Exploring the potential of DSCOVR EPIC data to retrieve clumping index in Australian terrestrial ecosystem research network observing sites

Jan Pisek, Stefan K. Arndt, Angela Erb, Elise Pendall, Crystal Schaaf, Timothy J. Wardlaw, William Woodgate, Yuri Knyazikhin

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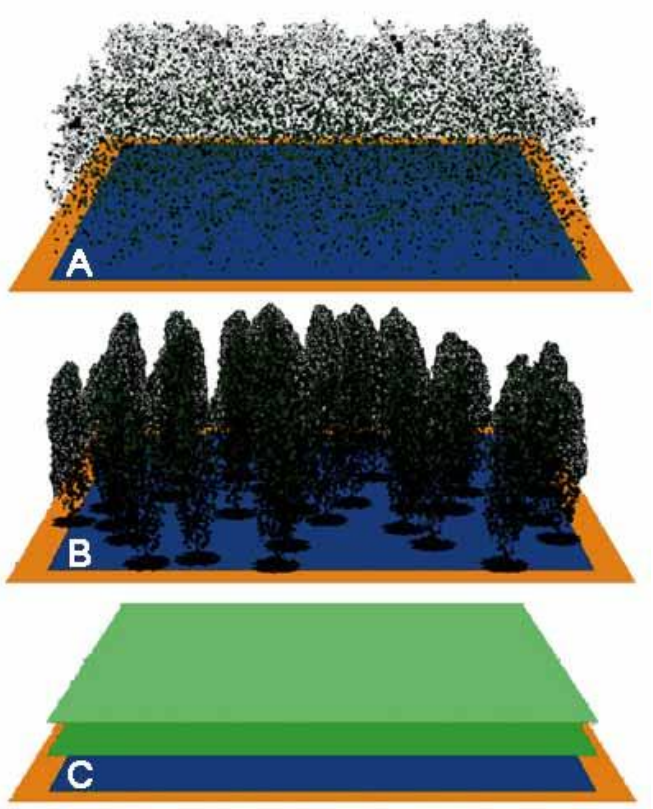

Images: Sylvain Leblanc

CI = 1

CI < 1

LAI=2
leaf area index

Affects
- **radiation interception and distribution within the canopy**
- **evapotranspiration**
- **plant growth**
- **carbon cycle**

Captures the ecological importance of existing canopy architectural difference of various vegetation types

Estimating clumping index with DSCOVR EPIC

optical path through the vegetation layer

view zenith angle

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

leaf projection function

leaf area index

Y. Knyazikhin, DSCOVR EPIC VESDR product documentation

Estimating clumping index with DSCOVR EPIC

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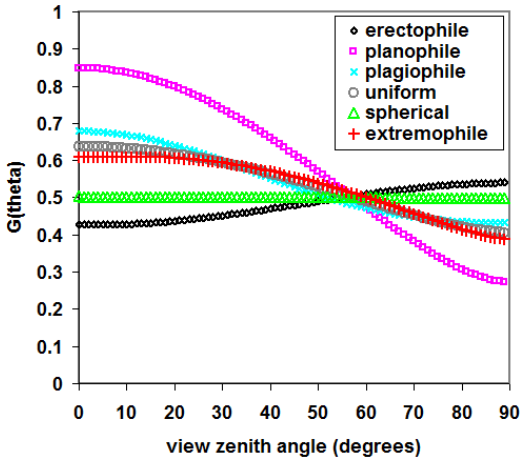
Photo: Andres Kuusk



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Estimating clumping index with DSCOVR EPIC

optical path through the vegetation layer

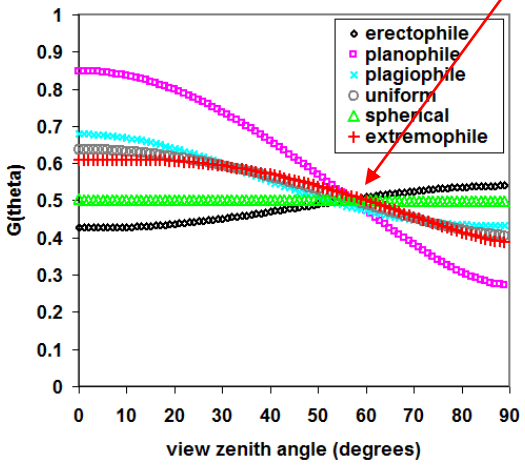
view zenith angle

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

0.5

leaf area index

Photo: Andres Kuusk



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Estimating clumping index with DSCOVR EPIC

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

sunlit fraction

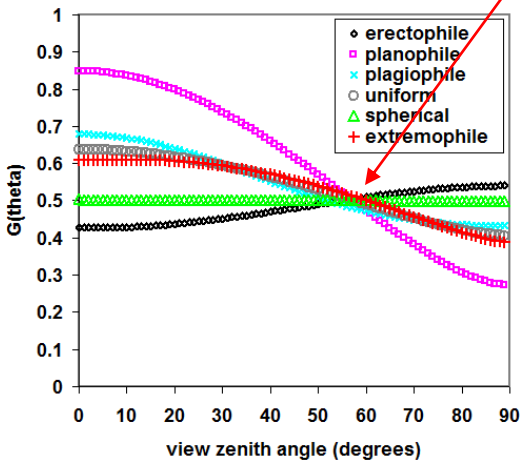
optical path through the vegetation layer

view zenith angle

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

0.5

leaf area index



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Estimating clumping index with DSCOVR EPIC

sunlit leaf area index

$$SF = \frac{SLAI}{LAI}$$

leaf area index

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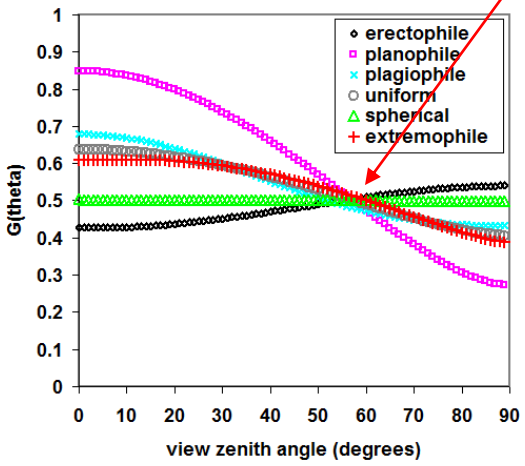

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Estimating clumping index with DSCOVR EPIC

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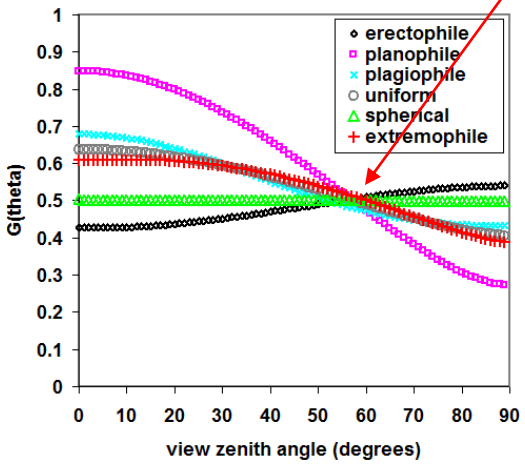

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Estimating clumping index with DSCOVR EPIC

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$$SF = \frac{SLAI}{LAI}$$

leaf area index

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

sunlit fraction

2

Solve for τ
(Yang et al., 2017, RSE)

optical path through the vegetation layer

view zenith angle

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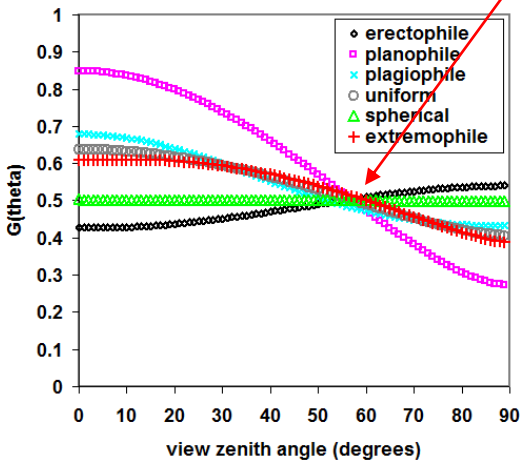
0.5

leaf area index



Y. Knyazikhin, DSCOVR EPIC VESDR product documentation

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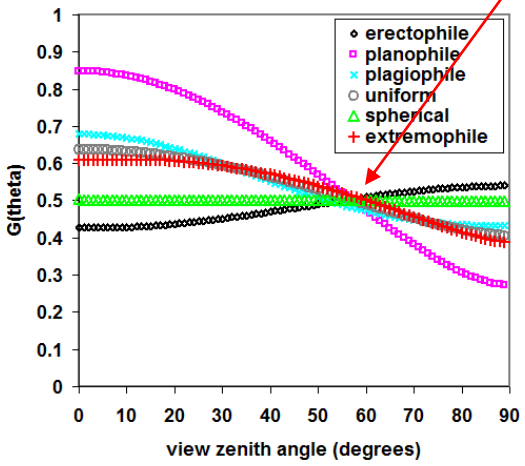

Y. Knyazikhin, DSCOVR EPIC VESDR product documentation

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.

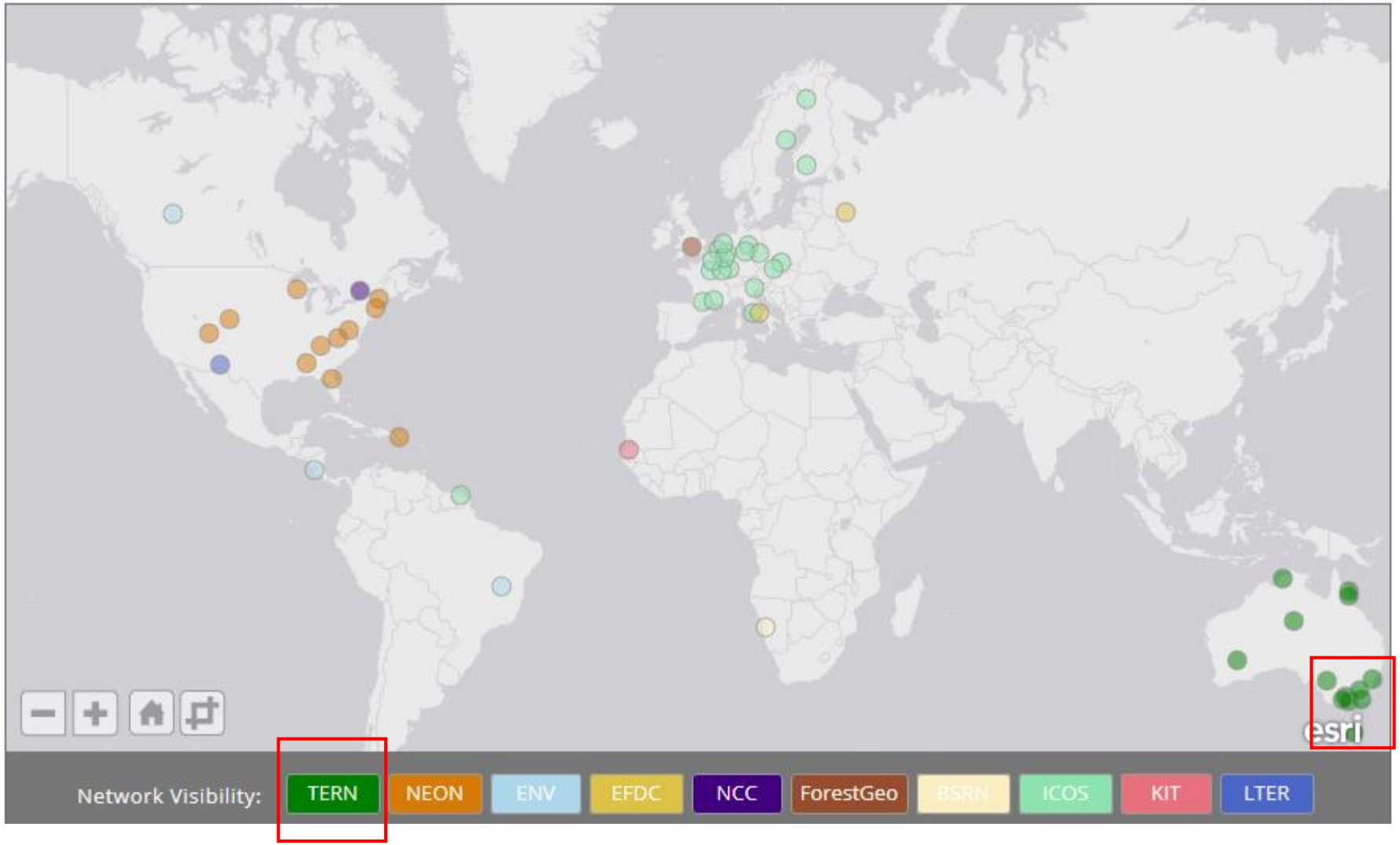
The sub-group consists of 11 Focus Areas, with 2 co-leads responsible for each land surface variable (essential climate and biodiversity variables).

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

https://lpvs.gsfc.nasa.gov/index.html

LPV Supersites

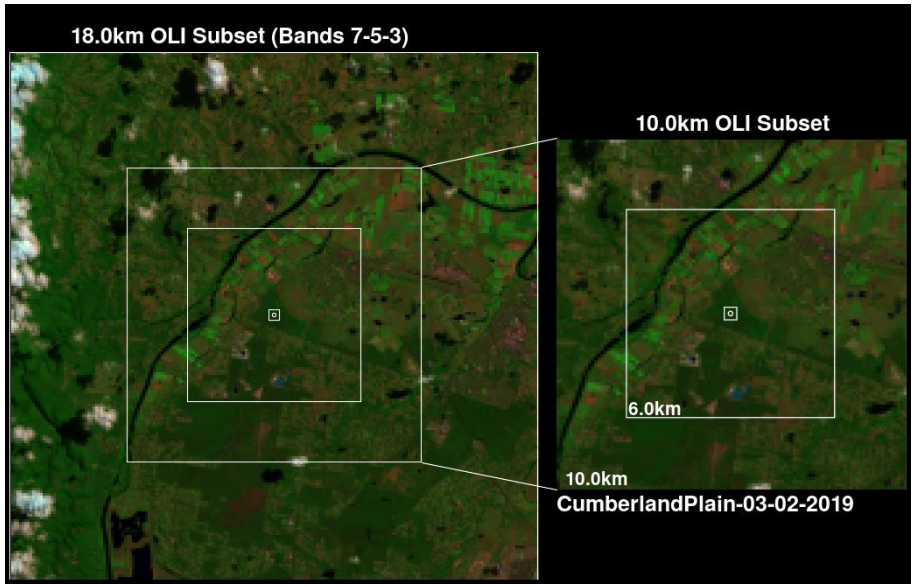


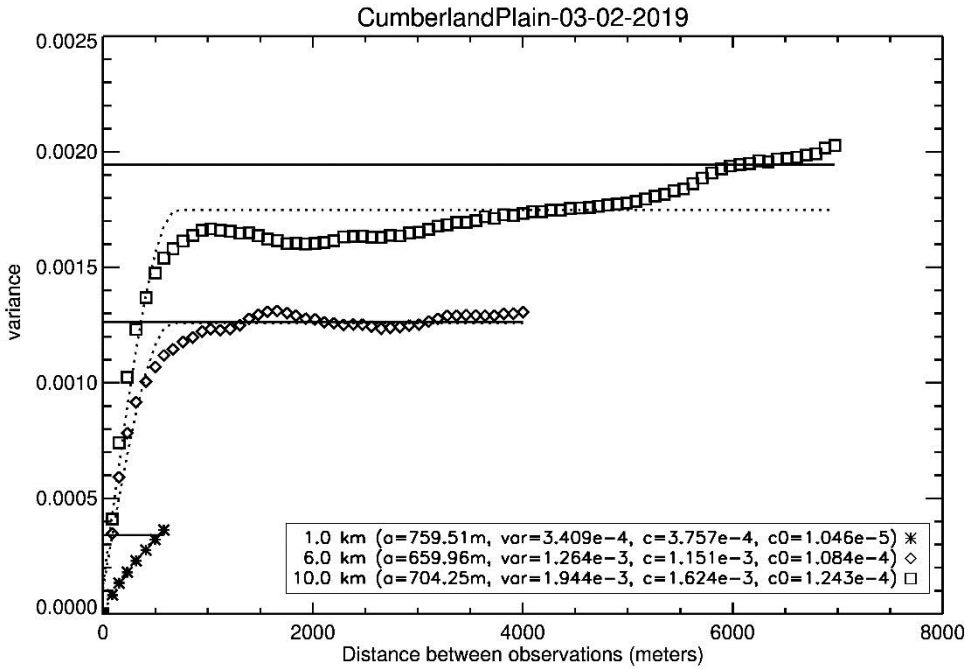
https://lpvs.gsfc.nasa.gov/LPV_Supersites/LPVsites.html

Site code	Site name	Lat (deg)	Lon (deg)	Forest type	Overstory	Tree height (m)	LAI	References
CBLP	Cumberland plain	−33.62	150.72	Remnant eucalypt woodland	EMo, EF	23	1.20	Beringer et al., 2016
TUMB	Tumbarumba	−35.66	148.15	Managed open wet schlerophyll eucalyptus forest	EDe, EDa	40	2.4	Keith et al., 2009
VICD–Whroo	Whroo	−36.67	145.03	Box woodland	EMi, EL	15.3 ± 0.2	1.0	Beringer et al., 2016
VICD-Wombat	Wombat	−37.42	144.09	Open eucalypt woodland	EO, ERa, ERu	25	1.75	Haverd et al., 2013
WRRA	Warra	−43.10	146.65	Tall wet eucalypt forest	EO	55	5.84	Neyland et al., 2000

In the column "Overstory" EMo, Eucalyptus moluccana; EF, Eucalyptus fibrosa; EDe, Eucalyptus delegatensis; EDa, Eucalyptus dalrympleana; EMi, Eucalyptus microcarpa; EL, Eucalyptus leucoxylona; EO, Eucalyptus obliqua; ERa, Eucalyptus radiata; ERu, Eucalyptus rubida.

Spatial representativeness

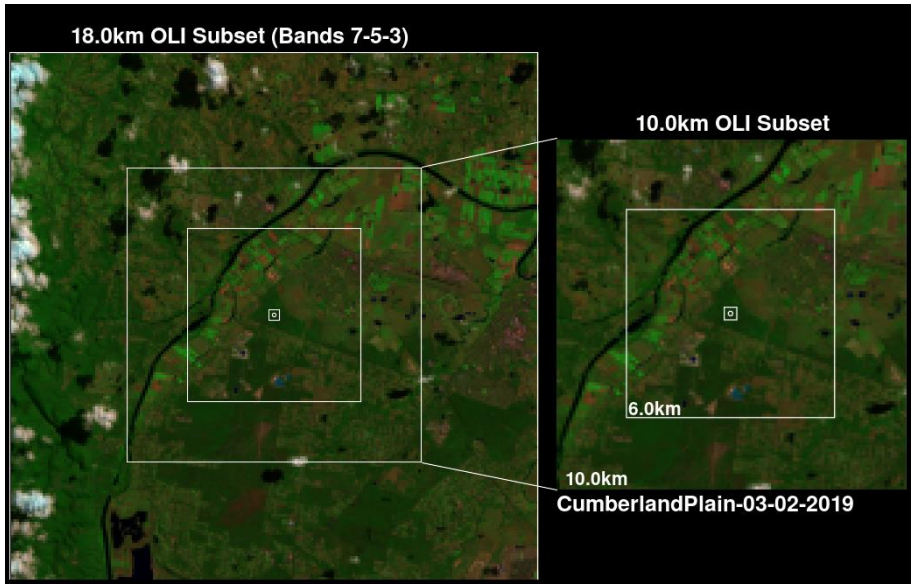


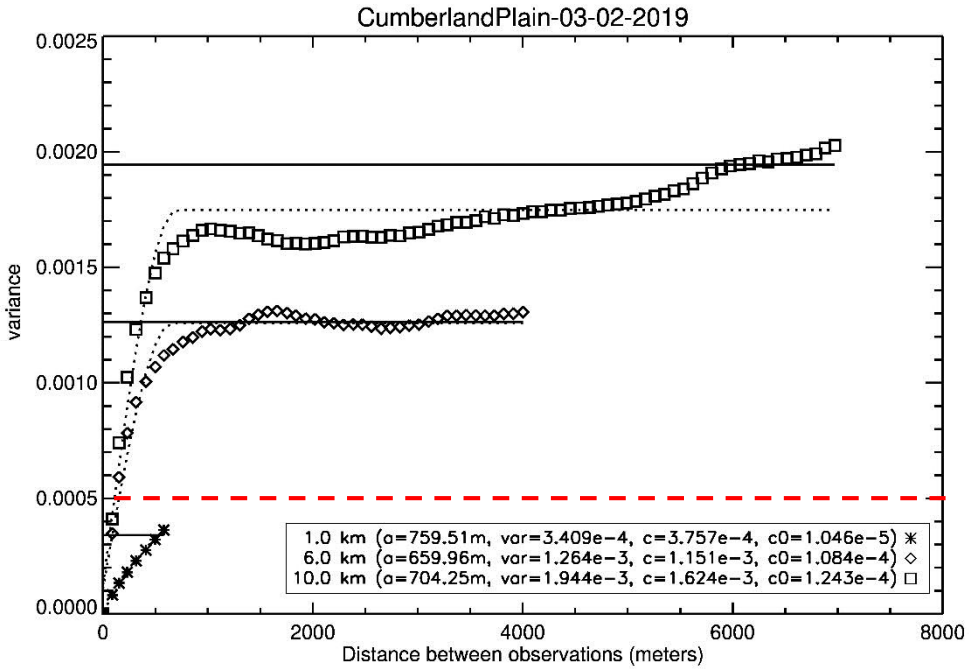


$$\gamma_E(h) = 0.5 \cdot \frac{\sum_{i=1}^{N(h)} \left(z_{xi} - z_{xi+h}\right)^2}{N(h)}$$

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

Spatial representativeness





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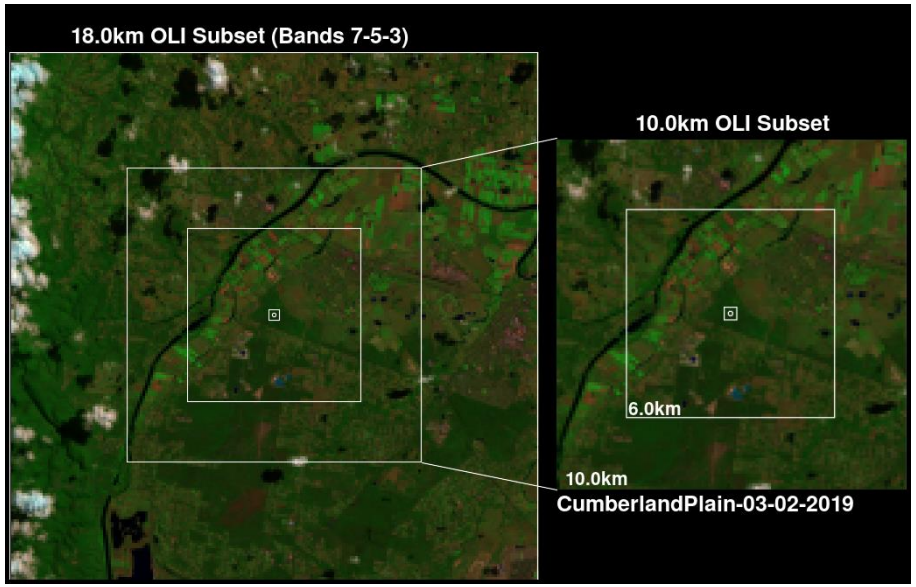

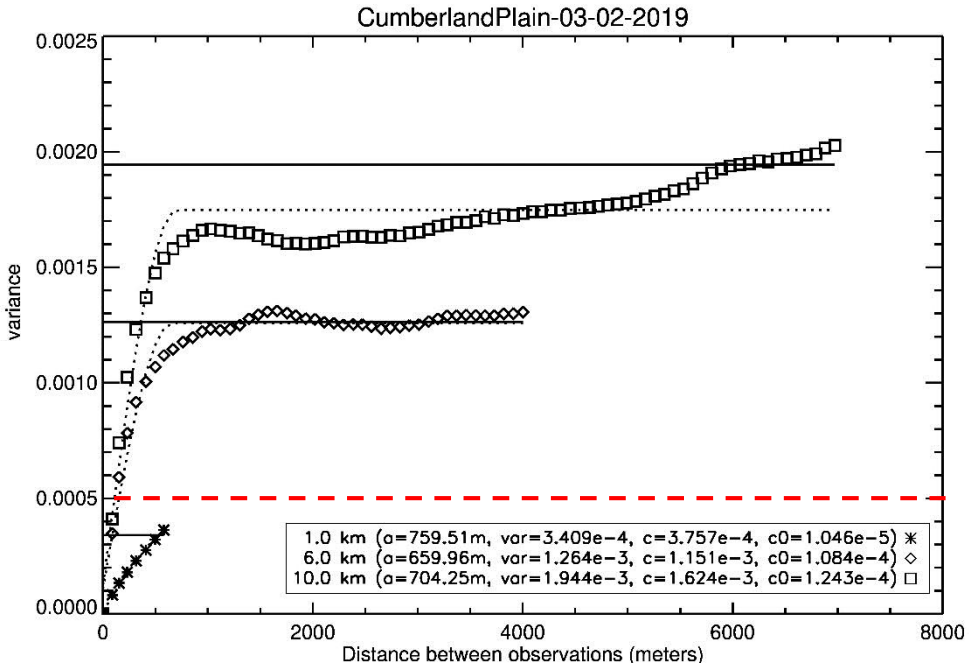

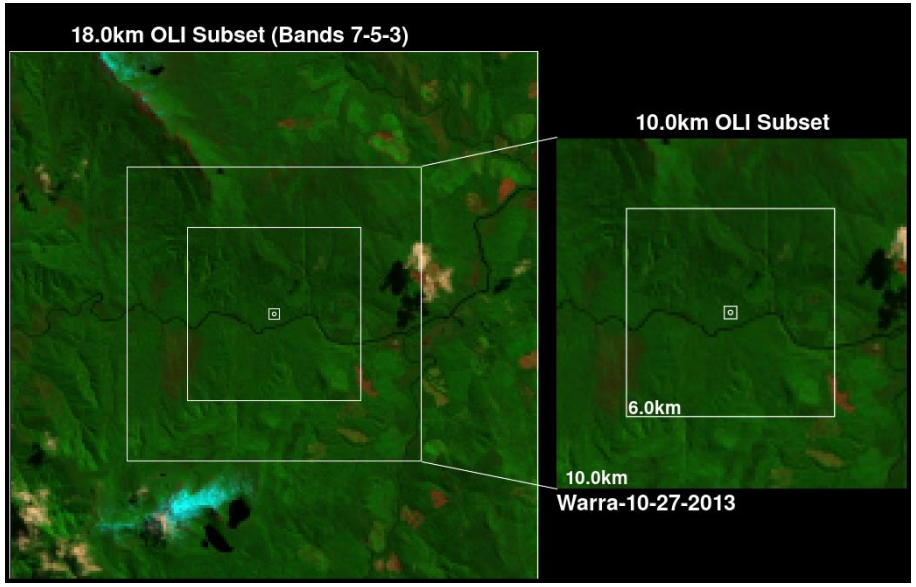

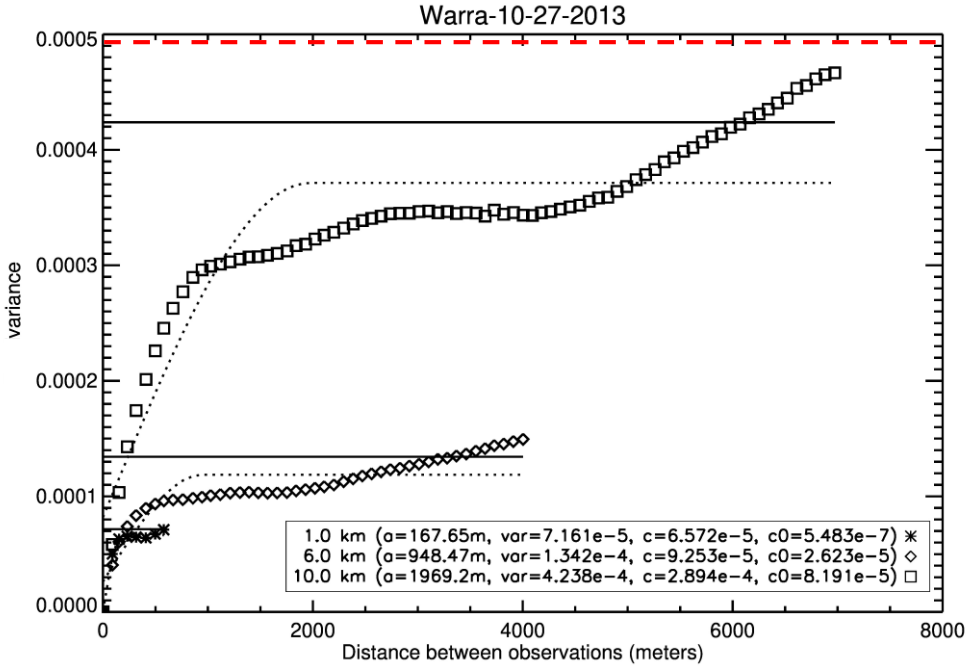

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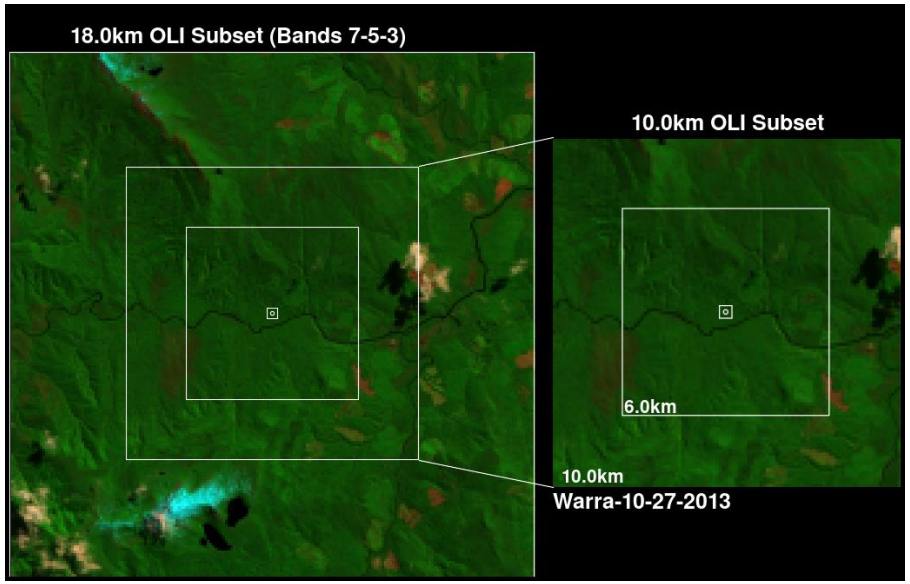
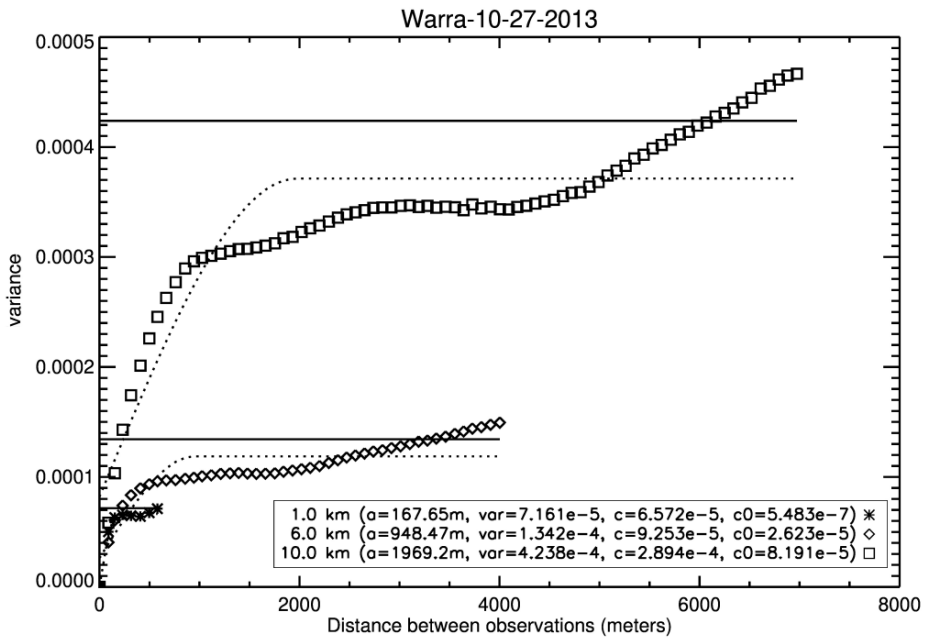
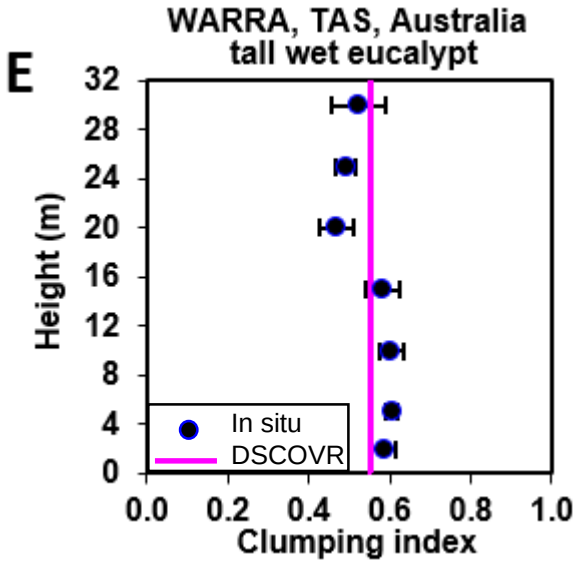
Román et al. 2009 RSE; Wang et al. 2017 RSE

Warra

Tall wet eucalypt forest

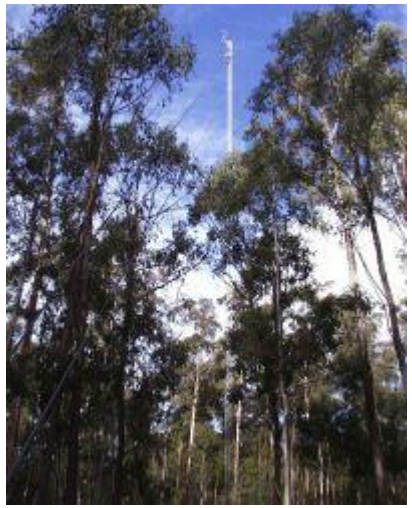


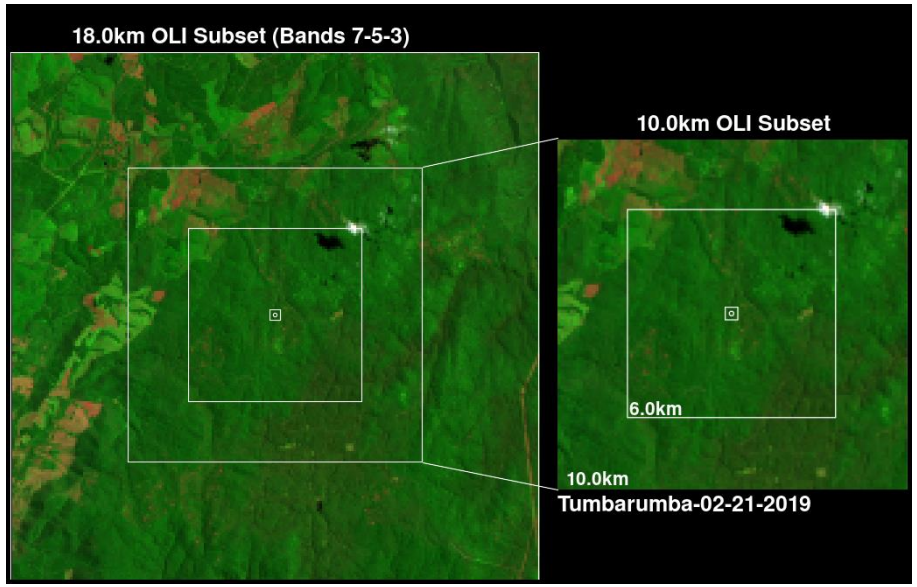


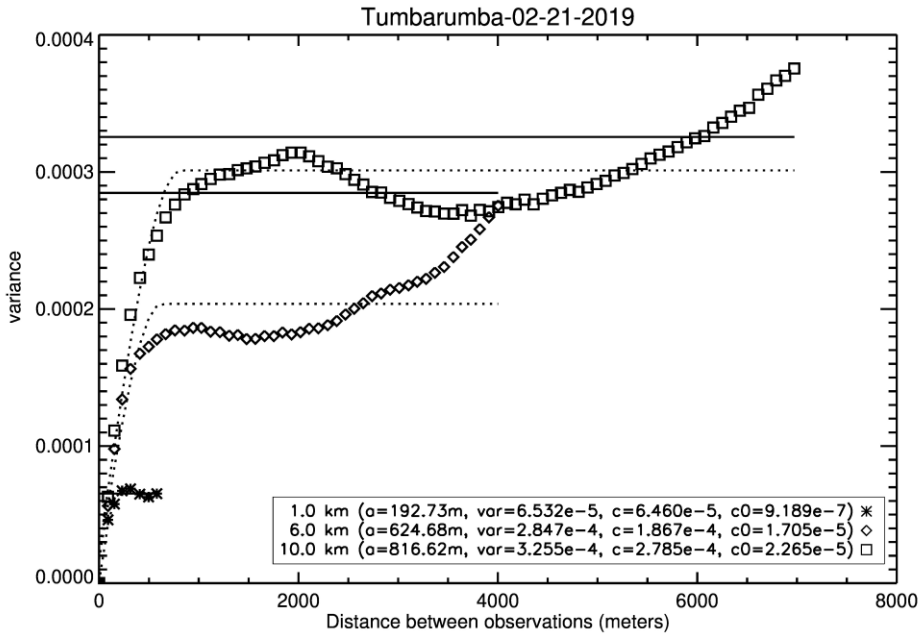


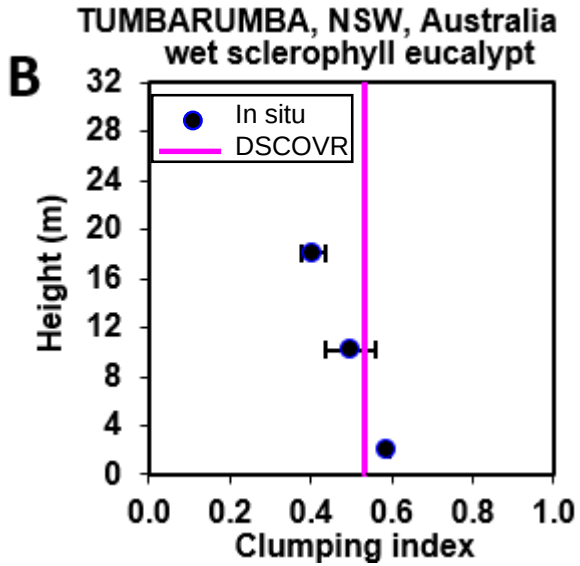
Tumbarumba

Managed open wet sclerophyll forest



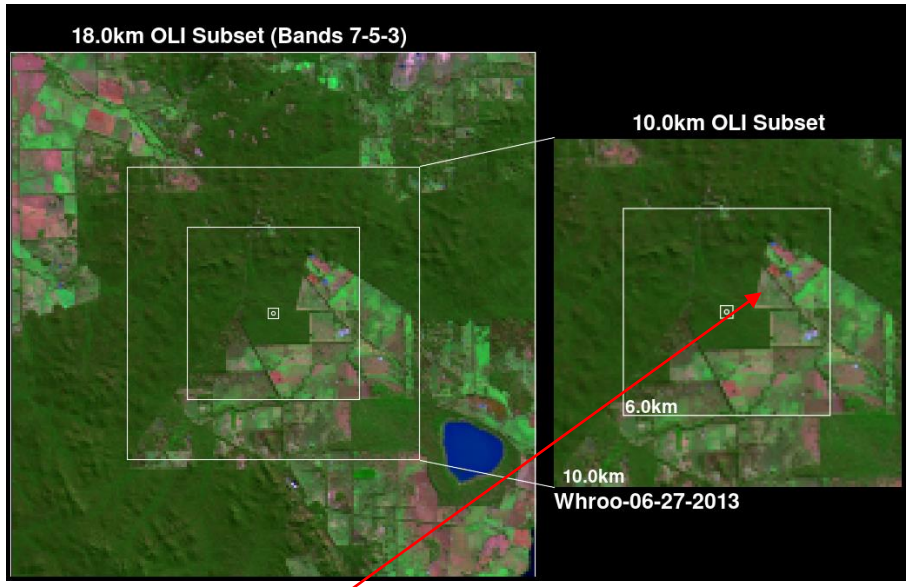


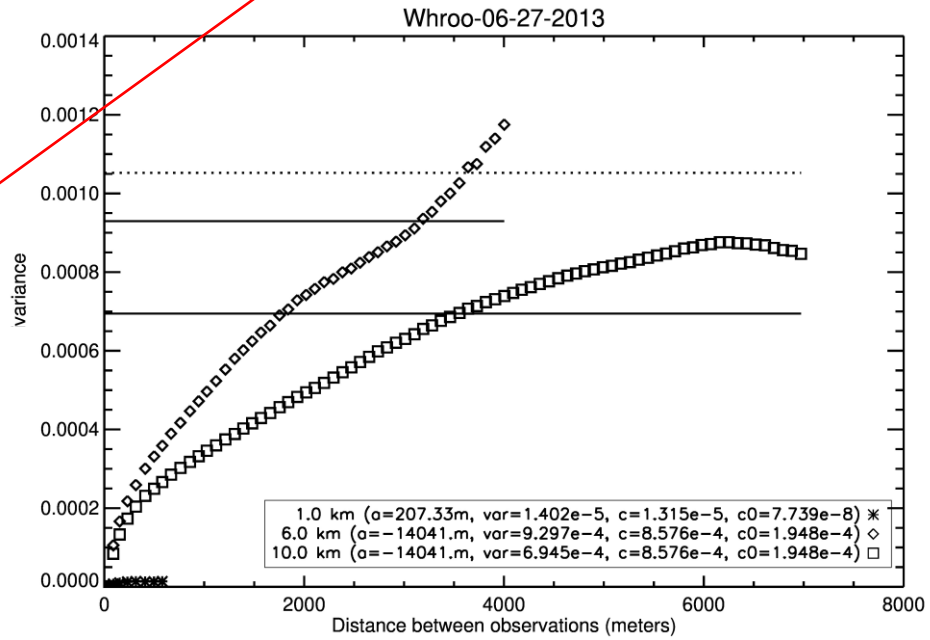


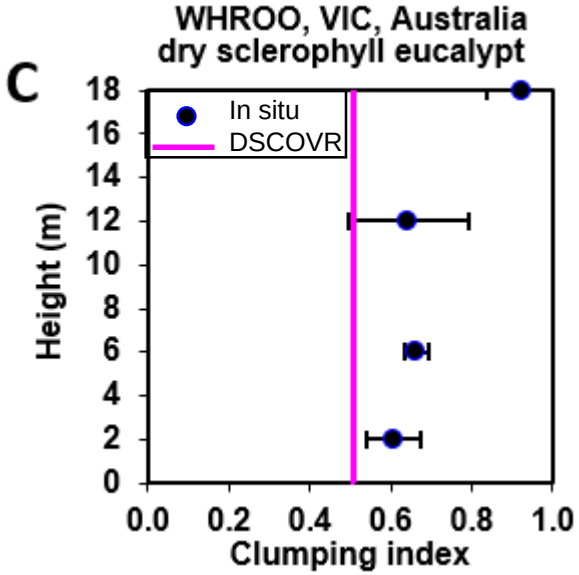


Whroo

Box woodland

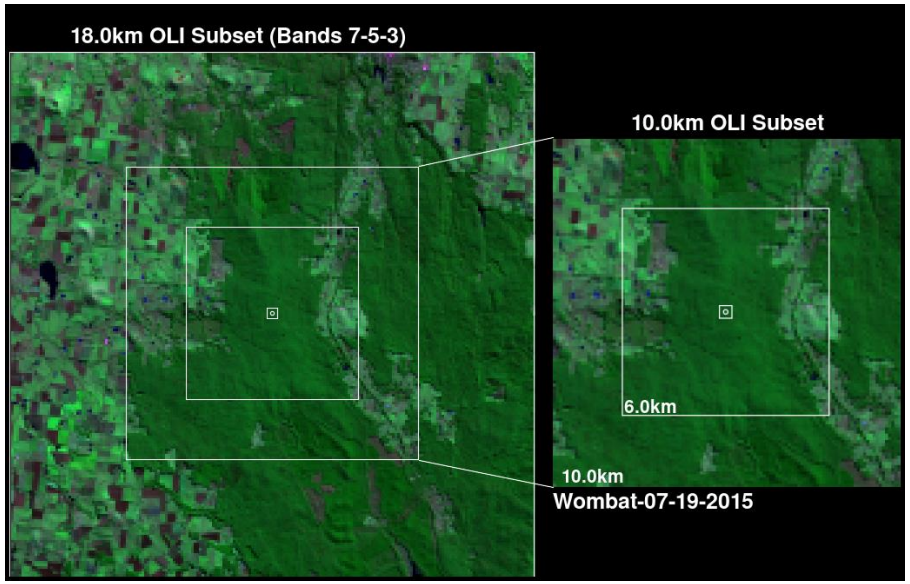


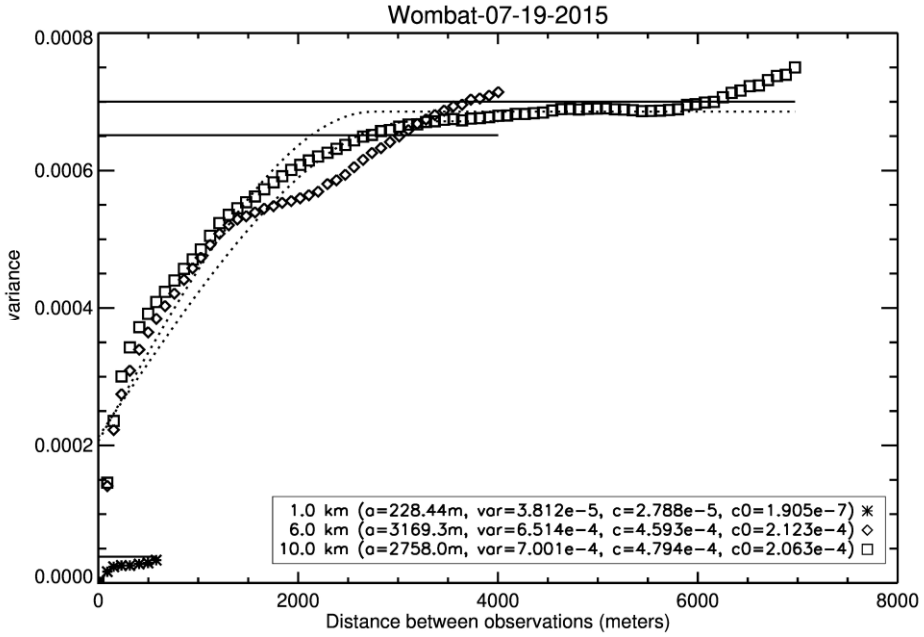


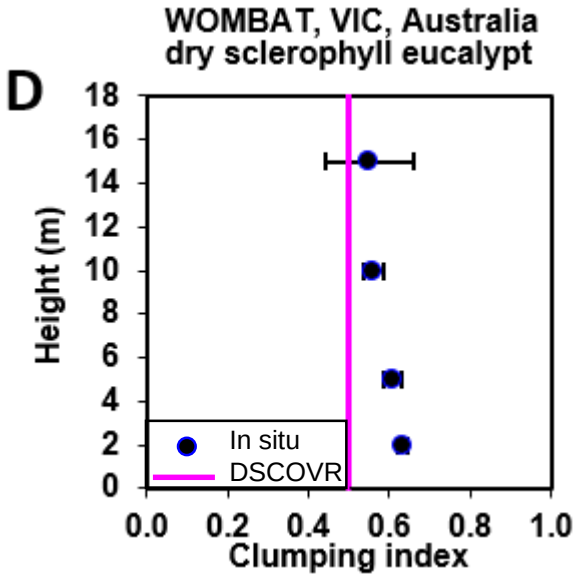


Wombat

Open eucalypt woodland

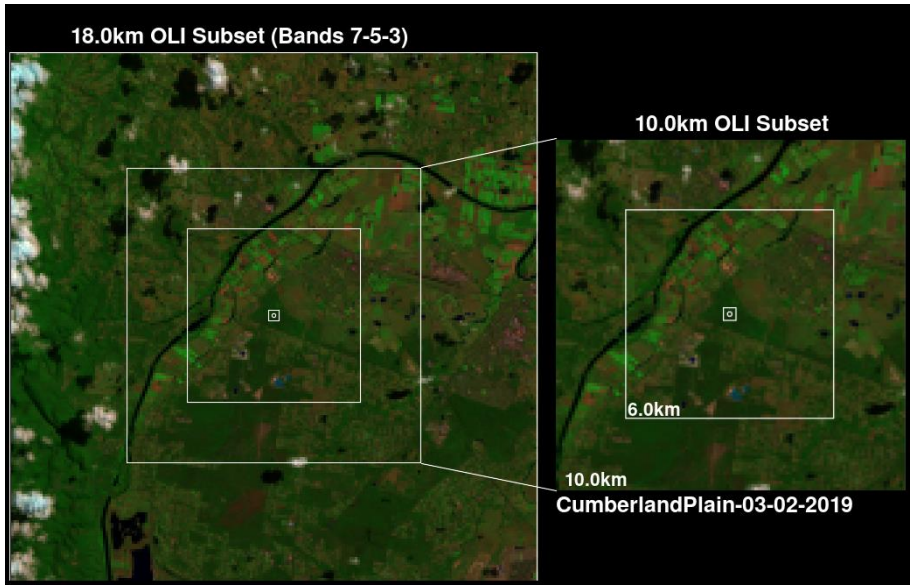


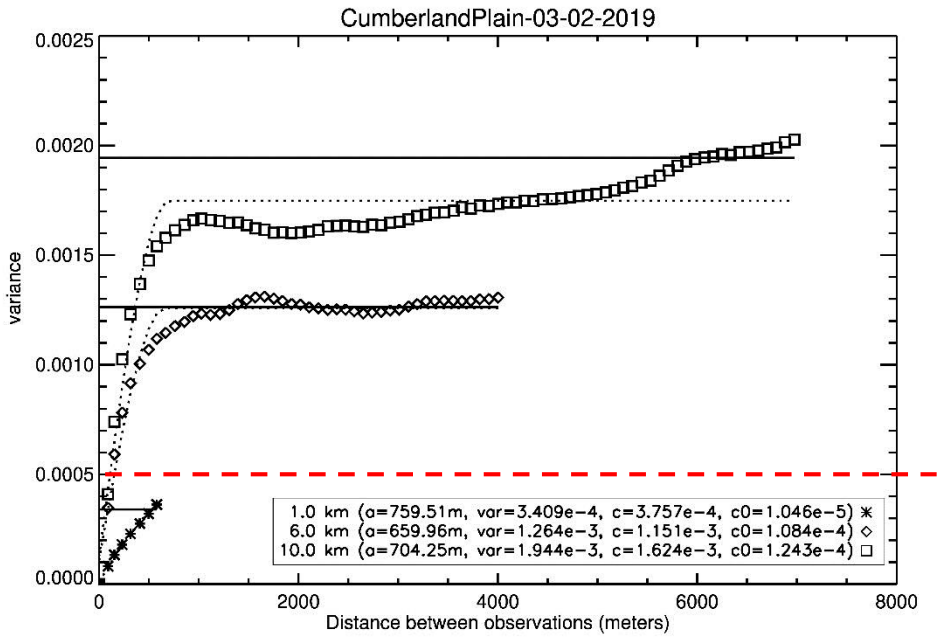


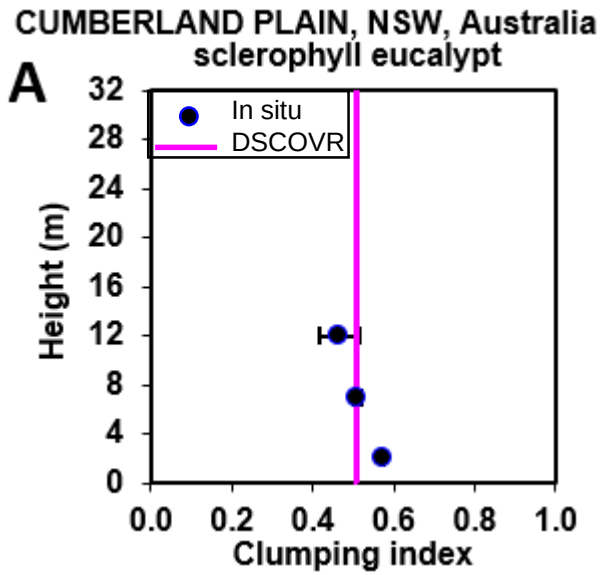


Cumberland Plain

Remnant eucalypt woodland







frontiers in Remote Sensing

BRIEF RESEARCH REPORT
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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]*

[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

News

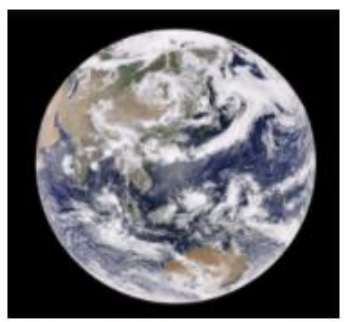
International environmental change research enabled by TERN

Published June 2021

TERN's national research infrastructure is being used by scientists from all around the world, including by a scientist from Estonia whose research will help new NASA technology be better utilised to monitor and measure environmental change. Meet the researcher, learn about an innovative method to assess vegetation clumping, and read his independent assessment of the importance of TERN for global satellite product validation.

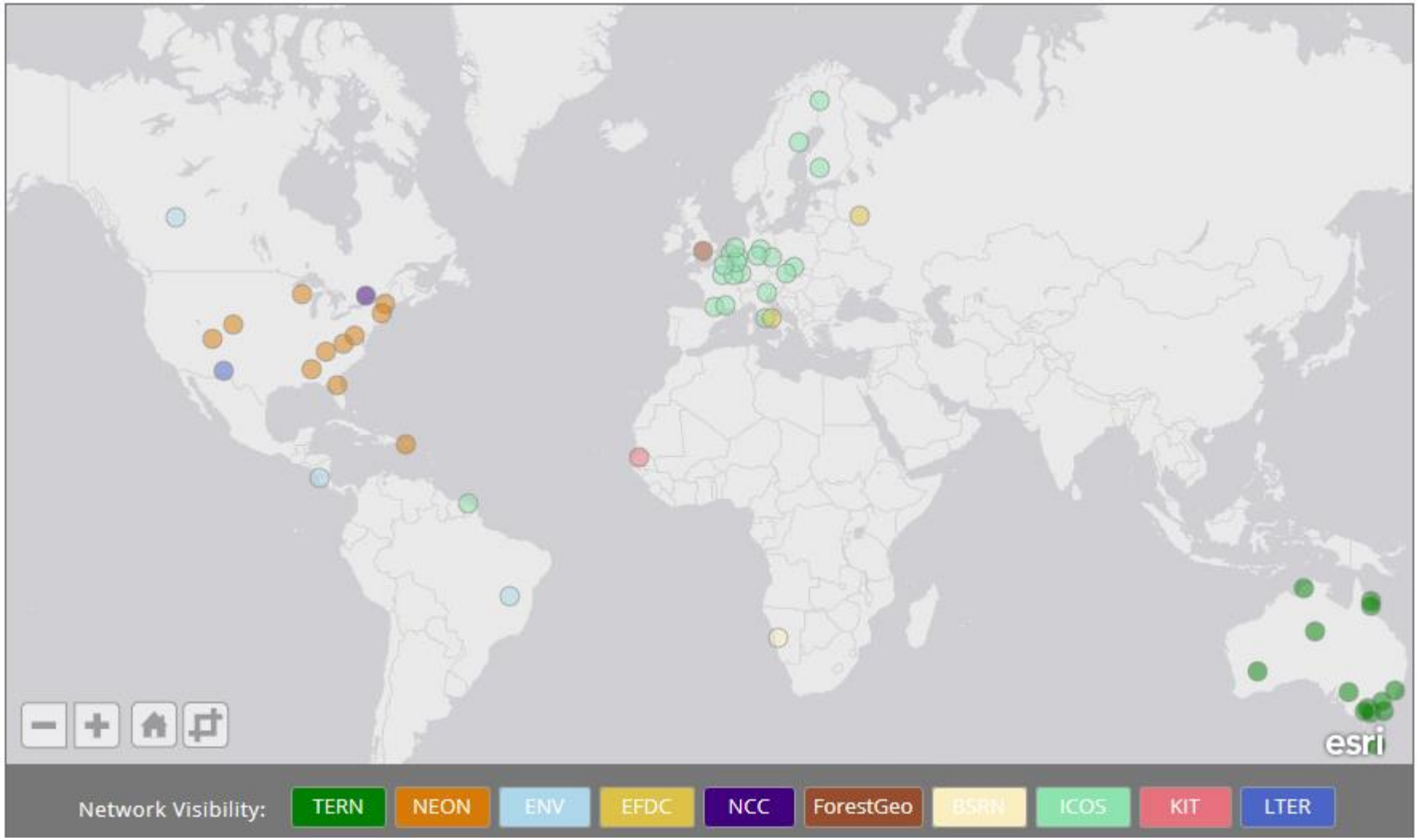
In 2015, SpaceX launched a revolutionary satellite to monitor space weather, space climate and provide a system of warning Earth of solar magnetic storms. The joint NASA NOAA (National Oceanic and Atmospheric Administration) satellite—called Deep Space Climate Observatory (DSCOVR)—also provides important Earth Observation data.

DSCOVR's Earth Polychromatic Imaging Camera (EPIC) takes multi-spectral images of the entire sun-lit side of Earth every one to two hours, allowing scientists around the world, including Dr Jan Pisek at Estonia's Tartu Observatory, University of Tartu, to monitor the land and how it's changing.



An enhanced image of Earth captured on 31 May 2021 by DSCOVR's Earth Polychromatic Imaging Camera (EPIC) (credit NASA)

LPV Supersites



https://lpvs.gsfc.nasa.gov/LPV_Supersites/LPVsites.html