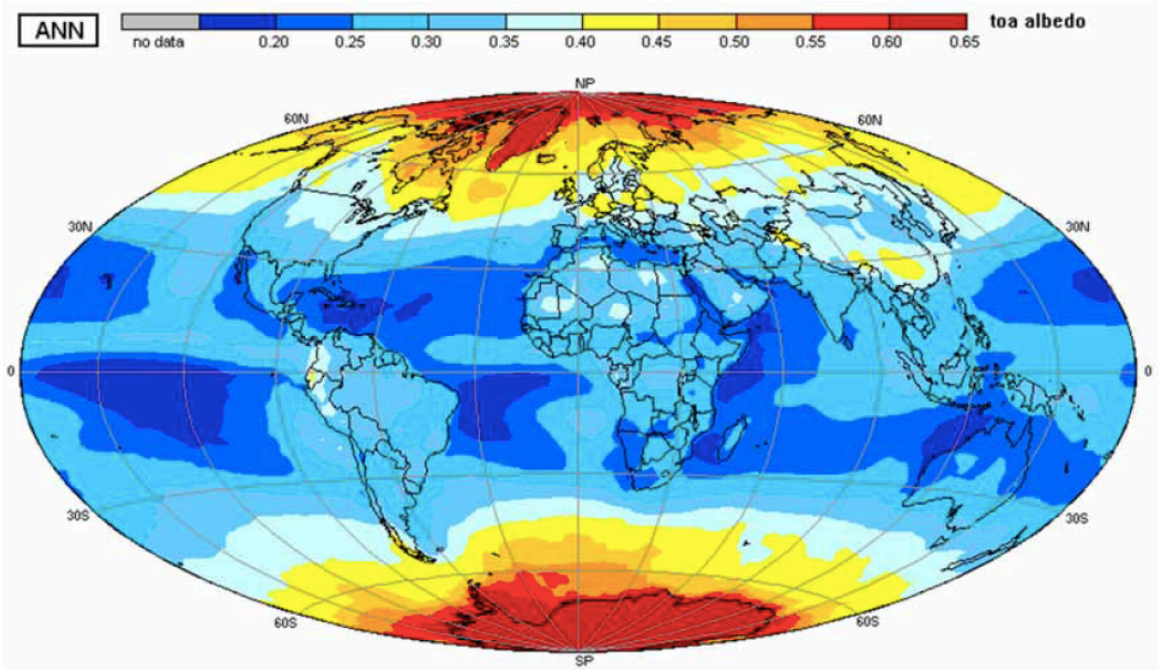
An Analysis of the Surface Albedo of Brookings, SD

James Deng 8/18/11

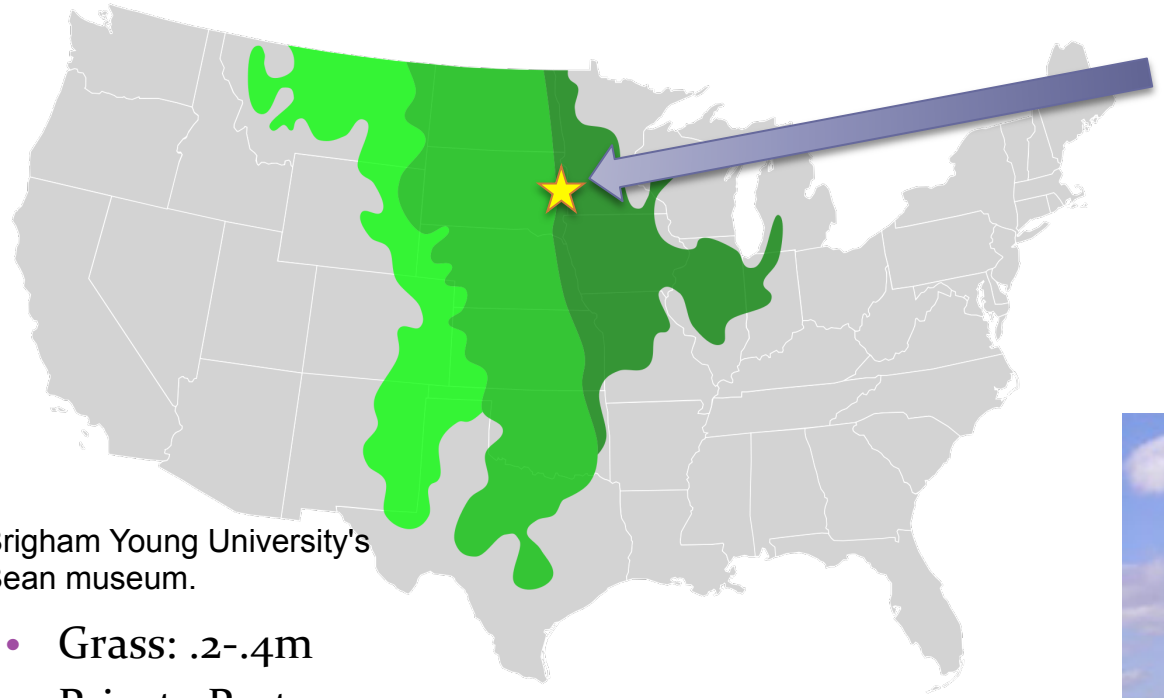
Project and Presentation Outline

- Background Information about the Site and Data
- Radiation and Albedo
  - Snow Cover
  - Diffuse Fraction
  - Cloud Cover
  - Solar Declination
  - Phenology
- Future Directions



Annual Average of Surface Albedo
Raschke and Ohmura, 2005

Site & Data Background



Brigham Young University's Bean museum.

Brookings, SD
44.3453 N 96.8362 W

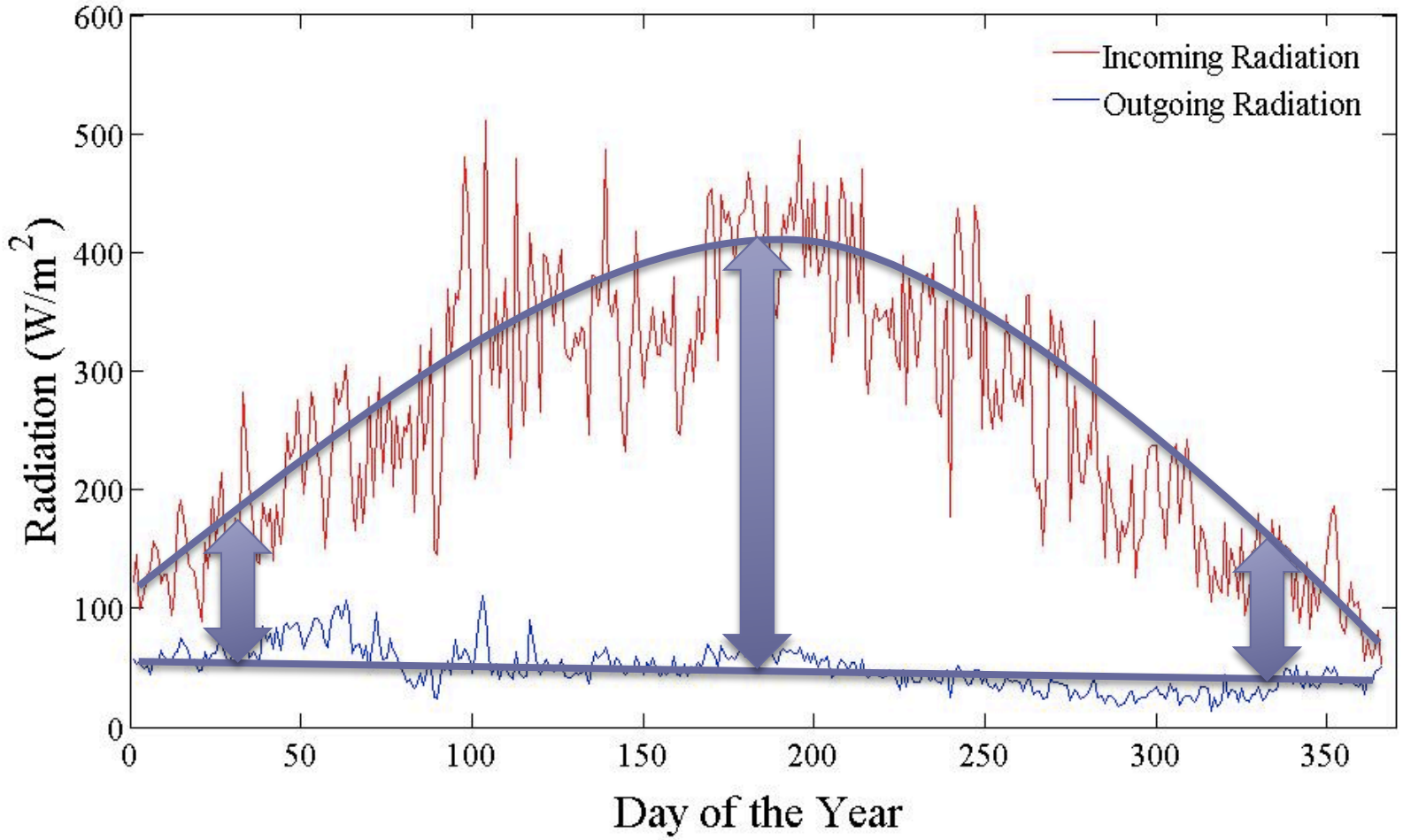
AmeriFlux Site

- Grass: .2-.4m
- Private Pasture
- Rain: 580mm, Snow: 607mm
- Flat - Gently Rolling
- PFT: C3, C4
- LAI: .2 - .3
- Elev: 510 m

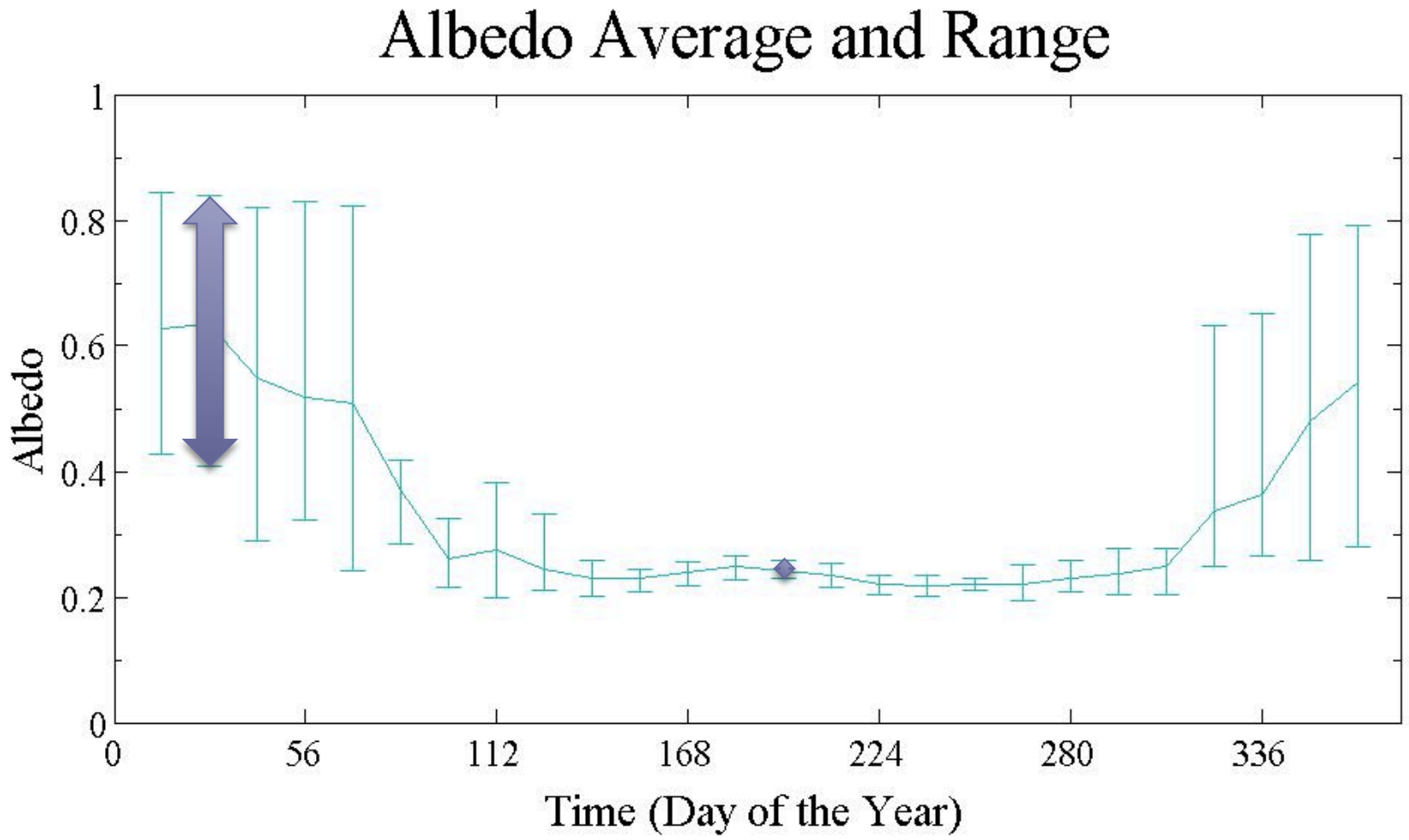
- Tower: 4 m
- Eddy Covariance System
- In use 2004-2011
- Temp/Humidity Probe, Net Radiometer, 3D anemometer, infrared gas analyzer, etc.

Annual Trends of Incoming and Outgoing Shortwave Radiation

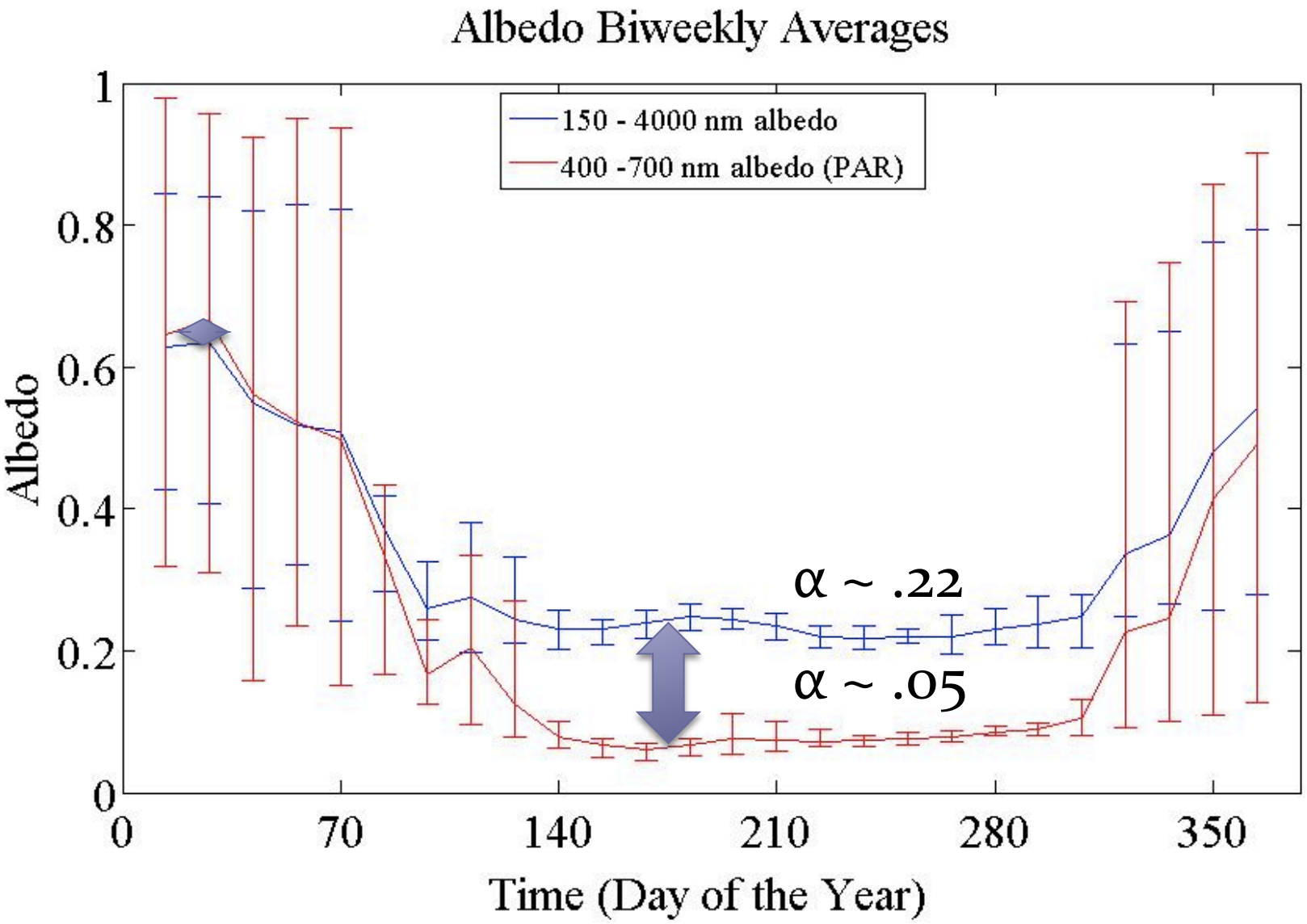
150-4000 nm



Annual Trends in Albedo



Annual Trends in Albedo



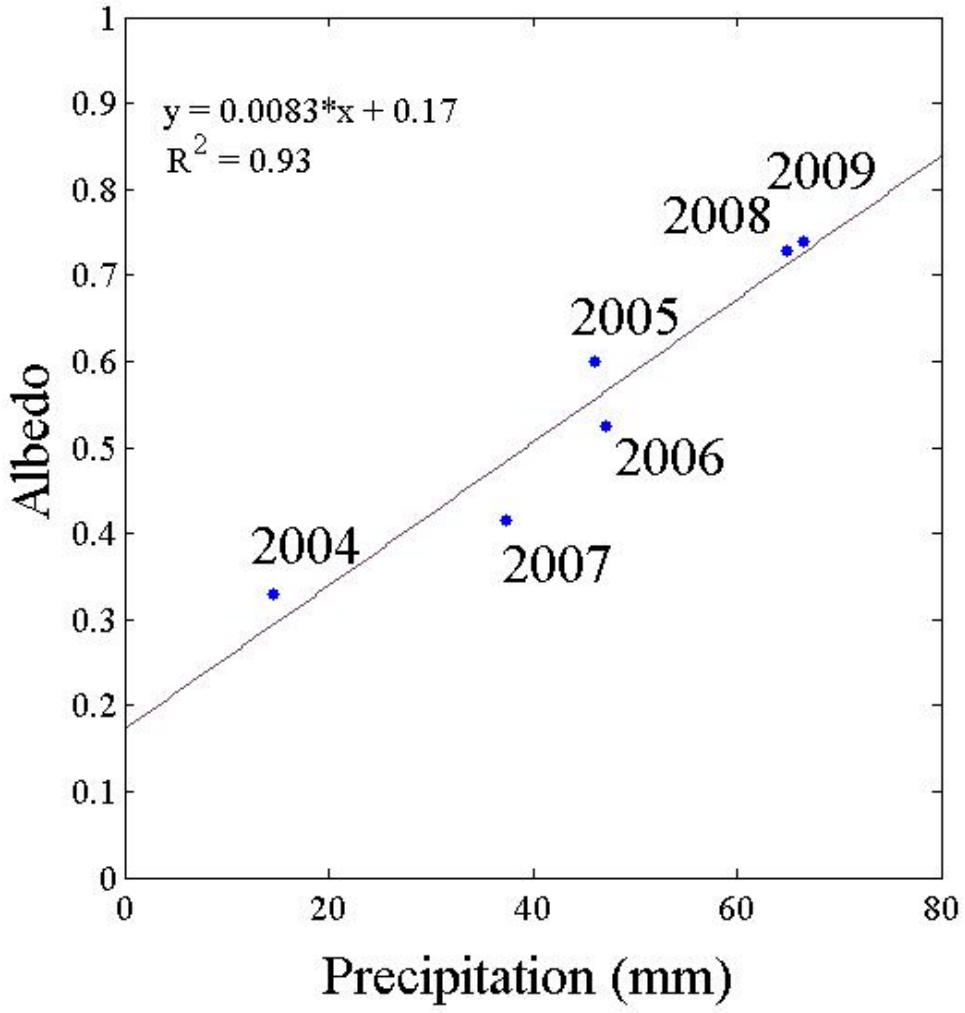
Snow Cover's Impact on Wintertime Albedo

December - February

- $\alpha_{Grassland}$ = .16-.26
- $\alpha_{Fresh\ Snow}$ = .80-.95
- $\alpha_{Old\ Snow}$ = .45-.70

(Bonan, 2008)

- Albedo increases linearly with precipitation (snowfall)

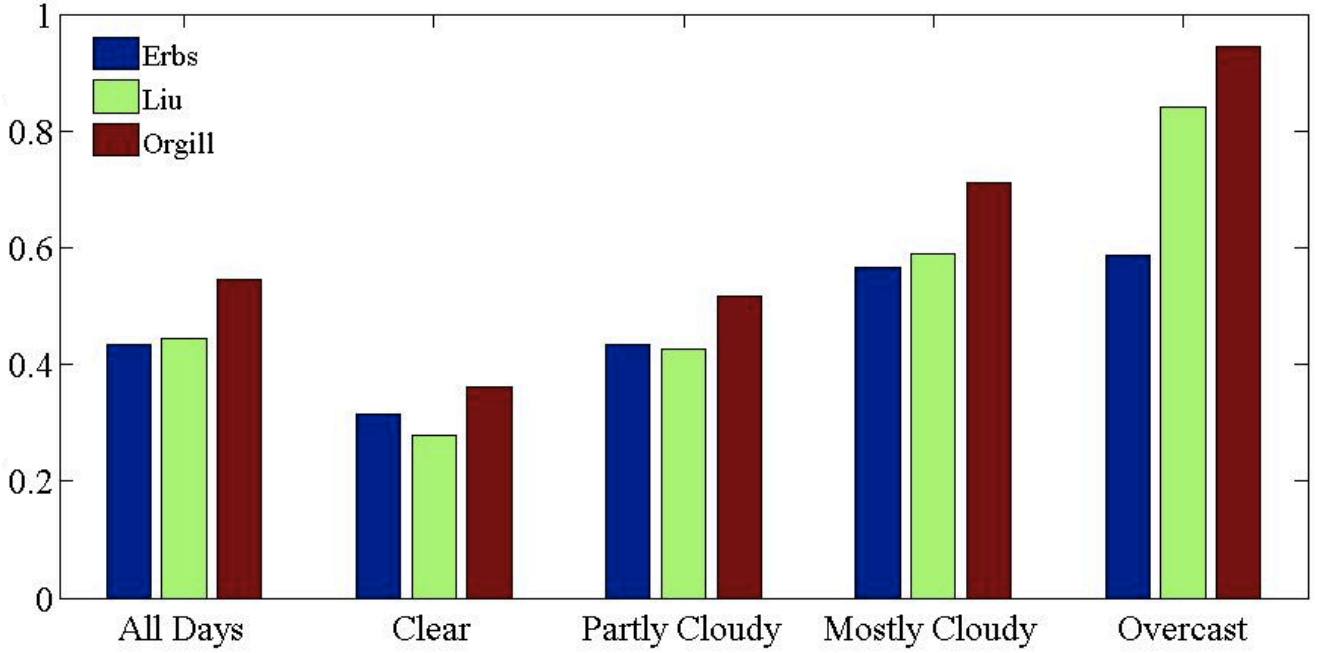


Diffuse Radiation for Varying Cloud Cover Conditions

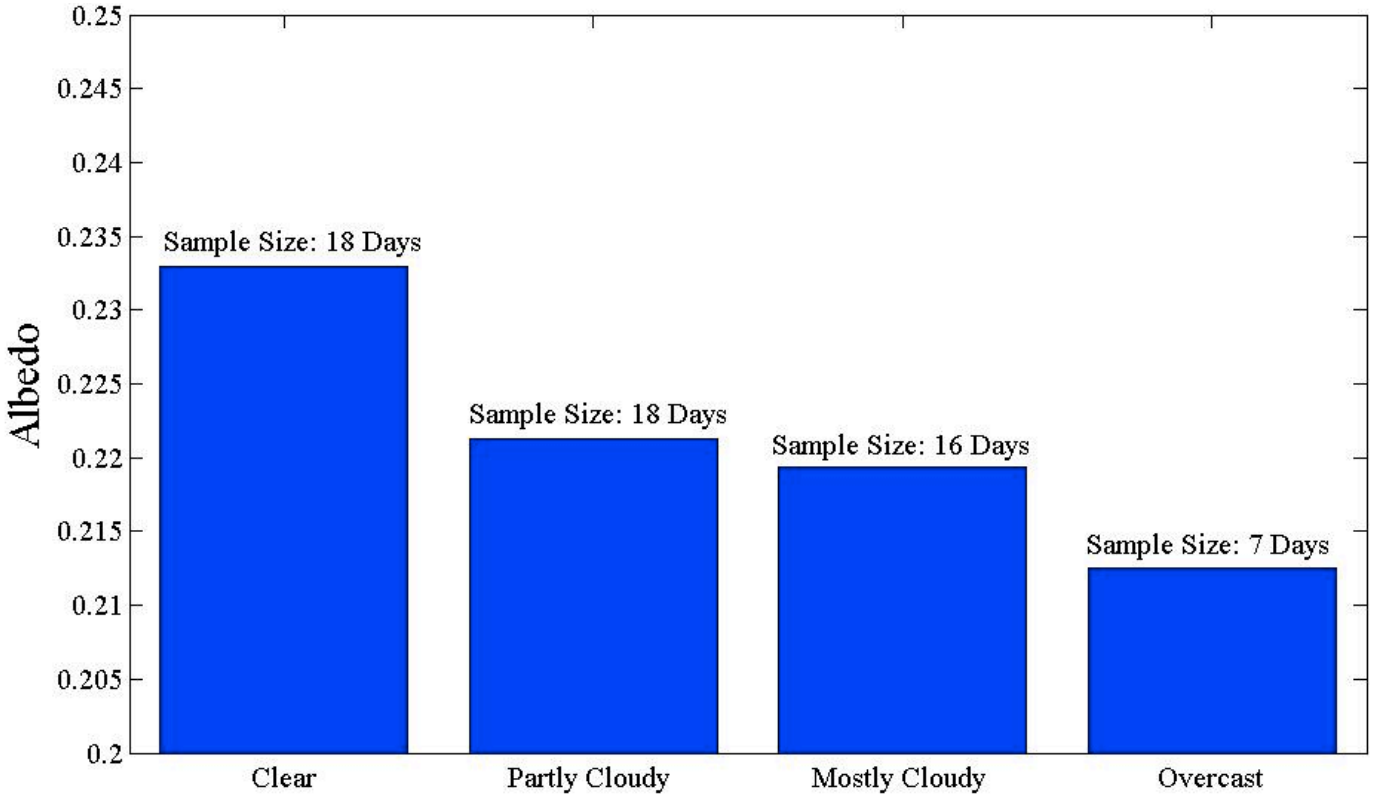
- Diffuse Radiation – not directly from sun
- Models:
  - Erbs *et al.* (1982) (various – 31 ° 5' – 42 ° 25')
  - Liu and Jordan (1960) (Massachusetts, 42 ° 13' N,)
  - Orgill and Hollands (1977) (Toronto, 43 ° 48' N)
- Brookings: 44° 21'

- Inputs:
  - Extraterrestrial Radiation (atmosphere)
  - Incoming Radiation (ground)

Diffuse Fraction (diffuse radiation/total incoming radiation)



Cloud Cover's Effects on Daily Average Albedo



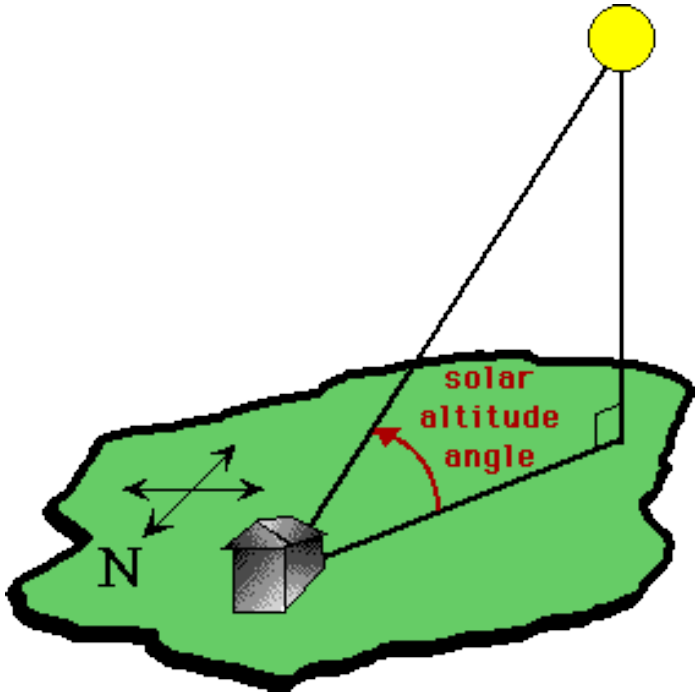
Increasing Cloudiness

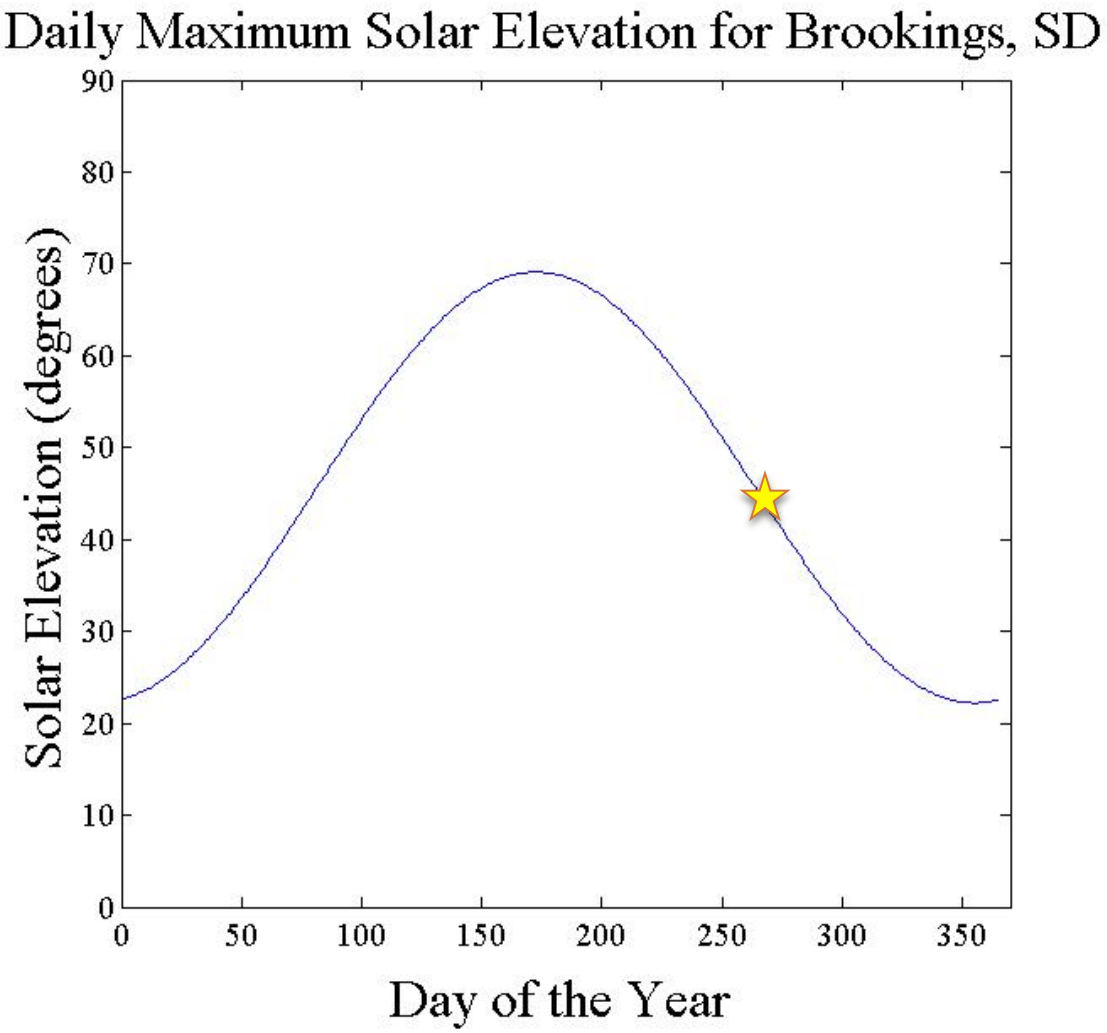
Decreasing Albedo

- Consistent with findings of Hollinger *et al.* 2010

Solar Elevation – Annual Variation

Solar Elevation
= Solar Altitude
= 90 – Solar Zenith Angle

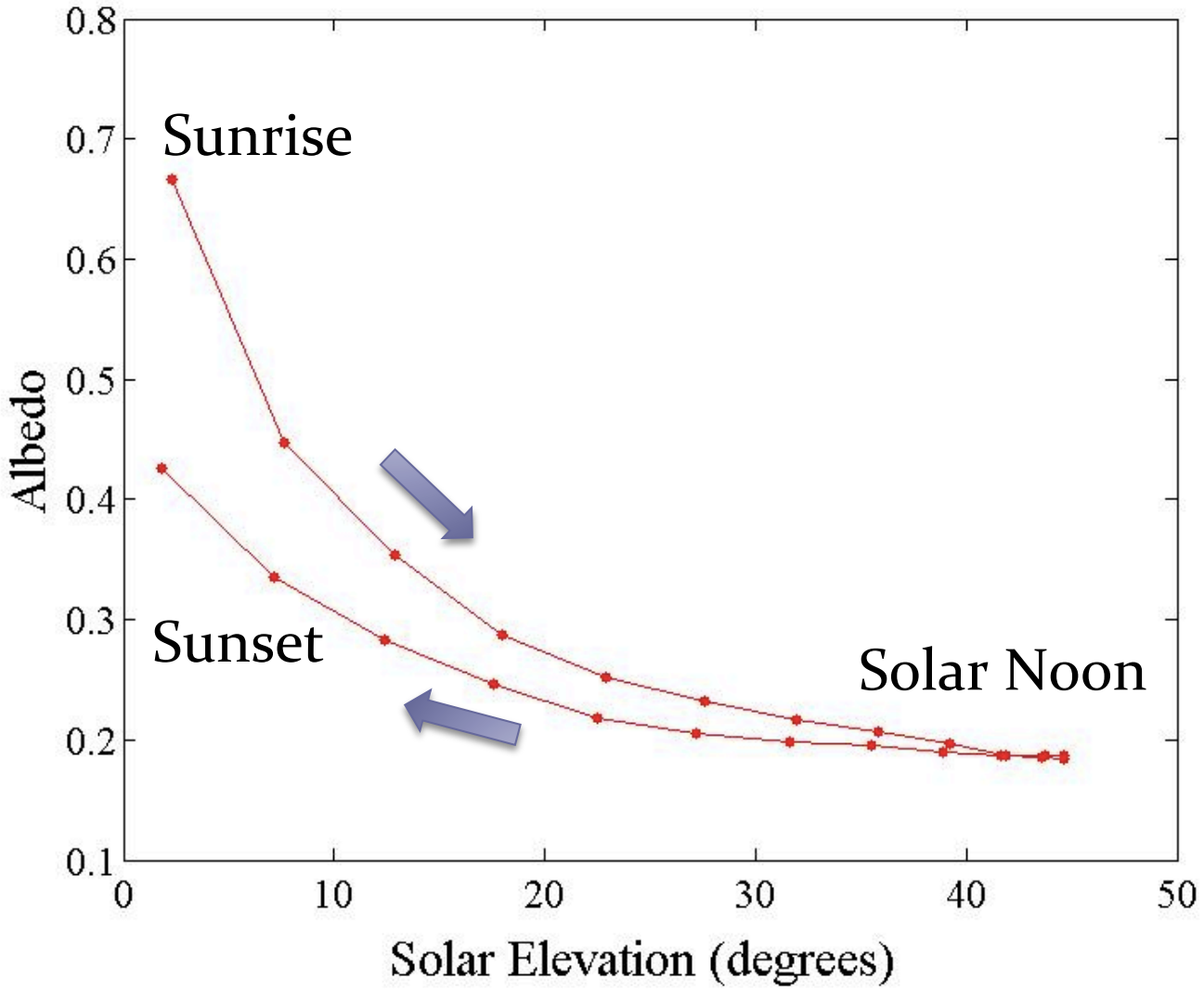




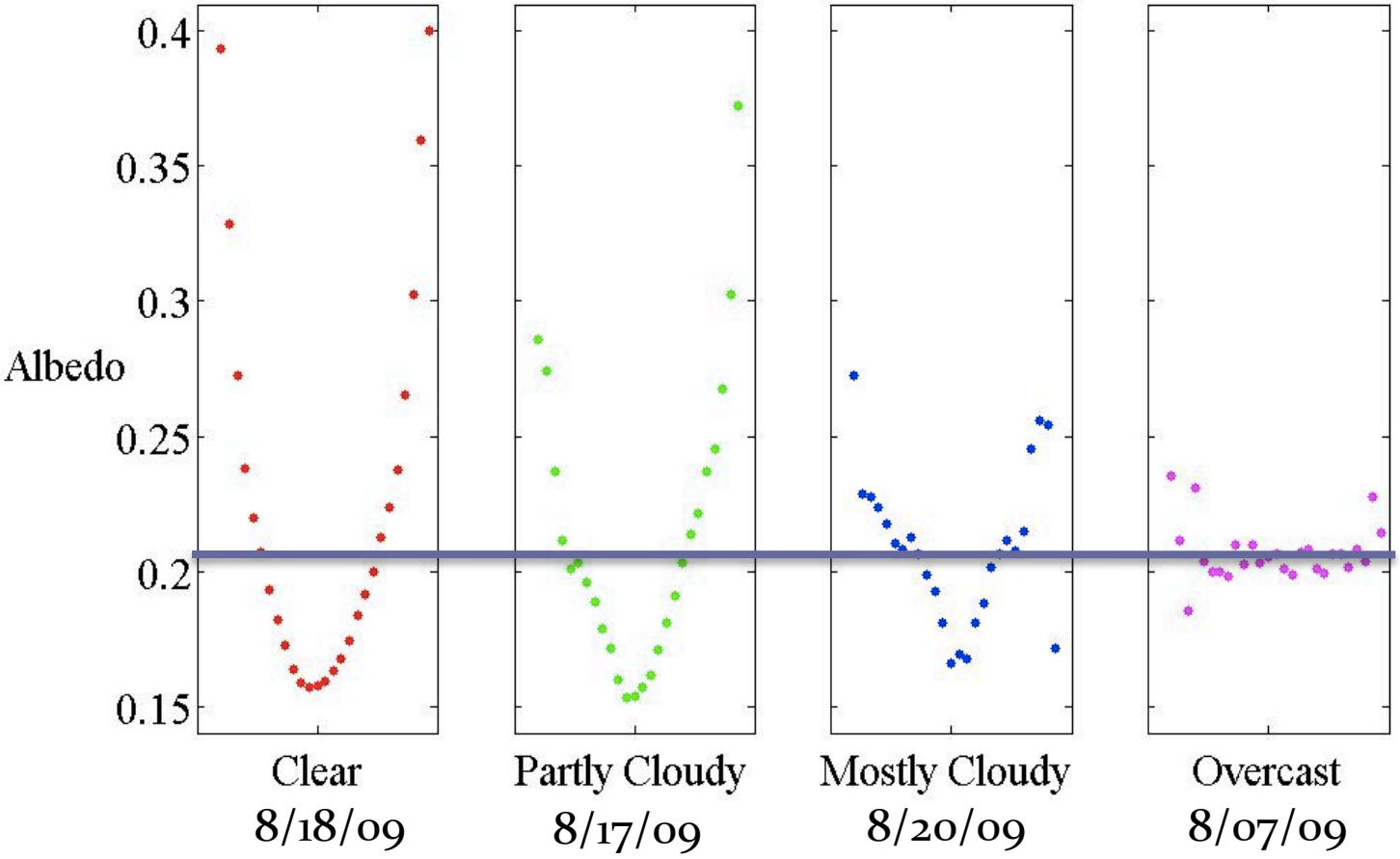
The Diurnal Effects of Solar Elevation on Albedo

- Background Information:
  - 9/23/2007
    - Autumnal Equinox
  - A Clear Day
- Diurnal Asymmetry
  - Dew, wind, other microclimatic factors

(Song, 1998)



Clouds Distort Diurnal Pattern in Albedo



- More cloud cover → More distortion
- $\alpha_{Overcast}$ and $\alpha_{Mostly\ Cloudy}$ have a smaller diurnal range

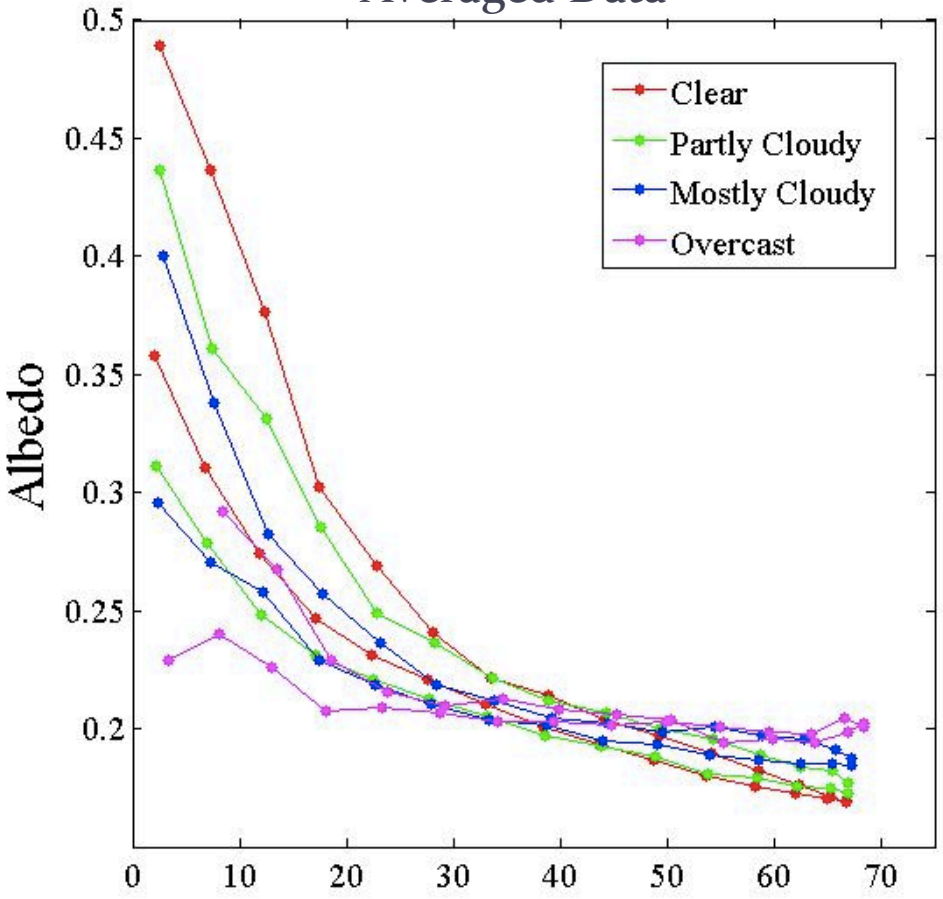
⇓ because

Radiation is diffuse and isotropic, solar declination is irrelevant

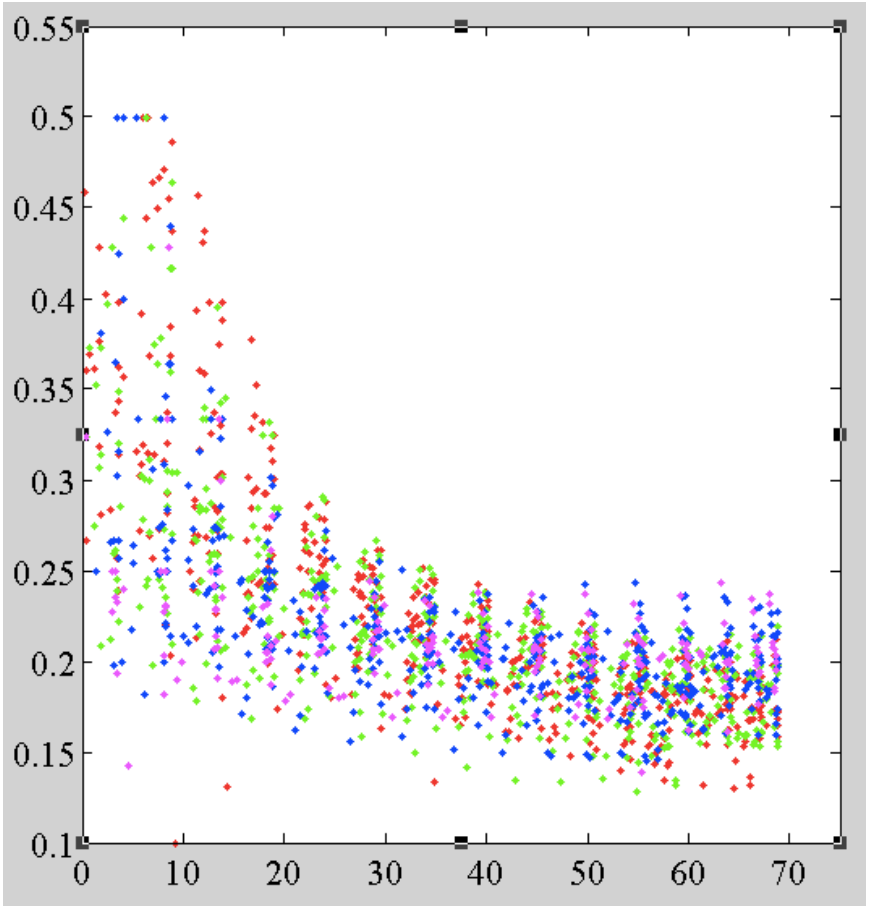
Cloud Cover and Solar Elevation: Combined Effects on Albedo

Albedo vs. Solar Declination for Various Cloud Conditions in the Summer

Averaged Data



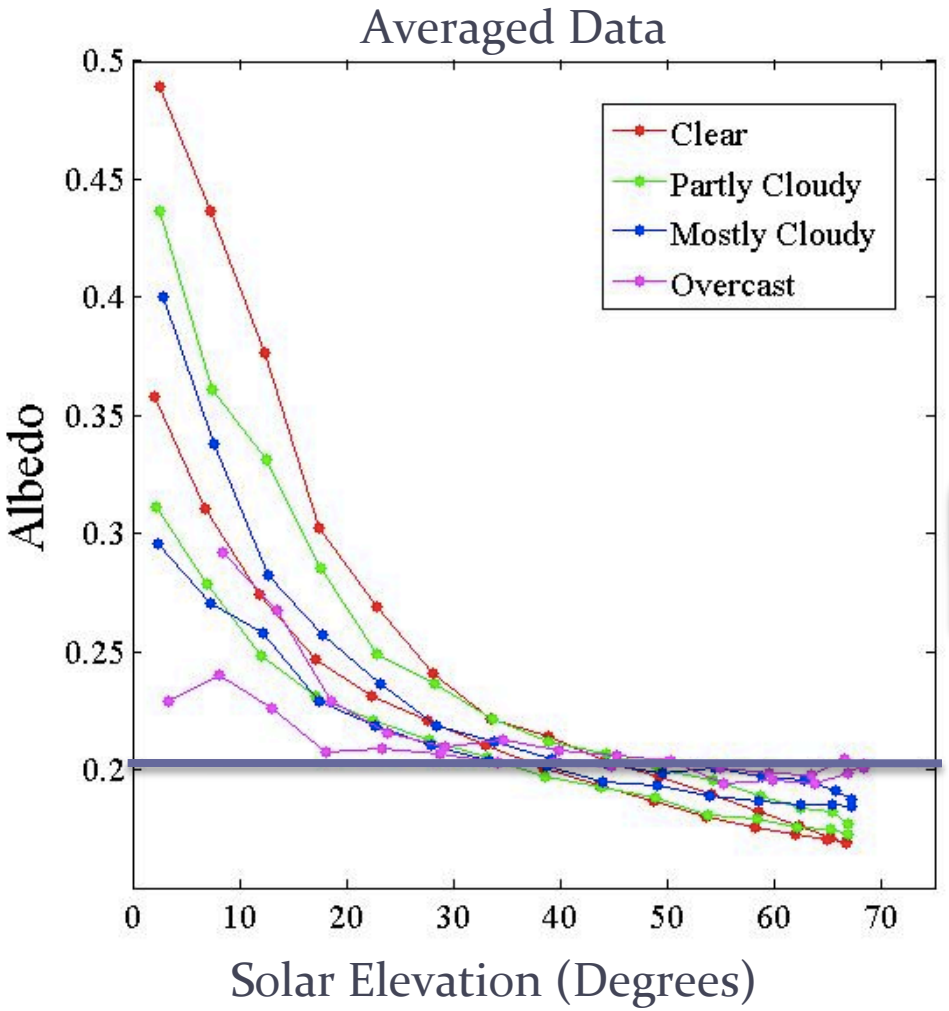
Individual Data



Solar Elevation (Degrees)

Cloud Cover and Solar Elevation: Combined Effects on Albedo

Albedo vs. Solar Declination for Various Cloud Conditions in the Summer

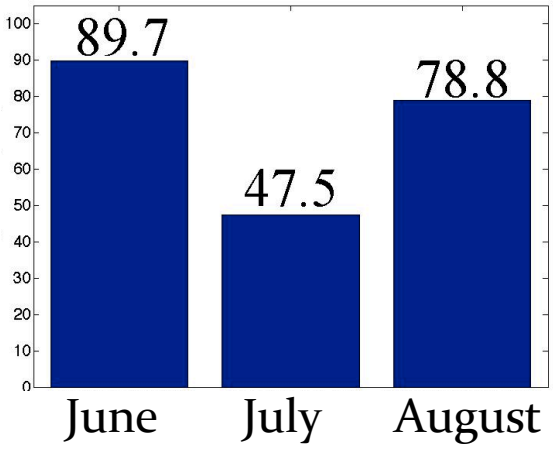


- High α at low solar elevation
- Low α at high solar elevation
- $\alpha_{morning} > \alpha_{afternoon}$
- Range of $\alpha_{clear} > \alpha_{overcast}$
- $\alpha_{overcast}$ is flat, inresponsive to changes in solar elevation

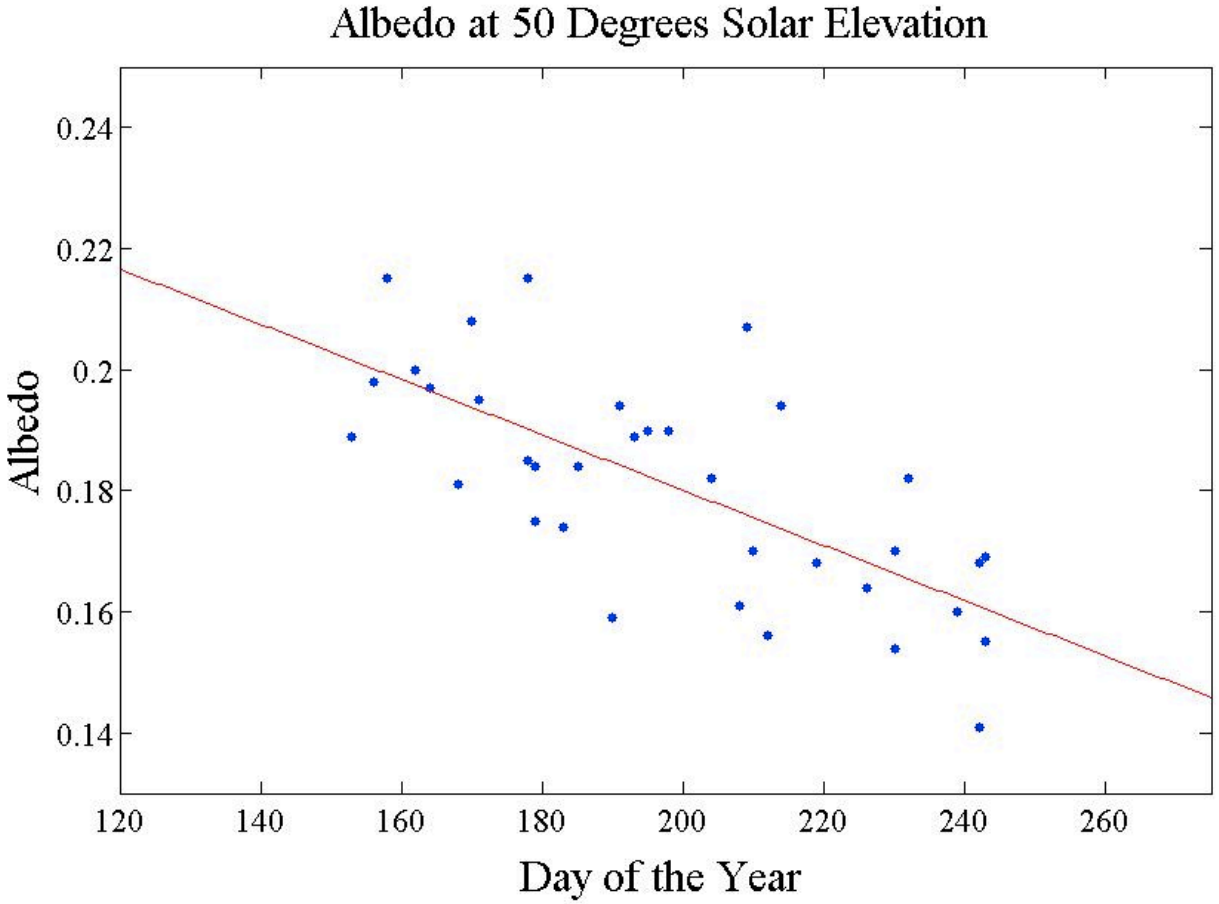
- Consistent with findings of Hollinger *et al.* 2010

Examining Phenology through Removal of Other Influences

- Decreasing trend, June through August
- Precipitation?



- Other Explanations



Conclusions

- Albedo increases linearly with snowfall
- Increasing cloud cover → Increasing diffuse fraction →
  - Lower overall albedo
  - Smaller diurnal range in albedo
  - Decrease in responsiveness of albedo to solar elevation
- After removing the influences of solar elevation and cloud cover,
  - Albedo shows a decreasing trend through summer

Future Directions

- PAR Albedo
  - Trends in the summer
- Radiation Balance Components
- Analysis of Surface Energy Balance
  - Seasonal and Diurnal Patterns
- Other Sites (other grasslands and non-grasslands)

Thank You!

- Bin
- Xuhui
- AmeriFlux
  - Tilden Meyers
  - Tagir Gilmanov
  - Bruce Wylie

References

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