Statistical Downscaling Research and Applications

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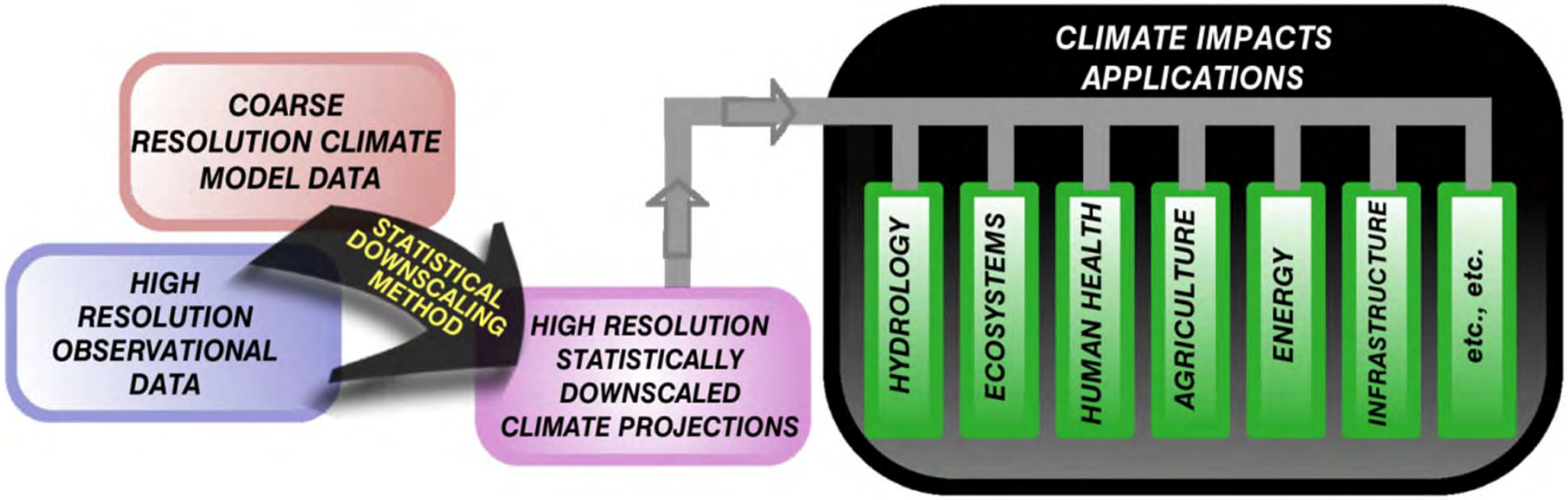
on behalf of the
GFDL Empirical Statistical Downscaling Team

Geophysical Fluid Dynamics Laboratory Review
October 29-31, 2019

Addressing model biases & adding spatial detail statistically

- Bias Correction and Empirical Statistical downscaling (ESD) methods use observational info to refine dynamical model predictions and projections across various time scales.



- ESD is generally considered a “value added” process, though many methods exist with varied performance characteristics.
- Our research focuses on evaluating methods and communicating findings to support better informed use of these data products and to promote ESD method development (think Consumer Reports®).

ESD Team efforts include…

Efforts encompass…

- Statistical model code development
- Design and execution of experiments
  - ***"Perfect Model"*** framework
  - ***Sensitivity studies***
- Data management & QC
- Analysis and communication of results

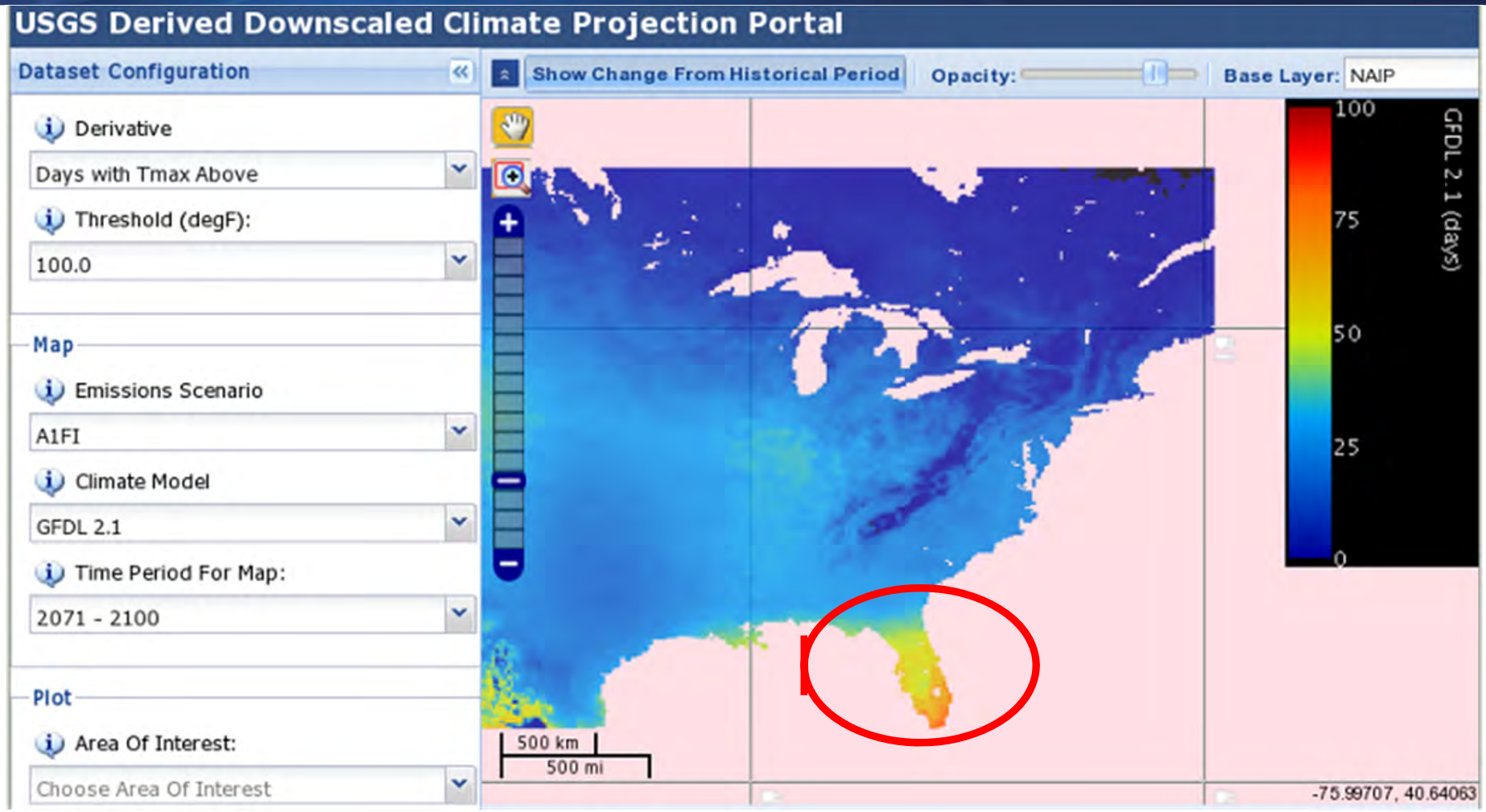
Some efforts are ESD Team only, while others involve intra-GFDL and external collaborations…

Often unappreciated in climate impacts studies…

- Reliance on a "stationarity assumption" with respect to the bias correction / statistical downscaling performance.
- Different statistical downscaling methods yield different outputs. *"statistical downscaling uncertainty"*

All combine knowledge of statistical and dynamical models with info on application needs.

A “Perfect Model” example

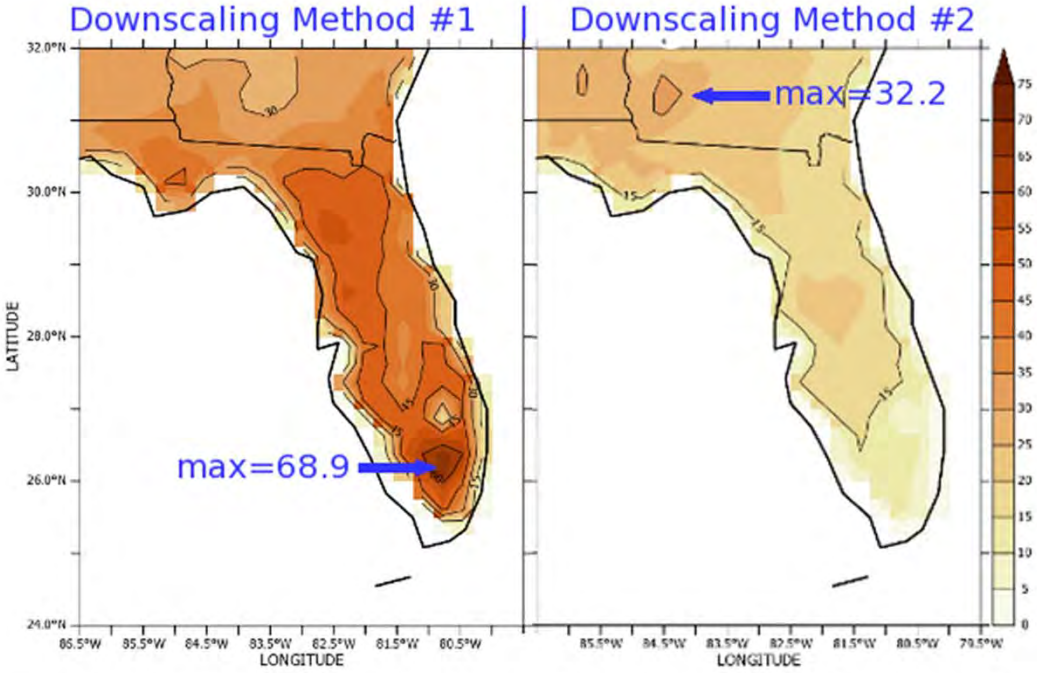


During a discussion of projections to be used as part of the NCA4 effort, this figure was shown. Attention was drawn to Florida, with an increase of >50 days / year with daily max temperatures > 100F in this statistically downscaled, high emissions scenario case. ***But is it reliable?***

A “Perfect Model” example

Avg # of Days per Year >100F
(RCP8.5 scenario; 2086-2095)

Identical inputs expect for downscaling method



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)

A “Perfect Model” example

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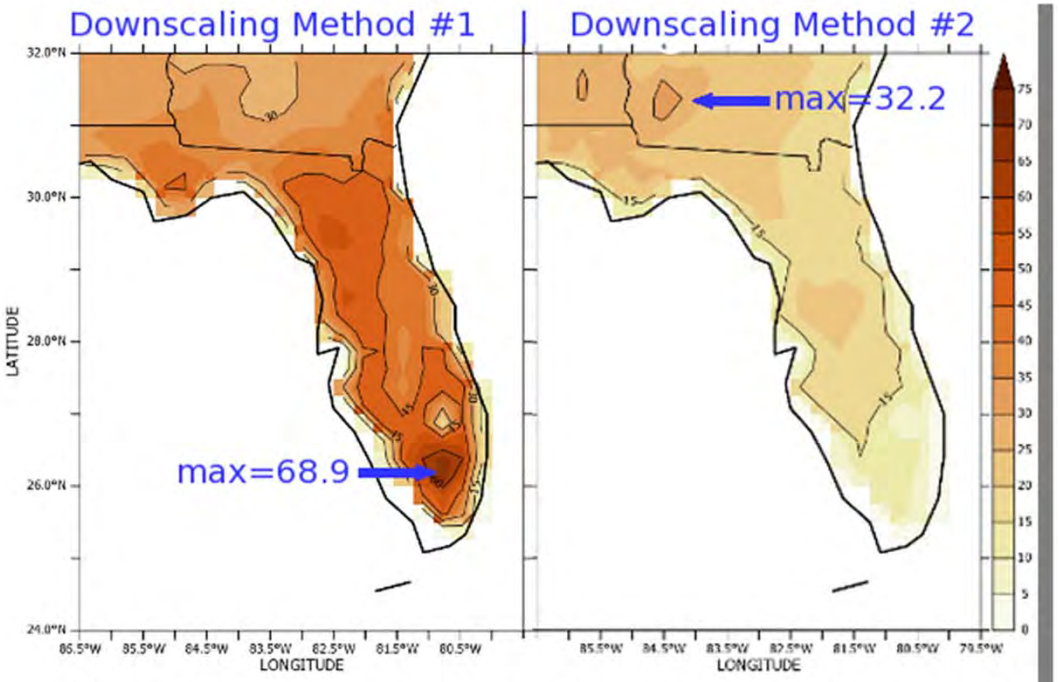

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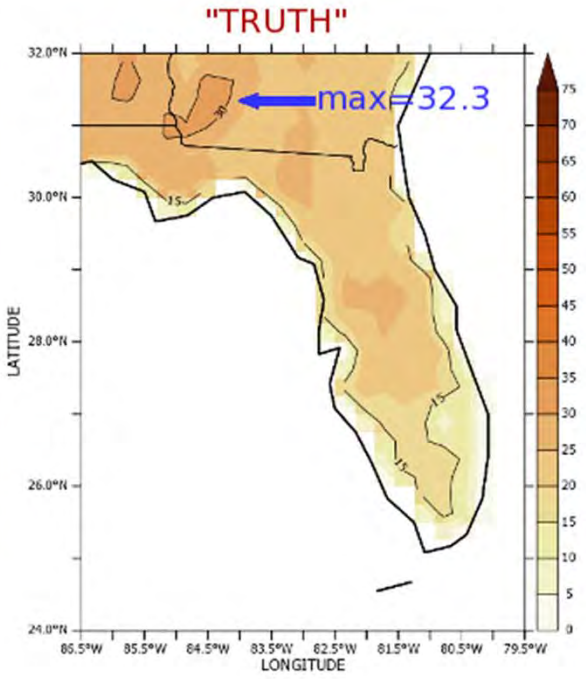
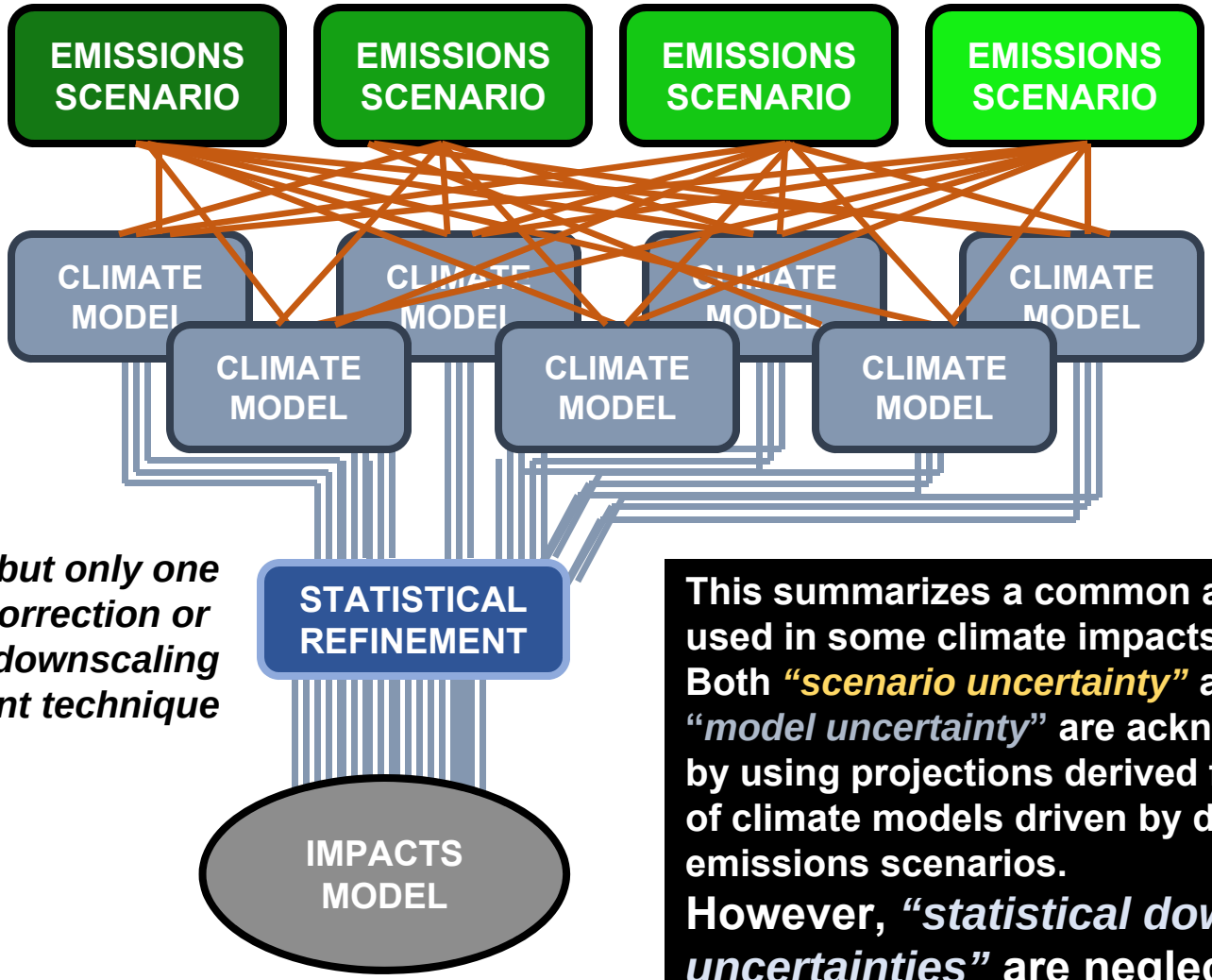


Method #1 suffers from violations of the stationarity assumption….

…and Method #1 was the one used to produce the earlier map from the NCA4 discussion.

* These results informed development of the next version of Method 1

A fairly common climate impacts experimental design



multiple emission scenarios

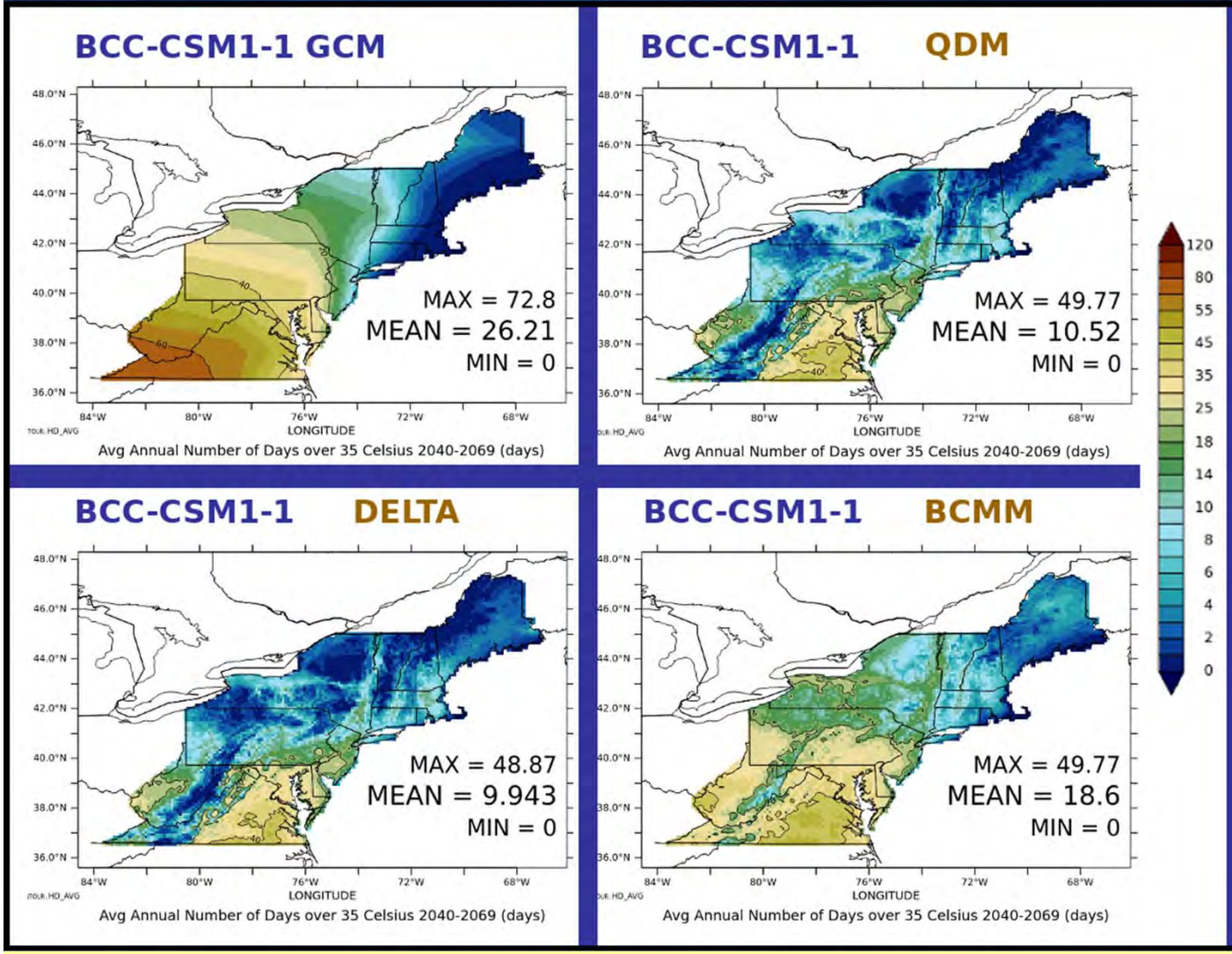
and

multi-climate model ensemble

…but only one bias correction or statistical downscaling refinement technique

This summarizes a common approach used in some climate impacts studies. Both *"scenario uncertainty"* and "*model uncertainty*" are acknowledged by using projections derived from a set of climate models driven by different emissions scenarios.
However, *"statistical downscaling uncertainties"* are neglected.

Example from a statistical downscaling sensitivity study



2040-2069 Average Number of Days >35C

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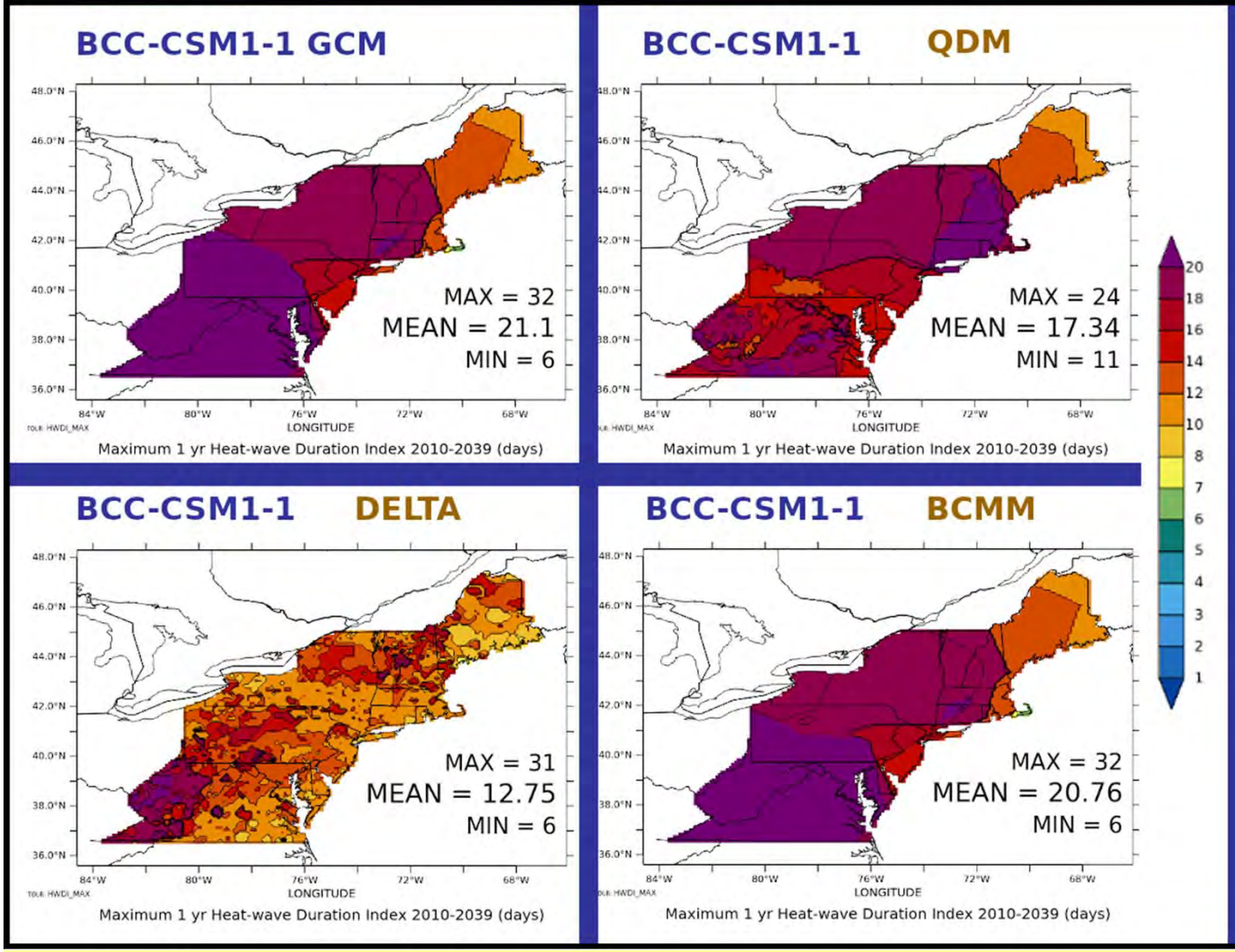
1 GCM and its 3 processed outputs

The differences across the 3 statistically processed output illustrates that the choice of bias correction / downscaling method can yield somewhat different results for time mean averages of this diagnostic.

Based on this diagnostic quantity (i.e. counts of days with temperatures above a threshold), one might conclude that the QDM & Delta methods generally yield similar results...

Example from a statistical downscaling sensitivity study



2040-2069 Longest Heat Wave Duration (MJJA)

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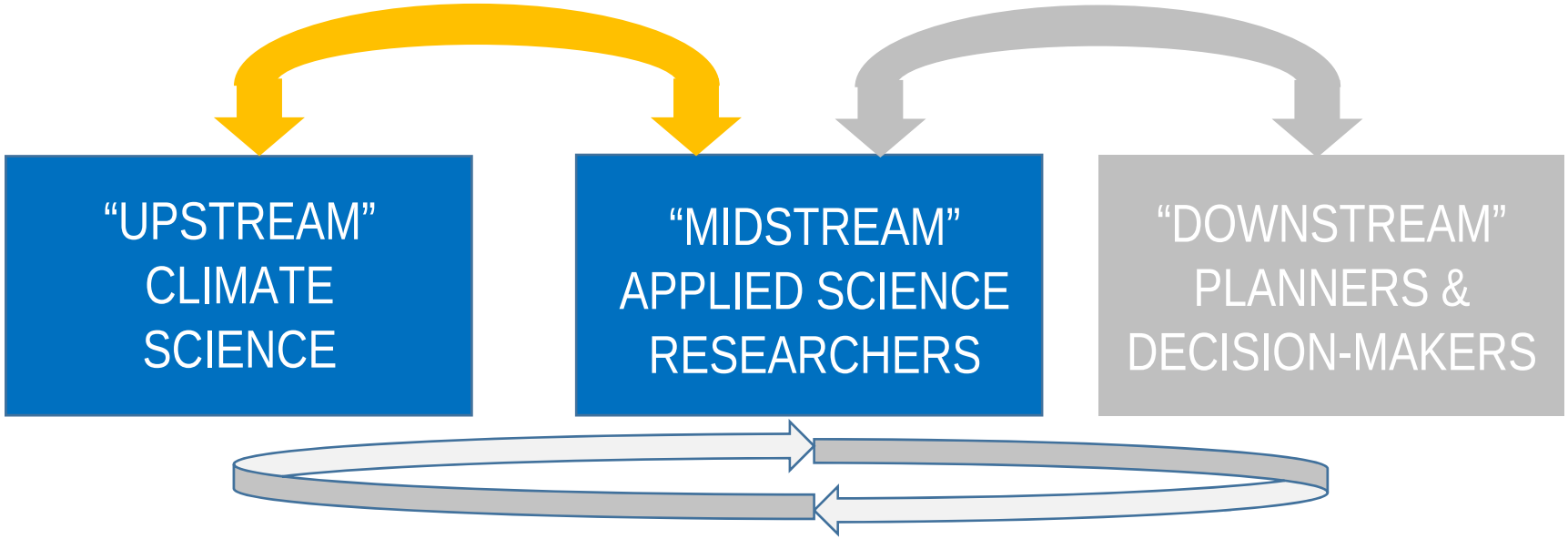
1 GCM and its 3 processed outputs

HWDI = consecutive days tasmax > 5C warmer than 1981-2005 climatological daily mean

The HWDI strongly reflects the weather sequences and inter-annual variability of the observations for Delta and of the GCM for QDM and BCMM.

…but the QDM & Delta results differ for the maximum heat wave duration diagnostic.
There is not one "best" ESD method. It's application dependent.

Aiming to strengthen the link between "Upstream" climate predictions & projections and applied research



From https://research.noaa.gov/About-Us ***"About NOAA Research"***

Our Mission - Conduct research to understand and predict the Earth system; develop technology to improve NOAA science, service, and stewardship; and ***transition the results so they are useful to society.***

How to convert research results into guidance?

1) Suggest Midstream researchers determine which climate variable characteristics their applications are sensitive to and then seek ESD methods with strengths that match.

2) Recommend Midstream researchers consider using projections generated by multiple ESD methods.

Potential Future Plans & Challenges

Building upon the foundation built thus far…

- **Challenge:** Matching and/or expanding the ESD Team's capacity and expertise to address topics of interest (in-house or via external collaborations).
  - Expanding the roster of ESD methods supported in our code base.
  - Developing new experimental designs and diagnostics to evaluate ESD method performance.

Some potential collaborative endeavors:

- *Marine resource & fisheries applications*
- *Processing and serving select GFDL CMIP6 data products (CONUS, daily surface variables, multiple ESD methods)*
- *Collaborating with "Midstream" applications researchers in sensitivity studies. (Strengthening the research and "best practices" link)*

www.gfdl.noaa.gov/esd