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Center for Coastal Physical Oceanography, Old Dominion University

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OLD DOMINION UNIVERSITY
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IDEA FUSION

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I Have to Do What to the Model? How Did I Get Here, Part II

Mike Dinniman, CCPO Research Scientist

I hadn't been at CCPO very long when I was asked to create a regional circulation model for the Ross Sea section of the Antarctic coastal ocean as part of a project to make a coupled physical-biological model of the area in order to study the dynamics of the large, recurring phytoplankton bloom there. At the time, I knew pretty much nothing about high-latitude physical processes and most of what I knew about the difference in Northern and Southern Hemisphere fluid circulation came from an episode of "The Simpsons"(which, by the way, is wrong about the toilets: http://www.smartereveryday.com/toiletswirl). We eventually got a relatively high horizontal resolution for the time (5 km) model to work, which, thanks in large part to a great comment from one of the reviewers of the initial version of a manuscript, we were able to use to do some nice work on examining the importance of momentum advection of flow along the Ross Sea continental shelf break in allowing the exchange of a relatively warm ocean water mass (Circumpolar Deep Water) onto the cold continental shelf.

However, we never really got the lower trophic level ecosystem model working with that version of the circulation model. One of the reasons was that the model simulation over the southern part of the continental shelf wasn't very good. This was because the southern boundary of our initial model ended with a solid wall at what was once known as the Great Ice Barrier *(Figure 1)*. Around much of Antarctica, the Antarctic ice sheet flows off the land and begins to float, giving rise to large ice shelves that surround the continent. The largest ice shelf on the planet is the Ross Ice Shelf, which is thicker than 1000 feet in many places and covers an area larger than California. While the

"I find it really cool that all this started about 10 years ago with me rolling my eyes and groaning that I was going to have to double the size of my model domain..." - Mike Dinniman

edge of this ice shelf appeared to the first explorers of the area as an impenetrable barrier of ice rising 40 to 50 feet above the ocean (Sir James Clark Ross said, "Well, there's no more chance of sailing through that than through the cliffs of Dover."), it actually covers a 500,000 km^2 coastal ocean that

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Letter from the Director:

John Klinck
Professor & CCPO Director

CCPO started a while ago with a focus on the coastal ocean. At the time, most "real oceanographers" worked in areas off the shelf break where the water was kilometers deep, although there were clearly people working on the shelf and in estuaries. As time passed by, a number of us started working in the coastal areas around Antarctica. The result was a thriving group at CCPO creating and analyzing ocean models, as explained by Mike in the lead article. Many of us have had opportunities to visit stations around Antarctica and to be on cruises to the region as part of multi-institution projects. Clearly at CCPO, coastal oceanography does not mean the warm shallow waters off Virginia, although it would be interesting to study that area, too.

I would like to take special notice of the retirement of Chet Grosch, who has been on the ODU faculty for four decades and has been an active member of CCPO. I appreciate his contributions to CCPO and look forward to continuing interaction with him after he "retires" but continues to come to his office.

I Have to Do What to the Model? How Did I Get Here, Part II - cont'd.

interacts with the "open" (although seasonally covered by much thinner ice that forms from freezing sea water in front of the ice shelf) ocean outside the ice shelf where the phytoplankton blooms are observed.

We eventually realized that we needed to include this water cavity underneath the Ross Ice Shelf in order to have a good simulation of the open coastal ocean. Luckily, others had already implemented ice shelves in different ocean models, so we were able to add ice shelves without too much difficulty that interacted mechanically (pushing down the top of the ocean surface to thousands of feet below sea level) and thermodynamically (melting and freezing at the ice shelf base) with the water in our particular circulation model.

This did improve the simulation over the southern part of the open continental shelf. However, we also realized that we could now examine a whole host of scientific questions involving the interactions between the oceans and the floating extensions of the Antarctic Ice Sheet. Meltwater from the base of the ice shelves can influence the local Antarctic ocean circulation, the creation of Antarctic Bottom Water (thus having an impact on the global overturning circulation) and even ocean biology (as a source of micro-nutrients, see Pierre St-Laurent's article in the Spring 2016 *CCPO Circulation*). Perhaps more important to life here in Norfolk, the most rapid loss of ice from the Antarctic Ice Sheet is observed where ice streams flow into the ocean forming the ice shelves. Since the ice shelves themselves are floating, their thinning does not impact sea level. However, the ice shelves also buttress the ice streams draining the ice sheet and so ice shelf changes can significantly influence sea level by altering the discharge of ice from land into the ocean. The current generation of global climate models does not simulate ice shelf/ocean interaction, and many of the important physical processes take place on scales that are too small for these models to resolve, which is why regional scale models, as done here at CCPO, are quite useful for these problems.

This has led to fantastic opportunities for me and others here at CCPO to work on circulation models in different areas around the Antarctic, examining many aspects of the interaction between the ocean and the ice shelves.

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Along with colleagues from around the U.S. and the world, CCPO researchers have worked on studies ranging from determining how seasonally warm water discovered by a new temperature sensor managed to get to a single spot below 500 feet of ice in the Ross Sea (Stern et al., 2013), to using a model of the entire ocean around Antarctica to look at how different estimates of the wind affect the simulation of ice shelf melt (Dinniman et al., 2015).

I find it really cool that all this started about 10 years ago with me rolling my eyes and groaning that I was going to have to double the size of my model domain to include the cavity under the Ross Ice Shelf "just to get the stupid southern boundary right". I'm not quite sure that it's changed my mindset to view all code problems as "opportunities", but it does help…sometimes.

References:

Stern, A.A., **M.S. Dinniman**, V. Zagorodnov, S.W. Tyler and D.M. Holland, Intrusion of warm surface water beneath the McMurdo Ice Shelf, Antarctica. *Journal of Geophysical Research*, 118, 7036-7048, doi:10.1002/2013JC008842, 2013.

Dinniman, **M.S.**, **J.M. Klinck**, L-S Bai, D.H. Bromwich, K.M. Hines and D.M. Holland, The effect of atmospheric forcing resolution on delivery of ocean heat to the Antarctic floating ice shelves. *Journal of Climate*, 28, 6076-6085, doi:10.1175/JCLI-D-14-00374.1, 2015.

Fig. 1- Iceberg B15 which calved from the front of the Great Ice Barrier (Ross Ice Shelf) in March 2000. Photo courtesy of Walker Smith.

CCPO SPOTLIGHT:

Brett Goes on an Antarctic Cruise

Brett Buzzanga, CCPO Graduate Student

In January of 2016, I went on an Antarctic research cruise as part of a team of scientists investigating the biogeochemistry of continental shelf sediments. Overall, the goal of the cruise was (is) to add a missing benthic/sediment geochemistry component to the current body of knowledge involving nutrient fluxes and cycling in the Palmer Long-Term Ecological Research (PAL) study area. The principal investigators of the study are Dr. David Burdige from Old Dominion University, and Dr. John Christensen from Green Eyes LLC. I was David's TA during the semester before the cruise and needed ship time as part of my masters degree requirements. Despite having limited chemistry knowledge and field experience, a late cancellation afforded me the opportunity to join as a research assistant.

Several fortunate events later found me rubbing the toe of the Magellan statue in Punta Arenas - a ritual required of all those who do not desire bad luck on an upcoming voyage to the Antarctic. And bad luck we were mostly able to avoid; though there were some lingering instrumentation issues as we departed, preparations were finalized and everything - everything - was tied down as we moved through the Straits of Magellan and into the 25+ foot waves of the Drake Passage.

Southern Hemisphere Sunset
Photo courtesy of Brett Buzzanga.

Fortunately, the *RVIB N.B. Palmer* has a broad, flat bottom, and handled the swell relatively smoothly. After everyone got their sea legs, the transit was spent getting to know each other and figuring out our individual tasks and responsibilities. Surprisingly, our team of 8 was the only group of scientists on board a ship that holds 37. This made for a very relaxed environment in terms of lab space and living arrangements, and allowed easy adjustment of our sampling sites when environmental conditions were not agreeable: like our first, most southern station in Marguerite Bay where there was too much sea ice to even attempt to collect sediment cores.

It's funny thinking back on how excited we all were to finally get sediment cores and begin doing science. It was very novel, seeing a strange contraption disappear into the depths of the ocean, anxiously watching the computer screen count off meters of cable, and finally swarming around the Megacore, scared to touch the cores and ruin them. By the end of the cruise, it was more like "I'm going back to bed; wake me when it's on deck" and then two of us would unload the Megacore in minutes.

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Thick sea ice occasionally prevented coring.
Photo courtesy of Brett Buzzanga.

But once unloaded, we were all up, and there was plenty of work to be done. My primary domain was in the cold van, which is more or less a storage unit kept 1-3° C to mimic the ocean floor. Here, Chris and I sectioned cores in a glovebag (a large plastic bag with built-in gloves) under a constant flow of nitrogen, which prevented any iron from oxidizing and precipitating. Each section of mud was carefully labeled by depth from the surface, centrifuged, and the pore waters extracted.

Meanwhile, Jeremy, David's lab technician, was in a cold room one deck up fighting - but winning - against extremely sensitive microelectrodes used to measure dissolved oxygen and mineral profiles at nanomolar concentrations. Rich and Anna were sectioning cores at centimeter resolution, preparing samples for future measurements of radioactive species such as Uranium and Thorium (that is, when they weren't flinging mud at each other). Steve was directly measuring fluxes of solutes and Cedric was assisting in various ways while waiting for us to hand over the centrifuged samples. And David was calmly supervising, ensuring that everything was on task whilst poring over bathymetric charts with the crew, trying to determine the best spot to sample next.

Then was lunch or dinner (depending on when we successfully finished coring), and the food on the whole was above average. Each day had a main, familiar meal - taco Tuesdays, pizza Fridays... but Wednesdays were the best: shrimp, sole and conger (eel), locally caught and spicy hot. There was also a consistent buffet with salad stuffs, rice, beans, soup and more. This allowed for some rather interesting choices, like water on cereal, mashed salads, and unsafe amounts of ice cream bars.

The rest of the day was spent doing lab work on the pore waters: preparing standards, performing assays, and praying the spectrophotometer responded correctly... although, there was a healthy bit of puzzle solving happening simultaneously due to the ~15 sq. ft. NY Times crossword printed and posted each day. Oh, and Ping-Pong playing. Also, the sauna - which came complete with an expert Latvian instructor/marine tech named George.

But the best moments were those spent on the bridge, gazing through the glass or braving frost and wind to revel at the spectacular alien landscape. Seeing seals lounging on ice couches, and whales surfacing with a spout of water and flash of fin. Watching penguins transform from graceful torpedoes to waddling invalids. Tasting salt and sea as the sun finally set, leaving not darkness but the eerie glow of endless, frozen summer evening.

The sense of wonderment was far beyond anything I could have imagined, making it an experience that I certainly hope to have again. And I am very much in debt to everyone who made this possible: thank you all for such unforgettable moments and for the incredible amount I learned along the way.

JUST THE FACTS

Graduations:

Jabs, E., M.S., August 2016, Advisor: Larry Atkinson.

Mack, S., Ph.D.,"Influence of Tides & Mesoscale Eddies in the Ross Sea," August 2016, Advisor: J.M. Klinck.

Special Recognition & Other:

A paper on Gulf Stream's induced sea level rise by CCPO scientists **Ezer**, **Atkinson**, Corlett and Blanco (JGR, 2013), was recognized by Thomson-Reuters Web of Science as a "Highly Cited Paper" (number of citations per year is in the top 1% of all publications in the academic field of Geosciences).

Dr. Plag was invited as international reviewer for the space-geodetic program at the HartRAO, South Africa, June 20-24, 2016. A full report is available at http://www.mari-odu.org/HartRAO_Review.php.

Jim Haluska was awarded the Best Student Presentation Award in the Environmental Science Section of the Virginia Academy of Science Annual Meeting at the University of Mary Washington, May 2016.

Publications:

Cheng, Y. C., **B. D. Hamlington**, and **H.-P. Plag**, and Q. Xu, Influences of ENSO on Annual Sea Level Cycle Variations in South China Sea, *Ocean Engineering*, doi:10.1016/j.oceaneng.2016.09.019, In Press, 2016.

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Ezer, T., I. D. Haigh, and P. L. Woodworth, Nonlinear Sea-Level Trends and Long-Term Variability on Western European Coasts, *Journal of Coastal Research*, 32(4),744-755, doi:10.2112/JCOASTRES-D-15-00165.1 , 2016.

Ezer, T., Revisiting the Problem of the Gulf Stream Separation: on the Representation of Topography in Ocean Models with Different Types of Vertical Grids, *Ocean Modelling*, 104, 15-27. doi:10.1016/j.ocemod.2016.05.008, 2016.

Jules-Plag, S., **H.-P.**, **Plag**, Supporting the Implementation of SDGs. *Geospatial World*, http://www.geospatialworld.net/article/supporting-implementation-sdgs/, 2016.

Pearlman, J., S. J. Khalsa, F. Pearlman, **H.-P. Plag**, and S. Holt, GEO Blue Planet - A Contribution to Ocean Monitoring and Applications, *OES Beacon*, 5(2), 43-45, 2016.

Plag, H.-P. The laboratory for "Patient Earth., Column 13, *On The Edge ApoGeo*, 31(3), 8-10, 2016.

Scholtz, F., **H.-P. Plag**, and D. Clarke, Review of South African Space Geodesy Programme, Final Report, National Research Foundation, South Africa, 2016.

Xu, Q., G. Zhang, X. Li, and **C. Y. Cheng**, An Automatic Method for Tropical Cyclone Center Determination from SAR, in *Proceedings of the IEEE International Geoscience and Remote Sensing Symposium*, *IGARSS*, 2250-2252, 2016.

Xu, Q., J. Zheng, **Y. C. Cheng**, S. Zhang, M. Chen, and Q. Huang, Detection of Marine Oil spills from SAR Images Using Artificial Neural Networks, *The 26th International Ocean and Polar Engineering Conference*, ISOPE-I-16-624, 2016.

Xu, Q., H. Y. Zhang, **Y. C. Cheng**, S. S. Zhang and W. Zhao, Monitoring and tracking the green tide in the Yellow Sea with satellite imagery and numerical model, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 9(11), doi.10.1109/JSTARS.2016.2580000, 2016.

Xu, Q., S. S. Zhang, **Y. C. Cheng**, and J. C. Zuo, Interannual Feature of Summer Upwelling around the Zhoushan Islands in the East China Sea. *Journal of Coastal Research*, doi: 10.2112/JCOASTRES-D-15-00197.1, 2016.

Presentations:

Dinniman, **M.** and **J. Klinck**, "Antarctic polynyas: A Coupled Process Requiring High Model Resolution in the Ocean and Atmosphere," International Workshop on Coupled Modeling of Polar Environments, Columbus, OH, June 2016.

Dinniman, **M.**, **J. Klinck**, and L. Padman, "Transport Pathways and Consequences for Antarctic Ice-Shelf Basal Meltwater," International Symposium on Interactions of Ice Sheets and Glaciers with the Ocean, La Jolla, CA, July 2016.

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JUST THE FACTS

Presentations, Cont'd:

Ezer, **T.**, "From POM-1996 to IWMO-2016: An Overview of 20 Years of Ocean Modeling and Users Participation (in Honor of Prof. Emeritus G. Mellor, the Recipient of the 2016 Historical Oceanography Society Award)," 8th International Workshop on Modeling the Ocean (IWMO-2016), Bologna, Italy, June 9, 2016.

Ezer, **T.**, "Review of Sea Level Change in the Chesapeake Bay Area,"Workshop #1 of NCPC Climate Science Task Group, National Capital Planning Commission, Washington, DC, June 28, 2016.

Ezer, **T.**, "Revisiting the Problem of the Gulf Stream Separation in Ocean Models," 8th International Workshop on Modeling the Ocean (IWMO-2016), Bologna, Italy, June 8, 2016.

Ezer, **T.**, "The science of Sea Level Rise and the Role of the Gulf Stream," Flood Adaptation Forum, Hampton Roads Planning District, Hampton, VA, July 29, 2016.

Haluska, **J.**,"Shore and Location Changes to Wreck Island, Virginia Since 1999," Virginia Academy of Science Annual Meeting at the University of Mary Washington, Fredericksburg, VA, May 2016.

Plag, **H.-P.**, "Urban Coasts and Coastal Ecosystems in Times of Sea Level Rise," The Symposium on Remotely-Sensed Measurement for a Resilient and Sustainable Urban Future at the University of Pennsylvania, Philadelphia, PA, September 15, 2016.

Hofmann, **E.E.**, E.N. Powell, **J.M. Klinck**, and G. Bidegain, "Modeling Within-host Pathogen Interactions in Marine Bivalves," Plenary Presentation, 14th Annual Meeting, Ecology and Evolution of Infectious Disease, Cornell University, Ithaca, NY, June 3-5, 2016.

St-Laurent, **P.**, **M.S. Dinniman**, **E.E. Hofmann**, R.M. Sherrell, S.E. Stammerjohn, and P.L. Yager. "Simulating the upward transport of sediment-derived iron associated with the overturning circulation in ice-shelf cavities of the Amundsen Sea, Antarctica", 2016 IGS Symposium on Ice shelves-Ocean interactions, La Jolla, CA, July 10-15, 2016.

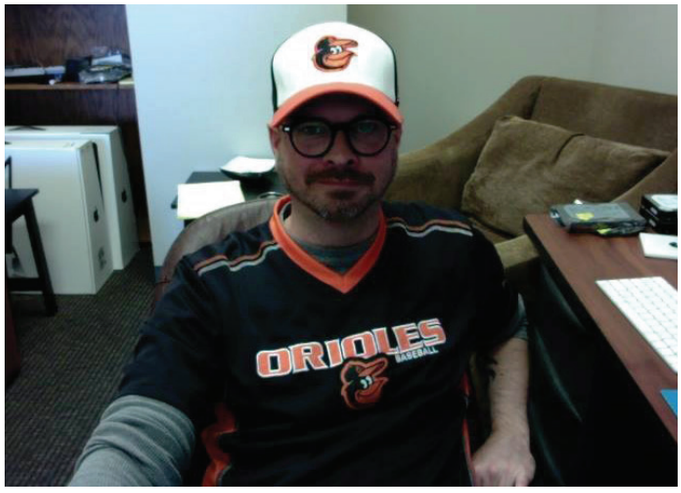
CCPO SPOTLIGHT:

Sean O'Brien
Systems Administrator

Hello! I'm Sean O'Brien, CCPO's new Systems Administrator. I joined the department in July. My background is in scientific computing, information security, and governmental/non-profit IT. Prior to my arrival, I worked at Johns Hopkins University Computer Science, the Enoch Pratt Free Library, the State of Hawaii Clean Air Branch, CSC & various NASA contracting firms.

I'm passionate about customer service and hope to provide CCPO's computer users with tools that will help them excel in their research. I have been an avid Linux user and administrator for many years, and have experience with most other major operating systems.

Currently, my major projects for CCPO are an extensive deployment of macOS machines for CCPO users and an upgrade and modernization of our data center. We will be significantly expanding our storage capabilities, as well as migrating to more contemporary infrastructure for ease of maintenance and more agile solution deployment.



It's a huge task, so Dr. Klinck and I are working closely in the planning phases in order to ensure things go smoothly over the coming year.

My door is always open, and I want to hear from you. Also, there's candy in my office. So stop by any time with questions or concerns.

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Join us on Mondays to hear expert speakers address topics focused on aspects of our changing climate.

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Reception begins @ 3 p.m. | Seminar @ 3:30 p.m.

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Seminar Series Schedule

SEPTEMBER 12	OCTOBER 3	NOVEMBER 7*
Navid Tahvildari Old Dominion University, Civil & Environmental Engineering	**Mark Luther** University of South Florida, College of Marine Sciences	**Rachel Davidson** University of Deleware, Civil & Environmental Engineering
SEPTEMBER 19	OCTOBER 24	NOVEMBER 14
Bob Tuleya Old Dominion University, CCPO	**Ingo Heidbrink** Old Dominion University, History Department	**Carlos Moffat** University of Delaware, School of Marine Science & Policy
SEPTEMBER 26*	OCTOBER 31	NOVEMBER 21*
Andy Keeler Old Dominion University, Coastal Studies Institute & Dept. of Economics	**Alon Stern** National Oceanic & Atmospheric Administration, Geophysical Fluid Dynamics Laboratory	**Colin Kelley** Columbia University International Research Institute for Climate & Society

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