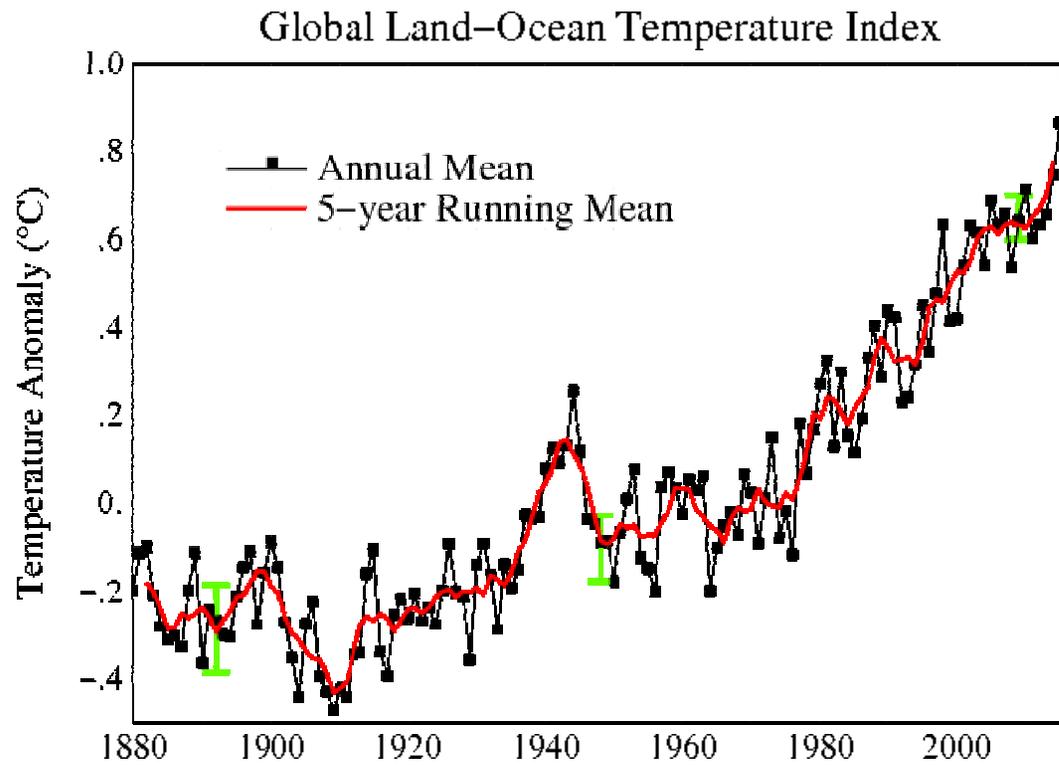


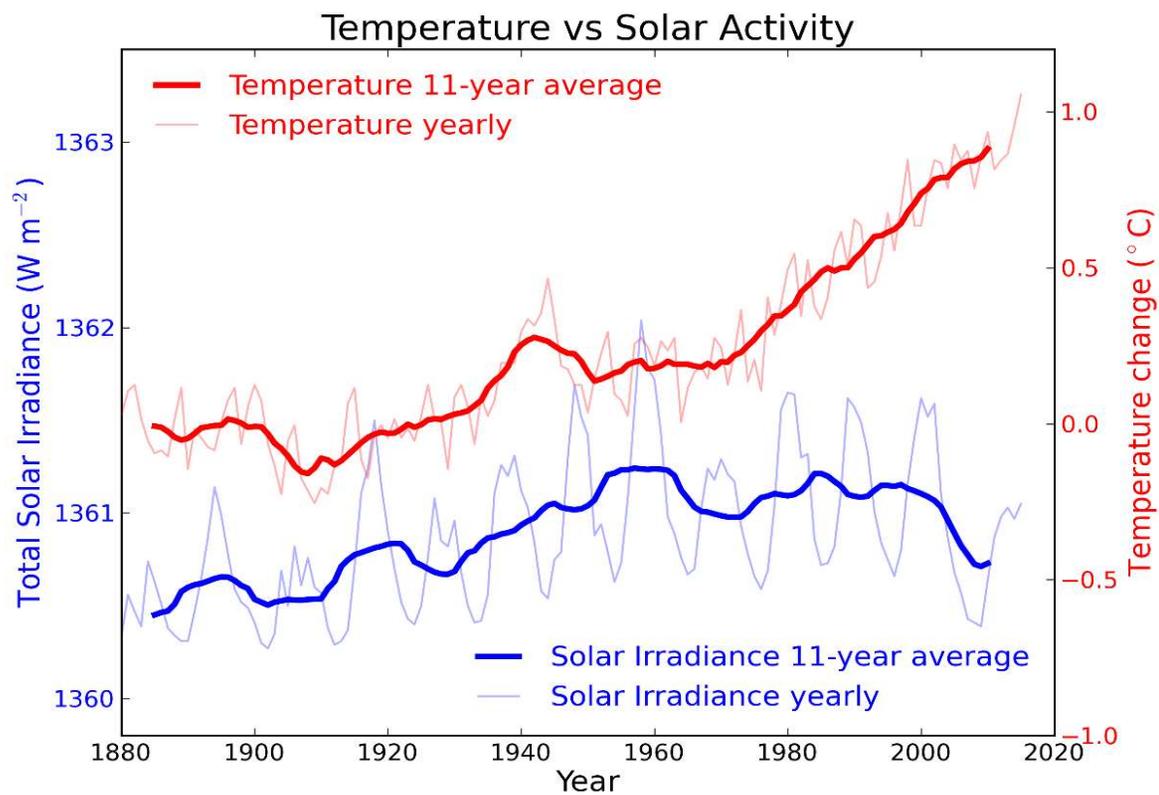
Global Warming caused by Human Activity  
Michael F. Patterson, P.E.  
Pine Creek Environmental Engineering

- Topic #1: Greenhouse gases and Global Warming caused by human activity.  
16 slides 24 minutes
- Topic #2: Measuring heat content in the upper 2000 meters of the oceans.  
6 slides 6 minutes
- Topic #3: Sea ice melting, drought, wildfires, and flooding associated with a warmer troposphere.  
5 slides 3 minutes
- Topic# 4: Human population that has tripled since 1950 and factory farming of livestock.  
6 slides 3 minutes
- Topic #5: Graphics and comments for Renewable Energy, Carbon energy, and a CO<sub>2</sub> Emissions Tax  
12 slides 10 minutes

Since 1975 global surface air temperatures have risen by  $1.8^{\circ}\text{F} = 0.45^{\circ}\text{F}$  per decade.



Since 1975 the ocean has been warming while the heat input from the sun has been decreasing.

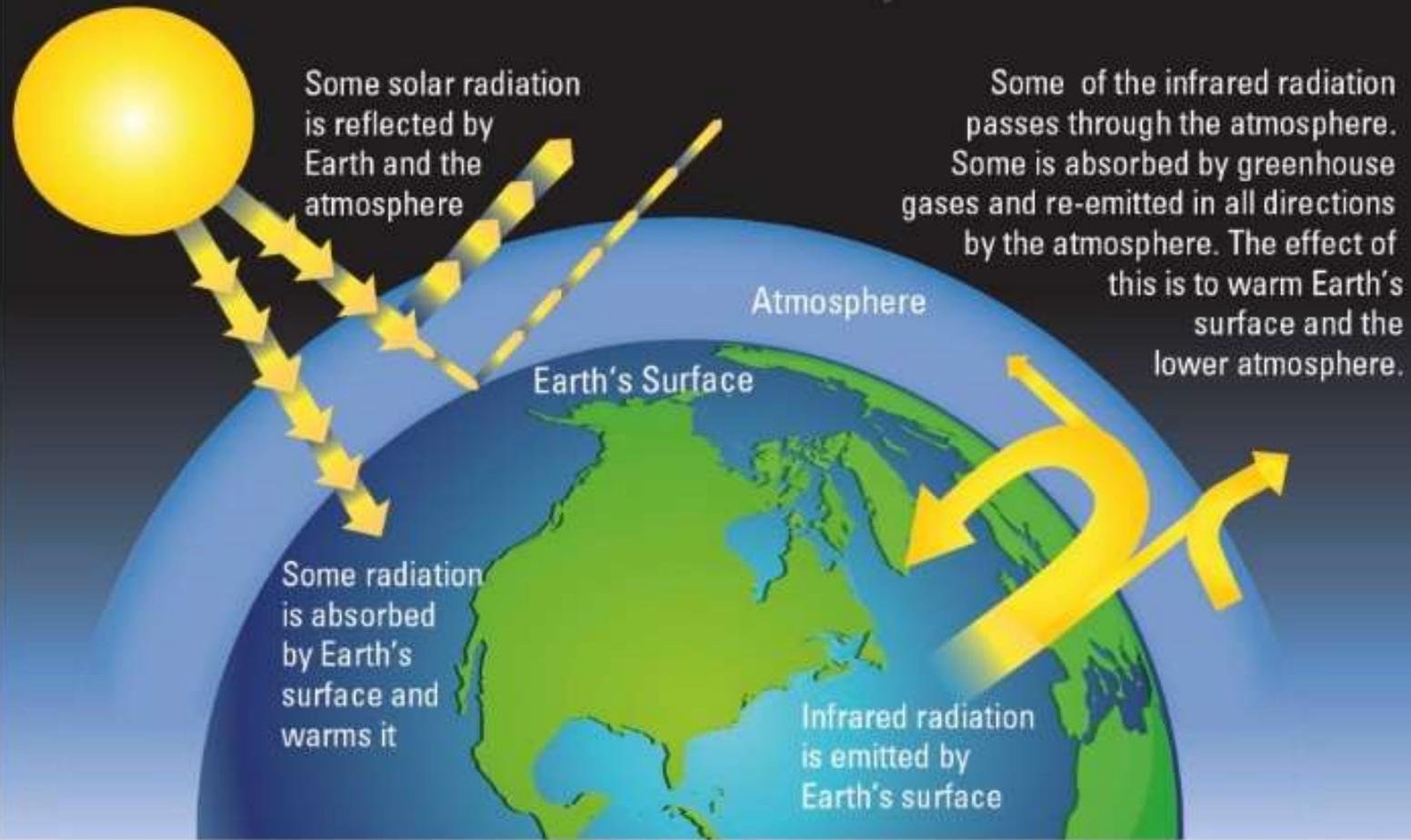


Question # 1 on Global Warming caused by human activity

What is the current rate of global surface warming expressed as °F per decade?

- (a) 0.65    (b) 1.5    (c) 0.15    (d) 0.45    (e) 0.85

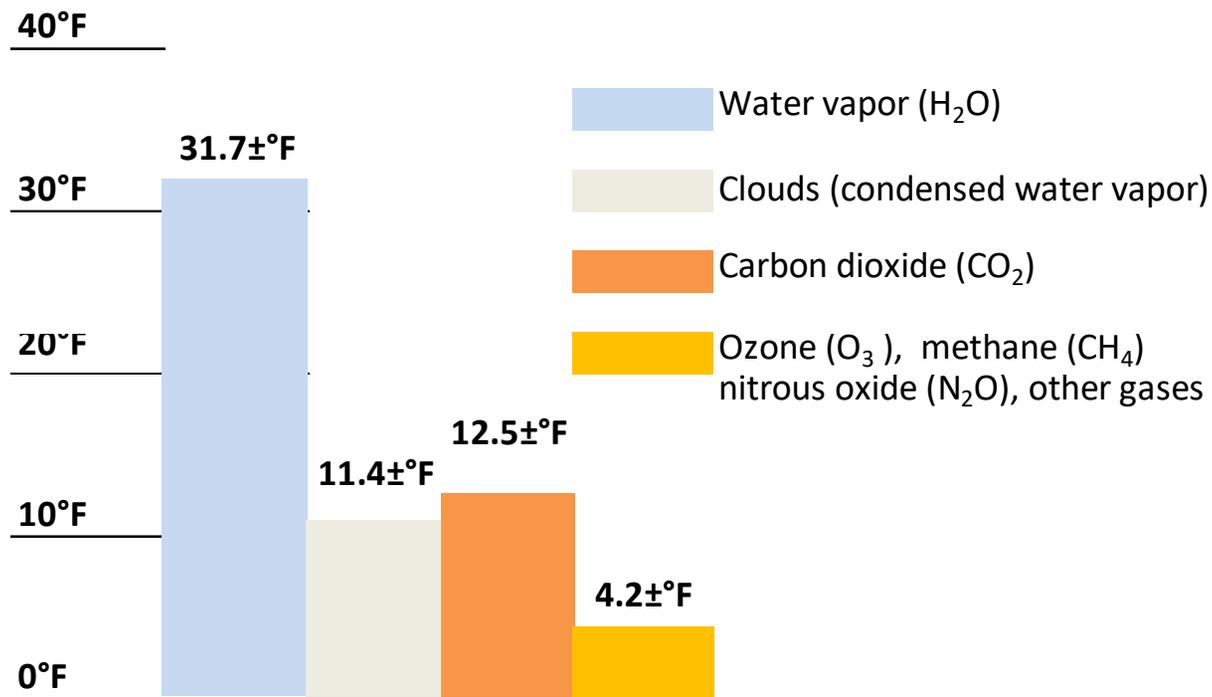
# THE GREENHOUSE EFFECT



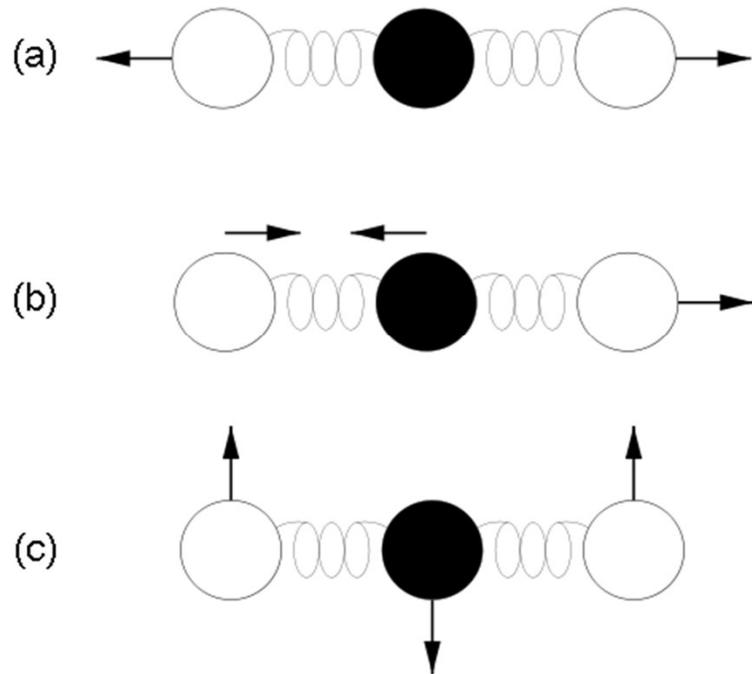
Global surface air temperature without warmth from greenhouse molecules =  $-2.8^{\circ}\text{F}$

Temperature contributions from greenhouse molecules provide  $59.8^{\circ}\text{F}$  of warmth.

5-year average GISS global mean surface air temperature for years 2012- 2017 =  $57^{\circ}\text{F}$



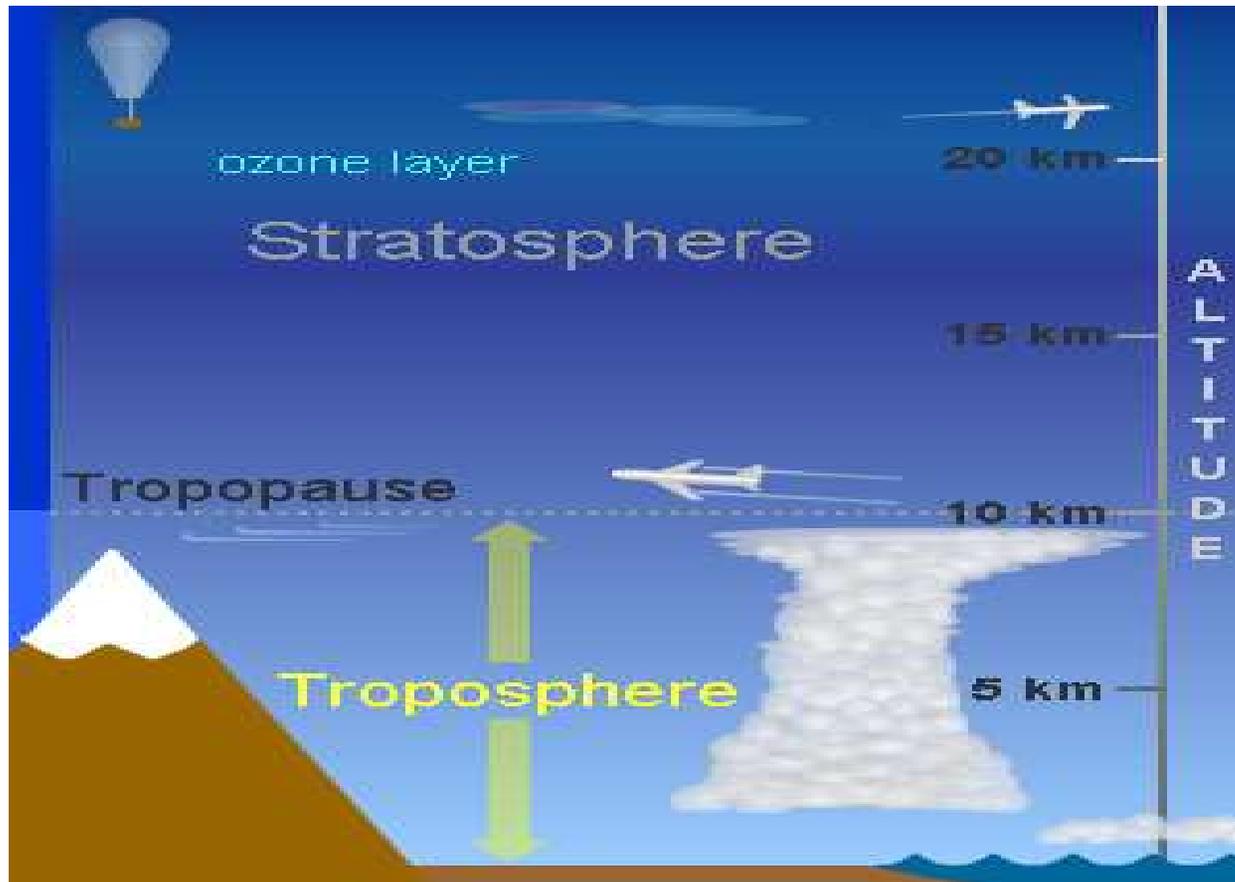
The most significant greenhouse molecules are  $\text{H}_2\text{O}$  (water) ,  $\text{CO}_2$  (carbon dioxide) ,  $\text{N}_2\text{O}$  (nitrous oxide) , ozone ( $\text{O}_3$ ) and  $\text{CH}_4$  (methane) .



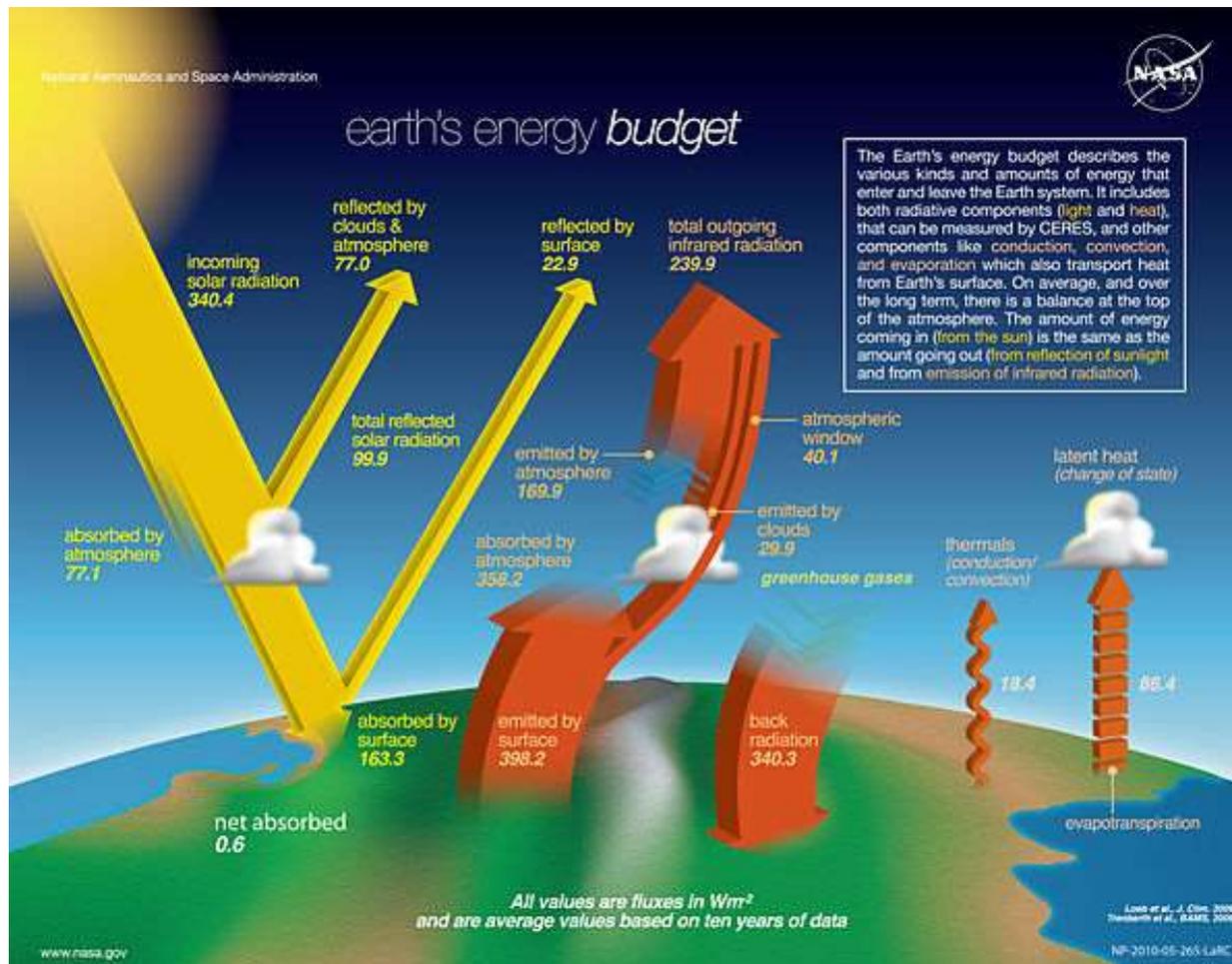
Detecting methane leaks from a natural gas pipeline valve. Infrared detector inside the blue casing is selective to methane



Greenhouse gases keep New Delhi (India) 100°F warmer than the top of Mt. Everest (Nepal)



Current warming of ocean and surfaces requires a miniscule 0.38% of the solar power being absorbed by these surfaces.

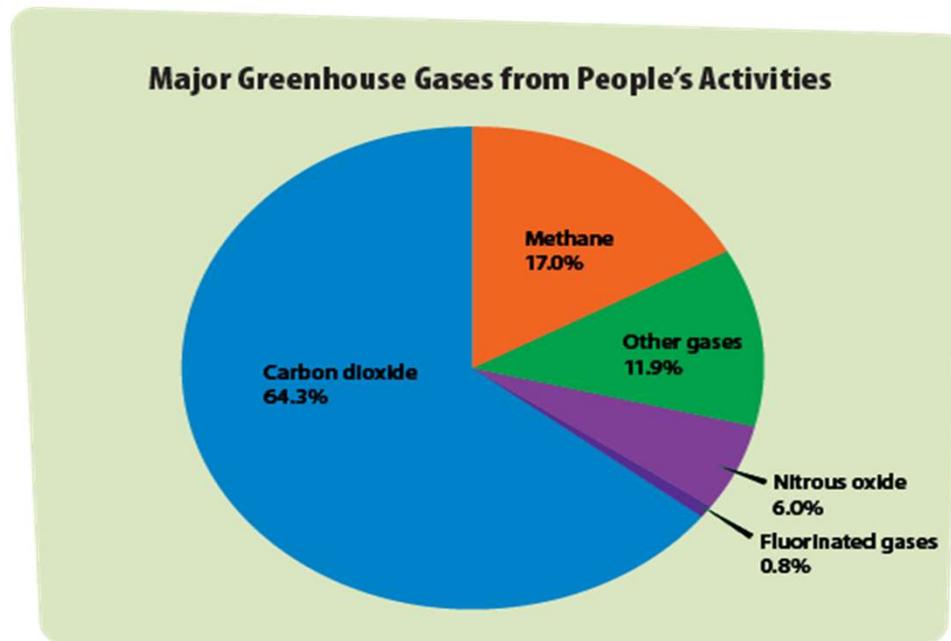


## Question # 2 on Global Warming caused by human activity

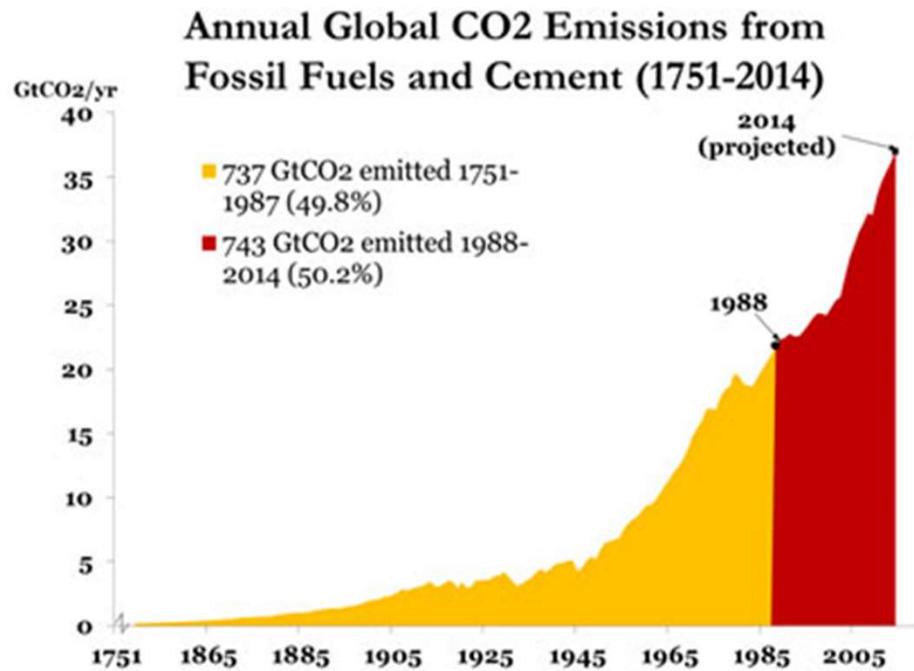
What percentage of the absorbed solar energy is not being radiated to outer space?

- (a)  $\pm 0.032\%$    (b)  $\pm 0.083\%$    (c)  $\pm 0.83\%$    (d)  $\pm 0.38\%$    (e)  $\pm 1.42\%$

Most of these greenhouse gases will remain in the atmosphere for hundreds of years.

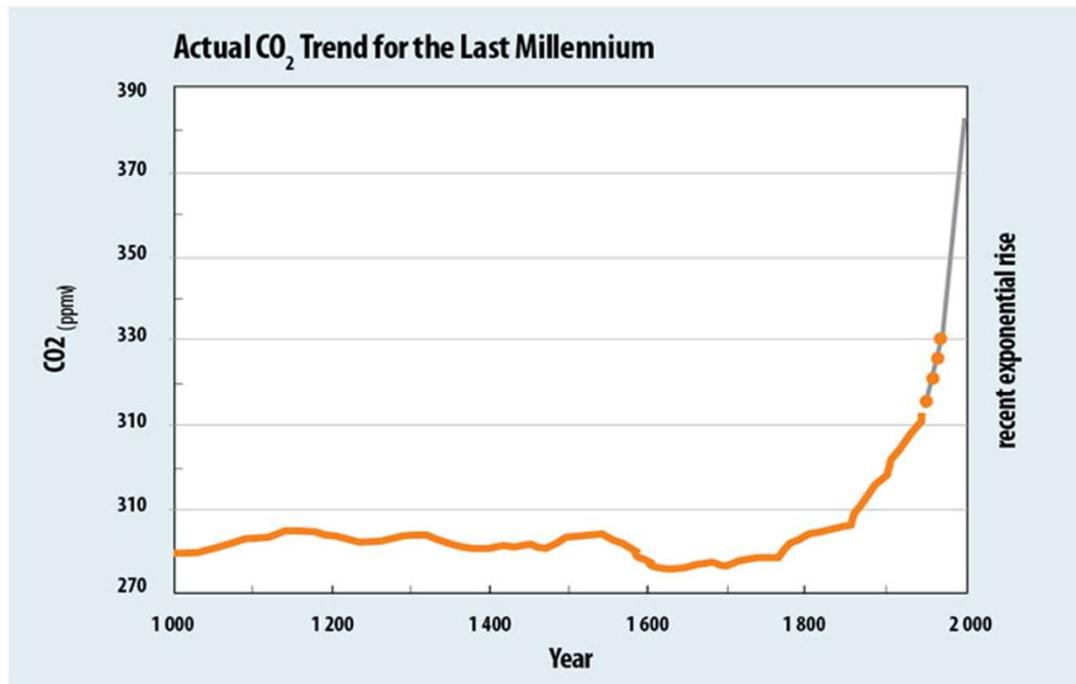


Since 1950 fossil carbon CO<sub>2</sub> emissions have **increased by a factor of seven.**

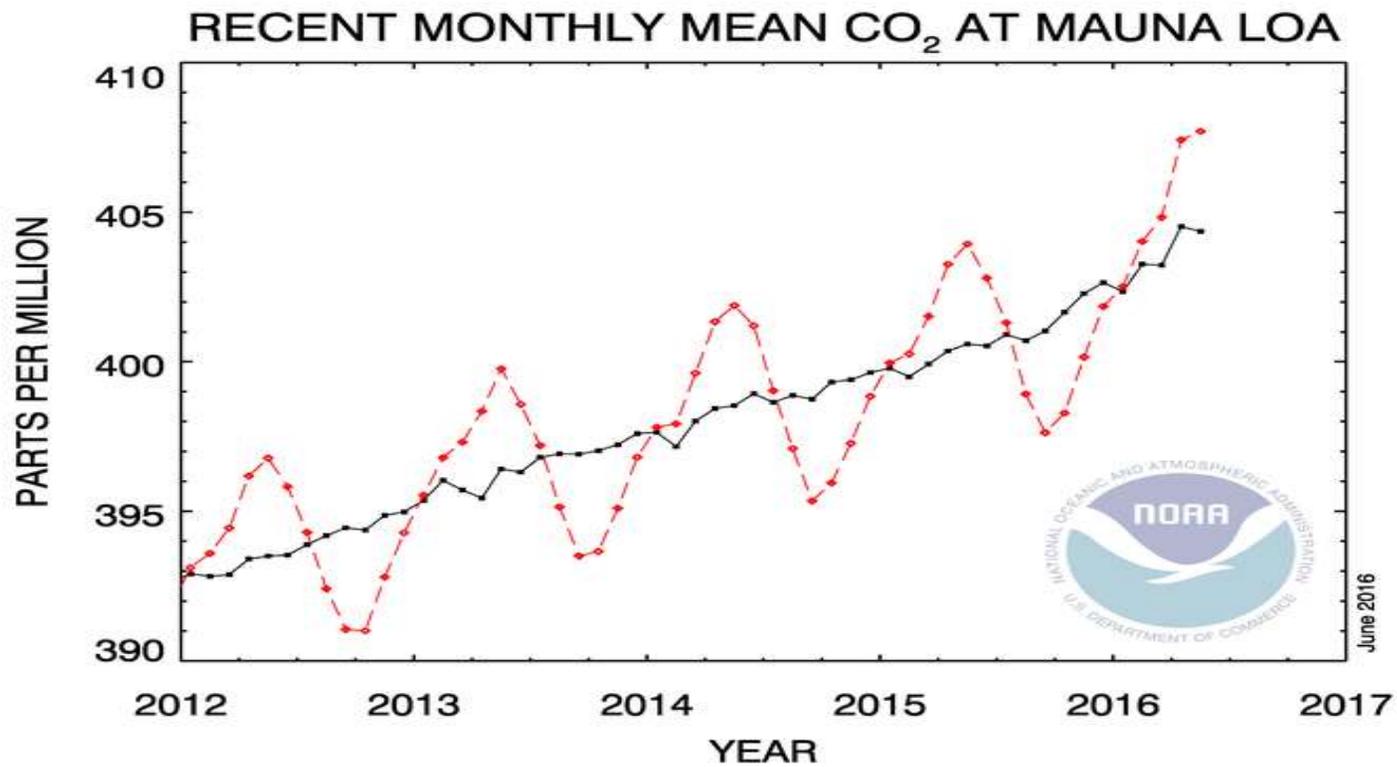


Since year 1800 atmospheric CO<sub>2</sub> concentration has increased by 35%.

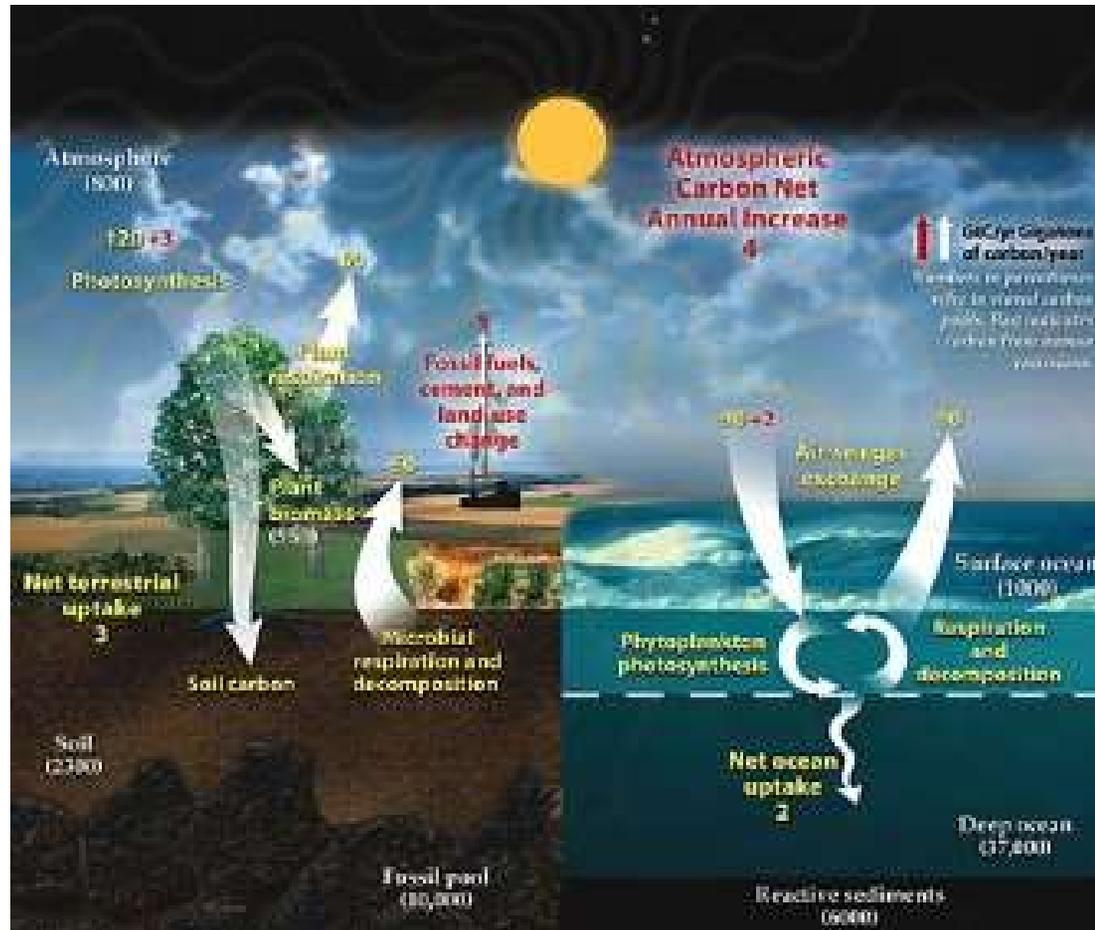
Figure 4.



Atmospheric CO<sub>2</sub> in the northern hemisphere is now rising at over 4 parts per million per year.  
This is equivalent to an increase of 1% per year.



Approximately 45 % of fossil fuel CO<sub>2</sub> emissions are being stored in the atmosphere.  
 Ocean is absorbing 22%, land surfaces 33%.

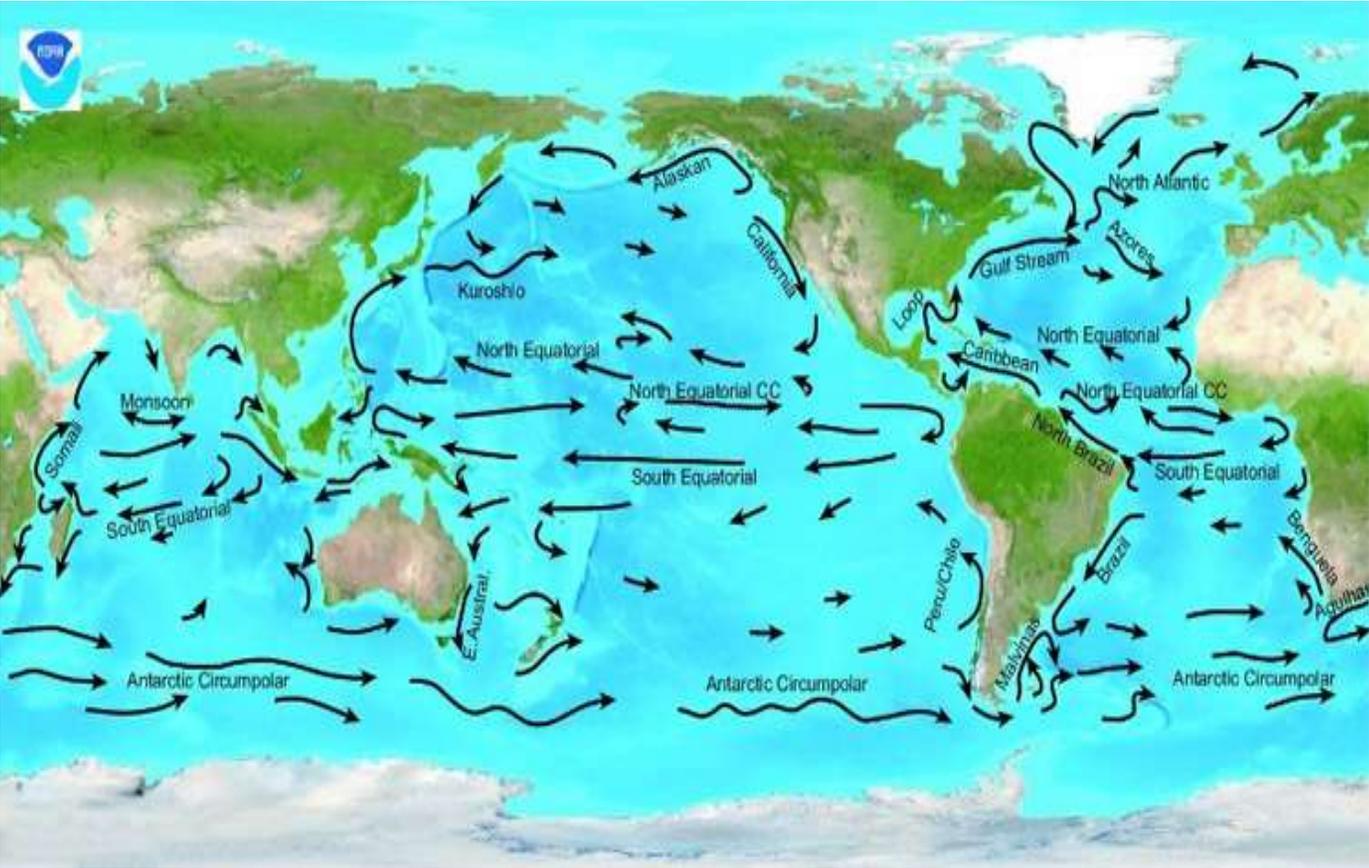


Question # 2 on Global Warming caused by human activity

What percentage of fossil carbon CO<sub>2</sub> emissions are presently being absorbed by the oceans?

- (a) ±5%    (b) ±33%    (c) ±22%    (d)± 16%    (e) ±55%

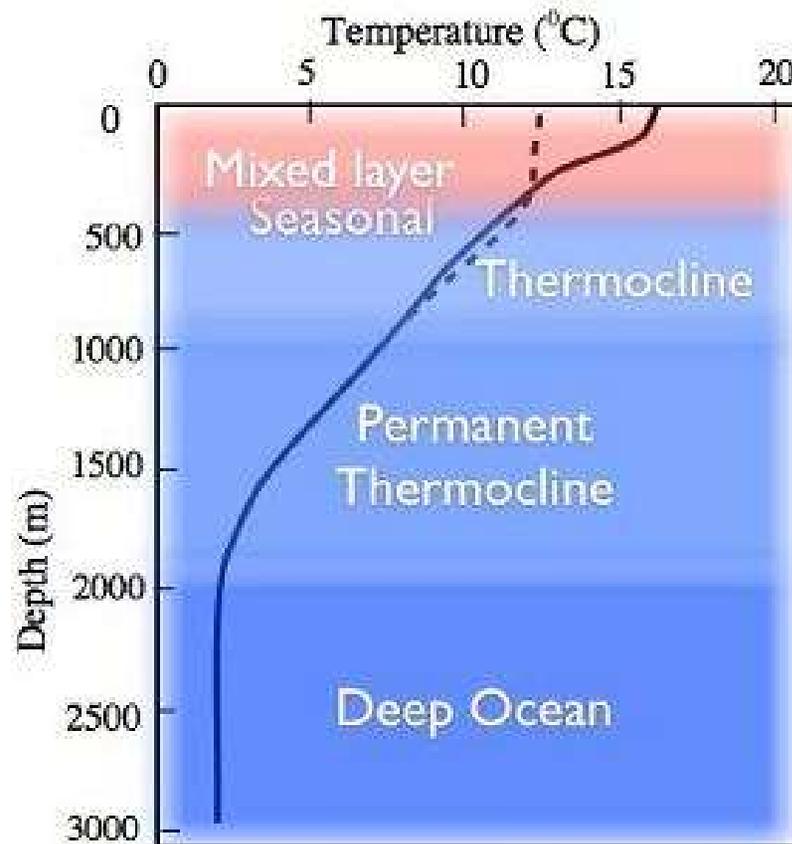
Currents in the upper ocean distribute heat absorbed from the sun



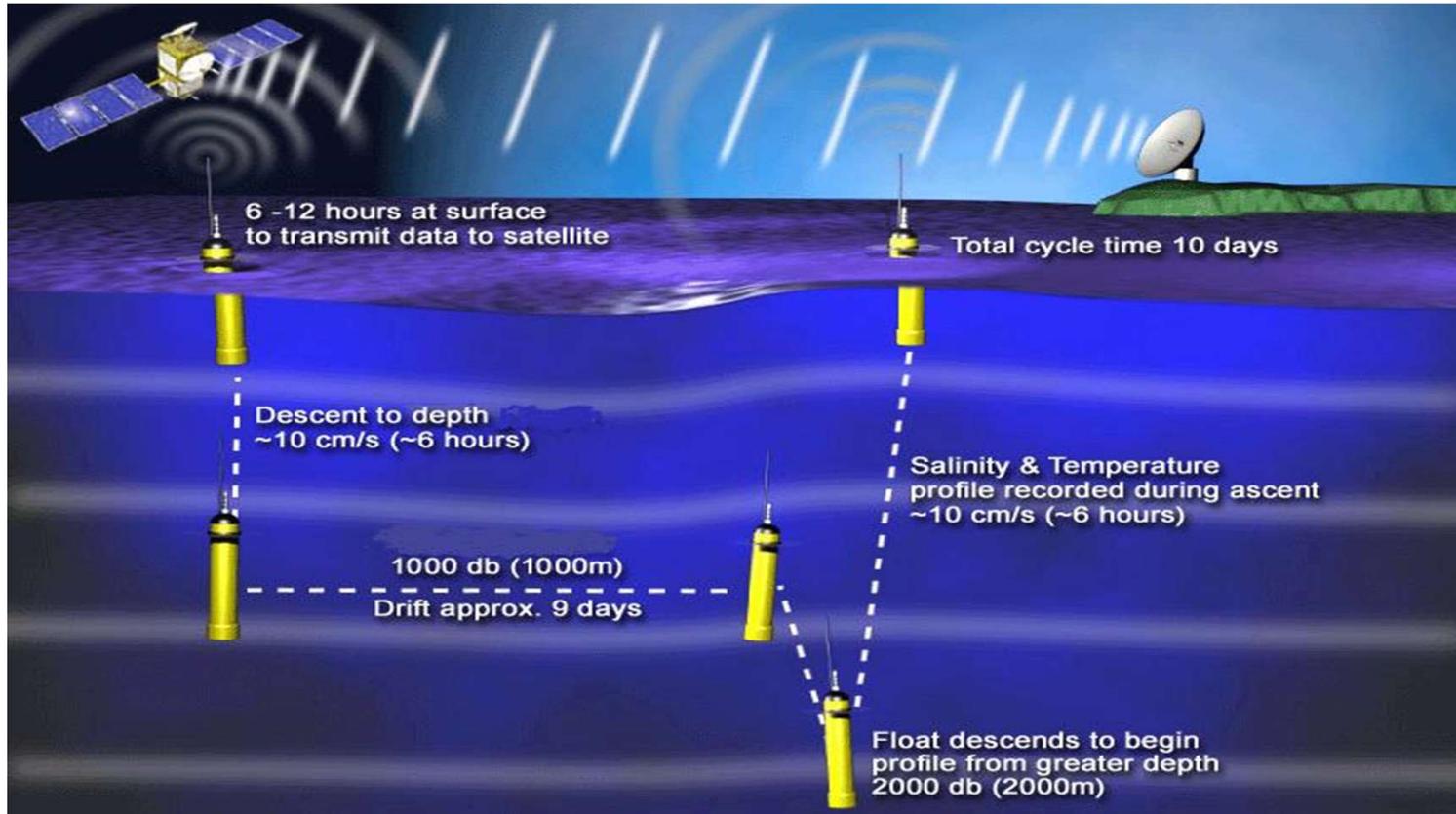
Scientists are measuring the rate of increase in heat content of the upper 2000m of the ocean.



Heat capacity of the first 2.4 meters of the ocean surface Mixed layer Seasonal is equivalent to the heat capacity of the entire atmosphere.



ARGO sensors have a cycle time of 10 days



Does anyone care about the bottom of the ocean?



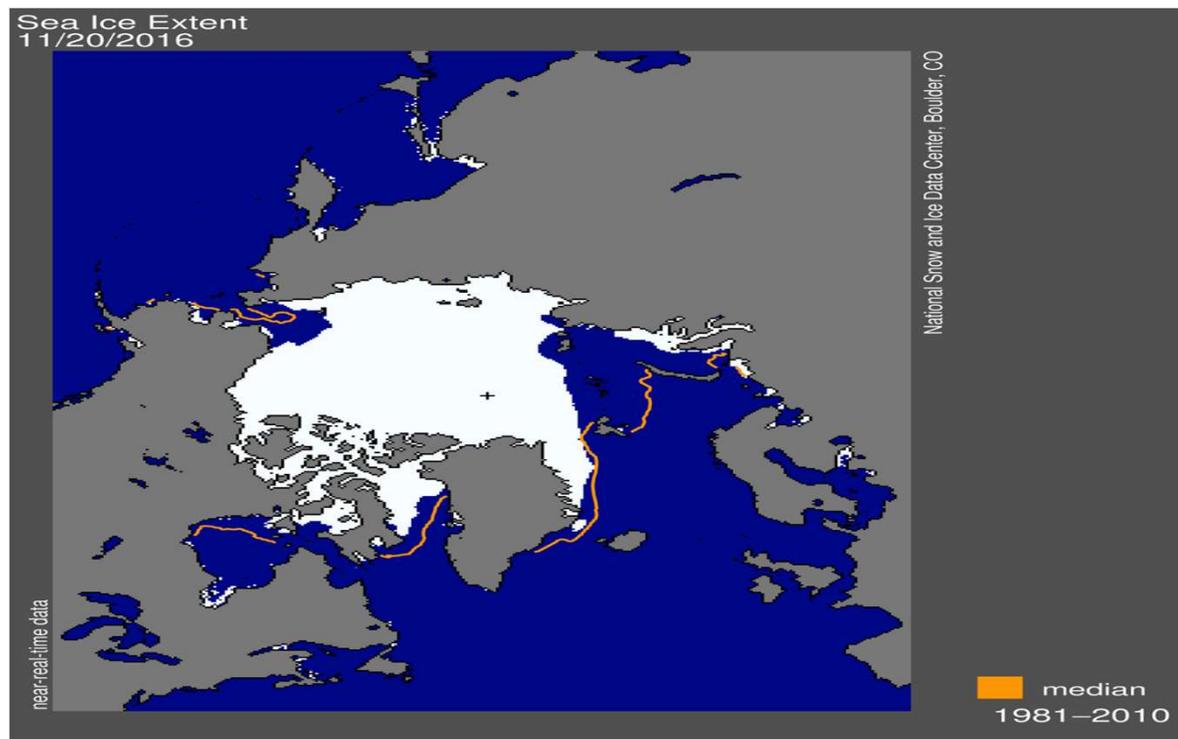
*"I don't know why I don't care about the bottom  
of the ocean, but I don't."*

Question # 4 on Global Warming caused by human activity

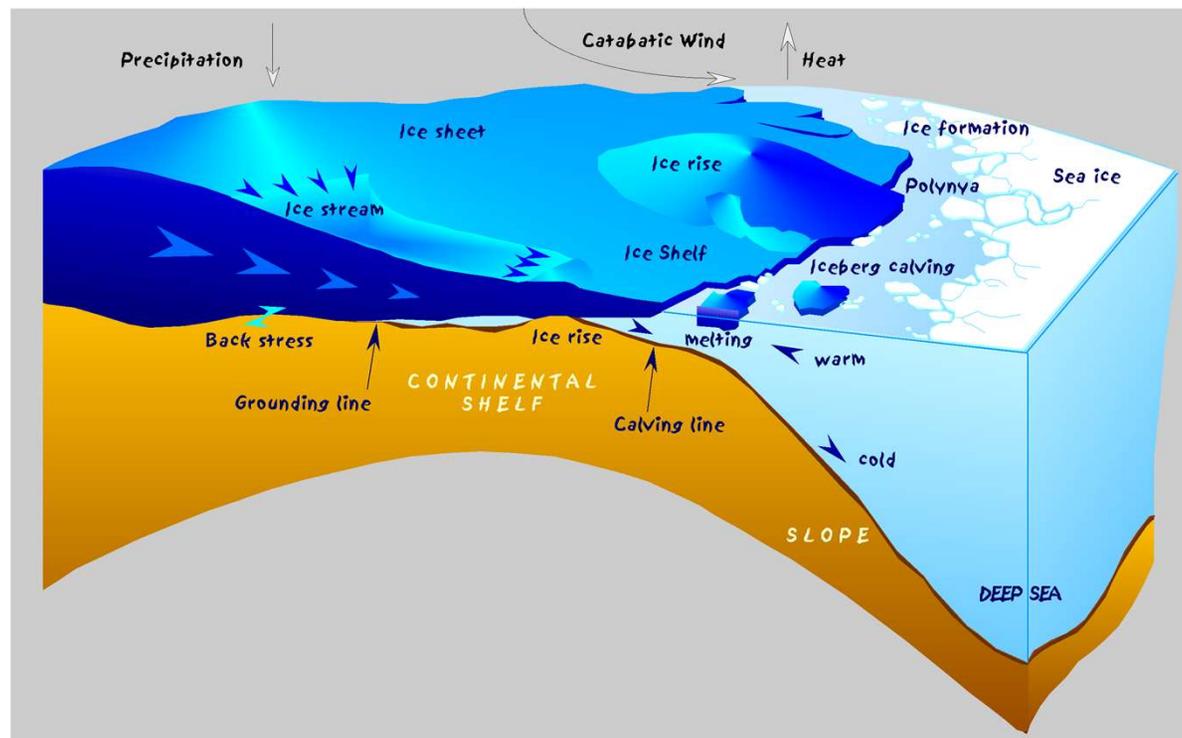
What depth of the ocean's Mixed layer Seasonal has the same heat capacity as the atmosphere?

- (a)  $\pm 2.4$  m    (b)  $\pm 7.2$ m    (c)  $\pm 1.2$ m    (d)  $\pm 10.2$ m

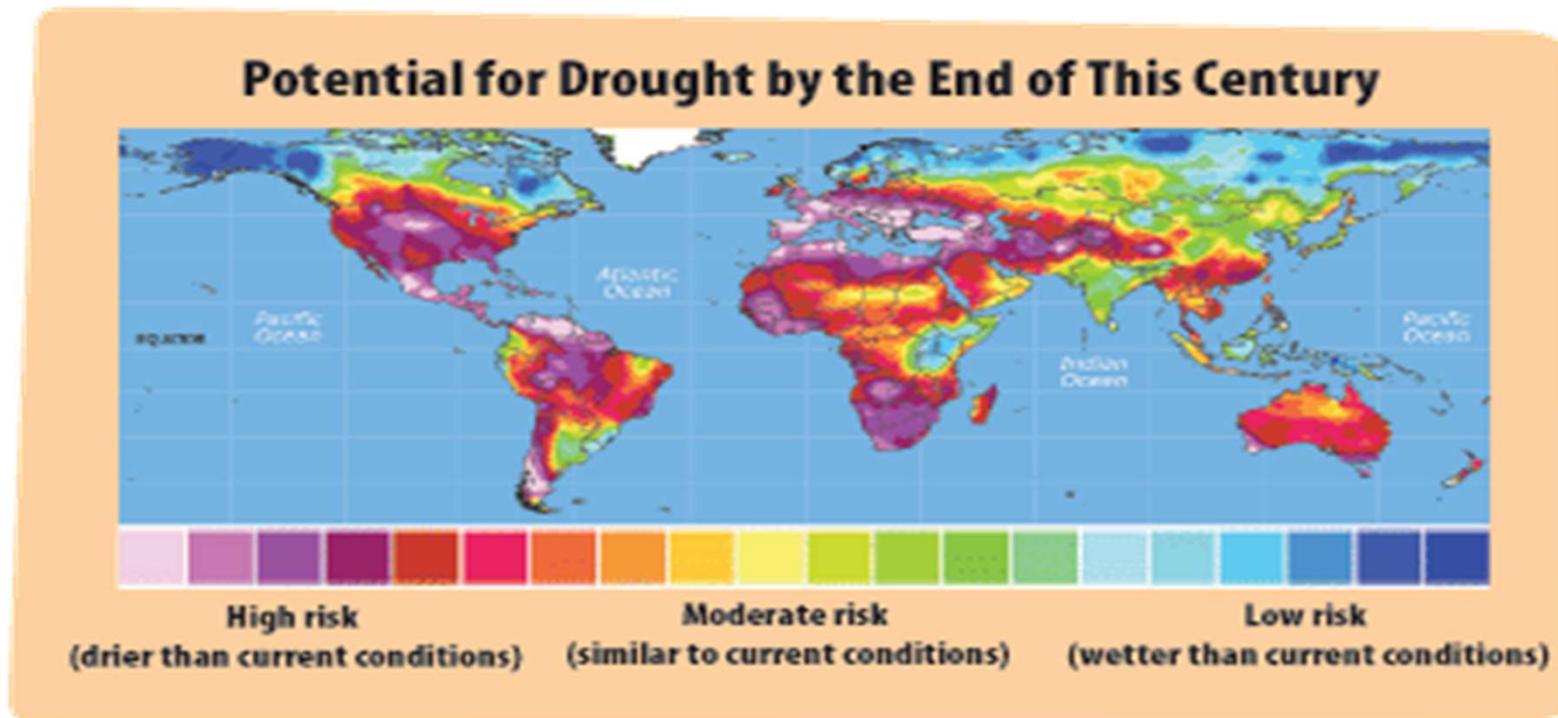
Since year 2010 there has been a 25% reduction in the November ice floating on the Arctic Ocean



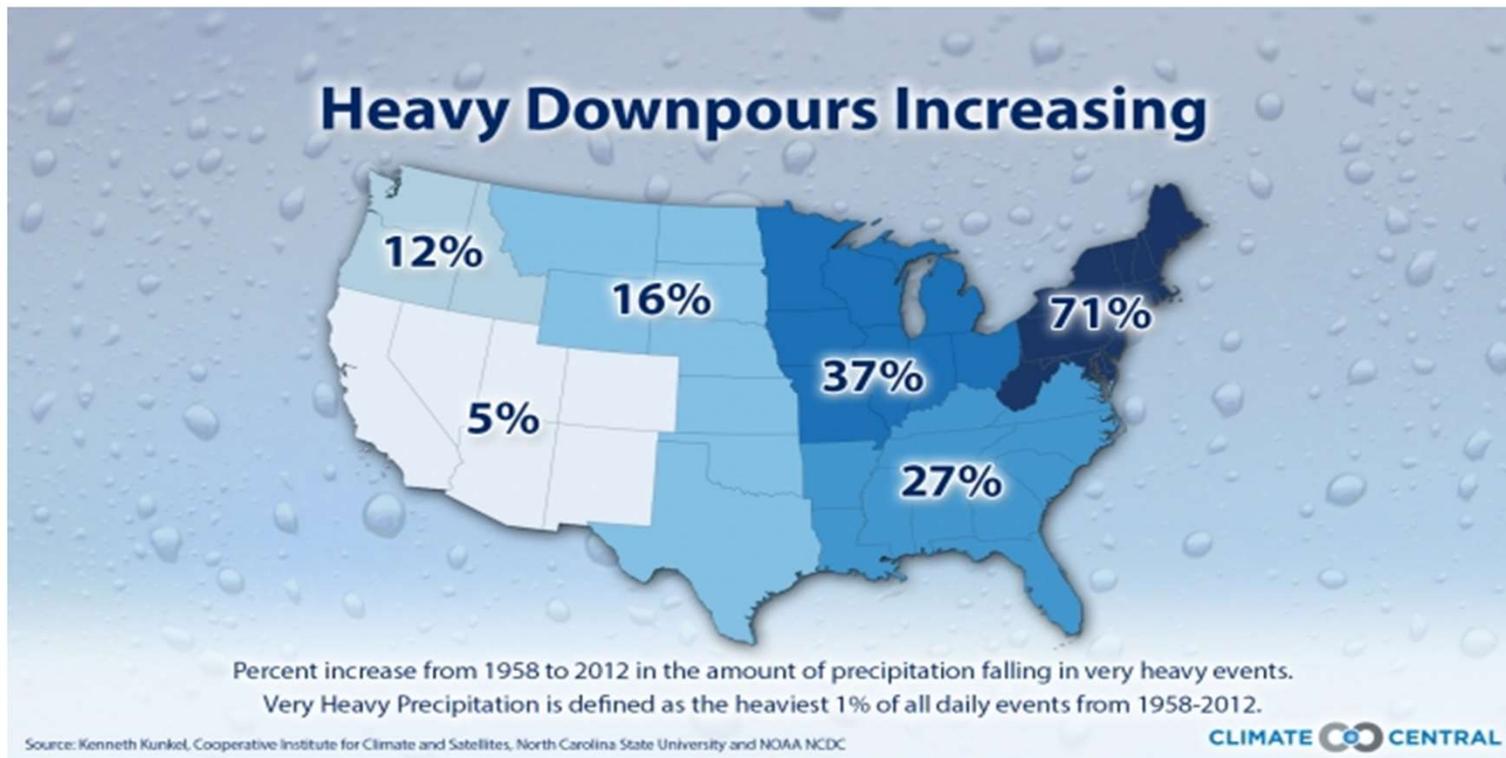
The warming ocean is melting the underside of the ice connecting the Antarctica Larsen ice shelf to the west side of the continent of Antarctica



Warmer winds are expected to create more drought



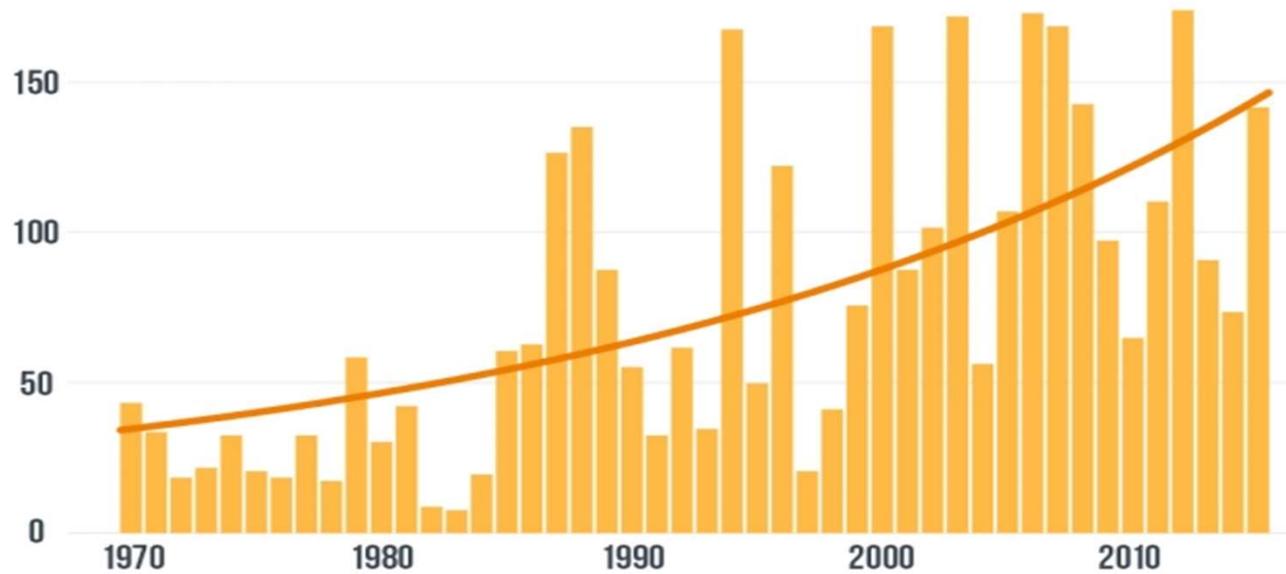
Warmer clouds contain more moisture and create intense rainfall that causes flooding



Drier ground is more subject to wildfire

## Large Wildfires Increasing Across the West

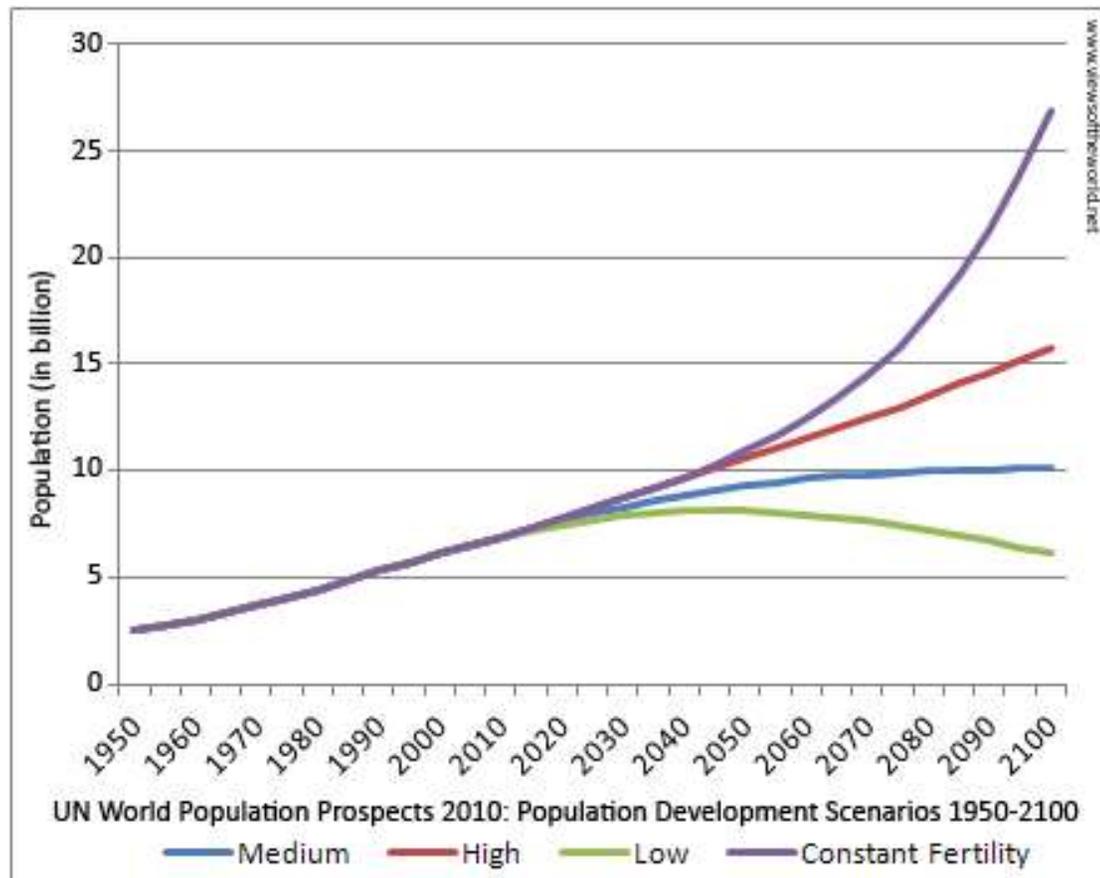
Number of fires larger than 1,000 acres per year on U.S. Forest Service land



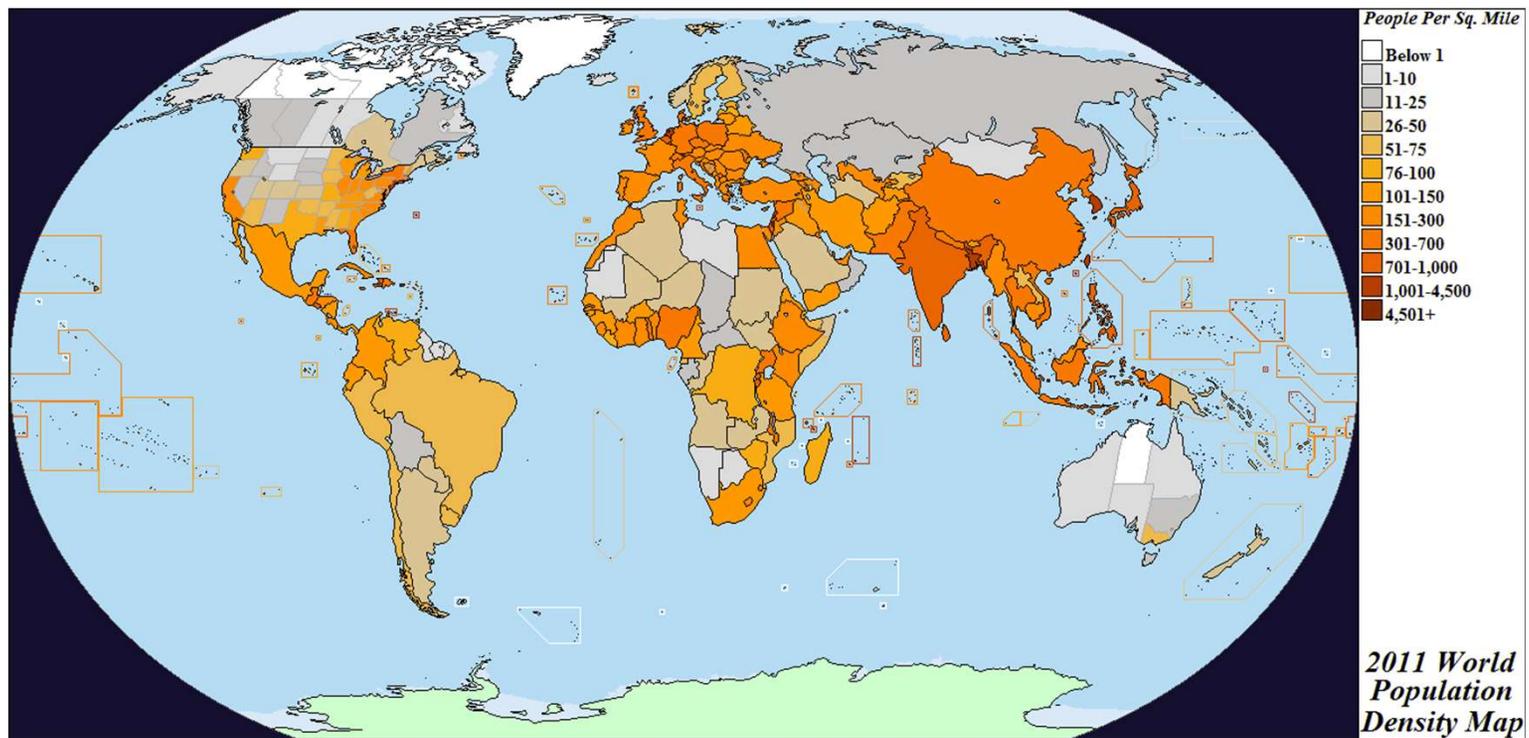
Source: Climate Central analysis of U.S. Forest Service records

CLIMATE CENTRAL

Modern medicine and disease control have increased world life expectancy from 48 years in 1950 to 71.4 years in 2015.



Population density of China is 4 times that of the United States.  
Population density of India is 12 times that of the United States.  
Population density of Japan is 10 times that of the United States.  
Population density of Germany is 7 times that of the United States.



## Feedlot factory farming of cattle



Covered manure pond at Illinois dairy farm.



## Factory farming of hogs



Beans can be used as a substitute for meat.



Baltic Sea wind turbines now have a 500-ft blade diameter and peak output of 8 MW.



400 MW Elk River Wind turbine farm near Wichita, Kansas  
Each turbine has a peak output of 2 MW ( requires 55 mph wind velocity)



40 MW (peak) Solar Farm, site area = 60 acres



Idaho Puts Online its First Large  
Solar Project at 40 MW-AC

**pv magazine**

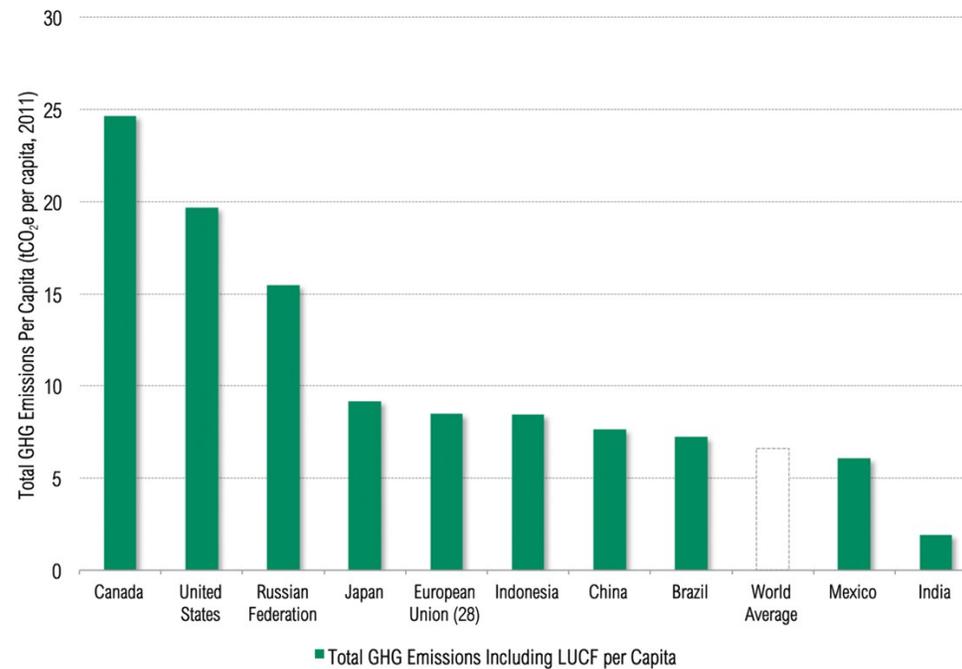


## EnerVault “electrolyte flow” battery



**In year 2011 Canada and the United States had the highest per capita CO<sub>2</sub> emissions.  
In year 2016 the value for each American was 16 metric tons/yr = 94# CO<sub>2</sub> /day.**

**Per Capita Emissions for Top 10 Emitters**



<http://bit.ly/11SMpjA>

## Climate Leadership Council

Proposal for administration of a CO<sub>2</sub> emissions tax of \$40/ton

This Program is intended to create awareness that CO<sub>2</sub> emissions are causing Global warming.

- For a family of four the additional cost of carbon based energy would be \$2560/yr.
- Pump price of gasoline/diesel will increase by 36 cents/gallon.
- Cost of coal-based electricity will double.
- Cost of natural gas based electricity will increase by 60%.
- Cost of natural gas used for heating will increase by 60%
- Emission tax dollars will be sent to Americans on a quarterly basis as dividend checks, direct deposits, or contributions to 401K plans.
- The amount sent to a family of four is estimated at \$2000/yr
- The Emission Tax program would be administered by the Social Security Administration.
- Eligibility would require a valid Social Security number.

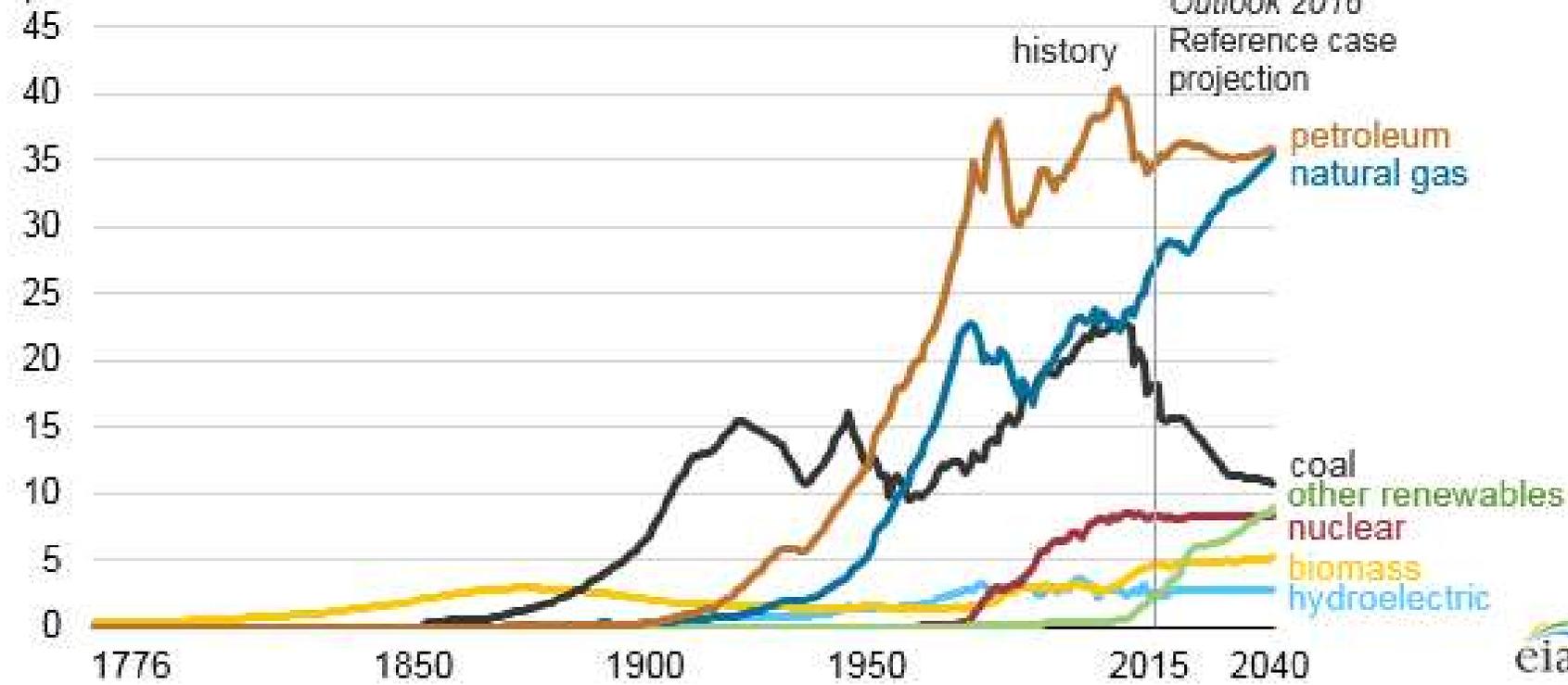
453 MW using (a) high pressure gas turbine-generators and (b) exhaust gas heat recovery to power high-pressure steam turbine-generators.  
This natural gas power plant is located in Mexico.



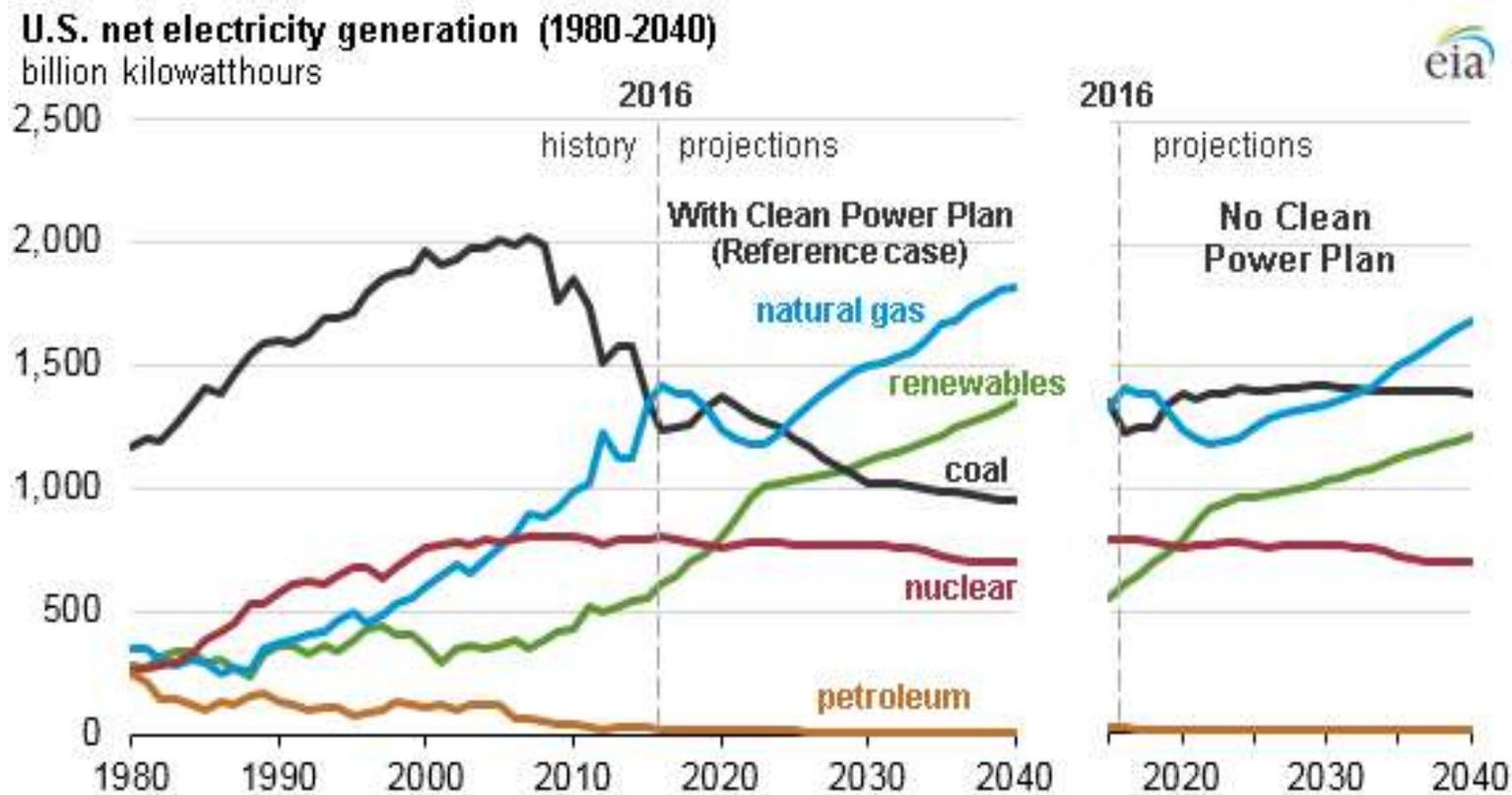
The EIA estimates that in year 2040 petroleum will still be producing 33% of our *total energy*.

### Energy consumption in the United States (1776-2040)

quadrillion Btu



The EIA estimates that by year 2040 renewables will supply 43% of our *electric energy*.

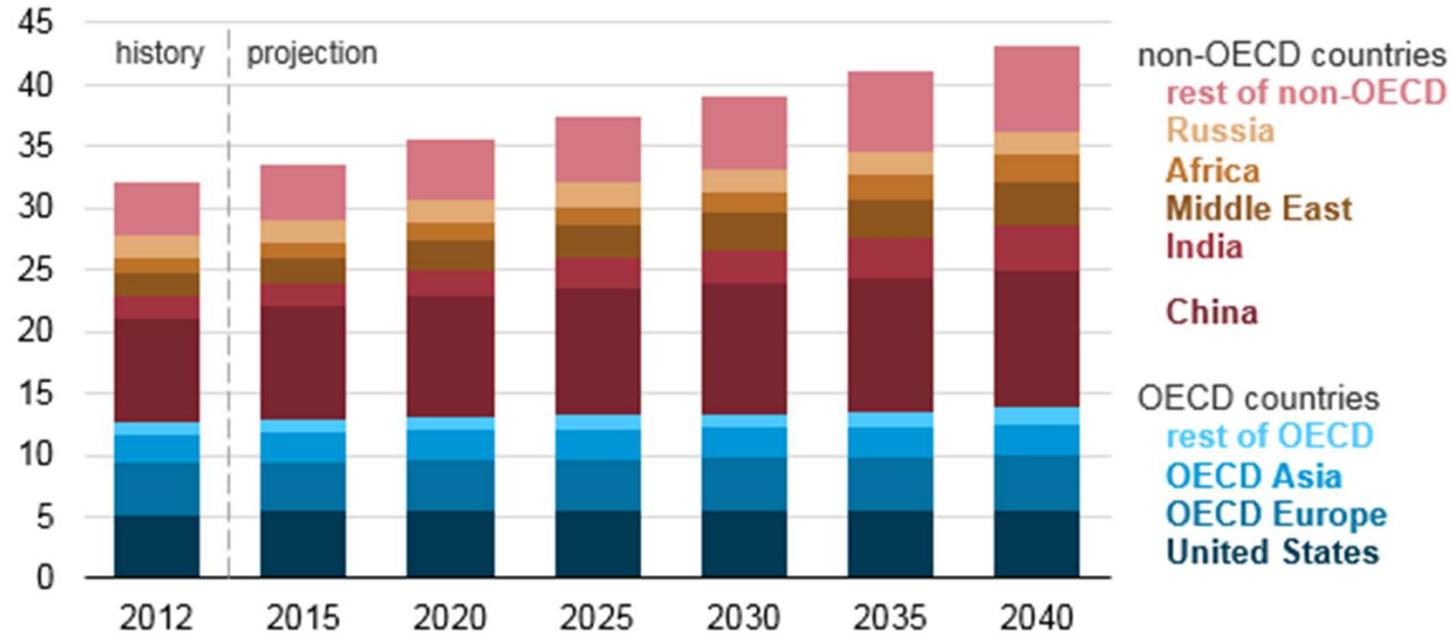


By year 2040 nations of the world are expected to be burning 30% more fossil carbon. The United States will be burning 8% of the total.

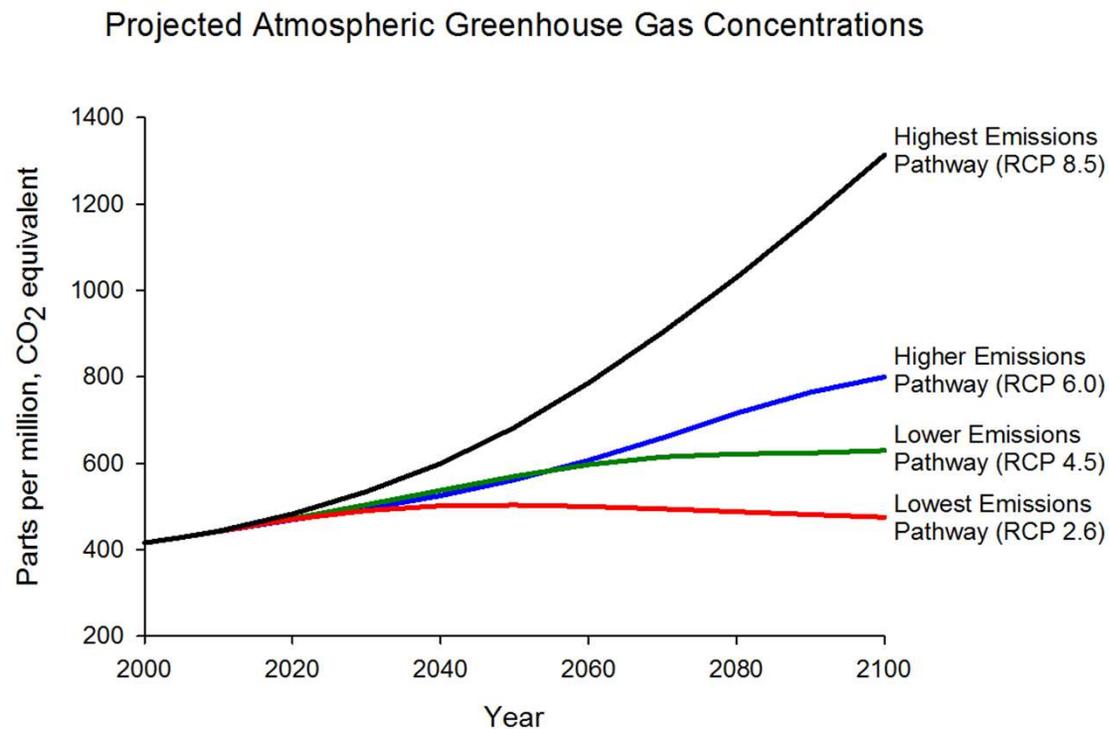
Energy-related carbon dioxide (CO<sub>2</sub>) emissions by country or region (2012-40)



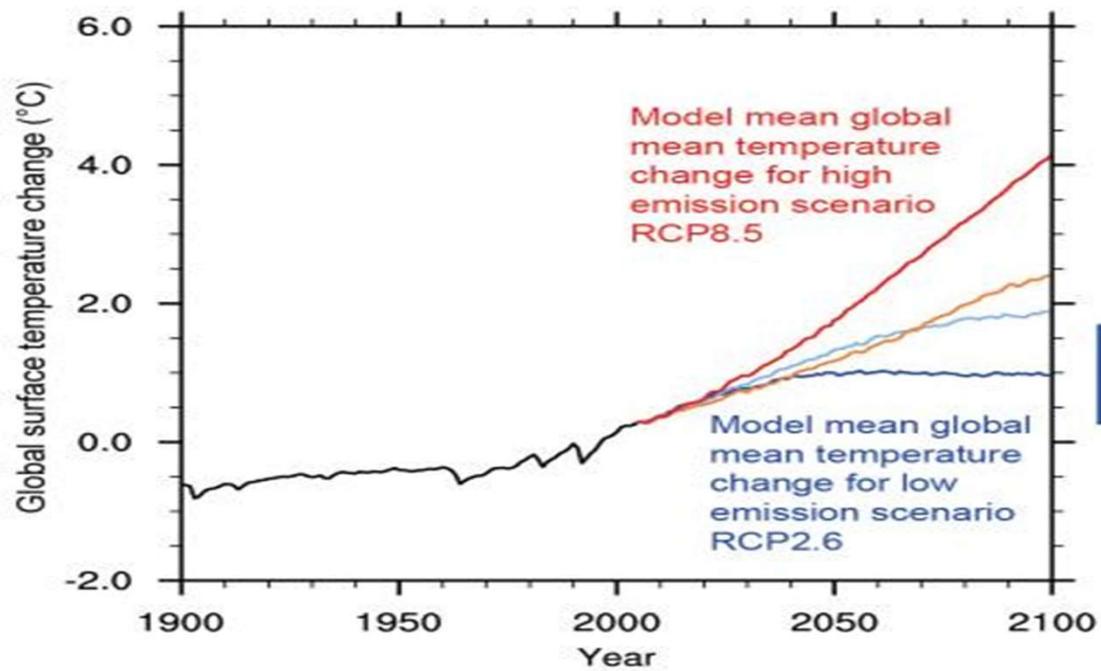
billion metric tons



Scenarios for human activity greenhouse gas emissions are called Emissions Pathways. Use the Higher Emissions Pathway (RCP 6.0) to allow for reductions in burning fossil carbon that may begin in year 2040.



Temperature predictions for Emission Pathways.  
Using the blue curve indicates 2.5°F additional warming by year 2100.



## Bonus point question on Global Warming caused by human activity

During the night, why did the water molecules leave the moist, soft bread left out on the kitchen counter?

- (a) The bread was too soft for sleeping.
- (b) Smedley's Phobia (fear of microwave ovens).
- (c) Greenhouse gases in the room air were having a party.
- (d) None of the above.