Abrupt Climate Change and WAIS

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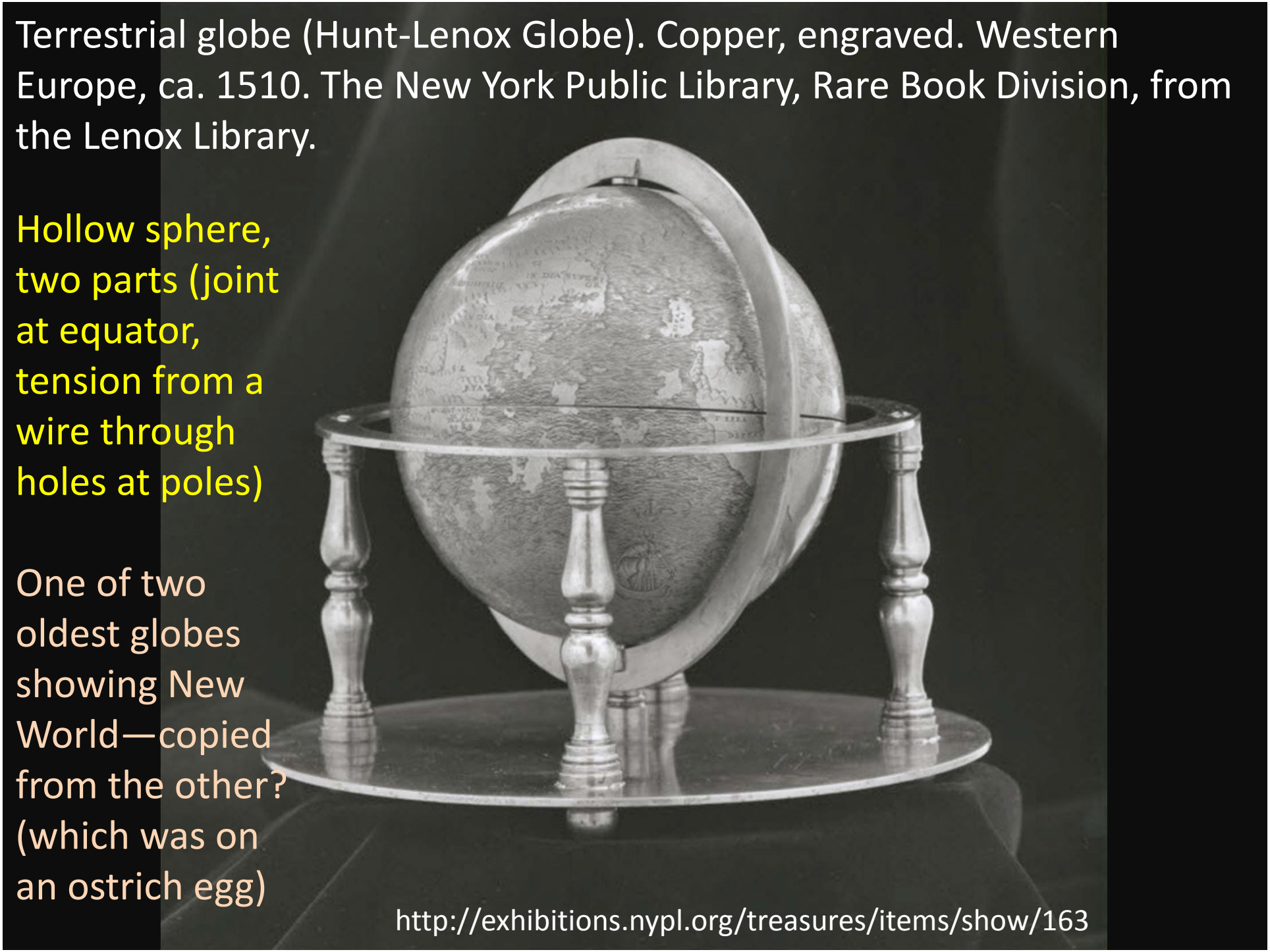
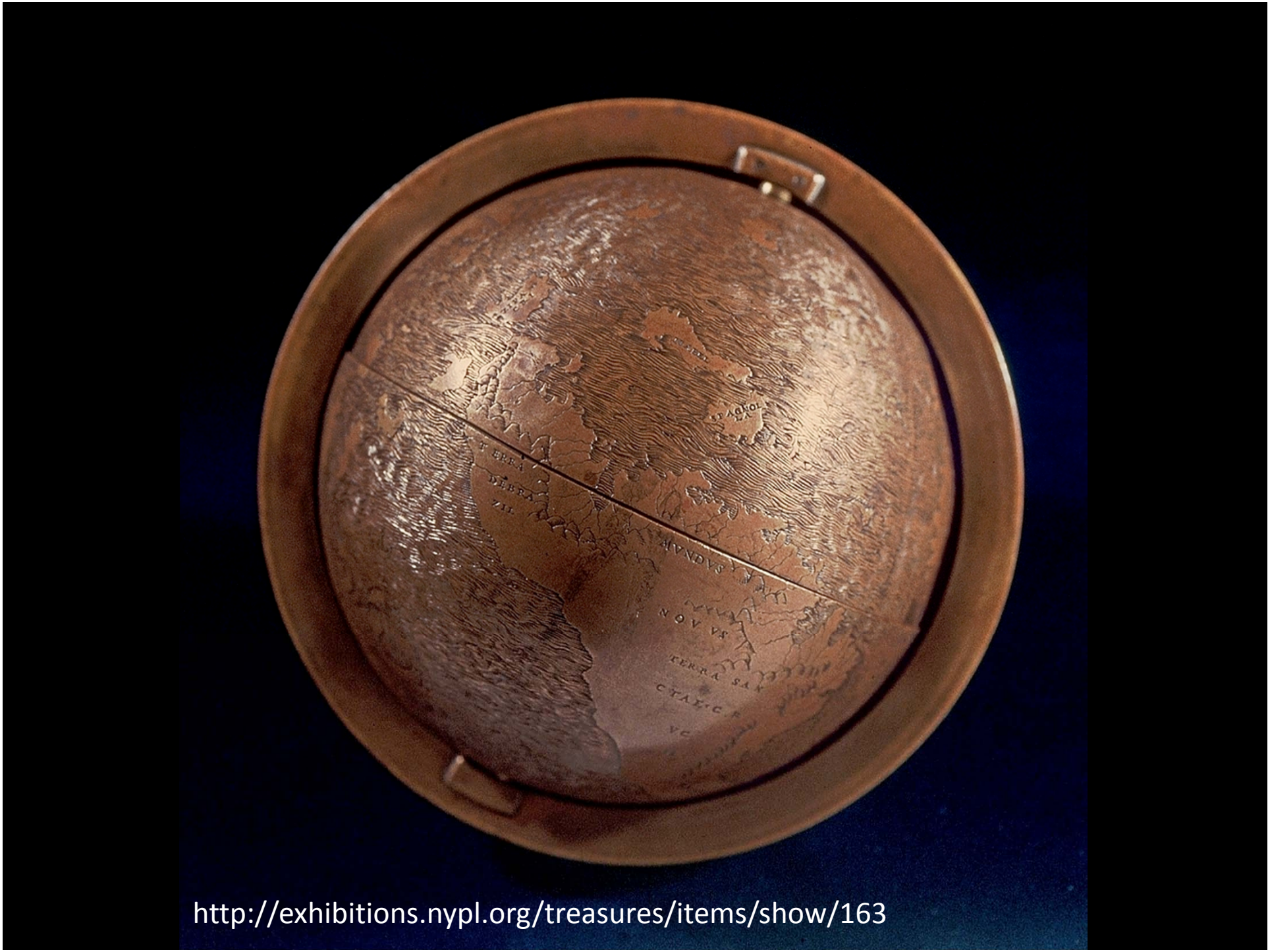
Sept. 30, 2013

NSF
CRESIS
PENNSTATE
NASA
G. Comer Foundation
earth
THE OPERATORS' MANUAL


Terrestrial globe (Hunt-Lenox Globe). Copper, engraved. Western Europe, ca. 1510. The New York Public Library, Rare Book Division, from the Lenox Library.
Hollow sphere, two parts (joint at equator, tension from a wire through holes at poles)
One of two oldest globes showing New World—copied from the other? (which was on an ostrich egg)
http://exhibitions.nypl.org/treasures/items/show/163



http://exhibitions.nypl.org/treasures/items/show/163

“Here be dragons" means dangerous or unexplored territories, in imitation of the medieval practice of putting dragons, sea serpents and other mythological creatures in uncharted areas of maps.

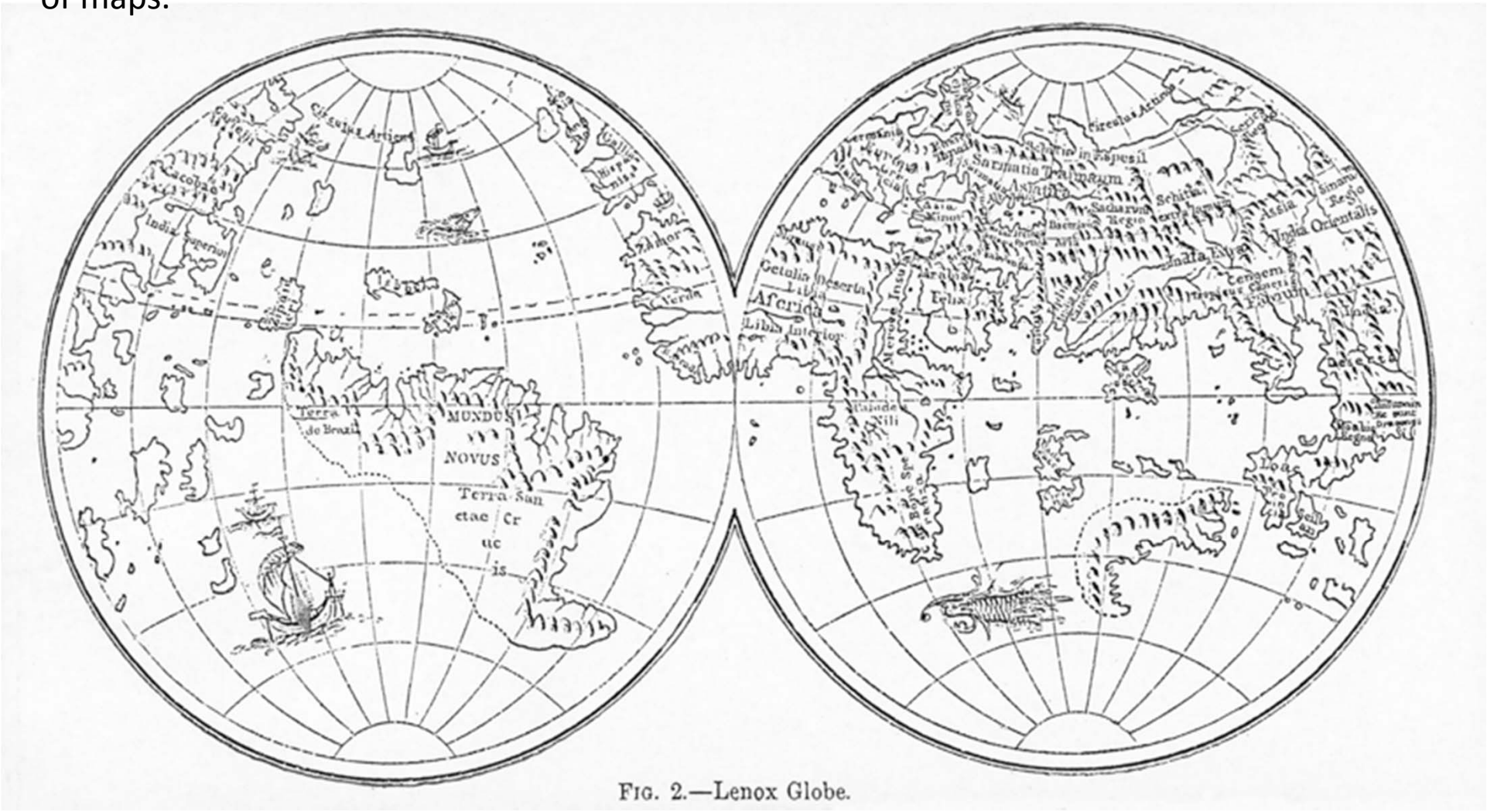
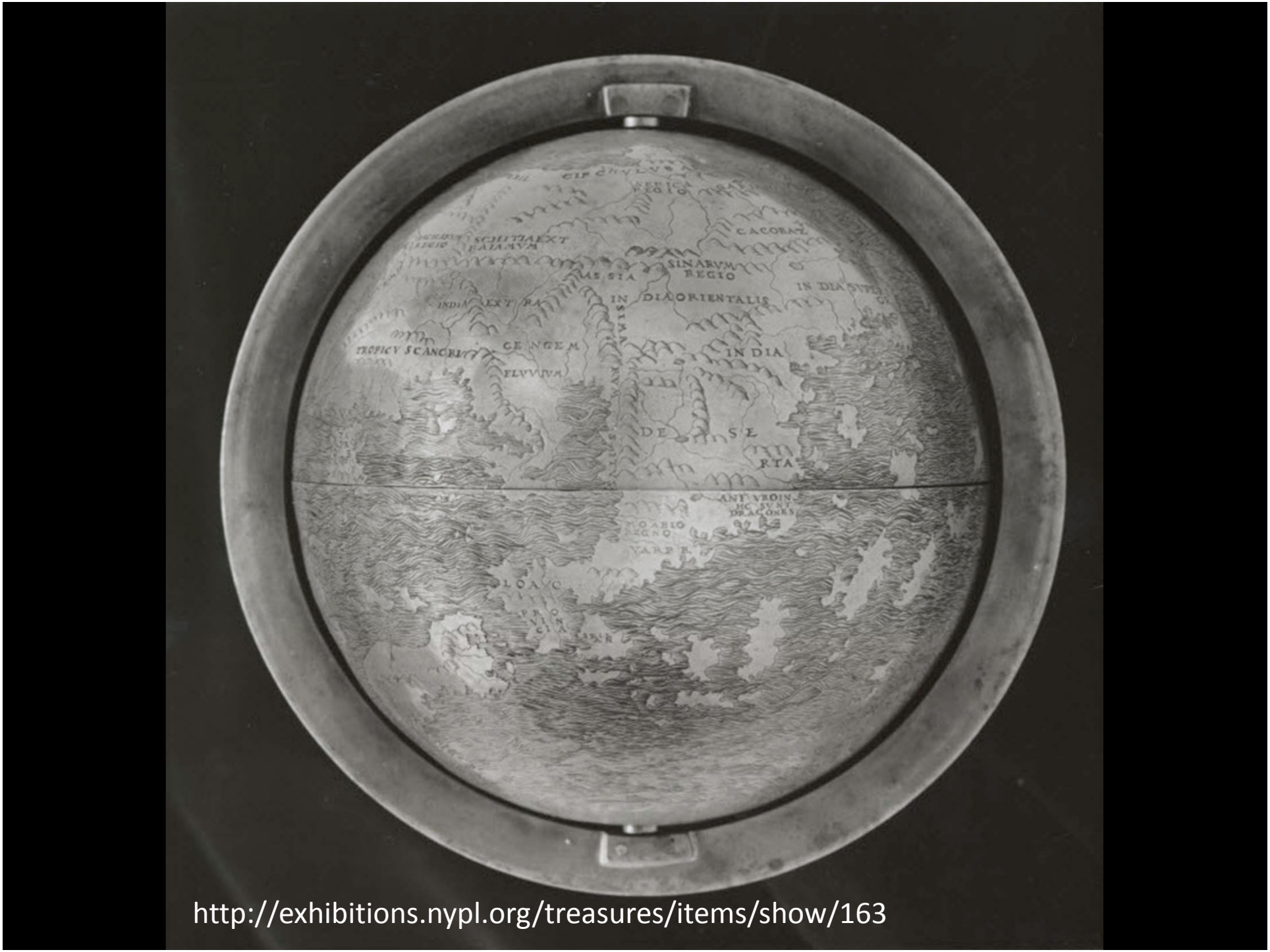


Fig. 2.—Lenox Globe.

http://commons.wikimedia.org/wiki/File:Lenox_Globe_%282%29_Britannica.png



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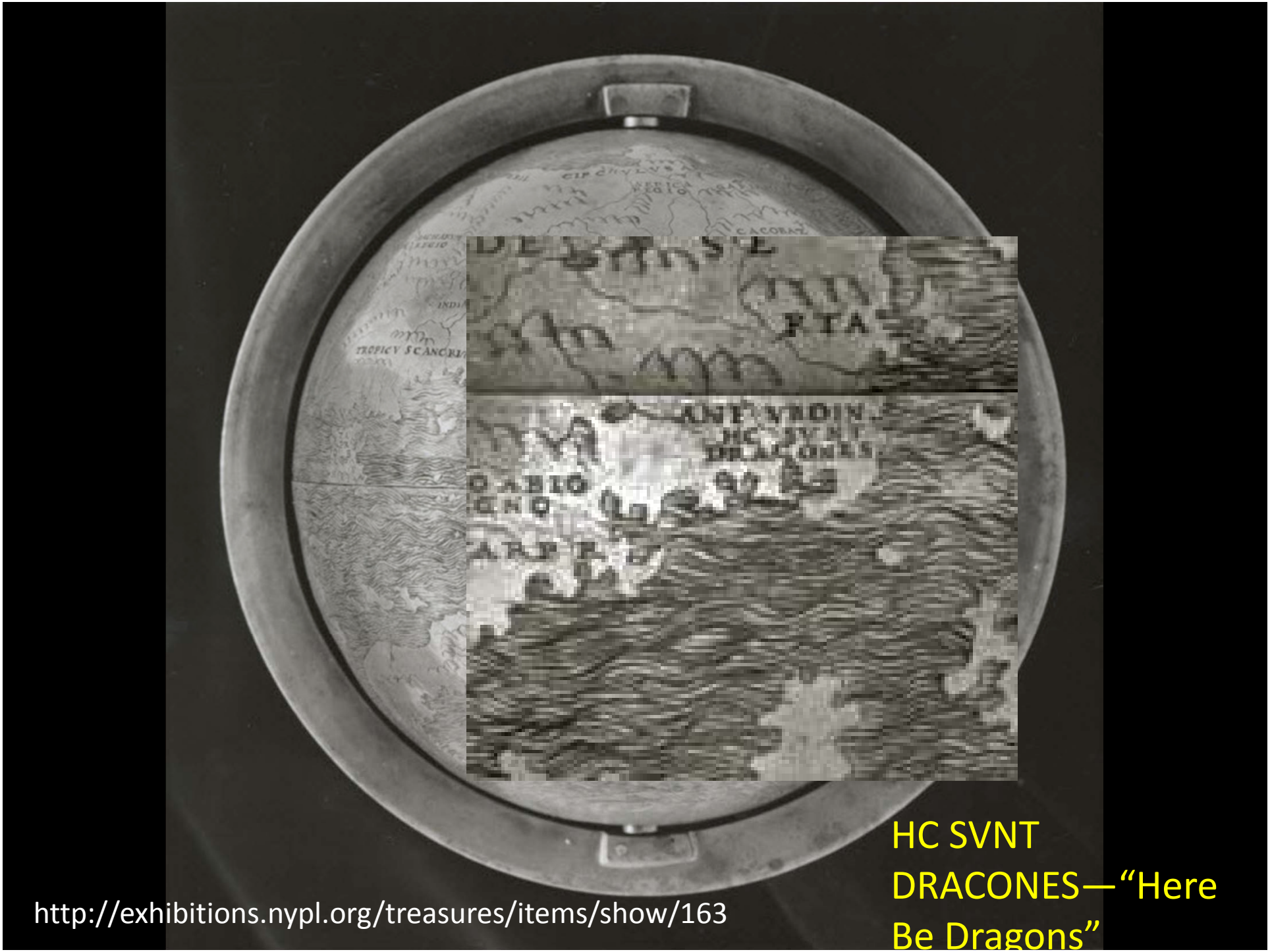
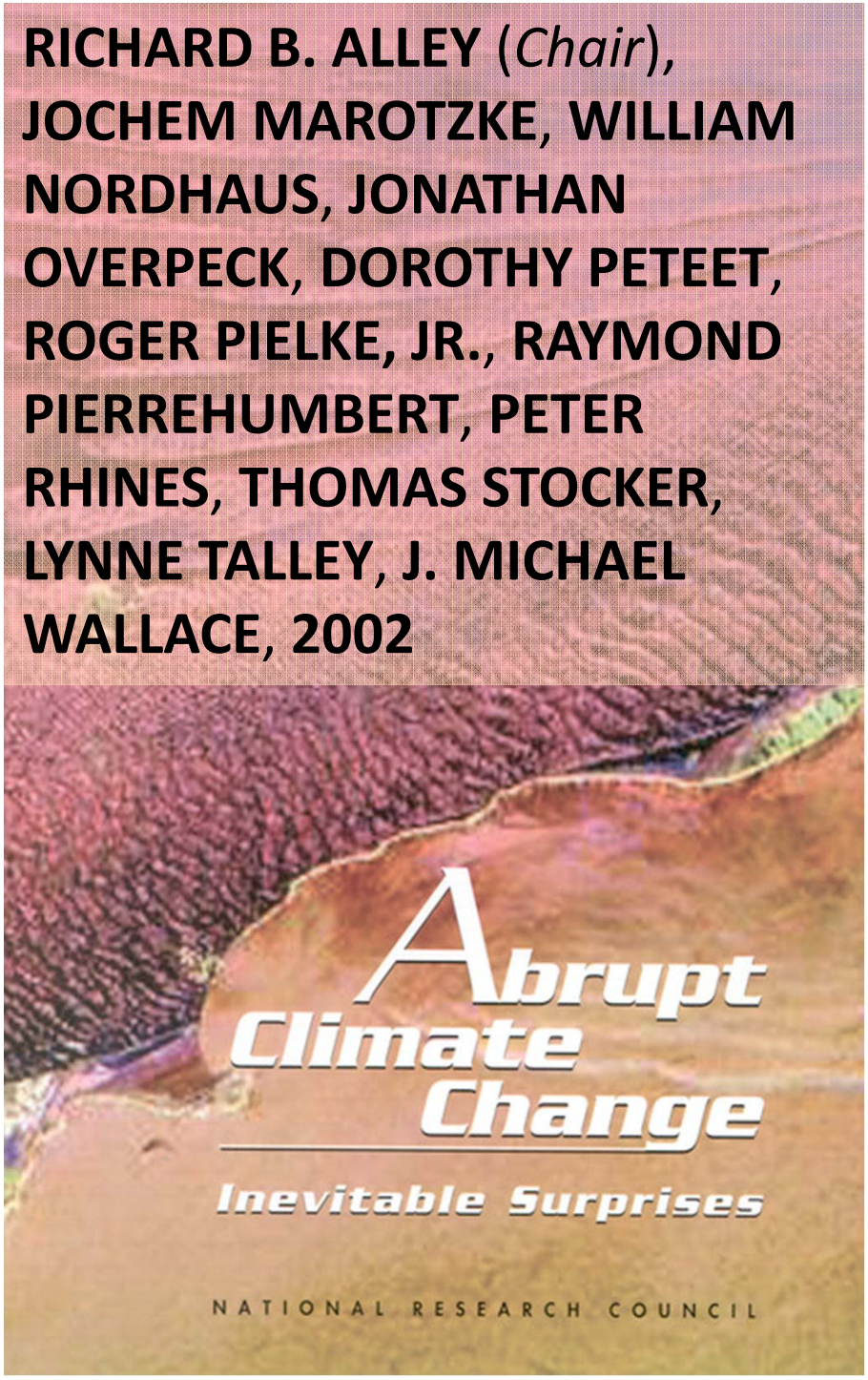

HC SVNT
DRACONES—“Here Be Dragons”
http://exhibitions.nypl.org/treasures/items/show/163

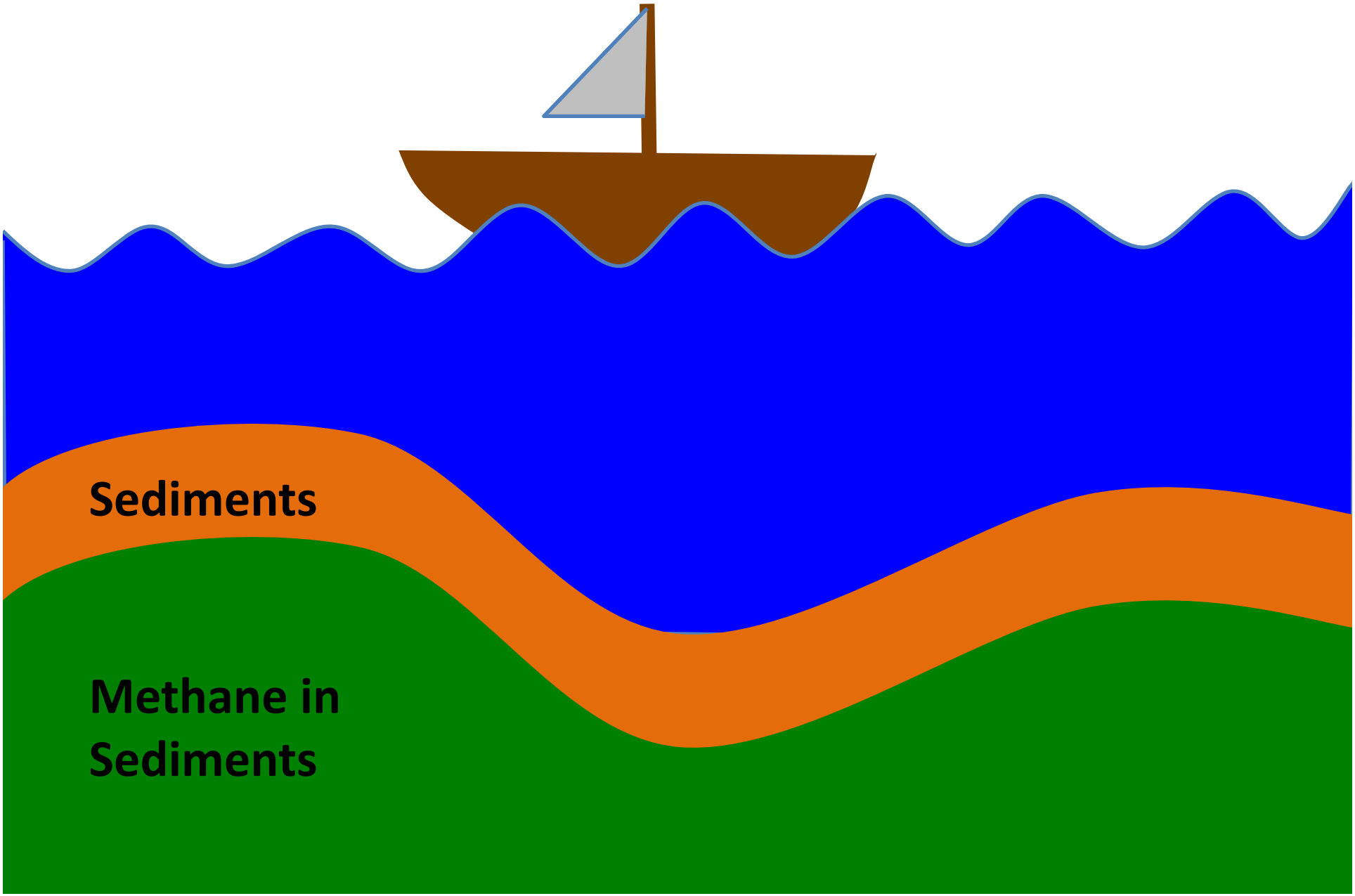
Exploration often works this way

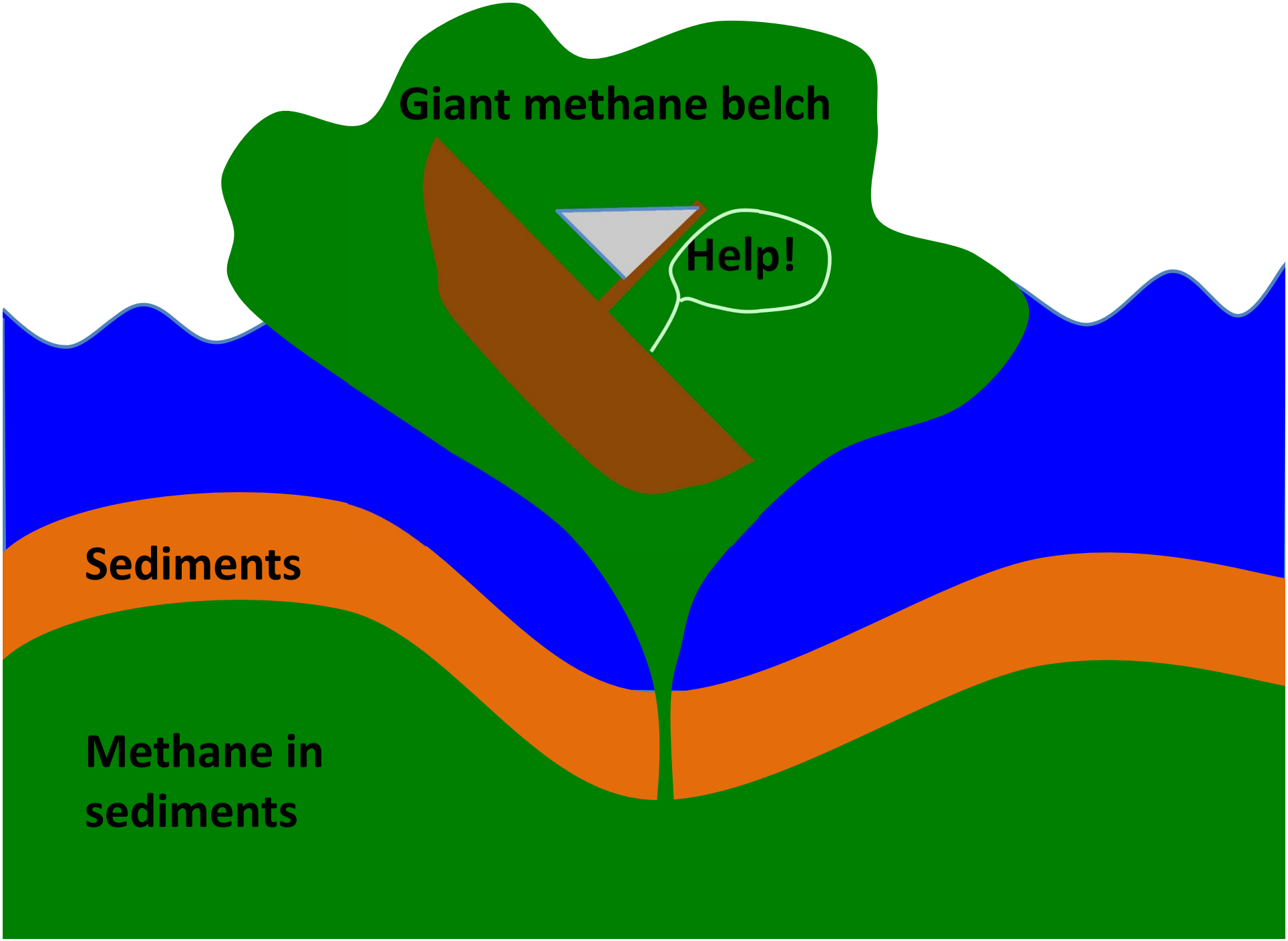
- Discovery highlights what we don't know
- There might be dragons there
- Further study cuts off dragon's long tail (or, the long tail of the probability density function that included chance of dragons)
- Communications challenge—some people accuse us of alarmism if early worst-case scenario doesn't play out
- Those same people would yell louder if we didn't warn and then found dragons!

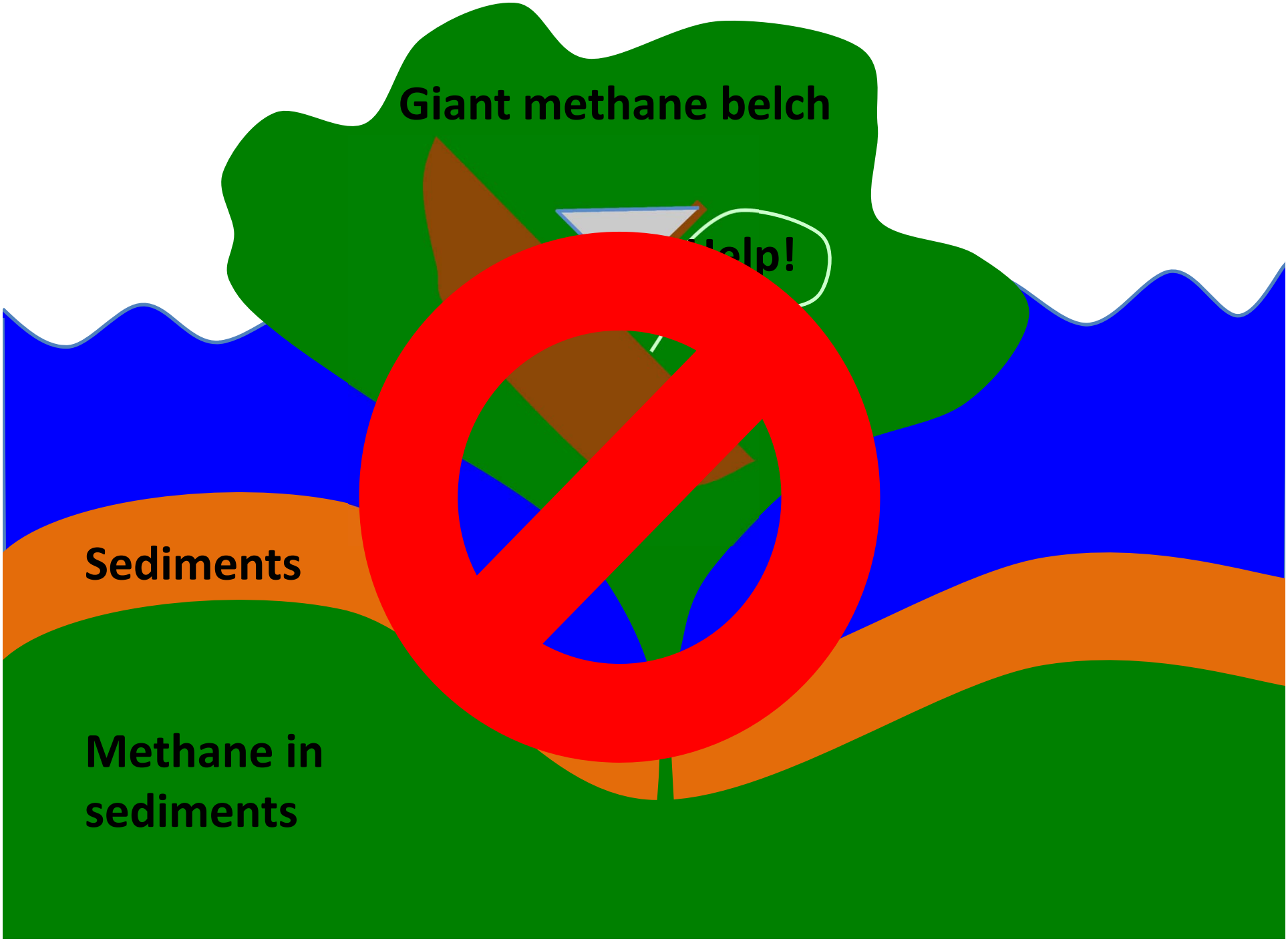


Abrupt Impacts of Climate Change: Anticipating Surprises

JAMES W.C. WHITE (*Chair*), **RICHARD B. ALLEY, DAVID ARCHER, ANTHONY D. BARNOSKY, JONATHAN FOLEY, RONG FU, MARIKA HOLLAND, SUSAN LOZIER, JOHANNA SCHMITT, LAURENCE C. SMITH, GEORGE SUGIHARA, DAVID W. J. THOMPSON, ANDREW WEAVER, STEVEN WOFSY, 2013 (coming)**


Sediments
Methane in
Sediments


Giant methane belch
Help!
Sediments
Methane in sediments


Giant methane belch
lp!
Sediments
Methane in sediments

Story of the Science

- Much methane is in and below clathrate
- Uncertainties heavily on "bad" side

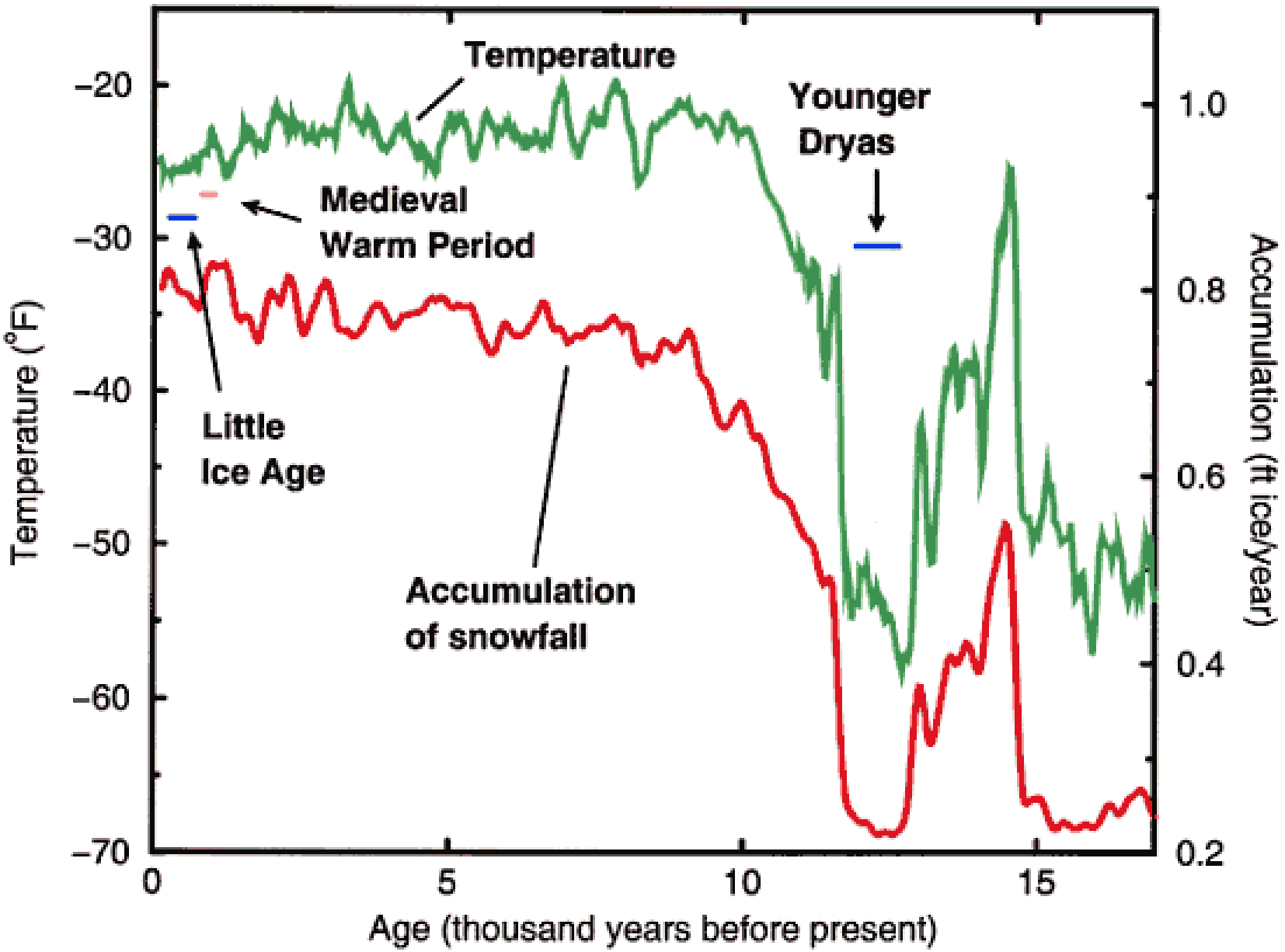
→ No physically plausible way to shift human CO_2 into new methane rapidly

→ Nonzero chance of very fast release

→ But subsequent research found "safety valves" that make fast release quite unlikely

- Methane likely a harmful feedback, but over decades to centuries
- Much useful knowledge from the research

Central Greenland Climate



Similar story in North Atlantic

- Huge, abrupt changes happened repeatedly
- Greenland melting pushes in "bad" way
- But, improvement of modeling has shown

→ Very unlikely to trigger a big change

→ At least until too hot for sea ice amplifier

- The research effort shows that the changes are fundamental in Earth system
- Likely controlled much of glacial-interglacial CO_2 change, and much more


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

Concerns

- Abrupt forcing (meteorite impact; 8k flood)
- Abrupt climate change from gradual forcing (most North Atlantic events; slow increase in meltwater crossing threshold)
- Abrupt ecosystem or economy response to gradual climate change

→ The water overtops the levee, or it doesn't

→ Triggered societal upheaval ("Arab spring" may be partially rooted in food shortage from climate change, for example)

Flooding from Hurricane Katrina, New Orleans, 2005.

http://www.mvd.usace.army.mil/hurricane/chr.php Miscellaneous Photos coe_20, US Army Corps of Engineers.

www.sciencemag.org SCIENCE VOL 341 13 SEPTEMBER 2013

Quantifying the Influence of Climate on Human Conflict

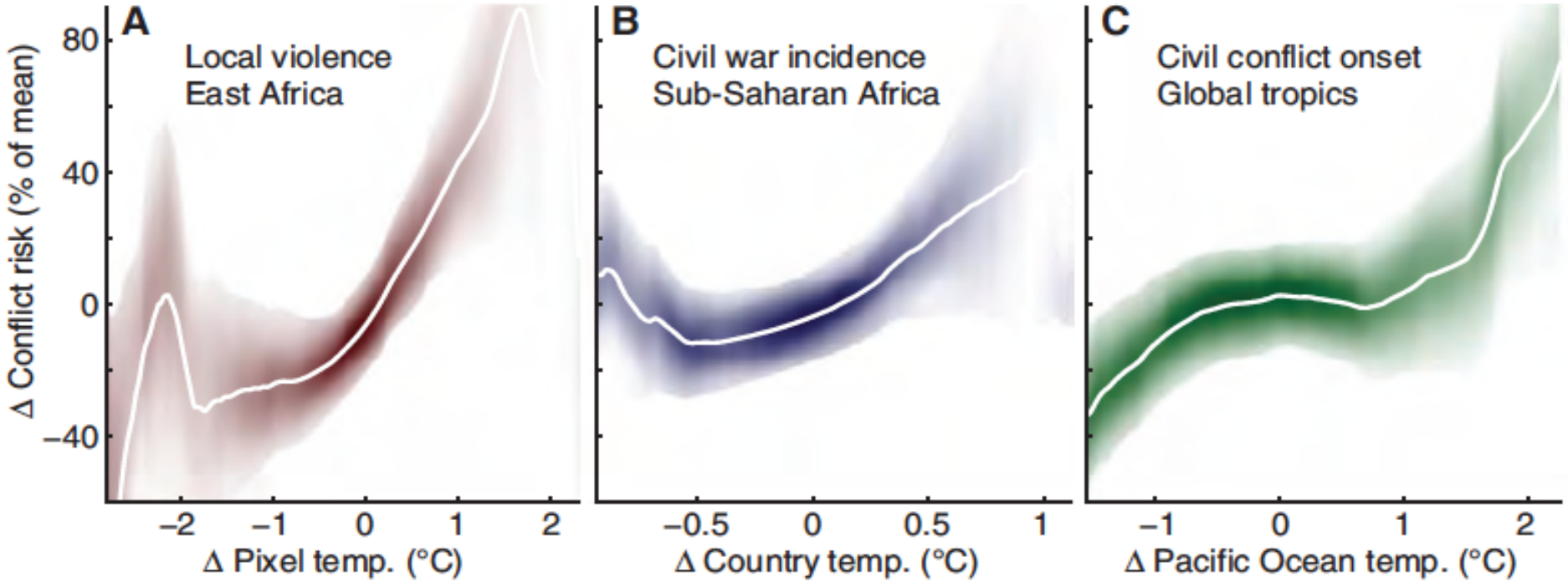
Solomon M. Hsiang,[1,2]*†‡ Marshall Burke,[3]† Edward Miguel[2,4]

Results: Deviations from normal precipitation and mild temperatures systematically increase the risk of conflict, often substantially. This relationship is apparent across spatial scales ranging from a single building to the globe and at temporal scales ranging from an anomalous hour to an anomalous millennium. Our meta-analysis of studies that examine populations in the post-1950 era suggests that the magnitude of climate's influence on modern conflict is both substantial and highly statistically significant ($P < 0.001$). Each 1-SD change in climate toward warmer temperatures or more extreme rainfall increases the frequency of interpersonal violence by 4% and intergroup conflict by 14% (median estimates).

Discussion: We conclude that there is more agreement across studies regarding the influence of climate on human conflict than has been recognized previously. Given the large potential changes in precipitation and temperature regimes projected for the coming decades—with locations throughout the inhabited world expected to warm by 2 to 4 SDs by 2050—amplified rates of human conflict could represent a large and critical social impact of anthropogenic climate change in both low- and high-income countries.

"Deviations from normal precipitation and mild temperatures systematically increase the risk of conflict, often substantially…amplified rates of human conflict could represent a large and critical social impact of anthropogenic climate change in both low- and high-income countries."

Climate and conflict across spatial scales. Evidence that temperature influences the risk of modern human conflict: (**A**) local violence in 1° grid cells, (**B**) civil war in countries, and (**C**) civil conflict risk in the tropics. The map depicts regions of analysis corresponding to nonparametric watercolor regressions in (A) to (C). The color intensity in (A) to (C) indicates the level of certainty in the regression line.

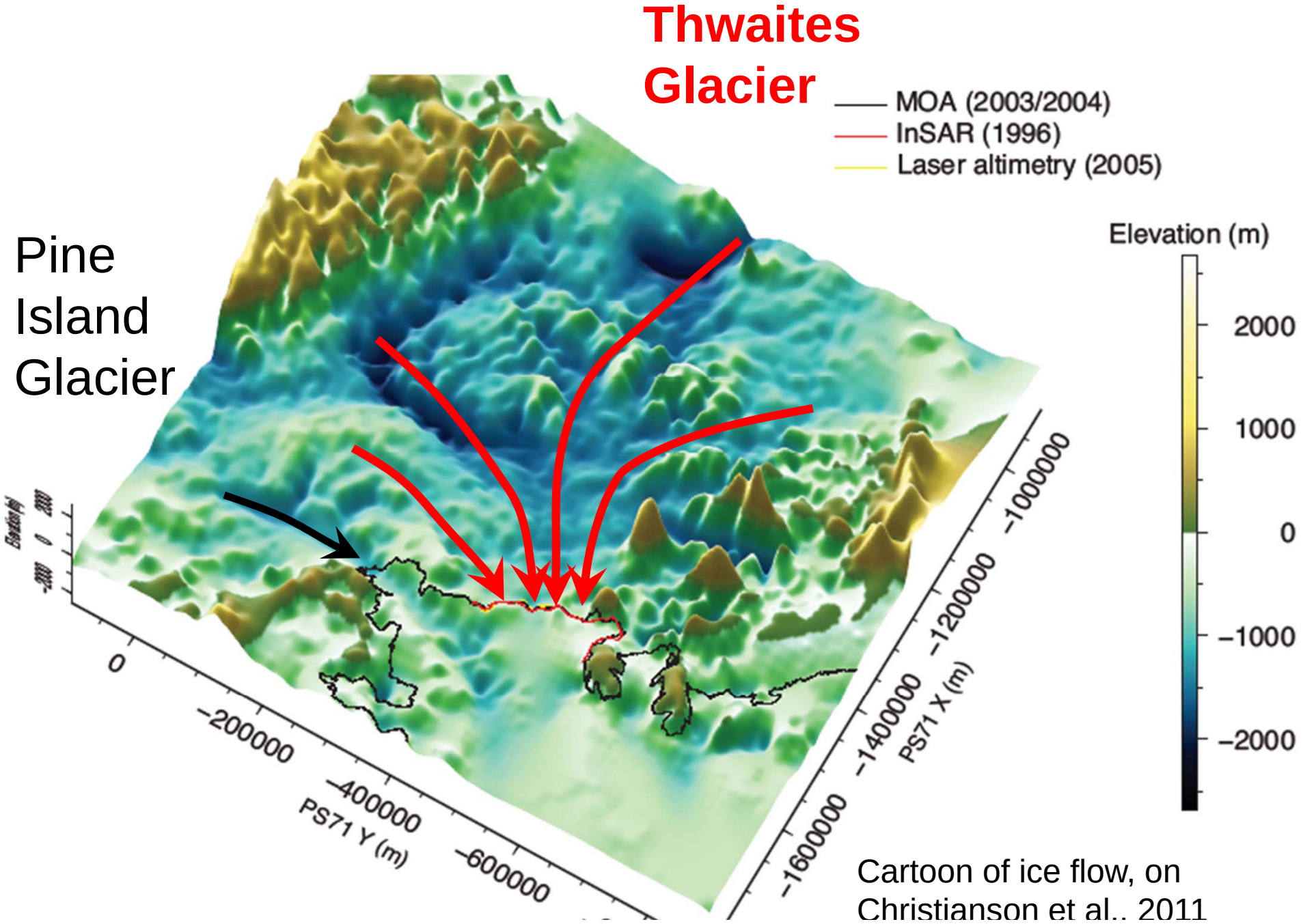


Too cold may be bad. Hotter is worse.

Navy Admiral Samuel J. Locklear III…said significant **upheaval related to the warming planet** "is probably the most likely thing that is going to happen . . . that **will cripple the security environment**, probably more likely than the other scenarios we all often talk about."

"People are surprised sometimes," he added, describing the reaction to his assessment. "You have the real potential here in the not-too-distant future of nations displaced by rising sea level. Certainly weather patterns are more severe than they have been in the past." Bryan Bender, Boston Globe, March 9, 2013 (emphasis added)

DOD photo by U.S. Navy Petty Officer 1st Class Chad J. McNeeley www.defense.gov



Cartoon of ice flow, on Christianson et al., 2011

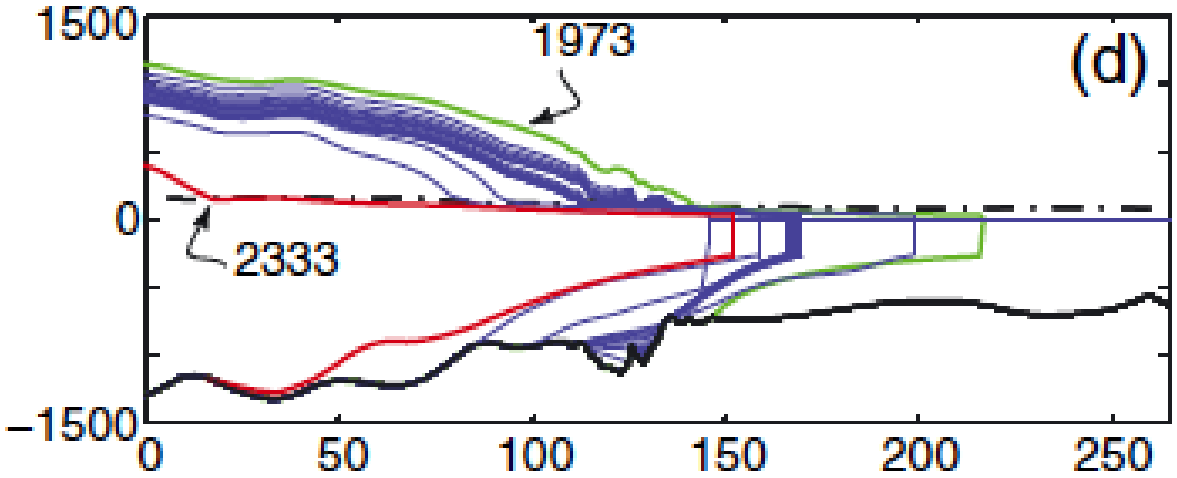
http://fastlane.dot.gov/2012/02/aashto-2012.html#.UR6jleg98Qw

JOURNAL OF GEOPHYSICAL RESEARCH: EARTH SURFACE, VOL. 118, 1–18, doi:10.1002/jgrf.20044, 2013

Dynamic (in)stability of Thwaites Glacier, West Antarctica

B. R. Parizek,[1] K. Christianson,[2,3] S. Anandakrishnan,[2] R. B. Alley,[2] R. T. Walker,[2,4] R. A. Edwards,[5] D. S. Wolfe,[6] G. T. Bertini,[7] S. K. Rinehart,[8] R. A. Bindschadler,[9] and S. M. J. Nowicki[9]

Also, Nowicki et al., 2013, JGR, "SeaRISE"



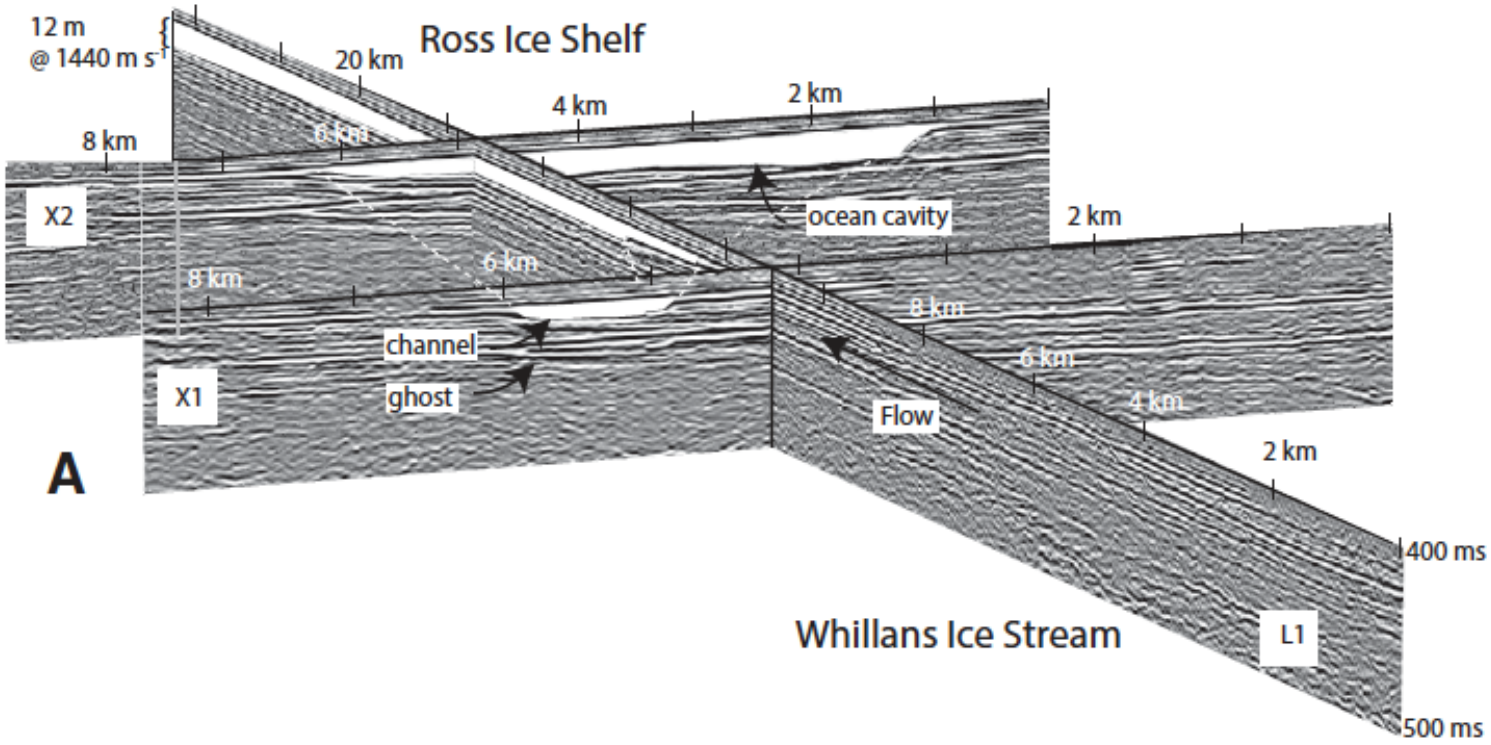
If ocean melting of ice shelves is restricted to fully floating regions beyond a grounding line, no huge changes over ~100 years.

If ocean melting can reach inland across a grounding zone, large melting can cause huge changes rapidly.

Estuaries beneath ice sheets

Geology, preissue publ Sept. 6, 2013

Huw J. Horgan[1], Richard B. Alley[2], Knut Christianson[3], Robert W. Jacobel[3], Sridhar Anandakrishnan[2], Atsuhiro Muto[2], Lucas H. Beem[4], and Matthew R. Siegfried[5]



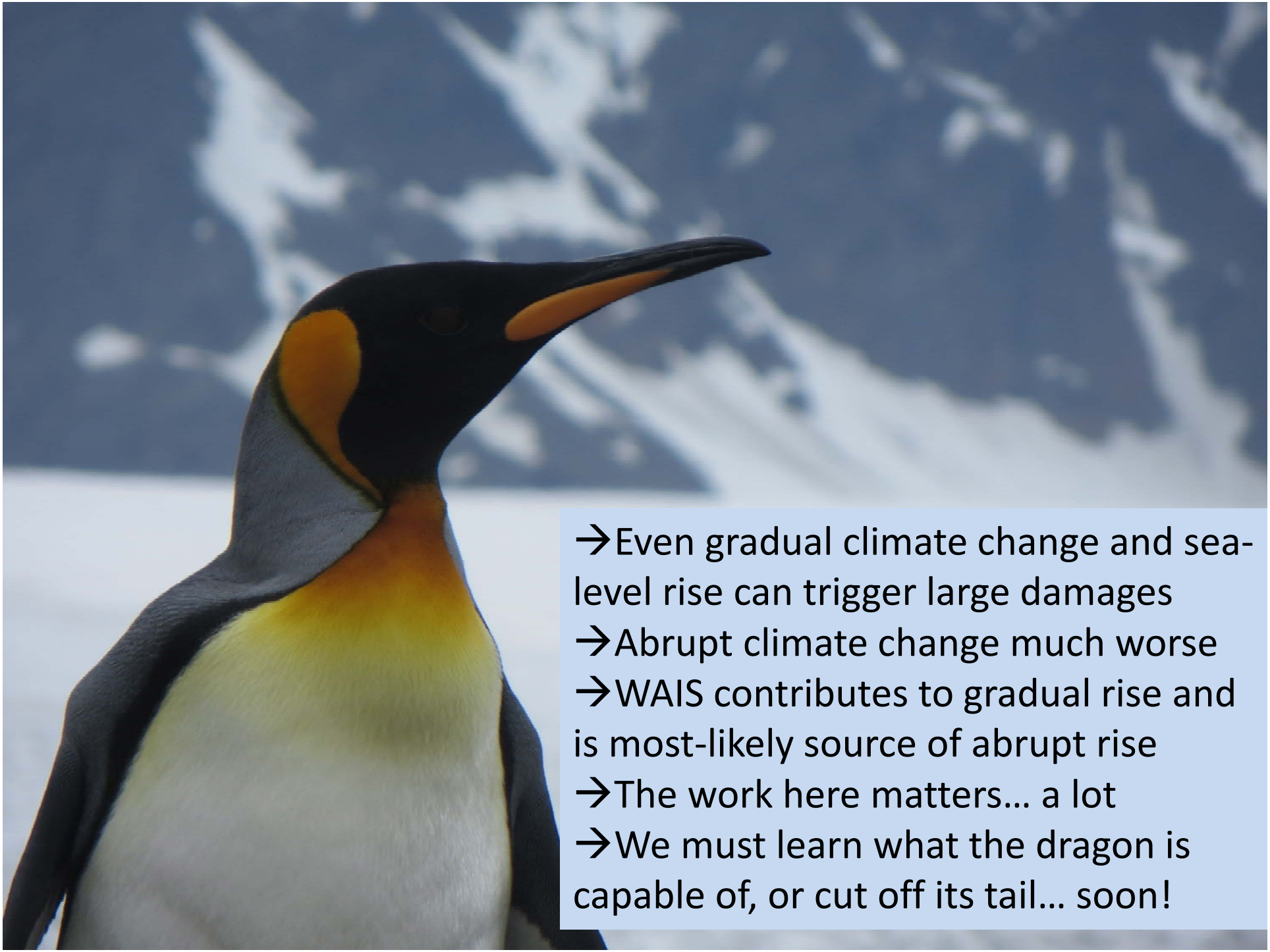
Ice-shelf flexure extends inland, pumping water.

Channels cross the grounding zone.

Lakes open behind grounding “lines” during thinning.

Ocean CAN reach inland.


Too-thin or too-short
ice shelves break off.
Too-high ice cliffs fail.



→Even gradual climate change and sea-level rise can trigger large damages
→Abrupt climate change much worse
→WAIS contributes to gradual rise and is most-likely source of abrupt rise
→The work here matters… a lot
→We must learn what the dragon is capable of, or cut off its tail… soon!

Abrupt Climate Change and WAIS; R.B. Alley and J.W.C. White; Penn State and CU

The concept of abrupt climate change has expanded greatly from its roots in North Atlantic circulation changes. Humans tend to focus most on how environmental change will affect us, our health and happiness, and how they are supported by economies and ecosystems. We build for the world we have, so at least in the short term most changes tend to be costly, but we are relatively skilled at adapting to sufficiently slow environmental changes that we see coming. Fast and unforeseen changes are thus especially damaging. Such abrupt changes can be caused by abrupt forcing—a meteorite impact or explosive volcanic eruption, for example. Or, slow changes in the physical environment can cross a threshold that triggers abrupt physical change, such as increasing meltwater into the North Atlantic triggering a "shutdown" with great extension of wintertime sea ice, leading to changes around the globe. But, even in the absence of abrupt physical thresholds, slow climate change may push ecosystems or economies or parts of the built environment across thresholds—either a storm surge will overtop a levee in New Orleans or the entrance to the New York subway system, or it won't, and the sea-level rise since the last design changes may be really important.

WAIS continues to play a major role in understanding and projecting abrupt changes. The paleoclimatic results from the WAIS Divide core and other studies are revealing key details of the ice-age events once viewed through a primarily North Atlantic lens. The real potential for large, rapid and difficult-to-predict sea-level rise from WAIS changes, shown through history, ongoing changes, physics and models, presents major challenges on multiple levels. Additional issues motivate continued vigorous research and communications efforts.