Micro2Macro

Origins of Climate Change Uncertainty

Workshop Summary and Closing Remarks

Wednesday, October 30

Wifi: UWyo Guest (no password)

Webpage

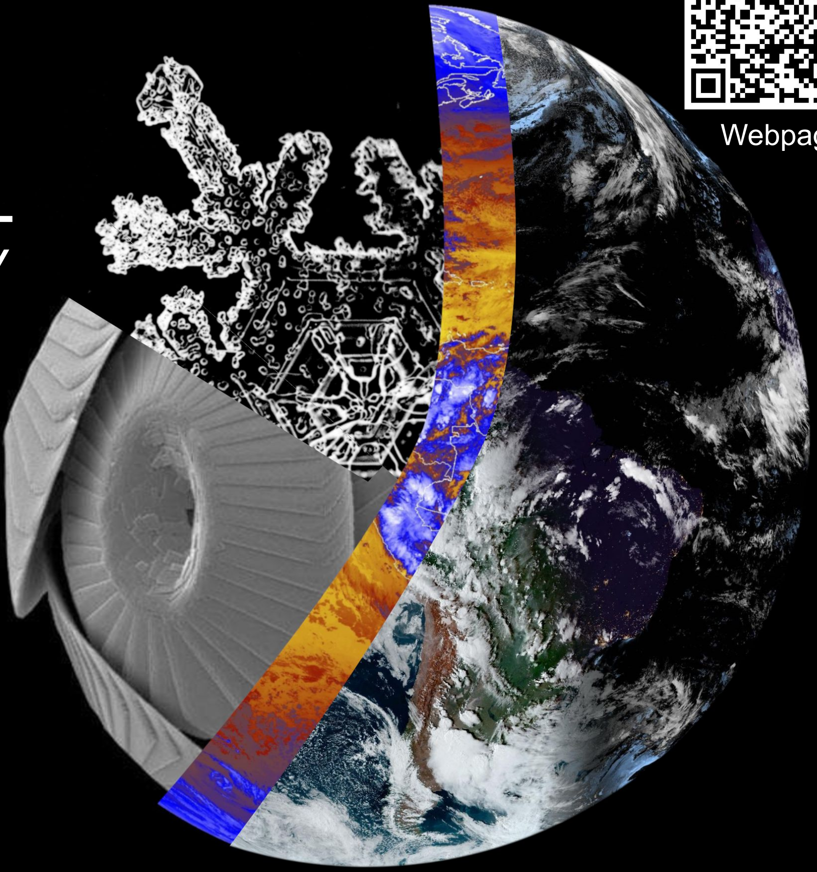


Image credit: Jeremy Young and Gabor Vali

Recap of Workshop Objectives

“The Micro2Macro workshop will develop the foundation of a set of new frameworks to confront and evaluate climate models using observations to improve our process-based understanding and strategically reduce **climate projection uncertainty at decadal time scales.**”

We proposed 4 frameworks to do this looking at:

- Climate model improvement
- Understanding uncertainty in remote sensing
- Using machine learning
- Planning impactful in situ and laboratory measurements

Why decadal time scales?

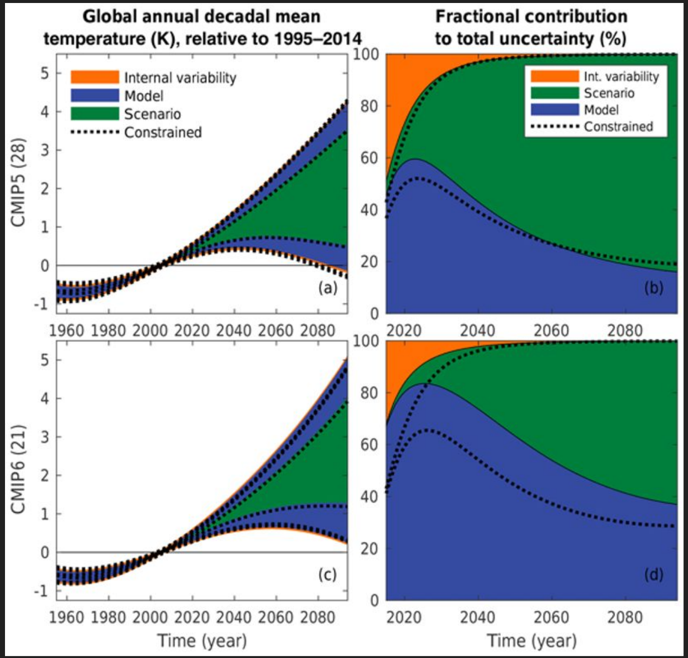
This is where climate model uncertainty matters most:

- Shorter time scales are dominated by internal variability uncertainty
- Longer time scales are dominated by scenario uncertainty

<u>Decadal time scales are also critical for decision makers</u>, including local/state governments, federal agencies, corporations, etc..

Infrastructure built today needs to be resilient to future climate extremes:

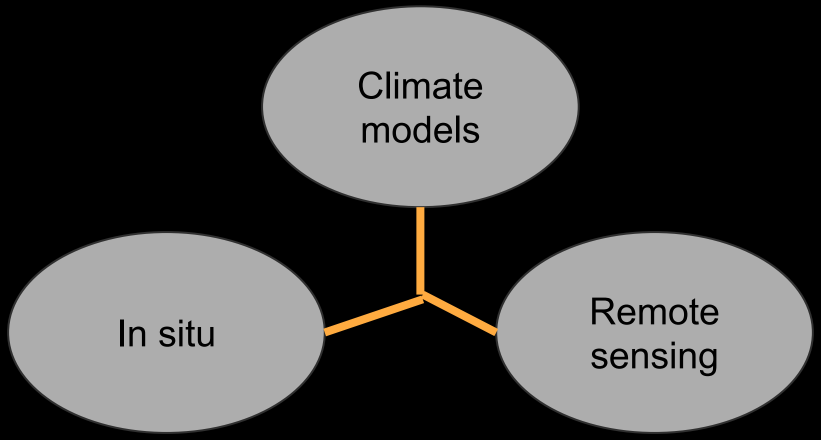
- Critical infrastructure
- Energy systems
- Coastal infrastructure
- Etc.



Lehner et al. (2020)

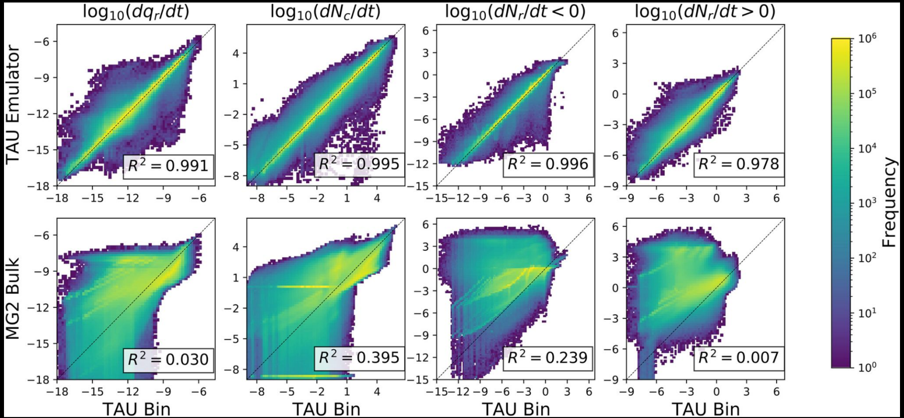
Recap of Workshop Objectives

Evaluation of model microphysics: This deliverable will seek the development and standardization of model evaluation procedures and data sets to facilitate optimal comparison between in situ observations, remote sensing, and climate models.



Recap of Workshop Objectives

Application of impactful, traceable, and interpretable uses of machine learning and artificial intelligence to enhance the use of observations to better inform microphysics parameterizations in models.

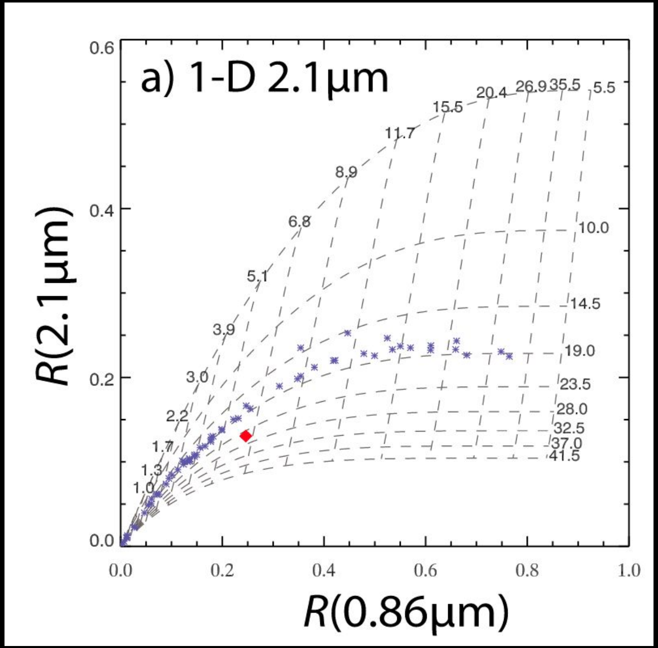


Gettelman, A., D. J. Gagne, C.-C. Chen, M. W. Christensen, Z. J. Lebo, H. Morrison, and G. Gantos, 2021: Machine Learning the Warm Rain Process. *Journal of Advances in Modeling Earth Systems*, **13**, e2020MS002268, https://doi.org/10.1029/2020MS002268.

Recap of Workshop Objectives

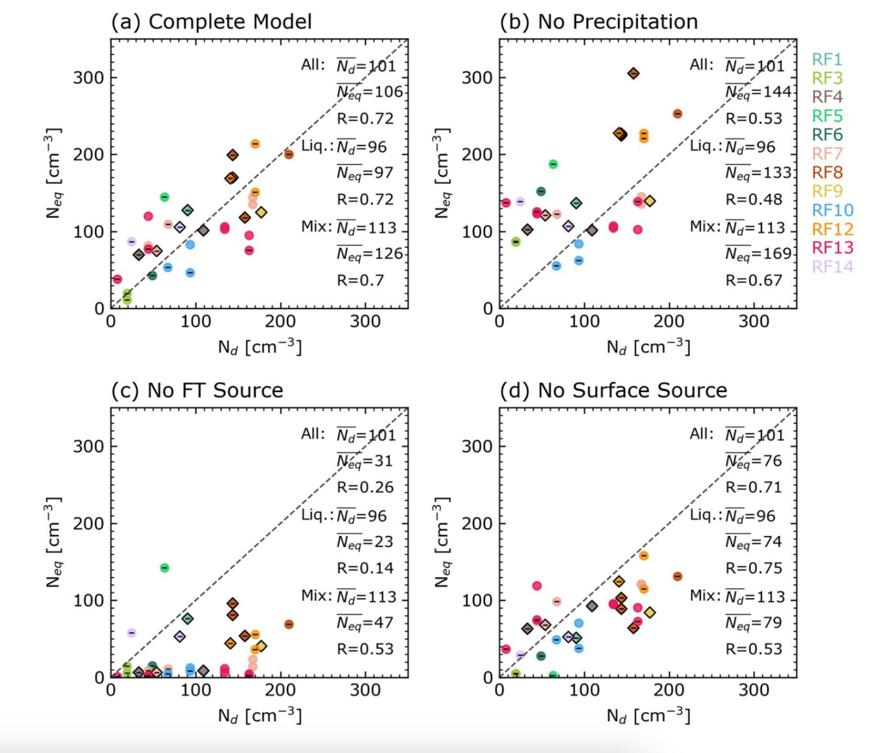
Grosvenor, D. P., and Coauthors, 2018: Remote Sensing of Droplet Number Concentration in Warm Clouds: A Review of the Current State of Knowledge and Perspectives. *Rev. Geophys.*, **56**, 409–453, https://doi.org/10.1029/2017rg000593.

Quantification of microphysical remote sensing retrieval uncertainty: This deliverable will develop suggestions for a probabilistic framework to evaluate remote sensing retrievals of microphysical properties that allow a characterization of uncertainty globally, beyond the relatively small set of direct observations.



Recap of Workshop Objectives

Identification of laboratory and field observation measurement gaps: This deliverable will identify gaps in current lab, in situ, and ground-based observational capabilities, that are priorities for reducing microphysical process uncertainties, including a) recommending future field campaigns and b) identifying needs for enhanced analysis of previous campaigns.

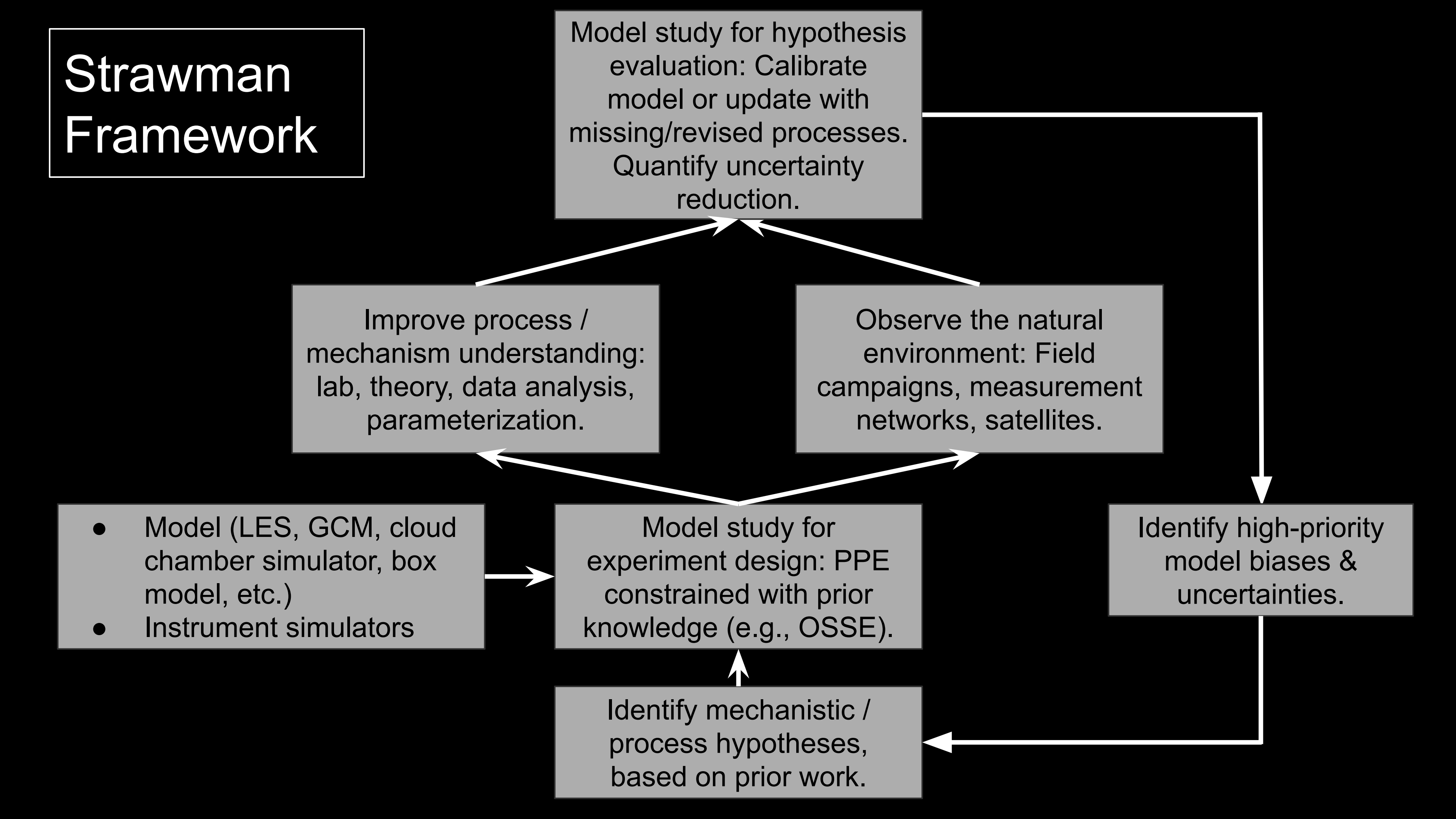


Kang, L., R. T. Marchand, R. Wood, and I. L. McCoy, 2022: Coalescence Scavenging Drives Droplet Number Concentration in Southern Ocean Low Clouds. *Geophysical Research Letters*, **n/a**, e2022GL097819, https://doi.org/10.1029/2022GL097819.

Online feedback on workshop outcomes (Slido)

Workshop Takeaways

- Model uncertainty quantification & <u>reduction</u>:
    - Strong CPE/PPE framework – both global and LES. Continued advances in ML critical.
    - Operationalized use of PPEs in model development.
    - Multi-model PPE intercomparisons.
    - We need to balance complexity, robustness, and climate uncertainty reduction.
- Measurement uncertainty quantification:
    - Measurement intercomparisons.
- Planning future observations to reduce climate projection uncertainty:
    - Hypothesis-driven pre-campaign simulations (e.g., OSSEs).
    - Quantitatively assess the technical requirements for future instruments and measurement networks to reduce climate projection uncertainty (climate OSSEs).
    - Long-term systematic measurements.
    - Campaigns that target persistent model uncertainties.
- Communication structures:
    - Model-measurement communication and joint projects.
    - Structures to work together across agencies and with international partners


Strawman Framework
Model study for hypothesis evaluation: Calibrate model or update with missing/revised processes. Quantify uncertainty reduction.
Improve process / mechanism understanding: lab, theory, data analysis, parameterization.
Observe the natural environment: Field campaigns, measurement networks, satellites.
● Model (LES, GCM, cloud chamber simulator, box model, etc.)
● Instrument simulators
Model study for experiment design: PPE constrained with prior knowledge (e.g., OSSE).
Identify high-priority model biases & uncertainties.
Identify mechanistic / process hypotheses, based on prior work.

What do we need to make progress?

- Critical need: Establish two new complementary interagency working groups:
- Reducing Uncertainty In Future Climate Projections Working Group:
  - Mission: Build and operationalize a framework for reducing uncertainty in future climate projections
  - Include representatives of all major U.S. Climate modelling centers
- Quantifying Uncertainties in Climate Observations Working Group:
  - Mission: Develop expert-driven quantification of uncertainties in key observed variables
  - Include representatives of key data products as well as modelling experts

Combining strengths across multiple agencies will accelerate progress in applying these tools to reduce climate projection uncertainty.

Why now?

- Timeliness: During the past 10-20 years, the community has produced and demonstrated powerful tools and methods for uncertainty reduction (e.g., observationally-constrained PPEs), and we are pushing the frontier of high-resolution global modelling.

- Urgency: Climate change is here: Decision-makers at all levels must consider climate resilience in future planning.

  What they need from the climate science community:

  - Trustworthy projections at decadal time scales
  - Robust quantification of uncertainties

Next Steps

- SOC will write up white paper based on workshop.
- Our ears are open [email SOC members if you want to give feedback on white paper].
- White paper will be presented by chairs to program managers.
- Convert white paper into BAMS article

Thank you to…

Scientific Organizing Committee

Daniel McCoy, University of Wyoming (Co-chair)

Rob Wood, University of Washington (Co-chair)

Susannah Burrows, DOE PNNL

Ann Fridlind, NASA GISS

Adele Igel, University of California, Davis

Coty Jen, Carnegie Mellon University

Leighton Regayre, University of Leeds / UK Met Office

Masa Saito, University of Wyoming

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Program Organizing Committee

Alyssa Cannistraci, US CLIVAR

Mike Patterson, US CLIVAR

Jessica Martinez, UCAR CPAESS

- Breakout and note-taking volunteers
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Thank you to our sponsors!

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Thanks to everyone for attending (both online and in-person)!