PLANET BIOMASS PROXY
TECHNICAL SPECIFICATION

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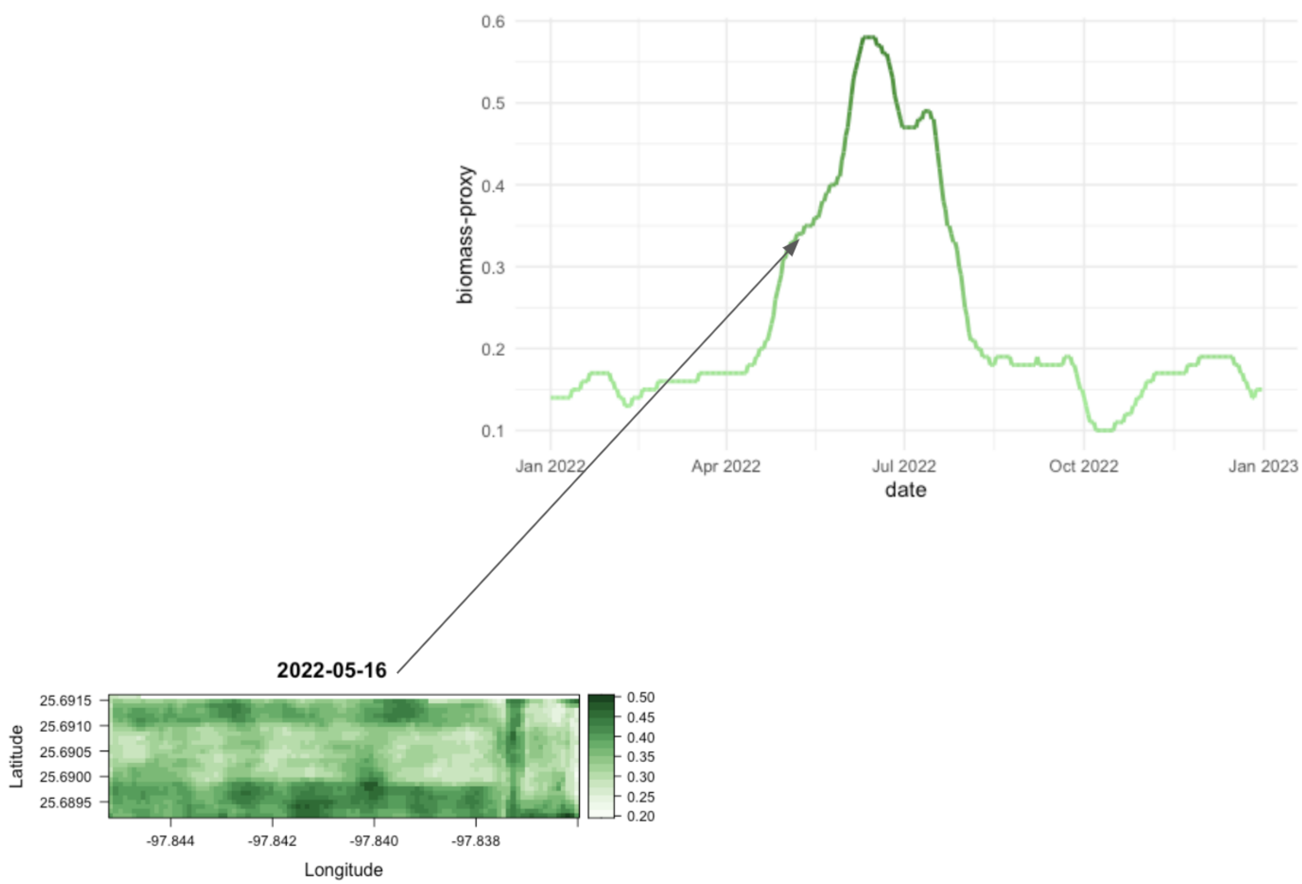
1. BIOMASS PROXY OVERVIEW

Biomass Proxy is a fusion of microwave and optical satellite imagery, using the advantages of each to accurately estimate relative aboveground crop biomass regardless of cloud cover and at a spatial resolution of 10-meters. This product integrates microwave data from the European Space Agency (ESA) Sentinel-1 satellites and optical images from Sentinel-2. The output from these combined data sources is fused in an algorithm designed to provide a reliable measurement of crop biomass over agricultural areas. This is a relative measure of biomass, so each pixel value has a value of 0 (low biomass) to 1 (high biomass). The product is provided daily and in near real time (latency <24 hours).

Figure 1: Example of biomass proxy proxy in NE Mexico



The Biomass Proxy uses the vegetation signal derived from cross polarizations of microwave observations in combination with a vegetation index from Sentinel-2. The vegetation signal in the microwave region is different to the one in the optical domain. The microwave signal is a direct function of the vegetation water content, dielectric properties of the water within the vegetation, and the vegetation structure (Ulaby et al., 1986; Kerr et al., 1994). Considering the strong relationship between vegetation water content and vegetation biomass, this microwave information is, in this case, used as a biomass indicator for crops (Vreugdenhil et al., 2018; Khabbazan et al., 2019). On the other hand, in optical imagery, spectral indices are used to estimate the vegetation conditions. The spectral measurements in the visible region are sensitive to the chlorophyll content, while the measurements in the near infrared are sensitive to the mesophyll structure of the leaves (Townshend, 1993).

The unique features of Planet Biomass Proxy data can be summarized as:

- daily
- cloud-free
- analysis-ready
- mid-resolution (10-m)

2. PRODUCT SPECIFICATION

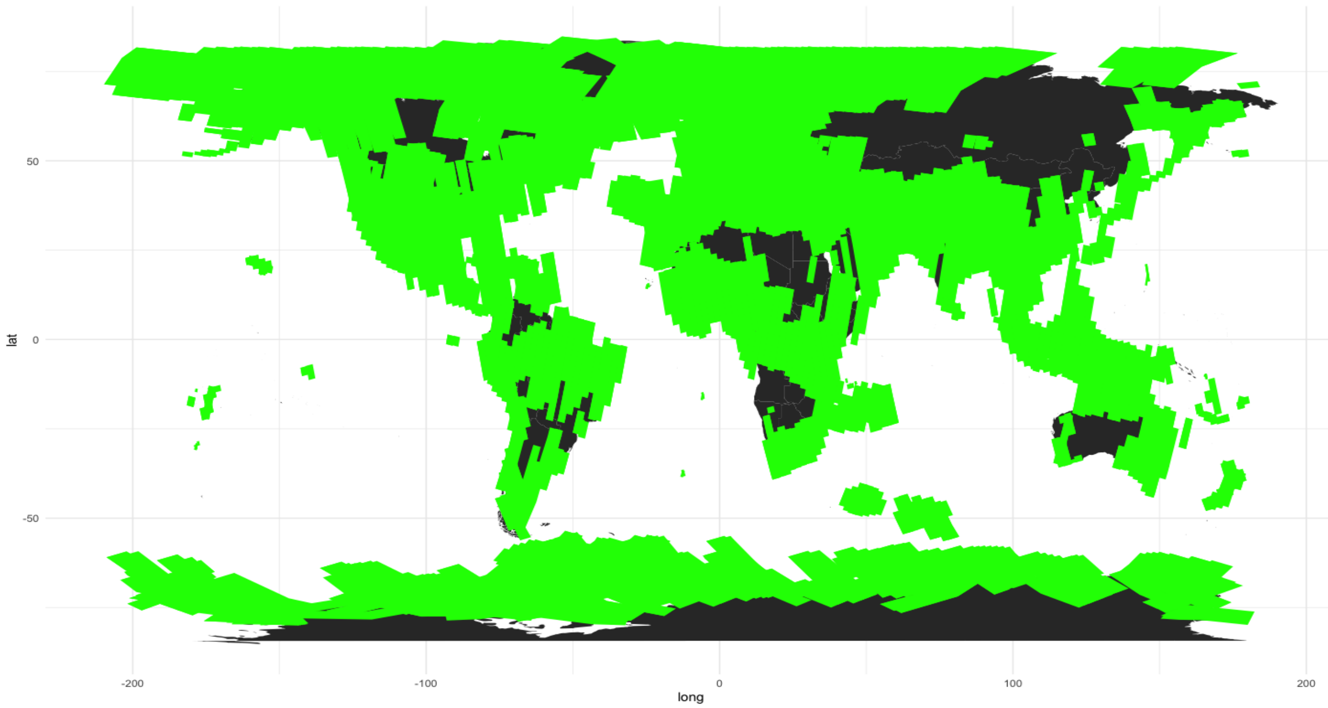
The biomass proxy product is delivered through the Planet subscription API as a 10-m pixel GeoTIFF raster. Documentation on the API can be found here. While the data is delivered daily for the fields subscribed, users also have access to the archive starting on 2019-01-01. The data is available every day at 6 am local time. The image properties are described in Table 1.

Table 1: GeoTIFF properties

Parameter	Value
Data type	uint16
Compression	LZW
Scale	0.001
Offset	0
Band 1	Biomass Proxy
NoData	65535

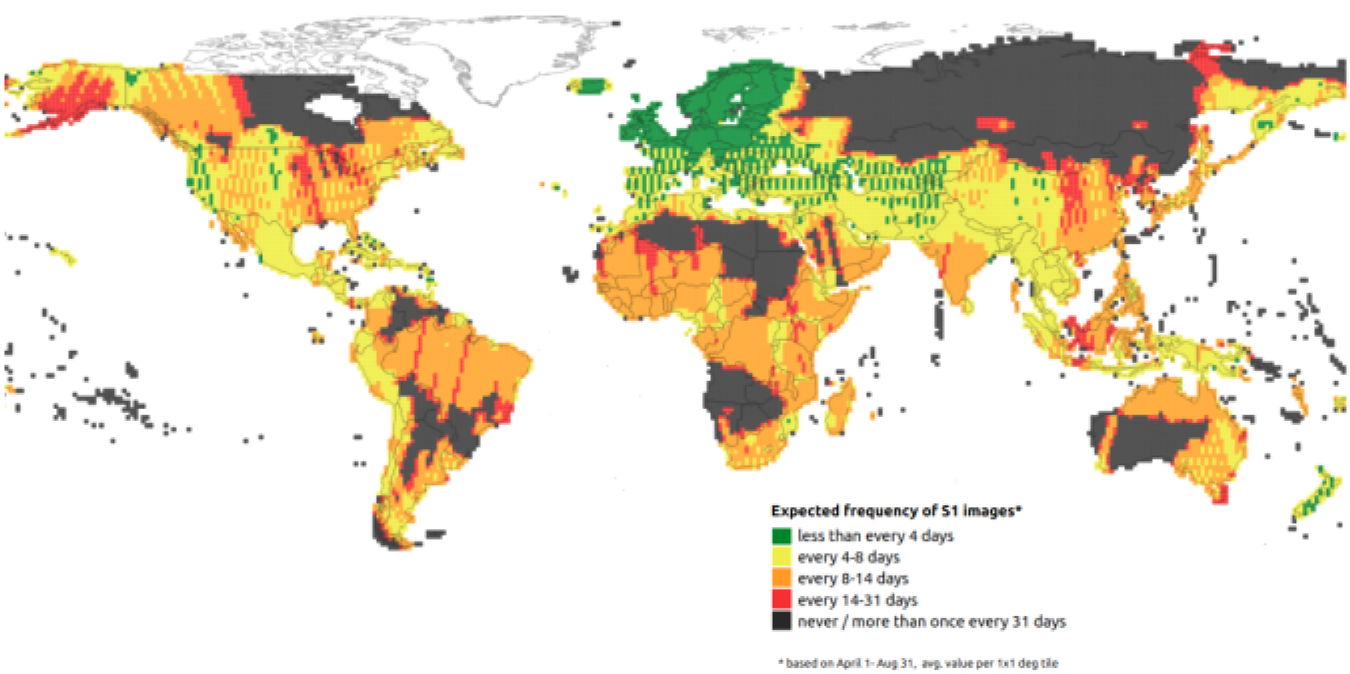
Originally, the biomass proxy had a global coverage but unfortunately, in December 2021, Sentinel-1B service was discontinued due to an issue with its power system. As a consequence, the only source of microwave data available is Sentinel-1A. This satellite does not cover some major agricultural areas of the world such as Southern Brazil, Western Australia and Northern US Midwest and Central Canada.

Figure 2: Sentinel 1-A coverage. The green areas are currently covered by Sentinel-1A.



In addition, the revisit rate in the covered areas went from 6 to 12 days in most areas except for Europe where it went from 1 to 2-3 days.

Figure 3: Current availability of the Biomass Proxy as of March 20, 2022



3. METHODOLOGY

4.1 Input data

Optical

NDVI is an abbreviation for Normalized Difference Vegetation Index and it is derived from optical satellite imagery. It is the most widely used vegetation index used in agriculture. NDVI is a measure of chlorophyll content in plants, which is responsible for photosynthesis. Chlorophyll absorbs visible light (from 0.4 to 0.7 μm) for use in photosynthesis, whereas plant cells strongly reflect near-infra-red light (0.7 to 1.1 μm). Since optical satellites generally measure bands in both spectra, an index can be constructed that makes use of the difference to evaluate chlorophyll activity. To make the index comparable worldwide it is normalized. The formula to calculate NDVI is (NIR-RED)/(NIR+RED). By design, the NDVI itself thus varies between -1.0 and +1.0. The higher the value, the more chlorophyll activity and therefore the more abundant, and the healthier the vegetation. Optical data is collected at a resolution of 10x10m from the Sentinel-2 satellites.

Microwave

Active microwaves are an entirely different part of the spectrum than optical waves but are also known for their ability to detect changes in vegetation. Since VV and VH (vertical transmit and vertical receive) backscatter - two different polarizations of SAR (synthetic aperture radar) - respond differently to vegetation, information on vegetation structure, vegetation water content, and the dielectric properties of vegetation water can be obtained (e.g. see Ulaby et al., 1986; Kerr et al., 1994). There are other factors that influence the backscatter signal such as moisture content and the texture and roughness of the underlying soil, so it is therefore important to isolate the vegetation signal in the radar signals. Beyond these challenges in isolating the vegetation signal, when successful, active microwaves are a very consistent and reliable source of information. This is because, unlike optical signals, they penetrate cloud cover. Microwave data is collected at a 10-m resolution from the Sentinel-1 satellites.

The cross-ratio (CR) is extracted from the SAR signal and filtered in time and space. CR is more sensitive to vegetation changes and less impacted by changes in soil water content and soil-vegetation dynamics (Meroni et al., 2021; Veloso et al., 2017). However, factors such as soil roughness and vegetation structure can affect its value (Vreugdenhil et al., 2018). The backscatter depends mainly on crop structure and vegetation water content (Steele-Dunne et al. 2017).

4.2 Fusion

The Biomass Proxy algorithm is designed for agricultural crops and uses both signals. For the development of this index the following steps were taken:

1. Pre-process the optical and microwave data using multiple cloud masking routines for the optical imagery and multi spatio-temporal filtering for the microwave images, as well as orbit corrections and bare soil mitigation from multipolarization derivatives.

2. Define a relationship between the different vegetation signals derived from both the optical and microwave domain.

3. For each field, build the temporal vegetation signal based on a dynamic weighting of each signal.

4. Redistribute for each day the derived temporal signal on each field pixel based on a different dynamic spatial weighting, generating the biomass maps.

REFERENCES

Kerr, Y.H. and Wigneron, J.-P. 1994: Vegetation models and observations - a review. In Choudhury, B.J. , Kerr, Y.H. , Njoku, E.G. and Pampaloni, P. , editors, Passive microwave remote sensing research related to land-atmosphere interactions, Utrecht: VSP, 317-44.

Khabbazan, S., Vermunt, P., Steele-Dunne, S., Ratering Arntz, L., Marinetti, C., van der Valk, D., Iannini, L., Molijn, R., Westerdijk, K., & van der Sande, C. (2019). Crop monitoring using Sentinel-1 data: A case study from The Netherlands. Remote Sensing, 11(16), 1887.

Meroni, M., d'Andrimont, R., Vrieling, A., Fasbender, D., Lemoine, G., Rembold, F., . . . Verhegghen, A. (2021). Comparing land surface phenology of major European crops as derived from SAR and multispectral data of Sentinel-1 and -2. Remote Sensing of Environment, 253. doi: 10.1016/j.rse.2020.112232

Michel, J., Youssefi, D., & Grizonnet, M. (2014). Stable mean-shift algorithm and its application to the segmentation of arbitrarily large remote sensing images. IEEE Transactions on Geoscience and Remote Sensing, 53(2), 952-964.

Steele-Dunne, S. C., McNairn, H., Monsivais-Huertero, A., Judge, J., Liu, P. W., & Papathanassiou, K. (2017). Radar Remote Sensing of Agricultural Canopies: A Review (Vol. 10) (No. 5). Institute of Electrical and Electronics Engineers. doi: 10.1109/JSTARS.2016.2639043

Townshend, J. R. G., Tucker, C. J., and Goward, S. N. (1993). Global vegetation mapping. In Gurney, R. J., Foster, J. L., and Parkinson, C. L., editors, Atlas of Satellite Observations related to Global Change. Cambridge University Press, New York.

Ulaby, F. T., Moore, R. K., & Fung, A. K. (1986). Microwave remote sensing: Active and passive. Volume 3-From theory to applications.

Valero, S., Morin, D., Inglada, J., Sepulcre, G., Arias, M., Hagolle, O., Dedieu, G., Bontemps, S., Defourny, P., & Koetz, B. (2016). Production of a dynamic cropland mask by processing remote sensing image series at high temporal and spatial resolutions. Remote Sensing, 8(1), 55.

Veloso, A.,Mermoz, S., Bouvet, A., Le Toan, T., Planells, M.,Dejoux, J. F., & Ceschia, E. (2017). Understanding the temporal behavior of crops using Sentinel-1 and Sentinel-2-like data for agricultural applications. Remote Sensing of Environment, 199, 415–426. doi: 10.1016/j.rse.2017.07.015

Vreugdenhil, M., Wagner, W., Bauer-Marschallinger, B., Pfeil, I., Teubner, I., Rüdiger, C., & Strauss, P. (2018). Sensitivity of Sentinel-1 backscatter to vegetation dynamics: An Austrian case study. Remote Sensing, 10(9), 1396.