

## **Persistent scientific uncertainties, recommendations to address improvements**

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### Measurement Uncertainties

- Data acquisition and accessibility at instrumented sites
- Sensor errors and noise
- Sensor upkeep
- Precipitation undercatch
- Representativeness of single station, and interpolation from station to landscape
- Precipitation phase
- Albedo impacts
- Wind redistribution of snow
- Complex relationship between vegetation and snow
- Complex relationship between surface and groundwater hydrology

### Modeling Uncertainties

- Propagation of measurement uncertainties into models, models can only be as good as the data forcing them
- The complexity of physically based models introduces uncertainty if all inputs/parameters are not known/understood
- Calibration and assumption bias
- Models developed in one region may not represent processes in another region, or represent processes that may occur in the future with a changing climate

*Recommendation: Carry out model intercomparisons at sites where all known inputs can be measured/defined. Know your models- don't assume all models will work everywhere or that they necessarily represent all current and future processes.*

### Definition Uncertainty

- For example, what constitutes glacier contribution to hydrology?

*Recommendation: Come up with definitions to limit ambiguity*

### Scale Uncertainty

- Catchment classification, for example, uncertainty in delineation and parameterization of HRU selection criteria
- Satellite data does not necessarily compare to point data, many processes are scale dependent

### Known vs unknown uncertainties

- Precipitation- not well represented by models nor measurements, unknown uncertainty
- Snow gauge undercatch- controlled by particle size and particle velocity, in turn controlled by temperature-known uncertainty

*Recommendation: Can instrument intercomparison help address the unknown uncertainty (like SPICE)? Could modeling help address the known uncertainties (upper atmosphere temperature modeling to inform particle size/velocity)?*