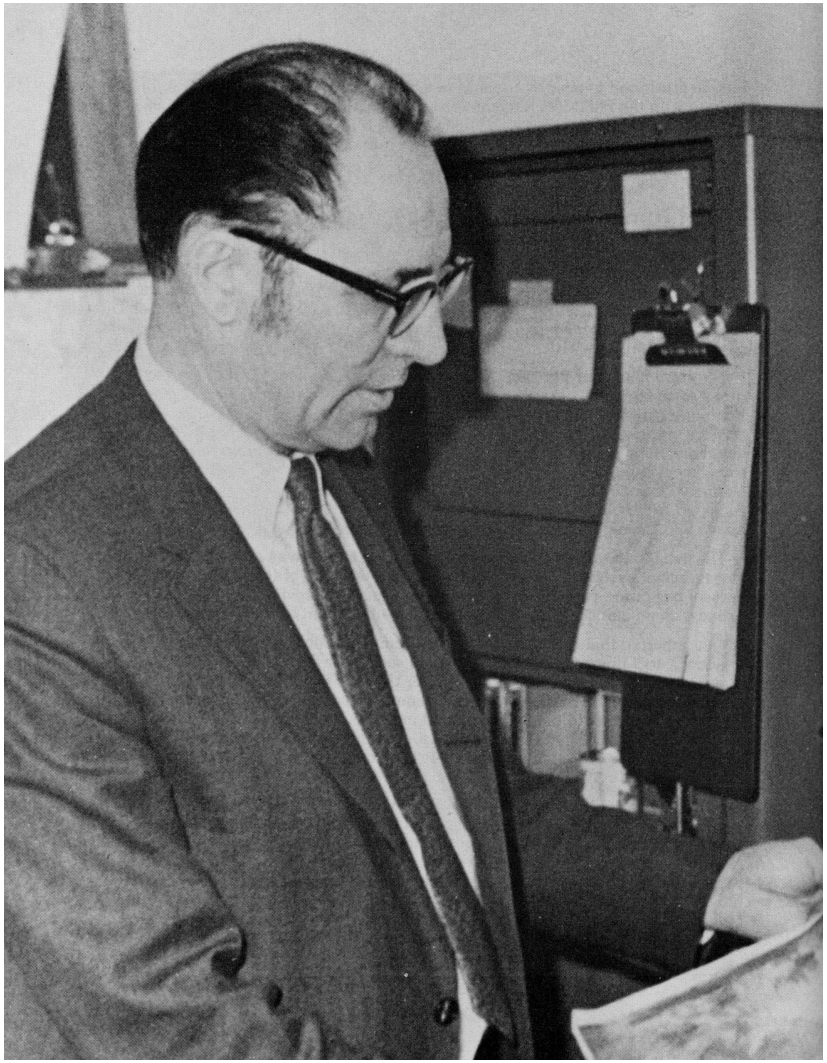
THE GREENHOUSE EFFECT AND YOUR FAMILY'S CONTRIBUTION TO IT



Stephen E. Schwartz

BROOKHAVEN NATIONAL LABORATORY

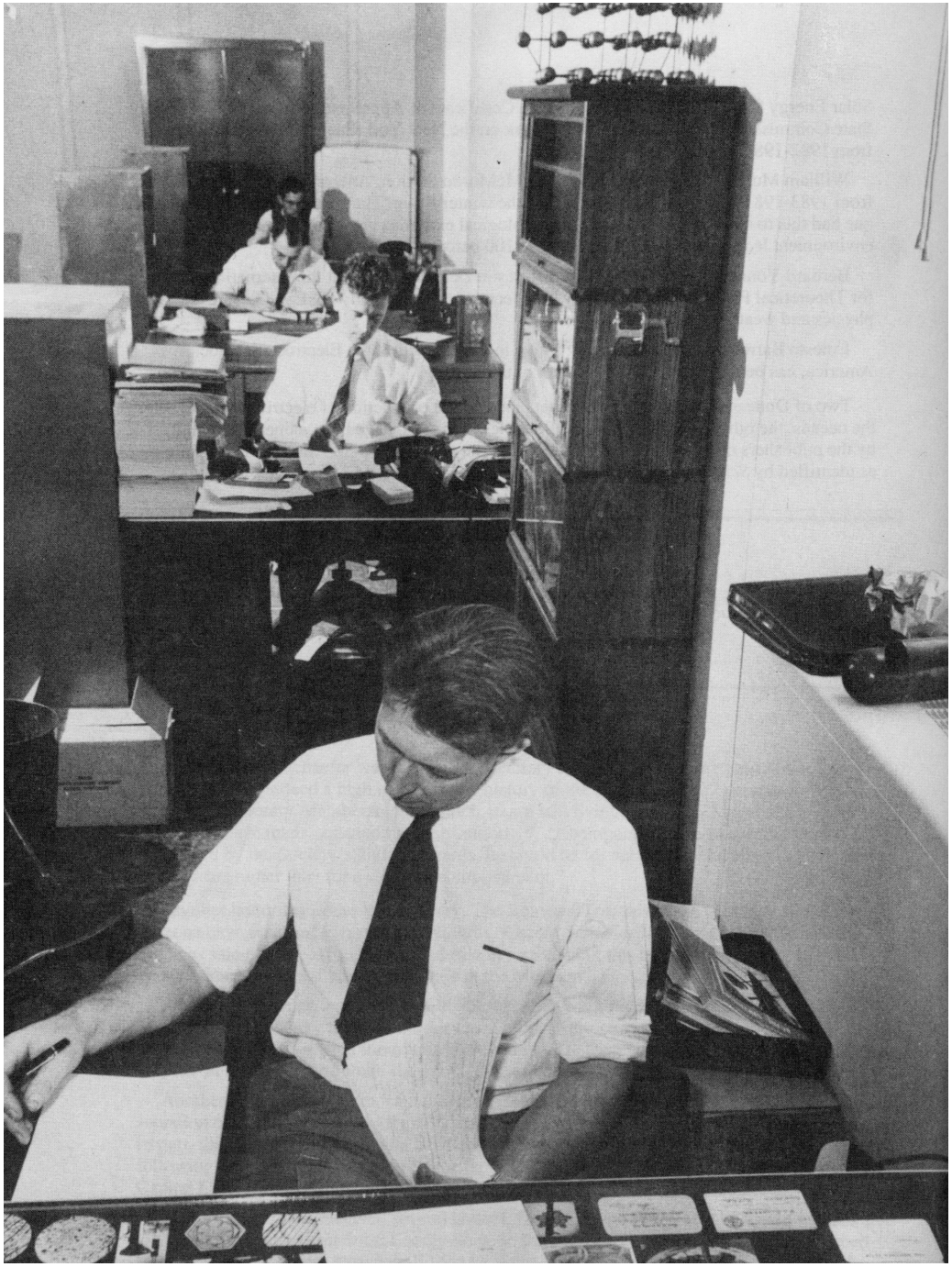
Falconer Natural History Lecture

Atmospheric Sciences Research Center

The University at Albany

April 18, 2006

www.ecd.bnl.gov/steve



Blanchard,

Falconer,

Vonnegut and

Schaefer

General Electric

Research Laboratory

1948

TIME MAGAZINE, APRIL 3, 2006

TIME MAGAZINE, APRIL 3, 2006

www.time.com

CANADA

www.time.com

INDIA

www.time.com

INDIA

www.time.com

NEW ORLEANS

www.time.com

ALASKA

www.time.com

UPSALA GLACIER, ANDES, ARGENTINA

1928

2004

www.time.com

RETREAT OF MID-LATITUDE GLACIERS

South Cascade Glacier, Washington

1928

2000

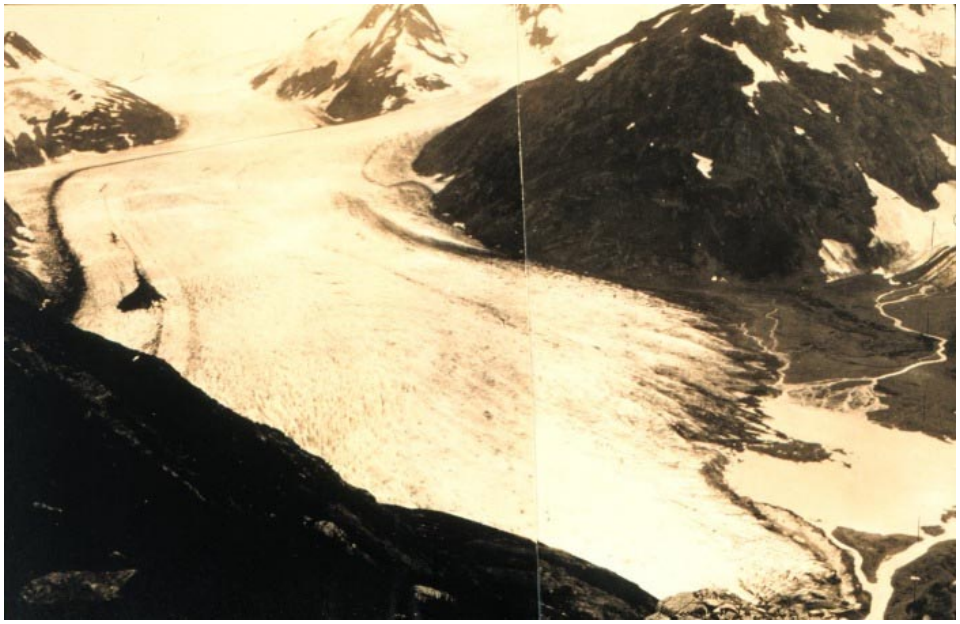
http://ak.water.usgs.gov/glaciology/south_cascade/1928-2000comparison.htm

PASTERZE GLACIER, AUSTRIA 1875 - 2004

About 2 km shorter.
Terminus replaced by artificial lake.
Decrease in length about 15 meters per year.
In 2003, decrease was 30 m in length and 6.5 m in thickness.

http://www.worldviewofglobalwarming.org/pages/glaciers.html

PORTAGE GLACIER, ALASKA 1914 - 2004



http://www.worldviewofglobalwarming.org/pages/glaciers.html

RHONE GLACIER, VALAIS, SWITZERLAND
1859 - 2001

Glacial retreat is 2.5 km.

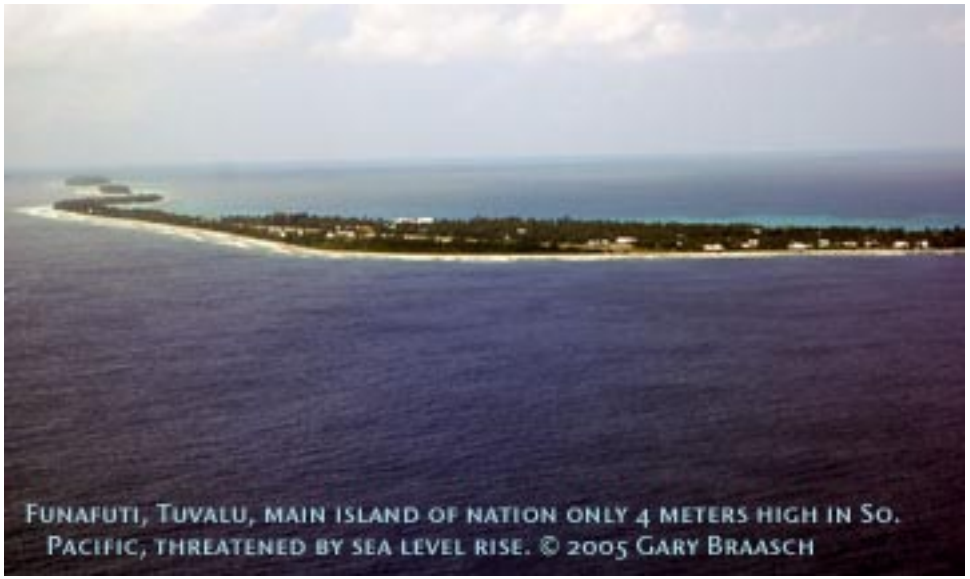
Base is 450 meters higher.

http://www.worldviewofglobalwarming.org/pages/glaciers.html

GRINNELL GLACIER
GLACIER NATIONAL PARK 1911 - 2000

http://www.worldviewofglobalwarming.org/pages/glaciers.html

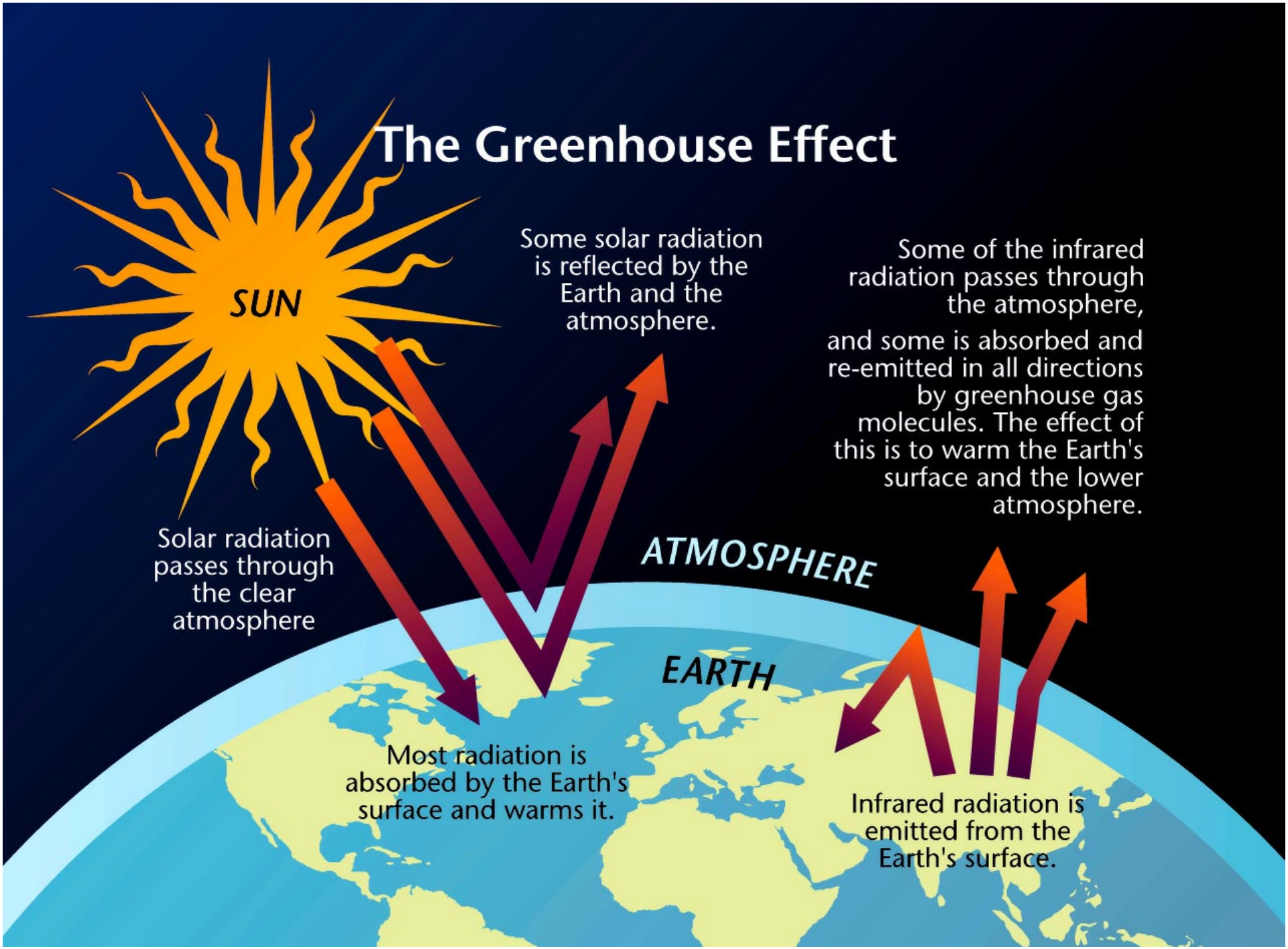
FUNAFUTI, TUVALU



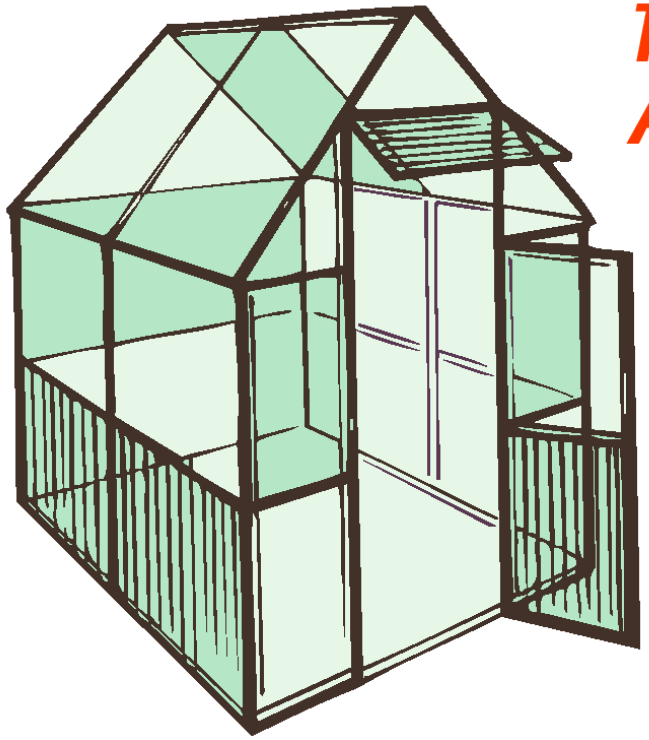
The 11,000 Tuvaluans live on nine coral atolls with typical elevation 2 meters and not exceeding 5 meters.

“Our whole culture will have to be transplanted.”

- Paani Laupepa, Former Assistant Environmental Minister
later Assistant Secretary for Foreign Affairs


The Greenhouse Effect
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere,
and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Solar radiation passes through the clear atmosphere
ATMOSPHERE
EARTH
Most radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

THE GREENHOUSE EFFECT



THE EARTH'S ENERGY BUDGET: A DELICATE BALANCE

- Sunlight heats the Earth.
- The warm Earth radiates energy (in the form of infrared radiation, or heat) back out to space.
- Some of this infrared radiation is trapped in the atmosphere, giving Earth its temperate climate.

This is the greenhouse effect. Without it, the Earth's climate would be like the moon's, harsh and severe.

ATMOSPHERIC RADIATION

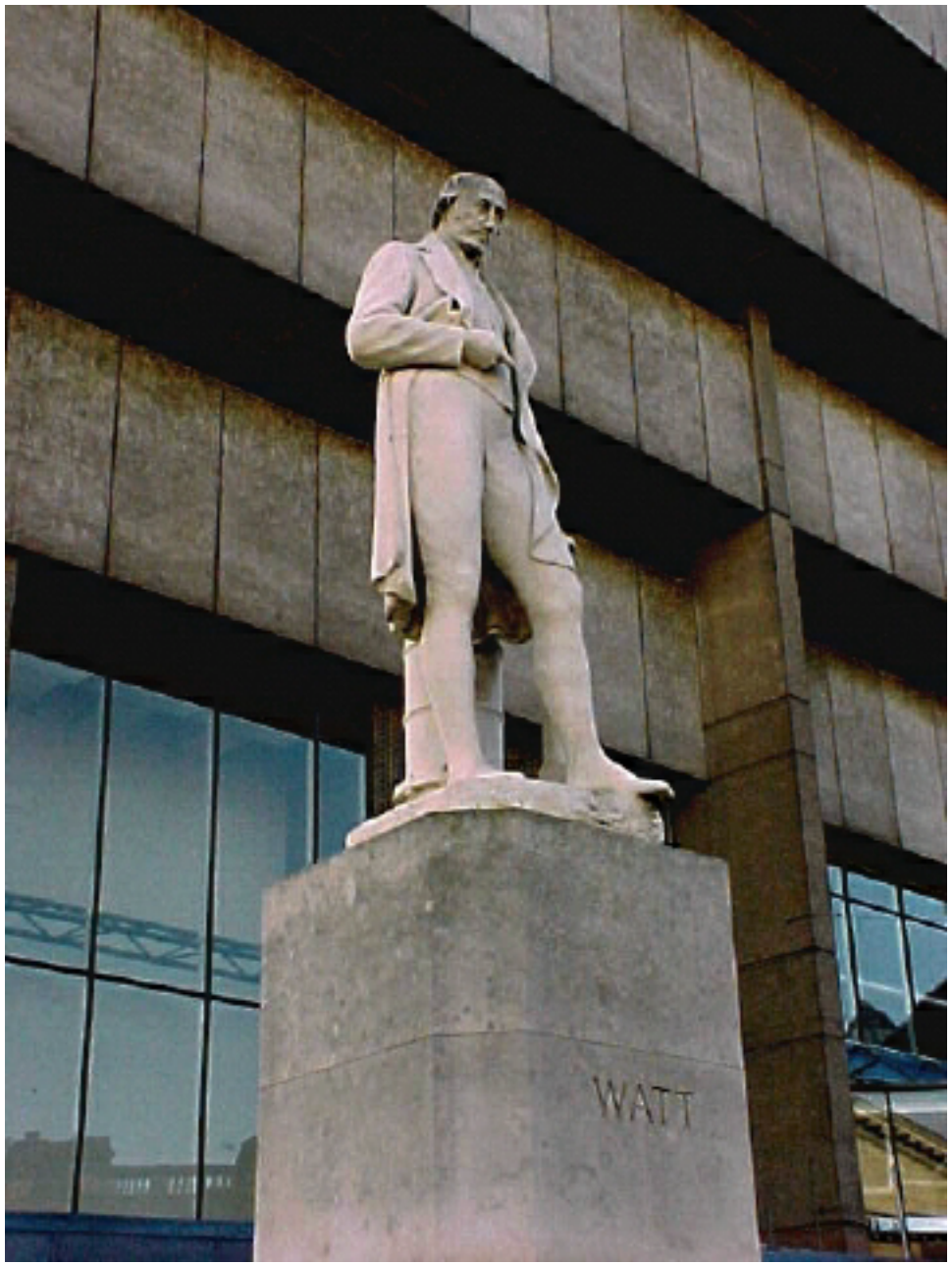
Energy per area per time

Power per area

Unit:

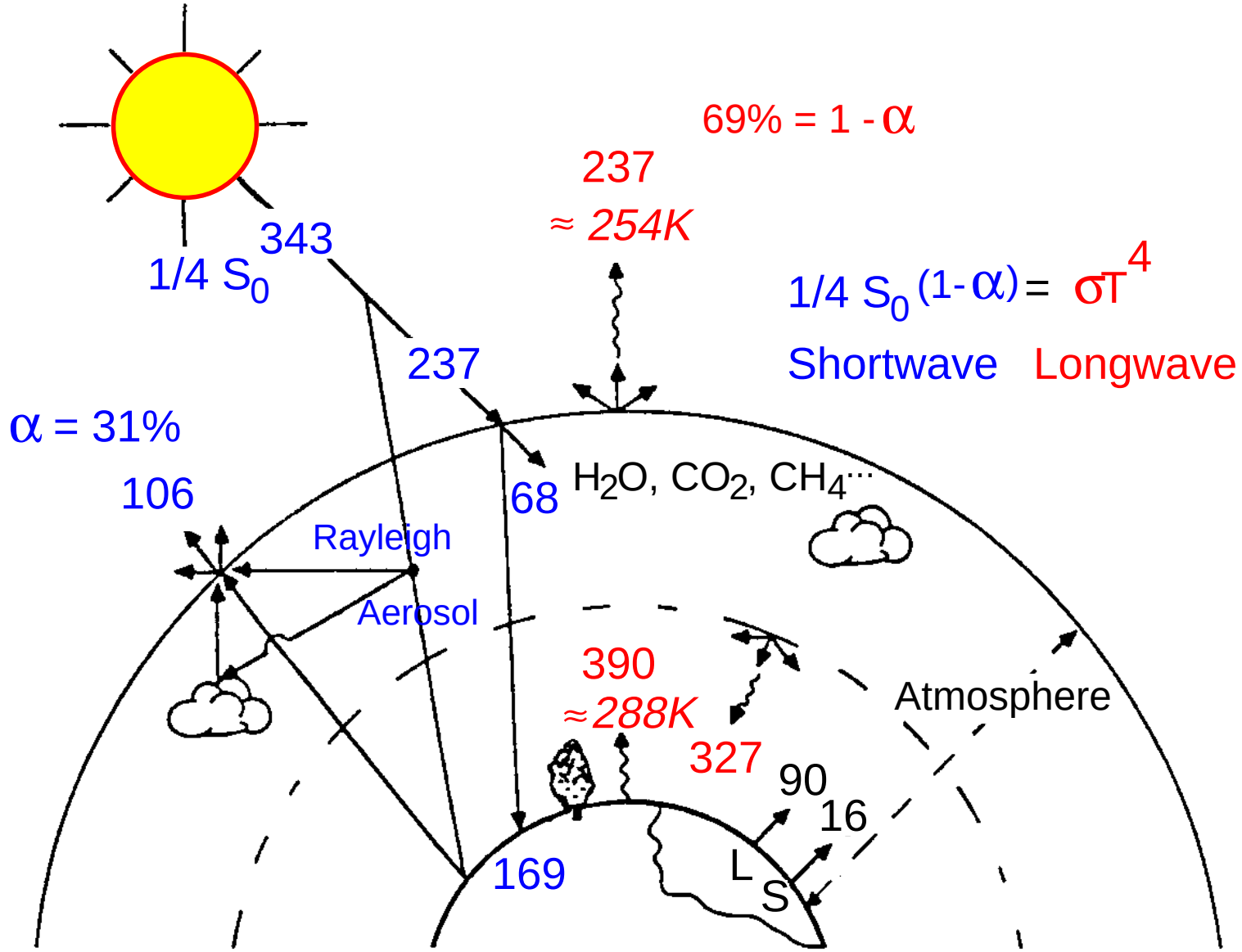
Watt per square meter

$W\ m^{-2}$



GLOBAL ENERGY BALANCE

Global and annual average energy fluxes in watts per square meter

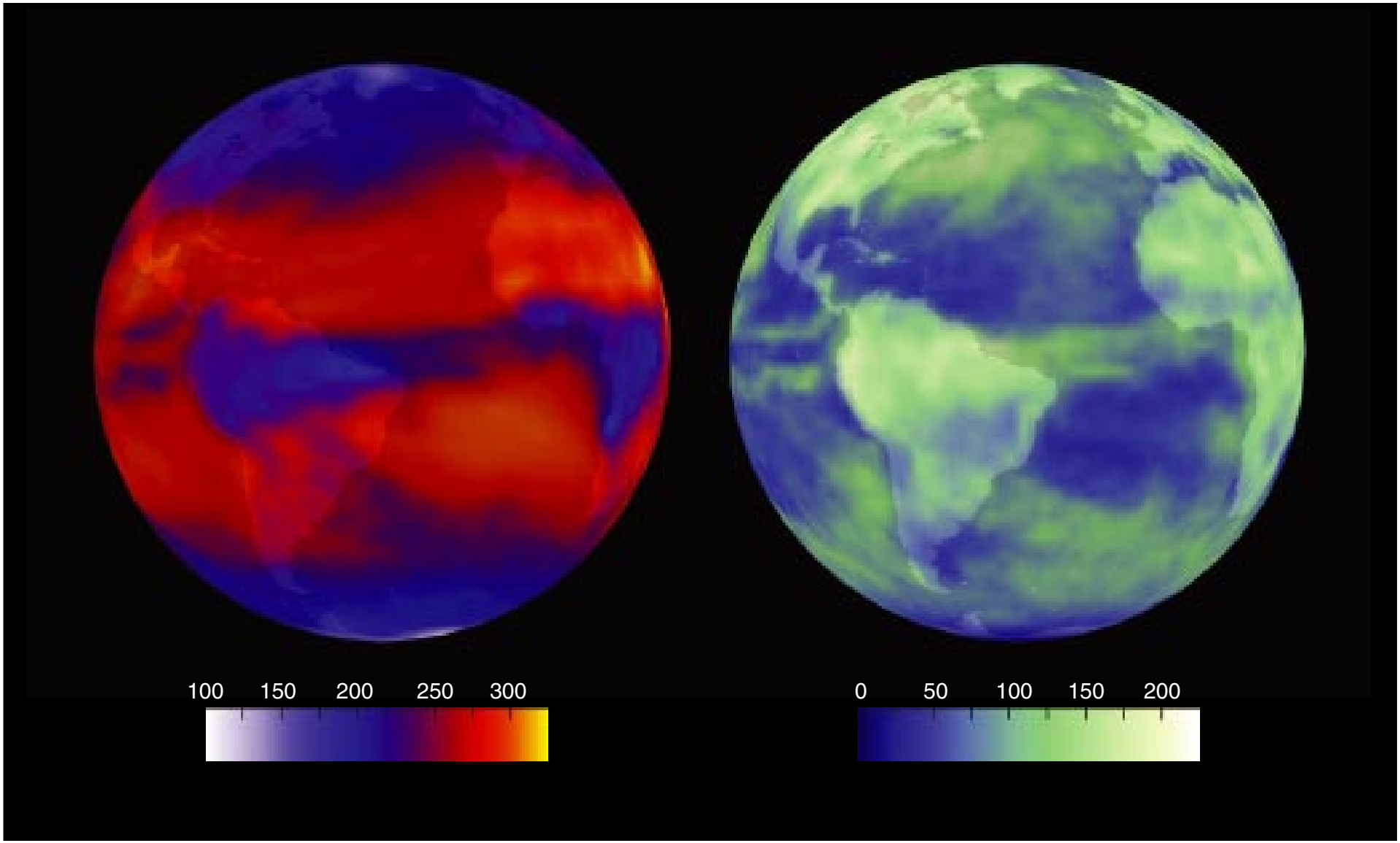


Schwartz, 1996, modified from Ramanathan, 1987

GEOGRAPHICAL VARIATION OF ATMOSPHERIC RADIATION

Annual average radiative flux at top of atmosphere, W m^{-2}

Emitted thermal infrared Reflected shortwave



CERES (Clouds and Earth's Radiant Energy System satellite, March, 2000 - May, 2001

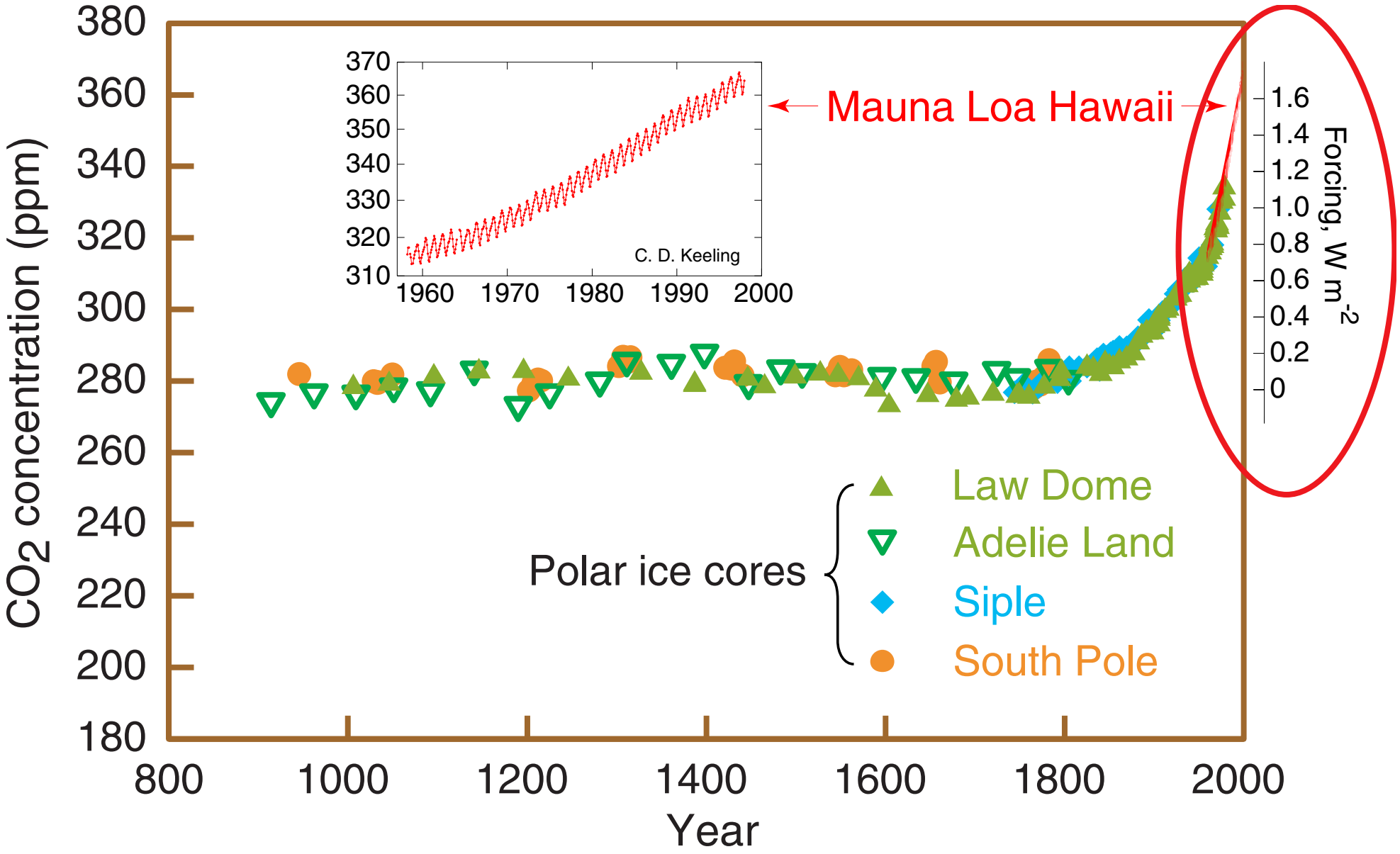
Everybody talks about the weather —

But nobody does anything about it.

– Mark Twain

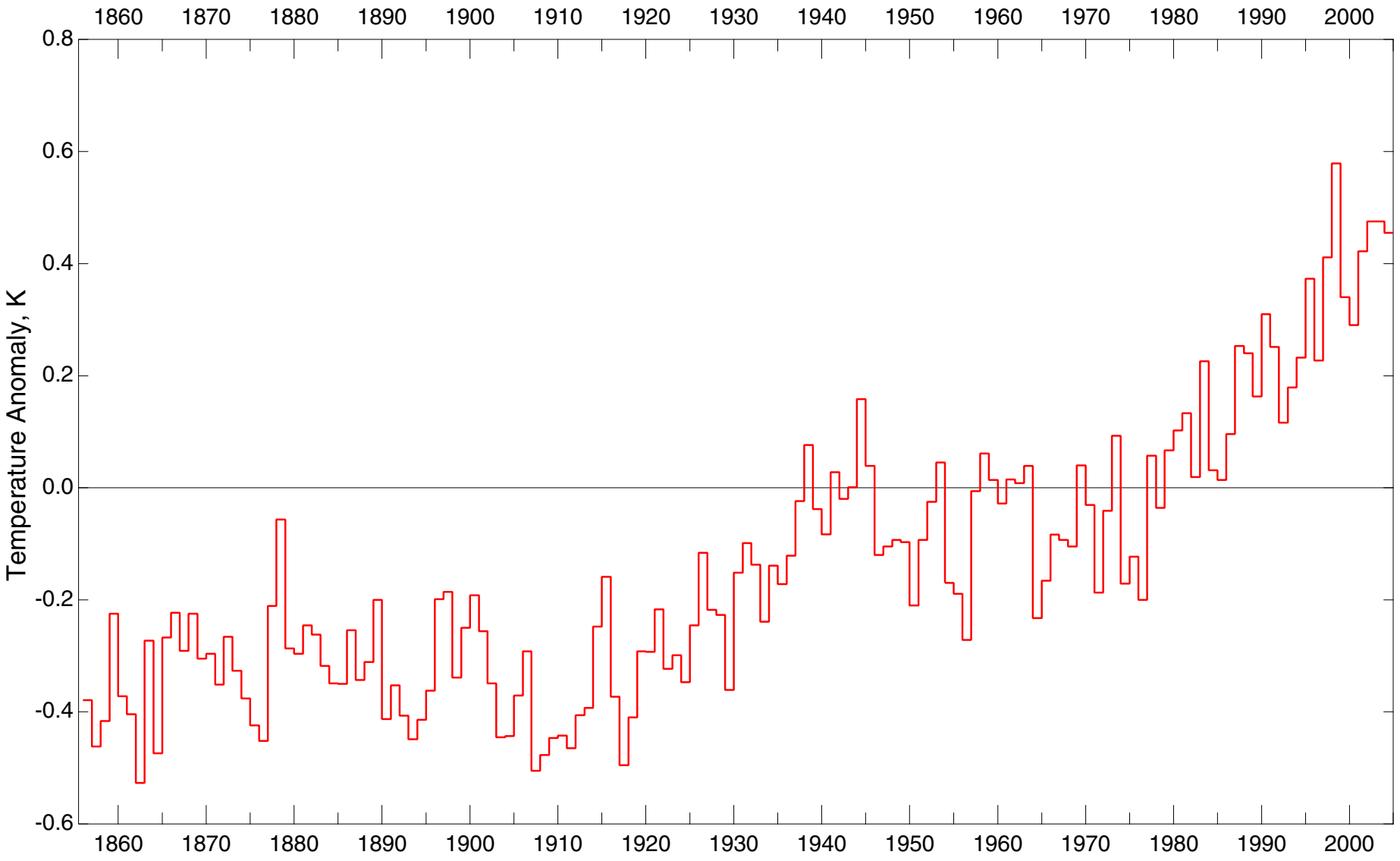
Now with the greenhouse effect,
we ARE doing something about it.
What are we doing?

ATMOSPHERIC CARBON DIOXIDE IS INCREASING



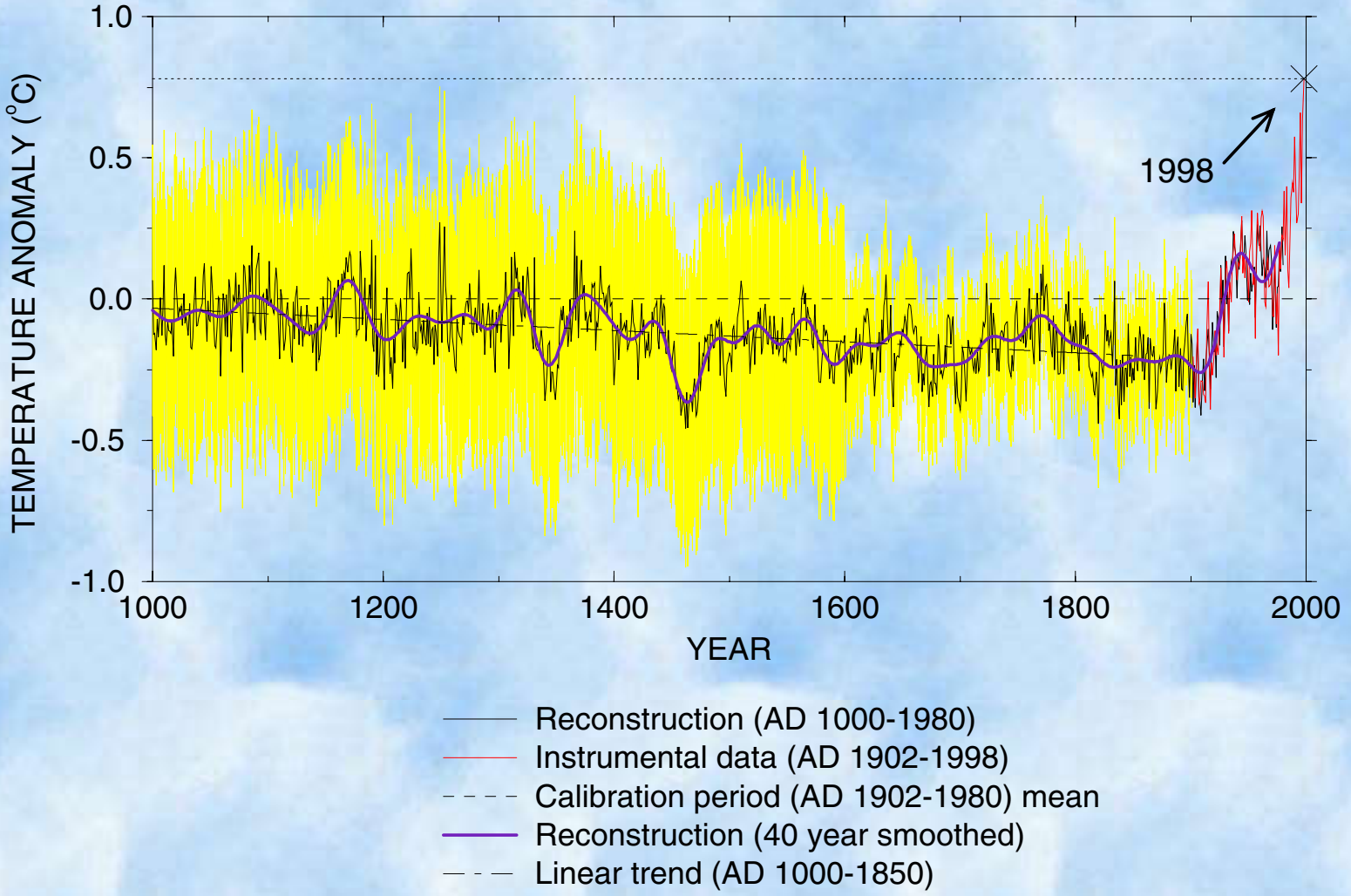
Global carbon dioxide concentration and infrared radiative forcing over the last thousand years

CHANGE IN GLOBAL MEAN SURFACE TEMPERATURE 1855-2004



Climate Research Unit, University of East Anglia, UK

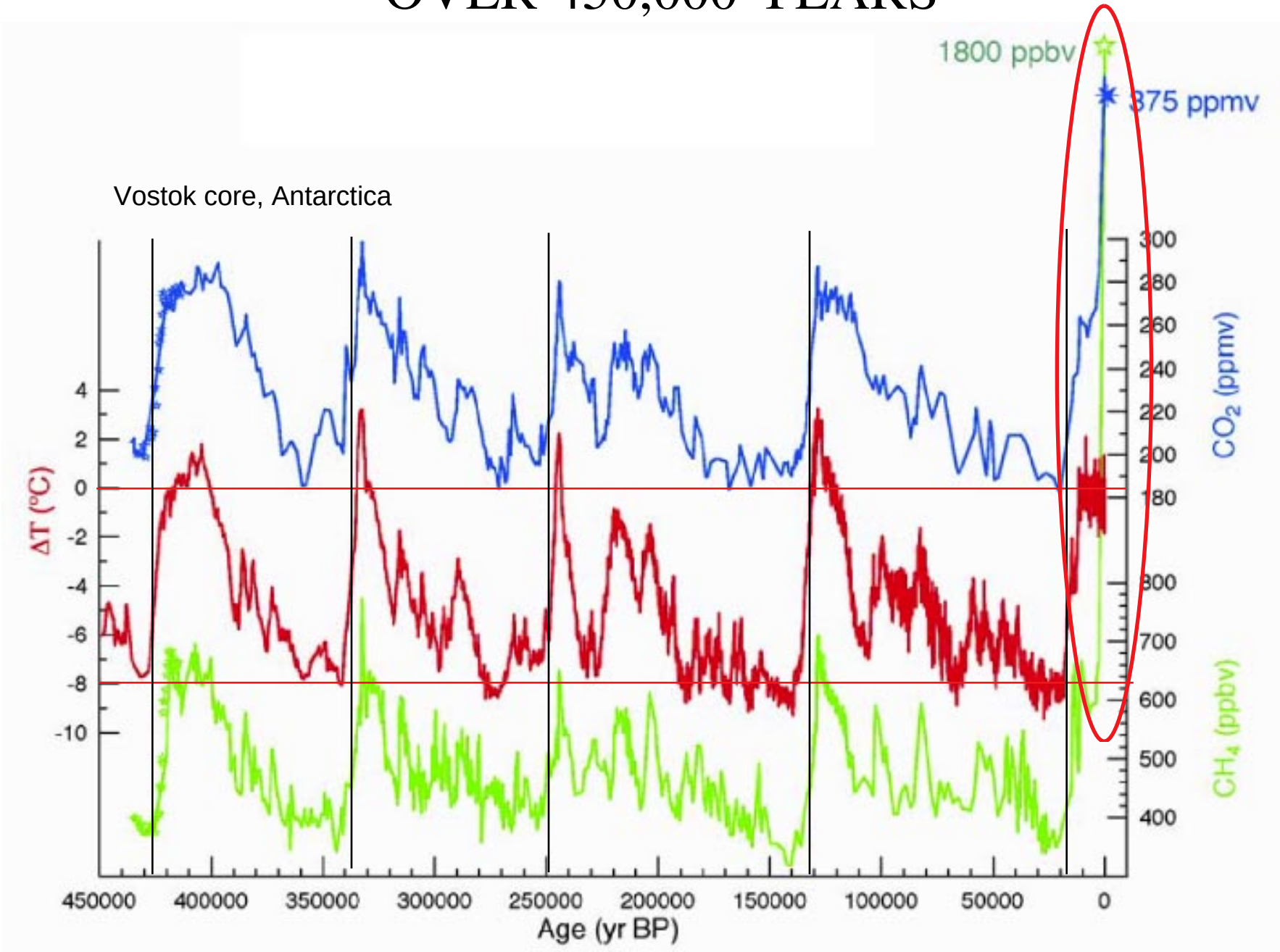
THE TEMPERATURE'S RISING



Northern Hemisphere temperature trend (1000-1998), from tree-ring, coral, and ice-core proxy records As calibrated by instrumental measurements.

Mann et al., Geophysical Research Letters, 1999

GREENHOUSE GASES AND TEMPERATURE OVER 450,000 YEARS

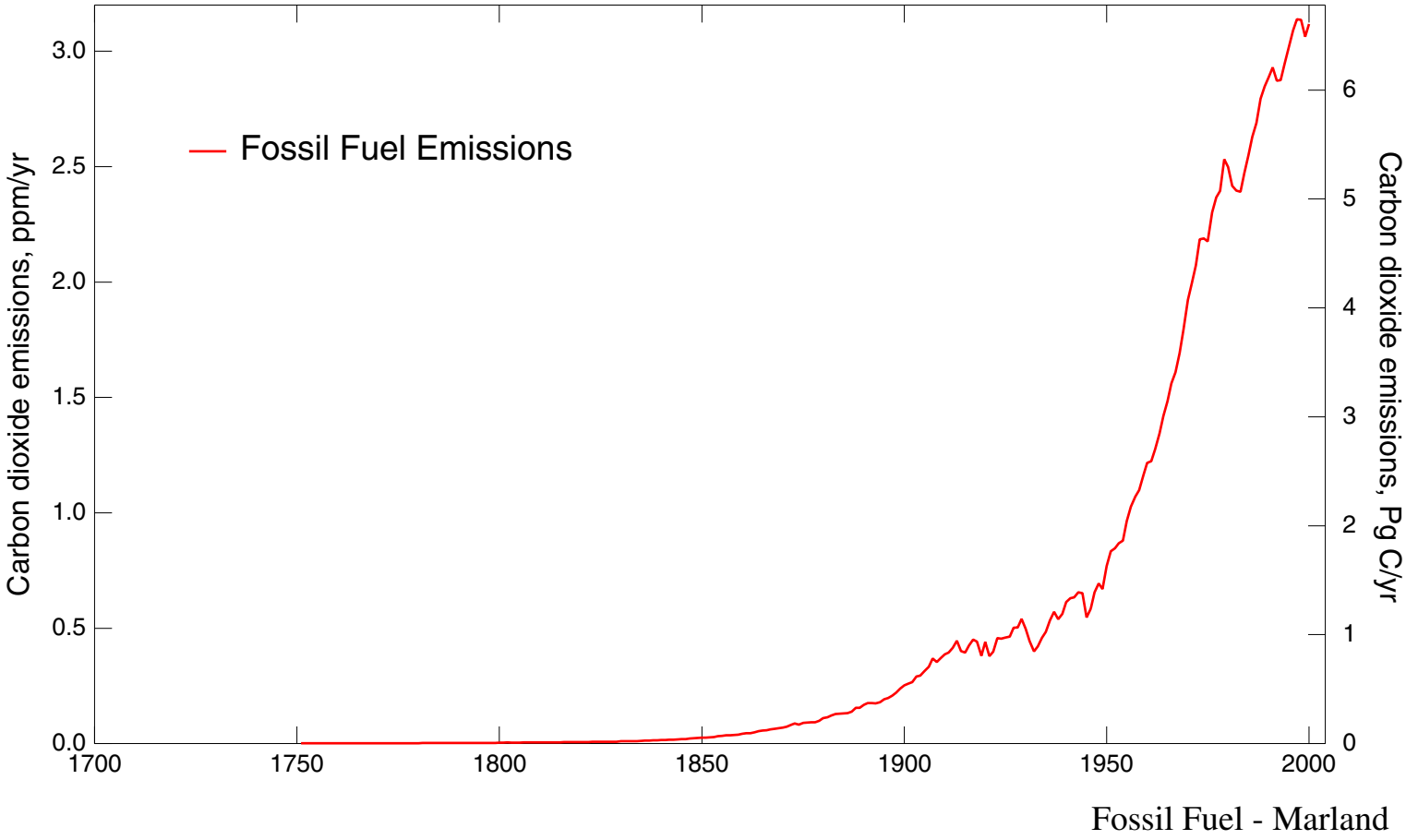


Modified from Petit et al., Nature, 1999

INCREASES IN CO_2 OVER THE INDUSTRIAL PERIOD

ATMOSPHERIC CO_2 EMISSIONS

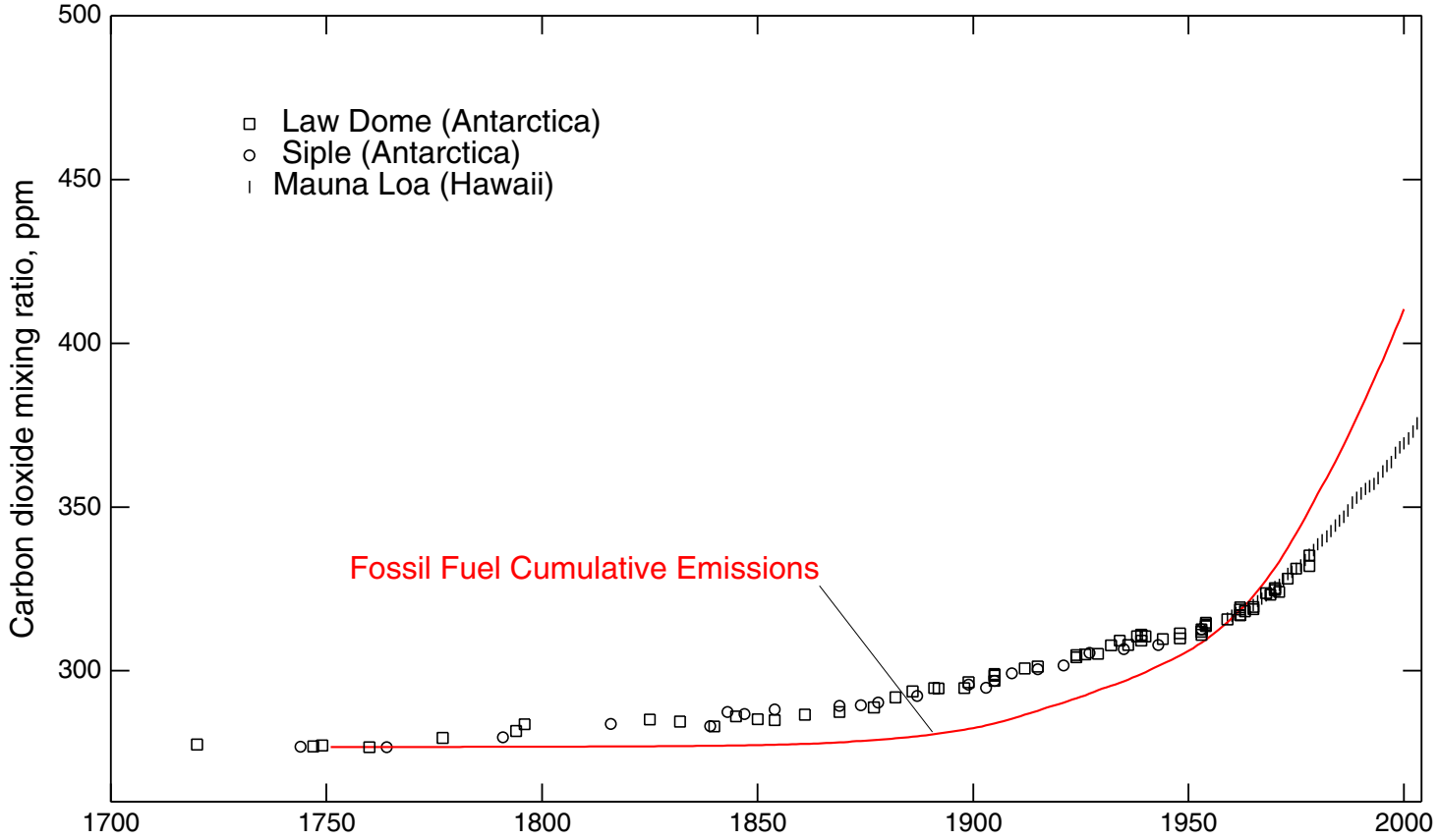
Time series 1700 - 2003



Fossil Fuel - Marland

ATMOSPHERIC CARBON DIOXIDE

Time series 1700 - 2003



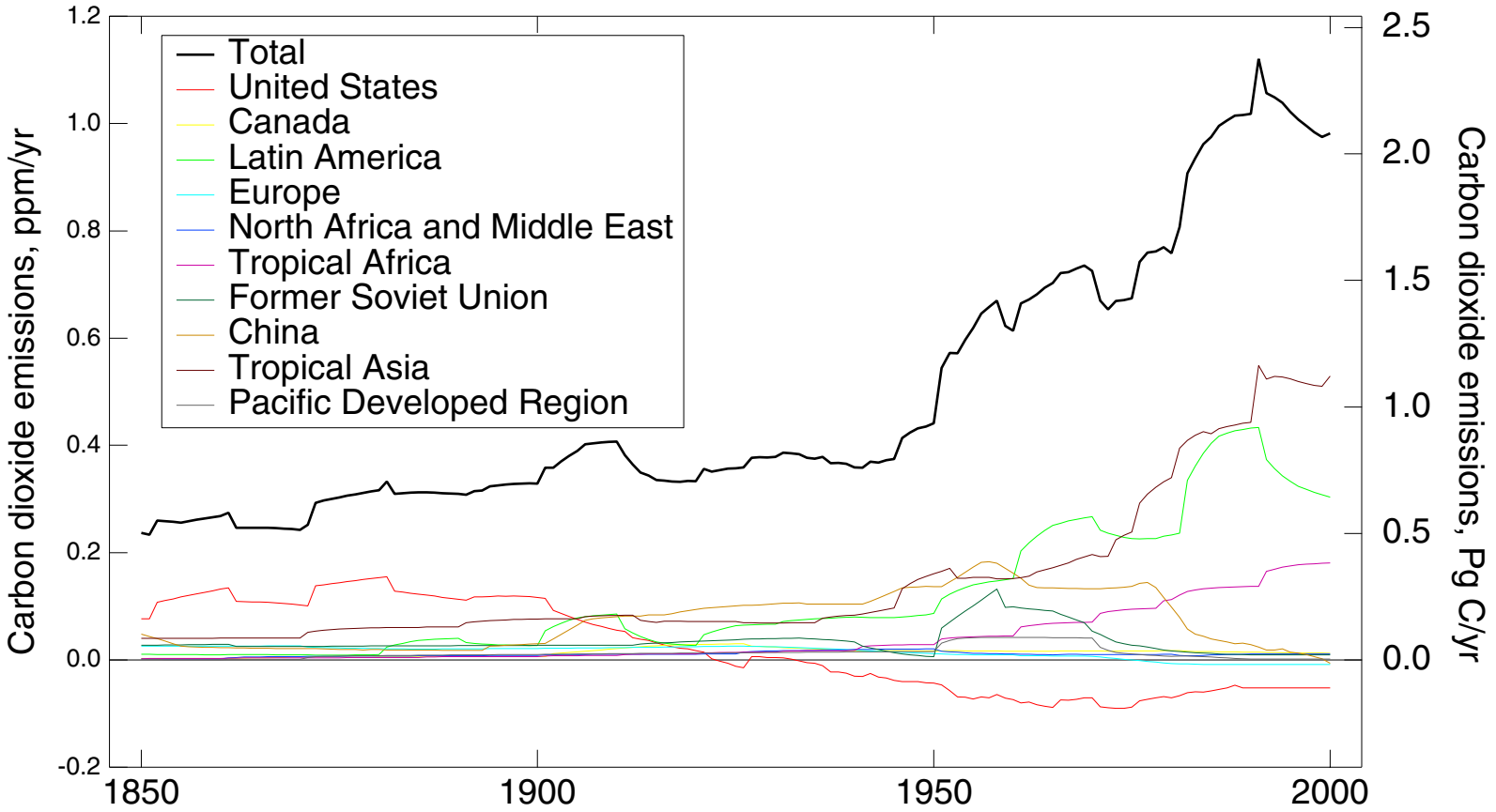
Law - Etheridge et al.
Siple - Friedli et al.
Mauna Loa - Keeling
Fossil Fuel - Marland

What's missing from this story?

DEFORESTATION AS A SOURCE OF ATMOSPHERIC CO_2

ATMOSPHERIC CO_2 EMISSIONS

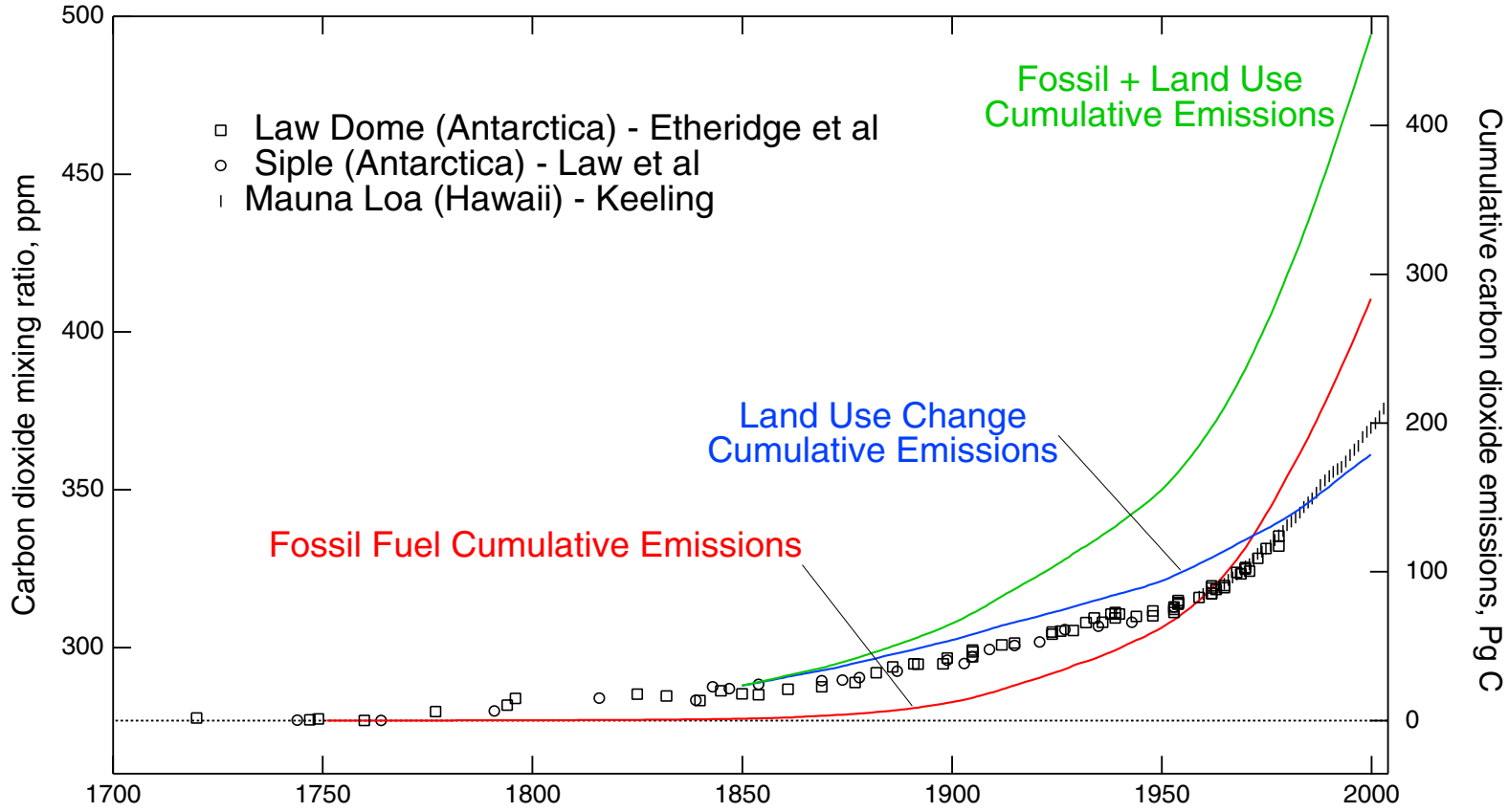
Land-use changes 1850 - 2000



Houghton, *Tellus*, 1999; Houghton and Hackler, 2002

ATTRIBUTION OF INCREASE IN ATMOSPHERIC CO_2

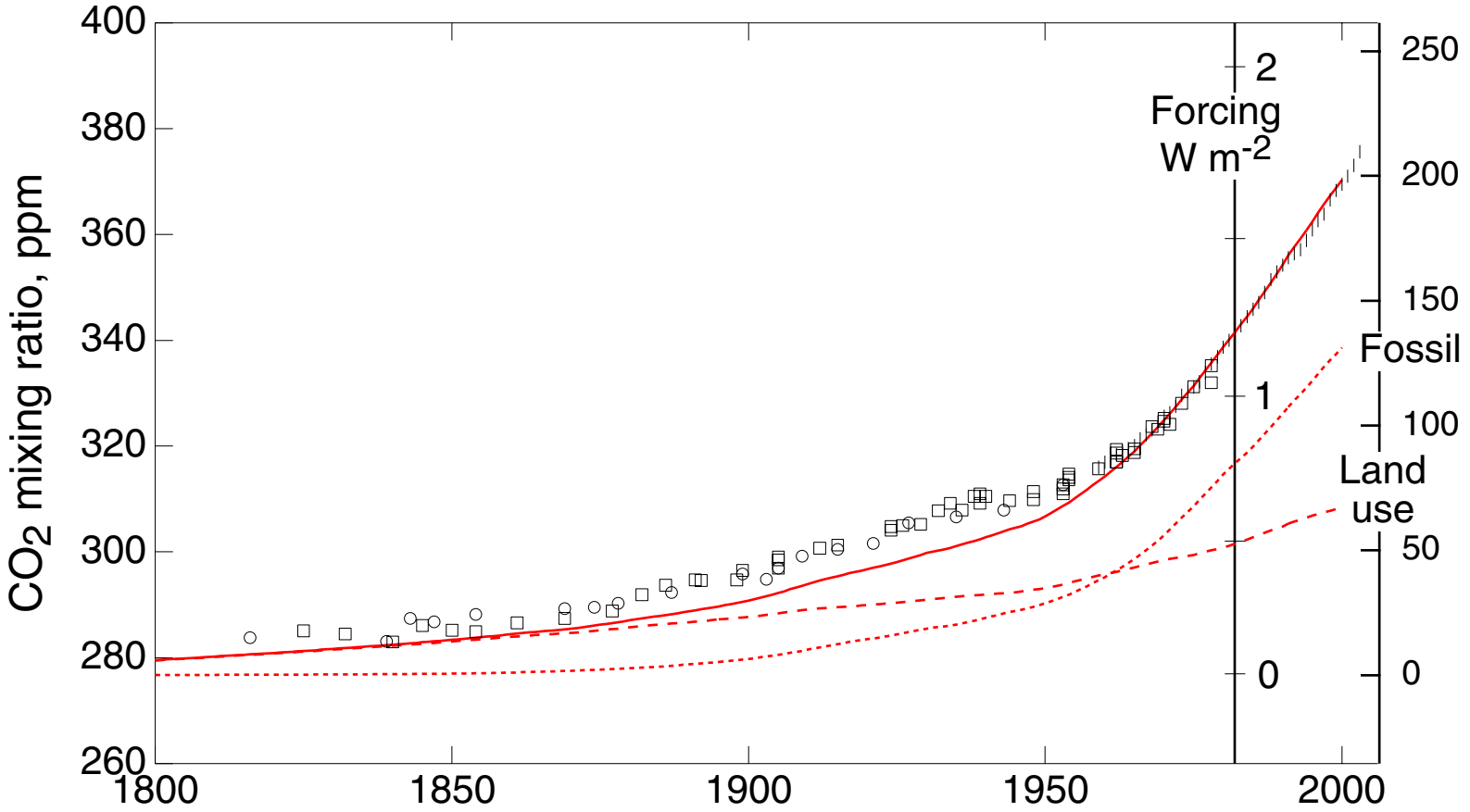
Comparison of ***cumulative*** CO_2 emissions from fossil fuel combustion and land use changes with measured increases in atmospheric CO_2.



Prior to 1970 the increase in atmospheric CO_2 was dominated by emissions from land use changes, not fossil fuel combustion.

ATTRIBUTION OF ATMOSPHERIC CO_2

Comparison of CO_2 mixing ratio ***and forcing*** from fossil fuel combustion and land use changes

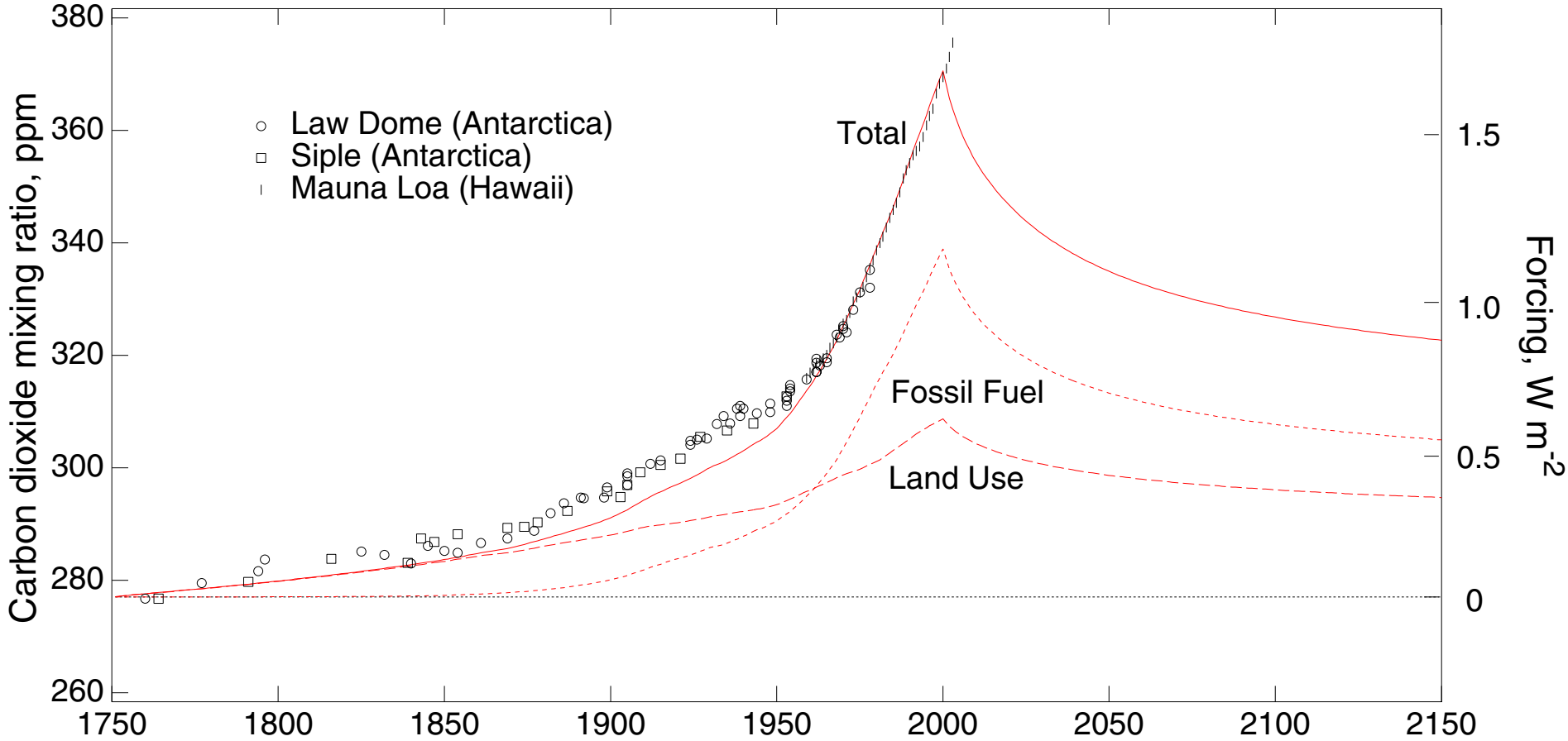


CO_2 from land use emissions – ***not fossil fuel combustion*** was the dominant contribution to atmospheric CO_2 and forcing over the 20th century.

Looking to the Future . . .

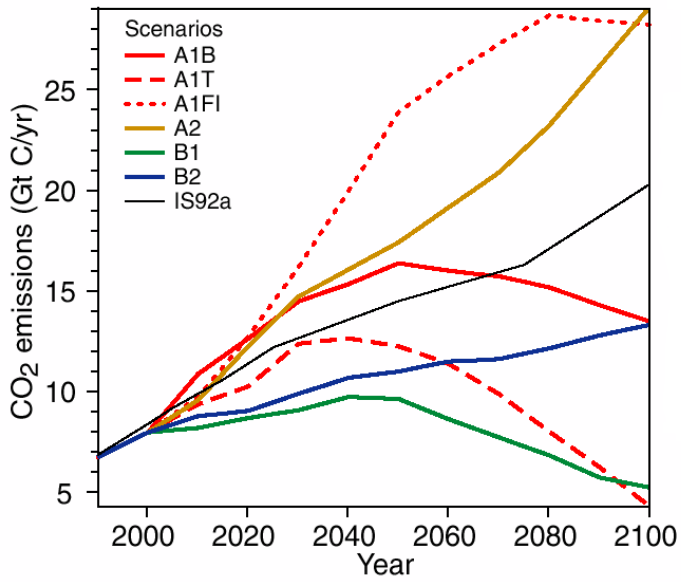
FUTURE ATMOSPHERIC CO_2

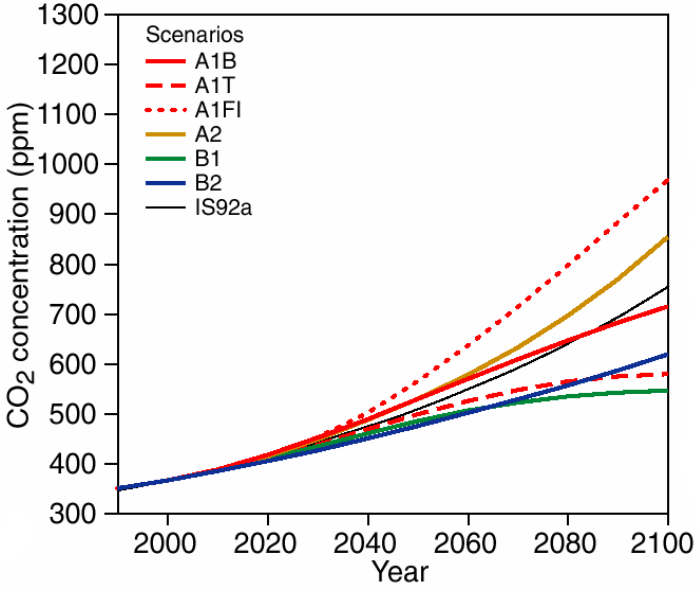
Projection of CO_2 ***mixing ratio and forcing*** due to anthropogenic emissions from 1750 to 2000

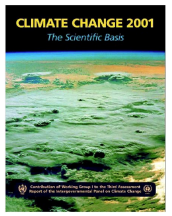


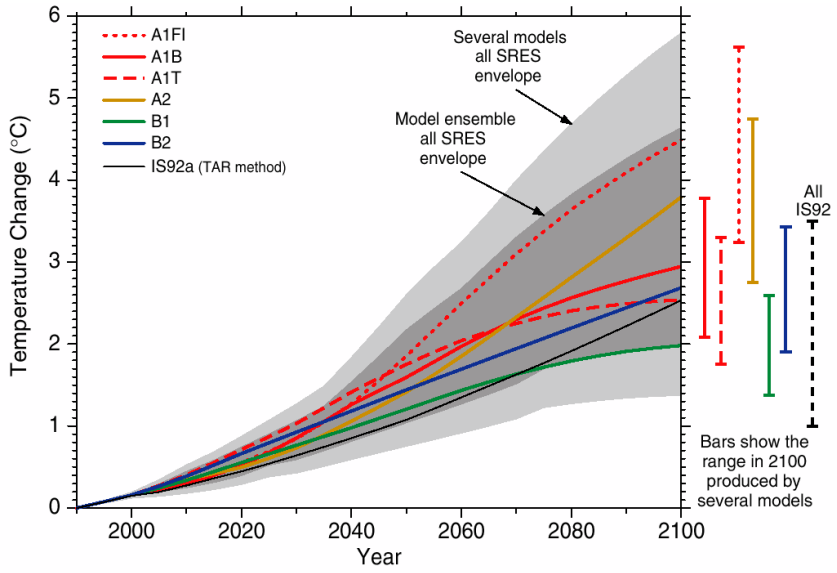
The footprint of prior CO_2 emissions lasts well beyond a century.

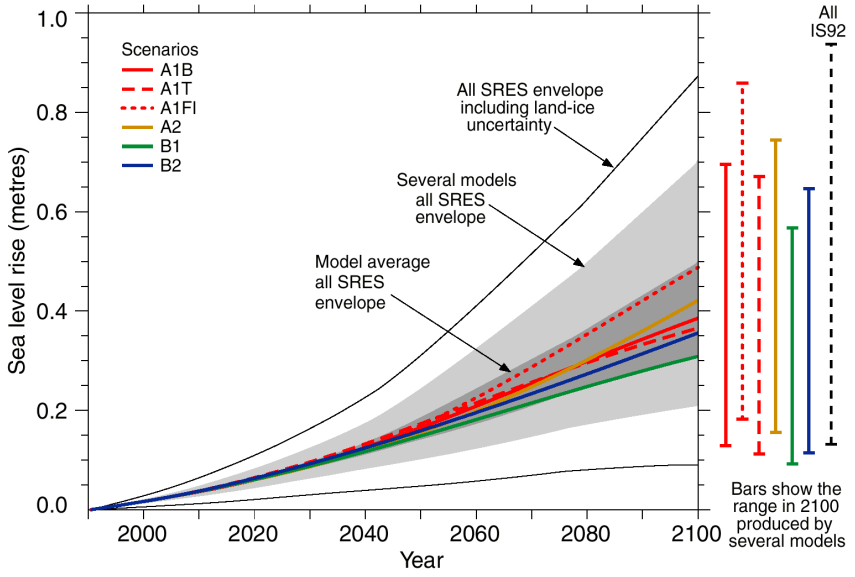
PROJECTIONS OF FUTURE CO_2, TEMPERATURE, AND SEA LEVEL











Contributors to uncertainty in future temperature include ***emissions***, ***concentrations***, and Earth's ***climate sensitivity***.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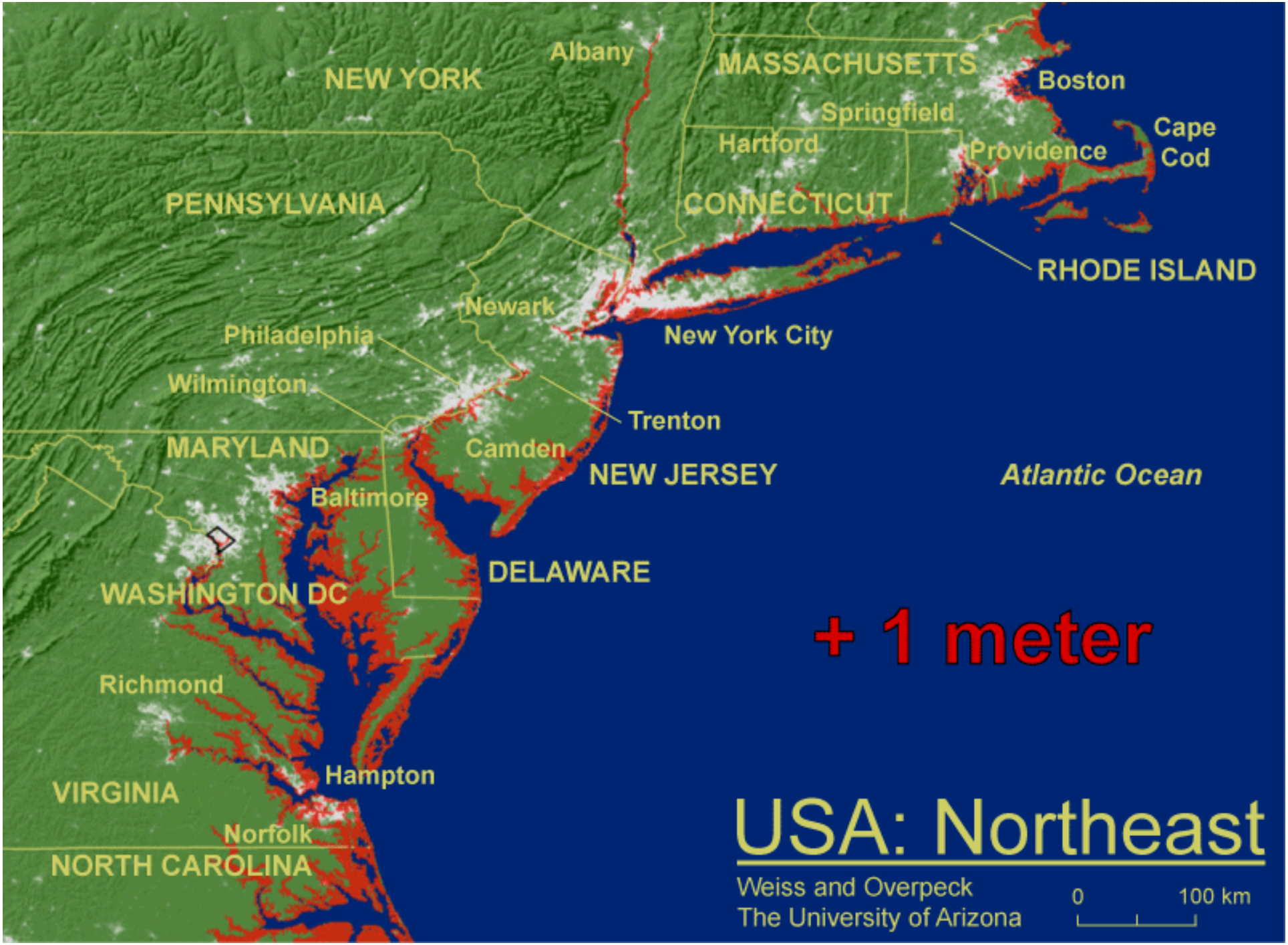
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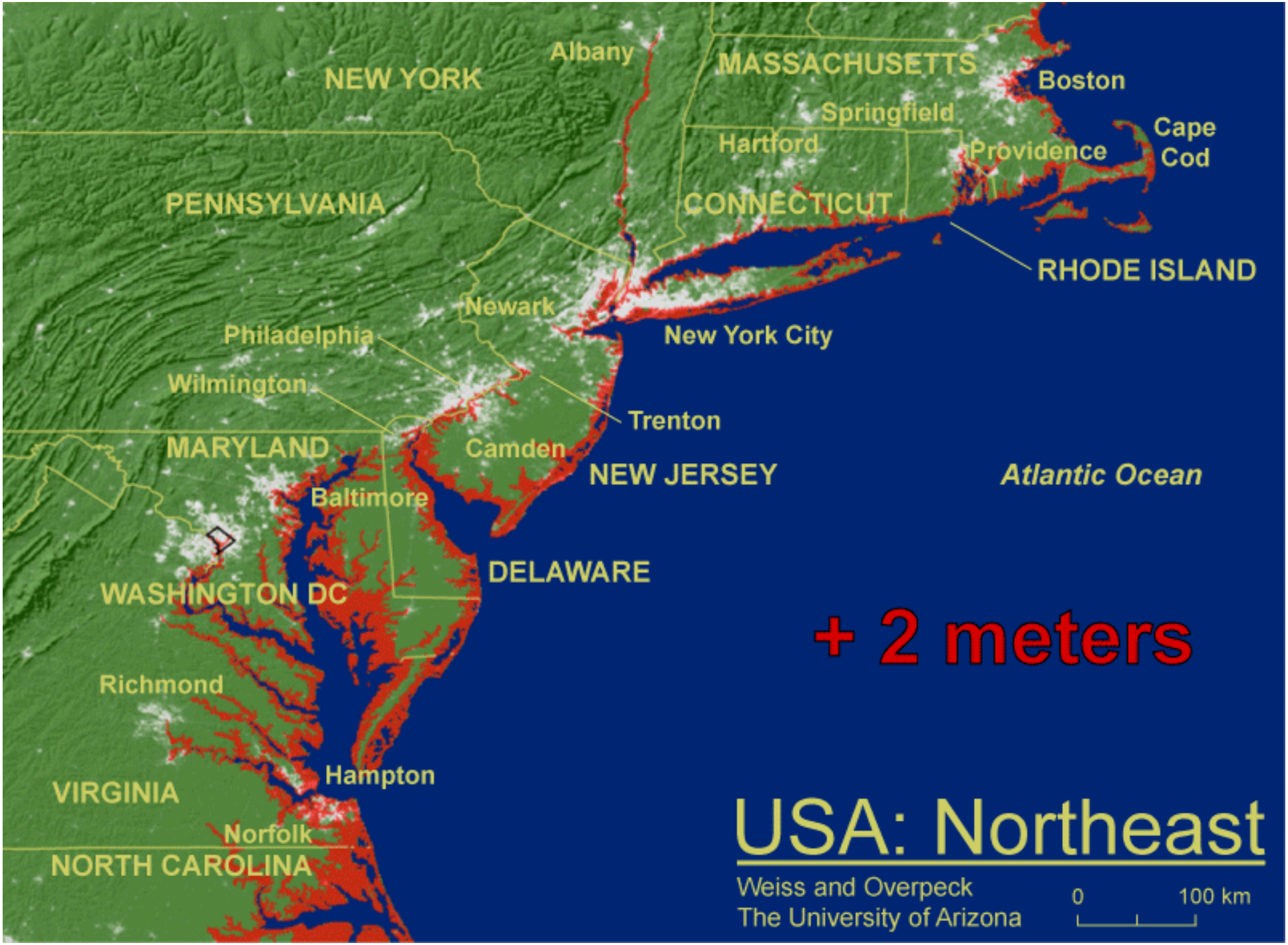
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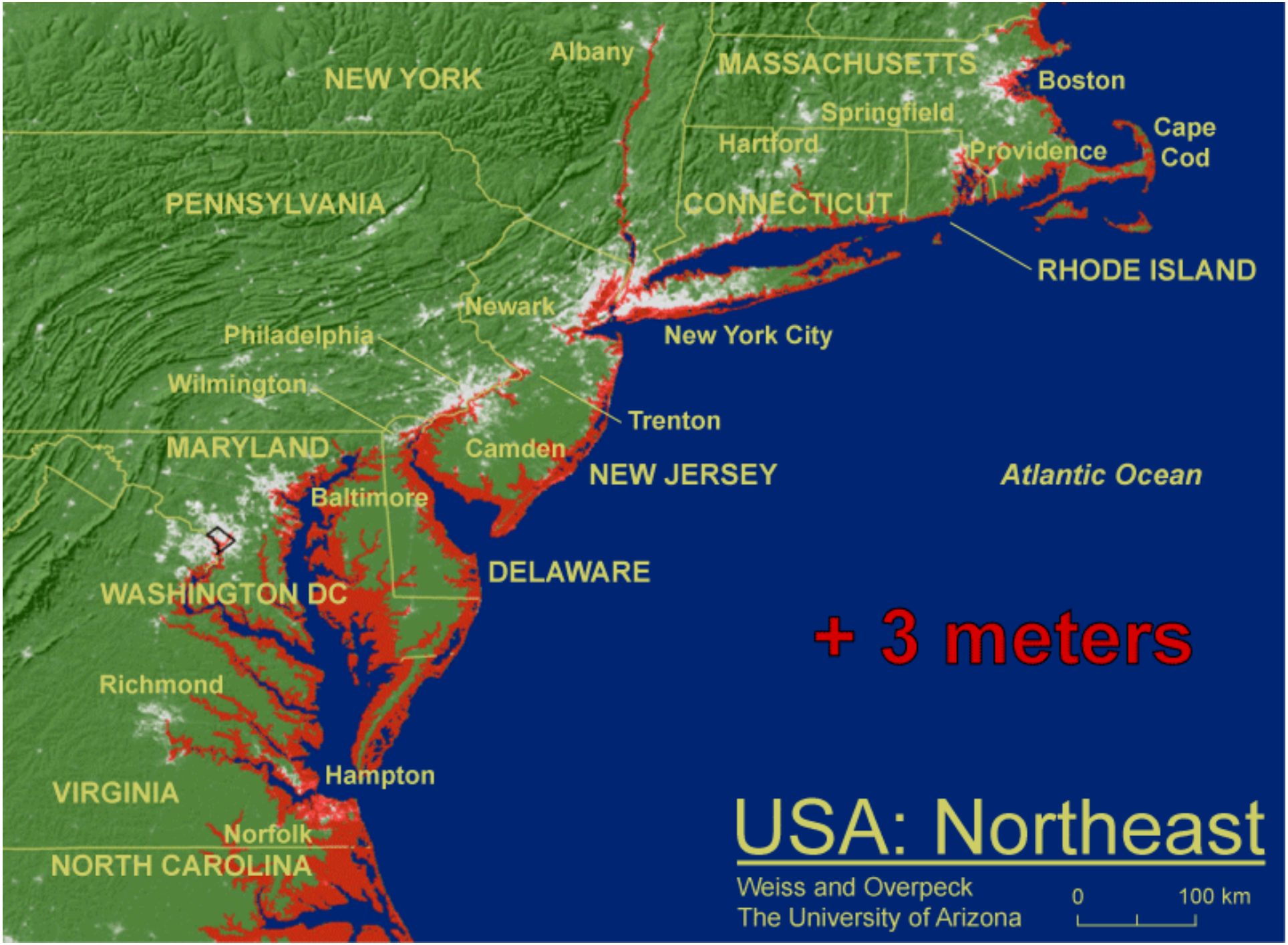
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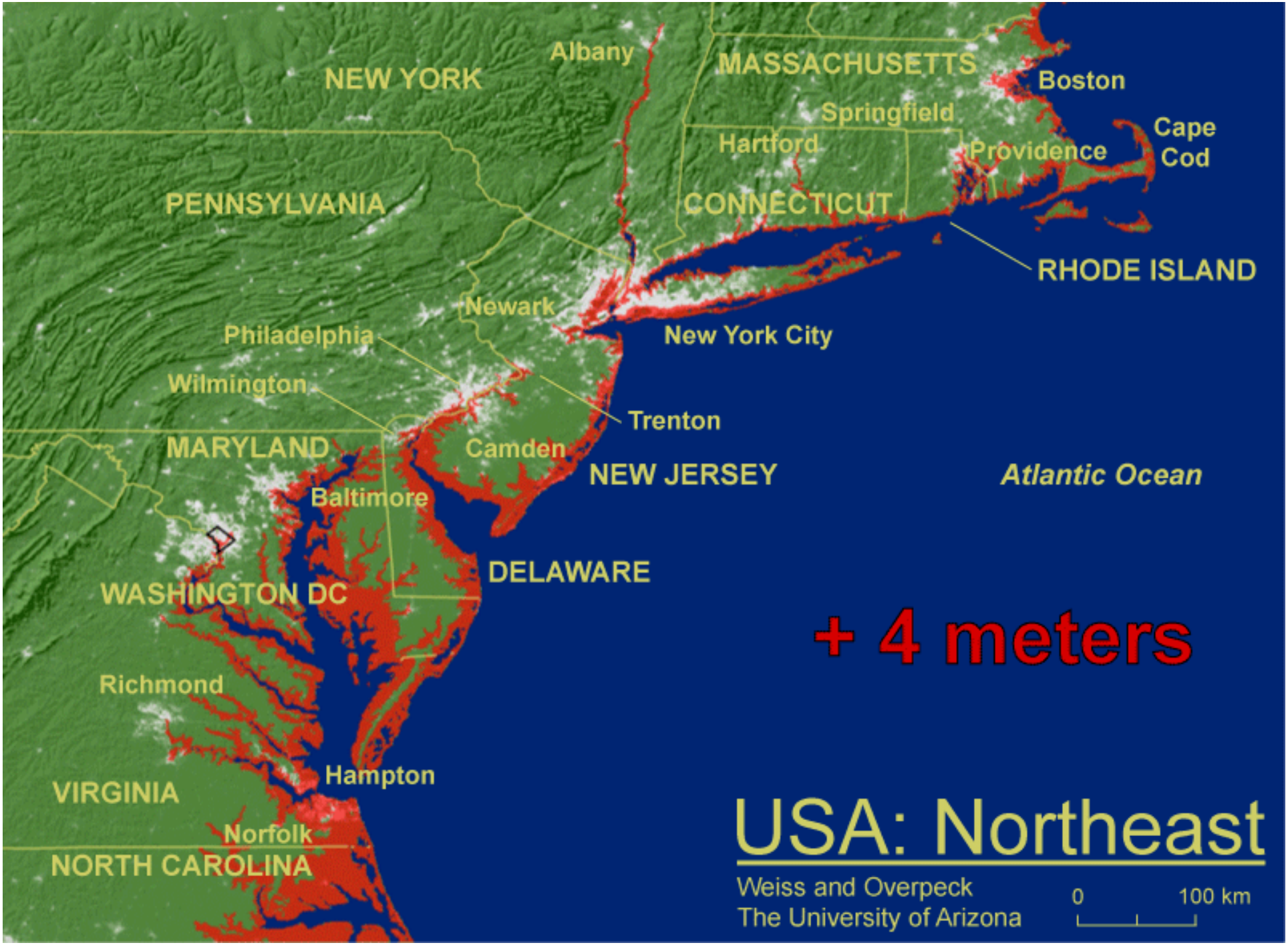
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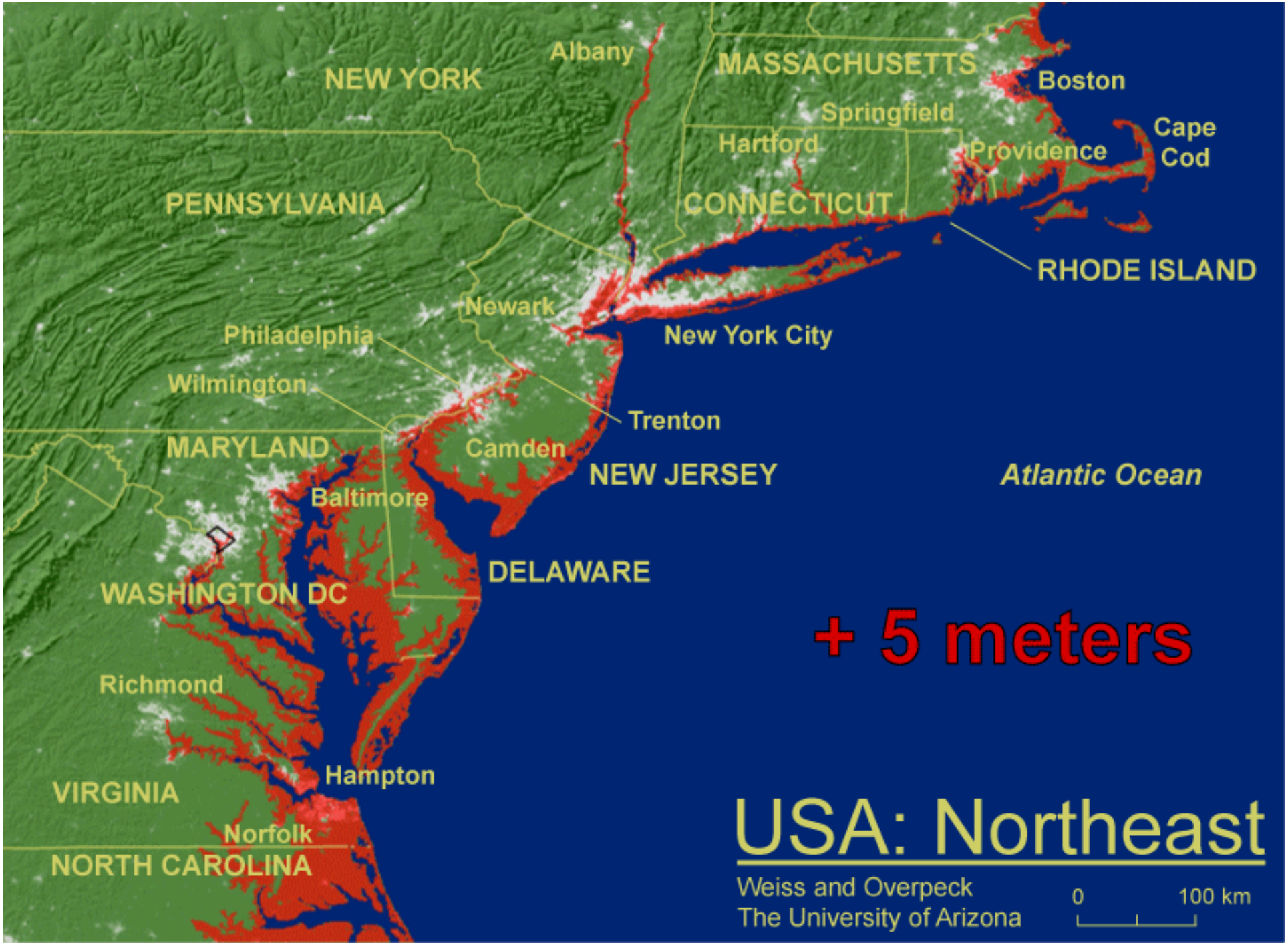
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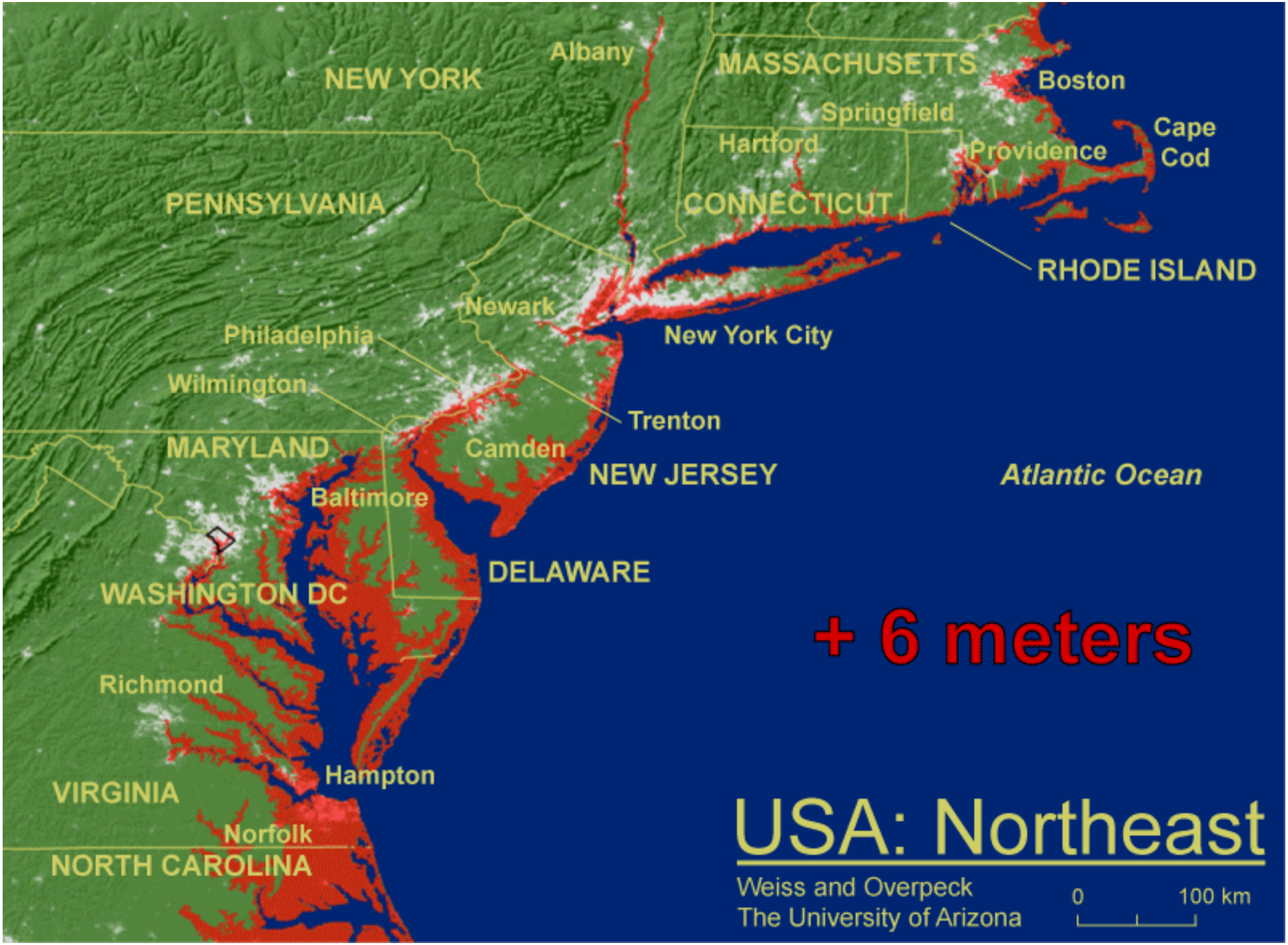
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NORTH CAROLINA
USA: Northeast
Weiss and Overpeck
The University of Arizona
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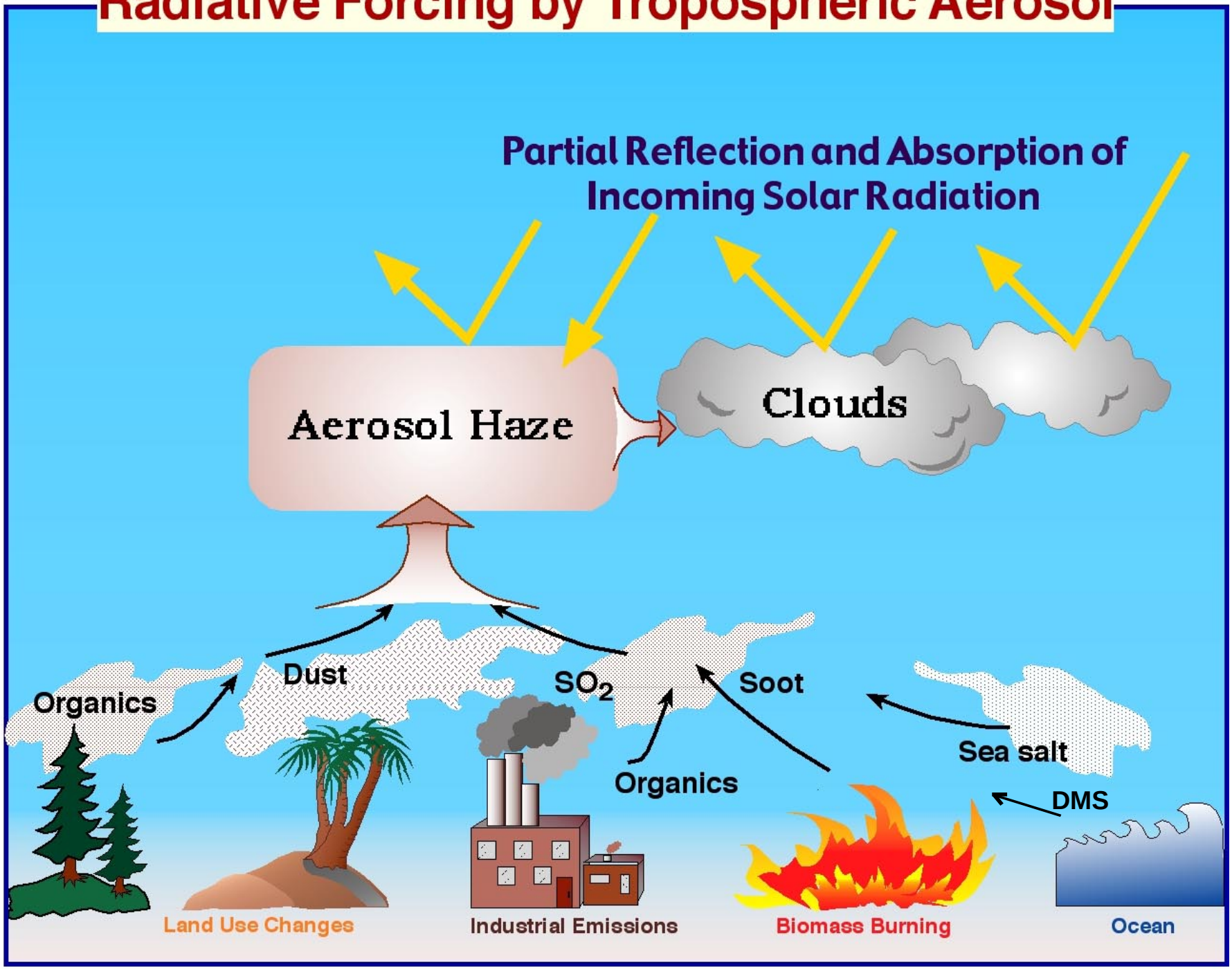
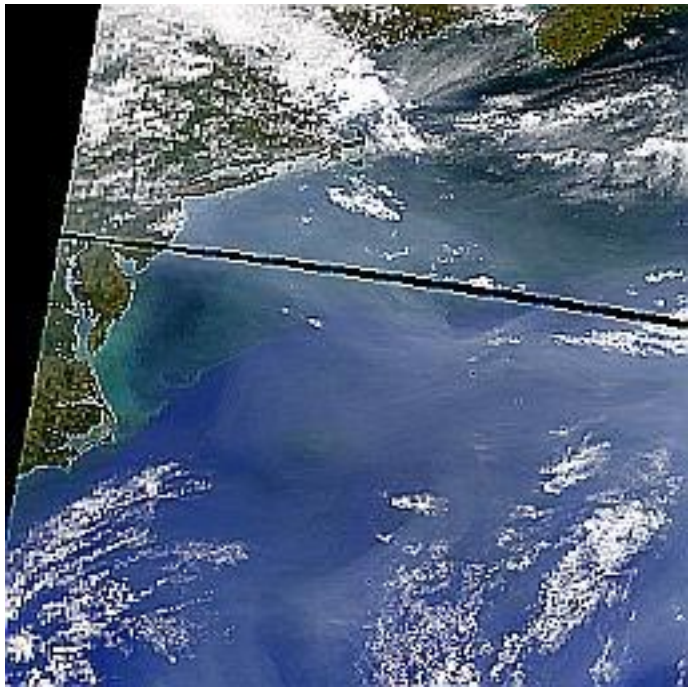
100 km

"Gentlemen, it's time we gave some serious thought to the effects of global warming."

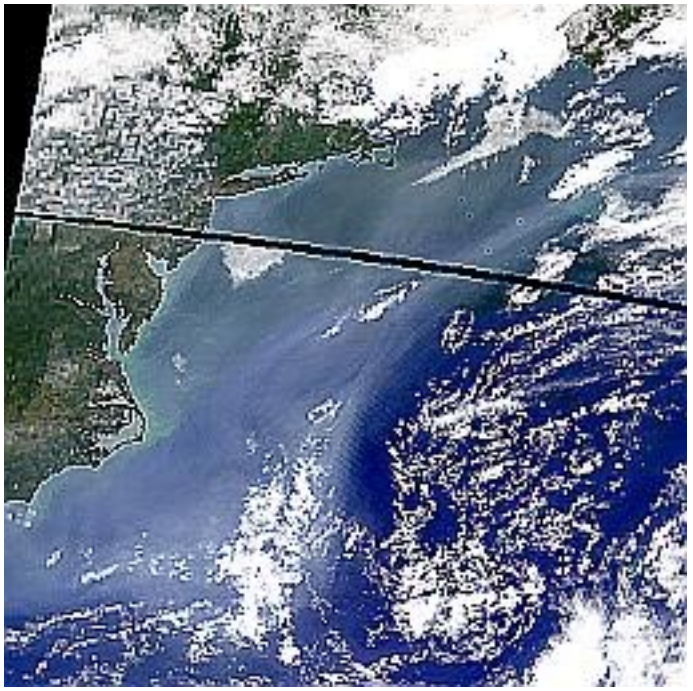
Radiative Forcing by Tropospheric Aerosol



LIGHT SCATTERING BY ANTHROPOGENIC AEROSOLS, 2000

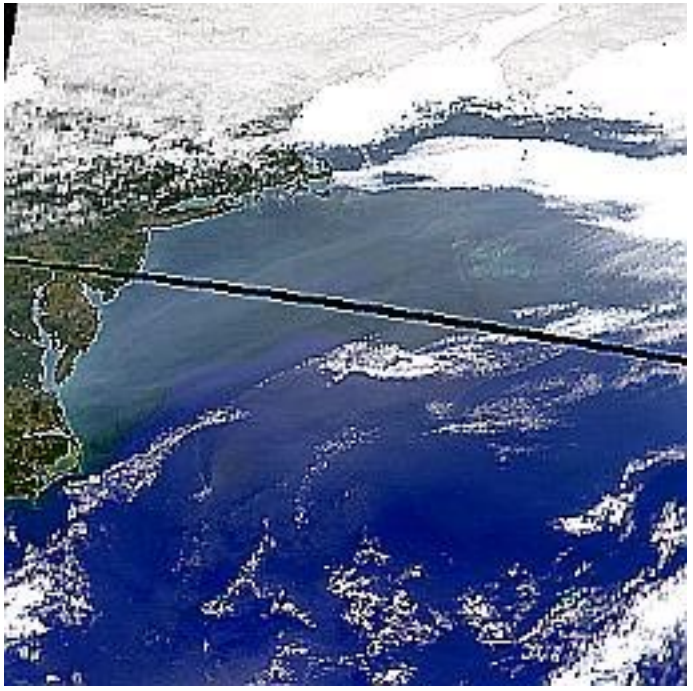


May 8



June 2

June 3



June 11

SEAWIFS images

IMPLICATIONS OF AEROSOL FORCING

- Aerosol negative (cooling) forcing is likely ***offsetting*** a substantial fraction of positive (warming) forcing by greenhouse gases.
- A substantial fraction of the forcing of 40 years of CO_2 emissions is being offset by ***a week's worth of aerosol***.
- It is very likely that the global warming due to CO_2 and other GHG's is ***substantially greater*** than has been experienced thus far.

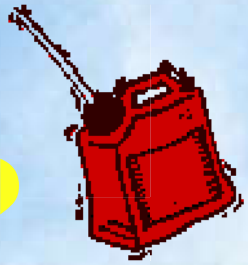
WHERE IS ALL THIS CO_2 COMING FROM?

WHO IS RESPONSIBLE?

HOW MUCH CARBON IS IN A GALLON OF GASOLINE?

1 lb?

2 lbs?



3 lbs!?

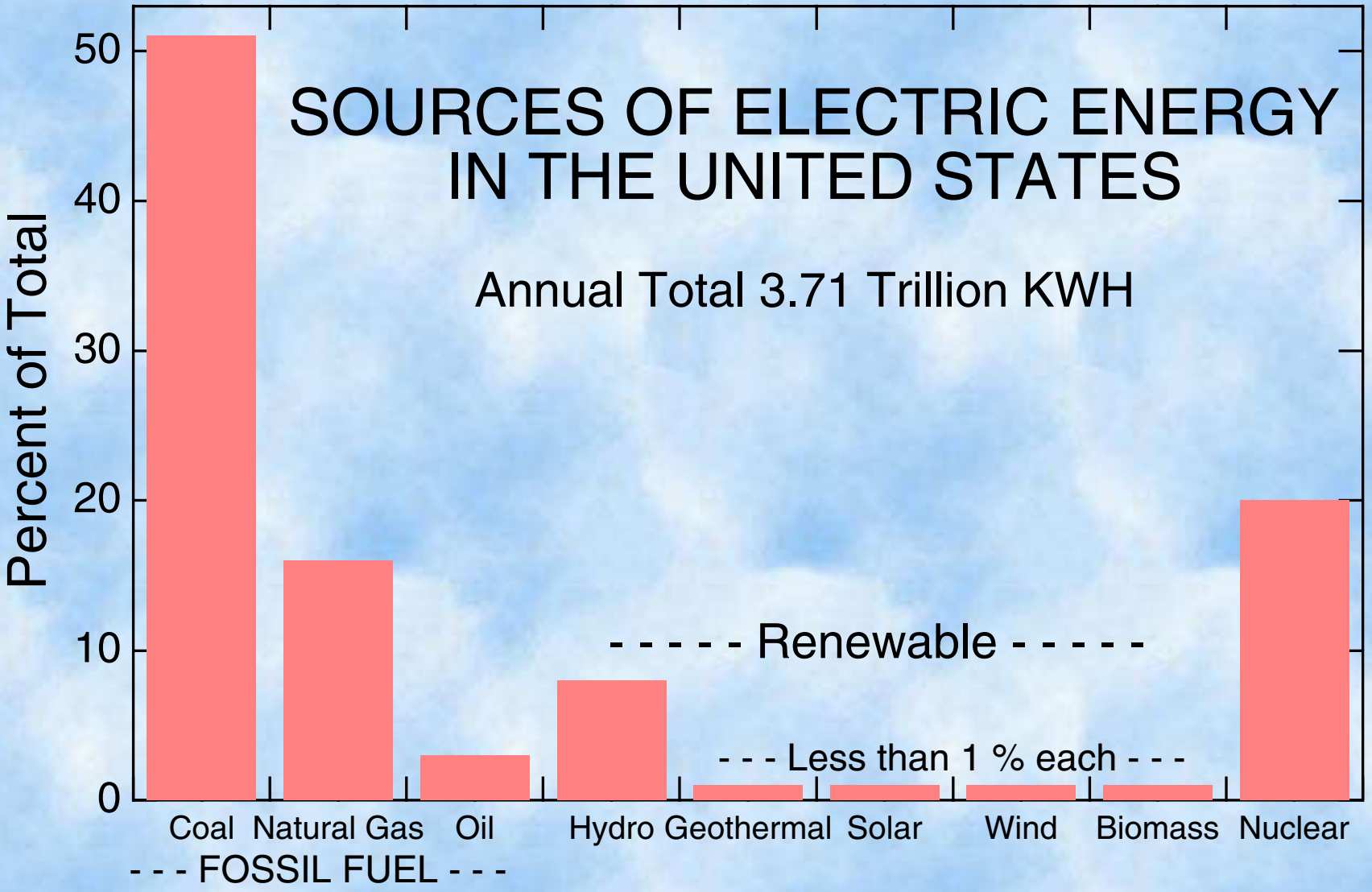
5 lbs!?!

All of this carbon goes into the atmosphere as carbon dioxide when you burn the gasoline in your car.

THE MOST EFFECTIVE WAY TO DOUBLE THE FUEL ECONOMY OF A CAR . . .

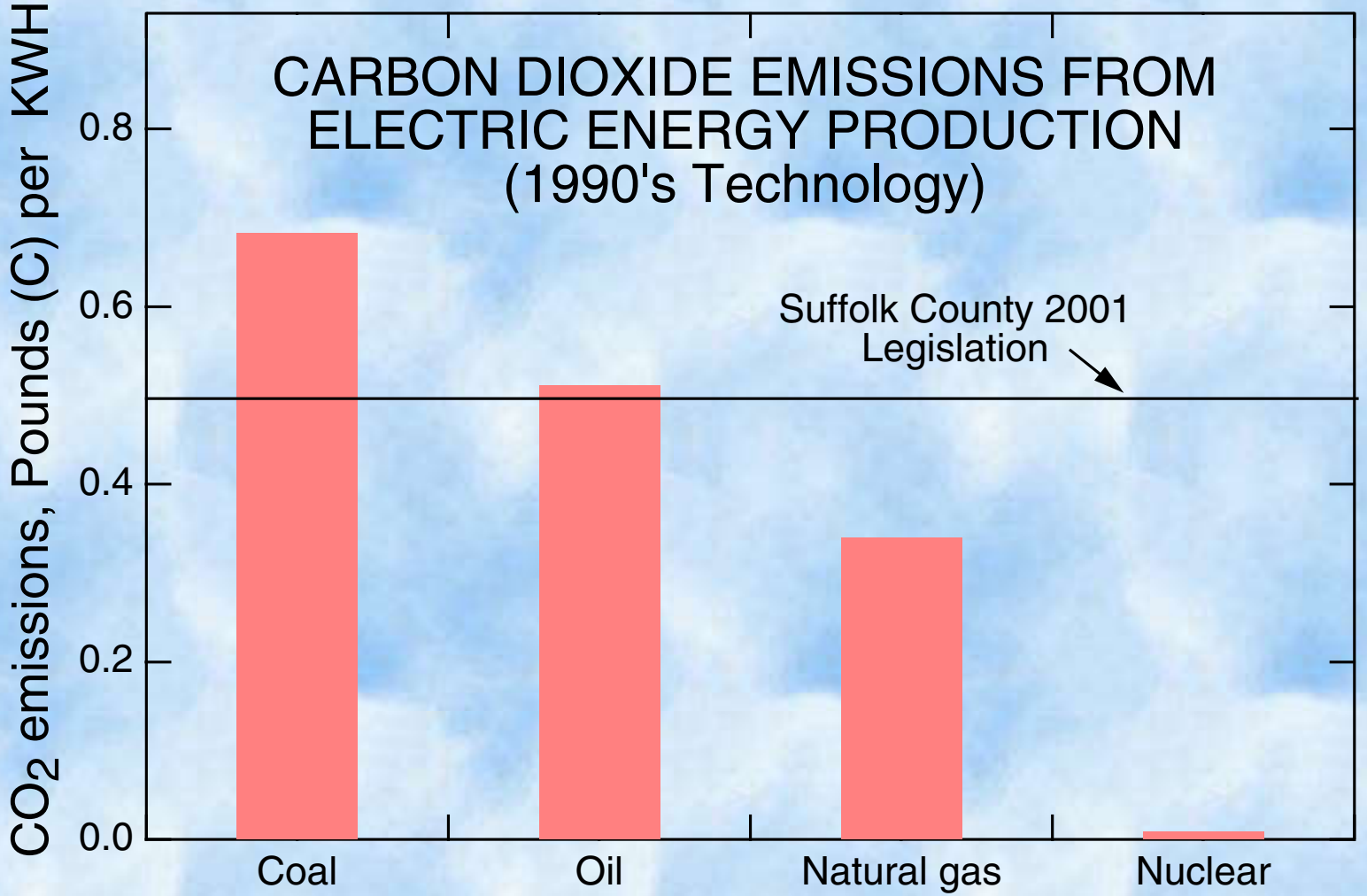
IS TO PUT TWO PEOPLE IN IT!

WHERE DOES YOUR ELECTRIC ENERGY COME FROM?



On Long Island most electric energy derives from combustion of oil.

YOUR FAMILY'S CONTRIBUTION TO THE GREENHOUSE EFFECT



A typical household using 1000 kilowatt hours of electricity per month is responsible for emission of 3 tons of carbon a year in the form of carbon dioxide.

How much does your household contribute?

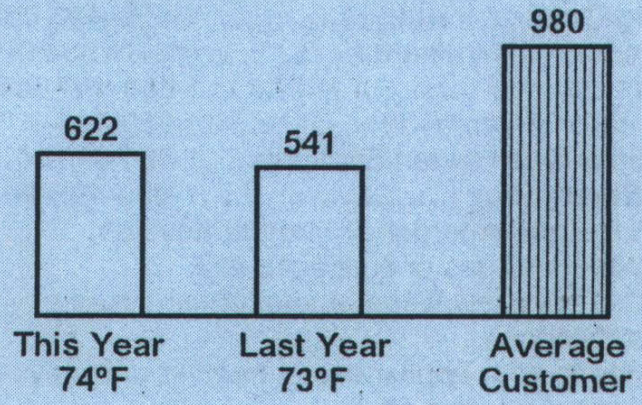
YOUR CONTRIBUTION TO THE GREENHOUSE EFFECT

ELECTRIC SUPPLY AND DELIVERY FROM LIPA

Meter Readings Meter # 15790134

	Jul 24	93155 Actual
	Jun 26	92533 Actual
Use	28 **Days**	622 **KWH**

Comparisons KWH



Cost Rate 880 - Water and Home Heating

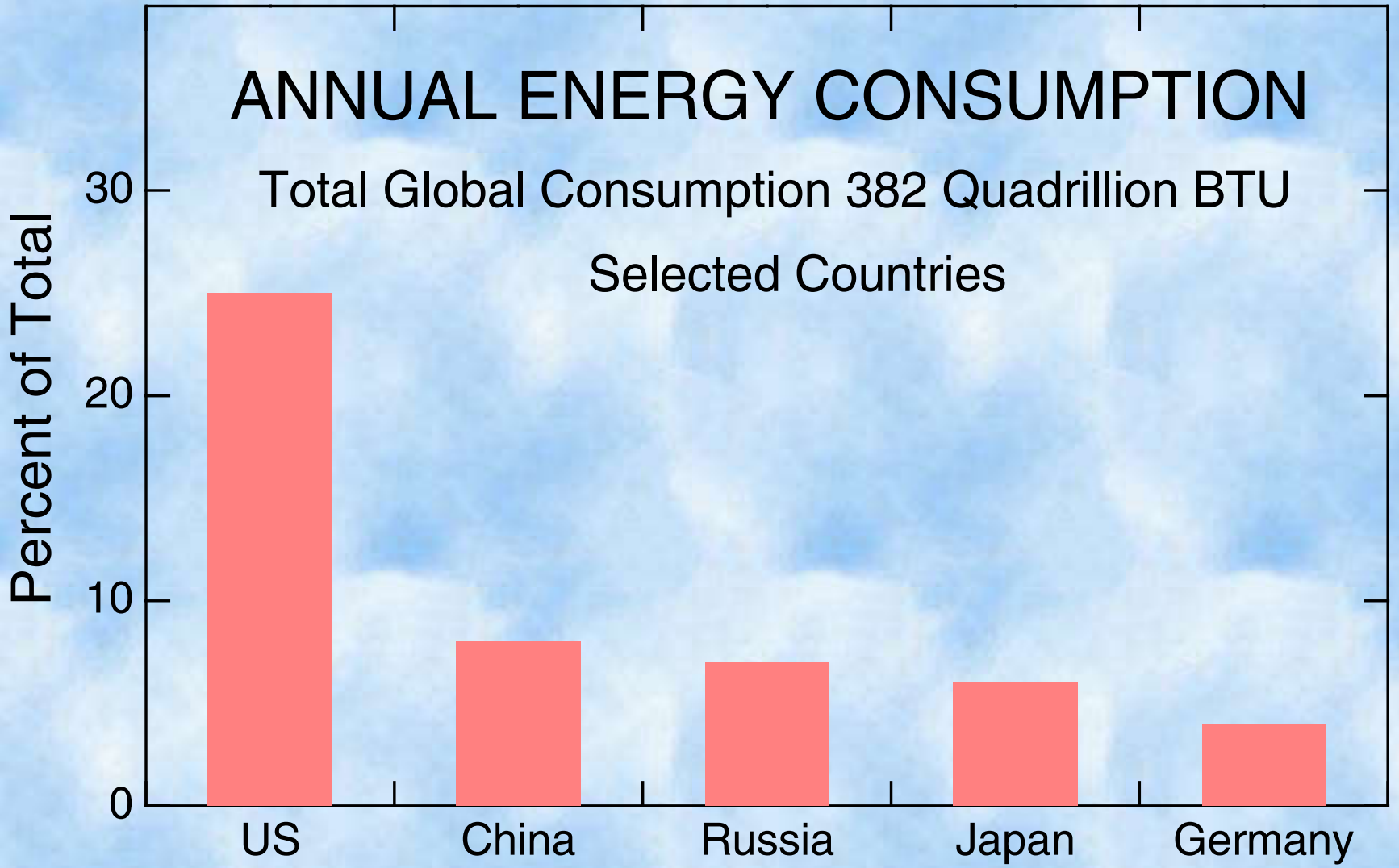
Basic Service: 28 Days @ 17.90¢	$5.01
Use: 233 KWH @ 12.49¢	29.10
140 KWH @ 13.67¢	19.14
249 KWH @ 9.78¢	24.35
Excess Fuel Price Surcharge	4.28
PILOTs and Credits	1.40
Shoreham Credit	-.59
Sales Tax: @ 1%	.83
Total	$83.52

LIPA
Long Island Power Authority

Jul 25, 2001	927 20 1805 3 5	1-800-490-0025	See Back Of Bill
Date	Account Number	Any Questions?	Service Problems

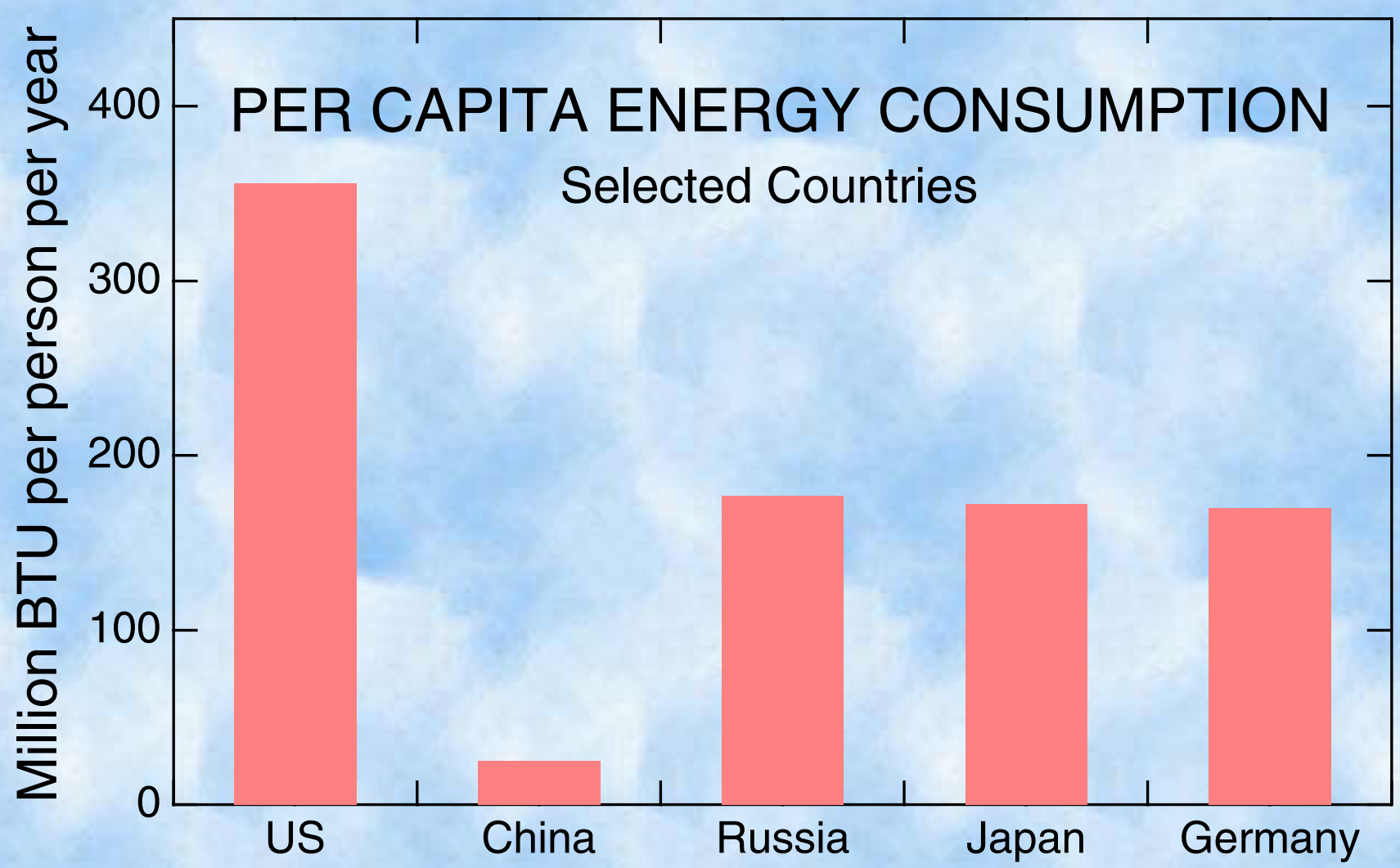
At half a pound of carbon per KWH, the average household is responsible for emission of 500 pounds of carbon a month .

WHAT COUNTRY USES THE MOST ELECTRIC POWER?



No surprise. It's the United States.

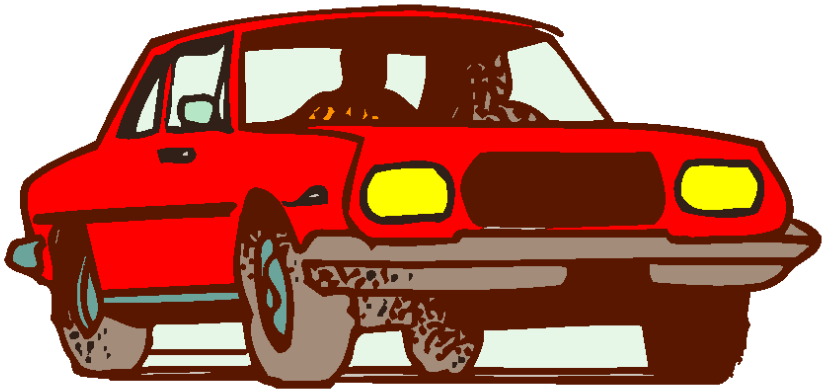
WHAT COUNTRY USES THE MOST ELECTRIC POWER ***PER CAPITA***?



No surprise. It's the United States again.

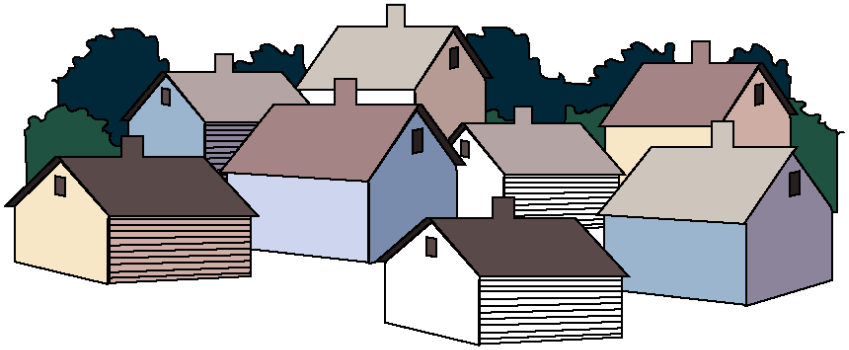
WHERE IS THIS CARBON DIOXIDE COMING FROM?

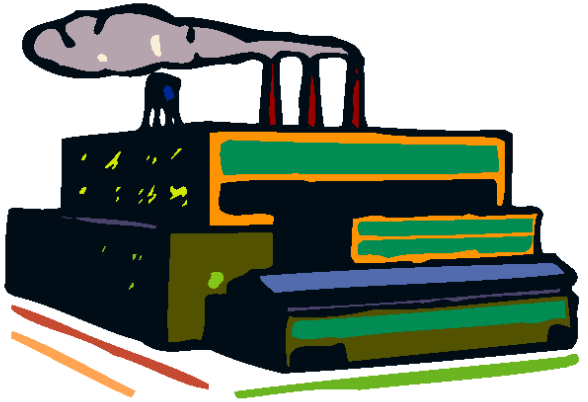
WE ARE ALL RESPONSIBLE.



Burning a gallon of gasoline in your car puts 5 pounds of carbon in the atmosphere as carbon dioxide (CO_2), and it will stay there for decades — maybe a century!

Other sources are home heating and electric power production.





Global Atmosphere, Global Warming

QUESTIONS ABOUT GLOBAL WARMING

- IS IT REAL?
- IS IT IMPORTANT?
- WHAT IS IT DUE TO?
- HOW MUCH MORE CAN WE EXPECT?
- ARE WE SEEING JUST THE TIP OF THE ICEBERG?

RESEARCH IS HELPING TO ANSWER THESE QUESTIONS.

www.ecd.bnl.gov/steve