



Climate Change, Energy & Vermont

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NASA/JPL

Climate Change

- **One of several challenges this century**
- **Dec 7-18, 2009: COP-15, Copenhagen**
 - *UN Framework Convention on Climate Change, 1992*
- **Action was postponed:** “Agreed they needed to act, and that what they could agree on now was not nearly enough”
- **We are already decades late in taking action**
 - *Sawyer, Nature, 1972, Man-made CO₂ and the “greenhouse” effect*
- ***Global issue & local issue;
societal & personal issue!***

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- **A core institution in Pittsford**
- **How can it help this community?**
 - *In a culture that has promoted individualism (freedoms, rights and consumerism) over community needs*
 - *After a year of economic collapse, driven by greed, debt & ‘virtualization of wealth’*
 - *When people are angry, realizing their dream has slipped away*
 - **A dream that was neither sustainable nor resilient: based largely on debt & cheap oil...**

The future is not our past

- Faced with
 - climate change & limited oil
 - global population growth & ‘consumer growth’
 - **past the carrying capacity of the Earth in 1980**
- What government can do is limited: too paralyzed by ideology/doctrine, bureaucracy & self-interest
- **Communities are a key**

Example: Transition towns

www.transitiontowns.org

The community also recognizes two crucial points:

- *that we used immense amounts of creativity, ingenuity and adaptability on the way up the energy upslope, and that there's no reason for us not to do the same on the downslope*
- *if we collectively plan and act early enough there's every likelihood that we can create a way of living that's significantly more connected, more vibrant and more in touch with our environment than the oil-addicted treadmill that we find ourselves on today.*

How do we manage the Earth?

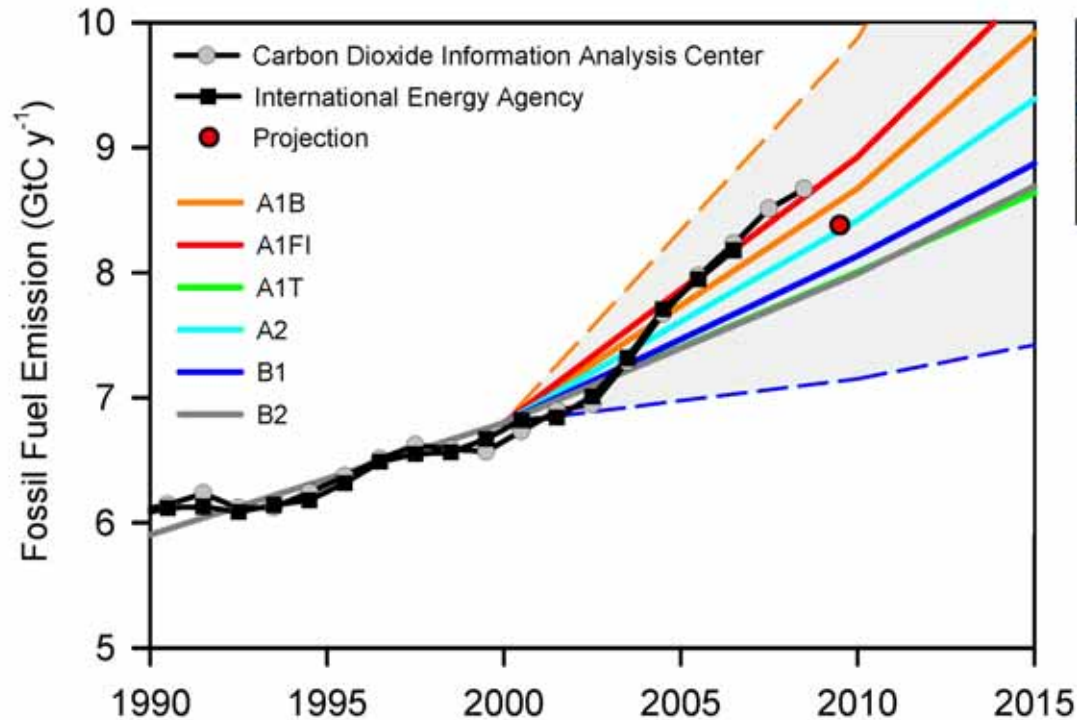
(When there is so much we don't know)

- ***Long time horizon: generational to century***
- *All waste products must have short lifetime in biosphere [think CFCs, CO₂, Pu-239]*
- *Minimize use of raw materials by remanufacturing*
- *Maximize efficiency of use of energy and water*
- *Relocalize to regain control/responsibility and minimize transport*

Examples of long-lived 'waste'

- CFCs – refrigerants – very stable – lifetime centuries - broken down by sunlight in stratosphere – catalyze **ozone** destruction, which protects earth from UV
- CO₂ from fossil fuels – lifetime centuries – a **greenhouse gas** that traps earth's heat radiation – pushing earth to warmer climate
- Nuclear waste – radioactive – plutonium-239 half-life, 24000 years – **nuclear weapons**

Fossil Fuel Emissions: Actual vs. IPCC Scenarios



Projection **2009**
Emissions: -2.8%
GDP: -1.1%
C intensity: -1.7%

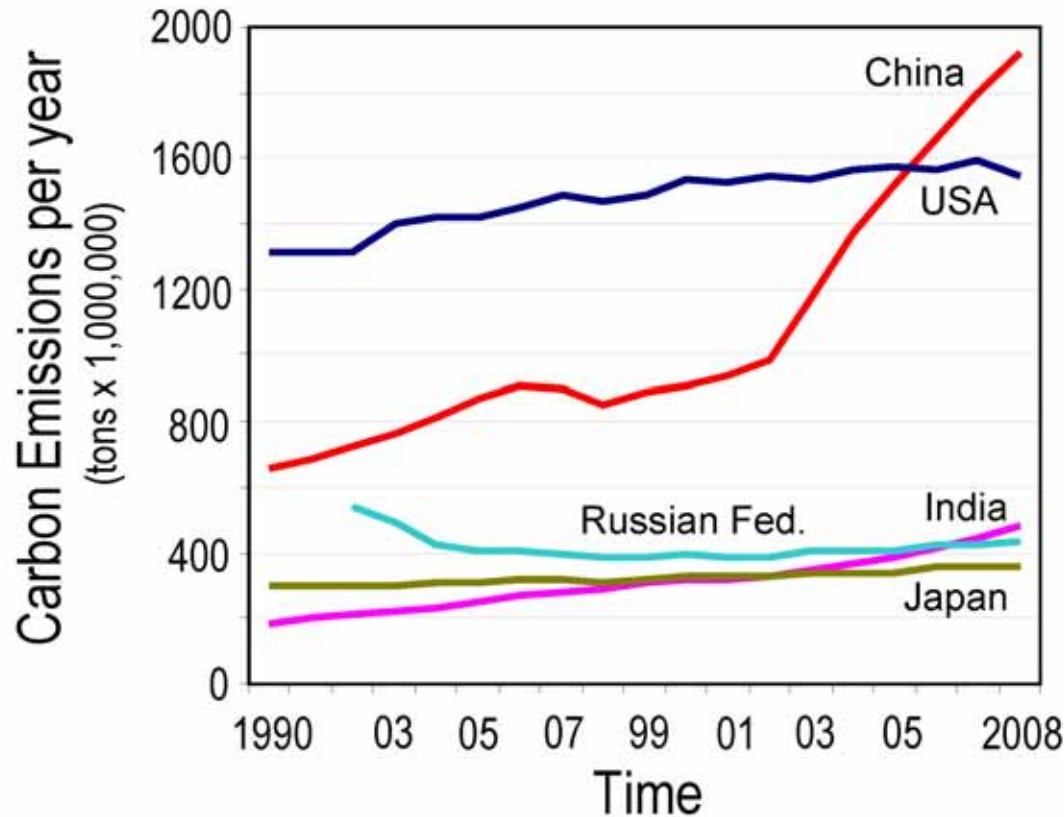


Raupach et al. 2007, PNAS, updated; Le Quéré et al. 2009, Nature Geoscience; International Monetary Fund 2009



- 2009 was 'good' for the Earth

Fossil Fuel Emissions: Top Emitters (>4% of Total)

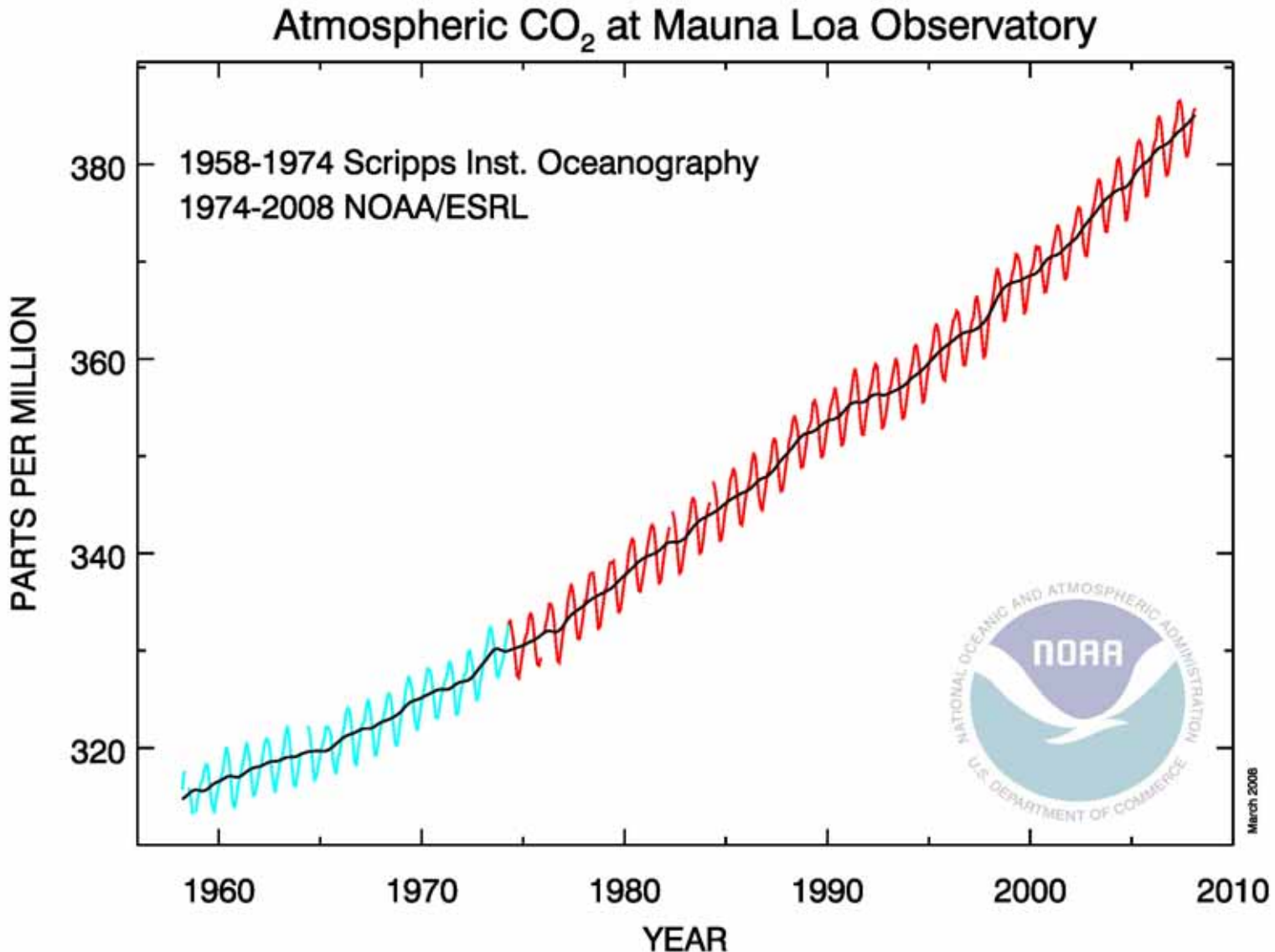


Global Carbon Project 2009; Data: Gregg Marland, CDIAC 2009



- China has overtaken the US [4 X population]

Carbon dioxide is increasing

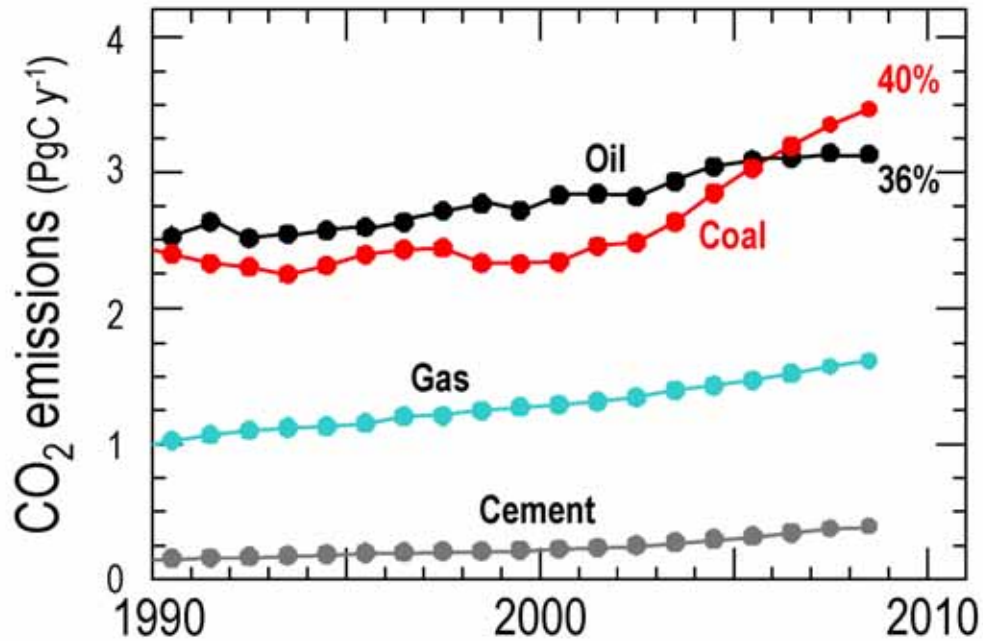


Photosynthesis: northern summer



- Leaves use **red light** to soak up carbon dioxide and grow. They give off oxygen.

Components of FF Emissions



Le Quéré et al. 2009, Nature Geoscience



- Rising coal use is big problem...

Fossil Carbon Reserves

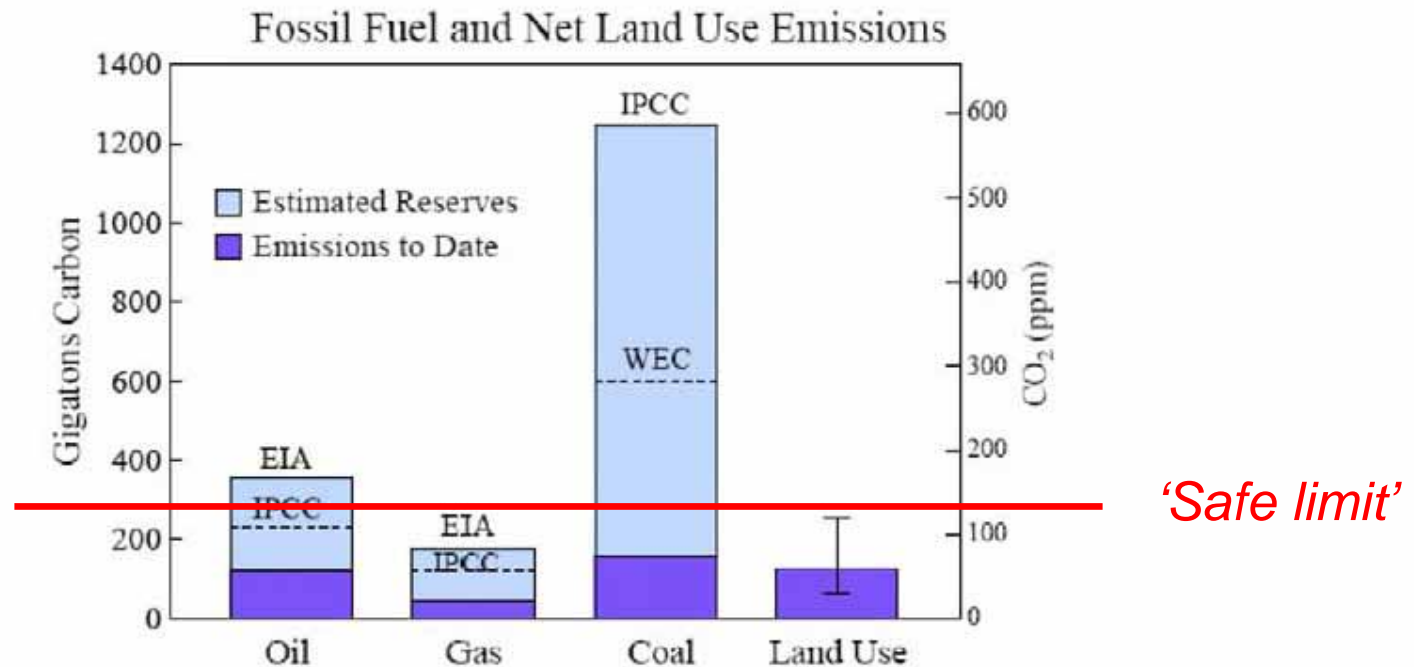


Figure 1. Fossil fuel and land-use CO₂ emissions, and potential fossil fuel emissions. Historical fossil fuel emissions are from the Carbon Dioxide Information Analysis Center [CDIAC, S34] and British Petroleum [BP, S35]. Lower limits on oil and gas reserves are from IPCC [S36] and higher limits are from the United States Energy Information Administration [EIA, 80]. Lower limit for coal reserves is from the World Energy Council [WEC, S37] and upper limit from IPCC [S36]. Land use estimate is from integrated emissions of Houghton/2 (Fig. S14) supplemented to include pre-1850 and post-2000 emissions; uncertainty bar is subjective. References are given by Hansen et al. (Open Atmos. Sci. J. 2, 217-231, 2008).

- **Coal reserves are huge:** *global total limit of 270 Gt fossil C means burning NO more coal.*

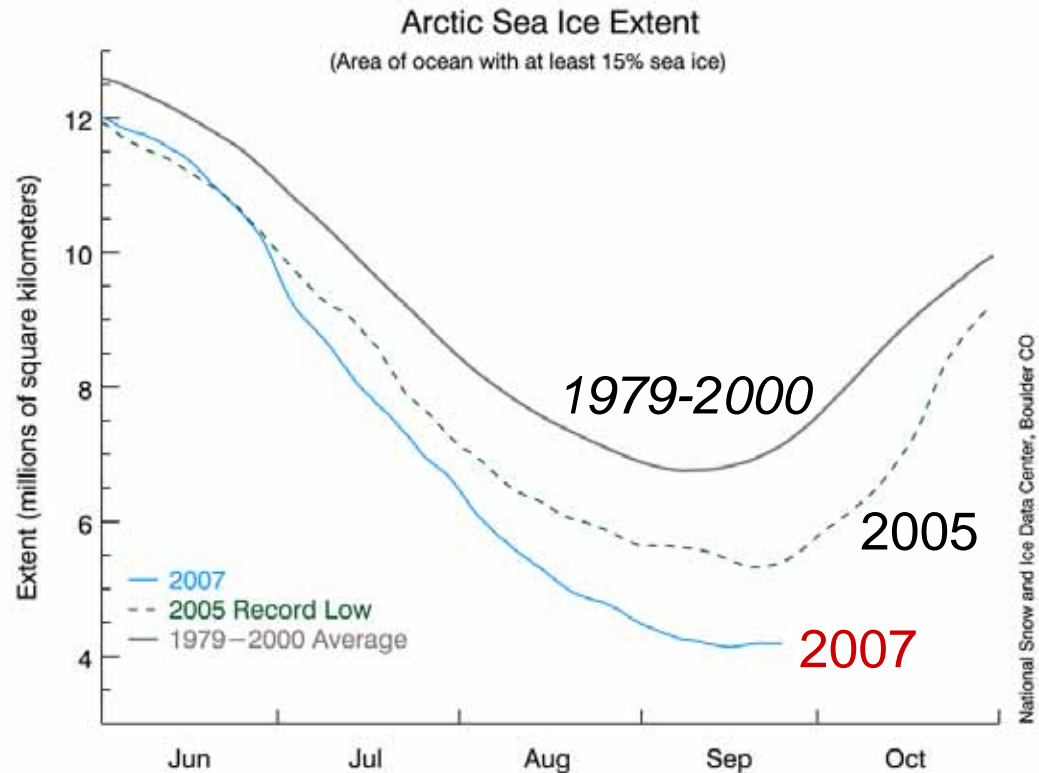
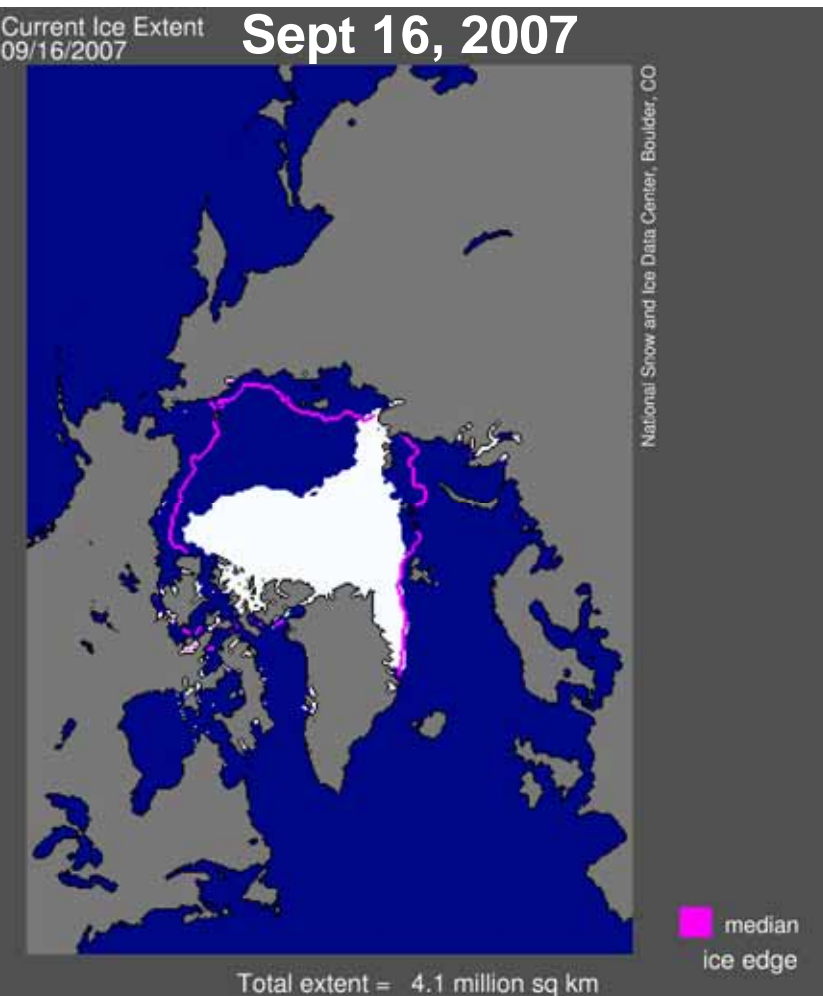
Efficiency comes first

- **Need to double or triple our energy efficiency**
- **Cannot replace current fossil fuel use with biofuels & renewable energy**
- **Oil and gas reserves are limited, but coal reserves are sufficient to push CO₂ well above 1000ppm [*and in time melt ice-caps*]. Can we “sequester” CO₂ [put it back in the earth]?**

Atmosphere is transparent to 'light' but not to 'infrared' radiation

- The earth cools by emitting infrared or heat radiation, but molecules H_2O , CO_2 , CH_4 and O_3 vibrate and absorb it: 'Greenhouse gases'
- Atmosphere blankets the earth and keeps it about 59°F warmer - so oceans don't freeze
- Increasing greenhouse gases are warming earth further: $\approx 5^\circ\text{F}$ this century, unless emissions reduced

Arctic sea-ice loss is accelerating

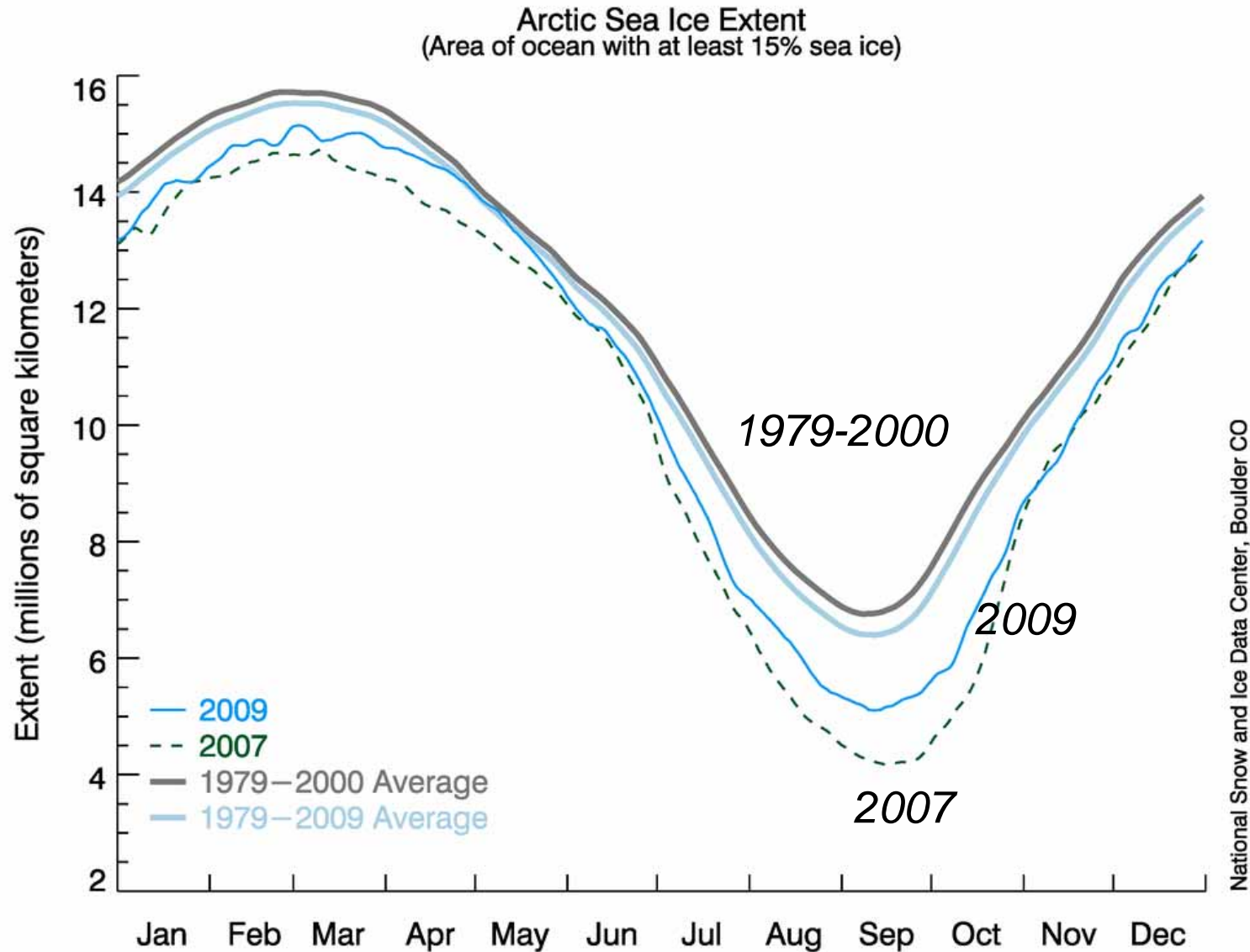


Double feedback: loss of reflective ice and increased water vapor greenhouse from more evaporation

(www.nsidc.org)

- 2007 saw new record ice-loss by huge margin
- 40% melted by September → warm Fall

2007 and 2009 Sea-Ice



Gardening in Pittsford, VT in January



Jan 7, 2007

December, 2006, *warmest on record*
[since 1894]



Jan 10, 2008

Warm Fall, *record Arctic sea-ice melt*
Snow cover in December, ground unfrozen

January 7, 2007



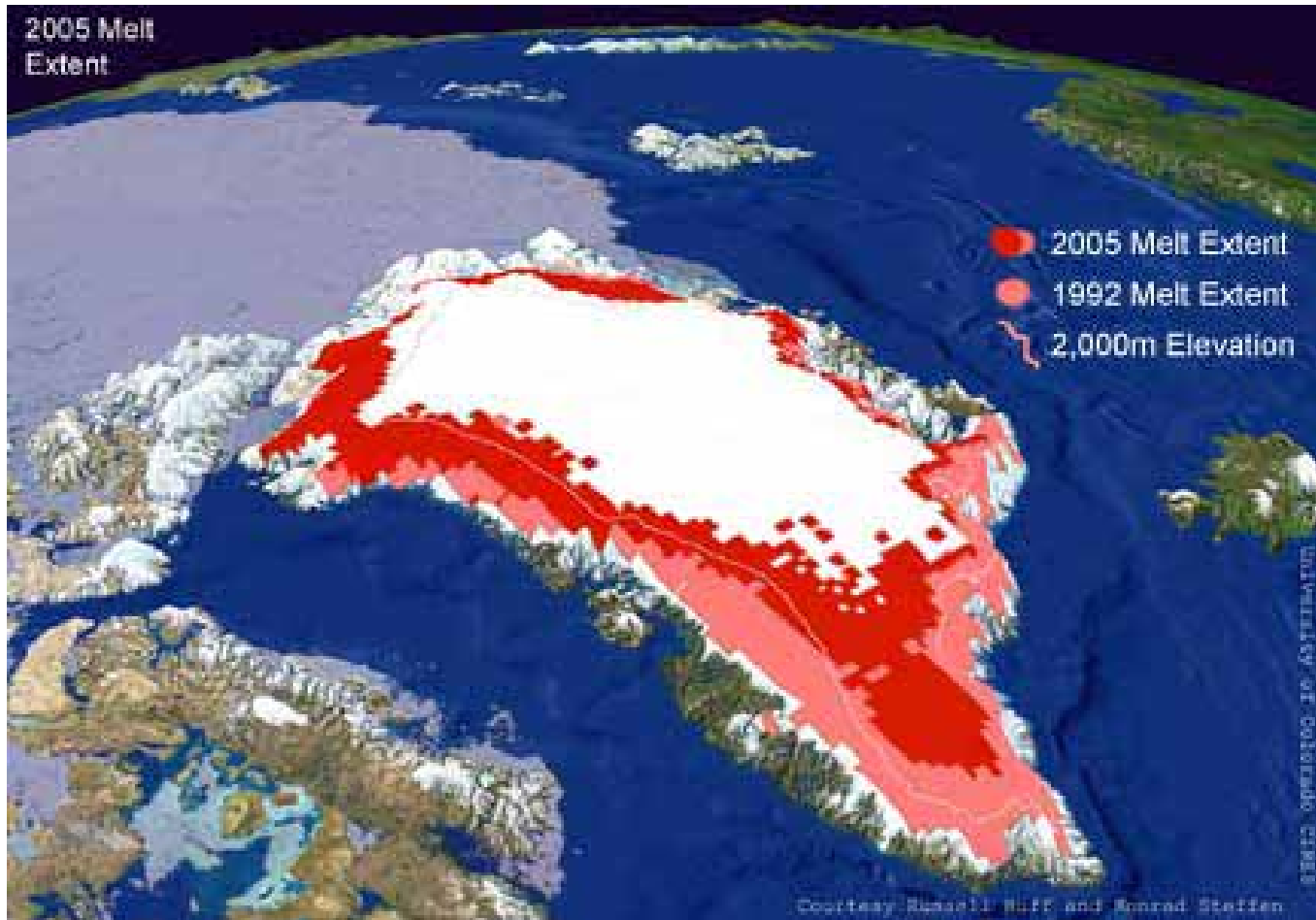
- **Rain, not snow; grass still green, evaporation continues**
- **Sunlight absorbed, not reflected; stays warmer, sky cloudy**

Vermont winter, 2006



- Sun is low; and snow reflects sunlight, except where trees!
- Sunlight reflected, stays colder; little evaporation, clear sky

Greenland ice-cap melt rapidly increasing



(Sea-level rise of 20 ft if ice-cap melts)

- Summer melt area increase from 1992 to 2005
- Ice loss doubled 1996 to 2005; **2007 larger still**

Melting water
cascades down a
crevasse to the
base of the
Greenland ice
sheet in summer

Glaciers speeding up:
when will the
ice-sheet become
unstable?

*Source: Roger Braithwaite,
University of Manchester (UK)*



Icesheet break-up?

- Ice-age termination
- Sea level has risen as fast as 3ft every 20 years for centuries with break-up of large ice-sheets

*J. Hansen, Scientific American,
March, 2004*

*[3-4ft this century & more
next century...]*



Sea-level rise will flood coastal cities; Storms will flood coastal plains

- Current sea-level rise 1 ft/century
- Expected to triple to 3-4 ft/century
- And continue at this rate for centuries
- **UNLESS** we drastically reduce burning of fossil fuels by 80 % by 2050

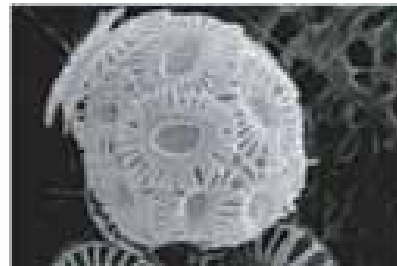
Rising ocean acidity threatens organisms



- From the tropics to the Arctic, the seas are sucking up emissions of carbon dioxide —from fossil-fuel burning.
- When carbon dioxide dissolves in water, carbonic acid is produced, so the oceans are becoming more acidic.



[Ruttiman, *Nature*, 31 Aug., 2006]

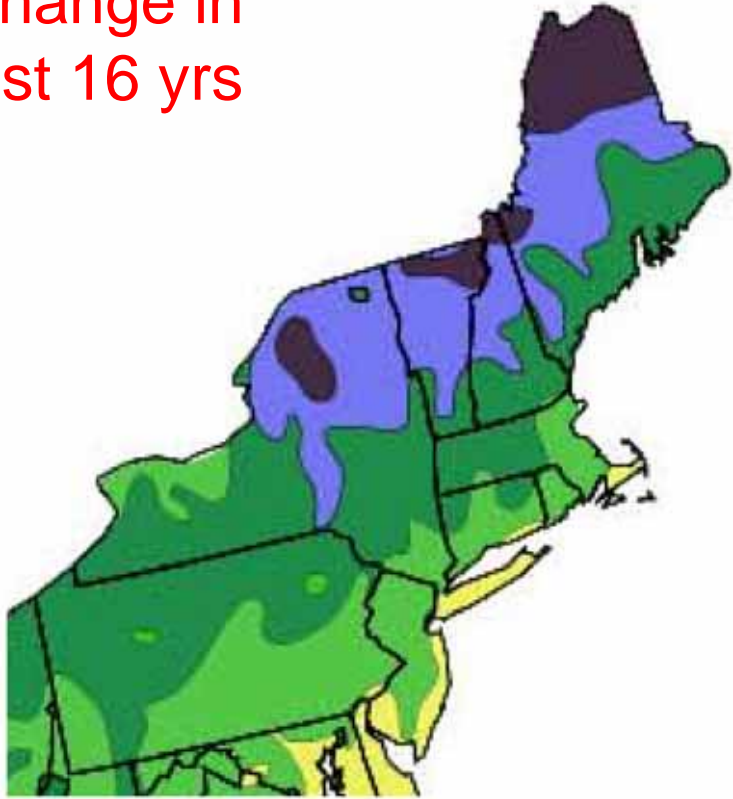


Earth system- critical issues

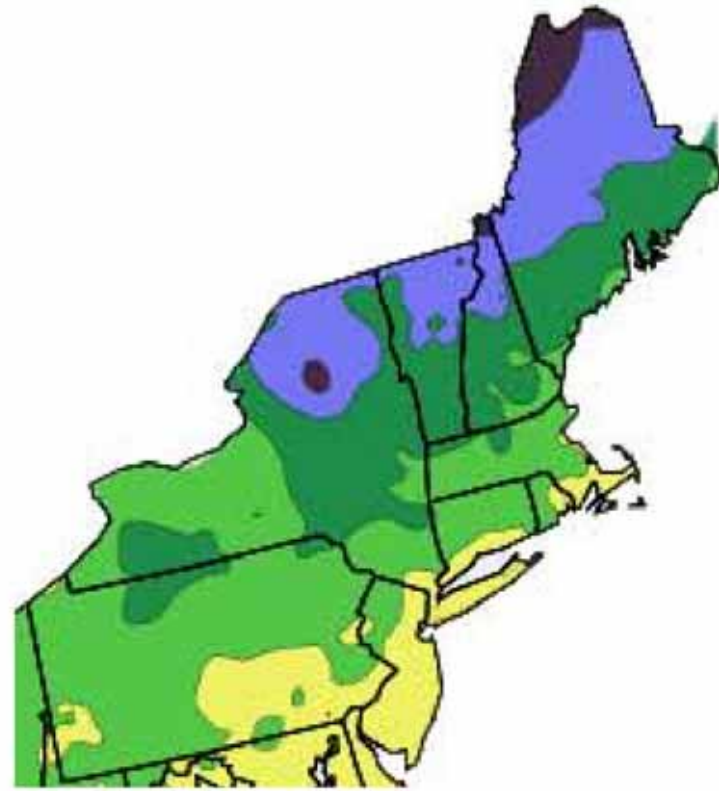
- **CO₂, H₂O, clouds & Greenhouse effect**
- **Ice-albedo feedback** [sea-ice melt]
- **Ice-melt and sea-level** [rising faster]
- **Ocean acidification** [impacts severe]
- **More extreme floods & droughts**
- **Melting permafrost; CH₄, tundra regrowth**
- **Unstable feedbacks**
- **Many unknowns**

USDA Hardiness Zones - Northeast

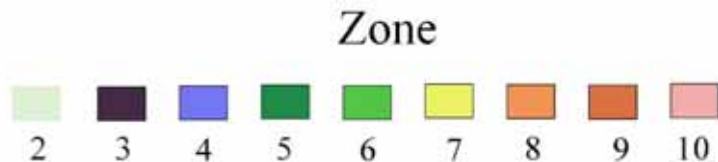
Change in
last 16 yrs



1990

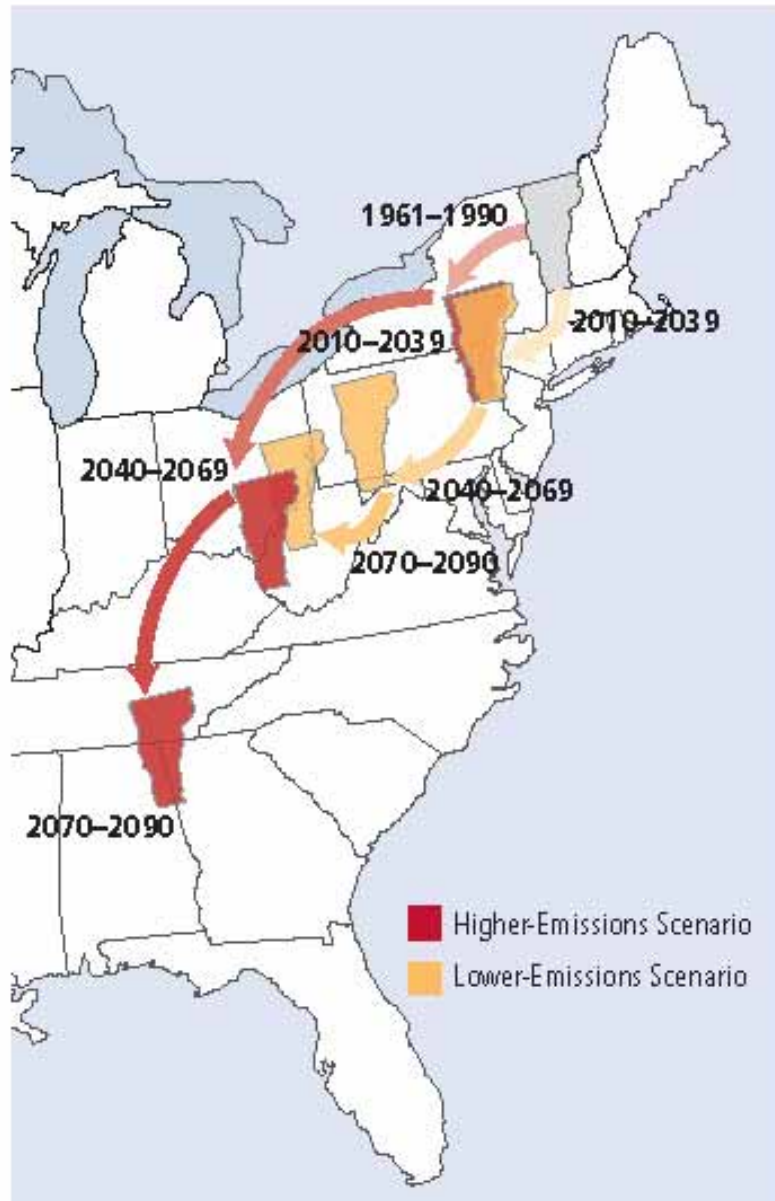


2006



USDA Hardiness Zones

Vermont's future with high and low GHG emissions



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.

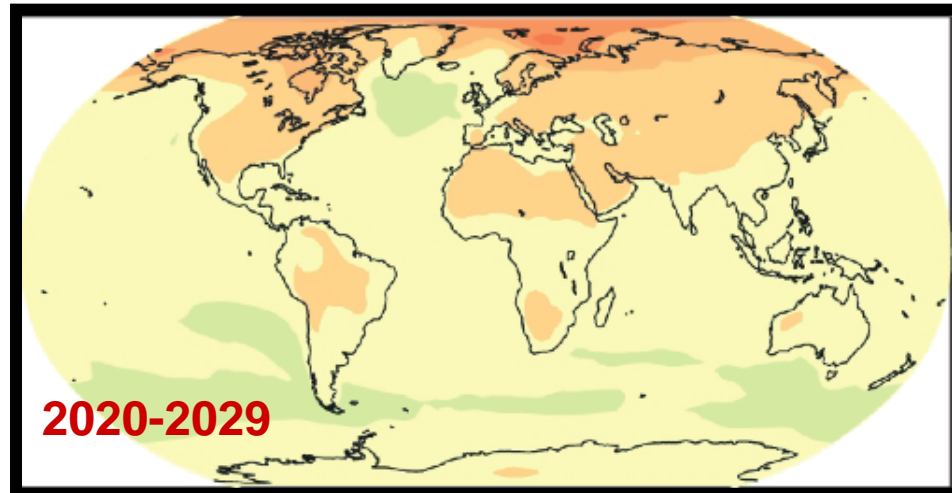
Red is high emissions

What about the tropics?

NECIA, 2007

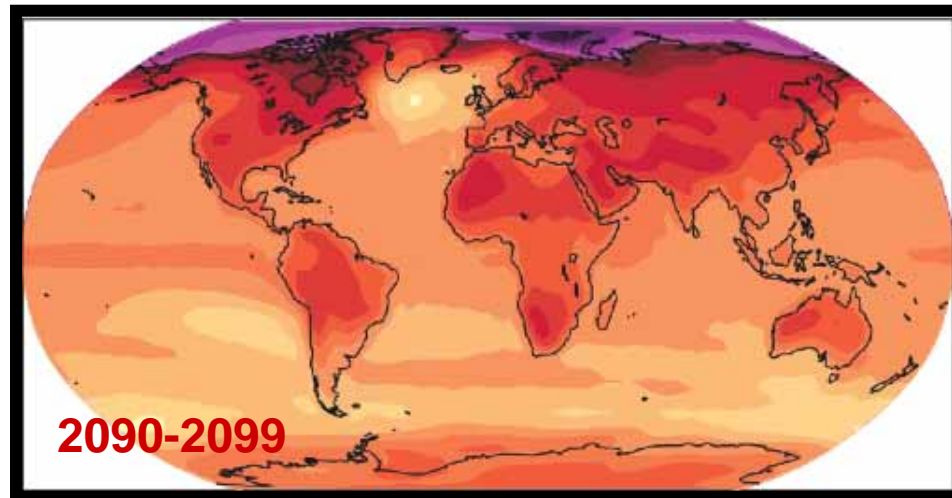
Multi-model Predicted Percent Change in Temperature (2020-2029 and 2090-2090 relative to 1980-1999) [$^{\circ}\text{C}$]

'Committed'

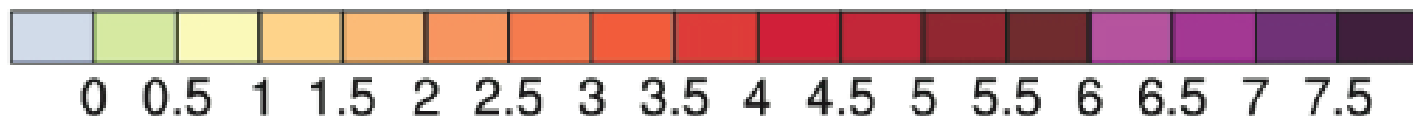


**(We did
nothing for
the last 20
years)**

Still up to us!



**(We could
halve this if
we act now)**



[$^{\circ}\text{C}$]

Our responsibility for future of the Earth



- **Discovery of fossil fuels drove the industrial revolution**
- **Current problem arises because our technology is having a global impact on the natural world**
- *As long as we burn fossil fuels [coal, oil and gas] at present rate, the earth will be driven 'rapidly' towards a warmer state*
 - *the climate system has many instabilities*
 - *ecosystems are vulnerable*



Climate Change is a huge challenge for humanity



- **We haven't integrated our science/technology and our moral responsibility for the earth**
- **We have a large investment in a fossil fuel infrastructure, that must be replaced**
- **We have major political problems finding consensus**
- *We are already decades late in taking action and the lags in the earth system are long*

(Self)-deception is still an issue

- *Three pillars of American dream are crumbling*
- “Economic growth” based on **fossil fuels, debt and consumerism** is **unsustainable**
 - and a disaster for the planet!
- **Individual “rights”** must be balanced against the needs of the **earth’s ecosystem**
- **We have no workable paradigm to guide and manage technology** – so result is tremendous successes and catastrophic failures

So what do we need?

- **Individual & societal understanding**
- **Local, State and Federal legislation to build an efficient society based on renewable energy**
- **Transforming infrastructure takes decades!**
- **Sustainable system** not “growth economy”
- *Yet despite the fiscal/economic crash; (almost) all want to return to “business as usual”!*
- *What would a sustainable society look like?*

Climate Neutrality?

- **We know what we need**
 - **Energy-efficient society**
 - **Energy sources renewable: not fossil**
- **What are the obstacles?**
- **Why are we taking such a huge risk for this planet?**

Choices

- **What can society do?**
- **What can you and your families do?**
- they are all interconnected!
- *How do we make the transition to a sustainable, resilient society?*
- *What can Rutland County do?*



Resources [Alan Betts' talk]

For science:

- www.realclimate.org for discussion/debate by scientists
- <http://www.climate-science-watch.org/> tracks govt. honesty
- *Jim Hansen's papers: archive at*
- <http://www.columbia.edu/~jeh1/>
- http://www.columbia.edu/~jeh1/case_for_vermont.pdf

Vermont Climate Change Commission :

- <http://www.vtclimatechange.us/>

Vermont Climate Action Network, VECAN

<http://www.vnrc.org/article/view/9452/1/625>

Vermont Earth Institute [<http://www.vtearthinstitute.org/>]

www.transitiontowns.org