

NGSS Webinar:

Quickly Increasing Anthropogenic Global Warming Acceptance: Five Experimentally-Vetted Methods and HowGlobalWarmingWorks.org

November 8, 2018

1:00 PM Pacific | 2:00 PM Mountain | 3:00 PM Central | 4:00 PM Eastern

The image shows a Zoom meeting toolbar with several icons: Unmute (with a red slash), Start Video (with a red slash), Invite, Participants (with a '2' icon), Share Screen, Chat, Record, and Leave Meeting. Below the toolbar are three callout boxes with arrows pointing to specific icons:

- Unmute/Start Video:** Please leave your **audio muted** and **video off** (both indicated by a red slash).
- Participants:** Click to open the **Participants** box. This will allow you to give nonverbal feedback. Below this is a sub-panel showing icons for: raise hand, yes, no, go slower, and go faster.
- Chat:** Click to open the **Chat** box. This will allow you to chat with Hosts and Participants. Below this is a sub-panel showing: To: Everyone, Type message here..., and a More dropdown arrow.

This webinar is being recorded

Quickly Increasing Anthropogenic Global Warming Acceptance: Five Experimentally-Vetted Methods and HowGlobalWarmingWorks.org

November 8, 2018

1:00 PM Pacific | 2:00 PM Mountain | 3:00 PM Central | 4:00 PM Eastern

Organizers:

Aida Awad, NAGT Past President / Secretary/Treasurer

Ed Robeck, American Geosciences Institute

Carla McAuliffe, NESTA Executive Director

Jessica Bean, UCMP Berkeley

Andrew Haveles, SERC/NAGT



Webinar overview:

- Welcome and introductions
- Presenter:

Michael Ranney
UC Berkeley

- Discussion and Q&A
- Post webinar survey link: <http://nagt.org/212735>

Upcoming Events & Resources:

➤ Future Events:

- AGU GIFT Workshop: December 11, 10-11:30 a.m.
 - Earth Science All Around: Using 360 Imagery To Support Place-based Instruction
- January NGSS-ESS webinar: Title TBA soon!
 - Save the date: January 10, 2019, 4 p.m. ET, 1 p.m. PT

➤ Not too late ... did you miss a previous webinar? You can still view the archived versions here:

- <http://bit.ly/webinarngss>

Please feel free to type your questions into the chat box during the webinar.

Today's presentation:

Quickly Increasing Anthropogenic Global Warming Acceptance: Five Experimentally-Vetted Methods and
HowGlobalWarmingWorks.org

Presented by: Michael Ranney, UC Berkeley



Quickly Increasing Anthropogenic Global Warming Acceptance: Five Experimentally-Vetted Methods and HowGlobalWarmingWorks.org

by

Michael Andrew Ranney

University of California, Berkeley

With

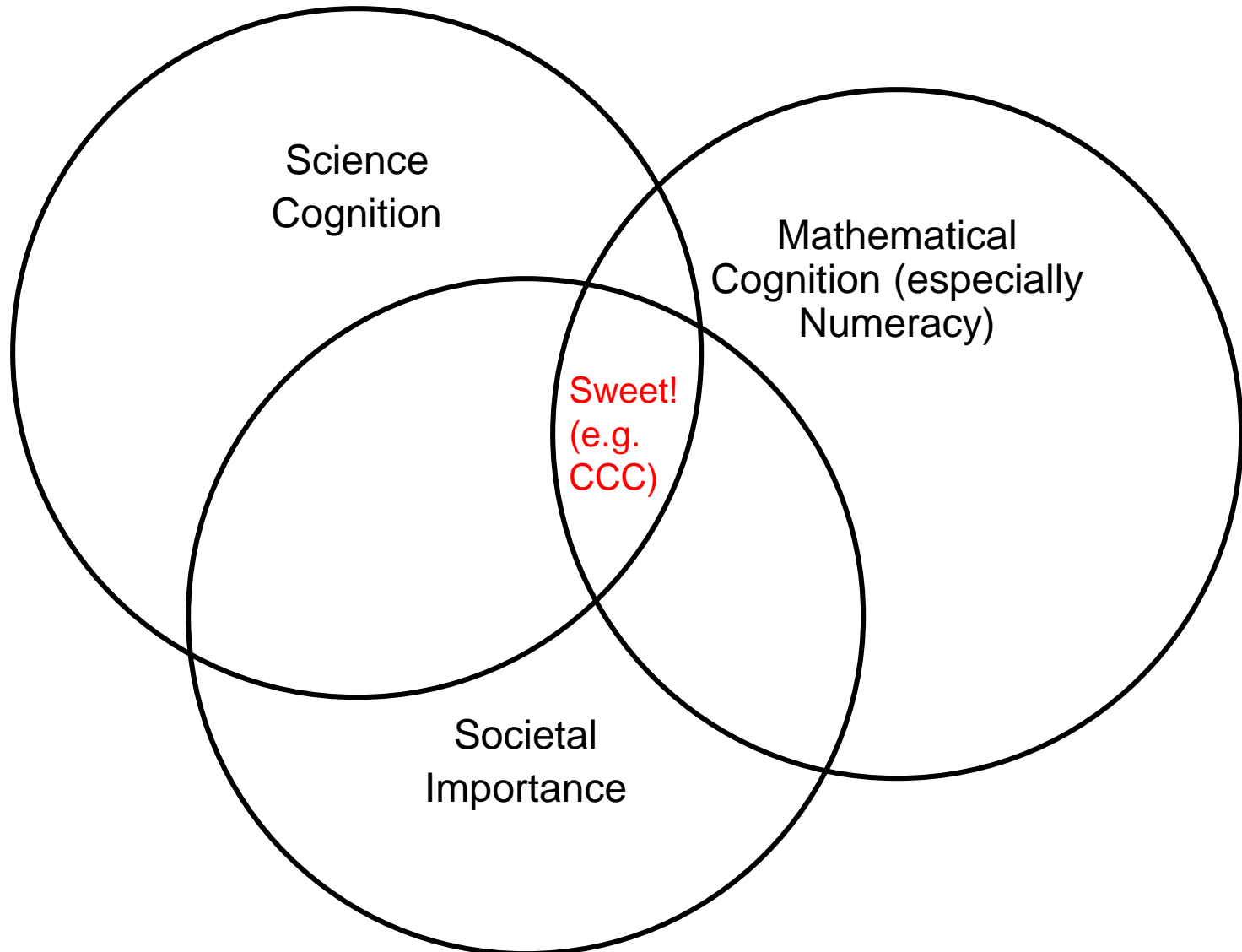
Lee Nevo Lamprey, Leela Velautham, Paras Kumar, Quin Brow, Kristy Drutman, Zerui Ma, Aditya Ranganathan, Katherine Eddinger, Ed Munnich, Charles Chang, Tommy Ng, JustinTeicheira, Tina Luong, Dav Clark, Kyle Fricke, Matthew Shonman, Oliver Arnold, B. Shirley Hu, Ryunosuke Fujinomaki, Emily Yan, Liam W. Gan, Lisa Zhang, Daniel Reinholz, Lloyd Goldwasser, Sarah Cohen, Kimberly Le, Rachel Ranney, E. Harrison, A. Payne, T. Lombrozo, B. Rai, T. Palhovskaia M. Labadi., M. Beale, P. Schank, F. Kaiser, L. Gierth, the Reasoning Group, & many others.

See, e.g.: [Ranney, M. A. & Clark, D. \(2016\). Climate change conceptual change: Scientific information can transform attitudes. *Topics in Cognitive Science*, 8, 49-75.](#)

And: [Ranney et al. \(2016\). Increased wisdom from the ashes of ignorance and surprise: Numerically-driven inferencing, global warming, and other exemplar realms. *The psychology of learning and motivation*, 8, 49-75.](#)

Current Reasoning Group Interests

The Intersection of Euler Circles & the sweet spot of **Climate Change Cognition**:



First-Person Experience: Choose for Yourself!

Which of these graphs represents the change in Earth's Surface Temperature?

...And which is the change in the (Adjusted-Inflation) Dow Jones Industrial Average?

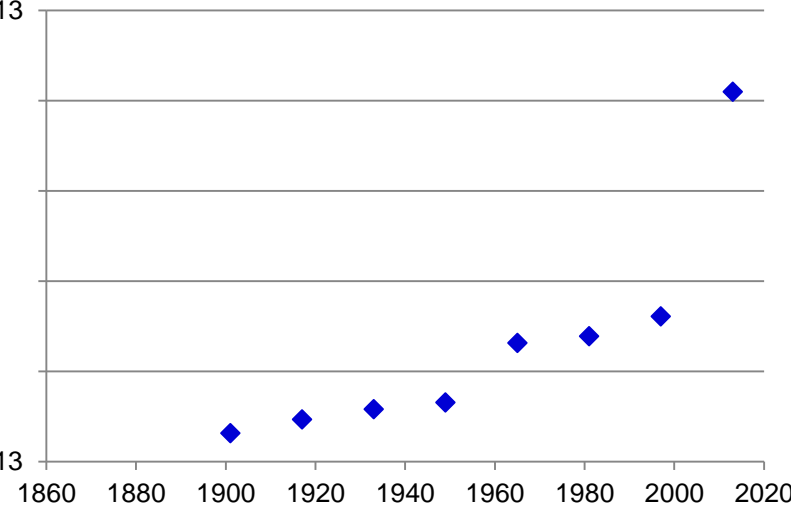
(Each point represents
16 years of data)

The graphs: **rising**, **dropping**, or flat?

Nb: +6°C = a 109.4°F body! (from 98.6°F)

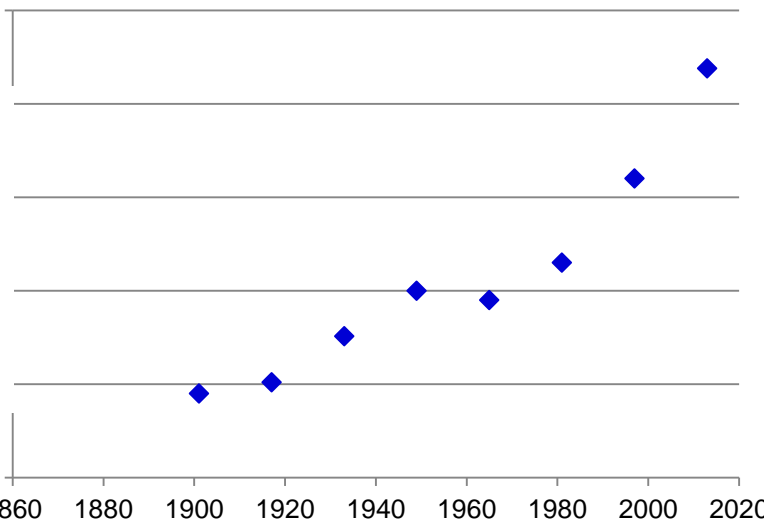
See Ranney et al., 2016

Max of Period 1880 to 2013



Min of Period 1880 to 2013

Max of Period 1880 to 2013



Min of Period 1880 to 2013

Such “Bex” graphs represent our “fifth way” of increasing global warming knowledge (inspired by Lewandowsky, 2011)!

[cf. MS-ESS3-4 ... HS-ESS3-6]

An (“If we had time”) Talk Outline re: **Five Ways**

- Background: The US “diverges” from peers nations (e.g., on GW); Changeable?
- A psychology-in-the-public-interest approach to Climate Change denial
 - * A Key: (Basically) No Deceptions! “You can share this w/ your family now!”
- Dearth of Climate Change knowledge: in San Diego, Germany, Japan, etc.
- ~7 400-word Mechanism Expt.s: CA, TX, German, US-MTurk samples
 - Huge increases in knowledge; increases in GW acceptance & concern
 - M-Turk Expts: similar gains bet. Conservatives & Liberals, no polarization
 - No stasis, good longevity! Studies used test-delays of up to 34 days
- Connecting GW work with NDI (Numerically Driven Inferencing): Stats, graphs
 - E.g.: 11th-grade curriculum w/ both Mechanism & Diagnostic numbers
 - 3 Representative-Statistics NDI Studies (e.g., about GW’s effects so far)
 - Also Other Statistics (e.g., re: Sea-Level Rise, along with map-projections)
 - Bex/graphs studies neutral-method on determining trends via Averaging
 - HowGlobalWarmingWorks.org: Direct-to-the-public, Now in **Mandarin**, etc.
 - A new mega-study comparing “dosages” of videos, texts, & stats
- Connections to NGSS Performance Expectations [5-ESS2-1 . . . HS-ESS3-6]
- Conclusions & Implications

NGSS Earth's Systems Performance Expectations that are relevant to our research & HowGlobalWarmingWorks.org

- **5th grade: 5-ESS2-1.** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
- **Middle School: MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- **Middle School: MS-ESS3-5.** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
- **High School: HS-ESS2-4.** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- **High School: HS-ESS3-1.** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- **High School: HS-ESS3-5.** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.
- **High School: HS-ESS3-6.** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Motivation, Science-Defamation, and a Pledge

- Real scientists overwhelmingly wish global warming weren't true
 - Especially parents—or people who care about “eating-while-old”
 - Also, PhD's have very low joblessness & quite-high job satisfaction
 - So, climate scientists can do other things & still get good pay!
 - Impugning climate scientists' goals = libel (i.e., passing falsehoods)
- I'd be ecstatic if human-caused GW weren't happening
- Thus, my **pledge**: (a) rent, (b) kiss, (c) cessation, & (d) give \$'s back.
 - Disconfirming GW → “Most famous scientist alive”
 - Heck, I'd (e) split half of the Nobel money!
- Still, misleading (e.g., cherry-picked) information is ubiquitous
 - E.g., about scientists' “bias”

Non-Stasis; that is: “People/Societies Change”

- Most companies & (all?) countries would love to disconfirm GW
 - You-know-who companies (even many that “publicly” accept GW)
 - Many nations: Iran, Russia, Saudi Arabia, Venezuela, Iraq, Norway, . . .
 - But why hasn’t GW been disconfirmed GW, given that all want that?
- The good news: People/societies learn; they are not in stasis!:
 - E.g., Galileo’s heliocentrism vs. Papal power
 - Cf. Smoking-causes-cancer vs. Tobacco money
- So, maybe knowledge helps re: climate, as w/ planets & smoking!
 - False dichotomy on attitudes from culture vs. info (cf. Kahan)
 - Compare to nature-nurture false-dichotomy
 - But cf. Kahan on MD’s & geo-engineering, though
- We can fix global warming “easily” (or at least “readily”!):
 - Switch our **\$5T/yr Fossil Fuel subsidy**—into solar & wind for all
 - For only ~ **\$45T - \$125T** in total (instead of 9-25 more subsidy yr.s)
 - Let’s become the (new) greatest generation!

How is it that Earth is getting hotter?

What' s the physical/chemical mechanism?

1. How would you explain how climate change occurs?
 - Think about this for 10 seconds!
2. Why does heat have a hard time getting away from Earth' s surface and troposphere?
 - Shouldn' t heat have just as hard a time getting in?
 - Why the asymmetry?

How Global Warming Works: *Climate Change's Mechanism Explained*

(From HowGlobalWarmingWorks.org,
part of the CLEAN Network)

How Global Warming Works: *Climate Change's Mechanism Explained*

(From HowGlobalWarmingWorks.org,
part of the CLEAN Network)

Haiku version (not given to participants):

**Earth turns sunlight to
IR light that's sponged by folks'
Greenhouse gases glut.**

[5-ESS2-1; MS-ESS3-4 & -5; HS-ESS2-4, HS-ESS3-5 & 6]

Highlighting the 35-Word Summary from our 400 words

How does climate change (“global warming”) work? The mechanism of the greenhouse effect

[Or: “Why do some gases concern scientists—like carbon dioxide (CO₂)—but not others, like oxygen?”]

Scientists tell us that human activities are changing Earth’s atmosphere and increasing Earth’s average temperature. What causes these climate changes?

First, let’s understand Earth’s “normal” temperature: When Earth absorbs sunlight, which is mostly visible light, it heats up. Like the sun, Earth emits energy—but because it is cooler than the sun, Earth emits lower-energy infrared wavelengths. Greenhouse gases in the atmosphere (methane, carbon dioxide, etc.) let visible light pass through, but absorb infrared light—causing the atmosphere to heat up. The warmer atmosphere emits more infrared light, which tends to be re-absorbed—perhaps many times—before the energy eventually returns to space. The extra time this energy hangs around has helped keep Earth warm enough to support life as we know it. (In contrast, the moon has no atmosphere, and it is colder than Earth, on average.)

Since the industrial age began around the year 1750, atmospheric carbon dioxide has increased by 40% and methane has increased by 150%. Such increases cause *extra* infrared light absorption, further heating Earth above its typical temperature range (even as energy from the sun stays basically the same). In other words, energy that gets to Earth has an even *harder* time leaving it, causing Earth’s average temperature to increase—producing global climate change.

[In molecular detail, greenhouse gases absorb infrared light because their molecules can vibrate to produce asymmetric distributions of electric charge, which match the energy levels of various infrared wavelengths. In contrast, non-greenhouse gases (such as oxygen and nitrogen—that is, O₂ and N₂) don’t absorb infrared light, because they have symmetric charge distributions even when vibrating.]

Summary: (a) Earth absorbs most of the sunlight it receives; (b) Earth then emits the absorbed light’s energy as infrared light; (c) greenhouse gases absorb a lot of the infrared light before it can leave our atmosphere; (d) being absorbed slows the rate at which energy escapes to space; and (e) the slower passage of energy heats up the atmosphere, water, and ground. By increasing the amount of greenhouse gases in the atmosphere, humans are increasing the atmosphere’s absorption of infrared light, thereby warming Earth and disrupting global climate patterns.

Shorter summary: Earth transforms sunlight’s visible light energy into infrared light energy, which leaves Earth slowly because it is absorbed by greenhouse gases. When people produce greenhouse gases, energy leaves Earth even more slowly—raising Earth’s temperature.

* Which part(s) of this does Donald Trump not accept? A Chinese Hoax?

How is it that Earth is getting hotter?

What' s the physical/chemical mechanism?

1. How would you explain how climate change occurs?

- Think about this for a bit!

2. Why does heat have a hard time getting away from Earth' s surface and troposphere?

- Shouldn' t heat have just as hard a time getting in?
- Why the asymmetry? **Do atmospheric molecules know “up” vs. “down”?**

Bonus: Are all gases “greenhouse gases” (GHGs)?

If not, what makes something a greenhouse gas?

Is O₂ a greenhouse gas? Is N₂? Is CH₄?

*** Videos narrated by Daveed Diggs (“Hamilton” Tony; “Blackish;” “Blindspotting”); storyboard & prototype by Rachel Ranney**

“Expert” Opinions

#1: “Wow, I guess I don’ t know the right answer!”

-- A 6th-year Environmental Sciences grad student

#2: “No, it’ s not ‘alright’ that I didn’ t know! You don’ t understand; I’ ve published papers about global warming!”

-- A famous colleague

#3: “Having spent nearly 20 years as a research scientist at UCSD's Scripps Institution of Oceanography . . . Certain emissions caused by *human activities have caused the "greenhouse effect"* and have been shown (with excellent scientific evidence) *to have affected the ozone layer* and contributed to global warming.”

-- A San Diego participant

Nope! #3 Confused greenhouse effect with global warming; also global warming is not due to ozone depletion.

270 San Diegans' (Mis)conceptions

- When asked the “mechanism” questions:
 - None (0!) of the 270 were *basically* correct re: global warming!
 - None of the 270 mentioned the visible --> infrared change
 - Most wrongly believed ozone depletion to be a major cause of climate change cause
- (We got similar results from 11th-grade chemistry students)
- It's odd that journalists & teachers haven't informed us!
- Glob. Warm. acceptance is linked to mechanistic knowledge
 - This link has now (2014) been replicated in Germany
 - Our effect has again (2014) been replicated in the U.S. (mTurk; $r \sim .5$)
 - Our findings conflict with “stasis view”—cf. Dan Kahan (2014):
“Efforts to promote scientific literacy can't be expected to dissipate ... public conflict over climate change.” (but cf. his other thoughts/findings)
- The San Diegans had modest knowledge, even though:
 - Most “strongly agreed” that global warming is occurring, and
 - Almost half “strongly agreed” that “Human activities are a significant cause of global warming.”
- So, why not just tell folks **how** climate change truly **works**?

What if we just told folks the mechanism? (5-7X Replicated) 400-word “Jam” expt.

- Does mechanistic ignorance (partly) explain the U.S. reluctance to accept Climate Change?
- A causal question? Time for an experiment!
- Metaphor: A “test” is a slice of bread
 - Intervention is the “jam”
 - “Sandwich” (S) group:
 - (*pre-test*) Knowledge and attitude
 - 400-word Description
 - (*post-test*) Knowledge and attitude
 - Another, “no-pretest,” group was used as a control & for replication

They Knew Way More After 400 Words!

I.e., giving folks the mechanism worked,
as *Knowledge doubled-to-tripled* (***p*'s < .01)

	Before Description	After Description
Light (visible ⇒ infrared)	20%	56% **
GHGs	27%	63% **
Energy Dynamics	19%	48% **

... and Knowledge correlates w/ GW Acceptance—both as occurring and anthropogenic, as in our San Diego data (*cf. stasis!*)₂₁

“But wait!” Learning the Mechanism Increased Climate Change Acceptance!!

- Participants closer to “extreme agreement” with Climate Change items:
 - UC Berkeley undergrads shifted, on average, 14% ($p = 0.01$)
 - UT Brownsville students shifted, on ave., 20% ($p < 0.0001$)
- So, (a) not only did we show that GW-learning is possible—
(b) attitude change is possible, too—**disconfirming stasis theory!** 😊
- [It worked w/ heliocentrism & the smoking-cancer link, too!]
- Also, both knowledge and acceptance predict folks’ global warming “willingness to sacrifice” (our S.D. data show)
- **Knowledge & Acceptance both corr. w/ Envir. Att./Behavior (German data)**
- Longevity: Ranney & Clark’s Expt. 5 (2016) showed & replicated the changes’ durability (in *Topics in Cognitive Science*)
 - Notable attitude & knowledge gains even after 5.5 - 9 days (US M-Turk sample) and **34 days** (high school chemistry students); p ’ s < .01
- Such findings disconfirm (a) “stasis theory”—which suggests futility in boosting public climate wisdom—and (b) polarization (cf. Kahan)

No Polarization From Mechanistic Info

- Change in acceptance was not negative for conservative political party members
- This coheres with a mega-study (N ~ 1100) we ran with 18 interventions, with **immediate** & **9-day** post-tests:
 - Democratic +.29 +.20
 - Republican +.31 +.30
 - Independent +.21 +.22
 - Libertarian +.40 +.46
 - Tea +.36 +.44
 - And the correlation between acceptance change & conservatism (both economic and social) was significantly positive after 9 days ($r \sim .1$, $p < .05$)

More “Evidential” Studies: Merging RTMD With NDI (Numerically Driven Inferencing)

Estimate this:

What has been the change in Earth’s atmospheric methane concentration since 1750 CE?

+/- ___%

Is it +5% ?

What would you think if the answer were:

+151% ?

...because it **is!**

Would you boost the \$’s you’ d give to stop climate change?

Merging NDI (e.g, *MoreNumerate.org*) with our experimental Climate-Change-Cognition methods

Somewhat like our “Sandwich” Mechanism group:

- Attitudes (& Knowledge) pre-test
- 7-9 estimation items w/ “why” rationales
- Then the feedback # for each estimate
- Attitudes (& Knowledge) post-test

Relevant NGSS Earth Systems’ Performance Expectations:

- * MS-ESS3-4 & -5; HS-ESS3-5 & -6

7-9 Representative Numbers (alone) Can Increase GW Acceptance! Three examples

1) Based on a set of 1372 researchers who are actively publishing in the field of climate research, **98%** believe in human-caused climate change (published in the *Proceedings of the National Academy of Sciences*). (Cf. Leiserowitz, Maibach, et al.; Cook, Lewandowsky et al.)

2) According to a published 2009 study using 9 years of data from the National Oceanic and Atmospheric Administration (NOAA), there were **204** record temperature *highs* observed in the U.S. for every 100 record temperature lows.

3) According to the National Climatic Data Center, including January of 2015, **358** of the last 358 months have been above that 20th-century average.

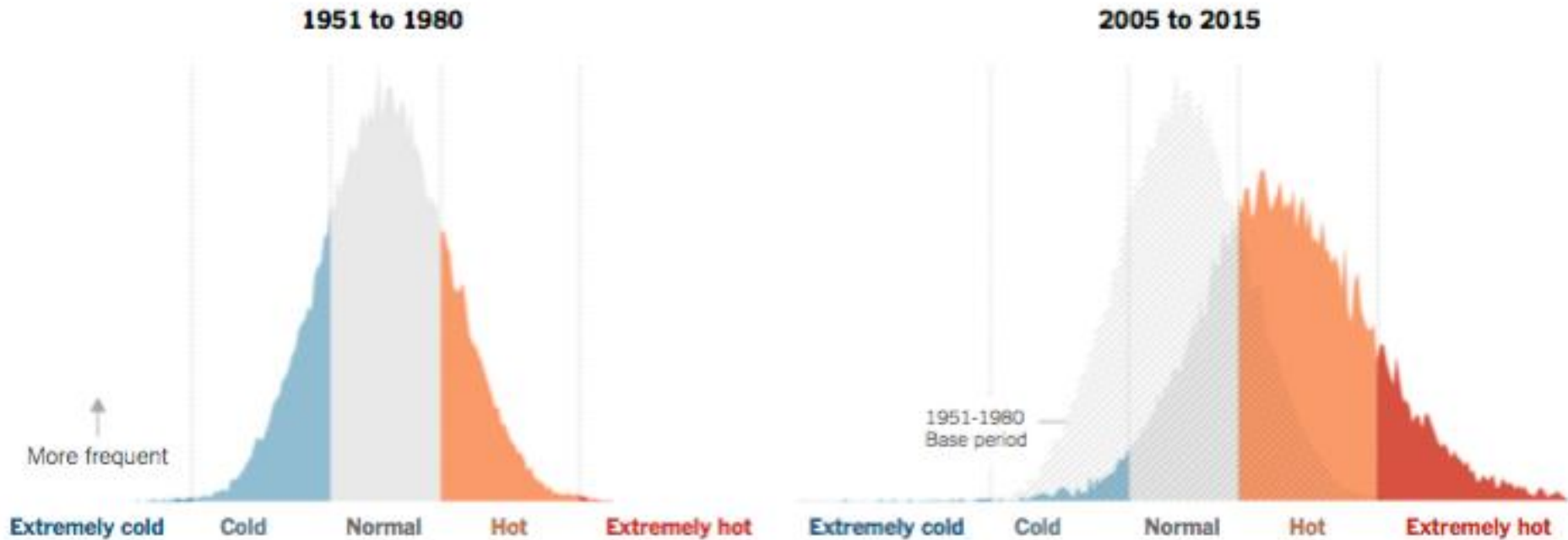
Cf. My “40 Numbers That Everyone Should Know But Most People Don’t” (2014 Data: Fukushima-affected people also underestimate GW’s effects)

!! Ranney & Clark ‘16: Such statistics **increase global warming acceptance in a wider (US M-Turk) sample ($p = .002$)**

*** Also—again, **no** polarization ($r \sim 0$; i.e., $r = -.07$; $p = .67$, ns)**

!! Twice replicated! And a **28% gain of what’s possible—even **9 days later** (Ng, ‘15; Ranney et al., 2016)**

Here's another way to think about Stat #2, but just looking at summer temperatures:



Seven Good, Experimentally-Vetted, Statistics:

A 2010 article examined the 908 active researchers with at least 20 climate publications on Google Scholar. What percentage of them have stated that it is “very likely” that human-caused emissions are responsible for “most” of the “unequivocal” warming of the Earth in the second half of the 20th century? **97.5%**

Global surface temperatures have been recorded since 1880. According to the U.S Government's National Climatic Data Center, how many of the years between 1995-2014 (a 20 year period) were among the hottest 20 years recorded? **19 years**

The U.S. Geological Survey provides us with data about the glaciers in Glacier National Park. In 1850 there were approximately 150 glaciers present in Glacier National Park. How many are present today? **25 glaciers**

The European Environmental Agency provides us with data about volume of glaciers in the European Alps. From 1850 to 2013, what was the percent change of volume of glaciers in the European Alps? **65% decrease**

The Intergovernmental Panel on Climate Change provides us with data about the atmosphere's level of methane. What has been the change in the amount of atmospheric methane (a greenhouse gas) since 1750? **151% increase**

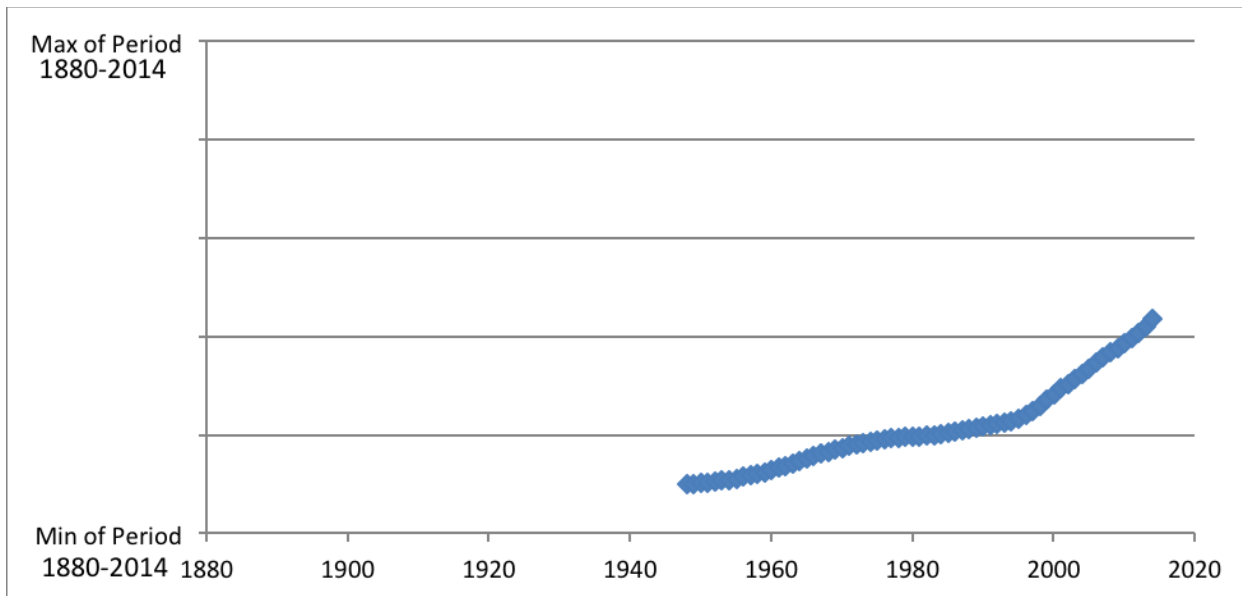
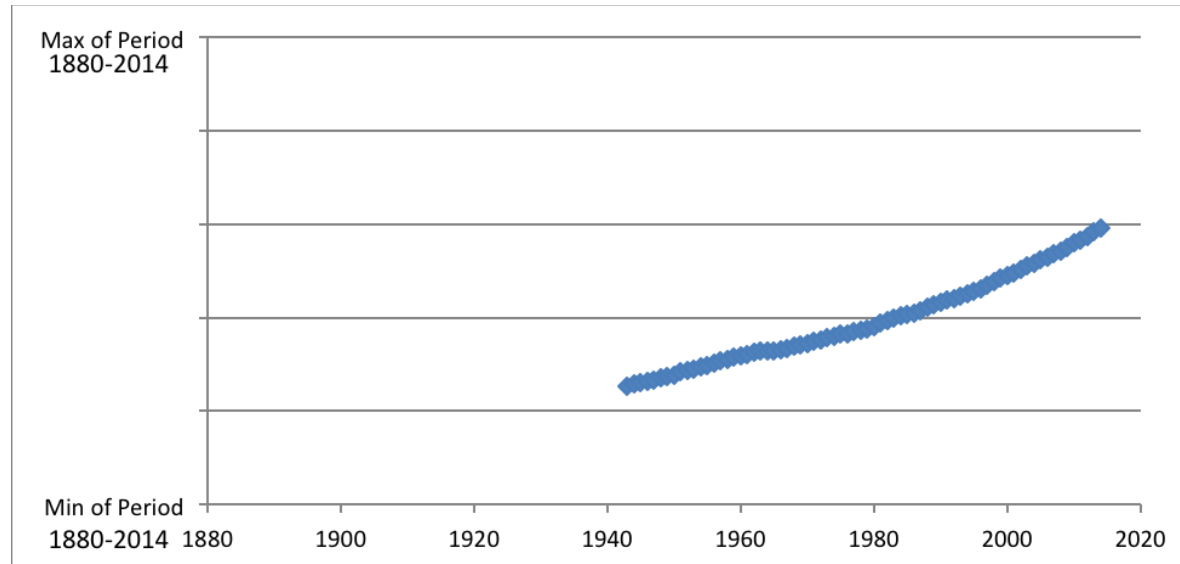
January of 2015 was above Earth's 20th-century average monthly temperature, according to the NCDC (National Climatic Data Center). According to the NCDC, including January of 2015, how many of the last 358 months have been above that 20th-century average? **358 months**

The federal National Oceanic and Atmospheric Administration (NOAA) observes temperatures at almost 2000 U.S. locations. According to a published 2009 study using 9 years of NOAA data, how many record temperature highs were observed in the U.S. for every 100 record temperature lows? **204 record temperature highs**

Returning to the Graphs: “Bex” Stories Were Compelling Even 9 Days Later

- Our (Chang/Ranney) reasoning: (a) It’s pretty obvious, visually, that both Temp & DJIA-Adj graphs are **rising** (Visual Evidence). (b) If one can’t be sure which is which, and they both seem to rise, then infer this: Temperature has been **rising** (Evidence+Logic). (c) If you firmly believe that DJIA-Adj has been rising and you have a hard time discriminating the graphs (even if you aren’t sure they are rising), then infer this: Temperature has been **rising** (Evidence+Logic).
- We tried 10 Bex interventions of different extents (N ~ 750)
 - “Full Sandwich” included: (1) Pretest/Posttest/DelayedPosttest, (2) 1,4,8,16,64-year averaging, (3) Span and Moving averages, and (4) Correct Feedback.
- Each intervention yielded robustly **signif. GW acceptance gains even after 9 days**
 - The 2 Full groups showed 26% denial reduction (i.e., increase w.r.t the possible gain) in GW Acceptance, even after 9 days

Bex's 64-year Moving averages



[cf. MS-ESS3-4
... HS-ESS3-6]

- Which is temperature and which is the DJIA(-inflation-adjusted)?
- The Bex curricula's GW acceptance-gains *again* show no polarization!

Our Interventions' Successes Led to: HowGlobalWarmingWorks.org

... A “Direct-to-the-Public” Wisdom Boost

- Part of the CLEAN network! (<https://cleanet.org/resources/56031.html>)
- [Grab a card, if you wish] **HGWW** explains GW' s physical-chemical mechanism
- Avoids the middlefolk of (data show) suboptimal instructors/ journalists
- We hope to make Global Warming “**round-earth evident**”
- Please go to the site and (if you would) share the link!
- So far, we have over 300,000 page-views (site + videos)
 - ✓ From 200 countries and over 20,000 towns
- If one adds in page-views about our videos, it' s well over 1,000,000
- We' re analyzing/incorporating the many comments generated
 - ✓ Few deniers; the main comment is “Thanks! This is great.”
 - ✓ Non-public comments seem different from public (e.g., NPR.org) ones
 - ✓ We' re analyzing **Chinese** comments (Gan, etc.); even Chinese deniers!
- We' ve included 7 Representative Statistics you can pass along!
- We' ve now added some Bex Graphs you can pass along!!

How Global Warming Works



VIDEOS TRANSCRIPTS 7 NUMBERS 35 WORDS 400 WORDS TRANSLATE FEEDBACK

This site's information helps people understand global warming's scientific mechanism.

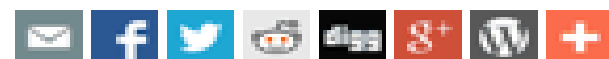
The 5 videos below explain how global warming (related to climate change) works in as few as 52 seconds. Even our most chemistry-rich video is less than 5 minutes long. Please click on the version you want to watch.

Global Warming In Under 5 Min.	Global Warming In Under 4 Min.	Global Warming In Under 3 Min.	Global Warming In 1.2 Min.	Global Warming In 52 Sec.
---------------------------------------	---------------------------------------	---------------------------------------	-----------------------------------	----------------------------------

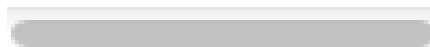
For a more full explanation, click on a longer version. For a more summarized explanation, watch a shorter version. Please [vote here](#) for your favorite video.

If you prefer to read an explanation, we now have several options available online: the [script](#) of the video, the [400-word explanation](#) the videos are based on, and the [35-word summary](#) (all available in several languages, with more coming soon).

Help spread this information to your family, friends and co-workers. Please [share](#) using any of the choices below or by telling others about [HowGlobalWarmingWorks.org](#).



Like 1.6k



New! Test yourself: Can you tell the difference between a graph of Earth's surface temperate and a graph of the Dow Jones? [Click here](#) to try.

New! [7 Numbers](#) Related to Climate Change.

New! Our site is now available in [Mandarin 中文](#) (with Youku videos). Other languages are also available.

Translate the site:



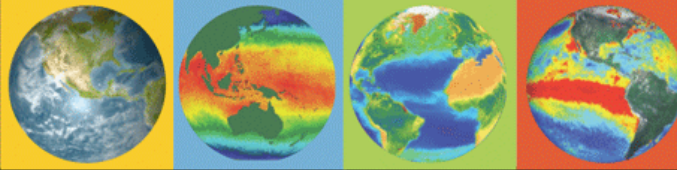
and turn the video captions (cc) on. [Click here](#) for more information about language options.

Coming Soon! New content and languages are on their way. Follow us on Facebook or Twitter for updates:



HowGlobalWarmingWorks.org: Some Features of the 5-minute Version

- HGWW usually crucially first asks for mechanism-guesses
- Makes explicit that we offer “secret knowledge” virtually nobody knows
- 1st big concept: different light yields a (leaky) 1-way valve
- 2nd big concept: global warming is an un-natural, human-caused(!) **extra** greenhouse effect
- Evidential impact: 40% and 3X increases are not trivial
- 2 sentences of technical info (4.7-min. video): Because it’ s real science, and the causal mechanism has many deeper levels!
 - But we got a **significant GW acceptance gain in a video** that excludes the sentences! (Arnold et al., 2014, with our German 4-min. video)
- Please go to HowGlobalWarmingWorks.org & share the link!
- Connections to NGSS Performance Expectations [5-ESS2-1 . . . HS-ESS3-6]



Collection of Climate and Energy Educational Resources

How Global Warming Works

<http://www.howglobalwarmingworks.org/in-under-5-minutes-ab.html>

How Global Warming Works

[Jump to this Video »](#)



This video succinctly explains the mechanism of the natural greenhouse effect and the cause of global climate change (anthropogenic global warming). It is short, basic, and to the point. It's also available in 12 languages!

Video length is 4:44 min. Other video lengths are available.

[Learn more about Teaching Climate Literacy and Energy Awareness»](#)



[See how this Video supports the Next Generation Science Standards»](#)

Middle School: 2 Disciplinary Core Ideas, 1 Cross Cutting Concept
High School: 3 Disciplinary Core Ideas, 1 Cross Cutting Concept

Notes From Our Reviewers

The CLEAN collection is hand-picked and rigorously reviewed for scientific accuracy and classroom effectiveness. Read what our review team had to say about this resource below or learn more about how [CLEAN reviews teaching materials](#)

[Teaching Tips](#) | [Science](#) | [Pedagogy](#) | [Technical Details](#)

Teaching Tips

- Multiple video lengths, all under 5 minutes, are available. Summaries (35 words and 400 words) explain "How Does Climate Change (Global Warming) Work?" Discussion questions are embedded in the video and offer an opportunity to stop the video for student input.

About the Science

- This is a short video that explains greenhouse gases, the greenhouse effect, and anthropogenic climate change. It could be used for a quick introduction for someone who is uninitiated with the topic.
- Comments from expert scientist:
Scientific strengths:
 - Explains how humans have increased GHG emissions and that is the reason why the planet is warming
 - Explains the reason why certain compounds such as methane and carbon dioxide absorb radiation

Topics

- Greenhouse Effect**
See more on this topic.
- Greenhouse Gas Emissions**
See more on this topic.
- Anthropogenic Changes**
See more on this topic.
- Causes of Climate Change**
See more on this topic.

Grade Level

- Middle (6-8)**
See more at this grade level.
- High School (9-12)**
See more at this grade level.
- Informal**
See more at this grade level.

[Climate Literacy](#)

“But Wait! There’s More!”

How Much Would You Pay For a Mandarin Version?”

- HGWW has gone even more international
- A full set of **Mandarin**, Czech, & German set of videos is now up!
 - A Technological/Political Challenge: **China** prohibits YouTube, Facebook, & Twitter—so we use sites such as Youku, Renren, Weibo, etc.
 - China-and-the-US = ~1/3 of Earth’s buying power & ~ 1/4 of humanity
- Good translations of our video-scripts now available for Mandarin, Spanish, **Japanese**, German, **Russian**, Czech, **Trad. Chinese**, etc.; 400 words, too!
- 71 other closed-caption languages ready (albeit Google-translate quality)
- Imminent languages: Portuguese, Arabic, Hebrew, French, Hindi, Korean (and then Thai, Vietnamese, Turkish), etc.
- We need help with Bengali, Arabic, Turkish, Hindi, other common languages
- Our goal modest: 7 Billion unique visitors; so spread the word!
 - This may help yield international agreements to reduce greenhouse gases
 - Sending our videos to your leaders (representatives, senators, president, etc.) can help, as many don’t know the mechanism either



视频 反馈

什么是全球变暖？

这个网站的信息是用来帮助大家了解全球变暖的科学原理的。

下面的五个视频在最短51秒的时间内解释全球变暖（与气候变化有关）是如何形成的。其中最富有化学知识的视频时长也少于5分钟。请点击你最想观看的版本。

什么是全球变暖？



(51秒)

什么是全球变暖？



(1.2分钟)

什么是全球变暖？



(少于3分钟)

什么是全球变暖？



(少于4分钟)

什么是全球变暖？



(少于5分钟)

如果你想得到一个更加全面的解释，请点击时长较长的版本。如果你想得到一个更简短地解释，请点击时长较短的版本。

[请点击这里为你最喜欢的视频投票。](#)

[Site in English](#)



为了让更多人看到这些视频，请用以下任何方式把你认为大家最愿意看的视频分享给你的朋友和同事们。



或把

HowGlobalWarmingWorks.com

告诉其他人。

Global Warming Denial Decrease

(i.e., in % of possible room to increase acceptance; N ~ 1,100)

	<u>Immediate post-test^A</u>	<u>Nine days later^B</u>
All interventions combined^C	10.6 ***	7.5 ***
35 word text	6.2 ^	2.0
400 word text	6.6 ^	6.6 *
596 word text (of 5-min video)	11.2 **	<u>13.6 **</u>
52 second video	11.3 **	5.8 ^
1.2 minute video	-2.2	5.0 ^
Two shortest videos combined	5.0 *	5.4 *
3 minute video	10.3 **	7.6 *
4 minute video	11.5 **	7.3 *
5 minute video	<u>20.7 ***</u>	8.5 *
9 statistics ^C	15.1 **	11.0 **
Control 1 (Mechanism-less Video) ^C	2.0	3.7
Control 2 (No Intervention)	N/A	2.9

^A = Bigger denial-reductions via consolidation using immediate post-tests

^B = Not a single significant decay over the 9-day retention period (n ~ 500)

^C = **Even our 9-statistics & control-video increased knowledge after 9 days**

*, **, *** => respective p' s of .05, .01, and .001; ^ = marginal significance

A Fifth Way via Sea Level Rise:

E.g., Real Estate Losses Due to Sea Level Rise

A peer-reviewed article in Nature (March 31, 2016) projected sea level to rise **6 feet** by the year **2100**.

With these data and elevation maps from the National Oceanic and Atmospheric Administration (NOAA), Zillow.com, a real estate company, calculated property losses based on that 6-foot change to the U.S. coastline: **1.9 million homes** in the U.S. (about **1 in 50 homes**) would be swamped, for a total loss of **\$882 billion dollars**.

State	Number of projected Swamped Properties	% of State's Total Housing Stock Swamped	Value of projected Swamped Properties
1. Florida	934,411	12.56%	\$413 Billion
2. New Jersey	190,429	7.35%	\$93.1 Billion
3. New York	96,708	2.10%	\$71 Billion
4. Massachusetts	62,069	3.10%	\$51.2 Billion
5. California	42,353	0.44%	\$49.2 Billion

From the New York Times (11/24/16):

Over the past five years, home sales in flood-prone areas grew about **25 percent less quickly** than in counties that do not typically flood, according to county-by-county data from Attom Data Solutions, the parent company of RealtyTrac. Many coastal residents are rethinking their investments and heading for safer ground.

Southeast Florida experiences about **10** tidal floods per year now. That number is likely to be around **240** floods per year by 2045, according to climate researchers.

In the past year, home sales have increased **2.6** percent nationally, but have dropped about 7.6 percent in high-risk flood zones in Miami-Dade County, according to housing data.

Nationally, median home prices in areas at high risk for flooding are still **4.4 percent below** what they were 10 years ago, while home prices in low-risk areas are up **29.7** percent over the same period, according to the housing data.

Cf. HS-ESS3-1 (how climate changes have influenced human activity)

Global Sea Level Rise Projections

Recent projections published in the *Proceedings of the U.S. National Academy of Sciences*:

With an extra increase in global mean temperature of 1° C, sea levels would eventually rise 7 feet.

With an increase in global mean temperature of 4° C, sea levels would eventually rise 29 feet.

Note:

Though the study's authors state that sea levels would eventually reach these elevations given a 1° Centigrade and 4° Centigrade increase in global average temperature, they don't predict when this will happen.



Sea levels don't respond immediately to warming, just as an ice cube doesn't melt immediately when removed from a freezer.

The next slides show how much land will be lost in **Florida's bottom half** with these **two** increases in global mean temperature:

SOUTHERN FLORIDA WITH 7 FOOT SEA LEVEL RISE (AFTER 1 °C RISE IN GLOBAL AVG. TEMP.)



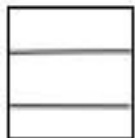
KEY


-  LAND UNDER WATER
-  CITIES

SOUTHERN FLORIDA WITH 29 FOOT SEA LEVEL RISE (AFTER 4 °C RISE IN GLOBAL AVG. TEMP.)



KEY

 LAND UNDER WATER

 CITIES

What if All of Earth's Ice Melted?

**Goodbye to NYC, Boston, Philly, D.C., Savannah,
Florida, New Orleans, Houston, etc.**

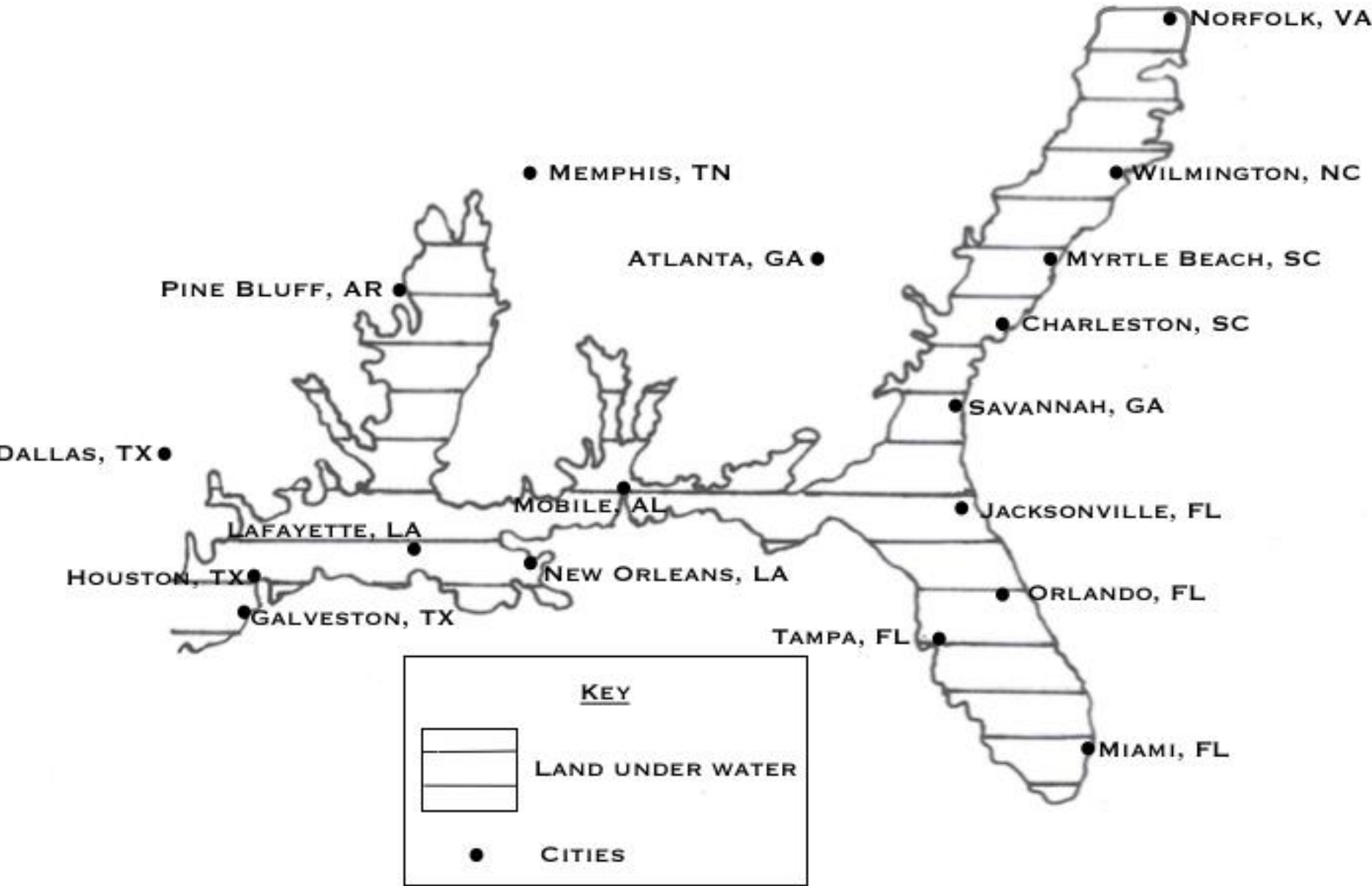
National Geographic recently calculated that a 214 foot sea level rise will occur if all glaciers and land-ice on Earth melted.

(This has happened pre-historically, when Earth was about 12° C warmer. It's meant to give an idea of how coastlines would be changed if all of Earth's solid water became liquid.)

The following slides show the coastline of the Southeastern United States with present day sea levels, and the coastline under 214 foot sea level rise.

Note that Arkansas would have a long ocean shoreline!

SOUTHEASTERN U.S. COASTLINE WITH 214 FOOT SEA LEVEL RISE



By Popular Demand: What Can You Do?

- Tell representatives & senators about your climate concern
- Vote for people who will inhibit global warming the fastest!

More Locally:

- Consider having one fewer child than you initially planned
- Consider having one fewer dog (or cat) than you initially planned
- Eat less GHG-yielding food
 - E.g., less lamb, beef, & non-canned shellfish etc.
- Don't buy dug-up stuff (e.g., gold, silver, diamonds); sell yours?
- According to G. Gardner & P. Stern, these are among the best:
 - Buy a more climate-friendly (e.g., more fuel-efficient) vehicle
 - Insulate—and/or upgrade attic insulation & ventilation
 - Carpool with at least one other person
 - Replace incandescent light bulbs with better ones
 - Get appropriately frequent tune-ups (including air filter changes)

Consider this slogan:

“History Will Not Be Kind to Diehard/Intentional Climate Change Deniers.”

Conclusions, Part 1

- We found that GW acceptance is (replicably) linked to both knowledge and willingness-to-sacrifice re: global warming
- Folks rarely know GW's ("extra greenhouse") mechanism
- But, many can learn it quickly—in a few minutes!! In 400 words!!
- Also in only 400 words—or 1-5-minute videos—we even obtain notable gains in Climate Change acceptance!!
 - Acceptance gains are likely attitude shifts via conceptual change
- Surprise, as in NDI experiments, was increased by asking for participants' knowledge up front (i.e., we controlled it)
- **Estimation-and-Feedback interventions can also effectively shift attitudes & self-assessments (e.g., w/ Representative stats)**
- We can move folks in a "**representative**" direction
- **A 5th way: Coast swamped (& financially harmed) by rising sea levels**
- Connections to NGSS Performance Expectations [5-ESS2-1 . . . HS-ESS3-6₆]

Conclusions, Part 2

- **Bex studies: the averaging idea & the averaged data change minds**
- **Our recent studies are also showing (9-day to 34-day) longevities**
 - **Combining mechanism and statistics seem best**
 - **Stasis theory is rejected; Also: little evidence for polarization**
- **Latest studies: Longer interventions are better, if attentions last**
 - * **Immediate consolidation (e.g., post-test) seems important**
- **A 6th way: Modulating one's sense of Nationalism**
- **A 7th way?: We can inhibit global warming “inexpensively” (~ 9-25 years of fossil fuel subsidy)**
- **A 8th way?: Scientists truly wish GW were false & would disconfirm it**
- **9 through 11?: Carbon DiLoopy? Golden Calf analogy? NTSB & NCA?**
- **We need to get to “tipping points” in many, or all, nations ASAP**
- **7.5 Billion people; they need (e.g., cognitive) scientists' help!**
- **HowGlobalWarmingWorks.org is part of that help ☺**
 - **Now in Mandarin! Other languages, too—and even better soon!**

> **Five Ways & How**GlobalWarmingWorks.org

Scientific / factual info boosts climate change acceptance

- **0% know the easily-learned basic global warming mechanism**
 - The haiku : *Earth turns sunlight to / IR light that's sponged by folks' / Greenhouse gases glut* (Ranney et al., 2016)
- **Mechanistic information breaks ties between competing claims**
 - ~ 500-word **texts** have repeatedly boosted knowledge & acceptance
 - Short (e.g., 1-5 minute) website **videos** yield similar effects
 - Longer videos and texts boost acceptance more than shorter ones
- **Two kinds of 7-9 statistics also boost climate change acceptance**
 - 1) Statistics that mostly involve **climate effects** (now replicated)
 - 2) Info about the **economics of future sea-level rise** (a smaller effect)
- **Temperature-over-time graphs** boost climate change acceptance
 - Temperatures from 1880-2014, with financial-stocks analogs
 - Used 8-year, 16-year, +/- or 64-year, etc., averagings to highlight trends
 - All 10 conditions (e.g., moving average or not) proved successful
- See “HGWW” site, Ranney & Clark, 2016, & Ranney et al., 2016

Thanks a bunch!

Please Share This!:

HowGlobalWarmingWorks.org

... and HowGlobalWarmingWorks.org/Chinese.html

Some recent products:

Ranney, M. A., & Clark, D. (2016). Climate change conceptual change: Scientific information can transform attitudes. *Topics in Cognitive Science*, 8, 49-75.

Ranney, M. A., Munnich, E. L., & Lamprey, L. N. (2016). Increased wisdom from the ashes of ignorance and surprise: Numerically-driven inferencing, global warming, and other exemplar realms. In B. H. Ross (Ed.), *The psychology of learning and motivation*, 65, 129-182. New York: Elsevier.



Post webinar survey:

NGSS Post Webinar Survey

Please reflect on this event and let us know what worked and what needs improvement.

Rate your overall satisfaction with this webinar.

- 4 - Highly satisfied
- 3 - Satisfied
- 2 - Somewhat satisfied
- 1 - Not satisfied

Rate

Rate the content of this webinar in relationship to your work.

- 4 - Highly valuable
- 3 - Valuable
- 2 - Somewhat valuable
- 1 - Not valuable

Post webinar survey:
<http://nagt.org/212735>

Upcoming Events & Resources:

- Future Events:
 - AGU GIFT Workshop: December 11, 10-11:30 a.m.
 - Earth Science All Around: Using 360 Imagery To Support Place-based Instruction
 - January NGSS-ESS webinar: Title TBA soon!
 - Save the date: January 10, 2019, 4 p.m. ET, 1 p.m. PT

- Not too late ... did you miss a previous webinar? You can still view the archived versions here:
 - <http://bit.ly/webinarngss>

Thank you for participating!

Contact information:

Aida Awad: aawad@totheclovedu.com

Edward Robeck: ecrobeck@agiweb.org

Carla McAuliffe: carla_mcauliffe@terc.edu

Jessica Bean: jrbean@berkeley.edu

