Yale 耶鲁大学-南京信息工程大学大气环境中心

Yale-NUIST Center on Atmospheric Environment

# Comparison of FLUXNET albedo observations with the MODIS albedo product

**YNCenter video conference**

Reporter: Chang Cao

2013-03-01

# Outline

- 1 Background
- 2 Objectives
- 3 Method
- 4 Results and interpretation
- 5 Conclusion
- 6 On-going work

# 1 Background

- Surface albedo is a critical parameter in the Earth's energy balance since it affects the amount of shortwave radiation absorbed by the surface.
- Winter precipitation (snow) can affect surface albedo and further influence the climate system.
- The in situ winter albedo (Dec-Feb) for 24 FLUXNET sites which include evergreen forests, deciduous forests, grassland and cropland have been analyzed.

## Table.1 Winter albedo for 24 FLUXNET sites

| Vegetation type | Station ID | Lat (° N) | Long(° E) | Country | Year included | in situ albedo |
|---|---|---|---|---|---|---|
| Evergreen forest | SK-OldJackPine | 53.92 | -104.69 | Canada | 1998-2006 | 0.198 |
| | QC-MatureBSpruce | 49.69 | -74.34 | Canada | 2005-2009 | 0.179 |
| | Wind River Crane Site | 45.82 | -121.95 | US | 1998-2009 | 0.099 |
| | Metolius Intermediate Pine | 44.45 | -121.56 | US | 2005-2010 | 0.207 |
| | ON-PlantnWPine1939-TP | 42.71 | -80.36 | Canada | 2002-2009 | 0.109 |
| | Niwot Ridge | 40.03 | -105.55 | US | 1999-2010 | 0.199 |
| | CBS | 42.4 | 128.08 | China | 2004-2008 | 0.134 |
| | QYZ | 26.73 | 115.05 | China | 2003-2008 | 0.078 |
| | DHS | 23.16 | 112.50 | China | 2004-2008 | 0.080 |
| | XSBN | 21.95 | 101.20 | China | 2003-2008 | 0.110 |
| | CLM | 24.58 | 121.40 | Taiwan | 2007-2008 | 0.097 |
| Deciduous forest | Lost Creek | 46.08 | -89.98 | US | 2000-2008 | 0.369 |
| | UMBS | 45.56 | -84.71 | US | 2007-2010 | 0.190 |
| | Bartlett Experimental Forest | 44.06 | -71.29 | US | 2004-2009 | 0.190 |
| | Morgan Monroe State Forest | 39.32 | -86.41 | US | 1998-2009 | 0.137 |
| | Missouri Ozark | 38.74 | -92.20 | US | 2004-2009 | 0.127 |
| | Chestnut Ridge | 35.93 | -84.33 | US | 2005-2010 | 0.144 |
| Grassland | SK-HarvestedJP2002 | 53.94 | -104.65 | Canada | 2003-2007 | 0.813 |
| | Fort Peck | 48.31 | -105.10 | US | 2000-2008 | 0.473 |
| | Brookings | 44.34 | -96.83 | US | 2004-2010 | 0.550 |
| | CBS openland | 42.4 | 128.08 | China | 2004-2008 | 0.570 |
| Cropland | Mead Irrigated Rotation | 41.16 | -96.47 | US | 2001-2010 | 0.456 |
| | Bondville | 40.00 | -88.29 | US | 2001-2008 | 0.349 |
| | ARM SGP Main | 36.61 | -97.49 | US | 2002-2010 | 0.279 |

- Limitation: FLUXNET sites cannot cover all the region and some of them do not provide accessible radiation data.
- Remote sensing (MODIS albedo product) offers a broad view of surface albedo due to its large spatial scale and coverage.

# 2 Objectives

- Use MODIS albedo product (MCD43A1) to retrieve the winter albedo for FLUXNET sites which include different plant functional types and compare them with the in situ albedo.

# 3 Method

# 3.1 MODIS albedo product

- MODIS BRDF/Albedo algorithm: three parameter semiempirical RossThickSparse-Reciprocal BRDF model
- MODIS BRDF / Albedo Model Parameter Product (MCD43A1)
- Seven spectral bands and three broadband (0.3-0.7, 0.7-5.0,and 0.3-5.0μm)
- The primary BRDF model parameters from MCD43A1 are used in the following equations to calculate black-sky, white-sky, and actual (blue-sky) albedo.

# 3.2 Calculation method

$$Black-sky\ Albedo = Parameter\_01 + Parameter\_02 \times (-0.007574 + (-0.070987 \times szn^2) + (0.307588 \times szn^3)) + Parameter\_03 \times (-1.284909 + (-0.166314 \times szn^2) + (0.041840 \times szn^3)) \quad (1)$$

$$White-sky\ Albedo = Parameter\_01 + Parameter\_02 \times (0.189184) + Parameter\_03 \times (-1.377622) \quad (2)$$

$$Blue-sky\ Albedo = White-sky\ Albedo \times f(optical\ depth, solar\ zenith\ angle, aerosol\ type, band) + Black-sky\ Albedo \times (1 - f(optical\ depth, solar\ zenith\ angle, aerosol\ type, band)) \quad (3)$$

- Black-sky albedo (BSA): directional hemispherical reflectance
- White-sky albedo (WSA): bihemispherical albedo

# 3.3 Data process

- Download the MCD43A1 broadband(0.3-5.0μm) 3 parameters from DOY345 to DOY57 during year of 2000-2009.
- Using equation (1) and (2) to calculate BSA at local solar noon and WSA.

# 3.4 FLUXNET sites land cover characteristics

To make sure the FLUXNET sites are homogeneous and minimize the uncertainty with spatial representativeness in the point-to-pixel comparison:

- Visual identification of the surrounding vegetation type around the FLUXNET tower using Google Earth.
- Retrieve the IGBP type for FLUXNET sites by using MODIS Land Cover product (MCD12Q1).

## Table.2 Vegetation types for FLUXNET sites

| Vegetation type | Station ID | MCD12Q1 IGBP | FLUXNET |
|---|---|---|---|
| **Evergreen forest** | SK-OldJackPine | Evergreen Needle-leaf Forest | Evergreen Needle-leaf Forest |
| | QC-MatureBSpruce | Evergreen Needle-leaf Forest | Evergreen Needle-leaf Forest |
| | Wind River Crane Site | Evergreen Needle-leaf Forest | Evergreen Needle-leaf Forest |
| | Metolius Intermediate Pine | Evergreen Needle-leaf Forest | Evergreen Needle-leaf Forest |
| | ON-PlantnWPine1939-TP | Mixed forest | Mixed forest |
| | Niwot Ridge | Evergreen Needle-leaf Forest | Evergreen Needle-leaf Forest |
| | DHS | Evergreen Broad-leaf Forest | Evergreen Broad-leaf Forest |
| | XSBN | Evergreen Broad-leaf Forest | Evergreen Broad-leaf Forest |
| | CLM | Evergreen Needle-leaf Forest | Evergreen Needle-leaf Forest |
| **Deciduous forest** | Bartlett Experimental Forest | Mixed forest | Evergreen Broad-leaf Forest |
| | Morgan Monroe State Forest | Evergreen Broad-leaf Forest | Evergreen Broad-leaf Forest |
| | Missouri Ozark | Evergreen Broad-leaf Forest | Evergreen Broad-leaf Forest |
| | Chestnut Ridge | Evergreen Broad-leaf Forest | Evergreen Broad-leaf Forest |
| **Grassland** | SK-HarvestedJP2002 | Evergreen needle leaf forest | Openland |
| | Fort Peck | Grassland | Grassland |
| | Brookings | Cropland | Grassland |
| **Cropland** | Mead Irrigated Rotation | Cropland | Cropland |
| | Bondville | Cropland | Cropland |
| | ARM SGP Main | Grassland | Cropland |

# 4 Results and interpretation

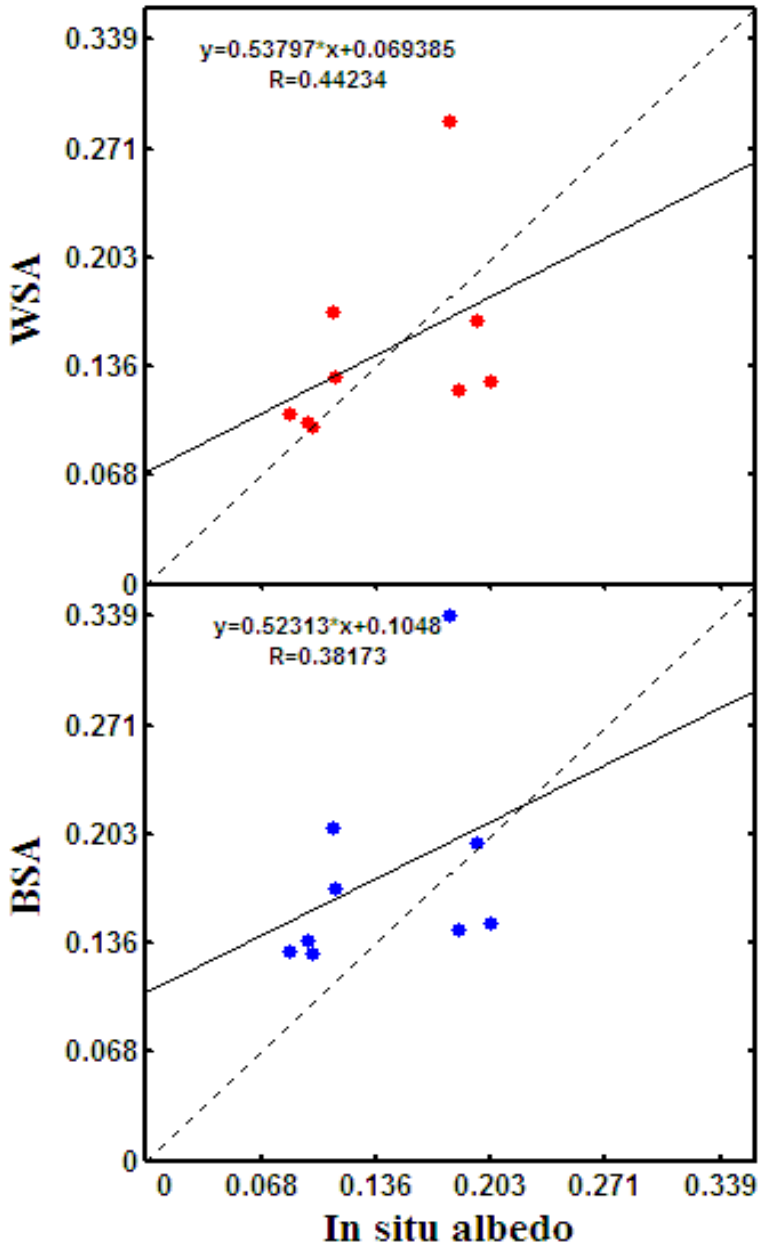


Figure.1 MODIS WSA and BSA versus in situ albedo observation of evergreen forests

- Most of the WSA and BSA of evergreen forests overestimate winter albedo.
- Satellite may see a larger fraction of sunlit gaps that forests stand and lead to higher albedo.

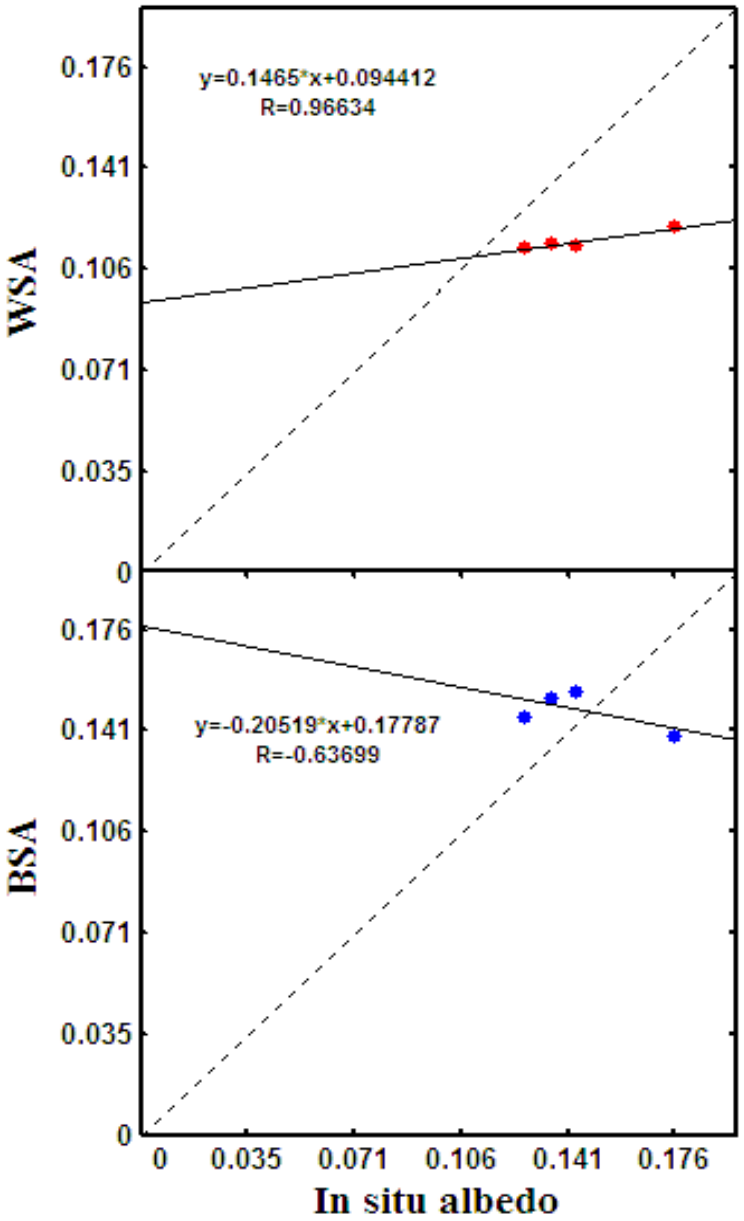


Figure.2 MODIS WSA and BSA versus in situ albedo observation of deciduous forests

- WSA of deciduous forests are lower than the in situ albedo while most of the BSA are higher than the ground measurements of albedo.

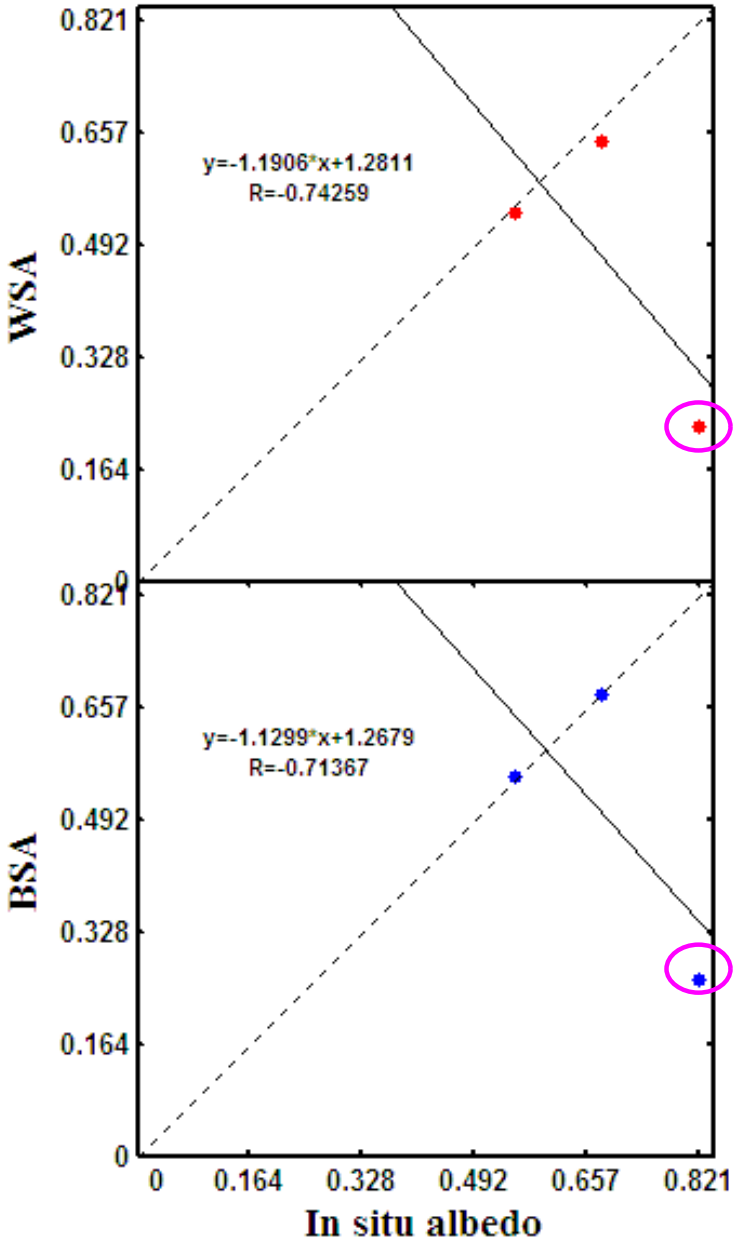


Figure.3 MODIS WSA and BSA versus in situ albedo observation of grassland

- Except SK site, the WSA and BSA of the other sites corrlate well with the in situ albedo observation.
- For SK-Harvested Jack Pine 2002, the winter albedo can be as high as 0.8 while MODIS WSA and BSA is about 0.2.

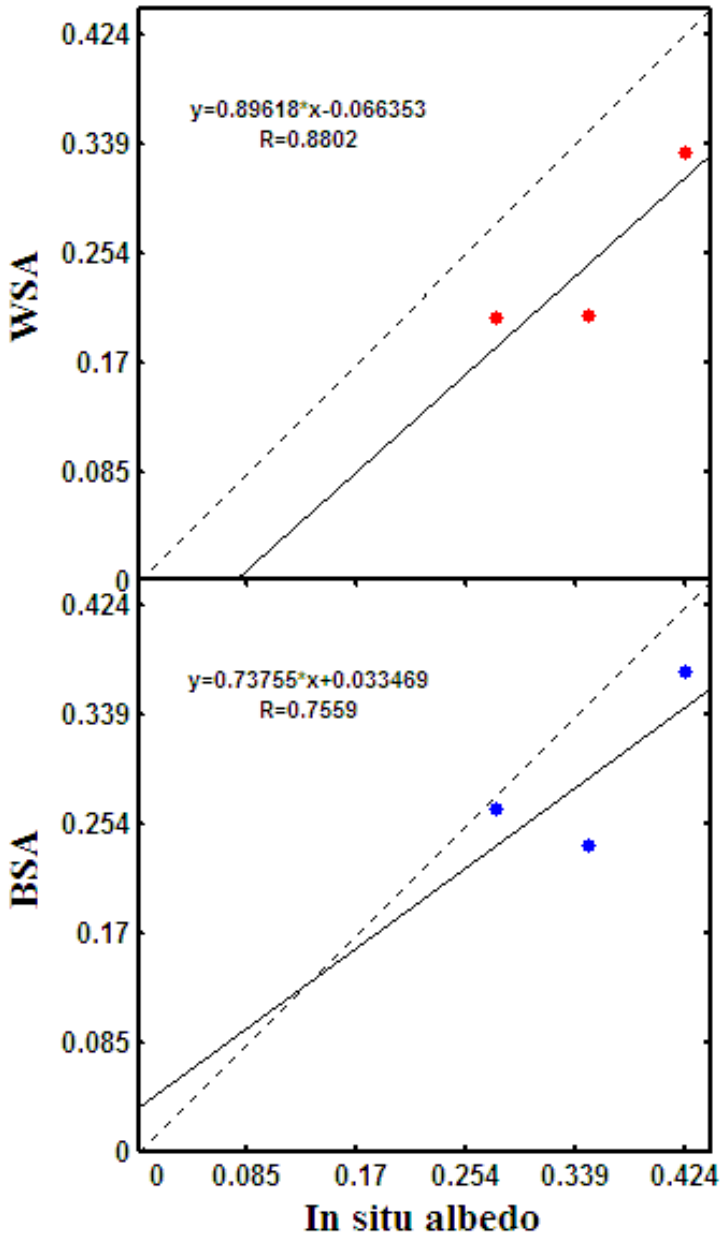


Figure.4 MODIS WSA and BSA versus in situ albedo observation of cropland

- WSA and BSA are lower than the in situ albedo observation.
- MODIS albedo estimates for bright surfaces such as snow have a low bias (the effect of aerosols) or the satellite instrument see the shadowing by snowdrift or dirty crystal snow.

**Table.3 Comparison between ground measurements of albedo and MODIS albedo**

| Vegetation type | Station ID | Year included | In situ albedo | WSA | Absolute difference | Relative difference | BSA | Absolute difference | Relative difference |
|---|---|---|---|---|---|---|---|---|---|
| Evergreen forest | SK-OldJackPine | 04,06 | 0.194 | 0.164 | -0.031 | -15.8% | 0.198 | 0.003 | 1.7% |
| | QC-MatureBSpruce | 05-08 | 0.179 | 0.288 | 0.108 | 37.7% | 0.339 | 0.160 | 89.1% |
| | Wind River Crane Site | 02,04,05,07 | 0.095 | 0.100 | 0.005 | 5.3% | 0.137 | 0.042 | 44.4% |
| | Metolius Intermediate Pine | 06,08 | 0.203 | 0.126 | -0.077 | -61.2% | 0.148 | -0.055 | -27.0% |
| | ON-PlantnWPine1939-TP | 03 | 0.110 | 0.169 | 0.059 | 34.8% | 0.208 | 0.098 | 88.8% |
| | Niwot Ridge | 00,02,03,05-09 | 0.184 | 0.121 | -0.063 | -52.0% | 0.144 | -0.040 | -21.8% |
| | DHS | 08 | 0.085 | 0.106 | 0.021 | 20.2% | 0.130 | 0.045 | 53.3% |
| | XSBN | 03-08 | 0.111 | 0.129 | 0.019 | 14.5% | 0.170 | 0.059 | 53.2% |
| | CLM | 07,08 | 0.097 | 0.098 | 0.001 | 0.9% | 0.128 | 0.031 | 31.7% |
| Deciduous forest | Bartlett Experimental Forest | 05,06,08 | 0.176 | 0.121 | -0.056 | -46.3% | 0.139 | -0.037 | -21.1% |
| | Morgan Monroe State Forest | 01-08 | 0.136 | 0.115 | -0.021 | -18.1% | 0.152 | 0.017 | 12.3% |
| | Missouri Ozark | 04-08 | 0.127 | 0.113 | -0.013 | -11.9% | 0.146 | 0.019 | 15.2% |
| | Chestnut Ridge | 05-09 | 0.144 | 0.114 | -0.029 | -25.7% | 0.155 | 0.011 | 7.6% |
| Grassland | SK-HarvestedJP2002 | 03,06 | 0.821 | 0.225 | -0.596 | -264.7% | 0.259 | -0.562 | -68.4% |
| | Fort Peck | 00,03 | 0.677 | 0.643 | -0.035 | -5.4% | 0.676 | -0.001 | -0.2% |
| | Brookings | 04,05,07-09 | 0.550 | 0.537 | -0.013 | -2.4% | 0.555 | 0.005 | 0.8% |
| Cropland | Mead Irrigated Rotation | 01-04 | 0.424 | 0.333 | -0.091 | -27.2% | 0.372 | -0.052 | -12.2% |
| | Bondville | 01-07 | 0.349 | 0.206 | -0.143 | -69.4% | 0.238 | -0.112 | -32.0% |
| | ARM SGP Main | 02-09 | 0.279 | 0.204 | -0.074 | -36.4% | 0.267 | -0.012 | -4.4% |

# 5 Conclusions

- For most FLUXNET sites, the difference of in situ albedo observation between WSA and BSA is within 0.091 and 0.098 respectively in terms of absolute value and within 70% and 90% respectively in terms of relative value.
- For evergreen forests sites, WSA and BSA overestimate the in situ albedo while for cropland, they underestimate the in situ albedo observation. For deciduous forests, WSA and BSA show contrary trends.
- For grassland sites, WSA and BSA are both closer with in situ albedo.
- WSA and BSA can be well representative of the in situ albedo for grassland.
- MODIS actual albedo may overestimate the albedo evergreen forests and underestimate that of cropland.

# 6 On-going work

- Whether WSA is accurate enough to represent the in situ albedo? If not, finding method of defining f in equation (3) to calculate blue-sky albedo for these FLUXNET sites will be needed and then compare them with the in situ observation.
- Expand research area: Choosing the weather stations which are surrounded by different vegetation types by using MODIS Land Cover product and get their MODIS albedo retrievals to further study the relationship between winter precipitation and surface albedo.

Yale 耶鲁大学-南京信息工程大学大气环境中心

Yale-NUIST Center on Atmospheric Environment

# Thank you