The Air We Breathe: It Is Not What It Used To Be!

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Questions for You?

1. How thick is the Earth's Atmosphere?

2. How may kilos of Carbon Dioxide (CO_2) are produced by burning 1 liter of fuel?

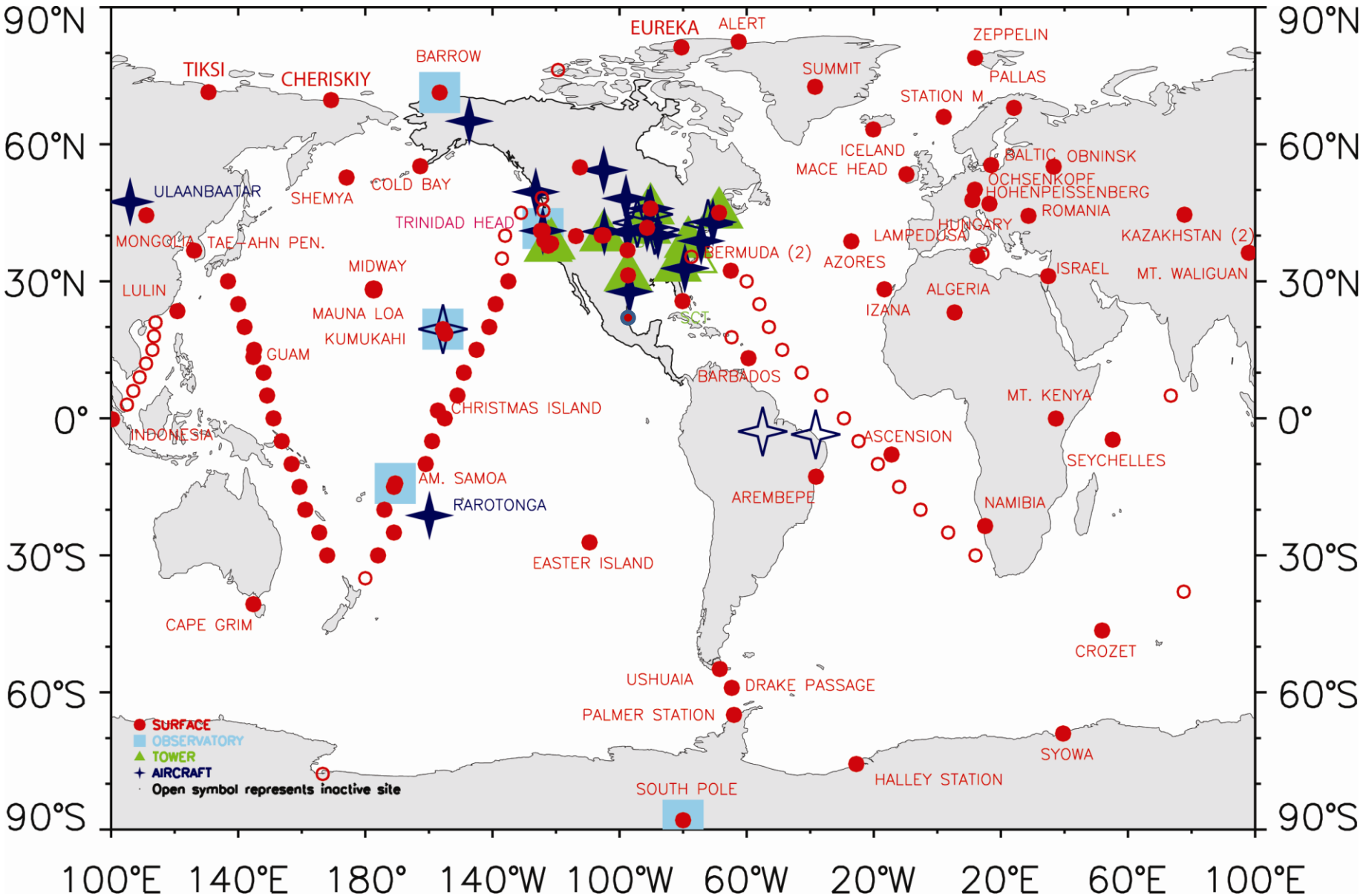
3. How long does CO_2 stay in the atmosphere?

4. Why do we care?

5. What will we do about it?

3, 6, 12

Cooperative Gas Sampling Network

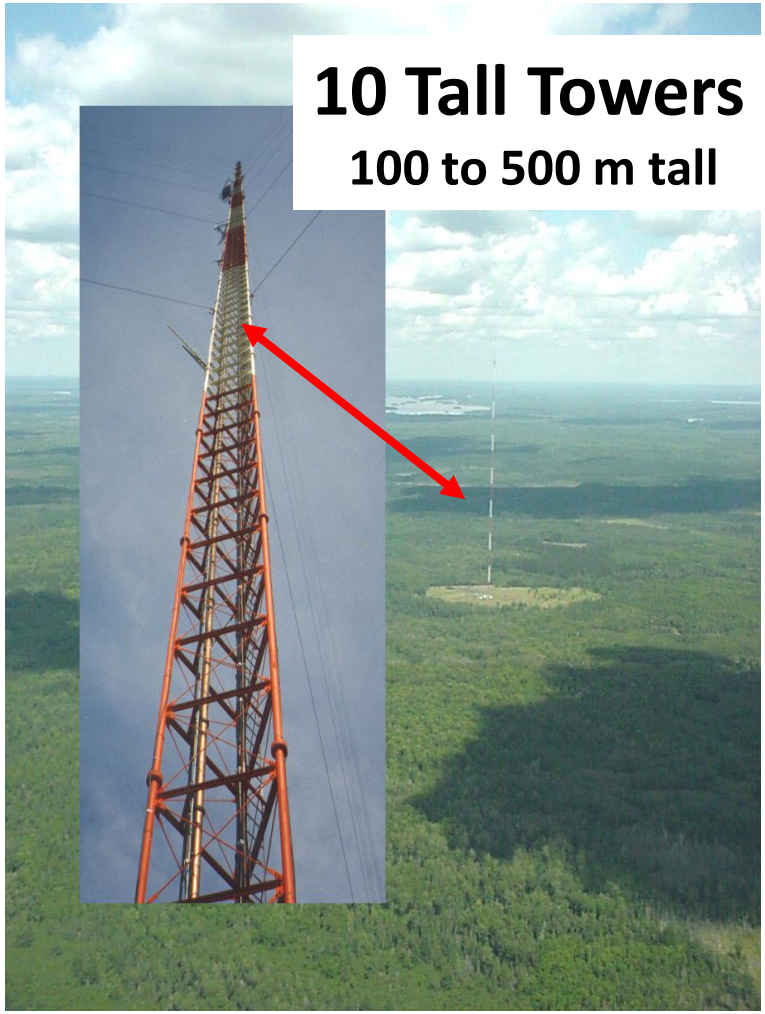


Atmospheric Baseline Observatories

Launching a Water Ozonesonde at Summit, Greenland (in the dark, -60C)

Flask Shipping and Analysis

NOAA Measures Trace Gases from the Surface, Tall Towers and Light Aircraft

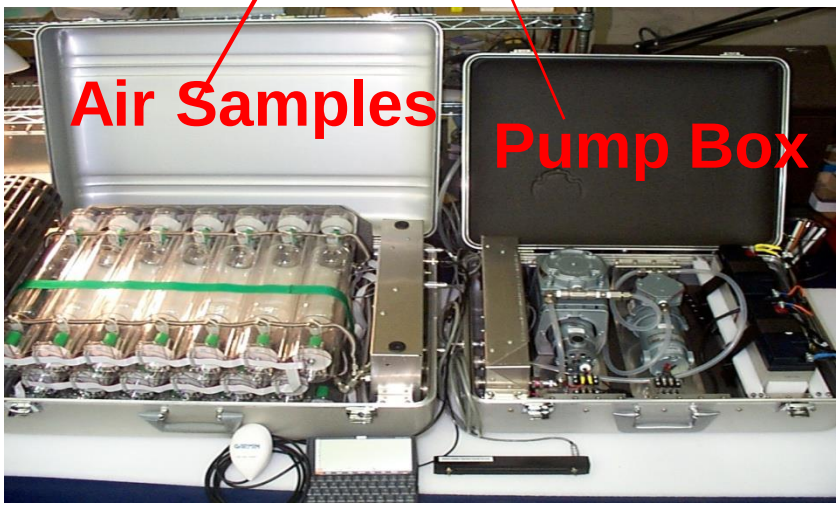


10 Tall Towers

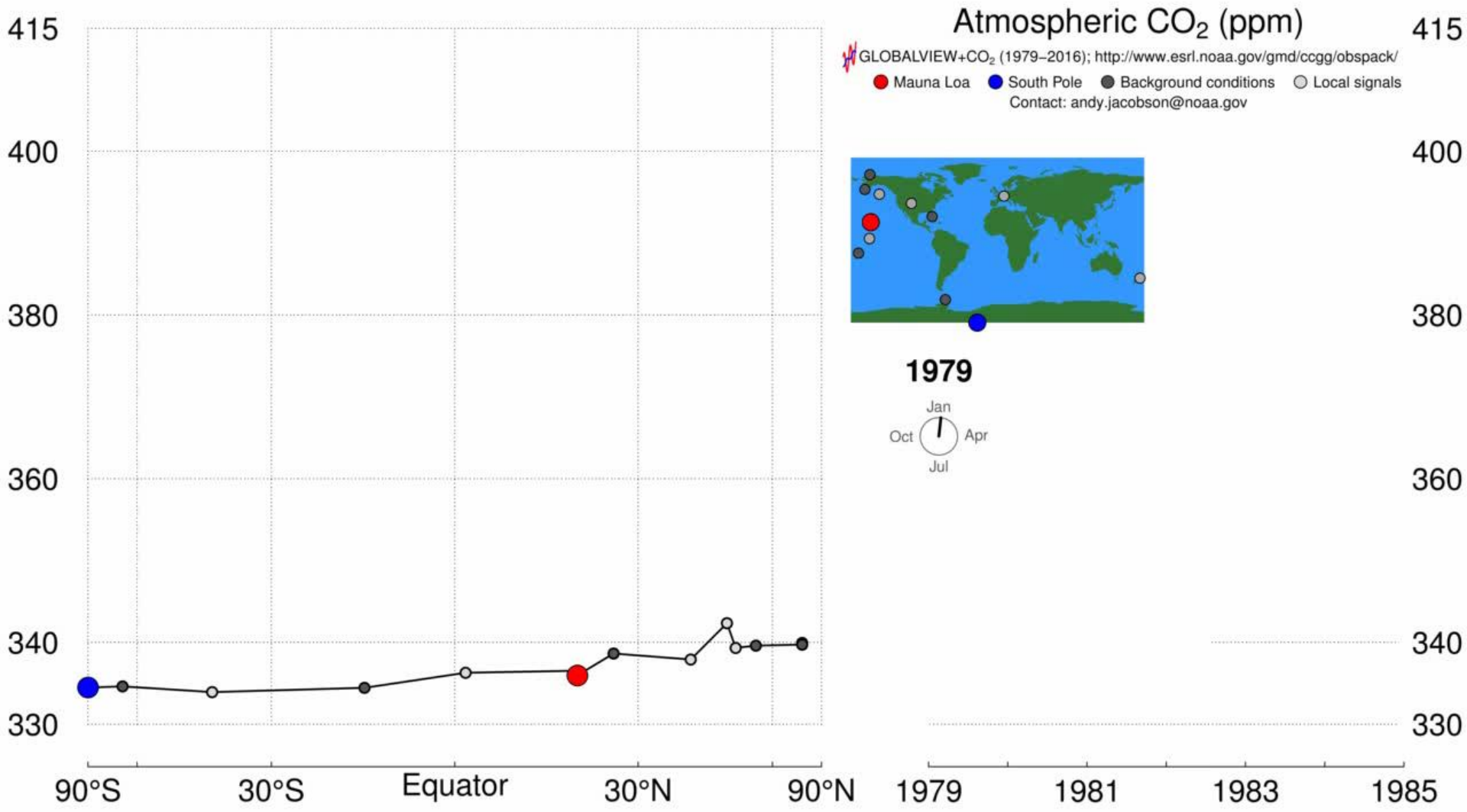
100 to 500 m tall

15 Light Aircraft

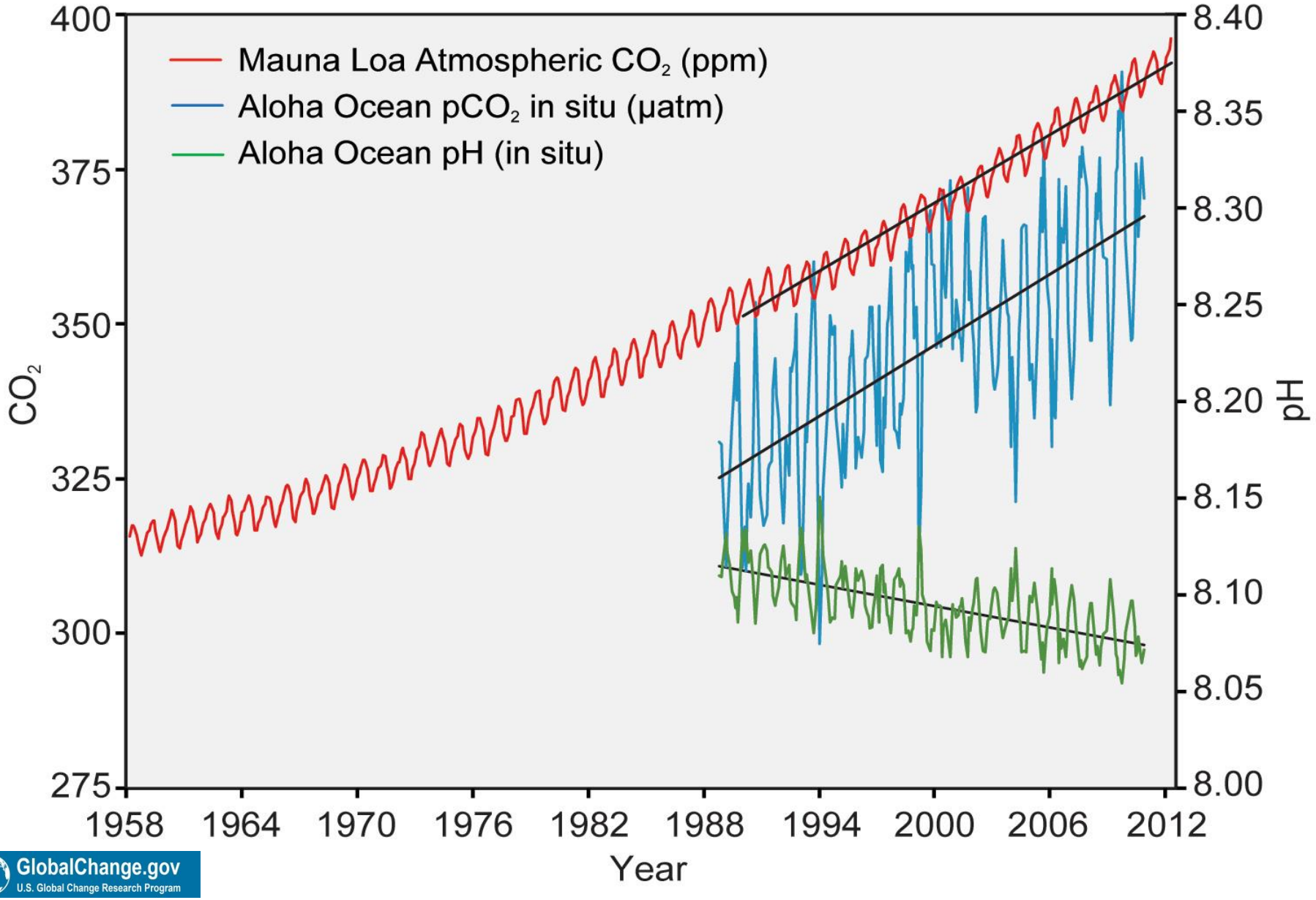
To 20,000 ft.



Annual cycle and increasing atmospheric CO_2



Oceans Absorb CO_2 and Become Acidic



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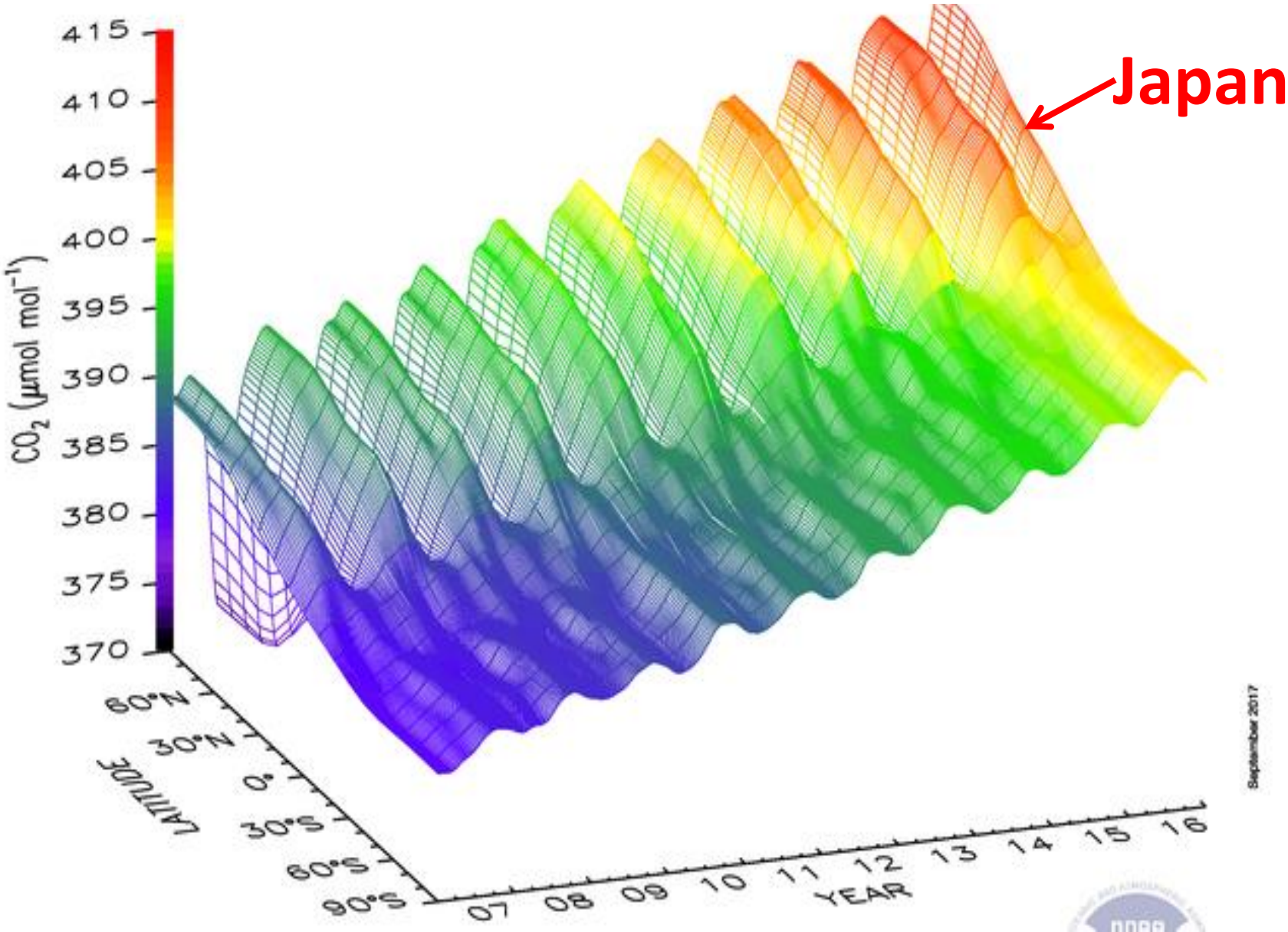
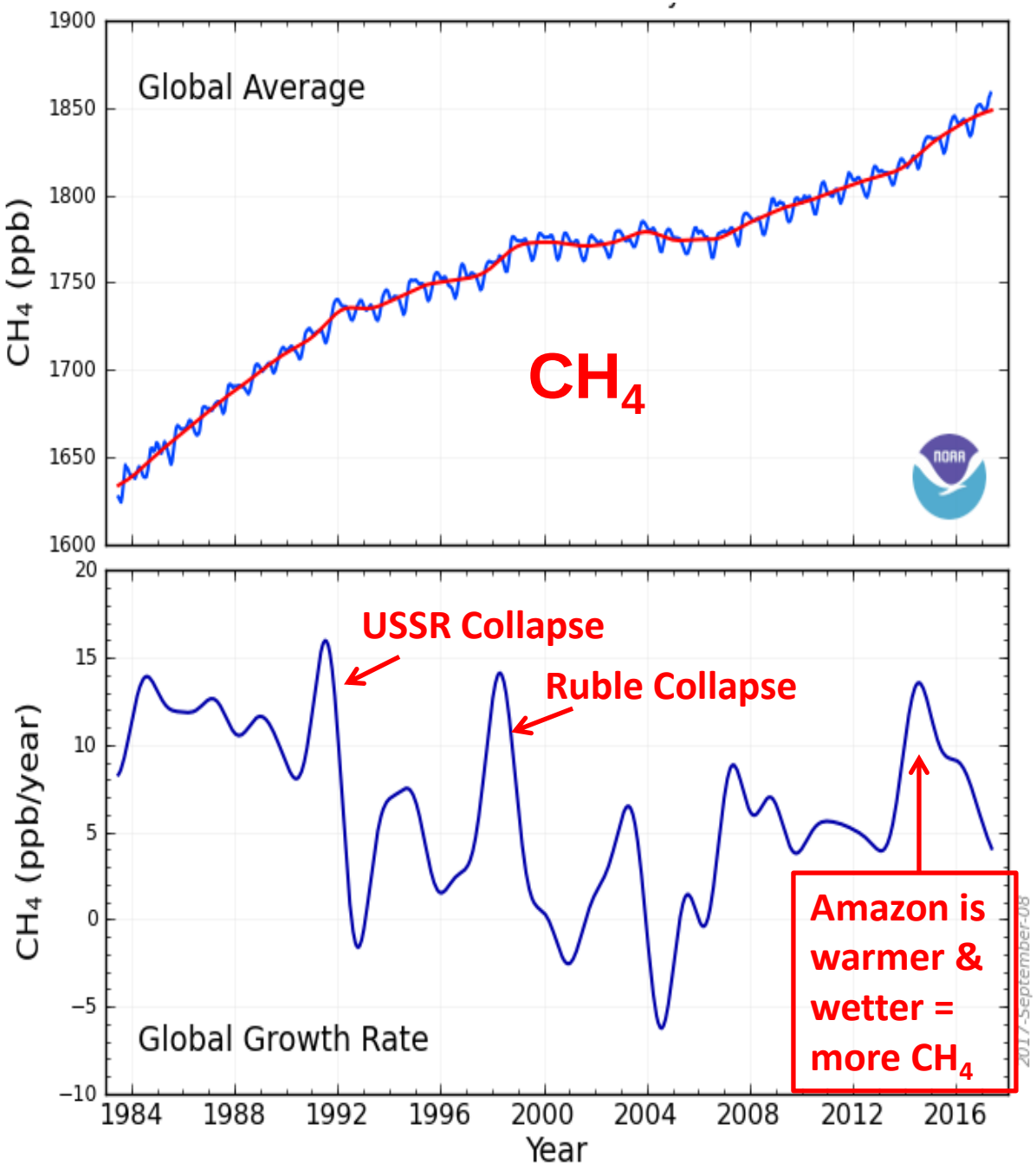
U.S. Global Change Research Program

Global Distribution of Carbon Dioxide

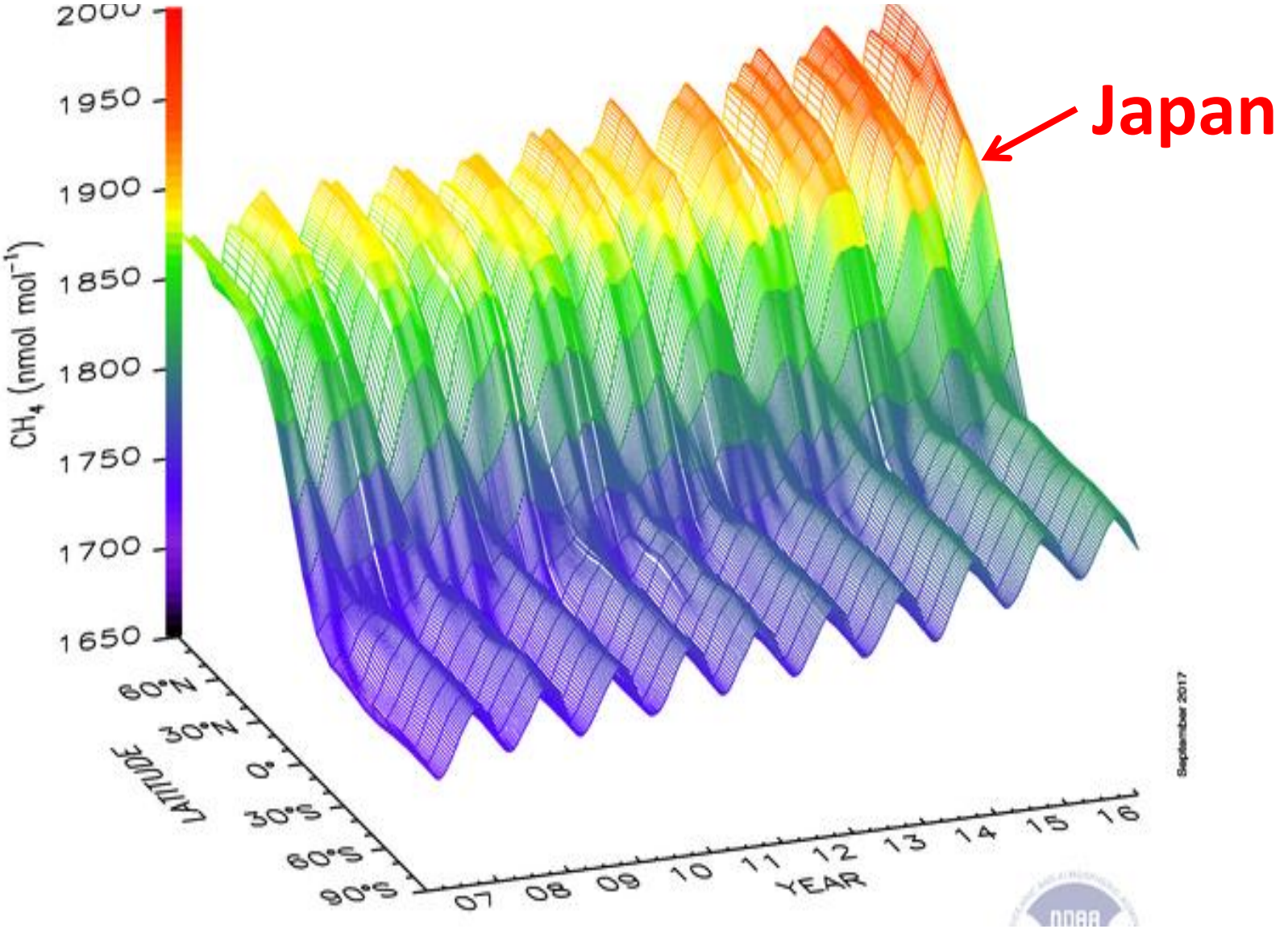


Global Methane Concentration & Trends



There is <u>no</u> solid evidence that the global methane rise is from oil and gas drilling, but there are some regional effects.

Global Distribution of Methane

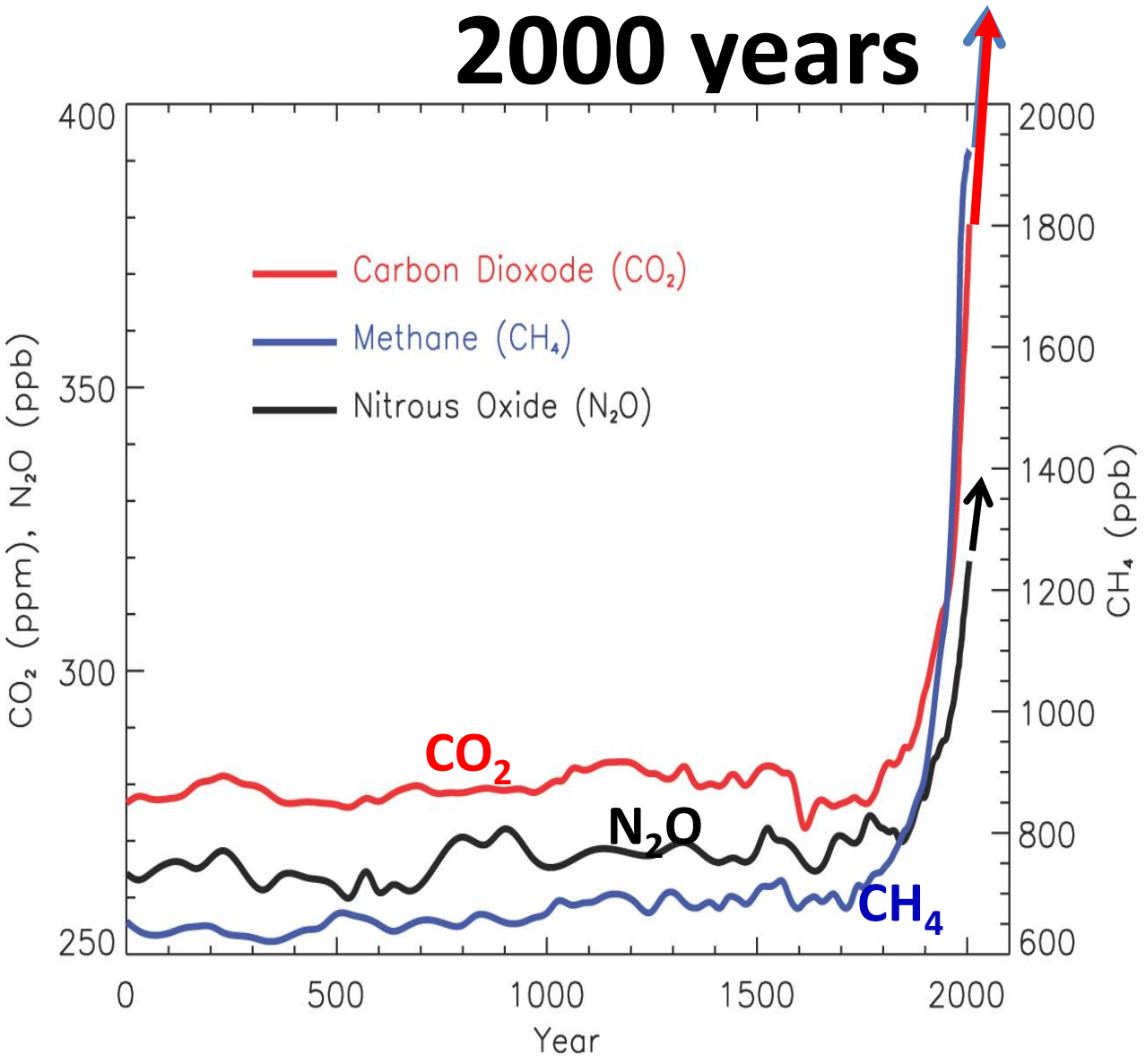


Cooperative Programs at Tiksi and Cherskyi, Siberia

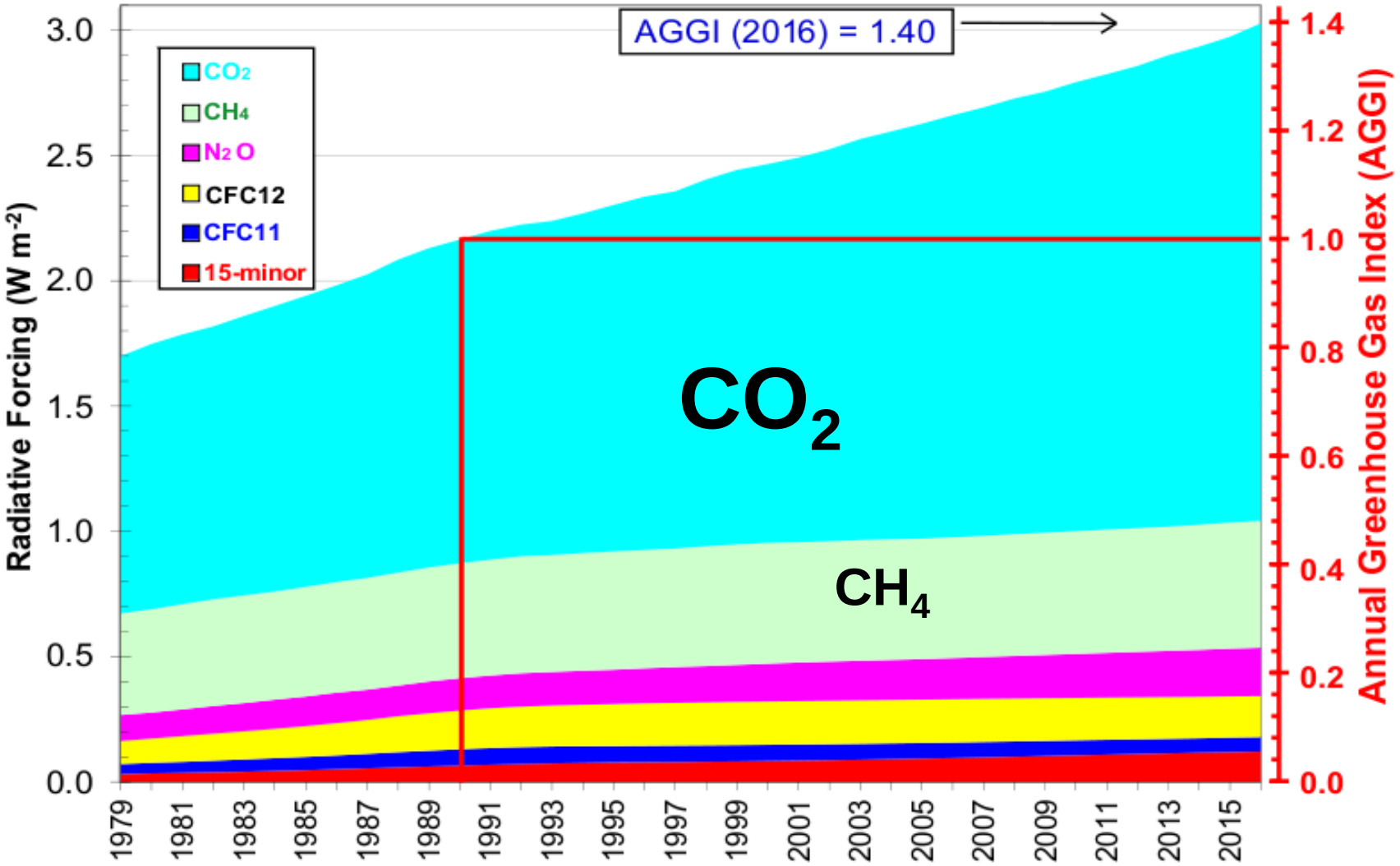
CH_4 Measurements in Siberia Permafrost

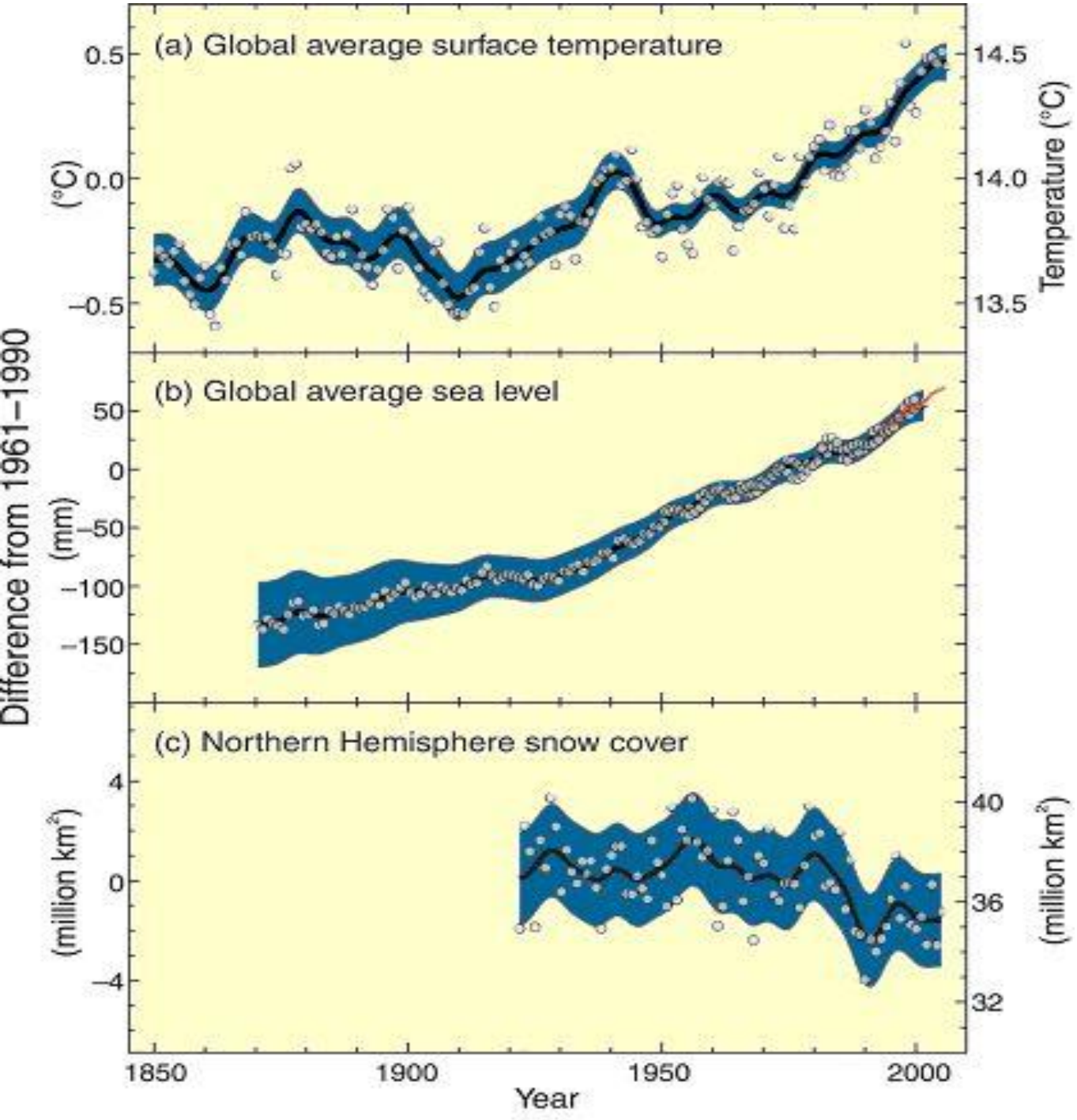
(Began Summer 2008)

Major Greenhouse Gases, past 2000 years



Greenhouse Gas Index: 1 in 1990, 1.4 times more heat by 2016



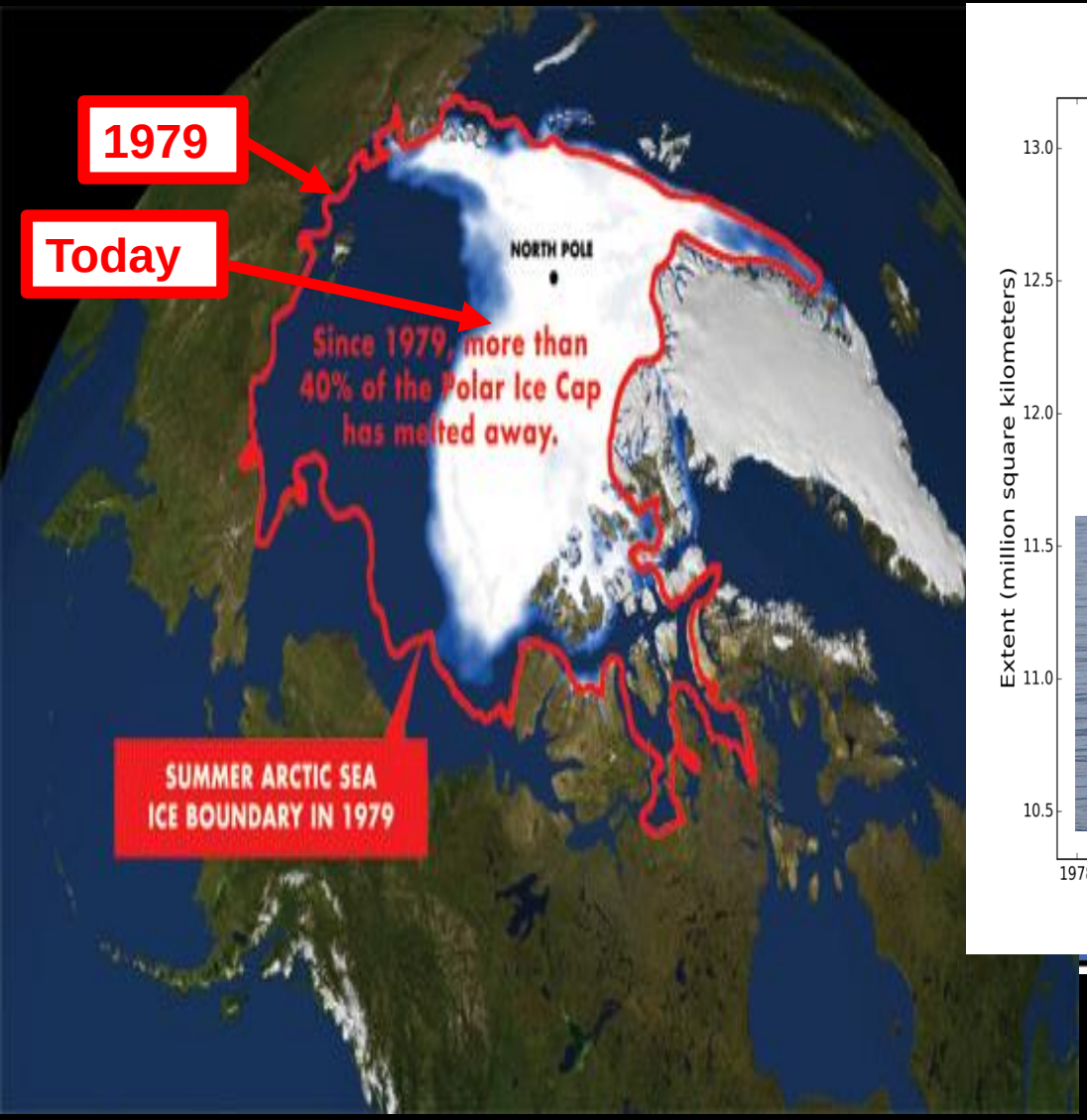


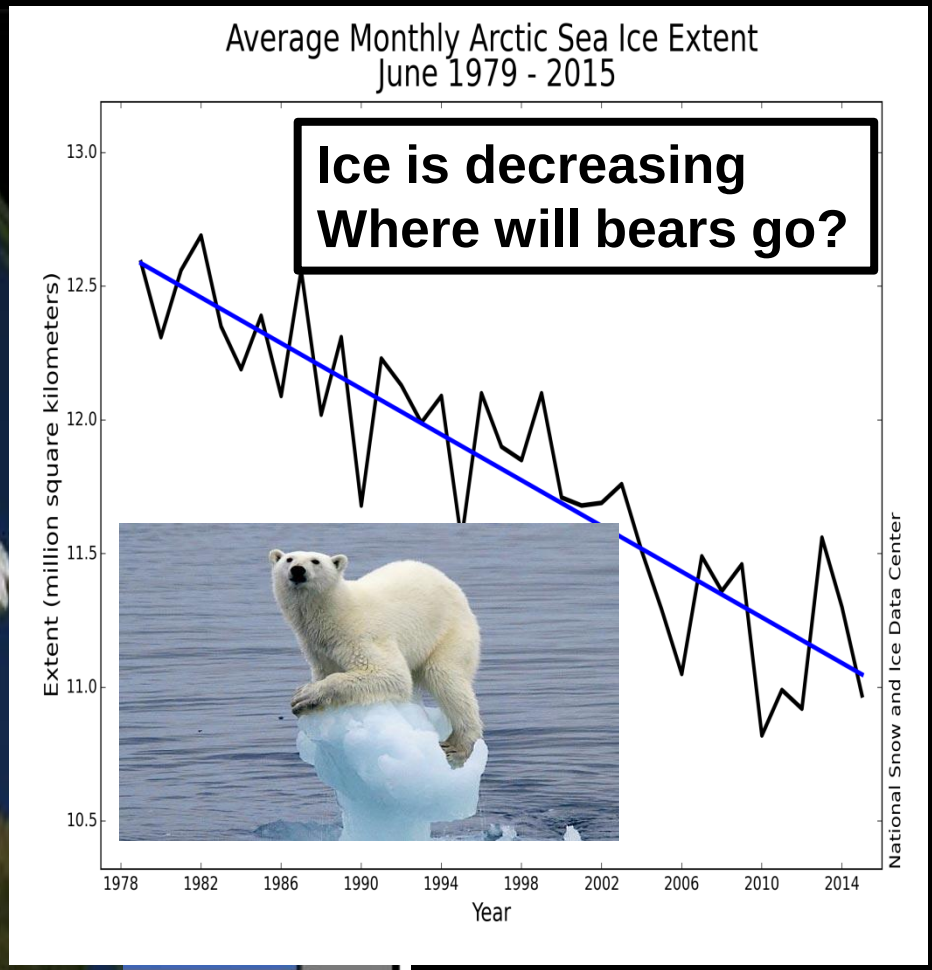
Temperature is Going Up!

Sea Level is Rising!

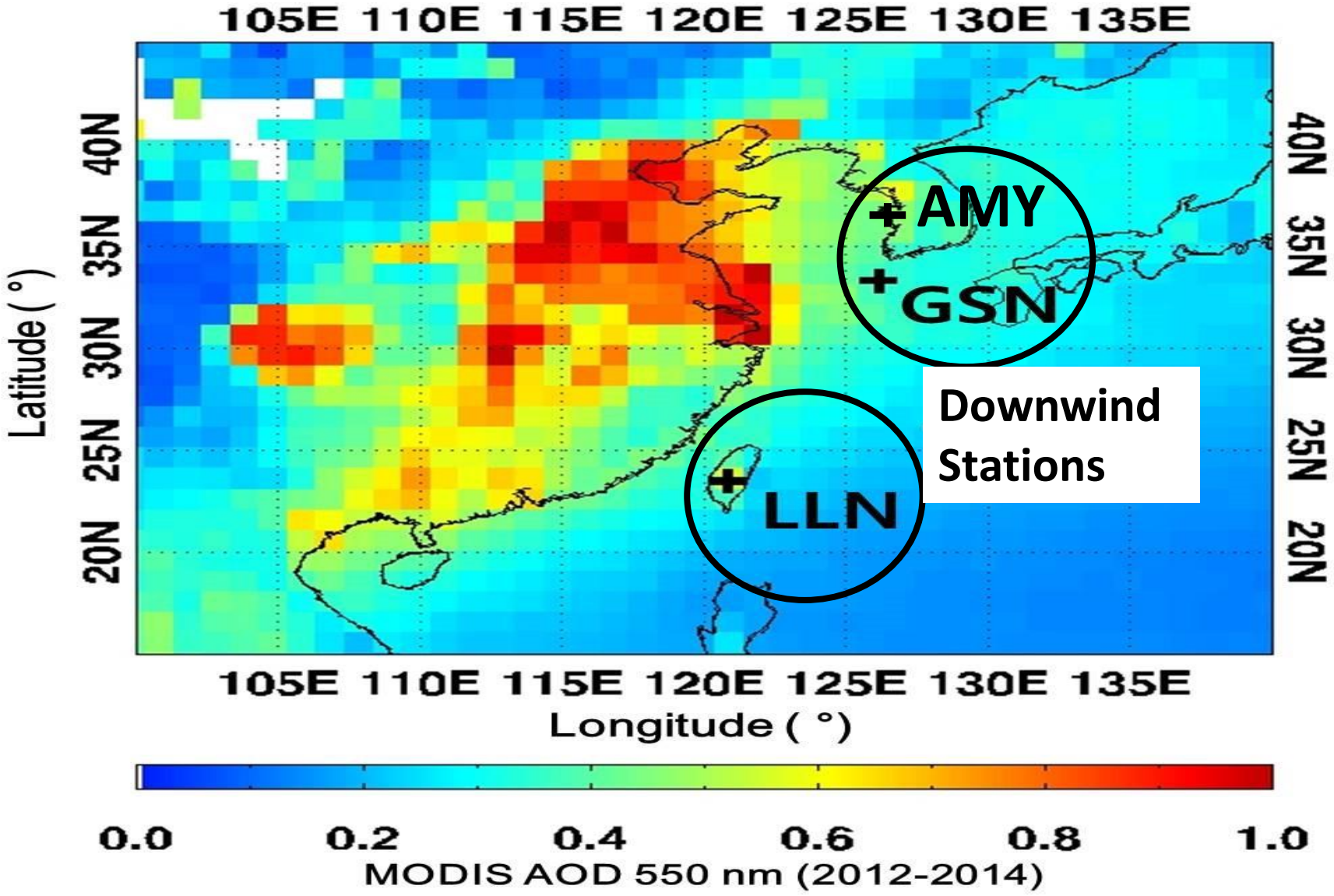
Snow Cover is Decreasing!

Summer Arctic Sea Ice Projected to Disappear by 2040?

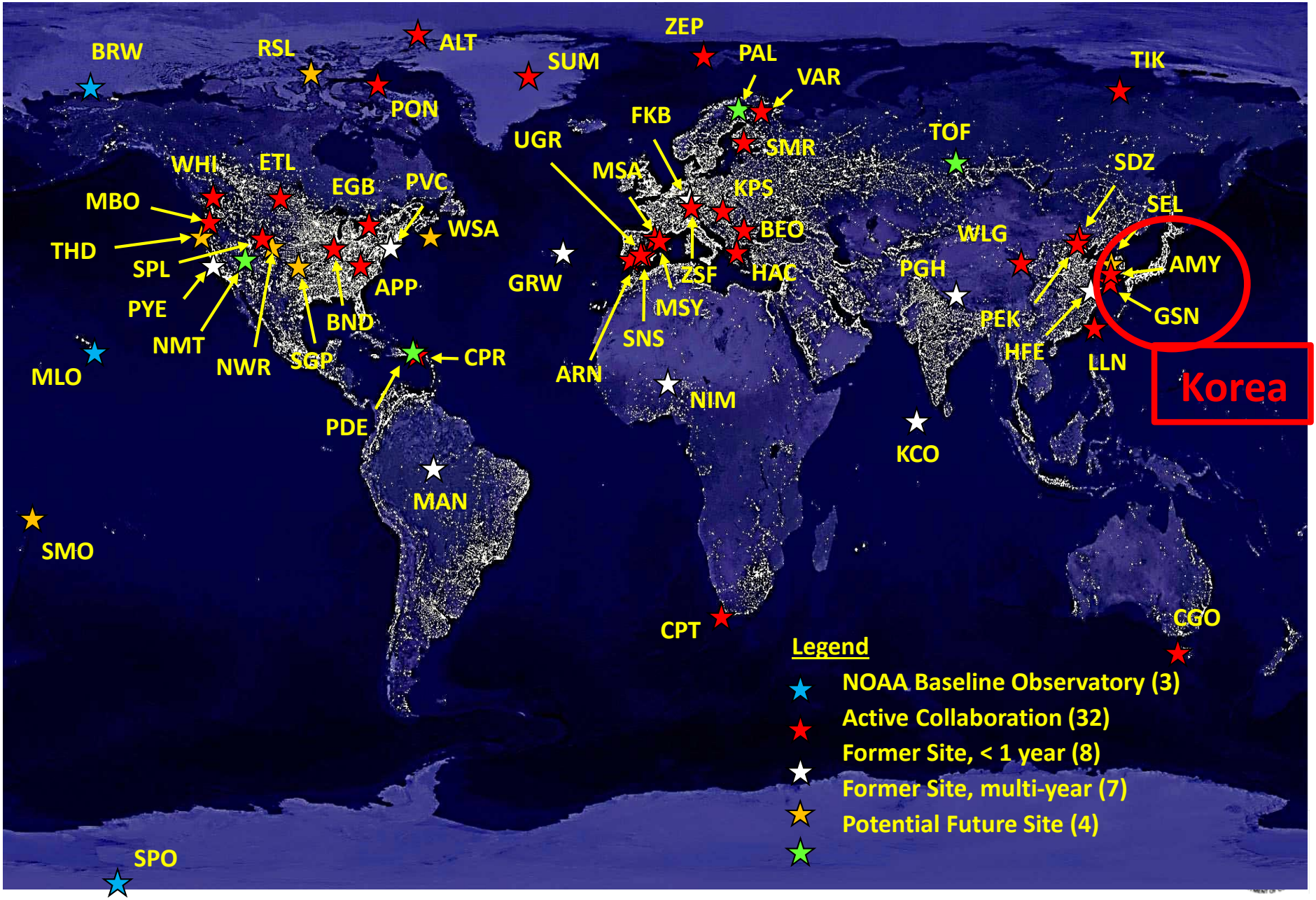




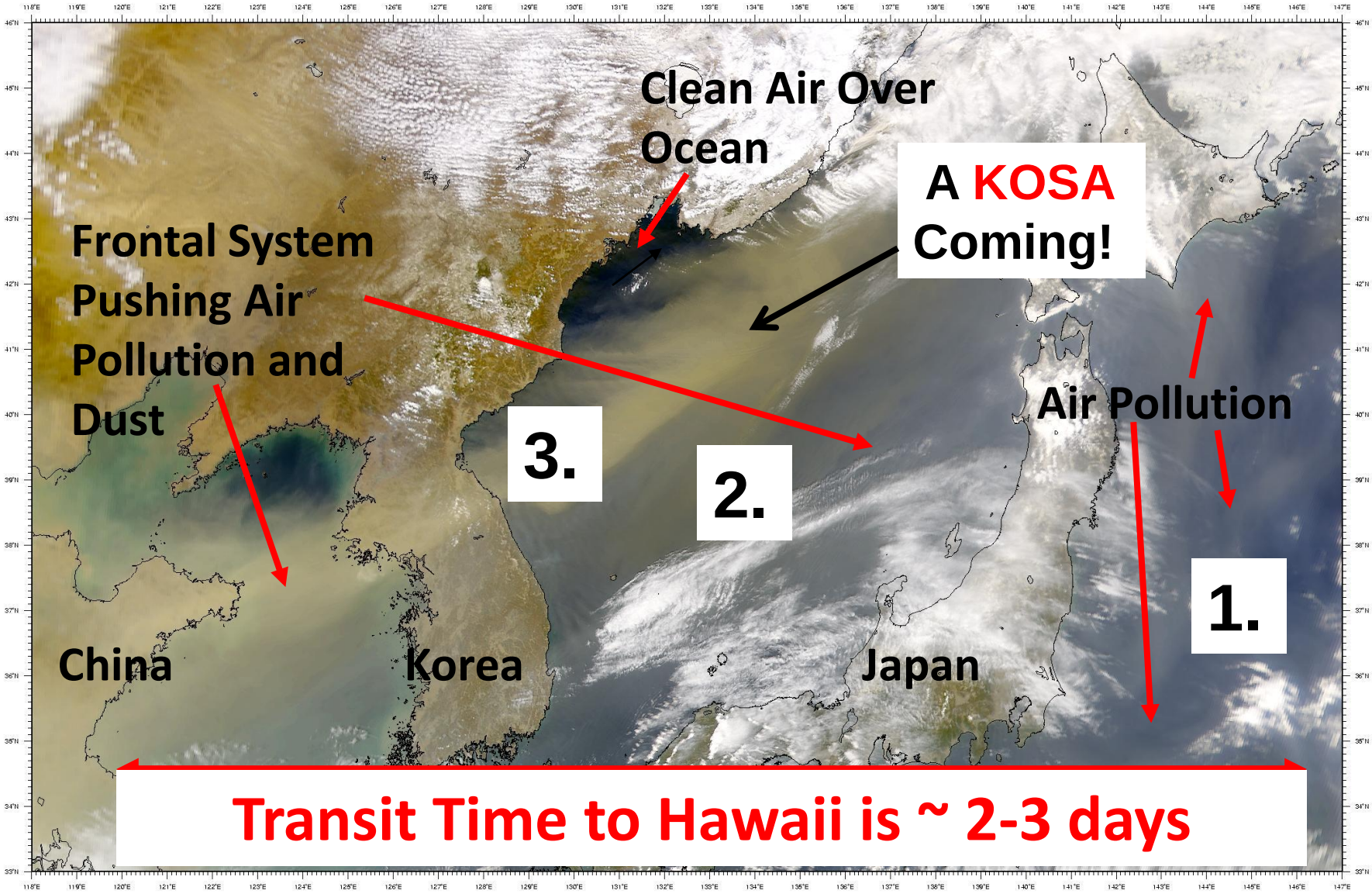
Satellite aerosol optical depth
Air pollution in China



NOAA Federated Aerosol Network



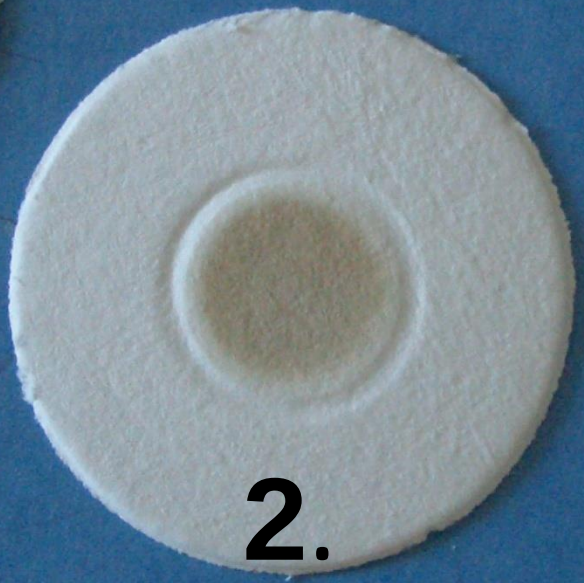
Dust and Air Pollution Out of Asia, April 2001



Mauna Loa Aerosol Samples: Passage of a Pollution/Dust Event, April 1997

1.

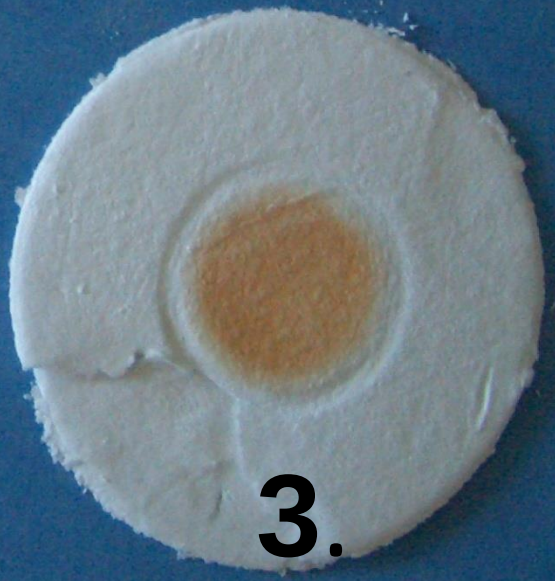
Air Pollution Pushed by the Front



2.

Air Pollution and Dust Mix

In the Dust

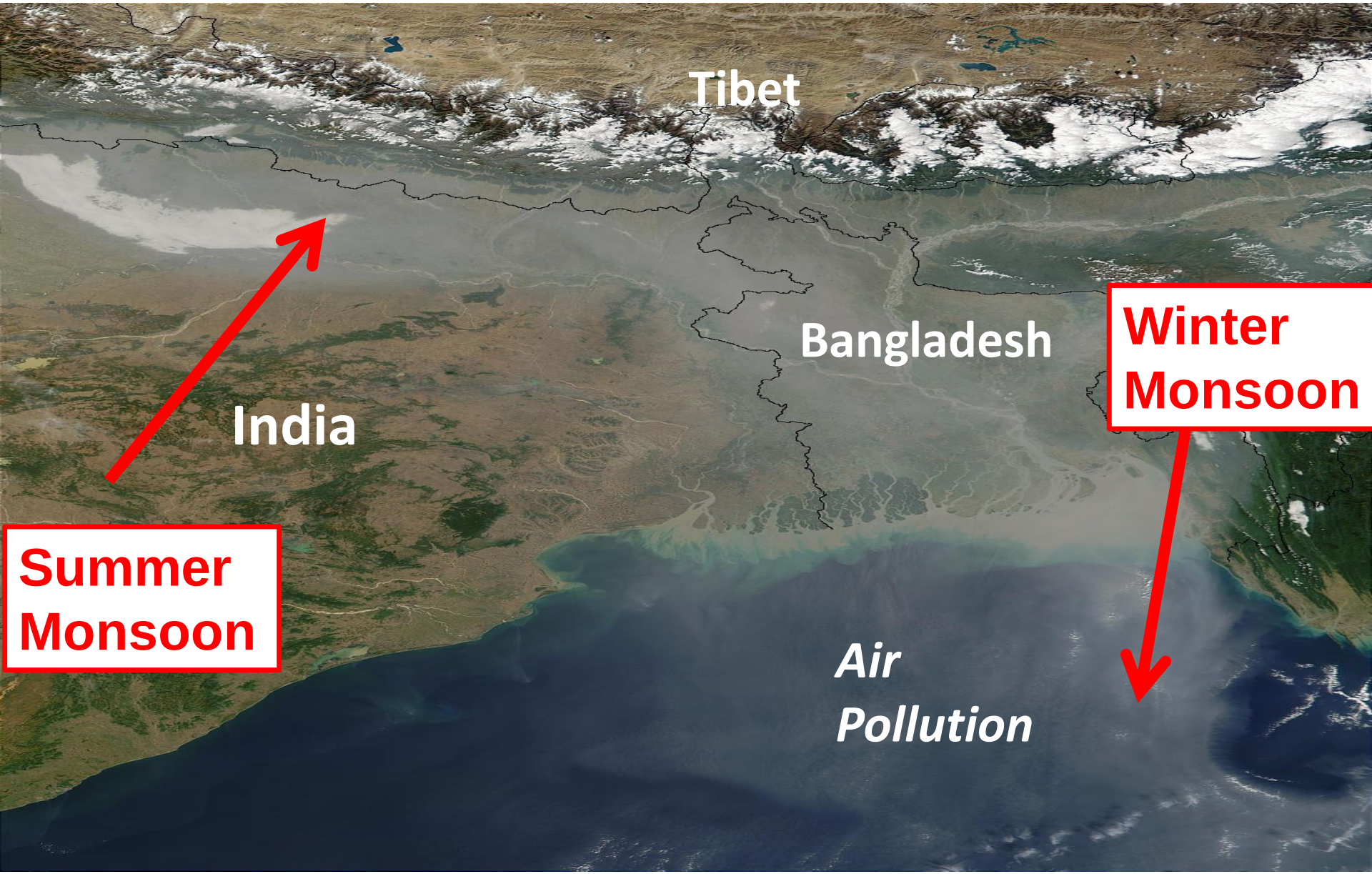


3.

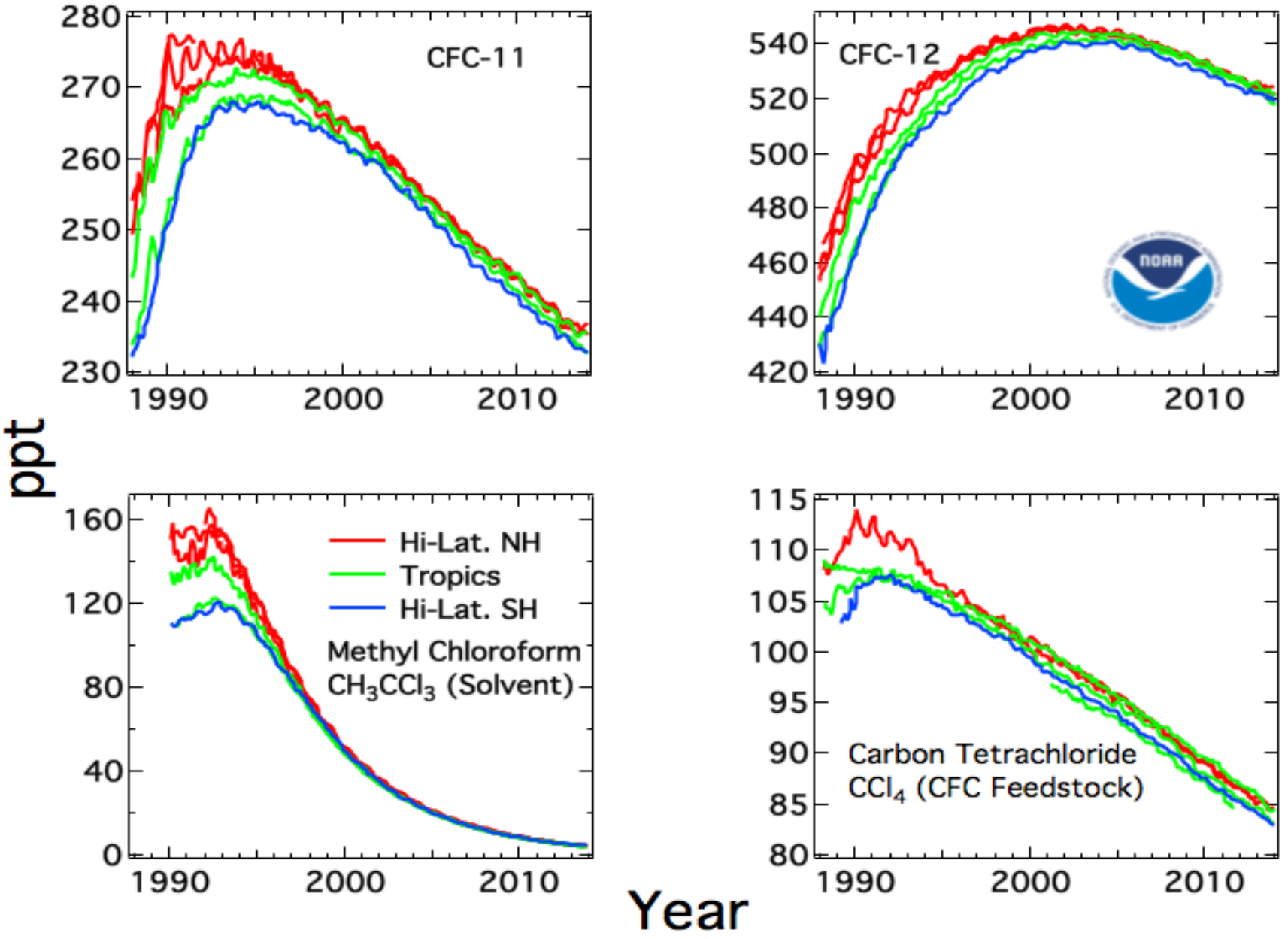
24 hour samples

South Asia: Increasingly Important

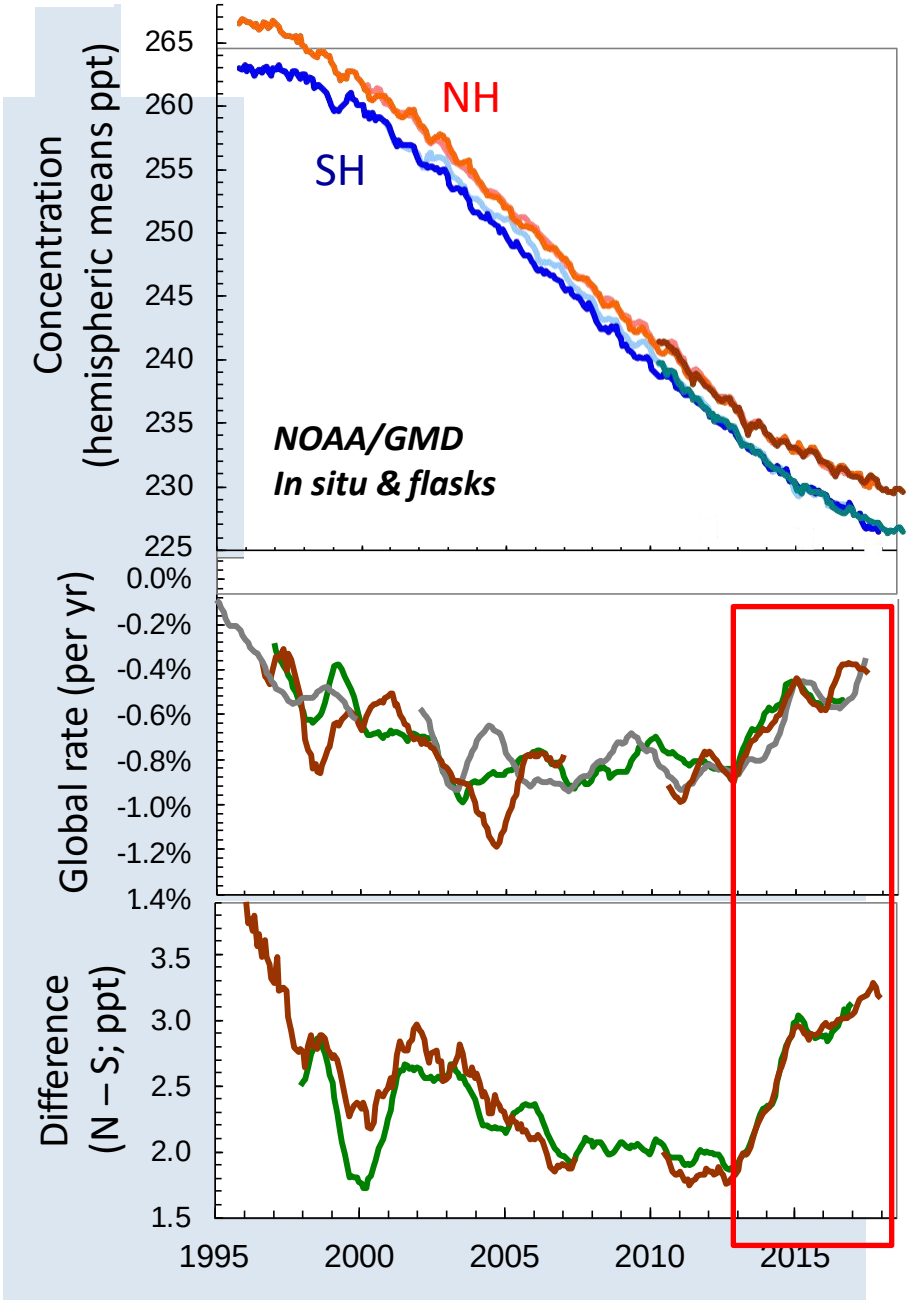
(Brown Aerosol)



Ozone Depleting Chemicals Are Decreasing



But Montreal Protocol is Being Violated!



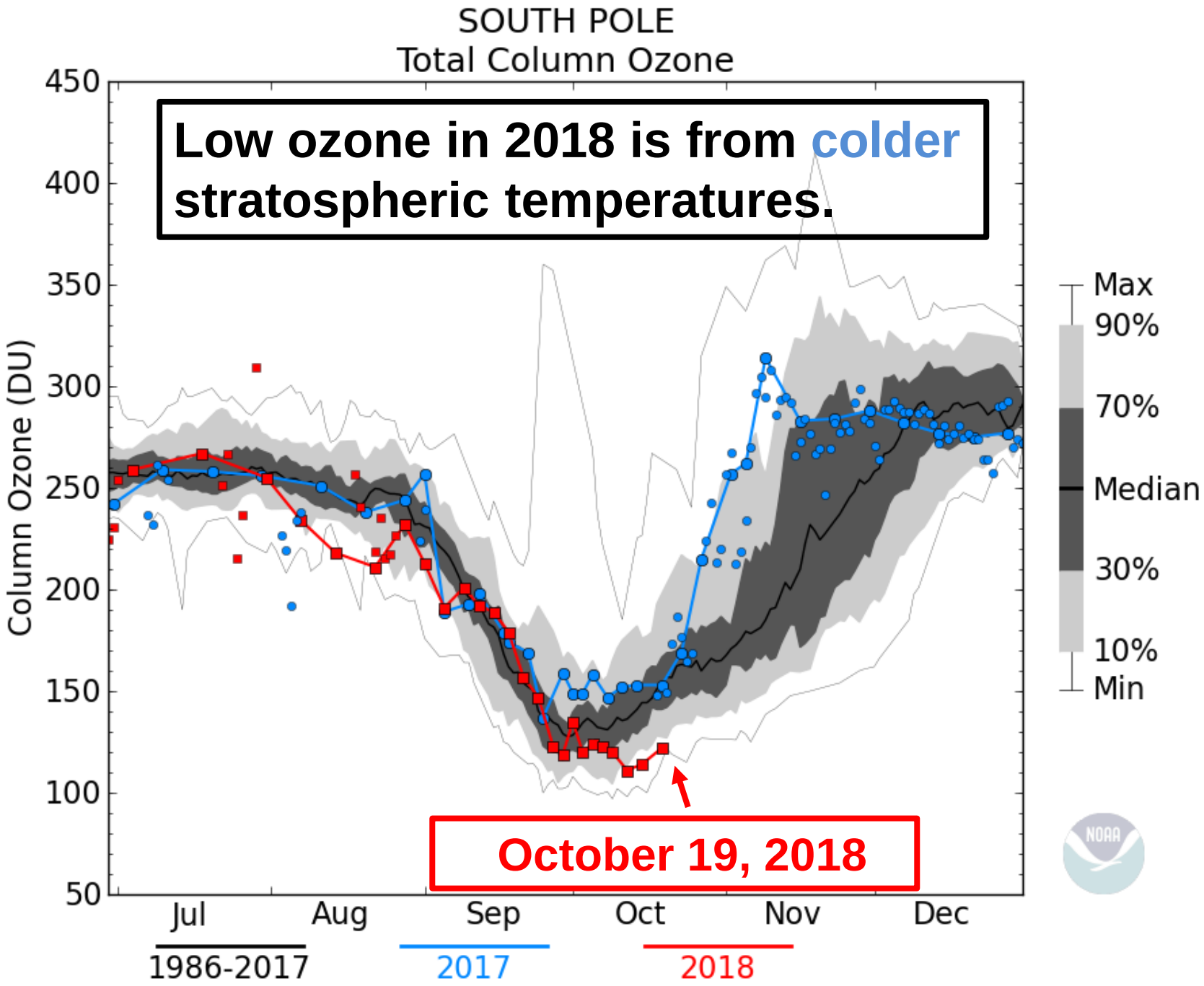
Hemispheric mean concentration.

Global rate of change.

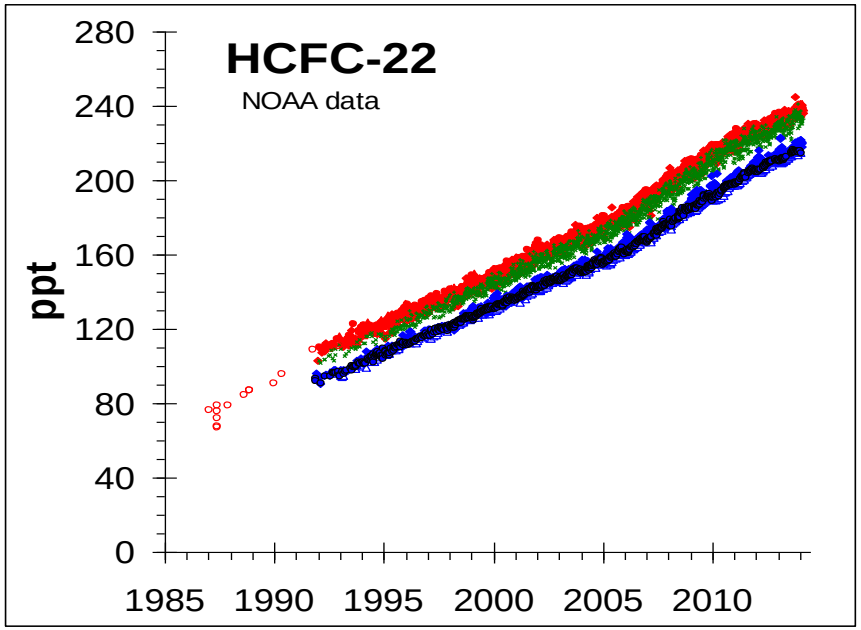
Northern minus southern hemisphere difference shows an increase in NH.

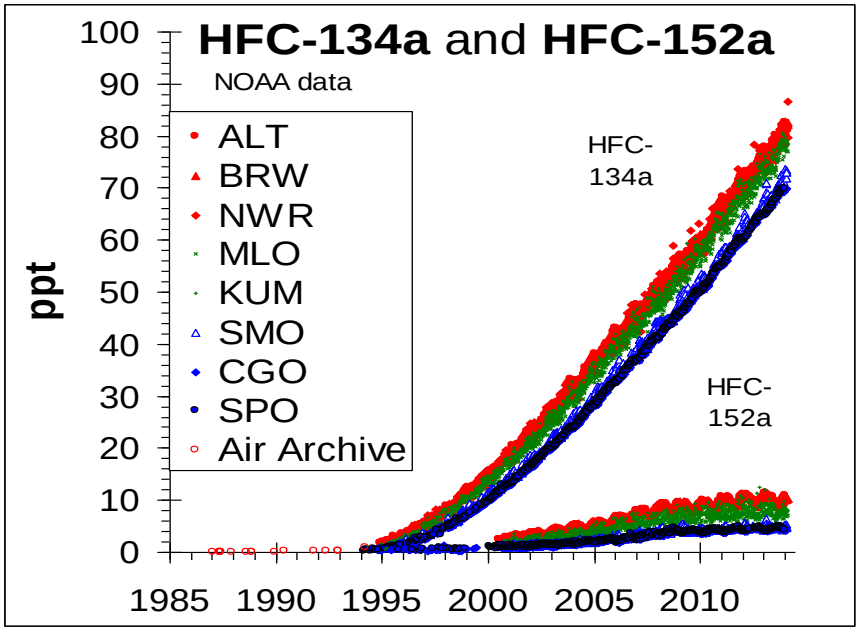
***New York Times* reporter quoting a refrigerator manufacturing company owner in China, May 2018…**

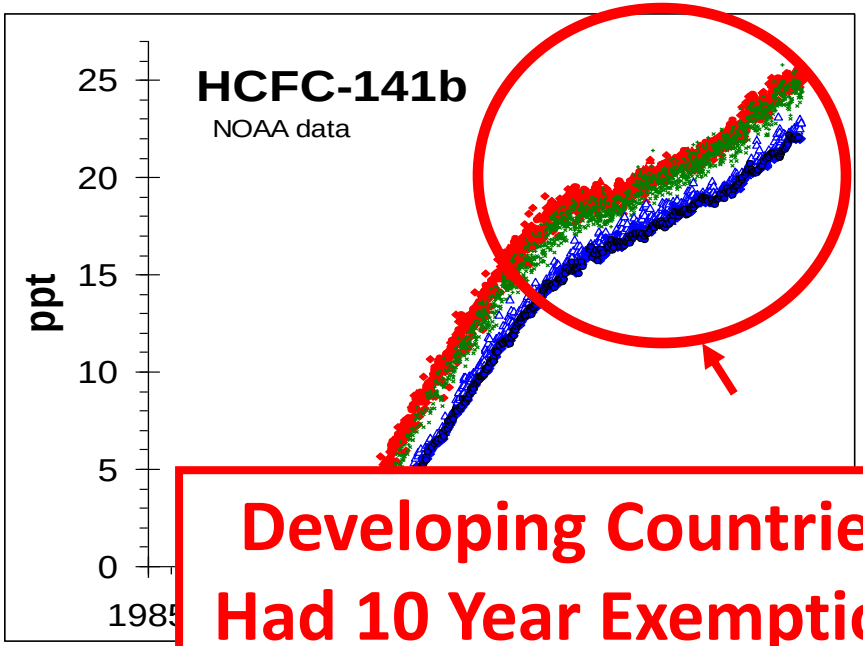
"You had a choice: Choose the cheaper foam agent that's not so good for the environment, or the expensive one that's better for the environment."

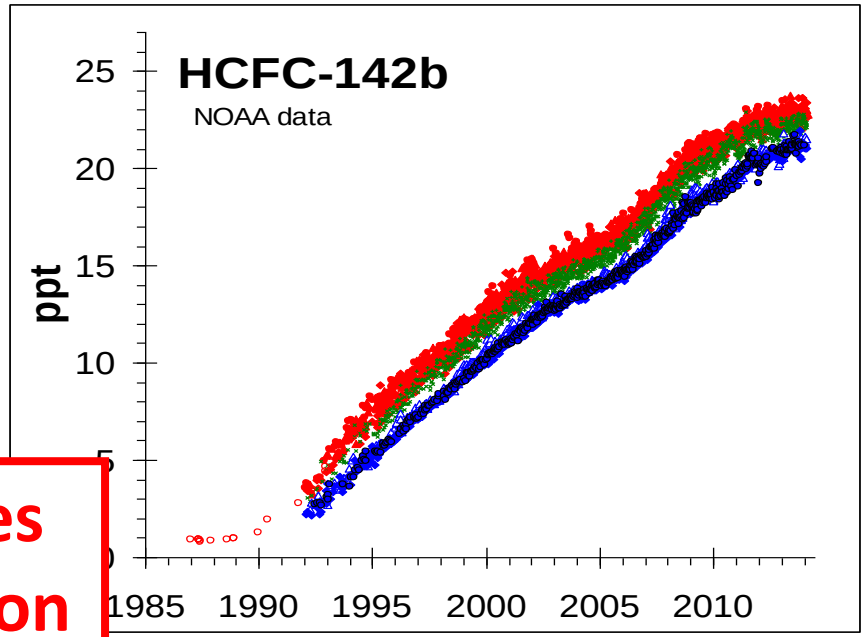

SOUTH POLE
Total Column Ozone
Low ozone in 2018 is from colder stratospheric temperatures.
Column Ozone (DU)
450
400
350
300
250
200
150
100
50
Jul
Aug
Sep
Oct
Nov
Dec
1986-2017
2017
2018
October 19, 2018
Max
90%
70%
Median
30%
10%
Min
NOAA

CFCs Replacements are Increasing



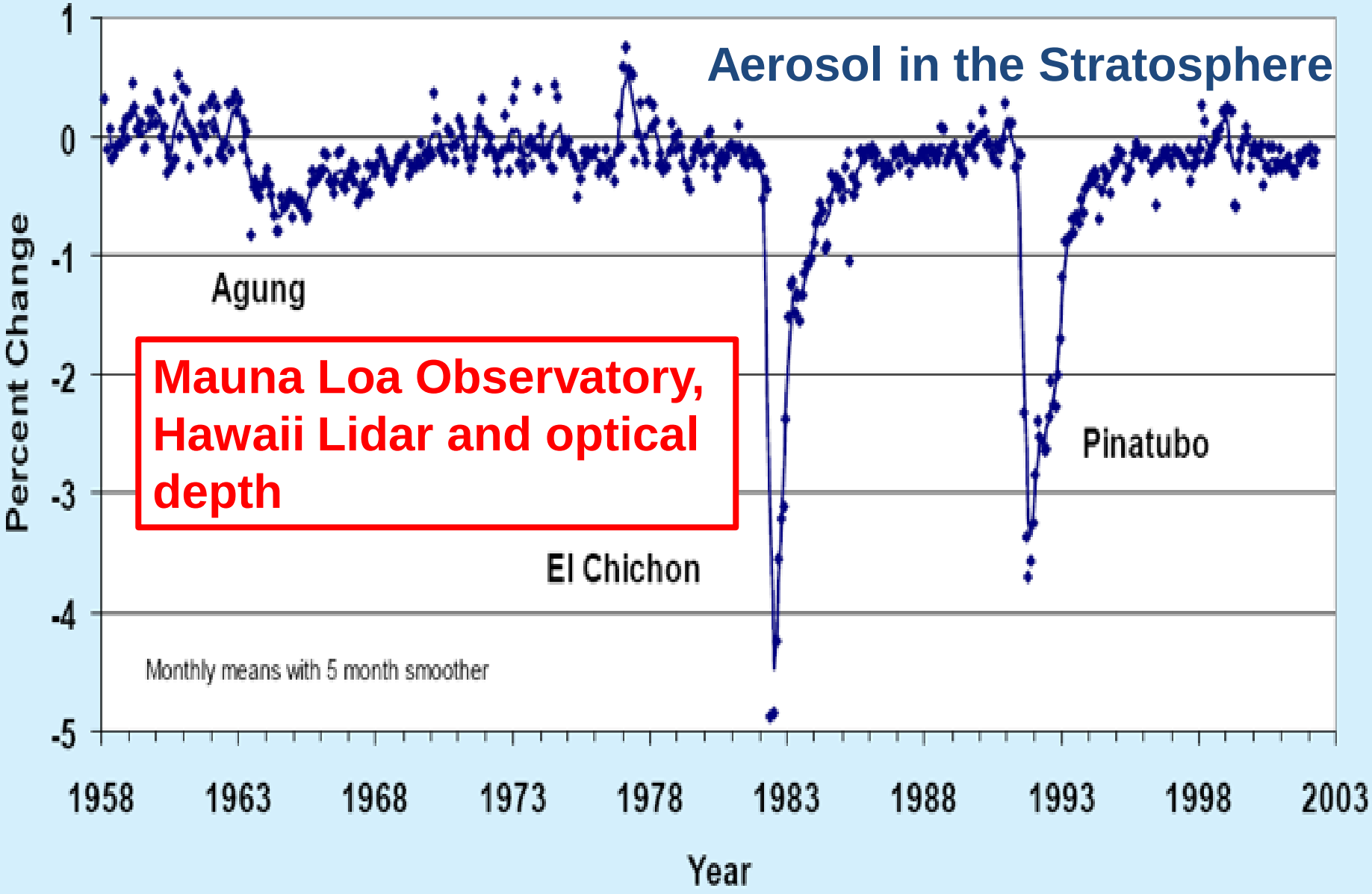






Developing Countries Had 10 Year Exemption

Solar Energy Reduced by Volcanic Eruptions



Some Energy and Climate Facts

- In U.S. we eat ~ 2400 Calories/day.
- Average US citizen uses ~ 240,000 calories/day.
- For transport, cooling, heating, pumping, plowing, flying, cooking, lighting, freezing etc.
- Like having ~100 servants working all day for you.
- Most energy comes from oil, coal and natural gas.
- Asia uses ~ 25% of the energy/capita compared to the U.S.

Thank You for Hanging in Until the

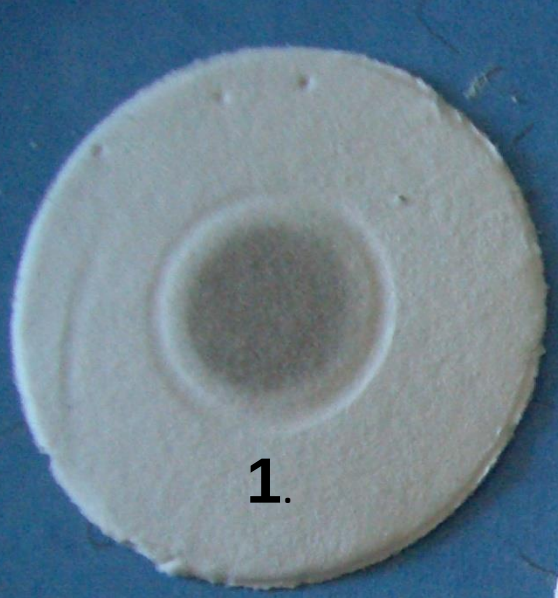
END!

Launching a Water Vapor/Ozone Package at Summit, Greenland (in the dark, -60C)

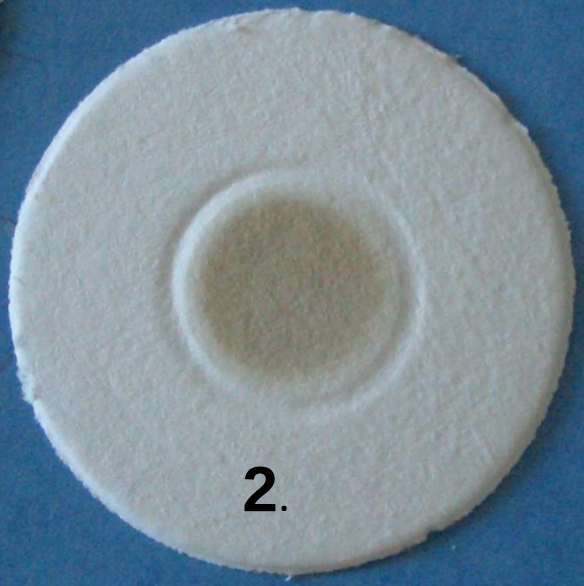
Cherskiy, Russia Tundra CH_4 Measurements

(Began Summer 2008)

Mauna Loa Aerosol Samples: Passage of a Pollution/Dust Event, April 1997

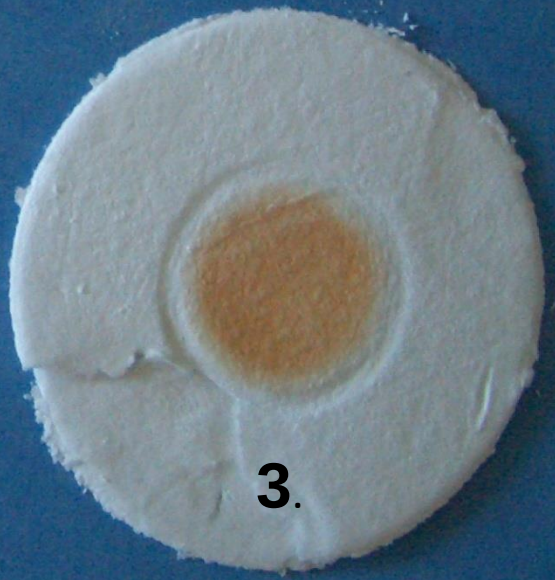


Air Pollution Pushed by the Front

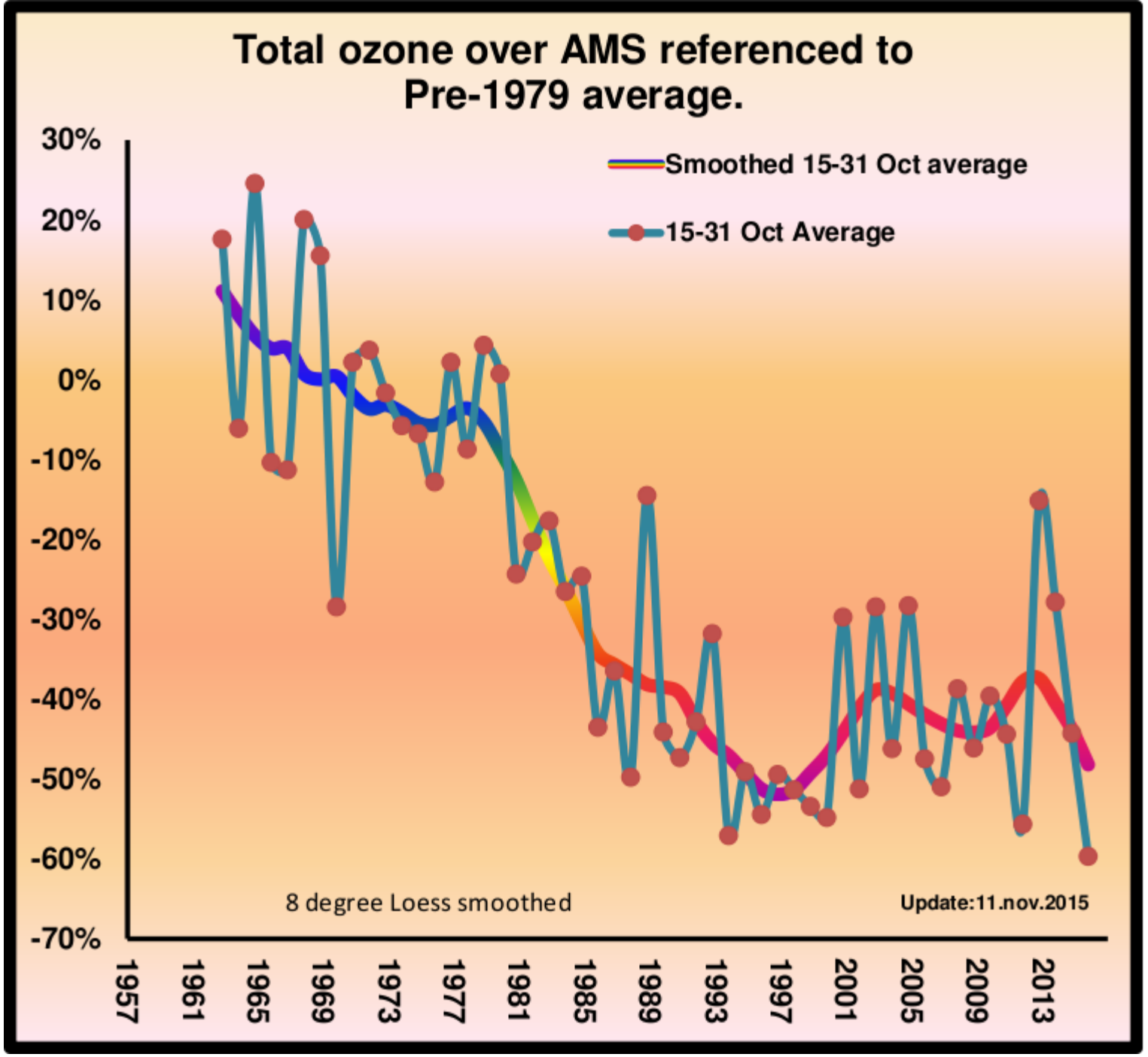


Air Pollution and Dust Mix

In the Dust

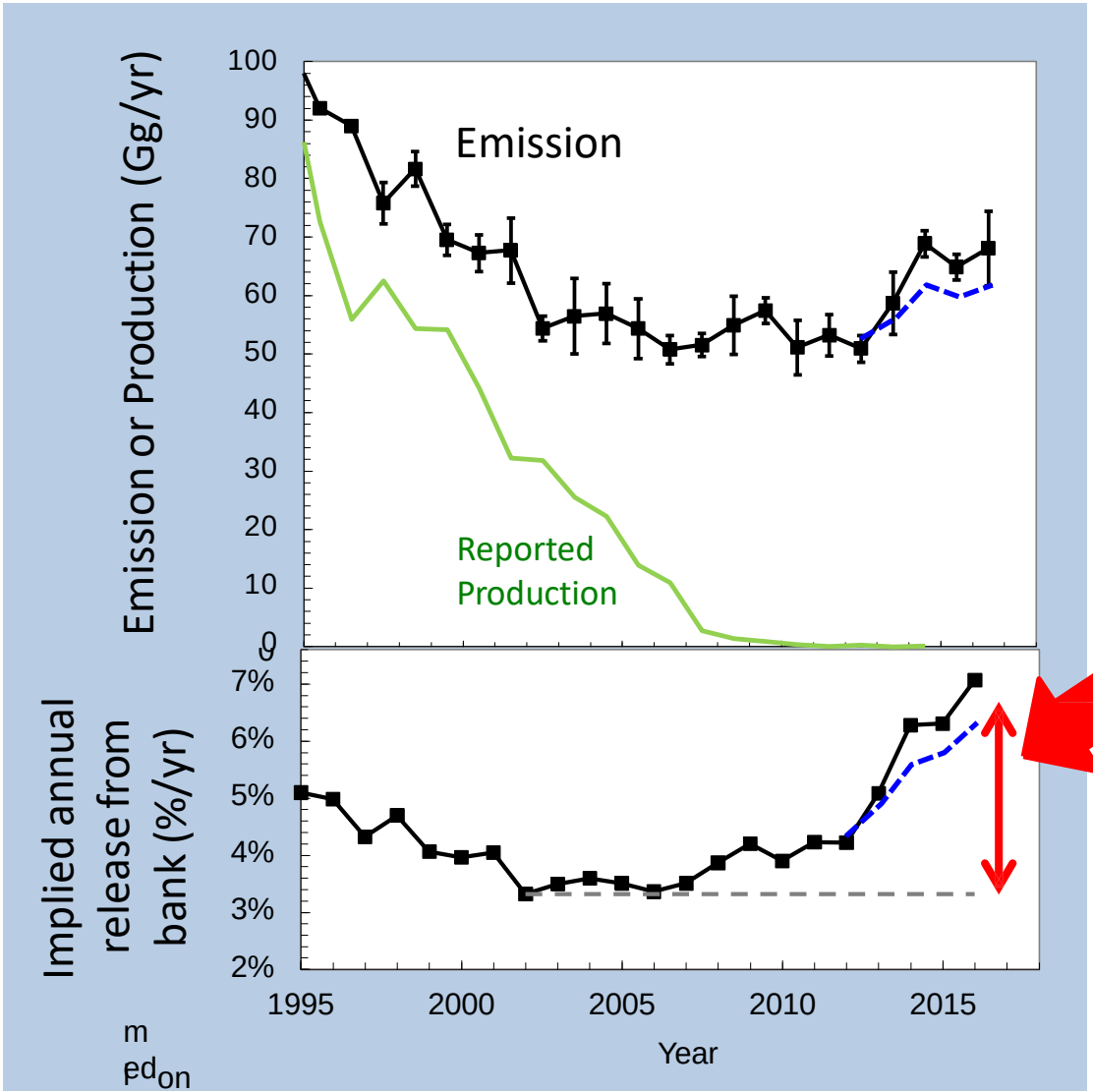


24 hour samples


Total ozone over AMS referenced to Pre-1979 average.
Smoothed 15-31 Oct average
15-31 Oct Average
30%
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
1957
1961
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
2013
8 degree Loess smoothed
Update:11.nov.2015

Is the Montreal Protocol being violated?

Are the 'increased' emissions from 'new' production?

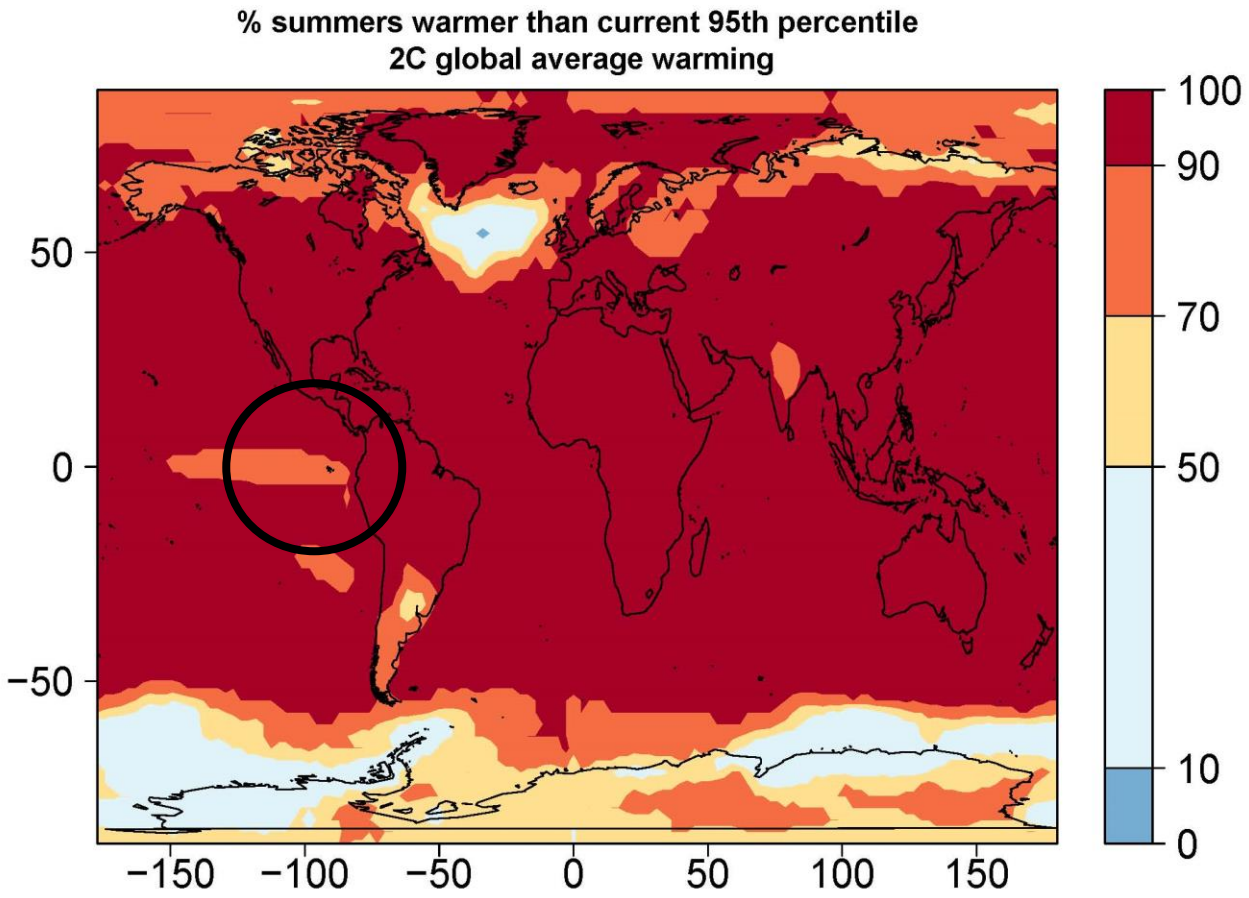


OR: Could a change in the escape rate of CFC-11 from the "bank" account for the increased emission?

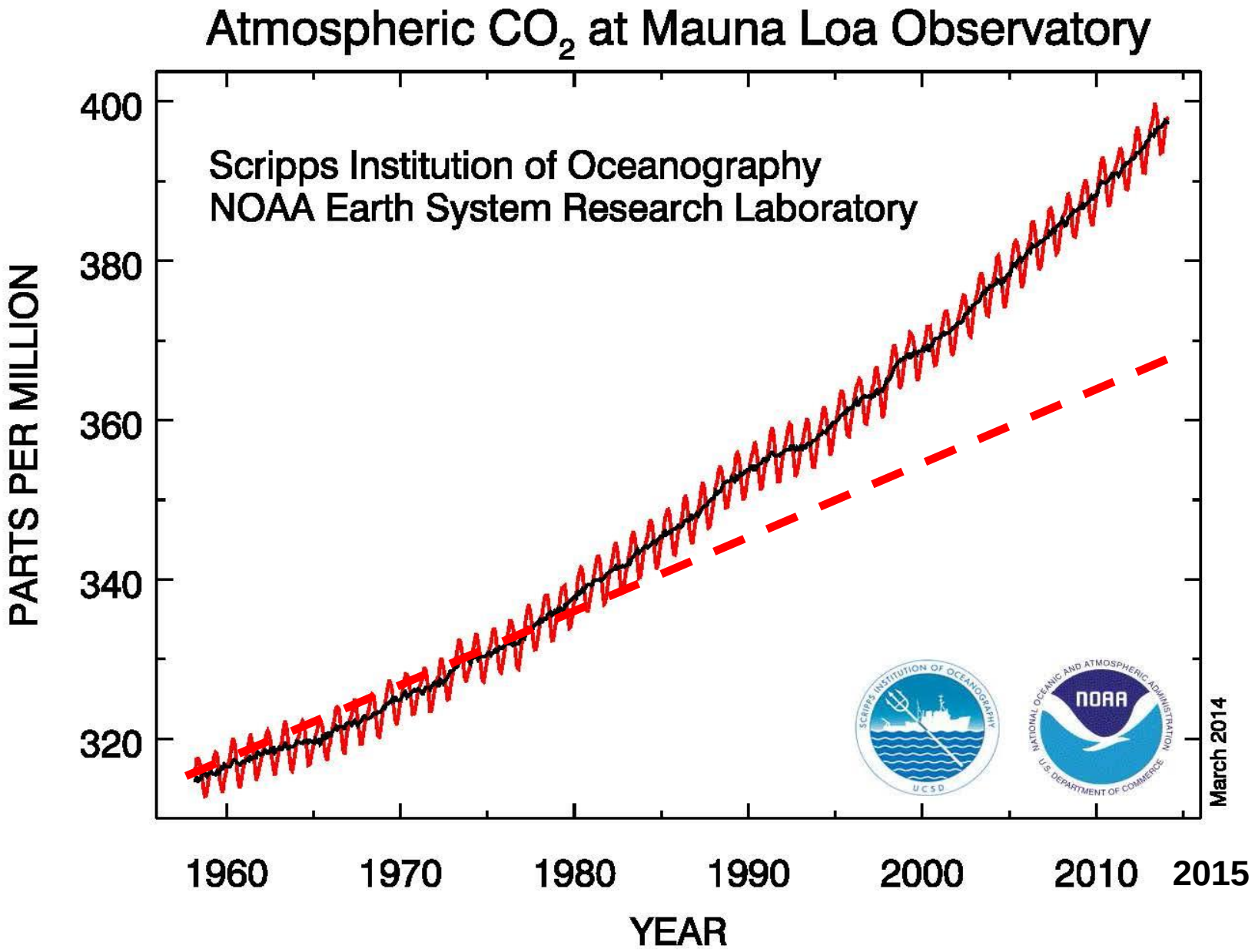
With no new production, the escape rate from the 'bank' would have had to double…

→ this seems highly unlikely

Very Hot Summers

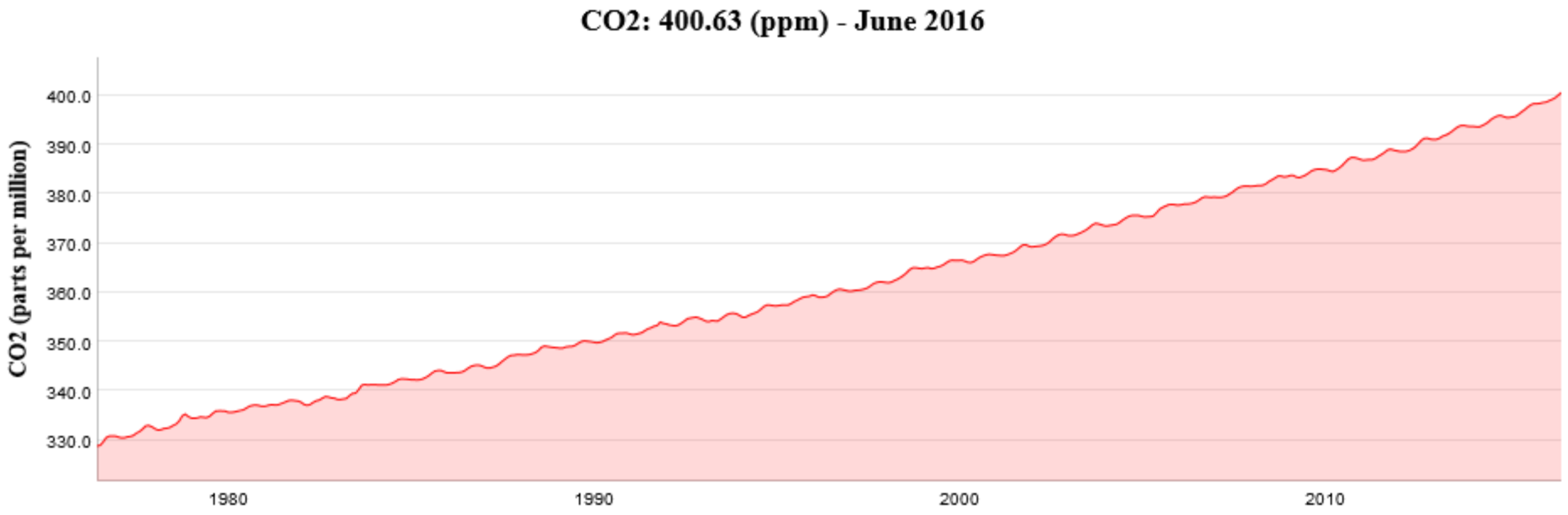


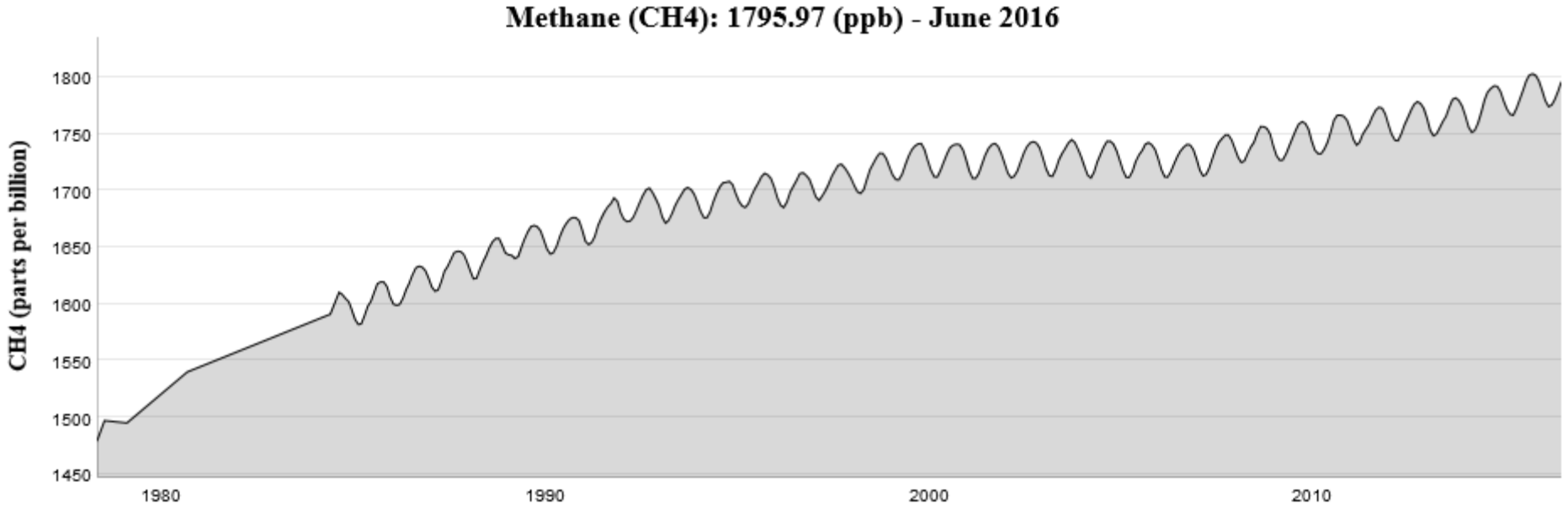
Almost every future summer as hot or hotter than the hottest people today have experienced.


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
2015
YEAR
March 2014

Cape Grim, Tasmania, Atmospheric Observatory

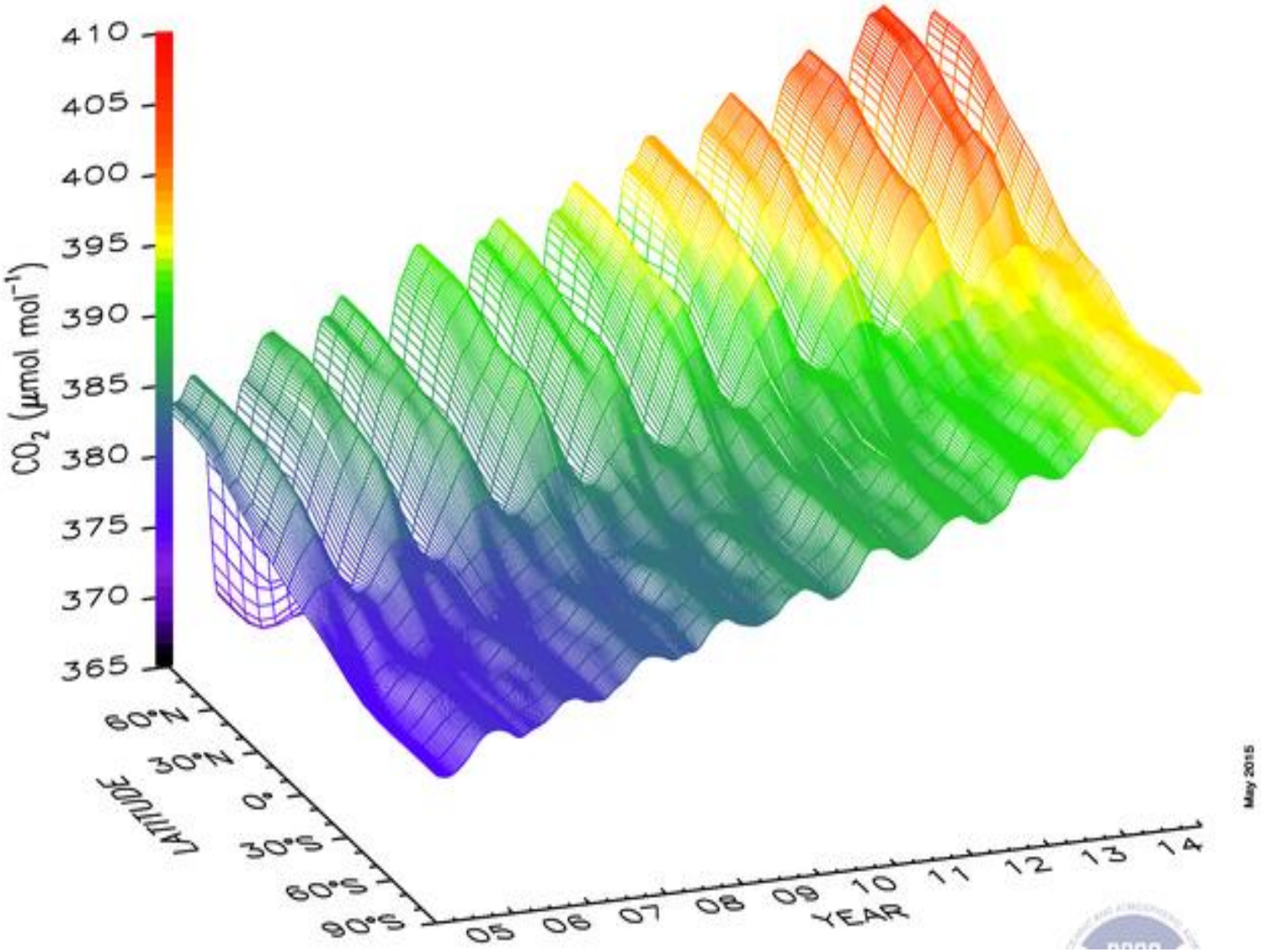
CO_2 and CH_4 at Cape Grim, Tasmania

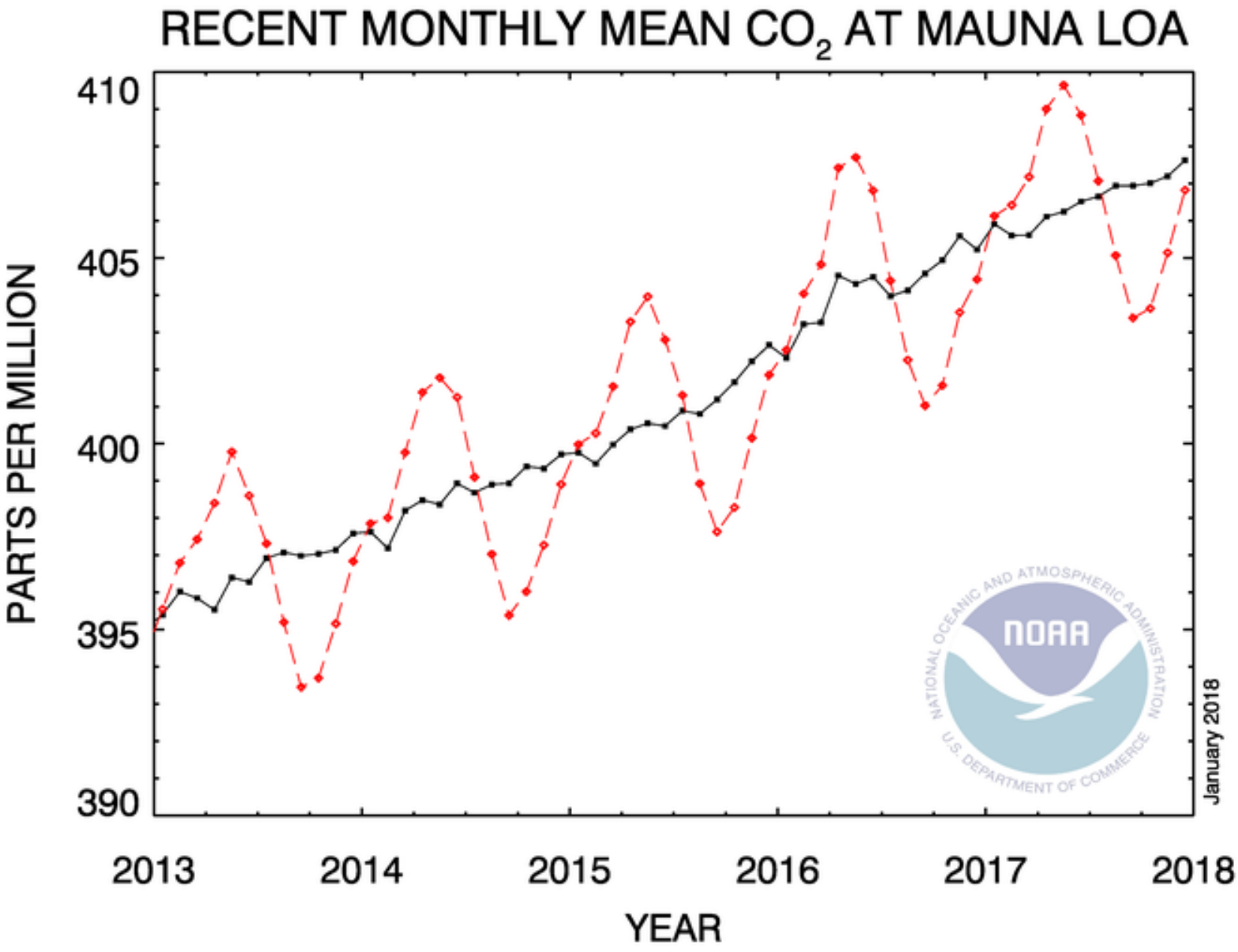


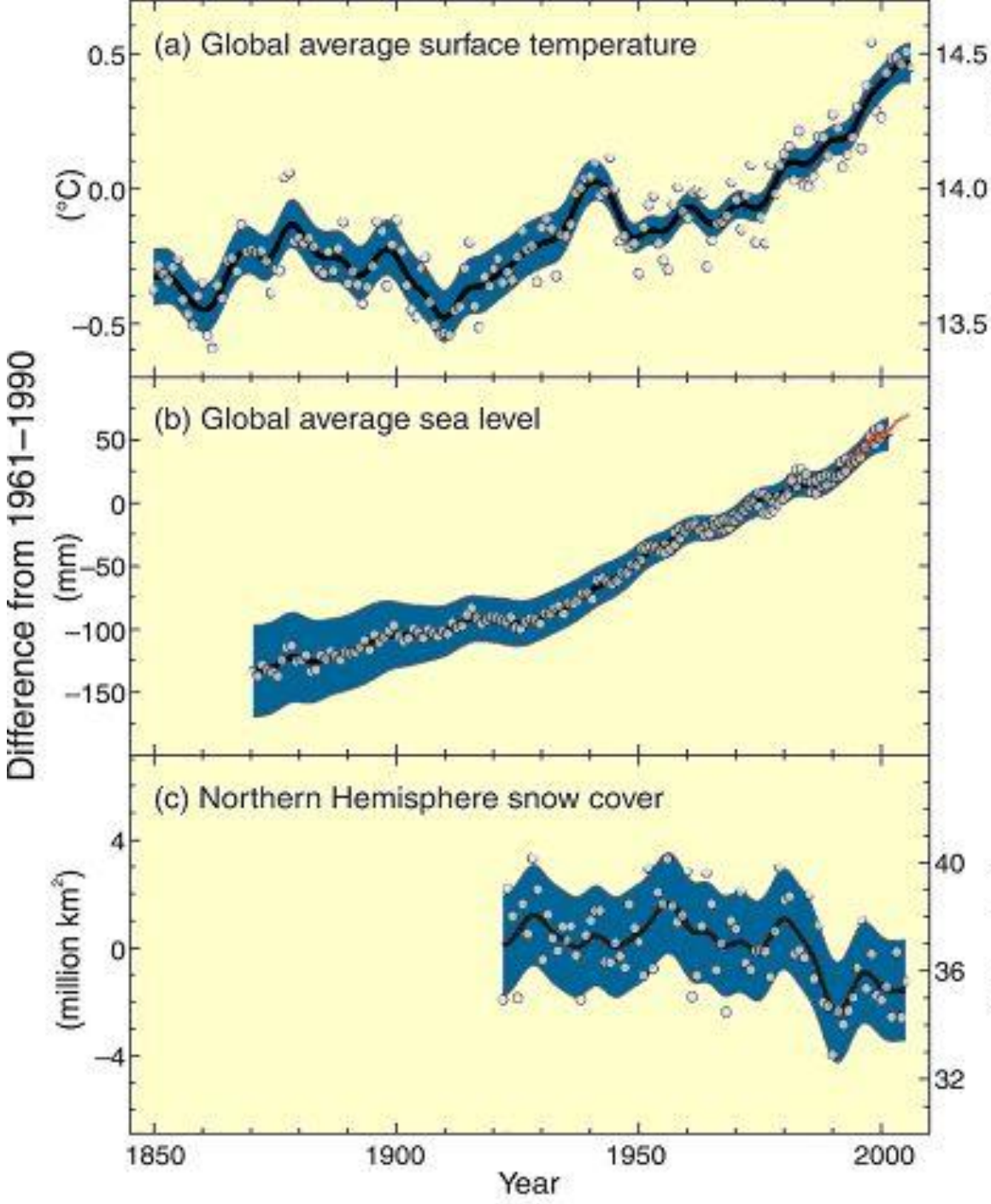


Global Distribution of Atmospheric Carbon Dioxide

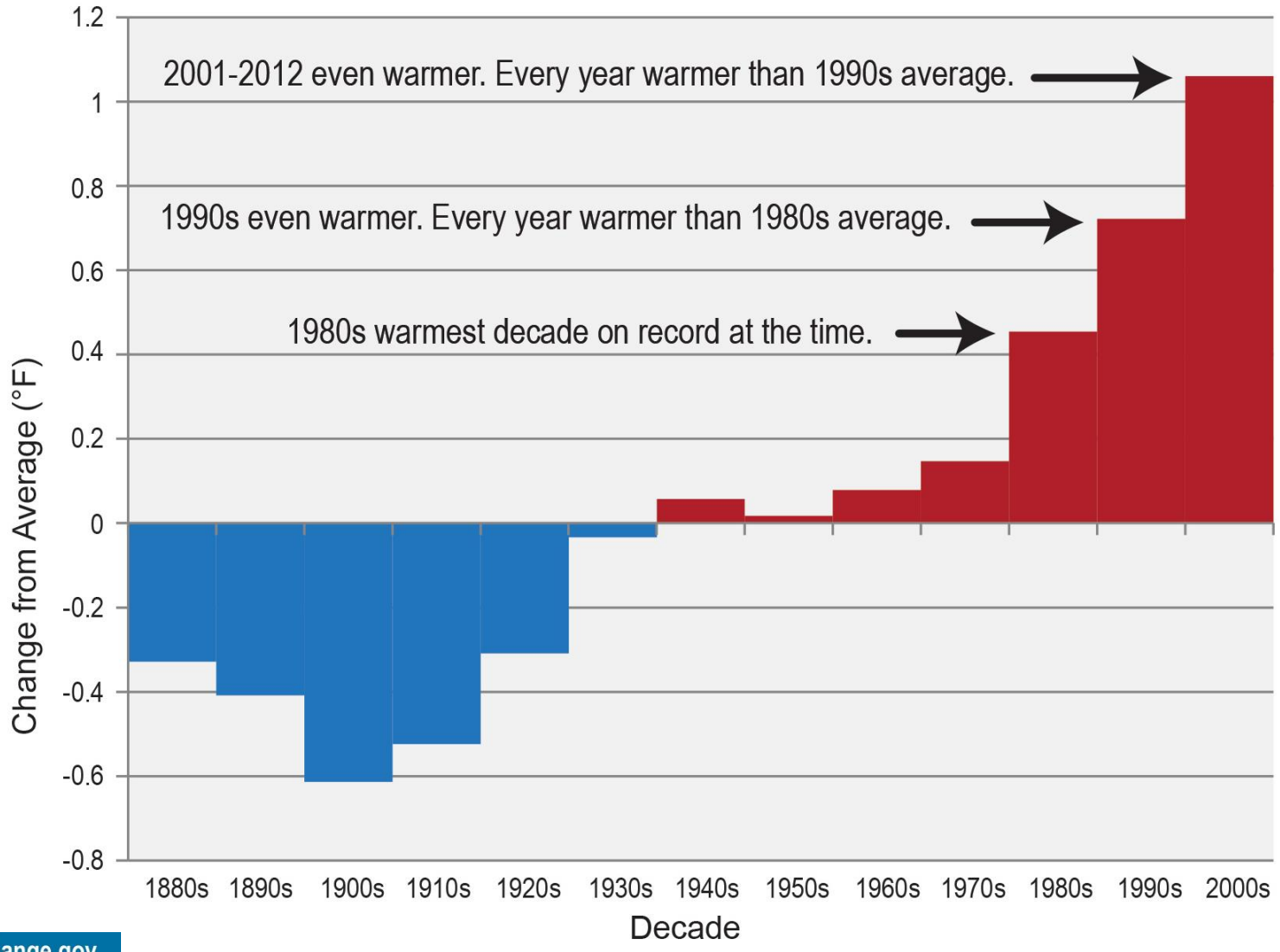
NOAA ESRL Carbon Cycle




RECENT MONTHLY MEAN CO2 AT MAUNA LOA
PARTS PER MILLION
410
405
400
395
390
2013
2014
2015
2016
2017
2018
YEAR
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
January 2018


(a) Global average surface temperature
(°C)
0.5
0.0
–0.5
14.5
14.0
13.5
(b) Global average sea level
(mm)
50
0
–50
–100
–150
(c) Northern Hemisphere snow cover
(million km²)
4
0
–4
40
36
32
Difference from 1961–1990
1850
1900
1950
2000
Year

Global Temperature Change by Decade



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