I. INTRODUCTION—D. S. Arndt, J. Blunden, and G. Hartfield

This is the 28th issuance of the annual assessment now known as *State of the Climate*, published in the Bulletin since 1996. As a supplement to the Bulletin, its foremost function is to document the status and trajectory of many components of the climate system. However, as a series, the report also documents the status and trajectory of our capacity and commitment to observe the climate system.

The year was nominally characterized as "ENSO neutral," although most metrics indicate La Niña or nearly La Niña status early and late in the year. As is typical for this series, the characterization of ENSO status varies slightly by discipline, region, and available pertinent data. Readers may notice some variation in the characterization and timing of ENSO status from section to section.

If the report's authors and their datasets are the lifeblood of this series, the chapter editors are surely the heart. They drive the development of their chapters, keeping pace with the evolution of available data, available authors, and the state of the science. The majority of sections of this report are updates. Although new technologies, new analysis methods, and new datasets contribute dynamism to this volume, it is inevitable that some passages, particularly those that describe observational or analytical methods, borrow heavily from the text of previous reports. Changes in this year's report, relative to recent years, include: explicit treatments of ocean acidification observations in both the Global Oceans chapter's global ocean carbon cycle section and the Antarctica chapter's Southern Ocean section; a subdividing of the Arctic chapter's section on sea ice cover to include explicit and separate analyses of ice age, extent, and thickness, including snow depth; a diversification of authors and nations addressed in the African section; and streamlining and combining of subsections within several chapters.

This edition's 16 sidebar articles remind us that the climate is not experienced in annual averages, and that living systems, including humans, experience climate change and variability most deeply in the form of impacts and extremes. Several sidebars deal with extreme precipitation, how it is assessed, or weather systems that delivered extreme precipitation during 2017. A multiyear look at this decade's repeated coral bleaching episodes provides a thorough, if sobering, assessment. Other sidebars address the profound physical and human toll of the 2017 North Atlantic hurricane season. Some feature new and advanced technologies for observing the climate system, while others highlight the value of less familiar observation approaches: those dealing with phenology, paleoclimate records, and, for the second consecutive *State of the Climate* report, indigenous knowledge.

Our cover this year reflects the interplay between the climate and living systems in the state of California. The early-2017 "superbloom" depicted on the front cover was an immediate response to the first productive wet season in several years for the region. Unfortunately, much of that new additional biomass became fuel for raging wildfires later in the year, as depicted on the back cover. The two covers illustrate these dichotomous outcomes—sublime and serene on the front, destructive on the back—with the same color palette.

We are saddened at the news of Dr. Olga Bulygina's passing in June, as this document was being assembled. Dr. Bulygina was a constant in the building, sharing, and analysis of climatological datasets. She was a reliable and skillful author of the Russian section for many editions of the *State of the Climate*, including this one. We will remember her fondly, and we wish her family and her colleagues well.

An overview of findings is presented in the Abstract, Fig. 1.1, and Plate 1.1. Chapter 2 features global-scale climate variables; Chapter 3 highlights the global oceans; and Chapter 4 discusses tropical climate phenomena including tropical cyclones. The Arctic and Antarctica respond differently through time and are reported in separate chapters (5 and 6, respectively). Chapter 7 provides a regional perspective authored largely by local government climate specialists. A list of relevant datasets and their sources for all chapters is provided as an Appendix.



Time series of major climate indicators are again presented in this introductory chapter. Many of these indicators are essential climate variables (ECVs), originally defined in GCOS (2003) and updated again by GCOS (2010). The following ECVs, included in this edition, are considered "fully monitored," in that they are observed and analyzed across much of the world, with a sufficiently longterm dataset that has peer-reviewed documentation:

- Atmospheric Surface: air temperature, precipitation, air pressure, water vapor, wind speed and direction
- Atmospheric Upper Air: Earth radiation budget, temperature, water vapor, wind speed and direction
- Atmospheric Composition: carbon dioxide, methane, other long-lived gases, ozone
- Ocean Surface: temperature, salinity, sea level, sea ice, current, ocean color, phytoplankton
- Ocean Subsurface: temperature, salinity
- Terrestrial: snow cover, albedo

ECVs in this edition that are considered "partially monitored," meeting some but not all of the above requirements, include:

- Atmospheric Upper Air: cloud properties
- Atmospheric Composition: aerosols and their precursors
- Ocean Surface: carbon dioxide, ocean acidity
- Ocean Subsurface: current, carbon

Terrestrial: soil moisture, permafrost, glaciers and ice caps, river discharge, groundwater, ice sheets, fraction of absorbed photosynthetically active radiation, lakes, biomass, fire disturbance

Remaining ECVs that are desired for the future include:

- Atmospheric Surface: surface radiation budget
- Ocean Surface: sea state
- Ocean Subsurface: nutrients, ocean tracers, ocean acidity, oxygen
- Terrestrial: water use, land cover, leaf area index, soil carbon

PLATE 1.1. Global (or representative) average time series for essential climate variables through 2017. Anomalies are shown relative to the base period in parentheses although base periods used in other sections of the report may differ. The numbers in the square brackets that follow in this caption indicate how many reanalysis (blue), satellite (red), and in situ (black) datasets are used to create each time series in that order. (a) N. Hemisphere polar stratospheric ozone (March) [0,0,1]; (b) S. Hemisphere polar stratospheric ozone (October) [0,0,1]; (c) Arctic air temperature (60°-90°N) [0,0,1]; (d) Surface temperature [0,0,4]; (e) Lower tropospheric temperature [3,2,4]; (f) Lower stratospheric temperature [3,3,4]; (g) Extremes [warm days (solid) and cool nights (dotted)] [0,0,1]; (h) Arctic sea ice extent [max (solid) and min (dashed)] [0,0,1]; (i) Antarctic sea ice extent [max (solid) and min (dashed)] [0,0,1]; (j) Glacier cumulative mean specific balance [0,0,1]; (k) N. Hemisphere snow cover extent [0,1,0]; (1) Lower stratospheric water vapor [0,0,1]; (m) Cloudiness [0,8,0]; (n) Total column water vapor - land [3,1,1]; (o) Total column water vapor - ocean [3,2,0]; (p) Upper tropospheric humidity [0,2,0]; (q) Specific humidity - land [3,0,4]; (r) Specific humidity - ocean [3,1,3]; (s) Relative humidity - land [3,0,4]; (t) Relative humidity - ocean [3,0,2]; (u) Precipitation - land [0,0,4]; (v) Southern Oscillation index [0,0,1]; (w) Ocean heat content (0-700m) [0,0,5]; (x) Sea level rise [0,0,1]; (y) Tropospheric ozone [0,1,0]; (z) Tropospheric wind speed at 850 hPa for $20^{\circ}-40^{\circ}N$ [4,0,1]; (aa) Land wind speed [0,0,1]; (ab) Ocean wind speed [3,1,0]; (ac) Biomass burning [0,3,0]; (ad) Soil moisture [0,1,0]; (ae) Terrestrial groundwater storage [0,1,0]; (af) Fraction of absorbed photosynthetically active radiation (FAPAR) [0,1,0]; (ag) Land surface albedo - visible (solid) and infrared (dashed) [0,1,0].



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Fig. 1.1. Geographical distribution of selected notable climate anomalies and events in 2017.