the contiguous U.S., low stream, reservoir, and stock pond levels, and depleted soil moisture combined with hot temperatures and high evaporation to ravage agricultural lands as the growing season progressed: in the Mid-Atlantic states by mid-summer, and the South and Ohio Valley by early to mid-fall. Dryness was especially severe in the Lower Mississippi Valley, with parts of Arkansas, Louisiana, and Mississippi having the driest year on record.

The United States had a below-average wildfire season for 2010. Wet conditions across the western regions of the country helped to limit the number of large fires and total acreage burned. During 2010, 71 839 fires burned nearly 1.4 million hectares. This marked the least acreage burned annually nationwide since 1998. Despite the below-average season, the Long Butte Fire in Idaho burned approximately 133 000 hectares during August, about nine percent of all acres burned in the United States during the year. The Fourmile Canyon fire near Boulder, Colorado in September only burned 2500 hectares, but containment costs and damages totaled more than $225 million (U.S. dollars)—the costliest fire in Colorado's history.

(iv) Tornadoes

Across the United States, 2010 was an above-average year for tornadoes. As of March 2011, confirmed tornado reports and estimates for 2010 indicated that there were 1280 tornadoes from January to December, which is above the 10-year (2000–09) average and the seventh highest annual count since 1990. The number

SIDEBAR 7.1: AN ASSESSMENT OF 2010 NORTH AMERICAN TEMPERATURES—M. HOERLING, D. EASTERLING, J. PERLWITZ, J. EISCHEID, P. PEGION, AND D. MURRAY

A Persistent Pattern of 2010 North American Temperature Anomalies

Surface air temperatures were very warm across Canada during all seasons of 2010, while the contiguous United States experienced much-below normal temperatures over the South and East in the first and latter portions of 2010. These cold conditions ended record high temperatures in those same U.S. regions during the warm half of the year (Fig. 7.5, left panels). January–March 2010 conditions included greater than +3°C departures over all Canadian provinces from the Pacific to the Atlantic coast; statistics compiled by Environment Canada indicated that winter 2010 was the warmest in Canada since records began in 1948. In sharp contrast, up to -3°C departures occurred over the U.S. Gulf Coast region. Following seasons

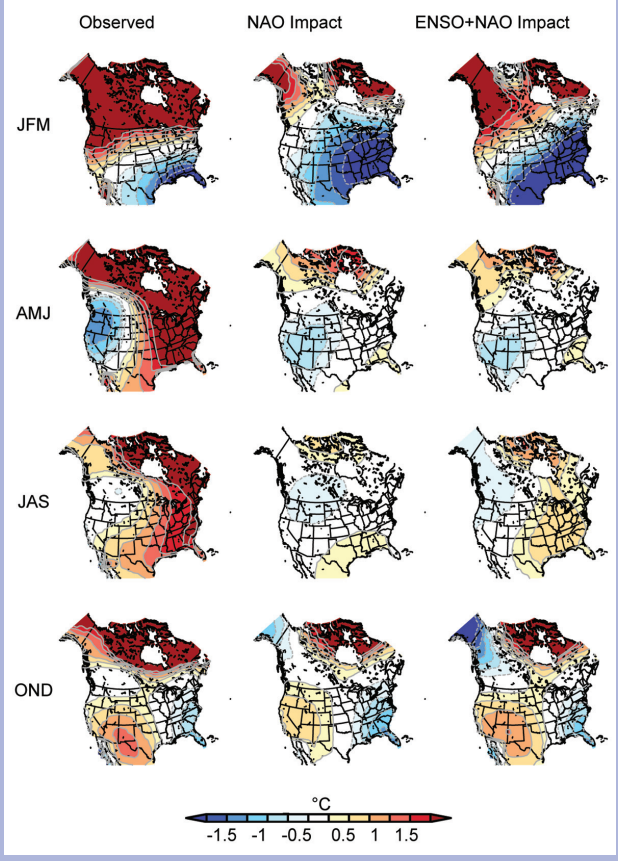

Fig. 7.5. (Left panels) North American surface air temperature departures (°C) during 2010 for winter (JFM), spring (AMJ), summer (JAS), and fall (OND) based on NASA gridded departures (based on 1961–90); (middle panels) surface temperature signal (°C) attributable to the state of the 2010 North Atlantic Oscillation (NAO); (right panels) surface temperature signal (°C) attributable to the combined effects of the state of NAO and ENSO. The NAO signal is calculated by regressing the monthly surface temperatures upon the Climate Prediction Center's NAO index time series for 1950–2009, and the 2010 anomalies are derived by multiplying the regression pattern by the observed 2010 standardized NAO index for each season. The ENSO signal is calculated by regressing the monthly surface temperatures upon a Nino-3.4 SST index time series for 1950–2009 and then scaling by the observed 2010 index values of Nino-3.4 SSTs. The combined 2010 anomalies are derived by adding the separate NAO and ENSO signals. All data used in regression were detrended. (Source: NOAA/ESRL-PSD1/GISS.)

of strong-to-violent tornadoes (rated EF3–EF5) reported in 2010 was 43, which was also above average, although no tornadoes were rated EF5. There were 45 tornado fatalities reported during 2010, associated with 21 tornadoes. The most deadly tornado of the year occurred in the state of Mississippi on 24 April, when a long-track EF4 killed 10 people in three counties. The tornado was on the ground for 240 km, the fourth longest tornado track for Mississippi on record.

Texas led the national tornado count with 107 individual tornadoes during 2010. Also remarkable were the 105 confirmed tornadoes that occurred in Minnesota, ranking the state as having the second most tornadoes in the United States during the year. The 105 tornadoes broke the state's previous annual record of 74, which occurred in 2001. Forty-eight of the Minnesota tornadoes occurred on 17 June alone, as part of the largest tornado outbreak during 2010 for the entire country. During this large severe weather episode, there were 74 confirmed tornado reports across the Upper Midwest and Northern Plains, including four EF-4 tornadoes. This high count marked the busiest tornado day for the U.S. since 23 May 2008 and one of the largest tornado outbreaks to occur across the region in the past decade.

3) México—V. Davydova-Belitskaya and F. J. Romero-Cruz

The year 2010 was a unique year for México. According to the National Meteorological Service, nationally-averaged annual mean temperature was about 21.0°C, only 0.3 °C above the normal temperature of 20.7°C (Fig. 7.7a). However, for precipitation,

showed a reversal in U.S. temperature conditions even while Canada remained consistently warm; April–September 2010 was very warm across the eastern U.S. and cold across the West. As a further testament to intense seasonal temperature variability over the U.S., fall 2010 saw a sharp turn to cold conditions in the East and the Gulf Coast region.

A Persistent Phase of the North Atlantic Oscillation during 2010

A notable extreme climate event during 2010 was the intense negative phase of the North Atlantic Oscillation (NAO), with the annual mean value of the Jones NAO index ranking as the most negative in historical record, which began in 1823. This negative phase is indicative of high latitude blocking, which was a prevailing feature during all seasons. The middle panels of Fig. 7.5 show the seasonal surface temperature signals attributable to the seasonal NAO index of 2010 based on regression analysis. The best agreement between observations and the NAO signal occurs over eastern North America. In particular, the Canadian warmth juxtaposed with the southeast U.S. cold during winter and fall seasons can be largely reconciled with a meridional dipole pattern of NAO-related temperature anomalies, features linked with persistent atmospheric blocking that extended from eastern Canada across Greenland.

A Sharp Reversal in the ENSO During 2010

Strong El Niño conditions prevailed over the tropical Pacific from January to March 2010, which swiftly transitioned to moderate La Niña conditions by early summer and continuing into fall. In light of ENSO's known impact on North American climate conditions, it is reasonable to inquire whether the strong seasonality in contiguous U.S. temperatures may have been linked to this abrupt swing of the ENSO cycle. We calculated the ENSO impact on 2010 North American temperatures using a regression analysis and combined that signal with the NAO signal of 2010, the result of which is shown in the right panels of Fig. 7.5. For North America as a whole, the spatial correlation of the observed anomalies and this combined signal is 0.7, 0.7, 0.8, and 0.8 for the winter, spring, summer, and fall 2010 seasons, respectively. What emerges clearly from this diagnosis is the dominant effect of the persistent NAO in generating cold eastern U.S. conditions in early and late 2010, with some indication that the reversal to warm summer conditions in the eastern U.S. was partly due to the region's sensitivity to La Niña conditions, which had emerged with considerable vigor by July 2010.

By no means are all the seasonal features of 2010 North American temperatures interpretable as a signal of NAO variability. In particular, the spatial scale and intensity of the observed Canadian warmth was considerably greater than one would have expected from NAO and ENSO relationships. An important research task is to ascertain the effect of other modes of variability and boundary forcings on North American conditions of 2010, including the state of global sea surface temperatures, sea ice, and anthropogenic greenhouse gas forcing.