

1 A Look at 2023: Takeaway Points from the *State of the Climate Supplement*—J. Blunden, and T.
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13 *The following salient events and trends are reported in greater depth in the State of the Climate*
14 *in 2023, the supplement to this issue of BAMS. Figures shown here are drawn from the*
15 *supplement and are not cited in the text below.*

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17

18 **GLOBAL CLIMATE**

19 In 2023, cool-phase La Niña conditions that prevailed in the eastern tropical Pacific
20 Ocean nearly continuously from mid-2020 into early 2023 gave way to the strongest warm-phase
21 El Niño since 2015/16. At the same time, concentration levels in the atmosphere of Earth’s major
22 greenhouse gases—carbon dioxide, methane, and nitrous oxide—all increased to new record
23 highs. The annual global average carbon dioxide concentration in the atmosphere rose to
24 419.3 ± 0.1 parts per million, which is 50% greater than the pre-industrial level. Annual growth in
25 global mean CO₂ has increased from 0.6 ± 0.1 parts per million per year in the early 1960s to an
26 average of 2.5 parts per million per year during the last decade of 2014–23. The growth from
27 2022 to 2023 was 2.8 parts per million, the fourth highest in the record since the 1960s.

28 The combination of the short-term warming due to El Niño and the long-term warming
29 due to increasing greenhouse gases contributed to the highest annual global temperature across
30 land and oceans in records dating as far back as 1850. The last seven months of the year—June
31 to December—were each record warm. The globally averaged annual land temperature was also
32 record high, with dozens of countries reporting record or near-record warmth for the year,
33 including China (warmest on record) and India (second warmest), which, combined, are home to
34 almost 30% of the world’s population. The Earth’s biota was affected by the record warmth. The
35 full bloom for the cherry trees in the Arashiyama district of Kyoto, Japan, occurred on March 25,
36 the earliest date in the over-1200-year record, and there was an early start in the spring for red
37 oak biological activity in North America. In the latter half of the year, leaf fall in boreal autumn
38 was delayed in North America and Europe as above-average temperatures prevailed.

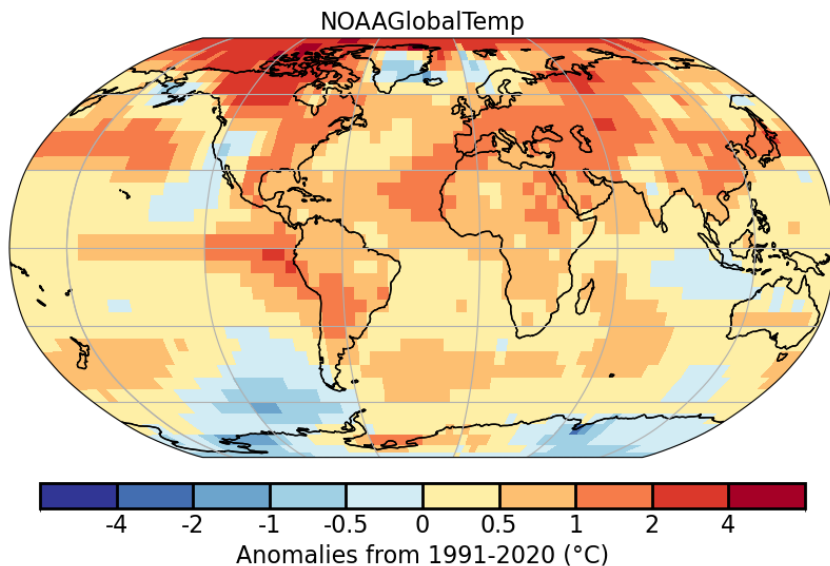
39 Above Earth’s surface, 2023 was the least cloudy since records began in 1980, meaning
40 that skies were clearer around the world on average. As a result, clouds reflected away to space a

41 record small amount of incoming shortwave radiation, or energy produced by the sun, but also
42 blocked a record small amount of outgoing longwave radiation, or heat energy, from leaving
43 Earth. The net effect was the weakest cooling effect of clouds on record. Over land areas, the
44 average global precipitation total for 2023 was one of the lowest among all years in the record
45 dating to 1979; however, global 1-day maximum totals were above average, indicating an
46 increase in rainfall intensity. In July, record high areas of land across the globe (7.9%) were
47 experiencing extreme drought, breaking the previous record of 6.2% in July 2022. Overall,
48 29.7% of land experienced moderate or worse categories of drought during the year, also a new
49 record.

50

51 **Global Surface Temperatures Were Above Average Across Most of the World**

52



53

54 Caption: During 2023, much-warmer-than-average conditions were observed across
55 most of the world's surface, with the largest positive temperature anomalies across
56 parts of the higher northern latitudes, shown here as areas shaded from orange to red.

57 Limited areas, including parts of Greenland, western Alaska, the southwestern
58 contiguous United States, and parts of the Southern Ocean and Antarctica, experienced
59 near-average to cooler-than-average conditions (blue shading). (Plate 2.1a in State of
60 the Climate in 2023; see discussion in section 2.b)

61

62 **GLOBAL OCEANS**

63 The annual global sea surface temperature for 2023 shattered the previous record of 2016
64 by 0.13°C, marking the highest average annual temperature in the 170-year record. Daily and
65 monthly records set from March until the end of the year contributed to this record. Among the
66 most notable, an all-time high globally averaged daily sea surface temperature of 18.99°C was
67 recorded on August 22.

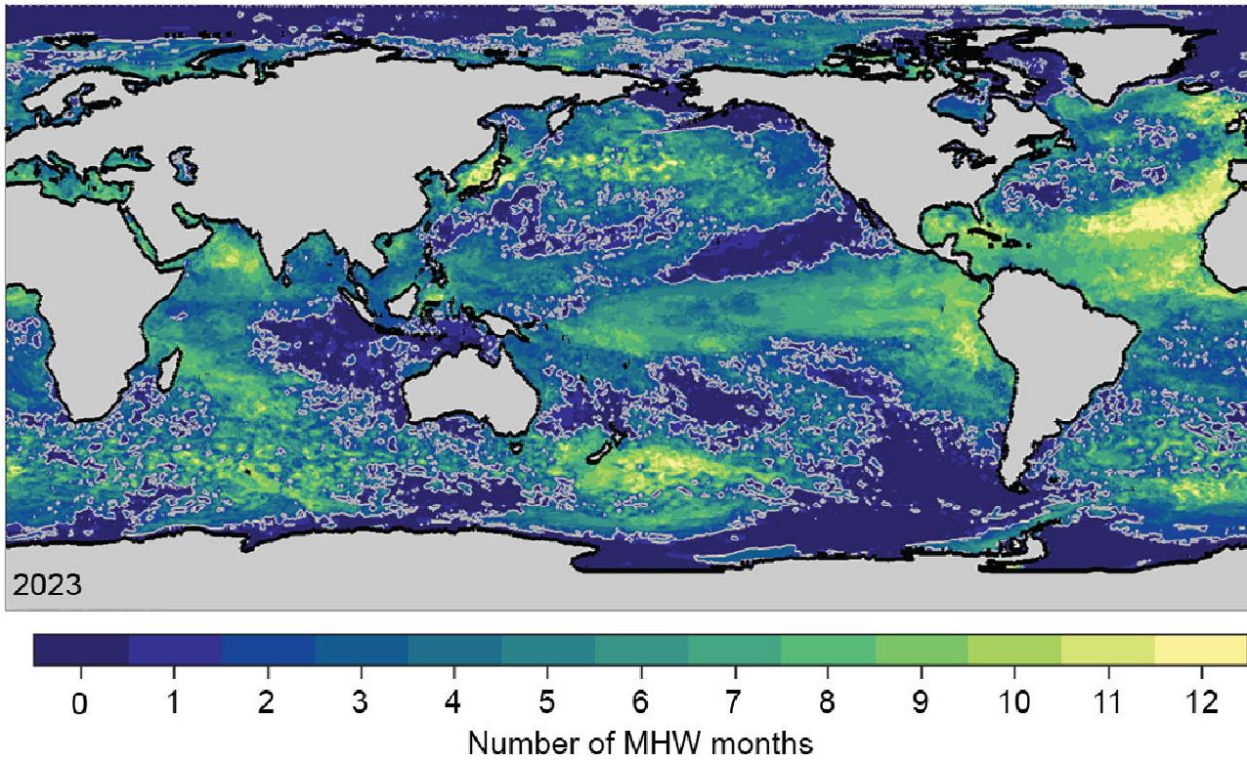
68 The melting of glaciers and ice caps contribute to rising seas, as do increasing ocean
69 temperatures that cause water to expand. In 2023, global mean sea level reached a new record
70 high for the 12th consecutive year, at 101.4 millimeters above the average from 1993, when
71 satellite measurements began. This rise is an increase of 8.1 ± 1.5 millimeters over 2022, marking
72 the third highest year-over-year increase in the record. Since 1993, the oceans have been rising at
73 an average rate of 3.2 ± 0.4 millimeters per year, and the rate of rise is accelerating.

74 Globally-averaged ocean heat content from the surface to 2000-meter depth—the amount
75 of heat stored in this portion of the oceans—was also record high in 2023. In line with increasing
76 carbon emissions from human activities, the oceans absorbed anthropogenic carbon at a rate of
77 ~ 3.8 Petagrams, or 3.8×10^{15} grams, of carbon in 2023, nearly 10% above the 2013–22 average
78 of ~ 3.5 Petagrams of carbon per year. The amount of carbon absorbed by the oceans during the
79 last decade of 2013–22 period equates to 26% of all the anthropogenic carbon released into the

80 atmosphere during that time. The absorption of this carbon is the main cause of acidification in
81 the oceans, which lowers the pH balance of the water and can alter and harm natural ecosystems.

82

83 **Marine Heatwaves Dominated the Oceans in 2023**



84

85 Caption: Approximately 94% of the global ocean surface experienced at least one
86 marine heatwave in 2023, while 27% experienced at least one cold spell. A heatwave is
87 detected when five or more consecutive days of temperatures are higher than 90% of all
88 temperatures recorded on that day, and a cold spell is detected when five or more
89 consecutive days of temperatures are lower than 90% of all temperatures recorded on
90 that day. The eastern tropical and North Atlantic Ocean, the Sea of Japan, the Arabian
91 Sea, the Southern Ocean near New Zealand, and the eastern tropical Pacific were in a
92 marine heatwave state for at least 10 months of 2023. The ocean experienced a new
93 global average record of 116 marine heatwave days in 2023—which was far more than

94 the previous 2016 record of 86 days in 2016—and a new record of 13 marine cold spell
95 days, far below the previous record of 37 days in 1982. (Figure SB3.1c in State of the
96 Climate in 2023; see discussions in Sidebar 3.1 and section 2.b.4)

97

98 **THE TROPICS**

99 Cool-phase weak La Niña conditions—average sea surface temperatures 0.5°C to 1.0°C
100 below the 1991–2020 average—were present in the central and eastern equatorial Pacific Ocean
101 at the beginning of 2023 but quickly faded, and warm-phase El Niño conditions emerged in the
102 Northern Hemisphere spring. The El Niño became strong by October, with average sea surface
103 temperatures more than 1.5°C above average. In the Northern Hemisphere autumn, a positive
104 Indian Ocean dipole event was established, with below-average temperatures in the east Indian
105 Ocean and above-average temperatures in the west. Positive events are linked to El Niño, and
106 this was the fourth-strongest such event in the 42-year record. La Niña and El Niño impact
107 climate patterns around the globe, while the phase of Indian Ocean dipole primarily affects the
108 weather of the surrounding continents in the Southern Hemisphere.

109 A total of 82 named tropical cyclones were observed during the Northern and Southern
110 Hemisphere storm seasons, below the 1991–2020 average of 87. There were seven Category 5
111 tropical cyclones across the globe; all of the basins, except for the Australian and southwest
112 Pacific, had at least one Category 5 storm. Globally, the accumulated cyclone energy—a
113 combined measure of the strength, frequency, and duration of tropical cyclones—rebounded
114 from the lowest in the 43-year record in 2022 to above average in 2023. The North Indian Ocean
115 had its second-highest accumulated cyclone energy on record behind 2019, and the North
116 Atlantic had its seventh above-normal season in the last eight years. In the western North Pacific

117 basin, impacts of Typhoon Doksuri (named Egay in the Philippines) caused \$18.4 billion U.S.
118 dollars in economic losses in the northern Philippines and China. The remnants of the storm led
119 to high rainfall rates; Beijing received 744.8 millimeters in a 40-hour period, which was the most
120 for the city in the 140-year record. Floods associated with this rainfall killed 137 residents.
121 Tropical Cyclone Freddy became the world’s longest-lived tropical cyclone on record, becoming
122 a tropical cyclone on 6 February and finally dissipating on 12 March. Freddy crossed the full
123 width of the Indian Ocean and made three landfalls in total: one in Madagascar and two in
124 Mozambique.

125

126 **Category 5 Major Hurricane Otis Devastates Acapulco, Mexico**



127

128 Caption: Off the west coast of Mexico, Hurricane Otis underwent an unprecedented
129 rapid strengthening, intensifying from Category 1 to Category 5 in a record nine hours
130 and became the strongest landfalling hurricane on record for that region. Based on
131 records since 1950, Otis became the first Category 5 hurricane to make landfall in the
132 state of Guerrero, Mexico, and is one of only two Category 5 hurricanes to make landfall
133 from the eastern Pacific basin, along with Hurricane Patricia in 2015. The impacts on
134 the city of Acapulco were devastating, with winds of up to 270 kilometers per hour and
135 up to 266 millimeters of accumulated precipitation in just 24 hours, causing floods and

136 severe damage to infrastructure. Otis caused at least 52 fatalities and damage
137 estimated at \$12–16 billion U.S. dollars. (Figure SB4.2 in State of the Climate in 2023;
138 see discussions in sections 4.g.3, 7.b.3, and Sidebar 4.1)
139

140

141 **THE ARCTIC**

142 In the high northern latitudes above 60°N, the annual surface air temperature across land
143 areas was the fourth highest in the 124-year record, with the summer season of July to September
144 record warm. At Svalbard Airport (78.2°N), the average July temperature exceeded 10°C for the
145 first time on record. Snowpack in early spring 2023 was above normal for North America and
146 Eurasia, but then rapid snow loss in much of the Arctic resulted in record-low average snow
147 water equivalent—the depth of water that would cover the ground if the snow cover was melted
148 into liquid water—for the North American Arctic in May and near-record-low snow cover for the
149 Eurasian Arctic in June. Below ground, permafrost temperatures were the highest on record at
150 over 9 of 17 reporting sites across the Arctic. Permafrost thaw disrupts Arctic communities and
151 infrastructure and can also affect the rate of greenhouse gas release to the atmosphere, potentially
152 accelerating global warming. Across the Arctic Ocean and adjacent seas, the minimum Arctic
153 sea ice extent for the year, which is typically reached in September, was the fifth-smallest in the
154 45-year record. The 17 lowest September extents in the satellite record have all occurred in the
155 last 17 years (2007–23).

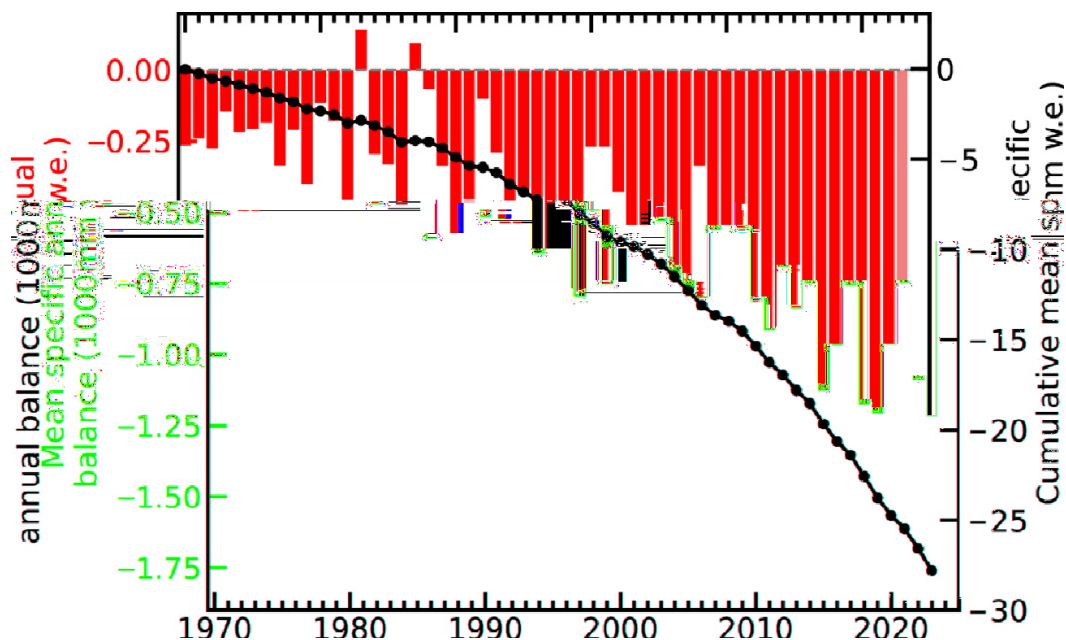
156 During the summer, both the Northern Sea Route and Northwest Passage became
157 accessible to non-ice-hardened marine traffic. The Northern Sea Route, which connects the
158 European Arctic to the Pacific Ocean via the north coast of Russia and the Bering Strait, saw 75
159 ship transits in the 2023 open season. This is the second-highest number of ships, but the 2.1
160 million tons of transported cargo (including crude oil) was the highest on record. The Northwest
161 Passage, which connects the Atlantic to the Pacific via northern Canada and Alaska waters, saw

162 a record number of ship passages: 42 ships made the complete Northwest Passage transit,
163 including 13 cargo ships. The previous high was 33 ships in 2017.

164 The tundra is sensitive to summer temperatures, as well as to sea ice, snow, and
165 permafrost conditions; this means that the higher the temperatures of the ground and air and the
166 lower the amount of ice and snow, the more vegetation will grow in the region. In 2023, average
167 peak greenness of the tundra was the third highest in the 24-year satellite record. The greenness
168 was much higher than normal across most of the North American Arctic and especially in the
169 eastern Beaufort Sea region, which experienced exceptionally warm summer temperatures.

170

171 **Glaciers Around the World are Shrinking and Thinning**



172

173 Caption: Glaciers in mountainous regions have continued to lose mass, with 2023
174 marking the 36th consecutive year of global mass balance loss and the 15th with losses
175 of more than 500 millimeters of water equivalent (w.e.), where a value of -500-
176 millimeters w.e. per year represents a loss of 500 kilograms per square meter of ice

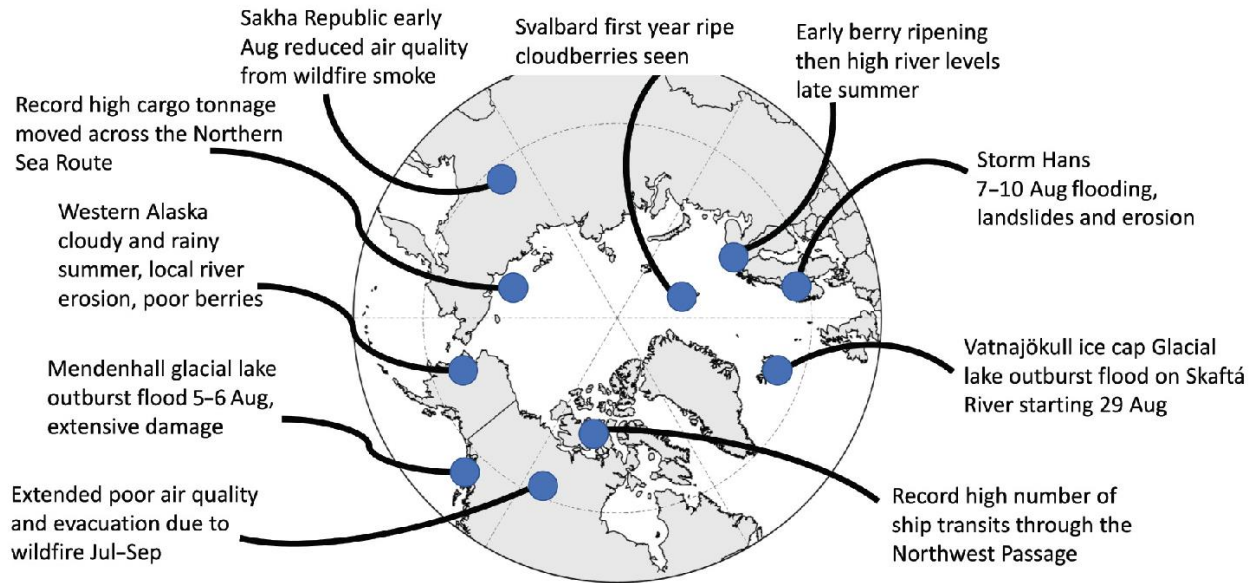
177 cover or an annual glacier-wide ice thickness loss of about 0.55 meters per year,
178 according to the World Glacier Monitoring Service. More frequent and intense
179 heatwaves contributed to 2023 experiencing the greatest average mass balance loss for
180 Alpine glaciers around the world since the start of the record in 1970. In August, a
181 glacial lake on a tributary of the Mendenhall Glacier in Alaska burst through its ice dam
182 and caused unprecedented flooding and severe property damage on Mendenhall River
183 near Juneau, a direct result of dramatic glacial thinning over the past 20 years. Due to
184 rapid volume loss beginning in 2021, St. Anna Glacier in Switzerland and Ice Worm
185 Glacier in the United States disappeared completely. While these were considered
186 small glaciers—less than 0.5 square kilometers in area—when the monitoring began,
187 these glacier disappearances are reflective of the global pattern of glacial mass loss. In
188 2023, the Global Land Ice Measurements from Space initiative added an extinct glacier
189 layer to its Glacier Viewer to indicate glaciers that have been lost. (Figure 2.17 in State
190 of the Climate in 2023; see discussion in section 2.c.3)

191

192

193 **A Record-Warm Summer in the Arctic Had Many Effects**

194



195

196 Caption: Several societal and environmental impacts were documented during the
 197 record-warm Arctic summer of 2023. These impacts are consistent with expectations of
 198 environmental extremes that are likely to occur in a rapidly warming Arctic environment.
 199 Some of these impacts were directly related to the record-high temperatures. (Figure
 200 SB5.3 in State of the Climate in 2023; see discussion in Sidebar 5.2)

201 **ANTARCTICA AND THE SOUTHERN OCEAN**

202 In Antarctica, temperatures for much of the year were 2°C to 6°C above the 1991–2020
203 average over the Weddell Sea and along coastal Dronning Maud Land. The Antarctic Peninsula
204 also experienced well-above-average temperatures and observed its fourth consecutive summer
205 of above-average surface melt on the Peninsula.

206 In the Southern Ocean, sea surface temperatures and ocean heat content from the surface
207 to 2000-m depth were both well above average in 2023, marking a continuation of the warming
208 trend observed in this region since 2005. On 21 February, Antarctic sea ice extent and sea ice
209 area both reached all-time lows, surpassing the previous record lows that were set just a year
210 earlier in February 2022. Eight months in 2023 had new monthly mean record lows in sea ice
211 extent and sea ice area, and 278 days during the year set new daily record-low sea ice extents; for
212 example, July 6 had a record-low daily sea ice extent that was 1.8 million square kilometers
213 smaller than the previous record low for that day. Additionally, the absence of pack ice resulted
214 in an unprecedented 154 days of record-high coastal exposure, during which there was a
215 complete lack of a protective sea-ice “buffer”. Lack of this buffer exposes shoreline and ice
216 shelves to erosion from strong winds and waves.

217 In the stratosphere, the 2023 ozone hole appeared earlier than normal and persisted for
218 longer than normal, not breaking up until December 20. Its overall size was the 16th largest in 44
219 years of satellite observations.

220

221 **REGIONAL CLIMATES**

222 *North America*

223 North America observed its warmest year since the start of its continental surface record
224 in 1910, with an average temperature that was 1.13°C higher than the 1991–2020 average. At the
225 national level, Canada experienced its second warmest year in the country’s 76-year record, with
226 summer and autumn both record warm. The contiguous United States reported its fifth warmest
227 in the 129-year record. Mexico was both record warm and record dry (84-year record); a
228 heatwave in June that was both the country’s most extensive and most intense on record
229 contributed to the warmth, with nearly three dozen weather observatories or airports across
230 Mexico reporting record-high temperatures. The highest recorded temperature was 48.0°C at the
231 Ciudad Obregón Observatory in Sonora, Mexico, which was 9.0°C above the average June high
232 temperature at that location. Following the June heat, July 2023 became the overall warmest
233 month on record for Mexico. According to the Mexican Ministry of Health, 286 deaths
234 associated with heat stroke and dehydration were reported through the end of July,

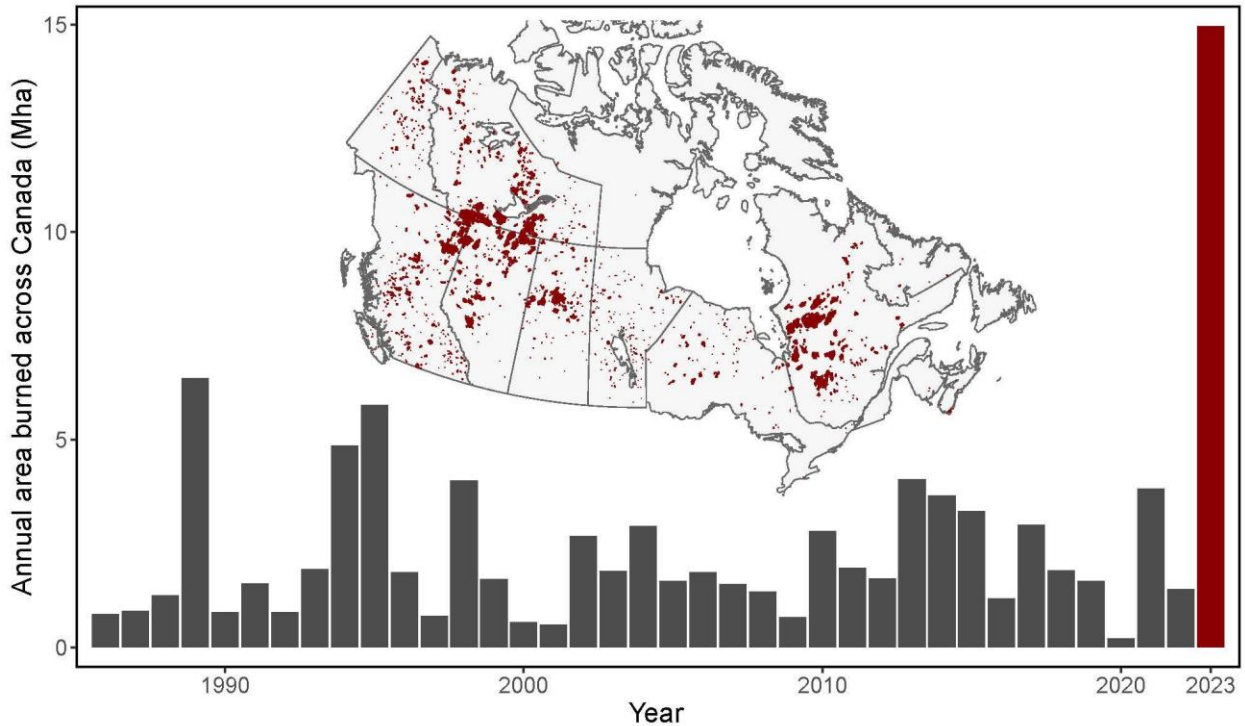
235 All three countries had widespread drought events during the year, with Canada
236 experiencing a record-breaking wildfire season, particularly in terms of the area burned (see
237 related figure for more details about the fires). Outside the contiguous United States, in Hawaii,
238 the lower elevations of Maui saw an expansion of severe drought in early August. These dry
239 conditions, combined with strong, dry winds instigated by Hurricane Dora, contributed to the
240 deadliest wildfire in the United States in more than a century.

241 There were also extreme wet conditions. A series of atmospheric rivers in early 2023
242 delivered heavy rains to California and parts of adjacent states to start the year, resulting in
243 floods and reservoirs being filled to capacity. The state of Alaska reported its fifth-wettest year
244 on record. In Nova Scotia, Canada, heavy rain fell on July 21–22, due to a slow-moving trough
245 of low pressure that interacted with moist flow from the tropics. This event resulted in more than

246 twice the monthly average total rainfall for July in just over two days in the hardest-hit areas.
247 Totals of up to 260 millimeters fell in parts of Halifax. This was the most rain to affect the region
248 in 50 years.

249

250 **Canada Has its Worst Wildfire Season on Record**



251

252 Caption: Wildfire seasons in Canada typically begin with the loss of snow cover in the
253 spring, and in 2023 the snowmelt was earlier than normal across much of the country.

254 This early melt, along with already-existing drought conditions and record to near-record

255 heat, contributed to the country's worst wildfire season on record. Approximately 15

256 million hectares (Mha) burned, an area more than twice the size of Ireland and more

257 than double the previous record from 1989. Much of the area burned in western Canada

258 aligns with the regions that experienced their hottest year on record, as well as those

259 that experienced prolonged drought conditions. Approximately 232,000 people were

260 evacuated due to the threat of wildfires, including the entire city of Yellowknife, which
261 has more than 20,000 residents. Smoke from the wildfires impacted regions across
262 Canada and also affected parts of the United State, including the heavily populated
263 cities of New York City and Chicago, and even areas of western Europe. (Figure
264 SB7.1a in State of the Climate in 2023; see discussion in Sidebar 7.1)

265

266 *Central America and the Caribbean*

267 Most stations across Central America had well-above-normal annual temperatures in 2023.

268 The Caribbean observed its warmest year since the start of the record in 1950 at 0.73°C higher

269 than the 1991–2020 average. Seasonally, summer and autumn were also record warm.

270 Additionally, the Caribbean heat season (May–October) was record warm at 18 of 36 reporting

271 stations. Overall, the region has been warming at a rate of 0.18°C per decade over the past half

272 century (since 1970).

273 Annually averaged rainfall for 2023 over the Caribbean was about 95% of the 1991–2020

274 average. Jimani in the Dominican Republic recorded its wettest year in 2023, Padre Las Casas,

275 Azua in the Dominican Republic its second wettest, and Lynden Pindling International Airport in

276 the Bahamas, its fourth-wettest year. Conversely, El Valle, Hato Mayor in the Dominican

277 Republic, and Lajas, Puerto Rico, each observed their second-driest year on record and E.T.

278 Joshua Airport in St. Vincent observed its third driest.

279 Tropical cyclone activity in the Caribbean and eastern tropical Pacific affecting Central

280 America was below normal. Even so, during June 2–6, heavy rains from Tropical Storm Arlene

281 caused flooding and landslides in Haiti. Seventy-eight deaths and damage in excess of \$420

282 million U.S. dollars were reported.

283

284 *South America*

285 Overall, annual maximum temperatures across northern South America were higher than

286 usual in 2023, while minimum and mean temperatures were variable. For central South America,

287 the annual mean temperature was the highest for the region in the last 50 years, surpassing the

288 previous record set in 2015. In southern South America, Argentina observed its warmest year on
289 record, Uruguay its second warmest, and Chile its third warmest.

290 Both cold and warm extremes were observed during the year. Following a February
291 heatwave, temperatures dropped significantly in parts of southern South America due to
292 intruding polar air, and several minimum temperature records were broken across Argentina and
293 Uruguay. On February 17–18, typical winter conditions occurred in the middle of what would
294 become the warmest austral summer on record for Argentina. Dry conditions and a persistent
295 high-pressure system in the region then led to several heatwaves in Uruguay and central-east
296 Argentina. The longest and most intense heatwave occurred during early March in both countries
297 and set new daily records of highest minimum and maximum temperatures at several stations.

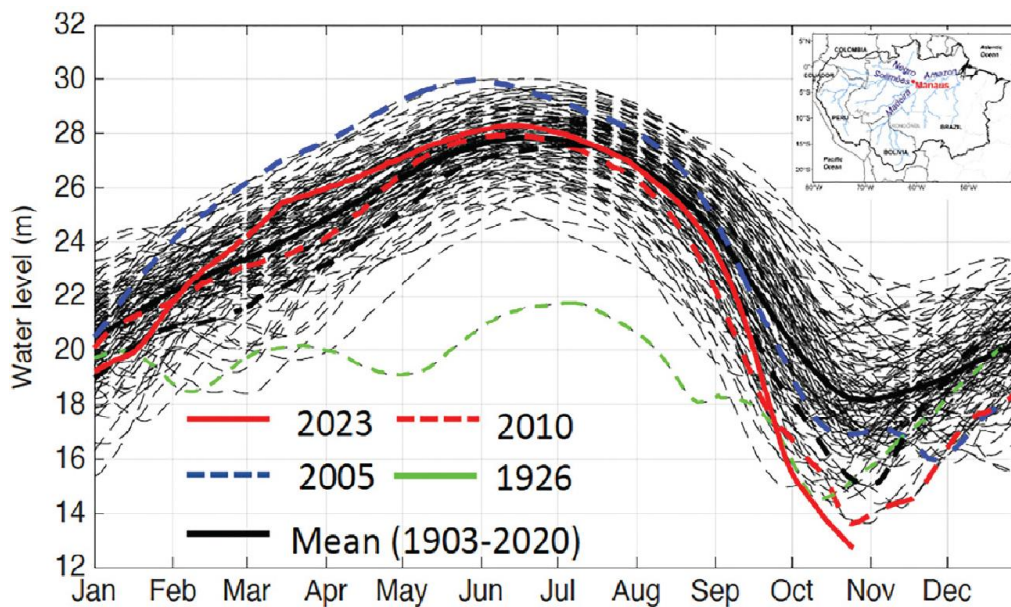
298 Three cold waves affected Brazil between May and July. In June, a cold air outbreak
299 from the south impacted the Brazilian Amazon. On June 13, some cities in the Amazon
300 experienced notably below-average temperatures, as low as 7.0°C at Santa Ana de Yacuma,
301 which was 10°C below its average. Later in the year, six intense heatwaves impacted central
302 tropical South America during August to December. At least 27 Bolivian cities recorded their
303 highest—monthly or absolute—temperatures from July to November, with every Andean and
304 lowland region affected. At several locations, maximum temperature records were broken two or
305 more times. By November 12, 1120 cities in Brazil recorded their highest temperatures,
306 including 40.4°C in Rio de Janeiro, which was 11.0°C above normal. On November 20, the
307 temperature reached 44.8°C in Araçuaí in Minas Gerais, potentially a new national high
308 temperature for Brazil and 12.8°C above normal for that area.

309 Large wildfires raged across the heat-affected regions in Paraguay and Brazil, including
310 Bahia, Pantanal, and the Amazon where at least 22,050 fires were recorded since October. Heavy

311 smoke from the fires impacted the entire city of Manaus, Brazil, which has a population of more
 312 than two million people. More than 3.5 million hectares also burned in Bolivia during September
 313 to November, causing severe air pollution that affected many Bolivian cities. In southern Brazil,
 314 however, rainfall was 200 millimeters to 300 millimeters per month above normal from August
 315 to December. Both the abundant rainfall in southern Brazil and drought in Amazonia were
 316 associated with El Niño. The El Niño phenomenon also intensified drought conditions in
 317 Colombia in northern South America during the second half of 2023.

318

319 **Amazon River at the Port of Manaus Drops to its Lowest Level in Brazil.**



320

321 Caption: Due to the warm and dry conditions in austral spring, most of the main rivers in
 322 the Amazon, including the Solimões, Purus, Acre, and Branco, suffered extreme drops
 323 in their levels in some regions, or dried up completely. By the end of October, the Rio
 324 Negro at Manaus, a major tributary of the Amazon River, fell to its lowest water level
 325 since records began in 1902. (Figure SB7.3 in State of the Climate in 2023; see
 326 discussion in Sidebar 7.2)

327

328 *Africa*

329 Above-average annual temperatures were observed over most of Africa in 2023. The
330 highest annual anomalies (compared to the 1991–2020 average) reached 1.8°C in places, notably
331 across almost all of Morocco and the western half of Mauritania in northwestern Africa. Several
332 Moroccan stations reported new local maximum temperature records during July and August,
333 including 50.4°C at Agadir. Temperatures were as much as 5°C above the normal in Algeria in
334 July. Tunisia reported its hottest July since records began in 1950, with an average temperature
335 4°C above normal. In the southern part of the continent, South Africa had its eighth-warmest
336 year on record since its record began in 1951. The Indian Ocean island countries were also
337 warmer than normal. Mayotte observed its warmest year on record, Reunion its second warmest,
338 and Seychelles its third warmest, based on their reporting stations. The start of the year was cold,
339 however, in some parts of Africa. January to March was the coldest such period on record
340 throughout both the Sahel and Gulf of Guinea regions, with February contributing the greatest
341 below-average departures.

342 Most of the Sahel experienced below-normal rainfall. Cameroon observed one of its
343 driest three-month periods (July–September) since the start of the record in 1991. Conversely,
344 record-high rainfall was observed over Libya in September, which was associated with Storm
345 Daniel, a tropical cyclone that formed in the Mediterranean Sea. The storm reached its peak in
346 northeastern Libya on September 10 and brought extreme rainfall. The city of Al-Bayda, for
347 example, received a total of 414.1 millimeters during September 10–11. Entire neighborhoods
348 disappeared after waters from burst dams flooded the city of Derna.

349 The transition from La Niña early in the year to a strong El Niño by autumn helped bring
350 relief to the prolonged drought conditions in equatorial eastern Africa. However, El Niño, along
351 with positive Indian Ocean dipole conditions, also led to excessive rainfall that resulted in
352 devastating floods over southeastern Ethiopia, Somalia, and Kenya during October to December
353 that displaced around 1.5 million people.

354 Tropical Cyclone Cheneso brought 200 millimeters to 500 millimeters of rain to Antalaha
355 (Sava Region) and the Diana Region in northern Madagascar during January 19–23, which
356 resulted in flooding and landslides that caused 53 fatalities. During February 24–March 11,
357 Tropical Cyclone Freddy impacted several provinces in Mozambique, resulting in 165 fatalities.
358 Rainfall totals ranged between 200 millimeters and 750 millimeters in central and southern
359 Mozambique. In Malawi, Freddy triggered flooding and landslides, which caused 679 fatalities.

360

361 *Europe and the Middle East*

362 The year 2023 was the warmest or second warmest on record for continental Europe,
363 according to a range of analyses, with above-average temperatures across most of the region.
364 Nationally, it was the warmest year on record for Ireland, Moldova, Kazakhstan, Romania,
365 Malta, Slovenia, Serbia, Germany, Czechia, Bulgaria, Austria, Slovakia, Hungary, Croatia,
366 Montenegro, and the Netherlands. Only the Scandinavian countries, Estonia, and Iceland
367 reported annual temperatures that were not among their five highest. Unusually high
368 temperatures of 1°C to 2°C above the 1991–2020 average were particularly notable across much
369 of the region during the summer due to the influence of high pressure. The United Kingdom and
370 the Netherlands each observed their warmest June on record. On August 10, a new local all-time
371 high temperature record of 46.8°C was recorded at Valencia airport in Spain, exceeding its

372 typical August temperatures by almost 10°C. On August 15, a new all-time national temperature
373 record of 49.5°C was set in Eskisehir in northwestern Türkiye, and on August 17, Lithuania set a
374 new national maximum record of 34.6°C.

375 It was also wet overall in Europe in 2023, either record wettest or third wettest according
376 to two different data analyses. Denmark reported its wettest year on record, with 129% of its
377 normal precipitation total. There were many extreme rainfall events across the continent. On
378 June 8, southern and central Germany received heavy rains, with up to 119 millimeters of
379 precipitation falling in two hours in the Hessen region. The return time for such an event is more
380 than 100 years. In September, Greece received record rainfall from Storms Daniel and Elias that
381 caused severe flooding in regions including Thessaly and central Greece. The town of Zagora
382 received the highest daily rainfall ever recorded in Greece (754 millimeters in 21 hours, after
383 which the station ceased reporting), resulting in significant damage to infrastructure and homes.
384 This daily total corresponded to the typical annual total for Zagora.

385 On July 24, a supercell produced record-size hail in the Friuli Venezia Giulia region of
386 northeastern Italy; in Azzano Decimo, a hailstone measuring 19 centimeters in diameter broke
387 the European record for hail size. In Estonia, a storm on August 7 produced hailstones that
388 measured 8 centimeters in diameter, a new national record for the country.

389 There were also dry spells. No measurable rain, meaning less than 1 mm, fell over France
390 for 32 consecutive days, from January 21 to February 21, the longest such occurrence since
391 records began in 1959. In Syria, summer heatwaves contributed to declining water levels of the
392 Euphrates River, which reached a historic low at Tabqa Dam in mid-August and affected nearly
393 one million residents in the Hassakeh governorate. Beginning on 19 August, the largest wildfire
394 since the start of the record in 2000 for the European Union destroyed many buildings in the

395 Alexandroupolis municipality of Greece, forced residents in 13 towns to evacuate, and killed at
396 least 21 people. The fire burned almost 94,000 hectares by September 3. Overall, the total area
397 burned in Greece in 2023 was more than four times its long-term average.

398

399 *Asia*

400 Annually averaged temperatures were above the 1991–2020 normal across most of Asia
401 in 2023, including more than 2°C above average across Central Asia and the Siberian plain.
402 China, South Korea, and northern, eastern, and western (equal with 1998) Japan reported their
403 warmest year on record, and Hong Kong (China), Singapore, and Vietnam each observed their
404 second warmest. Russia experienced its third-warmest year on record and also equaled its third
405 wettest year on record. A major and prolonged heatwave affected much of northern Vietnam in
406 May; an all-time national maximum temperature record of 44.2°C was observed at Tuong Duong
407 on May 7, surpassing the previous record of 43.4°C at Huong Khe on April 20, 2019. A
408 heatwave in June claimed more than 160 lives in various parts of India. While June is normally
409 hot for the region, the heatwave drove temperatures to as high as 43.3°C. During October,
410 extreme high temperatures affected northeast Asia. Northern China observed its hottest October
411 since the start of the record in 1961. The above-normal temperatures over this region lasted 26
412 days, with an average maximum anomaly of +8°C on October 25.

413 There were some notable cold extremes as well. Afghanistan experienced one of its
414 coldest Januarys on record due to a disrupted polar vortex. Temperatures during the month
415 reached –28°C and resulted in 162 fatalities. At the end of the year, extreme minimum
416 temperatures during 10–13 December were –25°C to –35°C across the Zhambyl region of

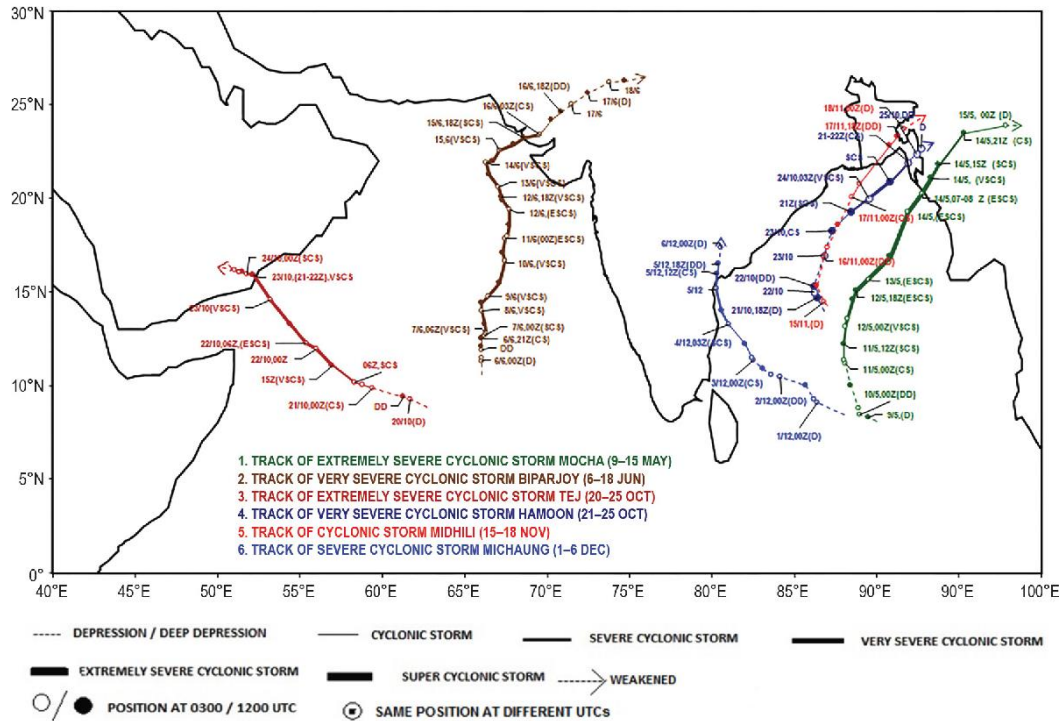
417 Kazakhstan, reportedly damaging gas pipelines in the region and leaving at least 1200 homes
418 without fuel.

419 India’s summer monsoon set in over Kerala—which is located in the southwestern state
420 of Kerala—on June 8, seven days later than the normal onset date of June 1. The monsoon
421 quickly covered the entire country on July 2, which is six days ahead of its normal date of July 8.
422 In total, the summer monsoon seasonal rainfall averaged over the country from June through
423 September was 95% of its long-term average, which is considered to be within the normal range.
424 The rain was variable through the season, however; August rainfall averaged across the country
425 was just 162.7 millimeters, the lowest since the start of the record in 1901. Monsoon rainfall over
426 Pakistan was also normal at 104% of its average. There was also large seasonal variability, with
427 July having significantly above-normal rainfall and August significantly below-normal.

428 During the year, Iran was in persistent drought that resulted in substantial losses for the
429 agricultural sector and produced severe hydrological challenges. Lake Urmia in northwestern
430 Iran nearly completely dried up, while Lake Hamoon in the east has been completely dry since
431 2021 due to long-term drought conditions. The dried lake beds have become a significant source
432 of rising dust during late spring and summer wind storms, leading to adverse health effects on
433 the local population.

434

435 **The North Indian Ocean Tropical Cyclone Basin Had a Busier-Than-Normal**
436 **Season in 2023**



437

438 Caption: Among the storms that formed in this basin, Extremely Severe Cyclonic Storm

439 Mocha, which developed in May during the pre-monsoon season, was one of the most

440 intense cyclones to ever form over the Bay of Bengal, with winds peaking at 260

441 kilometers per hour and a minimum central pressure of 918 millibars, equivalent to a

442 Category 5 hurricane on the Saffir-Simpson Hurricane Wind Scale. The storm formed

443 on May 11 and intensified as it moved north, reaching its peak intensity early on May 14

444 before making a catastrophic landfall in Myanmar, causing over \$1 billion U.S. dollars in

445 damage and hundreds of fatalities between Myanmar and Bangladesh. (Figure 7.55 in

446 State of the Climate in 2023; see discussions in sections 4.g.5 and 7.g.4)

447

448 *Oceania*

449 The El Niño–Southern Oscillation, a positive Indian Ocean dipole, and the long-term

450 warming trend all impacted Oceania in 2023. Sea surface temperatures in the Niño-4 region,

451 which covers a large area in the western and central tropical Pacific, reached record highs for the
452 July–December period as El Niño strengthened. These warm surface waters impacted air
453 temperatures in some places: Majuro, the capital of the Republic of the Marshall Islands, tied its
454 all-time highest minimum temperature of 28.9°C on September 8. New Zealand reported its
455 second-warmest year overall since the start of its record in 1909. May and September were both
456 the warmest on record for their respective months; August, however, was the first month with a
457 below-average national temperature since May 2017. For Australia, 2023 tied as the eighth-
458 warmest year since the start of its record in 1910. January was the coldest January since 2002,
459 but June–November was the warmest such period on record, contributing to the warm year
460 overall. The high temperatures in the second half of the year aligned with the developing El Niño
461 and positive Indian Ocean dipole, both of which are known to increase temperatures in the
462 austral winter and spring. Additionally, August to October 2023 was the driest three-month
463 period in Australia in the record dating to 1900, with an average of just 22.63 millimeters of total
464 rainfall. Due to the warm and dry conditions, millions of hectares of bushfires burned for weeks
465 in the Northern Territory during September and October.

466 Post-Tropical Cyclone Gabrielle affected New Zealand during February 12–15, resulting
467 in 11 fatalities, widespread flooding, and extensive damage. A National State of Emergency was
468 declared for only the third time in the country’s history. Floodwaters cut off entire communities
469 in Hawke’s Bay and Gisborne. Gabrielle was also one of the costliest natural disasters in New
470 Zealand history, with over an estimated \$9.5 billion U.S. dollars of costs to the insurance
471 industry. Severe Tropical Cyclones Kevin and Judy impacted Vanuatu within 48 hours of each
472 other in early March. Approximately 80% of the population were affected by at least Category 2
473 strength winds from one or both of the storms. In May, Typhoon Mawar became the strongest

474 tropical cyclone to impact Guam since Super Typhoon Pongsona in 2002, bringing over 600
475 millimeters of rain in less than 24 hours and maximum sustained winds up to 225 kilometers per
476 hour across the far north. Damage estimates exceeded \$4 billion U.S. dollars. Guam International
477 Airport reported its second-wettest year on record, behind 1976. Nearly 20% of the annual
478 rainfall was from Mawar.
479