Fusion of MODIS, VIIRS, and Landsat snow cover data to create high spatial and temporal resolution estimates of snow water equivalent in a well-instrumented and austere basin

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MODIS VIIRS Science Team Meeting, MODIS Land Science and Data Analysis, The Hotel at UMD, Calvert Ballroom Salon A/B, 11/19/2019 11:30 am


IMALAYAN


SKY ONE
SKY ONE

Why did we go to Manali, India?

- To add to our growing set of snow measurements in the Indus River Basin, and part of a broader effort for in situ snow validation measurements in High Mountain Asia
- Supplements our datasets from the Aga Khan Agency for Habitat (AKAH, Bair et al., in review), the Gulmarg Ski Area, and planned work in Shymbulak, Kazakhstan and Mt Yulong, China, both just selected as part of HiMAT2 (NASA 2019 A40)

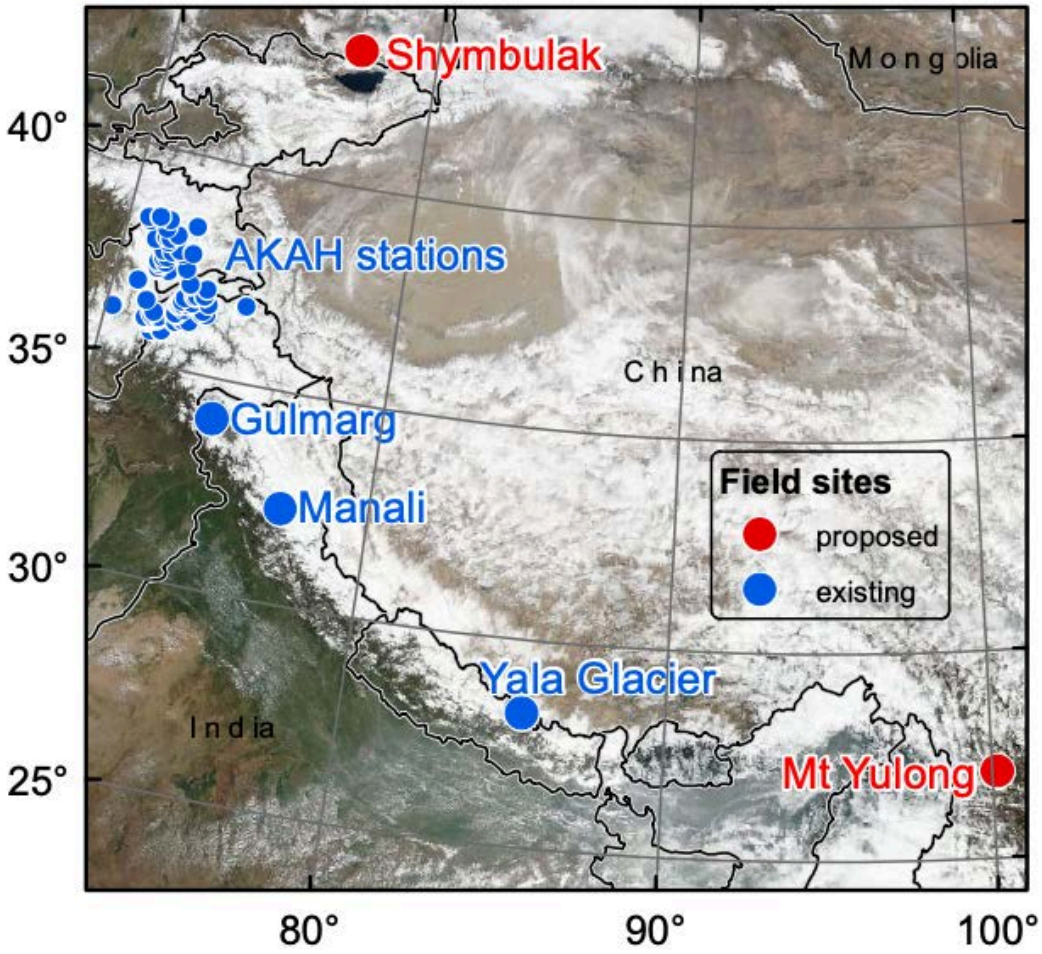
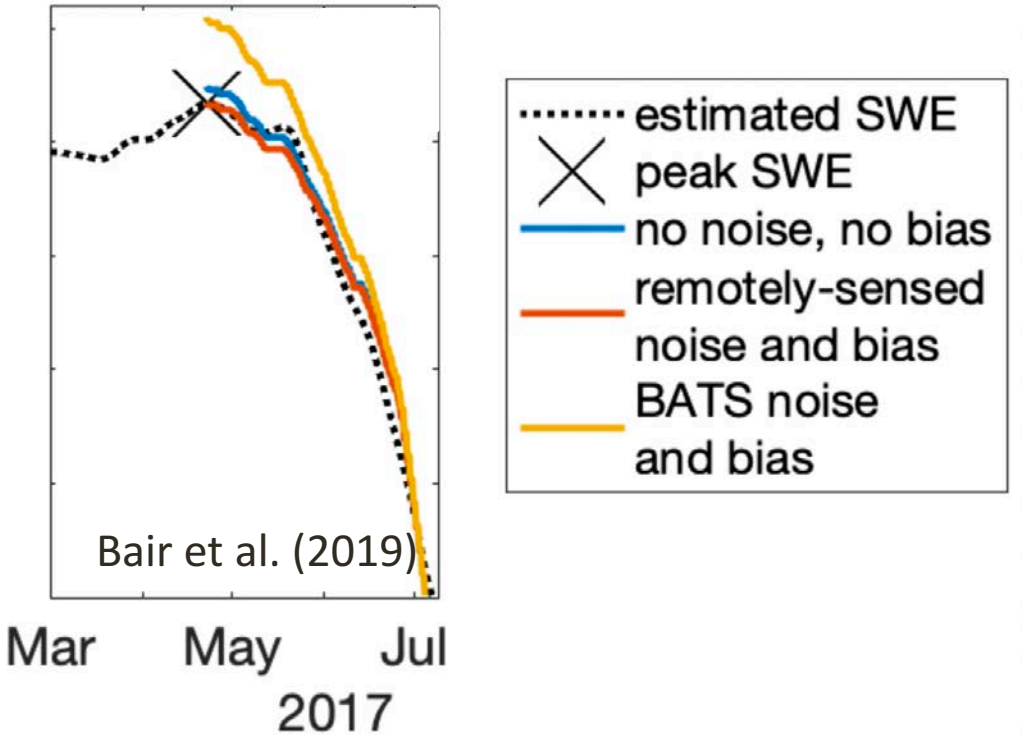


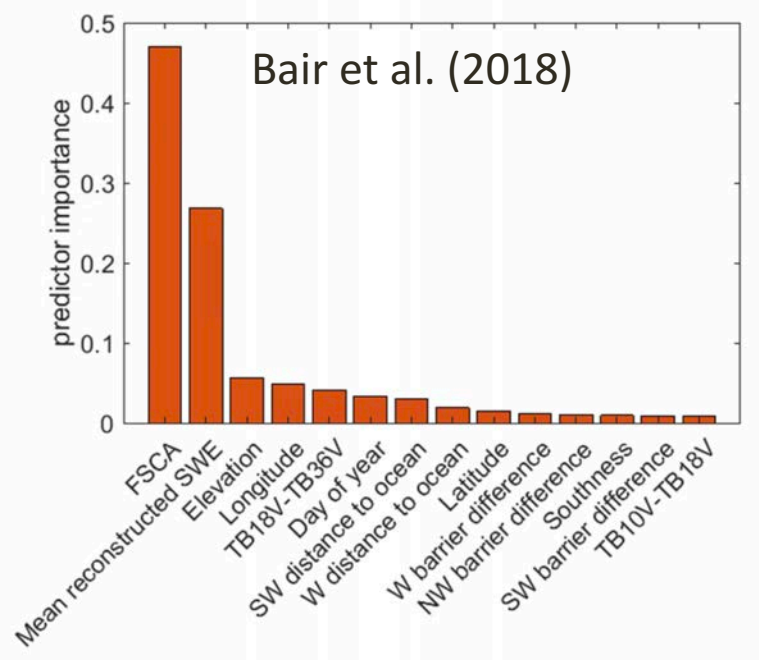
Figure 3: Study area with proposed and existing field validation sites.

from Rittger et al. (2019) HiMAT2 proposal

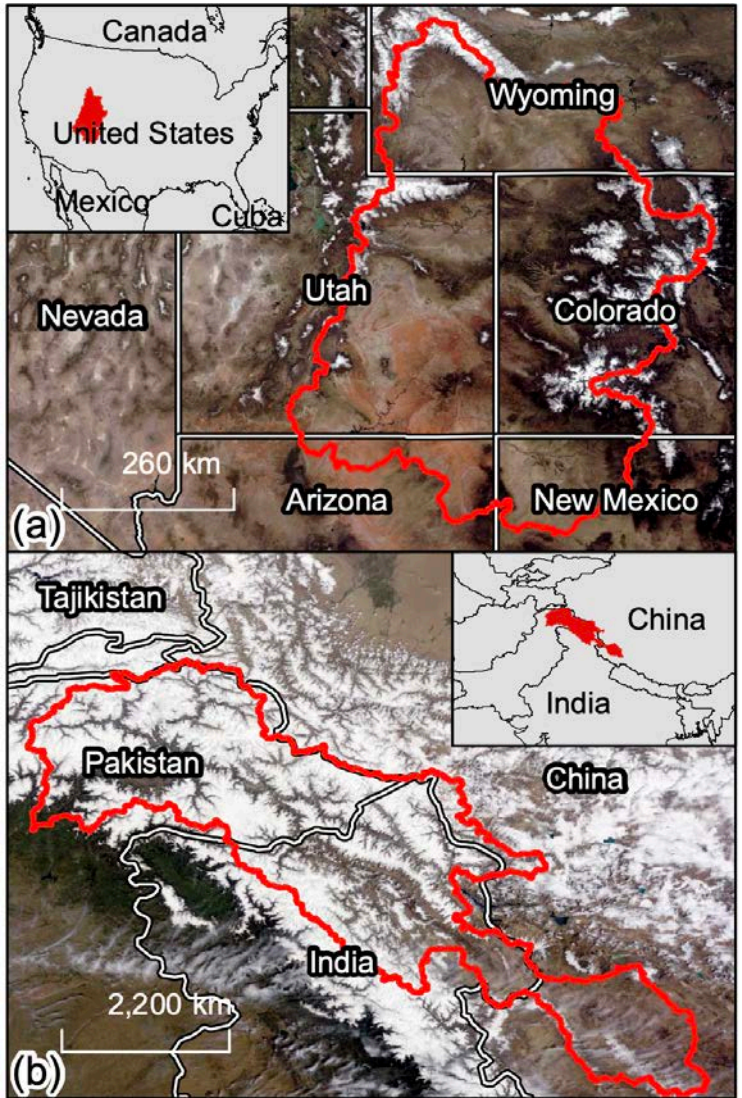
Approach

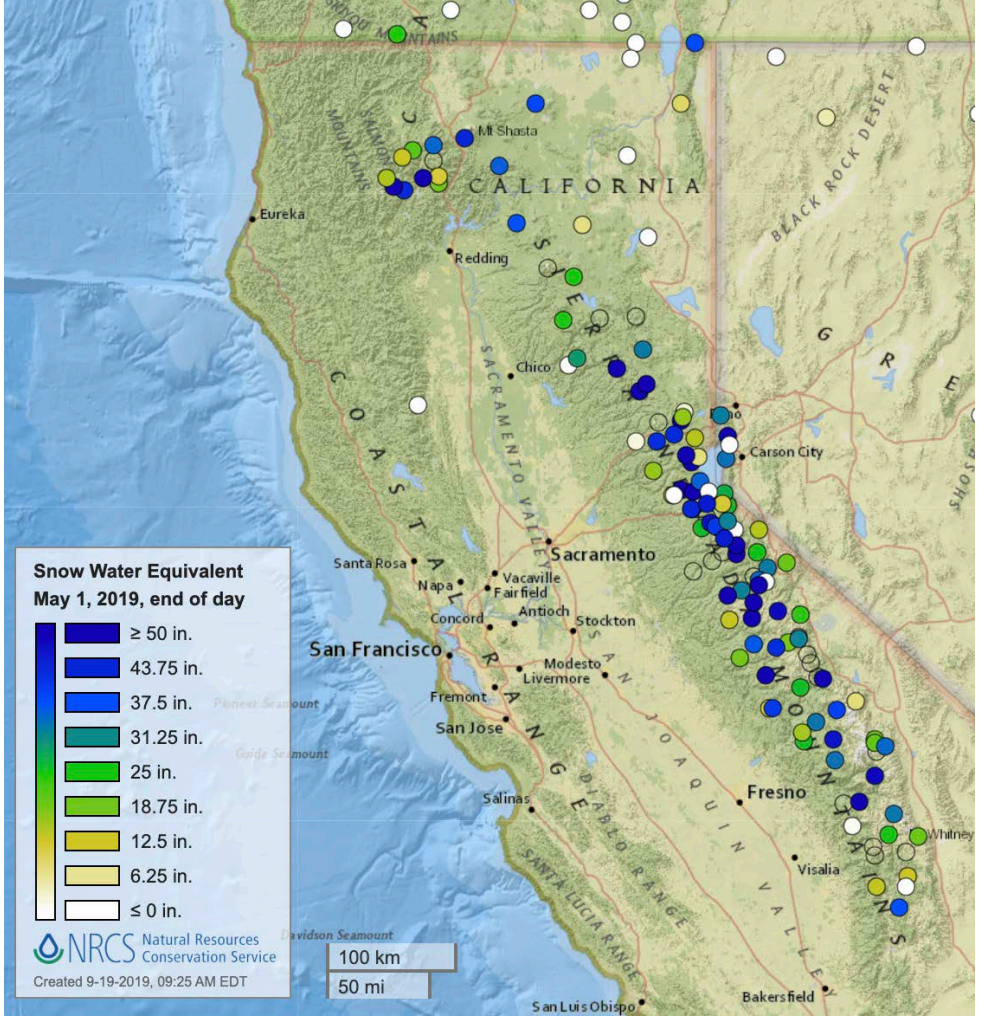
1. Working on a fused MODIS/VIIRS & Landsat high spatial and temporal resolution fractional snow covered area (fSCA) and snow albedo product
2. This snow cover product will be used to force a reconstruction model, where the snowpack is built up in reverse from melt out to peak snow water equivalent (SWE) using the energy balance components. Only works after snow has melted out.
3. Once we have a large catalog of reconstructed SWE (e.g. over the entire MODIS-era), we can train machine learning approaches to predict today's SWE using predictors available in real-time (e.g. fSCA, SWE climatology, physiographic variables)





Well instrumented & austere basin

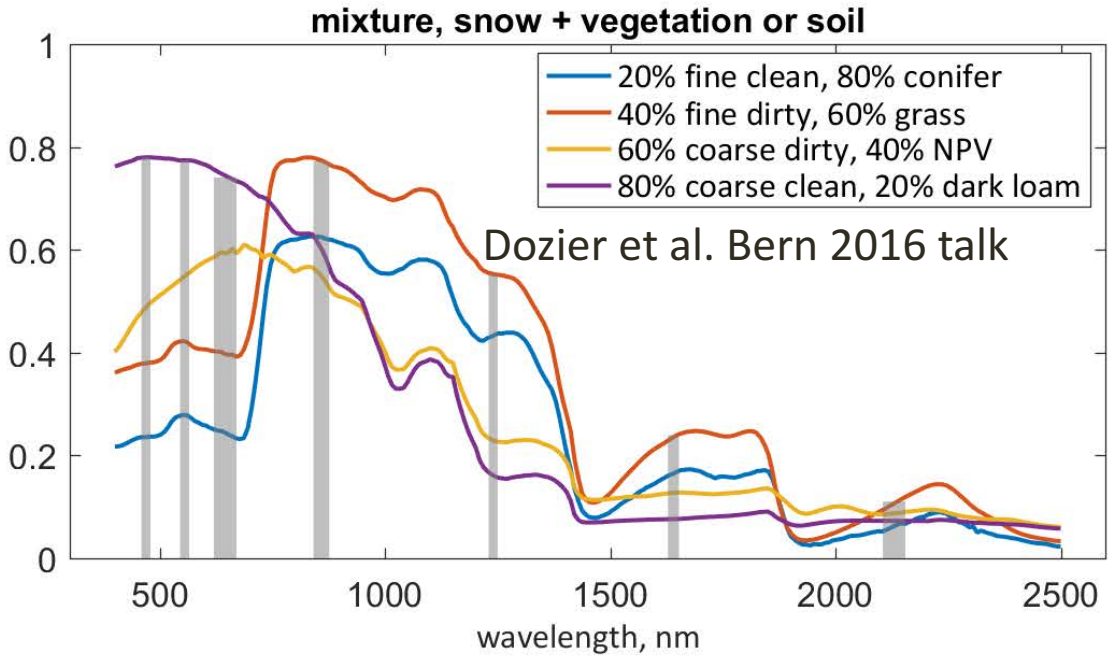




- We test and adjust these approaches using well instrumented basins, e.g. all of Sierra Nevada or upper CO
- Then we implement in a austere basin, e.g. upper Indus

Spectral unmixing approach

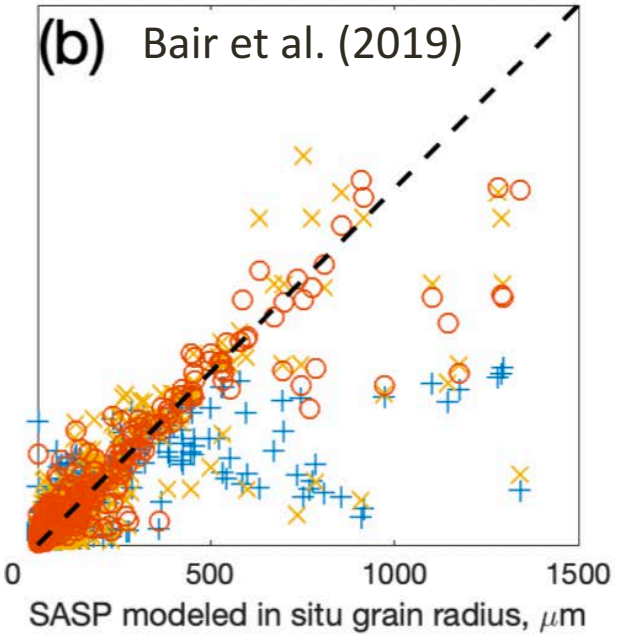
- As I talked about last year (e.g. Selkowitz et al. 2014), almost all pixels in the mountains are mixed, so we need to unmix them.

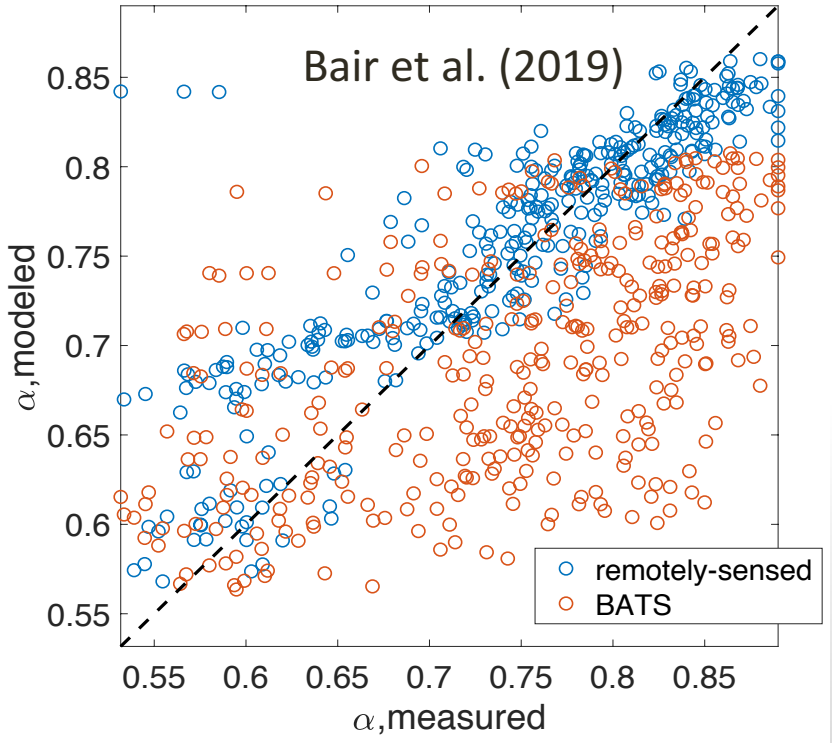


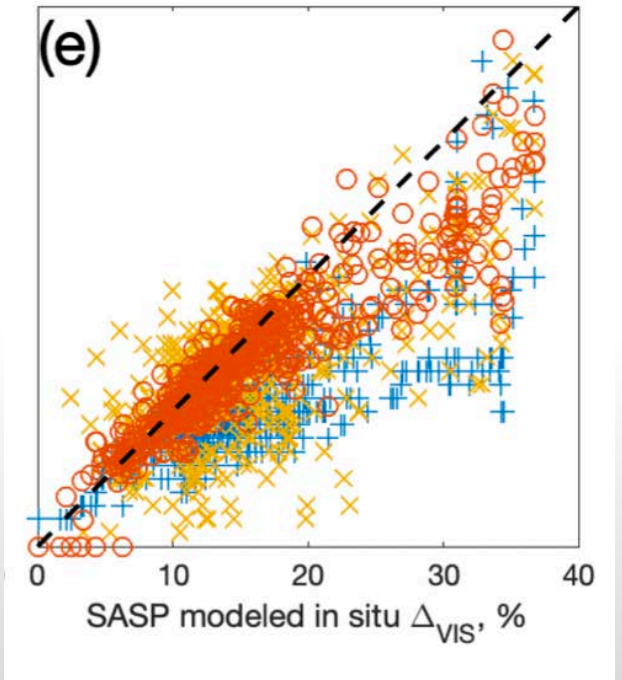
- We currently use time-spaced smoothed MODIS Snow Covered Area and Grain Size (MODSCAG, Painter et al. 2009) to get fSCA and grain size, then MODIS Dust and Radiative Forcing in Snow (MODDRFS, Painter et al. 2012) for the visible albedo degradation due to dust

Snow (not whole pixel) albedos can be accurately retrieved from MODIS

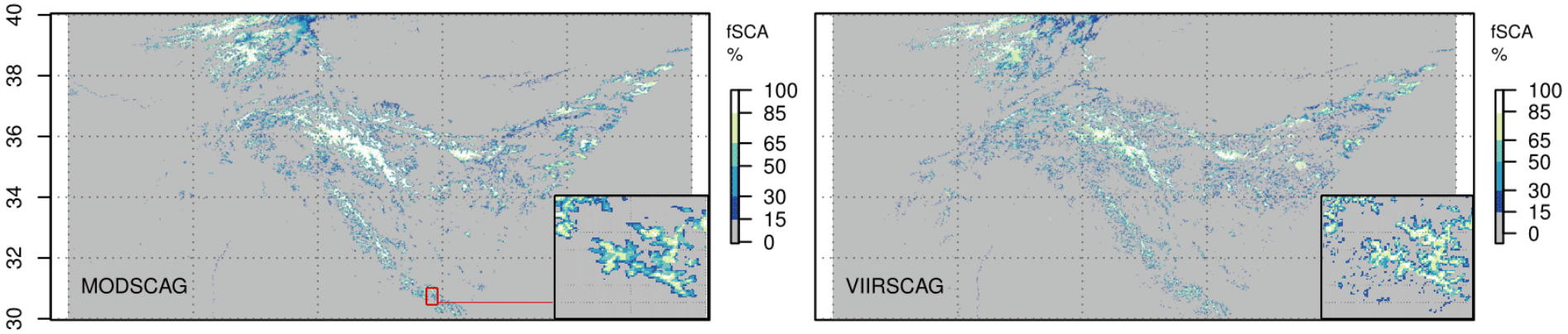
- The MODSCAG/MODDRFS albedos are much better than the widely used BATS (Dickinson et al., 1993) aging scheme
- Room for improvement for the large grain sizes and dirty snow



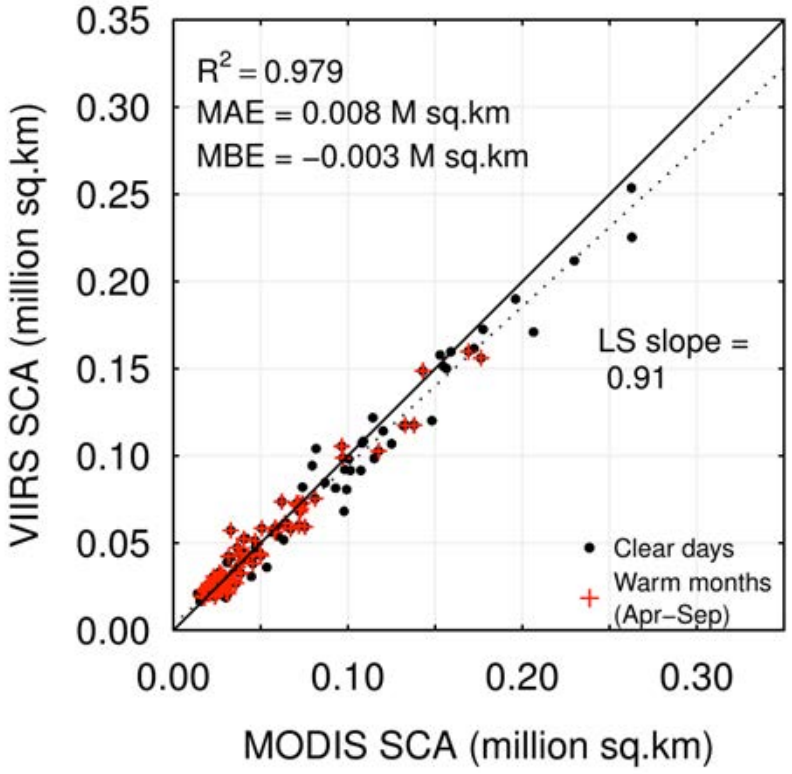




VIIRSCAG vs. MODSCAG



Rittger et al. (in prep)

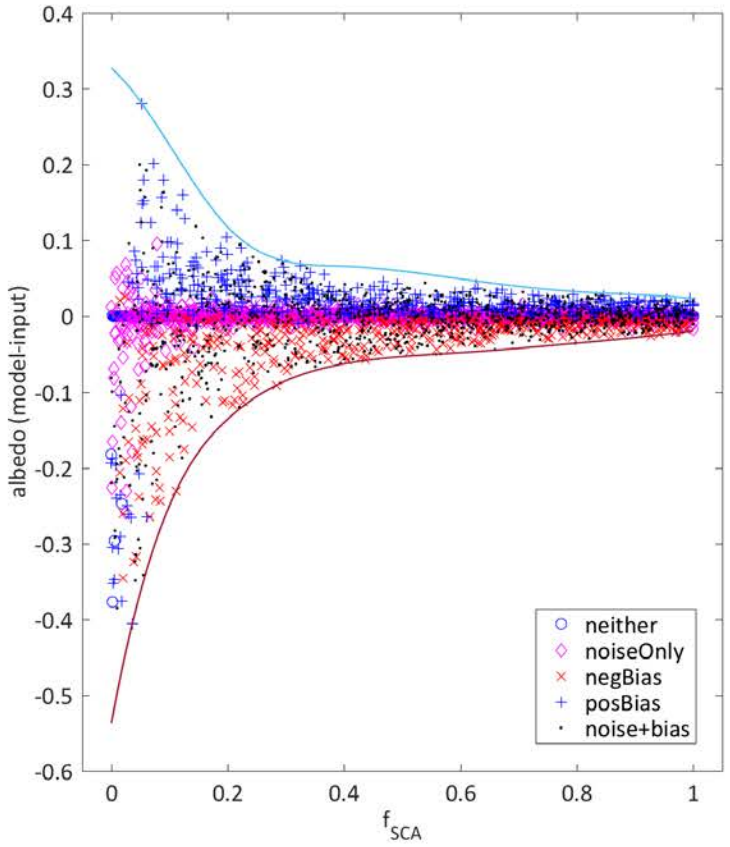


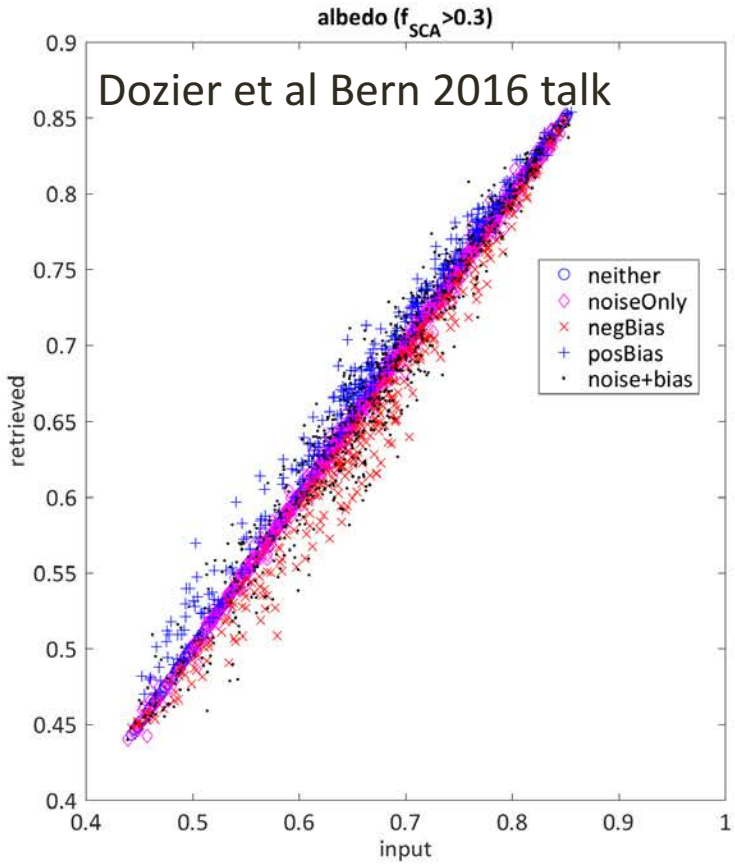
- MODSCAG & VIIRSCAG show comparable performance, despite coarser surface reflectance for VIIRS
- This was using early release surface reflectance (DSRF1KD) @ 1.0 km vs. MOD09GA @ 0.5 km, maybe because of subpixel de-aggregation
- Congressional justification sent to Roman:

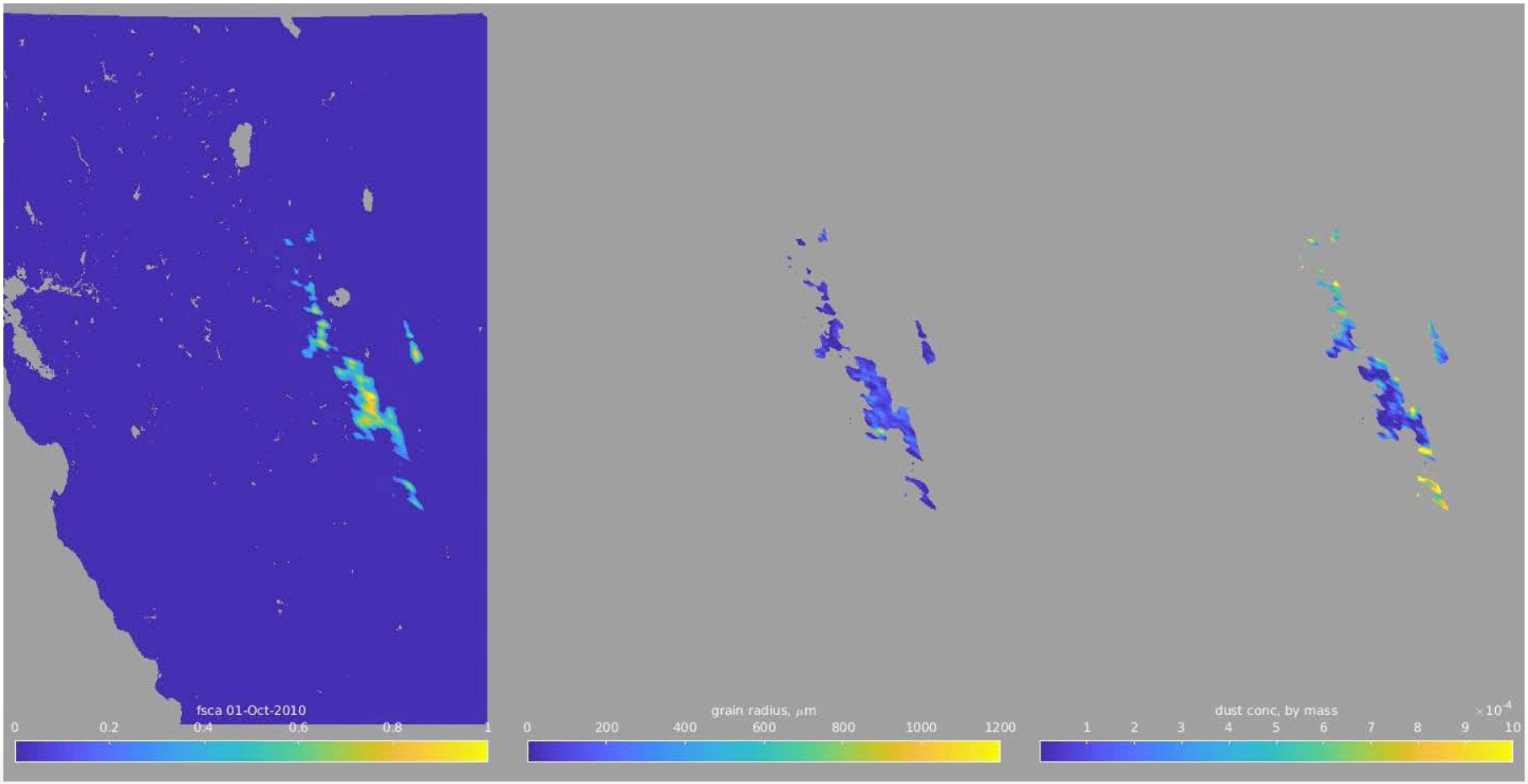
Researchers Kat Bormann (JPL), Karl Rittger (U Colorado, Boulder), and Ned Bair (U California, Santa Barbara) are developing a snow mapping algorithm for the VIIRS satellite sensor. This algorithm will allow researchers to continue mapping snow worldwide more accurately than the standard NASA snow cover products, and is timely as the MODIS sensors near their end of life.

New spectral unmixing approach

- Snow Covered Area and Grain Size + Dust (SCAGD) – no good name yet
- Innovations: 2 endmembers (snow & background); simultaneously solve for fsca and dirty snow albedo (grain size & impurity concentration)
- Should work theoretically, but having problems distinguishing vegetation from dust/black carbon

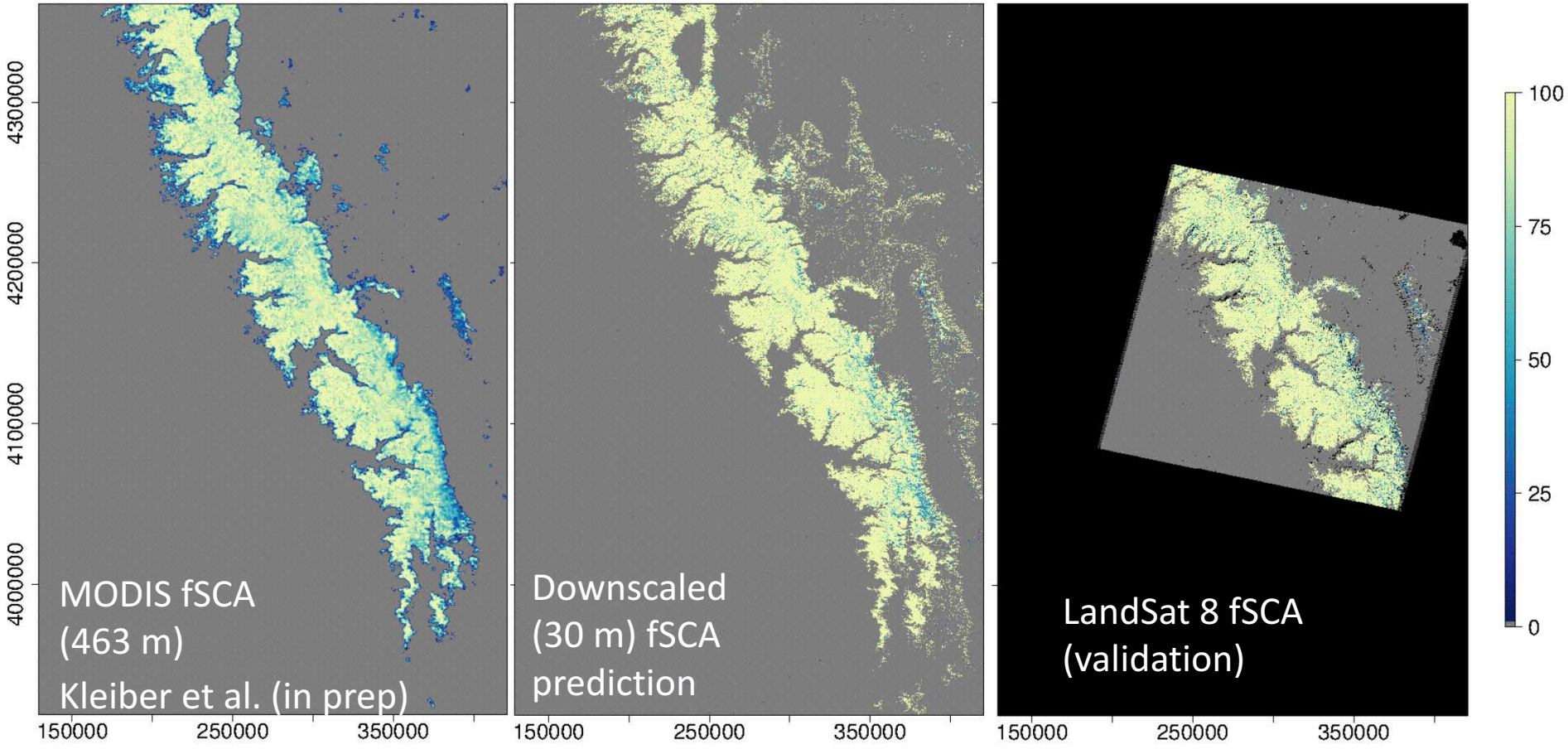





fsca 01-Oct-2010
0
0.2
0.4
0.6
0.8
1
grain radius, μm
0
200
400
600
800
1000
1200
dust conc, by mass
×10⁻⁴
1
2
3
4
5
6
7
8
9
10

MODIS/VIIRS & Landsat fusion

- For efficiency, 2 stages:
  1. Random Forest 3 group classification: 0%, 100%, or 0-100% fSCA
  2. On 0-100% fSCA, a second Random Forest regression is run
- Both stages use the same predictors: MODIS fSCA, day of year, and physiographic features (slope, aspect, elevation and land use type) and are fit with LandSat 8 fSCA (OLI SCAG).



Plan

- Started year 2/3 in October 2019

1. Adjust fusion downscaling model, e.g. try wind predictors
2. Once satisfied with downscaling model, create time/space cubes for well-instrumented and austere basins
3. Run reconstructions for well-instrumented and austere basins
4. Validation of reconstructions using new in situ snow measurements
5. Run machine learning for well-instrumented and austere basins
6. Continued parallel development of SCAGD & VIIRSCAG