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Supplement of

Estimating fractional snow cover from passive microwave brightness temperature data using MODIS snow cover product over North America

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Lists:

Table S1. MODIS NDSI snow cover layer recoding description

ID	Description	New ID
0 ~ 100	NDSI snow cover	Snow-covered/snow-free
200	Missing data	Cloud
201	No decision	
211	Night	
250	Cloud	
254	Detector saturated	
237	Inland water	Water
239	Ocean	
255	Fill	Fill

Table S2. The statistics of top nine important variables for random forest

ID	Variables	Count (the maximum is 4)
1	Latitude	4
2	T37h	4
3	T37v	4
4	T85h	4
5	T85v	4
6	T_19v_37v	4
7	T_22v_19v	2
8	T_22v_85v	4
9	T_37v_85v	4

Table S3. The optimization tests of learning rate of ANN on prairie dataset of 2017.

	Test A-1	Test A-2	Test A-3	Test A-4
Hidden Layers	1	1	1	1
Learning Rate	0.1	0.2	0.3	0.4
R	0.712	0.718	0.672	0.639
MAE	0.152	0.155	0.170	0.185
RMSE	0.192	0.198	0.212	0.230
Time spent modeling / s	50.86	13.18	13.95	13.47

Table S4. Variable selection tests in 6 scenarios on three land cover types (forest, shrub and prairie) for random forest method. The accuracy indexes of the estimation are calculated using OOB error estimates method.

Land cover type	Indexes	Scenario-1	Scenario-2	Scenario-3	Scenario-4	Scenario-5	Scenario-6
forest	R	0.699	0.594	0.505	0.696	0.688	0.646
	MAE	0.168	0.190	0.206	0.168	0.170	0.178
	RMSE	0.207	0.233	0.252	0.208	0.210	0.221
	Time spent modeling / s	8.38	6.81	3.77	6.34	6.4	6.73
shrub	R	0.808	0.749	0.702	0.804	0.800	0.771
	MAE	0.140	0.158	0.169	0.141	0.142	0.151
	RMSE	0.187	0.209	0.226	0.188	0.190	0.201
	Time spent modeling / s	3.98	3.22	1.83	3.02	3.17	3.1
prairie	R	0.743	0.650	0.599	0.743	0.743	0.698
	MAE	0.156	0.179	0.188	0.155	0.155	0.167
	RMSE	0.194	0.220	0.233	0.193	0.194	0.207
	Time spent modeling / s	8.45	6.82	4.18	7.08	6.53	6.43

Table S5. Variable selection tests in 6 scenarios on three land cover types (forest, shrub and prairie) for random forest method. The accuracy indexes of the estimation are calculated using 10-fold cross validation (CV).

Land cover type	Indexes	Scenario-1	Scenario-2	Scenario-3	Scenario-4	Scenario-5	Scenario-6
forest	R	0.704	0.599	0.506	0.699	0.693	0.652
	MAE	0.167	0.190	0.205	0.168	0.169	0.178
	RMSE	0.206	0.231	0.251	0.207	0.209	0.219
	Time spent modeling / s	8.38	6.81	3.77	6.34	6.4	6.73
shrub	R	0.808	0.754	0.704	0.806	0.802	0.773
	MAE	0.140	0.157	0.169	0.140	0.142	0.150
	RMSE	0.187	0.208	0.225	0.187	0.189	0.200
	Time spent modeling / s	3.98	3.22	1.83	3.02	3.17	3.1
prairie	R	0.746	0.659	0.606	0.746	0.747	0.701
	MAE	0.156	0.177	0.189	0.155	0.155	0.166
	RMSE	0.193	0.217	0.231	0.193	0.193	0.206
	Time spent modeling / s	8.45	6.82	4.18	7.08	6.53	6.43

Linear Regression formula, in which, FSC denotes fractional snow cover, $a_1 \sim a_{12}$ means the regression coefficient of each variable, b is the intercept term:

$$FSC = a_1 * lat + a_2 * lon + a_3 * dem + a_4 * slope + a_5 * aspect + a_6 * T\_19v\_19h + a_7 * T\_19v\_37v + a_8 * T\_19h\_37h + a_9 * T\_22v\_19v + a_{10} * T\_22v\_85v + a_{11} * T\_37v\_37h + a_{12} * T\_37v\_85v + b \quad \text{(S-1)}$$

Table S6. The parameters of Linear regression formula

	Forest	Shrub	Prairie	Bare land
a_1	1.7124	1.8286	1.3451	1.041
a_2	0.5667	0.7326	0.3796	1.041
a_3	0.6148	0.1765	-0.1648	0.1324
a_4	-0.1449	0.2597	-0.178	0.4921
a_5	0.0266	0.0134	-0.1605	0.0403
a_6	10.1795	13.1437	-23.7192	25.3841
a_7	-9.1104	-4.7906	31.3559	-32.695
a_8	8.8293	12.7346	-24.478	23.8666
a_9	-2.4825	8.1627	9.6261	-7.1022
a_{10}	2.2213	-5.2339	-4.2919	12.2749
a_{11}	-8.5071	-12.9567	22.4968	-23.3069
a_{12}	-0.8334	6.5589	6.4447	-10.2661
b	-1.1476	-9.7496	-9.1063	4.9851

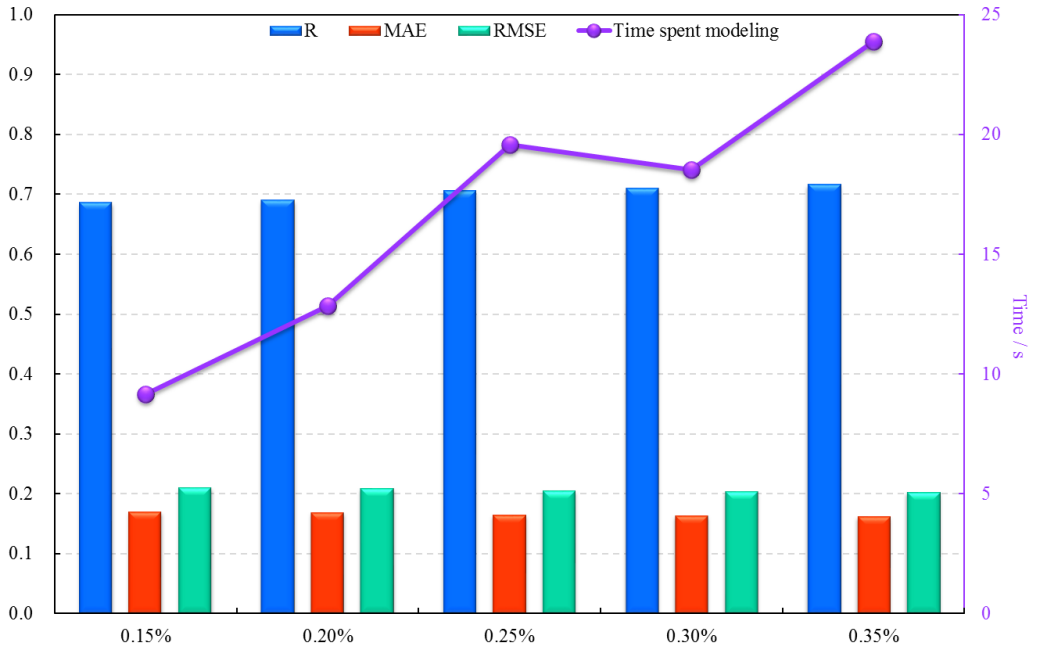

Figure S-1. The performance of random forest models with increasing training sample size for forest type

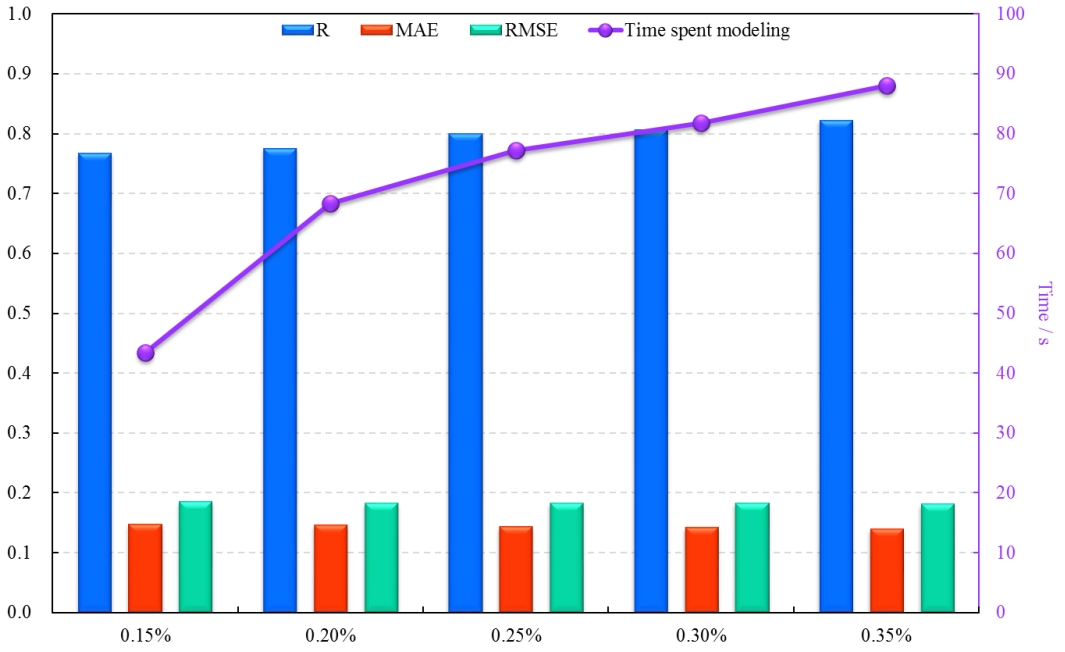

Figure S-2. The performance of random forest models with increasing training sample size for prairie type

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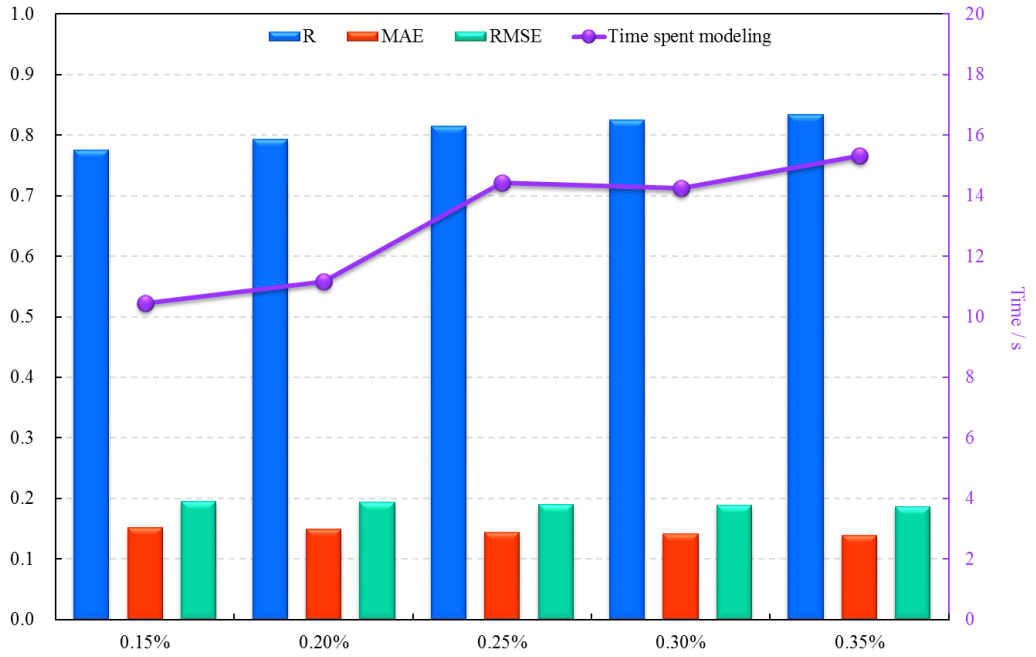

Figure S-3. The performance of random forest models with increasing training sample size for bare land type

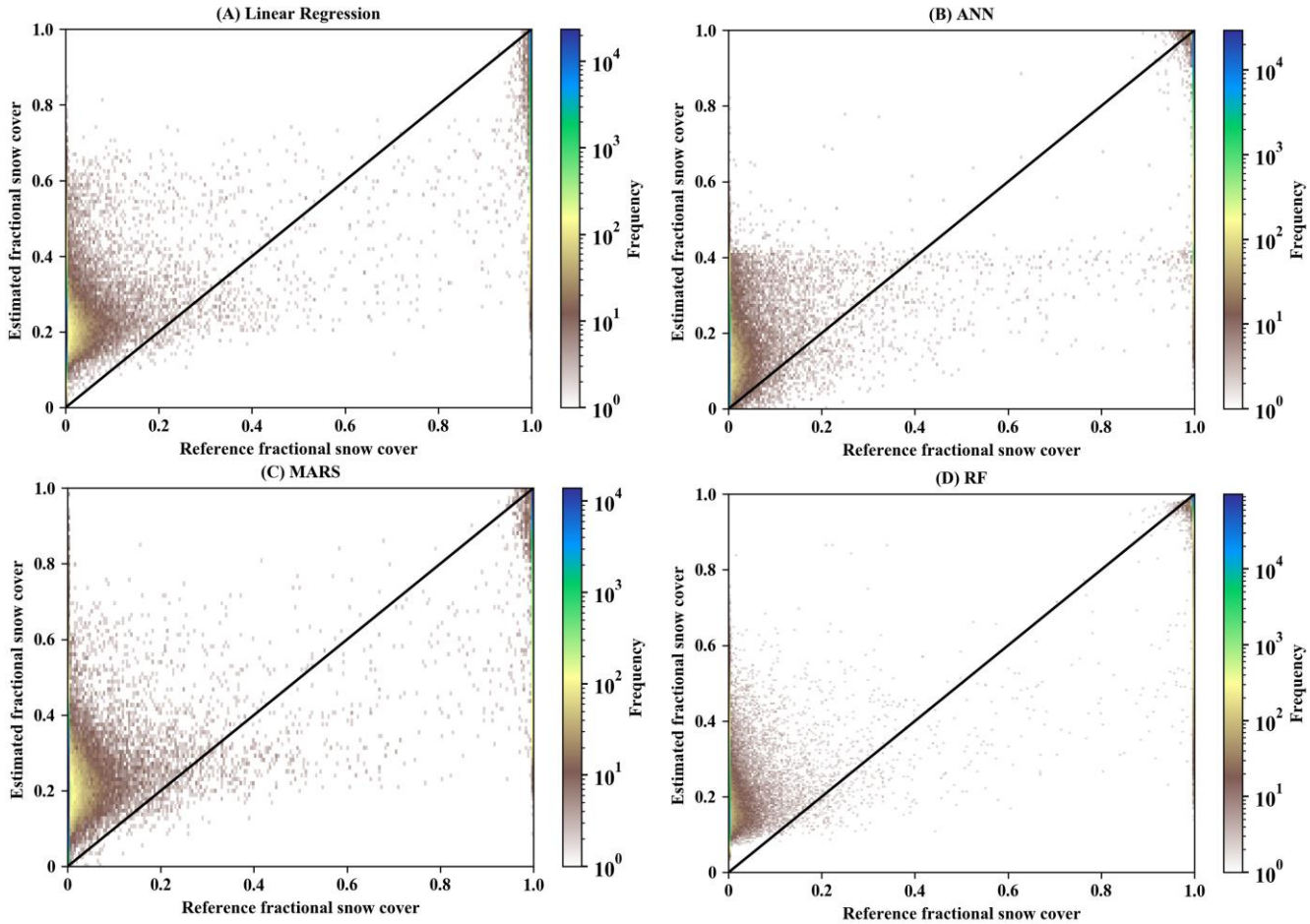

Figure S-4. The color-density scatter plots between the estimated fractional snow cover and MODIS-derived fractional snow cover for four algorithms (linear regression, ANN, MARS, and random forest) for shrub type. The accuracy metric refer to Table 5. [Note: out of range fractional snow cover values of linear regression, ANN and MARS were truncated on 0 and 1]. Noted that: all extracted records in January and February 2010 were used as the testing sample.

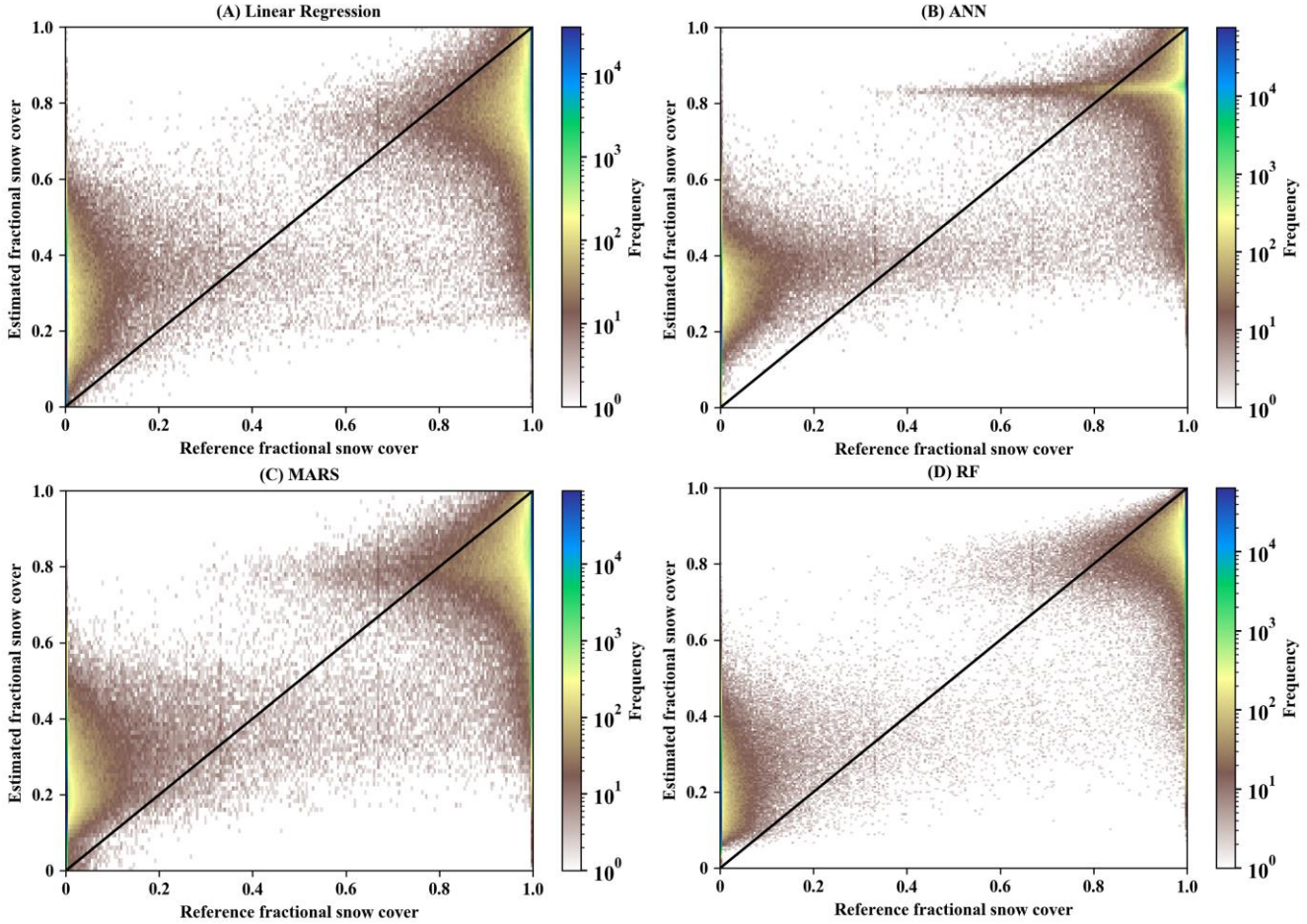

Figure S-5. The color-density scatter plots between the estimated fractional snow cover and MODIS-derived fractional snow cover for four algorithms (linear regression, ANN, MARS, and random forest) for prairie type. The accuracy metric refer to Table 5. [Note: out of range fractional snow cover values of linear regression, ANN and MARS were truncated on 0 and 1]. Noted that: all extracted records in January and February 2010 were used as the testing sample.

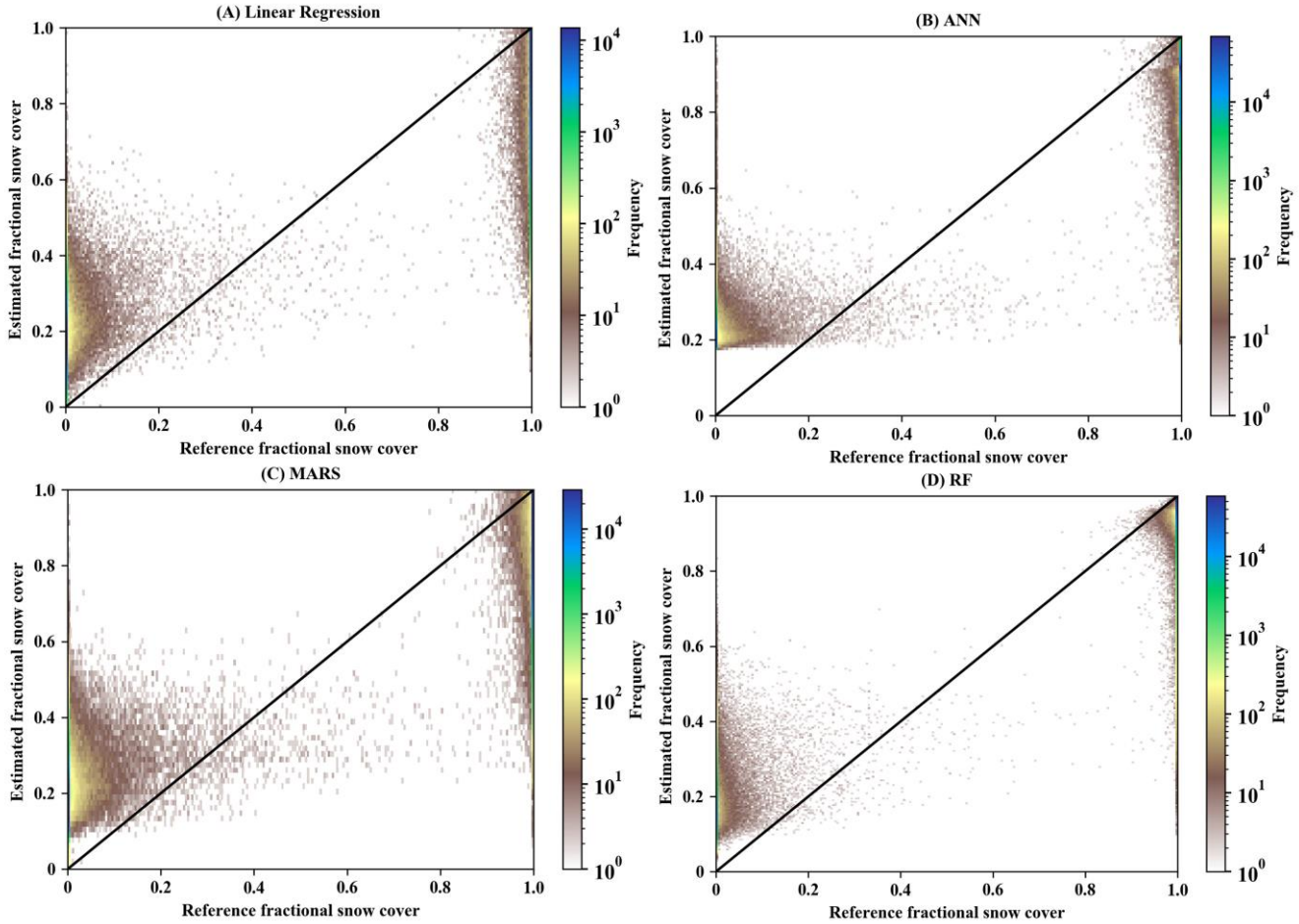

Figure S-6. The color-density scatter plots between the estimated fractional snow cover and MODIS-derived fractional snow cover for four algorithms (linear regression, ANN, MARS, and random forest) for bare land type. The accuracy metric refer to Table 5. [Note: out of range fractional snow cover values of linear regression, ANN and MARS were truncated on 0 and 1]. Noted that: all extracted records in January and February 2010 were used as the testing sample.

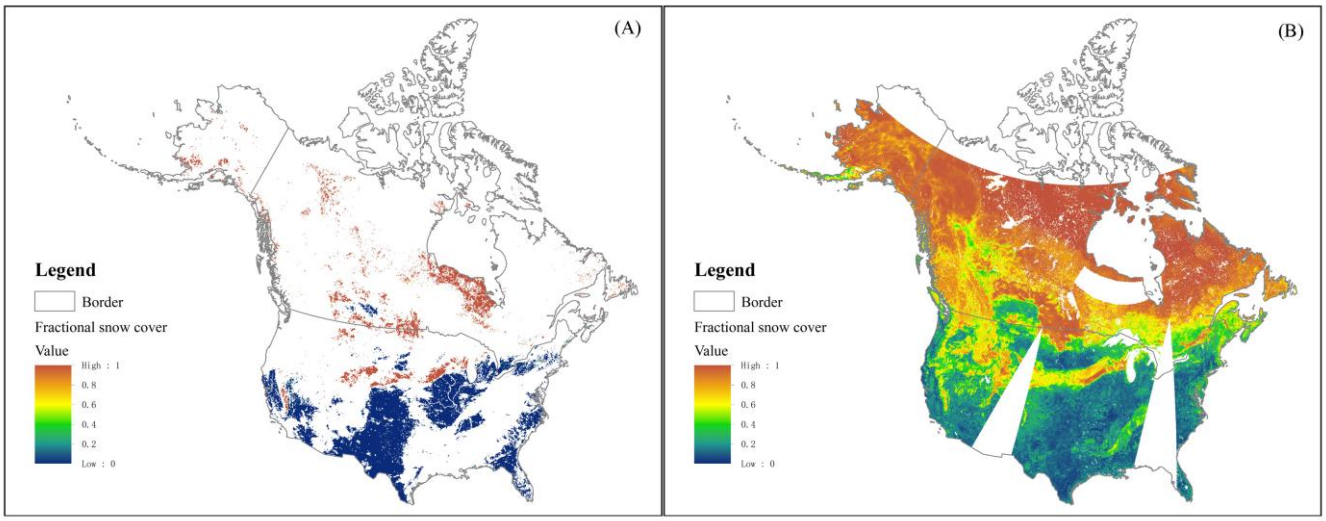

Figure S-7. Comparison of the reference MODIS fractional snow cover (A) with our estimated fractional snow cover (B) in continuous value (6.25-km) on February 27th, 2017 (2017058)

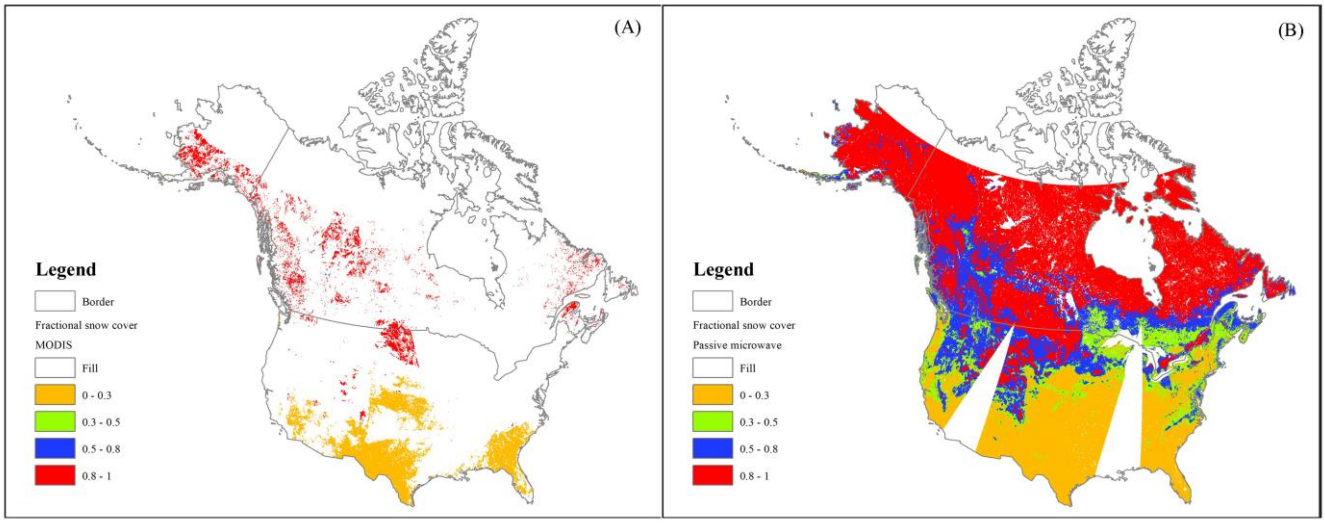

Figure S-8. Comparison of the reference MODIS fractional snow cover (A) with our estimated fractional snow cover (B) at 6.25-km spatial resolution on January 10th, 2017 (2017010)

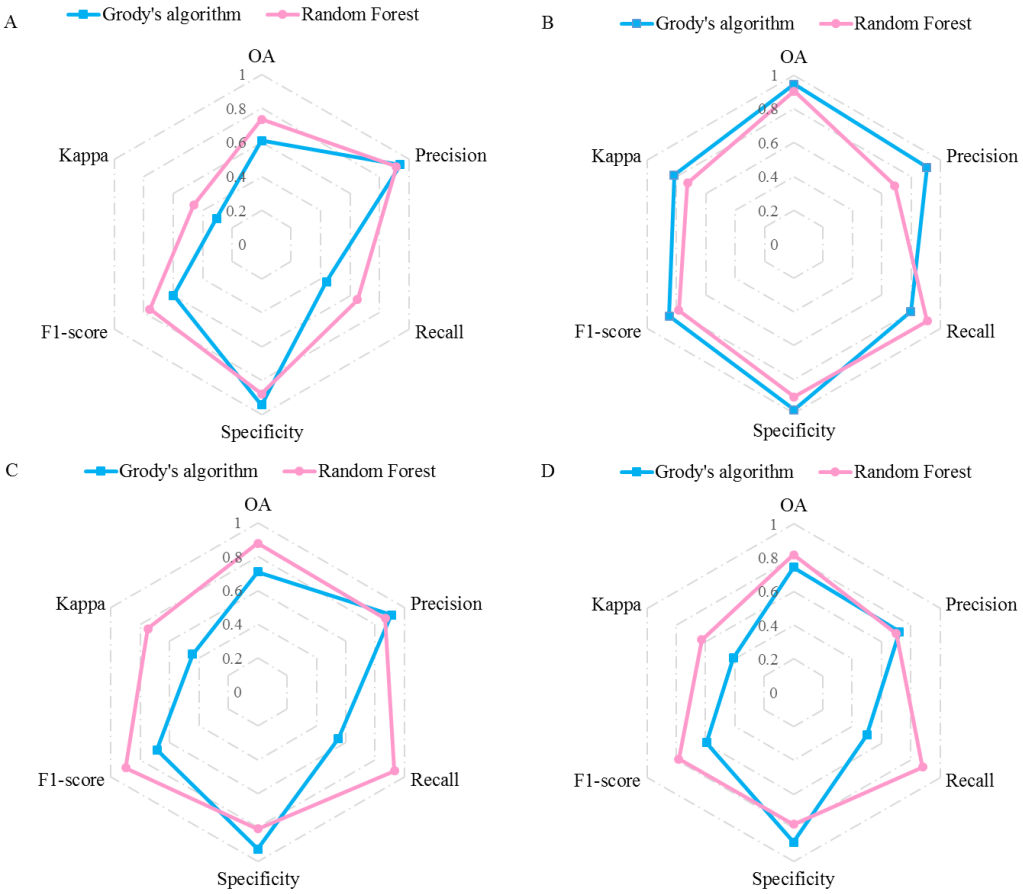

Figure. S-9. The accuracy indicators (OA, precision, recall, specificity, F1-score, kappa) of snow cover detection from two algorithm (Grody' algorithm; Random forest) for four land cover types (A: forest; B: shrub; C: prairie; D: bare land)