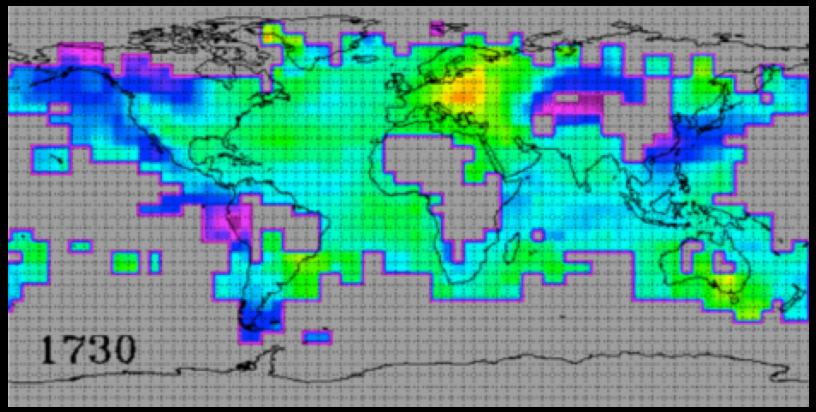
The Past as Prologue: Learning from the Climate Changes in Past Centuries



Michael E. Mann

Departments of Meteorology & Geosciences; Earth & Environmental Systems Institute

Penn State University

with contributions from:

Caspar Ammann, Raymond Bradley, Elizabeth Crespin, Jeff Donnelly, Kerry Emanuel, Fangxing Fan, Jose Fuentes, Hugues Goosse, Malcolm Hughes, Klaus Keller, Andrew Kemp, Stefan Rahmstorf, Scott Rutherford, Drew Shindell, Gavin Schmidt, Ryan Sriver, Eric Steig, Byron Steinman, Axel Timmermann, Jonathan Woodruff, Zhihua Zhang (and others…)

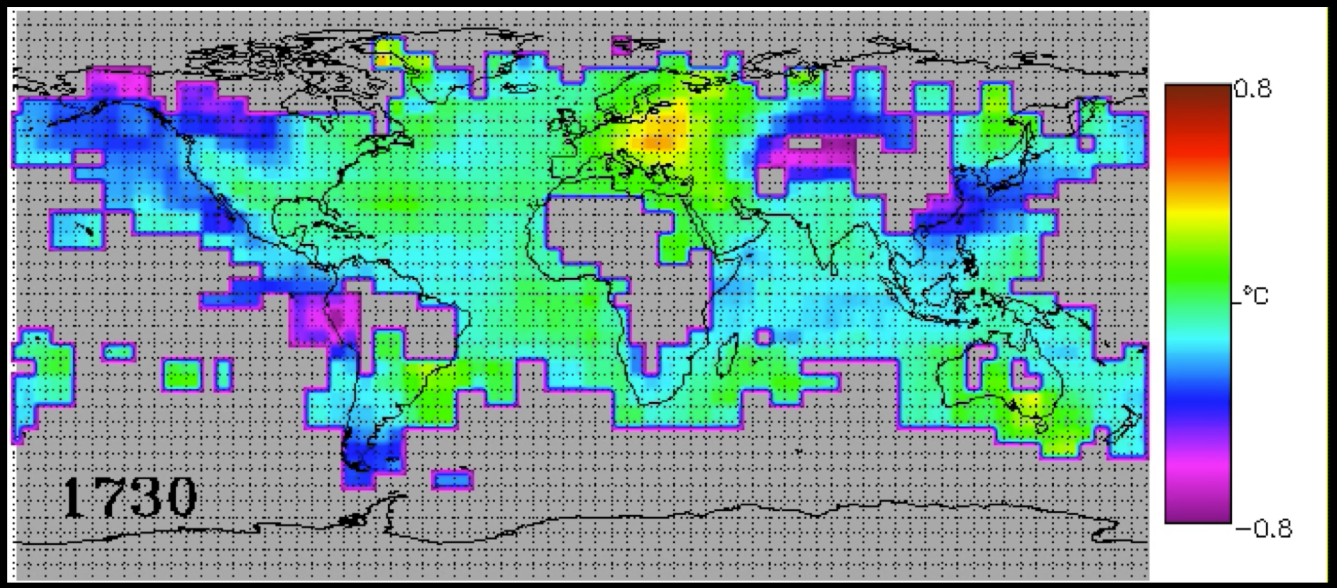
Geology 095 Guest Lecture

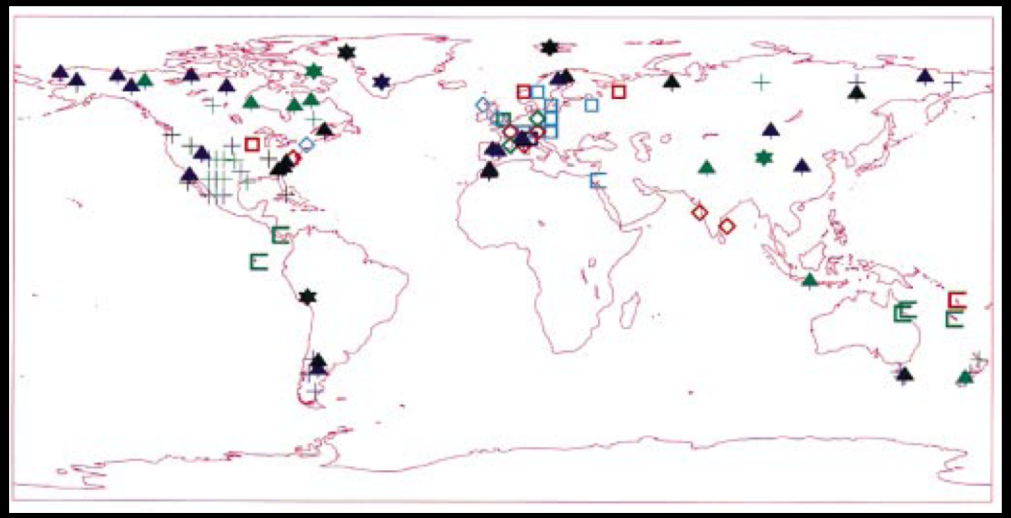
University of Vermont

Burlington VT

Oct 10, 2019

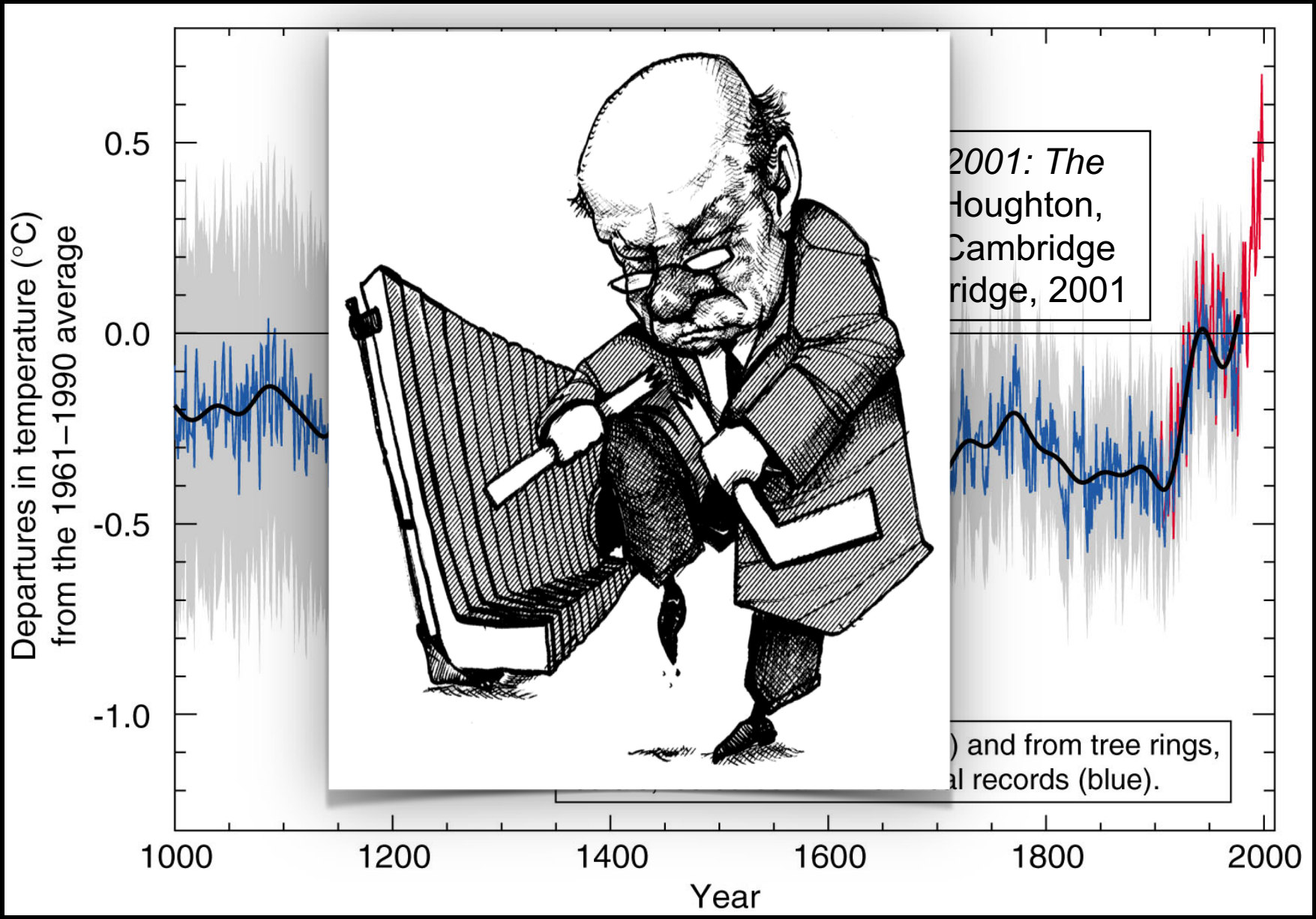
Reconstructions of Past Climate



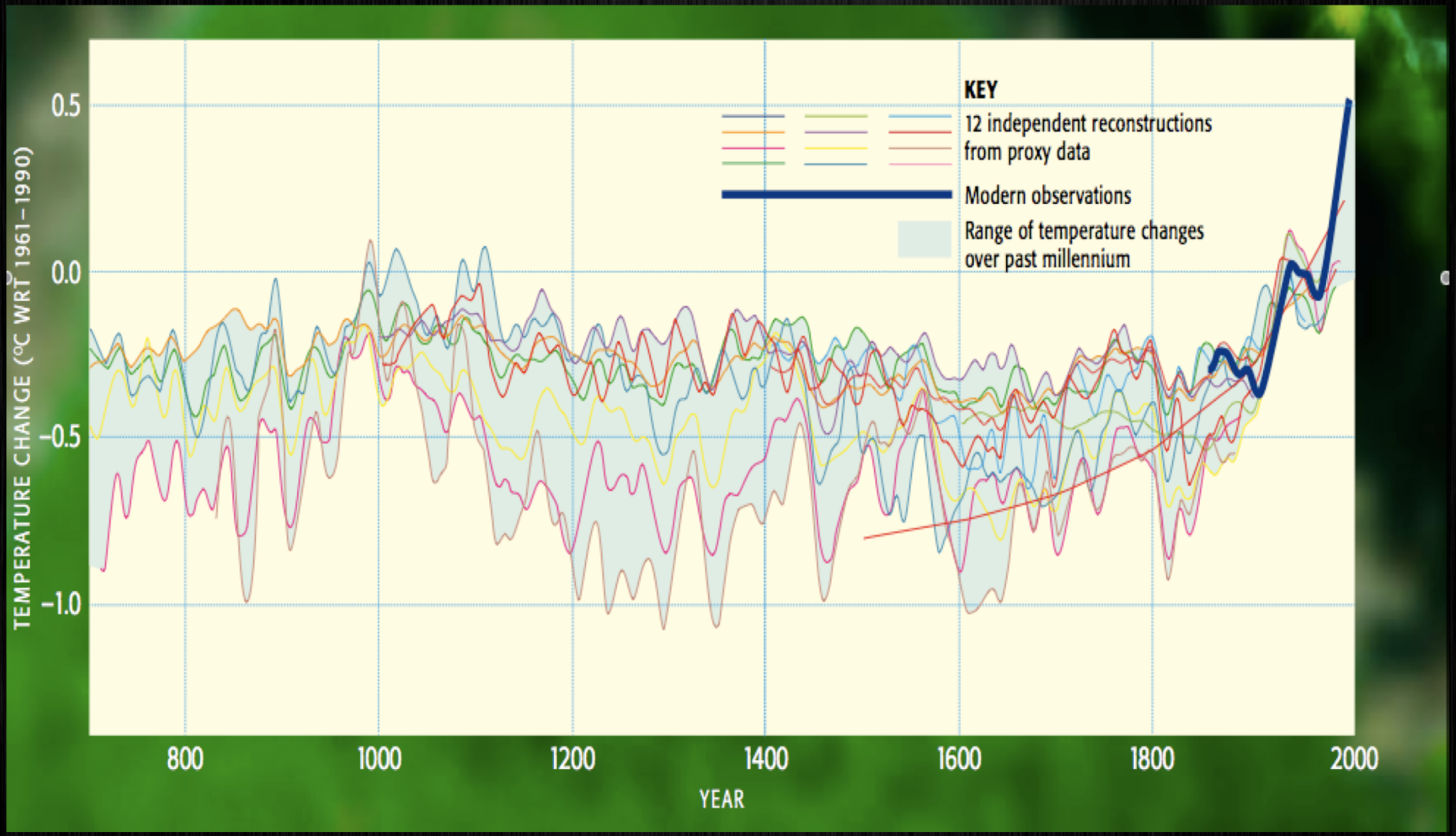


Climate "Proxy" Data…

Reconstructions of Past Climate



Hockey *League*



SUBSCRIBE

SCIENTIFIC

THE SCIENCES MIND HEALTH TE

Earth Day Si

On the 20th anniversary of t

New Scientist

SUBSCRIBE AND SAVE 49%
MANAGE MY SUBSCRIPTION
STUDENT
SCHOOLS AND UNIVERSITIES
GIVE A GIFT

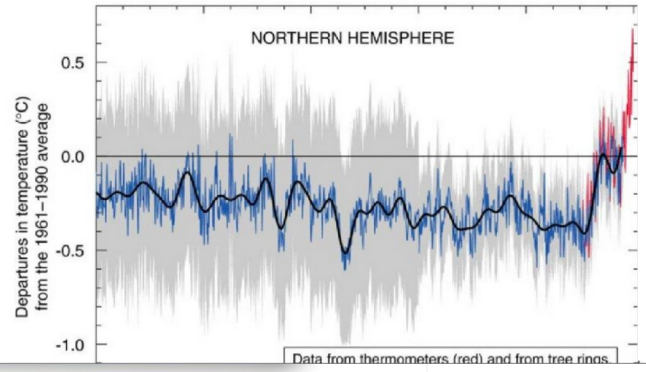
HOME NEWS TECHNOLOGY SPACE PHYSICS HEALTH EARTH HUMANS LIFE TOPICS EVENTS JOBS SUBSCRIBE SEARCH Michael

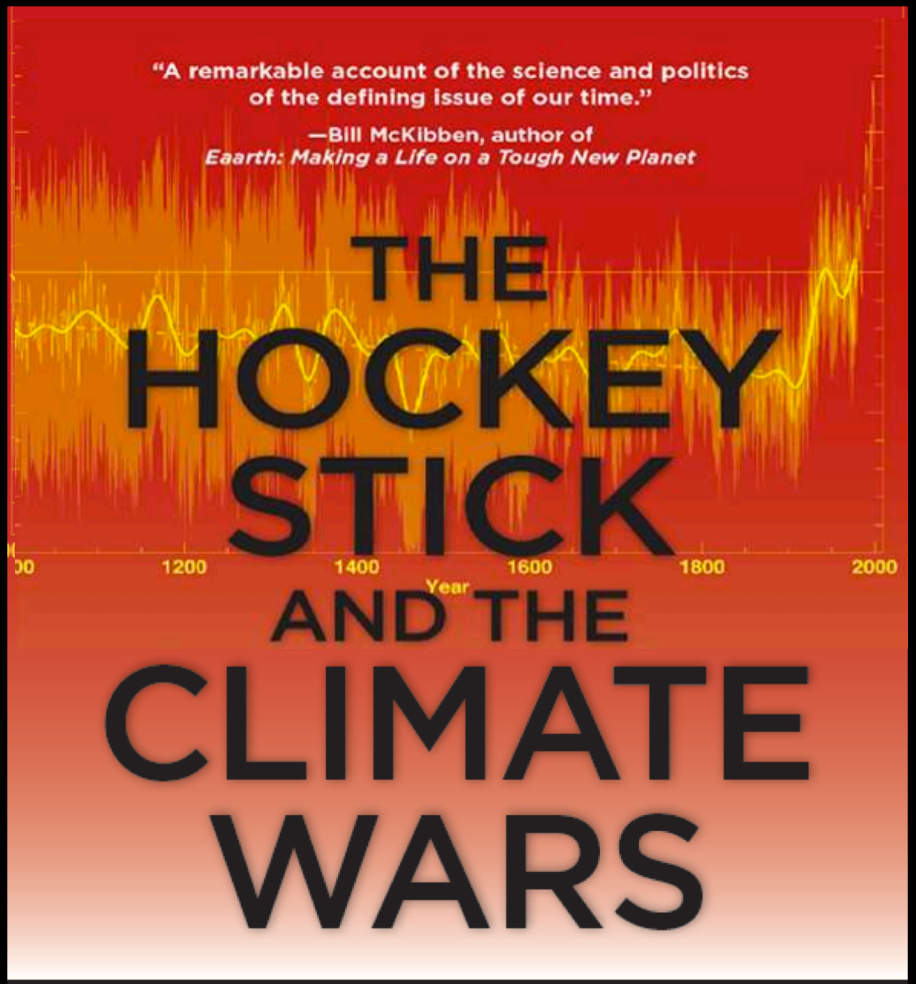
4

COMMENT 23 April 2018

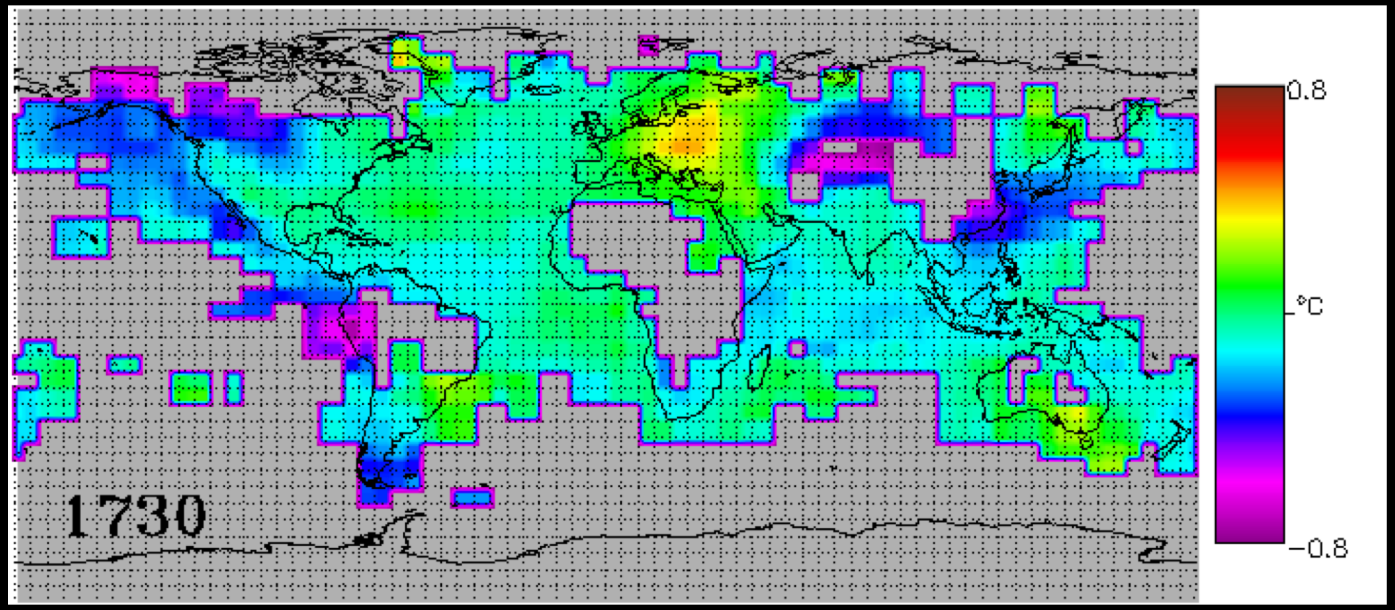
Why the hockey stick graph will always be climate science's icon

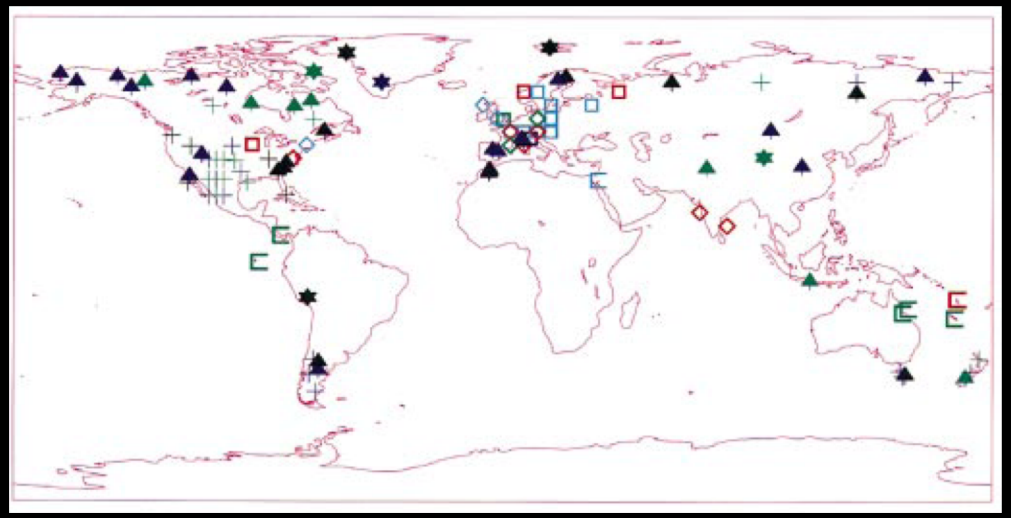
Two decades after it was first published, the chart linking carbon emissions and global warming is as relevant as ever, says **Olive Heffernan**



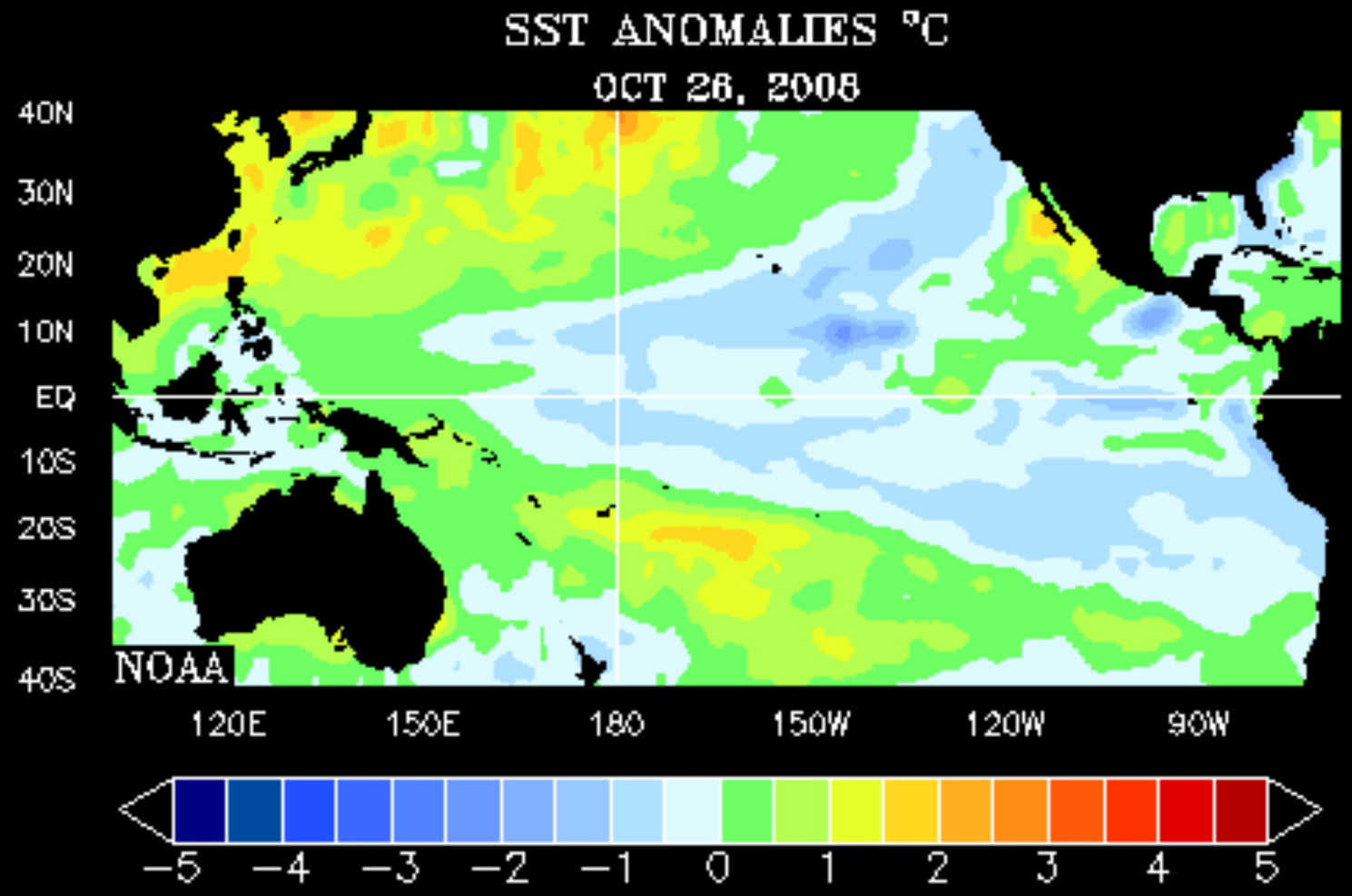

"A remarkable account of the science and politics
of the defining issue of our time."
—Bill McKibben, author of
Eaarth: Making a Life on a Tough New Planet
THE
HOCKEY
STICK
1200
1400
1600
1800
2000
Year
AND THE
CLIMATE
WARS
DISPATCHES FROM THE FRONT LINES
Michael E. Mann

Reconstructions of Past Climate





Climate "Proxy" Data…

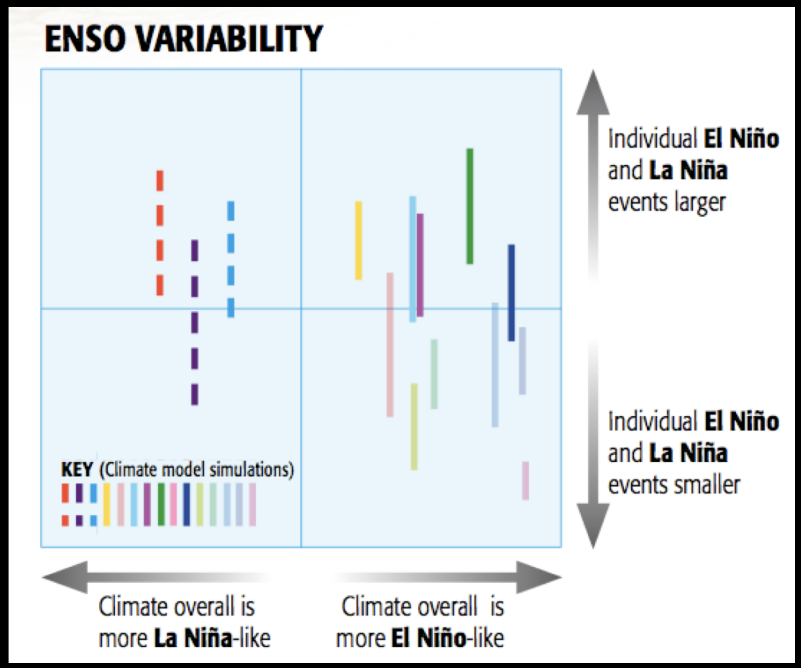

SST ANOMALIES °C
OCT 26, 2008
40N
30N
20N
10N
EQ
10S
20S
30S
40S
NOAA
120E
150E
180
150W
120W
90W
−5
−4
−3
−2
−1
0
1
2
3
4
5

El Nino

Sources of Uncertainty

Influences Atlantic hurricanes, drought in desert southwest, etc,

El Nino



How did Natural Forcings Influence influence ENSO and the Tropical Pacific During the Past Millennium?

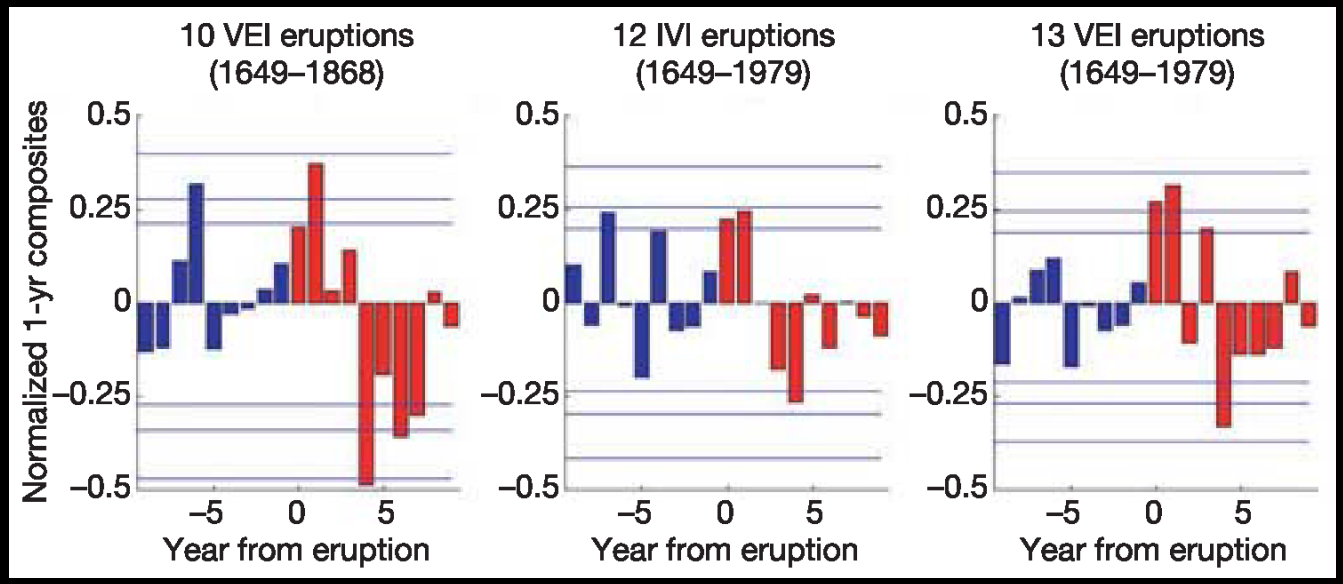
Proxy evidence for an El Niño-like response to volcanic forcing

J. Brad Adams[1], Michael E. Mann[1] & Caspar M. Ammann[2]

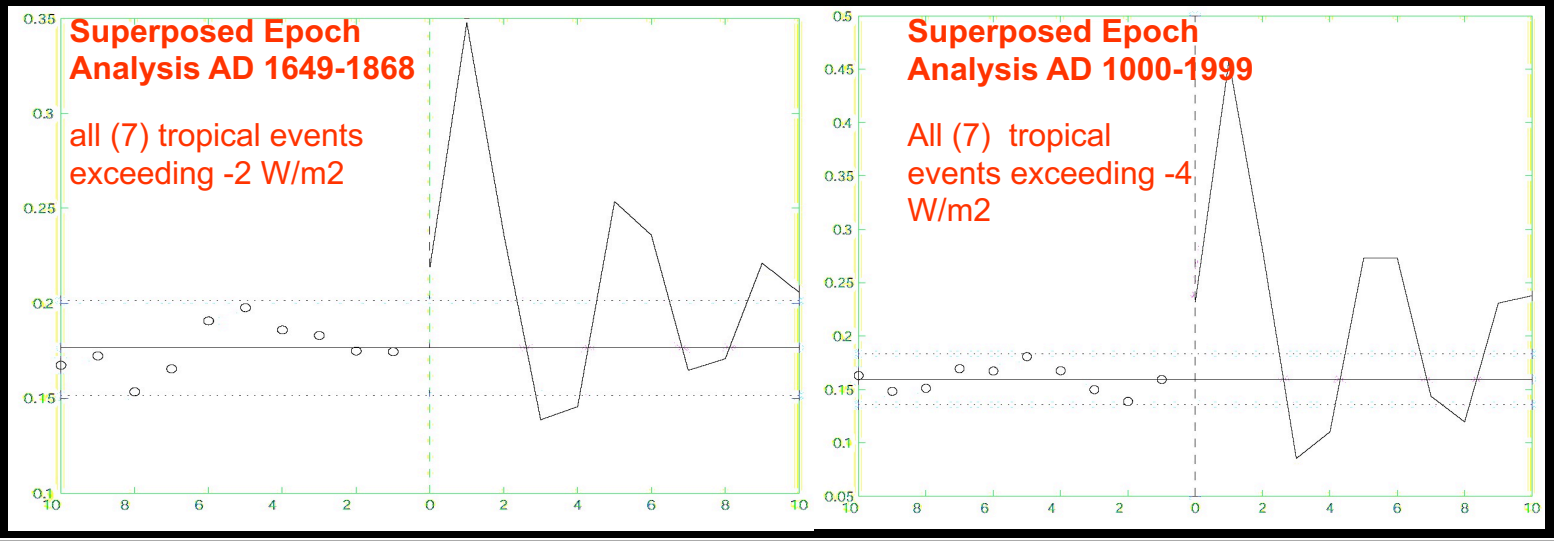
[1]*Department of Environmental Sciences, University of Virginia, Clark Hall, Charlottesville, Virginia 22903, USA*
[2]*Climate Global Dynamics Division, National Center for Atmospheric Research, 1850 Table Mesa Drive, Boulder, Colorado 80307-3000, USA*

NATURE | VOL 426 | 20 NOVEMBER 2003 | www.nature.com/nature

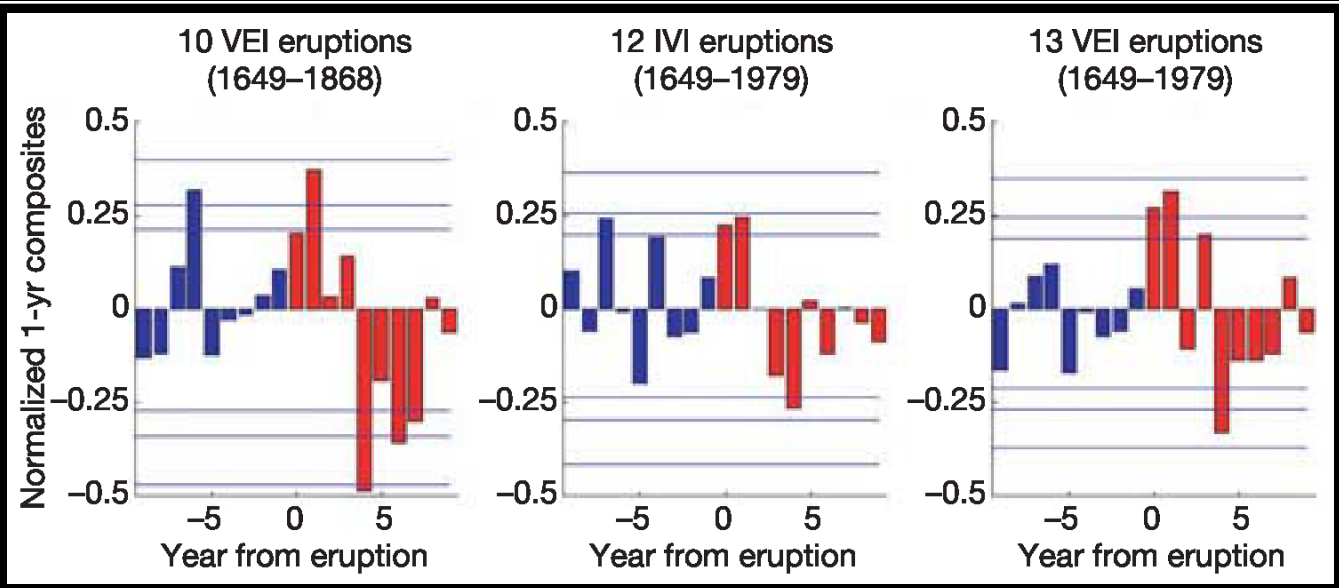
Brad Adams



How did Natural Forcings Influence influence ENSO and the Tropical Pacific During the Past Millennium?

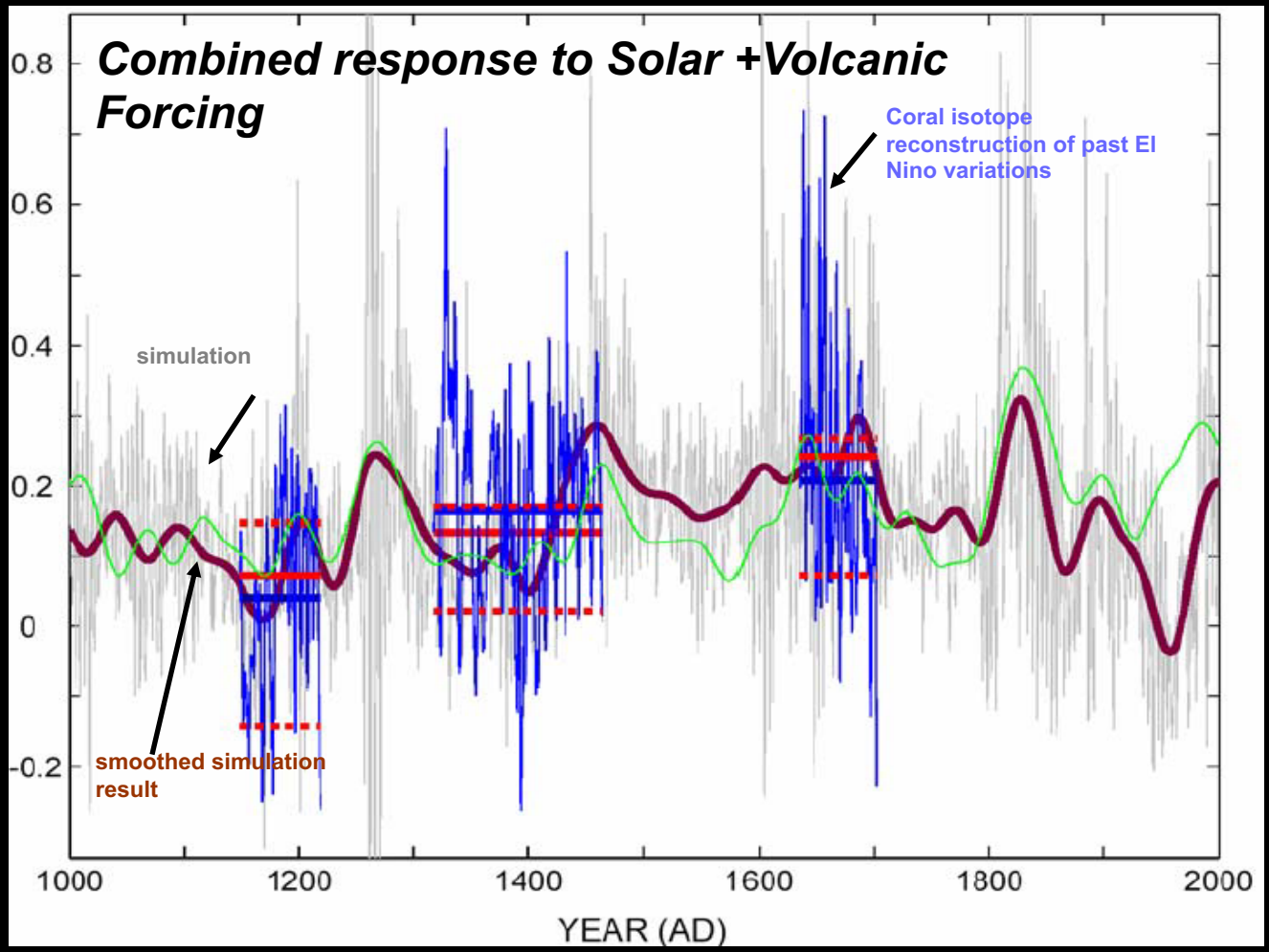


Mann, M.E., Cane, M.A., Zebiak, S.E., Clement, A., Volcanic and Solar Forcing of The Tropical Pacific Over the Past 1000 Years, *Journal of Climate*, 18, 447-456, 2005.

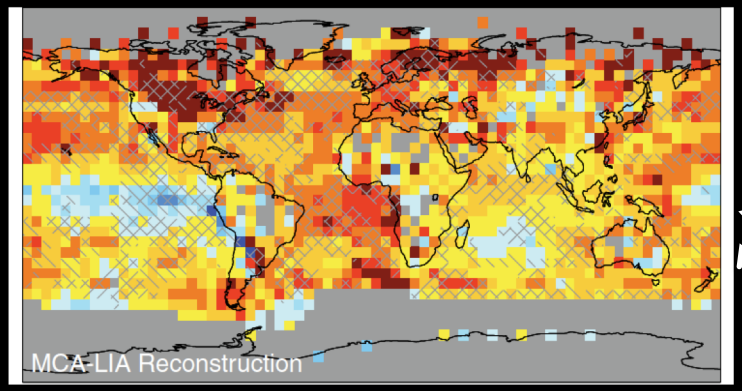


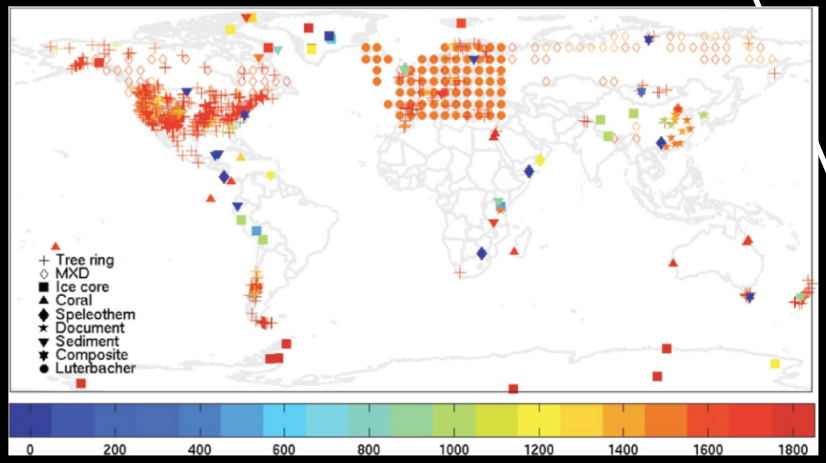
How did Natural Forcings Influence influence ENSO and the Tropical Pacific During the Past Millennium?

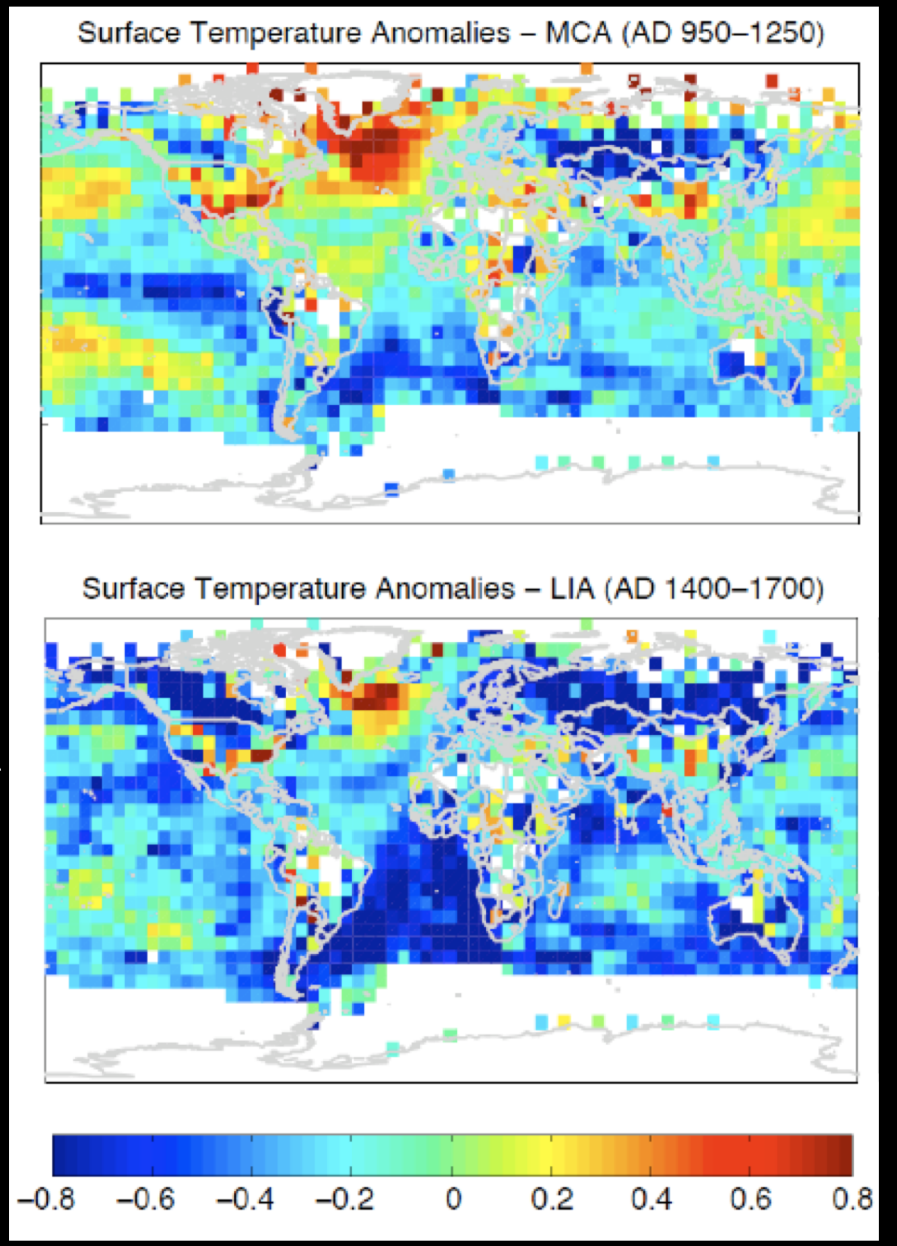
Mann, M.E., Cane, M.A., Zebiak, S.E., Clement, A., Volcanic and Solar Forcing of The Tropical Pacific Over the Past 1000 Years, *Journal of Climate*, 18, 447-456, 2005.



Surface Temperature Reconstructions





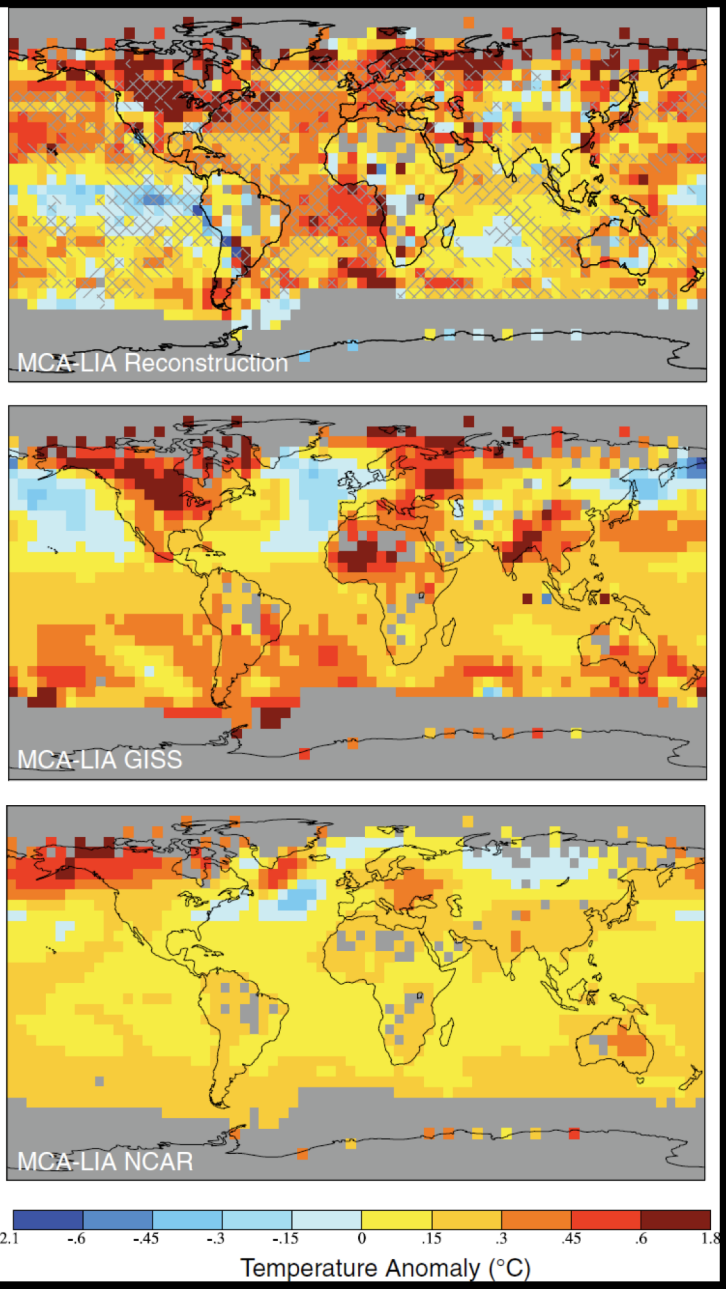


Science (Nov 27, 2009) REPORT

Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly

Michael E. Mann,[1*] Zhihua Zhang,[1] Scott Rutherford,[2] Raymond S. Bradley,[3] Malcolm K. Hughes,[4] Drew Shindell,[5] Caspar Ammann,[6] Greg Faluvegi,[5] Fenbiao Ni[4]

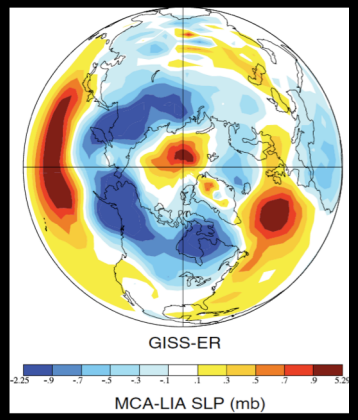
Model-Data Comparisons

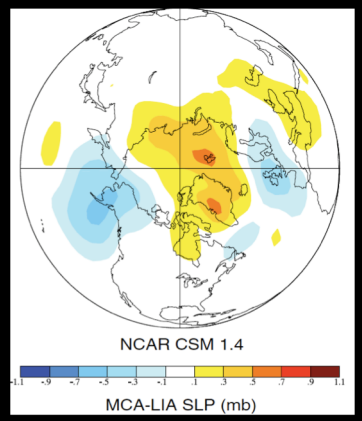


Science (Nov 27, 2009) REPORT

Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly

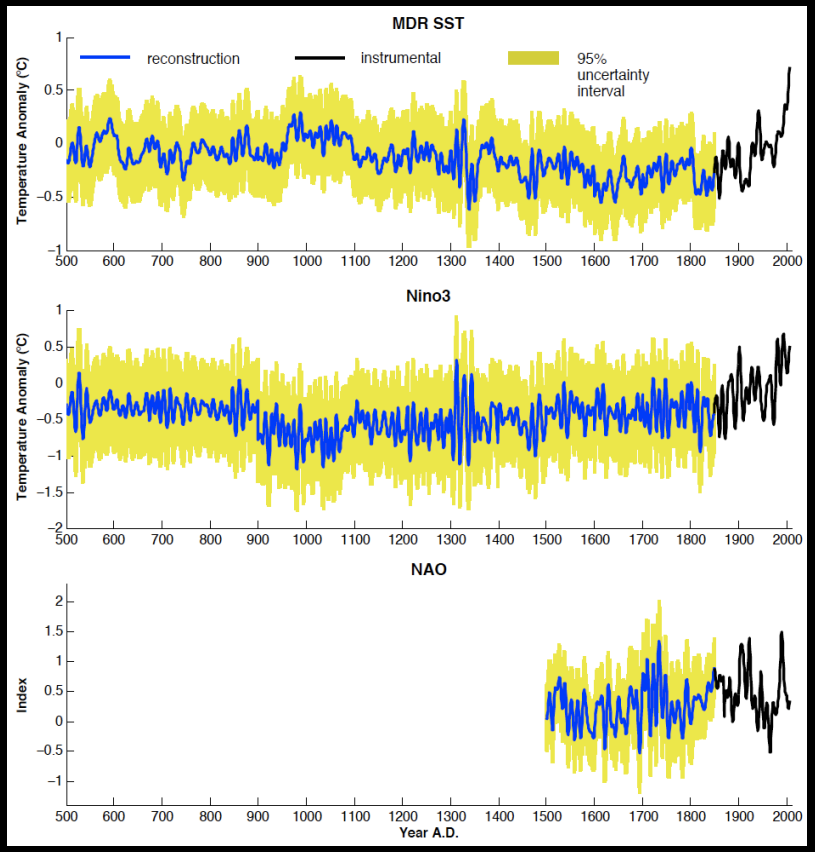
Michael E. Mann,[1*] Zhihua Zhang,[1] Scott Rutherford,[2] Raymond S. Bradley,[3] Malcolm K. Hughes,[4] Drew Shindell,[5] Caspar Ammann,[6] Greg Faluvegi,[5] Fenbiao Ni[4]

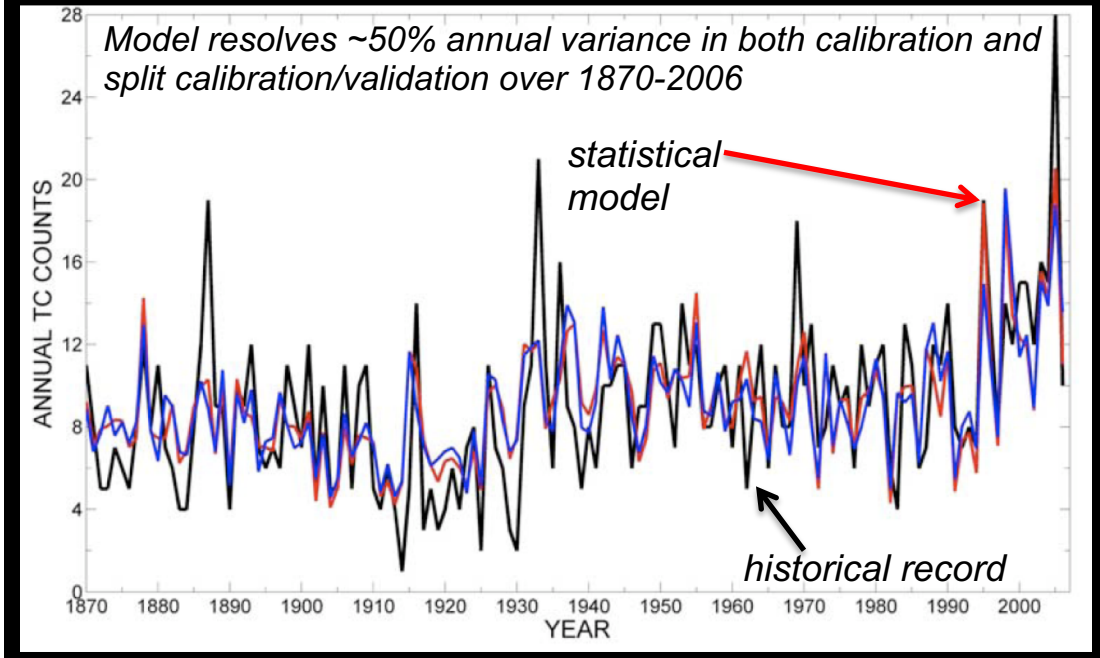




← ***Positive Phase of Northern Annual Mode***

Applications: Tropical Cyclones





nature

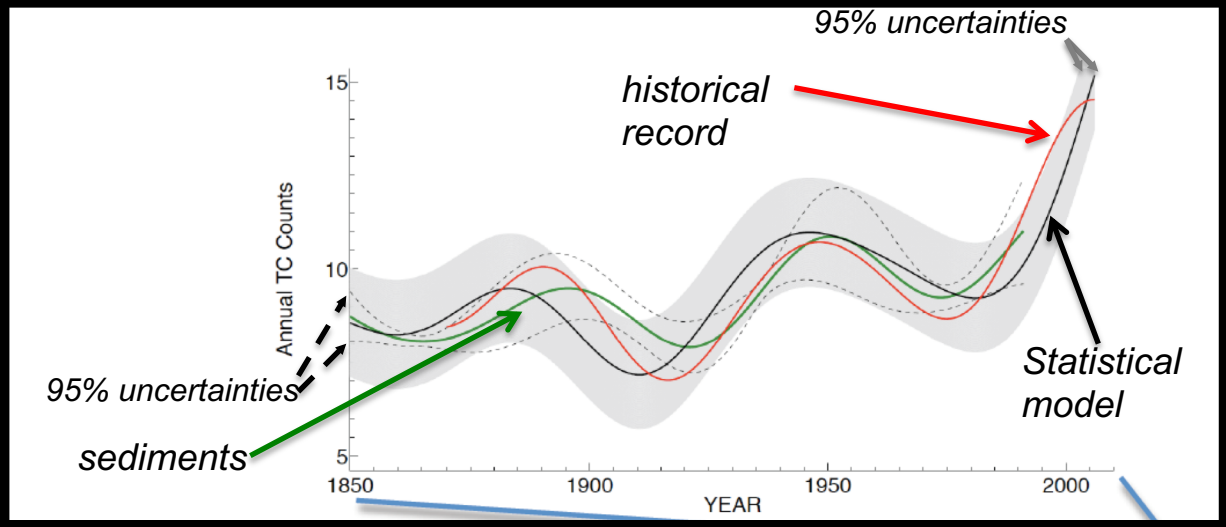
Vol 460|13 August 2009|doi:10.1038/nature08219

LETTERS

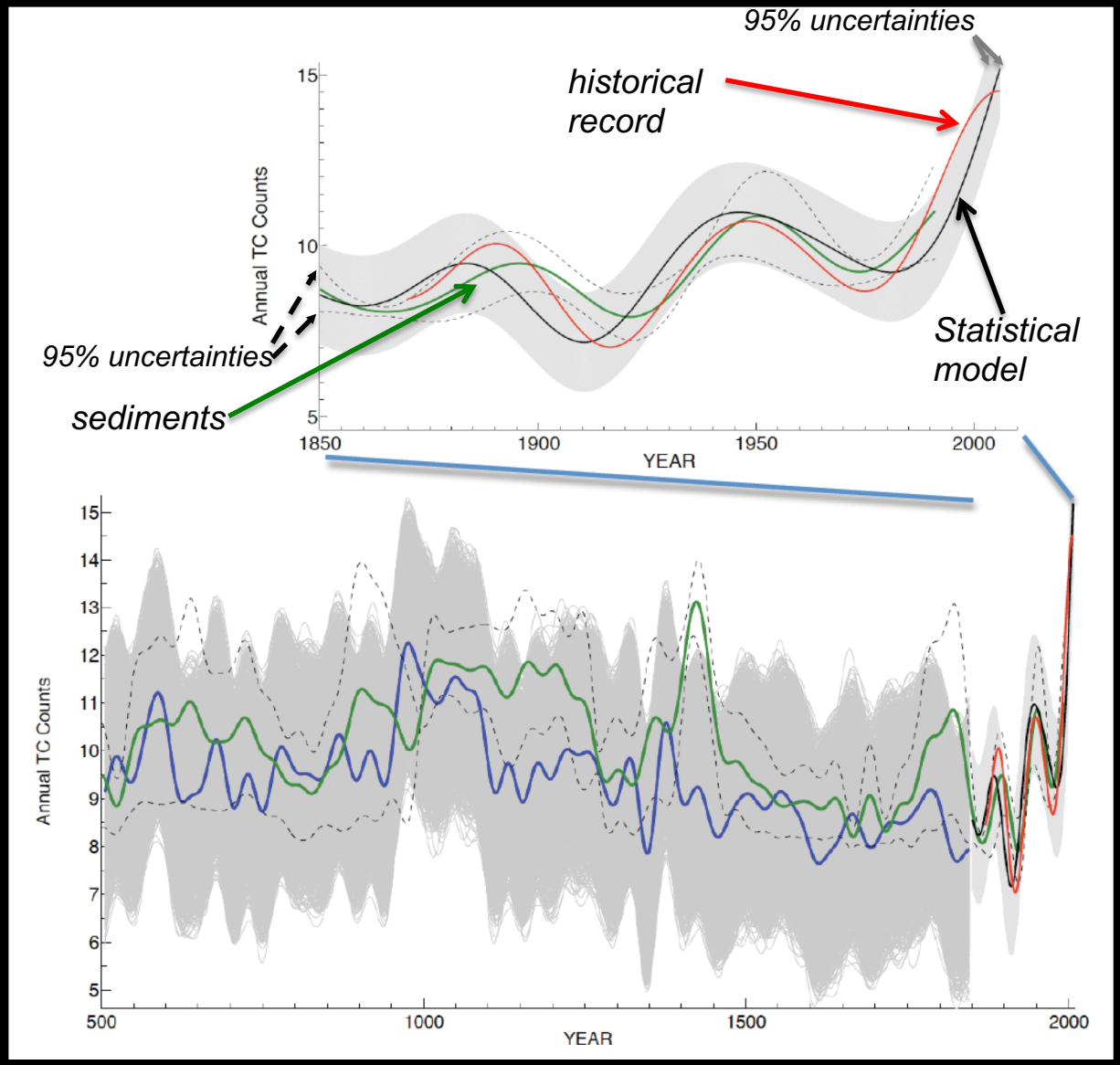
Atlantic hurricanes and climate over the past 1,500 years

Michael E. Mann[1], Jonathan D. Woodruff[2], Jeffrey P. Donnelly[3] & Zhihua Zhang[1]

Applications: Tropical Cyclones



Applications: Tropical Cyclones



Applications: Tropical Cyclones

An Analysis of North Atlantic Tropical Cyclones and Their Impacts on Coastal Inundation in New York and New Jersey during the Last Millennium

Andra J. Reed, Michael E. Mann,
Kerry A. Emanuel, Ning Lin,
Benjamin P. Horton, and Andrew C. Kemp

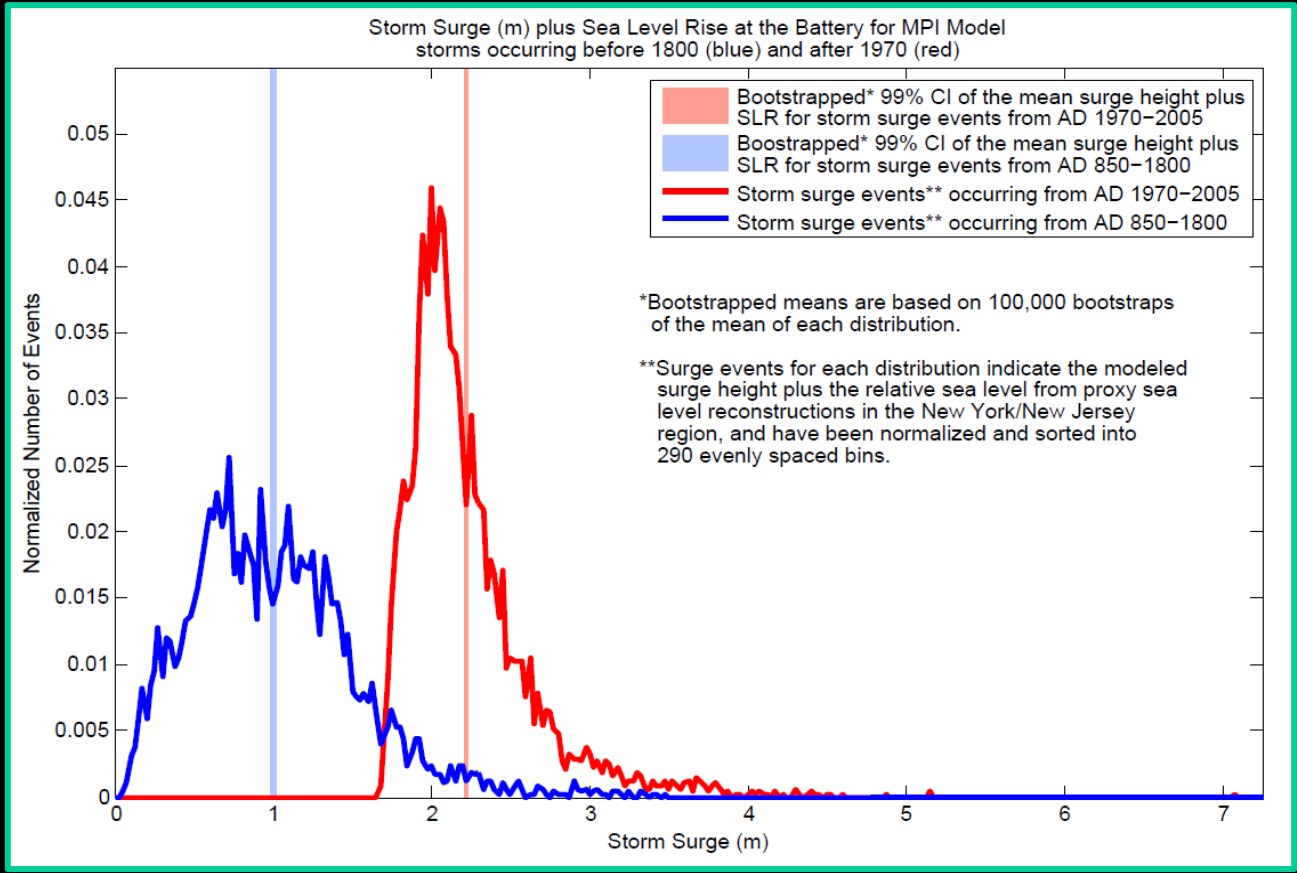
PNAS

Increased threat of tropical cyclones and coastal flooding to New York City during the anthropogenic era

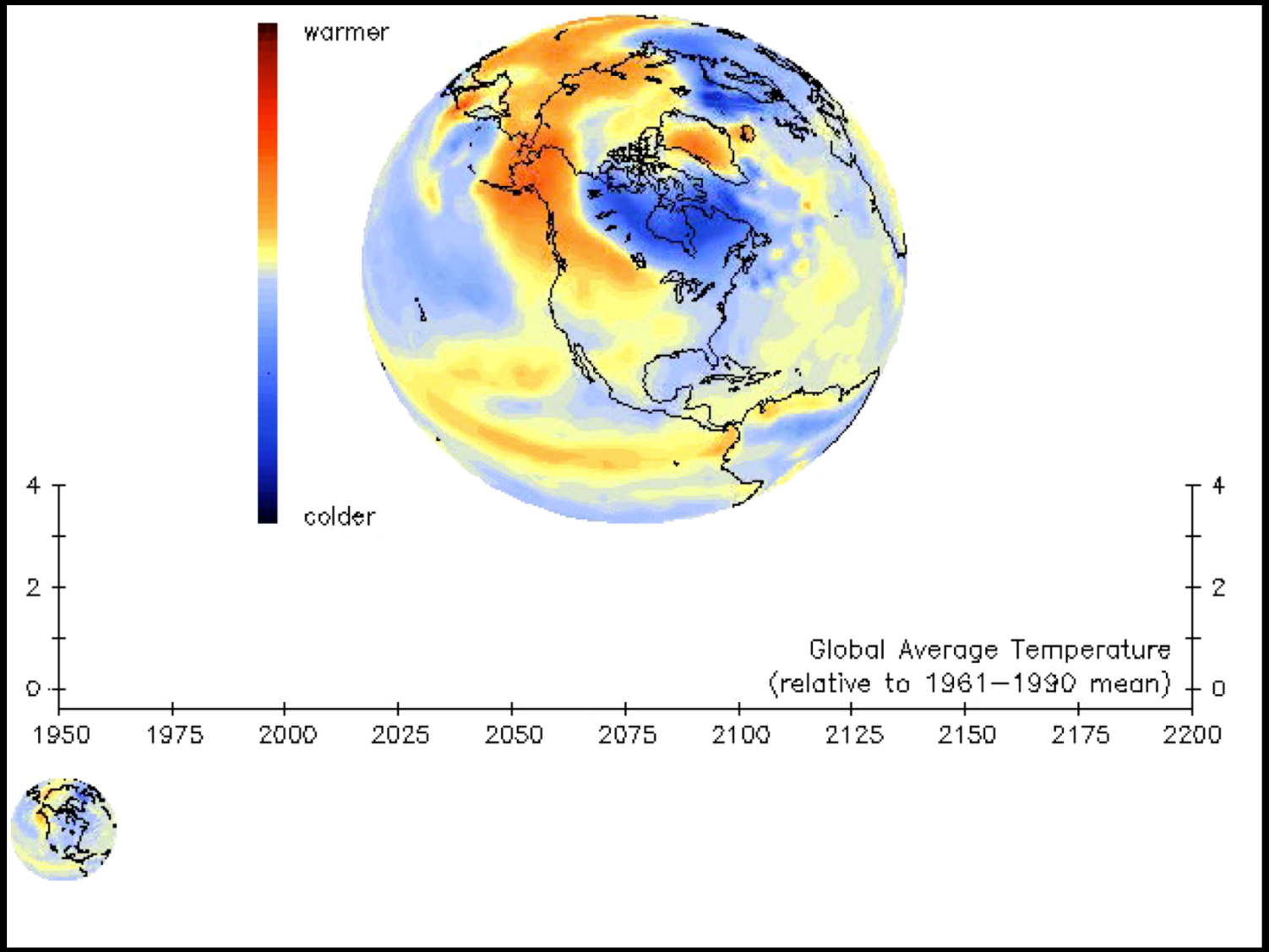
Andra J. Reed[a,1], Michael E. Mann[a,b], Kerry A. Emanuel[c], Ning Lin[d], Benjamin P. Horton[e,f], Andrew C. Kemp[g], and Jeffrey P. Donnelly[h]

[a]Department of Meteorology, The Pennsylvania State University, University Park, PA 16802; [b]Earth Environmental Systems Institute, The Pennsylvania State University, University Park, PA 16802; [c]Department of Earth, Atmospheric, and Planetary Sciences, Program in Atmospheres, Oceans, and Climate, Massachusetts Institute of Technology, Cambridge, MA 02913; [d]Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ 08544; [e]Department of Marine and Coastal Sciences, Rutgers, The State University of New Jersey, New Brunswick, NJ 08901; [f]Earth Observatory of Singapore and Asian School of the Environment, Nanyang Technological University, Singapore 639798; [g]Department of Earth and Ocean Sciences, Tufts University, Medford, MA 02155; and [h]Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543

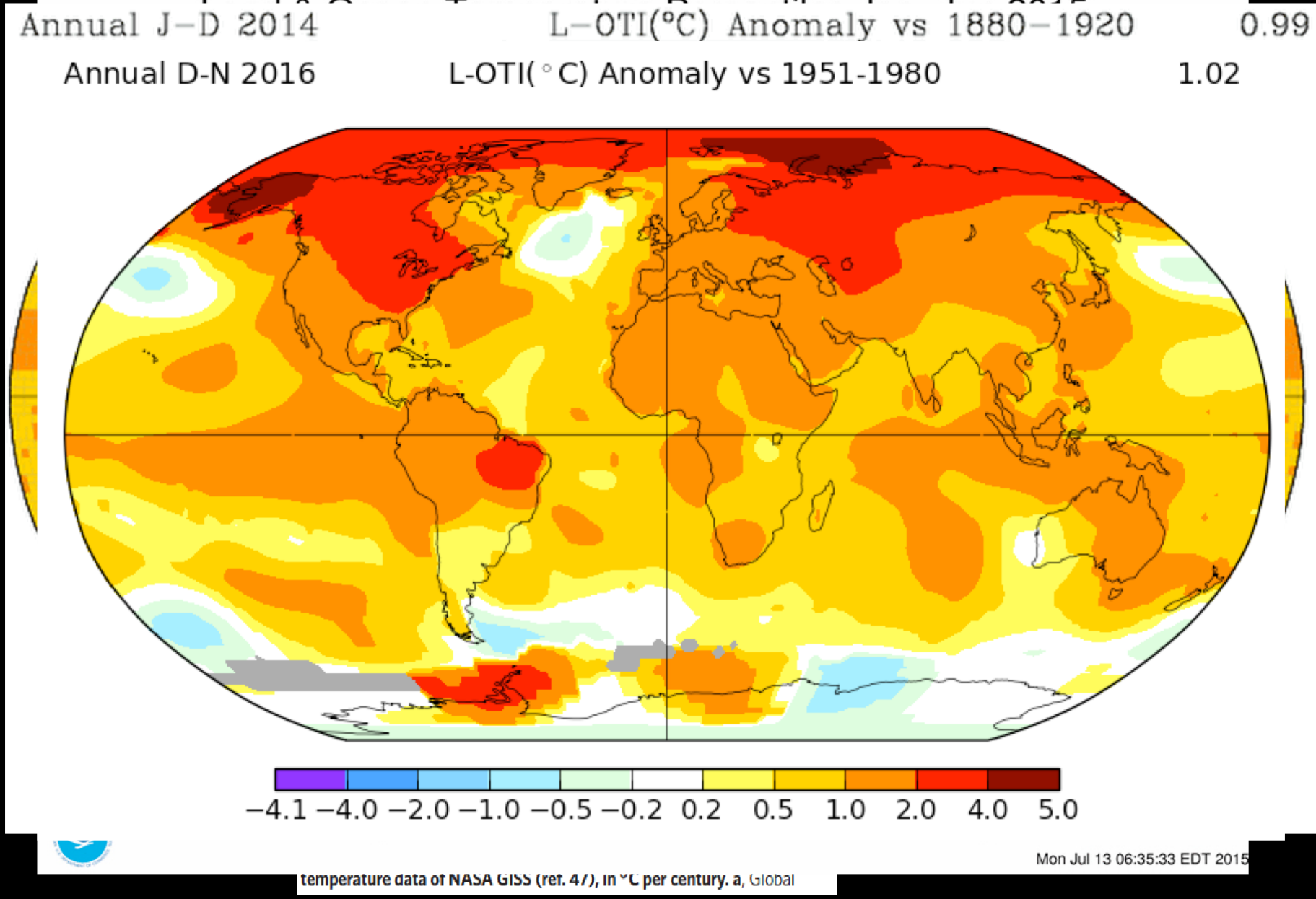
Edited by Mark H. Thiemens, University of California, San Diego, La Jolla, CA, and approved August 26, 2015 (received for review July 3, 2015)



Applications: AMOC slowdown

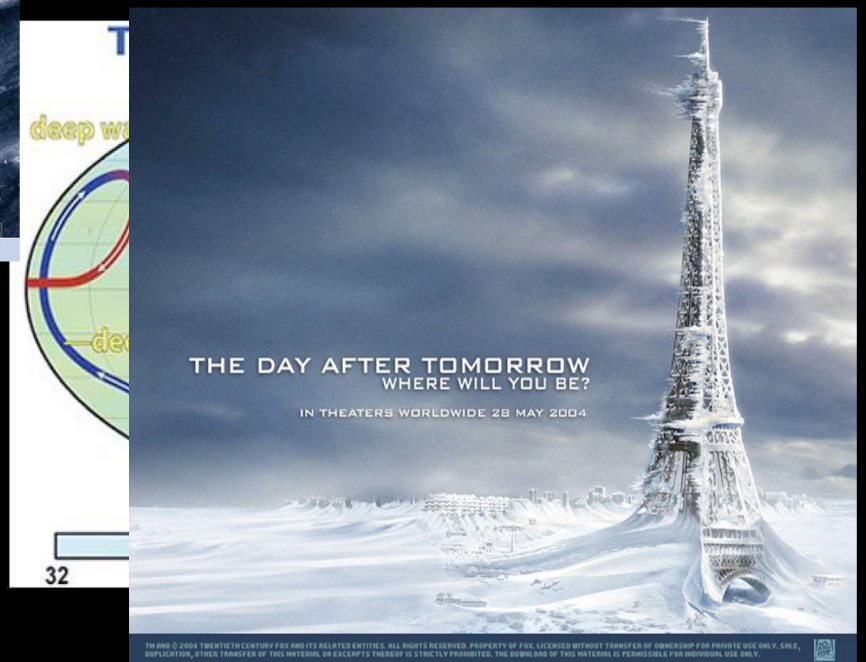


Applications: AMOC slowdown



Applications: AMOC slowdown

Figure 1 | Linear trends of surface temperature since AD 1901 based on the temperature data of NASA GISS (ref. 47), in °C per century. a, Global



Applications: AMOC slowdown

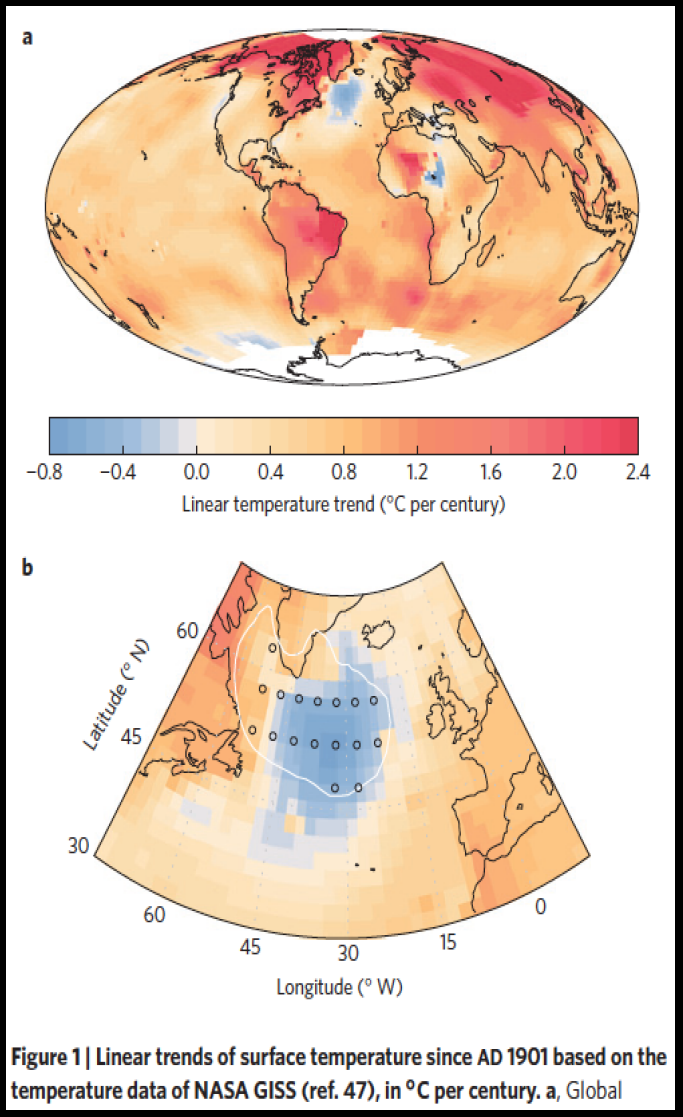


Figure 1 | Linear trends of surface temperature since AD 1901 based on the temperature data of NASA GISS (ref. 47), in °C per century. a, Global

nature climate change

ARTICLES

PUBLISHED ONLINE: 23 MARCH 2015 | DOI: 10.1038/NCLIMATE2554

Exceptional twentieth-century slowdown in Atlantic Ocean overturning circulation

Stefan Rahmstorf[1]*, Jason E. Box[2], Georg Feulner[1], Michael E. Mann[3,4], Alexander Robinson[1,5,6], Scott Rutherford[7] and Erik J. Schaffernicht[1]

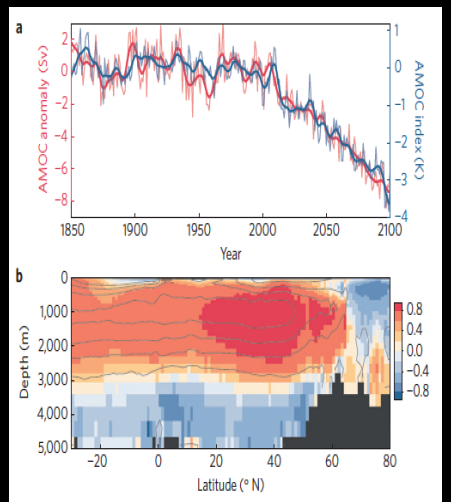


Figure 2 | Connection between the AMOC stream function and the temperature-based AMOC index in a global warming scenario (RCP8.5) simulated with the MPI-ESM-MR global climate model of the Max Planck Institute in Hamburg[11].

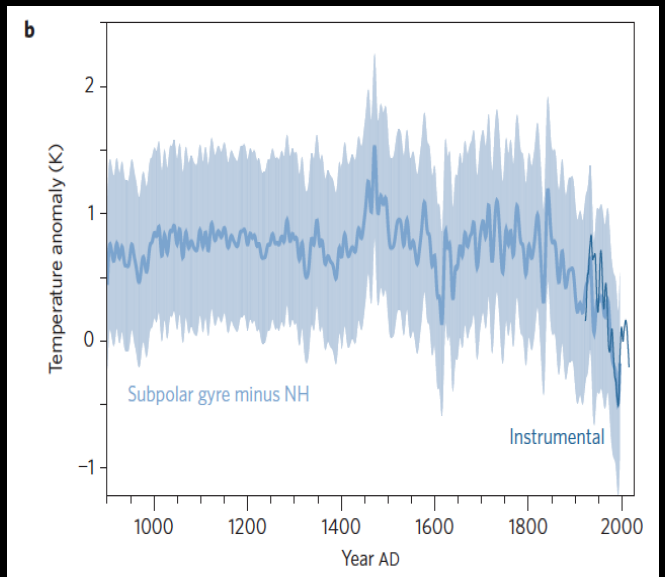
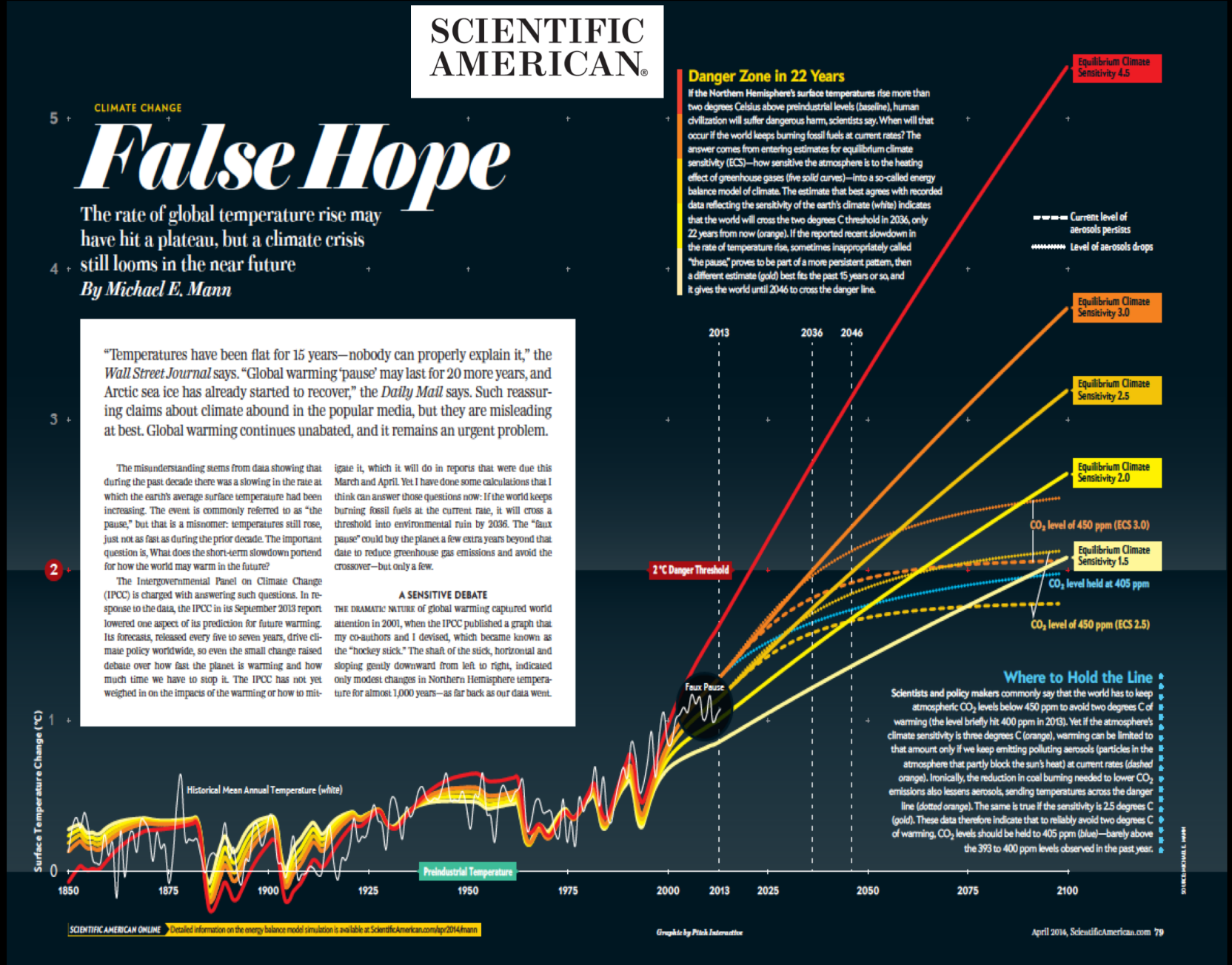


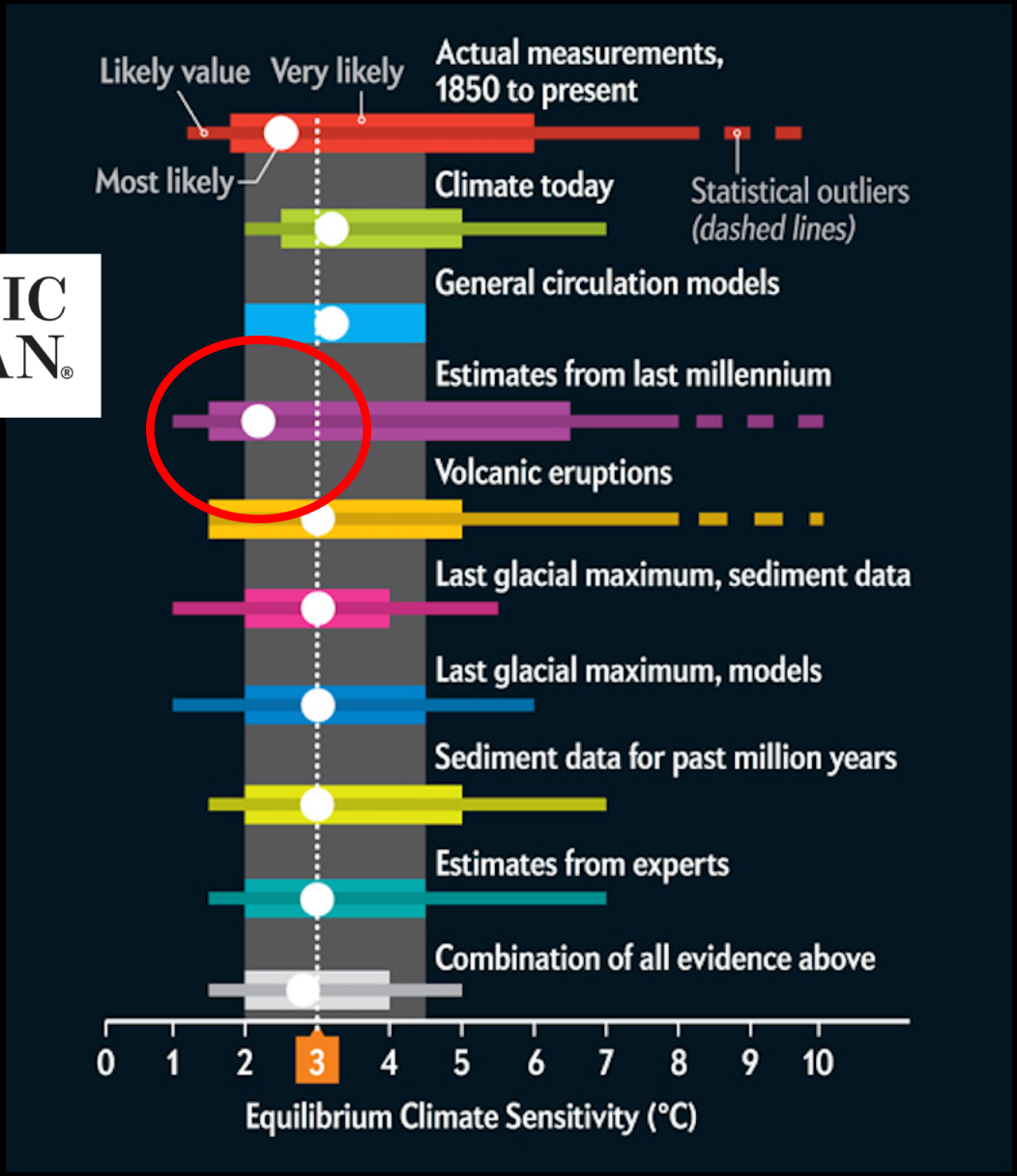
Figure 3 | Surface temperature time series for different regions from the proxy reconstruction of Mann *et al.*[12], including estimated 2-σ uncertainty bands, and from the HadCRUT4 instrumental data[48].

Applications: Climate Sensitivity

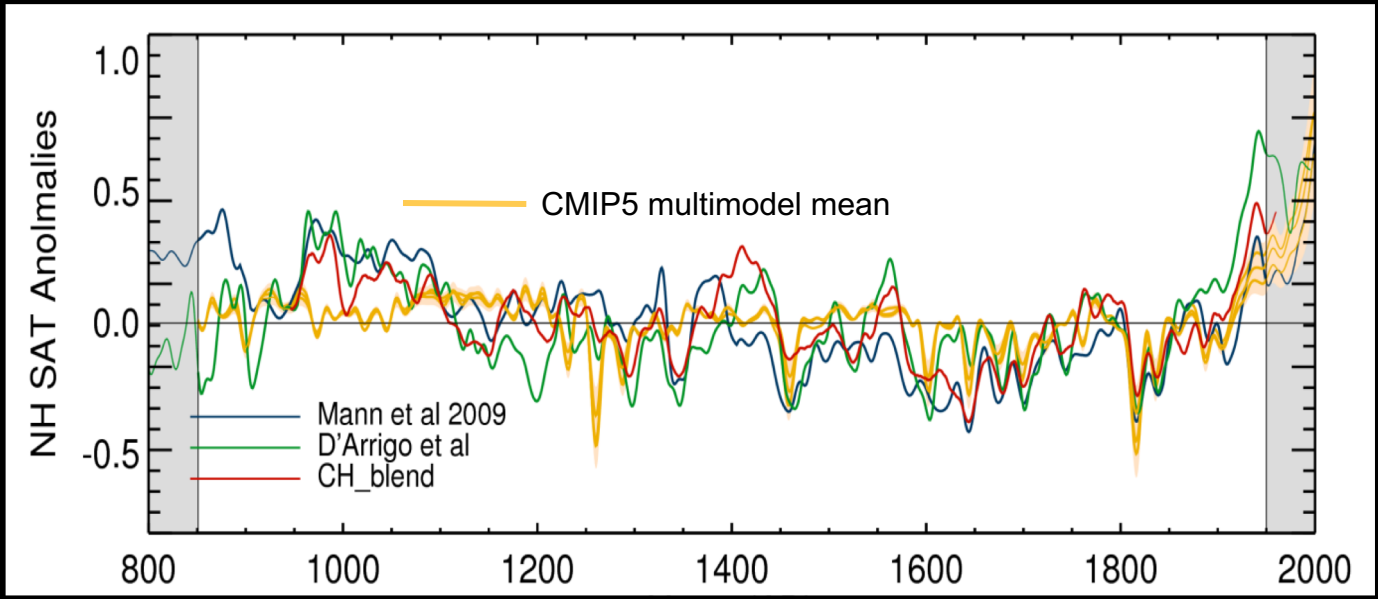


Applications: Climate Sensitivity

SCIENTIFIC AMERICAN®



Applications: Climate Sensitivity



JOURNAL OF CLIMATE VOLUME 26

Separating Forced from Chaotic Climate Variability over the Past Millennium

ANDREW P. SCHURER AND GABRIELE C. HEGERL

School of GeoSciences, The University of Edinburgh, Edinburgh, United Kingdom

MICHAEL E. MANN

Department of Meteorology, and Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, Pennsylvania

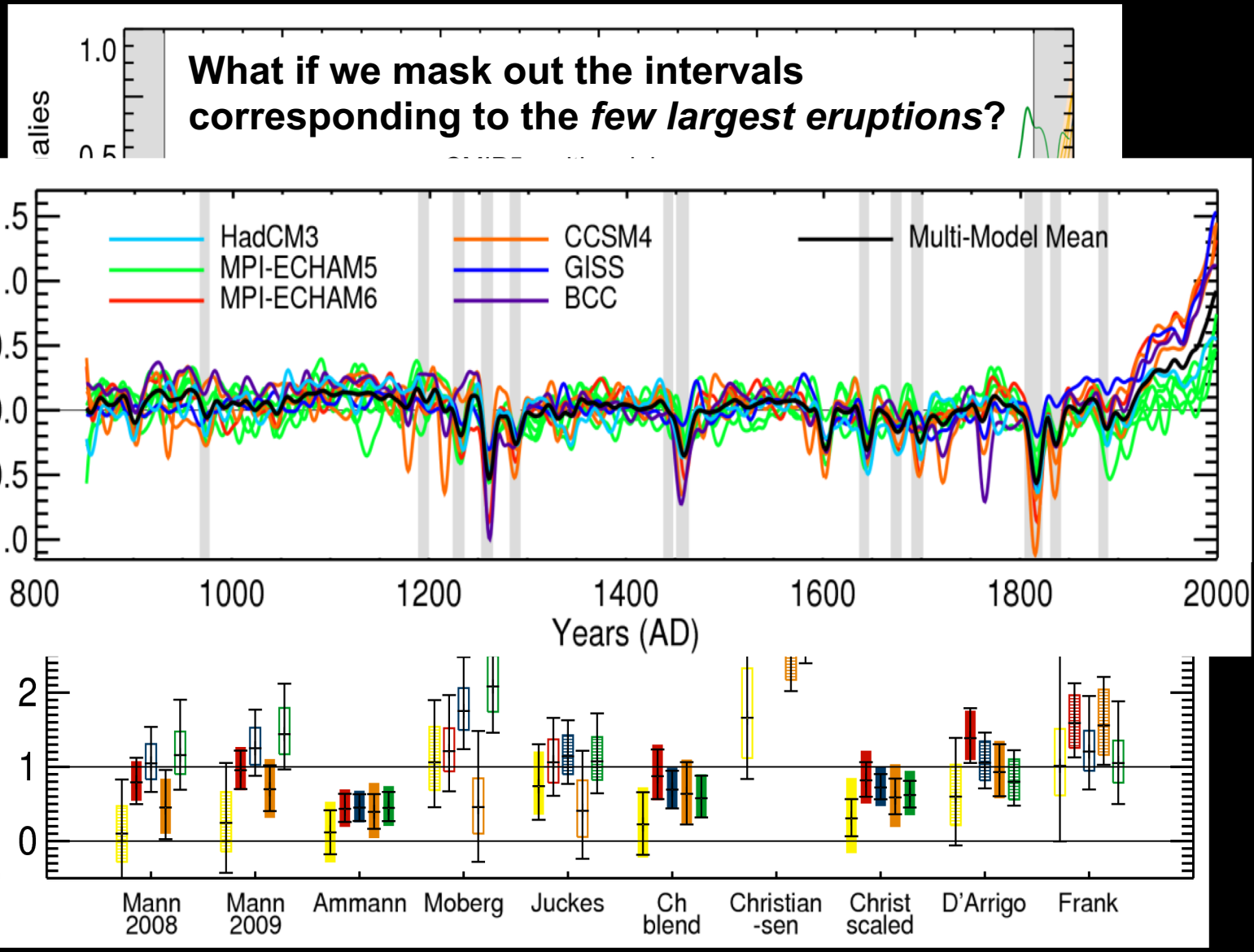
SIMON F. B. TETT

School of GeoSciences, The University of Edinburgh, Edinburgh, United Kingdom

STEVEN J. PHIPPS

Climate Change Research Centre, and ARC Centre of Excellence for Climate System Science, University of New South Wales, Sydney, New South Wales, Australia

Applications: Climate Sensitivity



Applications: Dangerous Warming Thresholds

nature climate change

LETTERS

PUBLISHED ONLINE: 24 JULY 2017 | DOI: 10.1038/NCLIMATE3345

Importance of the pre-industrial baseline for likelihood of exceeding Paris goals

Andrew P. Schurer[1]*, Michael E. Mann[2], Ed Hawkins[3], Simon F. B. Tett[1] and Gabriele C. Hegerl[1]

During the Paris conference in 2015, nations of the world strengthened the United Nations Framework Convention on Climate Change by agreeing to holding 'the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C' (ref. 1). However, 'pre-industrial' was not defined. Here we investigate the implications of different choices of the pre-industrial baseline on the likelihood of exceeding these two temperature thresholds. We find that for the strongest mitigation scenario RCP2.6 and a medium scenario RCP4.5, the probability of exceeding the thresholds and timing of exceedance is highly dependent on the pre-industrial baseline; for example, the probability of crossing 1.5 °C by the end of the century under RCP2.6 varies from 61% to 88% depending on how the baseline is defined. In contrast, in the scenario with no mitigation, RCP8.5, both thresholds will almost certainly be exceeded by the middle of the century with the definition of the pre-industrial baseline of less importance. Allowable carbon emissions for threshold stabilization are similarly highly dependent on the pre-industrial baseline. For stabilization at 2 °C, allowable emissions decrease by as much as 40% when earlier than nineteenth-century climates are considered as a baseline.

Applications: Dangerous Warming Thresholds

nature climate change

LETTERS

PUBLISHED ONLINE: 24 JULY 2017 | DOI: 10.1038/NCLIMATE3345

Importance of the pre-industrial baseline for likelihood of exceeding Paris goals

Andrew P. Schurer[1]*, Michael E. Mann[2], Ed Hawkins[3], Simon F. B. Tett[1] and Gabriele C. Hegerl[1]

During the Paris conference in 2015, nations of the world strengthened the United Nations Framework Convention on Climate Change by agreeing to holding 'the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C' (ref. 1). However, 'pre-industrial' was not defined. Here we investigate the implications of different choices of the pre-industrial baseline on the likelihood of exceeding these two temperature thresholds. We find that for the strongest mitigation scenario RCP2.6 and a medium scenario RCP4.5, the probability of exceeding the thresholds and timing of exceedance is highly dependent on the pre-industrial baseline; for example, the probability of crossing 1.5 °C by the end of the century under RCP2.6 varies from 61% to 88% depending on how the baseline is defined. In contrast, in the scenario with no mitigation, RCP8.5, both thresholds will almost certainly be exceeded by the middle of the century with the definition of the pre-industrial baseline of less importance. Allowable carbon emissions for threshold stabilization are similarly highly dependent on the pre-industrial baseline. For stabilization at 2 °C, allowable emissions decrease by as much as 40% when earlier than nineteenth-century climates are considered as a baseline.

Applications: Dangerous Warming Thresholds

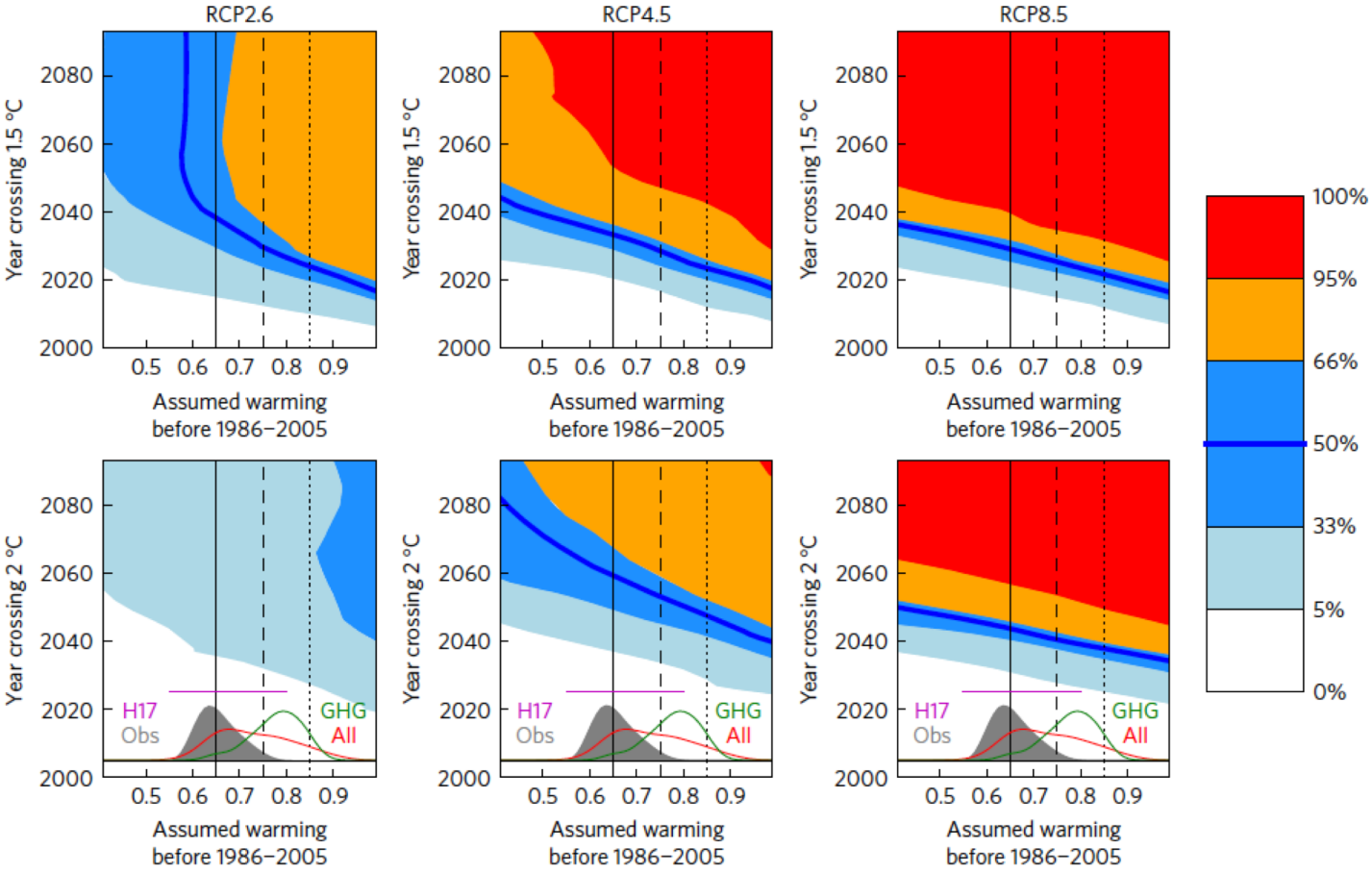


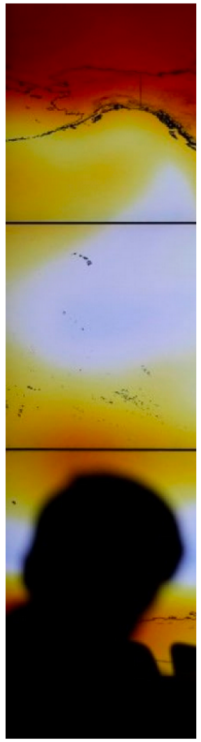
Figure 3 | Probability of exceeding temperature threshold for different assumed pre-industrial baselines. Probabilities for exceeding a particular global mean temperature threshold in any given year are given (%), smoothed by a 30-year Lowess filter for clarity (un-filtered version in Supplementary Information). The vertical lines indicate assumed pre-instrumental warming of 0 °C relative to 1850–1900 (solid), 0.1 °C (dashed) and 0.2 °C (dotted). Distributions in bottom panels show uncertainty in the observational estimate of warming from 1850–1900 to 1986–2005 (grey) and model distributions of 100-year mean temperatures in periods prior to 1800 relative to the 1850–1900 mean added to the mean warming from 1850–1900 to 1986–2005, using all forcings (red) and GHG forcings alone (green); the purple line shows the equivalent 1720–1800 temperature range estimated by Hawkins and colleagues[6].

Applications: Dangerous Warming Thresholds

Energy and Environment

We may have e
warmi

By Chris Mooney



A world map shows c

POLICY. SCIENCE. BUSINESS.

correspondence

Interpretations of the Paris climate target

To the Editor — In the 2015 UNFCCC Paris Agreement, article 2 expresses the target of "Holding the increase in global temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C … recognizing that this would significantly reduce the risks and impacts of climate change"[1]. Different interpretations of the precise meaning of the phrases 'increase in global temperature'[2] and 'pre-industrial'[3] could have large effects on mitigation requirements and corresponding social, policy and political responses. Here we suggest that levels of current global mean surface warming since pre-industrial times that are higher than those derived by Millar et al. could have been calculated using alternative, but equally valid, assumptions as the ones made by those authors.

In the work by Millar and colleagues[4], an observational dataset (HadCRUT4)[5] was used to estimate current levels of anthropogenic warming above 1861–1880 (0.93 °C as of 2015) and thereby determine the amount of warming remaining before the 1.5 °C target is reached. HadCRUT4, in common with most datasets, calculates global mean surface temperature (GMST) as a blend of surface air temperature (SAT) measurements over land and sea surface temperatures (SSTs) over the ocean. It only has partial global coverage, limited to where the observations exist. As such, data from the Arctic, which has been found to be warming much faster than the global

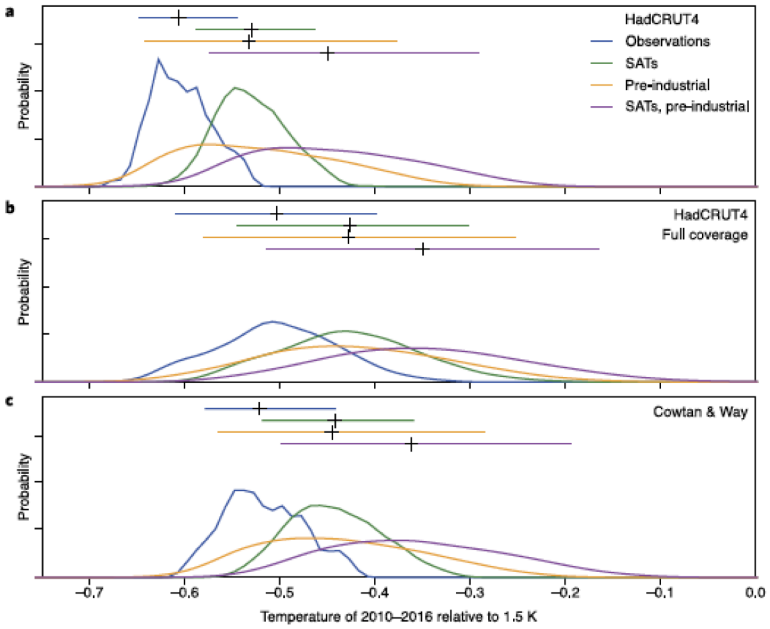


Fig. 1 | Present global temperatures relative to 1.5 °C above pre-industrial temperatures. Kernel density estimates and 5–95% range of the observed warming: HadCRUT4[5] (**a**, a dataset with partial coverage); HadCRUT4 scaled to full global coverage using a ratio calculated in model simulations (**b**); and Cowtan and Way[8] (**c**, a dataset that has been in-filled using kriging). Panels show observed GMST warming since 1850–1900 with published uncertainty (blue), GMST warming estimated as SATs over whole globe (green), observed GMST with anomalies from for a true pre-industrial baseline (orange), and SATs with pre-industrial baseline (purple). All conversion factors are calculated using model CMIP5 simulations with RCP2.6 projections.

e comparisons between models
between observed vs. modeled
sity who was not involved with the

eratures — the baseline against
he new study uses approximately
ver, another recent paper, which
e climate for at least 100 years
ntury significantly reduces the

Applications: Dangerous Warming Thresholds

MOTHERBOARD Moveable Hacking Environment Space Gaming Health Tech Science Influence

CLIMATE CHANGE | By Nafeez Ahmed | Oct 15 2018, 10:26am

The UN's Devastating Climate Change Report Was Too Optimistic

The IPCC has been criticized for being "too alarmist. If anything, it is the opposite. With their latest report, they have been overly conservative."

SCIENTIFIC AMERICAN

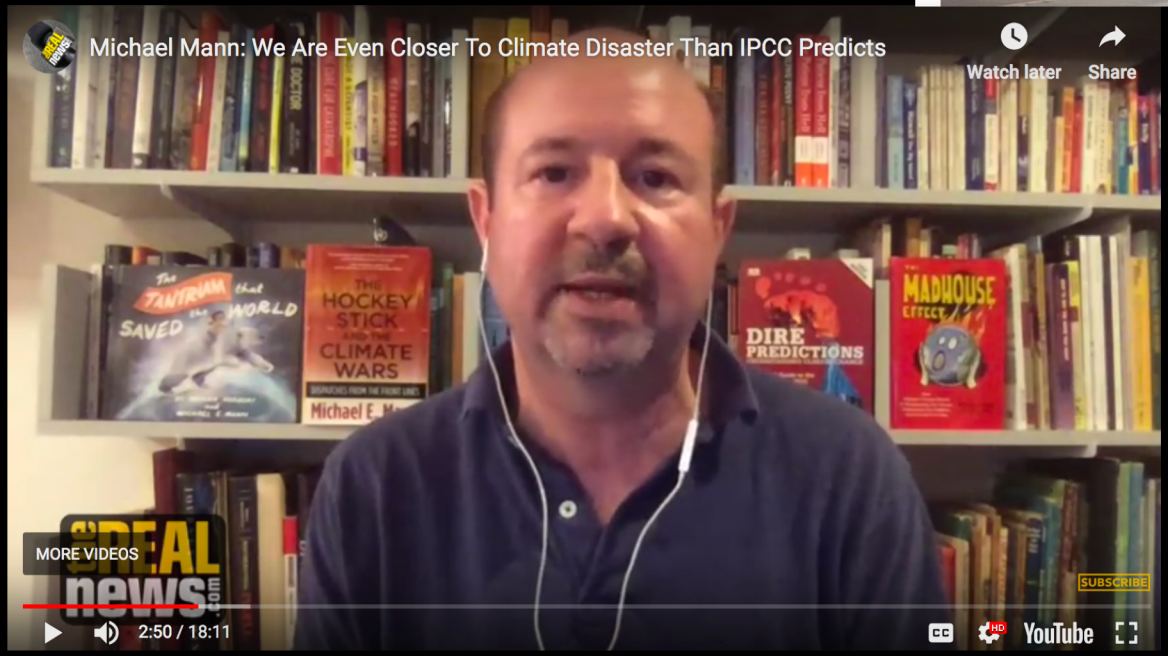
E&E NEWS

CLIMATE

New Climate Report Was Too Cautious, Some Scientists Say

rts cite important outcomes and costs of climate change left out of the latest IPCC report

By Scott Waldman, E&E News on October 11, 2018



CONCLUSIONS

- Recent hemispheric-scale warmth anomalous in at least a millennial context; can only be explained by anthropogenic impacts on climate
- Medieval warmth in high-latitude North Atlantic and parts of North America rivaled modern warmth
- Reconstructed La Nina-like pattern during Medieval times, and El Nino-like anomalies during the "Little Ice Age", suggest a 'thermostat'-like response response to natural radiative forcing
- Response of AO/NAO to natural volcanic and solar radiative forcing appears to explain enhanced 'Little Ice Age' and 'Medieval Warm Period' temperature signal in regions such as Europe
- Combination of warm tropical Atlantic and La Nina-like conditions in the tropical Pacific could explain periods of relatively high past Atlantic Hurricane activity
- Anthropogenic climate change impacts on TCs combined w/ SLR has led to dramatic increase in coastal risk relative to pre-anthropogenic era
- Evidence recent weakening of AMOC unprecedented in past millennium
- Use of true pre-anthropogenic baseline suggests we're closer to 1.5C/2C

Applications: Dangerous Warming Thresholds

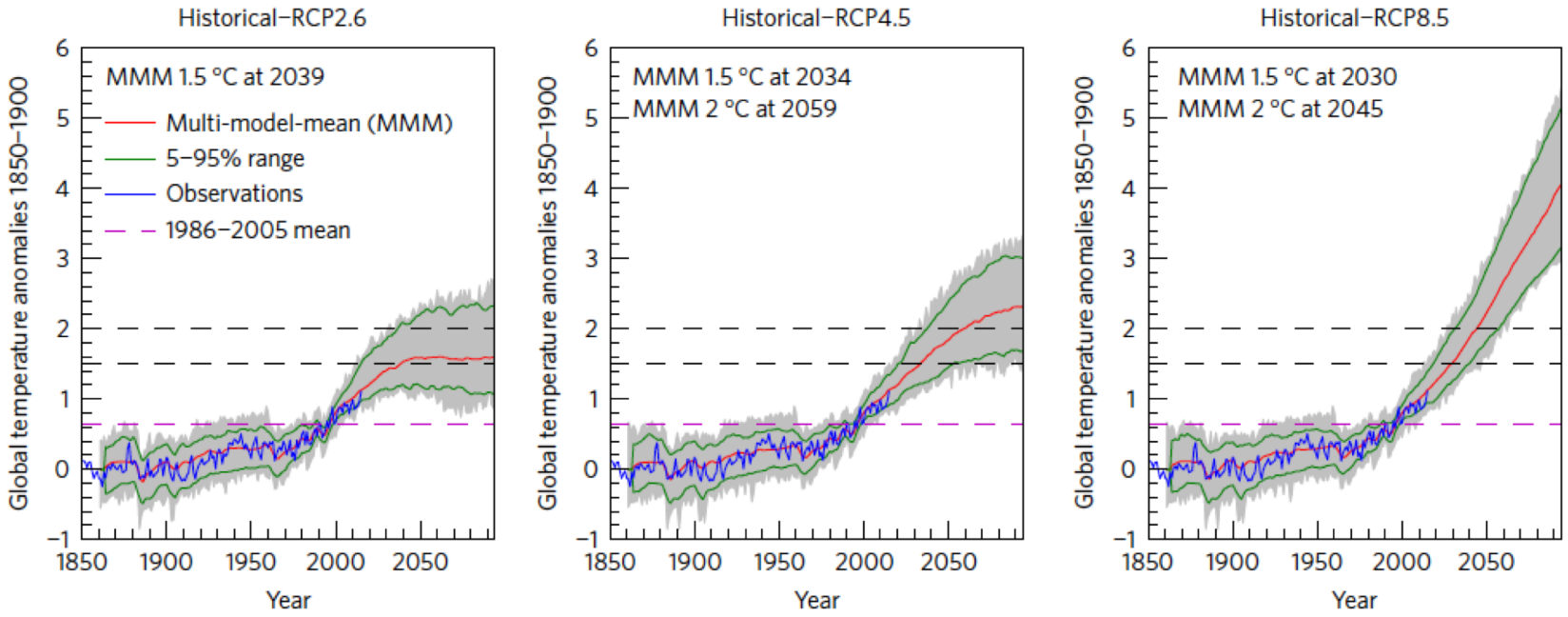


Figure 1 | Historical data and future projections for global mean temperature. Annual global mean temperature for observations[17] (blue) and model simulation range (grey) is shown for three different future scenarios. The probability distribution for the model simulations is represented by the model mean (red) and 5–95% range (green) smoothed by a 5-year running mean. All anomalies are first calculated for 1986–2005 and then observed warming since 1850–1900 (0.65 °C (ref. 17)—purple dashed line) has been added. Years when the median of the model distribution relative to 1850–1900 crosses the 1.5 °C and 2 °C thresholds are given in the text.

nature climate change

LETTERS

PUBLISHED ONLINE: 24 JULY 2017 | DOI: 10.1038/NCLIMATE3345

Importance of the pre-industrial baseline for likelihood of exceeding Paris goals

Andrew P. Schurer[1]*, Michael E. Mann[2], Ed Hawkins[3], Simon F. B. Tett[1] and Gabriele C. Hegerl[1]

Applications: Dangerous Warming Thresholds

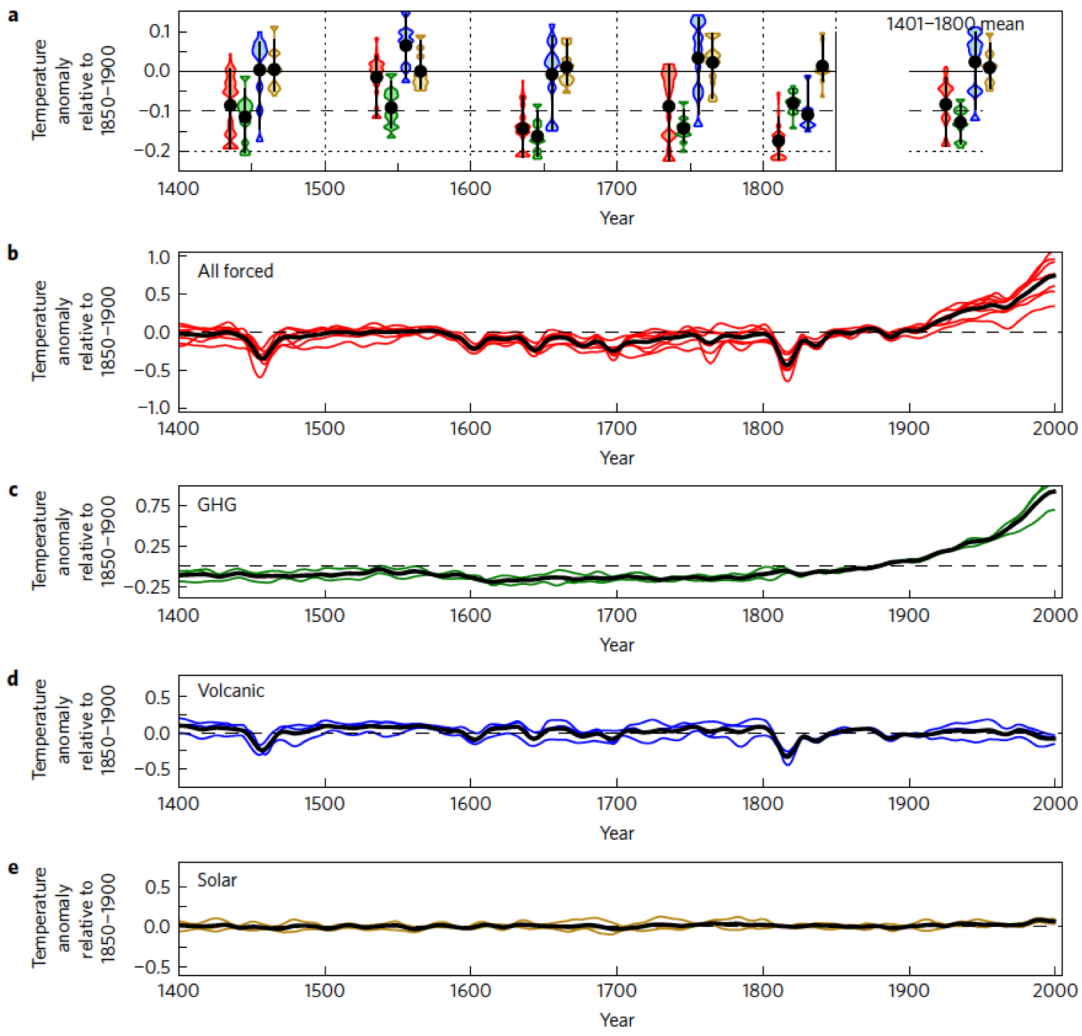
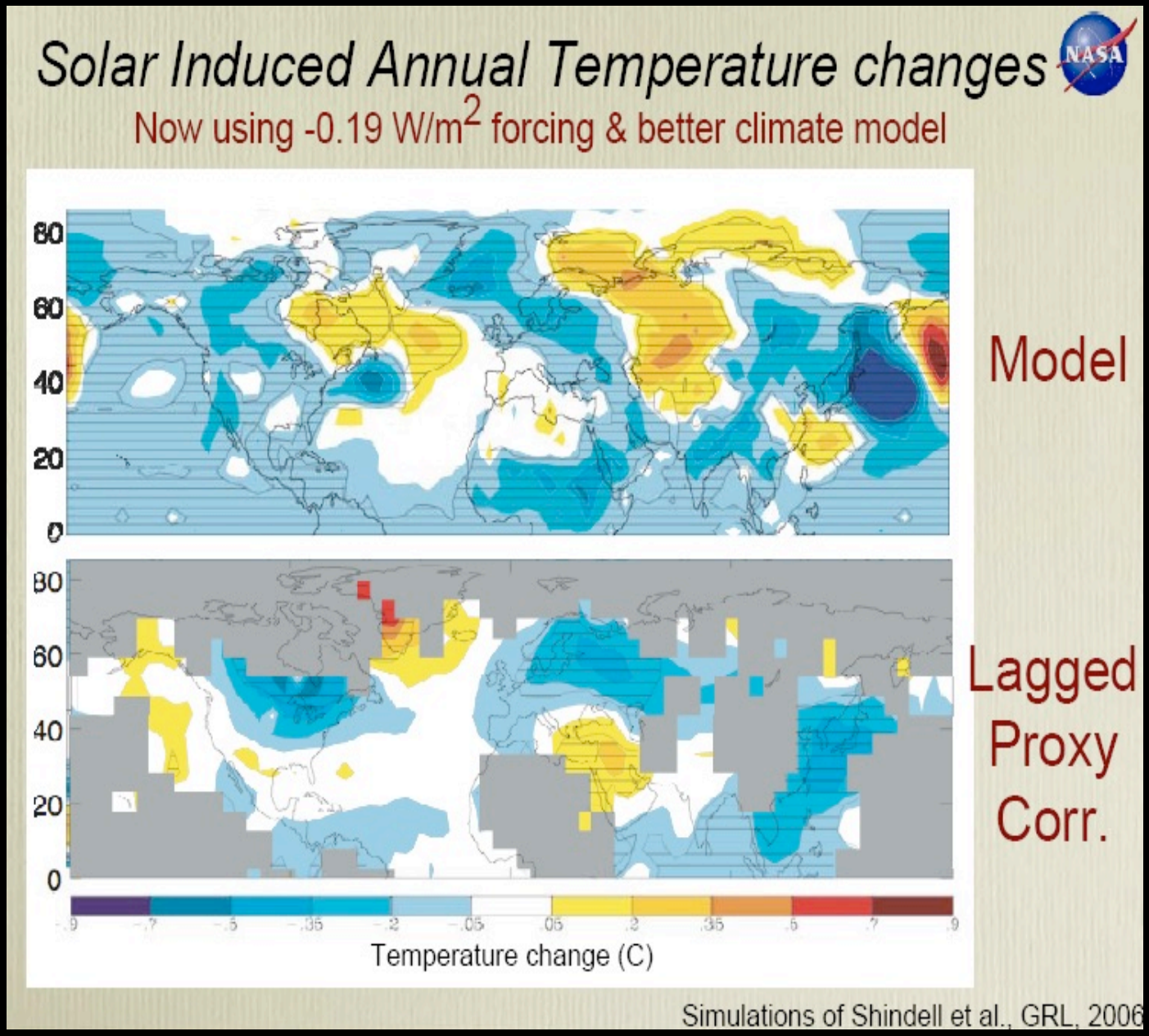


Figure 2 | Model-simulated difference in global mean temperature between different pre-industrial periods and 1850–1900. a, Range of ensemble means for different models, and for different forcing combinations. Model distribution fitted with a kernel density estimate (violin plot)—red, all forcings combined; green, greenhouse gas forcing alone; blue, volcanic forcing alone; yellow, solar forcing alone. Model mean: circle; 10–90% model range: bar. Differences refer to the mean of the period enclosed by the dashed lines; except on the far right, where they are means for the full period 1401–1800 (relative to 1850–1900). **b**–**e**, Model means for different forcing combinations—colours, ensemble means for individual models; black line, mean over all models.

European Winter Cooling During the *Little Ice Age*



CLIMATE CHANGE

False Hope

The rate of global temperature rise may have hit a plateau, but a climate crisis still looms in the near future

By Michael E. Mann

"Temperatures have been flat for 15 years—nobody can properly explain it," the *Wall Street Journal* says. "Global warming 'pause' may last for 20 more years, and Arctic sea ice has already started to recover," the *Daily Mail* says. Such reassuring claims about climate abound in the popular media, but they are misleading at best. Global warming continues unabated, and it remains an urgent problem.

The misunderstanding stems from data showing that during the past decade there was a slowing in the rate at which the earth's average surface temperature had been increasing. The event is commonly referred to as "the pause," but that is a misnomer: temperatures still rose, just not as fast as during the prior decade. The important question is, What does the short-term slowdown portend for how the world may warm in the future?

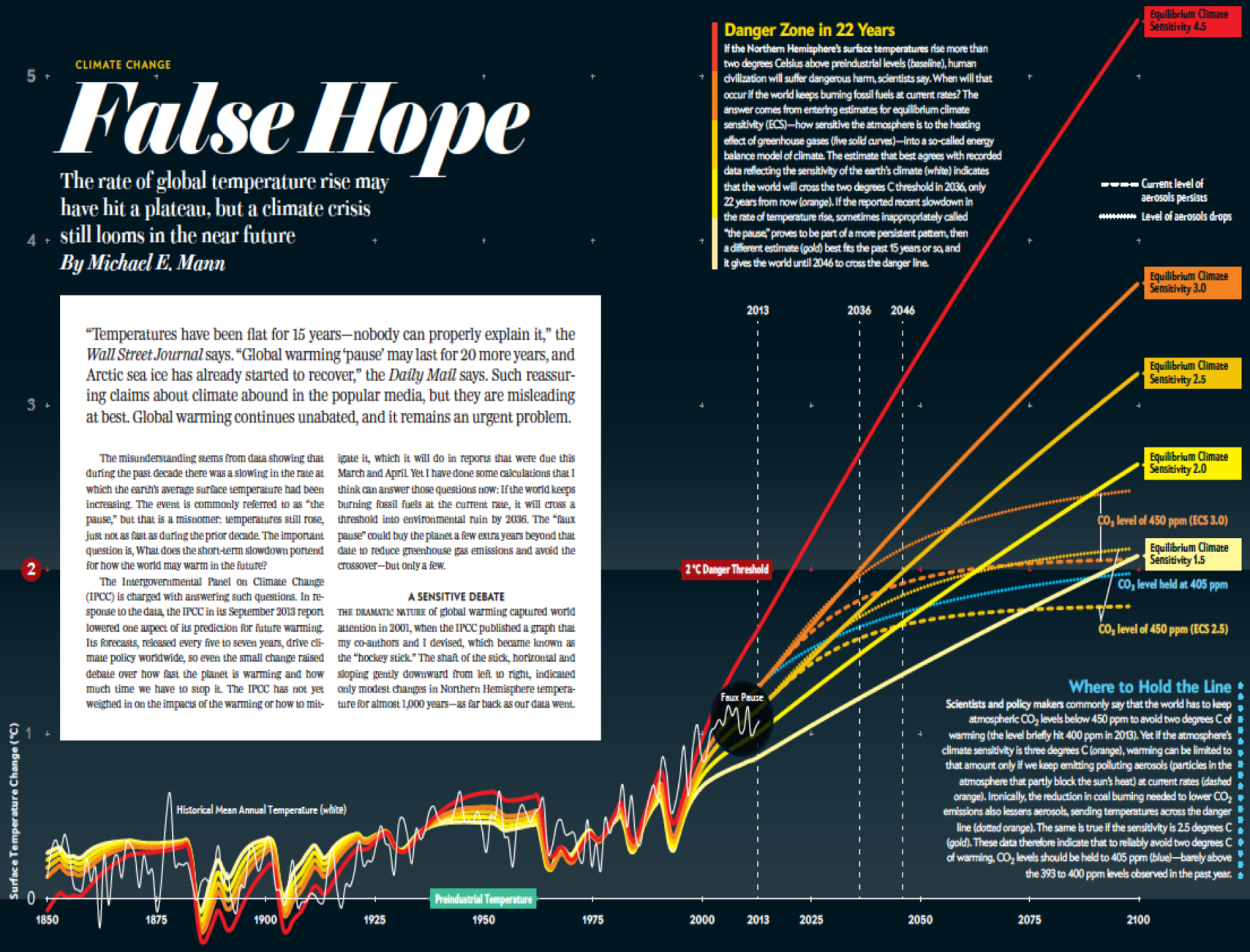
The Intergovernmental Panel on Climate Change (IPCC) is charged with answering such questions. In response to the data, the IPCC in its September 2013 report lowered one aspect of its prediction for future warming. Its forecasts, released every five to seven years, drive climate policy worldwide, so even the small change raised debate over how fast the planet is warming and how much time we have to stop it. The IPCC has not yet weighed in on the impacts of the warming or how to mitigate it, which it will do in reports that were due this March and April. Yet I have done some calculations that I think can answer those questions now: If the world keeps burning fossil fuels at the current rate, it will cross a threshold into environmental ruin by 2036. The "faux pause" could buy the planet a few extra years beyond that date to reduce greenhouse gas emissions and avoid the crossover—but only a few.

A SENSITIVE DEBATE

THE DRAMATIC NATURE of global warming captured world attention in 2001, when the IPCC published a graph that my co-authors and I devised, which became known as the "hockey stick." The shaft of the stick, horizontal and sloping gently downward from left to right, indicated only modest changes in Northern Hemisphere temperature for almost 1,000 years—as far back as our data went.

Danger Zone in 22 Years

If the Northern Hemisphere's surface temperatures rise more than two degrees Celsius above preindustrial levels (*baseline*), human civilization will suffer dangerous harm, scientists say. When will that occur if the world keeps burning fossil fuels at current rates? The answer comes from entering estimates for equilibrium climate sensitivity (ECS)—how sensitive the atmosphere is to the heating effect of greenhouse gases (*five solid curves*)—into a so-called energy balance model of climate. The estimate that best agrees with recorded data reflecting the sensitivity of the earth's climate (*white*) indicates that the world will cross the two degrees C threshold in 2036, only 22 years from now (*orange*). If the reported recent slowdown in the rate of temperature rise, sometimes inappropriately called "the pause," proves to be part of a more persistent pattern, then a different estimate (*gold*) best fits the past 15 years or so, and it gives the world until 2046 to cross the danger line.



Where to Hold the Line

Scientists and policy makers commonly say that the world has to keep atmospheric CO_2 levels below 450 ppm to avoid two degrees C of warming (the level briefly hit 400 ppm in 2013). Yet if the atmosphere's climate sensitivity is three degrees C (*orange*), warming can be limited to that amount only if we keep emitting polluting aerosols (particles in the atmosphere that partly block the sun's heat) at current rates (*dashed orange*). Ironically, the reduction in coal burning needed to lower CO_2 emissions also lessens aerosols, sending temperatures across the danger line (*dotted orange*). The same is true if the sensitivity is 2.5 degrees C (*gold*). These data therefore indicate that to reliably avoid two degrees C of warming, CO_2 levels should be held to 405 ppm (*blue*)—barely above the 393 to 400 ppm levels observed in the past year.

SOURCE: MICHAEL E. MANN

SCIENTIFIC AMERICAN ONLINE Detailed information on the energy balance model simulation is available at ScientificAmerican.com/apr2014/mann

Graphic by Pitch Interactive

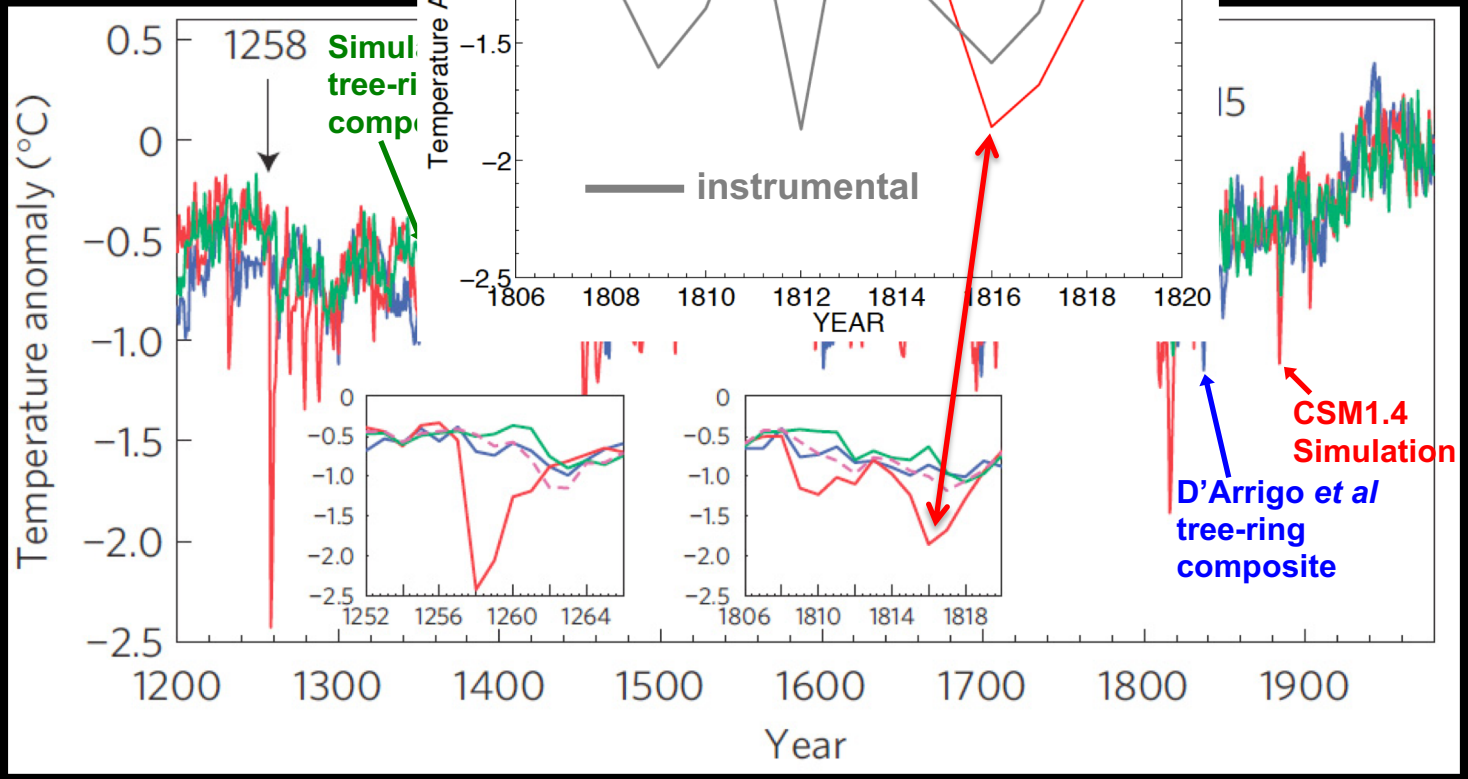
Applications: Refining parameter estimates

LETTERS
PUBLISHED ONLINE: 5 FEBRUARY 2012 | DOI: 10.1038/NGEO1394

Underestimation of volcanic coo based reconstructions of hemisp

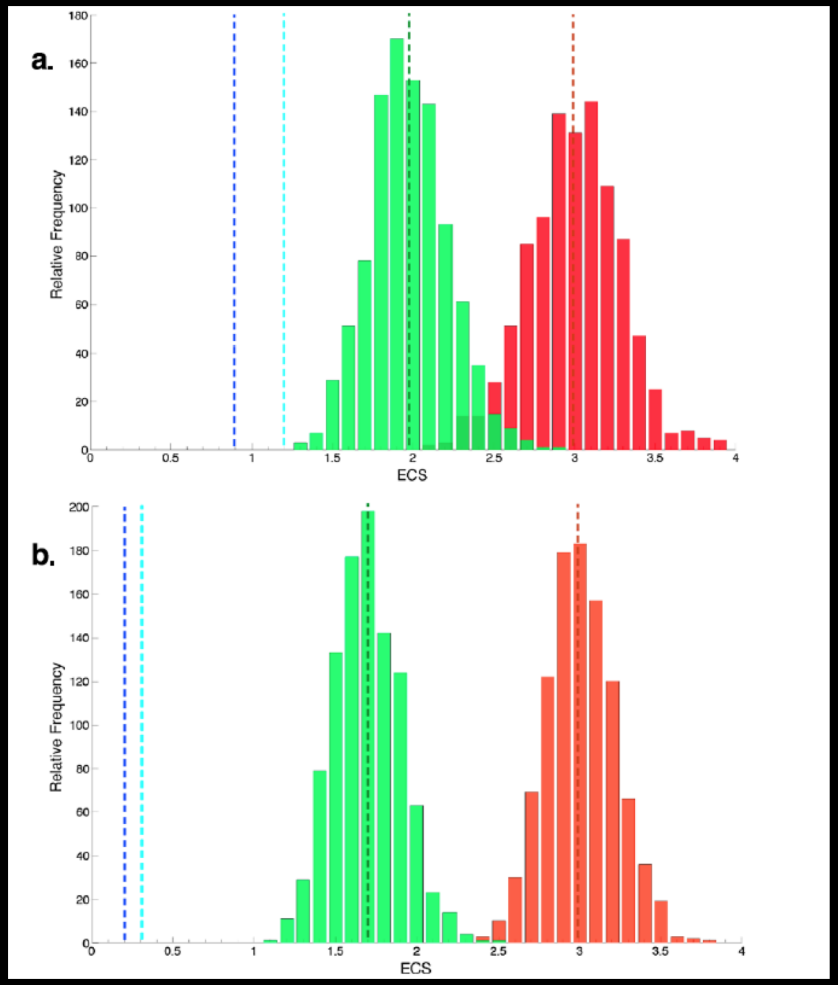
Michael E. Mann[1]*, Jose D. Fuentes[1] and Scott Rutherford[2]

Climate Sensitivity underestimated ?



D'Arrigo et al tree-ring based NH reconstruction (blue) along with the climate model (NCAR CSM 1.4) simulated NH mean temperatures (red) and the "simulated tree-ring" NH temperature series based on driving the biological growth model with the climate model simulated temperatures (green). The two insets focus on the response to the AD 1258 and AD 1809+1815 volcanic eruption sequences.

Applications: Refining parameter estimates



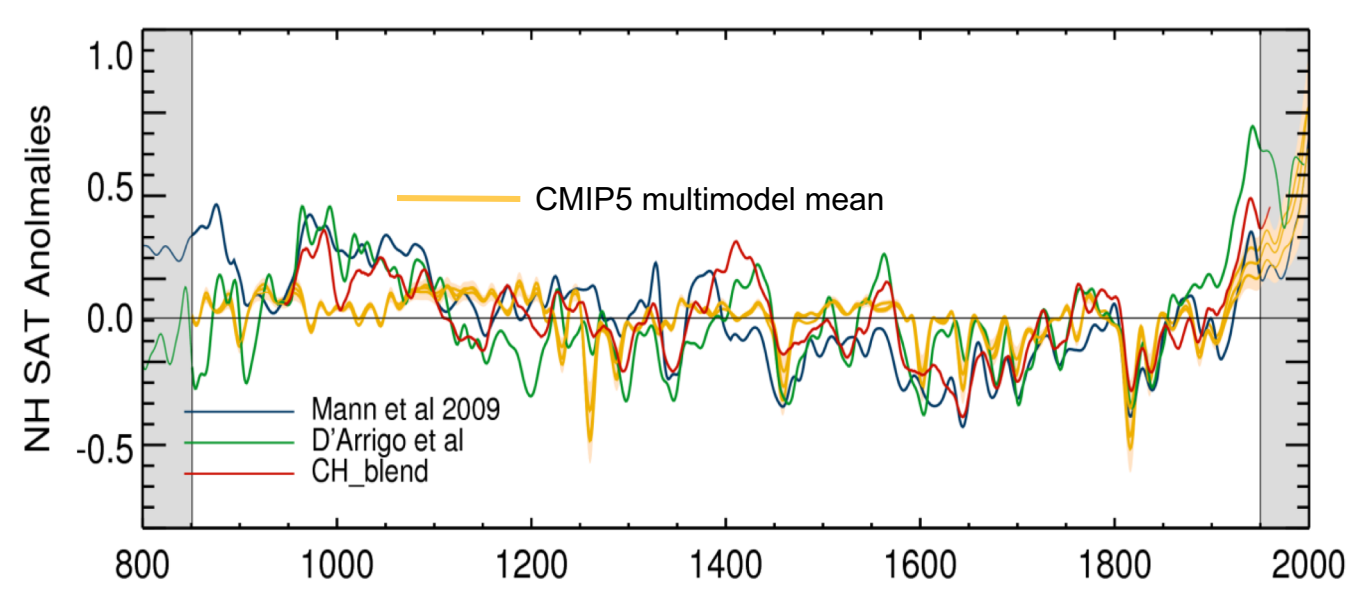
PDF of ECS using decadally smoothed data between (a) AD 1300–1849 and (b) AD 1200–1849 (red = simulated actual temperature series; green = synthetic tree ring temperature series). Shown by dashed vertical lines are mean of the ESC distribution for simulated temperature series (red), mean of ECS distribution for synthetic tree ring temperature series (green), ECS estimate using MFR12 simulated tree ring temperature series where chronological error accumulation due to inferred missing rings is taken into account (cyan), and sensitivity estimate for D06 tree ring temperature reconstruction (blue). True value of ESC is 3.0 in both cases.

JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES, VOL. 118, 7617–7627, doi:10.1002/jgrd.50609, 2013

Discrepancies between the modeled and proxy-reconstructed response to volcanic forcing over the past millennium: Implications and possible mechanisms

Michael E. Mann,[1] Scott Rutherford,[2] Andrew Schurer,[3] Simon F.B. Tett,[3] and Jose D. Fuentes[4]

NH Mean Temperature over past Millennium: Model/Data Comparison



JOURNAL OF CLIMATE VOLUME 26

Separating Forced from Chaotic Climate Variability over the Past Millennium

ANDREW P. SCHURER AND GABRIELE C. HEGERL

School of GeoSciences, The University of Edinburgh, Edinburgh, United Kingdom

MICHAEL E. MANN

Department of Meteorology, and Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, Pennsylvania

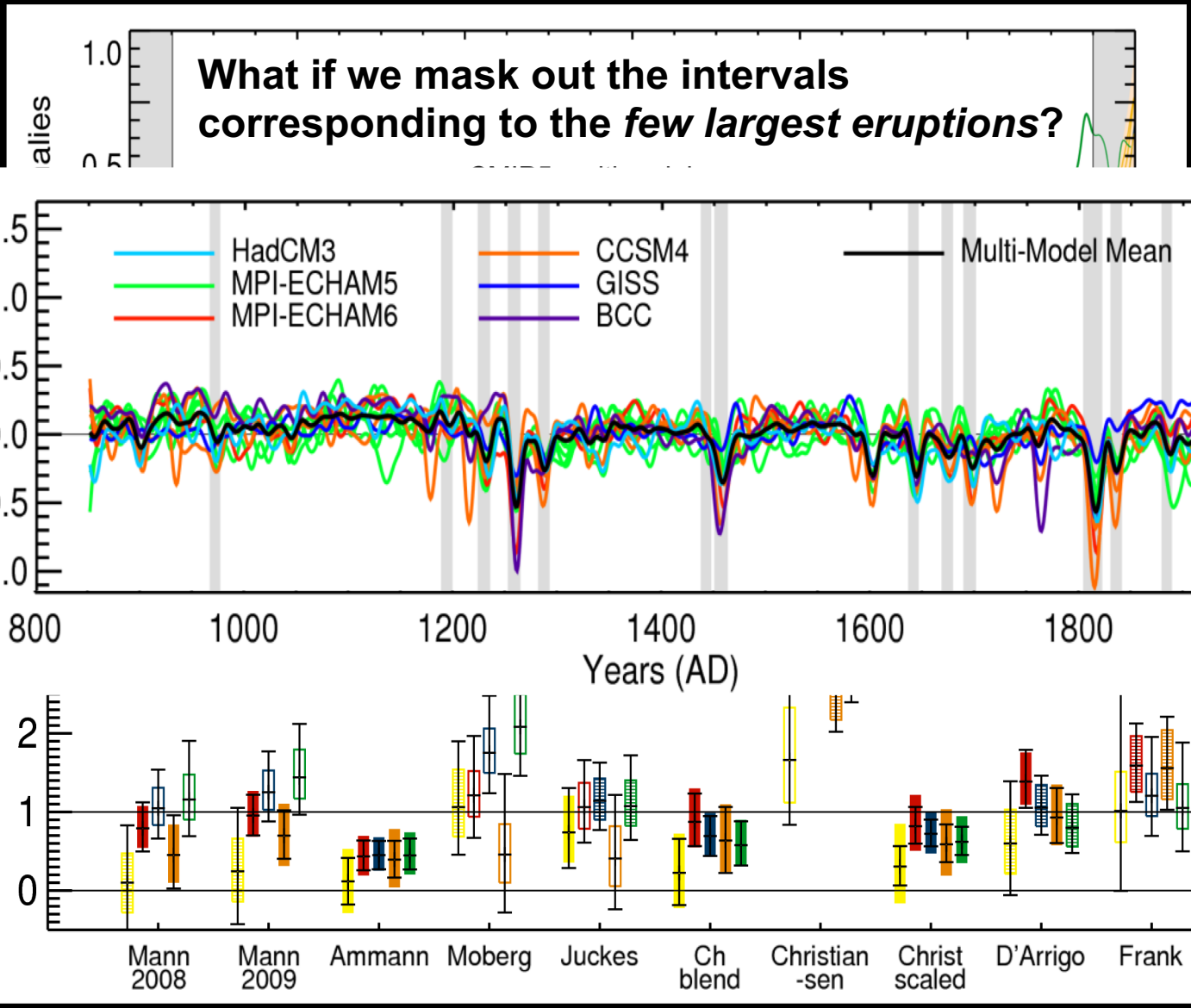
SIMON F. B. TETT

School of GeoSciences, The University of Edinburgh, Edinburgh, United Kingdom

STEVEN J. PHIPPS

Climate Change Research Centre, and ARC Centre of Excellence for Climate System Science, University of New South Wales, Sydney, New South Wales, Australia

NH Mean Temperature over past Millennium: Model/Data Comparison



Hockey *League*

The Telegraph

HOME | NEWS | WORLD | SPORT | FINANCE | COMMENT | BLOGS | CULTURE | TRAVEL | LIFE

Politics | Obits | Education | Earth | Science | Defence | Health | Scotland | Royal | Celebrities

BLOGS HOME » NEWS » ENVIRONMENT » GEOFFREY LEAN

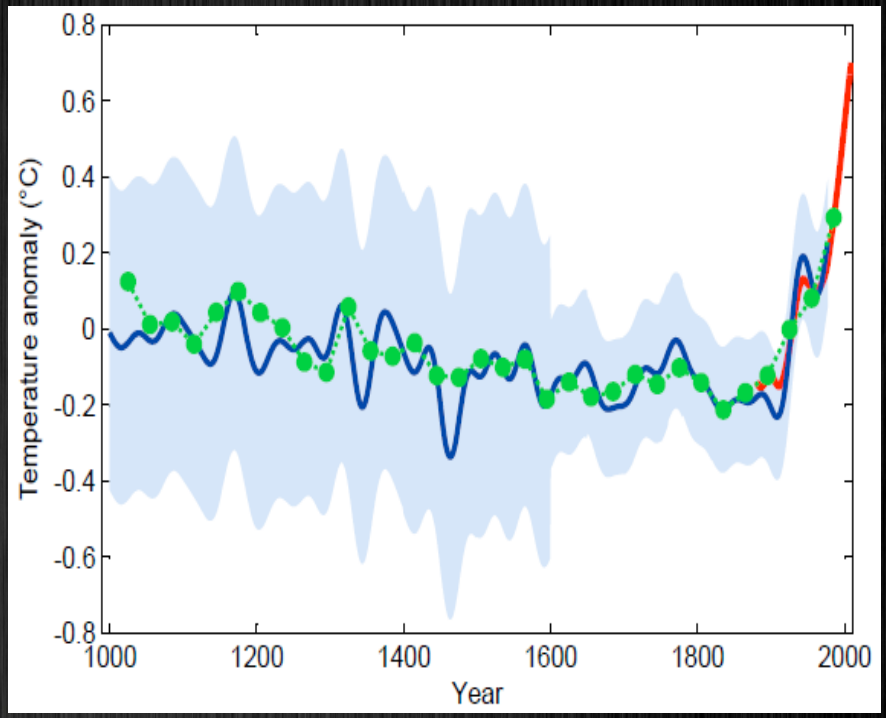
Geoffrey Lean

Geoffrey Lean is Britain's longest-serving environmental correspondent, having pioneered reporting on the subject almost 40 years ago.

Did the contentious global warming 'hockey stick' graph get it right after all?

By Geoffrey Lean | Science | Last updated: April 26th, 2013

Print this article



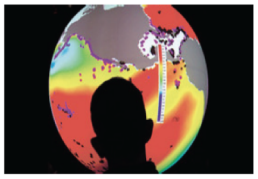
FINANCIAL TIMES

Welcome to FT.com, the global source of business news and analysis. Register now to receive 8 free articles per month.

April 21, 2013 6:33 pm

Research backs global warming theory

By Pilita Clark, Environment Correspondent



A study of global temperatures over the past 2,000 years has lent fresh weight to the so-called hockey stick graph which suggests that humans caused global warming.

The graph, first published in the late 1990s by US palaeoclimatologist Professor Michael Mann and colleagues, shows temperatures stayed roughly flat for about 900 years, like the handle of the hockey stick laid down, before rising sharply upwards in the 20th century, like the blade, after the industrial revolution prompted a rise in fossil fuel emissions.

nature geoscience

PROGRESS ARTICLE

PUBLISHED ONLINE: XX MAY 2013 | DOI: 10.1038/NGEO1797

Continental-scale temperature variability during the past two millennia

PAGES 2k Network*

Past global climate changes had strong regional expression. To elucidate their spatiotemporal pattern, we reconstructed past temperatures for seven continental-scale regions during the past one to two millennia. The most coherent feature in nearly all of the regional temperature reconstructions is a long-term cooling trend, which ended late in the nineteenth century. At multi-decadal to centennial scales, temperature variability shows distinctly different regional patterns, with more similarity within each hemisphere than between them. There were no globally synchronous multi-decadal warm or cold intervals that define a worldwide Medieval Warm Period or Little Ice Age, but all reconstructions show generally cold conditions between AD 1580 and 1880, punctuated in some regions by warm decades during the eighteenth century. The transition to these colder conditions occurred earlier in the Arctic, Europe and Asia than in North America or the Southern Hemisphere regions. Recent warming reversed the long-term cooling; during the past 30 years (AD 1971–2000), the area-weighted average reconstructed temperature was higher than any other time in nearly 1,400 years.