



CLIMATE CHANGE: A GROWING SCIENTIFIC IMPETUS FOR POLICY

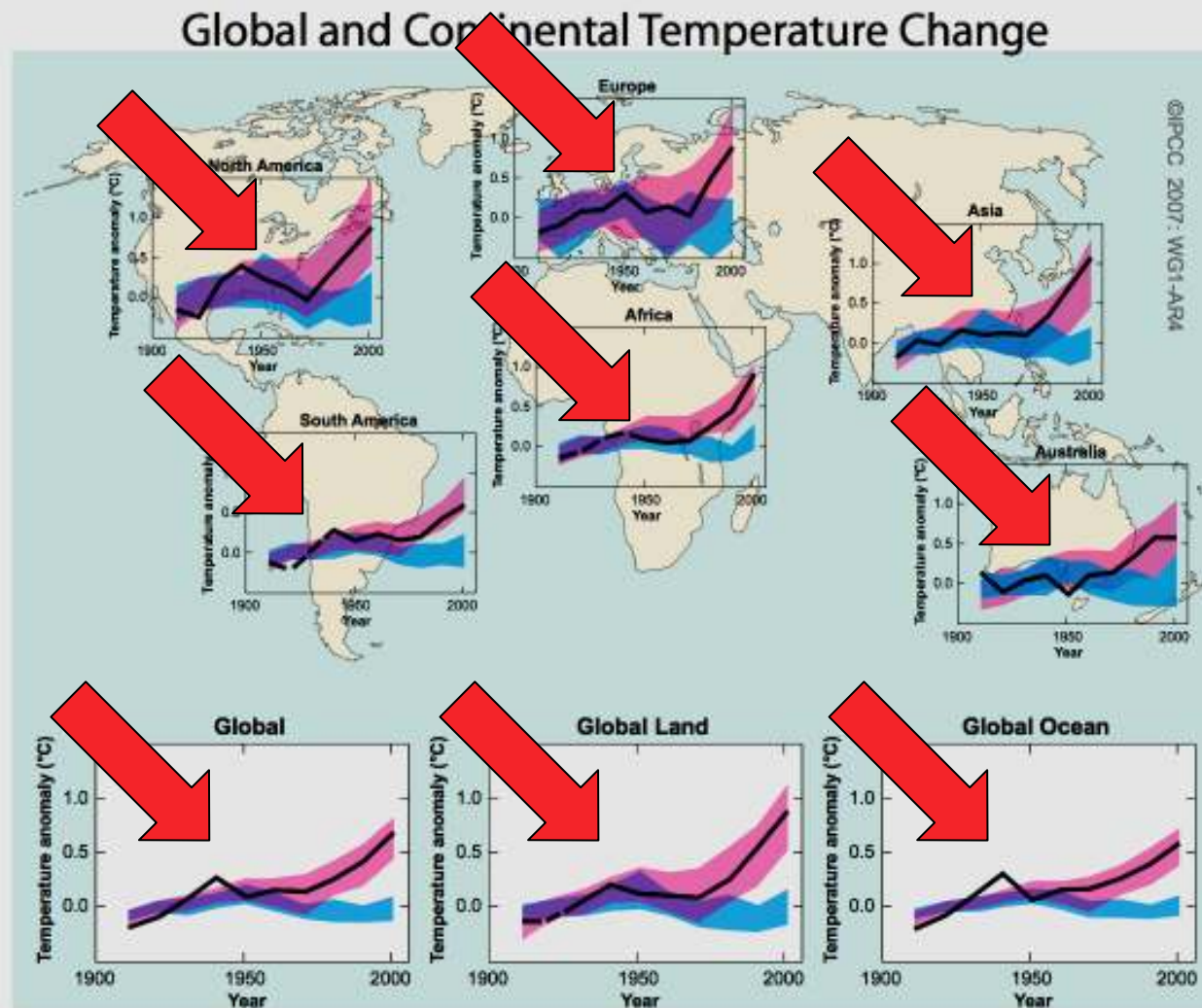
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***PRESENTATION TO THE CEDA SYMPOSIUM ON CLIMATE CHANGE
SYDNEY, AUSTRALIA, 15 November, 2007***

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HOW HAVE GLOBAL & CONTINENTAL TEMPERATURES CHANGED OVER THE PAST CENTURY (1906-2005), AND WHY?

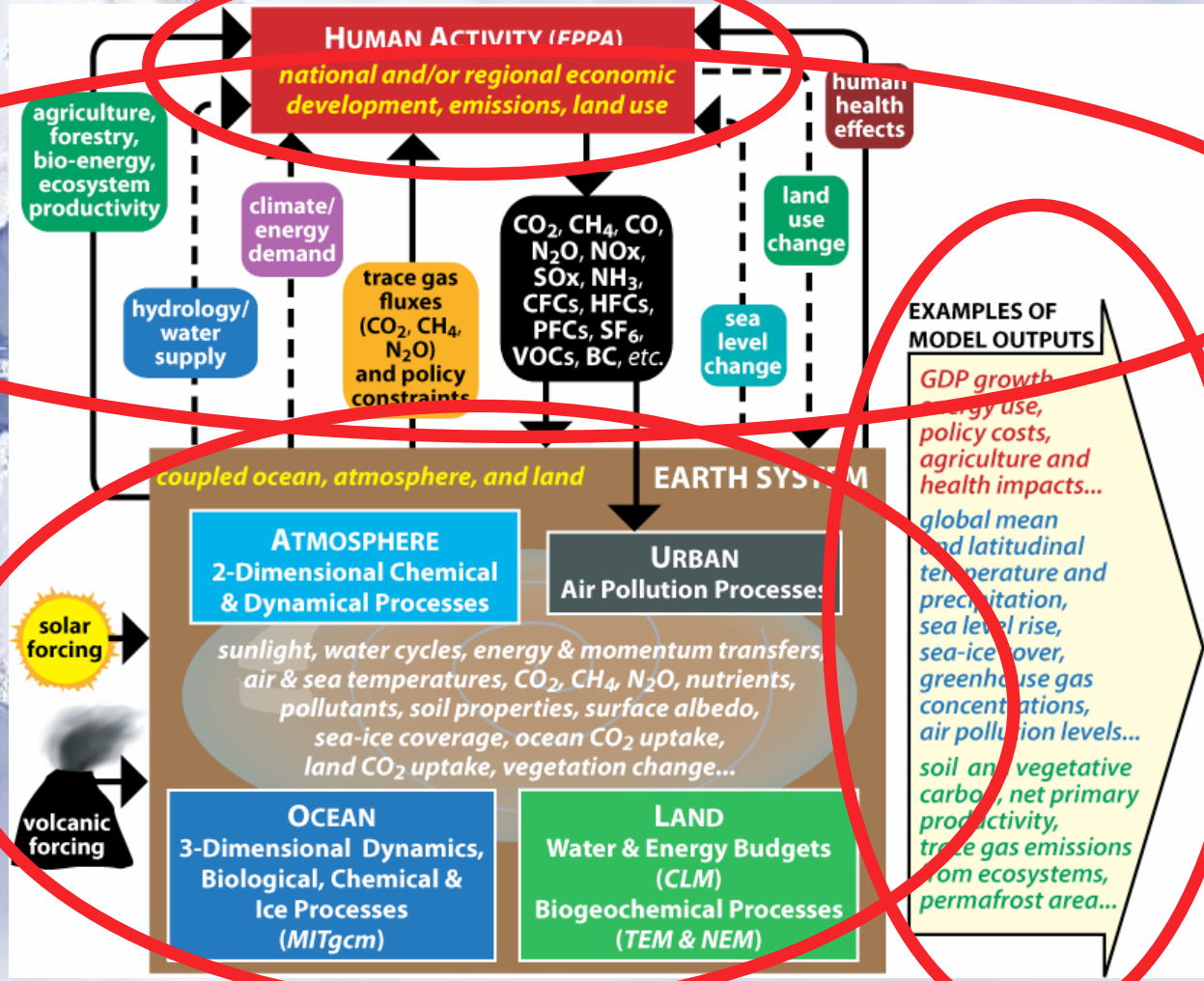


Black lines: observed changes. Blue bands: range for 19 model simulations using natural forcings. Red bands: range for 51 model simulations using natural and human forcings.

Ref: IPCC 4th Assessment, Summary for Policymakers, Feb. 2, 2007



**TO FORECAST CLIMATE CHANGE
WE NEED TO COUPLE THE HUMAN &
NATURAL COMPONENTS OF THE EARTH SYSTEM.**



MIT INTEGRATED GLOBAL SYSTEM MODEL

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HOW ACCURATE ARE CLIMATE FORECASTS?

THE MAJOR CLIMATE FORECAST MODEL UNCERTAINTIES INVOLVE CLOUDS, OCEAN MIXING & AEROSOL FORCING.

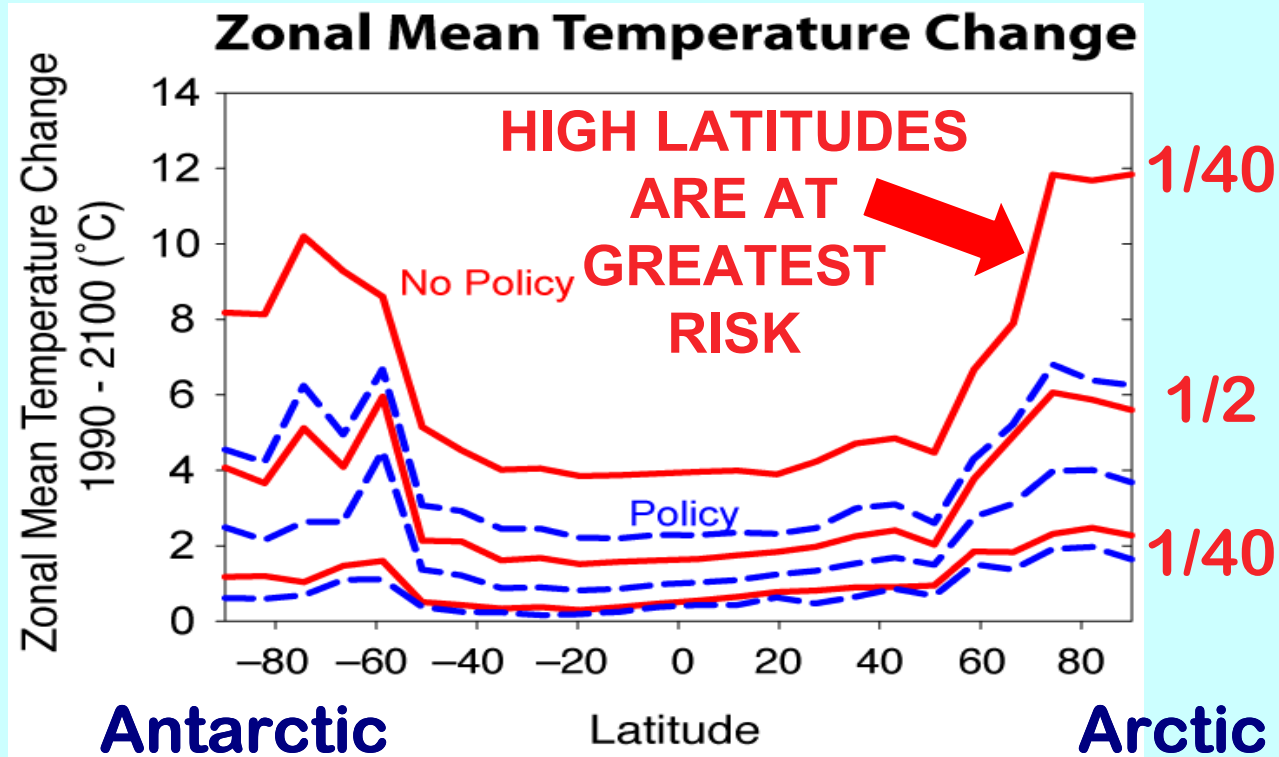
THESE UNCERTAINTIES ARE CONSTRAINED BY OBSERVATIONS

ADDED TO THESE ARE SUBSTANTIAL UNCERTAINTIES IN EMISSION FORECASTING

THESE UNCERTAINTIES SERIOUSLY LIMIT THE ACCURACY OF PREDICTIONS OF FUTURE CLIMATE

WE USE VERY LARGE ENSEMBLES OF IGSM RUNS TO ESTIMATE THE PROBABILITY OF VARIOUS AMOUNTS OF CLIMATE CHANGE

WHAT IS THE PROBABILITY OF VARIOUS AMOUNTS OF CLIMATE CHANGE BY LATITUDE for 1990-2100, WITH & WITHOUT A (550 ppm CO₂-equivalent) POLICY?

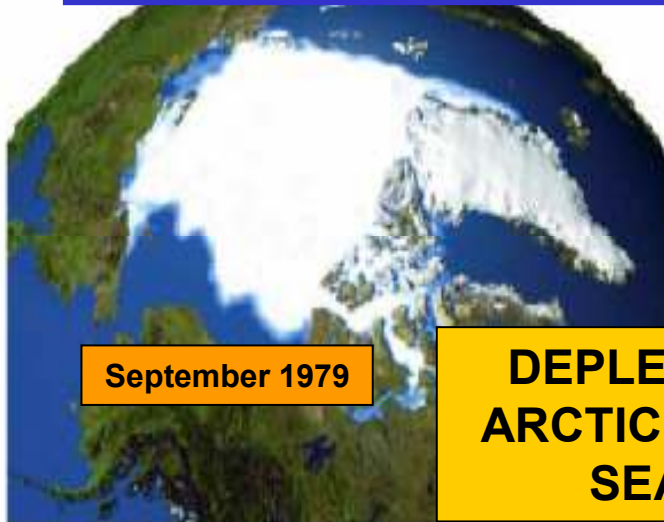


Projected change in surface warming by latitude band between 1990 and 2100. The median value, and lower 95% and upper 95% bounds are shown. Solid lines show distributions resulting from no emissions restrictions and dashed lines are distributions under the sample policy.

Ref: Webster et al, Climatic Change, 2003

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POLAR REGIONS WARM FASTER THAN TROPICS: WHAT ARE VULNERABLE SYSTEMS AT HIGH LATITUDES?



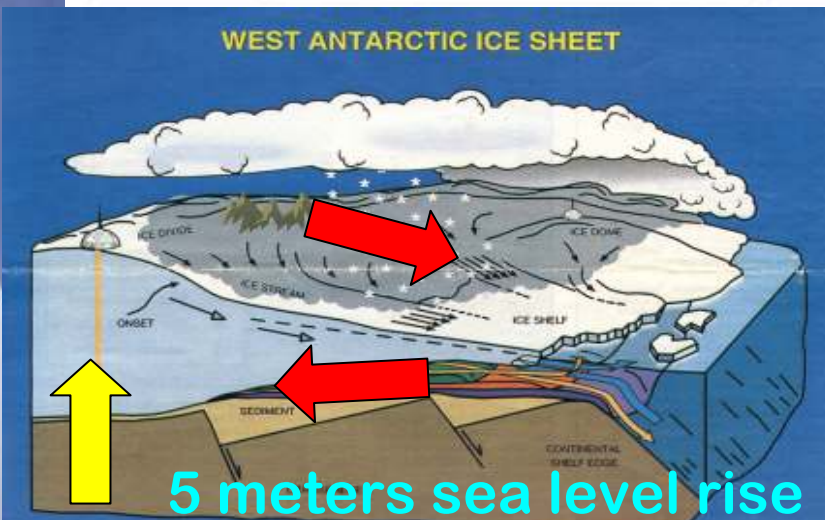
September 1979



September 2003

**DEPLETION OF
ARCTIC SUMMER
SEA ICE**

REF: ACIA, Impacts
of a Warming Arctic,
Climate Impact
Assessment
Report,
2004



5 meters sea level rise
**STABILITY OF WEST ANTARCTIC
ICE SHEET**

**About
550
billion
tons of
carbon
stored in
Arctic
tundra
& frozen
soils
(SCOPE
2004)**



**STABILITY OF
ARCTIC TUNDRA &
PERMAFROST**



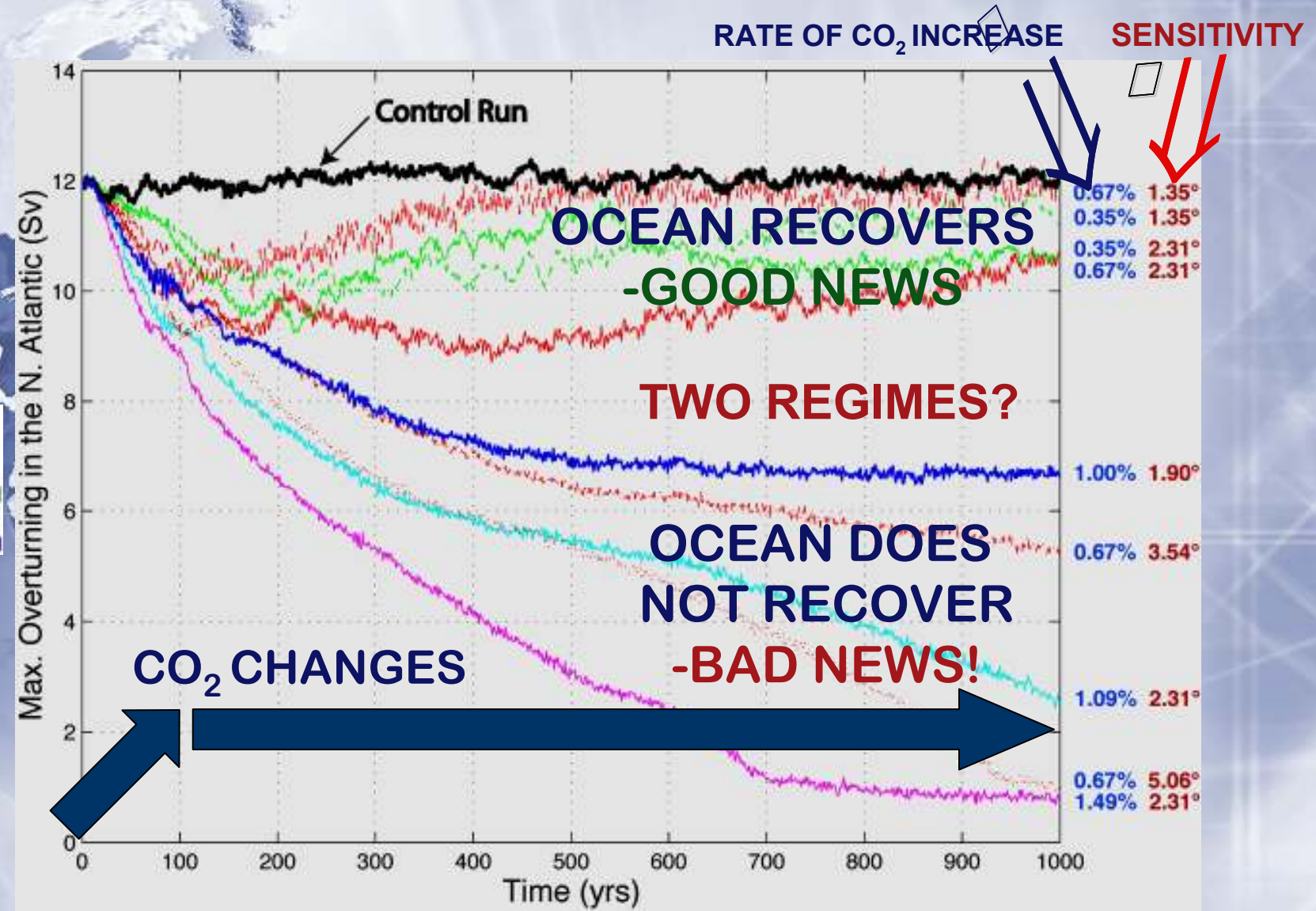
**ARCTIC ODYSSEY:
Voyage of the *Kapitan
Khlebnikov*
July 5-18, 2007**



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PHOTOS COURTESY OF BRUCE & MARTHA CUTHBERTSON

WILL THERE BE A DANGEROUS SLOWDOWN OF OCEANIC OVERTURN?
MIT IGSM 3D OCEAN MODEL (100 years of CO₂ increase then stabilization)

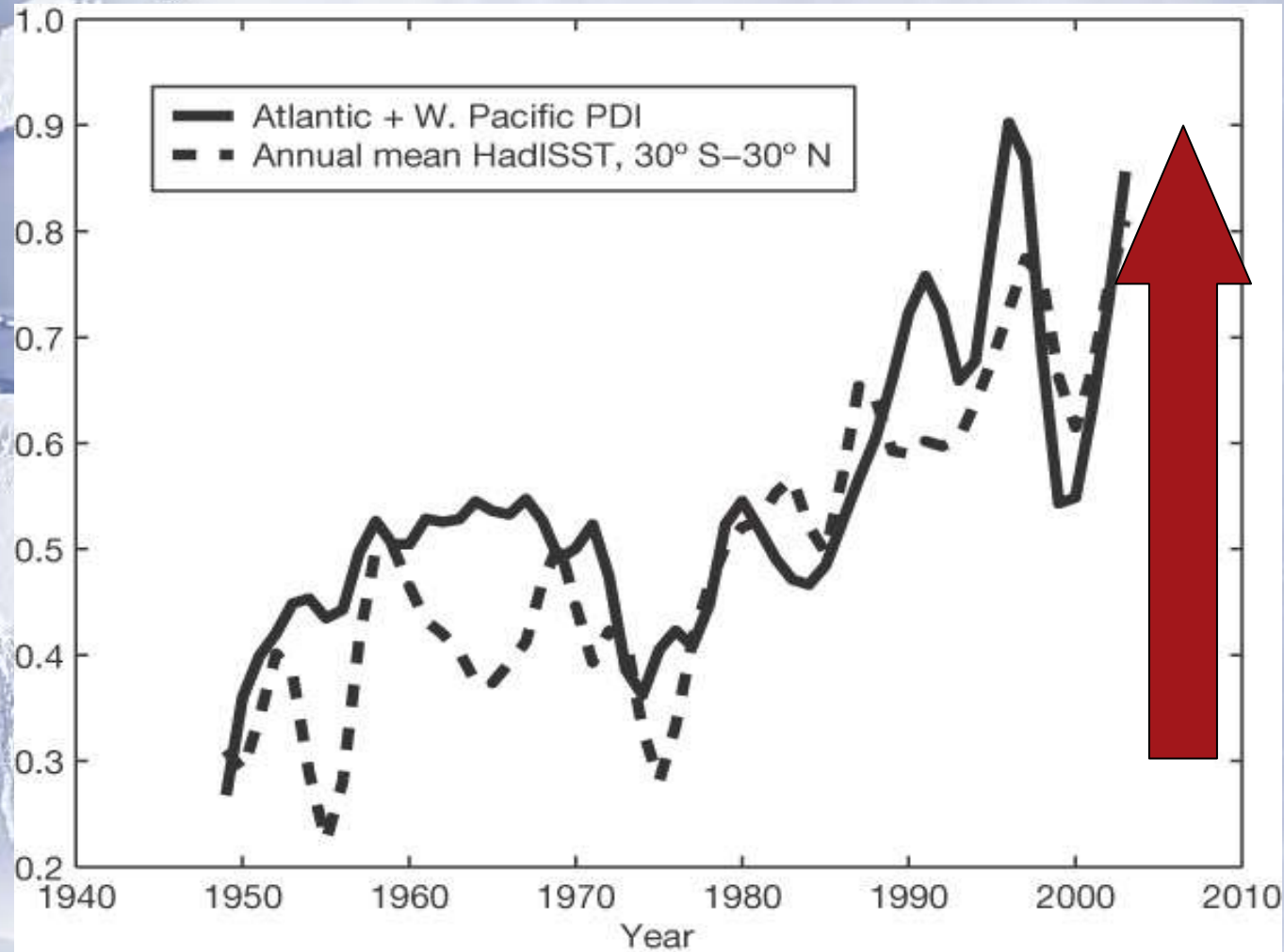


Ref: Scott et al, MIT Joint Program Report 148, Climate Dynamics, in press, 2007 Contact rprinn@mit.edu for citation permission

HURRICANES:

INCREASING DESTRUCTIVENESS OVER THE PAST 30 YEARS?

Power
Dissipation
Index (PDI)
 $= T \int_0^T V_{\max}^3 dt$
(a measure
of storm
destruction)



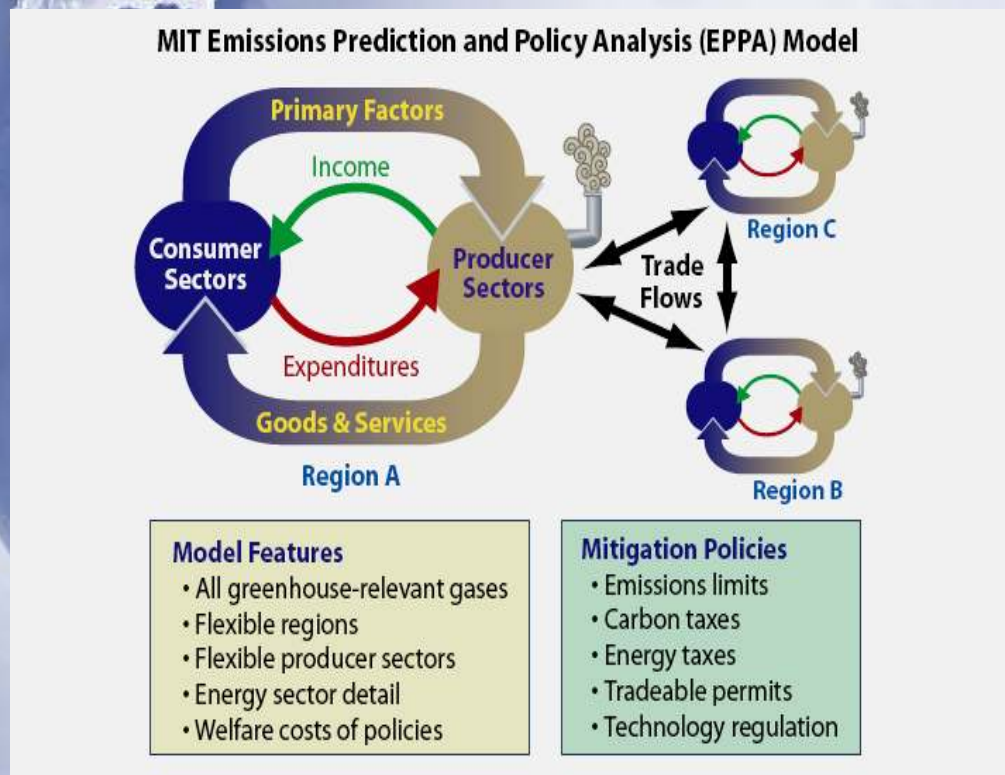
SOURCE: Emanuel, K., *Nature*, vol. 436, 4 August 2005

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HOW CAN WE MANAGE THE CLIMATE ISSUE?

A 550 ppm CO₂-equivalent Stabilization Scenario

IGSM's Model of Human Activity—Emissions Prediction and Policy Analysis (EPPA) Model.



Sectors

Non-Energy

Services
 Energy Intensive products
 Other Industries products
 Transportation
 Food Processing

Energy

Coal
 Crude Oil, Tar Sands, Shale Oil
 Refined Oil Products
 Biomass liquid fuel
 Natural Gas, Coal Gasification
 Electric: Fossil, Hydro, Nuclear,
 Solar & Wind, Biomass, Natural Gas
 Combined Cycle, Integrated Coal
 Gasification with Sequestration

Agriculture

Crops
 Livestock
 Forestry

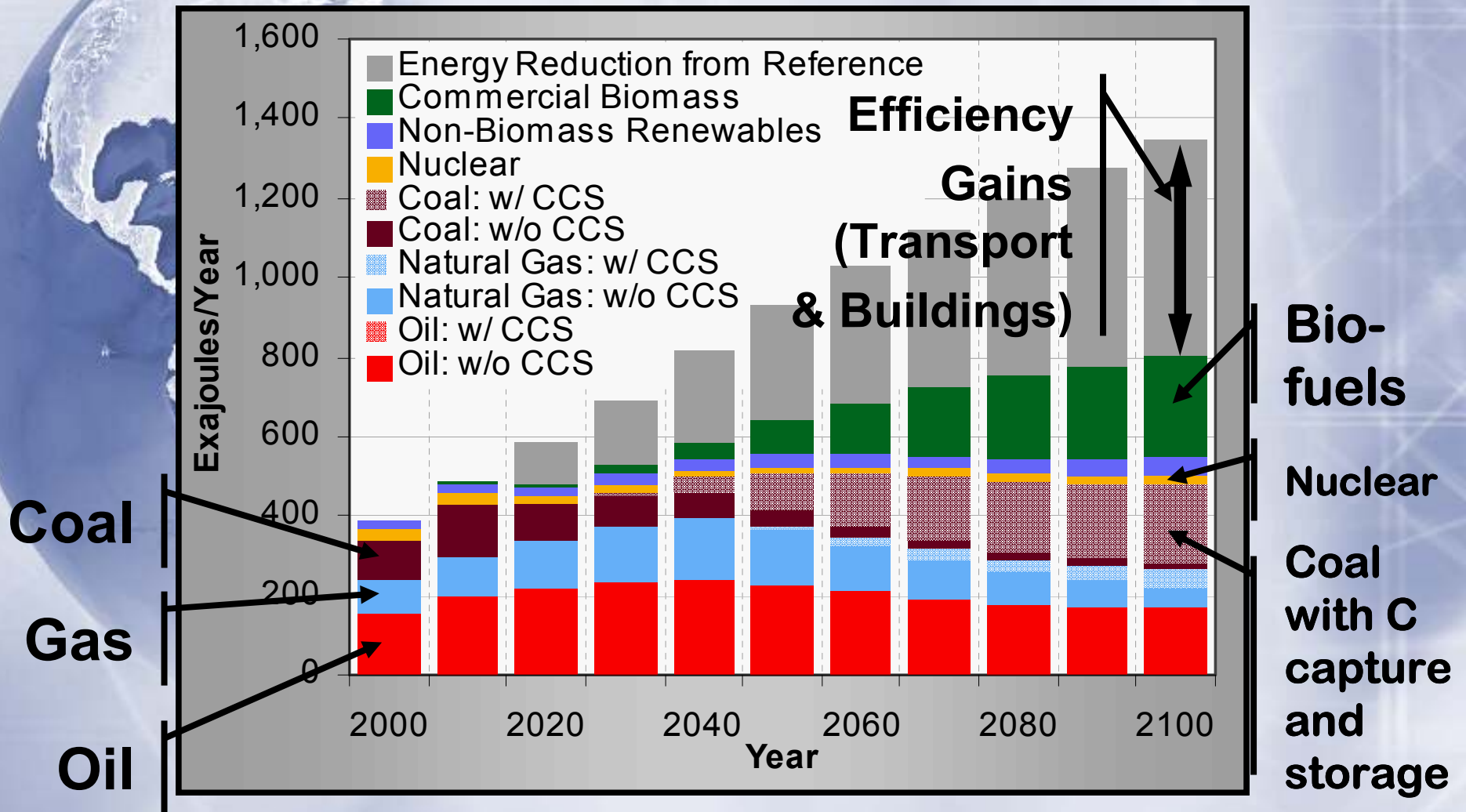


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AN EXAMPLE OF THE SCALE OF THE CHALLENGE

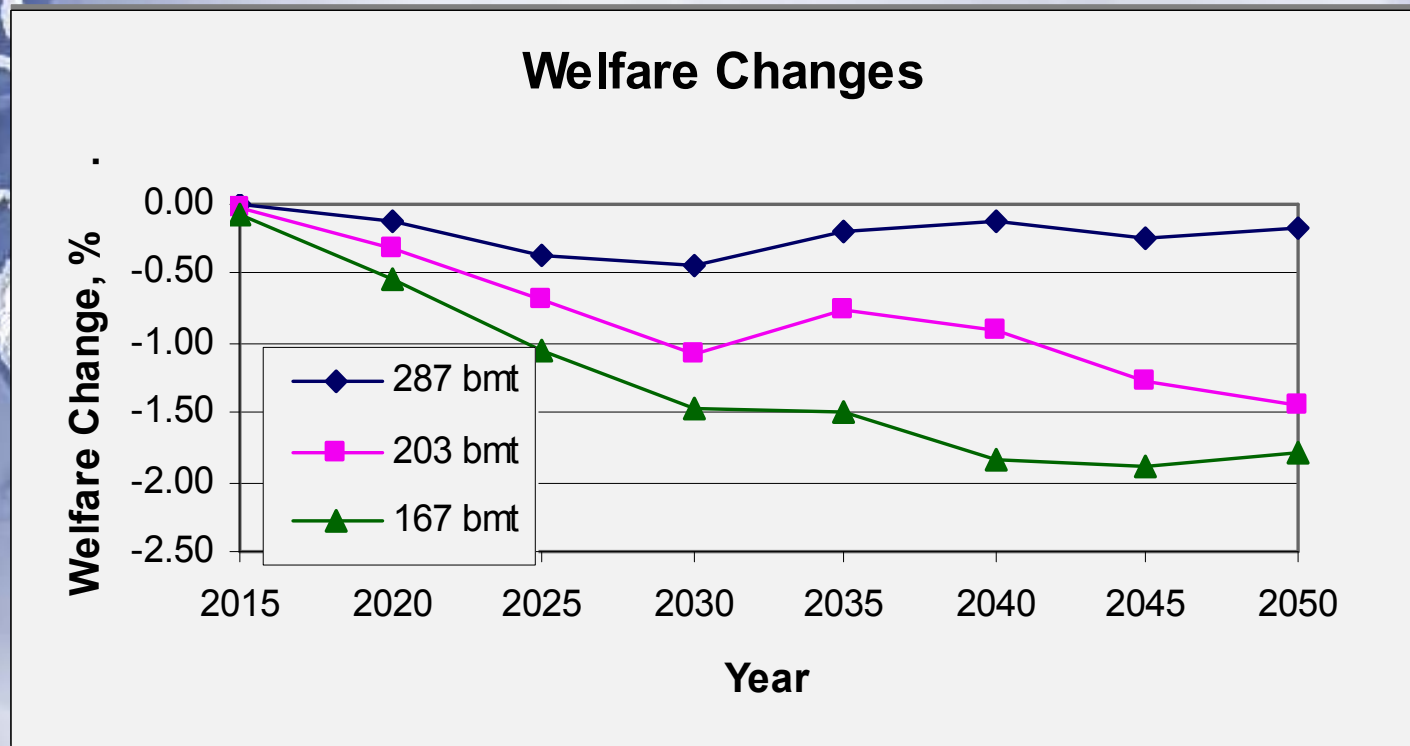
Global Primary Energy: 550 ppm-equivalent stabilization scenario (nuclear restricted)



ANALYSIS OF CURRENT BILLS IN THE U.S. CONGRESS

Roughly 3 types: emissions up to 2050 **CONSTANT** at 2008 levels, or 2050 emissions either **50%** and **80%** lower than 1990 levels.
(cumulative emissions of 287, 203 or 167 billion metric tons of CO₂-e for 2012-2050)

CAN WE AFFORD IT?



CON
80%
50%
80%
CON

Ref: Paltzev et al, MIT Joint Program Report 146, 2007

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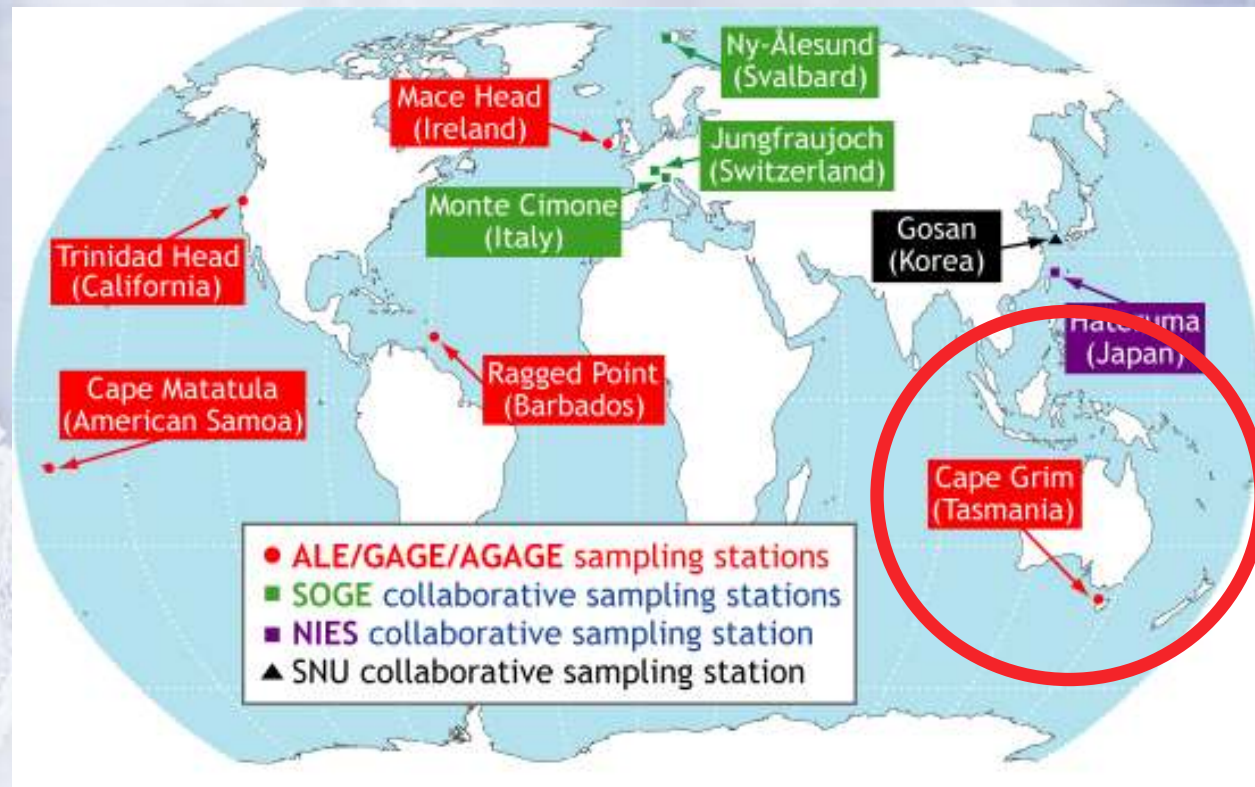




Verification of Emissions using Atmospheric Measurements and Inverse Methods

e.g. The Advanced Global Atmospheric Gases Experiment (AGAGE), and its predecessors (the Atmospheric Lifetime Experiment, ALE, and the Global Atmospheric Gases Experiment, GAGE) have been measuring the composition of the global atmosphere continuously since 1978.

The International AGAGE is distinguished by its capability to measure over the globe at high frequency almost all of the important species in the Montreal Protocol to protect the ozone layer and almost all of the significant non-CO₂ gases in the Kyoto Protocol to mitigate climate change.



The ALE/GAGE/AGAGE stations occupy coastal & mountain sites around the world chosen to provide accurate measurements of trace gases whose lifetimes are long compared to global atmospheric circulation times.

SOGE: System for Observation of Halogenated Greenhouse Gases in Europe. NIES: National Institute for Environmental Studies, Japan. SNU: Seoul National University, Korea.

Ref: Prinn, Weiss, Fraser, Simmonds, et al, J. Geophys. Res., 2000

HOW CAN WE EXPRESS THE VALUE OF A CLIMATE POLICY UNDER UNCERTAINTY?

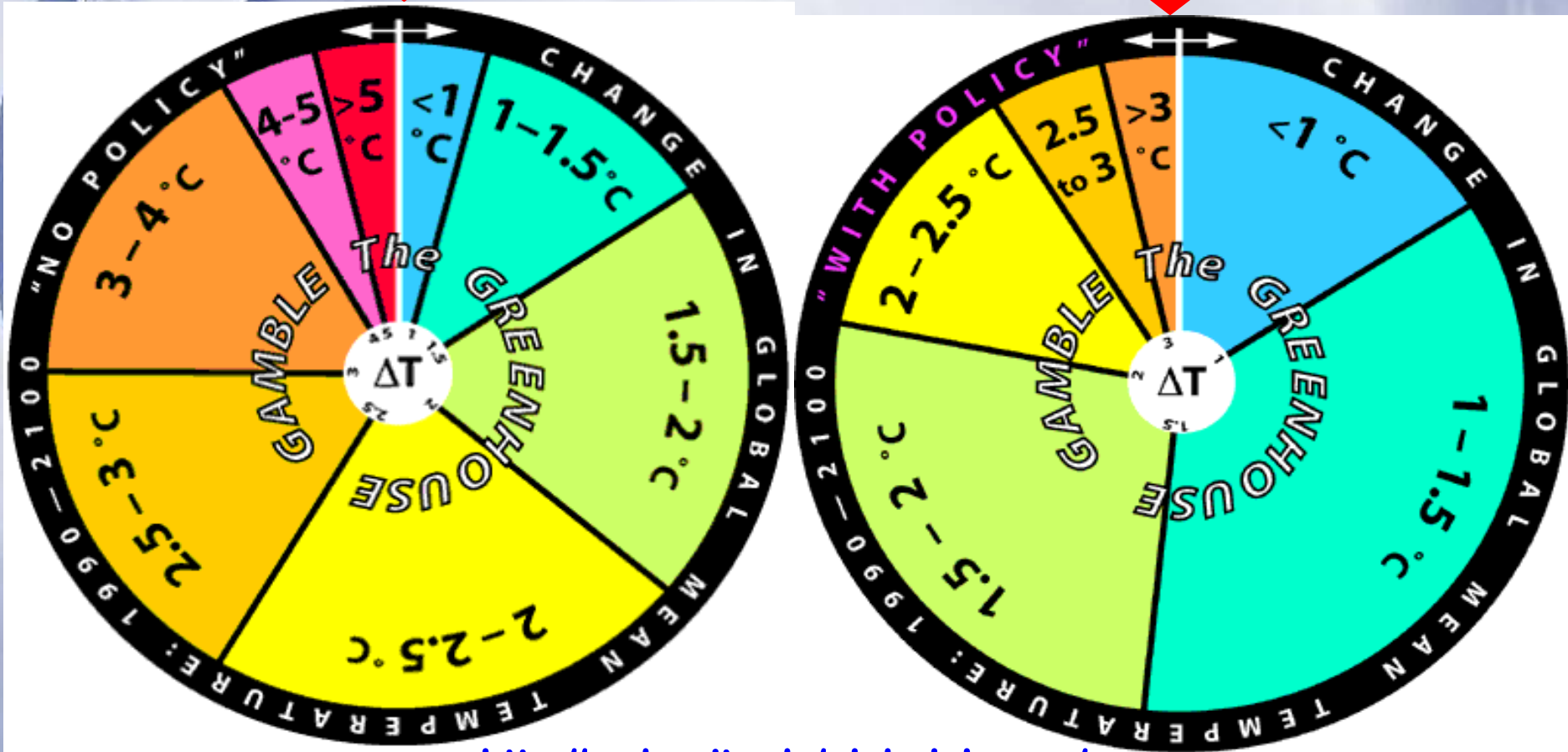
Compared with NO POLICY



What would we buy with STABILIZATION of CO₂ at 550 ppm?



A NEW WHEEL with lower odds of EXTREMES



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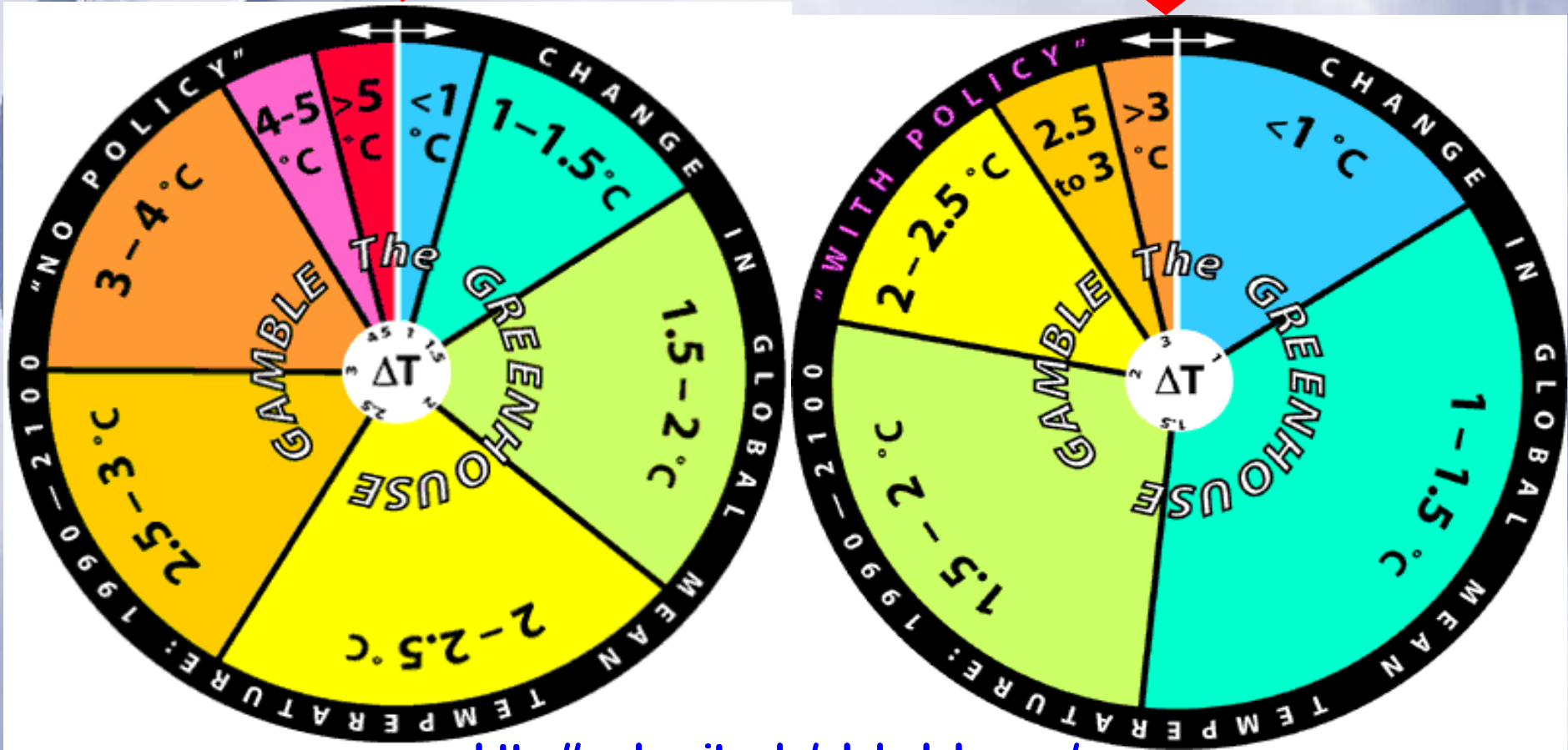
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<http://web.mit.edu/globalchange/>