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

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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
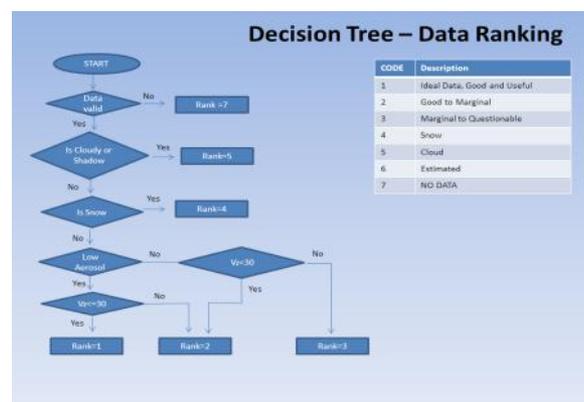
- Long term confidence interval
  - Lots of QA errors, especially with clouds, snow/ice, and aerosols
  - Mislabeling
  - Residual noise
- In combination, filtering and long term help address residual noise in the data
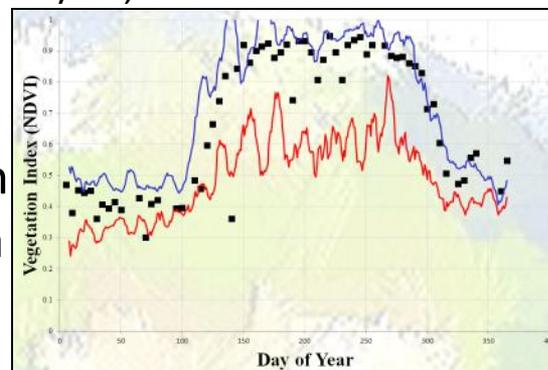
EVI2 : **Forward and backward compatibility with all sensors**

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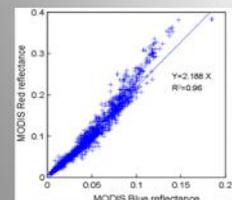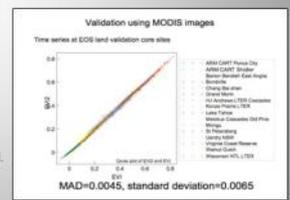 - Improved performance over partial cloud, snow/ice, and heavy aerosol
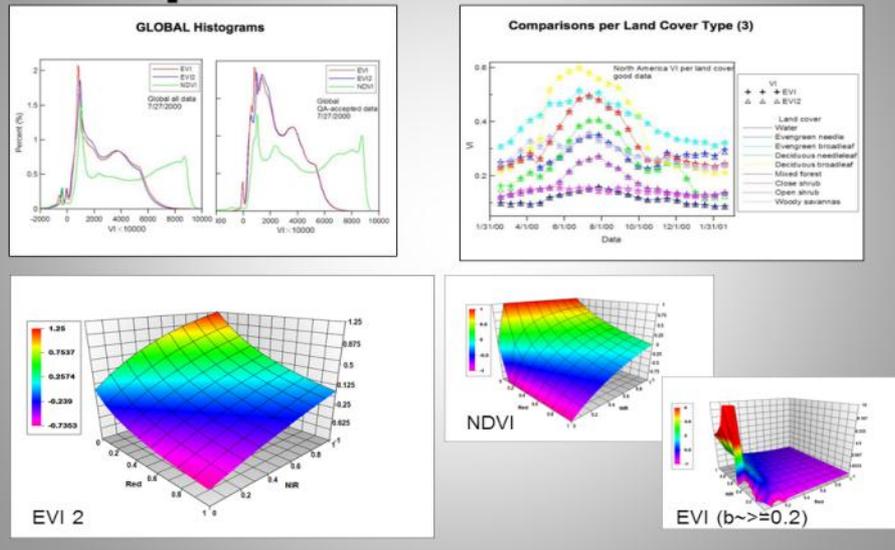
First good observation compositing

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)

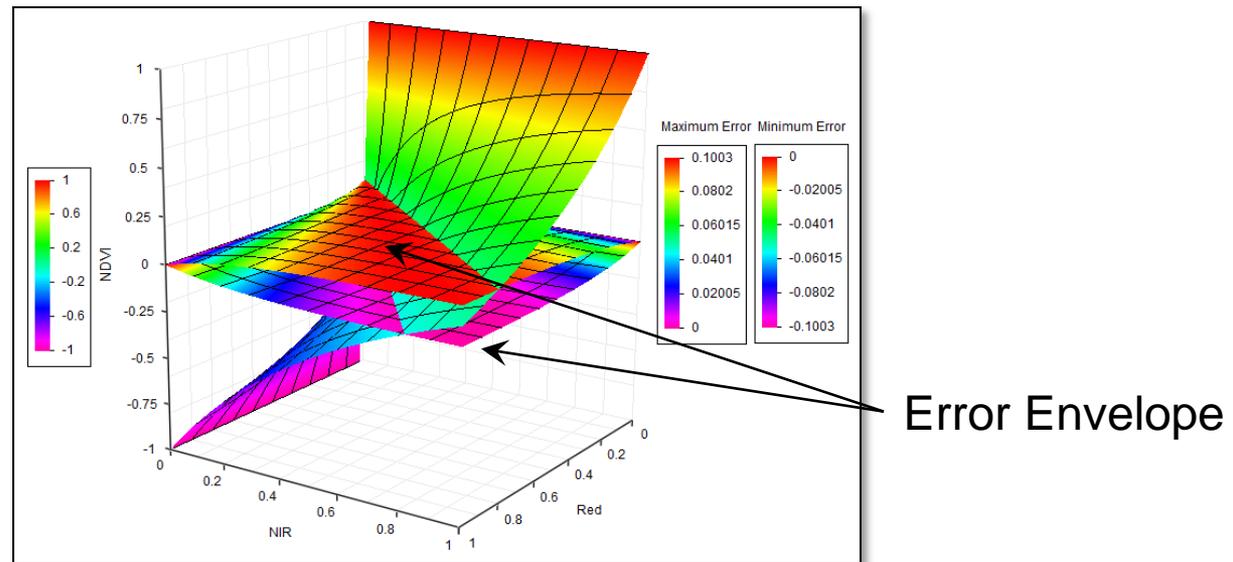# VI Record Error and Uncertainty

- Aims at Understanding and analyzing the VI associated error and uncertainty

- Focuses on the Input and Noise related error at this stage
    - Problem statement
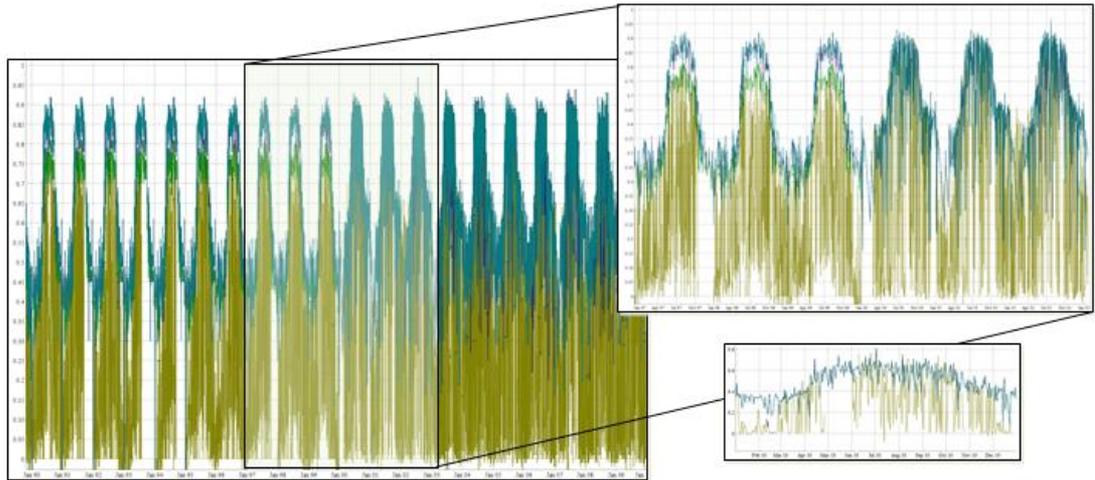
NDVI Time Series [Woodstock Valley, CT]. A close-up of the same site 1997-2003 and a single year profile, all showing the prevalence of random noise in the data. This error is as wide as the full dynamic range, with serious implications on research and the subsequent phenology derivation. The different 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 Envelope

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*
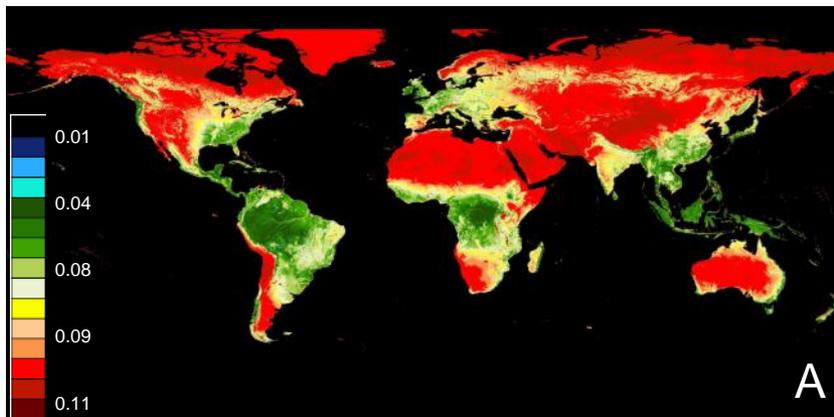
Absolute VI error
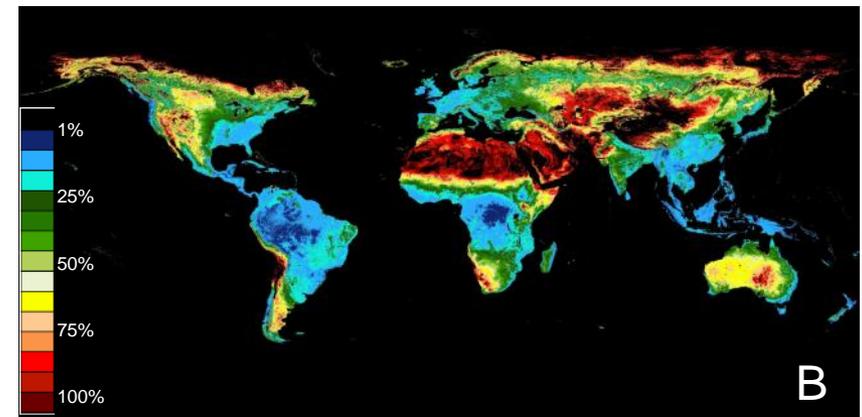
Relative VI error

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

MODIS EVI Range/Error Boreal Forest
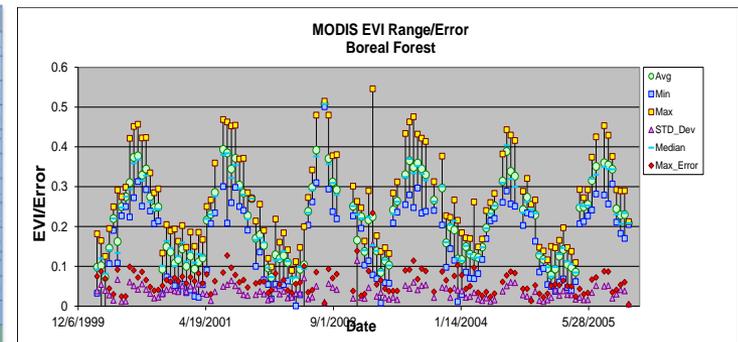
Site (EVI2)	Avg	Min	Max	Range	Abs_Error	STD_Dev	Median	Max_Error	Percent_Max_Err
Rain Forest	0.523	0.480	0.566	0.089	8.941	0.026	0.523	0.045	4.47
Desert	0.087	0.084	0.089	0.005	0.546	0.002	0.087	0.003	0.27
Cascades NL	0.357	0.250	0.482	0.233	23.333	0.063	0.358	0.117	11.67
SanatRita	0.198	0.167	0.236	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

Rain Forest NDVI Error Range
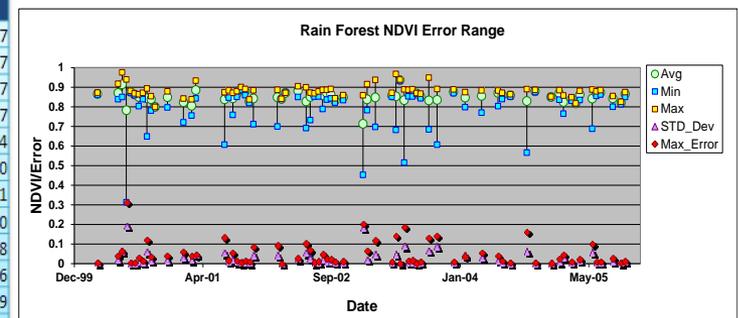
Reanalysis of the full MODIS VI record

- 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
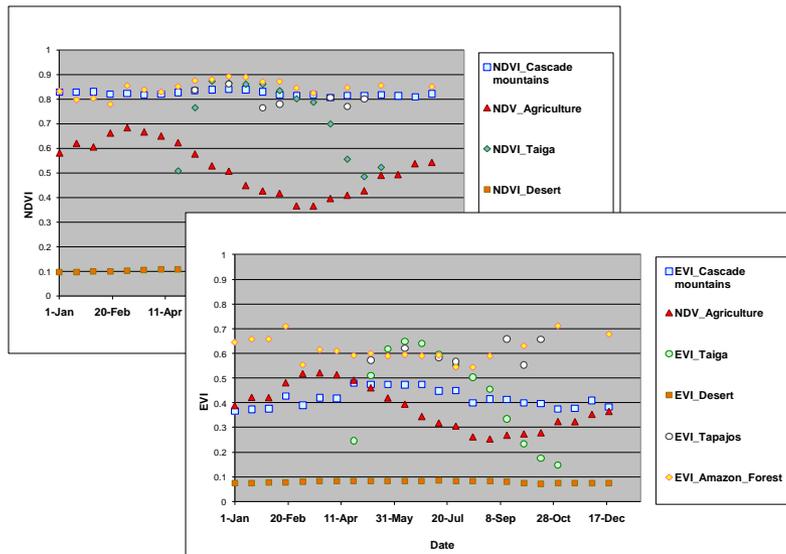

Hi-fidelity long term VI profiles
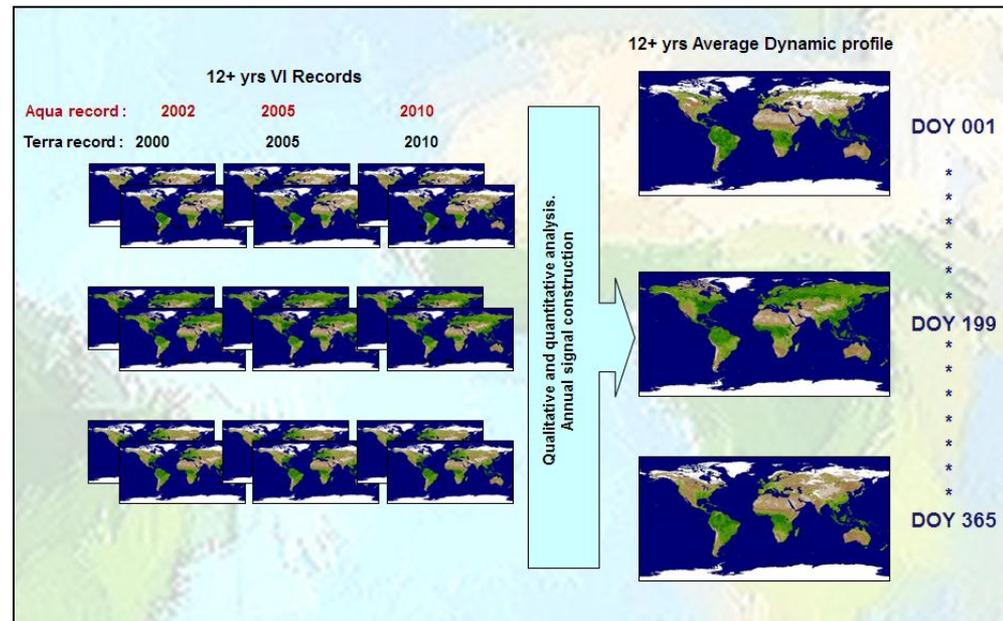
The VIP Effort

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
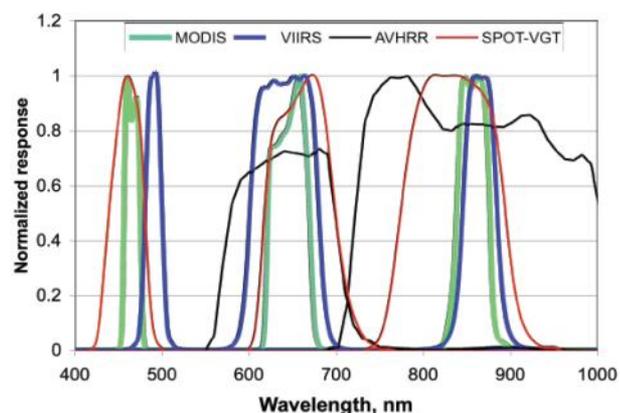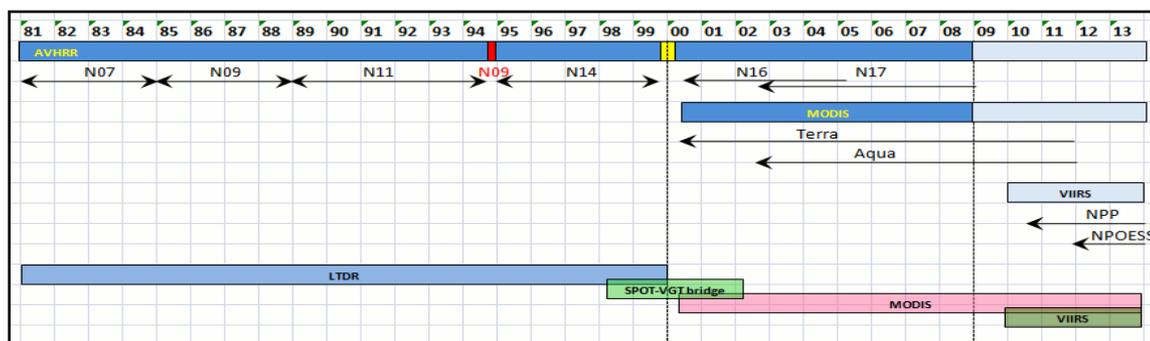
Project Overview

AVHRR record, '81 – ''99
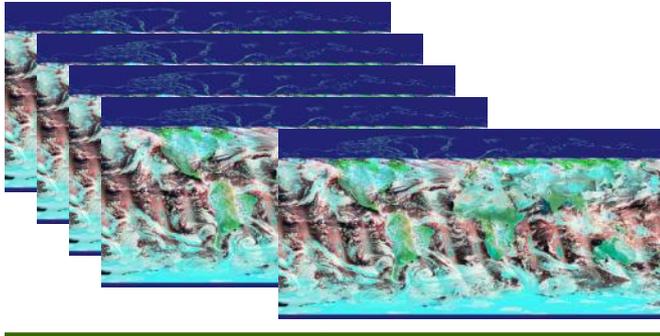
MODIS record, '00 – '13
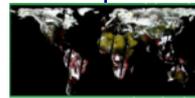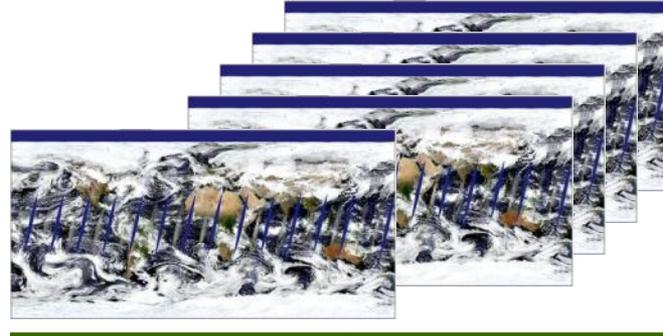
'98-'02 SPOT- VGT Data to
Bridge AVHRR & MODIS records
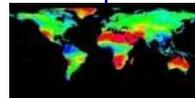
Data retention filter.
Only retain high quality data
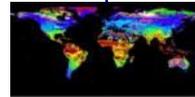
VIIRS ?

Homogenous clusters map.
Areas with same characteristics
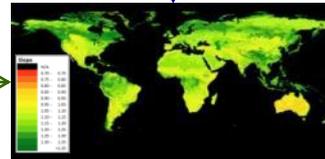
Continuity Transfer Functions map
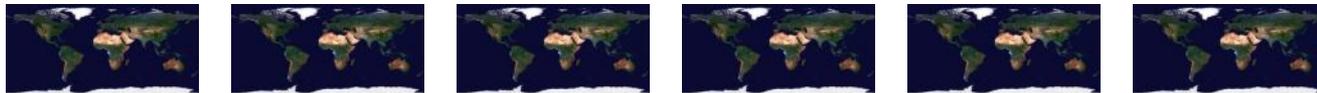
1981 -2013 sensor independent VI and Phen. ESDRs

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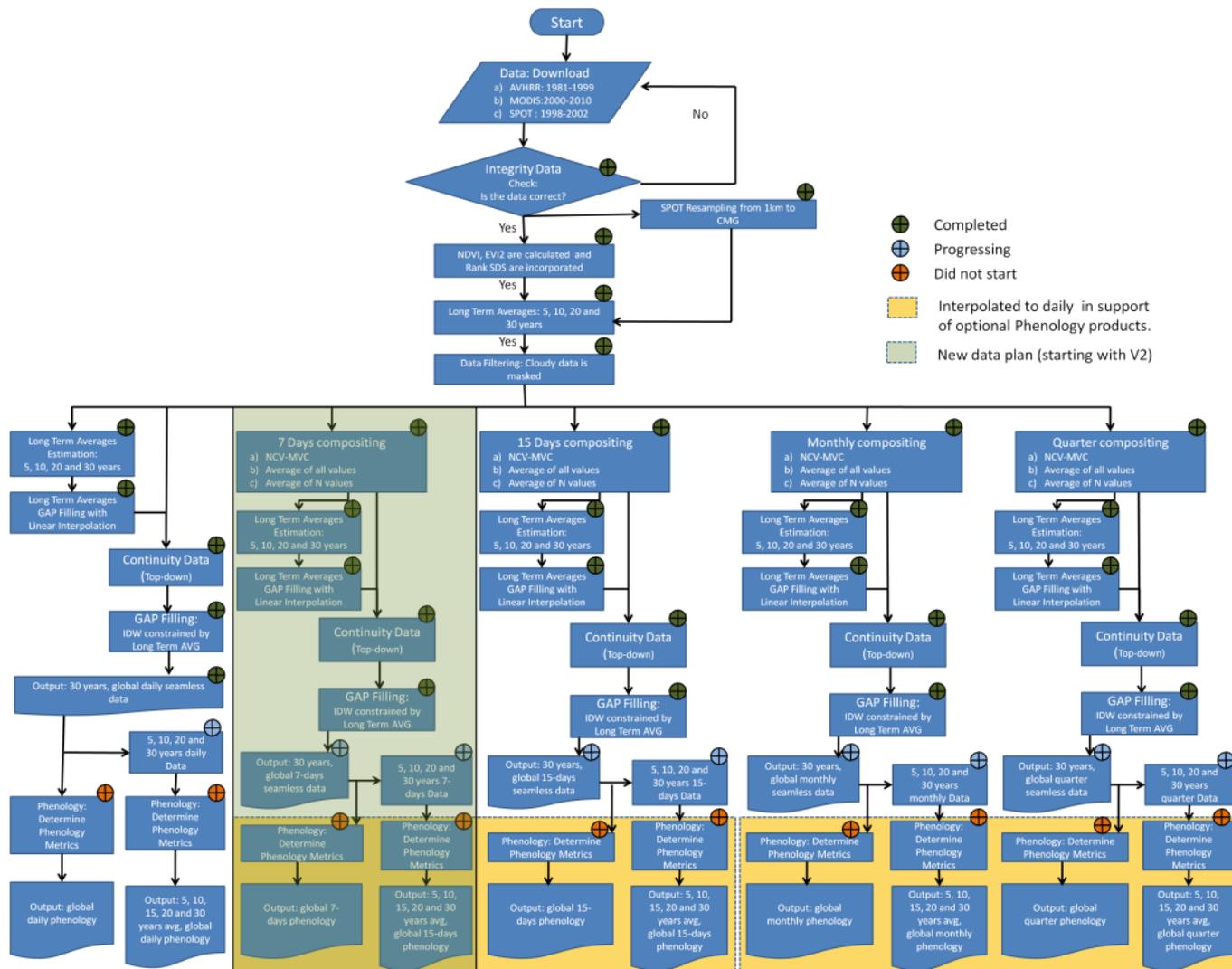
Spectral Transformation Equations to MODIS-equivalents (TOC, CMG)

NDVI (x 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 (x 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

Datasets Options

On Demand Time Series

Database Search and Order

Documentations

vip.arizona.edu/viplab_data_explorer.php