User Guide for the MEaSURES Vegetation Continuous Fields product, version 1

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1. Dataset overview

1.1 Background

The MEaSURES Vegetation Continuous Fields (VCF) products are maps of annual global fractional vegetation cover, at 1/5 degree resolution, in three layers: tree cover, non-tree vegetation and bare ground. Fractional vegetation cover is defined as the ratio of the area of the vertical projection of green vegetation onto the ground to the total area; it captures the horizontal arrangement and density of vegetation across the landscape. Fractional vegetation cover (FVC) is a key parameter for many environmental and climate-related applications. It is a primary means of measuring global forest cover change [Hansen et al. 2013; Kim et al. 2014, 2015] and is an important parameter for climate and carbon land surface models [Lawrence and Chase 2007; Tian et al. 2004; Jung et al. 2006] and the determination of biomass and forest structure [Cartus et al. 2011; Lefsky 2010].

When originally proposed the VCF product represented a revolutionary new approach to the characterization of vegetative land cover (DeFries et al, 1995, 1997). In the past, climate models, land surface models and other applications depended on land cover maps in estimating land surface bio-physical parameters. Traditional land cover maps assign each pixel to a single land cover class. Models are parameterized by assigning each land cover class a static set of parameter values. There are disadvantages in using land cover maps to estimate land surface attributes. In particular, land cover maps fail to capture sub-pixel and within-class variability. Boundaries between classes result in unrealistic spatial discontinuities in model results. Land cover maps are also highly dependent on the classes chosen to represent cover types, and it may be difficult to cross-walk between land cover maps with different class schemes; the classification scheme used may not be ideal for many applications. In order to improve accuracy, therefore, VCF products provide per-pixel fractions of three vegetation cover classes. The advantages of this approach have been recognized by the widespread adoption of the VCF product by many users in the modeling and monitoring communities. The VCF product has also been identified as an Earth System Data Record (ESDR) by the science community (Masek et al, 2006).

Historically, algorithms for the production of global land cover maps were largely hand crafted. The advent of machine learning algorithms and greater computing power has spurred research culminating in a completely automated process for extracting Earth science variables from remote sensing data, adapted for the production of both MODIS and MEaSURES global, annual VCF data. Relevant papers for the evolution of VCF products are Hansen et al. [2000, 2002, 2003] and Carroll [2010].

The MEaSURES products provide a long, consistent data record from 1981 to the present. This long record is especially pertinent to studies of deforestation over the past 30 years (Figure 1).

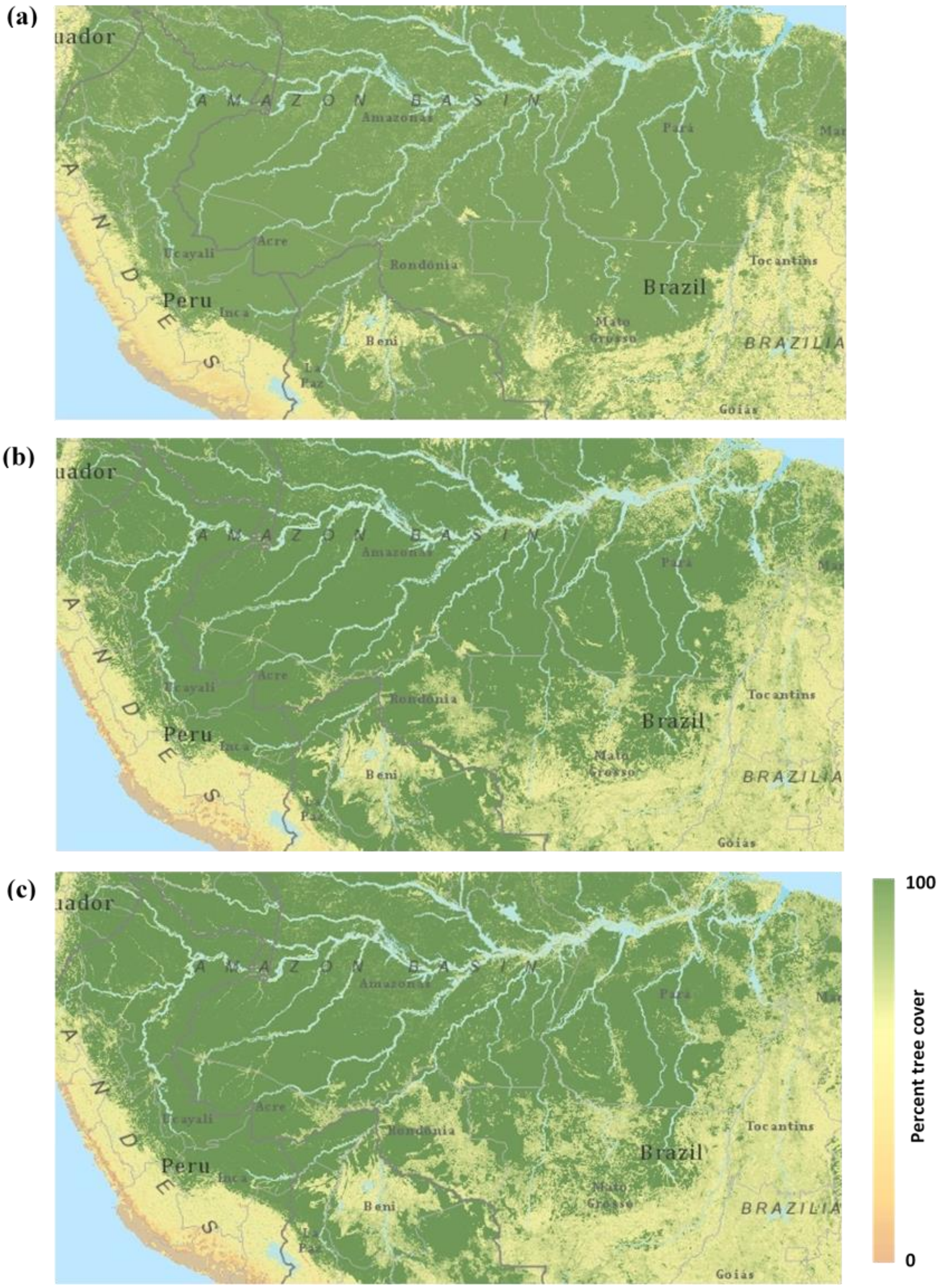

Figure 1. Time series of VCF tree cover for the Amazon Basin from the MEaSUREs VCF ESDR project. (a) 1990, (b) 2000, (c) 2010. Increasing deforestation can be noted in "arc of deforestation" shown in the lower and right sides of the images.

1.2 Methods

Measures VCF products are created with a bagged linear model algorithm (Figure 2). A brief description follows; for a more detailed description, please refer to the MEaSURES VCF Algorithm Theoretical Basis Document (ATBD).

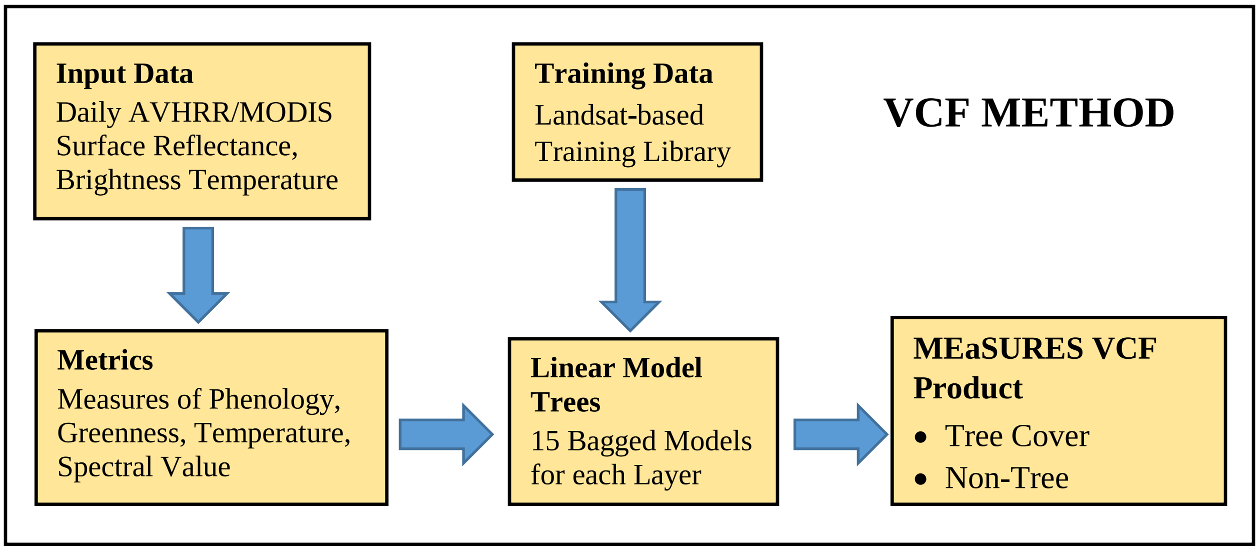

Figure 2. Summary of the MEaSURES VCF method.

Training. Landsat and higher resolution imagery is manually classified, assigning each pixel percent vegetation cover values based on expert knowledge, maps and fieldwork. Spatial coverage of scenes is chosen to be representative of global ecosystems and vegetation patterns. Classified imagery is reprojected and upscaled to match the projection and coarser resolution of the input data and output products.

Composites. Sixteen-day composites are formed from each annual collection of daily Land Long-Term Data Record (Pedelty et al., 2007). The goal of this compositing process is to eliminate cloud, cloud shadow, aerosols, far off-nadir views and other poor-quality or missing data, at the same time reducing the amount of data needing to be processed in subsequent steps. All available bands in the visible, near-infrared, and short-wave infrared are processed, as well as two thermal bands and the normalized difference vegetation index (NDVI).

Metrics. From the collection of composites, a number of metrics are calculated for each band and NDVI. These characterize vegetation attributes such as greenness, phenology and surface temperature. In an iterative process with step 4, metrics are retained or eliminated based on their predictive ability.

Models. Metrics and training are matched spatially and temporally, sampled and used to fit bagged linear tree models.

Prediction. The models developed in step 4 are applied to the set of metrics for each pixel, resulting in an annual map of vegetation cover fraction. Annual products are smoothed to reduce interannual variability due to noise while still retaining land cover change information.

Validation. Global products are compared to field data, Lidar point cloud data, and high-resolution imagery to determine the level of error in each ecoregion. Comparisons to land cover maps or other similar sources are also useful in identifying possible errors. The standard deviation of the estimates from bagged models also provides a representation of prediction accuracy.

2. Characteristics of the MEaSUREs VCF Version 1 Data Product

2.1 Long name: MEaSUREs Vegetation Continuous Fields (VCF) Yearly Global 0.05 Deg V001

2.2 Short name: VCF5KYR

2.3 File Name Format: All product files begin with the prefix "VCF5KYR" followed by the year and Julian day. The Julian day in all products will be "001" as each year's data begins on day 001 and finishes on day 365 of the following year. For example, year 1999 is created using daily data from 1999001 to 1999365. The remaining numerals in the file name are a timestamp indicating production time. Example file name: VCF5KYR_1999001_2017294232618.tif.

2.4 Temporal Granularity: Yearly

2.5 Temporal Extent: 1982 to 2015*

2.6 Spatial Extent: Global

2.7 Coordinate reference system and datum: Geographic, WGS84

2.8 Image dimensions: -180 to 180° east-west, -90 to 90° north-south

2.9 File format: GeoTiff

2.10 Columns/Rows: 7200 x 3600

2.11 Number of Science Dataset (SDS) Layers: 3

2.12 Pixel Size: 0.05 degree x 0.05 degree

2.13 Layer 1: Percent Tree Cover

Description: Percent of pixel covered by tree canopy
Units: Percent cover
Data Type: Unsigned 8-bit integer
Fill Value: None
Valid Range: 0-100%
Scaling: None

2.14 Layer 2: Percent Non-Tree Vegetation

Description: Percent of pixel covered by green vegetation not covered by tree canopy
Units: Percent cover
Data Type: Unsigned 8-bit integer
Fill Value: None
Valid Range: 0-100%
Scaling: None

2.15 Layer 3: Percent Bare Ground

Description: Percent of pixel not covered by living vegetation
Units: Percent bare ground
Data Type: Unsigned 8-bit integer
Fill Value: None
Valid Range: 0-100%
Scaling: None

3. Data Knowledge

MEaSURES VCF version 1.0 has only 3 data layers. Future versions will contain additional data layers (evergreen/deciduous tree cover, broadleaf/needleleaf tree cover) and quality layers.

The water mask was aggregated from 30m x 30m to 0.05 degree x 0.05 degree to derive percent water cover. The VCF values of all pure water pixels (defined as >= 95% water coverage) were set to zero [Hansen et al. 2013].

*Data from years 1981, 1994, and 2000 were excluded due to lack of data in the Long Term Data Record (LTDR) v4.

4. Examples of Application

Fractional vegetation cover products have widespread applicability to Earth science research communities. They have been used as input in the creation of 30m resolution tree cover products from Landsat data [Sexton et al. 2013; Hansen et al. 2013], which provide the ability to monitor deforestation and forest degradation in a consistent manner globally [Kim et al. 2014, 2015; Hansen et al. 2008, 2013]. They are being used to parameterize climate, carbon and land surface models [Lawrence and Chase 2007; Tian et al. 2004; Jung et al. 2006], and determine biomass and forest structure [Cartus et al. 2011; Lefsky 2010]. Studies of fire occurrence [Giglio et al. 2006; Wiedinmyer et al. 2006], ecosystem functioning [Nightingale et al. 2011; Villagra 2009], biodiversity [Coops et al. 2009; Hernandez et al. 2008], conservation [Sexton et al. 2013; DeFries et al. 2005], and public health [Calhoon 2013; Cecchi et al. 2008] depend on fractional vegetation cover products as fundamental input data.

5. Applicable Data Tools & Access Options

The MEaSURES VCF products can be opened, viewed and manipulated by most image processing software including ArcGIS, ENVI, QuantumGIS, PCI Geomatica, R and Matlab.

The following tools offer options to search the LP DAAC data holdings and provide access to the data:

Bulk download: LP DAAC Data Pool and DAAC2Disk

Search and browse: NASA Earthdata Search

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7. Citations

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