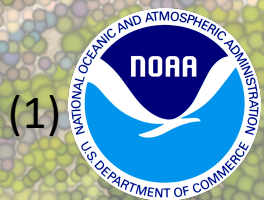


# The Study of Precipitation, the Lower-Atmosphere and Surface for Hydrometeorology (SPLASH)

**Gijs de Boer<sup>1,2</sup>**

Allen White<sup>1</sup>, Rob Cifelli<sup>1</sup>, Mimi Hughes<sup>1</sup>, Janet Intrieri<sup>1</sup>, Kelly Mahoney<sup>1</sup>, Chris Fairall<sup>1</sup>, Sara Morris<sup>1</sup>, James Wilczak<sup>1</sup>, Darren Jackson<sup>1,2</sup>, Elizabeth Thompson<sup>1</sup>, Matthew Shupe<sup>1,2</sup>, Jackson Osborn<sup>1</sup>, Ryan Currier<sup>1</sup>, Kathy Lantz<sup>1</sup>, Joseph Sedlar<sup>1,2</sup>, Laura Riihimaki<sup>1,2</sup>, Tilden Meyers<sup>1</sup>, Jack Elston<sup>3</sup>, Steve Borenstein<sup>4</sup>, Brian Argrow<sup>4</sup>, V. Chandrasekar<sup>5</sup>





# Introduction





# Introduction: NOAA PSL

## PHYSICAL SCIENCES LABORATORY



ADVANCING PREDICTIONS

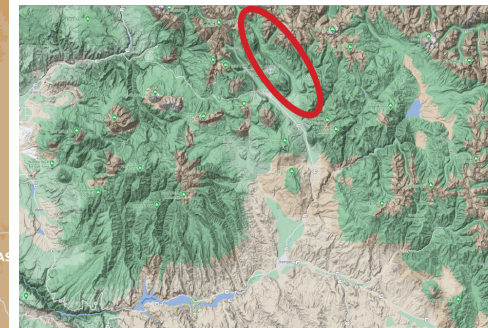
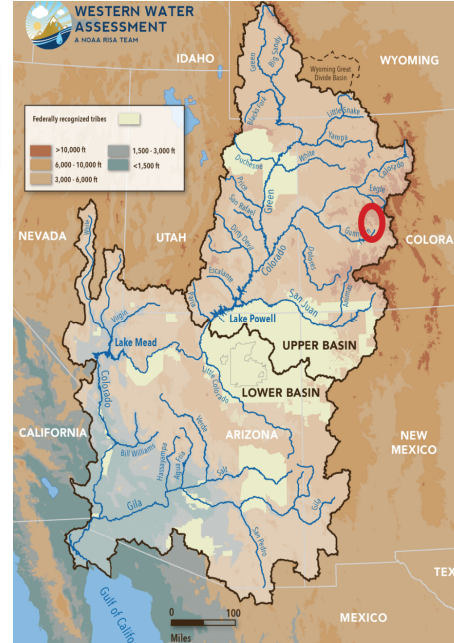
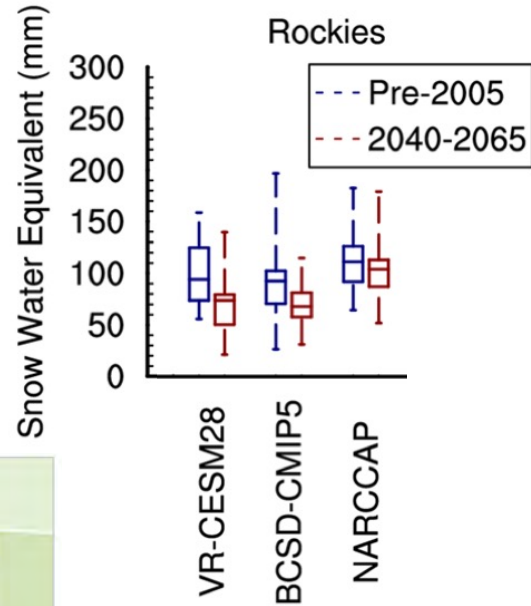
The **Physical Sciences Laboratory (PSL)** analyzes and interprets physical processes that influence weather and climate from hours to decades to provide scientific information to support NOAA's mission. One of the PSL's three primary research themes is **Water Resource Management**, which includes work to:

- Understand, predict, and assess severity of water-related extreme events such as droughts and floods
- Use observations to improve physical process understanding and guide model development for improved predictions
- Analyze atmospheric, cryospheric, land surface, and oceanic interface processes
- Assess, improve, and then assimilate the data used to drive the National Water Model
- Provide scientific information necessary for cost-effective decision making

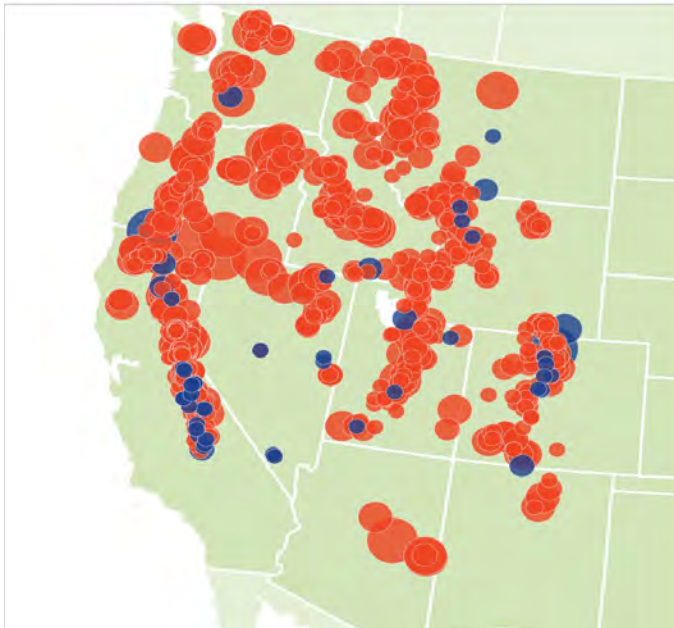




# Surface-Atmosphere Integrated Field Laboratory (SAIL)



SNOTEL SWE Trends



Percent change:



Mote and Sharp, 2016, BAMS



LBNL EESA Leadership Brief, 14 January 2020



# Community Needs

**PRECIPITATION PREDICTION  
GRAND CHALLENGE  
STRATEGIC PLAN**

**WEATHER, WATER,  
AND CLIMATE BOARD**

OCTOBER 30, 2020

**Colorado River Basin Climate and Hydrology  
State of the Science**

April 2020  
Western Water Assessment

NOAA Snow Workshop Report  
M.M. Hurwitz et al. 24-July-20 1

**Six Priorities for Investment in Snow Research and Product Development**

Meeting Summary for Submission to BAMS

**Author List**  
Margaret M. Hurwitz<sup>1</sup>, S. Baxter<sup>1</sup>, B. Brown<sup>2,3</sup>, J. Carman<sup>1</sup>, J. Dale<sup>4</sup>, C. Draper<sup>4,5</sup>,  
F. Horstfall<sup>6</sup>, M. Hugles<sup>1</sup>, J. Garth<sup>7</sup>, S. Kapnick<sup>8</sup>, C. Oelaiser<sup>9</sup>, M. Olsen<sup>1</sup>, C. Stachelski<sup>9</sup>,  
M. Vincent<sup>9</sup>, R. Webb<sup>4</sup>, J. Zdrojewski<sup>1</sup>

**Improvement and Suggestions for Snow Research**

**What:** Snow observations and research communities within NOAA's National Weather Service (NWS), Oceanic and Atmospheric Research (OAR), and National Environmental Satellite, Data, and Information Service (NESDIS), and other organizations came together to assess snow research goals and necessary improvements.

**When:** March 2020

**Where:** Virtual Snow Workshop

**Early Online Release:** This preliminary version has been accepted for publication in *Bulletin of the American Meteorological Society*, may be fully cited, and has been assigned DOI 10.1175/BAMS-D-20-0218.1. The final typeset copyedited article will replace the EOR at the above DOI when it is published.

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**EARTH SYSTEM PREDICTABILITY  
RESEARCH AND DEVELOPMENT  
STRATEGIC FRAMEWORK AND ROADMAP**

*A Report by the*  
**FAST TRACK ACTION COMMITTEE ON EARTH SYSTEM  
PREDICTABILITY RESEARCH AND DEVELOPMENT**  
*of the*  
**NATIONAL SCIENCE & TECHNOLOGY COUNCIL**

October 2020

## Common Themes:

- Advancing understanding of the land-atmosphere transition zone
- Improved understanding/characterization of atmospheric and surface spatial heterogeneity
- Evaluate and advance new modeling frameworks over complex terrain (UFS, RRFs, NWM)
- Develop and evaluate new technologies to fill critical surface and atmosphere observing gaps



# The SPLASH Team





# SPLASH Science

## Clouds and Precipitation:

- Quantitative Precipitation Estimation (QPE)
- Snow level and drivers
- Precipitation Microphysics
- Convective Initiation
- Rain-on-snow events

## Surface Properties:

- Snow cover
- Sublimation of surface snow
- Surface Albedo
- Soil Moisture
- Surface-atmosphere exchange and impact on hydrology



## Mountain Weather:

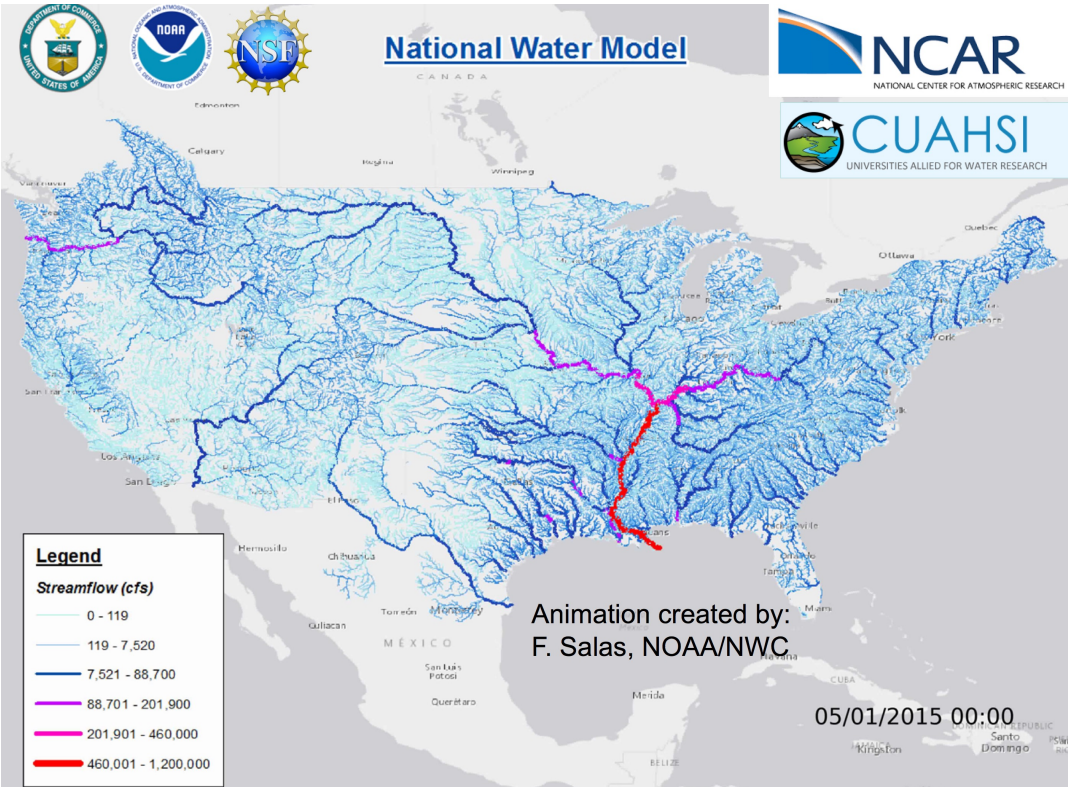
- Orographic flows
- Diurnal circulations for renewable energy
- Boundary layer development

## Improving Prediction:

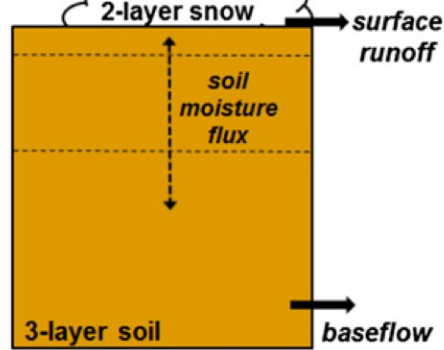
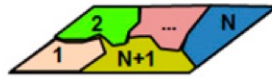
- Seasonal evolution of snowpack in the NWM
- NWM forcing, including precipitation
- Seasonal streamflow biases
- Soil moisture variability
- Improving convective initiation with DA
- UFS-NWM coupling
- UFS/RRFS evaluation
- Gap-filling radars



# Supporting Improved Prediction



Mosaic representation of different vegetation coverages at each cell

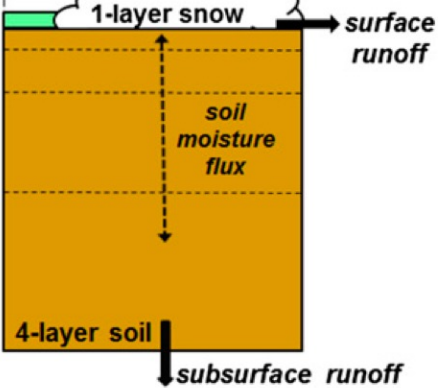


VIC

Each cell has average vegetation parameters

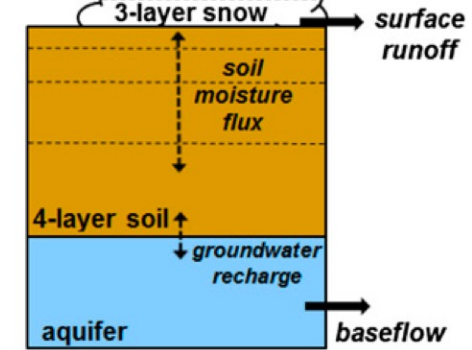
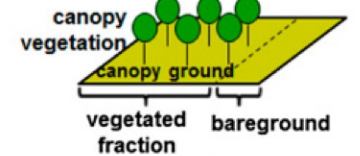


Implicit vegetation

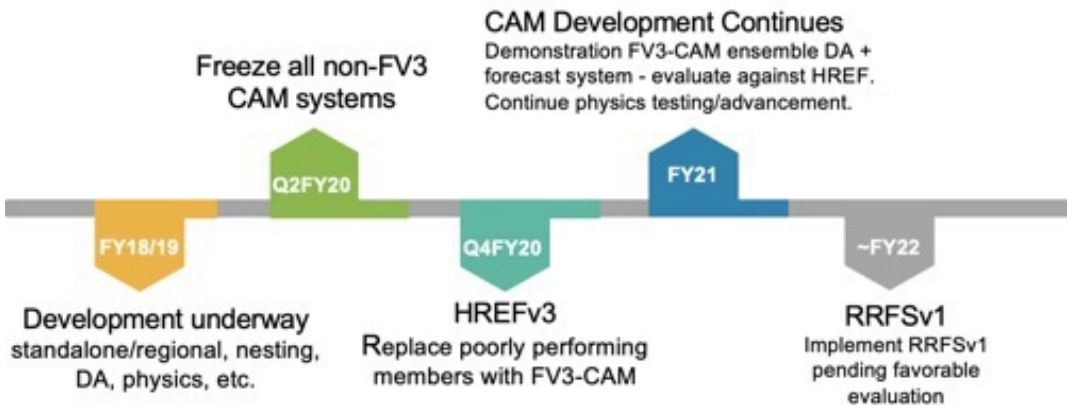


Noah-LSM

Semi-tile approach for computing longwave, latent heat, sensible heat and ground heat fluxes

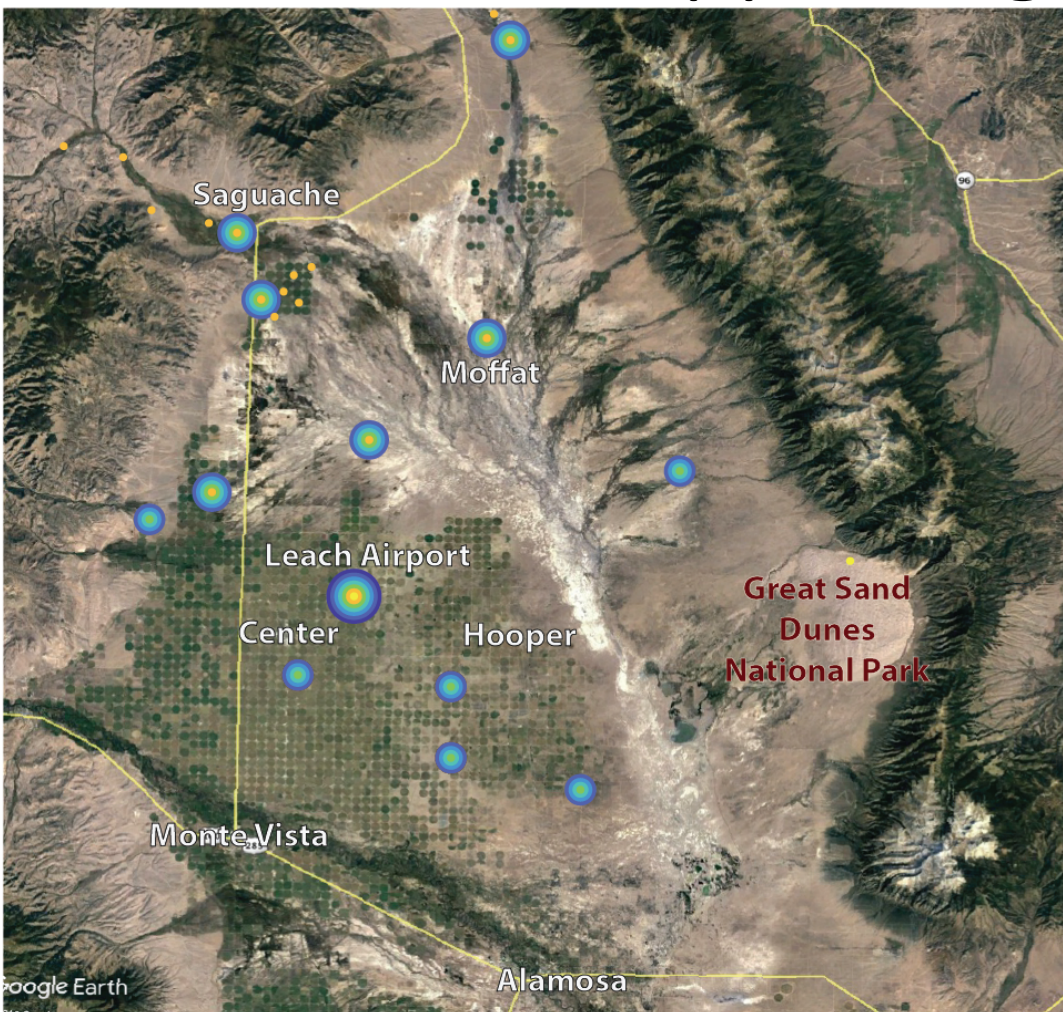


Noah-MP

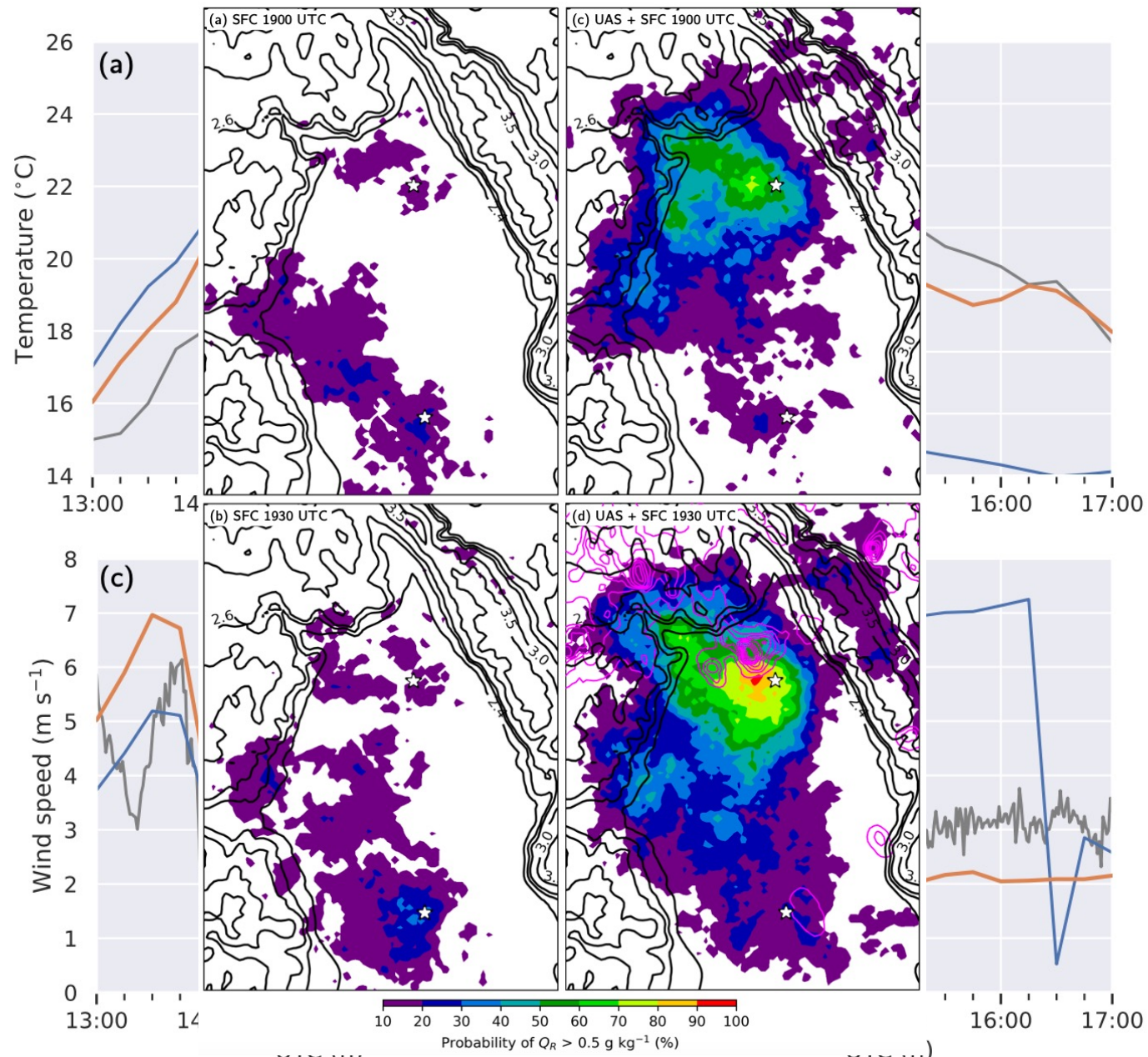




# Supporting Improved Prediction

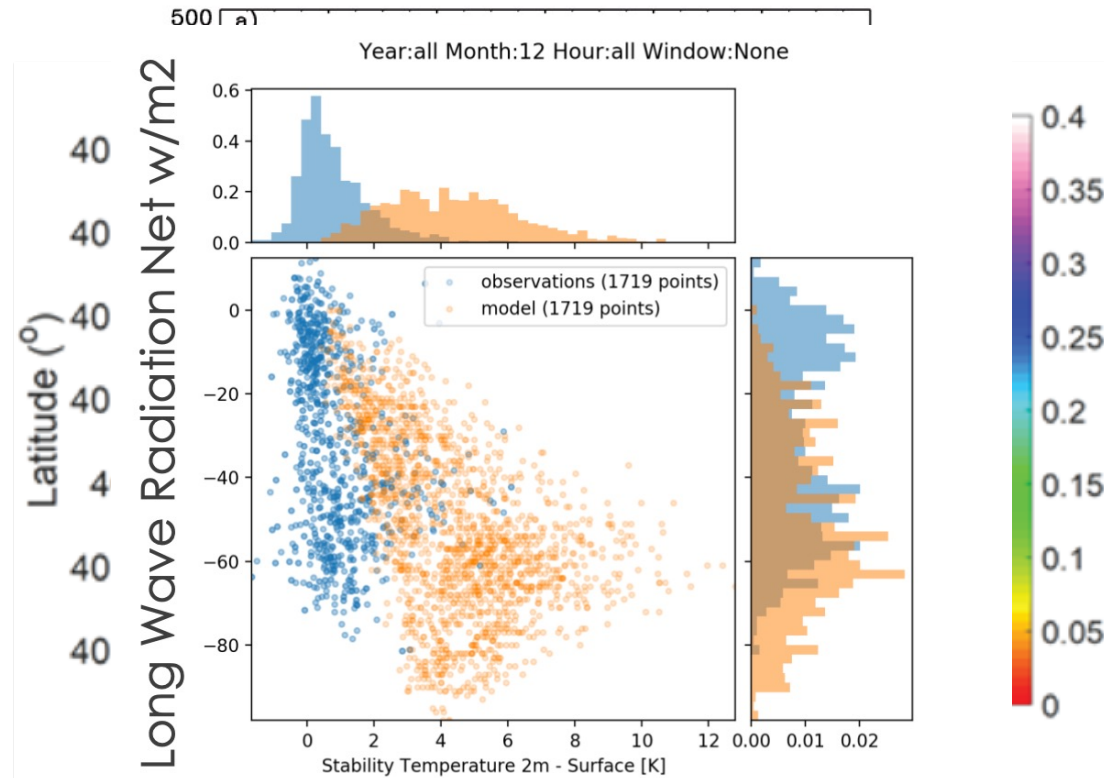
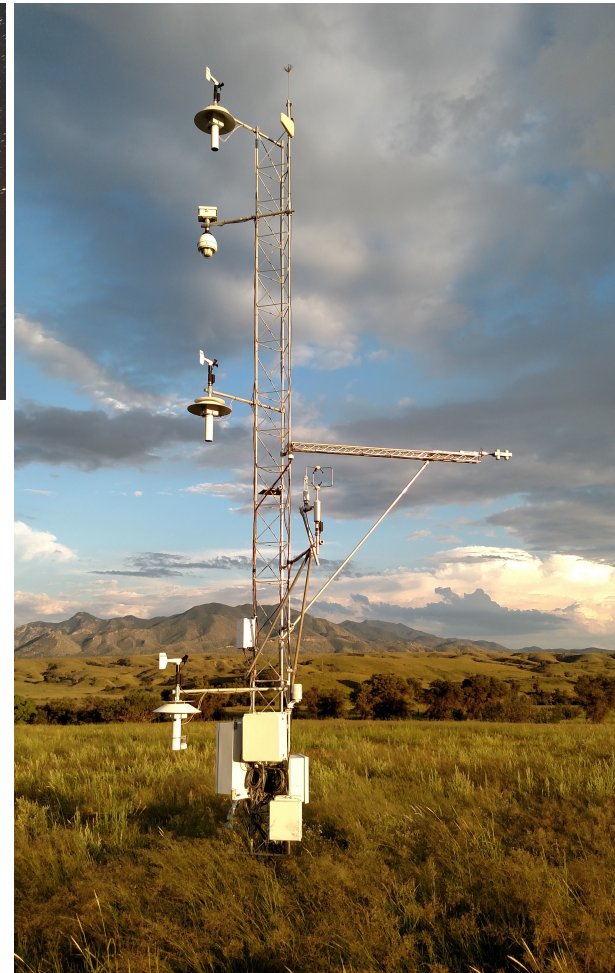


- 14 July
- 15 July
- 16 July
- 17 July
- 18 July
- 19 July
- 20 July





# The Land-Atmosphere Transition Zone



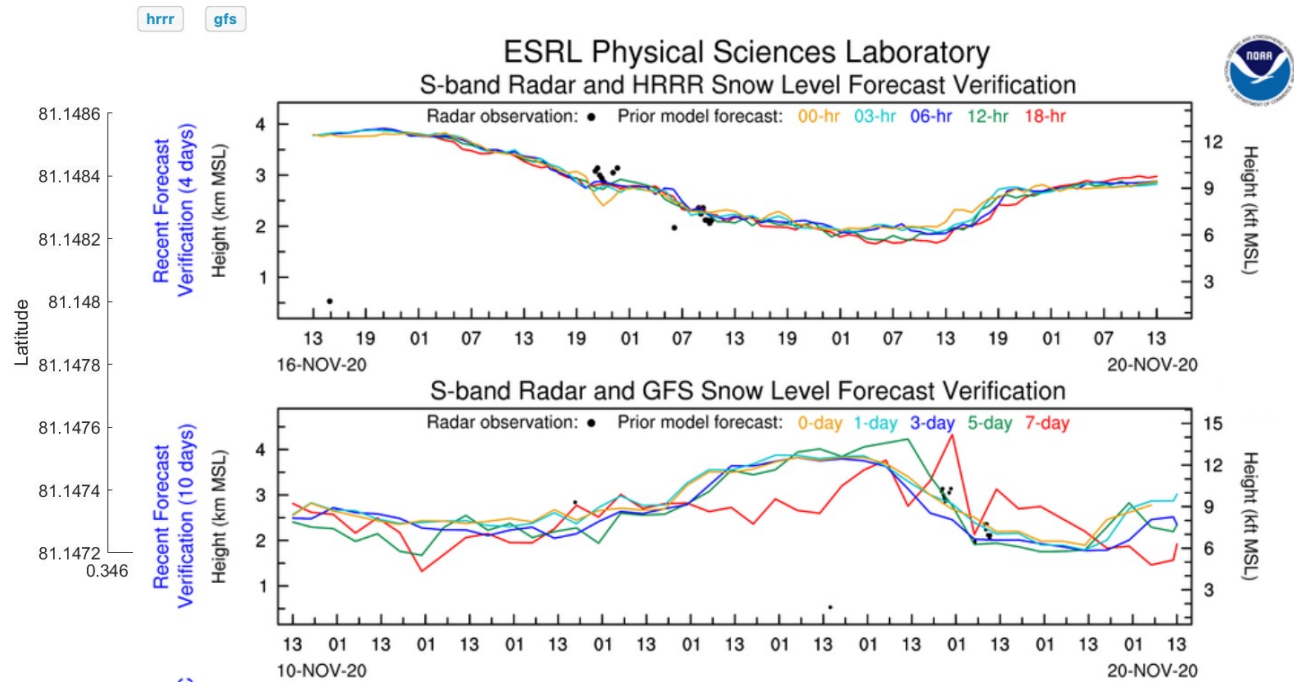
UFS Bench Mark Run 3 (December)

LBLN EESA Leadership Brief, 14 January 2020





# Precipitation and Snow Properties









# NOAA Collaborators and Programs

**Colorado River Basin Forecast Center:** Interest in surface fluxes, particularly evaporation and sublimation to help calibrate and improve hydrological modeling tools used to inform water resource management. Requires distributed, basin scale observations of key terms of evapotranspiration budget.

**Grand Junction Weather Forecast Office:** Would generally “love” (their words, not ours) to have access to additional observational data and are excited to collaborate with us to improve prediction of weather in this part of Colorado.

**Global Systems Laboratory:** Interest in dataset over complex terrain to support model evaluation and improvement.

**Global Monitoring Laboratory:** Interest in improved understanding of surface energy budget, with focus on radiative terms, particularly cloud and aerosol effects and their feedbacks, and their impact on seasonal snow melt.

**Air Resources Laboratory:** Interest in supporting surface energy budget studies in collaboration with GML

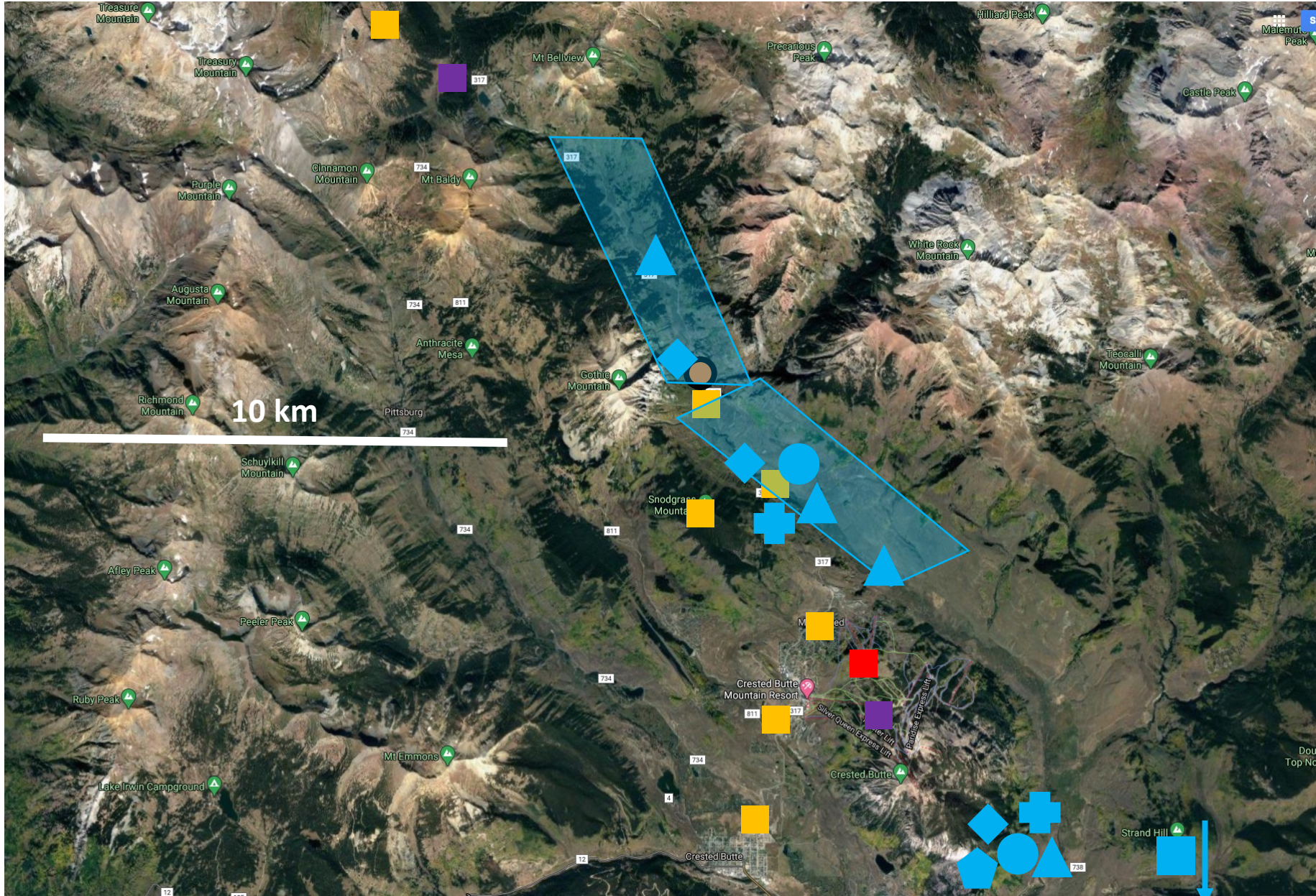
**Weather Program Office:** FY21 competition had specific interest in UAS support of weather prediction, UAS tools for mapping of the surface, gap-filling radar capabilities, snow observations, other innovative observing technologies with emphasis on those with high potential for improving weather and water forecasts and services with strong linkage to operational needs and those that can be used to improve and validate specific physics packages or processes in component models of the UFS.

**Atmospheric Science for Renewable Energy (ASRE) Program:** Interested in observations in support of evaluating the efficiency with which renewable energy can be harvested in areas of complex terrain, specifically including the potential harnessing of wind power in regions with dependable flow regimes (e.g. cold-air drainage events).

**NOAA Science Advisory Board:** Interest in observations and development of integration pathways to inform understanding of precipitation and improve predictive capabilities at various time scales in association with precipitation “grand challenge”.



# SPLASH Concept





# Outreach



## Opportunities:

- Community Day
- Student mentorship through Hollings and RECCS programs
- Development of collaborations with local institutes
- Gunnison Watershed RE-1J School District Summer Experience
- CIRES connections to 4-H and Girl Scouts
- Community engagement through Crested Butte Resort



# SPLASH Status and What's Next



**General:** In partnership with the US DOE and other partners, SPLASH aims to leverage NOAA observational and scientific research infrastructure foster improved prediction of weather and water over complex terrain.

## **Team:**

- NOAA PSL, with contributions from GML, GSL, ARL, CU, CSU, NCAR and industry partners and the US DOE SAIL team
- *In search of: Additional enthusiastic contributors and collaborators*

## **NOAA and Outside Stakeholders:**

- NWS (CBRFC, GJT WFO)
- ASRE program
- DOE Earth and Environmental Systems Science program
- Bureau of Reclamation
- *In search of: Additional stakeholders in NOAA and beyond*

## **Funding:**

- NOAA PSL supporting deployment of some observing assets, and science/analysis to support UFS and NWM advancement
- NOAA WPO proposal to support NWS stakeholder interface, UAS DA studies, and limited additional asset deployment
- *In search of: Additional support for deployment of UAS, x-band radar, SEB stations, boundary layer profilers, and analysis*