Climate Change: The State of the Earth

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Climate Change

- One of the many great challenges for the 21st century
- We are already decades late in taking action J. S. Sawyer (1972): Man-made CO₂ and the "greenhouse" effect
- It is a global issue & a local issue; a societal issue & a personal issue
- Earth science clashes with social values
- At the heart, it is a spiritual issue

Outline

- Science of climate change
 - Global scale: actual and future
 - Locally: with Vermont as example
- The transition we face
 - Managing the earth system
 - Why is it difficult?
 - What do we need?

Discussion

My Background: Peterhouse, Cambridge - UK

- Founded 1284
- Medieval warm period;
 Vinland colony flourishes



My Background: Nottingham High School

- Founded 1513
- 1550: Heading into "Little Ice Age"
- 1620: Pilgrim fathers face bitter winters





 "Proxy" records from before the time of thermometers provide uncertain data, but they're all we have

Global Temperature Rise 1880 – Present



NASA-GISS, 2011

2100: +5°F

Global Picture 2010

2010, warmest (tie) of 131 years 0.63 °C (1.2°F)



- Record summer temps
 - Russia (100°F) Moscow fires
 - Pakistan (128°F) Extreme monsoon floods

Arctic Sea Ice Loss Has Accelerated



[•] Record ice loss in 2007

- most ice now only 1-2 years old
- Open water in October contributes to warmer Fall

Sea Ice Trends

- Sea ice is thinning rapidly
- Observed September decline appears to be faster than IPCC climate model projections





Year

Carbon Dioxide Is Increasing



2009 Was "Good" for the Earth

Fossil Fuel Emissions: Actual vs. IPCC Scenarios



Key Diagnostic of the Carbon Cycle Evolution of the fraction of total emissions that remain in the atmosphere



It takes at least a century to remove CO₂ from the atmosphere, and many centuries to remove it from oceans

<u>Rising</u> Ocean Acidity Threatens Organisms

- From the Tropics to the Arctic, the seas are sucking up emissions of CO₂ from burned fossil fuels
- When CO₂ dissolves in water, carbonic acid is produced; the oceans are becoming more acidic



(Ruttiman, *Nature,* 31 Aug. 2006)









Why Is the Rise of Atmospheric CO₂ a Problem?

- The atmosphere is transparent to light from the sun, but not to infrared radiation from the earth
- Greenhouse gases: H₂O, CO₂, CH₄
 - trap the earth's heat, giving pleasant climate
- CO₂ rise alone has a small effect, BUT...

Why Is the Rise of Atmospheric CO₂ a Problem?

- As Earth warms, evaporation and water vapor increase and this amplifies warming a lot
- As Earth warms, snow and ice decrease and <u>this amplifies warming</u> in winter and northern latitudes, because less sunlight is reflected
- Doubling CO₂ will warm Earth about 5°F (3°C)
 - much more in the North and over land

Global Warming Is Unequivocal IPCC: February 2, 2007

Since 1970, a rise in:

- Global surface temperature
- Lower atmosphere temperatures
- Global sea-surface temperatures
- Global sea level
- Ocean heat content
- Water vapor
- Rainfall intensity
- Extratropical precipitation
- Hurricane intensity
- Drought
- Extreme high temperatures
- Heat waves

(www.ipcc.ch)

Decrease in:

- NH snow extent
- Arctic sea ice
- Glaciers
- Ocean pH (increasing acidity)



Predicted Change in Temperature 2020-2029 and 2090-2099, relative to 1980-1999 (°C)

"Committed"

Still up to us!

(We did nothing for the last 20 years)



(We could halve this if we act now)



Sea-level Rise Will Eventually Flood Coastal Cities

- Late 20th-century sea-level rise: 1 foot / century
- 21st century: Likely to triple to 3 4 feet / century
 - And continue at this rate for centuries
- Unless we drastically reduce burning of fossil fuels by 80% by 2050
- Sea-level rise will get our attention, but it will be too late!

Many Challenges Face Us

- Extreme weather: Floods, fires, & drought
- Melting Arctic and permafrost methane release?
- Ecosystem collapse, including perhaps forest and ocean ecosystems
- Collapse of unsustainable human population

Local Example: What Is Happening to Vermont?

- Local climate change indicators
- Easier to grasp than global view
- Warming twice as fast in winter than summer
- Winter severity decreasing
- Lakes frozen less by 7 days / decade
- Growing season longer 3.7 days / decade
- Spring coming earlier by 2-3 days / decade

Vermont Temperature Trends

- Summer mean (^oC) 22 20 Summer +0.4°F / decade 18 65 16 60 30 ູ່ບ Intel 25 Winter mean Winter +0.9°F / decade -6 20 -8 -10 1960 2000 1970 1980 1990 2010 Year
- Less snow drives larger winter warming

Lake Freeze-up & Ice-out Changing Frozen Period Shrinking Fast



- Ice-out earlier, by 3 days / decade
- Freeze-up later, by 4 days / decade

Vermont Winter 2006



- Sun is low; and snow reflects sunlight, except where there are trees!
- Sunlight reflected, stays cold; little evaporation, clear sky; earth cools to space

USDA Hardiness Zones - Northeast



© 2006 by The National Arbor Day Foundation®

Gardening in Pittsford, Vermont in January





January 7, <u>2007</u> December 2006: • Warmest on record

January 10, <u>2008</u>

Warm Fall:

- Record Arctic sea-ice melt
- Snow cover in December, ground unfrozen

First and Last Frosts Changing



- Growing season for frost-sensitive plants increasing 3.7 days / decade
- A help for growing "local food"

Vermont's Future with High and Low GHG Emissions

What about skiing?

What about tropics?



Migrating State Climate

Changes in average summer heat index—a measure of how hot it actually feels, given temperature and humidity—could strongly affect quality of life in the future for residents of Vermont, Red arrows track what summers in Vermont could feel like over the course of the century under the higher-emissions scenario, Yellow arrows track what summers in the state could feel like under the lower-emissions scenario.

NECIA, 2007

Can We Stop Dangerous Climate Change?

- Yes: Quickly stabilize atmospheric CO₂
- This means an 80% drop in CO₂ emissions!
- This is very difficult
 - Fossil fuels have driven our industrial growth and population growth for 200 years
 - Our "lifestyle" has become dependent on fossil fuel

How Do We Avoid "Dangerous Climate Change"?

Emissions Paths to Stabilisation [Stern, 2006]



How Do We Manage the Earth? (When there is so much we don't know)

- Need a long time horizon:
 - Generational to century
- We need some new rules / guidelines !
 - Our numbers are so great
 - Our industrial impact is too large
 - Maximizing profit as a guiding rule has failed us
- Re-localize to regain control / responsibility and minimize transport

Broad Guidelines or Rules to Minimize Impacts

- Minimize the lifetime of human waste in the Earth system and eliminate waste with critical biosphere interactions
- Minimize the use of non-renewable raw materials, and
- Maximize recycling and re-manufacturing
- Maximize the efficiency with which our society uses energy and fresh water, and
- Maximize the use of renewable resources

Efficiency Comes First

- We need to double or triple our energy efficiency because...
 - We cannot replace current fossil fuel use with biofuels & renewable energy
 - Oil and gas reserves are limited, but coal & oil shale reserves are sufficient to push CO₂ to 1,000 ppm—and in time melt icecaps
 - Can we "sequester" CO₂ (put it back in the earth)?

Why Is It Difficult for Us?

- The "American dream" is crumbling
 - "Economic growth" based on fossil fuels, debt, and consumerism is unsustainable—and a disaster for the planet!
- Individual "rights" and the needs of humanity must be balanced against the needs of the earth's ecosystem
- We have no workable paradigm to guide and manage technology—so the result is tremendous successes and catastrophic failures

But If Growth Can't Save Us, Surely Technology Can?

- We have lost sight of the critical distinction between the human-made world and the natural world
- We understand the human-made world, the world of computers & technology—because we made it—it is predictable and controllable, except when we are careless (& earthquakes) [E. F. Schumacher (1977). A Guide for the Perplexed]
- The same is not true of the natural world which is far more complex and alive. Our understanding is limited; prediction & control are not possible

But If Growth Can't Save Us, Surely Technology Can?

- Now our world of technology is having a global impact on the natural world and it must be carefully managed
 - But this is incompatible with our ideology

What Do We Need?

- So we need honest, truthful, smart pathways forward
 - That will not frighten people into paralysis
 - That will spread hope, not anger
 - That sidestep ideological barriers with new language
 - That develop adaptive governance
 - The US Constitution gives no rights to the Earth
 - That respect Earth system processes & limits

The Future Is Not Our Past

- Collectively, we create the future, so plan for a transition to a sustainable society
- Communities are one key:
 - www.transitiontowns.org
- Take the Earth into our spiritual practice

"Thy Will be done on Earth"

Resources

- <u>http://alanbetts.com</u>
- New books...
 - Edward Echlin (2010). *Climate and Christ: A Prophetic Alternative.* Columbia Press
 - Marian Van Eyk McCain, Ed. (2010). GreenSpirit: Path to a New Consciousness. O Books



