

Briefing: Understanding Decision-Relevant Regional Climate Projections Workshop

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Recent Context

For the Fifth National Climate Assessment (NCA5) it was essential to **identify climate datasets at the scales needed for stakeholders, policymakers and other data end-users.**

CMIP data was deemed insufficient because its resolution was too coarse to represent local scales.

Leads of **LOCA2 and STAR-ESDM** statistically downscaled data products (both available at ~5km grid spacing) volunteered to develop and contribute their data.

In early 2023, it was determined that a process was needed to **justify endorsement** of these products. This motivated the development of the **DOE-supported LOCA2/STAR-ESDM validation report**, which was released in November 2023.

Overall, this experience motivated a wider discussion on the state of climate data...



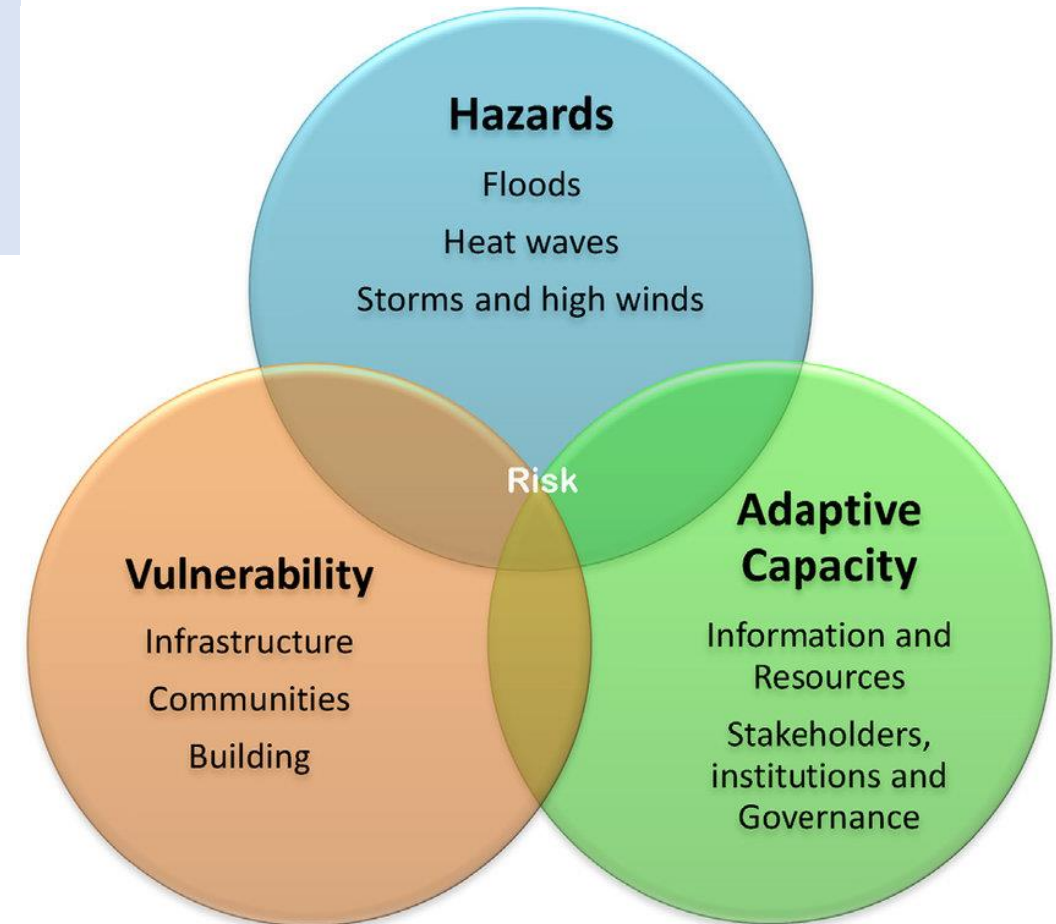
LOCA2/STAR-ESDM
Validation Report

Developed by the Program
for Climate Model Diagnosis
and Intercomparison
(PCMDI)

User Needs for Decision-Relevant Climate Data

Decision-relevant climate data is essential for mitigation and adaptation planning across a variety of regions and sectors. However, this data also needs to be:

- **Salient:** Localized to regions of interest for stakeholders and decision-makers. Including variables of relevance for a given application.
- **Credible:** Historically validated, capturing relevant processes and right for the right reasons.
- **Authoritative:** Backed by independent experts.
- **Accessible:** Ready for use.

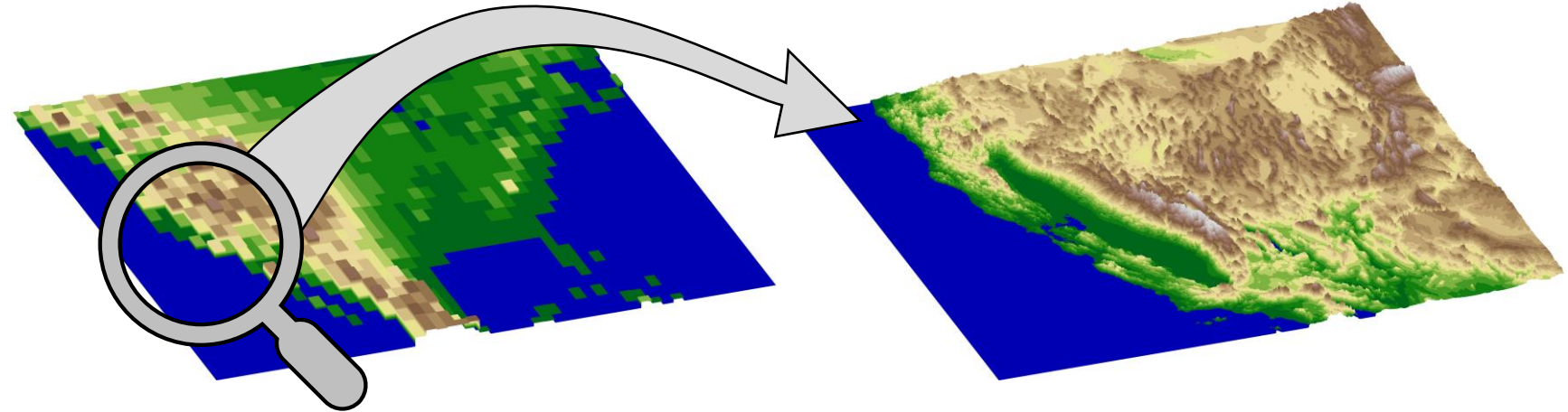


What is Downscaling?



Many different **global climate model (GCM)** simulations have been conducted as part of the **Coordinated Model Intercomparison Project (CMIP)**.

These cover both historical periods (what was possible) and future periods (what will be possible).



However, CMIP GCM data is typically too coarse for decision-makers, who are interested in **resolving local scales** (individual mountain peaks, towns, valleys and coastlines) and **assessing local impacts** (e.g., extreme weather, renewable energy production).

Downscaling techniques allow GCM output to be **enhanced to decision-relevant scales**, making it relevant on local scales and for understanding scale-sensitive phenomena.

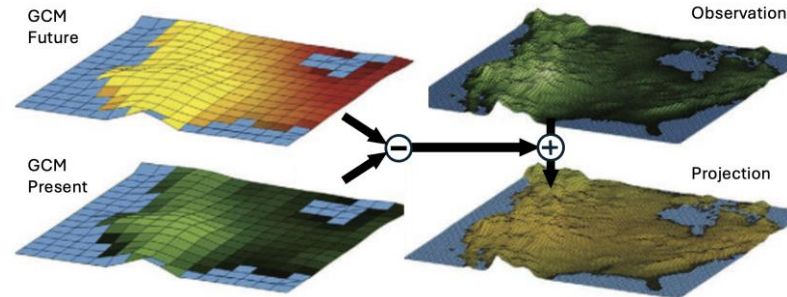
Types of Decision-Relevant Data Products

Statistically Downscaled Products (SDPs): Data products based on empirical and algorithmic relationships between coarse and fine scales, generally derived from observations (e.g., LOCA2, STAR-ESDM).

Dynamically Downscaled Products (DDPs): Data produced by regional climate models forced by coarse-resolution climate model inputs or reanalysis data.

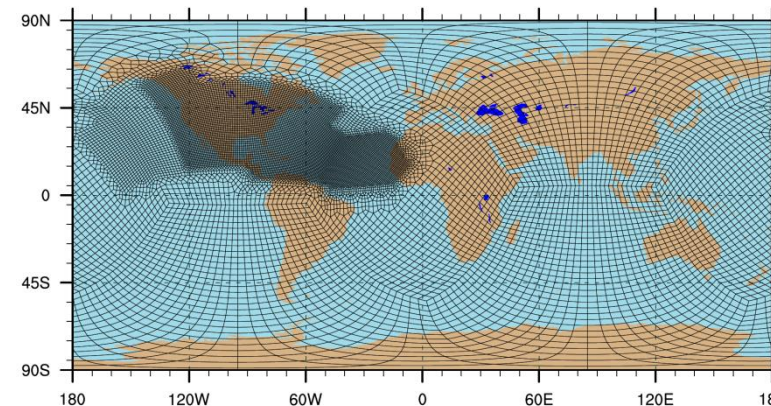
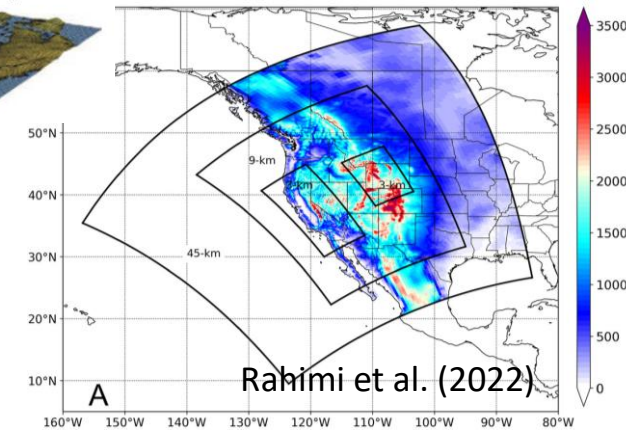
Regionally-Refined Models (RRMs): Data produced using global climate models with nested or refined grids over a region of interest (e.g., DOE's E3SM).

Artificial Intelligence / Machine Learning (AI/ML): Cutting-edge and exploratory techniques for downscaling using data-driven methods.



Left: A basic technique used for statistical downscaling.

Right: Nested dynamical downscaling domains used in recent work by UCLA.



Left: A regionally-refined E3SM mesh used by the DOE HyperFACETS project to develop a high-resolution ensemble for the CONUS.

Many New Climate Data Products over CONUS

Statistically Downscaled Products		Grid Spacing	Years
Localized Analogues v2 (LOCA2)		6km / 3km Calif.	1950-2100 (multiple)
Seasonal Trends and Analysis of Residuals (STAR) Empirical-Statistical Downscaling Model (ESDM)		4km	1950-2100 (multiple)
Multivariate			(multiple)
Dynamically Downscaled Products		Grid Spacing	Years
DOE Funded	Argonne Dyn		0 future (x3 models)
	IM3/HyperFACETS TGW Ensemble	12km	40 hist + 40 PGW (x8 scenarios)
	PNNL Western US Product	6km	42 hist + 30 PGW (x5 ensemble)
	Western U.S. Dynamically Downscaled Dataset	9km and 3km	40 hist + 85 SSP370 (x9 ensemble)
	NCAR CONUS1 Product	4km	13 hist + 13 RCP8.5
	NCAR CONUS2 Product	4km	21 hist + 21 RCP8.5
	NCAR CONUS404 Product	4km	42 hist + 44 SSP370

Which data should we use?

Why Do Users Choose Particular Data Products?

Selection of climate data products often occurs via:

- Word-of-mouth
- Existing collaborations
- Agency affiliation
- Government mandate
- Use elsewhere
- Highest resolution available
- It's what's available

Consideration of multiple data products is generally recommended for decision-making, but incompatibilities and inconsistencies means multiple products are rarely used in practice.

To a significant degree, this is because of:

- A lack of coordination in development
- A lack of standards for evaluation
- No user-ready evaluation tools
- Gaps in research on metrics and diagnostics
- No agreement on who should perform evaluation

Motivation

Our experience with the NCA5 motivated broader questions about **which data products should be endorsed and used within the federal government**. These questions also emerged in the PCAST report on extreme weather (April 2023).

Parallel conversations occurred among the Interagency Group on Integrative Modeling (IGIM) and the Federal Adaptation and Resilience Group (FARG), elsewhere in USGCRP and within federal agencies.

These conversations highlighted the importance of a unified effort to understand the space of decision-relevant climate data products.

- **What efforts are currently underway?**
- **What are the gaps in this area?**



PCAST Report on Extreme Weather

Recommendation 1.1: U.S. climate modeling centers... should... quantify annual extreme weather risks from present until mid-century.

Recommendation 1.2: ...maintain an extreme weather data portal where observations and modeling products are regularly updated and widely accessible

Understanding Decision-Relevant Regional Climate Data Products Workshop



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Kyo Lee, National Aeronautics and Space Administration Jet Propulsion Lab

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Understanding Decision-Relevant Regional Climate Data Products Workshop

November 14-16, 2023 in Berkeley, California

A meeting of scientists from DOE/PCMDI and DOD/SERDP, together with researchers, data producers, end-users and agency representatives to understand the state of the nation's decision-relevant regional climate datasets and projections.

All operational approaches considered, including statistical downscaling, dynamical downscaling, hybrid downscaling, regionally-refined global modeling and AI/ML based methods.

Workshop scope: How to characterize the strengths and weaknesses of decision-relevant climate data products and build bridges between data producers, data analysts and data users.



United States
Global Change
Research Program

Workshop Scientific Steering Committee



Paul Ullrich, LLNL



Dan Feldman, LBNL



Sarah Abdelrahim, FEMA



Dan Barrie, NOAA



Sam Basile, USGCRP



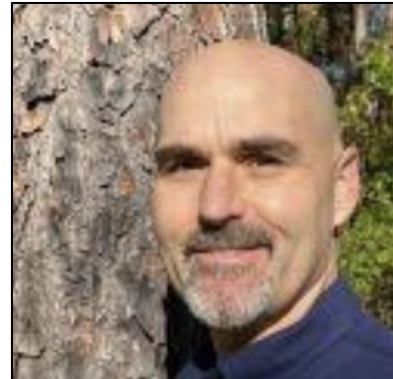
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Kyo Lee, NASA JPL



Fred Lipschultz, USGCRP

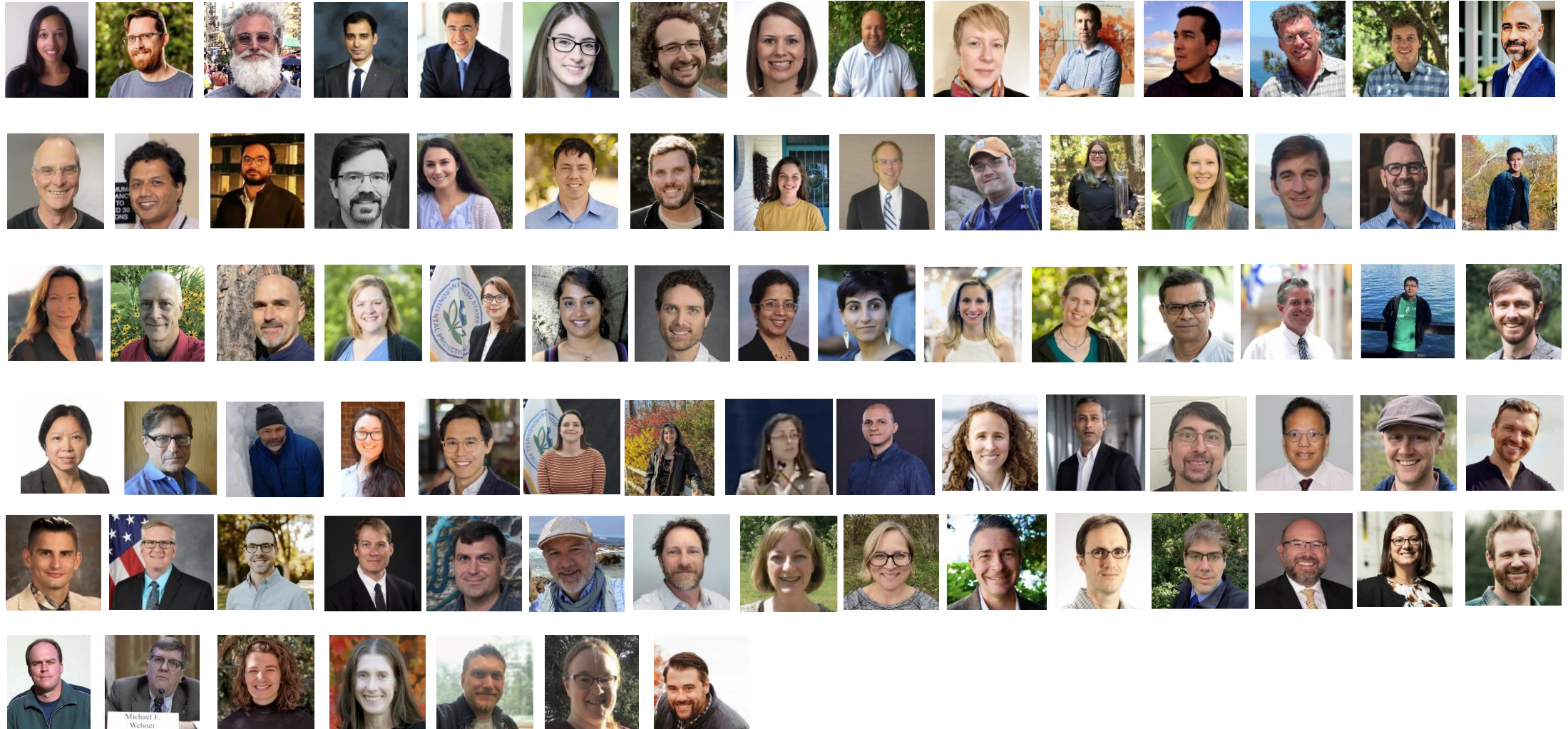


Tanya Spero, US EPA

Widespread Workshop Representation



Widespread Workshop Representation



Understanding Decision-Relevant Regional Climate Data Products

10 data producer talks

- 4 statistically downscaled products
- 6 dynamically downscaled products

2 panels focused on end-user needs

- Representation primarily from boundary organizations such as USBR, EPA, California DWR, USGS, USACE

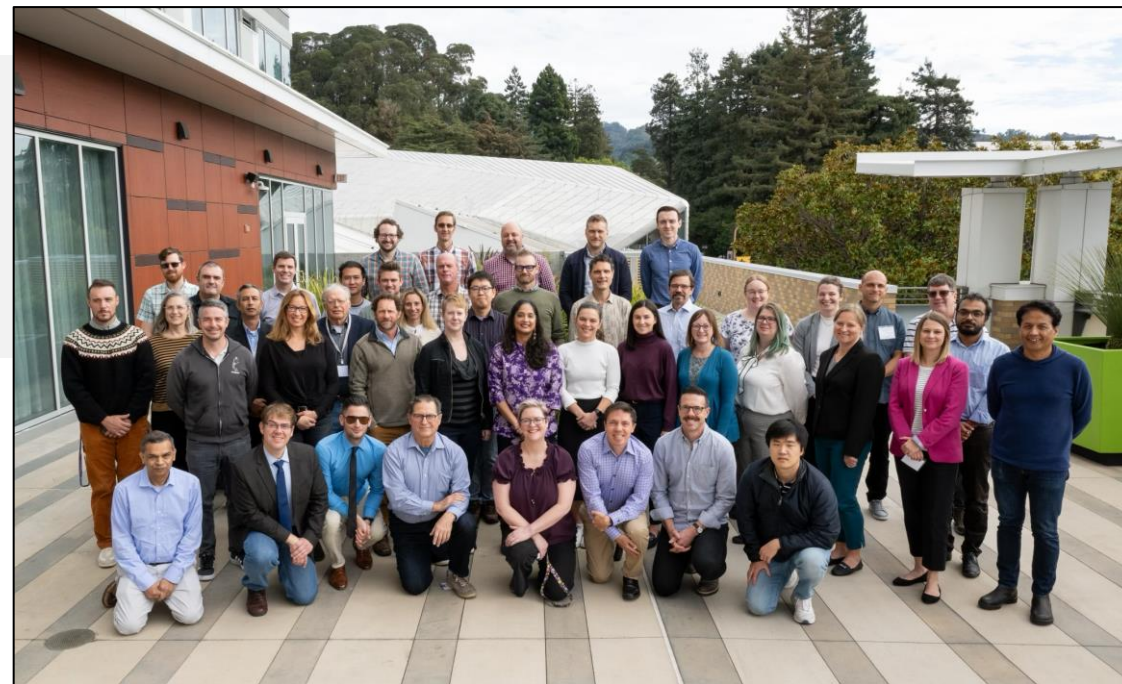
2 panels focused on data evaluation strategy

- Representation primarily from interagency space, including NOAA, NASA, EPA, DOE, DOD

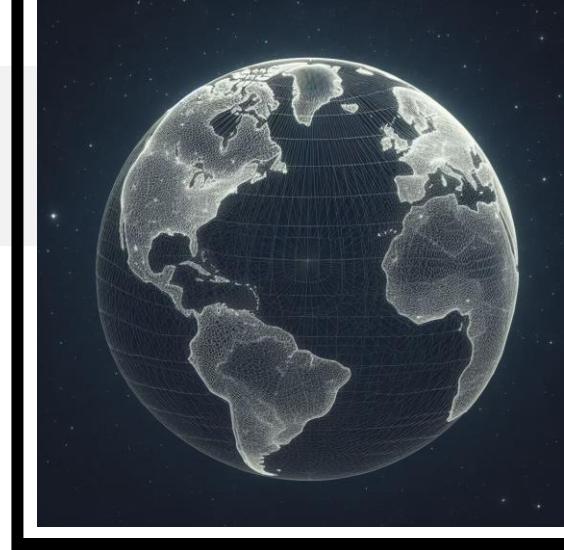
3 breakout sessions

- Decision-relevant data
- End-user needs
- Evaluation strategy

11 technical talks (model weighting, bias correction, ensembles, etc.)



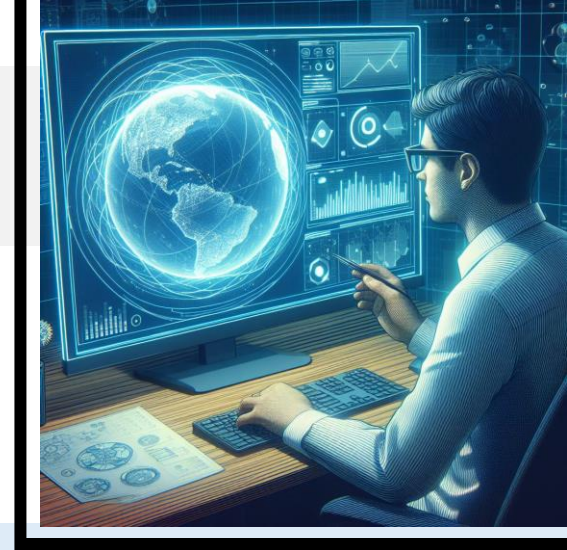
Gaps for Data Production



- More coverage of regions **outside the CONUS** at high resolution.
 - Particular need for data **over islands and in the Arctic**.
 - **More observations** needed to produce or validate products outside the CONUS.
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- Need for **more high-temporal resolution data** for renewable energy and extreme weather.
 - Need for **quantified uncertainties** in data products, including observational uncertainties.
 - Need holistic approaches for **secondary impacts variables**: flood extent, soil moisture and temperature.
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- A **community-supported framework for co-producing decision-relevant climate data** that specifies common variable names and file metadata.
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- A maintained **catalog** of available decision-relevant climate data products.
 - Cyberinfrastructure and support for **hosting and exchange** of climate data.
 - More communication among data producers to **leverage limited computational resources**.

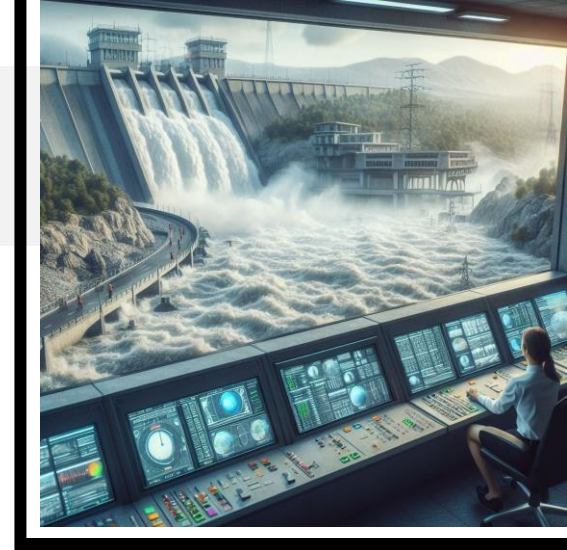
Gaps for Data Evaluation

- **A common community-supported framework for climate data product evaluation.**
 - Should consider how needs vary depending on type of climate data product.
- Development of advanced metrics **beyond temperature and precipitation:**
 - Surface winds, hub-height winds, snow metrics, circulation metrics, humidity, radiation.
 - Evaluation of relationships / covariances between different variables.
 - More complex impacts-relevant variables (e.g., fire weather, drought).
 - Includes quantification of observational uncertainties.
- **An organization tasked with performing independent evaluation.**
- Cyberinfrastructure to support **server-side analysis** of climate data products.

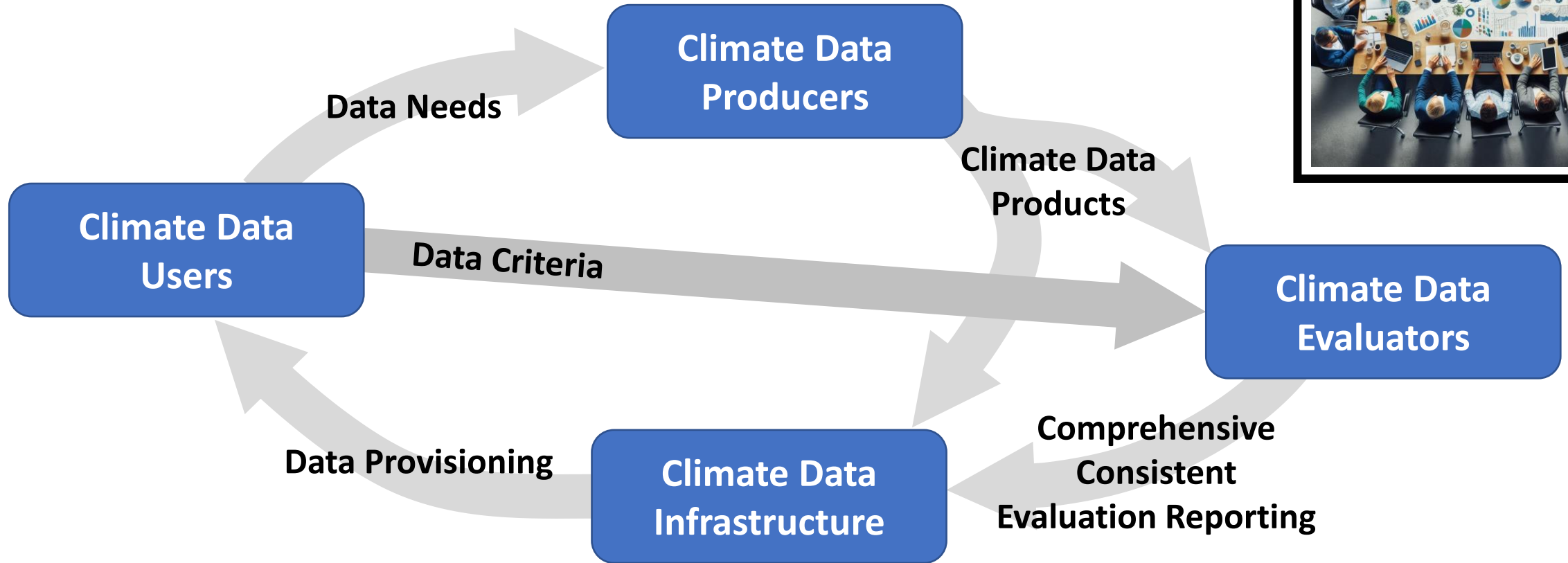


Gaps for Data Users

- Development of a **common vocabulary**:
 - “Extreme events”
 - “Actionable” and “Decision-relevant”
 - “Uncertainty” and “Confidence”
 - Scales, e.g. “Local”
- Better understanding of **how decision-relevant climate data is being used**.
 - Acknowledging how different user needs may affect the most appropriate data source.
- Need for **expert guidance** on differences in climate data products for different applications.
- **Credible evaluation of data products** with use-inspired or impacts-relevant metrics.
- **Guidance needed for Federal approval of data products (e.g., for NCA6).**



Need for a Community of Practice



Common standards can streamline communication among community members and reduce the effort necessary to incorporate data in the decision process.

PCMDI International Science and Leadership



DOE's PCMDI has been a leader of Model Intercomparison Projects (MIPs) since 1989 and a continued supporter of international climate research.



The DOE BER Advisory Committee 2022 recognized the benchmark achievement of CMIP leadership and support

“BER support and leadership in CMIP has been vital for the project’s far-reaching success In the international climate science community” (BERAC, U.S. Scientific Leadership Report, 2022, [link](#))



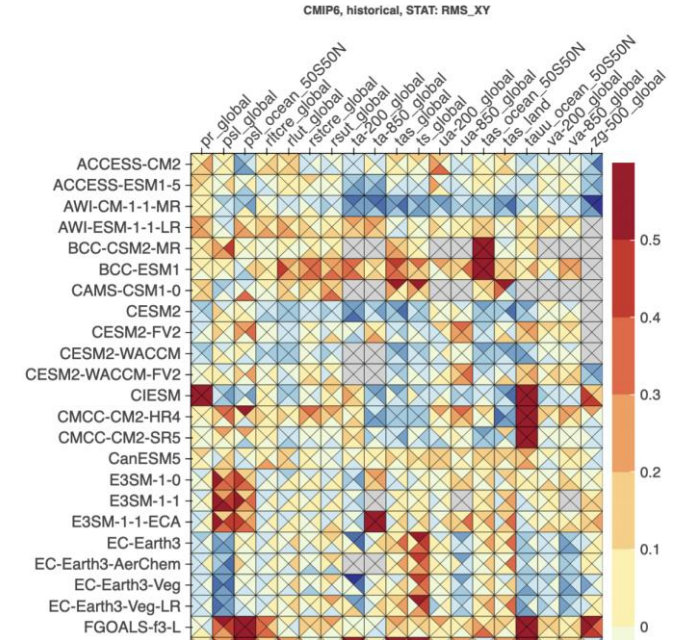
PCMDI Leadership for Decision-Relevant Data



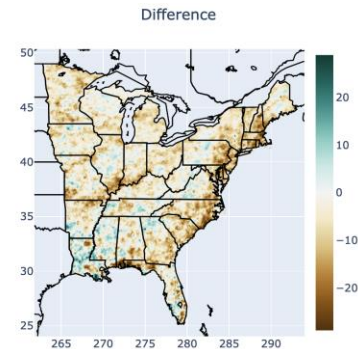
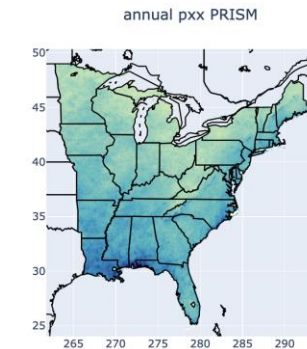
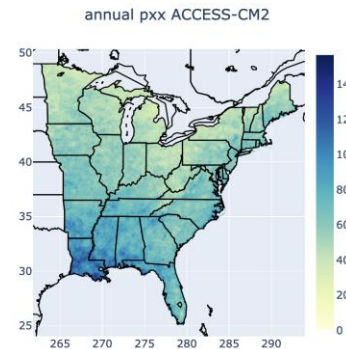
DOE's PCMDI project aims to leverage its past experience as a leader in the global climate data community to coordinate and tackle the challenges currently facing the decision-relevant climate data community.

Technical capabilities such as the PCMDI Metrics Package (PMP) and the Climate Model Output Rewriter (CMOR) will be leveraged to support data evaluation and standardization.

We will establish PCMDI as an authoritative source on all types of decision-relevant climate data products, and will advise on the selection and evaluation of data for NCA6.



In collaboration with



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Complementary to High-Resolution Simulations

- Multiple approaches needed to build confidence in conclusions related to future change.
- Downscaling methods are only able to amplify signals that are present in the parent GCMs. For example, CMIP-class GCMs do not represent tropical cyclones, and so these can be underestimated or absent in downscaled data.
- Statistically downscaled products are not necessarily internally consistent (since different variables are usually downscaled independently).
- Potential for significant improvement in downscaled products from a high-resolution parent GCM, or via regional refinement, both of which have consistent physical representations.

