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# STATE OF THE CLIMATE IN 2006

## Executive Summary\*

A. ARGUEZ, A. M. WAPLE, AND A. M. SANCHEZ-LUGO

The year 2006 was marked by continued global warmth, a severe Antarctic ozone "hole," and further declines in Arctic sea ice.

On the heels of 2005's record-breaking weather events, 2006 was also a year of records. This was especially the case over the polar regions, where the largest Antarctic ozone hole on record occurred in 2006. Sea ice extent in the Antarctic reached records at times for both maximum and minimum extent, and in the Arctic, scientists observed the second smallest sea ice extent on record (behind 2005). These record events came as attention to the polar regions gained greater focus, thanks in large part to the International Polar Year, during which an unprecedented effort is underway to monitor the Arctic and Antarctic from March 2007 through March 2009.

Several countries had their warmest years on record in 2006. These included, but were not limited to, China, the United Kingdom, Spain, and the

Netherlands. Also, parts of Australia reported record warmth, while Canada the United States experienced their second-warmest year on record, behind 1998. There was a transition between La Niña in the first half of the year to a weak to moderate El Niño in the latter half. While some regions had temperature and precipitation anomalies consistent with typical El Niño–Southern Oscillation (ENSO) impacts, it is noteworthy that the record warmth experienced over many parts of the world was not the result of a strong El Niño, as was the case in 1998. Record rainfall over parts of eastern Africa brought widespread damage to the region in 2006, while Australians were "Larried," as some Aussies referred to the destruction left behind by Tropical Cyclone (TC) Larry, including the near decimation of the banana crop.

This June issue of *BAMS* includes a supplemental publication entitled "State of the Climate in 2006." This supplement highlights the most salient weather events and overall climate conditions of 2006, and includes noteworthy weather events (e.g., floods, tropical cyclones, tornadoes, and heat waves), assessments of temperature and precipitation anomalies, and reports on some of the primary features of the global climate system—the Indian monsoon, the Siberian high, the Kuroshio and the Gulf Stream (western boundary currents in the North Pacific and North Atlantic Oceans, respectively), the intertropical convergence zone (ITCZ), and various jet streams, etc. To the extent possible, the conditions in 2006 are

\*For the complete "State of the Climate in 2006," see the supplement to this issue.

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placed in a historical context to provide perspective on variations and change that have occurred through time. The data and analyses contained therein represent the best available as of early 2007; values are subject to updating by the source agencies, although it is not expected that any key findings would be materially affected.

This is the 17th annual State of the Climate, the 11th year the report has been included in *BAMS*, and the second year it appears as a special supplement. The National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC) has been responsible for the report's publication for 7 years, although the report is truly an international effort. For 2006, over 150 scientists from around the world participated, as NCDC continued to focus on widening international participation. As part of this effort, special "Country spotlight" sidebars are included in the report, highlighting the 2006 climate events in the following six countries: Morocco, Mozambique, Cuba, Armenia, Turkey, and Bosnia. A determined effort has been made to ensure that all participants are duly acknowledged. In particular, authorship is noted for individual sections. In addition to authors, numerous reviewers and other facilitators have made the publication possible; these individuals are also listed in the acknowledgments section following the appendix.

With every new State of the Climate report, new topics and special features are incorporated. For 2006, the following new sections are included: cloudiness, aerosols, global winds, ocean salinity, and ocean color. These additions represent a marked increase in the number of "essential climate variables" covered by the report. Our ability to observe global climate elements has been dramatically increased by satellite observations, and this improvement will likely continue as new instruments are placed in orbit. Also new for 2006 are the sections on teleconnections and blocking, the Atlantic ITCZ, and a significantly augmented treatment of the Antarctic. The Australian tropical cyclone season is discussed in a special sidebar as well.

The following is an executive summary of the report's five main sections:

## **SECTION 2: GLOBAL CLIMATE.**

- Continued global warmth marked 2006. The 10 warmest years on record have all occurred since 1995, with 2006 ranking as the fifth or sixth warmest year on record, depending on the dataset analyzed. All datasets agree that global surface

temperatures continue to warm, with the rate of global temperature rise increasing from around  $0.06^{\circ}\text{C decade}^{-1}$  over the past century to nearly  $0.18^{\circ}\text{C decade}^{-1}$  for the last 30 yr.

- Northern Hemisphere snow cover extent was again below average for spring, and was near to slightly above average for winter in 2006.
- Global precipitation was above average in 2006 for the third consecutive year. Precipitation has increased globally since the start of the twentieth century, with the greatest increases in the mid- and high latitudes of the Northern Hemisphere.
- The concentration of carbon dioxide in the atmosphere increased by 2.3 ppm in 2006 to reach a global average of 381.1 ppm. The average rate of rise is  $1.6 \text{ ppm yr}^{-1}$  since 1980, however since the year 2000, this has increased to  $2.1 \text{ ppm yr}^{-1}$ . Prior to the Industrial Revolution, the atmospheric concentration was around 280 ppm.

## **SECTION 3: GLOBAL OCEANS.**

- Annual mean sea level anomaly (SLA) was above the 1993–99 baseline average for nearly 80% of the ocean. The global mean SLA change of +6 mm from 2005 was the highest increase since satellite altimeter measurements began in 1993. Relative sea level change was also the highest ever recorded.
- Significant heat flux anomalies were observed in the regions of the 2006 El Niño and Indian Ocean dipole mode event.

## **SECTION 4: THE TROPICS.**

- There were a near-average number of major (very strong) tropical cyclones worldwide. Certain basins were more active than normal, for example, the eastern tropical Pacific. The tropical Atlantic had near-average activity, though, in sharp contrast to 2005, there were few landfalls.
- A transition occurred from La Niña in the first quarter of the year to El Niño conditions during the last quarter of the year.

## **SECTION 5: THE POLES.**

- Springtime ozone depletion over the Antarctic in 2006 was by a small margin the most severe ever recorded, reaching an average late-September extent of 27.4 million  $\text{km}^2$ . At the South Pole itself, ozone depletion reached 99% in early October, which is the most on record.

- The year 2006 included both the record minimum and record maximum sea ice extents relative to the 1979–2006 period (the period of accurate satellite observations).
- Seasonal minimum sea ice extent in the Northern Hemisphere (typically occurring in September) was again near record low levels. The September rate of sea ice decline is now near 9% per decade<sup>-1</sup>, equating to a loss of over 60,000 km<sup>2</sup> of ice extent per year.

**SECTION 6: REGIONAL CLIMATES.** Numerous noteworthy climate events occurred in 2006 on the regional scale (Fig. 1).

- Africa: Precipitation was generally above average over much of sub-Saharan Africa. Flooding caused substantial loss of life and property, including over eastern Africa, which had been grappling with a multiyear drought before the deluge. Flooding also wreaked havoc in Nigeria, Malawi, and Algeria. Temperatures were above average for most of the continent.
- North America: Canada and the United States experienced one of their two warmest years on record. Heavy rainfall fell over the Northwest, Great Lakes, and New England regions of the United States, while much of the interior faced intense drought conditions. Mexico was warmer than normal and slightly wetter than average.
- Central America and the Caribbean: Much of the region was dry and warm. The lack of rain was attributable in part to the lack of tropical cyclones



Fig. 1. Geographical distribution of notable climate anomalies and events occurring around the planet in 2006.

impacting the region, as well as the emergence of El Niño late in the year.

- South America: The overall weather conditions varied from very wet to very dry. However, the year was warm throughout most of the continent. Classical ENSO teleconnections, as well as modulation by the Madden–Julian oscillation were observed.
- Asia: Russian temperatures were anomalously warm, especially in December when records were broken, including in Moscow. However, January was very cold across the country. China experienced its warmest year on record, and experienced rainfall deficits. The Indian monsoon onset commenced in the fourth pentad in May. Heat waves struck parts of south Asia in May and June.
- Europe: Europe was unusually warm, with new high temperature records set in many countries. A summer heat wave and a very warm autumn contributed to this warmth.
- Oceania: Parts of Australia were the warmest on record. Many locations were impacted by severe drought and TCs, including TC Larry, which was one of the strongest storms to hit Australia in decades.