Multi-sensor Translation of EOS Vegetation Index Products

Performance Evaluation of the "Isoline-based" Translation Technique

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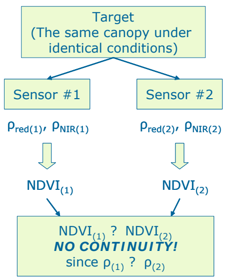
Introduction

- Long-term vegetation index (VI) as well as reflectance time series data sets, starting with AVHRR and now transitioning to MODIS, are of particular importance for monitoring ecosystem variability and response to seasonal and inter-annual environmental changes.
- Inter-sensor VI continuity is a critical and complicated issue due to different sensor characteristics and product generation algorithms (e.g., spectral bandpass filters, atmospheric correction schemes, compositing algorithms), requirements that need to be addressed.
- This poster highlights the latest development in our multi-sensor translation work.

Definition of VI Continuity

- The sensor characteristics and algorithms differences lead to the reflectance values obtained from two sensors not the same, resulting in dissimilar VI values (discontinuity).
- We define VI continuity as follows, which will be used as a measure of success throughout the project:

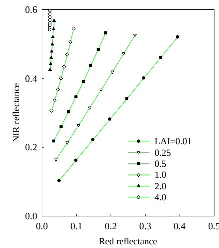
A VI is continuous if the VI values computed from the reflectance data produced by the two different sensors become the same for the same target under identical conditions.



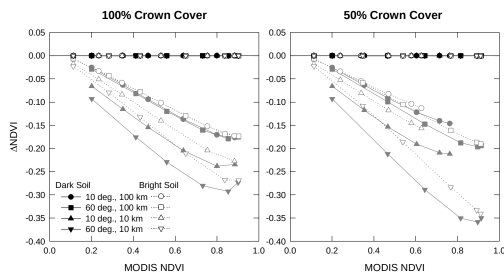
Discontinuation of the NDVI between two sensors.

Isoline-based Translation Approach

- Our approach is based on a theoretical justification of the existence of a functional form inter-relating VIs from two sensors, which has been derived using the "vegetation isoline" concept.
- The vegetation isoline consists of the canopy reflectance points (e.g., a pair of red and NIR reflectance) obtained by changing the optical properties of the canopy background materials with a constant biophysical condition for constant external conditions.
- The "exactness" of the translation results with this technique is demonstrated using a simulation data set for the AVHRR vs. MODIS NDVI (see the figure below). Note that the exact translation was possible because all the canopy and atmospheric parameters were known in this example.
- Our challenge is to derive a practical methodology of translating reflectance and VIs from this theory.



Plot of the canopy reflectance points simulated with the SAIL model for various LAI and soil reflectance. The vegetation isolines are shown in green color.



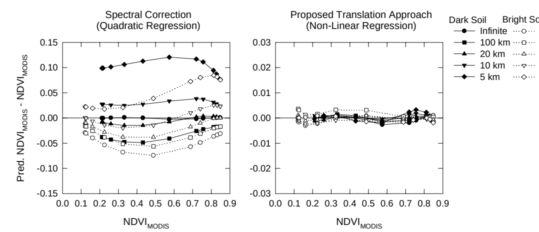
AVHRR and MODIS NDVI differences plotted against MODIS NDVI. The data were simulated using the GeoSAIL model with the tissue optical data set collected by the BOREAS TE-12 team (E. A. Walter-Shea, M.A. Mesarch, and L. Chen at the University of Nebraska-Lincoln) and the "6S" atmospheric model.

Approximation to the Isoline Equation

- An analytical expression inter-relating two vegetation indices (VIs) from two different sensors, v_1 and v_2, can be derived by applying the vegetation isoline concepts (equations) (Yoshioka et al., 2006):

$$v_1 = \frac{h_{11}v_2 - h_{12}}{h_{21}v_2 - h_{22}}$$

- The four coefficients, h_{ij}, vary with canopy, soil, and atmosphere conditions.
- We examined various functional forms to approximate the isoline-based translation equation, i.e., the h_{ij} functions.
- The results showed that a polynomial approximation to the h_{ij} functions, in which the Soil-Adjusted Vegetation Index (SAVI) and aerosol optical thickness (AOT) were used as predictor variables, performed well.



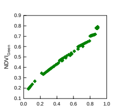
Comparison of two NDVI-to-NDVI translation techniques where NOAA-14 AVHRR NDVI was translated to MODIS NDVI-equivalent. The plot on the left hand side is the results of applying the "spectral correction (quadratic function)" method (Trishchenko et al. 2002), whereas the plot on the right hand side is the results obtained by applying our translation technique.

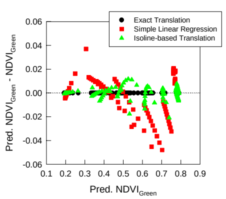
Performance Evaluation Results

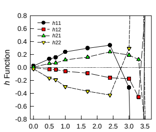
Cotton Experimental Data

An initial performance evaluation was conducted with the cotton data, in which two NDVI's (red & NIR, green & NIR) were translated.

Relationship between the red-based and green-based NDVI







h function values plotted against LAI

Translation Algorithm	RMSE (NDVI Unit)
Exact Translation	< 0.001
Linear Regression	0.018
Isoline-Based	0.005

MODIS, AVHRR, VEGETATION over EOS Validation Core Sites

The approximated form and calibration procedure of the isoline-based technique was applied to "real" satellite observations over the EOS validation core sites. We also applied simple linear regression to translate VI values and compared the results with the isoline-based translation results.

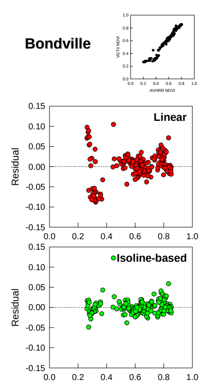
Data Sets Used

NOAA-14 AVHRR (Daily)
-. April 1, 1998 – March 31, 1999

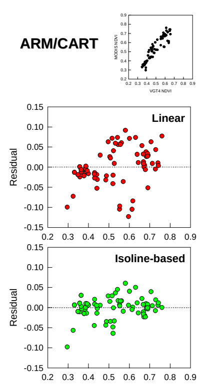
SPOT-4 VEGETATION (10-days)
-. Apr 1, 1998 – Mar 31, 1999
-. Jan 1, 2002 – Dec 31, 2002

Terra MODIS (Daily)
-. Jan 1, 2002 – Dec 31, 2002

AVHRR to VEGETATION Translation Results



VEGETATION to MODIS Translation Results

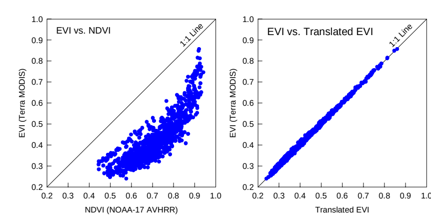


Site Name	VGT4 vs. AVH14		MOD vs. VGT4	
	Lin	*ISO*	*Lin*	*ISO*
ARM/CART Ponca			.045	.026
ARM/CART SGP	.028	.020		
ARM/CART Shidler	.033	.024		
BARC USDA-ARS	.040	.034	.040	.029
Bondville	.033	.016	.101	.029
Cascades			.091	.088
Old Pine	.044	.039	.083	.078
Young Pine	.039	.031	.076	.066
HJ Andrews	.040	.029		
Harvard	.031	.020		
Walker Branch	.064	.055	.030	.025
Konza	.033	.028		
San Pedro	.026	.023	.031	.023
Sevilleta	.028	.023	.030	.026
Jornada	.018	.012	.029	.028

The isoline approach resulted in a 10-50% reduction in variability. It was also felt that the isoline approach was less prone to bias errors.

Backward Compatibility of the Enhance Vegetation Index (EVI)

The "vegetation isoline" technique can also be applied to inter-relating two different VI formulas, i.e., NDVI to EVI.



Results of the NDVI-to-EVI translation via a non-linear regression approach (approximation to the isoline-based translation equation). The data used here were simulated using the SAIL2 model (Braswell et al. 1996) constrained with in situ measured parameter values for a tropical forest in Hawaii (Suzuki et al, 2006). Every parameter was varied within a range observed in a field randomly to generate the data set.

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