

Needs from Science

John Reilly

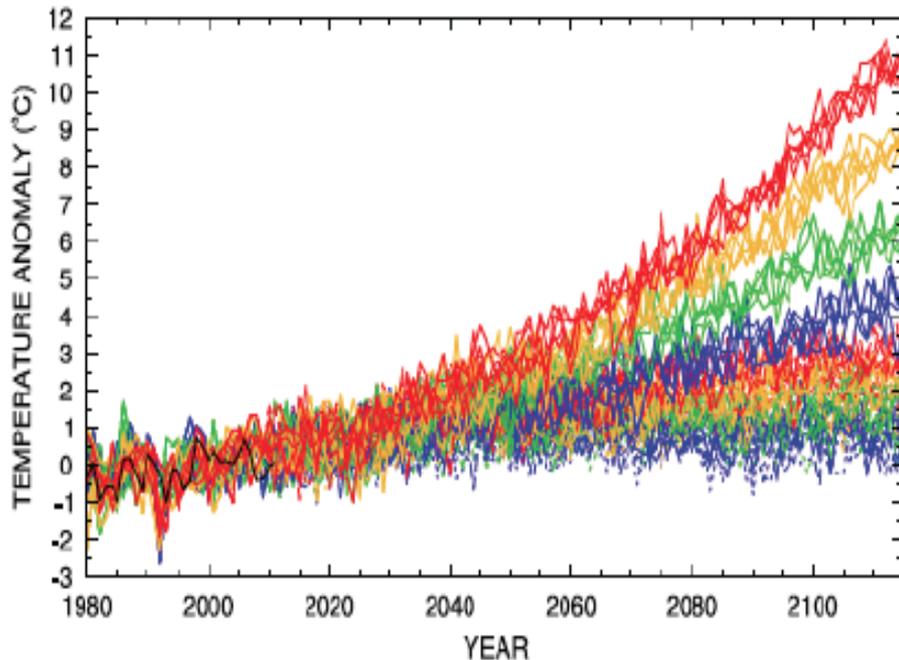
Joint Program on the Science and Policy of Global Change
Massachusetts Institute of Technology



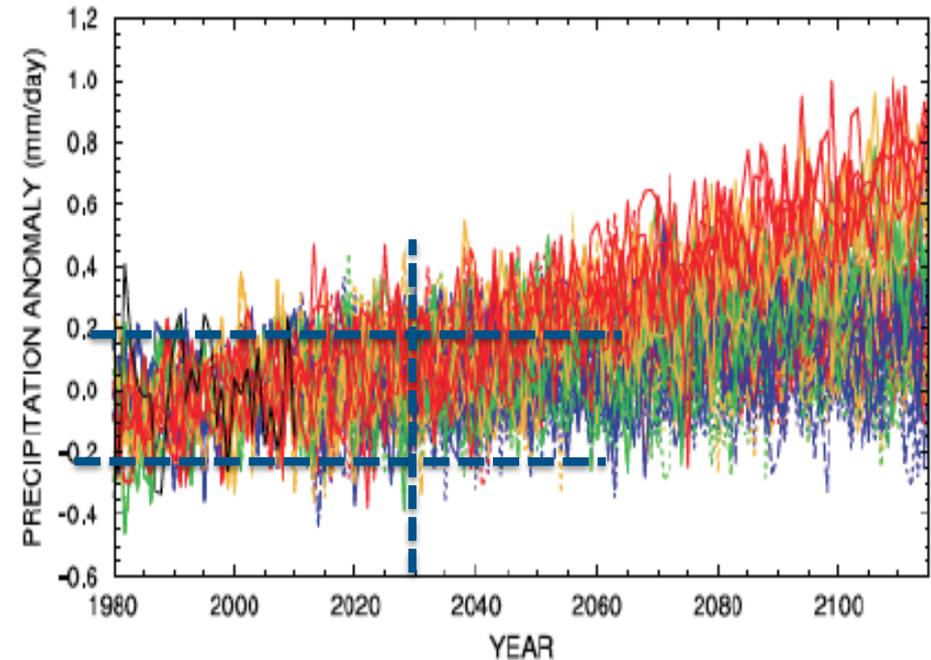
Creates an Adaptation Challenge

US mean Temperature (left) and Precip. (right)
Unconstrained, 4.5 W/m², and 3.7 W/m²; hi, median, low climate sensitivity

IGSM-CAM INDIVIDUAL SIMULATIONS



IGSM-CAM INDIVIDUAL SIMULATIONS

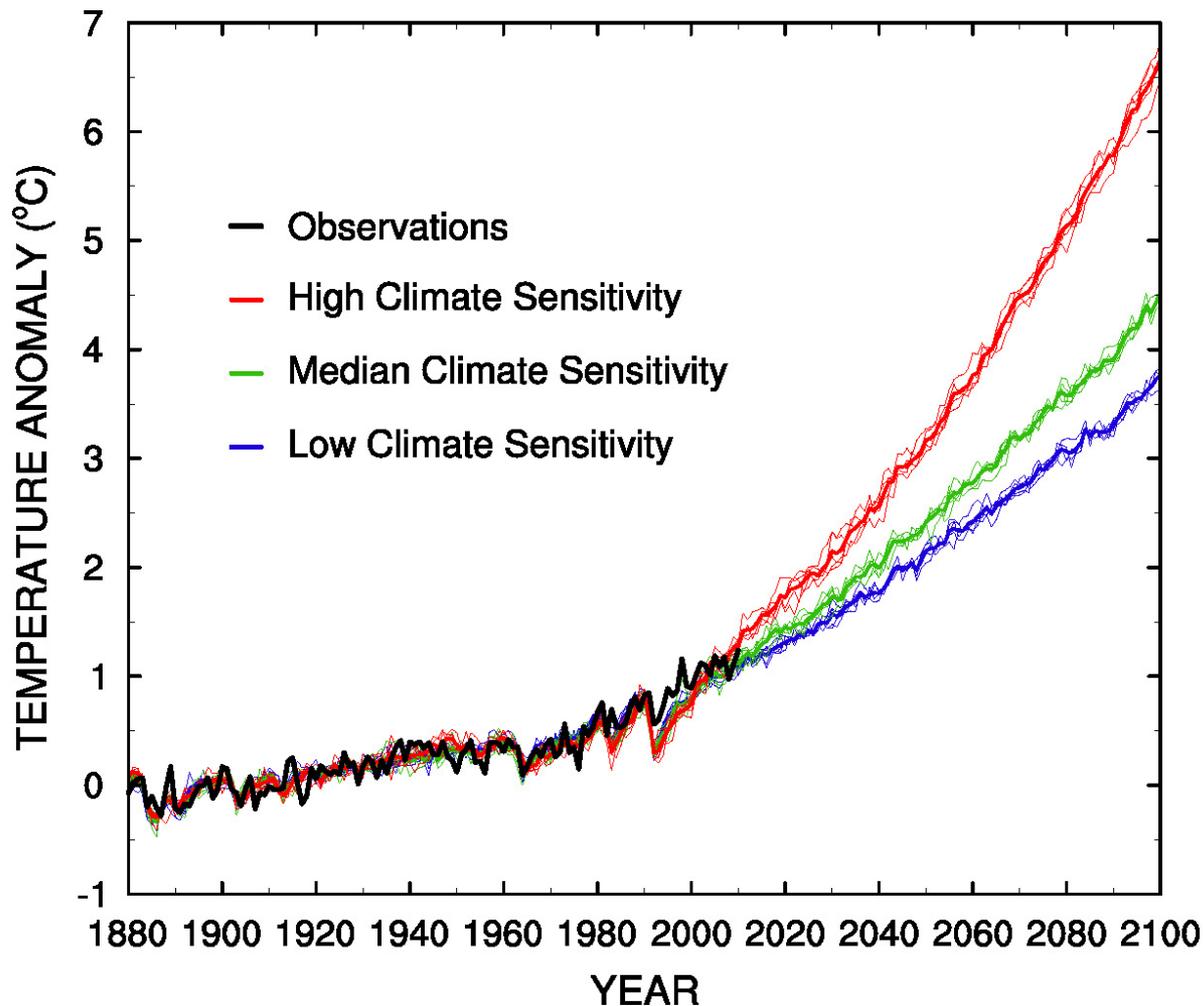


When we talk of climate change we tend to think of smoother change or distant future where alternatives are distinct.

But our near-term outlook is rife with uncertainty and variability.



Temperature Increase



Using 3 scenarios of climate sensitivity, the range of warming:

2050: 1.7°-3.0°C

Median: 2°C

2100: 3.6°-6.7°C

Median: 4.4°

Issue: Much closer to "No Policy" than any stabilization goal.

Cumulative PROBABILITY OF GLOBAL AVERAGE SURFACE AIR WARMING
from 1981-2000 to 2091-2100, WITHOUT (1400 ppm-eq CO₂) & WITH A 550,
660, 790 or 900 ppm-equivalent CO₂ GHG STABILIZATION POLICY
(400 forecasts per case. Ref: Sokolov et al, Journal of Climate, 2009)

	ΔT > 2°C <small>(values in red relative to 1860 or pre-industrial)</small>	ΔT > 4°C	ΔT > 6°C
No Policy at 1400	100% (100%)	85%	25%
Stabilize at 900 (L4)	100% (100%)	25%	0.25%
Stabilize at 790 (L3)	97% (100%)	7%	< 0.25%
Stabilize at 660 (L2)	80% (97%)	0.25%	< 0.25%
Stabilize at 550 (L1)	25% (80%)	< 0.25%	< 0.25%

ADDRESSING REGIONAL CLIMATE CHANGE UNDER UNCERTAINTY

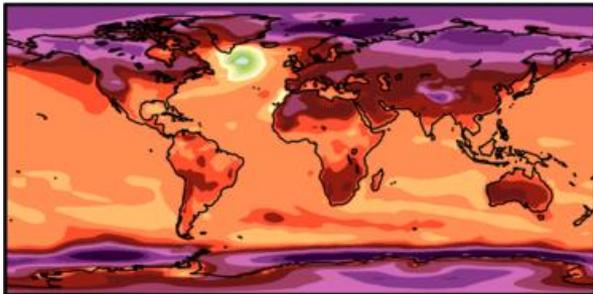
e.g. Cumulative **PROBABILITY OF ARCTIC (60°N to 90°N) SURFACE AIR WARMING** from 1981-2000 to 2091-2100, **WITHOUT** (1400 ppm-eq CO₂) & **WITH A 550, 660, 790 or 900 ppm-eq CO₂ GHG STABILIZATION POLICY** (Sokolov et al, J. Clim., 2009; Webster et al, MIT JPSPGC Rep.180, 2009; Clim. Change, in review, 2010)

	$\Delta T > 4^{\circ}\text{C}$	$\Delta T > 6^{\circ}\text{C}$	$\Delta T > 8^{\circ}\text{C}$
No Policy at 1400	100%	95%	70%
Stabilize at 900 (L4)	95%	30%	3%
Stabilize at 790 (L3)	80%	9%	0.25%
Stabilize at 660 (L2)	25%	0.25%	< 0.25%
Stabilize at 550 (L1)	0.5%	< 0.25%	< 0.25%

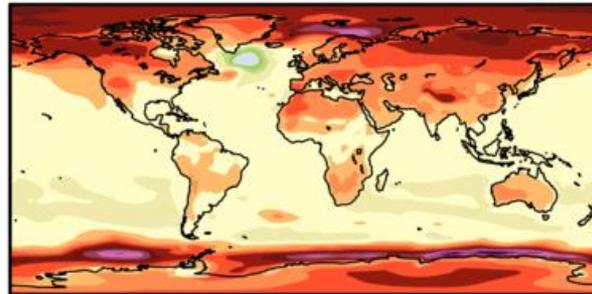
Range of climate outcomes, one GCM with varied climate sensitivity

Temperature 2080-2099 relative to 1980-1999 (in °C)

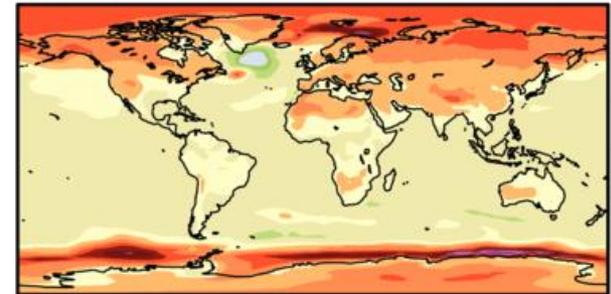
highCS_BAU



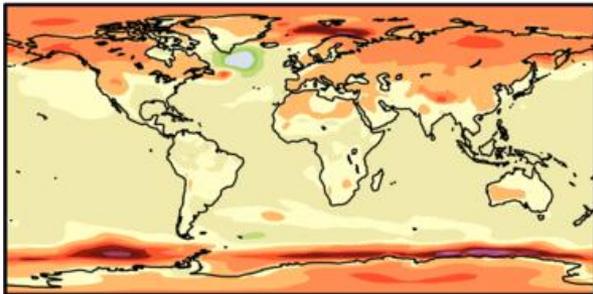
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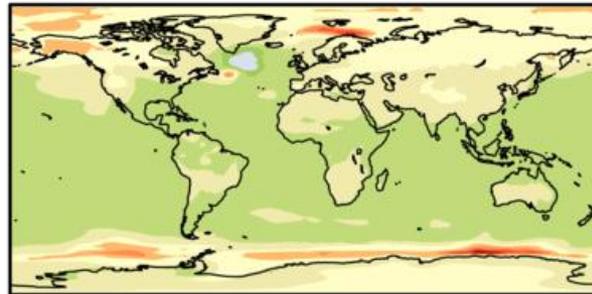
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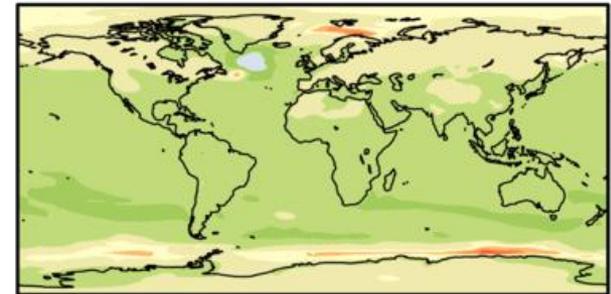
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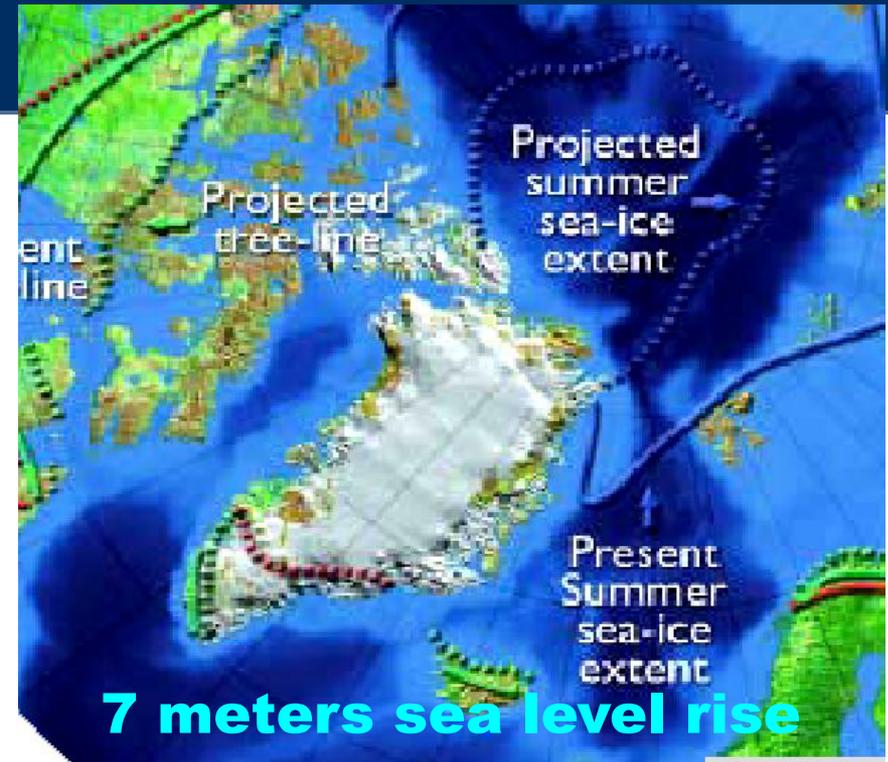
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lowCS_POL

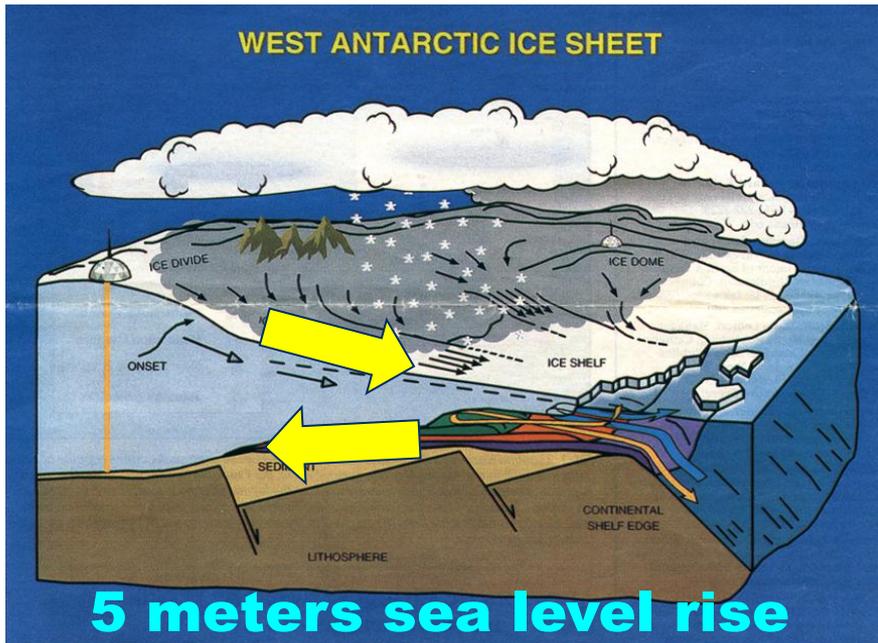


**POLES WARM MUCH FASTER THAN TROPICS;
IF ICE SHEETS MELT, HOW MUCH SEA LEVEL RISE COULD OCCUR?**

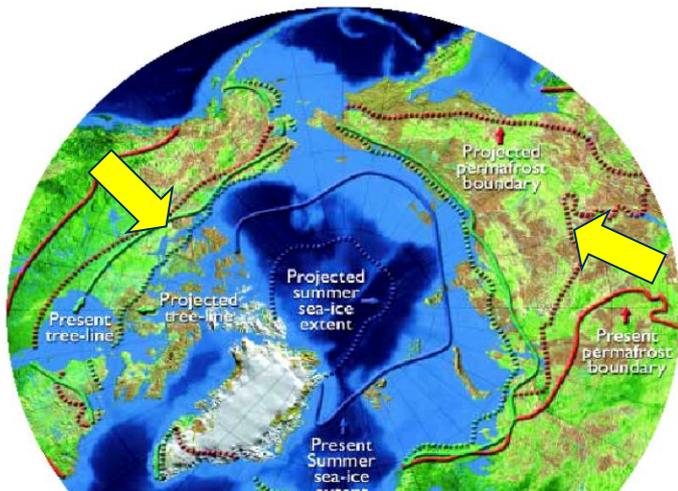


STABILITY OF GREENLAND ICE SHEET

The last time the polar regions were significantly warmer (~4 °C) than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 meters of sea level rise.



STABILITY OF WEST ANTARCTIC ICE SHEET

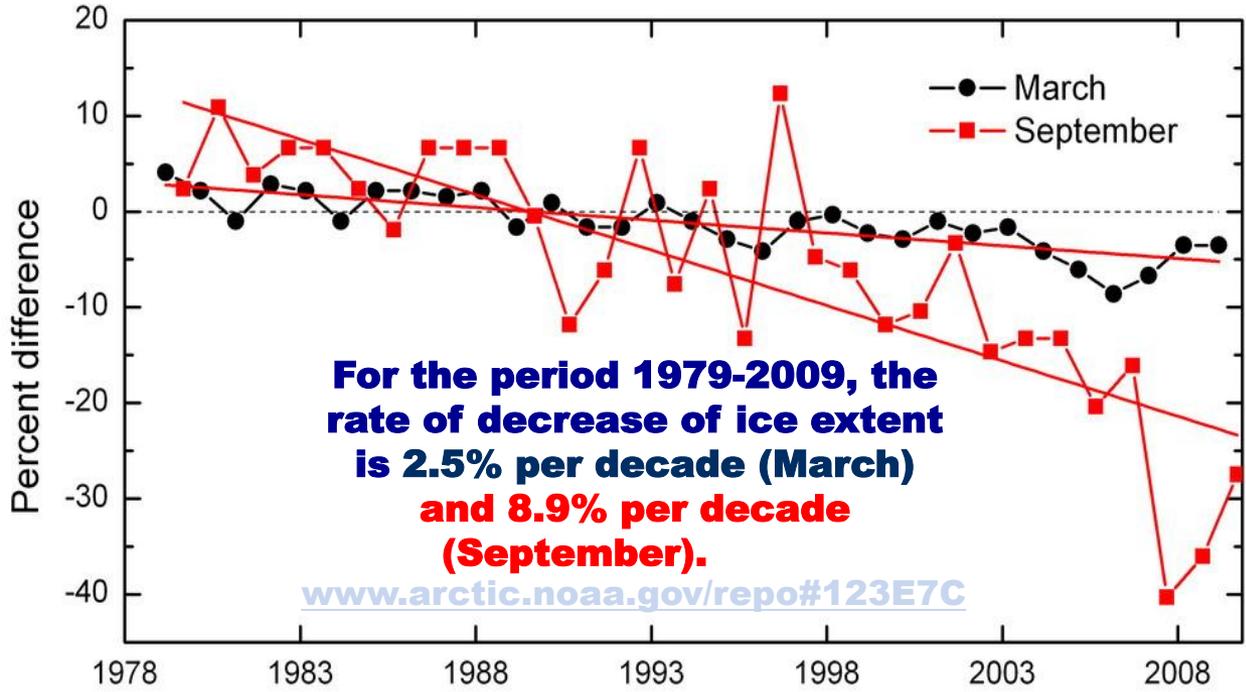


THIS WOULD INDUCE EMISSION OVER TIME OF THE 1670 BILLION TONS OF CARBON STORED IN ARCTIC TUNDRA & FROZEN SOILS (TARNOCAI ET AL, GBC, 2009). THIS IS ABOUT 200 TIMES CURRENT ANTHROPOGENIC CARBON EMISSIONS. THESE EMISSIONS WOULD INCLUDE METHANE FROM NEW & WARMER WETLANDS.

WHAT WOULD HAPPEN IF ARCTIC TUNDRA & PERMAFROST THAWS?

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

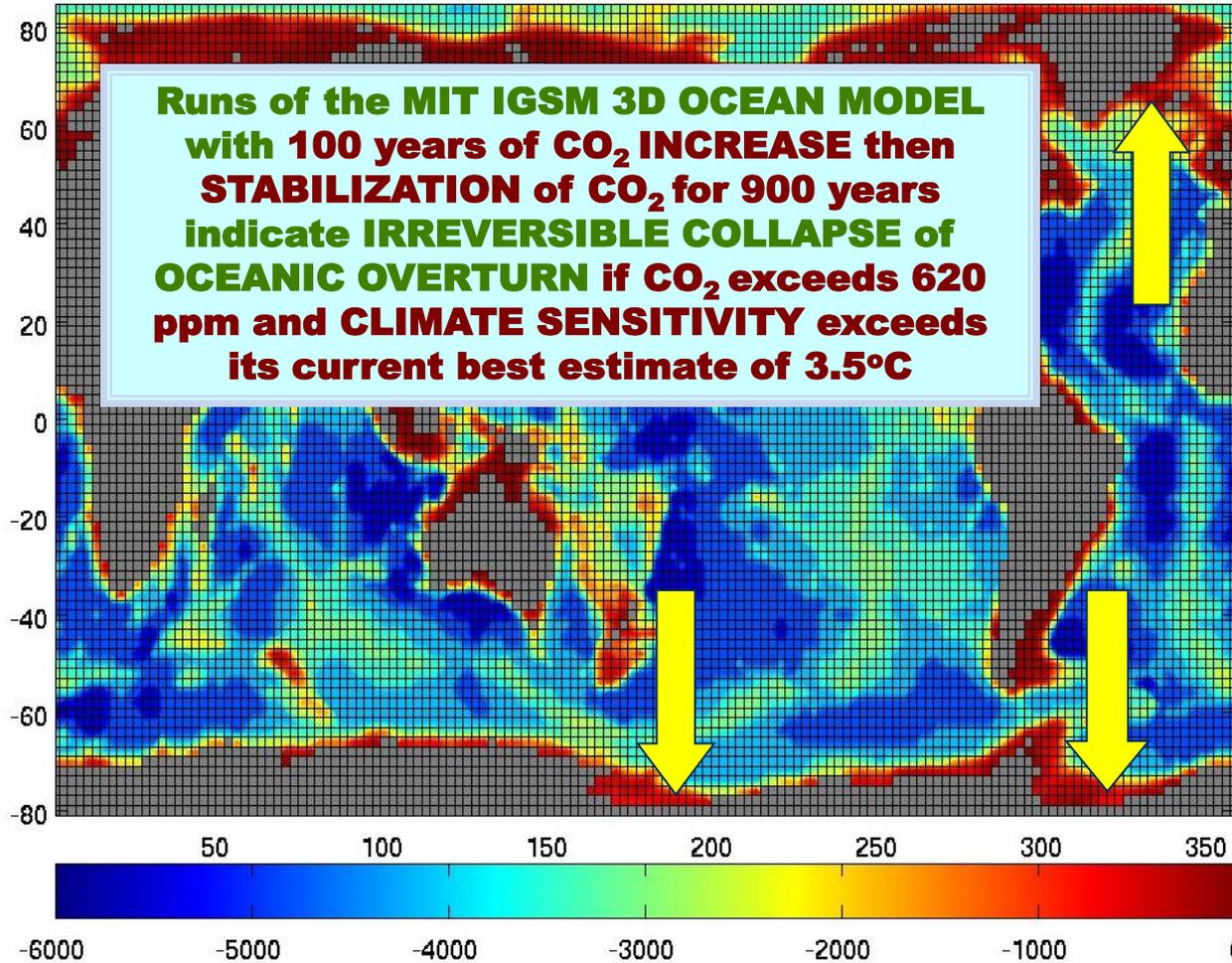
IS ARCTIC SEA ICE AT THE END OF WINTER & SUMMER DECREASING?
Time series of the percent difference in ice extent in March (the month of ice extent maximum) and September (the month of ice extent minimum) relative to the mean values for the period 1979–2000.



For the period 1979-2009, the rate of decrease of ice extent is 2.5% per decade (March) and 8.9% per decade (September).

www.arctic.noaa.gov/repo#123E7C

IF THE POLAR LATITUDES WARM TOO MUCH, COULD THE DEEP OCEAN CARBON & HEAT SINK COLLAPSE?



Runs of the MIT IGSM 3D OCEAN MODEL with 100 years of CO₂ INCREASE then STABILIZATION of CO₂ for 900 years indicate IRREVERSIBLE COLLAPSE of OCEANIC OVERTURN if CO₂ exceeds 620 ppm and CLIMATE SENSITIVITY exceeds its current best estimate of 3.5°C

OVERTURN DRIVEN BY SINKING WATER IN THE POLAR SEAS (Norwegian, Greenland, Labrador, Weddell, Ross)

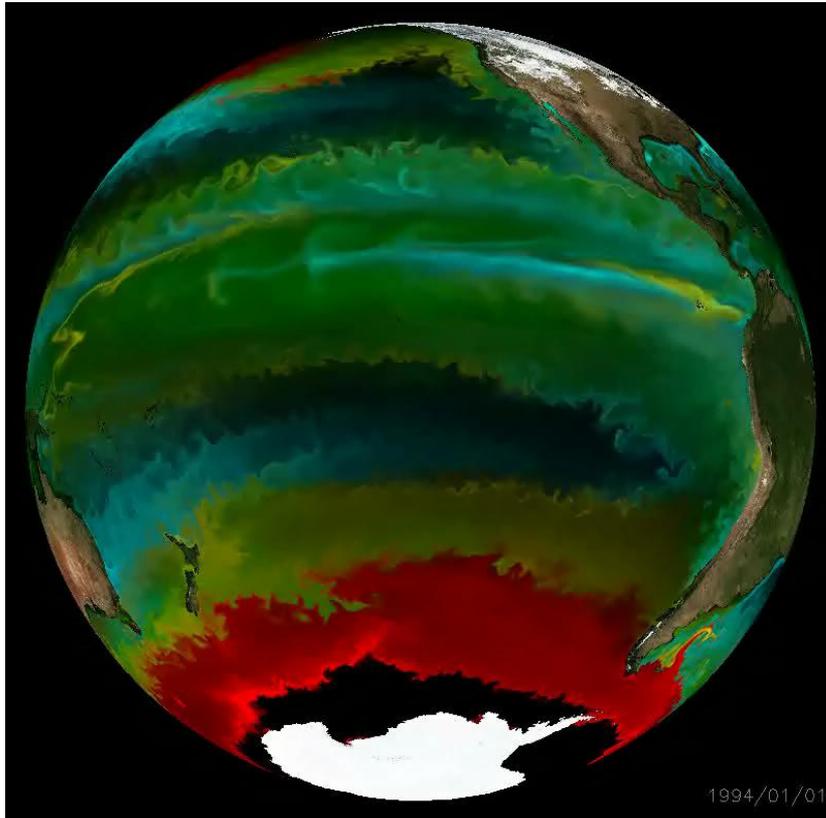
SLOWED BY DECREASED SEA ICE & INCREASED FRESH WATER INPUTS INTO THESE SEAS

INCREASED RAINFALL, SNOWFALL & RIVER FLOWS, & DECREASED SEA ICE, EXPECTED WITH GLOBAL WARMING

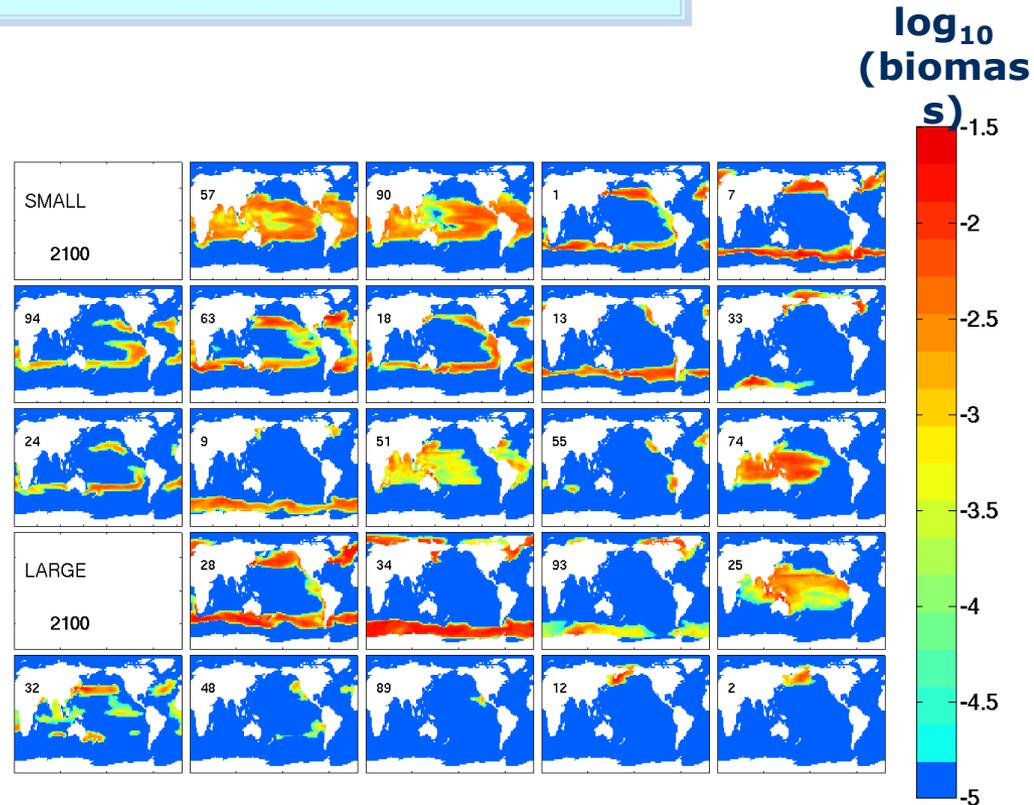
**OCEAN BOTTOM DEPTHS (meters)
(MIT IGSM 3D OCEAN MODEL)**

ABSENT POLICY, WHAT COULD HAPPEN TO PHYTOPLANKTON?

INCORPORATION OF THE "DARWIN" PHYTOPLANKTON EVOLUTION MODEL (Follows, Dutkiewicz, et al, <http://darwinproject.mit.edu>) INTO IGSM 3D OCEAN UNDERWAY



Phytoplankton Functional Groupings
 (red/yellow=large; green/blue=small)
 Courtesy of Oliver Jahn



“Business as usual” emissions scenario (2000-2100): by 2100, atmospheric CO₂ is 1300 ppm and global surface air temperature up 5°C

Thank you!

