GEOS 615, Sea Ice (3 CR), Fall 2012

Time & place: Mondays 4.30-6.00pm REIC 204, Thursdays 9.45-11.15am, REIC 207

Instructors & contact information:

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Class outline:
Sea ice plays a major role in the climate system, is an important habitat for a wide range of biota, controls the exchange of heat, matter and momentum between ocean and atmosphere in the polar seas and is of great significance to Arctic indigenous communities as well as in a broader socio-economic and geopolitical context. This course provides an overview of the geophysics of sea ice as pertaining to growth and decay of an ice cover, its properties and the different functions it serves in the environment.
In recent years, Arctic sea-ice change has figured prominently in the public's imagination and has led to a surge of interest in sea ice as a material, as the tangible product of key energy exchange processes and as a provider of important services to people and ecosystems. In the class we will examine these issues in more depth.
These concepts will be applied in a class project, centered around questions concerning sea-ice conditions and sea-ice use in the Chukchi and Beaufort Sea regions.
The course is primarily addressing graduate students in the fields of geophysics & geology, marine & atmospheric sciences, cold regions engineering and related disciplines. However, students with a different disciplinary background or advanced undergraduate students are also encouraged to enroll (please check back with the instructor prior).
A course schedule can be found here.

Expected outcomes:
• Students will gain an understanding of the fundamental sea-ice properties and processes in the polar and sub-polar regions and learn to apply them to evaluate overarching problems in the context of climate and ecosystem change
• Students will be familiarized with key concepts and techniques employed in the study of sea ice, including analytical and numerical models of ice growth and decay, models of key ice properties derived from sea-ice phase relations, strengths and drawbacks of remote sensing techniques and other relevant methodological approaches
• Students will synthesize their knowledge about sea-ice properties and processes in the context of services delivered by the sea-ice system
• Building on the case study of sea ice, students will gain deeper insight into one key aspect of present-day climate change and the challenges inherent in analyzing and forecasting such change and its impacts
• Students will develop a grasp of key issues underlying information transfer and application of sea-ice geophysics concepts to applied problems such as shipping in the Arctic or related issues
• Students will develop their ability to communicate effectively in oral and written form by

presenting results of their class project amongst their peers and generating a product in the form of, e.g., a report, manual or web page

Grading policy: Grades will be based on the mid-term (20%) and final exam (20 %), as well as a class project (50%, includes two presentations and a report), and class participation (10%), which is based on attendance and contribution to discussion in class.
The following letter grade system will be used: A+ for better than 95% performance (number of total possible points) summed over all categories, A >90 to 95%, A- >85 to 90%, B+ >80 to 85%, B >75 to 80%, B- >70 to 75%, C+ >67 to 70%, C >63 to 67%, C- >60 to 63%, D 50 to 60%, F <50%.

Required reading: Reading assignments for each lecture will be listed in the course schedule and include textbook chapters and scientific papers. Note that the course does not require purchase of a textbook; however, the textbook by Thomas and Dieckmann (2010, details below) is recommended and students are encouraged to consult references listed below.

Note that all these texts below will be placed on reserve for the duration of the semester at the Keith Mather Library-GI/IARC.

- Carsey, F. D., ed. (1992) *Microwave remote sensing of sea ice,* Geophysical Monograph 68, American Geophysical Union, Washington - still a prime reference for microwave remote sensing and the physical basis of microwave data over sea ice
- Doronin Yu. P., and D. E. Kheisin (1977) *Sea ice,* Amerind Publ. Co., New Delhi - a comprehensive work, offering something of a Russian perspective
- Eicken, H., R. Gradinger, M. Salganek, K. Shirasawa, D. K. Perovich, M. Leppäranta (eds., 2009) *Field techniques for sea ice research*. University of Alaska Press, Fairbanks - Introduction to field research methods with background on different sea ice themes; comes with a multimedia DVD with videos documenting sea ice, sea ice research and additional resources
- Hobbs, P., (1974 or 2010) *Ice Physics*, Oxford University Press, USA.
- Krupnik, I. et al. (2010) SIKU: Knowing our ice - Documenting Inuit sea ice knowledge and use. Springer-Verlag, New York
- Leppaeranta, M., ed. (1998) *Physics of ice-covered seas*, 2 vols. Helsinki University Press, Helsinki.
- Leppaeranta, M. (2011) *The drift of sea ice, 2nd edition*. Springer, Berlin. [Available as online electronic resource through Rasmuson Library]
- Lubin, D. & R. Massom (2006) *Polar remote sensing, vol. 1, atmosphere and oceans*. Springer, Berlin.

- Petrenko, V. F. and R. W. Whitworth (1999) *Physics of ice*. Oxford University Press, Oxford.

- Thomas, D. & G. S. Dieckmann, eds. (2010) *Sea ice*. London: Wiley-Blackwell - very good overview and introductory text - recommended text; [Available as online electronic resource through Rasmuson Library]
- Wadhams, P. (2000) *Ice in the ocean*, Gordon & Breach, London.

- Weeks (2010) *On sea ice*. University of Alaska Press, Fairbanks - Very insightful and personal perspective based on five decades of sea ice research [Available as online electronic resource through Rasmuson Library]
- Zubov N. N. (1945) *Arctic ice,* Izd. Glavsevmorputi, Moscow (translated by U.S. Navy Oceanogr. Office Springfield, 1963) - an almost timeless classic

Special needs. Students with learning or other disabilities who may need classroom accommodations are encouraged to visit the Disabilities website and make an appointment with the Office of Disability Services (474-5655). Please meet with the instructor so that the appropriate accommodations and supports to assist in meeting the goals of the course can be made in collaboration with the Office of Disability Services.

Academic integrity. Those enrolled in this class are subject to the Student Code of Conduct as outlined in University Regents' Policy on Student Rights and Responsibilities.

GEOS 615, Sea-Ice Geophysics: Schedule of lectures, project work etc.

Aug 30: Overview and introductory lecture "Sea ice in the earth system"
Reading: Overview article "Sea ice in the climate system" and presentation, Chapter 2 - The sea ice system services framework: Development and application, in Eicken et al. (2009), Field techniques for sea ice research, pp. 9-24.

Sept 4 : Sea-ice microphysics: Ice crystallography, nucleation, crystal growth
Resources: presentation
Reading: Chapter 2.2 in Thomas & Dieckmann, 2nd ed., pp. 26-35; sea-ice microstructure summary article (not required, only for those with interest in microstructure)
(also relevant but not required: Chapter 5 in Weeks (2010))

Sept 6 : Sea-ice phase diagram, equations of state and solute segregation
Resources: presentation
Reading: Chapter 2.3 in Thomas & Dieckmann, 2nd ed., pp. 35-47
(also relevant but not required: Chapter 6 in Weeks (2010))

Sept 10 : Sea-ice phase diagram
Resources: Spreadsheet (T, S, Vb, density); FREZCHEM model website

Sept 13: Microphysics and microstructural evolution: Sea-ice salinity profiles in relation to macroscopic ice properties
Resources: presentation
Reading: Chapter 2.3 in Thomas & Dieckmann, 2nd ed., pp. 36-45

Sept 17: No class during regular class hours; class projects introduction, time t.b.d.

Sept 20: Sea ice optical and electromagnetic properties
Reading: Chapter 2.4 in Thomas & Dieckmann, 2nd ed., pp. 52-59

Sept 21 (IARC/Akasofu 417); 1.30-3.00pm: Updates on class projects & sea ice phase diagram calculations

Sept 24 : Sea-ice optical and electromagnetic properties
Resources: Presentation
Reading: Chapter 2.4 in Thomas & Dieckmann, 2nd ed., pp. 52-59

Sept 27: Sea-ice thermal properties
Resources: Presentation
Reading: Chapter 2.4 in Thomas & Dieckmann, 2nd ed., pp. 47-52

Oct 1: Sea-ice thermal properties

Oct 4: No class during regular class hours

Oct 8: The surface energy balance of an ice-covered ocean
Reading: Chapter 2.5 in Thomas & Dieckmann, 2nd ed., pp. 63-69.

Oct 11: Guest lecture - Dr. Carleton Ray, University of Virginia - Sea ice as a habitat for marine mammals

Oct 15: Mid-term exam

Oct 18: The surface energy balance of an ice-covered ocean; Sea ice in the climate system

Oct 22: Sea ice in the climate system

Oct 25: Sea ice strength: Background and engineering information needs
Reading: Chapter 3.5 - Ice strength: In situ measurement, in Eicken et al. (2009), Field techniques for sea ice research, pp. 181-213

Oct 29: The sea-ice force/momentum balance & ice dynamics

Nov 1: Guest lecture - Dr. Christian Haas, York University, Canada - Ice thickness distribution - Advances in theory and measurement

Nov 5: The sea-ice force/momentum balance & ice dynamics

Nov 8: Ice dynamics and the ice-thickness distribution function
Reading: Chapter 4 by Haas in Thomas & Dieckmann, 2nd ed.

Nov 12: Sea-ice thickness distribution
Resources: Chapter 4 (Haas) in Thomas & Dieckmann, 2nd ed.

Nov 15: Thermodynamic sea-ice models
Resources: Chapter 2.5 in Thomas & Dieckmann, 2nd ed.

Nov 19: Sea Ice Knowledge & Use
Resources: Reading: Chapter in SIKU book on indigenous & geophysical sea-ice knowledge; Book chapters 1, 2, and 3 by Dr. Krupnik

Nov 22: Thanksgiving Holidays

Nov 26: Sea-ice remote sensing: Methods & techniques
Resources: Chapter 6 (Comiso) in Thomas & Dieckmann, 2nd ed.

Nov 29: Sea-ice remote sensing: Applications
Resources: Chapter 6 (Comiso) in Thomas & Dieckmann, 2nd ed.

Dec 3, 6: AGU Fall meeting, class t.b.d.

Dec 10: Class project workshop and presentations

December 12-15: Final exam week