STATE OF THE CLIMATE IN 2008

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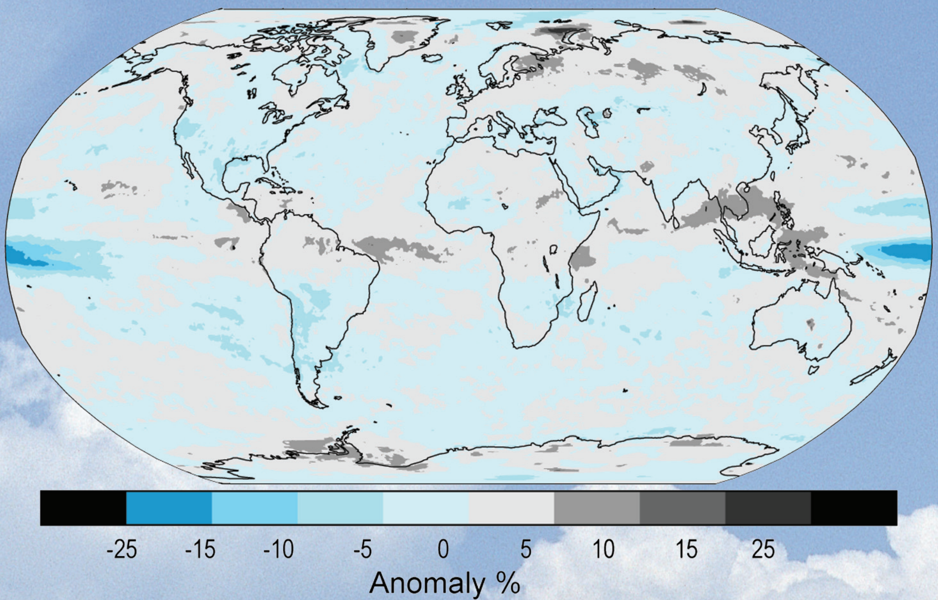
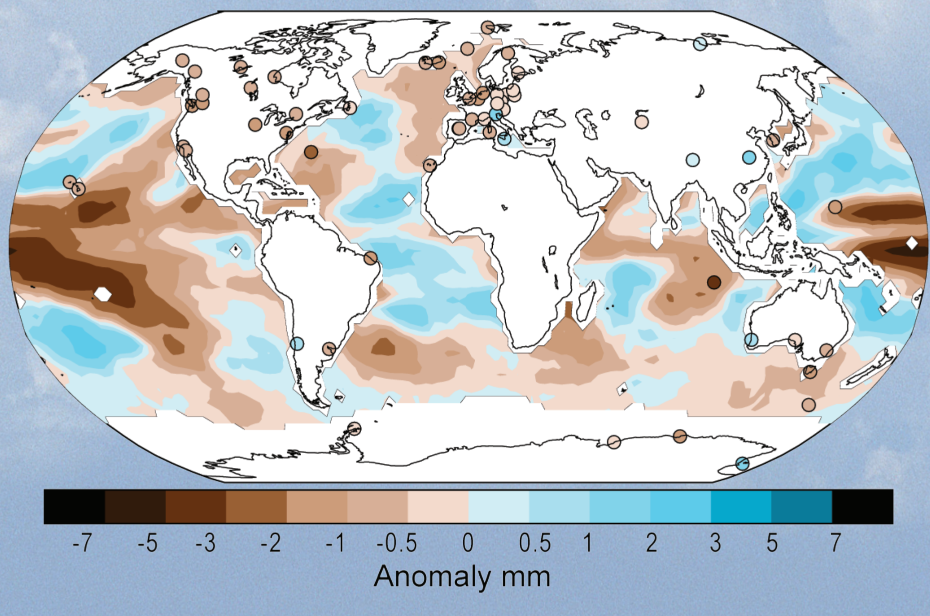
Cloud cover



Total column water vapor



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ABSTRACT—M. O. BARINGER AND T. C. PETERSON

The global mean temperature in 2008 was slightly cooler than that in 2007; however, it still ranks within the 10 warmest years on record. Annual mean temperatures were generally well above average in South America, northern and southern Africa, Iceland, Europe, Russia, South Asia, and Australia. In contrast, an exceptional cold outbreak occurred during January across Eurasia and over southern European Russia and southern western Siberia. There has been a general increase in land-surface temperatures and in permafrost temperatures during the last several decades throughout the Arctic region, including increases of 1° to 2°C in the last 30 to 35 years in Russia. Record setting warm summer (JJA) air temperatures were observed throughout Greenland.

The year 2008 was also characterized by heavy precipitation in a number of regions of northern South America, Africa, and South Asia. In contrast, a prolonged and intense drought occurred during most of 2008 in northern Argentina, Paraguay, Uruguay, and southern Brazil, causing severe impacts to agriculture and affecting many communities.

The year began with a strong La Niña episode that ended in June. Eastward surface current anomalies in the tropical Pacific Ocean in early 2008 played a major role in adjusting the basin from strong La Niña conditions to ENSO-neutral conditions by July–August, followed by a return to La Niña conditions late in December. The La Niña conditions resulted in far-reaching anomalies such as a cooling in the central tropical Pacific, Arctic Ocean, and the regions extending from the Gulf of Alaska to the west coast of North America; changes in the sea surface salinity and heat content anomalies in the tropics; and total column water vapor, cloud cover, tropospheric temperature, and precipitation patterns typical of a La Niña. Anomalously salty ocean surface salinity values in climatologically drier locations and anomalously fresh values in rainier locations observed in recent years generally persisted in 2008, suggesting an increase in the hydrological cycle.

The 2008 Atlantic hurricane season was the 14th busiest on record and the only season ever recorded with major hurricanes each month from July through November. Conversely, activity in the northwest Pacific was considerably below normal during 2008. While activity in the north Indian Ocean was only slightly above average, the season was punctuated by Cyclone Nargis, which killed over 145,000 people; in addition, it was the seventh-strongest cyclone ever in the basin and the most devastating to hit Asia since 1991.

Greenhouse gas concentrations continued to rise, with CO_2 increasing by more than expected based on the 1979 to 2007 trend. In the oceans, the global mean CO_2 uptake for 2007 is estimated to be 1.67 Pg-C, about 0.07 Pg-C lower than the long-term average, making it the third-largest anomaly determined with this method since 1983, with the largest uptake of carbon over the past decade coming from the eastern Indian Ocean. Global phytoplankton chlorophyll concentrations were slightly elevated in 2008 relative to 2007, but regional changes were substantial (ranging to about 50%) and followed long-term patterns of net decreases in chlorophyll with increasing sea surface temperature. Ozone-depleting gas concentrations continued to fall globally to about 4% below the peak levels of the 2000–02 period. Total column ozone concentrations remain well below pre-1980, levels and the 2008 ozone hole was unusually large (sixth worst on record) and persistent, with low ozone values extending into the late December period. In fact the polar vortex in 2008 persisted longer than for any previous year since 1979.

Northern Hemisphere snow cover extent for the year was well below average due in large part to the record-low ice extent in March and despite the record-maximum coverage in January and the shortest snow cover duration on record (which started in 1966) in the North American Arctic. Limited preliminary data imply that in 2008 glaciers continued to lose mass, and full data for 2007 show it was the 17th consecutive year of loss. The northern region of Greenland and adjacent areas of Arctic Canada experienced a particularly intense melt season, even though there was an abnormally cold winter across Greenland's southern half. One of the most dramatic signals of the general warming trend was the continued significant reduction in the extent of the summer sea-ice cover and, importantly, the decrease in the amount of relatively older, thicker ice. The extent of the 2008 summer sea-ice cover was the second-lowest value of the satellite record (which started in 1979) and 36% below the 1979–2000 average. Significant losses in the mass of ice sheets and the area of ice shelves continued, with several fjords on the northern coast of Ellesmere Island being ice free for the first time in 3,000–5,500 years.

In Antarctica, the positive phase of the SAM led to record-high total sea ice extent for much of early 2008 through enhanced equatorward Ekman transport. With colder continental temperatures at this time, the 2007–08 austral summer snowmelt season was dramatically weakened, making it the second shortest melt season since 1978 (when the record began). There was strong warming and increased precipitation along the Antarctic Peninsula and west Antarctica in 2008, and also pockets of warming along coastal east Antarctica, in concert with continued declines in sea-ice concentration in the Amundsen/Bellingshausen Seas. One significant event indicative of this warming was the disintegration and retreat of the Wilkins Ice Shelf in the southwest peninsula area of Antarctica.

I. INTRODUCTION—T. C. Peterson and M. O. Baringer

The primary goal of the annual *State of the Climate* collection of articles is to document the year's current weather and climate events from around the world, such as those shown in Fig. 1.1, and put them into accurate historical perspective, with a particular focus on unusual or anomalous events from the past year. This year the *State of the Climate* brings together more than 280 authors from every continent and from numerous different research groups to collaborate, to share data and insights, and to describe the observed changes in climate from different perspectives. Indeed, this year's report has gained an even wider international perspective with the addition of chapter editors from the Met Office, Environment Canada, and Australia's National Climate Centre, as well as an expanding list of international authors. One of the lessons learned from addressing apparent inconsistencies in observations is that one dataset is great but multiple datasets are better because they confirm results and/or help provide estimates of uncertainty (Karl et al. 2001). With this in mind, the authors and editors seek to provide an inclusive synthesis of diverse sources of weather and climate data to describe what took place across our planet last year.

As a guiding principle behind the inclusion of certain climatic variabiles into this report, the Global Climate Observing System has identified Essential Climate Variables (GCOS 2003) (see the appendix for a full list of abbreviations) that are necessary to support the United Nations Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change. These variables are defined as those required for international exchange and should be economically and technically feasible to acquire (Table 1). Some other variables important for research purposes are not included as ECVs; however, the GCOS list of ECVs as well as the other variables presented in this report are continually being reassessed as improved observing technologies emerge. The *State of the Climate* report has strived to include an increasing number of these climatically important variables as the data availability increases and the analysis techniques and attributions improve.

The degree to which each of these ECVs can be assessed and reported depends largely on the level of data availability both currently and within the homogeneous historical record; hence the variables can be divided into categories: being monitored, partially monitored, and not yet monitored. To be listed as monitored, the ECV not only has to be observed across much of the world but there also needs to be a moderately long-term dataset with accompanying analysis. For example, some ECVs, such as water vapor, have been observed across the world for over a century. But in that time, the observing instrumentation has changed, imparting artificial biases to the data. Therefore, to be effectively monitored requires not only observations but also adjustments to the historical data to remove or at least greatly diminish artificial biases. Also, the dataset needs to be updated in near-real time and be included in a peer-reviewed article documenting the reliability of all of these steps. It can be hard work, but progress is being made on many fronts. For example, surface water vapor is expected to be fully included in the report next year. In total, 34 GCOS Essential Climate Variables are reported in the 19th annual *State of the Climate* report.

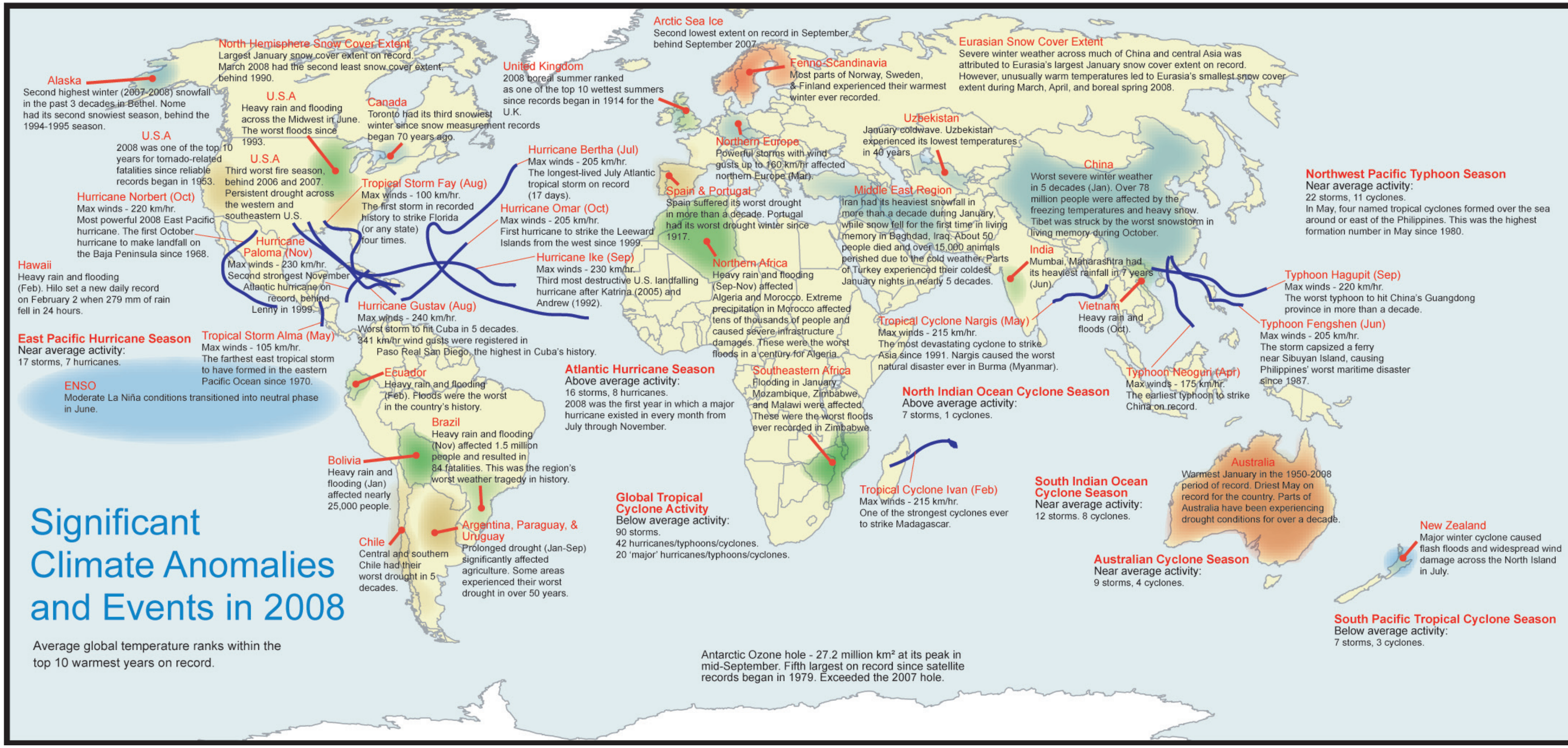

Fig. 1.1. Geographical distribution of notable climate anomalies and events occurring around the planet in 2008.

Table 1.1. The GCOS ECVs and soil moisture (an emerging ECV) and their monitoring status. Like traffic stop lights, green indicates yes, that this ECV is being monitored on a global or near-global scale and that this report includes a section that describes the ECV's changes over time. Amber indicates that the ECV is explicitly discussed in this year's *State of the Climate*, but the data are not updated through 2008 or the coverage is not global. Red indicates more work needs to be done to monitor and document this ECV.

Atmospheric	Ocean	Terrestrial
Surface	**Surface**	Soil moisture (Emerging ECV)
Air temperature	Sea surface temperature	Snow cover
Precipitation	Sea surface salinity	Permafrost and seasonally-frozen ground
Air pressure	Sea level	Glaciers and ice caps
Surface radiation budget	Sea state	River discharge
Wind speed and direction	Sea ice	Water use
Water vapor	Current	Ground water
Upper Air	Ocean color	Lake levels
Earth radiation budget	Carbon dioxide partial pressure	Albedo
Upper-air temperature	**Subsurface**	Land cover
Wind speed and direction	Temperature	Fraction of absorbed photosynthetically active radiation
Water vapor	Salinity	Leaf area index
Cloud properties	Current	Biomass
Composition	Nutrients	Fire disturbance
Carbon dioxide	Carbon	
Methane	Ocean tracers	
Ozone	Phytoplankton	
Nitrous oxide		
Chlorofluorocarbons		
Hydrochlorofluorocarbons		
Hydrofluorocarbons		
Sulphur hexaflurorides		
Perfluorocarbons		
Aerosol properties.		