How Universal Is the Relationship between Remotely Sensed Vegetation Indices (VI) and Crop Leaf Area Index (LAI)?

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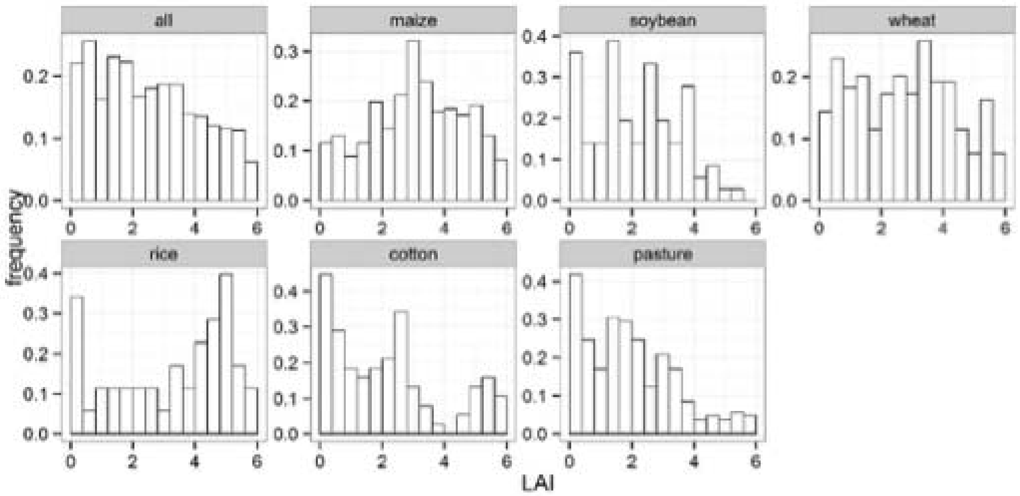

Figure 1

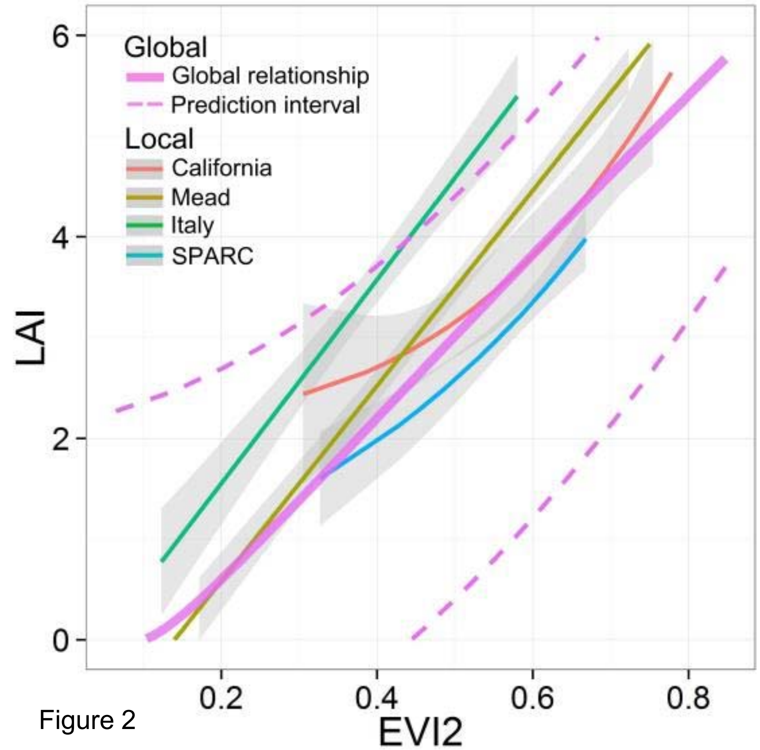

Figure 2

Global LAI-VI relationships are statistically significant, crop-specific, and mostly non-linear. This research enables the operationalization of large-area crop modeling and, by extension, has relevance to both fundamental and applied agroecosystem research.

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References:

Kang Y., Özdoğan M., Zipper S., M. O. Román, et al., **How Universal Is the Relationship between Remotely Sensed Vegetation Indices and Crop Leaf Area Index? A Global Assessment**, *MDPI Remote Sensing, doi:10.3390/rs8070597*

Data Sources: A global dataset of 1,459 quality-controlled in-situ crop Leaf Area Index (LAI) measurements were combined with Landsat TM/ETM+ satellite images to derive statistical relationships between LAI and five different Vegetation Indexes (VI), including Simple Ratio (SR), Normalized Difference Vegetation Index (NDVI), two versions of the Enhanced Vegetation Index (EVI and EVI2), and Green Chlorophyll Index (CI_{Green}). We also used the MODIS Collection V005 Nadir BRDF-adjusted reflectance (NBAR) product (MCD43A4) to produce LAI maps using the global LAI-VI relationships. Landsat products were downloaded from USGS Global Visualization Viewer (Glovis) website (http://glovis.usgs.gov). MODIS products were downloaded from the NASA Level 1 and Atmosphere Archive and Distribution System (LAADS) website (https://ladsweb.nascom.nasa.gov/).

Technical Description of Figures:

Figure 1: Frequency distribution of the global in-situ LAI dataset organized by crop types. The distribution of LAI values is positively skewed. Each crop type has a full range of LAI values (from less than 0.12 to more than 5.5 m^2/m^2), which nevertheless distribute differently. The distribution for maize is approximately unimodal, with a peak in the middle (~3 m^2/m^2), and the distribution for pasture is positively skewed. For soybean, wheat, rice, and cotton, the distribution is not as clear or in some cases multimodal.

Figure 2: Local LAI-EVI2 relationships of maize for four major sites compared to the global maize relationship. The thin colored lines are the best-fit functions for each site. The thick solid rose-colored line refers to the global relationship, with dashed rose line being the prediction interval. Gray shaded areas are the 95% confidence intervals. The trend of site-specific relationships are similar to the global relationship, but each relationship has a unique shape and location in the LAI-EVI2 space, leading to bias when using one curve in a different location.

Scientific significance, societal relevance, and relationships to future missions: This work is the first to compile a large dataset of crop LAI and VIs, and analyze the universality and diversity of the LAI-VI relationships globally. These findings not only support the Committee on Earth Observation Satellite's Land Product Validation framework for the validation of remote sensing LAI products, but also contribute to a greater community of users that are interested in producing long time series of LAI records; but do not have access to measured LAI data. The global LAI-VI relationships support the production of large scale fine resolution (30m) LAI maps, which are essential for agricultural applications, especially in regions where crop fields are relatively small. With the successful launch and operation of Landsat-8 and Sentinel-2 satellites, this synthesis can serve as a model for the assessment of terrestrial essential climate variables and key biospherical processes happening at the characteristic scales of vegetation change (e.g., above ground biomass, primary production (NPP), evapotranspiration, and crop yields). The easy accessibility, low cost, and the long historical coverage and continuity of the Landsat-8 and Sentinel-2 missions also render our findings useful to future scientific, governmental, and commercial applications. Finally, as more and more medium to high resolution sensors become available with additional narrow spectral bands (e.g., FLEX and HyspIRI), i.e., the red edge band, great opportunities exists to establish efficient models for global LAI estimation with various hyperspectral VIs.