



Polar Oceanography
OCP 5930
Fall 2007
W 15:00-17:45
OSB 327

CONTACT INFORMATION:

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COURSE MATERIALS:

Papers to read and reports to write will be assigned during the semester. These will cover physical oceanographic topics concerning polar regions.

General References:

- Study of Environmental Arctic Change: Plans for Implementation During the International Polar Year and Beyond. Report of the SEARCH Implementation Workshop, May 23 - 25, 2005. A PDF version is available at <http://www.arcus.org/search/resources/reportsandscienceplans.php>
- Rintoul, S. R., J. Church, E. Fahrbach, M Garcia, A. Gordon, B. King, R Morrow, A. Orsi, K. Speer (2001). Monitoring and Understanding Southern Ocean Variability and its impact on Climate: A Strategy for Sustained Observations. In: Observing the Ocean for Climate in the 21st Century , C. Koblinsky and N. Smith (Eds.), Bureau of Meteorology, Melbourne, Australia.
- V. V. Ivanov, G. I. Shapiro, J. M. Huthnance, D. L. Aleynik and P. N. Golovin, Cascades of dense water around the world ocean, Progress In Oceanography, Volume 60, Issue 1, January 2004, Pages 47-98.
- Online atlases: WOCE Southern Ocean Atlas (<http://woceatlas.tamu.edu/>) & <http://psc.apl.washington.edu/Climatology.html>

COURSE DESCRIPTION:

We will study the basic physical oceanography of the polar oceans, and work toward an understanding of the key climate components of the Southern Ocean and Antarctic continent and their feedbacks on the climate system. This course is expected to cover ice sheets and atmospheric issues as well as ocean components. A lab project may be carried out at the GFDI, involving the use of an experimental apparatus - rotating table - designed for circumpolar systems.

COURSE OBJECTIVES:

In this course, you will gain an appreciation for current research topics of the polar oceans.

GRADING/EVALUATION:

Grading will be based on:

1. Participation in presentations and discussions of papers (60%). Students will form small groups and focus on one or two papers to present, but should read over other papers too. Reading the papers is key to a productive class – pace yourself.

2. Written synopses of papers (20%).

2. Final project or report (20%). Examples of projects include: an experiment at GFDL on circular or annular flow or plumes, a numerical model (e.g. matlab) on plume-driven circulation (see reference list below) or barotropic gyres in polar geometry, or a box-model for paleo (long-term) evolution of sea-ice (<http://www.seas.harvard.edu/climate/eli/Level2/etc.html>), CO2 (<http://ocw.mit.edu/OcwWeb/Earth--Atmospheric--and-Planetary-Sciences/12-740Spring-2006/StudyMaterials/index.htm>) or tides (<http://www.esr.org/antarctic/barotropic.html>).

ASSIGNMENTS/RESPONSIBILITIES:

Reading assignments will be given 1 week in advance for each topic.

COURSE CONTENT AND OUTLINE:

Week 1 (08/29): Organizational meeting. General description of polar regions.

- Aagaard, K., and E. C. Carmack (1994) The Arctic Ocean and climate: a perspective. In: The Polar Oceans and their role in shaping the global environment. Geophys. Monograph 85, Amer. Geophys. Union.
- Jones, P. E., 2001: Circulation in the Arctic Ocean. *Polar Research*, 20, 139-146.

Week 2 (09/05) Arctic: hydrography

- McLaughlin, F.A., E. C. Carmack, R. W. Macdonald, H. Melling, J. H. Swift, P. A. Wheeler, B. F. Sherr and E. B. Sherr, The joint roles of Pacific and Atlantic-origin waters in the Canada Basin, 1997-1998, Deep Sea Research Part I: Oceanographic Research Papers, Volume 51, Issue 1, January 2004, Pages 107-128.
- Timmermans, M.-L., C. Garrett and Eddy Carmack. 2003. The thermohaline structure and evolution of the deep waters in the Canada Basin, Arctic Ocean. Deep Sea Research Part I: Oceanographic Research Papers. 50(10):1305-1321.
- Pickart, R.S., T.J. Weingartner, L.J. Pratt, S. Zimmerman, and D.J. Torres, Flow of winter-transformed Pacific water into the western Arctic, Deep Sea Res. (2005).

Week 3 (09/12) Arctic Dynamics

- Carmack, E.C. and D.C. Chapman, Wind—driven shelf/basin exchange on an Arctic shelf: The joint roles of ice cover extent and shelf—break bathymetry, Geophys. Res. Lett. 30, 2003GL017755 (2003).
- Karcher, M., F. Kauker, R. Gerdes, E. Hunke, and J. Zhang (2007), On the dynamics of Atlantic Water circulation in the Arctic Ocean, J. Geophys. Res., 112, C04S02, doi:10.1029/2006JC003630.
- Padman, L. and S. Erofeeva, 2004. A Barotropic Inverse Tidal Model for the Arctic Ocean, Geophys. Res. Lett., 31(2), L02303, doi:10.1029/2003GL019003.

Week 4 (09/19) Arctic: The Arctic Halocline.

- Rudels, B., L.G. Anderson and E.P. Jones, Formation and evolution of the subsurface mixed layer and the halocline of the Arctic Ocean, *J. Geophys. Res.* 101, 8807-21 (1996).
- Walsh, D., and E. Carmack (2003) The nested structure of Arctic thermohaline intrusions. *Ocean Modelling*, 5 (3), p.267-289, Jan 2003.
- Rudels, B., L.G. Anderson and E.P. Jones, Formation and evolution of the subsurface mixed layer and the halocline of the Arctic Ocean, *J. Geophys. Res.* 101, 8807-21 (1996).

Week 5 (09/26) No class. Work on project definition. Written synopsis of papers to date due. Read:

- Deep Circulation of the World Ocean, Bruce A. Warren, pp. 6-41.
(<http://ocw.mit.edu/ans7870/resources/Wunsch/wunschtext.htm>)

Week 6 (10/03) No class. Read Arctic Sea-Ice:

- Rothrock, D.A. and M. Wensnahan, The accuracy of sea-ice drafts measured from U. S. Navy submarines, *J. Atmos. Oceanic Technol.*, in press, 2007.
- Rothrock, D. A., Y. Yu and G.A. Maykut (1999) Thinning of the Arctic sea-ice cover, *Geophysical Research Letters*, **26**(23), pp. 3469-3472.
- Rothrock, D.A., and J. Zhang, Arctic Ocean sea ice volume: What explains its recent depletion?, *J. Geophys. Res.*, 110, C01002, doi:10.1029/2004JC002282, 2005.

Week 7 (10/10): Arctic Oscillation or Northern Annular Mode

- Thompson, D. W. J., and J. M. Wallace (1998), The Arctic Oscillation signature in the wintertime geopotential height and temperature fields, *Geophys. Res. Lett.*, 25(9), 1297–1300.
- Dickson et al (2000). R.R. Dickson, T.J. Osborn, J.W. Hurrell, J. Meincke, J. Blindheim, B. Adlandsvik, T. Vinje, G. Aleksev and W. Maslowski, The Arctic Ocean response to the North Atlantic Oscillation. *Journal of Climate* 13 (2000), pp. 2671–2696.
- Eisenman, I., N. Untersteiner, and J. S. Wettlaufer (2007), On the reliability of simulated Arctic sea ice in global climate models, *Geophys. Res. Lett.*, 34, L10501, doi:10.1029/2007GL029914.

Week 8 (10/17) Antarctic Oscillation or Southern Annular Mode

- Hall, A., and M. Visbeck (2002) Synchronous Variability in the Southern Hemisphere Atmosphere, Sea Ice, and Ocean Resulting from the Annular Mode. *J. Climate*, 15, 3043–3057.
- S. Aoki (2002) Coherent sea level response to the Antarctic Oscillation. *GRL*, 29, No. 20, 1950, doi:10.1029/2002GL015733.
- Sup W. and M. England (2005) Role of the Drake Passage in Controlling the Stability of the Ocean's Thermohaline Circulation. *J. Climate*, 18, 1957-1966.

Week 9 (10/24) Antarctic Bottom Water

- Jacobs, S. (2004) Bottom water production and its links with the thermohaline circulation. *Antarctic Science* 16 (4): 427–437, DOI:10.1017/S095410200400224X.
- Rintoul, S. R. (2007), Rapid freshening of Antarctic Bottom Water formed in the Indian and Pacific oceans, *Geophys. Res. Lett.*, 34, L06606, doi:10.1029/2006GL028550.
- Orsi, A. H., W. M. Smethie Jr. J. L. Bullister (2002) On the total input of Antarctic waters to the deep ocean: A preliminary estimate from chlorofluorocarbon measurements. *J. Geophys. Res.*, Vol. 107, No. C8, 3122, 10.1029/2001JC000976.

Week 10 (10/31) Antarctic Bottom Water in the Weddell Sea

- Foldvik, A., T. Gammelsrød, S. Østerhus, E. Fahrbach, G. Rohardt, M. Schröder, K. W. Nicholls, L. Padman, and R. A. Woodgate (2004), Ice shelf water overflow and bottom water formation in the southern Weddell Sea, *J. Geophys. Res.*, 109, C02015, doi:10.1029/2003JC002008.
- Klatt, O., E. Fahrbach, M. Hoppema and G. Rohardt (2005) The transport of the Weddell Gyre across the Prime Meridian, *Deep Sea Research Part II: Topical Studies in Oceanography*, Volume 52, Issues 3-4, Direct observations of oceanic flow: A tribute to Walter Zenk, February 2005, Pages 513-528.
- Pereira, A.F., A. Beckmann, and H.H. Hellmer, 2002: Tidal Mixing in the Southern Weddell Sea: Results from a Three-Dimensional Model. *J. Phys. Oceanogr.*, 32, 2151–2170.

Week 11 (11/07) Variability. Written synopsis of papers to date due.

- Jacobs, S.S., C. F. Giulivi, and P. A. Mele (2002) Freshening of the Ross Sea During the Late 20th Century. *Science* 297 (5580), 386. DOI: 10.1126/science.1069574.
- Assmann, K. M., and Ralph Timmermann (2005) Variability of dense water formation in the Ross Sea. *Ocean Dynamics* (2005) 55:68–87, DOI 10.1007/s10236-004-0106-7.
- Martinson, D. G., and R. A. Iannuzzi (2003) Spatial/temporal patterns in Weddell Gyre characteristics and their relationship to global climate. *J. Geophys. Res.*, VOL. 108, NO. C4, 8083, doi:10.1029/2000JC000538.

Week 12 (11/14)

- Stern, M. E., (1967). Lateral mixing of water masses. *Deep-Sea Research*, 14, 747--753.
- Joyce, T. M., (1977). A note on the lateral mixing of water masses. *Journal of Physical Oceanography*, 7, 626--629.
- Toole, J. M., (1981a). Intrusion characteristics in the Antarctic Polar Front. *Journal of Physical Oceanography*, 11, 780--793.
- Ruddick and Gargett review on Ocean Double Diffusion

Week 13 (11/21)

- Joyce, T. M., W. Zenk, and J. M. Toole, (1978). The anatomy of the Antarctic Polar Front in the Drake Passage. *Journal of Geophysical Research*, 83, 6093--6113.
- Read, J.F., R.T. Pollard, A.I. Morrison, and C. Symon, (1995), On the southerly extent of the Antarctic Circumpolar Current in the southeast Pacific, *Deep Sea Res. II* , **42** , 933-954.
- Y.-D. Lenn, Y.-D., T. K. Chereskin, J. Sprintall, and E. Firing (2007) Mean jets, mesoscale variability and eddy momentum fluxes in the surface layer of the Antarctic Circumpolar Current in Drake Passage. *Journal of Marine Research*, 65, 27–58, 2007
- Rintoul, S. R., and S. Sokolov (2001), Baroclinic transport variability of the Antarctic Circumpolar Current south of Australia (WOCE repeat section SR3), *J. Geophys. Res.*, 106(C2), 2795–2814.

Week 14 (11/28)

- Park, Y.H., and L. Gamberoni, (1997), Cross-frontal exchange of Antarctic Intermediate Water and Antarctic Bottom Water in the Crozet Basin, *Deep Sea Res. II* , **44** , 963-986.
- Sokolov, S. and Rintoul, S. R. (2007). Synoptic mapping of the Southern Ocean fronts and filaments using sea-surface height. *J. Phys. Oceanog.*, in press.
- Aoki, S., Bindoff, N., and Church, J. (2005). Interdecadal water mass changes in the Southern Ocean between 30E and 160E. *Geophys. Research Letters*, 32:L07607.

- Pollard, R.T., M.I. Lucas, and J.F. Read (2002) Physical controls on biogeochemical zonation in the Southern Ocean. DSR II.

Week 15 (12/05)

- Nicholls, K. W., S. Østerhus, K. Makinson, and M. R. Johnson (2001), Oceanographic conditions south of Berkner Island, beneath Filchner-Ronne Ice Shelf, Antarctica, *J. Geophys. Res.*, 106(C6), 11,481–11,492.
- Padman, L., S. Erofeeva, I. Joughin, 2003. Tides of the Ross Sea and Ross Ice Shelf Cavity, *Antarctic Science*, 15(01), 31-40.

Week 16 Finals Week. Projects and written synopsis of all papers due.

References for projects or reports:

Bush, J.W.M. and A.W. Woods, An investigation of the link between lead-induced thermohaline convection and arctic eddies, *Geophys. Res. Lett.* 27, 1179-82 (2000).

Carmack, E.C. 2000. The Arctic Ocean's freshwater budget: Sources, storage and export. pp. 91-126. In: E.L. Lewis et al. (eds.). *The Freshwater Budget of the Arctic Ocean*, Kluwer, The Netherlands.

Hallberg, R., and A. Gnanadesikan, 2006: The Role of Eddies in Determining the Structure and Response of the Wind-Driven Southern Hemisphere Overturning: Results from the Modeling Eddies in the Southern Ocean (MESO) Project. *J. Phys. Oceanogr.*, 36, 2232–2252.

Hughes, G.O., and R.W. Griffiths (2006) A simple convective model of the global overturning circulation, including effects of entrainment into sinking regions. *Ocean Modelling* 12 , 46–79.

Pickart, R.S., D. J. Torres, and R. A. Clarke (2002) Hydrography of the Labrador Sea during Active Convection. *Journal of Physical Oceanography* Volume 32, Issue 2, pp. 428–457.

Price, J.F. and M. O'Neil Baringer, Outflows and deep-water production by marginal seas, *Prog. Oceanog.* 33 161-200 (1994).

Russell, J. L., K. W. Dixon, A. Gnanadesikan, R. J. Stouffer, and J. R. Toggweiler, 2006: The Southern Hemisphere westerlies in a warming world: Propping open the door to the deep ocean. *Journal of Climate*, 19(24), 6382-6390.

Shimada, K., T. Kamoshida, M. Itoh, S. Nishino, E. Carmack, F. McLaughlin, S. Zimmermann and A. Proshutinsky. 2006. Pacific ocean inflow: influence on catastrophic reduction of sea ice cover in the Arctic Ocean. *Geophysical Research Letters*. 33(L08605). doi: 10.1029/2005GL025624.

Smith, D.C., J.W. Lavelle and H.J.S. Fernando, Arctic Ocean mixed-layer eddy generation under leads in sea ice, *J. Geophys. Res.* 107, 2001JC000822 (2002).

ACADEMIC HONOR CODE:

Students are expected to uphold the Academic Honor Code published in The Florida State University Bulletin and the Student Handbook. The Academic Honor System of The Florida State University is based on the premise that each student has the responsibility (1) to uphold the highest standards of academic integrity in the student's own work, (2) to refuse to tolerate violations of academic integrity in the university community, and (3) to foster a high sense of integrity and social responsibility on the part of the university community.

Please see the following web site for a complete explanation of the Academic Honor Code.
<http://www.fsu.edu/Books/Student-Handbook/codes/honor.html>

AMERICANS WITH DISABILITIES ACT:

Students with disabilities needing academic accommodation should: (1) register with and provide documentation to the Student Disability Resource Center; (2) bring a letter to the instructor indicating the need for accommodation and what type. This should be done during the first week of class.

For more information about services available to FSU students with disabilities, contact the Student Disability Resource Center

Dean of Students Department
08 Kellum Hall
Florida State University
Tallahassee, FL 32306-4400
(850) 644-9566 (voice)
(850) 644-8504 (TDD)
SDRC@admin.fsu.edu
<http://www.fsu.edu/~staffair/dean/StudentDisability>

SYLLABUS CHANGE POLICY:

This syllabus is a guide for the course and is subject to change with advanced notice.
