

# Improved snow albedo evolution in Noah-MP land surface model coupled with a physical snowpack radiative transfer scheme

Tzu-Shun Lin<sup>1</sup>, Cenlin He<sup>1</sup>, Ronnie Abolafia-Rosenzweig<sup>1</sup>, Fei Chen<sup>2</sup>,  
Wenli Wang<sup>3</sup>, Michael Barlage<sup>4</sup>, and David Gochis<sup>5</sup>

<sup>1</sup>NSF National Center for Atmospheric Research, Boulder, CO, USA

<sup>2</sup>Hong Kong University of Science and Technology, Hong Kong, China

<sup>3</sup>Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

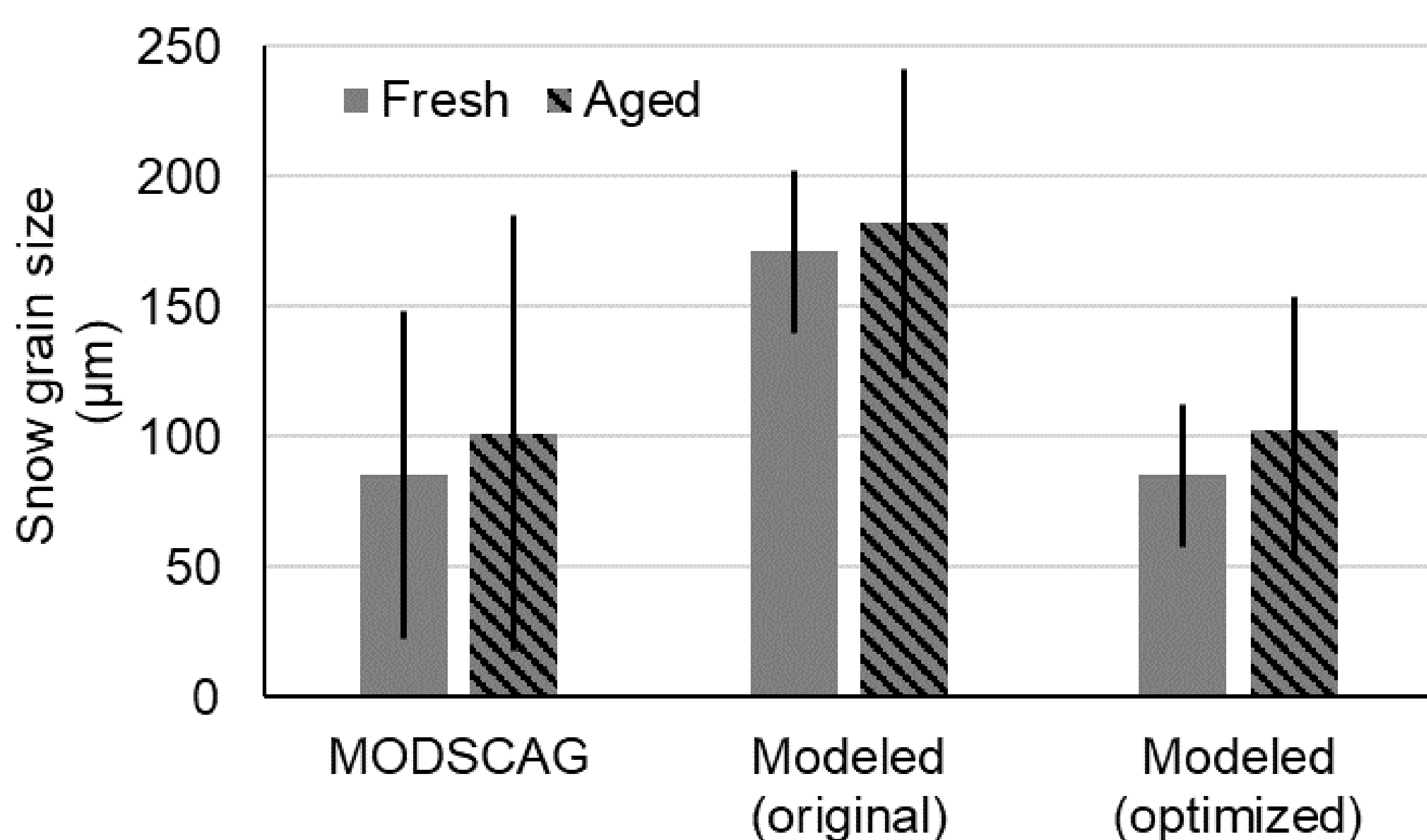
<sup>4</sup>National Oceanic and Atmospheric Administration, Boulder, CO, USA

<sup>5</sup>Airborne Snow Observatories, Inc., Crowley Lake, CA, USA

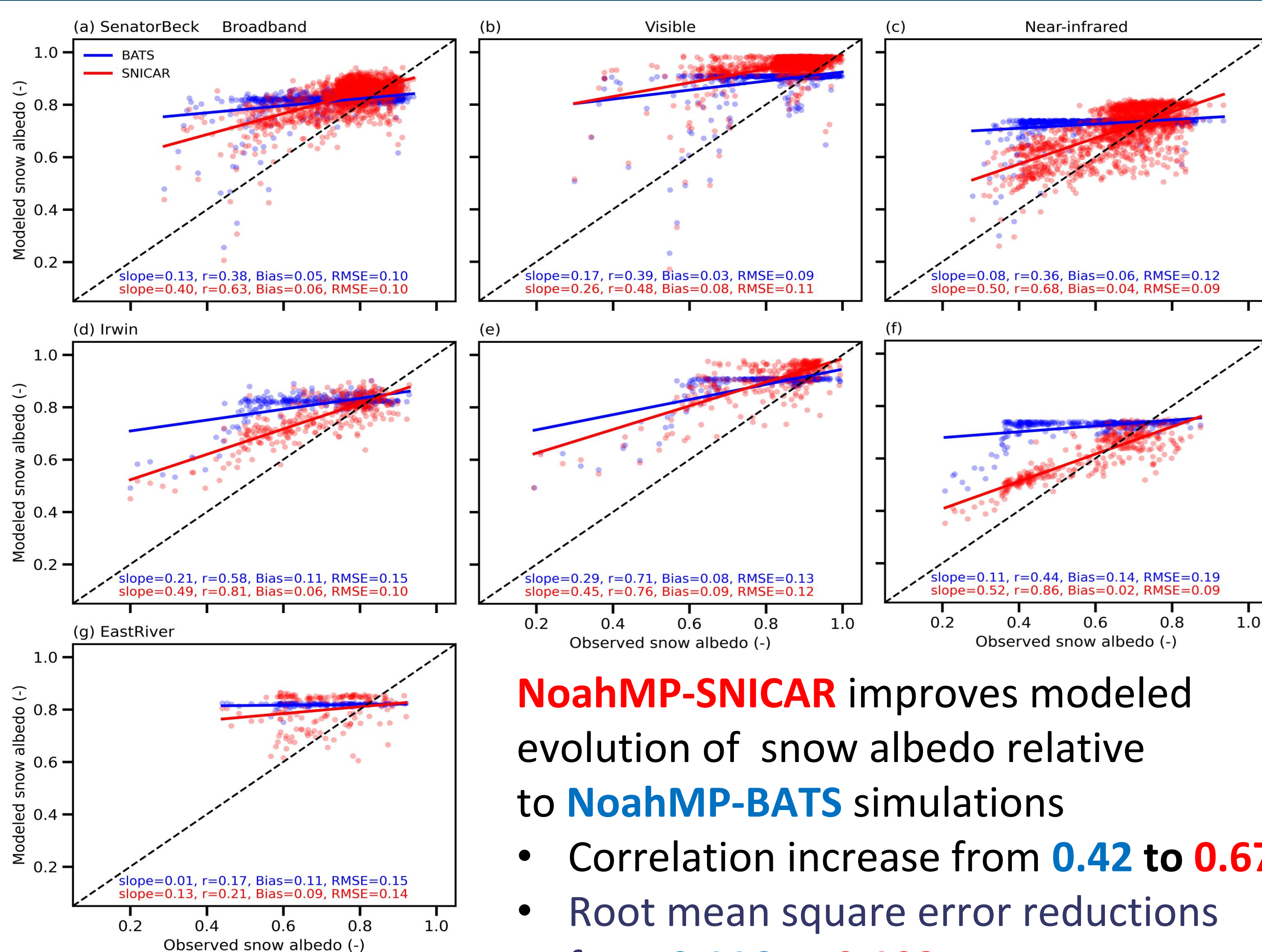
## Objective

- The widely-used community **Noah-MP land surface model (LSM)** currently adopts **snow albedo** parameterizations (Verseghy, 2007; Yang et al., 1997) that are **semi-physical** in nature that have systematic biases which impact the accuracy of weather and climate modeling systems.
- The **Snow, Ice, and Aerosol Radiative (SNICAR)** model (Flanner et al, 2007, 2021) is a snowpack radiative transfer models that simulates the snow albedo by considering snowpack properties such as **grain size and shape**, and environmental conditions including the presence of **light-absorbing particles (LAPs)**.
- An old version of SNICAR transfer calculation has been coupled with an old version of Noah-MP LSM over Tibetan Plateau (Wang et al., 2020).
- We have implemented the **latest SNICAR** model into the **latest modernized Noah-MP version 5.0** (He et al., 2023) and evaluated at three central-southern Rocky Mountain observation sites, Senator Beck, Irwin, and East River.

## Optimization of the snow grain size parameters



## Model evaluation



## Noah-MP model configurations

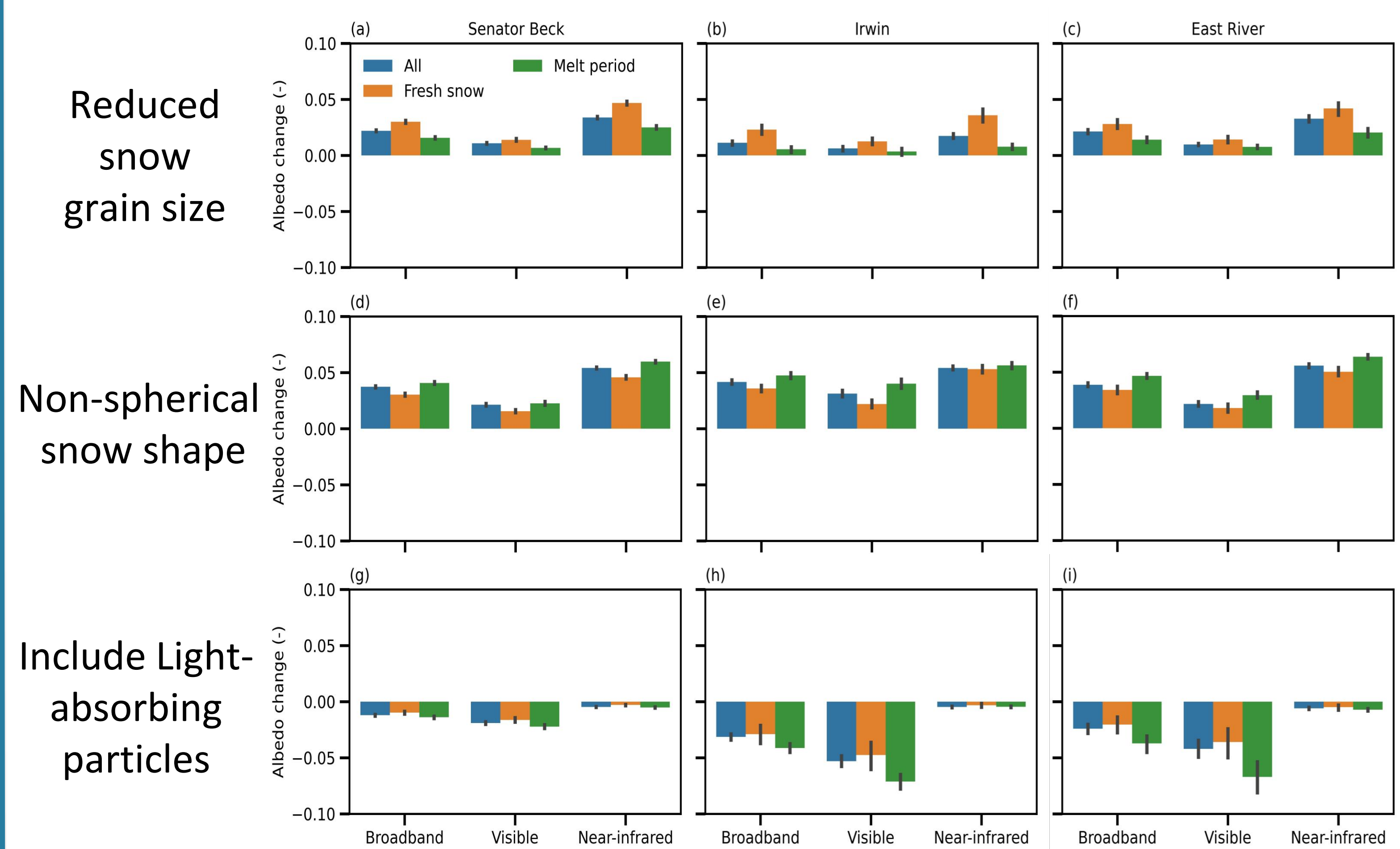
Experiments	Snow albedo scheme	Snow grain size <sup>1</sup>	Snow shape	Snow impurities <sup>2</sup>
Exp1 (baseline)	SNICAR	Optimized	Hexagonal	LAPs
Exp2	Same as Exp1	Original	Same as Exp1	Same as Exp1
Exp3	Same as Exp1	Same as Exp1	Spheres	Same as Exp1
Exp4	Same as Exp1	Same as Exp1	Same as Exp1	No LAPs
Exp5	BATS	-	-	-

<sup>1</sup>Optimize the snow grain size with the satellite retrieval, MODSCAG (Painter et al., 2009).

<sup>2</sup>Light-absorbing particles (LAPs) include the dust, organic carbon (OC), and black carbon (BC) with snow.

## Albedo changes in Noah-MP/SNICAR

Effects of changes in snow grain size (Exp1-Exp2), non-spherical snow shape (Exp1-Exp3), and light-absorbing particles (Exp1-Exp4)



- The average changes in albedo caused by snow grain size, snow shape, and light-absorbing particles are 0.018, 0.039, and -0.022

## Summary

- We enhance Noah-MP v5.0 snow albedo processes by integrating physical snow radiative transfer and aging processes from the latest SNICAR model.
- Snow albedo evolution and variability exhibits higher accuracy in NoahMP-SNICAR compared to the default Noah-MP v5.0 snow albedo scheme
- The new development of NoahMP-SNICAR physics provides a means to improve snow albedo accuracy and reduce corresponding uncertainties while providing new modeling capabilities such as hyperspectral snow albedo, and effects of snow grain size, snow grain shape, and light-absorbing particles in future studies.

NoahMP-SNICAR model code updates are publicly available:  
[https://github.com/tslin2/hirdas\\_snicar.git](https://github.com/tslin2/hirdas_snicar.git)