Arctic Change Detection

NOAA Arctic Program—Project Report, July 2006

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Our goal is to assemble and analyze credible information on ongoing environmental change in the Arctic and communicate these results to a wide audience. Two themes are to understand arctic change from a large number of perspectives and provide comparisons of current change to recent and long-term instrumental records. Major findings include:

- Surface air temperatures in spring have been greater than 1°C above average throughout most of the Arctic for the last six years (Figure 1). These conditions contrast with earlier periods in the 20th century when warmer temperatures were only found in different sub-regions of the Arctic.

- Over the last 25 years there is a loss of almost 20% sea ice cover in summer (illustrated in Figure 2). About 20% of tundra area is changing to shrubs and the incidence of large record breaking forest fires has increased in Alaska over the previous decade (Figure 3).

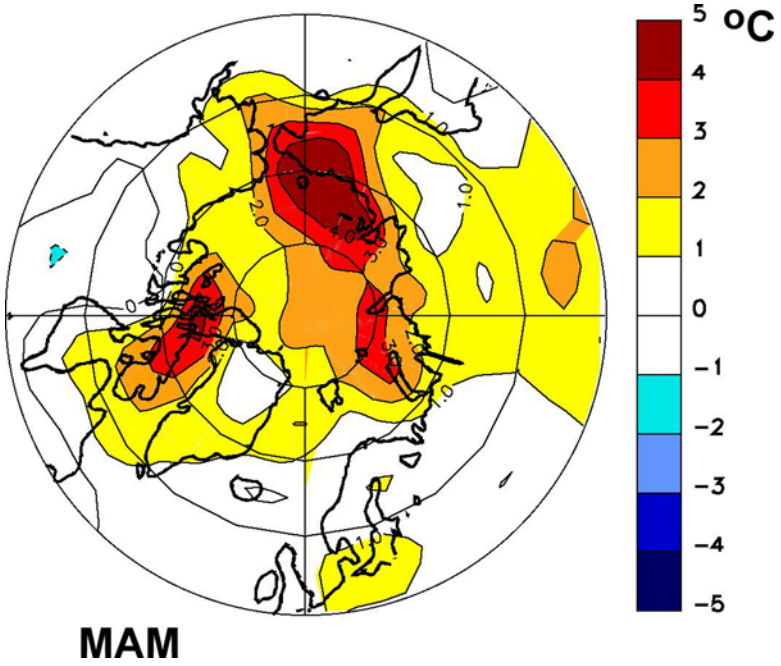

Figure 1. Map of springtime surface air temperature anomalies for 2000-2005. Most regions of the Arctic (yellow and red) show values at least 1° C above average, with two hot spots: one north of eastern Siberia and one in northeast Canada. This pattern differs from earlier temperature patterns in the 20th century.

Figure 2. While less sea ice may open the Arctic in general to increased shipping, important passes and straits could be clogged with wind-blown ice in some years, increasing hazards to shipping (Canadian Ice Service).

Figure 3. Major wild fires have impacted large parts of northern Alaska during the last two summers (Mike McMillan, Spotfire Images).

Figure 4 The pollock fishery in Alaskan waters has been favored in the last decade due to less sea ice and warmer ocean temperatures.

- Arctic species are being replaced by subarctic species. Increased sea temperatures and lack of sea ice in the southeastern Bering Sea has favored the continuation of an extensive groundfish fishery of 2 M metric tons per year. The Alaska pollock fishery has grown to become a $2 B industry which represents 40% of the US landed catch (Figure 4). Warmer sea temperatures are also affecting northern European fisheries, but in more complex ways.
- Although observations show a period of warm temperatures in the Arctic during the 1920s through the 1930s and observations from the 19th century from the Northwest Passage expeditions and the first International Polar Year (1882–1883) show substantial year to year variability, the Arctic-wide nature of changes over the last 15 years appear unique in the instrumental record.
- There is large natural variability in arctic climate represented by large regional and temporal changes in temperatures and wind patterns. Any analysis of future arctic climate must account for this large intrinsic variability.

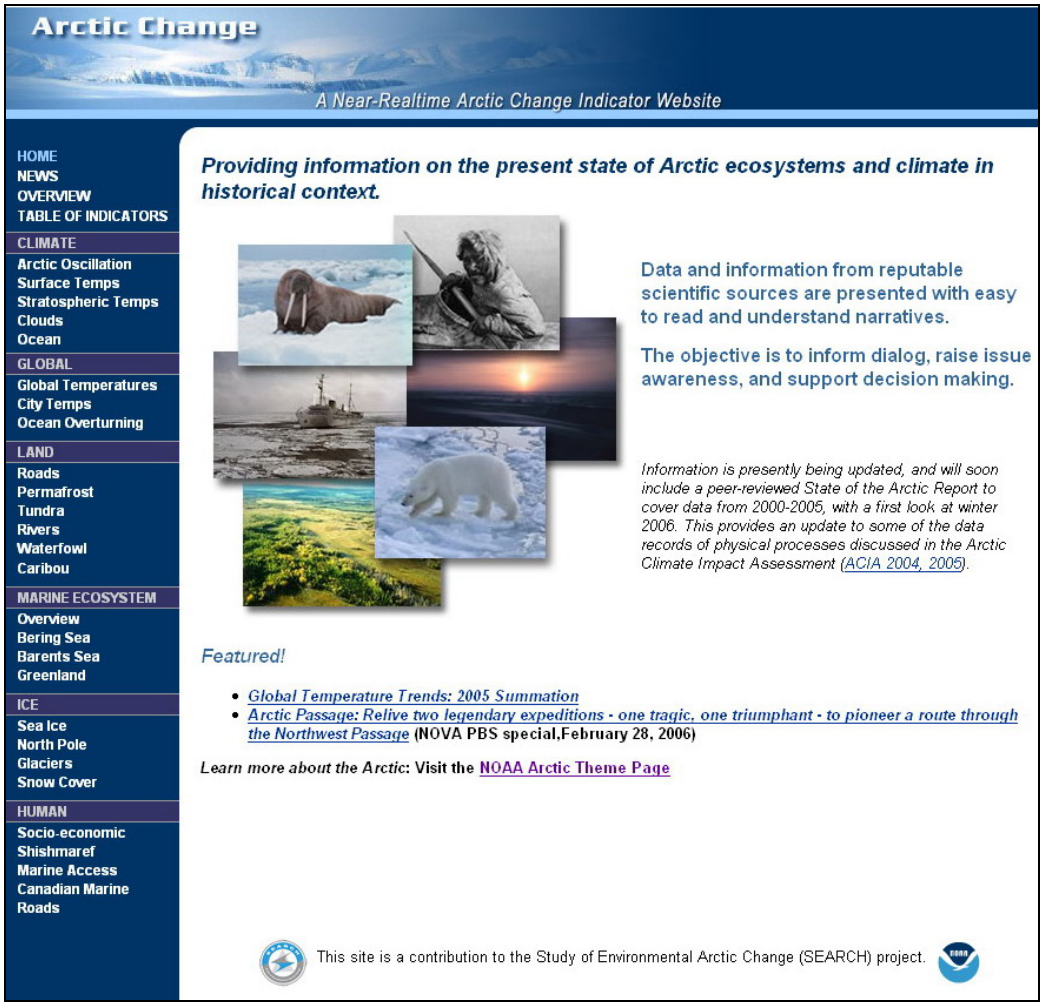

Figure 5. NOAA Arctic Change Detection website portal, http:// www.arctic.noaa.gov/detect/

Major communication/education accomplishments include:

- We have maintained an arctic change website: http://www.arctic.noaa.gov/detect/ (Figure 5). This site logs 33000 unique inquires per month. Our site developed an easy to understand format which combines visuals, quantitative information and a narrative style. Visitors can research based on their priorities. It is used by classrooms as well as international scientists.

- We have participated actively in production of a State of the Arctic (SoA) Report due summer 2006, which was written and reviewed by 26 international authors and provides an update to the Arctic Climate Impact Assessment (ACIA). Over the last four years some ACIA indicators have continued to show continuing warming trends as seen in surface and permafrost temperatures and loss of sea ice while some have not, such as deep ocean temperatures, permafrost active layer depths and atmospheric circulation patterns. We also provided material for the

Arctic section of the *Bulletin of the American Meteorological Society*—State of the Climate in 2005 Special Supplement (Shein, Ed., June 2006).

- We have published 12 journal articles and 3 more are in press. While we work toward synthesizing arctic information, it is important that NOAA provides information that is validated by peer-reviewed publications. A publication list is provided at the end of this report.
- We have been active in international science and planning. JEO served on the SEARCH steering committee and chaired the first SEARCH workshop; he presently serves on the AMAP Expert Group on Climate. NNS served as liaison at Arctic Council IT conferences, Arctic Portal and ARCUS meetings. JEO reviewed two ACIA chapters.
- We have given more than five major presentations per year; these included invited and keynote papers at the ACIA, ACSYS and the Association of American Geographers conferences and the CliC–SCAR–ICPM Workshop on Recent High Latitude Climate Change. Other venues were AMS, AGU, and the Bjerknes Symposium on High Latitude Climate.
- **Impacts**: We have reached scientists, educators, students, decision makers and the public through our presentations and website. SEARCH, ACIA, ICARPII and SoA represent contributions of scientific leadership. We have encouraged scientific communication through informal contacts, representing a large number of disciplines within the arctic research community. For natural resource management support we have made direct presentations to the North Pacific Fisheries Management Council and have supported John Calder in his AMAP functions.

Journal Publications and Selected Conference Proceedings:

Overland, J., J. Calder, F. Fetterer, D. McGuire, J. Morison, J. Richter-Menge, N.N. Soreide, and J. Walsh (2003): SEARCH Workshop on Large-Scale Atmosphere–Cryosphere Observations. *Bull. Am. Meteorol. Soc., 84*(8), 1077–1082.

Soreide, N.N., J.E. Overland, and J. Calder (2003): Improving public understanding of Arctic climate variations. In *Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High Latitude Climate Variations,* AMS, Session 2.16, Hyannis, MA, 12–16 May 2003.

Wood, K.R., and J.E. Overland (2003): Accounts from 19th-century Canadian Arctic explorers' logs reflect present climate conditions. *Eos Trans. Am. Geophys. Union, 84*(40), 410, 412.

Overland, J.E., M.C. Spillane, D.B. Percival, M. Wang, and H.O. Mofjeld (2004): Seasonal and regional variation of pan-Arctic surface air temperature over the instrumental record. *J. Climate, 17*(17), 3263–3282.

Overland, J.E., M. Spillane, and N.N. Soreide (2004): Integrated analysis of physical and biological pan-Arctic change. *Clim. Change, 63*(3), 291–322.

Overland, J.E., and P.J. Stabeno (2004): Is the Climate of the Bering Sea Warming and Affecting the Ecosystem? *Eos Trans. Am. Geophys. Union, 85*(33), 309–316.

Wang, M., and J.E. Overland (2004): Detecting Arctic Climate change using Köppen classification. *Clim. Change, 67*(1), 43–62.

Overland, J.E., N.N. Soreide, M.C. Serreze, and J. Francis (2005): Building and using an Arctic climate information system. In *8th Conference on Polar Meteorology and Oceanography,* The 85th AMS Annual Meeting, San Diego, CA, 9–13 January 2005, Paper J7.3

Overland, J.E., and M. Wang (2005a): The Arctic climate paradox: the recent decrease of the Arctic Oscillation. *Geophys. Res. Lett., 32*(6), L06701, doi: 10.1029/2004GL021752.

Overland, J.E., and M. Wang (2005b): The Third Arctic Climate Pattern: 1930s and early 2000s. *Geophys. Res. Lett., 32*(23), L23808, doi: 10.1029/2005GL024254.

Soreide, N.N., J. Calder, J.E. Overland, and F.M. Fetterer (2005): Arctic change detection website. In *The 21st International Conference on Interactive Information Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology,* The 85th AMS Annual Meeting, San Diego, CA, 9–13 January 2005, Paper J2.7

Grebmeier, J.M., J.E. Overland, S.E. Moore, E.V. Farley, E.C. Carmack, L.W. Cooper, K.E. Frey, J.H. Helle, F.A. McLaughlin, and S.L. McNutt (2006): A major ecosystem shift in the Northern Bering Sea. *Science, 311*(5766), 1461–1464.

Overland, J.E. (2006): Arctic change: Multiple observations and recent explanations. *Weather, 61*(3), 78–83.

Richter-Menge, J., J. Overland, A. Proshutinsky, V. Romanovsky, J.C. Gascard, M. Karcher, J. Maslanik, D. Perovich, A. Shiklomanov, and D. Walker (2006): The Poles: Arctic. In *State of the Climate in 2005*, K.A. Shein (ed.), *Bull. Am. Meteorol. Soc., 87*(6), S46–S52.

Wang, M., J.E. Overland, D. Percival, and H.O. Mofjeld (2006): Change in the Arctic influence on Bering Sea climate during the twentieth century. *Int. J. Climatol., 26*(4), 531–539.

Turner, J., J.E. Overland, and J.E. Walsh (2006): An Arctic and Antarctic perspective on recent climate change. *Int. J. Climatol.*, In Press.

Wang, M., J.E. Overland, V. Kattsov, and J.E. Walsh (2006): Intrinsic versus forced variation in coupled climate model simulations over the Arctic during the 20th century. *J. Climate,* In Press.

Wood, K.R., and J.E. Overland (2006): Climate lessons from the First International Polar Year. *Bull. Am. Meteorol. Soc.,* In Press. With accompanying website: http://www.arctic.noaa.gov/aro/ipy-1/ .