Arctic System Science (ARCSS) Program Synthesis Retreat Annotated Bibliography of Background Readings

Alley, R.B., J. Marotzke, W.D. Nordhaus, J.T. Overpeck, D.M. Peteet, R.A. Pielke, Jr., R.T. Pierrehumbert, P.B. Rhines, T.F. Stocker, L.D. Talley, and J.M. Wallace. 2003. Abrupt climate change. ***Science*** **299: 2005–2010.**

This paper represents the short version of a 2002 NAS report on Abrupt Climate Change, and makes the case that abrupt change poses the largest potential threat to society in the future, partly because of our current inability to anticipate abrupt climate change with enough detail to be of sufficient use to decision-makers, and also because global climate change may increase the probability of crossing abrupt change thresholds. Greenland Ice Sheet melting and weakened thermohaline circulation change could both occur more rapidly than generally anticipated.

Ambaum, Maarten H. P. and Brian J. Hoskins. 2002. The NAO troposphere-stratosphere connection. ***Journal of Climate*** **15(14): 1969–1978.**

Ambaum and Hoskins lay out a physical mechanism for the operation of a dominant Arctic mode of variability, in which a strong polar stratospheric jet elevates the polar tropopause, which spins up the tropospheric column and lowers the surface pressure over the central Arctic. This has been the first really convincing mechanism proposed for this mode, and as such holds real promise for further understanding of the Arctic atmospheric circulation. Nice little cartoon of the mechanism included!

Briffa, K.R., F.H. Schweingruber, P.D. Jones, T.J. Osborn, S.G. Shiyatov, and E.A. Vaganov. 1998. Reduced sensitivity of recent tree-growth to temperature at high northern latitudes. ***Nature*** **391: 678–682.**

This piece demonstrates recent changes in tree response to temperature at the arctic fringes. At first glance we might anticipate trees would grow better with warming - but this study (and work in Alaska by Jacobi et al and later work) suggests that this is not the case. It is possible these populations are now becoming moisture stressed. Not only does this paper address unanticipated ecosystem responses - but also highlights how some of our methods might be compromised.

Cuffey, K.M. and S.J. Marshall. 2000. Substantial contribution to sea-level rise during the last interglacial from the Greenland ice sheet. ***Nature*** **404: 591–594.**

This paper provides a realistic view of a much reduced Greenland Ice Sheet (GIS) during the last interglacial period – the last time the Arctic was warmer than present. The question is how much warming is needed to melt the ice sheet, and how fast could the ice sheet melt. Unpublished ARCSS PARCS and IGBP PAGES CAPE research indicates that the earth will be sufficiently warm to melt the GIS be the early part of the next century, and that the rate of warming could be an order of magnitude faster than estimated by the IPCC Third Assessment.

Edwards, M.E., C.J. Mock, B.P. Finney, V.A. Barber, P.J. Bartlein. 2001. Potential analogues for paleoclimatic variations in eastern interior Alaska during the past 14,000 yr: Atmospheric controls of regional temperature and moisture responses. ***Quaternary Science Reviews*** **20: 189–202.**

This paper provides insights into the range of environmental change experienced in Alaska and adjacent Russia over the past 14,000 years through a comparison of modern conditions to possible past analogues from the fossil pollen record. It attempts to use analogy to infer past atmospheric circulation patterns. It is a nice attempt to link changes in synoptic climatology to changes in past vegetation.

Eugster, W., W.R. Rouse, R.A. Pielke, Sr., J.P. McFadden, D.D. Baldocchi, T.G.F. Kittel, F.S. Chapin III, G.E. Liston, P.L. Vidale, E. Vaganov, and S. Chambers. 2000. Land-atmosphere energy exchange in Arctic tundra and boreal forest: available data and feedbacks to climate. ***Global Change Biology*** **6(S1): 84–115.**

This paper summarizes an extraordinary amount of data and is a good starting point for discussing what we know about land-atmosphere exchange in the arctic.

Fyfe, J.C. 2003. Separating extratropical zonal wind variability and mean change. ***Journal of Climate*** **16(5): 863–874.**

Fyfe performs a very careful analysis of high latitude variability (more rigorous than earlier EOF analyses) and suggests separate stratospheric and tropospheric origins for the AO. He also does a trend analysis of the 20th century changes in the strengths of these modes of variability.

Hamilton, L.C., B.C. Brown, and R.O. Rasmussen. 2003. West Greenland's cod to shrimp transition: Local dimensions of climatic change. ***Arctic*** **56(3): 271–282.**

West Greenland's transition from a cod-fishing to a shrimp-fishing economy, ca. 1960–1990, provides a case study in the human dimensions of climatic change. Physical, biological and social systems interacted in complex ways to affect coastal communities. This integrated case study examines linkages between atmospheric conditions (including the North Atlantic Oscillation), ocean circulation, ecosystem conditions, fisheries activities, and the livelihoods and population changes of two West Greenland towns: Sisimiut, south of Disko Bay; and Paamiut, on the southwest coast. Social networks and cohesion (social capital), in addition to skills (human capital), investments (physical capital) and alternative resources (natural capital) all shape how the benefits and costs are distributed.

Hollingsworth, R. and E.J. Hollingsworth. 2000. Major discoveries and biomedical research organizations: Perspectives on interdisciplinarity, nurturing leadership, and integrated structure and cultures. In ***Practising Interdisciplinarity*****, P. Weingart and N. Stehr, eds., 215–244. University of Toronto Press: Toronto.**

Although there is a lot of rhetoric about the benefits of 'interdisciplinarity', there are relatively few papers that talk about the actual practice of interdisciplinary synthesis and what makes it successful. This chapter is a very insightful study of the sociological 'process' factors that seem to be prerequisites for major biomedical discoveries. It reviews two highly productive interdisciplinary organizations (CalTech and the Rockefeller Institute) and highlights the importance of frequent and intense interaction among scientists from diverse disciplines and the need for a distinctive style of leadership. For a quicker read, you could focus on the two case studies (p221-239) and the conclusions (p242-244). See also the 1 page editorial from Nature.

Hurrell, J.W., Y. Kushnir, G. Ottersen, and M. Visbeck. 2003. An overview of the North Atlantic Oscillation. In ***The North Atlantic oscillation: Climate significance and environmental impact*****, 1–35. Geophysical Monograph 134, American Geophysical Union.**

This is the introductory chapter of an AGU monograph. It gives an excellent overview of the nature and environmental impacts of the North Atlantic Oscillation (NAO) and the basis of the NAO vs. Arctic Oscillation (AO) controversy. It also addressed the issue of trends and their causes. It is written in a very accessible style.

Lachenbruch, A. H. and B. Vaugh Marshall. 1986. Changing climate: geothermal evidence from permafrost in the Alaskan Arctic (with updated data to 2002 from Gary Clow). ***Science*** **234: 689–696.**

This is some of the best evidence for warming in arctic Alaska (2 to 4°C) and when Gary Clow's update (1987-2002) is added, indicates there are places where as much as 6°C warming has occurred since 1949! The paper also introduces the idea of permafrost and how it carries past thermal history. On land permafrost may be one of the most crucial parts of the Arctic System.

MacDonald, G.M. and 13 others. 2000. Holocene treeline history and climate change acrosss northern Eurasia. ***Quaternary Research*** **53: 302–311.**

This paper uses macrofossil wood evidence to show how far the continental arctic system in Eurasia was pushed by maximum warming in the Holocene. It allows us to conclude that anticipated changes may be beyond those of the past 10,000 years. It also examines the link between the Northern Atlantic system and those in the interior of the Arctic.

McGuire, A.D. and 22 others. 2002. Environmental variation, vegetation distribution, carbon dynamics and water/energy exchange at high latitudes. ***Journal of Vegetation Science*** **13(3): 301–314.**

This paper takes the scale of Eugster et al. (2000) to the next (pan-Arctic) level and will help us think about ecosystem response, carbon and scaling issues.

Nakamura, N. and A.H. Oort. 1988. Atmospheric heat budgets of the polar regions. ***Journal of Geophysical Research*** **98(D8): 9510–9524.**

While the Arctic is a complex system, a useful starting point towards understanding it is to consider the basic heat budget of the Arctic atmosphere. The rate of change of heat storage in the Arctic atmosphere can be described in terms of interactions between the net flux of energy coming on from the sides (the horizontal atmospheric transports), the net radiation budget at the top of the atmosphere and the net surface heat flux. The net surface heat flux is shown to be very important in the Arctic, the major terms being sea ice growth/melt and changes in sensible heat stored in the ocean.

Nature Editorial. 2003. Who'd want to work in a team? ***Nature*** **424:1.**

The kind of interdisciplinary synthesis that characterizes the ARCSS program cannot be done without scientific teamwork. This one-page editorial refers to some of the important intangibles of good teamwork (communication, personality issues, leadership and administration) and the challenges of joint publication and how to give due credit and recognition to team scientists.

Overpeck, J.T. and 17 others. 1997. Arctic environmental change of the last four centuries. ***Science*** **278: 1251–1256.**

The first iteration of ARCSS paleoclimate synthesis reveals that the Arctic is now warmer than at any time in the last four centuries, and that other aspects of the Arctic system are undergoing change unprecedented in millennia. More recent work, both published and unpublished, confirm these results, indicating that the Arctic is undergoing climate change not seen since the last interglacial.

Peterson, B.J., R.M. Holmes, J.W. McClelland, C.J. Vörösmarty, R.B. Lammers, A.I. Shiklomanov, I.A. Shiklomanov, and S. Rahmstorf. 2002. Increasing arctic river discharge: Responses and feedbacks to global climate change. ***Science*** **298: 2171–2173.**

This paper documents a long-term rise in the discharge from six large Eurasian rivers which empty into the Arctic Ocean. In addition to establishing the existence and magnitude of such change, this paper also makes linkages to the question of thermohaline circulation (THC). These documented changes are of sufficient magnitude to potentially affect THC on the century time scale.

Rühland, Kathleen, Alisha Priesnitz, and John P. Smol. 2003. Paleoliminological evidence from diatoms for recent environmental changes in 50 lakes across Canadian Arctic treeline. ***Arctic, Antarctic, and Alpine Research*** **35(1): 110–123.**

This paper gets at similar recent changes in the arctic system, but using lake sediments. It demonstrates that the recent past (50-100 years perhaps) lake ecosystems located in the sub-arctic-arctic transition have been experiencing pervasive shifts. This builds on similar diatom based work from the high Arctic that shows the late 20th century is witnessing something very unusual.

Serreze, M. C., J. E. Walsh, F. S. Chapin III, T. Osterkamp, M. Dyurgerov, V. Romanovsky, W. C. Oechel, J. Morison, T. Zhang, and R. G. Barry. 2000. Observational evidence of recent change in the northern high latitude environment. ***Climatic Change*** **46:159–207.**

This paper presents a broad spectrum of observational evidence for environmental change across the high northern latitudes. The results of several independent studies are offered, which taken together, point to coordinated changes in the arctic system, possibly brought about by climate change. This paper is by its very nature synthetic and has the broad arctic system as its focus. Its attempt to present a systematic picture of change should prove useful in the current ARCSS synthesis exercise.

Shaver, G.R. J. Canadell, F.S. Chapin III, J. Gurevitch, J. Harte, G. Henry, P. Ineson, S. Jonasson, J. Melillo, L. Pitelka, and L. Rustad. 2000. Global warming and terrestrial ecocsystems: A conceptual framework for analysis. ***BioScience*** **50(10): 871–882.**

This is a more general conceptual approach to the issues raised in Eugster et al., 2000. We suggest reading it instead of Eugster if you prefer a broad conceptual framework, or read both to get two perspectives of the same issue.