Symposium on a New Type of Major Power Relationship

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24 February 2014

Counsellors Office of the State Council

Beijing, China

Please Provide Suggestions & Criticisms

All charts will be left with organizers, also at:

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Summary of Key Points

Developed Countries Exceeded Carbon Budget

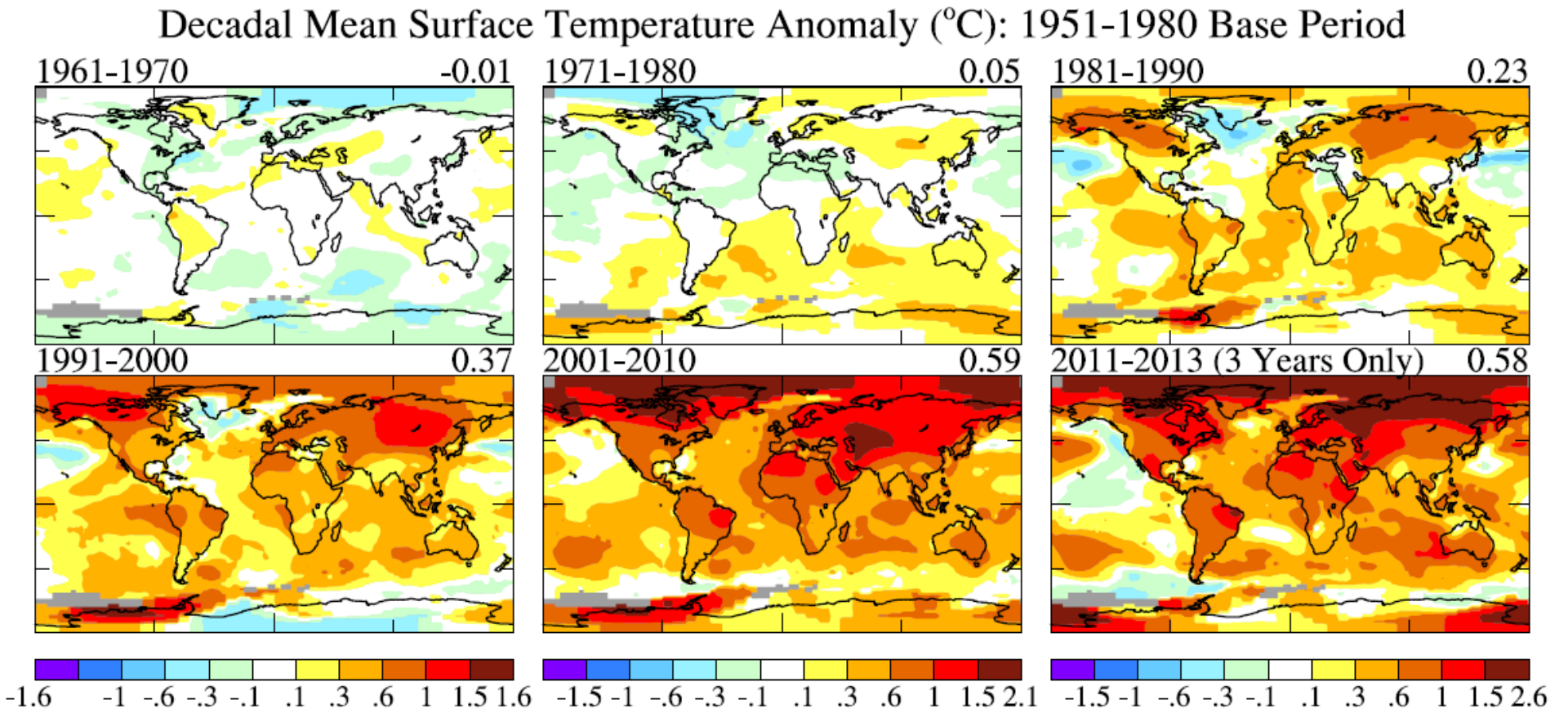
- Climate is global; We will sink or sail together
- Fossil fuels were used to reduce poverty

Developing World Requires Equal Opportunity

- Fossil fuels must be phased out for climate
- Alternative energy must be equal/better
- Bonus: solve air pollution (health) problem

Suggest Approach & Cooperation

- Rising domestic carbon fee, multiple benefits
- Technology cooperation between China & U.S.
- Nuclear power helps China reduce air pollution

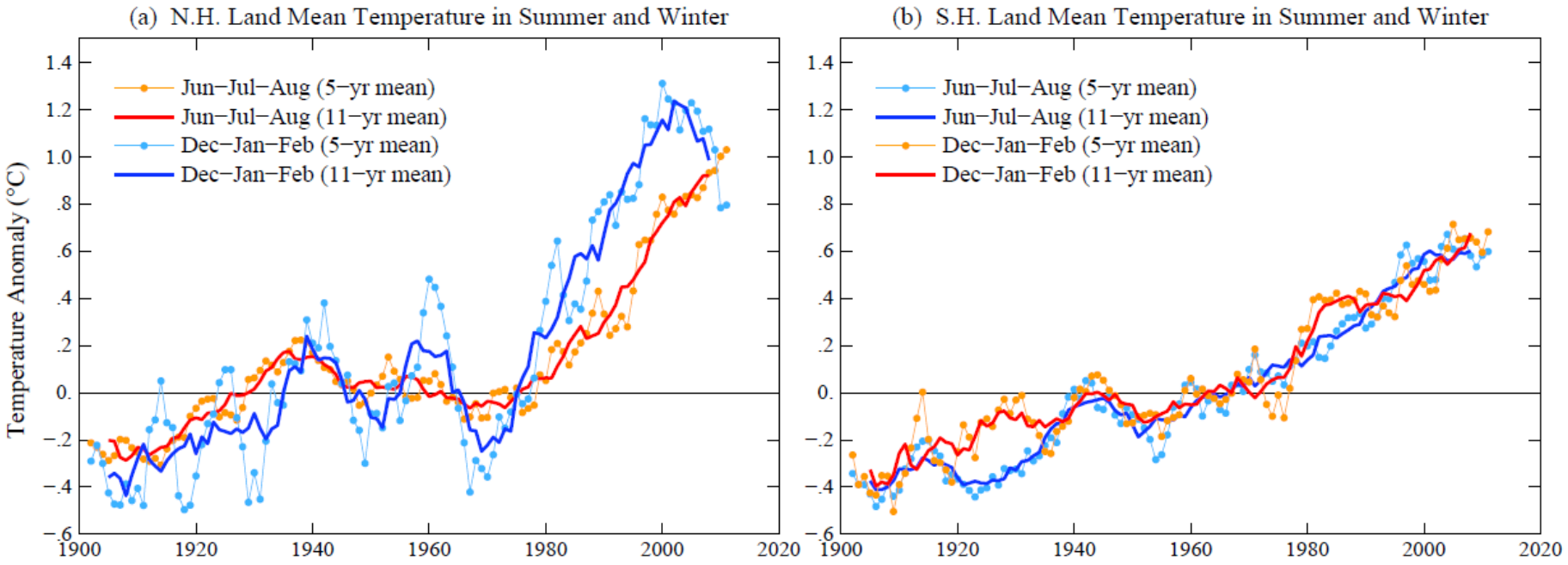


Decadal temperature anomalies relative to 1951-1980 mean.

Each successive decade is warmer.

First 3 years of this decade are warmer than prior decade over land, but unchanged globally.

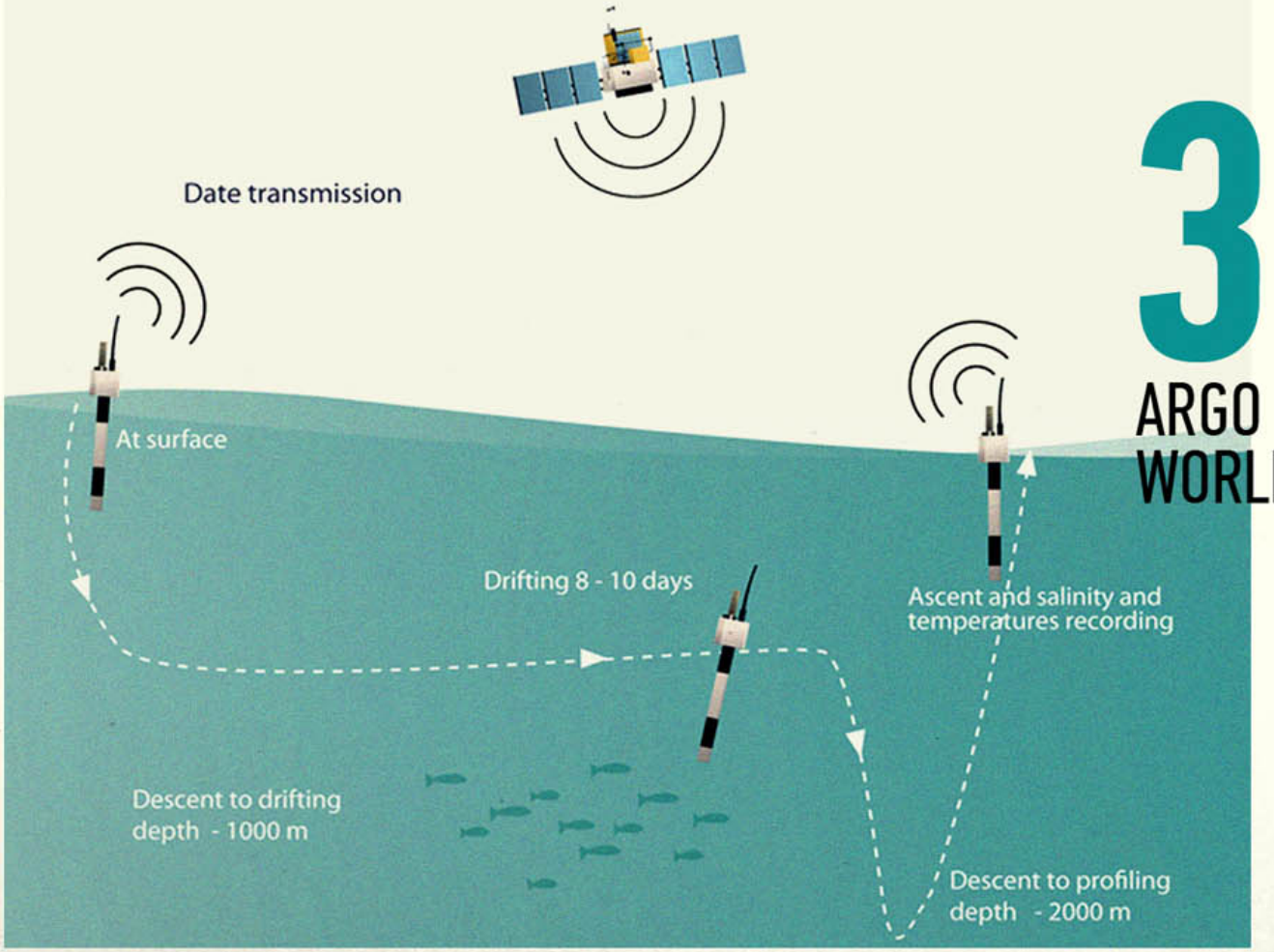
Recent seeming slowdown is a temporary natural fluctuation of Eastern Pacific temperature.



Left: Summer (Jun-Jul-Aug) and winter Northern Hemisphere temperature anomalies.

Right: Summer (Jun-Jul-Aug) and winter Southern Hemisphere temperature anomalies.

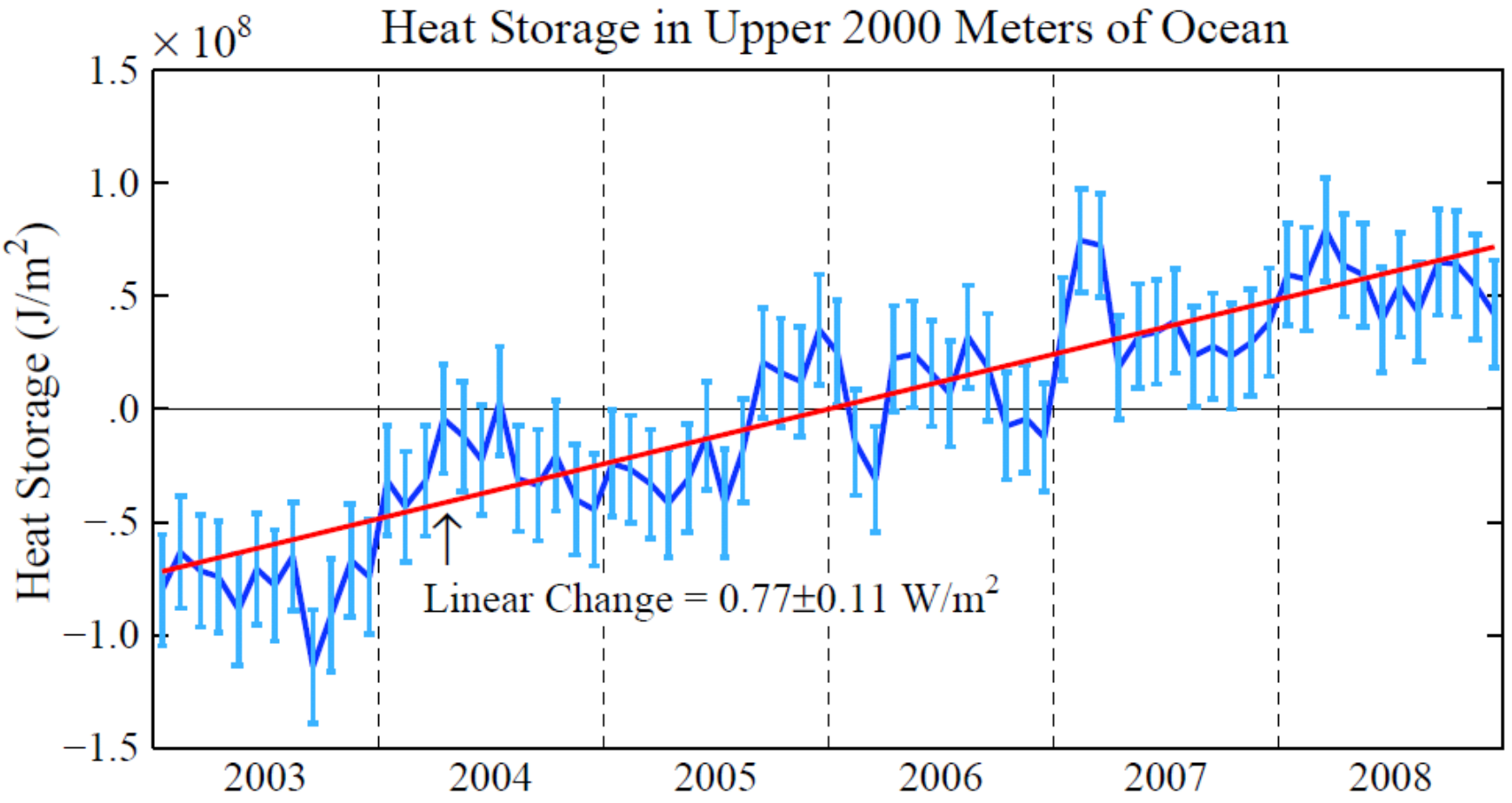
Earth's energy imbalance: more energy coming in than going out



3000

ARGO FLOATS AROUND WORLD OCEANS

ARGO floats have allowed accurate measurement of ocean heat gain since 2005. Earth is gaining energy at a rate 0.6 W/m^2, which is 20 times greater than the rate of human energy use. That energy is equivalent to exploding 400,000 Hiroshima atomic bombs per day, 365 days per year.



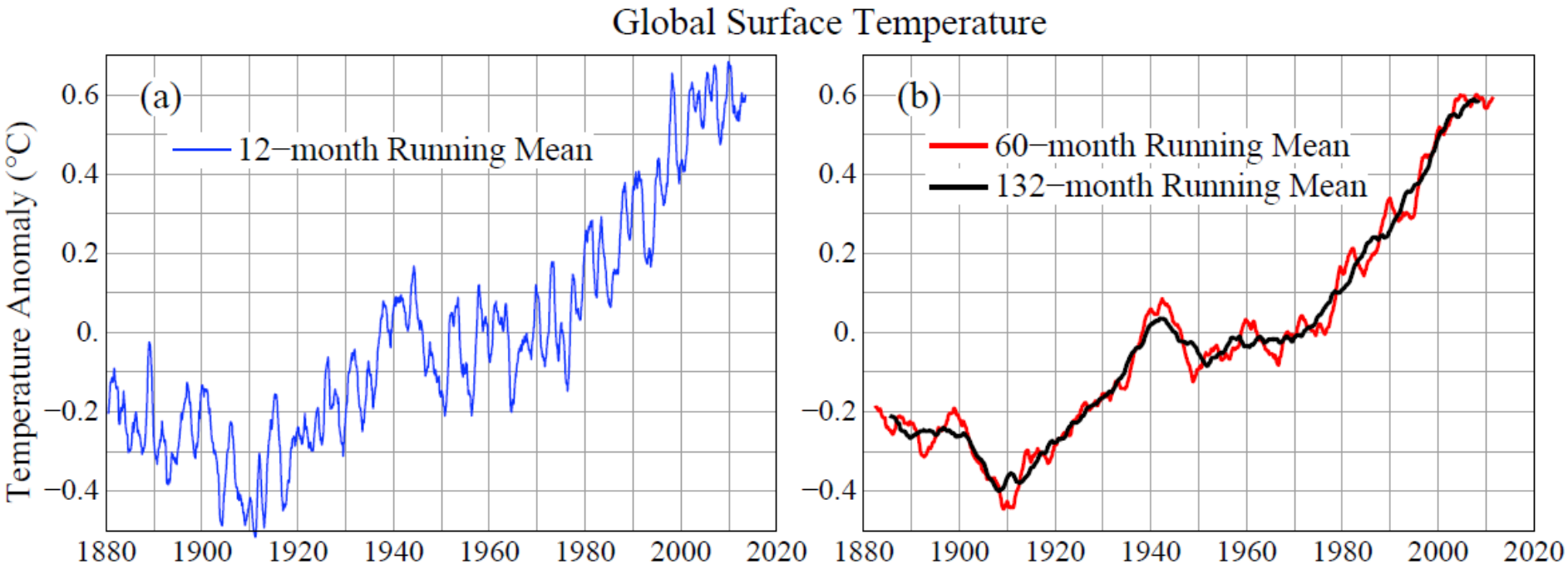
Heat storage in upper 2000 meters of ocean during 2003-2008 based on ARGO data.

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

This imbalance continues through the most recent (2013) data.

This imbalance assures that global warming will continue in coming decades.

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



Recent slowdown of global warming rate mainly a result of natural Pacific-Decadal Oscillation.

Reduced forcing from chlorofluorocarbons and solar irradiance contribute modestly.

Measured planetary energy imbalance (more in than out) assures continued decadal warming.

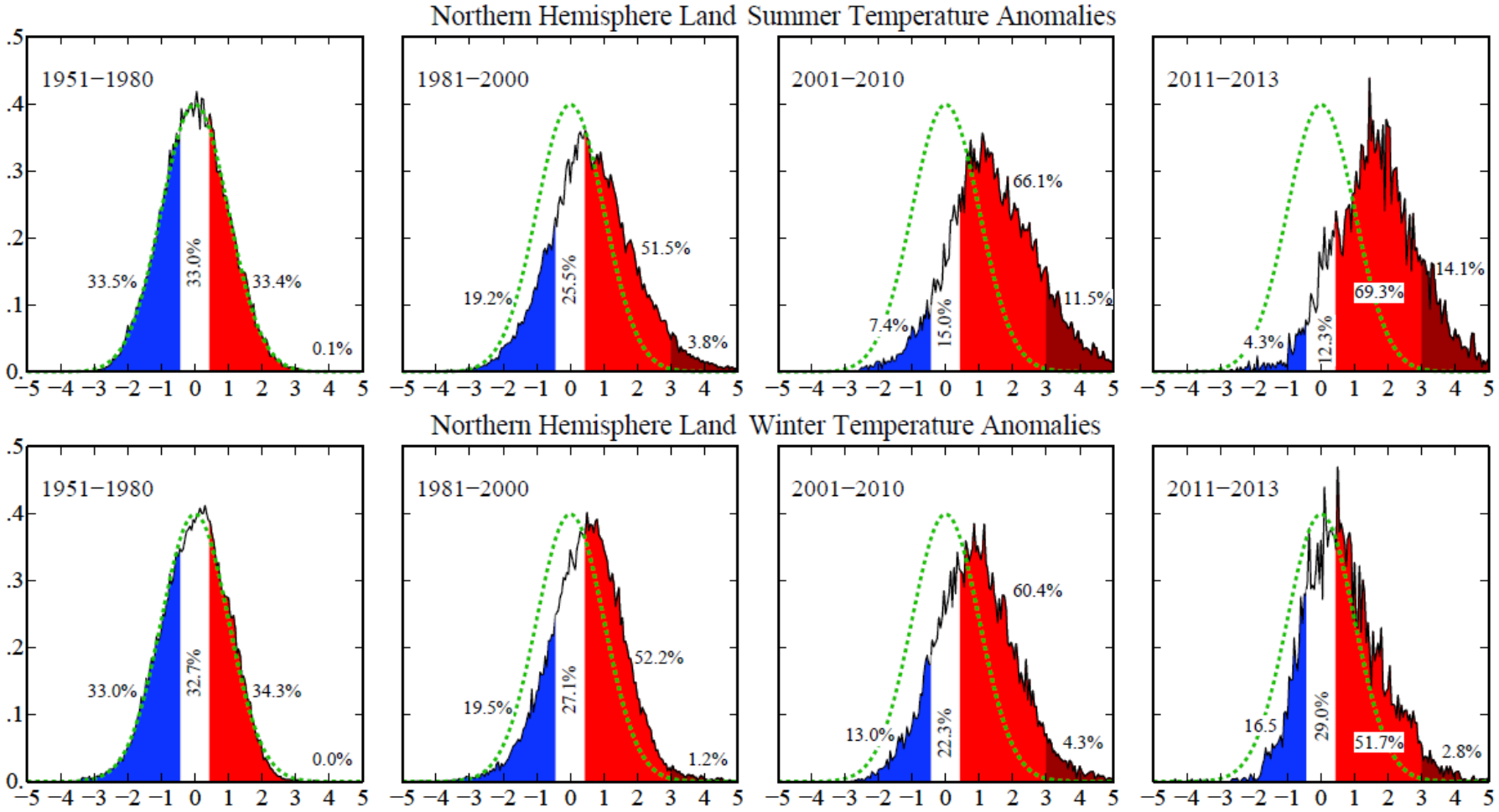
Developing En Niño will make 2014 or 2015 (or both) warmer than previous record.

Climate Impacts

1. **Ice Sheet Disintegration & Sea Level**
   - Ocean Warming → Ice Shelves Melt → Ice Streams Surge → Disintegration

2. **Species Extermination**
   - Shifting Climate Zones, Multiple Stresses, Species Interdependencies

3. **Climate Extremes**
   - Heat Waves, Drought, Fires
   - Heavier Rain, Floods, Stronger Storms



Global warming causes "bell curve" for seasonal-mean temperature to shift to the right.

Extreme (> +3σ) anomalies, relative to 1951-1980 climate, are increasing.

Winter warming (°C) is as large as in summer, but σ is much larger (~2-4 × larger) in winter.

Paleoclimate Guidance

Eemian sea level +5-9 meters

- **Eemian temperature +2°C***

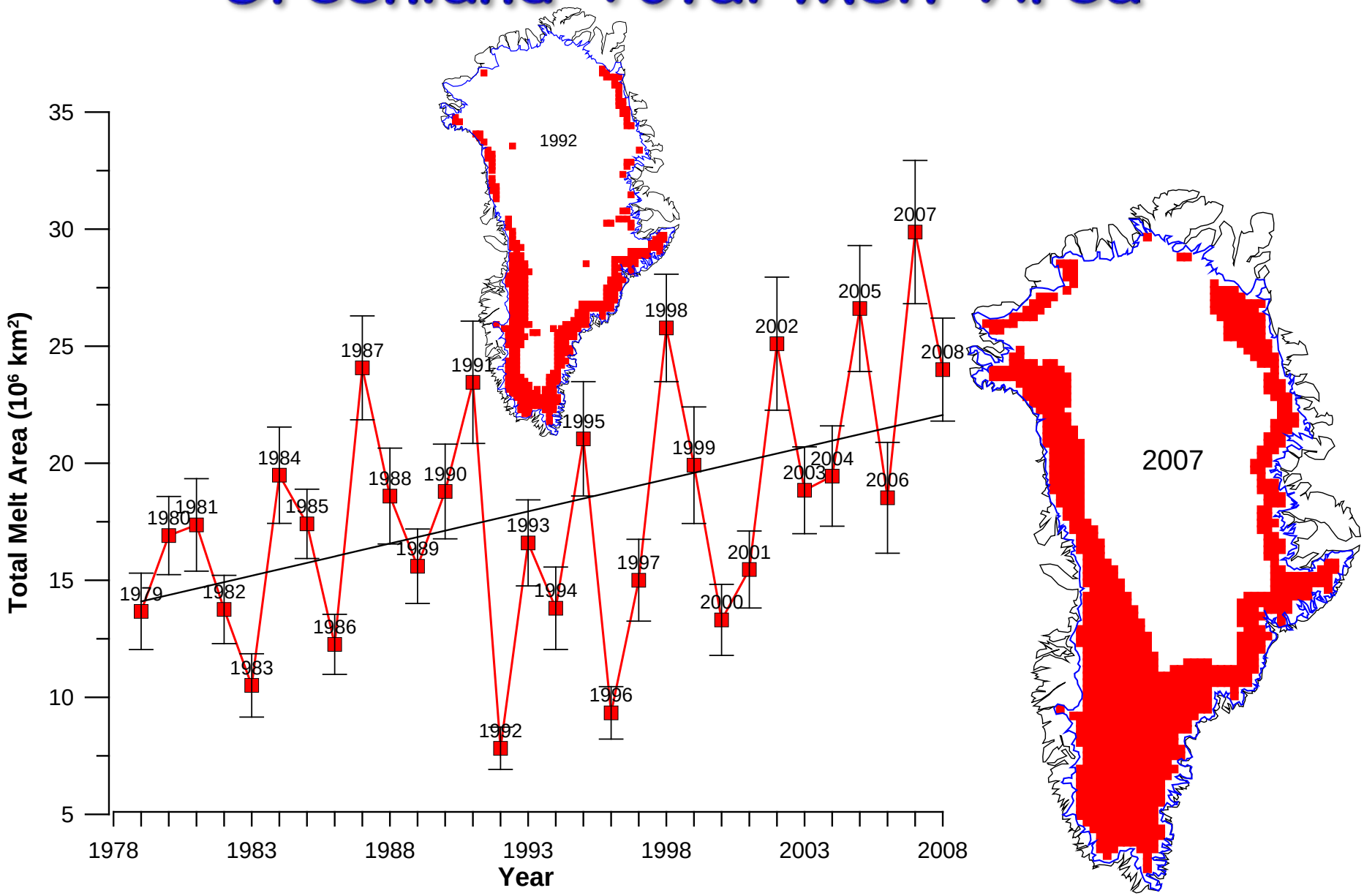
Pliocene sea level up to +15-25 meters

- **Pliocene temperature +3-4°C***

Ice sheet response time uncertain, but it is shorter than the lifetime of fossil fuel carbon and resulting global warming

***relative to pre-industrial times**

Greenland Total Melt Area



Area on Greenland with snowmelt is increasing.

Credit: Konrad Steffen, Univ. Colorado

Surface Melt on Greenland

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

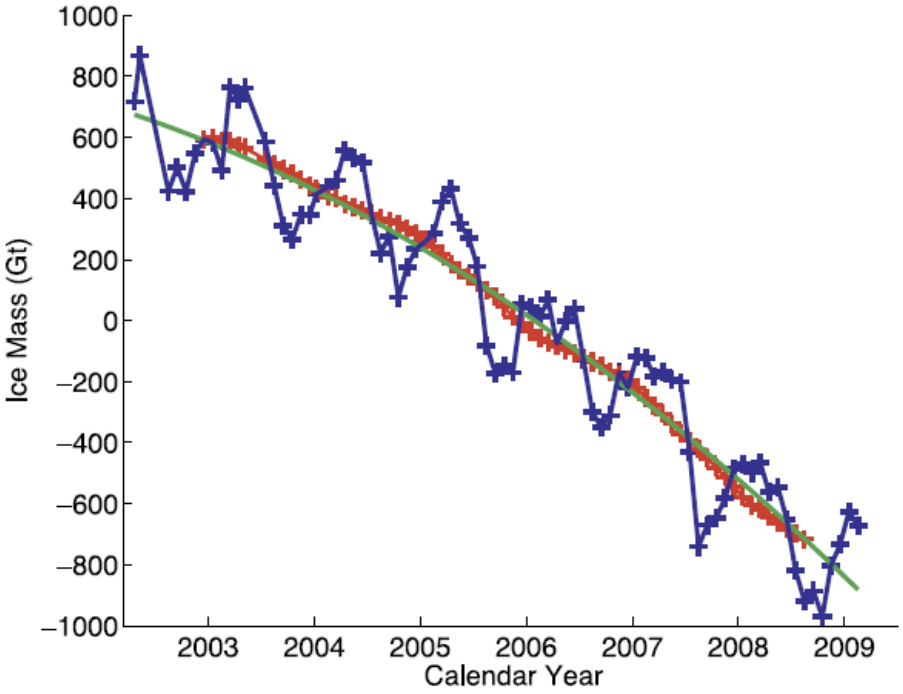
Source: Roger Braithwaite, University of Manchester (UK)

Jakobshavn Ice Stream in Greenland

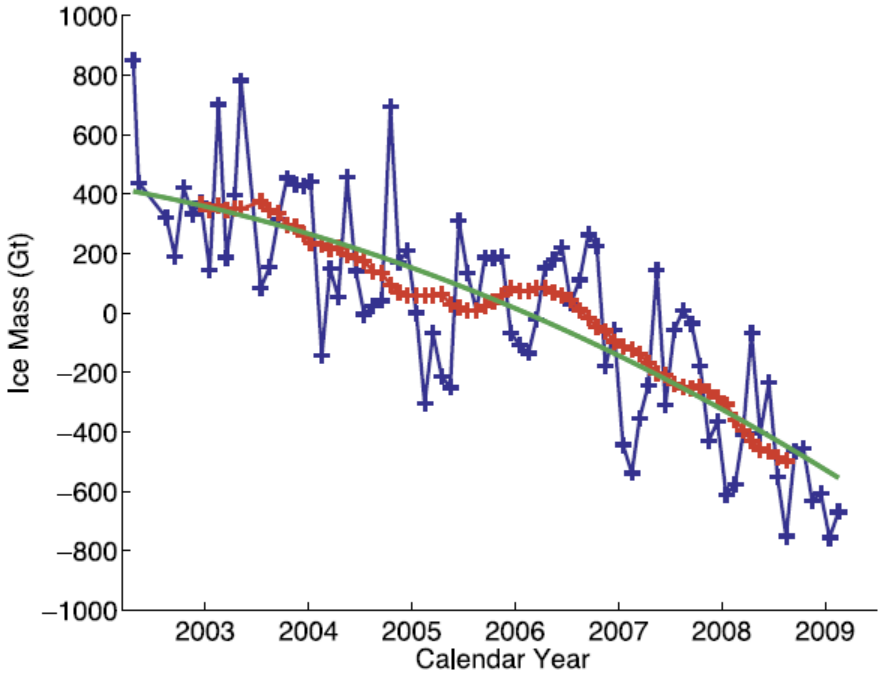
Discharge from major Greenland ice streams is accelerating markedly.

Source: Prof. Konrad Steffen, Univ. of Colorado

Gravity Satellite Ice Sheet Mass Measurements



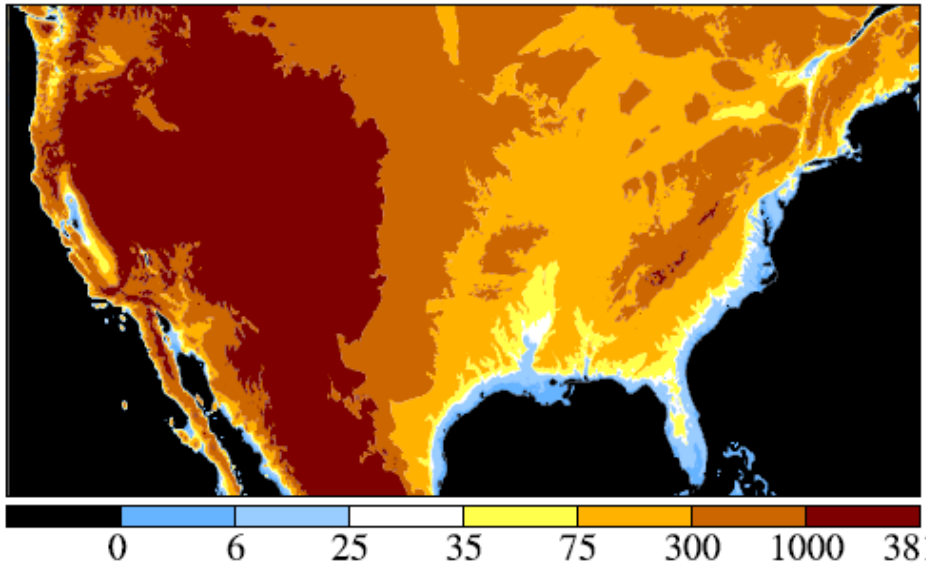
Greenland Ice Sheet



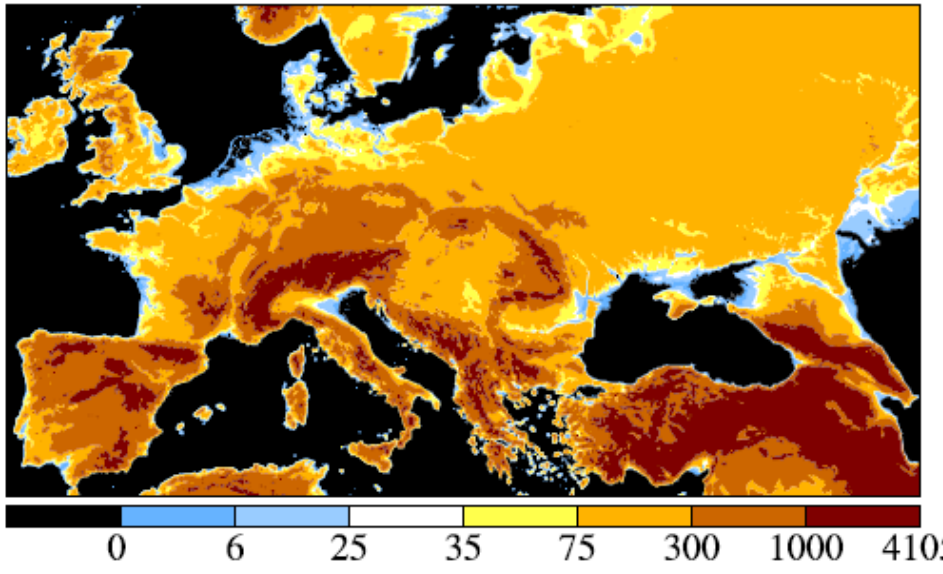
Antarctic Ice Sheet

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

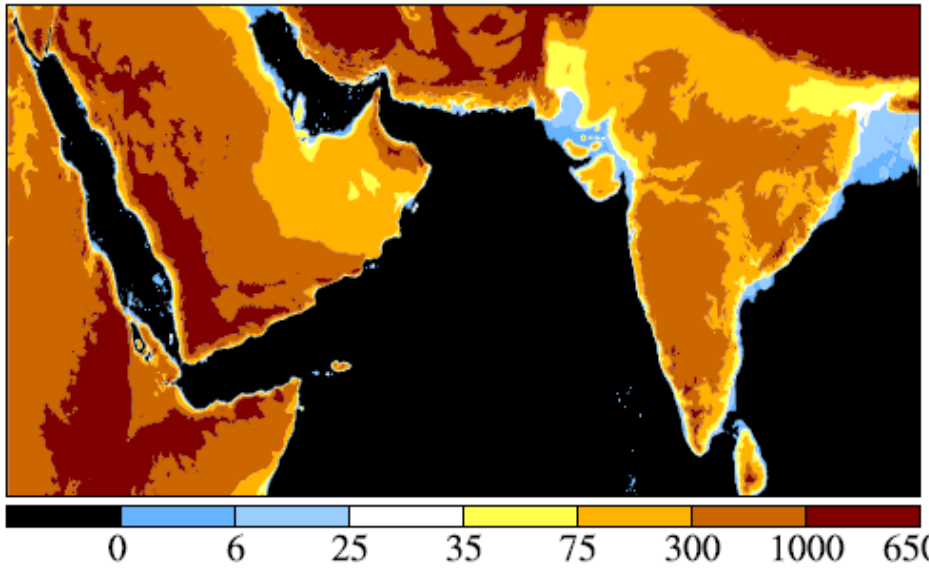
U.S. Area Under Water



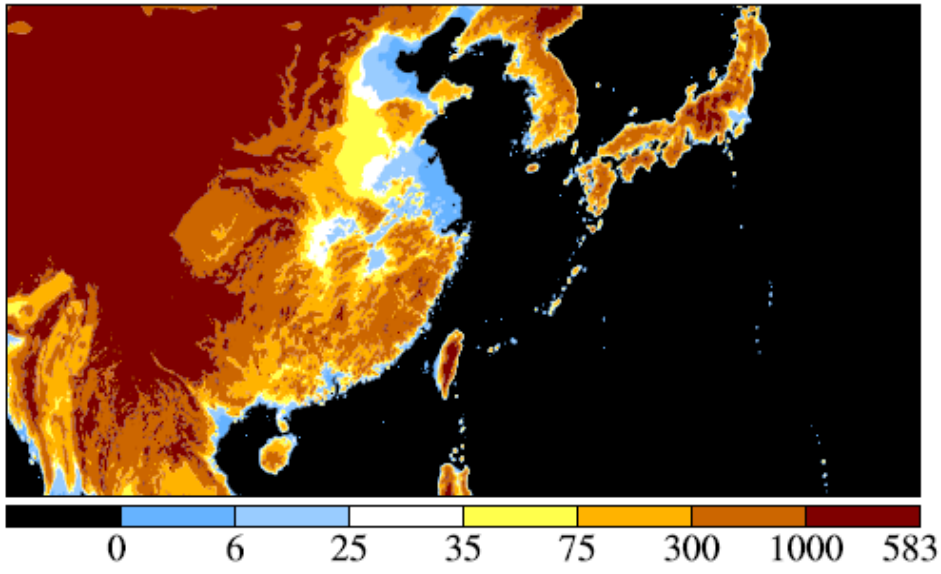
Europe Area Under Water

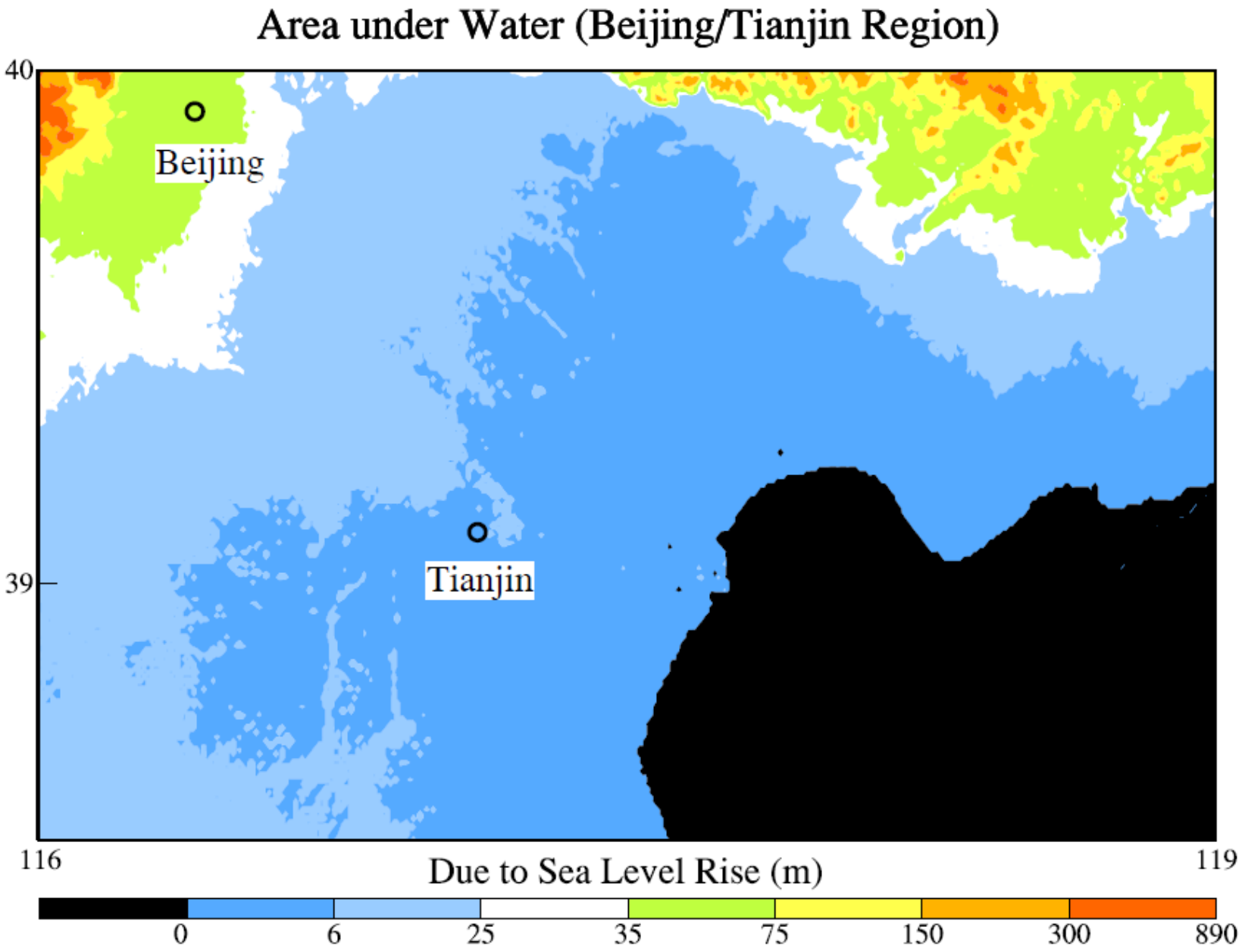


Central Asia: Area under Water



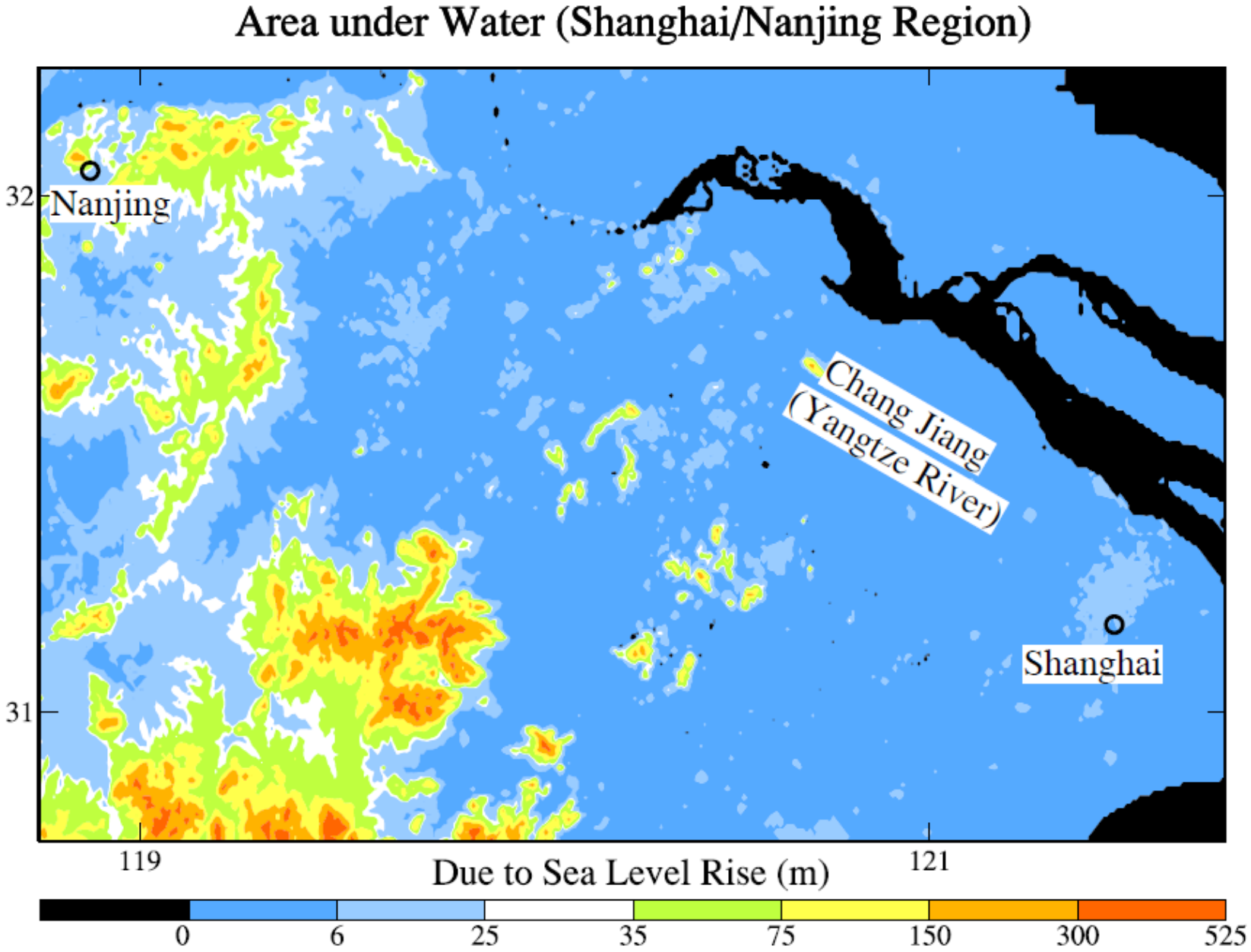
Far East: Area under Water





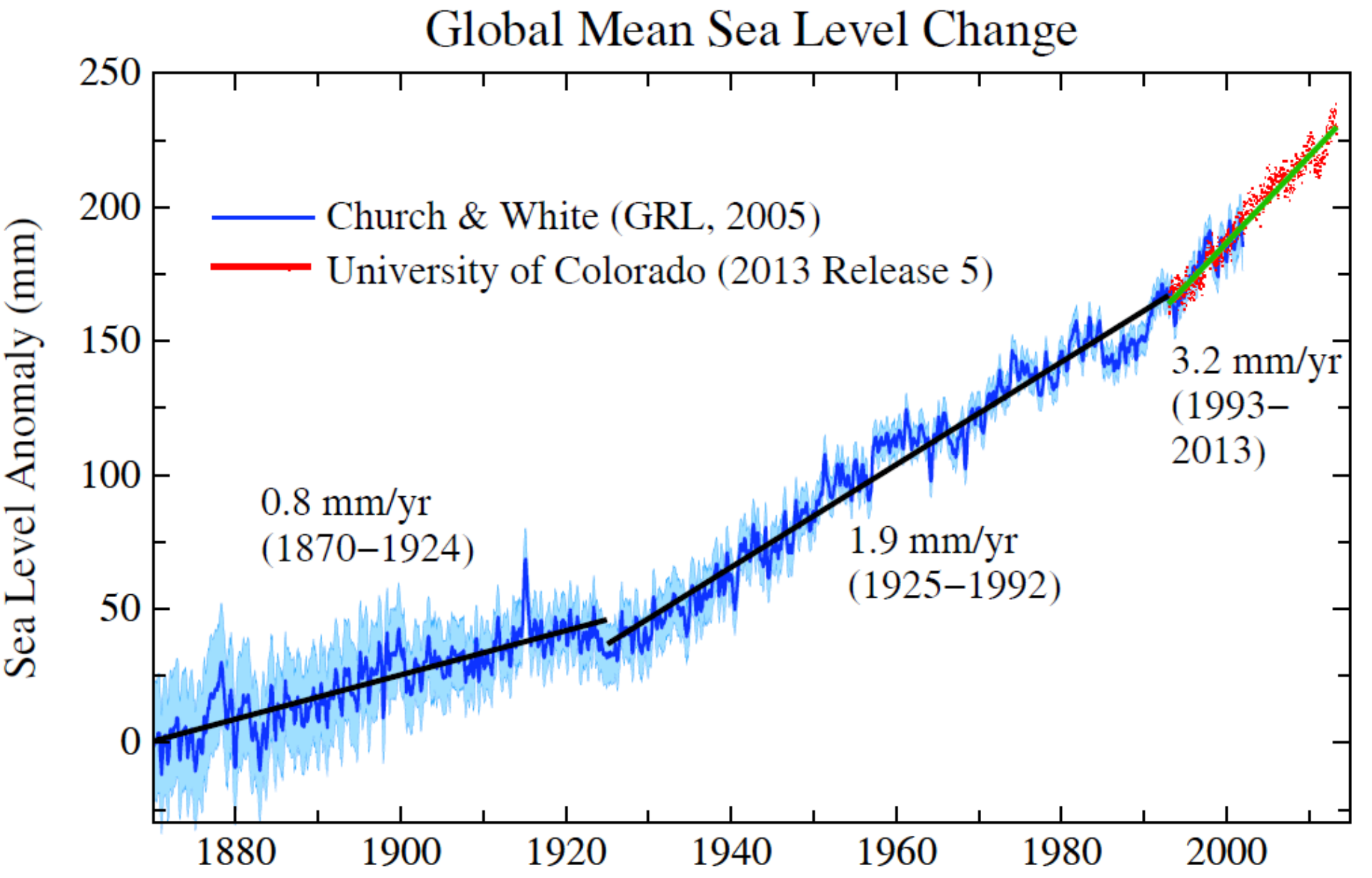
Beijing survives 6m sea level rise, even 25 m.

Good place from which to observe future, if world follows business-as-usual?



The Shanghai/Nanjing region is not as fortunate as Beijing.

With 6m sea level rise Shanghai will be on a small island - will need boat to get there.



Accelerating rate of sea level rise during the past century.

Threat of Mass Exterminations

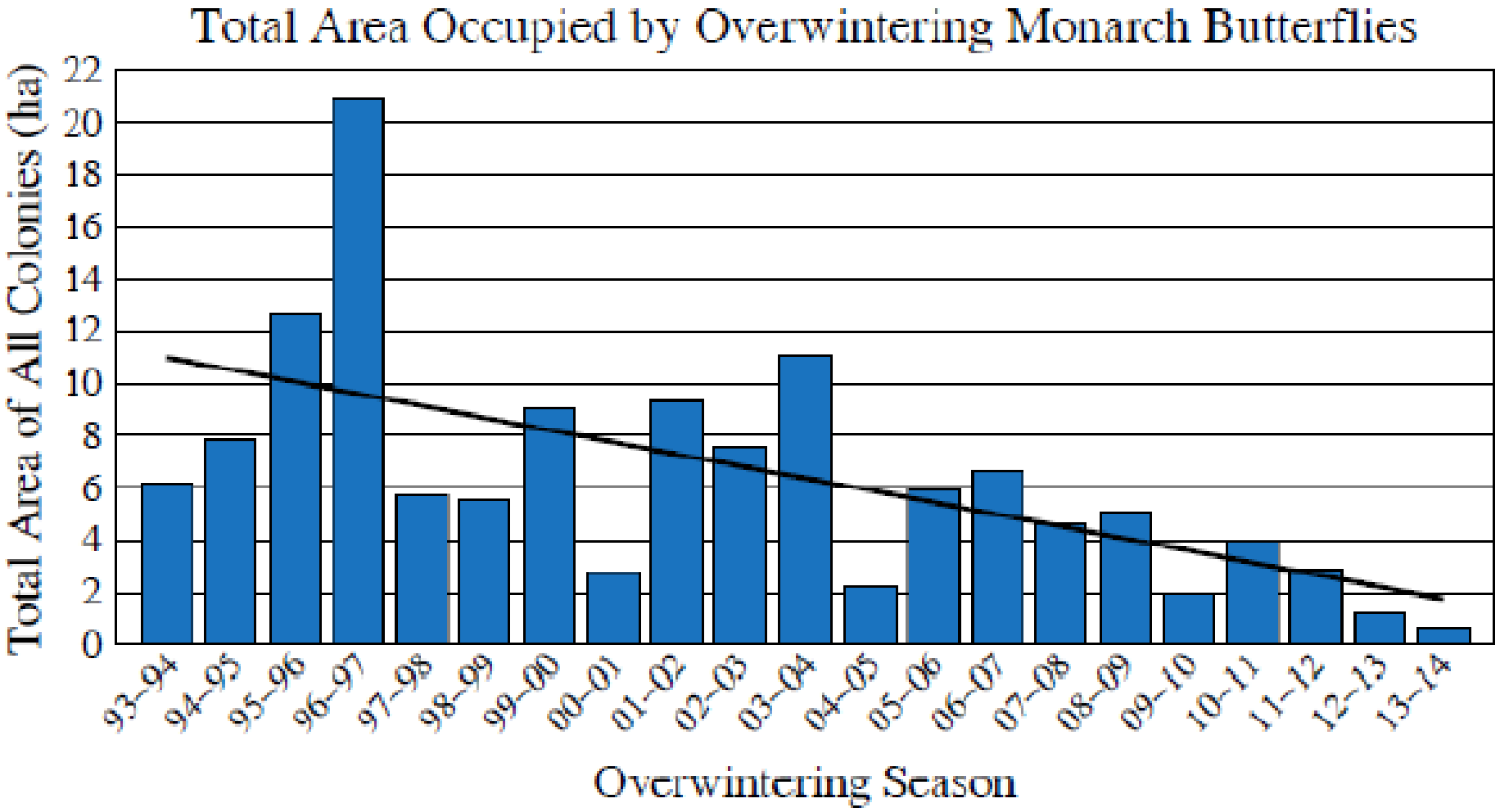
Multiple Human-Made Stresses

Overharvesting, Land use changes, Nitrogen fertilization, Introducing exotic species, etc.

in Combination with

Rapid Shifting of Climate Zones

Broken-wing female Monarch – species may be nearing commitment to extinction . An insect example of effect of other stresses combined with climate change.



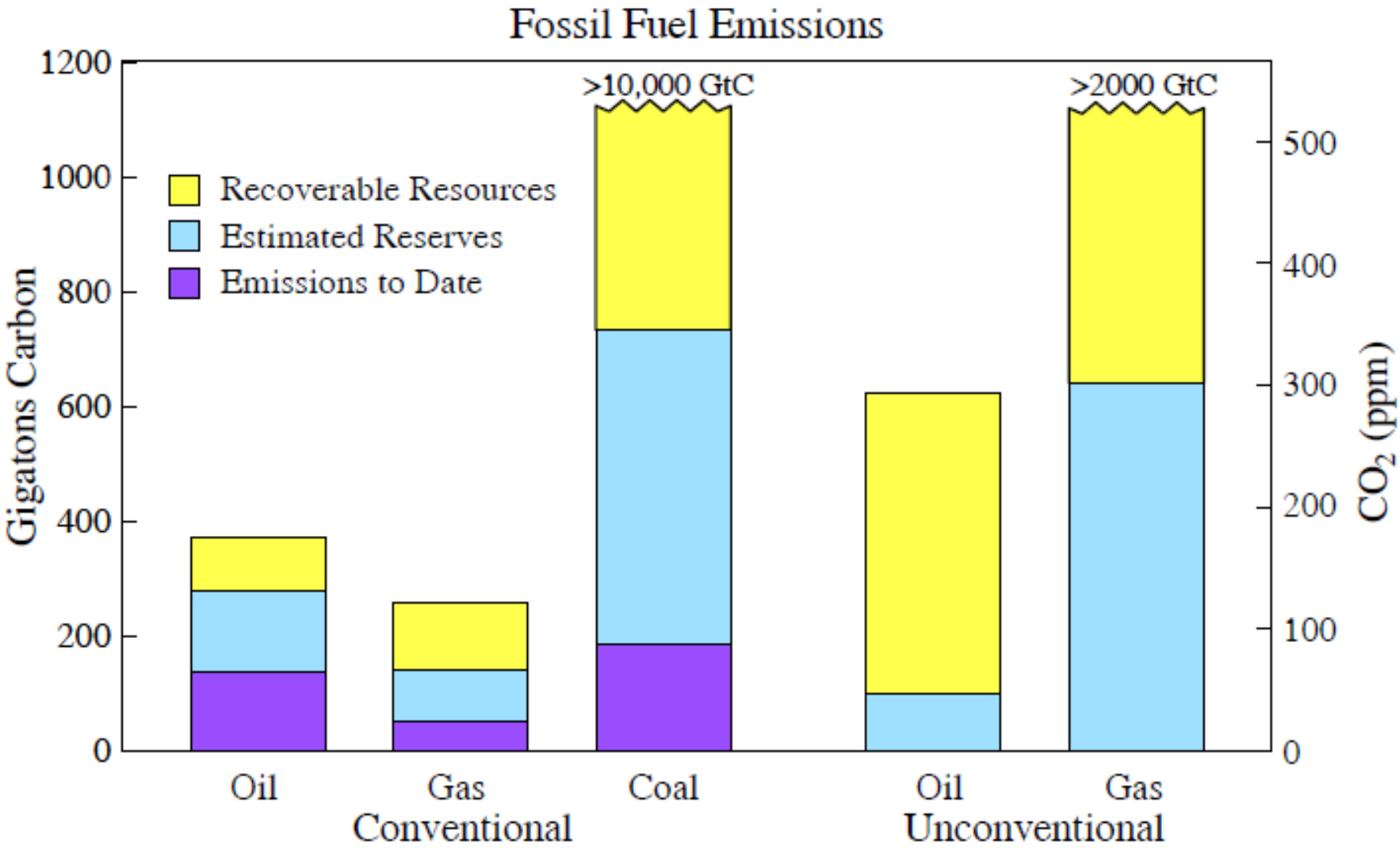
Area occupied by overwintering monarch butterflies

Source: Brower, LP, et al., Insect Conservation and Diversity 5, 95-100, 2012.

Stresses on Coral Reefs

Coral Reefs, rainforest of ocean, harbor more than a million species.
> 1% of coral lost per year to climate, acidification, other stresses.

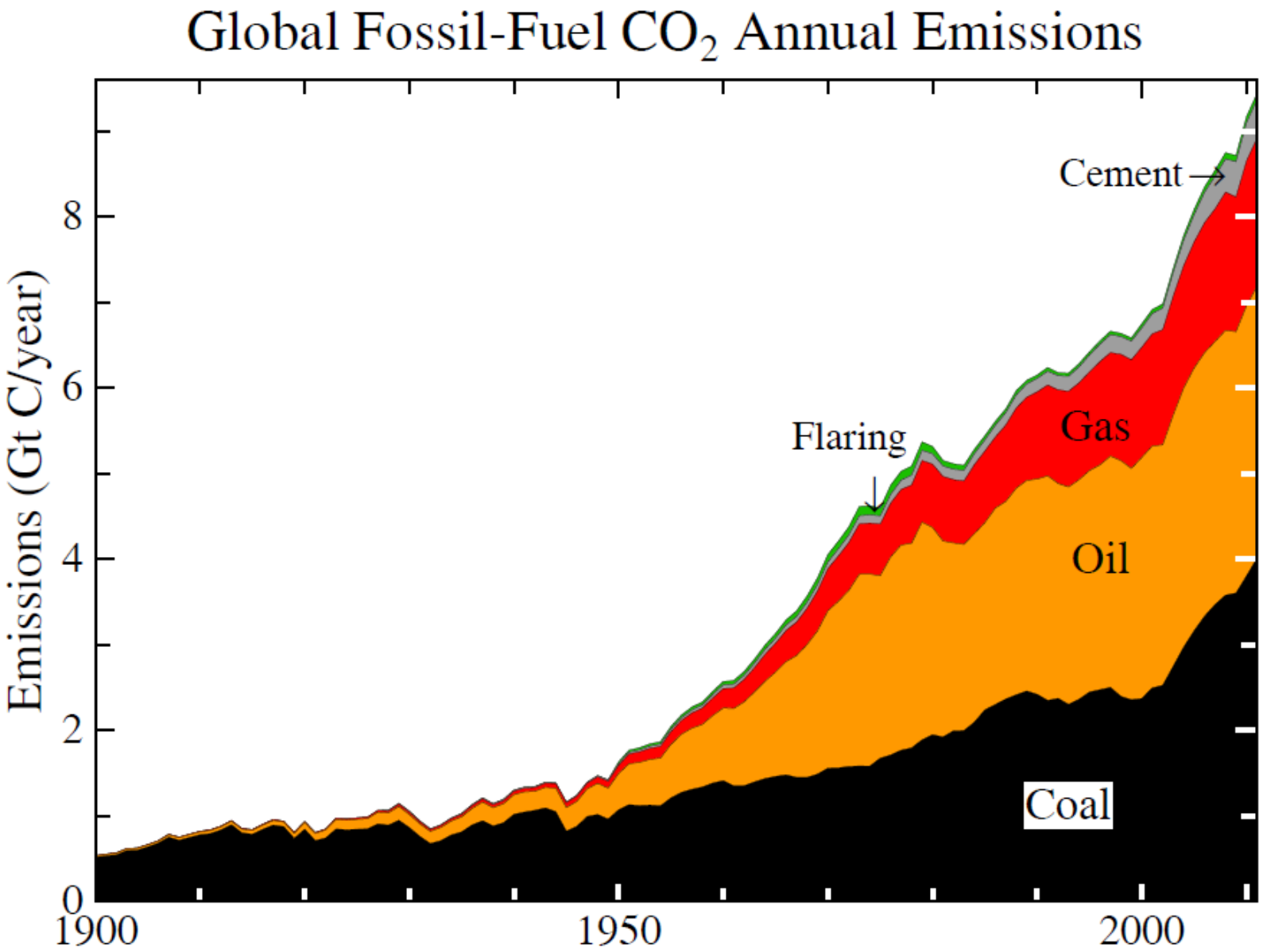
(Photo: Kevin Roland)



Fossil fuel emissions; purple area (370 GtC) is emissions through 2012.

Remaining carbon budget (to avoid disaster) is only a fraction of reserves.

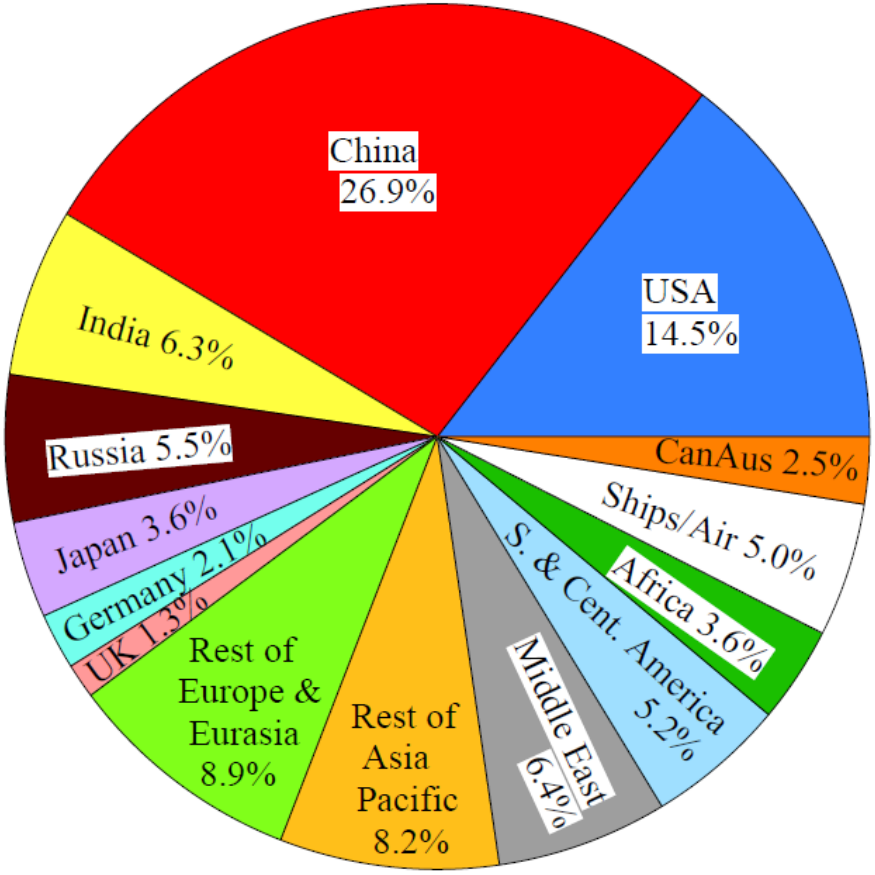
1 GtC (gigaton carbon) = 1 billion tons of carbon or ~3.7 $GtCO_2$; 1 ppm CO_2 ~2.12 GtC



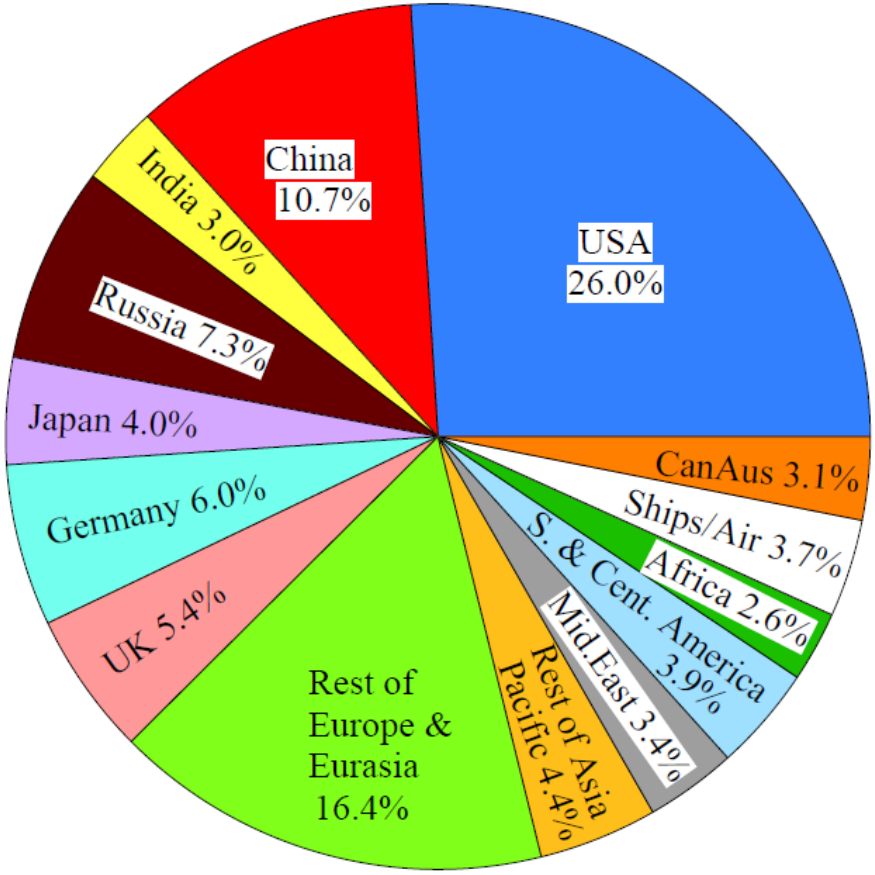
Yet global CO_2 emissions, especially from coal, are sky-rocketing

Source: Boden, TA, G Marland, and RJ Andres. 2011. Global, Regional, and National Fossil-Fuel CO2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge Natl Lab, U.S. Department of Energy http://cdiac.ornl.gov/trends/emis/meth_reg.html#

(a) 2012 Annual Emissions (9.6 GtC/yr)



(b) 1751–2012 Cumulative Emis. (384 GtC)



Surge in coal use has caused China to surge past U.S. in annual emissions

U.S. + China annual emissions are more than 40% of global fossil fuel carbon emissions

U.S. responsible for more than 25% of excess carbon in air today; China's % is growing.

On a *per capita* basis the U.S. fossil fuel emissions are much larger than China's.

Facts of the Situation

Burning All Fossil Fuels Will Sink Everyone

- Developed countries exceeded fair share
- We will all sink or sail together

Energy Is Required to Eliminate Poverty

- Are there alternatives to fossil fuels?
- Are there alternatives as good or better?

What Is Required to Achieve These?

- Rising carbon fee
- Technology cooperation

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 Fee Provides Enforcement
3. Technology Development Needed
   - Carbon Price Spurs All Technologies
   - Thermal & Fast Nuclear Reactors Included

Suggested Eventual China/U.S. Agreement

Rising Internal Carbon Fees

- Spurs technology innovations
- Improves economies
- Border duty on products of nations w/o fee
- Strong incentive for others to have fee/tax

Technology Cooperation Important

- In all clean technologies including nuclear
- In rapid deployment and training for best available, safe, economic nuclear power
- In development of improved nuclear power with proliferation safeguards & safer tech.

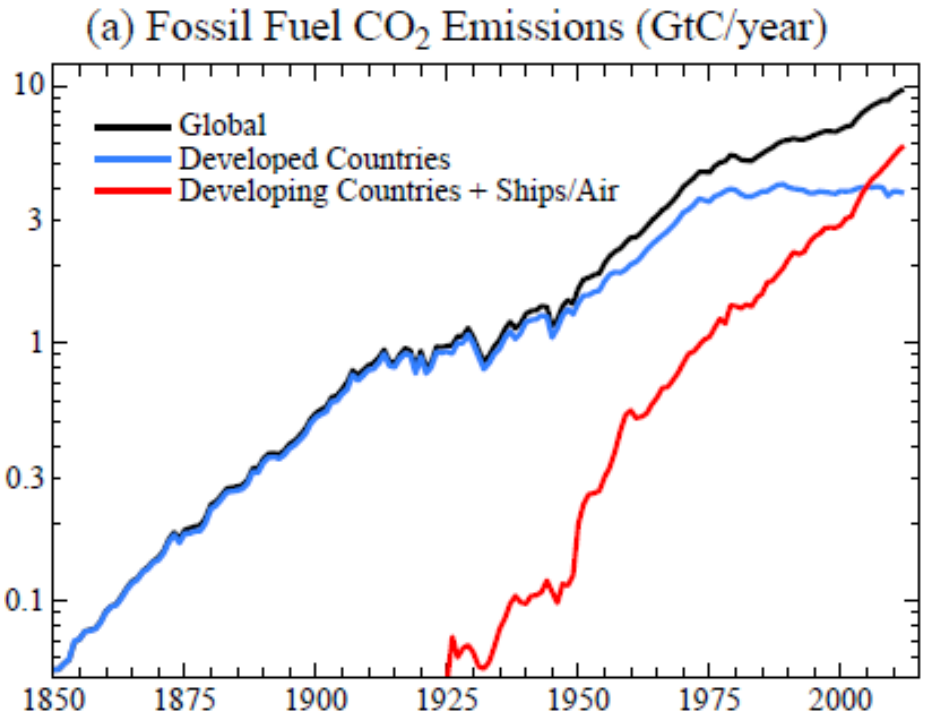
Goals of Cooperation

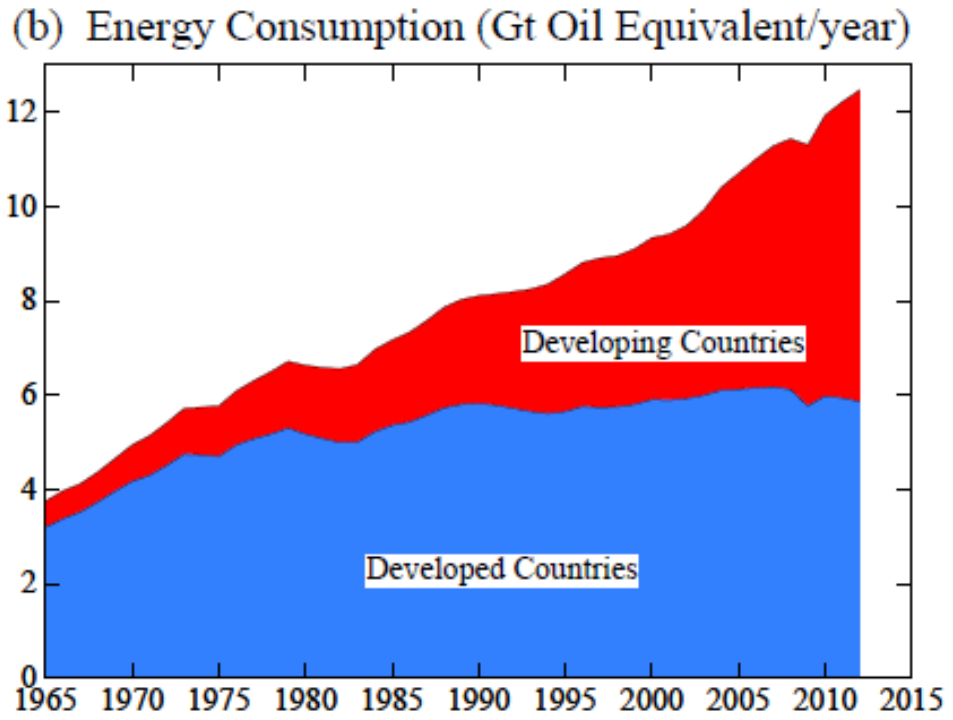
China Obtains Economic, Clean Energy

- Efficiency, Renewables, Nuclear Power all compete on a level playing field
- Nuclear Power treated as clean energy with best available technologies

Technology Available to Circle Back to U.S.

- Technologies developed on large scale in China, will drive down technology costs
- Technologies may circle back to the U.S., helping to deal with rebounding fossil fuel addiction spurred by unconventional fossil fuels





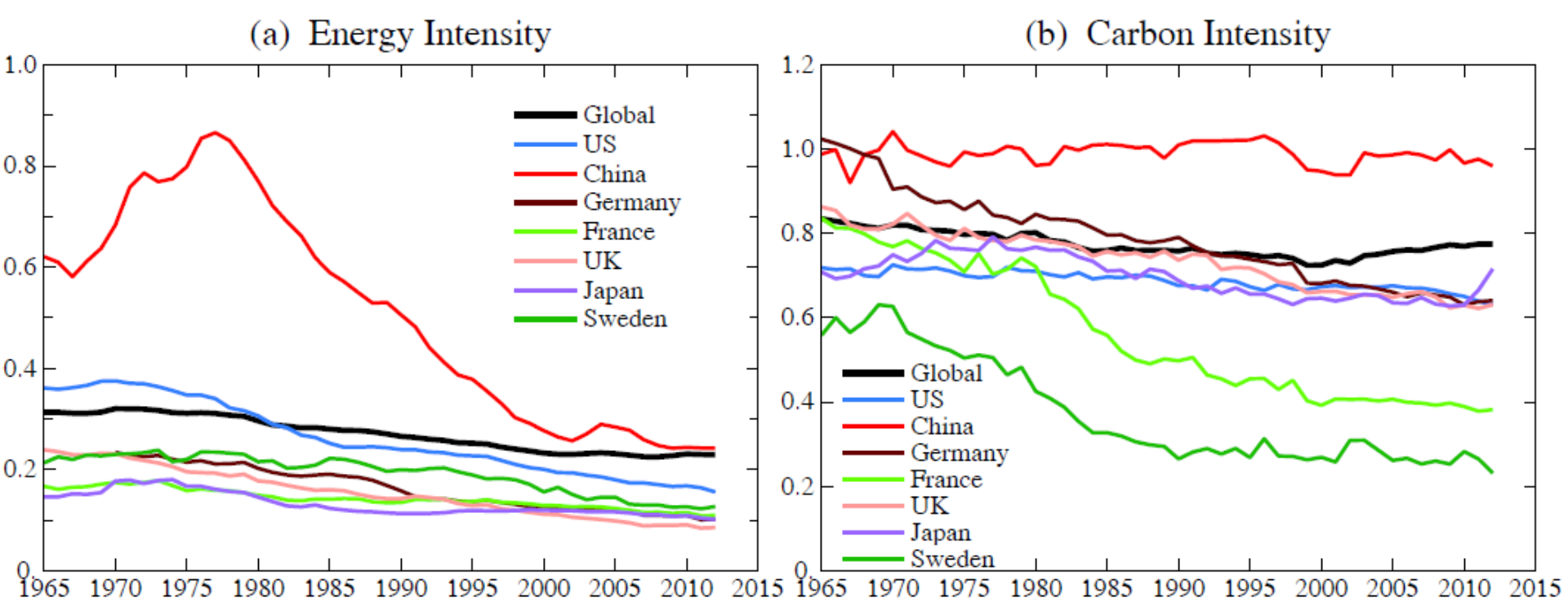
Global Fossil Fuel Emissions must peak by 2020, then decline 2%/year to keep global warming < 1.5°C & avoid dangerous climate change.

Developing Countries (China included) have a "right" to emit much more than that and developing countries need abundant affordable energy to eliminate poverty.

All Countries are in the same boat and will all sink together – or all swim together.

Is there a solution, i.e., an option that provides China and developing countries all the needed energy, clean energy(!), at a cost no higher than the fossil fuel cost?

Yes! It requires cooperation, taking advantage of the strengths of China and the United States.



<u>Global</u> Energy Intensity declines slowly, even if declining in all nations, because developing countries (with high energy intensity) are assuming a growing proportion of global total.

Global carbon intensity is actually increasing, because of growing use of coal.

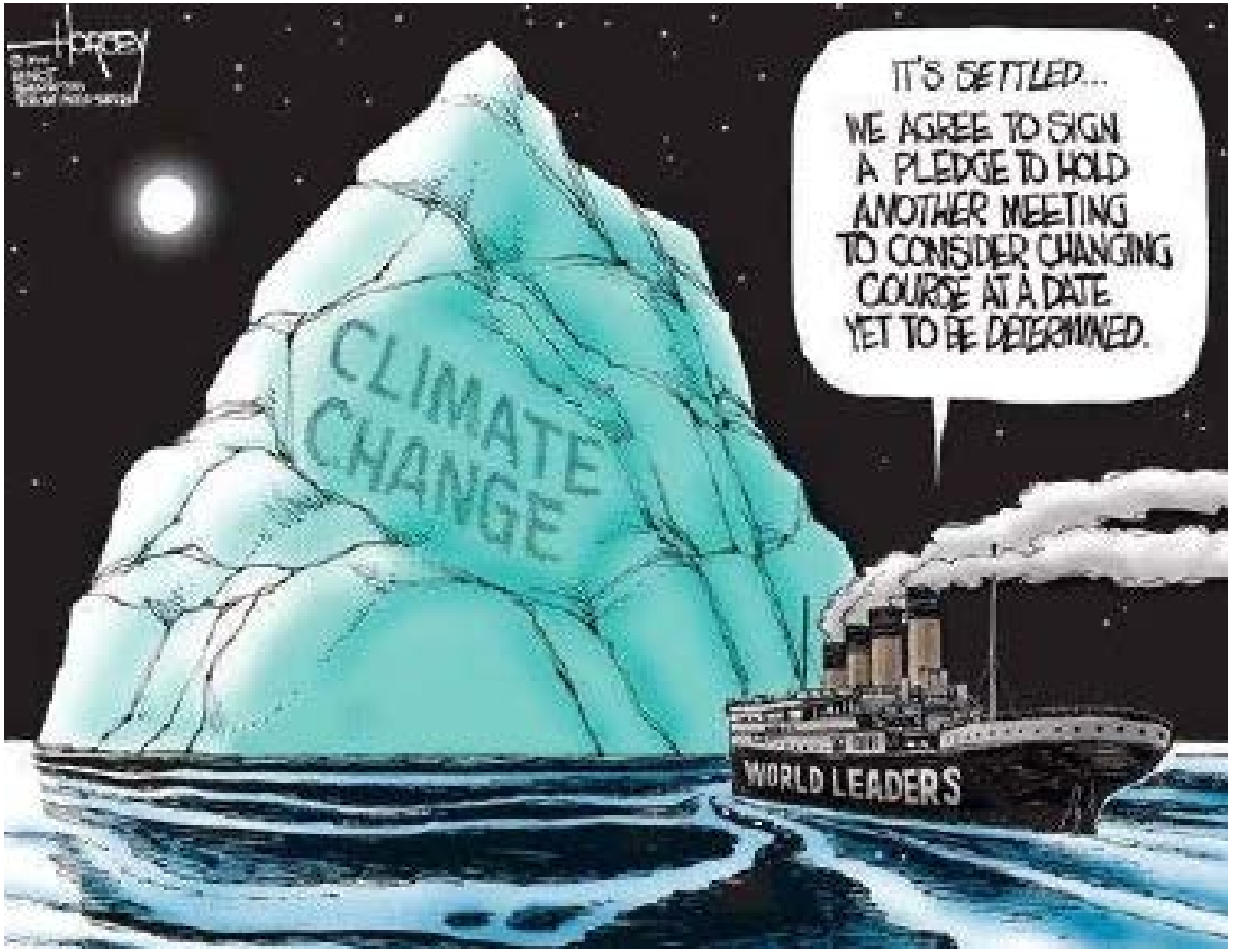
Rapid decreases of carbon intensity achieved in France and Sweden, via nuclear power.

Further decarbonization needed; probably requires decarbonized vehicles.

Urgent requirement is to decarbonize electricity generation.

Alternatives for carbon-free vehicles (electric, liquid fuels generated by renewable or nuclear, etc.) can compete as rising carbon fee provides economic incentive & stimulates innovation.

The Alternative



Web Sites

www.columbia.edu/~jeh1

www.350.org

www.CitizensClimateLobby.org

www.OurChildrensTrust.org