Application and Evaluation of Different Topographic Correction Models for Landsat -8 OLI Images

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Outline

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- Objectives
- Study Area and Dataset
- Approach
- Results and Discussions
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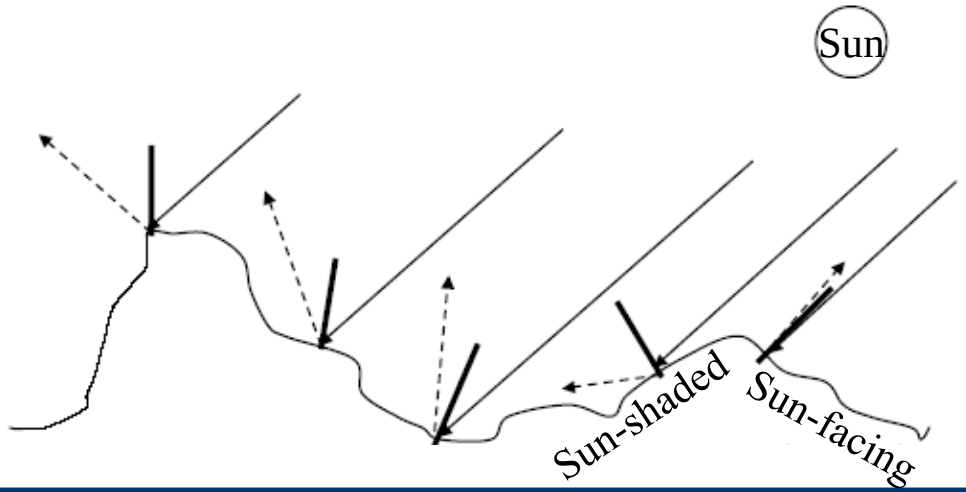
Introduction

- **Topographic effects in remote sensed image**
  - Irregular shape of terrain causes variable incidence angles and diverse reflection values within land cover type

  ➡ Sun-shaded slopes have a lower reflectance intensity than sun-facing slope

  - Topographic correction methods try to compensate topographically induced illumination variations



Introduction

- **Topographic correction methods**

  - A number of topographic correction methods have been developed to reduce the remote sensed image of mountainous region

  - The topographic correction methods are generally used in following:

- Cosine correction method (Teillet, 1982)	Lambertian surface approaches
- C correction method (Teillet, 1982)	
- Statistical-empirical method (Teillet, 1982)	Empirical correction approach
- Minnaert method (Smith et al., 1980)	Non-Lambertian surface approaches
- Minnaert+SCS method (Reeder, 2002)	

Introduction

- **Performance evaluation**

  - For the performance analysis, a number of evaluation methods have been proposed

  - They can be categorized into three types: in-situ analysis, impact on classification results, and statistical analysis

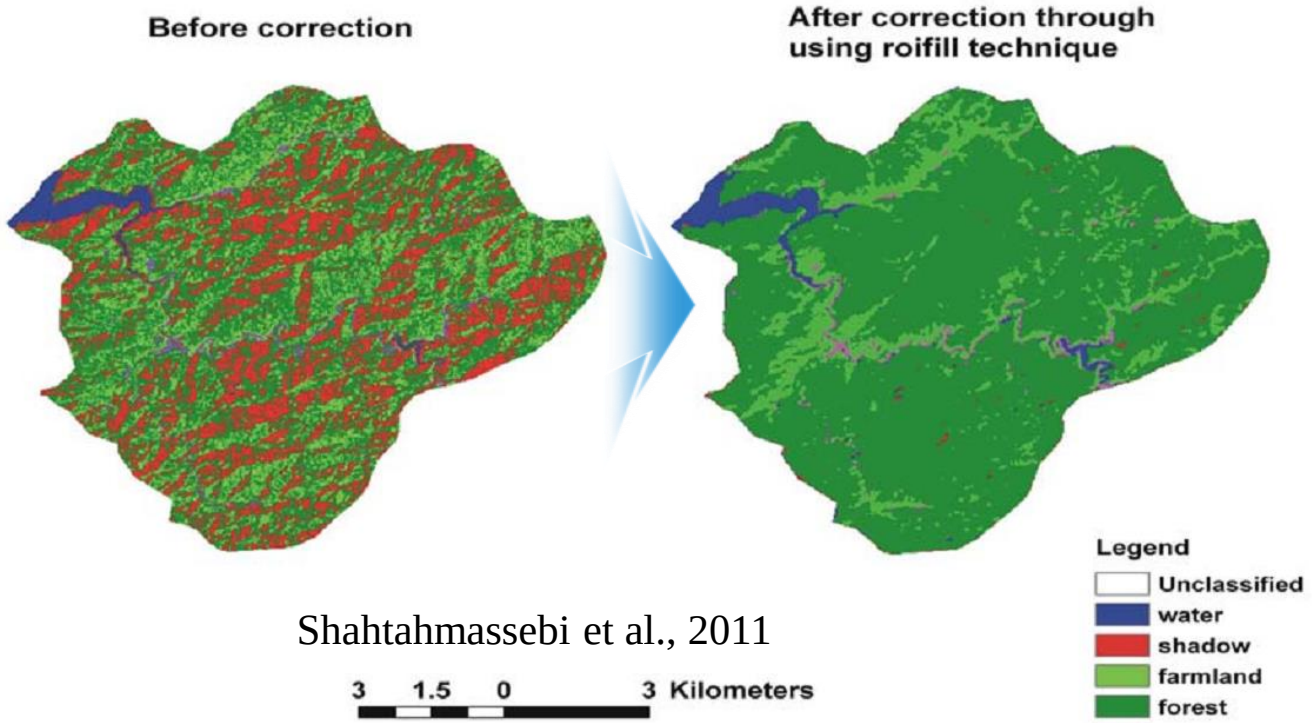
    1) In-situ analysis:
    - It require spectroradiometer instrument or filedwork class data
    - However, it has difficulties due to measurement of reflectance over forest canopy and filed accessibility

Introduction

2) Impact on classification:

- It measures the enhancement of classification accuracy from error matrix, visual analysis, or kappa statistics

- However, this also can be difficult to quantitatively evaluate for each band, because results was effected by land cover, bands and classification methods



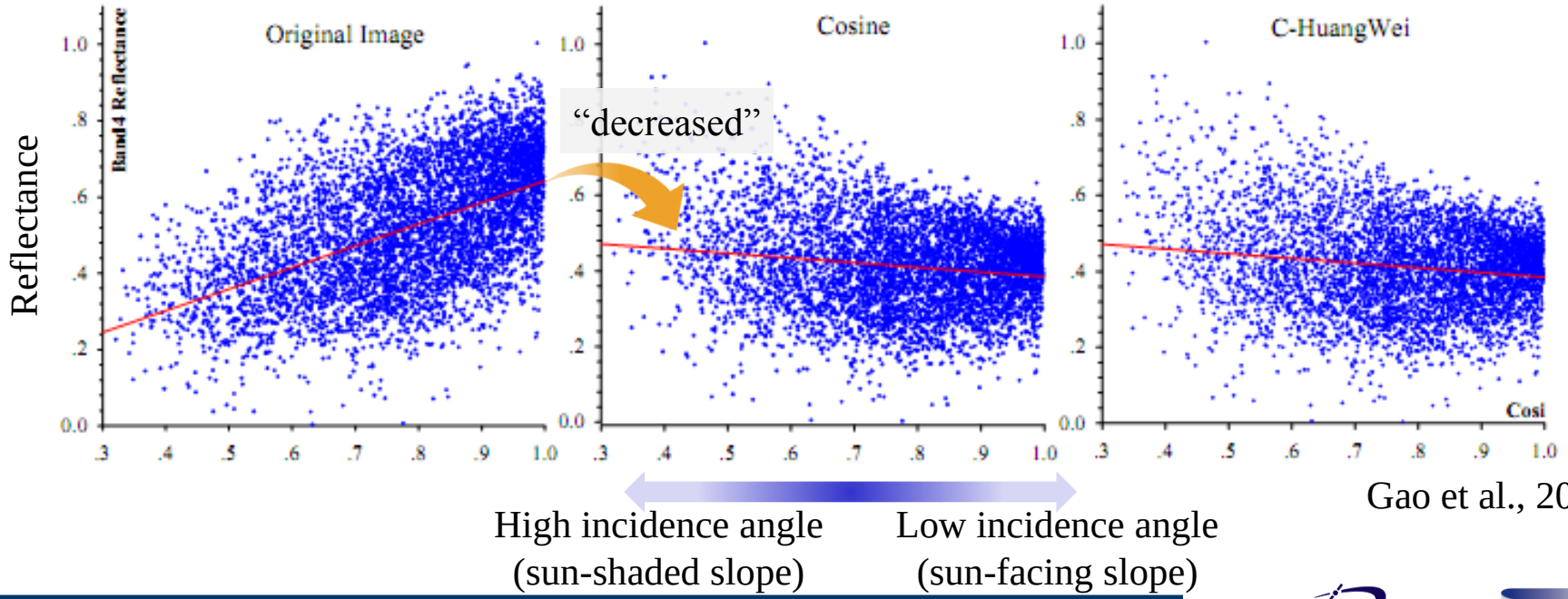
Shahtahmassebi et al., 2011

Introduction

3) Statistical analysis:

- Another approach is to directly assess using statistical parameter
- especially, liner regression analysis between incidence angle and reflectance value is commonly used for validation

- However, it can not compare the performance between correction models quantitatively, thus we need an efficient method to evaluate models



Gao et al., 2014

Objectives

- We have proposed an efficient method to evaluate the performance of topographic correction models

1) Quantitatively evaluate correction performances using histogram distance

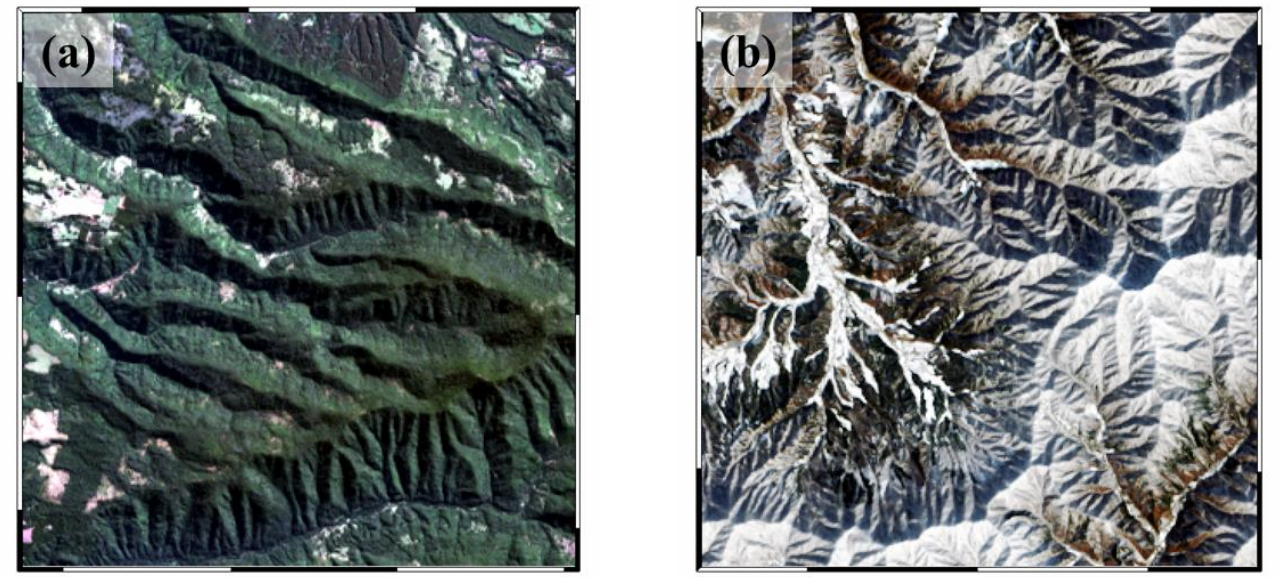
2) Classification performance improvement according to the combination of the best result

Study Area and Dataset

- **Study area**

  - Study sites were selected based on different land cover characteristics and geographic locations:

    1) natural vegetation area (central part of the Chile)
    2) snow covered area (east part of the South Korea)



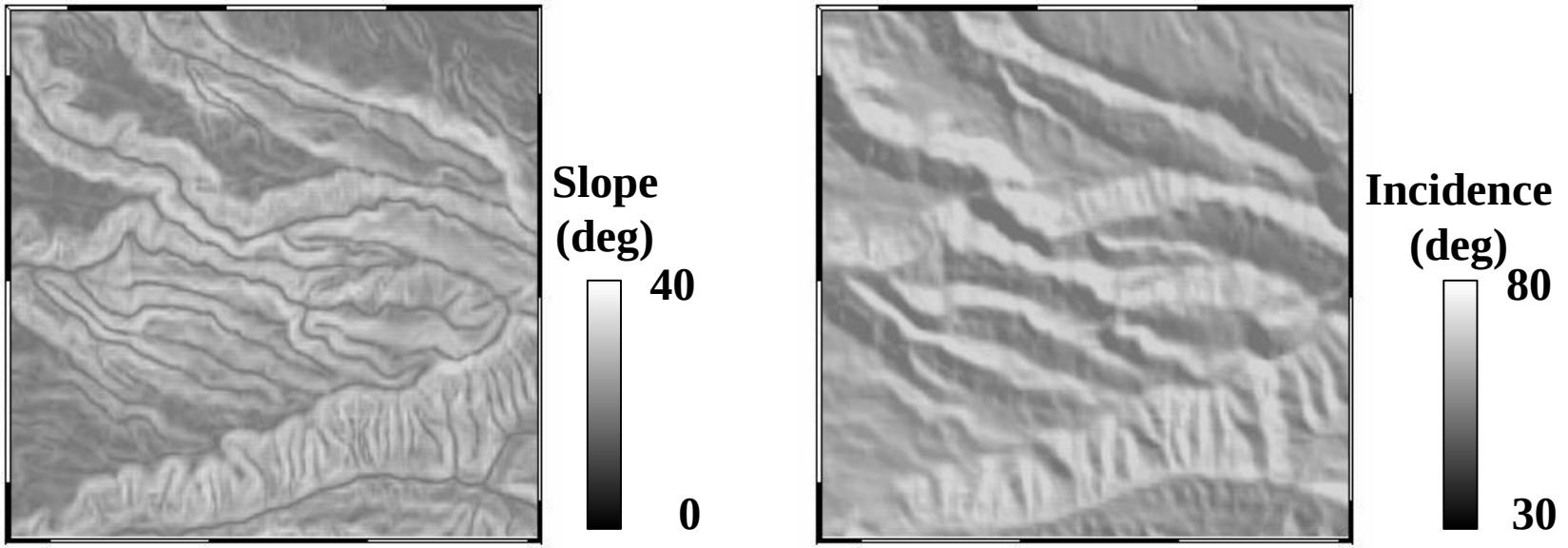
Study Area and Dataset

- **Dataset**
  - Landsat 8 OLI
    - 30 m spatial resolution with 9 bands
    - 12 bits radiometric quantization: higher than previous Landsat instruments (8 bit for TM and ETM+)
    - We acquired 2 Landsat 8 OLI images, and only use five bands: Blue, Green, Red, NIR, SWIR-1

Path/Row	Date	Sensor	Land Cover	Zenith Angle	Azimuth Angle
233/87	2013/03/12	OLI	Vegetation	56.79°	46.26°
115/34	2014/01/31	OLI	Snow Cover	59.10°	153.46°

Study Area and Dataset

- **Dataset**
  - SRTM (Shuttle Radar Topography Mission) DEM
    - SRTM DEM version 4 was resampled to a pixel size of 30 m × 30 m
    - And also, we made the slope, aspect and incidence angle image from SRTM DEM



Approach

- **Topographic correction methods**

  - Cosine correction

$$\rho_h = \rho \frac{\cos(\theta_s)}{\cos i}$$

ρ = surface reflectance
ρ_h = reflectance of horizontal surface

  - Statistical-empirical correction

$$\rho_h = \rho - \{a \cos i + b\} + \bar{\rho}$$

$\bar{\rho}$ = mean of ρ
a and b are the coefficients

  - C-correction

$$\rho_h = \rho \frac{\cos(\theta_s)+C}{\cos i+C}, \mathrm{C} = \frac{b}{a}$$

b = intercept from statistics
a= gradient between cos i and reflectance

  - Minnaert correction

$$\rho_h = \rho\left(\frac{\cos \theta_n}{(\cos i)^k \times (\cos\theta_n)^k}\right)$$

k = Minnaert constant

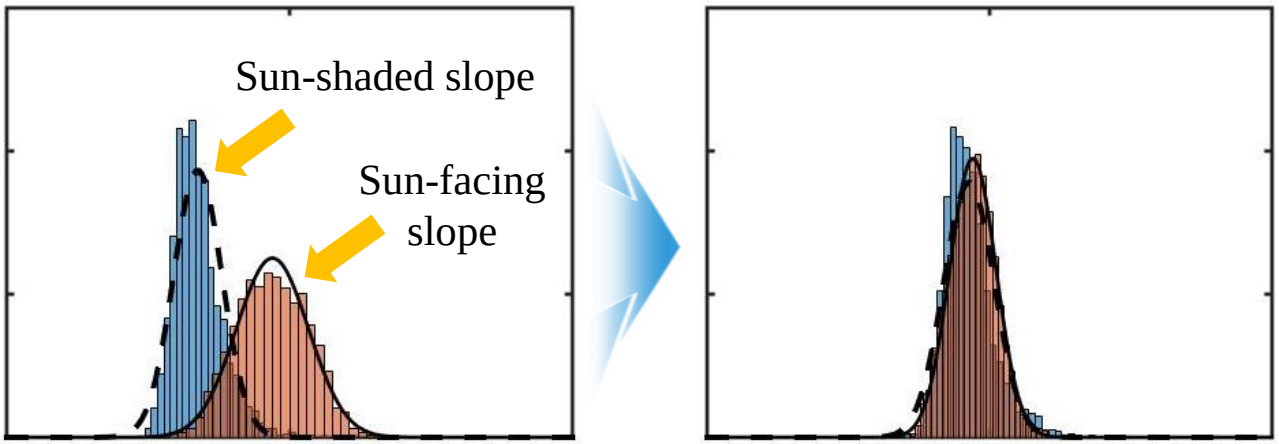
  - Minnaert+SCS correction

$$\rho_h = \rho\left(\frac{(\cos\theta_s)^{k'} \times \cos \theta_n}{(\cos i)^{k'}}\right)$$

k' = Minnaert constant

Approach

- **Evaluation methods**
  - For the performance analysis, we have measured histogram distance between sun-facing slopes and sun-shaded slopes
  - As the performance of models is enhanced, the distance could be measured closely



Approach

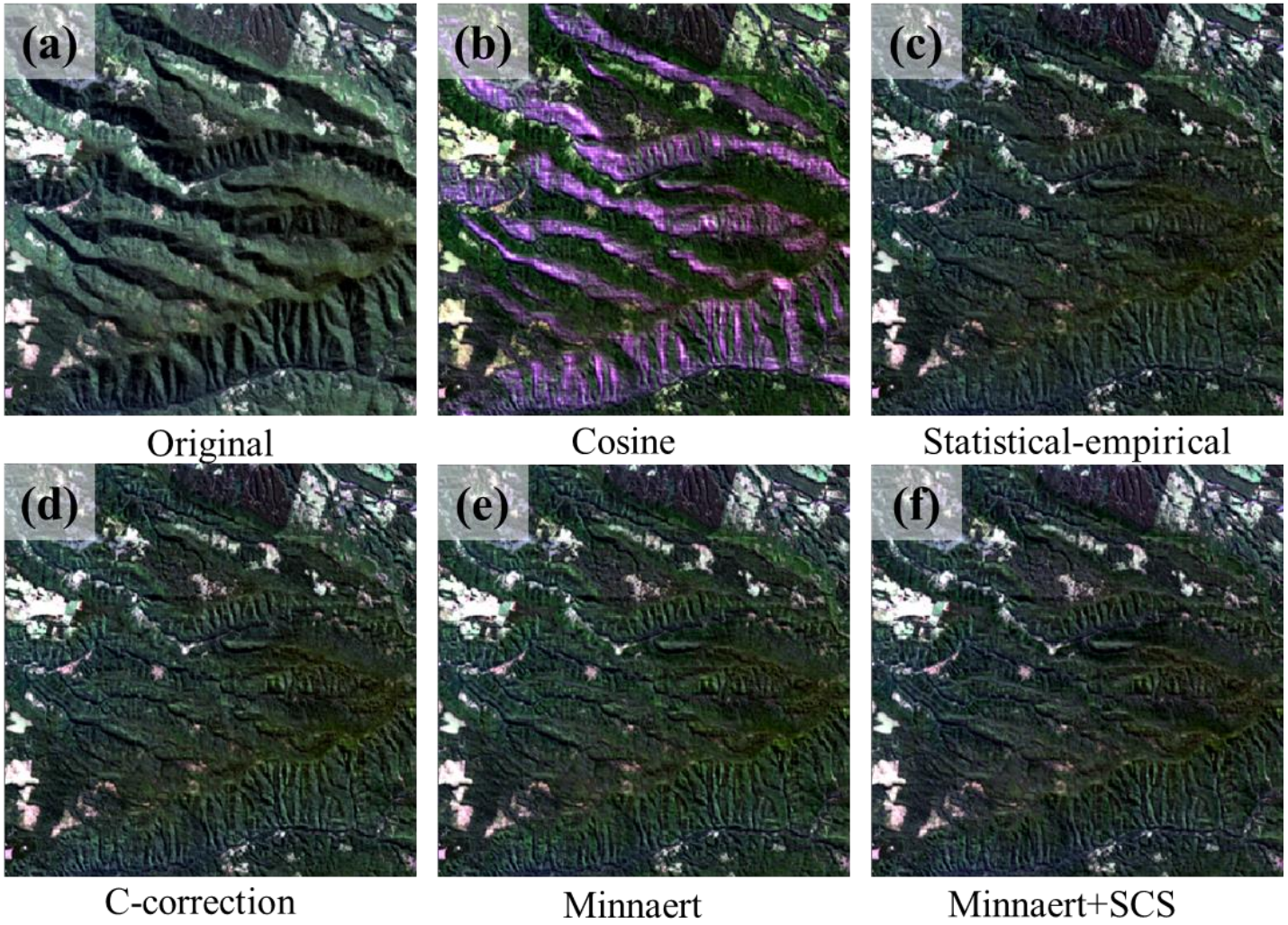
- **Evaluation methods**
  - We assumed that sample data are normally distributed and estimated the probability density function (PDF)
  - Our main idea for evaluating the performance of correction models is to quantitatively measure the similarity of both the PDFs.
  - In this study, the Bhattacharyya method is selected to compute distance

$$d(H_1, H_2) = \sqrt{1 - \sum_{i=1}^{n} \frac{\sqrt{(H_1(i) \cdot H_2(i))}}{\sqrt{\sum_{i=1}^{n} H_1(i) \cdot \sum_{i=1}^{n} H_2(i)}}}$$

$$\underbrace{0}_{\text{perfect match}} \leq d(H_1, H_2) \leq \underbrace{1}_{\text{bad mismatch}}$$

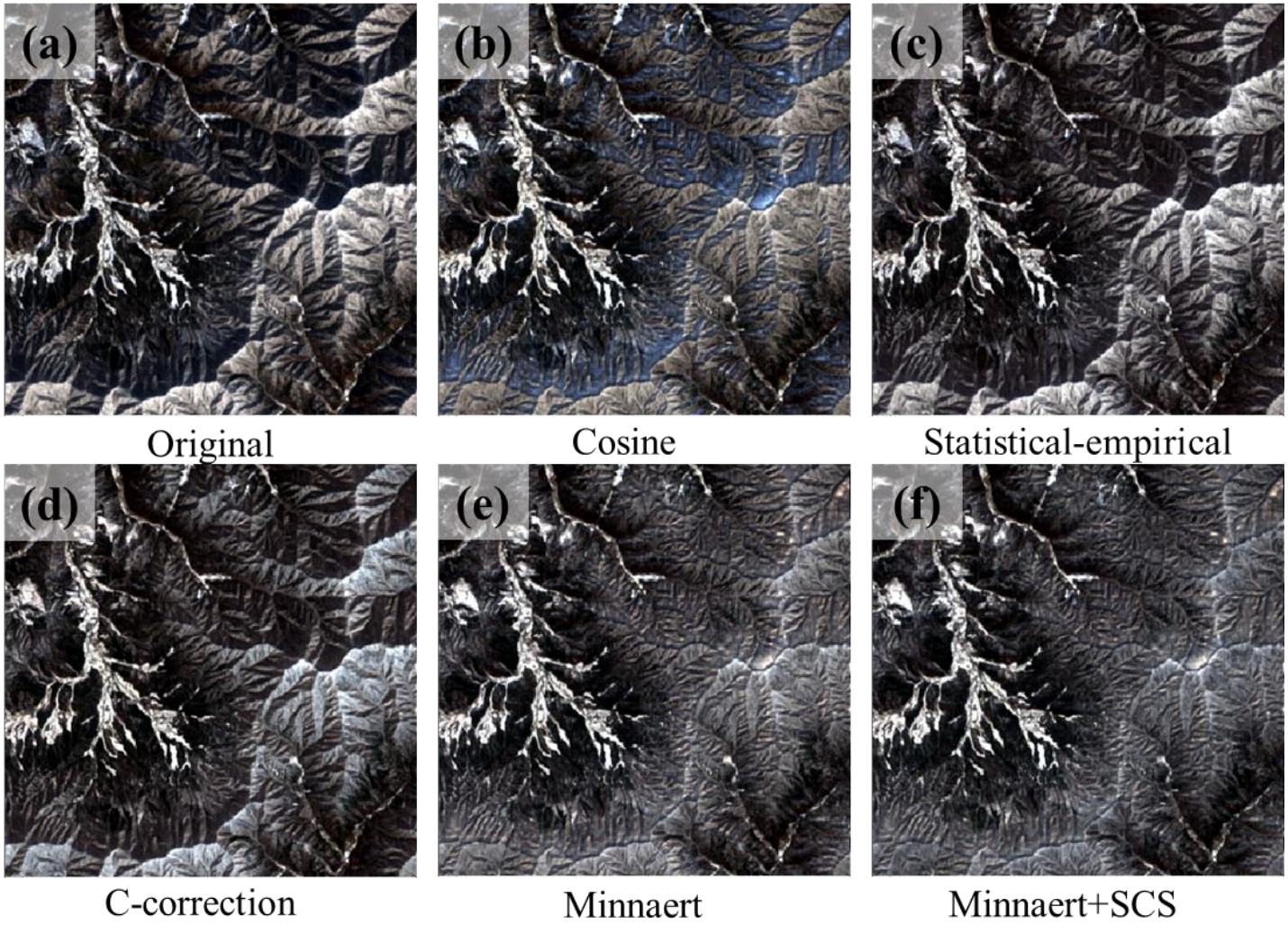
Results and discussions

1) Visual analysis in vegetation area



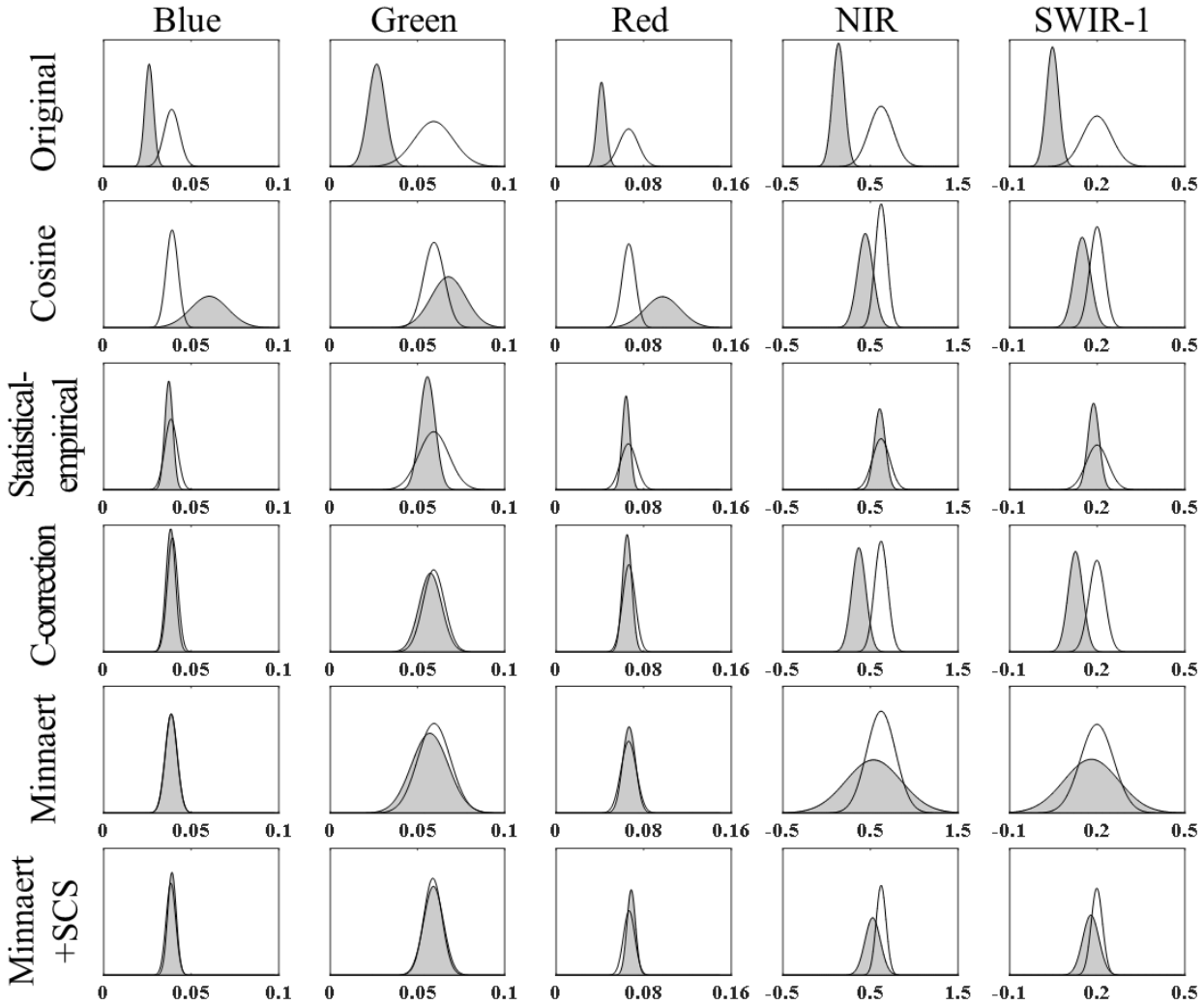
Results and discussions

1) Visual analysis in snow covered area



Results and discussions

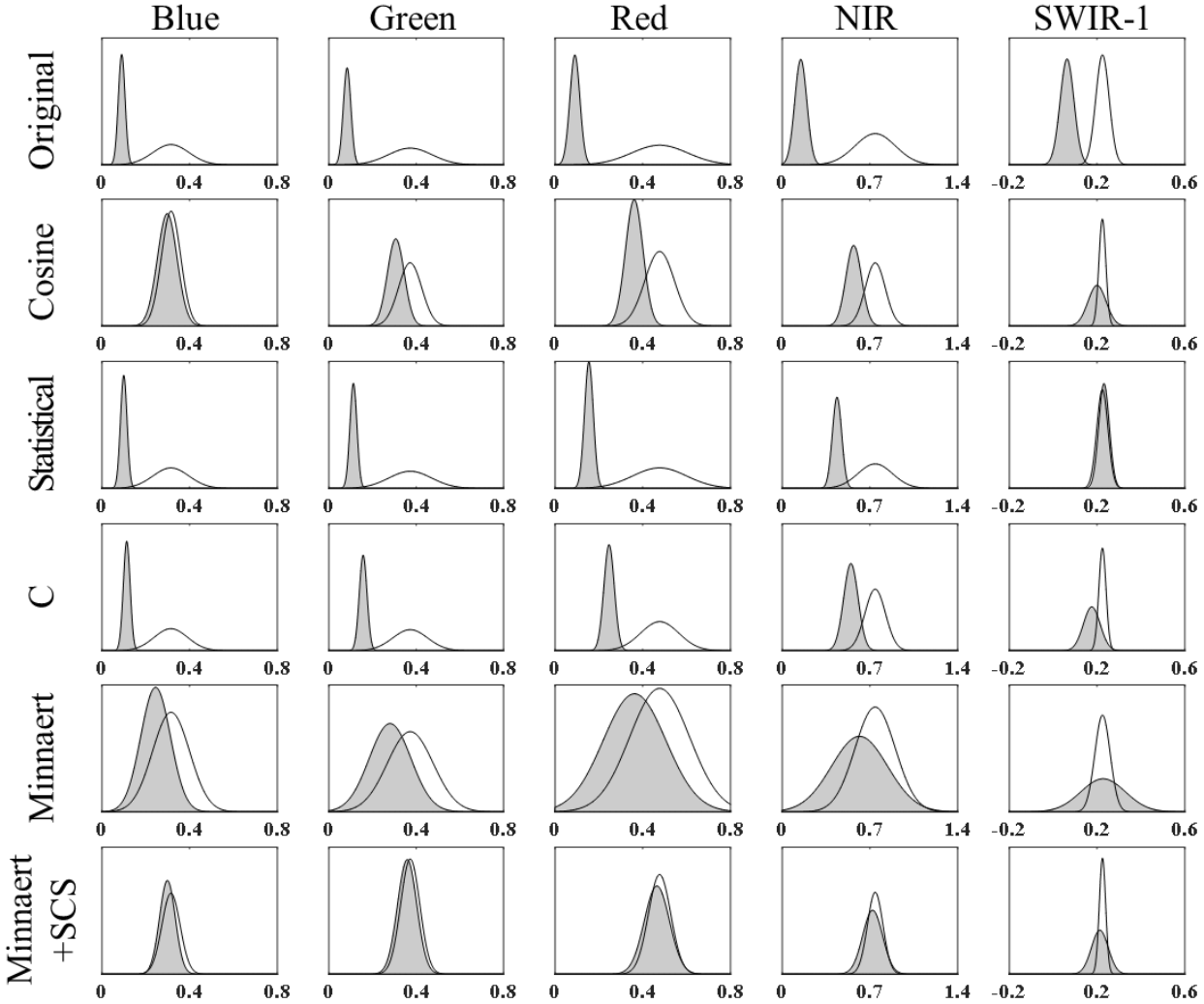
2) PDF graphs in vegetation area



- Slopes are easily distinguished in original image
- Cosine correction model cause over-correction
- Statistical correction has good performance in NIR, SWIR bands
- Dispersion has been increased in Minnaert correction
- C-correction, Minnaert and Minnaert+SCS show good performance in RGB bands

Results and discussions

2) PDF graphs in snow covered area



- Cosine correction model has best performance in Blue band, while vegetation area
- Statistical correction has best performance in SWIR band
- Dispersion has been also increased in Minnaert correction
- Minnaert+SCS model shows good performance in whole bands

3) Histogram distance in vegetation area

- In the vegetation area, the best models are as followed: Minnaert, Minnaert+SCS, Minnaert, Statistical-empirical, and Minnaert as Blue, Green, Red, NIR and SWIR-1 bands

Site	Correction Methods	Blue	Green	Red	NIR	SWIR-1
Vegetation	Original	0.90	0.93	0.91	0.96	0.94
	Cosine	0.83	0.42	0.80	0.69	0.61
	Statistical	0.25	0.36	0.35	**0.23**	0.34
	C-correction	0.13	0.11	0.18	0.85	0.79
	Minnaert	**0.01**	0.10	**0.09**	0.33	**0.25**
	Minnaert+SCS	0.10	**0.05**	0.20	0.48	0.34

3) Histogram distance in snow covered area

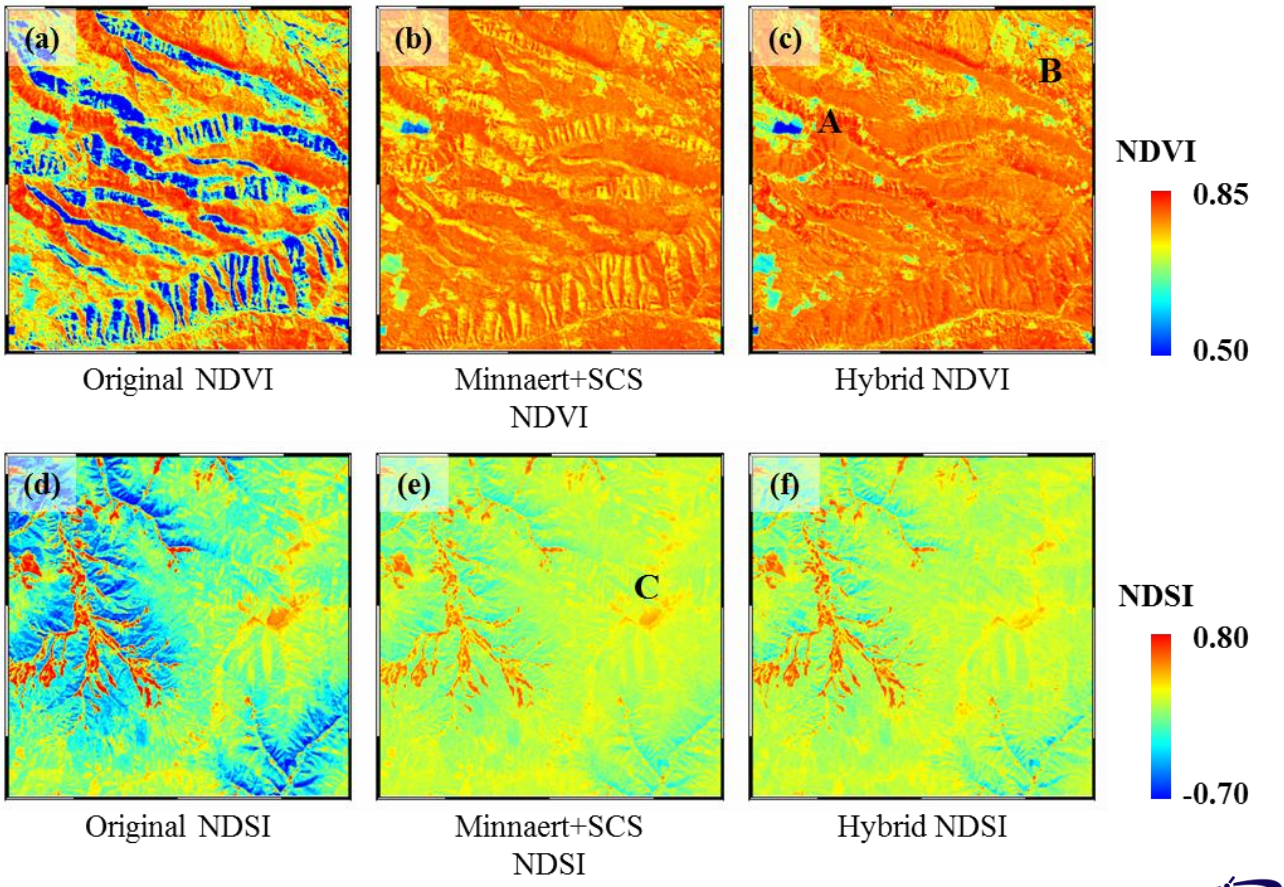
- On the other hand, in the snow covered area, the best models are different
- We can see best performance model largely depended on land cover
- And also, we can create the hybrid image from combining best models

Site	Correction Methods	Blue	Green	Red	NIR	SWIR-1
Snow covered	Original	0.95	0.96	0.97	0.98	0.98
	Cosine	**0.14**	0.49	0.67	0.72	0.49
	Statistical	0.94	0.95	0.95	0.88	**0.11**
	C-correction	0.94	0.94	0.93	0.78	0.63
	Minnaert	0.33	0.32	0.28	0.27	0.47
	Minnaert+SCS	0.16	**0.11**	**0.10**	**0.16**	0.45

Results and discussions

4) NDVI and NDSI results using hybrid image

- The best performing models can combine to hybrid image
- It can be utilized enhancing environment indices such as NDVI, NDSI



Summary

1) We have proposed an efficient method to quantitative evaluations topographic correction models using measurement of histogram distance

2) When correcting the topographic effect, the statistical-empirical, Minnaert and Minnaert+SCS models should be selected because these models are ranked within the top 3, in generally

3) The correction performance largely depended on land cover types. Therefore, when applying the correction models, you should combine the appropriate results through quantitative evaluation

4) The hybrid image has advantage in estimating vegetation and snow cover area than original image and singular correction method

Thank you for your attention!

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