

MODIS Science Team Meeting
Silver Spring, MD - April 15-16, 2013

MODIS VI Product Suite Status From C5 to C6

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Work inherited from Alfredo Huete and Kamel Didan

The University of Arizona



Outline

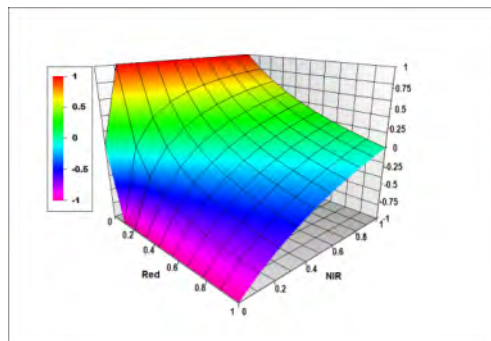
- VIs
- C5 approach
- C6 approach
- C6 Tests Evaluation
- PI SCF Work
 - MODIS VI Error Analysis
- Conclusions

Background

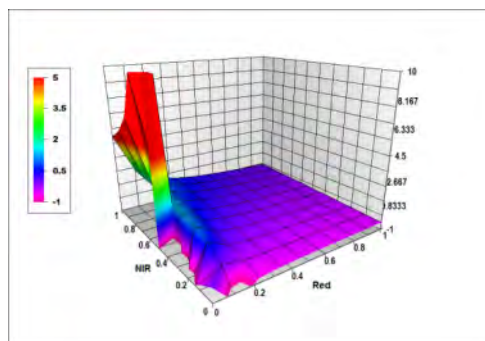
- Vegetation makes up most of the Earth land cover and plays a key role in the biosphere and atmosphere functioning
- Vegetation Indices : Not a physical parameters, but can proxy a long list of physical/biophysical parameters (LAI, fPAR, GPP, LC, Biomass, etc...)
 - NDVI : Strong history (Google : 70+K pubs, 100K+ of users, 1.1 M hits in Google). Plus historical value of AVHRR (30+ yrs)
 - EVI an improved/enhanced version that with strong correlation with biomass/Carbon, structure, less background noise
 - Requires backward compatibility - EVI2 (2 bands only)
- The value of the Vegetation index data record (30+) to science and research is supported by:
 - Science claims based on these data record, applications, Ease of access and use, and consistent reliability, no assumption about observations (TOC, TOA, etc...). Can derive Land Surface Phenology (or growing season characterization) from VI data. An excellent Integrator of climate impact and a barometer of change

Vegetation Indices

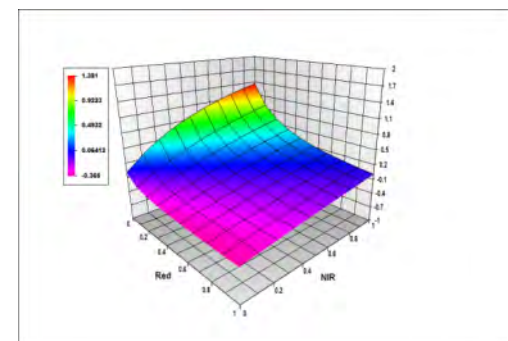
- NDVI – Widely used but has some issues
- EVI – A complimentary Index that works better over dense canopies/vegetation and addresses background noise
 - But requires the blue band (not available sometimes), and when available has a poor S/N ratio
 - EVI has also some issues:
 - Small dynamic range
 - Poor performance over areas with residual cloud, sub-pixel snow, and due to blue band noise (prone to noise)



NDVI



EVI (b~0.2)

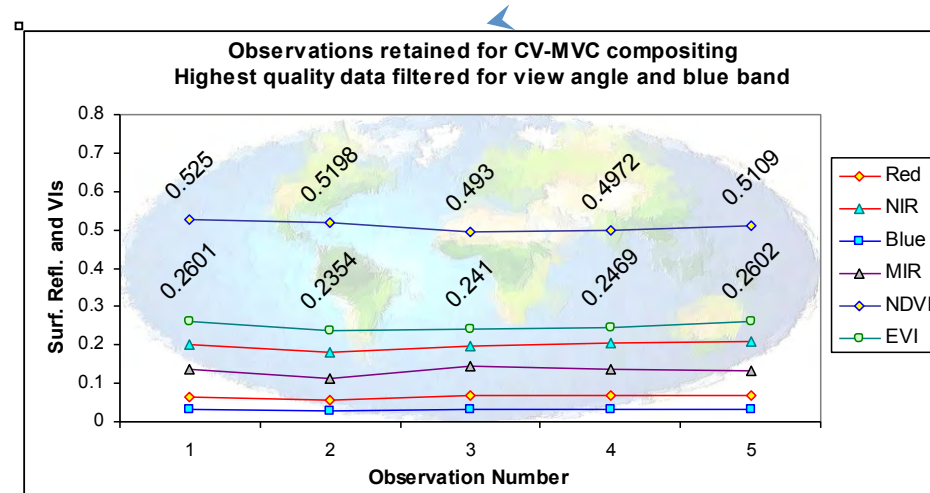
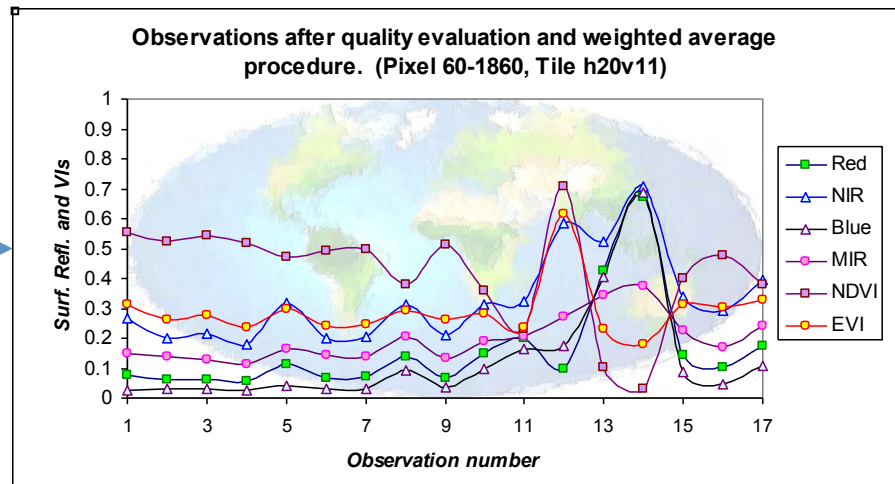
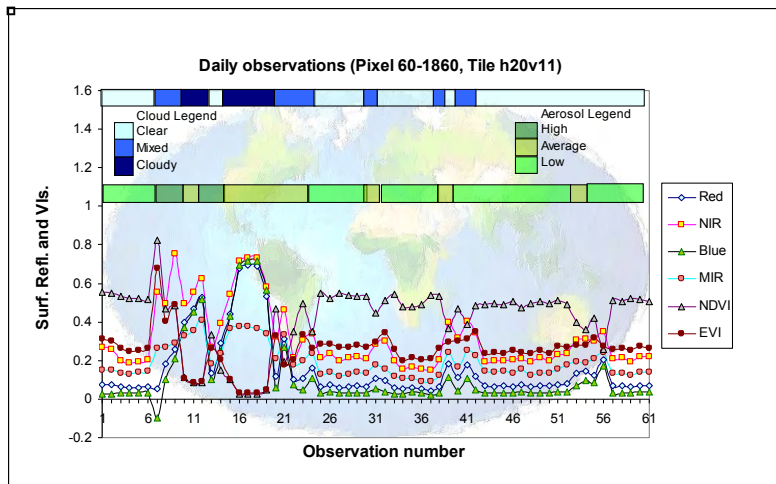


EVI (b~0.02)

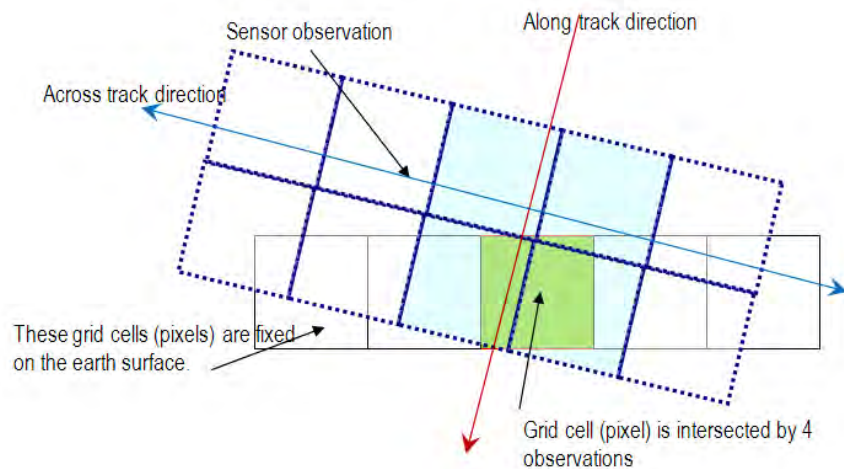
Our approach to generating consistent VI data records

- C2, C3, C4, and currently C5 (Limit changes to necessary and consistency drives the change)
 - Improved compositing: Not only simple MVC (prone to noise and disadvantageous to EVI). Introduced a simple and effective QA driven Compositing scheme:
 - Eliminates poor quality data first (since most methods are blind to poor data)
 - MVC is the last step
 - From Collection to Collection we kept changes consistent and aimed at converging towards a stable product suite, irrespective of input related errors and uncertainty (consistency only). We learned many lessons:
 - We learned that QA is key to compositing because MVC performs poorly when poor quality data is not filtered (show example of EVI over cloud and Snow/Ice/Thick Aerosols)
 - We also learned that the MODIS observations are stored in a rather peculiar fashion making them not fully representative of the grid (percent cover that changes from orbit to orbit)
 - Addressed this by reconstructing the pixel/grid value from all available observations (weighing scheme)
 - Introduced a simpler user friendly approach to QA via the “Pixel reliability”, a simple measure of usefulness (No need for bit manipulation)
 - VI Global Error and Uncertainty analysis shows a global input related error range of +/-5%

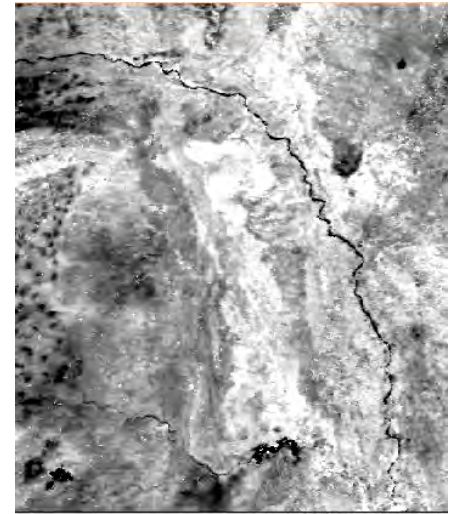
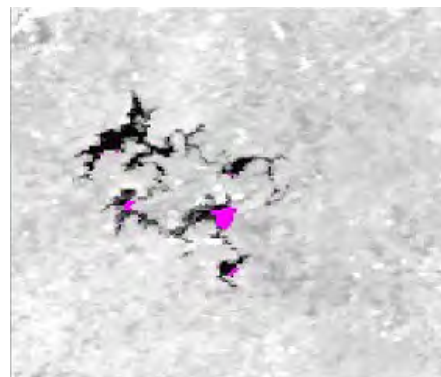
C5 VI Algorithm



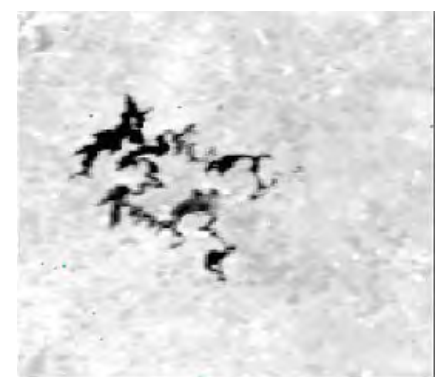
Observation coverage issue



Using only the observation with highest overlap/cover

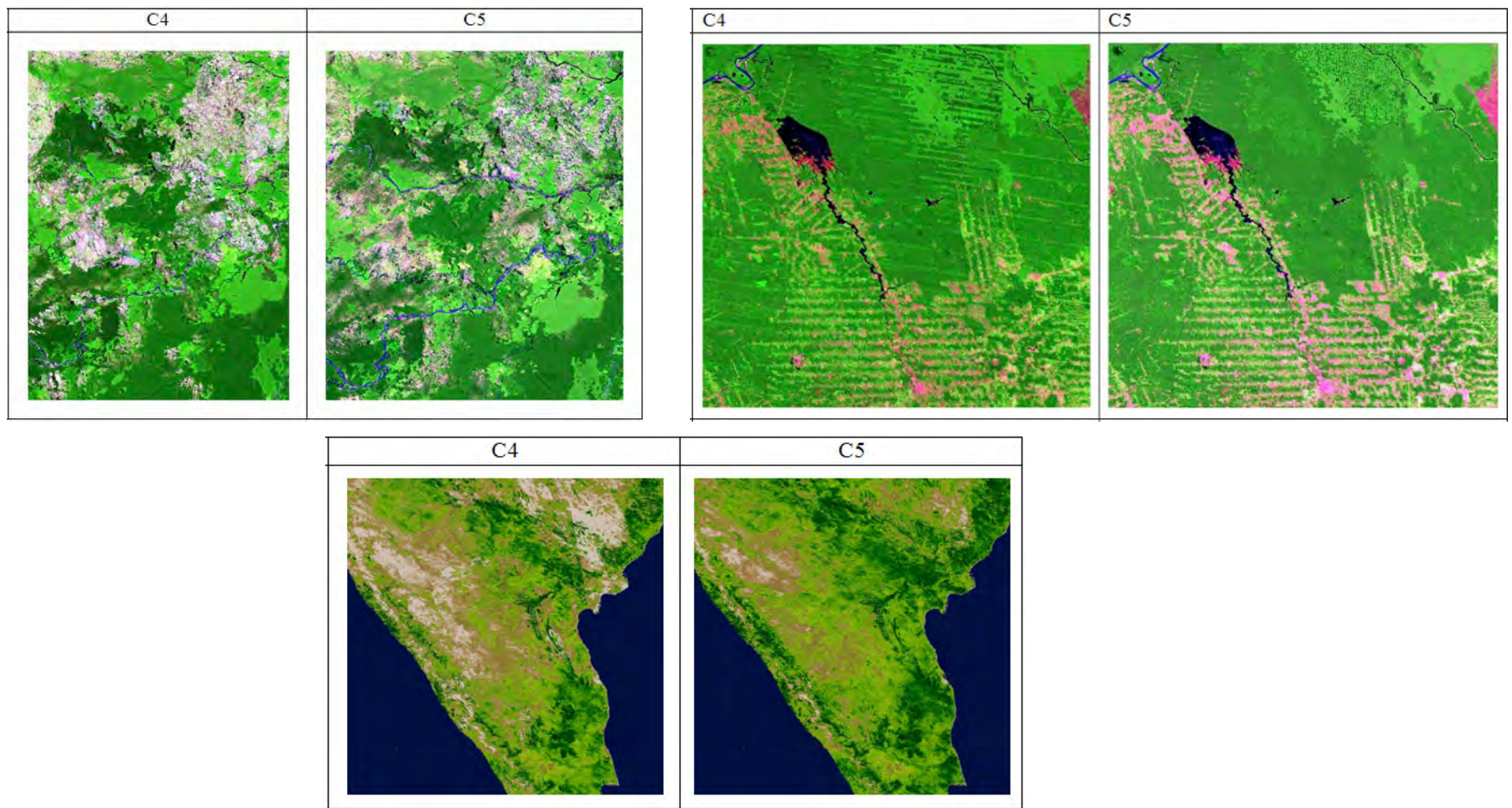


Reconstructing a new value from all observations



Convergence towards a consistent product suite

- This is key to good science

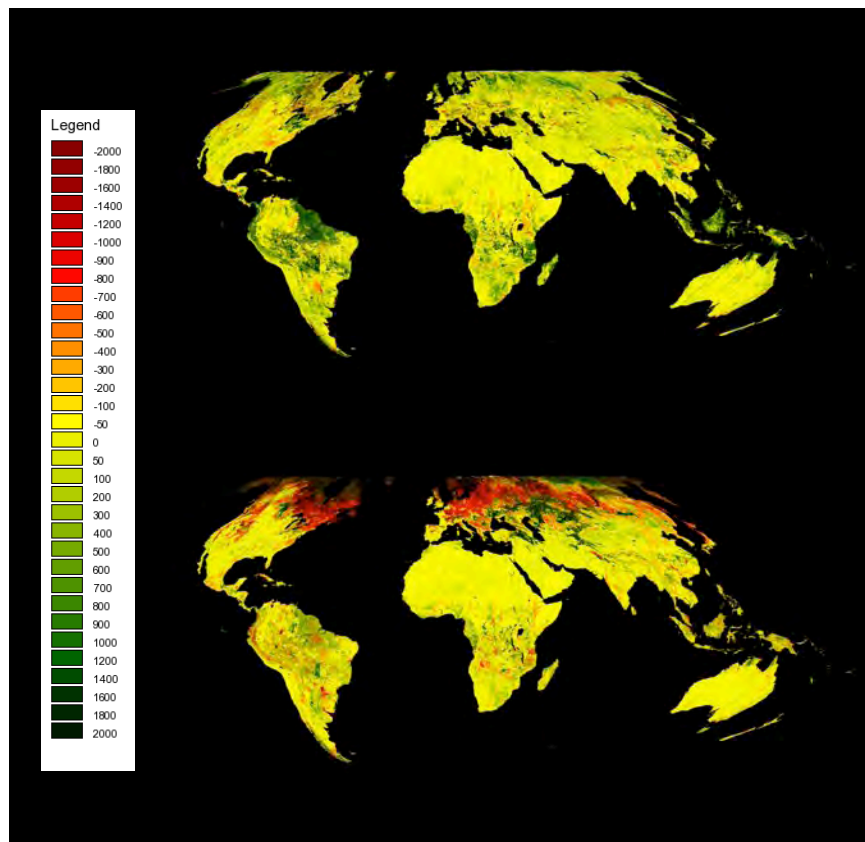


Starting C6

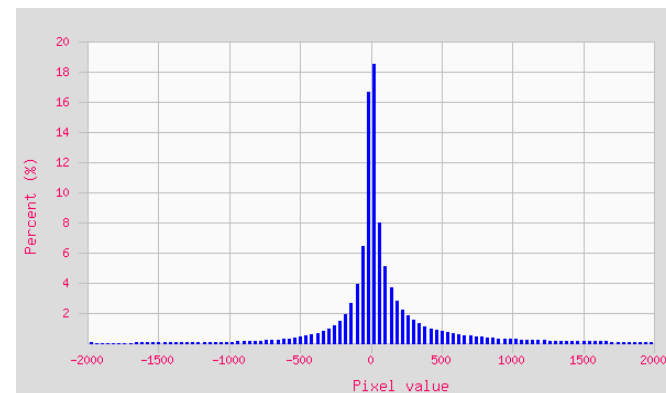
- The Algorithm changed hands due to funding and resources
- MODAPS maintains the Algorithm code
 - Started using a new method for compositing
 - No longer QA based compositing (hallmark of MODIS VI suite, as it was very effective at eliminating poor data)
 - Used minimum blue compositing (aimed at minimizing aerosol)
 - VI started using a pre-composited 8-day surface reflectance as input (2x 8-Day)
- PI-SCF effort focused on
 - Error Analysis
 - Creation of Value added VI Data Records

C6 Evaluation (Winter scene, 2003001)

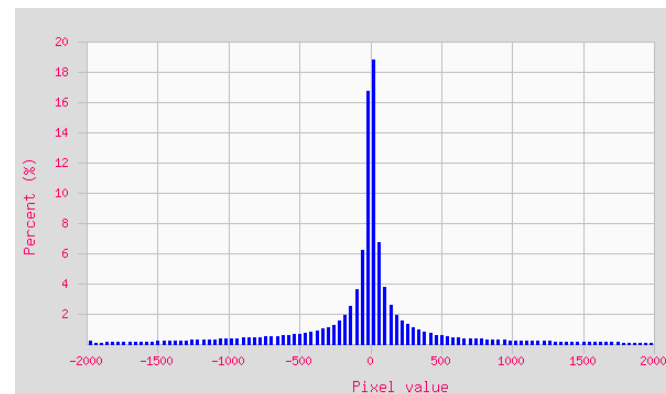
- Evaluation results based on [OLD-NEW]
- Largest observed change ($> \pm 10\%$) over tropics and high latitude regions
- NDVI and EVI changed differently



NDVI
Diff



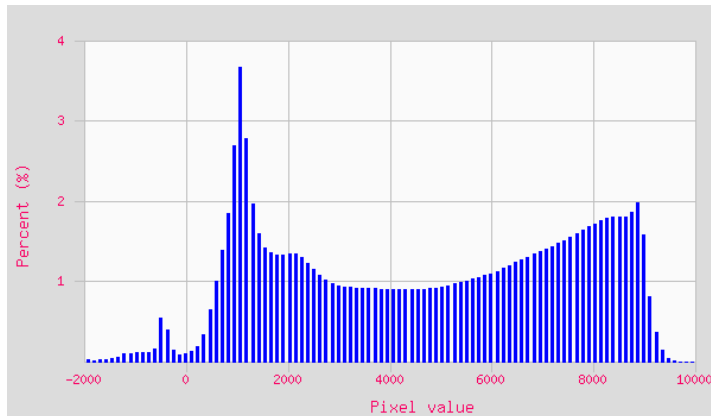
EVI
Diff



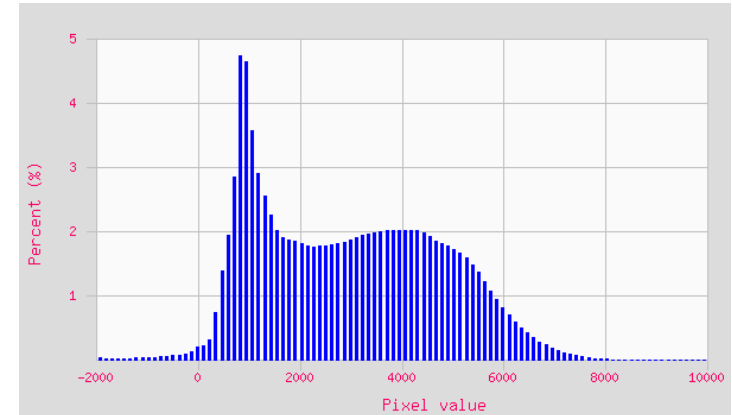
C6 VI Evaluation (Winter scene, 2003001)

- VI Histogram distribution

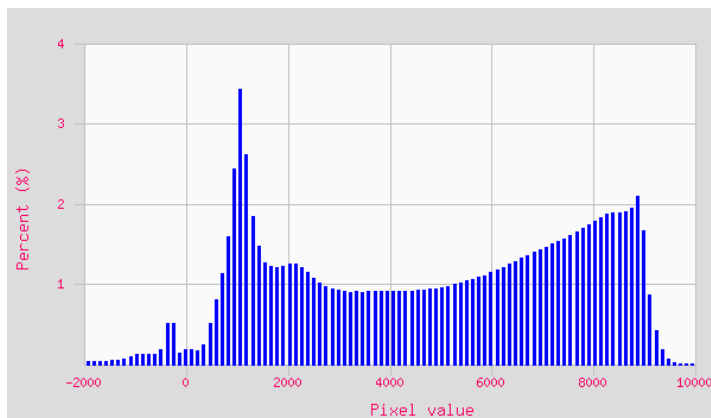
NDVI



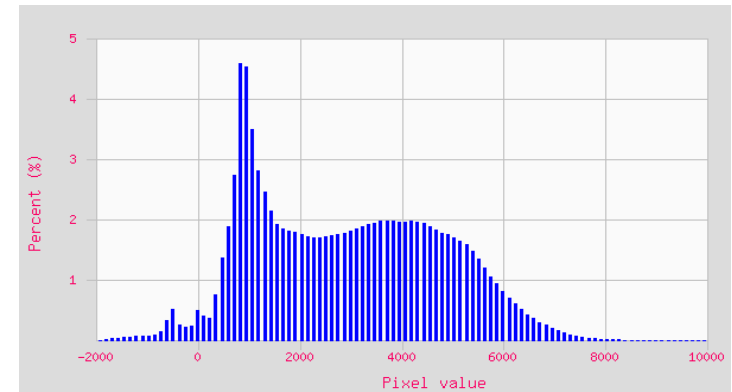
EVI



New



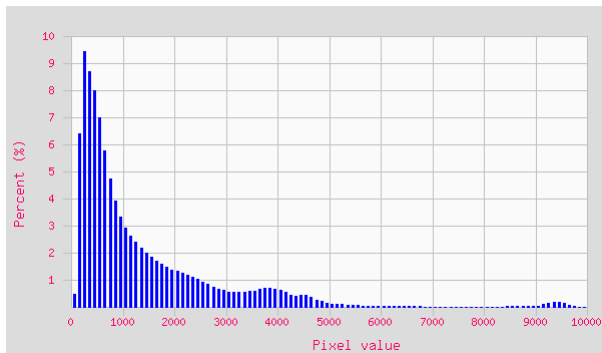
Old



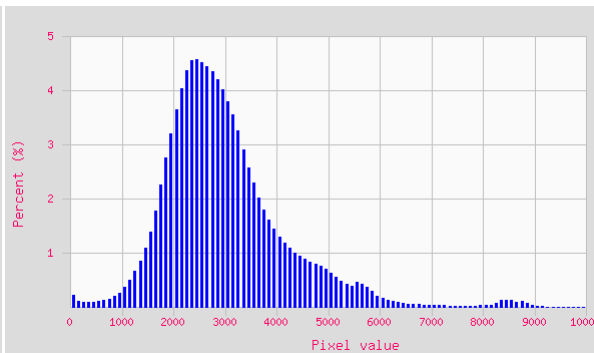
C6 LSR Evaluation (Winter scene, 2003001)

- SR Histogram distribution

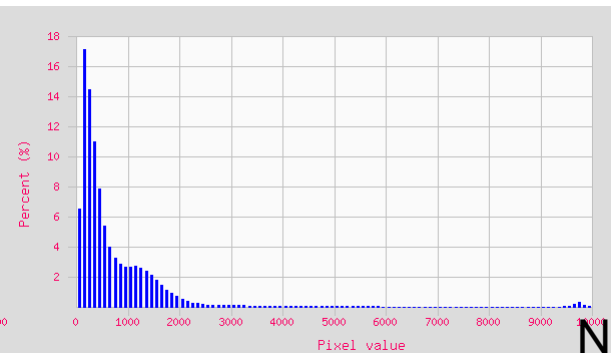
Red



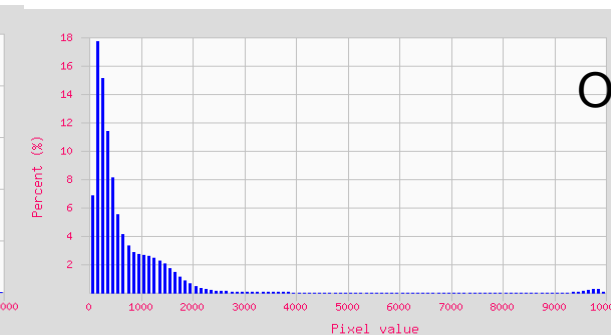
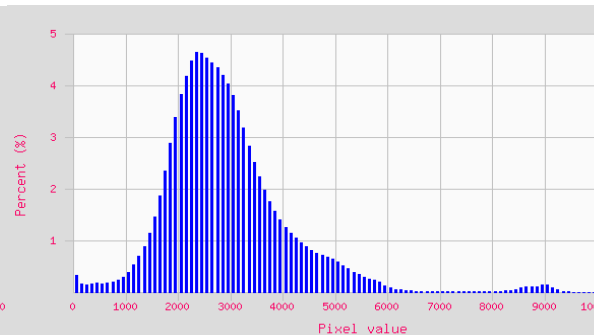
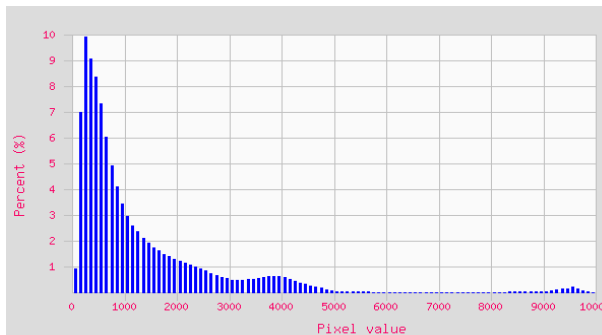
NIR



Blue



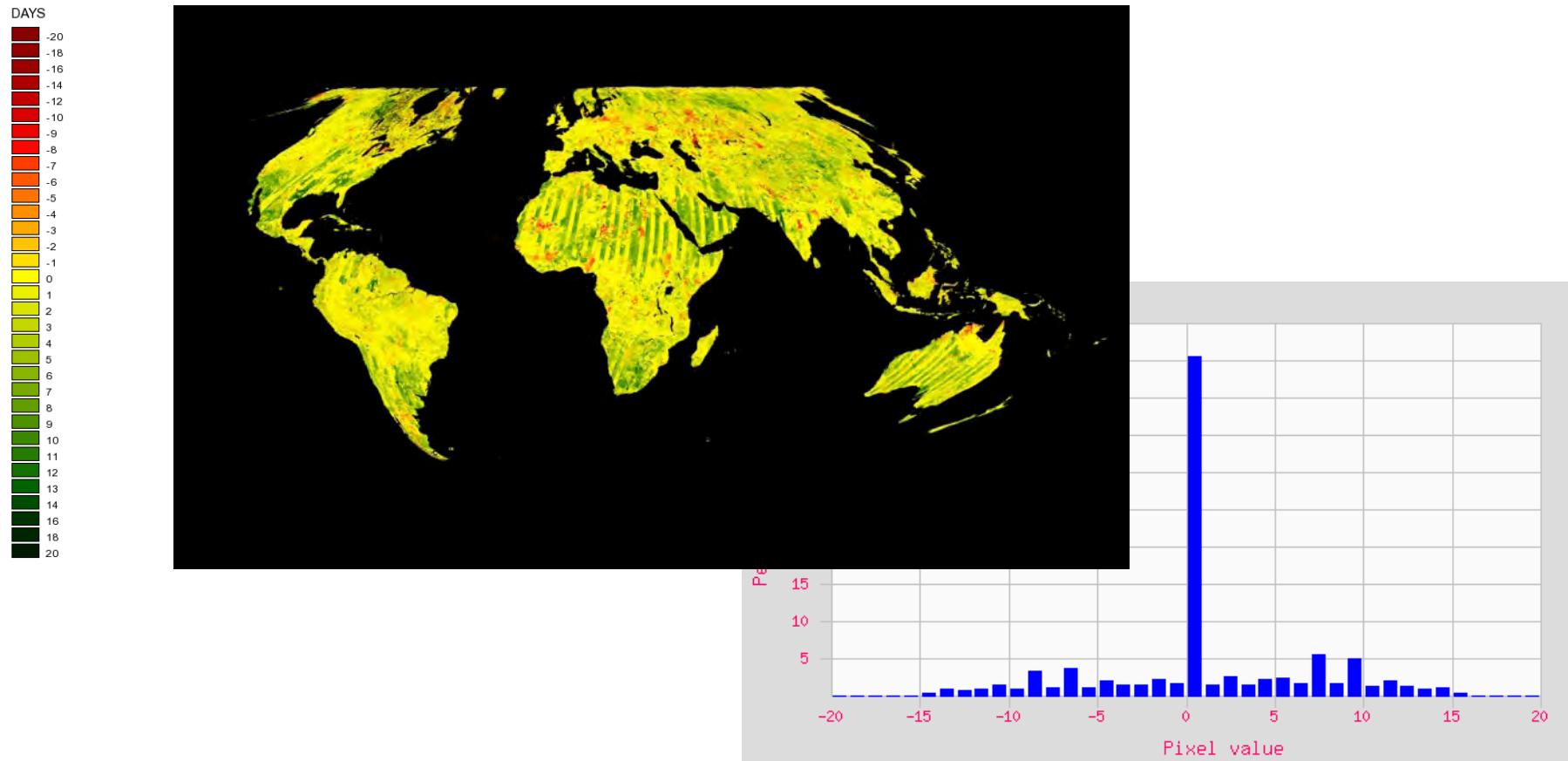
New



Old

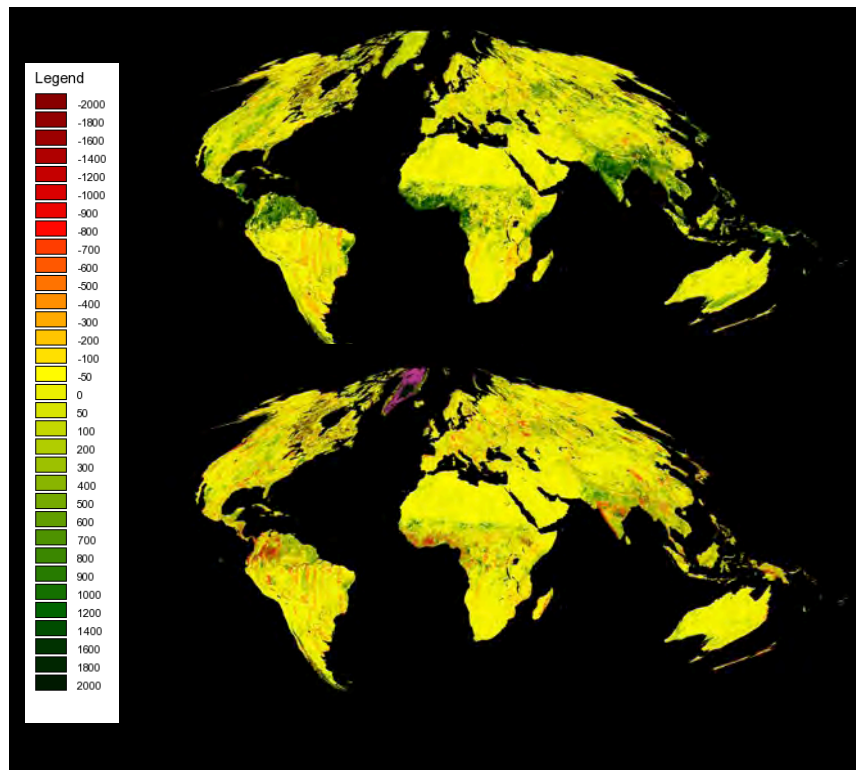
C6 Evaluation Composite DOY (Winter scene)

- Slight shift to selection of earlier days

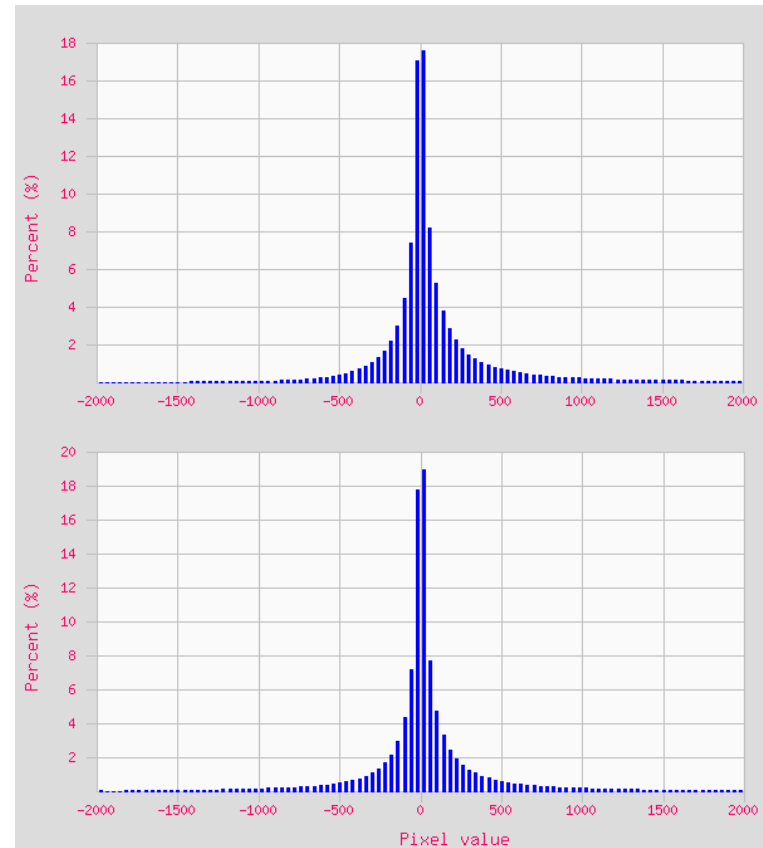


C6 Evaluation (Summer scene, 2003193)

- Again OLD-NEW
- Largest observed change over tropics
- NDVI and EVI changed differently



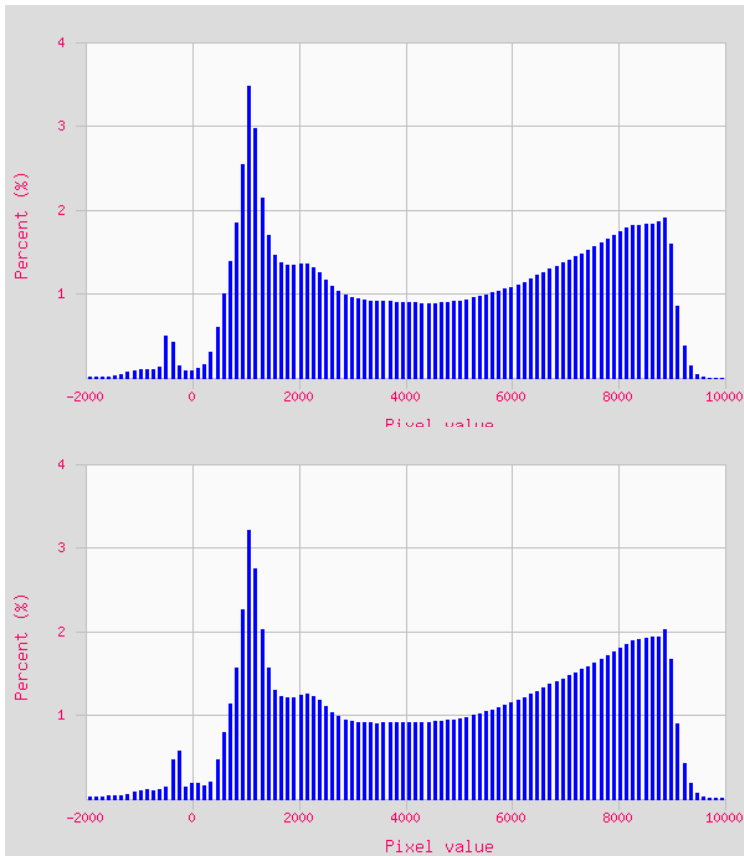
NDVI
Diff



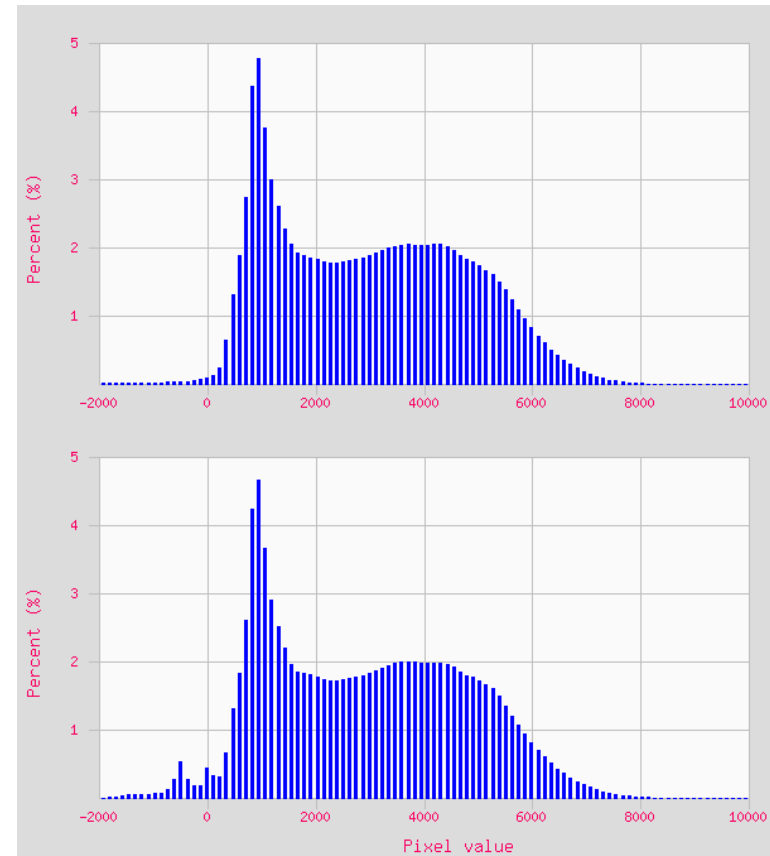
EVI
Diff

C6 VI Evaluation (Summer scene , 2003193)

NDVI



EVI



New

Old

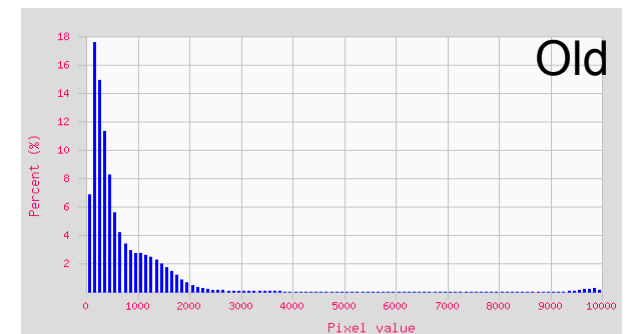
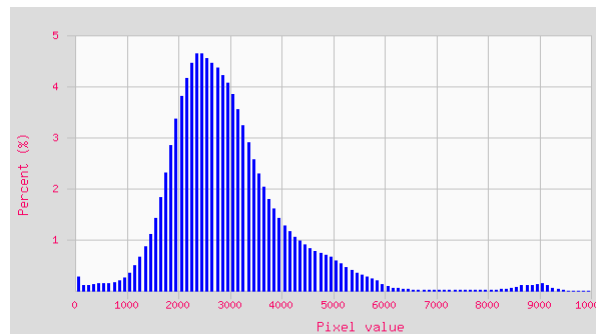
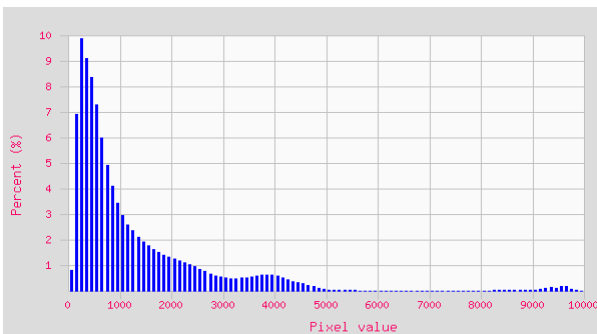
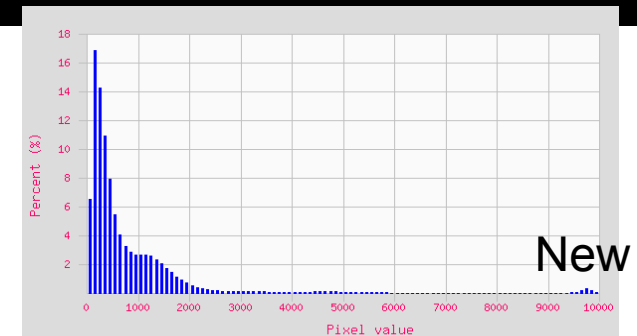
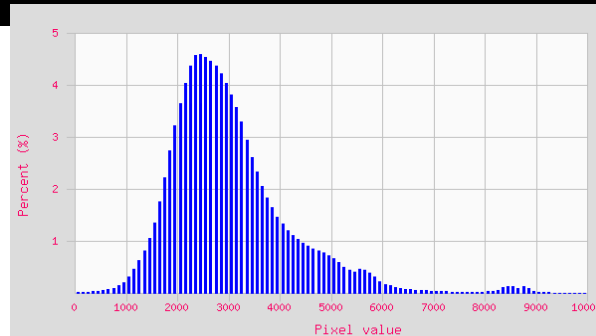
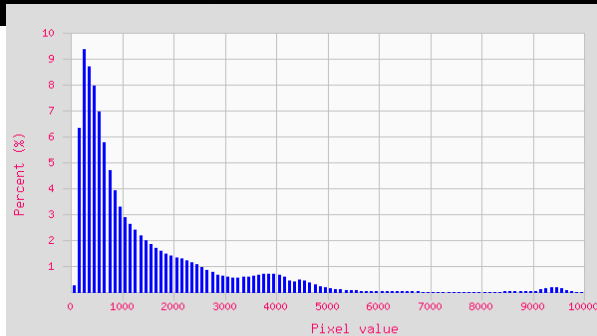
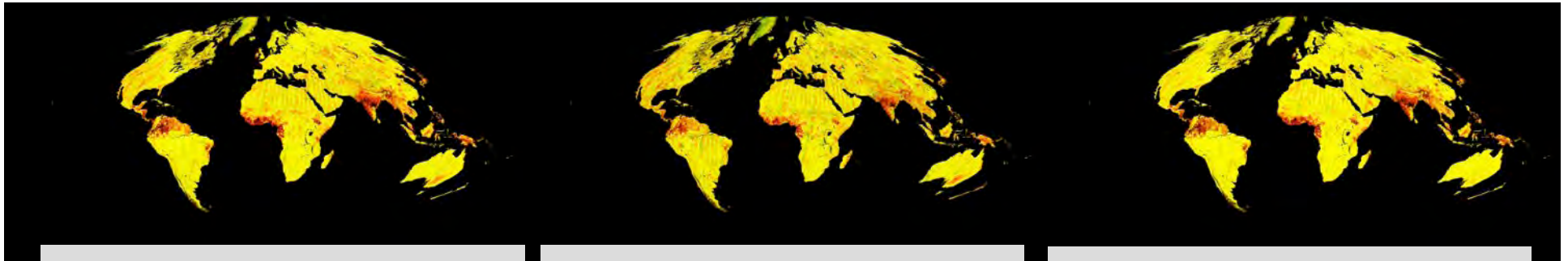
C6 LSR Evaluation (Summer scene , 2003193)

- All SR values increased around the tropics (not proportionally)

Red

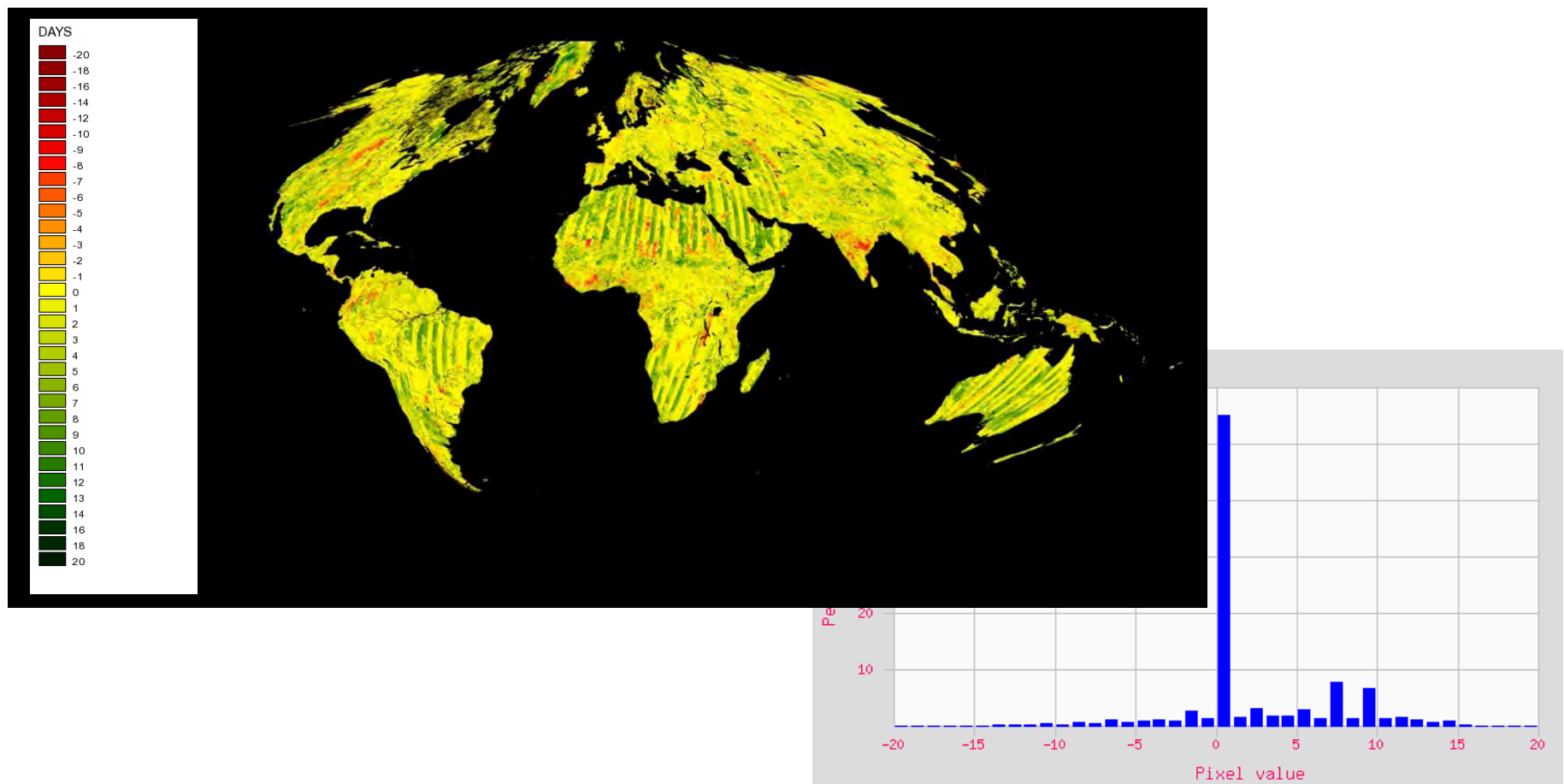
NIR

Blue



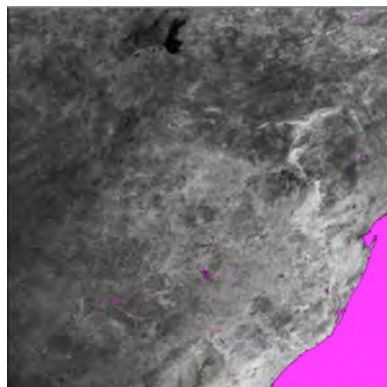
C6 Evaluation Composite DOY (Summer scene, 2003193)

- C6 slight shift to earlier days

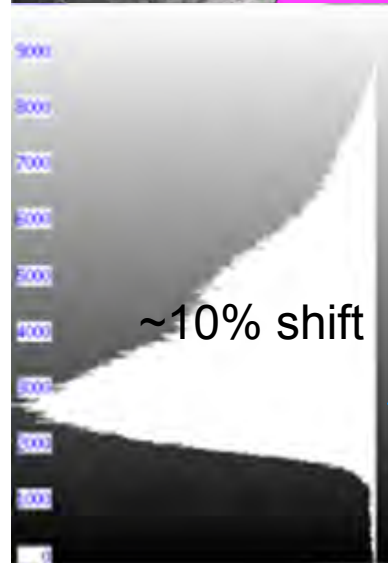
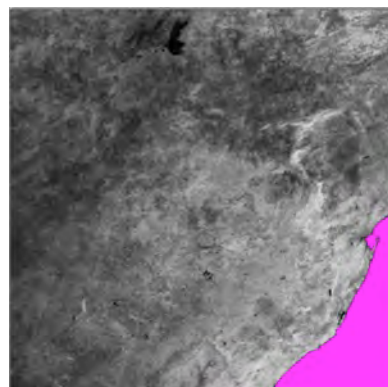


C6 Evaluation

OLD

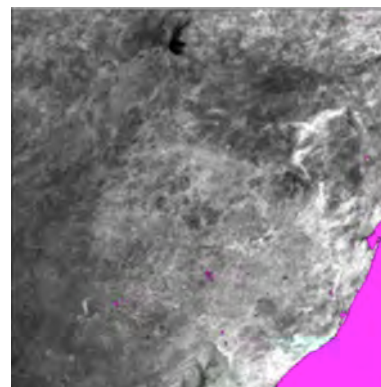


NEW

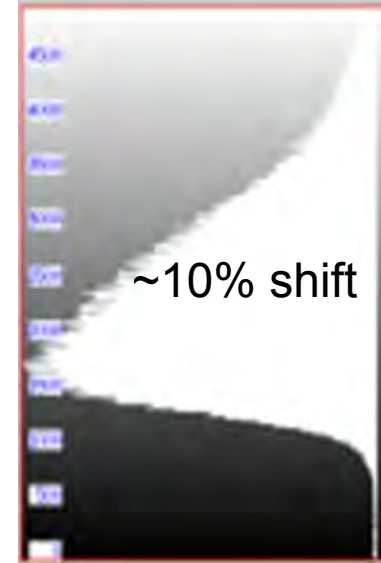
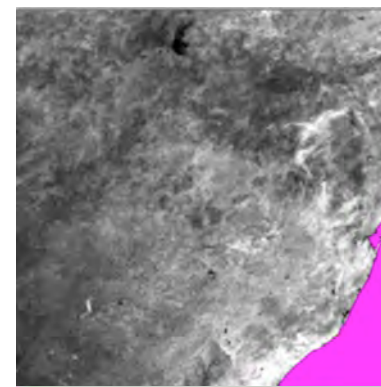


NDVI

OLD



NEW



EVI

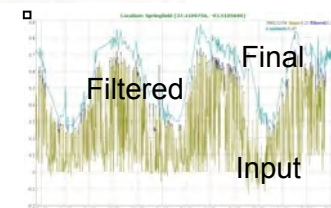
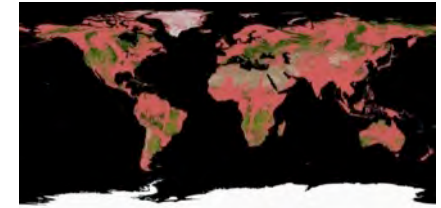
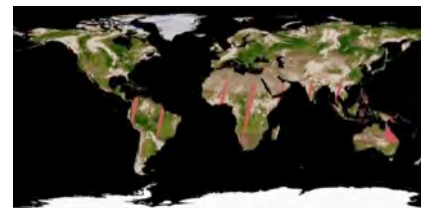
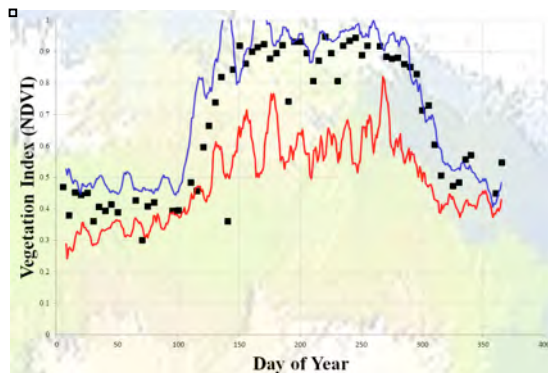
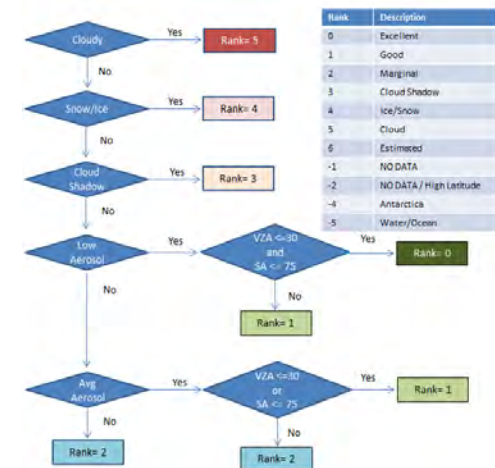
PI SCF Work focused on

1. “Error and Uncertainty” analysis of the full MODIS VI data record
2. Improving the data Filtering
 - Based on data ranking
 - And long term confidence interval (to eliminate residual noise)
3. Implemented EVI2 for forward and backward compatibility
 - A full EVI2 MODIS record is now available (at CMG resolution)
 - We’re producing a full 1km record
4. Developed the “First good observation” compositing scheme to generate high temporal frequency Vegetation Index data in support of phenology and detection of fast change/disturbance
5. Reanalyzed the full Terra and Aqua MODIS VI Data records to generate reference long term VI ESDRs

Improved Filtering

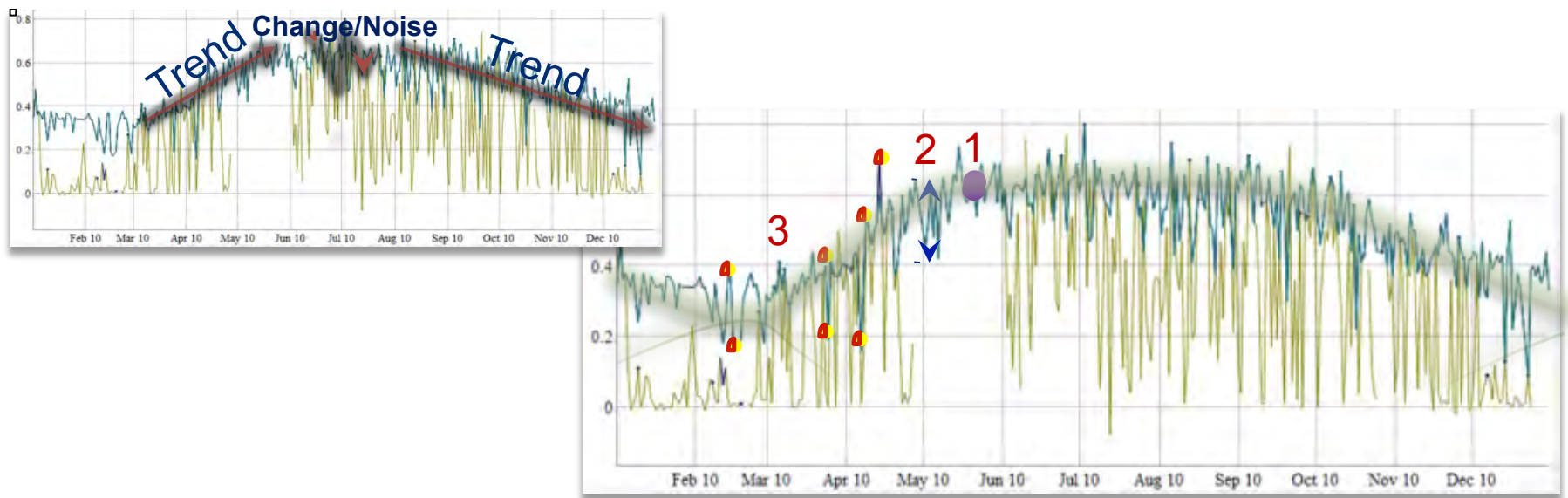
1. The objective is to help eliminate poor quality data and noise

- Based on Pixel QA ranking
 - Simplify post-processing
 - Categorize the data
 - Automate data filtering
- Long term confidence interval
 - Lots of QA error, especially with clouds, snow/ice
 - Mislabeling
 - Residual noise impact change analysis



Error Characterization Framework

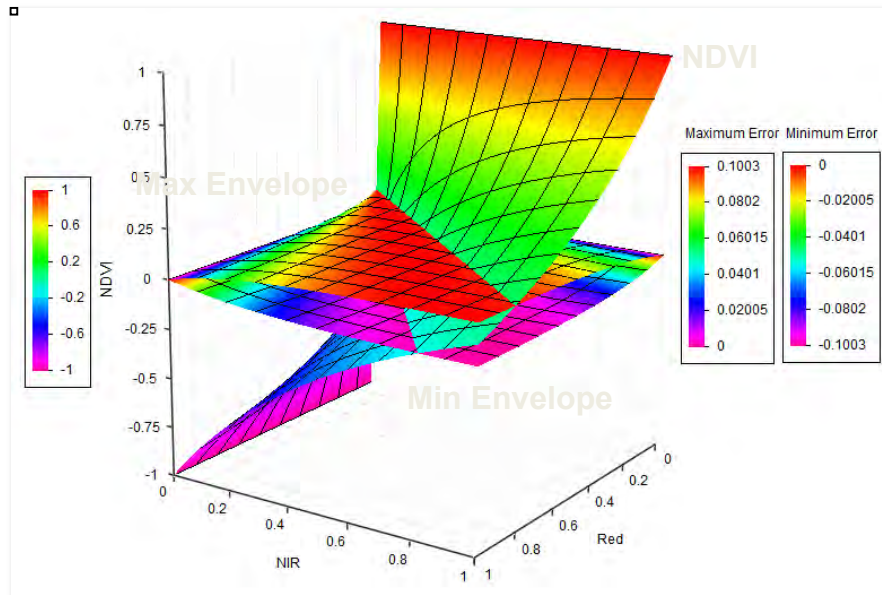
- Error related to input (1)
 - Based on accurate field validation (sunphotometers)
- Departure from normal/expected profile (2)
 - Based on long term standard deviations
- Temporal profile stability (3)
 - Based on change about normal/mean



LSR Input related error

Land Surface Reflectance

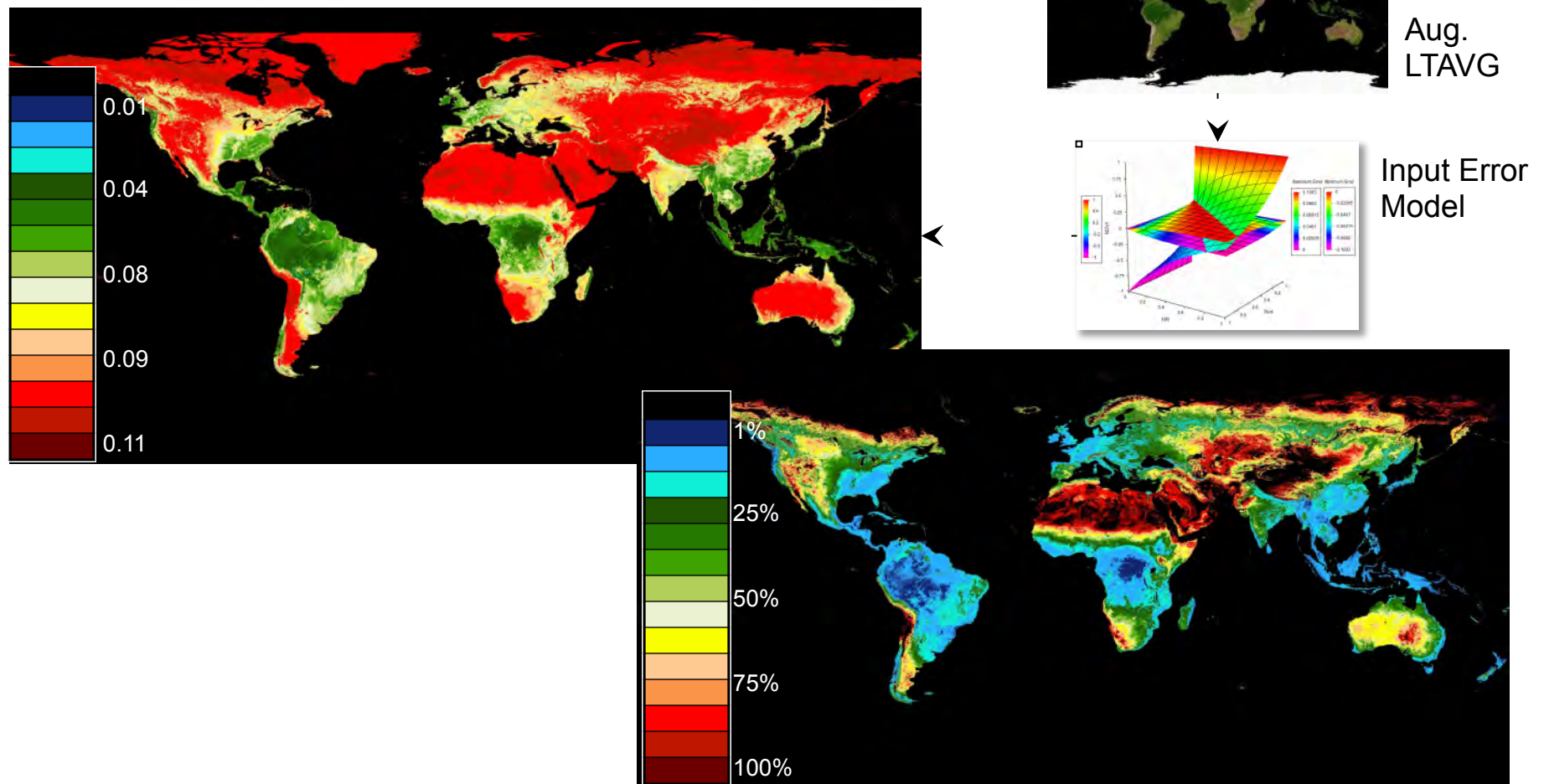
- $NDVI = (N-R)/(N+R)$
- We're not concerned with the VI formulation but the error in the input to this equation. In other words, how close we are to the TOC (Atm. Corr. Performance)
 - Approach: Use Surface Reflectance validation results & Error analysis over sunphotometers sites (ex: EOS Core sites, LPV). Although, the reported average error is about 2-5% in Red & NIR, we will estimate the impact of a 10% error in Red/NIR on the VI estimation.



Max. VI input related Error
Vegetated = 0.04-0.05 VI Unit (~1-5-%)
Non-vegetated = 0.11 VI Unit (~100%)

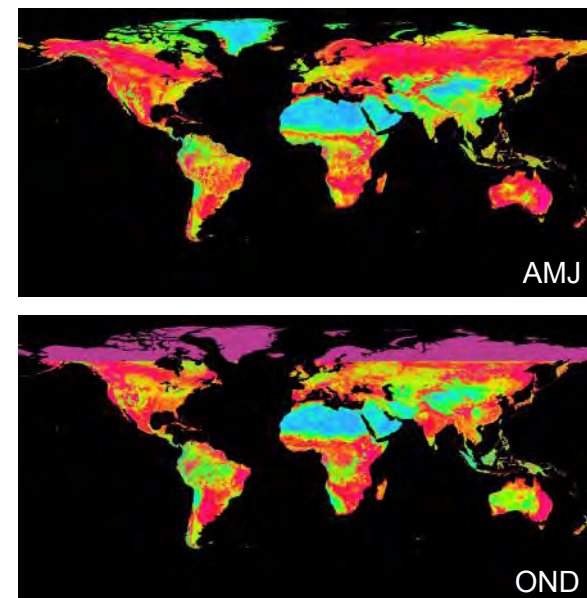
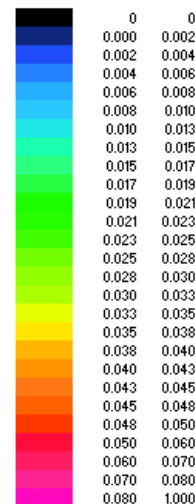
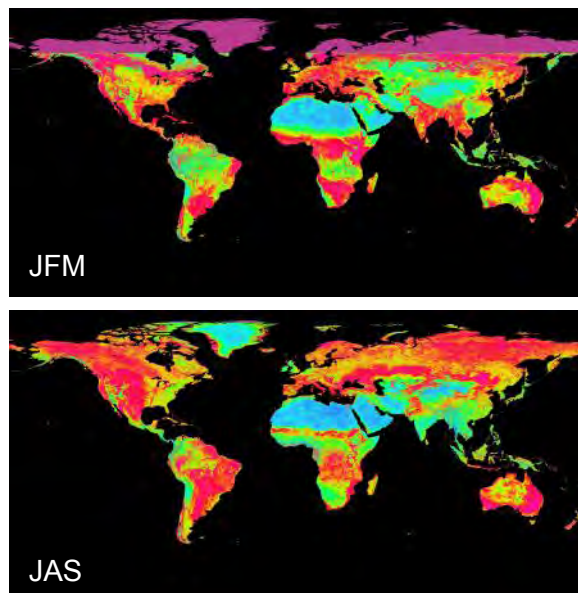
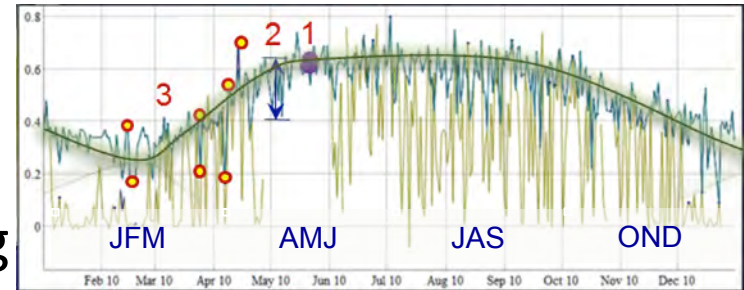
LSR Input Error Global Propagation

- Apply previous results to Long Term Avg. VI



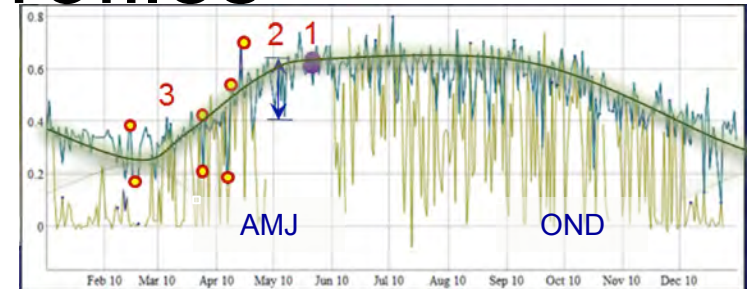
Departure from Normal Related Error

- Departure from normal/expected profile (2)
- Approach is to estimate error by long term standard deviation analysis
 - Error = 0.05 for vegetated and 0.005 for non-vegetated
 - Largest over vegetated area and during winter (snow/ice cover)

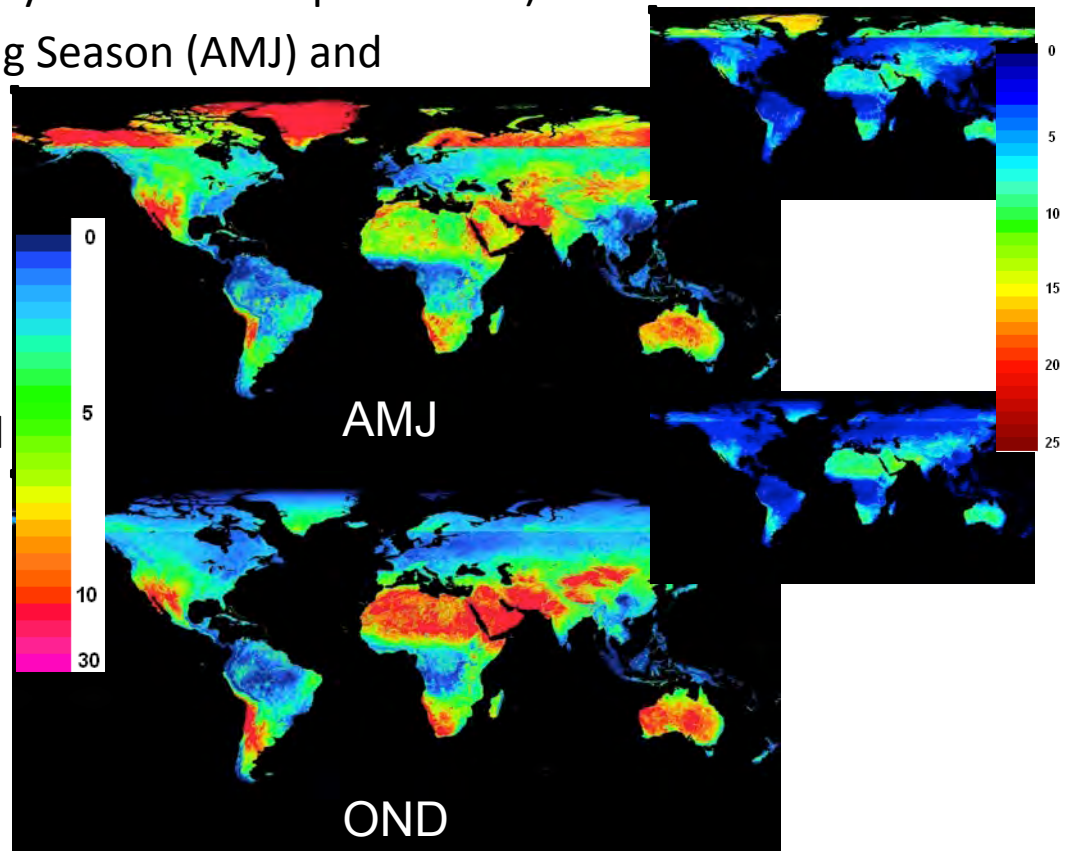


Stability of Time Series Profiles

- Number of peaks and valleys (3)
 - Assess the number of time the profile crosses the normal/expected profile



- Impact on cumulative VI (proxy of Carbon sequestration)
- Showing only Start of Growing Season (AMJ) and Start of Senescence (OND)
- Insets are standard deviation
- AMJ : Lowest over vegetated areas and highest over non-veg and high latitude.
- OND : Lowest over vegetated areas and highest over non-veg.



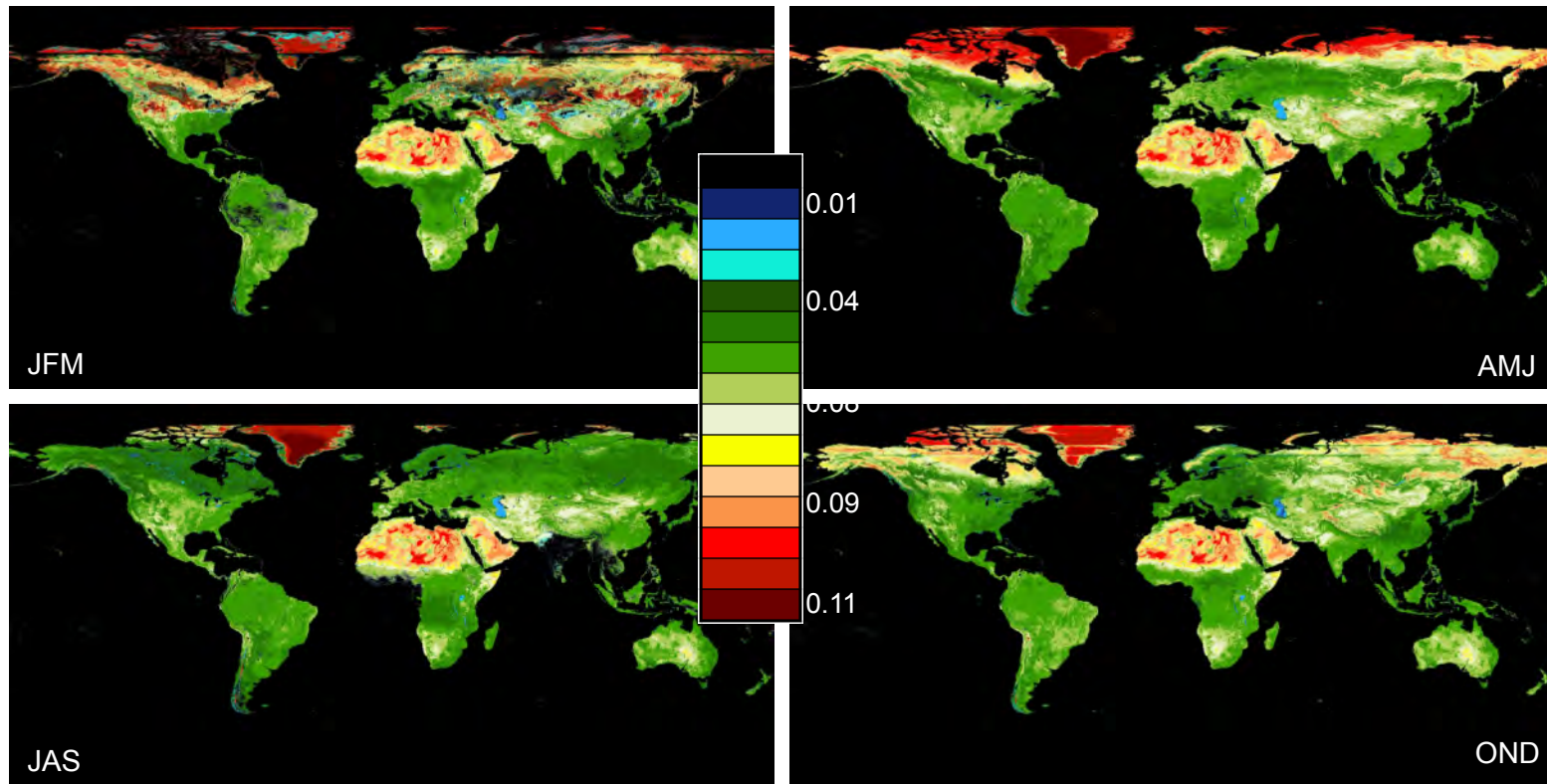
Conclusions

- C6 is different than all previous collections
 - From a VI perspective it is hard to say which is better
 - There was no clear convergence in C6. Differences cannot be attributed to a particular improvement
 - They are simply slightly different data sets
 - We will be able to answer this with a full time series record
- Is C5 better?
 - In some ways may be (consistency)
 - C6 did not build on previous work
- Error due to input is well constrained (absolute max ~ 0.05 or $\pm 5\%$). With Small impact on both NDVI and EVI. With EVI showing a slightly larger error
- Largest error is due to noise (0.1 absolute , 100% over sparsely vegetated areas)
- Impact on physical/biophysical parameters estimation
 - 8-10% on Sum-VI (proxy of GPP)
 - The error is largest during winter (cloud/snow)
 - Impact on estimating the exact day of event (10-40 days – analysis not shown here)
- PI SCF is generate a high frequency (quasi-daily) data record

BACKUP SLIDES

LSR Input Error Global Propagation

- EVI Seasonal Error



- Largest error During winter and Over barren, sparsely, or snow/ice covered land