Assessing Uncertainty in Climate Index Computations: Sensitivity Analyses and Methodological Considerations

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Nicole Zenes (SAIC@NOAA/GFDL) & Weixuan Rosa Xu (Princeton Univ./CIMES)

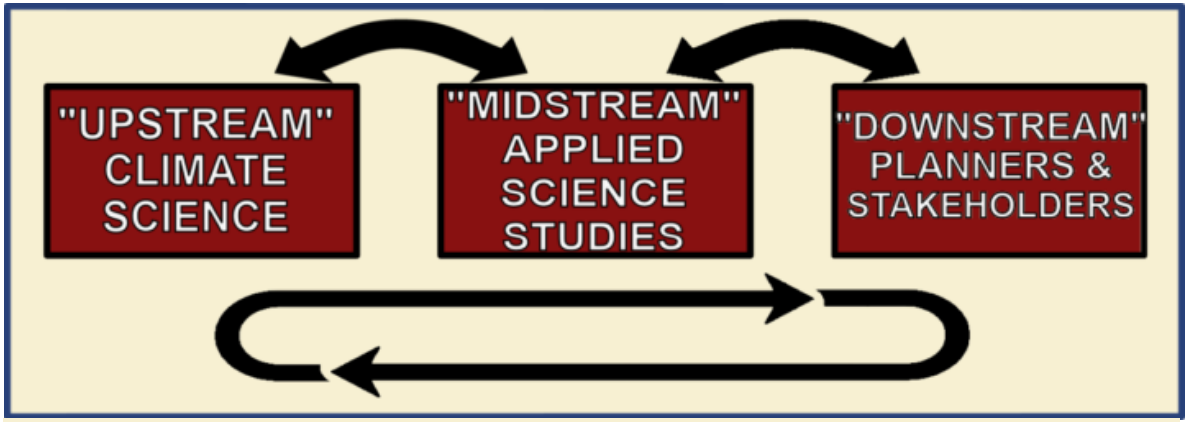
AMS 2005: 29th Conference of Applied Climatology
Session: Development of Indices for Applied Climatology Research in Large Datasets
Monday, 13 January 2005

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Framing:

Co-production of Actionable Science using Climate Model Projections

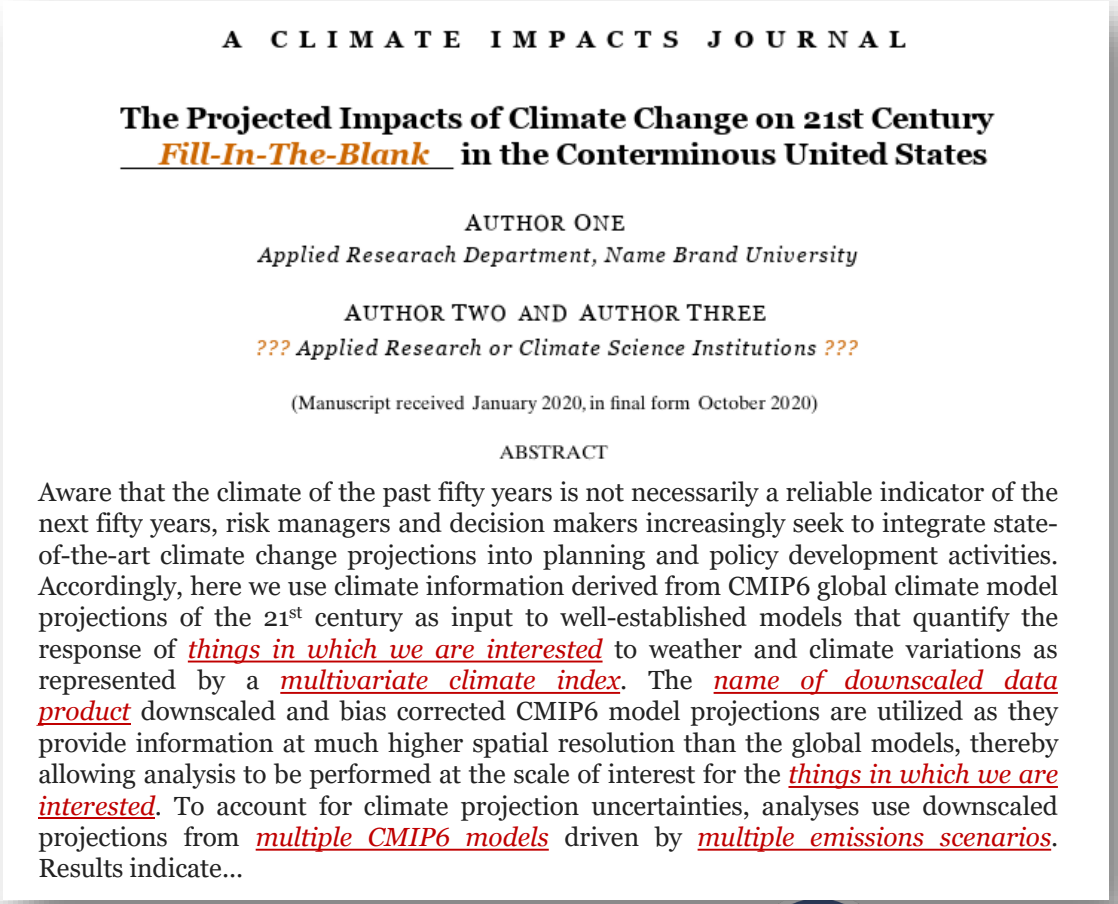


Considering the development of climate indices & their use in multi-decadal climate impacts studies

Focus on multi-variate indices that connect climate with terrestrial impacts
(e.g., human health, wild fires, energy use, crop yields, built environment infrastructure, etc.)

A not uncommon outline of a climate impacts study

- Linking climate to impacts based on obs-based relationships/models. *(impacts model uncertainty: associated with % variance explained by climate variables)*
- Using a set of downscaled/bias corrected climate projections with multiple scenarios & CMIP models. *(experimental design accounts for 'scenario uncertainty' & 'climate model response uncertainty')*



A CLIMATE IMPACTS JOURNAL

The Projected Impacts of Climate Change on 21st Century *Fill-In-The-Blank* in the Conterminous United States

AUTHOR ONE

Applied Researach Department, Name Brand University

AUTHOR TWO AND AUTHOR THREE

??? Applied Research or Climate Science Institutions ???

(Manuscript received January 2020, in final form October 2020)

ABSTRACT

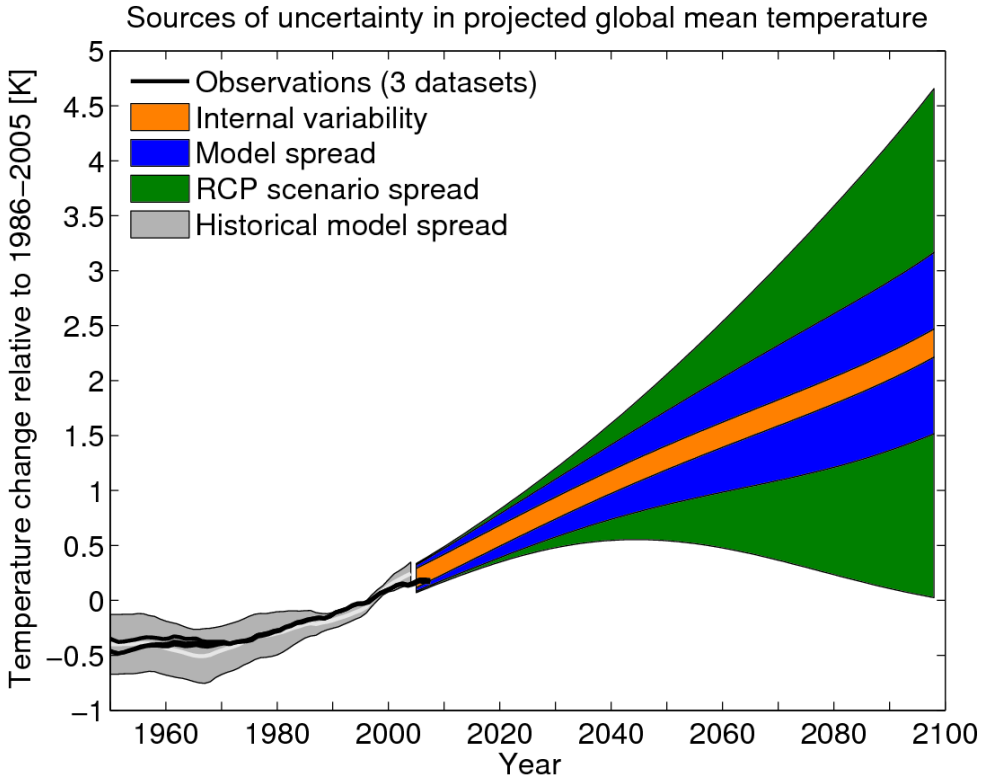
Aware that the climate of the past fifty years is not necessarily a reliable indicator of the next fifty years, risk managers and decision makers increasingly seek to integrate state-of-the-art climate change projections into planning and policy development activities. Accordingly, here we use climate information derived from CMIP6 global climate model projections of the 21st century as input to well-established models that quantify the response of *things in which we are interested* to weather and climate variations as represented by a *multivariate climate index*. The *name of downscaled data product* downscaled and bias corrected CMIP6 model projections are utilized as they provide information at much higher spatial resolution than the global models, thereby allowing analysis to be performed at the scale of interest for the *things in which we are interested*. To account for climate projection uncertainties, analyses use downscaled projections from *multiple CMIP6 models* driven by *multiple emissions scenarios*. Results indicate...

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‘Savvy Practitioners’ tend to be well aware of 3 sources of uncertainties in the climate projections they use as input to climate impacts models.

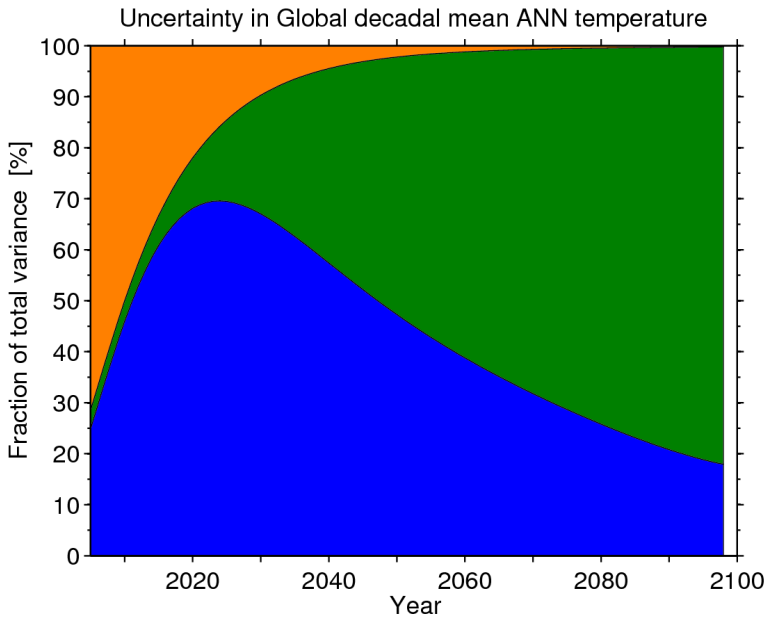
1. Scenario uncertainty
2. Model (sensitivity) uncertainty
3. Internal & natural variability

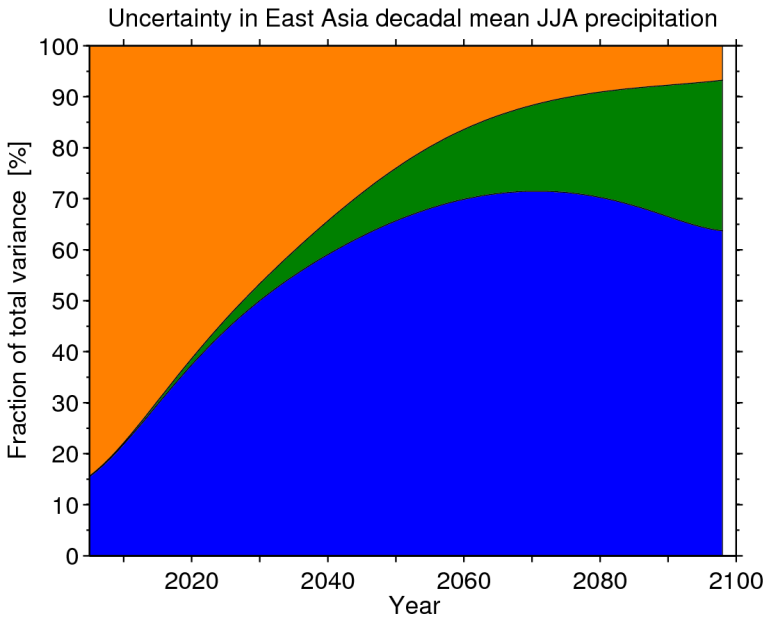


This and similar images based on work of Hawkins & Sutton, (2009) The Potential to Narrow Uncertainty in Regional Climate Predictions. *Bull. Amer. Meteor. Soc.*

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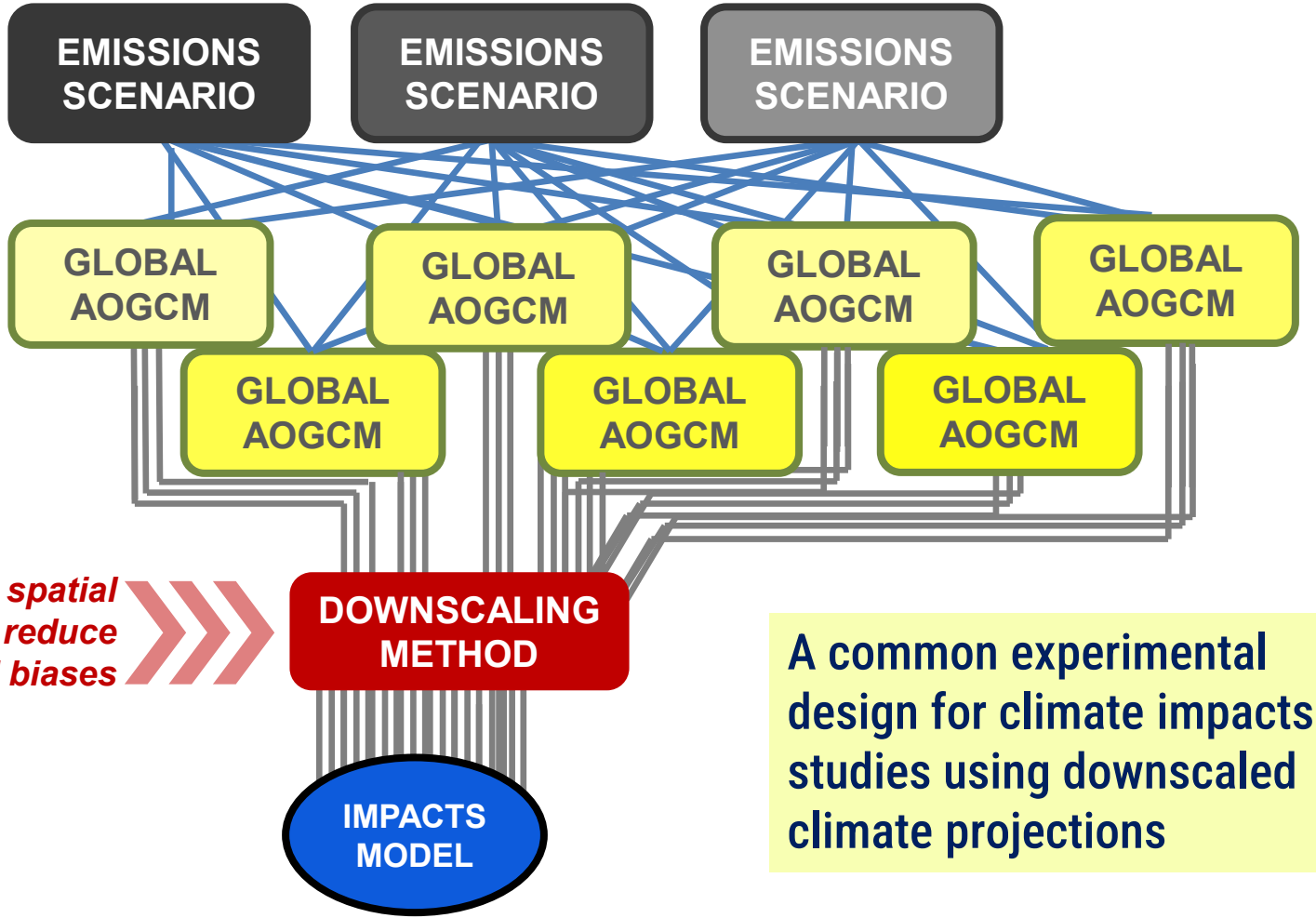


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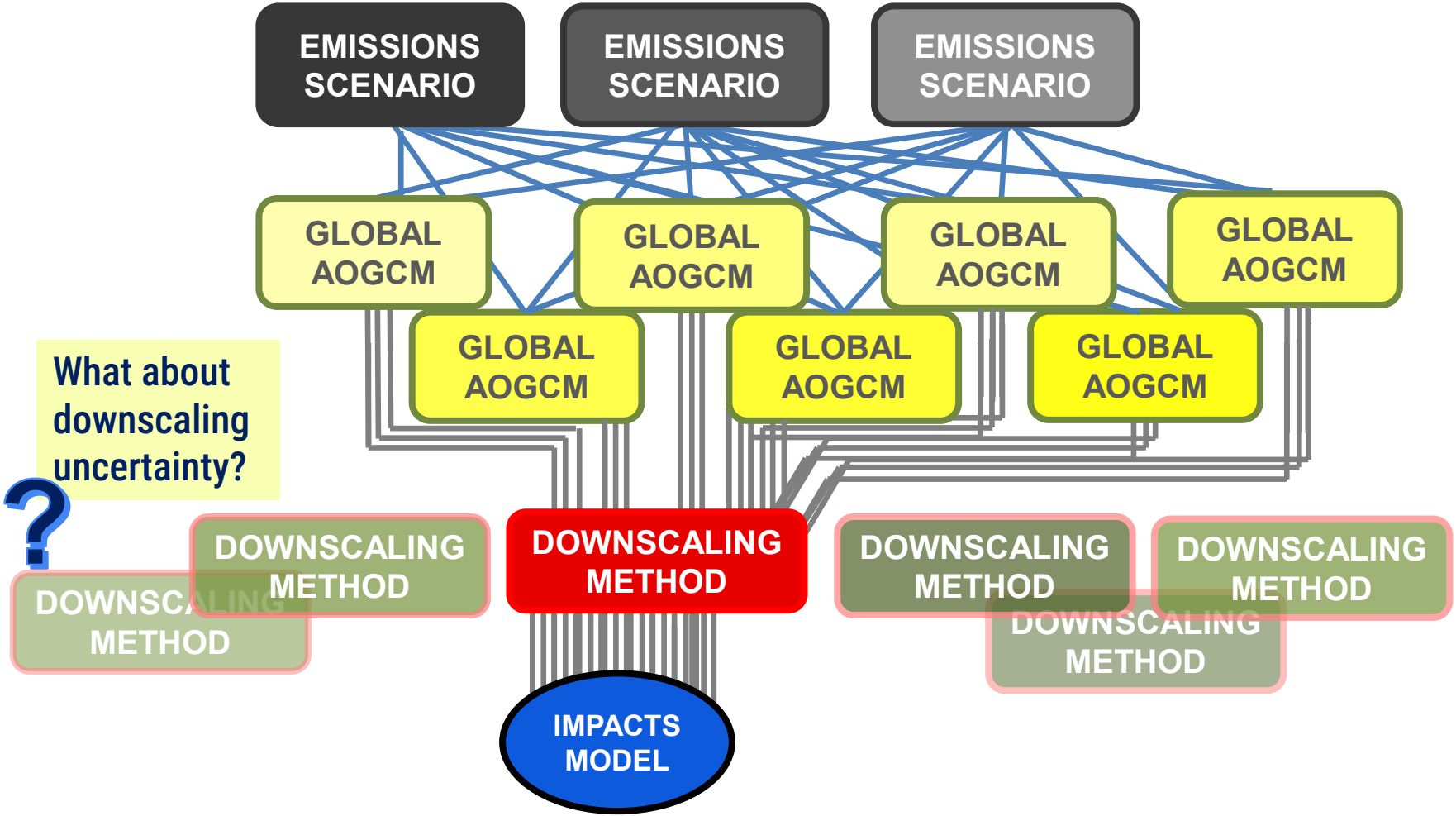
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A common experimental design for climate impacts studies using downscaled climate projections


EMISSIONS SCENARIO
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GLOBAL AOGCM
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GLOBAL AOGCM
GLOBAL AOGCM
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GLOBAL AOGCM
GLOBAL AOGCM
What about downscaling uncertainty?
?
DOWNSCALING METHOD
DOWNSCALING METHOD
DOWNSCALING METHOD
DOWNSCALING METHOD
DOWNSCALING METHOD
DOWNSCALING METHOD
IMPACTS MODEL

Commonly Appreciated

Uncertainties associated with global climate model projections

- Scenario uncertainty
- Model (sensitivity) uncertainty
- Internal & natural variability

Uncertainties in the relationship between climate variables and variations in the topic of interest

- Impacts model uncertainties

Often Underappreciated

Uncertainties associated with choice of downscaling technique

- Downscaling uncertainty

Uncertainties associated with projection data limitations vs. obs (e.g., temporal sampling)

- Data/Methodology Approximation Uncertainty
  (necessary and/or common approximations)

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Illustrating some underappreciated sources of uncertainty via an example using the Heat Index diagnostic.

The **Heat Index**, also known as an apparent temperature, is a function of temperature and humidity.
The heat index aims to represent what the temperature feels like to the human body, assuming shady conditions with a light wind.

```
e.g., T=86F & RH=72% ... Heat Index = 96.0F
      T=30C & RH=72% ... Heat Index = 35.6C
```

The Heat Index is part of NWS forecasts: **Warning** | **Watch** | **Advisory**

The Philadelphia Department of Public Health defines **Heat Health Emergencies (HHE)** based on **daily maximum Heat Index** thresholds and the duration of the exceedance of these thresholds.



Data/Methodology Approximation Uncertainty
(necessary and/or common approximations)

Q: How to determine the daily maximum heat index when many climate models do not save surface temperature and humidity variables hourly, and instead archive daily minima and maxima?

Several published studies estimate the daily maximum heat index as

$$f\,(tasmax,\ hursmin)$$

(daily maximum temperature, daily minimum relative humidity)

…assuming that coincides with the afternoon's maximum heat index.

(we refer to this estimate as *hismaxest*)

Q: How good is this estimate?

What is the nature of the errors?

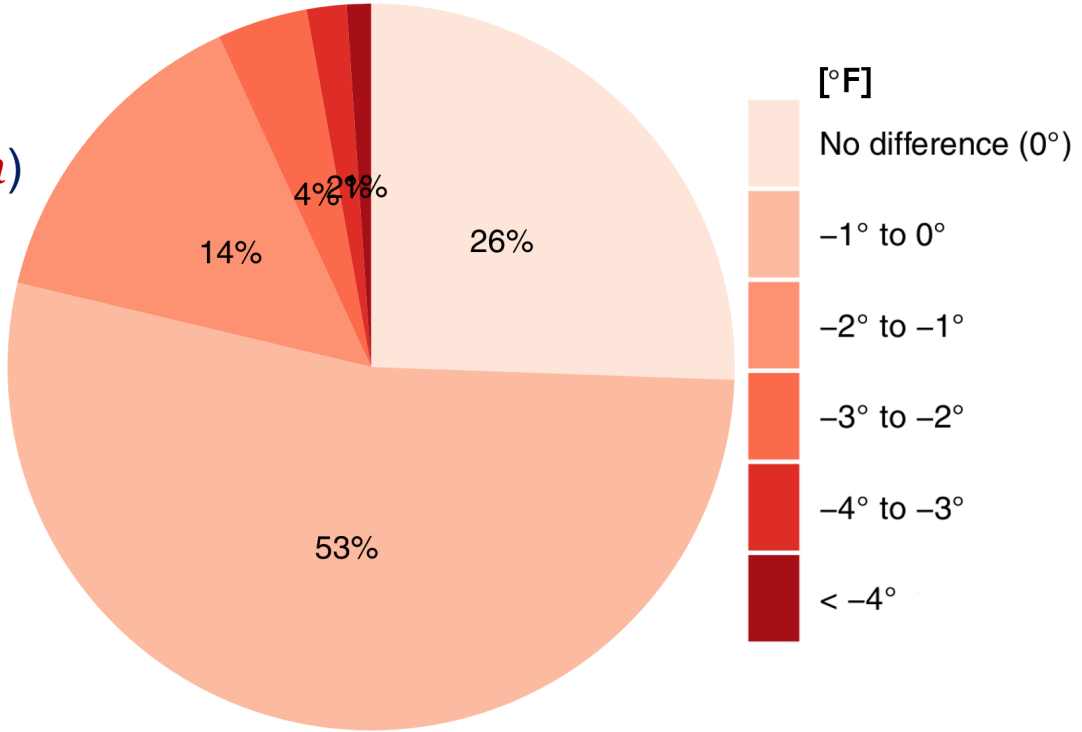
PHL airport observations
(MJJAS)

hismaxest = *f* (*tasmax, hursmin*)

vs.

hismax24 = *max of 24 hourly heat index values*

Percentages of heat season days with *tasmax* > 80F with *hismaxest – hismax24* differences of various amounts



Q: How good is this estimate? What is the nature of the errors?

A: In the NE USA, ~80% of errors are <1F. The estimate can be exact or too low, never too high.

Q: How good is this estimate?
What is the nature of the errors?

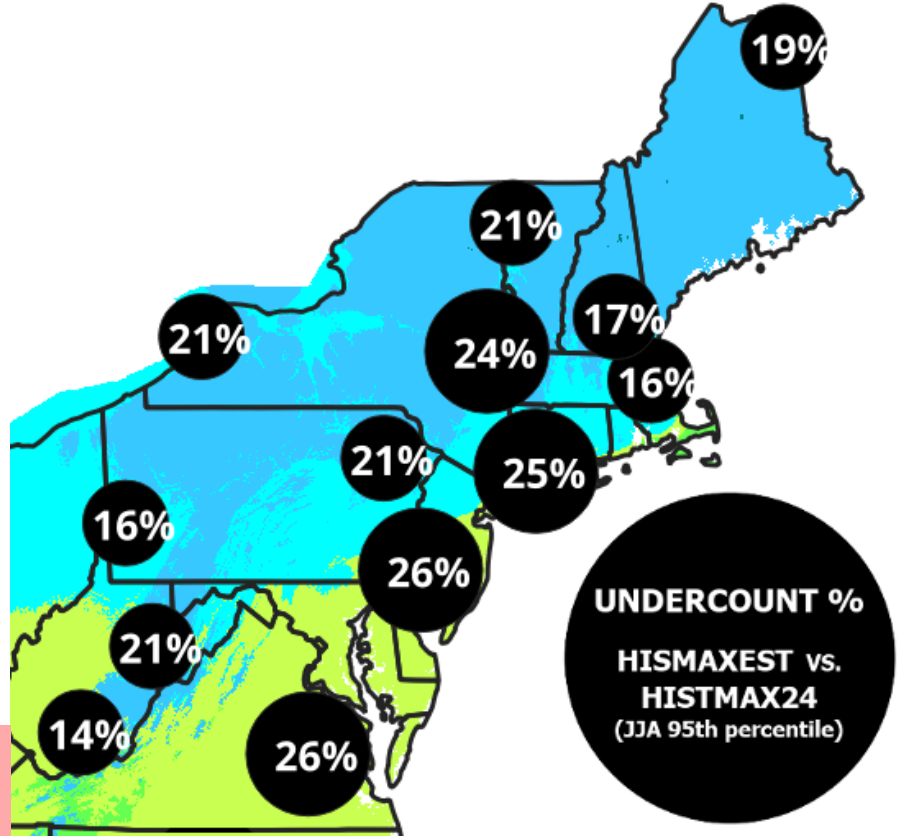
Viewed a different way ... Focusing on extreme heat, defined as the 95th percentile of the local JJA daily max Heat Index*

(* after Hondula, et al., 2022: Spatial Analysis of United States National Weather Service Excessive Heat Warnings and Heat Advisories, *Bulletin of the AMS*.)

Looking at 13 NE USA stations, over the 30 year period 1991-2020, how large is the undercount of days meeting the JJA p95 Heat Index criteria when using the tasmax, hursmin approximation vs. when determining the daily max HI from 24 hourly values?

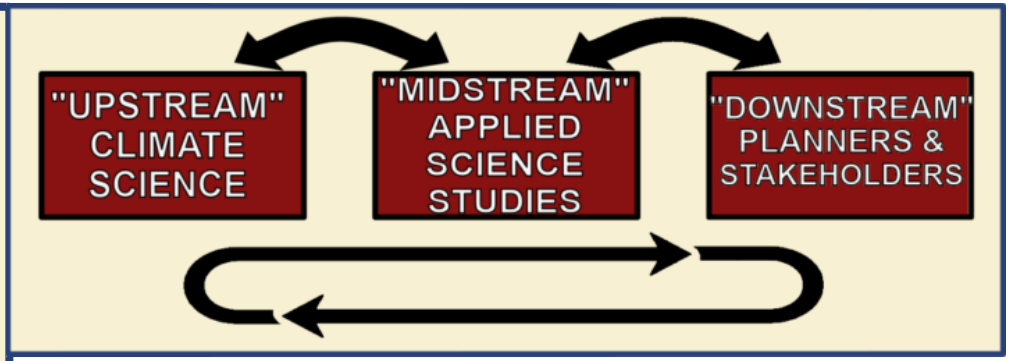
A: About a 20% undercount (14 – 26%)

A: Expanding the study to stations across CONUS we see undercounts from to <10% to >50%



ACTIONABLE SCIENCE QUESTION:

How many & which of the research methodology-related questions must be addressed for results to meet the 'uncertainty criteria' required to support well-informed decision making?



- Downscaling uncertainty
- Data/Methodology Approximation Uncertainty
  (necessary and/or common approximations)

Not wanting to allow perfect become the enemy of the good, but…

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Wednesday @ 11:45 AM; Room 214 (Talk)
Weixuan Rosa Xu
"*Assessing the Uncertainty from Methodological Choices in Multivariate Heat Indicator Calculations*"

Thursday @ 3:00-4:40 PM: Hall C (Poster)
Nicole Zenes
"*Evaluating Future Heat Health Emergencies in Philadelphia, PA: Blending Model Projections, Observations, and Downscaling Methods*"

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