to ravage agricultural (pasture, range, and crop) lands in Texas early in the growing season. Heavy irrigation of crops was required across much of Hawaii amidst low soil moisture and irrigation restrictions in some areas.

Beneficial rains beginning in September brought drought relief to southern Texas, but not before these areas turned in their driest September–August 12-month period in the 1895–2009 record. The PDSI plummeted to the extreme drought category by early summer, but it did not pass the levels of the record 1950s drought for southern Texas, both in terms of intensity or duration. An analysis of post oak tree-ring chronologies from 1652–1995 indicates that southern Texas has experienced a dozen individual years prior to the 20th century which had very low January–June precipitation similar to the lowest values of the past 110 years. The 1950s drought likely was matched and possibly exceeded by one that occurred during 1711–17.

Parts of the Southeast began 2009 with lingering moderate to extreme drought, but by the beginning of summer, drought in the Southeast was mostly gone. Parts of the Upper Mississippi Valley and adjacent western Great Lakes have been in some level of dryness or drought for most of the last seven years, with moderate to severe drought lingering at year's end. Northwest Wisconsin had the driest 12-month October–September period on record in 2009 (October 2008–September 2009).

Parts of the West, especially California, have suffered through three years of drought. Northern

STRONG SEASONALITY IN 2009 U.S. TEMPERATURES—NOAA CSI TEAM—M.P. HOERLING

What Happened?

Headlines regarding U.S. surface temperatures for 2009 should read "Strong Monthly and Seasonal Variability". This climate variability story is all too easily obscured by the mundane outcome that annually-averaged temperatures were just slightly above their 20th century average (+0.2°C). As illustrated in Fig. 7.5 (left panels), the year began (JFM) with much-above-normal temperatures (i.e., in the top quintile of the 115-yr record) over the Central and Southern Great Plains and the Desert Southwest, flanked to the north and east by below-normal temperatures. A southward expansion of cold conditions occurred across much of the Great Plains in the spring (AMJ). By the summer (JAS), much-below-normal temperatures shifted eastward, and a swath from the eastern Plains thru the upper Ohio Valley succumbed to record-breaking low July averaged temperatures. Meanwhile, the western third of the United States remained very warm during the summer, and September was the warmest month on record for California and Nevada. But that latter warmth too came to an abrupt end, with the West and Rockies experiencing much below temperatures during the fall (OND) that also engulfed the western Plains (notwithstanding a brief interlude of high temperatures during November). By all measures, a wild rollercoaster ride for U.S. temperatures through 2009!

Why did it happen?

Can any reason be given for this strong seasonality? Such seasonal extremes most certainly were not the result of human-induced climate change. It is known that the U.S. temperature impact of greenhouse gas (GHG) and aerosol forcing, as estimated from the climate models of the IPCC Fourth Assessment, is comparatively uniform across the seasons. Thus, the observed rapid swings between much-below- and much-above-normal temperatures in 2009 were unlikely a symptom of anthropogenic forcing. Natural processes of climate variability were instead more likely the dominant cause.

In the far-away reaches of the equatorial Pacific, a no-less dramatic seasonal reversal in SST conditions was taking place during 2009. La Niña conditions that developed in late 2008 persisted through March 2009. A swift transition occurred in early spring, leading to El Niño SST conditions by July. This El Niño increased to moderate intensity by October 2009. The impact of tropical east Pacific SST forcing on U.S. seasonal climate is well known, and the question we ask here is which, if any features of U.S. temperature seasonality may have resulted from the seasonal reversal in SST forcing. Six different global climate models were subjected to the monthly variability in observed 2009 global SSTs. The resulting ensemble-averaged seasonally varying U.S. temperature response (260 simulations in total) is shown in the right side plots of Fig. 7.5. Several qualitative aspects of the observed seasonality appear linked to fluctuations in the oceans. Notably, a warm JFM over much of the Great Plains gave way to cold conditions during JAS in the simulations. Likewise, the early winter warm conditions in the southern Plains and Gulf Coast were replaced by cold conditions in fall in the simulations. These simulated features are broadly consistent with the seasonality observed, and they

California began the year with moderate to extreme drought. Conditions improved throughout the year, but the state ended 2009 with areas of moderate to severe drought remaining. An analysis of blue oak tree-ring chronologies from the coast ranges of California revealed as many as seven three-year drought events in the 1332–1900 period which were more severe than the driest three-year drought events of the 20th to early 21st centuries.

The United States had a near-normal wildfire season for 2009, similar to 2008. The first half of the year was marked by above-average number of fires and acreage burned, primarily in the western and central regions of the country where ongoing drought had increased fire danger. The second half of the year was generally cool and wet for the nation and was associated with below-average fire activity. For the year as a whole, nearly 77 500 fires burned over 2 million hectares. Despite the near-normal season, the Station Fire in California burned an estimated 64 983 hectares, marking the largest recorded fire in Los Angeles County history and California's tenth largest fire since 1933.

(iv) Tornadoes

Across the United States, 2009 was a below-average year for tornadoes. As of February 2010, confirmed tornado reports and estimates for the end of 2009 indicated that there were 1150 tornadoes from January–December, which is below the 10-year (1999–2008) average of 1291 and the fifth lowest (sixth highest) total of the decade. The number of strong-to-violent

are mostly consistent with the known U.S. impacts of La Niña (during winter) and El Niño (during summer and fall).

By no means are all the seasonal features of 2009 U.S. temperatures interpretable as resulting from ocean forcing. In particular, the spatial scale and intensity of the observed cold summer conditions is considerably greater than the simulated SST-induced coolness. Likewise, the very cold conditions over the western United States during fall were apparently unrelated to that region's sensitivity to the SST forcings. These conditions are assumed to have resulted from purely atmospheric-driven variability. An important research task remains to ascertain how likely the cold summer and fall conditions were given both the state of global SSTs and anthropogenic GHG forcing in 2009.

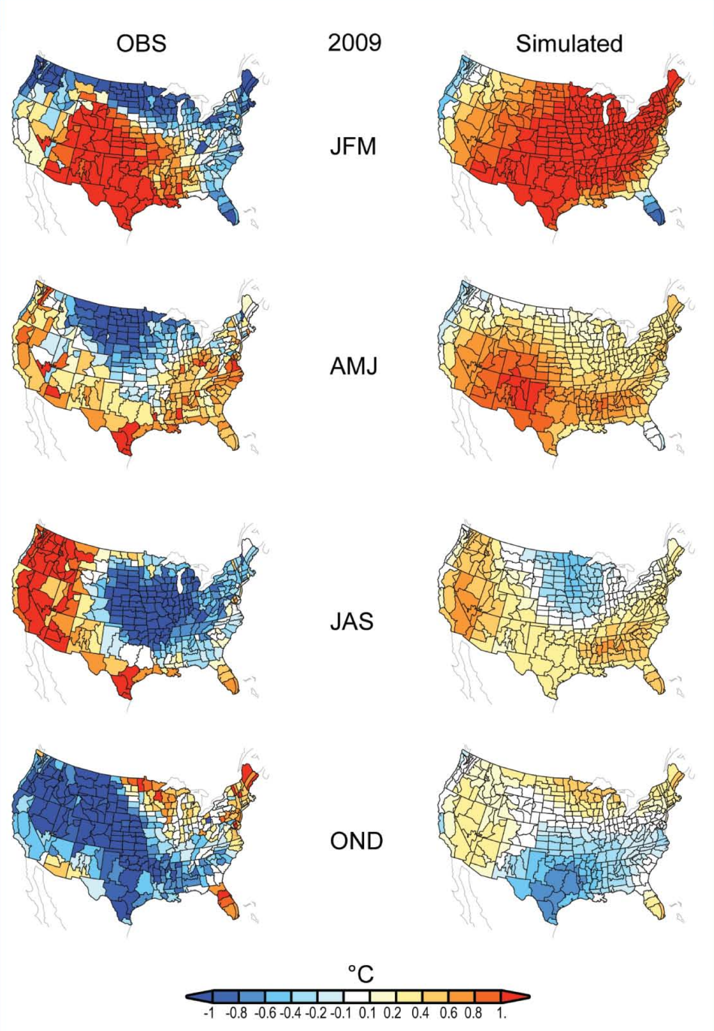

Fig. 7.5. Seasonally averaged surface temperature departures (relative to 1971–2000) during 2009 based on NCDC climate division data (left panels), and climate simulations forced with observed monthly varying global sea surface temperature and sea ice conditions during 2009 (right panels). The simulations consist of 6 different models and a total ensemble size of 260 members conducted for 2009. (Source: NOAA/ESRL.)