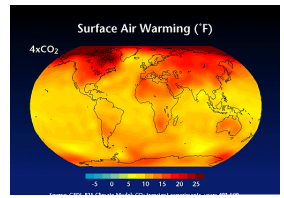
Improving Predictions from Minutes to Millennia

Alexander E. MacDonald, Ph.D.
Deputy Assistant Administrator for Labs
and Cooperative Institutes
& Director, Earth System Research Laboratory
National Oceanic & Atmospheric Administration

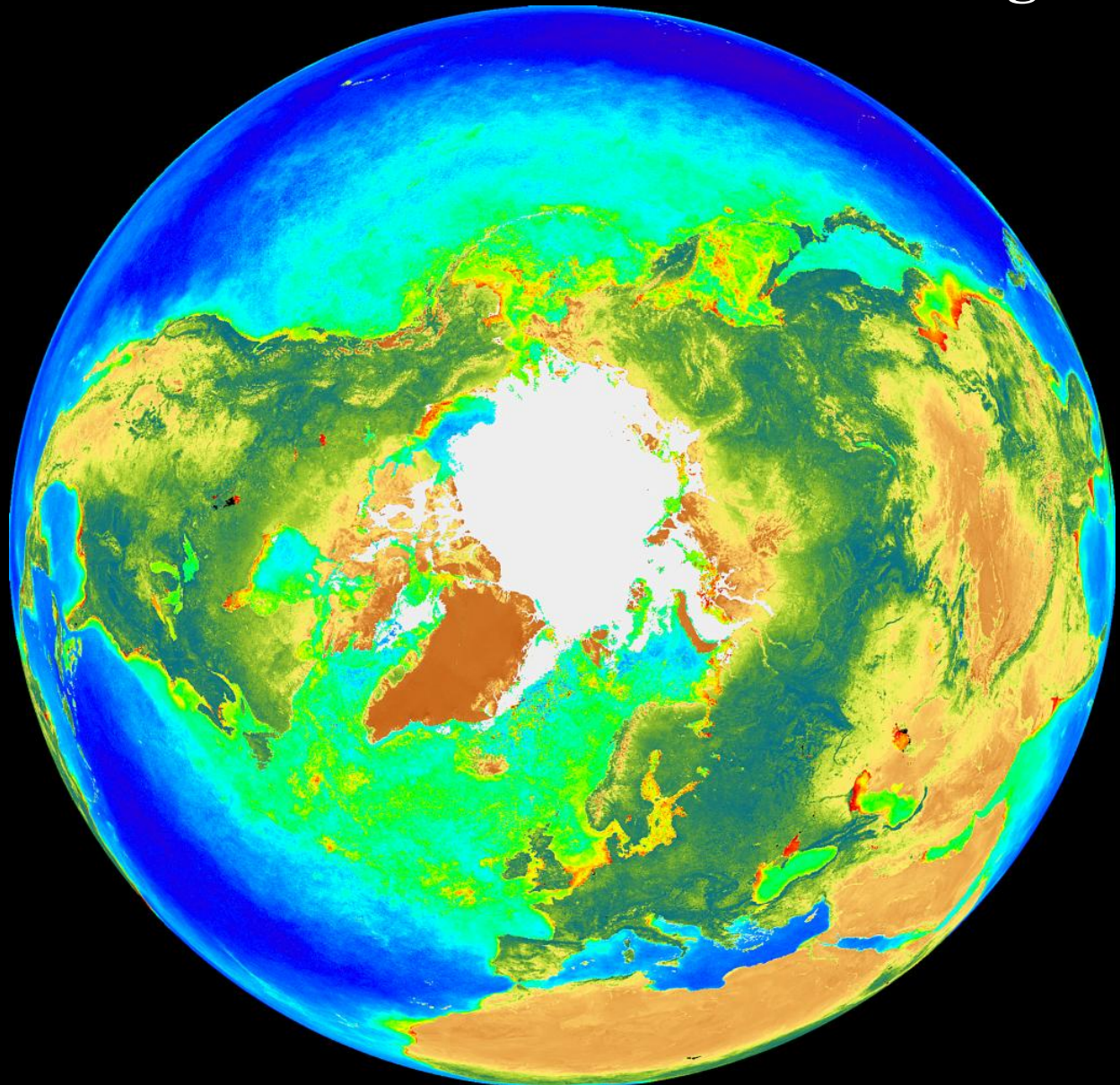
Commonality of Geophysical Prediction Technology

Technology	Doppler Radar Network AWIPS	Global Observing (Satellite and In-Situ) Modeling (Computing)		
Example	Tornado	Blizzard	Drought	Global Warming 
Phenomena	Weather Warning (convective)	Weather Prediction (deterministic)	Seasonal to Interannual Prediction	Long-Term Climate
Time Scale	10^1 Seconds	10^3 20 minutes	10^6 2 Weeks	10^8 3 years	10^{10} 300 Years

Earth System Research Laboratory

Mission: To observe and understand the Earth system and to develop products through a commitment to research that will advance NOAA's environmental information and service on global-to-local scales.

Earth System Science: In order to understand any of it, we must understand how it ALL works together.



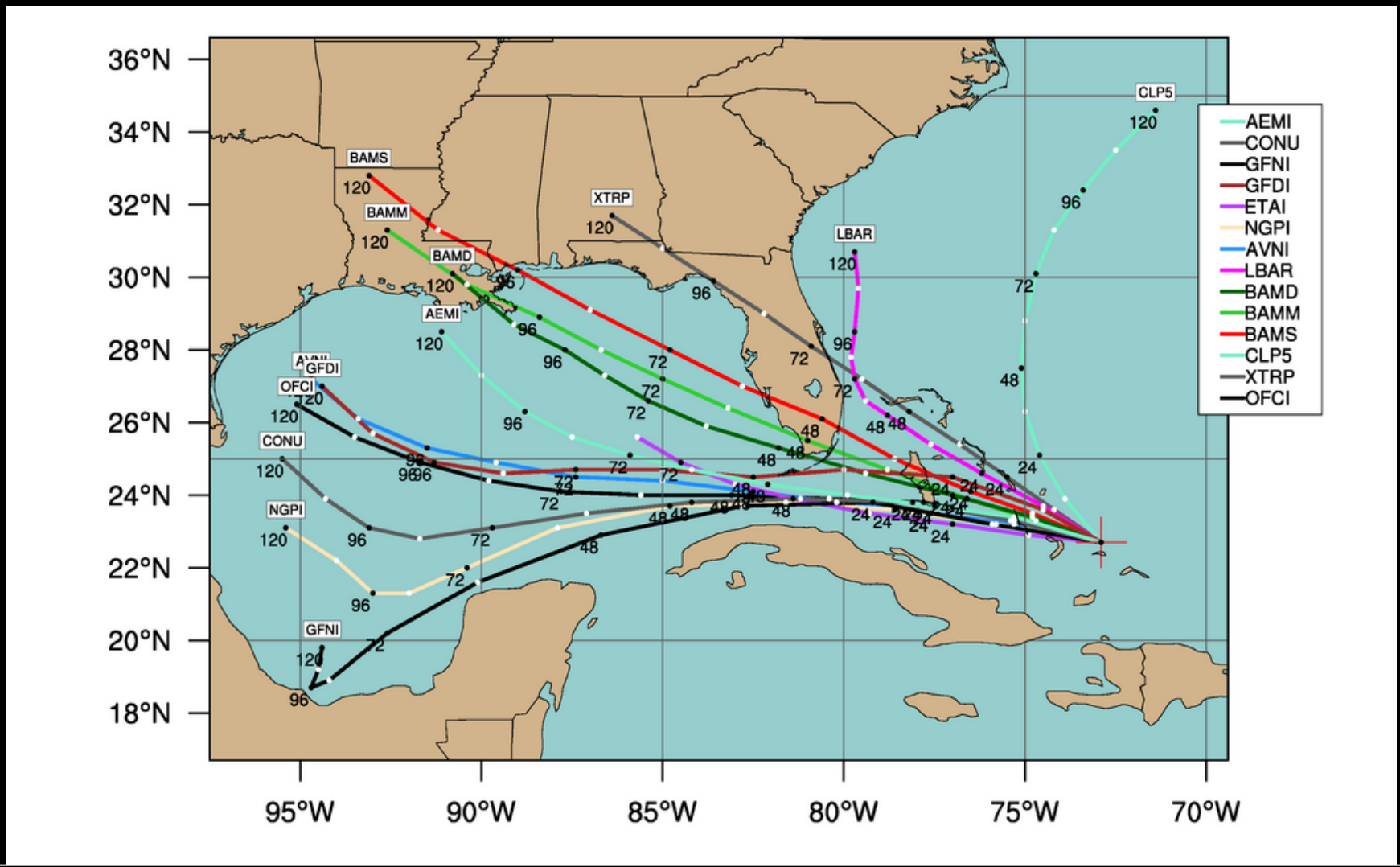
Overview

- 1. Improving hurricane prediction.
- 2. Improving long-term climate predictions.

Overview

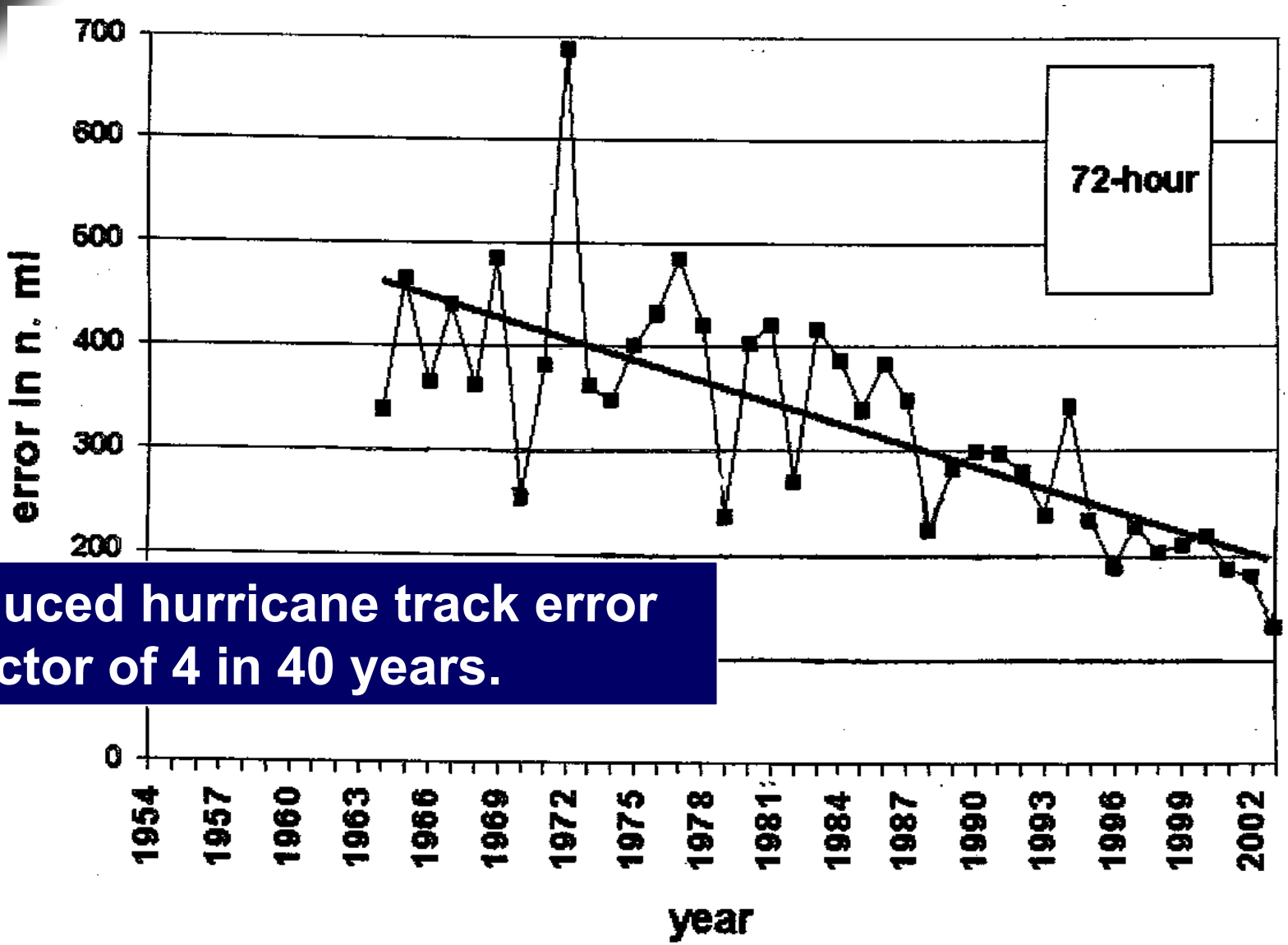
- **1. Improving hurricane prediction.**
- 2. Improving long-term climate predictions.

Reducing uncertainty for hurricane track



"According to our model, Hurricane Rita will make landfall at . . . "

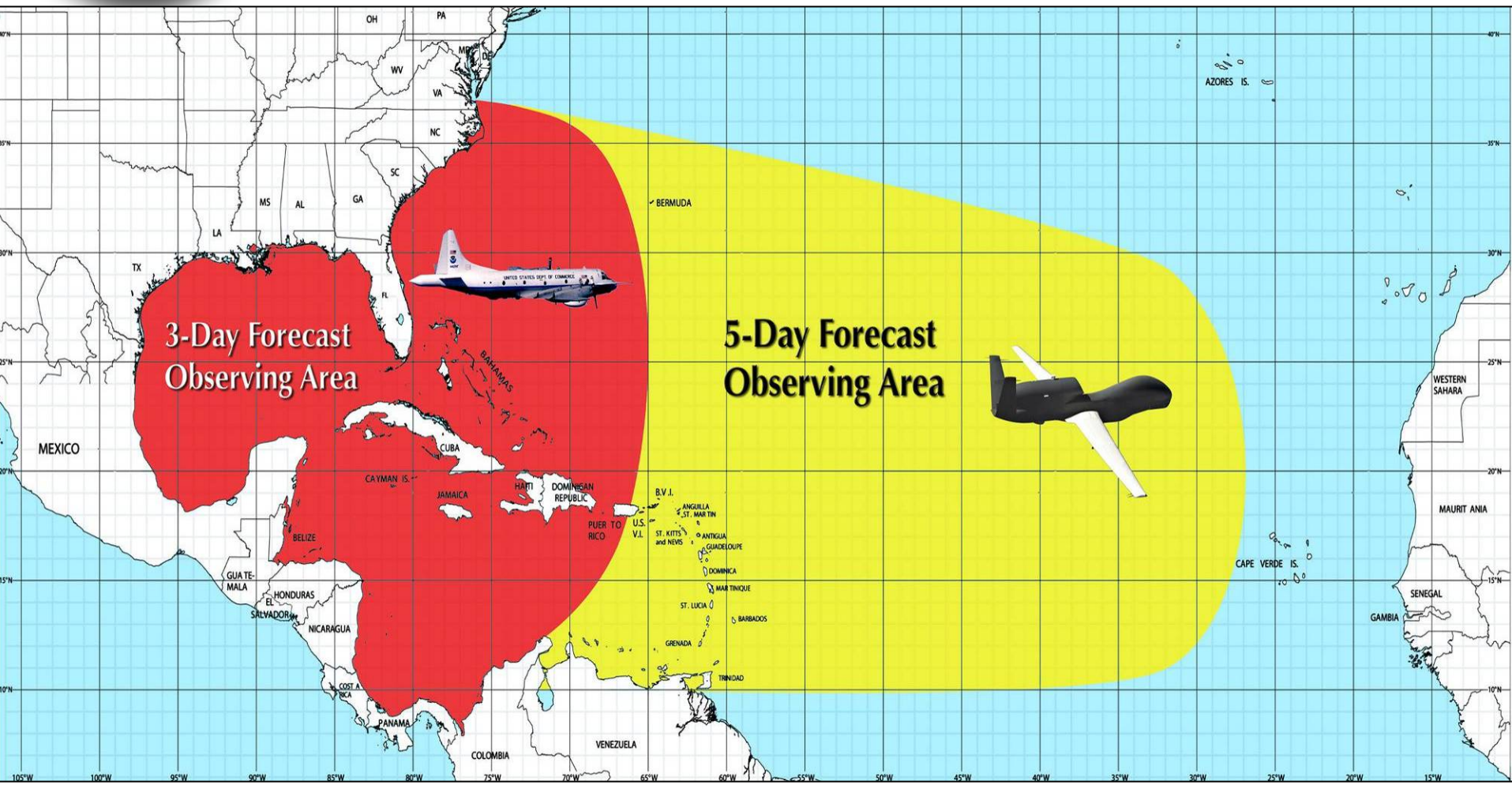
Tropical Prediction Center Performance Measures yearly-average official track forecast errors and trend lines, Atlantic Basin



We reduced hurricane track error by a factor of 4 in 40 years.

Better forecasts always require: Better observations, understanding and models.

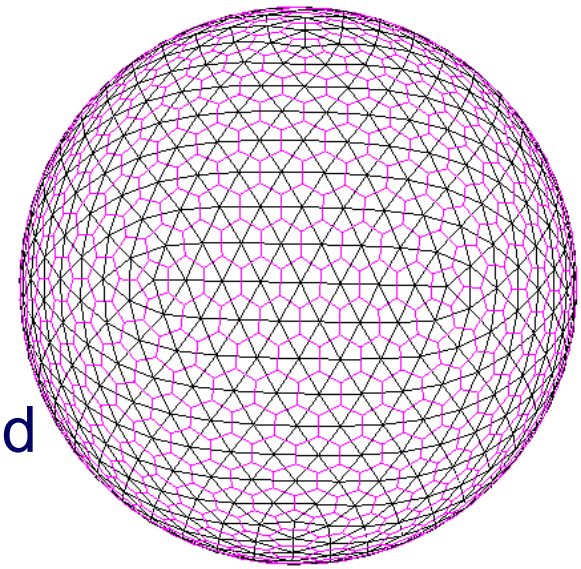
Extending Hurricane Prediction Lead Time



Road Map of the high-end Earth System Modeling

A plan by NOAA researchers to develop the worlds best model for weather and climate prediction.

2006-2013: The "Geodesic Grid" Planet Simulator, 3rd generation *non-hydrostatic* finite-volume model with ***1-4 km*** or finer resolution.

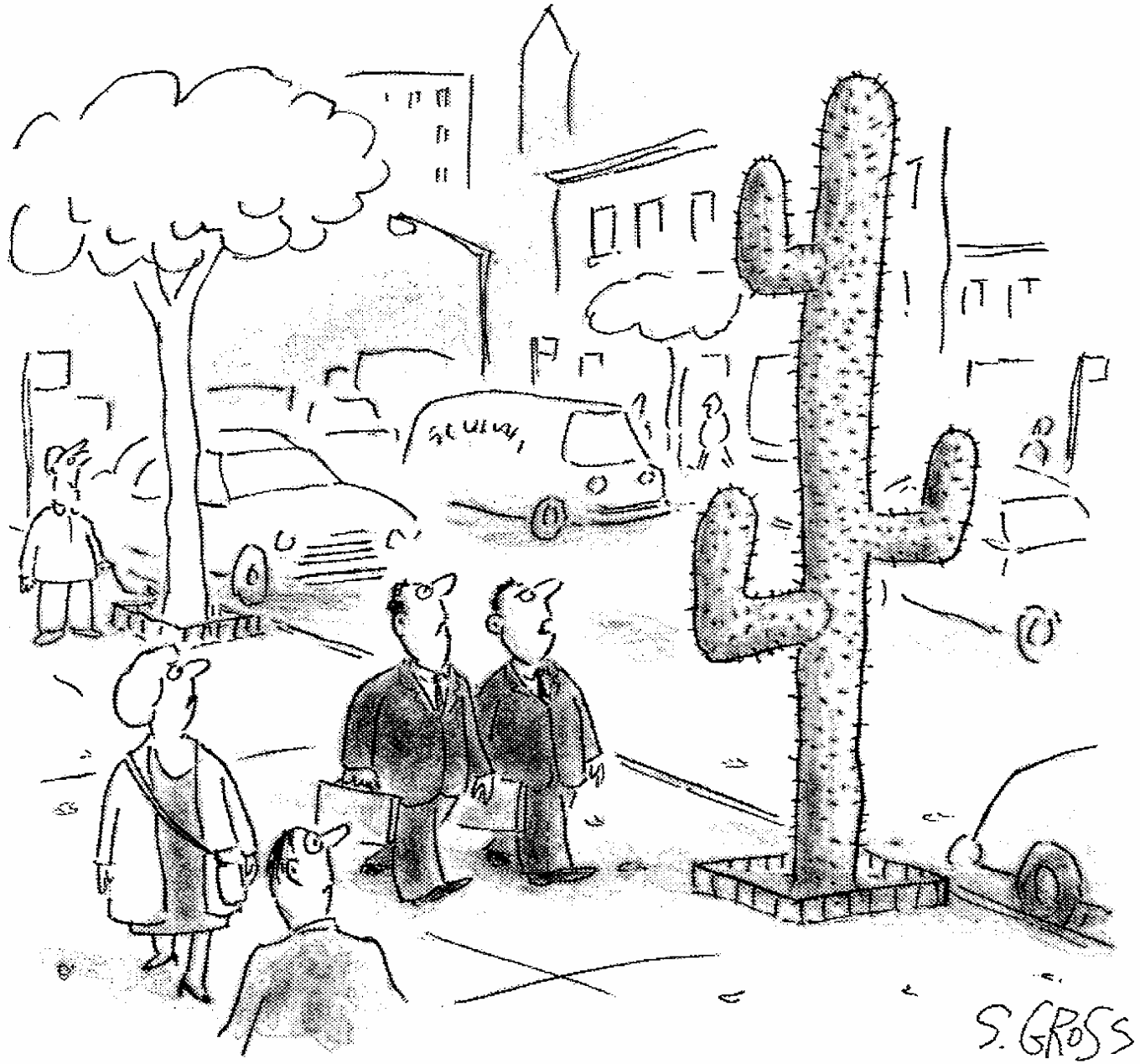


Primary model for:

- Medium Range Weather Prediction 0 to 2 weeks, including improve hurricane track and intensity.
- Seasonal to Inter-annual Prediction 2 weeks to 2 years
- Decadal to Centennial projection

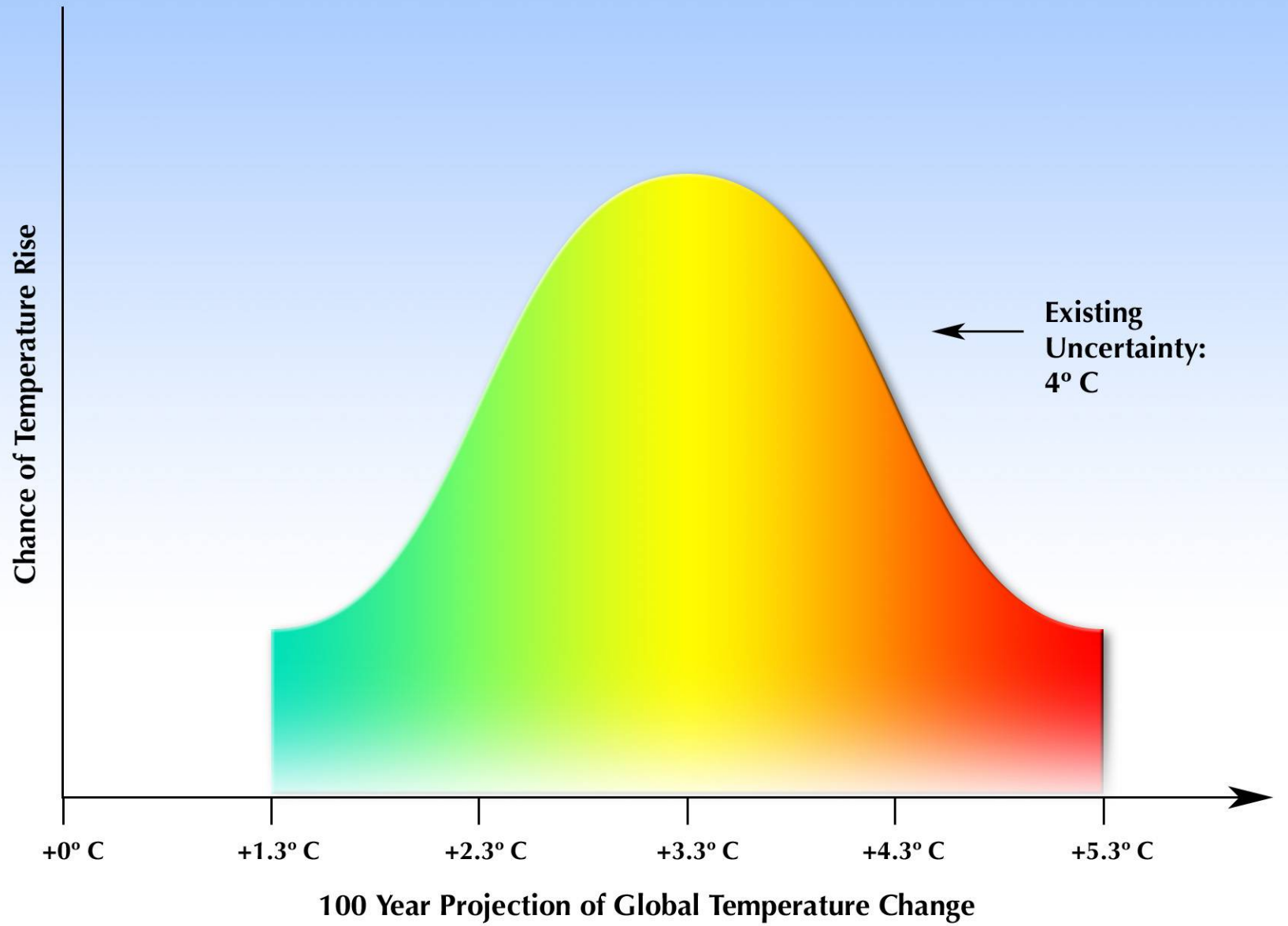
Overview

- 1. Improving hurricane prediction.
- **2. Improving long-term climate predictions.**

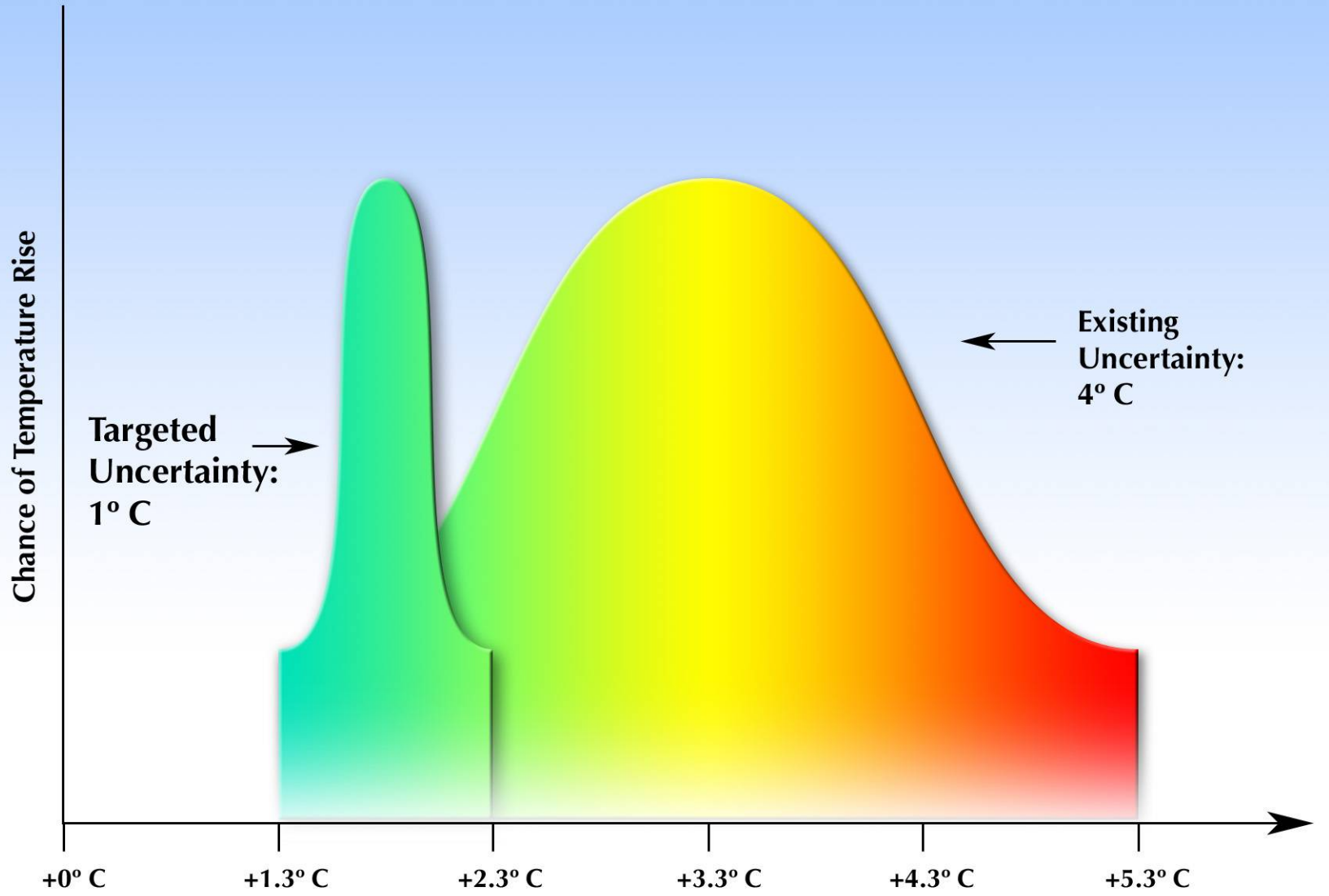


"I'm starting to get concerned about global warming."

Current:
Projection Uncertainty of 4º C



Requirement:
Limit Projection Uncertainty to 1° C

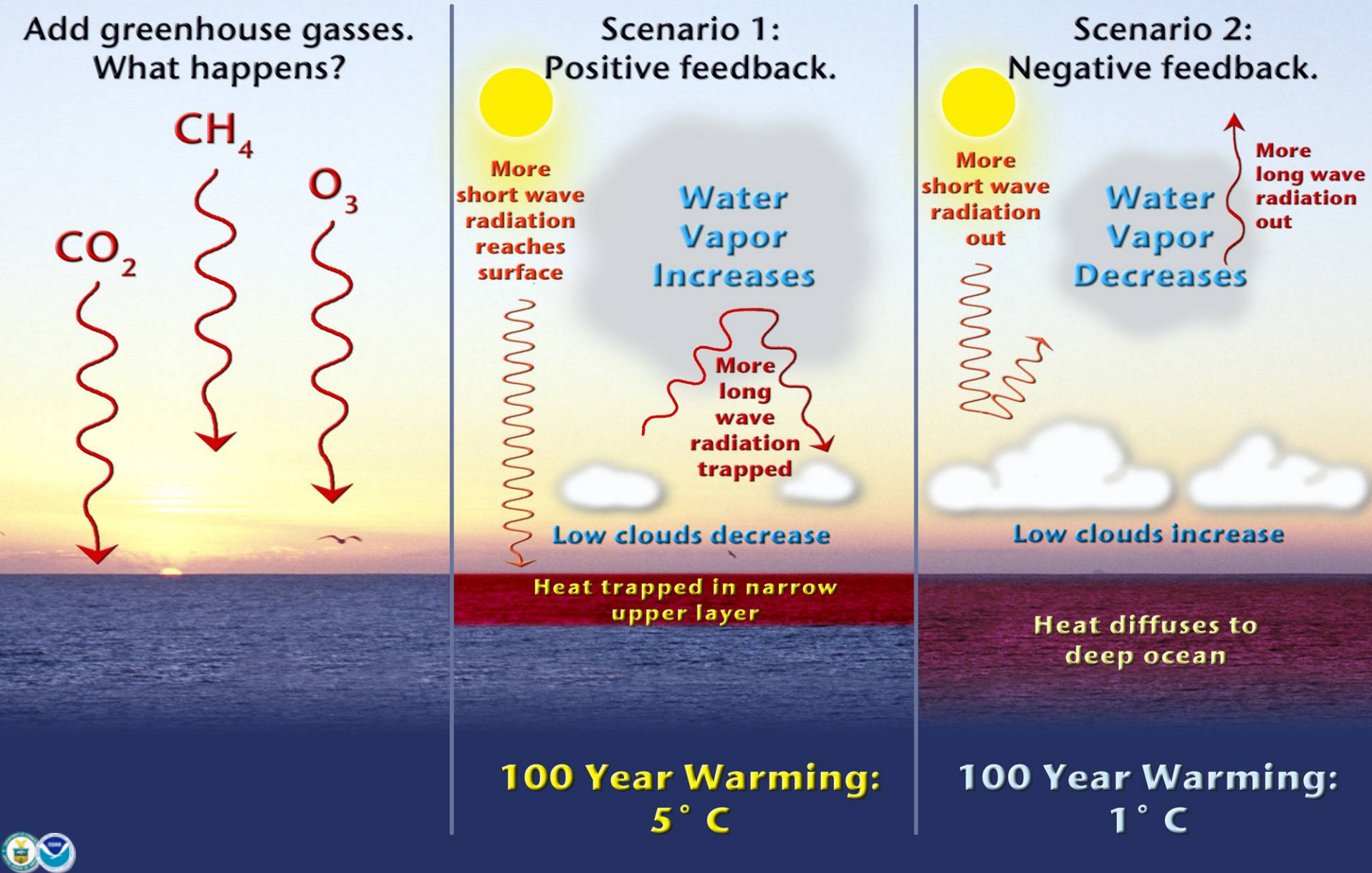


People have noticed our forecasts are not perfect. . .

OLIPHANT/Universal Press Syndicate

Vertical Energy Balance

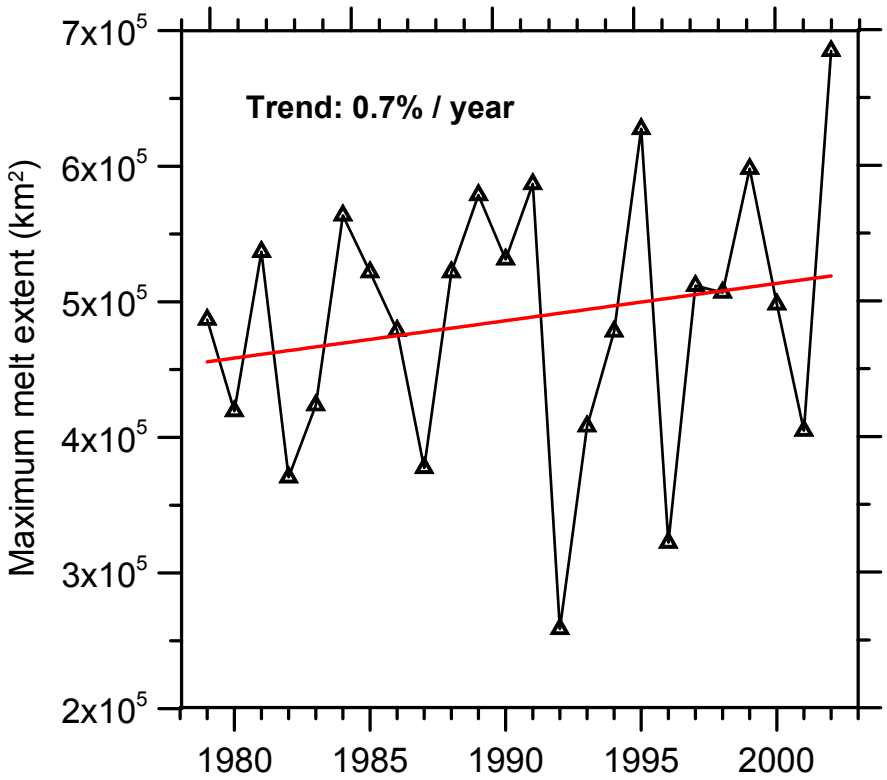
Crucial to credible climate prediction

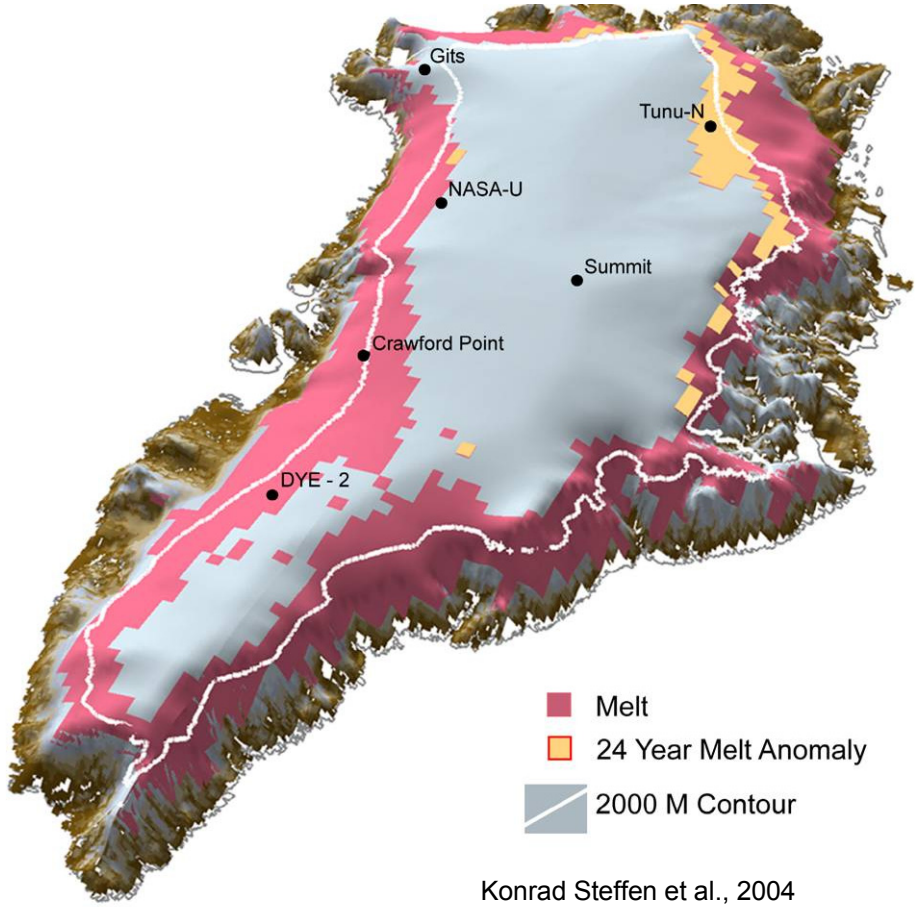


Pitfalls of Doubling Greenhouse Gases

- Collapse of glaciers leading to sea level rise.
- Runaway release of carbon into the atmosphere by the warming earth.
- Melt-off of the Arctic Ocean ice.

Response of the Greenland Ice Sheet to Climatic Forcing

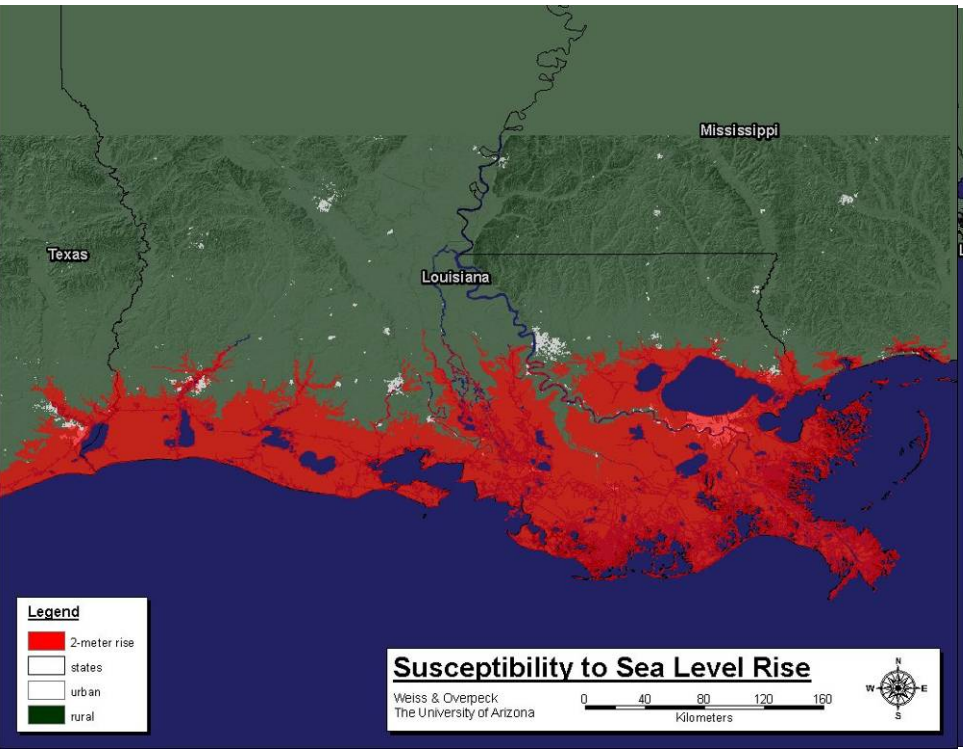




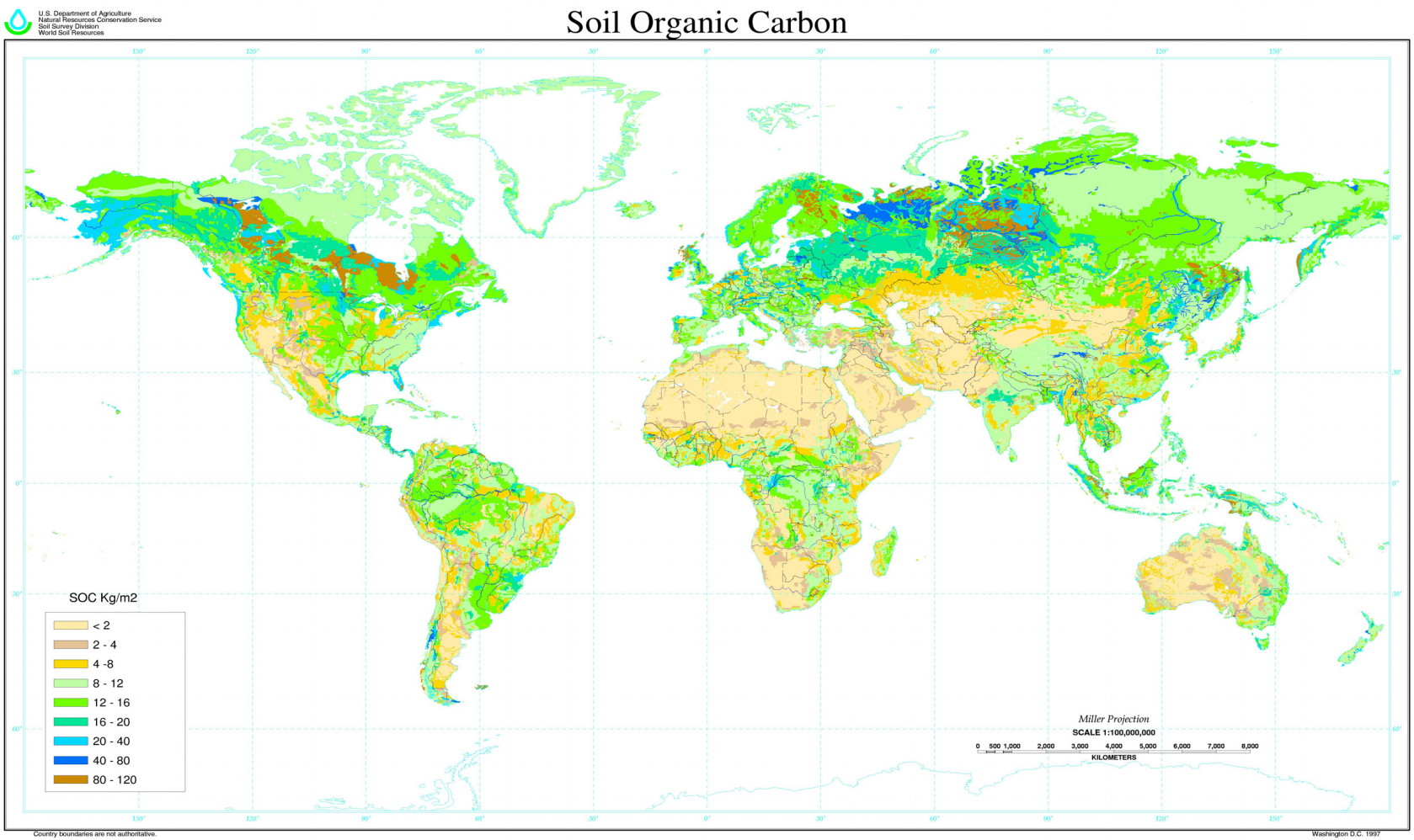
Konrad Steffen et al., 2004

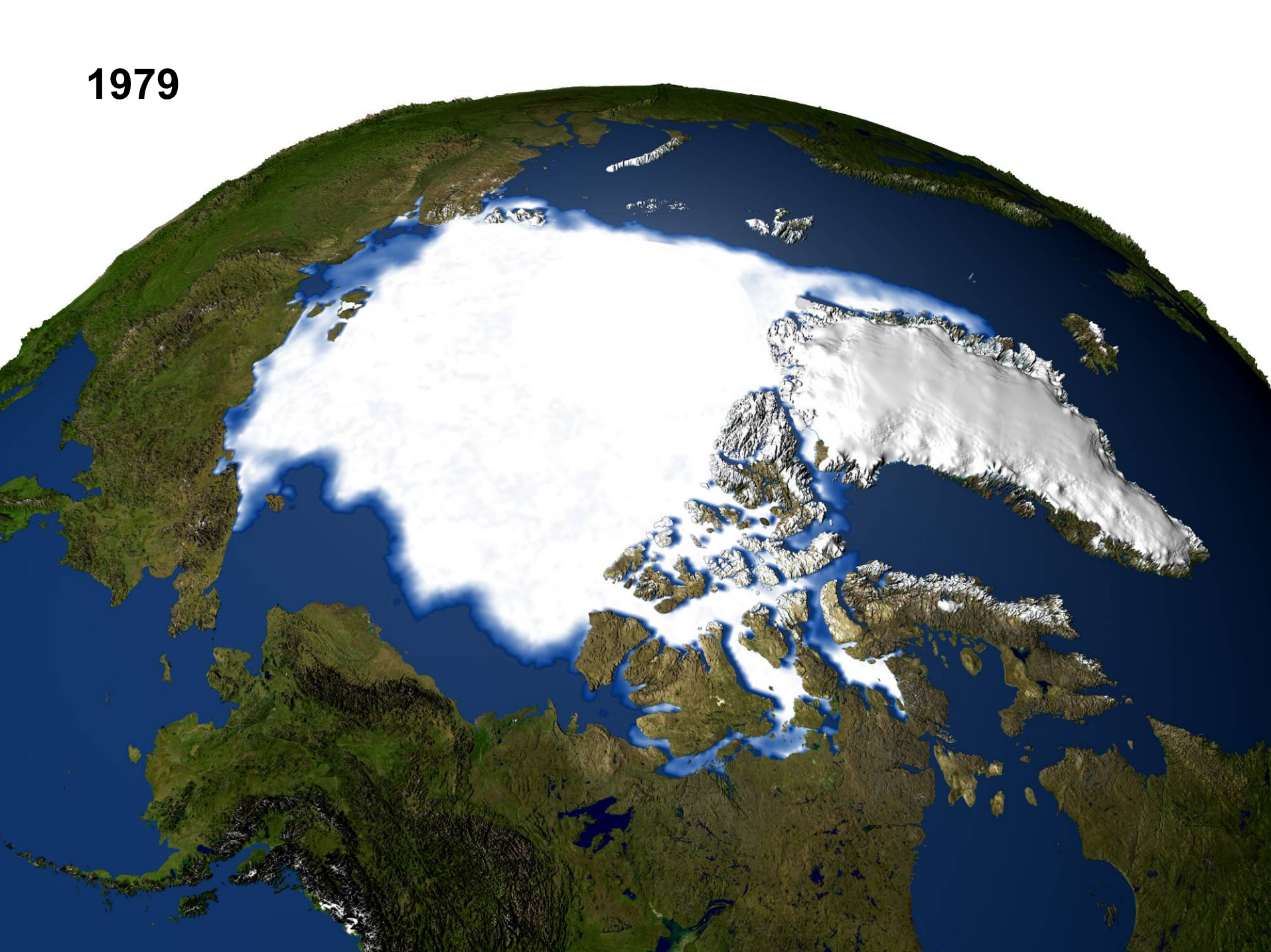
Greenland ice sheet melt area increased on average by 16% from 1979 to 2002. The smallest melt extent was observed after the Mt. Pinatubo eruption in 1992

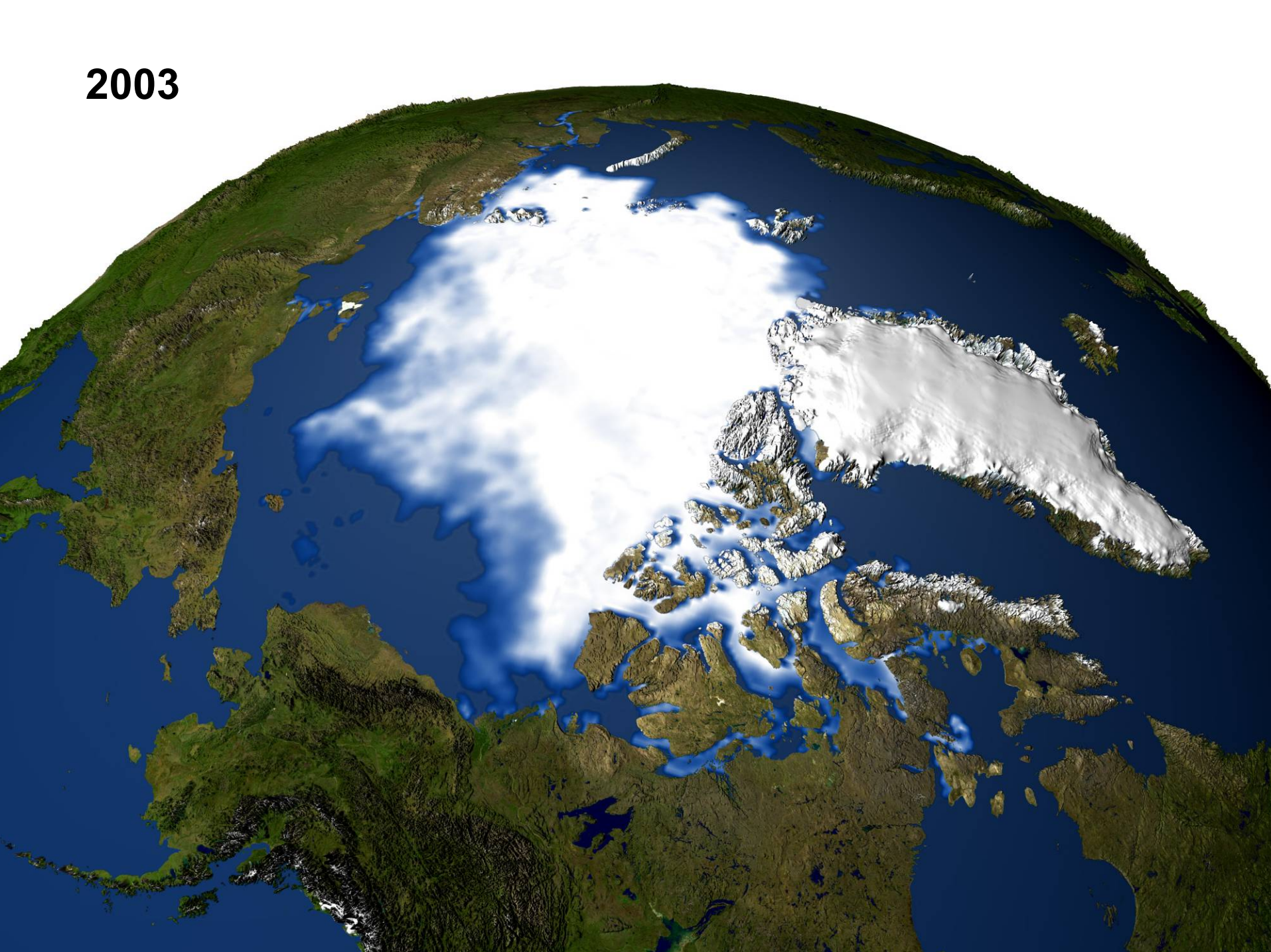
A rapid melt of Arctic ocean ice could increase the rate of Greenland ice melt. This chart from Overpeck shows a 2 meter sea level rise in red.



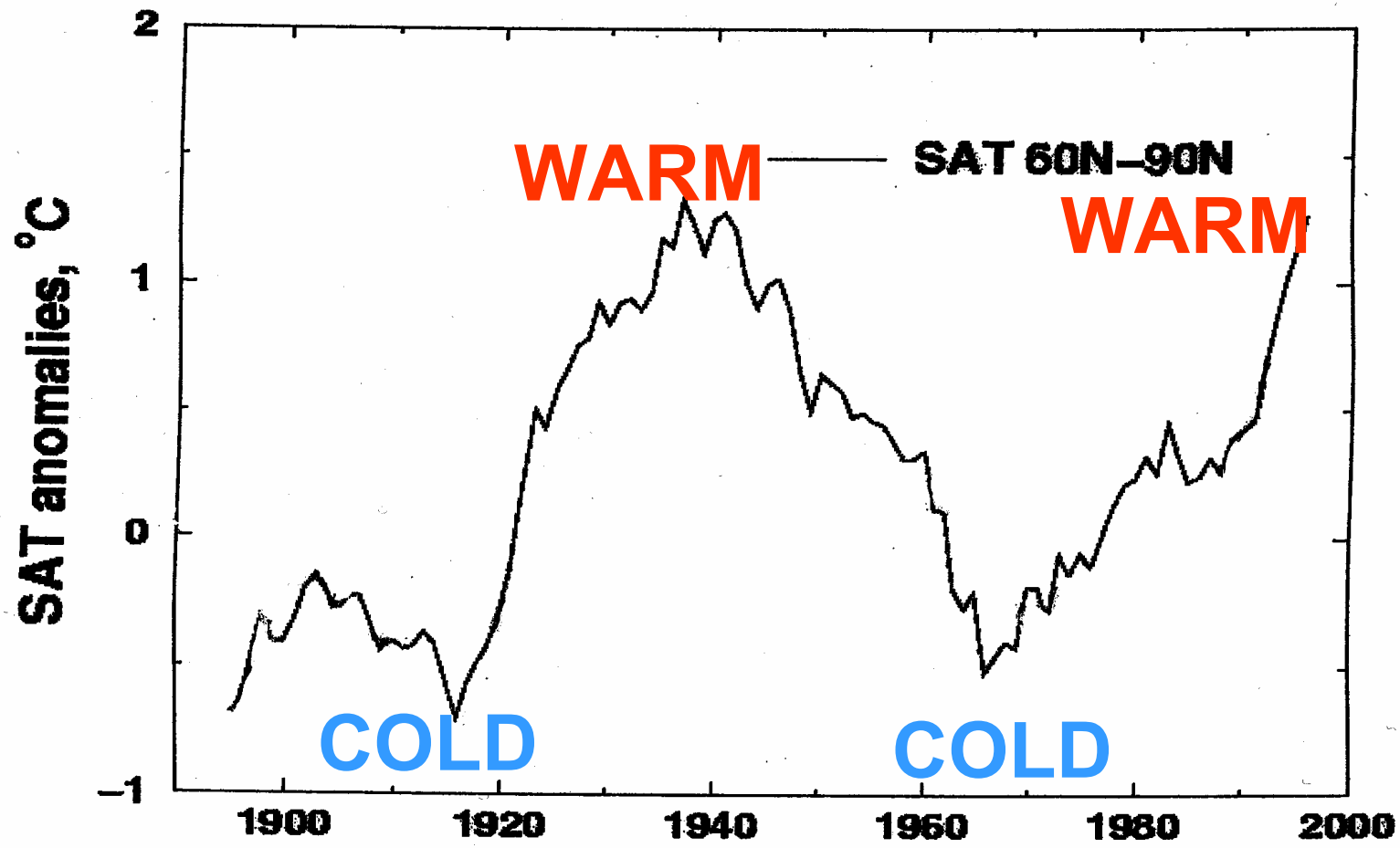
Will rising temperatures release large stores of high-latitude carbon?




1979


2003

Arctic Temperatures during the 20th Century

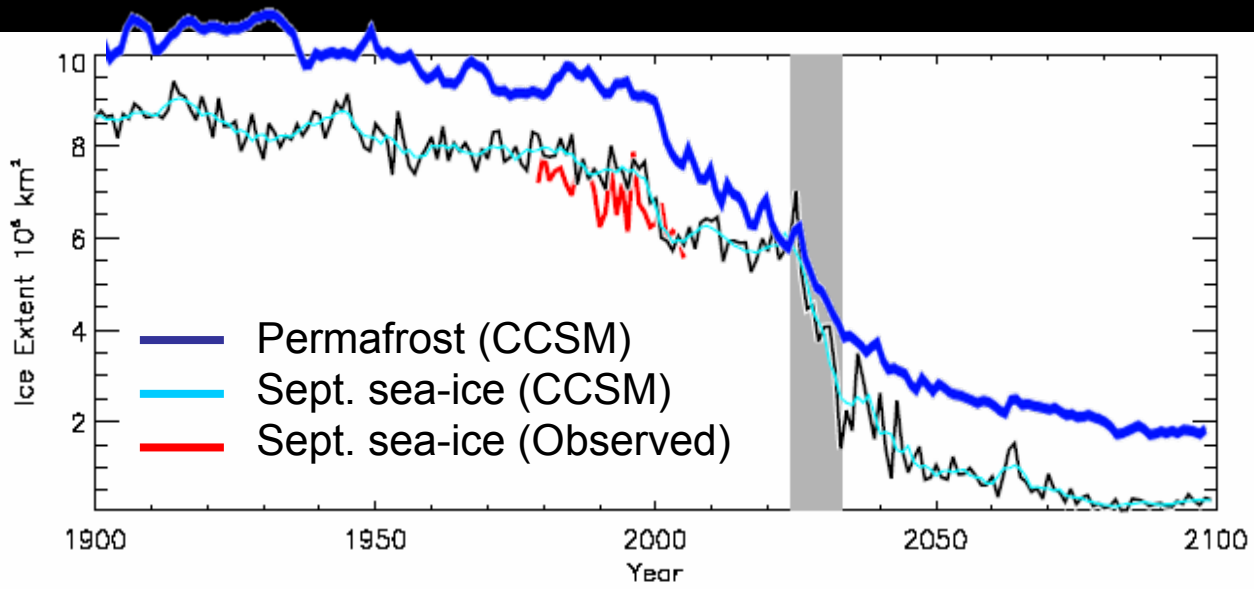


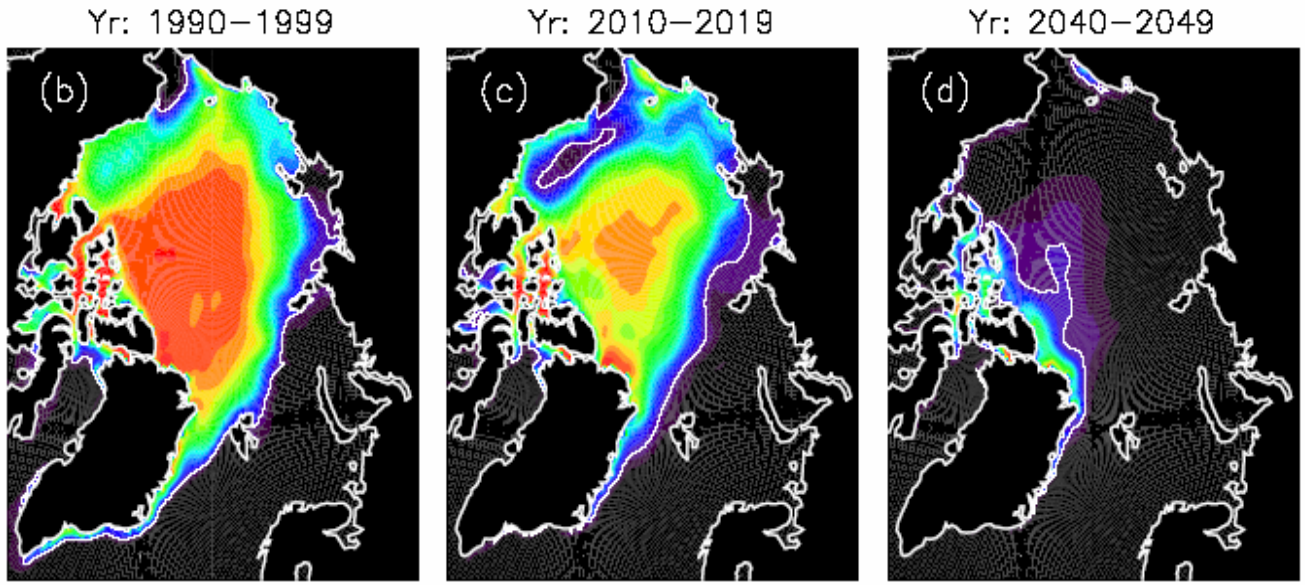
LEADEX 1992: Be careful when nature calls!!!

SHEBA 1998: Scientists spend a year on the Arctic Ocean ice . . .

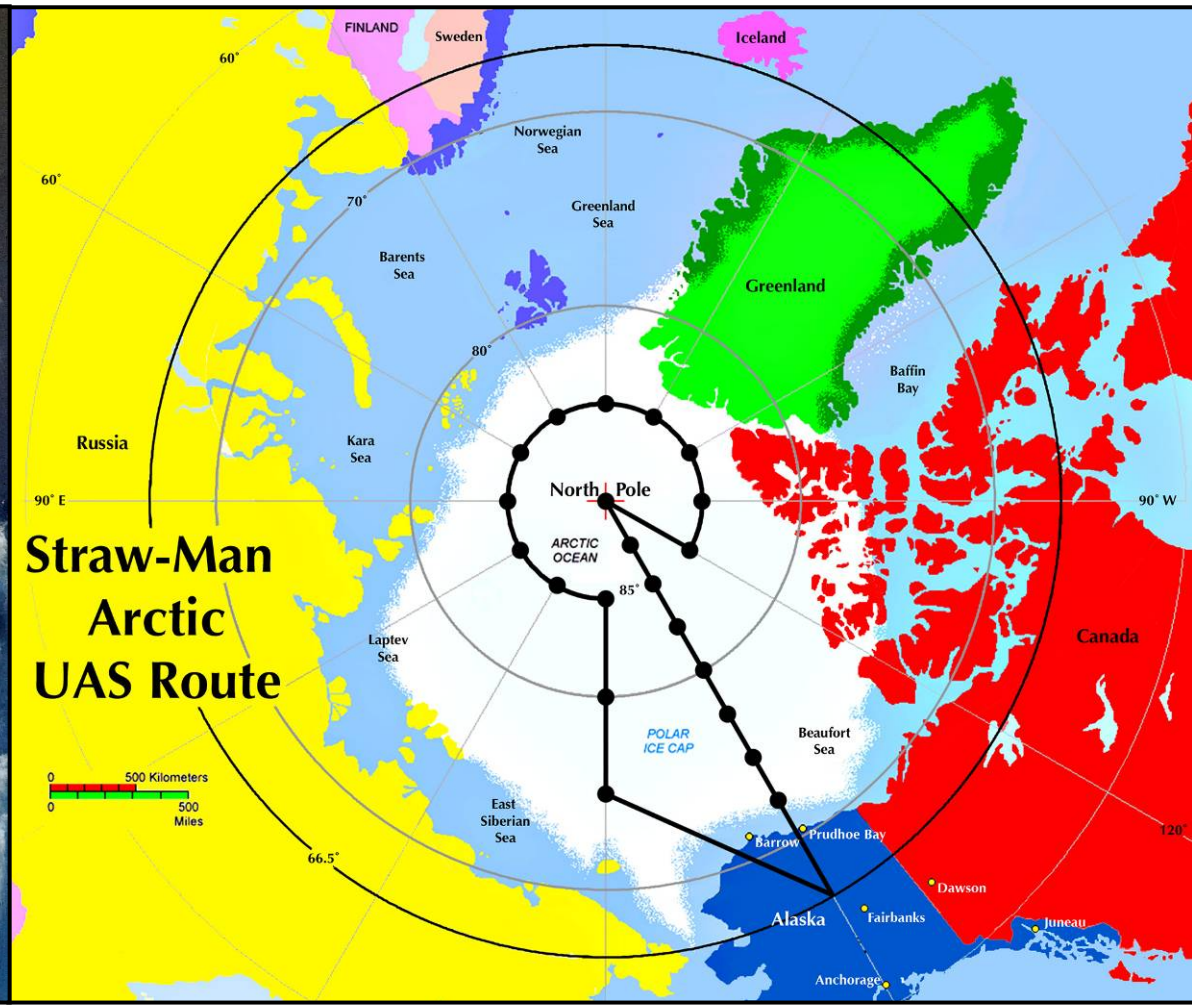
One of the latest models of the Arctic predicts the end of the Arctic as we know it during the 2030s.

(Holland et al, 2006)

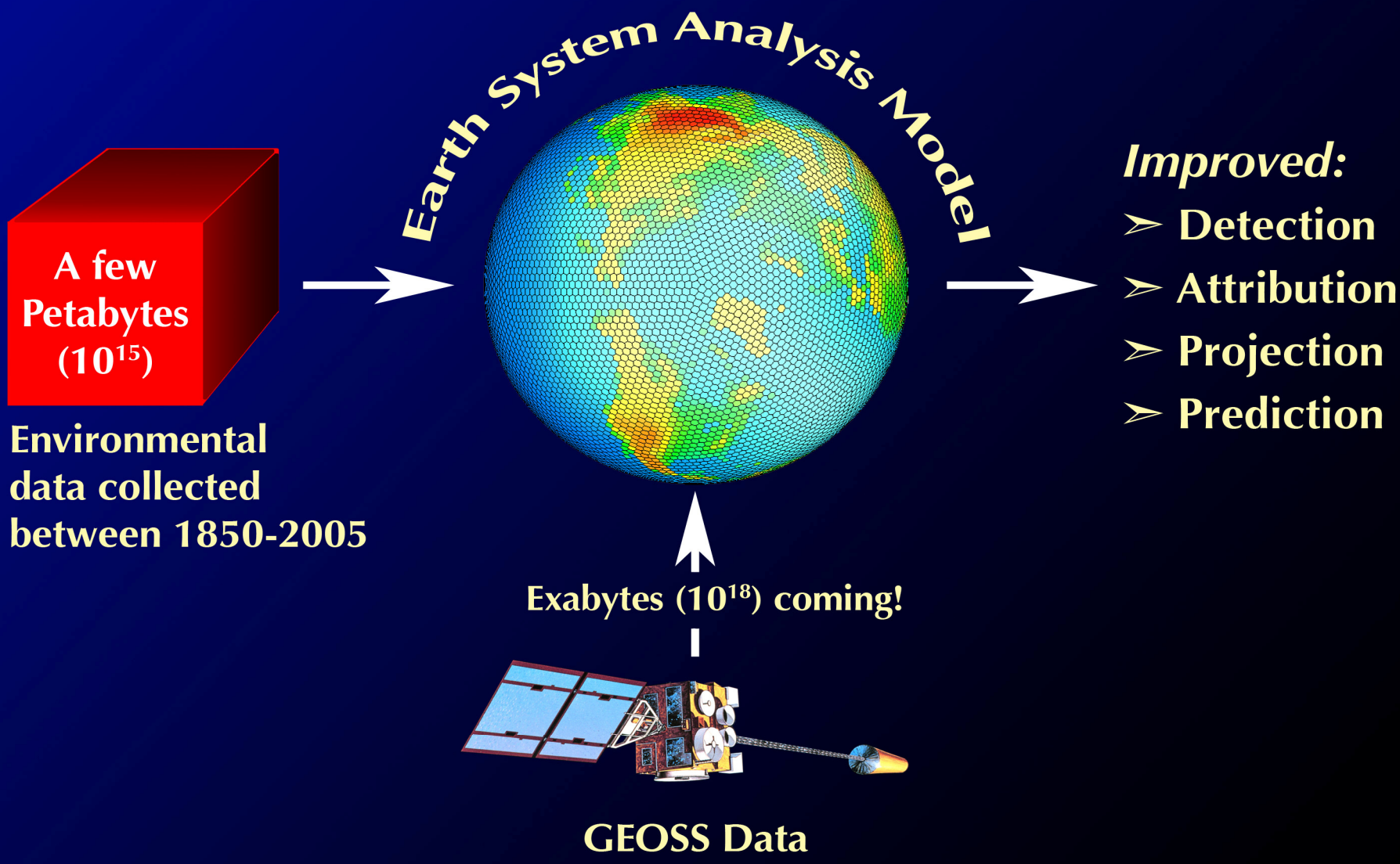




Unmanned Aircraft Systems could routinely measure the Arctic ice changes at the same points for decades.

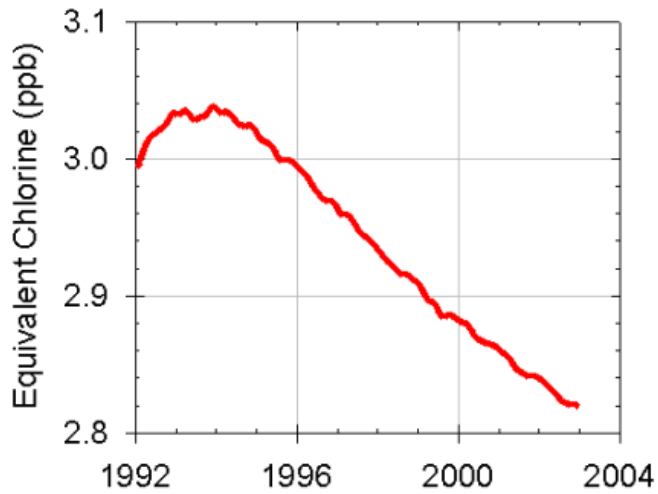


Predicting the Future Depends on Better understanding of the Past



Earth System Research Laboratory: Research to improve predictions at all time scales.

Ozone-Destroying CFCs are Declining
Ozone Layer Recovery expected by 2050



Credible and specific predictions provides the foundation for good policy.

Alexander.E.MacDonald@noaa.gov