

MODIS Science Team Meeting

Silver spring, MD. May 7-9, 2012

MODIS VI Product Suite Status & the VIP Data Explorer 30 Years of VI and Phenology Observations

Kamel Didan, et al.

The University of Arizona



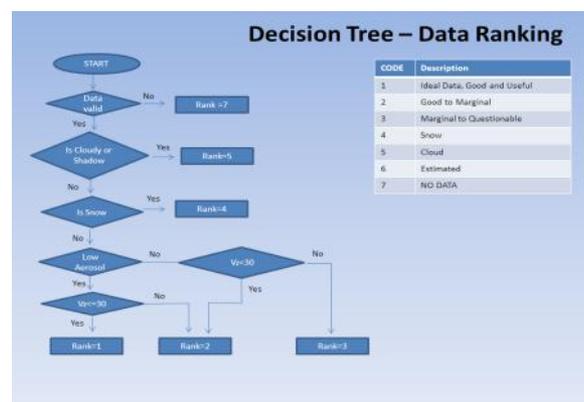
MODIS VI Product Suite Status

- All work is PI SCF facility based
 1. Improved Filtering
 - Based on data ranking
 - And long term confidence interval (to eliminate residual noise)
 2. Adoption of EVI2 for forward and backward compatibility
 - A full EVI2 MODIS record is now available (at CMG resolution)
 3. Development of a new “First good observation” compositing scheme to generate quasi-daily Vegetation Index data in support of phenology and fast change detection
 4. Initiated the “Error and Uncertainty” analysis of the MODIS VI data record
 5. Planning a reanalysis of the full Terra and Aqua MODIS VI Data records

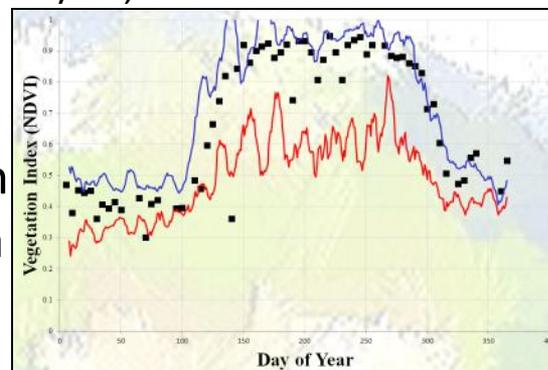
Improved Filtering

The objective is to help eliminate poor quality data and noise

- Based on Pixel QA ranking
 - Simplify post-processing
 - Categorize the data
 - Automate data filtering



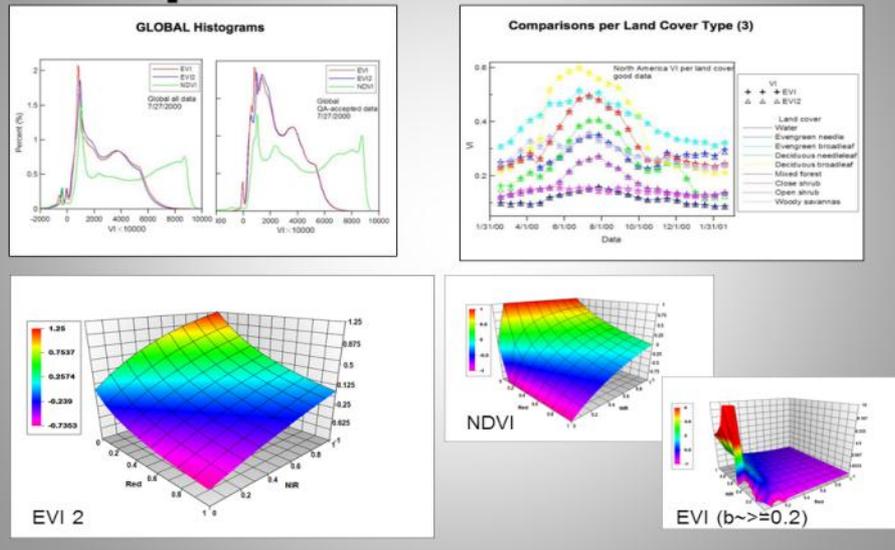
- Long term confidence interval
 - Lots of QA errors, especially with clouds, snow/ice, and aerosols
 - Mislabeling
 - Residual noise
- In combination, filtering and long term help address residual noise in the data



EVI₂ : Forward and backward compatibility with all sensors

- A full EVI₂ MODIS record is now available (at CMG resolution)
 - Improved performance over partial cloud, snow/ice, and heavy aerosol

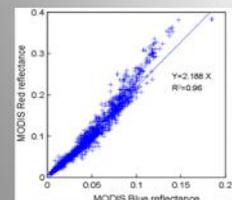
EVI₂ performance



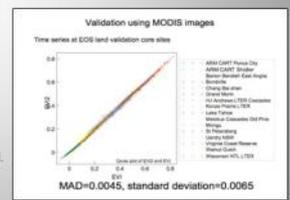
Backward compatible EVI₂ Algorithm

- From a 3-band blue dependent EVI to a 2-band universal EVI
 - Blue band in EVI provides additional atmosphere resistance and no biophysical information
 - But no blue band for backward compatibility

$$EVI = 2.5 \frac{N-R}{1+N+6R-7.5B} \xrightarrow[\text{Under condition } MAD = \sum_{i=1}^n |EVI_i - EVI2_i|]{\text{Backward compatible EVI algorithm}} EVI2 = 2.5 \frac{N-R}{1+N+(6-7.5/\epsilon)R}$$



This linear relation breaks over noisy data and/or over snow/ice, which are filtered.



Jiang, Huete, Didan, & Miura, RSE (2008)

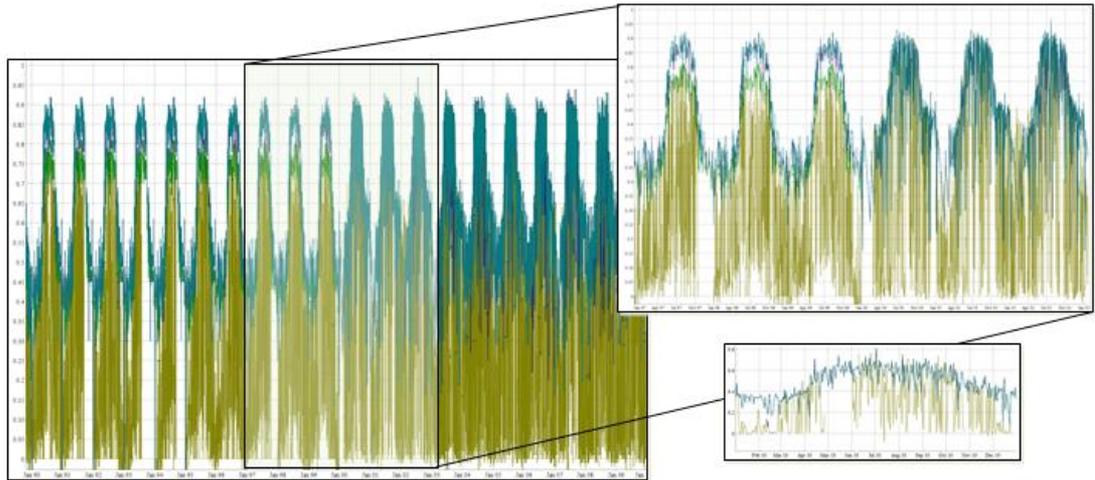
First good observation compositing

Aims at generating quasi-daily Vegetation Index in support of phenology and fast change detection.

- For each pixel retain any observation that passes the quality filter
 - Eliminate useless data (required by the compositing interval)
 - Focus on high quality data where and when it is available
 - Eliminate much of the required post-processing and generate only useful data
 - We currently implemented this compositing scheme to the full MODIS CMG VI record (available at our DataExplorer system)
 - **Next** : Implement this compositing scheme to the 1km resolution products record. The 250m & 500m may be implemented to NA only (disk space limitations)

VI Record Error and Uncertainty

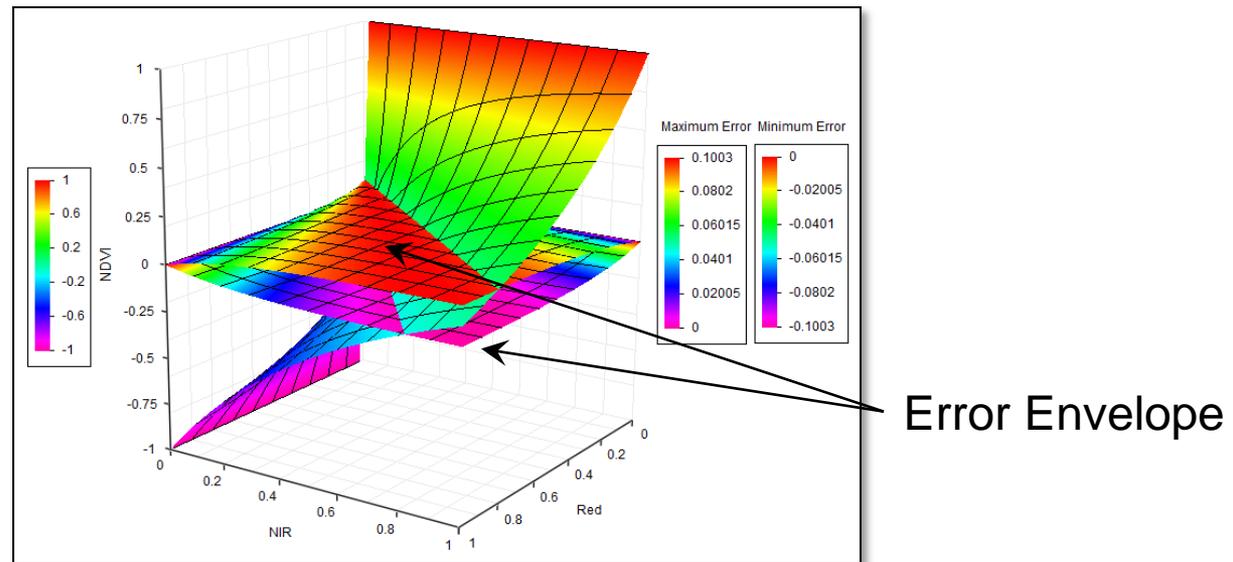
- Aims at Understanding and analyzing the VI associated error and uncertainty
- Focuses on the Input and Noise related error at this stage
 - Problem statement



NDVI Time Series [Woodstock Valley, CT]. A close-up of the same site 1997-2003 and a single year profile, all showing the prevalence of random noise in the data. This error is as wide as the full dynamic range, with serious implications on research and the subsequent phenology derivation. The different color graphs correspond to different levels of processing.

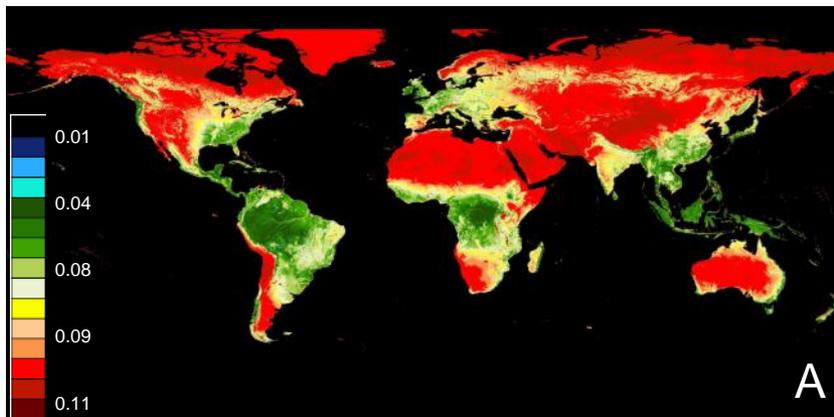
Error and Uncertainty – Simulated Input Error

- The Error/Uncertainty in the input data (surface reflectance), that is due to processing and sensor characteristics (ex: lack of or incomplete atmosphere correction, calibration, geolocation, etc...) are propagated to the VI records.
- To assess the impact of this error on the VI record we simulated an error of +/-10% in either of the surface reflectance (Red, NIR) and estimated the impact on the VI values.

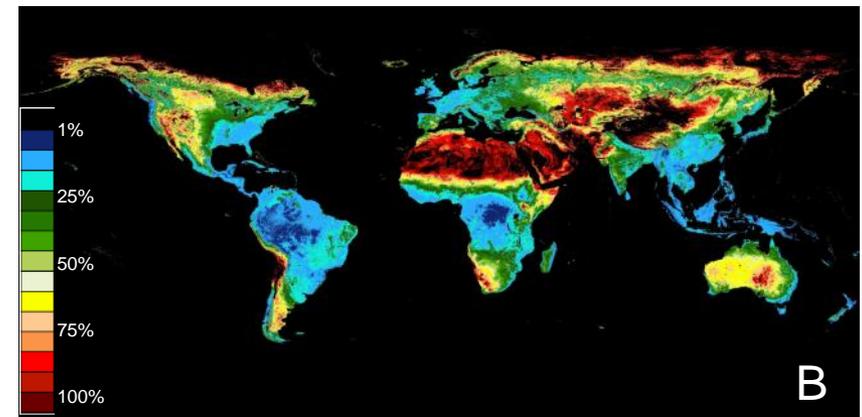


Error and Uncertainty – Input related

- *The Surface Reflectance Error impact on the NDVI.*
 - *Translate the error (from previous analysis) into the summer peak VI values*
 - *Absolute VI error (A): It is interesting to notice that the error is largest over less vegetated areas (.11 or 100%) and least over densely vegetated areas (.01 or 5%).*
 - *Similarly, the relative error (B) is largest over sparsely vegetated areas and smallest over dense biomes*



Absolute VI error

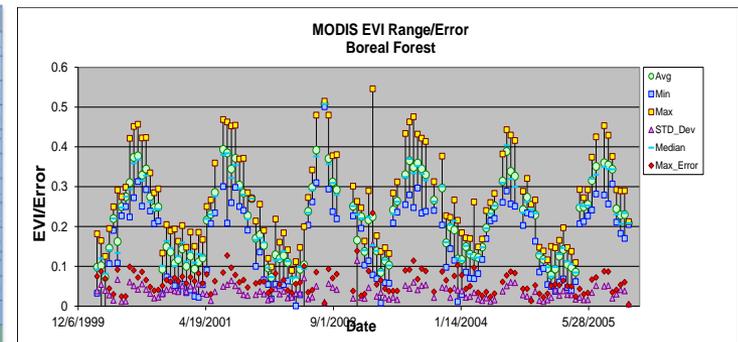


Relative VI error

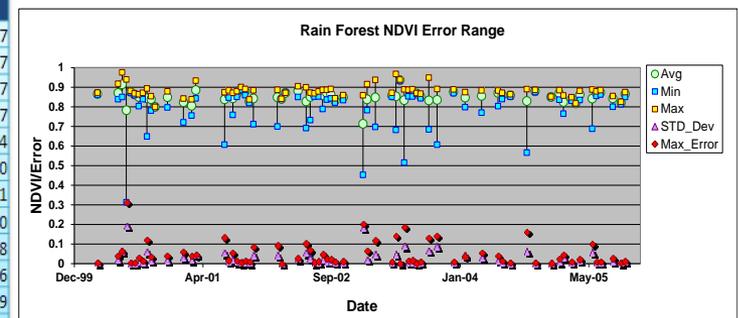
Random/Noise related Error and Uncertainty

- The table below summarize the random/noise error for few land cover classes/sites.
- The global relative error was about 5-6% for NDVI & EVI/EVI2 respectively

Site (NDVI)	Avg	Min	Max	Range	Abs_Error	STD_Dev	Median	Max_Error	Percent_Max_Err
Rain Forest	0.852	0.786	0.881	0.099	9.883	0.027	0.858	0.049	4.94
Desert	0.106	0.103	0.109	0.007	0.650	0.002	0.106	0.003	0.33
Cascades NL	0.832	0.661	0.901	0.242	24.243	0.073	0.860	0.121	12.12
SantaRita	0.408	0.344	0.480	0.136	13.589	0.036	0.407	0.068	6.79
Jornada_Grassland	0.194	0.180	0.211	0.033	3.339	0.010	0.194	0.017	1.67
Beltsville_ARC_MD	0.639	0.553	0.729	0.179	17.896	0.049	0.637	0.089	8.95
CASCADES_Andrews	0.803	0.618	0.874	0.261	26.077	0.079	0.833	0.130	13.04
Harvard_Forest	0.682	0.611	0.738	0.132	13.235	0.040	0.685	0.066	6.62
Konza	0.476	0.413	0.531	0.119	11.915	0.033	0.480	0.060	5.96
White_Sands	0.047	0.039	0.055	0.019	1.943	0.007	0.048	0.010	0.97
Santarem_Pasture	0.758	0.590	0.846	0.282	28.188	0.100	0.783	0.141	14.09
Mongu_Zambia	0.531	0.473	0.611	0.141	14.064	0.034	0.528	0.070	7.03
Global Average	0.467	0.391	0.519	0.133	13.257	0.039	0.474	0.066	6.63
	Avg	Min	Max	Range	Abs_Error	STD_Dev	Median	Max_Error	Percent_Max_Err

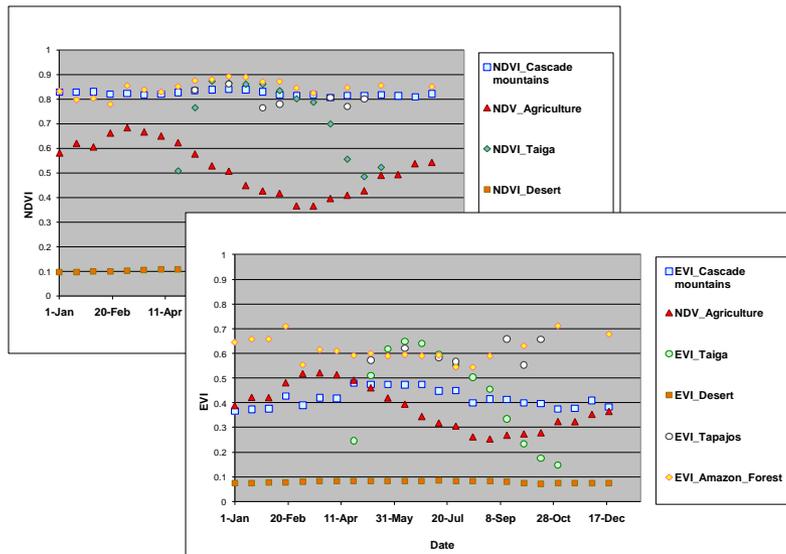


Site (EVI2)	Avg	Min	Max	Range	Abs_Error	STD_Dev	Median	Max_Error	Percent_Max_Err
Rain Forest	0.523	0.480	0.566	0.089	8.941	0.026	0.523	0.045	4.47
Desert	0.087	0.084	0.089	0.005	0.546	0.002	0.087	0.003	0.27
Cascades NL	0.357	0.250	0.482	0.233	23.333	0.063	0.358	0.117	11.67
SanatRita	0.198	0.167	0.236	0.069	6.933	0.019	0.197	0.035	3.47
Jornada_Grassland	0.128	0.116	0.139	0.025	2.479	0.007	0.128	0.012	1.24
Beltsville_ARC_MD	0.367	0.313	0.423	0.112	11.195	0.032	0.365	0.056	5.60
CASCADES_Andrews	0.337	0.222	0.439	0.220	22.015	0.060	0.344	0.110	11.01
Harvard_Forest	0.407	0.348	0.463	0.120	12.000	0.033	0.407	0.060	6.00
Konza	0.286	0.241	0.329	0.090	8.953	0.024	0.288	0.045	4.48
White_Sands	0.077	0.066	0.086	0.025	2.520	0.010	0.077	0.013	1.26
Santarem_Pasture	0.511	0.401	0.598	0.218	21.782	0.072	0.518	0.109	10.89
Mongu_Zambia	0.320	0.281	0.364	0.084	8.414	0.021	0.320	0.042	4.21
Global Average	0.270	0.220	0.318	0.101	10.138	0.029	0.272	0.051	5.069
	Avg	Min	Max	Range	Abs_Error	STD_Dev	Median	Max_Error	Percent_Max_Err

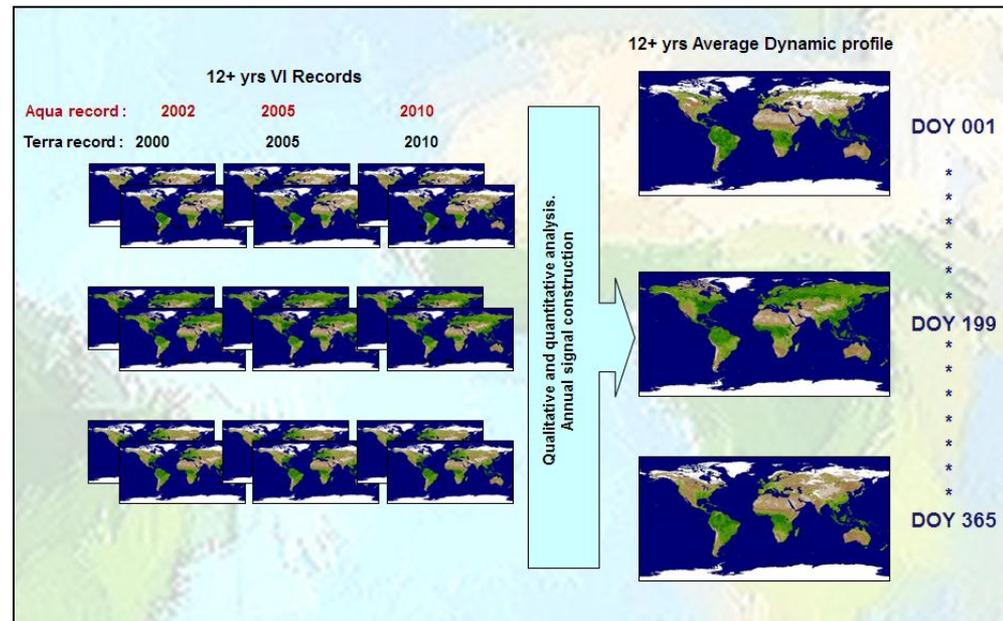


Reanalysis of the full MODIS VI record

- Aims at generating three reference data sets in support of VI-based global research
 - A Global Long Term (multi-year) Average VI record
 - Helps with change and anomaly detection (base signal)
 - A reference Phenology data set
 - Based on the long term average VI record from above
 - Establish an Max-Min VI Envelope
 - Establish the Global VI dynamic range



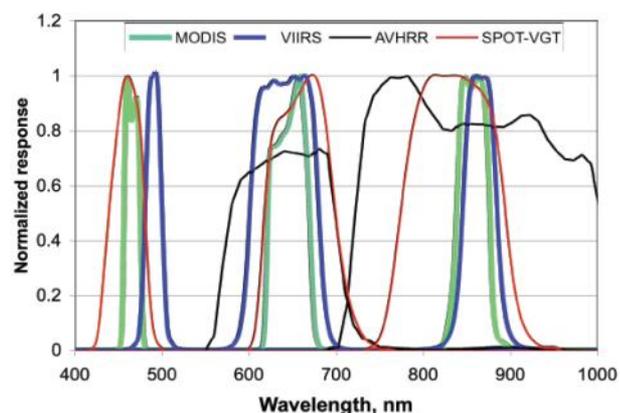
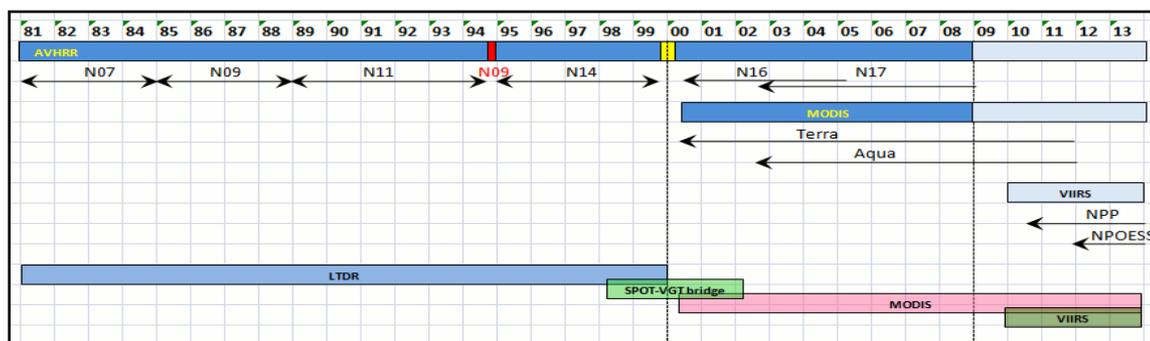
Hi-fidelity long term VI profiles



The VIP Effort

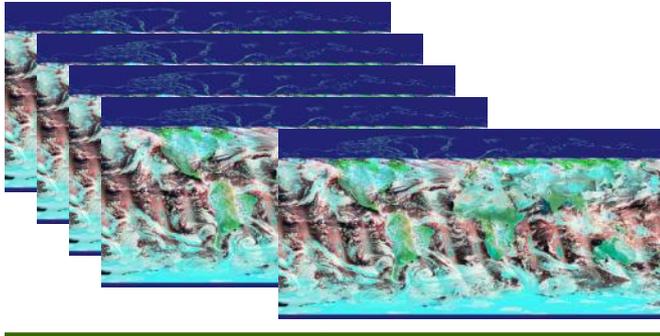
Project Objectives

- Create a long term data record (30+ yrs, '81+)
- NDVI + Backward compatible EVI (EVI2) (Resistance to background and atmosphere noise, no saturation over high biomass (High-C), strong correlation with canopy structure (Phenology), highly correlated with flux tower photosynthesis (GPP) in both tropical and temperate ecosystems at seasonal scales, widely and successfully used and adopted)
 - Independent of sensor (Seamless) and focused on consistency
 - Derive phenology metrics

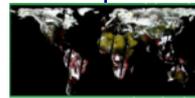
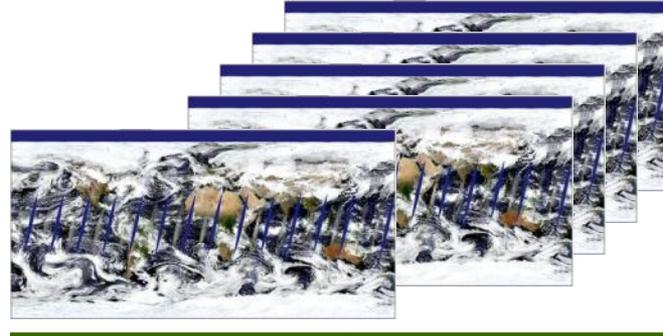


Project Overview

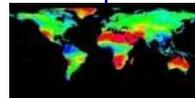
AVHRR record, '81 – '99



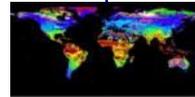
MODIS record, '00 – '13



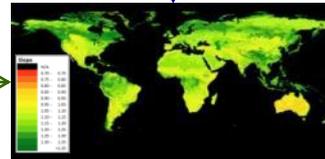
'98-'02 SPOT- VGT Data to Bridge AVHRR & MODIS records



Data retention filter.
Only retain high quality data

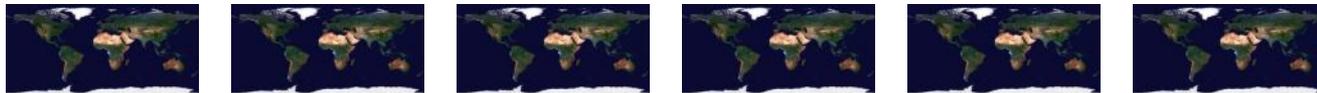


Homogenous clusters map.
Areas with same characteristics



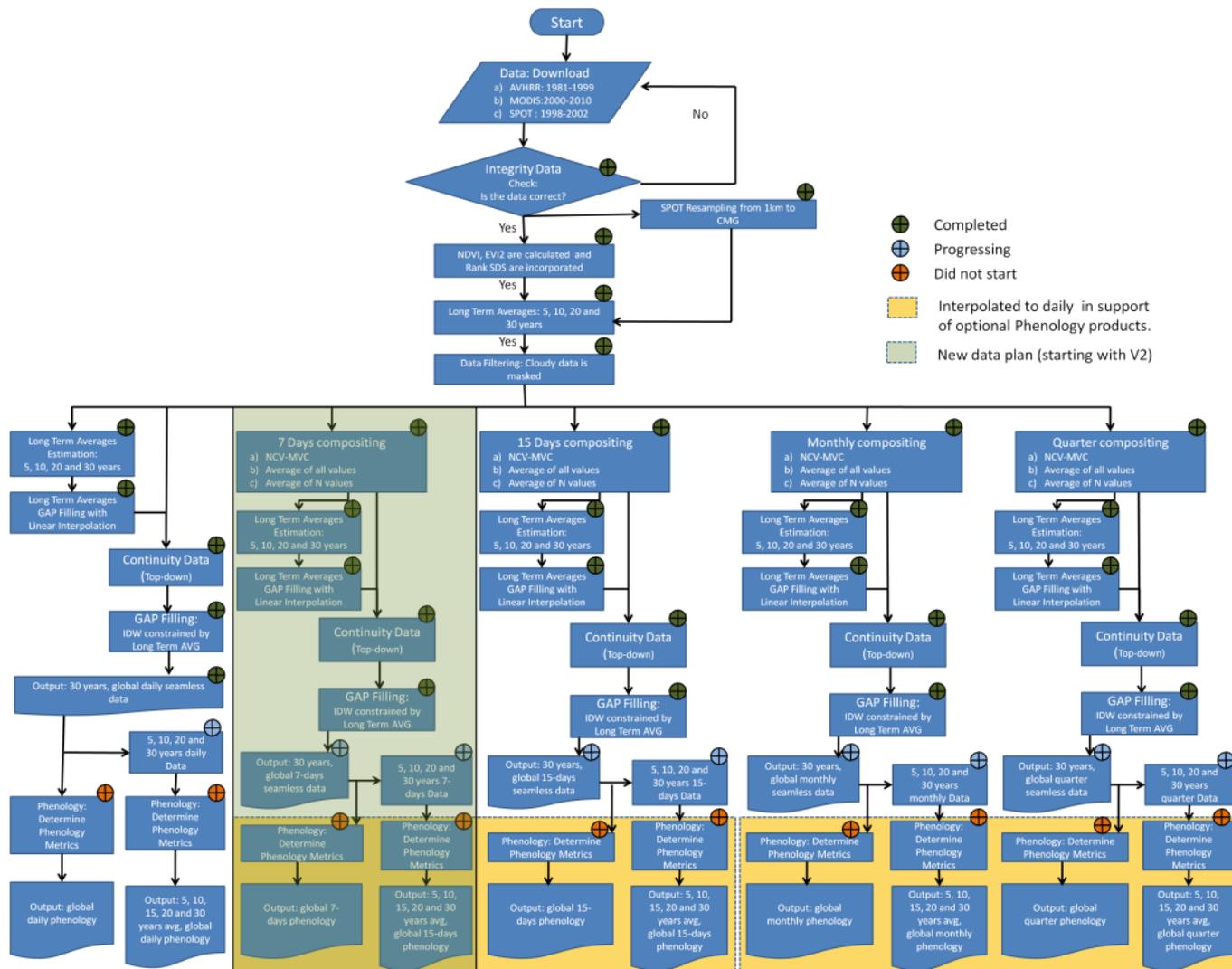
Continuity Transfer Functions map

VIIRS ?



1981 -2013 sensor independent VI and Phen. ESDRs

Processing plans



Spectral Transformation Equations to MODIS-equivalents (TOC, CMG)

NDVI (<i>x</i> variable)	Equation	Uncertainty (95% PI)
N-7 AVHRR, ROW, GAC	$y = -0.0646111 + 1.2409713x - 0.0304219x^2$	±0.0138
N-9 AVHRR, ROW, GAC	$y = -0.0621082 + 1.2487272x - 0.0307315x^2$	±0.0138
N-11 AVHRR, ROW, GAC	$y = -0.0606805 + 1.2456808x - 0.0335204x^2$	±0.0138
N-14 AVHRR, ROW, GAC	$y = -0.0571829 + 1.2372178x$	±0.0138
S-4 VEGETATION, TOC, CMGV	$y = 0.0156834 + 1.0610148x$	±0.061

EVI2 (<i>x</i> variable)	Equation	Uncertainty (95% PI)
N-7 AVHRR, ROW, GAC	$y = -0.0403338 + 1.2400319x$	±0.088
N-9 AVHRR, ROW, GAC	$y = -0.0403338 + 1.2400319x$	±0.088
N-11 AVHRR, ROW, GAC	$y = -0.0403338 + 1.2400319x$	±0.088
N-14 AVHRR, ROW, GAC	$y = -0.0403338 + 1.2400319x$	±0.088
S-4 VEGETATION, TOC, CMGV	$y = 0.0085842 + 1.1557716x$	±0.037

Work lead by Tomoaki Miura and Javzan Tsend-Ayush

VIP Data Explorer Interface

The screenshot shows the VIP Data Explorer web interface. At the top, two boxes labeled "DB and Cart System" and "Status and Documentations" have arrows pointing to the "Available Data" and "Cart" tabs, and the "ESDR Status" and "Documentation" tabs, respectively. The interface includes a navigation menu with tabs for "Data Viewer", "Available Data", "Cart", "ESDR Status", "Documentation", "Miscellaneous", "Help", and "F.A.Q.". Below the menu is a toolbar with options for "Borders", "Roads", "Grid", "Navigation Control", "Status Bar", "Overview Map", "Scale Legend", and "Atmosphere". The main content area features a globe map of North and South America. On the left, there are panels for "Datasets" (with "Daily" and "Vegetation Index" dropdowns), "Date" (with "Aug", "10", "2010" dropdowns), "Dataset" (with "Preprocessed Input Data" dropdown), and "Product" (with "RANK" dropdown). Below these are "Explore", "Animate", and "Add to Cart" buttons. A "Current Layers" panel lists several layers, including "NDVI 8/10/2008 GAP Filled". At the bottom left is a "Legend or additional info" panel with an NDVI color scale from -0.2 to 1.0. On the right side of the map, there are "GE Standard navigation tools" including a compass, a hand cursor, and a vertical zoom slider. Callout boxes on the right side of the interface identify "Time series", "Additional data", "Data Selection", "Overlay control", and "User uploaded data". The footer contains the VIP Lab logo, data sources (SIO, NOAA, U.S. Navy, NGA, GEBCO, Image IBCAO, DigitalGlobe, Cnes/Spot Image), and the address: "VIP Research Group, ECE Dept., The University of Arizona. 1230 E. Speedway, Tucson, Az 85721".

Datasets Options

Datasets Ancillary More
 Daily Vegetation Index
 Date Aug 10 2010
 Dataset Preprocessed Input Data
 Product NDVI
 Explore Animate Add to Cart

Datasets Ancillary More
 Monthly Vegetation Index
 Date Aug 10 2010
 Dataset Preprocessed Input Data
 Product NDVI
 Explore Animate Add to Cart

Datasets Ancillary More
 Daily Vegetation Index
 Date Aug 10 2010
 Dataset Preprocessed Input Data
 Product NDVI
 Explore Animate Add to Cart

Datasets Ancillary More
 Daily Vegetation Index
 Date Aug 10 2010
 Dataset Preprocessed Input Data
 Product Preprocessed Input Data
 QA Filtered Data
 GAP Filled Data
 Continuity Top-Down
 Continuity Bottom-Up

Datasets Ancillary More
 Daily Vegetation Index
 Date Aug 10 2010
 Dataset Preprocessed Input Data
 Product NDVI
 NDVI
 EVI2
 RANK
 MNR
 Explore Animate Add to Cart

Datasets Ancillary More

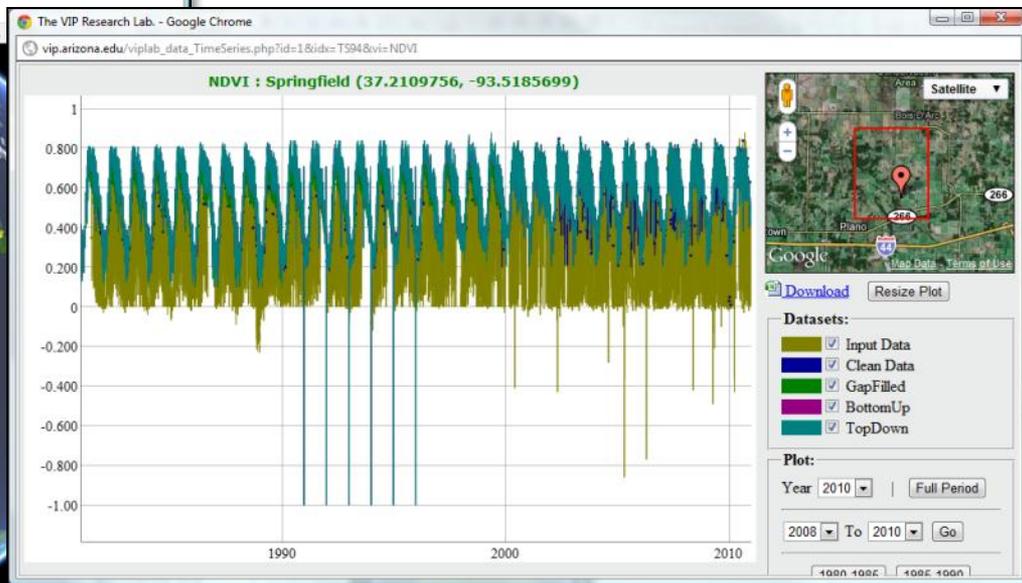
- Water / Land Mask
- Water / Land Mask from 250m
- Elevation 8KM
- Precipitation
- Temperature
- AVHRR Land Cover 92-93
- MODIS Land Cover
- AVHRR 92-93 Cluster
- MODIS 2003 Cluster
- MODIS Tiles

Datasets Ancillary More
 Find Place
 Tucson, AZ Fly
 TimeSeries VI
 Display Locations Refresh
 NDVI Select a Location
 Add New TS Location
 SPOT Dataset
 Date Aug 1
 Product NDVI
 Explore Animate

Datasets Ancillary More
 Daily LTAVG Phenology
 Period 2005-2010
 VI NDVI
 Method by Cluster
 Metric Start of Season S1
 Start of Season
 End of Season
 Length of Season
 Date of Peak
 Rate of Greening
 Rate of Senescence
 Cumulative VI
 Average VI

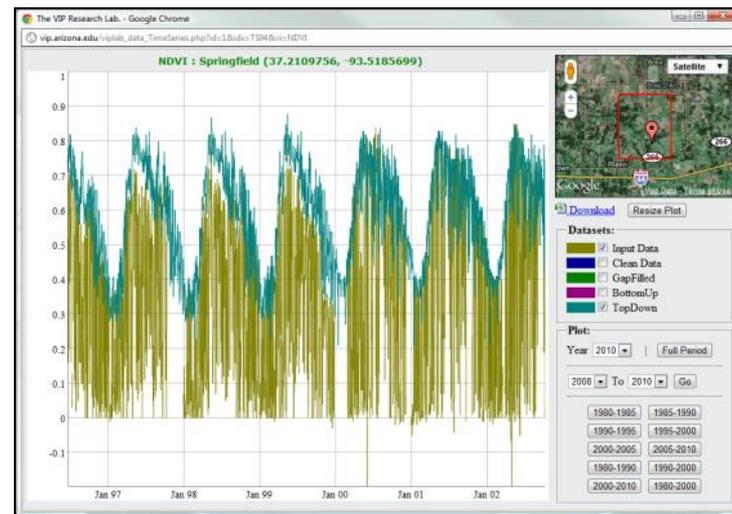
On Demand Time Series

The screenshot shows the 'Data Explorer' interface. On the left, there are panels for 'Datasets' and 'Ancillary'. The 'Find Place' field contains 'Tucson, AZ'. Below it, the 'TimeSeries VI' section has 'Display Locations' and 'Refresh' buttons, and a 'Select a Location' dropdown. The 'SPOT Dataset' section shows 'Date' as 'Aug' and 'Product' as 'NDVI'. At the bottom, there are 'Remove', 'Clear All', and 'Add Custom' buttons. A globe in the center shows yellow location markers. The bottom of the interface includes a 'VIP Lab.' logo and copyright information: 'Data SIO, NOAA, U.S. Navy, NGA, GEBCO Image © 2011 DigitalGlobe Image © 2011 Image Landsat Image © 2011 TerraMetrics' and 'VIP Research Group, ECE Dept., The University of Arizona, 1230 E. Speedway, Tucson, Az 85721'.



This is a close-up of the 'Add New TimeSeries Location' form. It features a 'Find Place' field with 'Tucson, AZ' and a 'Fly' button. Below, the 'TimeSeries VI' section has a red-bordered box containing the text 'Add New TimeSeries Location:' and instructions: '- Type your email (required)' and '- Click the Globe to add Location'. There is an 'Email' input field and 'Cancel' and 'Help' buttons at the bottom.

This screenshot shows the 'New TimeSeries Location' form with the following filled-in information: 'Label' (empty), 'Latitude' '37.590694427490234', 'Longitude' '-112.67185974121094', 'Window' '1 x 1' (with a note 'base on 5.6km pixel size'), and 'Email' (empty). There are 'Submit' and 'Cancel' buttons. A confirmation message at the bottom states: 'A confirmation email will be sent when processed data is ready.' A small satellite map on the right shows the location.



Database Search and Order

The screenshot shows the 'Data Explorer' interface with the following search criteria:

- Product:** Vegetation Index (selected), Long Term AVG VI, Phenology, LTAVG Phenology
- Period:** From 2008 Aug 1, To 2008 Aug 31
- Frequency:** Daily (checked), 15 Days, Monthly, Quarterly
- DataSet:** Preprocessed Input Data (checked), QA Filtered Data, GAP Filled Data, Continuity TopDown, Continuity BottomUp

Records Found: 97

DOY	Year	FileName	Resolution	Info	Images
233	2008	VIP01P1.A2008233.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
234	2008	VIP01P1.A2008234.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
235	2008	VIP01P1.A2008235.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
236	2008	VIP01P1.A2008236.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
237	2008	VIP01P1.A2008237.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
238	2008	VIP01P1.A2008238.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
239	2008	VIP01P1.A2008239.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
240	2008	VIP01P1.A2008240.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
241	2008	VIP01P1.A2008241.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
242	2008	VIP01P1.A2008242.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
243	2008	VIP01P1.A2008243.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
244	2008	VIP01P1.A2008244.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK

Sensor: MODIS TERRA DataSet: 15Days Preprocessed Input Data

DOY	Year	FileName	Resolution	Info	Images
228	2008	VIP15P1.A2008228.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
244	2008	VIP15P1.A2008244.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK

Sensor: MODIS TERRA DataSet: Daily Filtered Data

DOY	Year	FileName	Resolution	Info	Images
214	2008	VIP01P2.A2008214.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
215	2008	VIP01P2.A2008215.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
216	2008	VIP01P2.A2008216.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
217	2008	VIP01P2.A2008217.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
218	2008	VIP01P2.A2008218.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
219	2008	VIP01P2.A2008219.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK
220	2008	VIP01P2.A2008220.001.2011025220005.hdf	CMG	Metadata	NDVI EVI2 MNR RANK

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This screenshot shows the 'Data Explorer' interface with a list of records. The 'Cart' section is visible, showing 'Your Products Selection' and 'Create an Account' options. The list of records includes file names, resolutions, and image types.

Cart - Your Products Selection | Create an Account

Clean Cart | Remove Selected Items | Extent: Global | Size: | Request Products

<input type="checkbox"/>	VIP01P1.A2008233.001.2011025220005.hdf
<input type="checkbox"/>	VIP01P1.A2008234.001.2011025220005.hdf
<input type="checkbox"/>	VIP01P1.A2008235.001.2011025220005.hdf
<input type="checkbox"/>	VIP01P1.A2008236.001.2011025220005.hdf
<input checked="" type="checkbox"/>	VIP01P1.A2008237.001.2011025220005.hdf
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<input checked="" type="checkbox"/>	VIP01P1.A2008240.001.2011025220005.hdf
<input checked="" type="checkbox"/>	VIP01P1.A2008241.001.2011025220005.hdf
<input checked="" type="checkbox"/>	VIP01P1.A2008242.001.2011025220005.hdf
<input checked="" type="checkbox"/>	VIP01P1.A2008243.001.2011025220005.hdf
<input checked="" type="checkbox"/>	VIP01P1.A2008244.001.2011025220005.hdf

VIP Research Group, ECE Dept., The University of Arizona, 1230 E. Speedway, Tucson, AZ 85721

This screenshot shows the 'Data Explorer - Email Registration' form. The form includes fields for First Name, Last Name, Email Address, and Organization, along with a 'Register' button.

Data Explorer - Email Registration

Creating a Data Explorer account will allow users to request data online. We will send you an email to verify your account. Data is without account can be browsed on demand. Download data files from the all Data Explorer in Windows generated by other users.

Create Account

First Name:

Last Name:

Email Address:

Organization:

VIP Research Group, ECE Dept., The University of Arizona, 1230 E. Speedway, Tucson, AZ 85721
 Researcher: 10/25/08
 Contact: vip@arizona.edu
 Researcher: 10/25/08

vip.arizona.edu/viplab_data_explorer.php