teach this year included scientists from the USA, Hong Kong, Italy, Germany and Ukraine (Fig. 1). This diverse group of trainees and lecturers provided a forum aimed to advance ocean science in developing countries and encourage future international collaborations. This UNESCO-supported annual summer training course is organized

by the Ocean Dynamics and Climate (ODC) center at the First Institute of Oceanography (FIO) in Qingdao. This is the third time that I was invited to teach this course in China and my sixth visit to China since 2003.

As the location of the First Institute of Oceanography and the Ocean University of China, Qingdao is a center for ocean research and education, where many students and postdocs who come to ODU to study or do research received their education. Qingdao is a fast-growing coastal city (pop. ~9 million) and a major seaport on the shores of the Yellow Sea, where the sailing competition of the 2008 Olympics was held. Qingdao is known not only for attracting oceanographers, but also for its popular beaches, the Tsingtao Brewery and the annual beer festival.



Fig. 1. A group picture of the lecturers (front-center) and trainees, standing in front of the First Institute of Oceanography, Qingdao, China.

JUST THE FACTS

Graduations & Other Mentions:

Mack, S., PhD, "Influence of Tides and Mesoscale Eddies in the Ross Sea", August 25, 2017, Advisor: John Klinck.

Gatski, T., Member of the Industrial and Professional Advisory Council (IPAC) of the Penn State College of Engineering (Aerospace Engineering Department), Participant of the Annual Meeting of the Council, March 22- 23, 2017.

Hofmann, E.E., Appointed to steering committee to plan 'Fisheries Research and Monitoring for Atlantic Offshore Development—A Workshop', Ocean Studies Board, National Research Council, May 2017.

Publications:

Cheng, Y., T. Ezer, L. P. Atkinson, and Q. Xu, Analysis of Tidal Amplitude Changes Using the EMD Method," *Continental Shelf Research*, doi: 10.1016/j.csr.2017.09.009, 2017.

Ezer, T., and **L. P. Atkinson**, On the Predictability of High Water Level Along the U.S. East Coast: Can the Florida Current Measurement be an Indicator for Flooding Caused by Remote Forcing?, *Ocean Dynamics*, 67(6), 751-766, doi:10.1007/s10236-017-1057-0, 2017.

Kaufman, D.E., M.A.M. Friedrichs, W.O. Smith, Jr., **E.E. Hofmann, M.S. Dinniman**, J.C. Hemmings, Climate Change Impacts on Southern Ross Sea Phytoplankton Composition, Productivity, and Export, *Journal of Geophysical Research: Oceans*, 122.3: 2339-2359, 2017.

Lawson, G., M. Sosonkina, **T. Ezer** and Y. Shen, Empirical Mode Decomposition for Modeling of Parallel Applications on Intel Xeon Phi Processors, Proc., CCGrid '17 Proceedings of the 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, 1000-1008, doi:10.1109/CCGRID.2017.99, 2017.

Meyers, S.D., S.P. Geiger, M.E. Luther, D. Narváez, M.E. Frischer, and **E. Hofmann**, Predicting Larval Dispersal and Source/Sink Relationships of Eastern Oyster (*Crassostrea virginica*) Populations Using a Coupled Biophysical Model, *Journal of Shellfish Research*, 36, 101-118, 2017.

St-Laurent, P., P.L. Yager, R.M. Sherrell, S.E. Stammerjohn and **M.S. Dinniman**, Pathways and supply of dissolved iron in the Amundsen Sea (Antarctica), accepted for publication in *Journal of Geophysical Research: Oceans*, doi:10.1002/2017jc013162, 2017.

Presentations:

Dinniman, M., J. Klinck and L. Padman, "Transport Pathways and Consequences for Antarctic Ice Shelf Basal Meltwater," 2017 FRISP Workshop, Bergen, Norway, June 2017.

Hofmann, E.E., E.N. Powell, **J.M. Klinck**, D.M. Munroe, R. Mann, D.B. Haidvogel, D.A. Narváez, X. Zhang, K.M. Kuykendall, "Factors Affecting Distribution of the Atlantic Surfclam (*Spisula solidissima*), a Continental Shelf Biomass Dominant, During a Period of Climate Change," Oral Presentation, National Shellfisheries Association 109th Annual Meeting, Knoxville, TN, March 26-30, 2017.

Hofmann, E.E., "Modeling Marine Bivalve Populations: Approaches and Challenges," Invited Plenary Presentation, National Shellfisheries Association 109th Annual Meeting, Knoxville, TN, March 26-30 2017.

Hofmann, E.E., "Seasonal and Interannual Variability of Nitrogen Fluxes Along the Middle Atlantic Bight," Seminar Presentation, SEEDS Distinguished Speaker, RSMAS, University of Miami, Miami, FL, April 26, 2017.

Kaufman, D.E., M.A.M. Friedrichs, W.O. Smith Jr., **E.E. Hofmann**, **M.S. Dinniman**, and J.C.P. Hemmings, "Combining Bio-Optical Glider Observations and Biogeochemical Modeling to Examine Potential Ross Sea Phytoplankton Changes in the 21st Century," 2017 OCB Summer Science Workshop, Woods Hole, MA, June 2017.

Oliver, H., **P. St-Laurent**, R.M. Sherrell and P.L. Yager, "Physical and Biological Controls on Phytoplankton Blooms in the Amundsen Sea Polynya," 2017 International Goldschmidt Conference, Paris, France, August 13-18, 2017.

St-Laurent, P. and **M.S. Dinniman**, Ice Shelf Melt-Driven Circulation of the Deep Layers in the Amundsen Sea, Antarctica," 31st Forum for Research into Ice Shelf Processes (FRISP), Bergen, Norway, June 19-22, 2017.

Wiggert, J.D., C. Pan, **M. Dinniman**, Y. Lau, P. Fitzpatrick, S.J. O'Brien, T. Miles, M.K. Cambazoglu, S.L. Dykstra, B. Dzwonkowski, G. Jacobs, and **E. Hofmann**, "Impact of Circulation, Transport and Exchange Variability in the Northern Gulf of Mexico on Shelf Ecosystem Dynamics," 2017 OCB Summer Science Workshop, Woods Hole, MA, June 2017.

Willison, J.A., R. He, **M.S. Dinniman**, and X. Yuan, "Developing a Coupled Modeling Framework to Investigate Antarctic Bottom Water Formation in Prydz Bay," 21st Conference on Atmospheric and Oceanic Fluid Dynamics, Portland, OR, June 2017.

The Center for Coastal Physical Oceanography & The ODU Resilience Collaborative Fall 2017 Seminar Series

18 September

Mike Allen

**Political Science & Geography
Old Dominion University**

25 September

Se-Hyeon Cheon

**Center for Coastal Physical Oceanography
Old Dominion University**

2 October

Craig Landry

**Agricultural & Applied Economics
University of Georgia**

16 October

Jeremy Hoffman

Science Museum of Virginia

23 October

Margie Mulholland

**Ocean, Earth & Atmospheric Sciences
Old Dominion University**

30 October

Rebecca Asch

**Department of Biology
East Carolina University**

6 November

Michael Blum

**Ecology & Evolutionary Biology
University of Tennessee**

13 November

TBD

20 November

ODURC Seed Grant Presentations



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