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Development of a new forest snow mapping algorithm using MODIS data, machine learning and time-lapse photography

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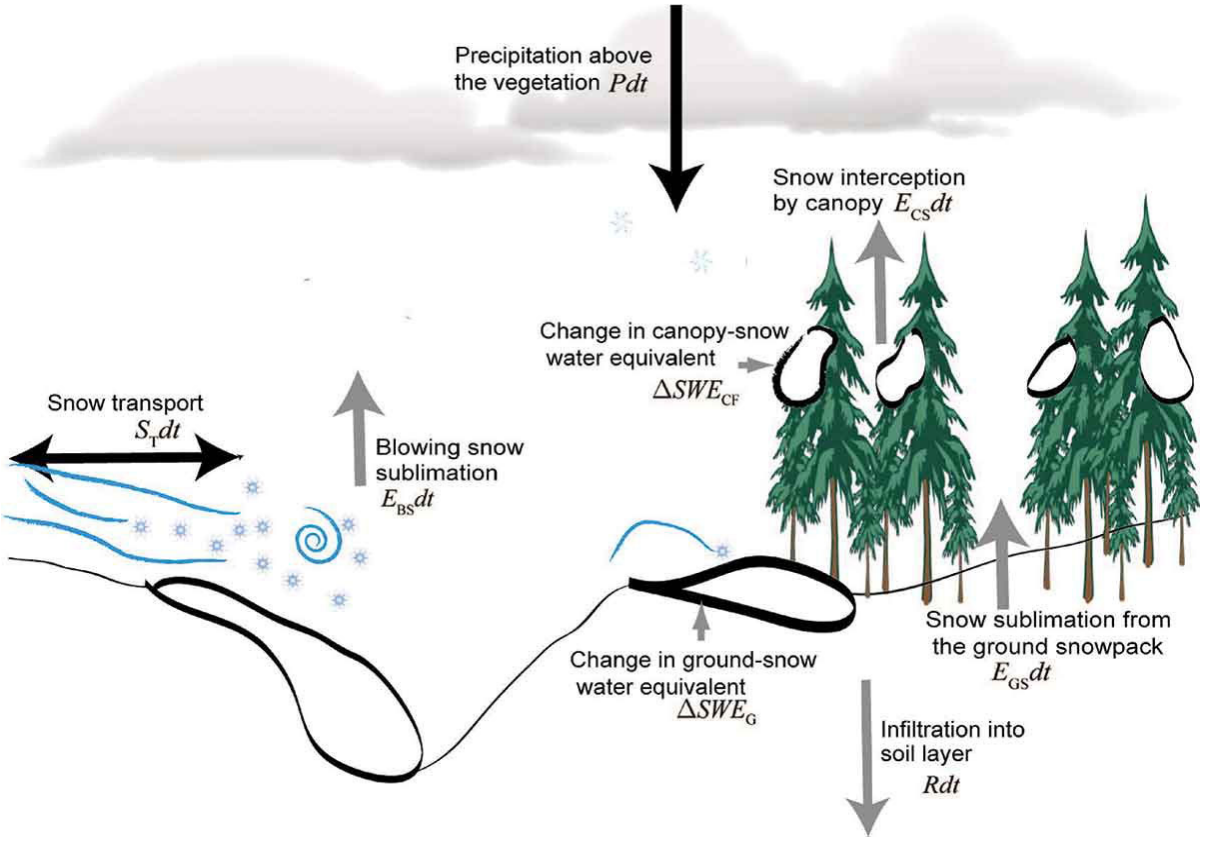
Motivation

Complex forest snow processes



(Suzuki et al., 2011 HSJ)

Ungauged Basins

Remote Sensing?

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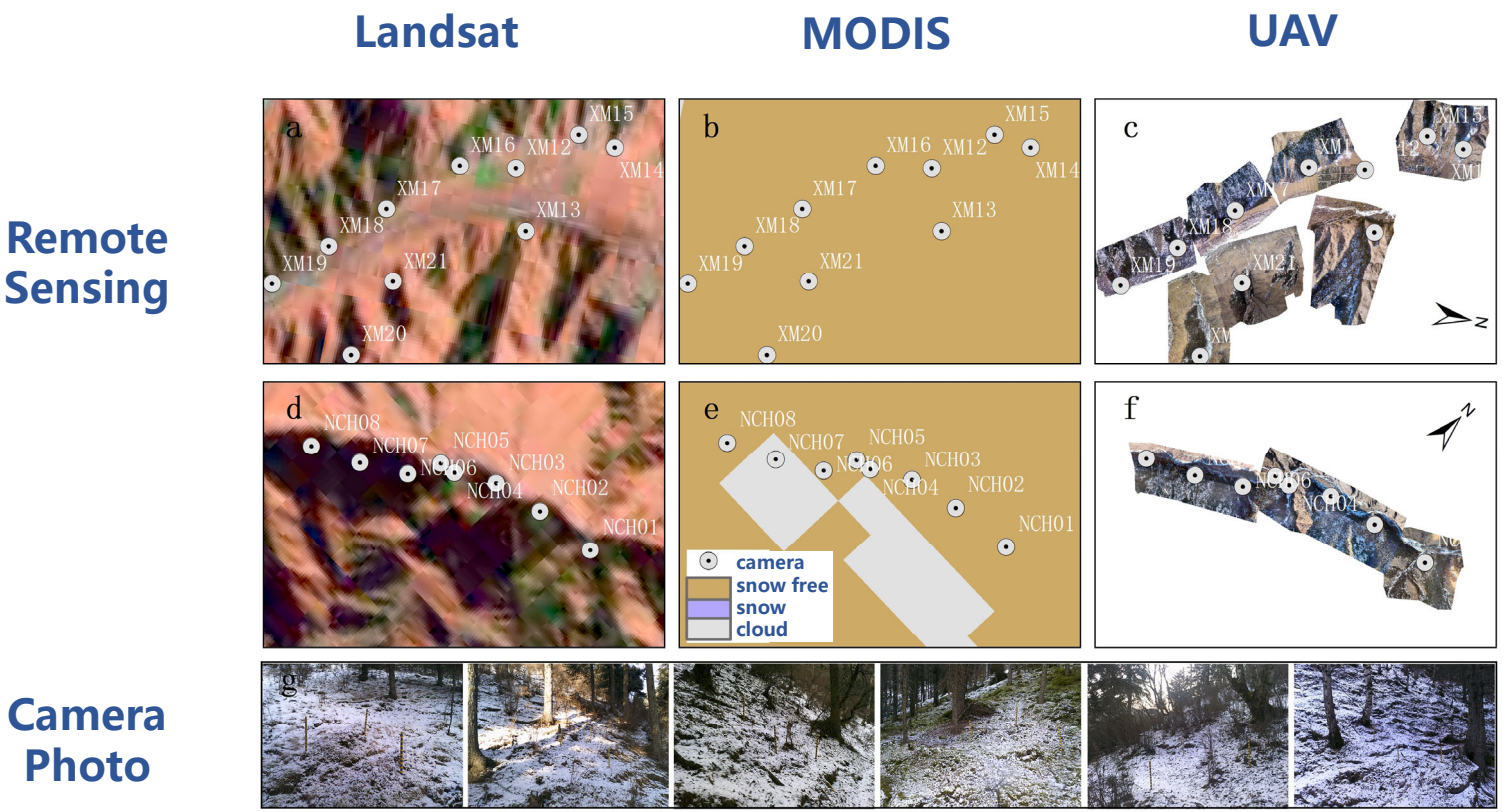
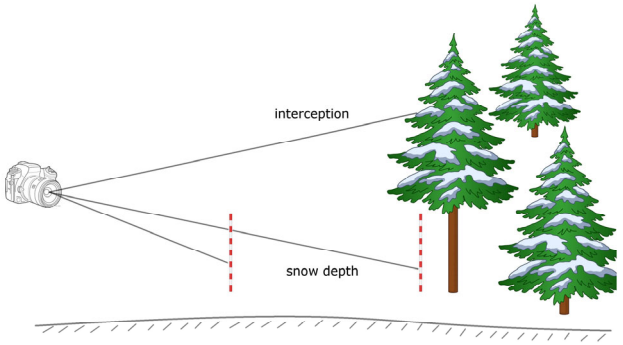
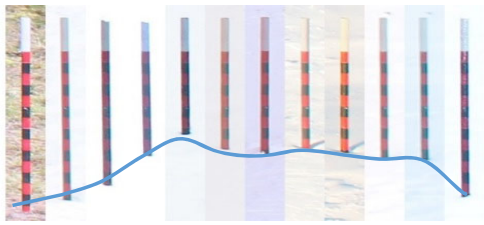
Issues of remote sensing in forest: **omission error**

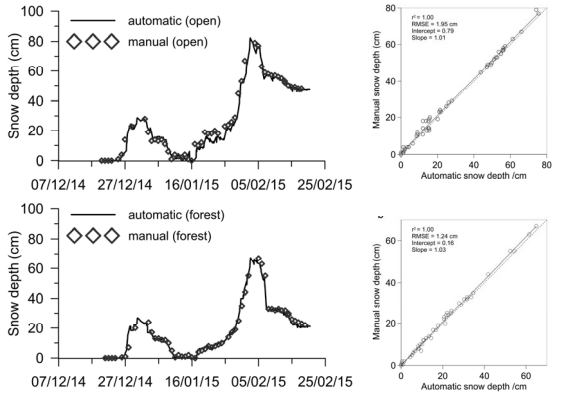


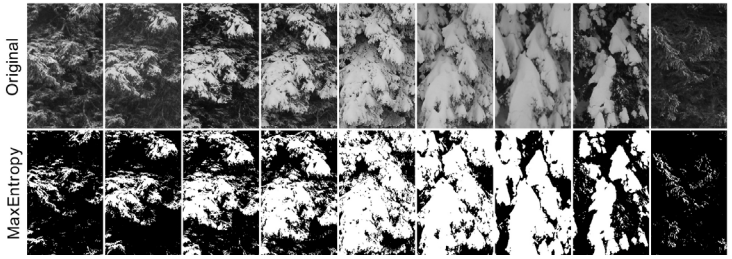
Monitoring forest snow processes using time-lapse camera

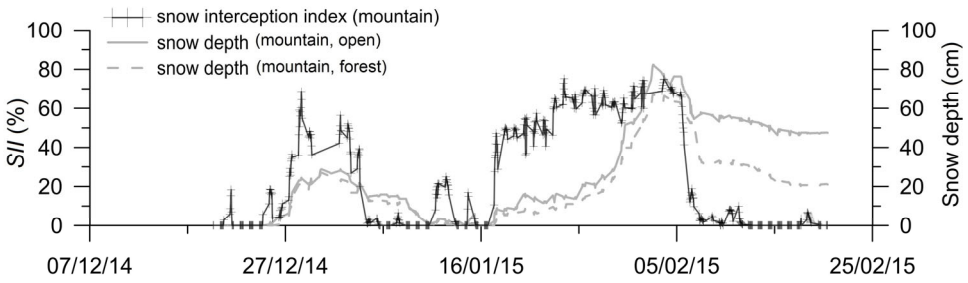
Snow depth in forests and open areas











Canopy snow interception

(Dong & Menzel, 2017 HP)

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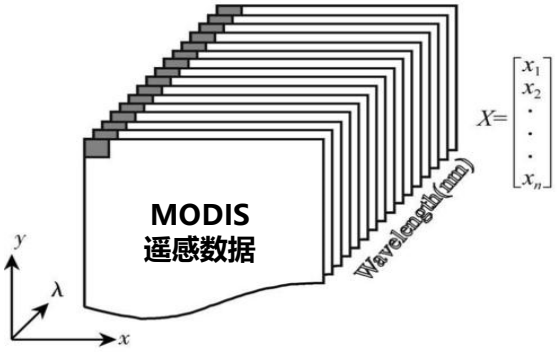
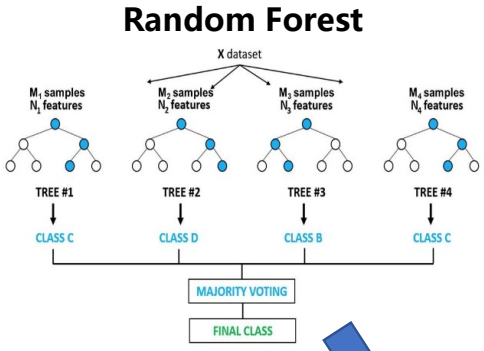
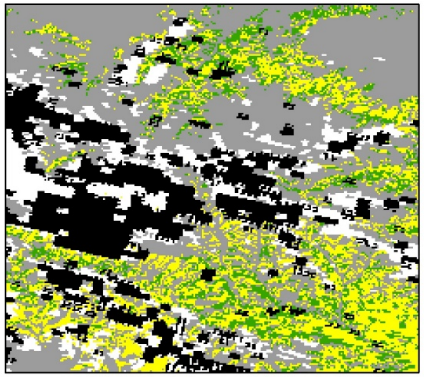
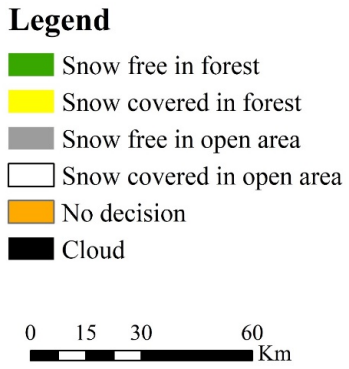
Using time-lapse camera data to develop forest snow remote sensing algorithm









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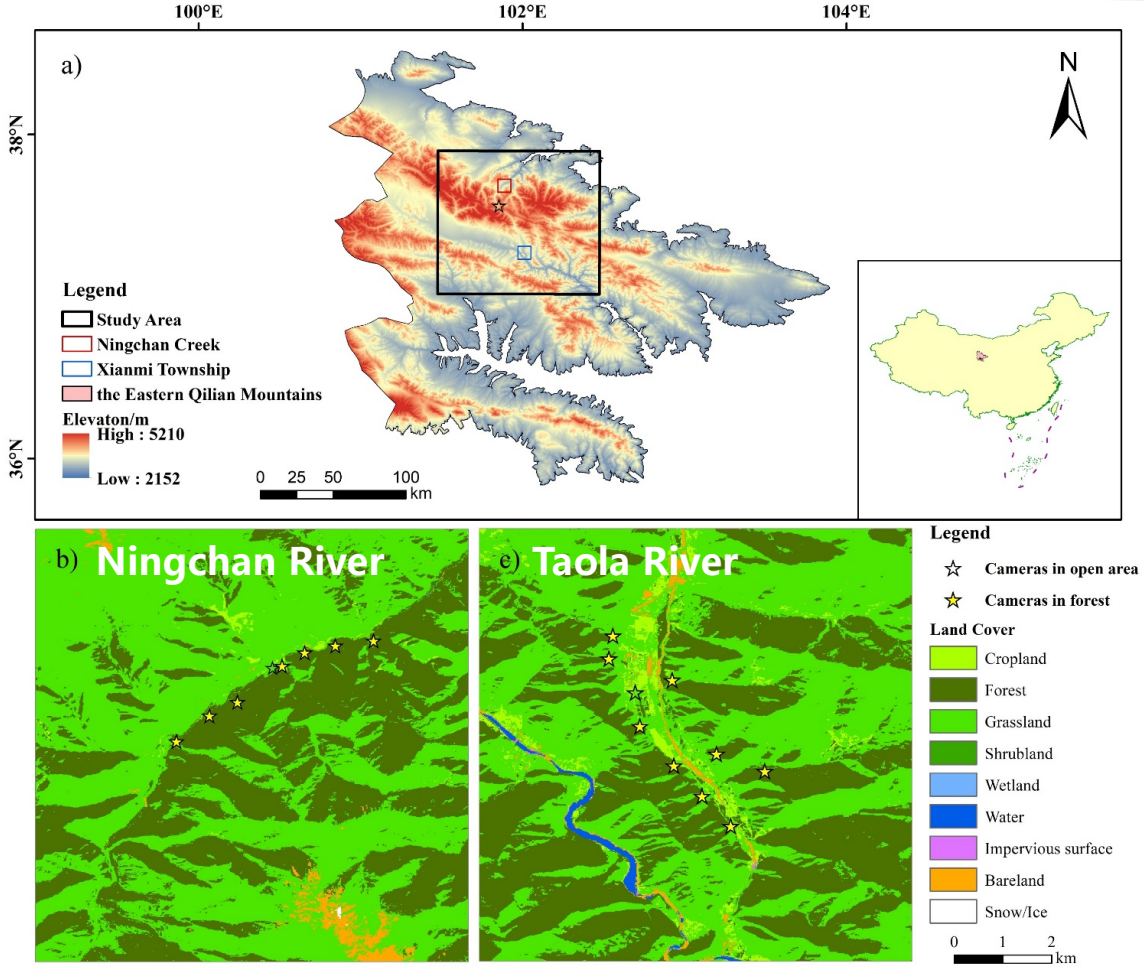
Study area：Qilian Mountain, NW China



boreal coniferous forest

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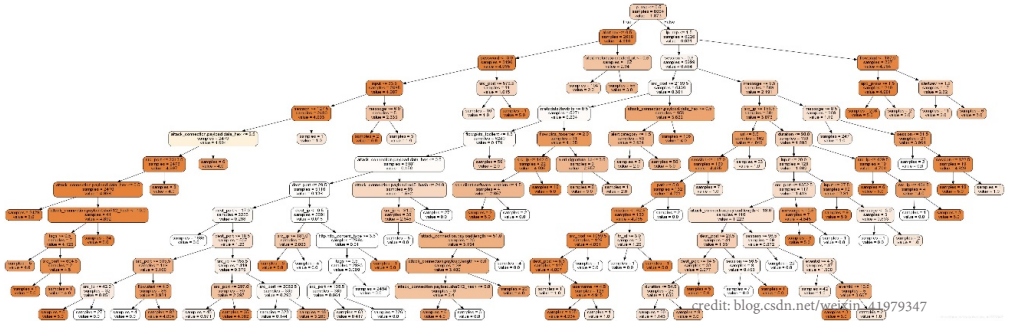
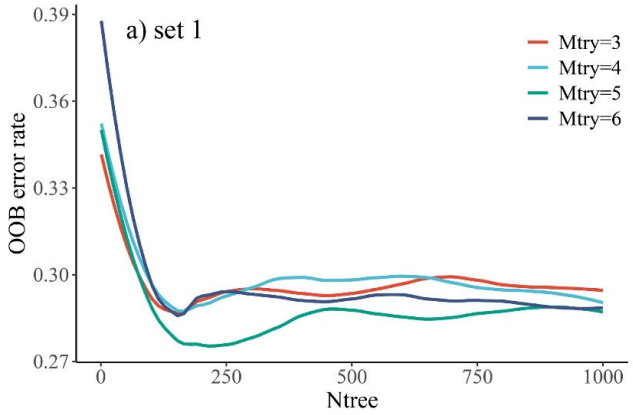
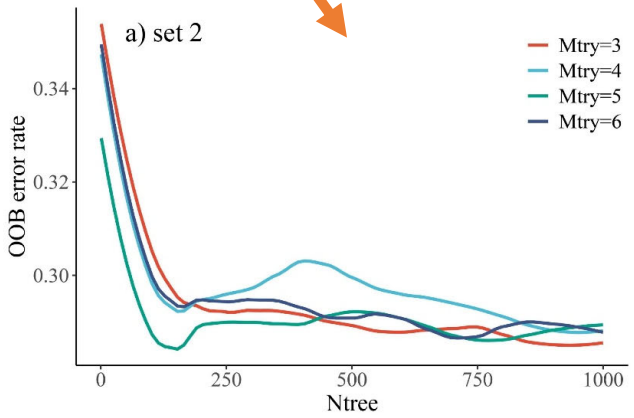
Method：Random Forest Machine Learning



Two sets of predictors

- Classification：Snow covered/Snow free (Ground truth: time-lapse camera data)
- Predictors：MODIS b1~b7 reflectance, forest cover fraction, slope, aspect





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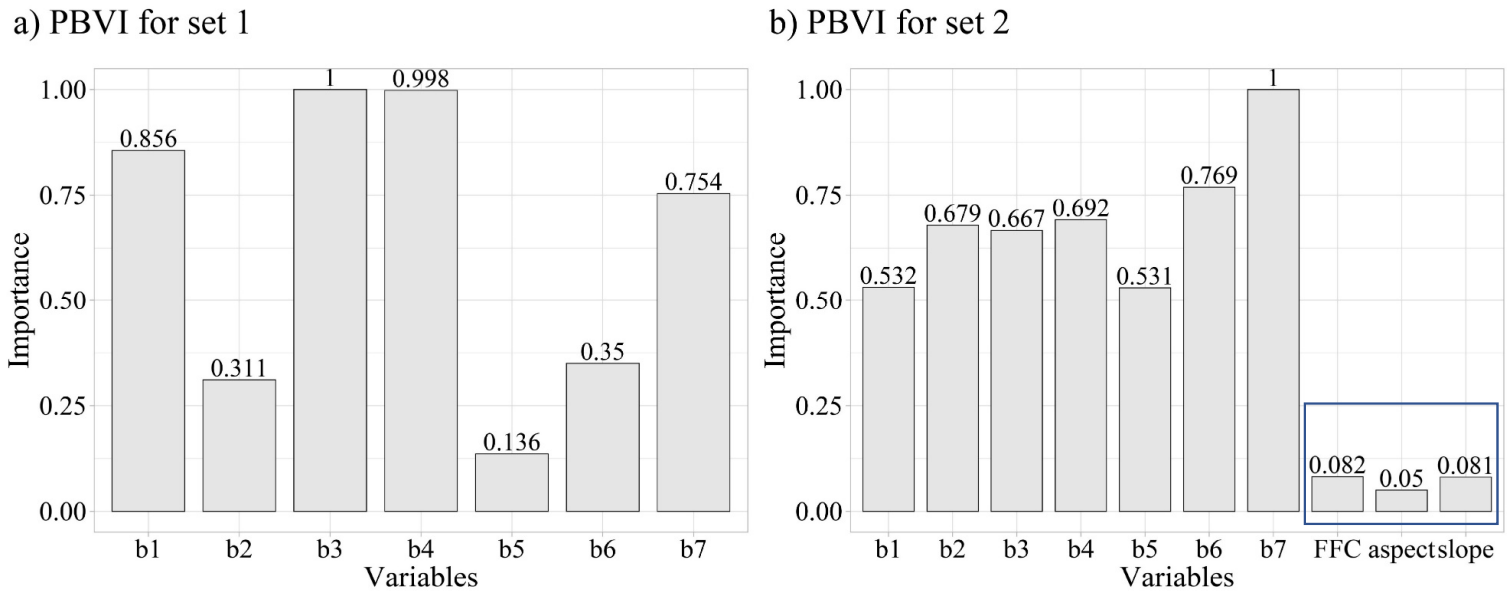
Relative importance of predictors

Set1：MODIS b1~b7 reflectance

Set2：MODIS b1~b7 reflectance, forest fraction, slope, aspect



Forest fraction, slope, and aspect contribute little to the model accuracy

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Accuracy Validation

Evaluation Indices

Precision $$PC = \frac{TP}{TP + FP}$$

Recall $$RC = \frac{TP}{TP + FN}$$

Accuracy $$AC = \frac{TP + TN}{Total}$$

F-score $$FS = 2 \times \frac{PC \times RC}{PC + RC} = \frac{2TP}{2TP + FP + FN}$$

False alarm ratio $$FAR = \frac{FP}{FP + TN}$$

Kappa coefficient $$CK = \frac{AC - Pr(e)}{1 - Pr(e)}$$

$$Pr(e) = \left(\frac{TP + FP}{Total} \times \frac{TP + FN}{Total} \right) + \left(\frac{TN + FP}{Total} \times \frac{TN + FN}{Total} \right)$$

$$Total = TP + FP + TP + FN$$

Confusion matrix

		Prediction	
		Snow	No snow
Observation	Snow	True positive (TP)	False negative (FN)
	No snow	False positive (FP)	True negative (TN)

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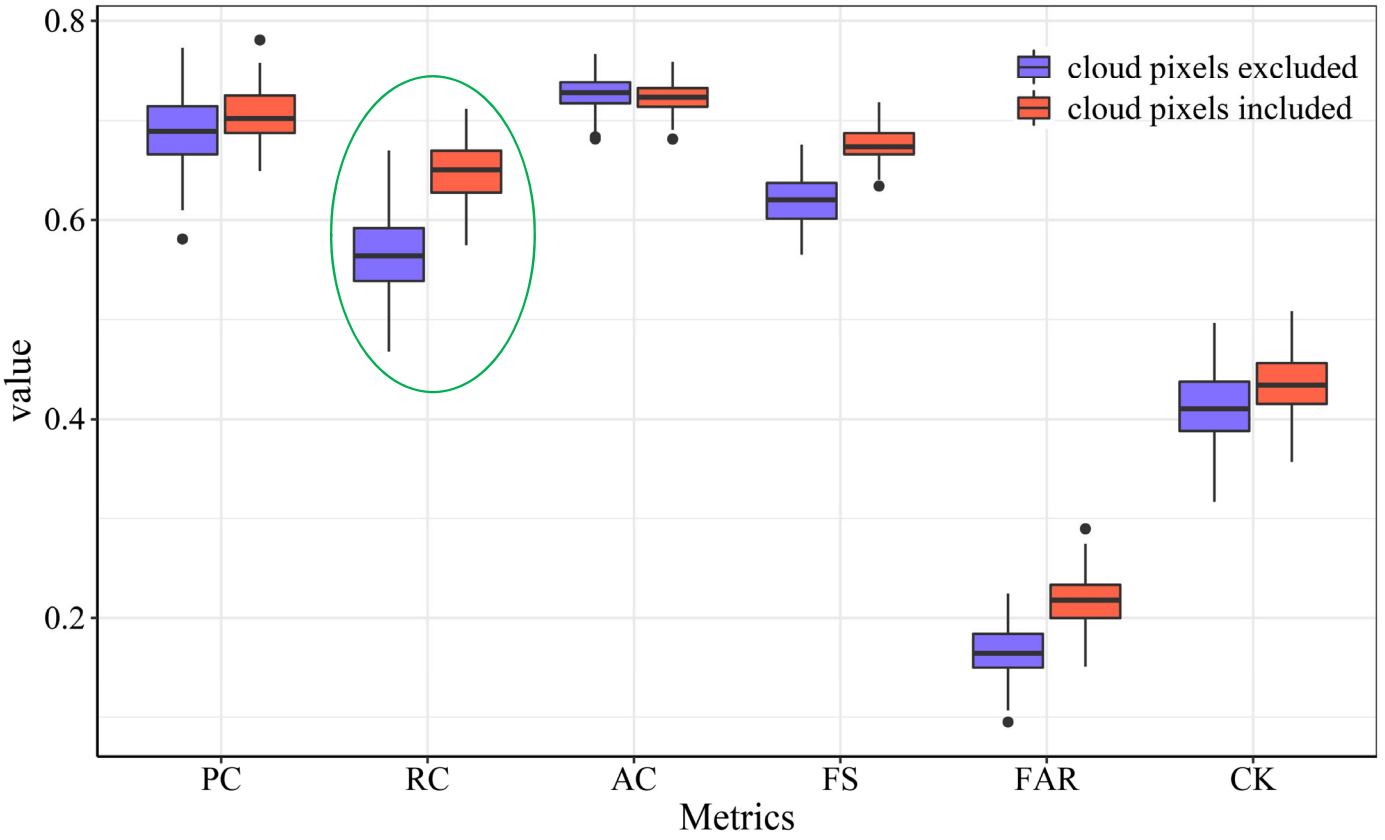
Effect of cloud pixels



Include cloud pixels: Recall ⬆

Cloud/Snow confusion in MODIS cloud mask?

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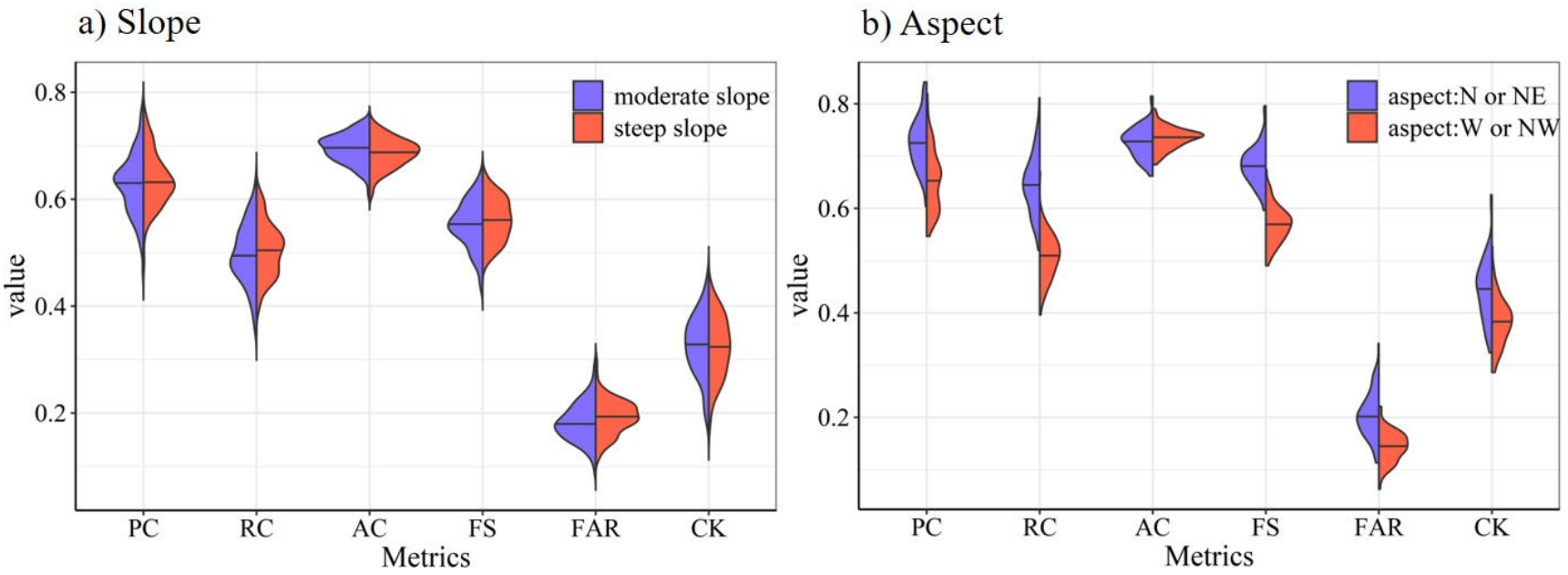
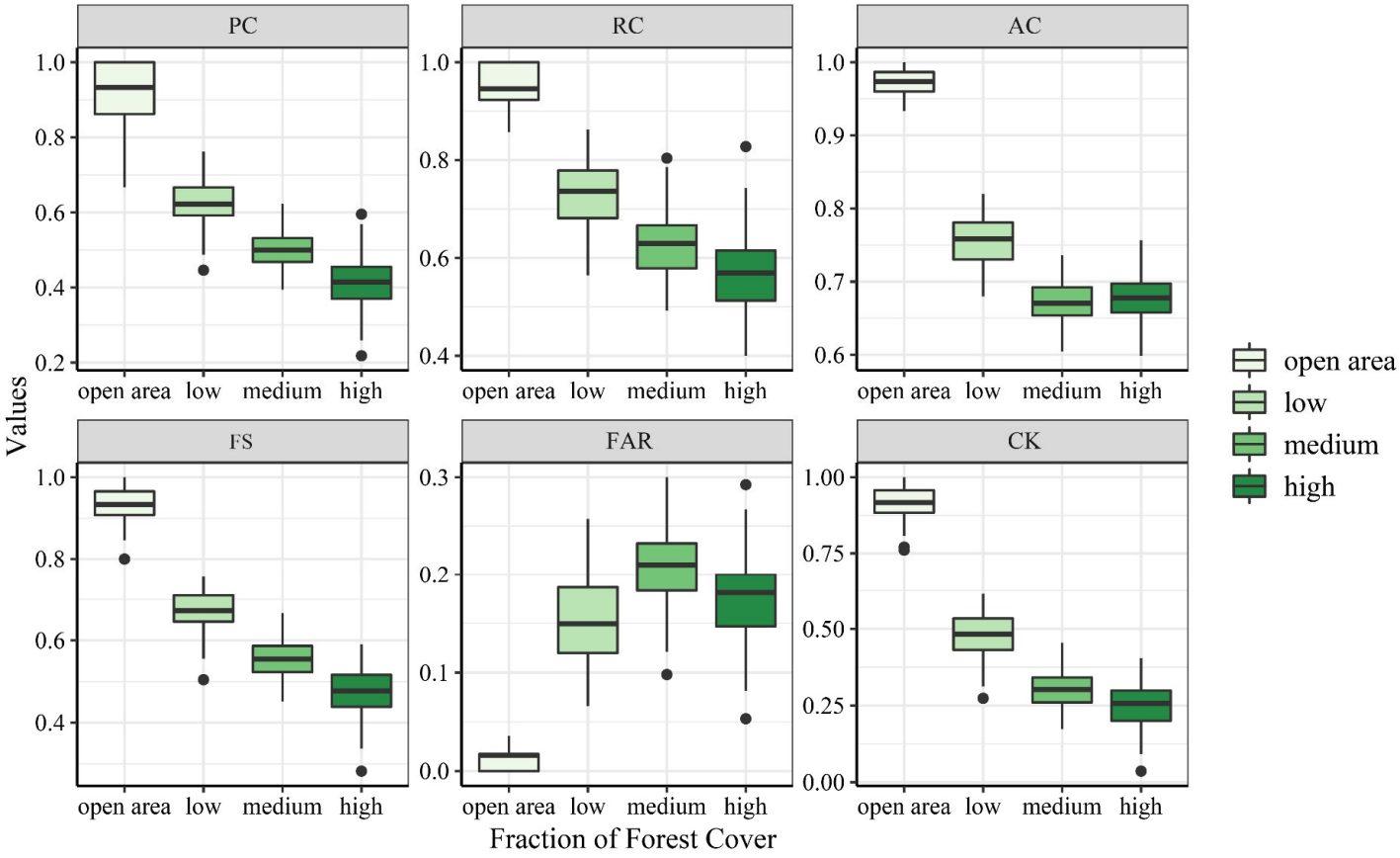
Effect of terrains



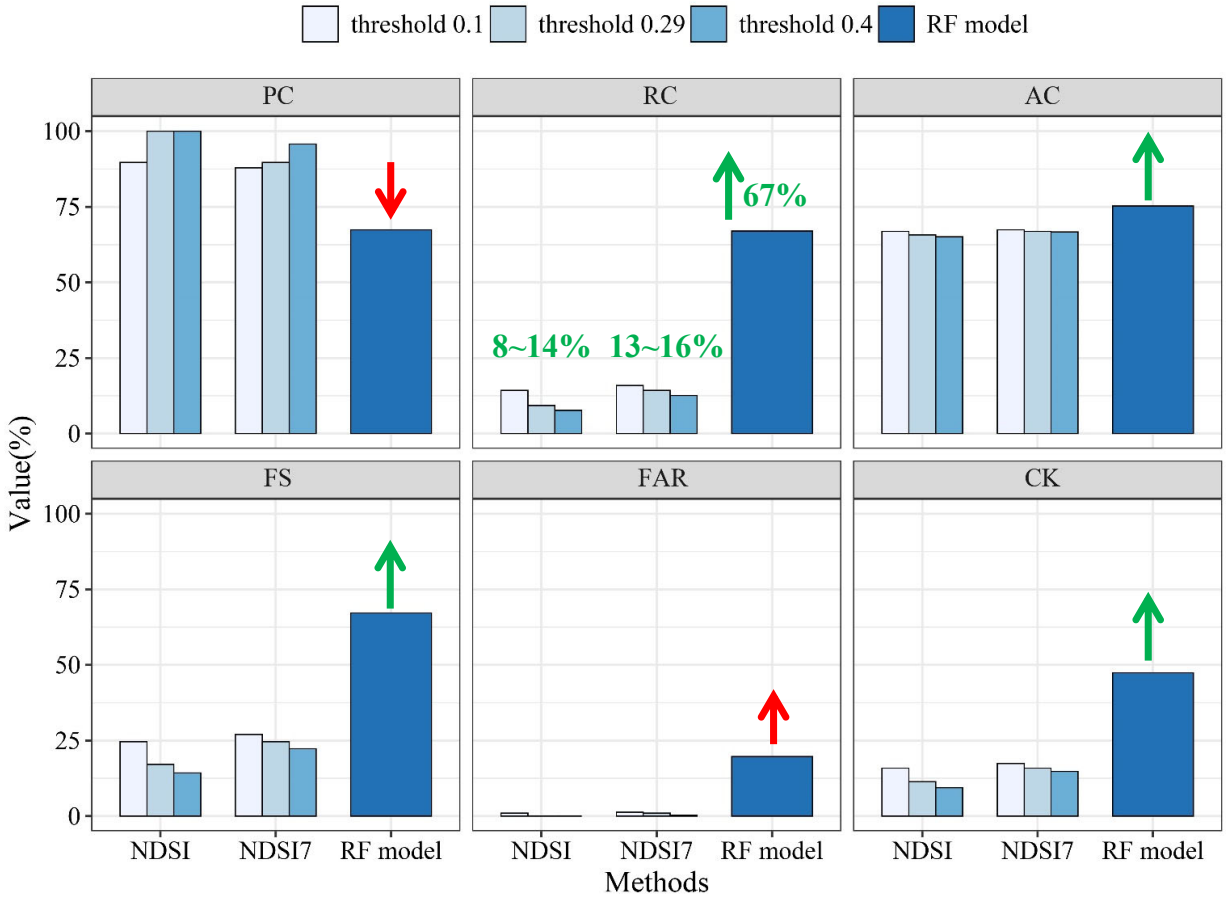
Aspect shows high

Effect of forest cover fraction

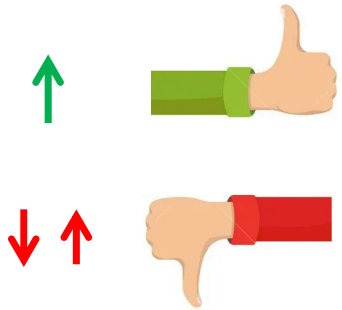


Forest cover fraction ↑ **Performance** ↓

New algorithm vs NDSI approach



$$NDSI = \frac{b4 - b6}{b4 + b6}$$



Large increase in forest snow detection of the new algorithm

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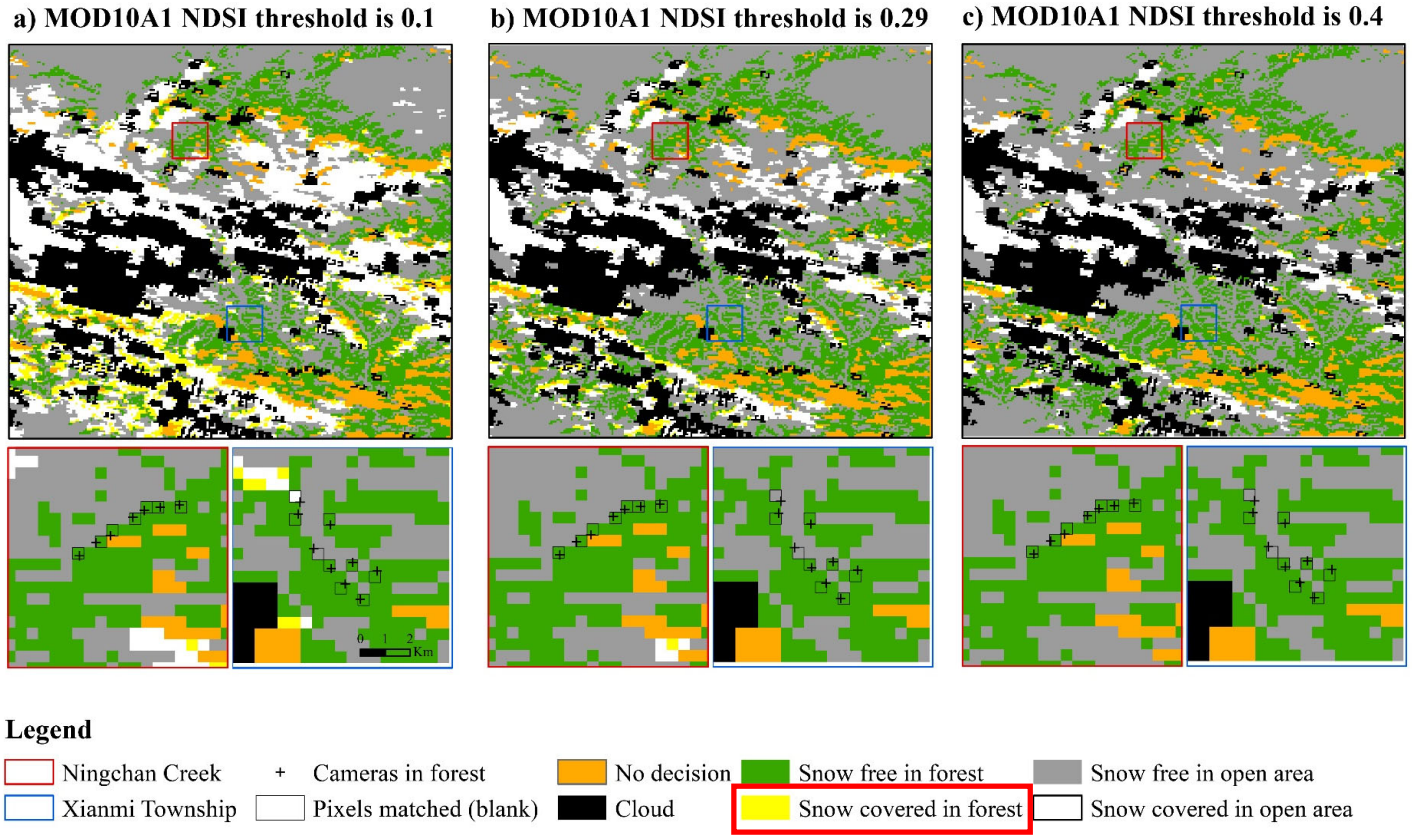
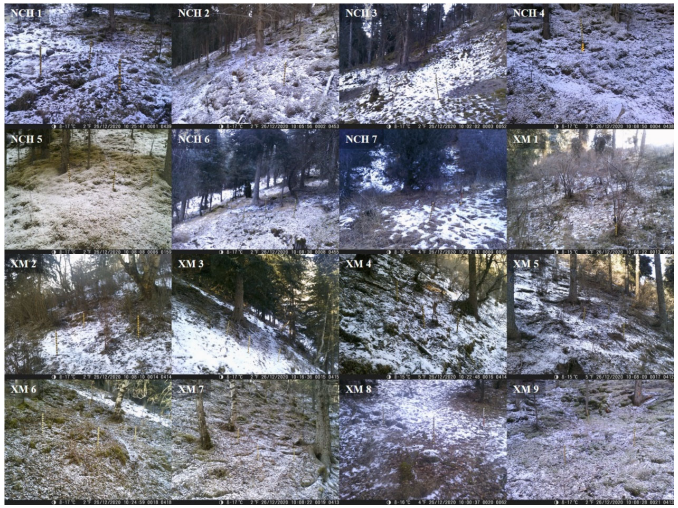
Snow map example: NDSI approach





Ground truth: all snow covered

Dec. 26, 2020 in Qilian Mount.

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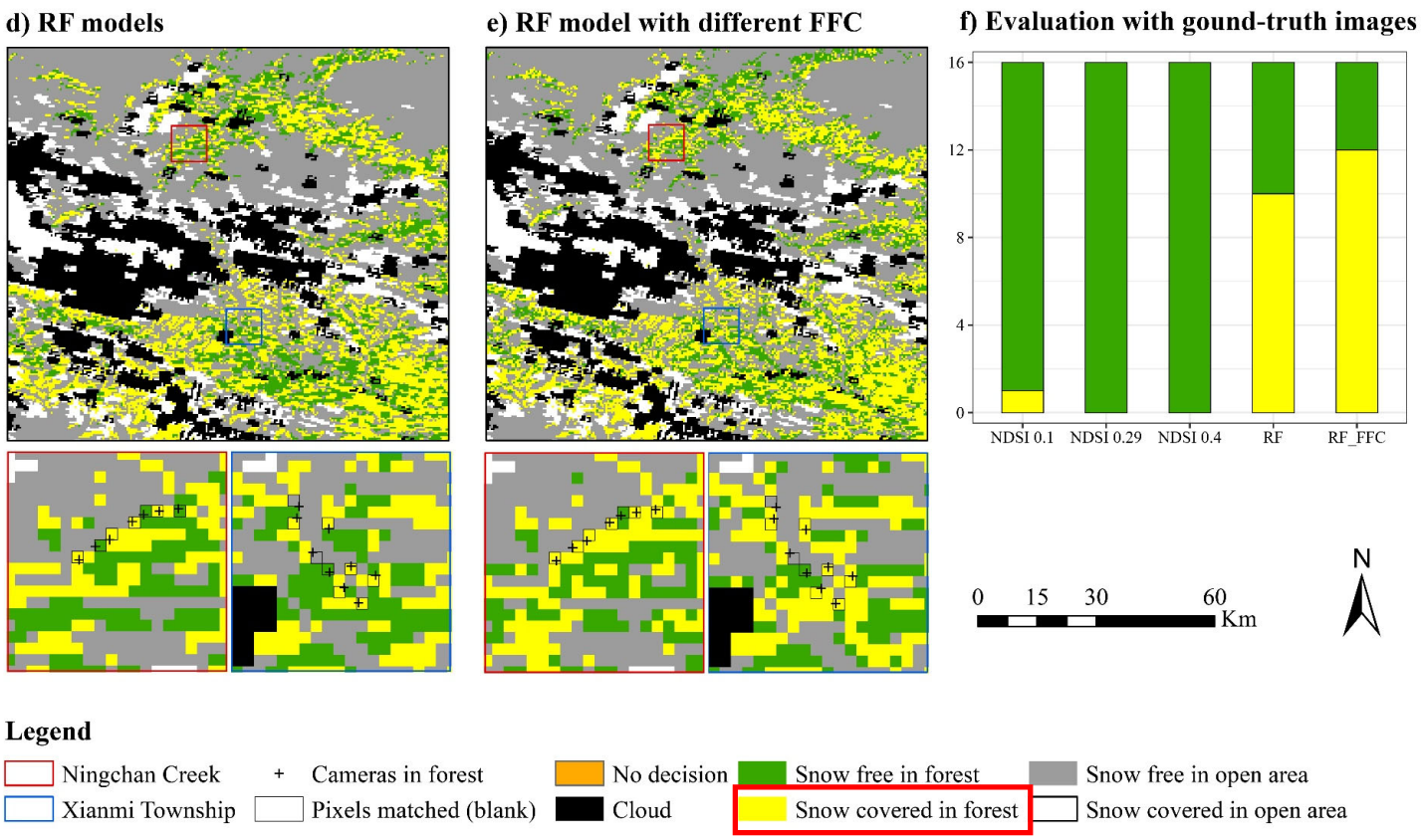
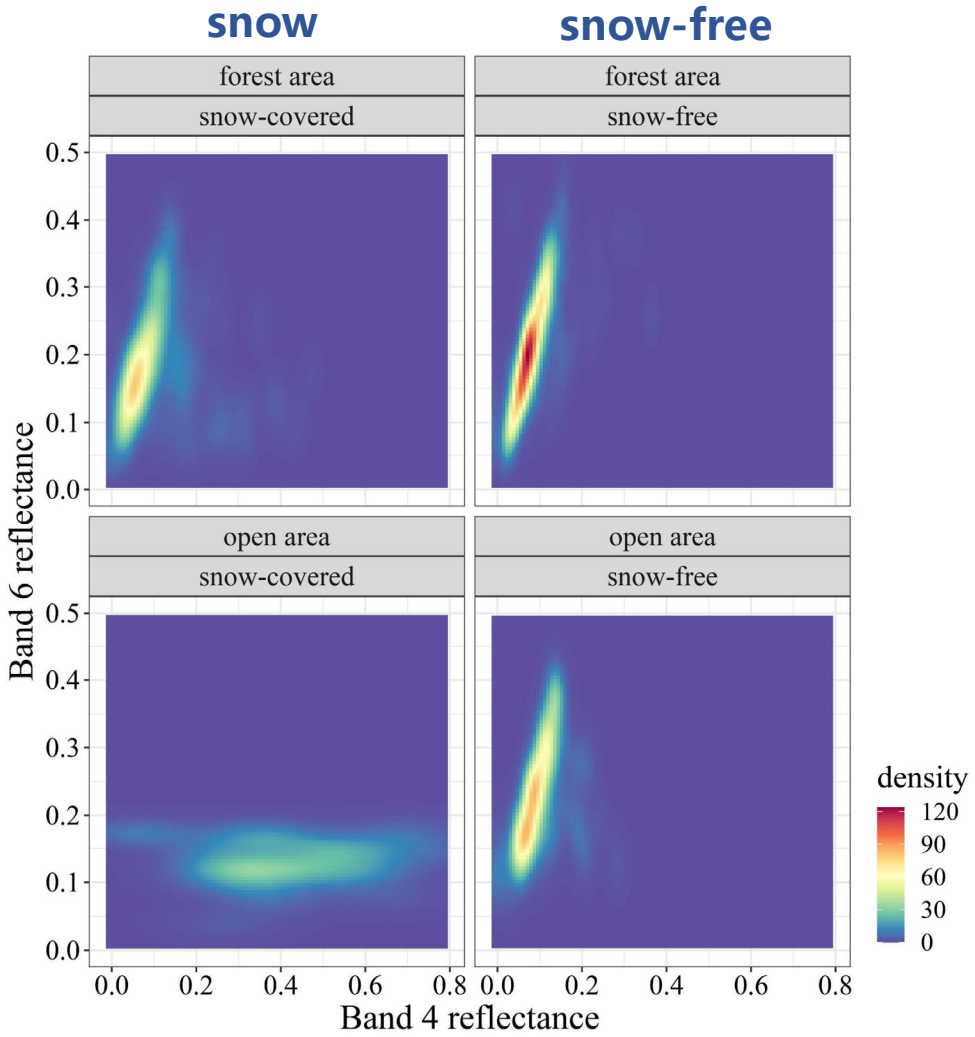
Snow map example: machine learning approach

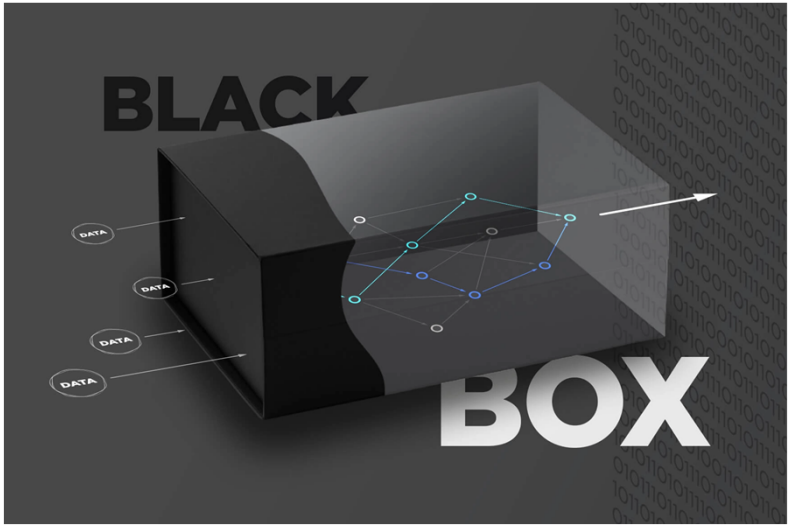


Discussion：Why machine learning?



$$NDSI = \frac{b4 - b6}{b4 + b6}$$

VS



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Conclusions

- Time-lapse photography is effective in monitoring forest snow process
- Machine learning-based algorithm can obviously detect more forest snow than NDSI-based approach
- Forest fraction and aspect can affect the algorithm accuracy by changing illumination

Article: Luo, J. Dong, C., et al., 2022, Remote Sensing of Environment

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Thanks!
Q & A

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Article: Luo, J. Dong, C., et al., 2022, Remote Sensing of Environment

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