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Vegetation hot spot signatures from synergy of DSCOVR EPIC, Terra MISR, MODIS and geostationary sensors

Vegetation Hot Spot Signatures from Synergy of DSCOVR EPIC, Terra MISR, MODIS Sensors

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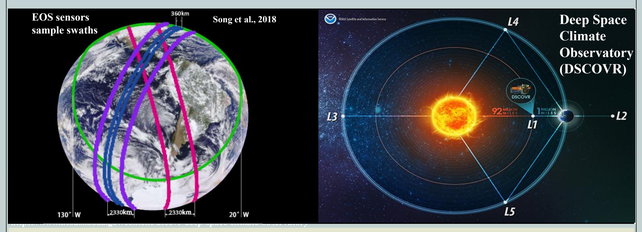
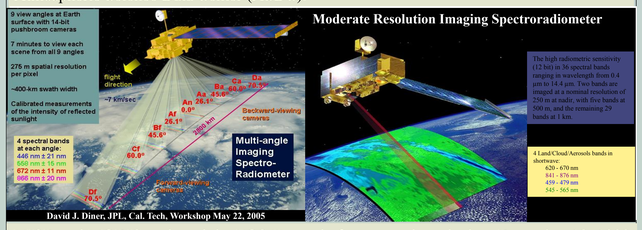
Abstract. It has been widely recognized that the hotspot region in Bidirectional Reflectance Factors (BRF) of vegetated surfaces represents the most information-rich directions in the directional distribution of canopy reflected radiation. The hotspot effect is strongly correlated with canopy architectural parameters such as foliage size and shape, crown geometry and within-crown foliage arrangement, leaf area index and its sunlit fraction. Here we present a new methodology that synergistically incorporate features of Terra Multi-angle Imaging SpectroRadiometer (MISR) and Moderate Resolution Imaging Spectroradiometer (MODIS), Earth Polychromatic Imaging Camera (EPIC) onboard the Deep Space Climate Observatory (DSCOVR) and results in a new type of hot spot signatures that maximally sensitive to vegetation changes. We discuss a physical basis for the synergy of multi-sensor data. Four areas that include Amazon Evergreen Broadleaf Forest, New England Deciduous Broadleaf Forest, Crixas Savannas and Heihe River Basin Grassland were selected to generate angular signatures of different land cover types for the period of concurrent Terra/DSCOVR observations. We discuss value of the hot spot signatures for monitoring changes in vegetated land through analyses of variations in magnitude and shape of angular distribution of canopy reflected radiation.

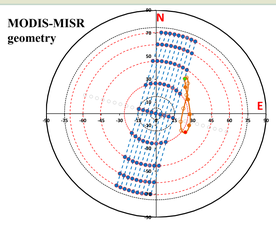
1. INTRODUCTION



EPIC on board DSCOVR mission was launched on February 11, 2015 to an orbit near the Sun-Earth L1 point where it started to obtain images in near backscattering directions in June 2015 from each of its 10 ultraviolet to near infrared (NIR) channels every 65 to 110 minutes. EPIC MAIAC surface reflectance product is available from the NASA Langley Atmospheric Science Data Center (ASDC).

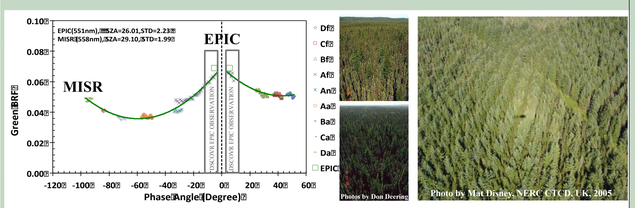


MISR and MODIS on board the EOS Terra platform were launched on December 18, 1999 to sun-synchronous polar. MISR obtains calibrated images in 4 spectral bands at each of 9 angles at 1.1 km resolution. MODIS provides calibrated images in 36 spectral bands at 250 m ~ 1 km resolution at nadir. MISR land surface BRF (MIL2ASLS) dataset is available from the ASDC and MODIS daily land surface reflectance product (MOD09GA) is distributed from the Level-2 and Atmosphere Archive & Distribution System (LAADS) Distributed Active Archive Center (DAAC).



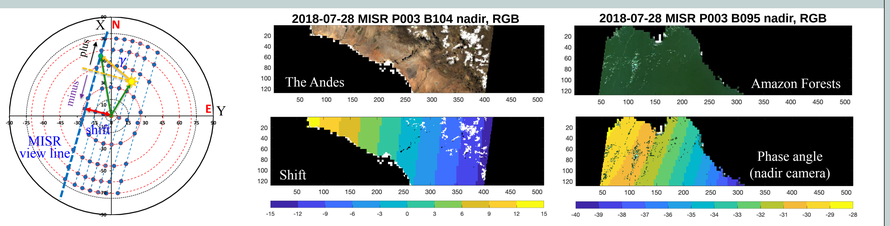
- MISR samples imageries at nine view angles (nadir, ± 26.1°, ± 45.6°, ±60.0° and ±70.5°) in the along-track direction with 360 km swath width;
- MODIS samples imageries at nadir in the across-track direction with 2330 km swath width.

2. ANGULAR SIGNATURES

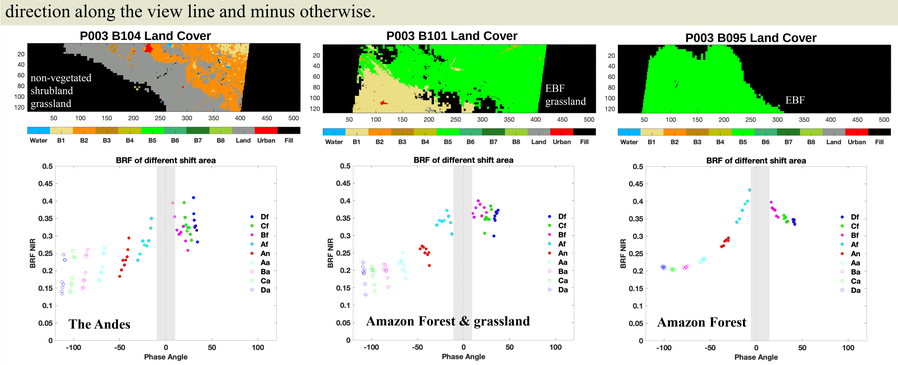


- sunlit and shaded leaves (e.g. DSCOVR EPIC SLAI)
- shaded leaves
- foliage size (e.g. hot spot width) and shape
- crown geometry and within-crown foliage arrangement
- leaf physiology

3. PARAMETERIZATION OF MISR BRF

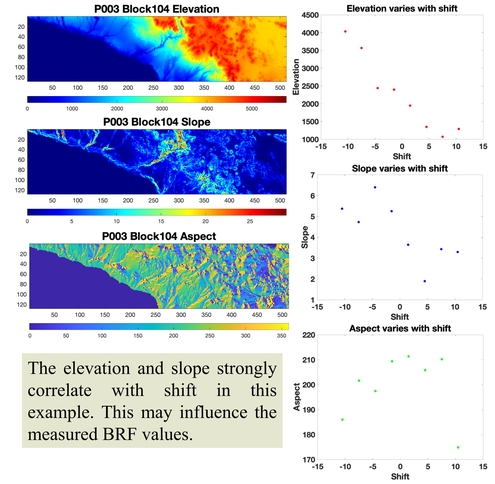


For a given pixel, MISR viewing directions projected on the XY plane form a line, called 'MISR view line'. The distance between MISR view line and nadir position, called '**shift**'.
The **phase angle** γ is the angle between the directions to the Sun and sensor. We assign the sign 'plus' to γ in forward direction along the view line and minus otherwise.

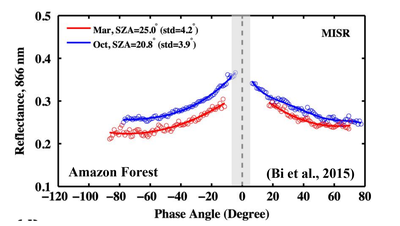


Left: angular signature of near-infrared BRF of Andes mountains, which represent a heterogeneous surface. BRF exhibits a very strong response to small variation in phase angle. *Middle:* angular signature of Amazon Forest and grassland. Magnitudes of variation around different phase angles are smaller, suggesting a smoother surface. *Right:* angular signature of a structurally homogeneous area in Amazon Forest. BRF is a smooth function with respect to the phase angle.

- Angular signature provides information on land surface heterogeneity;
- EPIC data is needed to extend MISR observations into hot spot region.



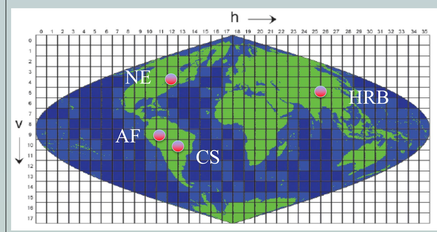
The elevation and slope strongly correlate with shift in this example. This may influence the measured BRF values.



Seasonal changes in angular signatures of canopy near-infrared reflectance from MISR under similar sun-sensor geometries.

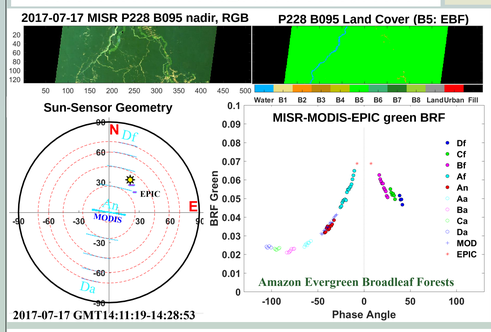
- Angular signature provides information on canopy structure properties;
- BRF varies with shifts, which represent different locations within MISR image. Variations are caused by landcover type, elevation, terrain slope and aspect.

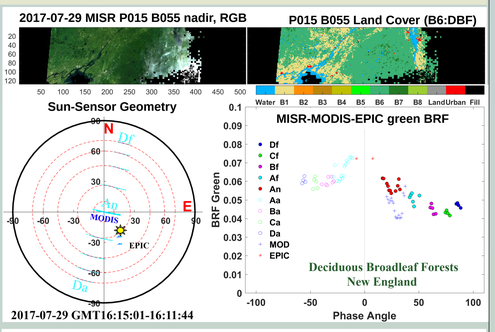
4. FOUR BIOME TYPE BRF ANGULAR SINGNATURE

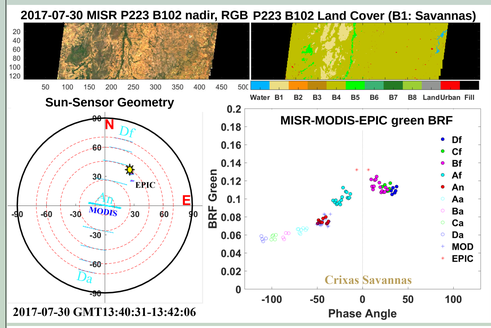


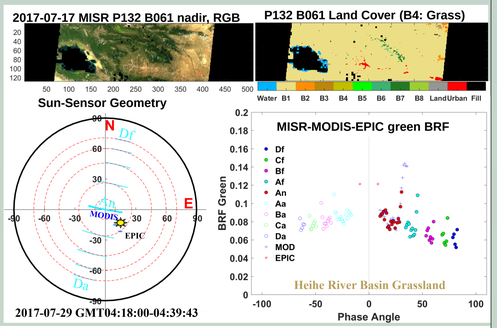
Study sites	Date	MISR Path
Amazon Evergreen Broadleaf Forest (AF)	July-17-2017	P228 B095
New England Deciduous Broadleaf Forest (NE)	July-29-2017	P015 B055
Crixas Savannas(CS)	July-30-2017	P223 B102
Heihe River Basin (HRB)	July-17-2017	P132 B061

Synergy MISR, MODIS and EPIC observation datasets are projected to WGS-84 Geographical Lat/Lon Coordinate System at 0.01° resolution grid.









- Similar sun-sensor geometry in AF and CS (left panel), angular signature depend on land cover type;
- AF and CS (left panel) are more homogeneous compared to NE and HRB (right panel), the BRF angular signatures of AF and CS are smoother than that of NE and HRB ;
- MODIS BRF agrees well with MISR An camera since the sun-sensor geometries are the same;
- EPIC data can be used to extend MISR and MODIS reflectance into hot spot region in the case of structurally homogeneous surfaces.

5. KEY POINTS

I. develop a new methodology that synergistically incorporates features of MISR, MODIS and DSCOVR EPIC observation geometries and results in a new type of angular signatures that maximally sensitive to vegetation changes;
II. generate BRF angular signatures of different land cover types globally for the period of concurrent Terra and DSCOVR data;
III. demonstrate the value of angular signature for monitoring changes and biophysical processes in tropical and boreal forests.

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