An Analysis of the Surface Albedo of Brookings, SD

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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

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.

Brigham Young University’s Bean museum.
Annual Trends of Incoming and Outgoing Shortwave Radiation

150-4000 nm
Annual Trends in Albedo

Albedo Average and Range
Annual Trends in Albedo

Albedo Biweekly Averages

- $\alpha \sim 0.22$
- $\alpha \sim 0.05$
Snow Cover’s Impact on Wintertime Albedo

December - February

- $\alpha_{\text{Grassland}} = 0.16 - 0.26$
- $\alpha_{\text{Fresh Snow}} = 0.80 - 0.95$
- $\alpha_{\text{Old Snow}} = 0.45 - 0.70$

(Bonan, 2008)

- Albedo increases linearly with precipitation (snowfall)

\[ y = 0.0083x + 0.17 \]
\[ R^2 = 0.93 \]
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)

![Bar chart showing diffuse fraction for different cloud conditions](chart.png)
Cloud Cover’s Effects on Daily Average Albedo

- Consistent with findings of Hollinger et al. 2010

Increasing Cloudiness

Decreasing Albedo

Sample Size: 18 Days

Sample Size: 16 Days

Sample Size: 7 Days
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
- $\alpha_{\text{Overcast}}$ and $\alpha_{\text{Mostly Cloudy}}$ 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

Albedo vs. Solar Elevation (Degrees)
Cloud Cover and Solar Elevation: Combined Effects on Albedo

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

Averaged Data

- High $\alpha$ at low solar elevation
- Low $\alpha$ at high solar elevation
- $\alpha_{\text{morning}} > \alpha_{\text{afternoon}}$
- Range of $\alpha_{\text{clear}} > \alpha_{\text{overcast}}$
- $\alpha_{\text{overcast}}$ 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 $\rightarrow$ Increasing diffuse fraction $\rightarrow$
  ▫ 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!

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References