Western Energy Balance of Snow (WEBS)

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JPL

SOL
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WEBS Sites

Senator Beck Basin Study Area

Swamp Angel Study Plot

Senator Beck Study Plot

CSAS

Grand Mesa Study Area

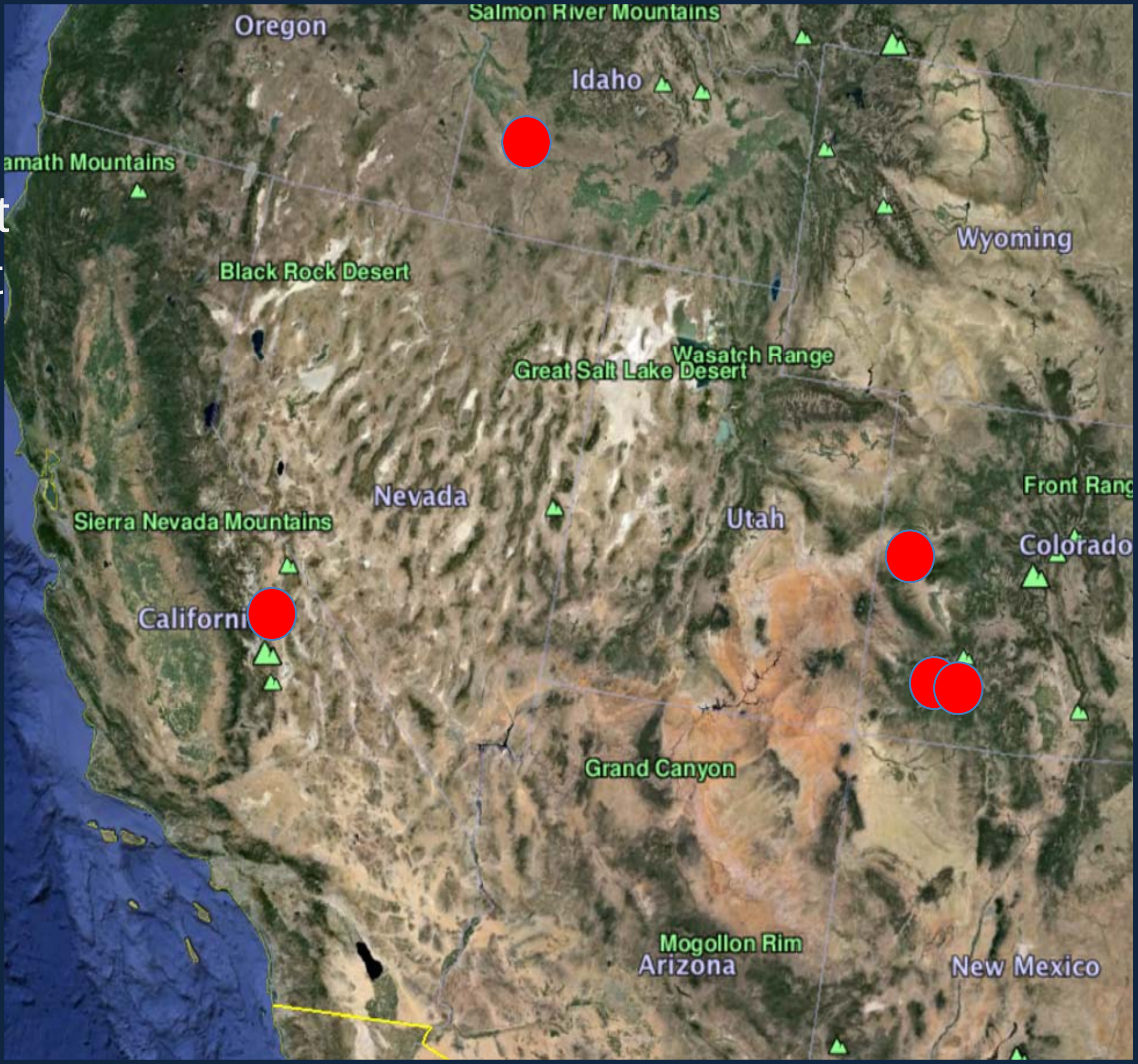
SOL-JPL

Mammoth CUES site

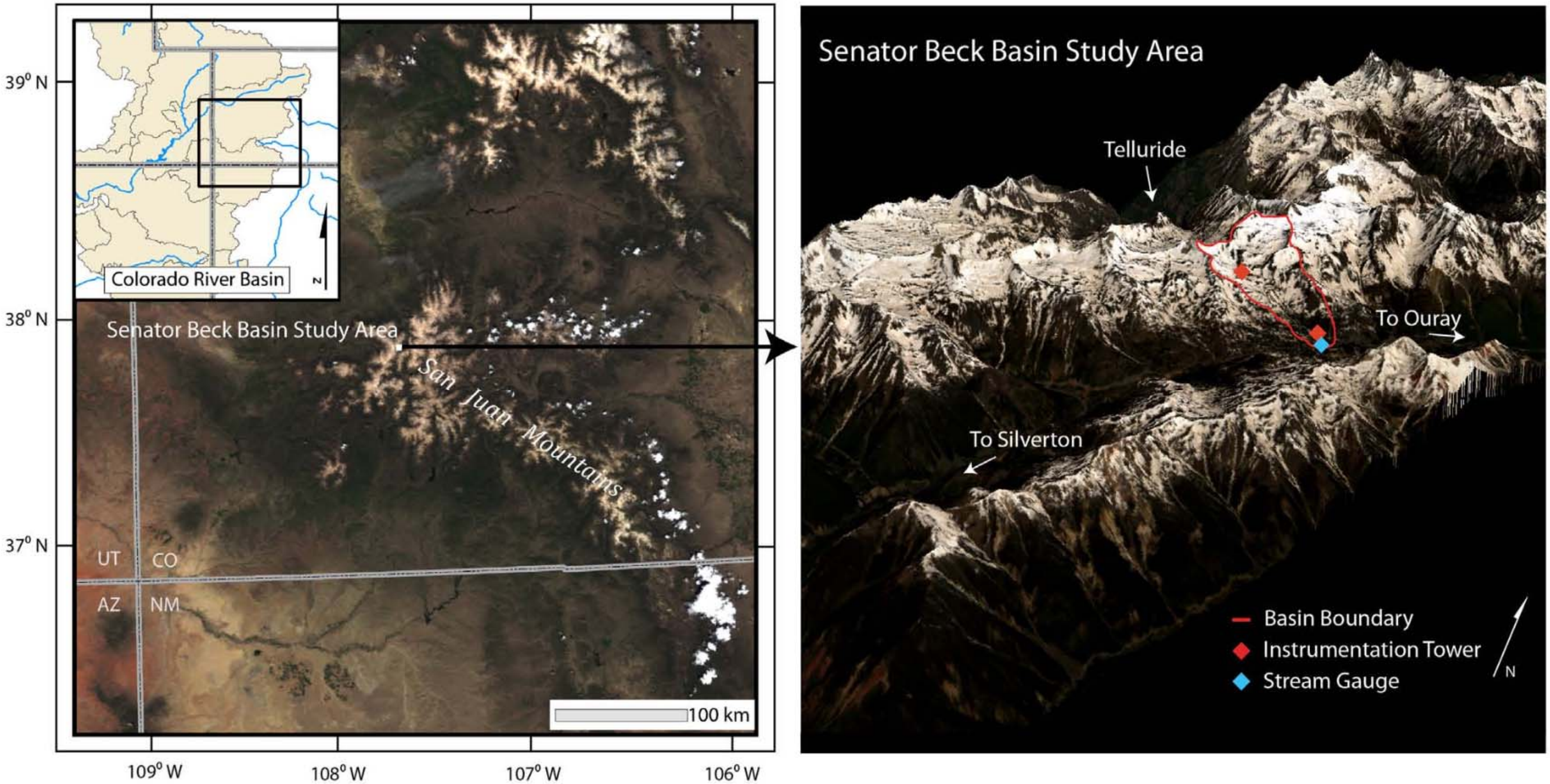
USCB-CRREL

Reynolds Creek Watershed

USDA-ARS



Senator Beck Basin Study Area (SBBSA)



Established by Thomas Painter and Chris Landry in 2003 to study the hydrologic impacts of dust on snow, first measurements began in WY 2005 (*Painter et al*., 2012; *Landry et al*., 2014)

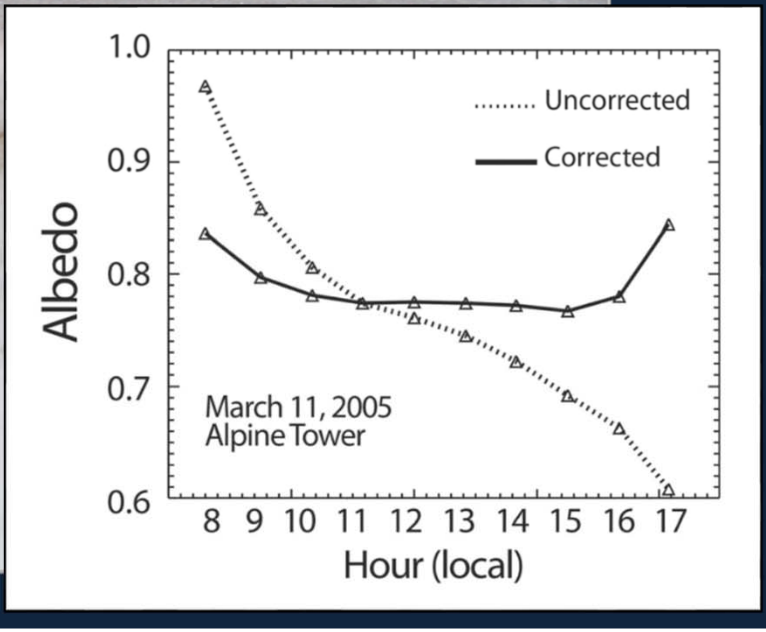
SBBSA
Senator Beck Study Plot

- 10 m tower
- 12x36 snow profile plot
- Alpine @ 3719 m
- Ski in access only, visited less frequented than subalpine site due to high avalanche danger
- Monthly ASO over flights (lidar/imaging spectrometer)

Measurement/Instrument/Range	Subalpine	Alpine
Up/down broadband shortwave fluxes; Kipp&Zonen CM21 pyranometer; 0.285–2.800 µm	•	•
Up/down filtered shortwave fluxes; Kipp&Zonen CM21 pyranometer w/RG695 glass; 0.695–2.800 µm	•	•
Longwave irradiance; Kipp&Zonen CG4 pyrgeometer; 4.500–42.000 µm	•	•
Snow surface temperature; AlpuG GmbH SnowSurf	•	•
Air temperature and relative humidity; Campbell/Vaisala CS500-U (2 heights)	•	•
Wind speed and direction; RM Young 05,103-5 (2 heights)	•	•
Barometric Pressure; Campbell/Vaisala PTB101B (CS105)	•	•
Precipitation; ETI Instrument Systems Noah II	•	

SBBSA Swamp Angel Study Plot

- 6 m tower
- 30x30 snow profile plot
- Subalpine @ 3368 m
- Easily accessible on skis/snowshoes



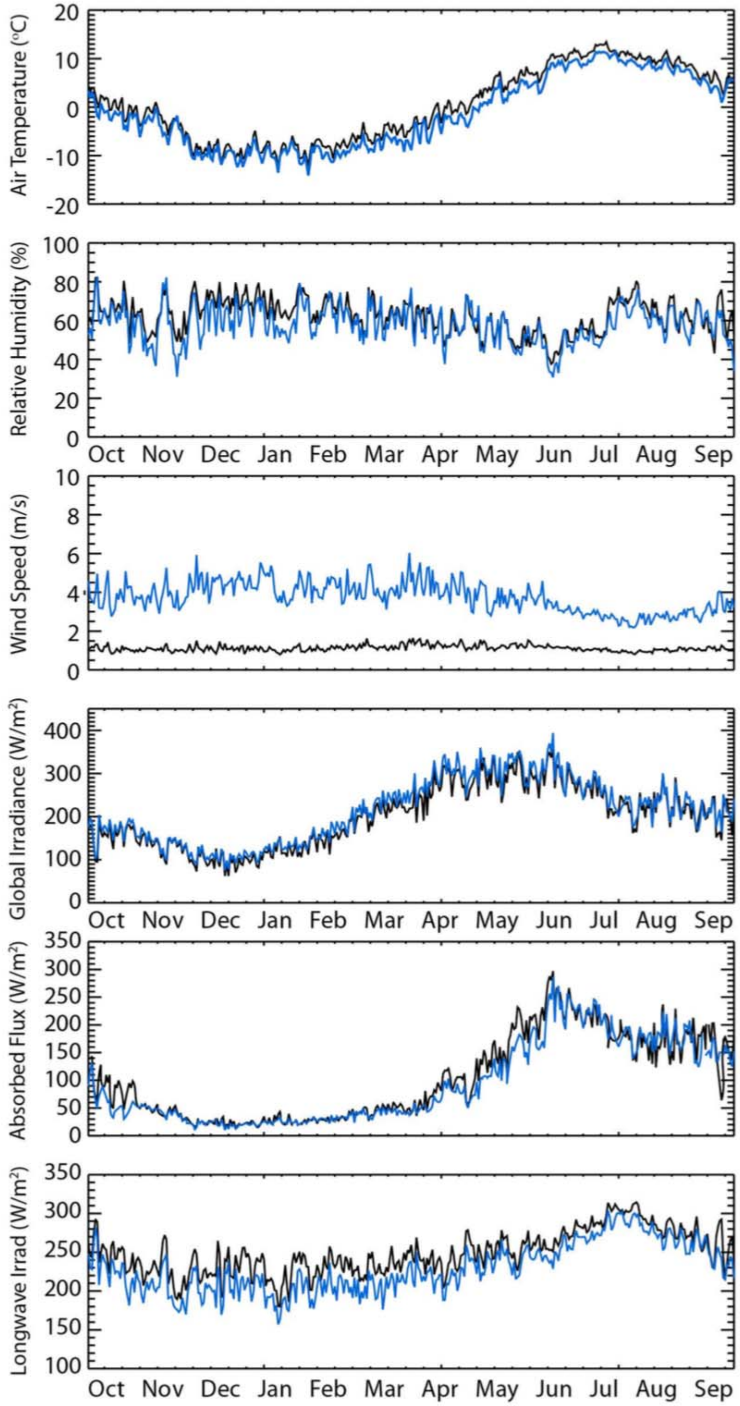
SBBSA Additional Instrumentation

- Aerosol optical depth and other atmospheric column properties are measured nearby the subalpine site with a CIMEL sunphotometer (NASA-AERONET; Red_Mountain_Pass)

- Runoff at the basin pour point (100 m below the subalpine site) is measured by the Senator Beck Stream Gauge (SBSG)

SBBSA Climatology

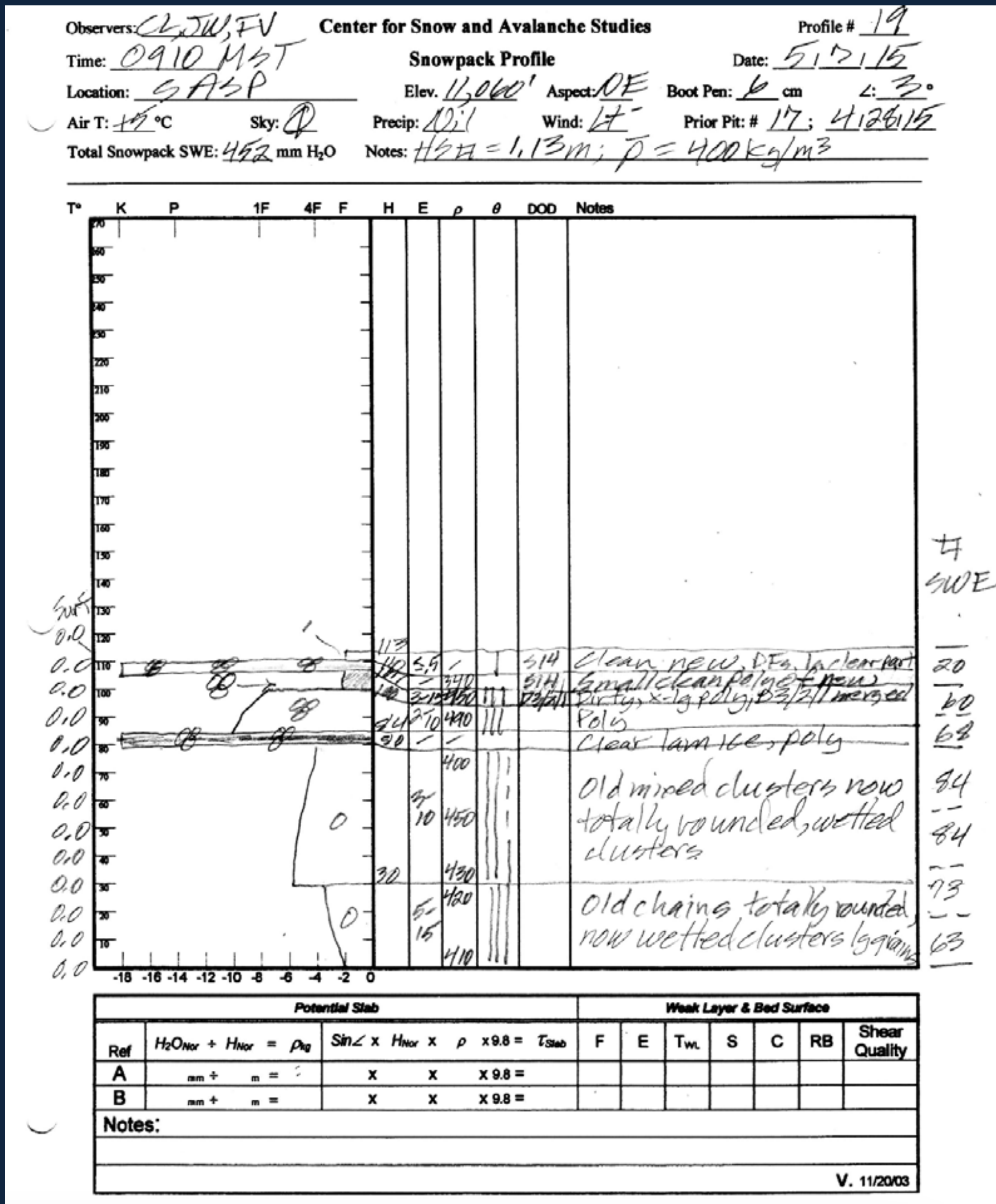
- SBSP is slightly colder, has lower relative humidity, and is much windier relative to SASP
- Given its higher elevation and lower optical air mass, SBSP irradiance is generally higher than that of SASP (217 vs. 205 Wm^{-2})
- Longwave irradiance is generally greater at the SASP site due to higher temperatures, greater relative humidity, and greater air mass
- Snow energy balance is almost solely dominated by net solar at both sites

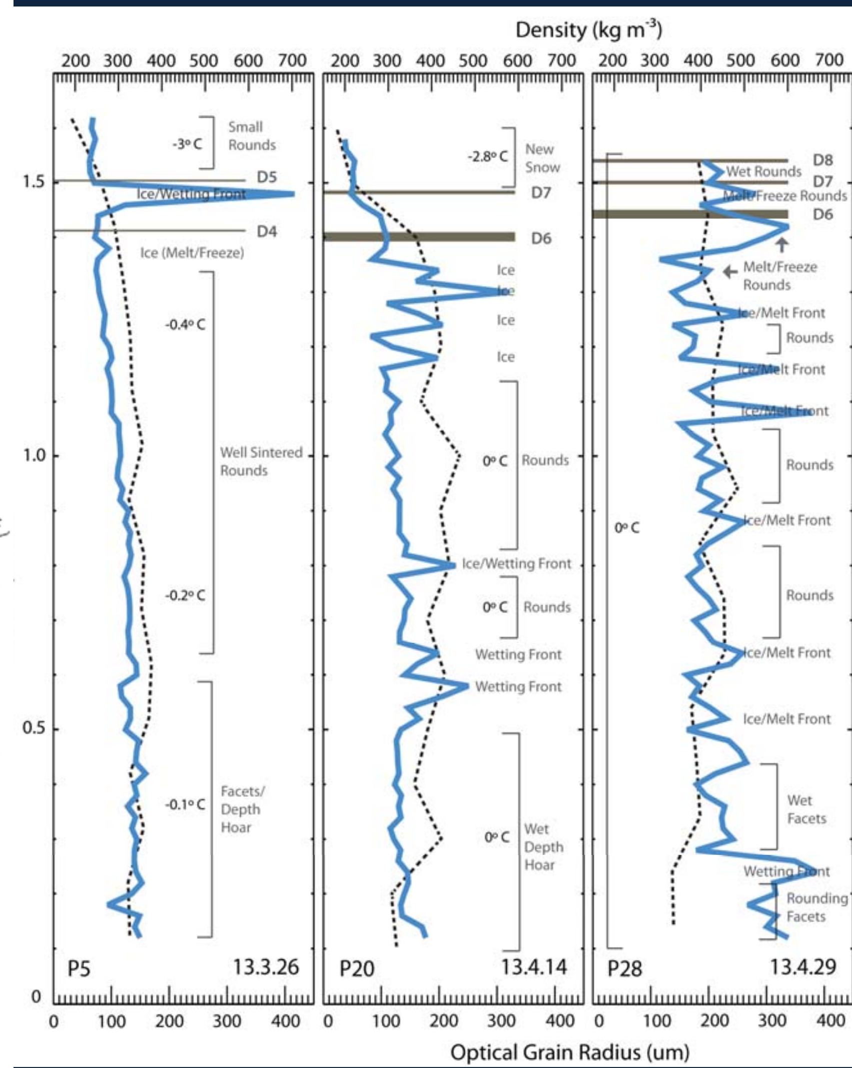


Painter et al., 2012

SBBSA Snow Measurements

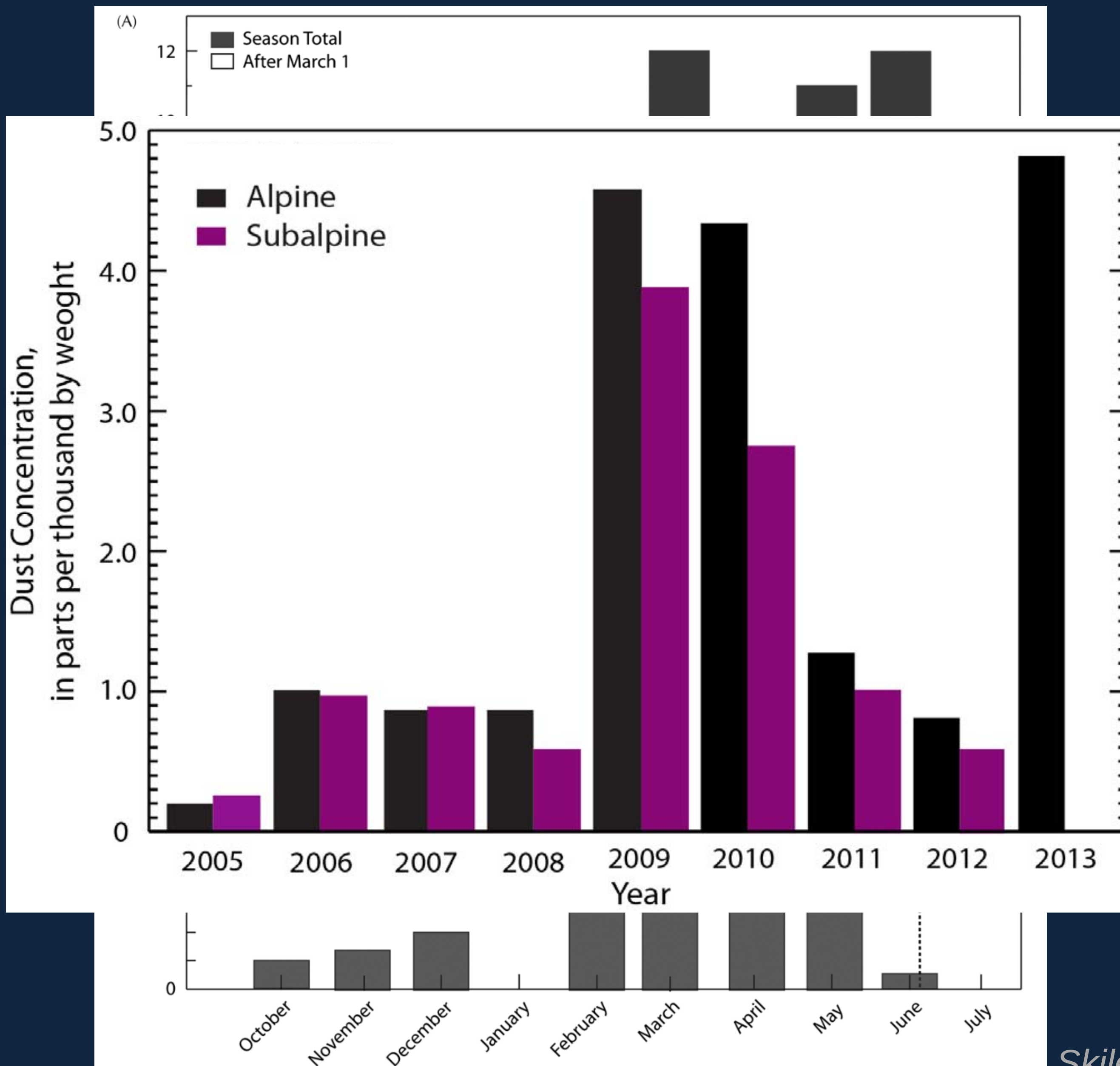
SBBSA Snow Measurements





Landry et al, 2014; *Skiles*, 2014

SBBSA Dust on Snow Record

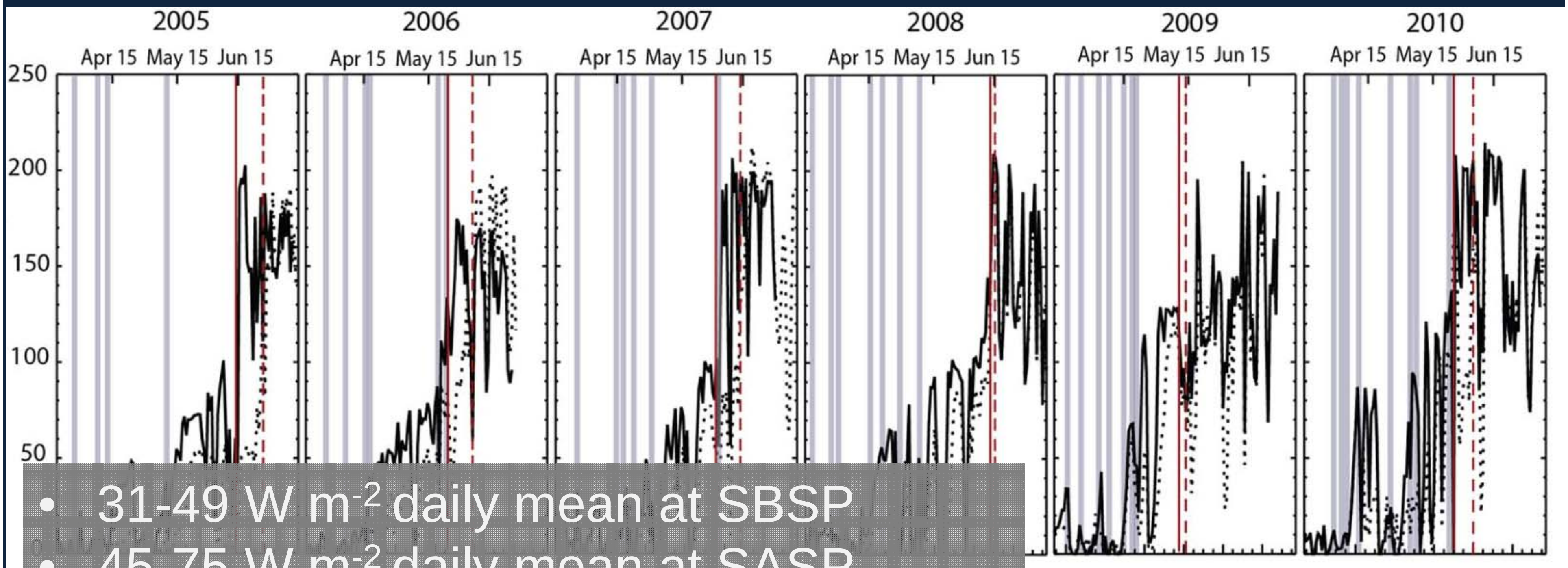


Skiles and Painter, 2015

SBBSA Dust Radiative Forcing Record

A semi-empirical relationship based on changes in snow reflectance at the towers

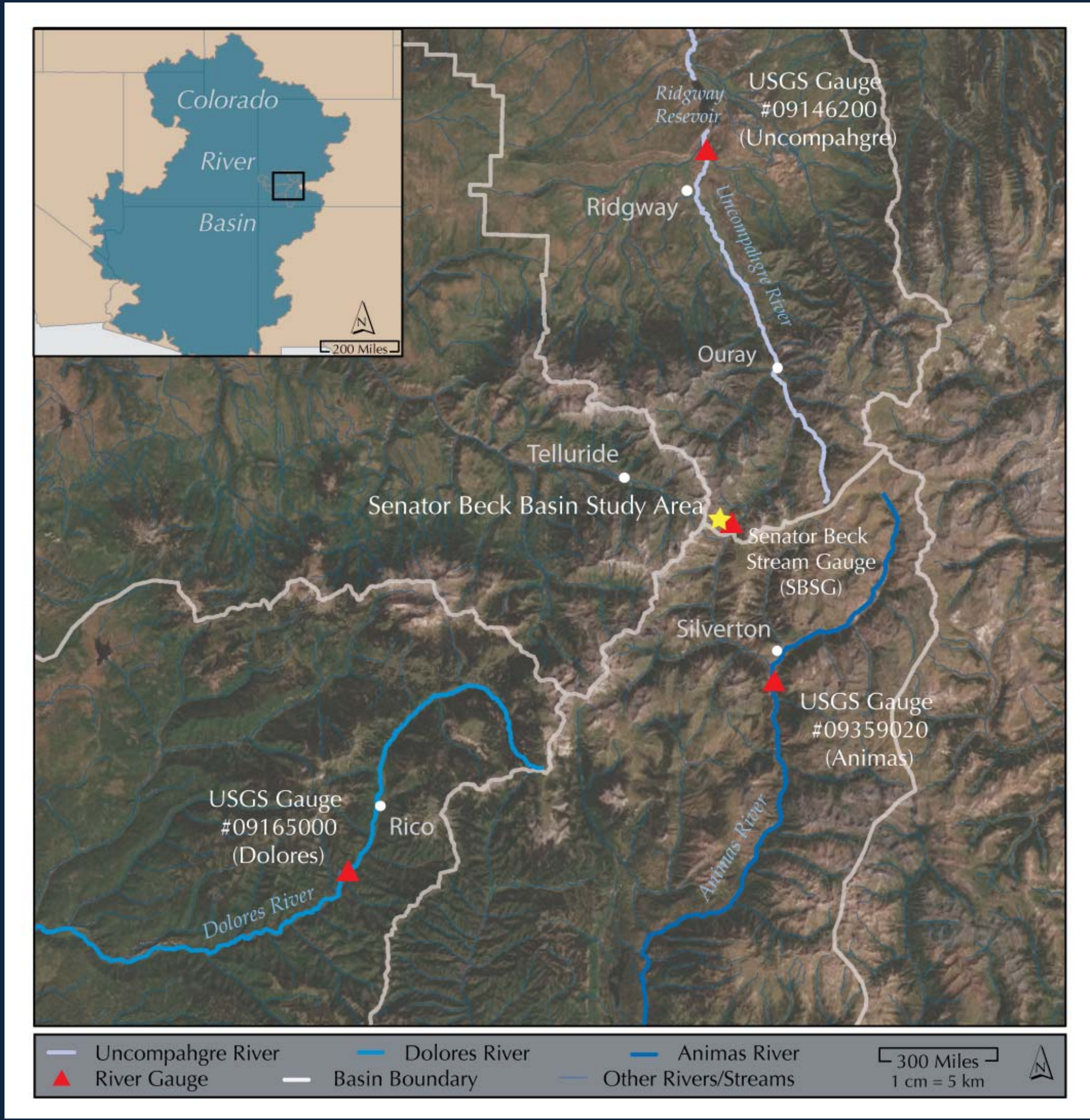
- Minimum RF addresses the direct effect of dust in snow by accounting for the reduction of snow albedo in the visible wavelengths only
- Maximum RF accounts for reduction in visible albedo due to dust and reductions in the near infrared/shortwave infrared (NIR/SWIR) albedo from increases in grain size

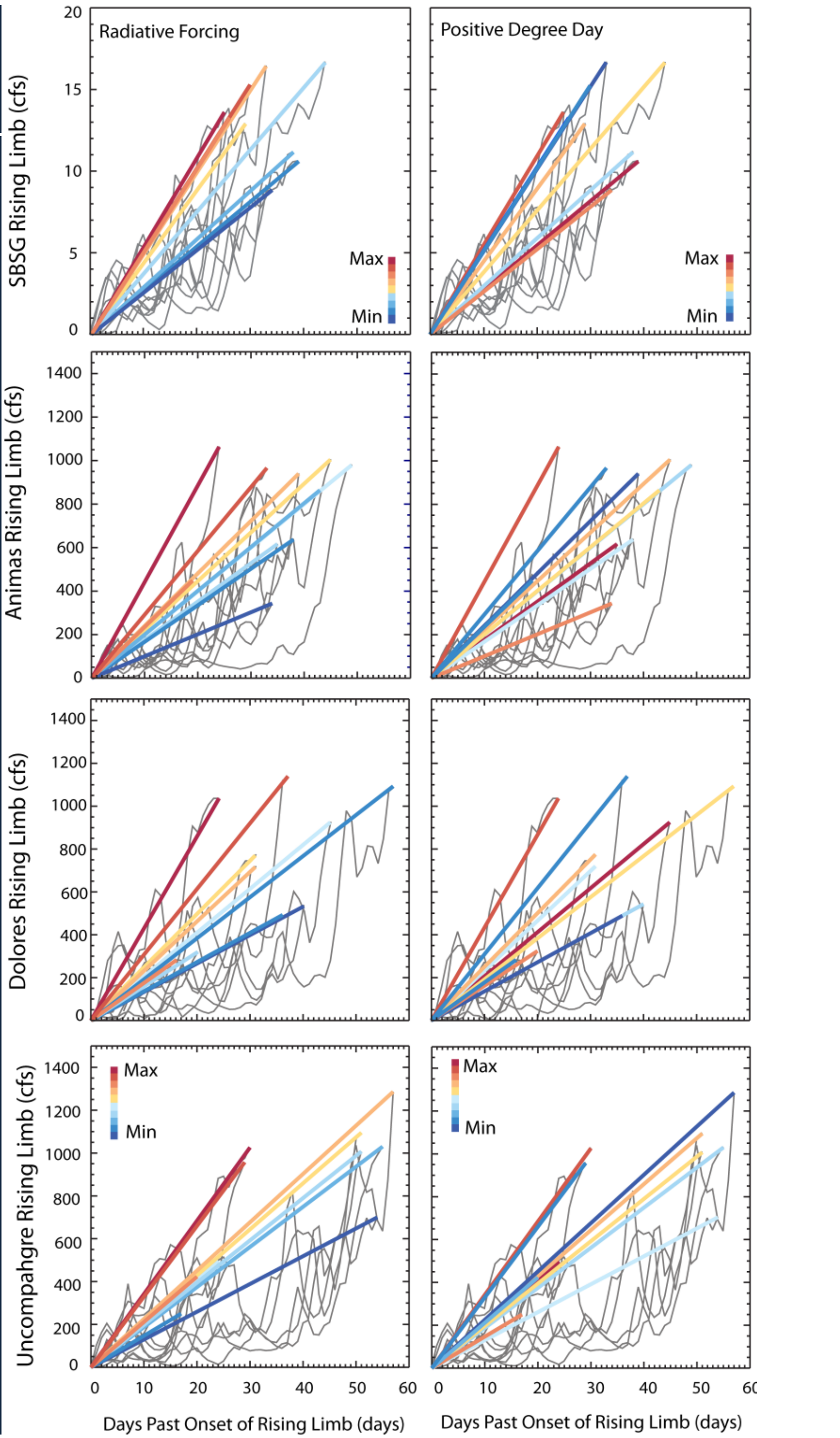


- 31-49 W m^{-2} daily mean at SBSP
- 45-75 W m^{-2} daily mean at SASP

Painter et al., 2007; Skiles et al., 2012

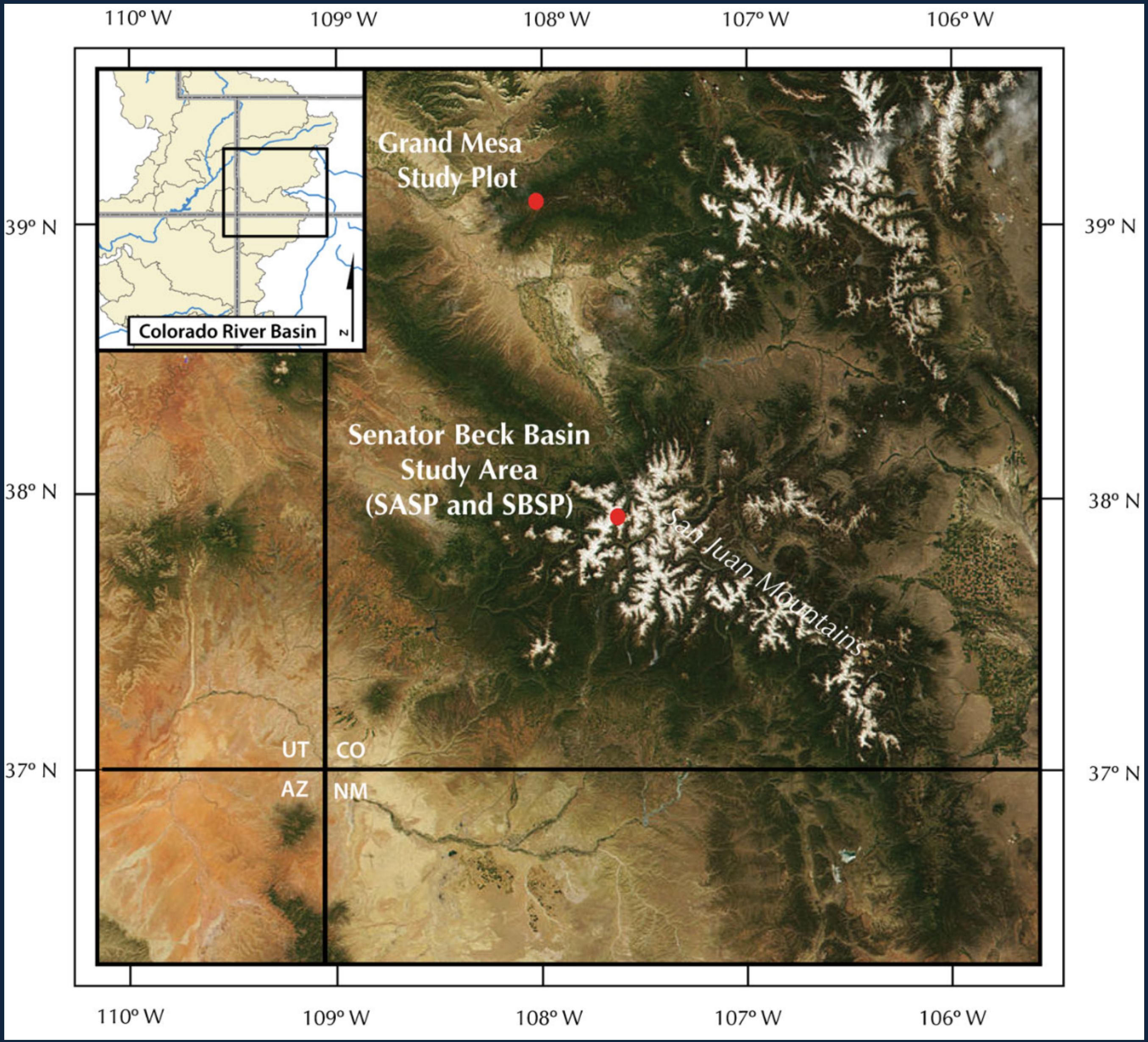
SBBSA RF vs PDD





Painter and Skiles, in prep

Grand Mesa Study Plot (GMSP)

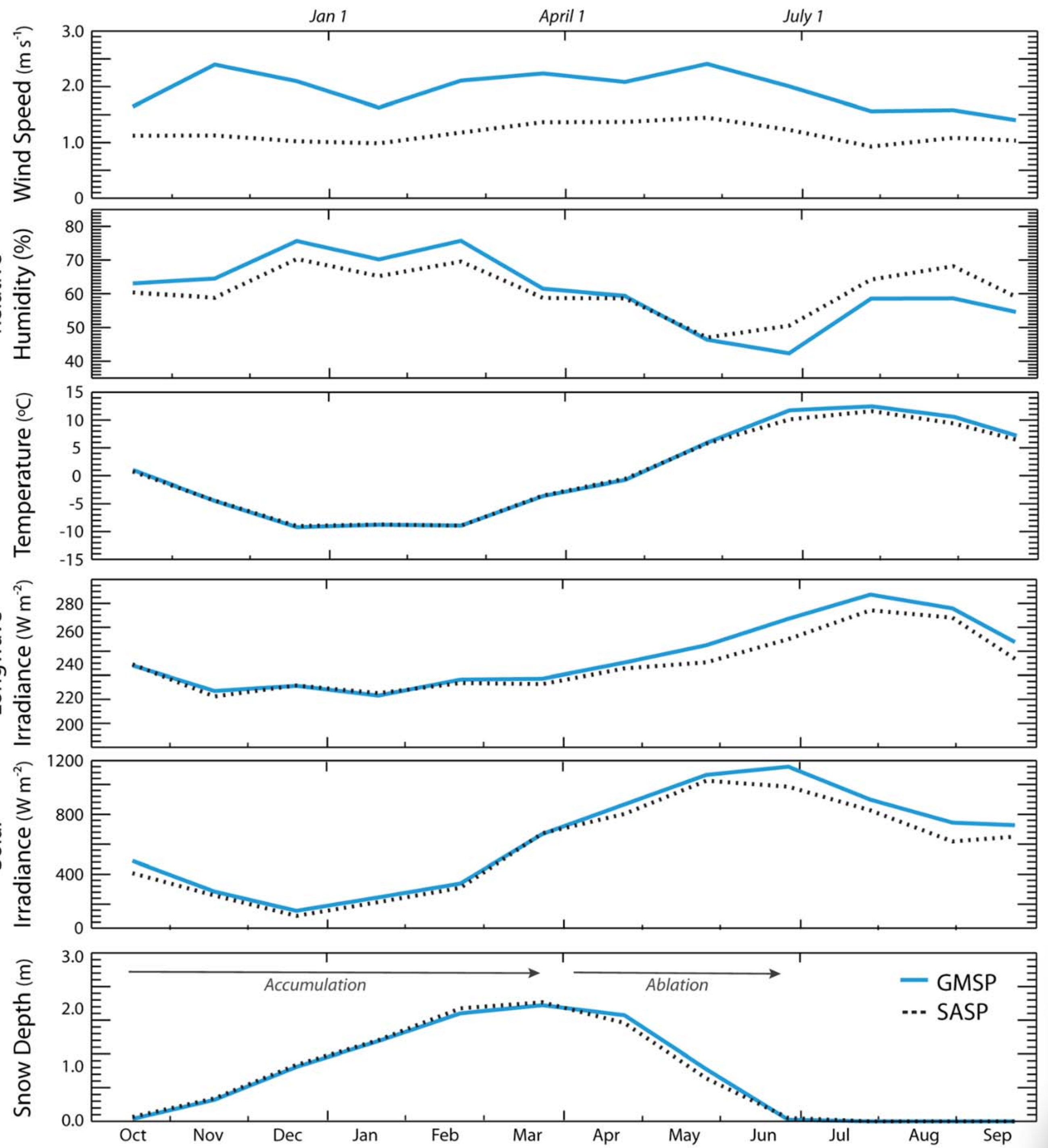


- Est. WY 2010
- 10 m tower
- 20x20 snow plot
- 3239 m
- Ski-in access
- Bi-monthly sampling
- 3 ASO overflights

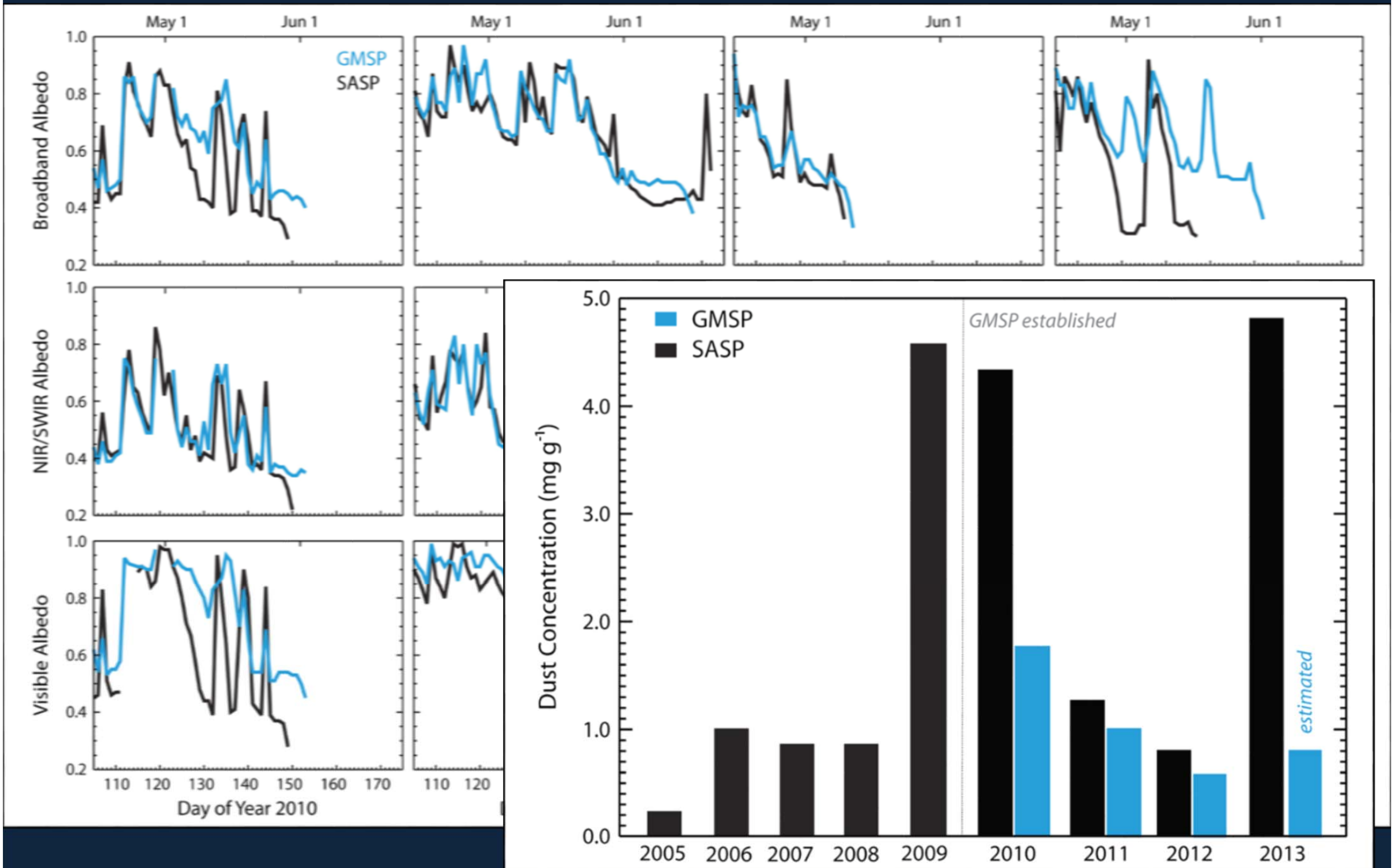
GMSP Climatology

- GMSP is very similar to SASP, with the same mean annual temperature and relative humidity
- Wind speeds are low but consistently higher at GMSP
- Radiation fluxes are slightly higher at GMSP (8 Wm^{-2} solar, 6 Wm^{-2} thermal)

Skiles et al., 2015

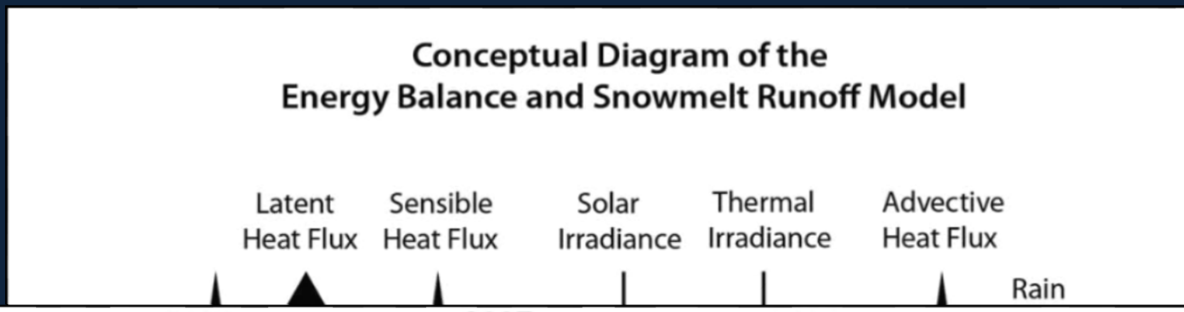


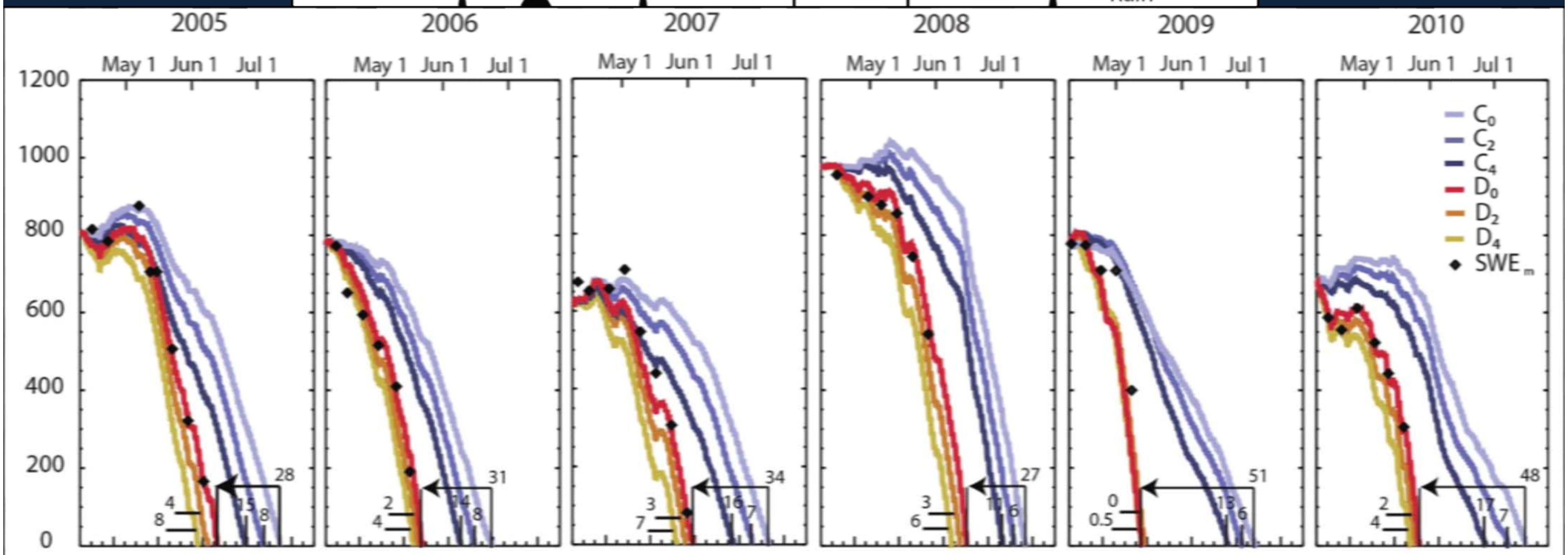
GMSP Dust on Snow Record



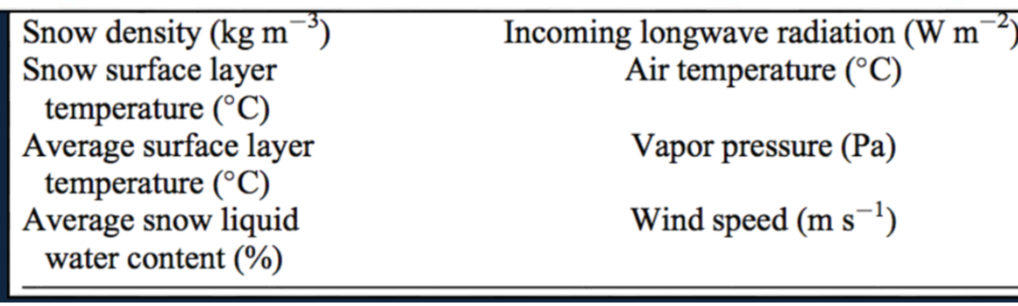
Skiles et al., 2015

Modeling SNOBAL





with snow measurements

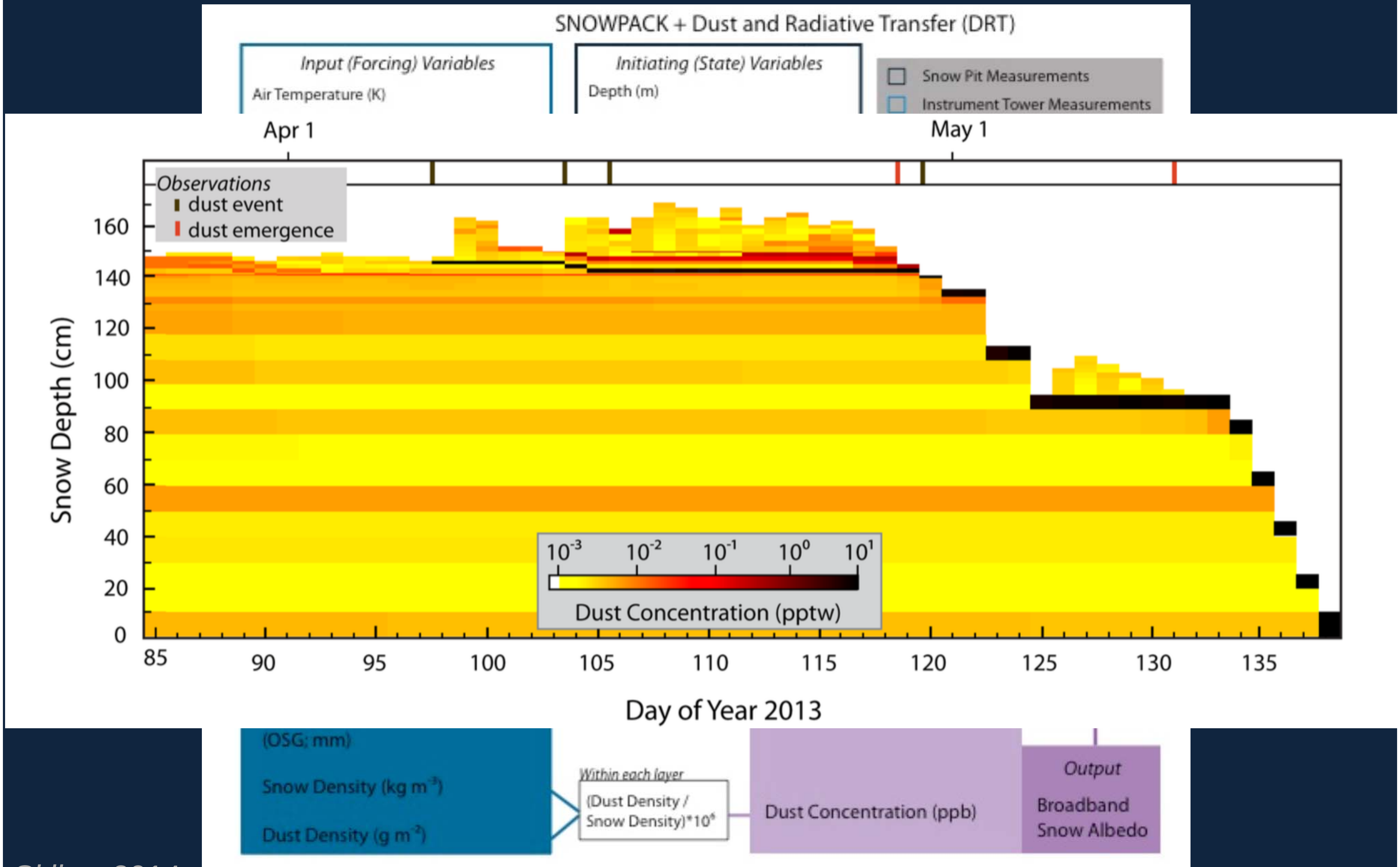


Snow density (kg m^{-3})	Incoming longwave radiation (W m^{-2})
Snow surface layer temperature (°C)	Air temperature (°C)
Average surface layer temperature (°C)	Vapor pressure (Pa)
Average snow liquid water content (%)	Wind speed (m s^{-1})

by tower data

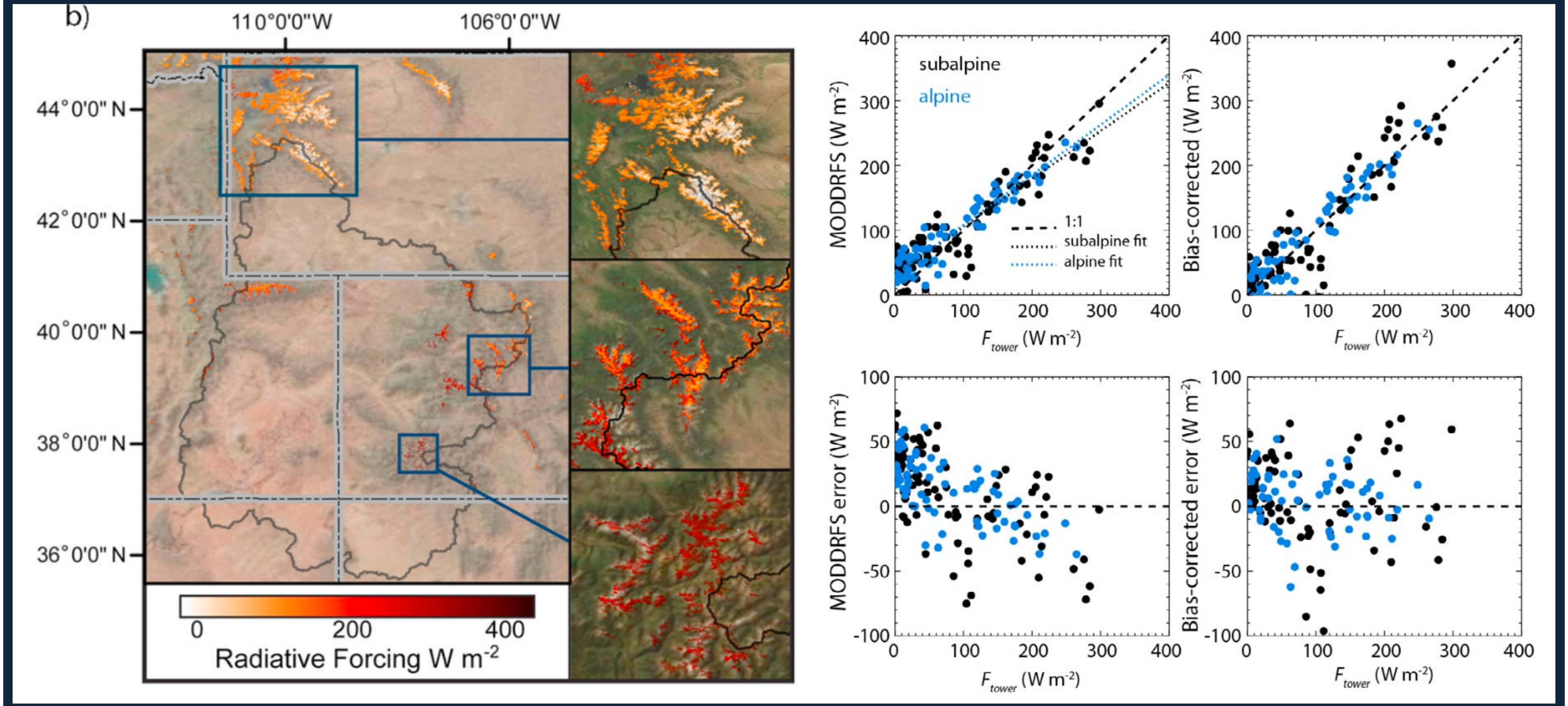
Skiles et al., 2012

Modeling SNOWPACK



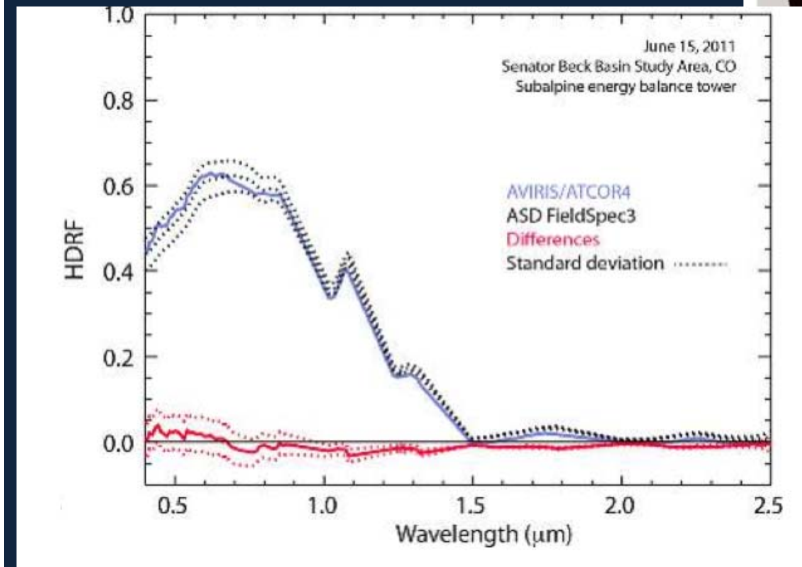
Skiles, 2014

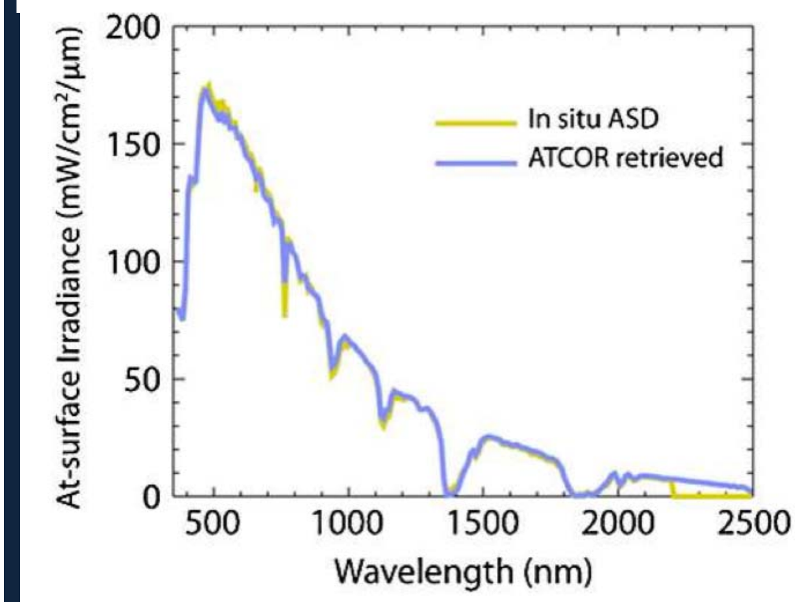
Remote Sensing MODIS-MODDRFS

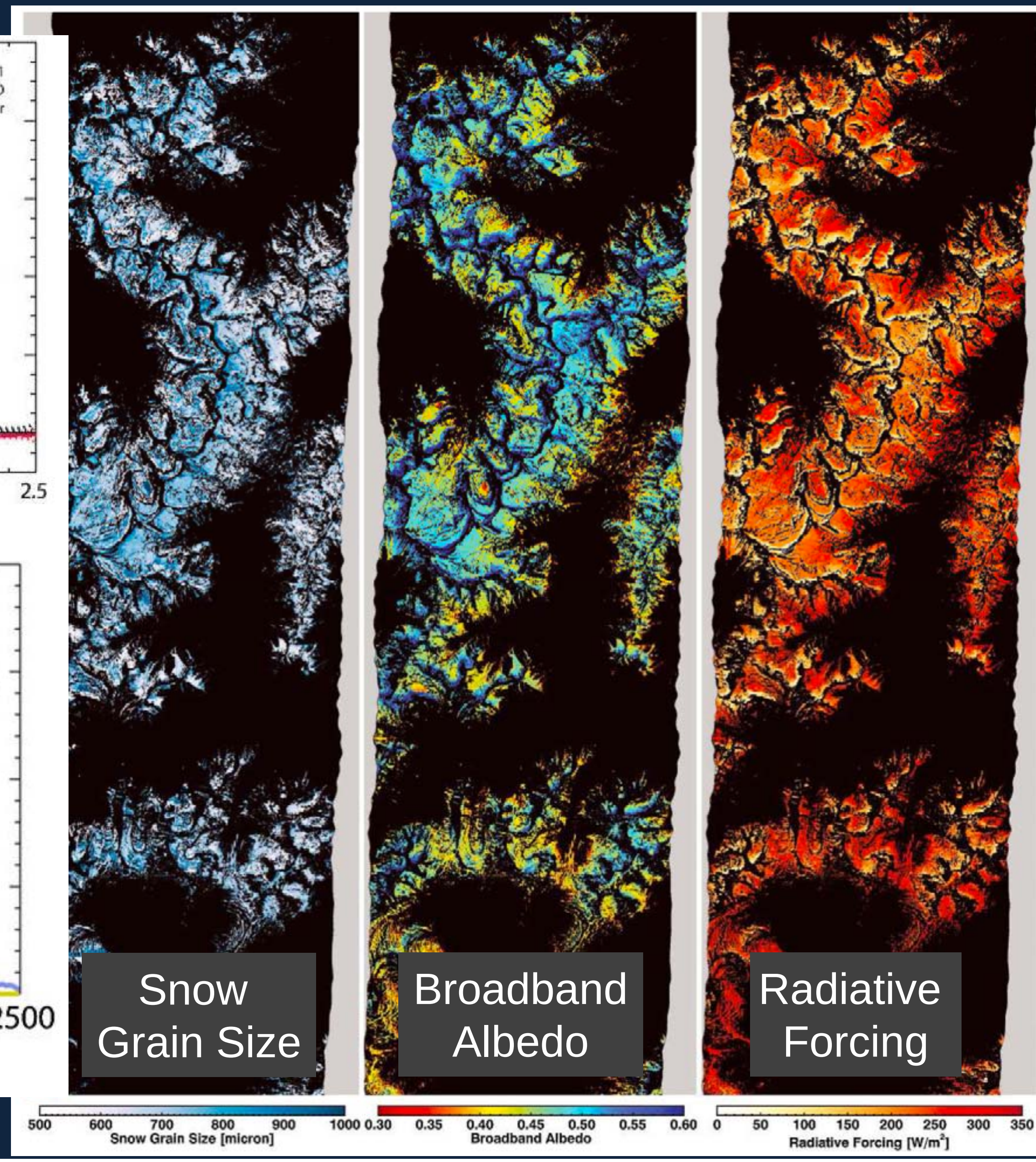


Painter, Bryant, and Skiles, 2013

Remote Sensing AVIRIS

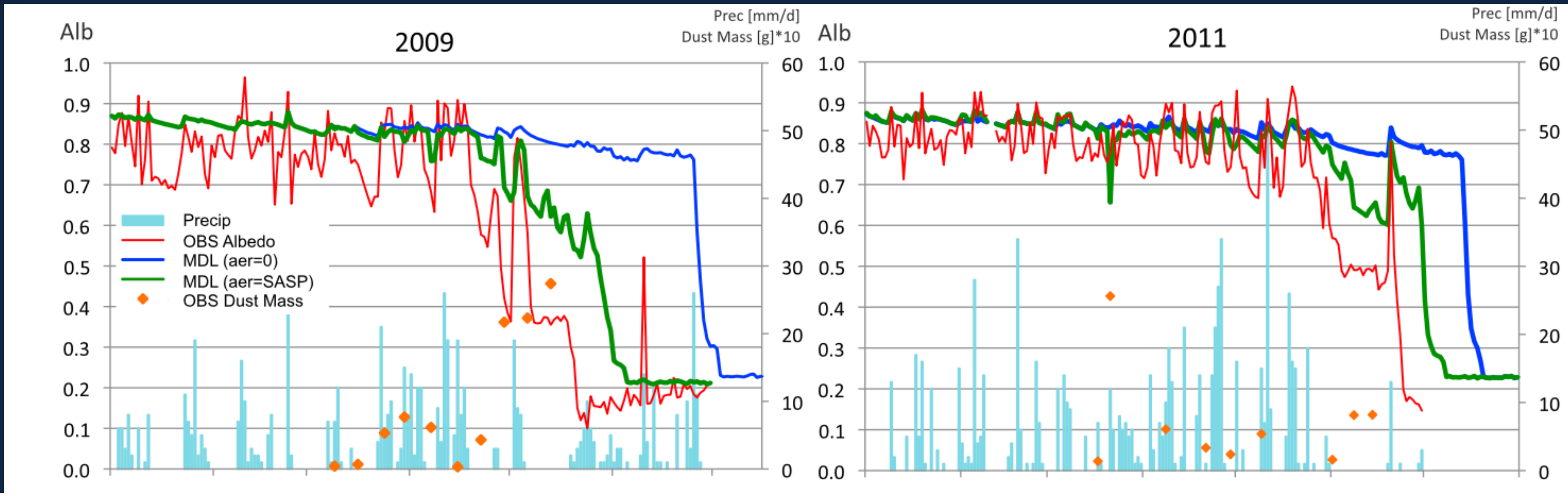


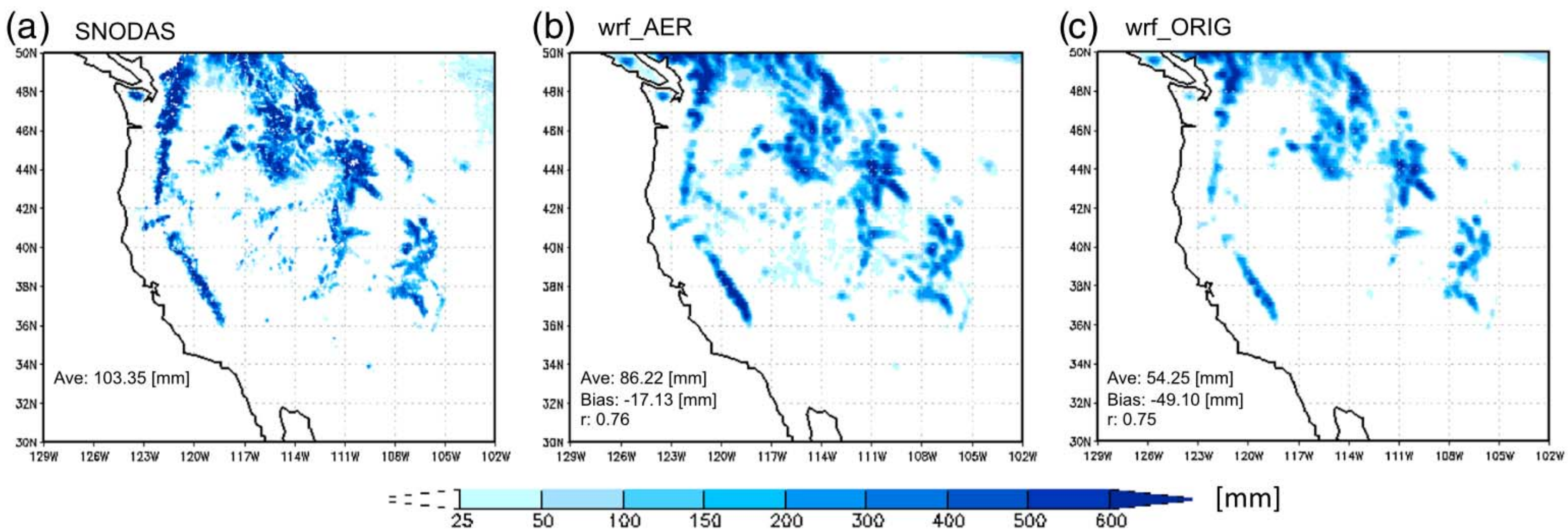




Painter et al., 2013

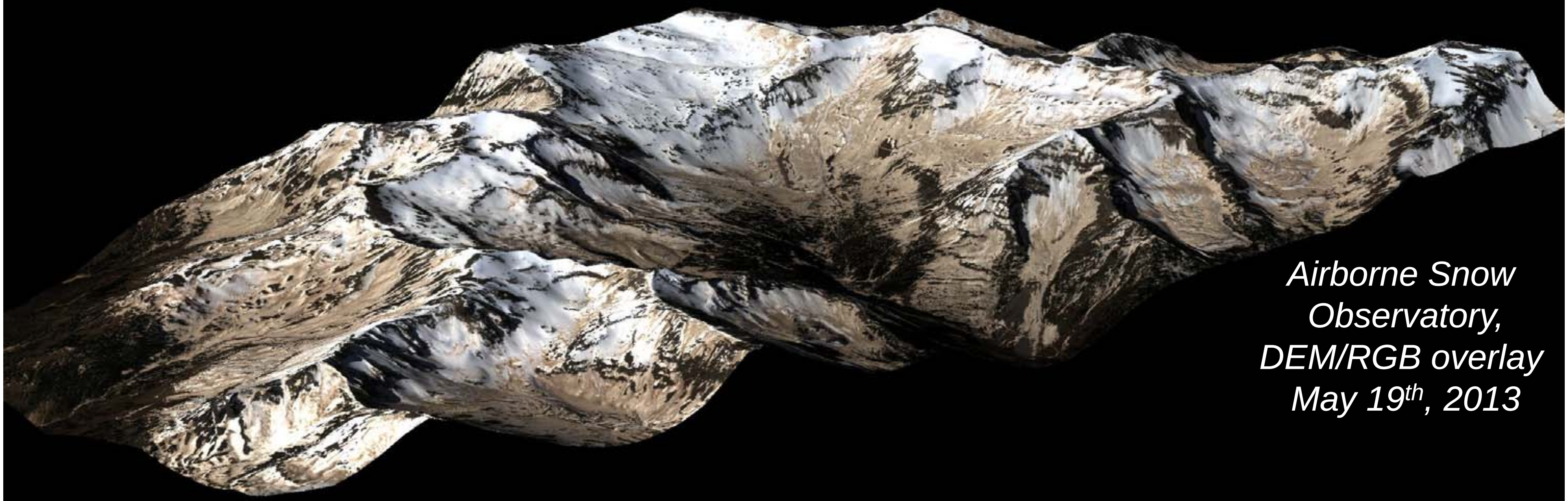
Model Validation WRF-SSIB (15 km)





Oiada et al., 2014

Interested in the data?
www.snowstudies.org
skiles@jpl.nasa.gov



Airborne Snow Observatory, DEM/RGB overlay May 19th, 2013

Center for Snow & Avalanche Studies

NASA JPL

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