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UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

A Novel Perspective on Mapping Snow Cover Under Forest Canopy With Sentinel-2 Multispectral Optical Satellite Sensor Over Black Forest Germany

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EGU General Assembly 2020

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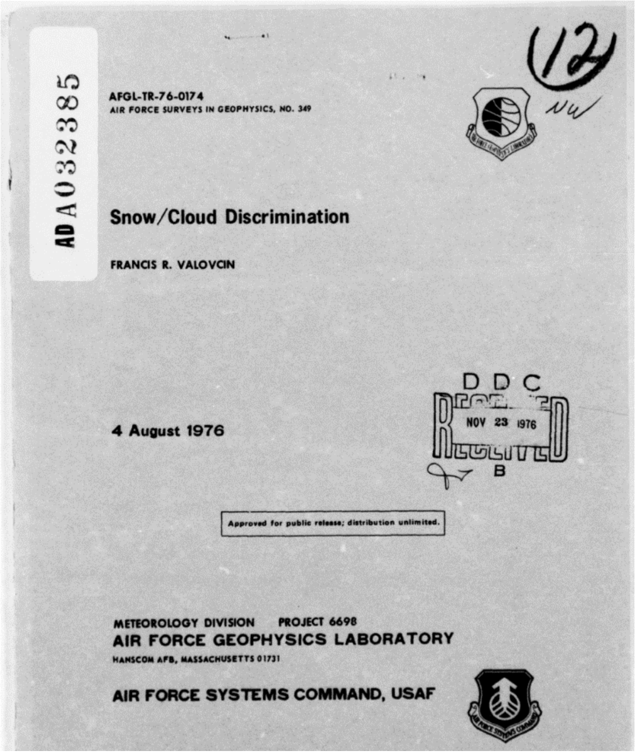
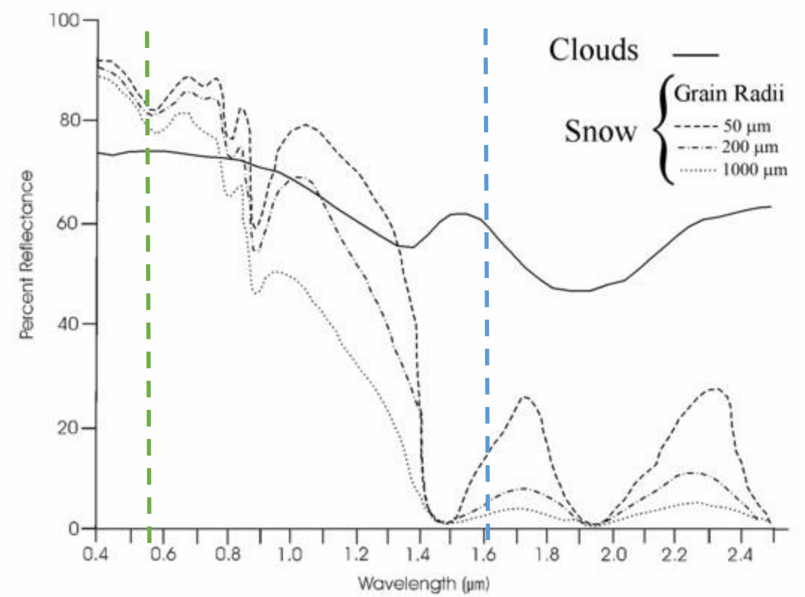
Mapping Snow Cover With Normalized Difference Snow Index (NDSI)



20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
The main objective of this investigation was to evaluate the usefulness of the data from the S192 Multispectral Scanner aboard Skylab in snow-cloud discrimination. From the available S192 screening films and digital tape data, the reflectance characteristics of snow, ice, and water clouds in different spectral bands from the visible into the near infrared spectral region can be determined. In the visible part of the spectrum, snow, ice, and water clouds

20. (Cont) micrometers
appear white. In the near infrared, Band 11 (1.55 to 1.75 µm), water clouds are white, ice clouds are gray and snow is black. The ratio of the radiance values in Band 6 (0.68 to 0.78 µm) to Band 11 (1.55 to 1.75 µm) appears to provide a method for discriminating between snow cover, ice, and water clouds.



Sentinel-2 Green Band: 560 nm

Sentinel 2 SWIR Band: 1610 nm

NDSI = ([green] - [blue]) / ([green] + [blue])

NDSI > 0.4 indicates snow covered areas

The Cryosphere, 12, 1629–1642, 2018
https://doi.org/10.5194/tc-12-1629-2018

The Cryosphere Open Access EGU

On the need for a time- and location-dependent estimation of the NDSI threshold value for reducing existing uncertainties in snow cover maps at different scales

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Received: 17 August 2017 – Discussion started: 15 September 2017
Revised: 4 March 2018 – Accepted: 30 March 2018 – Published: 4 May 2018

Abstract. Knowledge of current snow cover extent is essential for characterizing energy and moisture fluxes at the Earth's surface. The snow-covered area (SCA) is often estimated by using optical satellite information in combination with the normalized-difference snow index (NDSI). The NDSI thereby uses a threshold for the definition if a satellite pixel is assumed to be snow covered or snow free. The spatiotemporal representativeness of the standard threshold of 0.4 is however questionable at the local scale. Here, we … adapted threshold diminishes using a pixel size of 500 m or larger, underlining the general applicability of the standard threshold at larger scales.

1 Introduction

Numerous studies ranging from the local to the global scale

References:
Valovcin, Airforce Geophysical Laboratory (Meteorology Division, Project 6698), 1976.

Understanding Normalized Difference Vegetation Index (NDVI)

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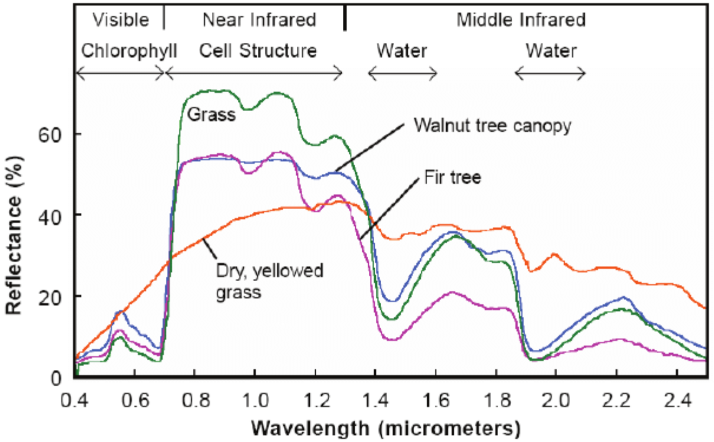
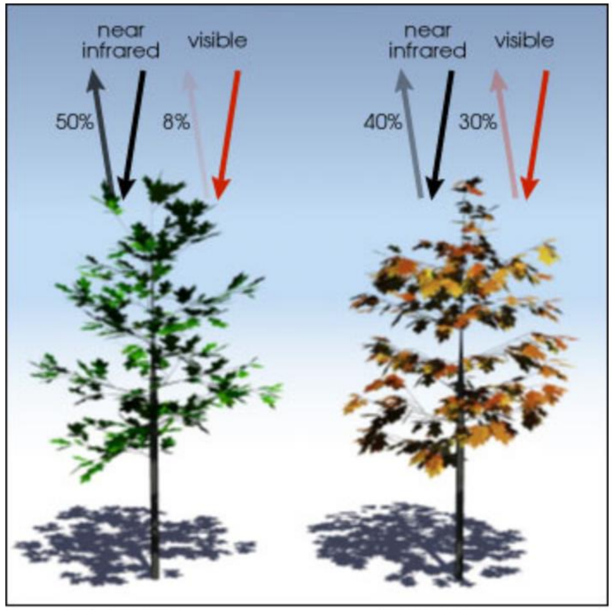
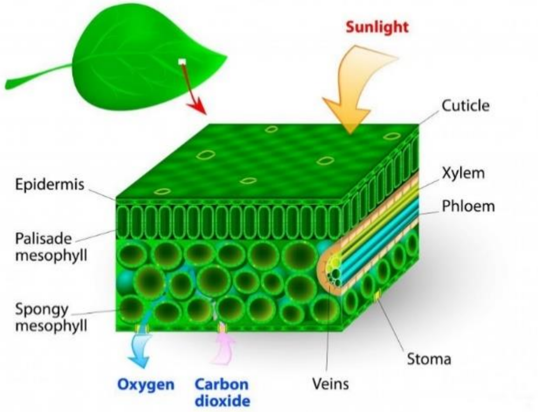


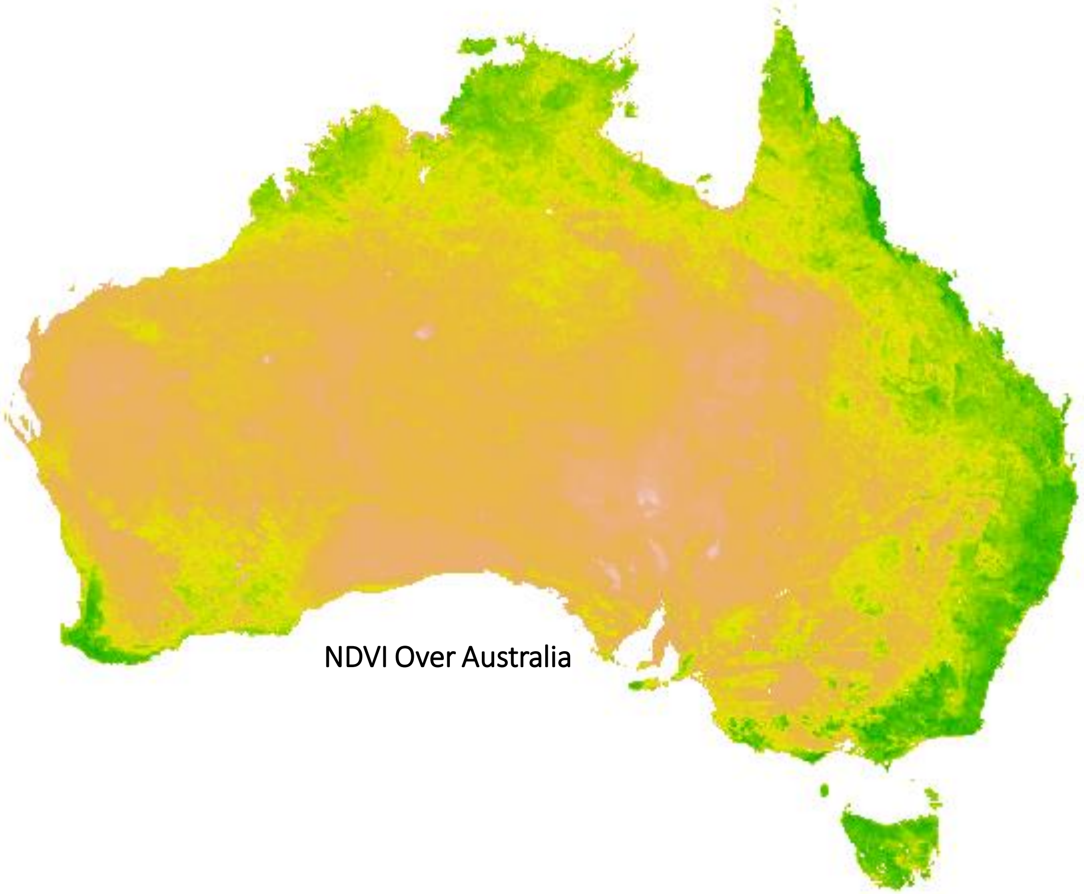
$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red})}$$



$$\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72 \qquad \frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14$$



Plant Cell Structure: Mesophyll



NDVI Over Australia

References:
http://www.bom.gov.au/
https://earthobservatory.nasa.gov/features/MeasuringVegetation/measuring_vegetation_2.php
https://www.researchgate.net/publication/228781235_A_review_of_hyperspectral_remote_sensing_and_its_application_in_vegetation_and_water_resource_studies

Normalized Difference Forest Snow Index (NDFSI) Over the Black Forest

remote sensing

MDPI

Article

An Effective Method for Snow-Cover Mapping of Dense Coniferous Forests in the Upper Heihe River Basin Using Landsat Operational Land Imager Data

Xiao-Yan Wang [1,2,*], Jian Wang [2], Zhi-Yong Jiang [1], Hong-Yi Li [2] and Xiao-Hua Hao [2]

Received: 10 October 2015; Accepted: 11 December 2015; Published: 18 December 2015
Academic Editors: Jose Moreno, Magaly Koch and Prasad S. Thenkabail

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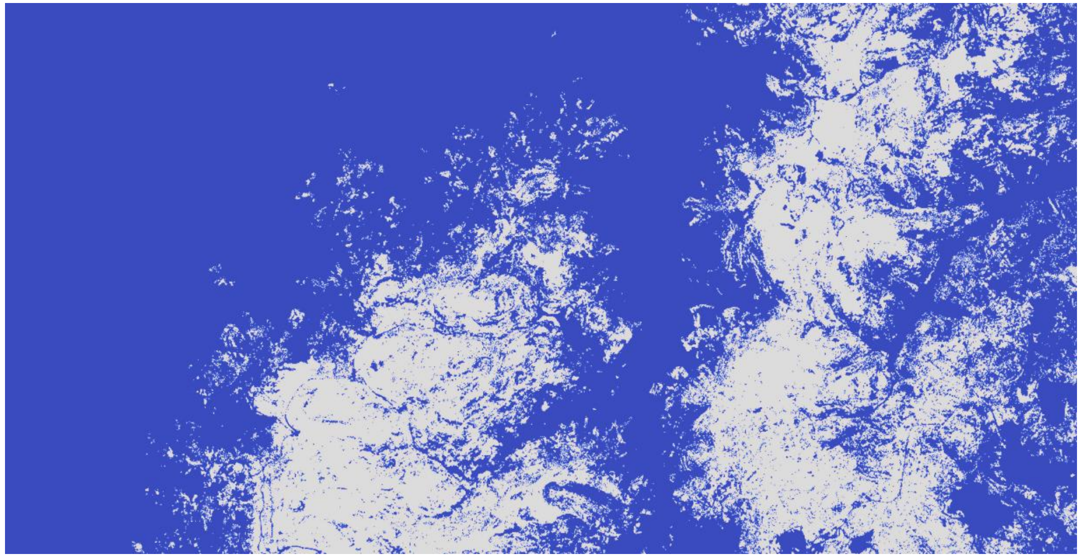
Abstract: The Normalized Difference Snow Index (NDSI) is an effective index for snow-cover mapping at large scales, but in forested regions the identification accuracy for snow using the NDSI is low because of forest cover effects. In this study, typical evergreen coniferous forest zones on Qilian Mountain in the Upper Heihe River Basin (UHRB) were chosen as example regions. By analyzing the spectral signature of snow-covered and snow-free evergreen coniferous forests with Landsat Operational Land Imager (OLI) data, a novel spectral band ratio using near-infrared (NIR) and shortwave infrared (SWIR) bands defined as $(\rho_{nir} - \rho_{swir})/(\rho_{nir} + \rho_{swir})$ is proposed. Our research shows that this band ratio, named the normalized difference forest snow index (NDFSI), can be used to effectively distinguish snow-covered evergreen coniferous forests from snow-free evergreen coniferous forests in UHRB.

Keywords: remote sensing; snow identification; forest; OLI

3.2. *Optical Properties of Snow-Covered Forest*

In forests, as trees obscure snow on the ground surface, the spectrum acquired by the sensor is a mixed spectrum that includes snow, canopy, and snow-free ground (if the ground is not fully covered by snow). We only tried to find the spectral difference between snow-covered and snow-free forests in the Landsat OLI images, without considering the complexity of the terrain, the density of the forest, or other factors. Some sample points of snow and snow-covered forest are chosen in Figure 2b. Figure 3a shows the spectral signature of these points. The figure shows that, because of the forest effect, the visible reflectance of snow-covered forest is not as high as that of snow. Accordingly, it can be inferred that the NDSI, which is based on the spectral properties of snow, is not an effective index to extract snow information from forested areas.



NDFSI

Problem Statement: Mapping Snow Under Forest Canopy

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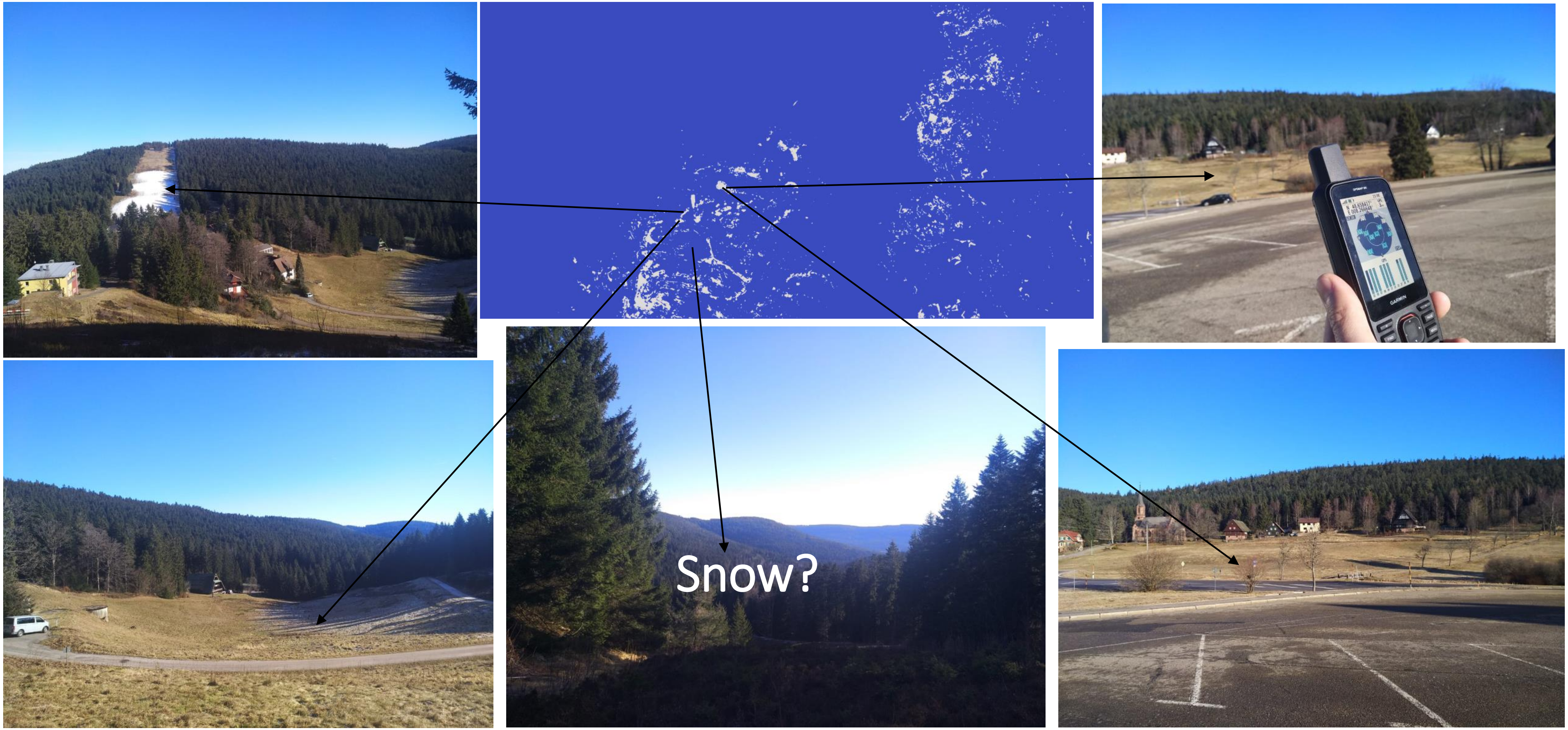
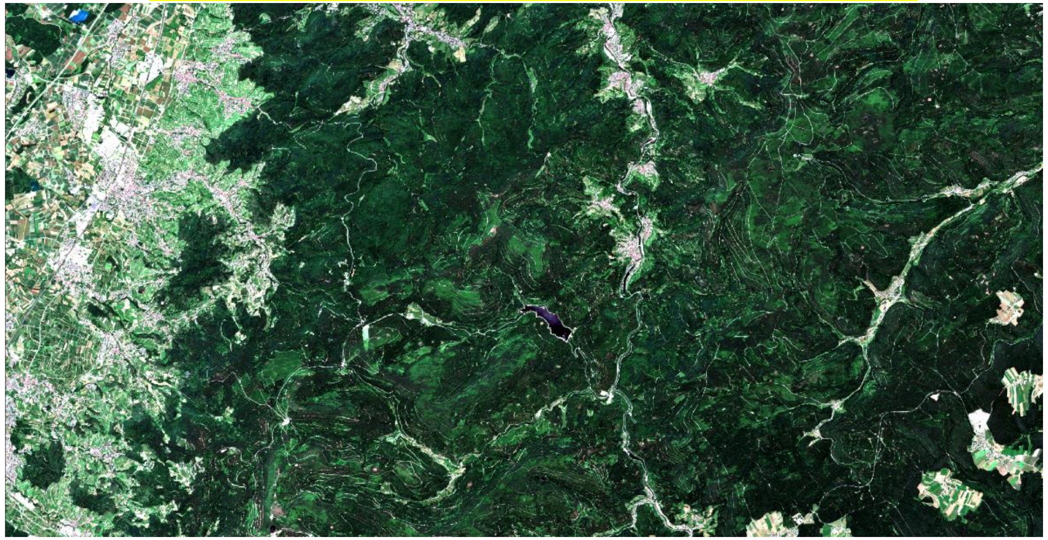
Hundsek Test Site, Black Forest Germany As On 24th February 2019

What Areas Are We Looking At? NDSI Over the Black Forest



How Does the NDVI Decreases Over Evergreen Forests in Winter?

1. Seasonal Drop in Chlorophyll Activity in the Black Forest



2. Under Canopy Snow Covers Moss on the Forest Floor in the Black Forest

3. Seasonal Change in the Solar Zenith Angle

NDSI-NDVI Temporal Statistics: Open Areas

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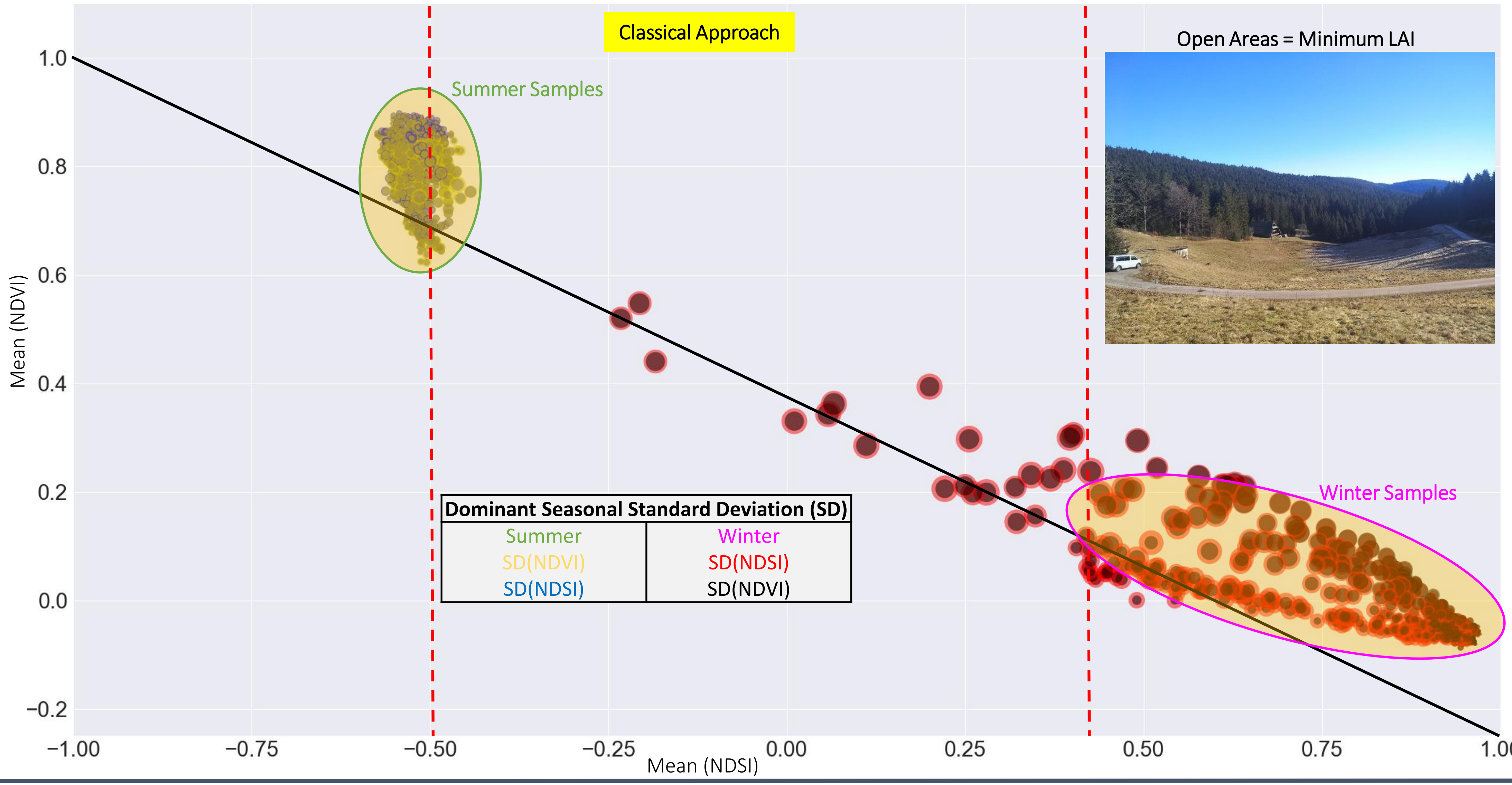

Dominant Seasonal Standard Deviation (SD)	
Summer	Winter
SD(NDVI)	SD(NDSI)
SD(NDSI)	SD(NDVI)

NDSI-NDVI Temporal Statistics: Moderately Forested Areas

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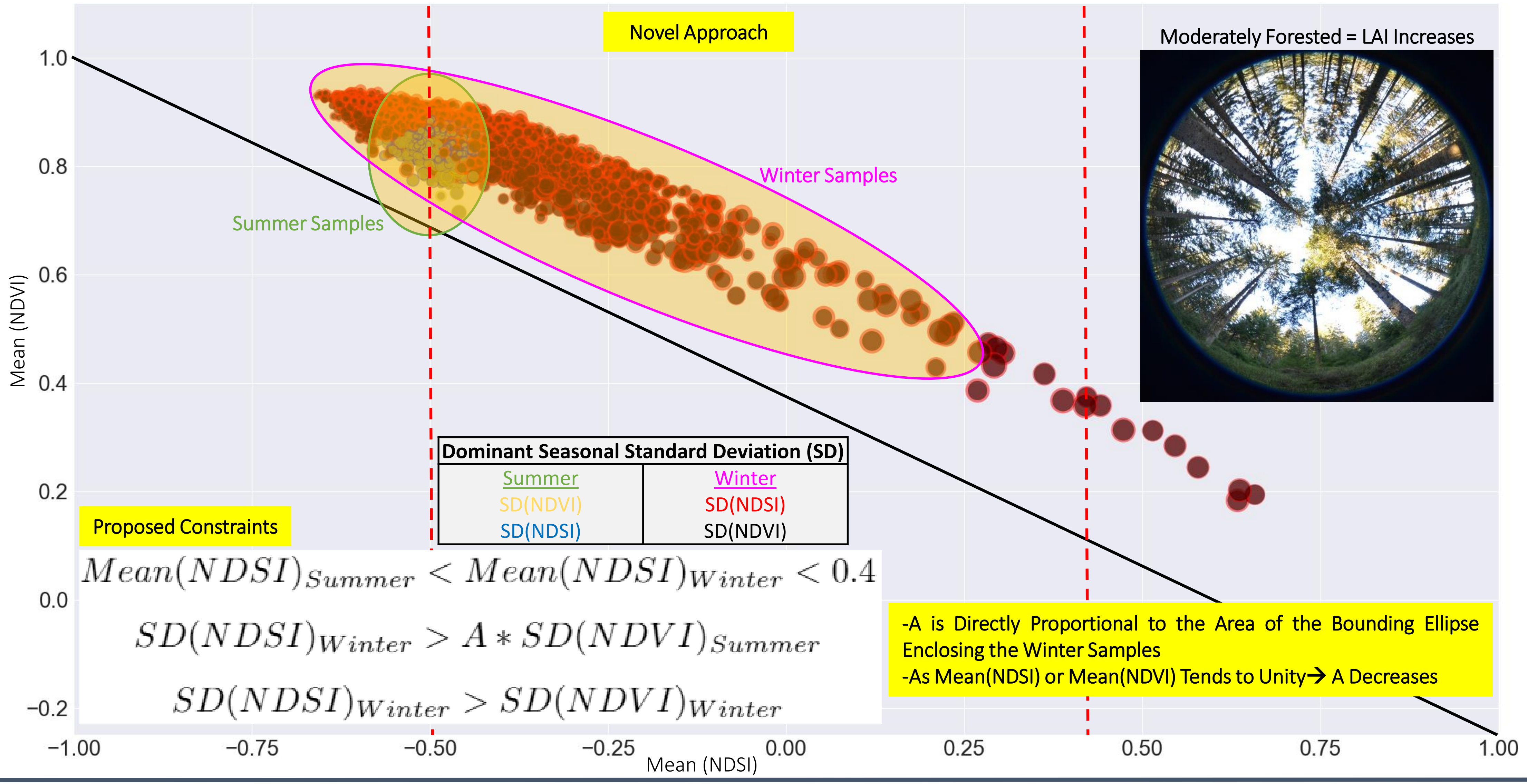


Moderately Forested = LAI Increases

Dominant Seasonal Standard Deviation (SD)	
Summer	Winter
SD(NDVI)	SD(NDSI)
SD(NDSI)	SD(NDVI)

Proposed Constraints

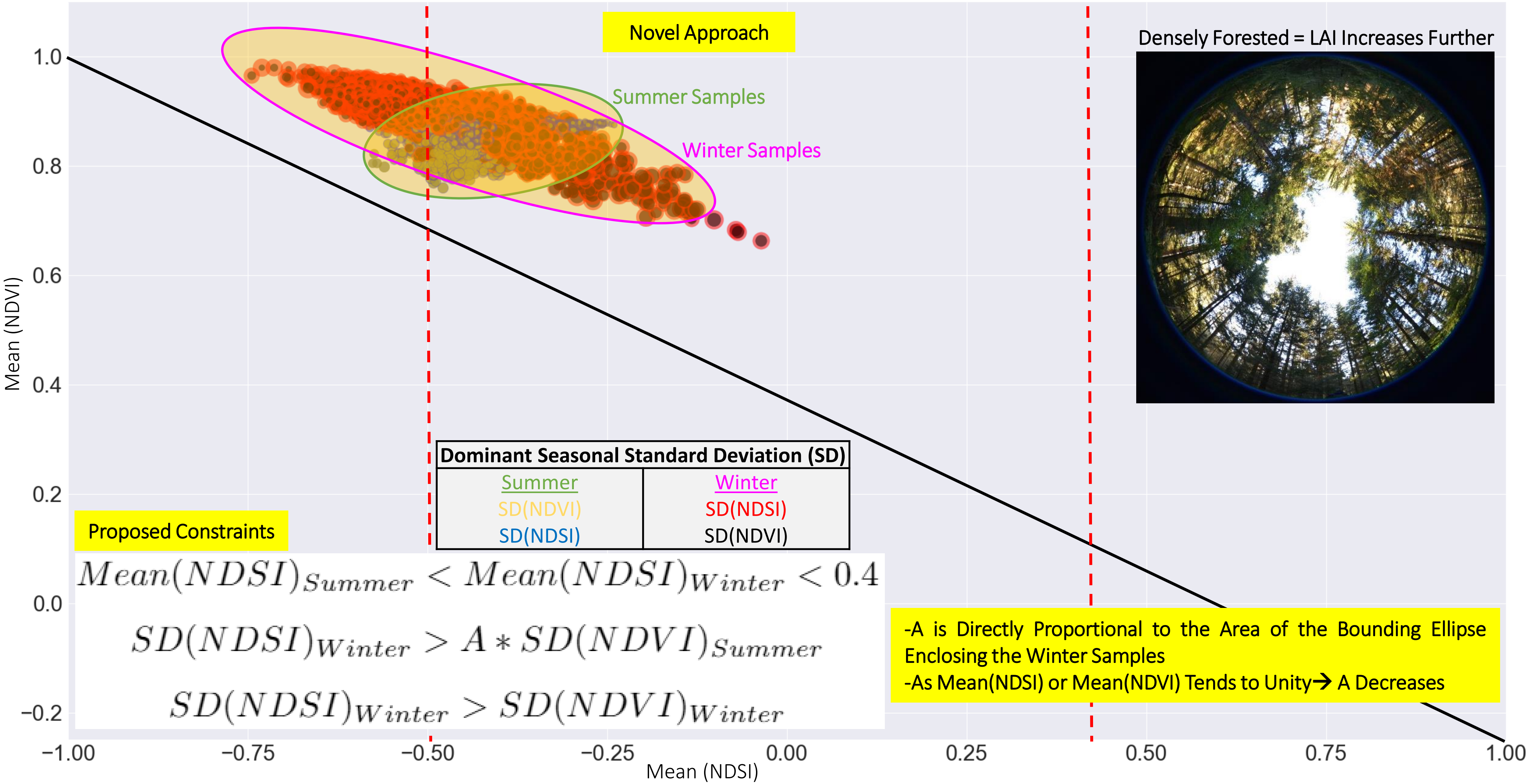
$$Mean(NDSI)_{Summer} < Mean(NDSI)_{Winter} < 0.4$$

$$SD(NDSI)_{Winter} > A * SD(NDVI)_{Summer}$$

$$SD(NDSI)_{Winter} > SD(NDVI)_{Winter}$$

-A is Directly Proportional to the Area of the Bounding Ellipse Enclosing the Winter Samples
-As Mean(NDSI) or Mean(NDVI) Tends to Unity→ A Decreases

NDSI-NDVI Temporal Statistics: Densely Forested Areas



Dominant Seasonal Standard Deviation (SD)	
Summer	Winter
SD(NDVI)	SD(NDSI)
SD(NDSI)	SD(NDVI)

Proposed Constraints

$$Mean(NDSI)_{Summer} < Mean(NDSI)_{Winter} < 0.4$$

$$SD(NDSI)_{Winter} > A * SD(NDVI)_{Summer}$$

$$SD(NDSI)_{Winter} > SD(NDVI)_{Winter}$$

-A is Directly Proportional to the Area of the Bounding Ellipse Enclosing the Winter Samples
-As Mean(NDSI) or Mean(NDVI) Tends to Unity→ A Decreases

Proposed Algorithm

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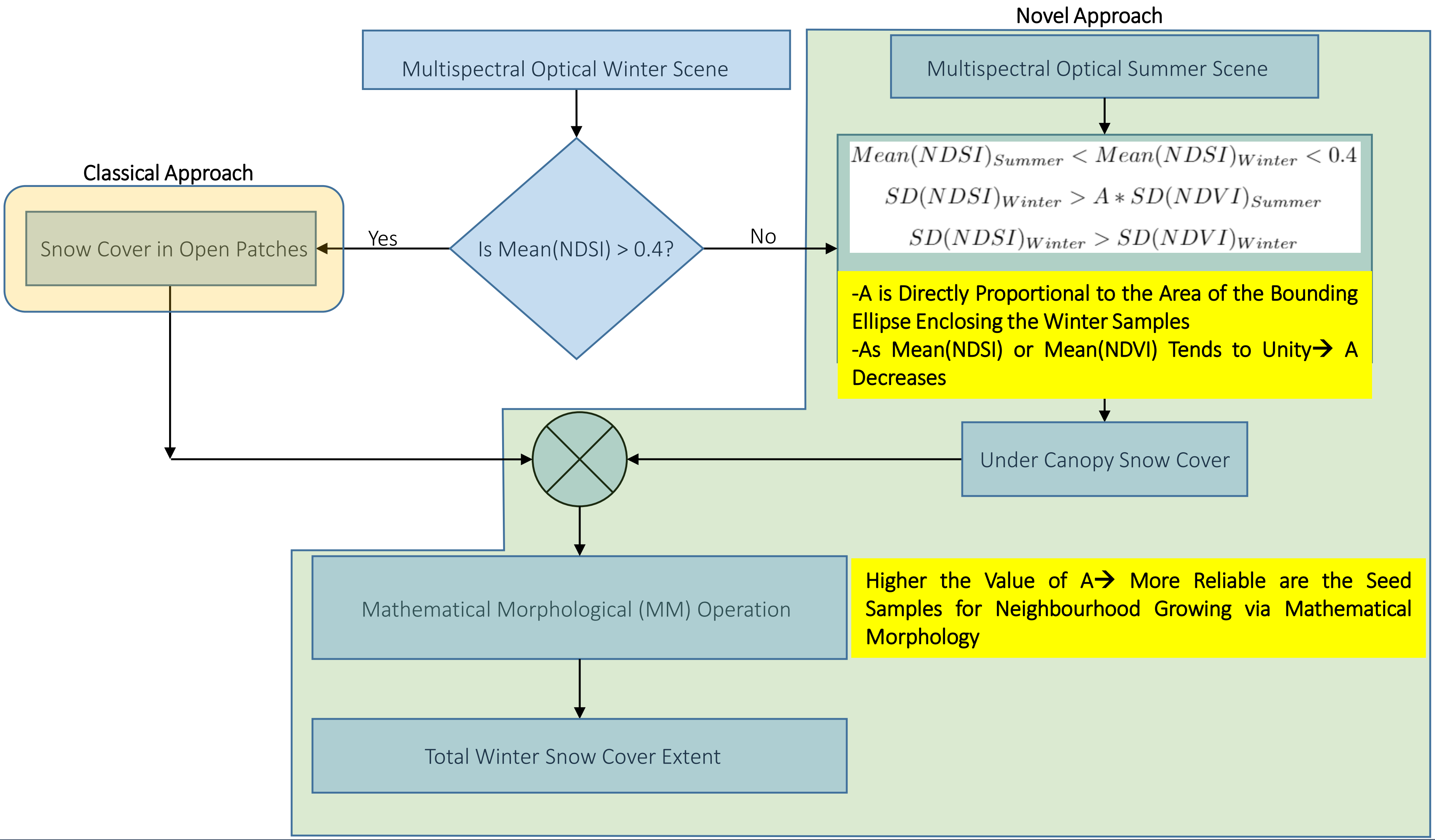

Mathematical Morphology (MM): A Neighborhood Growing Approach

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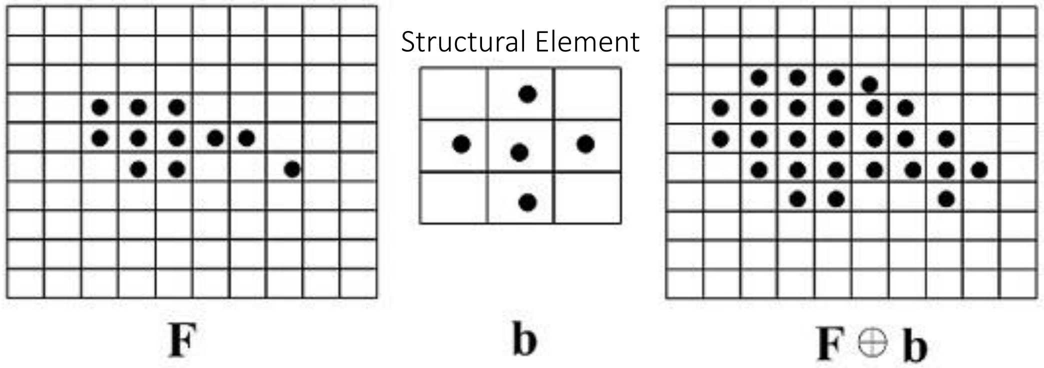
Structural Element



Original Image

Image Post Morphological Operation

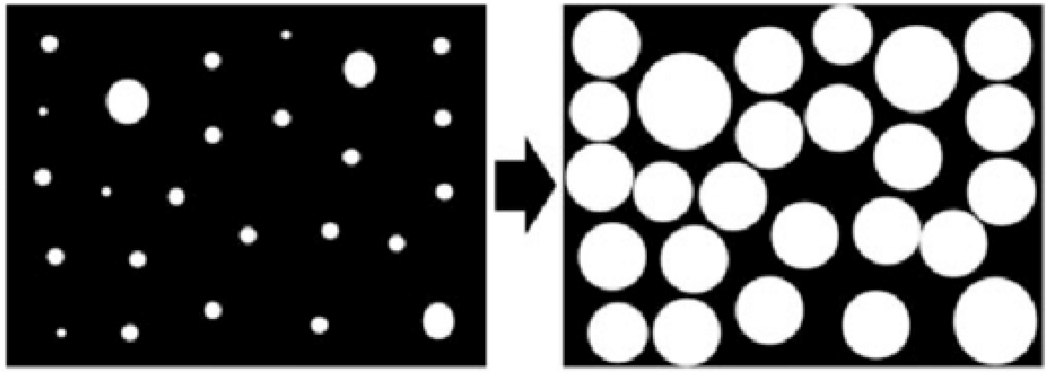
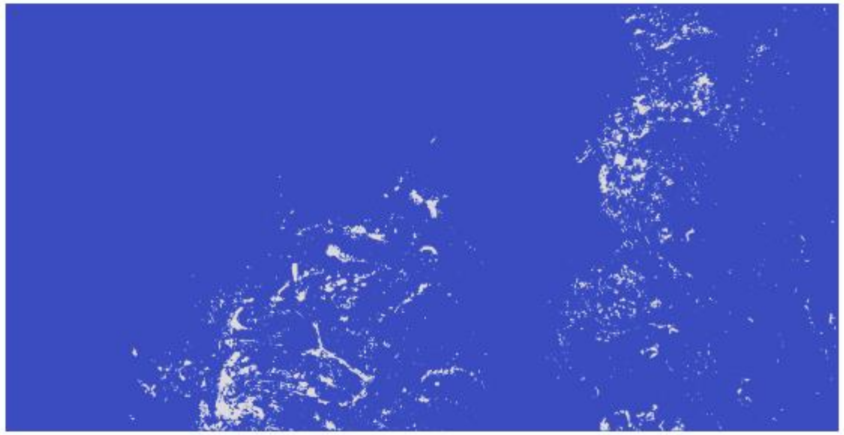


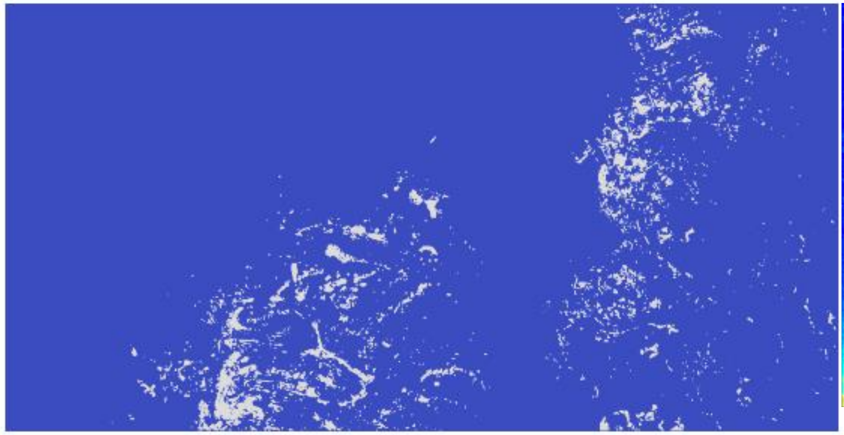
Image Before Morphological Operation

Image After Morphological Operation

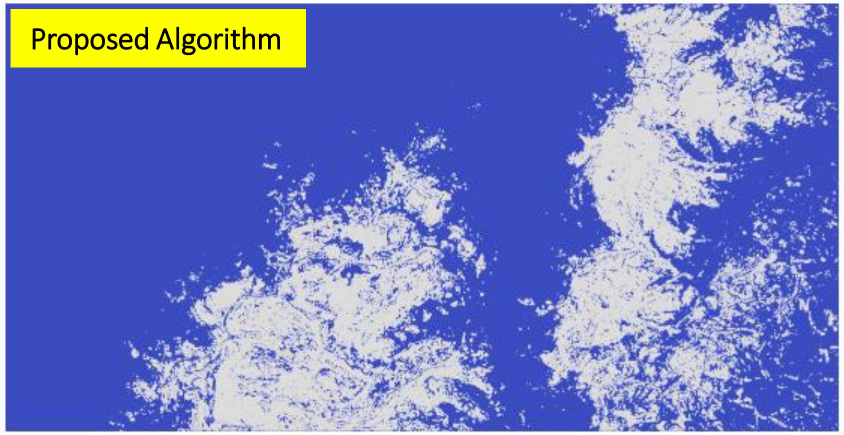
Performance & Conclusion



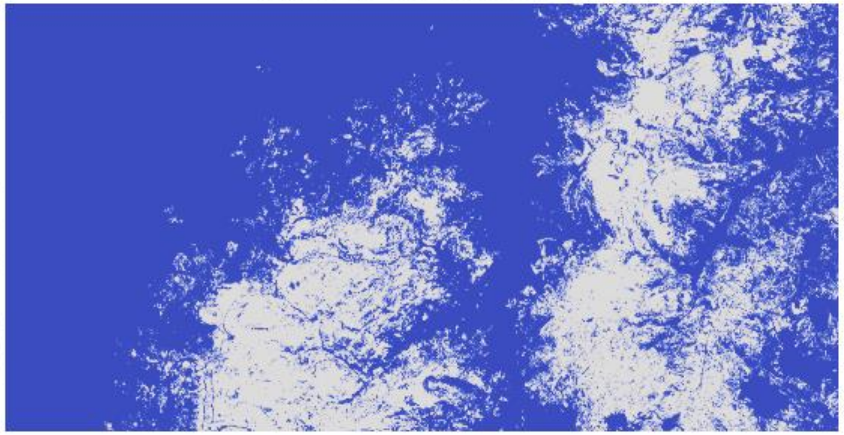
(a) Thresholded NDSI.



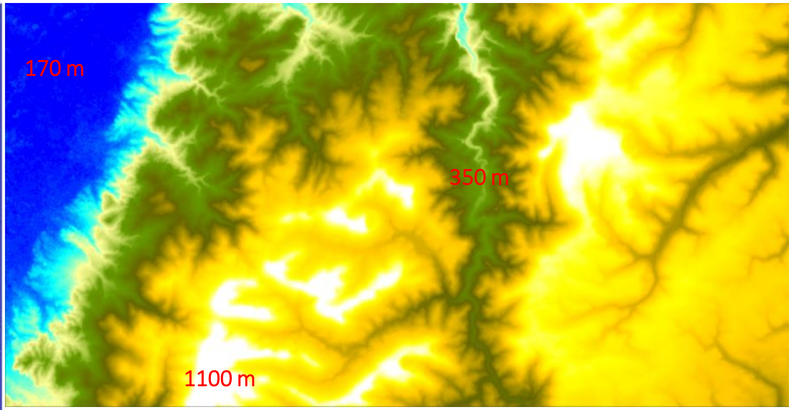
(b) MM on Thresholded NDSI.



(c) MM on Thresholded NDSI Merged With Temporal NDSI-NDVI Statistics.



(d) Thresholded NDFSI.



Elevation Distribution Over NW Black Forest

remote sensing MDPI

Article

An Effective Method for Snow-Cover Mapping of Dense Coniferous Forests in the Upper Heihe River Basin Using Landsat Operational Land Imager Data

Xiao-Yan Wang [1,2,*], Jian Wang [2], Zhi-Yong Jiang [1], Hong-Yi Li [2] and Xiao-Hua Hao [2]

Received: 10 October 2015; Accepted: 11 December 2015; Published: 18 December 2015
Academic Editors: Jose Moreno, Magaly Koch and Prasad S. Thenkabail

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3.2. Optical Properties of Snow-Covered Forest

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Further Investigations: Relationship Between A & LAI?

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Remote Sensing of Environment 113 (2009) 1628–1645

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Lidar-based mapping of leaf area index and its use for validating GLOBCARBON satellite LAI product in a temperate forest of the southern USA

Kaiguang Zhao *, Sorin Popescu

Spatial Sciences Lab, Department of Ecosystem Science and Management, Texas A&M University, College Station, TX-77840, USA

Agricultural and Forest Meteorology 149 (2009) 1152–1160

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Modeling approaches to estimate effective leaf area index from aerial discrete-return LIDAR

Jeffrey J. Richardson [a,1], L. Monika Moskal [a], Soo-Hyung Kim [a,b,1,*]

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Short communication

Estimation of leaf area index and covered ground from airborne laser scanner (Lidar) in two contrasting forests

David Riaño [a,d,*], Fernando Valladares [b], Sonia Condés [c], Emilio Chuvieco [d]

[a] *Department of Land, Air, and Water Resources, Center for Spatial Technologies and Remote Sensing, U. California, One Shields Avenue Davis, CA 95616-8617, USA*
[b] *Centro de Ciencias Medioambientales, CSIC, Serrano 115, E-28006 Madrid, Spain*
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Received 7 July 2003; received in revised form 16 December 2003; accepted 15 February 2004

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T Sauter, B Weitzenkamp... - International Journal of ..., 2010 - Wiley Online Library
... Taken together, NDVI and NDSI provide a strong signal that can be used to classify snow-covered forests (Klein et al., 1998; Hall et al., 2002) like the Black Forest ... The fractional snow cover calculation is applied to the full range of NDSI values (0.0–1.0) ...
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Snow cover distribution as mapped from satellite photography
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... In the Missouri River Basin the forest-covered Black Hills, near 44øN, 104øW ... Since clouds as viewed from a satellite seldom retain precisely the same pattern for more than a few hours, patterns that persist for a day or more are usually snow cover [Widger et al., 1964] ...
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MODIS snow-cover products — [PDF] nasa.gov, University of Heidelberg
DK Hall, GA Riggs, VV Salomonson... - Remote sensing of ..., 2002 - Elsevier
... (b) Daily tile snow-cover product showing snow cover in the Black Hills, South ... 1987 ATC Chang, JL Foster, DK HallNimbus-7 SMMR derived global snow cover parameters. Annals ... Scholar. Grody & Basist, 1996 NC Grody, AN BasistGlobal identification of snowcover using SSM/I ...
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Improving snow cover mapping in forests through the use of a canopy reflectance model — University of Heidelberg
AG Klein, DK Hall, GA Riggs - Hydrological Processes, 1998 - Wiley Online Library
... Compared with other land covers, its areal extent varies dramatically on very short time-scales ... Grey bars are the results for a full resolution TM scene and black bars are ... type percentages for the seasonally snow-covered portion of North America for February snow cover extent ...
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... within the boreal sites were predominantly composed of mature white and black spruce (Picea ... steady-state (ie, stable plant and soil C/N pools) forest conditions by ... These differences were attributed to increased volume scattering effects of snow cover, seasonal reductions in ...
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S Pettinato, E Malnes... - 2006 IEEE International ..., 2006 - ieeexplore.ieee.org
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Development of a technique to assess snow-cover mapping errors from space — [HTML] nasa.gov
DK Hall, JL Foster, VV Salomonson... - ... on Geoscience and ..., 2001 - ieeexplore.ieee.org
... 1723–1744, 1998. [6] A. Rango, "The response of areal snow cover to climate change in a snowmelt-runoff model," Ann. Glaciol., vol. 25, pp. 232–236, 1997. [7] GE Liston, "Interrelationships between snow distribution, snowmelt, and snowcover depletion: Implications ...
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Subpixel mapping of snow cover in forests by optical remote sensing — University of Heidelberg
D Vikhamar, R Solberg - Remote Sensing of Environment, 2003 - Elsevier
... The aerial photo to the left covers mainly birch forest, while the aerial photo to the right shows mainly pine forest. White areas in the TM image are unforested snow-covered areas ... Wavelength

INTERNATIONAL JOURNAL OF CLIMATOLOGY
Int. J. Climatol. **30**: 2330–2341 (2010)
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Spatio-temporal prediction of snow cover in the Black Forest mountain range using remote sensing and a recurrent neural network

Tobias Sauter,* Björn Weitzenkamp and Christoph Schneider
Department of Geography, RWTH Aachen University, North Rhine-Westphalia, Germany

ABSTRACT: Winter tourism is the main economic factor for many different regions in the German Mountain Range. Owing to warming trends experienced in the past and predicted for the future, precise knowledge about the development of snow cover and snow duration in the future is becoming more and more important. On the basis of the International Panel on Climate Change (IPCC) A1B scenario, this paper investigates the possible regional development of snow cover and snow duration in the Black Forest in southwest Germany until 2050. For this purpose, we developed a new method that combines Non-linear AutoRegressive networks with eXogenous inputs (NARX) with Remote Sensing and Geographic Information System (GIS). With this non-parametric approach, we try to define with preferably high accuracy a simple transferable model. Besides the general problem of developing a robust statistical model, our main focus is on the enhancement of the spatial resolution of snow patterns by incorporating complex structures of the underlying terrain using Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data. The results suggest a possible decrease in the number of snow days (snow cover ≥10 cm) in the decade 2041–2050 by 10 to 44% at altitudes higher than 1200 m, by 17 to 57% at 1000–1200 m and 25 to 66% at 500–1000 m. This results in a dramatic shortening of the snow season mainly caused by earlier snow melt initiation rather than by later first snow precipitation in autumn. These considerable changes in the snow season would cause enormous losses in the skiing and tourism industries. In this context, the obtained high-resolution snow data and maps can provide a useful tool and decision-making aid for the economy and politics. Copyright © 2009 Royal Meteorological Society

KEY WORDS recurrent neural network; snow cover prediction; downscaling; Black Forest; skiing; snow pattern; climate change; Germany

Received 27 February 2009; Revised 31 July 2009; Accepted 30 September 2009

Acknowledgement

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