The Threat to the Planet:
How Can We Avoid Dangerous Human-Made Climate Change?

Remarks of James E. Hansen on 21 November 2006
On Acceptance of WWF Duke of Edinburgh Conservation Medal
At St. James Palace, London

Your Majesty, I greatly appreciate your devotion to the environment and all the creatures on Earth. I am honored to receive the Duke of Edinburgh Conservation Medal and I welcome this opportunity to describe the threat to our planet posed by unbridled consumption of fossil fuels. I recognize the debt owed to my colleagues, who deserve most of the credit for the research findings that I describe, and to my wife Anniek, who generously tolerates my inordinate obsessions.

The rude scientific awakening to the threat of climate change has been sudden and profound. Only in recent years has the extent and immediacy of the threat become clear. The result is a huge gap between what is understood about global warming, by the relevant scientific community, and what is known about global warming, by those who need to know, the public and policymakers.

We must close that gap and begin to move our energy systems in a fundamentally different direction within about a decade, or we will have pushed the planet past a tipping point beyond which it will be impossible to avoid far-ranging undesirable consequences. These include loss of a large fraction of species on the planet due to rapid shifting of climatic zones and eventual rising sea level due to disintegration of the major ice sheets.

How can we be near a precipice, when global warming effects are just beginning to be apparent to observant people? My first chart (Chart 2) shows global mean temperature change for the past century. Temperature increased 0.8°C in 125 years, with 0.6°C warming in the past 30 years. That is much less than day-to-day weather fluctuations. But another half degree Celsius warming is in the pipeline from gases already in the air, due to the long time that it takes the ocean to warm. And more gases are in the pipeline, due to infrastructure of powerplants and vehicles.

Chart 3. All nations have agreed that we should stabilize atmospheric composition at a level that avoids dangerous human-made climate change, but what level is dangerous?

Chart 4. Critical metrics defining dangerous, I believe, include extinction of animal and plant species, because it is irreversible and many species are already under stress. Also ice sheet disintegration and sea level rise, because that is also irreversible on any practical time scale. Large regional climate shifts are also a serious threat.

Chart 5. Plants, animals and other species can survive only within certain zones. If climate changes, species attempt to migrate. A man in Arkansas told me that he had never seen an Armadillo until they appeared at the southern end of a 40-mile route he

drives every day. He observed them move farther north each year, and they now exist on his entire route. Armadillos are a tough species and may survive climate change.

Chart 6. Other species may have a hard time. There is no colder place for polar species to go. If we follow business-as-usual, with year-after-year increase in CO_2 emissions, polar species will be pushed off the planet. Some iconic species may survive in zoos (if that is considered survival). Species living on the biologically diverse slopes leading to mountains will also be pushed off the planet, as a given climate zone moves to higher levels, where the area is smaller, the surface rockier, the air thinner.

Trouble is brewing for many species. The distance that climate zones have moved so far is small, but the rate of movement of isotherms, lines of given temperature, is now poleward at 50 km per decade. Some species cannot migrate that fast, species are interdependent, and movement is hampered by human or natural barriers. The rate of isotherm movement will double this century if we follow business-as-usual, and climate change will surely become the greatest cause of extinction of species, which are already under stress for other reasons.

Chart 7. Sea level rise is another major concern. Global warming causes increased summer melt on the ice sheets. This melt-water goes into crevasses and makes holes that go to the base of the ice sheet, where the water lubricates the ground and increases movement of ice down-slope to the ocean.

Chart 8. As a result, the discharge of giant icebergs to the ocean has doubled in the past decade. Sea level is now rising 3.1 cm per decade, 31 cm (about 1 foot) per century. Continued for a century, that rate of rise will be more than a nuisance on coast lines, but it is piddling in comparison with what will happen if we follow business-as-usual fossil fuel use. The last time that an ice sheet collapsed, fourteen thousand years ago, sea level rose at an average rate of 1 meter every 20 years for centuries.

Sea level rise of several meters would be catastrophic for hundreds of millions of people in China, Bangladesh, India, Egypt, the United States and Europe. It takes time for an ice sheet to be softened up for cataclysmic collapse, but once it starts it is unstoppable. Some scientists believe that it may take centuries for ice sheets to collapse, but others, including me, believe that business-as-usual fossil fuel use would cause sea level rise measured in meters this century.

Chart 9. What level of global warming will cause disastrous effects? The history of the Earth is our best guide. This is the temperature in the most representative part of the world over the past million years, with time running from left to right, and the time scale greatly expanded for recent years.

A few interglacial periods were warmer than today, by almost 1°C. That range sets the level of warming that would allow us to keep a planet similar to the one that humanity developed on. Global warming of 2-3°C would produce a different planet, one without

sea ice in the Arctic, with catastrophic sea level collapse in the pipeline, and super-drought in the American West, southern Europe, the Middle East and parts of Africa.

Chart 10. Global warming of 2-3°C will occur if we follow business-as-usual, we are sure, because the sensitivity of climate is well-constrained by its history. Such a scenario threatens even greater calamity, because it could unleash positive feedbacks such as melting of frozen methane in the Arctic, as occurred 55 million years ago, when more than 90% of species on Earth went extinct. An alternative scenario, with additional warming less than 1°C is possible, but it requires that CO_2 emissions decrease about 25% by mid-century and about 75% by the end of century. It also requires a decrease of other human-made climate forcings, specifically black soot, methane and tropospheric ozone.

Chart 11. Fossil fuel use is the primary issue. It is a science fact that at least a quarter of CO_2 emissions remains in the air forever, by that I mean more than 500 years. Given fossil fuels already burned, we can keep additional global warming under 1°C only if we restrict further use to proven reserves and finite reserve growth of oil and gas, and if we phase out coal use by mid-century. Coal and unconventional fossil fuels can continue to be used only if the CO_2 is captured and sequestered underground.

Chart 12. It is an uncomfortable inconvenient scientific truth: we cannot pour into the atmosphere all of the fossil fuels that were buried in the ground over millions of years without creating a different planet, without destroying creation, without being miserable failures in our stewardship of the planet we were blessed with. For example, as conventional oil dwindles, squeezing oil from shale mountains is not an option that would allow our planet and its inhabitants to survive.

Chart 13. There are some reasonably straightforward implications of these scientific truths, yet I should describe these as opinions. On the time scale of the next one to two decades, energy efficiency can take us off the business-as-usual path onto the alternative scenario. But that will require both efficiency standards and a price on carbon emissions to drive innovation and avoid wasteful destructive emissions of CO_2. And it requires the United States to take a true leadership role.

Chart 14. Some final fossil fuel facts and opinions. The attraction of fossil fuels is that they are cheap to mine. But that results in a huge drain on our wealth, for the benefit of a few special interests, and a possibility that some of the wealth will be used to do us harm. Politicians are afraid to point out that the way to avert these ends is a gradually rising price on CO_2 emissions, which can drive innovation and alternative energies, so that our energy expenditures would stay within our borders. The losers would be those fossil fuel companies who are too incompetent to become energy companies.

Chart 15. My final chart shows another uncomfortable truth, uncomfortable for me and my compatriots. Some politicians like to point out that China will soon exceed the U.S. in CO_2 emissions. That is true, as indicated by the first pie chart and the fact that Chinese power plants and vehicles are increasing rapidly. However, the climate effect is not determined by current emissions, but rather by time-integrated emissions, the second pie

chart. The third pie chart corrects for the lifetime of CO_2, but that makes little difference. For many decades to come, the U.S. will be the largest single cause of climate change.

I am concerned about the burden that we will leave for our children and grandchildren, if we do not take a leadership role in addressing global warming. A moral burden, as species disappear from the planet, as people are displaced by rising seas, or impoverished by increased droughts in the subtropics and by increased floods and climate variability in other regions. Perhaps also a legal burden: will not people driven from their land seek reparation from countries most responsible? Science does not leave the opportunity for us to claim ignorance of the consequences of greenhouse gas emissions.

We are not alone. Australia and Canada stand almost shoulder-to-shoulder with the United States in per capita emissions, and they have also refused to participate effectively in international attempts to reduce emissions. Some countries are doing better, yet change so far has been small, and almost nowhere does action match rhetoric.

What can be done? The public is concerned about jobs, the economy, health care, schools, crime, terrorism. The planet's problems seem remote, stress on animal and plant species, future sea level rise, even increasing climate extremes. There is a connection among climate change, energy policies, and other public problems, yet it will not be easy to achieve fundamental changes in the face of opposition by special interests.

The best hope for saving the planet, for preserving creation, rests with the younger generation, I believe. They are the ones who will be most affected by climate change. My advice to them is that it may be time to act up, not in a destructive way, but to forcefully and effectively make their concerns known.

When a fossil fuel company refuses to become an energy company and bamboozles the public with advertisements such as "you call CO_2 pollution, we call it life", it is time to stop patronizing that company. When a politician accepts money from fossil fuel interests and then describes global warming as "a great hoax", it is time to draw attention to that and help vote him out. When our government stands on the side of polluters in court and connives with industries to continue pollution, characterizing it as a "clear skies" policy, it is time to help draw attention to the truth. In this era of the internet and instant global communication, young people may be capable of finding ways to galvanize stewardship for our planet that has so far been lacking.

Finally, I emphasize that the changes needed do not require hardship or reduction in the quality of life. Quite the contrary. They will result in a cleaner environment, healthier air and cleaner water, good-paying jobs in high-tech industries in our own countries, certainly better than mining coal, although coal may continue as one source of energy. The only losers will be those special interests who do not adapt, who prefer to spread misinformation and buy off politicians, to the detriment of life on Earth. We must be on the lookout for them and point them out for what they are.

Of course, although I am a government employee, these are just my opinions as a private citizen. They do not represent government policy. Thank you.

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Jim Hansen

21 November 2006

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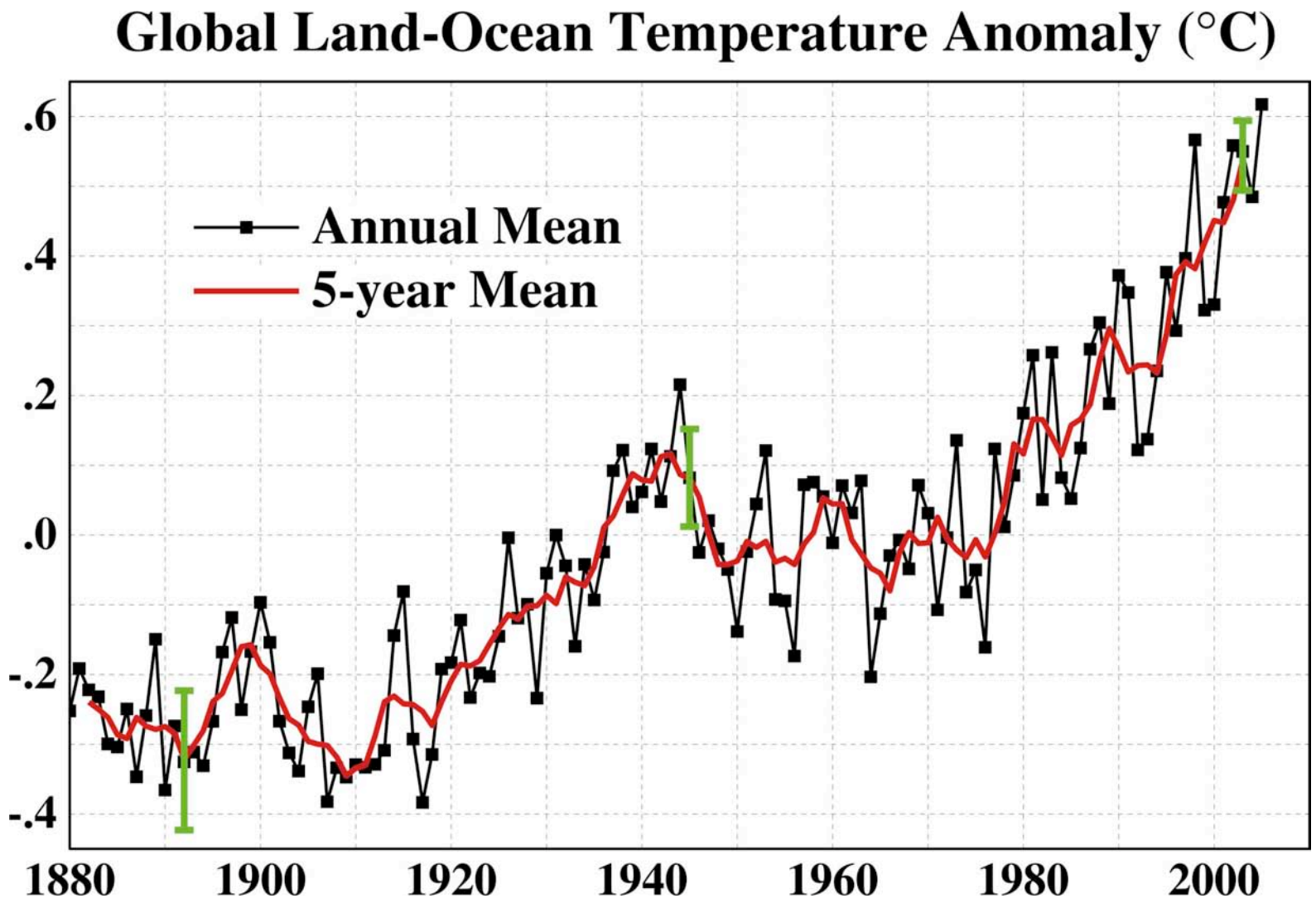

Global Land-Ocean Temperature Anomaly (°C)
.6
.4
.2
.0
-.2
-.4
Annual Mean
5-year Mean
1880
1900
1920
1940
1960
1980
2000

United Nations
Framework Convention on Climate Change

Aim is to stabilize greenhouse gas emissions…

"…at a level that would prevent dangerous anthropogenic interference with the climate system."

Metrics for "Dangerous" Change

Extermination of Animal & Plant Species

1. Extinction of Polar and Alpine Species
2. Unsustainable Migration Rates

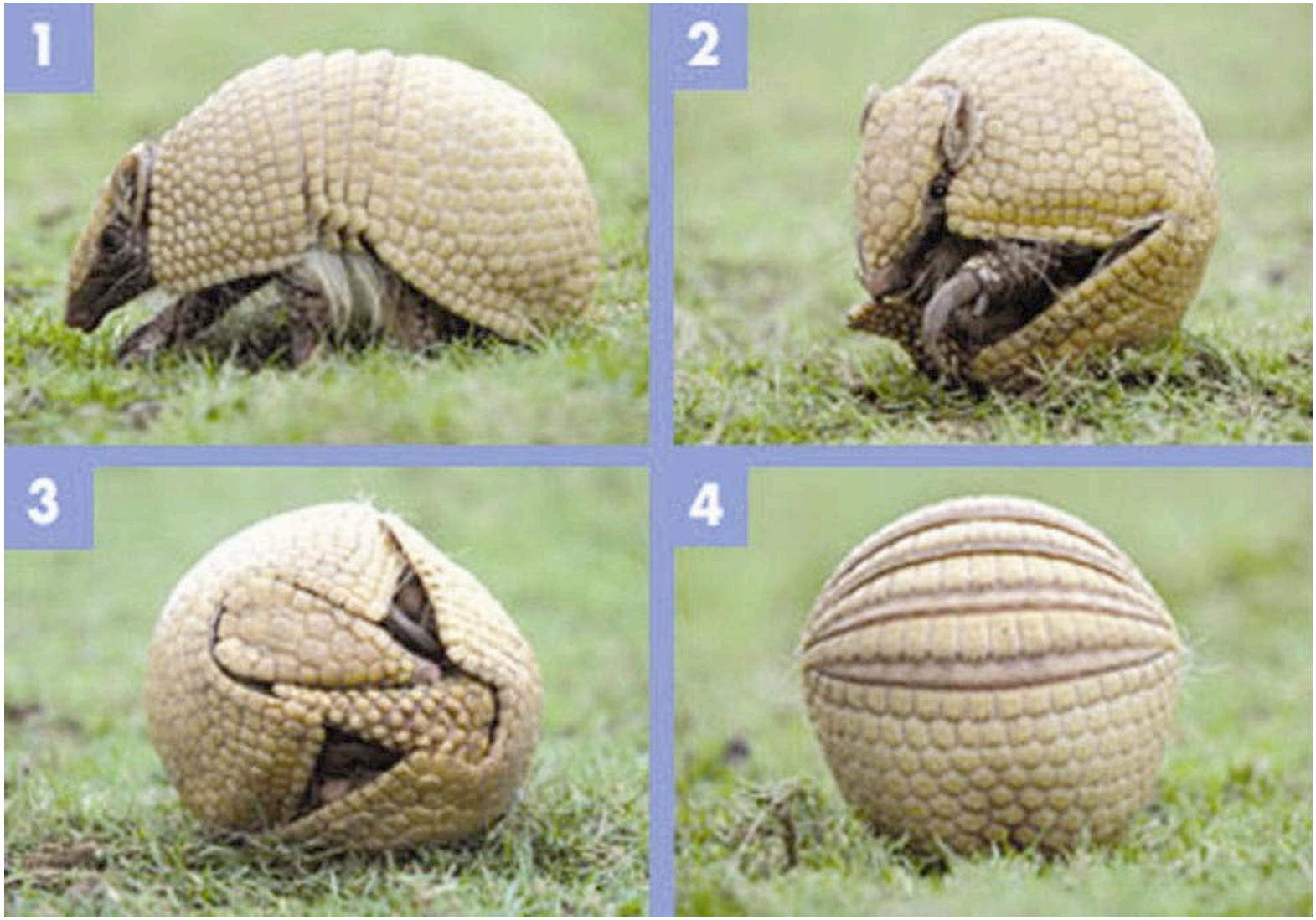
Ice Sheet Disintegration: Global Sea Level

1. Long-Term Change from Paleoclimate Data
2. Ice Sheet Response Time

Regional Climate Change

1. General Statement
2. Droughts/Floods

Armadillos: One of the Surviving Species?



Arctic Climate Impact Assessment (ACIA)

Sources: Claire Parkinson and Robert Taylor

Surface Melt on Greenland

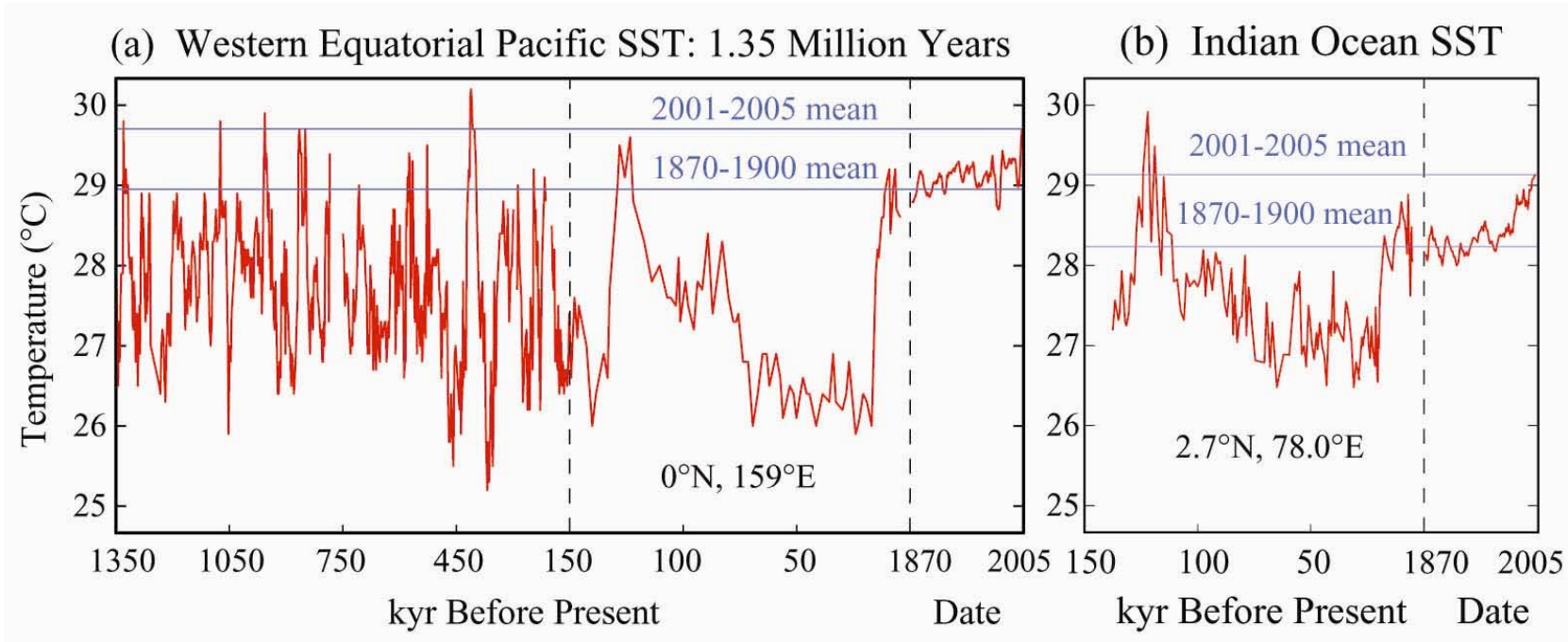
Melt descending into a moulin, a vertical shaft carrying water to ice sheet base.

Source: Roger Braithwaite, University of Manchester (UK)

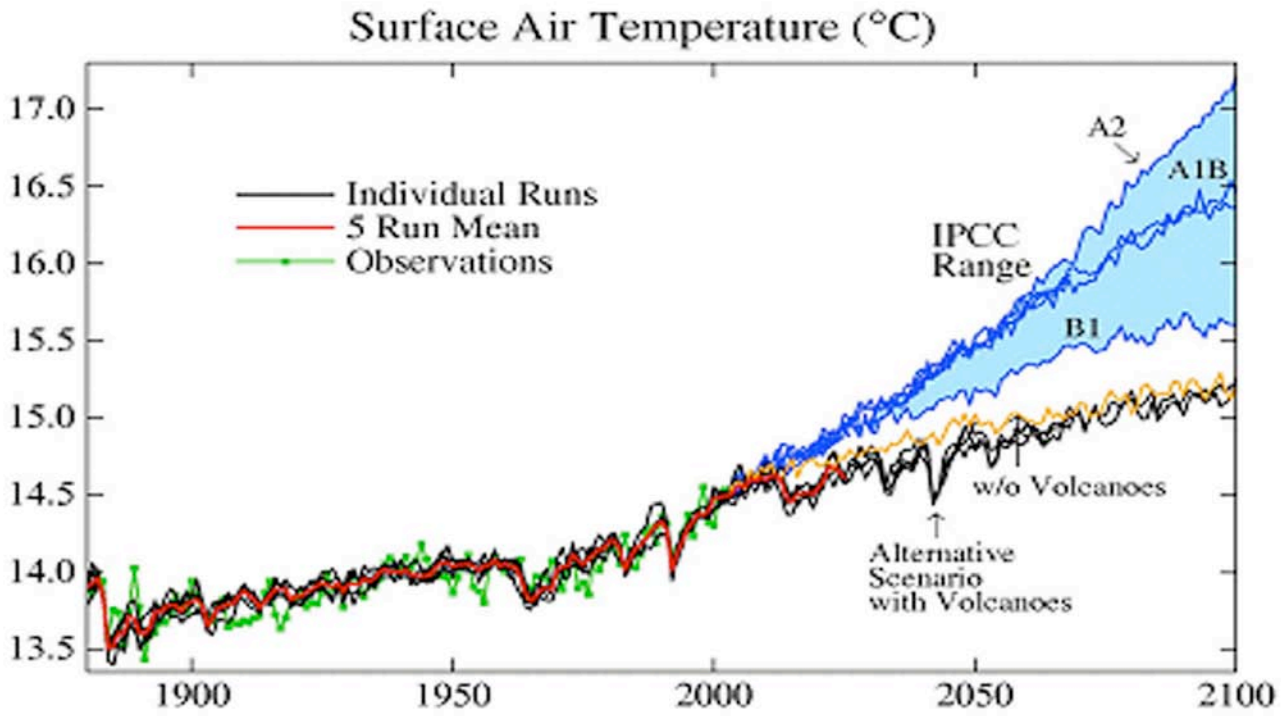
Jakobshavn Ice Stream in Greenland

Discharge from major Greenland ice streams is accelerating markedly.

Source: Prof. Konrad Steffen, Univ. of Colorado


(a) Western Equatorial Pacific SST: 1.35 Million Years
(b) Indian Ocean SST
Temperature (°C)
30
29
28
27
26
25
2001-2005 mean
1870-1900 mean
0°N, 159°E
2.7°N, 78.0°E
1350
1050
750
450
150
100
50
1870
2005
kyr Before Present
Date

21st Century Global Warming



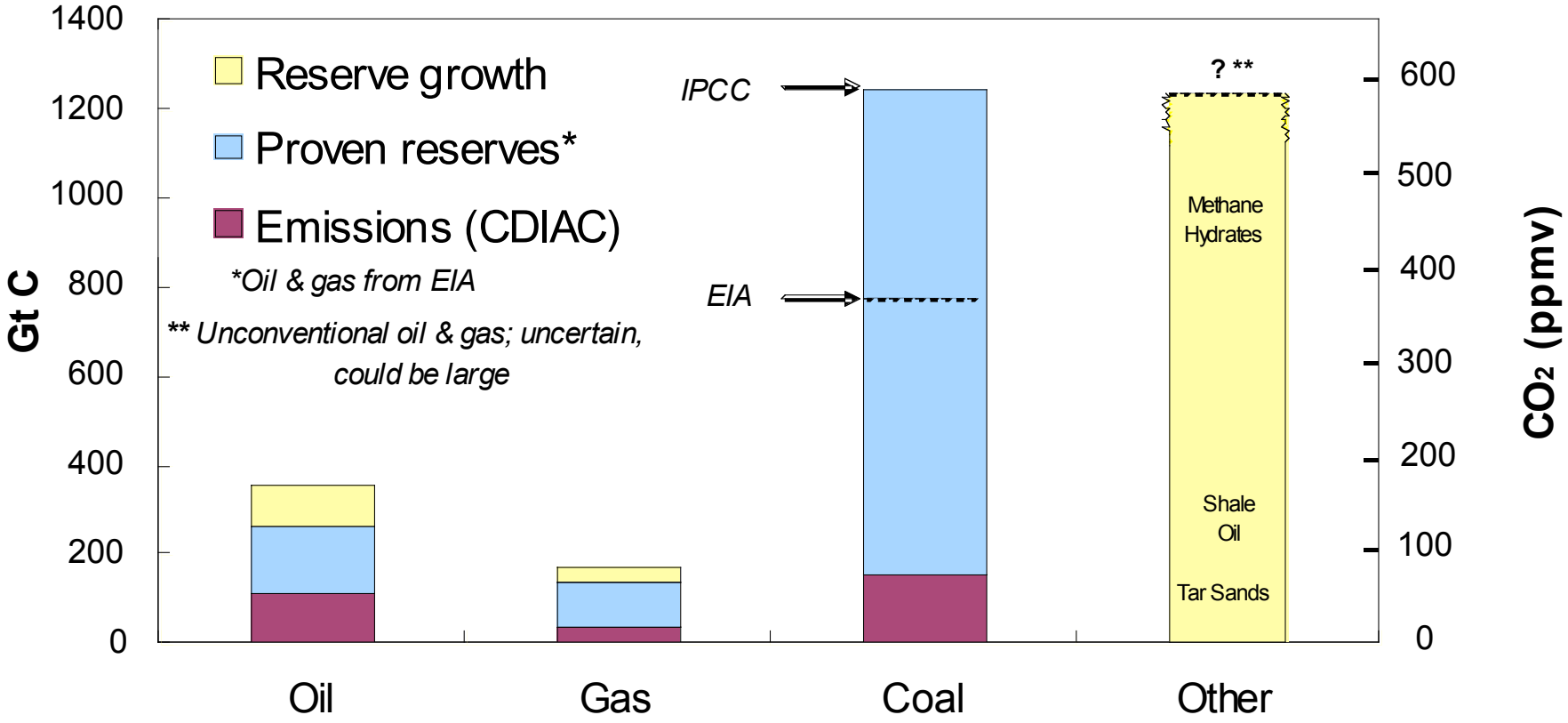
Climate Simulations for IPCC 2007 Report

- **Climate Model Sensitivity 2.7-2.9ºC for $2xCO_2$**
  (consistent with paleoclimate data & other models)
- **Simulations Consistent with 1880-2003 Observations**
  (key test = ocean heat storage)
- **Simulated Global Warming < 1ºC in Alternative Scenario**

Conclusion: Warming < 1ºC if additional forcing ~ 1.5 W/m²

Source: Hansen et al., *to be submitted to J. Geophys. Res.*

Fossil Fuel Reservoirs and 1750–2004 Emissions



Science & Implications

1. **Warming >1°C Risks 'Different Planet'**
   - Maximum CO_2 ~ 450 ppm
   - Slightly larger if non-CO_2 forcings ↓

2. **Quarter of CO_2 Stays in Air "Forever"**
   - Future Power Plants must be Zero-CO_2
   - Vehicles eventually must be Zero-CO_2

3. **Gas + Oil Use Most of 450 ppm Limit**
   - Gas + Oil must be stretched via efficiency
   - Coal & unconventional fossil fuels must be phased out or capture CO_2

Inferences (Opinions)

1. **Building/Vehicle Efficiencies Critical**
   - To Stretch Oil/Gas Supplies
   - For Future Non-Carbon Energy

2. **Standards and Incentives Both Needed**
   - Efficiency Standards Proven Effective
   - Carbon Price will Drive Innovation

3. **United States Leadership Essential**
   - Political & Tech Leader, Large Emissions
   - Developed Countries mainly responsible for the problem and must take first step

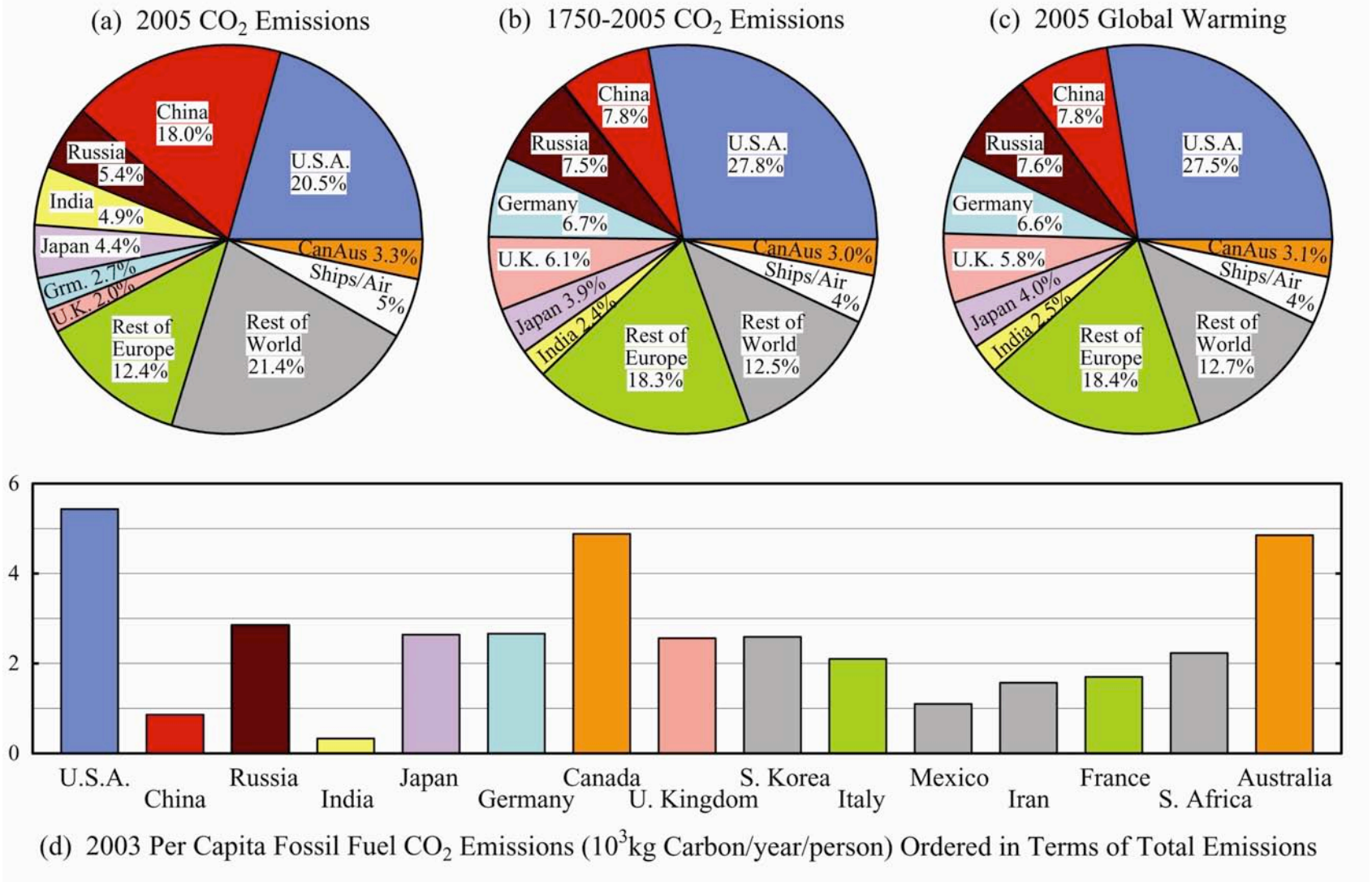
Fossil Fuel Facts & Opinions

1. **Value of Fossil Fuels >> Mining Cost**
   - $$$$ Pocketed by Middle East & Russia
   - Those $$$$ Fund Many Things

2. **Steadily Rising Carbon Price (Tax)**
   - Can Be Revenue Neutral
   - Nonpartisan Tsar Adjusts Rate (a la Fed. Res.)

3. **Results**
   - Spurs Technology Development & Efficiency
   - Energy Need per GDP Decreases
   - Energy Independence & National Security
   - $$$$ to Treasury, not Middle East/Russia
   - Improves Competitiveness of Industry
   - Good High-Tech High-Pay Jobs

Responsibility and Irresponsibility



Summary: Is There Still Time?

- Need Action Soon: Decade BAU Eliminates Alternative Scenario
- Public Attention Focuses on Near-Term Issues and Problems
- Potential Legacy: Great Moral Burden, Perhaps a Legal One
- Best Hope: Young Generation Becomes Informed and Involved