

ASCAT slope: a direct radar observable to constrain fast and slow processes in the terrestrial carbon cycle

Mariette Vreugdenhil and Susan Steele-Dunne

Contributions from: PETCHIAPPAN, ASHWINI; SHAN, XU; KAMINSKI, THOMAS; LEMMETYINEN, JUUHA; THUM, TEA; AURELA, MIKA; WILLIAMS, MATHEW; KNORR, WOLFGANG; SCHOLZE, MARKO; BUEECHI, EMANUEL; DORIGO, WOUTER

Metop ASCAT specifications



Active microwave scatterometer

- Frequency: C-band, 5.255 GHz
- Polarisation: VV

Spatial Resolution: 25 km/ 50 km Overpass: asc/desc 9:30 AM/PM Multi-incidence: 25-65° Daily global coverage: 82 %

Metop-A (Oct. 2006 – 2021) Metop-B (Sep. 2012 – ongoing) Metop-C (Nov. 2018 – ongoing) Metop-SG (2023, planned until 2040)



ASCAT geometry, backscatter vs incidence angle



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Relating slope to meteorological and phenology



Backscatter is sensitive to water content in soil and vegetation Slope is sensitive to vegetation phenology, driven by moisture availability or radiation



Study area: land cover types and regions of interest Source: Terrestrial Ecoregions of the World (WWF)

Legend

- Regions of interest
- Tropical & Subtropical Moist Broadleaf Forests
- Tropical & Subtropical Dry Broadleaf Forests
- Tropical & Subtropical Grasslands, Savannas & Shrublands
- Flooded Grasslands & Savannas
 Montane Grasslands & Shrublands
- Deserts & Xeric Shrublands
- Mangroves
 - 00 0 500 1000 1500 km

Petchiappan, A., Steele-Dunne, S.C., Vreugdenhil, M., Hahn, S., Wagner, W., Oliveira, R., 2022. The influence of vegetation water dynamics on the ASCAT backscatter–incidence angle relationship in the Amazon. Hydrology and Earth System Sciences 26, 2997–3019. https://doi.org/10.5194/hess-26-2997-2022



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Slope per land cover type









Maximum

DOY Maximum



60°W 57°W 54°W 51°W 48°W 45°W 42°W



Can we explain slope?





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Drought impact in backscatter and slope



2010 drought: most severe over southern and western Amazonia.

2015 drought: more widespread and strongest in eastern Amazonia.









Drought impact in slope for different land cover types

-0.050

-0.055

-0.060

-0.065

-0.070





VOD from slope



Temporal dynamics in VOD are from ASCAT slope



Vreugdenhil, M., Hahn, S., Melzer, T., Bauer-Marschallinger, B., Reimer, C., Dorigo, W.A., Wagner, W., 2017. Assessing Vegetation Dynamics Over Mainland Australia With Metop ASCAT. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 10, 2240–2248. https://doi.org/10.1109/JSTARS.2016.2618838

Land Carbon Constellation





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Land Carbon Constellation: Sodankyla





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Land Carbon Constellation: Sodankyla





Sensitivity to extremes







Measurement operator for slope

daily net ecosystem exchange	-0 59	-0.47	-0 57	- 0.6	
lahile hiomass	-0.56	-0.55	-0.57		
long-wave (thermal) transmissivity of canony	-0.38	-0.43	-0.38		
daily beterotrophic respiration	-0.1	-0.17	-0.058		
water in surface laver	-0.1	-0.096	-0.1		
fractional water content in surface layer	-0.1	-0.096	-0.1	- 0.4	
daily snowmelt	-0.087	-0.087	-0.082		10
fraction of plant available soil moisture	-0.07	-0.1	-0.033		
daily snow evaporation -	-0.049	-0.049	-0.049		
daily snowfall	-0.049	-0.049	-0.049		t - te
woody biomass -	-0.045	-0.03	-0.058	- 0.2	8 0.8
snow height -	-0.037	-0.037	-0.037	- 0.2	
snow mass –	-0.037	-0.037	-0.037		
water in root layer —	-0.015	-0.057	0.031		
snow albedo —	0.066	0.066	0.077		
daily canopy evaporation —	0.087	0.067	0.098		「夏島트弓「 ノ \ 」 ノ \ 」 ノ \ 」 ノ \ 」 ノ \ 」 / \ 』 / \ 」 / \ 」 / \ 』 / \ 」 / \ 』 / \
daily throughfall —	0.13	0.13	0.13	- 0.0	
daily precipitation —	0.13	0.13	0.13		
daily rainfall —	0.13	0.13	0.13		
soil albedo 🗕	0.15	0.15	0.15		
daily soil temperature —	0.25	0.25	0.25		
daily soil evaporation —	0.38	0.39	0.37	— -0.2	
daily potential canopy evaporation —	0.38	0.48	0.35		
plant hydrological wetting status (fast changing) 🗕	0.4	0.31	0.41		3000
foliar biomass —	0.43	0.45	0.41		
Leaf area index —	0.43	0.45	0.41		
daily potential soil evaporation —	0.44	0.44	0.43	— -0.4	
daily air temperature —	0.44	0.44	0.44		
daily transpiration —	0.47	0.45	0.46		
daily potential transpiration —	0.47	0.45	0.46		2015 2016 2017 2018 2010 2020 2021
daily autotrophic respiration -	0.52	0.34	0.48		2015 2016 2017 2018 2019 2020 2021
daily gross primary production —	0.57	0.46	0.53		
	l	shrub	tree	0.0	
	pixer	pft			

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Simple linear regression methods



wb = Plant woody biomass (low correlation, but trend/IAV) fb = Plant foliar biomass hf= plant hydrological status (fast) = ETACT/ETPOT

Similar measurement operator as L-VOD

Continued analysis with ML to understand the feature importances



Conclusions, knowledge gaps and priorities



- ASCAT Slope: Valuable long data record
- Explained sensitivity to vegetation dynamics (outside of winter period)
- "similar" to VOD, but less processing and fewer necessary assumptions

Potential with 6.25km full resolution and extending to ERS

More in-depth research on microwave signal knowledge gaps:

What are we really measuring?

- structure affecting the radar signal
- scattering from dry soils