STATE OF THE CLIMATE IN 2007

AFFILIATIONS (ALPHABETICAL BY AUTHOR)

1. Aceituno, Patricio, Universidad de Chile, Santiago, Chile
2. Achberger, Christine, Earth Sciences Centre, University of Gothenburg, Gothenburg, Sweden
3. Arguez, Anthony, NOAA/NESDIS National Climatic Data Center, Asheville, North Carolina
4. Armstrong, R., CIRES/NSIDC, University of Colorado, Boulder, Colorado
5. Ashik, I., Arctic and Antarctic Research Institute, St. Petersburg, Russia
6. Attaher, Samar M., Ministry of Agriculture and Land Reclamation, Cairo, Egypt
7. Bader, Stephan, MeteoSwiss, Zurich, Switzerland
8. Báez, Julián, Dirección Nacional de Aeronáutica Civil, Asunción, Paraguay
9. Bai, L.-S., Byrd Polar Research Center, The Ohio State University, Columbus, Ohio
10. Baringer, Molly O., NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory, Physical Oceanography Division, Miami, Florida
11. Barreira, S., Argentine Navy Meteorological Service, Argentine Hydrographic Service, Buenos Aires, Argentina
12. Baum, Bryan, Space Science and Engineering Center, University of Wisconsin—Madison, Madison, Wisconsin
13. Behrenfeld, Michael J., Oregon State University, Corvallis, Oregon
14. Bell, Gerald D., NOAA/NWS/NCEP Climate Prediction Center, Camp Springs, Maryland
15. Beswick, Mark, Met Office, Exeter, United Kingdom
16. Bidegain, Mario, Universidad de la República, Montevideo, Uruguay
17. Bissolli, Peter, German Meteorological Service, Offenbach, Germany
18. Blake, Eric, NOAA/NWS/NCEP National Hurricane Center, Miami, Florida
19. Boudet-Roco, Dagne, Instituto de Meteorología, La Habana, Cuba
20. Bourassa, Mark, Center for Ocean–Atmosphere Prediction Studies, The Florida State University, Tallahassee, Florida
21. Box, J., Byrd Polar Research Center, The Ohio State University, Columbus, Ohio
22. Bromwich, D., Byrd Polar Research Center, The Ohio State University, Columbus, Ohio
23. Buchel, Denise, Meteorological Service of Luxembourg, Luxembourg, Luxembourg
24. Bulygina, Olga N., All-Russian Research Institute of Hydrometeorological Information, Obninsk, Russia
25. Burgess, Stuart M., National Institute of Water and Atmospheric Research, Ltd., Wellington, New Zealand
26. Busuioc, Aristata, National Meteorological Administraion, Bucharest, Romania
27. Camargo, Suzana J., Lamont-Doherty Earth Observatory, The Earth Institute at Columbia University, Palisades, New York
28. Cappelen, John, Danish Meteorological Institute, Copenhagen, Denmark
29. Carmack, E., Arctic and Antarctic Research Institute, St. Petersburg, Russia
30. Carrión Romero, Ana M., Instituto de Meteorología, La Habana, Cuba
31. Cegnar, Tanja, Environmental Agency of the Republic of Slovenia, Ljubljana, Slovenia
32. Chen, Deliang, Earth Sciences Centre, University of Gothenburg, Gothenburg, Sweden
33. Chen, Yu, National Climate Center, China Meteorological Administration, Beijing, China
34. Christy, John R., University of Alabama in Huntsville, Huntsville, Alabama
35. Coelho, Caio A. S., CPTEC/INPE, Center for Weather Forecasts and Climate Studies, Cachoeira Paulista, Brazil
36. Colombo, Tiziano, CNMCA, Pomezia/Rome, Italy
37. Colwell, S., British Antarctic Survey, Cambridge, England, United Kingdom
38. Comiso, J., NASA Goddard Space Flight Center, Greenbelt, Maryland
39. Croci-Maspoli, Mischa, Zurich, Switzerland
40. Cupo, Jeffrey P., NOAA/NWS, San Juan, Puerto Rico
41. Cutié Cansino, Virgen, Instituto de Meteorología, La Habana, Cuba
42. Davydova-Belitskaya, Valentina, National Meteorological Service (SMN/CONAGUA), Mexico City, Mexico
43. Demircan, Mesut, Turkish State Meteorological Service, Kalaba/Ankara, Turkey
44. Derka, Helmut, ZAMG, Vienna, Austria
45. Diamond, Howard J., NOAA/NESDIS National Climatic Data Center, Silver Spring, Maryland
46. Djordjevic, Smilija, Republic Hydrometeorological Service of Serbia, Belgrade, Serbia
47. Dlugokencky, Edward, NOAA/OAR Earth Systems Research Laboratory, Boulder, Colorado
48. Dutton, Geoff S., NOAA/OAR Earth Systems Research Laboratory, Boulder, Colorado
49. Elkins, James W., NOAA/OAR Earth Systems Research Laboratory, Boulder, Colorado
50. Evan, Amato T., Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin—Madison, Madison, Wisconsin
51. Feely, Richard A., NOAA/OAR Pacific Marine Environmental Laboratory, Seattle, Washington
52. Fetterer, F., CIRES National Snow and Ice Data Center, University of Colorado, Boulder, Colorado
53. Fogt, R. L., NOAA/Earth Systems Research Laboratory, Boulder, Colorado
54. Fonseca Rivera, Cecilia, Instituto de Meteorología, La Habana, Cuba
55. Free, Melissa P., NOAA/OAR/Air Resources Laboratory, Silver Spring, Maryland
56. Fritsch, Rick, NOAA/NWS, Anchorage, Alaska
57. Frolov, I., Arctic and Antarctic Research Institute, St. Petersburg, Russia
58. Frutos, Ramon, National Meteorological/Hydrological Service, Belize City, Belize

59. García-Herrera, Ricardo, Universidad Complutense, Madrid, Spain
60. Gascard, J. C., Université Pierre et Marie Curie, Paris, France
61. Gill, Stephen, NOAA/NOS Center for Operational Oceanographic Products and Services, Silver Spring, Maryland
62. Gleason, Karin L., NOAA/NESDIS National Climatic Data Center, Asheville, North Carolina
63. Goldenberg, Stanley B., NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory, Miami, Florida
64. Gomboluudev, Purevjav, Institute of Meteorology and Hydrology, Ulaanbaatar, Mongolia
65. Goni, Gustavo Jorge, NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory, Physical Oceanography Division, Miami, Florida
66. Gordon, Ann, National Meteorological/Hydrological Service, Belize City, Belize
67. Gottschalck, Jonathan C., NOAA/NWS/NCEP Climate Prediction Center, Camp Springs, Maryland
68. Gouveia, Célia C., Instituto Politécnico de Setúbal and Universidade de Lisboa, Lisbon, Portugal
69. Grooters, Frank, KNMI, De Bilt, Netherlands
70. Guard, Charles, NOAA National Weather Service, Barrigada, Guam
71. Guo, Yanjun, National Climate Center, Beijing, China
72. Haimberger, Leopold, University of Vienna, Vienna, Austria
73. Halpert, Michael S., NOAA/NWS/NCEP Climate Prediction Center, Camp Springs, Maryland
74. Hardwick, Jen, Met Office, Exeter, United Kingdom
75. Hechler, Peer, German Meteorological Service, Offenbach, Germany
76. Heidinger, Andrew K., NOAA/NESDIS Center for Satellite Applications and Research, Cooperative Research Program, University of Wisconsin—Madison, Madison, Wisconsin
77. Heim, Richard R., Jr., NOAA/NESDIS National Climatic Data Center, Asheville, North Carolina
78. Hellström, Sverker, Swedish Meteorological and Hydrological Institute, Norrköping, Sweden
79. Hoerling, M. P., NOAA/CIRES Climate Diagnostics Center, Boulder, Colorado
80. Horvitz, Andy, NOAA/NWS/Office of Climate Water and Weather Services, Silver Spring, Maryland
81. Hotanova, Eva, Czech Hydrometeorological Institute, Prague, Czech Republic
82. Hovsepyan, Anahit, Armstatehydromet, Yerevan, Armenia
83. Hughes, Paul J., Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, Florida
84. Hurtado, Gonzalo, Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia, Bogotá, Colombia
85. Iden, Knut A., Norwegian Meteorological Office, Oslo, Norway
86. Itoh, M., Institute of Observational Research for Global Change, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan
87. Jaimes Espinoza, Ena M., Servicio Nacional de Meteorología e Hidrología (SENAMHI), Lima, Perú
88. Janowiak, John E., NOAA/NWS/NCEP Climate Prediction Center, Camp Springs, Maryland
89. Jezek, Ken, Byrd Polar Research Center, The Ohio State University, Columbus, Ohio
90. Jia, G., RCE/TEA, Chinese Academy of Science, Beijing, China
91. Johnson, Gregory C., NOAA/OAR Pacific Marine Environmental Laboratory, Seattle, Washington
92. Jonsson, Magnus, The Icelandic Meteorological Office, Reykjavik, Iceland
93. Kabidi, Khadija, Direction de la Météorologie Nationale, Rabat, Morocco
94. Kadi, Mohamed, African Centre of Meteorological Applications for Development, Niamey, Niger
95. Karkozas, Juozas, Lithuanian Hydrometeorological Service, Vilnius, Lithuania
96. Katusin, Zvonimir, Meteorological and Hydrological Service, Zagreb, Croatia
97. Kennedy, John J., Hadley Centre for Climate Change, Met Office, Exeter, United Kingdom
98. Khoshkam, Mahbobeh, Islamic Republic of Iran Meteorological Organization, Tehran, Iran
99. Kimberlain, Todd, NOAA/NWS/NCEP National Hurricane Center, Miami, Florida
100. Korshunova, Natalia N., All-Russian Research Institute of Hydrometeorological Information, Obninsk, Russia
101. Krishfield, R., Woods Hole Oceanographic Institution, Woods Hole, Massachusetts
102. Kruger, Andries C., South African Weather Service, Pretoria, South Africa
103. Kruk, Michael C., NOAA/NESDIS/NCDC, Asheville, North Carolina
104. Kulbida, Mykola, Ukrainian Hydrometeorological Center, Kiev, Ukraine
105. L'Heureux, Michelle L., NOAA/NWS/NCEP Climate Prediction Center, Camp Springs, Maryland
106. Lander, Mark A., Water and Environmental Research Institute, University of Guam, Mangilao, Guam
107. Landsea, Chris W., NOAA/NWS/NCEP National Hurricane Center, Miami, Florida
108. Lapinel Pedroso, Braulio, Instituto de Meteorología, La Habana, Cuba
109. Lawrimore, Jay H., NOAA/NESDIS National Climatic Data Center, Asheville, North Carolina
110. Lennon, Peter, Met Éireann, Dublin, Ireland
111. Levinson, David H., NOAA/NESDIS National Climatic Data Center, Asheville, North Carolina
112. Levy, Joel M., NOAA/OAR Climate Program Office, Silver Spring, Maryland
113. Liang, Xiaoyun, China Meteorological Administration, Beijing China
114. Lindsey, Scott, NOAA/NWS, Anchorage, Alaska
115. Liu, H., Department of Geography, Texas A&M University, College Station, Texas

116. Liu, Y., Cooperative Institute of Meteorological Satellite Studies, University of Wisconson—Madison, Madison, Wisconsin
117. López Carmona, Patricio, Centro Internacional para la Investigación del Fenómeno de El Niño (CIIFEN), Guayaquil, Ecuador
118. Lukac, Ivan, Meteorological and Hydrological Service, Zagreb, Croatia
119. Lumpkin, Rick, NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory, Physical Oceanography Division, Miami, Florida
120. Luo, Jing-Jia, Frontier Research Center for Global Change, JAMSTEC, Yokohama, Japan
121. Lyman, John M., NOAA/OAR Pacific Marine Environmental Laboratory, Seattle, Washington, and Joint Institute for Marine and Atmospheric Research, University of Hawaii, Honolulu, Hawai
122. Maddux, B., Department of Atmospheric and Oceanic Science, University of Wisconsin—Madison, Madison, Wisconsin
123. Marengo, Jose A., Instituto Nacional de Pesquisas Espaciais, Cachoeira Paulista, Brazil
124. Martínez Güingla, Rodney, Centro Internacional para la Investigación del Fenómeno de El Niño (CIIFEN), Guayaquil, Ecuador
125. Massom, R. A., Australian Government Antarctic Division and Antarctic Climate and Ecosystems CRC, University of Tasmania, Hobart, Tasmania, Australia
126. Maue, Ryan N., Center for Ocean–Atmospheric Prediction Studies, The Florida State University, Tallahassee, Florida
127. McLaughlin, F., Institute of Ocean Sciences, Sidney, Canada
128. Mears, Carl A., Remote Sensing Systems, San Rafael, California
129. Medany, Mahmoud A., Ministry of Agriculture and Land Reclamation, Cairo, Egypt
130. Meier, W., CIRES/NSIDC, University of Colorado, Boulder, Colorado
131. Meinen, Christopher S., NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory, Physical Oceanography Division, Miami, Florida
132. Menne, Matthew J., NOAA/NESDIS National Climatic Data Center, Asheville, North Carolina
133. Merrifield, Mark A., University of Hawaii at Manoa, Honolulu, Hawaii
134. Mikkelsen, N., Geologic Survey of Denmark and Greenland (GEUS), Copenhagen, Denmark
135. Mitchum, Gary T., University of South Florida, College of Marine Science, St. Petersburg, Florida
136. Monaghan, A., Byrd Polar Research Center, The Ohio State University, Columbus, Ohio
137. Montzka, Stephen A., NOAA/OAR Earth Systems Research Laboratory, Boulder, Colorado
138. Morales, Ernesto, NOAA/NWS, San Juan, Puerto Rico
139. Morison, J., Polar Science Center, University of Washington, Seattle, Washington
140. Mote, T., Department of Geography, University of Georgia, Atlanta, Georgia
141. Mullan, A. Brett, National Institute of Water and Atmospheric Research, Ltd., Wellington, New Zealand
142. Müller-Westermeier, Gerhard, German Meteorological Service, Offenbach, Germany
143. Newman, P. A., Laboratory for Atmospheres, NASA Goddard Space Flight Center, Greenbelt, Maryland
144. Nghiem, S., Jet Propulsion Laboratory, Pasadena, California
145. Njau, Leonard, African Centre of Meteorological Applications for Development, Niamey, Niger
146. Obregón, André, Laboratory for Climatology and Remote Sensing (LCRS), University of Marburg, Marburg, Germany
147. Ogallo, Laban, IGAD Climate Prediction and Applications Centre (ICPAC), Nairobi, Kenya
148. Oludhe, Christopher, University of Nairobi, Nairobi, Kenya
149. O'Malley, Robert T., Oregon State University, Corvallis, Oregon
150. Overland, J., NOAA, Pacific Marine Environmental Laboratory, Seattle, Washington
151. Ozcan, Halis, Turkish State Meteorological Service, Istanbul, Turkey
152. Papineau, John, NOAA/NWS, Anchorage, Alaska
153. Parker, David E., Hadley Centre for Climate Change, Met Office, Exeter, United Kingdom
154. Pasch, Richard, NOAA/NWS/NCEP National Hurricane Center, Miami, Florida
155. Pashiardis, Stelios, Meteorological Service Cyprus, Nicosia, Cyprus
156. Patricio, Domingos M., Instituto Nacional de Meteorologia (INAM), Maputo, Mozambique
157. Pavan, Valentina, ARPA-SIM, Bologna, Italy
158. Pérez Suárez, Ramón, Instituto de Meteorología, La Habana, Cuba
159. Perovich, D., ERDC-Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire
160. Perry, Matthew, Met Office, Exeter, United Kingdom
161. Pezza, Alexandre B., The University of Melbourne, Melbourne, Victoria, Australia
162. Phillips, David, Environment Canada, Ottawa, Ontario, Canada
163. Pires, Oliveira, Portuguese Meteorological Institute, Lisbon, Portugal
164. Polyakov, I., International Arctic Research Center, Fairbanks, Alaska
165. Prior, John, Met Office, Exeter, United Kingdom
166. Proshutinsky, A., Woods Hole Oceanographic Institution, Woods Hole, Massachusetts
167. Quintana, Juan M., Dirección Meteorológica de Chile, Santiago, Chile
168. Quintero Mercado, Alexander, Servicio de Meteorología de la Aviación Militar de Venezuela, Maracay, Venezuela
169. Rahimzadeh, Fatemeh, Atmospheric Science and Meteorological Research Center (ASMERC), Tehran, Iran

170. Rajeevan, Madhavan, National Climate Centre, India Meteorological Department, Pune, India
171. Ramírez, Patricia, Comité Regional de Recursos Hidráulicos (CRRH/SICA), San José, Costa Rica
172. Razuvaev, Vyacheslav N., All-Russian Research Institute of Hydrometeorological Information, Obninsk, Russia
173. Reid, P., Australian Bureau of Meteorology and Antarctic Climate and Ecosystems CRC, University of Tasmania, Hobart, Tasmania, Australia
174. Revadekar, Jayashree, Indian Institute of Tropical Meteorology, Pune, India
175. Reynolds, Richard W., NOAA/NESDIS National Climatic Data Center, Asheville, North Carolina
176. Richter-Menge, J., ERDC-Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire
177. Robinson, David A., Department of Geography, Rutgers–The State University of New Jersey, Piscataway, New Jersey
178. Romanovsky, V., Geophyiscal Institute, University of Alaska, Fairbanks, Fairbanks, Alaska
179. Romero-Cruz, Fernando, National Meteorological Service (SMN/CONAGUA), Mexico City, Mexico
180. Rudels, B., Finnish Institute of Marine Research, Helsinki, Finland
181. Rusticucci, Matilde, Universidad de Buenos Aires, Buenos Aires, Argentina
182. Sabine, Christopher L., NOAA/OAR Pacific Marine Environmental Laboratory, Seattle, Washington
183. Saku, Seppo, Finnish Meteorological Office, Helsinki, Finland
184. Salinger, M. James, National Institute of Water and Atmospheric Research, Ltd., Newmarket, Auckland, New Zealand
185. Sánchez-Lugo, Ahira M., NOAA/NESDIS/NCDC, Asheville, North Carolina
186. Sayouri, Amal, Direction de la Météorologie Nationale, Rabat, Morocco
187. Scambos, T. A., National Snow and Ice Data Center, University of Colorado, Boulder, Colorado
188. Schauer, U., Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremer-haven, Germany
189. Schnell, Russell C., NOAA/OAR Earth Systems Research Laboratory, Boulder, Colorado
190. Sensoy, Serhat, Turkish State Meteorological Service, Ankara, Turkey
191. Shiklomanov, A., University of New Hampshire, Durham, New Hampshire
192. Shimada, K., Institute of Observational Research for Global Change, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan
193. Siegel, David A., University of California, Santa Barbara, Santa Barbara, California
194. Skansi, María de los Milagros, Servicio Meteorológico Nacional, Buenos Aires, Argentina
195. Smith, Shawn R., Center for Ocean–Atmosphere Prediction Studies, The Florida State University, Tallahassee, Florida
196. Sokolov, V., Arctic and Antarctic Research Institute, St. Petersburg, Russia
197. Spence, Jacqueline M., Department of Physics, University of the West Indies, Mona, Jamaica
198. Stammerjohn, S., Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York
199. Steele, M., Polar Science Center, University of Washington, Seattle, Washington
200. Suda, Kazuto, Japan Meteorological Agency, Tokyo, Japan
201. Svabik, Otto, ZAMG, Vienna, Austria
202. Takahashi, Taro, Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York
203. Taylor, Michael A., Department of Physics, University of the West Indies, Mona, Jamaica
204. Thiaw, Wassila M., NOAA/NWS/NCEP Climate Prediction Center, Camp Springs, Maryland
205. Thoman, Rick, NOAA/NWS, Anchorage, Alaska
206. Thorne, Peter, Met Office Hadley Centre, Exeter, United Kingdom
207. Timmermans, M.-L., Woods Hole Oceanographic Institu tion, Woods Hole, Massachusetts
208. Tinni, Seydou, African Centre of Meteorological Applications for Development, Niamey, Niger
209. Titchner, Holly, Met Office Hadley Centre, Exeter, United Kingdom
210. Toole, J., Woods Hole Oceanographic Institution, Woods Hole, Massachusetts
211. Trewin, Blair C., National Climate Centre, Australian Bureau of Meteorology, Melbourne, Victoria, Australia
212. Trigo, Ricardo M., CGUL, IDL, Universidade de Lisboa and Universidade Lusófona, Lisbon, Portugal
213. Turner, J., British Antarctic Survey, Cambridge, United Kingdom
214. Veenhuis, B., Department of Meteorology, The Florida State University, Tallahassee, Florida
215. Velden, Chris, Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin— Madison, Madison, Wisconsin
216. Vinit, Francois, Météo France, Toulouse, France
217. Walker, D., Institute of Arctic Biology, University of Alaska–Fairbanks, Fairbanks, Alaska
218. Walsh, J., International Arctic Research Center, Fairbanks, Alaska
219. Wang, L., Department of Geography and Anthropology, Louisiana State University, Baton Rouge, Louisiana
220. Wang, M., Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, Washington
221. Wanninkhof, Rik, NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory, Ocean Chemistry Division, Miami, Florida
222. Watkins, Andrew B., National Climate Centre, Australian Bureau of Meteorology, Melbourne, Australia
223. Weidick, A., Geologic Survey of Denmark and Greenland (GEUS), Copenhagen, Denmark
224. Weller, Robert A., Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

225. Weyman, James, NOAA/NWS/central Pacific Hurricane Center, Honolulu, Hawaii
226. Whitewood, Robert, Environment Canada, Ottawa, Ontario, Canada
227. Willis, Joshua K., NASA/Jet Propulsion Laboratory, Pasadena, California
228. Woodworth, Philip L., Proudman Oceanographic Laboratory, Liverpool, United Kingdom
229. Xie, Pingping, NOAA/NWS/NCEP, Climate Prediction Center, Camp Springs, Maryland
230. Xue, Yan, NOAA/NWS Climate Prediction Center, National Centers for Environmental Prediction, Camp Springs, Maryland
231. Yu, Lisan, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts
232. Yun, Won-Tae, Korea Meteorological Administration, Seoul, South Korea
233. Zimmer, Jacques, Meteorological Service of Luxemburg, Luxemburg
234. Zou, Xukai, National Climate Center, China Meteorological Administration, Beijing, China
235. Zubair, Lareef, International Research Institute for Climate and Society, Palisades, New York

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ABSTRACT—
D. H. LEVINSON AND J. H. LAWRIMORE

The combined land and ocean surface temperature in 2007 fell within the 10 highest on record, while the average land temperature was the warmest since global records began in 1880. In the low to midtroposphere, the annual global mean temperature was among the five warmest since reliable global records began in 1958, but still cooler than the record warmest year of 1998. For the fourth consecutive year, the annual precipitation averaged over global land surfaces was above the long-term mean, although the anomaly was significantly less than in 2006 when the annual value was the eighth wettest since 1901.

The globally averaged concentration of carbon dioxide (CO_2) continued to increase in 2007, having risen to 382.7 ppm at the Mauna Loa Observatory in Hawaii. The average rate of rise of CO_2 has been 1.6 ppm yr^{-1} since 1980; however, since 2000 this has increased to 1.9 ppm yr^{-1}. In addition, both methane (CH_4) and carbon monoxide (CO) concentrations were also higher in 2007.

Over the oceans, global SST during 2007 showed significant departures from the 1971–2000 climatology. Annual average upper-ocean heat content anomalies declined between 2006 and 2007 in the eastern equatorial Pacific and increased in off-equatorial bands in that ocean basin. These changes were consistent with the transition from an El Niño in 2006 to a La Niña in 2007. The global mean sea level anomaly (SLA) in 2007 was 1.1 mm higher than in 2006, which is about one standard deviation below what would be expected from the 15-yr trend value of 3.4 mm yr^{-1}.

In the tropics, the Atlantic hurricane season was near normal in 2007, although slightly more active than in 2006. In the north and south Indian Ocean Basins, both the seasonal totals and intensity of tropical cyclones (TC) were significantly above average, and included two Saffir–Simpson category 5 TCs in the north Indian Ocean and a world record rainfall amount of 5510 mm over a 3–8-day period on the island of Reunion in the south Indian Ocean.

In the polar regions 2007 was the warmest on record for the Arctic, and continued a general, Arctic-wide warming trend that began in the mid-1960s. An unusually strong high pressure region in the Beaufort Sea during summer contributed to a record minimum Arctic sea ice cover in September. Measurements of the mass balance of glaciers and ice caps indicate that in most of the world, glaciers are shrinking in mass. The Greenland ice sheet experienced records in both the duration and extent of the summer surface melt. From the continental scale, as a whole the Antarctic was warmer than average in 2007, although the Antarctic Peninsula was considerably cooler than average. The size of the ozone hole was below the record levels of 2006, and near the average of the past 15 yr, due to warmer springtime temperatures in the Antarctic stratosphere.

1. INTRODUCTION—J. H. Lawrimore and D. H. Levinson

This special section represents the 18th annual State of the Climate report, the 12th year the report has been included in *BAMS,* and the third year it has appeared as a separate supplement. NOAA's NCDC (see the appendix for a complete list of acronym expansions) has been responsible for the report's publication for the past eight years, although the report is truly an interagency and international effort. For the 2007 article, over 200 scientists from around the world participated, as the editorial team continued to focus on expanding international participation.

The purpose of this annual summary is to highlight the most salient events and overall climate conditions of 2007, which include noteworthy weather events (e.g., floods, tropical cyclones, tornadoes, and heat waves), assessment of temperature and precipitation anomalies, and reports on some of the primary features and parameters of the global climate system: global temperature and precipitation, trace gases in the Earth's atmosphere, climate conditions in the ocean basins, climate-related conditions in the tropics and polar regions, details of continental and regional climates, etc.

One of the main goals of this and past State of the Climate articles has been to put the observed climate and weather events over the previous year into historical perspective, with a focus on long-term trends and variability of the primary climatic elements over the period of instrumental observations (since the late 1800s), and, if possible, to extend back in time through the use of paleoclimate data. Due to the large number of data sources, it was impossible to refer to a standard base period for each climatic element in the article. Therefore, the base period for each dataset varied according to scientific convention, and those noted for each dataset herein were chosen by the authors and contributors based on a number of practical and scientific factors. It should also be noted that the data and analyses contained herein represent the best available as of early 2008; the data included in each section are susceptible to updates by the source agencies, although it is not expected that any key findings would be significantly affected.

As in the past, a determined effort was made to ensure that all participants were acknowledged for their efforts. Therefore, authorship has been noted for individual sections where appropriate. In addition to authors, numerous reviewers and other facilitators made this publication possible, and these individuals are also listed in the acknowledgments section.

As with each subsequent State of the Climate report, new topics and special features have been incorporated. For 2007, a section on the Indian Ocean dipole was added in the tropics chapter, analysis of conditions on the Greenland ice sheet was greatly expanded, and a number of sidebar features were included to highlight specific events and climate-related milestones that occurred in 2007. Also new this year is the inclusion of a number of new countries in the chapter 6, including Belize, Jamaica, and Puerto Rico in the Central America/Caribbean section; Japan, South Korea, and Mongolia in the East Asia section; Micronesia in the Oceania section; and Egypt in the Africa section. In addition, the section on Europe was expanded and includes a much wider participation of scientists from that continent.

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

Section 2: Global climate

- The global land and ocean combined surface temperature for 2007 fell within the 10 highest on record, while the average land temperature was the warmest since global records began in 1880, with an annual departure of +0.64°C (+1.15°F).
- The annual global mean temperature in the low to midtroposphere was among the five warmest since records began in 1958, ~0.2°C (~0.36°F) cooler than the warmest year of 1998.
- The 12-month running mean of Northern Hemisphere snow cover extent was below the long-term average throughout 2007. Overall, there had been no negative annual anomaly of snow cover extent for the Northern Hemisphere as large as the one at the end of 2007 since the record lows of the satellite era were observed between 1988 and 1990.
- For the fourth consecutive year, the annual precipitation averaged over global land surfaces was above the long-term mean, although the anomaly was significantly less than in 2006 when the annual value was the eighth wettest since 1901. Since the start of the twentieth century land-based precipitation has increased globally, with the greatest increases in the mid- and high latitudes of the Northern Hemisphere.
- The globally averaged concentration of CO_2 continued to increase in 2007, having risen to 382.7 ppm at the Mauna Loa Observatory in Hawaii. This represents an increase of ~1.8 ppm above the 2006 global annual mean (380.9 ppm). The atmospheric concentration was around 280 ppm prior to the Industrial Revolution (ca 1850).
- Both CH_4 and CO concentrations were also higher in 2007.
- The average rate of rise of CO_2 has been 1.6 ppm yr^{-1} since 1980; however, since 2000 this has increased to 1.9 ppm yr^{-1}. This suggests that the fraction of CO_2 emitted from sources that remain in the atmosphere may be increasing.
- The 2006 elevated aerosol levels seen at the far northern latitudes or around Indonesia were absent in 2007, and smoke from biomass burning over the Amazon basin, an indication of regional deforestation, exhibited levels that were in agreement with the increasing aerosol trend observed from 2000 through 2005.
- In the Southern Ocean, above average wind speeds in March through August suggested an atypically strong surface manifestation of the polar vortex during the austral winter (June–August).

Section 3: Global oceans

- Global SST during 2007 showed significant departures from the 1971–2000 climatology in four regions: a positive anomaly in the high latitude North Atlantic that has persisted since 2002 continued into 2007; positive anomalies that have occurred each boreal summer since 2002 in the Arctic Ocean adjacent to the North Pacific reached their highest value of about 2.5°C in 2007; the positive anomaly in the tropical North Atlantic, which has had a downward trend from its highest value in 2005, returned to near-normal conditions in the summer of 2007; and positive anomalies in the central and eastern equatorial Pacific associated with the 2006 El Niño ended in February, and a moderate-strength La Niña developed in the fall.
- Annual average upper-ocean heat content anomalies declined between 2006 and 2007 in the eastern equatorial Pacific and increased in off-equatorial bands in that ocean basin. These changes were consistent with the transition from an El Niño in 2006 to a La Niña in 2007.
- Ocean heat fluxes demonstrated a coherent pattern of change in the tropical Pacific, in response to the east–west SST pattern of the 2007 La Niña episode. Evaporation decreased over the cooler SST region in the eastern Pacific and increased over the warmer SST region in the western Pacific.
- The tropical cyclone heat potential, a parameter proportional to the upper-ocean heat content that is linked to hurricane intensification, exhibited

high variability within each ocean basin. On average, all basins, except the eastern Pacific basin, showed areas of positive anomalies, with the largest anomalies in the west Pacific.

- Global sea surface salinity anomalies in 2007 continued to accentuate climatological patterns; fresh areas of the ocean have generally become fresher and salty areas have generally become saltier in recent years relative to a long-term climatology.
- The global mean SLA in 2007 was 1.1 mm higher than in 2006, which is about one standard deviation below what would be expected from the 15-yr trend value of 3.4 mm yr^{-1}. Dominant spatial patterns of sea level variability during 2007 included the strengthening La Niña in the tropical Pacific Ocean, and zonal anomalies in the tropical Indian Ocean, particularly south of the equator.
- A revised climatology of global surface pCO_2, which was assembled from over 3 million measurements spanning 36 yr, suggests a 30% larger inter-annual variability in ocean CO_2 uptake than that inferred from the previous climatology.
- Chlorophyll concentrations during 2007 were close to the mean value derived from 10 yr of climate-quality ocean color measurements, but exhibited significant deviations from the mean that were largely due to global changes in phytoplankton physiology rather than phytoplankton biomass.

Section 4: The tropics

- The year was characterized by a transition to La Niña conditions that, while not developed until August, resulted in suppressed convection near the date line beginning in early June. Therefore, La Niña–like impacts on the upper-tropospheric circulation were already evident during June–August across the subtropical South Pacific.
- The 2007 Atlantic hurricane season was near normal, although slightly more active than in 2006. In the north and south Indian Ocean Basins, both the seasonal totals and intensity of TCs were significantly above average, and included two Saffir–Simpson category 5 TCs in the north Indian Ocean and a world-record rainfall amount of 5,510 mm over a 3–8-day period on the island of Reunion in the south Indian Ocean.
- A very strong, positive phase of the Indian Ocean dipole occurred during 2007. This pattern likely contributed to the lack of a traditional La Niña signal in the Northern Hemisphere subtropics during the peak of the Atlantic hurricane season.

Section 5: The Poles

- The year 2007 was the warmest on record for the Arctic, continuing a general, Arctic-wide warming trend that began in the mid-1960s.
- A dramatic signal related to the anomalous warming was the significant reduction in the extent of the summer sea ice cover and in the relative amount of older, thicker ice, both showing signs of an increase in their relative rates of reduction.
- An unusually strong high pressure region in the Beaufort Sea during summer contributed to a record minimum Arctic sea ice cover in September. Accompanying the reduction in sea ice cover was an increase in the temperature and a decrease in the salinity of the surface ocean layer.
- Due to more open water at the end of the boreal summer, surface air temperature anomalies for 2005–07 remained above +6°C (+10.8°F) during October–November compared with the 1982–2007 mean over the central Arctic.
- Measurements of the mass balance of glaciers and ice caps indicate that in most of the world, glaciers are shrinking in mass. The Greenland ice sheet experienced records in both the duration and extent of the summer surface melt.
- The AO circulation regime, widely considered the main source of Arctic climate variability during the twentieth century, returned to a strongly positive wintertime index value for the first time in more than a decade.
- As a whole, Antarctica was warmer than average in 2007, although the Antarctic Peninsula was considerably cooler than average.
- The cool temperatures over the Antarctic Peninsula resulted in extensive fast ice accumulation on the eastern peninsula coast by the end of the calendar year, and an unusually late start to the summer melt season there.
- Ozone activity was below the record levels of last year, and near the average of the past 15 yr, due to warmer springtime temperatures in the stratosphere.

Section 6: Regional climates

Numerous noteworthy climate events occurred in 2007 on the regional scale (Fig. 1.1):

- The end of a weak El Niño episode in February 2007 followed by a transition to moderate-to-strong La Niña conditions during the latter half

of the year influenced climate conditions in many parts of the world.

- *Africa*: In East Africa, unusually wet conditions during the summer rainy season brought the level of the Blue Nile at Khartoum, the capital of Sudan, far above the record levels seen in 1988. The 2007 rainy season in West Africa featured above average rainfall across most areas of the Sahel and portions of the Gulf of Guinea region.
- *North America*: In Canada, 2007 was warmer and wetter than normal, with the country as a whole having its 13th warmest year on record, 0.9°C (1.6°F) above normal. For the United States, 2007 tied with 2005 as the ninth warmest year on record with a nationally averaged temperature of 12.4°C (54.3°F), the 10th consecutive year with temperatures much warmer than the long-term average. Continuing a string of record or near-record fire seasons, the wildfire season in 2007 had the second most acres burned in the historical record for the United States as a whole (9.3 million acres; ~3.8 million hectares). Above average temperatures prevailed across Mexico, as the nationwide mean was 21.8°C (71.2°F) in 2007, 1.1°C (~2°F) above the long-term average.
- *Central America and the Caribbean*: Much of the region was warm and wet in 2007. The above normal rainfall was attributable in part to the tropical cyclones that impacted the region, as well as the emergence of a La Niña during the latter half of the year. Cuba had its eighth warmest year since 1951, with a mean temperature of 25.99°C (78.78°F), ~0.5°C (~0.9°F) above normal.
- *South America*: Precipitation over South America during 2007 was below normal in the southern and eastern parts of the continent, very dry over the west, and near normal to wetter than normal in the region north of the equator and parts of the Amazon basin. An unusually cold winter was reported over the southern portion of the continent, while warmer-than-normal conditions prevailed in the Amazonian region.
- *Asia*: It was the warmest year on record in Russia, with a mean annual air temperature of 2.0°C (3.6°F) above normal. Winter and summer were also the warmest on record in 2007, registering anomalies of +3.2°C (+5.8°F) and +1.8°C (+3.2°F), respectively (meteorological observations in Russia date back to 1891). It was also record warm in China and near-record warm in Japan in 2007. The annual mean temperature in China was 1.3°C (~2.3°F) above normal, with all four seasons warmer than average, making 2007 the warmest year since reliable country-wide records began in 1951. In Japan, the annual mean temperature was 0.85°C (~1.5°F) above normal, the fourth highest on record since 1898.
- *Europe*: Based on data from the Hadley Centre in the United Kingdom, the annual average land surface temperature was +1.23 ± 0.08°C (+2.21 ± 0.14°F) above the 1961–90 mean for the European region between 35°–75°N and 10°W–30°E, and is virtually certain to be one of the five warmest years in the 1850–2007 period of record. It was the warmest year on record in the Netherlands, Belgium, the Czech Republic, and several countries in eastern and southeastern Europe. In addition, Denmark had its warmest and sunniest year on record in 2007, 1.8°C (3.2°F) above the 1961–90 mean. Since 1870, Danish temperatures have increased by 1.5°C (2.7°F).
- *Oceania*: Large areas of Australia continued to be impacted by both long- and short-term drought in 2007. In terms of mean temperatures it was Australia's sixth warmest year since high quality Australia-wide records commenced in 1950, 0.7°C (1.3°F) above the 1961–90 mean. For 2007 as a whole, above average SSTs were observed throughout much of the tropical southwest Pacific, south and west of the date line.

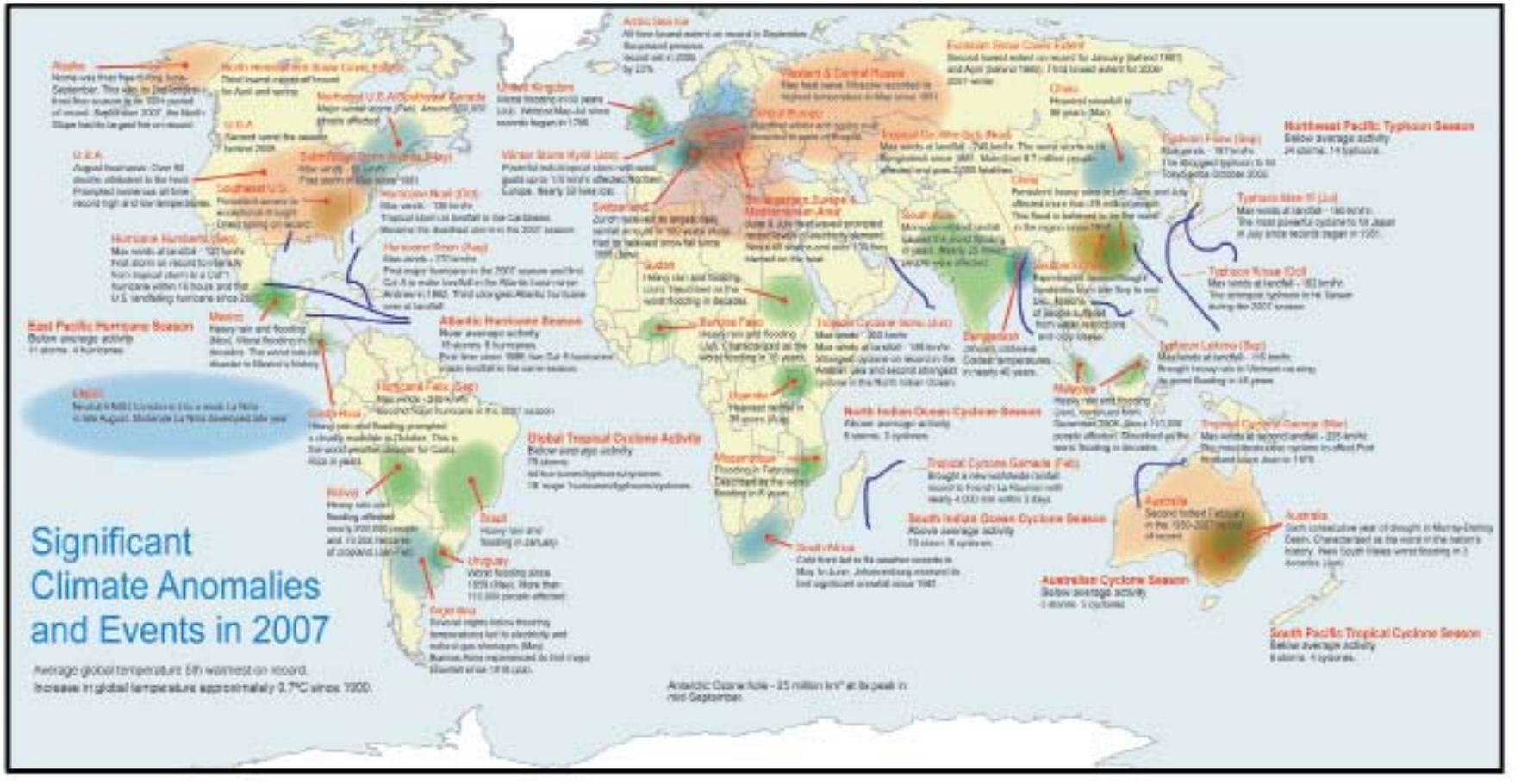

Fig. 1.1. Geographical distribution of notable climate anomalies and events occurring around the planet in 2007.