Perspectives from the "upstream" portion of the climate projection data *(& hopefully knowledge)* supply chain

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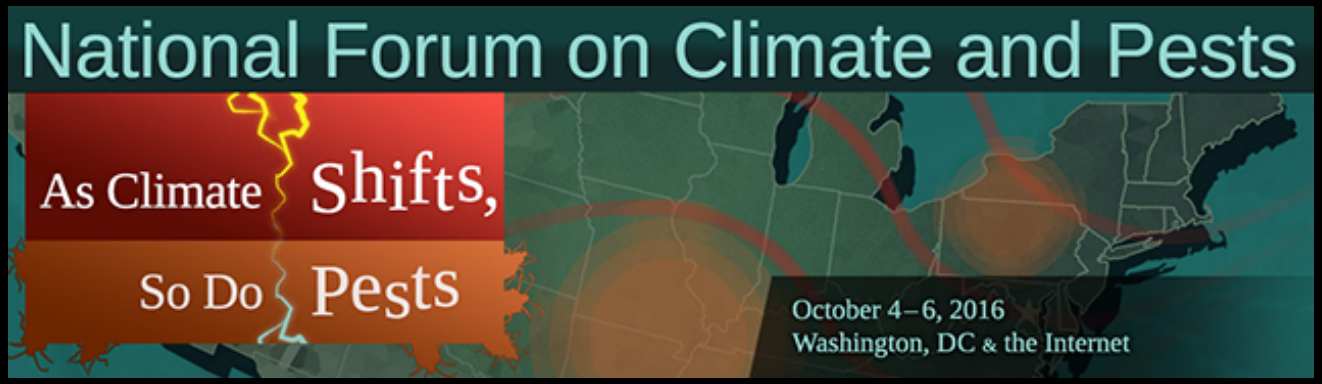
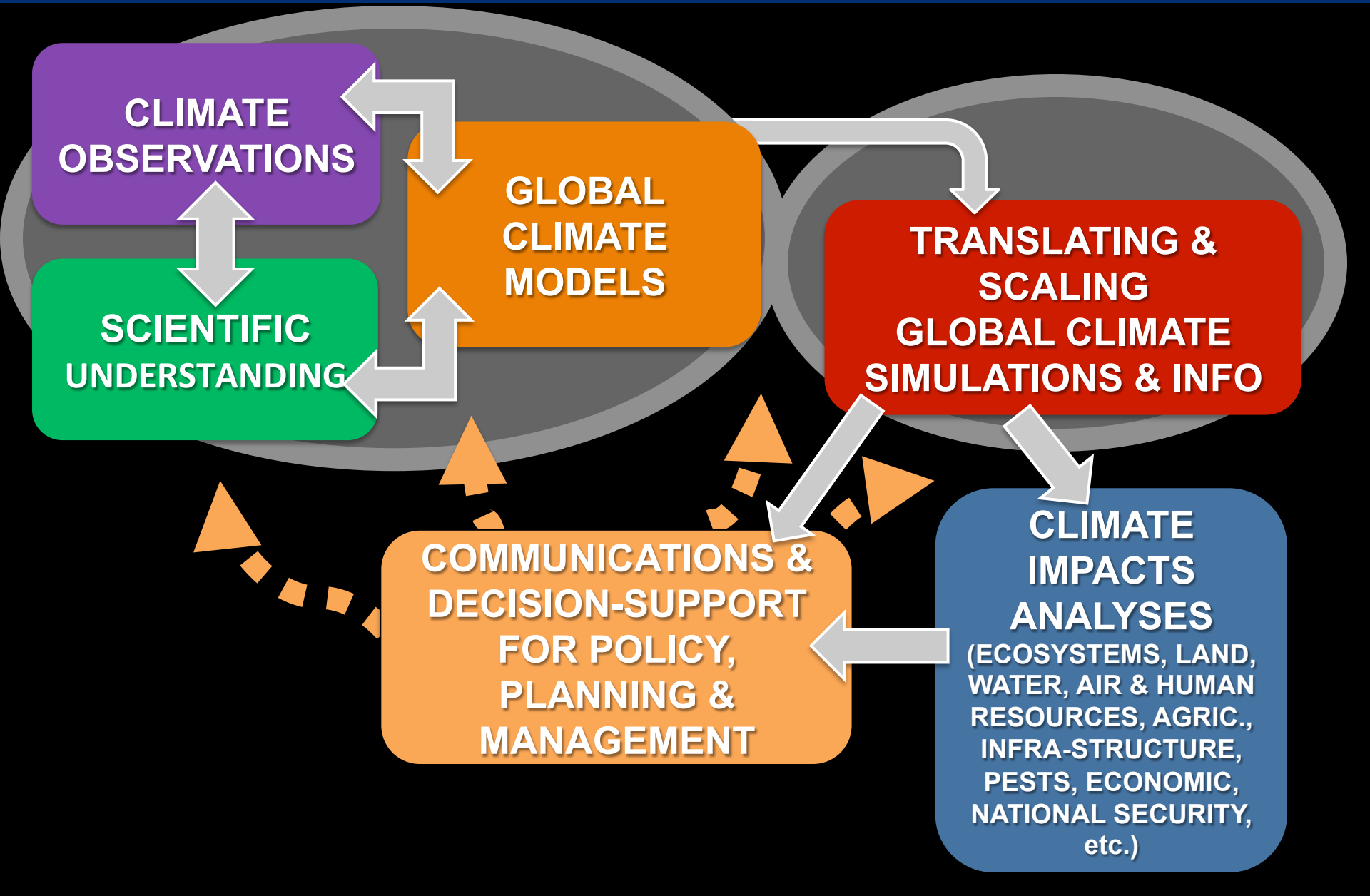


FROM GLOBAL-SCALE SCIENCE TO REGIONAL DECISION-MAKING

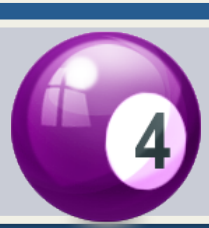


4 climate-related science questions

Is the planet's climate changing in significant ways?
[DETECTION]

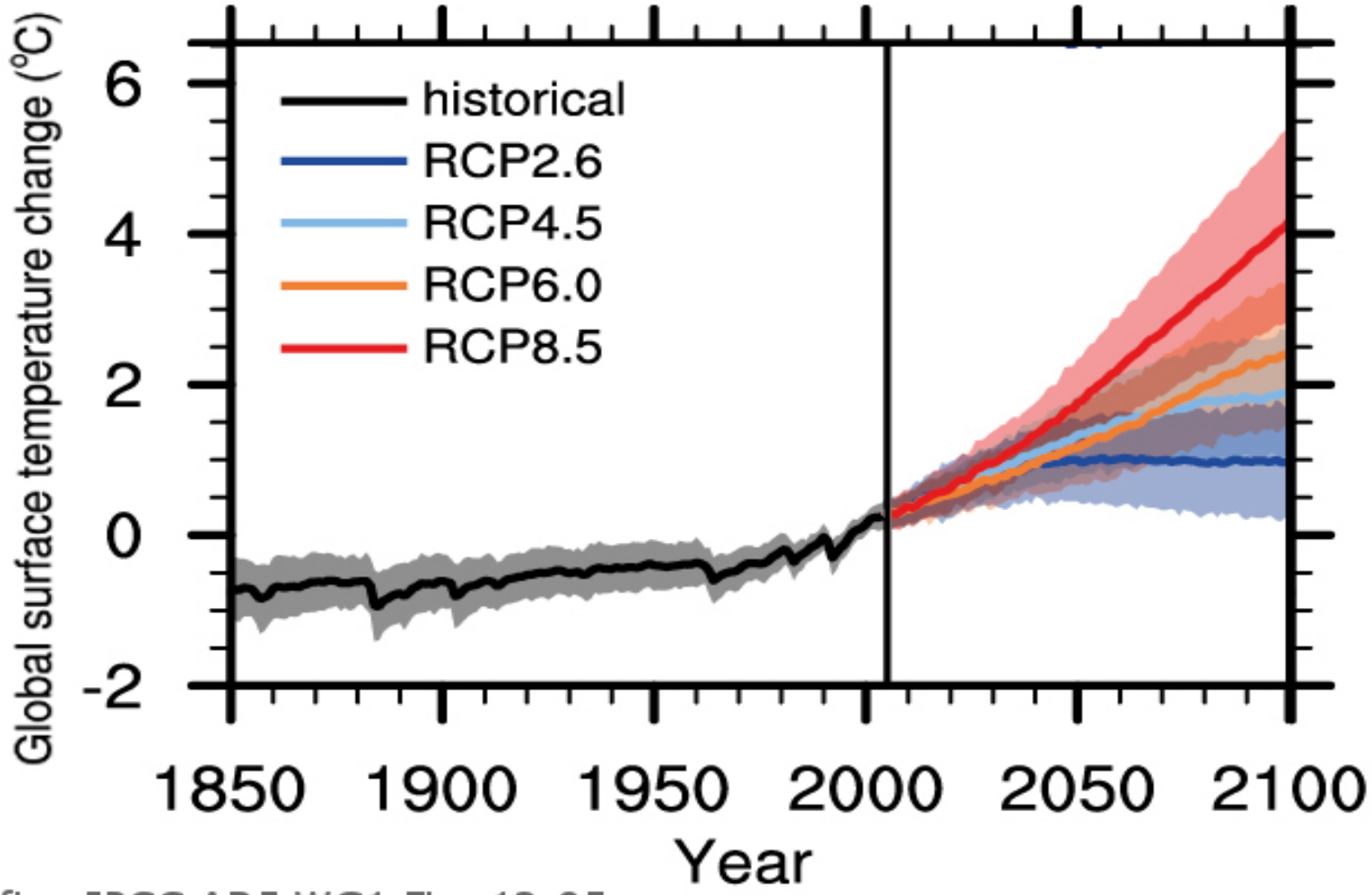
If so, what is causing it to change? (people, natural, both?)
[ATTRIBUTION]

How might the Earth's climate change in the coming decades & centuries?
[PROJECTION]

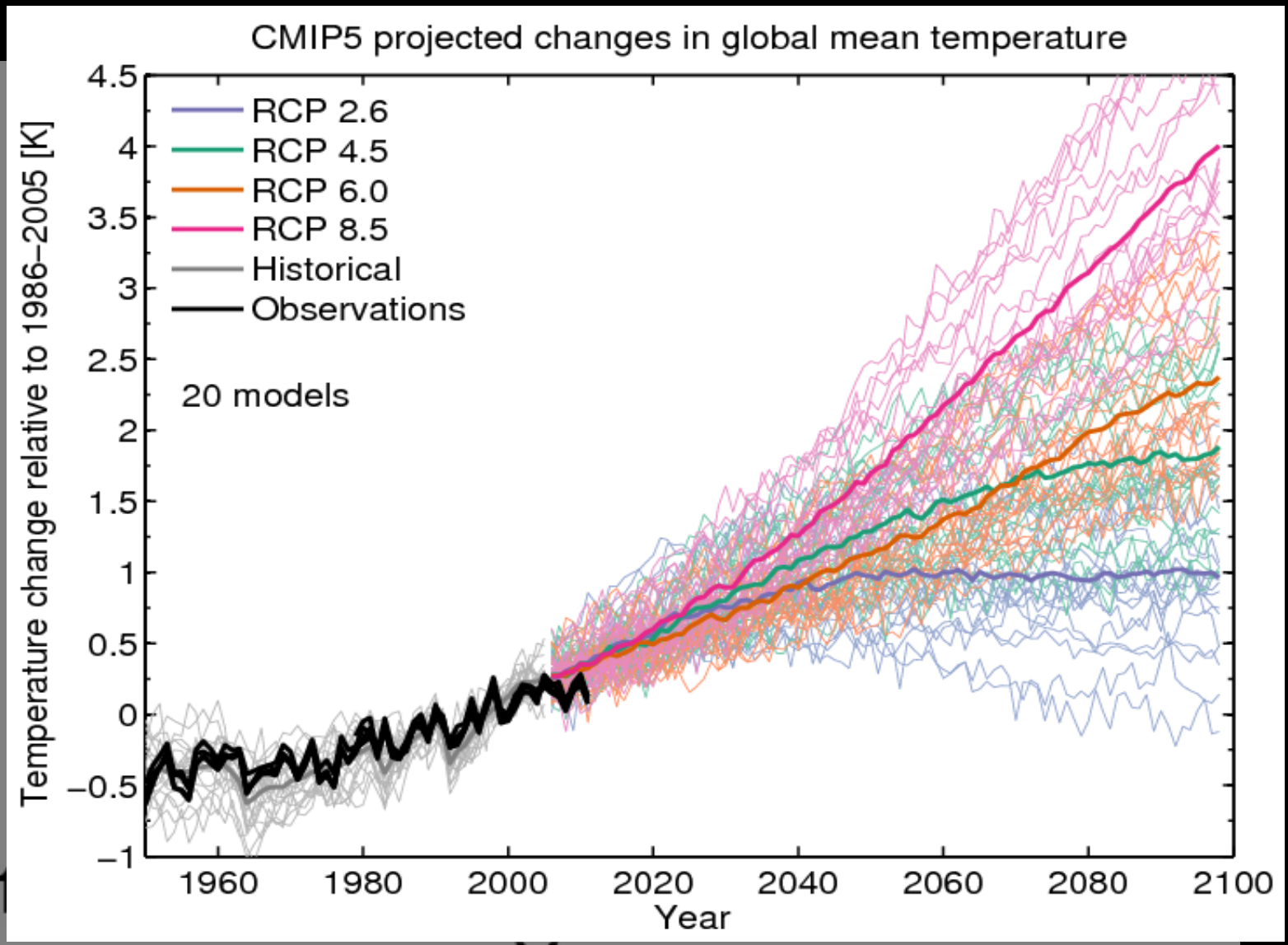


How might physical climate changes impact things people care about (e.g., human & ecological systems)**? [IMPACTS]**

How might the Earth's climate change in next 50 or 100 years? [PROJECTION]



after IPCC AR5 WG1 Fig. 12-05

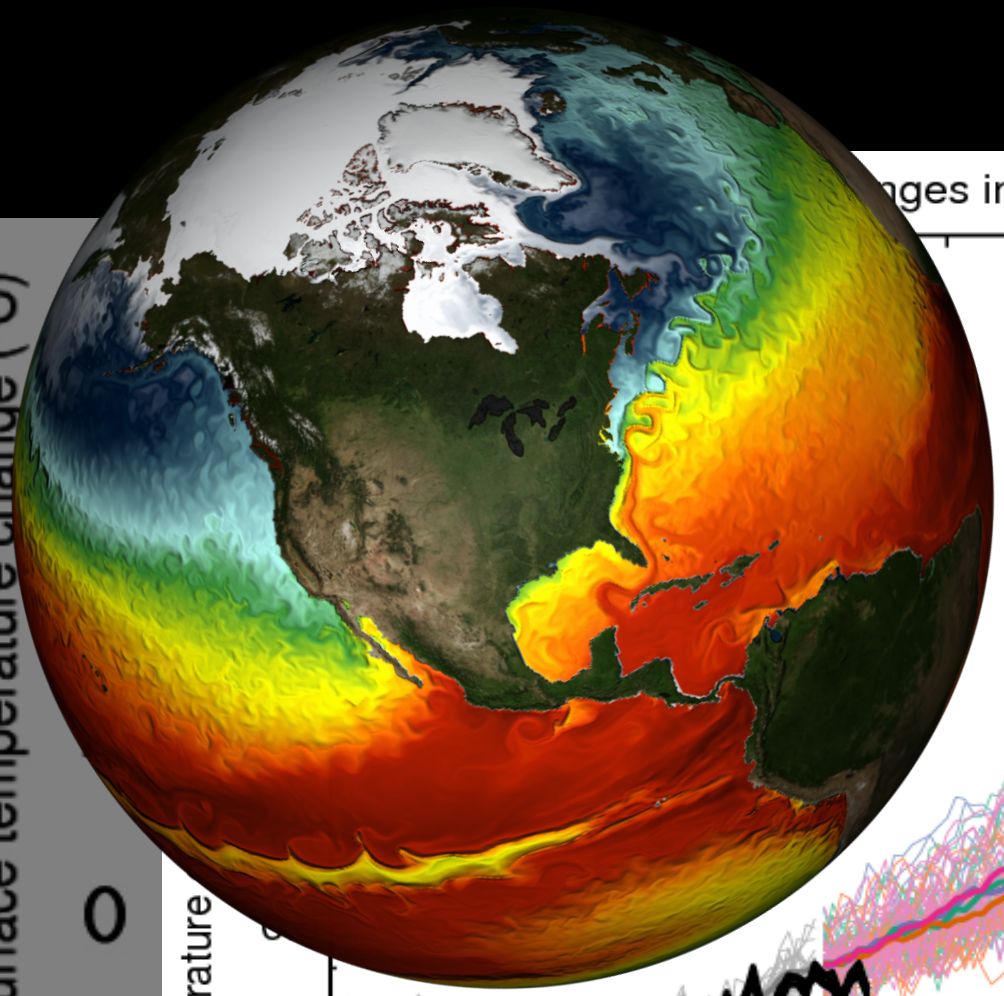


Global surface temperature change (°C)

6
4
2
0
-2

Year

after IPCC AR5 WG1 Fig. 12-05



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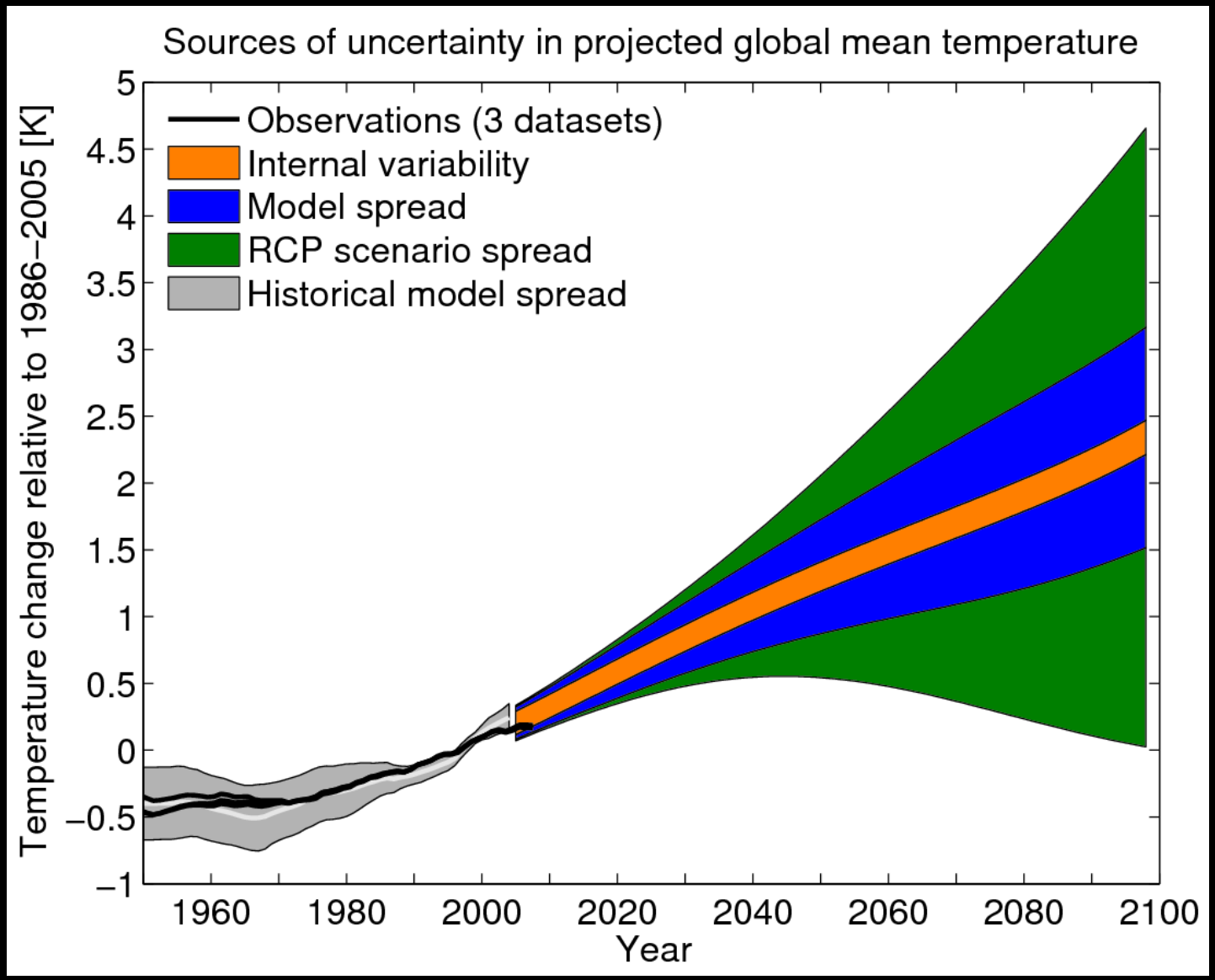


This and similar images based on work of Hawkins & Sutton, 2009: The Potential to Narrow Uncertainty in Regional Climate Predictions. *Bull. Amer. Meteor. Soc.*. http://dx.doi.org/10.1175/2009BAMS2607.1

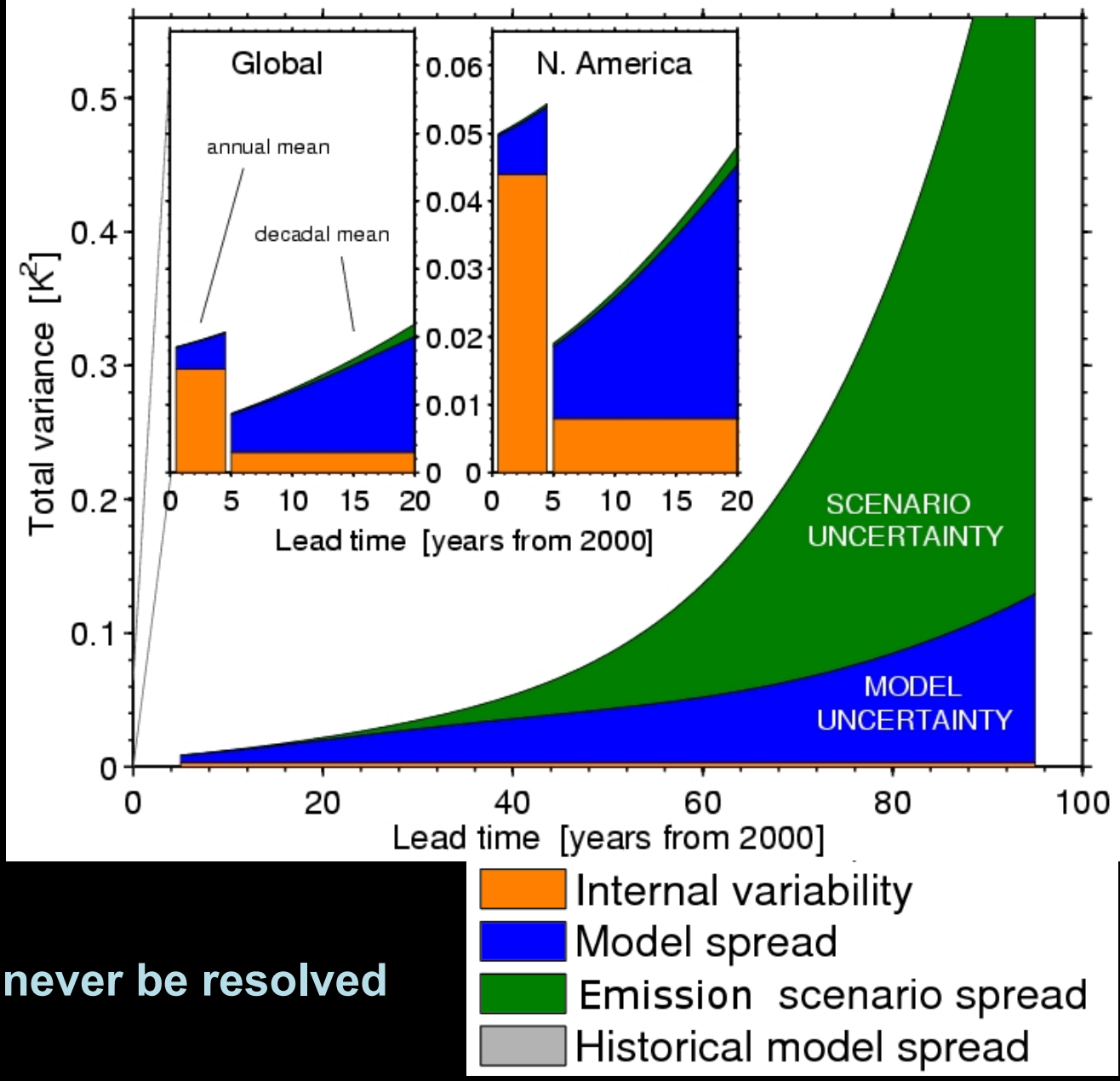
After
Hawkins & Sutton

Uncertainty varies with…

- **Lead time**
- **Spatial scale**
- **Time averaging length**
- **Variable of interest**

Internal variability is relatively more important at smaller spatial scales & shorter timescales

Some uncertainty will never be resolved



See also
http://barnes.atmos.colostate.edu/COURSES/AT780_F14/handouts_folder/lecture_2.pdf

Uncertainties In Climate Change Projections

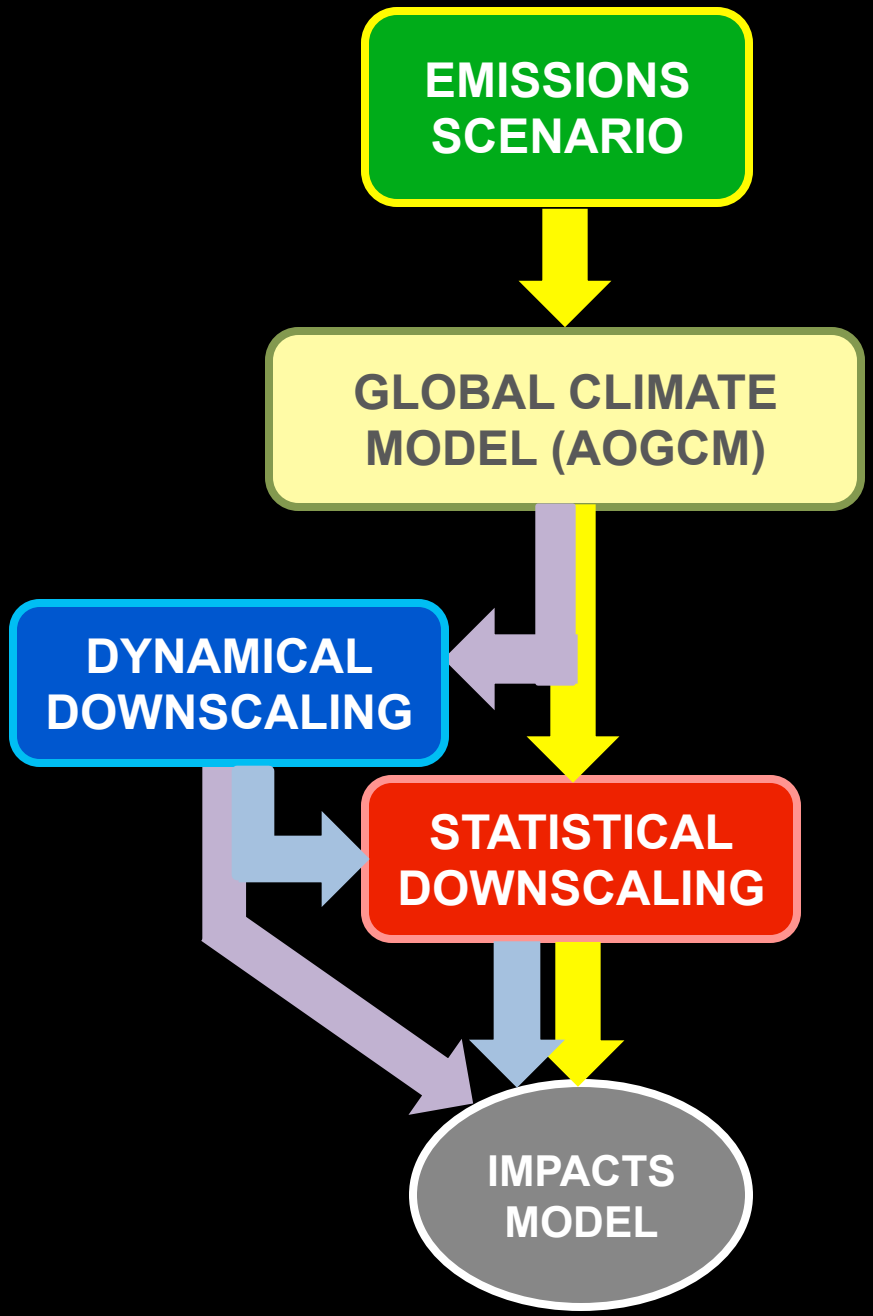
Four broad types of uncertainties:

1) What will be the future emissions of greenhouse gases, etc. in the atmosphere? (GREEN on previous figures)
   *(**these are climate model inputs** – they depend on population size, economic growth, energy use efficiency, alternative energy sources, treaties…)*

2) How will the climate system respond to the changes in greenhouse gases, etc.? (BLUE on previous figures)
   *(**these are climate model outputs** – they're valuable, but computer models are incomplete & are not perfect)*

3) What flaps of the butterfly's wings will take place?
   (internal variability, ORANGE on previous figures)

4) How will changes in the climate affect crops, viruses, polar bears, coastal erosion, etc., etc., etc.?
   *(**climate change impacts** – some researchers use climate model output as input to their own analyses)*

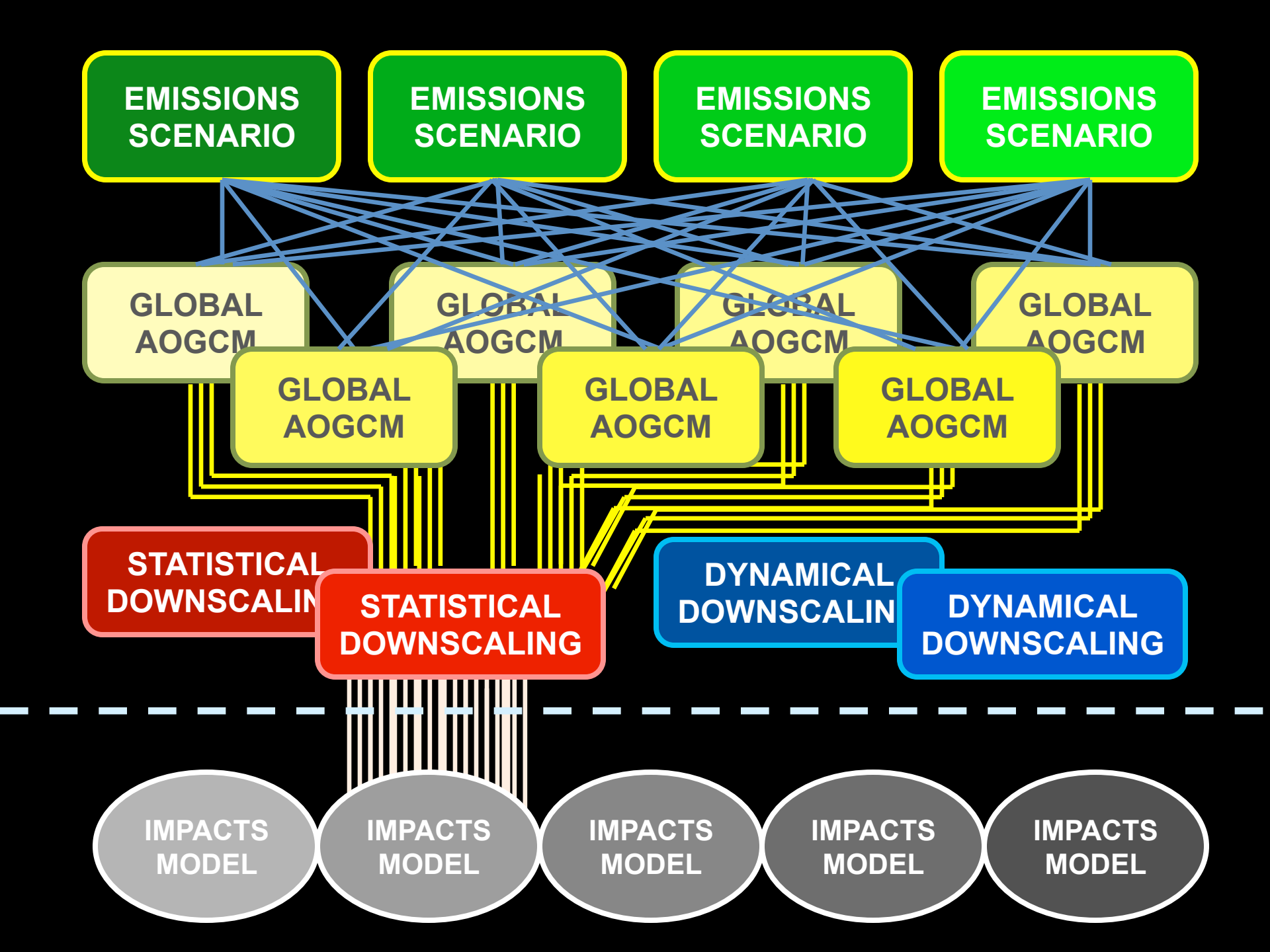


A simplified view of the "top down" process…

…mindful that "uncertainties" are introduced in each step of the process

- - -

"downscaling" aims to add value by (a) addressing global climate model biases & (b) adding finer scale spatial detail to the relatively coarse resolution global output (~100km)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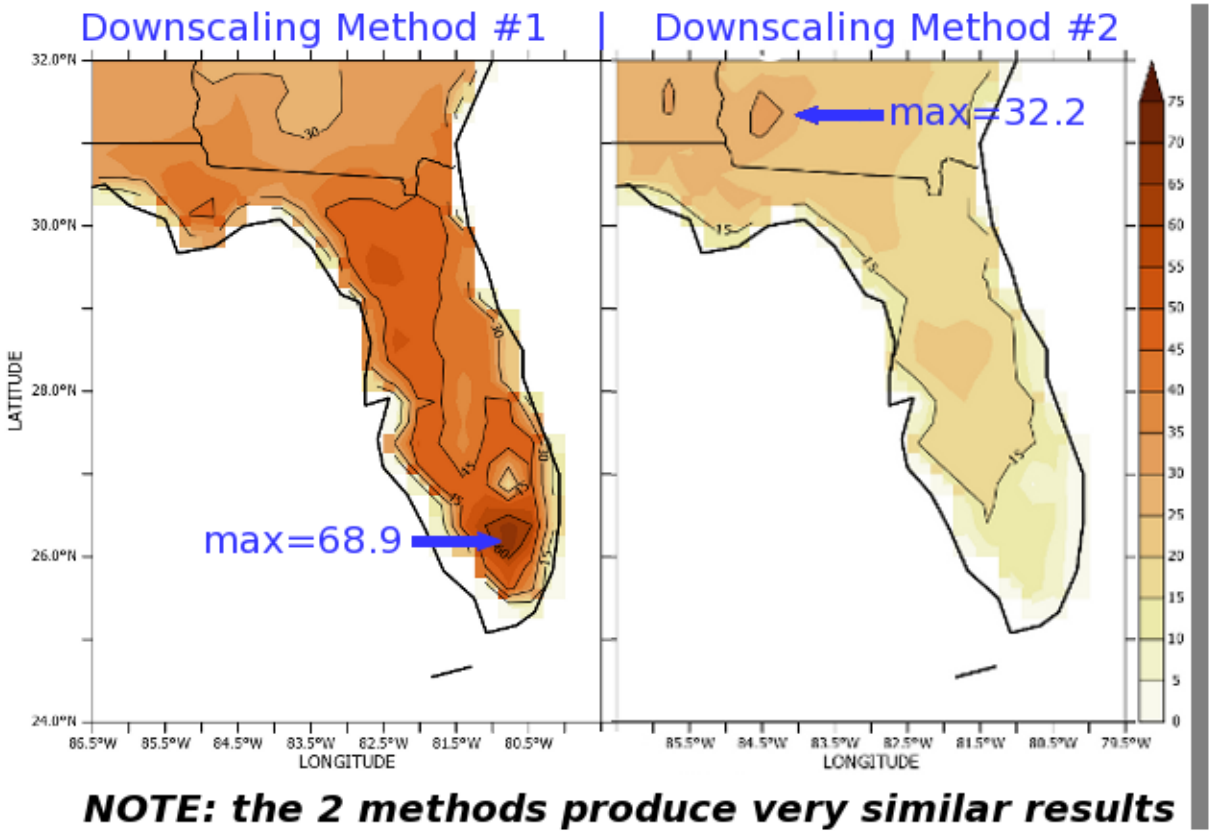
Avg # of Days per Year >100F (RCP8.5 scenario; 2086-2095)

2 identical cases (same input files) except differ in method details



NOTE: the 2 methods produce very similar results for the historical period 1979-2008. However, as shown here for a large warming case, results can vary greatly from method to method.

(color interval = 5 days; contour line overlay = 15 days)

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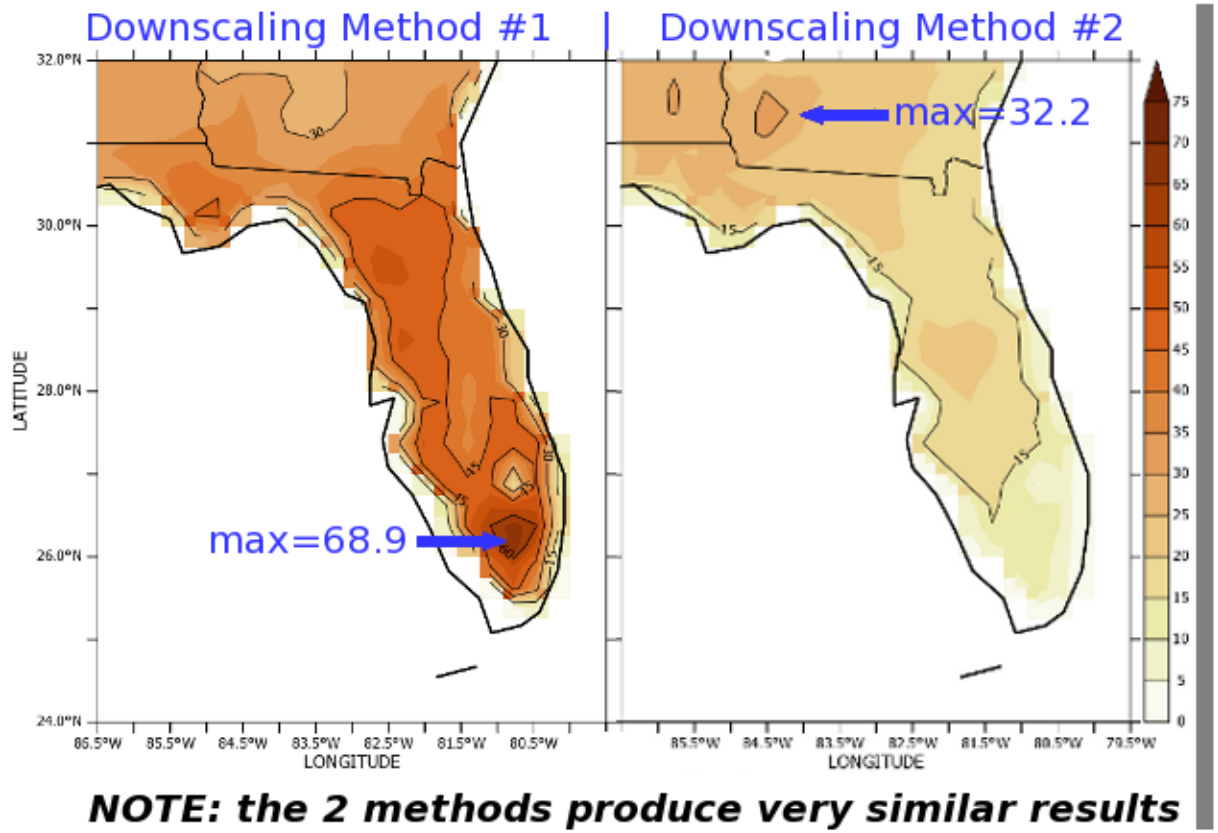

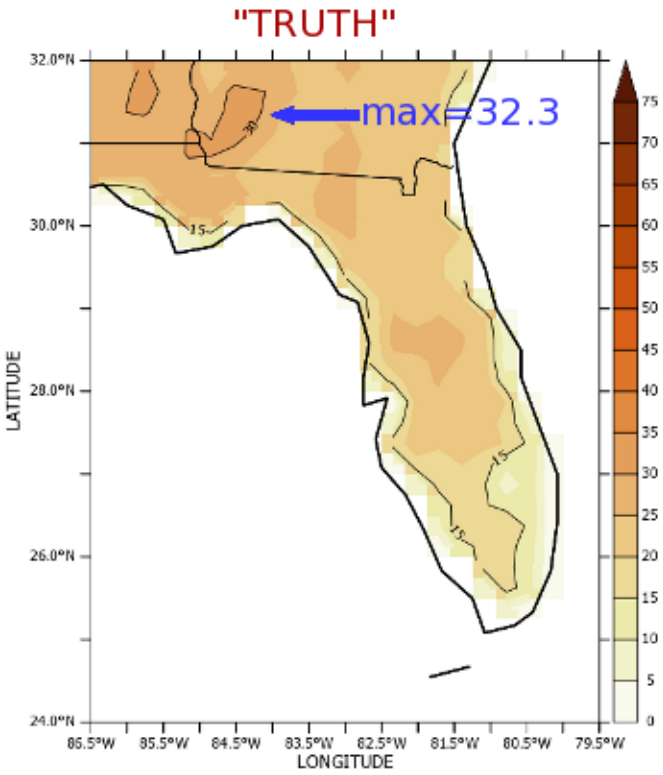

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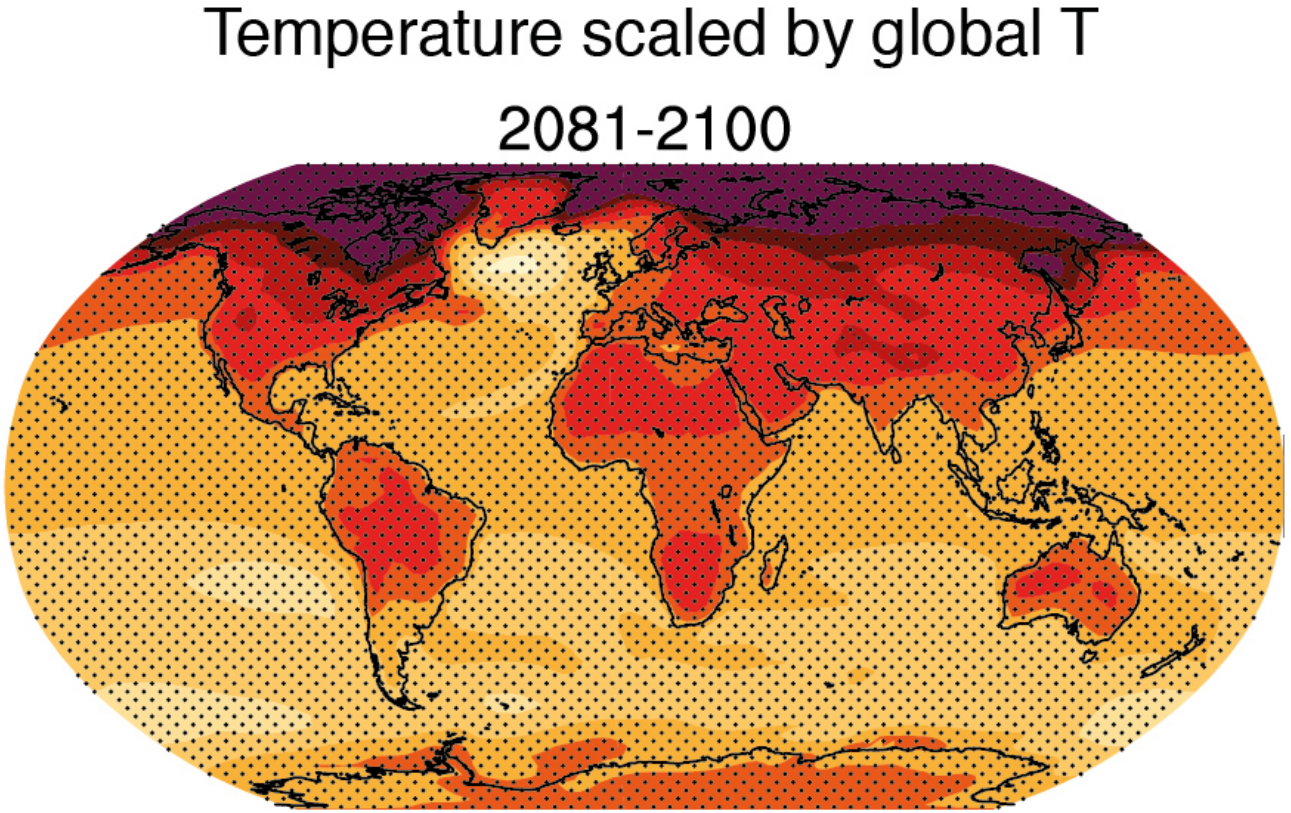
Dixon et al. (2016) in "Climatic Change" & Dixon et al., (manuscript in prep.)

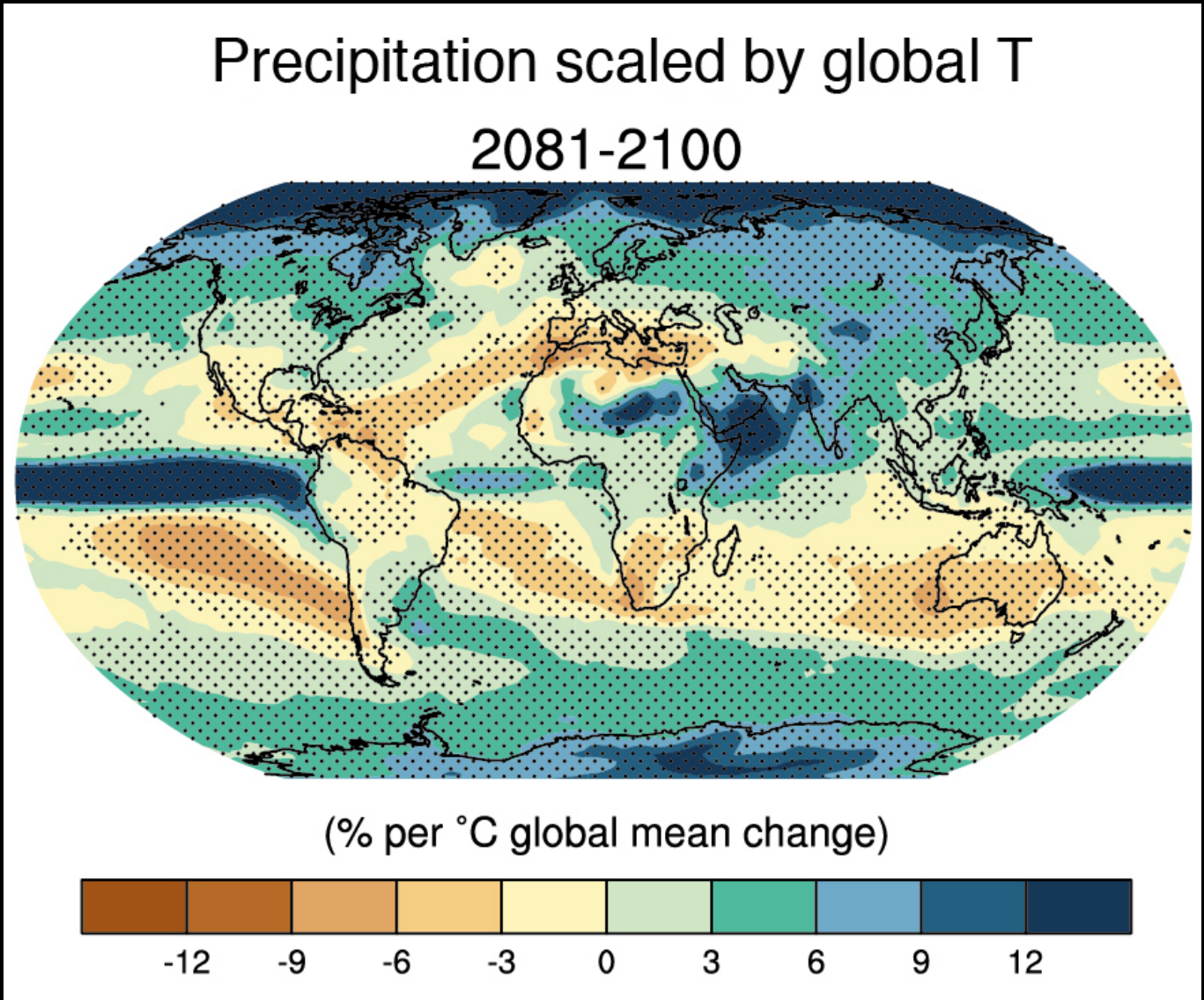
Patterns of projected climate change: annual mean surface air temperature



From IPCC AR5 WGI report – Fig. 12-10

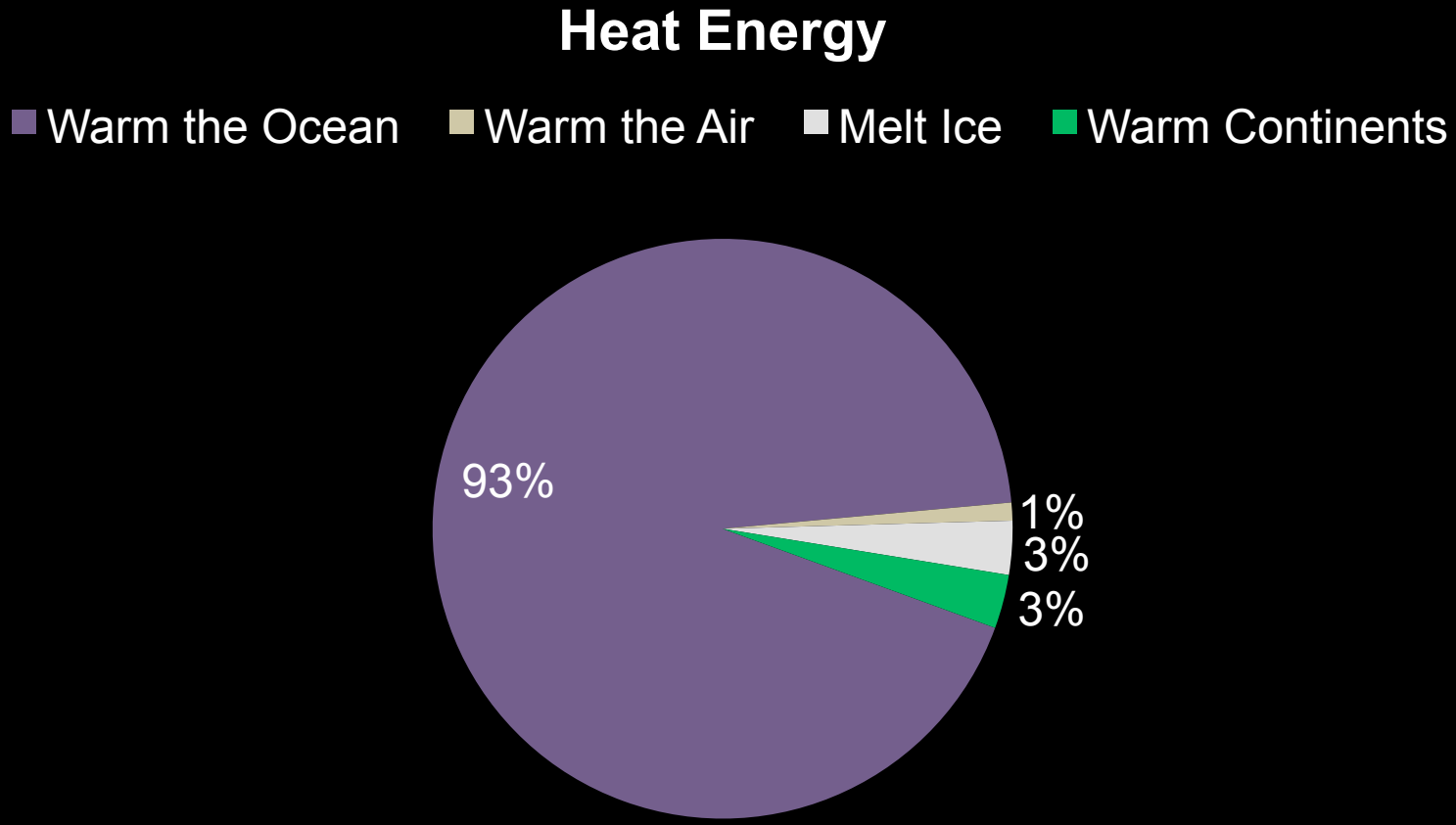
Patterns of projected climate change: annual mean precipitation

From IPCC AR5 WGI report – Fig. 12-10



On the Ocean's Role…

Where has the additional heat energy gone? (1971-2010)
Most of it resides in the global ocean.



Percentages are central estimates, adapted from the 2013 IPCC Working Group 1 Report's Summary for Policymakers (Section B2)
http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf

Projection-related excerpts from 12 “Key Findings” of the 2014 National Climate Assessment Ch. 2

Temperatures in the USA are expected to continue to rise. Because human-induced warming is superimposed on a naturally varying climate, the temperature rise has not been, and will not be, uniform or smooth across the country or over time.

Across the USA, the growing season is projected to continue to lengthen.

Droughts in the Southwest and heat waves everywhere are projected to become more intense, and cold waves less intense everywhere.

More winter and spring precipitation is projected for the northern USA, and less for the Southwest.

Increases in the frequency and intensity of extreme precipitation events are projected for all U.S. regions.

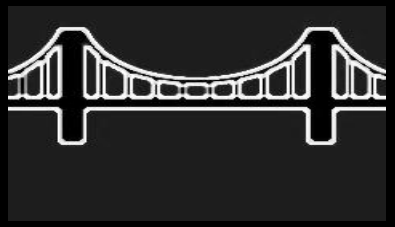
Hurricane-associated storm intensity and rainfall rates are projected to increase.

Global sea level is projected to rise another 1 to 4 feet by 2100

- Source: http://nca2014.globalchange.gov/report/our-changing-climate/introduction

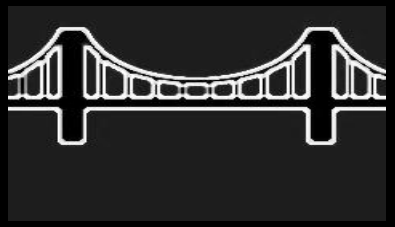
Challenges: "Bridging Gaps" to promote better-informed use of climate projections

Large-Scale, Climate Research Focus



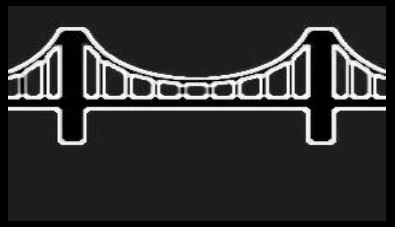
Smaller-Scale, Application Focus

Refinement of GCM output
(downscaling products)



Evaluation of downscaling strengths & limitations
(research topic)

Transfer of Data
(data servers, formats)



Translation of Knowledge
(guidance, caveats, uncertainties)

… raises questions of "Ownership" & The role of "Boundary Organizations"

Climate Boundary Organizations:

USDA Climate Hubs, DoI/USGS Climate Science Centers, NOAA RISAs, etc.

- **From a 2012 NRC report:**
  "[A]ddressing the wide spectrum of user climate information needs is outpacing the limited capacity of people within the climate modeling community." …Identified the…*"need for qualified individuals who can provide credible information to end users based on current climate models, wherever they work (public or private sector)"*

- **From Barsugli et al. (2013):** The dilemma for those seeking projections to aid in a decision-making process often is not the lack of climate projections, but rather *"how to choose an appropriate data set, assess its credibility, and use it wisely."*

- National Research Council (2012). *A National Strategy for Advancing Climate Modeling,* Natl. Acad. Press., (Washington, D.C.)
- Barsugli, et. al (2013). *The Practitioner's Dilemma: How to Assess the Credibility of Downscaled Climate Projections.Transactions* AmericanGeophysical Union. 94(46): 424-425.
- K. Dixon, *"From Global Climate Projections to Regional Planning: Matching What Science Can Supply With Decision Maker Demands"* http://scienceforglobalpolicy.org/conference/tucson-living-with-less-water/

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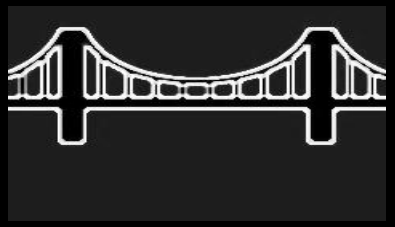

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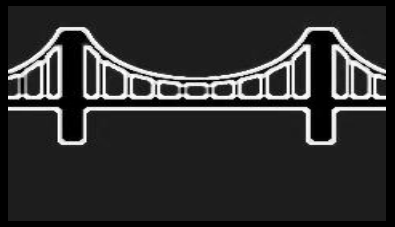

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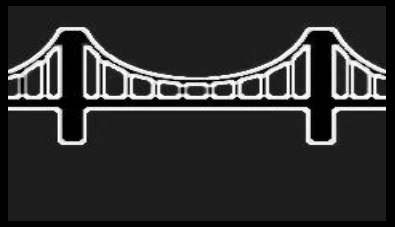

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