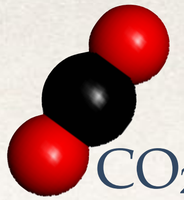
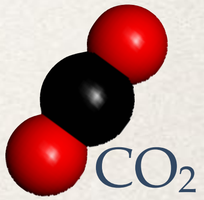
Expanding Spheres:
Atoms to Earth, Local to Global, Science to Society

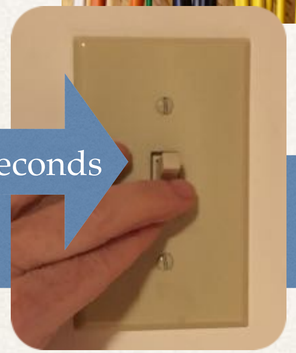
2018-02-15



A coal mine near Gilette, Wyo.
Credit: Greg Goebel/flickr




1885
Michigan Tech
CO_2



Seconds

Decades

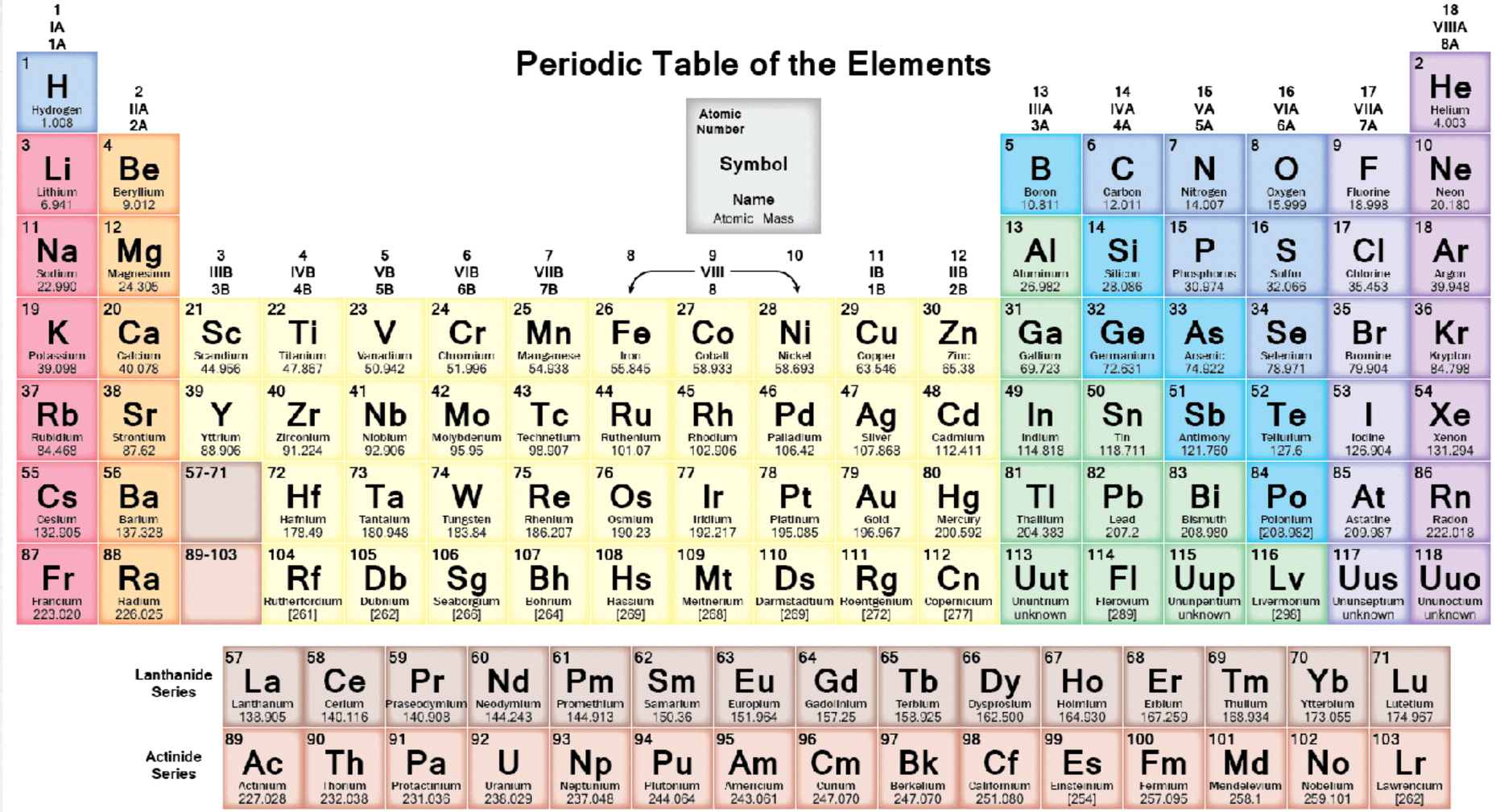
Millenia

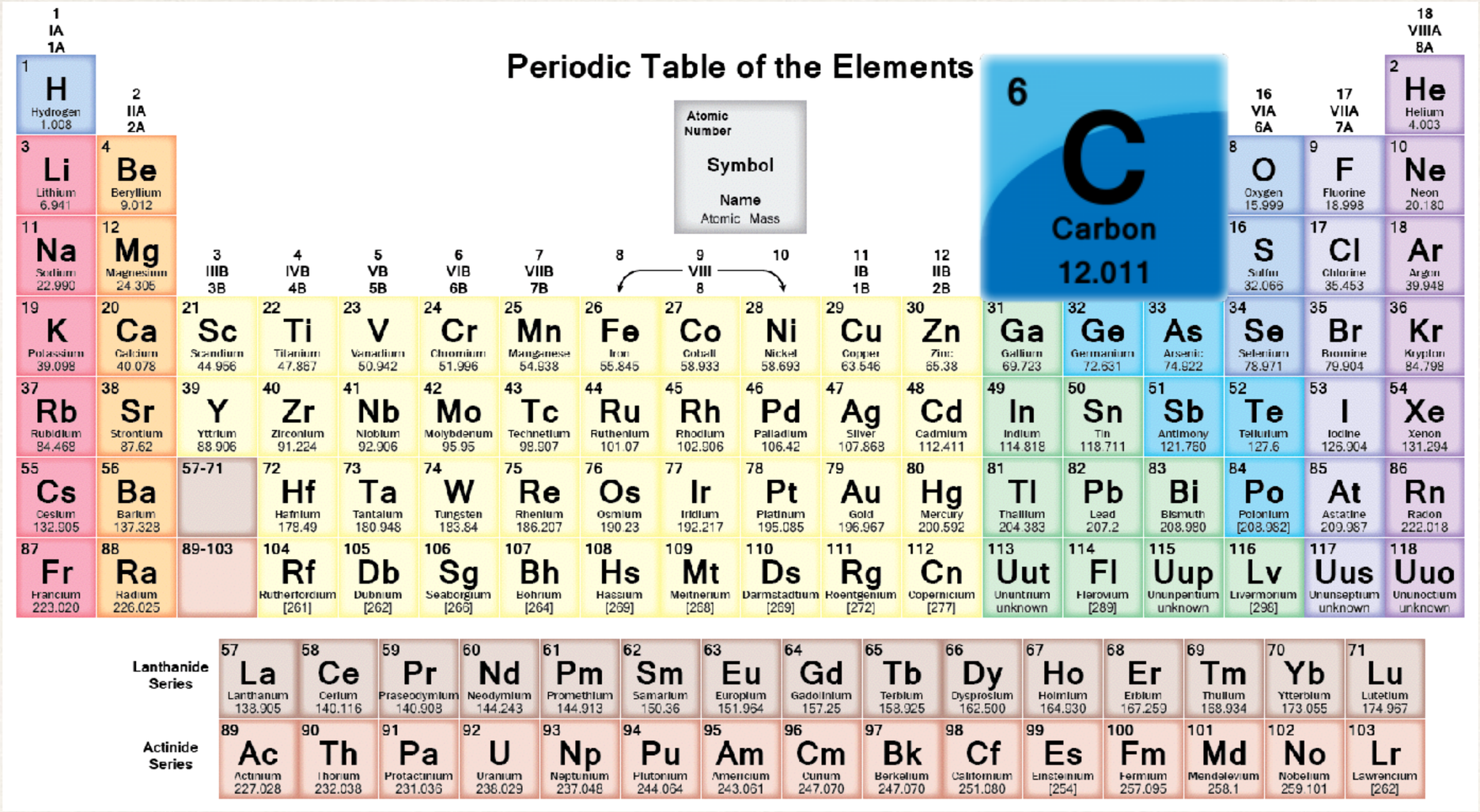
CO_2

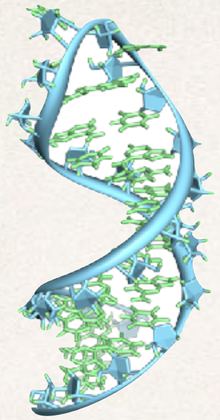
Centuries

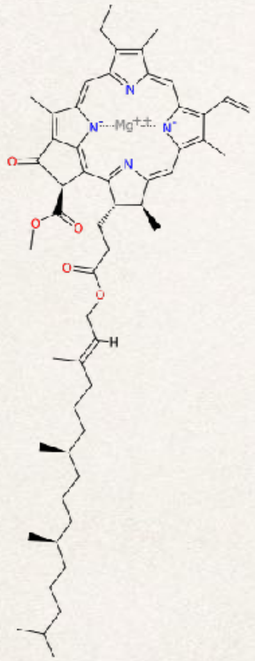
A coal mine near Gilette, Wyo.
Credit: Greg Goebel/flickr

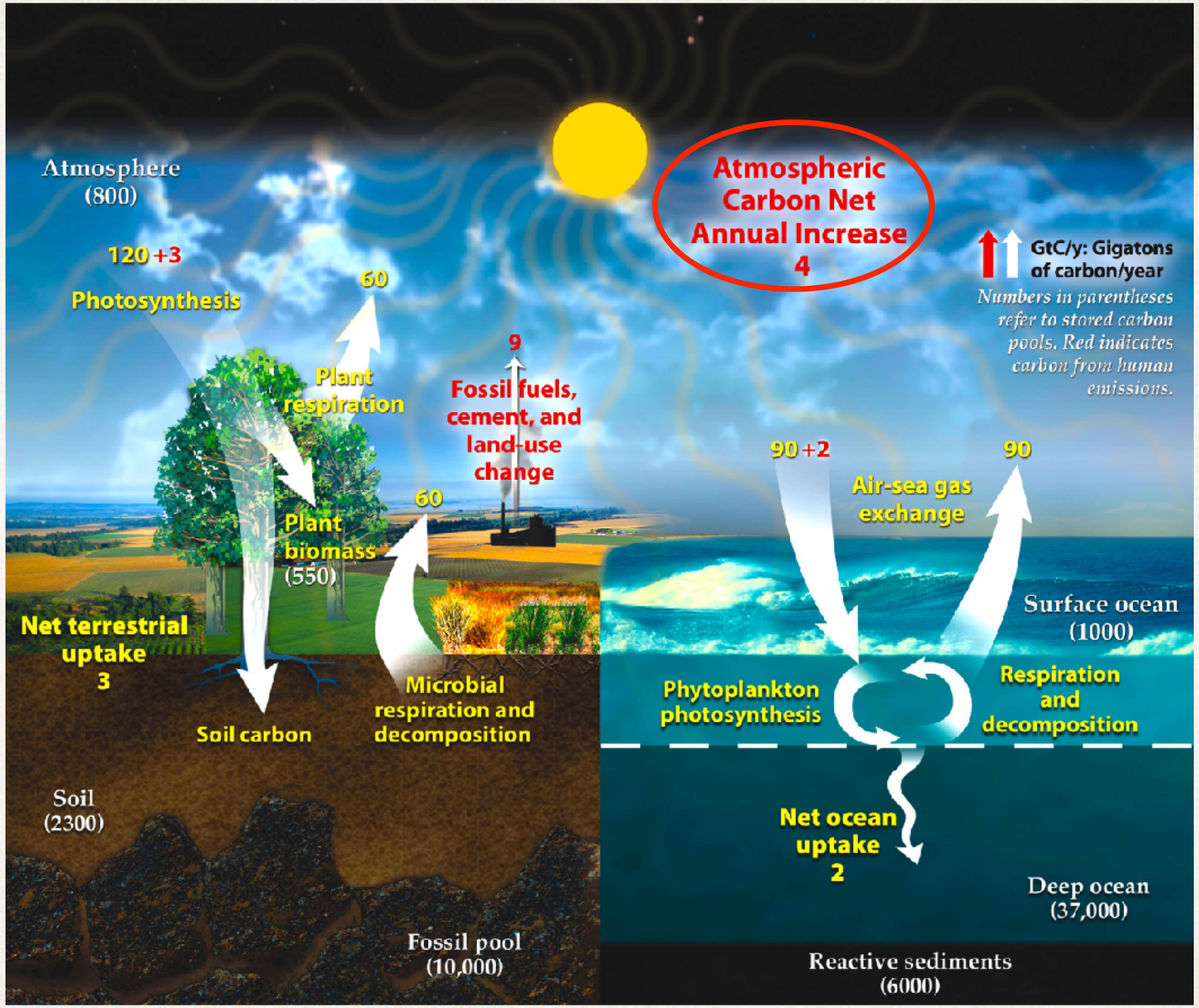
Periodic Table of the Elements




Periodic Table of the Elements
Atomic Number
Symbol
Name
Atomic Mass
6
C
Carbon
12.011
1 IA 1A
2 IIA 2A
3 IIIB 3B
4 IVB 4B
5 VB 5B
6 VIB 6B
7 VIIB 7B
8 9 VIII 10 8
11 IB 1B
12 IIB 2B
16 VIA 6A
17 VIIA 7A
18 VIIIA 8A
1 H Hydrogen 1.008
2 He Helium 4.003
3 Li Lithium 6.941
4 Be Beryllium 9.012
8 O Oxygen 15.999
9 F Fluorine 18.998
10 Ne Neon 20.180
11 Na Sodium 22.990
12 Mg Magnesium 24.305
16 S Sulfur 32.066
17 Cl Chlorine 35.453
18 Ar Argon 39.948
19 K Potassium 39.098
20 Ca Calcium 40.078
21 Sc Scandium 44.956
22 Ti Titanium 47.867
23 V Vanadium 50.942
24 Cr Chromium 51.996
25 Mn Manganese 54.938
26 Fe Iron 55.845
27 Co Cobalt 58.933
28 Ni Nickel 58.693
29 Cu Copper 63.546
30 Zn Zinc 65.38
31 Ga Gallium 69.723
32 Ge Germanium 72.631
33 As Arsenic 74.922
34 Se Selenium 78.971
35 Br Bromine 79.904
36 Kr Krypton 84.798
37 Rb Rubidium 84.468
38 Sr Strontium 87.62
39 Y Yttrium 88.906
40 Zr Zirconium 91.224
41 Nb Niobium 92.906
42 Mo Molybdenum 95.95
43 Tc Technetium 98.907
44 Ru Ruthenium 101.07
45 Rh Rhodium 102.906
46 Pd Palladium 106.42
47 Ag Silver 107.868
48 Cd Cadmium 112.411
49 In Indium 114.818
50 Sn Tin 118.711
51 Sb Antimony 121.760
52 Te Tellurium 127.6
53 I Iodine 126.904
54 Xe Xenon 131.294
55 Cs Cesium 132.905
56 Ba Barium 137.328
57-71
72 Hf Hafnium 178.49
73 Ta Tantalum 180.948
74 W Tungsten 183.84
75 Re Rhenium 186.207
76 Os Osmium 190.23
77 Ir Iridium 192.217
78 Pt Platinum 195.085
79 Au Gold 196.967
80 Hg Mercury 200.592
81 Tl Thallium 204.383
82 Pb Lead 207.2
83 Bi Bismuth 208.980
84 Po Polonium [208.982]
85 At Astatine 209.987
86 Rn Radon 222.018
87 Fr Francium 223.020
88 Ra Radium 226.025
89-103
104 Rf Rutherfordium [261]
105 Db Dubnium [262]
106 Sg Seaborgium [265]
107 Bh Bohrium [264]
108 Hs Hassium [269]
109 Mt Meitnerium [268]
110 Ds Darmstadtium [269]
111 Rg Roentgenium [272]
112 Cn Copernicium [277]
113 Uut Ununtrium unknown
114 Fl Flerovium [289]
115 Uup Ununpentium unknown
116 Lv Livermorium [296]
117 Uus Ununseptium unknown
118 Uuo Ununoctium unknown
Lanthanide Series
57 La Lanthanum 138.905
58 Ce Cerium 140.116
59 Pr Praseodymium 140.908
60 Nd Neodymium 144.243
61 Pm Promethium 144.913
62 Sm Samarium 150.36
63 Eu Europium 151.964
64 Gd Gadolinium 157.25
65 Tb Terbium 158.925
66 Dy Dysprosium 162.500
67 Ho Holmium 164.930
68 Er Erbium 167.259
69 Tm Thulium 168.934
70 Yb Ytterbium 173.055
71 Lu Lutetium 174.967
Actinide Series
89 Ac Actinium 227.028
90 Th Thorium 232.038
91 Pa Protactinium 231.036
92 U Uranium 238.029
93 Np Neptunium 237.048
94 Pu Plutonium 244.064
95 Am Americium 243.061
96 Cm Curium 247.070
97 Bk Berkelium 247.070
98 Cf Californium 251.080
99 Es Einsteinium [254]
100 Fm Fermium 257.095
101 Md Mendelevium 258.1
102 No Nobelium 259.101
103 Lr Lawrencium [262]



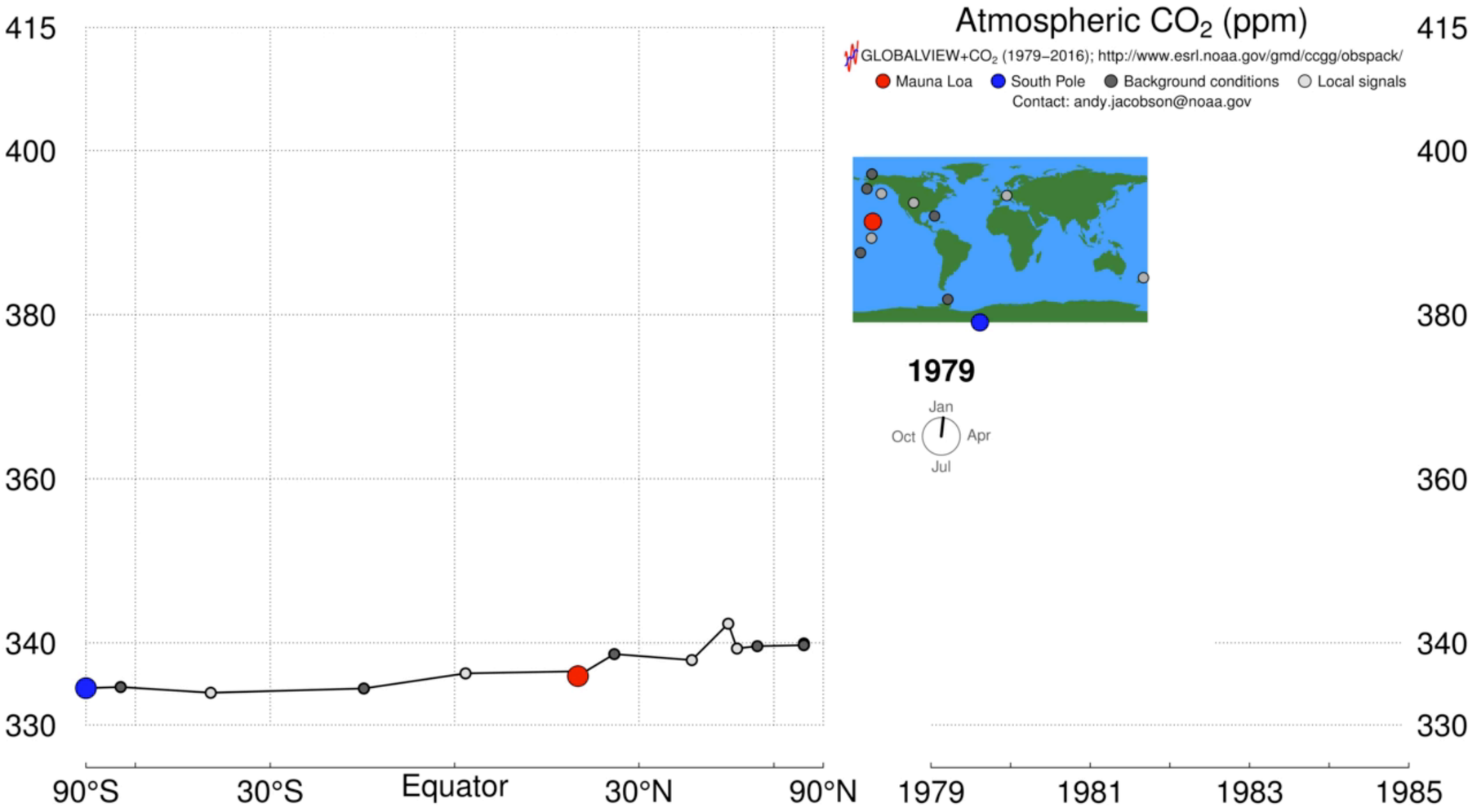




Global Carbon Cycle

U.S. DOE. 2008. Carbon Cycling and Biosequestration: Integrating Biology and Climate Through Systems Science (genomicscience.energy.gov/carboncycle/).

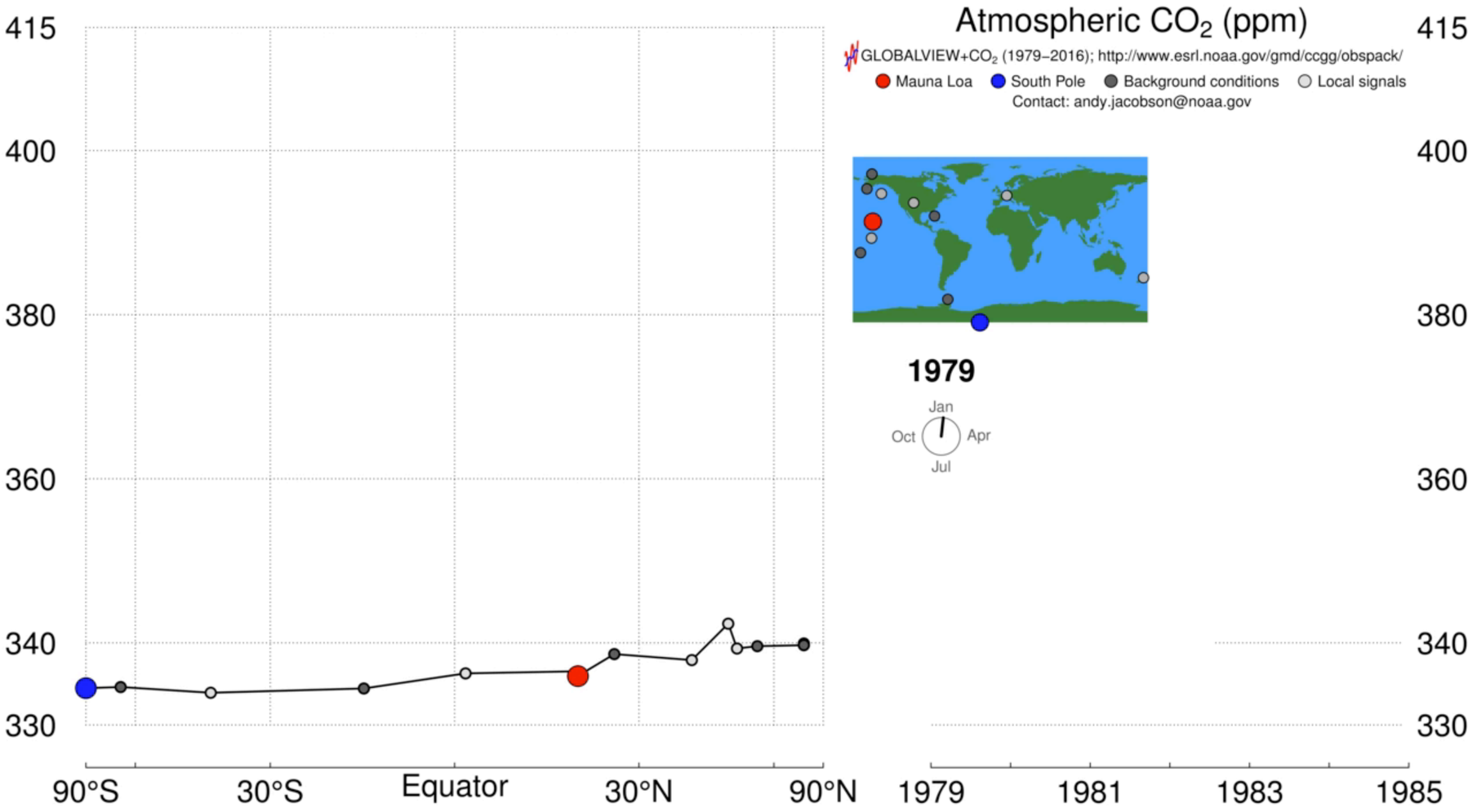
January 2018: 408 ppm



NOAA Earth System Research Laboratory

https://www.esrl.noaa.gov/gmd/ccgg/trends/history.html

January 2018: 408 ppm



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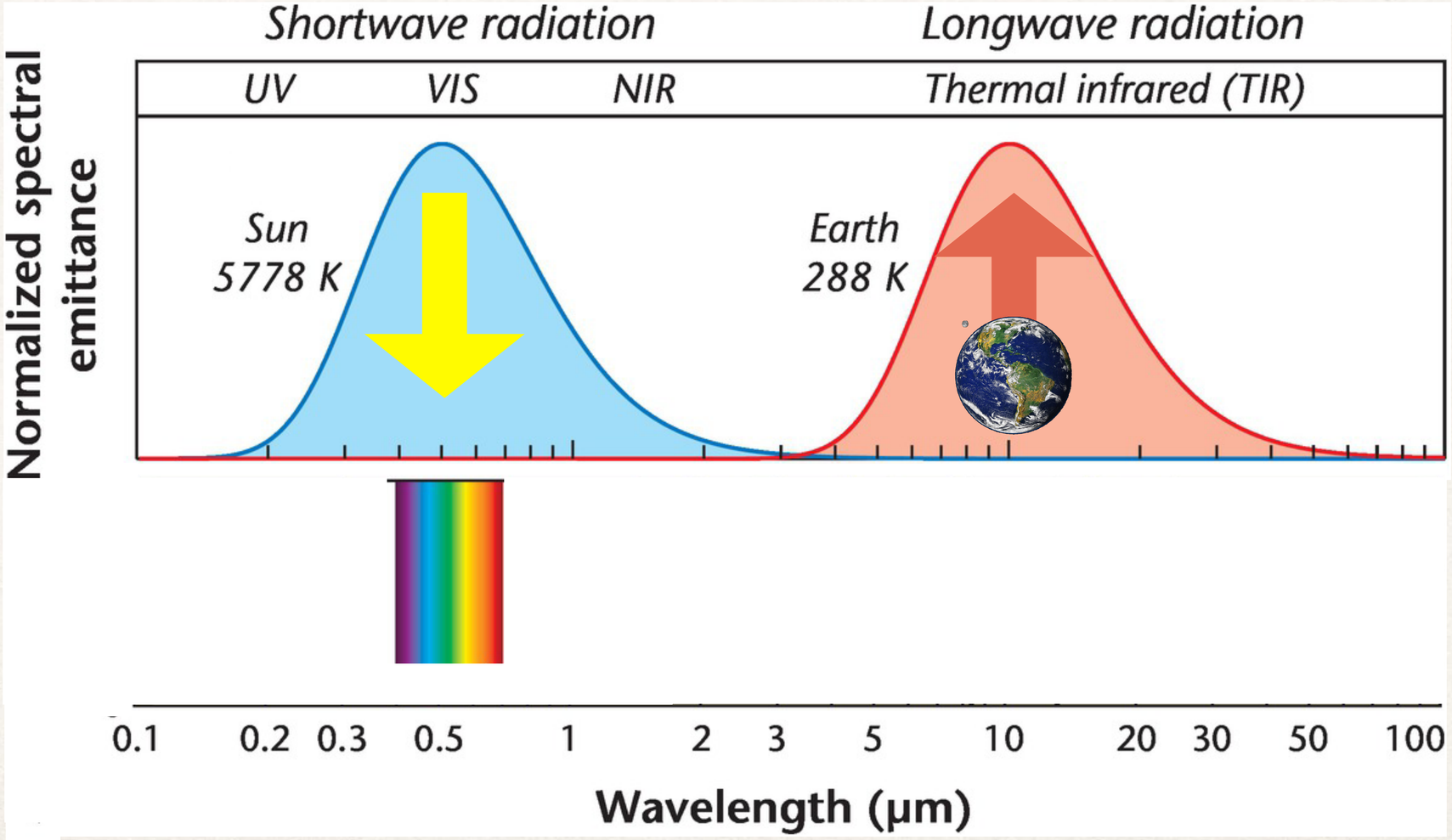
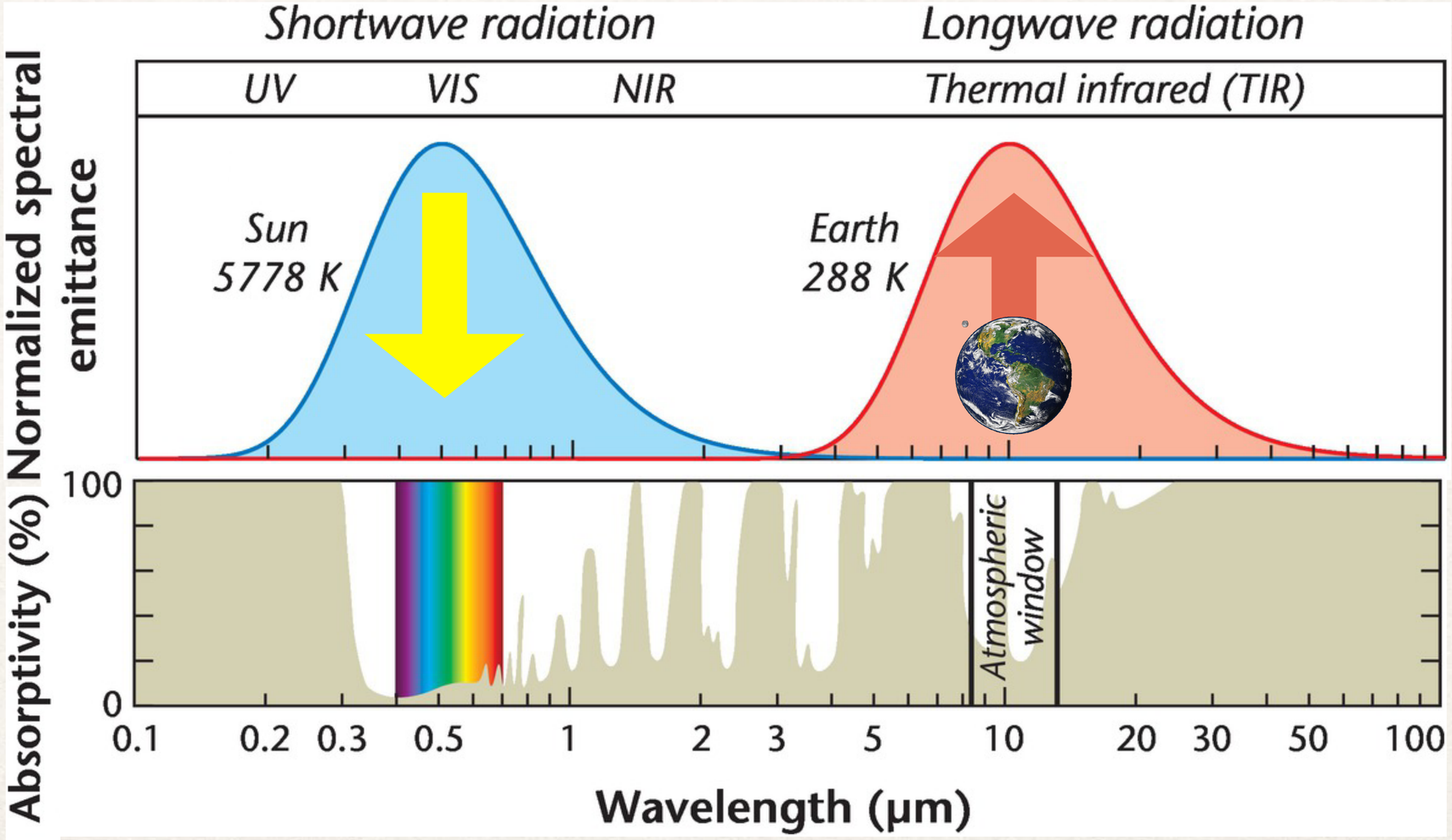
Greenhouse Effect



Adapted from: Oke, T., Mills, G., Christen, A., & Voogt, J. (2017). Radiation. In Urban Climates (pp. 122-155). Cambridge: Cambridge University Press. doi:10.1017/9781139016476.006

Greenhouse Effect



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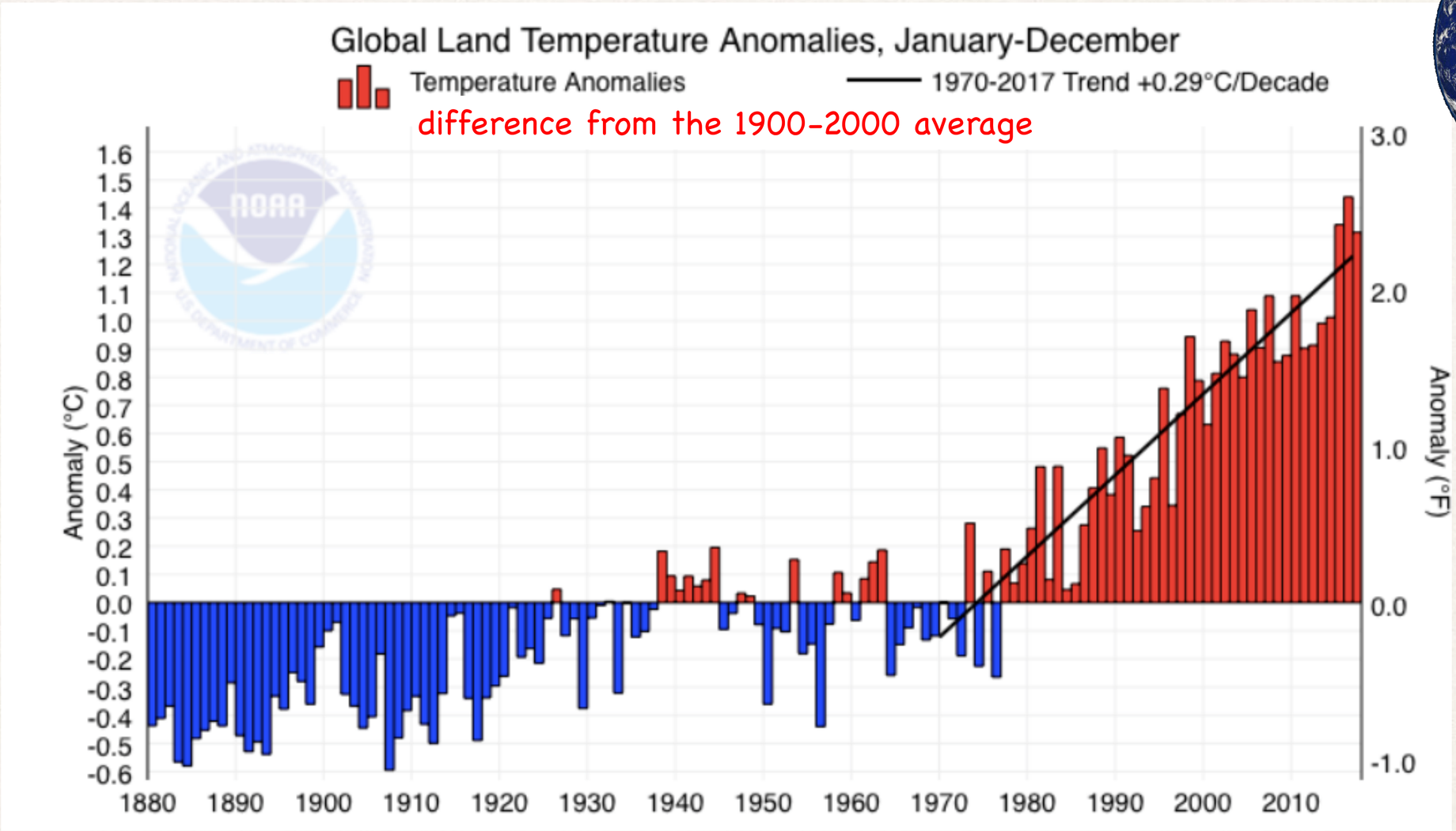
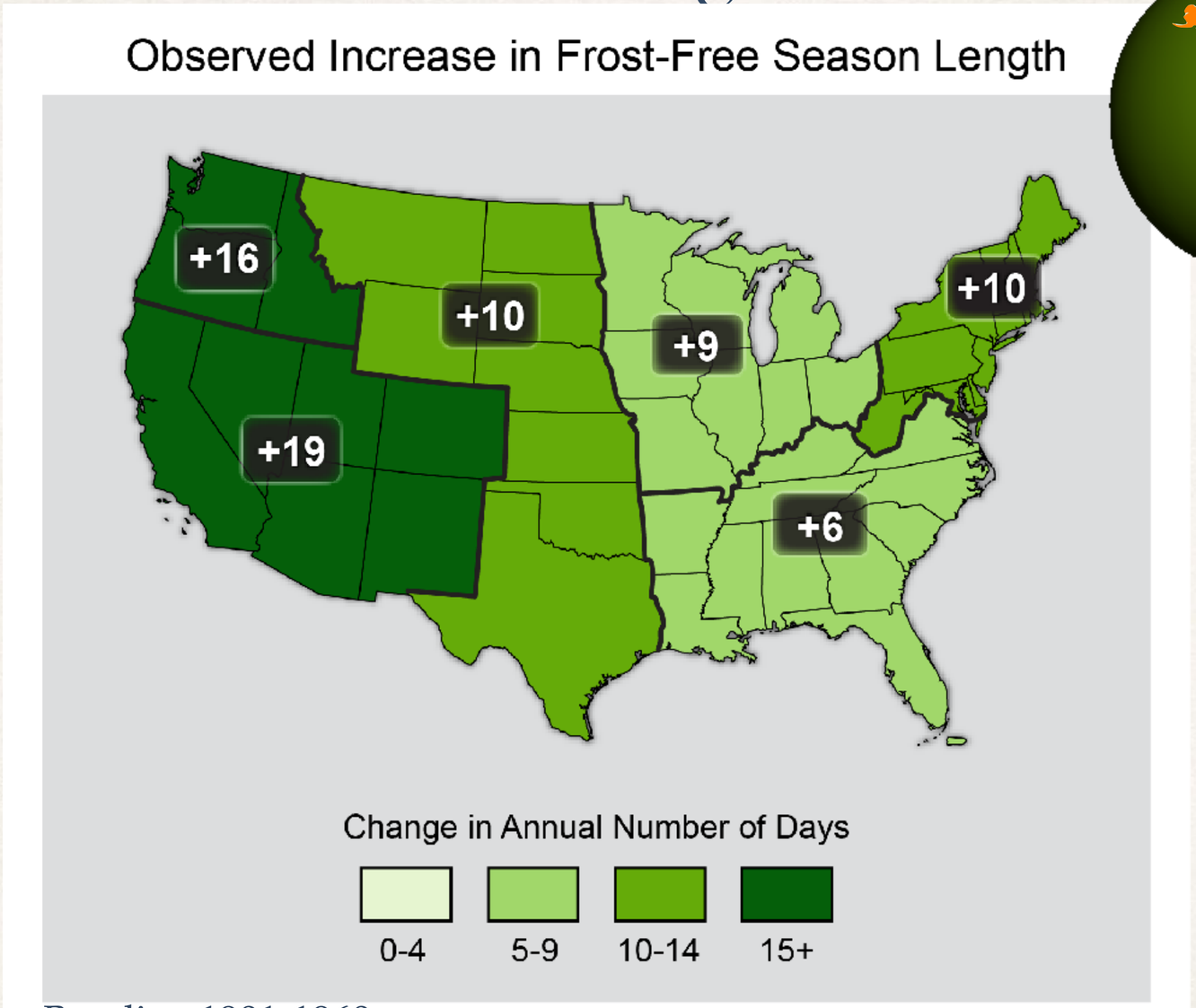
Observed changes



National Climate Data Center

http://www.ncdc.noaa.gov/cag/

Observed changes

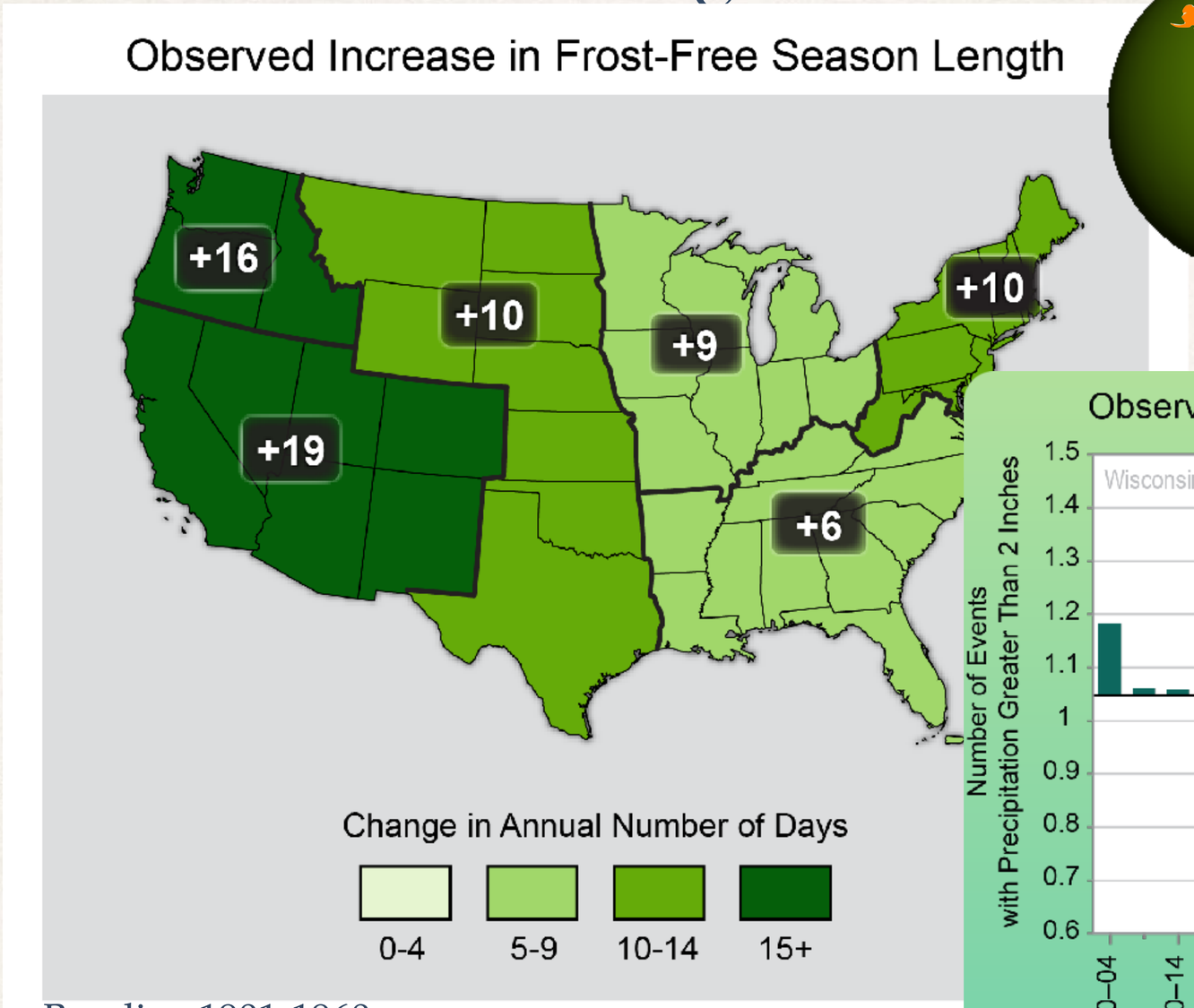


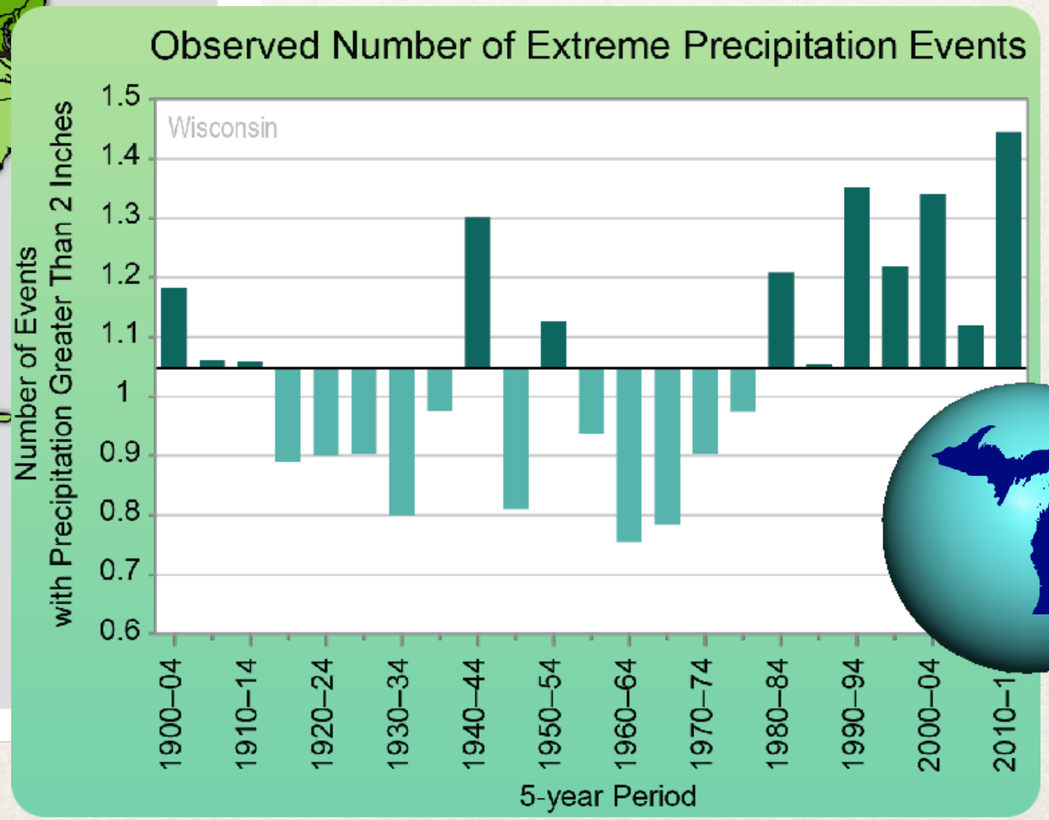
Baseline 1901-1960

http://nca2014.globalchange.gov/report/

https://statesummaries.ncics.org/

Observed changes





Baseline 1901-1960

http://nca2014.globalchange.gov/report/

https://statesummaries.ncics.org/

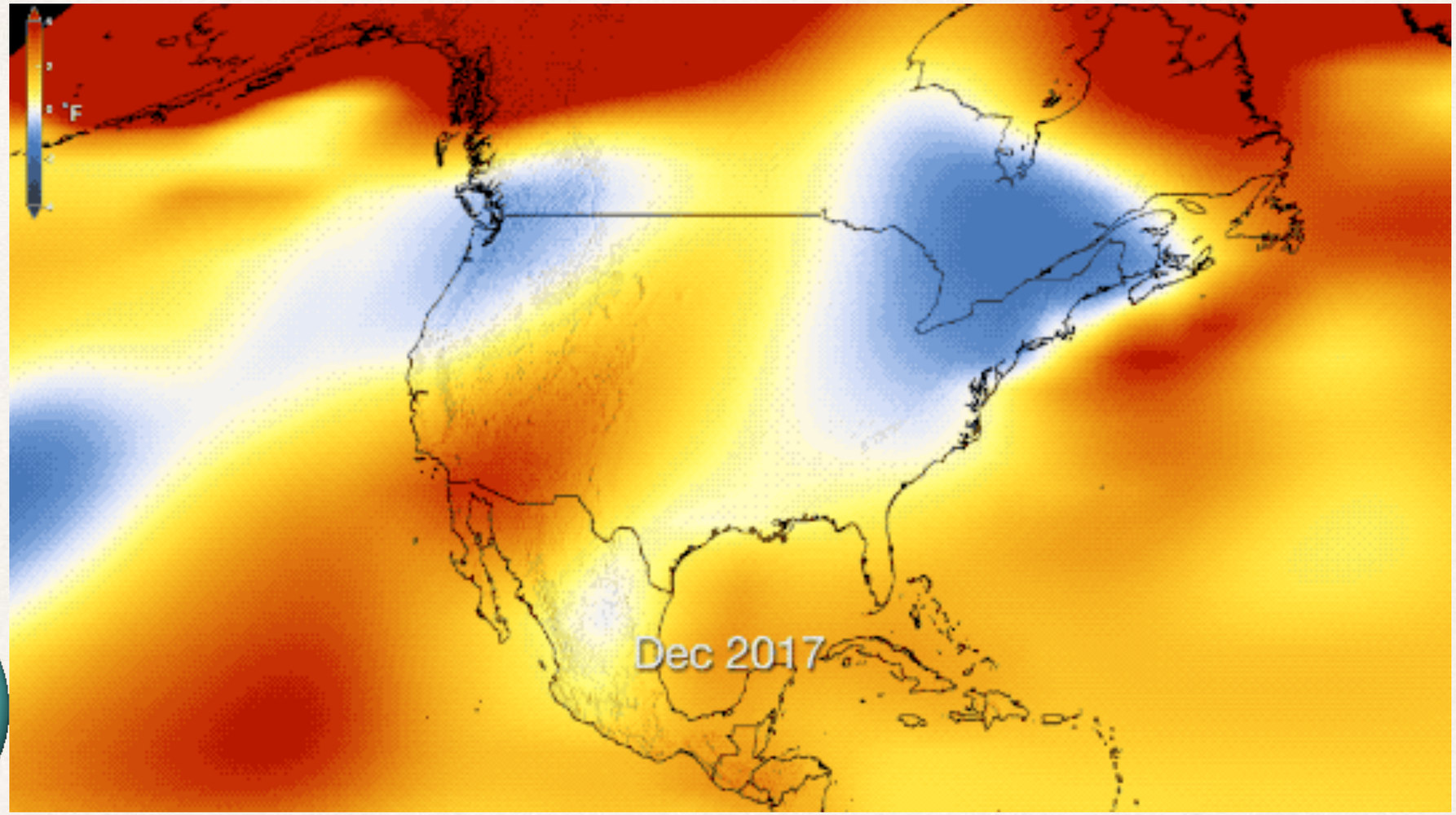
Observed changes

WI Hwy 13, July 2016

Photo: Ashland Daily Press

https://thisjustinfromfranklinwi.com/2016/07/17/photos-of-the-week-071716/

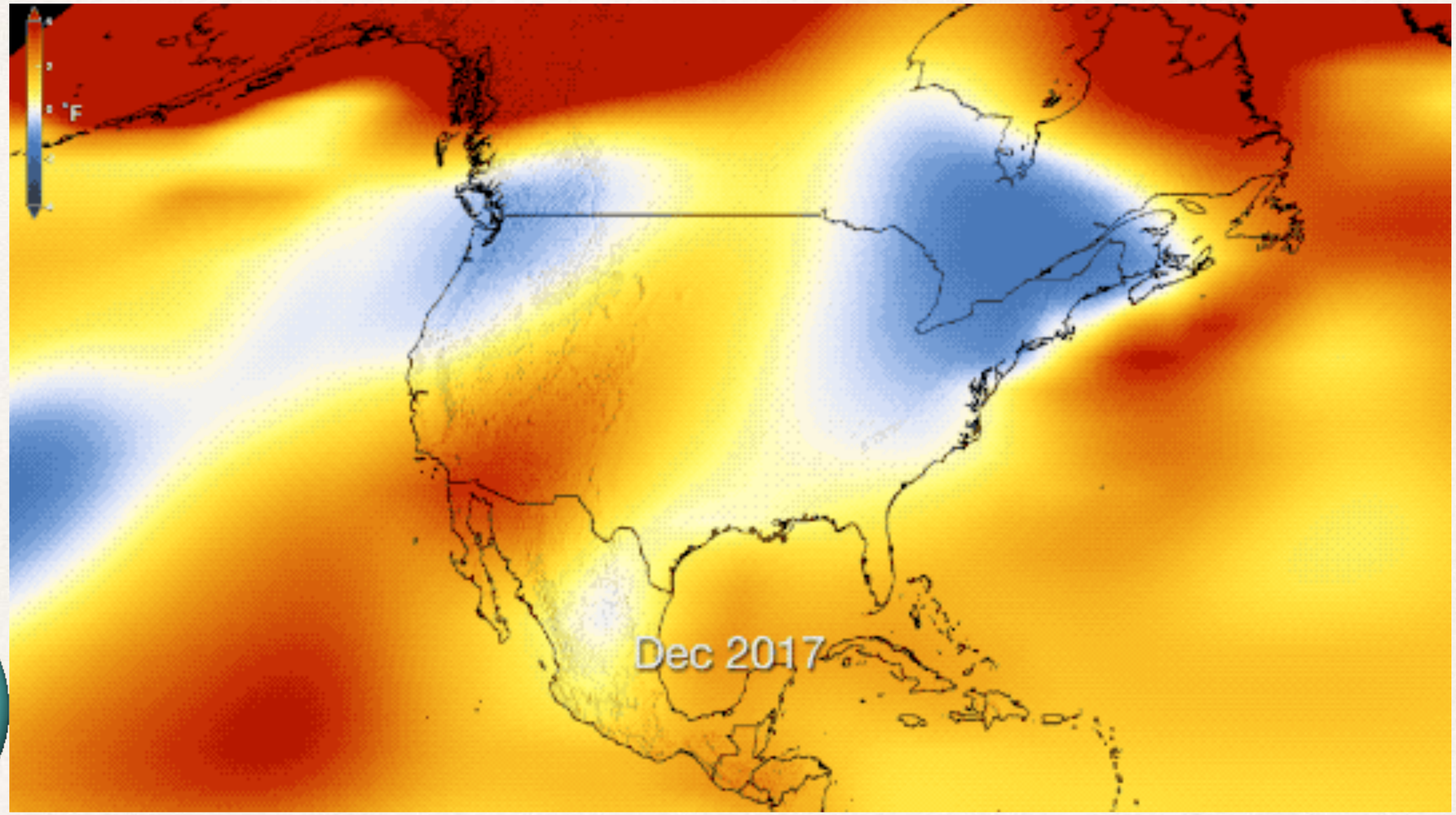
Observed changes: “but it’s freezing here!”



NASA 2017

https://svs.gsfc.nasa.gov/12822

Observed changes: “but it’s freezing here!”



NASA 2017

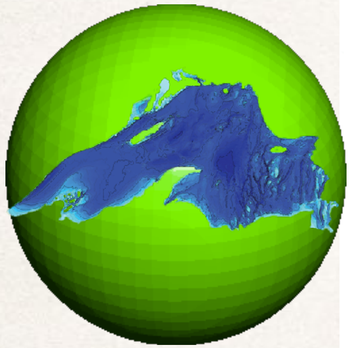
https://svs.gsfc.nasa.gov/12822

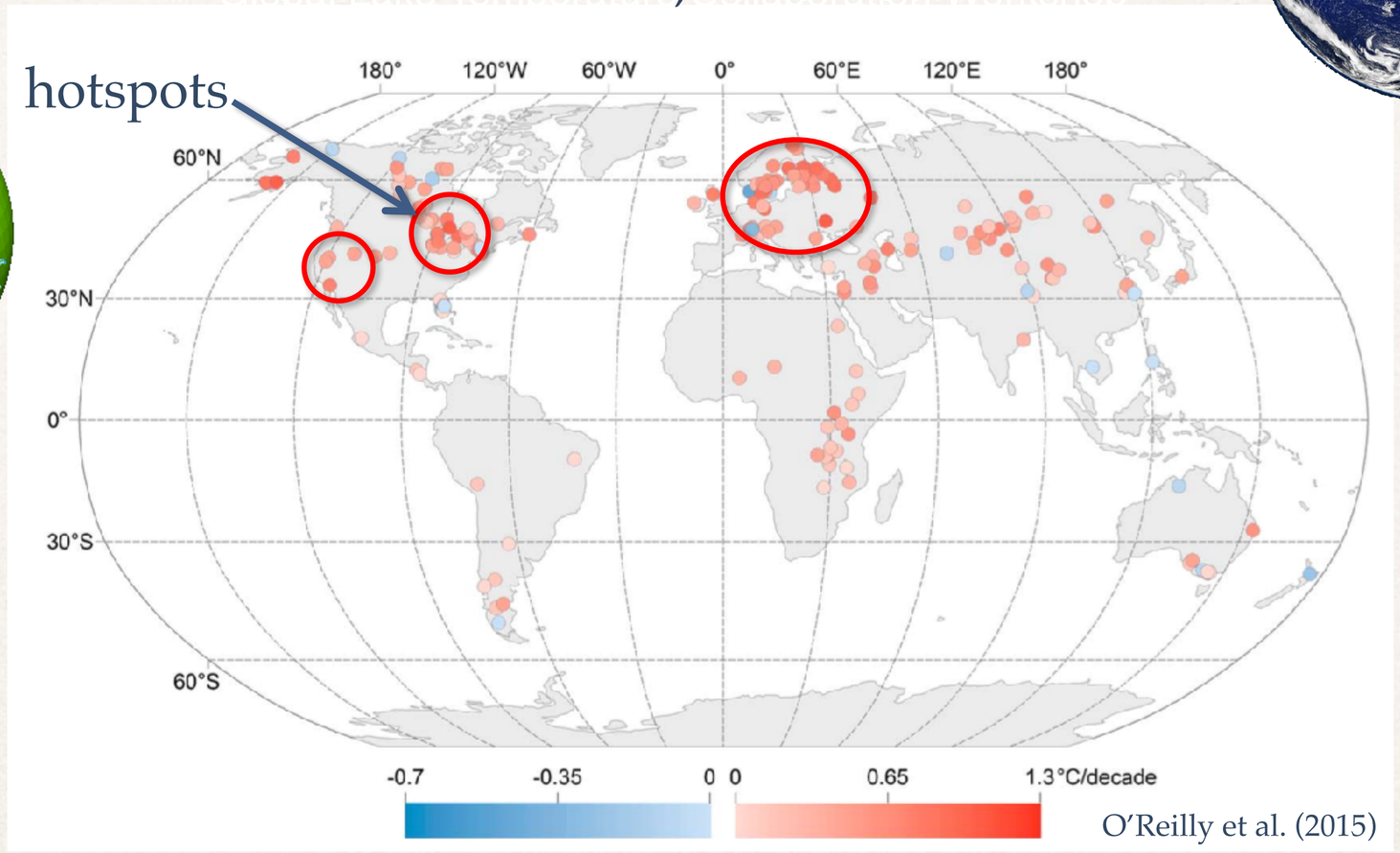
Observed changes

June 1-5, 2012
Lincoln, NE

Warming Lakes

Summer trends, 1985-2009

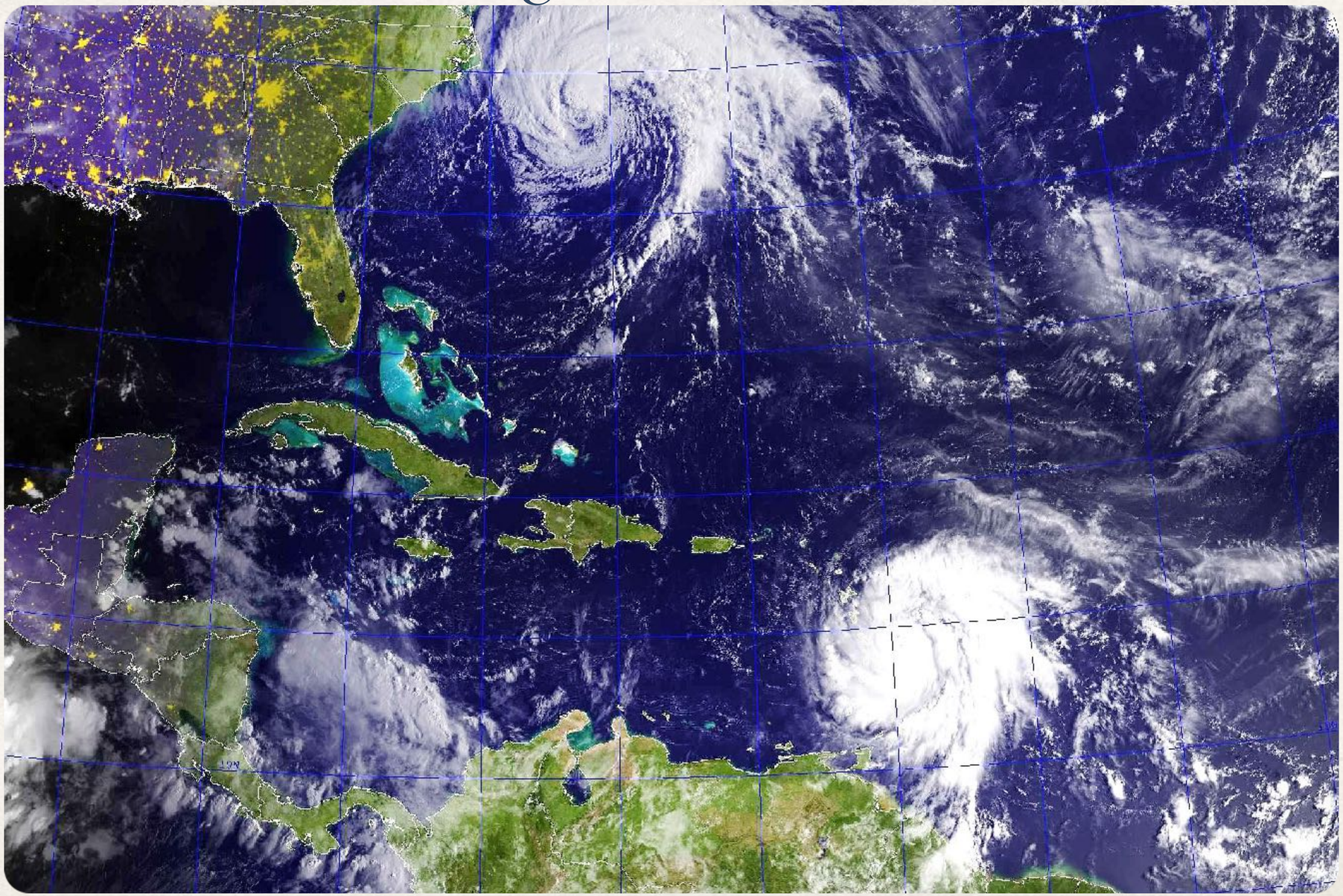




O'Reilly et al. (2015)

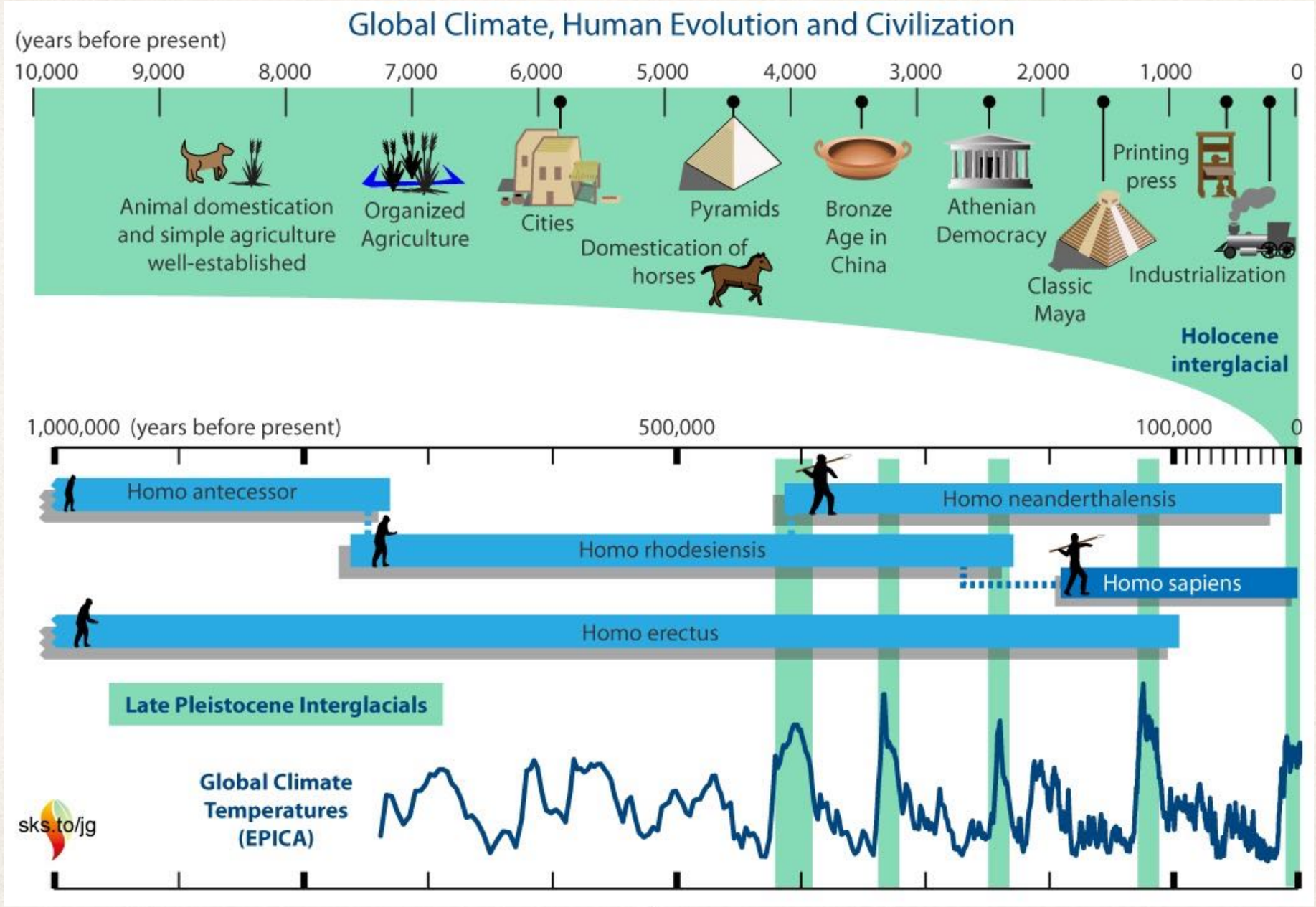
John Lenters

Observed changes: Jose and Maria



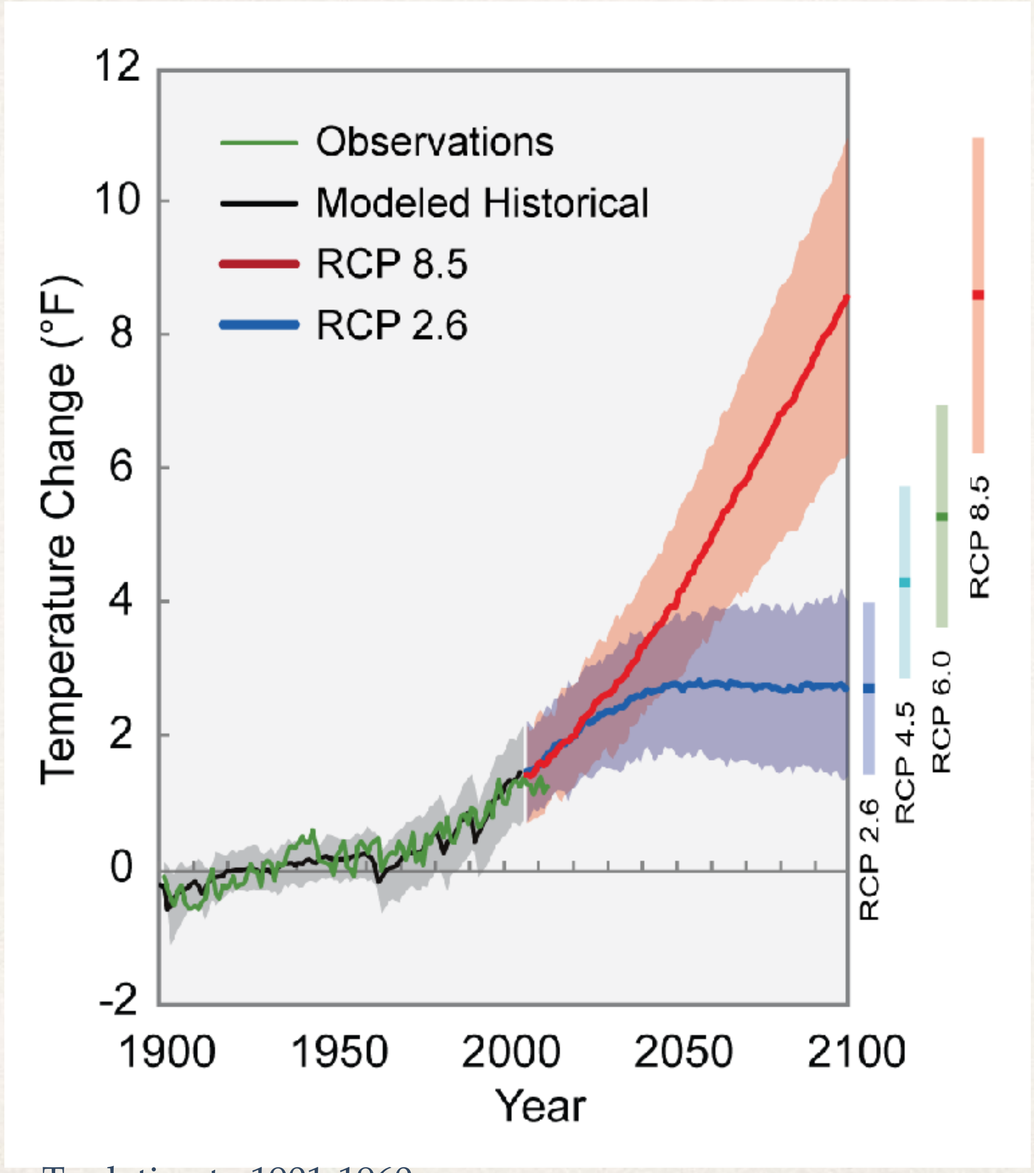
https://www.defense.gov/Photos/Photo-Gallery/igphoto/2001813740/

The Climate is Always Changing



John Garret, SkS

Future Climate

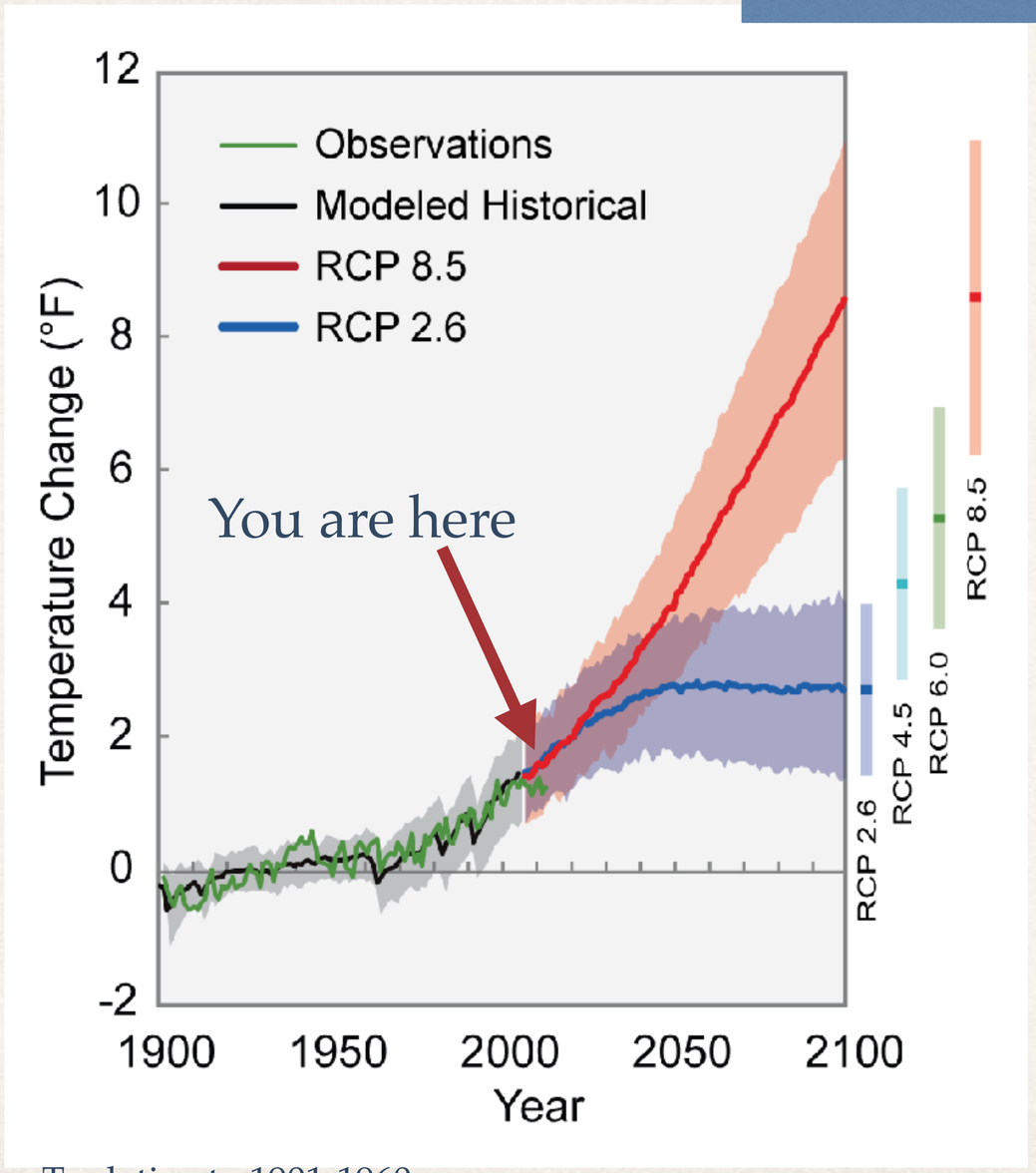


T relative to 1901-1960 average

https://nca2014.globalchange.gov/report/our-changing-climate/future-climate-change

Future Climate

Decades



T relative to 1901-1960 average

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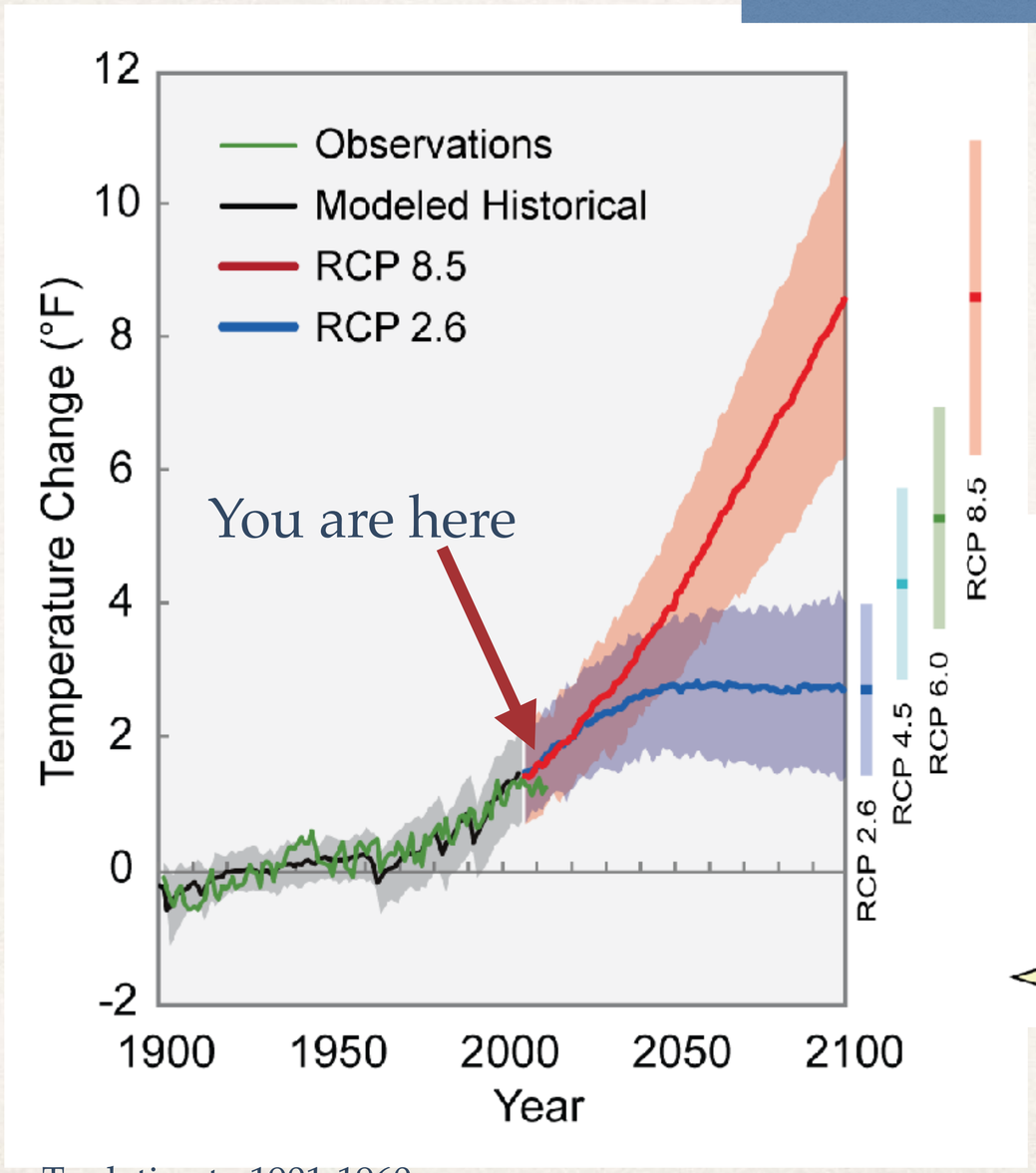
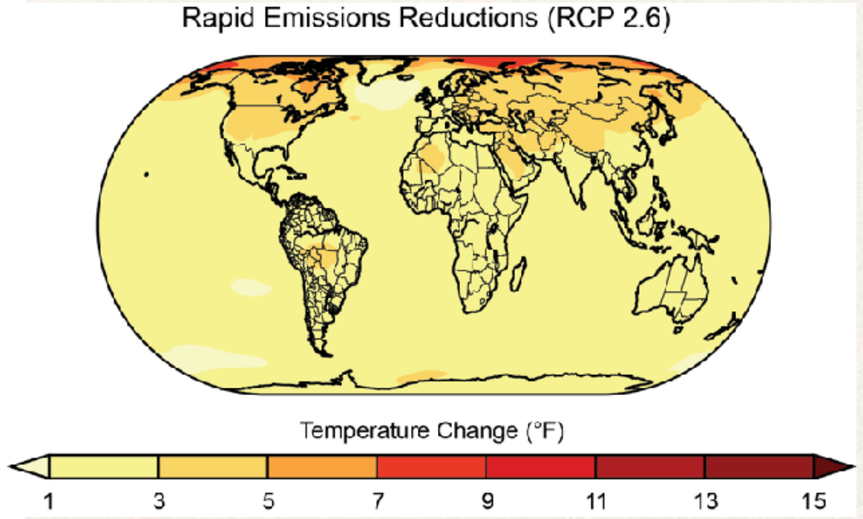
Future Climate

Decades





T relative to 1901-1960 average

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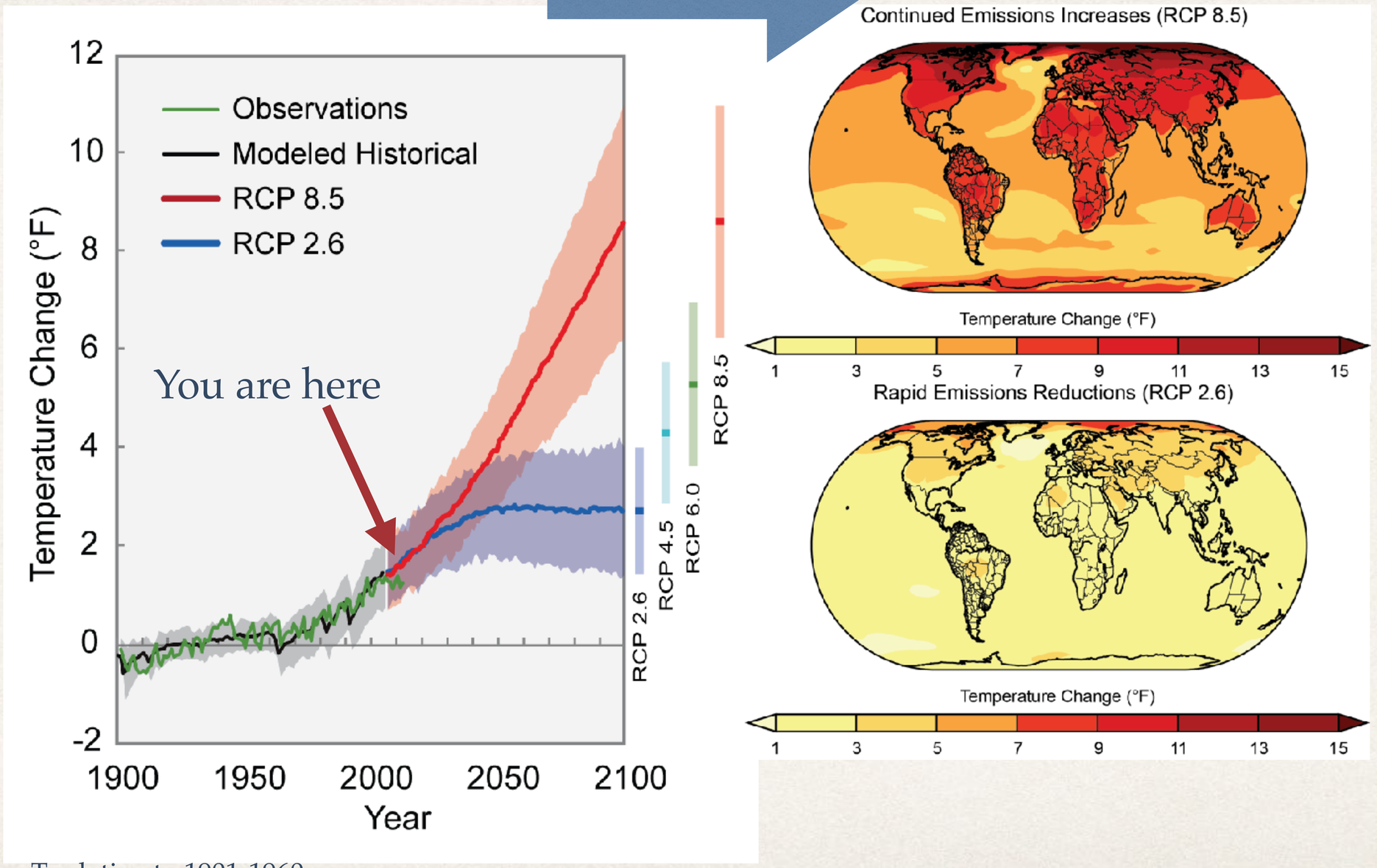
Future Climate

Decades



T relative to 1901-1960 average

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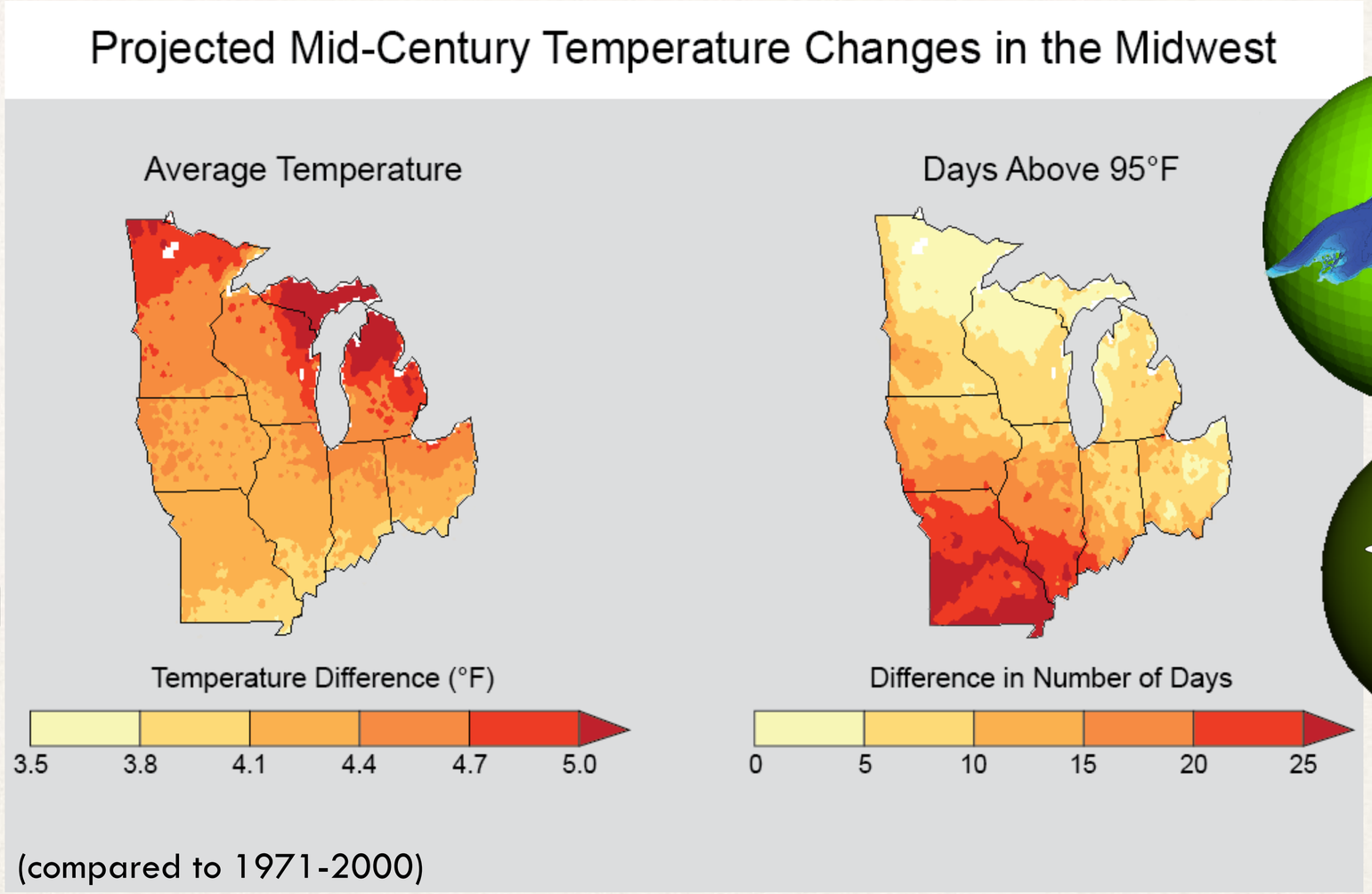
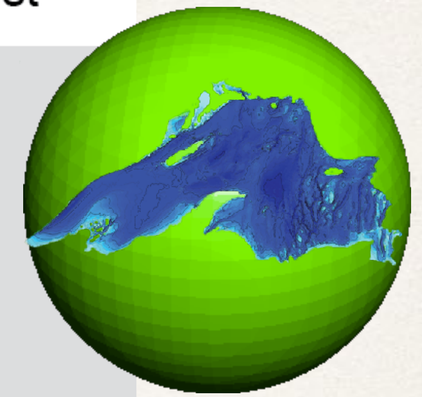
Future Climate: 2041-2070



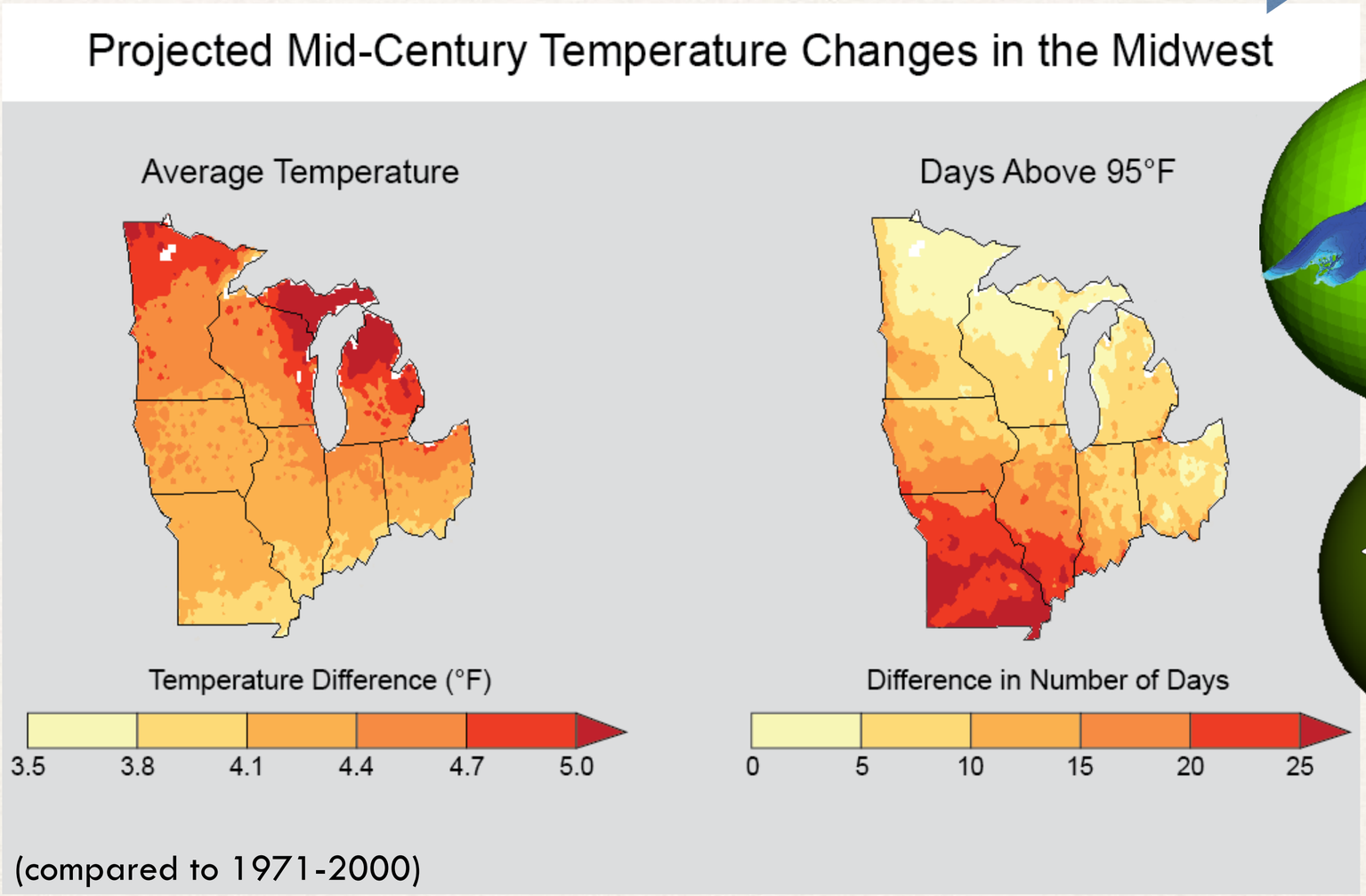


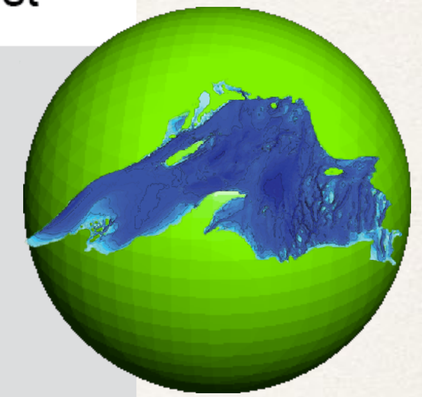
http://nca2014.globalchange.gov/highlights/regions/midwest/graphics/projected-climate-change

Climate Change Impacts in the United States: The Third National Climate Assessment

Future Climate: 2041-2070

Decades





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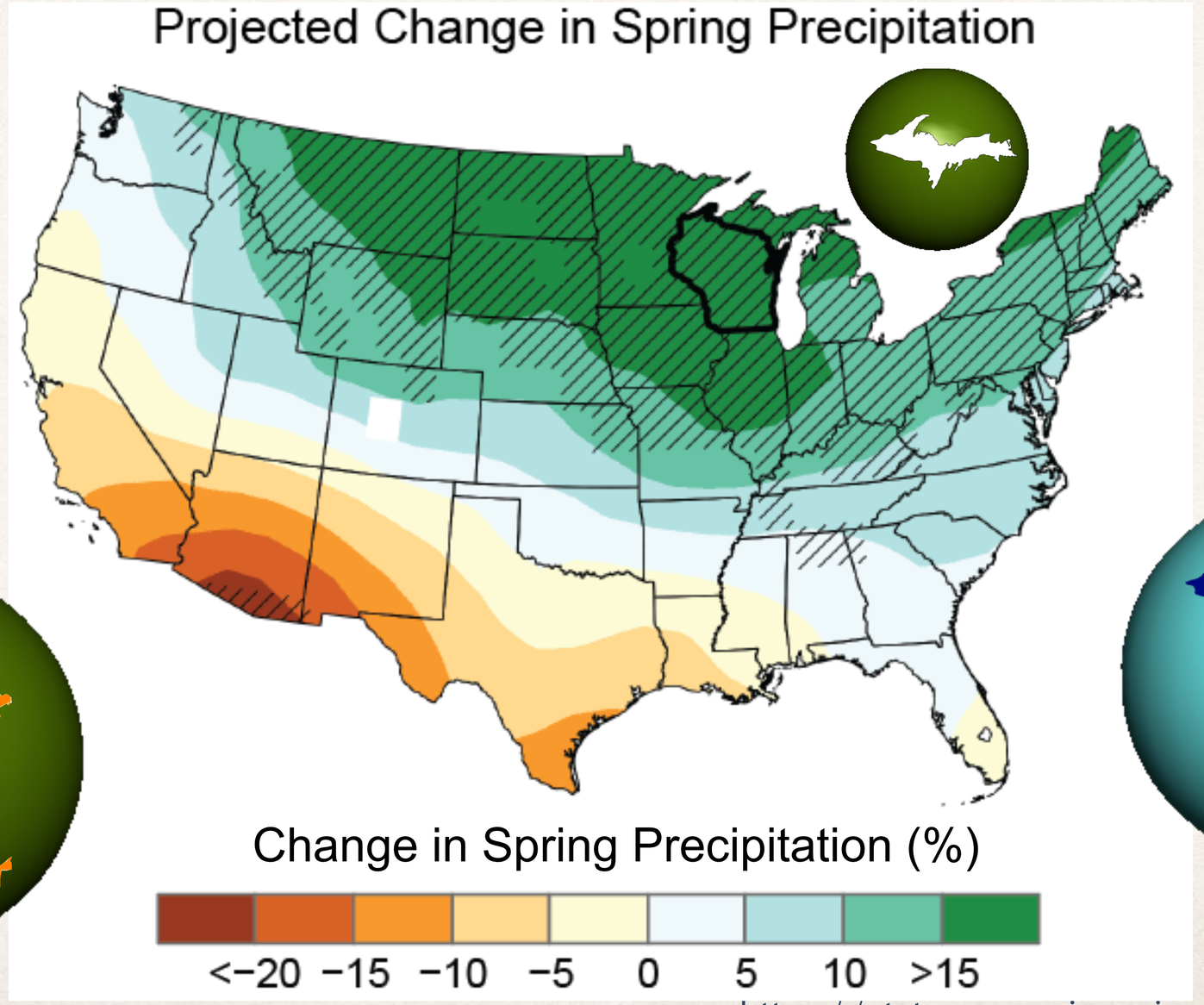
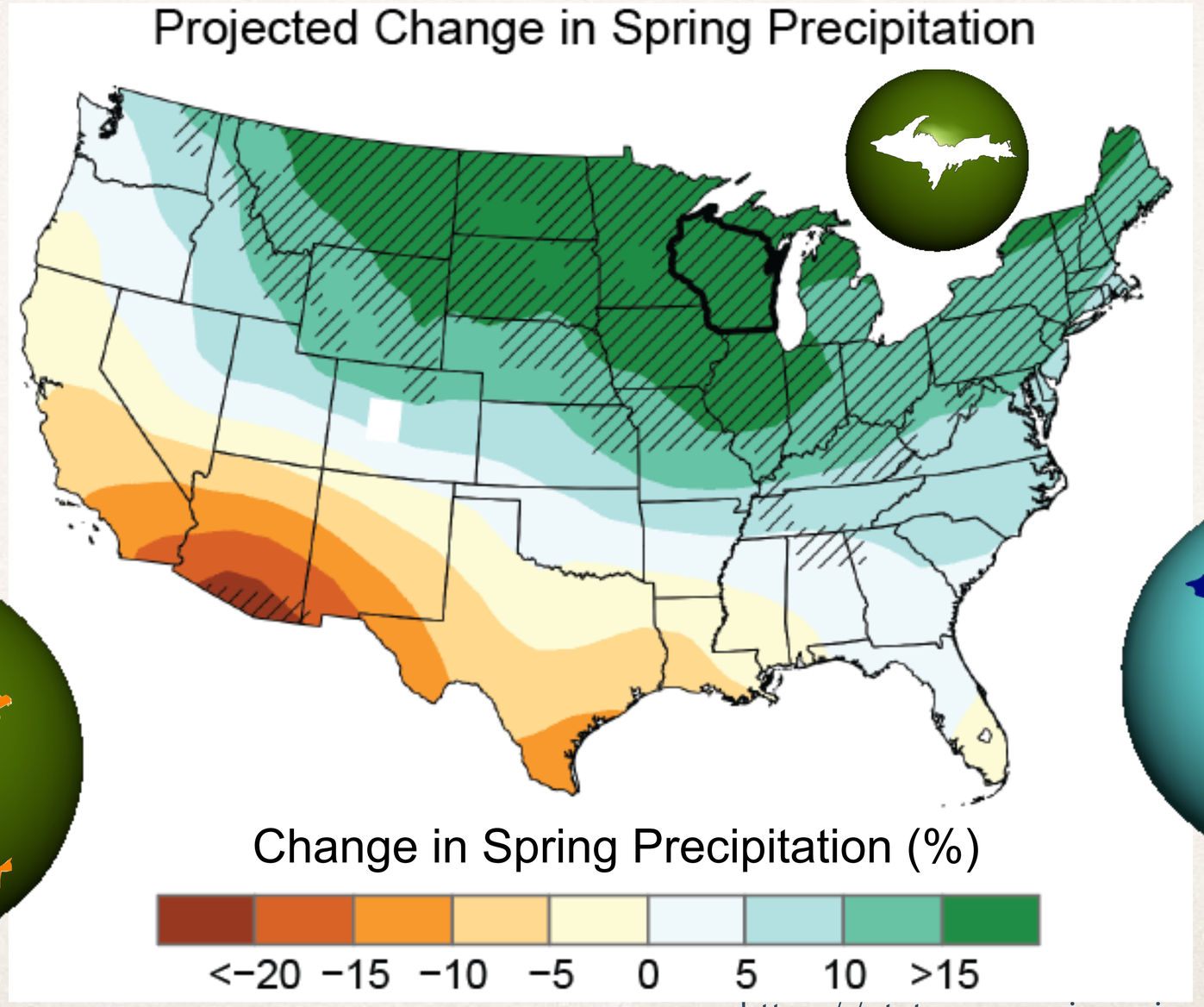
Future Climate

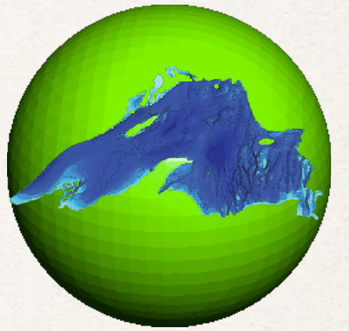


https://statesummaries.ncics.org/wi

Future Climate

Decades





https://statesummaries.ncics.org/wi

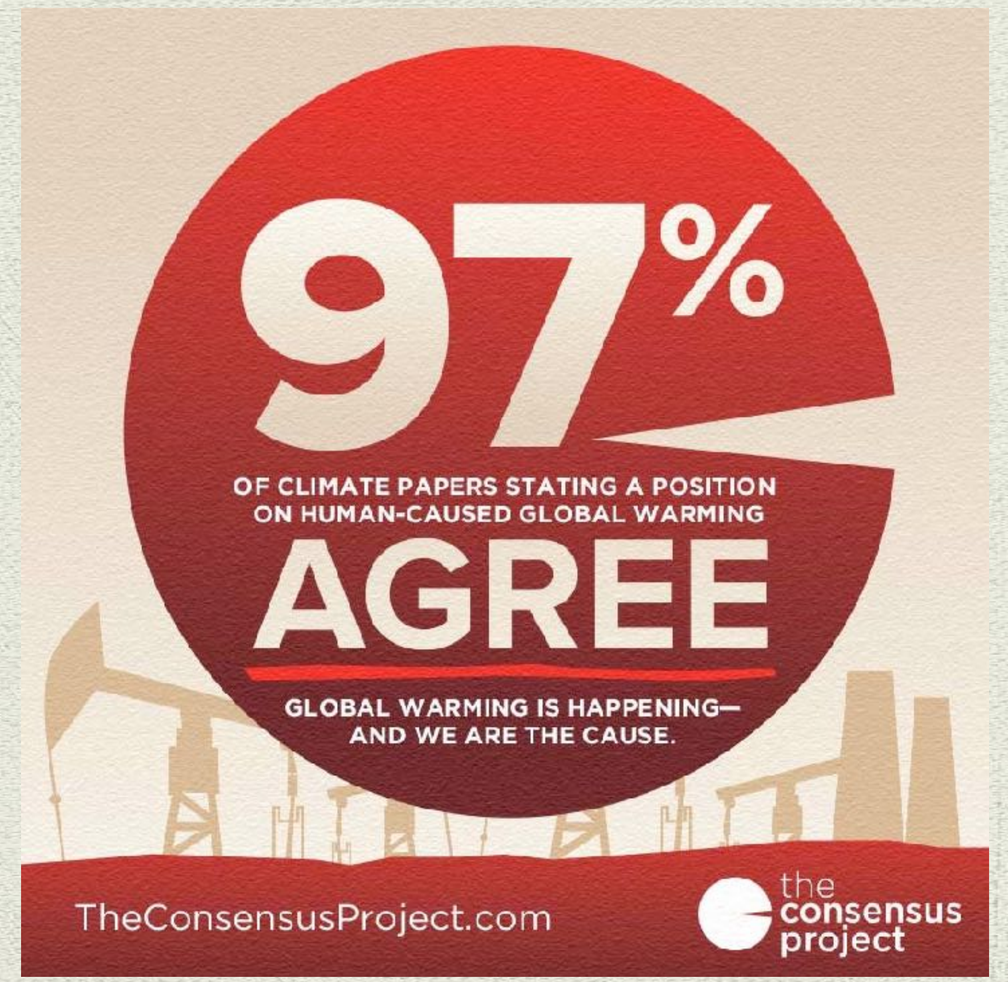
Responses: what to do?

International Panel on Climate Change

International Panel on Climate Change

Quantifying the consensus on anthropogenic global warming in the scientific literature

John Cook, Dana Nuccitelli, **Sarah A Green**, Mark Richardson, Bärbel Winkler, Rob Painting, Robert Way, Peter Jacobs and Andrew Skuce



2013 *Environ. Res. Lett.* **8** 024024
doi:10.1088/1748-9326/8/2/024024

http://skepticalscience.com

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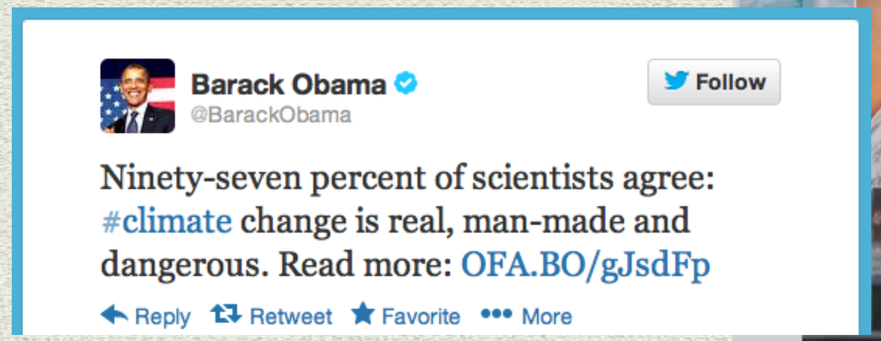

2013 *Environ. Res. Lett.* **8** 024024
doi:10.1088/1748-9326/8/2/024024

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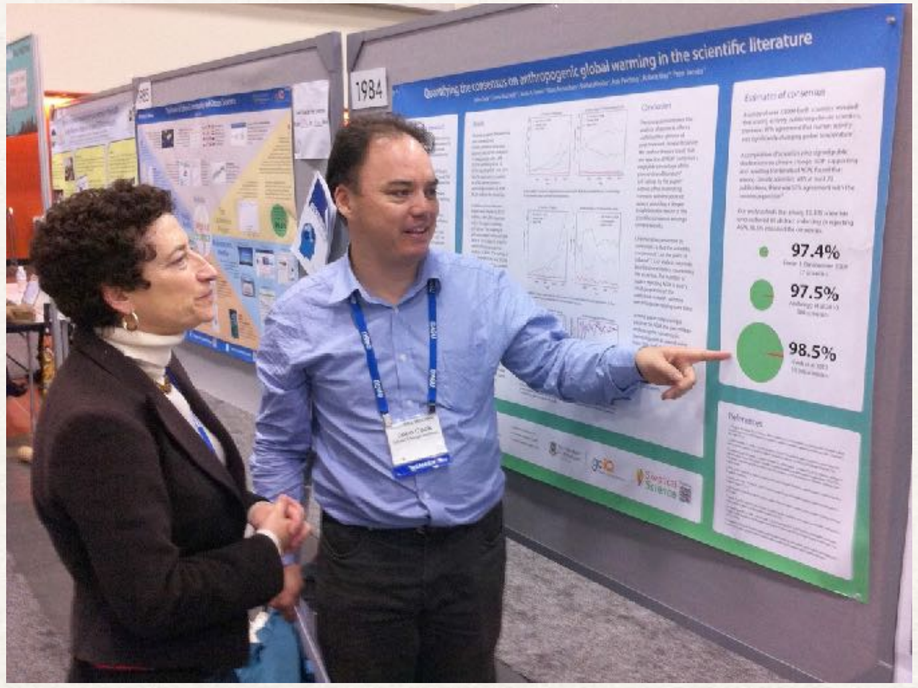
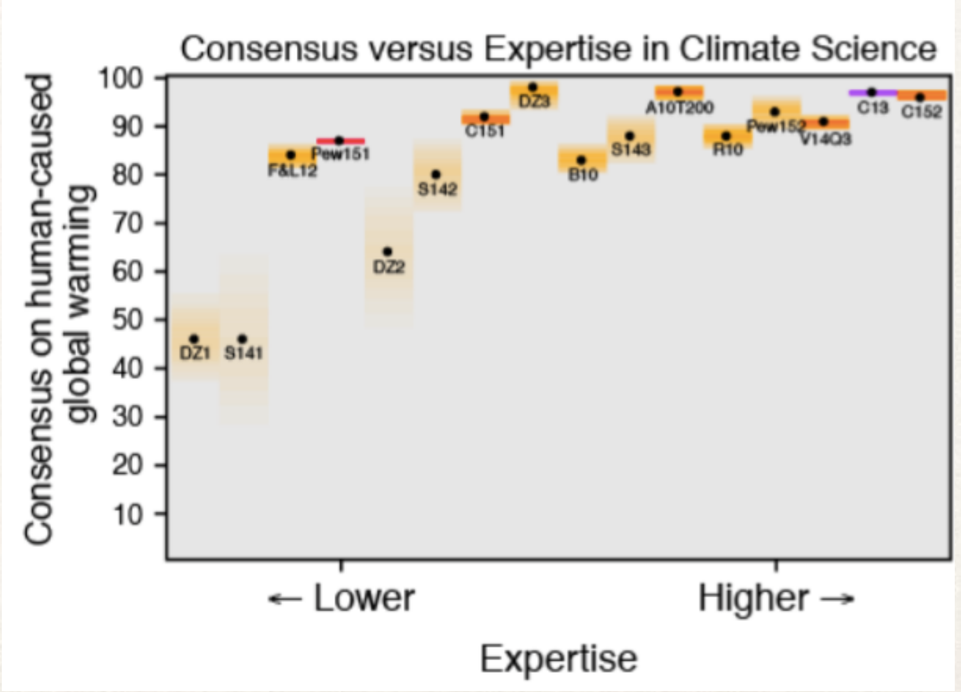
The Consensus on Consensus

a synthesis of consensus estimates on human-caused global warming

John Cook, Naomi Oreskes, Peter T Doran, William R L Anderegg, Bart Verheggen, Ed W Maibach, J Stuart Carlton, Stephan Lewandowsky, Andrew G Skuce, **Sarah A Green**, Dana Nuccitelli, Peter Jacobs, Mark Richardson, Bärbel Winkler, Rob Painting and Ken Rice





John Cook et al 2016 Environ. Res. Lett. 11 048002

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History

Geology

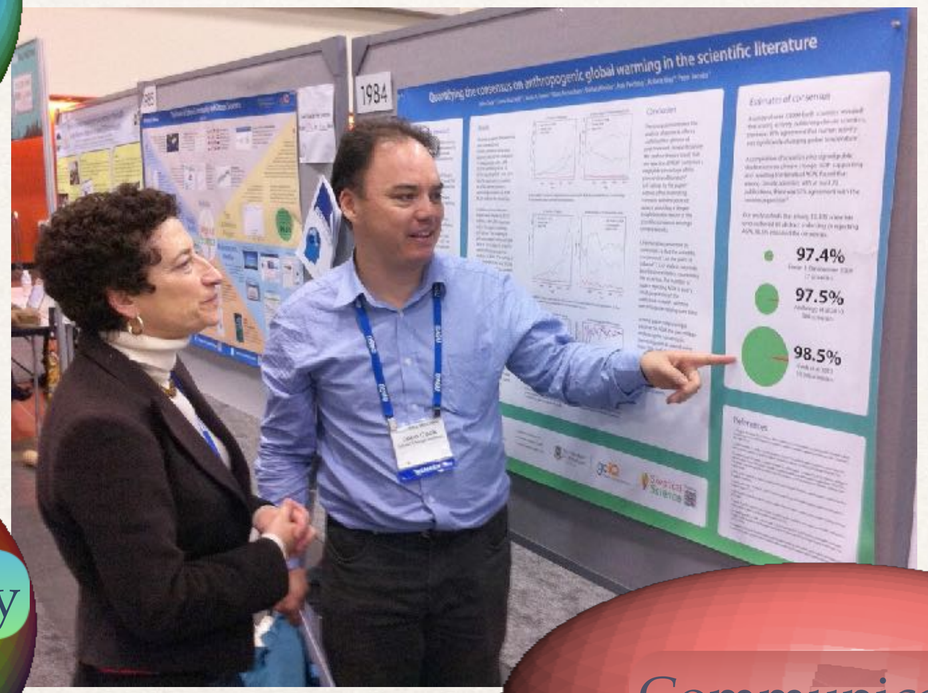
Chemistry

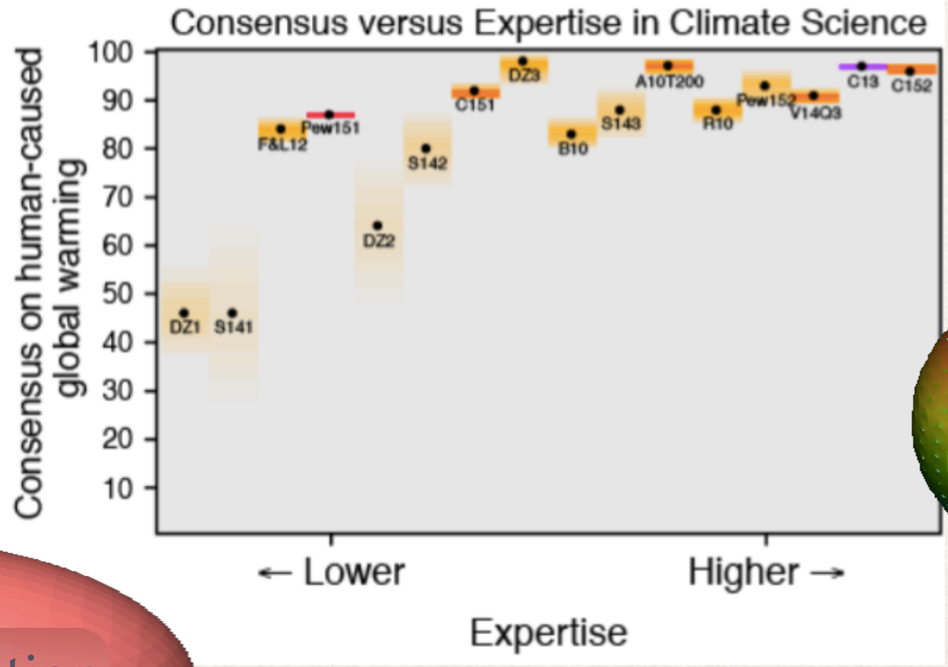
Computer Science

Physics

Communication

Psychology





John Cook et al 2016 Environ. Res. Lett. 11 048002

Responses: what to do?

Responses: what to do?

Sarah goes to Washington

Shaping international action for the environment

Sarah goes to Washington

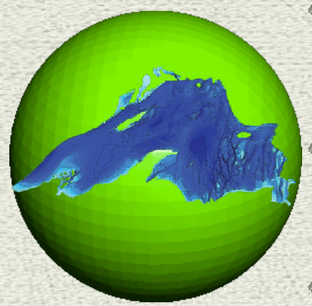
Shaping international action for the environment

Environmental problems are international

- Air pollution
- Freshwater Quality
- Endangered Species
- Mercury
- Chemical use and disposal
- Oil Spills

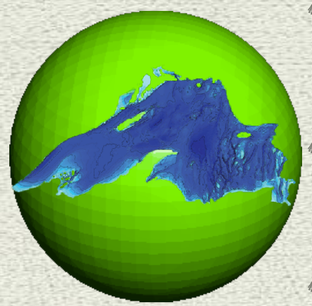
Climate

- Antarctica
- Arctic
- Biodiversity
- Oceans
  - pollution
  - fisheries
  - acidification



Environmental problems are international

- Climate
- Air pollution
- Freshwater Quality
- Endangered Species



- Mercury
- Chemical use and disposal
- Oil Spills
- Antarctica
- Arctic
- Biodiversity
- Oceans
  - pollution
  - fisheries
  - acidification

International Action

What?

How?

What we want to do:

- **Convince other governments**
  pass/enforce environmental laws.
- **Influence their national policies**
  e.g. energy, tax incentives.
- **Assist countries and people**
  Clean development.

Fred Dufour/Agence France-Presse — Getty Images

How we can do it:

- **Bilateral Agreements**
  e.g. US-China
- **Multilateral Agreements**
- **United Nations**
- **Development Aid**
  USAID
- **Finance**
- **Private Sector**
- **Non-Governmental Orgs**

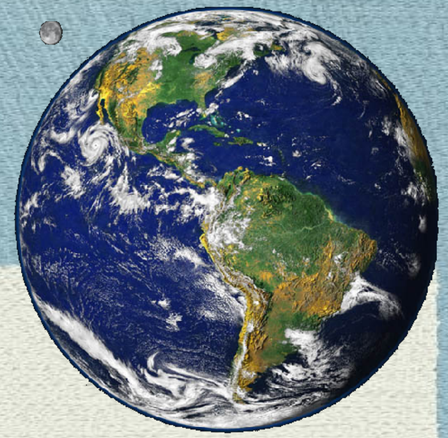
IMO INTERNATIONAL MARITIME ORGANIZATION

GLOBAL ALLIANCE FOR CLEAN COOKSTOVES

International Action

What?

How?



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GLOBAL ALLIANCE FOR CLEAN COOKSTOVES

International Action

Two major successes in 2015

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

International Action

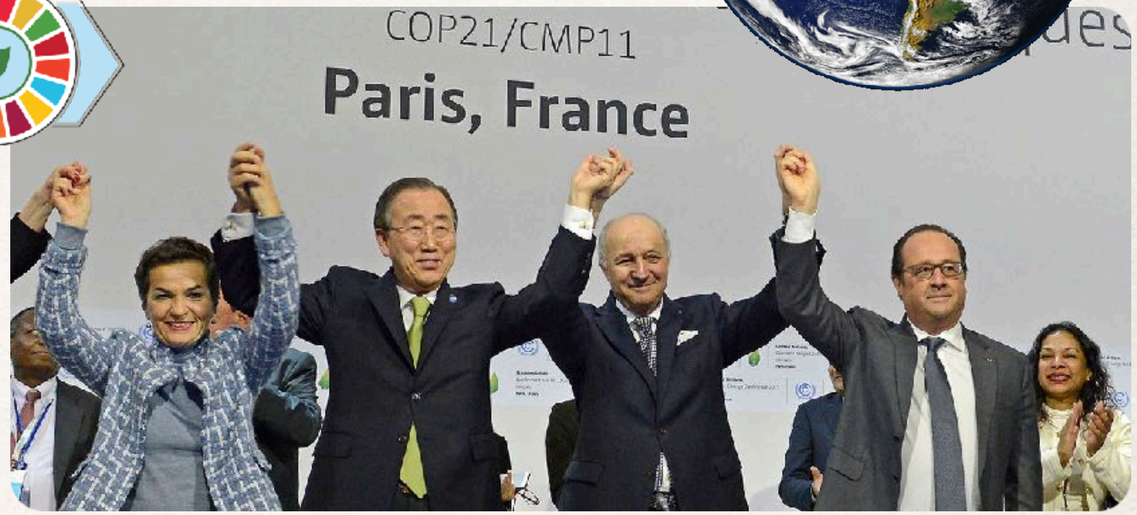
Two major successes in 2015

SUSTAINABLE DEVELOPMENT GOALS

1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

SUSTAINABLE DEVELOPMENT GOALS

UNITED NATIONS PARIS CLIMATE AGREEMENT SIGNING CEREMONY — 22 APRIL 2016



PARIS2015
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International Action

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SUSTAINABLE DEVELOPMENT GOALS

Adopted by the 193 countries of the UN General Assembly on 25 September 2015.

International Action

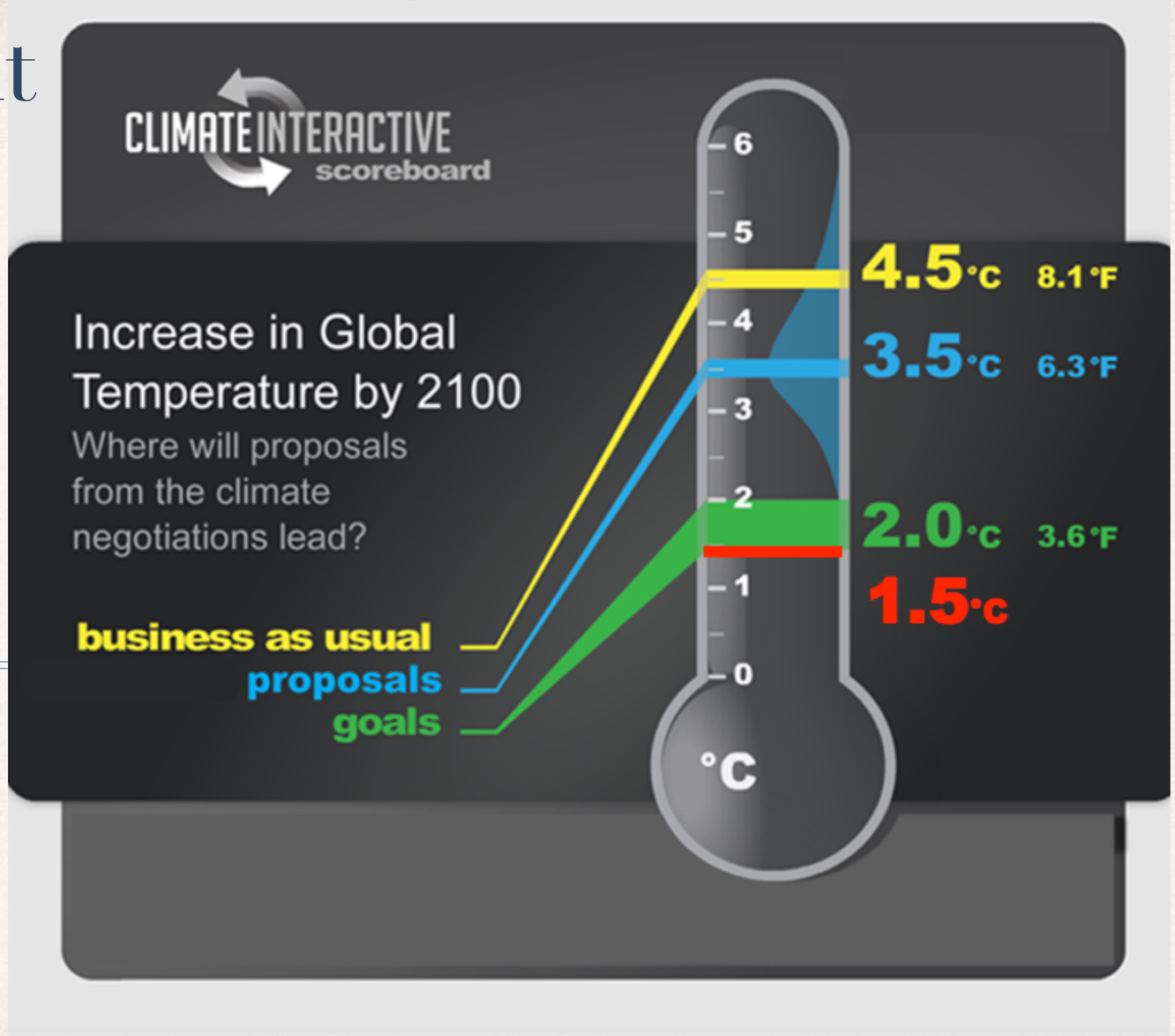
Paris Climate Agreement adopted on 12 December 2015

Secretary-General Ban Ki-moon (second left), UNFCCC's **Christiana Figueres** (left), **French Foreign Minister Laurent Fabius** and President of the UN Climate Change Conference in Paris (COP21), and **President François Hollande of France** (right), celebrate historic adoption of Paris Agreement.

John Kerry, U.S. secretary of state, holds granddaughter Isabelle Dobbs-Higginson, 2, while signing the climate-change pact at U.N. headquarters in New York. (JUSTIN LANE/EPA)

Climate Agreement

Projected results

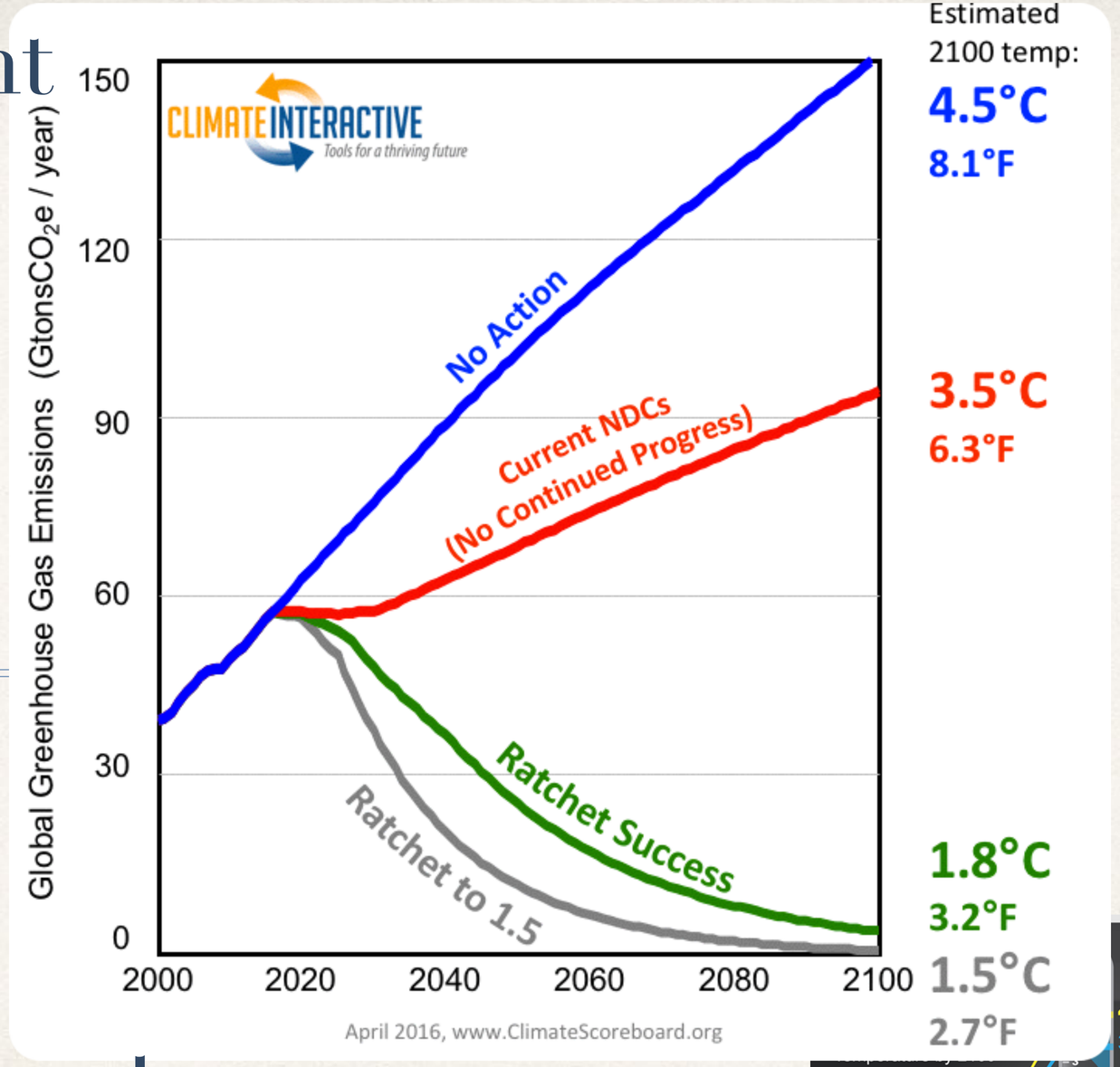


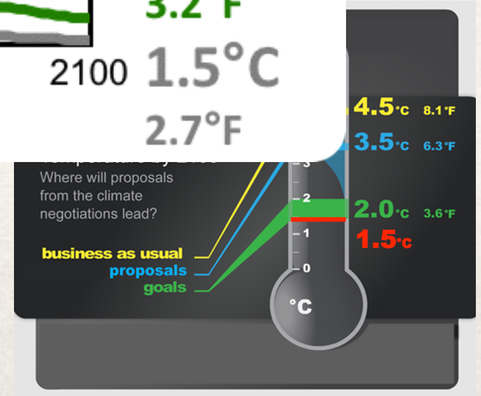
Paris commitments

Climate Agreement

Projected results

Paris commitments

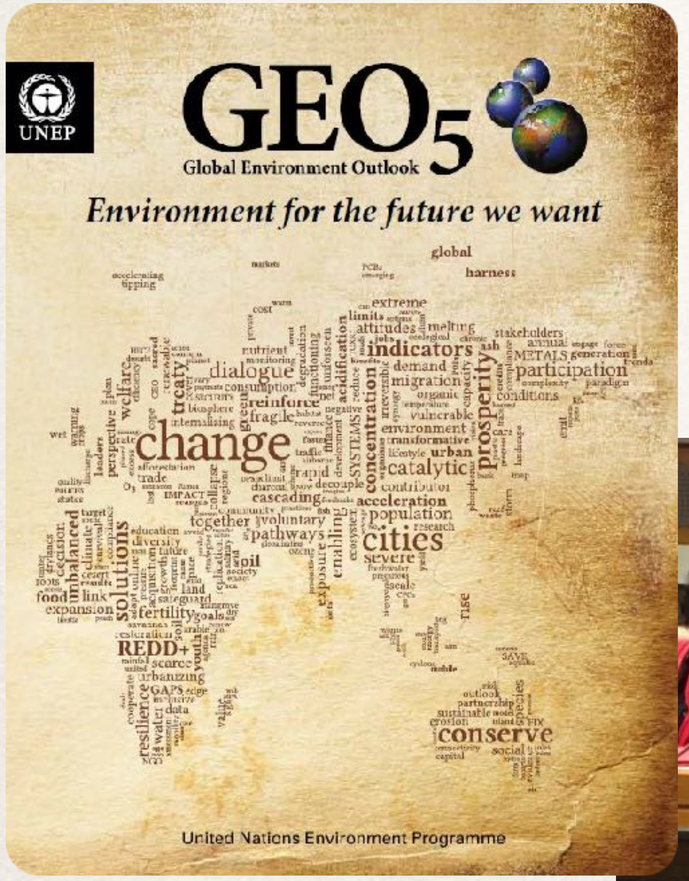




Sixth Global Environmental Outlook: GEO-6

GEO-6 Sections

- state of the environment
- assessing policy effectiveness
- possible futures & pathways.



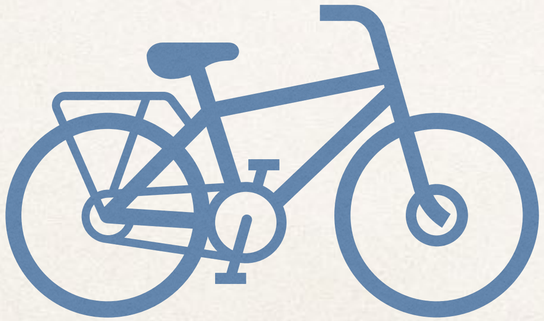
2012

Solutions

The Bad News

It's HARD.

You can't do it by yourself

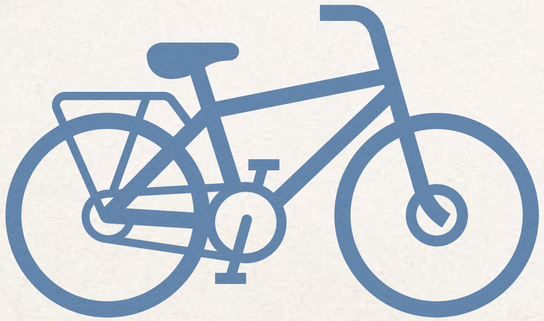


Solutions

The Bad News

It's HARD.

Redesign the global energy system and all energy-related activities.

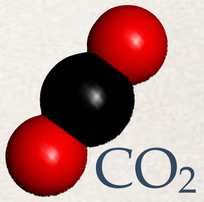


Solutions

The Better News

Collective action can change the world

- Earth System Thinking
  - Education
  - Accumulation of efforts
  - People drive policy change
  - Talk about what matters



Solutions

The Better News

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Confidential: China

TO: Negotiators for **China** at United Nations World Climate Summit

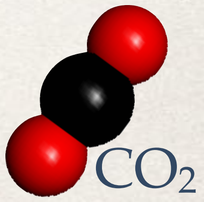
SUBJECT: Briefing on Negotiating Goals

You lead the Chinese delegation at the upcoming negotiations on climate change.

Goals: China seeks to negotiate a global agreement to reduce greenhouse gas emissions that can limit climate risks but also seeks the best outcome for our economy and vital national interests. At the 2015 UN climate

New courses

- Climate Science & Policy
- Green Chemistry



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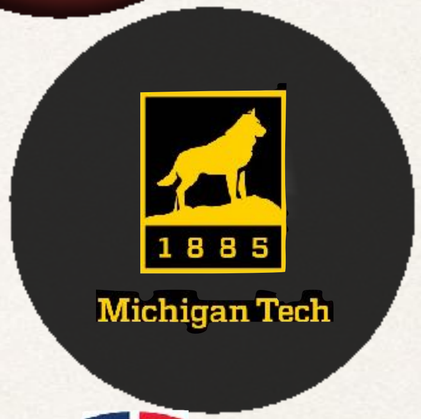


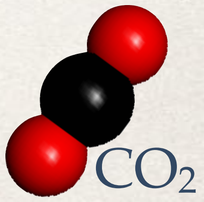

Spheres of Influence

Spheres of Influence

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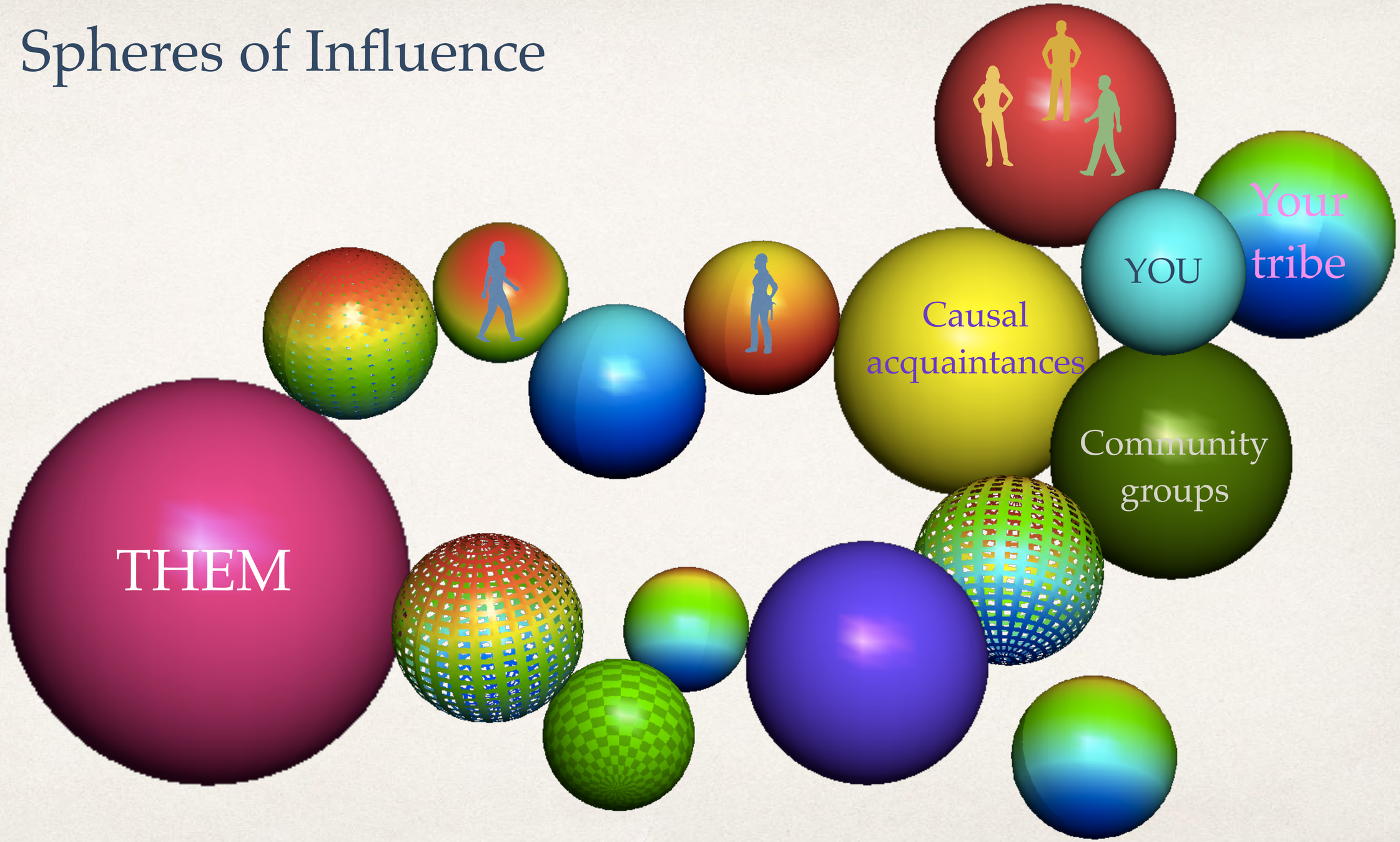
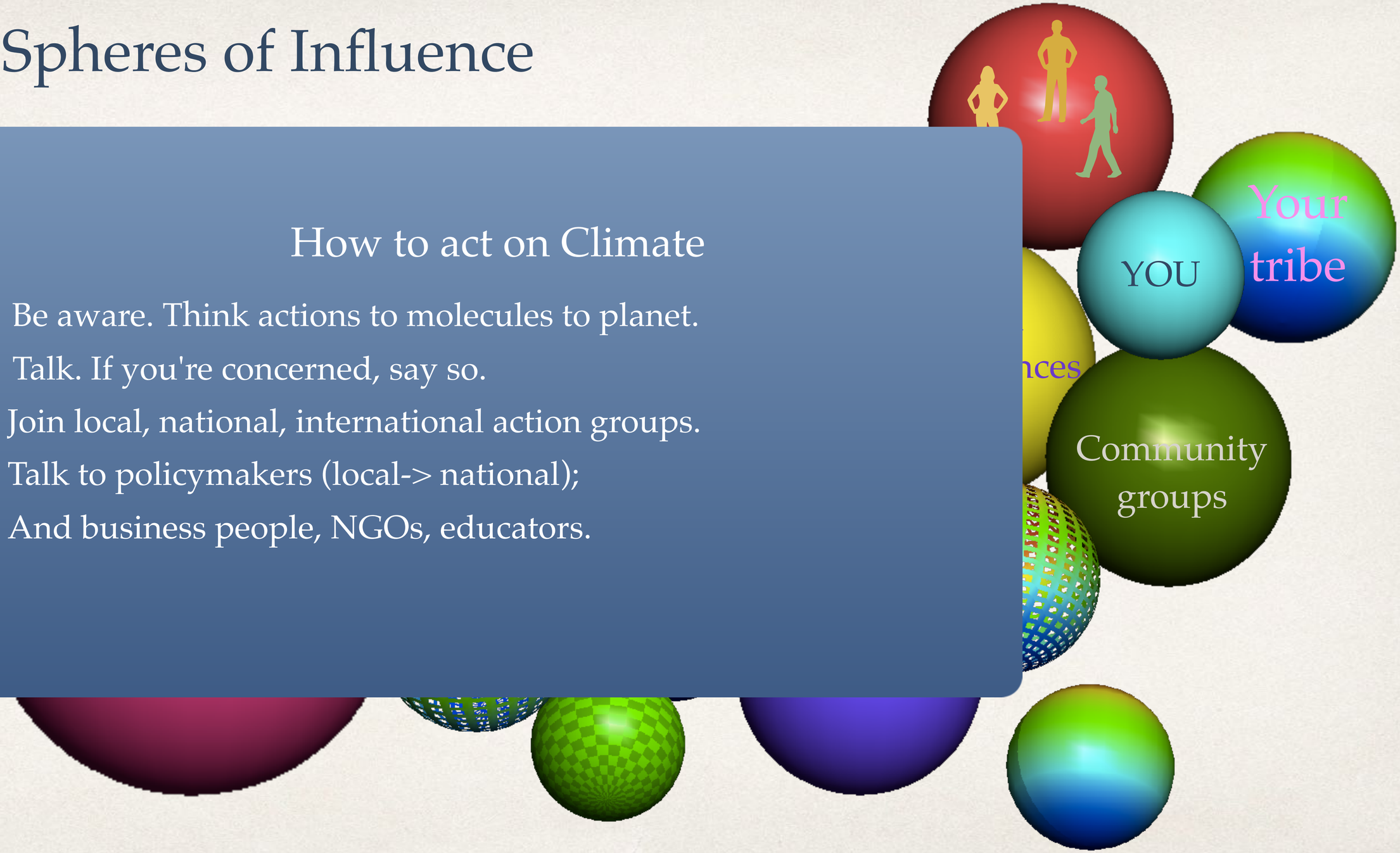
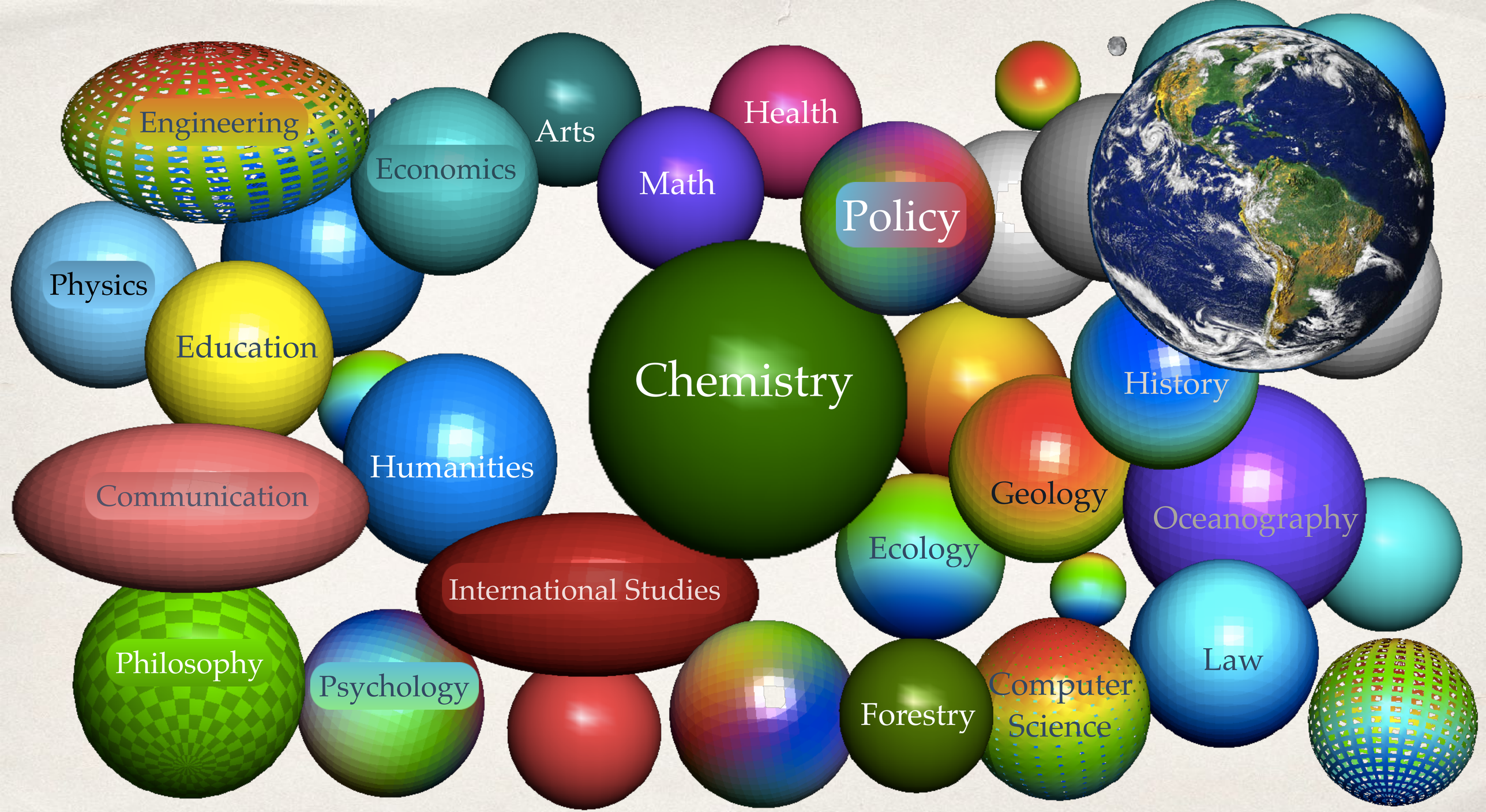


Spheres of Influence

How to act on Climate

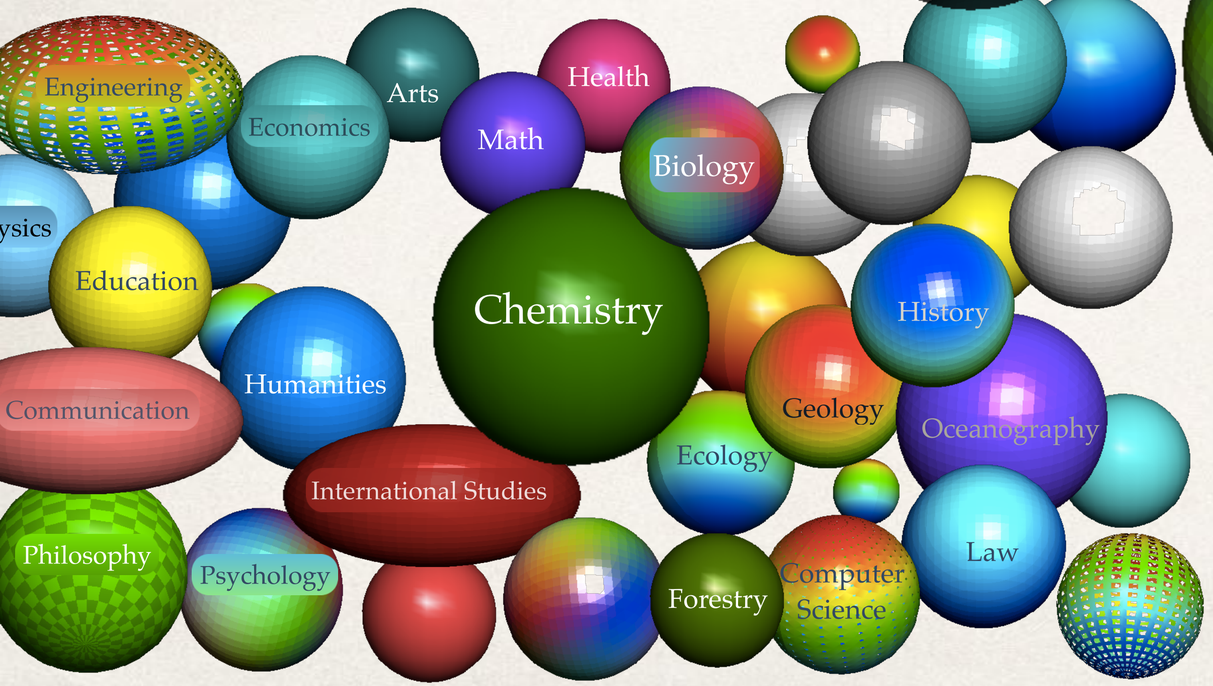
- Be aware. Think actions to molecules to planet.
- Talk. If you're concerned, say so.
- Join local, national, international action groups.
- Talk to policymakers (local-> national);
- And business people, NGOs, educators.




Engineering
Economics
Arts
Math
Health
Policy
Physics
Education
Chemistry
History
Humanities
Communication
Geology
Oceanography
Ecology
International Studies
Philosophy
Psychology
Forestry
Computer Science
Law

Solutions

Policy



THANKS!

Thousands of scientists, engineers, scholars, students around the world who are working on these problems.

Michigan Tech
Chemistry Department
Great Lakes Research Center
Earth, Planetary, and Space Sciences Institute
Skeptical Science Team
National Academies Jefferson Science Fellowship

Colleagues and students who teach me something new every day.

Floyd Henderson, Mary Durfee, Mike Abbott


6°C
Shouldn't we be turning?
LAST TURN! for a 5° C warmer world
SLOW DOWN! 4° C warmer world Next hard right!
TURN NOW! for a mere 3° C of warming
LAST CHANCE! for a 2° C warmer world
Not yet. We have enough fossil fuel to get all the way to 6...
... and then some.
sks.to