The Carbon Footprint

GEOG 401

2/6/2014

Guest Lecturer: Ryan Longman
Part 1
Carbon in our atmosphere

- The **Keeling Curve** is a graph which plots ongoing CO2 concentration in the Earth's Atmosphere since 1958.
- Based on continuous measurements taken at Mauna Loa Observatory (MLO) in Hawai‘i under the supervision of Charles David Keeling.
- Diurnal cycles
- Seasonal cycles
- Steady year to year increase
How has science concluded that humans are responsible for the increase of \( \text{CO}_2 \) in the Earth's Atmosphere?
Elements are presented in order of increasing atomic number (the number of protons in the nucleus).
Science has proven that fossil fuel emissions are changing atmospheric composition through the use of stable isotopes.

• What the heck is an Isotope?
• Isotope – different types of atoms of the same chemical element all having a different number of neutrons therefore a different atomic mass.
• There are 3 naturally occurring carbon Isotopes. $\delta^{12}C, \delta^{13}C, \delta^{14}C$
Calculating Atomic Mass

• Protons + **Neutrons** = Atomic Mass

• If Carbon (C) has 6 protons then:
  - 6 protons + 6 neutrons = 12 = δ₁₂C (Stable) - 99%
  - 6 protons + 7 neutrons = 13 = δ₁³C (stable) - 1%
  - 6 protons + 8 neutrons = 14 = δ₁⁴C (unstable) - 0.00001%

As you can see all three isotopes have a different atomic mass and Carbon-12 (δ₁²C) is the most abundant.
What does Isotope stability mean?

- $\delta^{14}\text{C}$ is an unstable isotope which means it decays over time.
- It has a half life of 5730 years

Using the $\delta^{14}\text{C}$ isotope is possible to go back ~50,000 yrs
Stable Carbon Isotopes.

- $\delta^{12}C$ and $\delta^{13}C$ are stable isotopes which means they do not decay over time.
- $\delta^{12}C$ and $\delta^{13}C$ can be used to tell us about our current atmospheric chemistry and allow us to compare it to the chemistry of the past.
- The atmospheric concentration ratio between these two isotopes also provides us the evidence we need to determine the amount of anthropogenic inputs of CO$_2$ into the atmosphere.
To understand this you need to first know something about photosynthesis.

- Plants draw in CO$_2$ from atmosphere and use the energy from the Sun to fix the inorganic carbon into a useable organic form.

- Plants prefer to take in $\delta^{12}$CO$_2$ because the lower atomic mass (12) of this isotope requires less energy to process than $\delta^{13}$CO$_2$ (atomic mass 13).

- Therefore plants discriminate against $\delta^{13}$CO$_2$. In other words, it’s not there favorite “flavor”
• If plants prefer $\delta^{12}\text{CO}_2$ over $\delta^{13}\text{CO}_2$ then there should be a steady concentration of $\delta^{13}\text{CO}_2$ in the atmosphere.

• Is it possible then to determine the atmospheric anthropogenic inputs of $\text{CO}_2$ using isotopes?

• First we have to ask some questions.
  – What are fossil fuels made of? Plants
  – What type of carbon atom is associated with plants? $\delta^{12}\text{C}$
  – If fossil fuels are burned what will happen to the $\delta^{13}\text{CO}_2$ concentrations in the atmosphere? Decrease
Part 2

The carbon footprint:
- Water
- CO₂ emissions
- Electricity
- Transport
- Offsets
- Recycling
- Waste
- Fuel
- Gas
- Personnel
What is a carbon footprint?

- **Carbon Footprint** – a measure of the impact that human activities have on the environment in terms of the amount of greenhouse gases (GHG) produced, measured in units of CO$_2$.
  - Measures the total greenhouse gas emissions caused directly and indirectly by a person, organization, event or product.
  - Is calculated by considering the amount of greenhouse gas emitted/removed or embodied in the life cycle of a product.
Life Cycle methodologies

• Many companies do not account for the entire supply chain that results in final goods and services.
  – Overlook up to 75% of the GHGs involved.
  – Are there better ways to calculate a carbon footprint?

1. Cradle to Grave – Full life cycle of a product. – resource extraction to disposal phase.
2. Cradle to gate – partial product life resource extraction to factory gate. Use and disposal are omitted.
3. Cradle to cradle – product is recycled.
4. Gate to gate – looks at only one value added process
Why is CO$_2$ used to measure footprints?

- **Radiative Forcing** — is a measure of the net change in the energy balance of the Earth system in response to some external perturbation.
- Measured in W m$^{-2}$. **Positive** = warming and **Negative** = cooling
- 61% of the forcing is a result of CO$_2$.
- 17% of the forcing is a result of CH$_4$
CO$_2$ Equivalent

- Green house gases have different atmospheric concentration and different strength as a GHG.
- Because of this variability, carbon footprints are measured in tons of CO$_2$ – eq, or the tons of CO$_2$ that would cause the same level of radiative forcing as the emissions of a given GHG.

![Graph: Carbon Dioxide from Fossil Fuel Combustion](source.png)
Total GHG Emissions 2011 in the U.S.

GHG emission from transportation have increased by a 18% since 1990.
- Over 90% of the fuel is petroleum based.
- Due to increased demand for travel
- Stagnation of fuel efficiency.

Why the decrease?

Over 70% of our electricity comes from burning fossil fuels, mostly coal and natural gas.

http://www.epa.gov/
An atlas of pollution: the world in carbon dioxide emissions

Carbon Dioxide emissions by country

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<th>Rank, 2009</th>
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Emissions from fossil fuels for largest emitters, 1990-2010 (metric tons C)

- Germany
- Japan
- Russian Federation
- USA
- India
- China

Comparison of emissions over the years 1990 to 2010.
Per Capita CO₂ Emissions

- Global Avg. = 4 tons of CO₂ -eq/yr
- USA Avg. = 20 tons of CO₂ -eq/yr

• Primary footprint is dominated by transportation and household electricity use.

• Secondary footprint is dominated by diet, clothing and personal products.

New study by the Renewable & Appropriate Energy Laboratory at UC Berkeley shows who you are and where you live makes a big difference in the activities that have the largest impact on your carbon footprint.

• California = Low electricity (5%)
• St. Louis = High electricity (25%)

http://coolclimate.berkeley.edu/
Urban/Suburban Carbon Footprint

- Where is the carbon footprint bigger, Cities or suburbs?
- Studies have shown that urbanization can deliver large carbon reductions by reducing per capita energy use in transport, housing, and construction.
- New study shows that this is offset by suburban areas.
- Carbon footprint actually increases until you reach 3000 person per square mile.

Jones and Kammen (2014)
Carbon Visuals

- If we could see carbon dioxide would we take it more seriously?

Carbon Footprint of the Super Bowl

The 48th annual Super Bowl may have been the most environmentally friendly one yet.

- It was outside
- Transportation to the event on mass transit.
- Organizers planted trees to offset carbon emissions and powered generators with biofuels.
- Collected electronic waste in NY and NJ.
- Serving local concessions
- Composting waste.
Carbon Credits

• **Carbon Credit** = 1 tonne of CO$_2$ –eq either removed, avoided or sequestered.
  – Renewable Energy
  – Forestation and Afforestation
  – Energy Efficiency
  – Methane capture

• The Carbon credit system was ratified in conjunction with the Kyoto Protocol.

• Credits are traded on the international market.

• Two Markets
  – Voluntary carbon offset market
  – Compliance carbon offset market
Who Gets the Money?

• In the **voluntary market** – carbon offsets are used to fund projects which absorb or eliminate an amount of carbon dioxide gas that is equal to the amount emitted.

• In the **compliance market** companies profit by reducing their footprints and selling their right to produce CO$_2$. (Cap and Trade)
Does it actually Work?

• Essentially, carbon offsets work by allowing polluters to pay others to make their carbon reductions for them.
  – Reduce personal responsibility? (do what I want without guilt?)
  – License for large companies to pollute freely
  – Corruption?
    • Are offset services actually being provided
    • Are companies reporting correctly
  – Is this superior to the idea of a carbon tax?

The American Clean Energy and Security Act (ACES) was approved by the House of Representatives on June 26, 2009 by a vote of 219-212, but was defeated in the Senate.
Carbon Tax

- **Carbon Tax** – polluters will pay per tonne of carbon they release into the atmosphere.
  - Price will be set at $23 and increase gradually until 2015
  - The amount of carbon pollution involved in producing a product would start to be factored into its final price.
  - Products produced through dirty processes will become more expensive.

- Finland was the first country in inact a carbon tax in 1990.


- Boulder (Colorado) – first in the US (2007)
Part 3
Where are we now? Where are we headed?
Our Current CO$_2$ Concentration

On May 9th the daily average of carbon dioxide (CO2) in the atmosphere passed the 400 ppm mark

Increasing at a rate of 2.07 ppm/yr

396.5 ppm

Preindustrial levels
280 ppm

Future Scenarios

- We are currently on the greatest trajectory (RCP 8.5).

IPCC (2013)
Your Personal Footprint

Proven results regardless of your impact on the environment.

- Eat Healthier
- Exercise more
- Entertain your mind
- Spend more quality time with your family
- Support the livelihood of your community.
EAT SMART. YOUR FOOD CHOICES AFFECT THE CLIMATE.

Different foods have different impacts. Here's how the greenhouse gas emissions (GHGs) of twenty common foods compare:

CARBON FOOTPRINT
Car Miles Driven per 4oz. Consumed

Highest carbon footprint of all meats: 50% higher than beef.

Learn more at ewg.org/neateatersguide

GHG data based on lifecycle assessment by CleanMetics.
www.cleanmetrics.com
Thank You

Any Questions