Expanding Spheres:
Atoms to Earth, Local to Global, Science to Society
A coal mine near Gillette, Wyo.
Credit: Greg Goebel/flickr
Global Carbon Cycle

January 2018: 408 ppm

Atmospheric CO₂ (ppm)

NOAA Earth System Research Laboratory

https://www.esrl.noaa.gov/gmd/ccgg/trends/history.html
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Atmospheric CO₂ (ppm)

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NOAA Earth System Research Laboratory
Greenhouse Effect

Greenhouse Effect

Observed changes

Global Land Temperature Anomalies, January-December

Temperature Anomalies

1970-2017 Trend +0.29°C/Decade

Observed changes in temperature anomalies over time, showing a trend of increasing anomalies since 1880, with significant increases from the 1900-2000 average.

National Climate Data Center

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

Observed Increase in Frost-Free Season Length

Change in Annual Number of Days

Baseline 1901-1960


https://statesummaries.ncics.org/
Observed changes

Observed Increase in Frost-Free Season Length

Change in Annual Number of Days

Baseline 1901-1960


https://statesummaries.ncics.org/
Observed changes

Behind Pat’s Foods, Hancock

WI Hwy 13, July 2016

Photo: Ashland Daily Press
Observed changes: “but it’s freezing here!”

NASA 2017

https://svs.gsfc.nasa.gov/12822
Observed changes: “but it’s freezing here!”

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

NASA 2017
Observed changes

Warming Lakes
Summer trends, 1985-2009

hotspots

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
Future Climate

T relative to 1901-1960 average

You are here

T relative to 1901-1960 average

Future Climate

Decades

T relative to 1901-1960 average

Future Climate

You are here

Temperature Change (°F)

Year

1900 1950 2000 2050 2100

RCP 2.6
RCP 4.5
RCP 6.0
RCP 8.5

You are here

T relative to 1901-1960 average

Future Climate: 2041-2070

Projected Mid-Century Temperature Changes in the Midwest

Average Temperature

Days Above 95°F

Temperature Difference (°F)

Difference in Number of Days

(compared to 1971-2000)


Climate Change Impacts in the United States: The Third National Climate Assessment
Future Climate: 2041-2070

Projected Mid-Century Temperature Changes in the Midwest

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(compared to 1971-2000)

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

Projected Change in Spring Precipitation

Change in Spring Precipitation (%)

[-20 -15 -10 -5 0 5 10 >15]

https://statesummaries.ncics.org/wi
Projected Change in Spring Precipitation

Change in Spring Precipitation (%)

Future Climate

Decades

https://statesummaries.ncics.org/wi
Responses: what to do?
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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The Consensus on Consensus

a synthesis of consensus estimates on human-caused global warming

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Responses: what to do?
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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
- Antarctica
- Arctic
- Biodiversity
- Oceans
  - pollution
  - fisheries
  - acidification
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  - Oceans
    - pollution
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    - acidification
### What we want to do:
- Convince other governments to pass/enforce environmental laws.
- Influence their national policies, e.g., energy, tax incentives.
- Assist countries and people with clean development.

### How we can do it:
- Bilateral Agreements, e.g., US-China
- Multilateral Agreements
- United Nations
- Development Aid, USAID
- Finance
- Private Sector
- Non-Governmental Orgs
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International Action

Two major successes in 2015
International Action

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International Action

ADOPTED BY THE 193 COUNTRIES OF THE UN GENERAL ASSEMBLY ON 25 SEPTEMBER 2015.

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

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.
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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New courses
✦ Climate Science & Policy
✦ Green Chemistry
Solutions

The Better News

Collective action can change the world

✦ Earth System Thinking
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Spheres of Influence

THEM

YOU
Spheres of Influence

- THEM
- Causal acquaintances
- Community groups
- YOU
- Your tribe
Spheres of Influence

- THEM
- Your tribe
- Causal acquaintances
- Community groups

YOU
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.
Physics
Economics
Arts
Health
Math
Policy
Chemistry
Geology
Education
Humanities
History
Oceanography
Communication
International Studies
Philosophy
Psychology
Forestry
Computer Science
Law
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
Shouldn’t we be turning?

Not yet. We have enough fossil fuel to get all the way to 6...

... and then some.