Vegetation Earth System Data Record from DSCOVR EPIC Observation: Product Description and Analyses

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Abstract

The NASA's Earth Polychromatic Imaging Camera (EPIC) onboard NOAA's Deep Space Climate Observatory (DSCOVR) mission was launched on February 11, 2015 to the Sun-Earth Lagrangian L1 point where it began to collect radiance data of the entire sunlit Earth every 65 to 110 min in June 2015. It provides imageries in near backscattering directions at ten ultraviolet to near infrared narrow spectral bands. The DSCOVR EPIC science product suite includes vegetation Earth System Data Record (VESDR) that provides leaf area index (LAI) and diurnal courses of normalized difference vegetation index (NDVI), sunlit LAI (SLAI), fraction of incident photosynthetically active radiation (FPAR) and Directional Area Scattering Function (DASF). The parameters at 10 km sinusoidal grid and 65 to 110 minute temporal frequency generated from the upstream DSCOVR EPIC BRF product are available from the NASA Langley Atmospheric Science Data Center. Whereas LAI is a standard product of many satellite missions, global diurnal courses of NDVI, FPAR, SLAI and DASF are new satellite derived products. Sunlit and shaded leaves exhibit different radiative response to incident Photosynthetically Active Radiation (400-700 nm), which in turn triggers various physiological and physical processes required for the functioning of plants. LAI, SLAI and FPAR are key state parameters in most ecosystem productivity models and carbon/nitrogen cycle. DASF provides information critical to accounting for structural contributions to measurements of leaf biochemistry from remote sensing. This poster provides an overview of the EPIC VESDR research. This includes a description of the algorithm and its performance, details of the product, initial assessment of its quality and obtaining new information on vegetation properties from the VESDR product.

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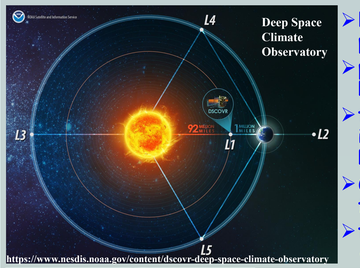
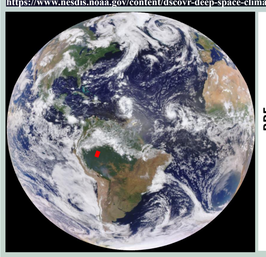
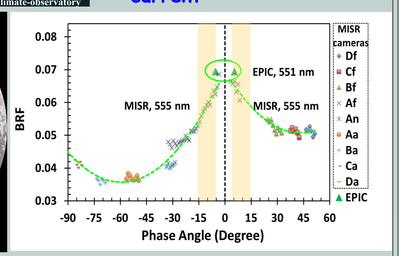
Abstract. The NASA's Earth Polychromatic Imaging Camera (EPIC) onboard NOAA's Deep Space Climate Observatory (DSCOVR) mission was launched on February 11, 2015 to the Sun-Earth Lagrangian L1 point where it began to collect radiance data of the entire sunlit Earth every 65 to 110 min in June 2015. It provides imageries in near backscattering directions at ten ultraviolet to near infrared narrow spectral bands. The DSCOVR EPIC science product suite includes vegetation Earth system data record (VESDR) that provides leaf area index (LAI) and diurnal courses of normalized difference vegetation index (NDVI), sunlit LAI (SLAI), fraction of incident photosynthetically active radiation (FPAR) absorbed by the vegetation and Directional Area Scattering Function (DASF). The parameters at 10-km sinusoidal grid and 65-110 min temporal frequency are generated from the upstream EPIC MAIAC surface reflectance product. The DSCOVR EPIC science team also provides two ancillary science data products derived from 500m MODIS land cover type 3 product: *10 km Land Cover Type* and *Distribution of Land Cover Types within 10 km EPIC pixel*. All products were released on June-7-2018 and publicly available from the NASA Langley Atmospheric Science Data Center (https://eosweb.larc.nasa.gov/project/dscovr/dscovr_epic_l2_vesdr_01). This poster presents an overview of the EPIC VESDR research, which includes descriptions of the algorithm and product, initial assessment of its quality and obtaining new information on vegetation properties from the VESDR product.

1. EARTH POLYCHROMATIC IMAGING CAMERA (EPIC)



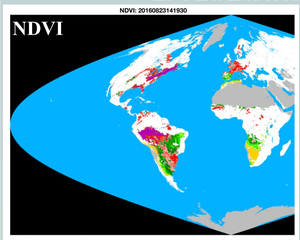
- located at Lagrangian L1 point
- provides imageries in near backscattering directions
- ten ultraviolet to near infrared narrow spectral bands
- 65 to 110 min temporal frequency
- temporal coverage:2015/06 - current





The DSCOVR EPIC sensor provides spectral imageries of the entire sunlit Earth in near backscattering directions every 65 to 110 min [1]. Its observing geometry is characterized by a nearly constant *phase angle* (angle between the directions to the Sun and sensor), making the reflectance data free of Sun-sensor bidirectional effects. *Left Panel* shows Enhanced RGB image of the sunlit face of the Earth taken at 1524:58 UTC 23 Aug 2016. *Right panel* illustrates Green BRF (551 nm) of an area in Amazonian rain forest (red circle in left panel) derived from Multiangle Imaging SpectroRadiometer (MISR) data (symbols) and EPIC (green triangles). The shaded area shows the range of phase angles of the DSCOVR EPIC sensor. Here SZA=28°±2°, local solar time=10:30am±20min. Reflectance of the vegetation reaches its maximum in the backscattering directions. This is known as the hot spot effect. The hot spot region represents the most information-rich directions in canopy reflected radiation. The uniqueness of the DSCOVR EPIC observing strategy is its ability to provide frequent observations of every region of the Earth in near hot spot directions that the existing Low-Earth-Orbiting and Geostationary satellites do not have.

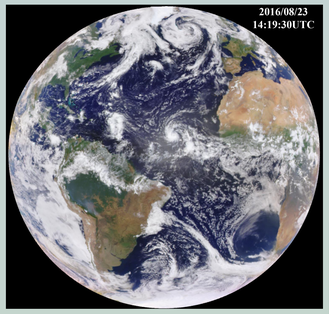
2. VEGETATION EARTH SYSTEM DATA RECORD (VESDR)



Normalized Difference Vegetation Index (NDVI): difference between Bidirectional Reflectance Factor (BRF) at 779.5 nm and 680 nm normalized by their sum

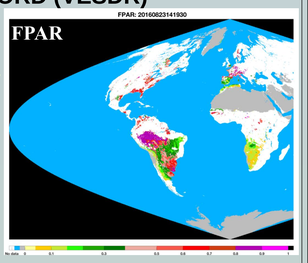
Sunlit Leaf Area Index (SLAI): leaf area illuminated by the direct solar beam per unit ground area

Spatial resolution: 10 km SIN grid
Temporal resolution: 65-110 min
Temporal coverage: 6/13/15-current
Version: 01
Maturity level: provisional
File format: HDF5



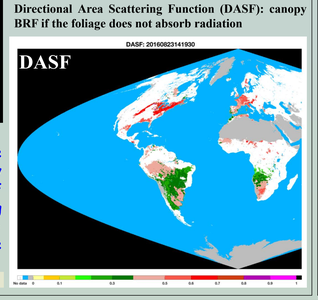
LAI, SLAI and FPAR are key state parameters in most ecosystem productivity models and carbon/nitrogen cycle. DASF provides information critical to accounting for structural contributions to measurements of leaf biochemistry from remote sensing.

A detailed VESDR product description can be found in [2]

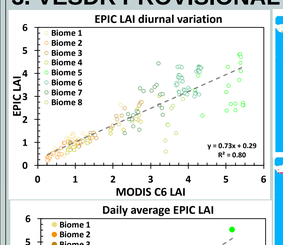


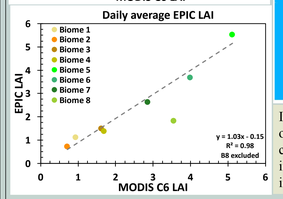
Fraction of Photosynthetically Active Radiation (400 – 700nm, FPAR) absorbed by vegetation

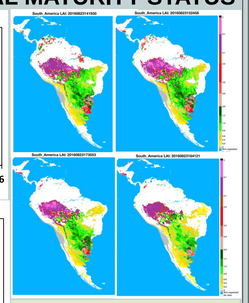
Directional Area Scattering Function (DASF): canopy BRF if the foliage does not absorb radiation



3. VESDR PROVISIONAL MATURITY STATUS







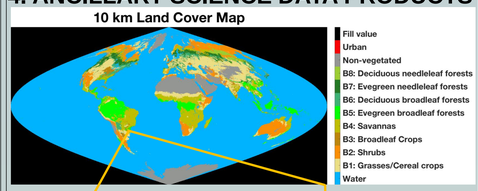
Ideally, LAI derived from multiple observations of a given area should be constant. In reality, uncertainties in input BRF introduce diurnal variation in satellite derived LAI.

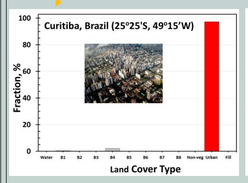
Provisional EPIC LAI for Biomes 1 to 7 agree with the MODIS LAI product to about 0.2-0.3 LAI units. EPIC LAI over Biome 8 (Deciduous needle leaf forests) under-estimates MODIS LAI.

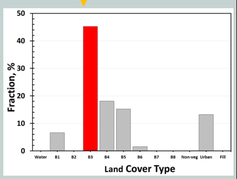
Test for the consistency of EPIC LAI with the MODIS C6 product underlay our decision to release the VESDR product at provisional maturity level, i.e.,

- ❑ limited comparisons with independent sources have been made and obvious artifacts fixed
- ❑ parameter can be used in publications as long as provisional quality is indicated
- ❑ incremental improvements are still occurring,
- ❑ validation and quality assessment are ongoing,
- ❑ may be replaced in the archive when an upgraded product becomes available

4. ANCILLARY SCIENCE DATA PRODUCTS

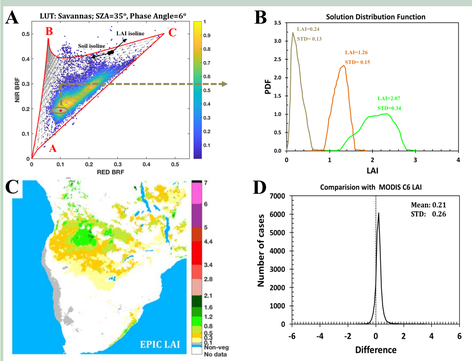






Global vegetation is stratified into eight canopy architectural types, or biomes. This classification is used by the VESDR algorithm. The DSCOVR EPIC science team provides two ancillary science data products: *10 km Land Cover Type* (upper panel) and *Distribution of Land Cover Types within 10 km EPIC pixel* (lower panel). These ancillary products were derived from 500m MODIS land cover type 3 product (MCDLCHKM), which was generated from 2008, 2009 and 2010 land cover products (MCD12Q1, v051). Details in [2].

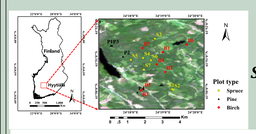
5. VESDR ALGORITHM



Schematic illustration of the VESDR algorithm. *Panel A*: LUT for savannas (isolines), SZA=35°, phase angle 6°. Also shown MAIC BRFs at red and NIR spectral bands (points) acquired on at 1208:34 Aug 13 1016 over savannas in south Africa. A point on the red-NIR plane and an area about it (an ellipse defined by a χ^2 distribution) are the measured BRF and its uncertainty. Each combination of canopy/soil parameters for which modeled reflectances belong to the ellipse is an acceptable solution. *Panel B*: Density distribution function of acceptable solutions. Shown are LAI distribution functions for three different pixels. The mean LAI and its dispersion are taken as a retrieved LAI and its precision. This technique is used to estimate mean SLAI and FPAR [4]. *Panel C*: DSCOVR EPIC LAI of savannas in southern part of Africa. *Panel D*: Difference between MODIS C6 LAI over savannas degraded to 10 km resolution and its EPIC counterpart.

The Look-up-Table approach implemented in the MODIS operational LAI/FPAR algorithm is adopted

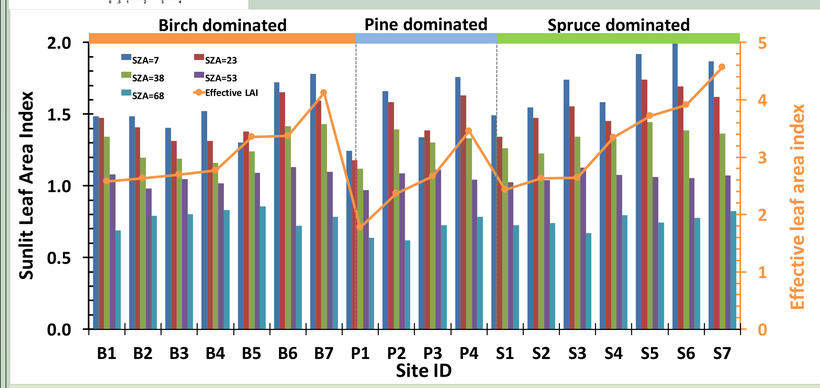
6. OBTAINING GROUND TRUTH SLAI DATA



$$SLAI = SFLA \cdot LAI = \frac{1 - t(\Omega)}{|\ln t(\Omega)|} LAI$$

- ○ *effective* Sunlit Fraction of Leaf Area (SFLA)
- ○ *effective* LAI

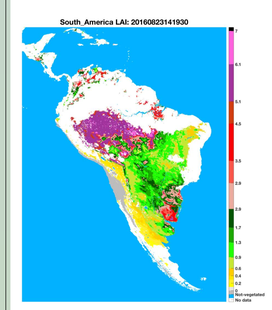
can be estimated from field measurements of canopy directional uncollided transmittance $t(\Omega)$ using LAI-2000PCA sensor [3]

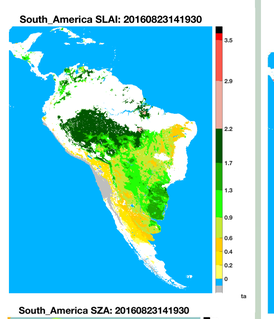


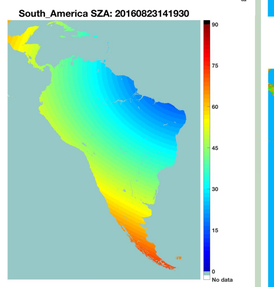
Angular profiles of SLAI (vertical axis on the left side) and effective LAI (vertical axis on the right side) for 18 sites in the Hyytiälä forest in southern boreal zone in Finland [4].

A method for obtaining ground truth SLAI and protocol for for validation of satellite derived SLAI have been developed.

7. OBTAINING NEW INFORMATION ON VEGETATION PROPERTIES FROM VESDR







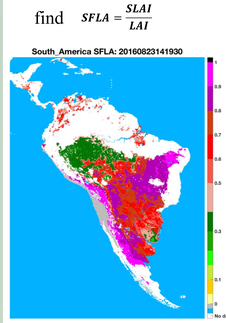
Given EPIC LAI, SLAI and SZA find

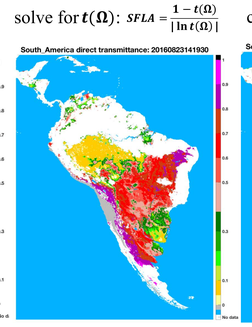
- ❑ **Canopy direct transmittance, *t***
- ❑ **Fractional Vegetation Cover**
- ❑ **Clumping Index (CI)**

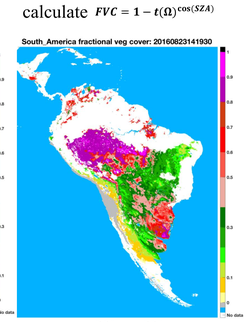
find $SFLA = \frac{SLAI}{LAI}$

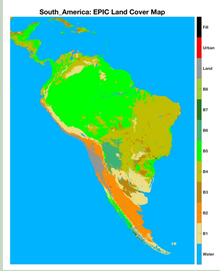
solve for $t(\Omega)$: $SFLA = \frac{1 - t(\Omega)}{|\ln t(\Omega)|}$

calculate $FVC = 1 - t(\Omega)^{\cos(SZA)}$

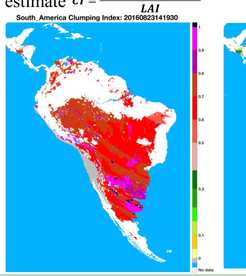




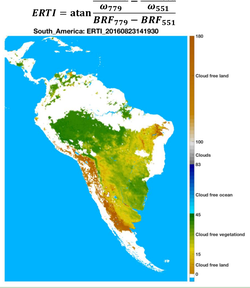




estimate $CI = \frac{2|\ln t(\Omega)|\cos(SZA)}{LAI}$



$$ERTI = \operatorname{atan}\frac{\frac{BRF_{779} - BRF_{551}}{\omega_{779} - \omega_{551}}}{BRF_{779} - BRF_{551}}$$



Details can be found in [2]

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