## 5. THE POLES—F. Fetterer, Ed.

### *a. Arctic*—J. Richter-Menge, Ed.

#### 1) Overview—J. Richter-Menge

The permanent presence of sea ice, ice sheets, and continuous permafrost are unique features of the polar regions. The Arctic is further distinguished because it sustains a human population in a harsh environment. These characteristics amplify the impact of global climate change on both the regional physical and societal systems. These impacts reach beyond the Arctic region. For instance, studies are underway to determine the extent to which the loss of sea ice cover and the conversion of tundra to larger shrubs and wetlands, observed to have occurred over the last two decades, have impacted multiyear persistence in the surface temperature fields, especially in the Pacific sector. In this chapter observations collected in 2007, combined with historical records, provide insights into continuing trends in the state of physical components of the Arctic system, including the atmosphere, ocean, sea ice cover, and land.

In 2007 there continued to be widespread evidence of the impact of a general warming trend in the Arctic region, where surface air temperatures reached their highest level on record. One of the most dramatic signals was the significant reduction in the extent of the summer sea ice cover and in the relative amount of older, thicker ice, both showing signs of an increase in the relative rate of reduction. Accompanying the reduction in sea ice cover was an increase in the temperature and a decrease in the salinity of the surface ocean layer. Water temperatures in deeper ocean layers also increased due to the influx of warmer waters into the Arctic Basin. On land, there was a general greening of tundra and browning of forested areas. Permafrost temperatures tended to increase and snow extent tended to decrease. Measurements of the mass balance of glaciers and ice caps indicate that in most of the world, glaciers are shrinking in mass. The largest of these, Greenland, experienced records in both the duration and extent of the summer surface melt.

#### 2) Atmosphere—J. Overland, J. Walsh, and M. Wang

The year 2007 was the warmest on record for the Arctic, continuing a general, Arctic-wide warming trend that began in the mid-1960s (Fig. 5.1). The AO circulation regime, widely considered the main source of Arctic climate variability during the twentieth century, returned to a strongly positive wintertime index value for the first time in more than a decade, but was still lower than the large positive values of the early 1990s (Fig. 5.2). A positive AO is associated with lower pressure over Arctic regions and higher pressure at midlatitudes. The SLP anomaly field for winter–spring (December–May) 2007 shows low anomalies over most of the Arctic with a minimum over northern Europe (Fig. 5.3, left). This pattern contrasts with that of the canonical positive AO, where the lowest anomalies are centered over Iceland and the central Arctic. The geostrophic wind pattern associated with the 2007 SLP anomaly field brought air flow from western Russia toward the North Pole, with a positive (warmer) SAT anomaly maximum over the northern Barents Sea (Fig. 5.4, left). During the previous years of weak and variable AO (1996–2006), the geostrophic wind flow anomaly was generally from the Pacific toward the North Pole with positive SAT

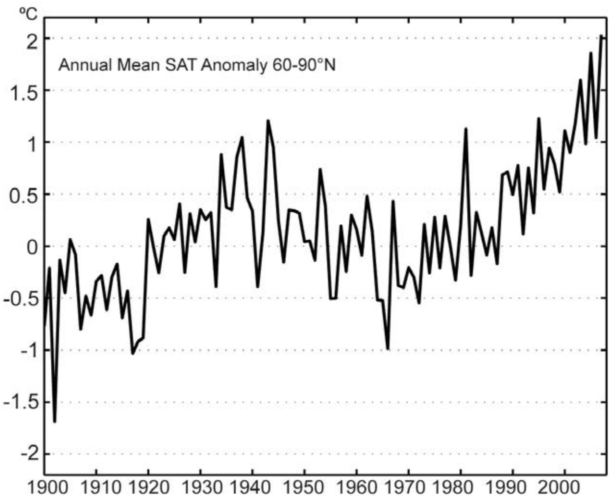


**Fig. 5.1. Arctic-wide annual averaged surface air temperature anomalies (60°–90°N) based on land stations north of 60°N relative to the 1961–90 mean. From the CRUTEM3v dataset, (available online at www.cru.uea.ac.uk/cru/data/temperature/).**

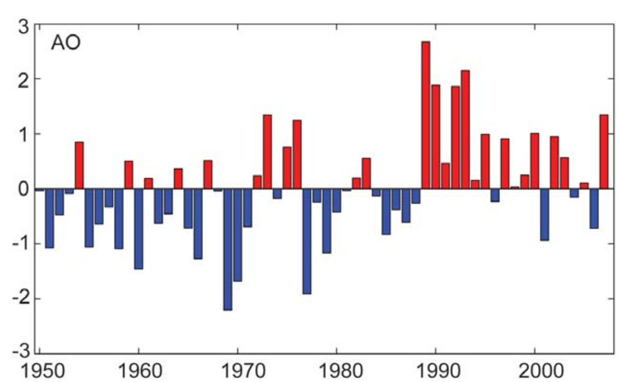


**Fig. 5.2. The extended winter (DJFM) Arctic Oscillation index, 1950 to 2007 (based on data available online at www.cpc.ncep.noaa.gov).**

anomalies north of eastern Siberia. It is difficult to say whether the strong positive AO will be sustained. There are historical examples of both single strong AO years and years where the anomaly is the beginning of a multiyear event.

A similarity of 2007 with the early years of the twenty-first century is the nearly Arctic-wide extent of positive SAT anomalies in winter, spring, and fall. These years contrast with the twentieth century in which positive and negative SAT anomalies were more evenly distributed. This Arctic-wide background SAT anomaly of greater than +1°C is consistent with projections from IPCC climate models (Chapman and Walsh 2007a). The exceptions are the Bering Sea and western Alaska, which were experiencing a third consecutive cold or average winter as 2007 came to a close.

The Arctic-wide negative SLP anomaly pattern of winter and spring was followed in summer by an unusually strong high pressure region in the Beaufort Sea and low SLP over central Russia (Fig. 5.3, right) that set up sustained geostrophic winds blowing from the North Pacific across the North Pole. These winds contributed to sea ice advection toward the Atlantic sector and the advection of warm moist air into the central Arctic, and to a record minimum Arctic sea ice cover in September (see section 5a4). The summers of 2005 through 2007 all ended with extensive areas of open water. As a result, freeze-up occurred later than usual, and surface air temperature remained high into the following autumn, with warm SAT anomalies above +6°C during October and November across the central Arctic. Such autumn SAT anomalies are also consistent with sea ice extent projections from IPCC climate model simulations performed with increasing greenhouse gas concentrations.

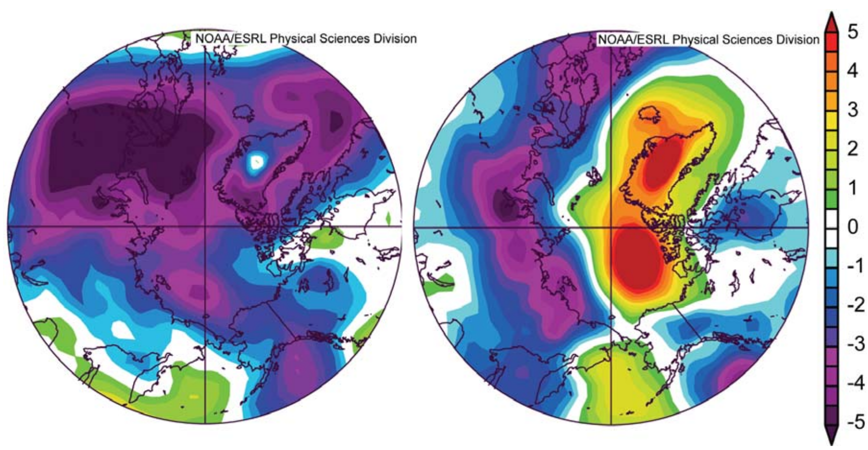


**Fig. 5.3. SLP anomaly pattern for (left) Dec 2006–May 2007 and (right) Jun–Aug 2007. Note the extensive Arctic-wide areas of low SLP in winter and spring, which project onto a positive AO index. Data are from the NCEP–NCAR reanalysis through the NOAA/Earth Systems Research Laboratory, generated online at www.cdc.noaa.gov. Anomalies are relative to a 1968–96 climatological period.**

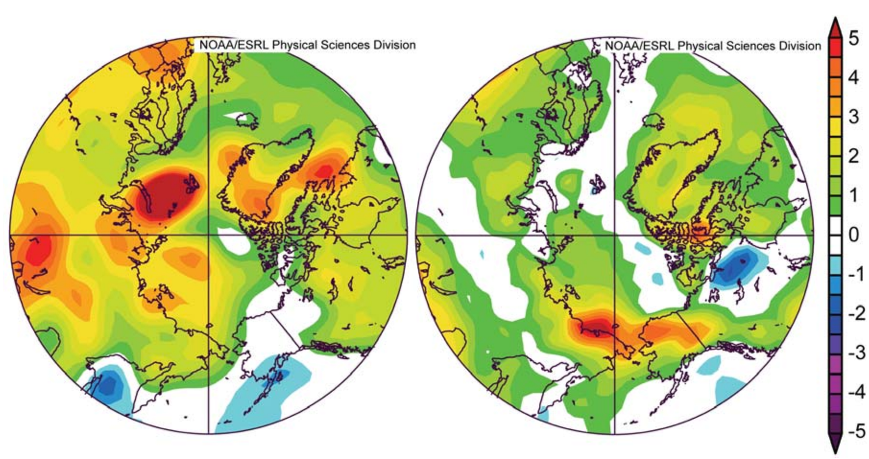


**Fig. 5.4. Similar to Fig. 5.3, but for surface air temperature anomalies in °C for (left) Dec 2006–May 2007 and (right) Jun–Aug 2007. Note the nearly Arctic-wide positive values in winter and spring. In summer, melting ice keeps air temperature near the surface close to zero. After fall freeze-up, air temperature anomalies exceeded 6°C over much of the Arctic Ocean (not shown). Anomalies are relative to a 1968–96 climatological period.**

### 3) Ocean—A. Proshutinsky, J. Morison, I. Ashik, E. Carmack, I. Frolov, J. C. Gascard, M. Itoh, R. Krishfield, F. McLaughlin, I. Polyakov, B. Rudels, U. Schauer, K. Shimada, V. Sokolov, M. Steele, M.-L. Timmermans, and J. Toole

#### (i) Circulation

In 2007, the ocean surface circulation regime in the Beaufort Sea was strongly anticyclonic (clockwise) in winter and summer (Fig. 5.5).