Science Topic 11-08-23
Updated in newsletters Oct'24, Nov'24, Dec'24, Oct'25
Mar'26, Apr'26, Oct'26

CliSciPol

Climate Science and Policy for Nonscientists

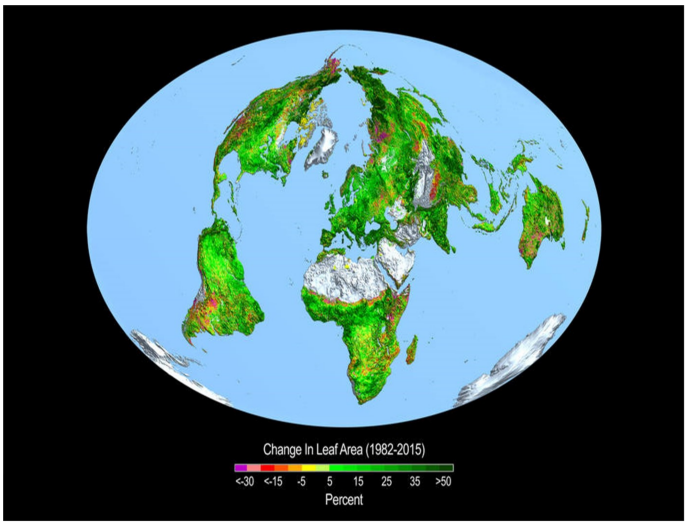
One picture is worth a thousand words.

The World is Getting Significantly Greener.

Food Production is Growing Faster than the Population.

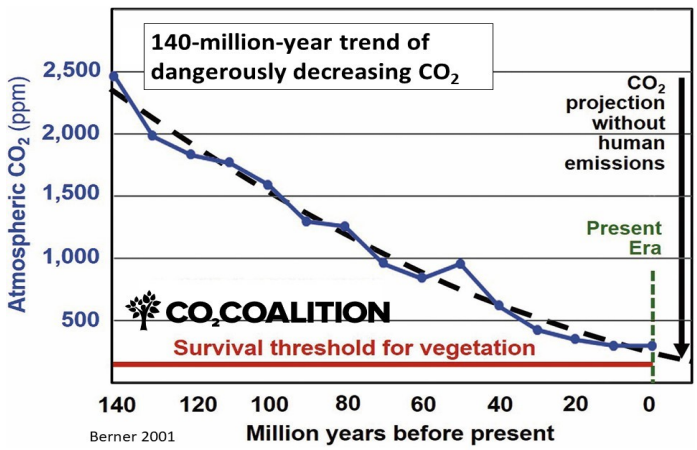
Rainfall is Slightly Increasing with Drought and Floods Decreasing

Rain, drought, and floods are closely connected. Heavy rain can lead to floods. The absence of rain leads to droughts that can threaten the water supply for direct human use and for agriculture. To the extent that there has been some small climate change with respect to rain, drought, and floods, these changes are of much smaller significance that than the two underlying trends: (1) the world is getting much greener, and (2) food production is soaring.



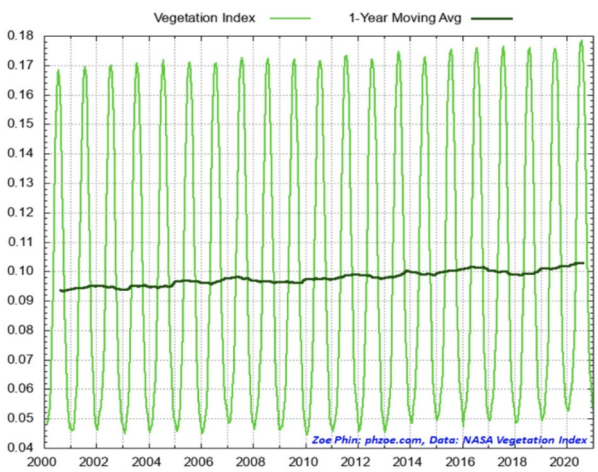
The world is greening. This image shows the results of a massive study organized by NASA (all the data was collected by satellite) and published in 2016. The study found that from 1982 to 2015 from a quarter to half of Earth's vegetated lands showed significant greening. Leaves on plants and trees increased equivalent in area to two times the continental US. The study attributed 70% of the greening to rising CO2 levels and 30% to rising temperatures, both of which are good for plant growth.

CO2 is plant food. With more CO2 in the air plants grow faster. Scientists call this the CO2 Fertilization Effect. The current level of atmospheric CO2 is 420 parts per million (ppm) or about 4 parts per 10,000.



For the last 500 million years CO2 levels in the air have been trending down. The graph shows the decline for the most recent 140 million years Not only are plants accustomed to a much higher level of CO2 than exists today, but they are food-deprived at current CO2 levels of 420 ppm. Plants die if CO2 falls to the vicinity of 200 ppm. In the preindustrial era CO2 levels were only about 280 ppm. By raising CO2 levels since the preindustrial period human activity has arguably averted a plant famine.

CO2 generators are routinely hung in green-houses to increase plant growth. The CO2 level in the air is now about 420 ppm. Green-houses usually operate at 800-1200 ppm and expect to see 20-50% extra plant growth as a result of the higher CO2 levels.



NASA's Vegetation Index has risen from 0.0936 to 0.1029, which is a 9.94% increase. Chart by Zoe Phin

The NASA Vegetation Index increased about 10% from 2000 to 2020.

Using satellite images, Venter et al. 2018 found an eight percent increase in woody vegetation in sub-Saharan Africa over the last three decades, underscoring the global "greening trend".

As CO2 levels rise plants can survive and grow with less water, so the entire South-ern rim of the Sahara desert is greening. The Sahara shrank by 8% from 1988 to 2018.

Recent study by Venter et al finds that the Sahara has shrunk by 8% over the past three decades. NASA image, public domain.

AR6 FINDINGS

Greenness has increased globally since the early 1980s. (WGI p. 292, 365-6

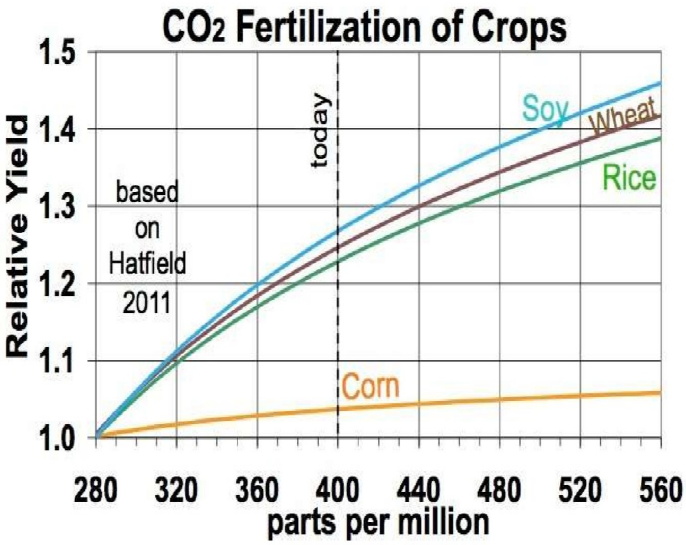
Increasing atmospheric CO2 concentrations have increased plant growth and water-use efficiency. (WGI p.1057)

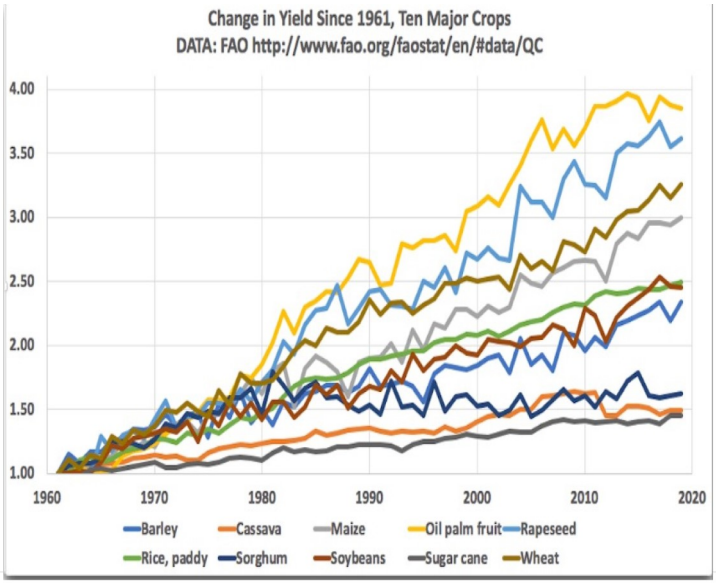
One study shows that there has been a 7% rise in global tree cover from 1982 to 2016, and another study found an expansion of shrub extent in the Arctic tundra from 1982 to 2017. (WGI p.365)

Increased greening is largely consistent with CO2 fertilization at the global scale. (WGI p.365)

In AR6 WGI, The Physical Science Basis (2021) the IPCC acknowledges these changes.

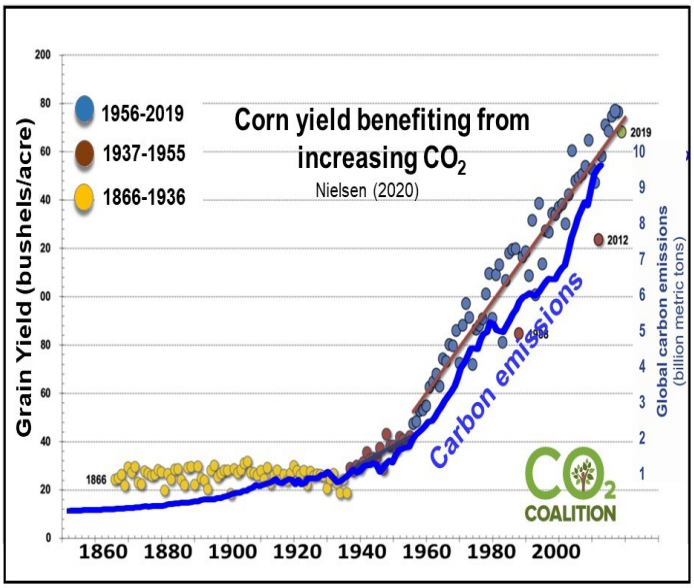
Not only does rising CO2 levels speed plant growth, but it also increases crop yields per acre. The image shows the increased yields of four important cereal crops versus rising CO2 levels as measured in various experiments. There are hundreds of peer-reviewed, published studies confirming increasing crop yields with rising CO2 levels.

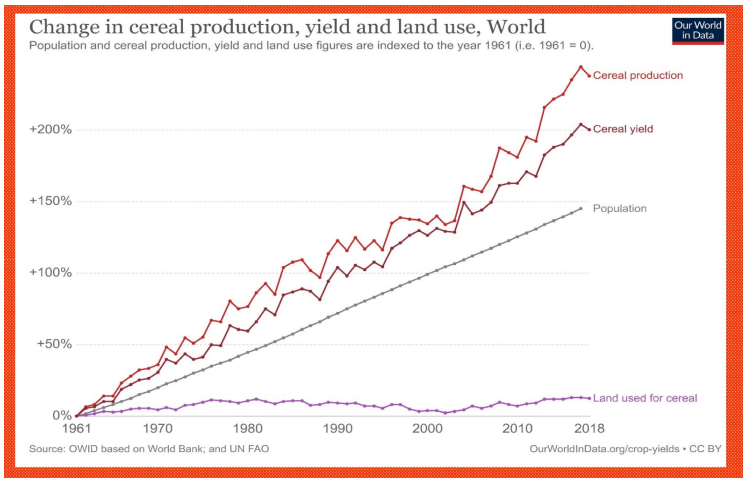




This image shows actual measured increases in yield of ten major crops versus time (since 1961) while CO2 levels were rising from about 320 ppm to today's level of about 420 ppm.

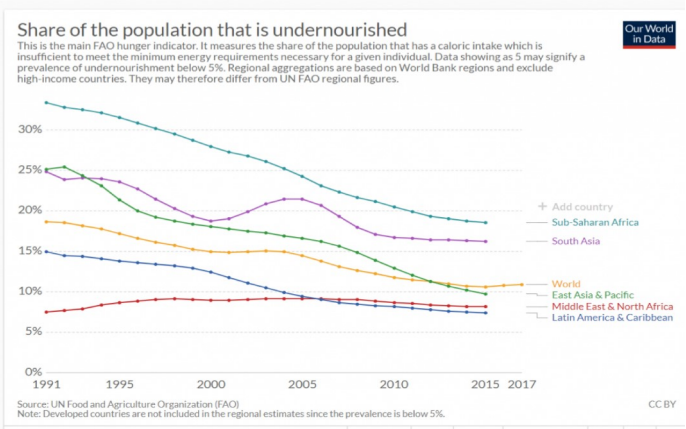
Since 1940 corn yield per acre has increased virtually at the same rate as carbon emissions have risen.

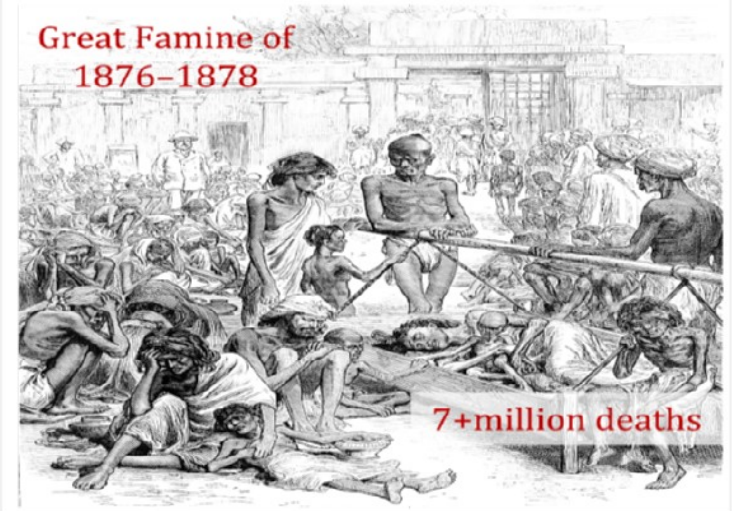




Since 1961 food production has been rising faster than the population. The IPCC has found that warming temperatures have caused the growing season to lengthen by up to two days per decade since the 1950s in the nontropical Northern Hemisphere, which includes the US. (AR6 WGI p.6).

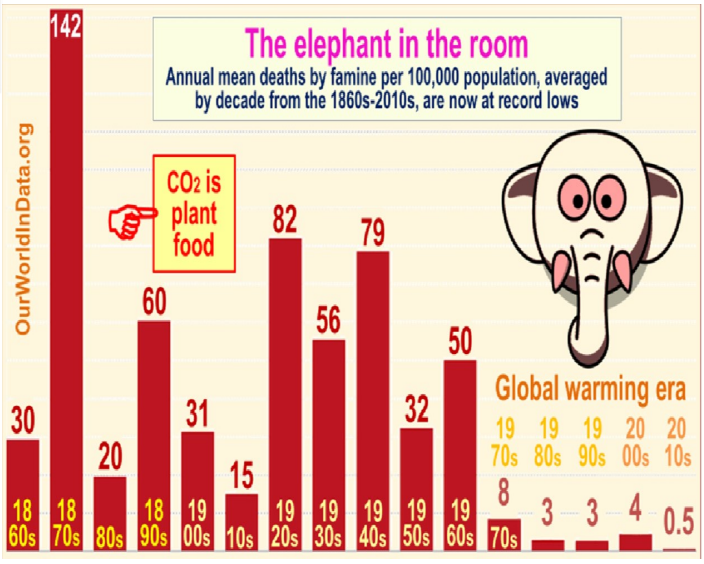
As a result of increasing food production since 1991 the percentage of the world's population that is undernourished has declined from 19% to 11%. This percentage reduction was achieved while the world population rose from 5.3 billion in 1990 to over 8 billion today, so the absolute number of people being adequately nourished increased from 4.3 billion (81% of 5.3) to over 7.1 billion (89% of 8).





The Great Famine in India and Pakistan 1876-1878 killed an estimated 7+ million people.

Since then, deaths by famine have been reduced to remarkably small numbers. This is extraordinary change for the better.



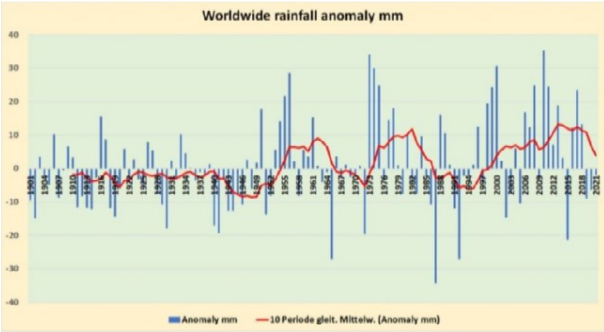
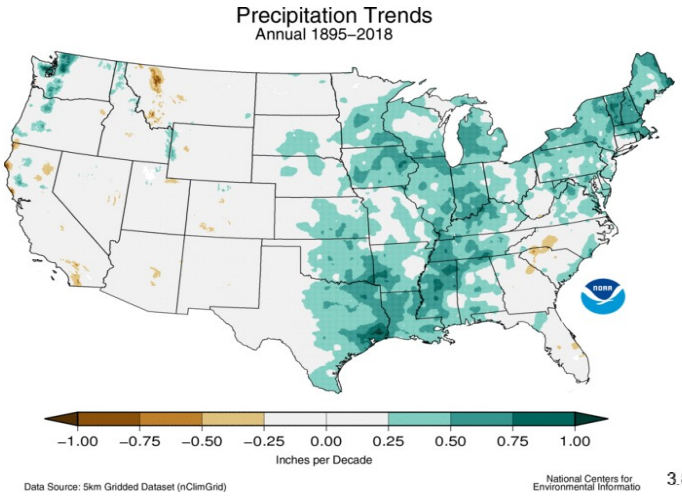


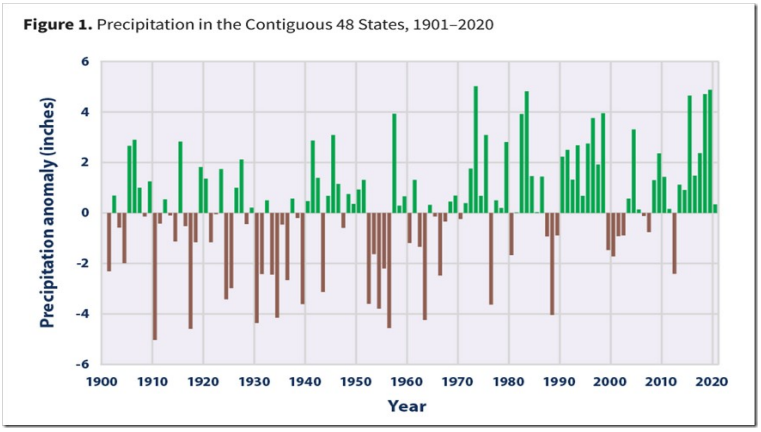
Fig. 6. The worldwide rainfall anomaly from 1901 to 2021 shows only a very weak upward trend of about 1 mm per year. Data: EPA 14) (Note that this graph shows only anomalies, not the full quantities as would be preferable. Given that the source

EPA data shows some US rainfall increase since 1900. The rainfall has been fairly steady for the last 50 years or so. About 85% of the water vapor in the air comes from the oceans, and about 77% of rain falls into the oceans. So rising temperatures involve the transformation of some salt water in the seas into fresh water on land, where it is available for human use. Global warming functions as a natural desalinization process.

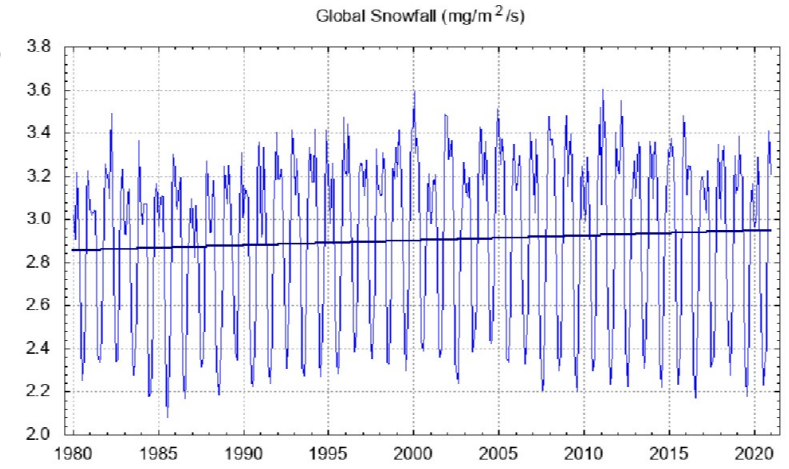


World snowfall has been up slightly (3.3%) over the last 40 years but with significant regional variation, so this may not have benefitted your favorite ski resort. This is a good example of why one can not generalize about world weather or climate from what is happening in a particular region.

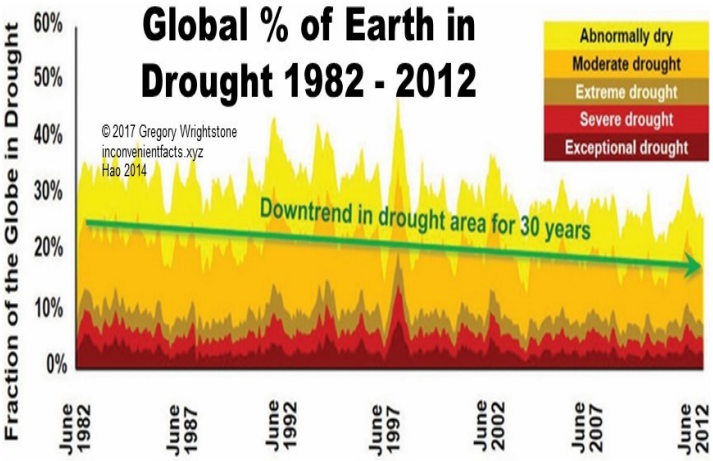
RAIN - Worldwide rainfall has been increasing by about 1 mm per year or about 4" per century, which is a minimal rate of change. The IPCC predicts that rain will increase by 1-3% per one degree C of warming (AR6 WGI p.615), which also is a minimal rate of change, because the world's rate of warming since the preindustrial period has been less than 1 C per century. (AR6 WGI p.5) Any increase of rain is *beneficial* climate change. The IPCC observes that about half the people in the world live under conditions of fresh water scarcity for at least one month per year. (AR6 WGI p. 1060)



Most all of the increase in US rainfall over the last century has been over the Eastern half of the country, while rainfall over the Western half has remained roughly constant. The Great Lakes are brimming with water. This is an example of regional climate change.

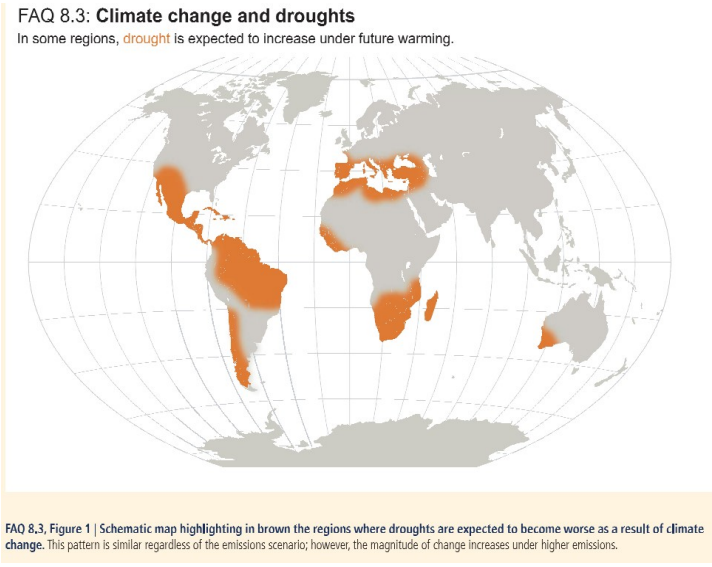


Since 1980 the total snow coverage around the world has gone up by 3.3 percent. But the hemispheres haven't progressed the same, so your experience of snowfall might depend on where you live.

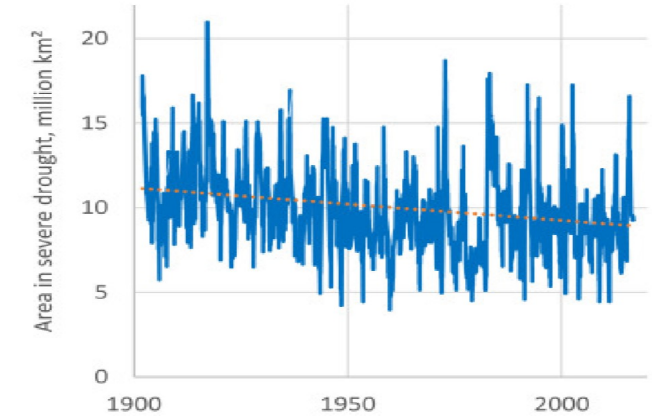


DROUGHT - A drought is defined as a deficiency of precipitation over an extended period of time, usually a season or more. With the world greening and rain and snow fall increasing, one would expect less overall drought, as confirmed in this graph.

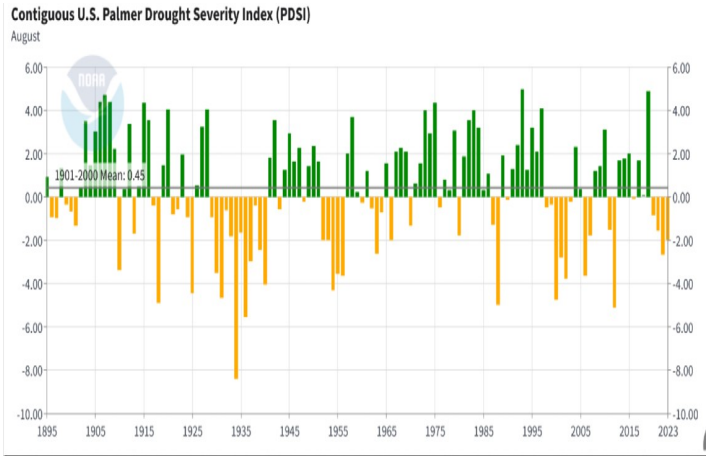
But the IPCC predicts increasing drought in some limited parts of the world, as shown here. (AR6 WGI p. 1158). The IPCC states, "Decreasing precipitation will emerge in very few regions by mid-century. ... There is limited evidence of drought trends emerging above natural variability in the 21st century." (AR6 WGI p.1770). The IPCC does not provide a comparable map showing the regions where greening is expected to increase under future increases in CO2 levels and temperatures.



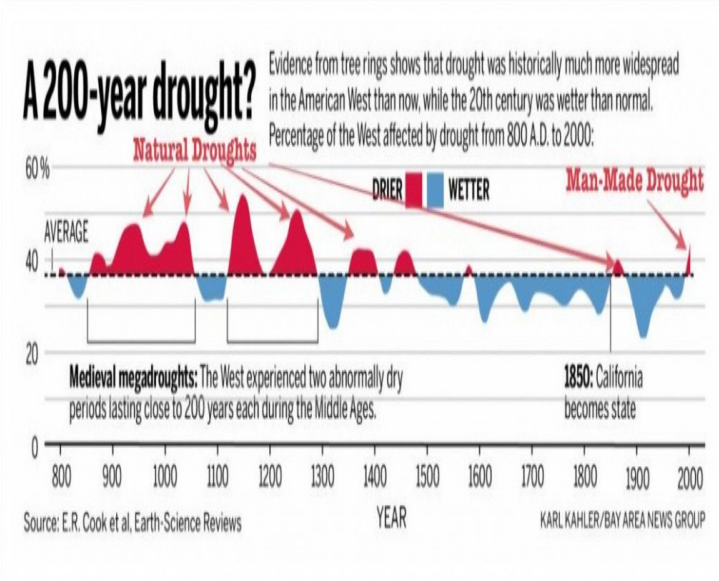
Lomborg reports that actually the area of the world under severe drought as measured by the gold-standard Standardized Precipitation Index (SPI) has been declining over the past century, as shown in this chart:



The area of the world experiencing severe drought has been declining since 1900. The IPCC defines three types of drought: meteorological (caused by reduced rain), hydrological (caused by reduced river or stream flow, which would also reduce flooding), and agricultural/ecological (cause by evaporation of water from the soil). The IPCC concludes that "few" regions show increases in meteorological drought, and that "trends in hydrological droughts have only been observed in a few regions." (AR6 WGI p.1575). The IPCC found an increase in agricultural/ecological drought in 12 of 45 regions of the world. (AR6 WGI p. 10).



For the US the Palmer Drought Index shows that the bad drought years were in the 1930s,. There is no trend up or down, and variability is high from year to year.



The US West in recent centuries has been much wetter than in prior centuries when it experienced lengthy "megadroughts." Mega-droughts come and go as part of natural climate variability. Megadroughts are believed to have played a role in the collapse of the Akkadian, the Assyrian, and the Mayan Empires, in addition to some of the native American cultures in the US West during the periods of the megadroughts shown.

The percentage of the US considered either "very wet" or "very dry" has not changed much at all since 1896. There is no trend for either variable. But notice how much natural variability exists from year to year. Rain tends to move around a lot.

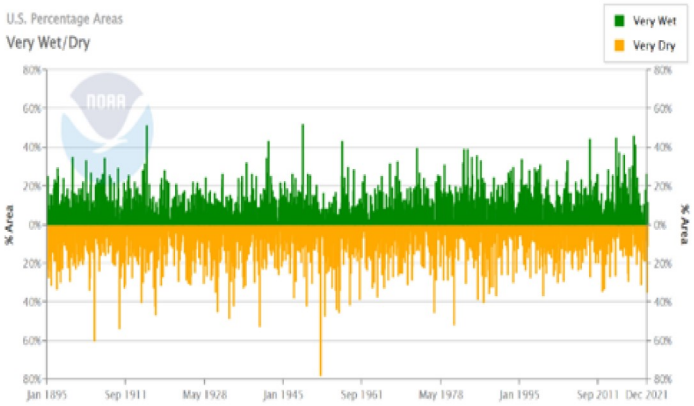


Figure 1. Percentage of United States experiencing "very wet" (in green) or "very dry" (in yellow) conditions. *Source*: National Centers for Environmental Information, "U.S. Percentage Areas (Very Warm/Cold, Very Wet/Dry)," U.S. National Oceanic and Atmospheric Administration, accessed February 1, 2022.

FLOODS - Significant floods occur when massive amounts of water overflow their river banks. The world has a long history of disastrous floods. For example, in California 45 days of storms caused the Great Flood of 1862, which covered 1/3d of the entire state.

The EPA monitors the frequency and magnitude of floods at hundreds of US locations. It has found during the period 1965-2015 that: (1) frequency of flooding increased at 186 locations and decreased at 295 locations, and (2) magnitude of flooding increased at 216 locations and decreased at 310.

THE DAILY TELEGRAPH, FRIDAY, AUGUST 21, 1931

30 MILLIONS HUNGRY

TERRIFIC FLOOD IN CHINA

(Special Service)

SHANGHAI, Thursday. THIRTY-ONE millions of Chinese are on the verge of starvation through the Yang-tse flood, which affects an area 1000 miles long and 50 miles wide.

Homes and crops in the flood belt have been destroyed. Hankow is inundated, and the horrors of the disaster have been augmented by disease resulting from floating corpses.

A shortage of drinking water and of food is causing alarm.

Damage running into millions has been done to property, while undermined buildings have collapsed, killing the inmates.

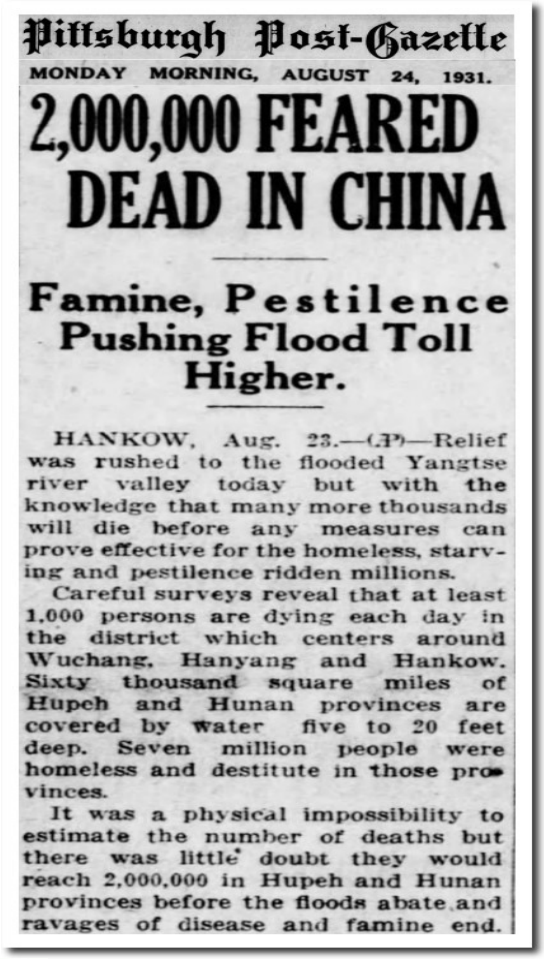
HIDEOUS PROSPECT

Hankow streets lie under seven feet of swirling water, which will take months to subside. Unless the city is rebuilt, it may go off the map.

The Government and foreigners in Shanghai are raising relief funds. Nanking proposes the purchase of 30,000,000 bushels of American wheat on 20 years' credit, by way of anticipating the inevitable winter famine.

This famine, it is feared, will be the greatest calamity that the nation has ever experienced.

China has a long history of Yangtze River floods, such as the August 1931 flood. In Southeast Asia Monsoon rains produce floods virtually every year. The degree of flooding varies with the El Nino/La Nino ocean current cycle in the South-Eastern Pacific Ocean.



Pittsburgh Post-Gazette

MONDAY MORNING, AUGUST 24, 1931.

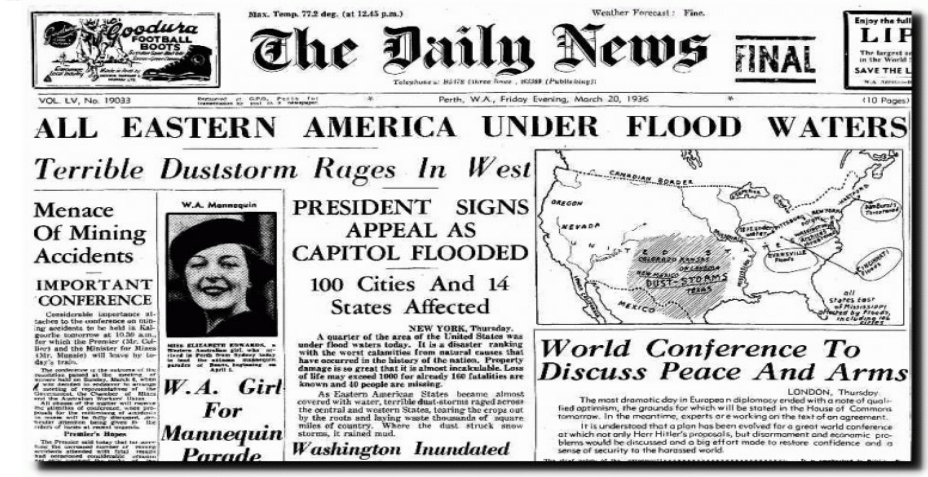
2,000,000 FEARED DEAD IN CHINA

Famine, Pestilence Pushing Flood Toll Higher.

HANKOW, Aug. 23.—(AP)—Relief was rushed to the flooded Yangtse river valley today but with the knowledge that many more thousands will die before any measures can prove effective for the homeless, starving and pestilence ridden millions.

Careful surveys reveal that at least 1,000 persons are dying each day in the district which centers around Wuchang, Hanyang and Hankow. Sixty thousand square miles of Hupeh and Hunan provinces are covered by water five to 20 feet deep. Seven million people were homeless and destitute in those provinces.

It was a physical impossibility to estimate the number of deaths but there was little doubt they would reach 2,000,000 in Hupeh and Hunan provinces before the floods abate and ravages of disease and famine end.



Goodyra FOOTBALL BOOTS

Max. Temp. 77.2 deg. (at 12.45 p.m.) Weather Forecast: Fine.

The Daily News FINAL

Enjoy the full LIF

VOL. LV, No. 19033 Perth, W.A., Friday Evening, March 20, 1936 (10 Pages)

ALL EASTERN AMERICA UNDER FLOOD WATERS

Terrible Duststorm Rages In West

Menace Of Mining Accidents

IMPORTANT CONFERENCE

W.A. Mannequin

W.A. Girl For Mannequin Parade

PRESIDENT SIGNS APPEAL AS CAPITOL FLOODED

100 Cities And 14 States Affected

NEW YORK, Thursday.

A quarter of the area of the United States was under flood waters today. It is a disaster ranking with the worst calamities from natural causes that have occurred in the history of the nation. Property damage is so great that it is almost incalculable. Loss of life may exceed 1000 for already 160 fatalities are known and 10 people are missing.

As Eastern American States became almost covered with water, terrific dust-storms raged across the central and western States, tearing the crops out by the roots and laying waste thousands of square miles of country. Where the dust struck snow storms, it rained mud.

Washington Inundated

CANADIAN BORDER

OREGON

NEVADA

COLORADO KANSAS OKLAHOMA NEW MEXICO DUST-STORMS TEXAS

MEXICO

World Conference To Discuss Peace And Arms

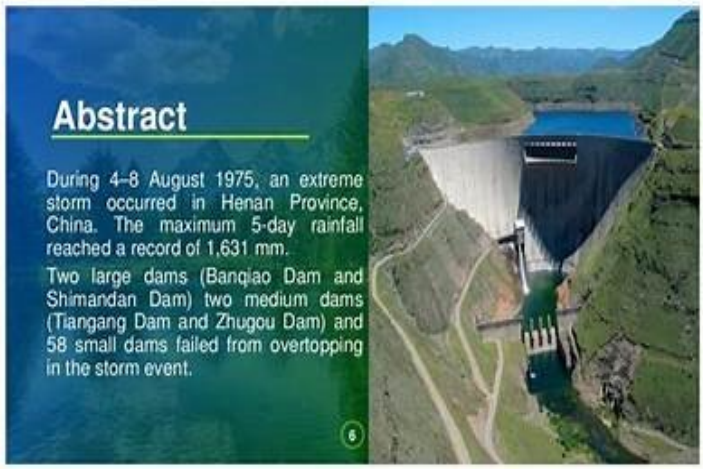
LONDON, Thursday.

The most dramatic day in European diplomacy ended with a note of qualified optimism, the grounds for which will be stated in the House of Commons tomorrow. In the meantime, experts are working on the text of an agreement.

It is understood that a plan has been evolved for a great world conference at which not only Herr Hitler's proposals, but disarmament and economic problems would be discussed and a big effort made to restore confidence and a sense of security to the harassed world.

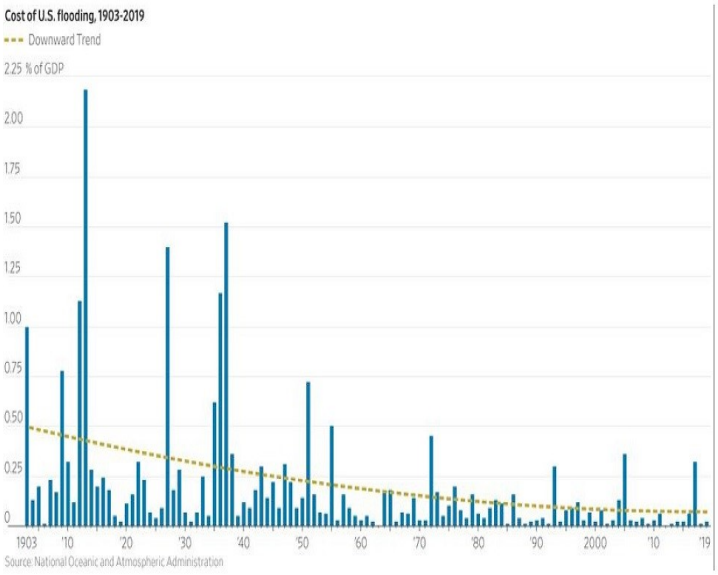
In March 1936 the Eastern half of the US had a massive flood at the same time that the Great Planes were experiencing an extreme drought (the "Dust Bowl").

To protect against floods governments build dams such as the controversial Three Gorges Dam on the Yangtze. Dams control river flow during the rainy season, preventing floods, and then release the water at other times of the year when it is needed and when it can be used constructively.



But then dams can fail like the Banqiao Dam in China in 1975. An estimated 85,000-240,000 people were killed. The flood rendered uninhabitable an area larger than the states of Delaware and Rhode Island combined. In the 21st century many floods can be attributed to failures of government planning, construction, or maintenance of flood control infrastructure.

North America is fortunate. Its dams, levees, wastewater-management and water conveyance facilities "have improved water supply and safety and have reduced flood and drought risks." (AR6 WGII p.1952). And there is "limited evidence and low agreement on observed climate change influences for river floods in North America." (AR6 WGI p.1830). As a result in the US flood damage as a percentage of GDP has steadily and significantly declined since 1903.



The IPCC does not find a growing flood problem. Rather, "On the global level, peak river flow trends are characterized by high regional variability and lack overall statistical significance of a decrease or an increase." (AR6 WGI p.1568). And government adaptation measures can have a tremendous impact in reducing the risk and damage of floods. One study estimates that flood damages could be reduced by 95% with "adequate adaptation strategies." (AR6 WGII p.607). Overall the IPCC concludes that, "There is *low confidence* in the emergence of heavy precipitation and pluvial and river flood frequency in observations, despite trends that have been found in a few regions." (AR6 WGI p.1854).

CONCLUSION

The increased greening of the world is an example of *beneficial* climate change. The increased worldwide food production is another example of *beneficial* climate change. The increased rainfall is a third example of *beneficial* climate change.

Droughts and floods are detrimental events, but they are part of natural variability. There have always been, and always will be, droughts and floods. But there is little evidence that the frequency or severity of these events is increasing globally. Governments have learned how to build irrigation systems to reduce the impact of drought and to build dams and other infrastructure to reduce flood frequency and magnitude.