Adapting to Climate change: Extreme Weather Events, a Worldwide Energy Revolution and Geoengineering options

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INTRODUCTIONS – part 1

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INTRODUCTIONS – part 2

Intro:

- Yourselves what brought you here
- Paul and Phil
- Web page <u></u>
- <u>http://denverclimatestudygroup.com/</u> (OLLI tab)
- Facebook -

https://www.facebook.com/denverclimatestudygroup/

A thought – passed on from Warren Hamilton

"In this age of specialization, men who thoroughly know one field are often incompetent to discuss another.
You must not fool yourself--and you are the easiest person to fool"

Richard Feynman, 1974

My comment:

We've become a country of selfproclaimed experts on everything.



So What is Climate Change

Weather vs. Climate

- Weather: consists of the short-term (minutes to months) changes in the atmosphere.
 - temperature, humidity, precipitation, cloudiness, brightness, visibility, wind, and atmospheric pressure, as in high and low pressure.
- Climate: long-term averages of daily weather.
 - The statistics of weather



Links to what is climate

http://www.metoffice.gov.uk/climate-guide

TAKE AWAY: This is Weather



This is NOT Climate Change

Chair of the Senate Environment Committee

What determines Earth's climate

- The Sun
- Orbital parameters aka Milankovitch
- Greenhouse Gases (GHGs)





Thus it leaves it to Greenhouse Gases

And so we will explore this a little further



FOR THERE TO HAVE NO CLIMATE CHANGE Energy in (Visible) =

Energy out (infrared)

- Relatively stable last 10,000 years
- GHGs Now Changing our climate but at an unprecedented rate
 - Threatens our sustainability as DO other factors:
 - Population
 - Sea level rise
 - Extreme weather
 - Resources (Energy, food)
 - Ocean acidification

Let's look at our atmosphere

 $-N_2 = 78\%$ $-O_2 = 21\%$ -Ar = 0.93%



oxygen O₂



 $-CO_2 = -.408\%$ $-H_2O = variable$ $-Other: CH_4$, CFCs, O_{3_1} etc.



GREENHOUSE GASES (GHGs)

- Water H₂O the amount is a feedback of temperature held in by the "blanket" of other GHGs
- Carbon dioxide CO₂
- Methane CH_4
- Ozone O₃
- Nitrous oxide- N_2O
- others



Some basic Meteorology

- First some facts:
 - Atmospheric circulation
 - Coriolis forces
- Then Background for some Explanations:
 - Gas laws
 - Weather: Highs and Lows
 - Causes
 - Coriolis effect
 - Latent heat

Atmospheric circulation



http://maps.unomaha.edu/Peterson/geog1 000/Notes/Notes Exam1/Seasons&Climate .htm



Cont.

http://maps.unomaha.edu/Peterson/geog1000/N otes/Notes Exam1/Seasons&Climate.htm

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Coriolis forces affecting movement

• prop



http://maps.unomaha.edu/Peterson/geog1000/N otes/Notes Exam1/Seasons&Climate.htm

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Gas laws

• Boyles Law, Charles Law, Gay-Lussac Law

BUT THIS IS THE RELATIONSHIP YOU NEED TO KNOW: • IDEAL GAS LAW (COMBINED): PV = nRT

http://chemistry.bd.psu.edu/jircitano/gases.html For more info: https://en.wikipedia.org/wiki/Gas_laws

T, P and V relationships with density

PV = nRT

• Temperature: INCREASES

- V increases and thus
- Density decreases

• Pressure: INCREASES

- V decreases and thus
- Density increase
- Volume: INCREASES
 - T decreases and thus
 - Density Decreases

HOWEVER:

Changes in the composition of medium can also cause density to change

Some basic Meteorology

• First some facts:

- Atmospheric circulation
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- Then Background for some Explanations:
 - Gas laws
 - Weather: Highs and Lows DENSITY
 - Causes
 - Along with the Coriolis force/effect
 - Latent heat

A TRICK QUIZ

- 2 ROOMS EQUAL IN SIZE, ELEVATION and TEMPERATURE
 - 1. ROOM 1 10% HUMIDITY
 - 2. ROOM 2 95% HUMIDITY

- WHICH ONE WEIGHS MORE (I.E. IS DENSER: DENSITY = MASS/VOLUME)
 - 1. ROOM 1?
 - 2. ROOM 2?

A TRICK QUIZ

- 2 ROOMS EQUAL IN SIZE, ELEVATION and TEMPERATURE
 - 1. ROOM 1 10 HUMIDITY
 - 2. ROOM 2 95% HUMIDITY
- YOU PROBABLY DON'T REALIZE YOU KNOW THE ANSWER
- HINT:
 - WEATHER:
 - WHAT'S A STORM ASSOCIATED WITH
 - HIGH PRESSURE
 - Or LOW PRESSURE?
 - WHY?

Our Atmosphere



ANSWER as to which weighs more:

- 2 ROOMS EQUAL IN SIZE, ELEVATION and TEMPERATURE
 - 1. ROOM 1 10% HUMIDITY WEIGHS MORE
 - 2. ROUME TOUL
 - WEATHER:
 - WHAT'S A STORM ASSOCIATED WITH
 - LOW PRESSURE? MOISTURE: STORMS, HURRICANES
 - WHY? WATER VAPOR WEIGHS LESS THAN $N_2 \& O_2$

Air Pressure - Water Vapor (Humidity)

- Water vapor is lighter than the oxygen, nitrogen, and hydrogen molecules that make up our air.
- · So as you add water vapor to the air, the air becomes lighter
- · Lighter air does not push down as hard, and the pressure is lower





TAKE AWAY:

adding H₂O VAPOR decreases density

A summary table:

Factors Affecting Air Pressure

FACTOR	Increase/Decrease	Air Pressure
Density	1	1
Density	-	
Temperature	1	-
Temperature	-	
Water Vapor	1	
Water Vapor		
Altitude	1	
Altitude	-	

TAKE AWAY: Low Atmospheric Pressure

ASSOCIATED WITH AN INCREASE OF WATER VAPOR

An Aside: ALTITUDE ALSO AFFECTS PRESSURE and BOILING POINT

How does the altitude affect the boiling point of water?	~
Why does it take longer to boil water at high altitude?	~
What is the boiling point of water at an elevation of 9000?	~

Boiling Point of Water at Different Altitudes

Altitude ft. (meters)	Boiling Point - Fahrenheit	Boiling Point - Celsius
7500 ft. (2286 m.)	198 °F	92 °C
8000 ft. (2438 m.)	197 °F	91.5 °C
8500 ft. (2591 m.)	196 °F	91 °C
9000 ft. (2743 m.)	195 °F	90.5 °C
17 more rows		

ALTITUDE ALSO AFFECTS PRESSURE and BOILING POINT

Level	Standard Height			
1000 MB	364 ft	111 m		
925 MB	2498 ft	762 m		
850 MB	4781 ft	1458 m		
700 MB	9882 ft	3013 m		
500 MB	18289 ft	5576 m		
400 MB	23574 ft	7187 m		
300 MB	30065 ft	9166 m		
250 MB	33999 ft	10366 m		
200 MB	38662 ft	11787 m		
[Bogueteweather.com]				
Copyright © 2007				

Boqueteweather.com

TAKE AWAY:

air cools 10°C for every km elevation gain due to decrease pressure

Water vapor

The amount of water vapor that the atmosphere can hold DOUBLES FOR EVERY 10°C





TAKE AWAY:

Water vapor in the atmosphere ~ DOUBLES WITH EVERY +10°C

AIR MOVES FROM H TO L BUT NOT IN A STRAIGHT LINE DUE TO CORIOLIS



AIR MOVES FROM H TO L BUT NOT IN A STRAIGHT LINE DUE TO CORIOLIS



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– Latent heat = ENERGY IN WATER VAPOR

The Energy involved with WATER VAPOR

- To melt ice (solid to liquid) = 80 calories / gram
- To heat water 1° C = 1 calorie / gram

 To go from 100° C liquid to 100° C steam/vapor – 540 calories / gram

The Energy in phase changes



http://www.uh.edu/~jbutler/physical/chapter6notes.html

The Energy in phase changes



TAKE AWAY:

- IF YOU INCREASE THE AVERAGE ATMOSPHERIC TEMPERATURE YOU INCREASE THE AMOUNT OF WATER VAPOR IT HOLDS
- IF YOU DO THAT YOU INCREASE THE AMOUNT OF ENERGY IN THE ATMOSPHERE

TO RE-EMPHASIZE: THE TAKE AWAY:

- IF YOU INCREASE THE AVERAGE ATMOSPHERIC TEMPERATURE YOU INCREASE THE AMOUNT OF WATER VAPOR IT HOLDS
- IF YOU <u>INCREASE THE AMOUNT OF</u> <u>WATER VAPOR IN THE</u> <u>ATMOSPHERE YOU INCREASE THE</u> <u>AMOUNT OF ENERGY</u> IN THE ATMOSPHERE
- The warmer the greater the increase!

EARTH'S HEAT BUDGET

RADIATION RECEIVED vs. RADIATION EMITTED BACK TO SPACE



IF EARTH'S HEAT BUDGET CHANGES WE HAVE EITHER:

- COOLING or
- WARMING

How GHGs Blanket the Earth

- Blanket Earth:
- http://climate.nasa.gov/causes/
- <u>https://www.youtube.com/watch?v=aqkGoCgl</u>
 <u>p_U&feature=youtu.be</u>
- <u>https://www.youtube.com/watch?v=we8VXw</u>
 <u>a83FQ</u>

The CO, greenhouse gas effect is concentrated The most potential decision of the polar regions !!!



Particularly in the Agretionhouse effect is controlled by temperature -Saturation doubles Greenhouse gases are evenly distributed throughout the As a result it is atmosphere concentrated in the lower atmosphere of the tropics

RESULTS:

- Greater warming at High Latitudes
- Reduction Arctic sea ice
- Melting glaciers
- Rising sea levels
- Average temperature increases
- Earlier springs / earlier snow melt
- Ocean acidification

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.





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

http://nsidc.org/arcti cseaicenews/2016/0 6/



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/*).

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.



Frequency of occurrence (vertical axis) of local June-July-August temperature anomalies (relative to 1951-1980 mean) for Northern Hemisphere land in units of local standard deviation (horizontal axis). Temperature anomalies in the period 1951-1980 match closely the normal distribution ("bell curve", shown in green), which is used to define cold (blue), typical (white) and hot (red) seasons, each with probability 33.3%. The distribution of anomalies has shifted to the right as a consequence of the global warming of the past three decades such that 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.*

So what do we do?

- NOTHING? AND ADAPT?
- CHANGE OUR WAYS AND MITIGATE
 - COSTS NOW vs.
 - COSTS LATER

Politicians debating climate change



THAT'S GOING NOWHERE!

IT'S UP TO US

NEXT

- Adaptation to extreme weather events (today and next 2 weeks)
- Mitigation: DIET and EXERCISE weeks 4-8
 - Reduce our emissions GHGs
 - decarbonize our electrical energy generation
 - Decarbonize our transportation sector
 - Sequester some of what we've already emitted: BIOCHAR, OTHER

A book to consider:

- Simple succinct Summary:
 - What We Know About Climate Change (Boston Review Books) by Kerry Emanuel (Nov 30, 2012)



- Web page to consider:
 - <u>https://skepticalscience.com/</u>

A book to consider for weeks 4-7:



Powering Forward: What Everyone Should Know About America's Energy Revolution Kindle Edition

by Bill Ritter Jr. * (Author)



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21 Used from \$5.59 28 New from \$6.29

Next up:

Phil Nelson



<u>https://i.kinja-img.com/gawker-</u> media/image/upload/t_original/ihsllhptnnm4vb7wuvgq.jpg