

# The U.S. GEWEX Office at USGCRP: Opportunities for U.S. Water and Energy Cycle Science

Update from U.S. Global Change Research Program's Water Cycle Group and the U.S. GEWEX Office at USGCRP

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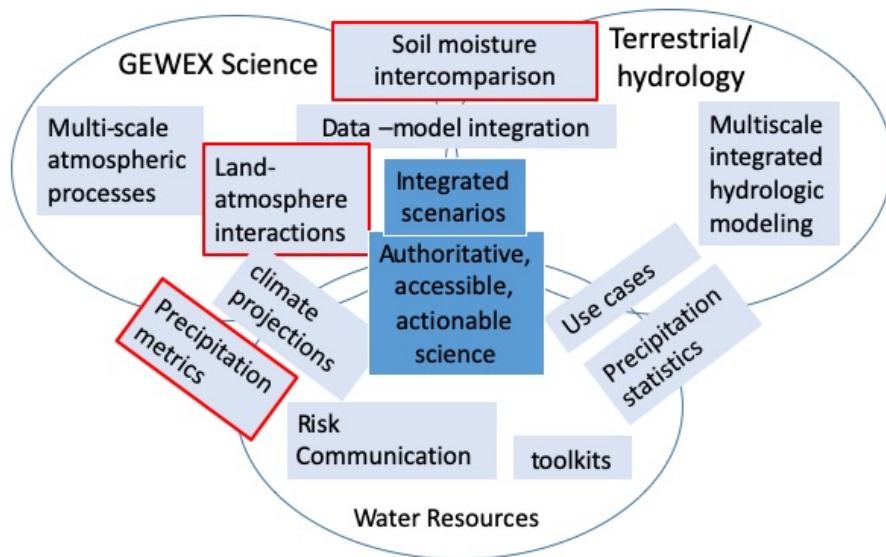
# What USGCRP does



## Through USGCRP, agencies:

- Coordinate global change research and **advance science** across the U.S. government
- Use research results and products to **inform decisions and responses** to a changing climate
- **Deliver mandated products**, including the quadrennial National Climate Assessment
- **Promote international cooperation** on global change research and coordinate U.S. activities with the programs of other nations and international organizations

# Integrated Water Cycle Group (IWCG)



- **Coordinates and integrates global-change relevant water cycle research**
- **Advances capabilities and infrastructure** that support water cycle observation, modeling and predictability at a range of scales
- **Develops approaches to apply and translate** our understanding and inform decisions surrounding preparedness and resilience
- Pursues **interagency and end-to-end approaches** across the Program



# U.S. GEWEX Office at USGCRP

- **Established August 2019** to support **U.S. interagency efforts focused on Federal water and energy cycle research**, that align scientifically with the Global Energy and Water Exchanges (GEWEX) core project of the World Climate Research Program (WCRP).
- **The Office facilitates the coordination of interagency activities** through regular discussions and meetings of program managers from the various USGCRP agencies interested in science relevant to GEWEX. **This group is chaired by two program managers (currently from NASA and DOE).**
- **The Office provides communication and infrastructure** to support these interagency activities and provide interaction with the research community.
- **The Office provides a point of contact** for the community to share and learn about U.S. agencies' activities related to GEWEX, and to support connection and coordination across science and activities.



# Initial Plans

1. Science Planning Exercise
  - Focus Areas developed during agency discussions, with mapping to GEWEX activities, WCRP, and other U.S. Programs (US CLIVAR, US CCSP)
2. Build on underway interagency coordination/ activities
  - U.S. Climate Modeling Summit, Precipitation Metrics Community Effort (DOE)
3. Kick – start with Land Atmosphere Interactions
  - Multiple agencies funding projects; series of seminars from GEWEX scientists
4. Engage the Community
  - Town Halls at AGU and AMS, what does the community want? (RHP?)

# Science Planning exercise

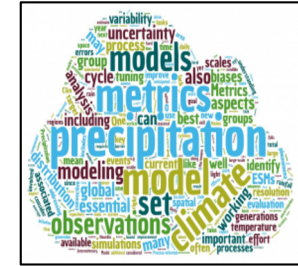
1. How can understanding and prediction of **water cycle extremes** and changes in the future be improved?
2. What are the roles of **land-atmosphere interactions** in water cycle and their changes in the future?
3. What are the **roles of cloud in the water cycle** and their changes in the future?
4. How can understanding of **the effects and uncertainties** of water and energy exchanges in the current and changing climate be **improved and conveyed**?
5. How do changes in the **high latitudes** affect the global water cycle?
6. What are the **impacts of integrated human-Earth system interactions** on water cycle?

## Crosscutting-Areas

1. Advancing climate and Earth system modeling
2. Advancing observing systems and measurement strategies
3. Advancing model-data integration, visual and data analytics

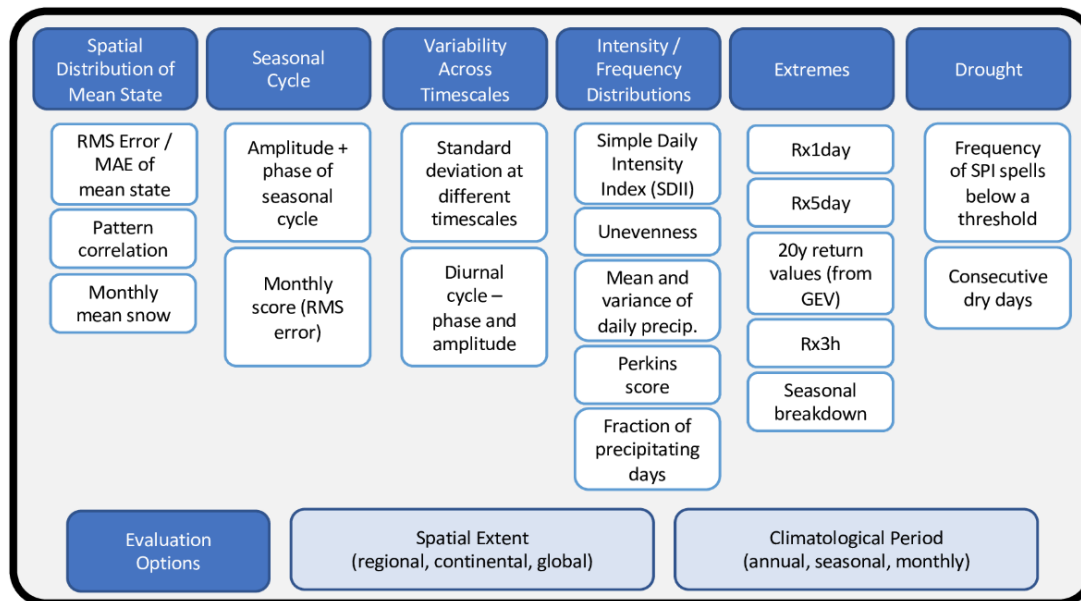


# DOE Precipitation metrics workshop

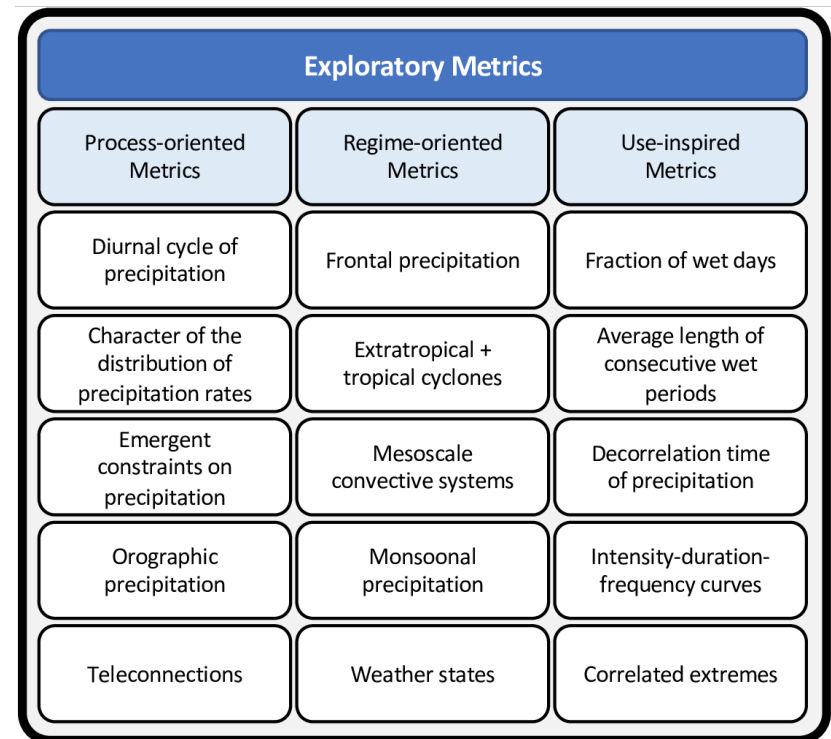


Sponsored by RGMA and co-organized by Gleckler, Pendergrass, Leung, and Jakob

## Baseline metrics



## Exploratory metrics





# 3-D Land Energy and Moisture Exchanges: Harnessing High Resolution Terrestrial Information to Refine Atmosphere-to-Land Interactions in Earth System Models



**Lead PI:** Kuo-Nan Liou, University of California, Los Angeles (UCLA)

**Co-PIs/Co-Is:** Yu Gu (UCLA), Gautam Bisht/L. Ruby Leung (DOE/PNNL), Forrest M. Hoffman (DOE/ORNL), Elena Shevliakova (NOAA/GFDL), David Lawrence (NCAR), Nathaniel Chaney (Duke University), Po-Lun Ma (DOE/PNNL), Peter Thornton (DOE/ORNL), Sergey Malyshev (NOAA/GFDL), Sarah B. Kapnick (NOAA/GFDL), Shian-Jiann Lin (NOAA/GFDL), Cenlin He (NCAR/UCLA)



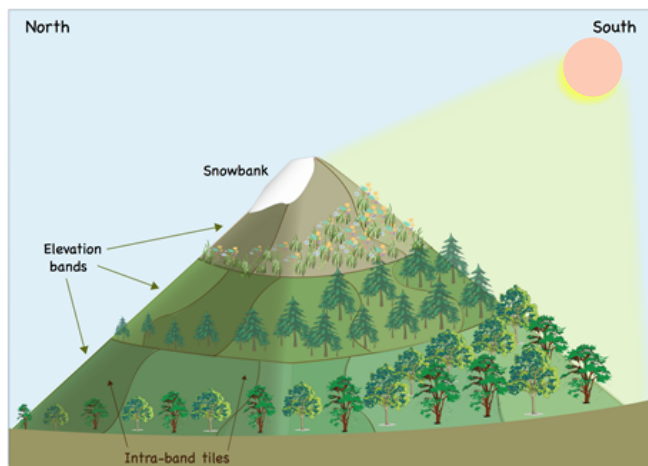
## Background:

- ❑ All comprehensive ESMs include land components, in which all sub-units within a land grid receive the same downward fluxes of radiation from an atmospheric grid. ESMs assume that the canopy air is clean and ignore tracers that may be present in the canopy air (e.g. dust or fire emissions).
- ❑ No complete and inherently consistent land surface radiation transfer treatment (e.g. mountains, multi-layer canopy, and snow) has been implemented in any CMIP6-class ESMs.

## Objective:

We propose to advance the representation of land radiation transfer in the NOAA/GFDL ESM4, DOE/E3SM, and NCAR/CESM2 models through the incorporation of

- radiation flux parameterization accounting for the effects of mountain shading and multiple reflections between mountains and snow;
- parameterizations for black carbon (BC) and dust mixing in snow and associated light absorption and scattering processes;
- multi-layer canopy energy transfer accounting for tracers (e.g. dust, BC) in the canopy air space;
- interactions of the above improvements with sub-grid land-heterogeneity (e.g., different vegetation/plant functional types, elevation bands, mountain aspects, hydrological hill-slopes, etc.)



## Four Criteria Met:

- ❑ **Relevance:** Current land components of ESMs ignore orography, vertical canopy structures, and tracers in canopy air and snow in radiation exchanges.
- ❑ **Readiness:** Parameterizations for 3D radiation scaling and snow impurities are transferable to climate models.
- ❑ **Focus:** A set of processes governing energy transfer from the atmosphere to land, with explicit treatments of orography-vegetation-snow interactions.
- ❑ **Model independence:** Three participating climate centers (NOAA/GFDL ESM4, DOE/E3SM, and NCAR/CESM2 models). Contribute to NOAA's capacity-building activities through advancing our understanding of the Earth's climate system, particularly hydro-climate and land ecosystems.





# Parameterizing the effects of sub-grid land heterogeneity on the atmospheric boundary layer and convection



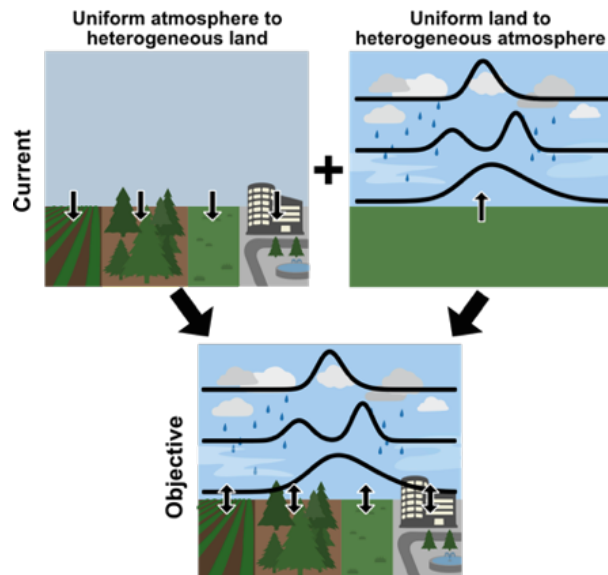
Lead PI/Co-PIs/Co-Is: Nathaniel Chaney (Duke), Kirsten Findell (NOAA/GFDL), Po-Lun Ma (DOE/PNNL), David Lawrence (NCAR), Joseph Santanello (NASA/GSFC), Paul Dirmeyer (GMU), Forrest M. Hoffman (DOE/ORNL), Elena Shevliakova (NOAA/GFDL), Michael Ek (NCAR), Gabriel Katul (Duke), L. Ruby Leung (DOE/PNNL), Nathan Arnold (NASA/GSFC), Randal Koster (NASA/GSFC), Ming Zhao (NOAA/GFDL)

**Motivation:** In existing climate models, simulated sub-grid heterogeneous states and fluxes over land are mostly disconnected from sub-grid parameterizations of the atmosphere. This is a recognized deficiency given the known role of multi-scale land heterogeneity in atmospheric processes including convection, rainfall initiation, and mesoscale circulations.

**Objective:** Parameterize the heterogeneous sub-grid exchange between the land and atmosphere and characterize its implications for surface climate, variability, and extremes.

## Project Tasks:

1. Implement a novel interaction scheme between the heterogeneous land and atmosphere in the DOE/E3SM, NOAA/ESM4, NASA/GEOS, and NCAR/CESM2 Earth system/climate models.
2. Leverage and enhance coupling metrics to evaluate the modeling of heterogeneous land-atmosphere interactions.
3. Evaluate and improve the parameterization using coupled land model/large eddy simulations and observations.
4. Perform global simulations to gain understanding of the role of land spatial organization in the climate system.



# Science Talks 2018-19

- **Land Modeling:** Perspectives from 2018 US Climate Modeling Summit
  - John Dunne (NOAA) – USCMS Land workshop report and summary
  - Elena Shevliakova – GFDL current and future capabilities and interests
  - Ruby Leung - E3SM's current and future capabilities and interest
- Joe Santanello: **Land-Atmosphere Interactions:** The LoCo (& NASA) Perspective
- Dave Turner: NOAA's Bedrock-to-Boundary Layer Effort and an Update on the **Land-Atmosphere** Feedback Experiment (LAFE) (July 2019)
- Paul Dirmeyer (GMU): Briefing to USGCRP (A US **RHP**)
- Mike Bosilovich (NASA): **Reanalyses** for Water and Energy Climate Studies
- Mike Ek: Climate, Water Energy Exchanges (CWEX): **Perspectives from GEWEX/GLASS, WGNE**, and the NCAR Joint Numerical Testbed and NCAR-NOAA Developmental Testbed Center (DTC)
- Continuing in 2020...



# 2020 Outlook: What comes next?

## AGU (2019) and AMS 2020 Town Halls

- Initial community discussion of science questions
  - Requires community effort, how will they become tangible and specific?
- Close coordination with GEWEX science and activities
  - Important to synthesize and create synergy with work that is already being done. Focus on communication and exchange between scientists of the national and international community.
  - Agencies are looking for places to work together – but things are most successful when they are driven by the community
- What's the driving need?
  - Agencies can have workshops
  - RHP has come up numerous times (AGU, AMS, US GEWEX PMG meetings)
  - Science needs and near- term goals can help - agencies can work together to find the resources