SOCIETY OF ACTUARIES®

2019 ANNUAL MEETING & EXHIBIT

October 27-30
Toronto, Canada

Session 066: The Nexus of Climate Data, Insurance and Adaptive Capacity

SOA Antitrust Compliance Guidelines
SOA Presentation Disclaimer

2019 ANNUAL MEETING & EXHIBIT

The Nexus of Climate Data, Insurance and Adaptive Capacity

Rob Montgomery ASA, MAAA

Session 066 October 28, 2019

SOCIETY OF ACTUARIES®

SOCIETY OF ACTUARIES
Antitrust Compliance Guidelines

Active participation in the Society of Actuaries is an important aspect of membership. While the positive contributions of professional societies and associations are well-recognized and encouraged, association activities are vulnerable to close antitrust scrutiny. By their very nature, associations bring together industry competitors and other market participants.

The United States antitrust laws aim to protect consumers by preserving the free economy and prohibiting anti-competitive business practices; they promote competition. There are both state and federal antitrust laws, although state antitrust laws closely follow federal law. The Sherman Act, is the primary U.S. antitrust law pertaining to association activities. The Sherman Act prohibits every contract, combination or conspiracy that places an unreasonable restraint on trade. There are, however, some activities that are illegal under all circumstances, such as price fixing, market allocation and collusive bidding.

There is no safe harbor under the antitrust law for professional association activities. Therefore, association meeting participants should refrain from discussing any activity that could potentially be construed as having an anti-competitive effect. Discussions relating to product or service pricing, market allocations, membership restrictions, product standardization or other conditions on trade could arguably be perceived as a restraint on trade and may expose the SOA and its members to antitrust enforcement procedures.

While participating in all SOA in person meetings, webinars, teleconferences or side discussions, you should avoid discussing competitively sensitive information with competitors and follow these guidelines:

- Do not discuss prices for services or products or anything else that might affect prices
- Do not discuss what you or other entities plan to do in a particular geographic or product markets or with particular customers.
- Do not speak on behalf of the SOA or any of its committees unless specifically authorized to do so.
- Do leave a meeting where any anticompetitive pricing or market allocation discussion occurs.
- Do alert SOA staff and/or legal counsel to any concerning discussions
- Do consult with legal counsel before raising any matter or making a statement that may involve competitively sensitive information.

Adherence to these guidelines involves not only avoidance of antitrust violations, but avoidance of behavior which might be so construed. These guidelines only provide an overview of prohibited activities. SOA legal counsel reviews meeting agenda and materials as deemed appropriate and any discussion that departs from the formal agenda should be scrutinized carefully. Antitrust compliance is everyone's responsibility; however, please seek legal counsel if you have any questions or concerns.

Presentation Disclaimer

Presentations are intended for educational purposes only and do not replace independent professional judgment. Statements of fact and opinions expressed are those of the participants individually and, unless expressly stated to the contrary, are not the opinion or position of the Society of Actuaries, its cosponsors or its committees. The Society of Actuaries does not endorse or approve, and assumes no responsibility for, the content, accuracy or completeness of the information presented. Attendees should note that the sessions are audio-recorded and may be published in various media, including print, audio and video formats without further notice.

SOA Practice Research:
Climate & Environmental Sustainability

- Published Research:
  - https://www.soa.org/research/topics/research-emerging-topics/#climate
    - Published research project reports
    - Resources for actuaries
    - Monthly extreme weather / economic and insured impact series
    - Multi-Sponsor (SOA, AAA, CIA, CAS) Actuaries Climate Index
- Research Projects In Progress:
    - Current value of future climate costs
    - Catastrophe pooling
    - Climate impact on health
- Planned Programs:
  - Environmental Risk Introductory Paper Series
    - A series of research papers introducing actuaries to various topics related to environmental risks.

SOA Strategic Research Programs

The SOA Strategic Research Programs emphasize the skillset and thought leadership of actuaries, and help provide insights to members, stakeholders, and the public on socially relevant topics.

Catastrophe and Climate:

The SOA Catastrophe and Climate Strategic Research Program studies climate trends and their impact on extreme and catastrophic events, and focuses on the impact of shifting climate patterns and frequency/severity of events on the public and insurance industry.

A systematic long-lasting interconnected program, steadily providing themed research

- Advisory Group and Steering Committee include members from a very diverse group of
  - Backgrounds:
    - Actuaries, University Researchers, Regulators, Meteorologists, Catastrophe Risk Modelers, Climate Scientists, Insurance Industry Support Groups
  - Geographies:
    - US, Canada, UK, Central Europe, Asia, Australia

Catastrophe & Climate Strategic Research Program Opportunities / Research Goals

- Identify gaps in the body of existing research / Benefit the actuarial profession.
- Engage with existing multi-disciplinary climate and environmental research communities.
- Determine how the actuarial profession can quantify risks related to climate trends, propose mitigation, facilitate investment in solutions, and inform decision making.
- Prepare for Transition Risks.
- Sponsor research which ultimately helps "solve" climate change by identifying and facilitating incentivized insurance solutions.

The Nexus of Climate Data, Insurance and Adaptive Capacity

SOCIETY OF ACTUARIES®

The Nexus of Climate Data, Insurance and Adaptive Capacity

Rob Erhardt, Ph.D., A.C.A.S.
Wake Forest University

Two Quick Questions:

1. Before you came to this conference, did you bother to see if this venue complies with all building safety codes?

Two Quick Questions:

1. Before you came to this conference, did you bother to see if this venue complies with all building safety codes?
2. Do you know precisely which fire department district you are located in right now?

"Insurance is a form of adaptive capacity." (Mills 2005)

- "Can insurers extend their self-chosen historical role in addressing root causes (as founders of the first fire departments, building codes, and auto safety testing protocols) to one of preventing losses at a much larger scale, namely, the global climate?" (Mills, 2005).

Overview

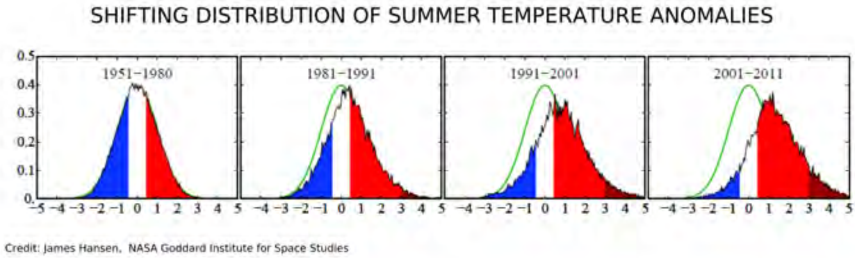
1. **Background on Measuring and Projecting Climate Change**
2. The Nexus Workshop

Weather and Climate

“Climate is what we expect, weather is what we get.” Robert Heinlein.

(image: Monument Valley)

Weather and Climate



(Image credit: NASA/GISS).

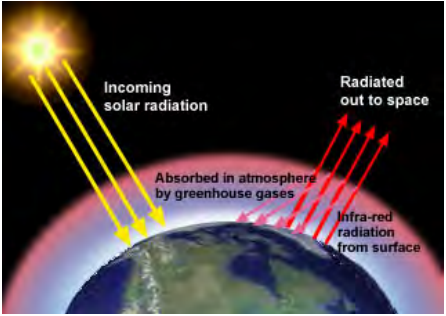
"Climate is the distribution of weather."
American Statistical Association, 2010.

Weather and Climate

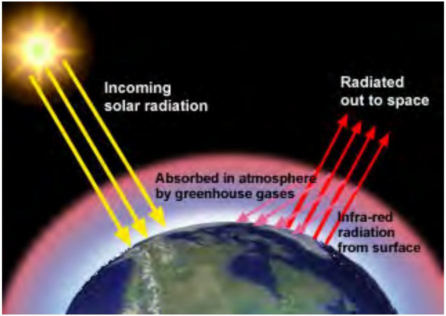
Climate change is "any systematic change in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer." American Meteorological Association.

(image: Glacier National Park)

Energy:


Incoming
solar radiation
Radiated
out to space
Absorbed in atmosphere
by greenhouse gases
Infra-red
radiation
from surface

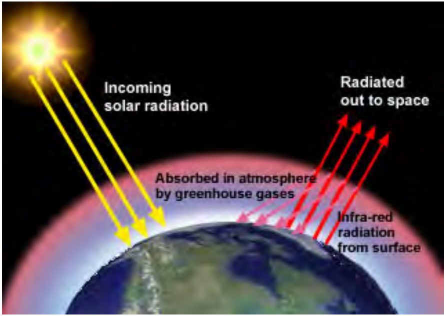
What goes in...



$$S \cdot \pi r^2 (1 - a) =$$

- $S = 1360 \ \ W/m^2$ is the solar constant.
- $r = 6400 \ \ km$ is the radius of the earth
- a is the earth's albedo (reflectivity)

… must go out.



$$= 4\pi r^2 \cdot \epsilon \cdot \sigma \cdot T^4$$

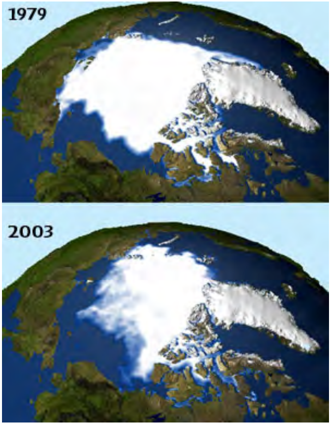
- ϵ is the *emissivity* (transparency of atmosphere)
- σ is the *Stefan-Boltzman* constant
- T is temperature

Conservation of Energy

$$T^4 = \frac{S(1-a)}{4\epsilon \cdot \sigma}$$

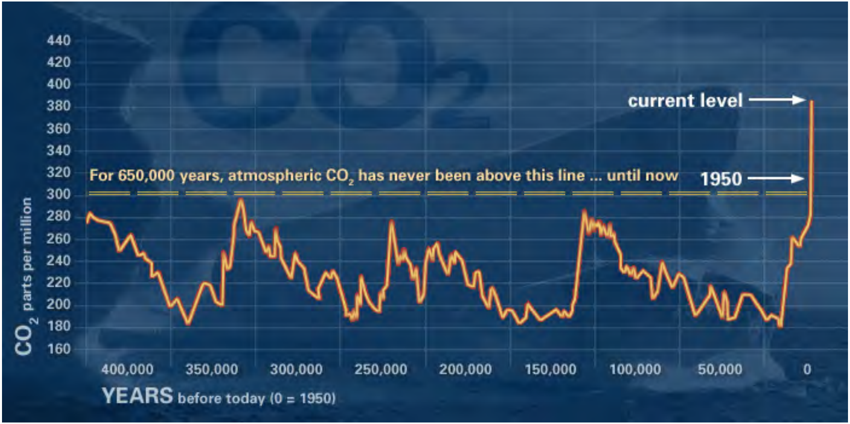
- Plug in actual a, σ, ϵ, S, get $T = 14.8°C$ $(58°F)$
- Start changing stuff:
  - If S went up 1%, T goes up $0.7°C$ $(1.3°F)$
  - If a went down 1%, T goes up $0.3°C$ $(0.55°F)$
  - If ϵ went down 1%, T goes up $0.7°C$ $(1.3°F)$

Why Would the Albedo Change?



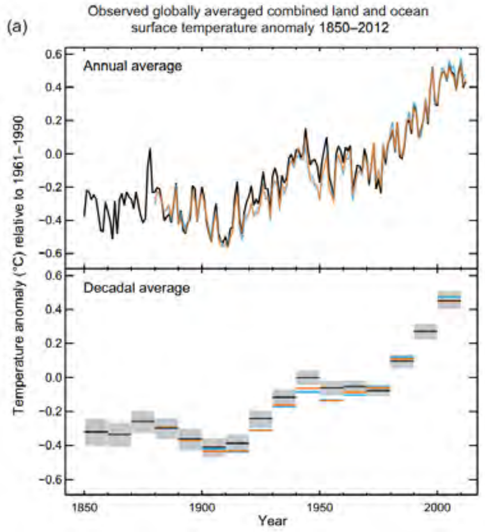
(source: NASA/Goddard Space Flight Center)

Why Would the Emissivity Change?



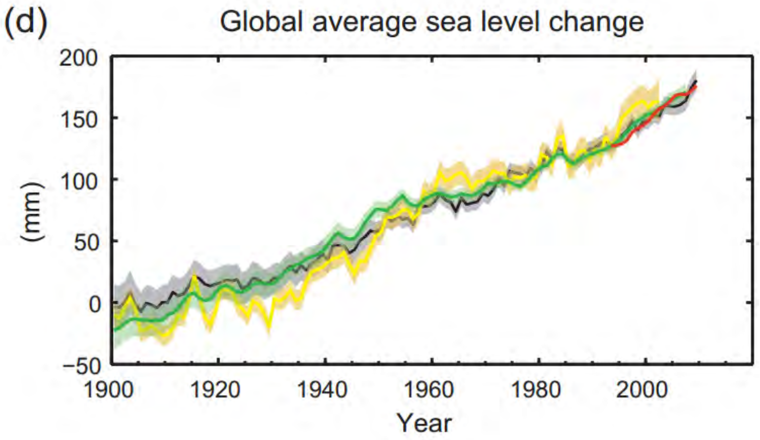
(source: NASA)

Global surface temperatures



(source: IPCC AR5 2014)

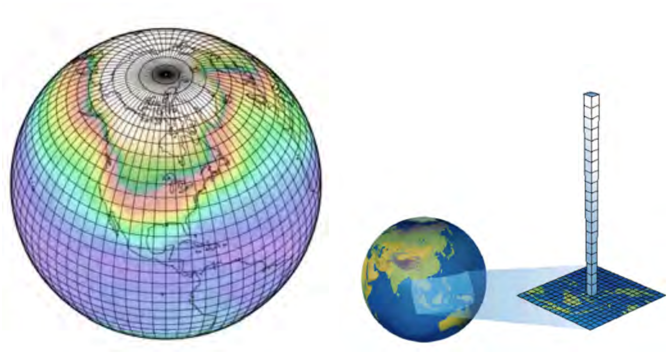
Sea levels



(source: IPCC AR5 2014)

Climate Model Projections

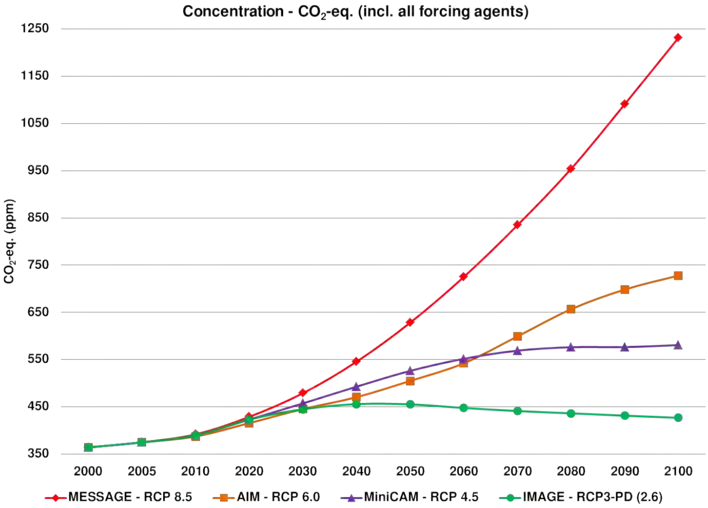
Climate Model Projections



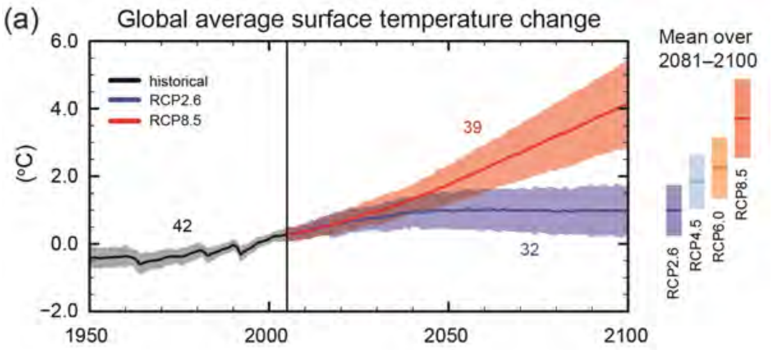
Climate Model Projections

1. Discretize space on earth ($\approx 66,000$ grid cells on surface, times 20 layers is 1.32 million cells.)
2. Discretize time to 3-hour intervals (8 per day, 2920 per year)
3. Model relationship of climate variables (temperature, pressure, wind, atmospheric carbon content, etc.) as **partial differential equations** in discretized time and space.
4. Run under 4 different **scenarios** of atmospheric CO2
5. (Show movie here)

Climate Model Projections

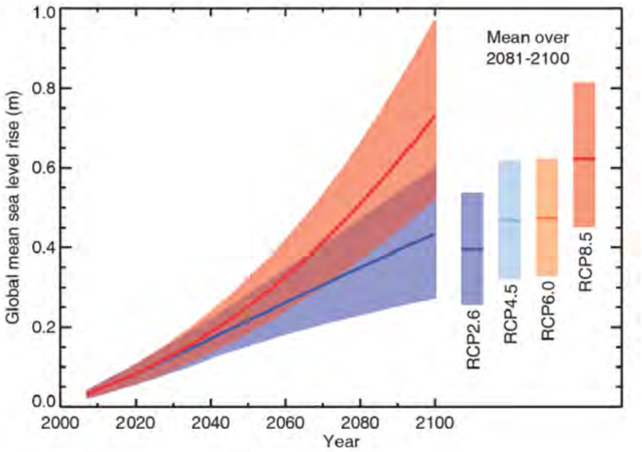


Climate Model Projections



(source: IPCC AR5 2014)

Climate Model Projections



(source: IPCC AR5 2014)

Climate Model Projections

1. Only changing input across model runs is the emissions scenario
2. Difference *across* scenarios is very large as compared to the (random) difference *within* a scenario
3. Changes are projected for multiple climate variables, over periods of many decades.

Overview

1. Background on Measuring and Projecting Climate Change
2. **The Nexus Workshop**

The Nexus of Climate Data, Insurance, and Adaptive Capacity

Rob Erhardt, Wake Forest University; Jesse Bell, University of Nebraska Medical Center; Brian Blanton, RENCI; Frank Nutter, Reinsurance Association of America; Megan Robinson, The Collider; Richard Smith, UNC-Chapel Hill

Workshop:

- November 8 and 9, 2018
- Held at The Collider in Asheville, NC
- Funded by NSF SES DRMS 182439
- Fifty-seven active researchers in climate sciences, insurance and reinsurance, applied mathematics and statistics
- Eleven invited speakers

Workshop:

- Eleven Invited Speakers from: NCAR, FEMA, Broward County FL, NOAA NCEI, etc.

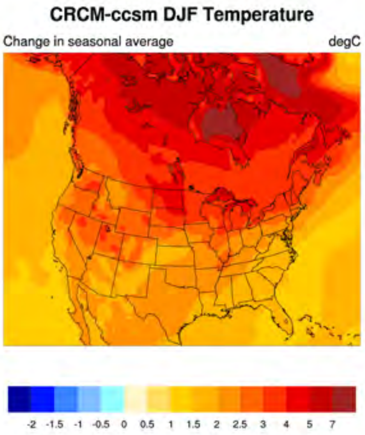



- Four **breakout discussion groups** to form actionable research items
- **Sponsored Reception**

1. How to Build a Better Flood Map

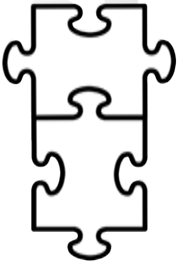
- Beyond binary flood zones to probabilistic or graded maps with uncertainty estimates.
- Incorporating projected land-use changes
- Risk-scoring for individual policyholders
- Commercial insurance has stronger incentive for long-term planning

2. Climate Models in Insurance



- Mismatched time scales (annual policies, decadal planning, century models)
- Recast observed catastrophes (e.g. Hurricane Harvey) under past and projected future climates (Emanuel, 2017)
- Use of multi-model climate ensembles for catastrophe models (approval process)

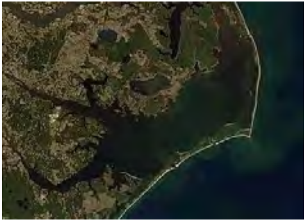
3. Mitigation and Adaptation



- **Mitigation**: addressing the *causes* of climate change. Attempting to slow or stop the changes themselves.
- **Adaptation**: addressing the *consequences* of climate change. Attempting to minimize the impacts.
- **Geoengineering**: actively intervening in the climate system to modify it

3. Mitigation and Adaptation

"Certain measures that integrate climate change mitigation and adaptation can simultaneously reduce insurance losses." (Mills, 2005)



- Losses from Billion Dollar Disasters are going up (NOAA, 2019); many of these costs are borne to insurers, then later reinsurers.

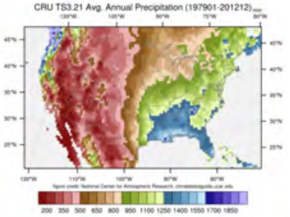
4. What Keeps you Up at Night?

March '18|March '19
Omaha, NE

- Mismatched time scales for climate models (what about next 10-20 years)
- Extremes. But sometimes non-extreme causes (i.e. coupled events) combine to cause extreme loss.
- Tools to navigate the (underutilized) 36 PB of data at NOAA-NCEI

Spatial Diversification for Flood Risk

- Boudreault (UQAM) and Erhardt (WFU) with CIA and CAS support
- How will climate change impact spatial diversification of flood risk?



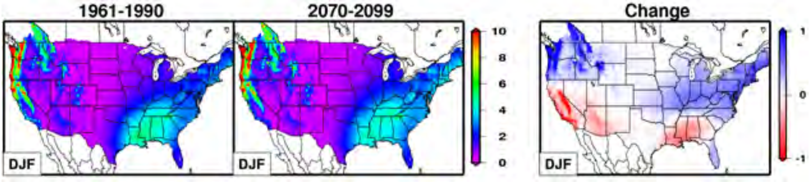
- **Occurrence** $p_i = P(Y_i = 1) \sim f(X_1, \ldots, X_p)$
- **Intensity** $Z_i \sim g(X'_1, \ldots, X'_q)$,

where $X_1, \ldots, X_p$ are environmental variables (precipitation, temperature, soil type, etc.)

Hydrobasins as exposure units

hybasin.jpg

Will Climate Change Impact Occurrence or Intensity?



X_{past} X_{future}

$$\hat{p}_{past} \sim f(X_{past}) \quad \hat{p}_{future} \sim f(X_{future})$$
$$\hat{Z}_{past} \sim g(X_{past}) \quad \hat{Z}_{future} \sim g(X_{future})$$

Thanks.

Acknowledgments: Many thanks to: The Society of Actuaries, The Climate and Environmental Sustainability Research Committee, The Casualty Actuarial Society, SAMSI, Wake Forest Center for Energy, Environment and Sustainability

Emanuel, K. (2017). Assessing the present and future probability of Hurricane Harvey's rainfall. *Proceedings of the National Academy of Sciences*, 114(48), 12681-12684.

Erhardt, R., Bell, J., Blanton, B., Nutter, F., Robinson, M., Smith, R. Stronger Climate Resilience Through Insurance. *Bulletin of the American Meteorological Society*, (accepted, forthcoming).

Erhardt R. (2017). Climate, Weather, and Environmental Sources for Actuaries. Society of Actuaries. `https://www.soa.org/research-reports/2017/climate-weather-environmental-sources/`

Mills, E. (2005). Insurance in a climate of change. *Science*, 309(5737), 1040-1044.

Mills, E. (2009). A global review of insurance industry responses to climate change. *The Geneva Papers on Risk and Insurance Issues and Practice*, 34(3), 323-359.

NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2019). https://www.ncdc.noaa.gov/billions/