Integrated Mountainous HydroClimate Workshop

DOE Integrated Mountain Hydroclimate Workshop

DOE ASR Annual Meeting - October 2022

Drs. Michelle Newcomer, Ruby Leung, and Kristen Rasmussen

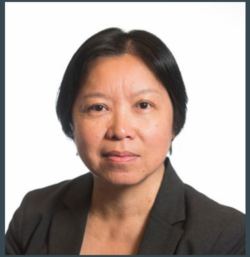
U.S. DEPARTMENT OF ENERGY

Leadership Team

Dr. Michelle Newcomer(Lawrence Berkeley National Laboratory): Hydrology, Reactive Transport Modeling

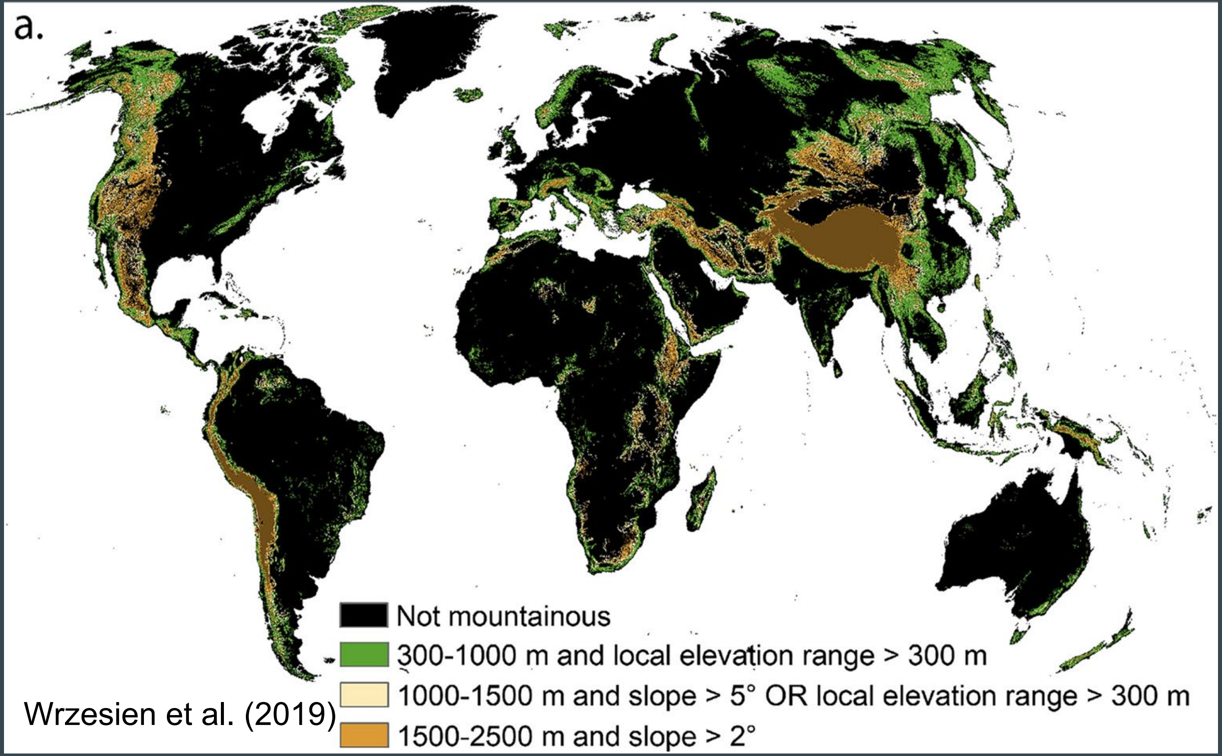
Dr. Kristen Rasmussen (Colorado State University): Mesoscale/Cloud Processes, Weather-Climate Interface

Dr. Ruby Leung (Pacific Northwest National Laboratory): Earth System Modeling, Water Cycle and Extreme events



Global distribution of mountainous regions

- Earth's mountains cover ~23% of global land
- Mountains provide 60-90% fresh water for people worldwide

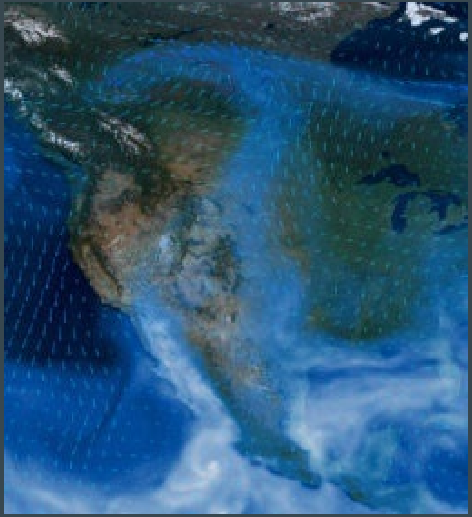


Mountainous Systems are Important and they are Changing

- Projected declines and potential disappearance of mountain snowpacks (Siirila-Woodburn et al. 2021)

- Increases in growing season length have cascading effects on terrestrial and aquatic ecosystems (Huss, 2017), and hydrological partitioning and water delivery (Rumsey 2017)

- Increasingly vulnerable to disturbances, extreme events, and climate change



Motivation for the IMHC Workshop

Research will address the bi-directional feedbacks between the atmospheric and the terrestrial and subsurface component, and the embedded human systems.

Charge: Provide insight on priority challenges, regions, and future research needs

Outcomes: (1) Presentations at AGU, DOE PI meeting, and DOE ASR meeting (2) A workshop report

Quick summary - IMHC Workshop Structure

- Session 1: November 15-16, 2021
  - Breakout 1: Disciplinary Topics
  - Breakout 2: Cross-Disciplinary Topics
  - Breakout 3: Cross-Cutting Topics
  - Breakout 4: Integrated Activities/Experiments
    - Integrated activities on extreme events, transferable knowledge, and actionable science
- Session 2: January 19, 2022
  - Opportunities and Challenges for Inter-agency collaboration
  - Inter-Agency panels
  - Program manager roundtable

184	Participants
34	Universities
9	Federal Agencies
5	Local/State Agencies
4	International Universities/Agencies

Workshop Co-Leads

Atmospheric
- Adam Varble (PNNL)
- Alan Rhoades (LBNL)

Terrestrial
- Matthias Sprenger (LBNL)
- Nate Chaney (Duke)

Human-Terrestrial-Atmospheric Interactions
- Andreas Prein (NCAR)
- Peter Thornton (ORNL)
- Naresh Devineni (CUNY)

Human Systems
- Nathalie Voisin (PNNL)
- Andy Jones (LBNL)

Integrated Climate Variability and Change
- Erica Woodburn (LBNL)
- Paul Ullrich (UC Davis)
- Ning Sun (PNNL)

Societal Connections
- McKenzie Skiles (Univ Utah)
- Simon Wang (Utah State)
- Ian Kraucunas (PNNL)

Takeaways: Gaps, Grand Challenges, and Opportunities

- Mountain Extremes
- Scaling of Mountain Processes and Data
- Modeling and Prediction of Mountain Processes
- Data-model Integration in Mountain Regions
- Uncertainty in Mountain Hydroclimate Research
- Coordination and Collaboration

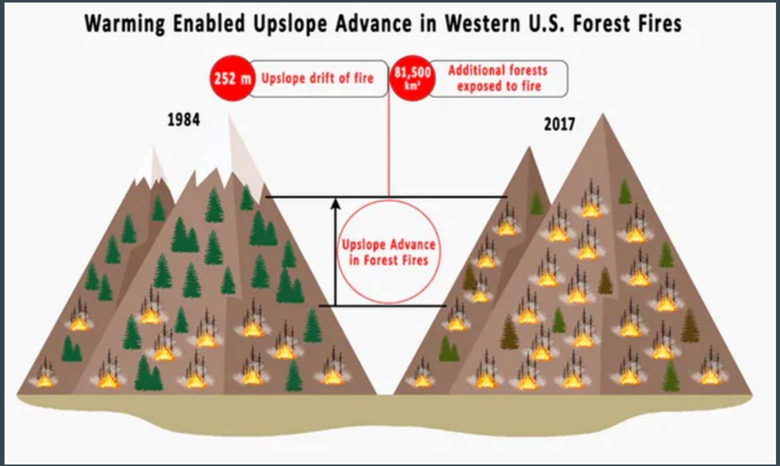
Mountain Extremes

Challenge Quantifying thresholds and tipping points before and after extreme events and the scale at which they interact

Opportunity Improve quantification of the downstream impacts of extreme events and thresholds and tipping points by developing long term and rapidly deployable observations of mountain biomes to quantify ecosystem steady states before/after extremes

Rapidly deployable campaigns. ...

..enable extreme event analysis



Snow and Wildfire Change at the Wildland Urban Interface (Charles Luce, USFS)

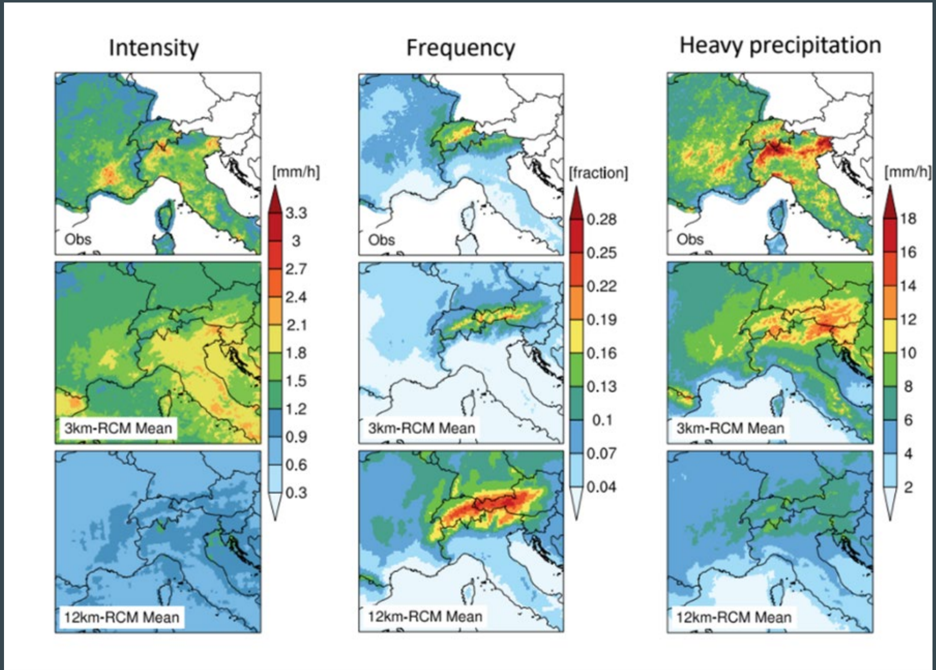
Scaling of Mountain Processes and Data

Challenges: 1) a wealth of data already exists that has yet to be fully utilized

2) land-atmosphere models are now posited to outpace the skill of observational networks

3) Gridded interpolated products have limited to no validation in mountain regions

4) Vast under-sampling across elevation gradients with limited temporal breadth



Nikolina Ban (2021, University of Innsbruck, Austria)

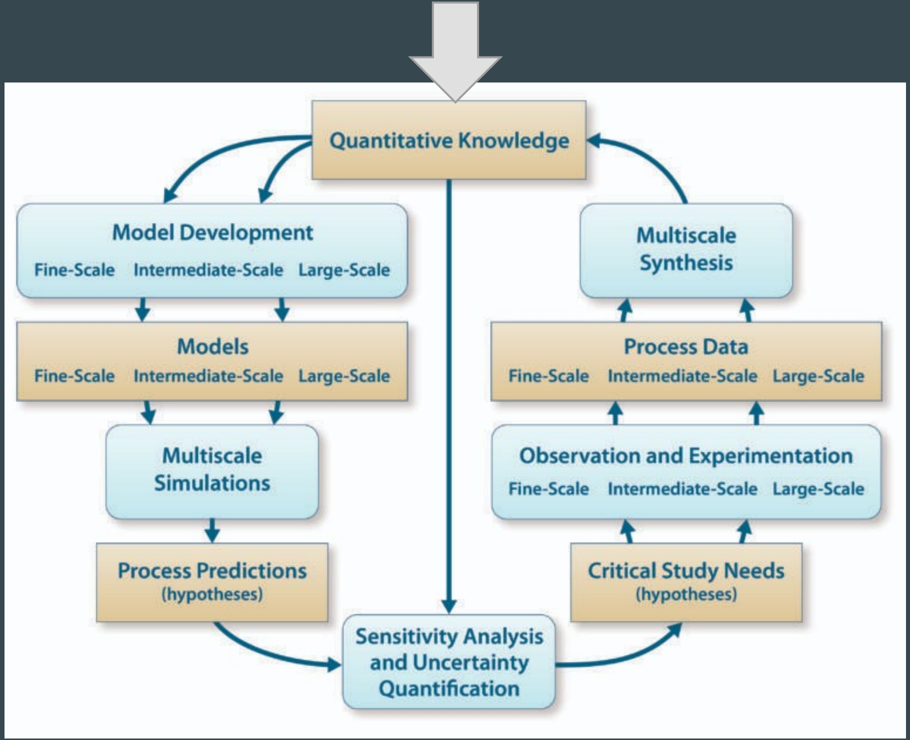
Scaling of Mountain Processes and Data

Opportunities:

1) Overcome underutilization of data by analyzing data from past field campaigns and inputting such data into state-of-the-art models before developing new operational and observational networks as a pre-MODEX activity,

2) Closing short-and-long term spatiotemporal observational gaps and optimizing experimental sampling design using systematic approaches

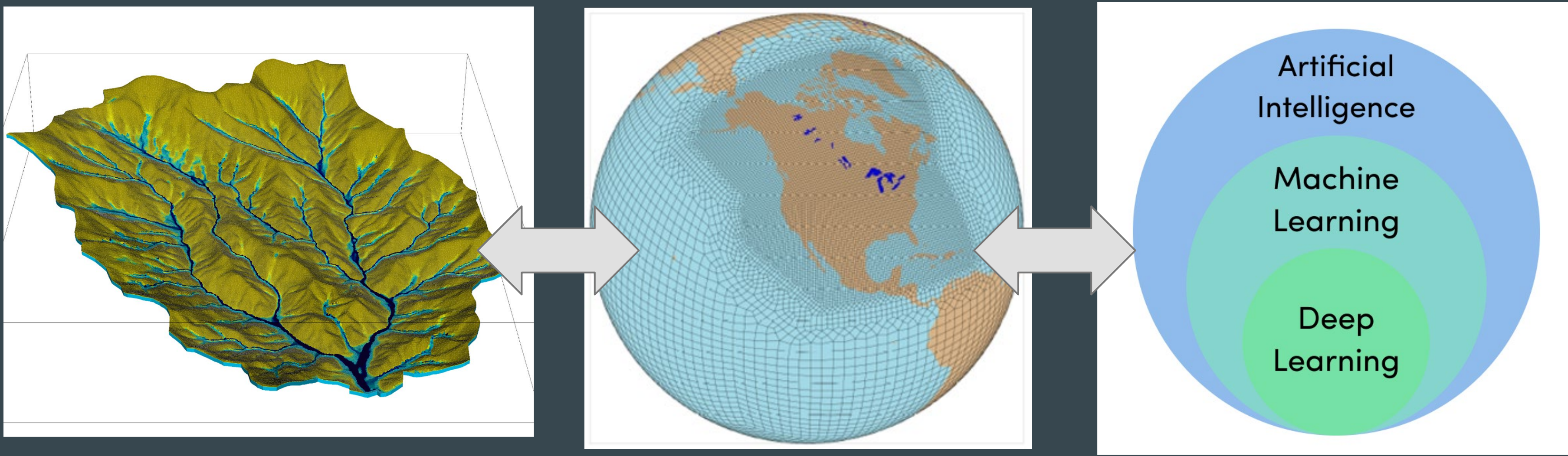
Pre-MODEX: Turn existing data from other regions into quantitative knowledge



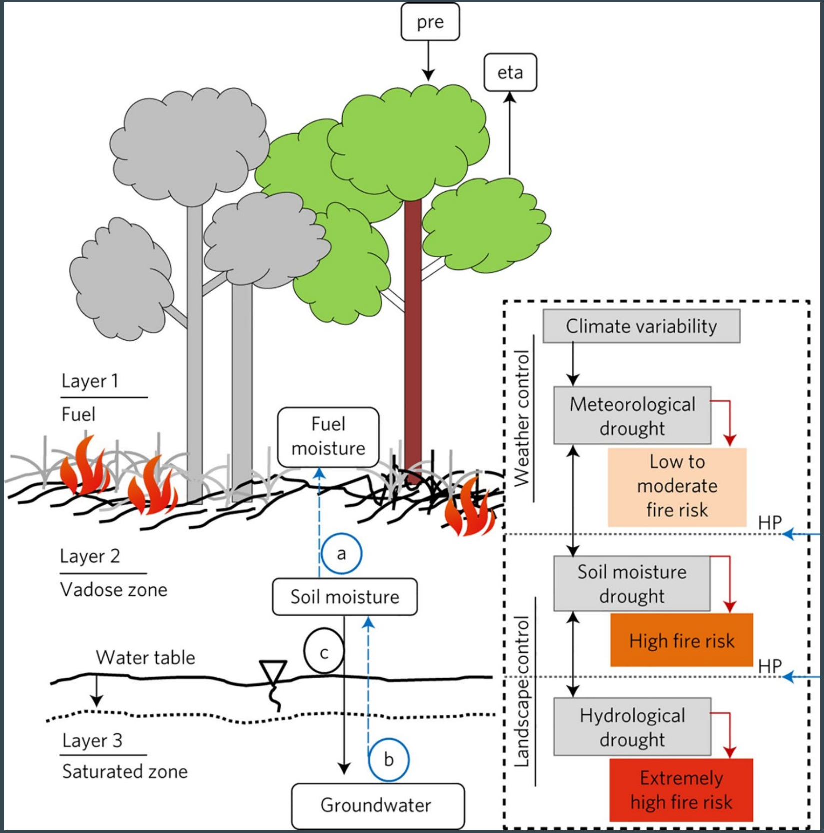
Modeling and Prediction of Mountain Processes

Challenge determine the minimum but sufficient process representation to credibly simulate mountain hydroclimate variability and change

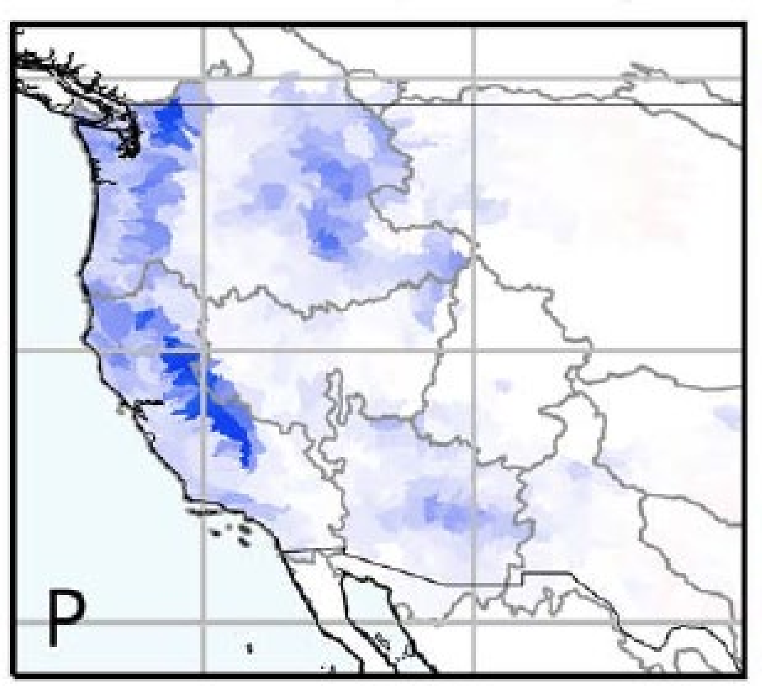
Opportunity to better integrate measurements, multi-scale models, and machine learning for scientific advances and improved guidance of observational needs and model development



Model Development: Evapotranspiration, Wildfire, Orographic Precipitation



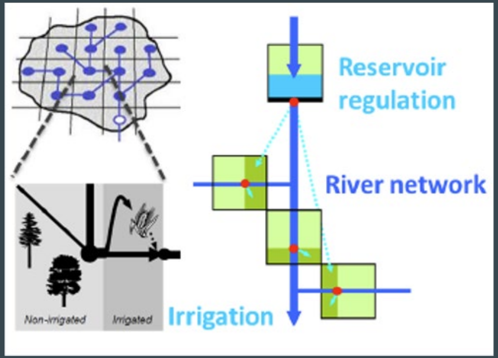
Taufik et al. (2017)



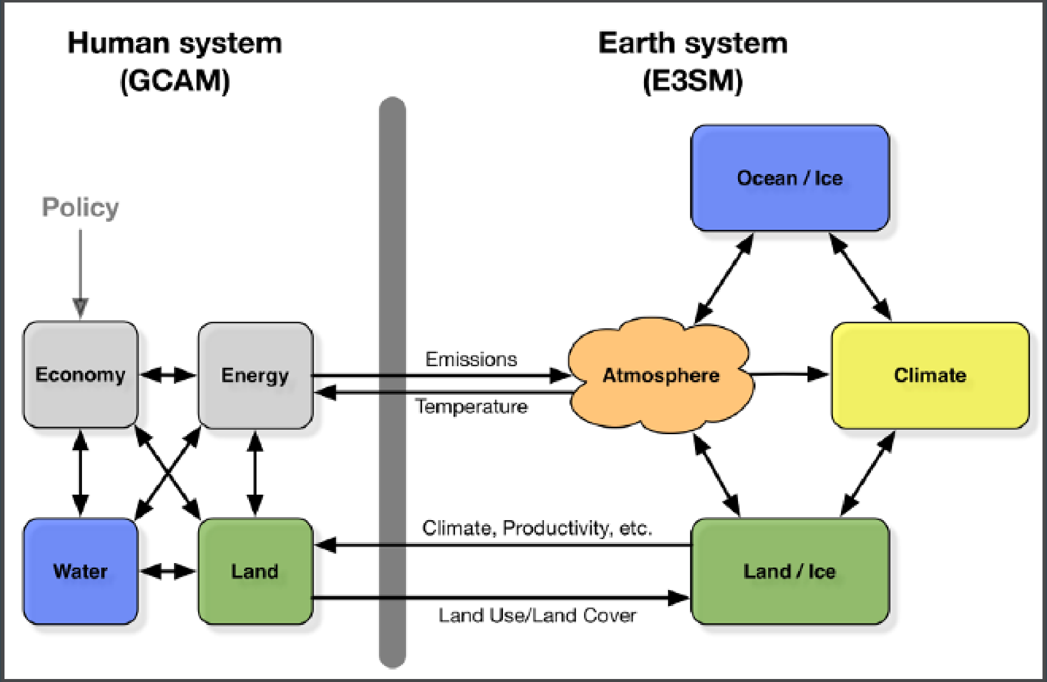
Model Development: Human Systems, Multi-Sector Dynamics and Risk Evaluation

Challenge: Need for long-term observational platforms and models that include human-multi sector dynamics

Opportunities: 1) leverage observational datasets and various stakeholders and science communities to develop model evaluation and improvement testbeds, 2) Implement regional climate modeling and storyline development



Modeling natural-human interactions in E3SM



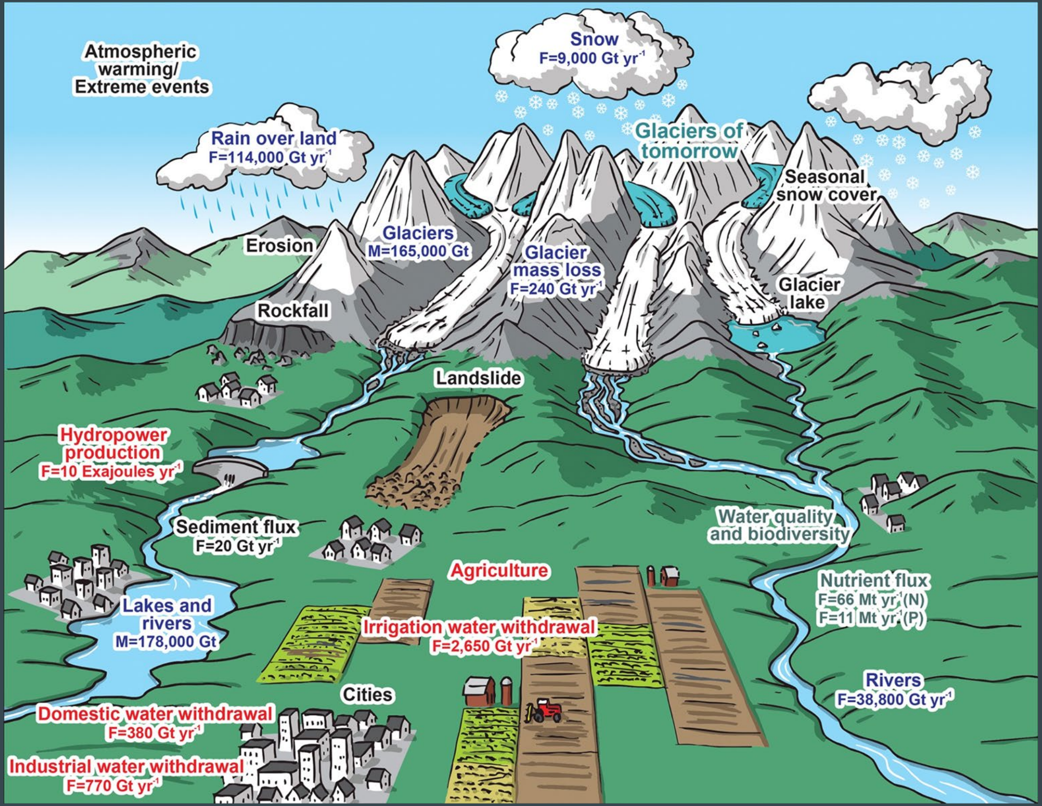
Uncertainty in Mountain Hydroclimate Research

(1) Downscaling approaches used for global or regional climate models

(2) Model resolution and representation of land use and land cover spatial variability, and its interplay with terrestrial processes such as snow and soil-water processes

(3) Model representation atmospheric and terrestrial feedbacks

(4) Inadequate or no representation of human multi-sector dynamics



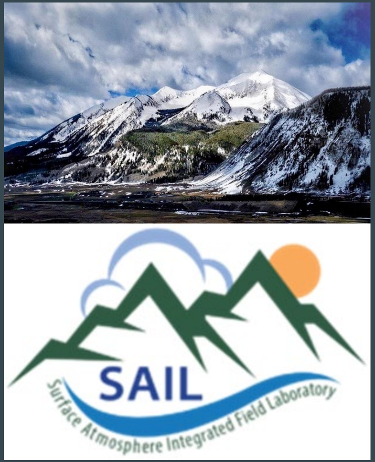
Huss et al. (2017)

Cross-Divisional Collaboration and Coordination

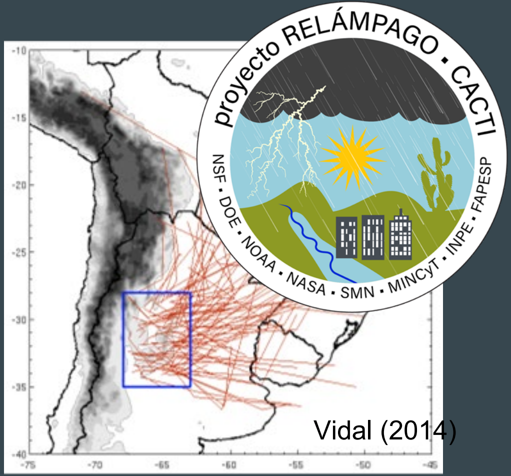
Challenge: Need for long-term observational platforms and models

Opportunities: As there are already several mountainous catchments instrumented around the globe, a concerted effort to foster more collaborations across sites and inter-site comparisons

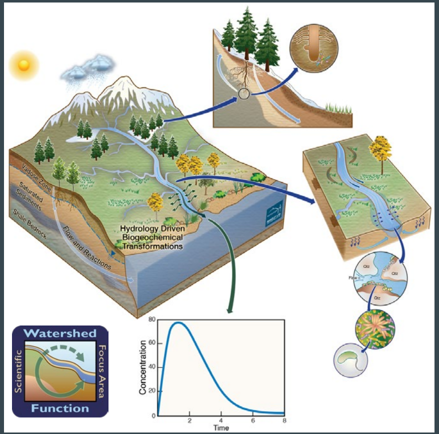
SAIL: Surface Atmosphere Integrated Field Laboratory



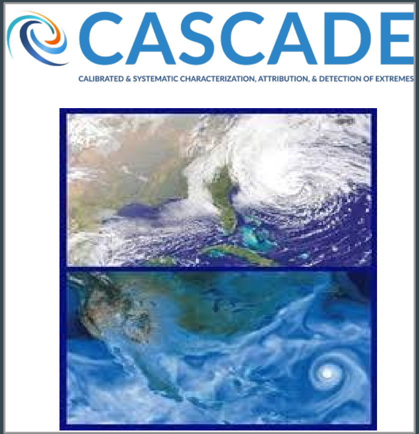
CACTI: Cloud, Aerosol, and Complex Terrain Interactions



DOE Watershed Function SFA



DOE CASCADE



Inter-Agency Roundtable Reflections: Successful Collaboration Requires…

- Research-2-Operations (R2O) and Operations-2-Research (O2R) development cycles
- A shared understanding of the prediction problem
- Approaches geared towards stakeholder co-production of research
- Bottom-up and top-down collaboration business models
- Defining priority regions

Key Takeaways

- Scaling Challenges are pervasive: Scale inconsistency between models/observations/decisions
- Lack of model process representation in mountains
- Need for longer term observations across the globe
- Poor definition/monitoring/modeling of extreme events and their impacts (wildfire, wind, snow)
- Need for models that include human and multi-sector dynamics to enable actionable science and decision making
- Transferability of models and data to new regions is limited: Need for cross scale model development and intercomparison
- Understanding/quantifying uncertainty


Thank You!