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Precipitation effect on winter land surface albedo

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◆Outline

- **Background**
- **Objectives**
- **Method**
- **Results**
- **Conclusion**
- **Future work**

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◆Background

- Land use change (deforestation) often leads to the change of land surface albedo which has great impact on surface energy balance.
- Due to climate change, the grassland will expands northward. More boreal forests which have relatively low albedo will be replaced by grassland of high albedo. This change will lets more solar radiation be reflected and has a cooling effect for climate system.

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Surface albedo (α)

- The ratio of the reflected solar radiation to the incoming solar radiation

$$\alpha = S\downarrow / S\uparrow \qquad (1)$$

- Shortwave radiation consists of two major parts: direct and diffuse radiation. It often refers to a spectrum that includes ultraviolet(150-400nm), visible (VIS)(400-700nm) and near-infrared (NIR)(700-4000nm)radiation.

Source: Deng,2010

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Albedo versus Surface Energy Balance

$$R_n = S\downarrow(1-\alpha)+L\downarrow-L\uparrow \qquad (2)$$

R_n: Net radiation

$S\downarrow$: Incoming solar radiation

α : The ratio of the reflected solar radiation to the incoming solar radiation

$L\uparrow$: Upwelling long-wave radiation

$L\downarrow$: Downwelling long-wave radiation

Source: Betts,1997

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Physical climate system

- Albedo affects the radiation balance of surface, therefore impacts the surface temperature and the structure of boundary layer.

Ecological system

- Albedo controls the microclimate conditions of plants : radiation absorption which affects ecosystem physical, physiological and biogeochemical processes: photosynthesis, evapotranspiration and respiration.

Source:Wang et al,2001

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Albedo values for common natural surfaces

Surface	*Albedo*
Fresh snow	0.80-0.95
Old snow	0.45-0.70
Desert	0.20-0.45
Glacier	0.20-0.40
Soil	0.05-0.40
Cropland	0.18-0.25
Grassland	0.16-0.26
Deciduous Forest	0.15-0.20
Coniferous Forest	0.05-0.15
Water	0.03-0.10

Source: Bonan,2008

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Factors

- Vegetation types (dense canopy) [Betts,1997]
- Snow absence/presence [Wang,2007]
- Strong wind [Betts, 1997]
- Temperature (more important in transitional season) [Wang,2007]

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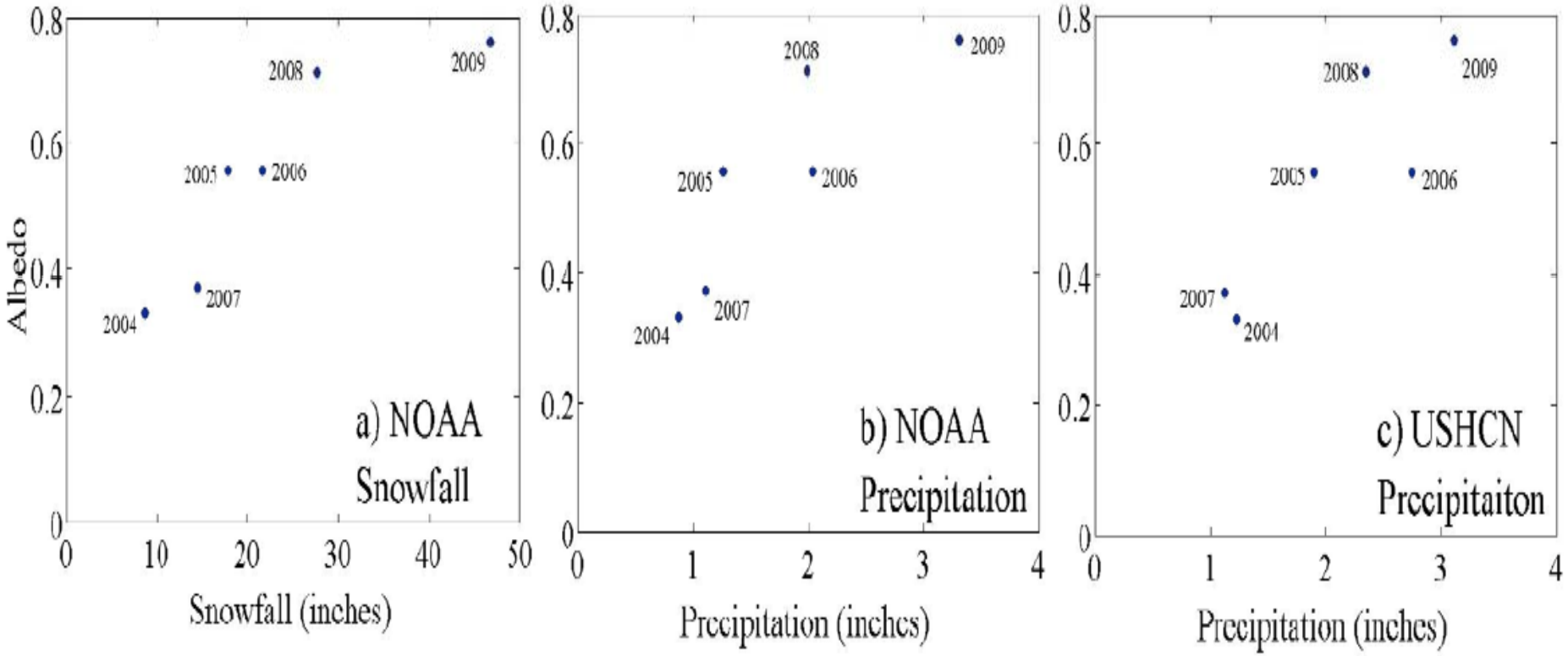
Brookings Site, Ameriflux



Source: Deng,2010

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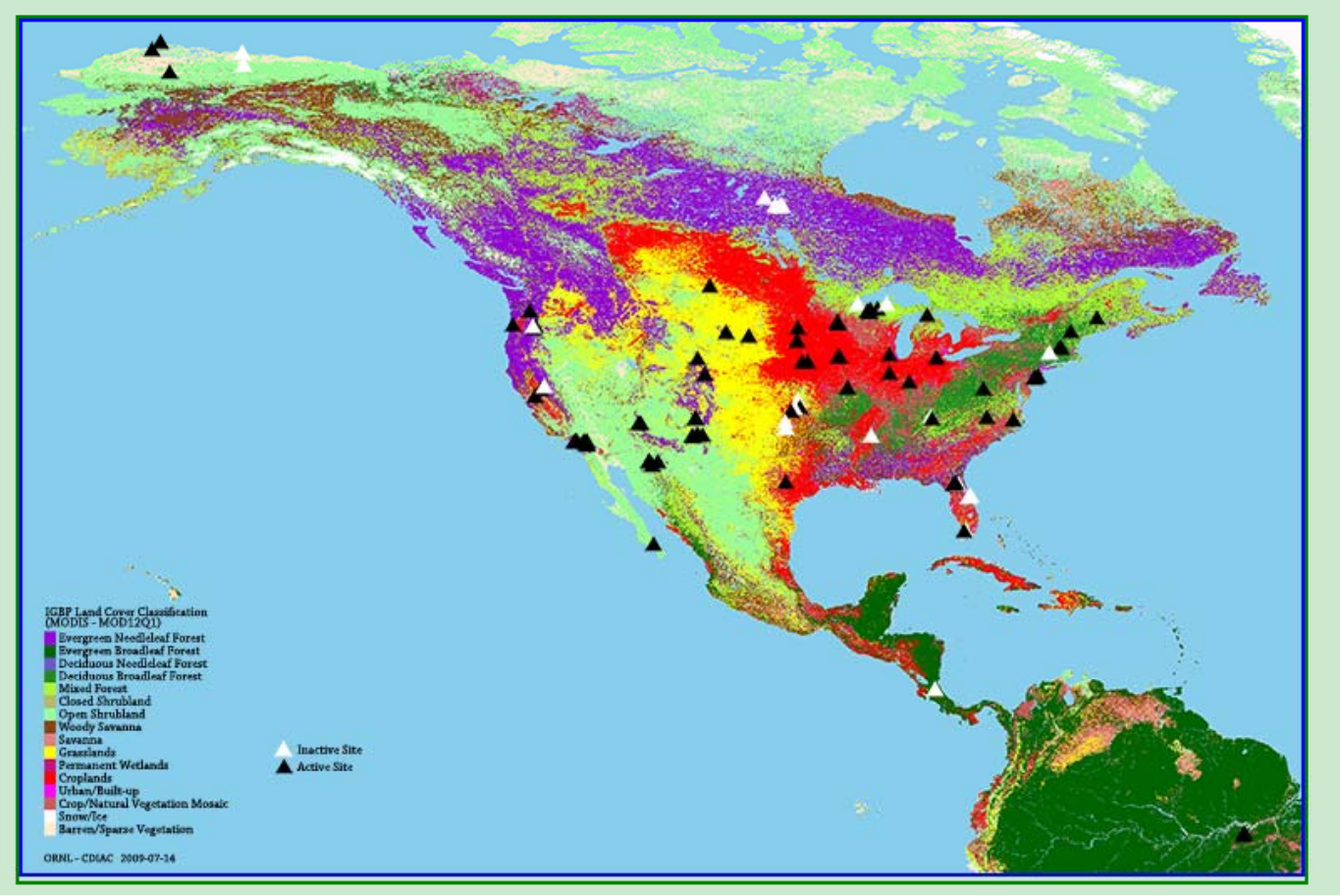
◆Objective

- To describe the relationship between precipitation and albedo in winter for four different kinds of vegetation types.

◆Method

Sites distribution of Ameriflux



Source: http://public.ornl.gov/ameriflux/site-select.cfm

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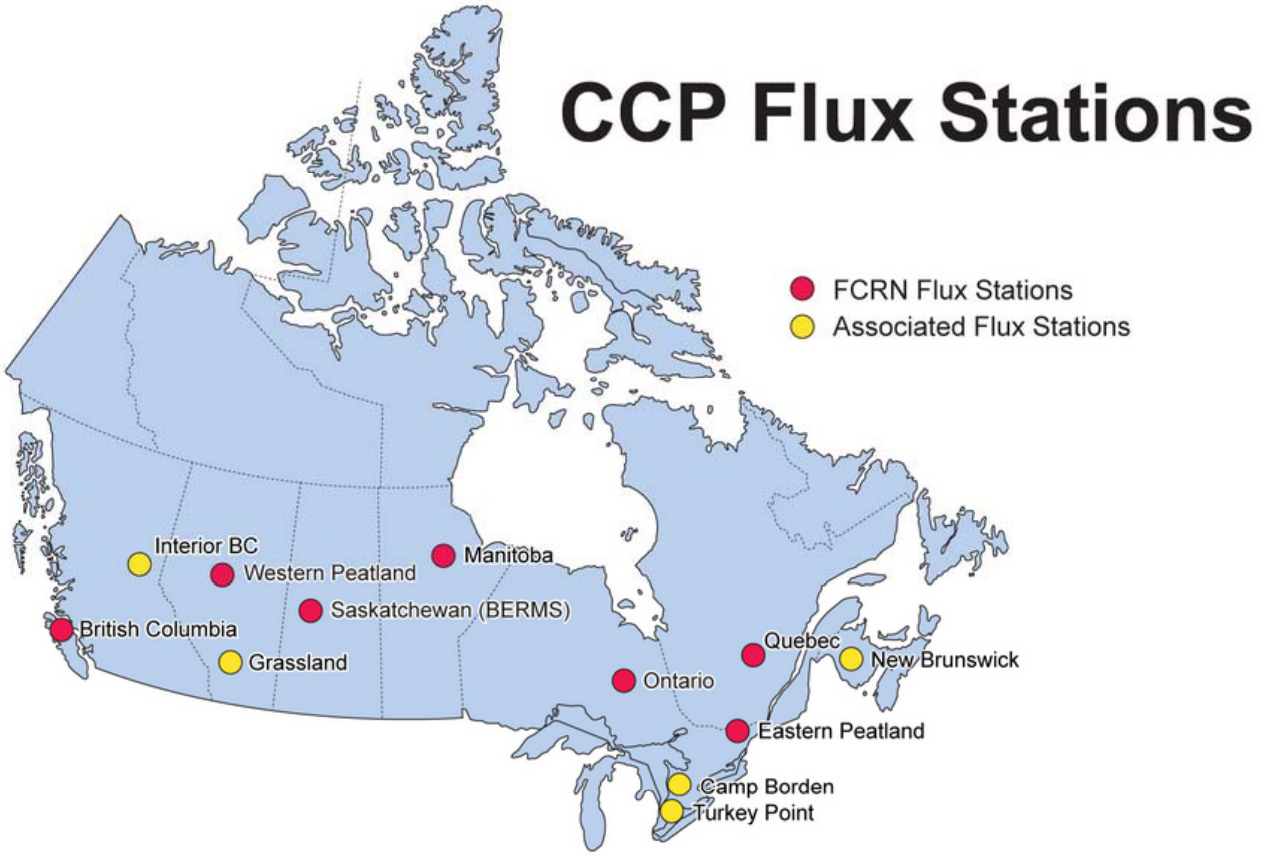

Source:http://fluxnet.ccrp.ec.gc.ca/PublicMeasuredData/0_Map_CCP-Flux-Stations_2008.jpg

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Sites information of Ameriflux

Sites Information				
Type	Site Name	Latitude	Longitude	Year Included
Grassland	Fort Peck	48.31° N	105.10° W	2000-2008
	Brookings	44.34° N	96.83° W	2004-2010
Deciduous Forest	Lost Creek	46.08° N	89.98° W	2000-2008
	UMBS	45.56° N	84.71° W	2007-2011
	Bartlett Experimental Forest	44.06° N	71.29° W	2004-2009
	Morgan Monroe State Forest	39.32° N	86.41° W	1998-2009
	Missouri Ozark	38.74° N	92.20° W	2004-2009
	Chestnut Ridge	35.93° N	84.33° W	2005-2010
Coniferous Forest	Wind River Crane Site	45.82° N	121.95° W	1998-2009
	Metolius Intermediate Pine	44.45° N	121.56° W	2005-2010
	Niwot Ridge	40.03° N	105.55° W	1999-2010
Cropland	Sioux Falls Portable	43.24° N	96.90° W	2007-2009
	Mead Irrigated Rotation	41.16° N	96.47° W	2001-2010
	Bondville	40.00° N	88.29° W	2001-2008
	ARM SGP Main	36.61° N	97.49° W	2002-2010

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Weather Station Information of USHCN

Weather Station Selected					
Type	Station Name	Station ID	Latitude	Longitude	Year Included
Grassland	Glasgow Int	245572	48.48° N	104.45° W	2000-2008
	HOWARD	394037	44.01° N	97.52° W	2004-2010
Deciduous Forest	MINOCQUA	475516	45.89° N	89.73° W	2000-2008
	CHEBOYGAN	201492	45.65° N	84.47° W	2007-2010
	BETHLEHEM 2	270706	44.31° N	71.66° W	2004-2009
	COLUMBUS	121747	39.20° N	85.92° W	1998-2009
	JEFFERSON CITY WTP	234271	38.59° N	92.18° W	2004-2009
	CROSSVILLE ED AND RESEARCH	402202	36.01° N	85.13° W	2005-2010
Coniferous Forest	GOLDENDALE	453222	45.81° N	120.84° W	1998-2009
	CASCADIA	351433	44.39° N	122.48° W	2005-2010
	BOULDER	050848	39.99° N	105.27° W	1999-2010
Cropland	CANTON	391392	43.31° N	96.59° W	2007-2009
	ASHLAND NO 2	250375	41.04° N	96.38° W	2001-2010
	URBANA	118740	40.08° N	88.24° W	2001-2008
	JEFFERSON	344573	36.72° N	97.79° W	2002-2010

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Sites Information of Fluxnet Canada

Type	Site Name	Latitude	Longitude	Year Included
Grassland	SK-HarvestJP2002	53.94° N	104.65° W	2003-2009
Coniferous Forest	SK-OldJackPine	53.92° N	104.69° W	1998-2009
	QC-MatureBSpruce	49.69° N	74.34° W	2003-2009
	ON-PlantnWPine1939-TP	42.71° N	80.36° W	2002-2009

Weather Station Information of Environment Canada

Type	Site Name	Latitude	Longitude	Year Included
Grassland	PRINCE ALBERT A	53.22° N	105.67° W	1998-2007
Coniferous Forest	PRINCE ALBERT A	53.23° N	105.68° W	1998-2008
	BAIE-COMEAU A	49.13° N	68.20° W	2005-2009
	HAMILTON A	43.17° N	79.93° W	2002-2009

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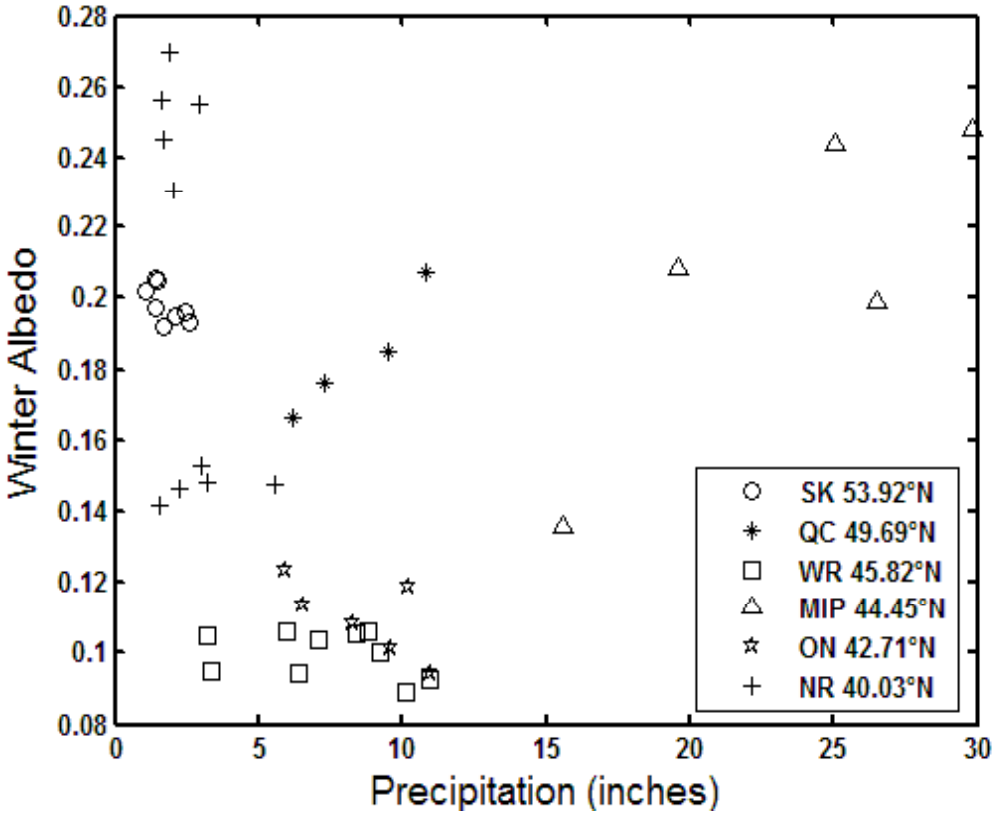
- Albedo calculation $\alpha = \sum k_{out} / \sum k_{in}$

- Winter (Dec-Feb) precipitation calculation $P = \sum_{1}^{n} p_n$

◆Results

Coniferous Forest



- Winter albedo of MIP and QC increase as the total precipitation amount increase.
- However, the albedo of SK, WR, ON and NR decrease as the total precipitation amount increase.

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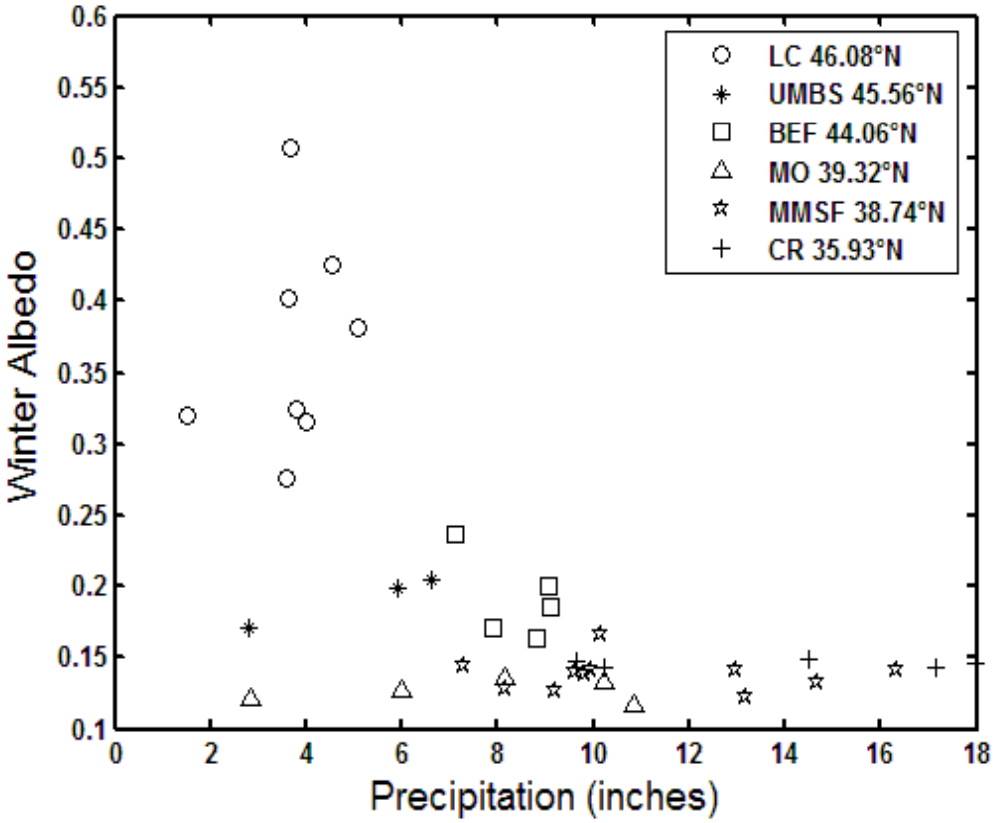
Deciduous Forest



- The winter albedo of LC and UMBS increase as the total precipitation amount increase.
- The relationship between albedo and total precipitation amount of BEF shows the contrary trend.
- The relationship between winter albedo and total precipitation amount of the other three sites do not show obvious tendency.

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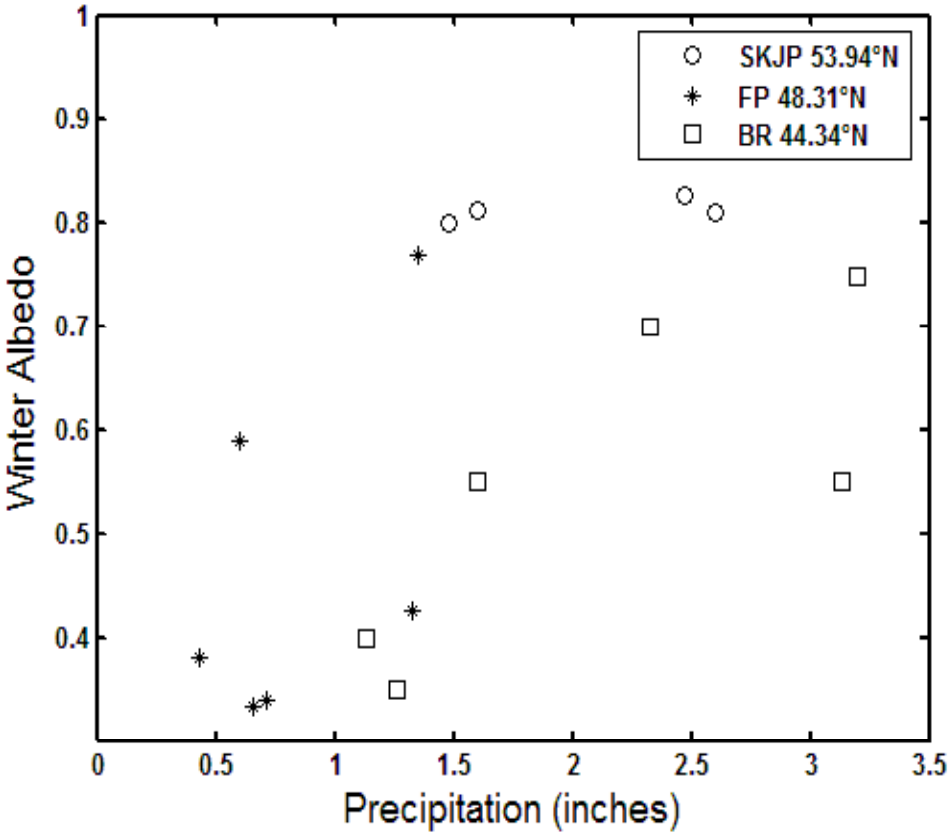
Grassland/ Harvest land



- For all the three sites, their albedo increase as total precipitation amount increases.

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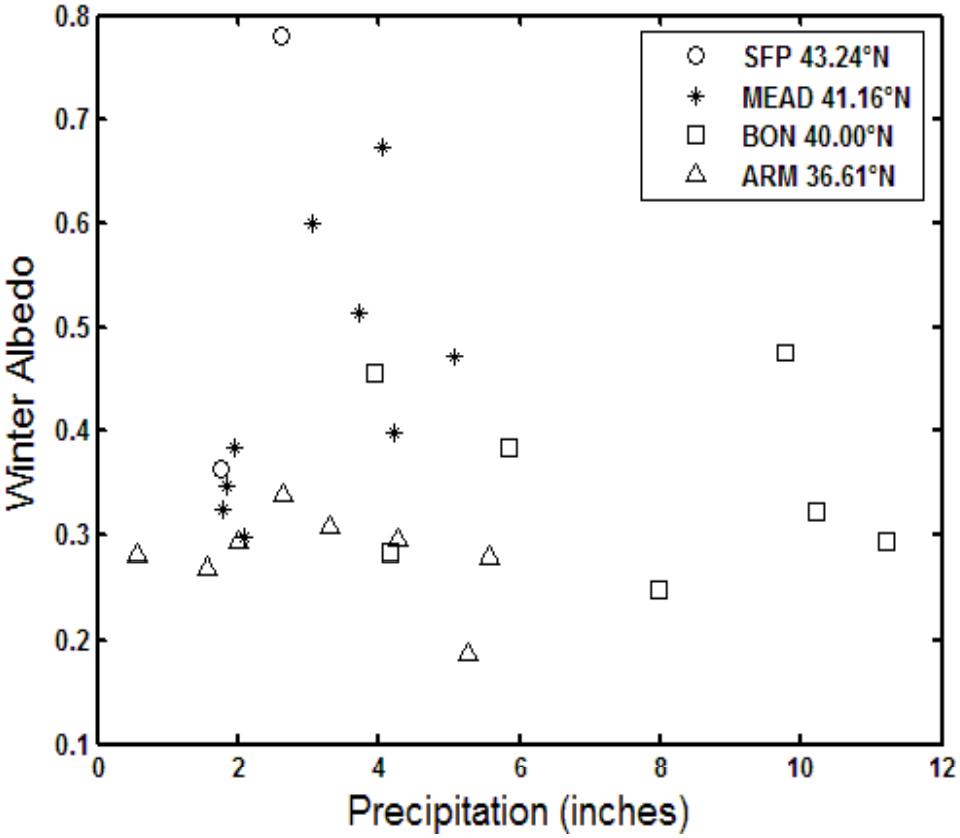
Cropland



- For SEP and MEAD, their albedo increase as the total precipitation amount increase.
- For BON and ARM, the albedo decrease slightly when the total precipitation amount increase.

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Fitting Equations for Some Sites

Type	Site Name	Fitting Equation	R^2
Coniferous Forest	SK(53.92° N)	y=-0.0064x+0.2095	0.4468
	QC(49.69° N)	y=0.008x+0.1161	0.9177
	MIP(44.45° N)	y=-0.0066x+0.0528	0.6857
	ON(42.71° N)	y=-0.0037x+0.1415	0.463
	NR(40.03° N)	y=-0.0201x+0.2512	0.1942
Deciduous Forest	UMBS(45.56° N)	y=0.0087x+0.1474	0.9999
	BEF(44.06° N)	y=-0.0191x+0.3515	0.3301
Grassland/ Harvest land	SKJP(53.94° N)	y=0.012x+0.7878	0.4085
	FP(48.31° N)	y=0.2338x+0.2751	0.2841
	BR(44.34° N)	y=0.1346x+0.2662	0.6116
Cropland	MEAD(41.16° N)	y=0.0613x+0.2508	0.3577
	ARM(36.61° N)	y=-0.009x+0.3095	0.1365

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◆Conclusion

- For sites which locate in higher latitudes, their albedo usually increase as the total precipitation amount increase. Because of the snow presence in these sites.
- Grassland has showed obvious positive relationship between winter albedo and precipitation. Deciduous forest has show the latitude dependent phenomenon.
- Cropland and grassland usually have higher albedo than deciduous forest and coniferous forest due to the canopy shading of forests.

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◆Future work

- Knowledge preparation and information collections for MODIS albedo products and their applications through reading literature and books.
- Site Choosing: Choosing some weather stations which are surrounded by different kinds of vegetation types.
- Using MODIS albedo products and then compare the satellite albedo values with in situ observations to look for new points.

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Thank You