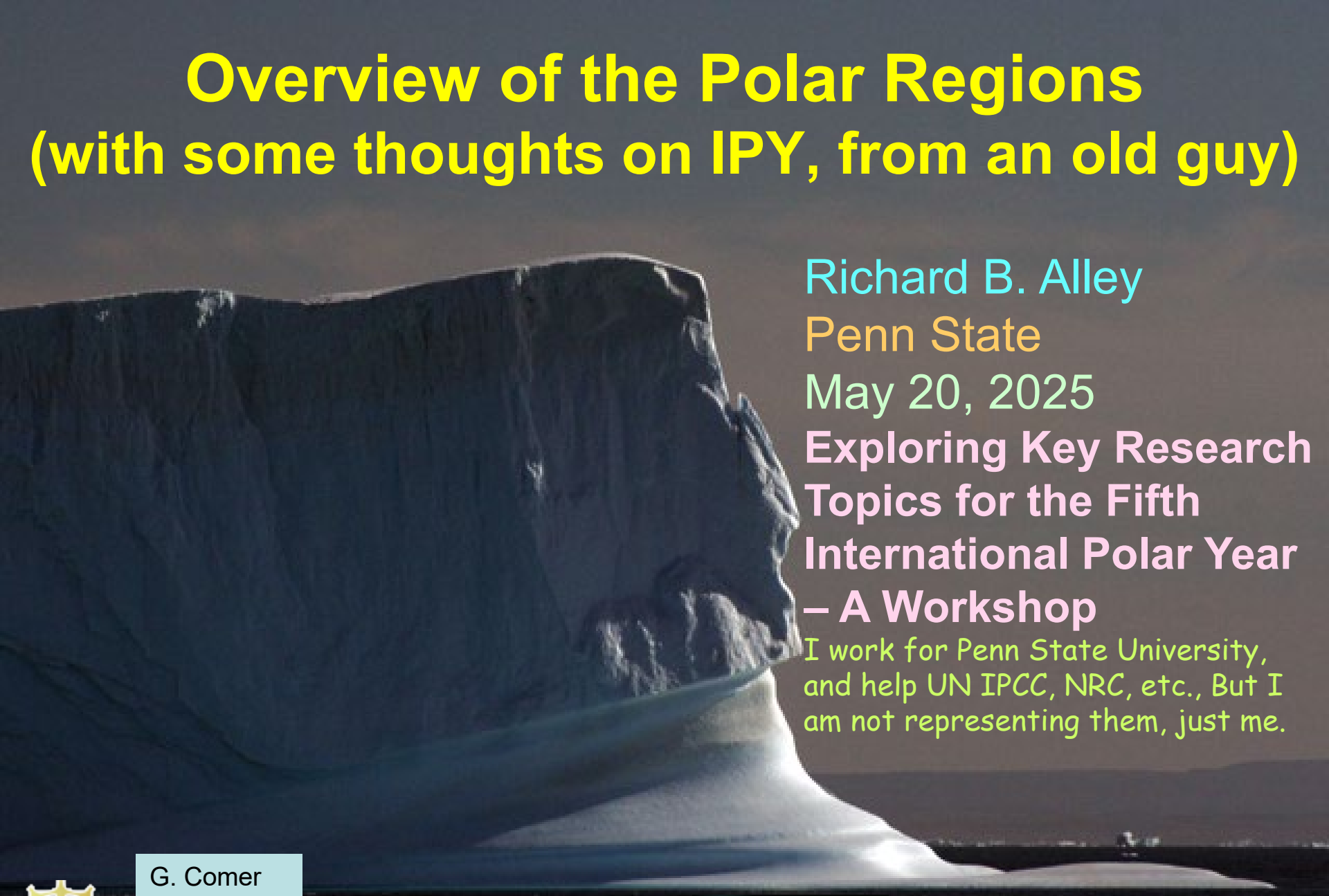
Overview of the Polar Regions
(with some thoughts on IPY, from an old guy)



Richard B. Alley
Penn State

May 20, 2025

Exploring Key Research Topics for the Fifth International Polar Year – A Workshop

I work for Penn State University, and help UN IPCC, NRC, etc., But I am not representing them, just me.

G. Comer Foundation


Thanks to National Academies,
Morgan Monz, Annie Manville
And you for coming

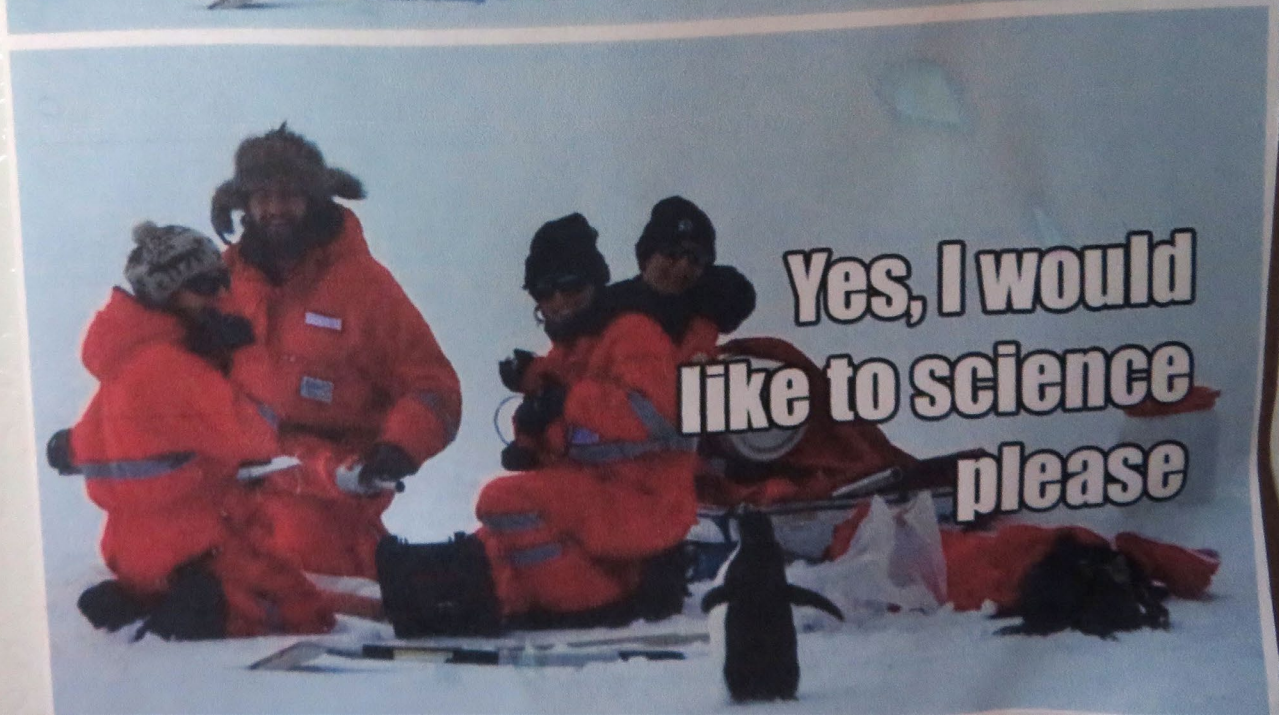
Talks often end with a call for education and outreach.
I'd like to "tern" that around and start with education…
supporting and inspiring young people should be IPY's lead!

Refrigerator-freezer at our house

Now holds art from our granddaughter

Once held art from daughters who now are a brilliant science teacher and a brilliant glaciologist


Hello


Yes, I would
like to science
please

Great current grad students

Emma Perkins

Sierra Melton

Emily Schwans

Thomas Givens

Amanda Willet

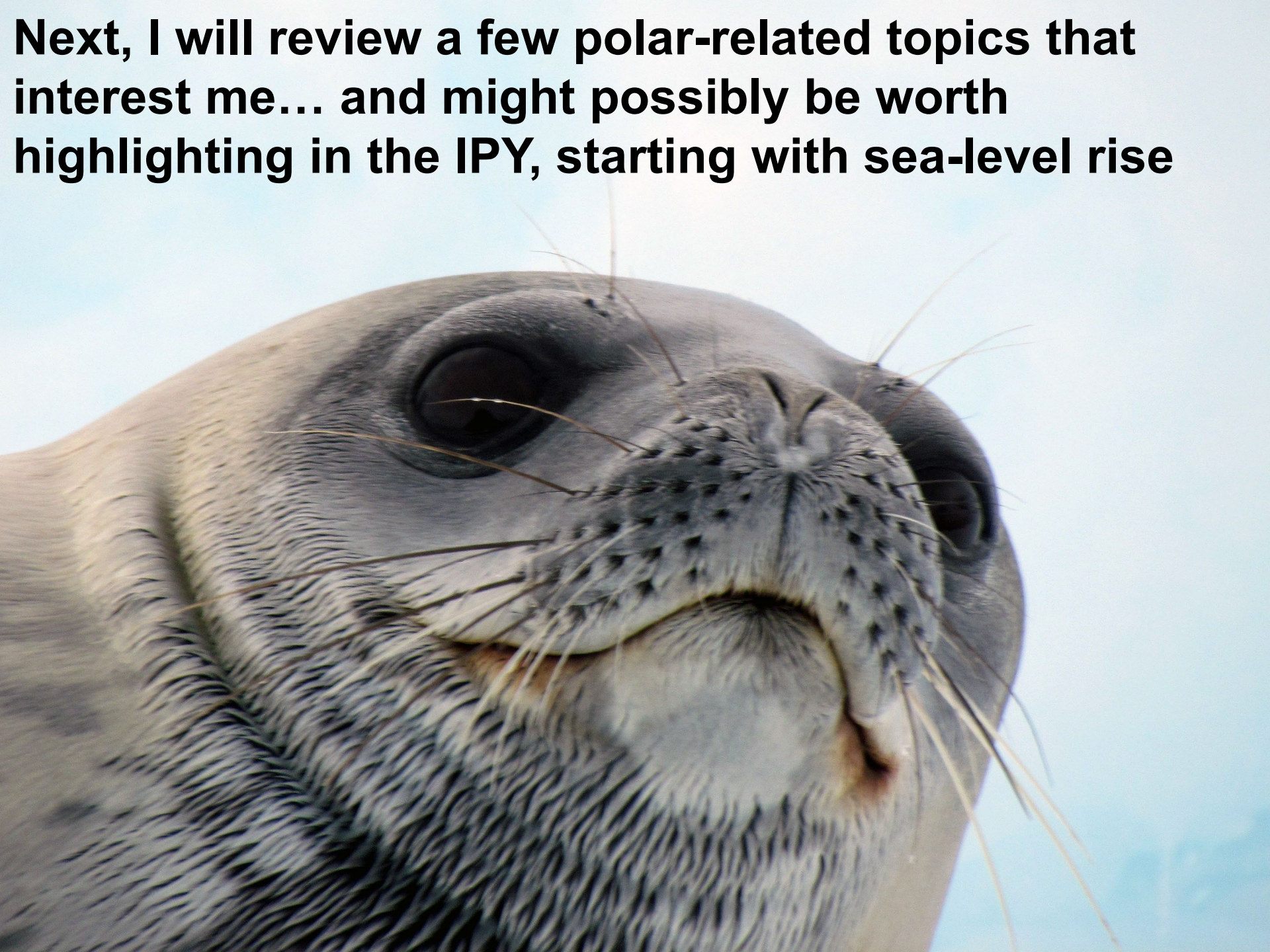
Ian Lee

One of our former students went from measuring sound velocity in Greenland ice cores to serving as an Air Force officer validating safety of jets because slower sound velocity reveals hidden cracks

Another former student took skills from field work in Antarctica to help people get clean water, then confirm slope stability to help recovery operations after LA fires


IPYs drive innovation and discovery, excite students and the public, and do much more
Scientists in the field
Education and outreach central
“I would like to science, please!”

Next, I will review a few polar-related topics that interest me… and might possibly be worth highlighting in the IPY, starting with sea-level rise



Texas “Ike Dike” coastal barrier project could cost $57 billion with inflation, Army Corps says

> The latest figure is 68% higher than an earlier estimate of $34 billion, and it’s unclear when — or whether — Congress will appropriate the money to build the massive system of gates intended to protect the Houston region from storm surge.

BY ERIN DOUGLAS AND EMILY FOXHALL SEPT. 28, 2023 5 PM CENTRAL SHARE

$57 billion for an “Ike Dike” for Houston

$52 billion for a “Sandy Shield” for NYC

$110 billion for San Francisco Bay and another $13 billion for SF port

$230 billion for three cities

Just a small part of US coast,

which is just a small part of world coast

Corps looks at low, medium, high sea-level-rise scenarios, picks one…

Build for too much sea-level rise?

→Waste much construction cost

→Lose ecosystem services

→Lose recreational opportunities

Build for too little sea-level rise?

→Waste construction cost

→Lose valuable things “protected”

→And new things built behind wall

Katrina ~$300 for each person in US—lives & livelihoods

Special Report: Hurricane Katrina 10 Year An aerial view shows flooded roadways as the Coast Guard flies over New Orleans, Aug. 29, 2005, to assess initial Hurricane Katrina damage. *U.S. Coast Guard photograph by Petty Officer 2nd Class Kyle Niemi*

IPCC on future sea-level rise, informs Corps of Engineers

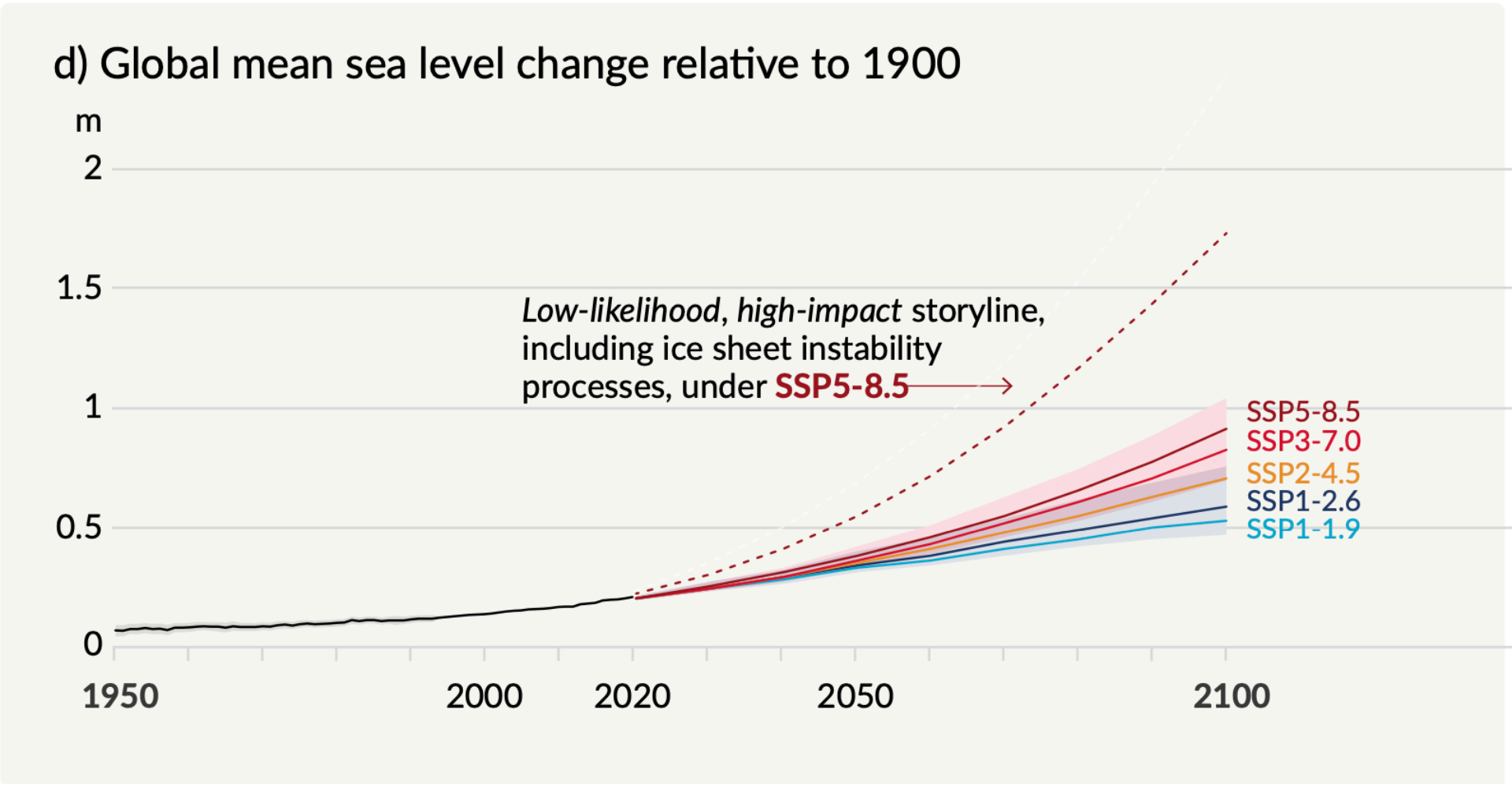


Fig. SPM8, IPCC AR6, 2021

Historically, central IPCC estimates have been:

→Lower than much supporting literature (Garner et al., 2018)

→Lower than rise that then occurred (Rahmstorf et al., 2007, 2011)

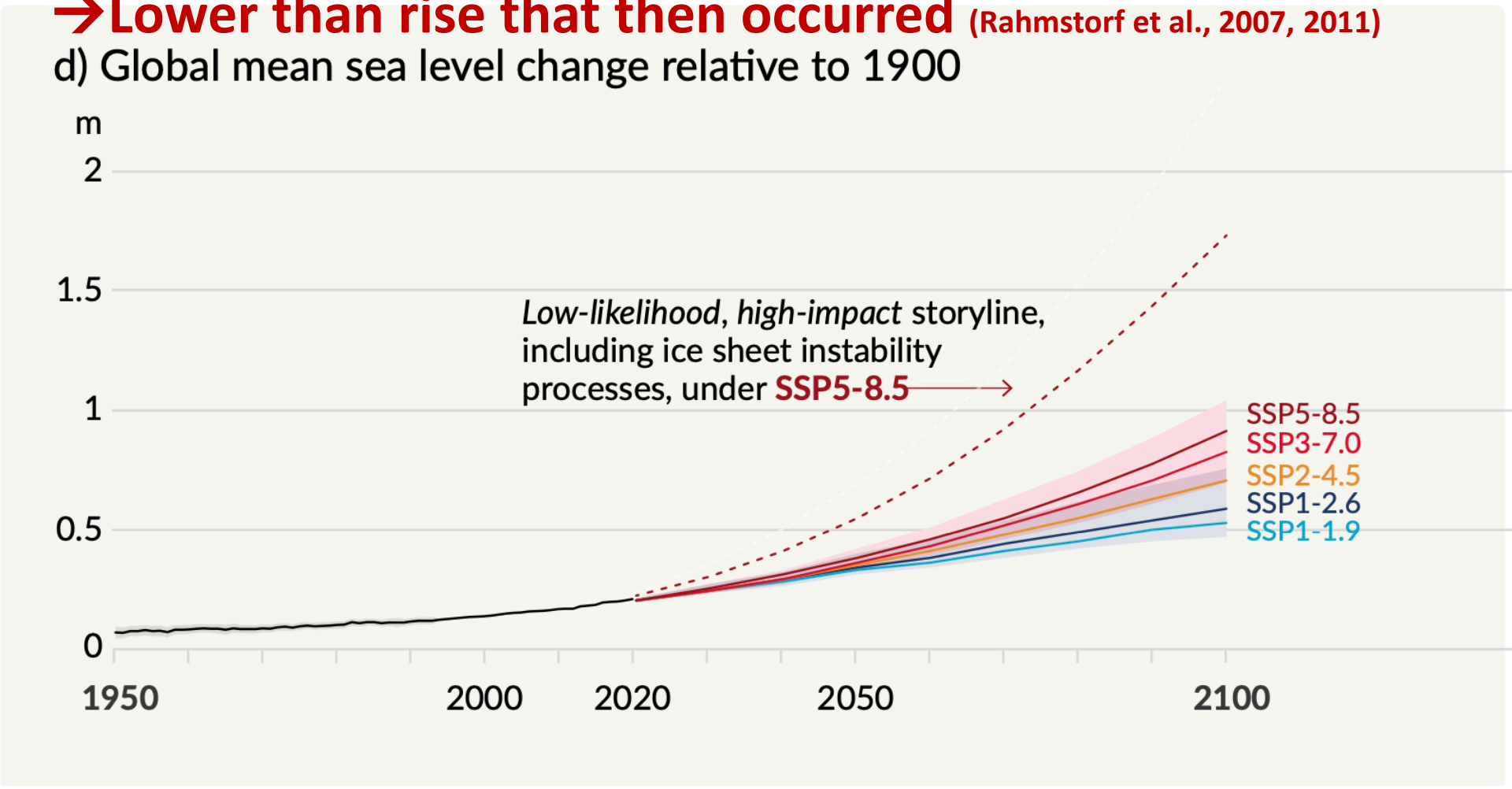
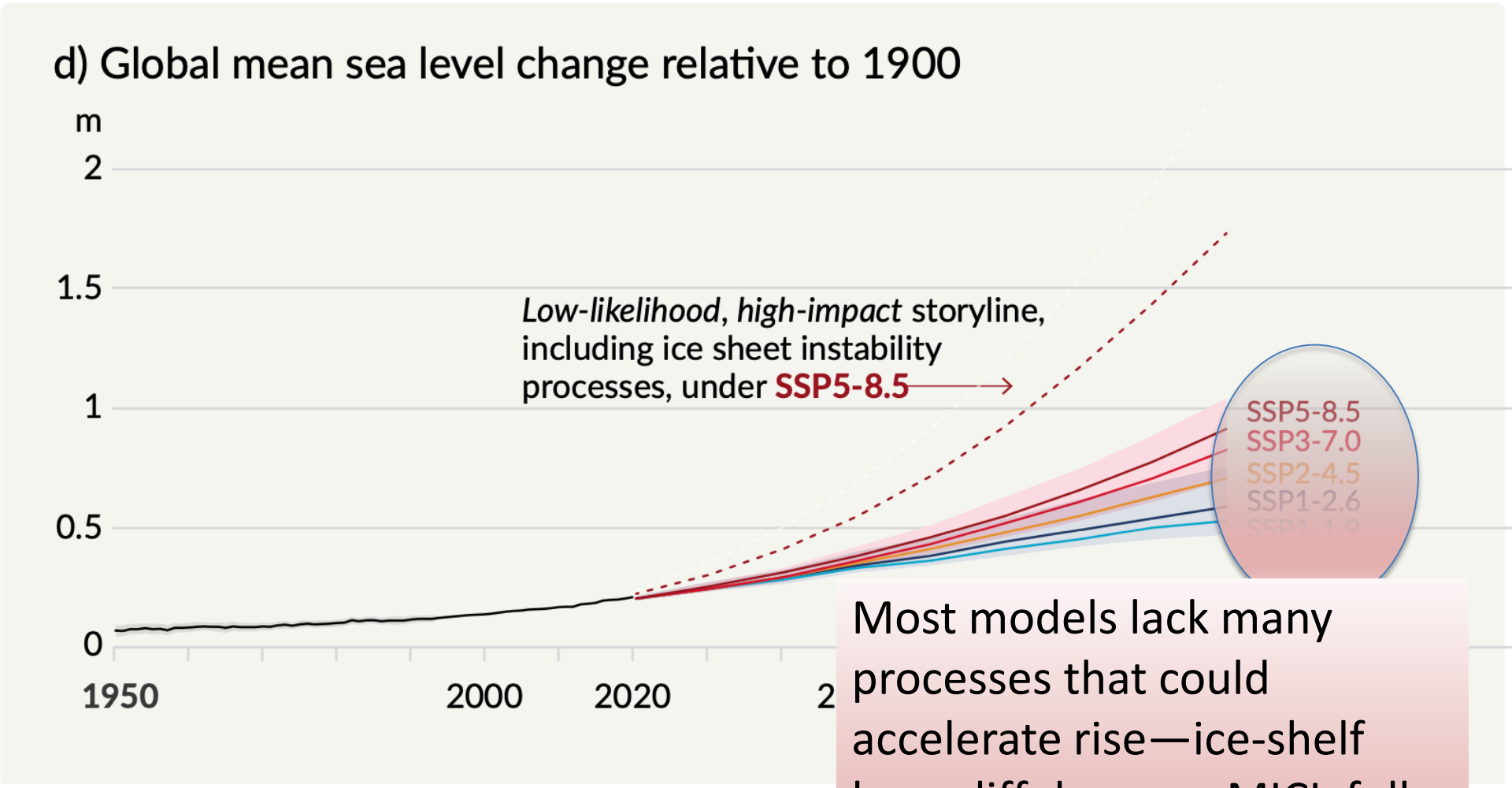


Fig. SPM8, IPCC AR6, 2021

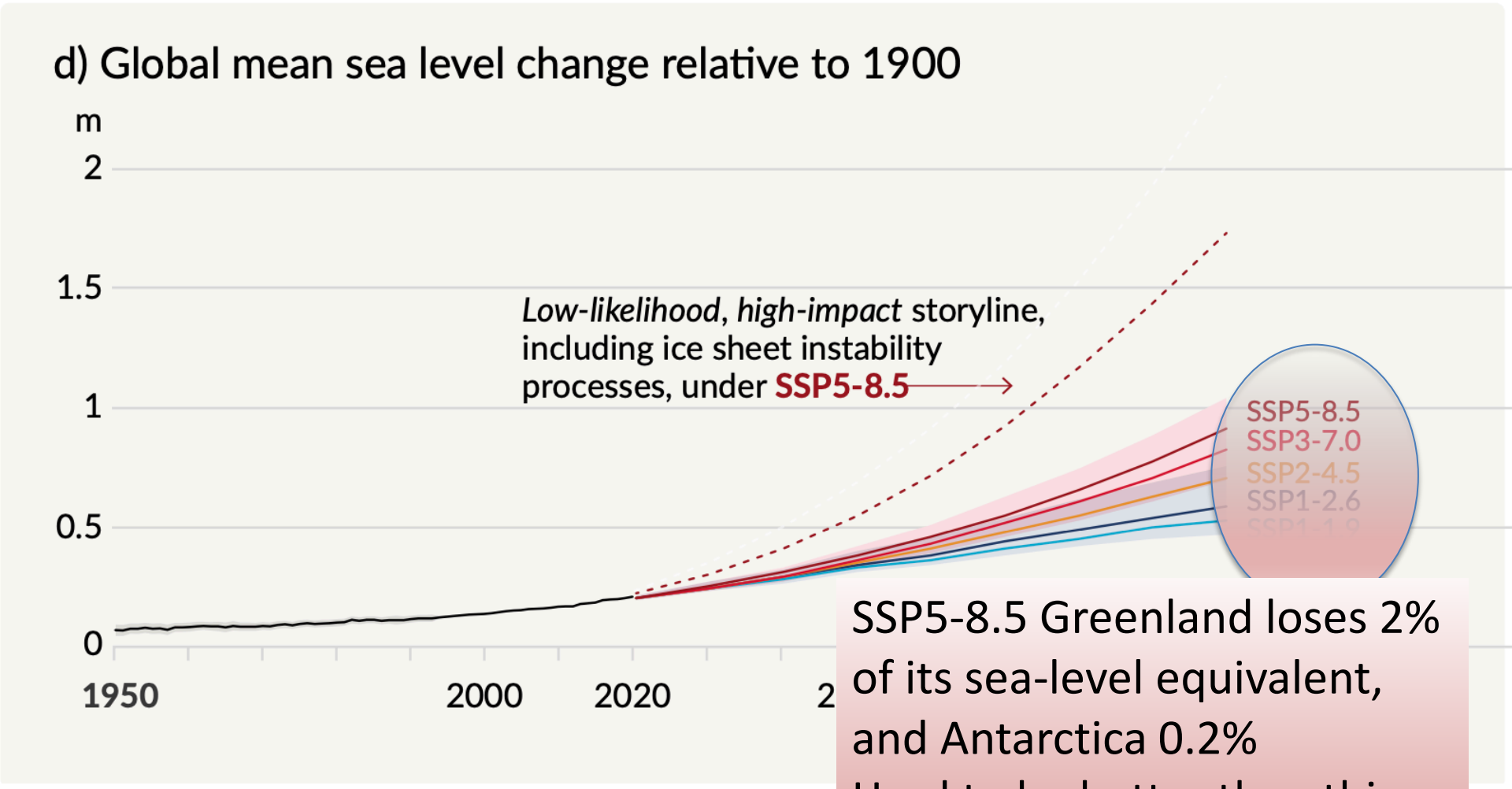
IPCC on future sea-level rise, informs Corps of Engineers



Most models lack many processes that could accelerate rise—ice-shelf loss, cliff damage, MICI, full stresses at cliff, estuarine sub-ice circulation, and more

Fig. SPM8, IPCC AR6, 2021

IPCC on future sea-level rise, informs Corps of Engineers



SSP5-8.5 Greenland loses 2% of its sea-level equivalent, and Antarctica 0.2%
Hard to be better than this, and easy to be worse

Fig. SPM8, IPCC AR6, 2021

IPCC on future sea-level rise, informs Corps of Engineers

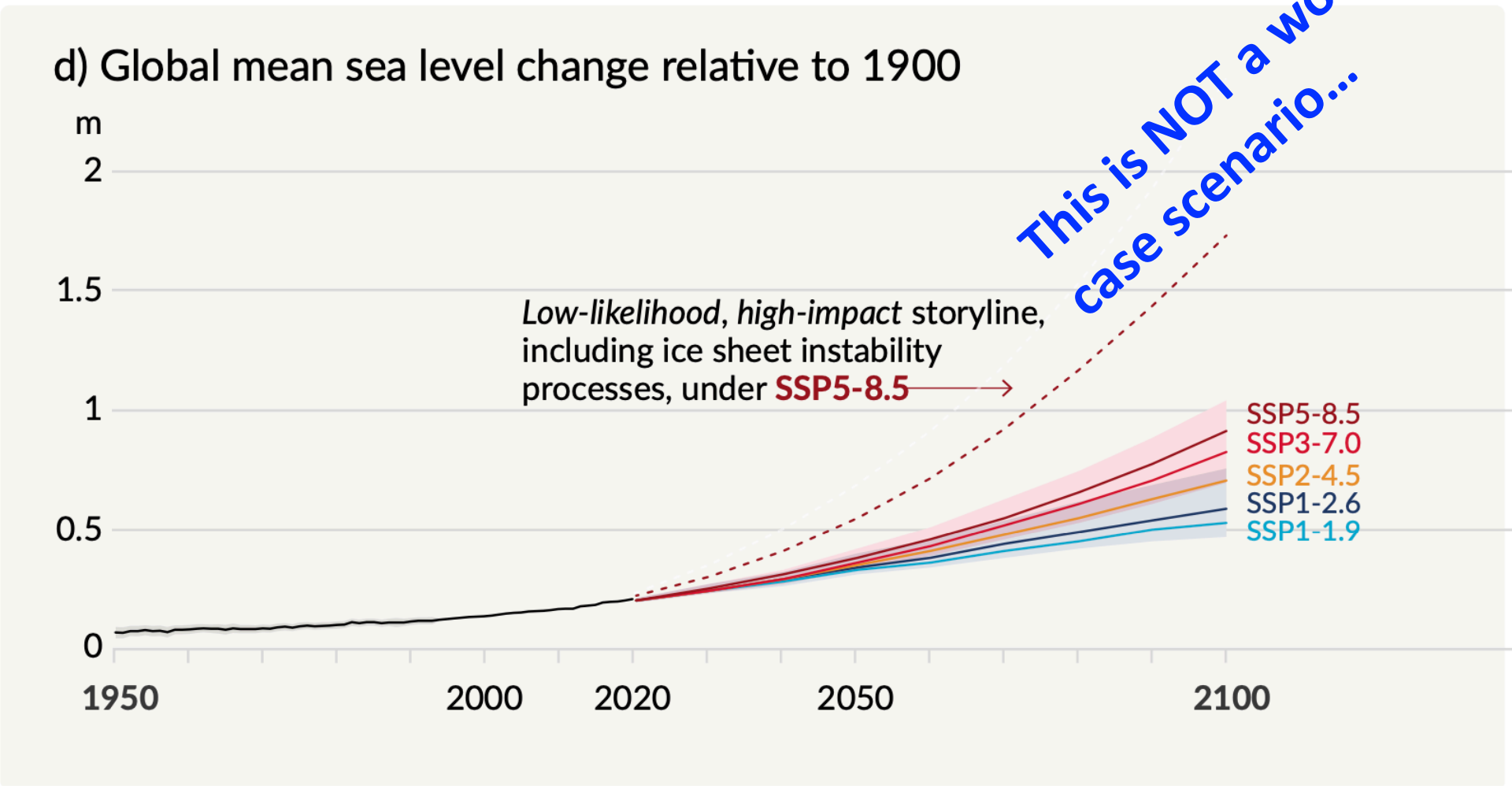


Fig. SPM8, IPCC AR6, 2021

Important recent paper

State-of-the art models

World-class scientists

(but, models mostly lacking many processes that would accelerate mass loss)

Seroussi, H., Pelle, T., Lipscomb, W. H., Abe-Ouchi, A., Albrecht, T., Alvarez-Solas, J., et al. (2024). Evolution of the Antarctic Ice Sheet over the next three centuries from an ISMIP6 model ensemble. *Earth's Future*, *12*, e2024EF004561. https://doi.org/10.1029/2024EF004561

Evolution of the Antarctic Ice Sheet Over the Next Three Centuries From an ISMIP6 Model Ensemble

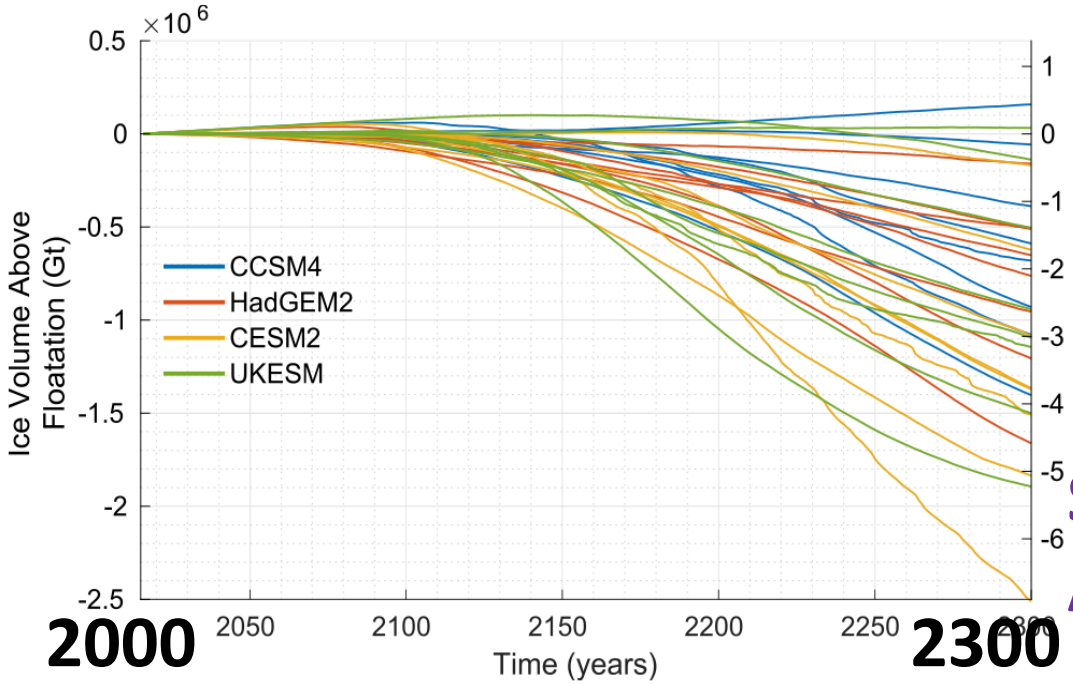
Hélène Seroussi[1], Tyler Pelle[2], William H. Lipscomb[3], Ayako Abe-Ouchi[4], Torsten Albrecht[5], Jorge Alvarez-Solas[6,7], Xylar Asay-Davis[8], Jean-Baptiste Barre[9], Constantijn J. Berends[10], Jorge Bernales[10], Javier Blasco[6,7,11], Justine Caillet[12], David M. Chandler[13], Violaine Coulon[11], Richard Cullather[14], Christophe Dumas[15], Benjamin K. Galton-Fenzi[16,17], Julius Garbe[5,18], Fabien Gillet-Chaulet[12], Rupert Gladstone[19], Heiko Goelzer[13], Nicholas Golledge[20], Ralf Greve[21,22], G. Hilmar Gudmundsson[23], Holly Kyeore Han[8,24], Trevor R. Hillebrand[8], Matthew J. Hoffman[8], Philippe Huybrechts[25], Nicolas C. Jourdain[12], Ann Kristin Klose[5,18], Petra M. Langebroek[13,26], Gunter R. Leguy[3], Daniel P. Lowry[27], Pierre Mathiot[12], Marisa Montoya[6,7], Mathieu Morlighem[28], Sophie Nowicki[29], Frank Pattyn[11], Antony J. Payne[30], Aurélien Quiquet[15], Ronja Reese[5,23], Alexander Robinson[6,31], Leopekka Saraste[32], Erika G. Simon[14], Sainan Sun[23], Jake P. Twarog[1], Luke D. Trusel[33], Benoit Urruty[12], Jonas Van Breedam[25], Roderik S. W. van de Wal[10,34], Yu Wang[17], Chen Zhao[17], and Thomas Zwinger[32]

Major result: "Overall, these results highlight large sea-level contributions from Antarctica and suggest that the choice of ice sheet model remains the leading source of uncertainty in multi-century projections."

Seroussi, H., Pelle, T., Lipscomb, W. H., Abe-Ouchi, A., Albrecht, T., Alvarez-Solas, J., et al. (2024). Evolution of the Antarctic Ice Sheet over the next three centuries from an ISMIP6 model ensemble. *Earth's Future*, *12*, e2024EF004561. https://doi.org/10.1029/2024EF004561

Range for Antarctic contribution from:

Sea-level fall of ~0.5 m as Antarctic grows



Sea-level rise of ~7 m as Antarctic shrinks

Great need for

→Improved data (field, remote)

→Lab, theory, simple models

→Informing parameterizations

→For improved models

→Assimilating data

→With serious support!

Note: 1% of cost of defending 3 US cities would be $2.3 billion!!

Ice sheets are losing mass, affecting climate.

Geophysical Research Letters

Research Letter | Open Access

Anomalous Meltwater From Ice Sheets and Ice Shelves Is a Historical Forcing

Gavin. A. Schmidt, Anastasia Romanou, Lettie A. Roach, Kenneth D. Mankoff, Qian Li, Craig D. Rye, Maxwell Kelley, John C. Marshall, Julius J. M. Busecke

First published: 13 December 2023 | https://doi.org/10.1029/2023GL106530 | Citations: 5

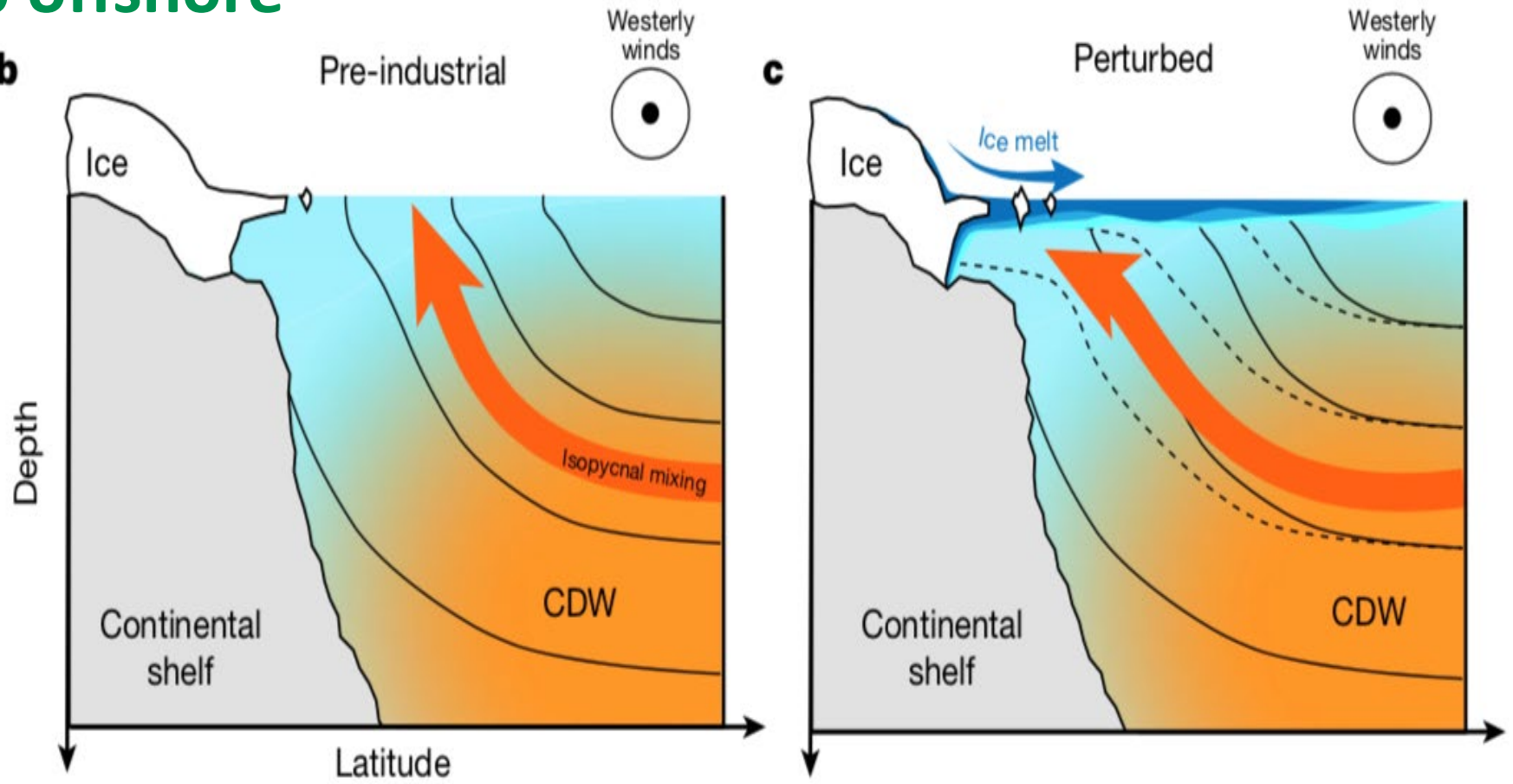
"Recent mass loss from ice sheets and ice shelves is now persistent and prolonged enough that it impacts downstream oceanographic conditions."

(Reconstructions and projections are wrong. Predicting weather and projecting climate need better.)

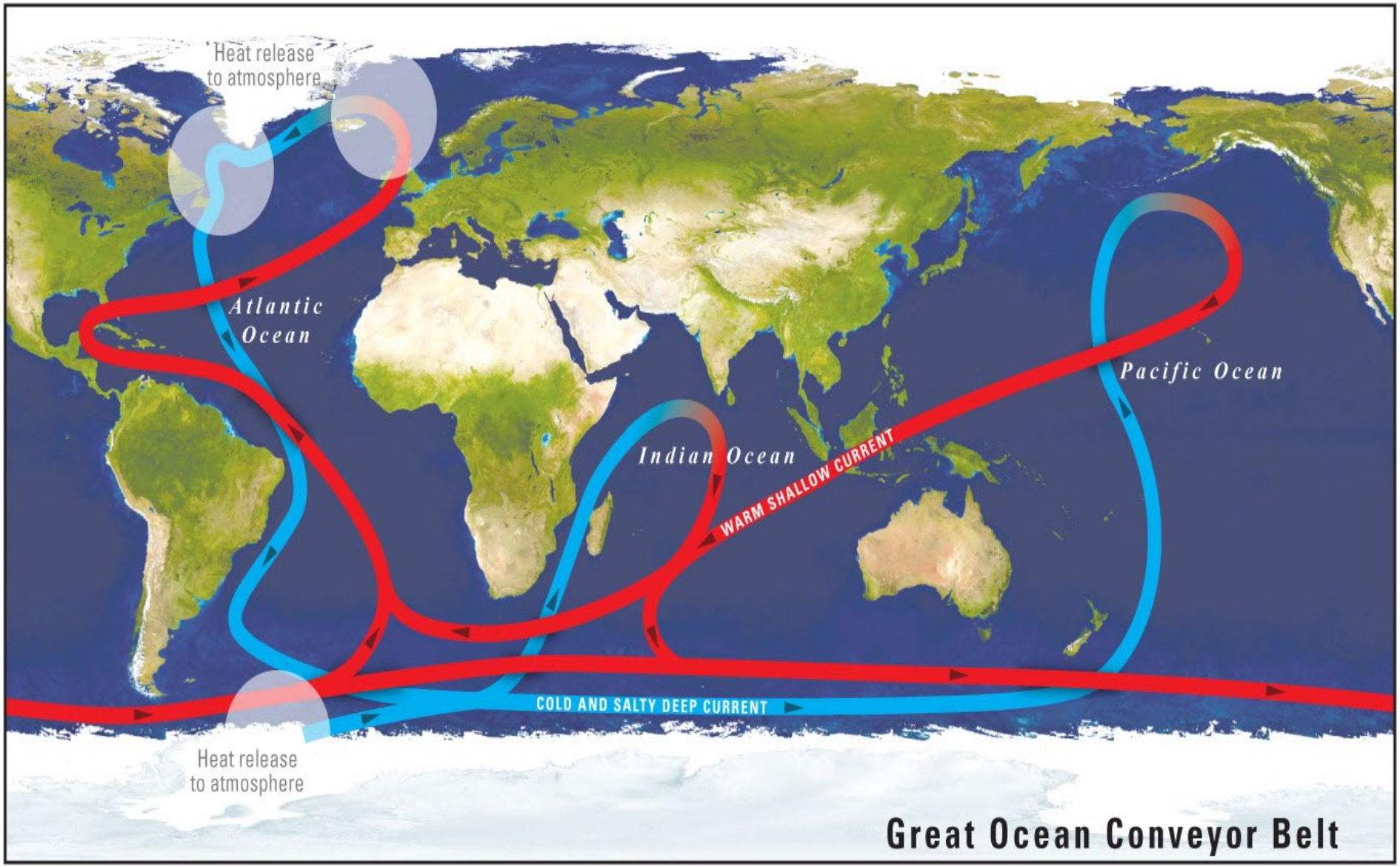
IPCC-class models (AOGCMs) have tended to treat ice sheets as giant white mountains that never change rather than as interacting elements of the Earth system… this is a big problem that needs to be fixed, which is NOT easy!

Antarctic today, warm water comes up offshore

With too much meltwater, surface cooling, deep heating →a future Heinrich event…



(Bronselaer et al., 2018, Nature)



Sinking in the North Atlantic makes North Atlantic Deep Water (NADW), part of the great ocean conveyor belt circulation

https://pubs.usgs.gov/pp/p1386a/images/gallery-2/full-res/pp1386a2-fig31.jpg


THE DAY AFTER TOMORROW
IN THEATRES WORLDWIDE 28 MAY 2004
WHERE WILL YOU BE?


THE DAY AFTER TOMORROW
IN THEATRES WORLDWIDE 28 MAY 2004
WHERE WILL YOU BE?

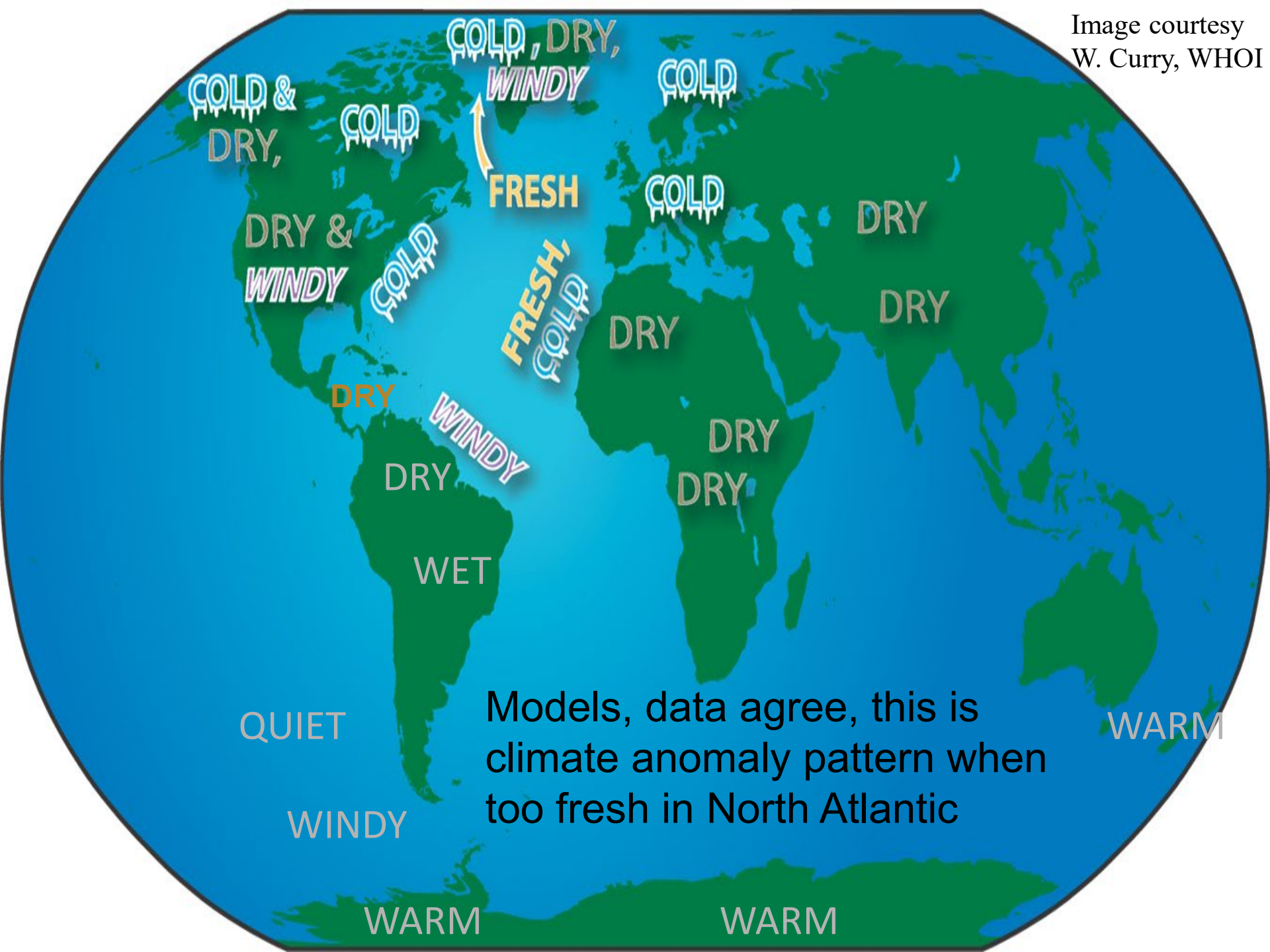
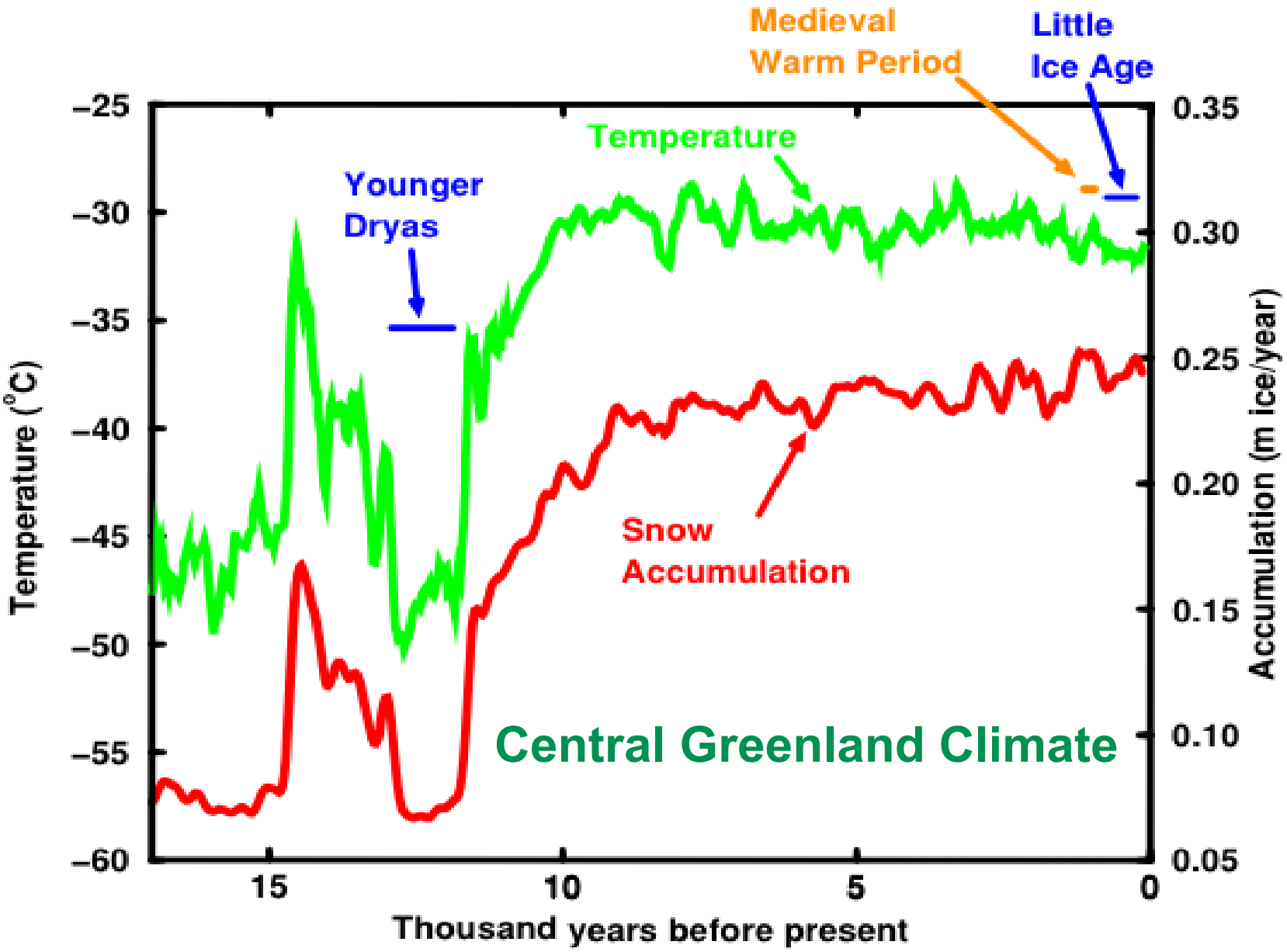


Image courtesy
W. Curry, WHOI

The public and policymakers are deeply confused about the likelihood and impacts of major North Atlantic changes

Such confusion hurts everyone, so we should work hard to clarify

Jumps were linked to ocean circulation and fresh water, but were big because of amplifying changes in sea ice



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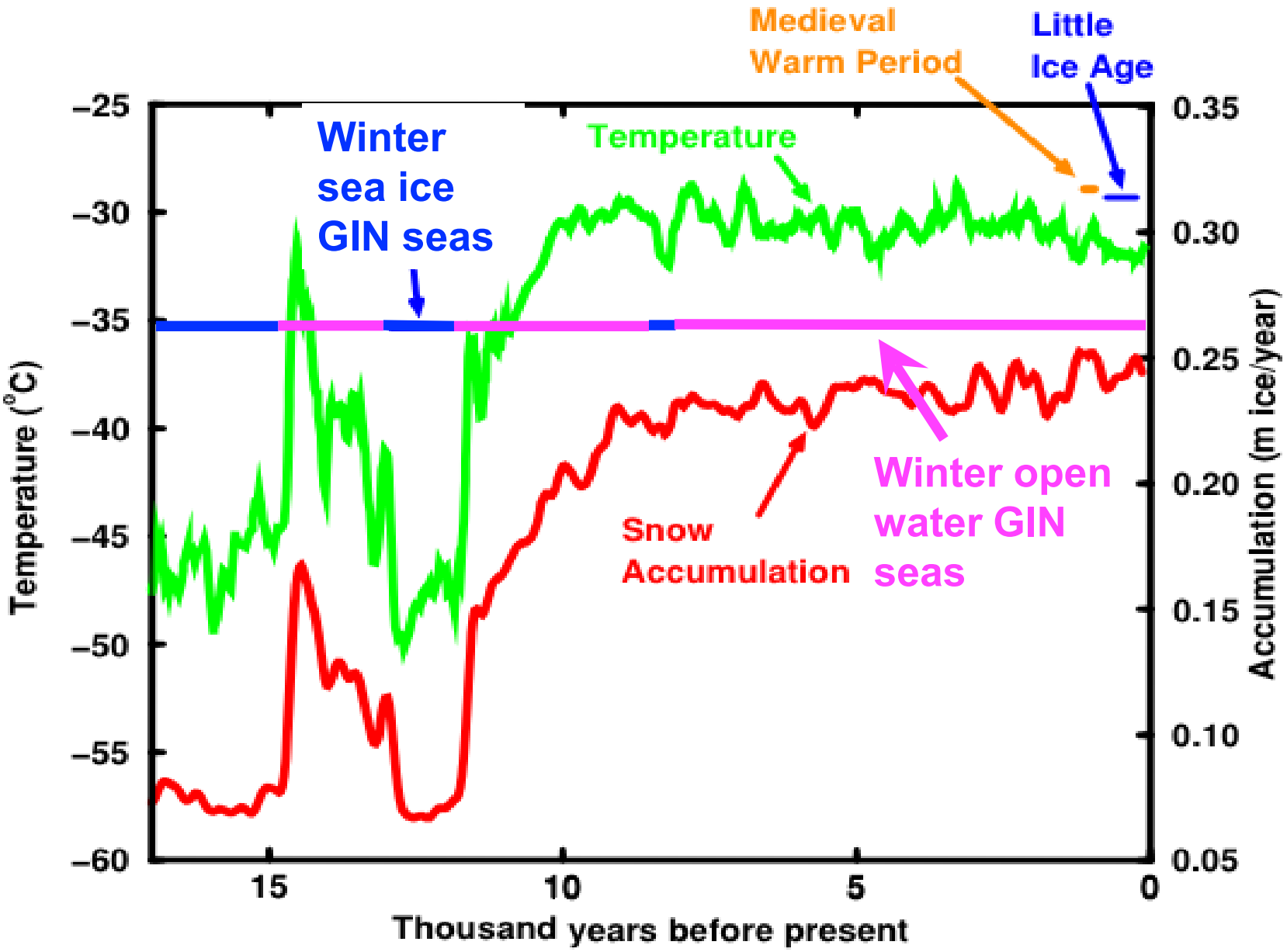
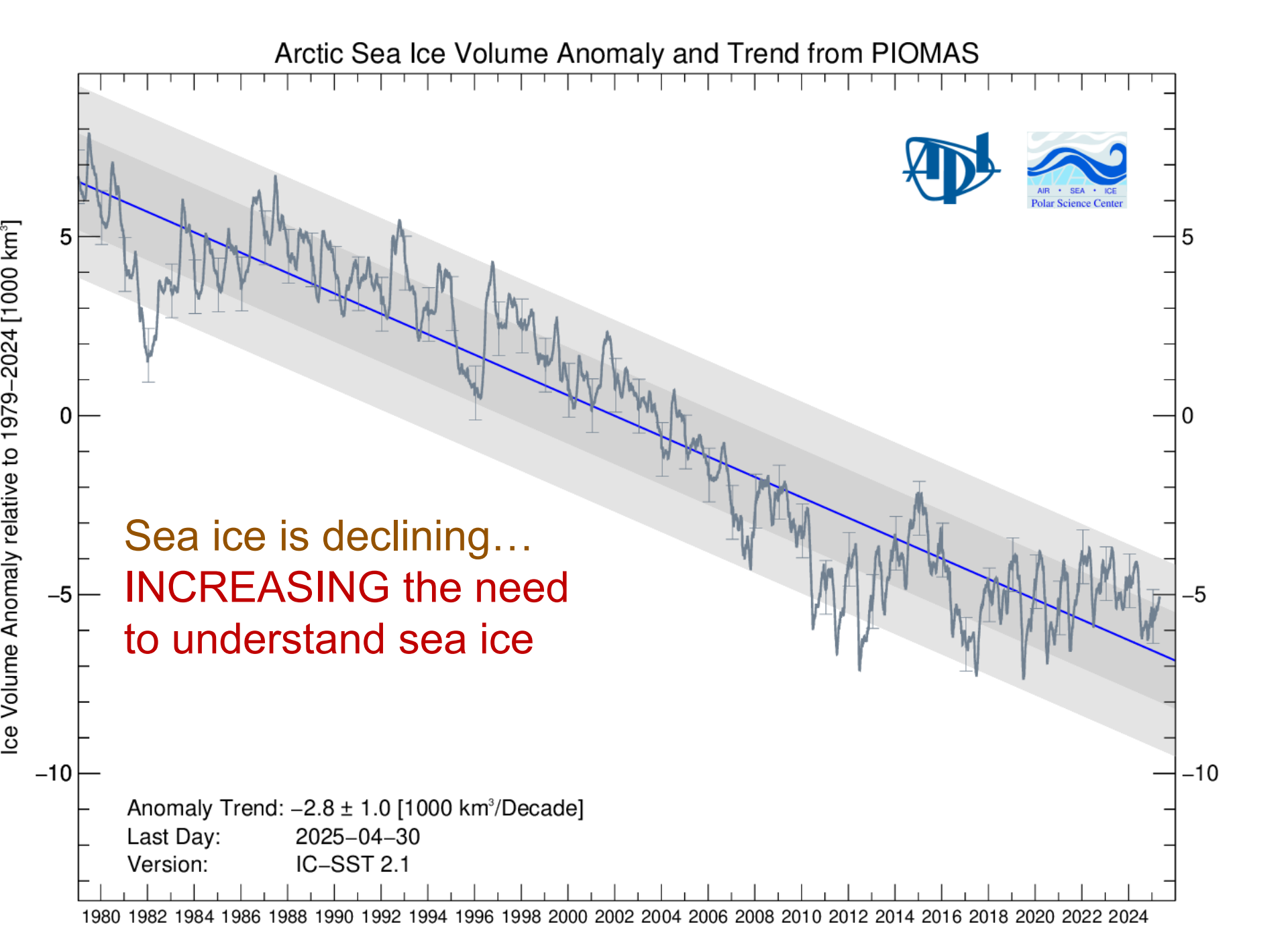
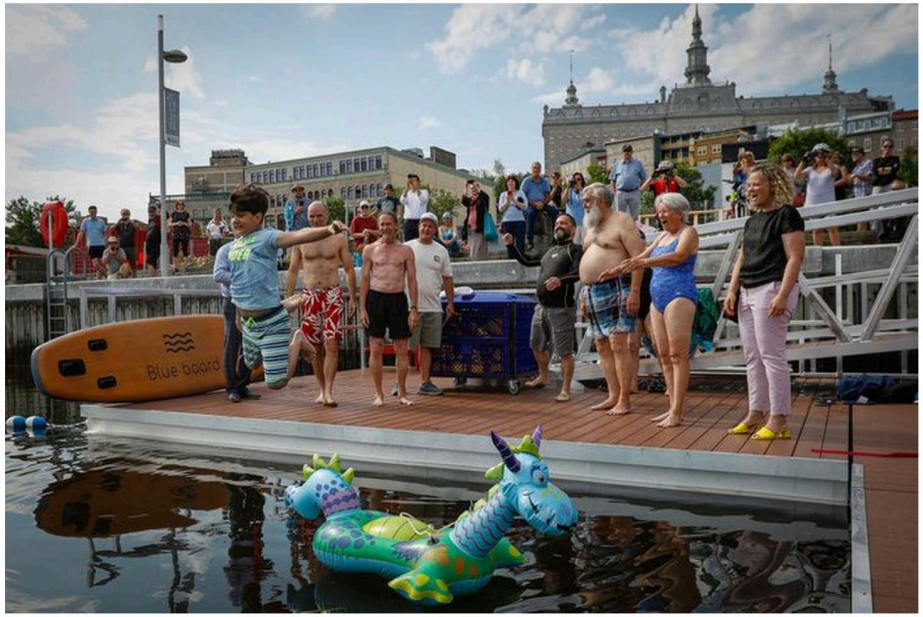




https://psc.apl.uw.edu/wordpress/wp-content/uploads/schweiger/ice_volume/BPIOMASIceVolumeAnomalyCurrentV2.1.png



Francis Vachon *Montreal Gazette*

https://www.montrealgazette.com/news/article95683.html

https://www.cbc.ca/news/canada/montreal/icebreakers-called-in-to-free-ferries-in-st-lawrence-1.2483650

St. Lawrence **summer** and **winter**

Montreal

Icebreakers called in to free ferries in St. Lawrence

Icebreakers Amundsen and Martha L. Black are working in Lake St-Pierre near Sorel-Tracy

CBC News · Posted: Jan 03, 2014 5:33 PM EST | Last Updated: January 3, 2014

CCGS Amundsen has been working for nearly two days in the St. Lawrence's Lake St-Pierre to break up the ice that is forming there. (Canadian Coast Guard)

When the Arctic Ocean was impassable, ships didn't pass

Now seasonally open water lures shipping, tourism, etc.

Need is increasing rapidly for icebreakers, and for sea-ice forecasts at all time scales for operations and planning

Requiring improved scientific understanding and support

When I discuss such issues with people, they usually respond, “But what about the penguins and polar bears???”

Article | Open access | Published: 13 June 2024

Ice-free period too long for Southern and Western Hudson Bay polar bear populations if global warming exceeds 1.6 to 2.6 °C

Julienne Stroeve, Alex Crawford, Steve Ferguson, Ian Stirling, Louise Archer, Geoffrey York, David Babb & Robbie Mallett

Communications Earth & Environment **5**, Article number: 296 (2024) | Cite this article

Brilliant if disturbing work: "However, with longer ice-free periods already substantially impacting recruitment, extirpation for polar bears in this region may already be inevitable."
Important introduction to MANY questions about biodiversity, traditional lifestyles, fisheries…—probably more important than the physical issues, but somewhat outside my limited expertise

Our family went up to Churchill to collect teaching slides and try to understand this. The bear-watching was great for tourists because the climate was bad for bears, who were stuck on land with nothing to eat, waiting for the ice…

A US Senator once told me
"Climate has always changed naturally,
so we should NOT worry about humans changing climate!"

https://inciweb.nwcg.gov/photos/CAANF/2014-01-16-1131-COLBY/picts/2014_01_18-20.07.15.072-CST.jpeg

https://earthobservatory.nasa.gov/NaturalHazards/view.php?id=82878

Can you imagine a sane person saying "Fires have always burned naturally, so we should NOT worry about humans causing fires!" (accidents, arson)

https://inciweb.nwcg.gov/photos/CAANF/2014-01-16-1131-COLBY/picts/2014_01_18-20.07.15.072-CST.jpeg

https://earthobservatory.nasa.gov/NaturalHazards/view.php?id=82878

Or "People have always died naturally, so we should NOT worry about humans killing others!" (accidents, murder, war)

Paleoclimatology tells us

→ Climate has always changed, so climate is changeable

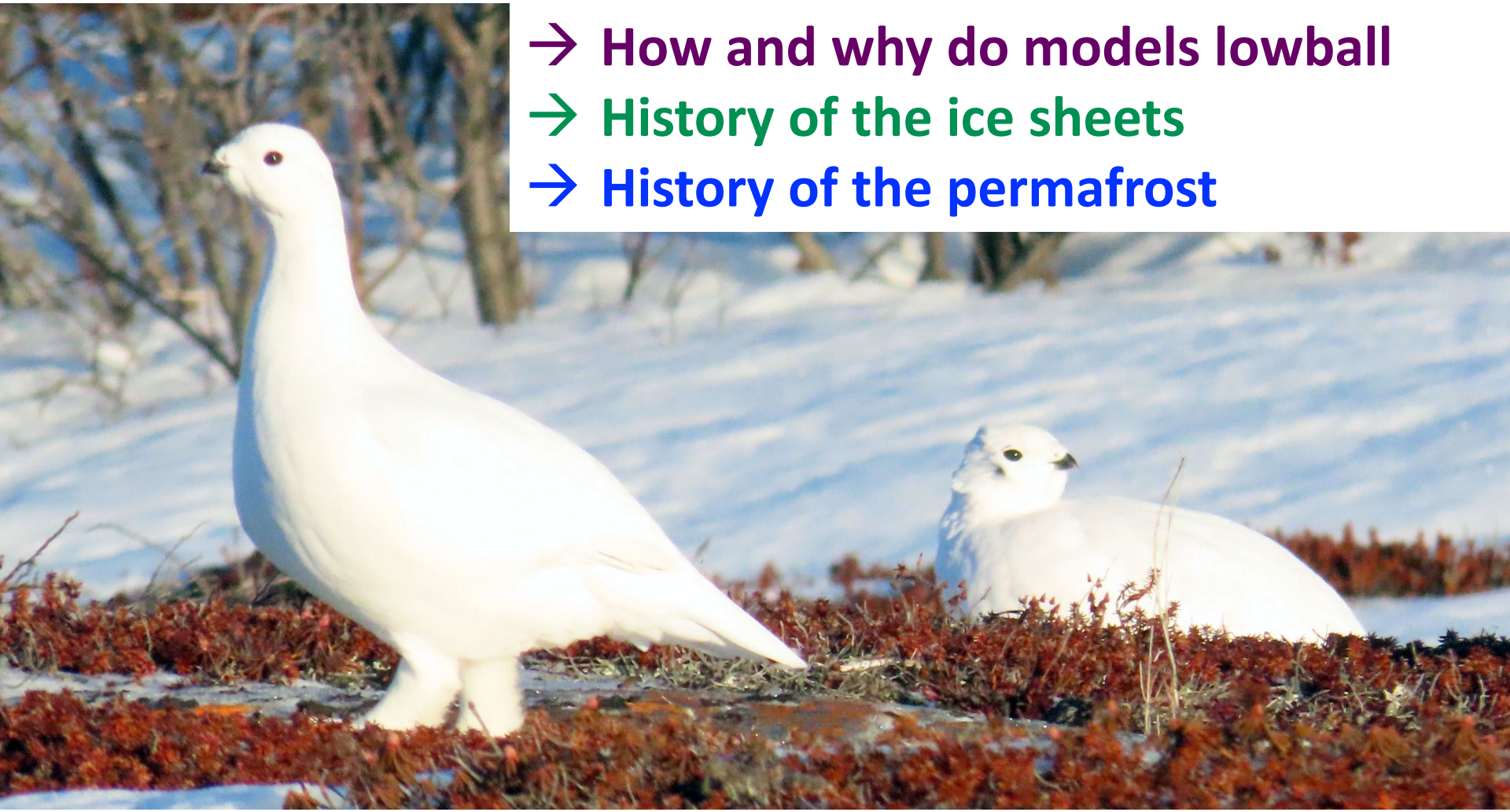
→ Climate change has always affected life, so climate change is important

→ Climate has changed for many reasons, but especially CO_2, so our CO_2 is important

In my experience

- → Those who learn more about past climate change become more worried about humans changing climate
- → We could cause bigger, faster changes than almost any
- → If we're wrong, climate changes more and influences life more in real world than in our models

There's much left to do, including but not limited to:



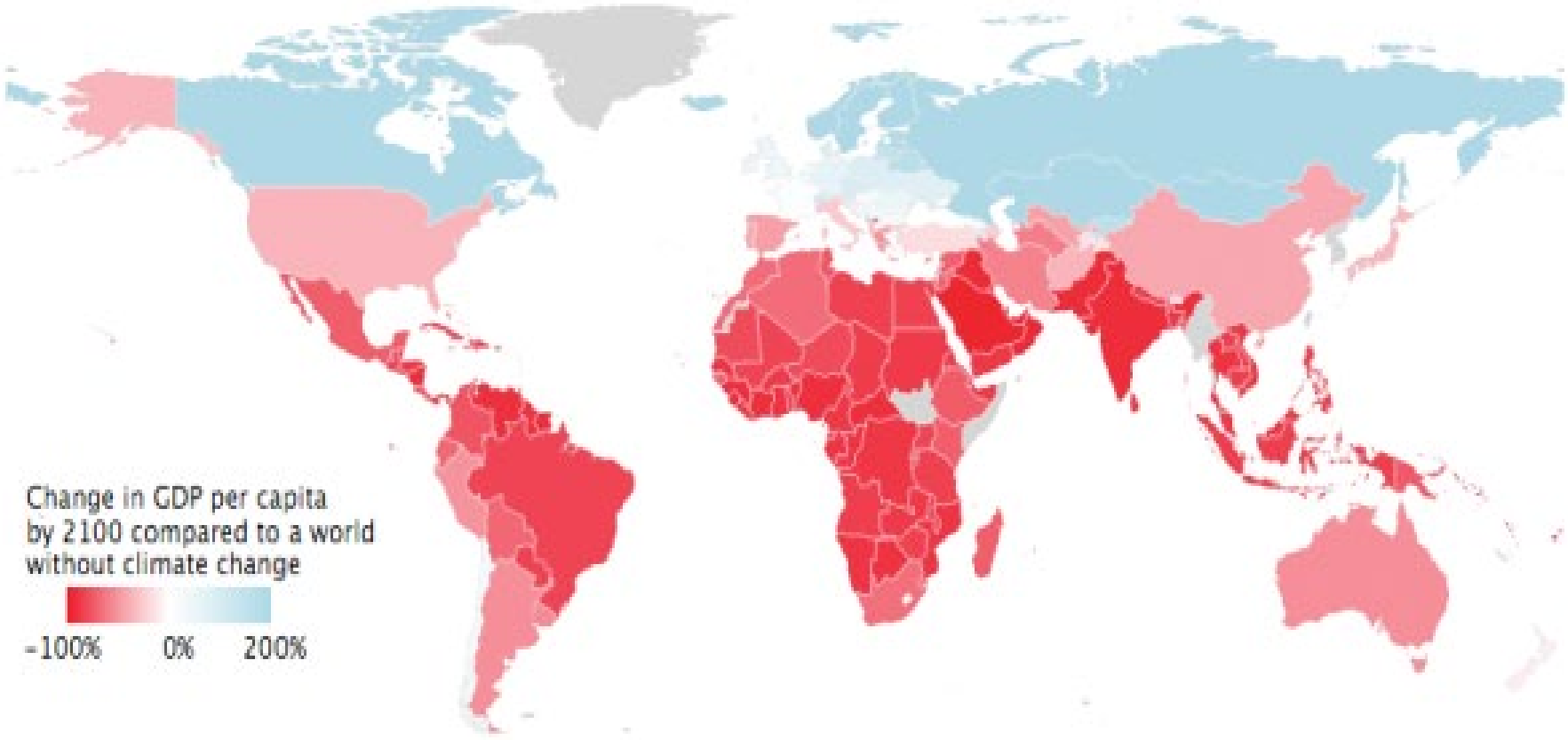
→ How and why do models lowball

→ History of the ice sheets

→ History of the permafrost

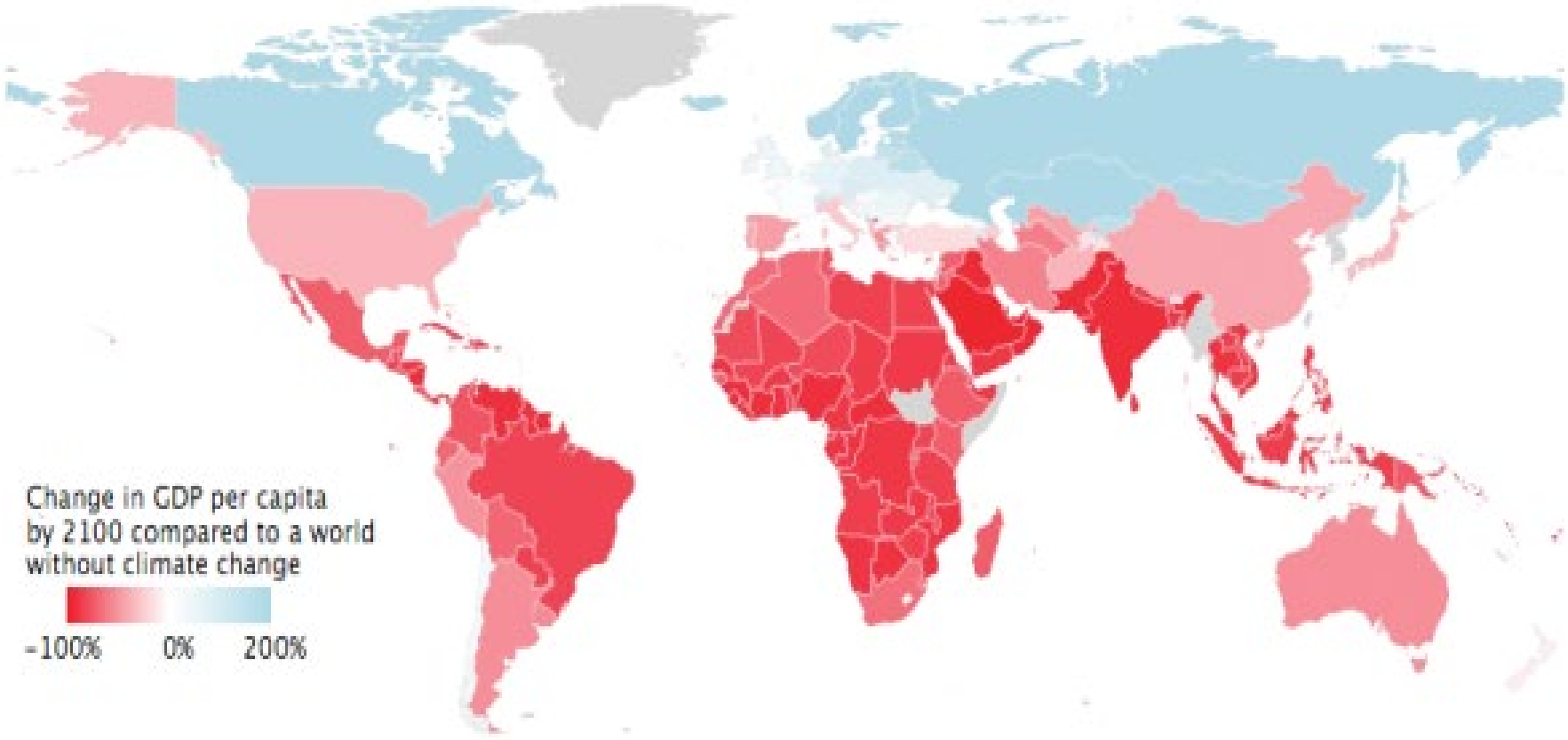
→ History of fire. During the PETM, nature rather clearly became a CO_2 source. If that happened now through boreal fires, etc., it would be really bad

http://thinkprogress.org/climate/2015/10/22/3714991/climate-change-world-economies-study/



A prediction for how gross domestic product (GDP) will change across the globe by 2100. Colder countries, like Canada, will see an economic boost with climate change, while most tropical nations will witness a drop. This model assumes a “business as usual” global warming scenario, wherein unmitigated climate changes raises temperatures by 4.3 degrees Celsius (8 degrees Fahrenheit) by the end of the century. Photo by Burke M, Hsiang SM and Miguel E., Nature, 2015. http://www.pbs.org/newshour/updates/best-temperature-economic-happiness/

http://thinkprogress.org/climate/2015/10/22/3714991/climate-change-world-economies-study/



Persistent economic narrative: warming hurts almost everyone, but at least helps finances in the Arctic.

But, *I've* heard economists wonder whether costs have been underestimated, of change itself, the value of things lost, and the damages from nearby failures where warming is bad.

Could an IPY diversify enough to study such issues?

→With $230 billion to protect or doom just three US cities, the value of IPY information is likely to grossly exceed the costs

→I have barely scratched the surface of possible research areas

→With polar influences on sea level, ocean circulation, weather, climate, carbon sequestration, fisheries, and so much more, a global effort is obviously required

→Big issues of climate justice, traditional lifestyles, biodiversity…

→I haven't even mentioned the political value of the Antarctic Treaty, or war gaming over Svalbard, or…


“Yes, I would like to science, please.”
Onward!