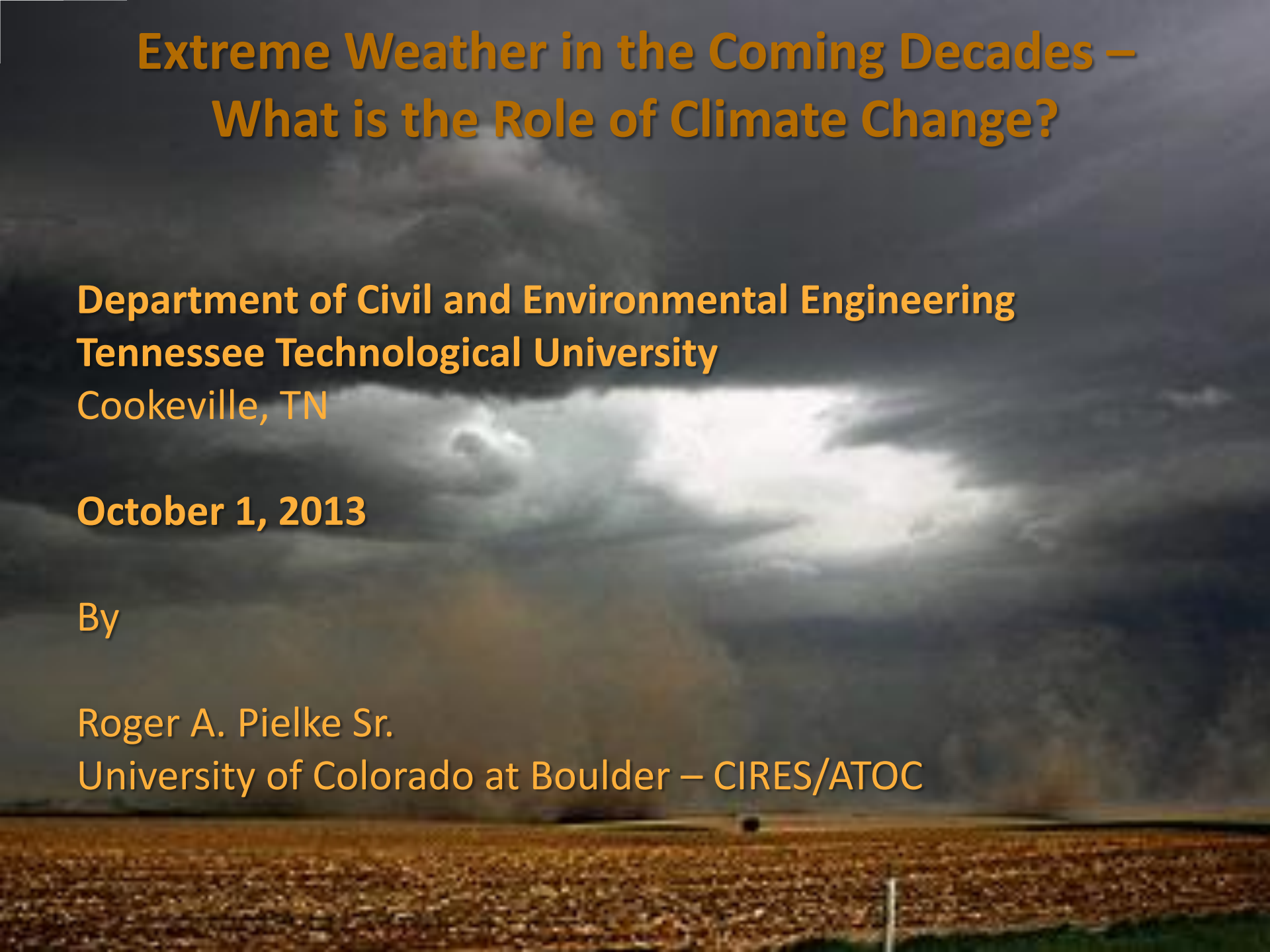
Extreme Weather in the Coming Decades – What is the Role of Climate Change?



Department of Civil and Environmental Engineering
Tennessee Technological University
Cookeville, TN

October 1, 2013

By

Roger A. Pielke Sr.
University of Colorado at Boulder – CIRES/ATOC

The Colorado Flood of 2013

First – My Comments on the recent Colorado Flood

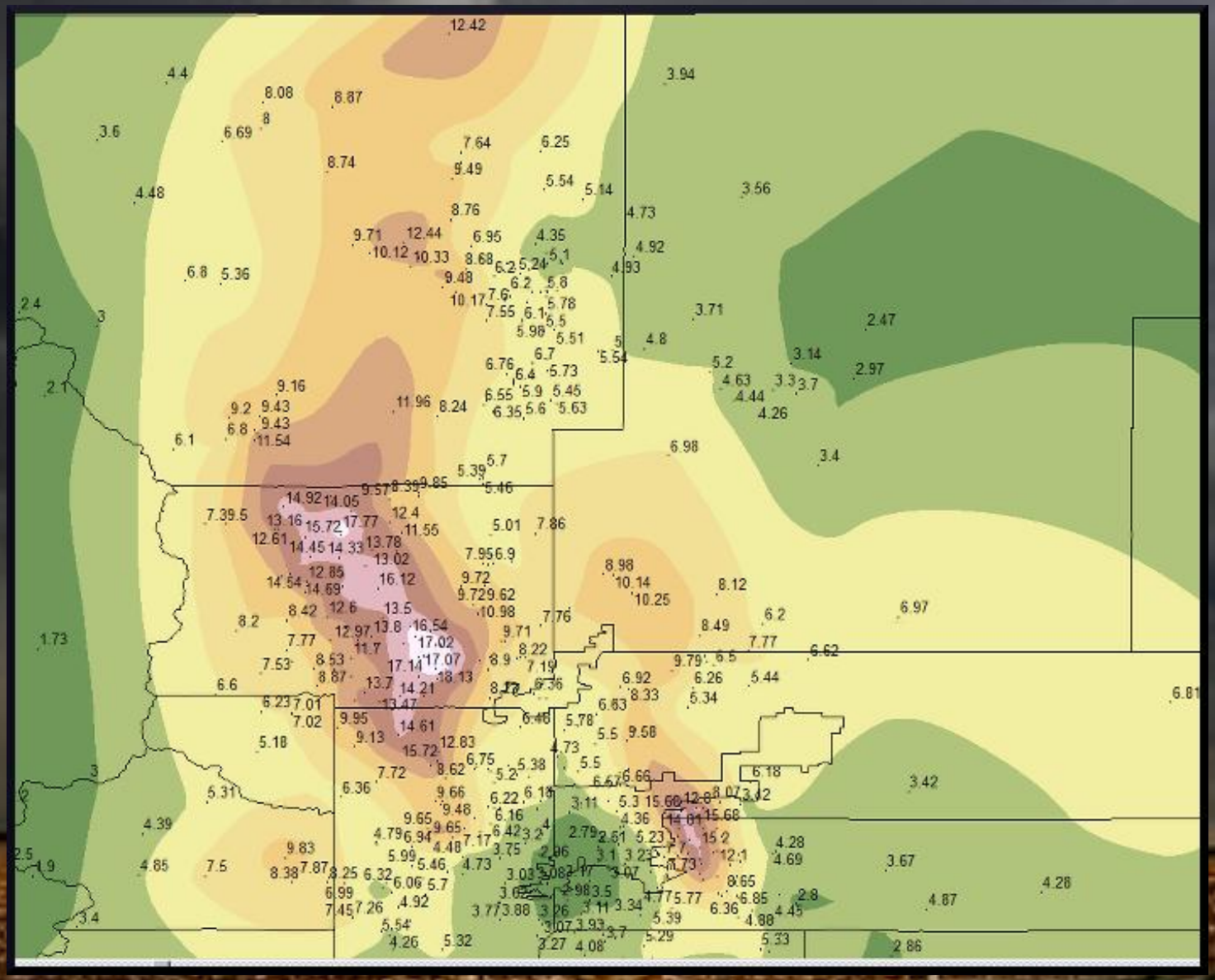
Was the September 2013 flood a 1 in 1000 year event?

Time Magazine

"The Science Behind Colorado's Thousand-Year Flood" [http://science.time.com/2013/09/17/the-science-behind-colorados-thousand-year-flood/]

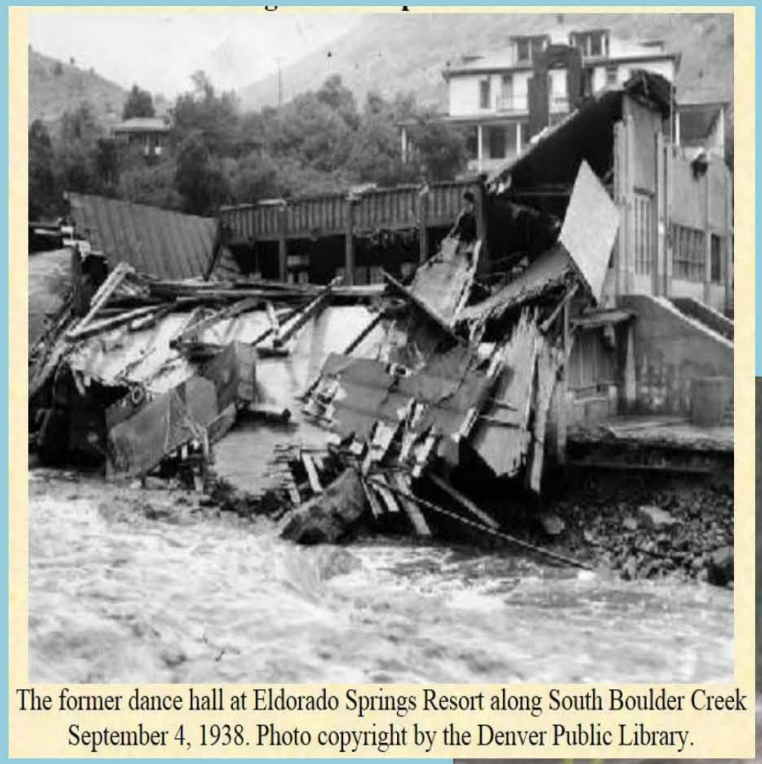
"the National Weather Service called [the heavy rain] "biblical".

http://www.crh.noaa.gov/bou/?n=stormtotals_092013



http://www.crh.noaa.gov/images/bou/precip/Presentation2.pdf

Two Notable September Colorado Front Range Floods



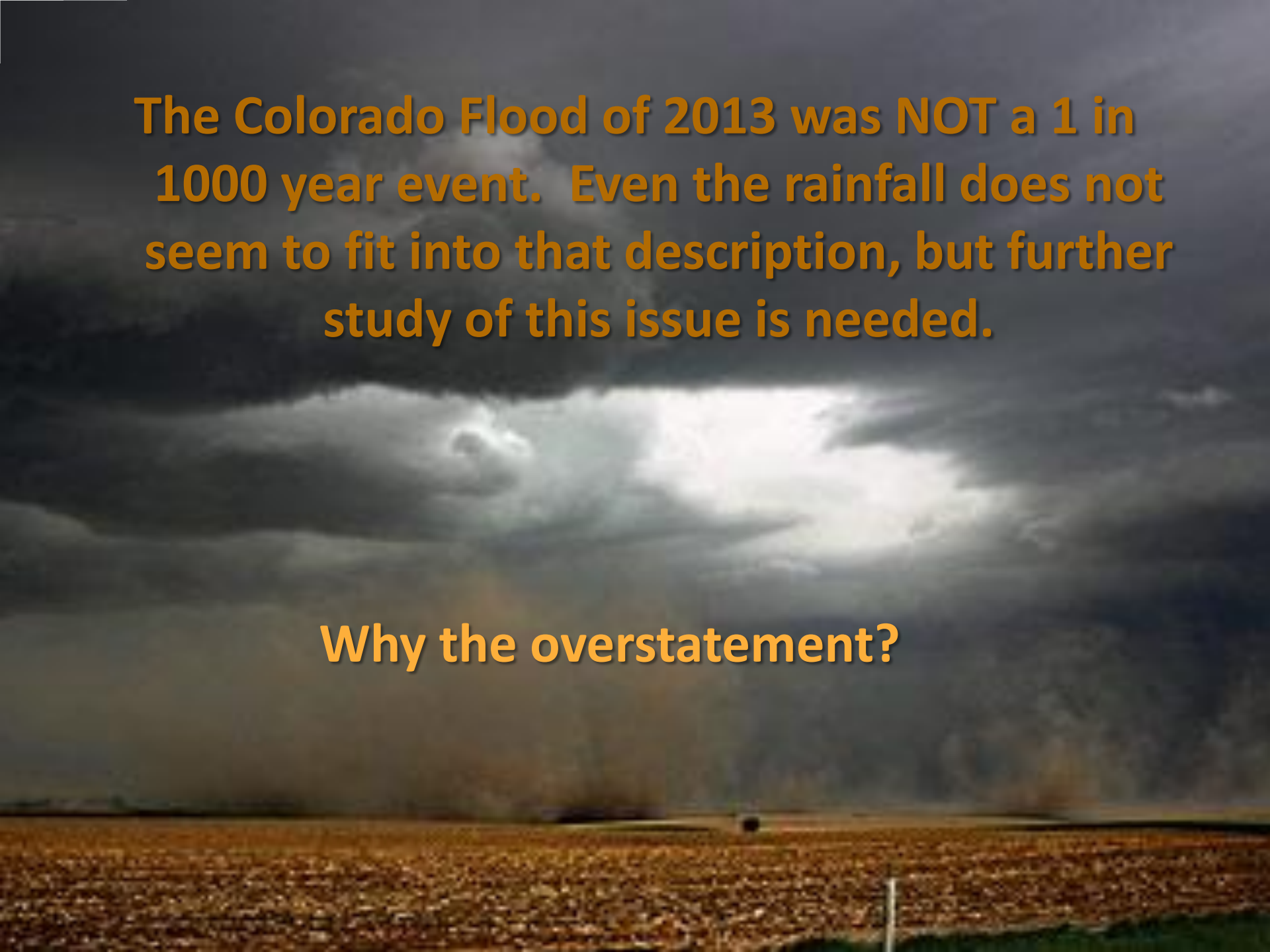
The former dance hall at Eldorado Springs Resort along South Boulder Creek September 4, 1938. Photo copyright by the Denver Public Library.

North Fork Big Thompson River at Drake
September 13, 2013

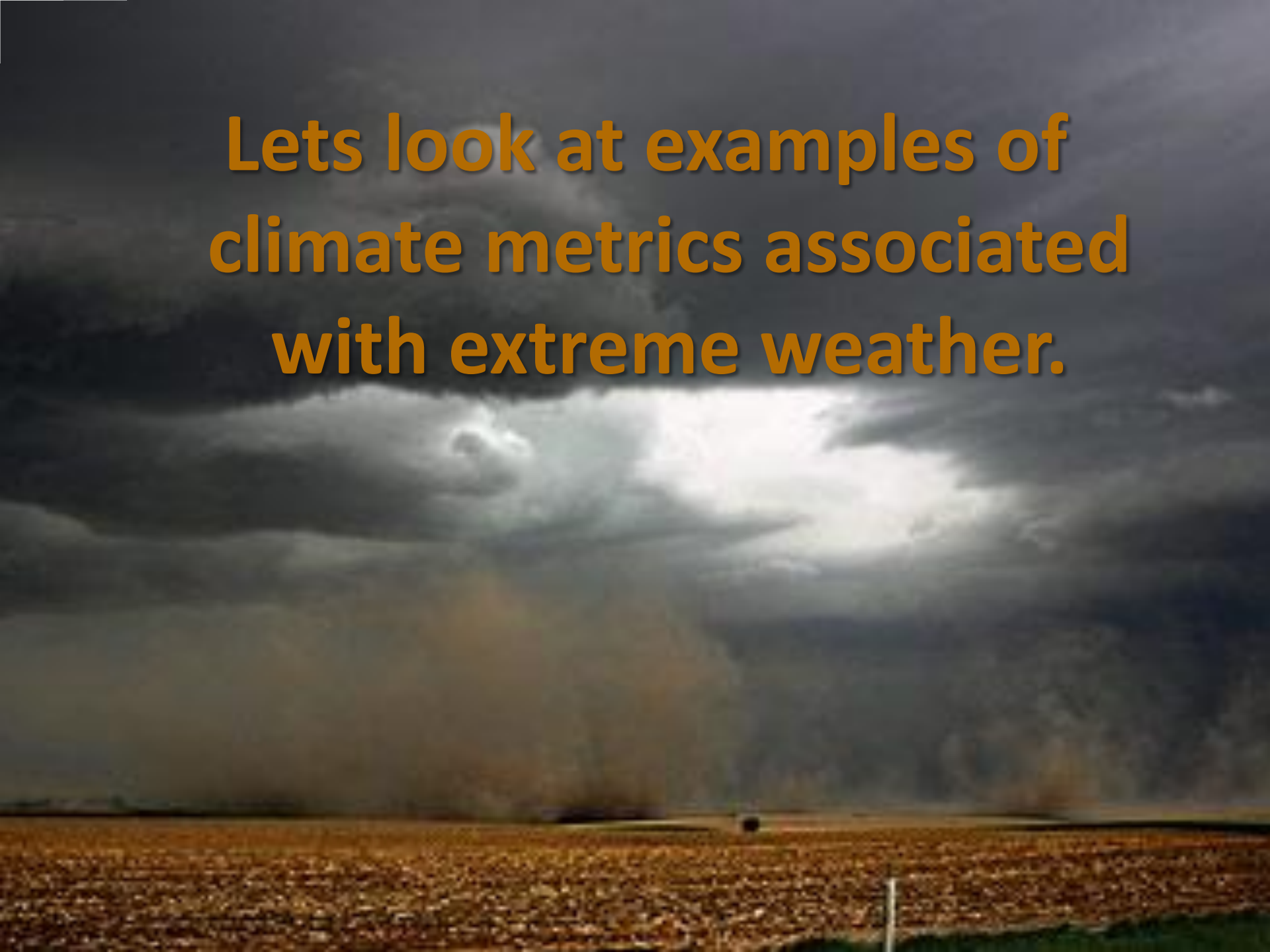
Photo courtesy of 9News.com

http://www.crh.noaa.gov/images/bou/precip/Presentation2.pdf

- On September 2nd and 3rd of 1938, flooding of similar magnitude to the recent flooding hit the Front Range of Colorado, from the Wyoming border south to Colorado Springs.
- Precipitation intensity of the two floods was comparable, with more precipitation recorded during the 2013 flood because of its longer duration. Some locations, such as Fort Collins, Morrison and areas east of Denver received more precipitation during the 1938 flood.

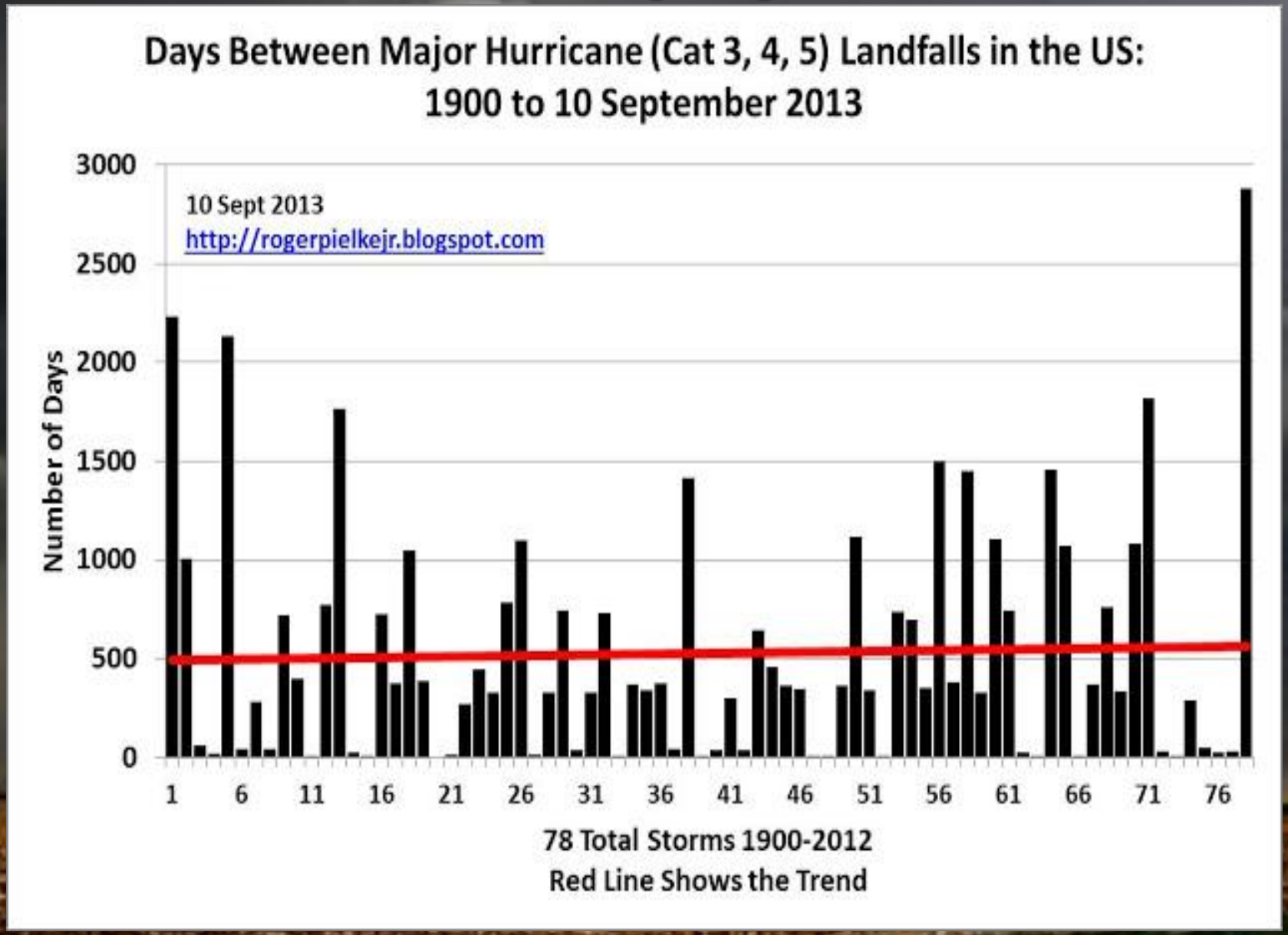

The Colorado Flood of 2013 was NOT a 1 in 1000 year event. Even the rainfall does not seem to fit into that description, but further study of this issue is needed.
Why the overstatement?

Because the flood can be attributed to “climate change”.


Lets look at examples of climate metrics associated with extreme weather.

Hurricanes

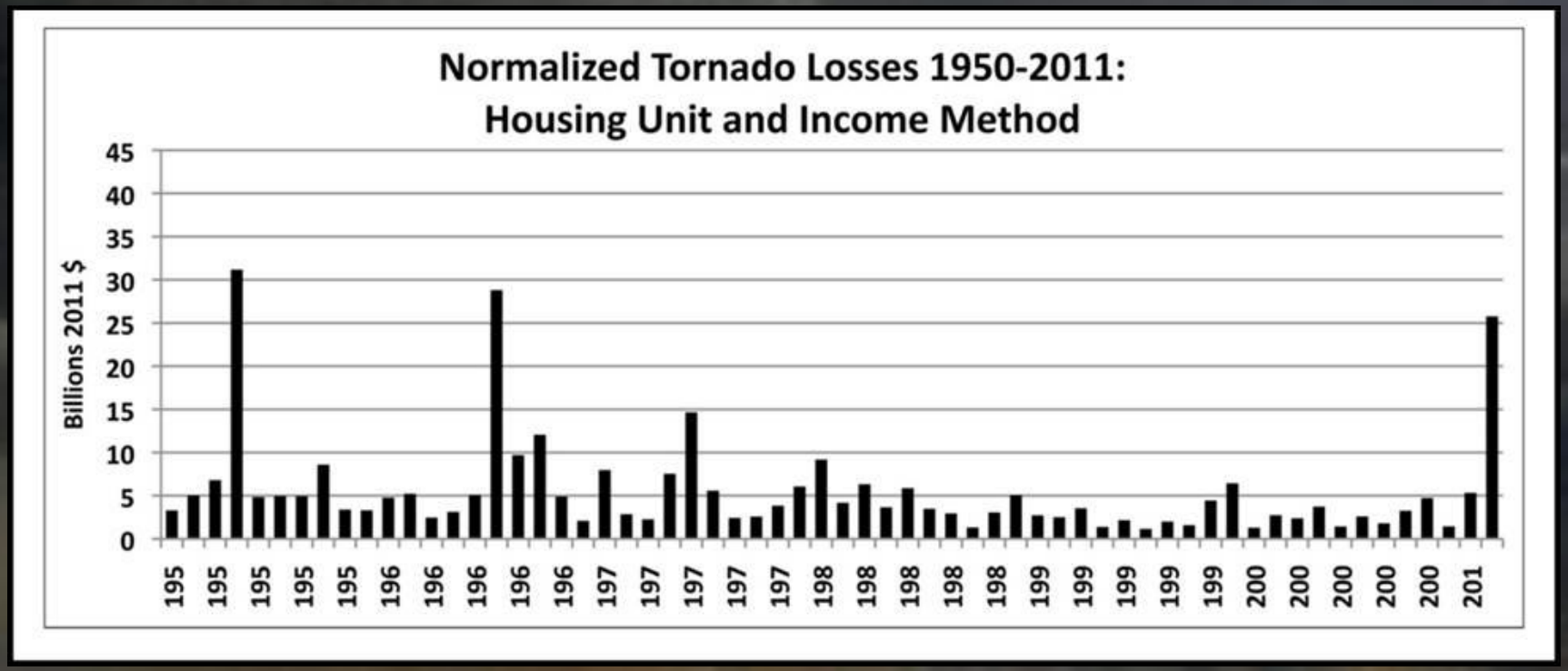
http://rogerpielkejr.blogspot.com/2013/09/updated-major-hurricane-drought-figure.html



Tornadoes

http://rogerpielkejr.blogspot.com/2012/10/new-paper-normalized-tornado-damage-in.html

http://rogerpielkejr.blogspot.com/2012/10/new-paper-normalized-tornado-damage-in.html



Now on to the misrepresentation of climate science

"A difficult question for the climate science community is, how is it that this broad community of researchers -- full of bright and thoughtful people -- allowed intolerant activists who make false claims to certainty to become the public face of the field?" - Roger Pielke, Jr.

http://rogerpielkejr.blogspot.com/2013/09/global-temperature-trends-and-ipcc.html

"Climate change - caused by carbon pollution - is one of the most significant public health threats of our time,"

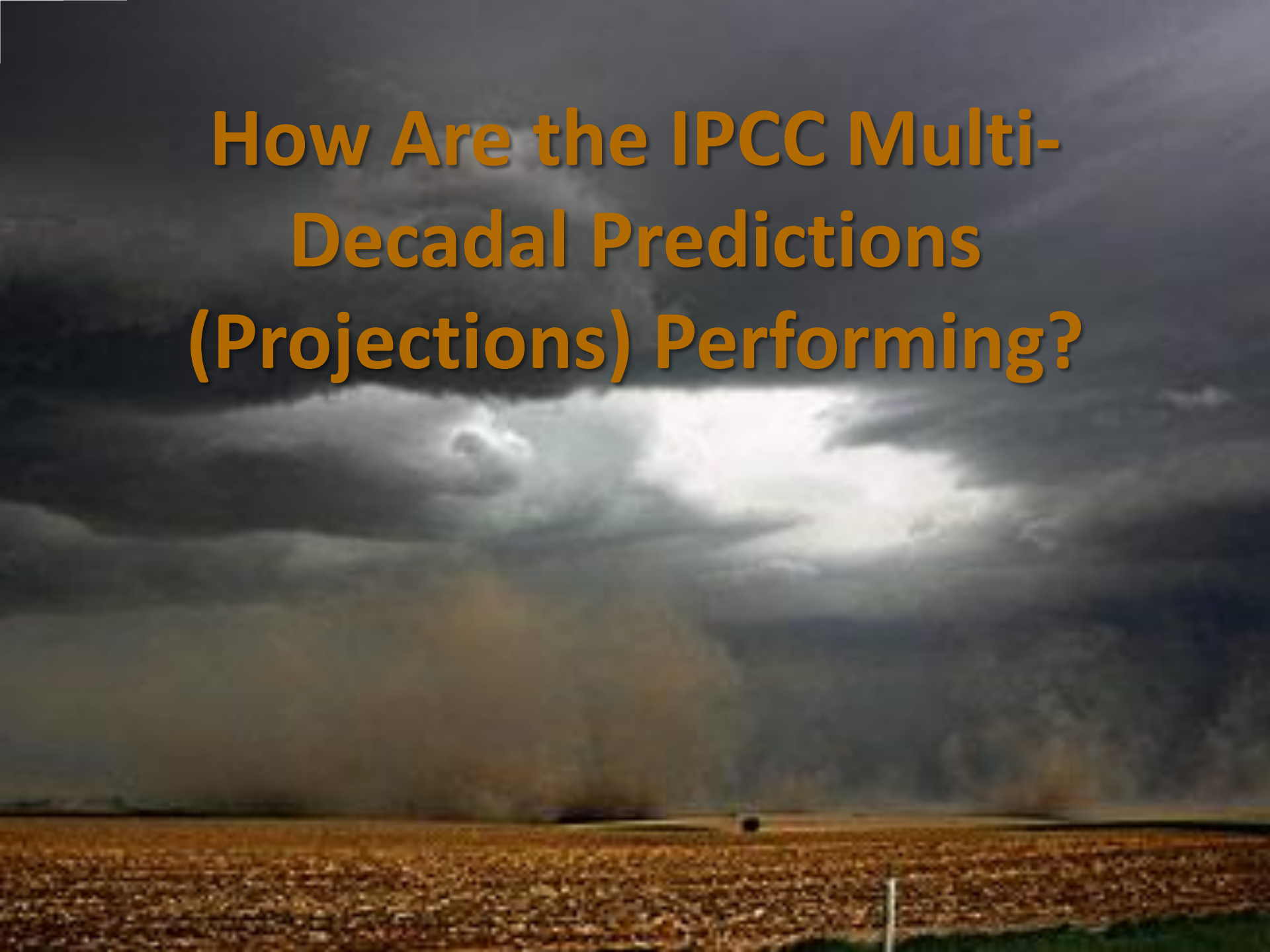
Environmental Protection Agency Head - Gina McCarthy

http://www.bbc.co.uk/news/business-24181341

"Most climate scientists wouldn't say that the 15-year period is a good reason to question the overall quality of models."

Jean-Pascal van Ypersele, vice-chair of the IPCC

http://www.bbc.co.uk/news/science-environment-24173504

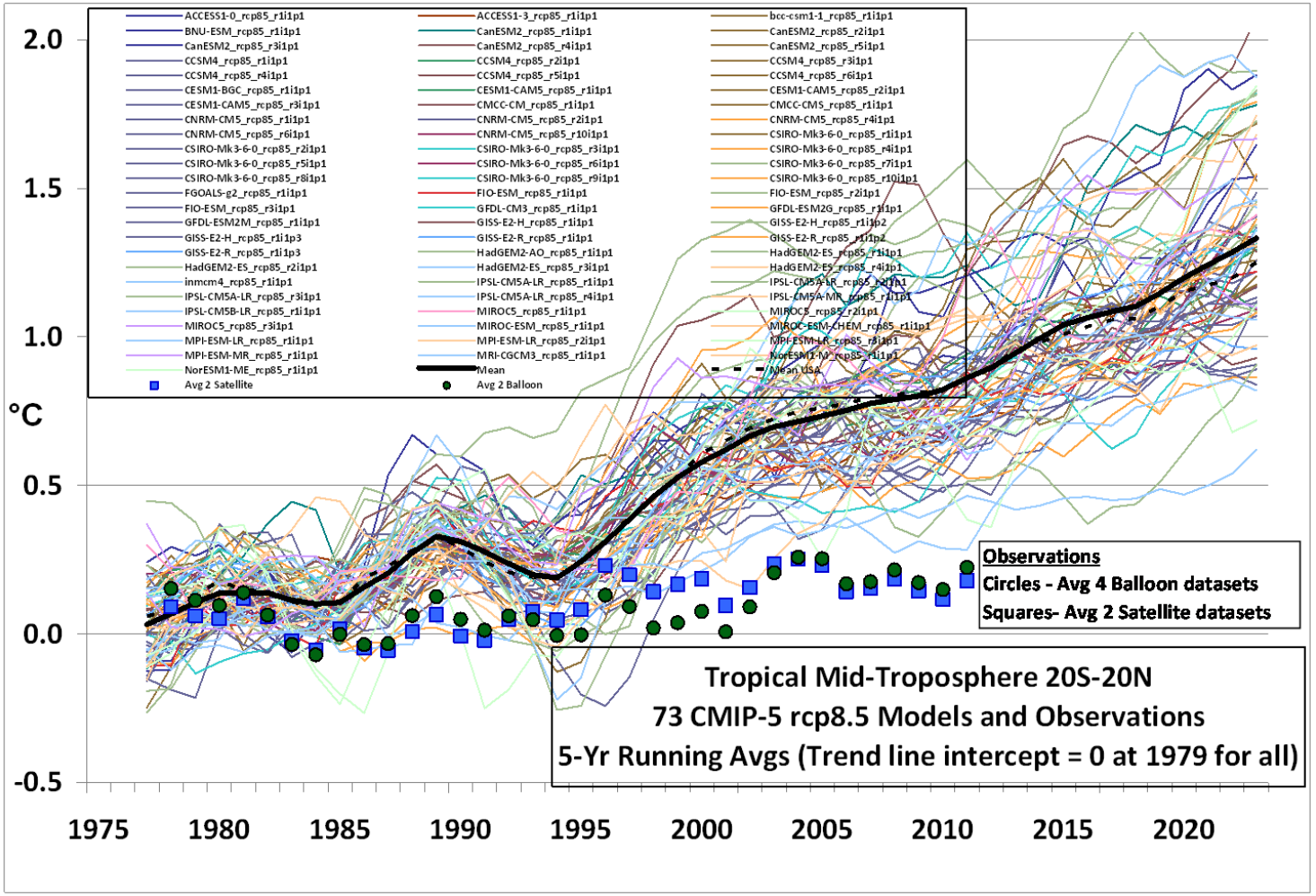

How Are the IPCC Multi-Decadal Predictions (Projections) Performing?

Necessary Conditions For Skillful Multi-Decadal Predictions of Extreme Events

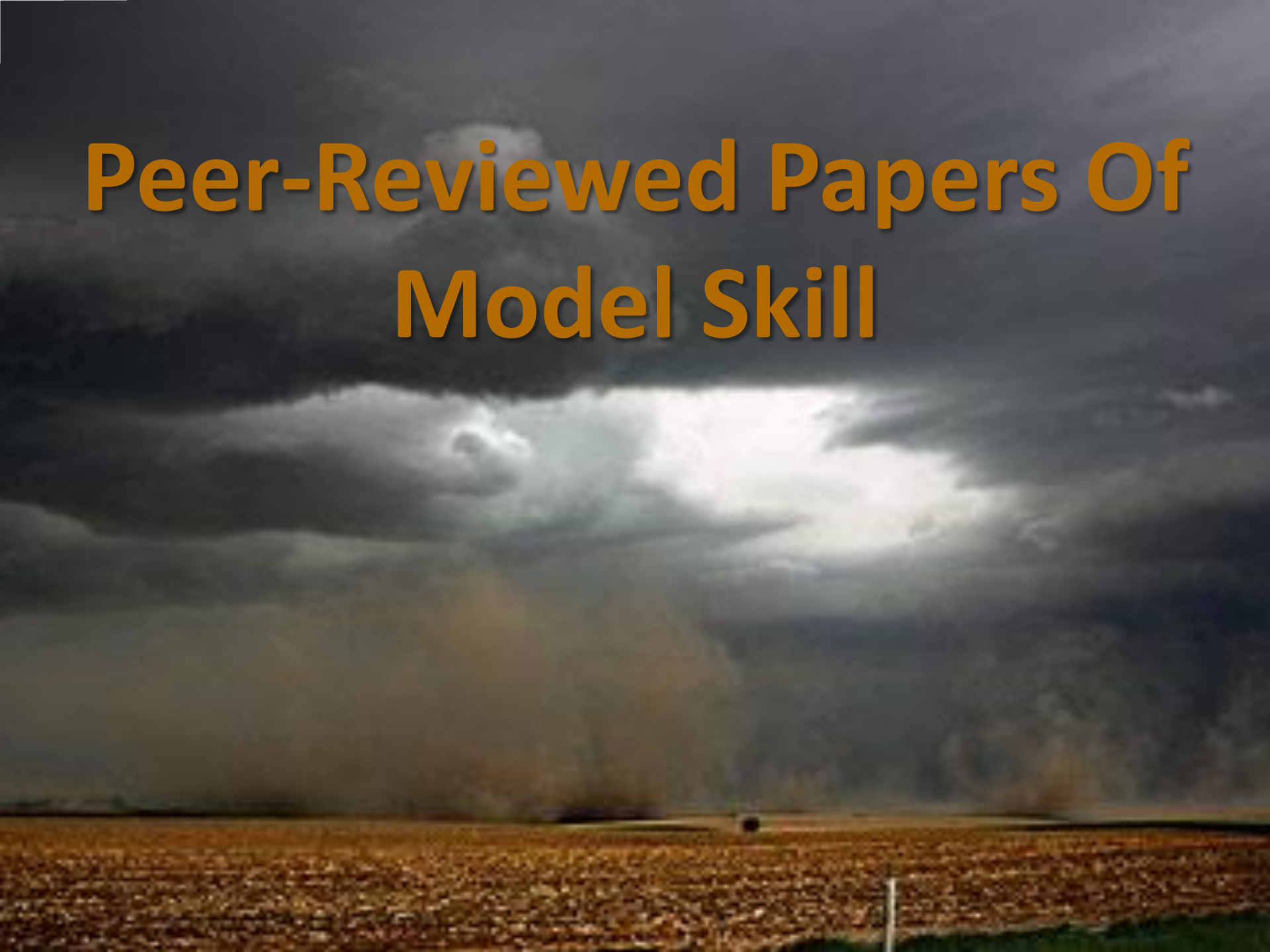
In hindcast runs (the last several decades), skillful predictions must be demonstrated which include:

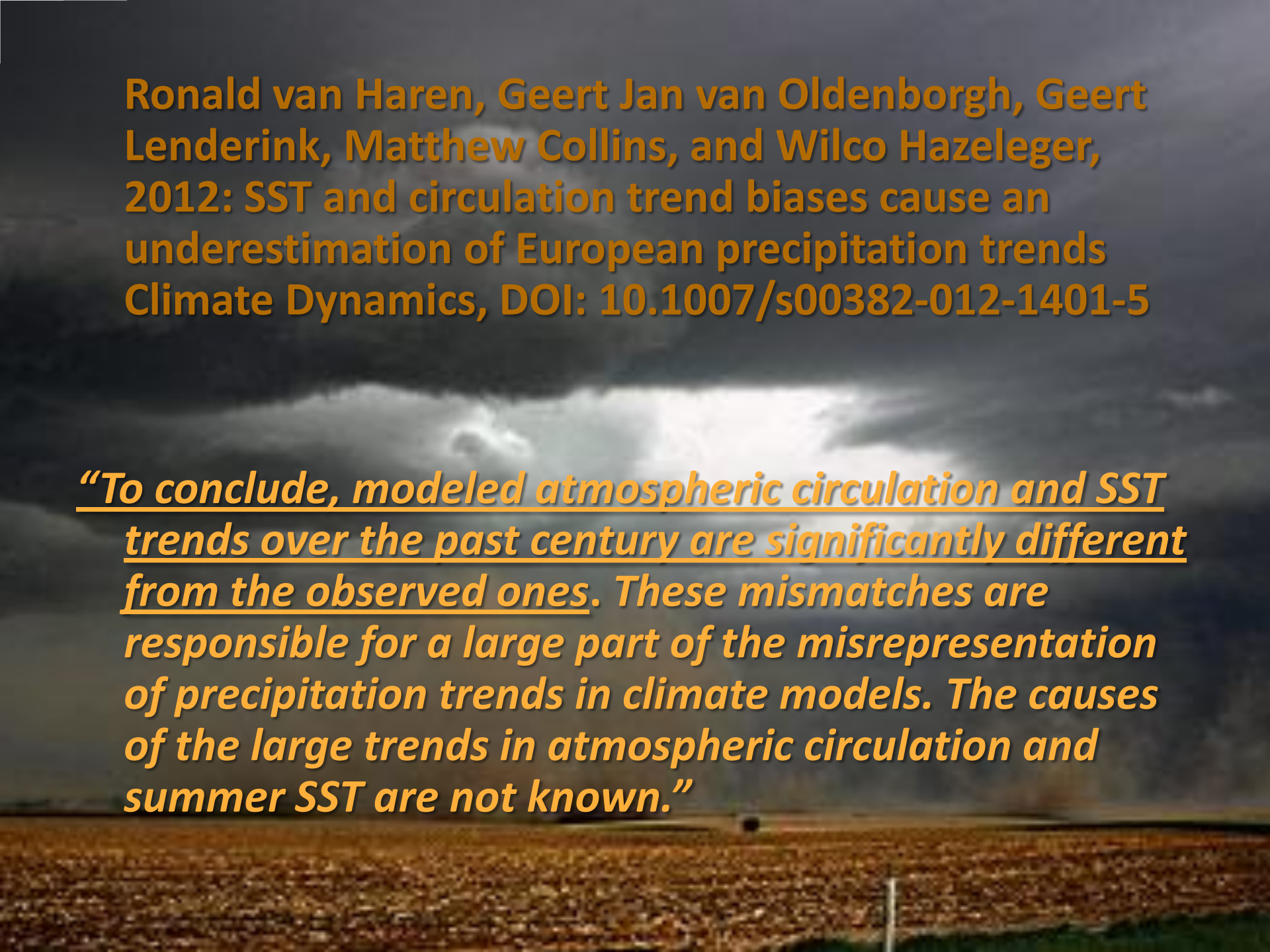
1. The average (annual, monthly, etc.) global, regional and local climate.
2. The changes in these averages over the past several decades
3. The statistics of extreme weather events
4. The changes in these extremes over the last several decades.

Analysis by Roy Spencer University of Alabama at Huntsville - http://www.drroyspencer.com/2013/06/still-epic-fail-73-climate-models-vs-measurements-running-5-year-means/



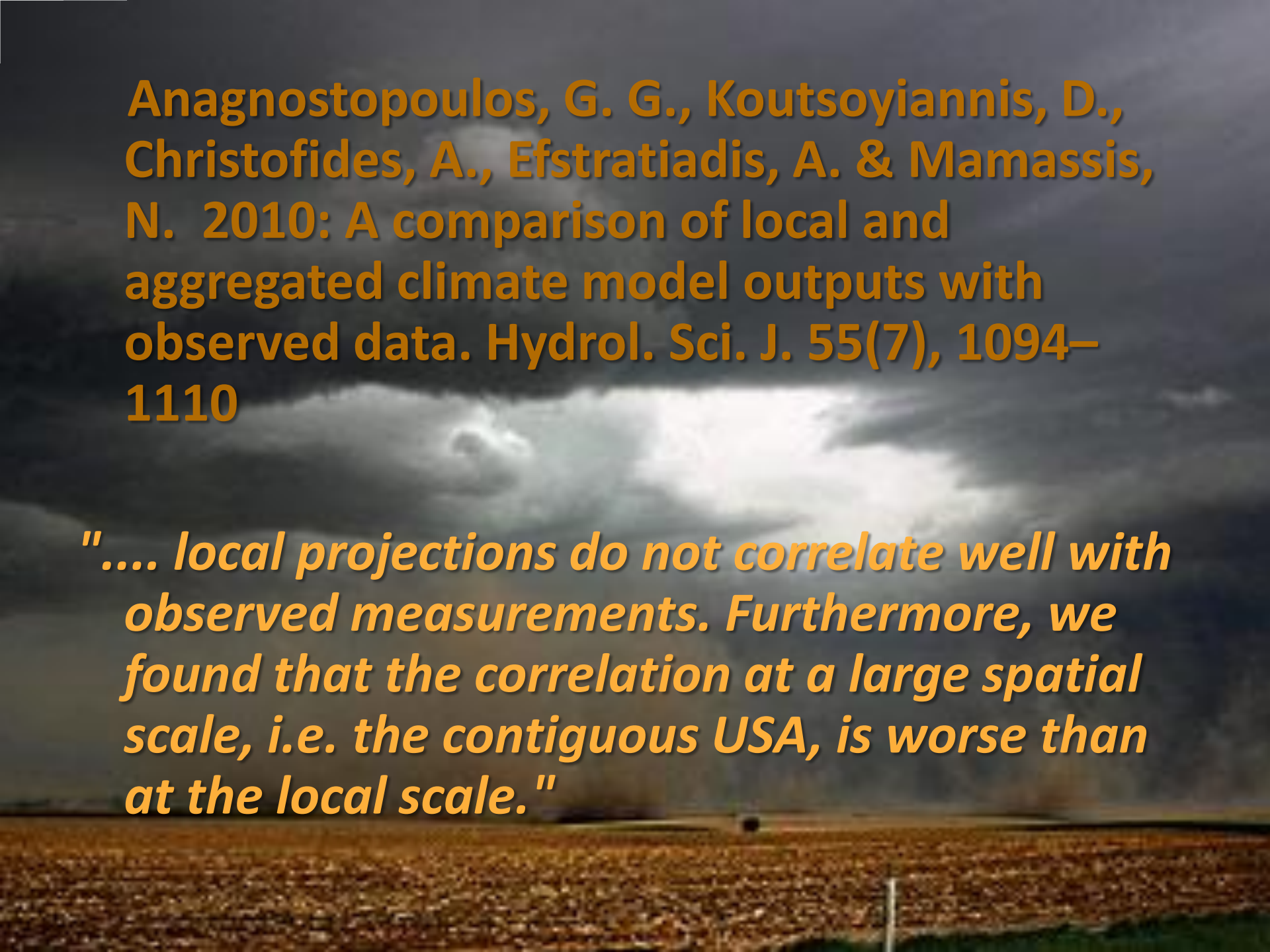
Peer-Reviewed Papers Of Model Skill





Ronald van Haren, Geert Jan van Oldenborgh, Geert Lenderink, Matthew Collins, and Wilco Hazeleger, 2012: SST and circulation trend biases cause an underestimation of European precipitation trends Climate Dynamics, DOI: 10.1007/s00382-012-1401-5

"To conclude, modeled atmospheric circulation and SST trends over the past century are significantly different from the observed ones. These mismatches are responsible for a large part of the misrepresentation of precipitation trends in climate models. The causes of the large trends in atmospheric circulation and summer SST are not known."



Anagnostopoulos, G. G., Koutsoyiannis, D., Christofides, A., Efstratiadis, A. & Mamassis, N. 2010: A comparison of local and aggregated climate model outputs with observed data. Hydrol. Sci. J. 55(7), 1094–1110

".... local projections do not correlate well with observed measurements. Furthermore, we found that the correlation at a large spatial scale, i.e. the contiguous USA, is worse than at the local scale."

Sun, Z., J. Liu, X. Zeng, and H. Liang, 2012: Parameterization of instantaneous global horizontal irradiance at the surface. Part II: Cloudy-sky component, J. Geophys. Res., doi:10.1029/2012JD017557

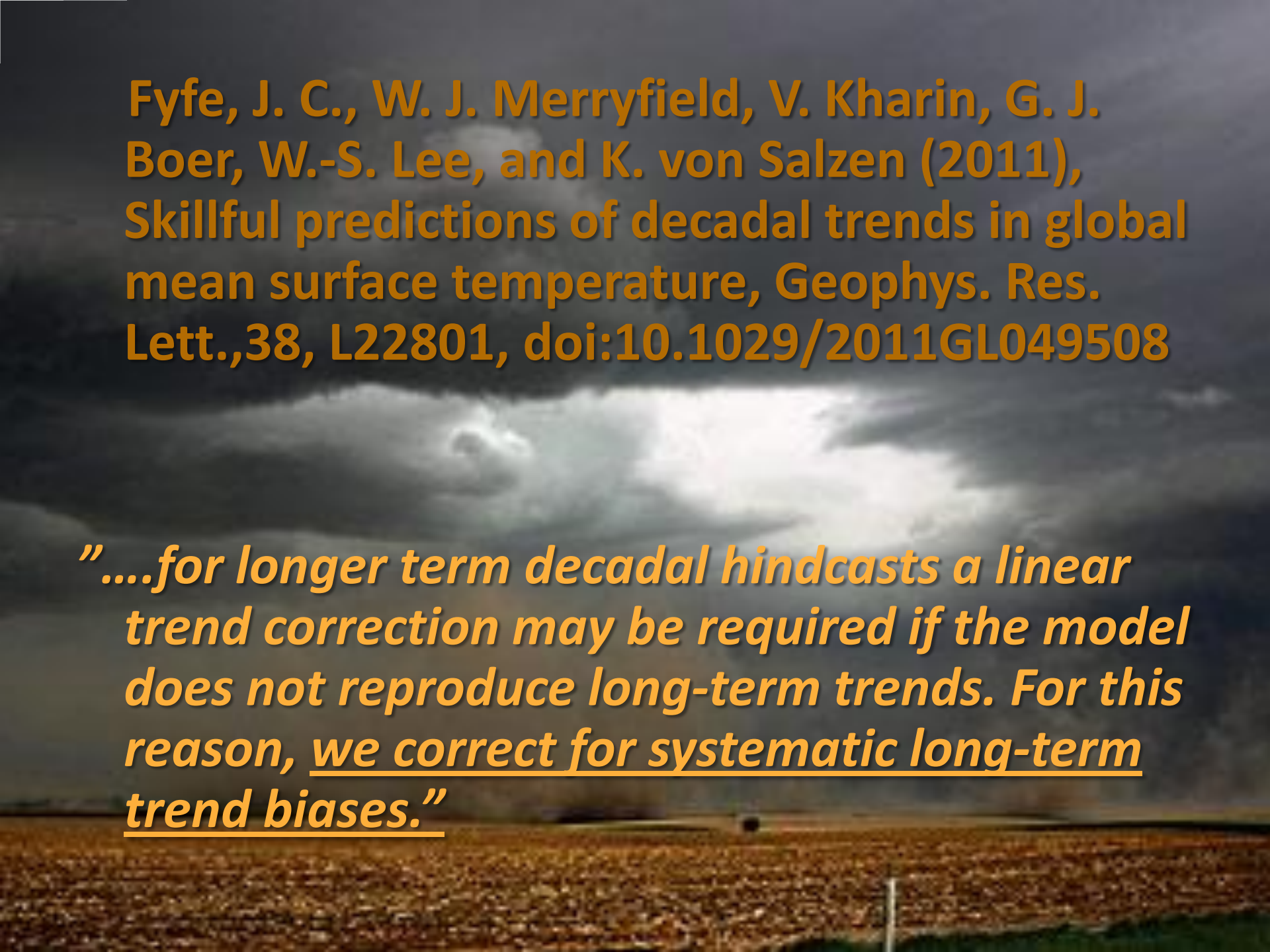
"Radiation calculations in global numerical weather prediction (NWP) and climate models are usually performed in 3-hourly time intervals in order to reduce the computational cost. This treatment can lead to an incorrect Global Horizontal Irradiance (GHI) at the Earth's surface, which could be one of the error sources in modelled convection and precipitation. ..... An important application of the scheme is in global climate models....It is found that these errors are very large, exceeding 800 W m-2 at many non-radiation time steps due to ignoring the effects of clouds...."

Stephens, G. L., T. L'Ecuyer, R. Forbes, A. Gettlemen, J.-C. Golaz, A. Bodas-Salcedo, K. Suzuki, P. Gabriel, and J. Haynes , 2010: Dreary state of precipitation in global models, J. Geophys. Res., 115, D24211, doi:10.1029/2010JD014532.

"...models produce precipitation approximately twice as often as that observed and make rainfall far too lightly.....The differences in the character of model precipitation are systemic and have a number of important implications for modeling the coupled Earth system .....little skill in precipitation [is] calculated at individual grid points, and thus applications involving downscaling of grid point precipitation to yet even finer-scale resolution has little foundation and relevance to the real Earth system."

Xu, Zhongfeng and Zong-Liang Yang, 2012: An improved dynamical downscaling method with GCM bias corrections and its validation with 30 years of climate simulations. Journal of Climate 2012 doi: http://dx.doi.org/10.1175/JCLI-D-12-00005.1

”…the traditional dynamic downscaling (TDD) [i.e. without tuning) overestimates precipitation by 0.5-1.5 mm d-1.....The 2-year return level of summer daily maximum temperature simulated by the TDD is underestimated by 2-6°C over the central United States-Canada region".



Fyfe, J. C., W. J. Merryfield, V. Kharin, G. J. Boer, W.-S. Lee, and K. von Salzen (2011), Skillful predictions of decadal trends in global mean surface temperature, Geophys. Res. Lett.,38, L22801, doi:10.1029/2011GL049508

"….for longer term decadal hindcasts a linear trend correction may be required if the model does not reproduce long-term trends. For this reason, we correct for systematic long-term trend biases."

Taylor et al., 2012: Afternoon rain more likely over drier soils. Nature. doi:10.1038/nature11377. Published online 12 September 2012

"…the erroneous sensitivity of convection schemes demonstrated here is likely to contribute to a tendency for large-scale models to `lock-in' dry conditions, extending droughts unrealistically, and potentially exaggerating the role of soil moisture feedbacks in the climate system."

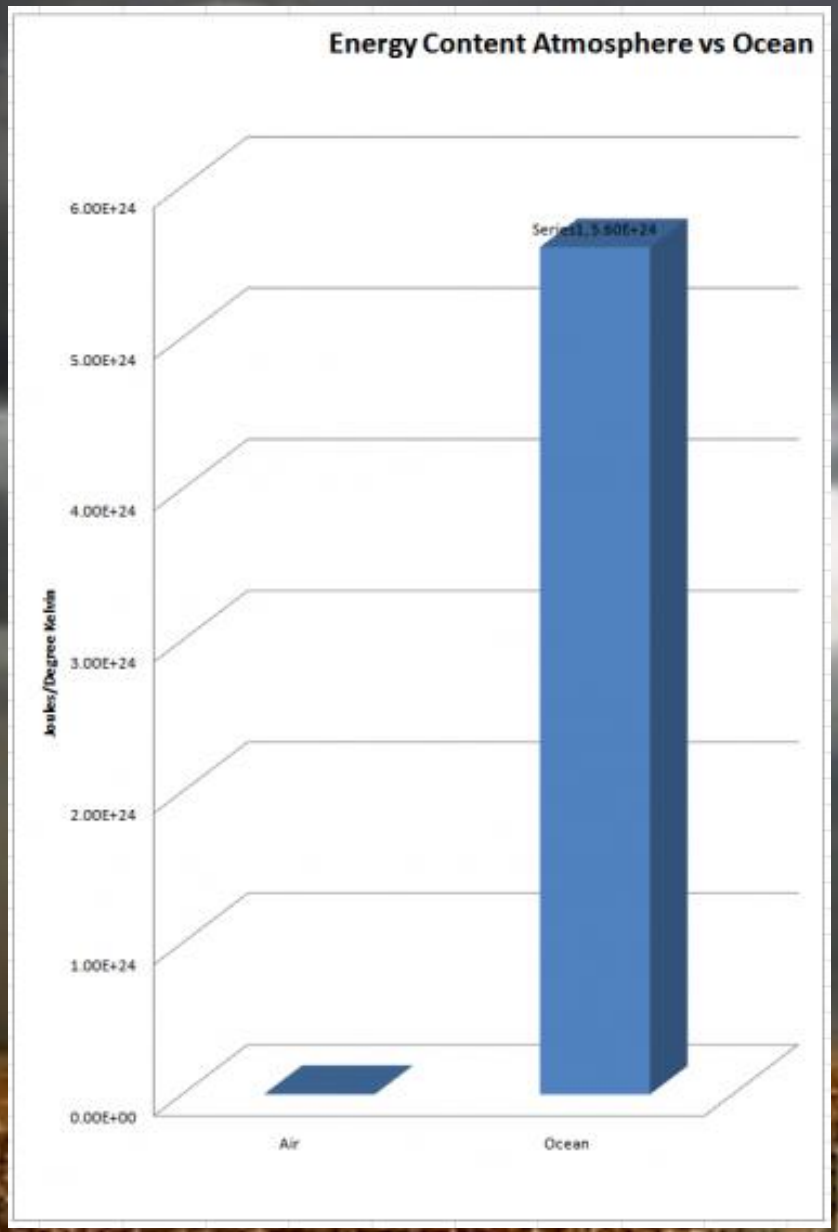
Driscoll, S., A. Bozzo, L. J. Gray, A. Robock, and G. Stenchikov, 2012: Coupled Model Intercomparison Project 5 (CMIP5) simulations of climate following volcanic eruptions, J. Geophys. Res., 117, D17105, doi:10.1029/2012JD017607.

"The study confirms previous similar evaluations and raises concern for the ability of current climate models to simulate the response of a major mode of global circulation variability to external forcings."

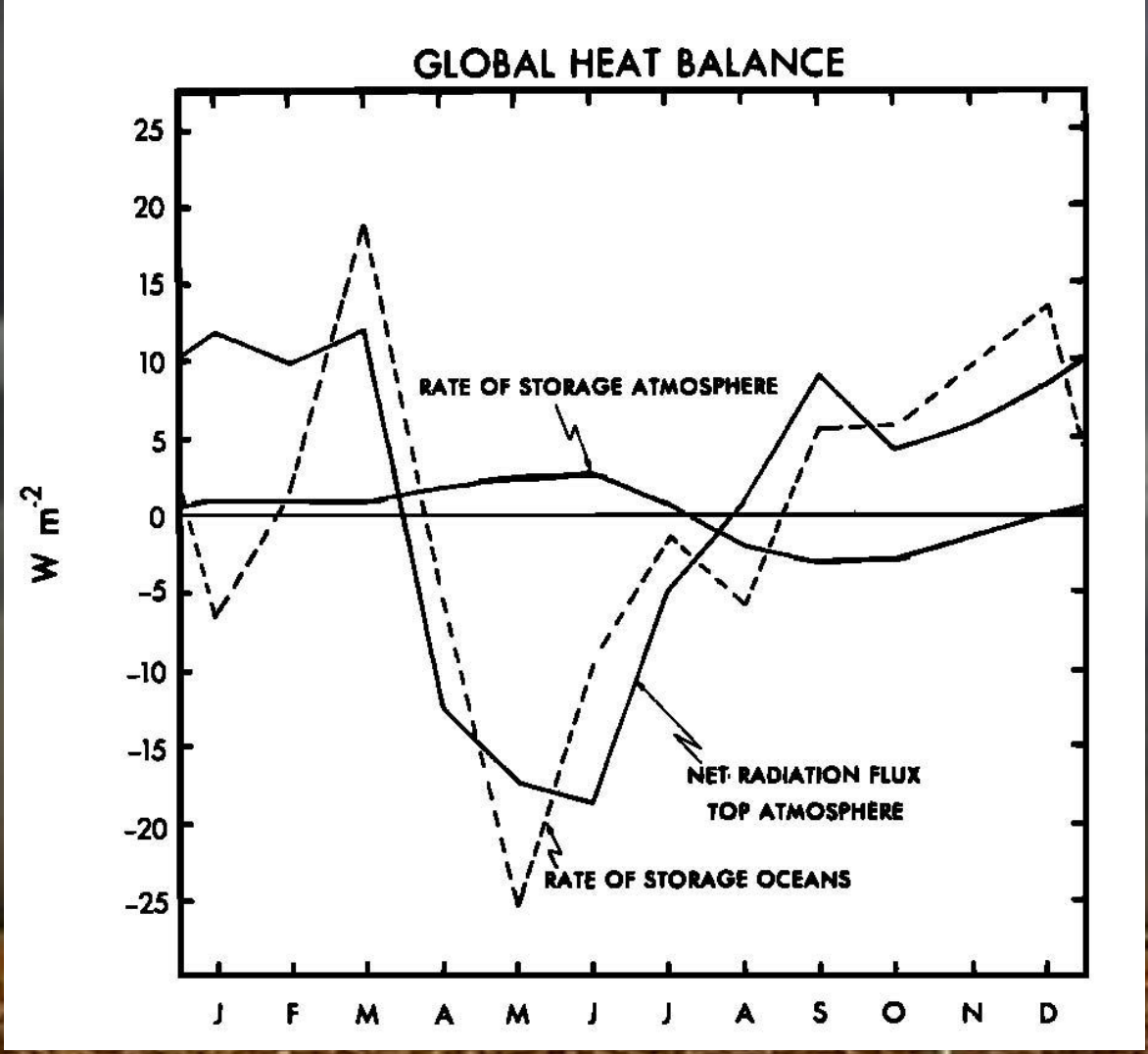
Global Warming/Cooling

Global warming involves the accumulation of heat in Joules within the components of the climate system. This accumulation is dominated by the heating and cooling within the upper layers of the oceans.

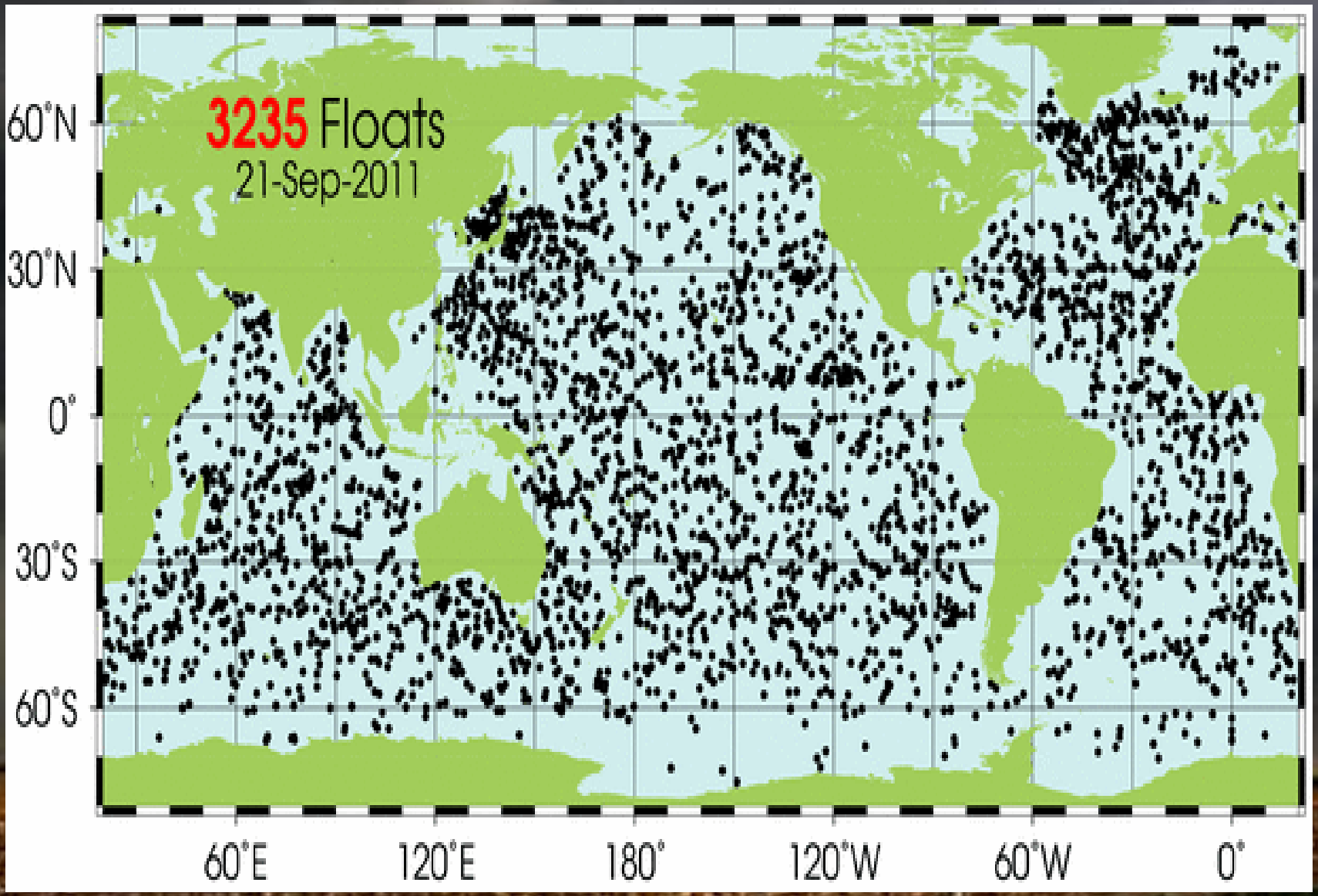
From the Weblog Air Vent



From Ellis et al. 1979



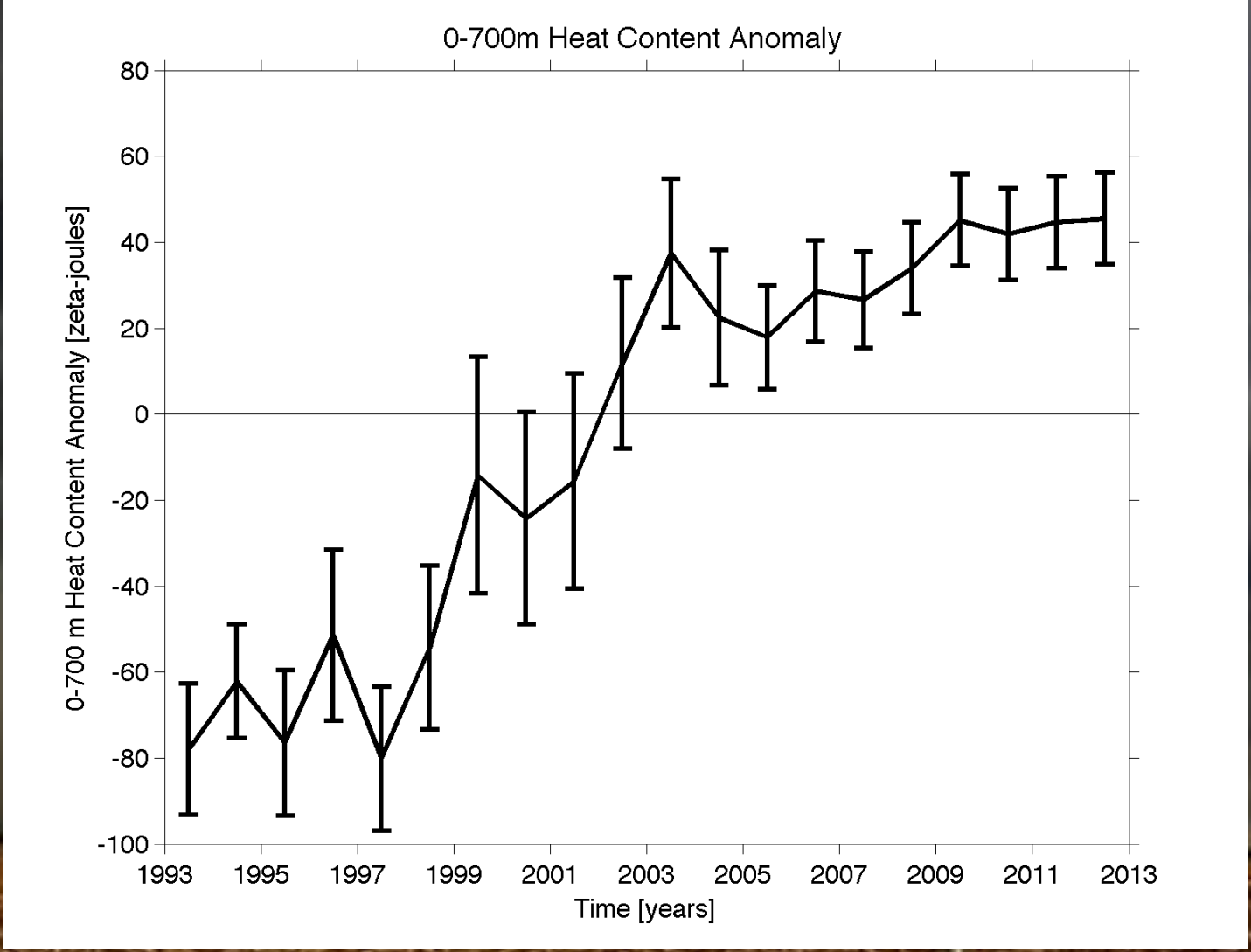
Argo Network



"Our simulated 1993-2003 heat storage rate was 0.6 W/m^2 in the upper 750 m of the ocean The decadal mean planetary energy imbalance, 0.75 W/m^2, includes heat storage in the deeper ocean and energy used to melt ice and warm the air and land. 0.85 W/m^2 is the imbalance at the end of the decade".

From Jim Hansen, 2005

Source: http://oceans.pmel.noaa.gov/



WHERE IS THE EXTRA HEAT?

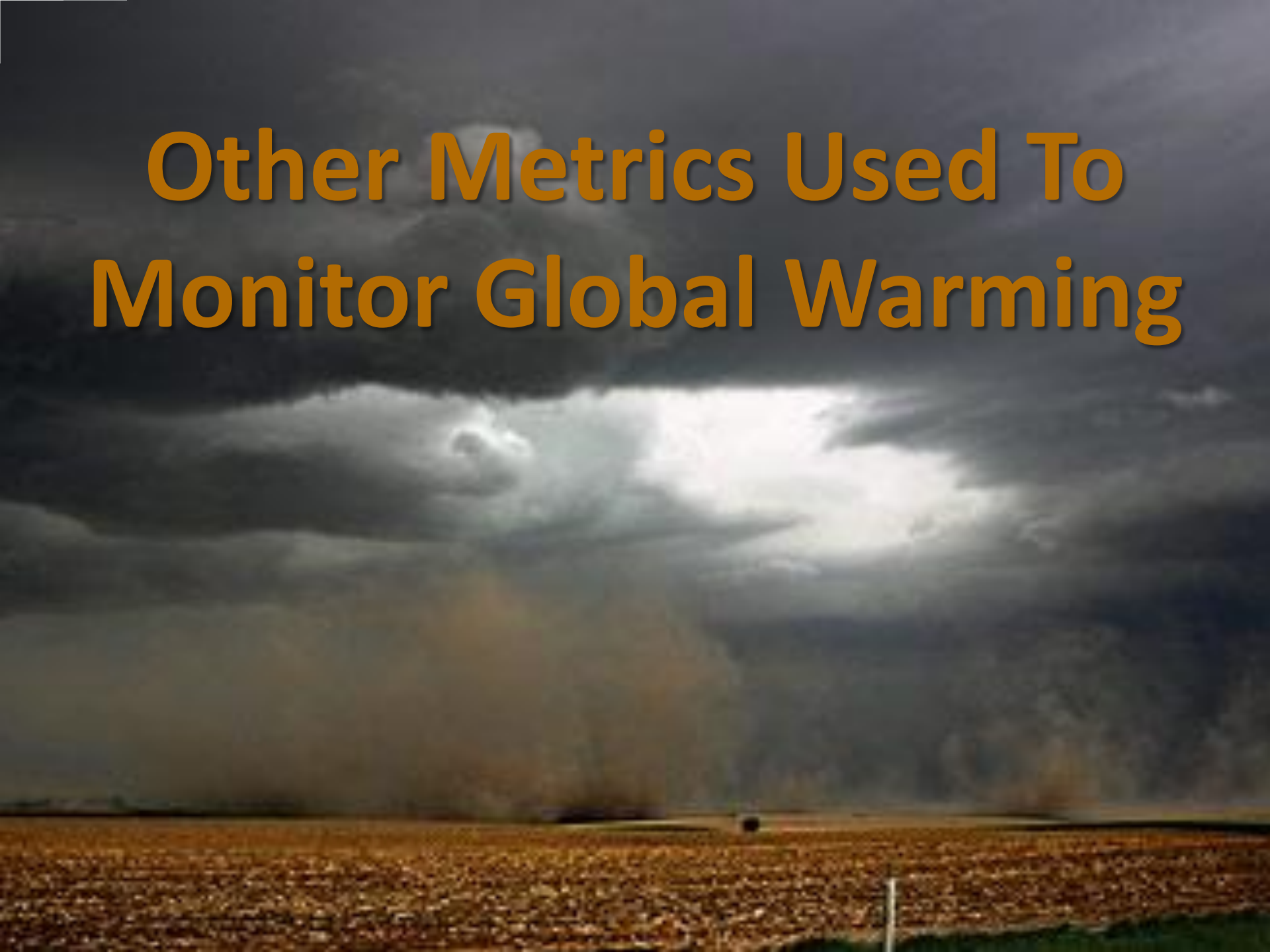
Deeper in the Oceans?

Lost to Space?

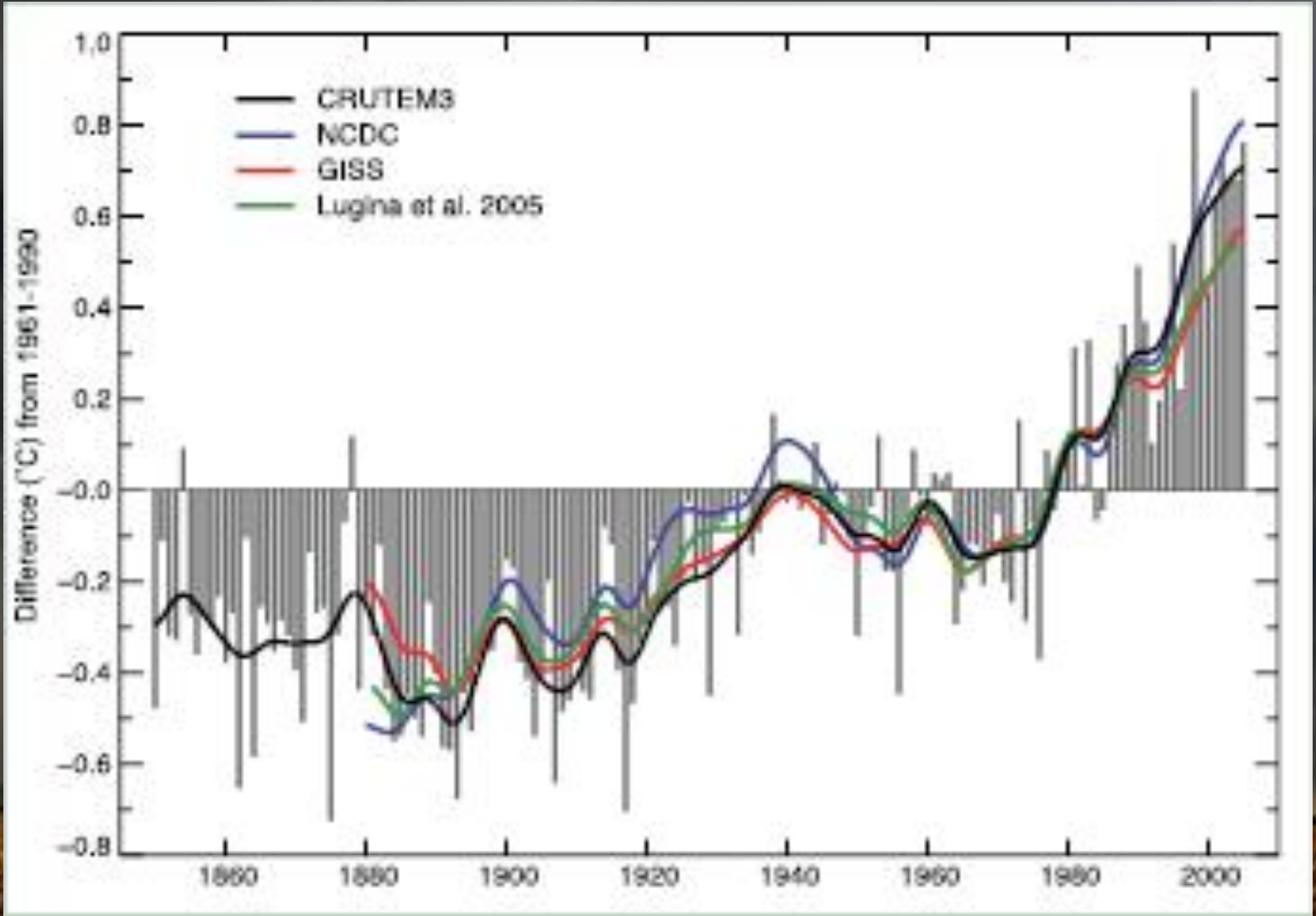
Melting Glaciers?

Being Absorbed By Land?

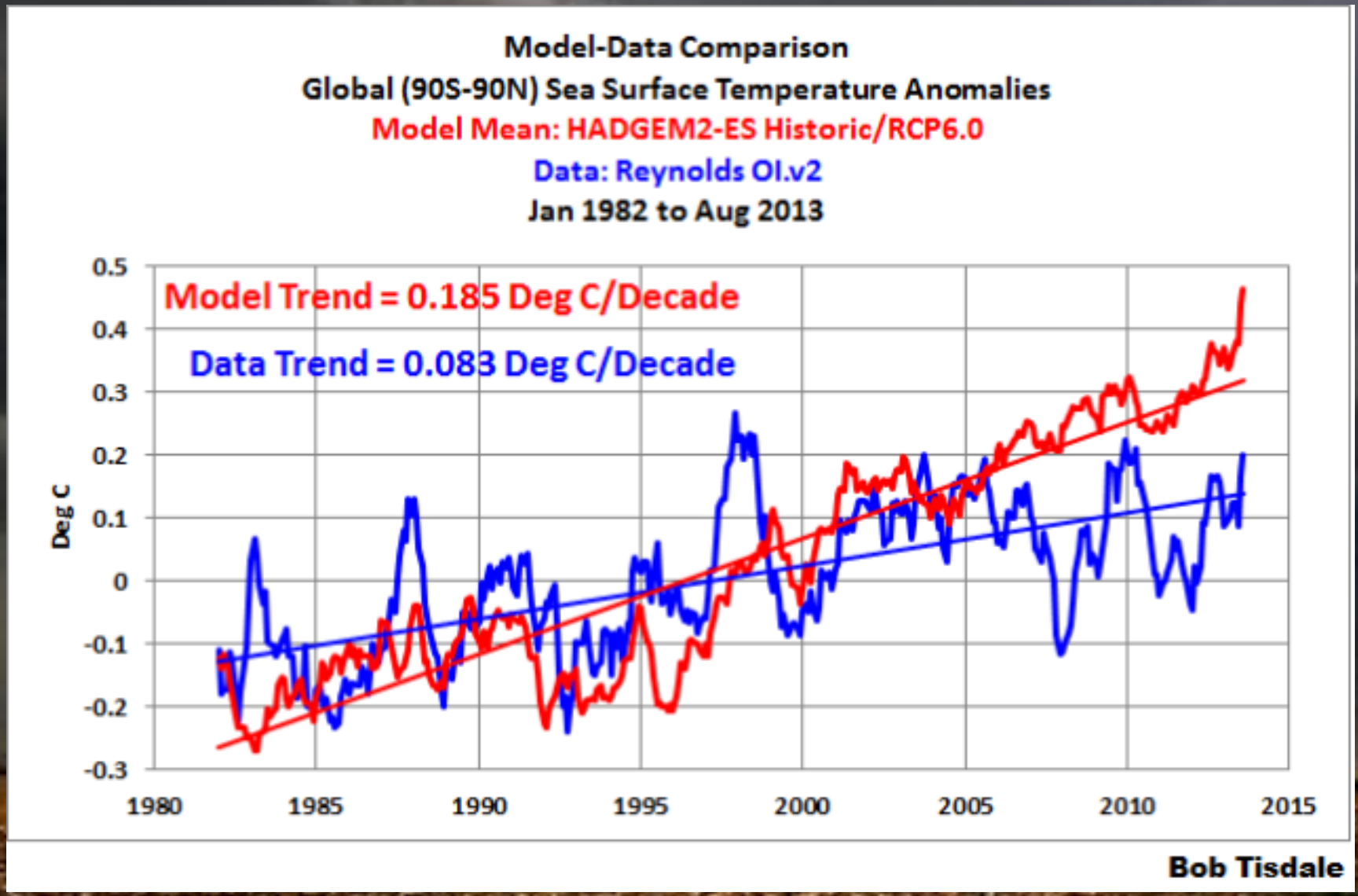
Absorbed in the Atmosphere?


Other Metrics Used To
Monitor Global Warming

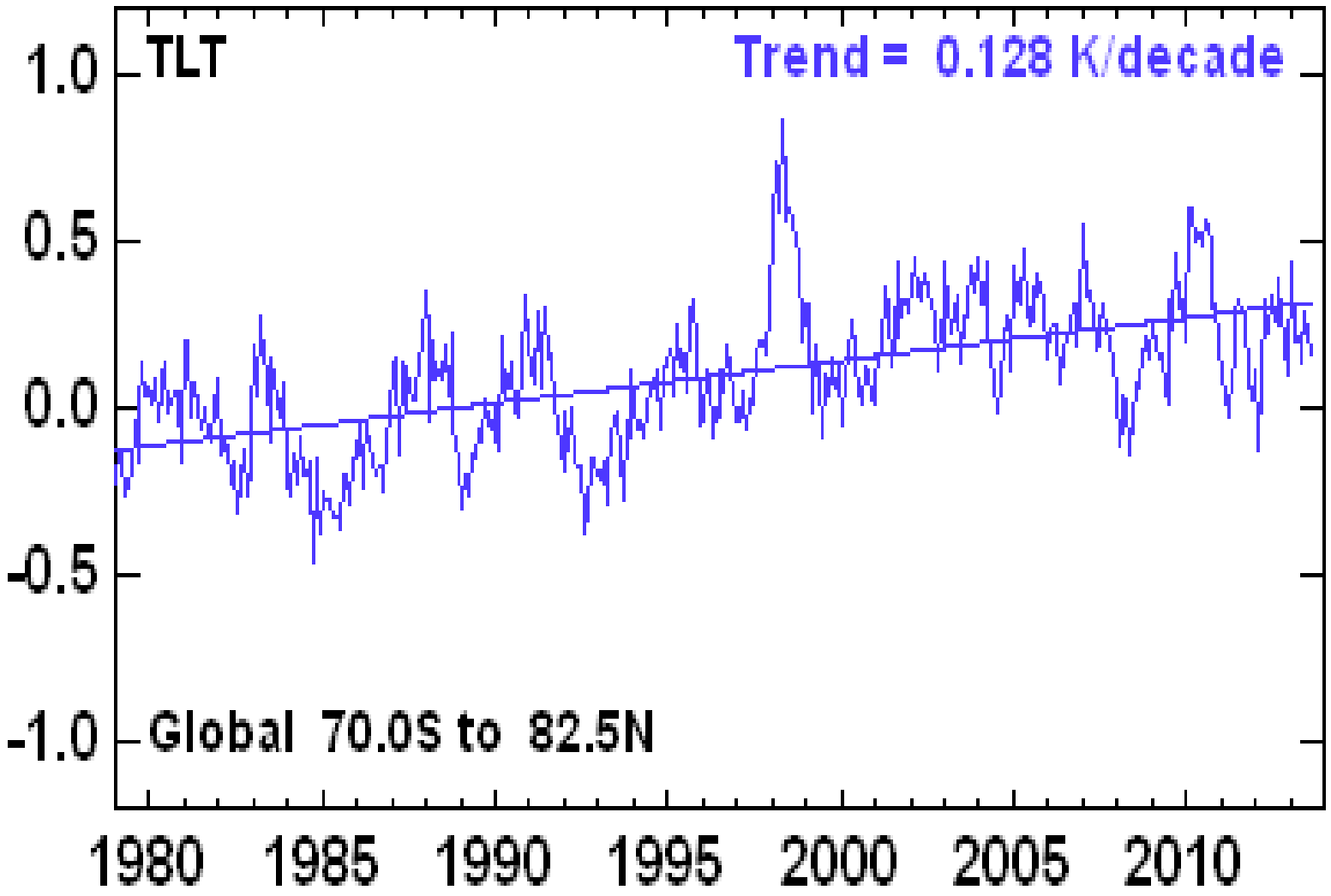
http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch3s3-2-2.html



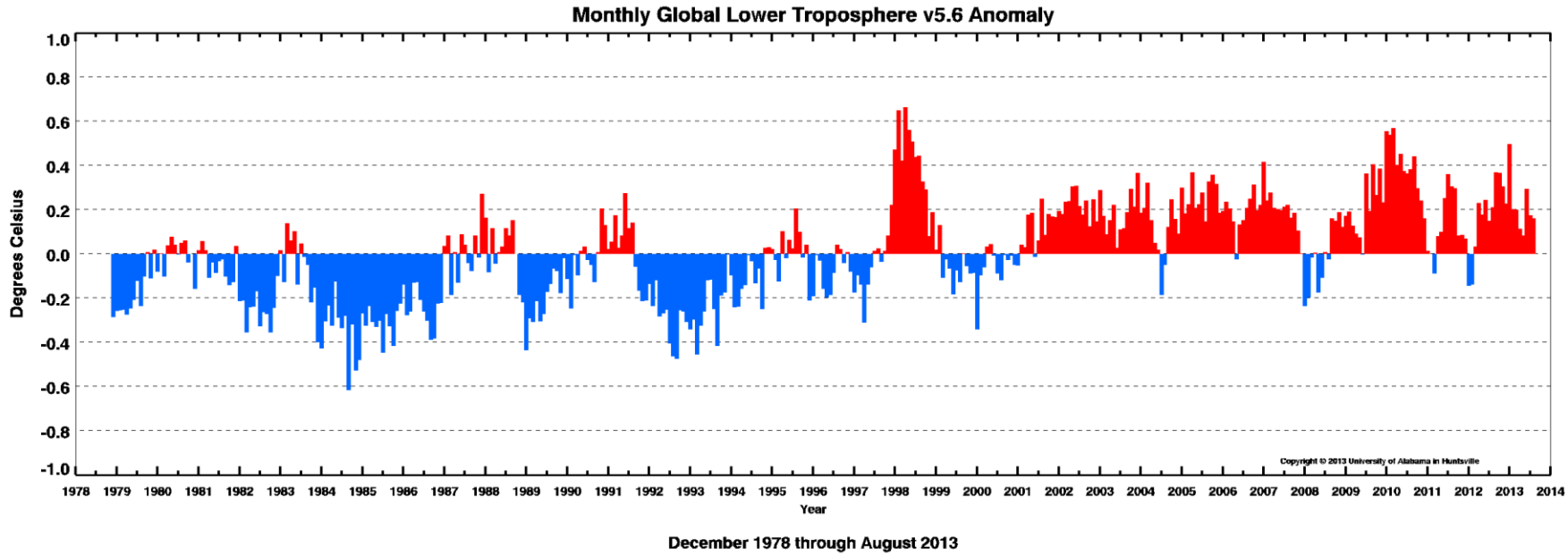
http://bobtisdale.wordpress.com/



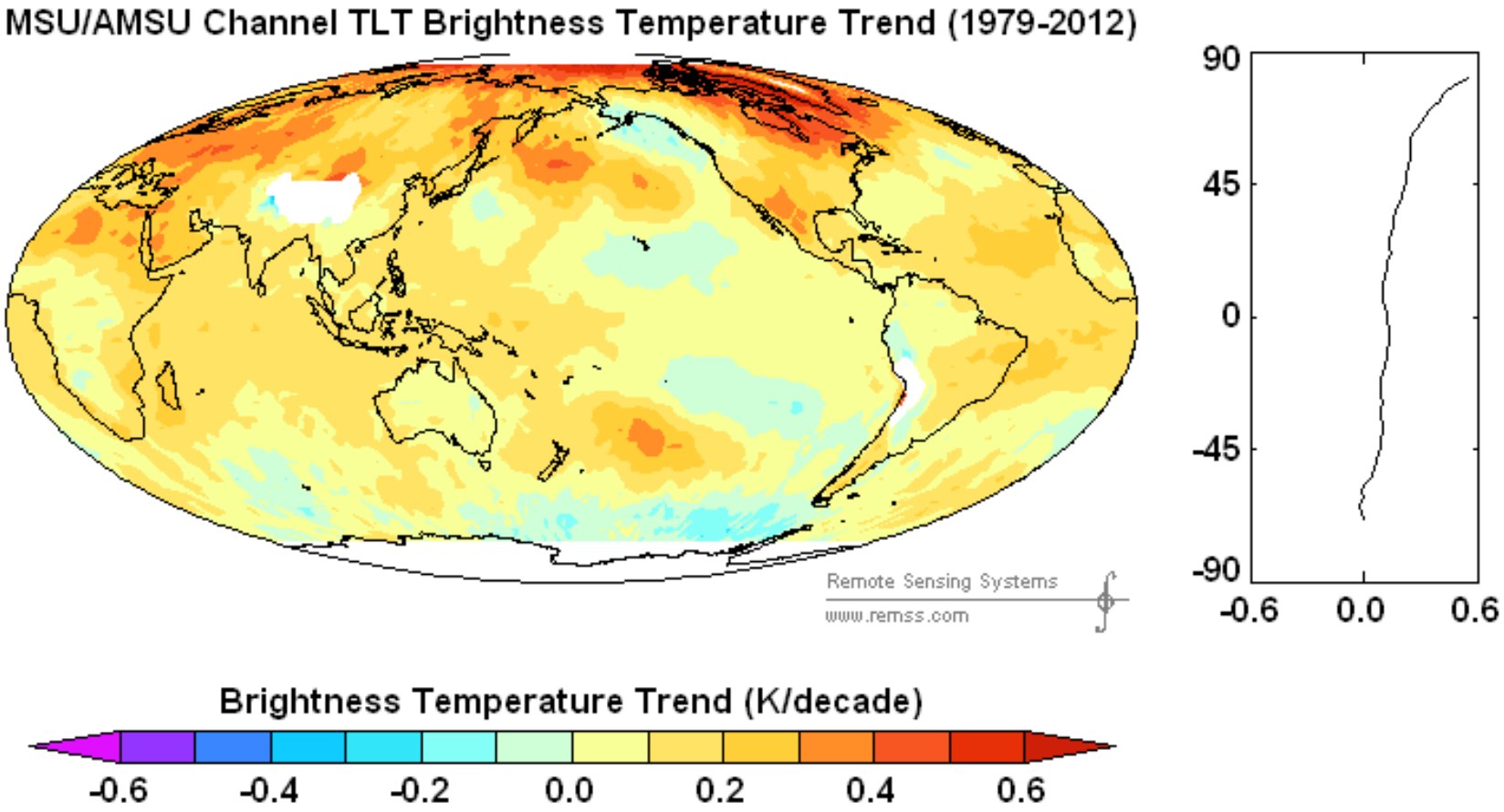
http://www.ssmi.com/msu/msu_time_series.html



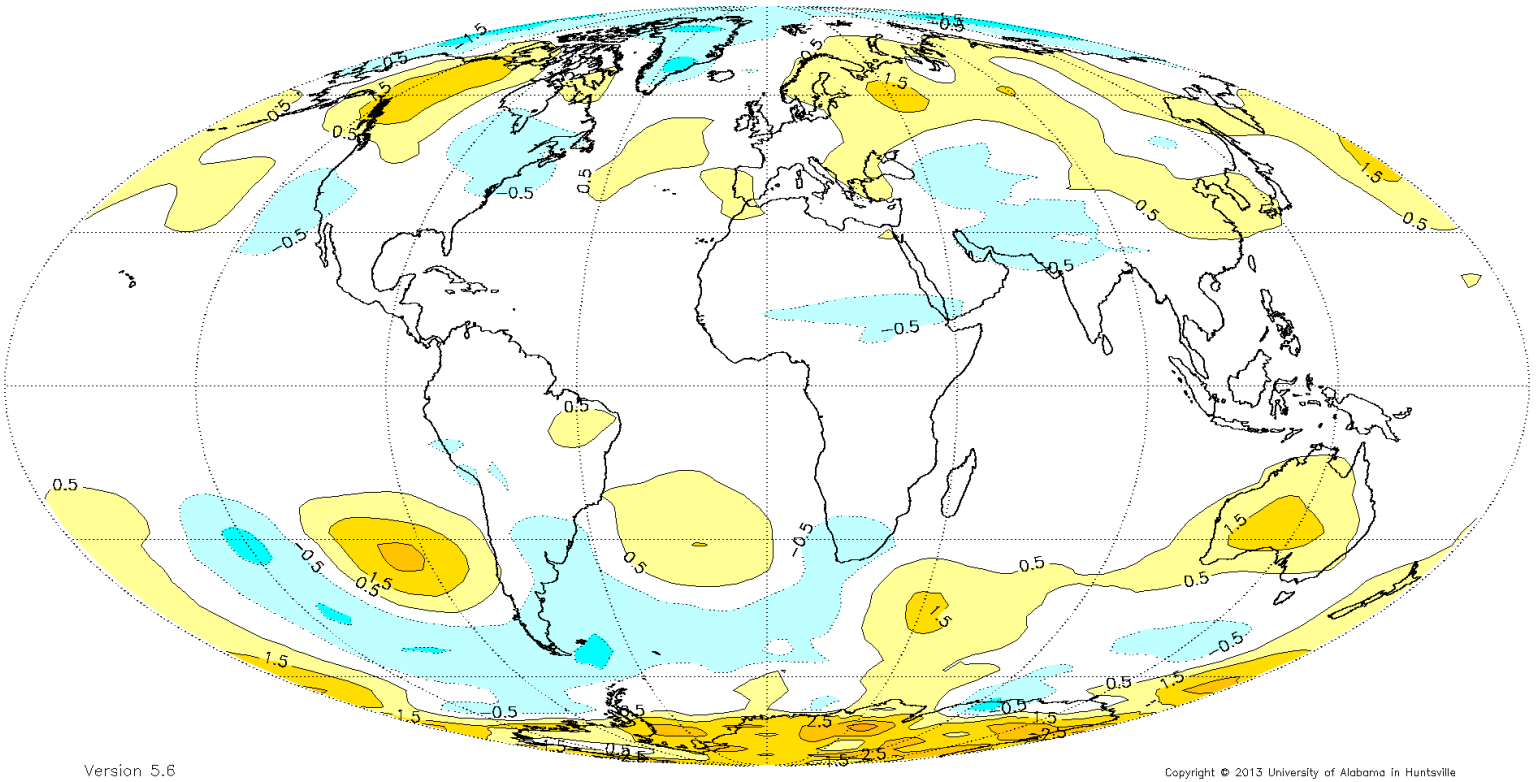
University of Alabama - Huntsville



http://www.ssmi.com/msu/msu_data_monthly.html?type=trend&channel=2

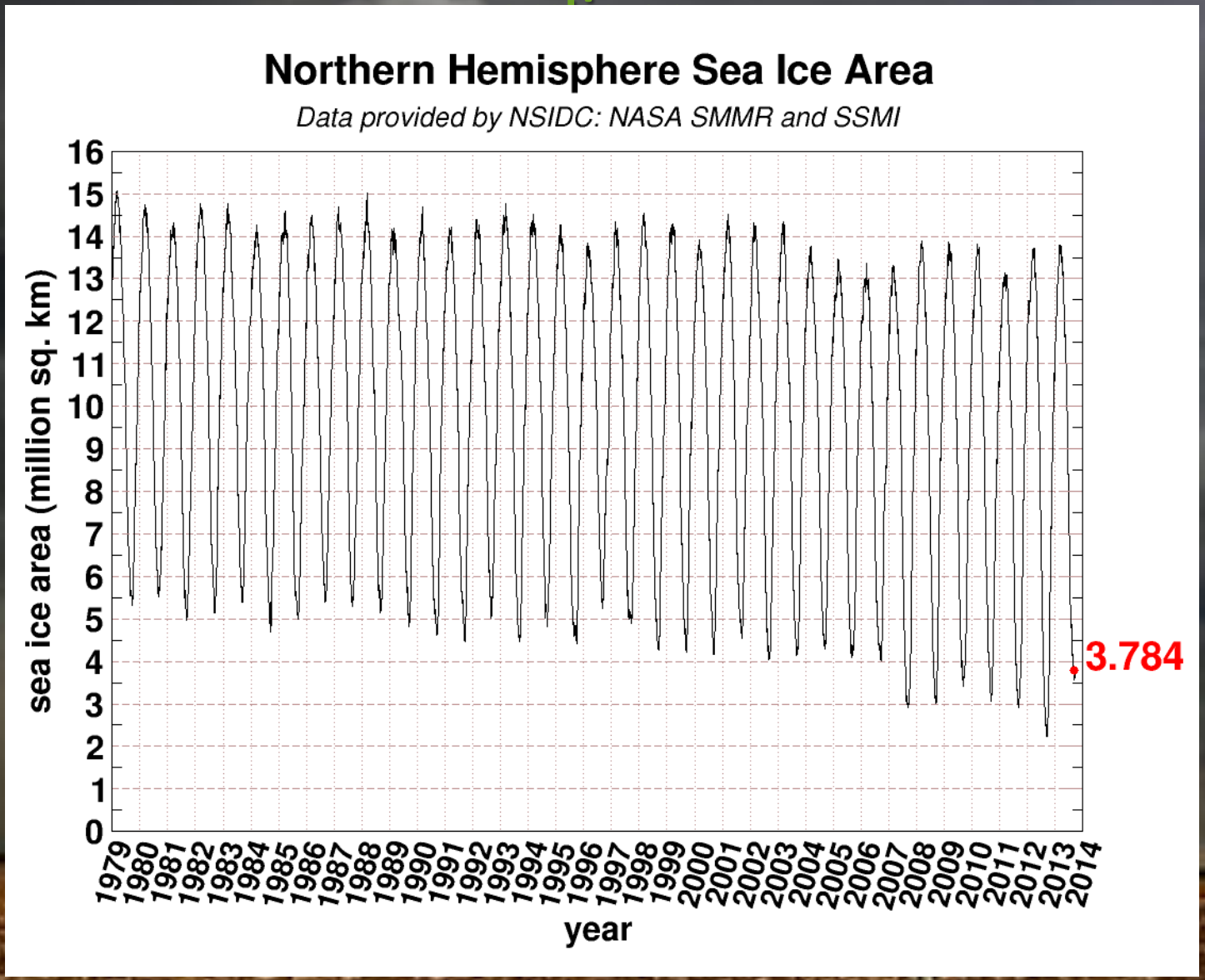


University of Alabama -Huntsville

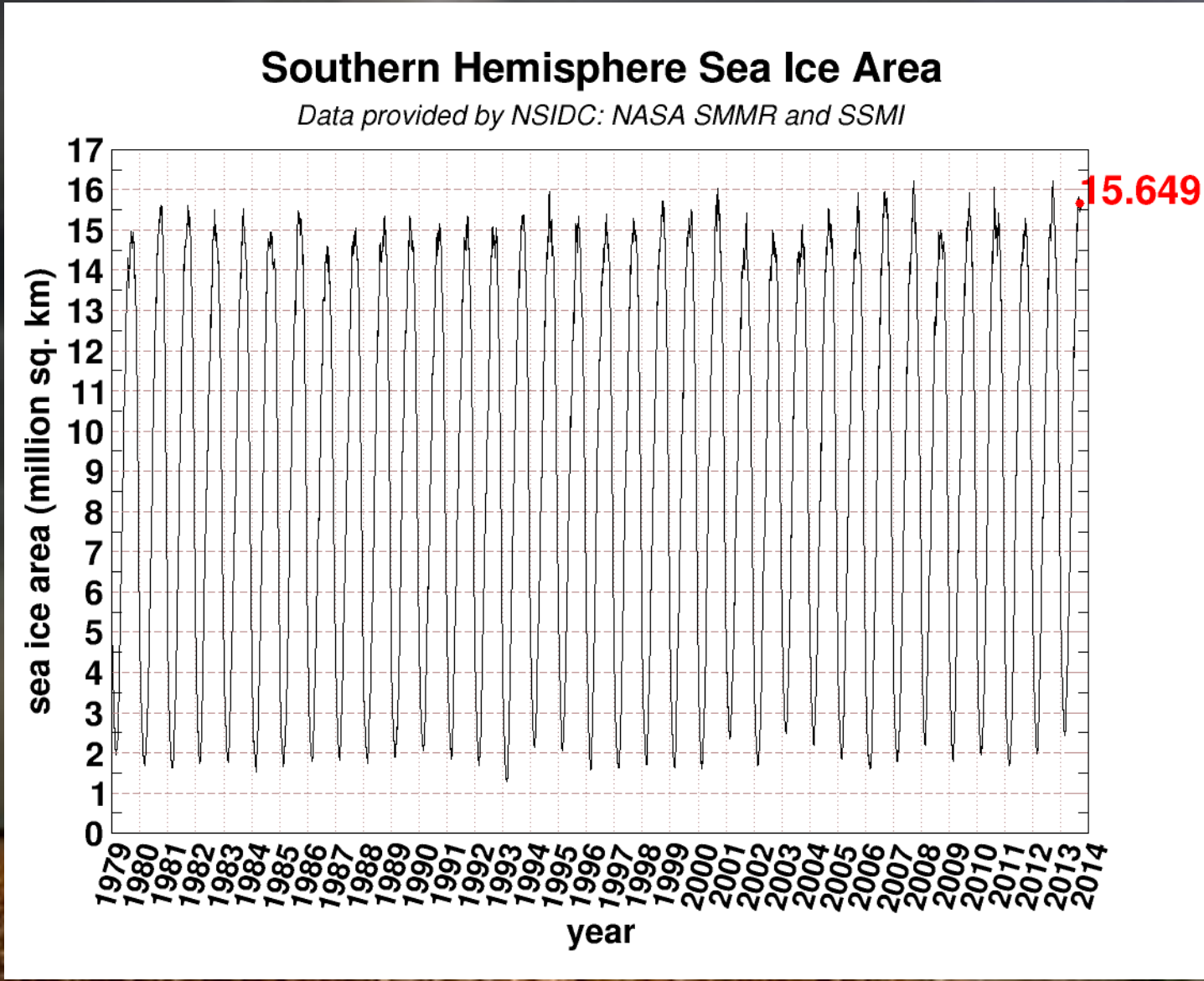


Broken lines outline areas that were cooler than seasonal norms; solid lines outline areas that were warmer than seasonal norms. Each contour represents one degree Celsius, starting at −0.5 and +0.5 degrees C.

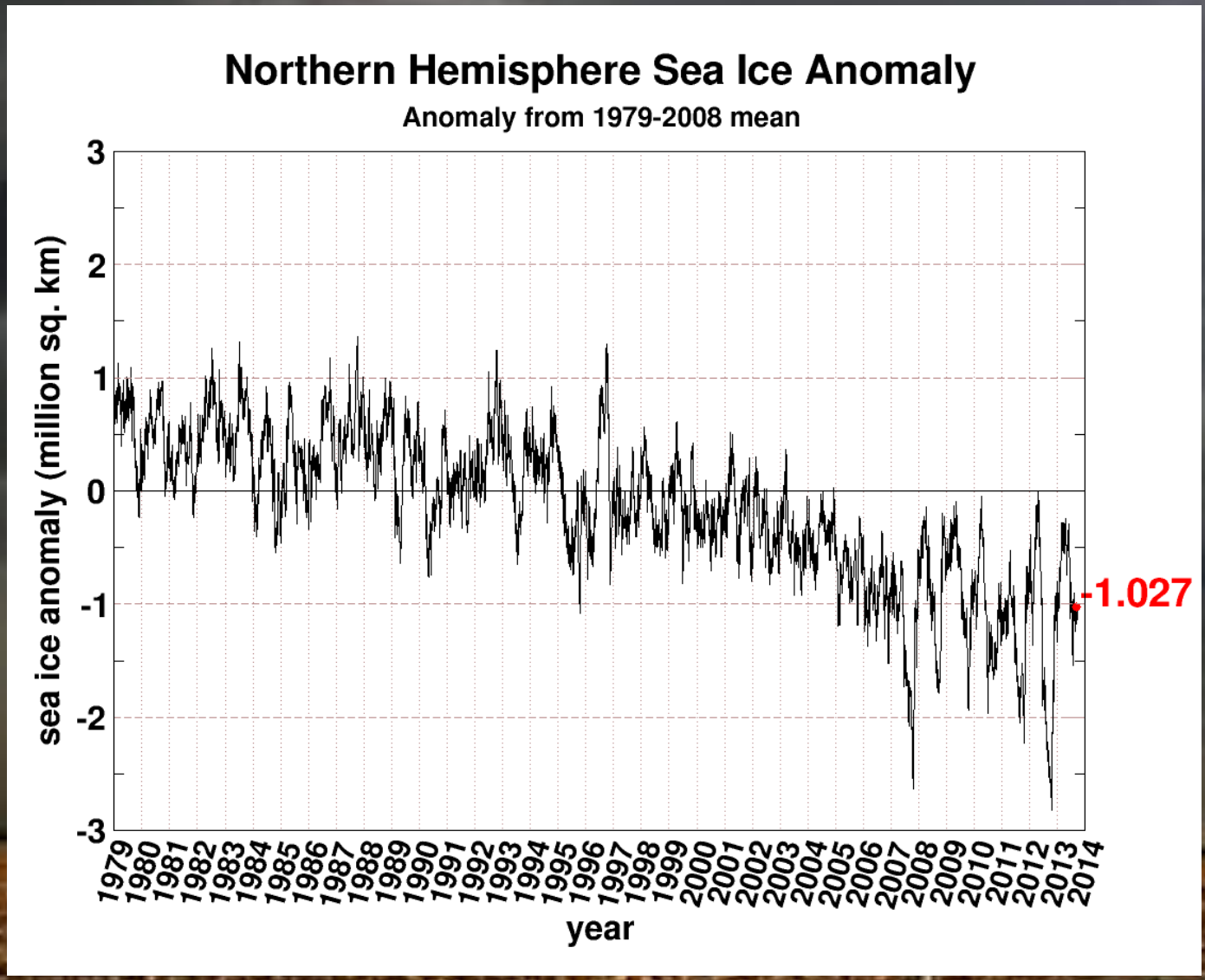
http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/seaice.area.



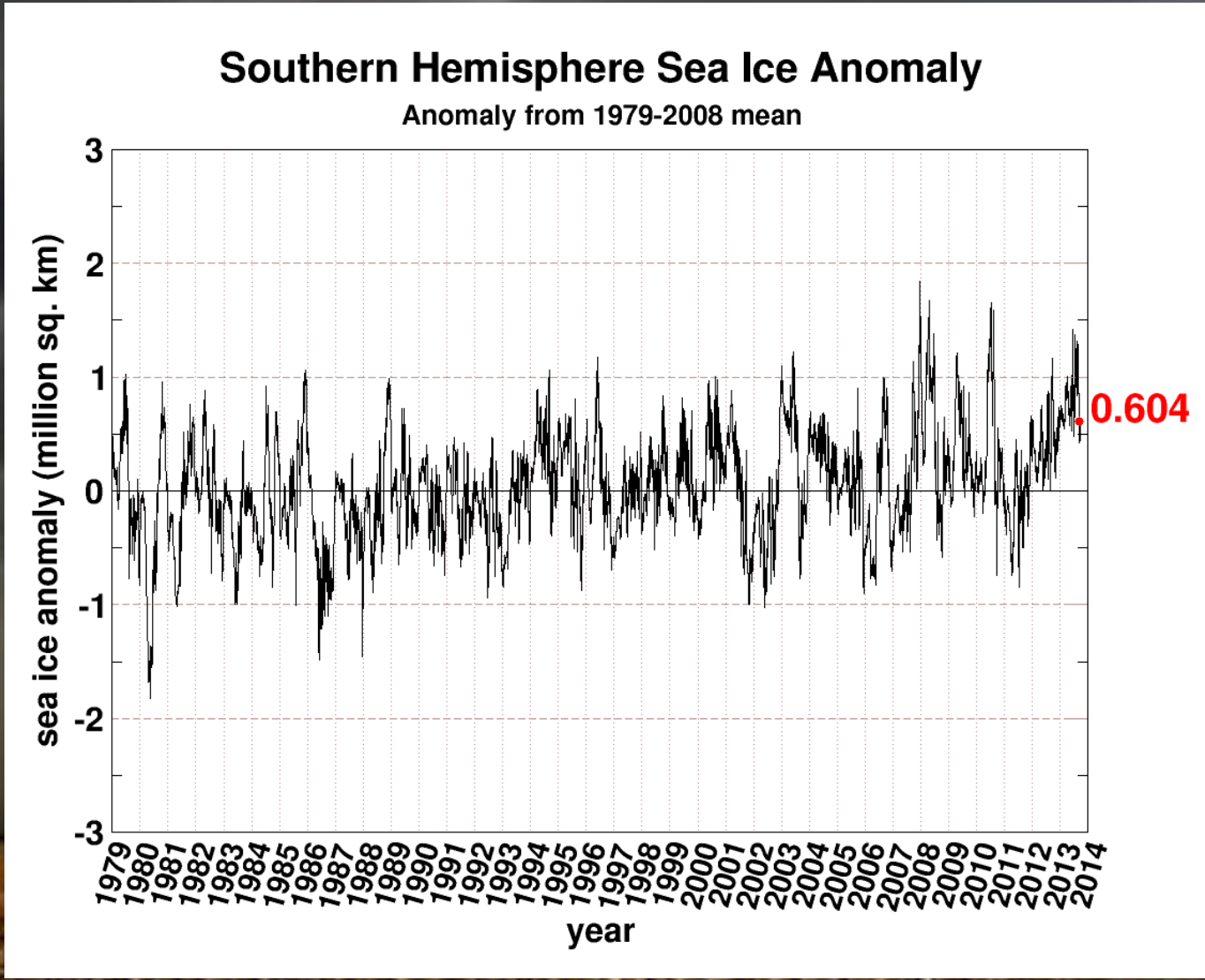
http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/seaice.area.antarctic.png



http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/seaice.anomaly.arctic.png



http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/seaice.anomaly.antarctic.png

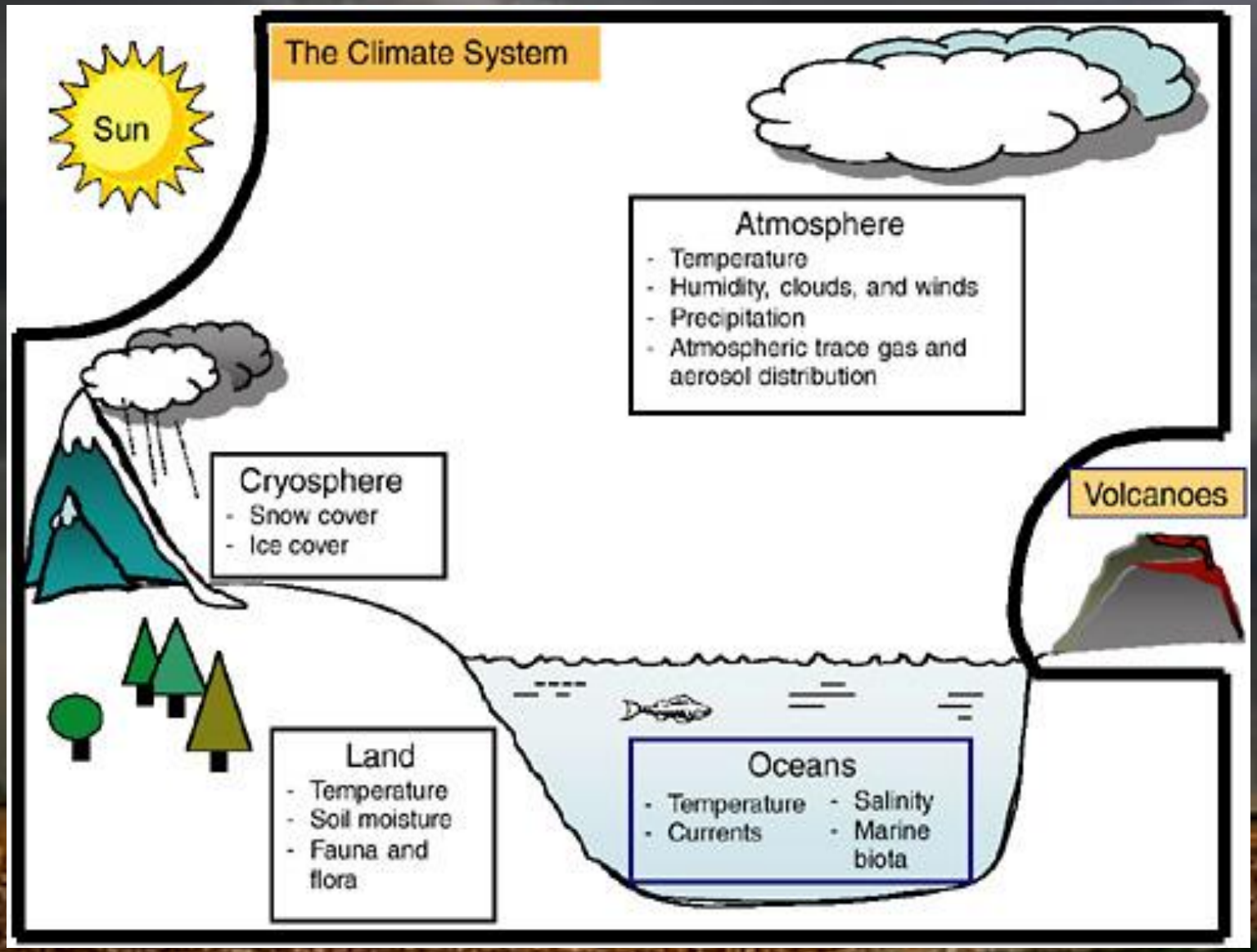


However, what is “climate change”?

Climate Change is any multi-decadal or longer alteration in one or more physical, chemical and/or biological components of the climate system. Climate change includes, for example, changes in fauna and flora, snow cover, etc which persist for decades and longer. Climate variability can then be defined as changes which occur on shorter time periods.

Climate Is Much More Than Climate Change. Indeed, the addition of the word “Change” is redundant. Climate is always changing, just like the weather

Source: National Research Council, 2005: Radiative forcing of climate change: Expanding the concept and addressing uncertainties.



Climate Change >>
Global Warming

Observed Climate And Social Metrics Indicate A Very Complex Climate System That Is Not Properly Defined By The Concept Of "Global Warming"

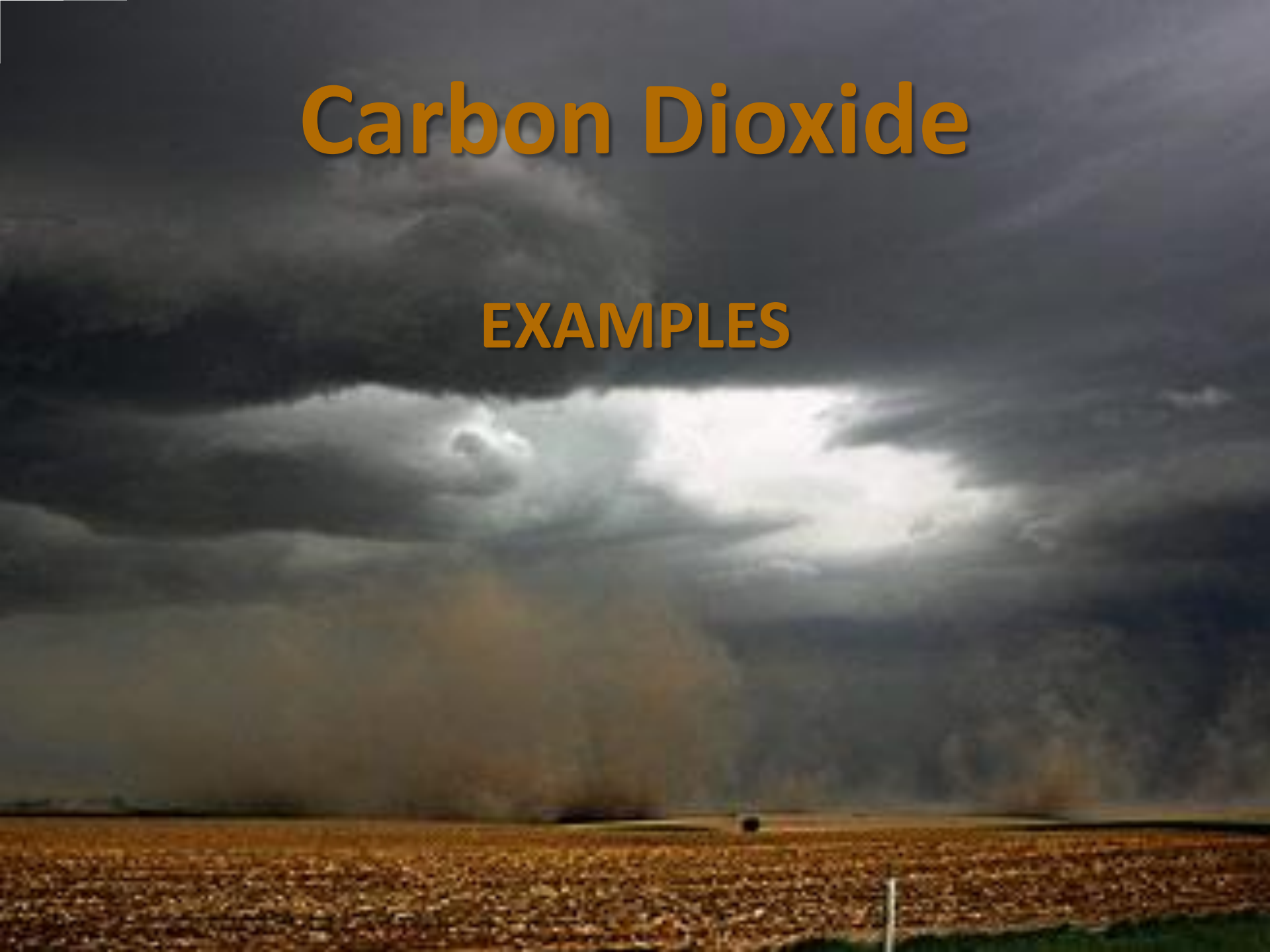
Climate Forcings

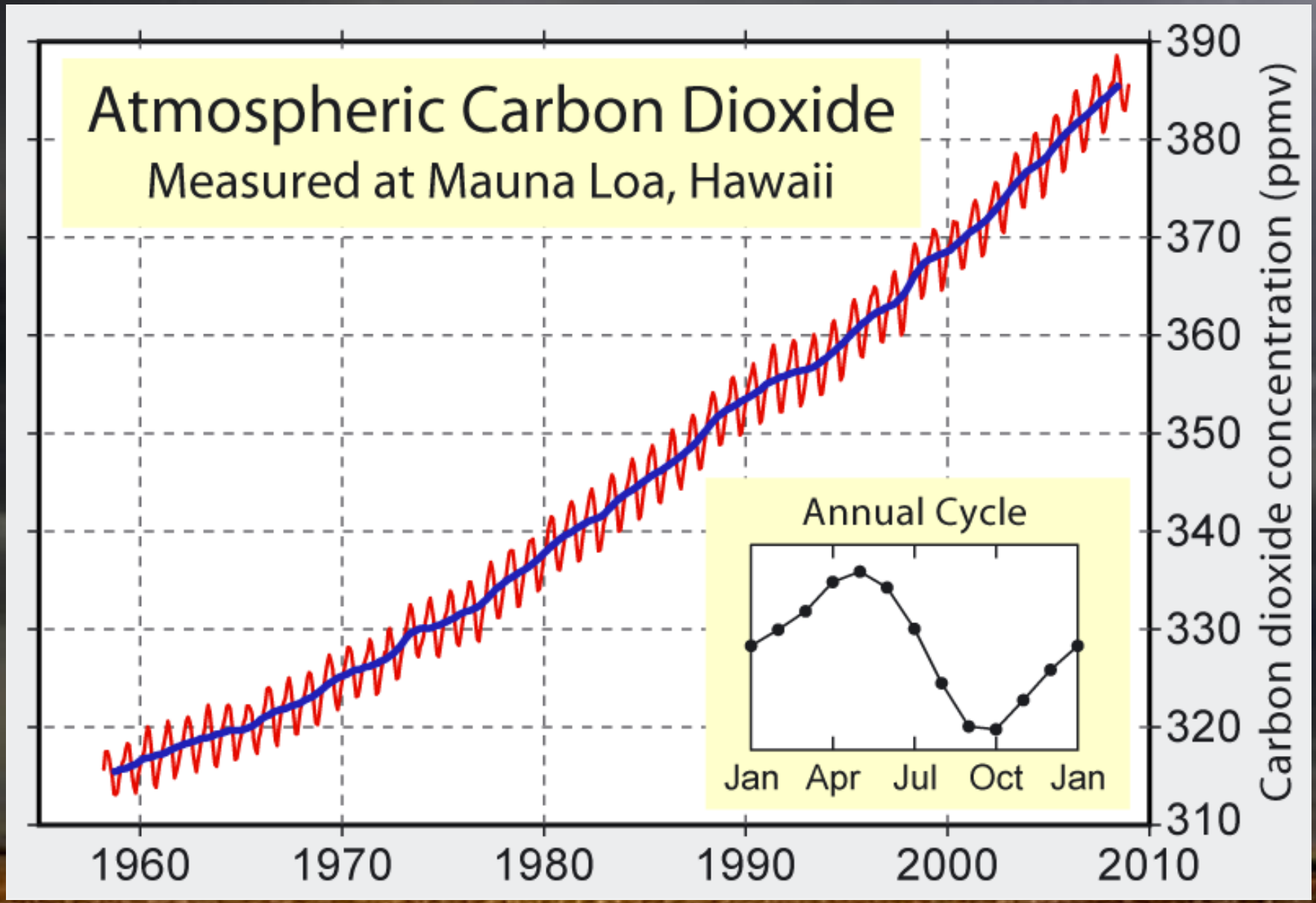
Human Climate Forcings

- The influence of the human input of CO_2 and other greenhouse gases on regional and global radiative heating
- The influence of human-caused aerosols on regional (and global) radiative heating
- The effect of aerosols on clouds and precipitation
- The influence of aerosol deposition (e.g. soot; nitrogen) on climate
- The effect of land cover/ land use on climate
- The biogeochemical effect of added atmospheric CO_2

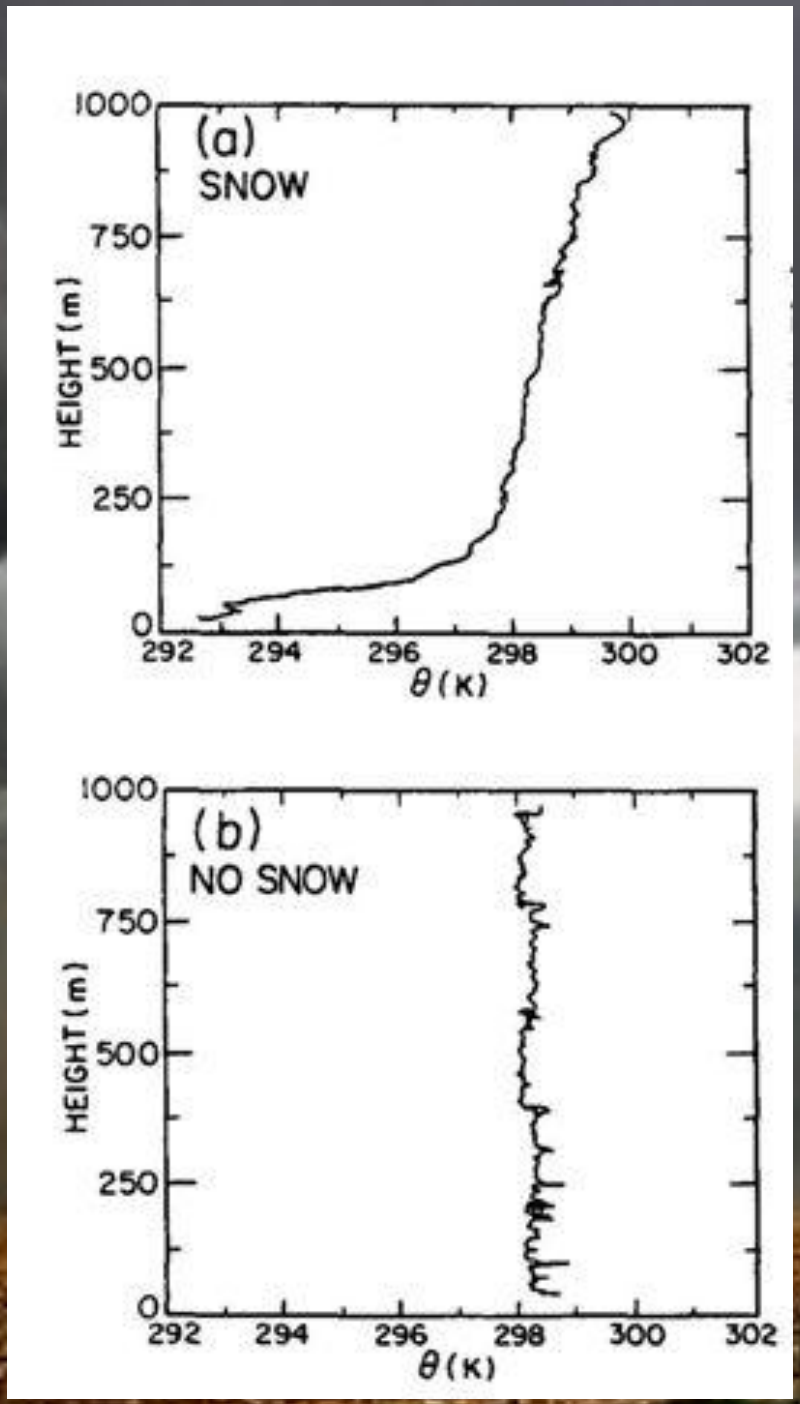
Carbon Dioxide

EXAMPLES

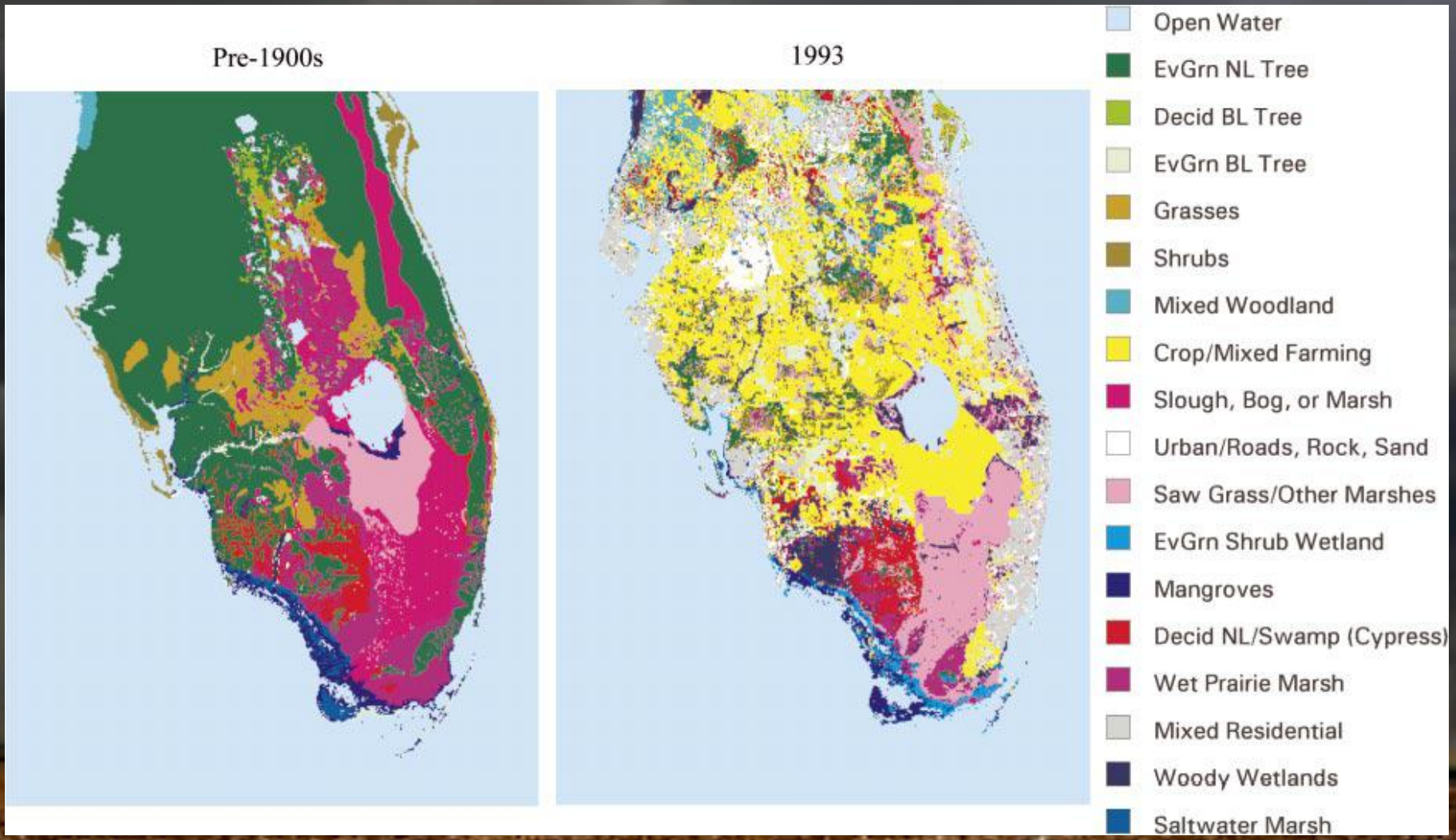


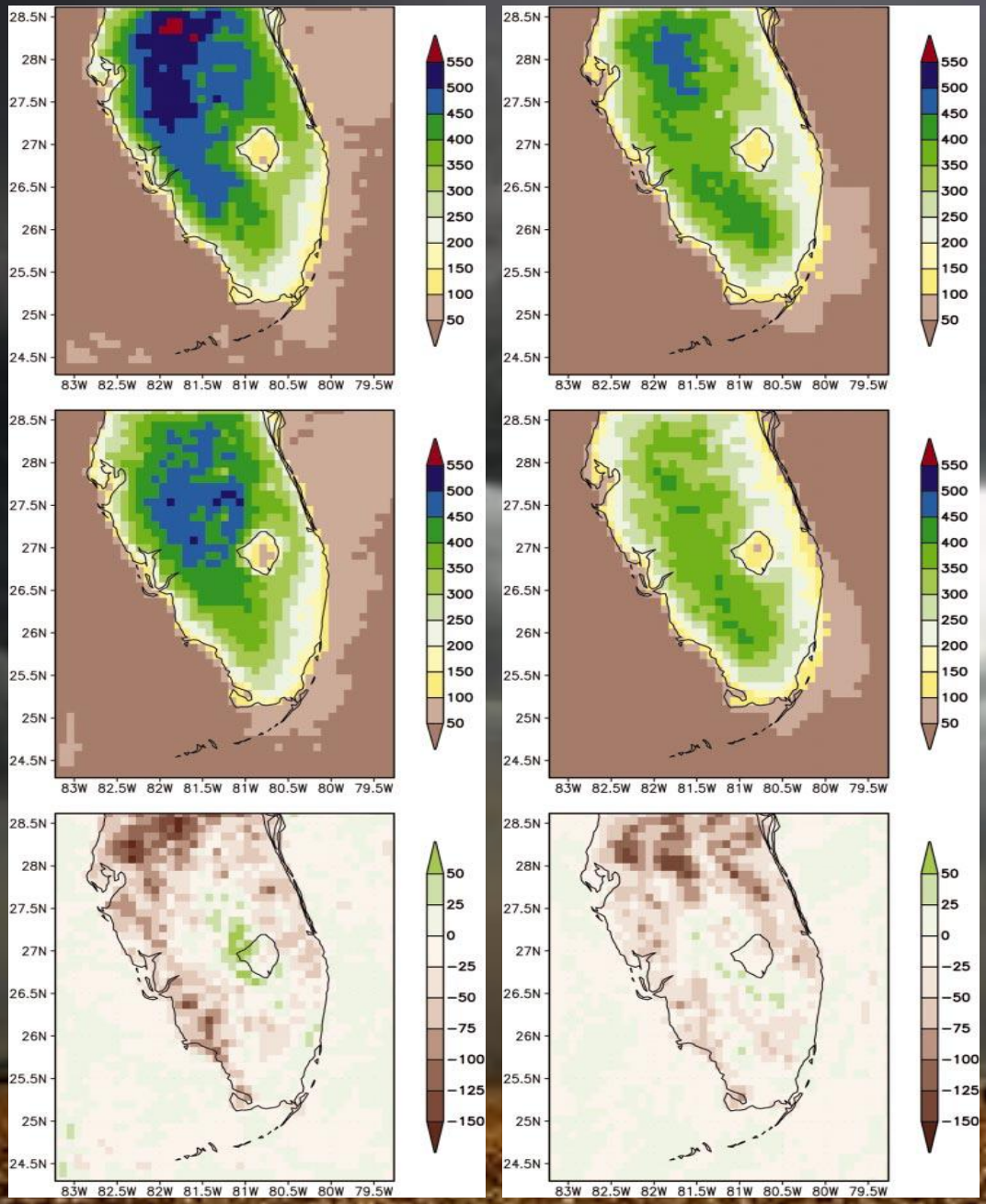

Atmospheric Carbon Dioxide
Measured at Mauna Loa, Hawaii
Annual Cycle
Jan
Apr
Jul
Oct
Jan
1960
1970
1980
1990
2000
2010
310
320
330
340
350
360
370
380
390
Carbon dioxide concentration (ppmv)

LAND USE/LAND COVER CHANGE


(a)
SNOW
HEIGHT (m)
1000
750
500
250
0
292
294
296
298
300
302
θ (K)
(b)
NO SNOW
HEIGHT (m)
1000
750
500
250
0
292
294
296
298
300
302
θ (K)

From Marshall et al. 2004

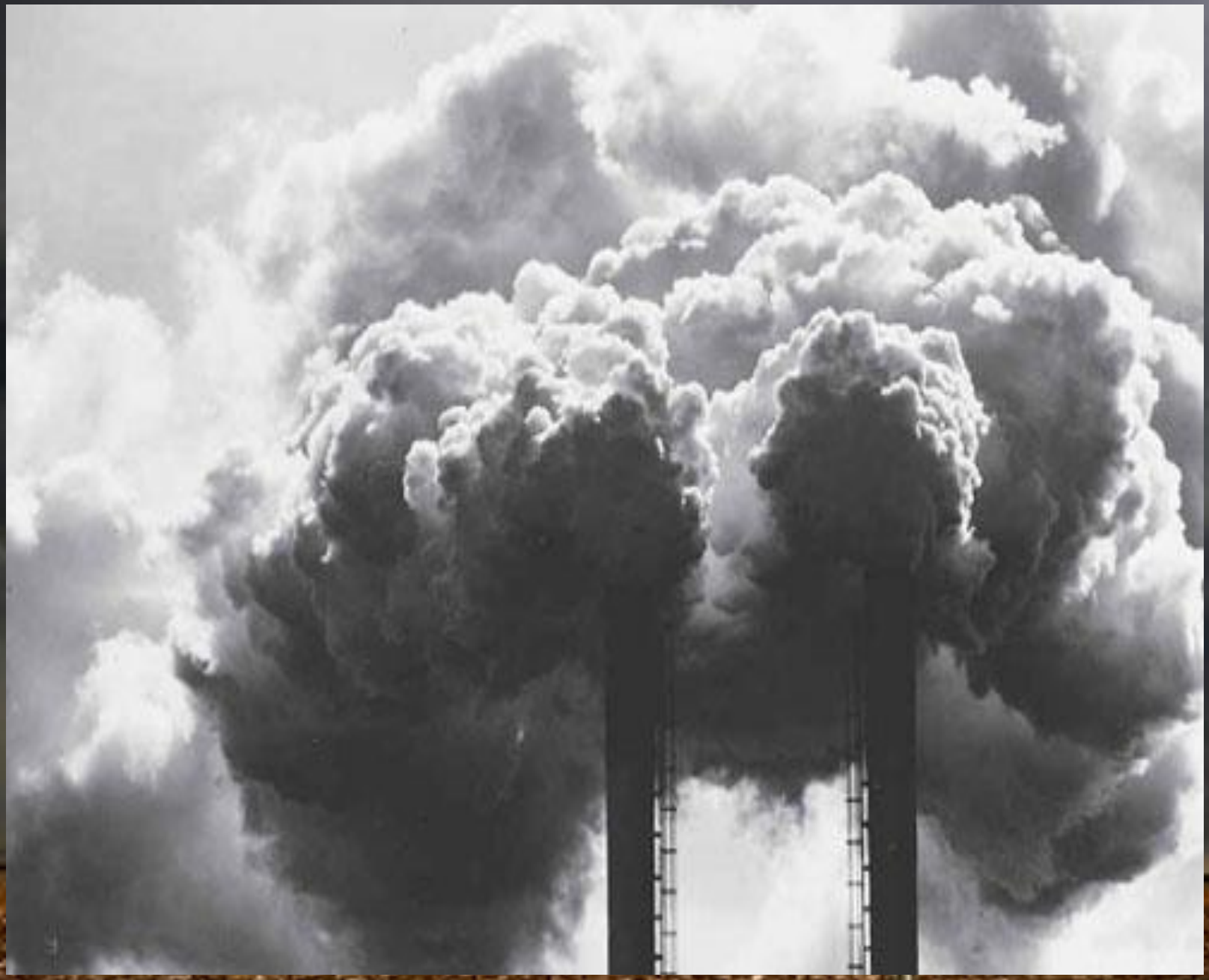




Accumulated July-August precipitation in two different years 1973 (left) and 1989 (right)

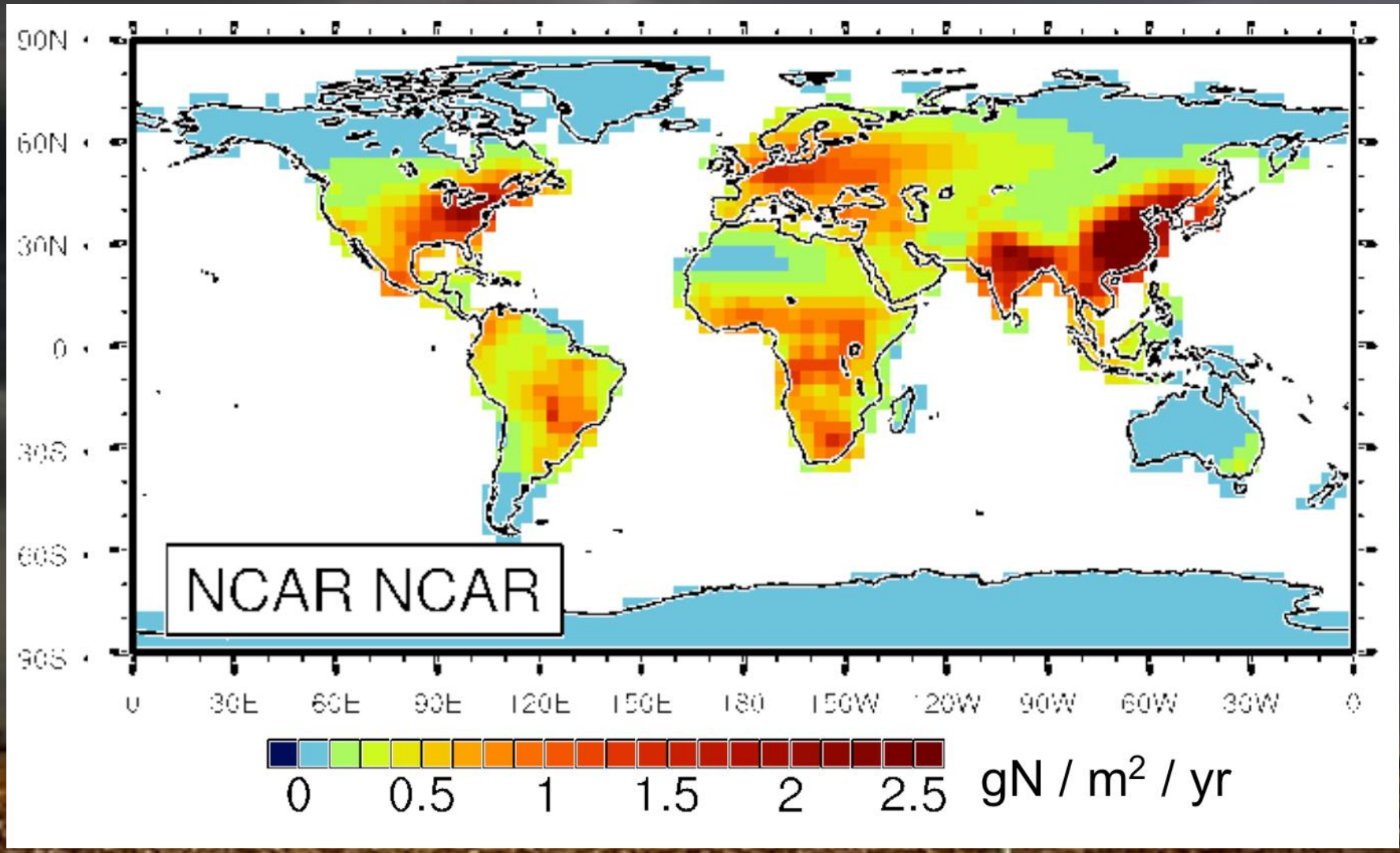
Aerosols

From Industrial
Emissions



From Biomass Burning

Nitrogen Deposition



Aerosol Direct Effects

- Sulfates - radiative cooling

- Black carbon (soot) - radiative warming

  i) in the atmosphere

  ii) surface deposition on snow and ice

Overview of the Different Aerosol Indirect Effects Associated with Clouds [NRC,2005]

First indirect aerosol effect (cloud albedo or Twomey effect)

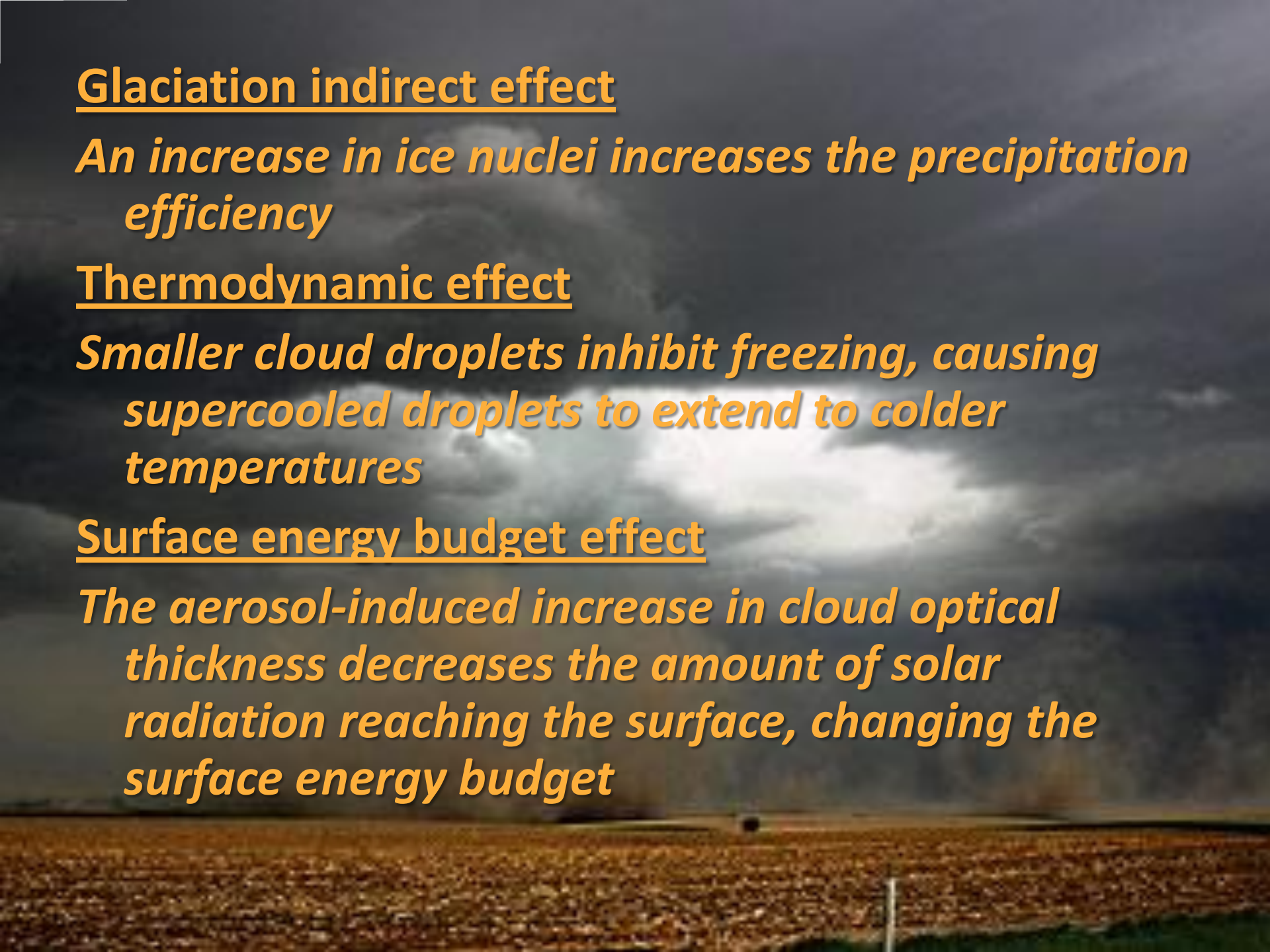
For the same cloud water or ice content, more but smaller cloud particles reflect more solar radiation

Second indirect aerosol effect (cloud lifetime or Albrecht effect)

Smaller cloud particles decrease the precipitation efficiency, thereby prolonging cloud lifetime

Semidirect effect

Absorption of solar radiation by soot leads to evaporation of cloud particles



Glaciation indirect effect

An increase in ice nuclei increases the precipitation efficiency

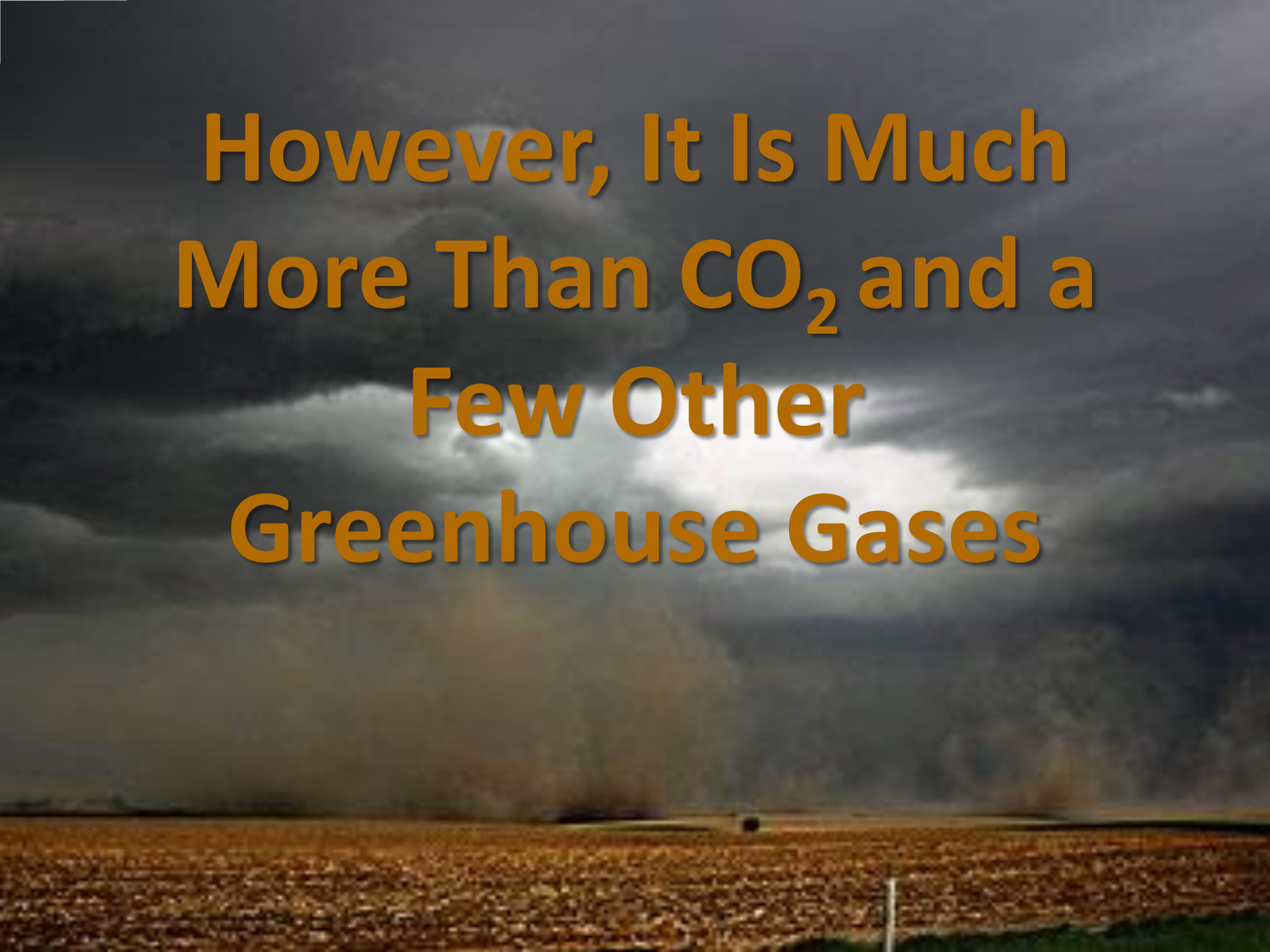
Thermodynamic effect

Smaller cloud droplets inhibit freezing, causing supercooled droplets to extend to colder temperatures

Surface energy budget effect

The aerosol-induced increase in cloud optical thickness decreases the amount of solar radiation reaching the surface, changing the surface energy budget

The Human Influence on
Climate is Everywhere!


However, It Is Much More Than CO_2 and a Few Other Greenhouse Gases

Natural Climate Forcings

- Solar
- Volcanic
- Internal atmospheric/ocean circulation variability [PDO, NAO, ENSO, etc]
- Other

As Mike Hulme of the University of East Anglia writes of two views:

1) "The overwhelming scientific evidence tells us that human greenhouse gas emissions are resulting in climate changes that cannot be explained by natural causes. Climate change is real, we are causing it, and it is happening right now."

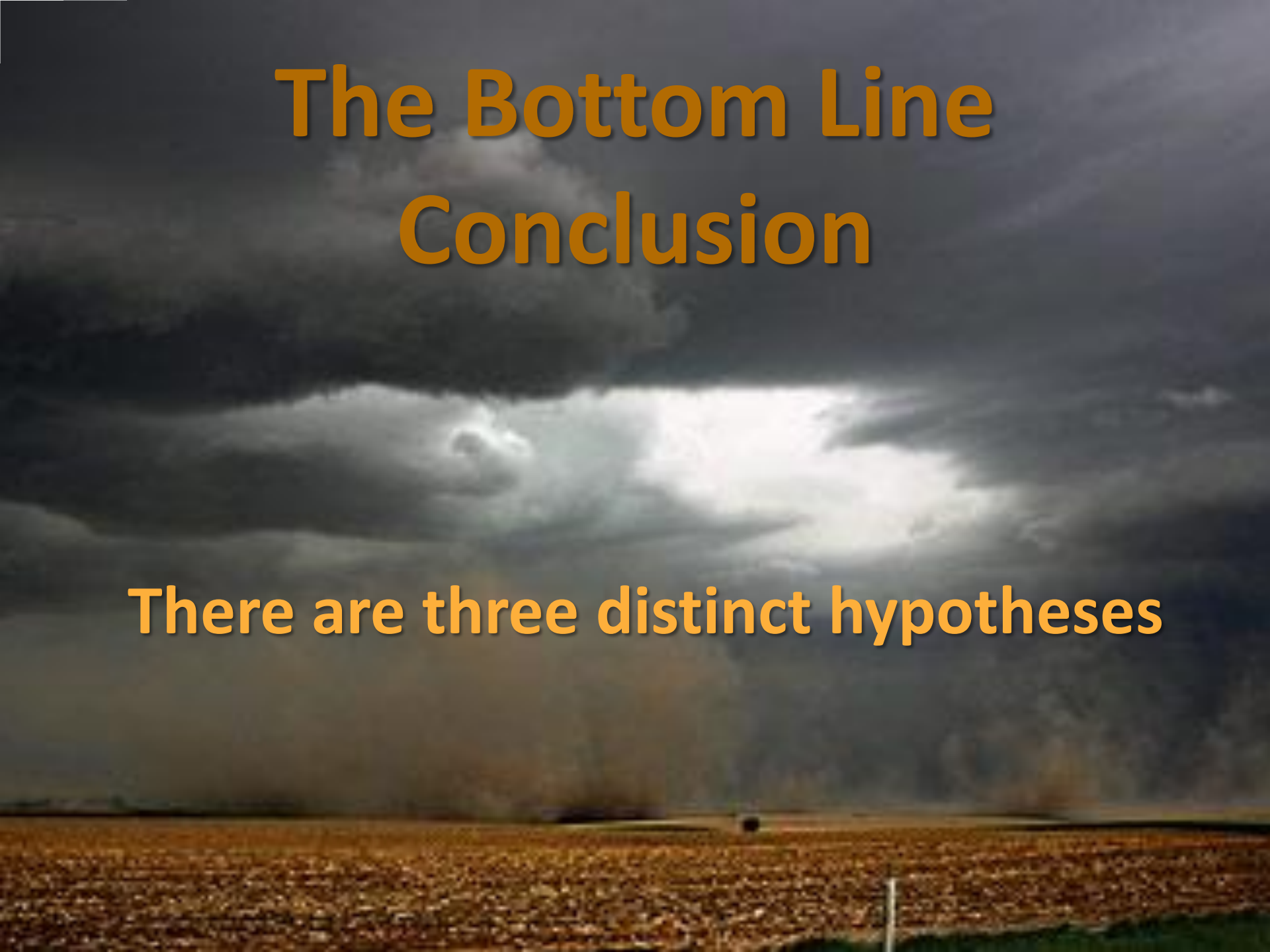
or

2) "The overwhelming scientific evidence tells us that human greenhouse gas emissions, land use changes and aerosol pollution are all contributing to regional and global climate changes, which exacerbate the changes and variability in climates brought about by natural causes. Because humans are contributing to climate change, it is happening now and in the future for a much more complex set of reasons than in previous human history."

As Mike Hulme writes

"….these two different provocations – two different framings of climate change – open up the possibility of very different forms of public and policy engagement with the issue. They shape the response.

http://theconversation.edu.au/youve-been-framed-six-new-ways-to-understand-climate-change-2119



The Bottom Line Conclusion

There are three distinct hypotheses

- Hypothesis 1: Human influence on regional climate variability and change is of minimal importance, and natural causes dominate climate variations and changes on all time scales. In coming decades, the human influence will continue to be minimal.

- Hypothesis 2a: Although the natural causes of regional climate variations and changes are undoubtedly important, the human influences are significant and involve a diverse range of first- order climate forcings, including, but not limited to, the human input of carbon dioxide (CO_2). Most, if not all, of these human influences on regional and global climate will continue to be of concern during the coming decades.

- Hypothesis 2b: Although the natural causes of regional climate variations and changes are undoubtedly important, the human influences are significant and are dominated by the emissions into the atmosphere of greenhouse gases, the most important of which is CO_2. The adverse impact of these gases on regional climate constitutes the primary climate issue for the coming decades. [IPCC]

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Hypotheses 1 is an inaccurate characterization of the climate system.

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Hypothesis 2b must also be rejected; only Hypothesis 2a is robust

AGU Updates Climate Change Position Statement – Aug 20 2013

Human-Induced Climate Change Requires Urgent Action - http://onlinelibrary.wiley.com/doi/10.1002/2013EO340006/pdf

I sought to answer the following questions, which the Statement accepted by the Committee incompletely does and/or does not address at all.

1. What is the definition of climate and climate change?

2. What are the societally and environmentally important climate metrics (e.g. a global average surface temperature trend; changes in ocean and atmospheric circulation patterns over multi-year time periods; sea level rise, trends in extreme weather etc)?

3. What are the main human and natural climate forcings?

4. What is the observational evidence for climate change?

5. What is the skill of the global and regional climate model projections (predictions) of changes in these metrics on multi-decadal time scales?

6. What are recommended pathways forward to reduce the risk from climate, including changes in climate over time?

My Minority Statement

Humanity Has A Significant Effect on Climate – The Scientific Community Has The Responsibility To Communicate The Current Understanding Of What is Certain And What Remains Uncertain –

http://pielkeclimatesci.files.wordpress.com/2013/08/rpt-851.pdf

"The panel did not review the wholly separate statement he drafted because it did not meet the charge from AGU's Board."

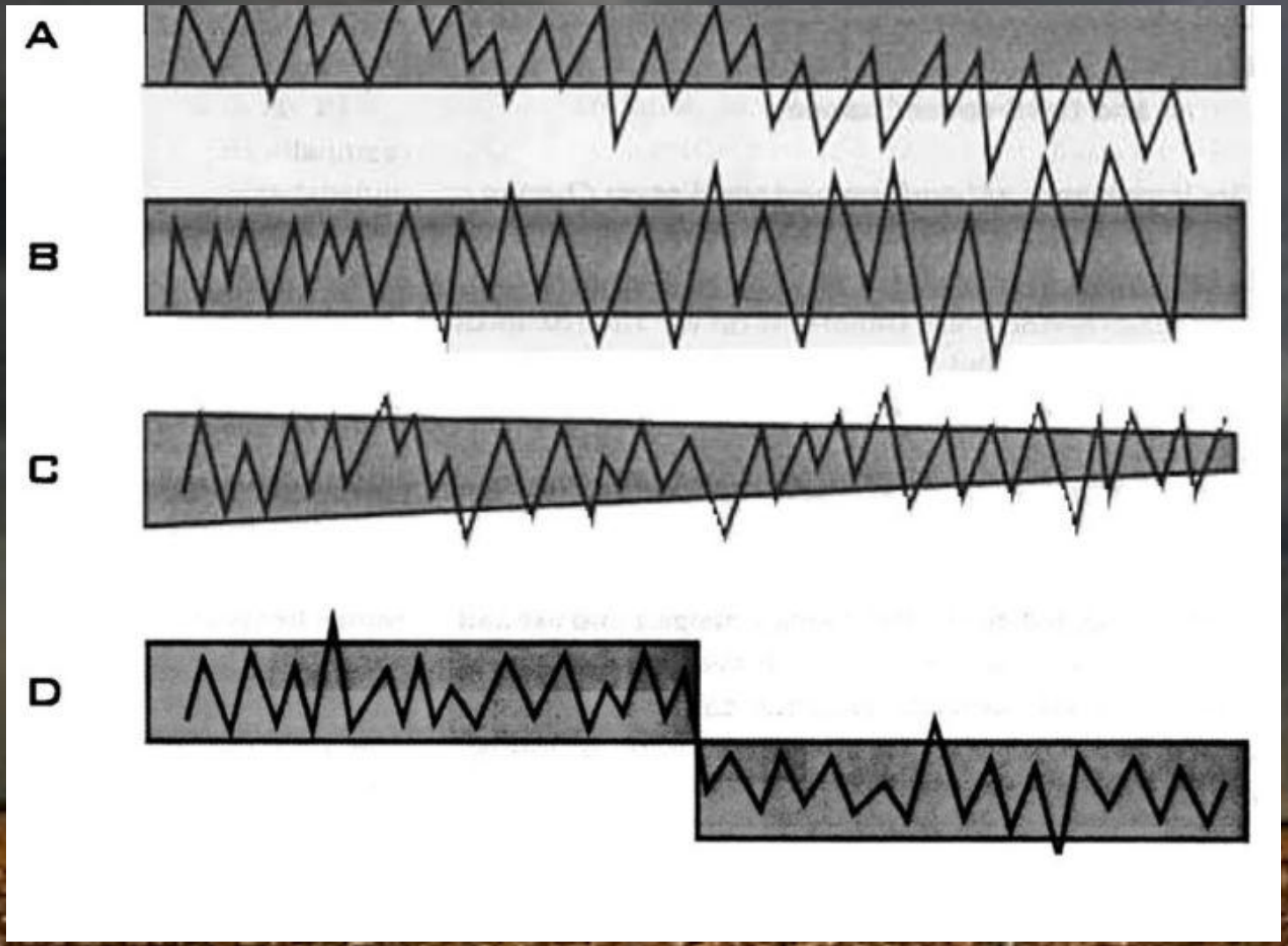
Carol Finn, President AGU

A New Approach Is Needed!

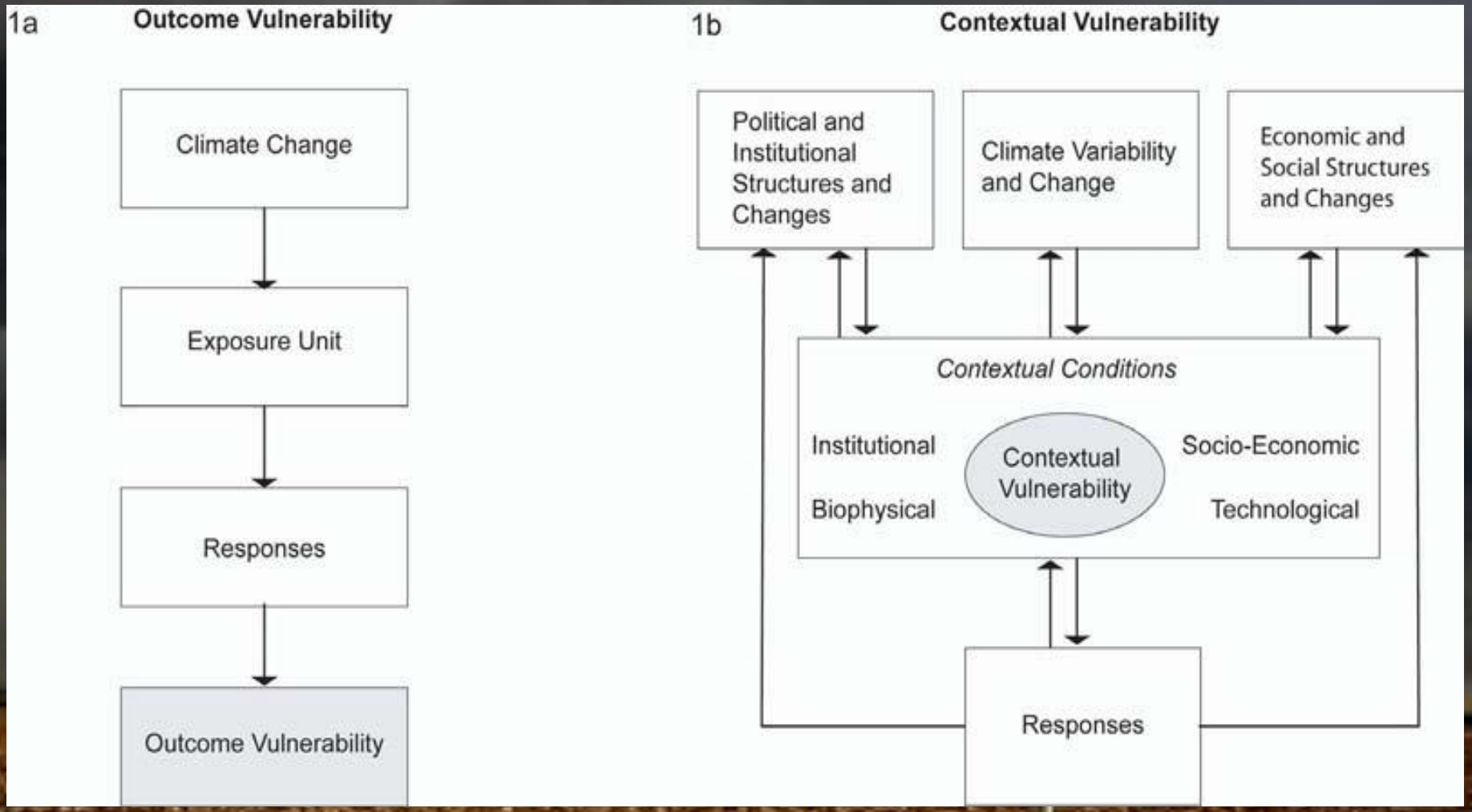
We Need To Replace The IPCC Top-Down Approach To Predict Future Environmental And Social Risk With A Bottom-Up Resource-Based Assessment of Vulnerability

Our Key Resources Are Water, Food, Energy, Ecosystem Function and Human Health

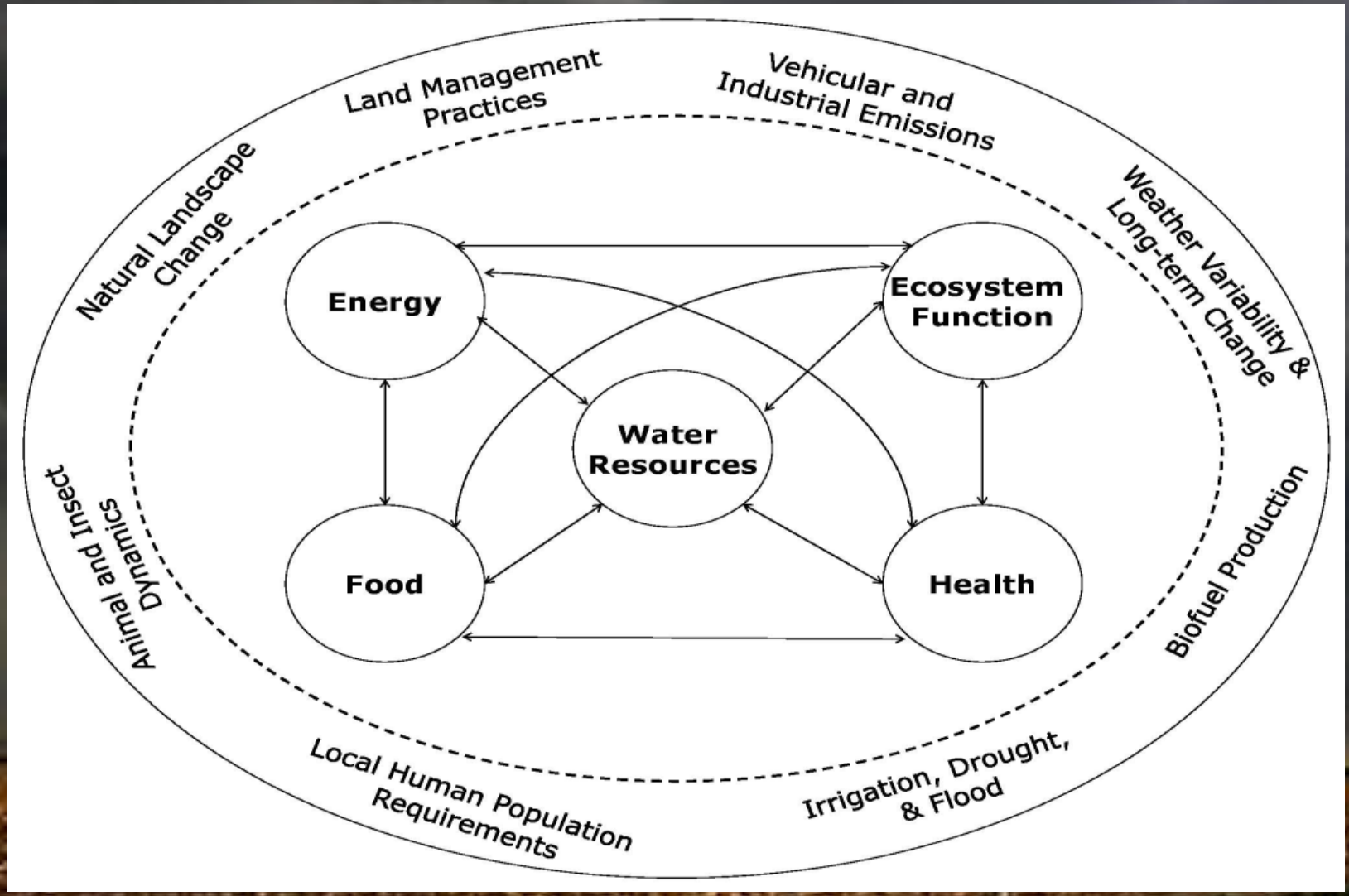
How Vulnerability Can Change Over Time



O'Brien et al., 2007: Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy* 7 (1): 73–88



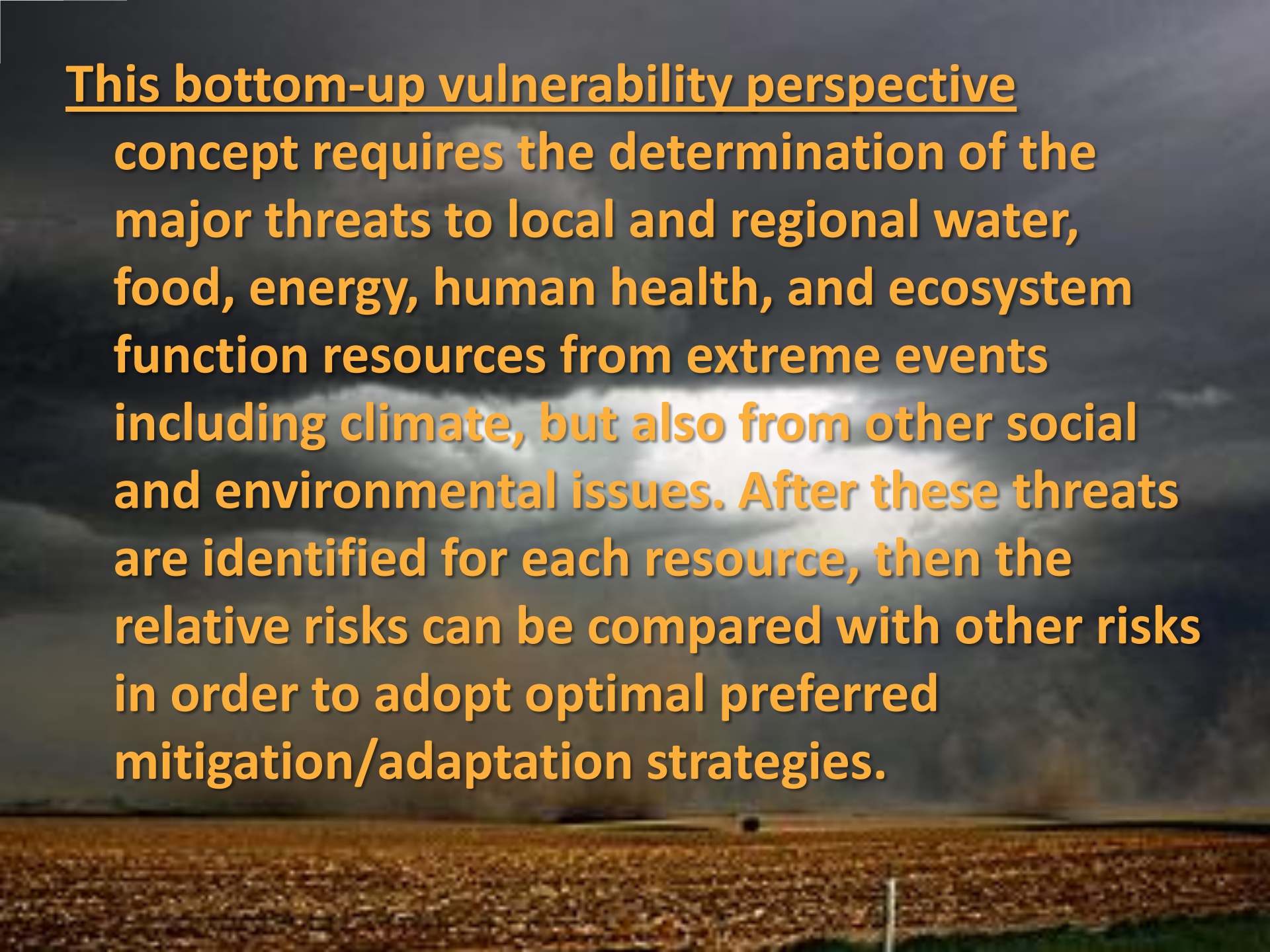
Pielke et al. 2011: Dealing with Complexity and Extreme Events Using a Bottom-up, Resource-based Vulnerability Perspective. AGU Monograph on Complexity and Extreme Events in Geosciences



Questions For Stakeholders On The Bottom-Up Approach

1. Why is this resource important? How is it used? To what stakeholders is it valuable?
2. What are the key environmental and social variables that influence this resource?
3. What is the sensitivity of this resource to changes in each of these key variables? (This may include but is not limited to, the sensitivity of the resource to climate variations and change on short (days); medium (seasons) and long (multi-decadal) time scales).

4. What changes (thresholds) in these key variables would have to occur to result in a negative (or positive) outcome for this resource?
5. What are the best estimates of the probabilities for these changes to occur? What tools are available to quantify the effect of these changes? Can these estimates be skillfully predicted?
6. What actions (adaptation/mitigation) can be undertaken in order to minimize or eliminate the negative consequences of these changes (or to optimize a positive response)?
7. What are specific recommendations for policymakers and other stakeholders?


This bottom-up vulnerability perspective
concept requires the determination of the major threats to local and regional water, food, energy, human health, and ecosystem function resources from extreme events including climate, but also from other social and environmental issues. After these threats are identified for each resource, then the relative risks can be compared with other risks in order to adopt optimal preferred mitigation/adaptation strategies.

Climate Vulnerability

Understanding and Addressing Threats to Essential Resources

Editor:
Roger A. Pielke, Sr

AP

Vulnerability of Water Resources to Climate

5.1 Factors affecting recent trends in global extreme precipitation patterns

5.2 Epitomes Toward An Integrated Theoretical And Modeling Framework To Mitigate Climate Change In Coastal Ecosystems

5.3 Factors affecting precipitation patterns in urban landscapes

5.4 Orographic precipitation and water resources management in mountainous regions

5.5 Hydrological risk management

5.6 Global water use/sustainability in deltaic environments

5.8 Vulnerability-based Flood Mapping

5.9 Urban water resources management for the 21st century

5.12 Remote Sensing of Precipitation for Water Resources Management in Semi-Arid Regions

5.14 Pacific Northwest - Sustainability of hydropower generation in North America: Comparison with other renewal options

5.17 Eastern Africa - Water resources of East Africa

5.18 West Africa - Water resources vulnerability using a Multi-dimensional approach: Case study of Volta Basin

5.19 South America (Amazon) - Rainfall patterns and forest logging

5.20 South Asia - Surface hydrologic controls of public health in coastal regions of South Asia

5.21 South Asia - Changing patterns of water availability due to large scale groundwater extraction in South Asia

5.22 South America - Snow pack trends and implications on water supply for the Andes.

5.24 Europe - Natural Hazards assessment in mountainous terrains of Europe

5.26 Arctic - Changing discharge patterns of Arctic Rivers

5.27 China - Water resources of China under high development stress

5.28 Climate change adaptation strategies for water resources management in Bangladesh

5.31 North Africa. Nubian Sandstone Aquifers: History, Consumption, Recharge and Sustainability

5.36 Flood Inundation and Crop Damage Mapping and the Impact on Rural Income and Migration for Humid Deltas: Case Study on Bangladesh

5.38 Case studies of Adaptation against Water Resource: Vulnerability for the Netherlands from Climate and non-Climate Scenarios

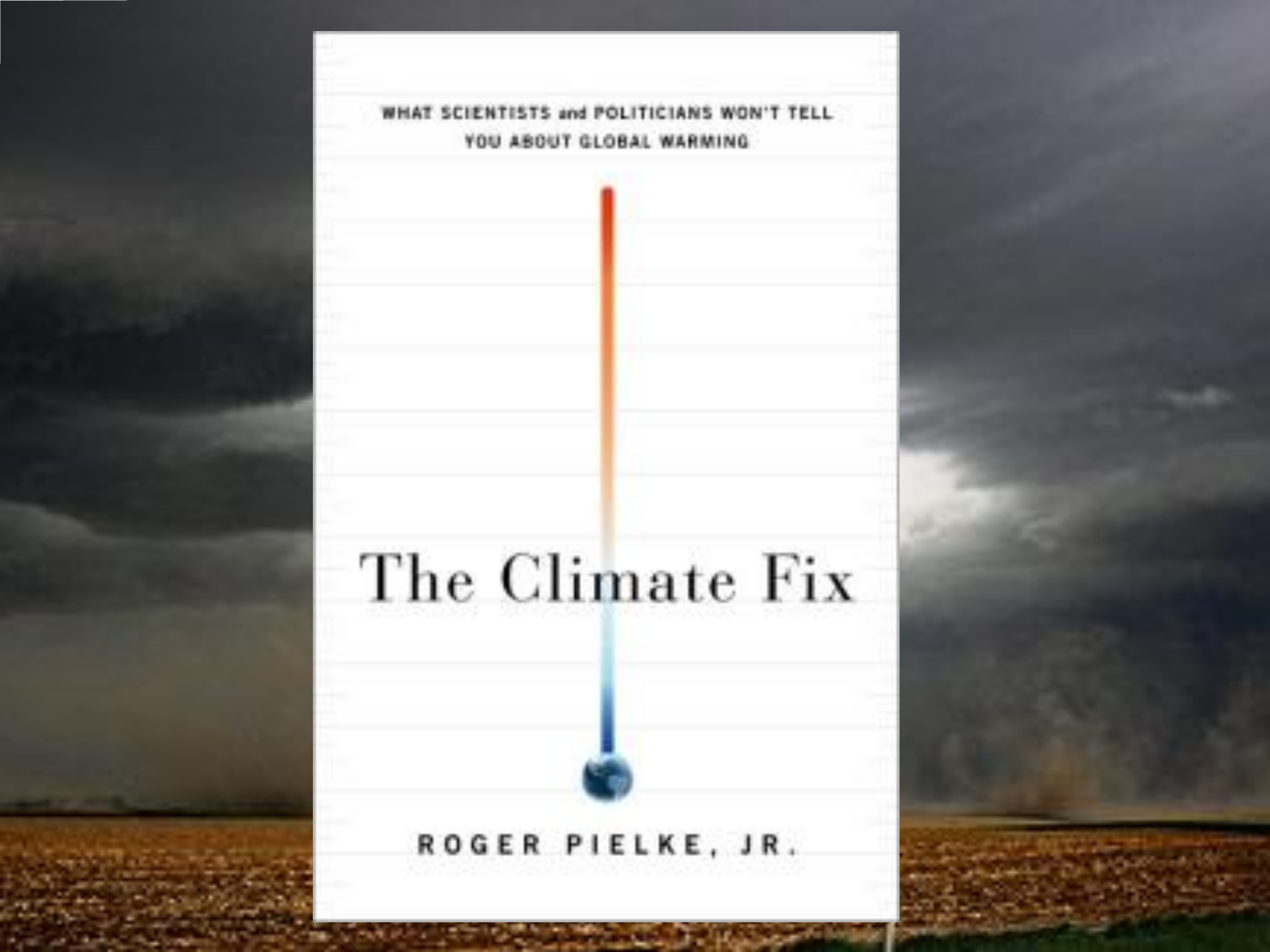
5.39 Paleo-climate record Analysis for Understanding the Tropical Hydrologic Cycle in Abrupt Climate Change

5.40 Water resources vulnerability in the context of rapid urbanization of Dhaka city (a south Asian mega city)

The Rising Tide By Faisal Hossain – An example of the need for a bottom-up assessment of vulnerability

Currently a contender for Sundance-2014 and Berlin-2014 Film Festivals in the short-films category

http://www.youtube.com/watch?feature=player_embedded&v=AjxRLp6OP4Q


WHAT SCIENTISTS and POLITICIANS WON'T TELL
YOU ABOUT GLOBAL WARMING
The Climate Fix
ROGER PIELKE, JR.

Our websites

http://cires.colorado.edu/science/groups/pielke/

http://pielkeclimatesci.wordpress.com/

Thanks, as usual, to Dallas Staley in the preparation of the PowerPoint slides!

Thank you for the opportunity to speak to you today!

Background Photograph Courtesy
of Mike Hollingshead
http://www.extremeinstability.com/
index.htm