

MODIS /Terra Snow Cover Maps Accuracy Assessment for Connecticut in 2014-2015 Winter

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INTRODUCTION

Moderate-Resolution Imaging Spectroradiometer (MODIS) data, available since 2000, derived from MODIS observations of the land, oceans and the atmosphere, provide an efficient way to observe earth dynamics and natural resources. MOD10A1 is one kind of snow cover data, consisting of 1200 km by 1200 km tiles of 500m spatial resolution data gridded in a sinusoidal map projection. This product identifies snow cover on land and inland water. The main limitation of this data, however, is cloud obscuration and forest canopy obstruction. As such, the accuracy of MODIS snow products must be known in order to optimize their use. Connecticut is defined as the study area in this research, and the winter of 2014-2015 was selected as the time period since snowfall during that winter season was above average. Through comparing MOD10A1 snow cover maps with snow depth observation in cloud-free condition, which is used as ground truth, overall accuracy was calculated. Mapping accuracy was analyzed under varied snow depth, topography and forest canopy to determine which factors are highly related to accuracy of MOD10A1 snow cover maps. The overall accuracy of MODIS daily snow cover mapping algorithm in clear sky condition in Connecticut in 2014-2015 winter was 89.1%. Findings show snow depth influences the accuracy of MODIS snow cover maps, while mapping accuracy is not related to slope, aspect and elevation and forest canopy. Mapping accuracy increases with snow depth. When snow depth is over 15 centimeters, MODIS identified snow cover at a mapping accuracy of nearly 100%.

METHODS

Data

1. Daily snow depth observation in cm from NWS-COOP
2. MOD10A1 snow cover maps
3. 1 arc-second DEM map and land cover map
4. NLCD 2011 percent tree canopy maps

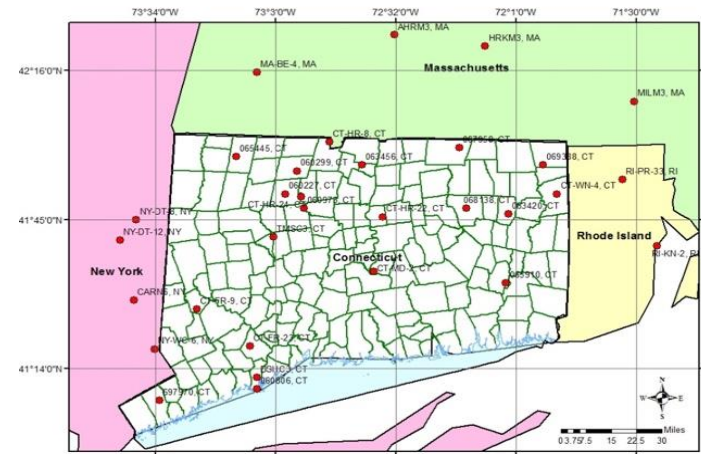


Figure 1. The study area (Connecticut), with locations and names of 31 snow stations

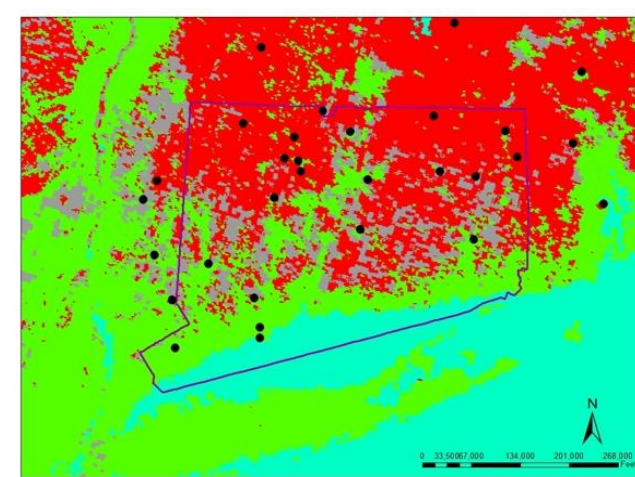


Figure 2. MOD10A1, 3/23/2015, in Connecticut



Figure 3. Figure19. Mosaicked NLCD 2011 percent tree canopy map of NYC, MA, CT, RD

Methodology

1. Projection and Extracting values
2. Neighborhood analysis, by reclassification and neighborhood function.
3. Accuracy assessment
 - 3.1 Select and valid data, using Microsoft Access
 - 3.2 Accuracy assessment of MOD10A1 and correlation analysis

RESULTS

Error Matrix for MOD10A1 Accuracy Assessment

Table 1. Confusion matrices for 153 MODIS maps comparing with climate stations during November 13th, 2014 to April 15th, 2015

	Snow(Truth)	No Snow(Truth)	Total	Commission
Snow(MOD)	262	20	282	92.9%
No Snow(MOD)	66	441	507	87.0%
Total	328	461	789	
Omission	79.9%	95.7%		89.1%

- Accuracy is highly related to snow depth. $y = 0.15 \ln(x) + 0.56, r^2 = 0.80$

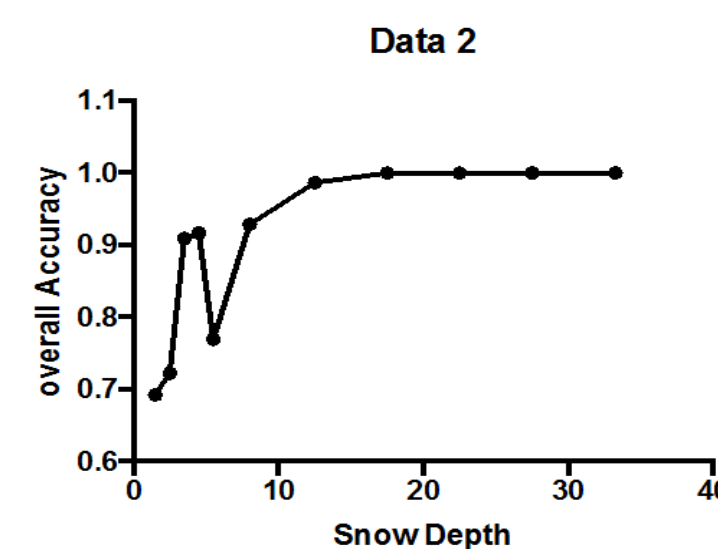


Figure 4. The Correlation between overall accuracy and snow depth

Table 2. Accuracy of MODIS snow cover maps by snow depth

Snow Depth	Mean	Accuracy
0-1	0.5	26.1%
1-2	1.5	69.2%
2-3	2.5	72.2%
3-4	3.5	90.9%
4-5	4.5	91.7%
5-6	5.5	76.9%
6-10	8.0	92.9%
10-15	12.5	98.6%
15-20	17.5	100.0%
20-25	22.5	100.0%
25-30	27.5	100.0%
30-36.5	33.3	100.0%

- There is no significant correlation between accuracy and topography. (75%elevation + 10% slope +5% aspect) When $P > 0.01$, not related.

Table 2. Comparison between MODIS snow cover maps and individual climate stations from November 13th, 2014 to April 15th, 2005, the correlation between accuracy and topography factors

Snow Station	Elevation	Aspect	Slope	Aggrement		Disagreement		Accurac
				S(O)S(M)	N(O)N(M)	S(O)N(M)	N(O)S(M)	
MA- BE-4	412.9	90.3	0	13	10	3	0	88.5%
HRKM3	177.2	74.2	0	18	19	1	0	97.4%
60299	171.0	79.8	0	15	11	1	4	83.9%
63456	51.6	264.1	0	4	26	2	1	90.9%
AHRM3	44.9	88.2	0	18	10	0	1	96.6%
60806	1.5	192.6	0	6	38	3	1	91.7%
60227	172.0	275.3	1	14	15	7	1	78.4%
NY- WC-6	150.6	335.8	3	6	27	8	0	80.5%
697970	61.4	157.2	3	0	40	0	3	93.0%
BSHC3	8.1	96.4	3	8	19	4	0	87.1%
MILM3	90.7	7.8	4	7	31	1	0	97.6%
67958	223.0	102.2	6	16	20	1	2	92.3%
69388	105.3	115.3	8	10	27	2	1	92.5%
TMSC3	168.6	335.8	9	12	19	3	0	91.2%
65445	445.0	44.9	10	12	11	6	1	76.7%
60973	153.5	40.2	11	10	24	0	1	97.1%

Table 3. Results of topographic correlation analysis

Coefficients	Value	Pr(> t)
Intercept	24.35	0.00000
Slope	0.492	0.63
Aspect	0.786	0.46
Elevation	1.997	0.07

- Accuracy of MOD10A1 in CT is not related to tree canopy cover and distance from shoreline, either.

CONCLUSIONS

In Connecticut from November 2014 through April 2015, the overall accuracy for MOD10A1 snow cover maps was found to be 89.1%, through the comparison of the MOD10A1 snow cover map product and reported snow depth observation (ground truth) under cloud-free conditions. In disagreement, MODIS is more likely to misidentify existing snow as no snow (omission error) rather than misidentify no snow as snow (commission error).

Snow depth plays an important role in snow mapping accuracy, while accuracy is not significantly related to elevation, slope and aspect, tree canopy and distance from shoreline. Snow agreement or overall agreement significantly increases with snow depth, because it is difficult for MODIS to detect thin snow cover and thin snow sometimes can't cover whole pixel of MODIS products (463m×463m). However, in general, tree canopy cover is related. The result in this research is possibly caused by not enough days.

The effect of cloud cover on MOD10A1 products is severe. Clouds cover is still a huge problem for MODIS snow cover maps. In this research, there are 31 snow stations and 118 days in snow season (3658 series data can be used in general). Actually, only 798 series of valid data can be used. So, it is necessary for MODIS to figure out how to eliminate cloud mass.

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