STATE OF THE CLIMATE IN 2010

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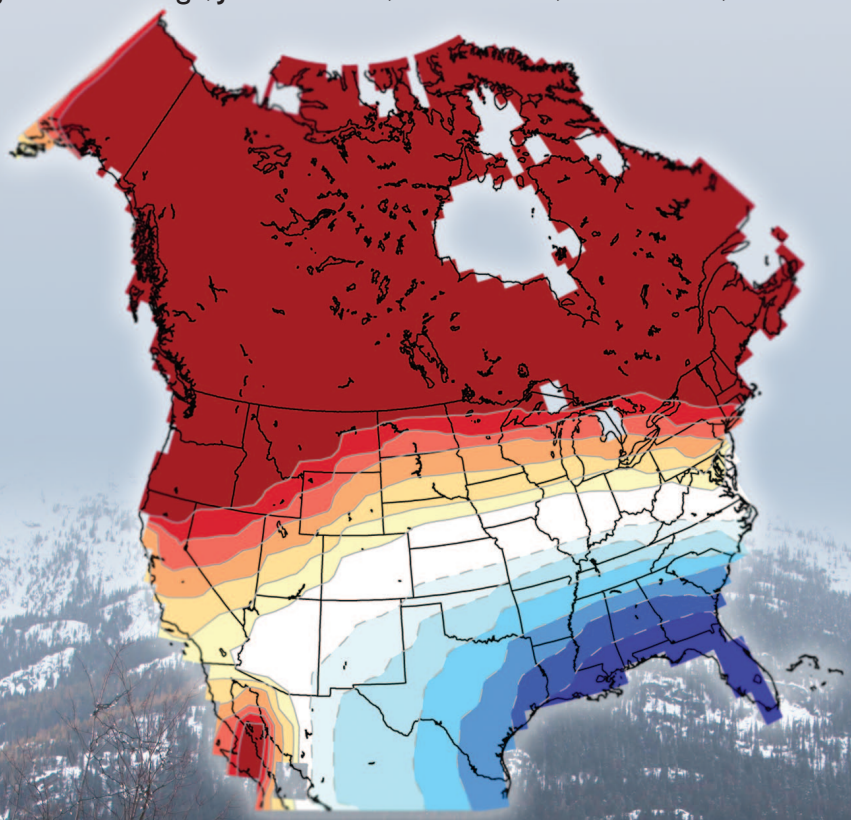

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ABSTRACT—J. BLUNDEN, D. S. ARNDT, AND M. O. BARINGER

Several large-scale climate patterns influenced climate conditions and weather patterns across the globe during 2010. The transition from a warm El Niño phase at the beginning of the year to a cool La Niña phase by July contributed to many notable events, ranging from record wetness across much of Australia to historically low Eastern Pacific basin and near-record high North Atlantic basin hurricane activity. The remaining five main hurricane basins experienced below- to well-below-normal tropical cyclone activity. The negative phase of the Arctic Oscillation was a major driver of Northern Hemisphere temperature patterns during 2009/10 winter and again in late 2010. It contributed to record snowfall and unusually low temperatures over much of northern Eurasia and parts of the United States, while bringing above-normal temperatures to the high northern latitudes. The February Arctic Oscillation Index value was the most negative since records began in 1950.

The 2010 average global land and ocean surface temperature was among the two warmest years on record. The Arctic continued to warm at about twice the rate of lower latitudes. The eastern and tropical Pacific Ocean cooled about 1°C from 2009 to 2010, reflecting the transition from the 2009/10 El Niño to the 2010/11 La Niña. Ocean heat fluxes contributed to warm sea surface temperature anomalies in the North Atlantic and the tropical Indian and western Pacific Oceans. Global integrals of upper ocean heat content for the past several years have reached values consistently higher than for all prior times in the record, demonstrating the dominant role of the ocean in the Earth's energy budget. Deep and abyssal waters of Antarctic origin have also trended warmer on average since the early 1990s. Lower tropospheric temperatures typically lag ENSO surface fluctuations by two to four months, thus the 2010 temperature was dominated by the warm phase El Niño conditions that occurred during the latter half of 2009 and early 2010 and was second warmest on record. The stratosphere continued to be anomalously cool.

Annual global precipitation over land areas was about five percent above normal. Precipitation over the ocean was drier than normal after a wet year in 2009. Overall, saltier (higher evaporation) regions of the ocean surface continue to be anomalously salty, and fresher (higher precipitation) regions continue to be anomalously fresh. This salinity pattern, which has held since at least 2004, suggests an increase in the hydrological cycle.

Sea ice conditions in the Arctic were significantly different than those in the Antarctic during the year. The annual minimum ice extent in the Arctic—reached in September—was the third lowest on record since 1979. In the Antarctic, zonally averaged sea ice extent reached an all-time record maximum from mid-June through late August and again from mid-November through early December. Corresponding record positive Southern Hemisphere Annular Mode Indices influenced the Antarctic sea ice extents.

Greenland glaciers lost more mass than any other year in the decade-long record. The Greenland Ice Sheet lost a record amount of mass, as the melt rate was the highest since at least 1958, and the area and duration of the melting was greater than any year since at least 1978. High summer air temperatures and a longer melt season also caused a continued increase in the rate of ice mass loss from small glaciers and ice caps in the Canadian Arctic. Coastal sites in Alaska show continuous permafrost warming and sites in Alaska, Canada, and Russia indicate more significant warming in relatively cold permafrost than in warm permafrost in the same geographical area. With regional differences, permafrost temperatures are now up to 2°C warmer than they were 20 to 30 years ago. Preliminary data indicate there is a high probability that 2010 will be the 20th consecutive year that alpine glaciers have lost mass.

Atmospheric greenhouse gas concentrations continued to rise and ozone depleting substances continued to decrease. Carbon dioxide increased by 2.60 ppm in 2010, a rate above both the 2009 and the 1980–2010 average rates. The global ocean carbon dioxide uptake for the 2009 transition period from La Niña to El Niño conditions, the most recent period for which analyzed data are available, is estimated to be similar to the long-term average. The 2010 Antarctic ozone hole was among the lowest 20% compared with other years since 1990, a result of warmer-than-average temperatures in the Antarctic stratosphere during austral winter between mid-July and early September.

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