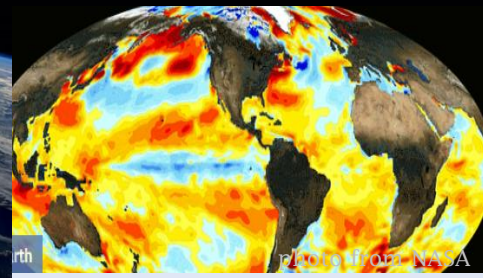


# *The OLLI West Campus Mitigating & Adapting to our Changing Climate*

Presented by Paul Belanger, Ph.D.  
Geologist, Paleoclimatologist

**Friday April 7<sup>th</sup>, 2017**

[denverclimatestudygroup.com/](http://denverclimatestudygroup.com/)  
[www.facebook.com/denverclimatestudygroup](https://www.facebook.com/denverclimatestudygroup)  
[pebelanger@glassdesignresources.com](mailto:pebelanger@glassdesignresources.com)  
c. 303-249-7966;



# *Mitigating & Adapting to our Changing Climate*

## *OUTLINE*

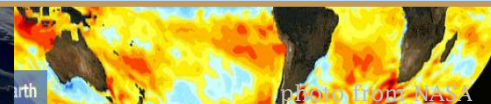
### **Part 1: Global Warming:**

#### **A. The Science**

#### **B. The Consequences**

- i. Warming & Extreme weather**
- ii. Ice, Glacial Melting**
- iii. Ultimate Sea Level Rise**
- iv. Associated Refugees**
- v. Ocean Acidification**
- vi. Degraded Sustainability**

**BREAK**



# *Mitigating & Adapting to our Changing Climate*

## *OUTLINE (cont.)*

### **Part 2: Solutions:**

- **Overcome our Inertia and Apathy**
  - A. Reduce Carbon Emissions in Electric Generation, Transportation and in Heating**
  - B. Carbon Dioxide Removal (CDR); Negative Emission Technology (NET); Greenhouse Gas Removal (GGR)**

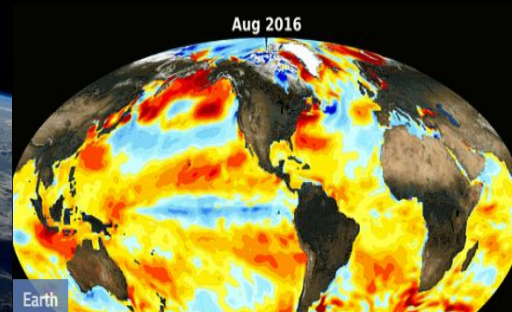


# *Mitigating & Adapting to our Changing Climate*

## *POP QUIZ*

1. Do you think climate change is an urgent problem?
2. Do you think getting the world off fossil fuels is difficult?

**MOST** answer Yes to one or the other, but not both

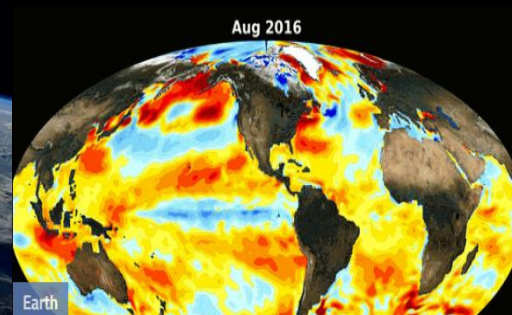


# *Mitigating & Adapting to our Changing Climate*

## *POP QUIZ*

1. Do you think climate change is an urgent problem?
2. Do you think getting the world off fossil fuels is difficult?

IF you answered “yes” to both you’re  
in a minority



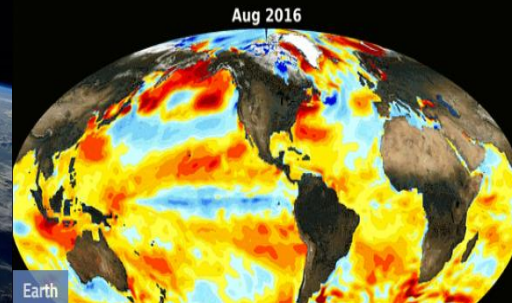
# *Adapting to our Changing Climate*

## *POP QUIZ*

1. Do you think climate change is an urgent problem?
2. Do you think getting the world off fossil fuels is difficult?

My goal/my hope for a take-away:

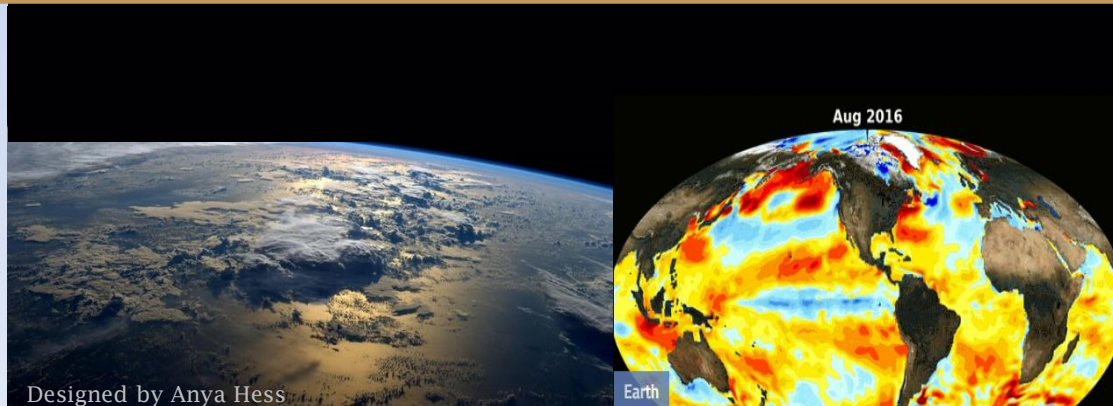
**1. Yes**  
**2. Yes, but NOT**  
**Insurmountable**





# *Adapting to our Changing Climate*

## *Global warming: The Science*



# Greenhouse gas analogy

## 1820's – Joseph Fourier

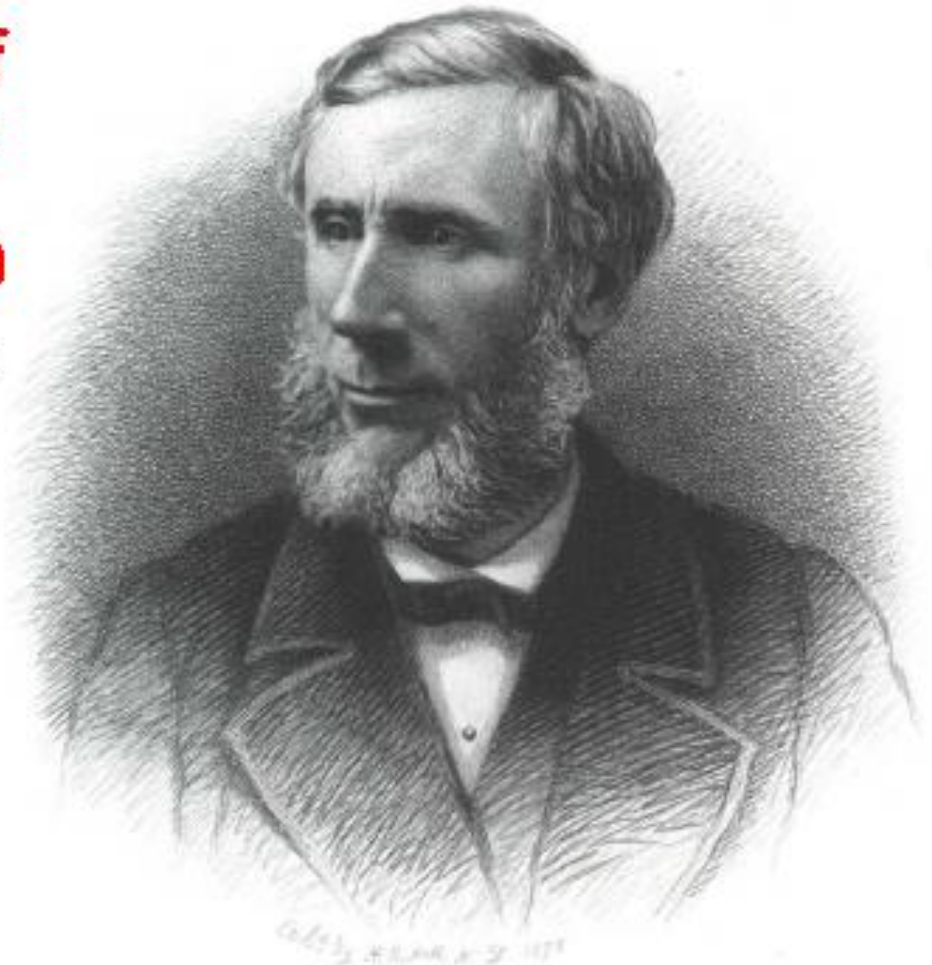


- Showed that solar heat alone isn't enough to explain Earth's warm climate
- Coined the **"Greenhouse" analogy**

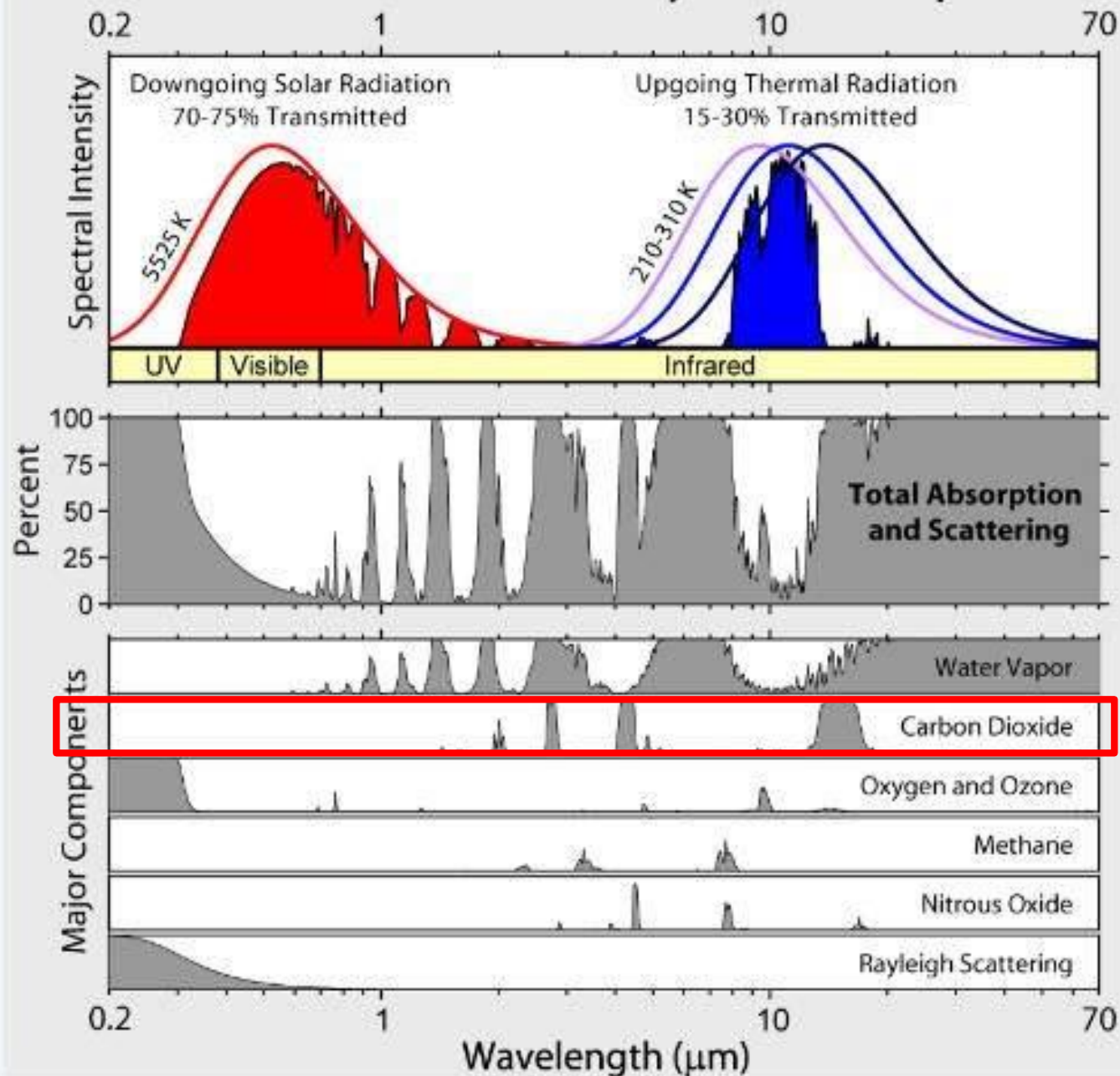


# 1860's – John Tyndall

- First **direct** measurements of the absorption of infrared radiation by **CO<sub>2</sub>** gas in the laboratory
- CO<sub>2</sub> absorbs IR the wavelengths emitted by Earth



# Radiation Transmitted by the Atmosphere



# 1890's – Svante Arrhenius



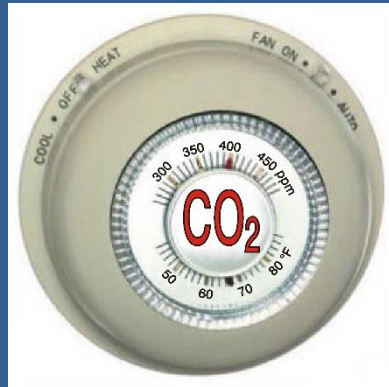
- Measured IR absorption by the Earth's atmosphere
- Showed doubling CO<sub>2</sub> would warm global average temperature by 3 Celsius



The  $\text{CO}_2$  greenhouse gas effect is concentrated in the polar regions !!!  
The most potent greenhouse gases are  $\text{H}_2\text{O}$  - vapor



Particularly in the Arctic!  
The large  $\text{H}_2\text{O}$  greenhouse effect is controlled by temperature –  $\text{H}_2\text{O}$  saturation doubles with every  $10^\circ\text{C}$  increase  
 $\text{CO}_2$  and other Greenhouse gases are evenly distributed throughout the atmosphere  
As a result it is concentrated in the lower atmosphere of the tropics



Human  
Activity



Warmer Air,  
Warmer Water  
(Global Warming)

More Water Vapor  
and Clouds



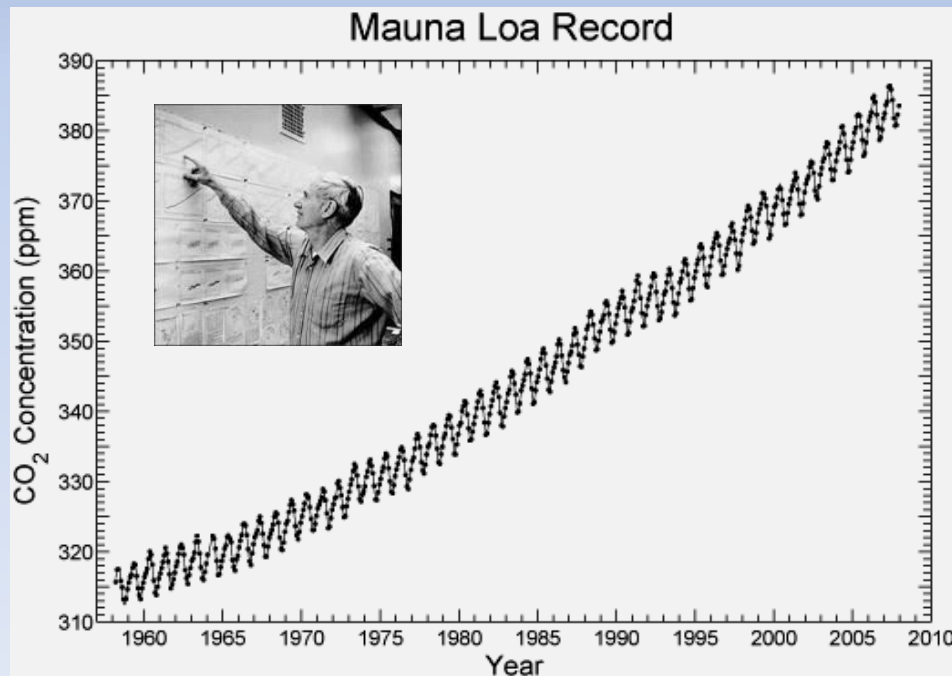
Atmosphere  
Biosphere  
Hydrosphere  
Cryosphere  
(Climate Change)



J

# EMISSIONS FROM HUMAN ACTIVITIES LARGELY TO BLAME

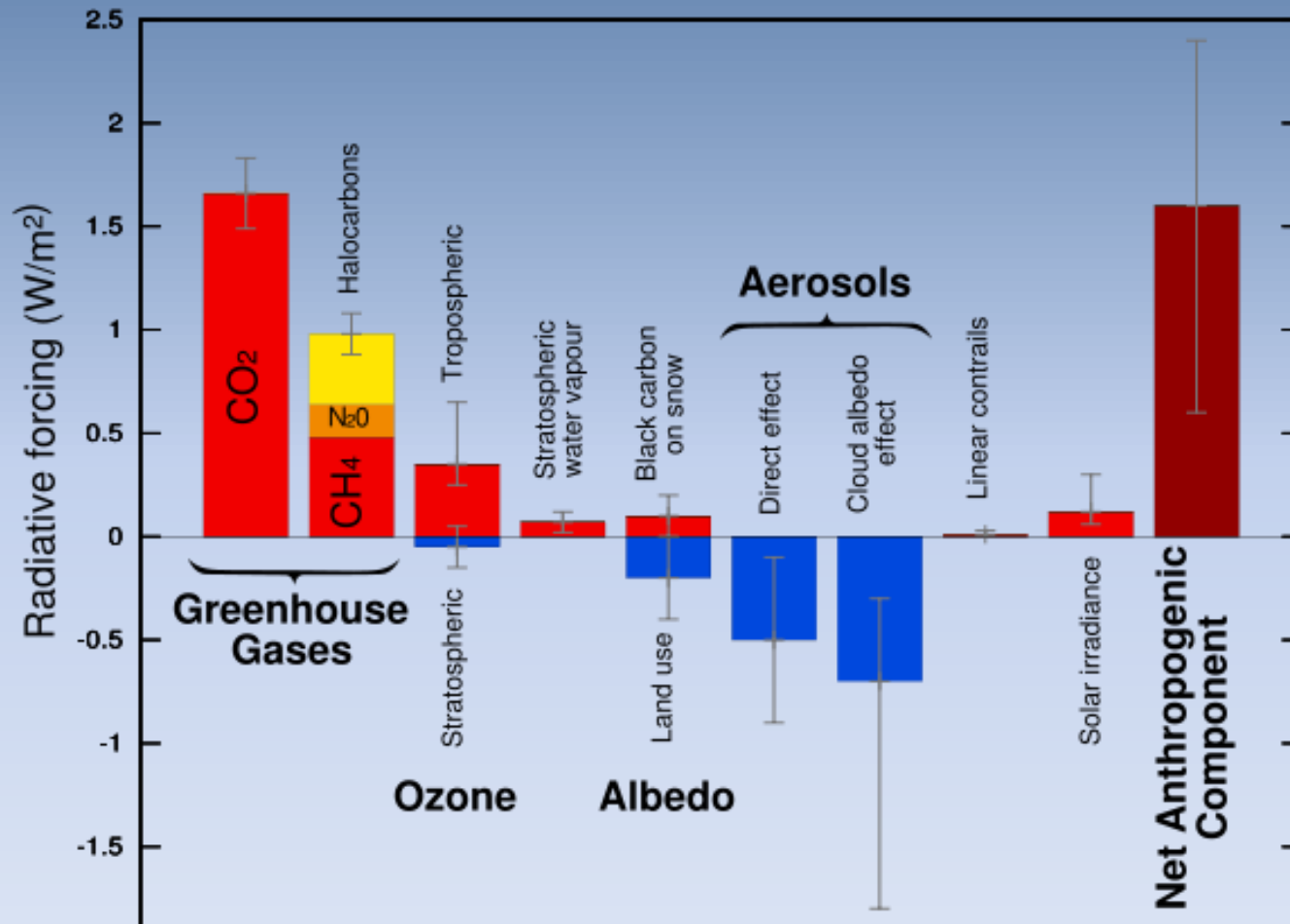
- 40% increase in CO<sub>2</sub>
- Dead carbon altering atmospheric C<sup>14</sup>
- That Carbon is more negative/enriched in C<sup>12</sup>





# GLOBAL WARMING CONCERNS

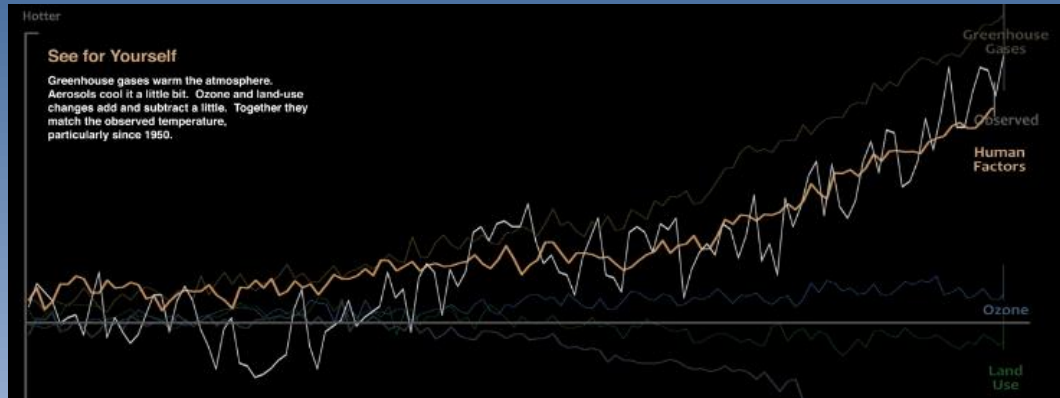
## Radiative Forcing Components



Incoming Solar irradiance:  $342 \text{ W/m}^2$

IPCC, 2007

# How global warming stacks up

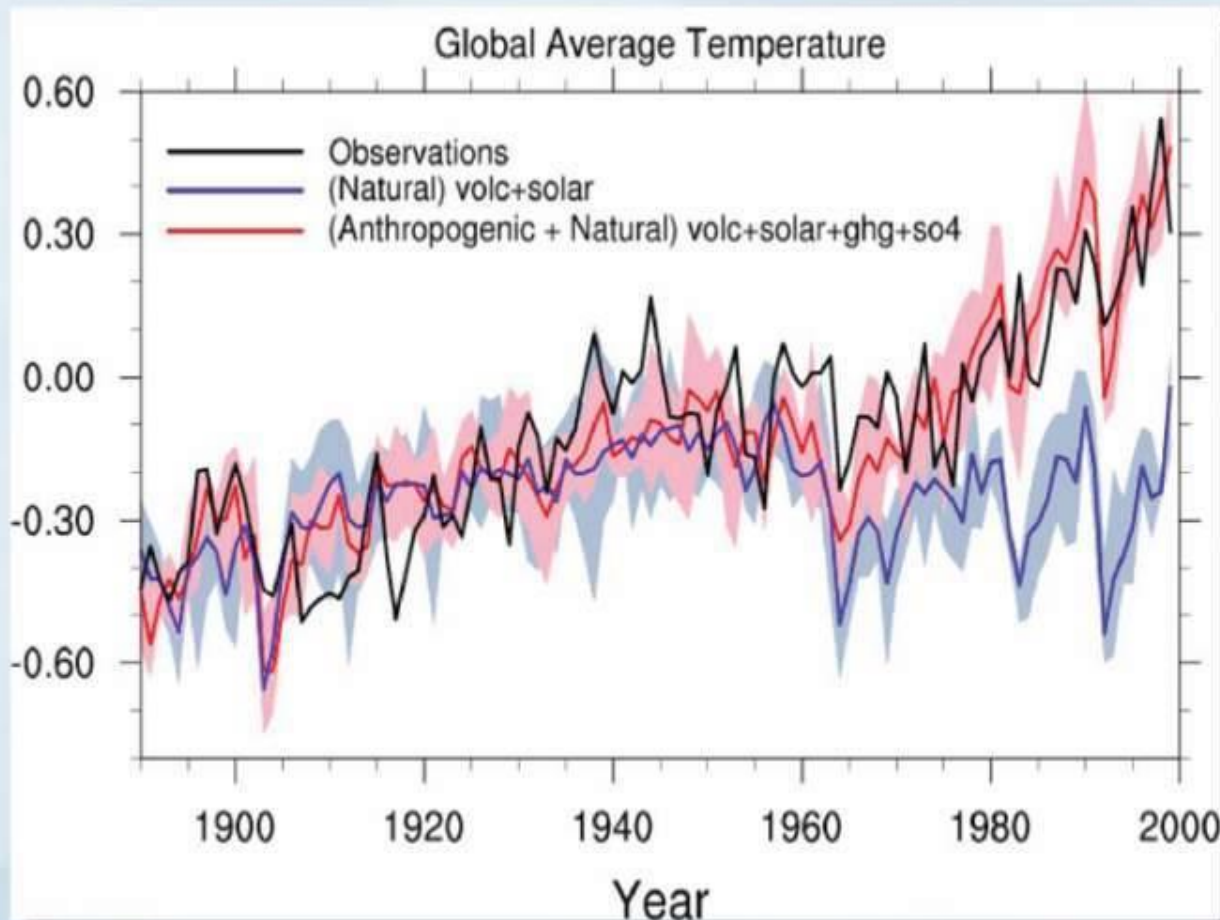


- <https://www.youtube.com/watch?v=-gHUHoqBn-Y>
- Published on Sep 15, 2016
- Skeptics of manmade climate change offer various natural causes to explain why the Earth has warmed 1.4 degrees Fahrenheit since 1880. But can these account for the planet's rising temperature? Watch to see how much different factors, both natural and industrial, contribute to global warming, based on findings from NASA's Goddard Institute for Space Studies.

# Simulations of the 20th century: Time



NCAR



All  
forcings

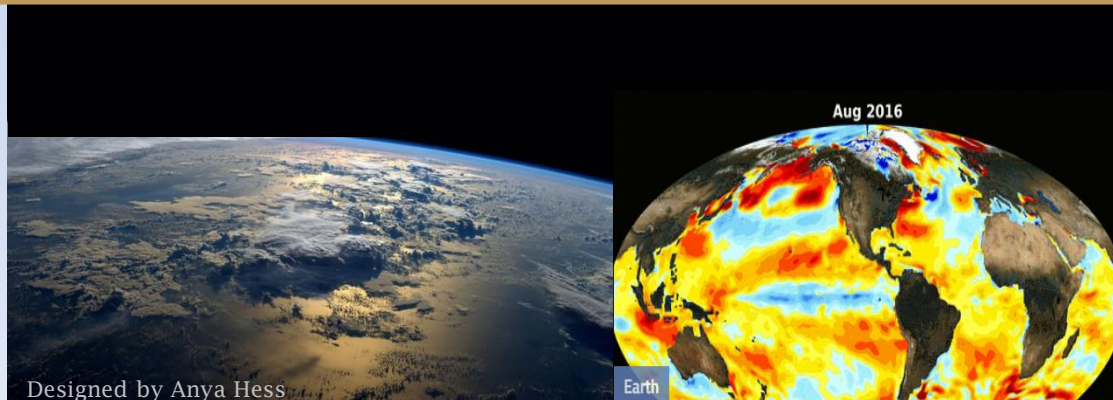
Natural  
only

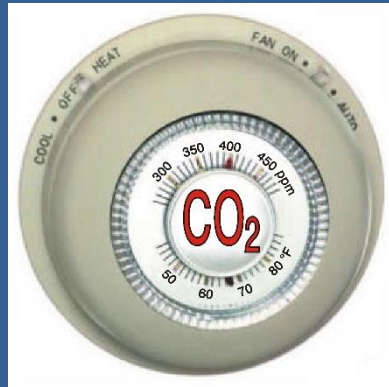
Meehl et al. 2004



# *Adapting to our Changing Climate*

## *Global warming: The Consequences*





Human  
Activity



Warmer Air,  
Warmer Water  
(Global Warming)

More Water Vapor  
and Clouds



Atmosphere  
Biosphere  
Hydrosphere  
Cryosphere  
(Climate Change)



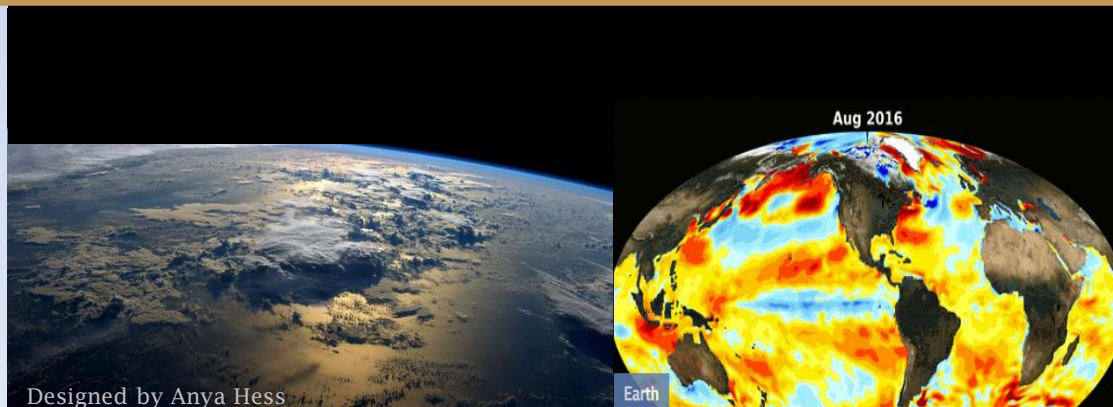
# *Adapting to our Changing Climate*

*Global warming:*

## *The Consequences*

### **i. Warming & Extreme Weather**

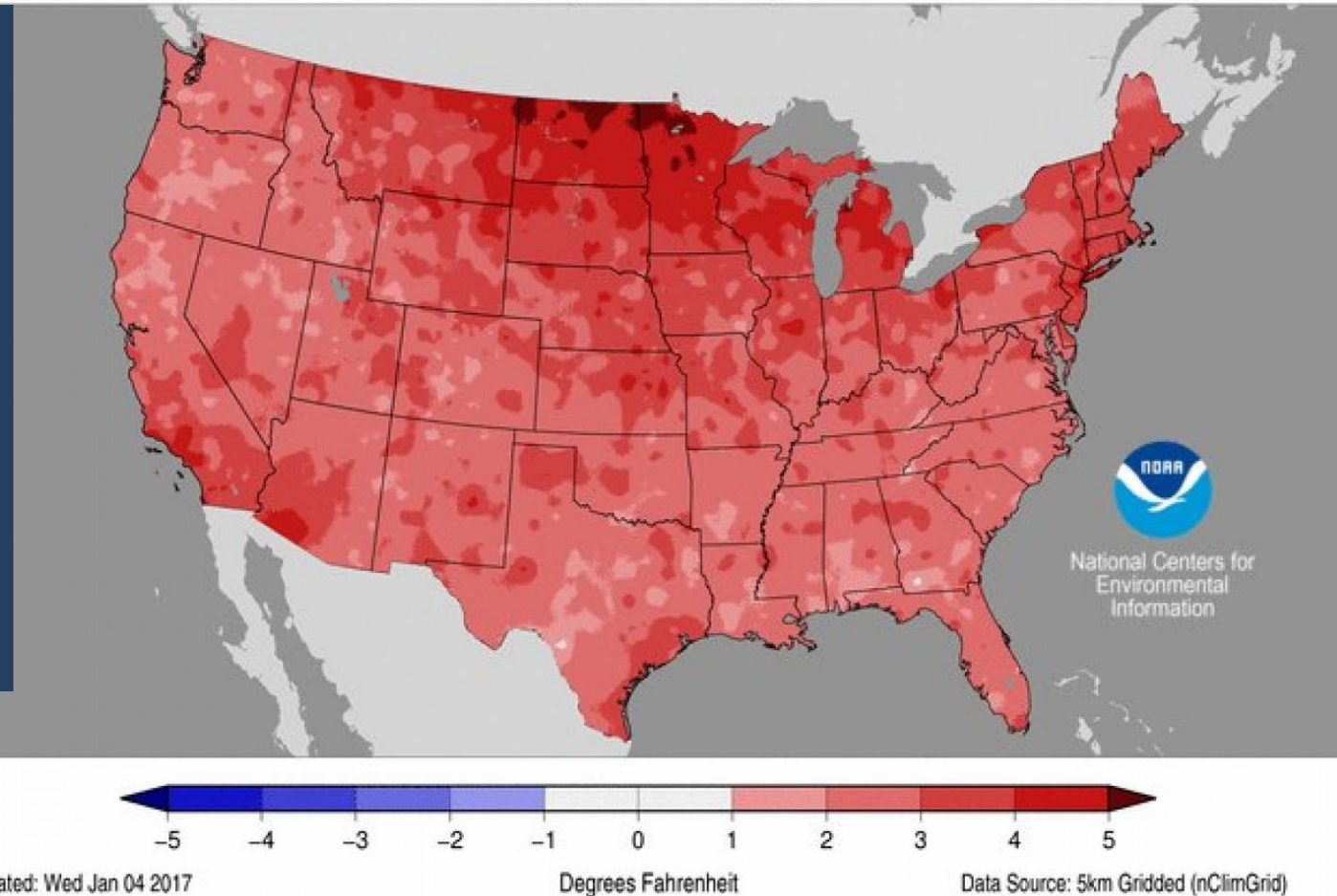
**It's what people identify with most easily**





# U.S. posts second-warmest year (2016) on record, breadth of warmth 'unparalleled' Washington Post, 9 Jan 2017

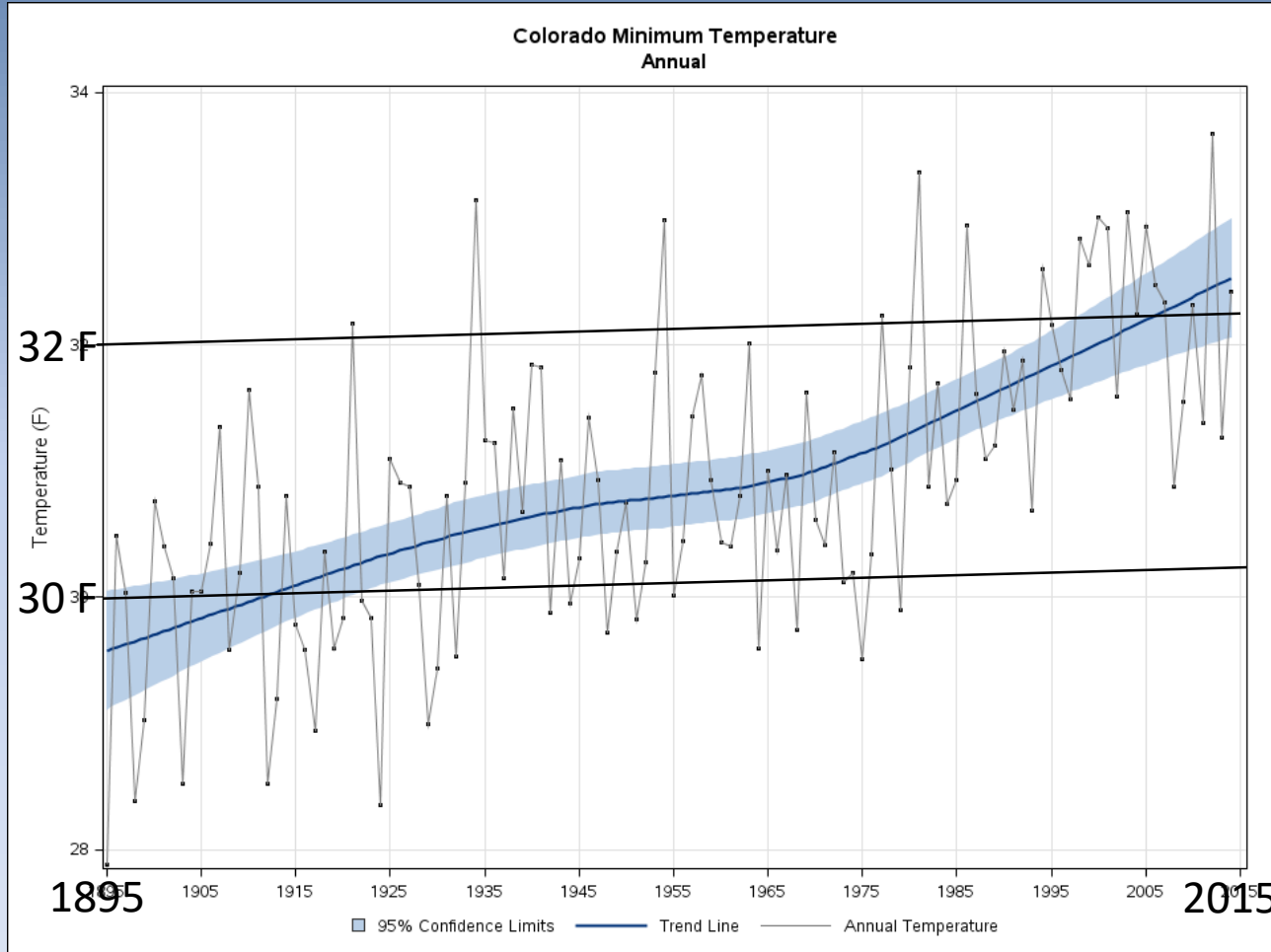
Mean Temperature Departures from Average  
January–December 2016  
Average Period: 20<sup>th</sup> Century



NOAA:

- “The breadth of the 2016 warmth is unparalleled in the nation’s climate history,”
- “No other year had as many states breaking or close to breaking their warmest annual-average temperature.”

# In Colorado, an increase in the minimum annual temperature over 120 years.

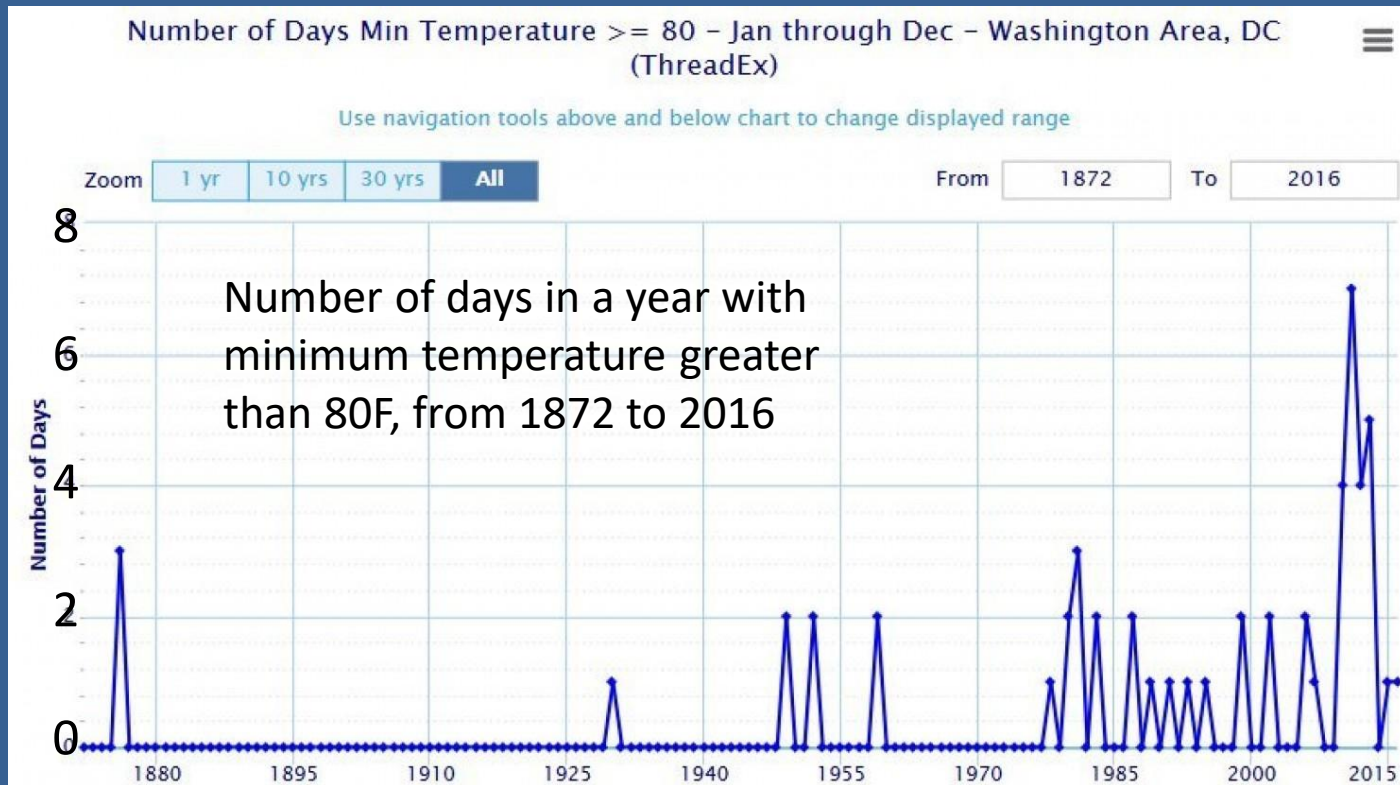


Jagged brown line—  
annual temperature  
Solid blue line—  
smoothed trend line  
Blue shading—95%  
confidence interval

Source: National  
Climatic Data Center,  
NOAA

# Hot nights have increased at a startling rate in Washington, D.C.

- Since the turn of the 19<sup>th</sup> century, Washington, D.C., has witnessed a stunning increase in unusually warm nights.
- Happening five to 10 times more frequently than they used to.



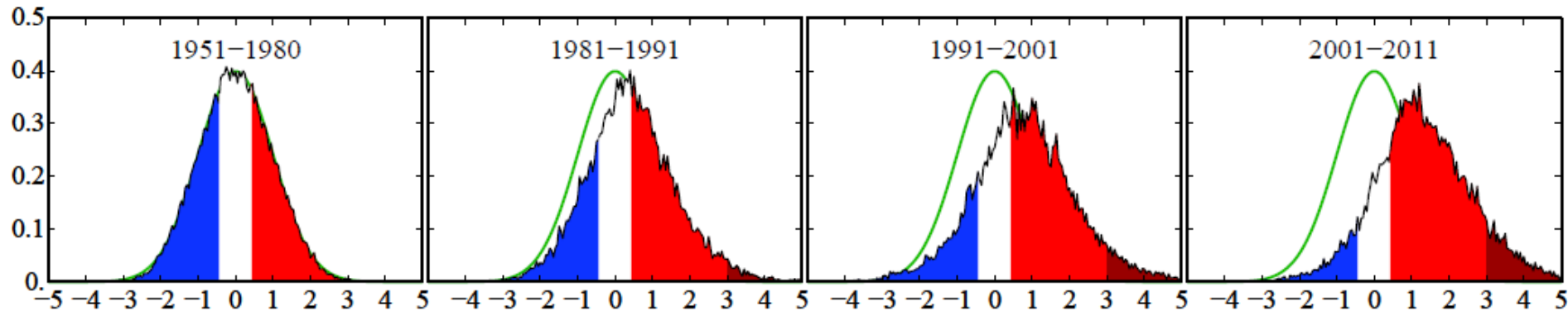
Washington Post July 25, 2016

# Loaded Climate Dice:

- global warming is increasing extreme weather events.
- Extreme summer heat anomalies now cover about 10% of land area, up from 0.2%.

This is based on observations, not models.

Shifting Distribution of Summer Temperature Anomalies



- **Vertical axis: Northern Hemisphere:** Frequency of local June-July-August temperature anomalies (relative to 1951-1980 mean)
- **Horizontal axis:** Units of local standard deviation.
- **OBSERVATION:**
  - 1951-1980 match closely the normal distribution ("bell curve", shown in green) separated:
  - cold (blue), typical (white) and hot (red) seasons = 33.3% probability for each
  - SHIFT to the right as a consequence of the global warming of the past three decades
  - **CONCLUSION:** cool summers now cover only half of one side of a six-sided die, white covers one side, red covers four sides, and an extremely hot (red-brown) anomaly covers half of one side.

Source: Hansen, J., Sato, M., and Ruedy, R., *Proc. Natl. Acad. Sci.*, 2012.



# North America is flooded in warmth and there is no sign of real winter

Washington

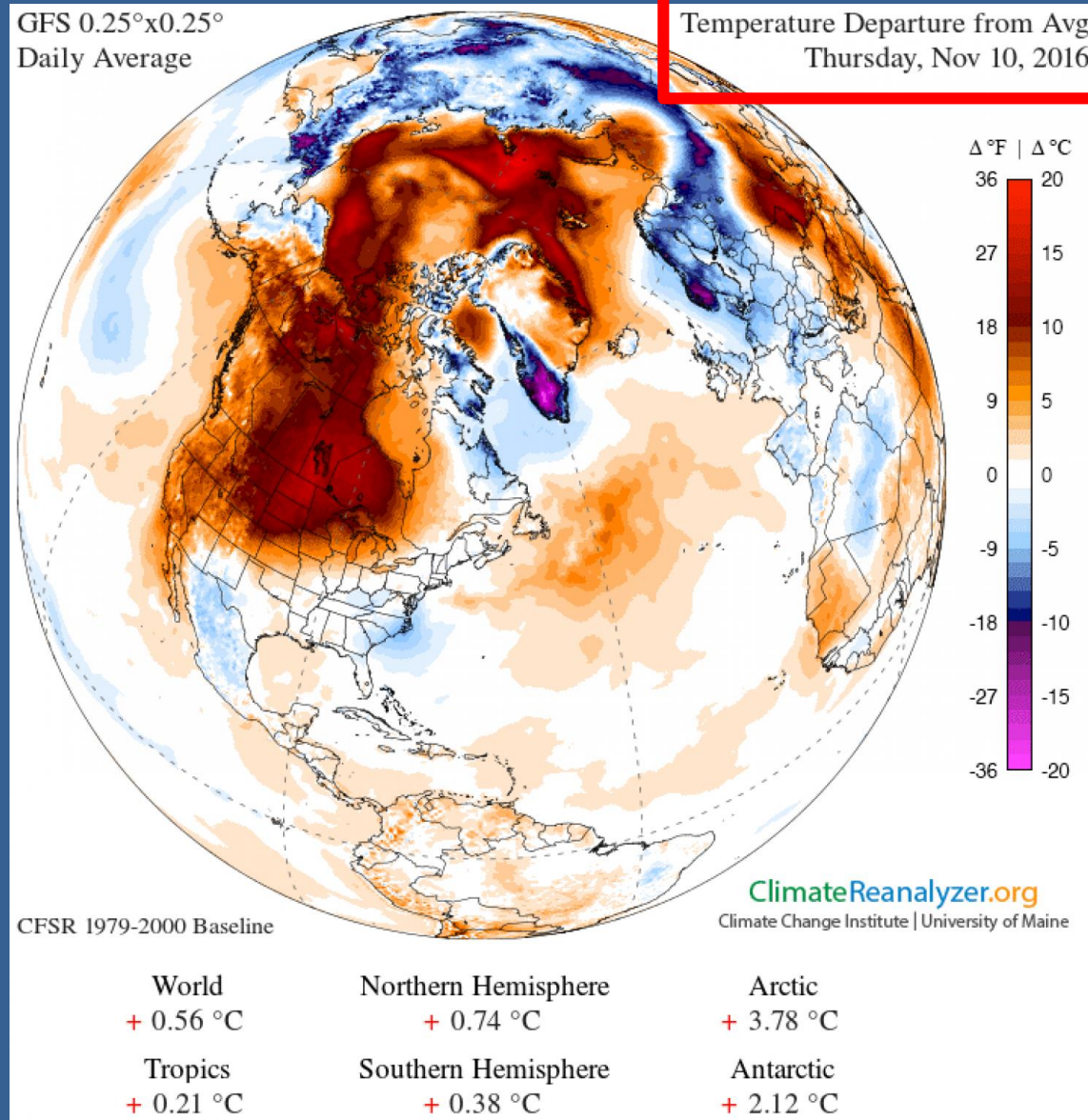
Post, 10 Nov 2016

The United States experienced its third-warmest October on record, and warmth has continued through the first third of November.

*[This fall has been so warm, some cities are setting records for latest first freeze]*

GFS 0.25°x0.25°  
Daily Average

Temperature Departure from Avg  
Thursday, Nov 10, 2016



Temperature difference from normal over the Northern Hemisphere, Nov. 10, 2016. (Climate Reanalyzer, Climate Change Institute, University of Maine, USA.)

# There has never been a hotter February day in Denver, Colorado Springs or Pueblo

The temperature reached  
80 degrees — yes,  
seriously — at Denver  
International Airport

Denver Post 17 Feb 2017



## Record High Temperatures across Northeast Colorado set February 16<sup>th</sup>

Only Stations with a Period of Record of 30+ Years shown

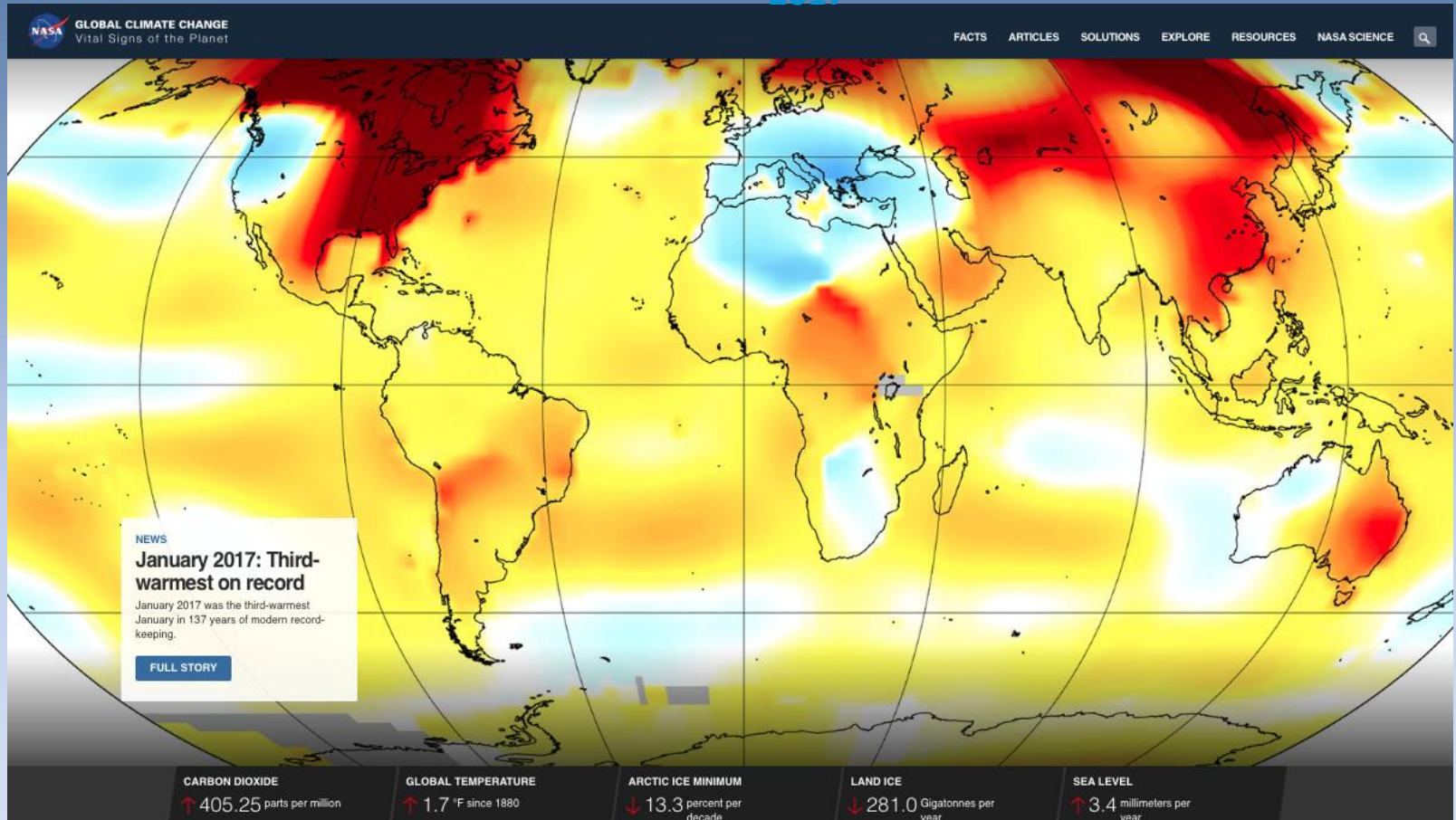
Location	Record Temp	Feb 16 <sup>th</sup>	Old Temp	Previous	Station Age Years
AKRON - CO Plains Rgnl AP	73°	2017	68°	2011	81
Bailey	61°	2017	60°	1970	117
Boulder	73°	2017	69°	1982	125
Cabin Creek	54°	2017	45°	2004	50
Denver Area / now DIA	75°	2017	70°	1970	146
Denver Stapleton	76°	2017	70°	1970	70
Evergreen	70°	2017	63°	1996	57
Ft Collins	70°	2017	67°	2011	125
Ft Morgan	75°	2017	65°	1982	122
Genoa	60°	2017	60°	2011	48
Georgetown	57°	2017	54°	1996	125
Grand Lake 1 NW	49°	2017	47°	1997	79
Grant	55°	2017	52°	1970	55
Greeley UNC	75°	2017	74°	2011	51
Gross Rsvr	63°	2017	57°	2011	40
Hohnholz Ranch	49°	2017	49°	2011	33
Karval	69°	2017	69°	1991	38
Kassler	75°	2017	72°	1996	100
Lakewood	70°	2017	69°	1970	56
Limon AP	70°	2017	65°	2011	48
Lindon 5NWN	66°	2017	62°	2011	30
New Raymer 21N	69°	2017	66°	2011	31
Northglenn	77°	2017	69°	2014	34
Ralston Rsvr	69°	2017	62°	2014	40
Strontia Springs Dam	70°	2017	68°	1996	34

National Weather Service – Denver / Boulder





## Nasa Climate Change Website: January 2017



<http://climate.nasa.gov/>



## Probing a global problem



**Niwot Ridge: A NOAA Scientist, Jen Morse, collects CO2 flasks; measurements reached 413 ppm**

she wrestles with the question that's been bothering her all week: **How humans can know that potentially ruinous climate change is happening yet balk at trying to stop it.**

"We understand we are sealing our own fate. We can see it happening," Morse said with fat, wet snowflakes pelting her face. "And we mostly know how to solve it. We know what is producing emissions and we know what we have to do."

**"Part of it is that everyone is so busy living their lives day to day. And we don't have a good system in place for solving global problems. This is a global problem,"** she said.

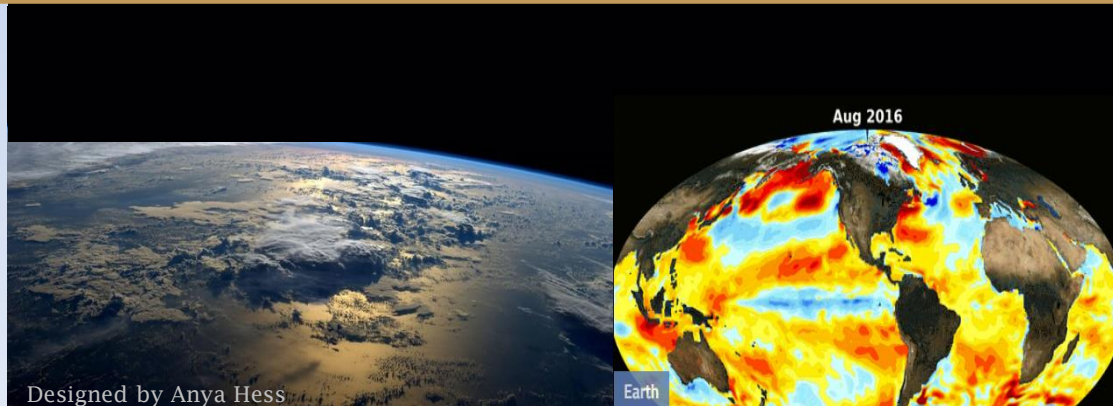
<http://www.denverpost.com/2017/04/03/measuring-climate-change-in-the-rockies/>

# *Adapting to our Changing Climate*

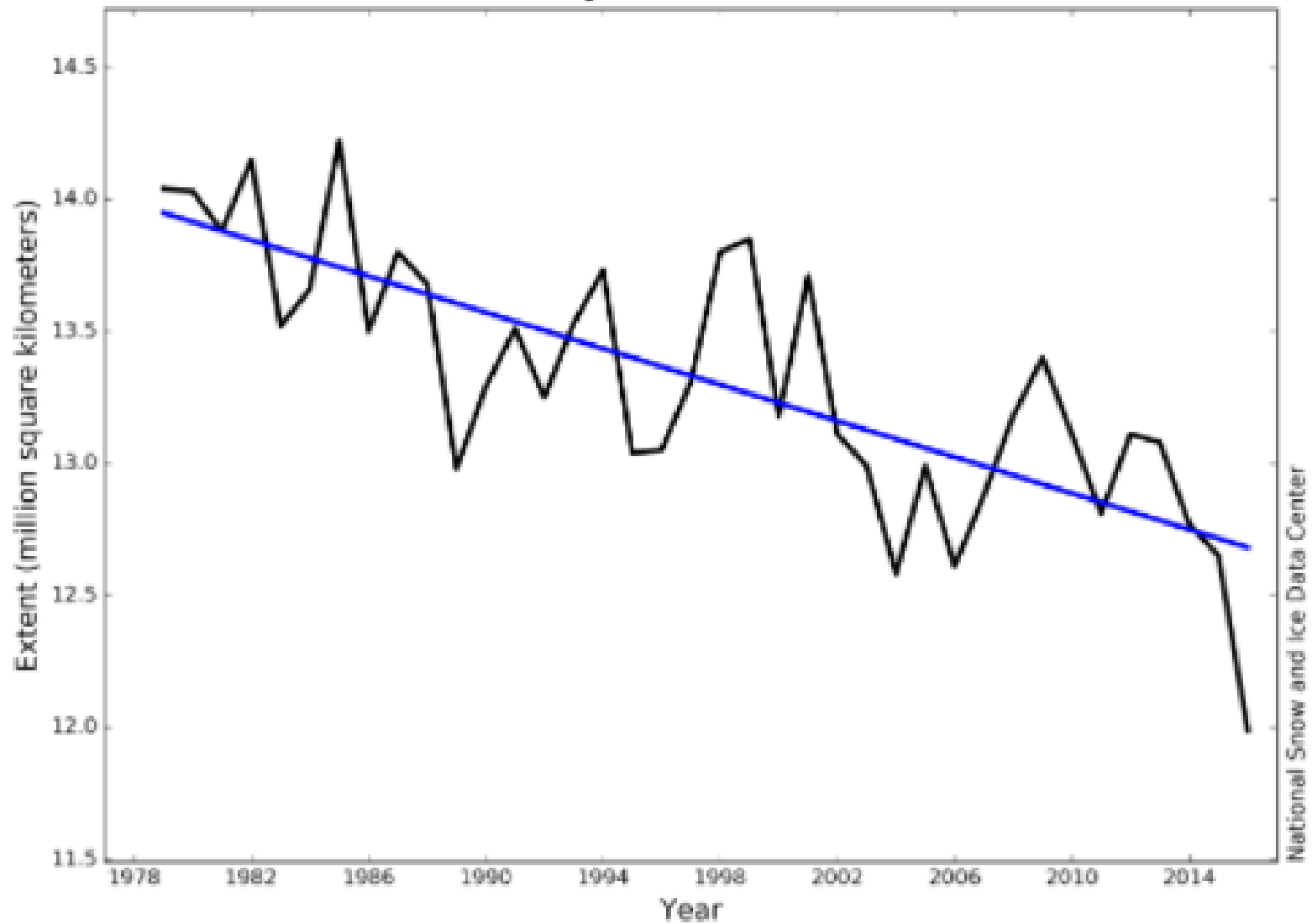
*Global warming:*

*The Consequences*

## **ii. Ice & Glacial Melting**



## Average Monthly Arctic Sea Ice Extent May 1979 - 2016

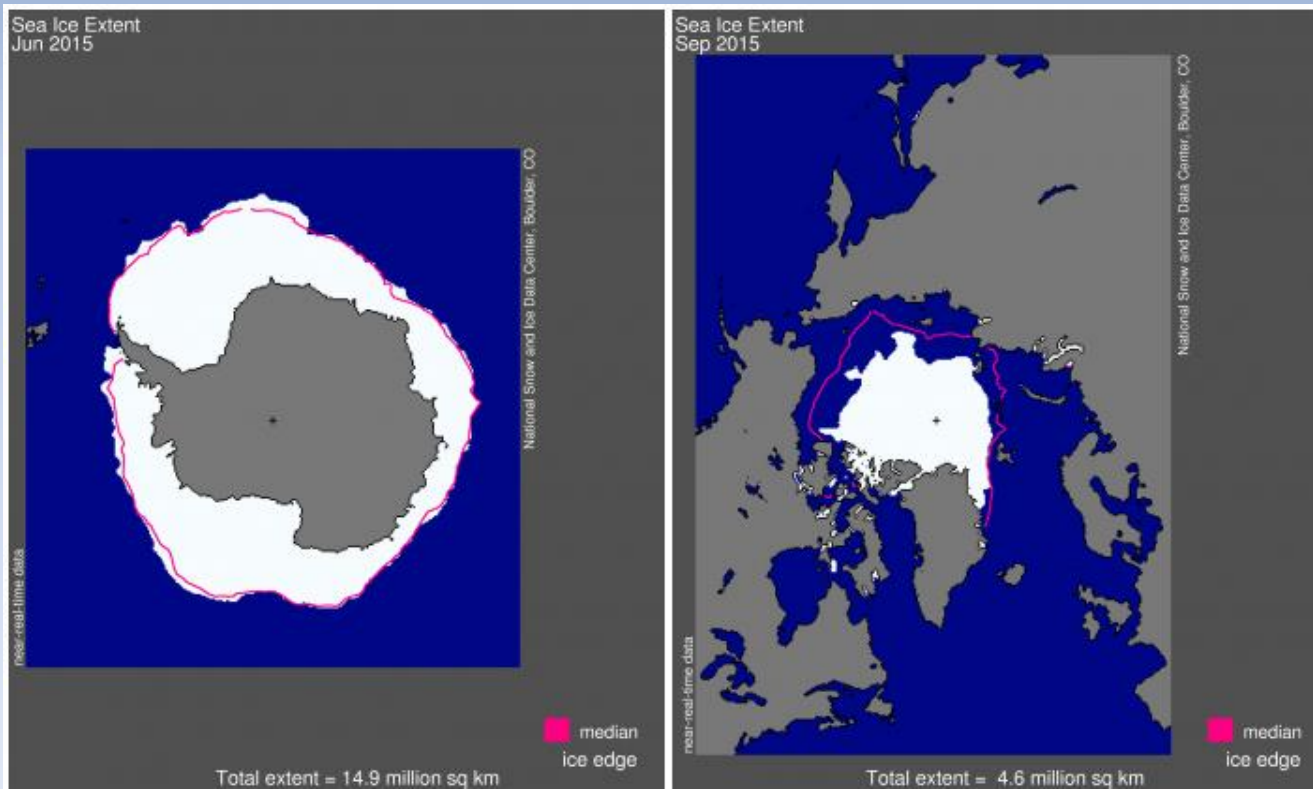


For more see: <http://www.skepticalscience.com/melting-ice-global-warming.htm>

<http://nsidc.org/arcticseaicenews/2016/06/>

## 12. ARCTIC ICE vs. ANTARCTIC SEA ICE

- Ans. More moisture in air around Antarctica (AA) to nucleate sea ice
- Despite > AA is does not compensate for Arctic loss



**2015**

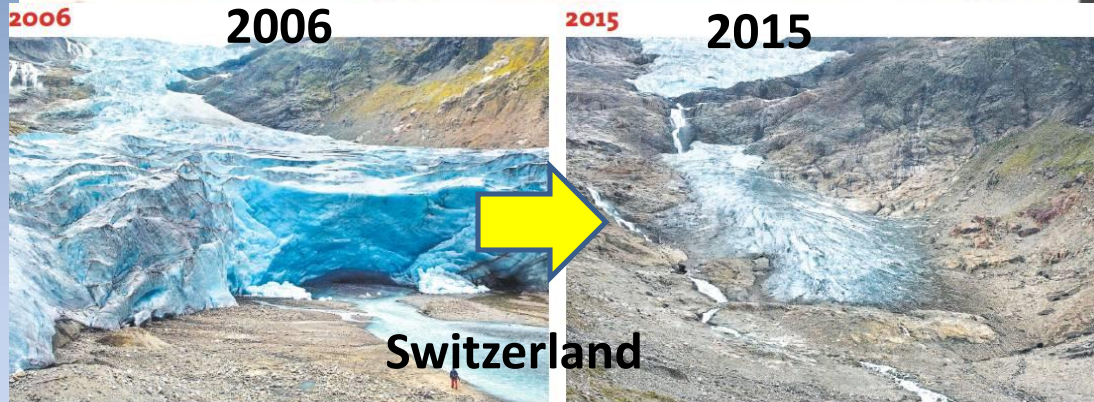
<http://nsidc.org/arcticseaicenews/2015/>



# Evidence

Wednesday, Denver Post 4/5/2017

Photos are stark evidence that  
the world's glaciers are melting



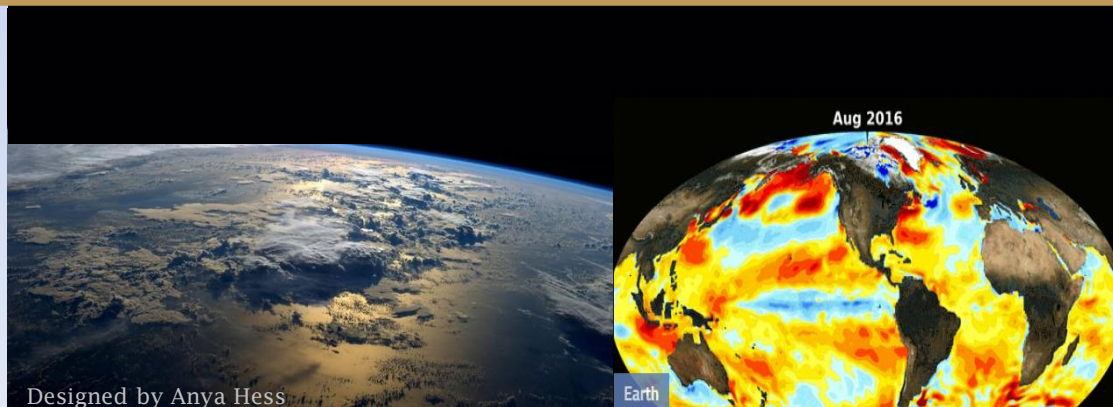


# *Adapting to our Changing Climate*

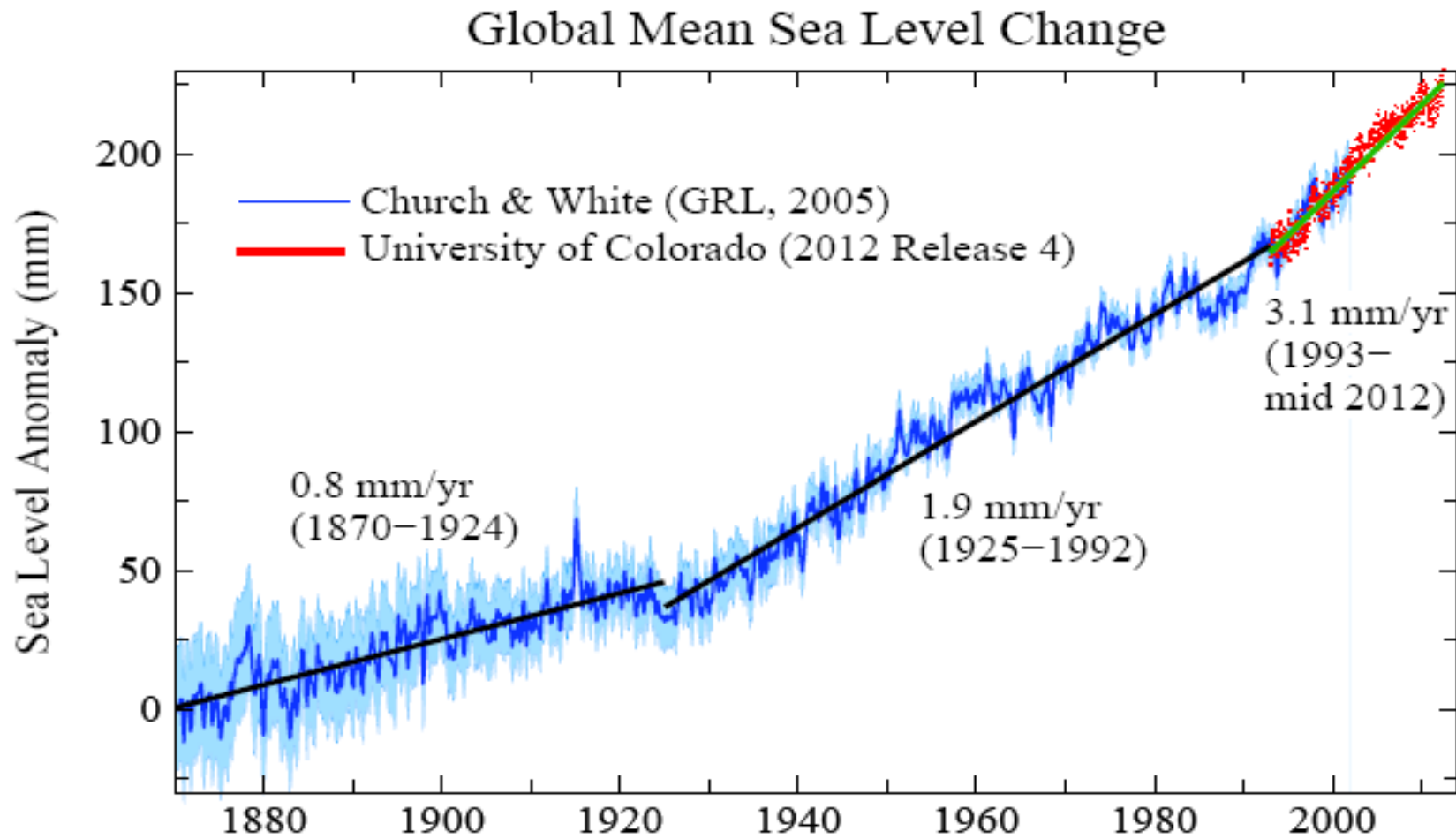
*Global warming:*

*The Consequences*

## **iii. Sea Level Rise**



# 14: HOW FAST IS SEA LEVEL RISING?



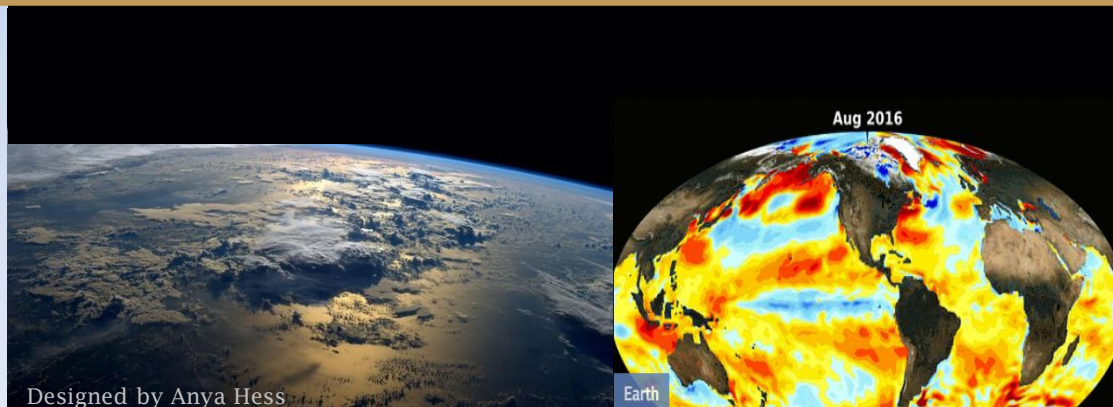
Blue: Sea level change from tide-gauge data (*Church J.A. and White N.J., Geophys. Res. Lett. 2006; 33: L01602*)  
Red: Univ. Colorado sea level analyses in satellite era (<http://www.columbia.edu/~mhs119/SeaLevel/>).

# *Adapting to our Changing Climate*

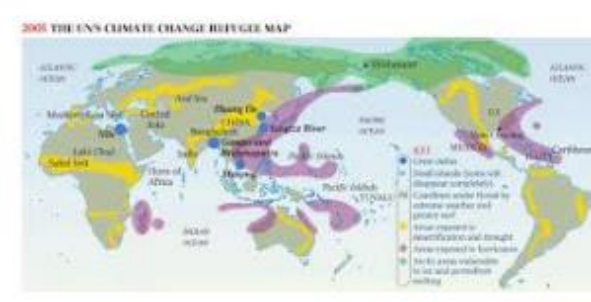
*Global warming:*

*The Consequences*

## **iv. Associated Refugees**



# We have not seen anything yet regarding future refugee problems



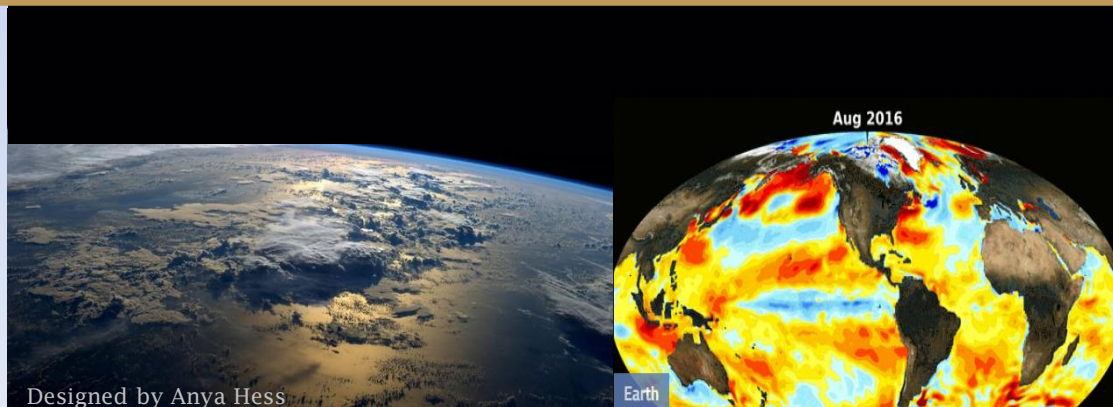


# *Adapting to our Changing Climate*

*Global warming:*

*The Consequences*

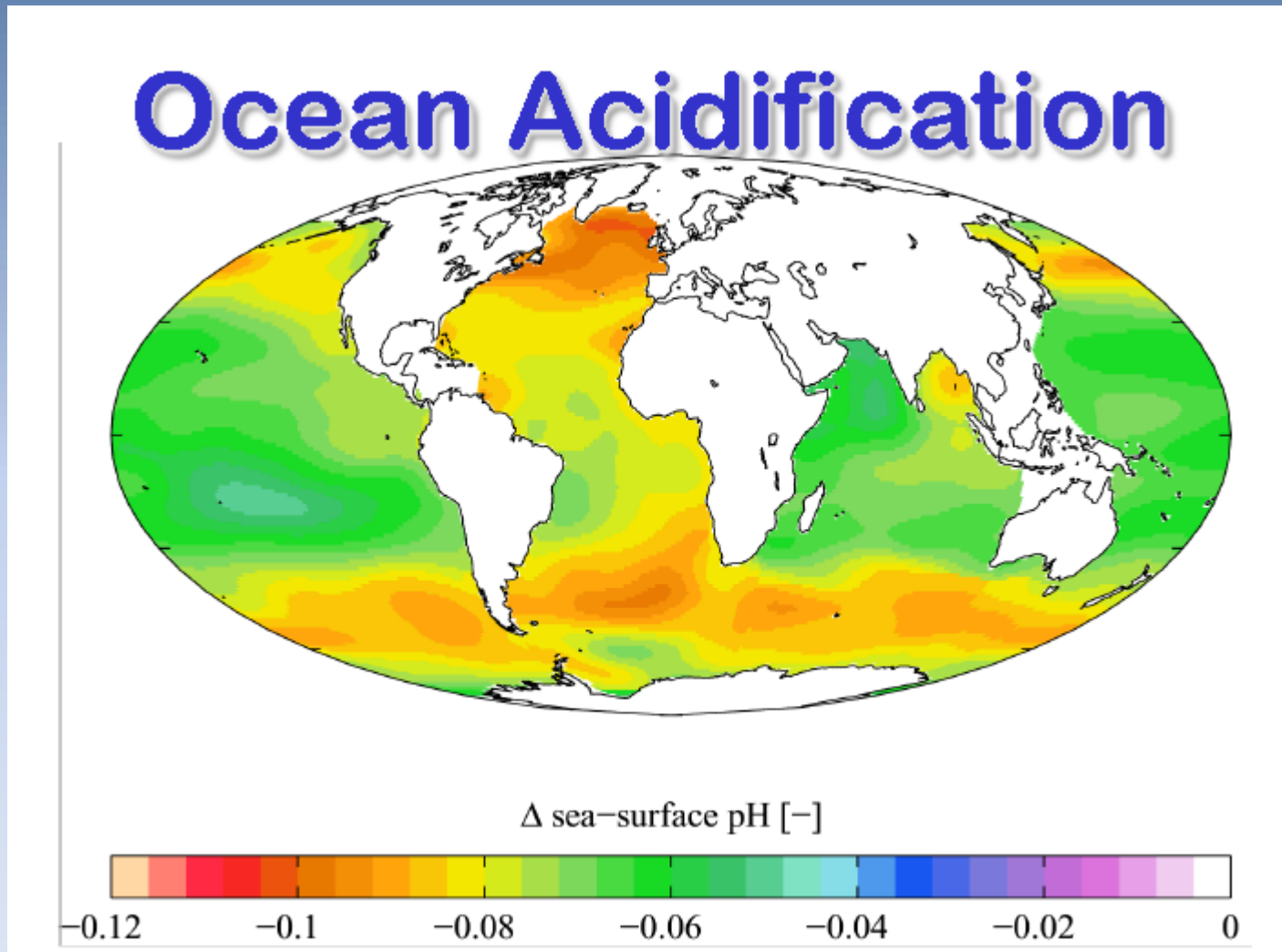
**v. Ocean Acidification**





# Ocean Acidification

What's will be its impact on the food chain?

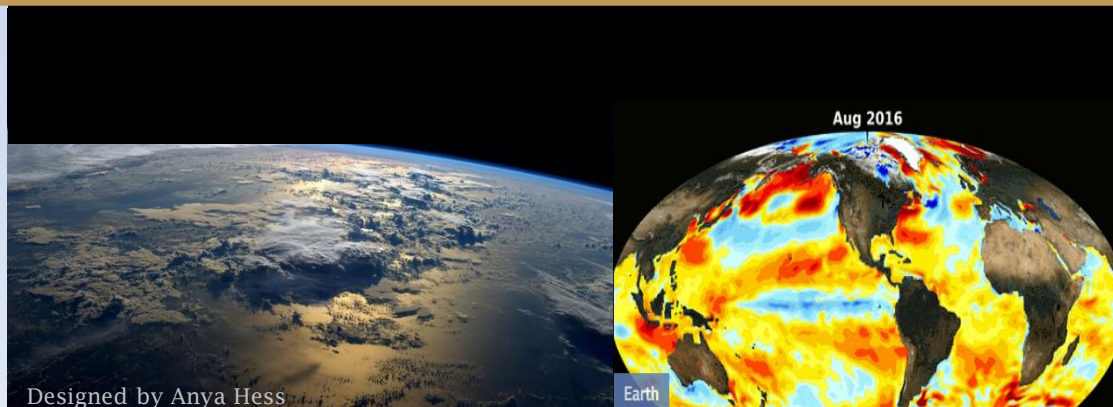


# *Adapting to our Changing Climate*

*Global warming:*

*The Consequences*

## **vi. Degraded Sustainability**



# Floods

# Drought

# Wildfires

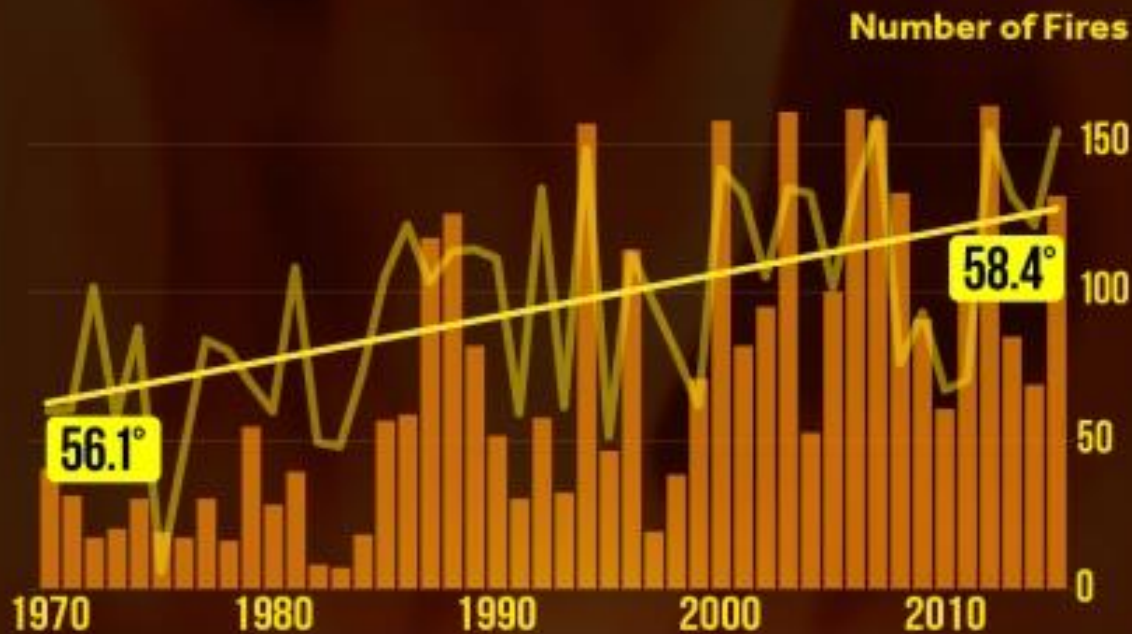


The 2015 wildfire season was the worst on record in the U.S., with more than 10 million acres burned



## Hotter Years, More Fires

Western States



Source: NCEI Climate at a Glance (spring and summer temperature)  
Climate Central analysis of U.S. Forest Service Records (fires)

CLIMATE CENTRAL

There are now three times more large wildfires burning across the West each year than in the 1970s.

The annual area burned in these wildfires has increased six-fold. And wildfire season is now an average of 105 days longer than it was in the 1970s.

# Are Consequences Statistically Significant?

- Attribution and risk

**The Attribution confidence varies**  
**There are other factors as well**

- Maybe they are not currently statistical but should be wait for that?

# Pollution

**Not Attributable to climate change  
But is related to our fossil fuel burning  
that is causing climate change**

# Denver's Brown Cloud



Vs. NO Brown Cloud – all the time!





# The American Public and Climate Change

Yale Program on Climate Change Communication

Climate Change and the American Mind  
- November, 2016

- 70% believe global warming is occurring
- 55% understand it is caused by human activity
- Only 5% believe anything can or will be done

# How does one respond to Deniers of climate change?

## With Simple Facts and Logic

- **1. Is climate changing? YES**
  - Scientific ....
- **2. Do people have anything to do with it? YES**
  - Greenhouse gas emissions (primarily carbon dioxide from fossil fuel burning) have to warm the atmosphere—it is what they do. ....
- **3. Is climate change bad? YES**
  - ...change in the environment of stable civilizations is disruptive to those civilizations....
  - Alterations in areas in which crops can be grown... when leaves fall, when insects emerge, etc.), ...
  - Shifting storm tracks, and rising sea level may have devastating economic, social, and political consequences on modern societies.
  - Ocean Acidification
- **4. Can we do anything about it? YES**
  - ....cessation of emissions can stabilize climate in the 21st century....
- **5. Is it worth doing anything about? YES**
  - Economic analyses ....

# WHAT TO DO?

- PLEASE QUESTION MOTIVES IF ONE SAYS:  
“Well I’m not really sure how much is man-made”
- AND ASK or think about their credentials!
  - Are they climate scientists?
- AND Don’t spend too much time (waste?) expecting to change world views

# Web Links on Climate

- <https://skepticalscience.com/>
  - <https://skepticalscience.com/denial101x-videos-and-references.html>
- <http://www.realclimate.org/>
- <http://climatecentral.org/>
- <https://climate.nasa.gov/> <https://climate.nasa.gov/causes/> , etc.
- Jeffrey Bennett: <http://www.globalwarmingprimer.com/tour/>
  - <http://www.globalwarmingprimer.com/primer/primer4/>
- Jeff Masters/Weather underground: <https://www.wunderground.com/weather-infographics/climate-change-today>
  - <https://www.wunderground.com/blog/JeffMasters/show.html>
- <http://www.nationalgeographic.com/magazine/2017/04/seven-things-to-know-about-climate-change/>
- Extreme Weather: Phil Nelson:  
<https://www.youtube.com/watch?v=gQ1kPMYCFEY&t=9s>

# *Mitigating & Adapting to our Changing Climate*

## *OUTLINE (cont.)*

**BREAK**

**NEXT:**

## **Part 2: Solutions:**

- **How to Overcome our Inertia and Apathy**







[https://i.kinja-img.com/gawker-media/image/upload/t\\_original/ihsllhptnnm4vb7wuvqq.jpg](https://i.kinja-img.com/gawker-media/image/upload/t_original/ihsllhptnnm4vb7wuvqq.jpg)

**Paul Belanger**

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**[pebelanger@glassdesignresources.com](mailto:pebelanger@glassdesignresources.com)**

**c. 303-249-7966;**

# *Mitigating & Adapting to our Changing Climate*

## *OUTLINE (cont.)*

**BREAK**

**NEXT:**

### **Part 2: Solutions:**

- **Overcome our Inertia and Apathy**
- A. **Reduce Carbon Emissions in Electric Generation, Transportation and in Heating**
- B. **Carbon Dioxide Removal (CDR); Negative Emission Technology (NET); Greenhouse Gas Removal (GGR)**



# Part 2: Solutions

## How to Overcome our Inertia and Apathy



# The American Public and Climate Change

Yale Program on Climate Change Communication

Climate Change and the American Mind  
- November, 2016

- 70% believe global warming is occurring
- 55% understand it is caused by human activity
- Only 5% believe anything can or will be done

<http://climatecommunication.yale.edu/>

Kathleen Wells, Denver CCL, 2017

# APATHY / INERTIA

## WHY?

- IT'S too late
- It's too big a problem
- It's up to the government
- I'm not long for here anyway
- It's too expensive
- I'm too busy



<https://eos.org/articles/climate-scientists-new-hurdle-overcoming-climate-change-apathy>



# APATHY / INERTIA vs. good motives:

- IT'S our planet
- It's the right thing to do
- I CARE FOR FUTURE GENERATIONS!
- It's for our grandkids, or dogs or cats 😊
- I believe in promoting the best of human values by example



<https://eos.org/articles/climate-scientists-new-hurdle-overcoming-climate-change-apathy>

# SOLUTIONS TO APATHY

**#1 - CHANGE OUR WAY OF THINKING**

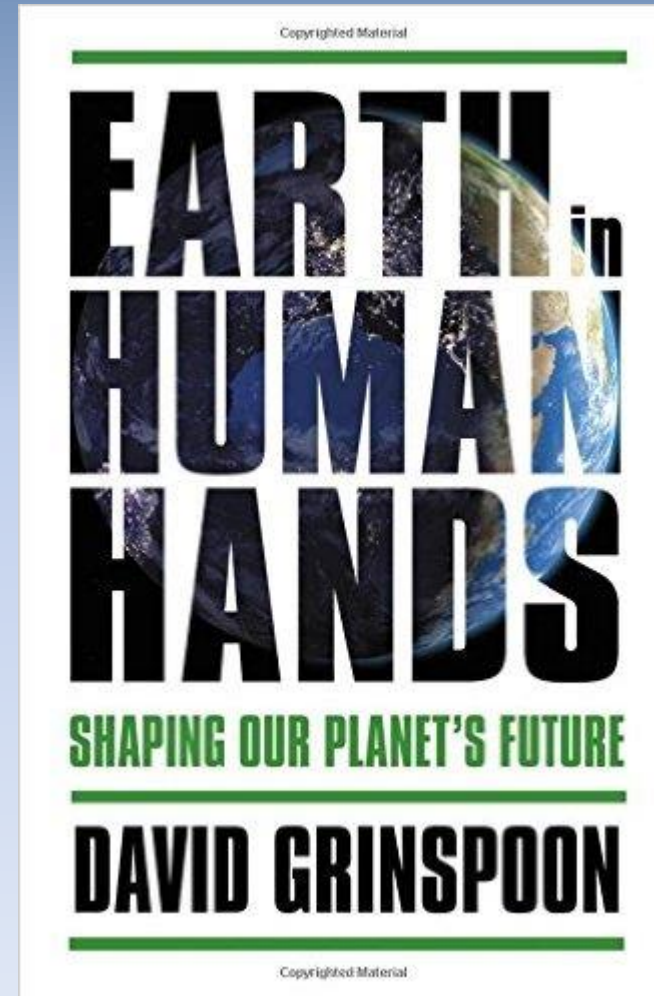
# Earth in human hands

- Kerry Emanuel, MIT Prof. Meteorology:
- “...there are few, if any, historical examples of civilizations consciously making sacrifices on behalf of descendants two or more generations removed”
- NEEDED CABINET POSTION:
  - **Secretary of the future**

# We are a planet with brains

- Climate change is only the most visible of the modifications we've made--up until this point, inadvertently--to the planet.
- And our current behavior threatens not only our own future but that of countless other creatures.
- ....shows what a strange and novel development it is for a species to evolve to build machines, and ultimately, global societies with world-shaping influence.

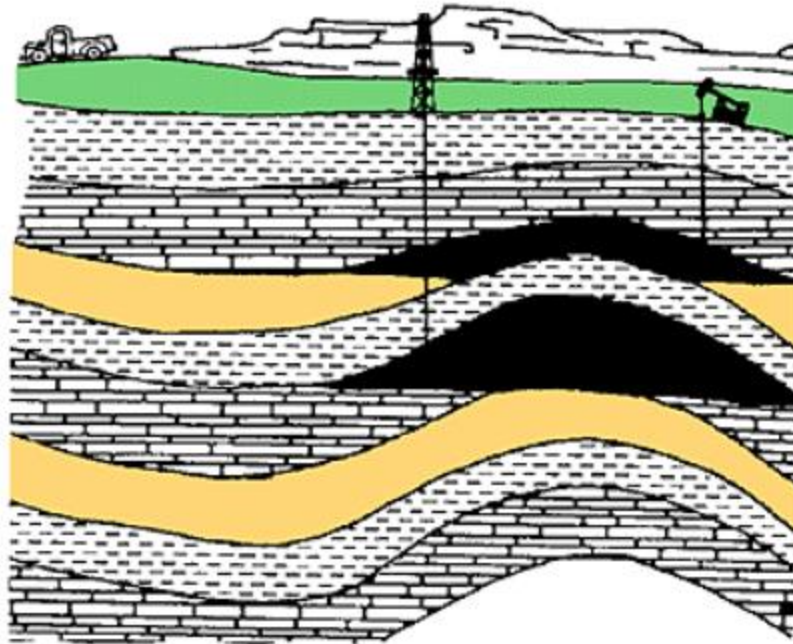
BTW – David Grinspoon will be at Conf. World Affairs (CWA), Boulder NEXT week of 4/8: <http://www.colorado.edu/cwa/>



# Fossil fuels: oil, gas, coal

- We owe a lot to fossil fuels
- It's only recently we've fully appreciated its consequences
- It's time for change!

## Fossil Fuels



Some of the stored solar energy in biomass can be **preserved in fossilized remains**

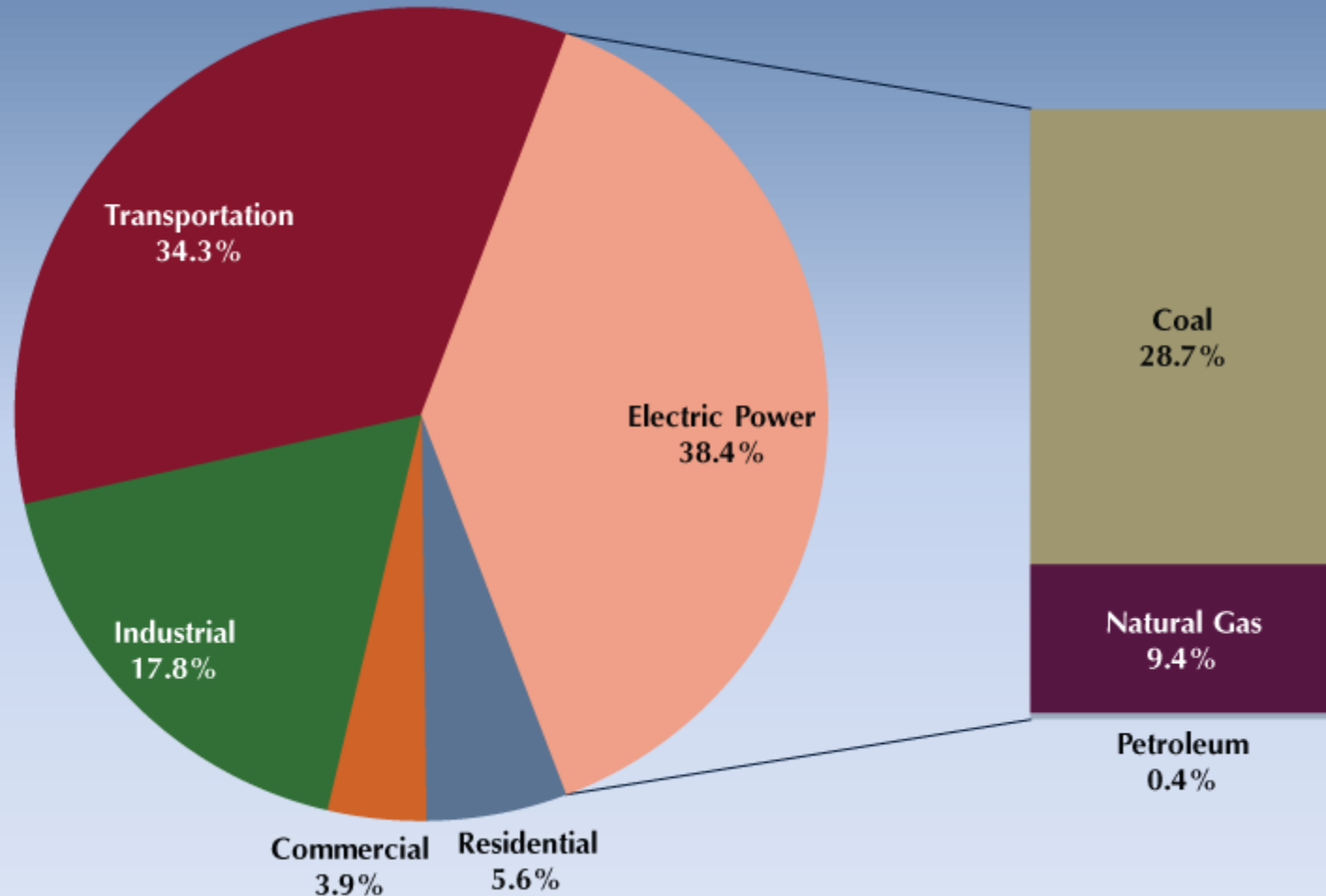
# **SOLUTIONS**

## **Part A: - REDUCE OUR GREENHOUSE GAS (GHGs) EMISSIONS**

- **Electric Generation**
- **Transportation**
- **in Heating**



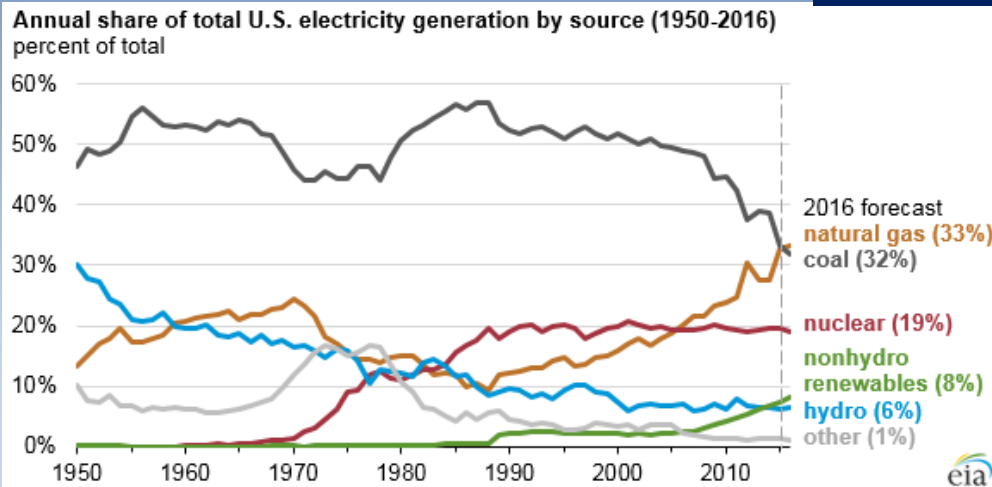
# Source of CO<sub>2</sub> Emissions



# Sources of Electricity in Colorado: 2015

- 60% coal
- 22% natural gas
- 18% renewable energy

## NATIONALLY:

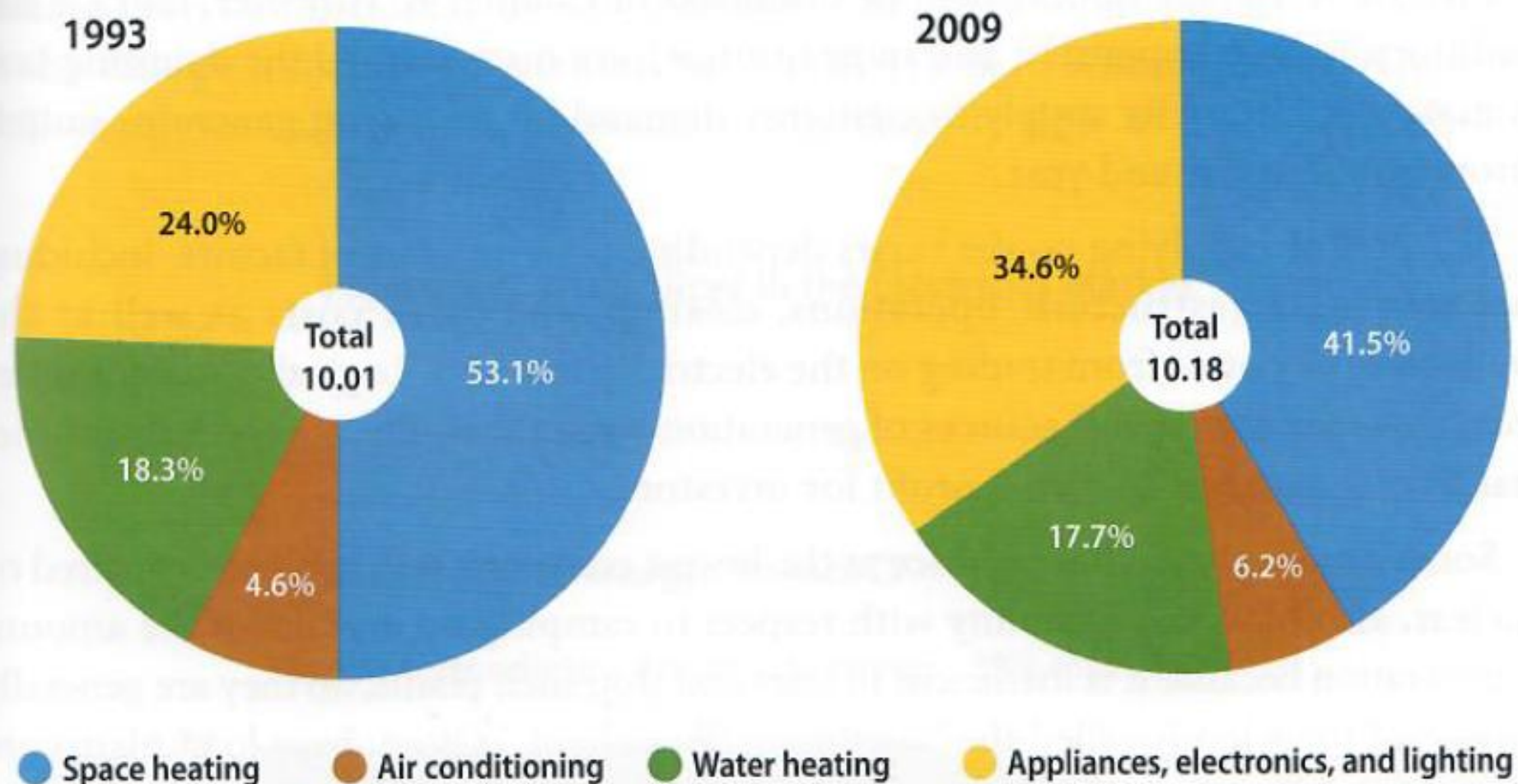


- 32% coal
- 33% natural gas
- 19% nuclear
- 8%+6% renewable/hydro
- 1% other

## Colorado Is a Magnet for Renewable Energy Companies:

- Colorado 6<sup>th</sup> in nation overall potential
- Denver 5<sup>th</sup> in clean-tech employment
- Fastest growing industry in the region

**Figure 5.3. Energy Consumption in Homes by End Uses**  
quadrillion Btu and percent



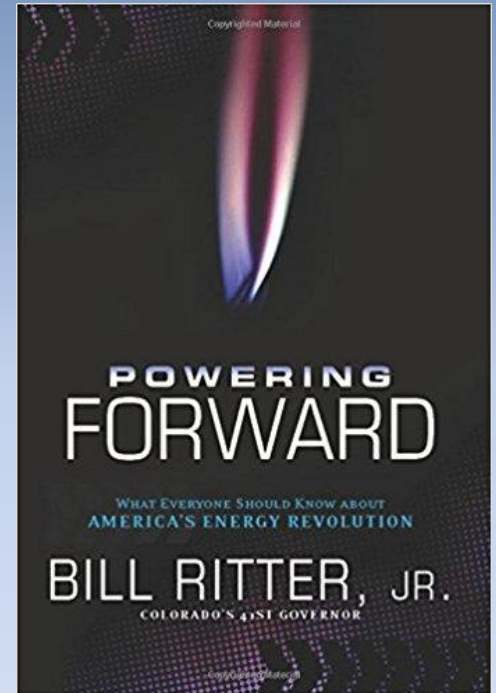
Source: U.S. Energy Information Administration, <http://www.eia.gov/todayinenergy/detail.cfm?id=10271>.

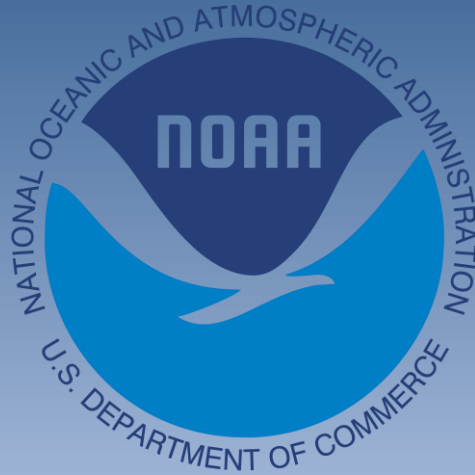
**SOLUTIONS TAKE AWAY:**

**ELECTRIFY EVERYTHING BY NON-CARBON  
SOURCED ELECTRICAL GENERATION!  
OR SOLAR THERMAL**

# Powering Forward: ...America's Energy Revolution

- A historic energy revolution is underway in the United States & THE WORLD:
  - Wind, sunlight, and other sustainable resources
  - Power plants on their roofs
  - Entire communities are switching to 100 percent renewable energy; Hawaii has such a commitment!
  - Urgent need to prevent climate change is causing people around the planet to question their reliance on carbon-intensive oil, coal, and natural gas.





National Oceanic and Atmospheric Administration  
estimated in 2016:

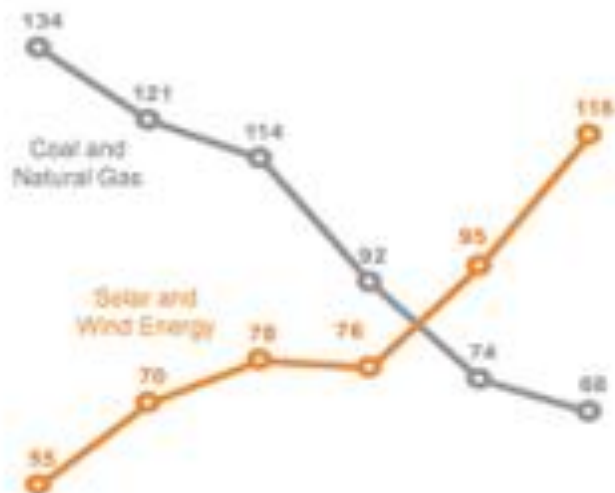
“renewable sources could supply (within  
15 years) most of the nation’s electricity  
at costs similar to today’s”



# Renewable Energy is Expanding

## The power industry is changing

Wind, solar are adding capacity faster than fossil fuel

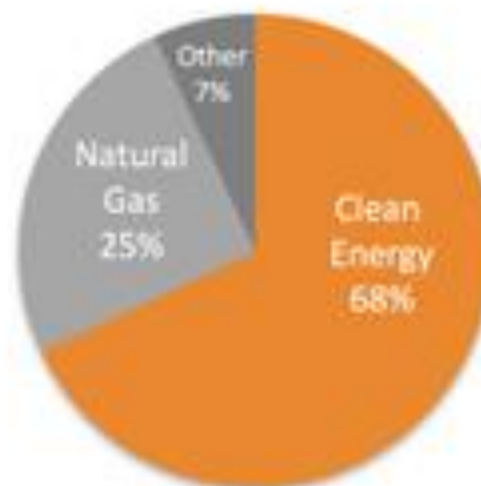


Global Capacity Installations<sup>5</sup>  
Gigawatts, 2010–2015

**2010-2015**

## United States energy mix is changing

Clean energy lowers cost and inflation risk



United States Capacity Additions 2015<sup>6</sup>

Solar and wind dominated the market for new energy

**2015**

[www.generation180.org](http://www.generation180.org)

Kathleen Wells, Denver CCL, 2017

# Perceptions

- LAST WEEK'S unfortunate and misguided rollback of Environmental protections has led to a DEPRESSING and widespread belief that the U.S. can no longer meet its commitment under the Paris climate change agreement:
  - **WRONG!**
- WE ARE overestimating Washington's influence
- **WE CAN – don't make the same mistake of those:**
  - that think they will put coal miners back to work
  - that underestimate the role that cities, states, businesses and consumers are playing in driving down emissions of their own
  - > 250 coals plants ARE switching to cleaner fuels and/or renewables – because consumers don't want fuels that poison their air and water – and because there are cheaper alternatives
    - **Wind \$20/megawatt vs. \$30/ for coal plants in region**
    - Sierra club "beyond coal program" <http://content.sierraclub.org/coal/>
    - Vehicle fuel efficiency and
    - EVs with greater range
    - **81 companies in 2015 signed pledges (including Apple, Wal-Mart; Anheuser-Busch 100% energy from renewables by 2025**
    - **Pueblo** – similar <https://www.compactofmayors.org/>

# SOLUTIONS

## Part A: - REDUCE EMISSIONS

**Liken it to “DIET”**

**NOW**

## Part B: - Carbon Dioxide Removal

**Liken it to “EXERCISE”**

**To get ride of the “fat – CO<sub>2</sub>” we’ve put in  
the atmosphere**

# SOLUTIONS

## Part B: - Carbon Dioxide Removal

Part of what's called GEOENGINEERING OPTIONS:

1. Solar Radiation Management (SRM) – not discussed today/not recommended
2. Carbon Dioxide Removal (CDR); Negative Emission Technology (NET); Greenhouse Gas Removal (GGR)
  - GOALS of 350.org: <https://350.org/>

# One way: Biochar



<http://www.biochar-international.org/>



<http://biochar-international.org/biochar>



coolplanet

About Cool Terra Cool Fauna Cool Fuels Media Contact

**Cool Terra® Engineered Biocarbon**

**Sustainability AND Profitability**

A Colorado company

<http://www.coolplanet.com/>

# Colorado Biochar Resolution 17-002

Former State Senator Ellen  
Roberts (R) SW Colorado



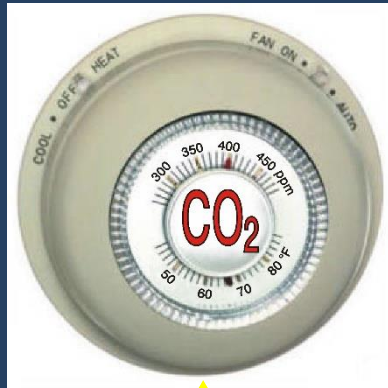
SENATE JOINT RESOLUTION 17-002

BY SENATOR(S) Baumgardner and Merrifield, Cooke, Jones, Aguilar, Coram,

- 98 of 100 senators/representatives sponsored:
- **Be It Resolved by the Senate** of the Seventy-first General Assembly of the State of Colorado, the House of Representatives concurring herein: That we, the members of the Colorado general assembly, **support** the United States Forest Service, the Agricultural Research Service of the United States Department of Agriculture, and other research into the removal of fuel loads on the forest floor for the creation of **biochar** and the use of **biochar** as a soil amendment for reforestation, **the continued creation of biochar** from woody biomass



So What can **WE** do?



More Water Vapor  
and Clouds

Warmer Air,  
Warmer Water  
(Global Warming)

## HUMAN RESPONSES

Personal  
Family, Friends, Neighbors  
Town and City  
State  
National  
International

Atmosphere  
Biosphere  
Hydrosphere  
Cryosphere  
(Climate Change)

# PERSONAL -- Save Energy at Home



GB3 Energy, Golden Colorado

Energy audit, add insulation, replace windows, heating system upgrade, weatherize, crawlspace insulation, .....

# We can Invest in Solar Panels or Community Solar

- AN INVESTMENT - Here's why:
  - A personal story
    - SPENT:
      - \$30,000 (minus 30% fed credit) for 30 panels (rounding out cost)
    - RETURN:
      - Saved **\$1000** in electricity for 1 year
      - With my Leaf – powered by solar panels I drove 14,000 miles replacing a car 25mpg say \$2.50 / gallon = i.e. I did NOT spend **\$1,400 on gasoline**
      - RETURN \$2,400 in ONE year on \$30,000 investment! = **8%**
      - RETURN WITH 30% FED TAX CREDIT = **11.4%**

# Buy and Electric Vehicle (EV)

- 100 mpg equivalent
- Batteries > 100,000 miles
- Motor 1,000,000 miles
- No oil change EVER
- No maintenance
- Why Gasoline Powered Cars Are Obsolete - Jim Smith

<https://www.youtube.com/watch?v=d7tRIsoZgdl>



# EVs no Emissions



**Steve Stevens with Tesla X**  
90 kWh = 300 mile range



**Paul Belanger & Phil Nelson with  
their Nissan Leafs**  
30 kWh = 107 mile range

**Ron Larson with Tesla S**  
75 kWh = 250 mile range





# Imagining a World After Fossil Fuels

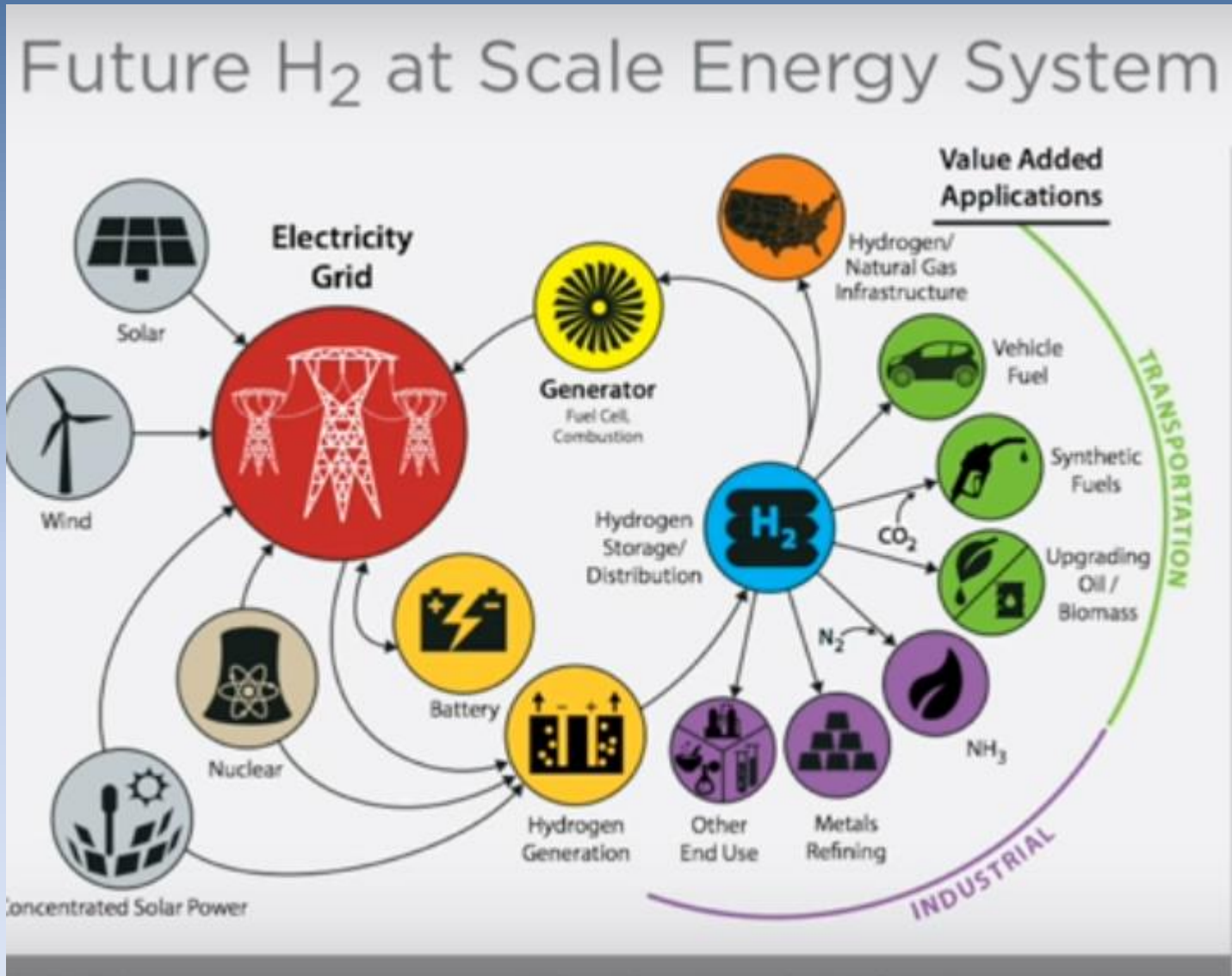


# **BREATHE EASY: COAL is not coming back Renewables win!**

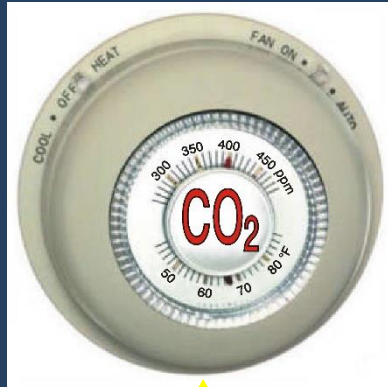
- **RENEWABLES are cheaper!**
  - Wind especially
  - PV next – but will become even cheaper
  - Battery backup
  - Concentrated Solar Power for Thermal backup



# When you have excess power:



# What Can Town, Cities and Communities DO?



More Water Vapor  
and Clouds

Warmer Air,  
Warmer Water  
(Global Warming)

Atmosphere  
Biosphere  
Hydrosphere  
Cryosphere  
(Climate Change)

## HUMAN RESPONSES

Personal  
Family. Friends. Neighbors  
Town and City  
State  
National  
International

**RATHER**

**ITS WHAT THEY ARE ALREADY DOING!**

# Golden wants Rooney Road soccer fields to share space with solar garden, but needs voter OK first

Josie Klemaier, YourHub, Denver Post, 30 March 2017

Golden's Sustainability Advisory Committee has been exploring the possibility of a community solar garden since 2008 as a way to help meet the goal to have 50 percent of all energy used by the city and its residents come from renewable sources by 2027.

Golden already has solar power for 10 of its city facilities, eight of which are net zero, meaning they get all of their energy from solar power.



Rooney Road Sports Complex.  
On the ballot in November 2017.



# On May 11, 2015 City Council approved Lakewood's first community-wide Sustainability Plan

Lakewood.org extracted Feb 2017

**Sustainability plan: climate adaptation; energy-water-environment; sustainable economy; zero waste; public health; natural systems; transportation**



**Sustainability Division (2 permanent staff) in the Planning Department.**

Courtesy Phil Nelson

# **CITIES: Sustainable Denver Summit, 14 Nov 2016**



Mayor Michel B. Hancock

**The Sustainable Denver Summit brought together 580 leaders from across the city's business, nonprofit and civic communities to develop and announce commitments for new and expanded initiatives that will help Denver achieve its ambitious 2020 Sustainability Goals.**

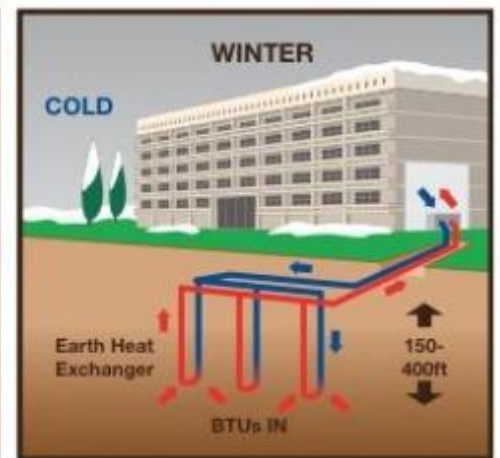
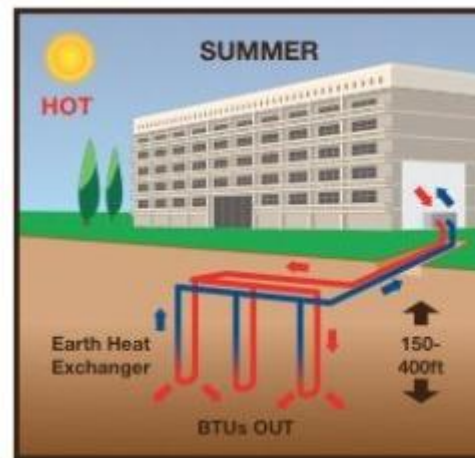
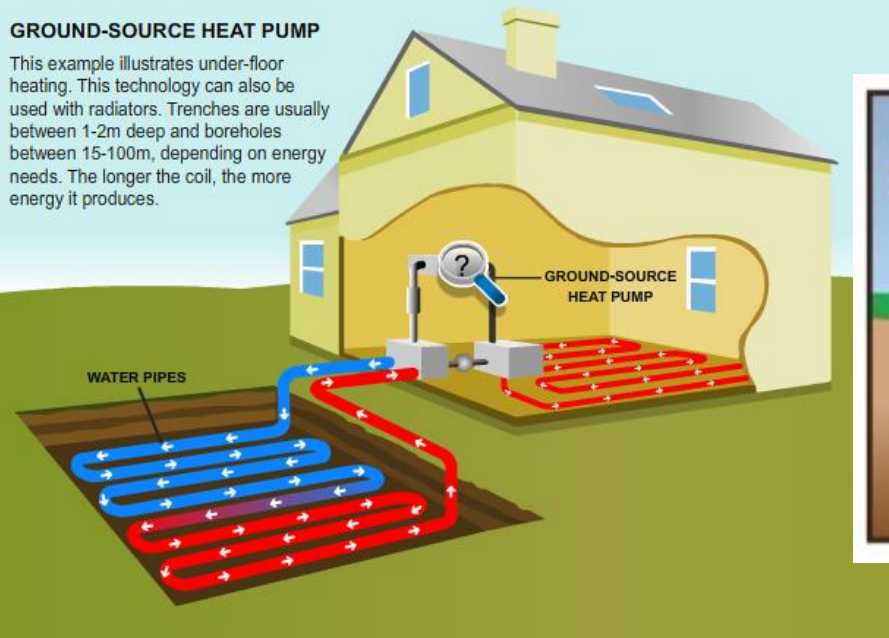
Courtesy Phil Nelson

# Geothermal:

## Personal level or city level

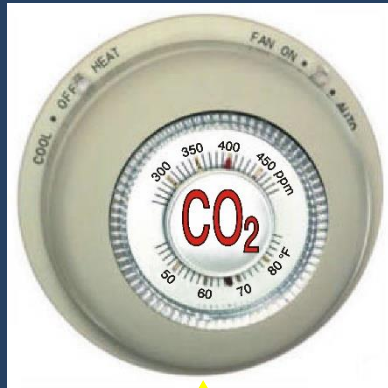
### GROUND-SOURCE HEAT PUMP

This example illustrates under-floor heating. This technology can also be used with radiators. Trenches are usually between 1-2m deep and boreholes between 15-100m, depending on energy needs. The longer the coil, the more energy it produces.



In operation:

- Pagosa Springs
- Glenwood Springs
- Others



## HUMAN RESPONSES

Personal

Family, Friends, Neighbors

Town and City

State

National

International

More Water Vapor  
and Clouds

Warmer Air,  
Warmer Water  
(Global Warming)

Atmosphere  
Biosphere  
Hydrosphere  
Cryosphere  
(Climate Change)

# We'd like the role of Government BUT IT DOES NOT LOOK PROMISING RIGHT NOW?

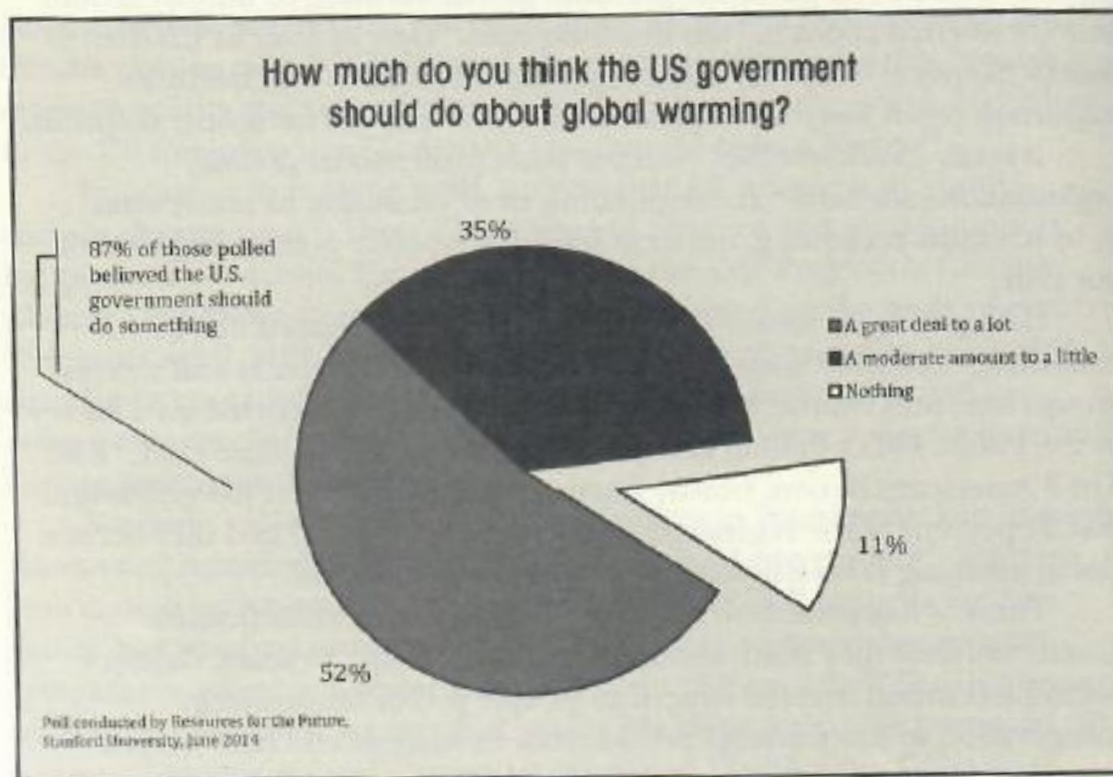


Figure 6.2

# It isn't going to happen right now

## RESPONSES

**State level:** Varies by State

PUCs

Munis/Power companies/Co-ops

**Nations:** Also Varies by Nation

- China proving to be #1
- Europe – especially Germany: also a leader
- U.S. – not so much



# SOLUTION

- VOTE
- SUPPORT YOUR SENATORS AND REPRESENTATIVES SPEAKING OUT
- WRITE/HARRASS THOSE THAT ARE NOT

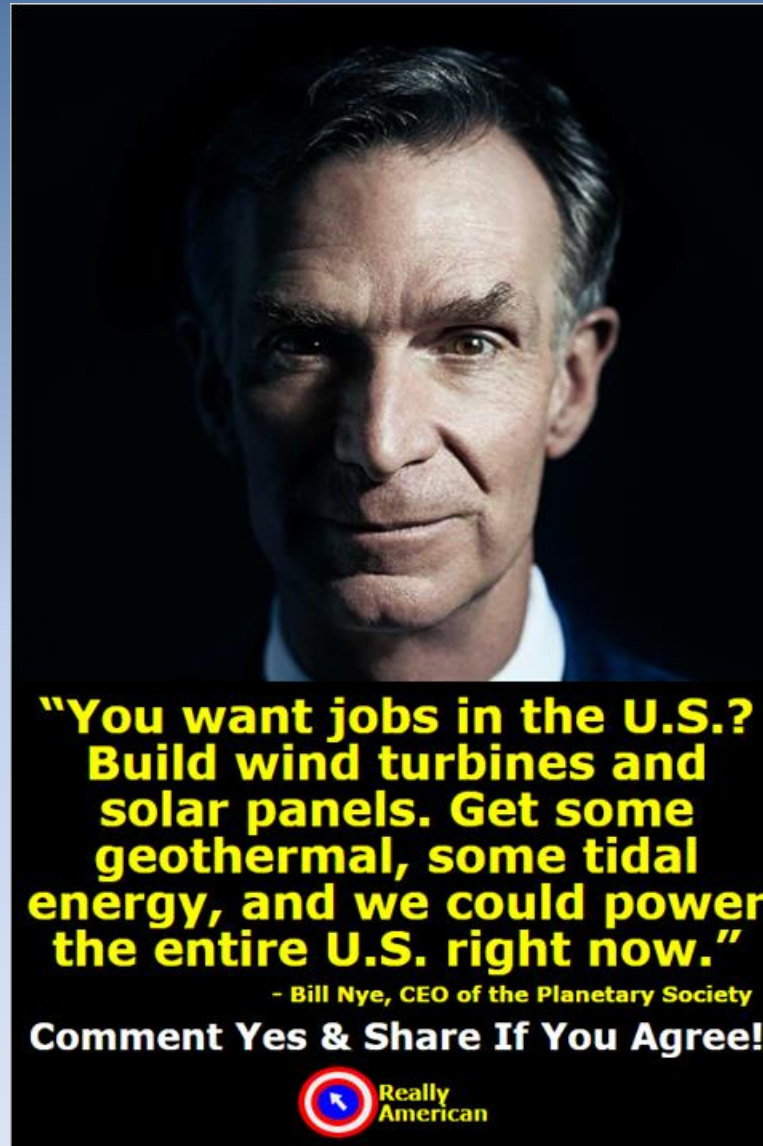
# Senator Bennet

- <https://www.bennet.senate.gov/?p=blog&id=3860>
  - **Bennet Urges President to Rescind Anti-Climate Executive Order:**  
<https://www.bennet.senate.gov/?p=blog&id=3860>

# Rep. Ed Perlmutter

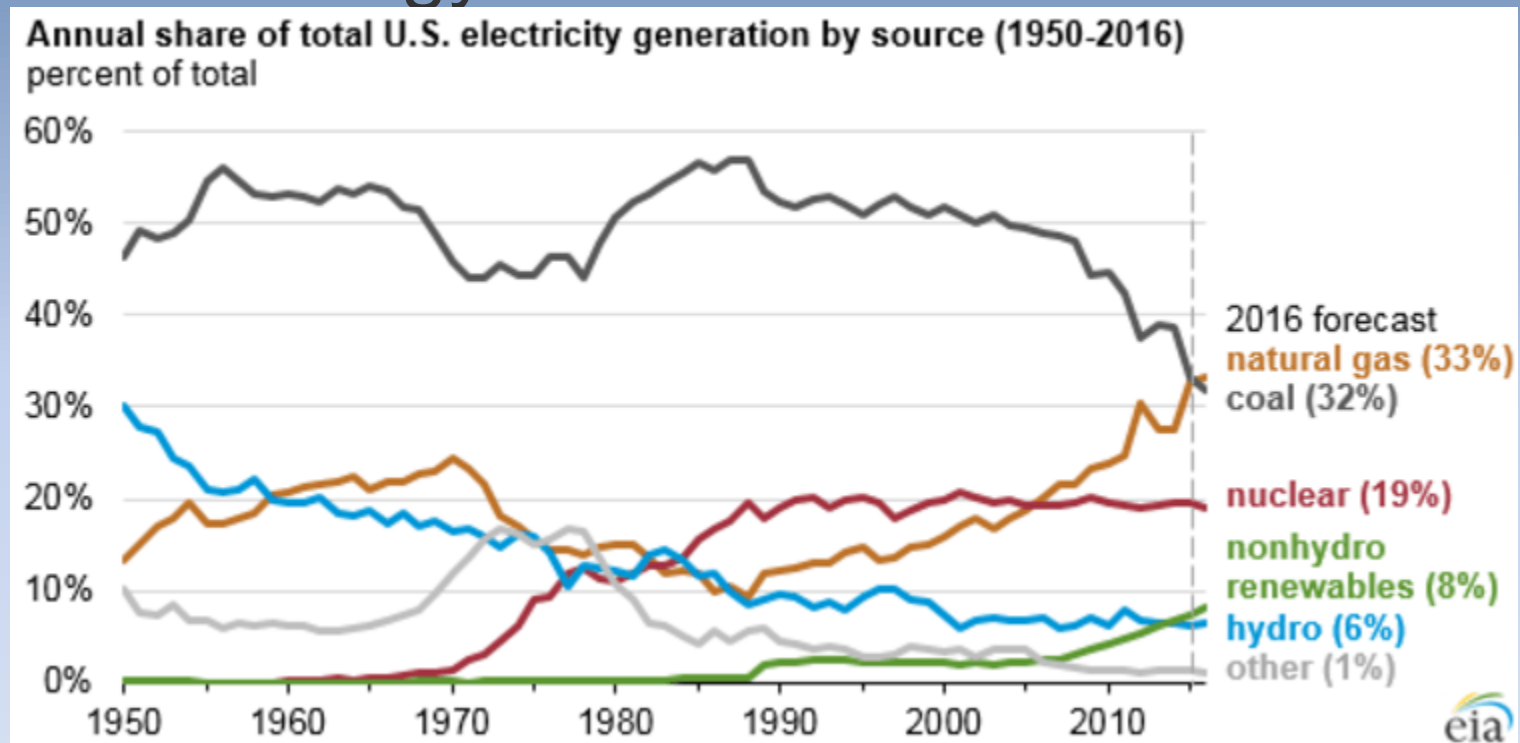
- <http://perlmutter.house.gov/>
- **Perlmutter Responds to Trump's Climate Change Executive Order:**  
<http://perlmutter.house.gov/news/documentsingle.aspx?DocumentID=1671>

# JOB Concerns



# Former Gov. Bill Ritter

- One in 50 new jobs in America is now in solar energy.



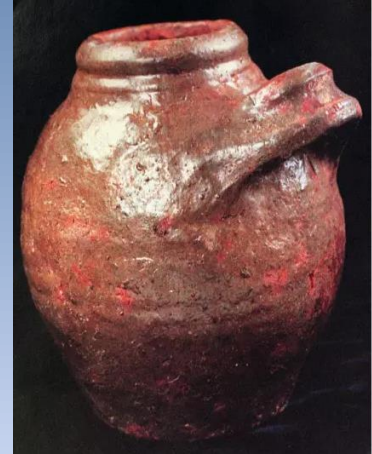
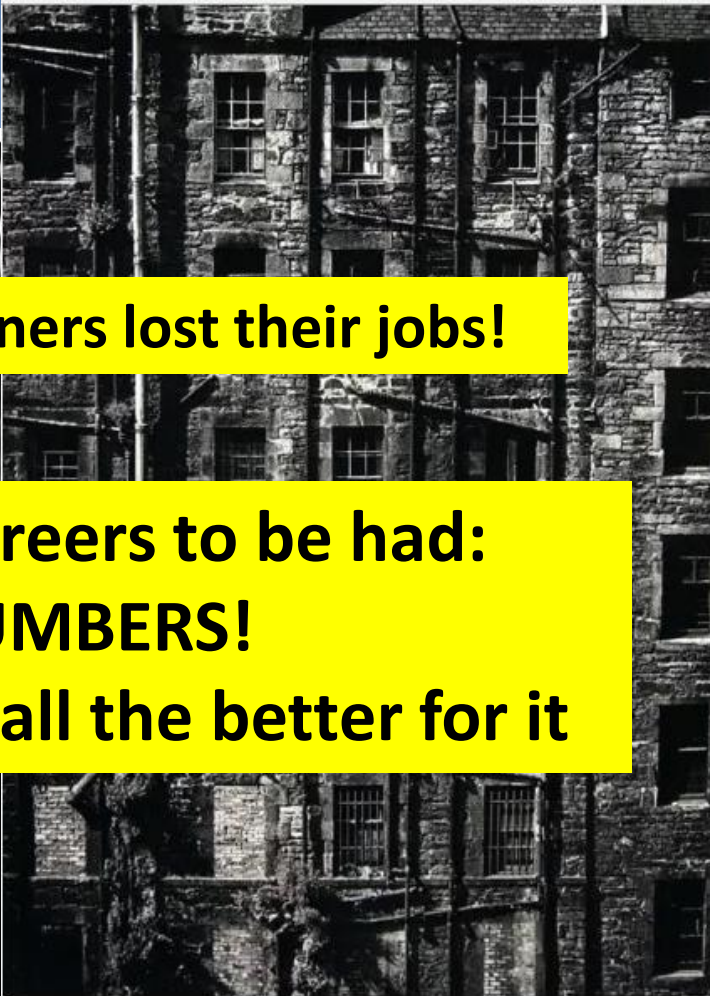
<http://www.coloradoindependent.com/164687/bill-ritter-colorado-clean-energy-trump-coal>

# Gardyloo “Gardez L’eau”: The grim story of unsanitary Edinburgh



**The street cleaners lost their jobs!**

**But new careers to be had:  
PLUMBERS!  
And we were all the better for it**



<http://www.scotsman.com/heritage/people-places/gardyloo-the-grim-story-of-unsanitary-edinburgh-1-4073295>



# JOB Concerns

- NREL could be hit hard by deep cuts to parent agency's budget

<http://www.denverpost.com/2017/04/03/nrel-cuts-trump-budget/>



# Job Concerns

- EPA could be hit hard by deep cuts to parent agency's budget
  - What the West was like before the EPA:
    - <http://www.hcn.org/articles/what-the-west-was-like-before-the-epa>



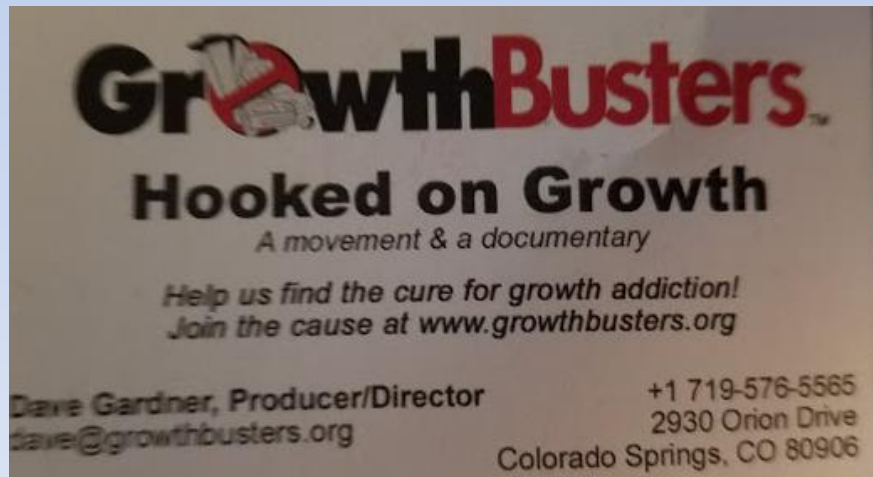
# Is it only about Economics

## SHOULD IT BE?

- Credit to Steve Stevens for reaffirming the following thoughts:
  - Well ... I hope it is not only for the economics
  - I Hope we are caring about Future Generations
  - For Nature,
  - For Human Values ....

# Herman Daly: Steady State Economics Limits to Growth

- Alec Tsoucatos teaches these concepts at Regis and OLLI West class winter 2017
- Growth Busters



Jefferson County Open School  
4/22/2017

# BECOME AN ACTIVIST

## Get Involved

- April 22<sup>nd</sup>: Earth Day Activities
- April 29<sup>th</sup> March;  
<https://actionnetwork.org/events/peoples-climate-march-on-denver-2?source=facebook&>
- Join Citizens Climate Lobby
  - Here at JUC 2<sup>nd</sup> Saturday 10 a.m.
  - TOMORROW April 8th

# Jim Hansen, Bill McKibben among others: activists



Jim Hansen

[https://en.wikipedia.org/wiki/James\\_Hansen](https://en.wikipedia.org/wiki/James_Hansen)  
<http://www.columbia.edu/~jeh1/>



**BILL MCKIBBEN**  
AUTHOR. EDUCATOR. ENVIRONMENTALIST.

<https://350.org/>



**March 24, 2017**

## Common Dreams | Colorado Youth Score Decisive Legal Victory Against Fracking Industry



Xiutezcatl Martinez, 16-year-old plaintiff and youth director of the Boulder-based Earth Guardians,

<https://www.ourchildrenstrust.org/news>

# So a little more on Citizens Climate Lobby

## Guiding Principles

- Politicians don't create political will, they respond to it.
- The **bipartisan** carbon fee and dividend policy is a simple, transparent policy to address the climate crisis.
- CCL volunteers show respect for diverse views and appreciation for the work of others.

# Strategies

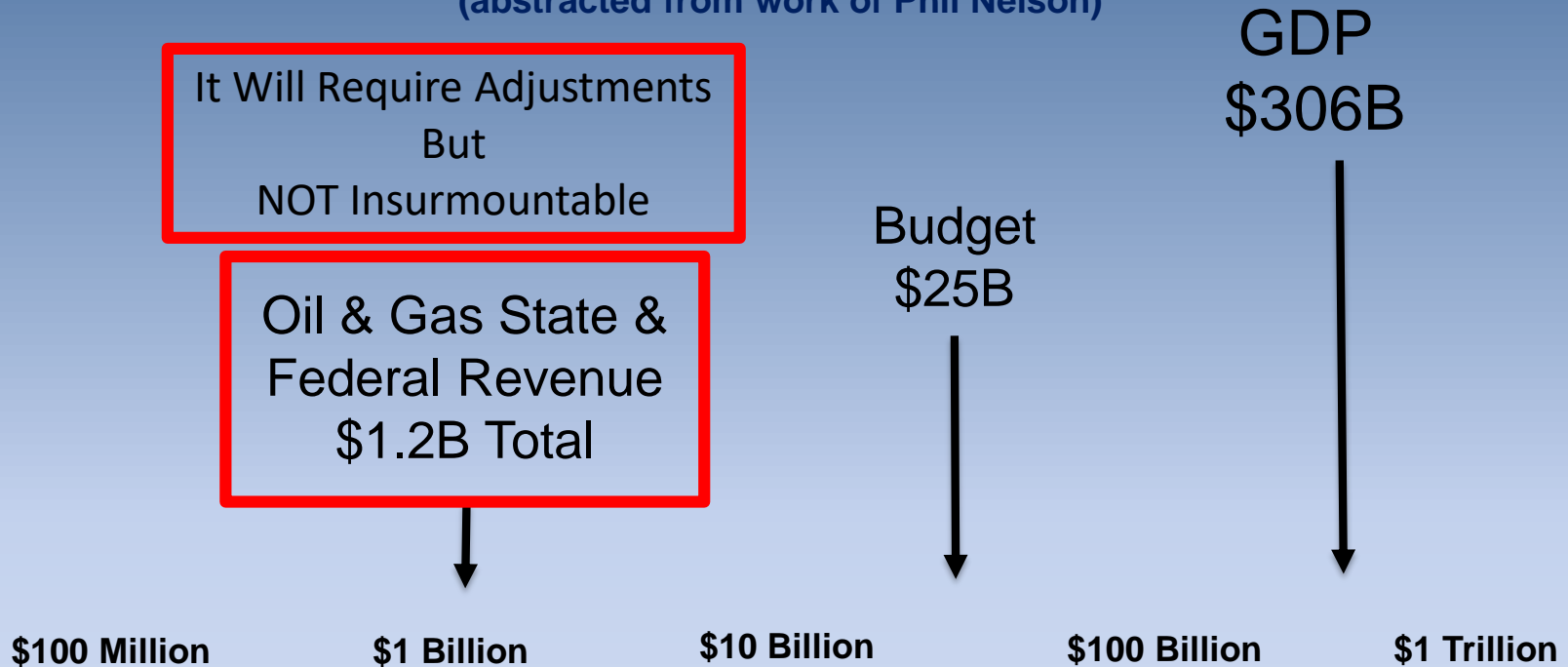
CCL Website: [www.citizensclimatelobby.org](http://www.citizensclimatelobby.org)  
<https://www.facebook.com/CitizensClimateLobbyDenverChapter>

- Lobbying
- Writing
- Educating
- Building Partnerships

**JOIN US HERE TOMORROW April 8<sup>th</sup>  
10:30 A.M.**

# Concerns about Colorado Economy and Fossil Fuels?

(abstracted from work of Phil Nelson)



Oil, gas, & coal revenues within Colorado economy in 2014

# The Transition to Renewable Energy and The Colorado Economy

- Colorado economy is robust and diverse
- Colorado fossil fuel industry has a modest impact on state economy
- Colorado is a magnet for the renewable energy industry
- Colorado economy can adjust to gradually declining fossil fuel industry

# Fossil Fuel Industry in Colorado: 2014 Summary

(abstracted from work of Phil Nelson)

Oil and gas contributed **4% of state revenues** in 2014.

**Employment in clean-tech (23,400) closing in on that of oil and gas (38,650).**

Colorado distributes funds to counties impacted by oil and gas drilling.

Tax revenues from oil and gas are distributed to a variety of entities, as determined by legislation.



# Web Links Energy/Other

- **U.S. Energy Information Administration** <https://www.eia.gov/>
- **CRES** <https://www.cres-energy.org/>
  - YouTube <https://www.youtube.com/channel/UCr81EUb2qVJVfmmIIMxEHVw>
  - NREL Presentation: GREG WILSON  
<https://www.youtube.com/watch?v=7CDPHxcnq4c&t=23s>
  - Governor Ritter Presentation  
<https://www.youtube.com/watch?v=agowW1QKwms&t=6s>
- <https://skepticalscience.com/How-Green-is-My-EV.html>
- <http://energysouldbe.org/>
  - Why Storage is Key for a Renewable Energy Future:  
[https://www.youtube.com/watch?v=Yc\\_hULwykvQ&t=13s](https://www.youtube.com/watch?v=Yc_hULwykvQ&t=13s)
  - Clean Energy through Open Electricity Markets:  
<https://www.youtube.com/watch?v=seGwTKTm38A>

# In closing

**“ASK NOT WHAT YOU OUGHT TO DO, RATHER ASK WHAT YOU MUST DO!”**  
**(attributed to a philosopher – please let me know who)**

**AND**

**For those that say “it can’t be done” I say: Stay out of the way of those that are  
DOING IT!**

# What if?



# Acknowledgments

- OLLI West for giving me to opportunity to give this talk
- Ron Larson
- Phil Nelson, CCL
- Kathleen Wells, CCL
- Steve Stevens
- Martin Voelker, CRES
- All my colleagues committed to future Sustainability
- And anyone else I've omitted



[https://i.kinja-img.com/gawker-media/image/upload/t\\_original/ihsllhptnnm4vb7wuvqq.jpg](https://i.kinja-img.com/gawker-media/image/upload/t_original/ihsllhptnnm4vb7wuvqq.jpg)

**Paul Belanger**

**<http://denverclimatestudygroup.com/>**

**<https://www.facebook.com/denverclimatestudygroup/>**  
**[pebelanger@glassdesignresources.com](mailto:pebelanger@glassdesignresources.com)**

**c. 303-249-7966;**