WEATHER CLIMATE WATER
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WMO OMM
World Meteorological Organization
Organisation météorologique mondiale

WMO provisional Statement on the Status of the Global Climate in 2016

Highlights

2016 is very likely to be the world's hottest year on record. Global temperatures for January to September 2016 have been 0.88 °C (1.58 °F) above the average for the 1961-90 reference period and approximately 1.2°C above those of the pre-industrial period. Preliminary reanalysis data for October indicate that temperatures are continuing to be at a sufficiently high level to remain well above the 0.77 °C (1.39 °F) annual value set in 2015.

Atmospheric concentrations of major greenhouse gases continue to increase and reached the highest levels in the instrumental record. Arctic sea ice remained at very low levels and there was significant melting of continental ice on Greenland. The warming continued to affect ice on sea and land. Arctic sea ice extent was well below average throughout the year. Antarctic sea ice extent had fallen to near average by the start of 2016 after several years of well-above-average values . Greenland ice sheet surface melting during summer was substantially above the average. Northern Hemisphere snow cover remained well below average through most of the first half of 2016.

A strong El Niño event in the Pacific Ocean declined during the early months of 2016 and finished by May. In addition to contributing to elevated global temperatures, El Niño-related droughts continued into early 2016 in numerous parts of the world, including southern Africa, southeast Asia, northern South America, India, Ethiopia, eastern Australia and various islands of the tropical western Pacific.

Numerous weather events have had major impacts in 2016. The most significant, in terms of casualties, was Hurricane Matthew in October, which resulted in at least 546 deaths in Haiti before continuing to have significant impacts in Cuba, the Bahamas and the United States. Other tropical cyclones to have major impacts include Typhoon Lionrock, which caused destructive flooding and heavy casualties in the Democratic People's Republic of Korea, and Cyclone Winston, the most severe tropical on record to affect Fiji. The Yangtze basin in China had its most significant summer floods since 1999, whilst a wildfire which destroyed large parts of the city of Fort McMurray, was the most costly natural disaster in Canada's history.

Global temperatures at record levels

Global temperatures for January to September 2016 were 0.88 °C (1.58 °F) above the average for the 1961-90 reference period[1] and approximately 1.2 °C above pre-industrial levels[2]. They were especially warm in the early months of the year, with monthly anomalies of +1.12 °C (+2.02 °F) in February and +1.09 °C (+1.96 °F) in March, the largest monthly anomalies ever recorded. Conditions cooled slightly from May as the influence of the declining El Niño event decreased, but all months were still at least 0.7 °C above the 1961-90 average. Operational October data from the ECMWF ERA-40 reanalysis indicate that October temperature anomalies were similar to those which have prevailed from May to September, making it very likely that global temperatures for 2016 will surpass the record, set in 2015, of 0.77 °C (1.39 °F) above the 1961-90 average.

[1] The 1961-90 period is used as the reference for averages in this document unless otherwise stated. Where other averaging periods are used, it is generally because data are not available back to 1961 (e.g. most satellite-based data sets begin during the 1970s or 1980s).

[2] A number of definitions exist for the pre-industrial period, the most commonly used being 1850-99 and 1880-99. The value of 1.2 °C is valid (to the nearest 0.1 °C) whichever of these periods is chosen.

Temperatures in January-September 2016 were above the 1961-90 average over most oceans and the vast majority of land areas. In parts of Arctic Russia around the Ob River estuary and Novaya Zemyla, they were 6 °C to 7 °C above average. Many other Arctic and sub-Arctic regions in Russia, Alaska and northwest Canada were at least 3 °C above average (with Alaska's temperatures for the period being 1.3 °C above the previous record), and more than 90% of Northern Hemisphere land areas outside the tropics were at least 1 °C above average. Land temperature anomalies were less extreme in the Southern Hemisphere, but many areas were still 1 °C or more above average, including northern South America, northern and eastern Australia, and much of southern Africa.

The only large land area with below-average temperatures in 2016 was an area of subtropical South America encompassing northern and central Argentina and adjacent parts of Paraguay and lowland Bolivia, with smaller below-average areas in southwestern Australia and southern China.

At the continental scale, January-September 2016 was the warmest on record by substantial margins for North America and Asia. Africa is also near record levels for the year to date. Asia had its warmest spring and summer on record, Oceania its warmest summer and autumn, South America its warmest summer, and North America its warmest winter. Whilst the warmth was very extensive, a relatively small number of countries had their warmest January-September on record, two being the Russian Federation and India. It was the second-warmest January-September on record for China and the continental United States, and the fifth-warmest for Canada.

Warmth also affected the oceans

Temperatures were above average over most ocean areas, and were 1 °C or more above average in many parts of the tropical eastern and central Pacific, the eastern tropical Indian Ocean and the Indonesian archipelago, the Tasman Sea, the western subtropical North Atlantic and the far north Pacific. The most prominent area of below-average sea surface temperatures was the Southern Ocean south of 45°S (especially around the Drake Passage between South America and Antarctica, where temperatures were more than 1 °C below average in places). There were also cool areas in the North Atlantic southwest of Iceland (although this cold pool was less significant than in 2015) and in the central North Pacific south of the Aleutian Islands.

The very warm ocean temperatures contributed to significant coral bleaching in some tropical waters. Amongst the areas significantly affected was the Great Barrier Reef off the east coast of Australia, where record high sea surface temperatures occurred in March. Coral mortality of up to 50% was reported in northern parts of the Reef north of Lizard Island. Coral bleaching was also reported from Pacific island countries such as Fiji and Kiribati, with associated fish deaths also reported in Fiji. Significantly higher sea surface temperatures, as much as 3°C above average in some areas, are implicated in dramatic changes to the physical, chemical, and biological state of the marine environment with great impacts on food chains and marine ecosystems, as well as socio-economically important fisheries.

Global sea levels rose very strongly during the 2015-16 El Niño, rising about 15 millimetres between November 2014 and February 2016, well above the post-1993 trend of 3 to 3.5 mm per year, with the early 2016 values reaching new record highs. Since February, sea levels have remained fairly stable as the influence of the El Niño declines.

Greenhouse gas concentrations continue to increase; a relatively small 2016 ozone hole

Concentrations of major greenhouse gases in the atmosphere continue to increase, with mean annual global carbon dioxide concentrations in 2015 reaching 400 parts per million (ppm) for the first time. Whilst global figures for 2016 are not yet available, observations from Mauna Loa (Hawaii) and Cape Grim (Australia)

indicate the highest concentrations in the instrumental record of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). At Cape Grim, CO_2 levels in August averaged 401.42 ppm, compared with 398.13 ppm in August 2015[3] and 398.60 in December 2015. Methane levels in August 2016 averaged 1804.8 parts per billion (ppb) compared with 1801.7 ppb in August 2015, whilst N_2O levels in August 2016 were 327.9 ppb compared with 327.3 ppb in August 2015. At Mauna Loa, mean weekly concentrations of CO_2 as of 23 October were 402.07 ppm, compared with 398.50 ppm at the same time in 2015, and the May 2016 value of 407.7 ppm was the highest monthly value on record.

The Antarctic ozone hole in 2016, despite having an early onset, was relatively small compared with recent years, as a result of the polar vortex being centred away from the South Pole. The maximum ozone hole size for 2016 was 23.1 million square kilometres on 28 September, close to the 1979-2016 median and slightly below the average of the last decade. It was substantially smaller than the ozone hole in 2015, which peaked at 28.2 million square kilometres.

El Niño finishes in 2016, strong negative Indian Ocean Dipole

2016 began with a strong El Niño event in place. The 2015-16 El Niño event ranks amongst the three strongest since 1950, along with 1982-83 and 1997-98. It declined steadily through the early months of 2016, following the typical breakdown pattern of El Niño, and most indicators had fallen below El Niño thresholds by May.

Since May, sea surface temperatures in the equatorial central and eastern Pacific Ocean have been near or slightly below average. As of early November, they have not yet fallen below La Niña thresholds, although some climate model forecasts are indicating the possibility of weak La Niña conditions in the final weeks of 2016.

A strong negative phase of the Indian Ocean Dipole (IOD) developed in the Southern Hemisphere winter and spring. Sea surface temperatures were particularly abnormal in the eastern node of the IOD, with record high temperatures in the oceans between northwest Australia and Indonesia. IOD indices reached some of their lowest levels on record in July, and again in September. The strong negative phase of the IOD was associated with well-above-average rains from May onwards in much of Australia and parts of Indonesia, and below-average rains in parts of east Africa.

El Niño influence on global precipitation declines during the year

In the early months of 2016, precipitation in many parts of the world was strongly influenced by El Niño. Precipitation for the 12 months from July 2015 to June 2016 was well below average in many areas which typically show a dry signal during El Niño, such as Indonesia and the islands of the tropical western Pacific, much of southern Africa, and the northern half of South America along with parts of Central America and the Caribbean. However, rainfall was only near or slightly above average in California, and on the coasts of Peru and Ecuador, two regions which typically experience very wet conditions during strong El Niño events. In the case of California, this meant that 2015-16 only provided modest relief from long-term drought in the region.

For the period from January to September 2016, the largest region with precipitation well above average was a region extending from northern Scandinavia southeast across western and southern European Russia to Kazakhstan. Other major regions with well above average rainfall included eastern Australia south of the tropics, Alaska and Arctic Canada, the Yangtze basin in China, and the eastern side of the Andes in Argentina. Regions with well below average precipitation included central Siberia, Chile from Santiago southwards (extending to southern Argentine Patagonia and Tierra del Fuego), and scattered regions in the Amazon basin

[3] As greenhouse gas concentrations, particularly that of methane, have a seasonal cycle, it is more appropriate to compare with the same time last year than it is to compare with values at the end of 2015.

and southern Africa. Monsoon season rainfall in the Sahel was generally above average, whilst in the Indian subcontinent it was generally close to average, with all-India rainfall from June to September 3% below average, having been more than 10% below average in both 2014 and 2015.

Warming continuing to affect ice on sea and land

Arctic sea ice extent has been well below average throughout the year to date. The seasonal minimum in September was 4.14 million square kilometres, the equal-second (with 2007) lowest extent on record after 2012. Earlier in the year, sea ice extent had been at record low levels for the time of year, with the winter maximum in March being the lowest on record. The autumn freeze-up after the September minimum has also been much slower than normal; the sea ice extent as of the end of October is the lowest on record for that time of year.

After several years of well-above-average values, Antarctic sea ice extent had fallen to near average by the start of 2016. It reached a seasonal maximum of 18.44 million square kilometres (10^{th} lowest in the 1979-2015 period) on 30 August, nearly a month earlier than the usual date. Following this unusually early maximum, sea ice extent fell well below average and is still well below average as of the end of October.

Summer melting on the Greenland ice sheet was substantially above the 1990-2013 average, with especially strong melting in July, but was less than in the record melting year of 2012. Global data are not yet available for mountain glacier mass balance, for which strong melting had been recorded in 2015. There are also no comprehensive data yet available for 2016 for Antarctic ice sheet mass balance.

Northern Hemisphere snow cover was above average in January, but fell well below average in February after rapid melting in Europe, and remained well below average through the remainder of the first half of 2016, as warm temperatures led to early melting of snow cover in both Russia and North America. April snow cover extent was the lowest on record and all months from February to June ranked in the lowest three years since 1966. In contrast, autumn snow cover has been above average, as has been common in recent years, with early-season snows most pronounced in European Russia and Kazakhstan.

Tropical cyclones losses in many parts of the world

Tropical cyclones triggered major natural disasters in several parts of the world. The most damaging event of 2016 has been Hurricane Matthew in October, which, after reaching category 5 intensity to the country's south, the first category 5 system in the Atlantic since 2007, made landfall in western Haiti as a category 4 system. Matthew resulted in at least 546 deaths in Haiti, the worst meteorological disaster of 2016 to date in terms of casualties, with 1.4 million people requiring humanitarian assistance. After crossing Haiti, Matthew tracked north and went on to damage Cuba and the Bahamas, before tracking along the east coast of the United States and making landfall in South Carolina, leading to major coastal and river flooding in several places along its path.

Another event, which contributed to a major disaster, was Typhoon Lionrock in late August. The major effect of Lionrock was in north-eastern areas of the Democratic People's Republic of Korea (DPRK), where rainfall of up to 320 millimetres in four days led to catastrophic flooding. According to government reports, which described the event as the most significant natural disaster since the foundation of the DPRK, there were 133 deaths with 395 people missing, and 11,600 dwellings destroyed.

Cyclone Winston crossed the islands of Fiji in late February as a category 5 system, making it the strongest cyclone on record for Fiji. The cyclone led to major damage, especially on the north shore of the main island of Viti Levu. According to the International Disaster Database of the Université Catholique de Louvain (EM-DAT),

44 deaths were reported and total damage was estimated at US$1.4 billion. Winston also led to significant damage in Tonga.

Other significant tropical cyclones in 2016 included Typhoon Nepartak, which led -according to EM-DAT- to 86 deaths in Taiwan Province of China and mainland China and featured an observed pressure of 911 hPa from a buoy near the coasts; Typhoon Meranti, which was reported to be the most intense landfall on record in Fujian province in China after first crossing the far northern islands of the Philippines; and Cyclone Fantala, which generated 10-minute average winds of 250 km/h on 17 April south of the Seychelles, making it one of the most intense cyclones ever recorded in the southwest Indian Ocean.

In total, there have been 78 tropical cyclones globally in 2016 as of 31 October, close to the long-term average. Activity has been above average in the Northeast Pacific (20 cyclones, long-term average 15) and North Atlantic (14 cyclones, long-term average 12), and near average in the Northwest Pacific (22 cyclones). On the other hand, the 2015-16 Southern Hemisphere season saw below-average activity, especially in the Australian region, where there were only three cyclones, the lowest seasonal count since comprehensive satellite records began in 1970.

Major droughts in several parts of the world

Major droughts affected several parts of the world in 2016, most of them associated with the 2015-16 El Niño event. Whilst some of these droughts eased during the year as the El Niño broke down, others are still having serious impacts.

The most serious drought affected much of southern Africa. The region has experienced two consecutive poor rainy seasons, with rainfall well below average in both 2014-15 and 2015-16. Most of the region normally receives little rain between May and October, meaning that there is little prospect for recovery before the 2016-17 rainy season. According to the Food and Agriculture Organisation (FAO), there have been substantial agricultural losses throughout the region, badly affecting food production, with cereal production in 2015-16 12% lower than the already below-average amounts in 2014-15. The World Food Programme estimates that 17 million people will require assistance by early 2017, with the most-affected countries including Malawi, Angola, Zambia, Zimbabwe, Mozambique, Madagascar and Lesotho.

Regions where significant drought existed in the early months of 2016 included much of northern South America and nearby areas of Central America and the Caribbean; the Mekong basin in southeast Asia, particularly in Vietnam; parts of India; Indonesia, the Philippines and various islands of the tropical western Pacific; northern and central Ethiopia; and parts of eastern Australia.

According to FAO, there were also significant agricultural losses in Vietnam, where 83% of the national territory was assessed as being affected by drought or salt water intrusion, and water shortages in India, whilst drought also led to shortfalls in production of hydro-electricity in Venezuela. Conditions eased in all three of these regions during the year, as monsoon/rainy seasons through the middle of 2016 saw near-average rainfalls.

Average to above-average rainfall through mid-2016 also eased drought conditions in Ethiopia, where about 10 million people had required humanitarian assistance. Further south, rainfall was generally below average in the “long rains” (March-May) season in Kenya and Tanzania, and a very dry October at the start of the “short rains” season indicates a high risk of intensifying drought in that region.

In eastern Australia, there was a sharp turnaround from below-average to above-average rainfall. This was particularly dramatic in Tasmania, which had its driest September-April on record from September 2015 to April 2016, followed by its wettest May-October on record from May to October 2016. There was also a rapid

transition from below-average to above-average rainfall in much of Indonesia, particularly in Java and Sumatra.

The heavy rains which affected most of eastern Australia from May onwards also greatly eased the multi-year drought which had been in place since 2012 in inland Queensland and parts of Victoria and South Australia. However, there was little change in long-term droughts in Brazil and the southwestern United States, with near-average precipitation in the 2015-16 winter having only modest impacts on accumulated deficits in California.

Most significant flood season since 1999 in parts of China

The Yangtze basin in China experienced, overall, its most significant flood season since 1999, with some tributaries suffering record flood levels. Rainfall was consistently high across the middle and lower Yangtze region from April to July, with total April-July rainfall over the region about 40% above average, and similar to, or slightly above, that of 1998 and 1999. Over shorter timescales, very heavy rains from 18-20 July, centred on the Beijing region, also caused destructive flooding. In total, 310 deaths and 94 billion RMB (US$14 billion) were attributed to flooding in the Yangtze region and Beijing region. Also during this period, a tornado caused 99 deaths in Yancheng in Jiangsu province, one of the most destructive tornadoes in recorded Chinese history.

According to EM-DAT, flooding and landslides in Sri Lanka in mid-May left more than 200 people dead or missing, and displaced several hundred thousand. Significant flooding was also reported in various parts of India during the monsoon season, particularly in the Ganges basin, where the Ganges River reached record heights at some locations.

Consistently above-average rainfall through May and early June in parts of western Europe, reaching up to double the monthly average in northern France, culminated in four-day totals from 28-31 May of 80 to 120 millimetres in the Paris region. This led to major flooding in the region at the start of June. The worst-affected areas were in France, where the Seine River at Paris reached its fifth-highest level on record (and the highest outside the winter months), leading to major property damage.

Generally above-average seasonal rainfall in the Sahel led to significant flooding in the Niger River basin. In the upper Niger, the river reached its highest level since 1964 at Mopti (Mali) on 6 September, and flooding in the inner Niger Delta in Mali in November and December is expected to be or near its highest levels of the last 50 years. Flooding also occurred further downstream, particularly in Niger and northern Nigeria, and was also reported in other parts of West Africa outside the Niger basin, including Gambia, Senegal and Ghana. Significant flooding was also reported in the southern half of Sudan. Heavy seasonal rains also led to long-lived flooding on various inland rivers in Australia, especially in New South Wales where the Lachlan River at Forbes reached its highest level since 1952 in early October, closing the main highway from Melbourne to Brisbane for six weeks.

Summer heatwaves again a frequent occurrence, but cold not completely absent

There were a number of major heatwaves during 2016. The year started with an extreme heatwave in southern Africa, exacerbated by the ongoing drought. Many stations set all-time records in the first week of January; in some cases, these broke records which were only a few weeks old following previous heatwaves in November and December 2015. On 7 January, temperatures reached 42.7 °C at Pretoria and 38.9 °C at Johannesburg, both of which were 3 °C or more above the all-time records at those sites prior to November 2015.

Extreme heat also affected south and southeast Asia in April and May, prior to the start of the summer monsoon. Southeast Asia was badly affected in April. The extreme heat was centred on Thailand, where a

national record of 44.6 °C was set at Mae Hong Son on 28 April, and many individual locations set all-time records. A few weeks later, 51.0 °C was observed on 19 May at Phalodi, the highest temperature on record for India.

Record or near-record temperatures occurred in parts of the Middle East and north Africa on a number of occasions from late July to early September. The highest temperature observed was 54.0°C at Mitribah (Kuwait) on July 21 which (subject to ratification[4]) will be the highest temperature on record for Asia. Other extremely high temperatures included 53.9 °C at Basra (Iraq) and 53.0 °C at Delhoran (Iran – a national record), both on 22 July, whilst significant high temperatures were also reported in Morocco, Tunisia, Libya and the United Arab Emirates.

The most significant cold wave of 2016 occurred in late January in east Asia, with extreme low temperatures extending southwards from eastern China as far south as Thailand. In southern China, Guangzhou recorded its first snow since 1967 and Nanning its first since 1983, whilst the temperature fell to 3.1 °C at the Hong Kong Observatory, the sixth-lowest temperature on record there. Another significant cold wave occurred at the same time in the eastern United States, accompanied by very heavy snow, with accumulations of up to 100 centimetres in parts of Virginia and West Virginia. The snow caused major disruptions throughout the region, including in Washington D.C., Philadelphia and New York City, with the heaviest storm-total snowfalls on record at Baltimore and at several sites in the New York City area.

The most damaging wildfire in Canadian history

The most damaging wildfire in Canadian history, leading to the country's most costly natural disaster, occurred in May. After an unusually dry and mild start to the year, with the driest winter-spring on record, fire broke out near Fort McMurray in Alberta early in the month, before moving through the city on 4 May as temperatures reached 33 °C – the highest on record so early in the year -accompanied by strong winds and low humidity. The fire led to the total evacuation of the city and ultimately destroyed 2,400 buildings, causing 4 billion CAD (US$3 billion) in insured losses and several billion more in other losses. No deaths were directly caused by the fire, although two people died in a road accident during the evacuation. The fire ultimately burned an area of about 590,000 hectares before it was declared under control in early July.

Long-lived fires affected large parts of central and western Tasmania (Australia), which at the time was badly affected by drought, during the summer of 2015-16. These fires, which mostly broke out in mid-January, extended to areas on the Central Plateau where fire is extremely rare, causing significant damage to some sensitive alpine vegetation communities within the Tasmanian Wilderness World Heritage Areas. The fires burned for several weeks with some not brought under control until mid-March.

Serious humanitarian and environmental consequences have been recorded in 2015-2016[5]

According to the International Organisation for Migration (IOM), greater frequency and potentially greater intensity of weather related disasters, competition over shrinking resources due to climate and environmental changes -- and the induced tensions and conflicts -- as well as rising sea levels rendering coastal and low lying zones uninhabitable, are ways by which climate change is expected to increase population migration globally.

[4] Following standard procedures, WMO is establishing an evaluation committee to assess this potential continental record.

[5] Information on humanitarian and environmental impacts was provided by the UN High Commissioner for Refugees, the International Organization for Migration, the World Food Programme, the Food and Agriculture Organization of the United Nations and the United Nations Environment Programme

The United Nations High Commissioner for Refugees (UNHCR) reported that weather-related hazards triggered 14.7 million displacements in 2015. South and East Asian regions, countries and events again dominated in terms of the highest absolute figures, but no region of the world was unaffected. India, China and Nepal accounted for the highest numbers, with 3.7 million, 3.6 million and 2.6 million respectively. Equivalent data for 2016 are not yet available.

Extreme weather and climate related events, which were influenced by the strong El Niño of 2015-16, had significant negative impacts on agriculture and food security. The livelihoods of smallholder farmers, pastoralists, fisher folks and forest and tree dependent communities were severely affected by droughts, storms, floods, wildfires and hot and cold spells. FAO data indicates that more than 60 million people around the world, especially in developing countries were affected by these events.

The humanitarian impacts of the two-yearlong Southern Africa drought of 2014-16 were also very high. According to the World Food Programme (WFP), the humanitarian needs continued to grow over the period and are expected to peak in early 2017.

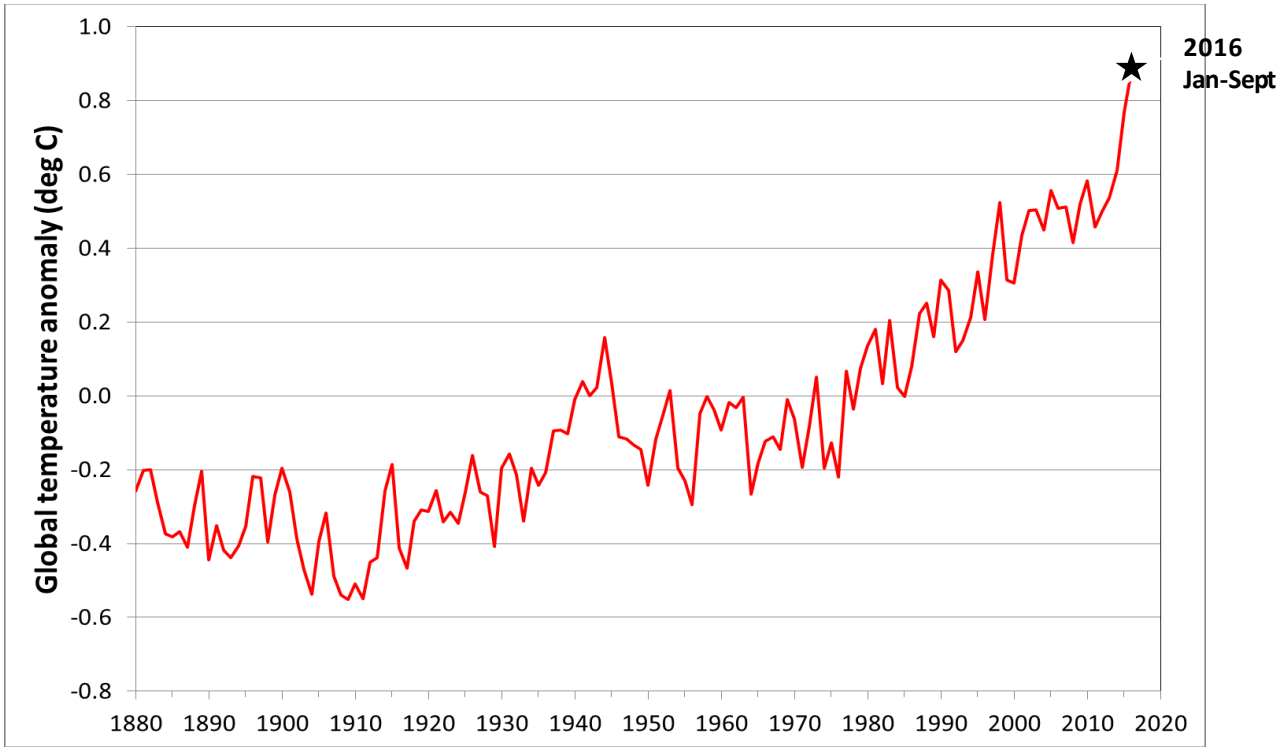
According to FAO, drought has also caused successive crop failures and widespread livestock deaths in Ethiopia, with more than one-third of the districts officially classified as facing a food security and nutrition crisis, and about 10 million people in need of humanitarian food assistance. In total, 24 million people have been reported as being in a situation of food insecurity in eastern Africa, through a combination of ongoing effects of El Niño-related droughts centred on Ethiopia which reached their maximum intensity in 2015, and developing droughts during 2016 elsewhere in east Africa, particularly in Somalia. Elsewhere, the Dry Corridor in Central America (El Salvador, Guatemala, Honduras and Nicaragua) was hit by severe and prolonged droughts which jeopardized agricultural production and contributed to food insecurity affecting over 3.5 million people. The Caribbean region suffered the harsh consequences of prolonged drought: in Haiti, for instance, over 1.5 million people were found to be severely food insecure owing in part to drought-related impacts. Several small islands in the Pacific have been facing the agricultural and food security-related consequences of drought in 2016, including the Federated States of Micronesia, Fiji, New Caledonia, Niue, Tonga, western Kiribati, southern Cook Islands, northern Vanuatu, Marshall Islands and Palau.

Ecosystem integrity and biodiversity are threatened by human activities coupled with the impact of climate change. Studies have shown that certain climatic regimes are associated with particular plant communities or functional types. Changes in climate will alter the configuration of terrestrial and marine ecosystems.

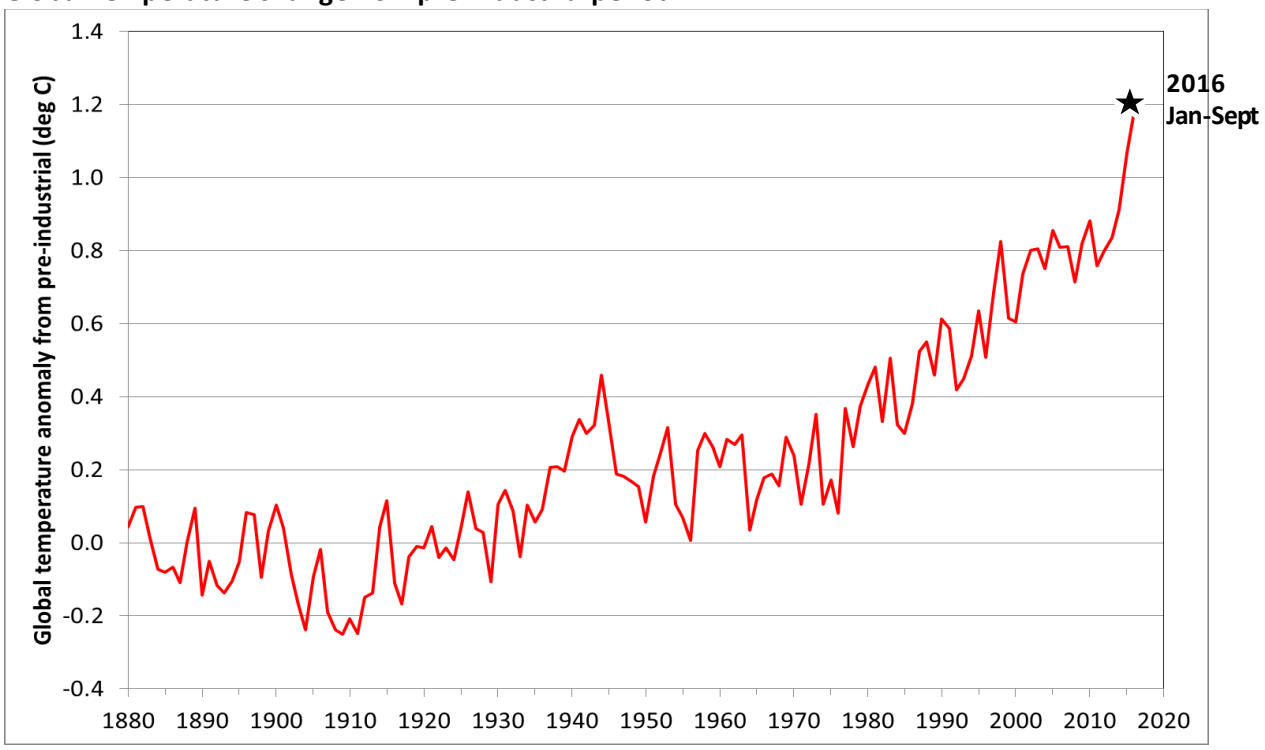
According to the United Nations Environment Programme (UNEP), changes to marine ecosystems driven by climate change raise serious concerns for instance in South East Asia and Pacific region for the possible decline in seagrass meadows and seaweed beds due to storms and warmer waters; the migration of tropical pelagic fish and other marine species to previously cooler waters; the loss of diversity in coral fish and coral-dependent organisms; and risks to the marine food chain from ocean acidification, potentially affecting fisheries. Coral reefs in the region are already affected by coral bleaching due to high thermal stress from climate change-induced temperature increases .

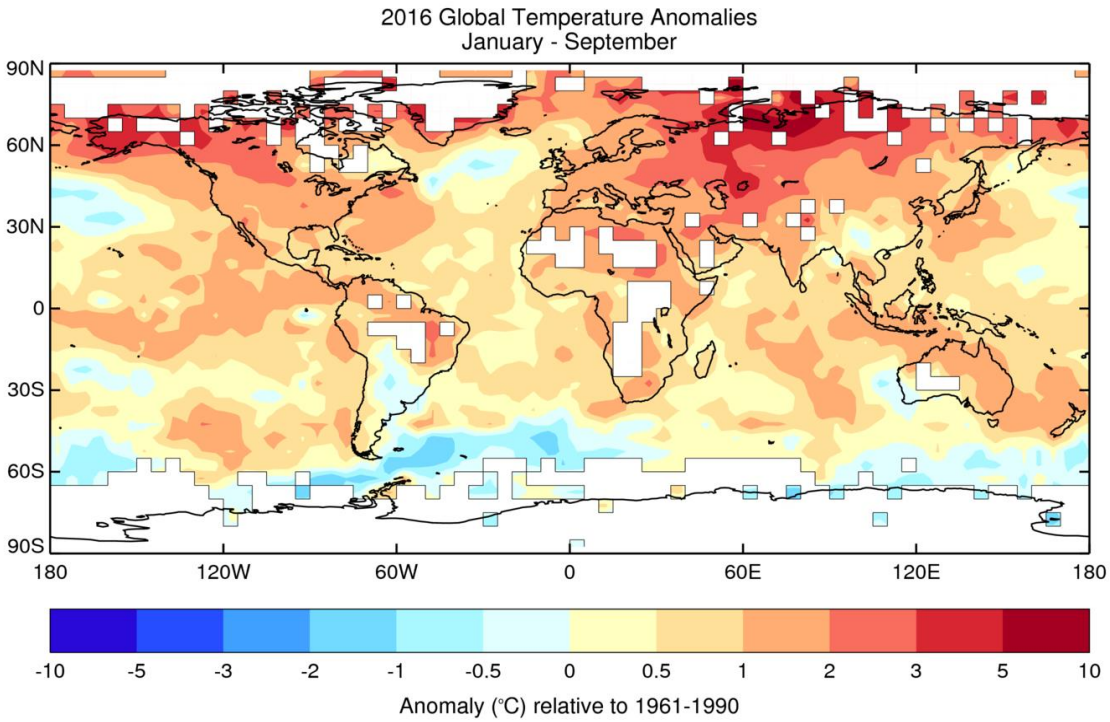
Between 2013 and 2015 exceptionally warm waters predominated in large parts of the Pacific. Previous to that, in 2011 the Indian Ocean along the west coast of Australia was affected by ocean warming. Also amongst the areas significantly affected in 2016 was the Great Barrier Reef off the east coast of Australia, where record high sea surface temperatures occurred in March. The Australian Meteorological Society reported Coral mortality of up to 50% in northern parts of the Reef north of Lizard Island. Coral bleaching was also reported from Pacific island countries such as Fiji and Kiribati, with associated fish deaths also reported in Fiji. UNEP indicated that significantly higher sea surface temperatures, by as much as 3°C above the long-term average in some areas, are implicated in dramatic changes to the physical, chemical, and biological state of the marine environment with great impacts on food chains, marine ecosystems, as well as socio-economically important fisheries

Global mean temperatures anomalies 1880 to 2016. Reference period 1961-1990



Global Temperature change from pre-industrial period





Source: UK Met Office/CRU

GHG concentration (WMO GHG bulletin, 2016)

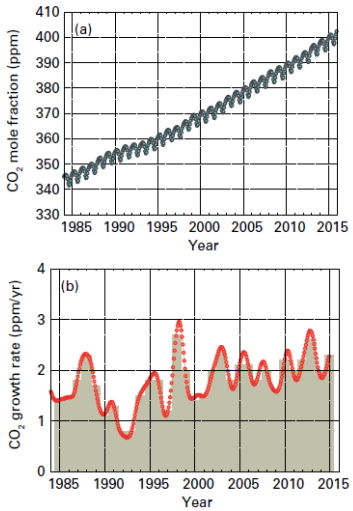


Figure 3. Globally averaged CO_2 mole fraction (a) and its growth rate (b) from 1984 to 2015. Increases in successive annual means are shown as columns in (b).

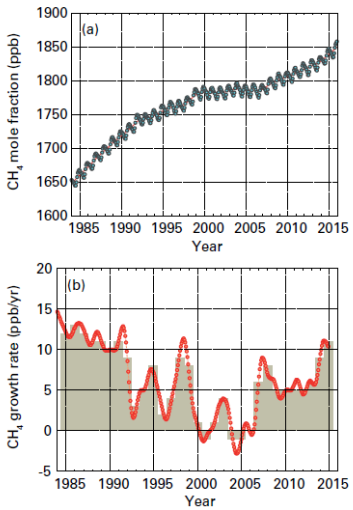


Figure 4. Globally averaged CH_4 mole fraction (a) and its growth rate (b) from 1984 to 2015. Increases in successive annual means are shown as columns in (b).

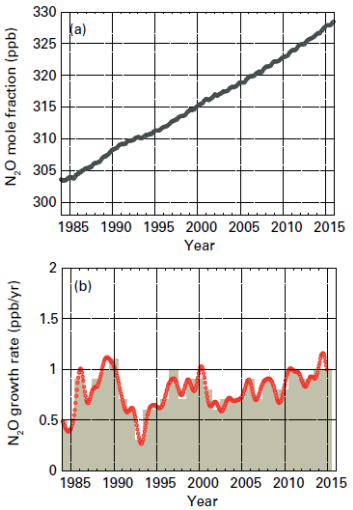
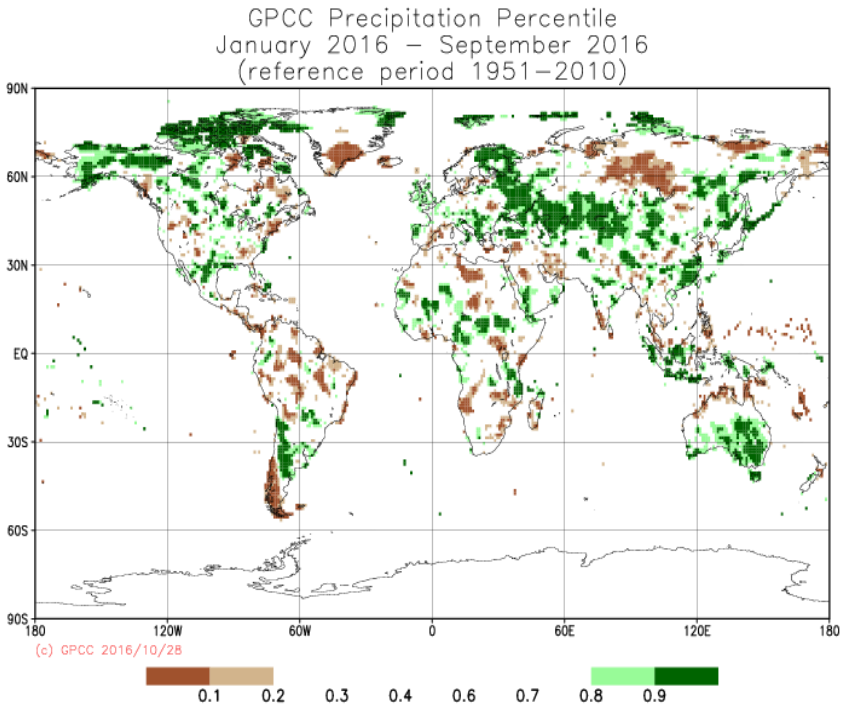
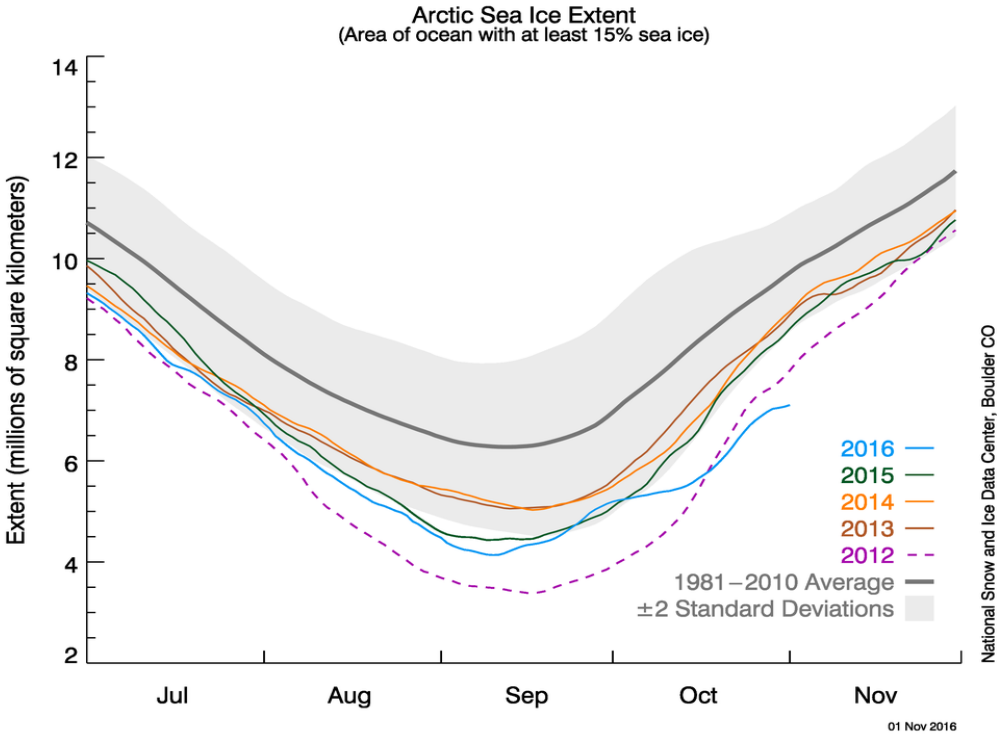


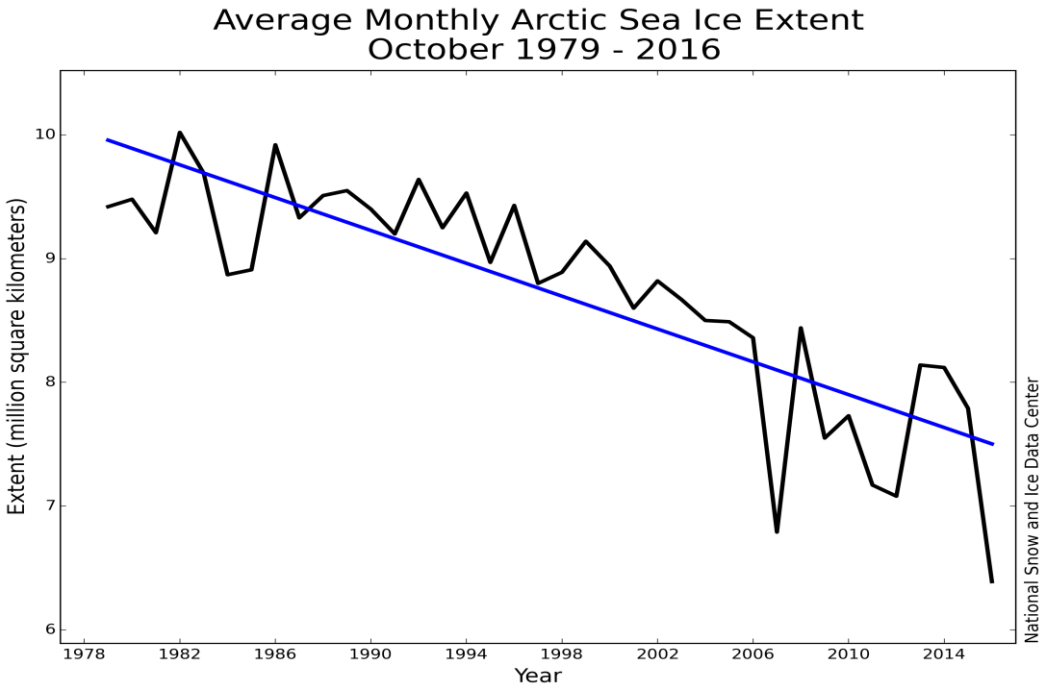
Figure 5. Globally averaged N_2O mole fraction (a) and its growth rate (b) from 1984 to 2015. Increases in successive annual means are shown as columns in (b).

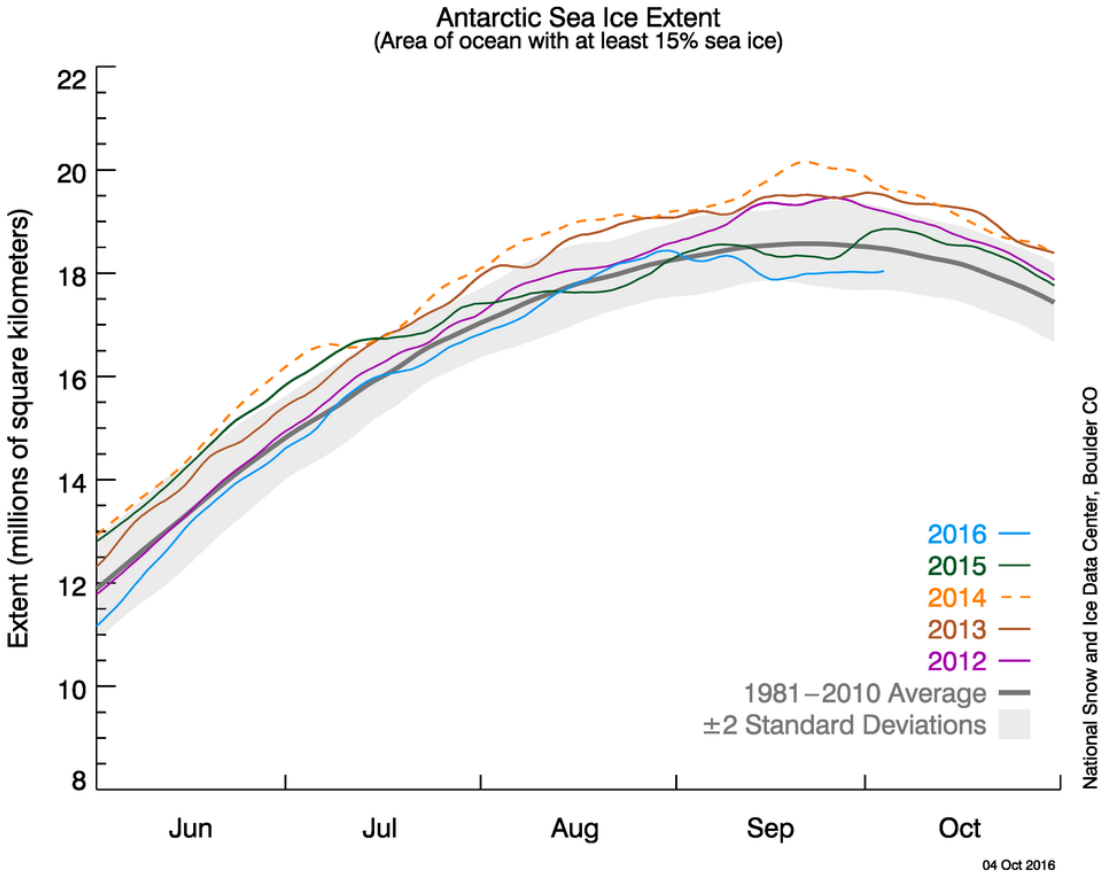
Table 1. Global annual surface mean abundances (2015) and trends of key greenhouse gases from the WMO/GAW global greenhouse gas monitoring network. Units are dry-air mole fractions, and uncertainties are 68% confidence limits [10]; the averaging method is described in [11].

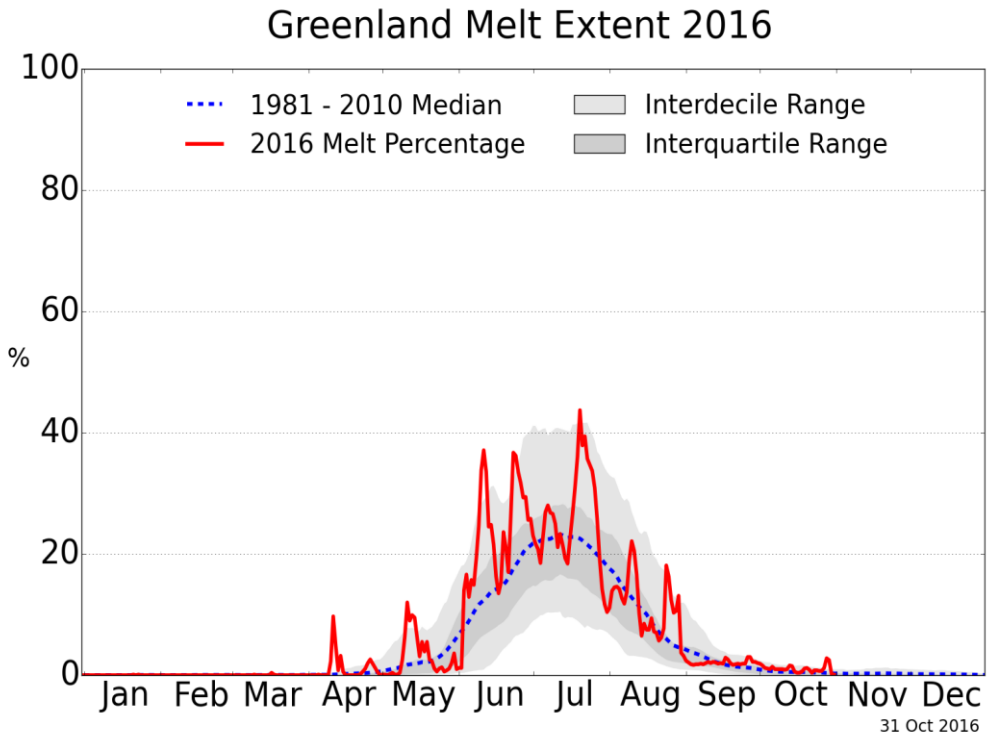
	CO_2	CH_4	N_2O
Global abundance in 2015	400.0±0.1 ppm	1845±2 ppb	328.0±0.1 ppb
2015 abundance relative to year 1750[a]	144%	256%	121%
2014–2015 absolute increase	2.3 ppm	11 ppb	1.0 ppb
2014–2015 relative increase	0.58%	0.60%	0.31%
Mean annual absolute increase during last 10 years	2.08 ppm yr^{-1}	6.0 ppb yr^{-1}	0.89 ppb yr^{-1}

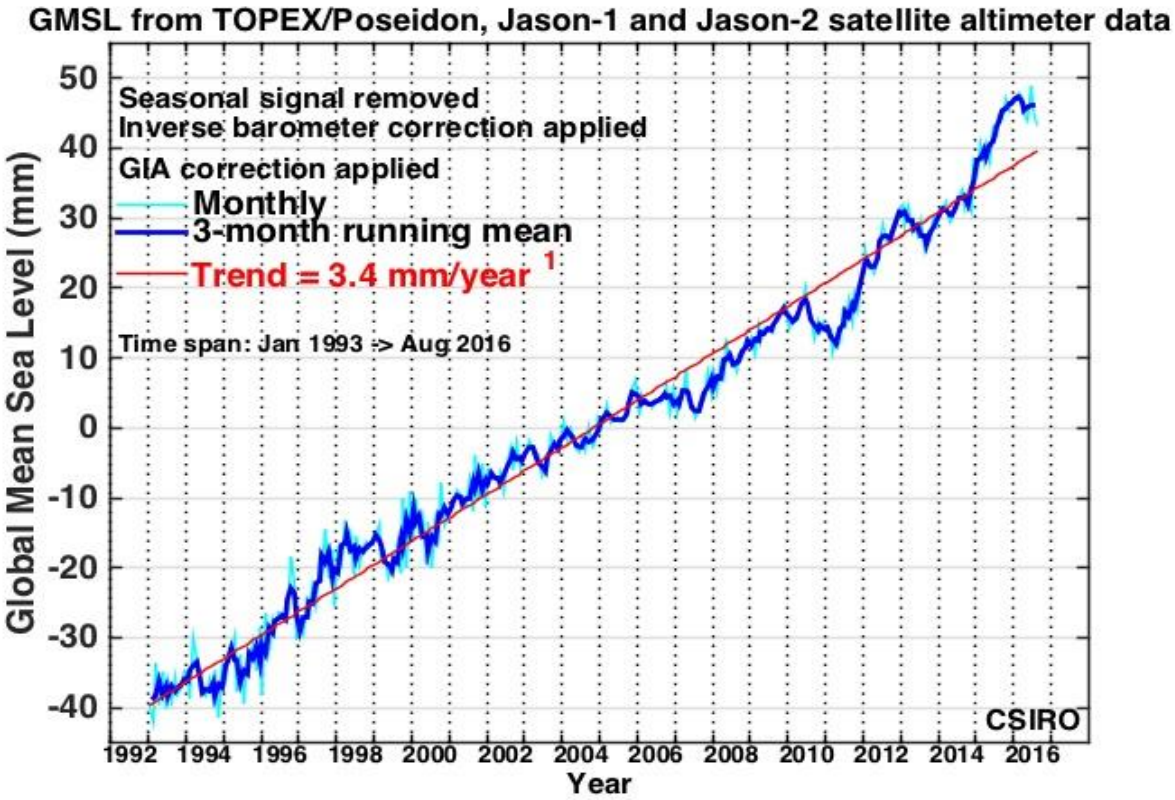

GPCC Precipitation Percentile
January 2016 – September 2016
(reference period 1951–2010)
90N
60N
30N
EQ
30S
60S
90S
180
120W
60W
0
60E
120E
180
(c) GPCC 2016/10/28
0.1
0.2
0.3
0.4
0.6
0.7
0.8
0.9

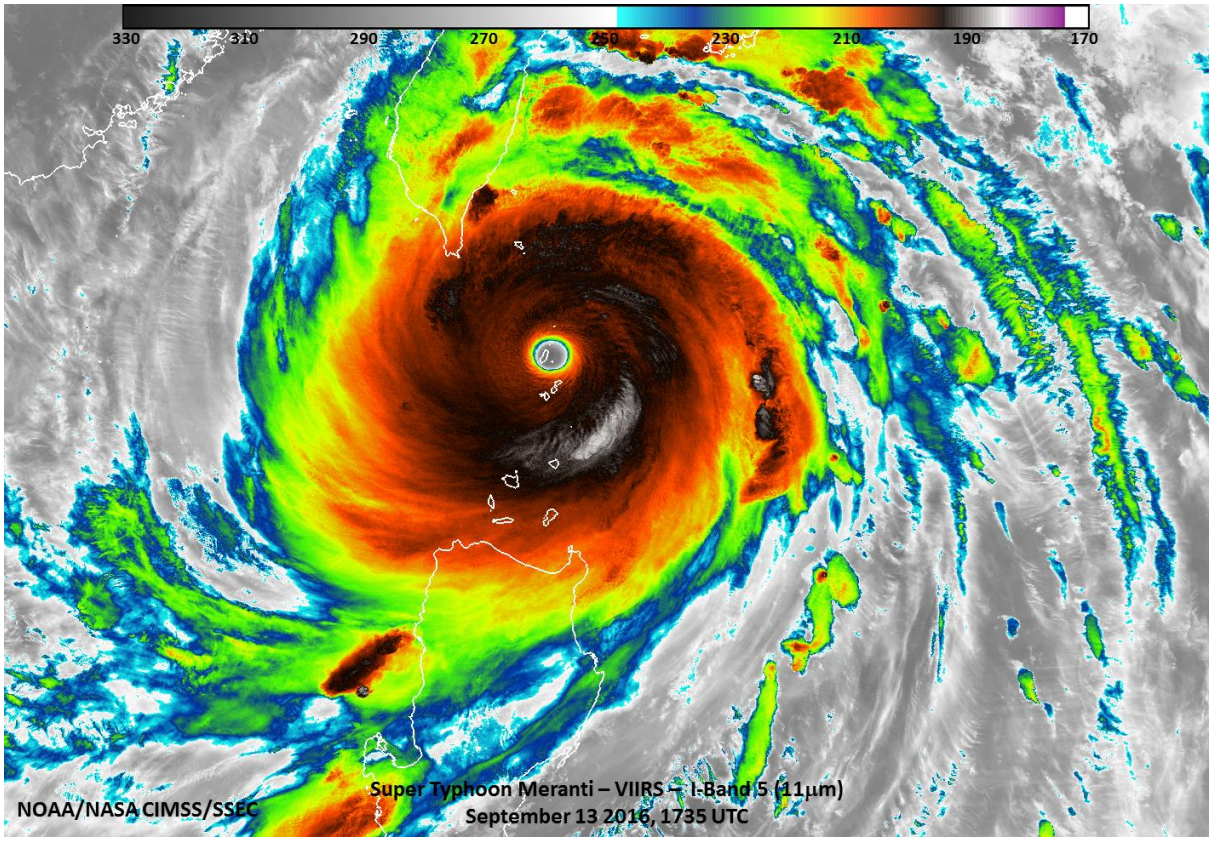

Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
Extent (millions of square kilometers)
14
12
10
8
6
4
2
Jul
Aug
Sep
Oct
Nov
2016
2015
2014
2013
2012
1981–2010 Average
±2 Standard Deviations
National Snow and Ice Data Center, Boulder CO
01 Nov 2016


Average Monthly Arctic Sea Ice Extent
October 1979 - 2016
Extent (million square kilometers)
10
9
8
7
6
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
Year
National Snow and Ice Data Center


Antarctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
Extent (millions of square kilometers)
22
20
18
16
14
12
10
8
Jun
Jul
Aug
Sep
Oct
2016
2015
2014
2013
2012
1981–2010 Average
±2 Standard Deviations
04 Oct 2016
National Snow and Ice Data Center, Boulder CO


Greenland Melt Extent 2016
1981 - 2010 Median
2016 Melt Percentage
Interdecile Range
Interquartile Range
%
100
80
60
40
20
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
31 Oct 2016
NSIDC / Thomas Mote, University of Georgia


GMSL from TOPEX/Poseidon, Jason-1 and Jason-2 satellite altimeter data
Seasonal signal removed
Inverse barometer correction applied
GIA correction applied
Monthly
3-month running mean
Trend = 3.4 mm/year [1]
Time span: Jan 1993 -> Aug 2016
Global Mean Sea Level (mm)
50
40
30
20
10
0
-10
-20
-30
-40
1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Year
CSIRO



Southern and Eastern Africa most affected countries by drought in 2015/2016 (Source FAO)