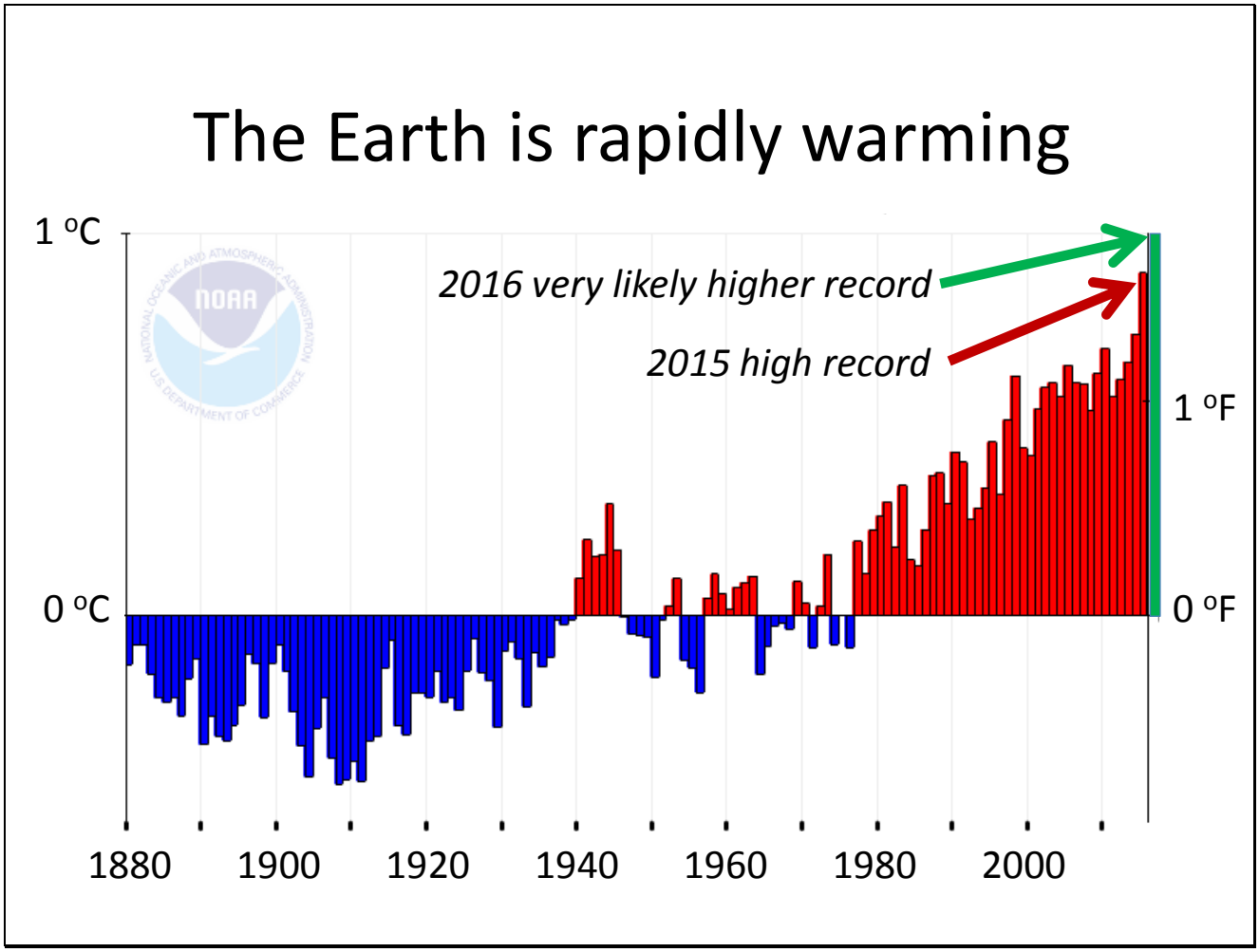
Slide 1

How humans are changing the climate

Raymond Najjar
Professor of Oceanography
Department of Meteorology and Atmospheric Science
The Pennsylvania State University

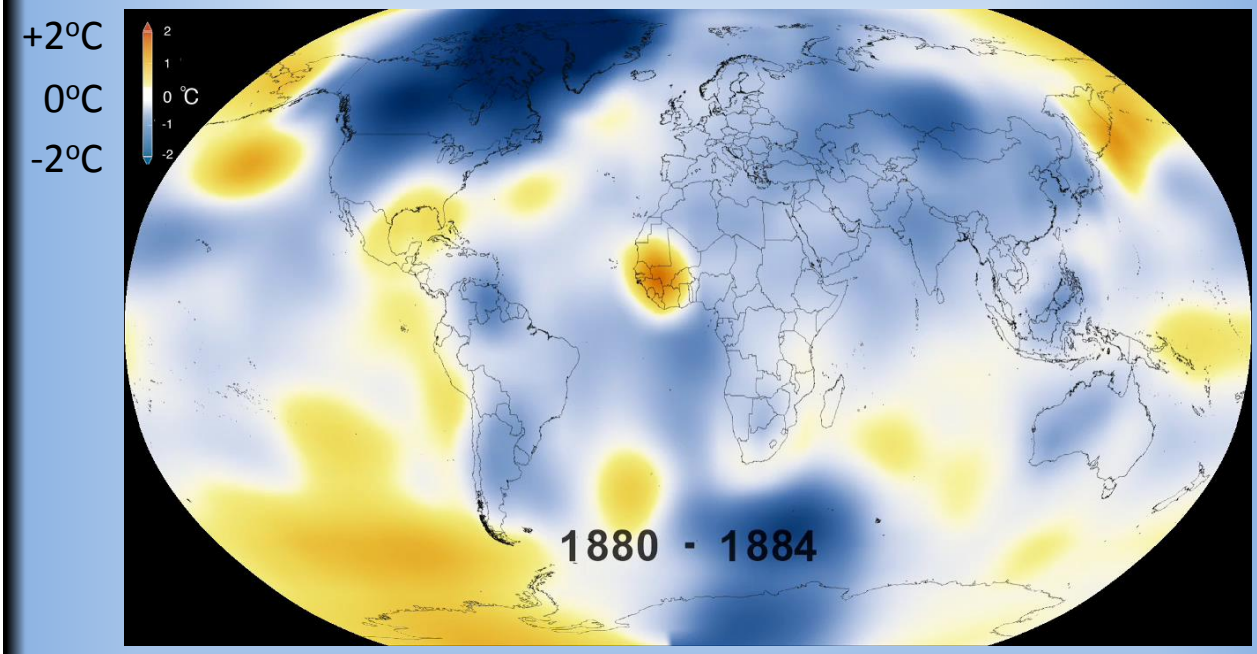
Association of Moving Image Archivists Conference
November 10, 2016

Slide 2


The Earth is rapidly warming
1 ºC
0 ºC
1 ºF
0 ºF
2016 very likely higher record
2015 high record
1880
1900
1920
1940
1960
1980
2000

Slide 3

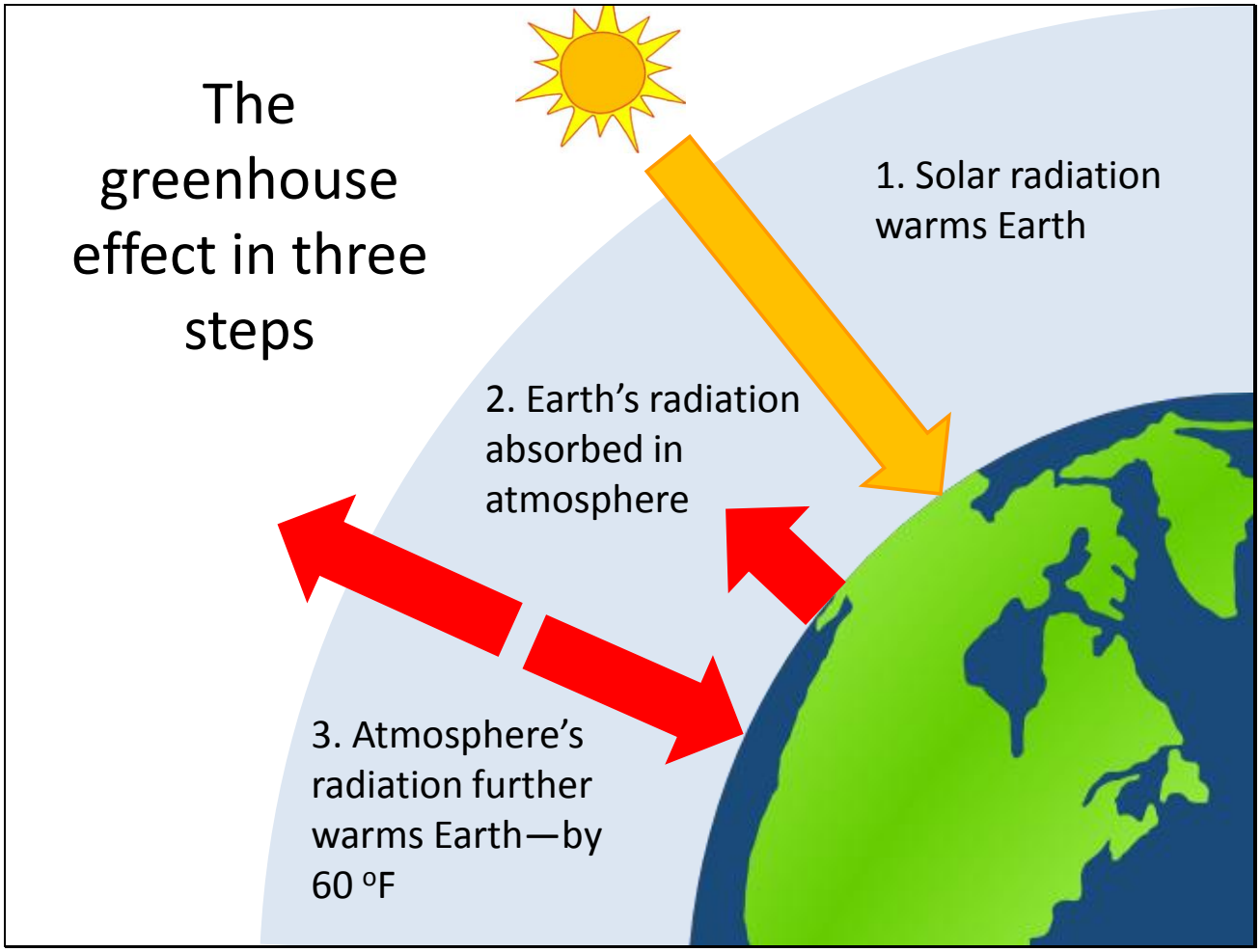
But the warming is not uniform



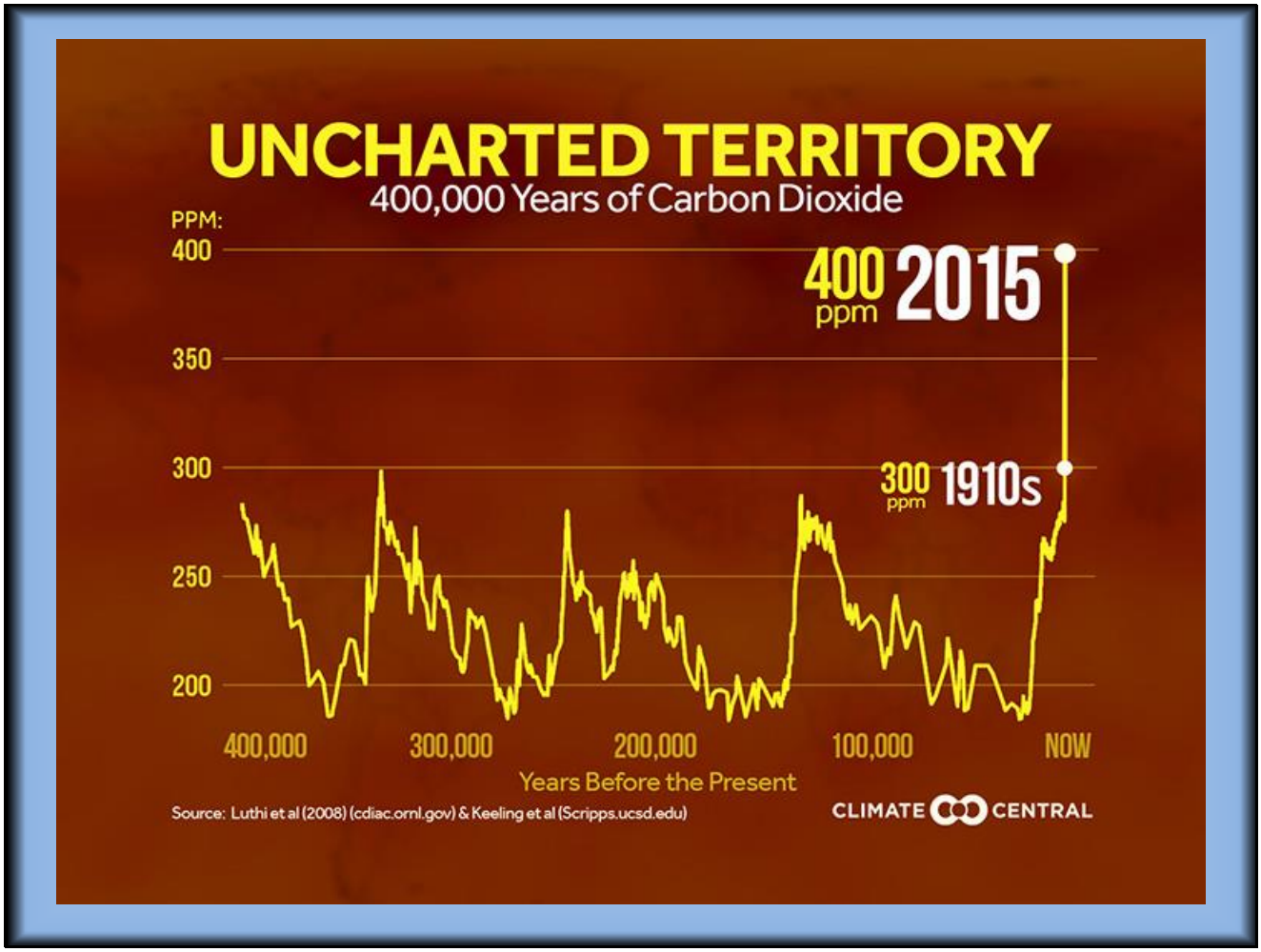
NASA GISS data. 5-year means with respect to 1951-1980 average.

https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4419
Temperature anomaly appears to be with respect to the 1951-1980 base period. Data are from NASA GISS. See http://data.giss.nasa.gov/gistemp/faq/

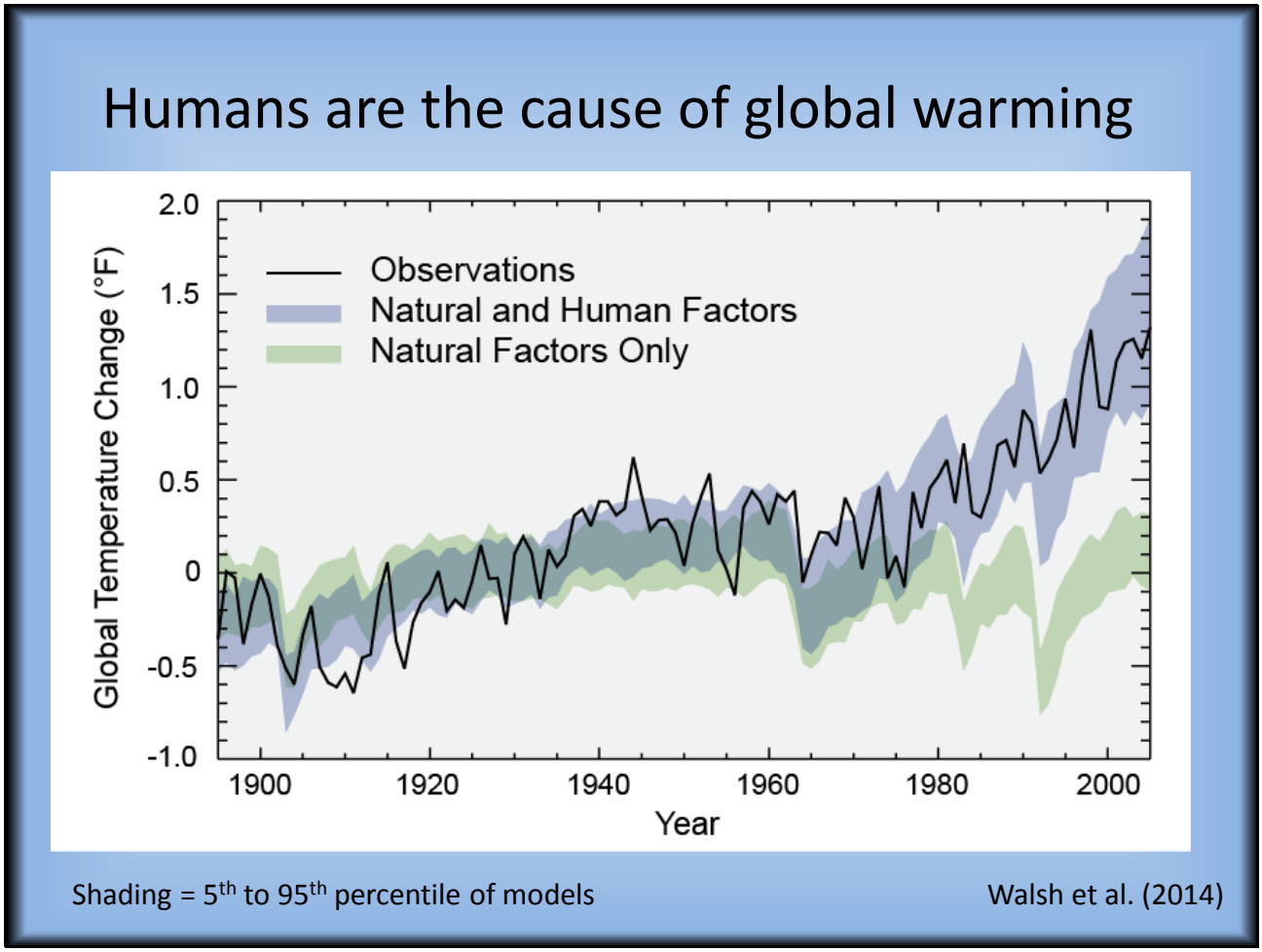
Slide 4


The greenhouse effect in three steps
1. Solar radiation warms Earth
2. Earth's radiation absorbed in atmosphere
3. Atmosphere's radiation further warms Earth—by 60 °F

Slide 5


UNCHARTED TERRITORY
400,000 Years of Carbon Dioxide
PPM:
400
350
300
250
200
400 ppm 2015
300 ppm 1910s
400,000
300,000
200,000
100,000
NOW
Years Before the Present
Source: Luthi et al (2008) (cdiac.ornl.gov) & Keeling et al (Scripps.ucsd.edu)
CLIMATE CENTRAL

Slide 6

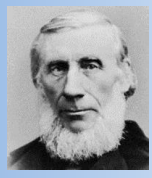


Walsh, J., Wuebbles, D., Hayhoe, K., Kossin, J., Kunkel, K., Stephens, G., Thorne, P., Vose, R., Wehner, M., Willis, J., Anderson, D., Doney, S., Feely, R., Hennon, P., Kharin, V., Knutson, T., Landerer, F., Lenton, T., Kennedy, J., Somerville, R., 2014. Chapter 2: Our Changing Climate. In: J.M. Melillo, T.C. Richmond, G.W. Yohe (Editors), Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, pp. 19-67.

Slide 7

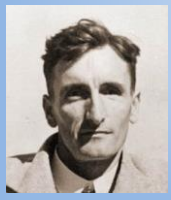
The greenhouse effect is well established

1824: Joseph Fourier describes natural greenhouse effect



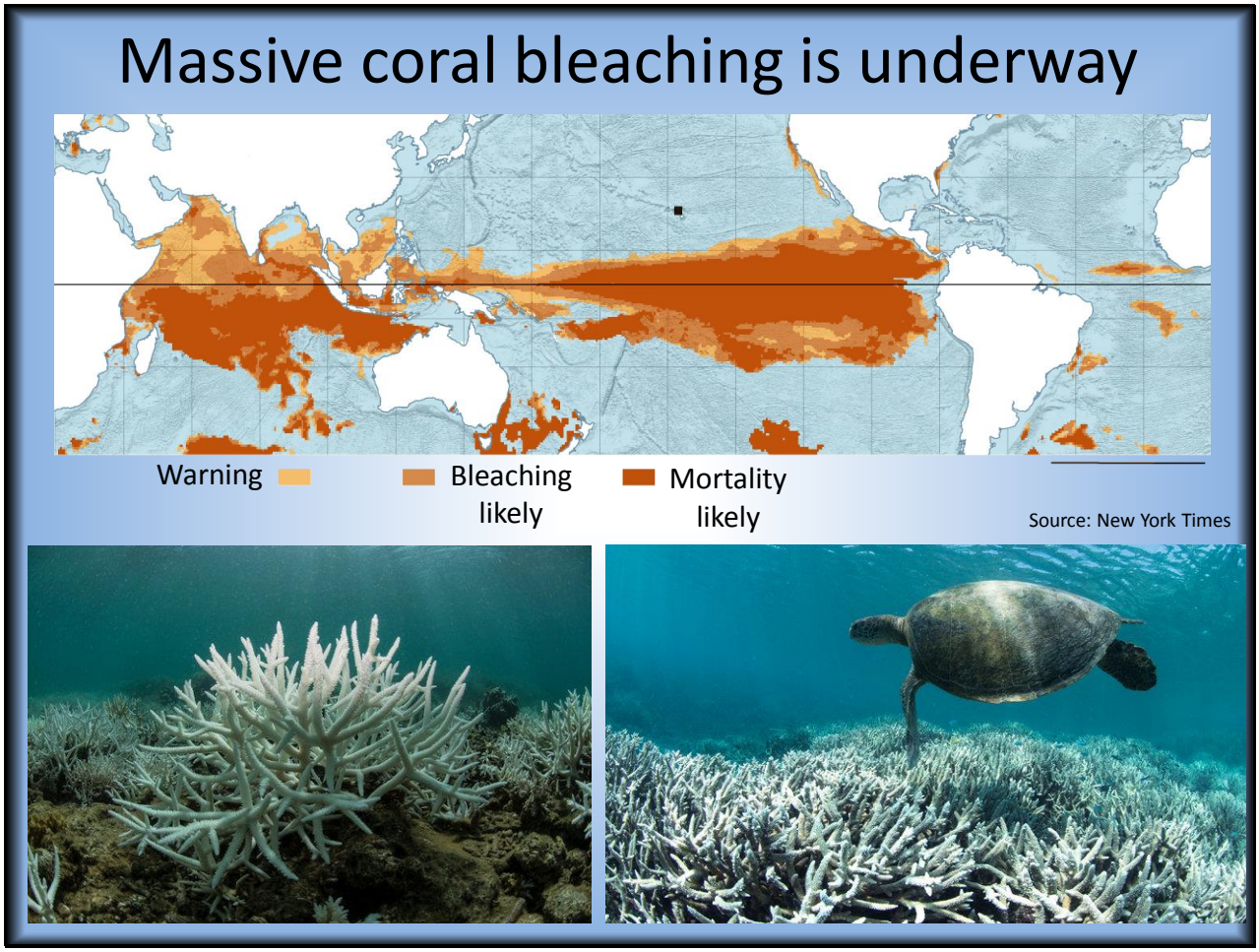
1861: John Tyndall identifies greenhouse gases

1896: Svante Arrenhius estimates greenhouse effect of fossil fuel CO_2



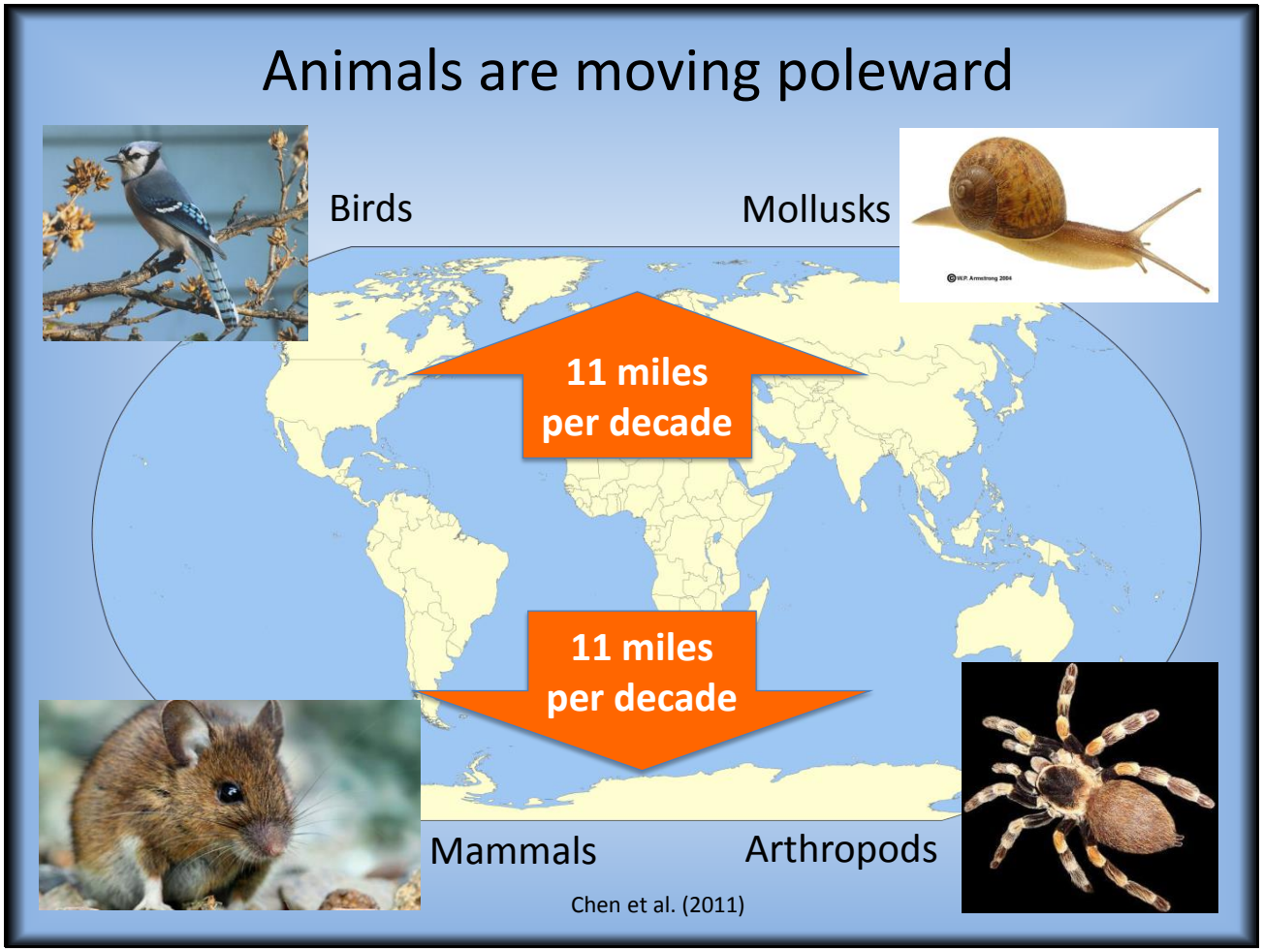
1938: Guy Callendar documents warming and CO_2 increase

Slide 8



NY times article

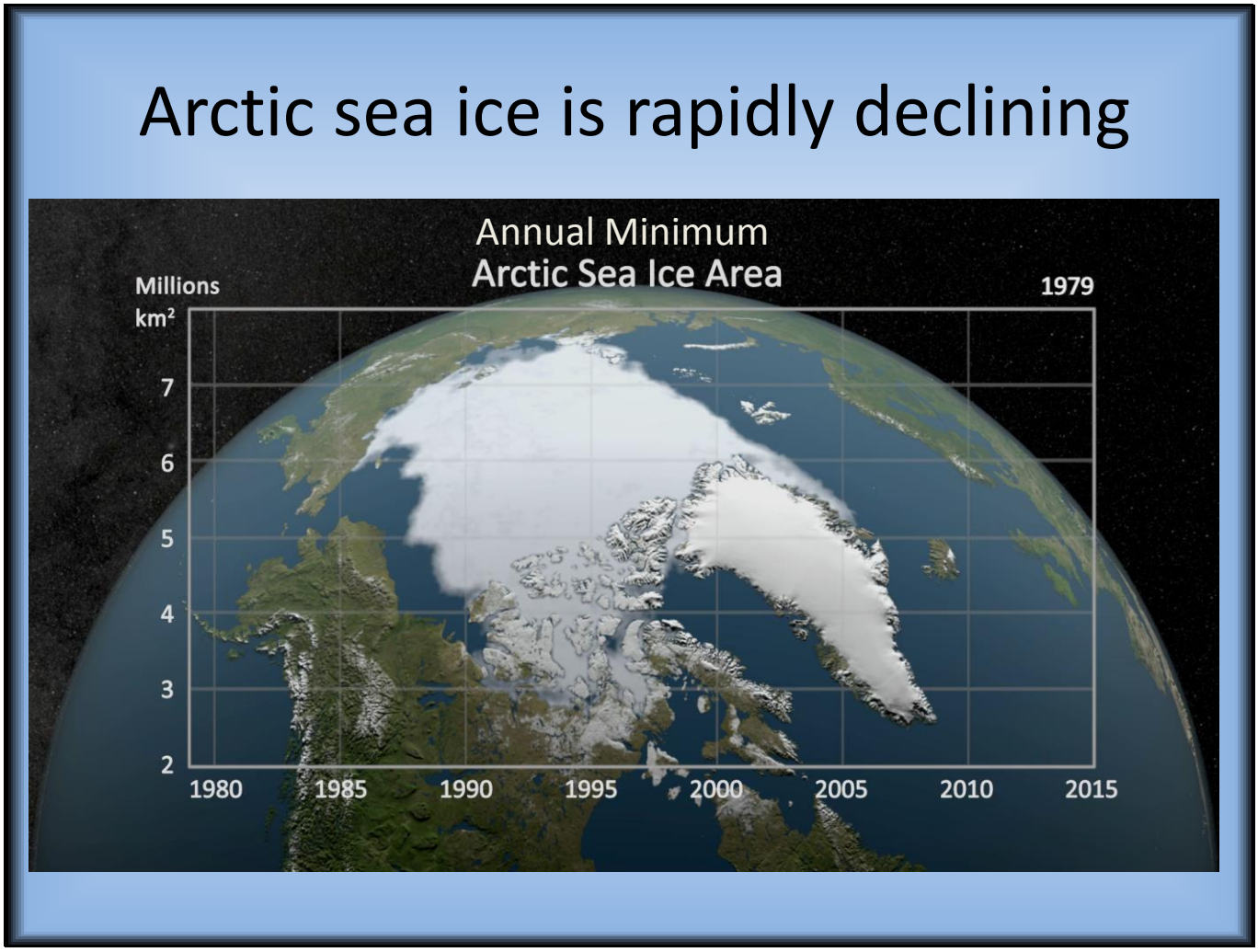
Slide 9



www.encyclopedia.com, waynesword.palomar.edu, dispatch.com, liveanimalist.com, en.wikipedia.org

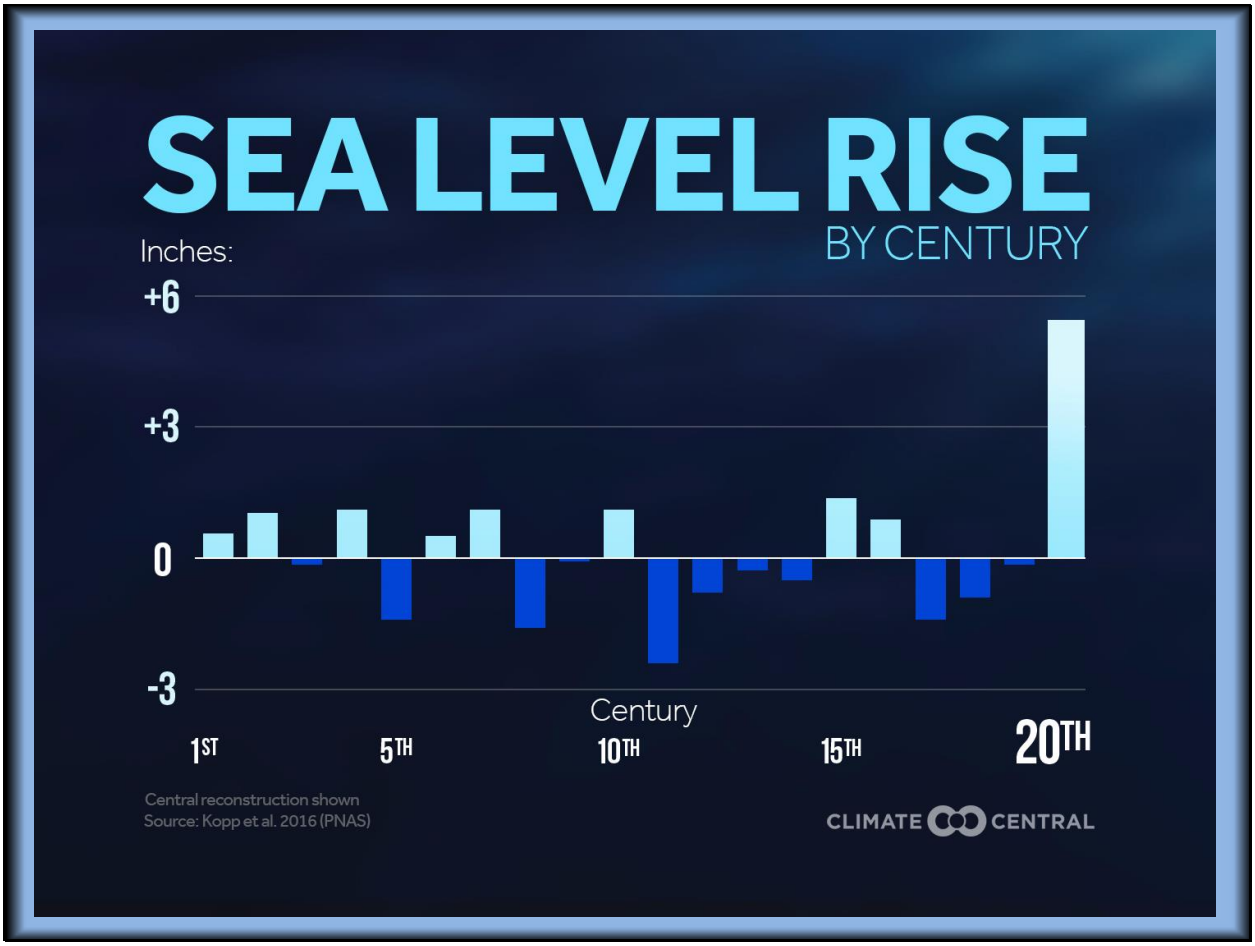
Chen, I.C., Hill, J.K., Ohlemüller, R., Roy, D.B., Thomas, C.D., 2011. Rapid range shifts of species associated with high levels of climate warming. Science 333, 1024-1026.

Slide 10



http://svs.gsfc.nasa.gov/4435

Slide 11

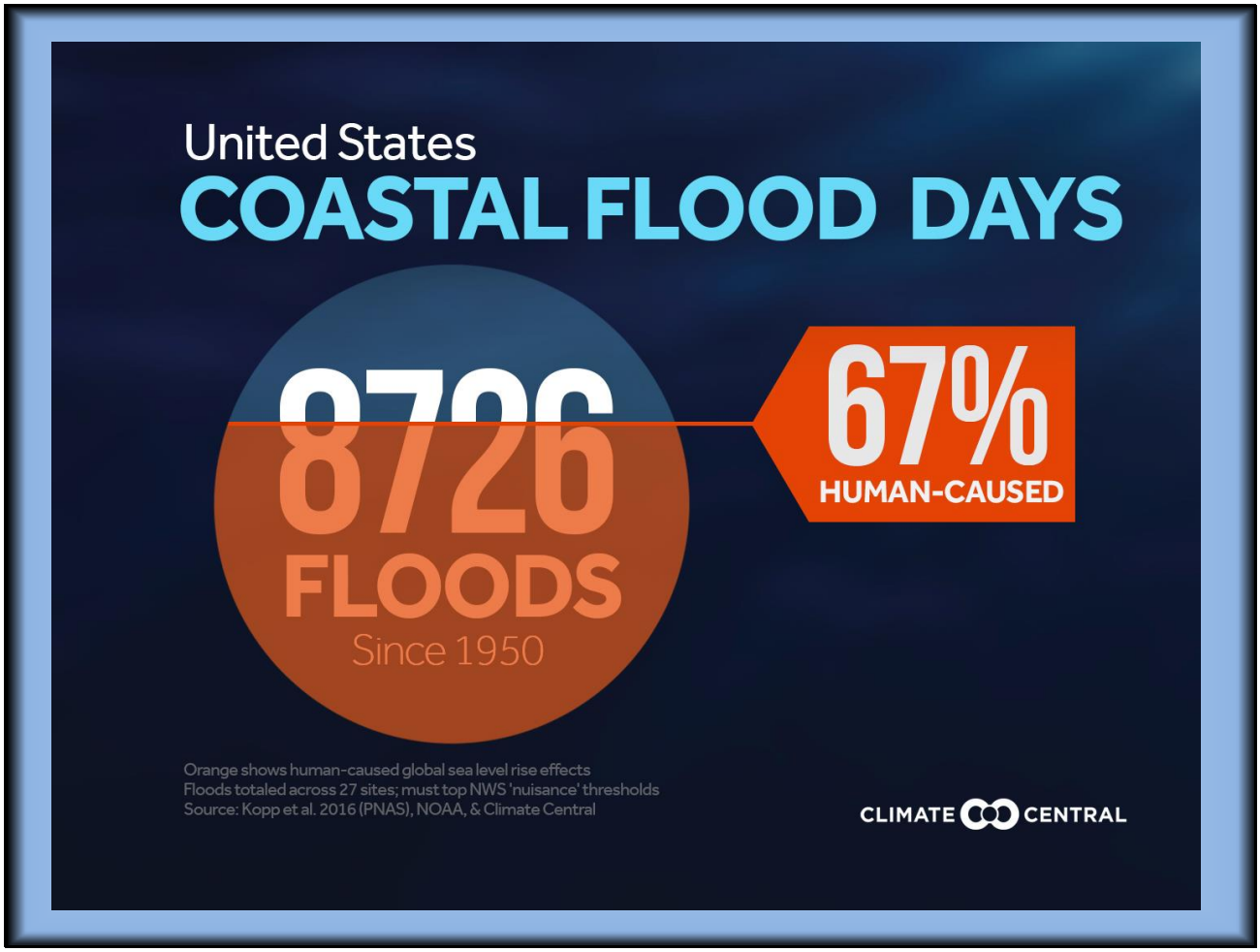

SEA LEVEL RISE
BY CENTURY
Inches:
+6
+3
0
-3
Century
1ST
5TH
10TH
15TH
20TH
Central reconstruction shown
Source: Kopp et al. 2016 (PNAS)
CLIMATE CENTRAL

Slide 12

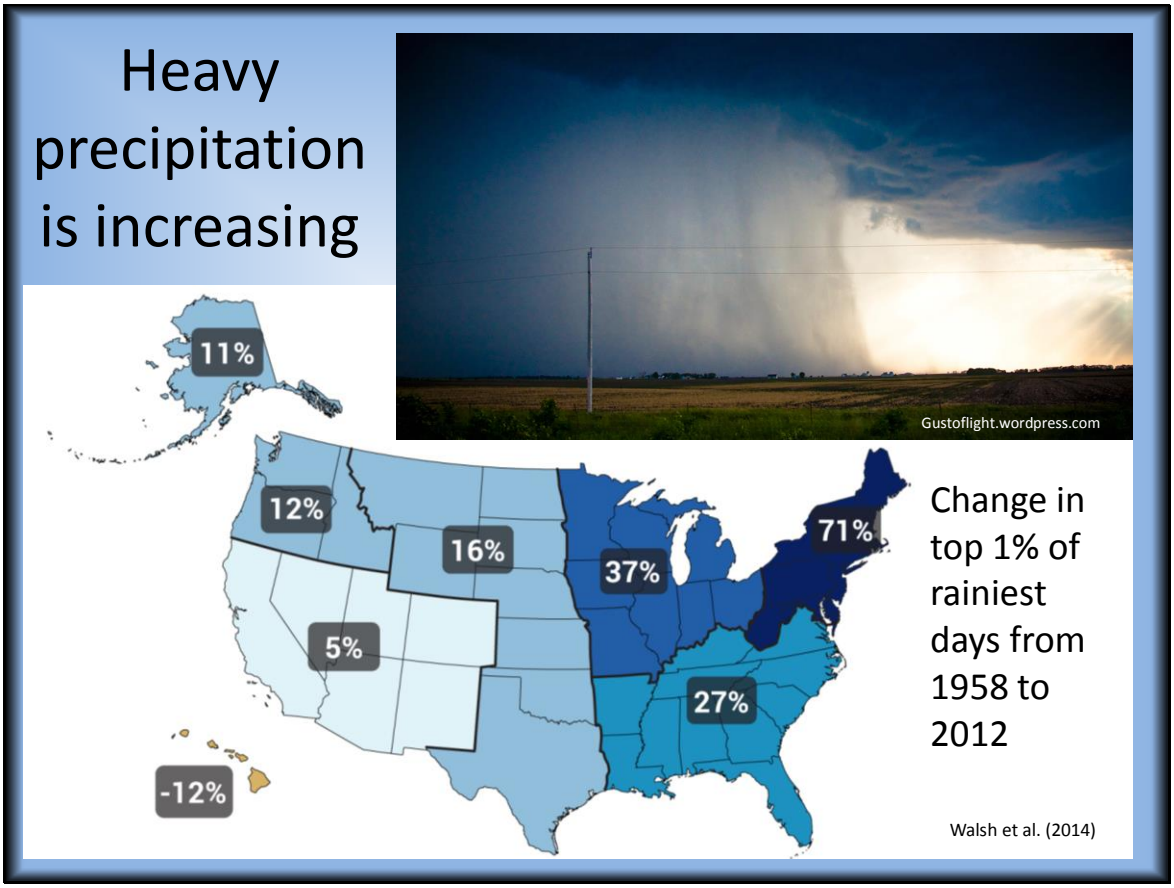
“Sunny day” flooding in Miami

Photo source: Grist

Slide 13

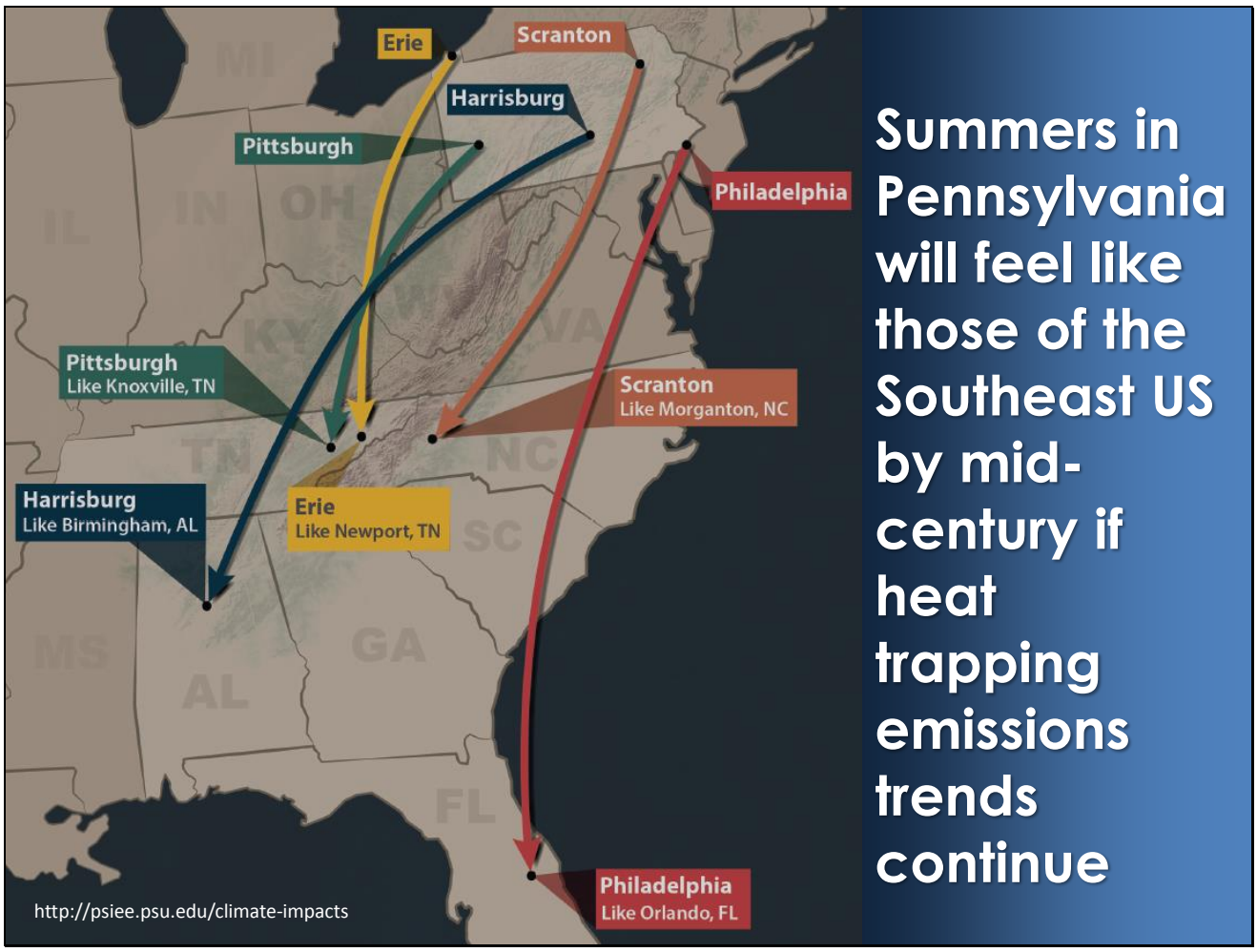

United States
COASTAL FLOOD DAYS
8726
FLOODS
Since 1950
67%
HUMAN-CAUSED
Orange shows human-caused global sea level rise effects
Floods totaled across 27 sites; must top NWS 'nuisance' thresholds
Source: Kopp et al. 2016 (PNAS), NOAA, & Climate Central
CLIMATE CENTRAL

Slide 14

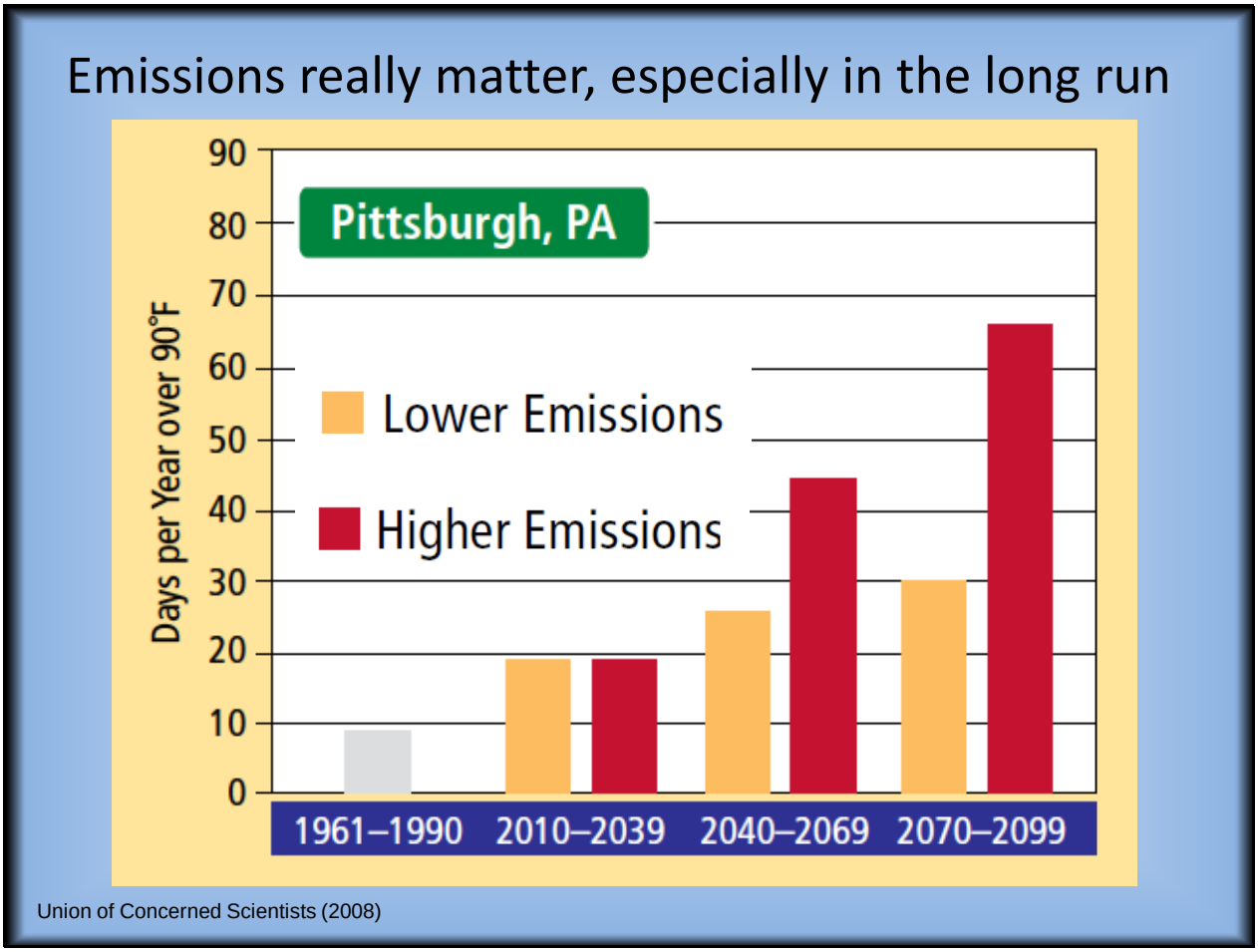


Walsh, J., Wuebbles, D., Hayhoe, K., Kossin, J., Kunkel, K., Stephens, G., Thorne, P., Vose, R., Wehner, M., Willis, J., Anderson, D., Doney, S., Feely, R., Hennon, P., Kharin, V., Knutson, T., Landerer, F., Lenton, T., Kennedy, J., Somerville, R., 2014. Chapter 2: Our Changing Climate. In: J.M. Melillo, T.C. Richmond, G.W. Yohe (Editors), Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, pp. 19-67.

Slide 15


Erie
Scranton
Harrisburg
Pittsburgh
Philadelphia
Pittsburgh
Like Knoxville, TN
Scranton
Like Morganton, NC
Harrisburg
Like Birmingham, AL
Erie
Like Newport, TN
Philadelphia
Like Orlando, FL
http://psiee.psu.edu/climate-impacts
Summers in Pennsylvania will feel like those of the Southeast US by mid-century if heat trapping emissions trends continue

Slide 16



Union of Concerned Scientists, 2008. Climate Change in Pennsylvania: Impacts and Solutions for the Keystone State. Cambridge, MA, 54 pp.

Slide 17

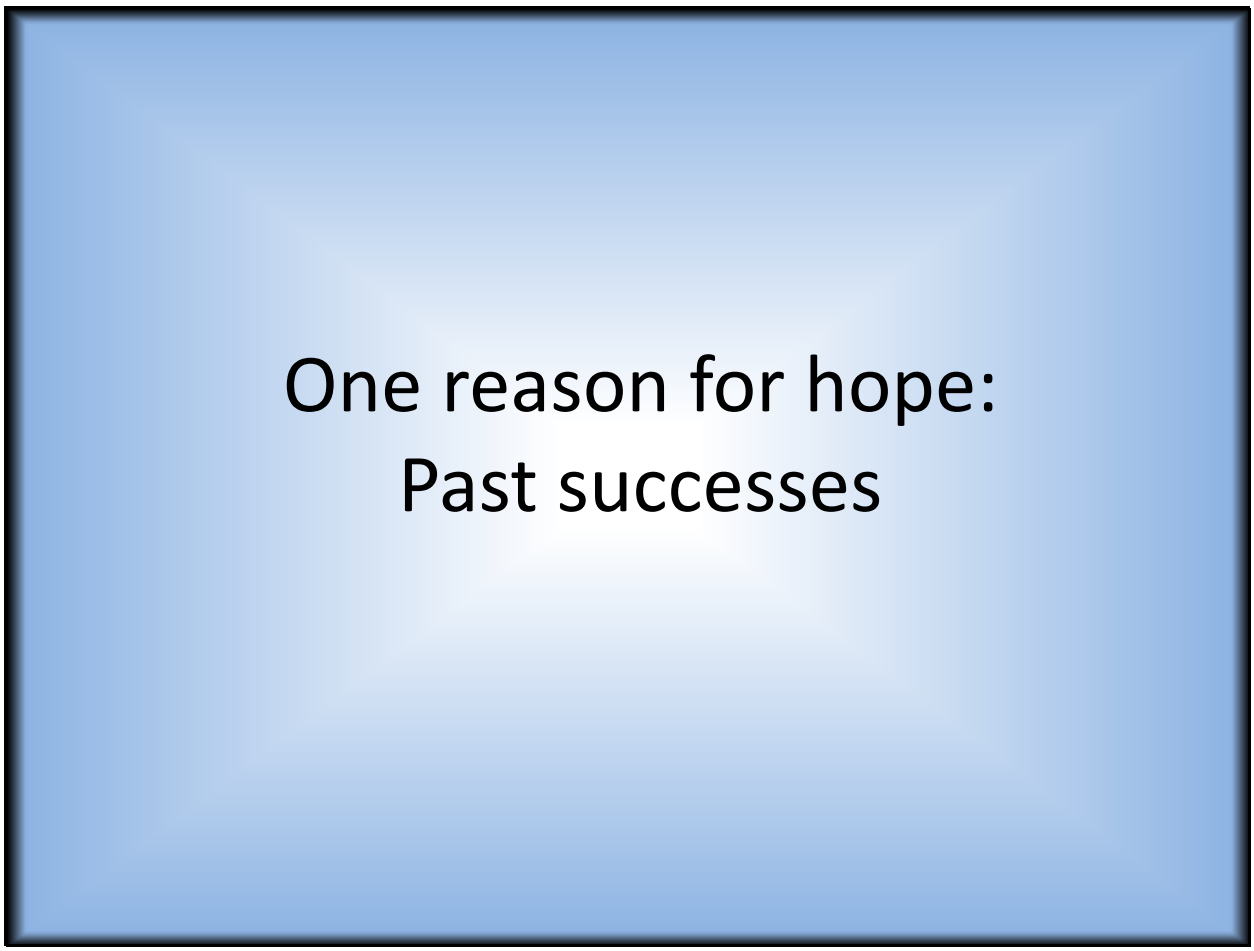
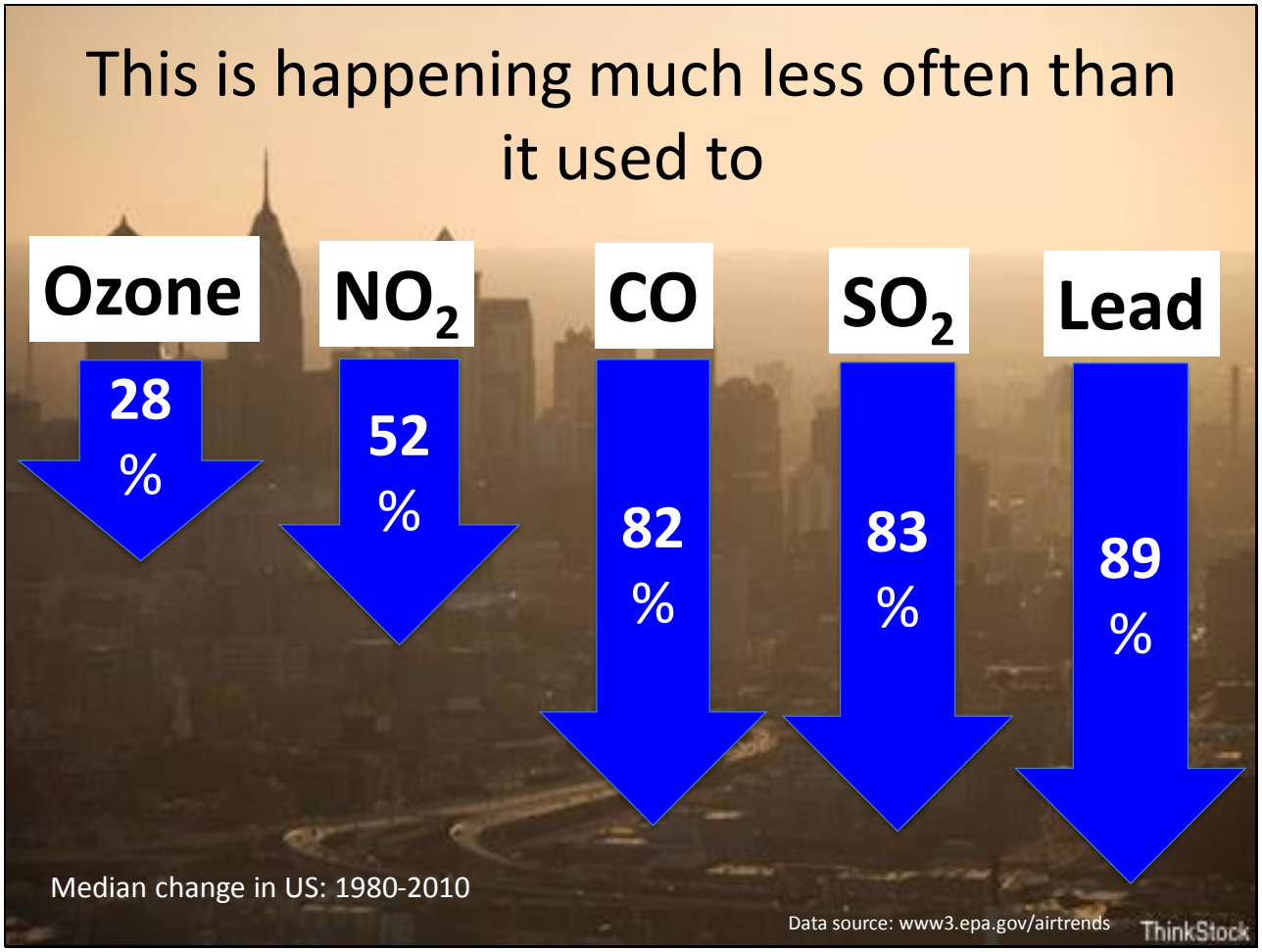
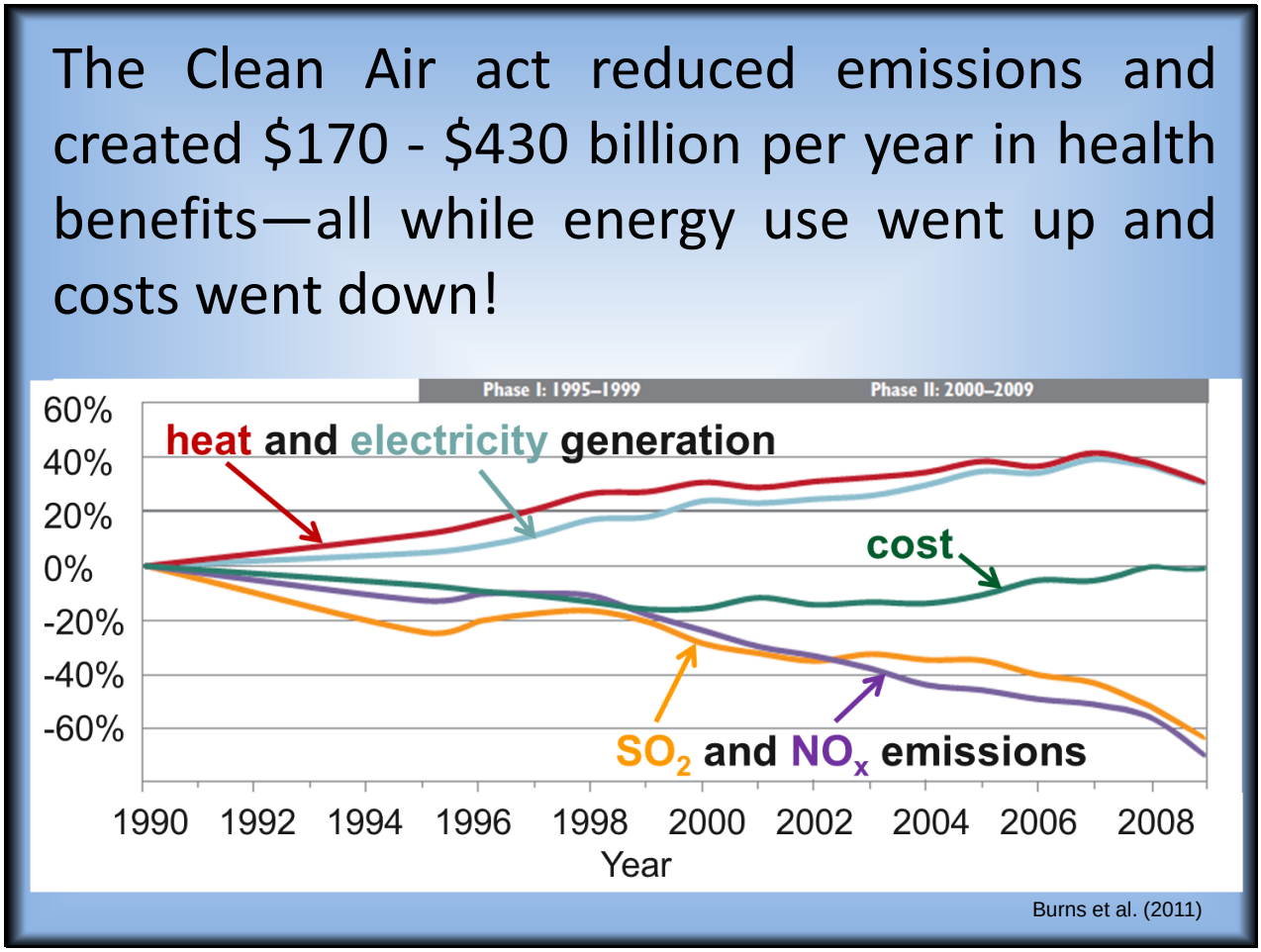


Image istockphoto

Slide 18


This is happening much less often than it used to
Ozone
28 %
NO_2
52 %
CO
82 %
SO_2
83 %
Lead
89 %
Median change in US: 1980-2010
Data source: www3.epa.gov/airtrends
ThinkStock

Slide 19

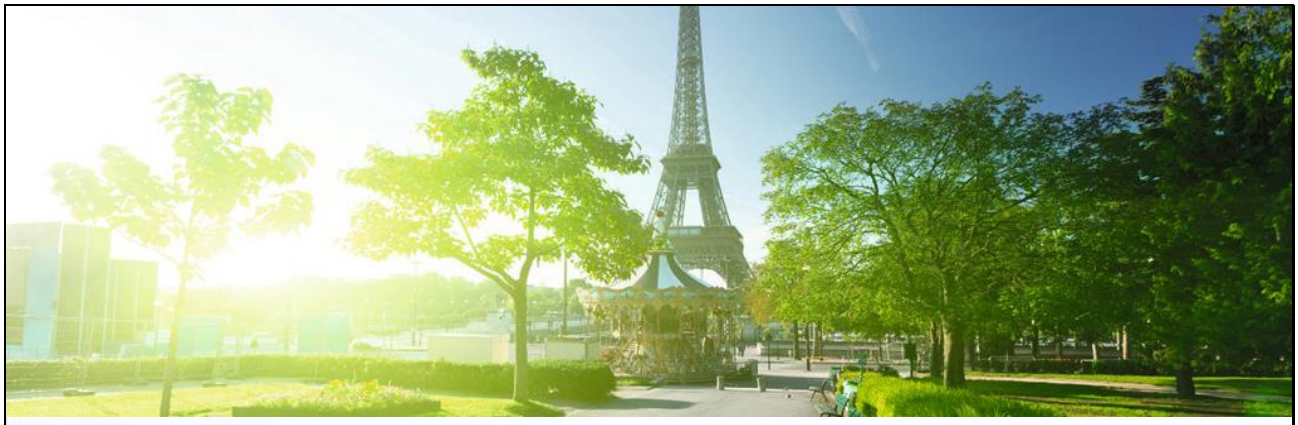


Burns, D.A., Baron, J.S., Cosby, B.J., Fenn, M.E., Lynch, J.A., 2011. National Acid Precipitation Assessment Program Report to Congress 2011: An Integrated Assessment. National Science and Technology Council, United States Government, Washington, D.C., 114 pp.

Slide 20

Another reason for hope:
People are responding

Slide 21



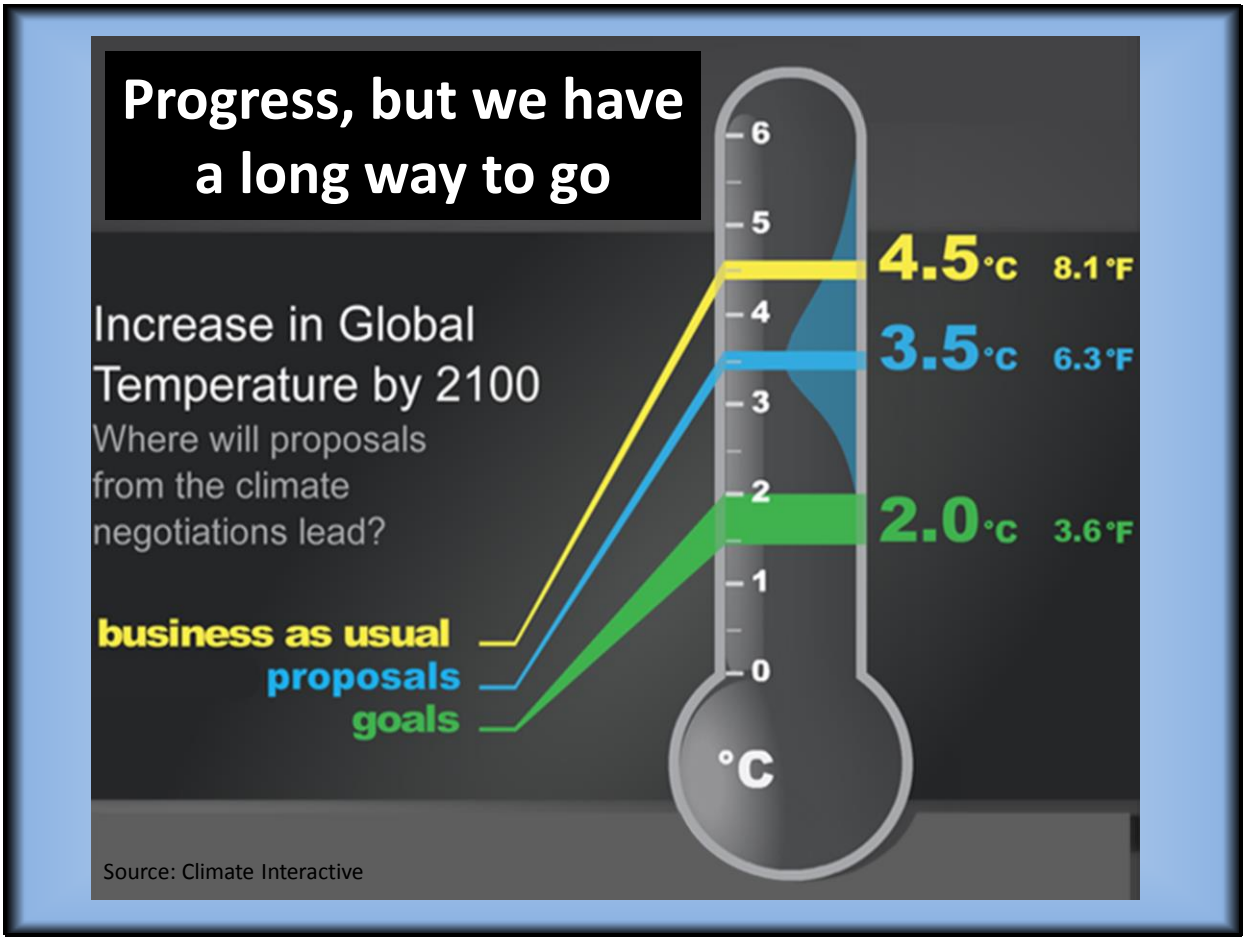
Paris Climate Conference 2015

Agreement to keep global warming well below 2.0 °C (3.6 °F)

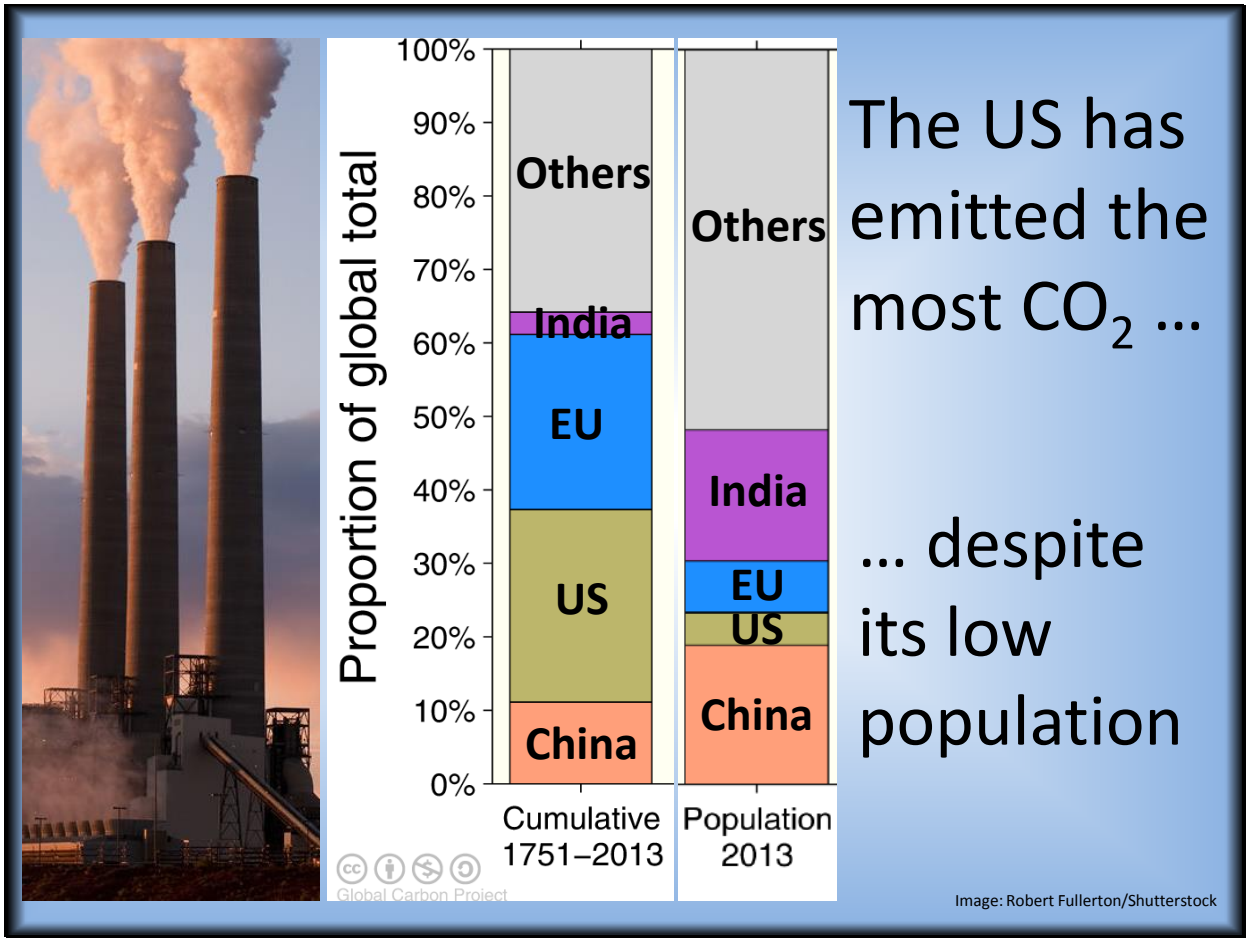
Source: COP21 Paris

UCAR
UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

Slide 22

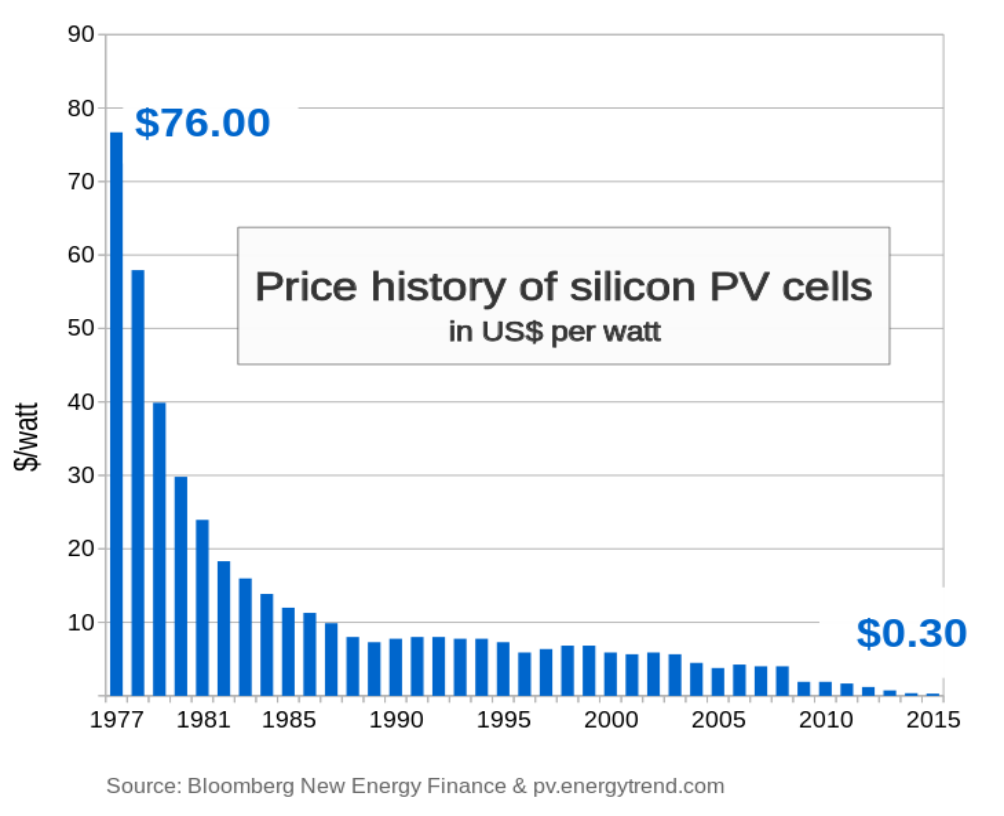

Progress, but we have a long way to go
Increase in Global Temperature by 2100
Where will proposals from the climate negotiations lead?
business as usual
proposals
goals
6
5
4
3
2
1
0
°C
4.5°C 8.1°F
3.5°C 6.3°F
2.0°C 3.6°F
Source: Climate Interactive

Slide 23


Proportion of global total
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Others
India
EU
US
China
Cumulative 1751–2013
Population 2013
Global Carbon Project
The US has emitted the most CO_2 …
… despite its low population
Image: Robert Fullerton/Shutterstock

Slide 24

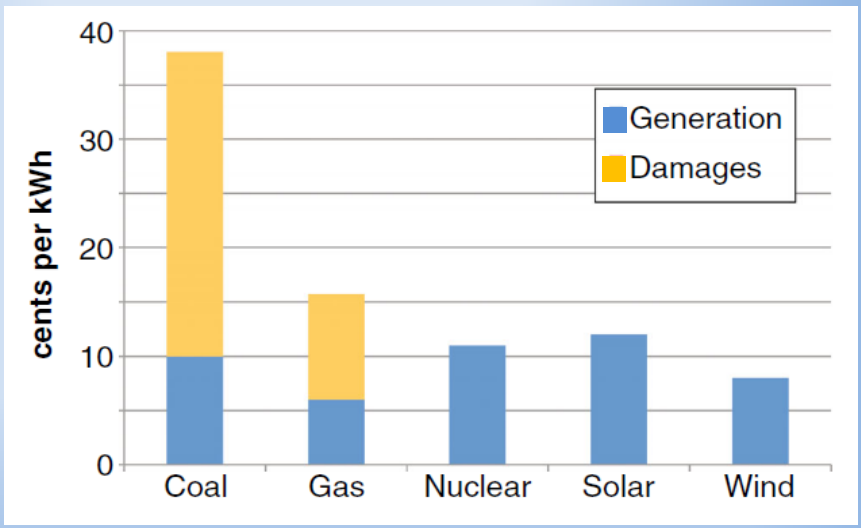
The cost to install solar has plummeted



Slide 25

When damages to agriculture and health are considered, new electricity based on renewables is cheapest

Costs of new US electricity

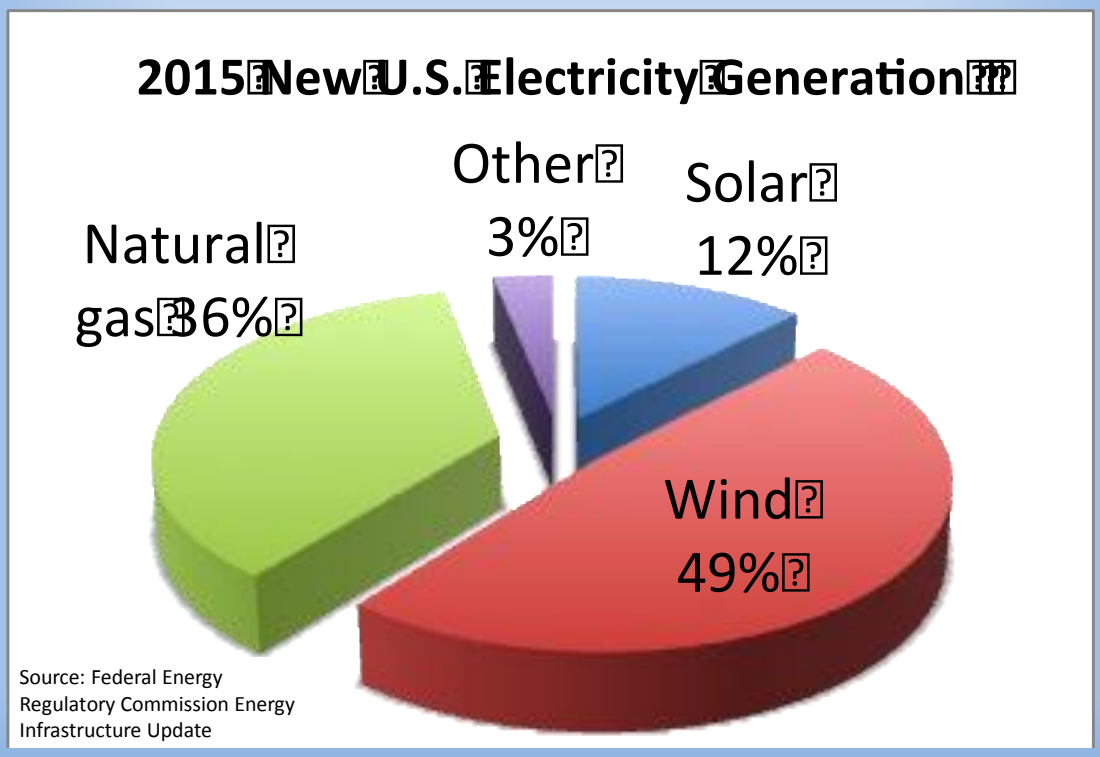


Shindell (2015)

Shindell, D.T., 2015. The social cost of atmospheric release. Climatic Change 130, 313–326.

Slide 26

2/3 of new electricity in the US in 2015 was renewable



Source: Federal Energy Regulatory Commission Energy Infrastructure Update

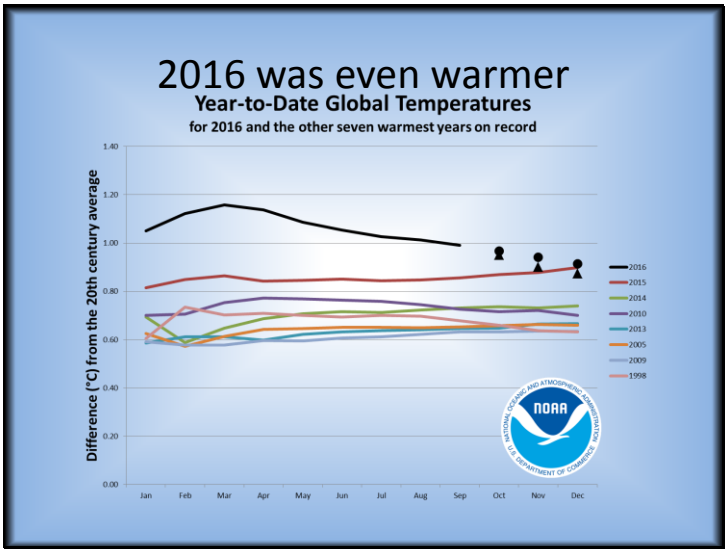
Slide 27

Bottom lines about global warming:

- It’s real
- It’s us
- It’s a serious threat
- It’s solvable

Slide 28

Slide 29


2016 was even warmer
Year-to-Date Global Temperatures
for 2016 and the other seven warmest years on record
Difference (°C) from the 20th century average
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2016
2015
2014
2010
2013
2005
2009
1998
NOAA