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

## 1. Observations of Arctic Change

**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.

**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 500 years, and that other aspects of the Arctic system are undergoing change unprecedented in millennia. More recent work, both published and unpublished, confirms these results, indicating that the Arctic is undergoing climate change not seen since the last interglacial.

**Serreze, M.C., J.E. Walsh, F.S. Chapin, 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. Climate 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. See also Overland et al 2004 (listed in section 4 below)

**Sturm, M., D.K. Perovich, and M.C. Serreze. 2003. Meltdown in the North. Scientific American 289: 60-67.**

This article, intended for a lay audience, provides a basic overview of the suite of changes observed in the Arctic over the last several decades. It is illustrated with several graphics that help convey the broad scope of arctic change.

## 2. Model Projections of Arctic Change

**Allen, M.R., and W.J. Ingram. 2002. Constraints on future changes in climate and the hydrologic cycle. Nature 419: 224-232.**

A nice overview article on the inherent sensitivity of the hydrologic cycle to changes in greenhouse forcing. This highlights the idea of blending knowledge from a detailed but fragmentary observational data base with consistent but admittedly imperfect earth system simulation.

**Holland, M.M. and C.M. Bitz. 2003. Polar Amplification of Climate Change in the Coupled Model Intercomparison Project. Climate Dynamics 21: 221-232.**

Arctic amplification projected by fifteen different global climate models in doubled $CO_2$ conditions is compared and analyzed as to the spatial distribution and seasonality of surface warming. The models differed markedly in the magnitude of the amplification as well as the timing and location of maxima, but models all agree that Arctic amplification will occur.

**Serreze, M.C., J.A. Francis. 2004. The arctic amplification debate. Climatic Change (in review).**

The reality of model-predicted arctic amplification of climate warming has been questioned in the literature. While models disagree about magnitude, seasonality, and spatial patterns of Arctic warming, they all project enhanced Arctic warming in doubled $CO_2$ conditions. Observed temperature changes have not validated these projections. In this paper the idea is proposed that the Arctic is presently in a "preconditioning" phase, in which sea ice has retreated but not enough to produce the temperature anomalies projected for $2xCO_2$. Recent observations, however, are consistent with near-future model predictions, suggesting that Artic amplification is underway.

**Vinnikov, K.Y., A. Robock, R.J. Stouffer, J.E. Walsh, C.L. Parkinson, D.J. Cavalieri, J.F.B. Mitchell, D. Garrett, and V.F. Zakharov. 1999. Global warming and northern hemisphere sea ice extent. Science 286: 1934-1937.**

This paper discusses the recent observed changes in Arctic sea ice extent. It uses both control (no changing greenhouse gases) and transient model simulations to suggest that the observed changes in sea ice are anthropogenically forced. It provides an example of how using model simulations can inform us as to the mechanisms and forcing of observed changes.

## 3.Impacts and Implications of Change

Thes following eleven readings deal with some of the potential implications of arctic change. Whereas readings in the other three sections are arranged alphabetically, these articles are arranged by topic.

### Thermohaline circulation:

**Clark, P.U., N.G. Pisias, T.F. Stocker, and A.J. Weaver. 2002. The role of the thermohaline circulation in abrupt climate change. Nature 415: 863-869.**

This review article discusses the stability of the thermohaline circulation (THC) and its role in abrupt climate change. The paleoclimate record indicates that abrupt climate change occurred during the last glaciation, with rapid warming (over years to decades) followed by gradual cooling (over centuries). Interestingly, these abrupt warmings have a preferred timescale of approximately 1500 years. Evidence from both paleoclimate data and models support that this rapid climate change occurred in response to changes in the THC that were likely driven by relatively small perturbations to the hydrological cycle at high latitudes.

**Sea level rise:**

**McLean,R.F., Tsyban,A., Burkett,V. et al. 2001. Coastal Zones and Marine Ecosystems. Chapter 6 in *Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the IPCC.* Cambridge Press, pp. 343-379.**

This chapter from the Intergovernmental Panel on Climate Change (IPCC) Working Group II 2001 report presents the current state of knowledge about climate change impacts, adaptation, and vulnerability for coastal zones and marine ecosystems.

**$CO_2$ Change:**

**Oechel, W.C., G.L. Vourlitis, S.J. Hastings, R.C. Zulueta, L. Hinzman, D. Kane. 2000. Acclimation of ecosystem $CO_2$ exchange in the Alaskan Arctic in response to decadal climate warming. Nature 406: 978-981.**

Here the authors report on an analysis of summer $CO_2$ flux data for two arctic ecosystems from 1960 to the end of 1998. They find a previously undemonstrated capacity for ecosystems to metabolically adjust to long-term changes in climate. They report that despite this observed acclimation, the ecosystems studied are still an annual net source of $CO_2$ to the atmosphere.

**Permafrost changes:**

**Nelson, F.E., O.A. Anisimov, and N.I. Shiklomanov. 2001. Subsidence risk from thawing permafrost. Nature 410: 889-890.**

This brief article provides an overview of subsidence risk from thawing permafrost and the attendant damage to infrastructure. The authors describe a preliminary analysis of geographic regions that are at high risk for damage from melting permafrost.

**Romanovsky, V.E., M. Burgess, S. Smith, K. Yoshikawa, J. Brown. 2002. Permafrost temperature records: Indicators of climate change. EOS 83(50): 589 & 593-594.**

Deep boreholes throughout Alaska, Canada and Russia have been visited by scientists periodically over the last two to four decades to collect measurements of the temperatures of the permafrost. These data display marked variability in rates of warming, but consistent warming in almost all regions of the Arctic and Subarctic. Thermal measurements in permafrost filter out short-term variations in weather and provide a good assessment of changes in climate.

**Ecosystem changes:**

**O'Brien, C.M., C.J. Fox, B. Planque, and J. Casey, 2000. Climate variability and North Sea cod. Nature 404: 142.**

In this very brief article, the authors report on the potential collapse of the North Sea cod fishery from a combination of fishing pressure and a recent warming of North Sea waters.

**Chavez, F.P., J. Ryan, S.E. Lluch-Cota, and M. Niquen C. 2003. From anchovies to sardines and back: Multidecadal change in the Pacific Ocean. Science 299: 217-221.**

This review article describes large-scale variations in anchovy and sardine populations in the Pacific during the 20th century. The authors find a close correlation between these biological regime shifts and a variety of physical processes. They caution that these natural variations must be taken into account when considering human-induced changes and marine resource management.

**Chapin, F.S., E.S. Zavaleta, V.T. Eviner, R.L. Naylor, P.M. Vitousek, H.L. Reynolds, D.U. Hooper, S. Lavorel, O.E. Sala, S.E. Hobbie, M.C. Mack, and S. Diaz. 2000. Consequences of changing biodiversity. Nature 405:234-242.**

This review article argues that the wide-ranging threats to species biodiversity from human-induced environmental change have potentially negative consequences for mitigating future environmental problems. The authors describe several components of species diversity and the influence of species diversity on resilience and resistance to environmental changes. The authors also provide a "blueprint for action" for scientists, the general population, and decision-makers to mitigate losses to species diversity.

**Sala ,O.E., and 18 others. 2000. Global biodiversity scenarios for the year 2100. Science 287: 1770-1774**

In this review article, the authors take current projections for changes in atmospheric $CO_2$, climate, vegetation, and land use, as well as the current understanding of the sensitivity of biodiversity to these changes and develop several future global biodiversity scenarios.

### Food Security:

**Rosenzweig, C. and M. Parry. 1994. Potential impacts of climate change on world food supply. Nature 367: 133-138.**

In this seminal work on the implications for global food security from climate change, the authors combine data from several local and regional studies to present a global picture of simulated change in crop yield associated with several climate change scenarios. They then use a world food trade model to project the economic consequences of these potential changes to crop yield. They find that a doubling of atmospheric $CO_2$ will lead to a relatively small reduction in world food production, but that there is a significant disparity between the impacts on the developing and developed word.

**Pittock, A.B. Climate and Food Supply. Nature 371: 25.**

In this response to the Rosenzweig and Parry article above, the author challenges several of the underlying assumptions and ultimately the major result of Rosenzweig and Parry.

### Decision makers and Adaptation:

**Pielke, Jr., R. A. and R. T. Conant. 2003. Best practices in prediction for decision making: Lessons from the atmospheric and Earth sciences. Ecology 84: 1351-1358.**

The authors here identify three best practices for quantitative ecosystem modeling and prediction gleaned from atmospheric and earth sciences. The three lessons learned are: 1) effective use of prediction results from focusing on prediction as one component in the process of decision-making; 2) don't conflate prediction for science and prediction for policy; 3) prediction products are difficult to evaluate and easy to misuse.

**Tol, R.S.J., S. Fankhauser, and J.B. Smith. 1998. The scope for adaptation to climate change: what can we learn from the impact literature? Global Environmental Change 8: 109–123.**

This review article provides a brief overview of the environmental change impacts literature (as of 1998). The authors find that there is a dearth of literature that realistically assesses the costs and benefits of climate changes, but the literature that does exist provides some initial direction for future work. The authors also provide a useful critique of the four approaches to dealing with adaptation that emerges from the impacts literature.

## 4. Interdisciplinarity and Scientific Synthesis

**Fisher, T.R., D. Correll, R. Constanza, J.T. Hollinbaugh, C.S. Hopkinson Jr., R.W. Howarth, N.N. Rabalais, J.E. Richey, C.J. Vörösmarty, and R. Wiegert. 2000. Synthesizing drainage basin inputs to coastal systems. In *Estuarine Science*, ed. J.E. Hobbie, 81-101. Washington, D.C.: Island Press.**

This chapter demonstrates how another community struggled a couple of years back to formulate strategies that approach land-to-ocean linkages in a systematic manner.

**Nicolson, C.R., A.M. Starfield, G.P. Kofinas, and J.A. Kruse. 2002. Ten heuristics for interdisciplinary modeling projects. Ecosystems 5: 376-384.**

The authors reflect on some of the practical (but often intangible) aspects that can make or break an interdisciplinary effort. Their ten rules of thumb cover various parts of the life-cycle of a project, and are geared mainly toward integrated assessment projects in which synthesis modeling plays a key role.

**Overland, J.E., M.C. Spillane, and N.N. Soreide. 2004. Integrated analysis of physical and biological pan-arctic change. Climatic Change 63: 291-322.**

This paper discusses the recent changes in the Arctic and does an EOF analysis across multiple datasets, including both physical and biological data. It provides an example of an interesting, quantitative way to tackle Arctic system science.

**Rastetter, E.B., J.D. Aber, D.P.C. Peters, D.S. Ojima, and I.C. Burke. 2003. Using mechanistic models to scale ecological processes across space and time. BioScience 53 (1): 68-76.**

This paper shows ecological modelers grappling with the issue of how to model system dynamics using component knowledge. In particular, they demonstrate several modeling approaches for handling processes that are usually studied at one scale (e.g. plot-level) but need to be applied at a larger scale (e.g. watershed). It also includes some insightful ideas on how to use models to highlight knowledge gaps.

**Ritchey, T. 1991. (Revised 1996). Analysis and Synthesis: On Scientific Method - Based on a Study by Bernhard Riemann. Systems Research 8 (4):21-51.**

In this paper, Ritchey distinguishes between two different perspectives on any given 'system': the system as a functioning unit and the system as a set of interacting parts. Using a non-arctic example (the middle ear!) he discusses the appropriate relationship between synthesis and analysis. We hope that this article might give us some useful clues on how to think about the arctic as a system, and how to think about the task of scientific synthesis.