WEATHER MEDIC INC
JACK W. KANACK
Web site:
www.weathermedic.com
Email:
info@weathermedic.com
Phone: (716) 245-5755

PEACE CENTER
RENEWABLE ENERGY TASK FORCE
CHARLEY BOWMAN
renewableenergy@wnypeace.org

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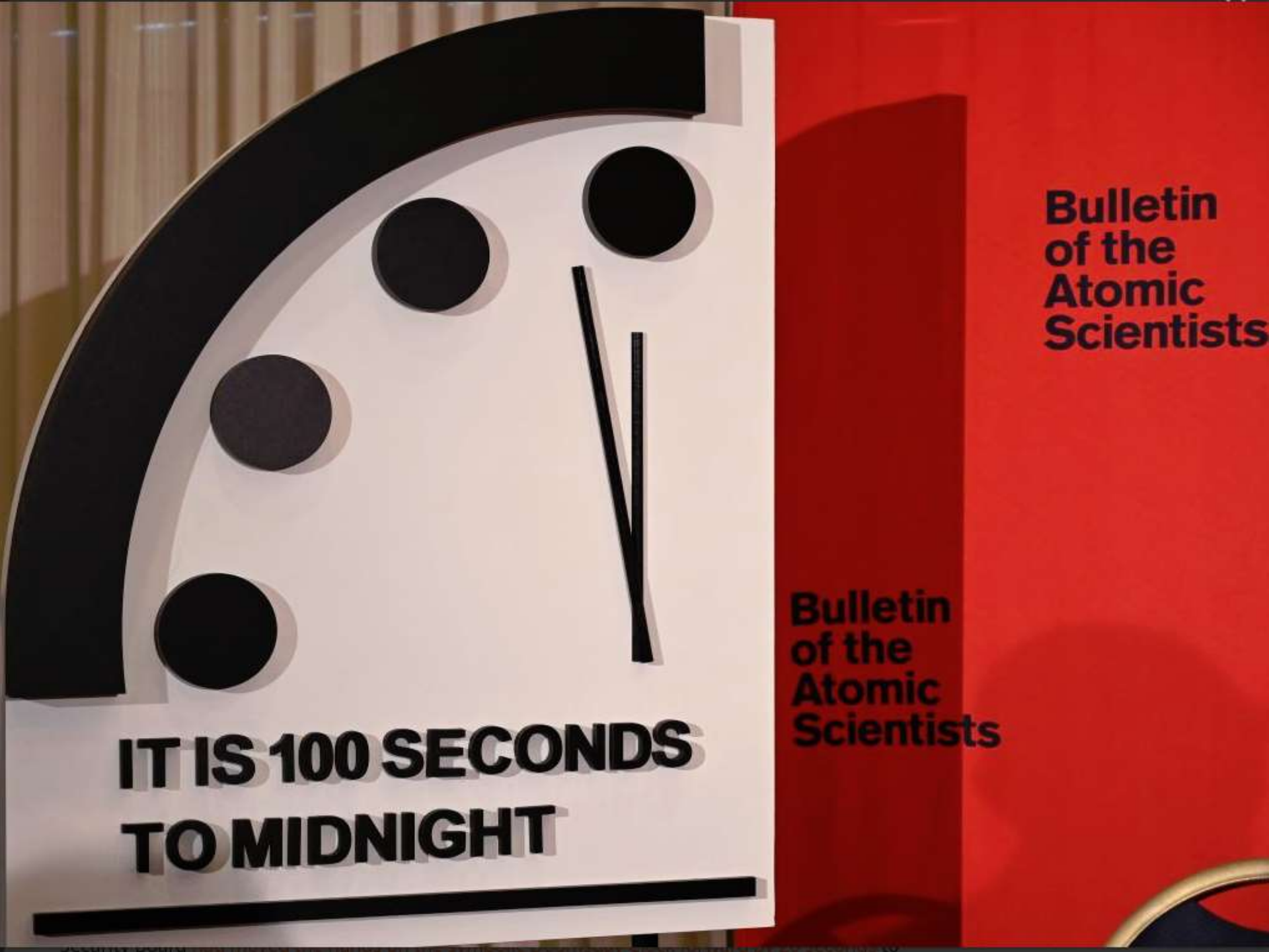
GLOBAL WARMING DENIERS ARE FULL OF HOT AIR!

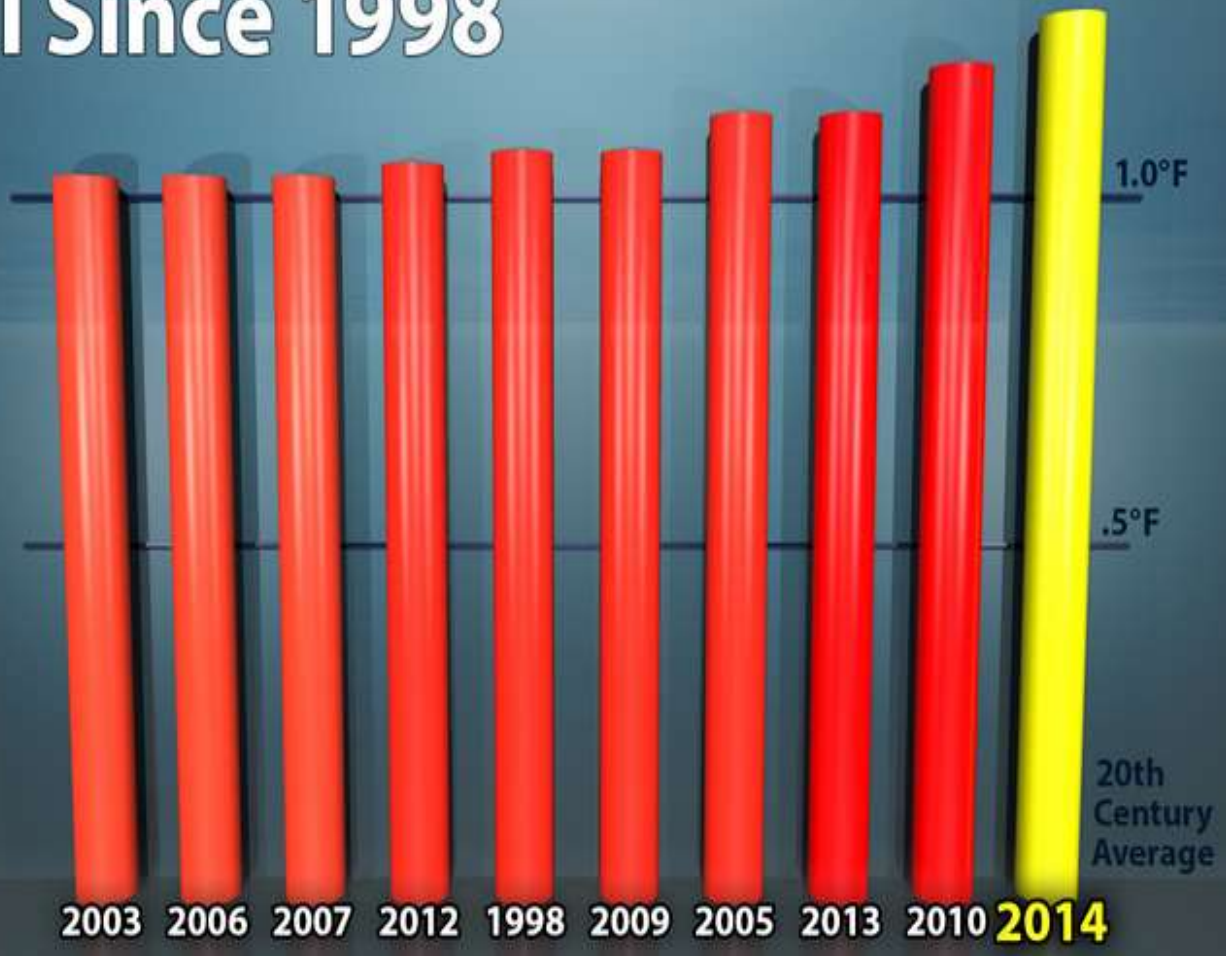
EVERY DAY, ON THE AIRWAVES, ONLINE, AND THROUGHOUT THE MEDIA ECHO CHAMBER, THE LOUDEST, MOST MISINFORMED GLOBAL WARMING DENIERS SPOUT THEIR OPINIONS AND BELIEFS. BUT THERE IS NO BELIEVING OR NOT BELIEVING IN CLIMATE CHANGE – IT IS A MATTER OF KNOWING THE FACTS.

THIS PRESENTATION WILL GIVE YOU THE FACTS.


IT IS 100 SECONDS
TO MIDNIGHT
Bulletin
of the
Atomic
Scientists
Bulletin
of the
Atomic
Scientists

10 Hottest Years Globally

All Since 1998

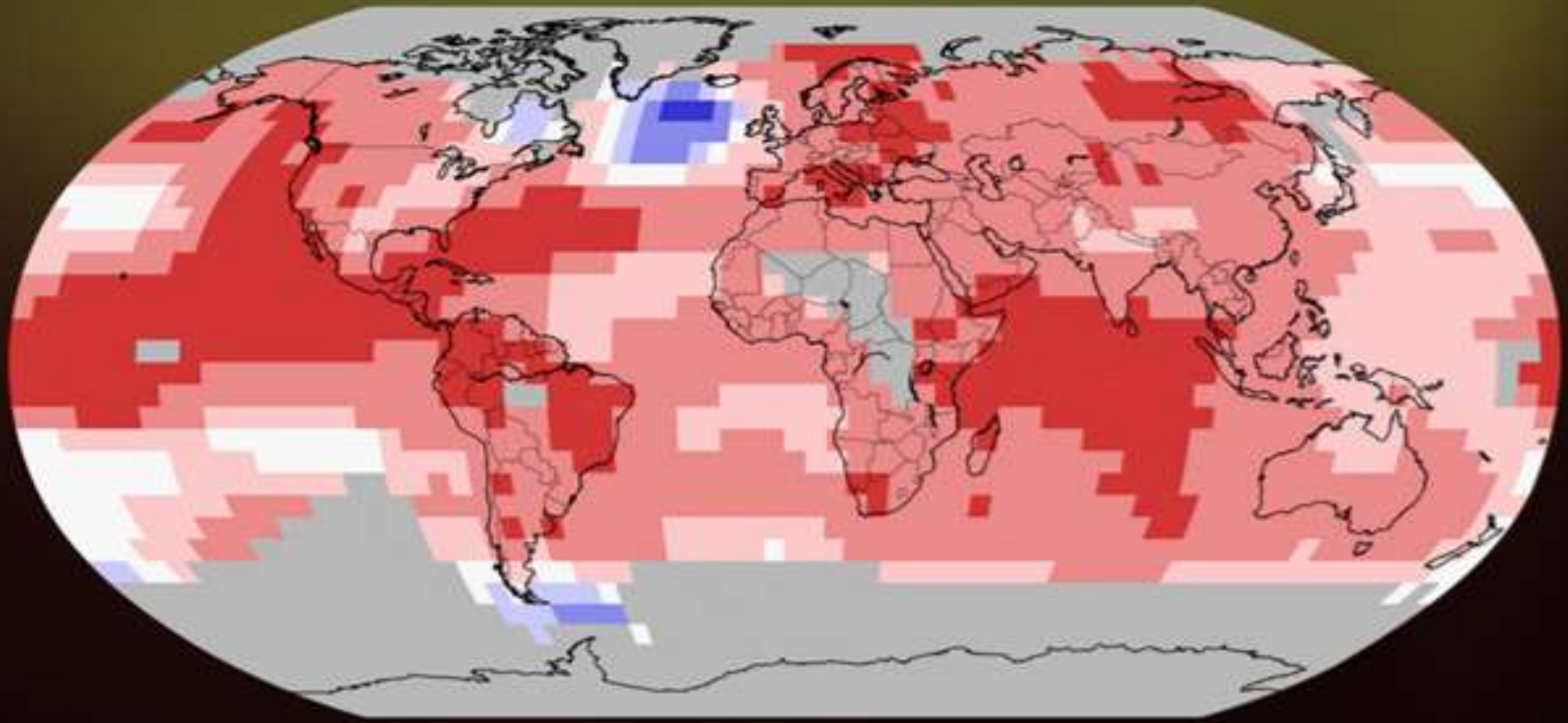


Columns represent difference from 20th century average
Data as of September 23, 2015. Subject to change based on NCEI revisions.
Source: NOAA/NCEI

CLIMATE CENTRAL

2015: HOTTEST ON RECORD

Land and Ocean Temperature Percentiles



Record Coldest | Much Colder | Colder | Near Average | Hotter | Much Hotter | Record Hottest

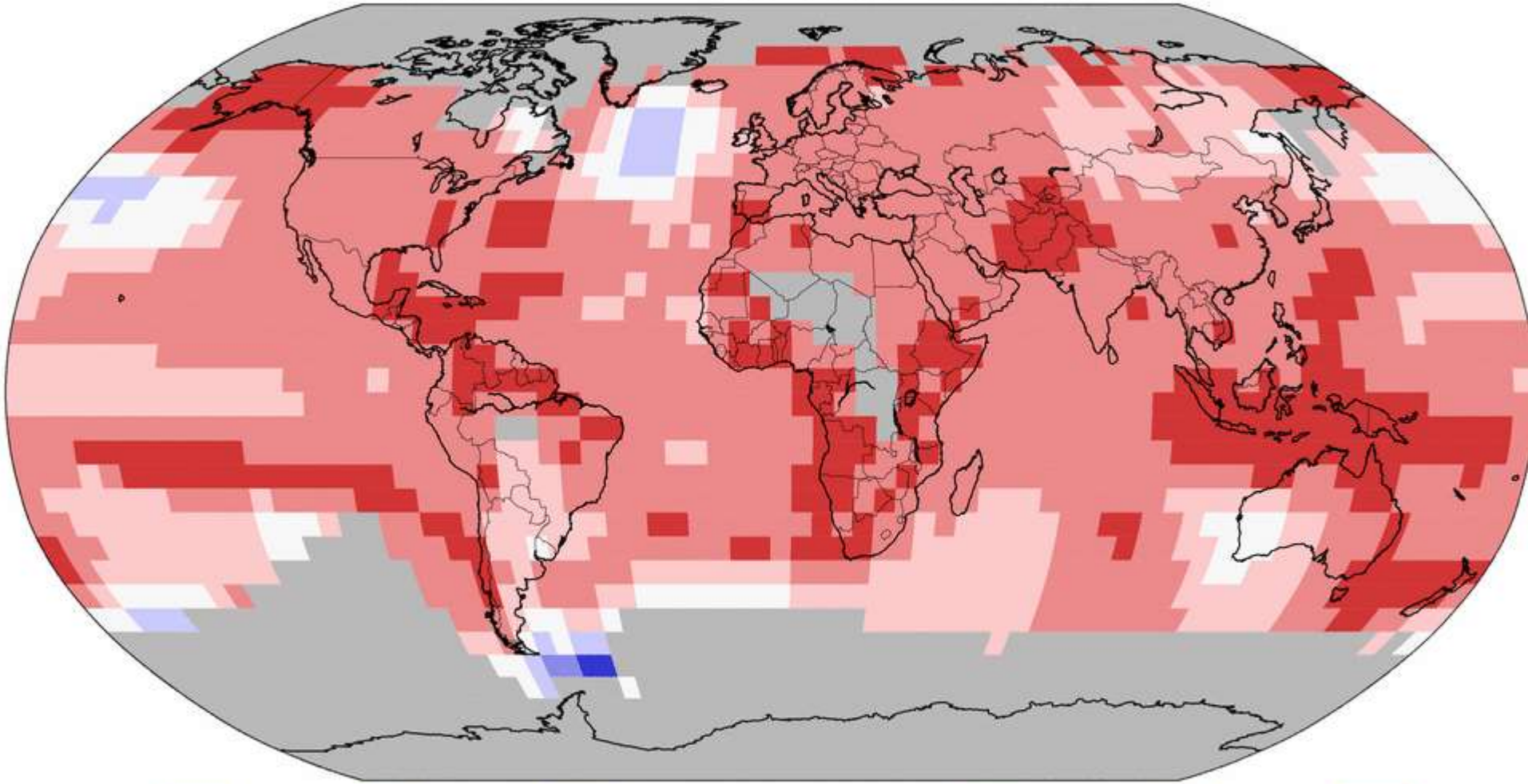
Source: NOAA

CLIMATE CENTRAL

Land & Ocean Temperature Percentiles Jan–Dec 2016

NOAA's National Centers for Environmental Information

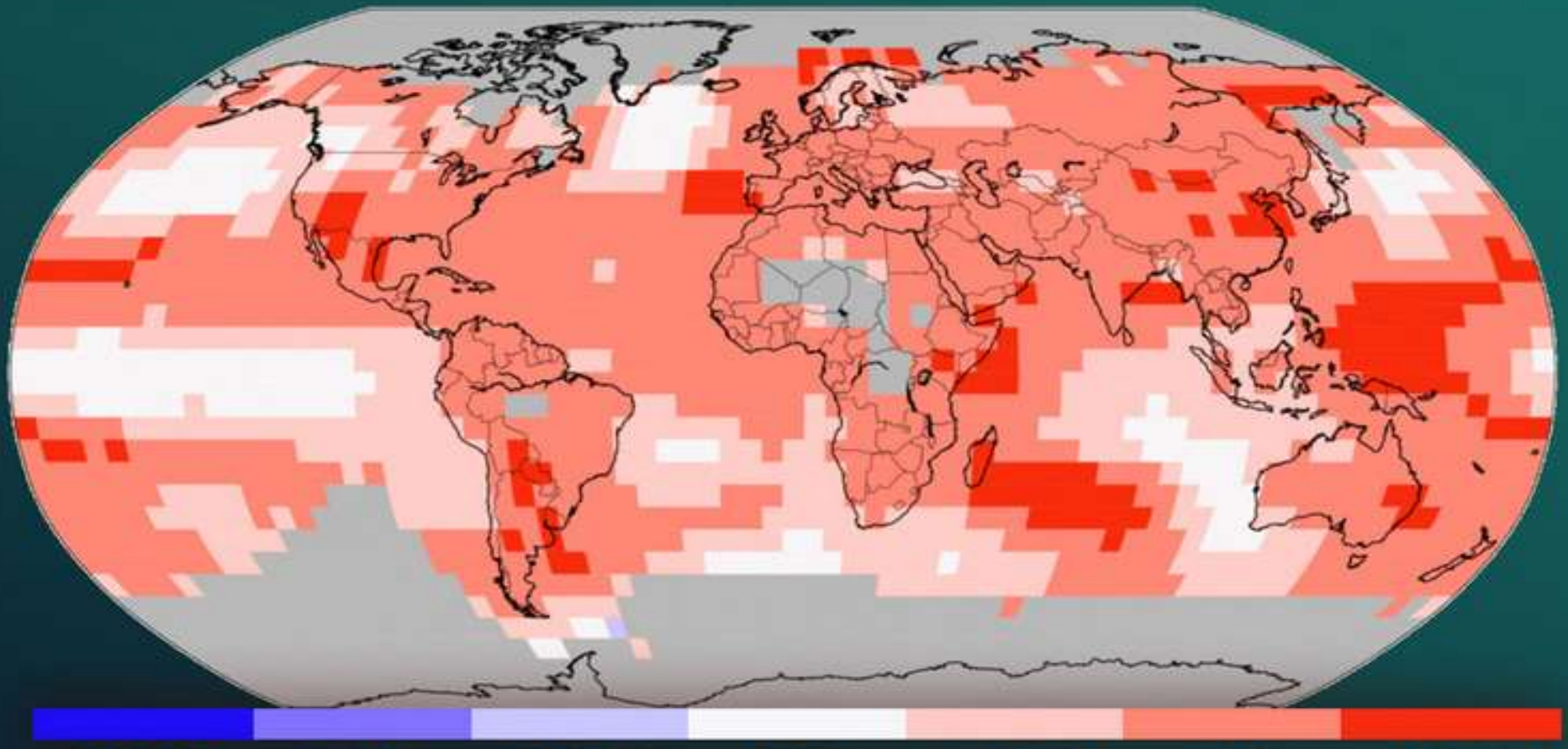
Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0



Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

2017: 3RD HOTTEST YEAR ON RECORD

HOTTEST WITHOUT EL NINO



RECORD COLDEST | MUCH COOLER | COOLER | NEAR AVERAGE | WARMER | MUCH WARMER | RECORD WARMEST

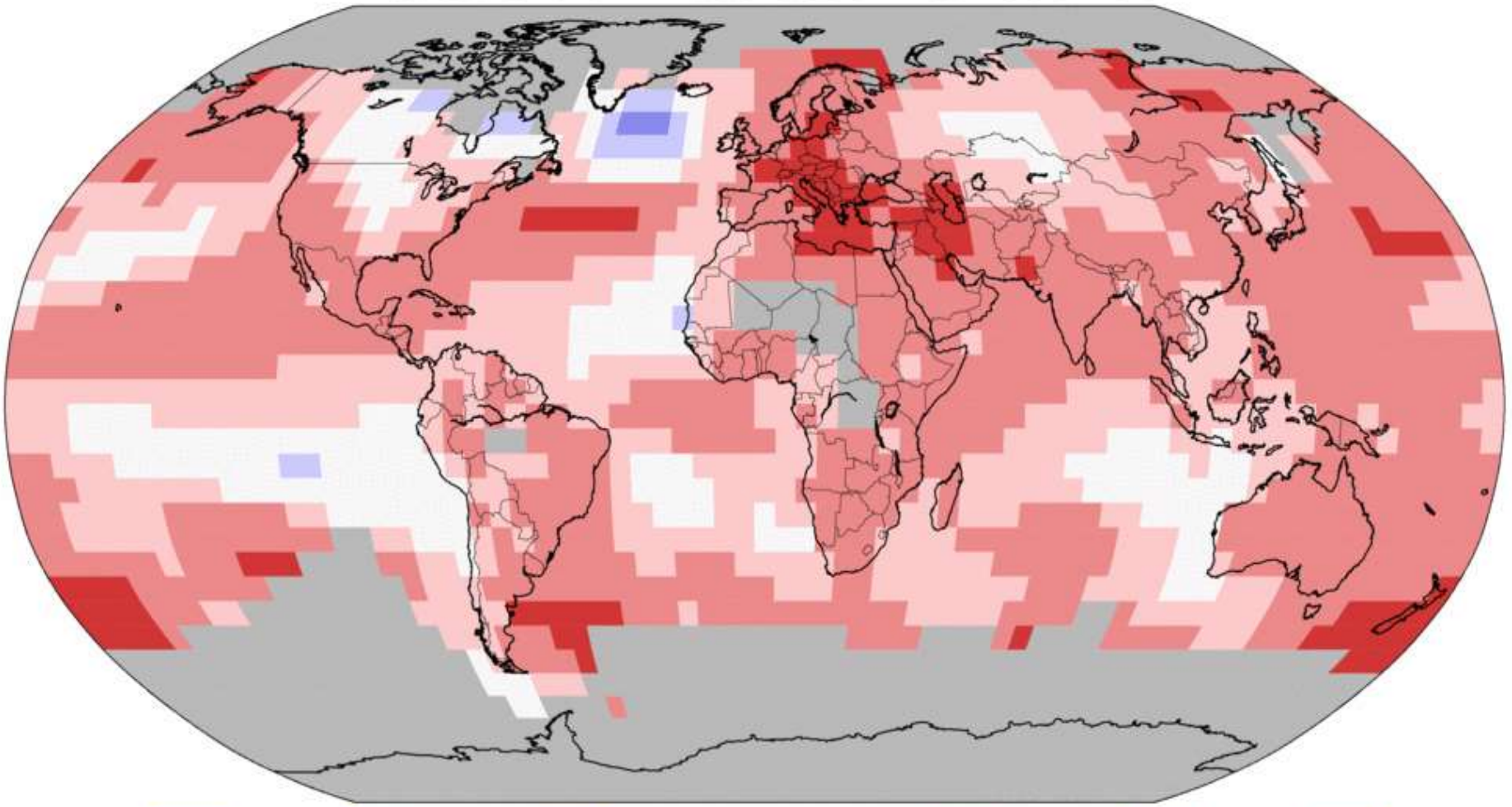
Land & ocean temperature percentiles
Source: NOAA/NCEI Climate at a Glance

CLIMATE CENTRAL

Land & Ocean Temperature Percentiles Jan–Dec 2018

NOAA's National Centers for Environmental Information

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0

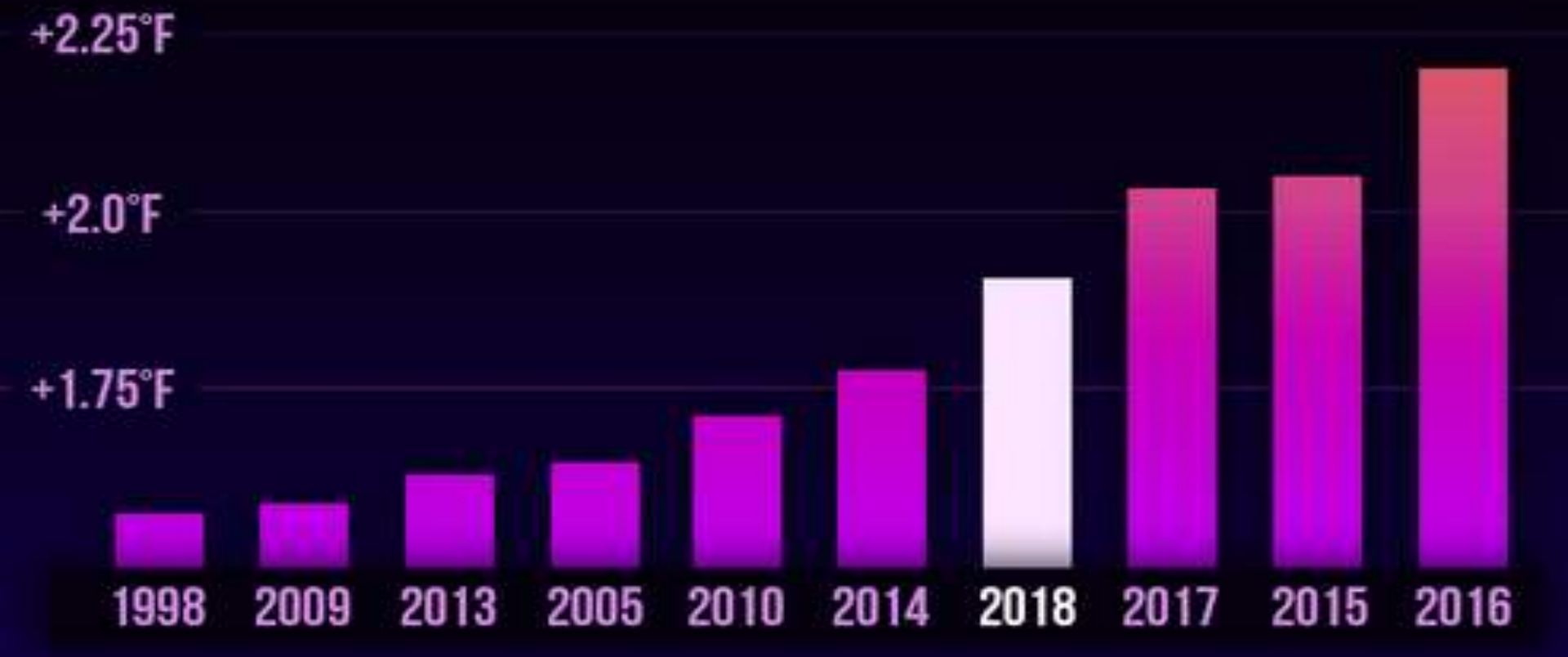


Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

Thu Jan 31 15:29:34 EST 2019

HOTTEST YEARS ON RECORD GLOBALLY

LAST 5 = HOTTEST 5



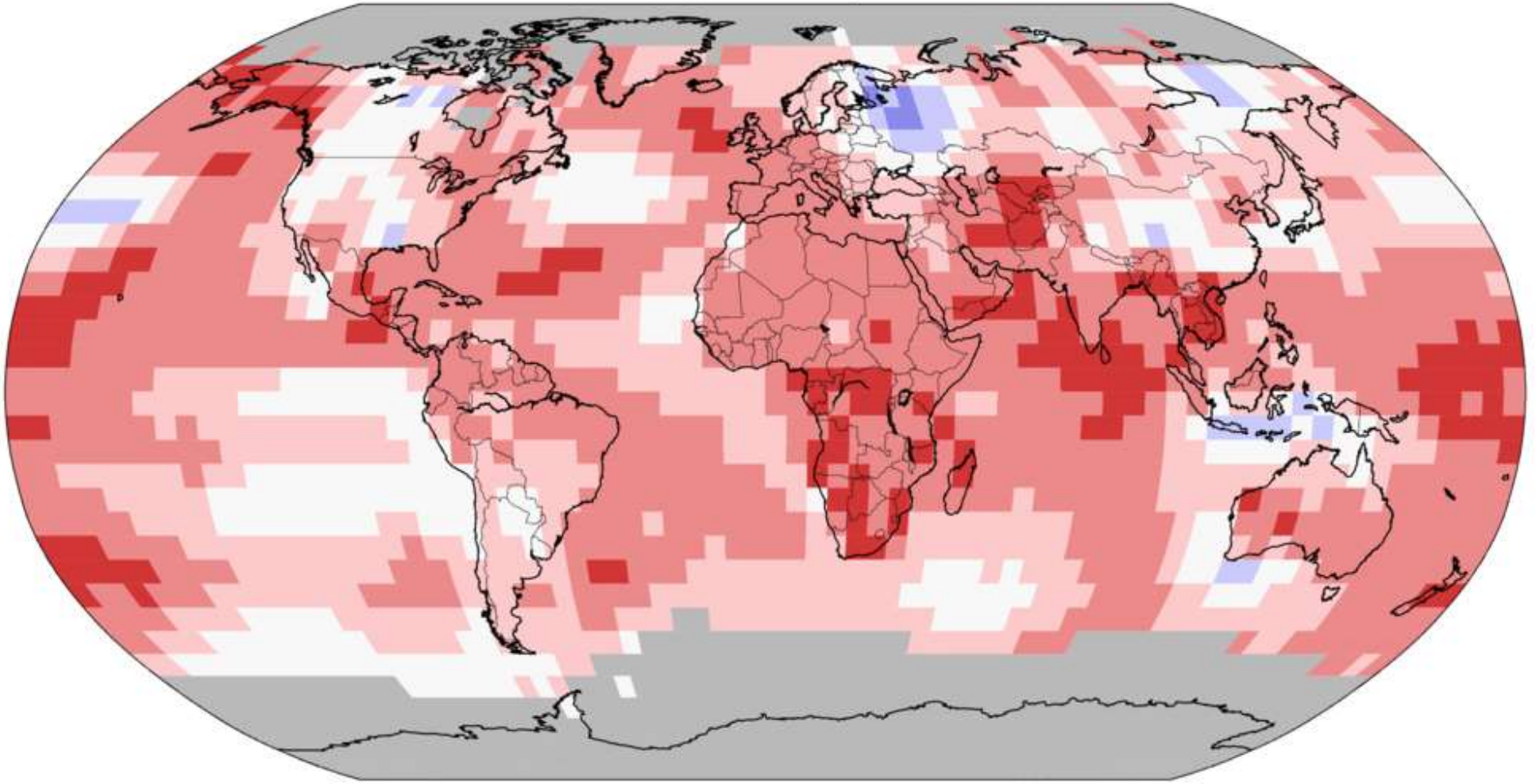
Source: NASA GISS & NOAA NCEI global temperature anomalies (°F) averaged and adjusted to early industrial baseline (1881-1910). Data as of 2/6/2019

CLIMATE CENTRAL

Land & Ocean Temperature Percentiles Jul 2019

NOAA's National Centers for Environmental Information

Data Source: NOAAGlobalTemp v5.0.0–20190808



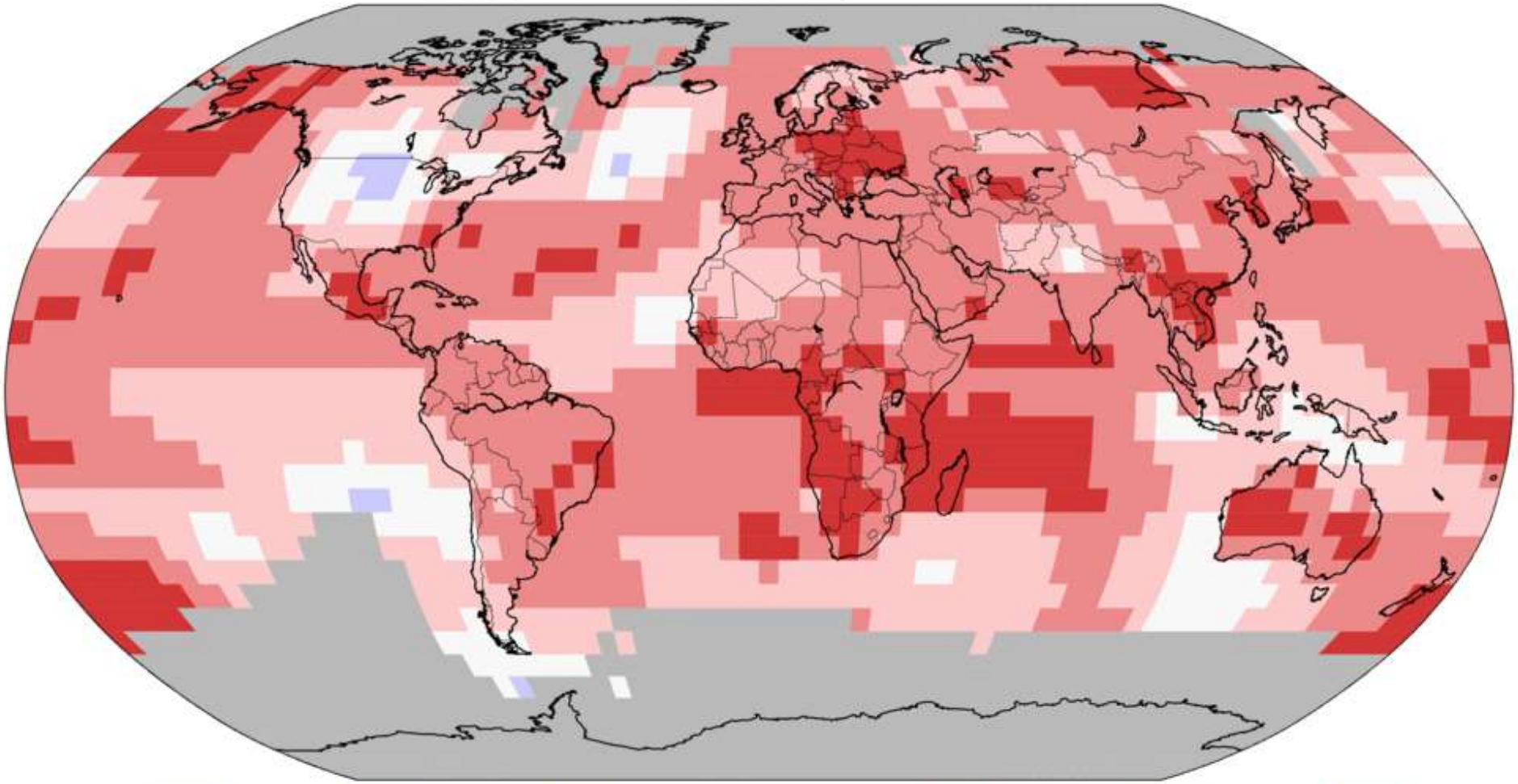
Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

GHCNM v4.0.1.20190806.qfe

Land & Ocean Temperature Percentiles Jan–Dec 2019

NOAA's National Centers for Environmental Information

Data Source: NOAAGlobalTemp v5.0.0–20200108

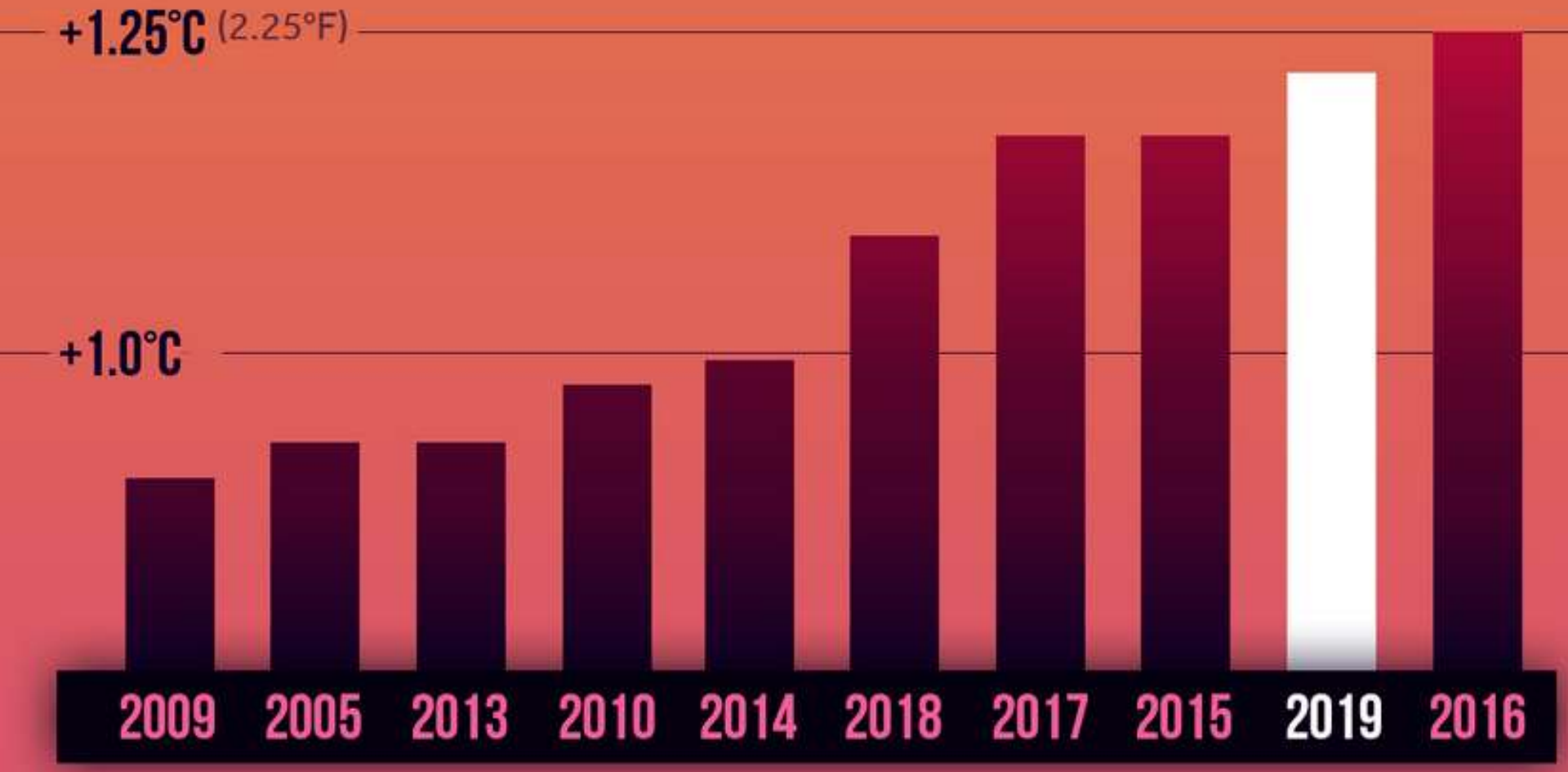


Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

GHCNM v4.0.1.20200106.qfe

10 HOTTEST YEARS ON RECORD GLOBALLY

Last 5 = Hottest 5

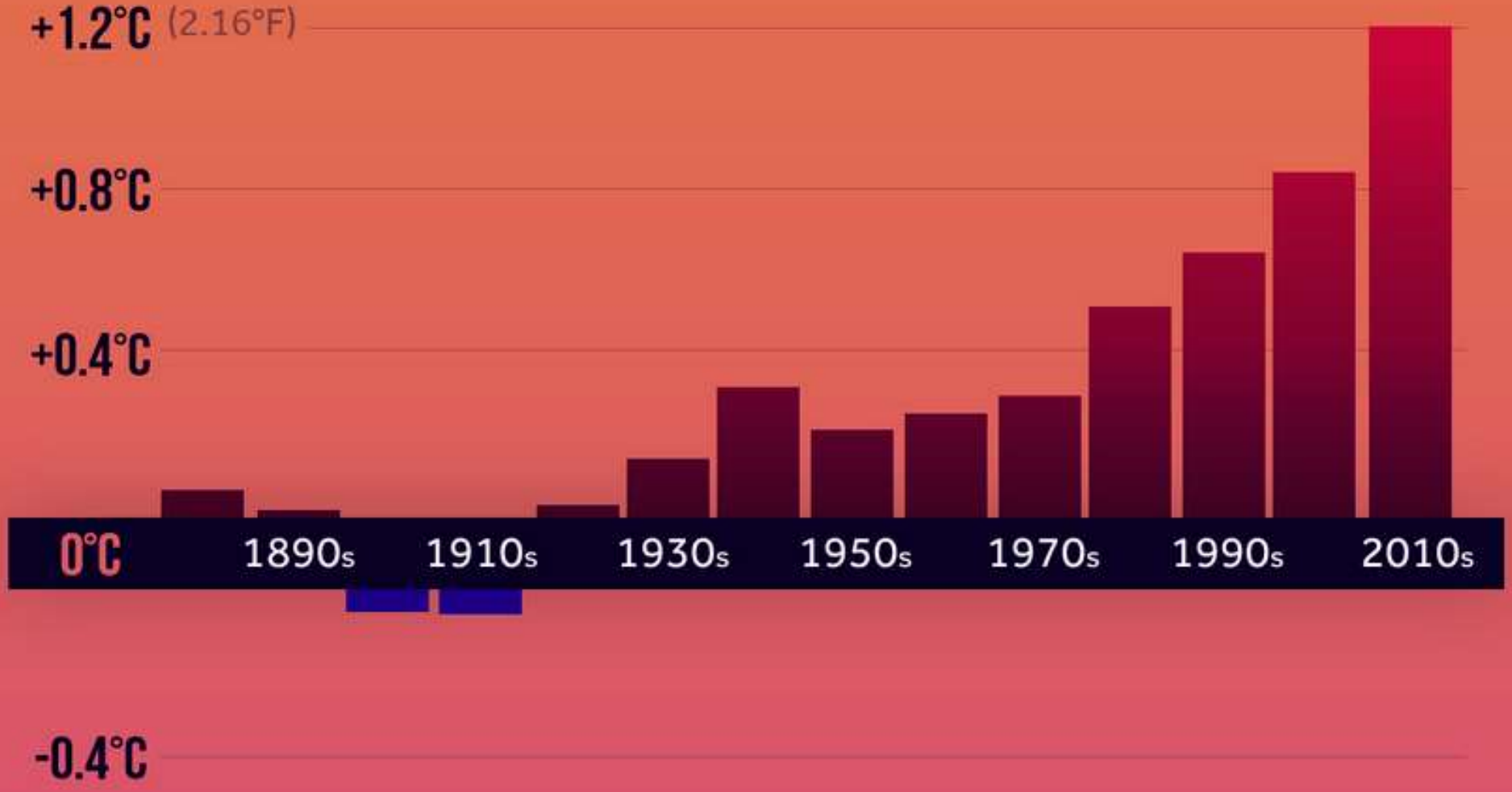


Source: NASA GISS & NOAA NCEI global temperature anomalies (°C) averaged and adjusted to early industrial baseline (1881-1910). Data as of 1/15/2020.

CLIMATE CENTRAL

GLOBAL DECADES OF WARMING

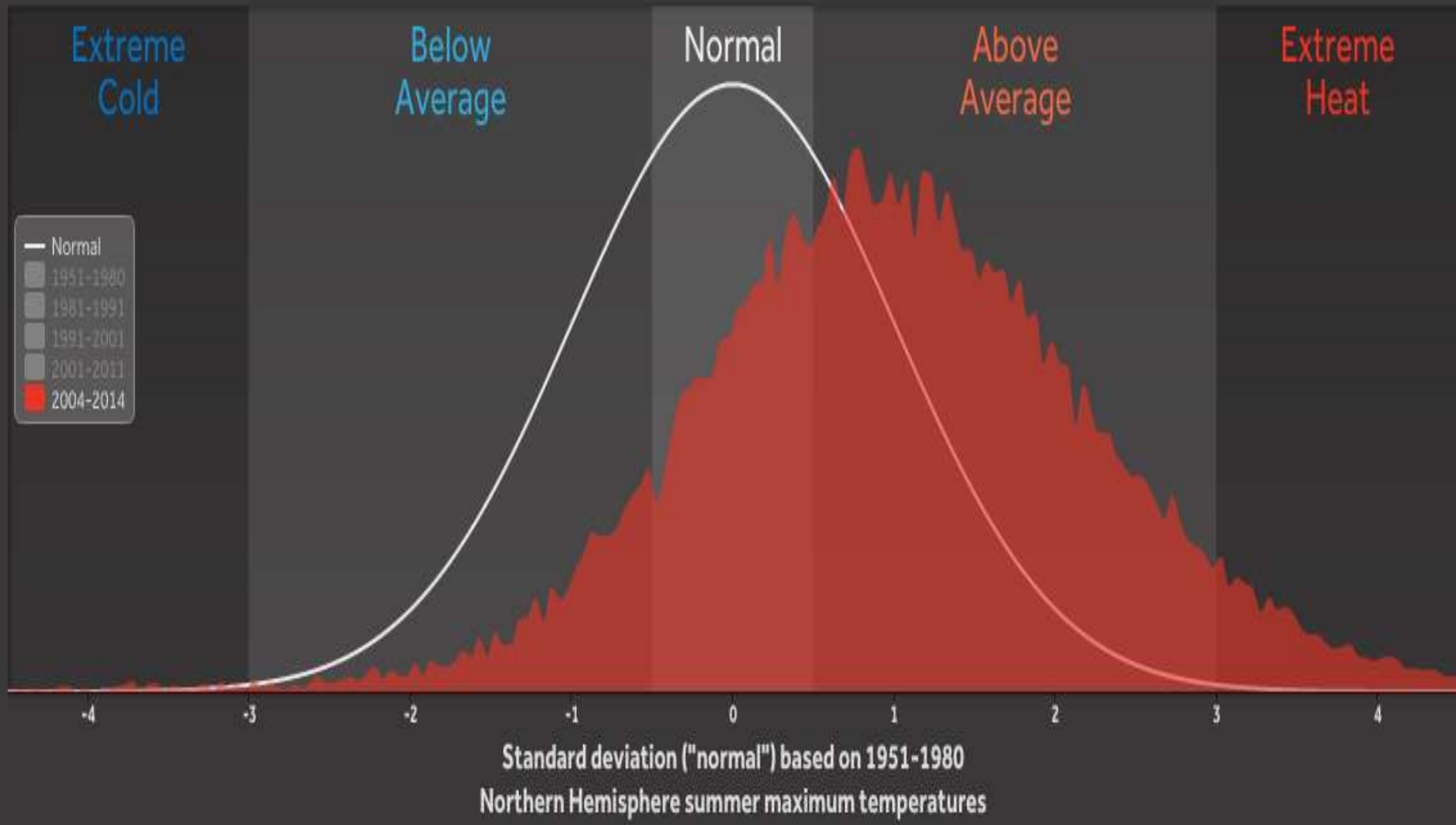
Average Decadal Temperature Anomalies



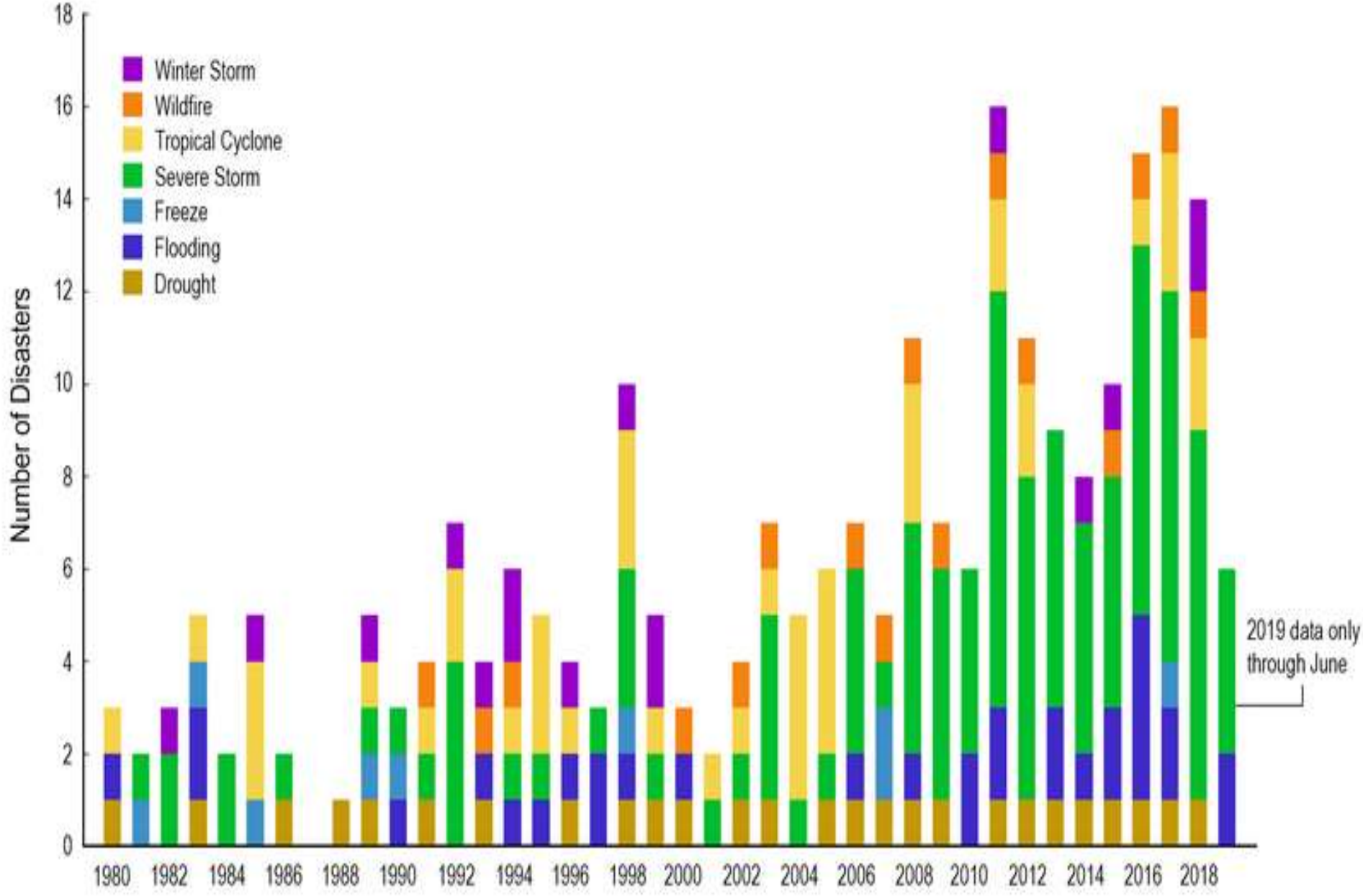
Source: NASA GISS & NOAA NCEI global temperature anomalies averaged and adjusted to early industrial baseline (1881-1910). Data as of 1/15/2020

CLIMATE CENTRAL

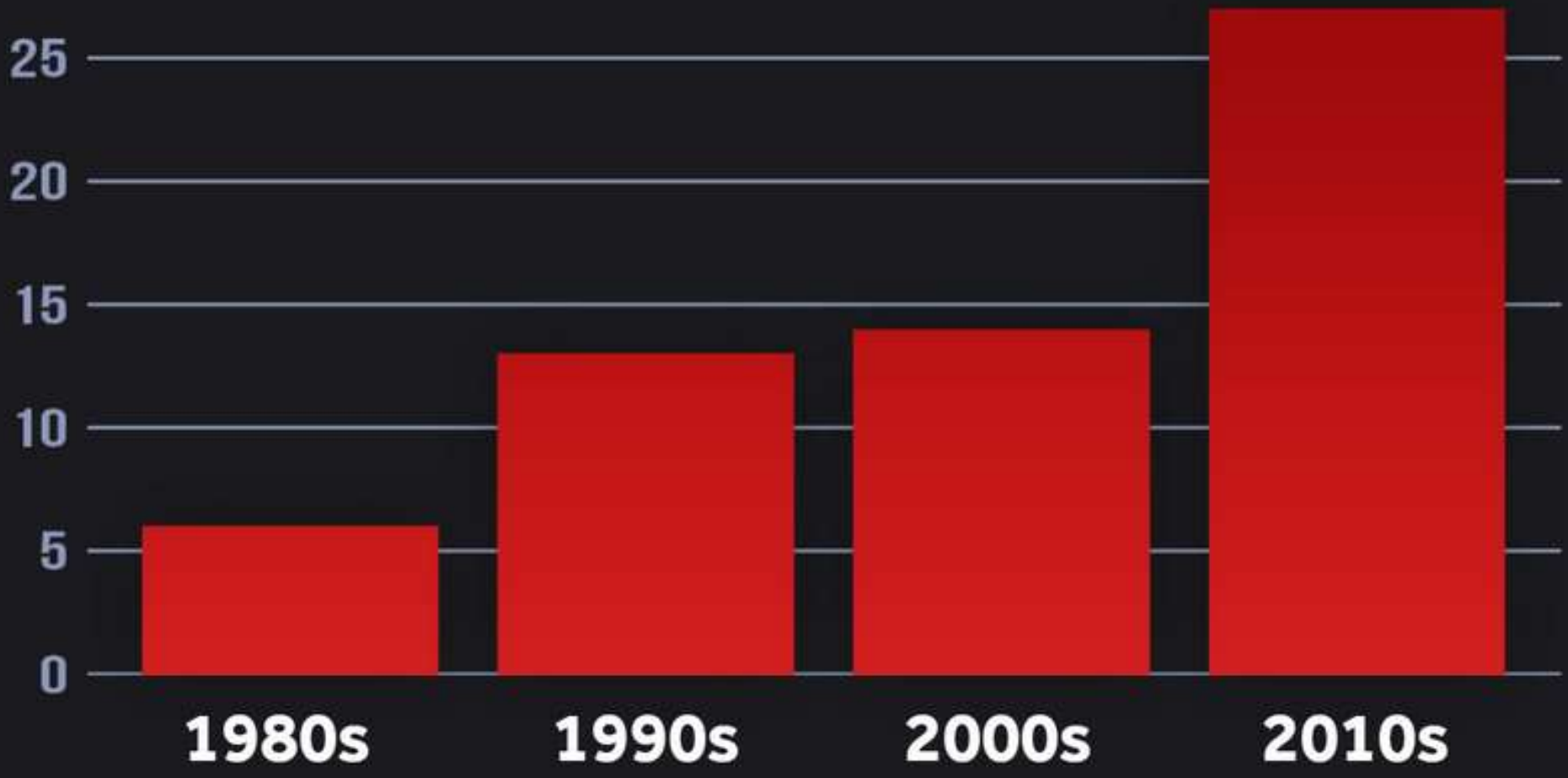
Extreme heat events are **more frequent**



U.S. Billion Dollar Weather and Climate Disasters



NEW YORK
BILLION-DOLLAR DISASTERS
WEATHER & CLIMATE EVENTS



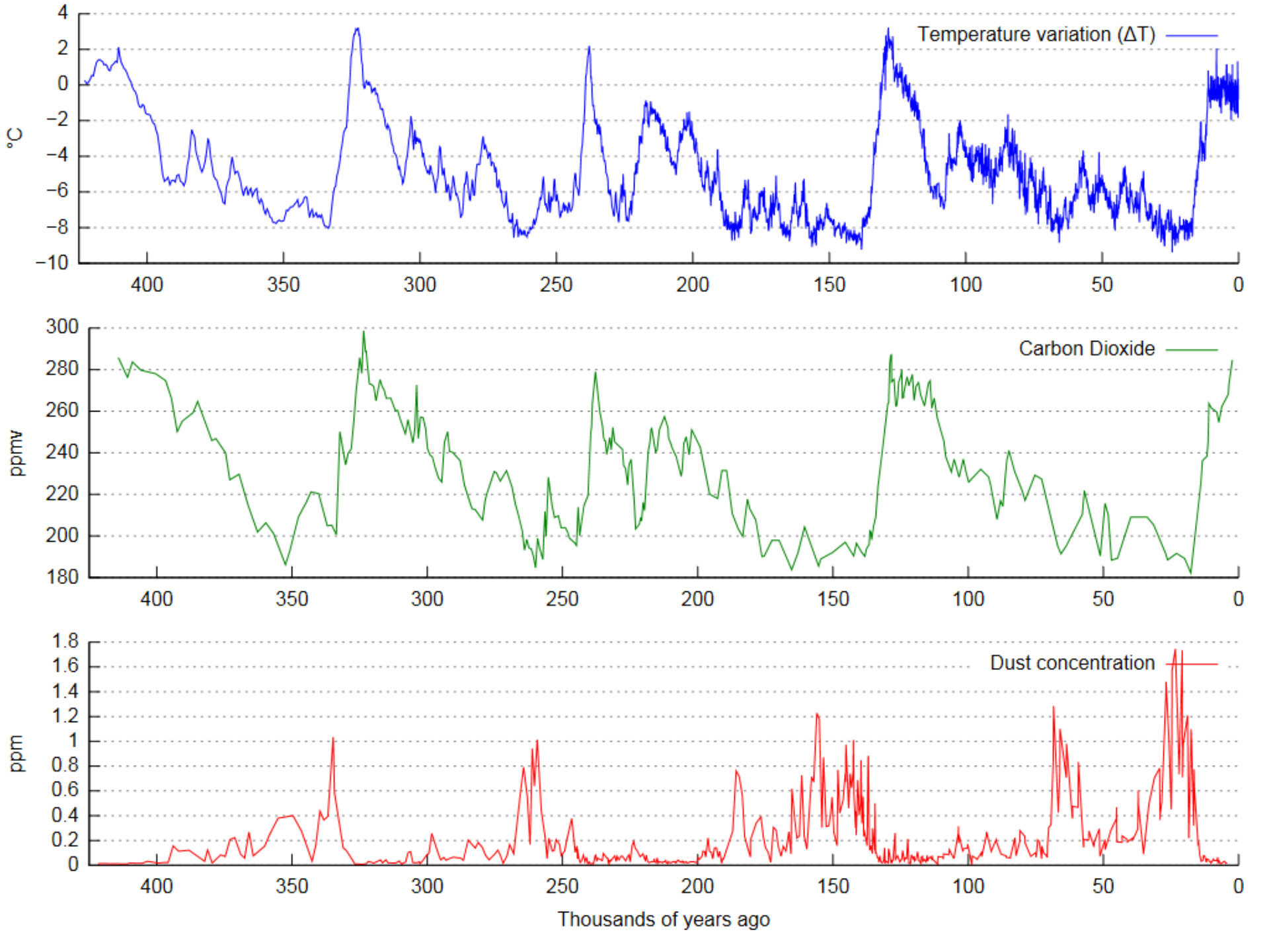
1980–2019 billion-dollar weather and climate disasters (CPI-adjusted).
Source: NOAA/NCEI. Produced 2/12/2020

CLIMATE CENTRAL

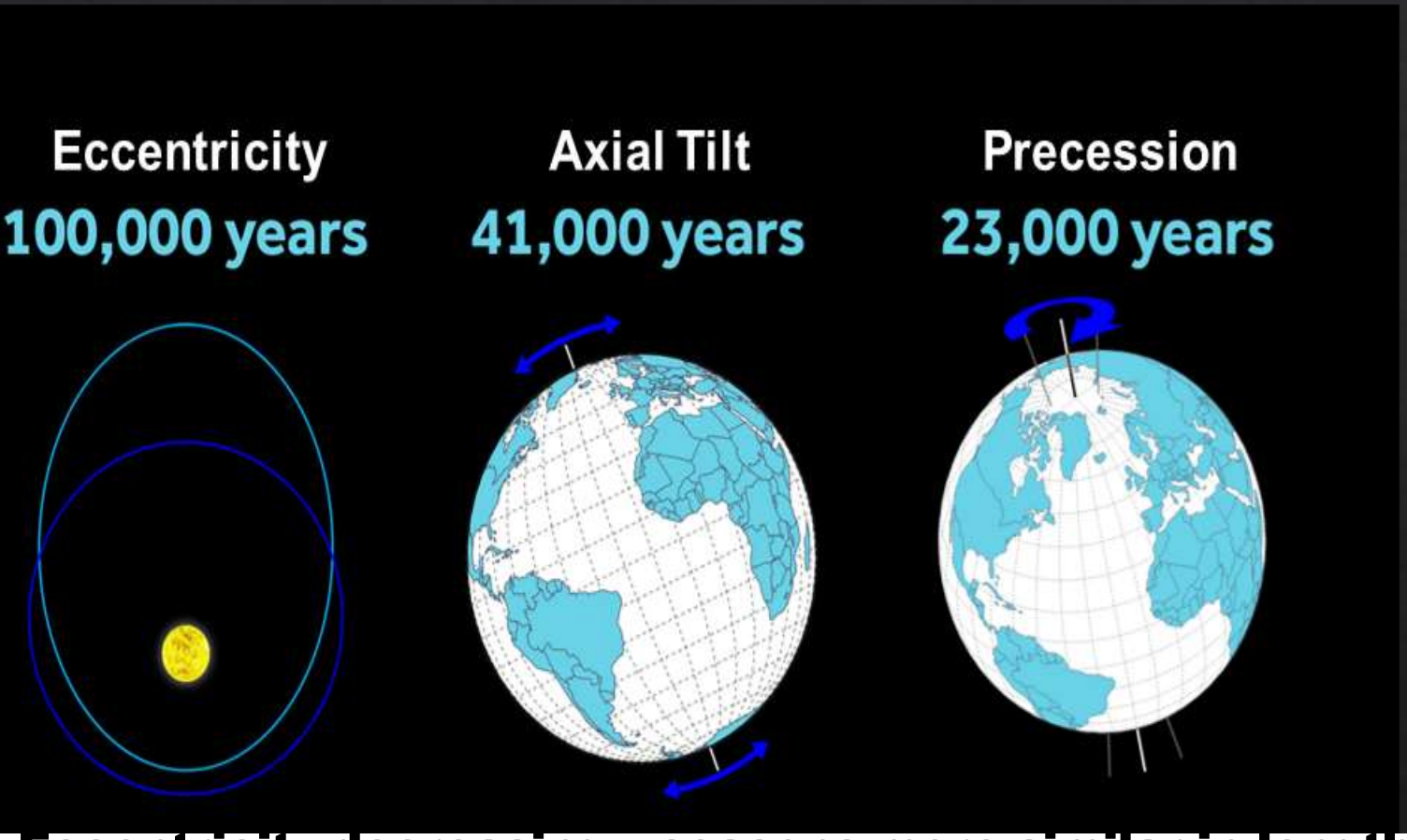
Science: Atmospheric Gases

99% nitrogen and oxygen, with important trace greenhouse gases:

- Water vapor
- Carbon dioxide
- Methane
- Nitrous oxide


Temperature variation (ΔT)
°C
4
2
0
−2
−4
−6
−8
−10
400
350
300
250
200
150
100
50
0
Carbon Dioxide
ppmv
300
280
260
240
220
200
180
Dust concentration
ppm
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Thousands of years ago

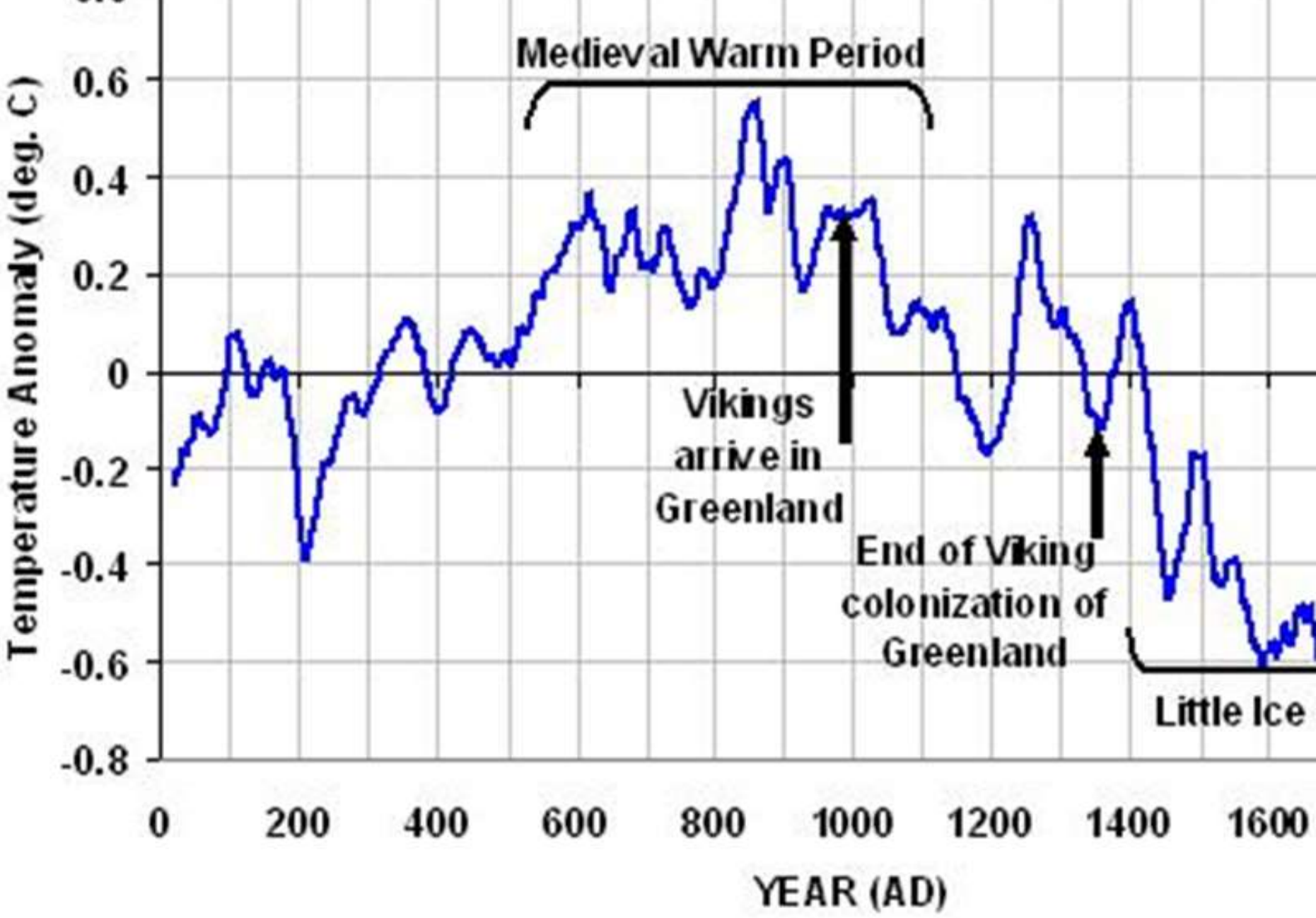
Science: Natural Variation – Orbital Cycles

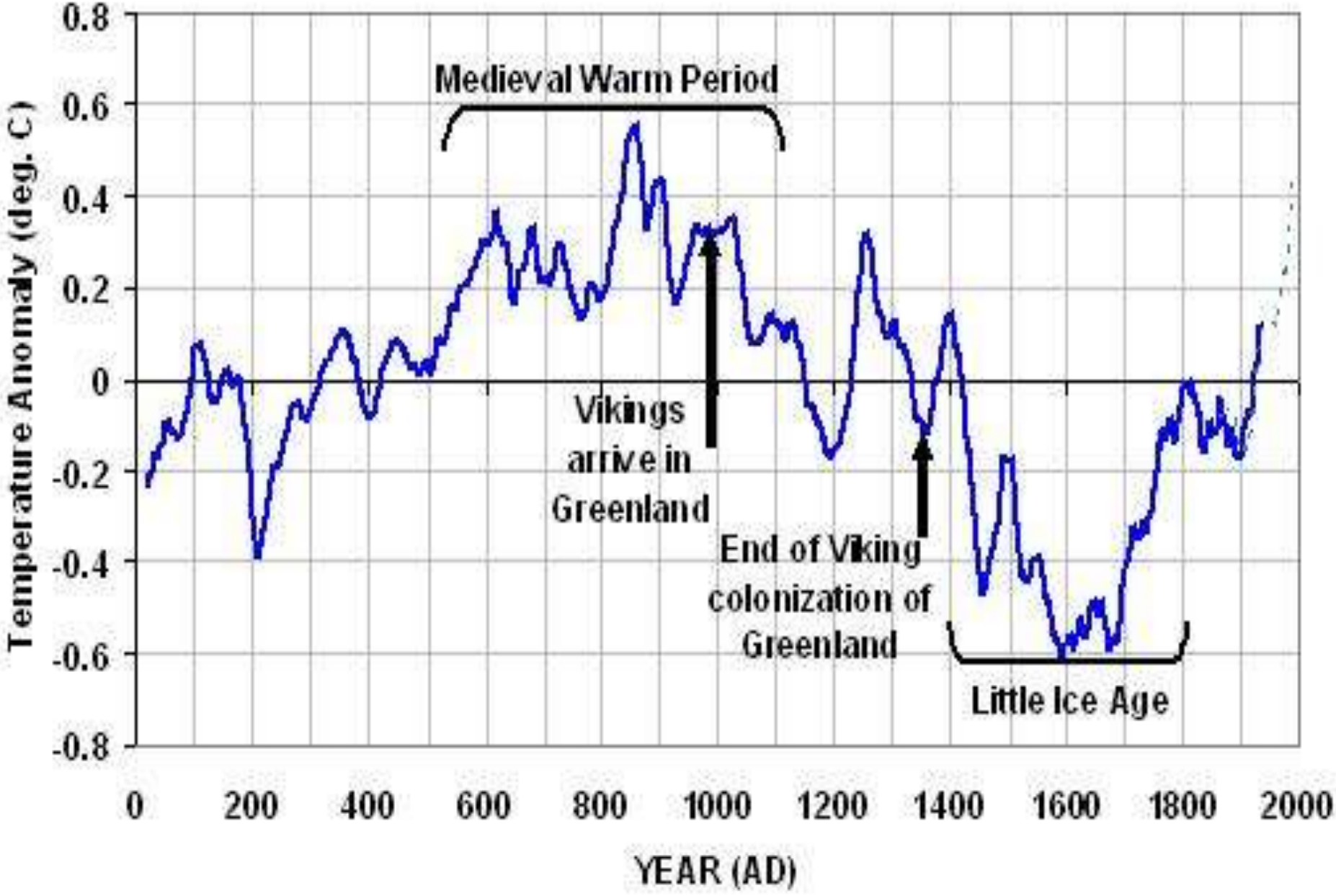


- These cycles change distribution of solar energy
- Largely responsible for ancient warming and cooling periods

Eccentricity decreasing – seasons more similar in length – promotes colder.

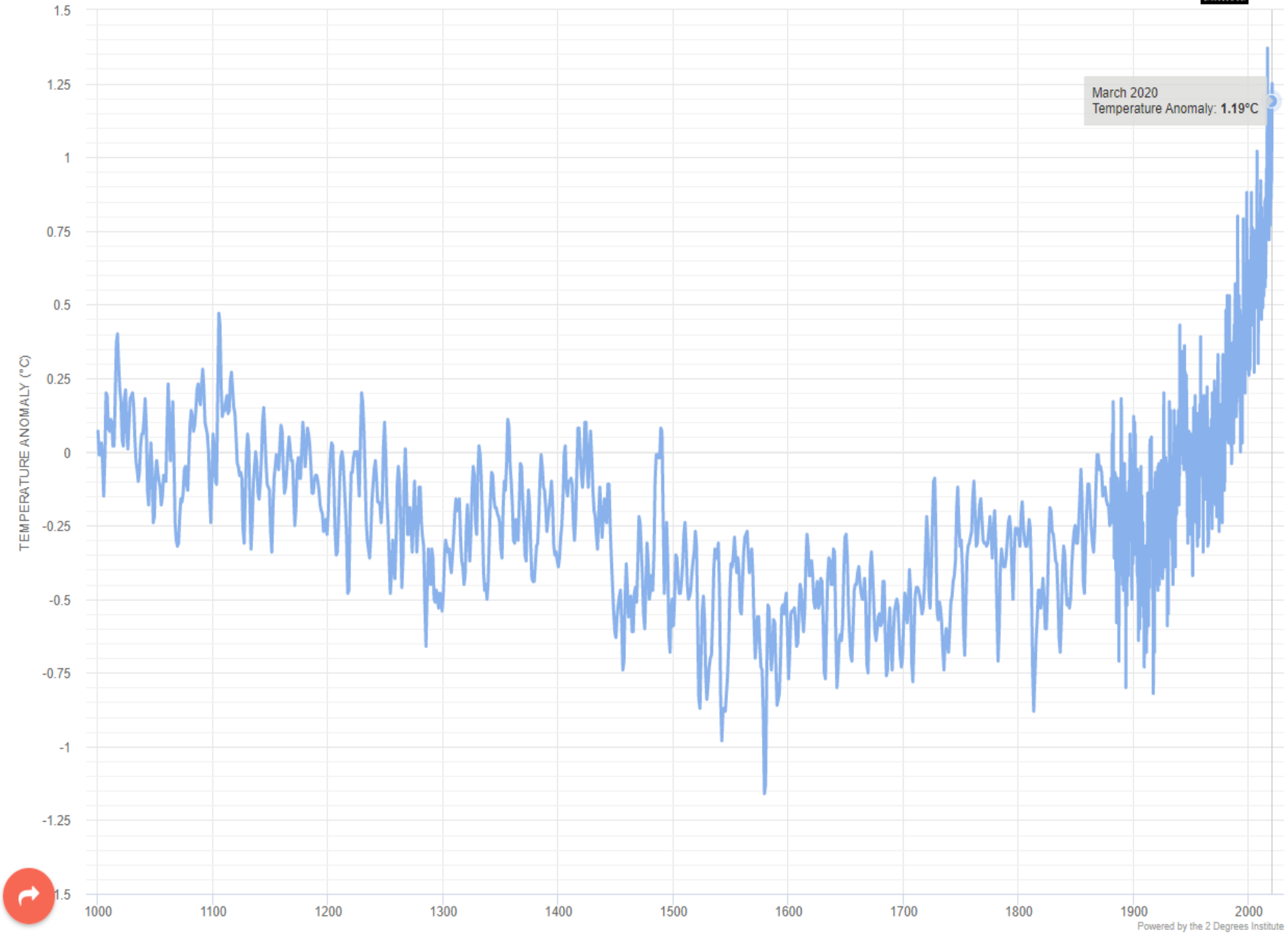
Tilt – 22.1-24.5 degrees, currently 23.44 degrees – also decreasing – promotes colder.


Medieval Warm Period
Vikings arrive in Greenland
End of Viking colonization of Greenland
Little Ice
Temperature Anomaly (deg. C)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
200
400
600
800
1000
1200
1400
1600
YEAR (AD)


Temperature Anomaly (deg. C)
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
Medieval Warm Period
Vikings arrive in Greenland
End of Viking colonization of Greenland
Little Ice Age
0
200
400
600
800
1000
1200
1400
1600
1800
2000
YEAR (AD)

GLOBAL TEMPERATURE RECORD

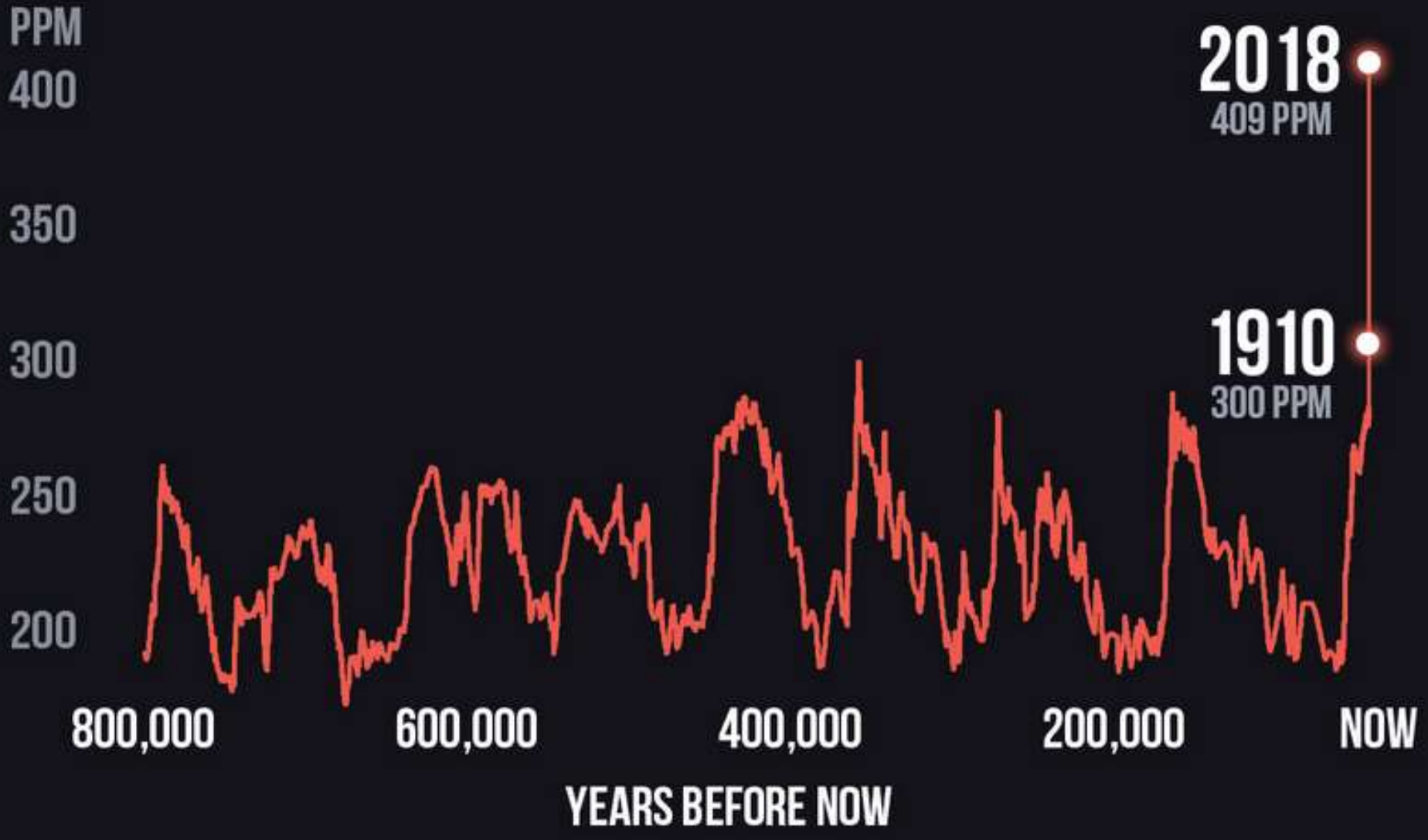
Click and drag in the plot area to zoom in



Powered by the 2 Degrees Institute

CHANGING OUR ATMOSPHERE

800,000 Years of Carbon Dioxide

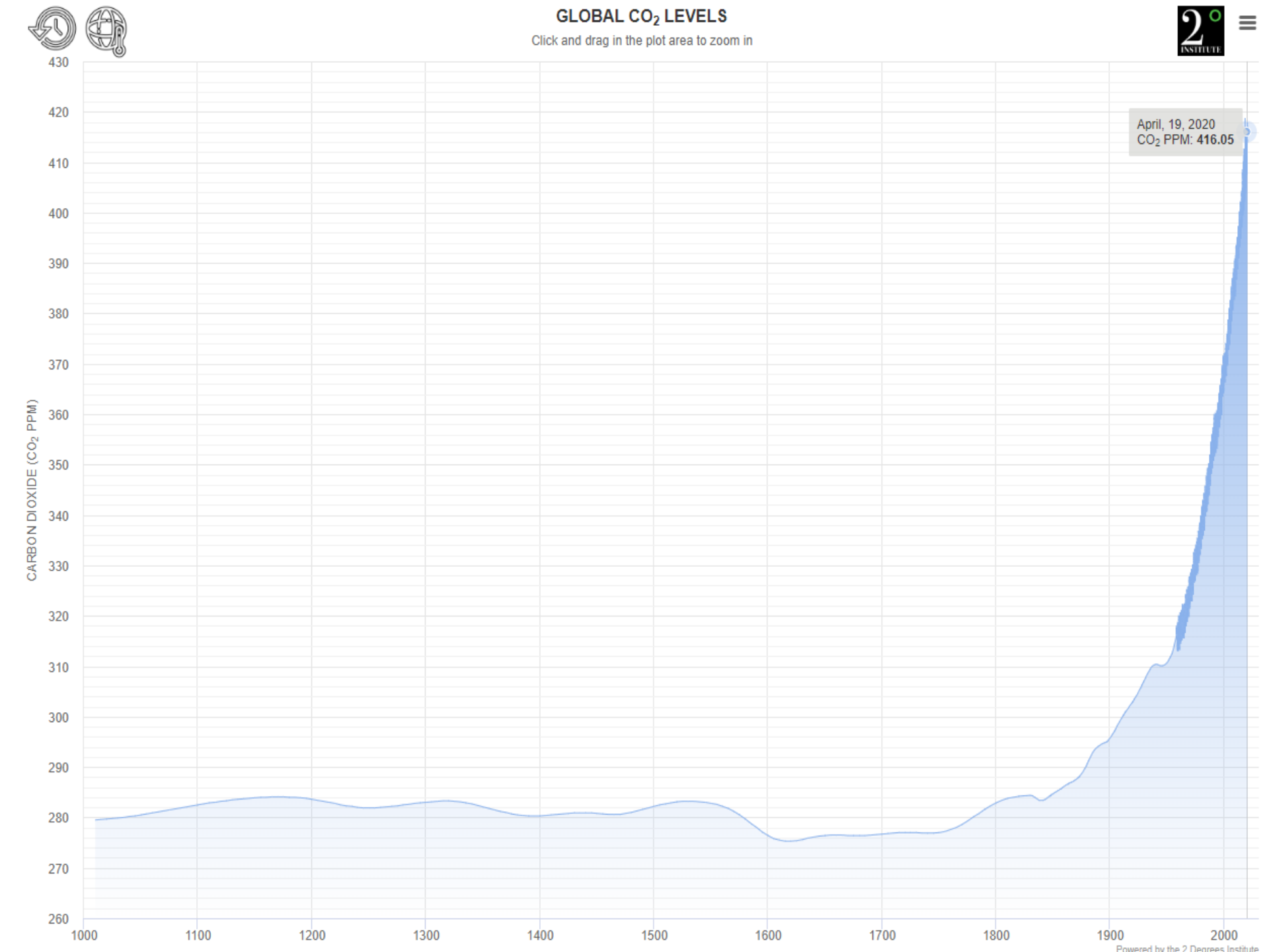


Source: Luthi et al (2008) (cdiac.ornl.gov) & NOAA ESRL (esrl.noaa.gov)

CLIMATE CENTRAL

GLOBAL CO_2 LEVELS

Click and drag in the plot area to zoom in

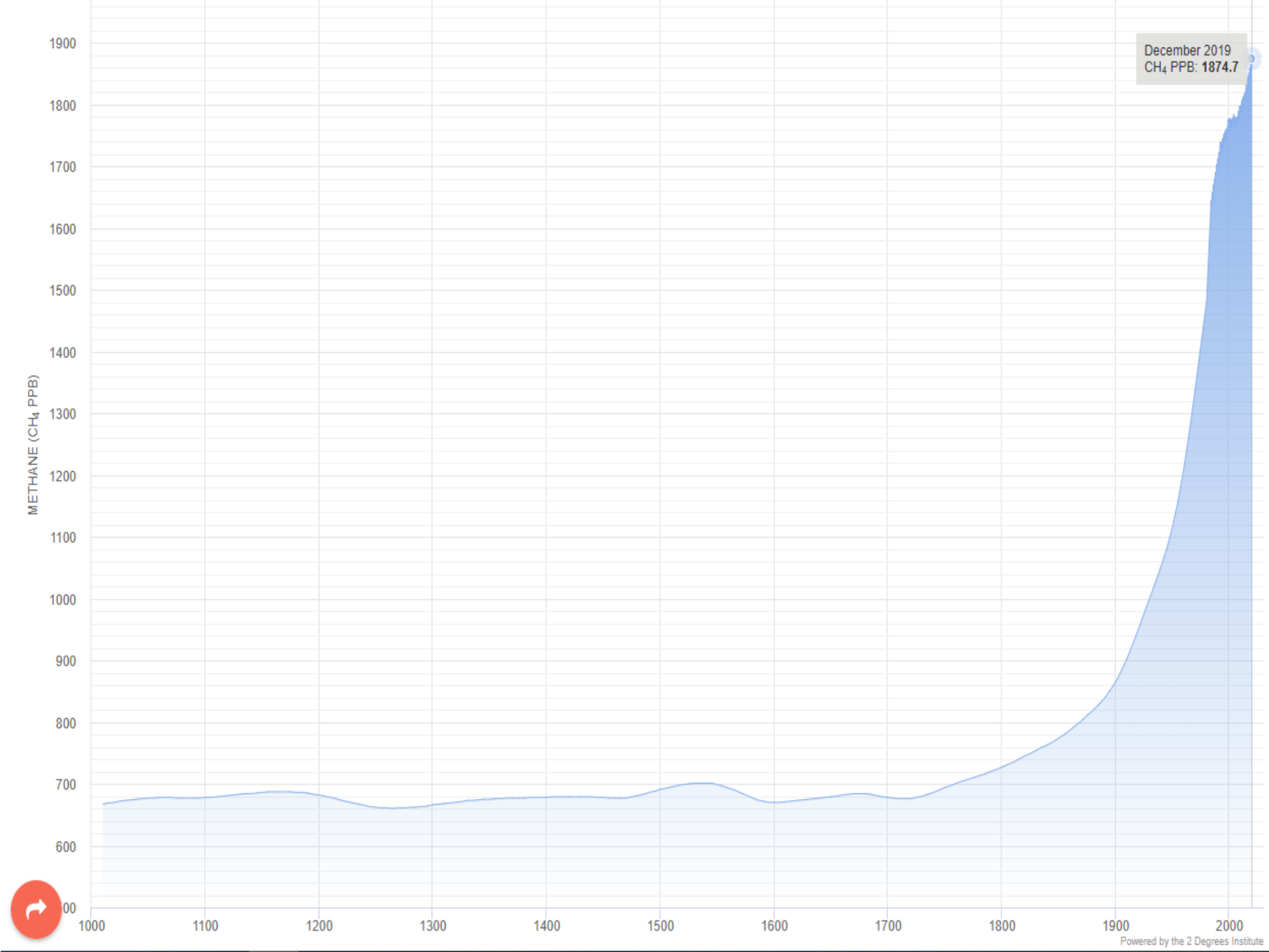


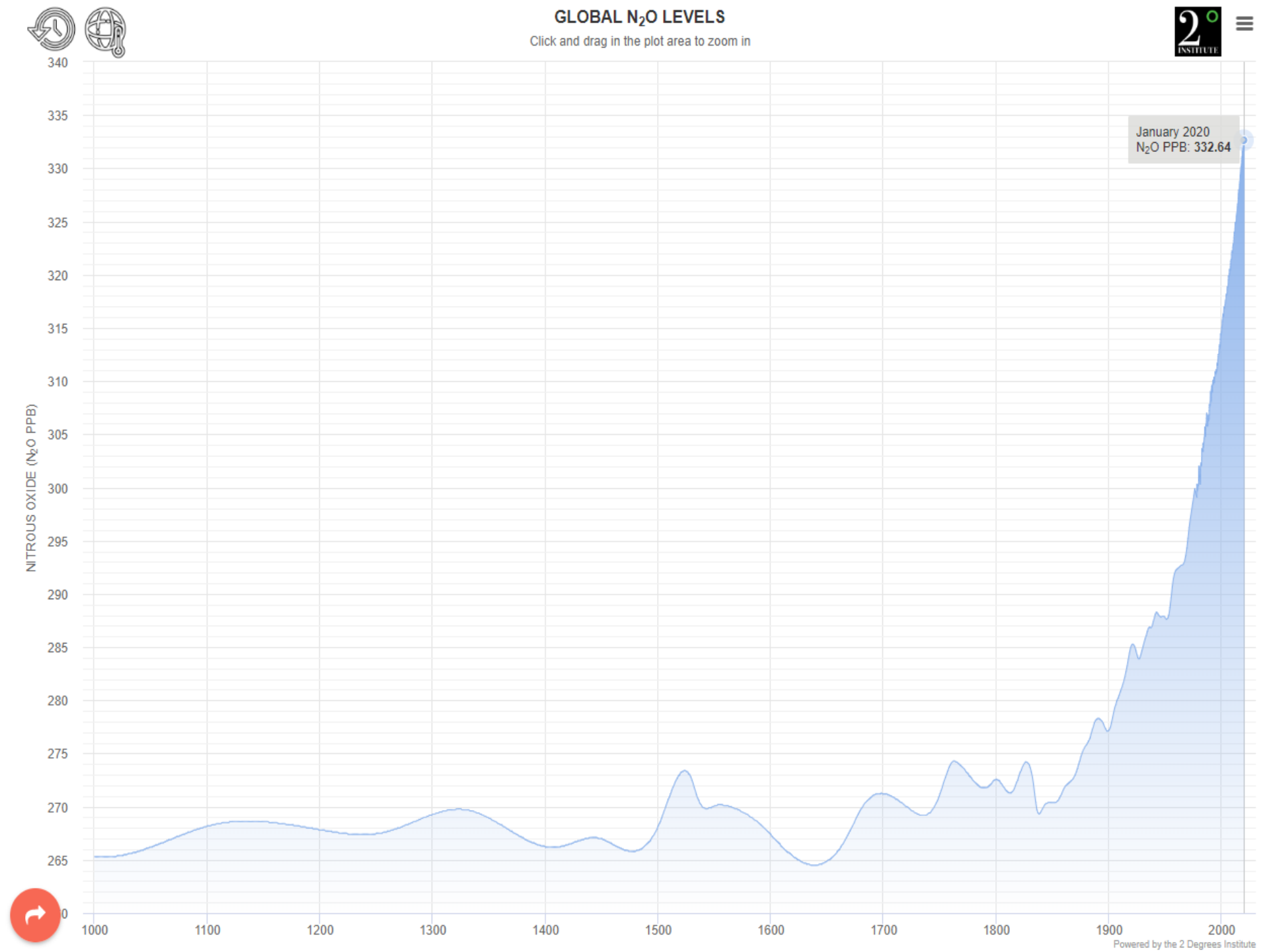
CARBON DIOXIDE IS THE PRIMARY GREENHOUSE GAS DRIVING CLIMATE CHANGE.

55% OF THE TOTAL PRESENT WARMING RATE IS DUE TO CARBON DIOXIDE.

SCIENTISTS ESTIMATE THAT THE LAST TIME CO2 LEVELS WERE THAT HIGH WAS MORE THAN 3 MILLION YEARS AGO, WHEN THE ARCTIC WAS 32°F WARMER THAN IT IS TODAY AND SEA LEVELS WERE UP TO 90 FEET HIGHER.

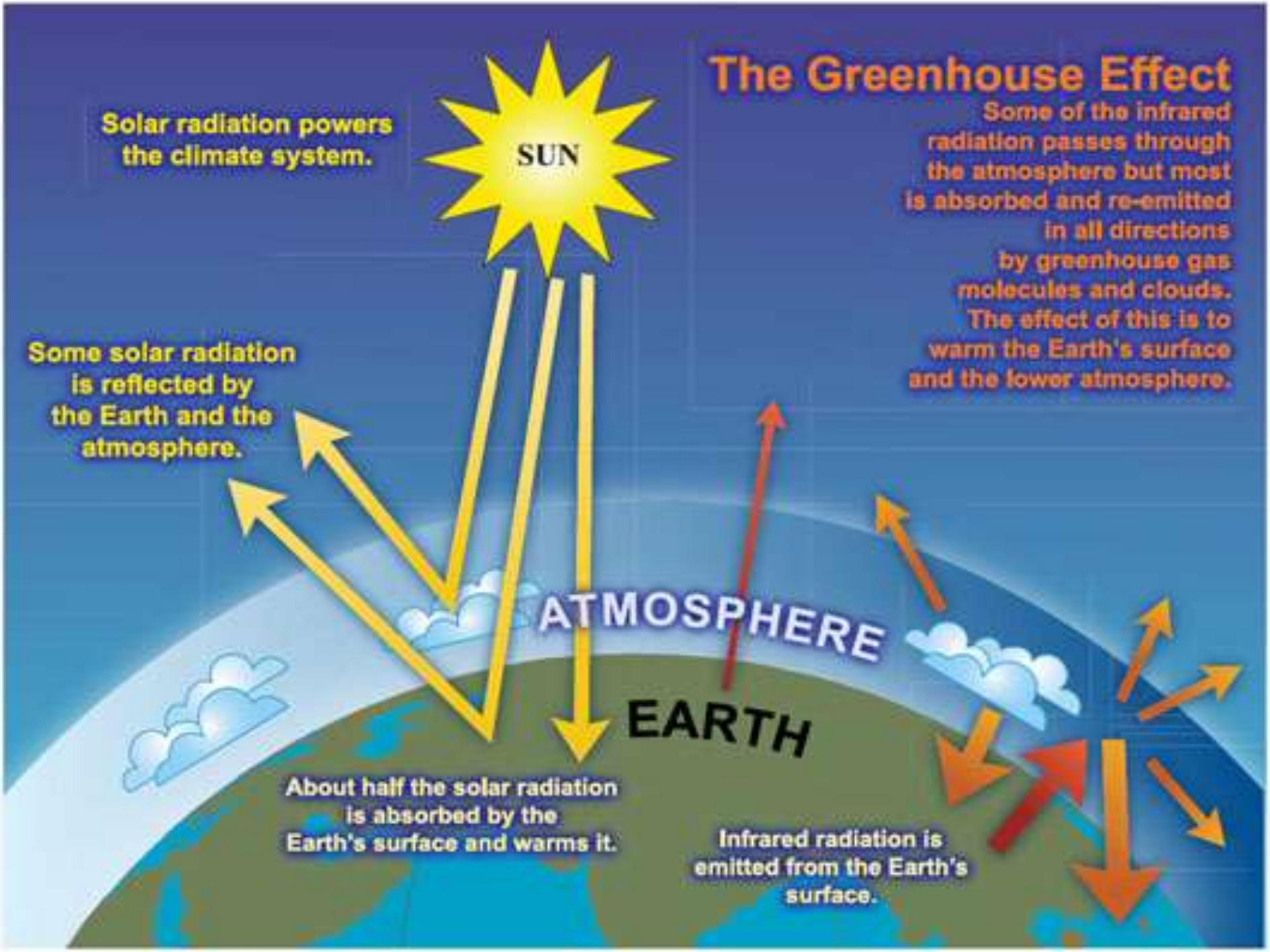
THE CLIMATE RESPONDS SLOWLY TO CHANGES IN CO2 LEVELS, SO EVEN IF ALL CARBON EMISSIONS STOPPED TODAY, GLOBAL TEMPERATURES WOULD KEEP RISING AND OTHER CLIMATE IMPACTS WOULD CONTINUE TO BE FELT FOR DECADES OR CENTURIES TO COME.


December 2019
CH4 PPB: 1874.7
METHANE (CH4 PPB)
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Powered by the 2 Degrees Institute

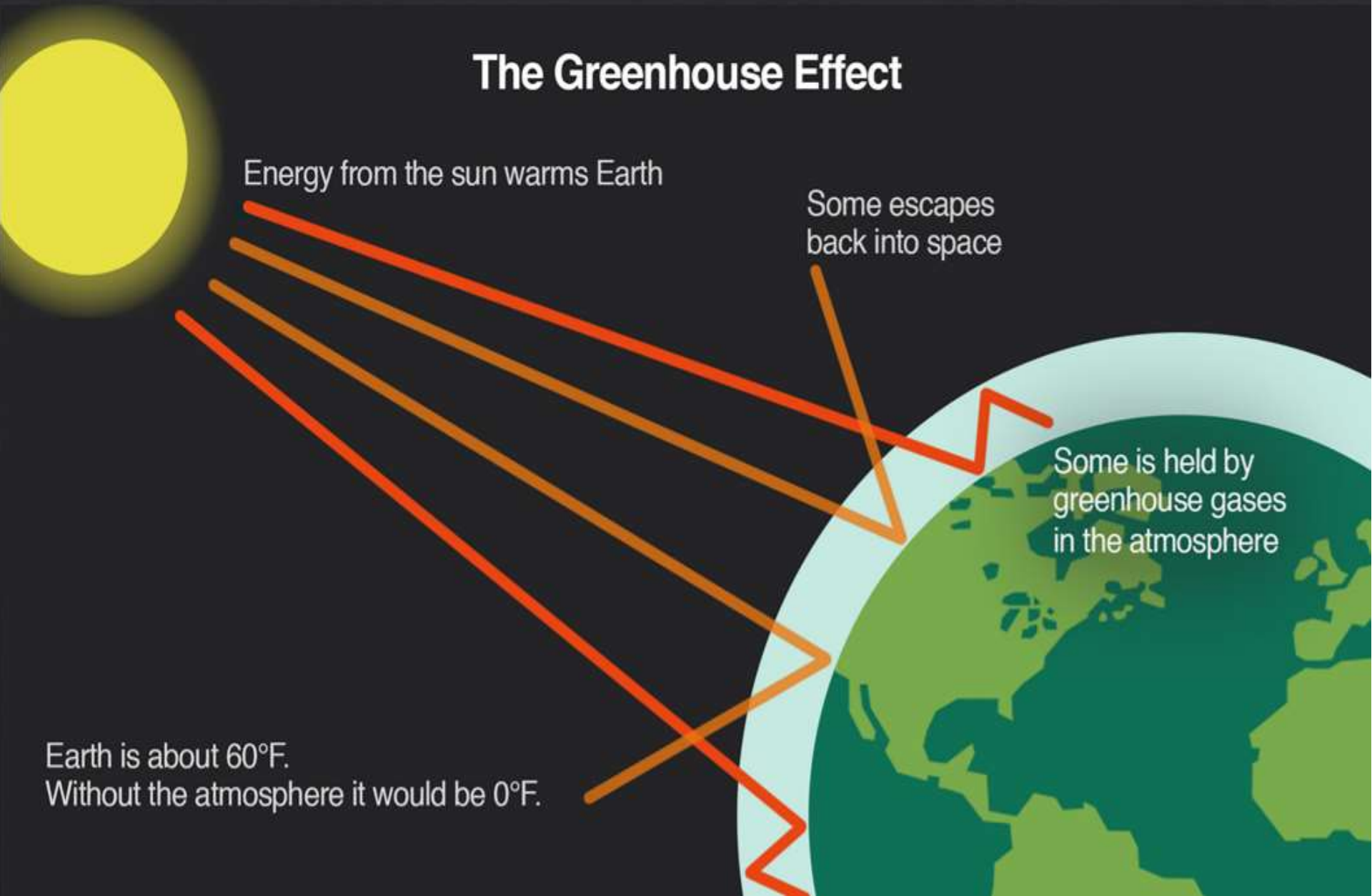

GLOBAL N_2O LEVELS
Click and drag in the plot area to zoom in
January 2020
N_2O PPB: 332.64
NITROUS OXIDE (N_2O PPB)
340
335
330
325
320
315
310
305
300
295
290
285
280
275
270
265
0
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Powered by the 2 Degrees Institute

Current greenhouse gas concentrations

Gas	Pre-1750 tropospheric concentration	Recent tropospheric concentration	Absolute increase since 1750	Percentage increase since 1750
Carbon dioxide (CO_2)	280 ppm	416.1 ppm	136.1 ppm	48.6%
Methane (CH_4)	700 ppb	1875 ppb	1175 ppb	168%
Nitrous oxide (N_2O)	270 ppb	332.6 ppb	62.6 ppb	23.2%

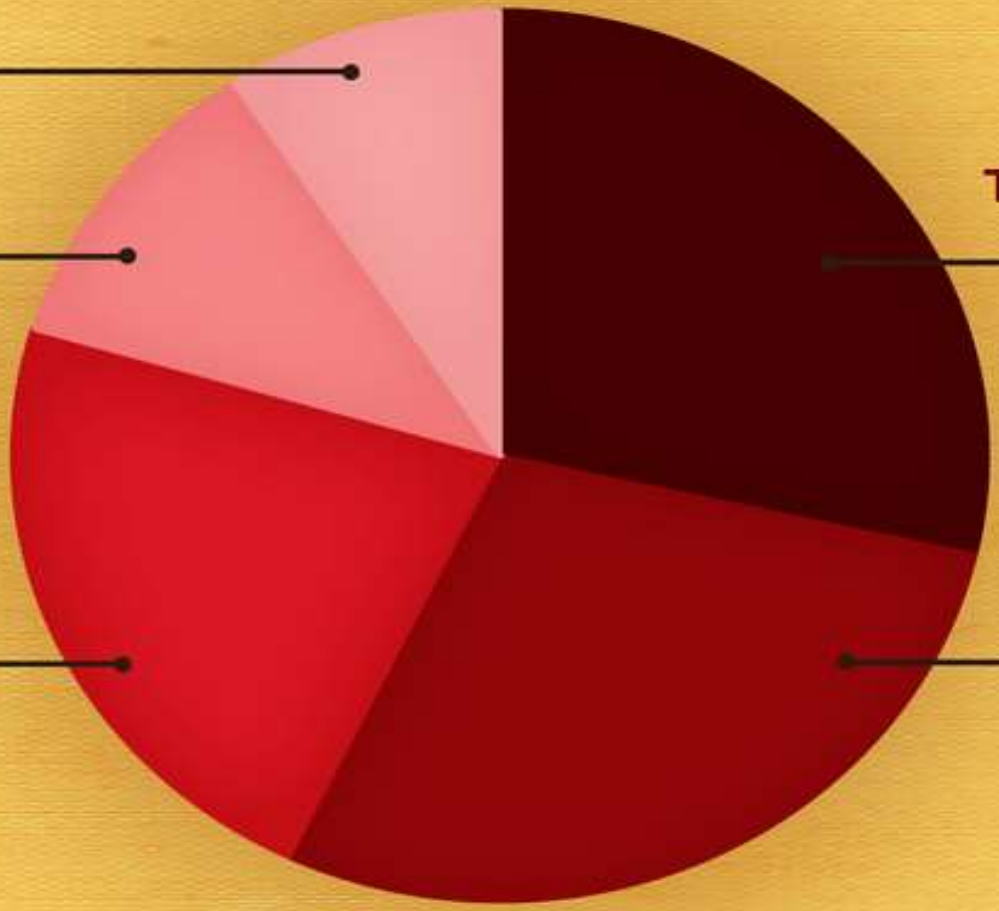

The Greenhouse Effect
Some of the infrared radiation passes through the atmosphere but most is absorbed and re-emitted in all directions by greenhouse gas molecules and clouds. The effect of this is to warm the Earth's surface and the lower atmosphere.
Solar radiation powers the climate system.
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
ATMOSPHERE
EARTH
About half the solar radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

Science: Greenhouse Effect



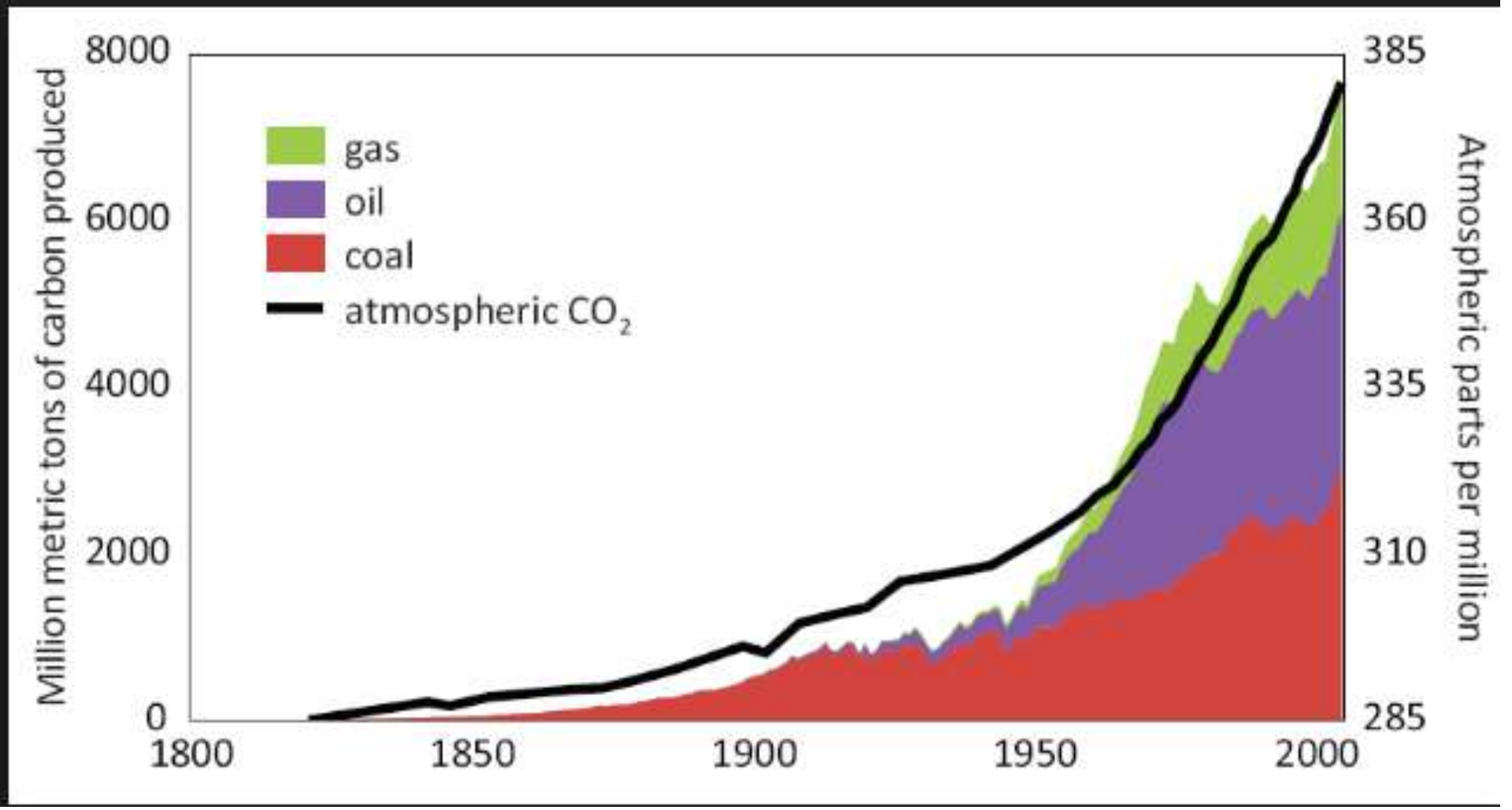
GREENHOUSE GAS SOURCES

UNITED STATES EMISSIONS BY SECTOR

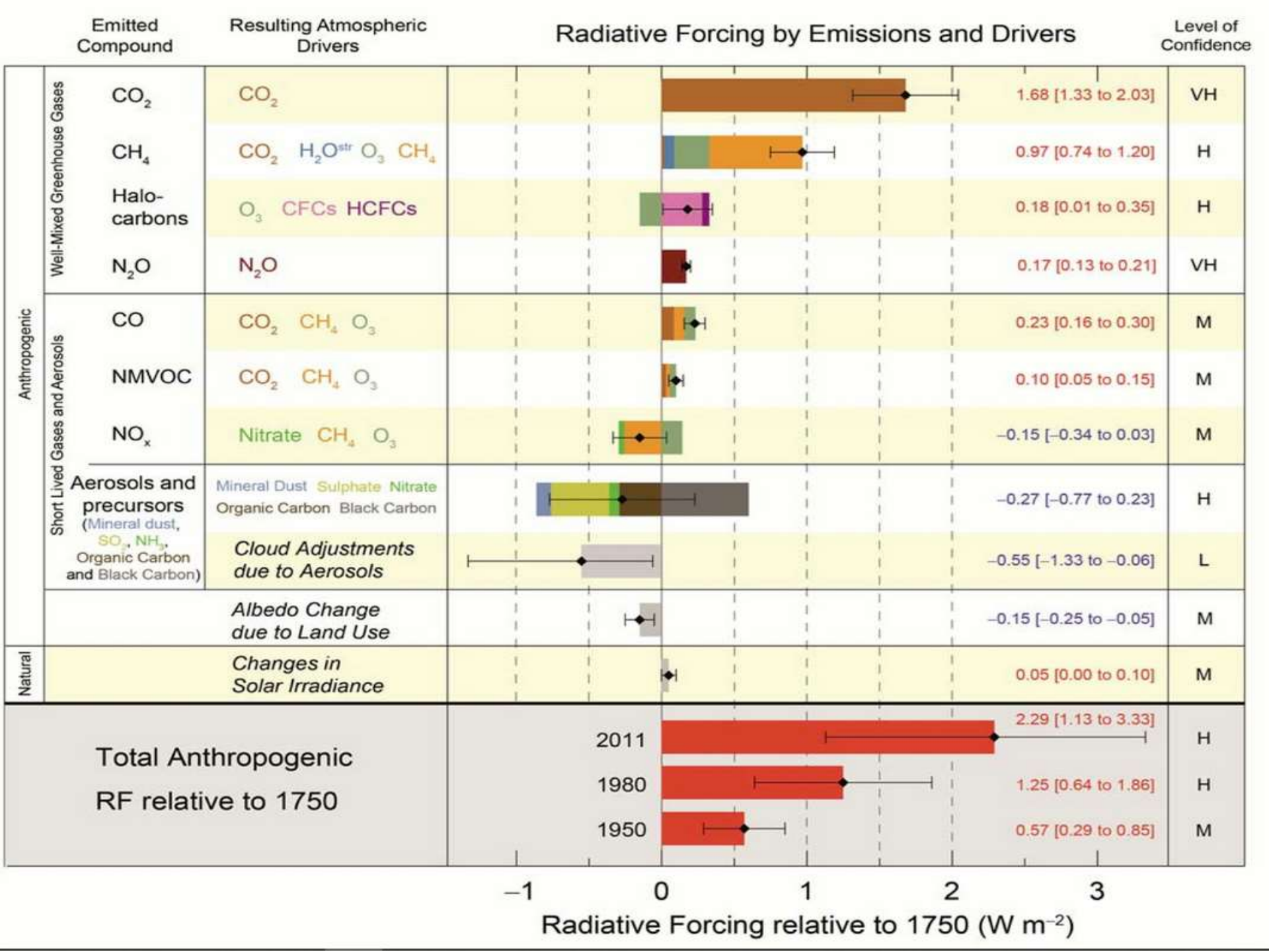


Source: U.S. EPA 2017 (released 2019)

CLIMATE CENTRAL

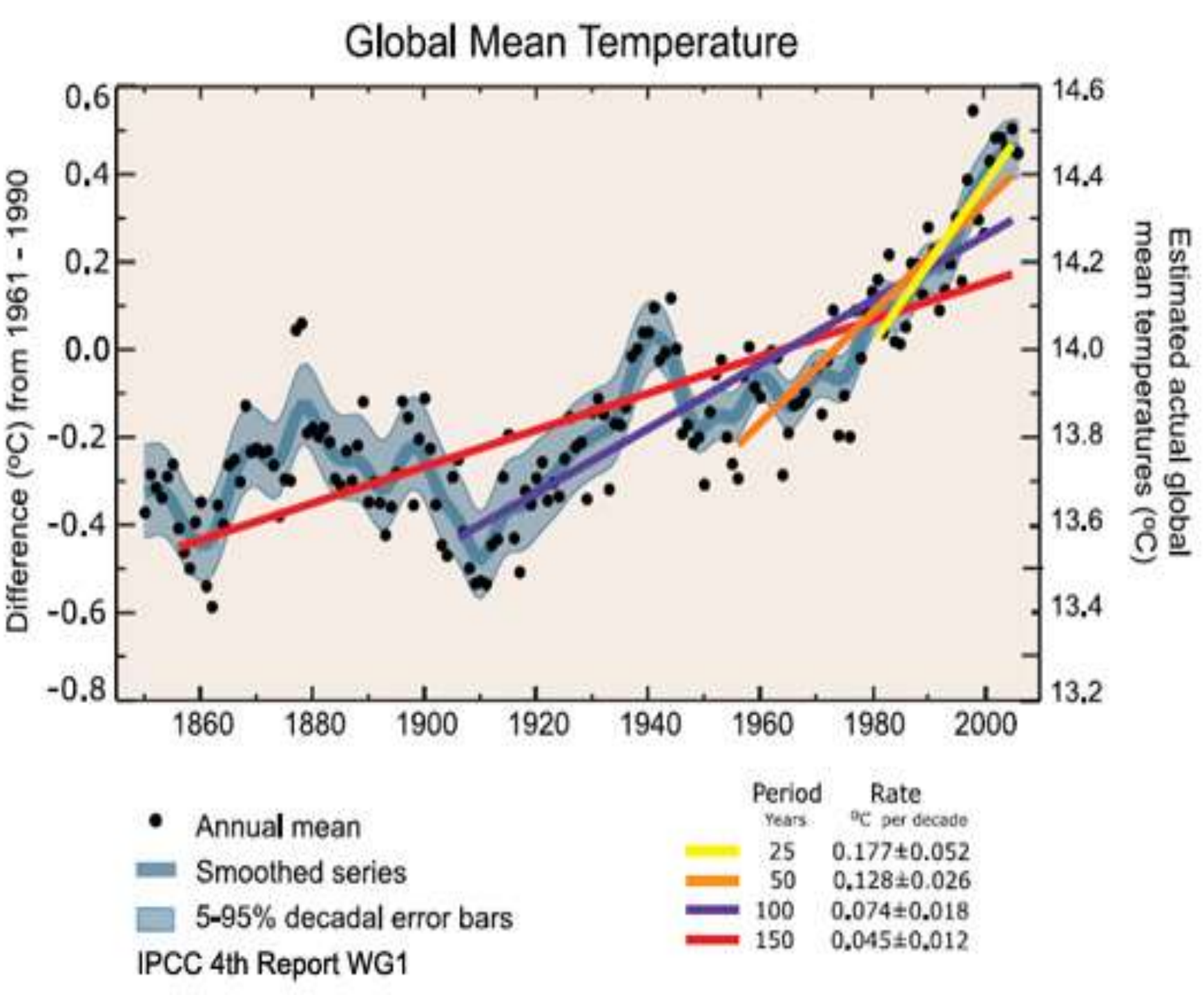


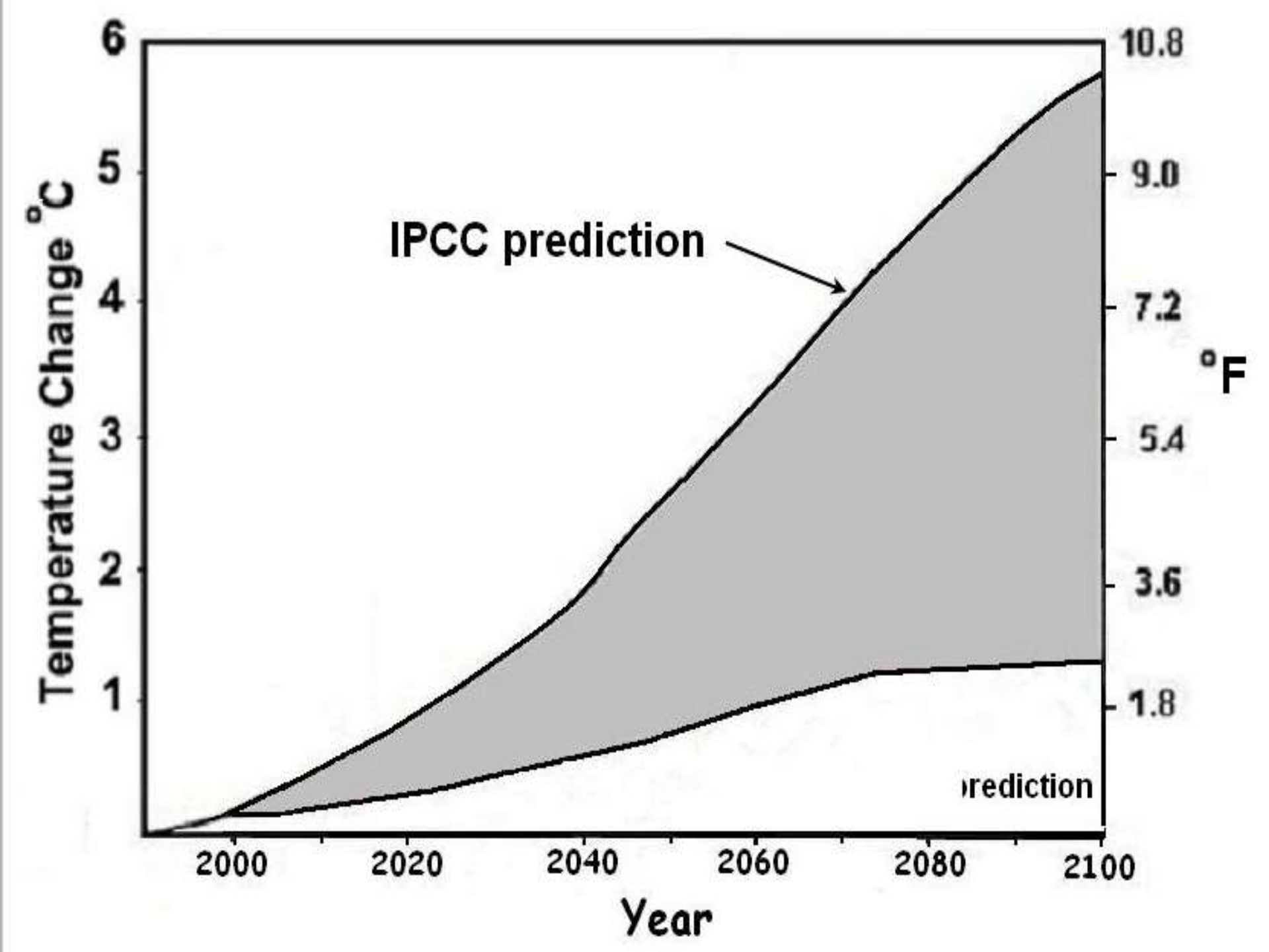
YES, IT IS HUMANS!


Emitted Compound
Resulting Atmospheric Drivers
Radiative Forcing by Emissions and Drivers
Level of Confidence
Anthropogenic
Natural
Well-Mixed Greenhouse Gases
Short Lived Gases and Aerosols
CO2
CO2
1.68 [1.33 to 2.03]
VH
CH4
CO2 H2Ostr O3 CH4
0.97 [0.74 to 1.20]
H
Halo-carbons
O3 CFCs HCFCs
0.18 [0.01 to 0.35]
H
N2O
N2O
0.17 [0.13 to 0.21]
VH
CO
CO2 CH4 O3
0.23 [0.16 to 0.30]
M
NMVOC
CO2 CH4 O3
0.10 [0.05 to 0.15]
M
NOx
Nitrate CH4 O3
–0.15 [–0.34 to 0.03]
M
Aerosols and precursors (Mineral dust, SO2, NH3, Organic Carbon and Black Carbon)
Mineral Dust Sulphate Nitrate Organic Carbon Black Carbon
–0.27 [–0.77 to 0.23]
H
Cloud Adjustments due to Aerosols
–0.55 [–1.33 to –0.06]
L
Albedo Change due to Land Use
–0.15 [–0.25 to –0.05]
M
Changes in Solar Irradiance
0.05 [0.00 to 0.10]
M
Total Anthropogenic RF relative to 1750
2011
2.29 [1.13 to 3.33]
H
1980
1.25 [0.64 to 1.86]
H
1950
0.57 [0.29 to 0.85]
M
–1
0
1
2
3
Radiative Forcing relative to 1750 (W m–2)

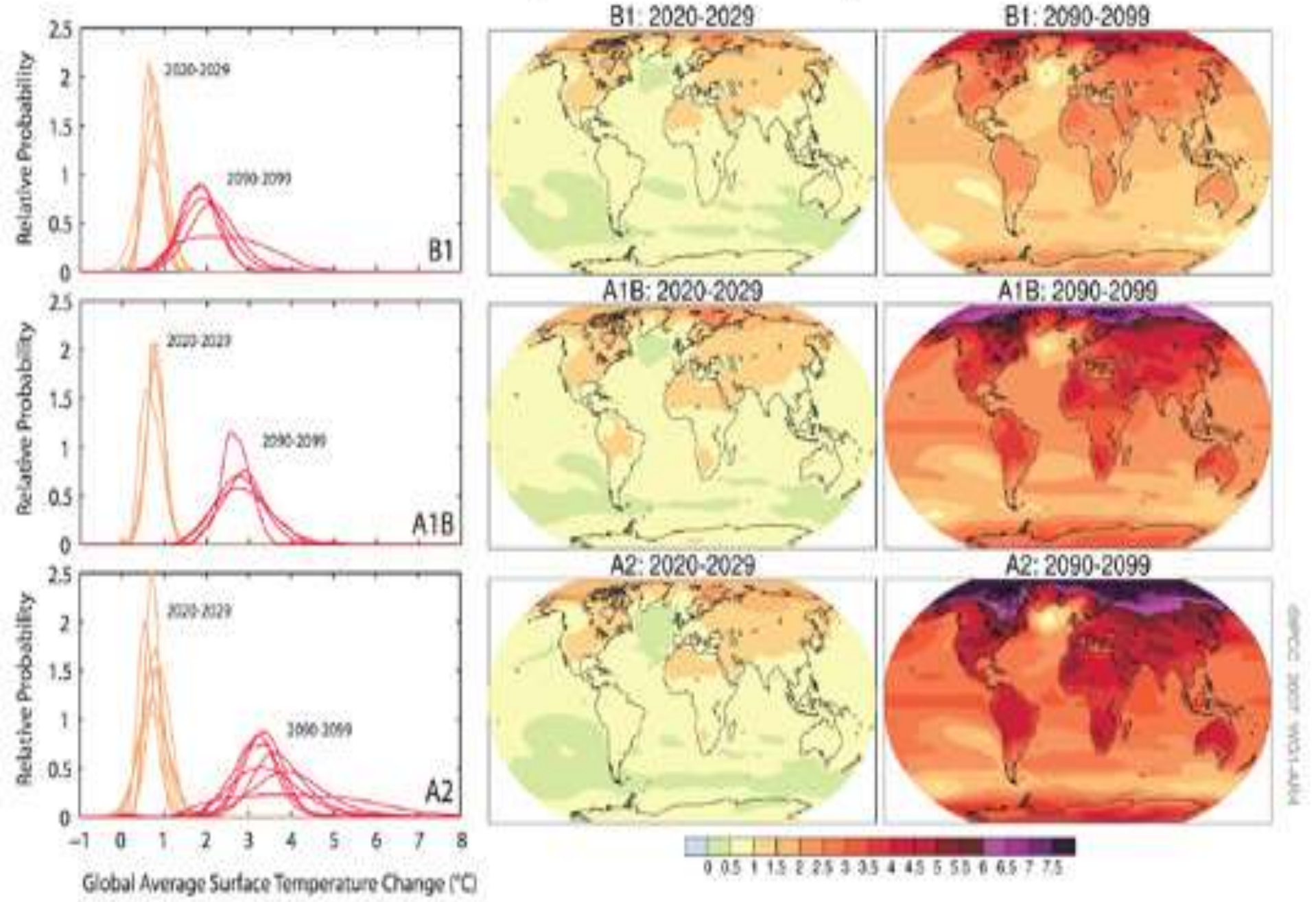
Atmospheric lifetime and GWP relative to CO2 at different time horizon for various greenhouse gases.

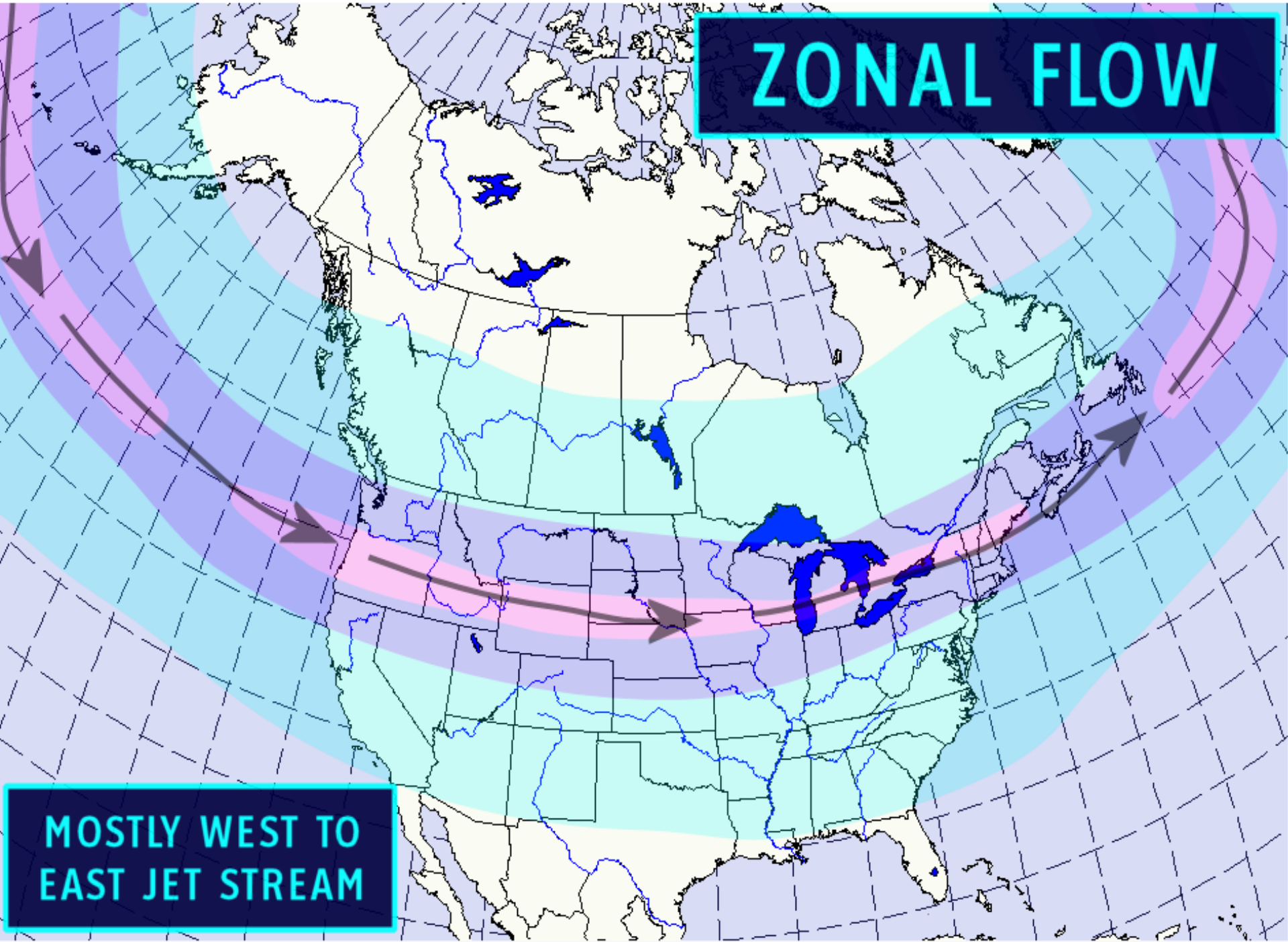
Gas name	Chemical formula	Lifetime (years)	Global warming potential (GWP) for given time horizon		
			20-yr	100-yr	500-yr
Carbon dioxide	CO2	See above	1	1	1
Methane	CH4	12	72	25	7.6
Nitrous oxide	N2O	114	289	298	153
CFC-12	CCl2F2	100	11 000	10 900	5 200
HCFC-22	CHClF2	12	5 160	1 810	549
Tetrafluoromethane	CF4	50 000	5 210	7 390	11 200
Hexafluoroethane	C2F6	10 000	8 630	12 200	18 200
Sulfur hexafluoride	SF6	3 200	16 300	22 800	32 600
Nitrogen trifluoride	NF3	740	12 300	17 200	20 700

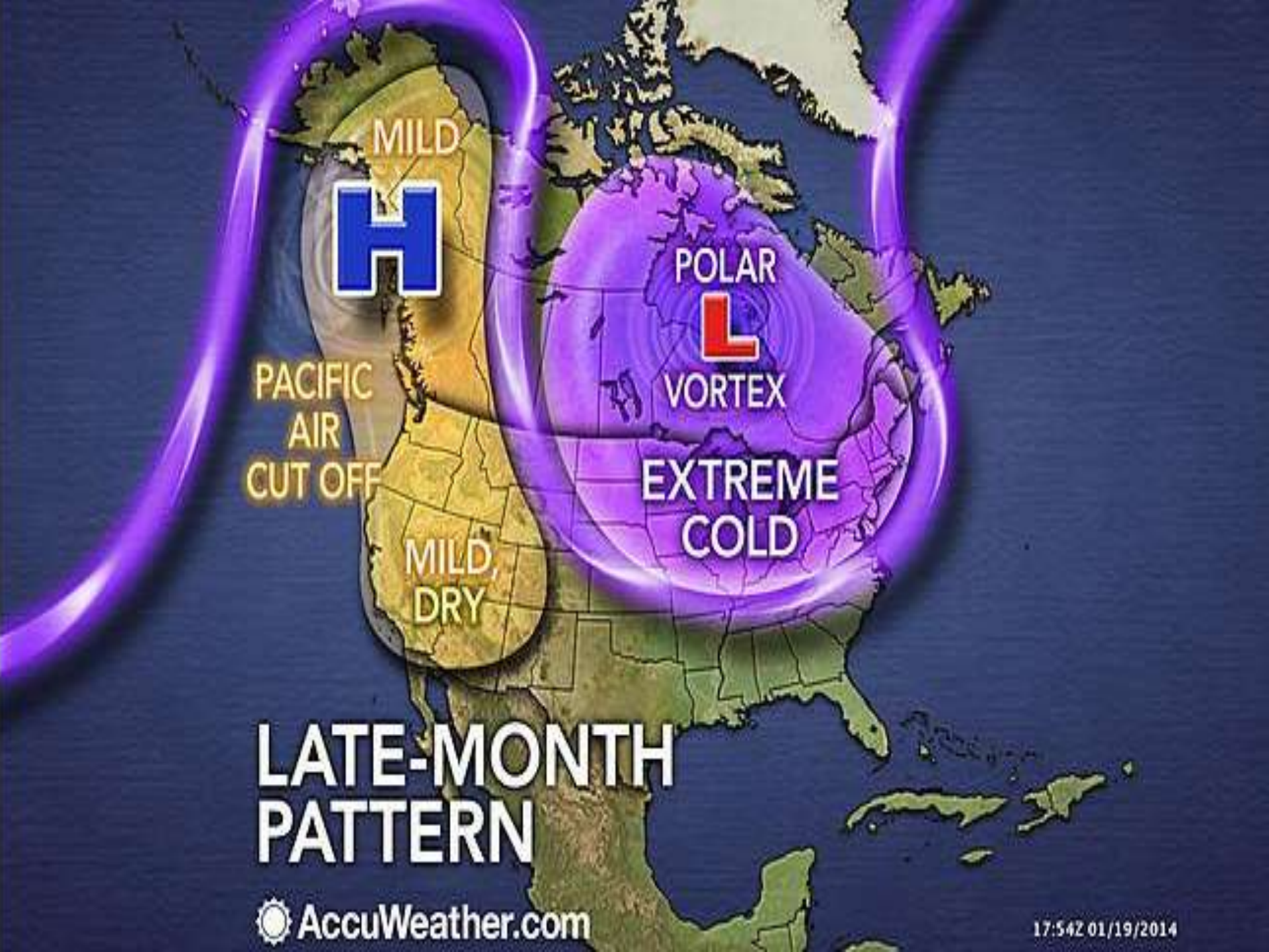

Global Mean Temperature
Difference (°C) from 1961 - 1990
Estimated actual global mean temperatures (°C)
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
14.6
14.4
14.2
14.0
13.8
13.6
13.4
13.2
1860
1880
1900
1920
1940
1960
1980
2000
Annual mean
Smoothed series
5-95% decadal error bars
IPCC 4th Report WG1
Period
Years
Rate
°C per decade
25
0.177±0.052
50
0.128±0.026
100
0.074±0.018
150
0.045±0.012

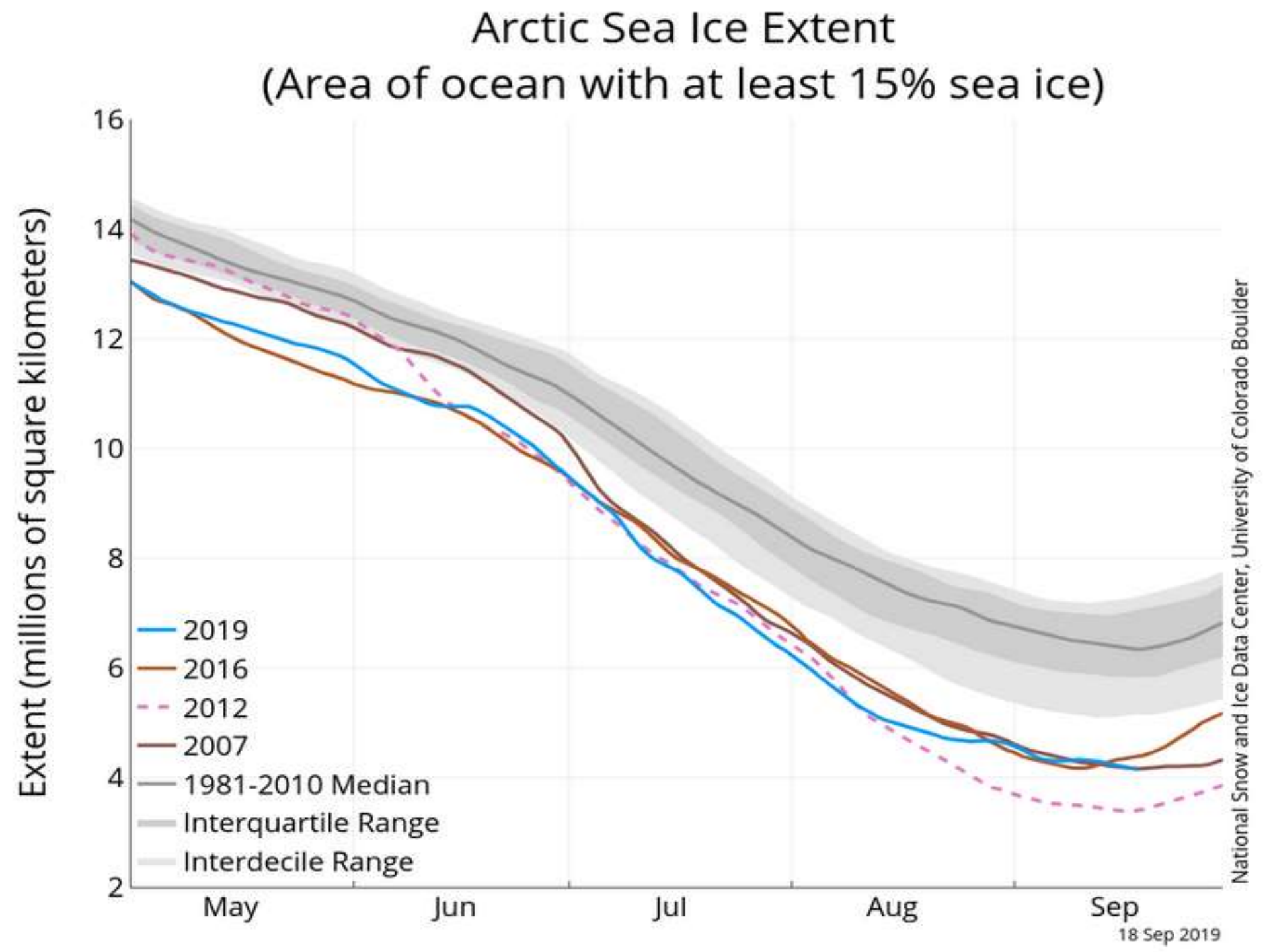

6
5
4
3
2
1
Temperature Change °C
10.8
9.0
7.2
5.4
3.6
1.8
°F
IPCC prediction
rediction
2000
2020
2040
2060
2080
2100
Year

AOGCM Projections of Surface Temperatures

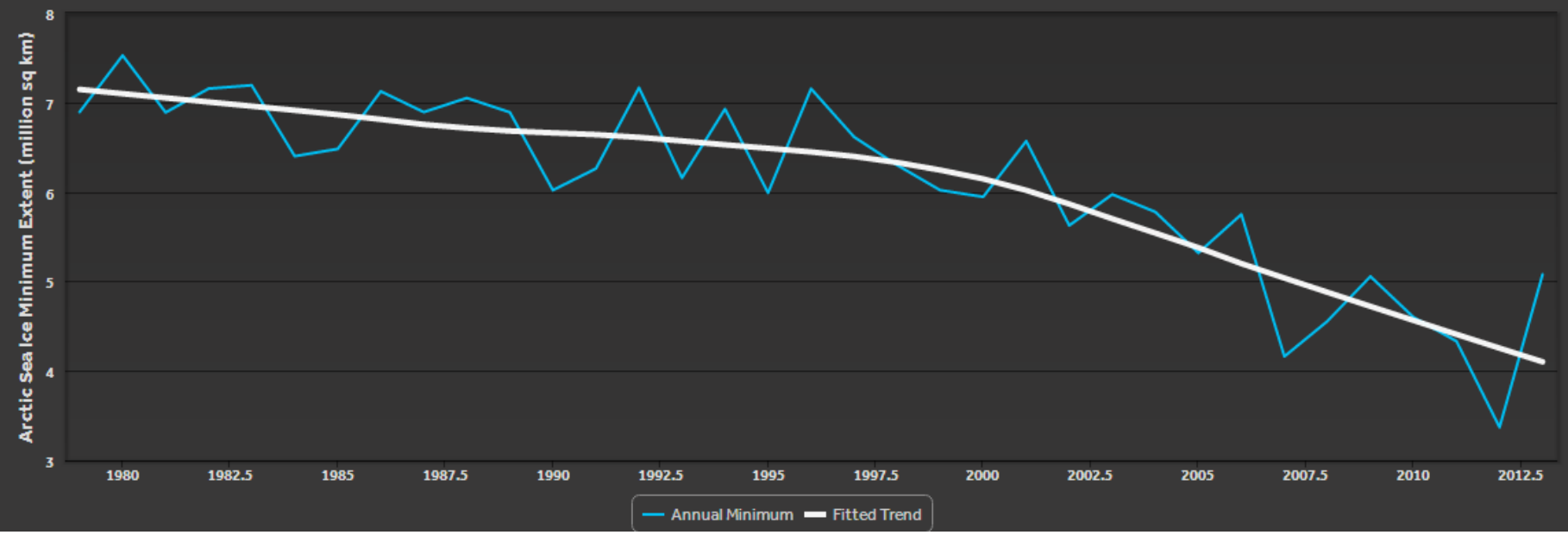



ZONAL FLOW
MOSTLY WEST TO EAST JET STREAM

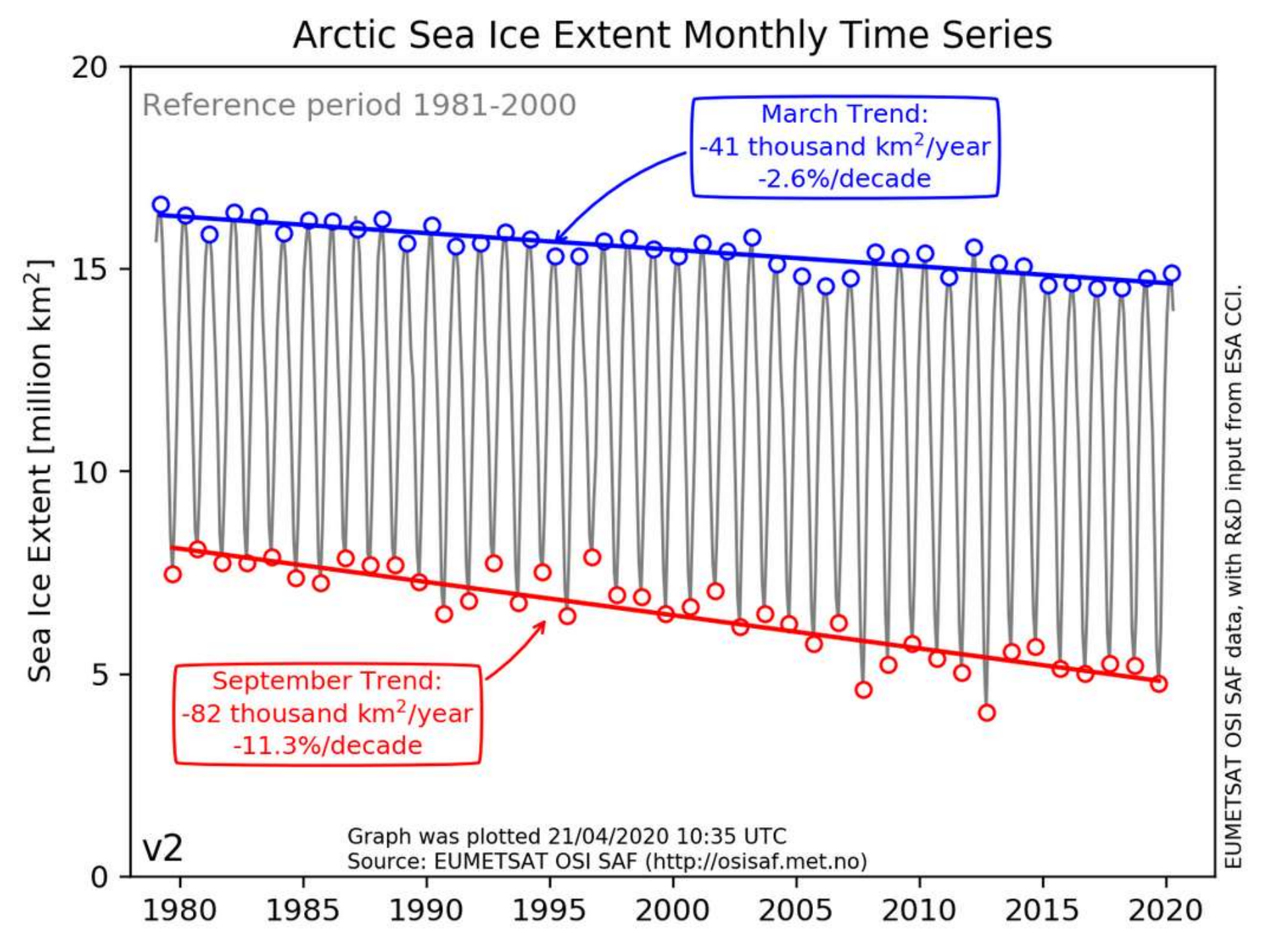

MILD
H
POLAR
L
VORTEX
PACIFIC
AIR
CUT OFF
EXTREME
COLD
MILD,
DRY
LATE-MONTH
PATTERN
AccuWeather.com
17:54Z 01/19/2014

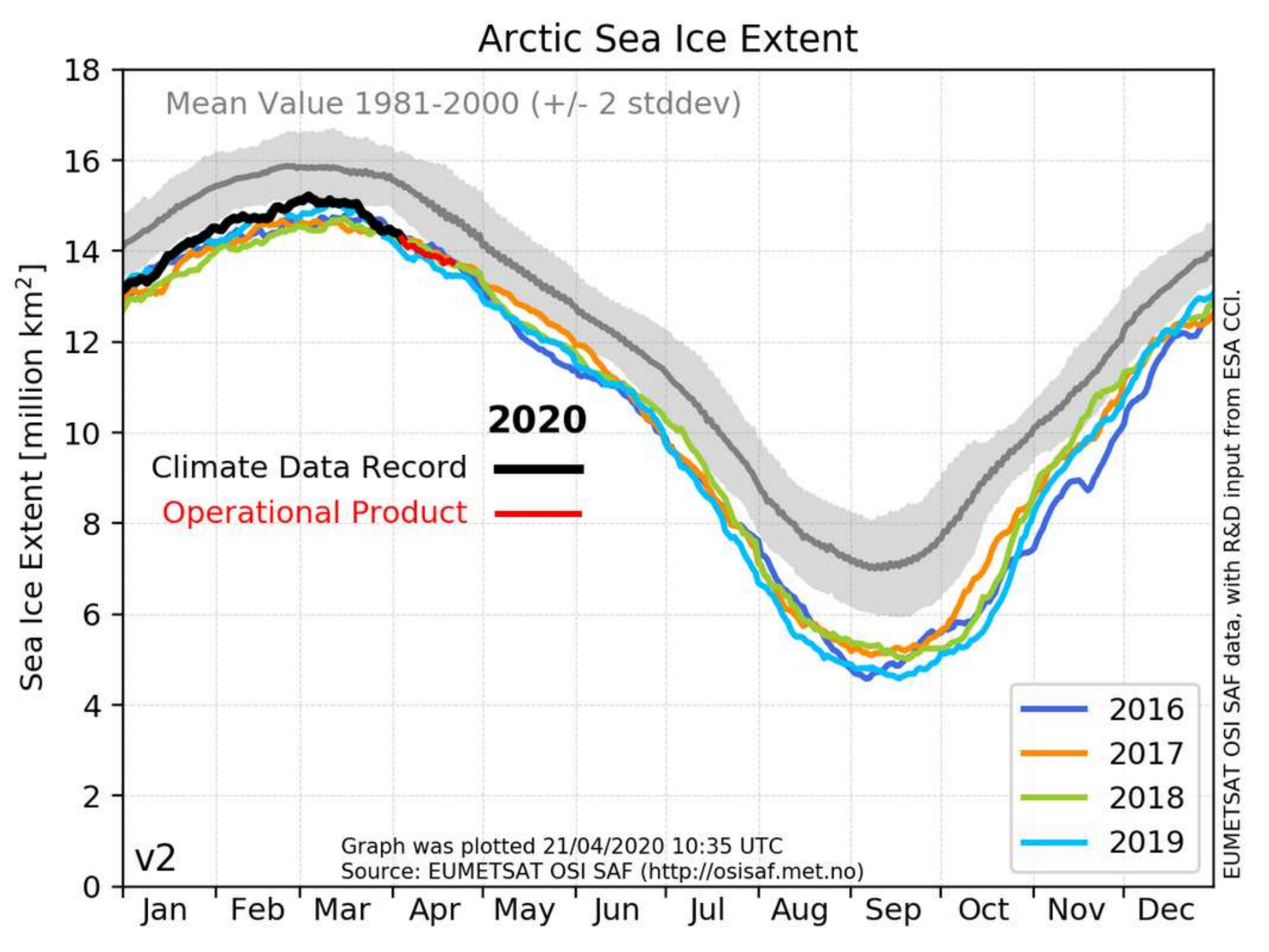

Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
Extent (millions of square kilometers)
16
14
12
10
8
6
4
2
2019
2016
2012
2007
1981-2010 Median
Interquartile Range
Interdecile Range
May
Jun
Jul
Aug
Sep
18 Sep 2019
National Snow and Ice Data Center, University of Colorado Boulder

Arctic sea ice's dramatic **decline**



Since satellite observations began in the late 1970s, Arctic sea ice has declined precipitously. The annual minimum sea ice has been declining at a rate of 13.3 percent per decade since 1979. About 1 million square miles of ice have disappeared, or roughly a patch of ice four times the size of Texas. In 2012, Arctic sea ice reached its lowest extent in satellite record, and its seven lowest levels occurred in the past seven years. And extent isn't the only thing changing: Arctic sea ice is getting younger and more brittle, making it easier for waves and warmer waters to break it up.


Arctic Sea Ice Extent Monthly Time Series
Reference period 1981-2000
March Trend:
-41 thousand km²/year
-2.6%/decade
September Trend:
-82 thousand km²/year
-11.3%/decade
Sea Ice Extent [million km²]
20
15
10
5
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
v2
Graph was plotted 21/04/2020 10:35 UTC
Source: EUMETSAT OSI SAF (http://osisaf.met.no)
EUMETSAT OSI SAF data, with R&D input from ESA CCI.


Arctic Sea Ice Extent
Mean Value 1981-2000 (+/- 2 stddev)
Sea Ice Extent [million km^2]
18
16
14
12
10
8
6
4
2
0
2020
Climate Data Record
Operational Product
2016
2017
2018
2019
v2
Graph was plotted 21/04/2020 10:35 UTC
Source: EUMETSAT OSI SAF (http://osisaf.met.no)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
EUMETSAT OSI SAF data, with R&D input from ESA CCI.

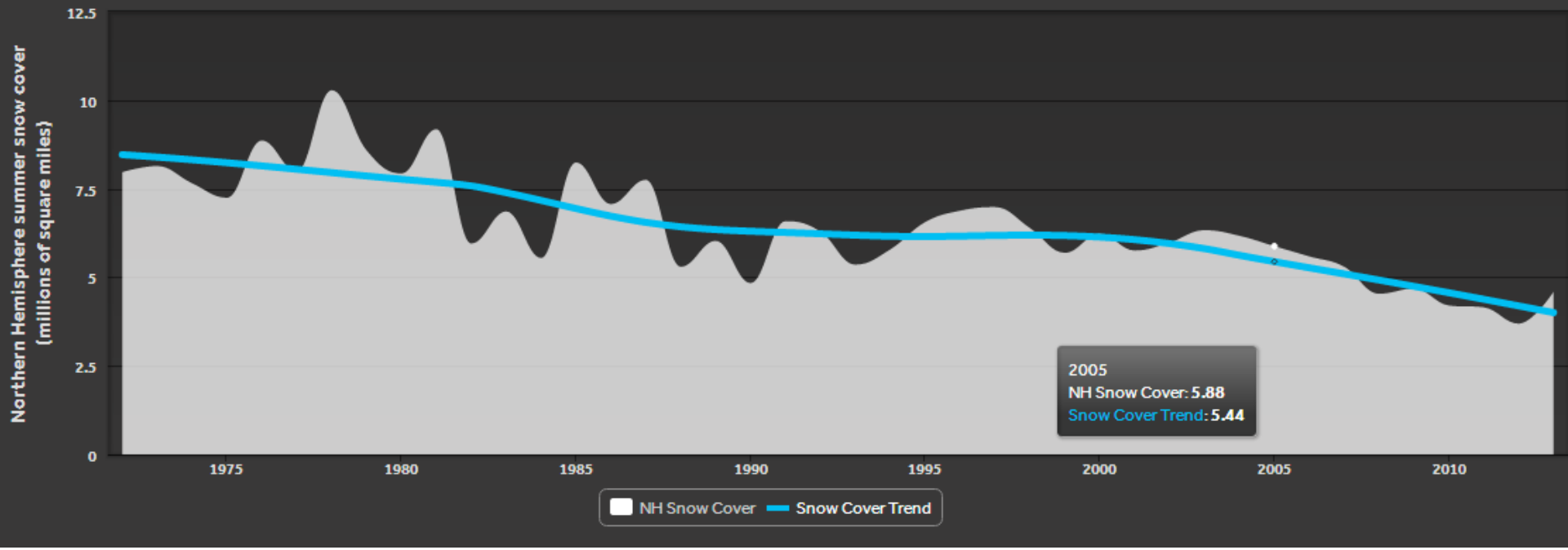
A KEY SPECIAL PROPERTY OF ICE IS ITS EXTRAORDINARY HIGH LATENT HEAT OF FUSION, 80 KILOCALORIES PER KILOGRAM.

LATENT HEAT IS THE AMOUNT OF HEAT THAT YOU HAVE TO SUPPLY TO MELT A KILOGRAM OF ICE WHEN IT IS ALREADY AT ITS MELTING POINT, AS OPPOSED TO SPECIFIC HEAT, WHICH IS THE HEAT NEEDED TO RAISE THE TEMPERATURE OF A SUBSTANCE BY 1 DEGREE C.

THE SPECIFIC HEAT FOR WATER IS 1 KILOCALORIE PER KILOGRAM.

SO, IF YOU PUT 2 SAUCEPANS TOGETHER ON A STOVE WITH EQUAL HEAT, ONE CONTAINING A KILOGRAM OF ICE AT ITS MELTING POINT AND THE OTHER CONTAINING A KILOGRAM OF WATER AT 20 DEGREES C (68 DEGREES F), THE WATER IN THE PAN AT 20 DEGREES C WILL START TO BOIL AT THE SAME TIME THE LAST OF THE ICE IS MELTED FROM THE ICE PAN.

Northern Hemisphere snow cover is **decreasing**

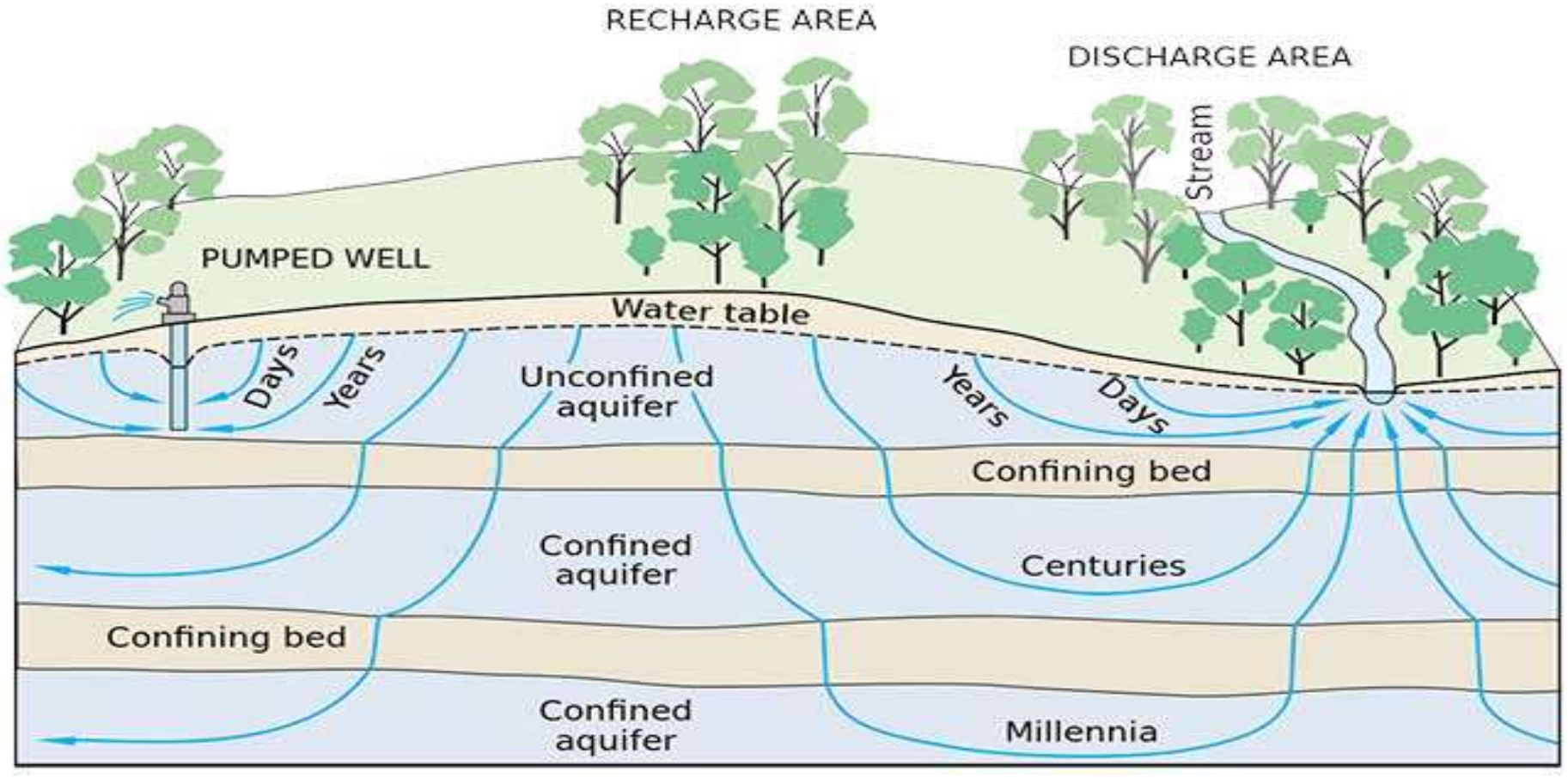


Spring snow cover is also on the decline and this reduced snow cover is consistent with rising temperatures driving increased snowmelt.

Like ice, snow has a high reflectivity, so a shorter snow season increases the amount of sunlight absorbed by the Earth's surface. The earlier spring snowmelt thus exhibits a feedback relationship with rising temperatures, driving further temperature increases. Snowmelt also affects water supplies, and decreasing snowpack may decrease water supplies in areas around the world that rely on spring runoff. Although fall and winter snow cover has remained fairly consistent over the past 40 years, spring and summer snow cover is typically more important in influencing water supplies.

Boulder Glacier in Nth America retreated 450m between 1987 -2005

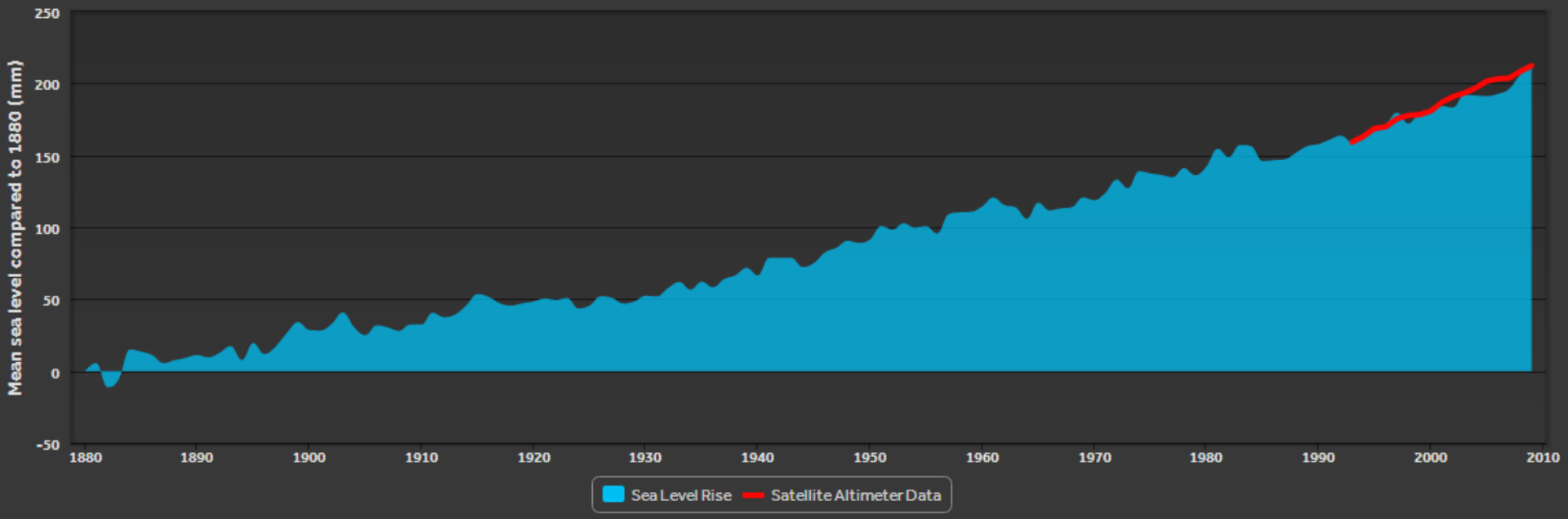
IN CALIFORNIA, CENTRAL VALLEY FARMERS WHO GREW UP WITH 200-FOOT WELLS ARE FINDING NOW THAT 1,000-FOOT WELLS AREN'T DEEP ENOUGH TO HIT THE RETREATING WATER TABLE. DRILLING CREWS HAVE MONTHS-LONG WAITING LISTS FROM DESPERATE FARMERS LOOKING AT PRODUCTIVE FIELDS THAT WILL TURN TO DUST WITHOUT IRRIGATION.



SOME FOODS AND THE PERCENTAGE CONSUMED BY AMERICANS THAT IS GROWN IN CALIFORNIA (OR RATHER WERE, THESE NUMBERS ARE FROM 2007):

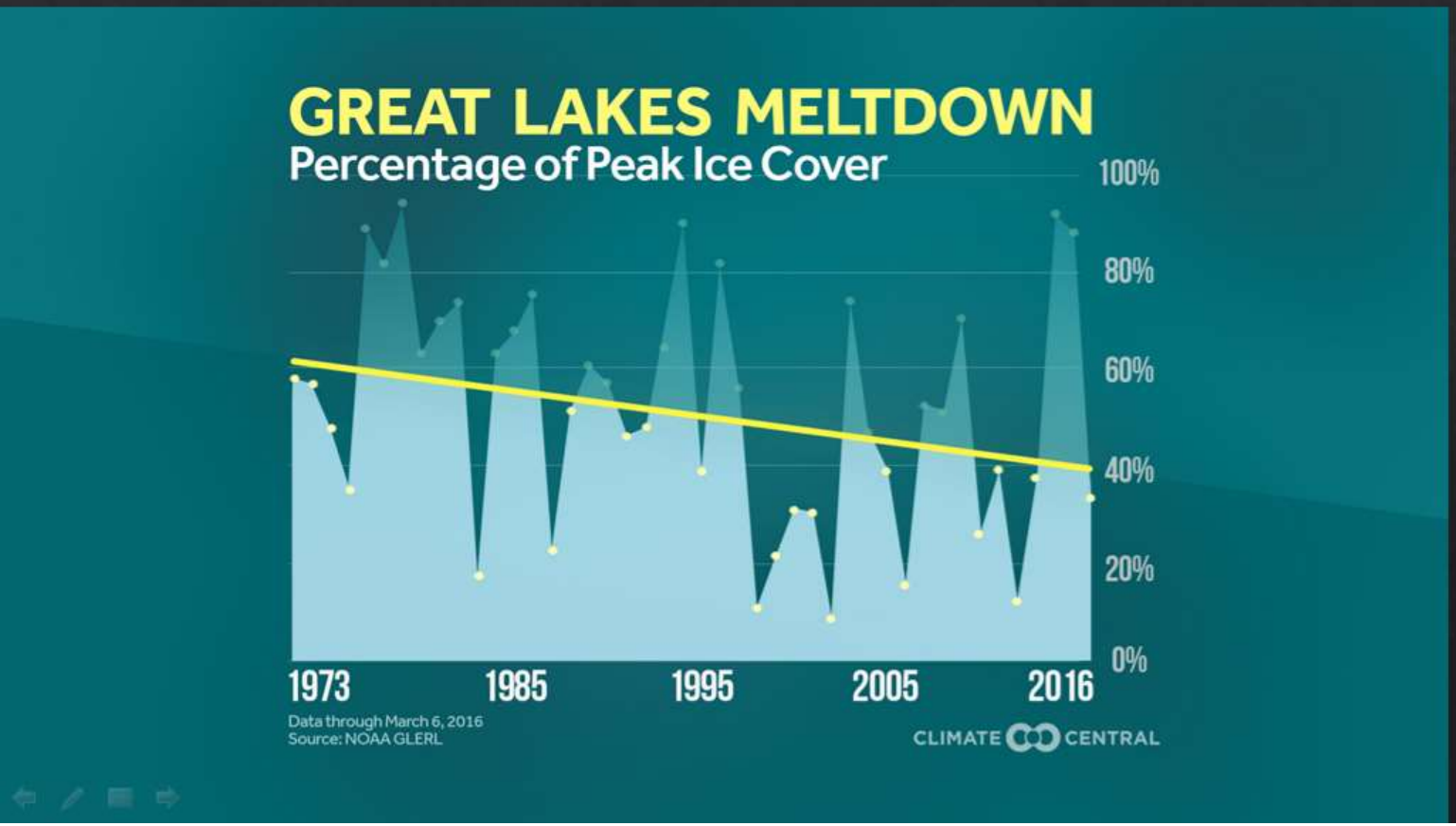
POMEGRANATES- 100 PERCENT
ARTICHOKES- 99 PERCENT
KIWI- 97 PERCENT
OLIVES- 96 PERCENT
PLUMES AND PRUNES- 94 PERCENT
AVOCADOS- 90 PERCENT
NECTARINES- 89 PERCENT
GARLIC- 85 PERCENT
GRAPES- 82 PERCENT
LEMONS- 79 PERCENT
TOMATOES- 76 PERCENT
STRAWBERRIES- 59 PERCENT

Global sea level is **rising**



Water expands as it warms and this thermal expansion causes water levels to rise. Hotter temperatures are also melting land ice, like glaciers and polar ice caps, which adds more water to the ocean. Satellite and tide gauge measurements have shown an absolute sea level increase of 1.7 mm per year from 1880 to 2011 across the world's oceans, a rate that increased to 2.7 to 3.2 mm per year from 1993 to 2011. In the U.S. alone, nearly 30,000 square miles of land – home to 12.3 million people today – lies less than 10 feet under the high-tide line, including more than half the area of 40 large U.S. cities. Roughly one third of the U.S. population lives on low-lying land that is vulnerable to consequences of varying severity, from permanent inundation to saltwater intrusion into freshwater sources. Unless adaptation measures are taken, sea level rise could cost the globe $1 trillion annually by 2050.

Indicators: Great Lakes Ice Is Declining



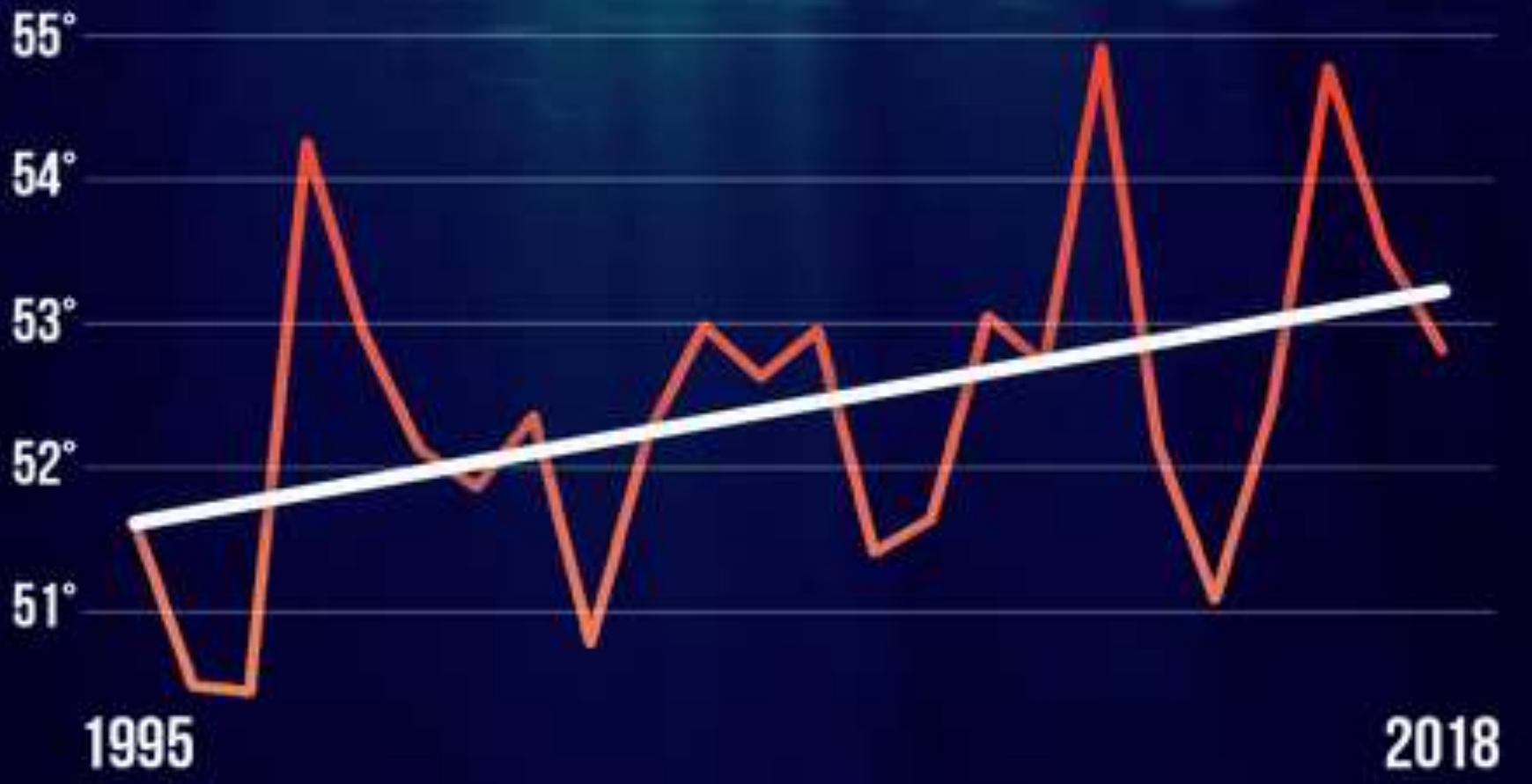
- Annual maximum in ice coverage on the Great Lakes is decreasing
- Supports longer lake-effect snow season

Snow amounts in Buffalo should be the same until 2050 then decline due to warming temperatures.

Ski resorts are projected to be out of business by 2039 as warmer temperatures make resorts unprofitable.

GREAT LAKES WARMING

LAKE ERIE



Average annual surface water temperature since 1995 (°F)
Source: NOAA's Great Lakes Environmental Research Laboratory

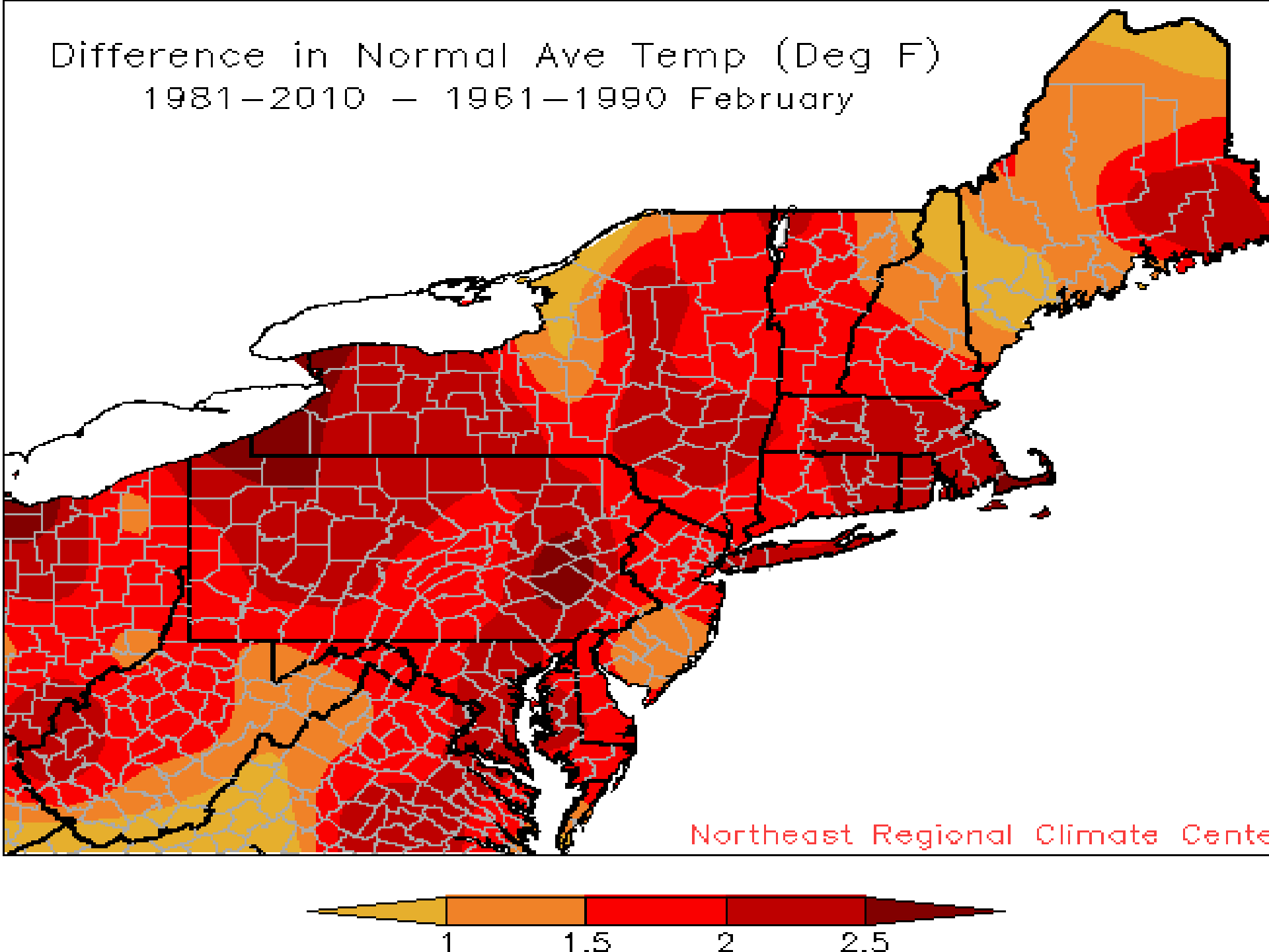
CLIMATE CENTRAL

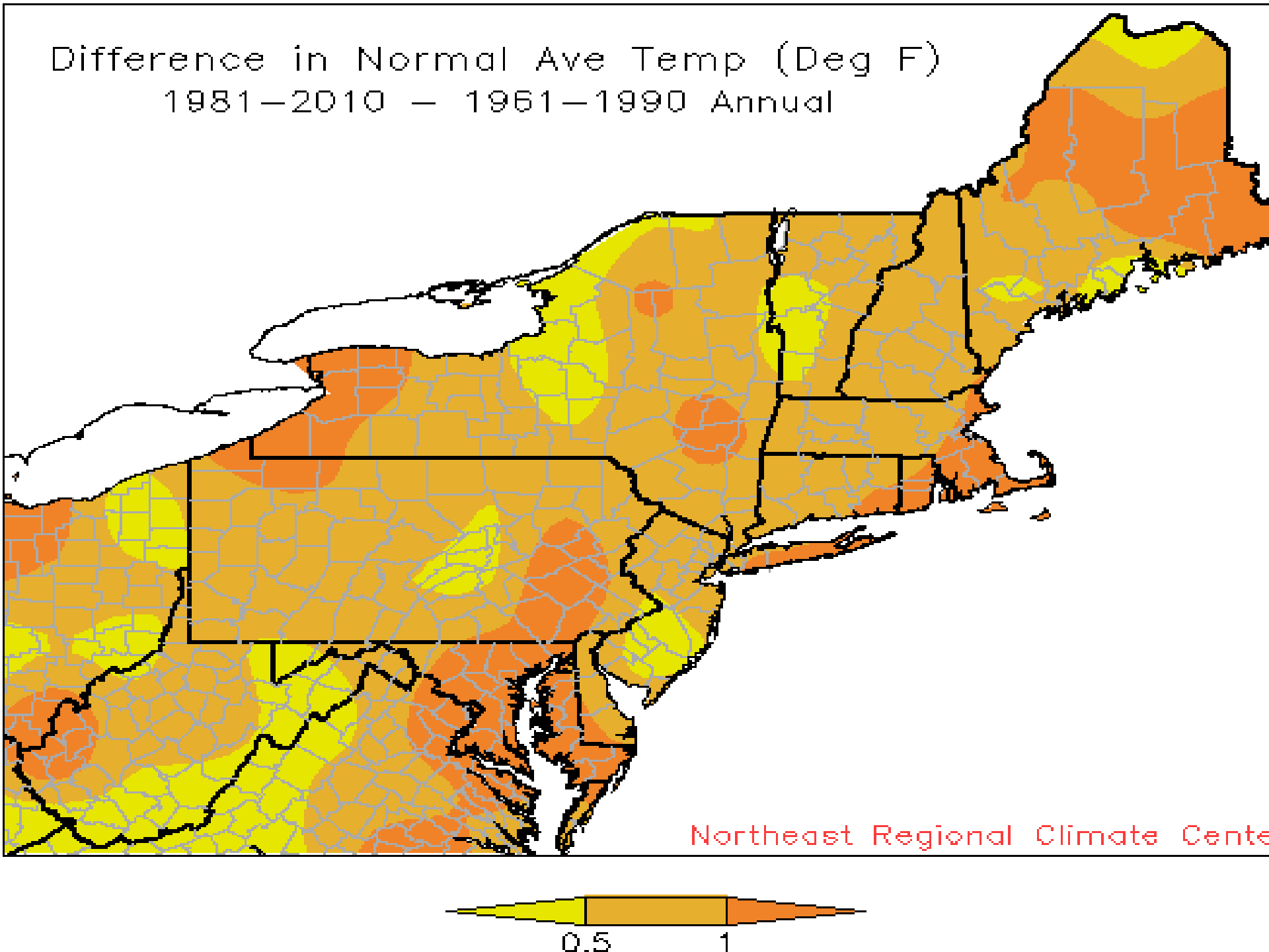
UNITED STATES

RECORDS SET BY DECADE

Maximum daily temperate & minimum daily temperature for POR through 2018.
Produced 8/30/2019
Source: Guy Walton & NOAA/NCEI

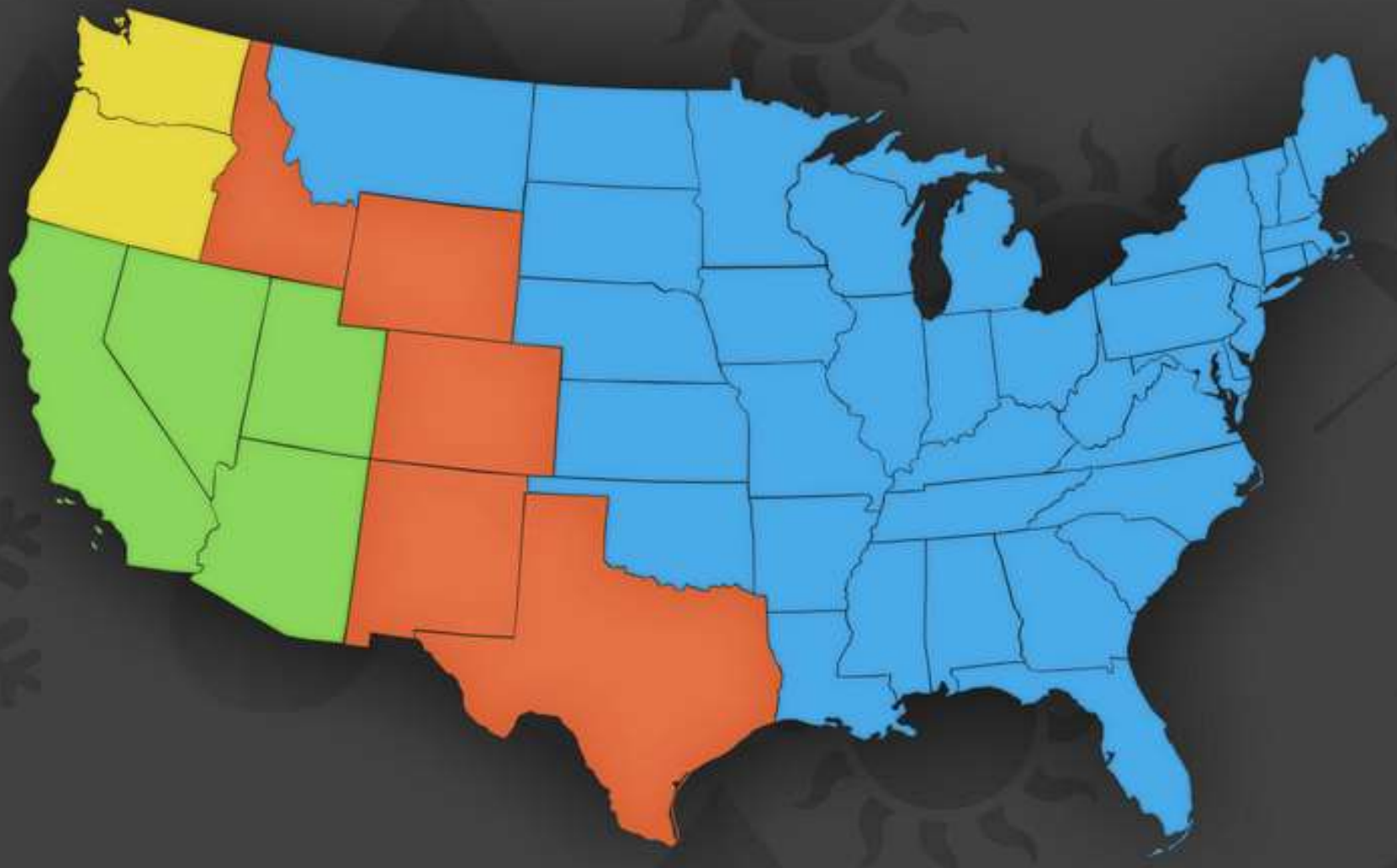
CLIMATE CENTRAL


Difference in Normal Ave Temp (Deg F)
1981-2010 - 1961-1990 February
Northeast Regional Climate Cente
1
1.5
2
2.5


Difference in Normal Ave Temp (Deg F)
1981–2010 – 1961–1990 Annual
Northeast Regional Climate Cente
0.5
1

FASTEST WARMING SEASONS

WINTER SPRING SUMMER FALL



Linear seasonal trends fitted to 1970-2017 data
Source: NOAA/NCEI Climate at a Glance

CLIMATE CENTRAL

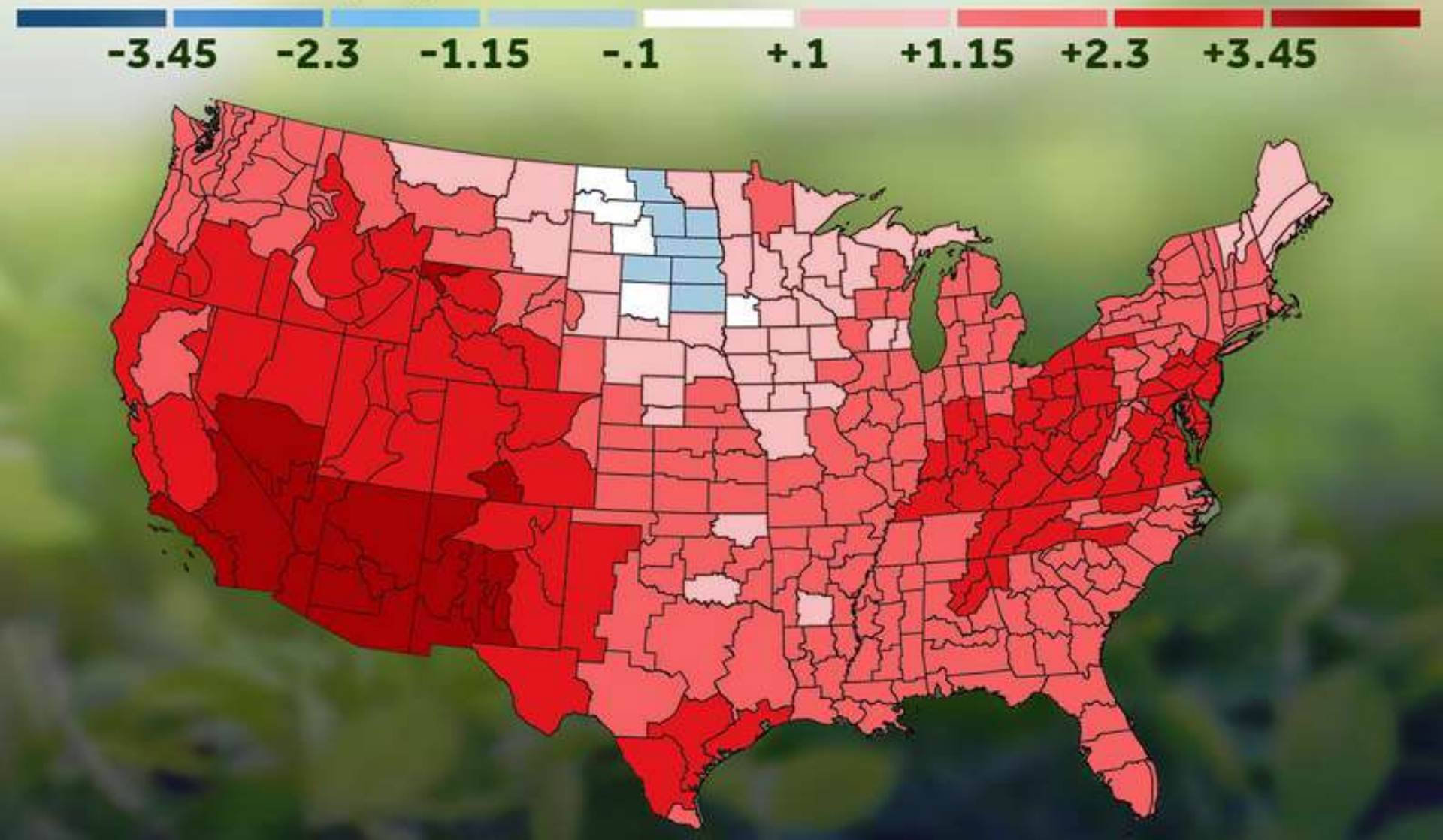
SEASONAL WARMING

Linear seasonal trends fitted to 1970-2017 data
Source: NOAA/NCEI Climate at a Glance

CLIMATE CENTRAL

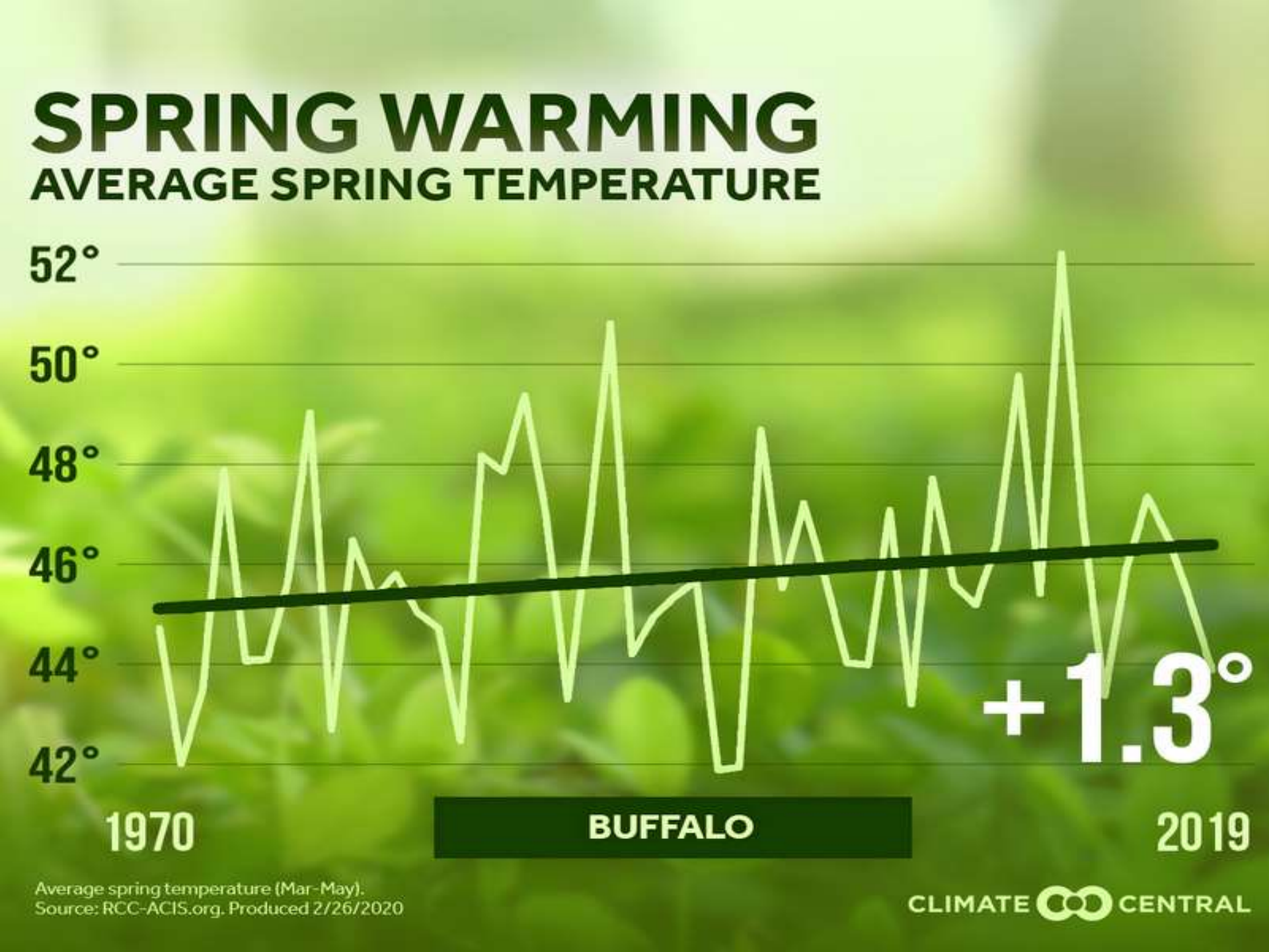
SPRING WARMING

SINCE 1970 (°F)



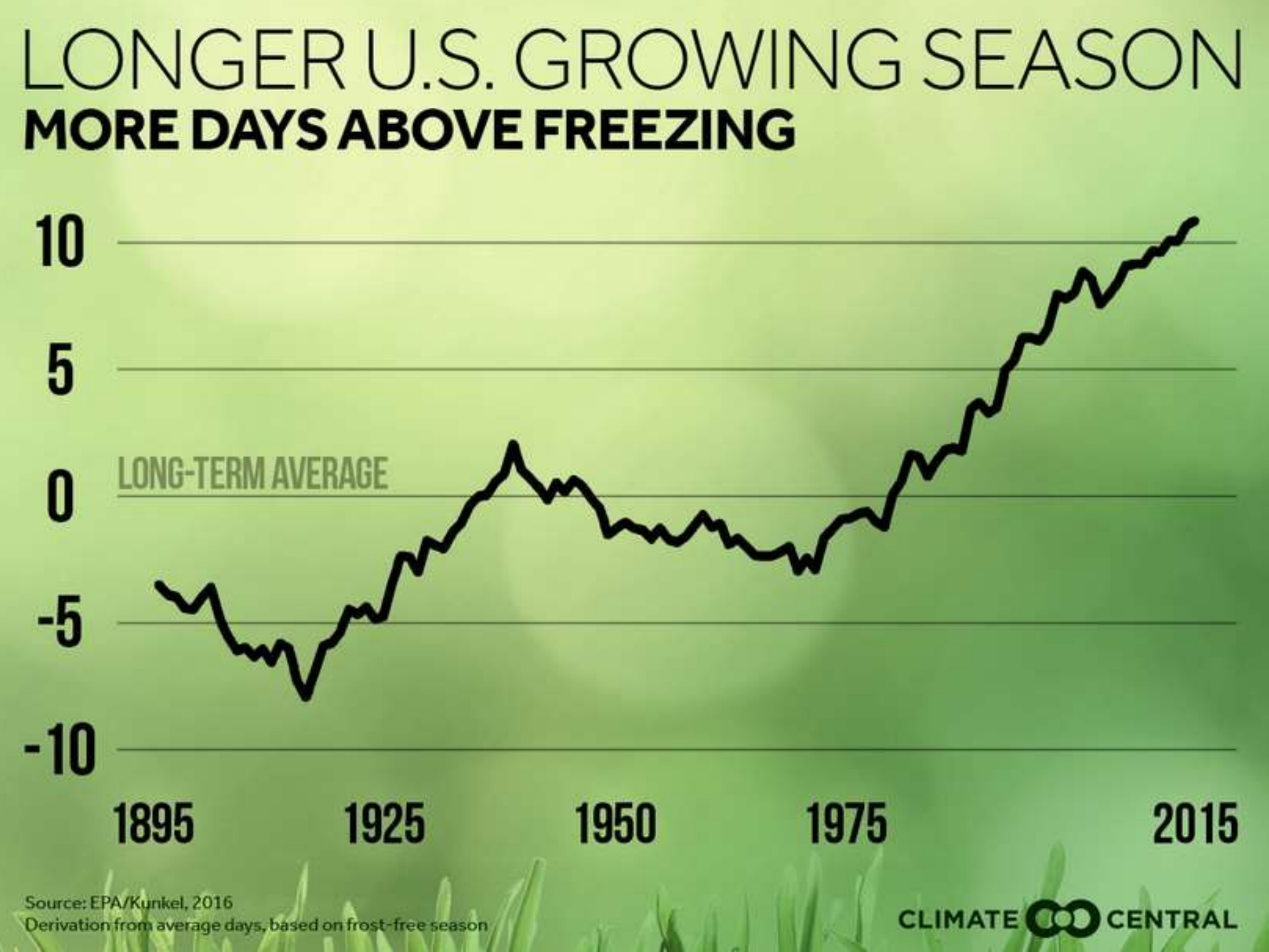
Source: NOAA/NCEI Climate at a Glance. Average spring temperature (Mar-May).

CLIMATE CENTRAL


SPRING WARMING
AVERAGE SPRING TEMPERATURE
52°
50°
48°
46°
44°
42°
+1.3°
1970
BUFFALO
2019
Average spring temperature (Mar-May).
Source: RCC-ACIS.org. Produced 2/26/2020
CLIMATE CENTRAL

LONGER U.S. GROWING SEASON

MORE DAYS ABOVE FREEZING



Source: EPA/Kunkel, 2016
Derivation from average days, based on frost-free season

CLIMATE CENTRAL

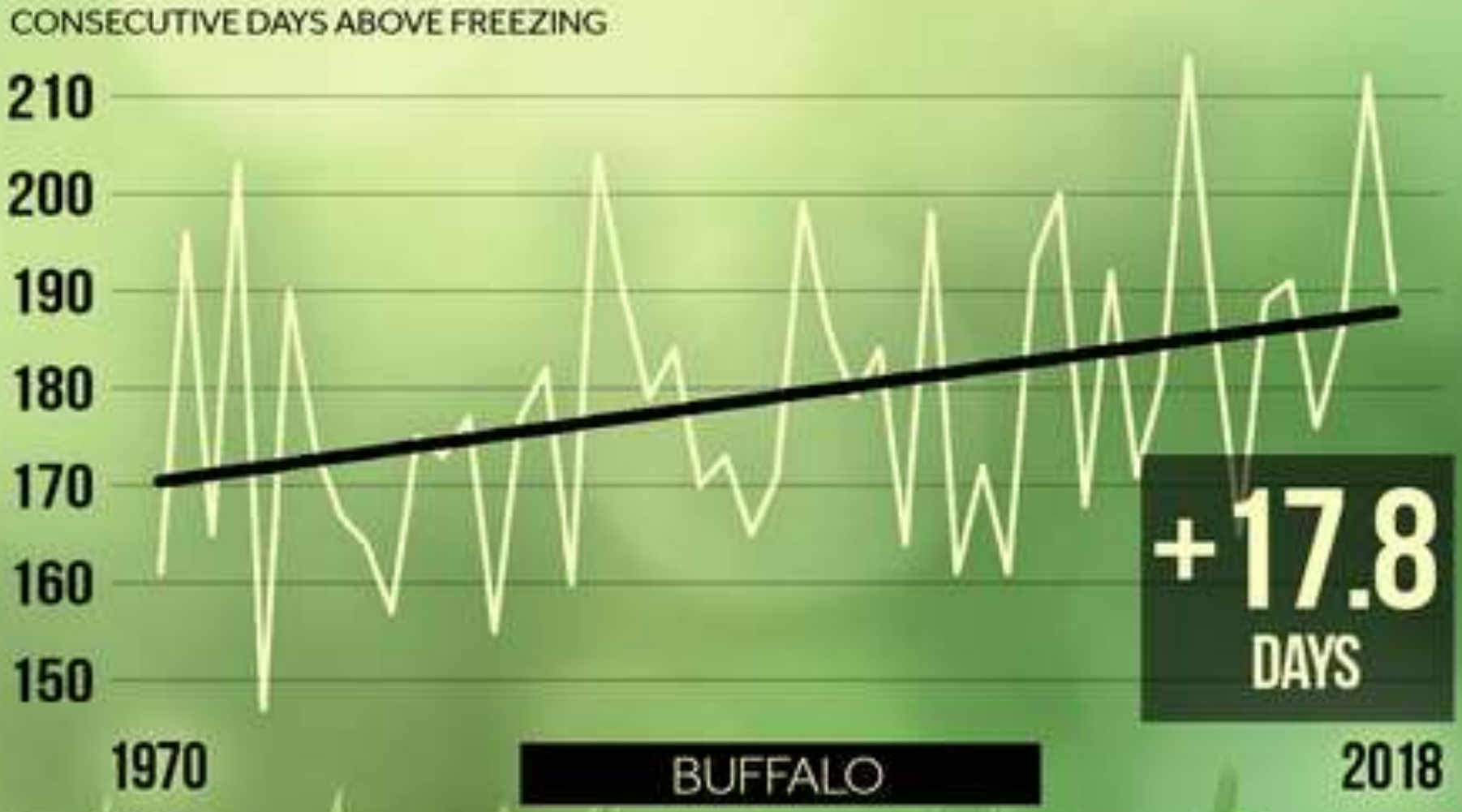
LAST FREEZE COMING EARLIER

DATE OF LAST FREEZE

Source: RCC-ACIS.org. Produced 2/26/2020

CLIMATE CENTRAL

LONGER GROWING SEASON = LONGER ALLERGY SEASON



Source: RCC-ACIS.org
Days between the annual last and first occurrence of 32°F. Produced 5/21/2019.

CLIMATE CENTRAL

U.S. SUMMERS ARE GETTING HOTTER

U.S. TEMPERATURE TREND

Average temperature June - August
Source: NOAA/NCEI Climate at a Glance

CLIMATE CENTRAL

SUMMERS ARE GETTING HOTTER

BUFFALO

Average temperature June - August

Source: NOAA NCEI

CLIMATE CENTRAL

FALL WARMING

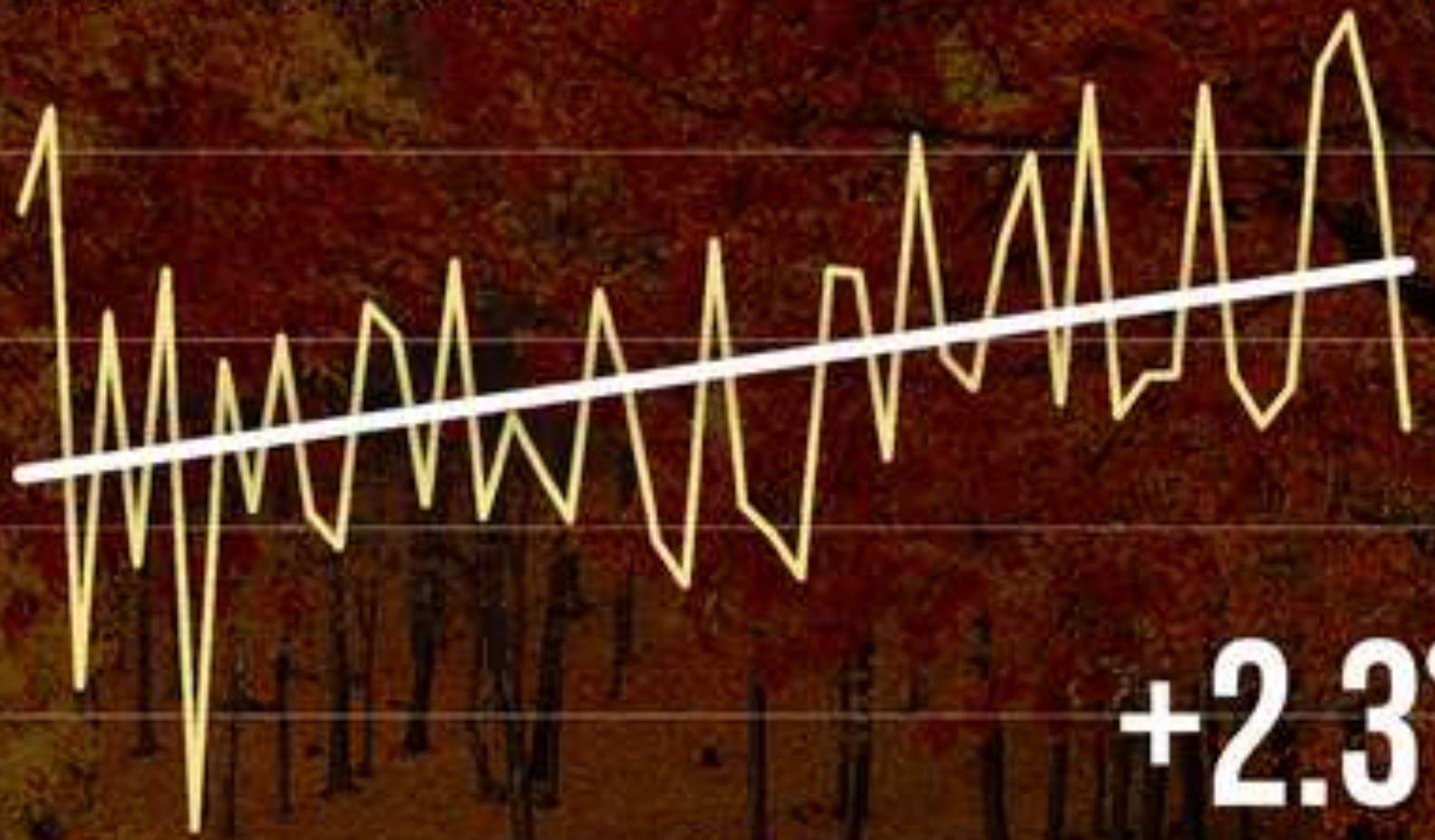
AVERAGE TEMPERATURE

Average temperature September-November. Produced 9/4/2019
Source: RCC-ACIS.org

CLIMATE CENTRAL

FALL WARMING

AVERAGE TEMPERATURE

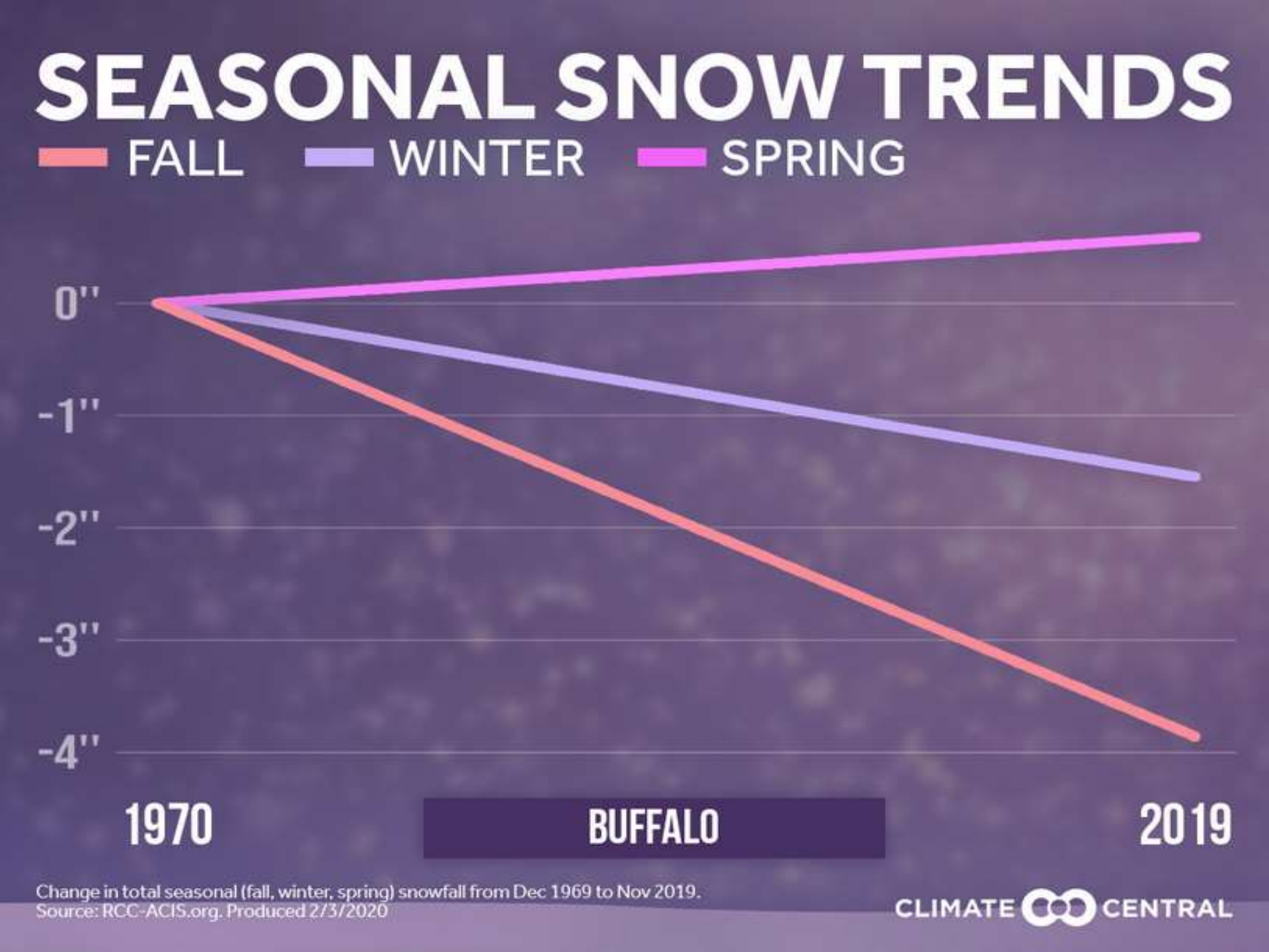


BUFFALO

Average temperature September-November. Produced 9/4/2019
Source: RCC-ACIS.org

CLIMATE CENTRAL

SEASONAL SNOW TRENDS



Change in total seasonal (fall, winter, spring) snowfall from Dec 1969 to Nov 2019.
Source: RCC-ACIS.org. Produced 2/3/2020

CLIMATE CENTRAL

WINTER LOSING ITS CHILL

CHANGE IN LONGEST WINTER COLD SNAP (DAYS)

-8 -4 0 +4 +8

Change in average number of days in the longest annual streak of consecutive winter days below normal (1970-2019). Normal based on NCEI 1981-2010. Source: RCC-ACIS.org

CLIMATE CENTRAL

SHORTER COLD SNAPS

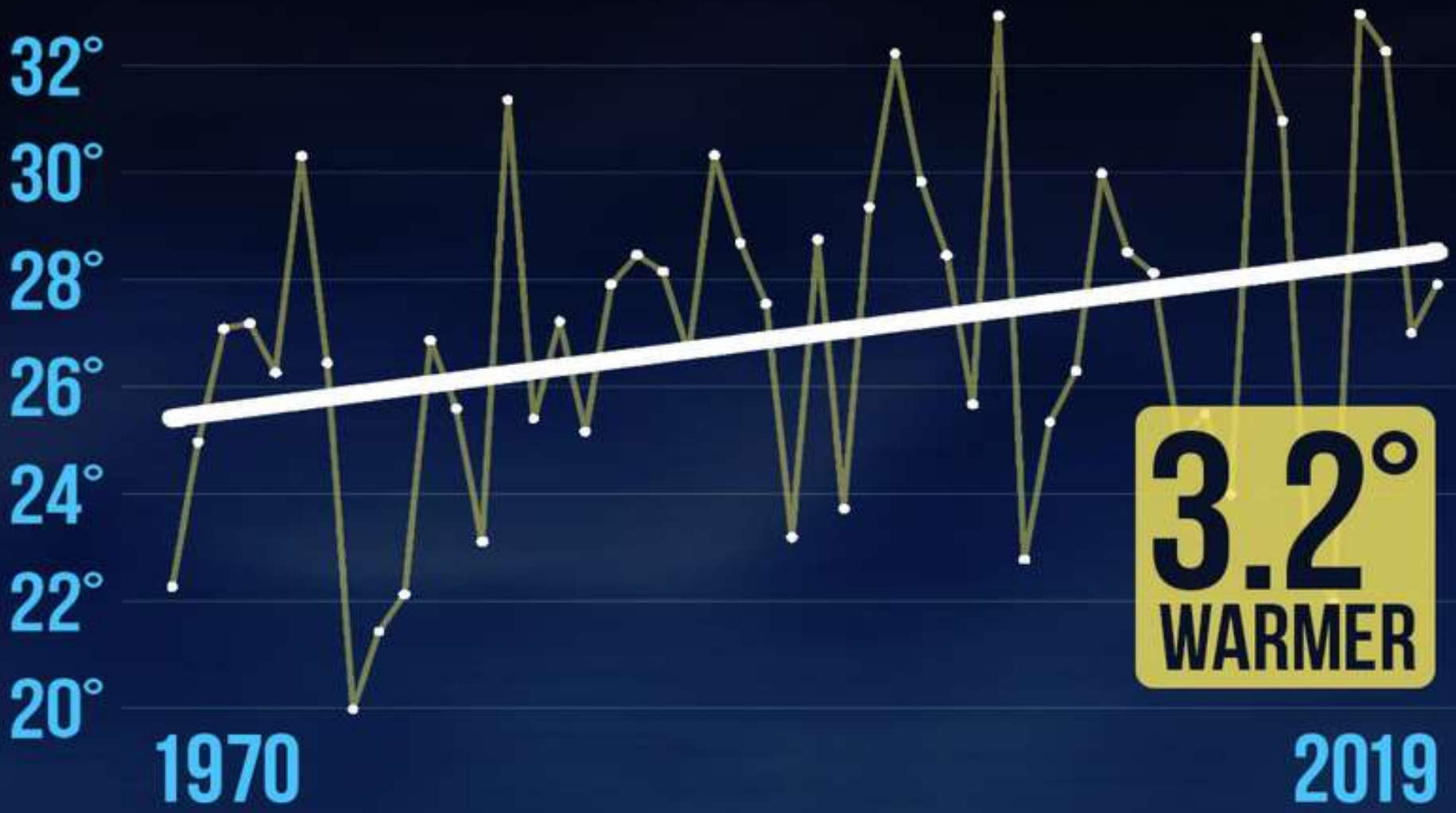
CONSECUTIVE WINTER DAYS BELOW NORMAL

Most consecutive days that Dec-Feb average daily temperature is below NCEI 1981-2010 normal
Source: RCC-ACIS.org. Produced 1/22/2020

CLIMATE CENTRAL

WINTER WARMING

Buffalo

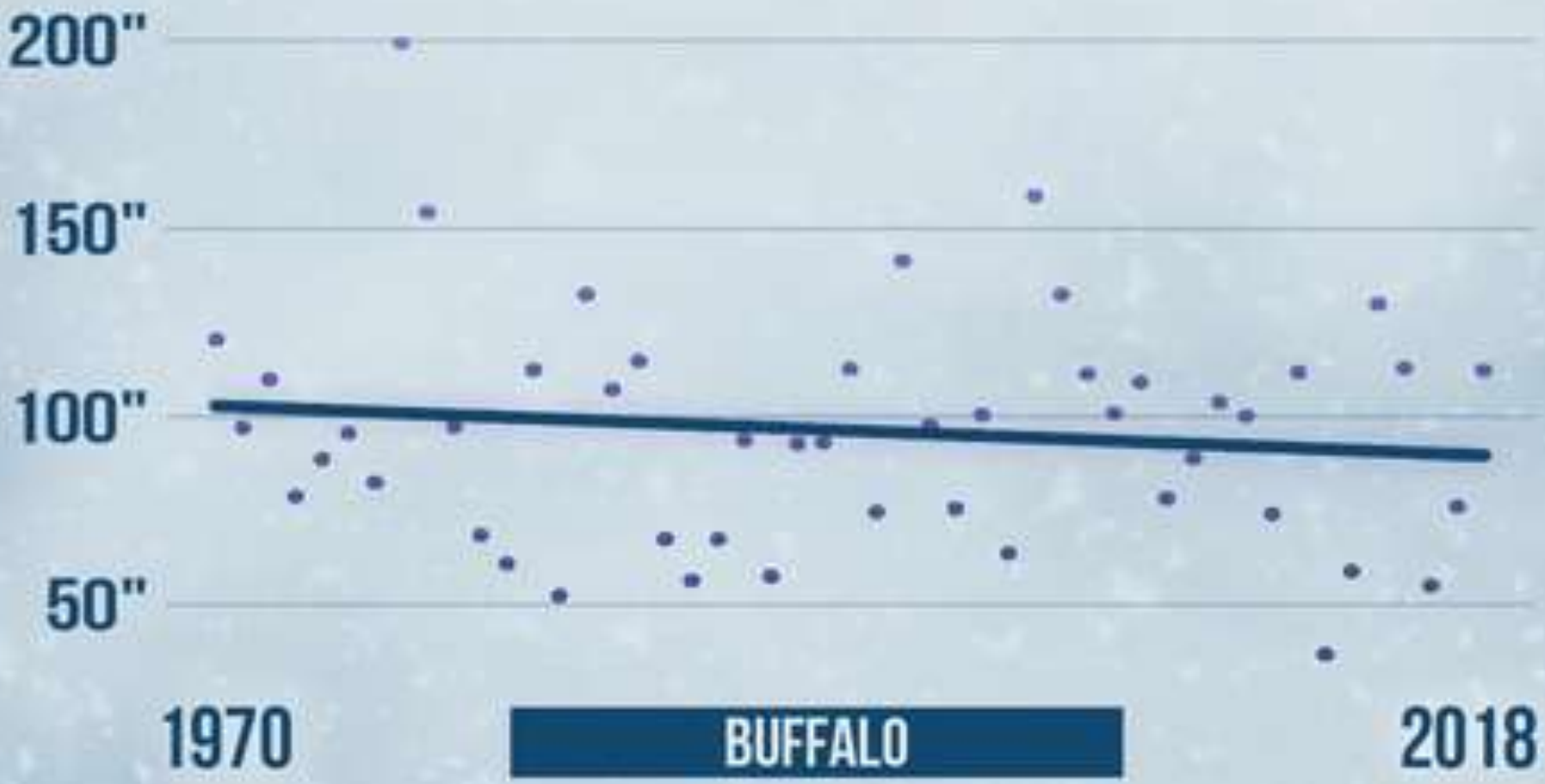


Source: RCC-ACIS.org. Average winter temperature (Dec-Feb). Produced 11/26/2019

CLIMATE CENTRAL

SNOWFALL

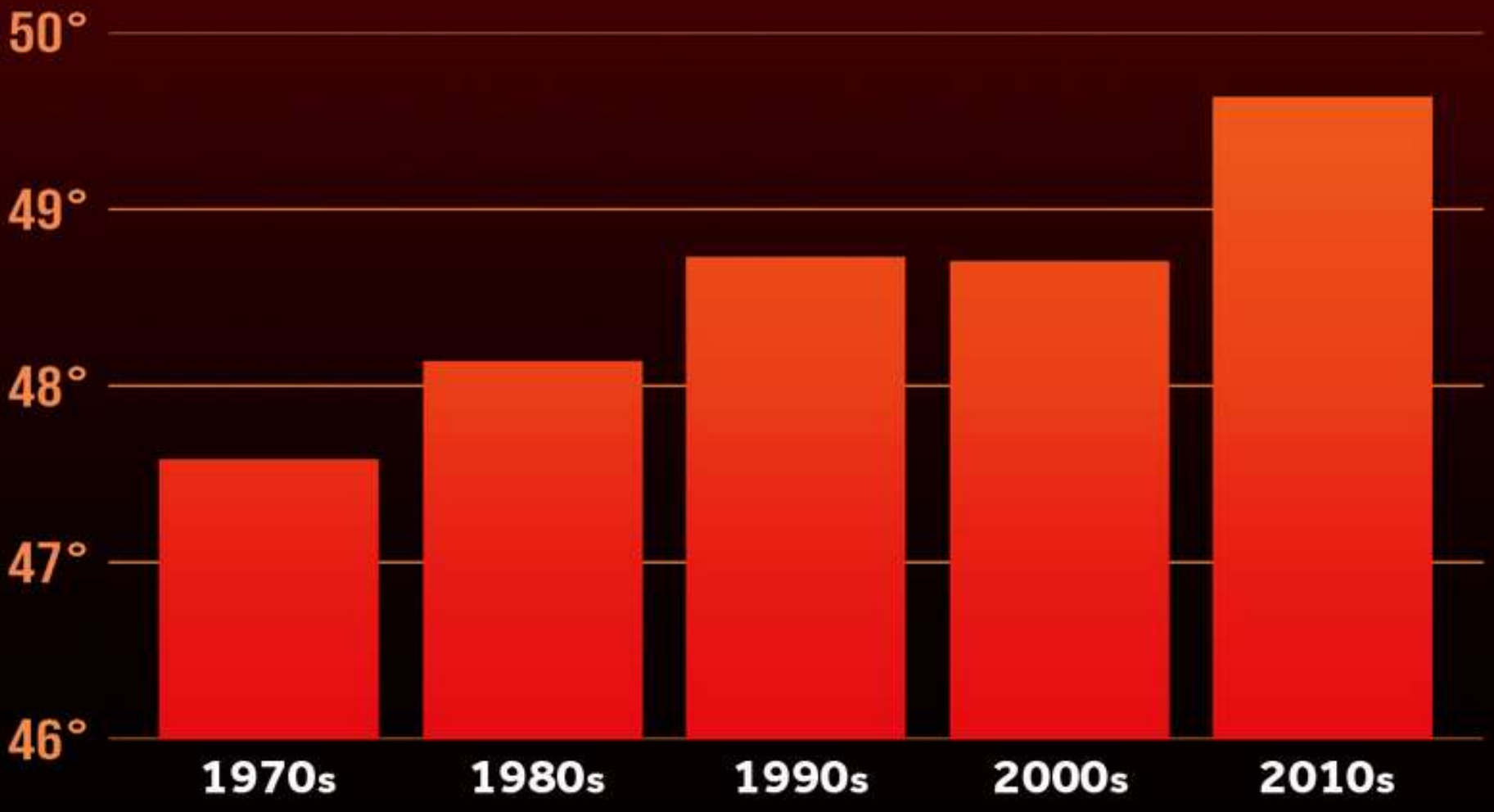
YEARLY SNOW TOTALS



July-June totals
Source: RCC-ACIS.org

CLIMATE CENTRAL

BUFFALO
DECADES OF WARMING

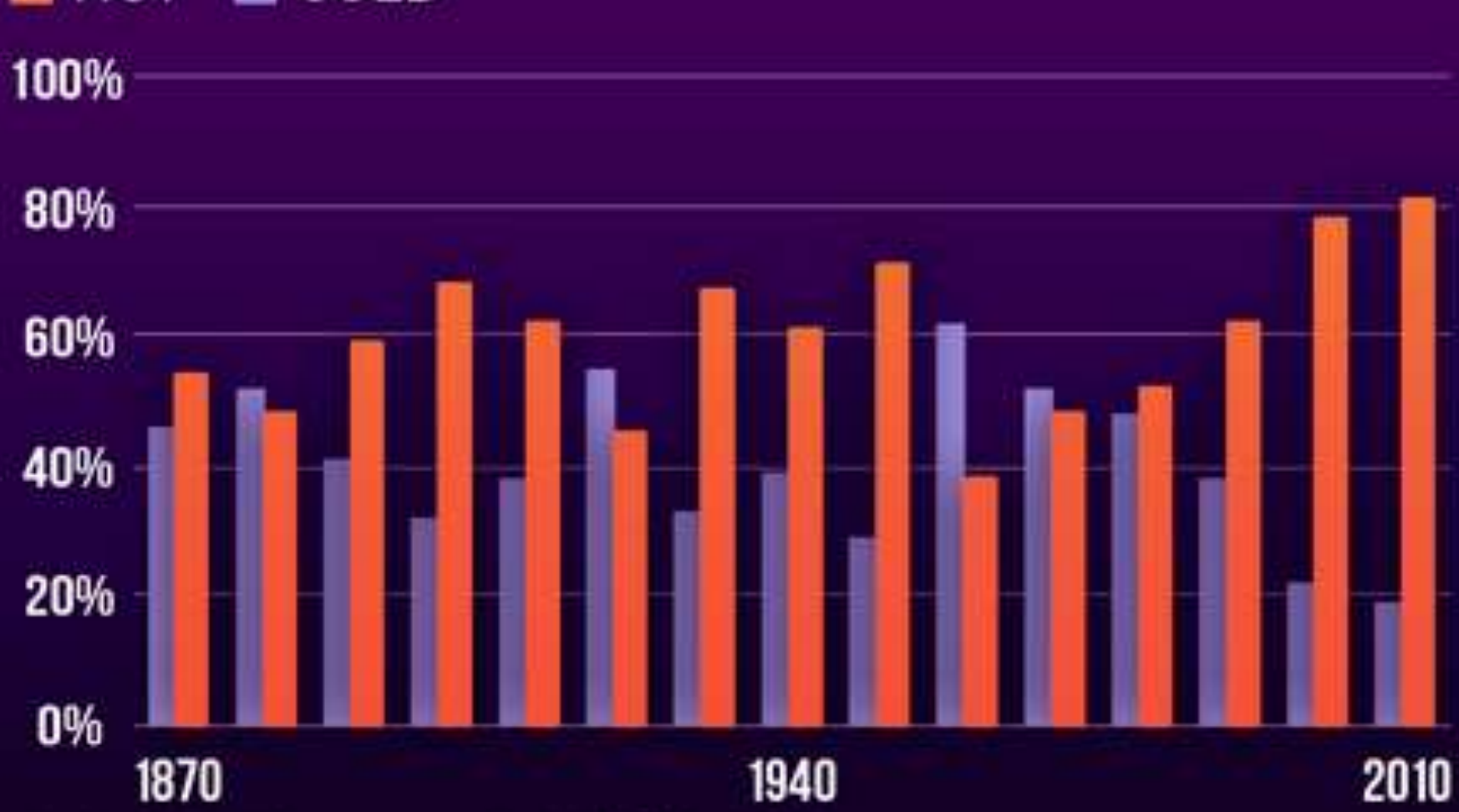


Average decadal temperature (°F). Data through 12/1/2019.
Source: RCC-ACIS.org

CLIMATE CENTRAL

BUFFALO

RECORDS SET BY DECADE

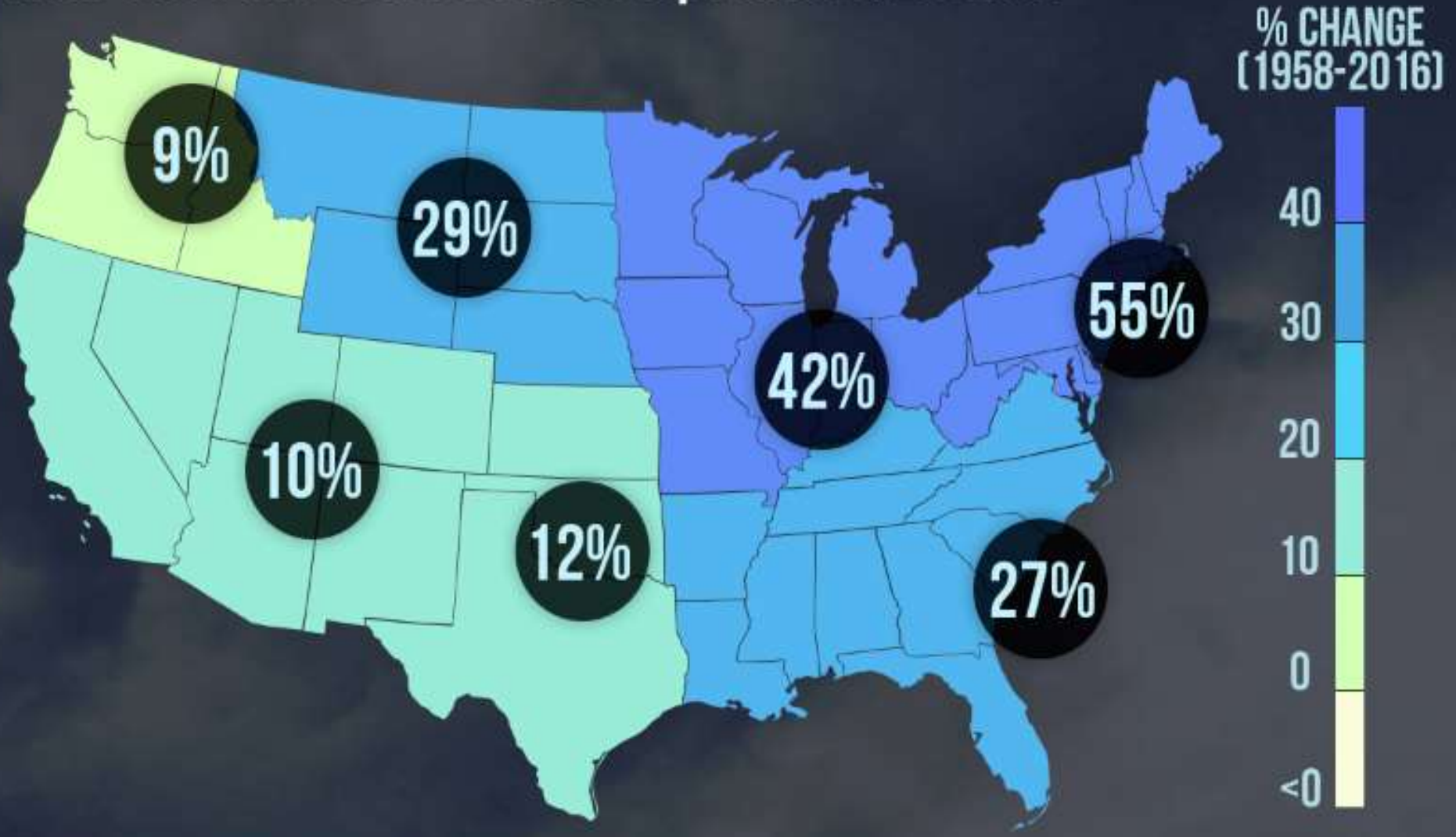


% maximum & minimum daily temperature records by decade for POR through 2018
Source: RCC-ACIS.org

CLIMATE CENTRAL

MORE DOWNPOURS

Increase in Heaviest Precipitation Events

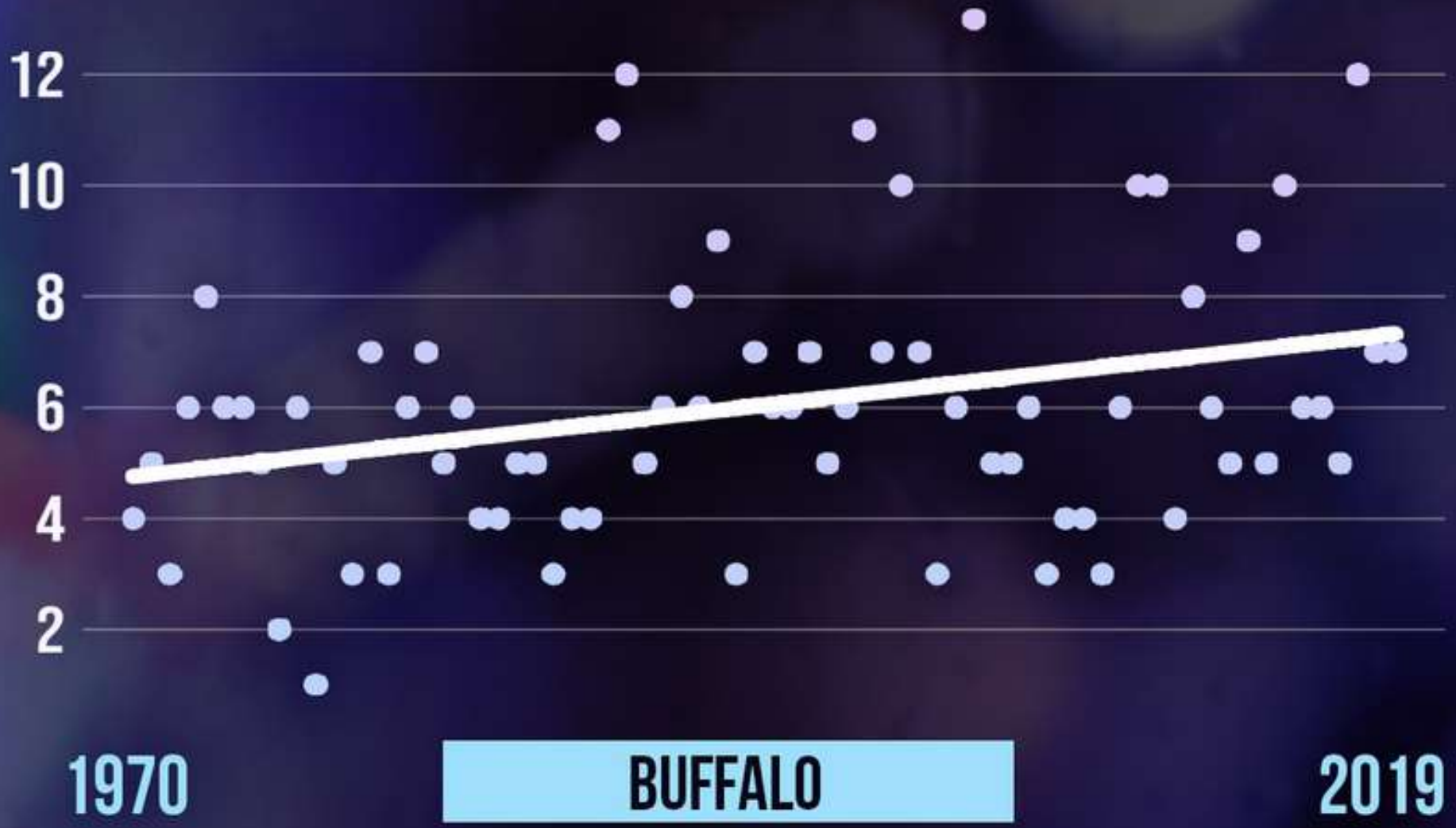


Heaviest events defined as top 1% of events
Source: USGCRP Climate Science Special Report 2017

CLIMATE CENTRAL

HEAVY PRECIPITATION

DAYS WITH 1" OR MORE



Source: RCC-ACIS.org

CLIMATE CENTRAL

COLD MATTERS

Fruit trees need winter chill for spring growth

Source: Alabama Cooperative Extension; Mississippi State Univ. Extension

CLIMATE CENTRAL

CHILL TIME NEEDED

Hours required before spring growth

800-1,100 HOURS

900-1,000 HOURS

400-1,050 HOURS

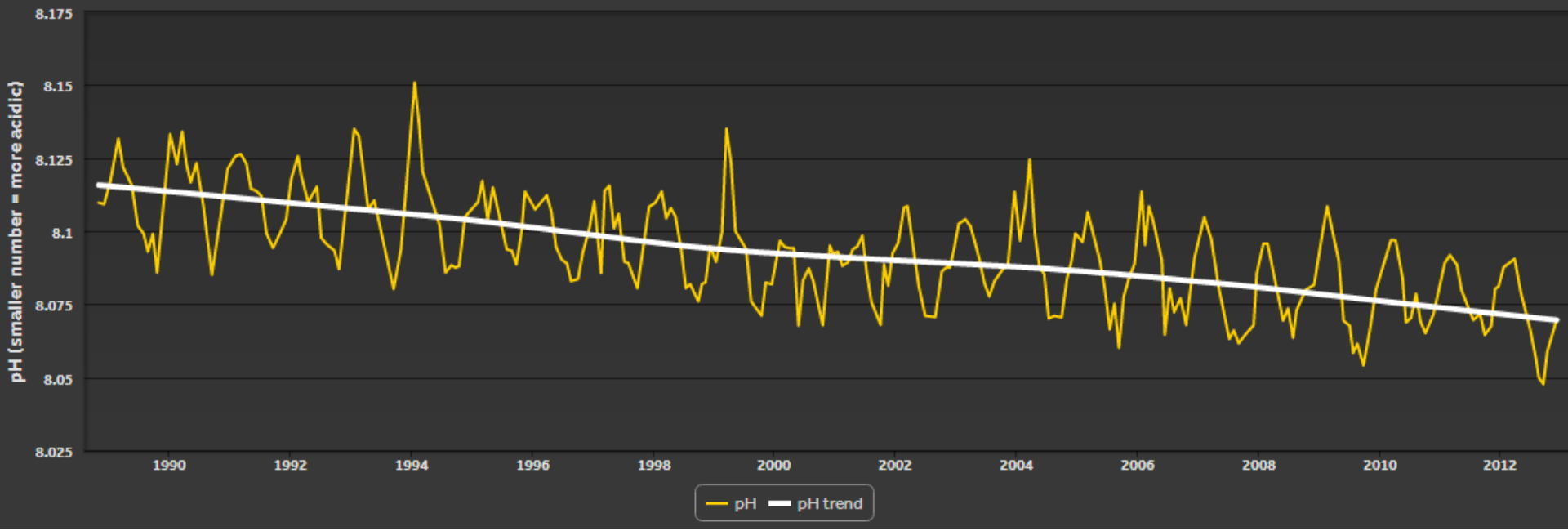
1,000 + HOURS

Source: Alabama Cooperative Extension

CLIMATE CENTRAL


1600
1400
1200
1000
800
600
400
200
0
<1000
UNITED STATES
CHILLING

Oceans are becoming **more acidic**



About a quarter of the carbon dioxide emitted into the atmosphere is currently taken up by the oceans, where it reacts with seawater and forms carbonic acid. This "acidification" of global oceans is observed as lower pH levels. Since preindustrial times, the average pH of ocean surface water fell from 8.21 to 8.10. While that does not sound like much, that is a 30 percent increase in acidity, and it could decrease another 0.3 pH units by the end of the century. At that rate, it would create an ocean more acidic than any seen in the past 100 million years.

WHY SHOULD WE BE CONCERNED ABOUT OCEAN ACIDIFICATION?

The current rate in acidity change is about 50 times faster than any known historical change, making it difficult for marine life to adapt. Carbonate ions in the ocean become less abundant in a more acidic ocean, making it difficult for shellfish (clams, oysters, mussels) to build shells and skeletons. Additionally plankton, which form the base of the oceanic food web, also have trouble adapting.

In a cascading effect, this will alter ecosystems in a way that could threaten seafood staples around the world. More than 1 billion people rely on oceans for food, as well as their livelihood.

By one estimate, ocean acidification will cost the global economy $1 trillion annually by 2100. Corals are similarly threatened. With less calcium carbonate available, it hinders the ability for corals to maintain their reefs, which are important habitats for other marine organisms and provide some coastal protection from storms.

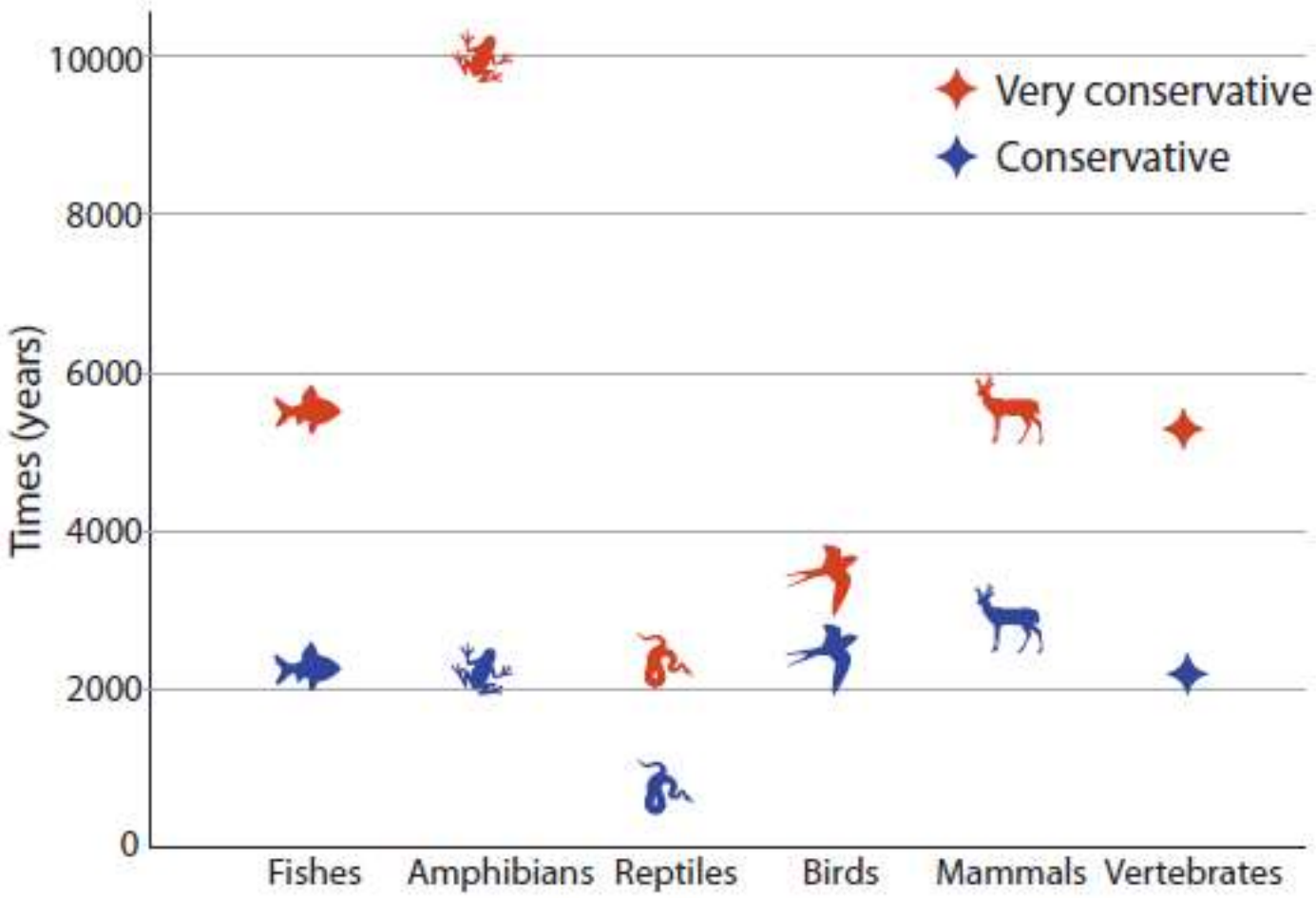
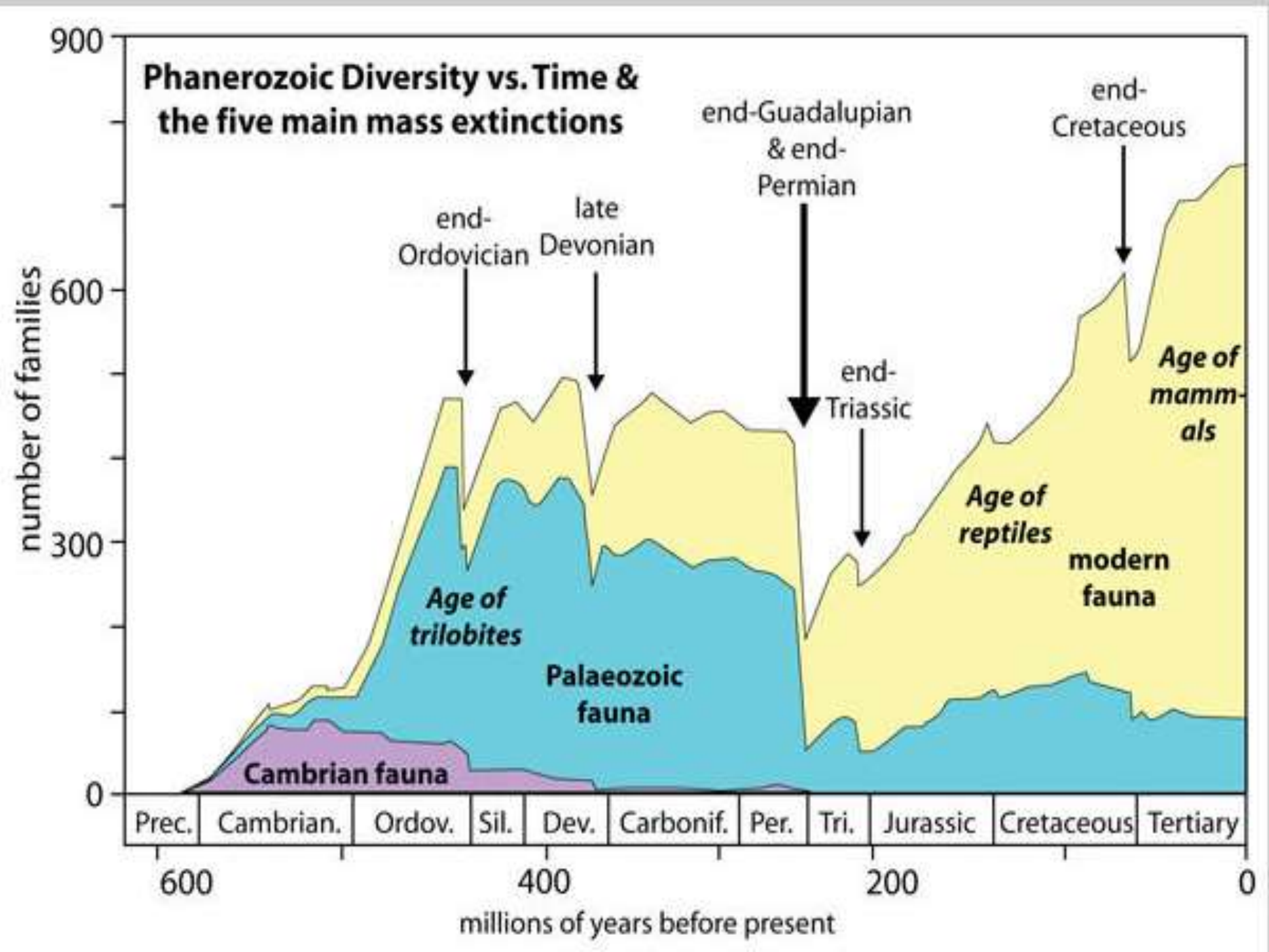


Fig. 2. Number of years that would have been required for the observed vertebrate species extinctions in the last 114 years to occur under a background rate of 2 E/MSY. Red markers, highly conservative scenario; blue markers, conservative scenario. Note that for all vertebrates, the observed extinctions would have taken between 800 to 10,000 years to disappear, assuming 2 E/MSY. Different classes of vertebrates all show qualitatively similar trends.


Phanerozoic Diversity vs. Time &
the five main mass extinctions
900
600
300
0
number of families
end-
Ordovician
late
Devonian
end-Guadalupian
& end-
Permian
end-
Triassic
end-
Cretaceous
Age of
trilobites
Palaeozoic
fauna
Cambrian fauna
Age of
reptiles
modern
fauna
Age of
mamm-
als
Prec.
Cambrian.
Ordov.
Sil.
Dev.
Carbonif.
Per.
Tri.
Jurassic
Cretaceous
Tertiary
600
400
200
0
millions of years before present

THE PERMIAN ENDED WITH THE MOST EXTENSIVE EXTINCTION EVENT RECORDED IN PALEONTOLOGY: THE PERMIAN-TRIASSIC EXTINCTION EVENT. 90% TO 95% OF MARINE SPECIES BECAME EXTINCT, AS WELL AS 70% OF ALL LAND ORGANISMS. IT IS ALSO THE ONLY KNOWN MASS EXTINCTION OF INSECTS. IT TOOK 30 MILLION YEARS FOR LAND VERTIBRATES TO FULLY RECOVER.

THERE IS ALSO SIGNIFICANT EVIDENCE THAT MASSIVE FLOOD BASALT ERUPTIONS FROM MAGMA OUTPUT LASTING THOUSANDS OF YEARS IN WHAT IS NOW THE SIBERIAN TRAPS CONTRIBUTED TO ENVIRONMENTAL STRESS LEADING TO MASS EXTINCTION. THE REDUCED COASTAL HABITAT AND HIGHLY INCREASED ARIDITY PROBABLY ALSO CONTRIBUTED. BASED ON THE AMOUNT OF LAVA ESTIMATED TO HAVE BEEN PRODUCED DURING THIS PERIOD, THE WORST-CASE SCENARIO IS AN EXPULSION OF ENOUGH CARBON DIOXIDE FROM THE ERUPTIONS TO RAISE WORLD TEMPERATURES FIVE DEGREES CELSIUS.[16]

ANOTHER HYPOTHESIS BUILDS ON THE FLOOD BASALT ERUPTION THEORY. FIVE DEGREES CELSIUS WOULD NOT BE ENOUGH INCREASE IN WORLD TEMPERATURES TO EXPLAIN THE DEATH OF 95% OF LIFE. BUT SUCH WARMING COULD SLOWLY RAISE OCEAN TEMPERATURES UNTIL FROZEN METHANE RESERVOIRS BELOW THE OCEAN FLOOR NEAR COASTLINES MELTED, EXPELLING ENOUGH METHANE, AMONG THE MOST POTENT GREENHOUSE GASES, INTO THE ATMOSPHERE TO RAISE WORLD TEMPERATURES AN ADDITIONAL FIVE DEGREES CELSIUS.

IT ALSO HELPS EXPLAIN WHY THE FIRST PHASE OF THE LAYER'S EXTINCTIONS WAS LAND-BASED, THE SECOND WAS MARINE-BASED (AND STARTING RIGHT AFTER THE INCREASE IN C-12 LEVELS), AND THE THIRD LAND-BASED AGAIN.
FURTHER EVIDENCE FOR ENVIRONMENTAL CHANGE AROUND THE P–TR BOUNDARY SUGGESTS AN 8 °C (14 °F) RISE IN TEMPERATURE,[18] AND AN INCREASE IN CO2 LEVELS BY 2000 PPM (BY CONTRAST, THE CONCENTRATION IMMEDIATELY BEFORE THE INDUSTRIAL REVOLUTION WAS 280 PPM.)

Nearly two-thirds of carbon dioxide emitted since the 1750s can be traced to the 90 largest fossil fuel and cement producers, most of which still operate.

63 percent of the carbon dioxide and methane emitted between 1751 and 2010 to just 90 entities. Fifty are investor-owned companies such as Chevron, Peabody, Shell, and BHP Billiton. Thirty-one are state-owned companies such as Saudi Aramco and Statoil, and nine are government-run industries in countries such as China, Poland, and the former Soviet Union.

Classified on the next slide are the 90 entities according to type of fossil fuel extracted and marketed.

There are 56 oil and natural gas companies, and 37 coal producers. In addition, the CO2 emissions from seven cement manufacturers are included.

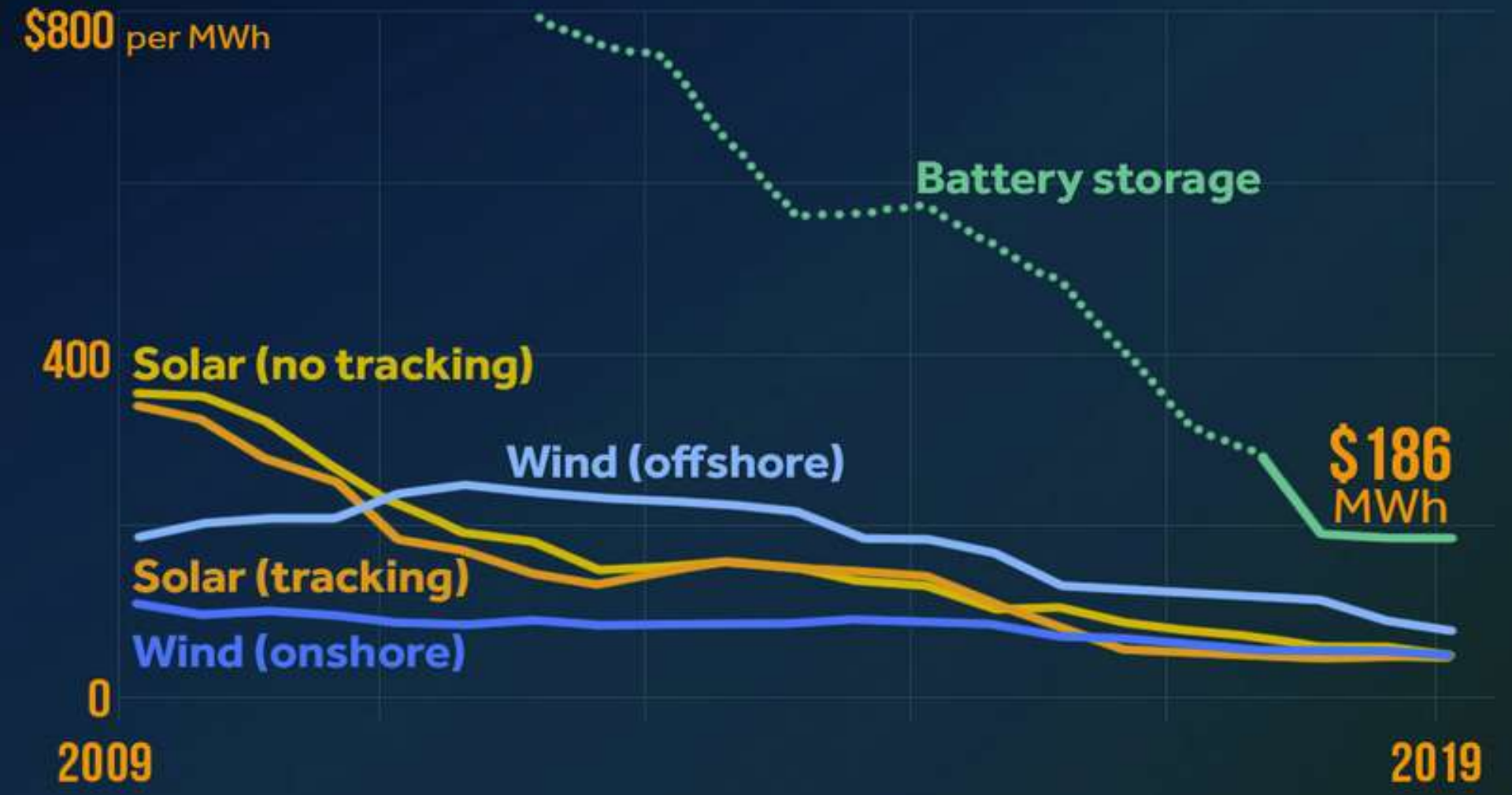
Top 20 investor- and state-owned entities and attributed CO2 & CH4 emissions 2010

Entity	2010 EmissionsMtCO2e	Cumulative 1854-2010MtCO2e	Percent of Global1751-2010
1. Chevron, USA	423	51,096	3.52%
2. ExxonMobil, USA	655	46,672	3.22%
3. Saudi Aramco, Saudi Arabia	1,550	46,033	3.17%
4. BP, UK	554	35,837	2.47%
5. Gazprom, Russian Federation	1,371	32,136	2.22%
6. Royal Dutch/Shell, Netherlands	478	30,751	2.12%
7. National Iranian Oil Company	867	29,084	2.01%
8. Pemex, Mexico	602	20,025	1.38%
9. ConocoPhillips, USA	359	16,866	1.16%
10. Petroleos de Venezuela	485	16,157	1.11%
11. Coal India	830	15,493	1.07%
12. Peabody Energy, USA	519	12,432	0.86%
13. Total, France	398	11,911	0.82%
14. PetroChina, China	614	10,564	0.73%
15. Kuwait Petroleum Corp.	323	10,503	0.73%
16. Abu Dhabi NOC, UAE	387	9,672	0.67%
17. Sonatrach, Algeria	386	9,263	0.64%
18. Consol Energy, Inc., USA	160	9,096	0.63%
19. BHP-Billiton, Australia	320	7,606	0.52%
20. Anglo American, United Kingdom	242	7,242	0.50%
Top 20 IOCs & SOEs	11,523	428,439	29.54%
Top 40 IOCs & SOEs		546,767	37.70%
All 81 IOCs & SOEs	18,524	602,491	41.54%
Total 90 Carbon Majors	27,946	914,251	63.04%
Total Global Emissions	36,026	1,450,332	100.00%

http://carbonmajors.org/download-the-study/

SOLAR, WIND AND BATTERY PRICES FALLING

BloombergNEF Levelized Cost of Energy



Source: BloombergNEF. Note: The global benchmark is a country weighted-average using the latest annual capacity additions. The storage LCOE is reflective of a utilityscale Li-ion battery storage system with four-hour duration running at a daily cycle and includes charging costs assumed to be 60% of wholesale average power price. Data as of October 22, 2019.

CLIMATE CENTRAL

100% UNITED STATES OF AMERICA

A vision for the transition to 100% wind, water & solar energy

2050 PROJECTED ENERGY MIX

- Residential rooftop solar **14.5%**
- Solar plants **19.5%**
- Concentrating solar plants **11.5%**
- Onshore wind **21.3%**
- Offshore wind **17.1%**
- Commercial & government rooftop solar **11.8%**
- Wave devices **1.1%**
- Geothermal **0.4%**
- Hydroelectric **2.8%**
- Tidal Turbines **0%**

40-Year Jobs Created

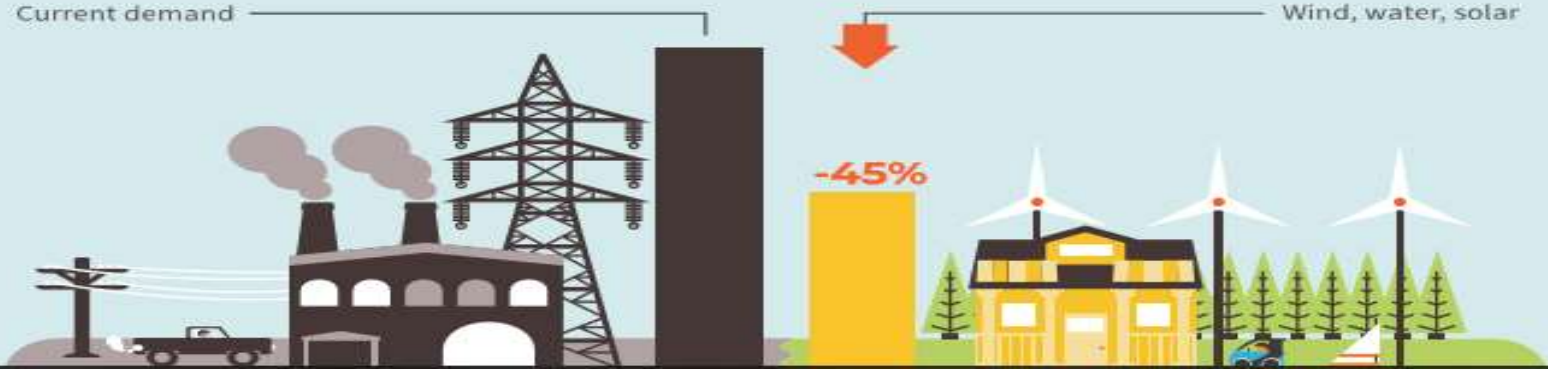
Number of jobs where a person is employed for 40 consecutive years

Construction jobs: **1,983,745**

Operation jobs: **2,154,051**

Reducing Energy Demand

Improving energy efficiency and powering the grid with electricity from the wind water and sun positively reduces the overall energy demand.



Health Cost Savings

Avoided health costs per year:

$602.24B

1.48% of country GDP

Lives lost to air pollution that we could save each year:

45,761

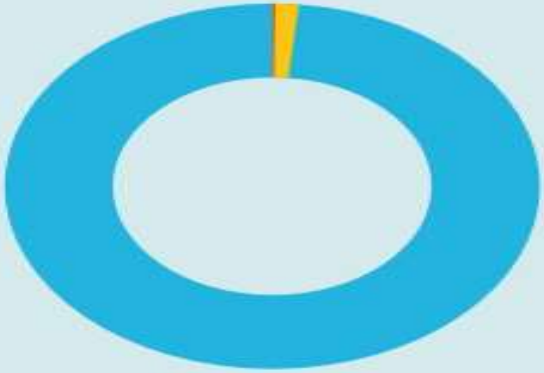
The transition pays for itself in as little as **3.2 years** from air pollution and climate cost savings alone

Land Usage

Percentage of United States of America Land Needed for All New Wind, Water & Solar Generators

0.21%
Footprint Area

1.39%
Spacing Area



Average Energy Costs in 2050

10¢
/kWh*

9.62¢
/kWh*

- Fossil Fuels & Nuclear Energy
- Wind, Water & Solar

*Health and climate externality costs of fossil feuls are another 5.7¢/kWh

Money in your Pocket

Energy cost savings per person:
$304.40

Energy, health, and climate cost savings per person:
$8,316

100% NEW YORK

A vision for the transition to 100% wind, water & solar energy

2050 PROJECTED ENERGY MIX

- Residential rooftop solar **3.6%**
- Solar plants **35.8%**
- Concentrating solar plants **0%**
- Onshore wind **10%**
- Offshore wind **40%**
- Commercial & government rooftop solar **3.2%**
- Wave devices **0.8%**
- Geothermal **0%**
- Hydroelectric **6.5%**
- Tidal Turbines **0.1%**

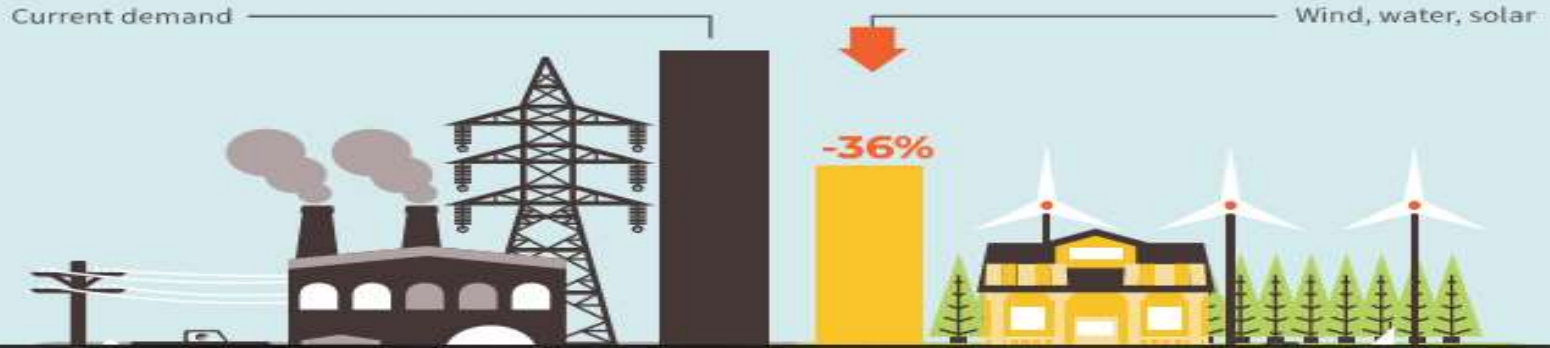
40-Year Jobs Created

Number of jobs where a person is employed for 40 consecutive years

- Construction jobs: **174,775**
- Operation jobs: **94,644**

Reducing Energy Demand

Improving energy efficiency and powering the grid with electricity from the wind water and sun positively reduces the overall energy demand.



Health Cost Savings

Avoided health costs per year:

1.23% of state GDP

Lives lost to air pollution that we could save each year:

3,137

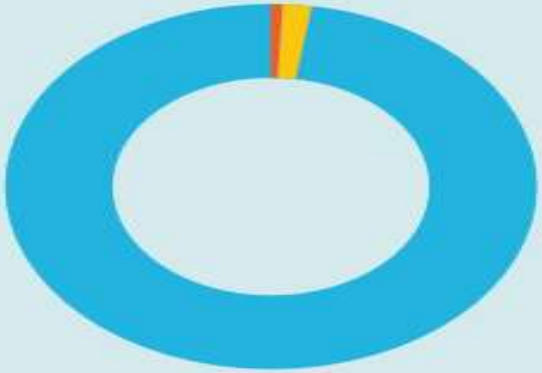
The transition pays for itself in as little as **6.1 years** from air pollution and climate cost savings alone

Land Usage

Percentage of New York Land Needed for All New Wind, Water & Solar Generators

0.7%
Footprint Area

1.77%
Spacing Area



Average Energy Costs in 2050

● Fossil Fuels & Nuclear Energy
● Wind, Water & Solar

*Health and climate externality costs of fossil feuls are another 5.7¢/kWh

Money in your Pocket

100% BUFFALO

A vision for the transition to 100% wind, water & solar energy

2050 PROJECTED ENERGY MIX

- Residential rooftop solar **2%**
- Solar plants **43%**
- Concentrating solar plants **0%**
- Onshore wind **10%**
- Offshore wind **36%**
- Commercial & government rooftop solar **2%**
- Wave devices **1%**
- Geothermal **0%**
- Hydroelectric **7%**
- Tidal Turbines **0%**

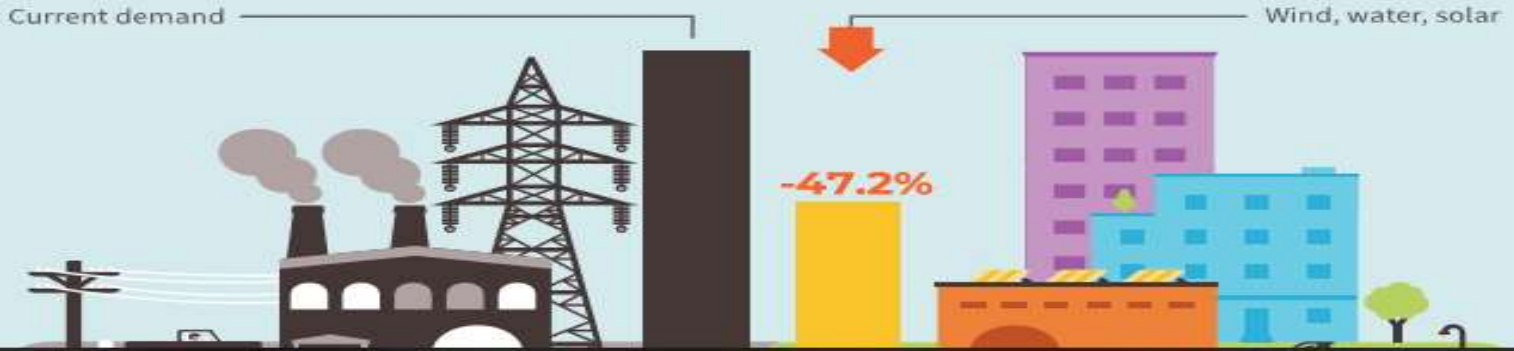
40-Year Jobs Created

Number of jobs where a person is employed for 40 consecutive years

- Construction jobs: **2,101**
- Operation jobs: **1,029**

Reducing Energy Demand

Improving energy efficiency and powering the grid with electricity from the wind water and sun positively reduces the overall energy demand.



Health Cost Savings

Avoided health costs per year:

1.25% of city GDP

Lives lost to air pollution that we could save each year:

59

The transition pays for itself in as little as **3.4 years** from air pollution and climate cost savings alone

Average Energy Costs in 2050

12.23¢ /kWh*

11.7¢ /kWh*

- Fossil Fuels & Nuclear Energy
- Wind, Water & Solar

*Health and climate externality costs of fossil feuls are another 5.7¢/kWh

Money in your Pocket

Energy cost savings per person:

$106

Energy, health, and climate cost savings per person:

$6,168

CLIMATE DRAWDOWN IS THE POINT AT WHICH GREENHOUSE GAS CONCENTRATIONS IN THE ATMOSPHERE BEGIN TO DECLINE ON A YEAR-TO-YEAR BASIS.

DRAWDOWN IS A GOAL FOR REVERSING CLIMATE CHANGE, AND EVENTUALLY REDUCING GLOBAL AVERAGE TEMPERATURES.

PROJECT DRAWDOWN PROJECT DRAWDOWN IS A CLIMATE CHANGE MITIGATION PROJECT INITIATED BY PAUL HAWKEN AND CLIMATE ACTIVIST AMANDA JOY RAVENHILL.

CENTRAL TO THE PROJECT IS THE COMPILATION OF A LIST OF THE "100 MOST SUBSTANTIVE SOLUTIONS TO GLOBAL WARMING." THE LIST, ENCOMPASSING ONLY TECHNOLOGICALLY VIABLE, EXISTING SOLUTIONS, WAS COMPILED BY A TEAM OF OVER 200 SCHOLARS, SCIENTISTS, POLICYMAKERS, BUSINESS LEADERS AND ACTIVISTS; FOR EACH SOLUTION THE CARBON IMPACT THROUGH THE YEAR 2050, THE TOTAL AND NET COST TO SOCIETY, AND THE TOTAL LIFETIME SAVINGS WERE MEASURED AND MODELLED.

THERE ARE 100 SOLUTIONS TO REVERSE GLOBAL WARMING, 80 OF WHICH EXIST TODAY AND CAN BE IMPLEMENTED WITH CURRENT TECHNOLOGY AND 20 WHICH ARE COMING ATTRACTIONS.

ALL THESE SOLUTIONS HAVE THE FOLLOWING TAKE THE FOLLOWING THREE OBJECTIVES INTO ACCOUNT

1. **PLACE FOSSIL FUELS WITH RENEWABLE RESOURCES.**
2. **REDUCE CONSUMPTION THRU INCREASED TECHNOLOGY, EFFICIENCY AND BEHAVIORAL CHANGE.**
3. **BIOSEQUESTER CARBON THRU PHOTOSYNTHESIS.**

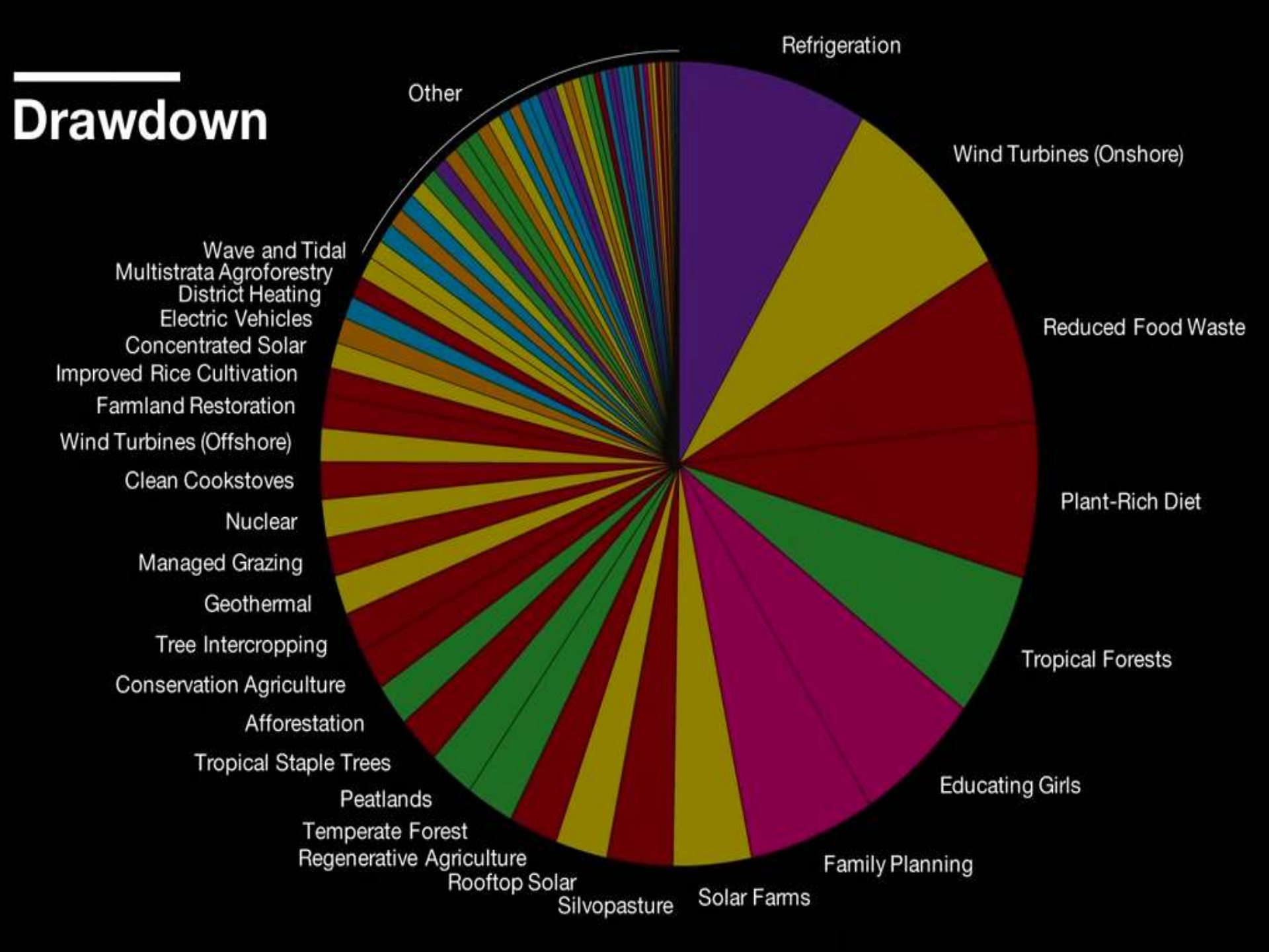
COST TO IMPLEMENT THESE 80 SOLUTIONS IS $29 TRILLION OVER 30 YEARS.

GLOBAL YEARLY GDP IS $ 80 TRILLION.

COST SAVINGS IS $ 74 TRILLION OVER 30 YEARS.

NET SAVINGS OF $ 45 TRILLION OVER 30 YEARS OR $ 1.5 TRILLION PER YEAR.

Drawdown


Refrigeration
Wind Turbines (Onshore)
Reduced Food Waste
Plant-Rich Diet
Tropical Forests
Educating Girls
Family Planning
Solar Farms
Silvopasture
Rooftop Solar
Regenerative Agriculture
Temperate Forest
Peatlands
Tropical Staple Trees
Afforestation
Conservation Agriculture
Tree Intercropping
Geothermal
Managed Grazing
Nuclear
Clean Cookstoves
Wind Turbines (Offshore)
Farmland Restoration
Improved Rice Cultivation
Concentrated Solar
Electric Vehicles
District Heating
Multistrata Agroforestry
Wave and Tidal
Other

TOP 20

RANK	SOLUTION	SECTOR	REDUCED CO2
1	**Refrigeration**	Materials	89.74 GT
2	**Wind Turbines (Onshore)**	Energy	84.60 GT
3	**Reduced Food Waste**	Food	70.53 GT
4	**Plant-Rich Diet**	Food	66.11 GT
5	**Tropical Forests**	Land Use	61.23 GT
6	**Educating Girls**	Women and Girls	59.60 GT
7	**Family Planning**	Women and Girls	59.60 GT
8	**Solar Farms**	Energy	36.90 GT
9	**Silvopasture**	Food	31.19 GT
10	**Rooftop Solar**	Energy	24.60 GT
11	**Regenerative Agriculture**	Food	23.15 GT
12	**Temperate Forest**	Land Use	22.61 GT
13	**Peatlands**	Land Use	21.57 GT
14	**Tropical Staple Tree Crops**	Food	20.19 GT
15	**Afforestation**	Land Use	18.06 GT
16	**Conservation Agriculture**	Food	17.35 GT
17	**Tree Intercropping**	Food	17.20 GT
18	**Geothermal**	Energy	16.60 GT
19	**Managed Grazing**	Food	16.34 GT
20	**Nuclear**	Energy	16.09 GT

TOP 20 SOLUTIONS TO REVERSE GLOBAL WARMING

PROJECT DRAWDOWN

TOP 20

Electricity
is only
5 of top 20

RANK	SOLUTION	SECTOR	REDUCED CO2
1	Refrigerant Management	Materials	89.74 GT
2	Wind Turbines (Onshore)	Energy	84.60 GT
3	Reduced Food Waste	Food	70.53 GT
4	Plant-Rich Diet	Food	66.11 GT
5	Tropical Forests	Land Use	61.23 GT
6	Educating Girls	Women and Girls	59.60 GT
7	Family Planning	Women and Girls	59.60 GT
8	Solar Farms	Energy	36.90 GT
9	Silvopasture	Food	31.19 GT
10	Rooftop Solar	Energy	24.60 GT
11	Regenerative Agriculture	Food	23.15 GT
12	Temperate Forest	Land Use	22.61 GT
13	Peatlands	Land Use	21.57 GT
14	Tropical Staple Tree Crops	Food	20.19 GT
15	Afforestation	Land Use	18.06 GT
16	Conservation Agriculture	Food	17.35 GT
17	Tree Intercropping	Food	17.20 GT
18	Geothermal	Energy	16.60 GT
19	Managed Grazing	Food	16.34 GT
20	Nuclear	Energy	16.09 GT

TOP 20

Food system
is 8 of top 20

RANK	SOLUTION	SECTOR	REDUCED CO2
1	Refrigerant Management	Materials	89.74 GT
2	Wind Turbines (Onshore)	Energy	84.60 GT
3	Reduced Food Waste	Food	70.53 GT
4	Plant-Rich Diet	Food	66.11 GT
5	Tropical Forests	Land Use	61.23 GT
6	Educating Girls	Women and Girls	59.60 GT
7	Family Planning	Women and Girls	59.60 GT
8	Solar Farms	Energy	36.90 GT
9	Silvopasture	Food	31.19 GT
10	Rooftop Solar	Energy	24.60 GT
11	Regenerative Agriculture	Food	23.15 GT
12	Temperate Forest	Land Use	22.61 GT
13	Peatlands	Land Use	21.57 GT
14	Tropical Staple Tree Crops	Food	20.19 GT
15	Afforestation	Land Use	18.06 GT
16	Conservation Agriculture	Food	17.35 GT
17	Tree Intercropping	Food	17.20 GT
18	Geothermal	Energy	16.60 GT
19	Managed Grazing	Food	16.34 GT
20	Nuclear	Energy	16.09 GT

TOP 20

Land Management is 4 of top 20

RANK	SOLUTION	SECTOR	REDUCED CO2
1	Refrigeration	Materials	89.74 GT
2	Wind Turbines (Onshore)	Energy	84.60 GT
3	Reduced Food Waste	Food	70.53 GT
4	Plant-Rich Diet	Food	66.11 GT
5	**Tropical Forests**	**Land Use**	**61.23 GT**
6	Educating Girls	Women and Girls	59.60 GT
7	Family Planning	Women and Girls	59.60 GT
8	Solar Farms	Energy	36.90 GT
9	Silvopasture	Food	31.19 GT
10	Rooftop Solar	Energy	24.60 GT
11	Regenerative Agriculture	Food	23.15 GT
12	**Temperate Forest**	**Land Use**	**22.61 GT**
13	**Peatlands**	**Land Use**	**21.57 GT**
14	Tropical Staple Tree Crops	Food	20.19 GT
15	**Afforestation**	**Land Use**	**18.06 GT**
16	Conservation Agriculture	Food	17.35 GT
17	Tree Intercropping	Food	17.20 GT
18	Geothermal	Energy	16.60 GT
19	Managed Grazing	Food	16.34 GT
20	Nuclear	Energy	16.09 GT

TOP 20

Land + **Food**
is 12 of top 20

RANK	SOLUTION	SECTOR	REDUCED CO2
1	Refrigeration	Materials	89.74 GT
2	Wind Turbines (Onshore)	Energy	84.60 GT
3	Reduced Food Waste	Food	70.53 GT
4	Plant-Rich Diet	Food	66.11 GT
5	Tropical Forests	Land Use	61.23 GT
6	Educating Girls	Women and Girls	59.60 GT
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16	Conservation Agriculture	Food	17.35 GT
17	Tree Intercropping	Food	17.20 GT
18	Geothermal	Energy	16.60 GT
19	Managed Grazing	Food	16.34 GT
20	Nuclear	Energy	16.09 GT

TOP **20**

Women & girls:
when combined,
it is top solution.

RANK	SOLUTION	SECTOR	REDUCED CO2
1	Refrigerant Management	Materials	89.74 GT
2	Wind Turbines (Onshore)	Electricity	84.60 GT
3	Reduced Food Waste	Food	70.53 GT
4	Plant-Rich Diet	Food	66.11 GT
5	Tropical Forests	Land Use	61.23 GT
6	**Educating Girls**	**Women and Girls**	**59.60 GT**
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8	Solar Farms	Electricity	36.90 GT
9	Silvopasture	Food	31.19 GT
10	Rooftop Solar	Electricity	24.60 GT
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15	Afforestation	Land Use	18.06 GT
16	Conservation Agriculture	Food	17.35 GT
17	Tree Intercropping	Food	17.20 GT
18	Geothermal	Electricity	16.60 GT
19	Managed Grazing	Food	16.34 GT
20	Nuclear	Electricity	16.09 GT

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