

# *Our* Climate: A Global Challenge

Academy for Lifelong Learning Denver, CO Feb. 26, 2015 Jonathan F. Ormes JFOrmes@comcast.net



"Climate change does not respect border; it does not respect who you are - rich and poor, small and big. Therefore, this is what we call 'global challenges,' which require global solidarity." Ban Ki-moon



#### Humans are an incredibly successful species.

- well adapted to the living in the present climate
- able to control/conquer the environment
  - sea walls, control fire (heat), air conditioning
  - agriculture, feeding >7 billion people
  - domesticated animals, can kill dangerous ones
  - conquered disease
  - been everywhere (top of Everest, bottom of sea, moon)
- we should be able to rise to this new challenge









- the Earth's crust is ours to control
  - removing oil and minerals from underground
  - harvesting Nature's bounty (redwoods to fish)
  - controlled rivers







Are we too successful for our own good?

# Remember Alfred E. Neuman?

I can't do anythi don't woffy<sup>at</sup>abou WHAT-ME WORRY

plem for me. I eithe<sup>worry?</sup>

I've been working on this for 40 years and nothing has been done by the government. You can't light big money.

I recycle. I got a higher mileage car. What more do you want me to do?

We've done our part. Now it really China's problem. They're the biggest polluters now.

I'm going to be dead anyway, before it really gets bad.



### Vulcan De Fuego, Guatemala Jan 1, 2015 Earth Picture of the Day

### Public Announcement

Presentation slides and handouts can be downloaded from either the link at the Academy's web site or directly from this Web site at DU:

#### http://portfolio.du.edu/OurClimate

The site is public. You do not need to create an account. Search for "<u>OurClimate"</u>.

The Academy also has a link to my page there. Click on **Courses** and then on the last item on the scroll down menu **Course Materials** 

http://www.academyll.org/course-materials/

# Handouts for today

### 1. Overview of course

- How to get copy of my presentations
- Bibliography
- 2. Instructions for NICL tour (April 2)
- 3. Energy units (dealing with big numbers)
- 4. Glossary of terms

# Visit NICL (April 2<sup>nd</sup>)



### This from Richard Nunn regarding access to the NICL.

Denver Federal Center One Denver Federal Center Building 810, Entrance E-11, MS 975 Denver, CO 80225-0046

Bring warm coat, gloves and hat.

Take 6th Avenue to the Kipling Avenue south exit. Take Kipling Avenue south to the second light at **Gate 1** of the Denver Federal Center. Turn right into Gate 1. Be prepared to show picture identification at the gate. After clearing security, drive through the gate straight ahead (the road curves somewhat to the left) to the second stop sign. Turn left. As you turn you will see the first in a series of blue and white signs that will guide you around Building 810 to NICL. Follow these signs to Door S25. Parking is unrestricted.

Everyone will need to have some form of ID such as a drivers license.

Non-US citizens, must have their green cards or passports for identification.

### Credits

Dr. John Turner, NREL Dr. Compton Tucker, GSFC Rev. Chris Schriner, retired Prof. Scott Denning, CSU

Dr. Michael King, GSFC, U of CO Dr. Thorsten Markus, GSFC Dr. Kevin Trenberth, NCAR Prof. Al Bartlett, U of Colo.

Dedicated to Prof. Albert Bartlett, physics, U. of Colo. who inspired my interest in population and climate.

"The greatest shortcoming of the human race is our inability to understand the exponential function." - Prof. Al Bartlett



# Thank you

The Academy: Lynn Wells and Karen Long Co-directors for inviting me to present this course

Technical backup is from Cassie Babtkis (call 303-770-0786 for help)

#### Stanford University



#### 🔼 University of Minnesota







### New Yorker Cartoon by J.B. Handelsman





#### with all due apologies





An astrophysicist's point of view: It's about the physics, the data, perspective and the time scales.

A manager's mindset: It's about risk management.

A concerned citizen's perspective: What can I do?





### Questions to be considered

Climate change: our euphemism for "global warming":

"What is climate change?"
 "What is understood and what isn't?"
 "How human activity affects the climate."
 "How serious is it?"
 "What can we do about it?"

# Weather or Climate



# Weather or climate: Jan 2014



We all need to take a global point of view! http://sciences.blogs.liberation.fr/home/2014/02/janvier-2014-chaud-en-europe.html

### CO<sub>2</sub> is a greenhouse gas. It is released by burning fossil fuels.



Fossil fuels have driven an extraordinary period of human expansion and prosperity. We have all benefitted greatly from inexpensive energy. But the piper is asking to be paid.

# The Keeling curve



**Charles David Keeling** 





# How urgent is it?

#### Has the global warming "tiger" has left its feet?







CO<sub>2</sub> at

# How urgent is it?

#### Has the global warming "tiger" has left its feet?







**Stabilize** 

350 ppm

CO<sub>2</sub> at

# How urgent is it?

Has the global warming "tiger" has left its feet?





CO<sub>2</sub> at



Has the global warming "tiger" has left its feet?





### Course will consider

- Population and affluence as drivers on energy use
   Population growth rate is declining (ZPG by 2100??)
  - Per capita energy use is growing
  - Energy use => fossil fuels => global warming
- Carrying capacity of Earth
  - How many people can we feed
  - Land and water as resources
- Human impact
   on biosphere



# Greenhouse gas (GHG) trends



# Energy footprint



# Energy consumption rises

#### **World Energy Consumption**



# Summary

- That CO<sub>2</sub>, methane, other greenhouse gases are warming the planet is well established.
  - Keep an eye on news about Greenland and West Antarctica
     \*\* if the ice sheets on these land masses disappear, we will have significant rise in sea level.
  - Aerosols, clouds and the carbon cycle are poorly understood and require more study.
- Improved management of water and land resources is essential.
- There are things we can do if we have the will.
- Expect the unexpected:
  - Predictions and planning are adiabatic (e.g. slow cookin')
  - Changes tend to be catastrophic (Katrina, Sandy)

### It's a complex business

Climate science is multi-disciplinary

- Astrophysics, physics, chemistry, geology, fluid dynamics, etc.
- Now add the human social and geopolitical aspects of the problem etc.
- It's an interesting complex problem keeping the mind of an old man active.



# Excess heat is prodigious

Our climate is accumulating 4 Hiroshima atomic bombs worth of heat every second.



Most of the energy is going to heat the oceans.





### Notes on numbers

Will use numbers in the class. Not so important to remember specific numbers.

Relative numbers are important.

Logarithmic scales (factors of 2 or 10)

Look at the uncertainties (number of significant figures).

Watch for how fast things change.

# Energy units (see handout)

A human being at rest emits about the same energy as a 100-120 watt lightbulb.

Gives new meaning to the phrase "He's not the brightest bulb in the room."

Everyday energy is in the range of few joules. boil a cup of water raise an apple and eat it walk slowly



# Energy units: human usage

So how much energy does it take just to keep us all alive for a year?

7.3 x  $10^9$  humans \*100 watts \*3600 s/hr \*24 hr/day \*365 days/yr \*1 yr = 2 x  $10^{19}$  joules = 2 quintillion joules

(a 2000 Cal/day diet is about 10 times this energy; this allows us to think, move around, play tennis, or get fat).

Total annual energy consumption on Earth is  $0.5 \times 10^{21}$  joules = **500 quintillion joules.** So on average, each person is consuming 250 times the energy required to stay alive & 25 times the energy we need to be active.

Change in heat content of the Earth since 1975:  $2 \times 10^{23}$  joules = = 0.2 YJ = 200 sextillion Joules

Gigajoule (GJ) = 1 *billion* ( $10^9$ ) joules.

Six gigajoules is about the amount of potential chemical energy in a barrel of oil, when combusted. A barrel is about 42 gallons.

Terajoule (TJ) = 1 *trillion* ( $10^{12}$ ) joules.

About 63 terajoules were released by the atomic bomb that exploded over Hiroshima.

Petajoule (PJ) = 1 quadrillion (10<sup>15</sup>) joules.

210 PJ is equivalent to about 50 megatons of TNT. This is the amount of energy released by Khrushchev's so-called Tsar Bomba, the largest man-made nuclear explosion ever (1961).

Exajoule (EJ) = 1 quintillion ( $10^{18}$ ) joules.

The 2011 Tōhoku earthquake and tsunami in Japan had 1.41 EJ of energy. Energy usage per year in the United States is roughly 94 EJ.

Zettajoule (ZJ) = 1 *sextillion* ( $10^{21}$ ) joules. Annual global energy consumption is approximately 0.5 ZJ.

Yottajoule (YJ) = 1 *septillion* ( $10^{24}$ ) joules.

This is approximately the amount of energy required to heat the entire volume of water on Earth by 1 °Celsius. The solar energy striking Earth is 5.5 YJ/

vr.

### Climate change should not be a question of taking polls of scientists "Consensus: 97% of climate scientists agree<sup>1</sup>"



1. W. R. L. Anderegg, "Expert Credibility in Climate Change," Proceedings of the National Academy of Sciences Vol. 107 No. 27, 12107

A serious point here: 2500 scientists may have their opinion changed by new data and/or improved theoretical understanding.

So far, however, I think the data suggest they have been conservative in their predictions.

# People will "get it".

#### **One reason for optimism!**



"Facts are stubborn things; and whatever may be our wishes, our inclinations, or the dictates of our passion, they cannot alter the state of facts and evidence." John Adams, US diplomat & politician (1735 - 1826)

'Argument in Defense of the Soldiers in the Boston Massacre Trials,' Dec. 1770

# Reanalysis by "Berkeley Earth"

Tavg fit by function f( Ln(CO<sub>2</sub>) - 1.5 x mVS (Tg))

mVS = Mass of Volcanic Sulfates in Terragrams



# Analysis done by a physicist, a converted skeptic





**Richard A. Muller** 

Work on previous slide was partially funded by the Koch brothers.

# Course outline

- Introduction
- Where we came from
- History of Earth's Climate
  - Ice Ages (NICL tour)
  - Comparative Planetary Climatology (Climate on Venus and Mars)
- Population and Affluence as Climate Drivers
- What Is (and Isn't) Climate?
- What Causes Global Warming?
- Circulation: Atmosphere and Oceans
- Earth Observations from Space
- What Can Be Done?

### Issues to be discussed

- History of Global warming science
- The young Sun and paleontological climate
- Milankovitch cycles and the Ice Ages
- Oceans and atmospheric circulations
- Accuracy vs. reliability of climate modeling
- Glaciers, water and pine bark beetles
- Tipping points
- Heavy rains (and flood insurance)
- Evidence for anthropomorphic warming
- The jetstream and the winter of 2014
- Arguments against human causation

### Why the government cares

- Expense of dealing with natural disasters
- Security concerns as nations fight over ever more limited resources
- Dealing with the instabilities caused by loss of arable land and water ->famine and disease
- Lower dependence on foreign oil
- Conversion to renewable energy makes sense
  - Renewable jobs: 142,000 🗡
  - Coal industry jobs: 174,000 💊

### Why I care about global warming

- Love of nature (species loss)
- Personal investment in science
- Respect for beauty and order
- Don't foul the air (global commons)
- Concern for the less fortunate, grandchildren
- Fear of weather extremes
- It's an intellectually challenging problem
- It's a morally challenging problem
  - overpopulation
  - overindulgence

# And I could feel insulted

### Anti-science

- Real skeptics are the scientists themselves
  - Critical part of the scientific method
  - It's the self-correcting machinery
- The climate change deniers are *pseudo-skeptics*
  - Prof. Michael E. Mann, Penn State
- If anything, the scientists have erred by under-predicting effects

# Why can't we convince everyone about climate change?

For this see the book Don't Even Think About It; Why Our Brains Are Wired to Ignore Climate Change by George Marshall (2014, Bloomsbury) It's a fascinating read and sociologically important.



# Where are you on this scale?



Proportion represented by area

Source: Yale Project on Climate Change Communication

### What is the point?

Make an hel guilty?
Make A hel guilty?

lifestyle?

 Stop the poisoning of the atmosphere?





### Awareness of Earth from the 1960s

- Almost 50 years
- Earthrise photo 1968
- Earth Day 1970



 People may feel threatened, hopeless, anxious, guilty, avoidant, thoughtful, challenged, .....
 What are your feelings? (3 x 5 card)

### Reasons for optimism?

- Impacts are probably manageable
- There is time to do something
- Change is happening (cost of solar panels)
- The human species is not at risk (at least from climate change directly)

All species go extinct eventually

- Mass migrations have happened before
- We have an incredible ability to adapt

### Let's discuss

Why are you taking this class?
What do you want to get out of taking it?
What do we have now that you would be most unwilling to lose?