1. INTRODUCTION—K. A. Shein[82]

This past year, 2005, was a year of weather records. Unfortunately, many of these records came with a record price. At the December 2005 United Nations Climate Change Conference [Conference of the Parties to the Convention (COP) 11 & COP/Meeting of the Party to the Protocol (MOP) 1] in Montreal, Quebec, Canada, the Munich Re Foundation (reinsurance) noted that preliminary estimates of global economic losses in which the weather was a contributing factor exceeded $200 billion U.S. Dollars (USD). This easily tops the previous record of $175 billion USD in losses in 1995, and makes 2005 the costliest weather year on record [source: Inter-Press Service and United Nations Framework Convention on Climate Change (UNFCCC)]. Of these losses, approximately $185 billion USD are attributed to windstorms (e.g., tropical cyclones), of which $125 billion were due to Hurricane Katrina, the costliest hurricane in recorded history (Munich Re 2006).

In addition, the several global temperature datasets currently used by various institutions to estimate globally averaged annual temperatures were in agreement that 2005 was one of the warmest years in the historical record. The Smith and Reynolds (2005) surface (land and ocean) temperature dataset in use at the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) places 2005 as the warmest on record, although the 2005 anomaly was statistically indistinguishable from the previous record warmth of 1998. This record 2005 temperature is made even more remarkable given that it occurred in the absence of a strong El Niño anomaly.

This special supplement to *BAMS* presents a discussion and analysis of the global climate system for 2005, and discusses some of the more notable regional climatic events that had impacts on society. The purpose of the State of the Climate series of publications is to summarize the climate conditions of the past calendar year, and to put those conditions into a historical perspective, both globally and regionally.

Overall, this is the 16th annual State of the Climate report (known as the Climate Assessment until 2001) and the 10th year that the article has appeared as part of *BAMS*. However, this is the first year that the State of the Climate is appearing as a special supplement to *BAMS*. For the past six years, NOAA's NCDC has taken the lead in the document's development and production. However, this effort is truly international, with contributions from scientists from numerous institutions and organizations around the world. Special effort has been made to acknowledge all contributors, and authorship has been noted through citation by individual sections, as well as in the list of authors and the acknowledgements in the appendix. Furthermore, we acknowledge the important contribution of the World Meteorological Organization (WMO) in helping to identify and encouraging the participation of authors from regions previously underrepresented in this publication.

It should be noted that, given the complexity and variability of the global climate system, it is impossible to provide comprehensive coverage of all aspects of the observed annual climate in a document of this length. However, the authors, editors, and contributors to the State of the Climate have made every effort to address the most important aspects and events related to the climate of 2005, and have attempted to convey these to a broad audience. Additionally, data-gathering efforts, quality control, and analysis continue long after year end. Thus, although the information presented in the State of the Climate in 2005 reflects the most current data available as of early 2006, values should be considered open to update as datasets are refined.

Each year, the scope of this publication is broadened with the discussion of additional climatic variables, introduction of new or unusual topics, and expansion of coverage of regional climate summaries. Included this year is an in-depth analysis of the record Atlantic basin tropical storm season, the addition of a section on tropical convergence zones, and the improved coverage of the oceans through close collaboration with authors of the Annual Report on the State of the Oceans (NOAA OCO 2006).

The following is an executive summary that highlights many of the most important topics and statistics of the climate of 2005.

Section 2: Global climate

- Globally averaged mean annual air temperature in 2005 slightly exceeded the previous record heat of 1998, making 2005 the warmest year on record. Monthly average surface air temperatures were above normal in all 12 months.
- The globally averaged annual air temperature in 2005 was 0.62°C above the 1880–2004 mean (0.53°C above the 1961–90 mean), while 1998 was +0.59°C (+0.50°C) according to the Smith and Reynolds (2005) dataset in use at NOAA/NCDC. Comparatively, other global temperature datasets obtained slightly different values and rankings for 2005; however, no dataset was able to identify a statistically significant difference between the temperatures of the two years.

- Precipitation was, globally, at or near mean annual totals over land areas, but snow cover was below average across much of the Northern Hemisphere (NH). The NH annual snow cover extent averaged 24.7 million km^2 in 2005, 0.9 million fewer than average.
- The year was the second warmest on record for lower tropospheric temperature, with polar regions being the warmest on record. Similar warm anomalies were reported for the middle–upper troposphere. High-latitude lower-stratospheric temperatures were very cold in the NH, but were warmer than average over the Southern Hemisphere (SH).

Section 3: Global oceans

- Globally averaged sea surface temperature (SST) was above normal in 2005 (1971–2002 base), as measured by ship and buoy in situ data as well as Advanced Very High Resolution Radiometer (AVHRR) satellite remote sensing. Such positive anomalies reflect a continuance of the general warming trend seen in SST since 1971. As with 2004, high-latitude locations in the North Atlantic and North Pacific experienced the greatest positive departures. Furthermore, the areal extent of July–August SST greater than 28°C in the tropical North Atlantic increased from 2004 to 2005.
- Ocean currents were near to slightly stronger than normal in 2005, while thermohaline circulation, as measured in the Florida Straits, was near the long-term mean.
- Sea levels, based on tide gauges and satellite altimetry, were generally above average over most of the global ocean (1993–2001 base), and were consistent with long-term increases of 2.9 ±0.4 mm yr^{-1}. The highest positive anomalies were in the Tropics and SH.
- Carbon inventories may be increasing in the Pacific basin at about twice the rate of the Atlantic.

Section 4: The Tropics

- The 2004/05 El Niño did not materialize beyond a weak warm phase, which largely ended by February. Convection was suppressed across the equatorial Pacific for much of the year. Two active phases of the Madden–Julian oscillation (MJO) generated Kelvin waves that contributed to intra-annual oscillations in equatorial Pacific SST.
- The tropical cyclone season was extremely active in the North Atlantic, but was below normal in several other basins. There was an above-average number (103) of named storms globally in 2005, but the number of hurricanes/typhoons/cyclones (53) was below average. The number of major storms (28) was slightly above average. The Atlantic basin had record tropical activity, as well as several record-setting storms [e.g., lowest central pressure (Hurricane Wilma), most category 5 storms in a season (3), and most northeasterly genesis (Hurricane Vince)].

Section 5: The Poles

- In the Arctic, annually averaged surface air temperature remained above the twentieth century mean, although it was cooler than in the past two years.
- The Arctic Oscillation (AO) index was slightly negative in 2005, consistent with low index values since the mid-1990s.
- In the Arctic Ocean, the heat content of the Beaufort Gyre increased (the result of a twofold increase in Atlantic layer water temperature), and the center of freshwater shifted toward Canada and intensified.
- Record minimum NH sea ice extents were observed in every month of 2005 except May. This continues a substantial negative trend in NH sea ice extent since 1979.
- In 2005, the Arctic tundra greenness, as measured by the Normalized Difference Vegetation Index (NDVI), continued a marked trend toward greener conditions. This was coupled with a general increase in total annual discharge from large Eurasian pan-Arctic rivers, and an increase in permafrost temperatures over the past several decades.

Section 6: Regional climates

A number of significant climatic conditions affected various regions in 2005 (Fig. 1.1). This section expands upon the global coverage of previous sections by summarizing and discussing the climatic conditions and notable events that occurred in many of the world's geographic regions.

- *Africa:* Patchy and sporadic rainfall was common during the rainy seasons in the Greater Horn region, resulting in persistent drought over much of the region throughout the year. A few strong April storms generated flash floods in parts of the region. Meanwhile, western Africa experienced its second wettest rainy season since 1994, although a few areas were drier than normal. The heavy precipitation and flooding fostered a widespread cholera epidemic. Northern Africa experienced 0.25°–1.5°C above-normal average temperatures in 2005, but began the year with record cold tem-

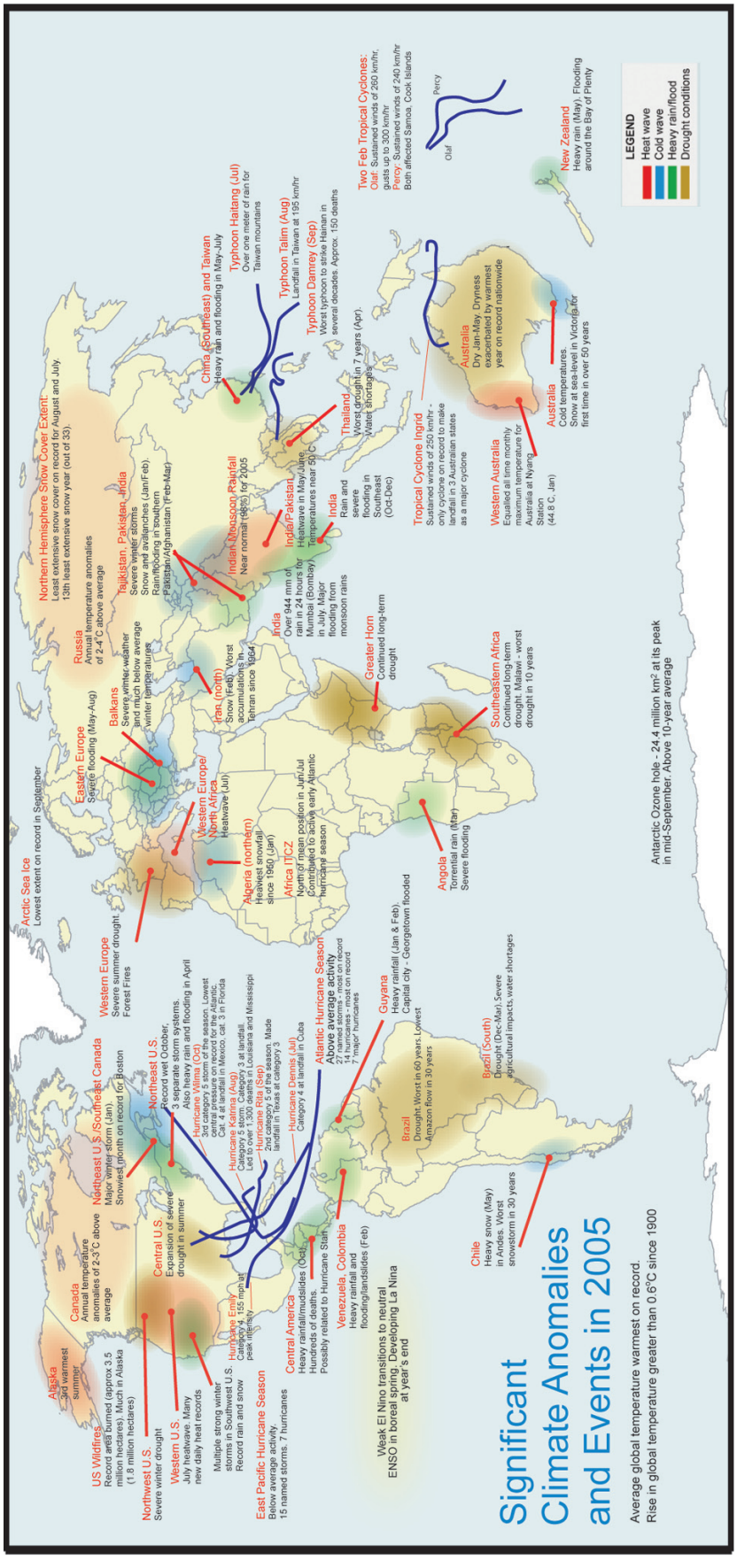

Fig. 1.1. Geographical distribution of notable climate anomalies and events occurring around the planet in 2005. [Source: NOAA/NCDC; online at www.ncdc.noaa.gov/oa/climate/research/2005/ann/ann05.html]

peratures in places. With a few exceptions, North African precipitation was generally below normal. Similarly, southern Africa also experienced warmer-than-normal annual average temperatures, but precipitation was near average after a dry start to the year.

- *North America:* In general, North America was warmer and wetter than normal in 2005. Canadian high latitudes experienced the greatest positive temperature anomalies (some near record), as well as substantially above-normal precipitation. This year was the wettest in recorded history for Canada, which included several widespread flood events in Manitoba, Alberta, and Ontario. Furthermore, Canadian Arctic sea ice extent dropped to its record lowest level, continuing the decline of roughly 8% decade^{-1} since the 1970s. The contiguous United States recorded its seventh warmest year on record, reinforcing the warming trend of the past 30 years. Unlike Canada, the United States experienced near-normal precipitation, with drought conditions in central regions and excessive precipitation in the northeast and southwest. The United States was struck by several major hurricanes, including Katrina and Rita, which resulted in losses over $125 billion USD and well over 1,000 fatalities (Munich Re 2006). A record area of the United States also was impacted by wildfires. Mexico observed above-normal precipitation, partially due to the active tropical season (e.g., Hurricanes Stan and Wilma), and had its second warmest year on record. Wilma was Mexico's most powerful landfalling hurricane on record.
- *Central America:* Annual mean temperatures were slightly above normal across Central America and the Caribbean in 2005, and conditions were generally drier than the long-term average (1979–2000). Cuban drought conditions eased, with above-normal conditions in eastern parts of the island. The region experienced heavy damage and a high death toll from the tropical storm season. Hurricane Stan brought torrential rain to Guatemala, and roughly 1,500 fatalities were reported in association with the storm.
- *South America:* Generally below-normal precipitation occurred across most of South America, except in the west and southwest. Eastern South America experienced above-normal temperatures, while western regions were below normal. Western Amazonia recorded its worst drought in 40 years.
- *Asia:* Russia observed its second warmest year on record, with some areas in northeastern Russia up to 10°C above normal in January, and Siberia had its warmest October in 65 years. In China, the annual average temperature was slightly above the 1971–2000 mean (the ninth consecutive warmer-than-normal year) and precipitation was 17.7 mm above normal. An above-normal eight tropical systems struck China in 2005, impacting millions of people and causing large economic losses. The Southeast Asian monsoon was delayed by about 10 days and was weaker than normal. As a result, precipitation in 2005 was below normal over much of continental Southeast Asia, with temperatures slightly above normal. Above-normal rainfall was experienced by many of the Southeast Asian islands. In southern Asia, severe cold started the year, but summer heat waves took their toll, and late-year winter conditions hampered relief efforts related to the 8 October earthquake in Pakistan. The region experienced a variable and delayed monsoon season, with south and west India receiving abundant rainfall while other regions were below normal. One storm deposited 944.2 mm of rainfall over 24 h on Mumbai (Bombay). In southwest Asia, well-above-normal annual average temperatures were observed, and annual precipitation was slightly below normal, although some regions experienced record snowfall or well-above-normal seasonal precipitation.
- *Europe:* Annually averaged air temperatures over Europe were slightly above normal (1961–90), except in parts of the southeast. The United Kingdom and northern Scandinavia experienced exceptional warmth. Precipitation was generally above normal in Eastern Europe and below normal in western regions. Southwest Europe had well-below-average precipitation, with severe drought across the Iberian Peninsula. Several strong extratropical cyclones affected Scandinavia, and flooding occurred in several eastern European countries.
- *Oceania:* For Australia, 2005 was the hottest year on record and temperatures were above normal across much of the region. Australia also recorded extremely dry conditions during the first half of the year, but rebounded in the second half. In general precipitation was below average for the year. New Zealand experienced above-normal temperature in 2005. Spatially variable precipitation ranged from near-record deficits to flooding rains, but on average the country observed slightly below-normal totals for the year. Over the South Pacific, temperatures also were above normal, and precipitation was spatially variable, but averaged near normal. Five strong tropical storms impacted the region, causing damage on several islands.