AOS215 Class Notes:

Oceanic Circulation

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Fall 2006

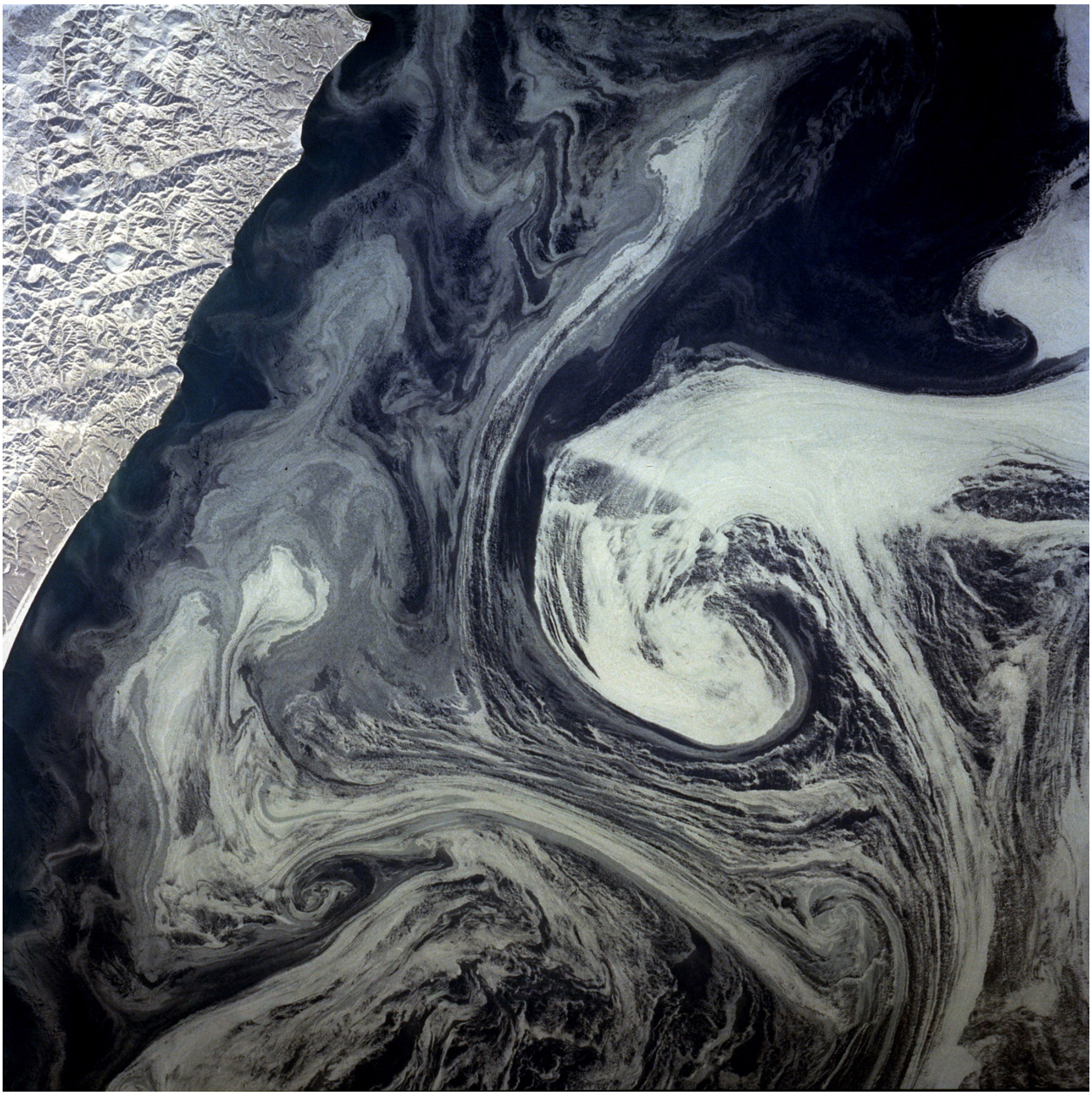

Figure 1: Mesoscale and submesoscale eddy patterns seen in fragmentary sea ice just off the coast of the eastern Kamchatka Peninsula in the Bering Sea.

Preface

Course Description: We examine the phenomena, theory, and modeling of oceanic circulation and material property distributions. The scope ranges from global to regional. Circulation types include thermohaline, wind- and wave-driven currents, mesoscale eddies, and coastal and equatorial regimes. We also examine relationships between oceanic circulation and both atmospheric climate and biogeochemical distributions.

Prerequisites: Knowledge of geophysical fluid dynamics and climate, in particular through AOS 201A. Students are strongly encouraged to consider also taking AOS 235, Ocean Biogeochemical Dynamics and Climate.

Format: Lectures will be given Tuesday and Thursday from 2-3:30 in MS7121, with rescheduling as necessary. The first class meeting is September 28. The course requirements are reading, class attendance and discussion, plus a term paper and an associated class presentation. Students should enroll on a S/U basis unless otherwise arranged with the instructor. Class notes are accessible at

`http://www.atmos.ucla.edu/web/grads/fall2006/215.html`.

Lectures will be on selected topics from these notes, and further reading — for preview, review, and broader perspective — is expected. Office hours are by appointment.

Literature: There is no singularly satisfactory book on the subject, although there is an enormous literature on many aspects of oceanic circulation. A bibliography of papers referenced in the lectures is provided in the class notes. Among the primary reference books on oceanic circulation are the following (on reserve in the Science and Engineering Library):

- Csanady (1982): *Circulation in the Coastal Ocean*.
- Haidvogel and Beckman (1999): *Numerical Ocean Circulation Models*.
- Mellor (1996): *An Introduction to Physical Oceanography*.
- Pedlosky (1996): *Ocean Circulation Theory*.
- Robinson (1963): *Wind-driven Ocean Circulation: A Collection of Theoretical Studies*.
- Stern (1975): *Ocean Circulation Physics*.
- Sverdrup et al. (1942): *The Oceans: Their Physics, Chemistry, and General Biology*.

- Tomczak and Godfrey (2003): *Regional Oceanography: An Introduction*.

There are many more good oceanographic review papers than books. In a previous year I taught this course from the following collection of such papers (chosen with more attention to historical context than latest perspective):

- Beardsley and Boicourt (1981): On estuarine and continental-shelf circulation in the Middle Atlantic bight.
- Fischer (1975): Numerical models of estuarine circulation and mixing.
- Gill (1975): Models of equatorial currents.
- Gordon (1975): General ocean circulation.
- Hickey (1979): The California current system—hypotheses and facts.
- Kamenkovich (1975): Basic concepts in modeling the ocean circulation.
- Leetma et al. (1981): Equatorial currents: observations and theory.
- Marshall (1986): Wind driven ocean circulation theory— steady free flow.
- McWilliams (1996): Modeling the oceanic general circulation; and McWilliams (1998): Oceanic general circulation models.
- Niiler (1992): The ocean circulation.
- O'Brien (1975): Models of coastal upwelling.
- Pedlosky (1987): Thermocline theories.
- Rhines (1986): Lectures on ocean circulation dynamics.
- Veronis (1981): Dynamics of the large-scale ocean circulation.
- Welander (1986): Thermohaline effects in the ocean circulation and related simple models.
- Young (1987): Baroclinic theories of the wind-driven circulation.

Although one can learn a great deal from examining these books and review papers, I believe a better course can be presented from the lectures I shall present here, in part because so much of the oceanographic literature resides in journal articles that have not yet been well synthesized in reviews or books.

Contents of Class Notes (PDF files):

References

Beardsley, R. and W. Boicourt, 1981: On estuarine and continental-shelf circulation in the middle atlantic bight. *Evolution of Physical Oceanography*, B. Warren and C. Wunsch, eds., MIT Press, 198–233.

Csanady, G., 1982: *Circulation in the Coastal Ocean*. Reidel, 279 pp.

Fischer, H., 1975: Numerical models of estuarine circulation and mixing. *Numerical Models of Ocean Circulation*, R. Reid, ed., Nat. Acad. Sci. Press, 10–20.

Gill, A., 1975: Models of equatorial currents. *Numerical Models of Ocean Circulation*, R. Reid, ed., Nat. Acad. Sci. Press, 181–203.

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Haidvogel, D. and A. Beckman, 1999: *Numerical Ocean Circulation Modeling*. Imperial College Press, 318 pp.

Hickey, B., 1979: The california current system. *Prog. Oceanog.*, **8**, 191–279.

Kamenkovich, V., 1975: Basic concepts in modeling the ocean circulation. *Numerical Models of Ocean Circulation*, R. Reid, ed., Nat. Acad. Sci. Press, 21–25.

Leetma, A., J. McCreary, and D. Moore, 1981: Equatorial currents: Observations and theory. *Evolution of Physical Oceanography*, B. Warren and C. Wunsch, eds., MIT Press, 184–196.

Marshall, J., 1986: Wind driven ocean circulation theory — steady free flow. *Large-Scale Transport Processes in Oceans and Atmosphere*, J. Willebrand and D. Anderson, eds., Reidel Press, 225–246.

McWilliams, J., 1996: Modeling the oceanic general circulation. *Tellus*, **48A**, 179–192.

— 1998: Oceanic general circulation models. *Ocean Modeling and Parameterization*, E. C. . J. Verron, ed., Kluwer, 1–44.

Mellor, G., 1996: *An Introduction to Physical Oceanography*. Springer-Verlag, 260 pp.

Niiler, P., 1992: The ocean circulation. *Climate System Modeling*, K. Trenberth, ed., Cambridge University Press, 117–148.

O'Brien, J., 1975: Models of coastal upwelling. *Numerical Models of Ocean Circulation*, R. Reid, ed., Nat. Acad. Sci. Press, 204–215.

Pedlosky, J., 1987: Thermocline theories. *General Circulation of the Ocean*, H. Abarbanel and W. Young, eds., Springer-Verlag, 55–101.

— 1996: *Ocean Circulation Theory*. Springer-Verlag, 453 pp.

Rhines, P., 1986: Lectures on ocean circulation dynamics. *Large-Scale Transport Processes*, J. Willebrand and D. Anderson, eds., Reidel Press, 105–162.

Robinson, A., 1963: *Wind-driven Ocean Circulation: A Collection of Theoretical Studies*. Blaisdel, 161 pp.

Stern, M., 1975: *Ocean Circulation Physics*. Academic Press, 246 pp.

Sverdrup, H., M. Johnson, and R. Fleming, 1942: *The Oceans: Their Physics, Chemistry, and General Biology*. Prentice-Hall, 1087 pp.

Tomczak, M. and J. Godfrey, 2003: *Regional Oceanography: An Introduction*. Pergamon Press, 390 pp.

Veronis, G., 1981: Dynamics of the large-scale ocean circulation. *Evolution of Physical Oceanography*, B. Warren, ed., MIT Press, 140–183.

Welander, P., 1986: Thermohaline effects in the ocean circulation and related simple models. *Large-Scale Transport Processes*, J. Willebrand and D. Anderson, eds., Reidel Press, 163–200.

Young, W., 1987: Baroclinic theories of the wind-driven circulation. *General Circulation of the Ocean*, H. Abarbanel and W. Young, eds., Springer-Verlag, 134–201.