DSCOVR EPIC/NISTAR: 5 years of Observing Earth from the first Lagrangian Point

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Zhendong Lu · Jun Wang · Xiaoguang Xu · Xi Chen · Shobha Kondragunta · Omar Torres · Eric M. Wilcox · Jing Zeng

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Alexander Marshak · Alfonso Delgado-Bonal · Yuri Knyazikhin

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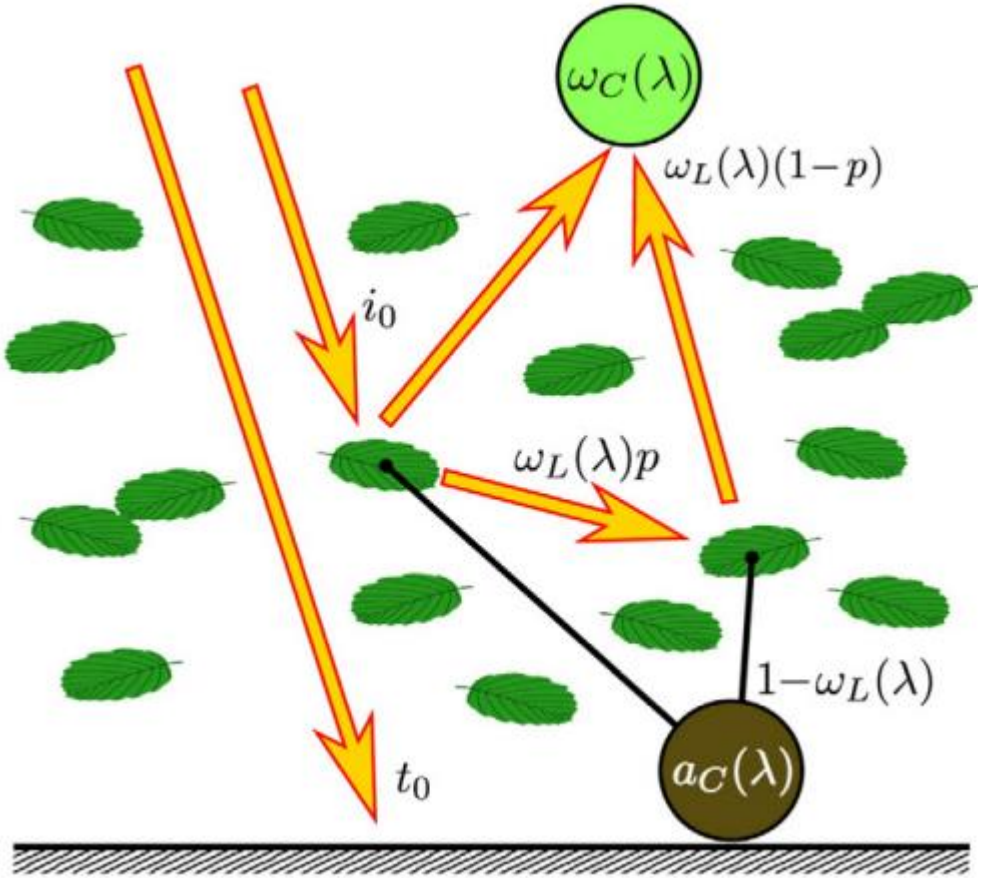
First validation of Earth Reflector Type Index (p) parameter from DSCOVR EPIC VESDR Data product using Australian Terrestrial Ecosystem Research Network observing sites

Jan Pisek, Catherine Odera, Mihkel Kaha, Lauri Korhonen, Angela Erb, Alexander Marshak, Yuri Knyazikhin

UNIVERSITY OF TARTU Tartu Observatory · UMASS BOSTON · NASA · BOSTON UNIVERSITY

The spectral invariants theory states that canopy reflectance, transmittance, and absorption can be approximated based on optical properties of the foliage elements and spectrally invariant parameters (Knyazikhin et al., 1998). Smolander and Stenberg (2005) interpreted one of these spectrally invariant parameters as photon recollision probability (p), i.e., 'the probability that a photon, being scattered by the canopy, will interact with the canopy again'.

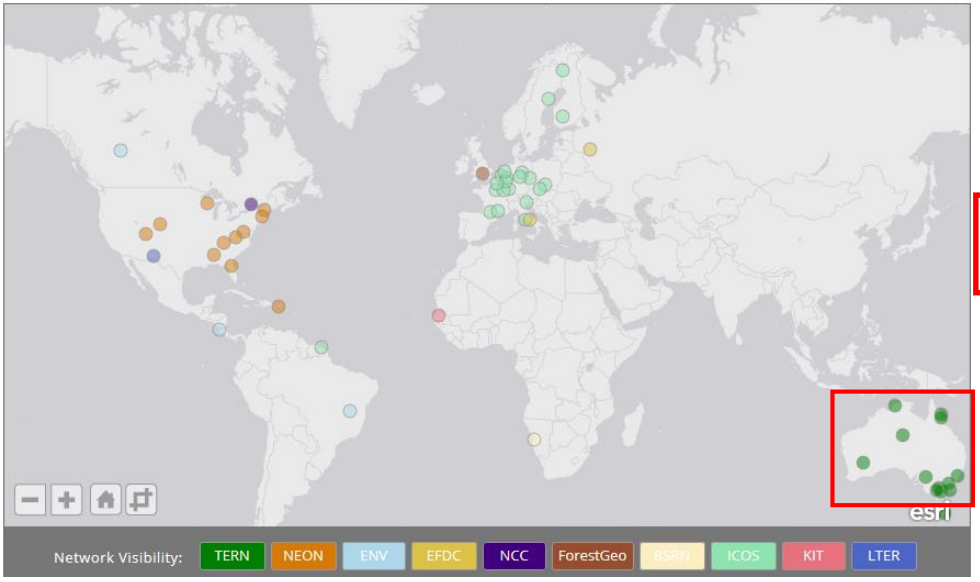


Stenberg et al., 2016, RSE

Table 1: Vegetation Parameter Suite in the Level 2 Vegetation Earth System Data Record (VESDR)

Parameter name	Units	Resolution		Comments
		Temporal	Spatial	
Normalized Difference Vegetation Index (NDVI)	none	65 to 110 min	10018.7542 m	Difference between Reflectance Factor (BRF) at 779.5 nm and 680 nm normalized by their sum
Fraction vegetation absorbed Photosynthetically Active Radiation (FPAR)	fraction	65 to 110 min	10018.7542 m	Fraction of photosynthetically active radiation (400 – 700nm) absorbed by vegetation
Leaf Area Index (LAI)	$\frac{m^2_{plant}}{m^2_{ground}}$	65 to 110 min	10018.7542 m	One-sided green leaf area per unit ground area in broadleaf canopies and the projected needle area in coniferous canopies
Sunlit Leaf Area Index (SLAI)	$\frac{m^2_{sunlit}}{m^2_{ground}}$	65 to 110 min	10018.7542 m	Sunlit green leaf area per unit ground area
Precision of Leaf Area Index (Dlai)	$\frac{m^2_{plant}}{m^2_{gound}}$	65 to 110 min	10018.7542 m	Retrieval dispersion of LAI
Directional Area Scattering Factor (DASF)	none	65 to 110 min	10018.7542 m	Estimate of Canopy Bidirectional Reflectance Factor as if the foliage does not absorb radiation
Earth Reflector Type Index (ERTI)	none	65 to 110 min	10018.7542 m	Estimate of the recollision probability p transformed to the interval $[0°,180°]$ as $\text{atan}(p)$ if $\text{atan}\, p \geq 0$ and $\text{atan}(p) + 180°$ otherwise.
Scattering coefficient at 443 nm	none	65 to 110 min	10018.7542 m	Estimate of the fraction of intercepted radiation that has been reflected from, or diffusively transmitted through, the vegetation at 443 nm.
Scattering coefficient at 551 nm	none	65 to 110 min	10018.7542 m	... at 551 nm
Scattering coefficient at 680 nm	none	65 to 110 min	10018.7542 m	... at 680 nm
Scattering coefficient at 780 nm	none	65 to 110 min	10018.7542 m	... at 780 nm
Quality Assessment variable	none	65 to 110 min	10018.7542 m	Overall quality of the VESDR parameters and 'Status_QA' copied from DSCOVR EPIC L2 MAIAC (version 2)
Aerosol Optical Depth at 443 nm	none	65 to 110 min	10018.7542 m	AOD at 443 nm copied from upstream DSCOVR EPIC L2 MAIAC (version 2) product
Aerosol Optical Depth at 551 nm	none	65 to 110 min	10018.7542 m	AOD at 443 nm copied from upstream DSCOVR EPIC L2 MAIAC (version 2) product
Cloud Mask and Land- Water Mask	none	65 to 110 min	10018.7542 m	Cloud mask and Land-Water mask copied from upstream DSCOVR EPIC L2 MAIAC (version 2) product

Y. Knyazikhin, DSCOVR EPIC VESDR product documentation



National Aeronautics and Space Administration
Goddard Space Flight Center

Keywords

CEOS Working Group on Calibration and Validation

Land Product Validation Subgroup

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LPV Focus Areas

- LAI
- Fapar
- Fire/Burn Area
- Phenology
- Vegetation Index
- Land Cover
- Snow Cover
- BRDF/Albedo
- Soil Moisture
- LST and Emissivity
- Biomass

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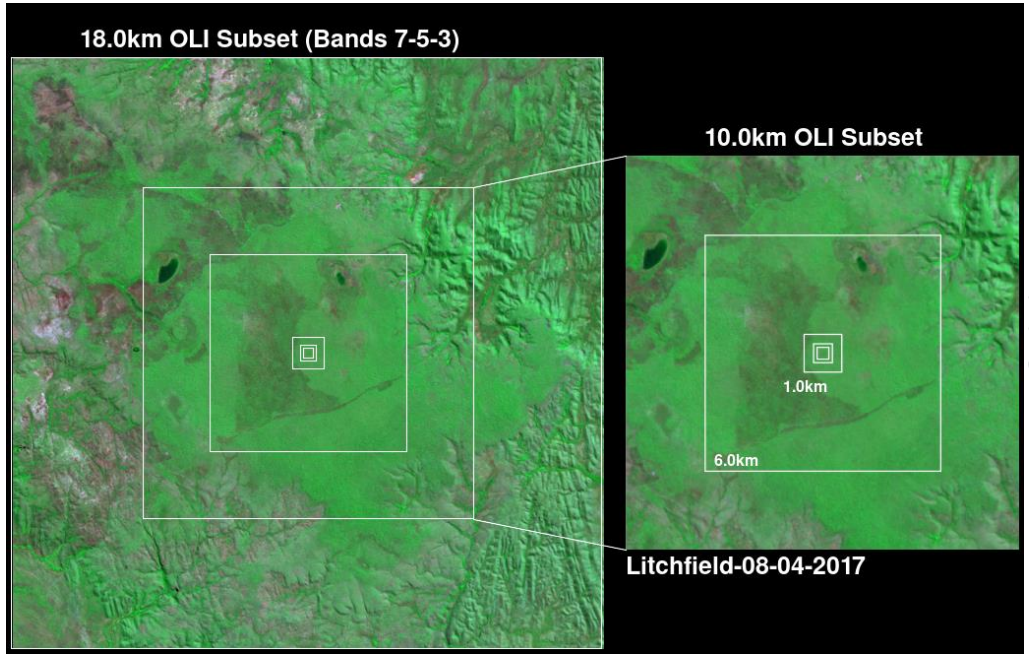
The mission of the CEOS Land Product Validation (LPV) subgroup is to coordinate the quantitative validation of satellite-derived products. The focus lies on standardized intercomparison and validation across products from different satellite, algorithms, and agency sources.

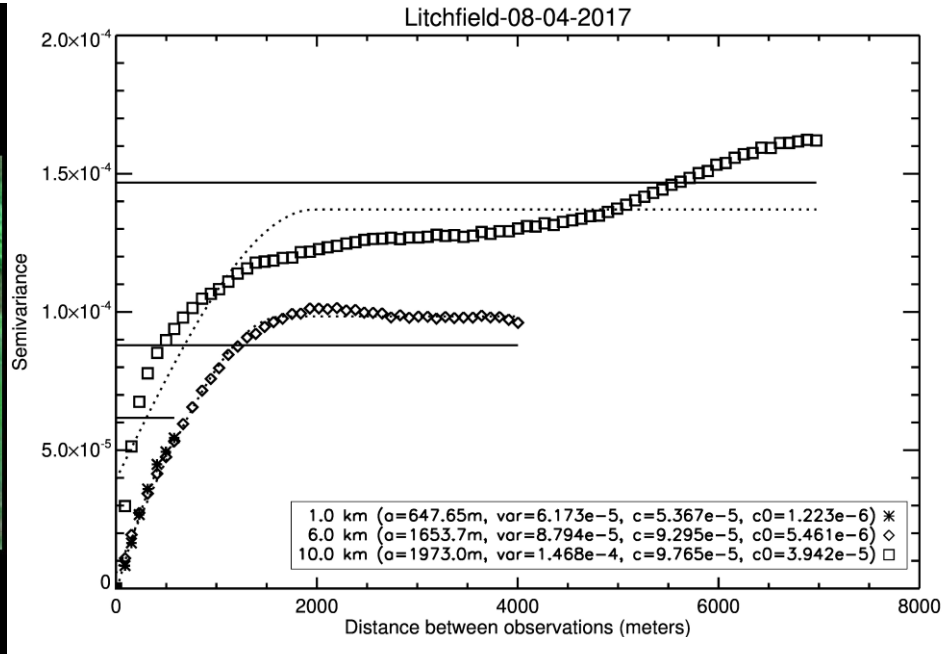
The sub-group consists of 11 Focus Areas, with 2 co-leads responsible for each land surface variable (essential climate and biodiversity variables).

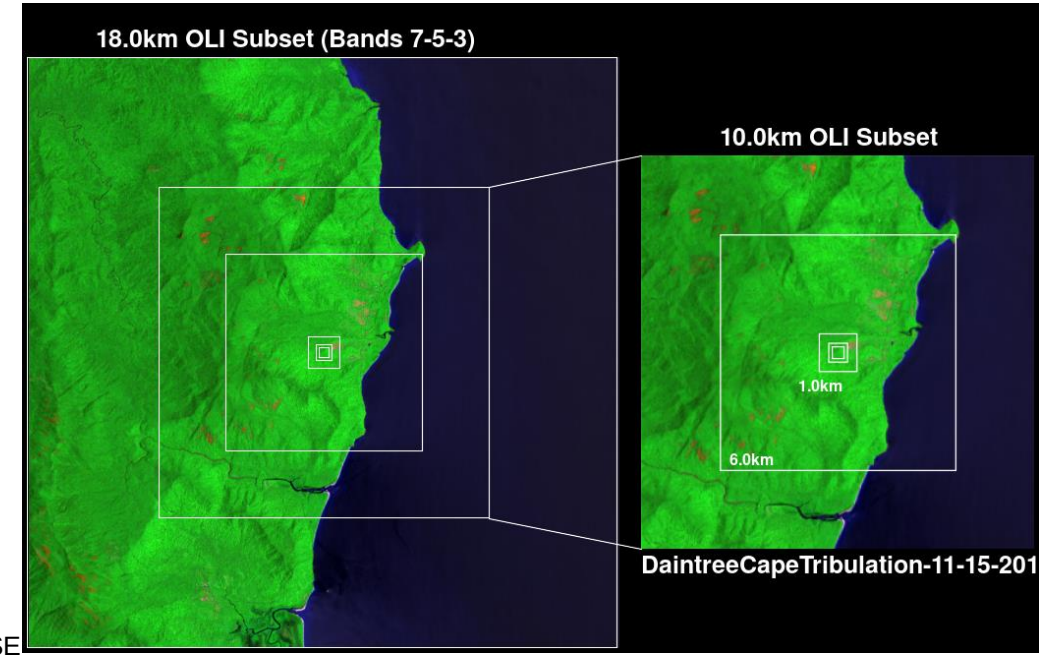
CEOS VALIDATION HIERARCHY

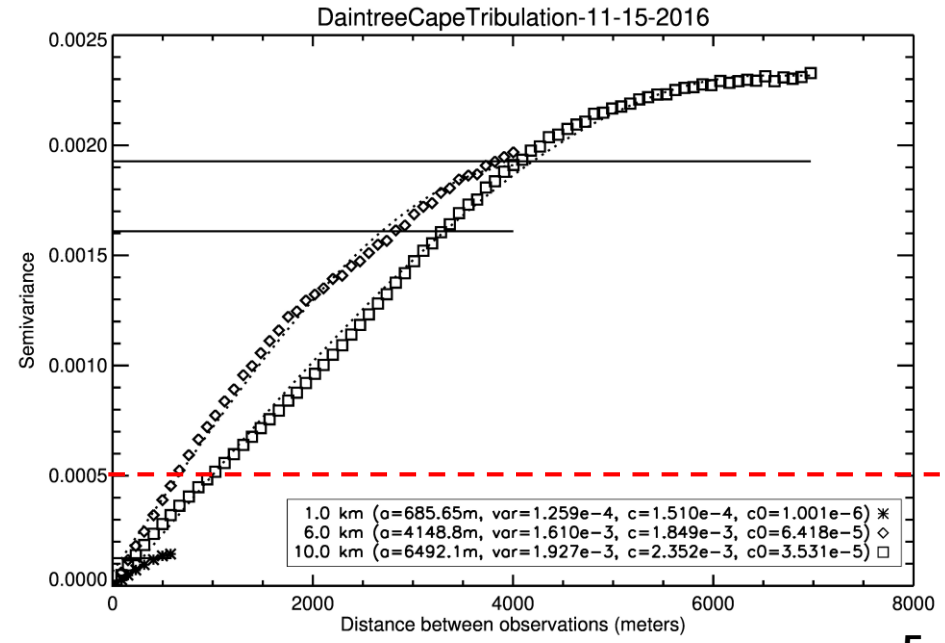
	Validation Stage - Definition and Current State	Variable
0	No validation. Product accuracy has not been assessed. Product considered beta.	
1	Product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with in-situ or other suitable reference data.	Snow Fire Radiative Power
2	Product accuracy is estimated over a significant set of locations and time periods by comparison with reference in situ or other suitable reference data. Spatial and temporal consistency of the product and consistency with similar products has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.	Fapar Phenology Burned Area Land Cover LAI
3	Uncertainties in the product and its associated structure are well quantified from comparison with reference in situ or other suitable reference data. Uncertainties are characterized in a statistically rigorous way over multiple locations and time periods representing global conditions. Spatial and temporal consistency of the product and with similar products has been evaluated over globally representative locations and periods. Results are published in the peer-reviewed literature.	Vegetation Indicies Albedo Soil Moisture LST & EmissiSvity Phenology
4	Validation results for stage 3 are systematically updated when new product versions are released and as the time-series expands.	Active Fire

Spatial representativeness



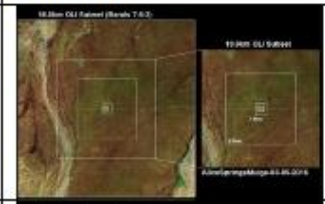
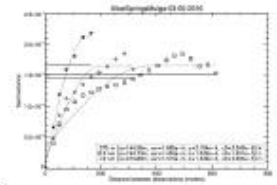
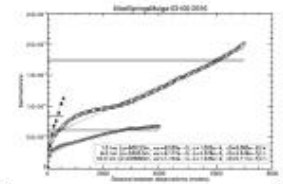
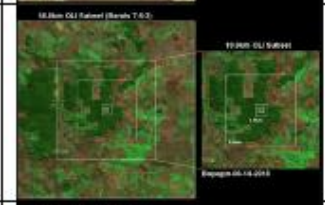
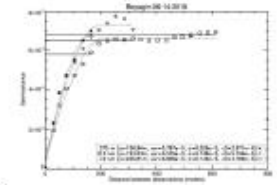
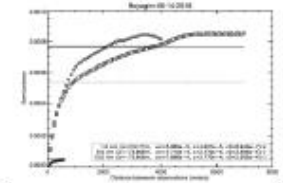
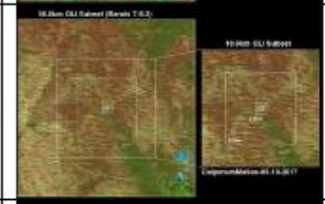
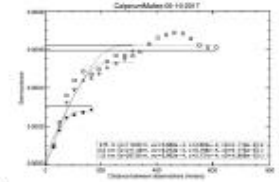
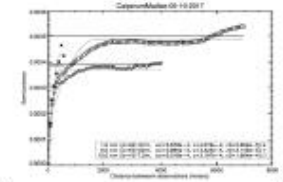
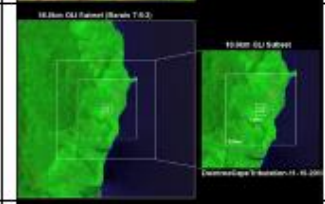
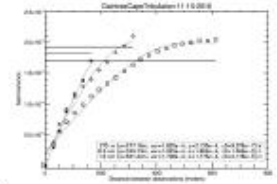
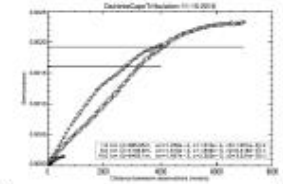
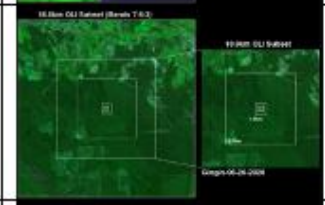
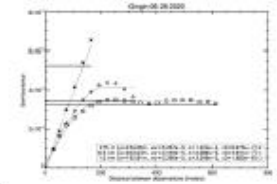
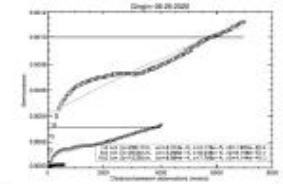
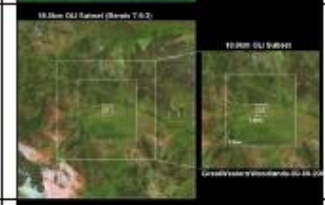
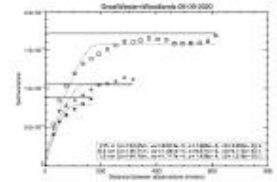
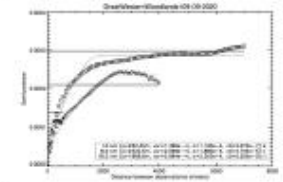
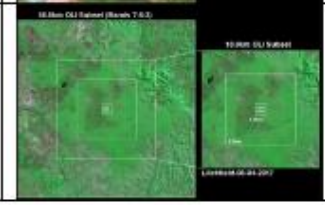
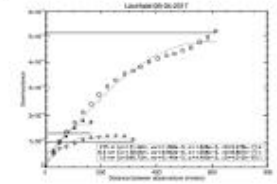
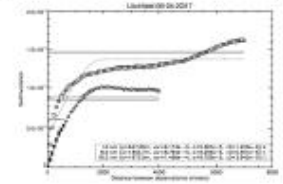


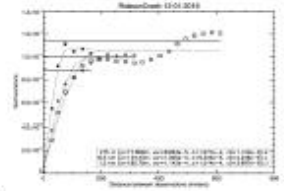
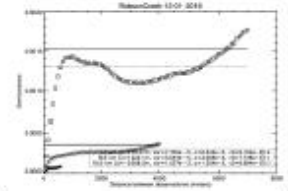
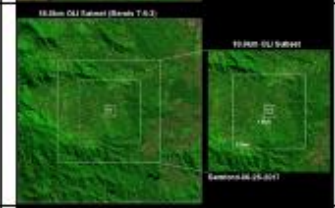
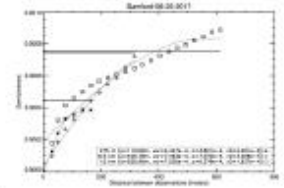
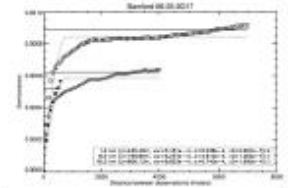
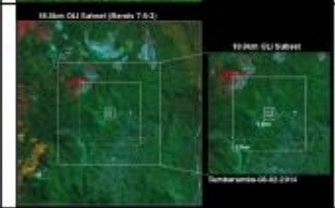
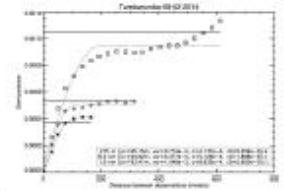
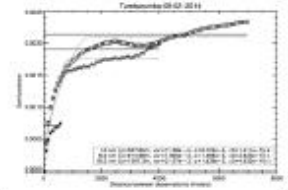
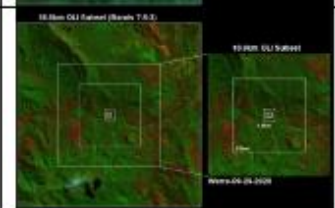
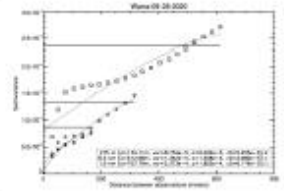
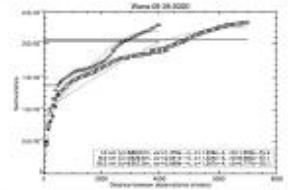
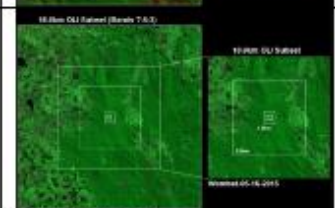
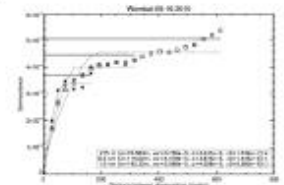
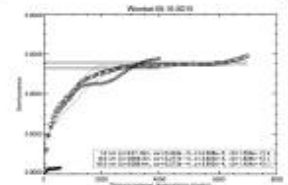
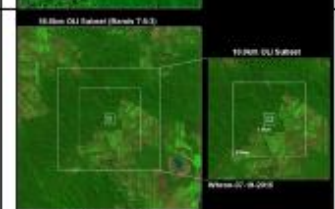
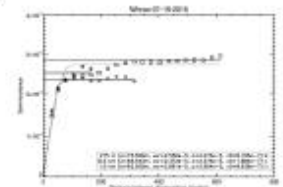
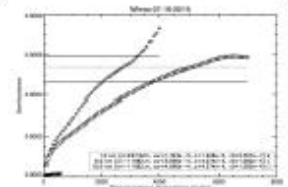




$$\gamma_E(h) = 0.5 \cdot \frac{\sum_{i=1}^{N(h)} \left(z_{xi} - z_{xi+h}\right)^2}{N(h)}$$

Román et al. 2009 RSE; Wang et al. 2017 RSE

Site name	Latitude	Longitude	Date (YYYYMMDD)	Subsets-30m	Variogram- 30m res	Variogram- 90m res	Semivariance (Sill)		Assessment
Alice Springs Mulga	-22.2828	133.2493	20160308				C_{30} 0.275m		Model Not Fit
							C_{30} 0.5m		Model Not Fit
							C_{30} 1.0km	0.000133	Representative
							C_{90} 1.0km		Model Not Fit
							C_{90} 6.0km	0.000044	Representative
							C_{90} 10.0km		Model Not Fit
Boyagin	-32.4771	116.9386	20180706				C_{30} 0.275m		Model Not Fit
							C_{30} 0.5m	6.74E-05	Representative
							C_{30} 1.0km	6.15E-05	Representative
							C_{90} 1.0km	4.01E-05	Representative
							C_{90} 6.0km	0.00028	Representative
							C_{90} 10.0km	0.00028	Representative
Calperum Mallee	-34.0027	140.5877	20170502				C_{30} 0.275m	0.00028	Representative
							C_{30} 0.5m		Model Not Fit
							C_{30} 1.0km	0.00057	Representative
							C_{90} 1.0km		Model Not Fit
							C_{90} 6.0km	0.00034	Representative
							C_{90} 10.0km	0.00032	Representative
Daintree Cape Tribulation	-16.1056	145.447	20151124				C_{30} 0.275m		Model Not Fit
							C_{30} 0.5m		Model Not Fit
							C_{30} 1.0km		Model Not Fit
							C_{90} 1.0km		Model Not Fit
							C_{90} 6.0km		Model Not Fit
							C_{90} 10.0km		Model Not Fit
Gingin	-31.3764	115.7139	20200709				C_{30} 0.275m		Model Not Fit
							C_{30} 0.5m	4.09E-05	Representative
							C_{30} 1.0km	3.27E-05	Representative
							C_{90} 1.0km	2.18E-05	Representative
							C_{90} 6.0km		Model Not Fit
							C_{90} 10.0km		Model Not Fit
Great Western Woodlands	-30.1913	120.6541	20200916				C_{30} 0.275m	7.66E-05	Representative
							C_{30} 0.5m	9.57E-05	Representative
							C_{30} 1.0km	0.00014	Representative
							C_{90} 1.0km	0.00012	Representative
							C_{90} 6.0km	0.00019	Representative
							C_{90} 10.0km	0.00023	Representative
Litchfield	-13.179	130.7945	20170804				C_{30} 0.275m	1.63E-05	Representative
							C_{30} 0.5m	1.06E-05	Representative
							C_{30} 1.0km		Model not fit
							C_{90} 1.0km		Model not fit
							C_{90} 6.0km	9.3E-05	Representative
							C_{90} 10.0km	9.77E-05	Representative

Robson Creek	-17.1175	145.6301	20170106				C_{30} 0.275m	0.00011	Representative
							C_{30} 0.5m	9.35E-05	Representative
							C_{30} 1.0km	0.00010	Representative
							C_{90} 1.0km	6.54E-05	Representative
							C_{90} 6.0km	0.00021	Representative
							C_{90} 10.0km	Only cloud contaminated imagery available	
Samford	-27.3881	152.8778	20170724				C_{30} 0.275m	0.00038	Representative
							C_{30} 0.5m		Model not fit
							C_{30} 1.0km		Model not fit
							C_{90} 1.0km		Model not fit
							C_{90} 6.0km	0.00046	Representative
							C_{90} 10.0km	0.00067	Representative
Tumbarumba	-35.6566	148.1517	20160822				C_{30} 0.275m	0.00041	Representative
							C_{30} 0.5m	0.00051	Representative
							C_{30} 1.0km	0.00089	Representative
							C_{90} 1.0km		Model not fit
							C_{90} 6.0km	0.00149	Sill > 0.001
							C_{90} 10.0km	0.00164	Sill > 0.001
Warra	-43.095	146.6545	20170822				C_{30} 0.275m		Model not fit
							C_{30} 0.5m		Model not fit
							C_{30} 1.0km		Model not fit
							C_{90} 1.0km		Model not fit
							C_{90} 6.0km		Model not fit
							C_{90} 10.0km		Model not fit
Wombat	-37.4222	144.0944	20150611				C_{30} 0.275m	3.45E-05	Representative
							C_{30} 0.5m	3.88E-05	Representative
							C_{30} 1.0km	4.01E-05	Representative
							C_{90} 1.0km	2.51E-05	Representative
							C_{90} 6.0km	0.00036	Representative
							C_{90} 10.0km	0.00040	Representative
Whroo	-36.6732	145.0294	20160623				C_{30} 0.275m	2.47E-05	Representative
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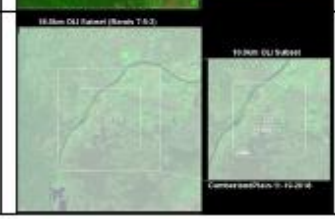
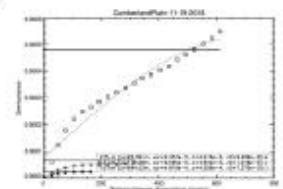
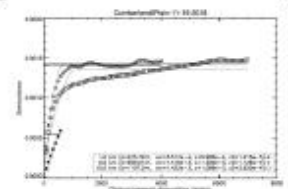
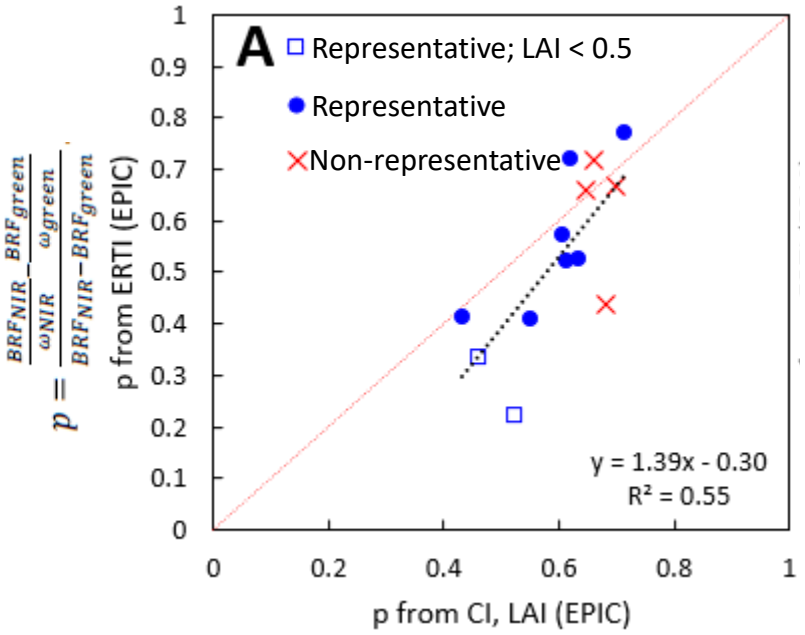
							C_{30} 1.0km	2.65E-05	Representative
							C_{90} 1.0km	1.23E-05	Representative
							C_{90} 6.0km		Model not fit
							C_{90} 10.0km		Model not fit
Cumberland Plain	-33.6152	150.7236	20181016				C_{30} 0.275m	2.22E-05	Representative
							C_{30} 0.5m	4.94E-05	Representative
							C_{30} 1.0km		Model not fit
							C_{90} 1.0km		Model not fit
							C_{90} 6.0km	0.0013	Sill > 0.001
							C_{90} 10.0km	0.00109	Sill > 0.001



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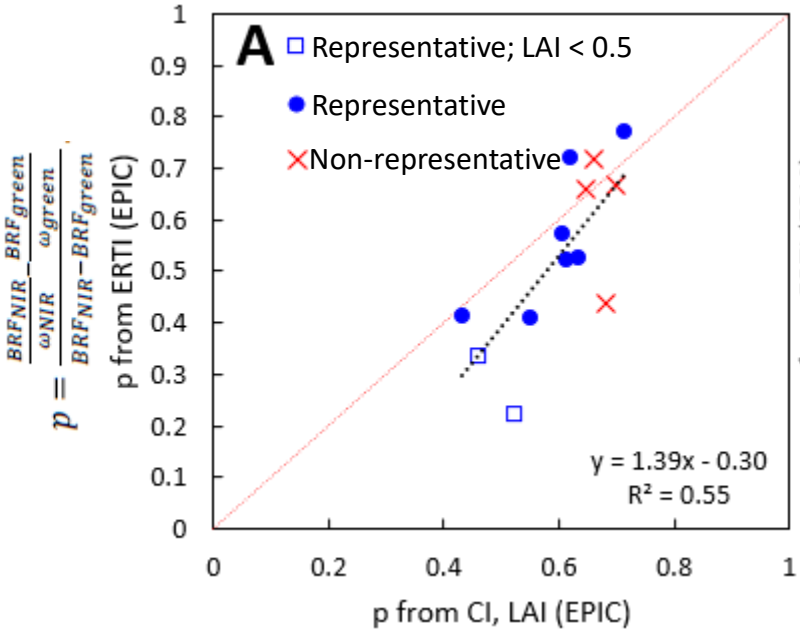
Pisek et al., RSE, submitted



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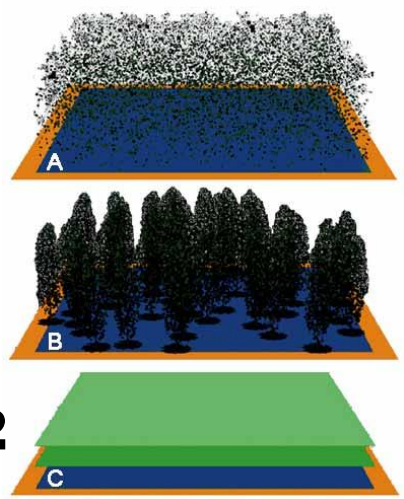
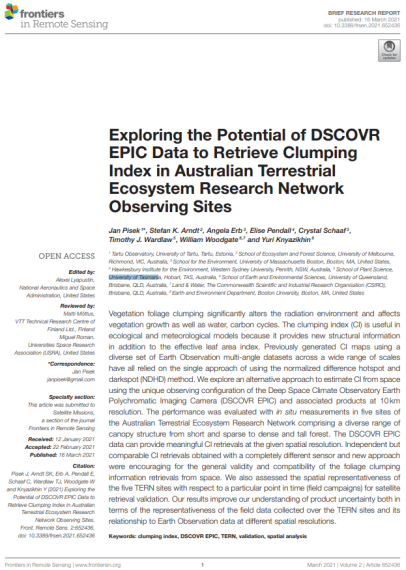
LAI=2





frontiers in Remote Sensing

BRIEF RESEARCH REPORT

Exploring the Potential of DSCOVR EPIC Data to Retrieve Clumping Index in Australian Terrestrial Ecosystem Research Network Observing Sites

Jan Pisek[1], Stefan K. Arndt[2], Angela Erb[3], Elise Pendall[4], Crystal Schaaf[5], Timothy J. Wardlaw[3], William Woodgate[6,7] and Yuri Knyazikhin[8]*

[1] Tartu Observatory, University of Tartu, Tartu, Estonia, [2] School of Ecosystem and Forest Science, University of Melbourne, Richmond, VIC, Australia, [3] School for the Environment, University of Massachusetts Boston, Boston, MA, United States, [4] Hawkesbury Institute for the Environment, Western Sydney University, Penrith, NSW, Australia, [5] School of Plant Science, University of Tasmania, Hobart, TAS, Australia, [6] School of Earth and Environmental Sciences, University of Queensland, Brisbane, QLD, Australia, [7] Land & Water, The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Brisbane, QLD, Australia, [8] Earth and Environment Department, Boston University, Boston, MA, United States

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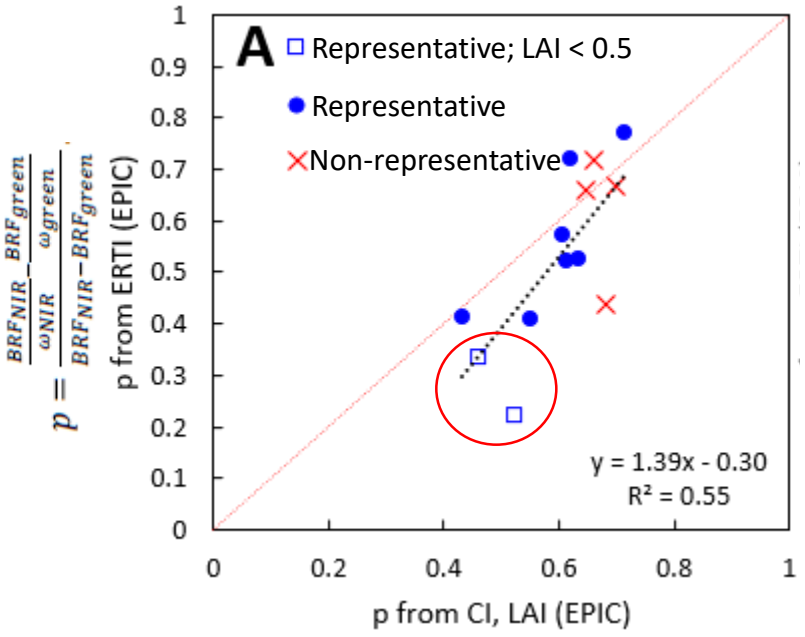
Vegetation foliage clumping significantly alters the radiation environment and affects vegetation growth as well as water, carbon cycles. The clumping index (CI) is useful in ecological and meteorological models because it provides new structural information in addition to the effective leaf area index. Previously generated CI maps using a diverse set of Earth Observation multi-angle datasets across a wide range of scales have all relied on the single approach of using the normalized difference hotspot and darkspot (NDHD) method. We explore an alternative approach to estimate CI from space using the unique observing configuration of the Deep Space Climate Observatory Earth Polychromatic Imaging Camera (DSCOVR EPIC) and associated products at 10 km resolution. The performance was evaluated with *in situ* measurements in five sites of the Australian Terrestrial Ecosystem Research Network comprising a diverse range of canopy structure from short and sparse to dense and tall forest. The DSCOVR EPIC data can provide meaningful CI retrievals at the given spatial resolution. Independent but comparable CI retrievals obtained with a completely different sensor and new approach were encouraging for the general validity and compatibility of the foliage clumping information retrievals from space. We also assessed the spatial representativeness of the five TERN sites with respect to a particular point in time (field campaigns) for satellite retrieval validation. Our results improve our understanding of product uncertainty both in terms of the representativeness of the field data collected over the TERN sites and its relationship to Earth Observation data at different spatial resolutions.

Keywords: clumping index, DSCOVR EPIC, TERN, validation, spatial analysis

Pisek et al., RSE, submitted



$$p = \frac{\frac{BRF_{NIR}}{\omega_{NIR}} - \frac{BRF_{green}}{\omega_{green}}}{BRF_{NIR} - BRF_{green}}$$

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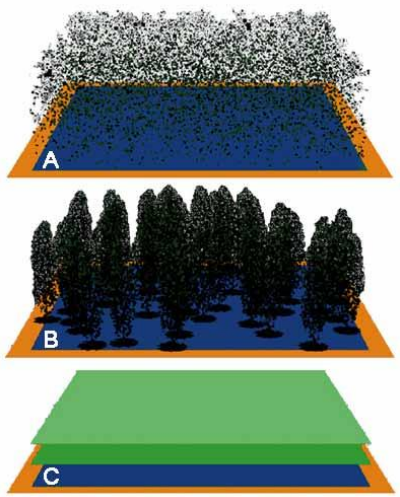

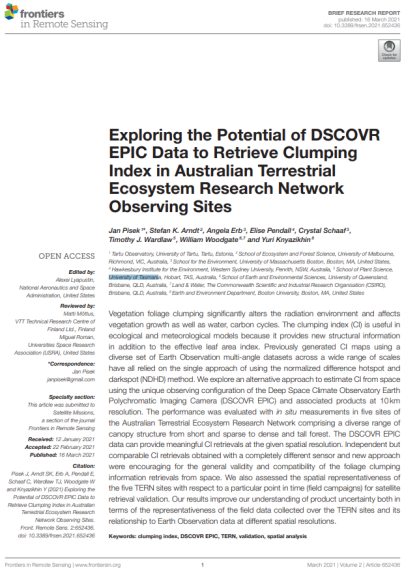

frontiers in Remote Sensing

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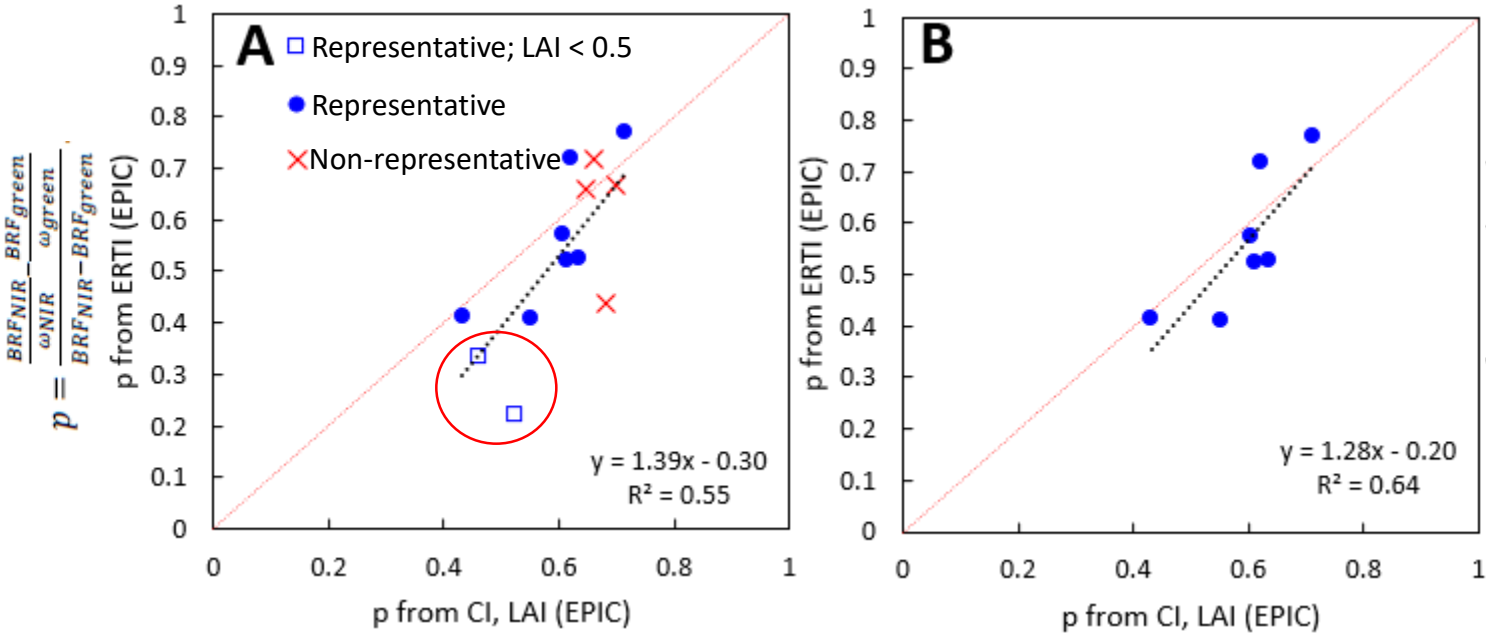

$$p = 1 - (1 - \exp[-G(\theta)CI\ LAI_{true}/\cos\theta])/LAI_{true}$$

Pisek et al., RSE, submitted

In situ data **digital cover photography (DCP)** **digital hemispherical photography (DHP)**

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Region Types and Regions
Description of region types and regions

Sites, Plots, and Site Visit Ids (1)
Sites, plots and site visits

Sites Clear
Alice Springs Mulga ×

Plots
Select plot

Image Types and Camera Types (1)
Site image types and camera types used

Image Types Clear
Leaf Area Index ×

Method Clear
dcp ×

Camera Types
Select camera type

Date Range

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Page Size: 25 | « ‹ 12 › » | Sort by: **Image Creation Date** Ascending


Alice Springs Mulga
Leaf Area Index
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Alice Springs Mulga
Leaf Area Index
2014-08-08T10:04:40


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Feedback


Boyagin
Leaf Area Index
2018-02-22T18:07:18


Boyagin
Leaf Area Index
2018-02-22T18:11:00


Boyagin

https://ecoimages.tern.org.au/

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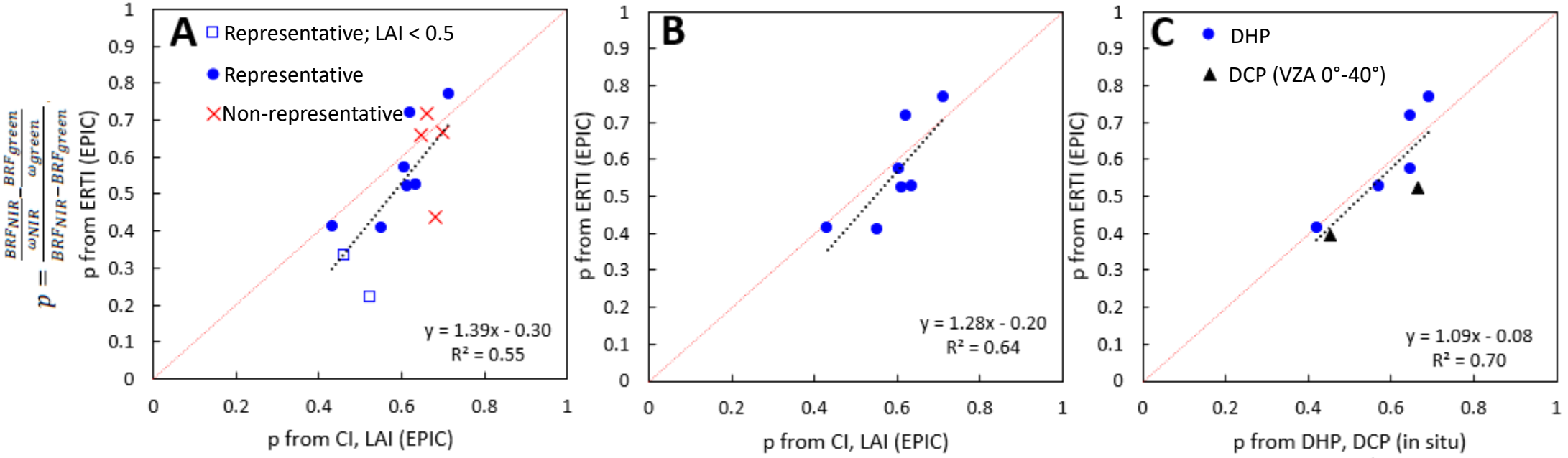

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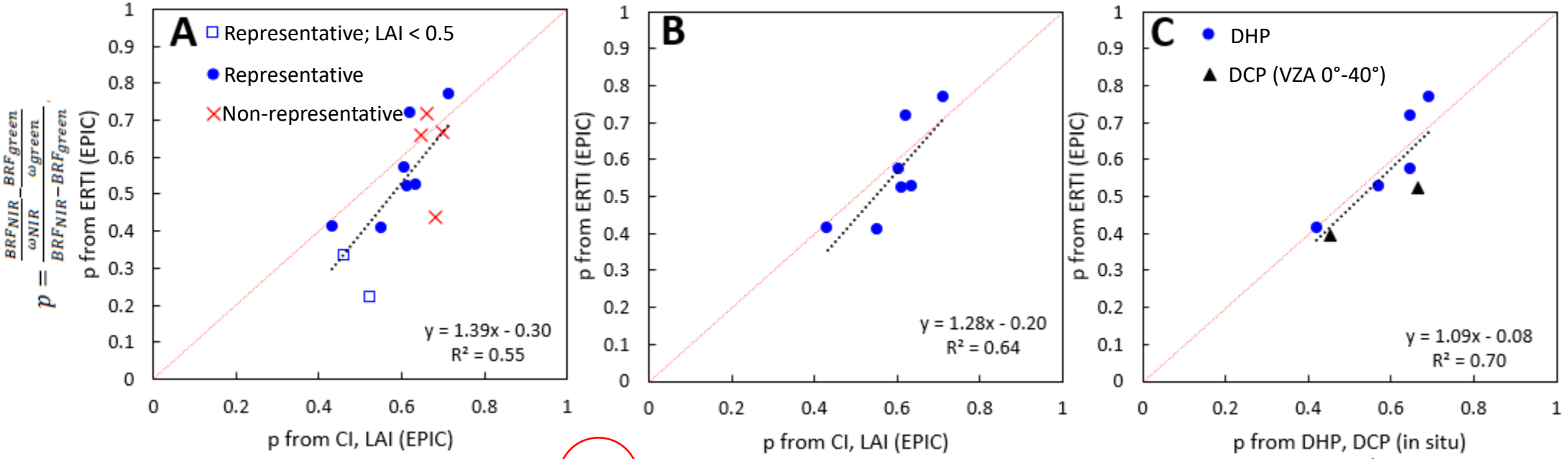

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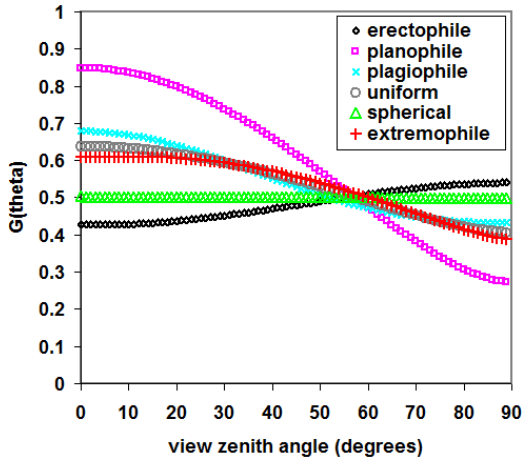
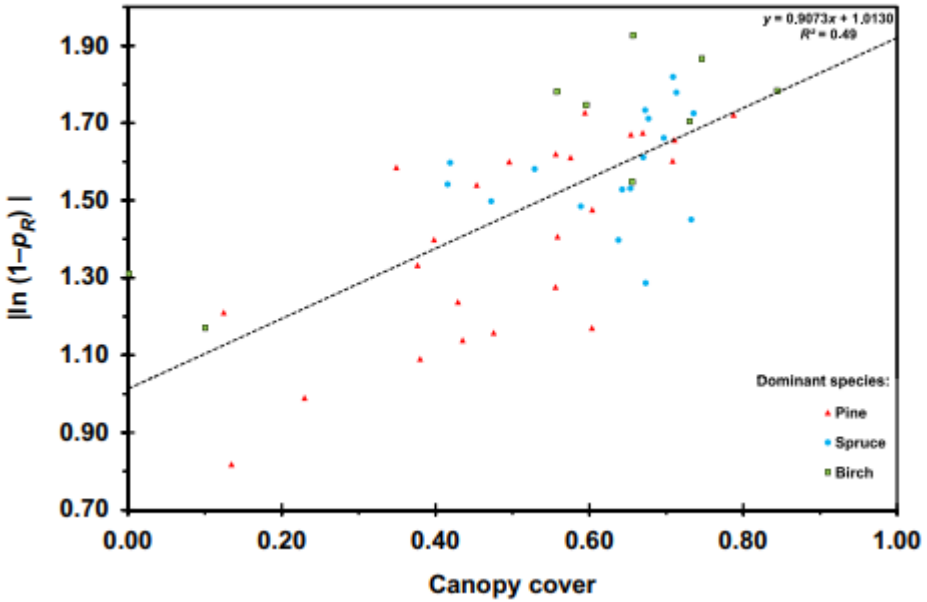
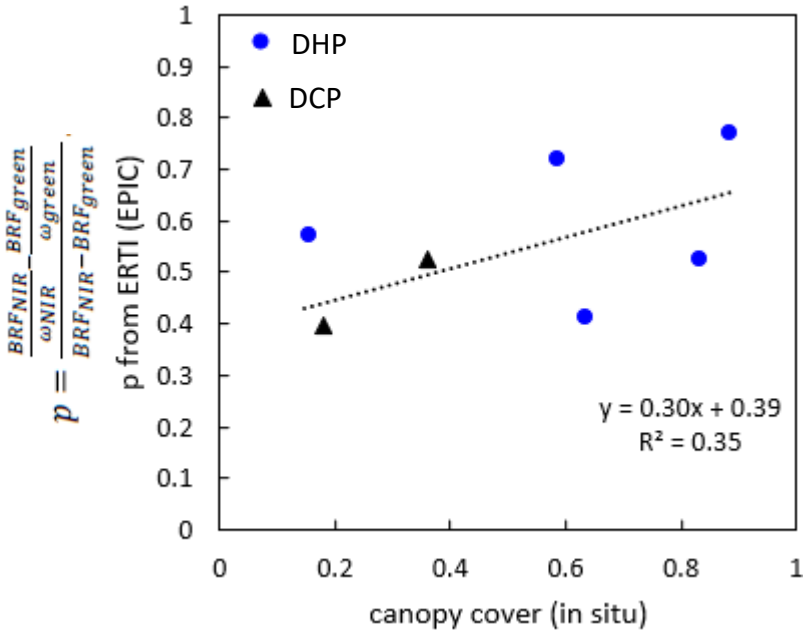


Pisek et al., RSE, submitted

Relationships between p and canopy structure

K.M. Vanhatalo et al. / Journal of Quantitative Spectroscopy & Radiative Transfer 133 (2014) 482–488





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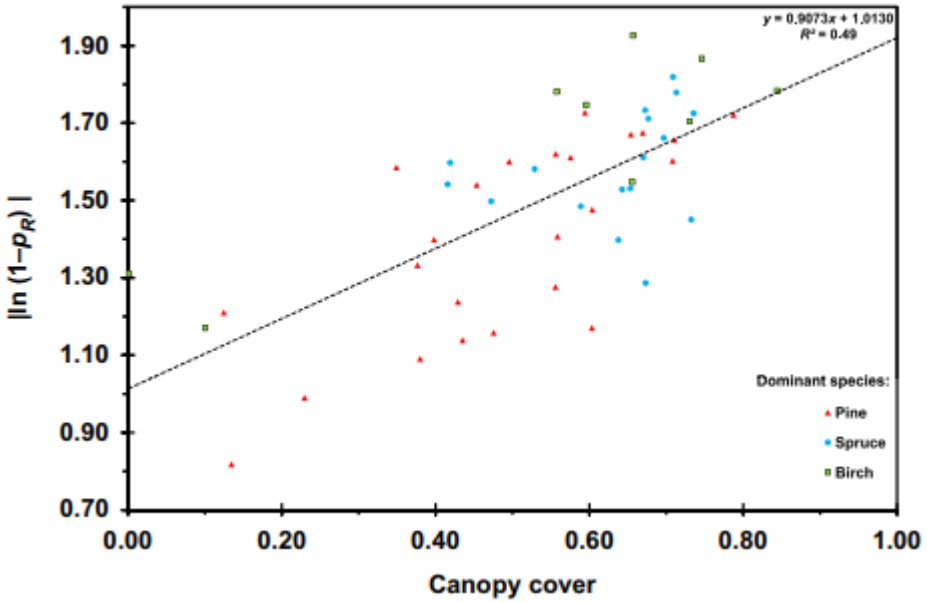

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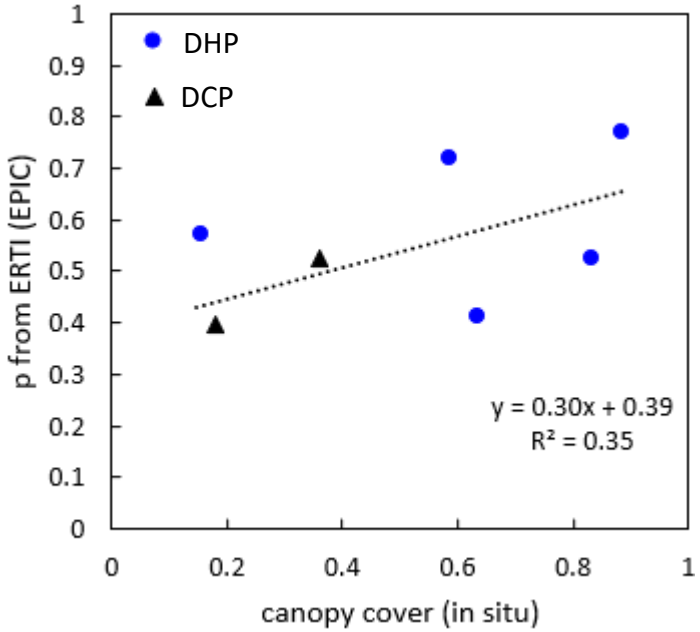
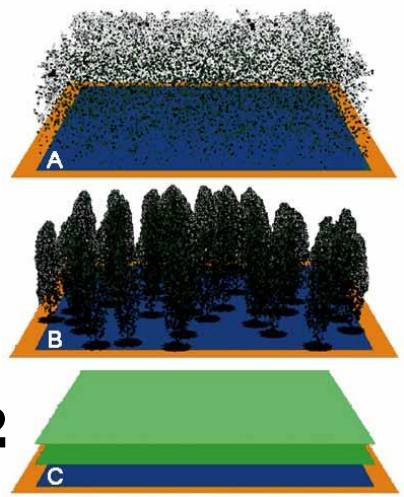
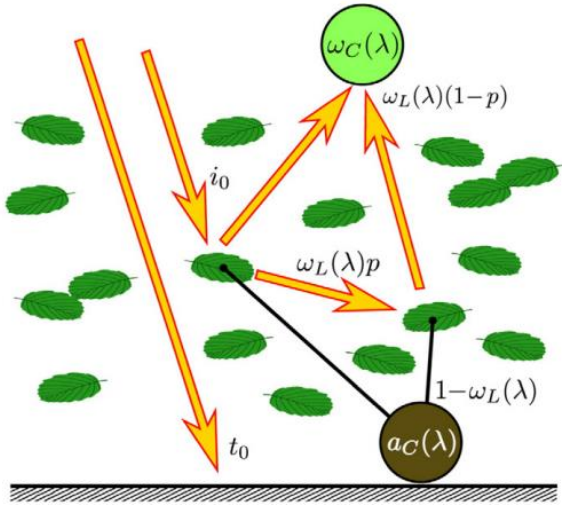


CI = 1

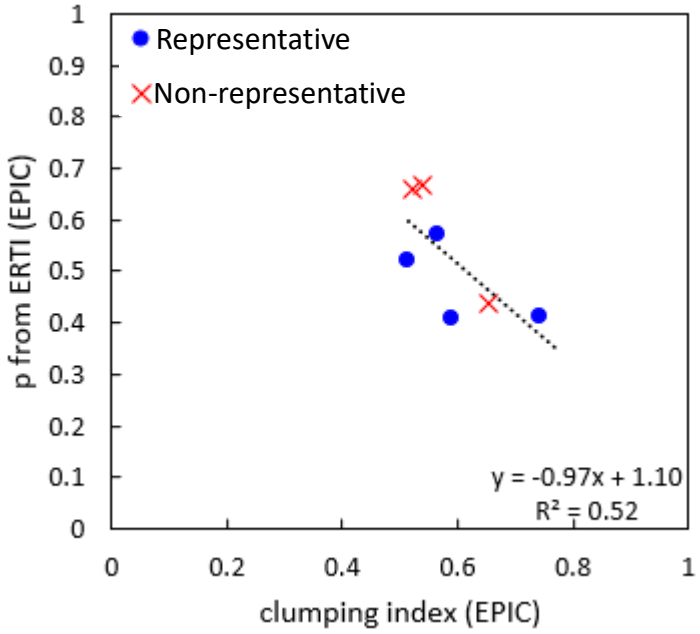
CI < 1

LAI=2





Stenberg et al., 2016, RSE



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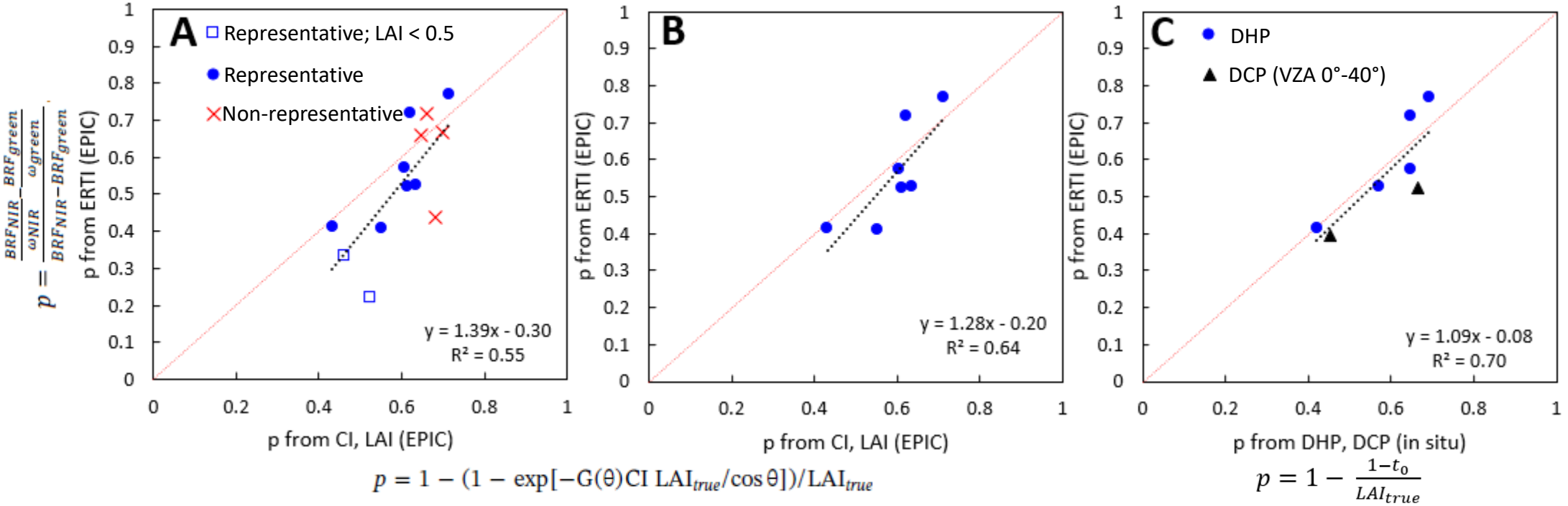

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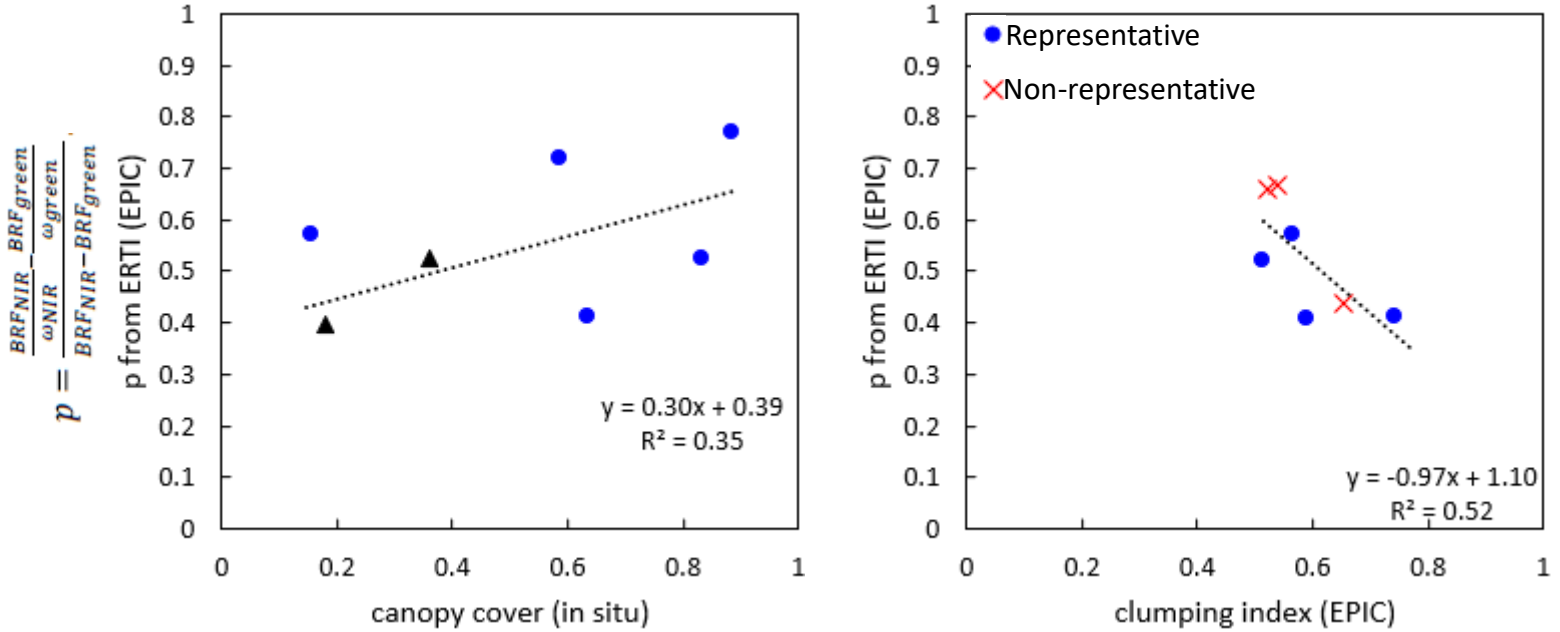


Pisek et al., RSE, submitted

Estimating clumping index with DSCOVR EPIC

1

sunlit leaf area index

$$SF = \frac{SLAI}{LAI} \rightarrow SF = \frac{1 - \exp(-\tau)}{\tau}$$

leaf area index

sunlit fraction

2

Solve for τ
(Yang et al., 2017, RSE)

optical path through the vegetation layer

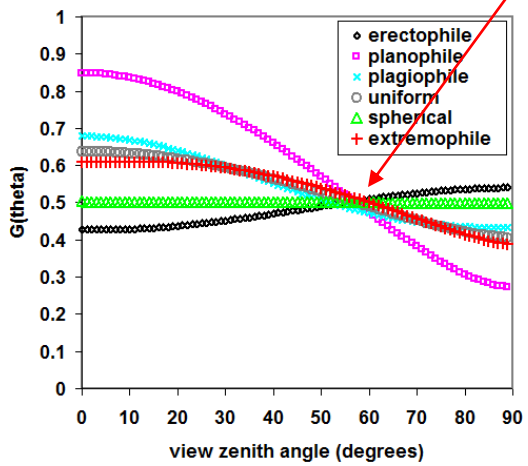
view zenith angle

3

$$CI(\theta) = \frac{\tau(\theta) \cdot \cos\theta}{G(\theta) \cdot LAI}$$

0.5

leaf area index



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Exploring the Potential of DSCOVR EPIC Data to Retrieve Clumping Index in Australian Terrestrial Ecosystem Research Network Observing Sites

Jan Pisek[1], Stefan K. Arndt[2], Angela Erb[3], Elise Pendall[4], Crystal Schaaf[3], Timothy J. Wardlaw[5], William Woodgate[6,7] and Yuri Knyazikhin[8]*

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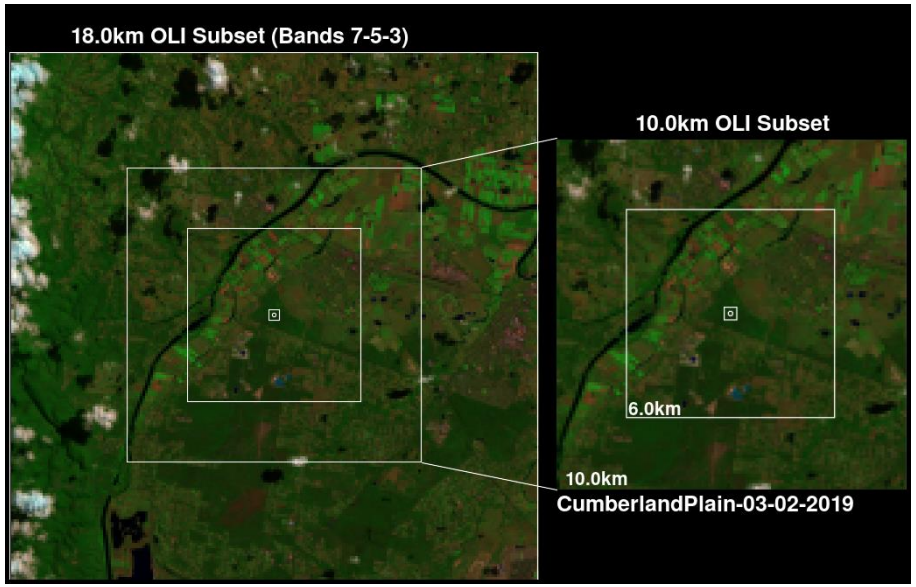
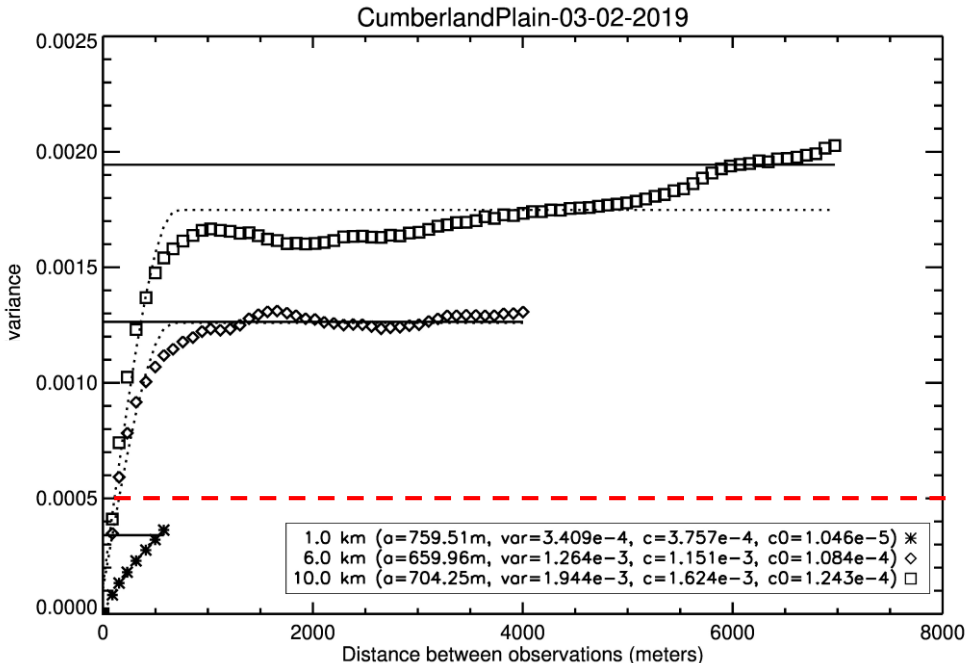
Vegetation foliage clumping significantly alters the radiation environment and affects vegetation growth as well as water, carbon cycles. The clumping index (CI) is useful in ecological and meteorological models because it provides new structural information in addition to the effective leaf area index. Previously generated CI maps using a diverse set of Earth Observation multi-angle datasets across a wide range of scales have all relied on the single approach of using the normalized difference hotspot and darkspot (NDHD) method. We explore an alternative approach to estimate CI from space using the unique observing configuration of the Deep Space Climate Observatory Earth Polychromatic Imaging Camera (DSCOVR EPIC) and associated products at 10 km resolution. The performance was evaluated with *in situ* measurements in five sites of the Australian Terrestrial Ecosystem Research Network comprising a diverse range of canopy structure from short and sparse to dense and tall forest. The DSCOVR EPIC data can provide meaningful CI retrievals at the given spatial resolution. Independent but comparable CI retrievals obtained with a completely different sensor and new approach were encouraging for the general validity and compatibility of the foliage clumping information retrievals from space. We also assessed the spatial representativeness of the five TERN sites with respect to a particular point in time (field campaigns) for satellite retrieval validation. Our results improve our understanding of product uncertainty both in terms of the representativeness of the field data collected over the TERN sites and its relationship to Earth Observation data at different spatial resolutions.

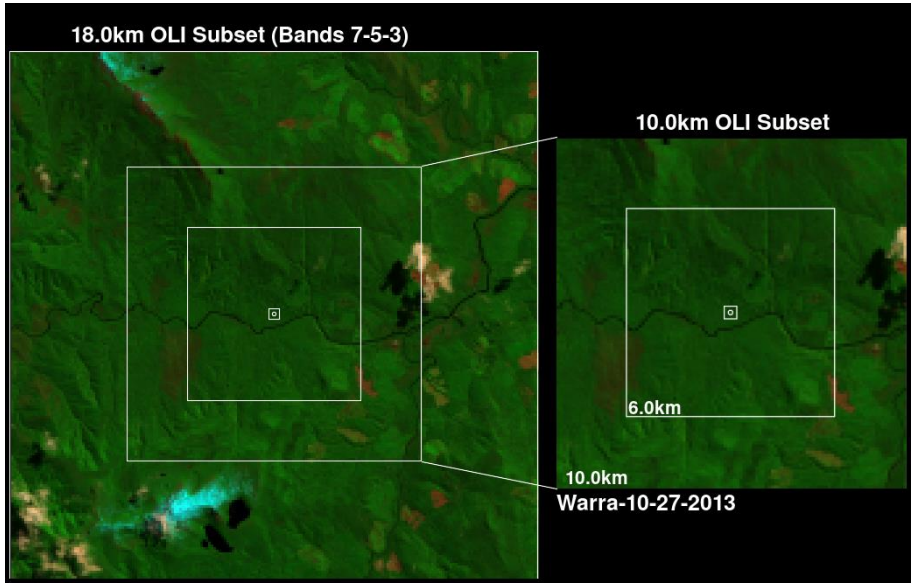
Keywords: clumping index, DSCOVR EPIC, TERN, validation, spatial analysis

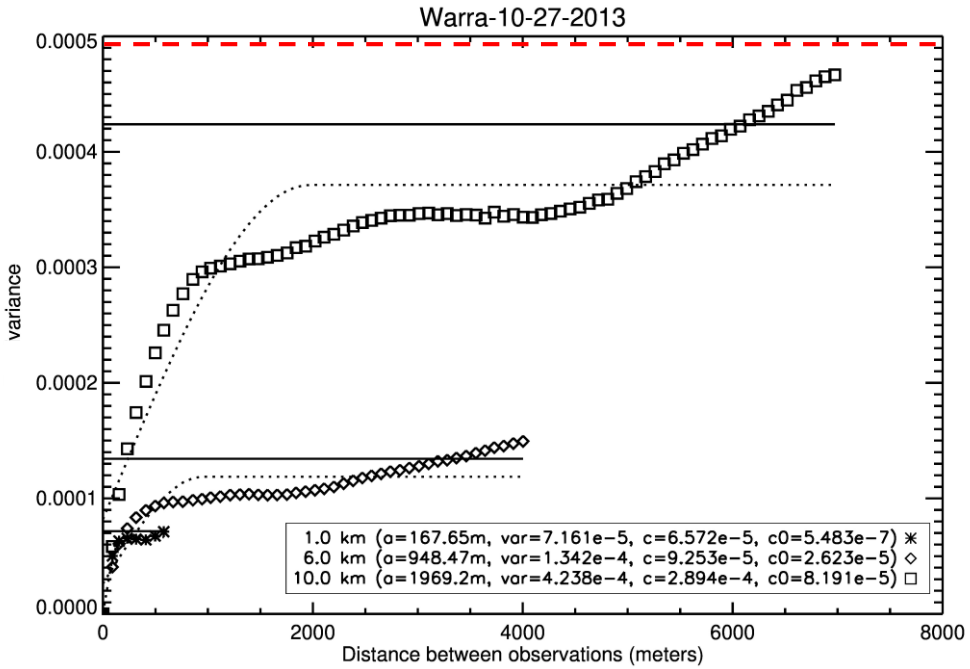
Y. Knyazikhin, DSCOVR EPIC VESDR product documentation

Spatial representativeness









$$\gamma_E(h) = 0.5 \cdot \frac{\sum_{i=1}^{N(h)} \left(z_{xi} - z_{xi+h}\right)^2}{N(h)}$$

Román et al. 2009 RSE; Wang et al. 2017 RSE