

# **Human-Made Climate Change:** **A Scientific, Moral and Legal Issue\***

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**\*Statements relating to policy are personal opinion**

## **Global Warming Status**

### **1. Knowledge Gap Between**

- What is Understood (scientists)
- What is Known (public)

### **2. Planetary Emergency**

- Climate Inertia → Warming in Pipeline
- **Tipping Points → Could Lose Control**

### **3. Bad News & Good News**

- Safe Level of CO<sub>2</sub> < 350 ppm
- Multiple Benefits of Solution

## **Climate Tipping Points**

### **1. Ice Sheet Disintegration**

- Ocean Warming → Ice Shelves Melt  
→ Ice Streams Surge → Disintegration

### **2. Species Extinction**

- Shifting Climate Zones, Multiple Stresses, Species Interdependencies

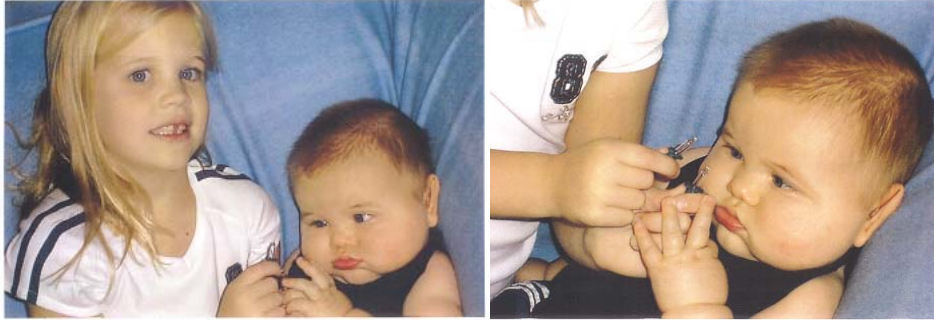
### **3. Methane Hydrate 'frozen methane'**

- In Tundra & On Continental Shelves
- Depends On Ocean & Ice Sheets



**First grandchild, Sophie – at age almost two years**

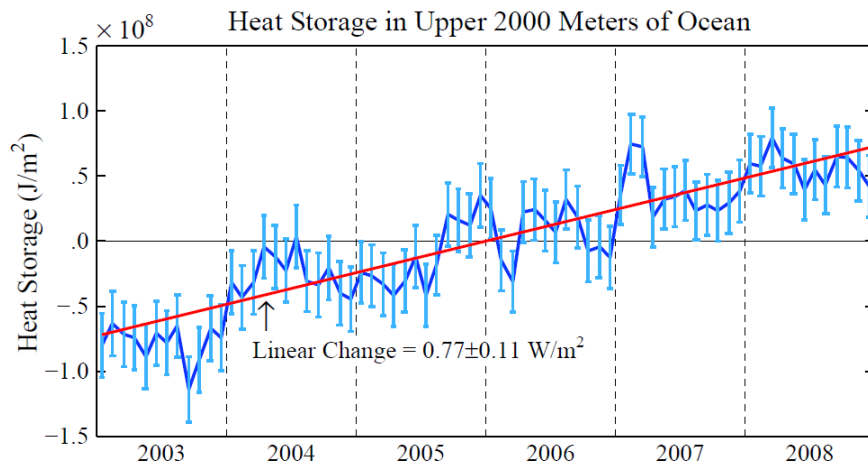
## Sophie explains 2 Watts of forcing to brother Connor



**Sophie Explains GH Warming:**

**Connor only counts 1 Watt**

**"It's 2 W/m<sup>2</sup> Forcing."**



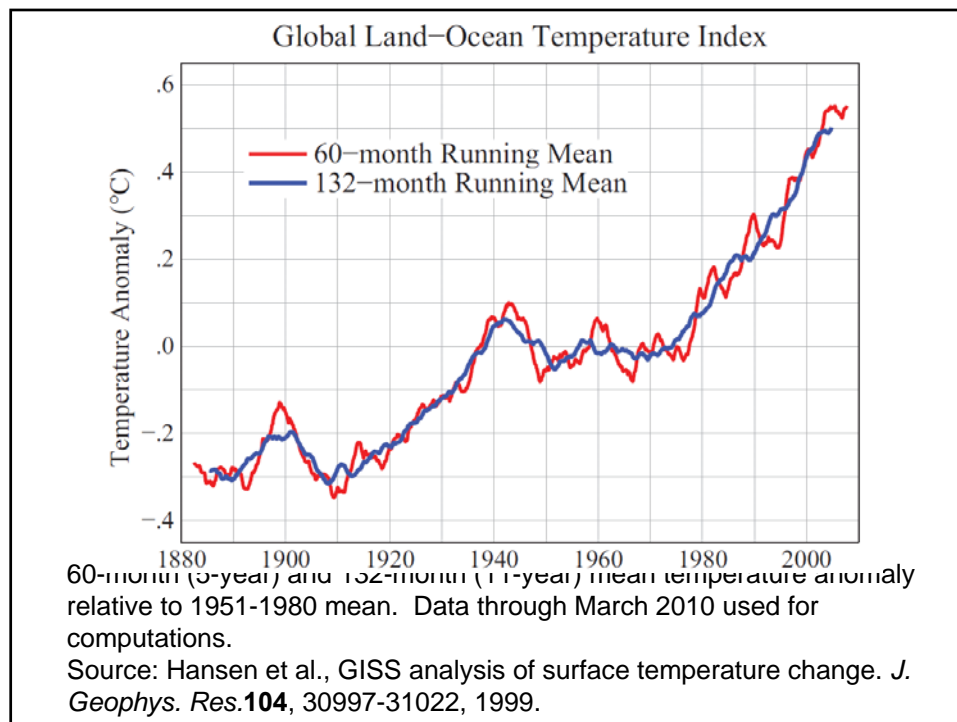
**Heat storage in upper 2000 meters of ocean during 2003-2008 based on ARGO data.**

**Knowledge of Earth's energy imbalance is improving rapidly as ARGO data lengthens.**

**Data must be averaged over a decade because of El Nino/La Nina and solar variability.**

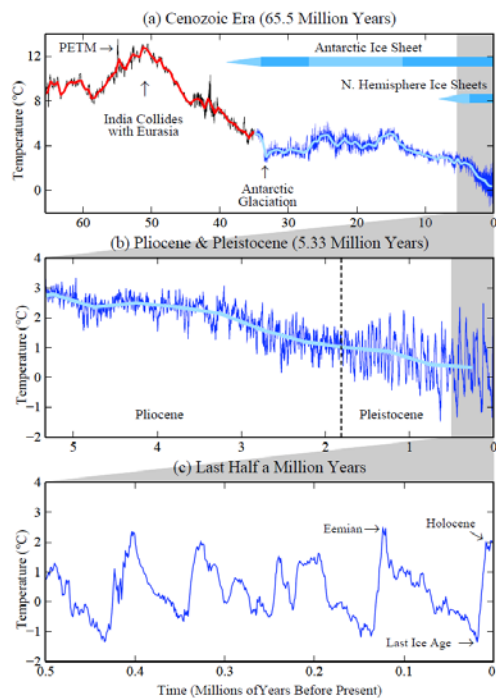
**Energy imbalance is smoking gun for human-made increasing greenhouse effect.**

Data source: von Schuckmann *et al. J. Geophys. Res.* **114**, C09007, 2009, doi:10.1029/2008JC005237.



## Basis of Understanding

1. **Earth's Paleoclimate History**
2. **On-Going Global Observations**
3. **Climate Models/Theory**



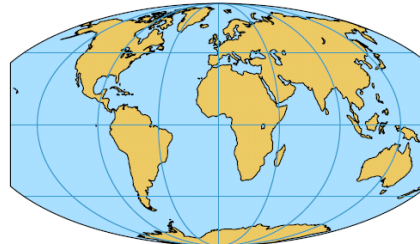
Global deep ocean temperature over past 65 million years.

Time scale is successively expanded in lower figures.

## Cenozoic Era



End of Cretaceous (65 My BP)



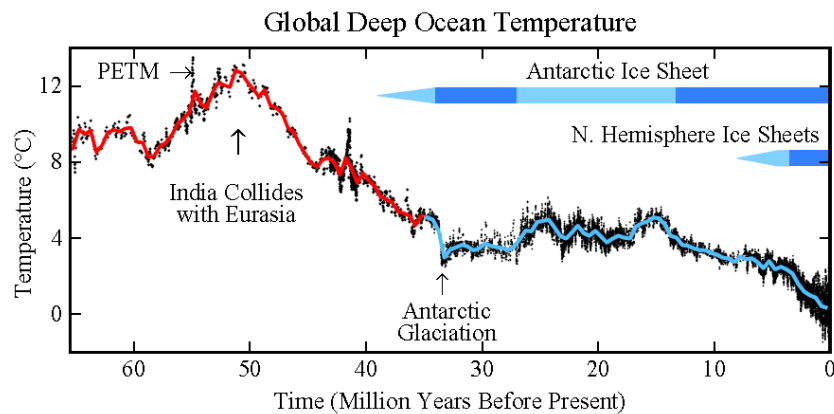
Present Day

### Global Climate Forcings

External (solar irradiance):  $+1 \text{ W/m}^2$

Surface (continent locations):  $\sim 1 \text{ W/m}^2$

Atmosphere ( $\text{CO}_2$  changes):  $> 10 \text{ W/m}^2$



**50 million years ago (50 MYA) Earth was ice-free.**

**Atmospheric CO<sub>2</sub> amount was of the order of 1000 ppm 50 MYA.**

**Atmospheric CO<sub>2</sub> imbalance due to plate tectonics ~ 10<sup>-4</sup> ppm per year.**

## Summary: Cenozoic Era

### 1. Dominant Forcing: Natural $\Delta\text{CO}_2$

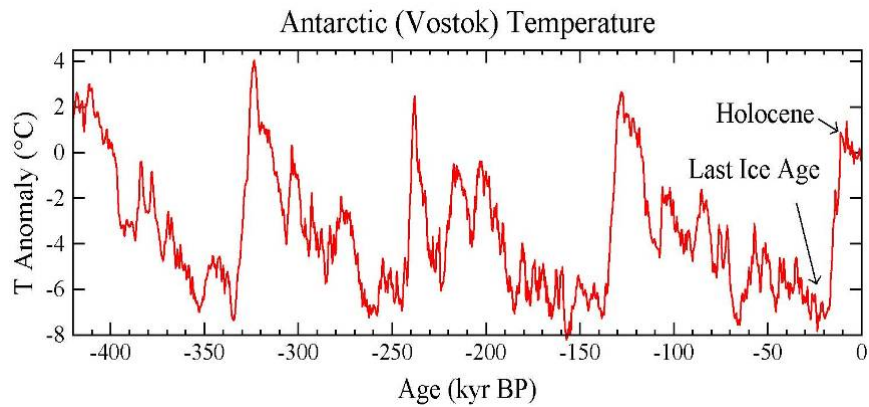
- Rate ~100 ppm/My (0.0001 ppm/year)
- Human-made rate today: ~2 ppm/year

**Humans Overwhelm Slow Geologic Changes**

### 2. Climate Sensitivity High

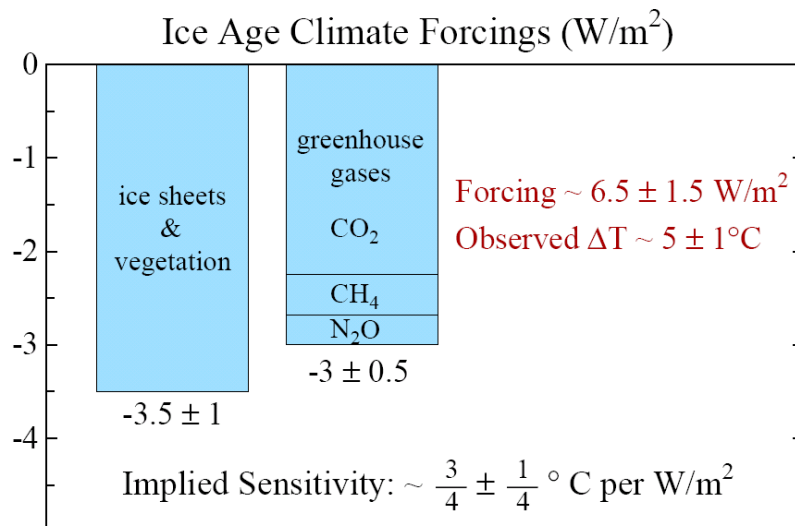
- Antarctic ice forms if CO<sub>2</sub> < ~450 ppm
- Ice sheet formation reversible

**Humans Could Produce “A Different Planet”**

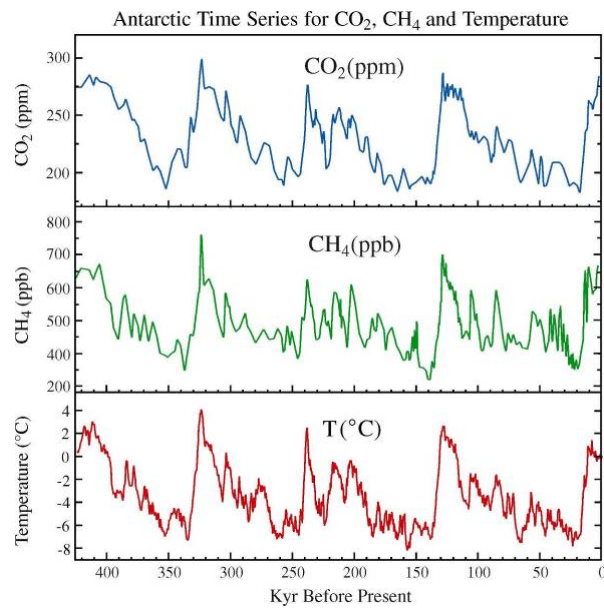


**Earth's history provides important information on global warming.**

**Recorded human history occurs within the Holocene warm period.**

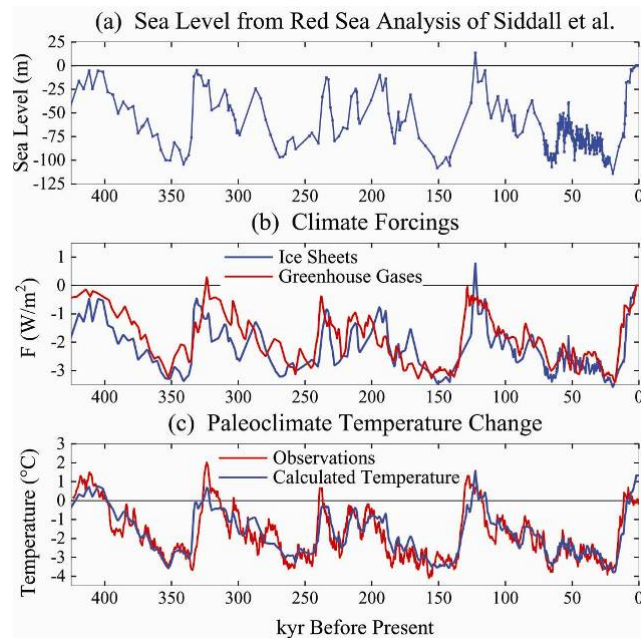


Climate forcings during ice age 20 ky BP, relative to the present (pre-industrial) interglacial period.



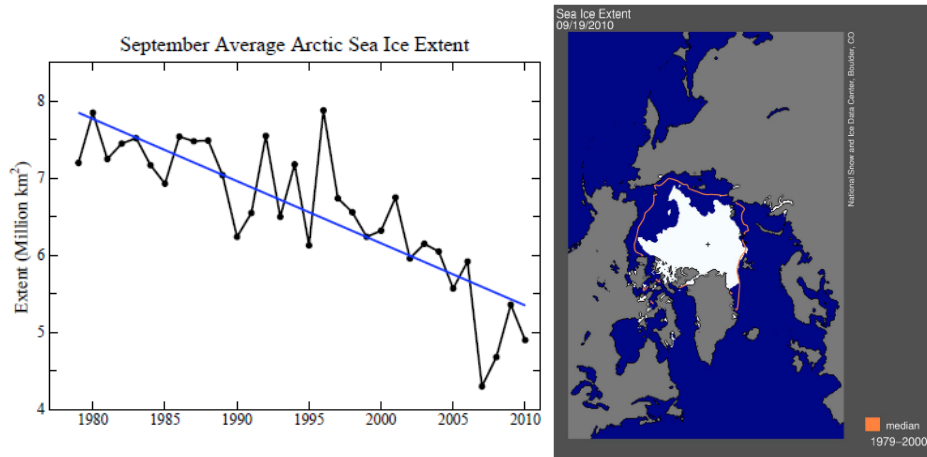
CO<sub>2</sub>, CH<sub>4</sub> and temperature records from Antarctic ice core data

**Source:** Vimeux, F., K.M. Cuffey, and Jouzel, J., 2002, "New insights into Southern Hemisphere temperature changes from Vostok ice cores using deuterium excess correction", *Earth and Planetary Science Letters*, **203**, 829-843.

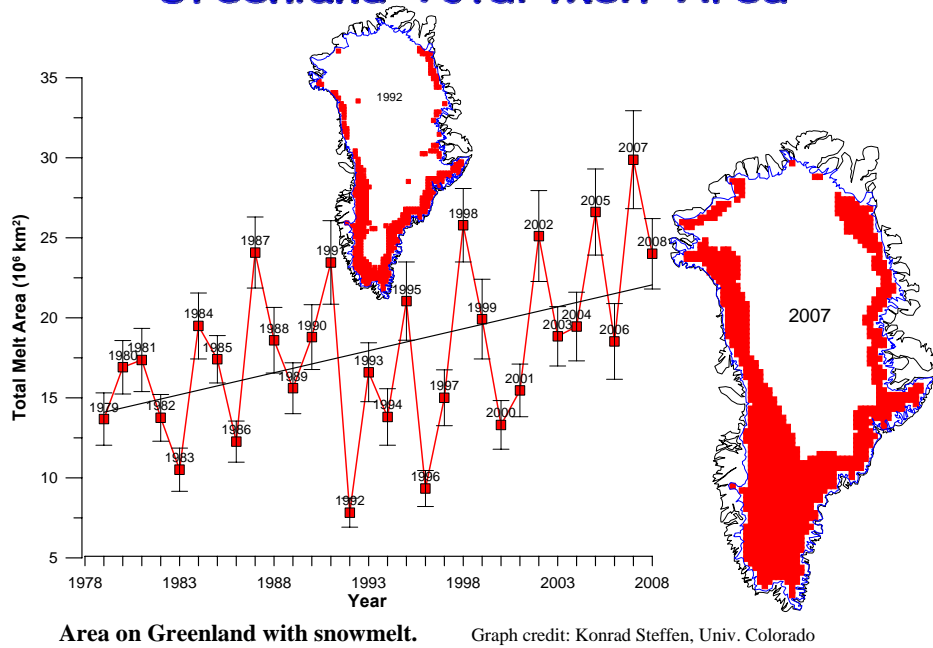




## Arctic sea ice area at summer minimum.



## Greenland Total Melt Area



## Surface Melt on Greenland

Melt descending into a moulin, a vertical shaft carrying water to ice sheet base.

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



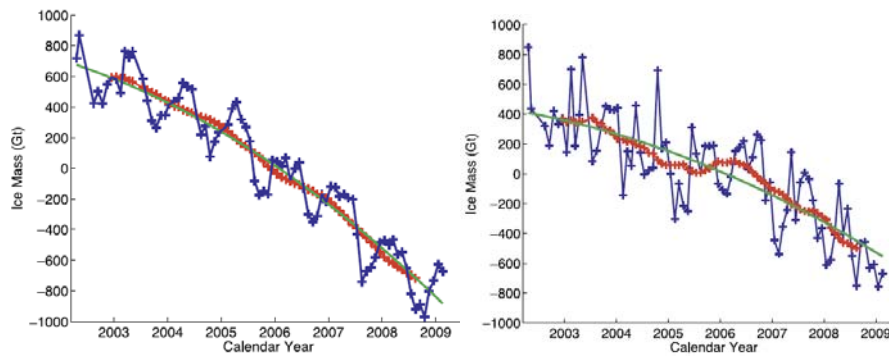
## Jakobshavn Ice Stream in Greenland

Discharge from major Greenland ice streams is accelerating markedly.

*Source: Prof. Konrad Steffen,  
Univ. of Colorado*



## Gravity Satellite Ice Sheet Mass Measurements



**Greenland Ice Sheet**

**Antarctic Ice Sheet**

Source: Velicogna, I. *Geophys. Res. Lett.*, **36**, L19503, doi:10.1029/2009GL040222, 2009.

## Pier on Lake Mead

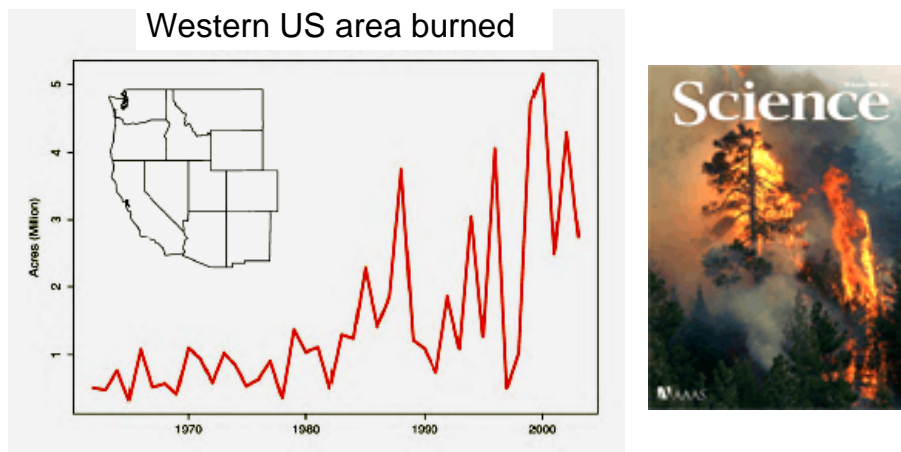


**Subtropics are expected to expand with global warming.**

**Observations show, on average, 4 degrees of latitude expansion.**

## Fires Are Increasing World-Wide

Wildfires in Western US have increased 4-fold in 30 years.



Source: Westerling et al. 2006



## Himalayan (Rongbuk) Glacier



Rongbuk, the largest glacier on Mount Everest's northern slopes, in 1968 (top) and 2007. Glaciers are receding rapidly world-wide, including the Rockies, Andes, Alps, Himalayas. Glaciers provide freshwater to rivers throughout the dry season and reduce spring flooding.



## Stresses on Coral Reefs



**Coral Reef off Fiji**

(Photo credit: Kevin Roland)

## Assessment of Target CO<sub>2</sub>

<u>Phenomenon</u>	<u>Target CO<sub>2</sub> (ppm)</u>
1. Arctic Sea Ice	300-350
2. Ice Sheets/Sea Level	300-350
3. Shifting Climatic Zones	300-350
4. Alpine Water Supplies	300-350
5. Avoid Ocean Acidification	300-350

→ Initial Target CO<sub>2</sub> = 350\* ppm

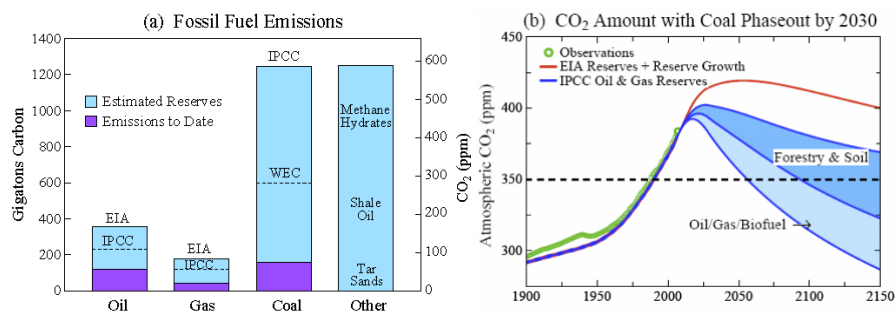
\*assumes CH<sub>4</sub>, O<sub>3</sub>, Black Soot decrease

# Target CO<sub>2</sub>:

## < 350 ppm

To preserve creation, the planet  
on which civilization developed

### Fossil Fuel Reservoirs & CO<sub>2</sub> Scenarios



**Scenarios assume no "Other" = Tar Sands, Oil Shale, Methane Hydrates**  
**Coal phase-out by 2030 → peak CO<sub>2</sub> ~400-425 ppm, depending on oil/gas.**  
**Faster return below 350 ppm requires additional actions**

Source: Hansen *et al.*, Target atmospheric CO<sub>2</sub>: where should humanity aim? *Open Atmos. Sci. J.*, 2, 217-231, 2008.

## **<350 ppm is Possible, But...**

### **Essential Requirements**

- 1. Quick Coal Phase-Out Necessary**  
All coal emissions halted in 20 years
- 2. No Unconventional Fossil Fuels**  
Tar sands, Oil shale, Methane hydrates
- 3. Don't Pursue Last Drops of Oil**  
Polar regions, Deep ocean, Pristine land

## **What's Really Happening**

- 1. Tar Sands Agreement with Canada**  
Pipeline planned to transport oil
- 2. New Coal-fired Power Plants**  
Rationalized by 'Clean Coal' mirage
- 3. Mountaintop Removal Continues**  
Diminishes wind potential of mountains
- 4. Oil & Gas Extraction Expands**  
Arctic, offshore, public lands

## Global Action Status

### 1. Huge Gap: Rhetoric & Reality

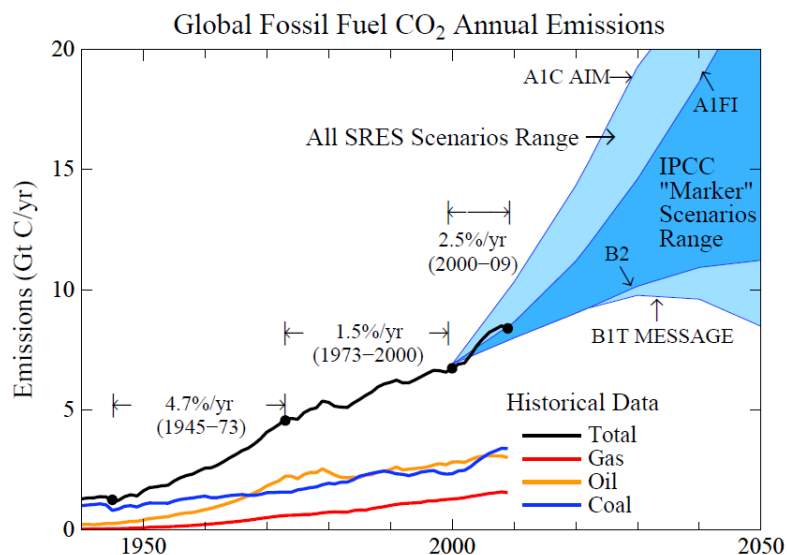
- Rhetoric: Planet in Peril
- Policies: Small Perturbation to BAU

### 2. Greenwash/Disinformation Winning

- Appeasement of Fossil Interests
- Still Waiting for a Winston Churchill

### 3. Kyoto & Copenhagen Failures

- Kyoto → accelerating emissions
- Copenhagen → still “cap-&-trade”



**Global fossil fuel carbon dioxide emissions accelerated after Kyoto Protocol.**

Date sources: Marland et al. (U.S. Dept. Energy, Oak Ridge and extended with BP Statistical Review of World Energy.)



## **Problem & Solution**

- 1. Fossil Fuels are Cheapest Energy**
  - Subsidized & Do Not Pay Costs
  - Solution: Rising Price on Carbon
- 2. Regulations also Required**
  - Efficiency of Vehicles, Buildings, e.g.
  - Carbon Price Provides Enforcement
- 3. Technology Development Needed**
  - Driven by Certainty of Carbon Price
  - Government Role Limited

## **Fee & Green Check (Dividend)**

- 1. Fee Applied at First Sale/Port of Entry**
  - Covers all Oil, Gas, Coal → No Leakage
- 2. Fee Specified: No Speculation, No Volatility**
  - No Wall Street Millionaires at Public Expense
- 3. Other Merits**
  - Only Potentially Global Approach
  - Simple, Honest, Can be Implemented Quickly
  - Market Chooses Technology Winners
  - Most Efficient & Largest Carbon Reductions

## Cap-and-Trade Flaws

1. **Designed for Banks & Fossil Interests**  
Impossible to exclude big money
2. **Price Volatility**  
Discourages clean energy investments
3. **Ineffectual**  
Real carbon reductions small
4. **Cannot be made global**  
China/India will not (& should not) accept caps

## Fee & Green Check Addresses

1. **Economy: Stimulates It**  
Puts Money in Public's Hands– A Lot!
2. **Energy: Fossil Fuel Addiction**  
Stimulates Innovation – Fastest Route to Clean Energy Future
3. **Climate**  
Only Internationally Viable Approach - -  
Zero Chance of China/India Accepting a Cap  
Would Result in Most Coal & Unconventional Fossil Fuels, and some Oil, left in the Ground

## Intergenerational Justice

**Jefferson to Madison:** ...self-evident that  
“Earth belongs in usufruct to the living”\*

**Native People:** obligation to 7<sup>th</sup> generation

**Most Religions:** duty to preserve creation

**Governments (with fossil interests):** we set  
emissions at whatever level we choose

**Public:** when will it become involved?

\*Legal right to use something belonging to another

Lauren Emma (age 2½ days) and Jake (age 2½ years)



Lauren Emma (age  $2\frac{1}{2}$  days) and Jake (age  $2\frac{1}{2}$  years)



Sophie writing letter to President Obama



Opa reads the letter to President Obama.



Sophie, Opa and Connor celebrate good letter.

## Notes of Optimism

### 1. China

Enormous investments in carbon-free energy (solar, wind, nuclear power)

### 2. Legal Approach

Judicial branch less influenced by fossil fuel money (than executive and legislative branches)

## Atmospheric Trust Litigation\*

### 1. Atmosphere is a public trust asset

Governments have fiduciary obligation to manage asset – it is not political discretion

### 2. Courts can enforce via injunction

Require carbon accounting, with schedule specified by science

### 3. Force governments at all levels

\*

Wood, M., Atmospheric Trust Litigation, in *Adjudicating Climate Change: Sub-National, National, and Supra-National Approaches* (William C.G. Burns & Hari M. Osofsky, eds.) (2009, Cambridge University Press

## **Web Site**

**[www.columbia.edu/~jeh1](http://www.columbia.edu/~jeh1)**

**includes**

**Target Atmospheric CO<sub>2</sub>: Where Should  
Humanity Aim?**

**Global Warming Twenty Years Later:  
Tipping Points Near**

**In Defence of Kingsnorth Six**