How the airborne measurements will help to assess the accuracy of snow-covered reflectance and albedo products from satellites (forested/mountainous landscapes)

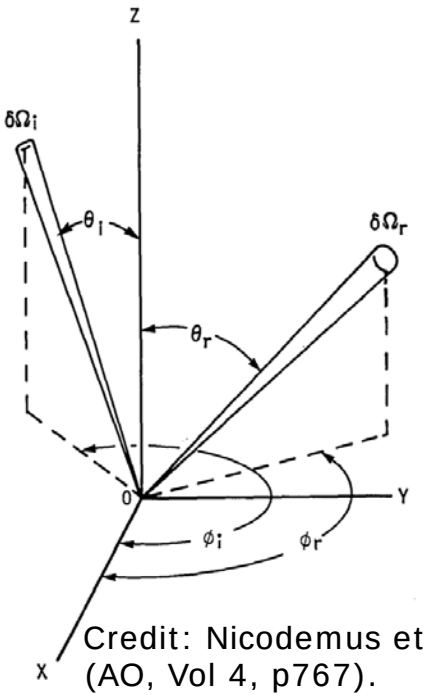
C. Gatebe[1,2], R. Poudyal[2,3], K. Rush[2], W. Li[4], N. Chen[4], Y. Fan[4], K. Stamnes[4], S. Kharbouche[5] & J.P. Muller[5]

[1]Universities Space Research Association (USRA), [2]NASA Goddard Space Flight Center, [3]Science Systems and Applications, Inc. (SSAI), [4]Stevens Institute of Technology (SIT), USA, [5]Mullard Space Science Laboratory, University College London, UK

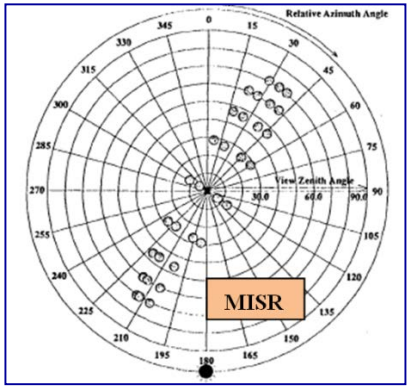
First Workshop on NASA SnowEx Results. August 8– 10, Longmont, Colorado

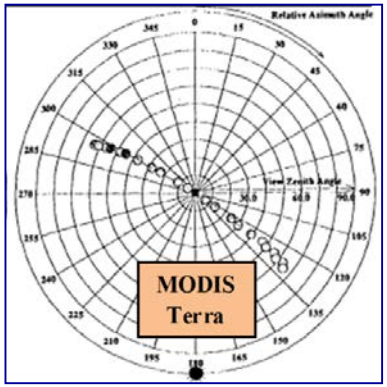
Motivation-1

- Snow is anisotropic (not a Lambertian reflector).
- Current satellite systems are capable of measuring reflected energy, but in limited directions.
- The conversion from directional reflectance as measured by satellites, to spectral albedo requires a bidirectional reflectance-distribution function (BRDF) model.

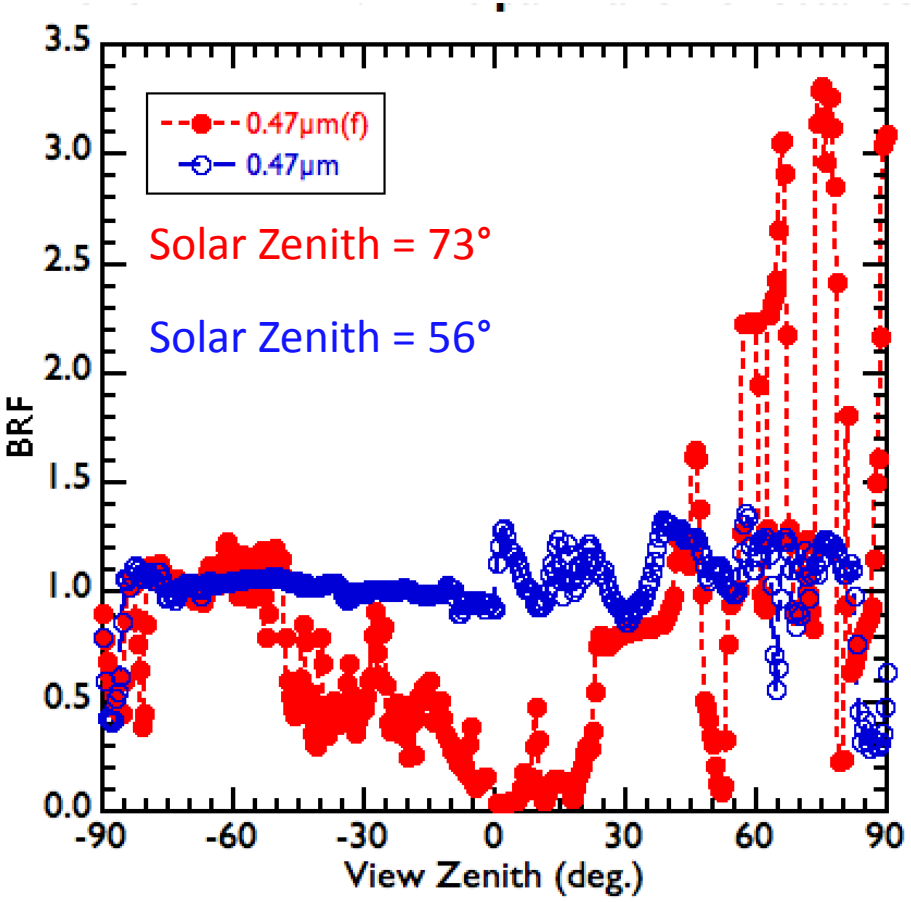


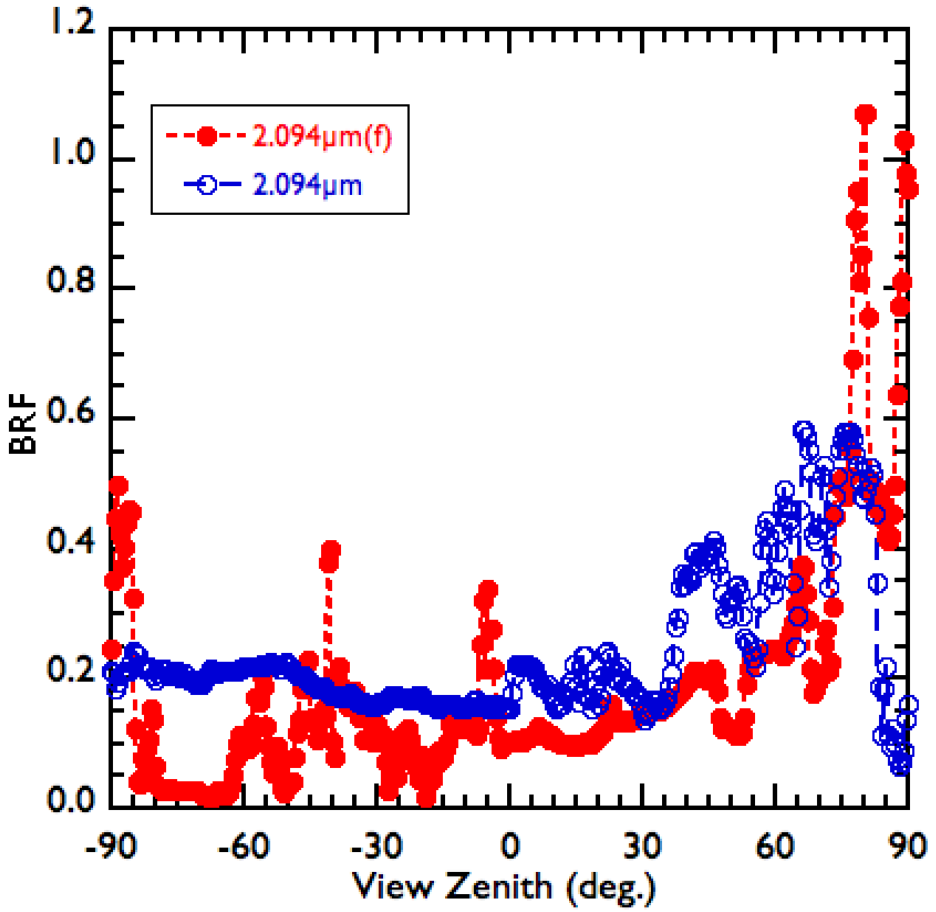
Credit: Nicodemus et al. (1965) (AO, Vol 4, p767).





SnowEx'17 BRDF Meas./Solar Plane

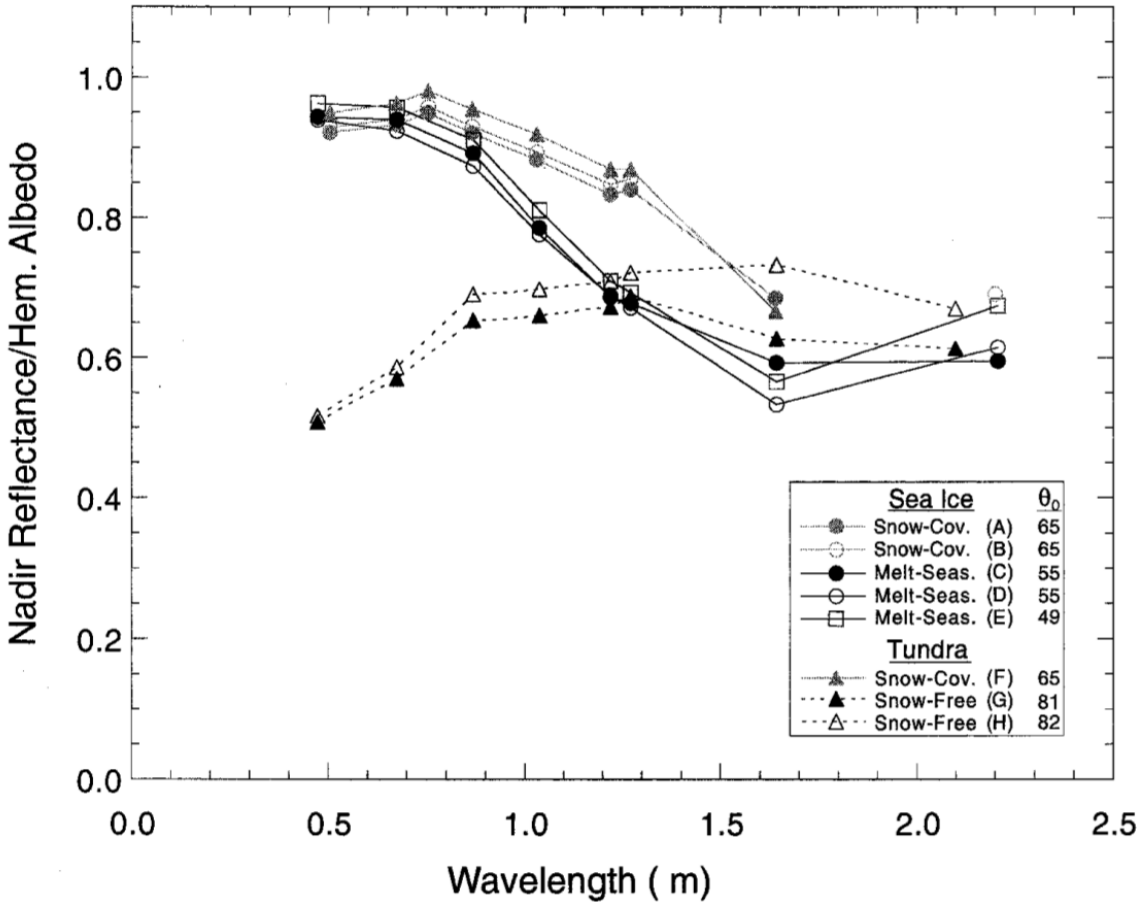




Grand Mesa -- variable snow-covered vegetation and topography and Sargents/Parlin -- snow-covered open area.

Consequences of ignoring BRDF Effects

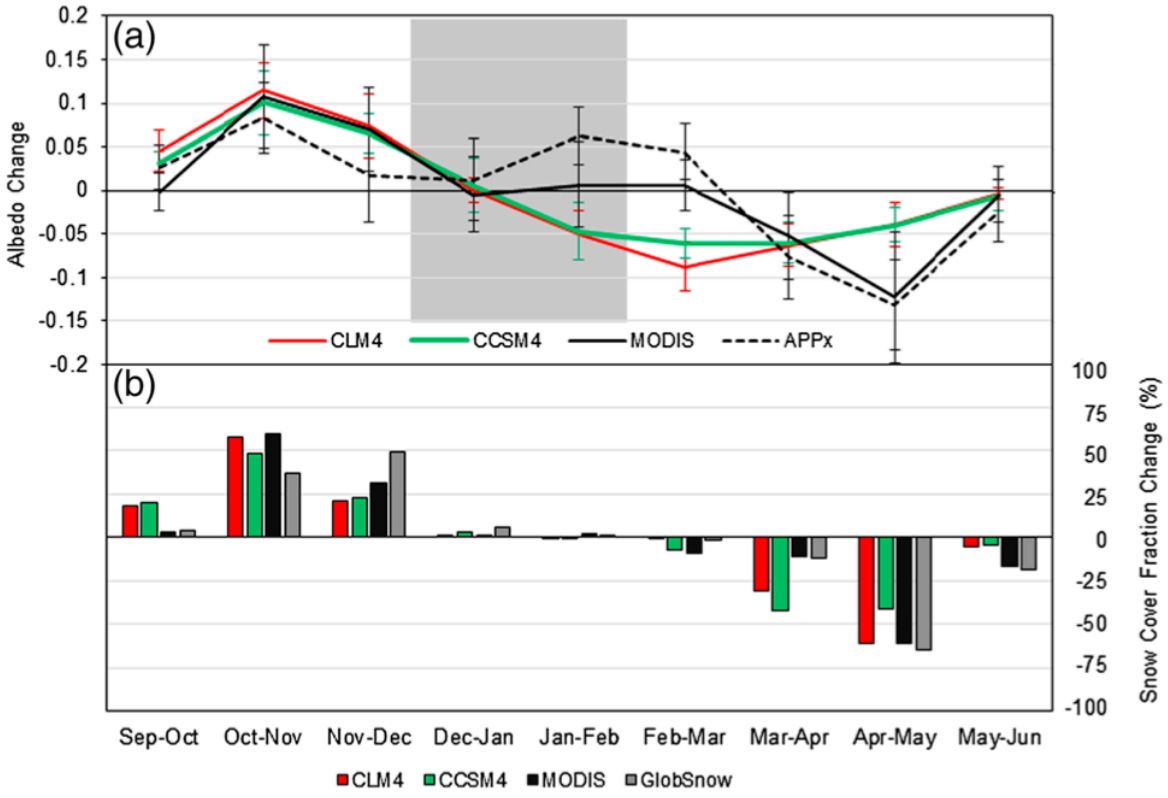
- Ratio of nadir reflectance to hemispherical albedo plotted as a function of wavelength for BRFs (A–H).
- nadir reflectance 5–50% smaller



Arnold et al. 2002: Airborne spectral measurements of surface–atmosphere anisotropy for arctic sea ice and tundra int. j. remote sensing, vol. 23, p.3763

Consequences of Ignoring BRDF Effects

- Monthly change in (a) albedo and (b) snow cover fraction (SCF) for boreal forest (>75%) using 4 snow products.
- Grey area shows high observational uncertainty during winter due to high solar zenith angle (>75°) & the associated shading effects.

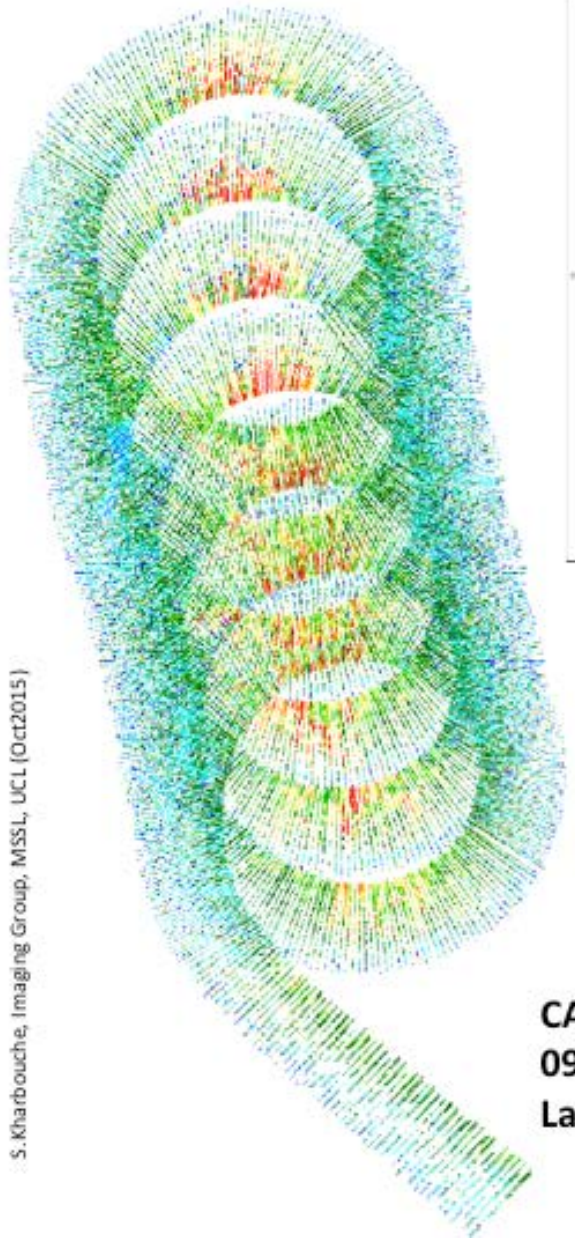


Thackeray, Fletcher & Derksen (2014): The influence of canopy snow parameterizations on snow albedo feedback in boreal forest regions, JGR, vol. 119, p.9810

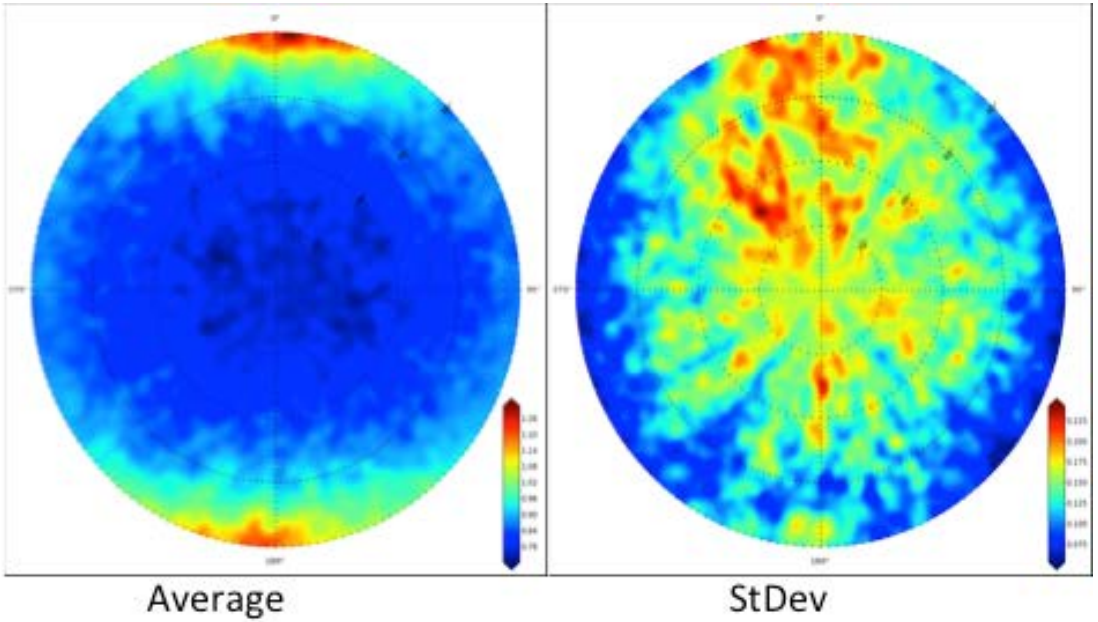
Motivation-2

- the high spatial and temporal variability of snow albedo and the fact that most snow covered areas are difficult places to access, makes remote sensing the most suitable tool to determine spatial and temporal variability of snow albedo.

Snow BRF Spatial Variability/Arctic



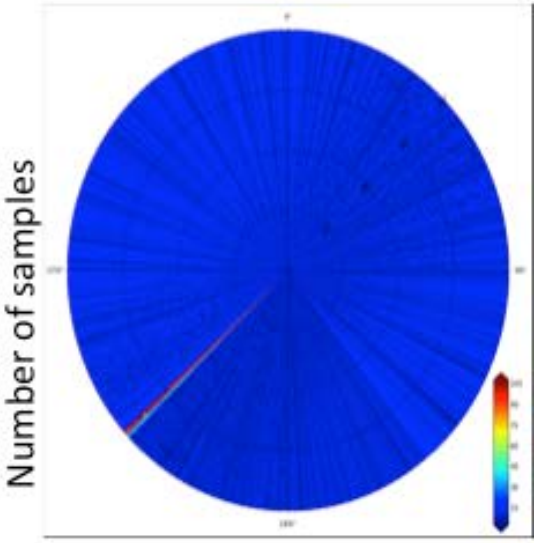
S. Kharbouche, Imaging Group, MSSL, UCL (Oct2015)



Average

StDev

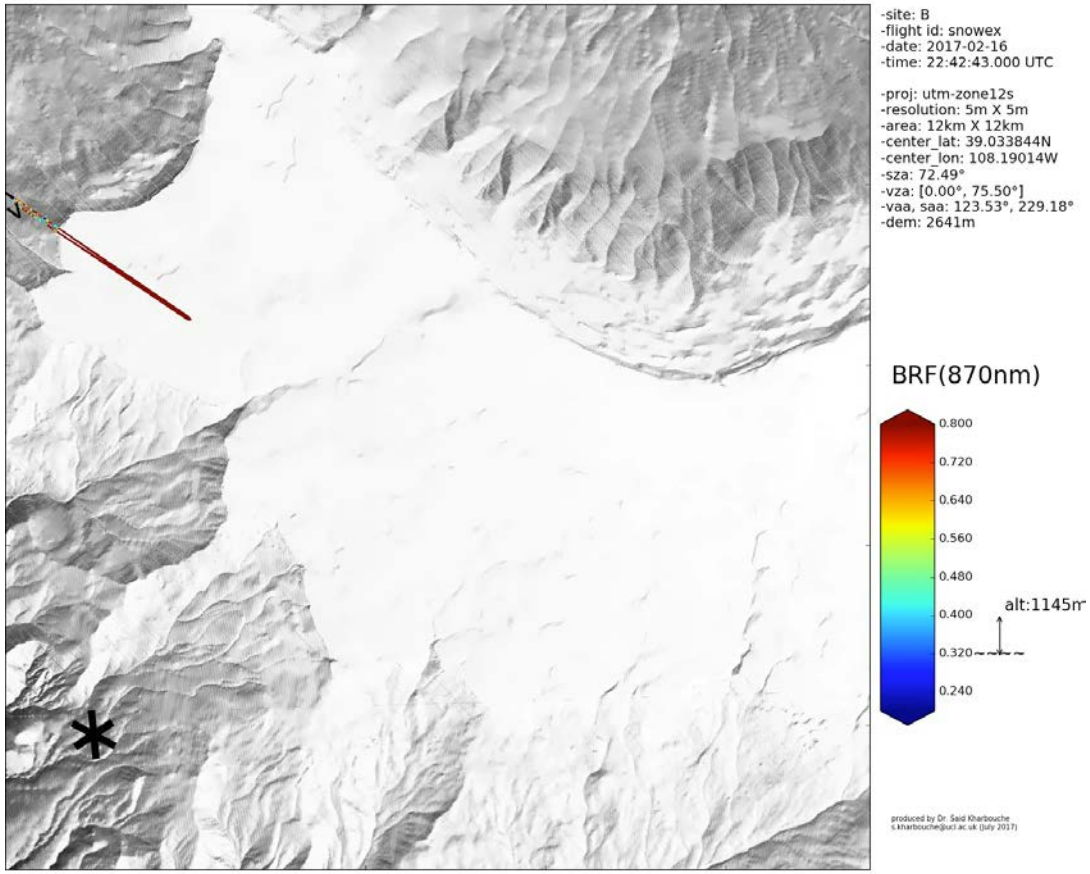
CAR_lambda: 870nm
09-April-2008
Lat/lon: (*80°, 100.8°*)



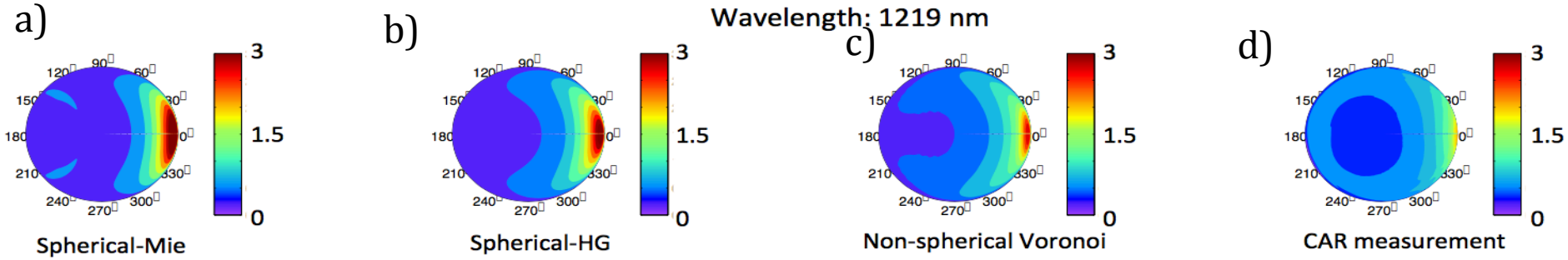
Obs. Over Grand Mesa

- CAR BRDF observations over the western Grand Mesa show high spatial variability.
- Snow albedo varies a lot with solar position in the sky, wavelength, and snow physical parameters (snow grain size, shape, water content, surface roughness, depth and presence of impurities).

12 km x 12 km area



SnowEx data provide insights into the variability questions



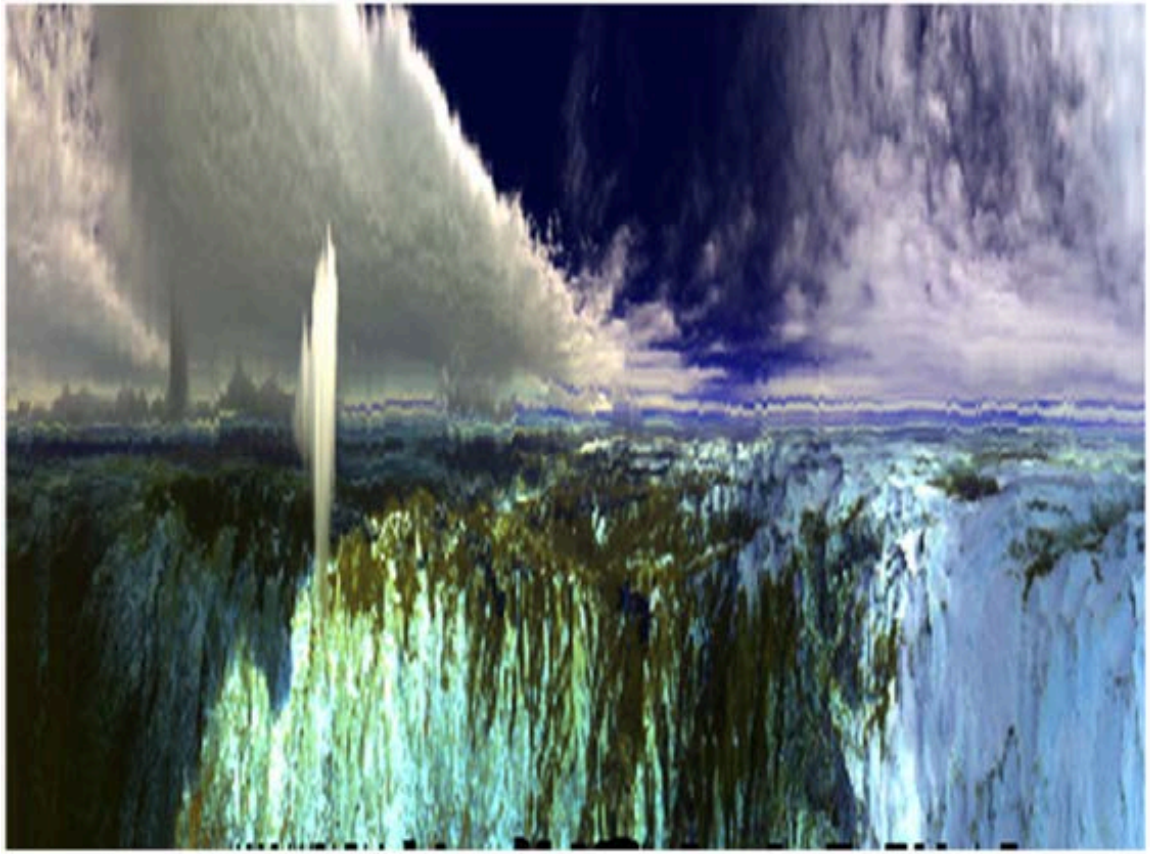
CAR data from SnowEx are unique and can be used to assess the accuracy of BRDFs calculated by different snow models:

a) Spherical grain model with Mie phase function,
b) Spherical grain model using Henyey Greenstein (HG) phase function,
c) Non-spherical grain model (Voronoi aggregates) and
d) comparison to CAR measurements at 1219 nm wavelength.

Effects of shadows, forests & clouds

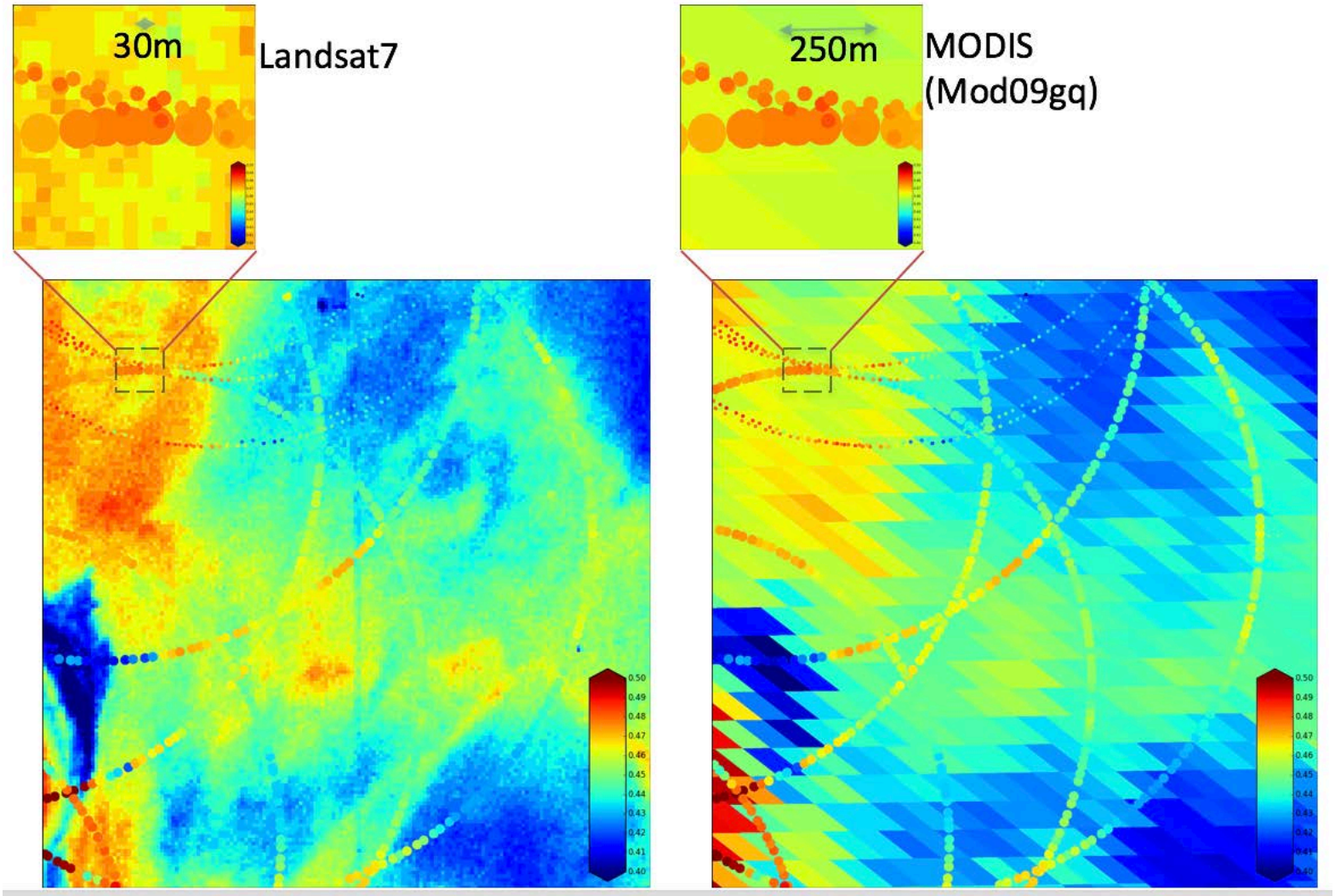
- the interpretation may be necessary to identify and separate the effects of shadows, forests and clouds.
- BRDF measurements have a potential to identify brightness variations resulting from forest effects or mountain shadows.

CAR Measurements/SnowEx'17



Nan Chen presentation "Enhanced cloud/snow identification in snow mixed vegetation/soil areas based on machine learning techniques"

Motivation 3: Satellite Validation



Kharbouche et al., 2017 (Remote Sens. 2017, 9, 562; doi:10.3390/rs9060562)

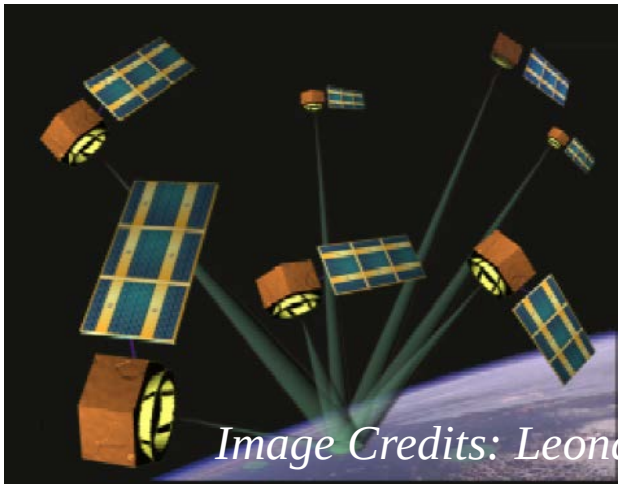
Summary

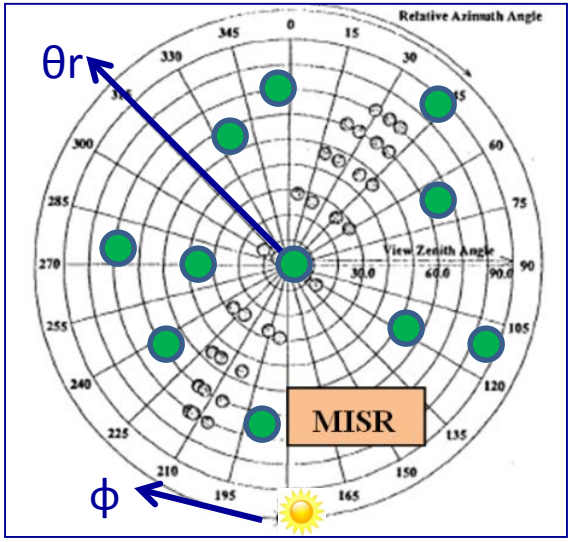
- SnowEx Level-1 data are now available at the National Snow and Ice Data Center (NSIDC). Check out our poster & data tutorial.
- Next Step:
  - Atmospheric correction.
  - Finalize geometrical correction.
  - Compute spectral albedo, broadband albedo.
  - Gridding the data at different scale.
  - Compare with ground, airborne/ASO and satellite obs.

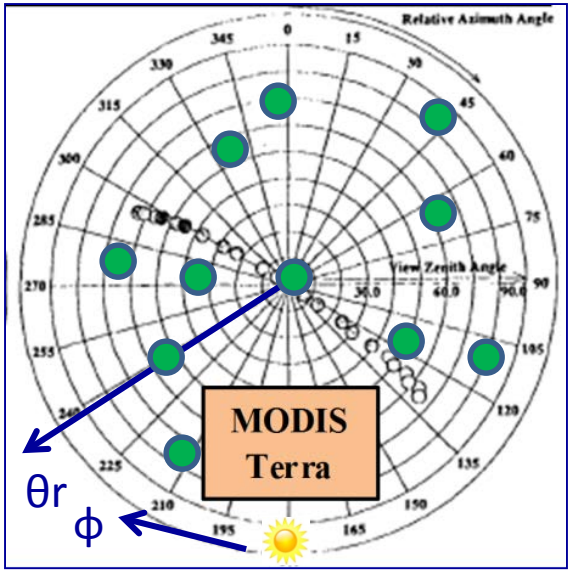
Future Satellite Mission

Major Gap: Angular under-sampling (θs,θr,ϕ)

Potential Solution: Clusters of nano-satellites since each sat will be small







Additional advantages:- 6U cubesats under development, Standard bus, Secondary payload launches, Cubesat GS network

Disadvantages:- Restrictive h-i combinations, mass/volume constraints

Nag S, Gatebe CK, Hilker T (2016): IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing