WMO Provisional statement on the State of the Global Climate in 2018

Global Temperature

Global mean temperature for the period January to October 2018 was 0.98±0.12°C above the pre-industrial baseline (1850-1900). The estimate comprises five independently maintained global temperature data sets[1] and the range represents the spread of the data sets (see Notes for further details).

2018 is on course to be the 4th warmest year on record. This would mean that the past four years – 2015, 2016, 2017 and 2018 – are also the four warmest years in the series. 2018 is the coolest of the four. In contrast to the two warmest years, 2018 began with weak La Niña conditions, typically associated with lower global temperatures. The 20 warmest years have all occurred in the past 22 years.

The IPCC Special Report on Global Warming of 1.5°C (IPCC SR15) reported that the average global temperature for 2006-2015 was 0.87°C above a pre-industrial baseline (see Notes). For comparison, the average increase above the same baseline for the most recent decade 2009-2018 was 0.93±0.07°C, and the average for the past five years, 2014-2018 was 1.04±0.09°C. Note that both of these periods include the warming effect of the strong El Niño of 2015-2016.

2018 started with a weak La Niña event, which continued until March. By October, sea-surface temperatures in the eastern Tropical Pacific were showing signs of a return to El Niño conditions, although the atmosphere as yet has shown little response. If El Niño develops, 2019 is likely to be warmer than 2018.

Greenhouse Gases

Increasing levels of the greenhouse gases in the atmosphere are key drivers of climate change and atmospheric concentrations reflect a balance between emissions due to human activities and the net uptake by the biosphere and oceans. In 2017, greenhouse gas concentrations reached new highs, with CO_2 at 405.5±0.1 parts per million (ppm), CH_4 at 1859±2 parts per billion (ppb) and N_2O at 329.9±0.1 ppb. These values constitute,

[1] The data sets are: HadCRUT.4.6.0.0 produced by the UK Met Office in collaboration with the Climatic Research Unit at the University of East Anglia; NOAAGlobalTemp produced by National Oceanic and Atmospheric Administration, National Centers for Environmental Information; GISTEMP produced by the National Aeronautics and Space Administration Goddard Institute for Space Studies; JRA-55 produced by the Japan Meteorological Agency; and ERA-Interim produced by the European Centre for Medium-range Weather Forecasts.

respectively, 146%, 257% and 122% of pre-industrial levels (before 1750). Global average figures for 2018 will not be available until late 2019, but real-time data[2] from a number of specific locations, including Mauna Loa (Hawaii) and Cape Grim (Tasmania) indicate that levels of CO_2, CH_4 and N_2O continued to increase in 2018.

The IPCC SR15 report found that limiting warming to 1.5°C above pre-industrial implies reaching net zero[3] CO_2 emissions globally around 2050 and concurrent deep reductions in emissions of non-CO_2 forcers, particularly methane.

Decadal predictions[4] suggest an increasing risk of temporary exceedance of 1.5°C above preindustrial conditions[5]. Although the Paris Agreement refers to a long-term exceedance of 1.5°C and not individual months or years, such short-term exceedances will become more common as the threshold is approached, highlighting the importance of closely monitoring the Paris Agreement targets.

Oceans – Ocean Heat Content, Sea Level and Acidification

More than 90% of the energy trapped by greenhouse gases goes into the oceans. Ocean heat content provides a direct measure of the energy accumulating in the upper layers of the ocean. For each three-month period in 2018 (to July-September 2018[6]), the ocean heat content in the upper 700m (data from 1955) and upper 2000m (data from 2005) were the highest or 2nd highest on record. In each case, where 2018 was 2nd highest, the highest was recorded in 2017.

Sea level data for 2018 is currently available to late October[7]. Global Mean Sea Level (GMSL) for the period from January to July 2018 has been around 2 to 3 mm higher than for the equivalent period in 2017. Year to year changes in sea level arise from changes in ice-sheet loss, land storage of water, as well as variations in ocean temperature. Sea level in 2018 has been close to the long-term trend following a rapid increase associated with the 2015-16 El Niño.

In the past decade, the oceans absorbed around 25% of anthropogenic CO_2 emissions. Absorbed CO_2 reacts with seawater and changes the pH of the ocean. This process is known as ocean acidification. Observations[8] in the open-ocean over the last 30 years have shown a clear trend of decreasing pH. The IPCC Fifth Assessment[9] report found that there was a decrease in the surface ocean pH of 0.1 units since the start of the industrial revolution (1750). Changes in pH are linked to shifts in ocean carbonate chemistry that can affect the ability of marine organisms such as molluscs and reef-building corals, to build and maintain

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[2] Provided by NOAA

[3] Net zero CO_2 emissions are achieved when anthropogenic CO_2 emissions are balanced globally by anthropogenic CO_2 removals over a specified period.

[4] Decadal predictions differ from climate projections in that they are started from current climate conditions and run forwards for several years. Like with weather forecasts, decadal forecasts typically produce a range of outcomes from which the probability of various events occurring can be estimated.

[5] Smith, D. M., Scaife, A. A., Hawkins, E., Bilbao, R., Boer, G. J., Caian, M., et al. (2018). Predicted chance that global warming will temporarily exceed 1.5 °C. Geophysical Research Letters, 45. https://doi.org/10.1029/2018GL079362

[6] Data from National Oceanic and Atmospheric Administration, National Ocean Data Center

[7] Data from European Space Agency Climate Change Initiative, Copernicus Marine Environmental Monitoring Service and AVISO (Archiving, Validation and Interpretation of Satellite Oceanographic data)

[8] Source IOC-UNESCO, Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization

[9] IPCC Fifth Assessment Report, Working Group 1, Chapter 3, FAQ3.3

shells and skeletal material. This makes it particularly important to fully characterise changes in ocean carbonate chemistry.

Sea ice

Arctic sea-ice extent was well below average throughout 2018 with record-low levels in the first two months of the year. The annual maximum occurred in mid-March and the March monthly extent was 14.48 million square kilometres, the 3rd lowest on record and approximately 7% below the 1981-2010 average (15.64 million square kilometres)[10]. The Arctic sea-ice extent reached its minimum in mid-September. The September monthly sea-ice extent was 4.62 million square kilometres, approximately 28% below average (6.40 million square kilometres). This ranked as the 6th smallest September extent on record. The 12 smallest September extents have all occurred in the 12 years since 2007. Sea-ice volume, estimated from reanalysis in 2018, was slightly higher than in 2017 and nominally the 6th lowest on record[11].

Antarctic sea-ice extent was also well below average throughout 2018. For the months February through August, the monthly extent ranked among the 10 smallest on record. The Antarctic sea-ice extent reached its annual maximum extent in late-September and early-October. The September monthly average extent was 17.82 million square kilometres, 5% below average (18.72 million square kilometres) and ranked among the five smallest[12].

Socio-economic Impacts

The socio-economic impacts described in this section are based on contributions from the following organizations: Food and Agriculture Organization, World Food Programme, United Nations High Commissioner for Refugees, International Organization for Migration, United Nations Environment Programme and Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization.

Agriculture and Food Security

Exposure of the agriculture sector to climate extremes is threatening to reverse gains made in ending malnutrition. New evidence shows a continuing rise in world hunger after a prolonged decline[13]. In 2017, the number of undernourished people was estimated to have increased to 821 million. Severe droughts associated with the strong El Niño of 2015–2016 and a number of localized extreme weather and climate events contributed to the recent rise in undernourishment. [14] Climate events in 2017 had the biggest impact on acute food insecurity and malnutrition in Africa[15], affecting 59 million people in 24 countries and requiring urgent humanitarian action. Much of the vulnerability to climate variability is associated with the dryland farming and pastoral rangeland systems supporting 70–80% of the continent's rural population.

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[10] according to data from the National Snow and Ice Data Center's (NSIDC) and Copernicus Climate Change Service (C3S)

[11] Consensus Statement for the Arctic Winter 2018-2019 Season Outlook from the Second Session of the Pan-Arctic Regional Climate Outlook Forum (PARCOF-2), virtual forum, October 2018 https://www.arctic-rcc.org/parcof-2

[12] 2nd smallest on record according to the C3S dataset and 5th smallest according to the NSIDC data

[13] FAO, IFAD, UNICEF, WFP and WHO. 2018. *The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition*. Rome, FAO. Licence: CC BY-NC-SA 3.0 IGO. Data are from 2005-2017

[14] FAO, IFAD, IOM and WFP. 2018. The Linkages between Migration, Agriculture, Food Security and Rural Development. Rome. 80pp. (http://www.fao.org/3/CA0922EN/CA0922EN.pdf). Licence: CC BY-NC-SA 3.0 IGO

[15] FAO, IFAD, UNICEF, WFP and WHO. 2018. The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome, FAO. Licence: CC BY-NC-SA 3.0 IGO. Table 7

Globally, 39 countries continue to be in need of external assistance for food. Persisting conflicts together with climate events have affected food availability and access. In 2018, unfavourable weather conditions limited Southern African cereal outputs, heightening food insecurity, while ample rains in East Africa boosted production prospects but also resulted in localized flooding that contributed to food insecurity. Favourable spring weather boosted production in North Africa, while in West Africa, harvests are expected to revert back to average levels. In Asia, cereal harvests are anticipated to be below-average in the Near East[16] and CIS (Commonwealth of Independent States) Asia, because of rainfall deficits and conflict. Cereal production in Latin America and the Caribbean in 2018 is forecast at 240.7 million tonnes, a 7.3% decline from the record output in 2017. The forecast production decline would mostly result from drought-reduced maize outputs in Argentina and Brazil. In Central America and the Caribbean, unfavourable rains affected 2018 maize production. [17]

In Somalia, about 2.7 million people were estimated to be in need of emergency assistance. These were mainly Internally Displaced Persons (IDPs) and agro-pastoral communities affected by drought between mid-2016 and late 2017[18]. In Southern Africa, especially in Madagascar, the number of people affected by food insecurity increased to 1.3 million in southern regions, associated with dry spells and tropical cyclones that kept cereal production in 2018 at below-average levels[19].

Typhoon Manghkut/Ompong, which crossed the Philippines in mid-September, was associated with losses in crops and fisheries that put the population's food security at risk. According to the Department of Agriculture of the Philippines, over 550 000 hectares of agricultural land were affected, and agricultural losses could reach at least US$ 265 million. Disruption to agricultural production will affect the country's food supply for the following months, while the loss of livelihood for farmers and fisher folk during the September-October harvest could worsen food insecurity and malnutrition. [20]

Population Displacement

Out of the 17.7 million Internally Displaced Persons (IDPs) tracked by the International Organization for Migration Displacement Tracking Matrix (IOM DTM) [21], over 2 million people were displaced due to disasters linked to weather and climate events as of September 2018[22]. Drought, floods and storms (including hurricanes and cyclones) are the events that have led to the most disaster-induced displacement in 2018. In all cases, the displaced populations have protection needs and vulnerabilities.

[16] Near East is an area from Turkey east to Afghanistan, including the Arabian Peninsula in the south.

[17] FAO. 2018a. Crop prospects and food situation. Food and Agriculture Organization of the United Nations. Quarterly Global Report, September 2018. http://www.fao.org/3/CA1487EN/ca1487en.pdf

[18] FAO. 2018b. Crop prospects and food situation. Food and Agriculture Organization of the United Nations. Quarterly Global Report, June 2018.

[19] FAO. 2018a. Crop prospects and food situation. Food and Agriculture Organization of the United Nations. Quarterly Global Report, September 2018. http://www.fao.org/3/CA1487EN/ca1487en.pdf

[20] NDRRMC, 2018. NDRRMC Update on preparedness measures and effects for Typhoon OMPONG (I.N. MANGKHUT"), National Disaster Risk Reduction and Management Council, The Philippines, 27 September 2018.

[21] The International Organization for Migration Displacement Tracking Matrix (IOM DTM) is a system to track and monitor displacement and population mobility. It represents the largest source of primary data on internal displacement in the world and it is used by a large number of humanitarian actors in their operations to support a more enhanced response to affected populations. See more at: https://displacement.iom.int/.

[22] See the IOM DTM Global Figures at: https://displacement.iom.int/, access on 23 October 2018.

In Madagascar, a long process of interlinked climate events is leading to population displacements[23]. Out of around 5 700 IDPs tracked by IOM in the 10 southern communes between 2009 and 2018, 42% were displaced in connection with drought, as of August 2018. The largest displacements in the assessed communes were noted between 2013 and 2016, a period corresponding to the prolonged drought between 2015 and 2016. The number of displaced persons decreased significantly in 2017 in period of improved rains and humanitarian assistance in the region. Early displacements were tracked in Madagascar in 2018 due to the lack of rain during the crop cycle from December 2017 to May 2018. In addition to drought, which largely affected the south of Madagascar, over 250 000 IDPs were tracked in 2017 because of Cyclone Enawo.

In some parts of the world, human mobility can be understood in the context of the relationship between conflict and climate events, where climate events act as a 'threat multiplier'. Somalia is one such context.[24] In 2018, a combination of sudden- and slow-onset events compounded by the protracted conflict have led to continued population displacement both internally and across borders.[25] As of July 2018, there were an estimated 2.6 million IDPs in Somalia against a backdrop of multi-faceted conflicts and intensified competition for resources due to climate-related events.[26] According to UNHCR's (United Nations High Commissioner for Refugees) Protection and Return Monitoring Network (PRMN) some 642 000 new internal displacements were recorded between January and July 2018, with flooding the primary reason for displacement (43%), followed by drought (29%), and conflict (26%).[27] Flooding can contaminate drinking water often leading to Acute Watery Diarrhoea (AWD) and Cholera[28]. During the same period in 2017, the vast majority of IDPs (84%) cited drought-related reasons for their displacement compared to only 0.4% indicating flooding.

Existing refugee and IDP sites are particularly vulnerable to climate and weather events such as storms. In 2018, hundreds of thousands of Rohingya refugees have been affected by secondary displacement due to extreme weather events[29][30][31]. The monsoon rains in Bangladesh between May and September put these refugees at heightened risk of landslides and flooding, particularly in Cox's Bazaar district, where the majority of Rohingya refugees reside. As of September 2018, up to 200 000 of the total estimated 900 000 Rohingya refugees were exposed to these natural hazards.[32] UNHCR provided emergency

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[23] IOM DTM Madagascar profile at: https://displacement.iom.int/madagascar, including the displacement report: https://displacement.iom.int/reports/madagascar-%E2%80%94-rapport-de-suivi-des-d%C3%A9placements-ao%C3%BBt-2018?close=true.

[24] HCT Somalia, https://reliefweb.int/sites/reliefweb.int/files/resources/Somalia%20Revised%20HRP%20July%202018-FINAL.pdf, p.4

[25] UNHCR, https://data2.unhcr.org/en/documents/download/65450

[26] UNHCR, https://data2.unhcr.org/en/situations/horn

[27] UNHCR, https://unhcr.github.io/dataviz-somalia-prmn/index.html#reason=&month=2018-01-01%2C2018-07-31&pregion=&pregionmap=&pdistrictmap=&cregion=&cregionmap=&cdistrictmap=

[28] OCHA, https://reliefweb.int/report/somalia/ocha-somalia-flash-update-5-humanitarian-impact-heavy-rains-15-may-2018-enso

[29] UNHCR, www.unhcr.org/rohingya-emergency.html

[30] See IOM DTM Needs and Populations Monitoring in Bangladesh during the Monsoon season, available at: http://iom.maps.arcgis.com/apps/MapSeries/index.html?appid=1eec7ad29df742938b6470d77c26575a and https://displacement.iom.int/reports/bangladesh-%E2%80%94-npm-acaps-analysis-hub-report-%E2%80%94-rohingya-crisis-impact-cyclones-report-april?close=true.

[31] Ibid.

[32] Ibid.

shelter, and made temporary emergency relocation arrangements for those most at risk, as well as extending its support to Bangladeshi communities affected by monsoon rains through the distribution of family kits.[33]

Environmental Impacts

In addition to direct socio-economic impacts on human health and well-being, United Nations organizations[34] are additionally tracking environmental impacts associated with climate change. These include coral bleaching and reduced levels of oxygen in the oceans. Others – loss of "Blue Carbon" associated with coastal ecosystems such as Mangroves, Seagrasses and Salt Marshes; and ecosystems across a range of landscapes – are important coastal, ocean and terrestrial components of the carbon cycle.

Peatlands are important to human societies around the world. They contribute significantly to climate change mitigation and adaptation through carbon sequestration and storage, biodiversity conservation, water regime and quality regulation, and the provision of other ecosystem services that support livelihoods. Climate change has emerged as a significant threat to peatland ecosystems, because it exacerbates the effects of drainage and increases fire risk. It exposes peatlands currently protected by permafrost to thawing and possible increased methane emissions and loss of carbon. Sea-level rise increases the risks of coastal erosion and salination of freshwater peatlands.

Grazing lands cover five billion hectares worldwide and sequester 200-500kg of carbon per hectare per year, playing an important role in climate change mitigation. In addition to containing the bulk of the world's terrestrial inorganic carbon, rangelands store organic carbon in biomass and in the soil. The unique climatic features of the rangelands means that in many places the majority of carbon is below ground. Restored rangeland not only contributes to climate change mitigation, but provides other ecosystem services including protection of watersheds, habitat for biodiversity and reduction of dust storms.

High Impact Events in 2018

Of the countries that provided information for this report, over 1 600 deaths were associated with heat waves and more than 100 with the wildfires in Greece and California.

Hot and dry conditions in Europe led to heavy agricultural losses in many countries, with expected crop losses in Germany of 43% (relative to the 2013-17 average) for maize and 21% for potatoes[35]. Production losses are likely to be in the billions of euros. Dry conditions in Argentina resulted in heavy losses to summer crops, especially soybeans and maize, with agricultural losses estimated at US$3.9 billion.

The western Cape Province of South Africa experienced acute water shortages in the first half of 2018 as a result of low rainfall in each of the previous three years, especially 2017. Rainfall in 2018 to date has generally been close to average. This, along with reduced consumption, has allowed for recharge of water storages in the region, with Cape Town's major water stores at 74% of capacity (as of 5 November[36]), compared with 38% at the same time in 2017, and close to 20% in southern hemisphere autumn of 2018.

[33] UNHCR, https://data2.unhcr.org/en/documents/download/65468
[34] UNEP (United Nations Environment Programme) and IOC-UNESCO
[35] From https://ec.europa.eu/jrc/sites/jrcsh/files/jrc-mars-bulletin-vol26-no10.pdf
[36] Weekly water report, City of Cape Town

Tropical Storms

It was an active tropical cyclone season in the Northern Hemisphere (NH) in 2018. The number of tropical cyclones[37] was above average in all four NH basins. As of 20 November, there had been 70 NH cyclones in 2018, well above the long-term average of 53 for this stage of the year. The Northeast Pacific basin was especially active, with an Accumulated Cyclone Energy (ACE)[38] value of 316.3 kt^2, the highest since reliable satellite records began. Southern Hemisphere activity in the 2017-18 season was near average, with 22 cyclones.

Two of the strongest tropical cyclones of the year were Mangkhut (Ompong) and Yutu (Rosita) in the Northwest Pacific. Mangkhut (Ompong), crossed the northern Philippines in mid-September, then passed just south of Hong Kong before making landfall in Guangdong province of China. It affected more than 2.4 million people. 134 deaths were reported, 127 of them in the Philippines. In Hong Kong, the storm surge of 2.35 m at Victoria Harbour was the highest since instrumental water level measurements started in 1954. Yutu (Rosita), which crossed the northern Mariana Islands in October at near peak intensity, brought extensive damage to that region.

Jebi, which made landfall near Kobe on 4 September, was the strongest landfall in Japan since 1993. There was widespread river and storm surge flooding, with much of Kansai International Airport's runway (near Osaka) being inundated and temporarily shut down. Son-Tinh, in July, caused extensive flooding in Vietnam and Laos, and contributed to the collapse of a dam in Laos which resulted in at least 36 deaths. Soulik, in late August, crossed the Korean Peninsula and contributed to severe flooding in the Democratic People's Republic of Korea in which at least 86 lives were lost.

There were two significant hurricane landfalls on the United States mainland in 2018, each associated with severe damage. Florence weakened from category 4 to category 1 before landfall in North Carolina in September, but still caused extreme rainfall and significant flooding, especially in coastal regions as it tracked parallel to the coast before moving inland. Some rivers in the affected areas reached their highest levels after the storm had passed, prolonging the impacts. Michael, in October, made landfall in the Florida Panhandle as a category 4 system with a central pressure of 919 hPa, the most intense known landfall in this region and the most intense landfall in the continental United States since 1969 based on central minimum pressure, with severe wind and storm surge damage. At least 50 deaths in the United States were associated with Florence and 45 with Michael.

Three of the five North Indian cyclones affected Yemen: Sogar and Mekunu in May, and Luban in October. The most intense of these was Mekunu, which made landfall near Salalah, Oman in late May. At least 24 died, most on the island of Socotra[39]. Titli made landfall on 11 October in Andhra Pradesh, on the east coast of India, and there were at least 85 deaths, associated with flooding.

Two tropical cyclones affected the east coast of Madagascar in early 2018, Ava in January and Eliakim in March. Both approached very close to the coast and were associated with major flooding, with significant loss of life in both cases.

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[37] The annual numbers for 2018 are based on 2018 season in the Northern Hemisphere basins and the 2017-18 season in the Southern Hemisphere basins.

[38] The Accumulated Cyclone Energy (ACE) index combines the intensity and lifetime of each cyclone to provide a measure of overall activity.

[39] Reliefweb: https://reliefweb.int/sites/reliefweb.int/files/resources/IB_YE_2018.05.31.pdf

Gita in the South Pacific in February 2018 was the most intense tropical cyclone ever to affect Tonga, passing 30 km south of the most heavily populated island of Tongatapu and causing severe damage. Significant damage also occurred in Samoa, American Samoa and on outlying islands of Fiji.

Floods, extreme rainfall and extratropical storms

In August, the southwest Indian state of Kerala suffered major flooding, reportedly the worst since 1924, as a result of persistent heavy monsoon rains. Rainfall for the state for August was 96% above the long-term average, with weekly totals for the weeks 9-15 August and 16-22 August 255% and 219% above average respectively. 398 mm fell at Nilambur on 9 August, and 623 mm in two days at Peermade To on 15-16 August. 223 deaths were reported and according to reports from the National Disaster Management Authority, more than 1.4 million people were accommodated in relief camps, and more than 5.4 million were affected in some way. Total economic losses were estimated at US$ 4.3 billion.

Large parts of western Japan experienced destructive flooding in late June and early July as a result of persistent rains from a near-stationary Baiu front. Rainfall totals at Yanase, on Shihoku island, reached 1 025 mm in 48 hours at the system's peak, with a total of 1 853 mm for the period from 28 June to 8 July. In total, at least 230 deaths were reported and 6 695 houses were destroyed.

Flooding affected many parts of east Africa in March and April. This included Kenya and Somalia, which had previously been suffering from severe drought, as well as Ethiopia and northern and central Tanzania. Rainfall for the period from March to May was at least double the average over most of Kenya and northern Tanzania. At least 87 deaths were attributed to flooding in Kenya, and 14 in Tanzania.

Heatwaves and drought

Large parts of Europe experienced exceptional heat and drought through the late spring and summer of 2018. Temperatures were well above average, and rainfall well below average, from April onwards in much of northern and western Europe.

Some of the most abnormal conditions affected northern Europe from May to July. This period was the driest and warmest on record in many parts of central and southern Scandinavia; rainfall for May to July at Lund in southern Sweden, with observations back to 1748, was only about half the previous lowest recorded. This culminated in a prolonged heatwave in late July and early August, which included numerous record high temperatures north of the Arctic Circle, and record long runs of warm temperatures, including 25 consecutive days above 25 °C at Helsinki-Vantaa (Finland) and 8 consecutive days above 30 °C at Lääne-Nigula (Estonia). Warm nights and high humidity were also a feature of this period, with records including seven consecutive nights above 20 °C at Riga (Latvia) and a national record dewpoint of 24.8 °C on 1 August at Karlskrona (Sweden). It was also an exceptionally warm and dry period in the United Kingdom and Ireland.

Conditions in these regions moderated from mid-August, but it remained unusually warm and dry further south. Dry conditions were especially persistent in Germany, where the April-September period was the 2nd driest on record, and eastern Switzerland (April-October 2nd driest on record), with western Poland, the Czech Republic (with its driest January to August on record), the Netherlands and northeast France also amongst the areas affected. The most significant heatwave in central Europe was in late July and early August; in France it was of similar duration, but less intense, than the heatwave of 2003; still, around 1 500 excess deaths were reported. In Germany, some sites in the Frankfurt area had 18 consecutive days above 30 °C from 23 July to 9 August. Further southwest, a short but intense heatwave affected Spain and Portugal in early August. In Portugal, 4 August was the country's hottest day of the 21st century with 40% of stations setting records, including Lisbon – Gago Coutinho (44.0 °C). Armenia had its warmest July on record and In Yerevan 43.7 °C was recorded, the highest temperature on record.

Wildfires reached an unprecedented extent in Sweden with over 25 000 hectares burned, and abnormal wildfire activity also occurred in Latvia, Norway, Germany, the United Kingdom and Ireland. The dry conditions also led to very low flows on some central European rivers, with the Rhine approaching record low flows by mid-October, seriously disrupting river transport.

Eastern Australia experienced significant drought during 2018. The most extensively affected area was inland eastern Australia, particularly in New South Wales and southern Queensland, with much of the region receiving less than half its average rainfall for the period from January to September. Over the Murray-Darling Basin, the rainfall for January to September was the lowest since 1902. The abnormally dry conditions also extended to coastal areas in eastern Victoria, where it was the second dry year in succession, and on the east coast around and south of Sydney. The dry conditions extended to parts of Indonesia in mid-year, with significant drought affecting Java from July onwards.

Severe drought affected Uruguay, and northern and central Argentina, in late 2017 and early 2018, with the most intense period lasting from October 2017 to March 2018. Rainfall for the 6-month period over the five most affected Argentine provinces (Entre Ríos, Santa Fe, Córdoba, Buenos Aires and La Pampa) was 43% below the 1981-2010 average, the lowest on record. The drought eased from April, with May being Argentina's wettest on record. The dry conditions resulted in heavy losses to summer crops, especially soybeans and maize.

A historically significant heatwave affected parts of East Asia in late July and early August. The worst-hit area was Japan, following on from the severe floods they experienced in early July. A national record of 41.1 °C was set at Kumagaya on 23 July. In total, over 150 deaths in Japan were associated with the heat. It was the hottest summer on record for eastern Japan. The Korean Peninsula was also seriously affected, with a national record also set for the Republic of Korea (41.0 °C at Hongcheon on 1 August), as well as a city record for Seoul (39.6 °C), and heat illness and agricultural losses reported in the Democratic People's Republic of Korea.

Exceptionally high temperatures occurred in many parts of the Middle East and North Africa in late June and early July. On 26 June, the overnight temperature at Quriyat (Oman) only fell to 42.6 °C, amongst the highest known minimum temperatures. In early July the heat extended to north Africa, with records set at a number of locations in Algeria, the highest being 51.3 °C at Ouargla, a national record[40].

Cold and snow

One of the most significant cold outbreaks of recent years affected Europe in late February and early March. Cold conditions initially became established in northeast Europe in late

[40] Confirmed by Algerian Met Service

February, where the 21-28 February period was the second-coldest on record for Estonia. Ireland and southern France experienced abnormal snow, with falls of 15 to 30 cm around Nimes and Montpellier, and in southern Italy around Naples. Unusually heavy snow also fell at higher elevations in Algeria. A rare freezing rain event also occurred in Portugal. A maximum temperature of −4.7 °C on 1 March at Tredegar (Wales), was a United Kingdom record for March. Earlier in the winter, there were unusual snowfalls in some desert areas of Morocco, with Zagora receiving its first snow since 1960 on 30 January. A very wet winter in much of the European Alps resulted in heavy snow accumulation at higher elevations. At Arosa, Switzerland (1880 m), a cumulative snowfall of 5.3m, 2nd highest on record, fell during the winter of 2017/18.

Severe storms

The severe weather season in the United States had below-average levels of activity. 876 tornadoes had been reported as of the end of September, about 20% below the 1991-2010 average, with none of EF4 or EF5 intensity[41]. However, destructive hailstorms affected the Dallas-Fort Worth region on 6 June, and the Denver-Boulder-Fort Collins corridor on 18-19 June, causing an estimated US$ 1 billion and US$ 2.1 billion damage respectively.

An intense low-pressure system in the Mediterranean Sea in late October brought flooding and high winds to several countries. Italy was the worst affected. Peak wind gusts on 29 October included 179 km/h at Monte Cimone and 148 km/h at Capo Carbonara, while a gust of 161 km/h occurred at Kredarica (Slovenia). Extremely heavy rainfall also occurred, with 24-hour totals up to 406 mm in the northeast alpine foothills, and 308 mm in Liguria. 3-day totals in excess of 400 mm also occurred in southern Switzerland and Austria, and in western Slovenia, while damaging winds were also reported in the Czech Republic and southern Poland. In Italy 30 deaths were associated with the October storm.

Wildfires

Major wildfires affected the region around Athens (Greece) on 23 July. The fires spread rapidly in high winds, unusual for the time of year, with peak gusts of 124 km/h north of Athens. There was significant loss of life.

The most significant fires of the US fire season occurred in northern California in late July and August. The Mendocino Complex fire was the largest in California history with a total area of 185 800 hectares, whilst the Carr fire led to the loss of 1 604 structures and 8 lives, and insured losses of US$ 1.5 billion, with the city of Redding being the worst affected. It was a severe fire season in western Canada. British Columbia broke its record for the most area burned in a fire season for the second successive year, with a total of 1.35 million hectares burnt as of 3 November. Property losses were modest given the scale of the fires and no casualties were reported.

A wildfire to the northeast of San Francisco, known as The Camp Fire, which burned in November, is now the deadliest fire in over a century for the U.S. and, in terms of property loss, the most destructive on record for California. There have been at least 79 fatalities and the number is likely to rise.

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[41] The Enhance Fujita (EF) scale categorises the intensity of tornadoes according to the damage they cause. It runs from EF0 to EF5. https://www.weather.gov/oun/efscale

Contributors

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Notes on baselines and methods for calculating global temperature series

The report uses the period 1850-1900 as a baseline against which to measure global temperature change. This period was adopted by the IPCC Special Report on 1.5°C as representative of pre-industrial conditions.

Of the global temperature data sets used, only HadCRUT4 goes back to 1850. The NOAAGlobalTemp and GISTEMP datasets are offset to match the average anomaly for HadCRUT4 in the period 1880-1900. The reanalyses are offset to match the average anomaly in HadCRUT4 for the period 1981-2010.

The choice of datasets used to calculate temperature changes since pre-industrial can lead to small differences in the estimated series. The IPCC SR15 report used four datasets: HadCRUT4, GISTEMP, NOAAGlobalTemp and a fourth data set produced by Cowtan and Way (2014). The Cowtan and Way data set is a version of HadCRUT4 in which data gaps have been filled using a statistical method known as kriging. Differences between series calculated using the IPCC method and the series calculated using the method described above amount to one or two hundredths of a degree, much smaller than the estimated uncertainty.

Notes on IPCC calculation of human-induced warming

The IPCC SR15 Technical Summary noted that “Human-induced warming reached approximately 1°C (±0.2°C likely range) above pre-industrial levels in 2017, increasing at 0.2°C (±0.1°C) per decade (high confidence)”. They also noted that “Since 2000, the estimated level of human-induced warming has been equal to the level of observed warming with a likely range of ±20% accounting for uncertainty due to contributions from solar and volcanic activity over the historical period (high confidence).“