



National Space Society
International Space Development Conference 2017
St. Louis, Missouri

Why addressing anthropogenic CO₂ and fossil fuel energy insecurity is the key to selling space solar power

Mike Snead, PE
President
Spacefaring Institute™

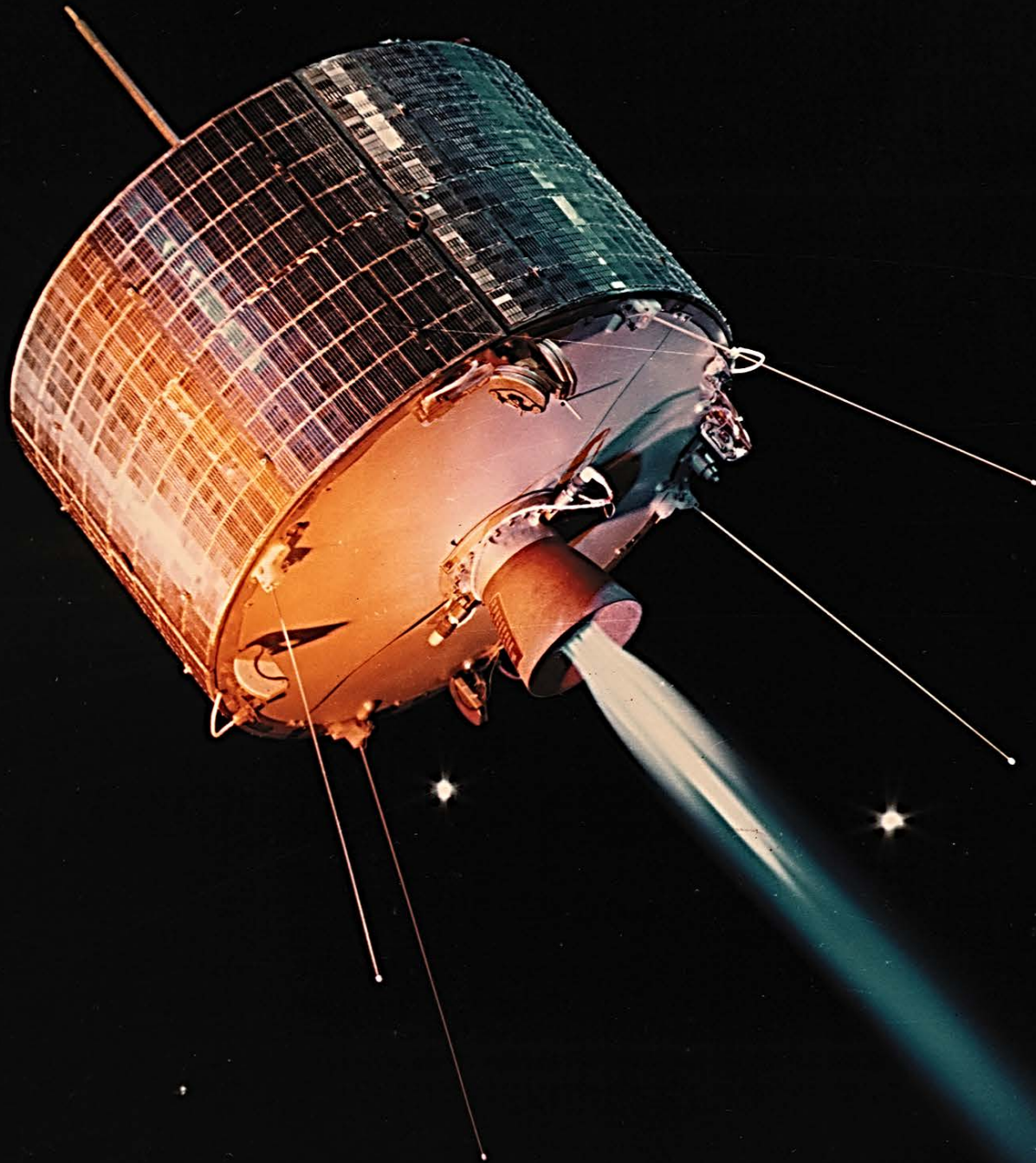
© 2017 Spacefaring Institute™. All rights reserved.

1968

Spacefaring Institute
ISDC 2017



1964



1968

Dr. Peter Glaser

Spacefaring Institute
ISDC 2017



Credit: National Space Society

Space solar power concept



Credit: Arthur D. Little Inc.





1973

SHEET 1 OF 4

3,781,647

SOLAR
RADIATION

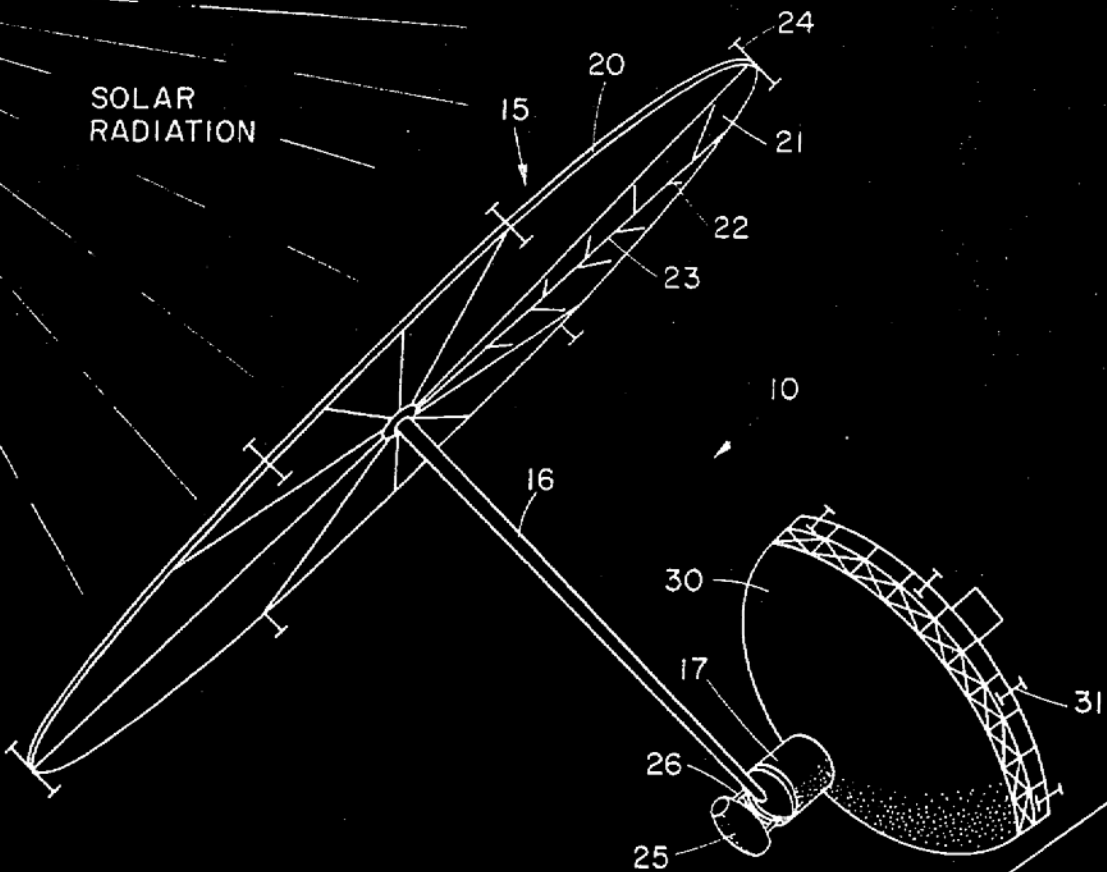


Fig. 1

INVENTOR.

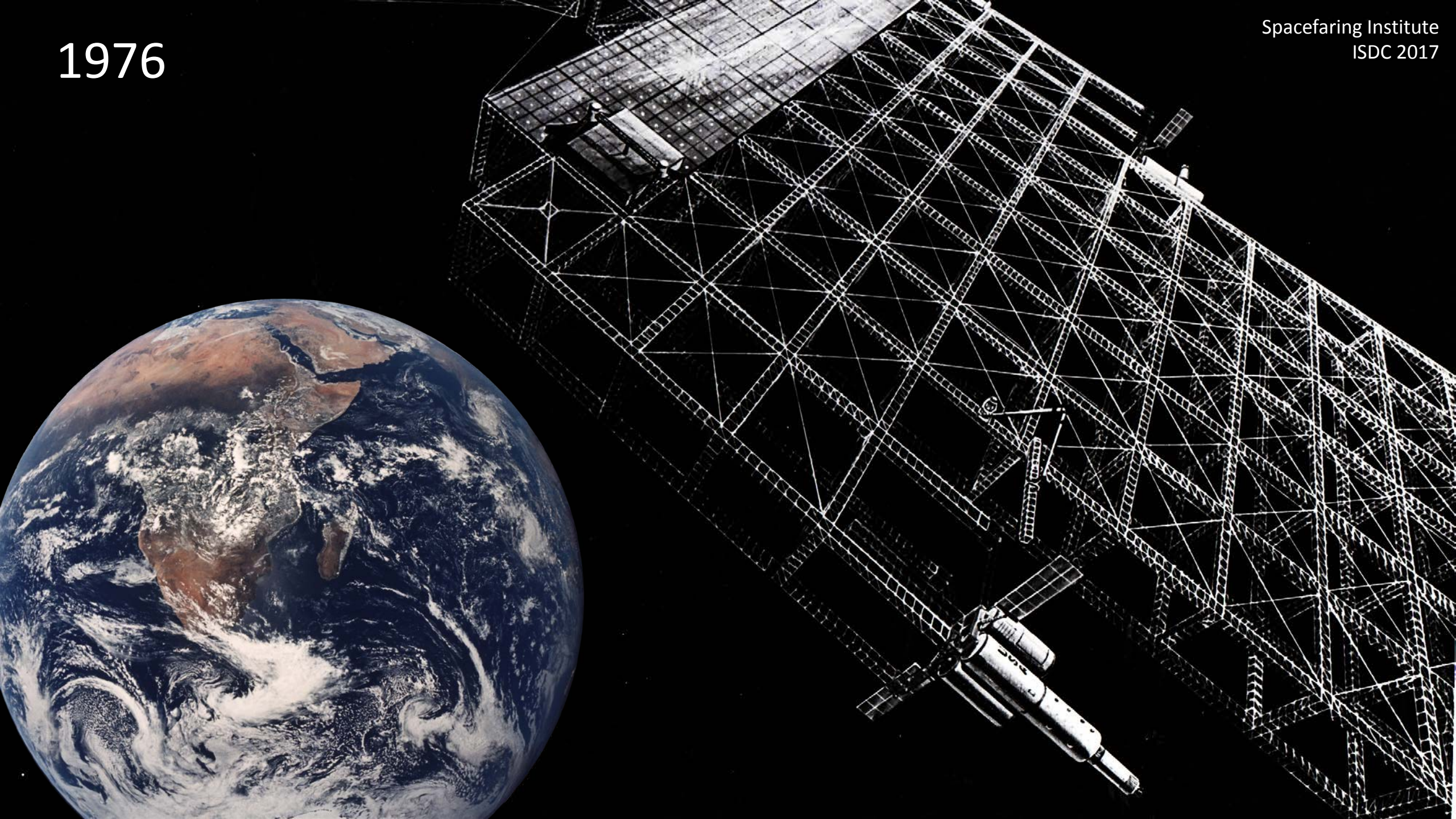
Peter E. Glaser

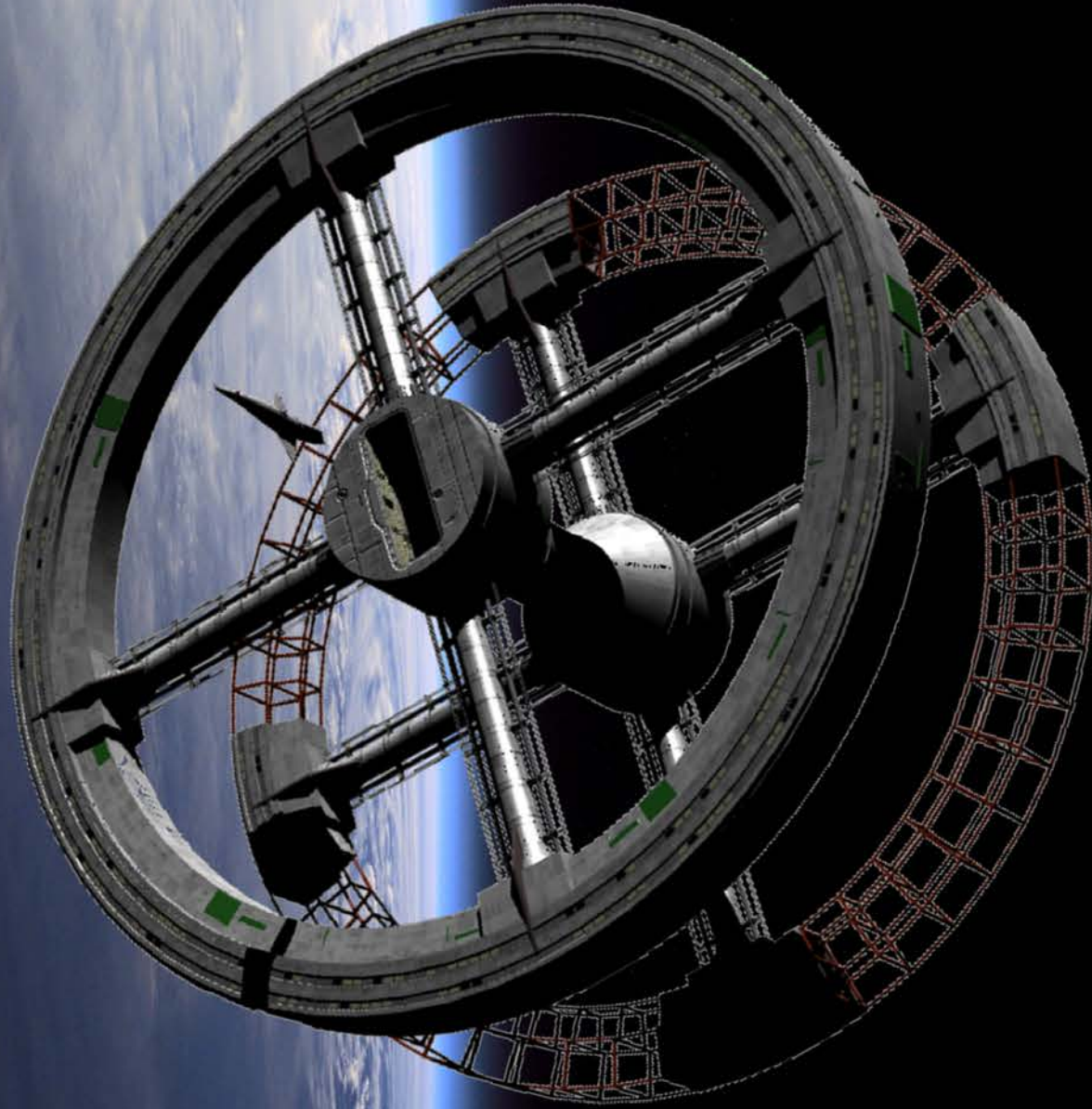
BY

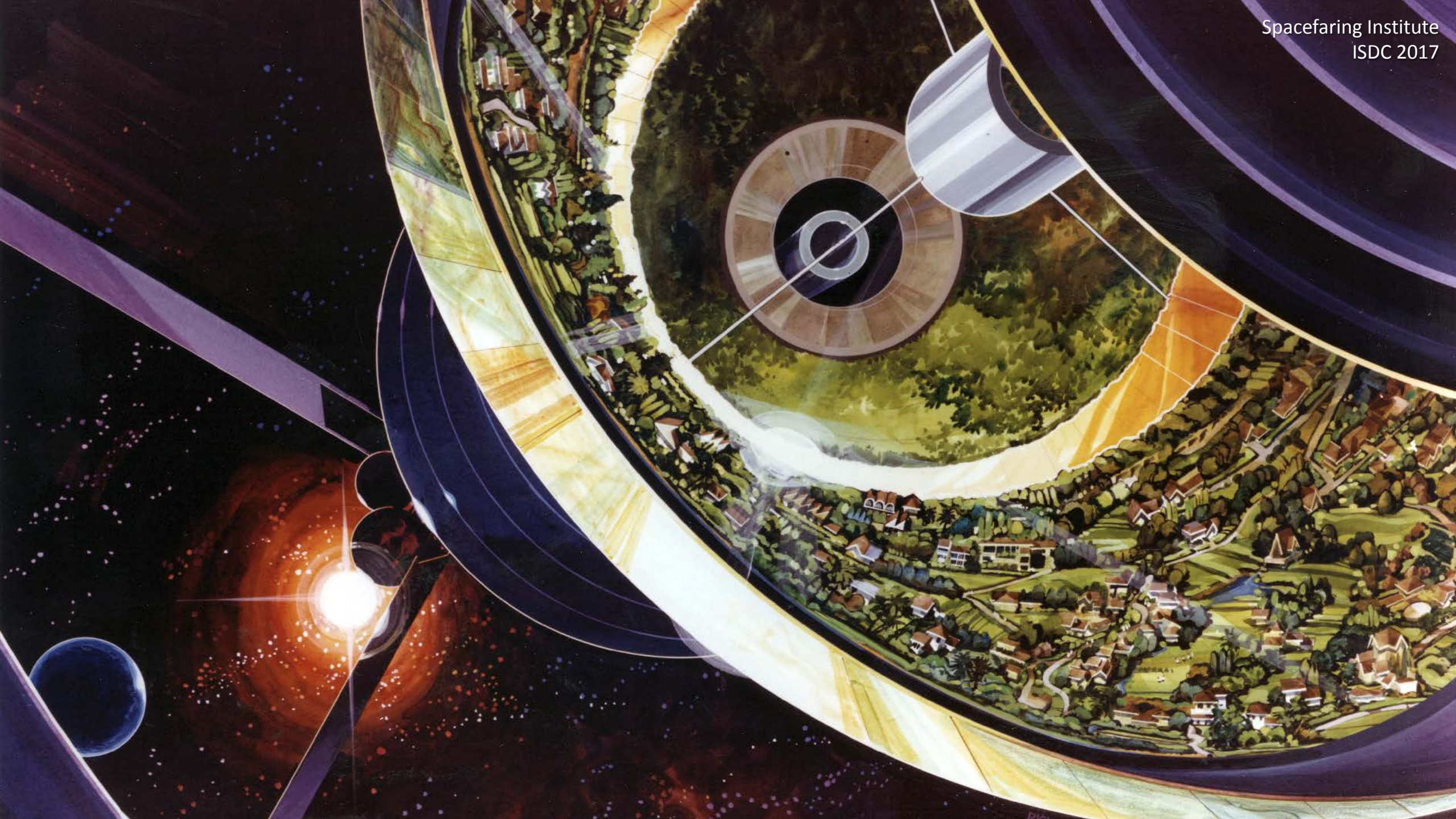
Frederic A. Loggner
Attorney

1976

Spacefaring Institute
ISDC 2017

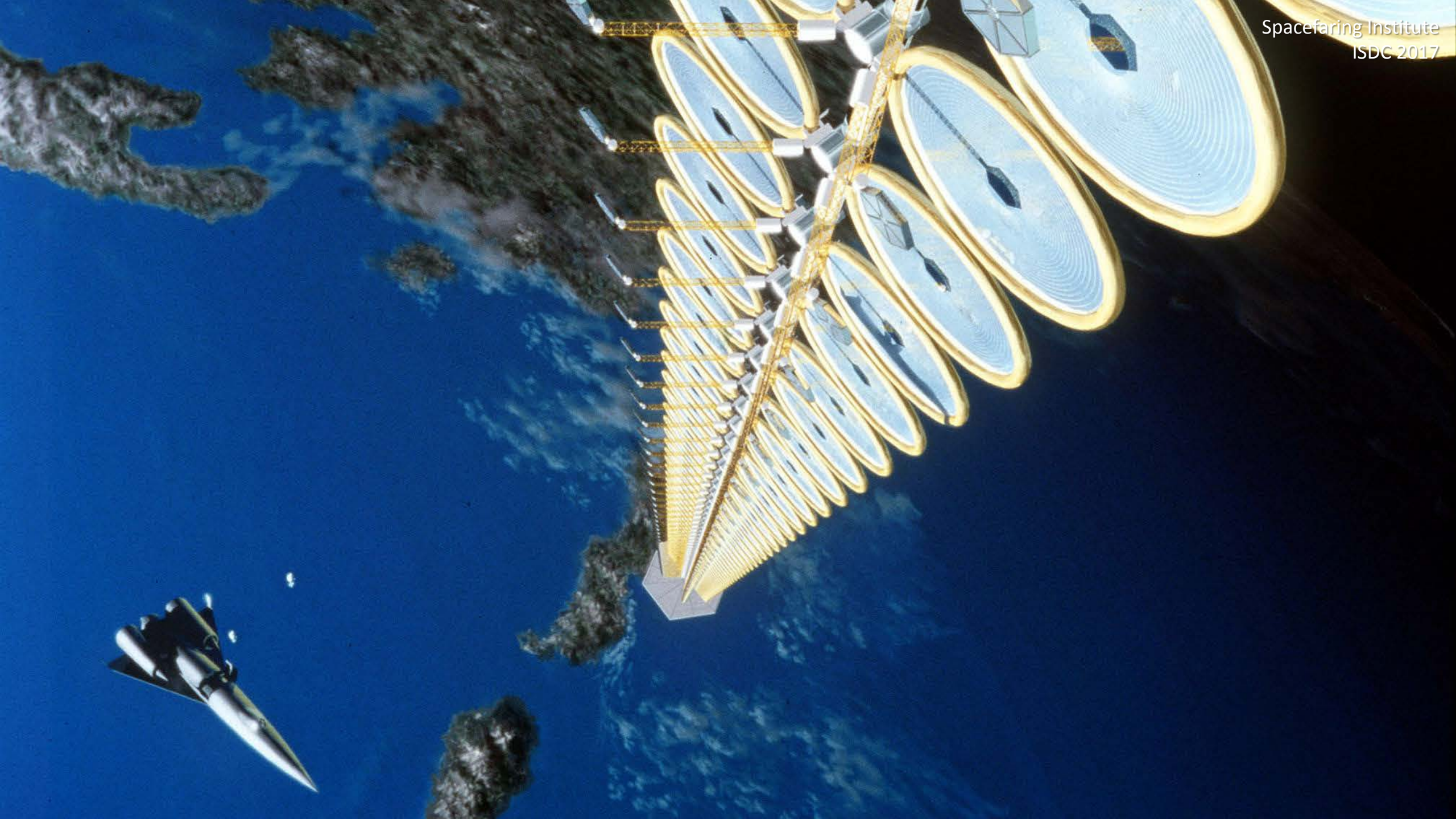












Sunrise – January 20, 2017

Anthropogenic
CO₂

Energy
independence

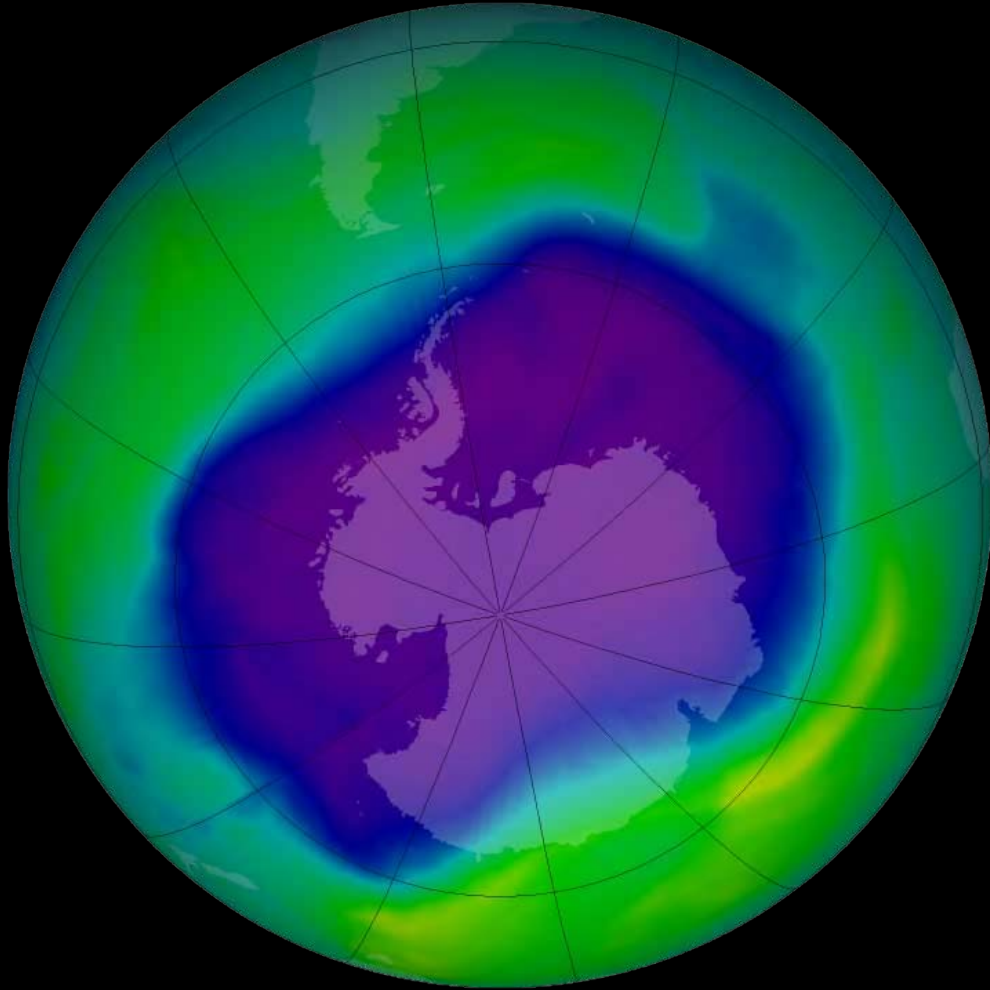


President Trump – March 28, 2017, EPA Headquarters

“We are going to continue to expand energy production, and we will also create more jobs in infrastructure, trucking, and manufacturing. This will allow the EPA to focus on its primary mission of protecting our air and protecting our water. Together, we are going to start a new energy revolution -- one that celebrates American production on American soil.”



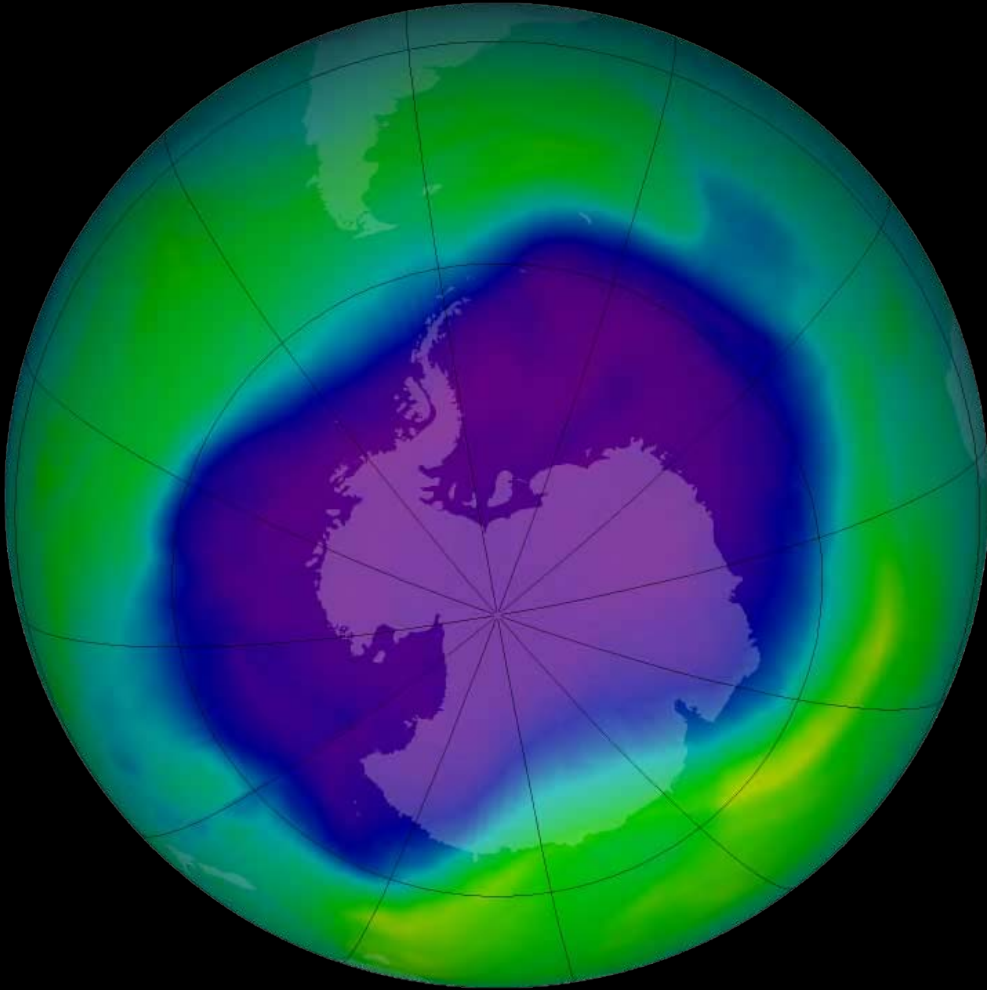
1973



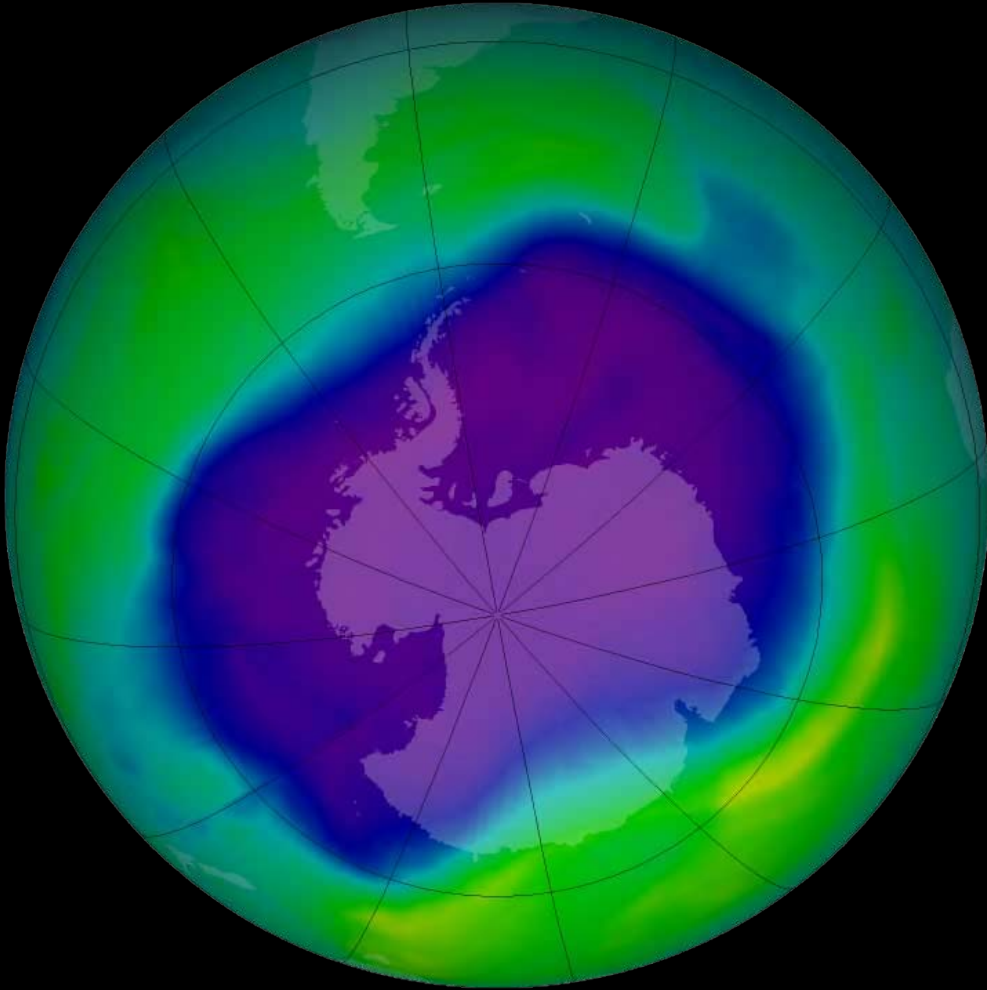
Ozone depletion
over Antarctica

1985

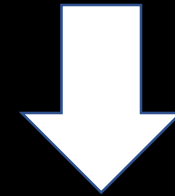
Vienna Convention for the Protection of the Ozone Layer



1987



Vienna Convention for the
Protection of the Ozone Layer

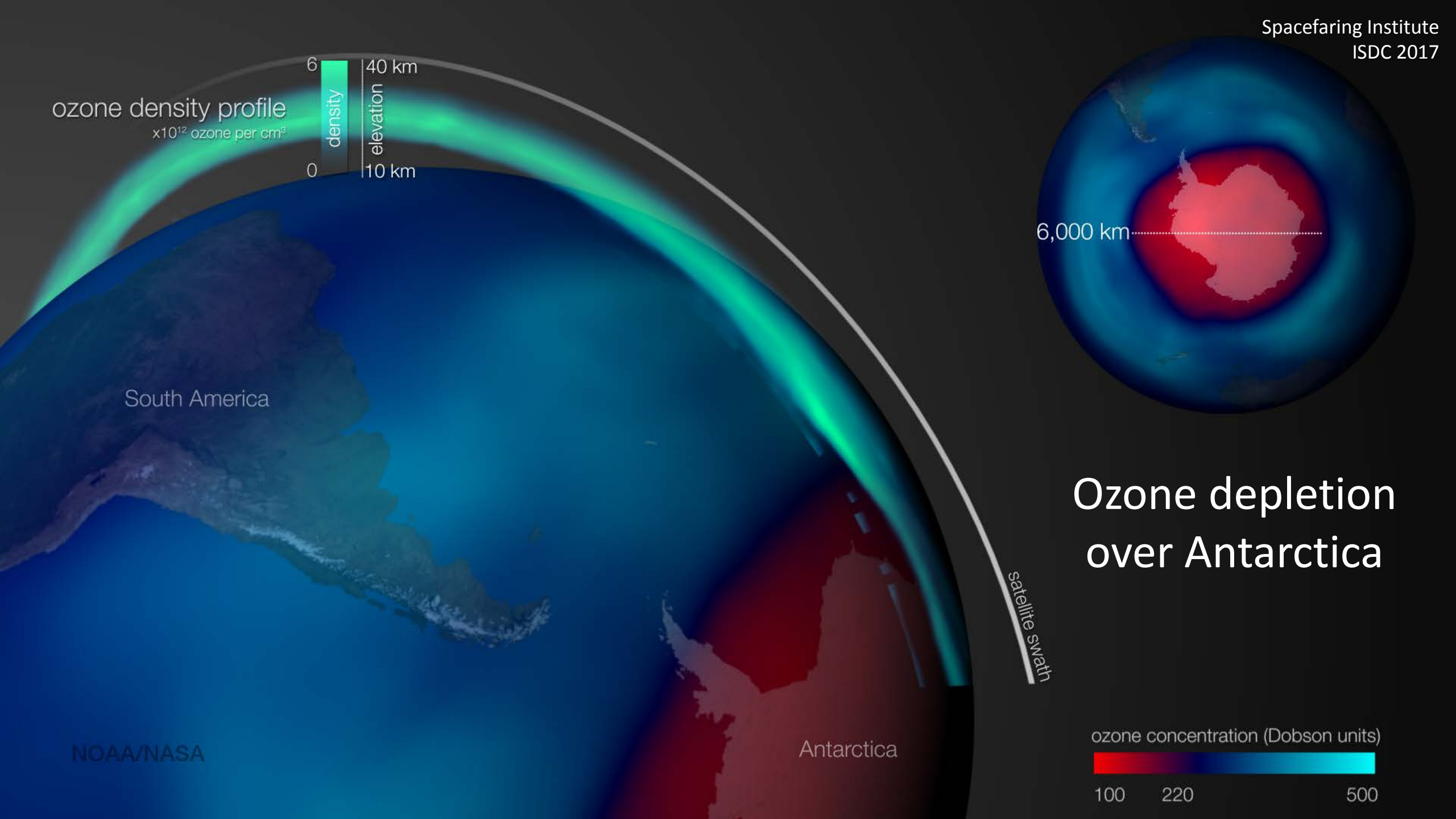


Montreal Protocol on Substances
that Deplete the Ozone Layer

President Reagan:

“I am pleased to sign the instrument of ratification for the Montreal protocol on substances that deplete the ozone layer. The protocol marks an **important milestone** for the future quality of the global environment and for the health and well-being of all peoples of the world. Unanimous approval of the protocol by the Senate ...”











1992



United Nations
Framework Convention on
Climate Change
(UNFCCC)

1992

United Nations Framework Convention on Climate Change

“The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”



1992

United Nations Framework Convention on Climate Change

“The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”

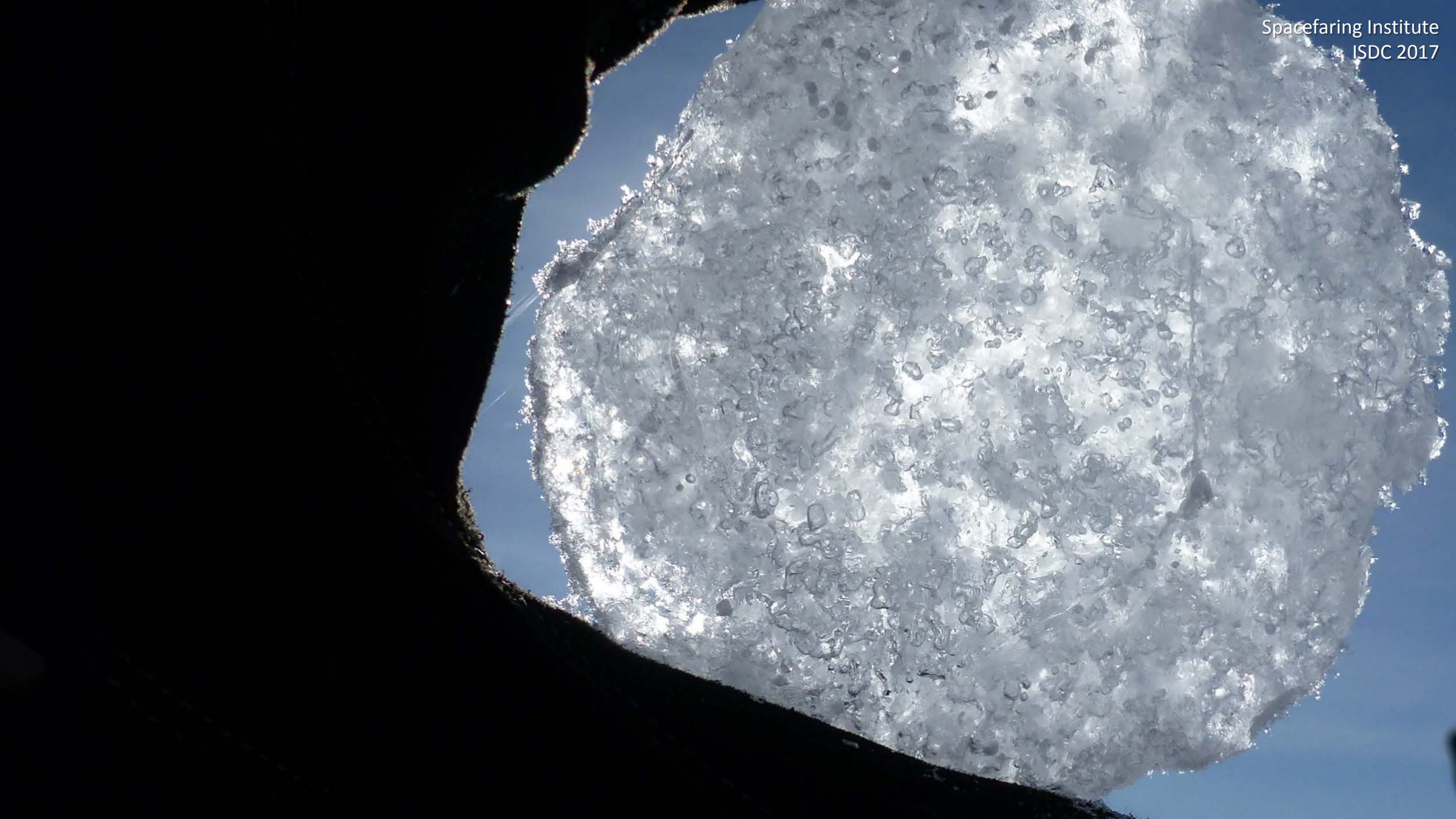
UNFCCC

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

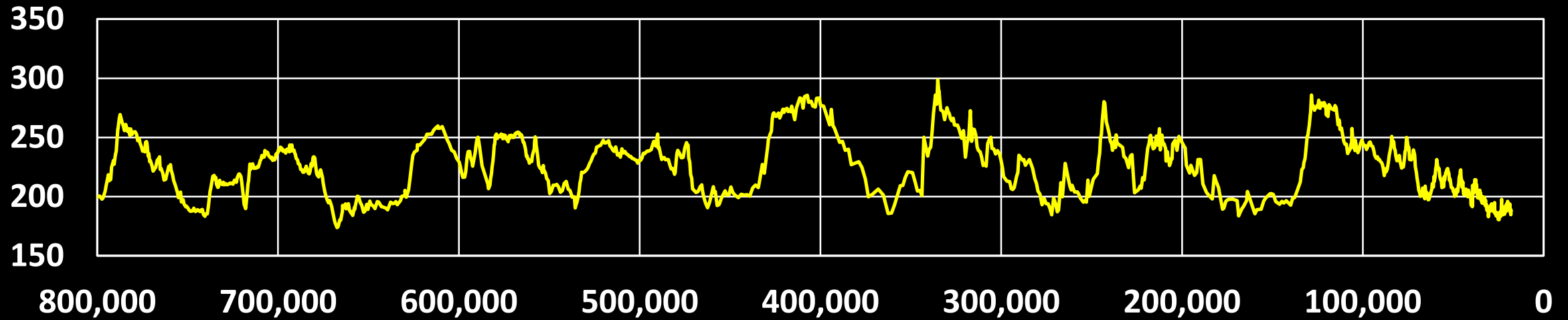
Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.





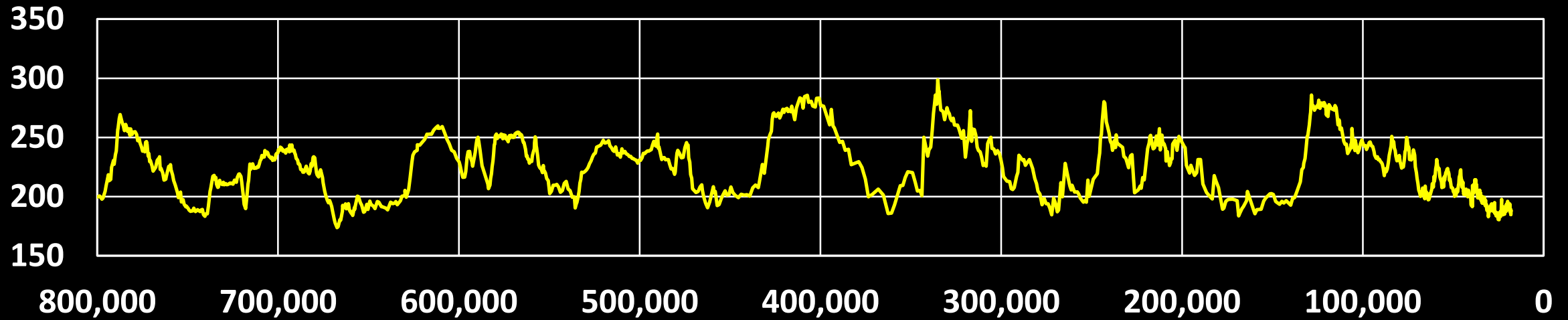


Natural atmospheric CO₂ variation (Parts per million by volume—PPM)

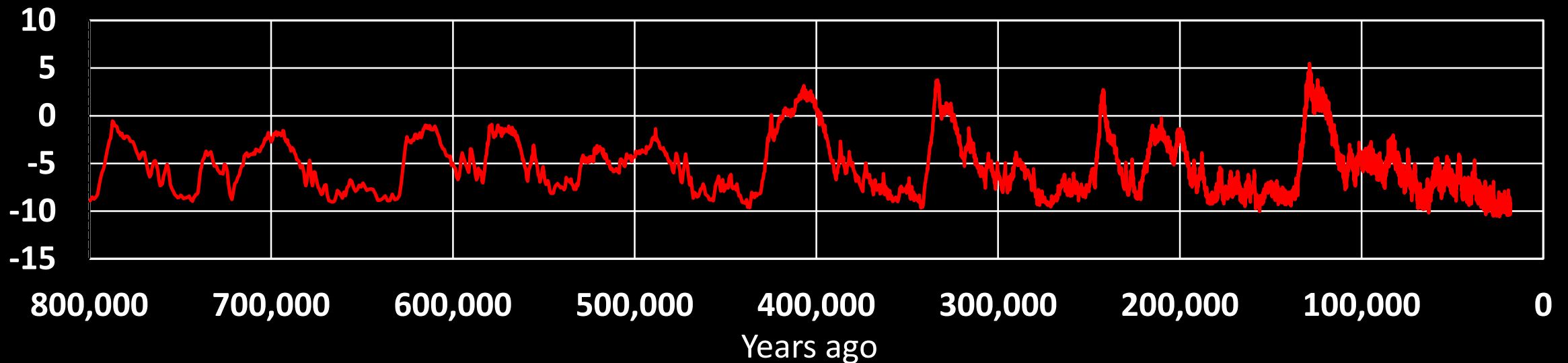


Source: World Data Center for Paleoclimatology, Bolder, and NOAA Paleoclimatology Program, retrieved 2016 and 2017

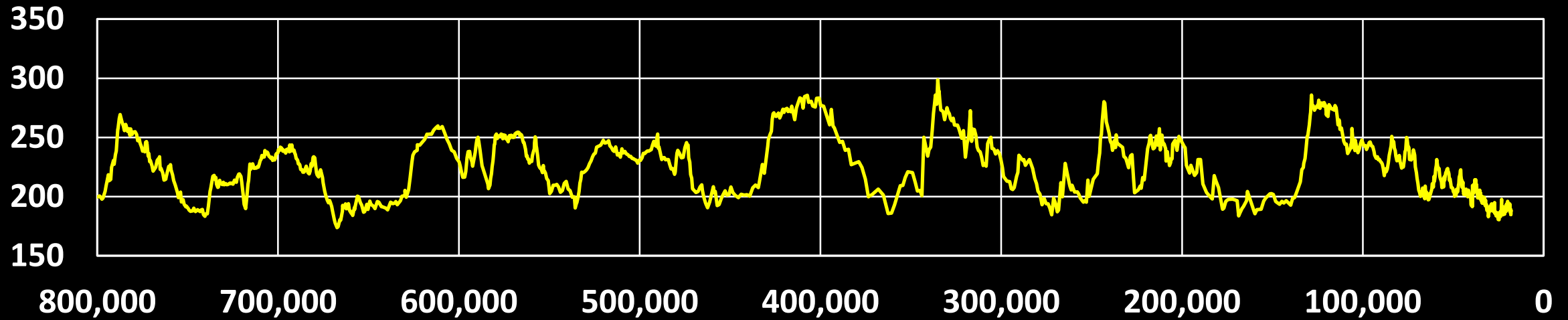
Natural atmospheric CO₂ variation (Parts per million by volume—PPM)



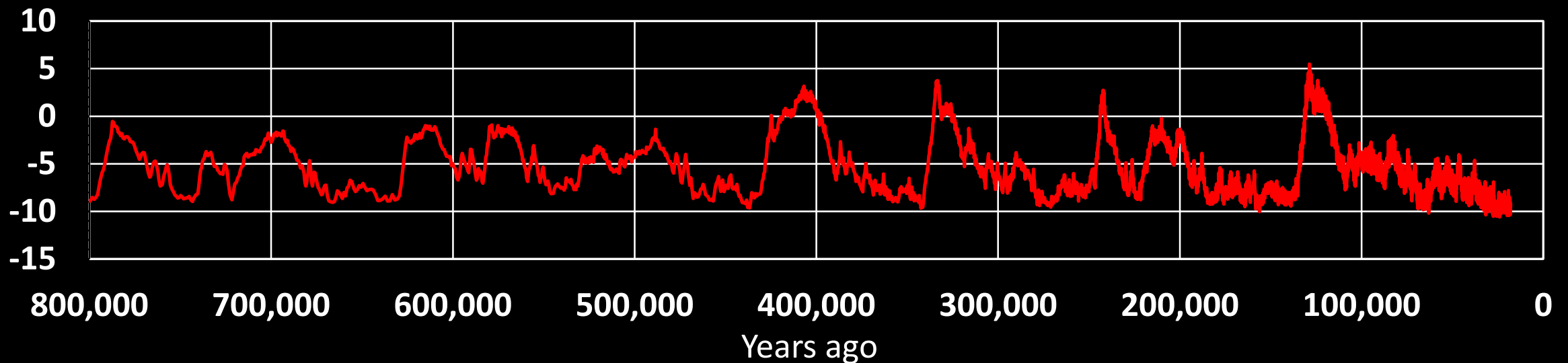
Natural Antarctica temperature change (°C) (Relative to mean temperature during last 1000 years)



Natural atmospheric CO₂ variation (Parts per million by volume—PPM)



Natural Antarctica temperature change (°C) (Relative to mean temperature during last 1000 years)



Source: World Data Center for Paleoclimatology, Bolder, and NOAA Paleoclimatology Program, retrieved 2016 and 2017

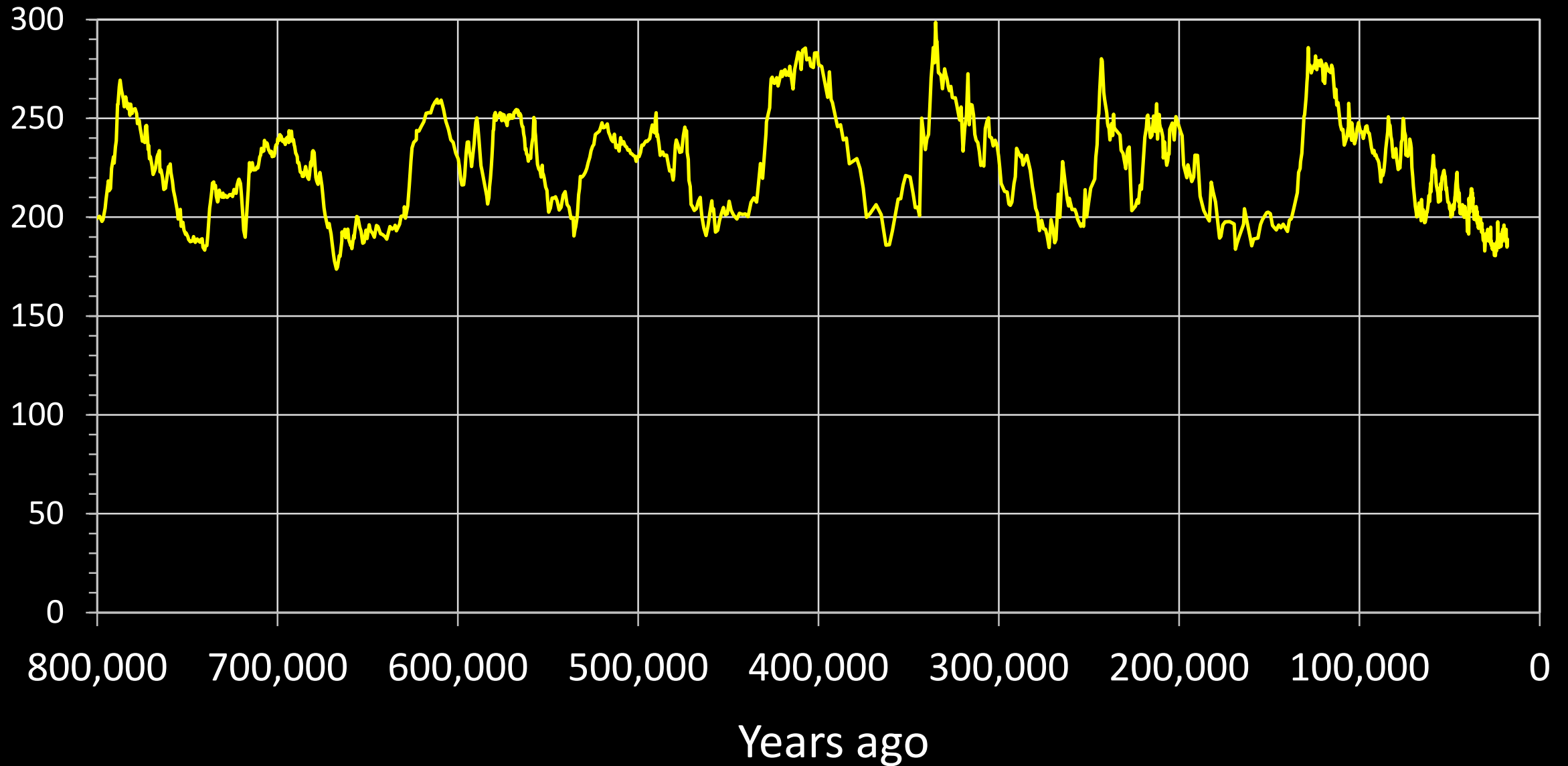
1992

United Nations Framework Convention on Climate Change

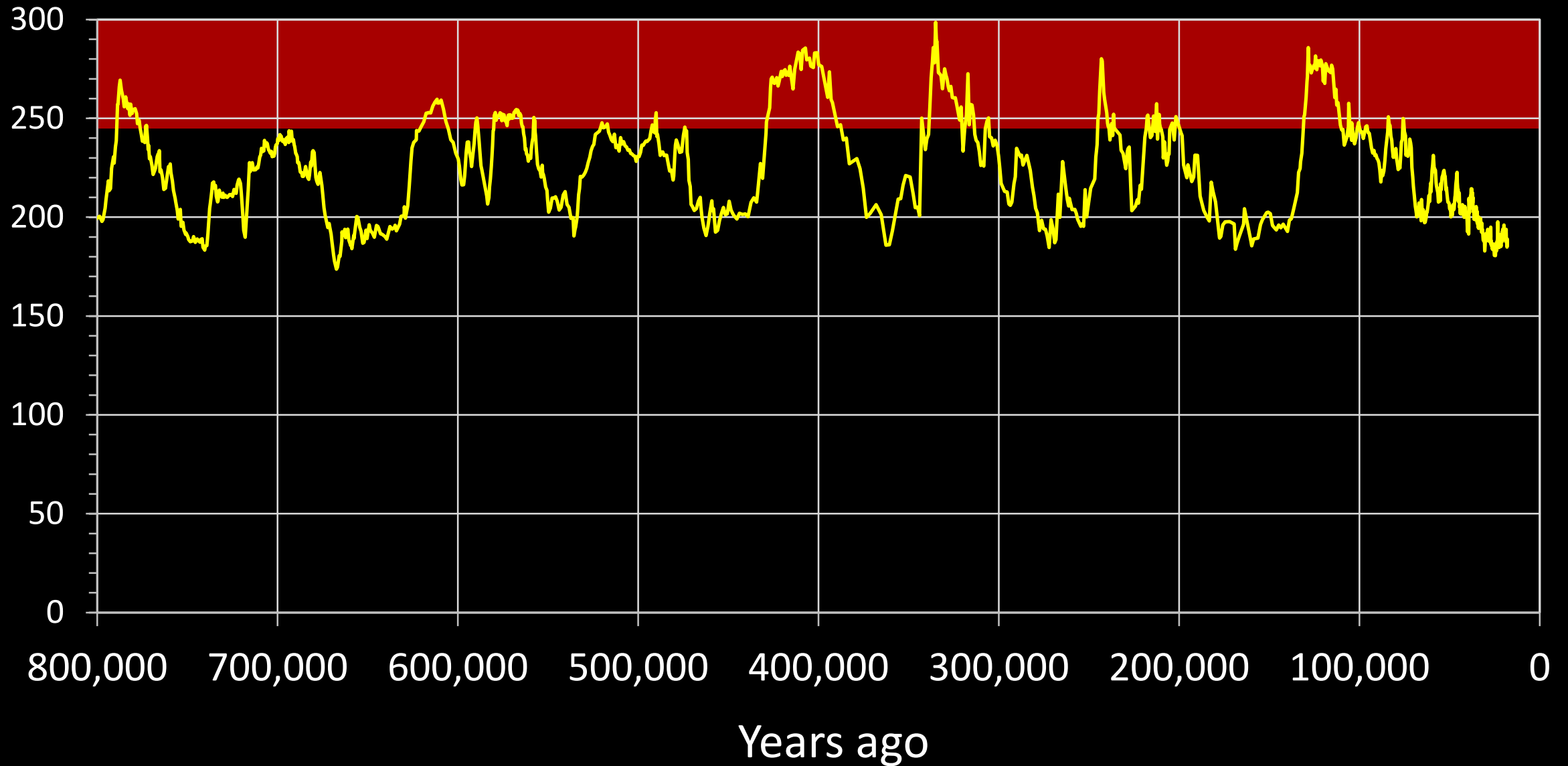


The **ultimate objective** of this Convention and any related legal instruments that the Conference of the Parties may adopt **is to achieve**, in accordance with the relevant provisions of the Convention, **stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system**.

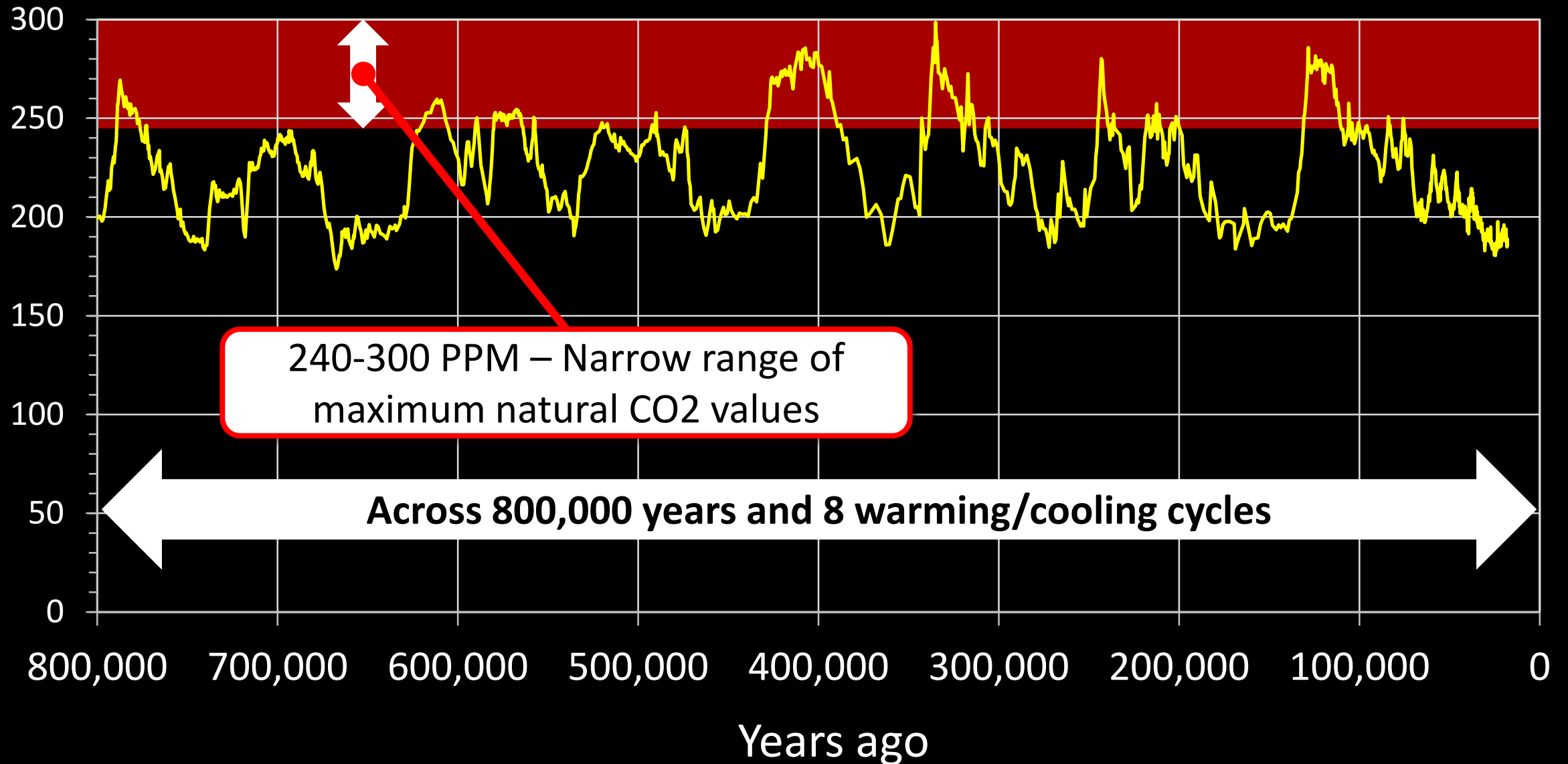
Atmospheric CO₂ concentration – parts per million (PPM) by volume

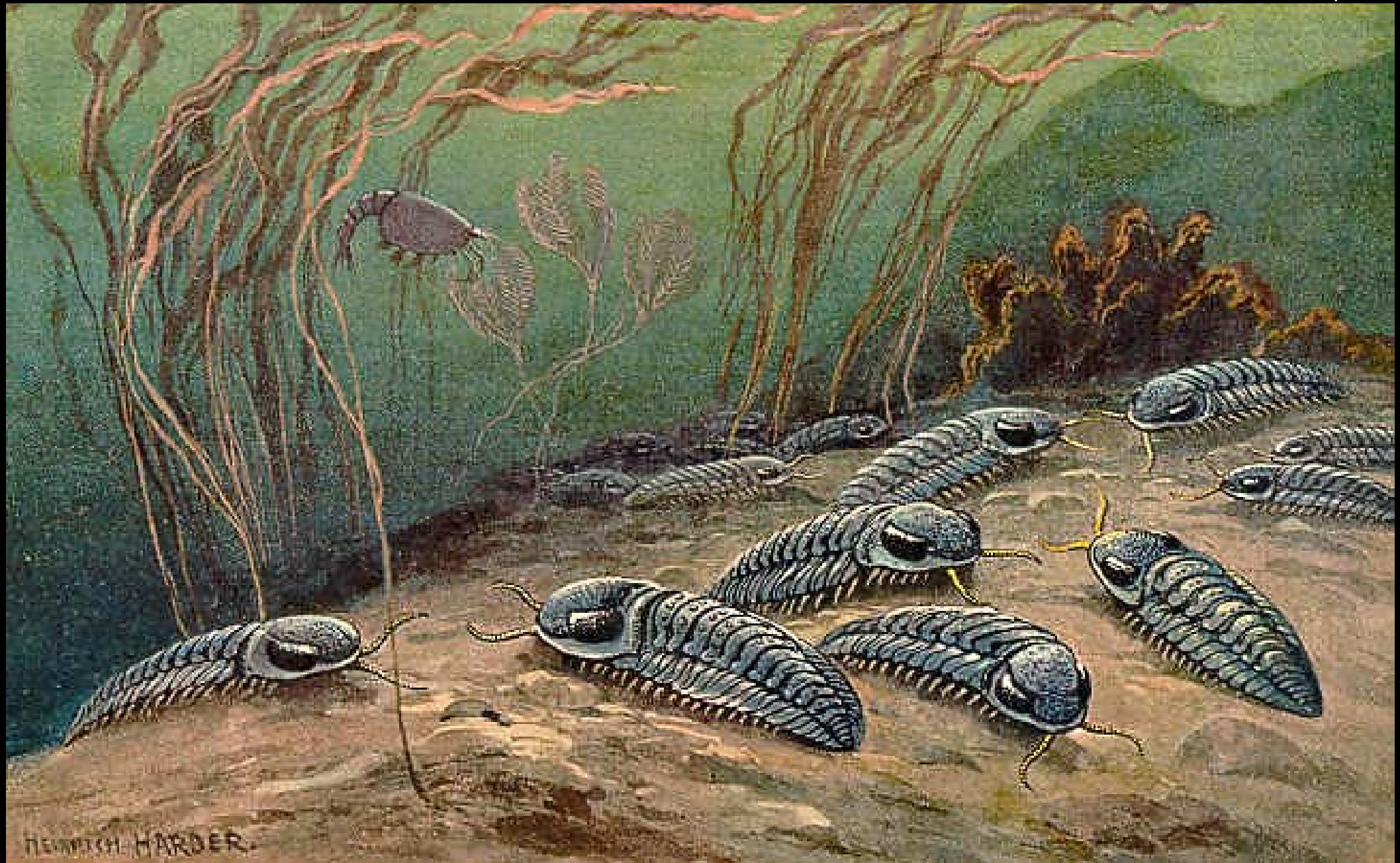


Atmospheric CO₂ concentration – parts per million (PPM) by volume

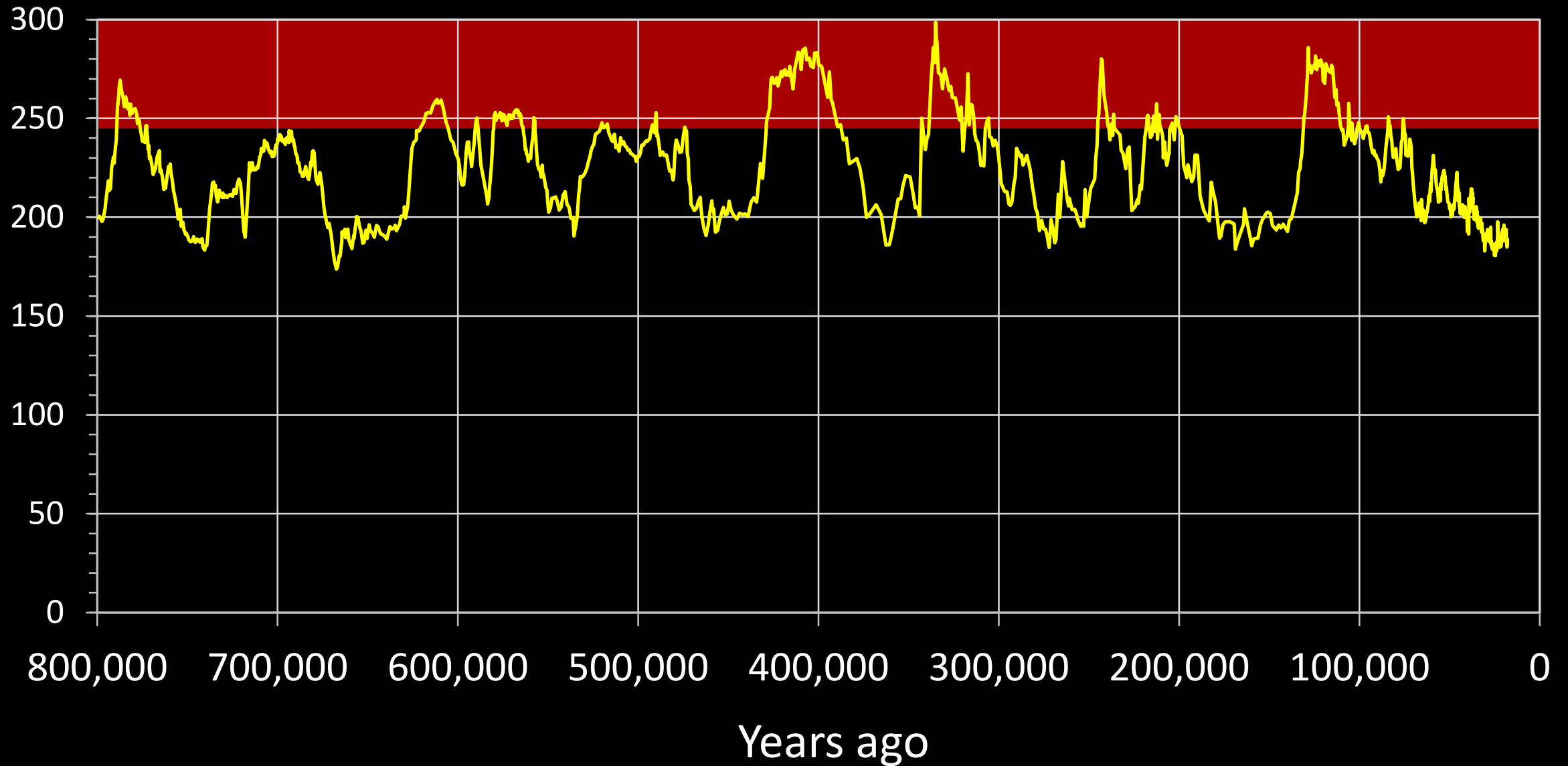


Atmospheric CO₂ concentration – parts per million (PPM) by volume

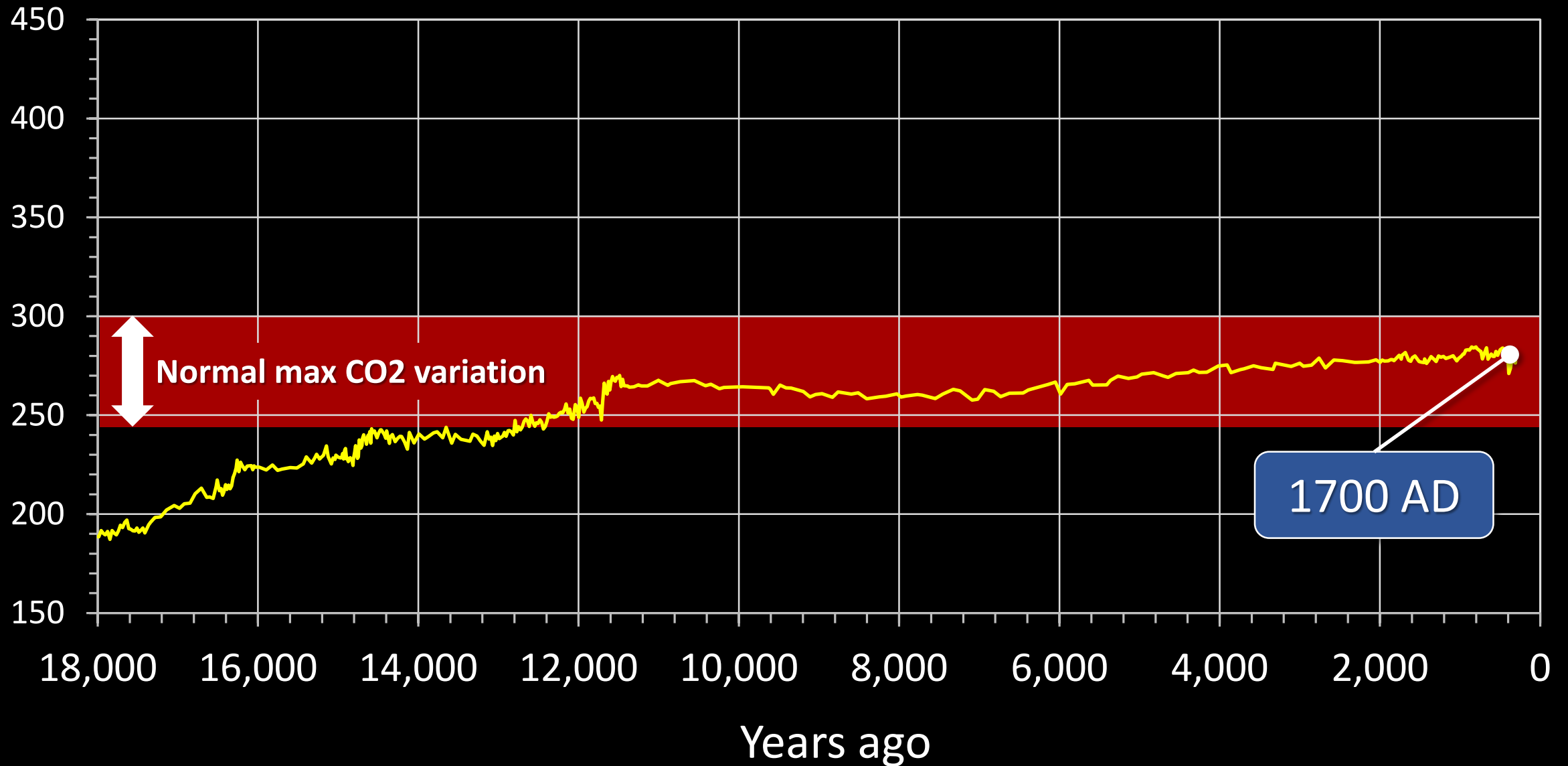




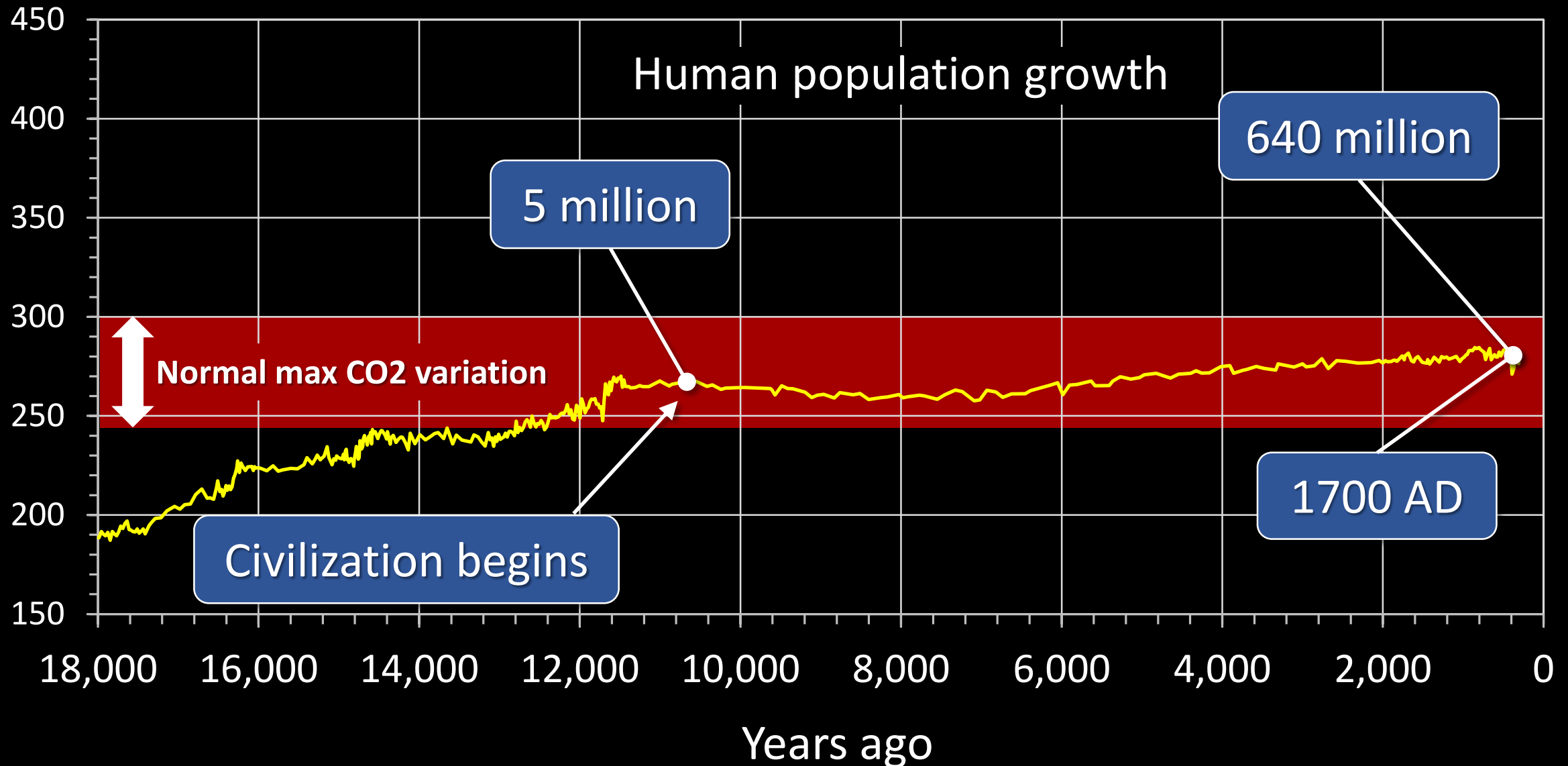
Atmospheric CO₂ concentration – parts per million (PPM) by volume



Atmospheric CO₂ concentration – parts per million (PPM) by volume



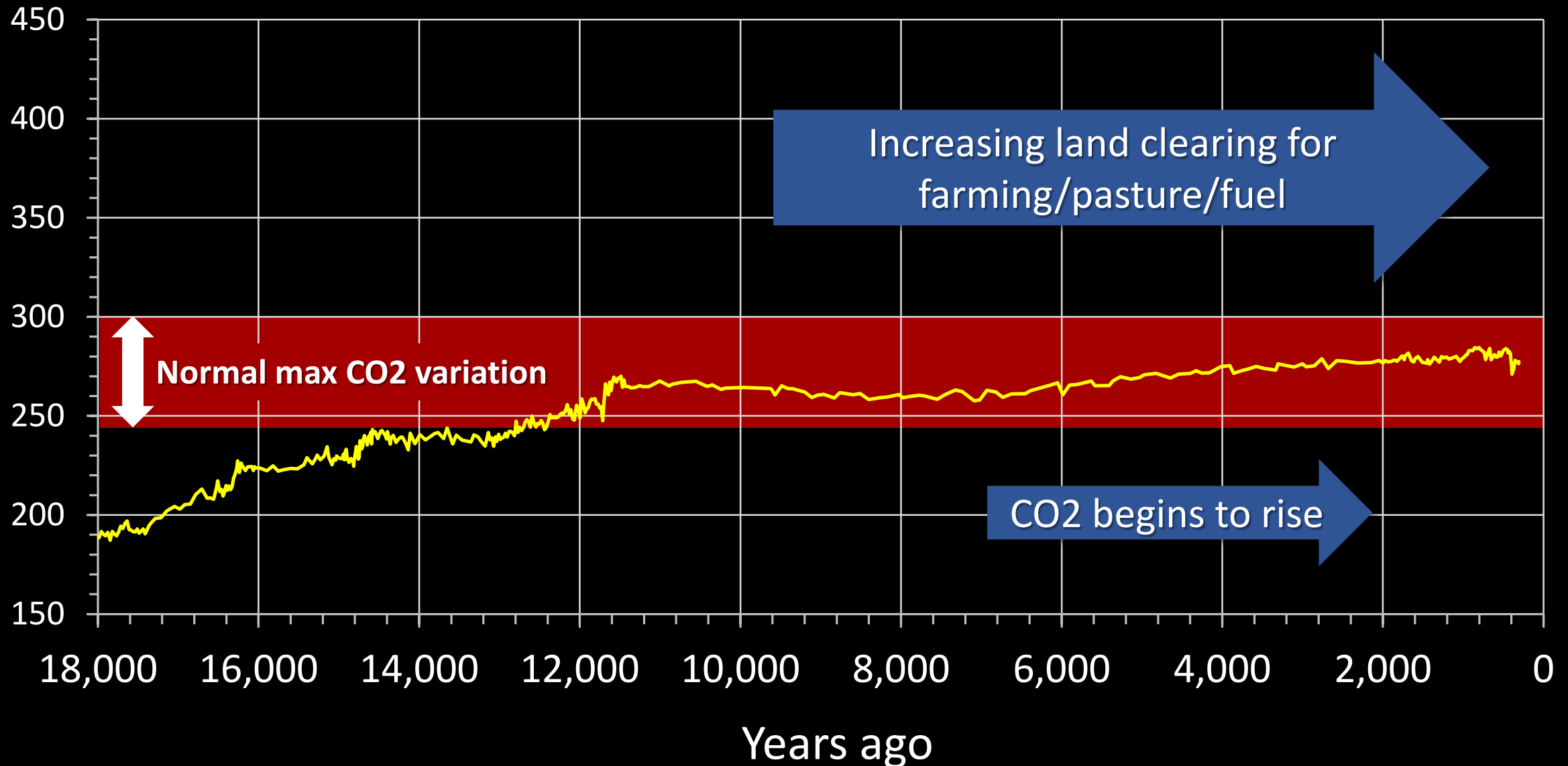
Atmospheric CO₂ concentration – parts per million (PPM) by volume

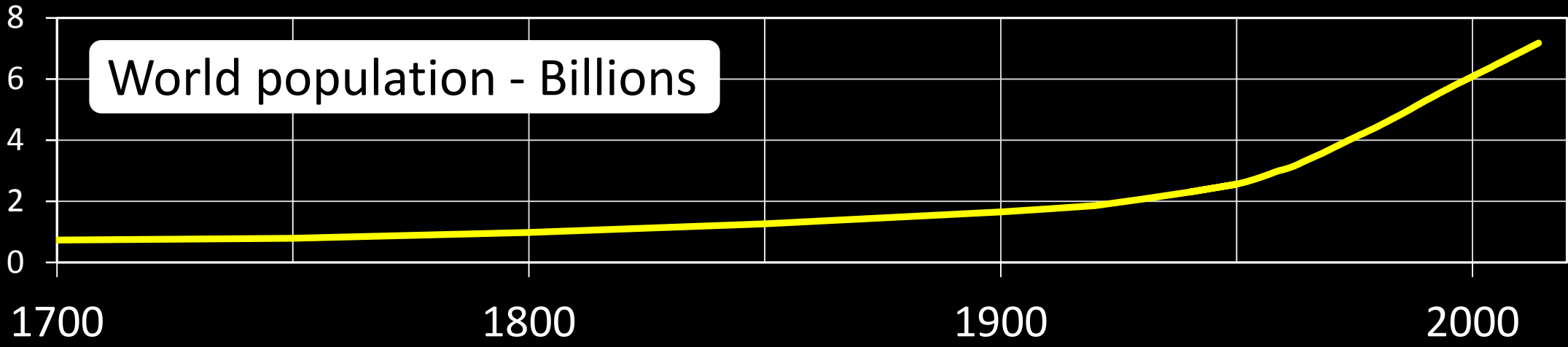


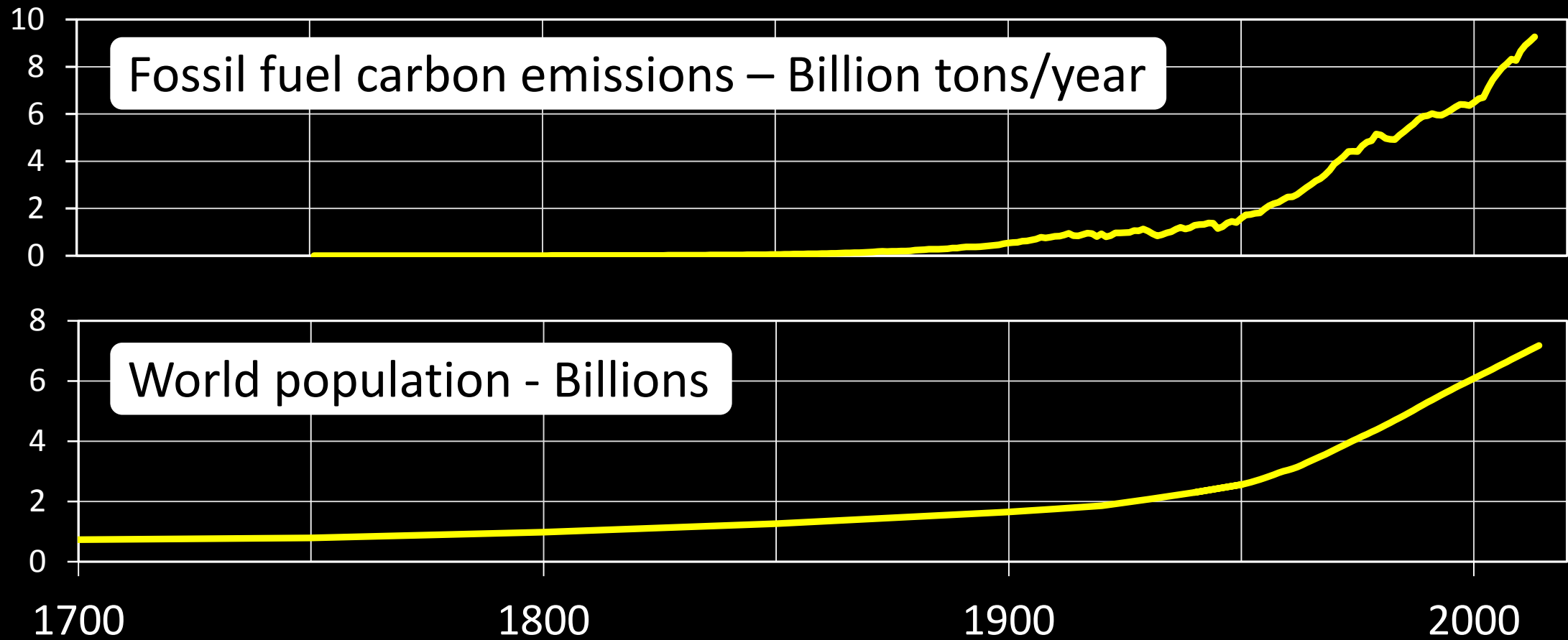


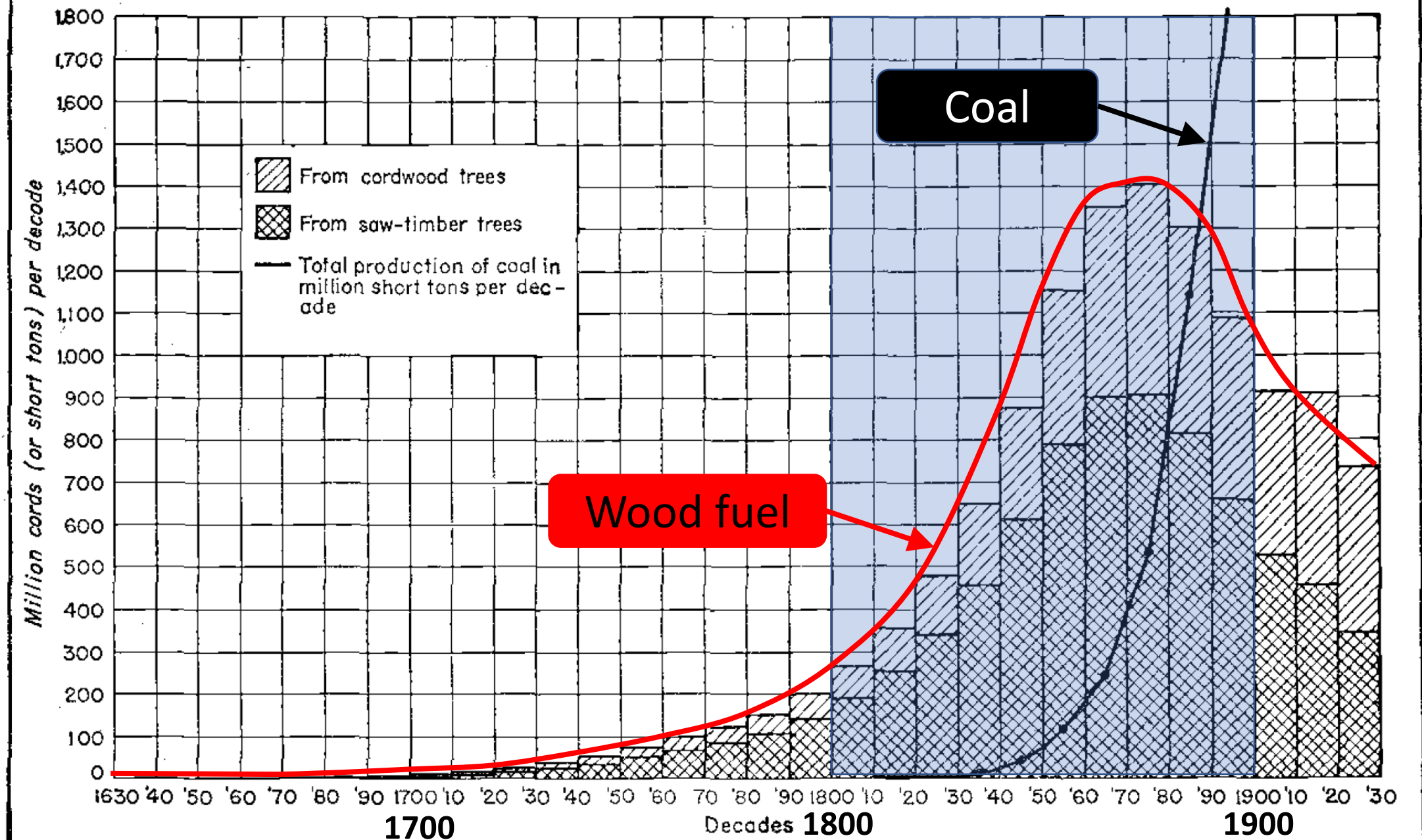


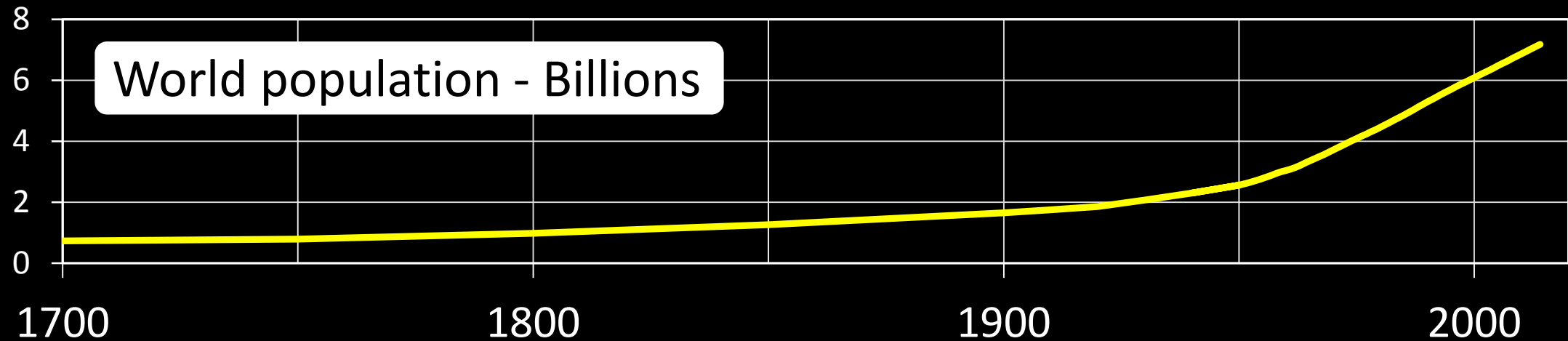
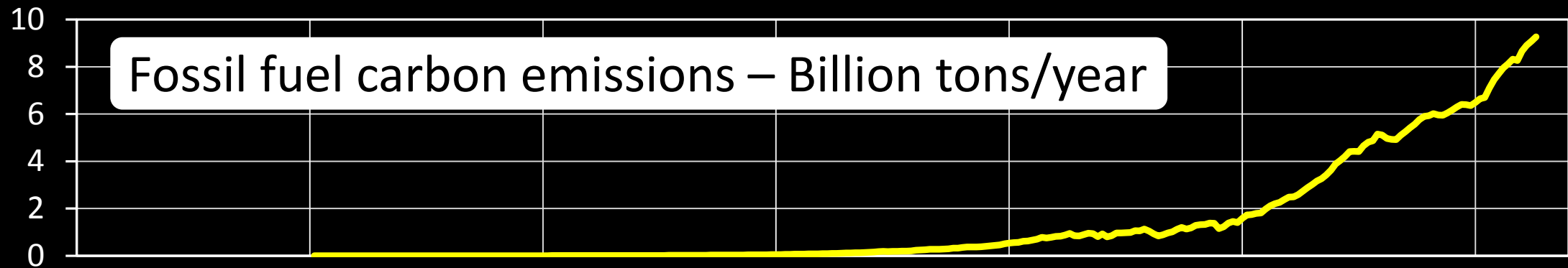
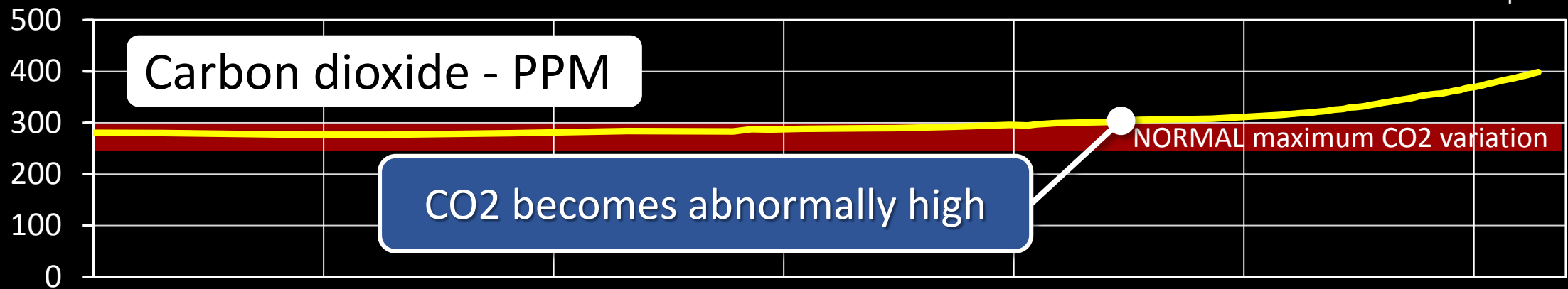
Atmospheric CO₂ concentration – parts per million (PPM) by volume

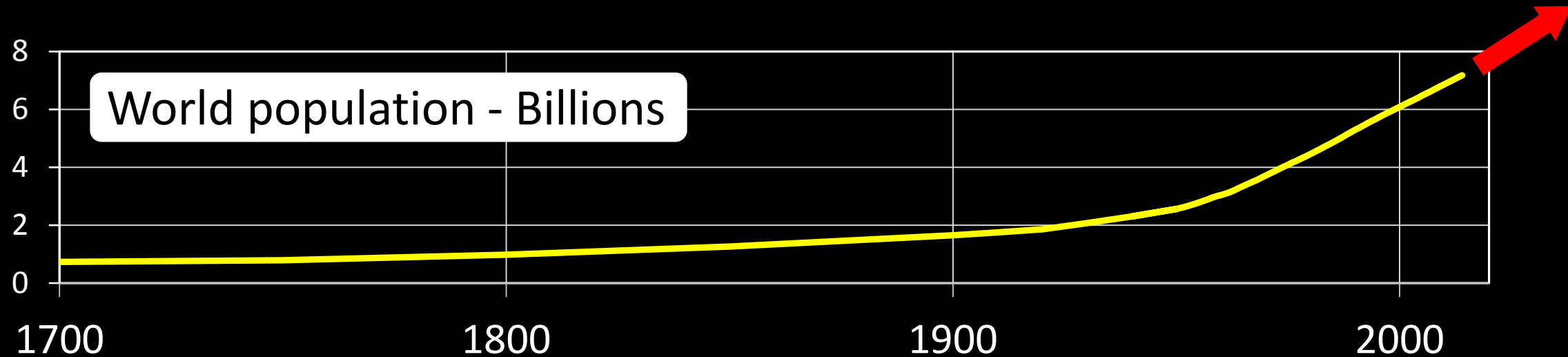
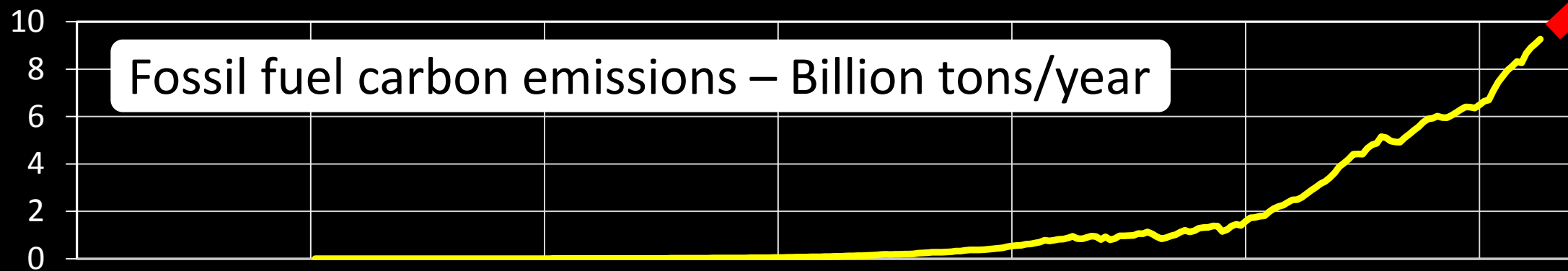
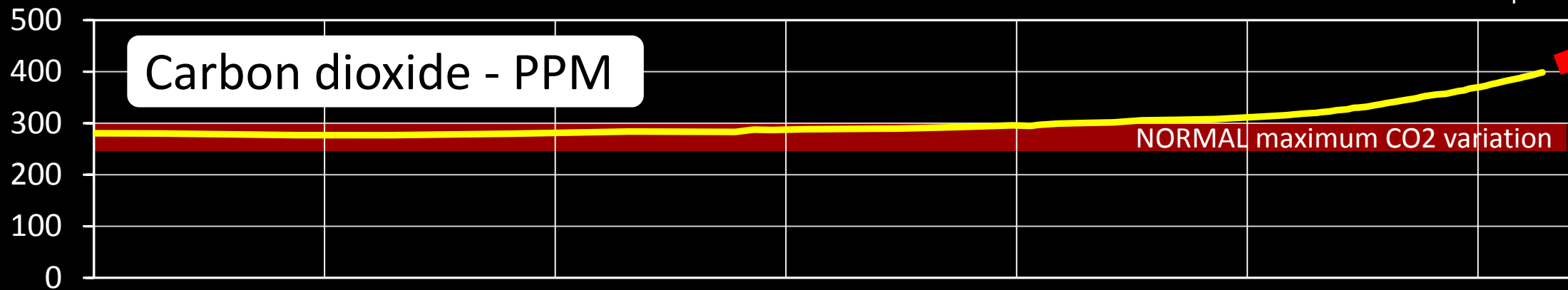












1992

United Nations Framework Convention on Climate Change

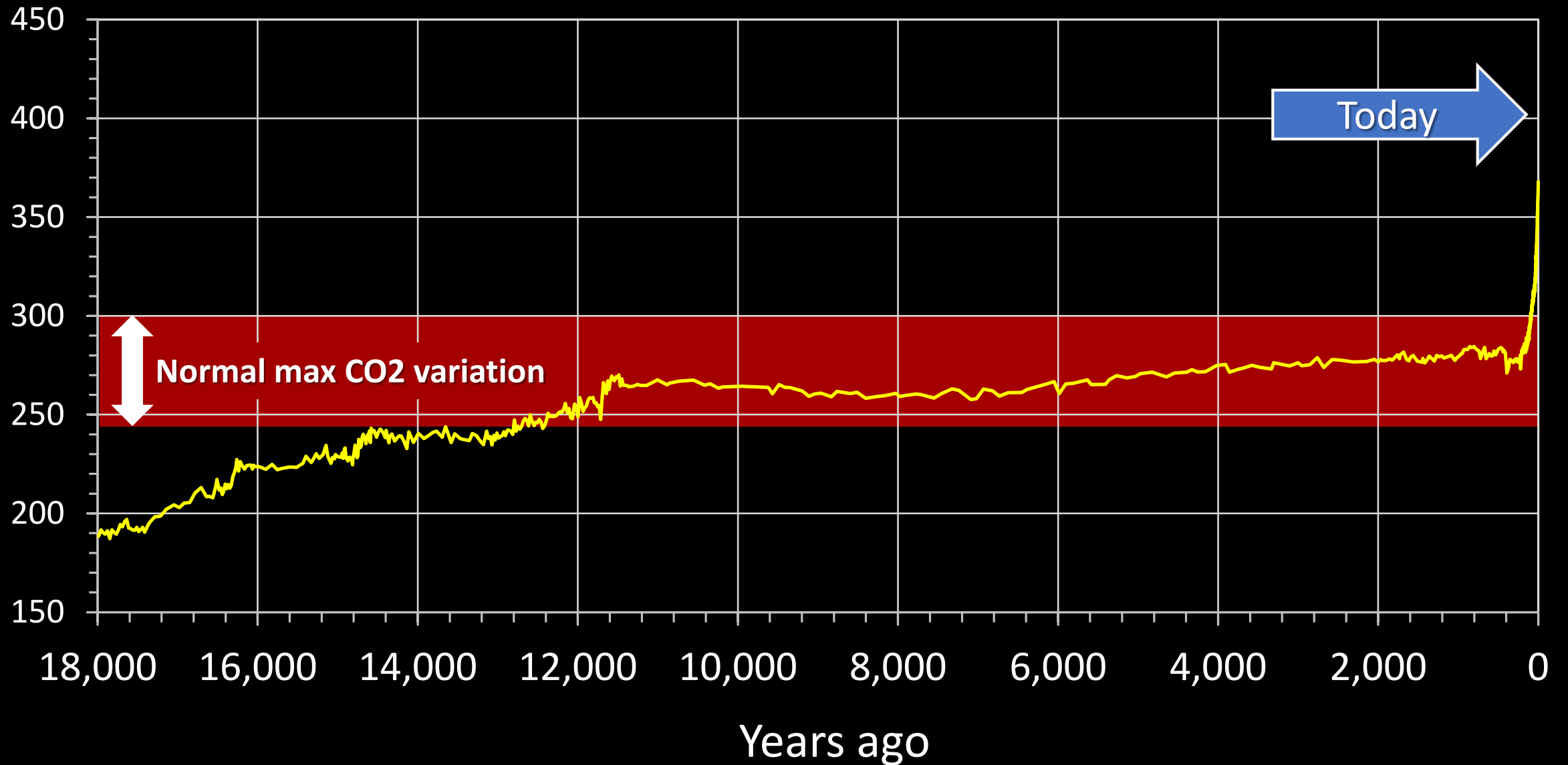


The **ultimate objective** of this Convention and any related legal instruments that the Conference of the Parties may adopt **is to achieve**, in accordance with the relevant provisions of the Convention, **stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system**.

A photograph of a courtroom interior. The room features dark wood paneling on the walls and a large wooden bench with several leather-upholstered chairs. The chairs are arranged in rows, facing towards the front of the room. The lighting is soft, coming from windows in the background. The floor is made of polished wood.

What maximum CO₂ concentration will NOT cause dangerous interference with the climate system?

Atmospheric CO₂ concentration – parts per million (PPM) by volume



President Trump – March 28, 2017, EPA Headquarters

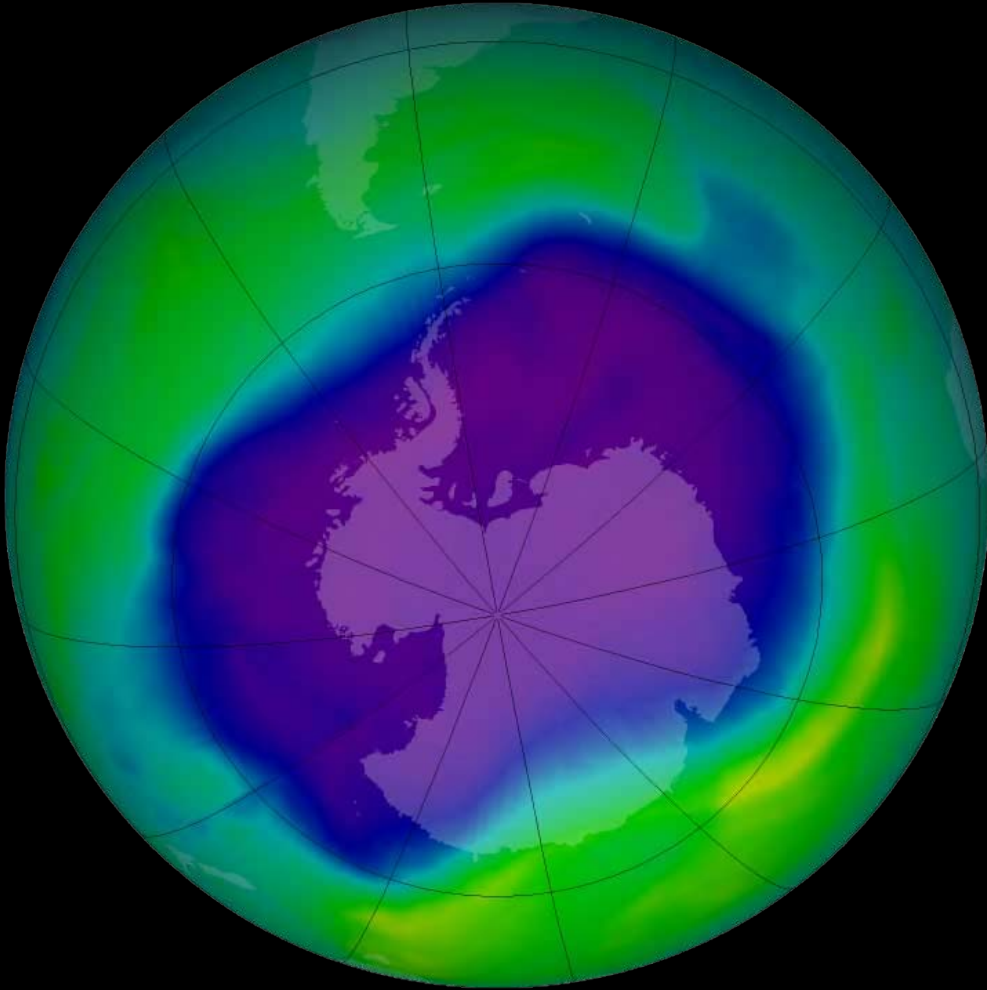
We are going to continue to expand energy production, and we will also create more jobs in infrastructure, trucking, and manufacturing. **This will allow the EPA to focus on its primary mission of protecting our air and protecting our water.** Together, we are going to start a new energy revolution -- one that celebrates American production on American soil.

1992

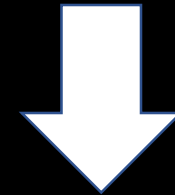


United Nations
Framework Convention on
Climate Change

1987



Vienna Convention for the
Protection of the Ozone Layer

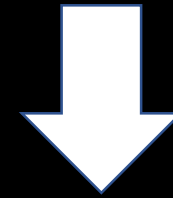


Montreal Protocol on Substances
that Deplete the Ozone Layer

2016



United Nations
Framework Convention on
Climate Change



Paris Climate Agreement

A photograph of U.S. Secretary of State John Kerry, an older man with grey hair, wearing a dark blue suit and a light blue patterned tie. He is seated at a desk, holding a pen and signing a document. A young child with blonde hair, wearing a patterned top, is sitting next to him, looking down at the document. The background is a plain, light-colored wall.

**“We are now –
finally – on **the
path to protecting
the future** for
our children,
our grandchildren
and generations
to come.”**

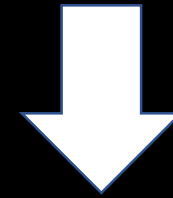
– U.S. SECRETARY OF STATE JOHN KERRY
ON THE ANNOUNCEMENT THE
PARIS AGREEMENT TO ENTER INTO FORCE
OCTOBER 5, 2016

#ActOnClimate
STATE.GOV

2016



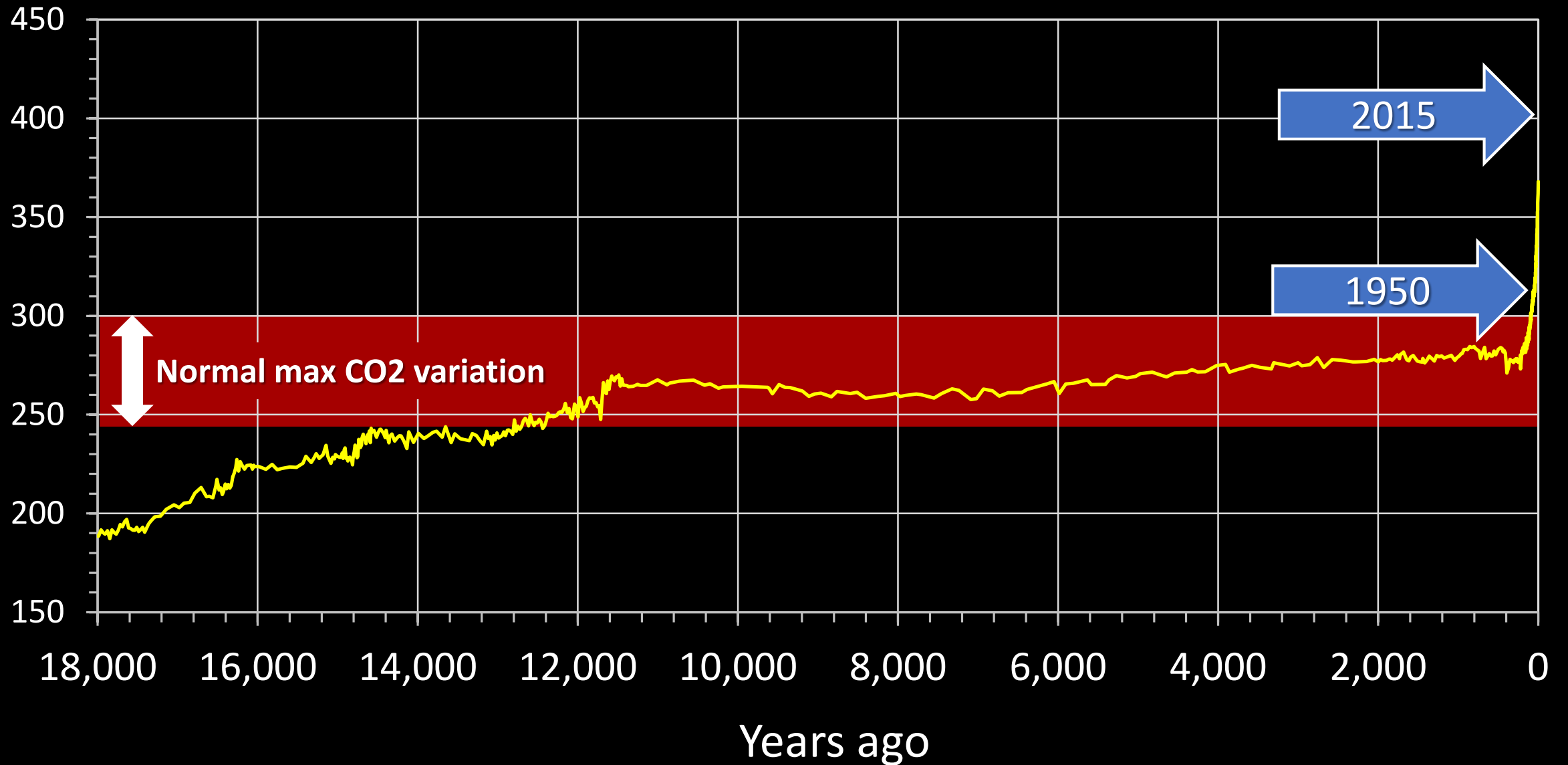
United Nations Framework Convention on Climate Change

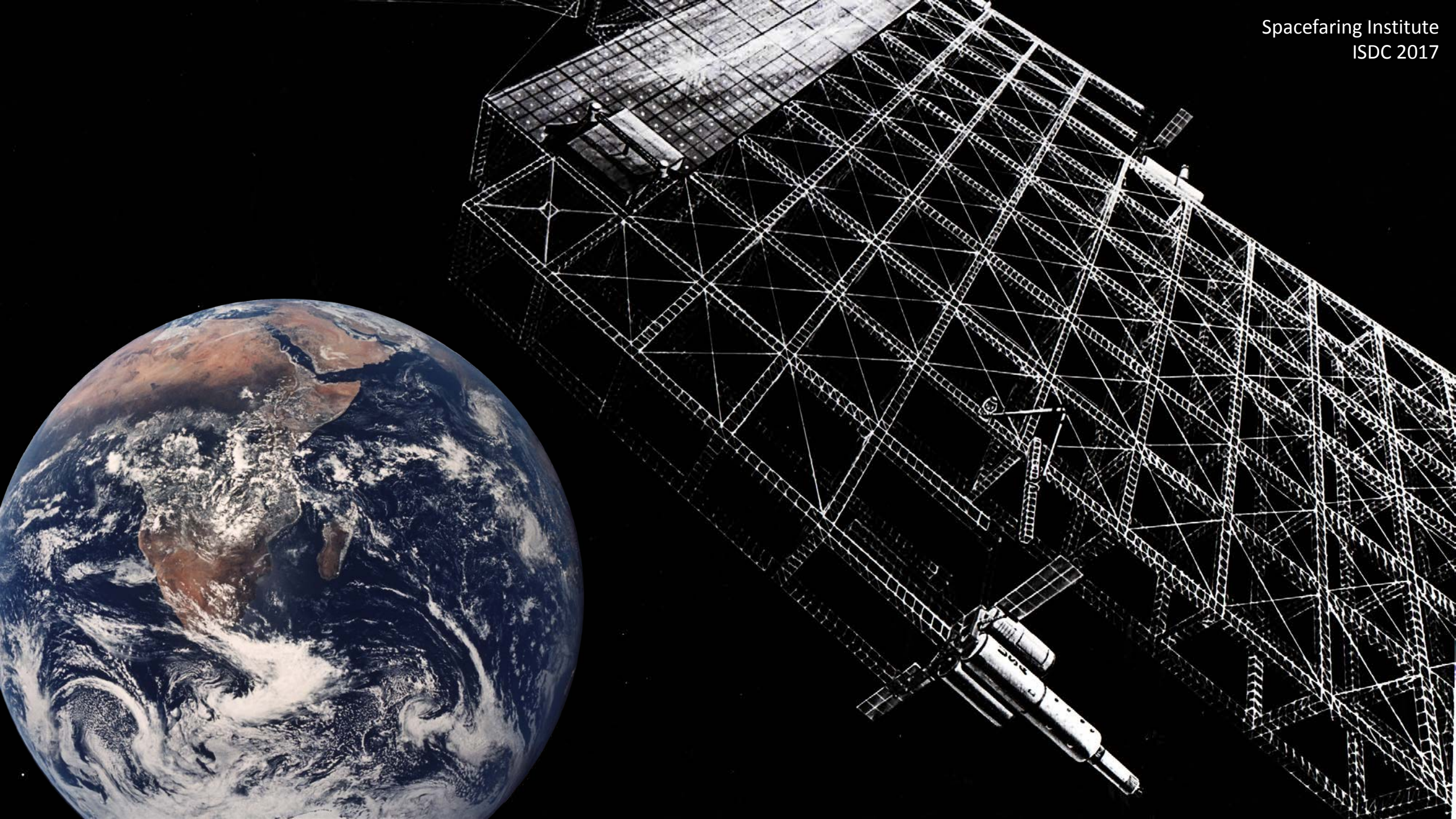


Paris Climate Agreement

REPLACE

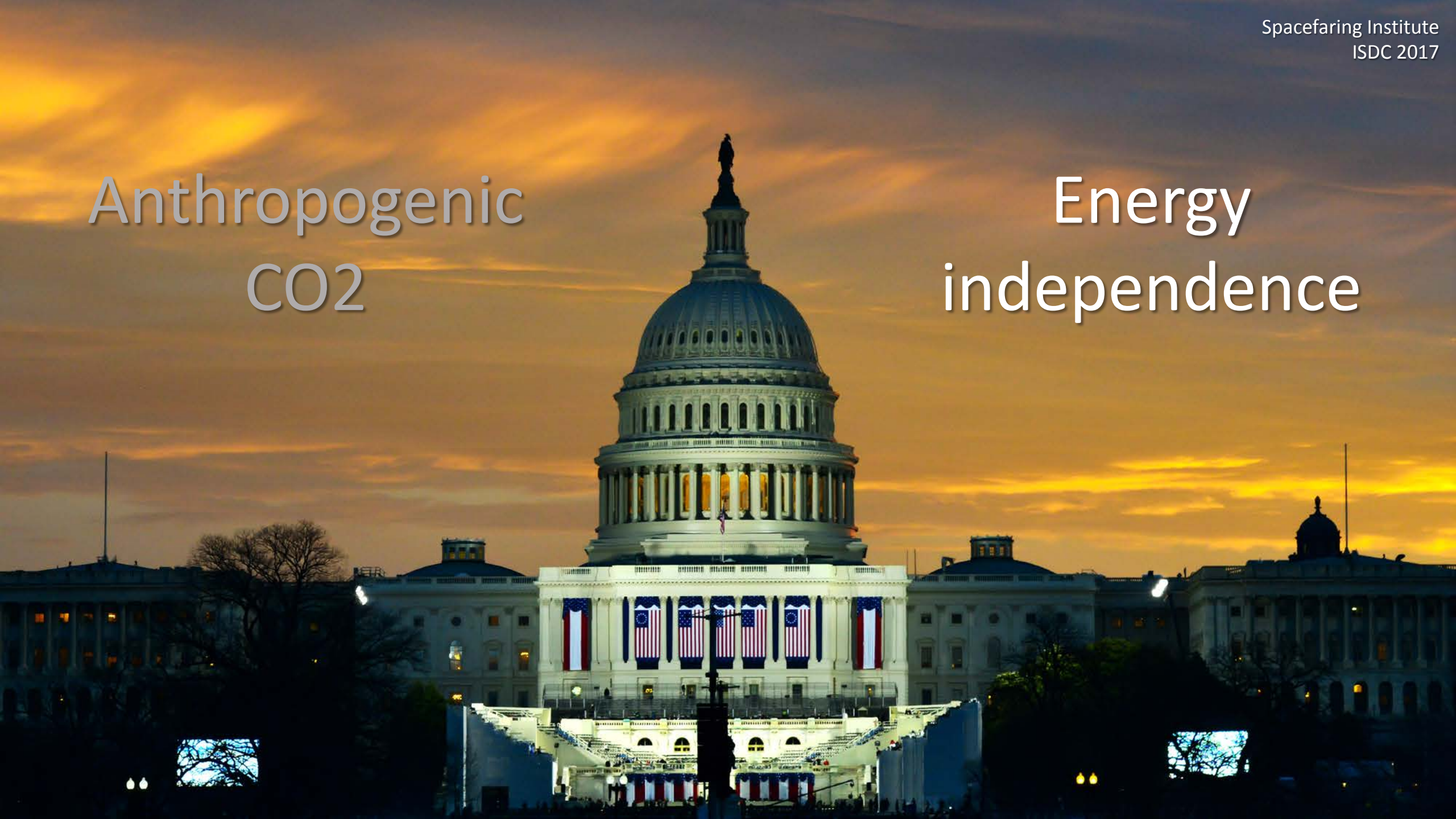
Atmospheric CO₂ concentration – parts per million (PPM) by volume





Anthropogenic
CO₂

Energy
independence



Barrels of Oil Equivalent (BOE)

42 gallons
of crude oil



1 BOE

1 ton of coal



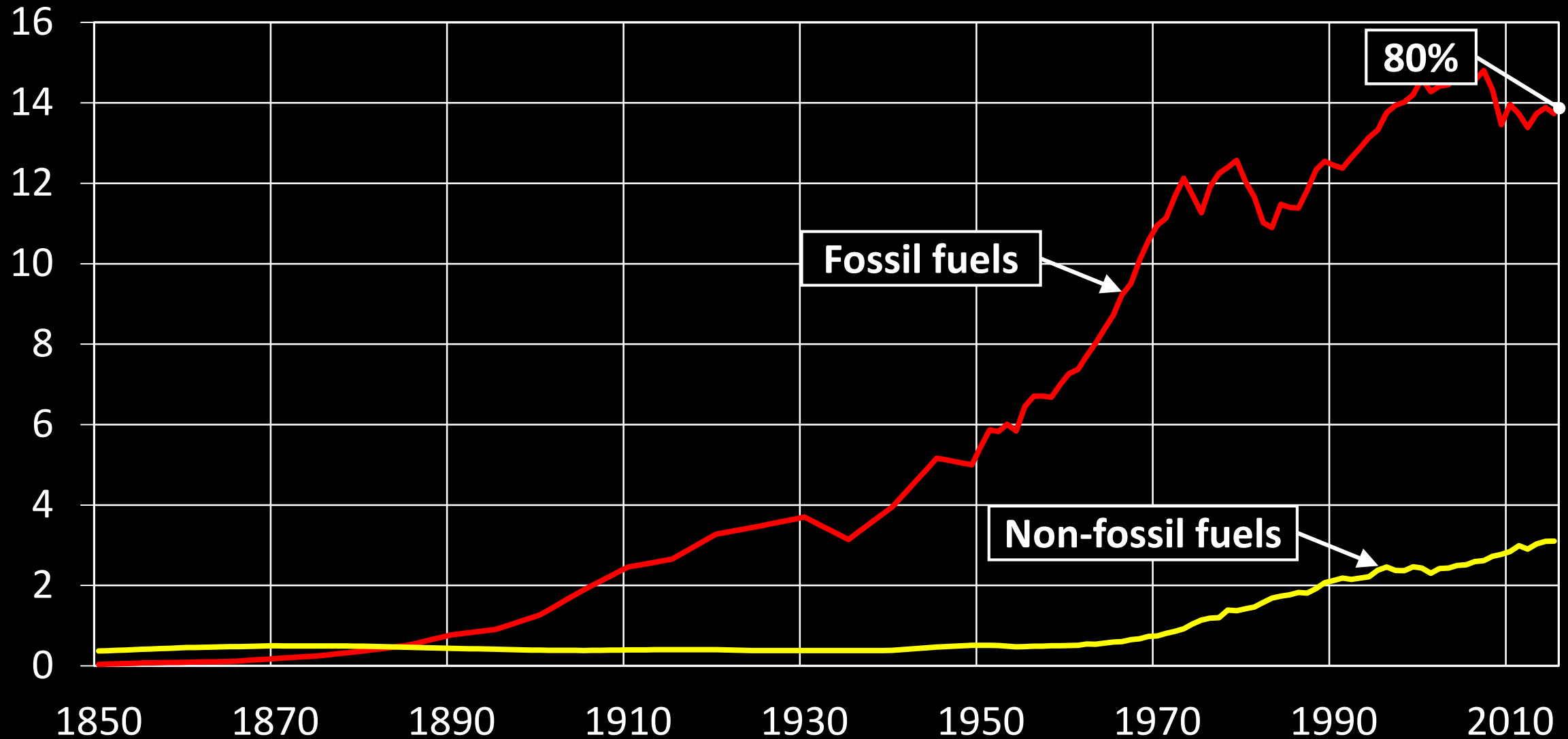
3.45 BOE

1,000 cubic feet
of natural gas

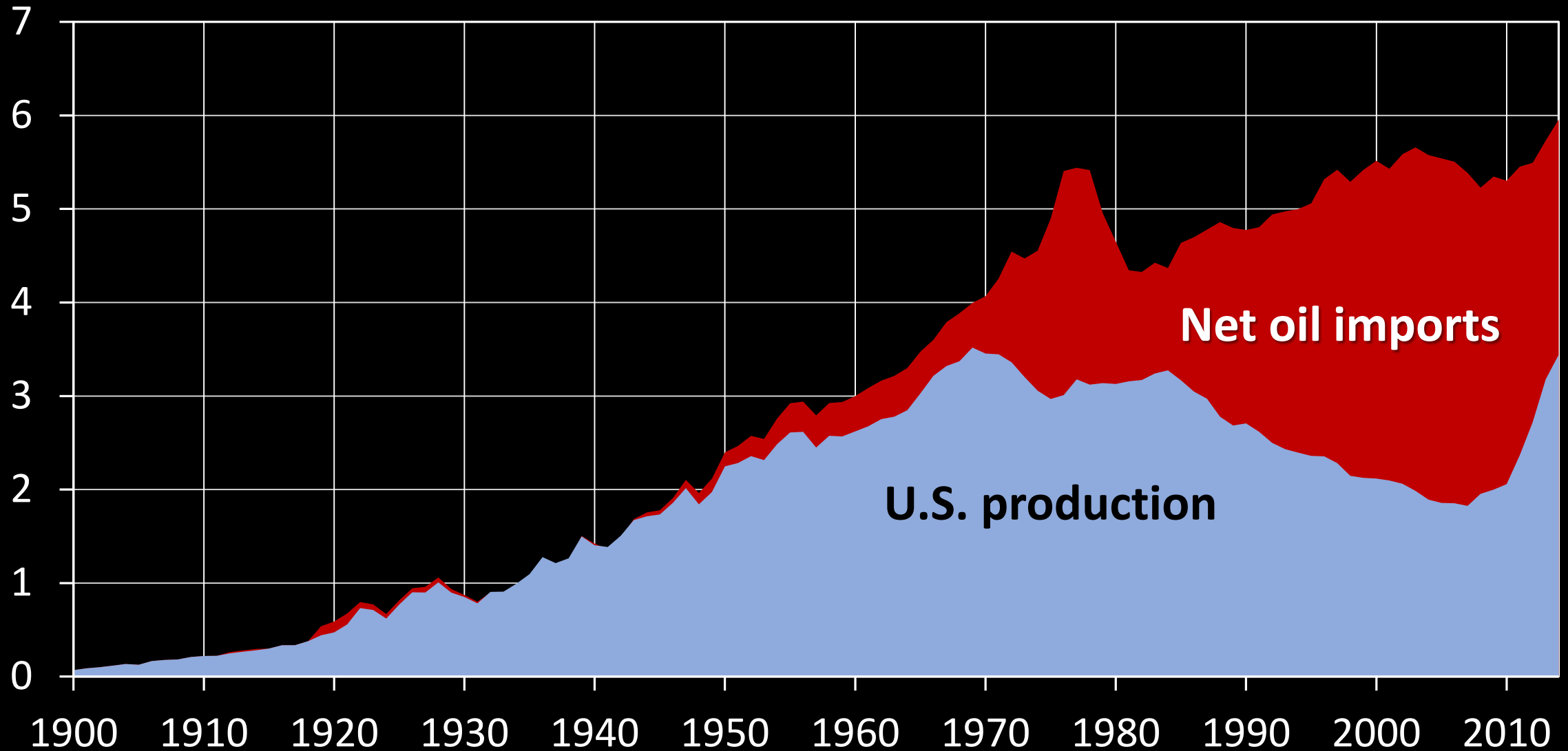


0.18 BOE

U.S. annual fossil fuel and non-fossil fuel energy use (1850–2015) (Billion BOE per year)



U.S. oil production and total consumption (Billion barrels per year)



1973

PUMPS
CLOSED

PLEASE
NO
SMOKING

When did you last
change your oil?

SHELL REGULAR



SUPER REGULAR
Low Lead



SUPER SHELL



1979

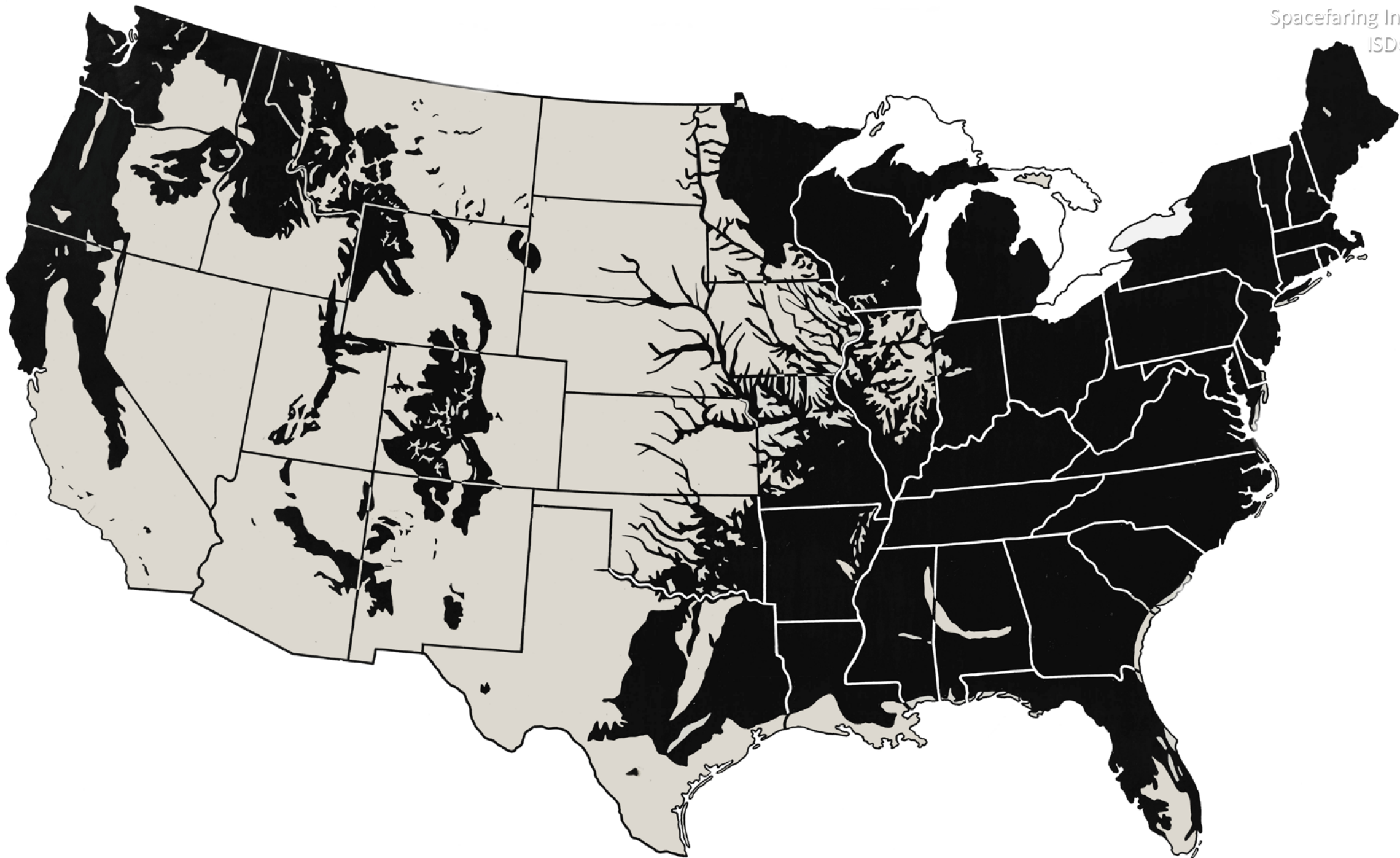


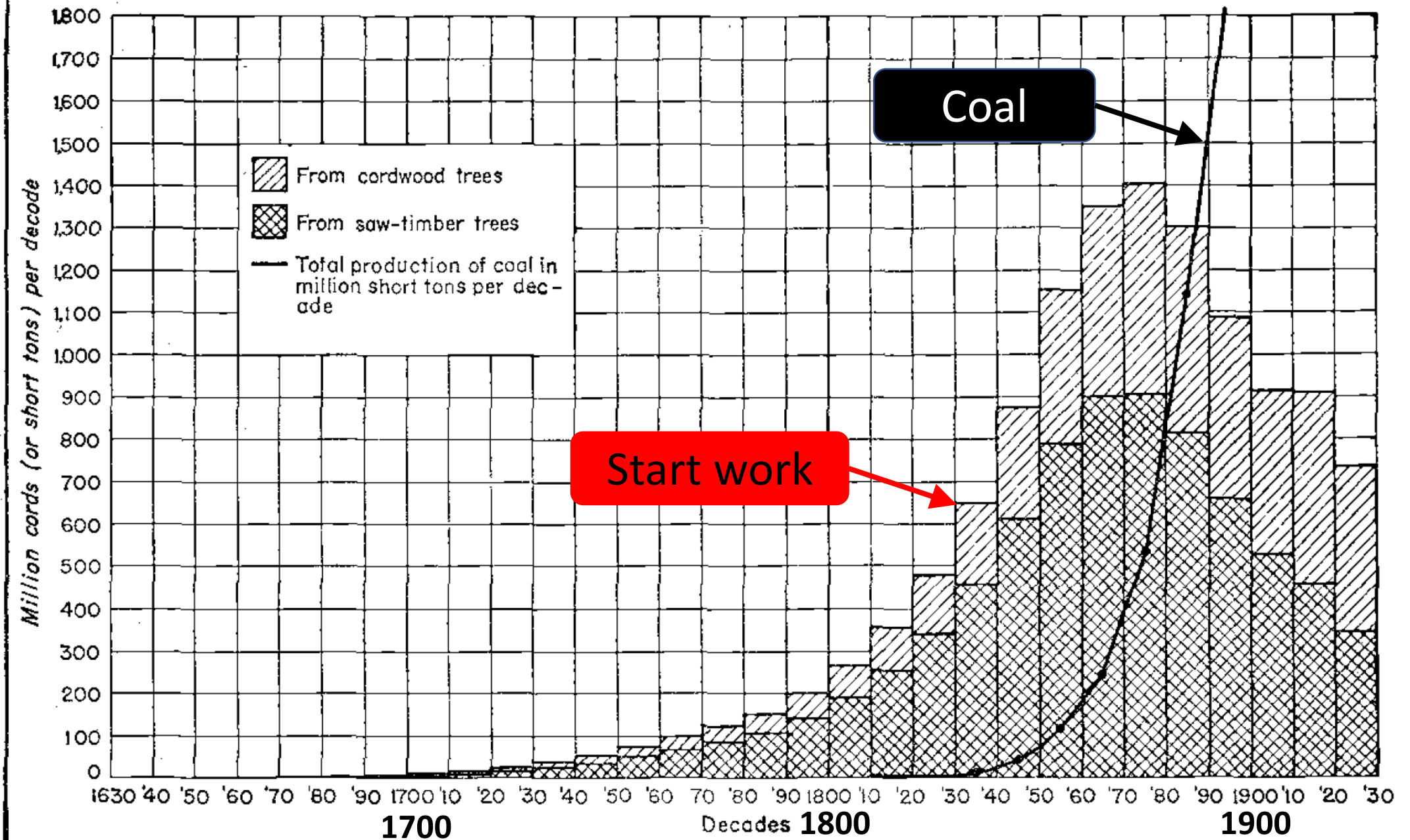
1991

Spacefaring Institute
ISDC 2017

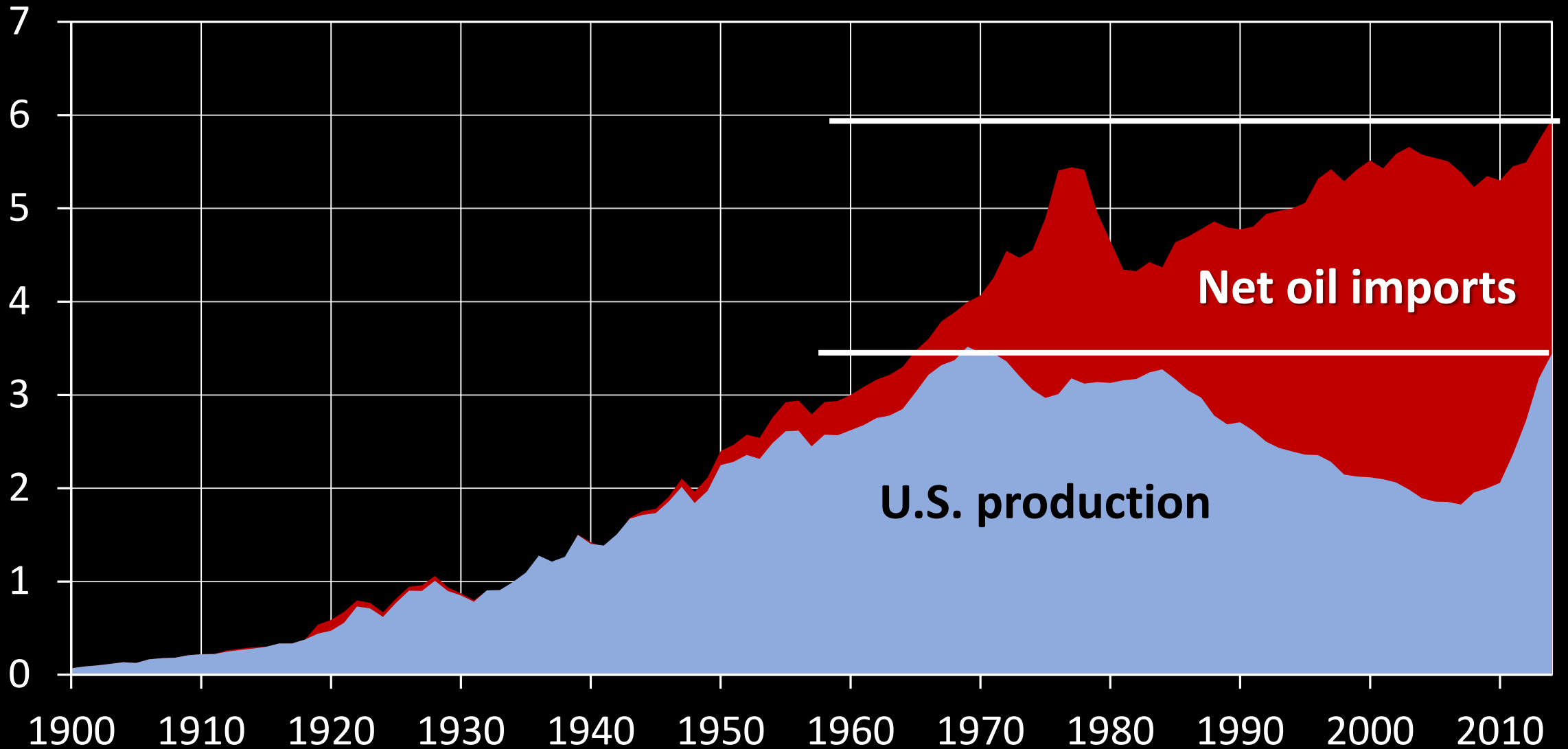








U.S. oil production and total consumption (Billion barrels per year)





#ActOnClimate
STATE.GOV

“We are now –
finally – on **the**
path to protecting
the future for
our children,
our grandchildren
and generations
to come.”

– U.S. SECRETARY OF STATE JOHN KERRY
ON THE ANNOUNCEMENT THE
PARIS AGREEMENT TO ENTER INTO FORCE
OCTOBER 5, 2016

U.S. 2016 technically recoverable fossil fuel endowment

<i>Fossil fuel</i>	<i>Native units</i>	<i>BOE (Billion)</i>	<i>% Unproved</i>
Oil	274.2 billion barrels ¹	274.2	87
Natural gas	2,474.4 trillion cu. ft. ²	438.5 ⁴	86
Coal	254.9 billion short tons ³	879.4 ⁵	--
<i>Total</i>		1,592.1	

1. U.S. Energy Information Administration, Table 9.1, Technically recoverable U.S. Crude oil resources as of January 1, 2014, Chapter 9, Oil and Gas Supply Module, Assumptions to the Annual Energy Outlook 2016, page 132, January, 2017.
2. U.S. Energy Information Administration, Table 9.2, Technically recoverable U.S. dry natural gas resources as of January 1, 2014, Chapter 9, Oil and Gas Supply Module, Assumptions to the Annual Energy Outlook 2016, page 133, January, 2017.
3. U.S. Energy Information Administration, Table 15, Recoverable Coal Reserves at Producing Mines, Estimated Recoverable Reserves, and Demonstrated Reserve Base by Mining Method, Annual Coal Report 2015, November, 2016.
4. 1 cu. ft. natural gas = 1,028 Btu; 1,000,000 cu. ft. = 177.2 BOE
5. 1 short ton of coal = 19.988 million Btu; 1 short ton = 3.45 BOE

President Trump – March 28, 2017, EPA Headquarters

“We are going to continue to expand energy production, and we will also create more jobs in infrastructure, trucking, and manufacturing. This will allow the EPA to focus on its primary mission of protecting our air and protecting our water. Together, we are going to **start a new energy revolution -- one that celebrates American production on American soil.**”

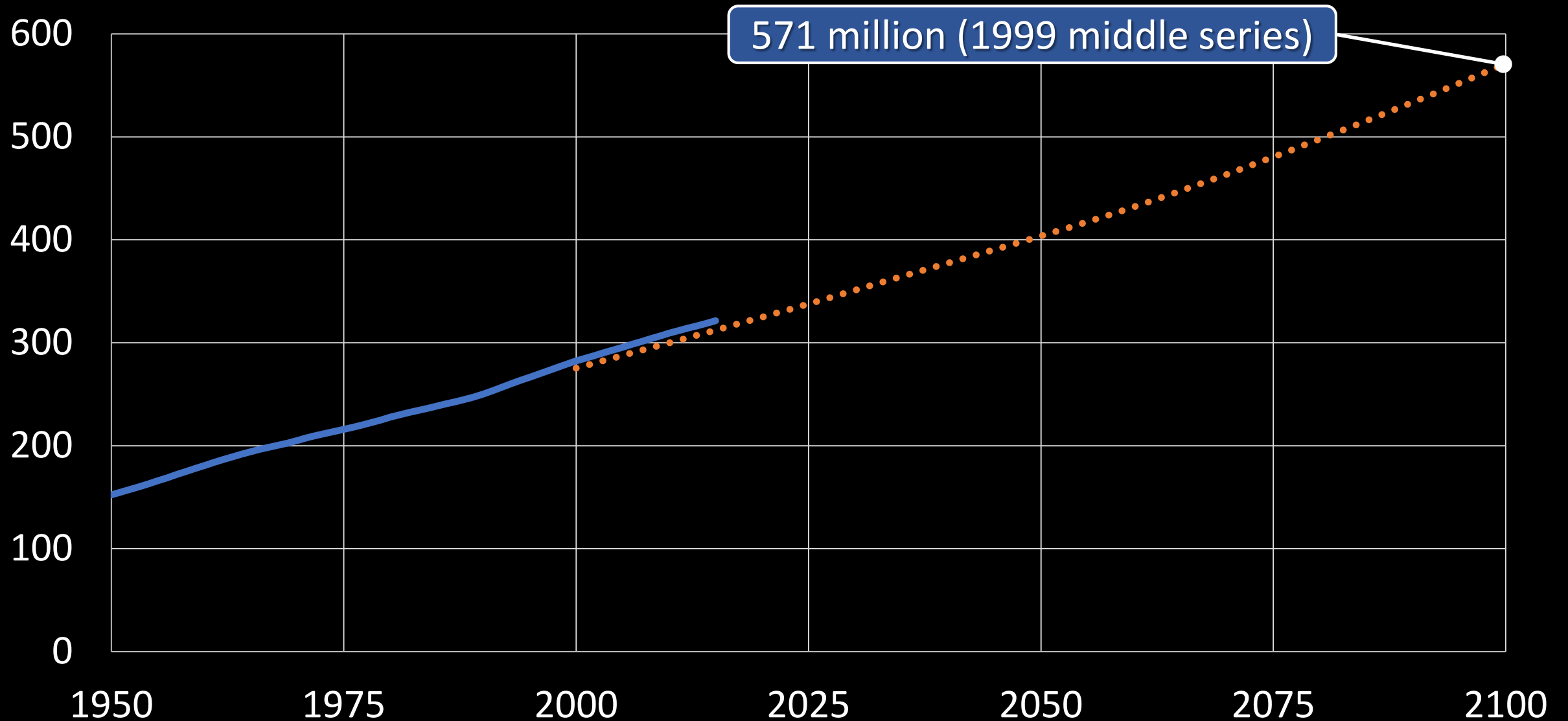
Life of America's remaining fossil fuel endowment (Assuming American oil energy independence)

<i>Fossil fuel</i>	<i>2015 remaining endowment BOE (Billion)</i>	<i>2015 consumption BOE/year (Billion)</i>	<i>2015 life (Year)</i>
Oil	274.2	6.1 (45%)	2060
Natural gas	438.5	4.9 (36%)	2105
Coal	879.4	2.7 (20%)	2341
<i>Total</i>	1,592.1	13.7	

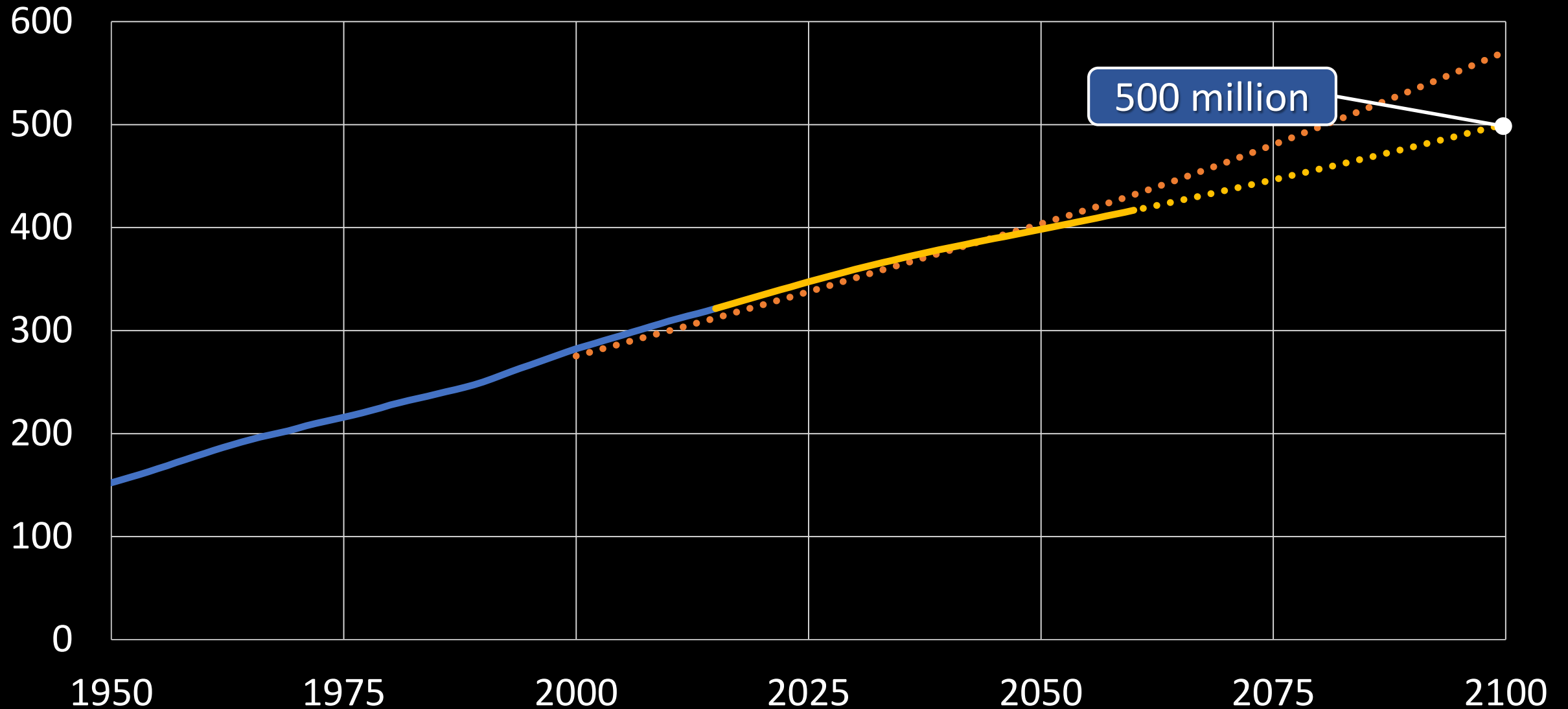
Life of America's remaining fossil fuel endowment (Assuming American oil energy independence)

<i>Fossil fuel</i>	<i>2060 remaining endowment BOE (Billion)</i>	<i>2015 consumption BOE/year (Billion)</i>	<i>2060 life (Years)</i>
Oil	0	0	0
Natural gas	218	4.9	2105
Coal	758	2.7 → 18	2102
<i>Total</i>	976	13.7	

U.S. population projection to 2100 (Millions)



U.S. population projection to 2100 (Millions)



Life of America's remaining fossil fuel endowment (Assuming American oil energy independence)

<i>Fossil fuel</i>	<i>2060 remaining endowment BOE (Billion)</i>	<i>2015 consumption BOE/year (Billion)</i>	<i>2060 life (Years)</i>
Oil	0	0	0
Natural gas	218	4.9	2105
Coal	758	2.7 → 18	2102
<i>Total</i>	976	13.7	

1973

PUMPS
CLOSED

PLEASE
NO
SMOKING

When did you last
change your oil?

SHELL REGULAR



SUPER REGULAR
Low Lead



SUPER SHELL



Terrestrial energy solutions for 500 million Americans

Nuclear



Wind



Ground solar



Terrestrial energy solutions for 500 million Americans

Nuclear



5000 1-GW plants

100,000 people/GW

Terrestrial energy solutions for 500 million Americans

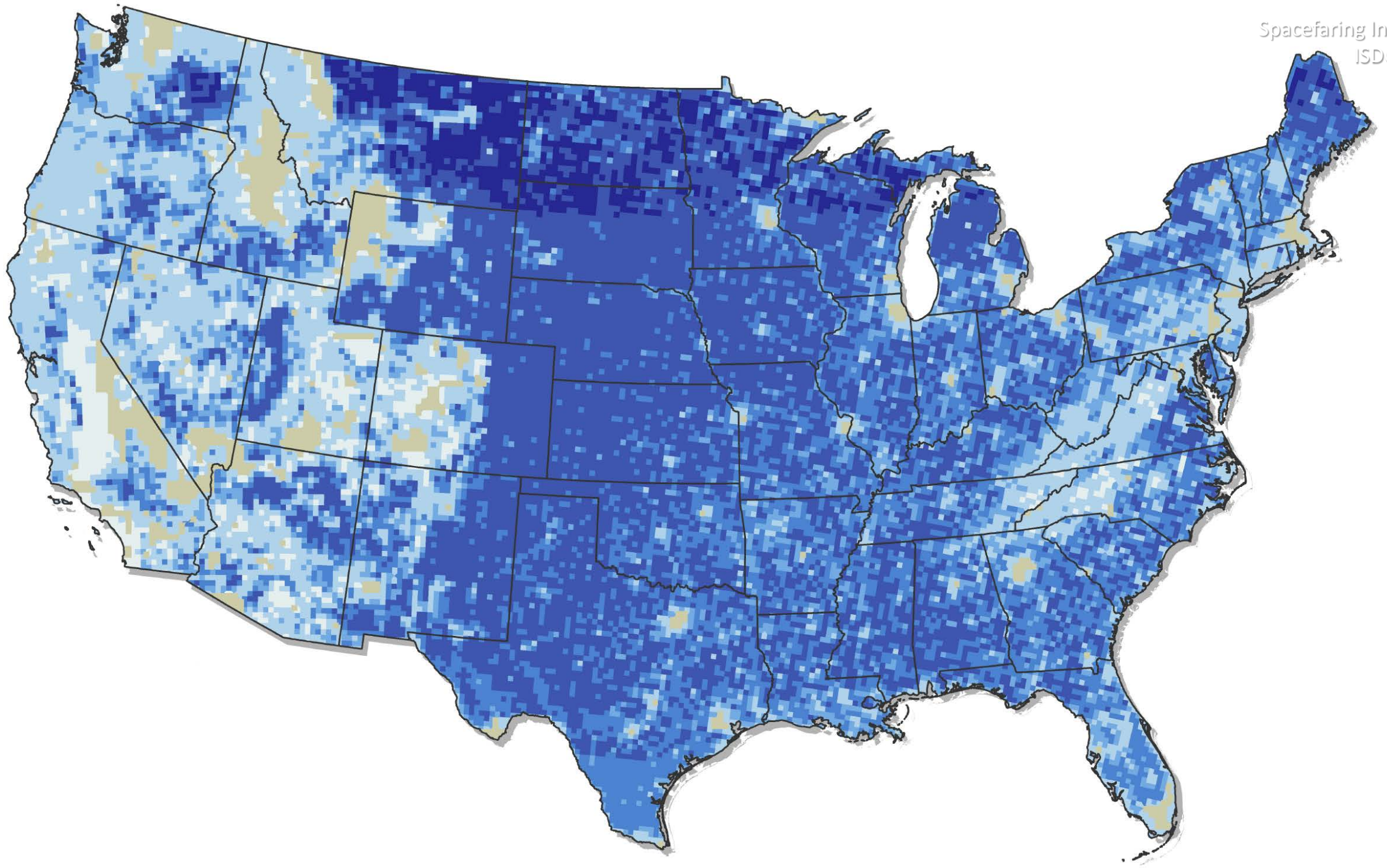
Wind



4 turbines/sq. mi.

200 people/sq. mi.

2.5 million sq. mi.

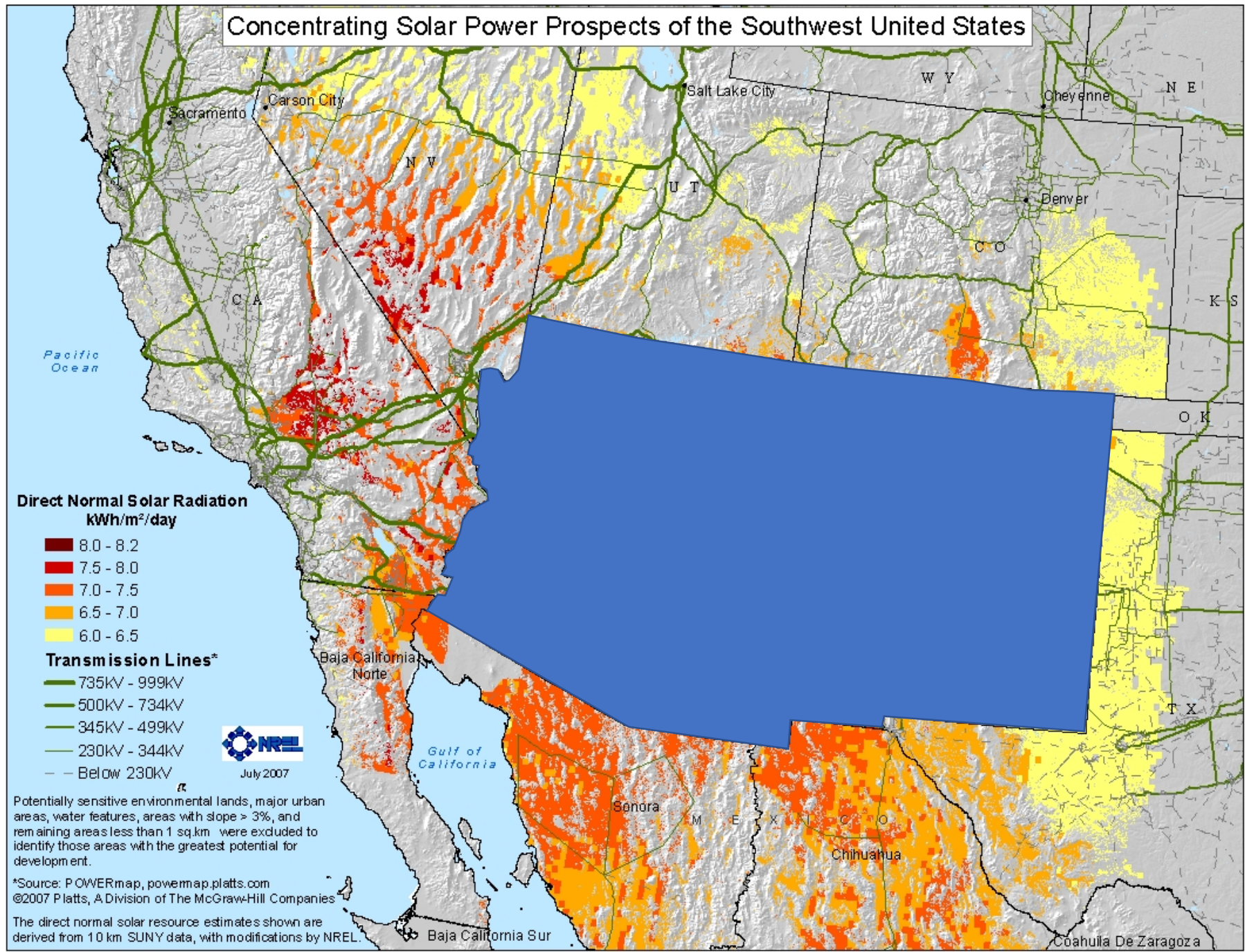


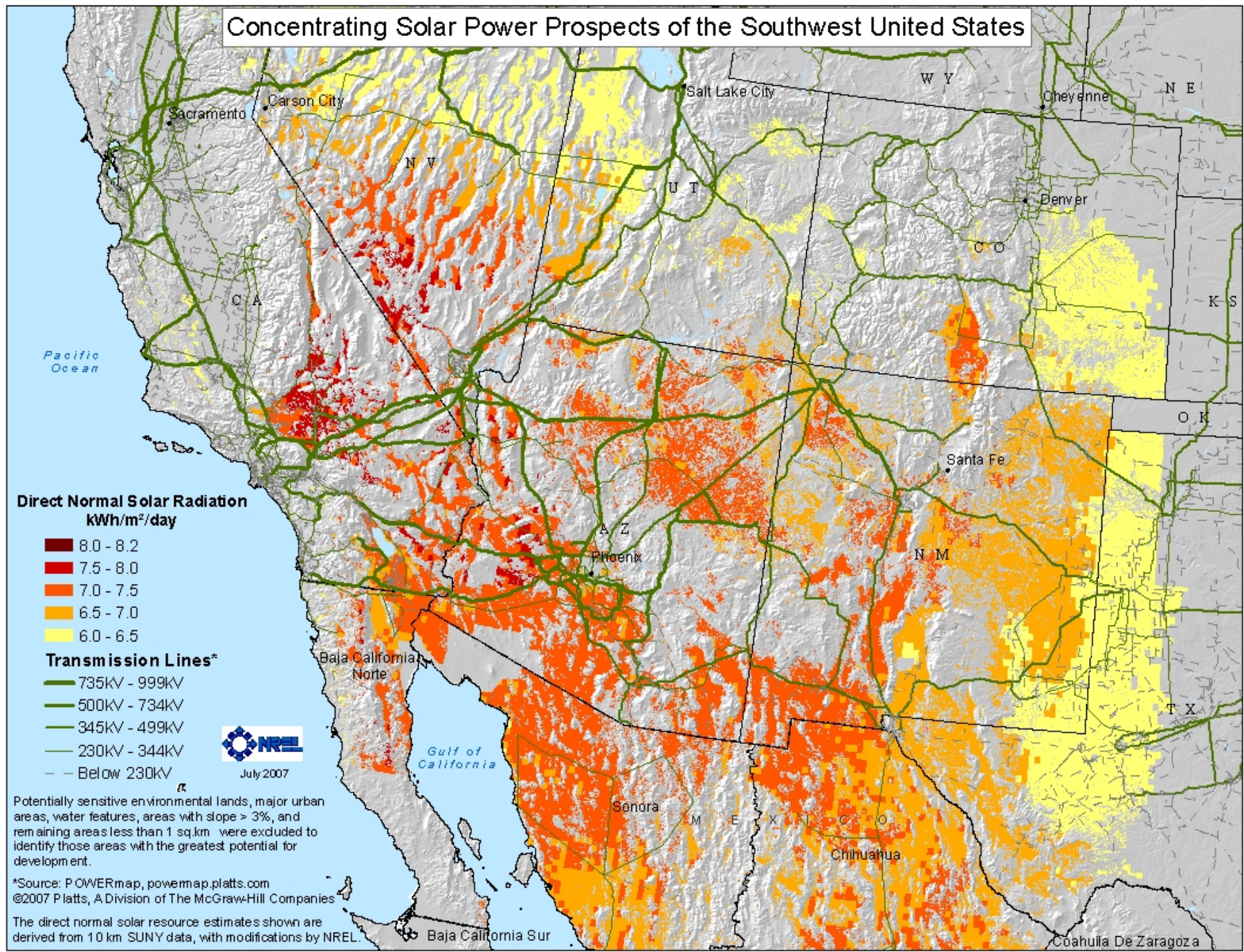
Terrestrial energy solutions for 500 million Americans

Ground solar



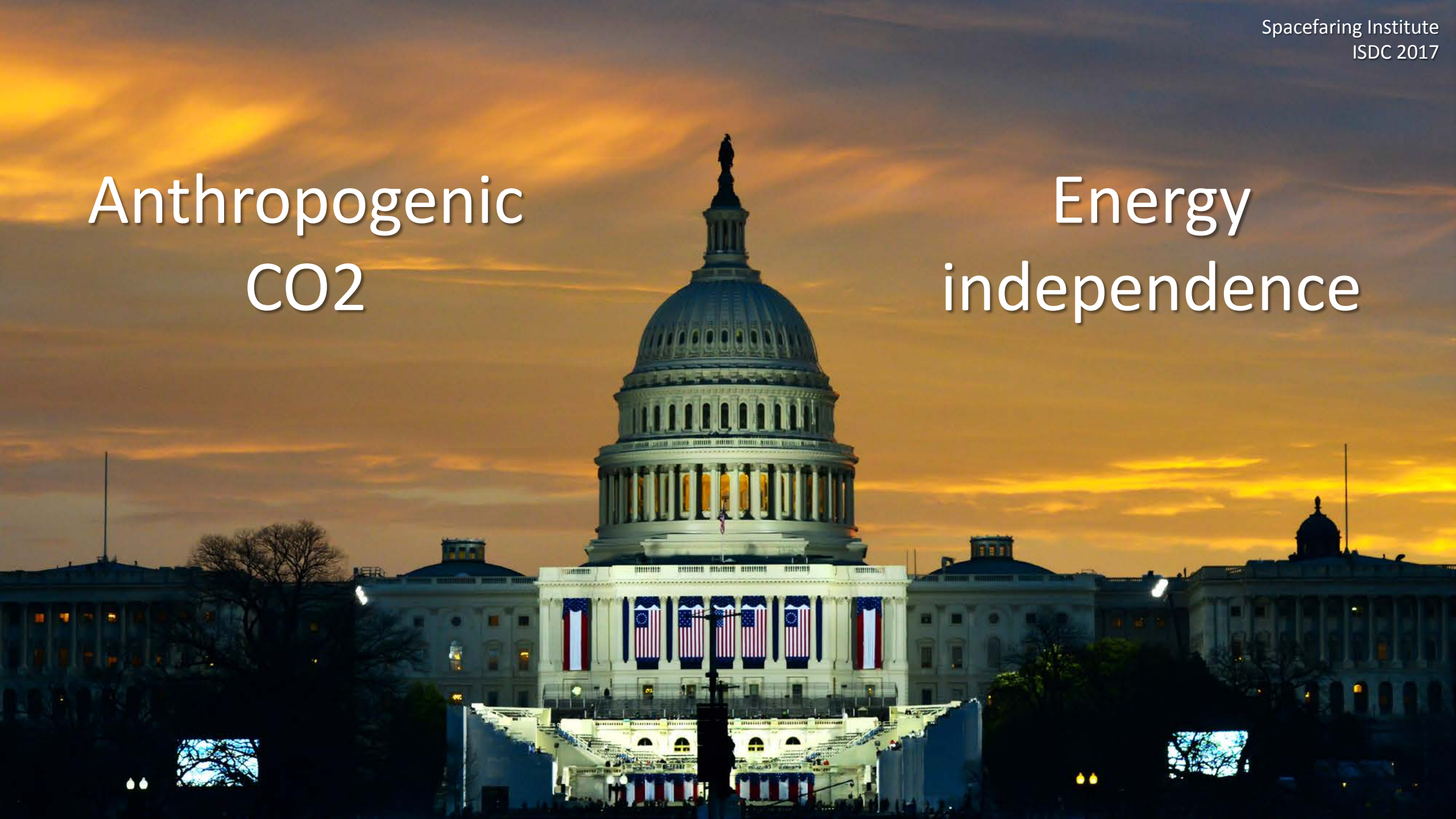
225,000 sq. mi. of
actual solar farms





Anthropogenic
CO₂

Energy
independence





Credit: National Space Society

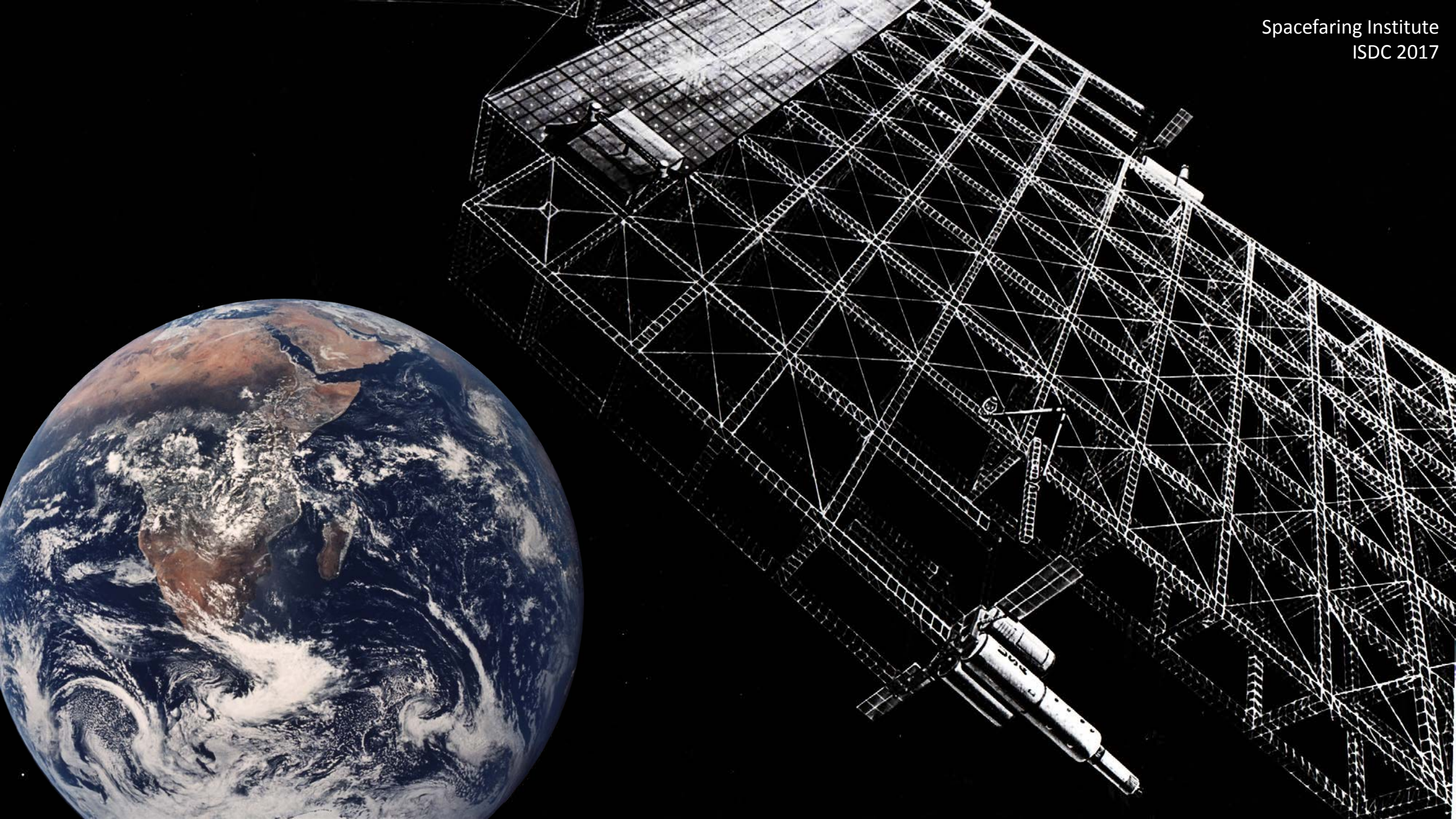
Space solar power concept



Credit: Arthur D. Little Inc.



Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and **to enable economic development to proceed in a sustainable manner.**



An aerial photograph of the Hoover Dam, a massive concrete structure spanning a deep canyon. The dam is curved, with a highway running along its crest. To the right of the dam, two large cylindrical structures, likely part of the spillway or intake system, extend into the dark water of the reservoir. Below the dam, the power plant is visible, featuring a long, low building with a series of vertical structures, possibly cooling towers or intake pipes, and a large white roof. The surrounding landscape is arid and rocky, with some sparse vegetation. The text "2-GW" is overlaid in the center of the image.

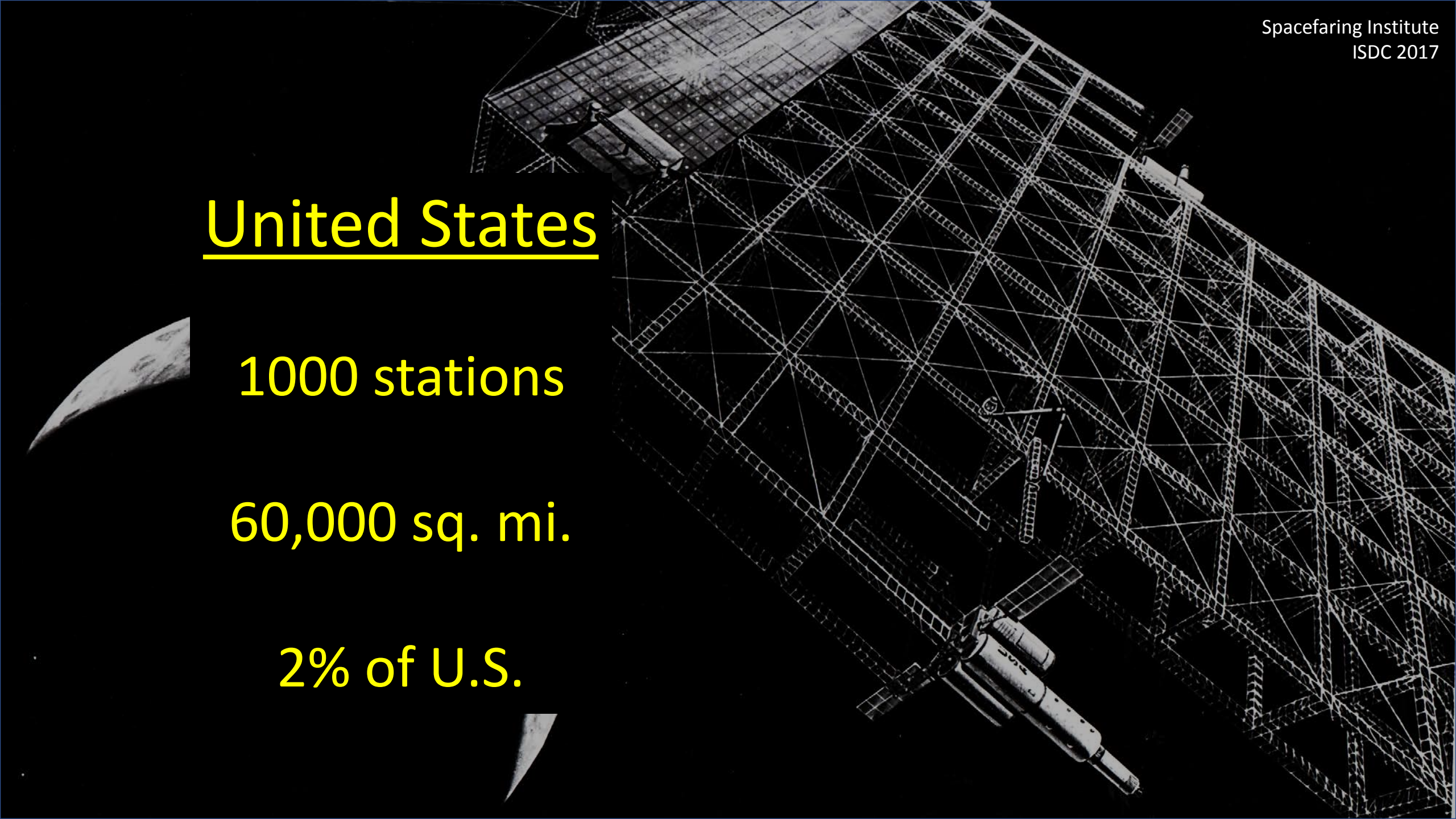
2-GW

United States

1000 stations

60,000 sq. mi.

2% of U.S.



United States

1000 stations

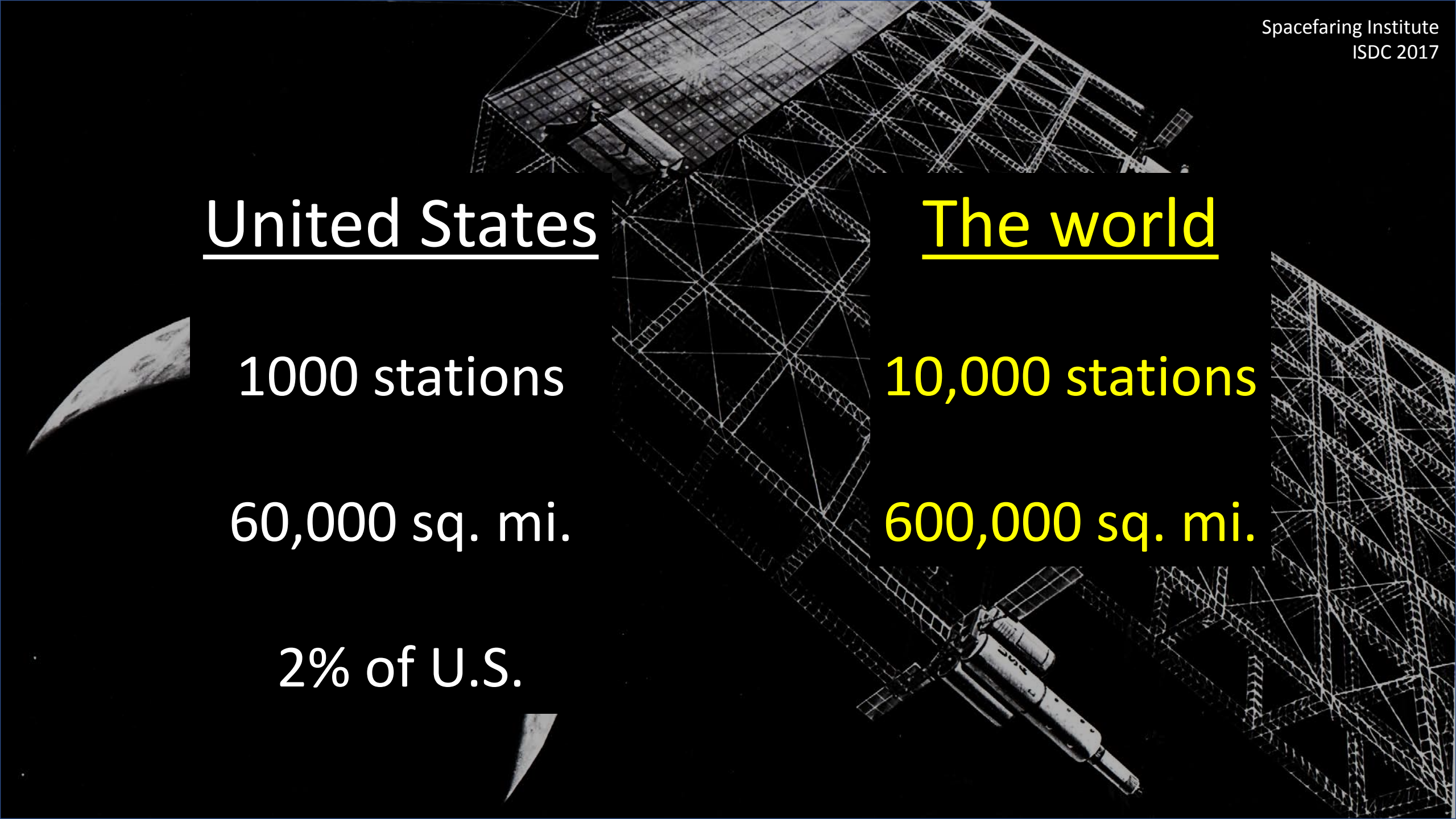
60,000 sq. mi.

2% of U.S.

The world

10,000 stations

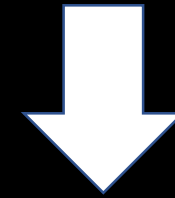
600,000 sq. mi.



2016



United Nations
Framework Convention on
Climate Change



New protocol



Mirrors

Solar arrays

Transmitter

