Development of the surface reflectance Fundamental Climate Data Record from the Landsat archive, the LDCM mission and future Landsats

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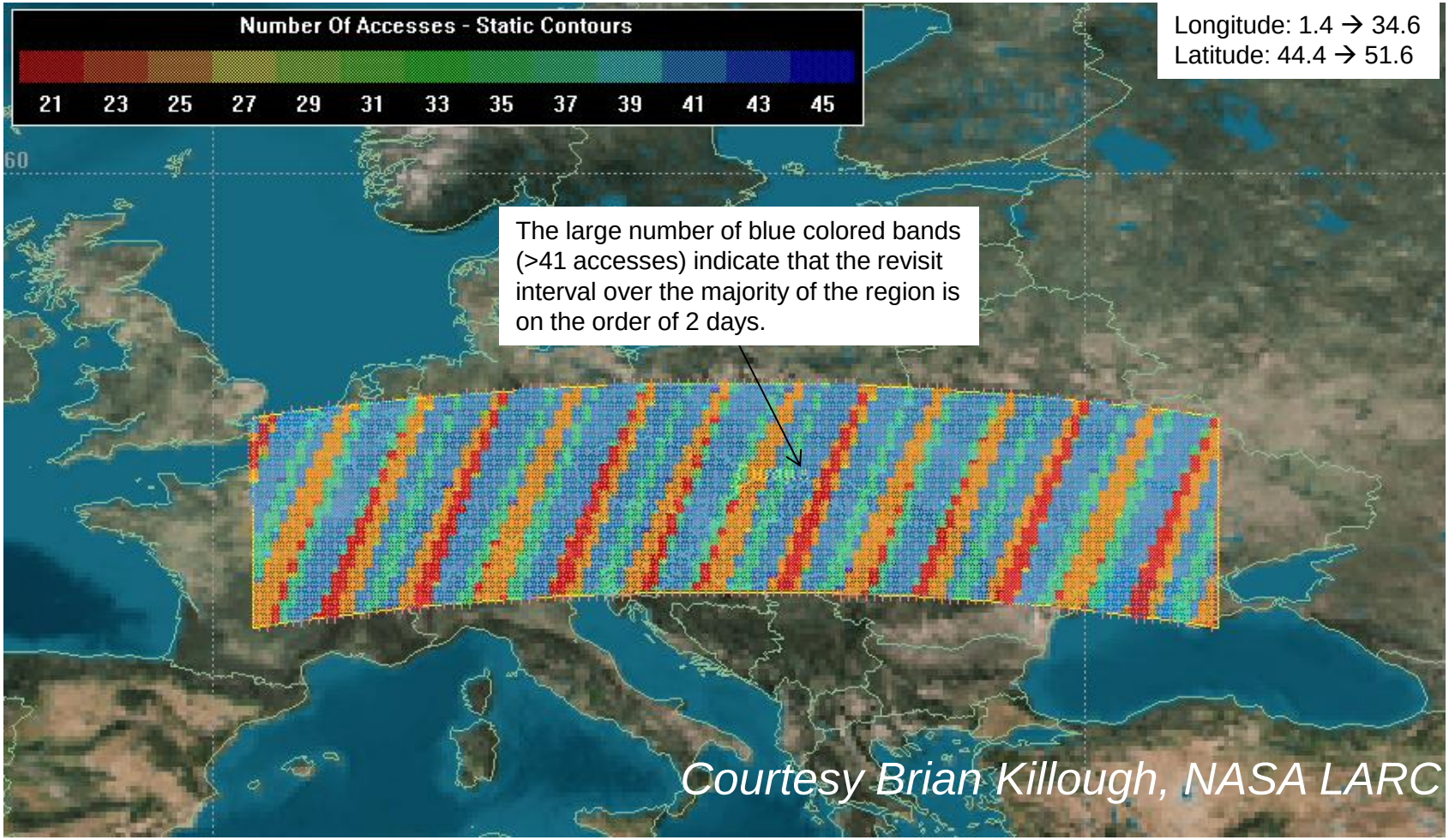
Landsat Science Team Meeting, Sioux Falls, SD. October 29-31, 2013

Objectives

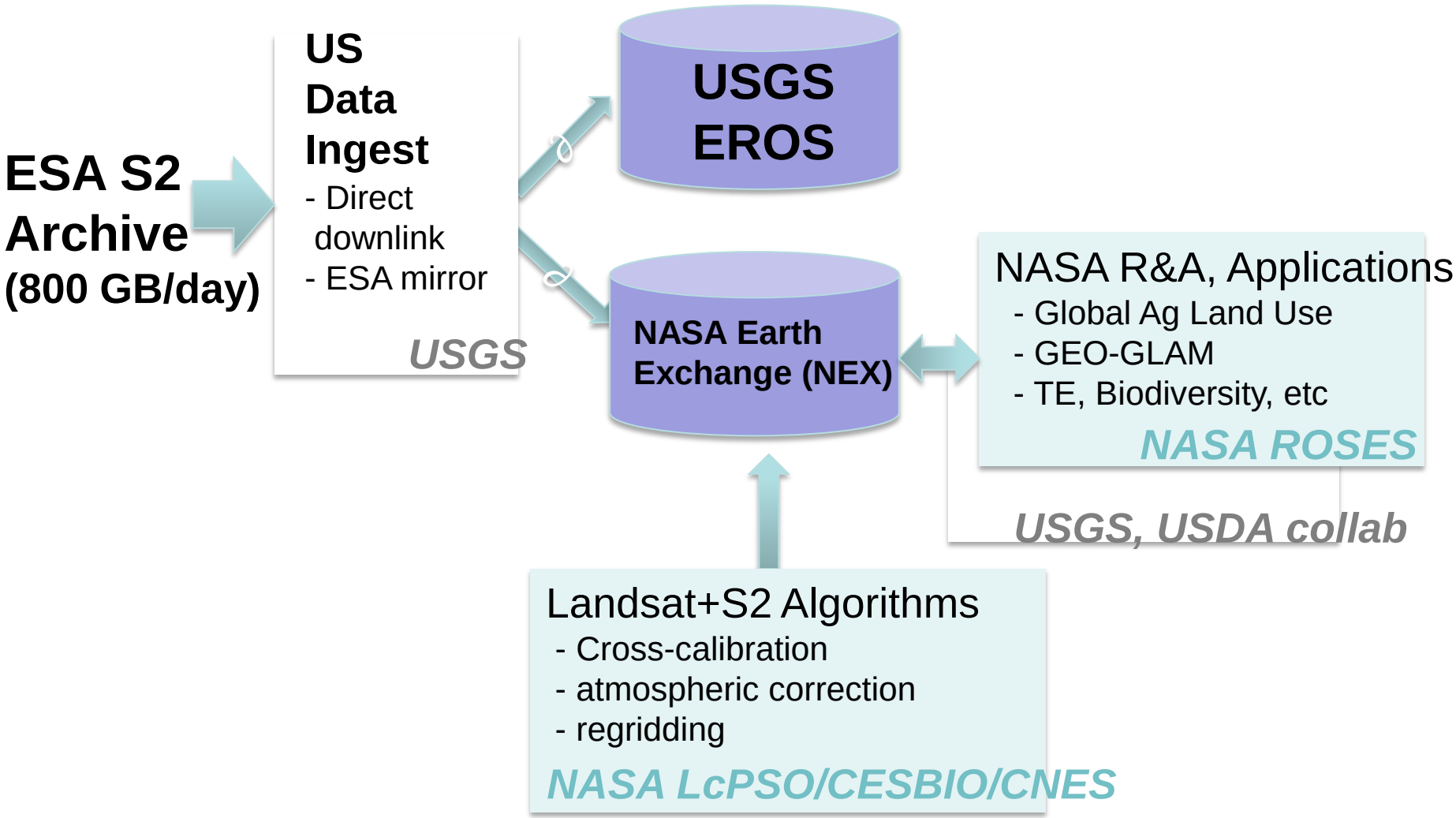
- to provide an algorithm and code for a Surface Reflectance Standard Product for integration into the LDCM processing system.
- to validate the resulting LDCM product, using data from AERONET
- to provide a cloud masking and cloud shadow screening algorithm for LDCM
- to undertake vicarious calibration of the LDCM instrument
- to advise on and contribute to the LDCM program outreach and explore the potential synergy with other high resolution international earth observation programs (e.g. through the LCLUC, GLAM GOFC/GOLD and IGOL programs).
- to be an active contributor to the LDCM Team, participating in telecons, science team meetings and working groups as appropriate.
- ***Explore in particular the possibility to create a fused surface reflectance product from LDCM and Sentinel 2 (prototype with Formosat data and SPOT4 –Take 5 experiment).***

Sentinel 2A and B - LDCM Europe

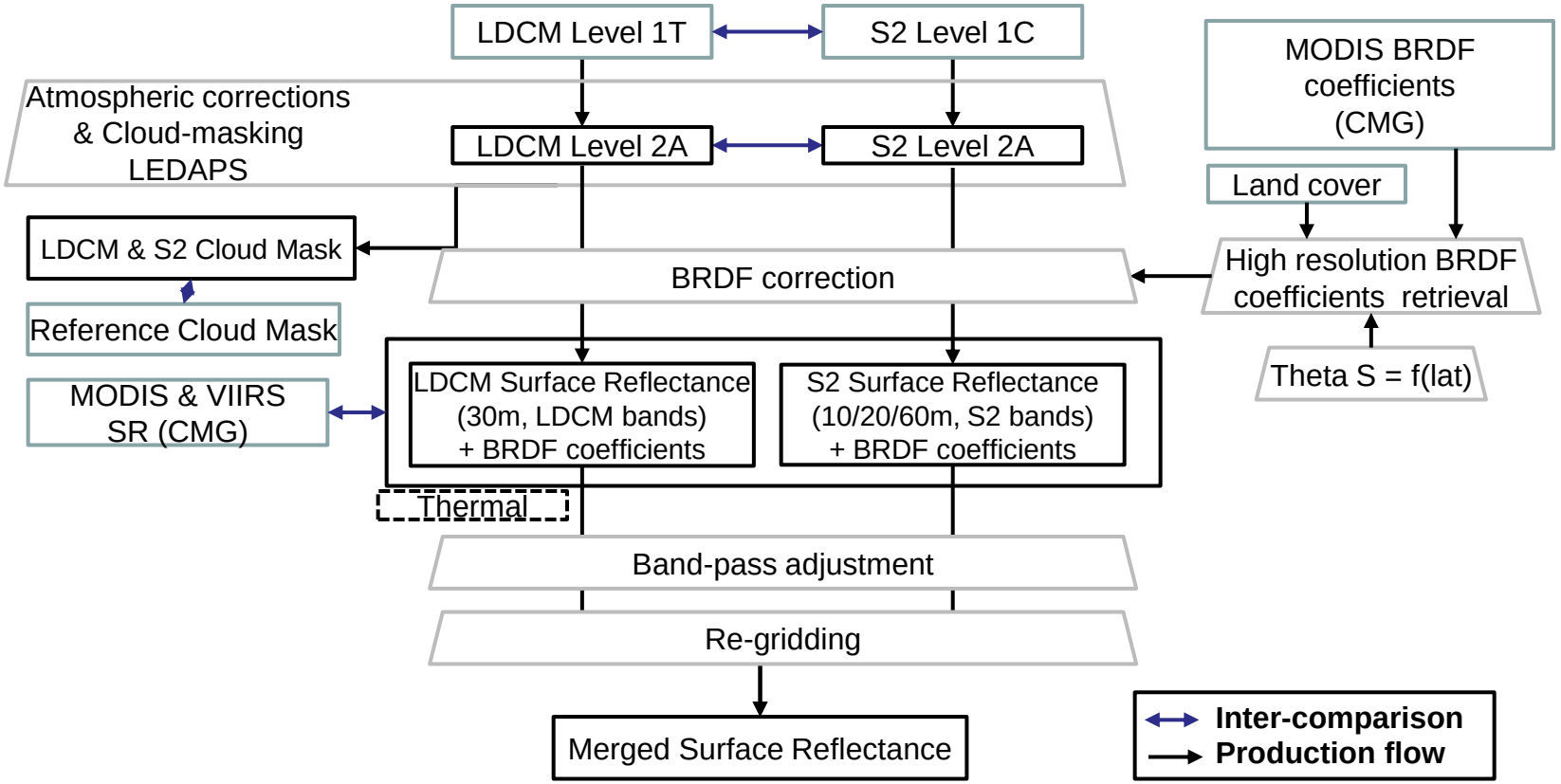


- The picture shows the number of times LDCM and the Sentinel 2 satellites accessed areas on the ground over an 80 day period of time.
  - 21 accesses indicates a maximum revisit interval of ~3 days 19 hours
  - 46 accesses indicates a minimum revisit interval of ~1 day 18 hours

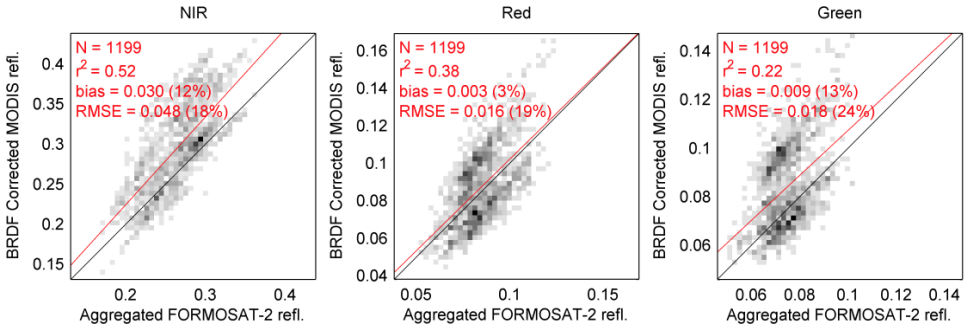
Proposed Sentinel-2 / Landsat Architecture



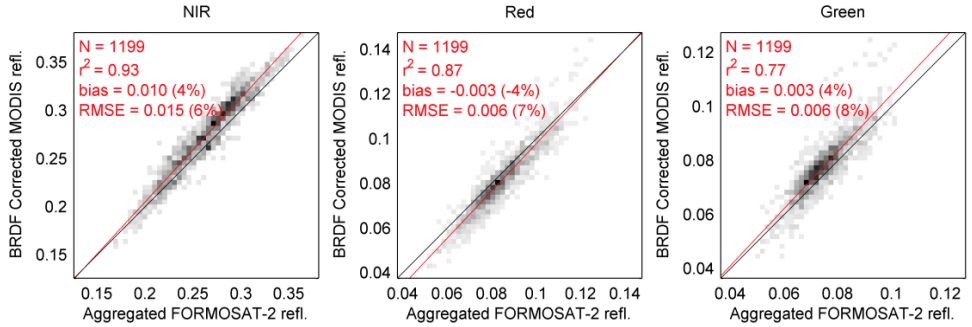
LDCM / Sentinel-2 Fusing



Cross-comparison of MODIS SR with product derived using independent approach 1/2

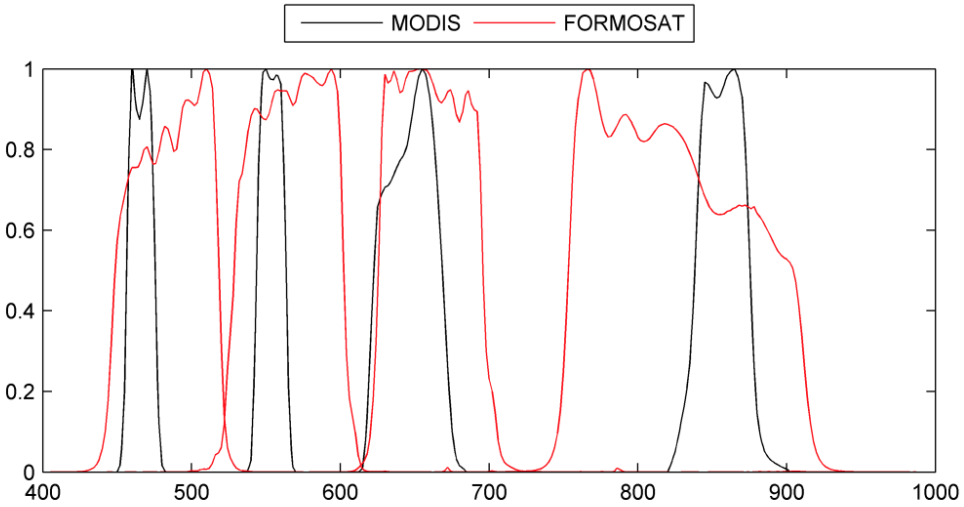


Comparison of aggregated FORMOSAT-2 reflectance and MODIS reflectance. No BRDF correction. Density function from light grey (minimum) to black (maximum); white = no data.

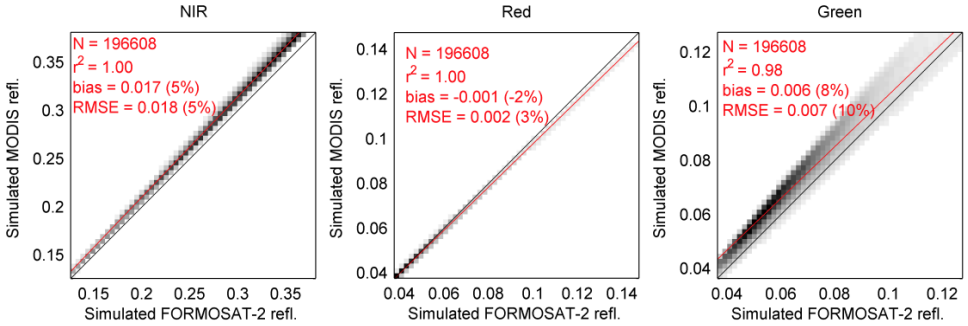


Comparison of aggregated FORMOSAT-2 reflectance and BRDF corrected MODIS reflectance. Corrections were performed with Vermote al. (2009) method using for each day of acquisition, the angular configuration of FORMOSAT-2 data.

Cross-comparison of MODIS SR with product derived using independent approach 2/2



Spectral Bands of MODIS and FORMOSAT-2

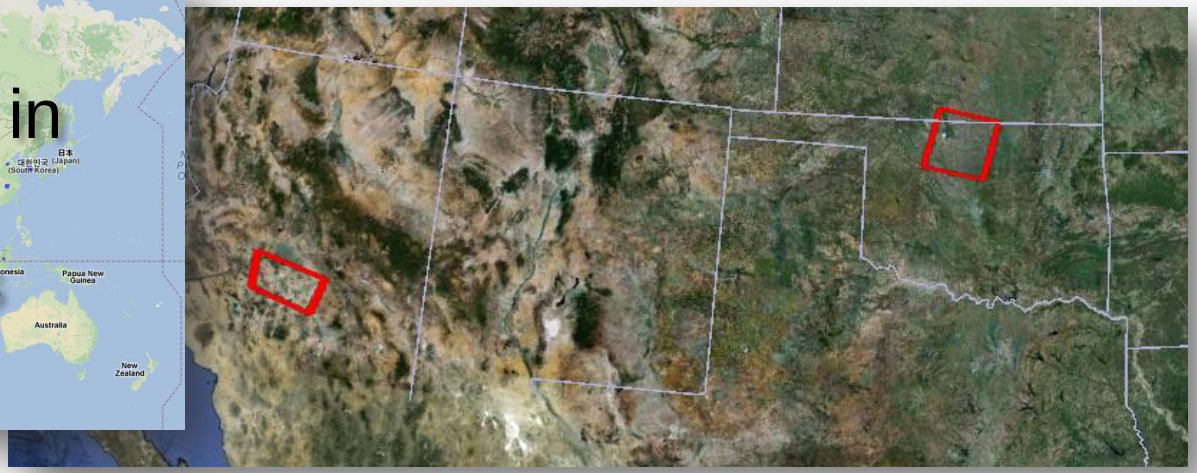


Comparison of simulated FORMOSAT-2 and MODIS reflectance performed with PROSAIL model. The simulated dataset is the same as the one described in Baret et al. (2007).

SPOT-4 Take five Experiment

- Data every 5th day
- Constant View Angle
- 4 spectral bands (b, g, r, nir)
- 4 months: February – May

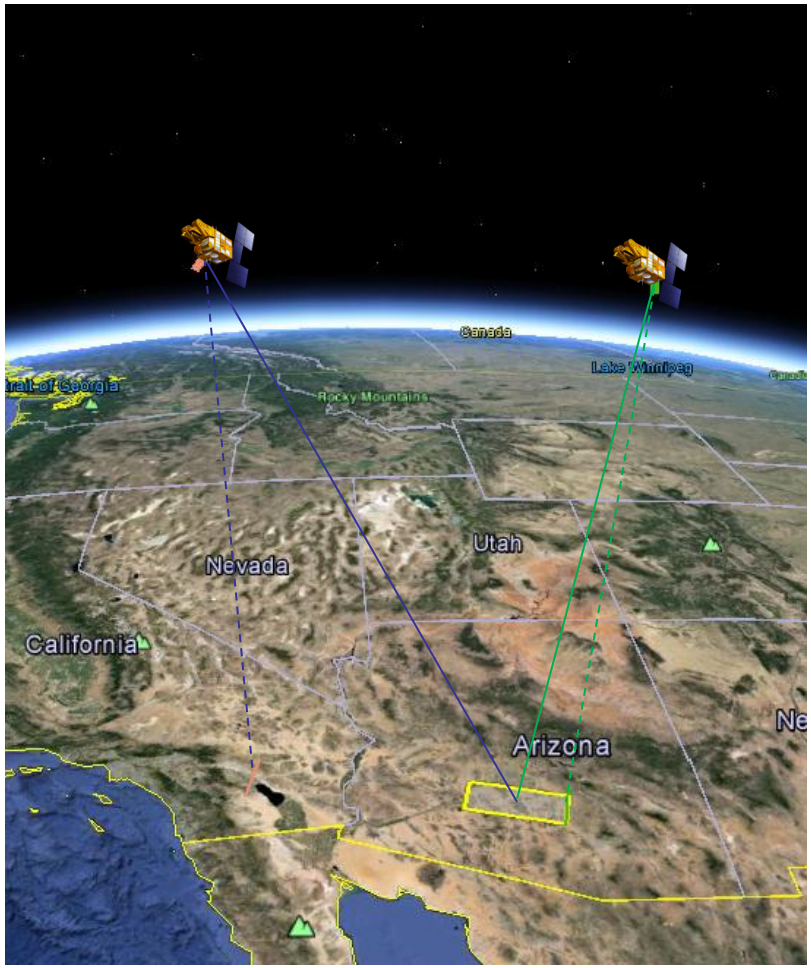
- 42 sites (worldwide, mostly in France)
- 2 US Ag sites funded by NASA:
  - Southern Great Plains (OK, USA)
  - Maricopa (AZ, USA)
- All data free



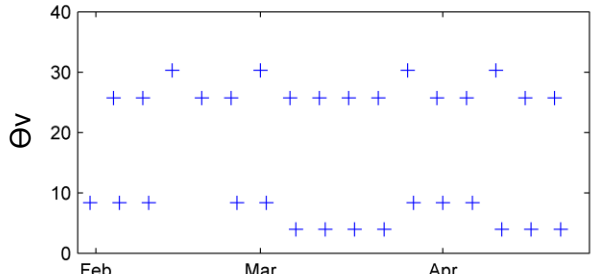
SPOT-4 Take 5 Analysis (Maricopa)

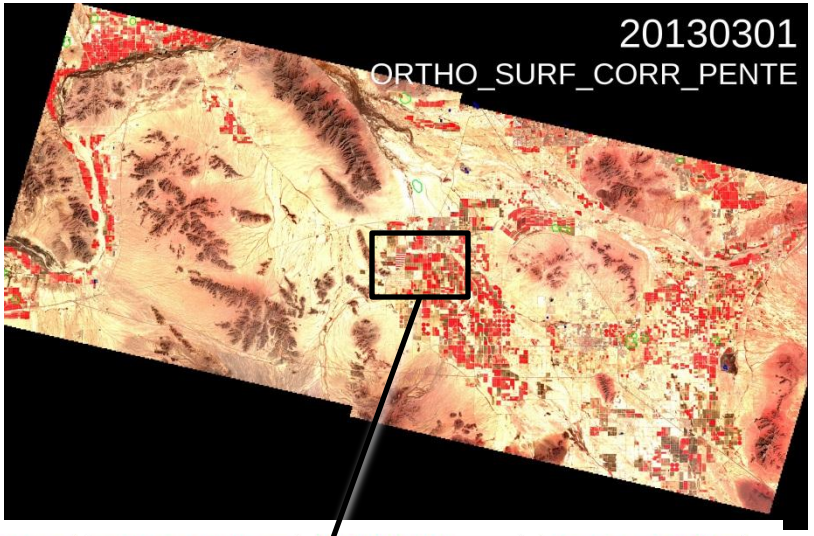
- SPOT4 TAKE 5 specs
  - 20 meters
  - 5-day repeat cycle with constant view angle
  - 4 spectral bands: Green (550 nm), Red (650 nm), NIR (820 nm), MIR (1600 nm)
  - Constant View angle
  - SR processed by O. Hagolle

- Maricopa site
  - 120 km x 60 km
  - 2 acquisitions from 2 various cycles
    => day 1, 5, 6 , 10, 11, 15, 16, …
  - (Θv=25°, Φv=-77°)
  - (Θv=8° , Φv=100°)
  - Low cloud cover (+/- 15 % for Feb-Apr 2013)
  - Flat and non-flat terrain
  - Mainly desert surface with irrigated cropland

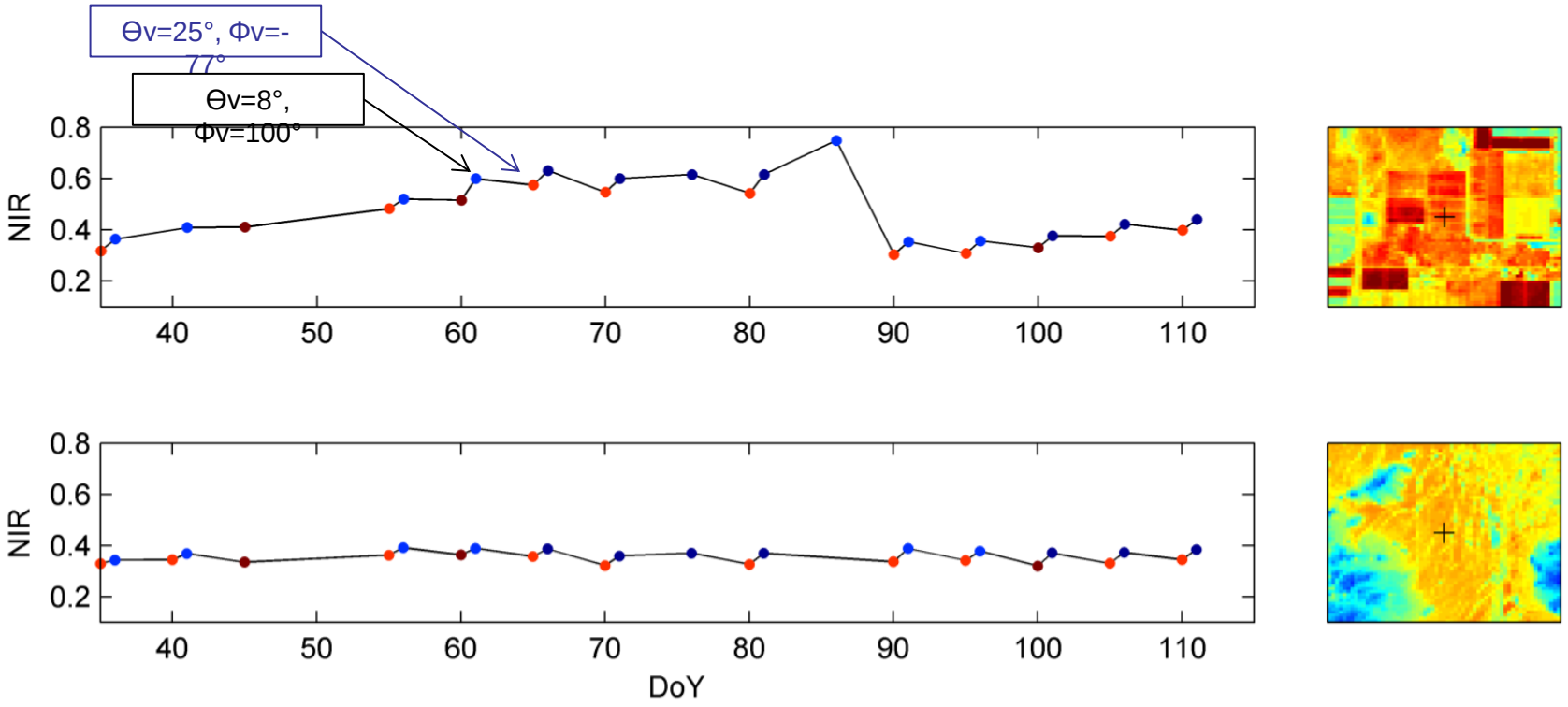


Data overview

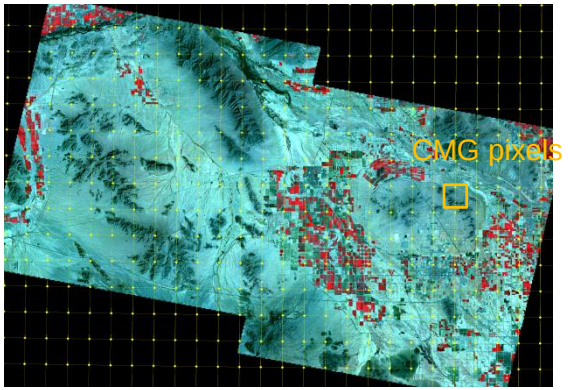




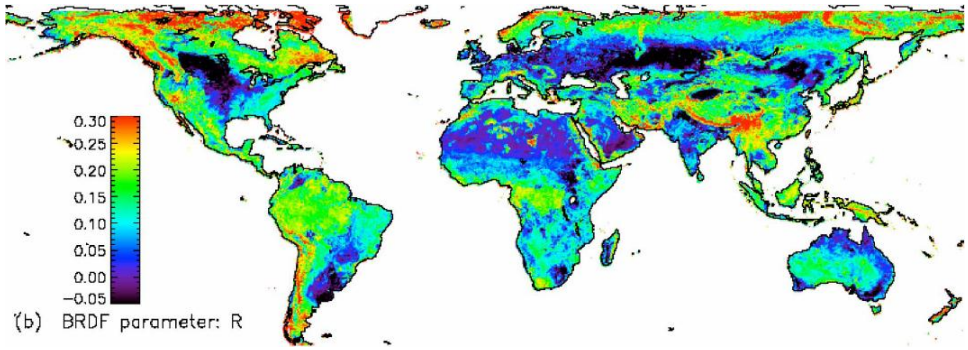
Time series analysis and BRDF effects



VJB model to correct BRDF



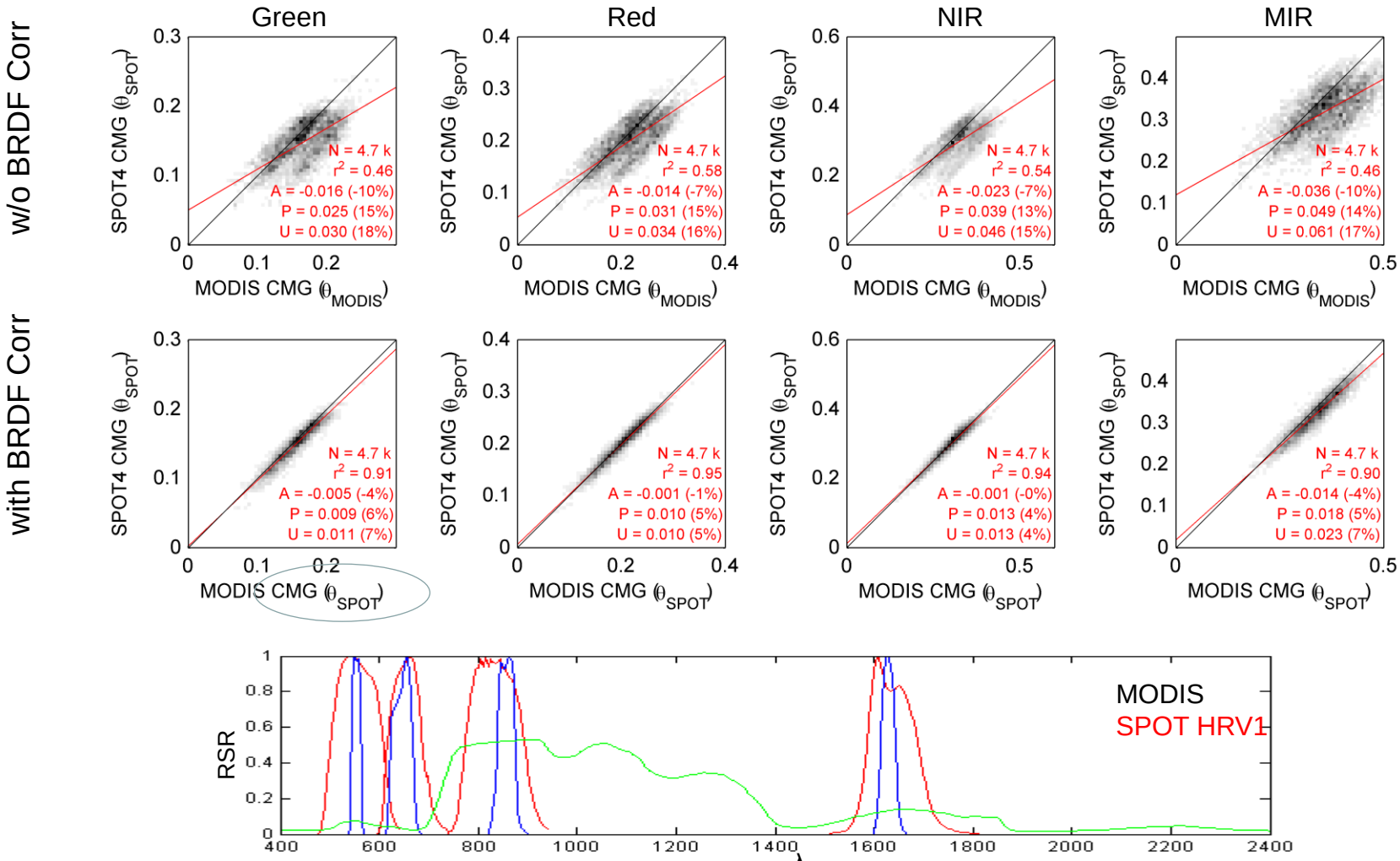
- VJB Model (Vermote et al. 2009)
  - Relate BRDF parameter to NDVI
  - Simplification of BRDF Kernels using 2 proxy: R & V
  - $\rho(\theta\_out) = \rho(\theta\_in) \times K(\theta\_in,\theta\_out,R,V)$ & θ stands for θs, θv, Δδ
  - using MODIS CMG (0.05°), R & V were found well-correlated to NDVI
    - $R = a_1 \times NDVI + b_1$
    - $V = a_2 \times NDVI + b_2$
  - a_1,b_1,a_2,b_2 parameters were retrieved at global scale (at 0.05°) for each MODIS band



Vermote et al. (2009)

Surface Reflectance Comparison: MODIS

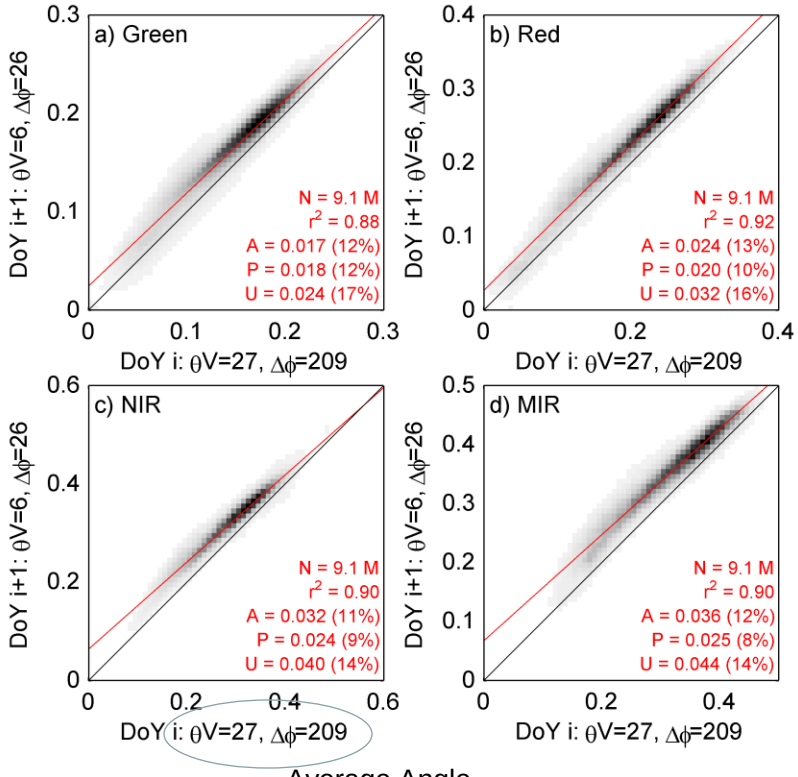
Comparison processed at CMG (0.05°)
S4 and AQUA acquisitions on the same day



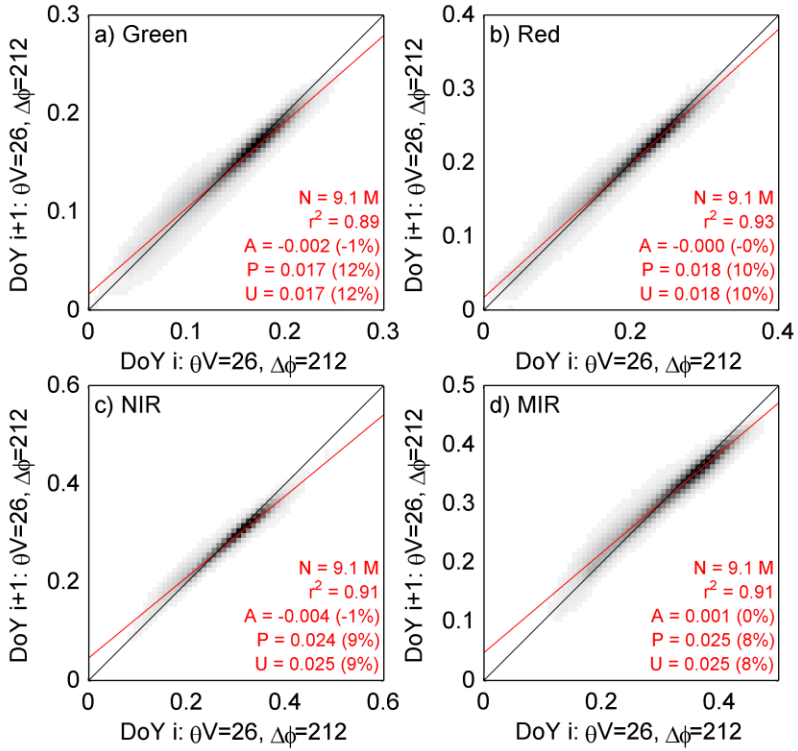
A = Accuracy (bias); P = Precision (repeatability); U = Uncertainty (actual statistical deviation of the deviation)

Comparison of consecutive acquisitions

Without BRDF Correction

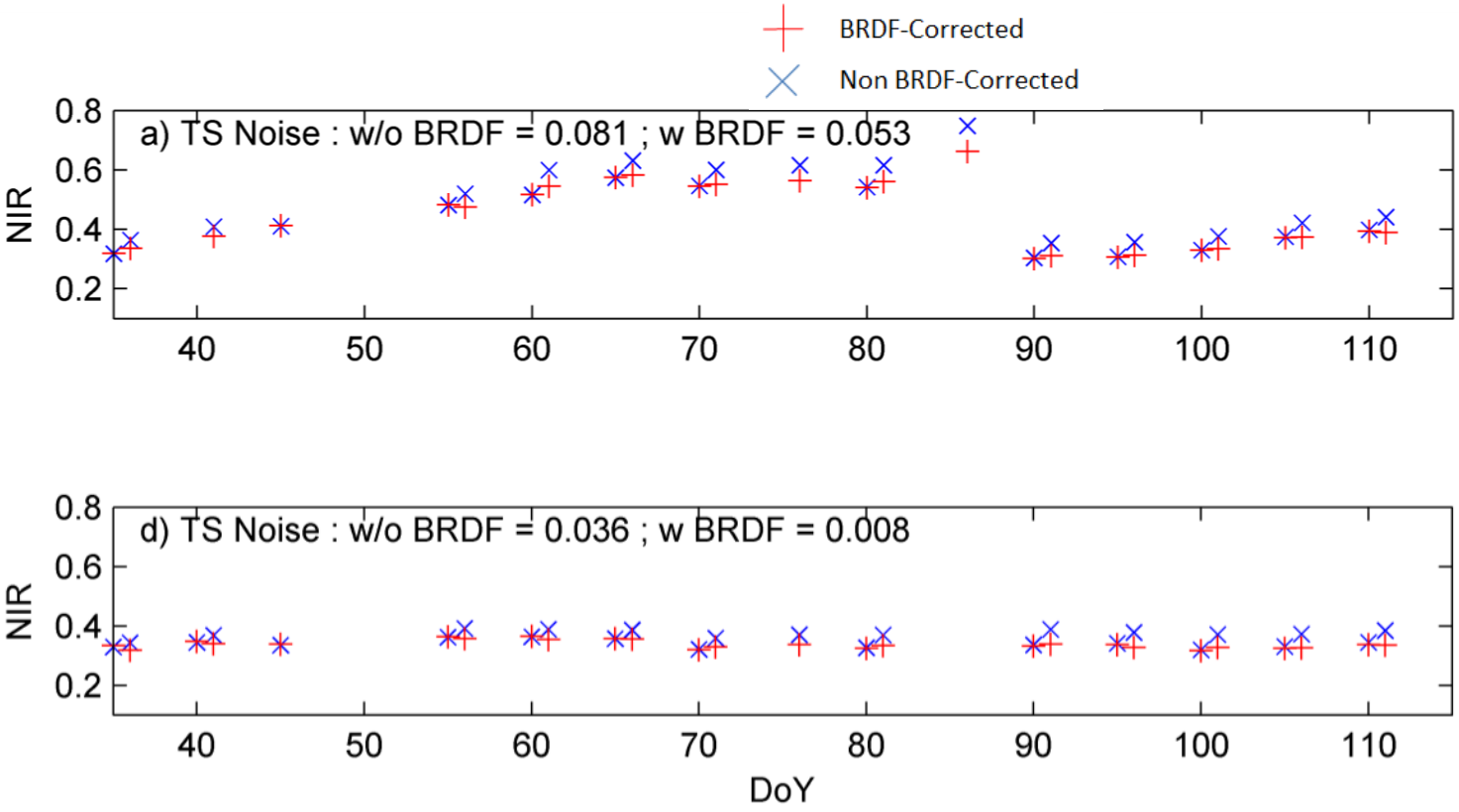


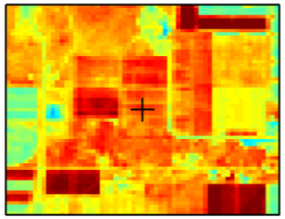
With BRDF Correction

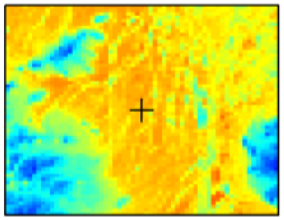


A = Accuracy (bias); P = Precision (repeatability); U = Uncertainty (actual statistical deviation of the deviation)

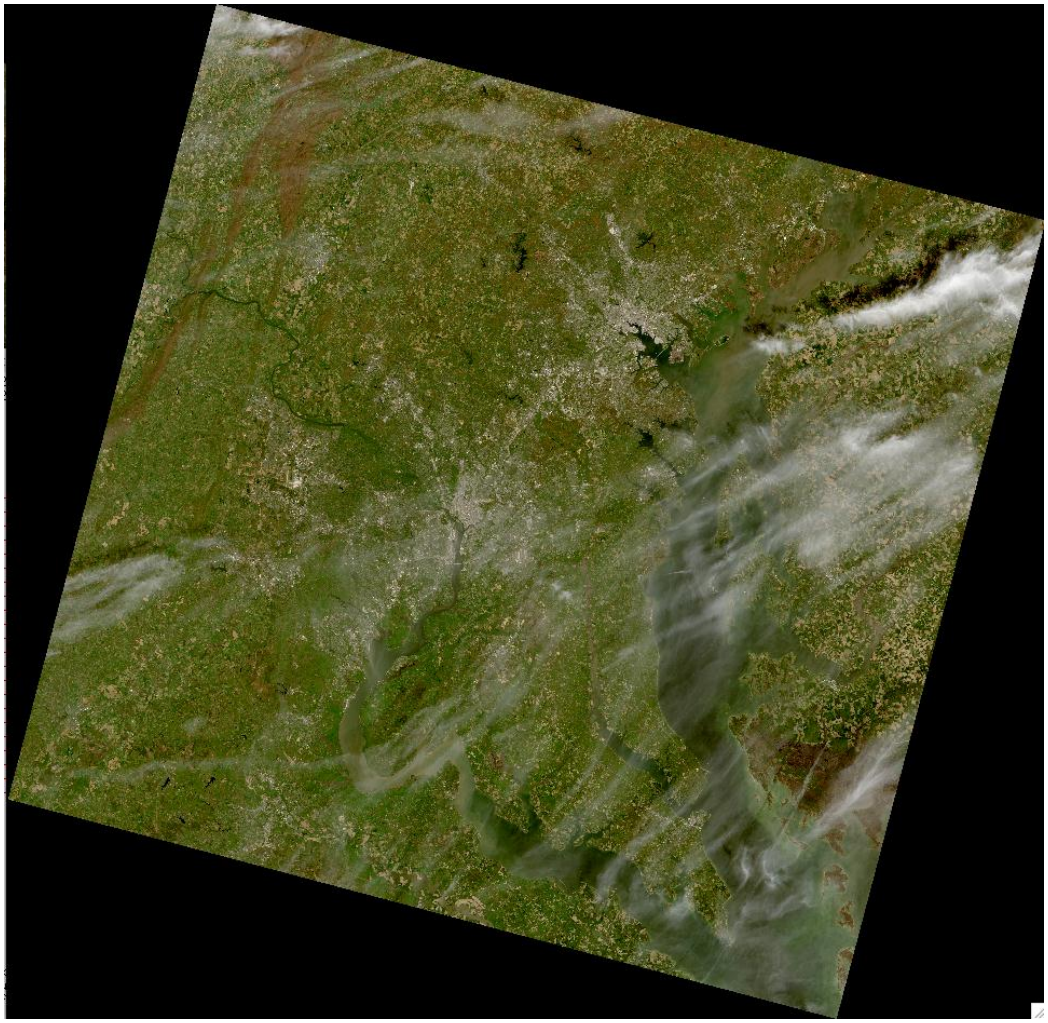
Time series analysis and BRDF effects correction





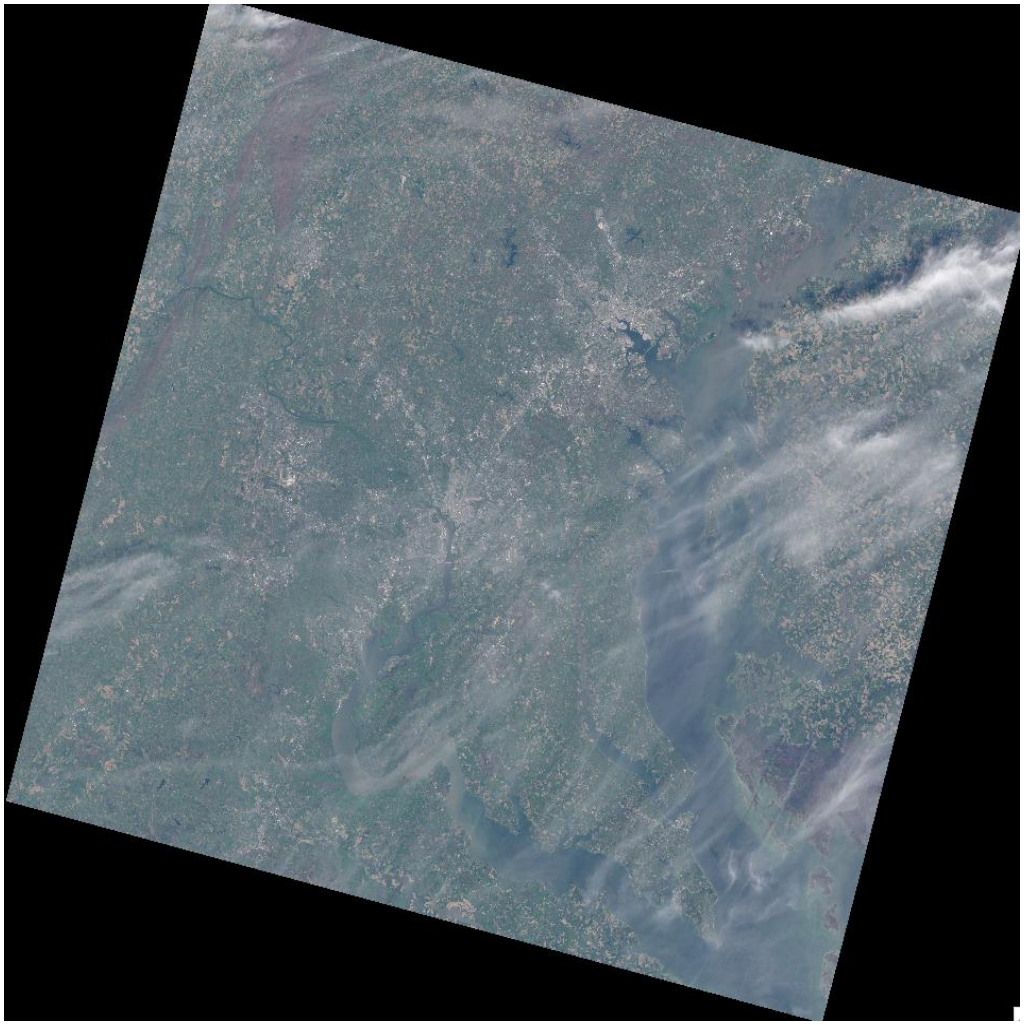


Landsat 8 results



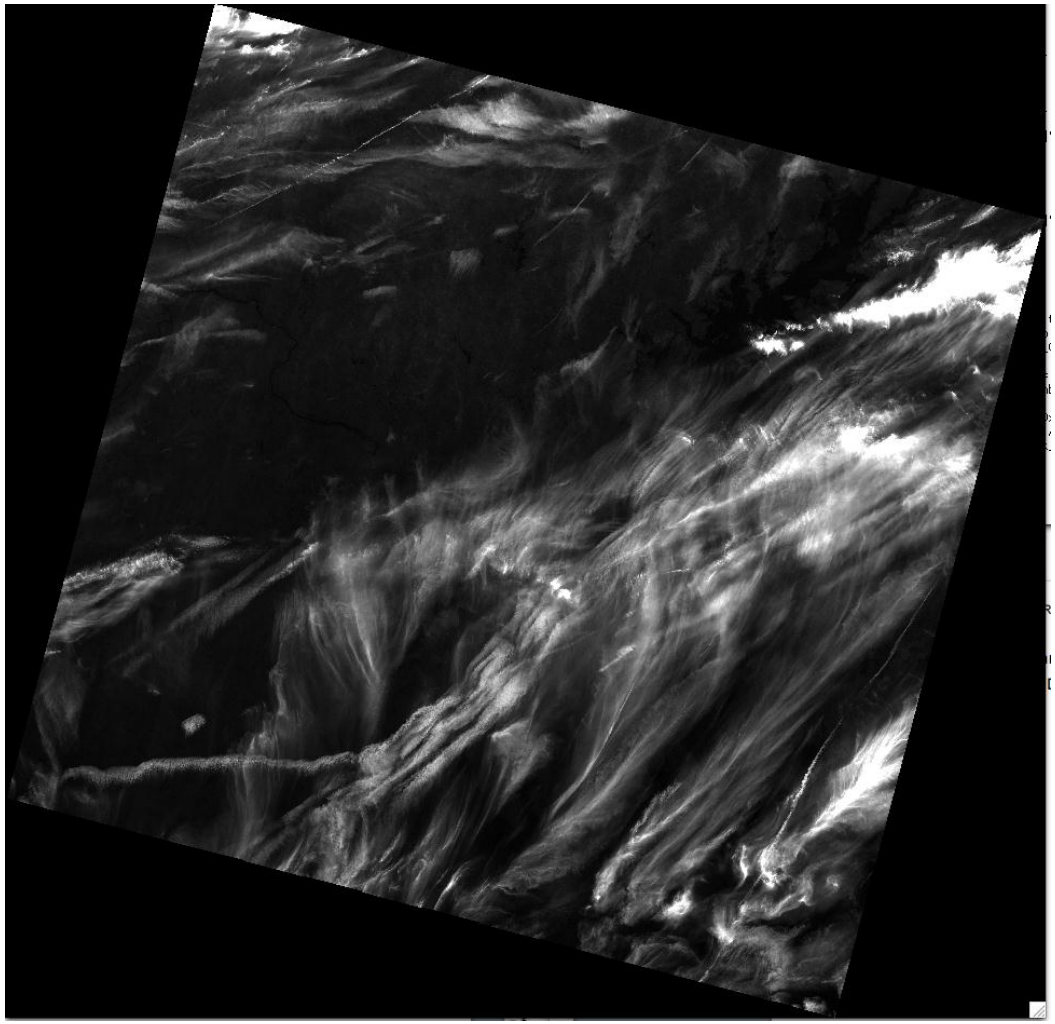
Prototype surface reflectance product from LDCM. Image acquired on April 21 2013. This true-color composite was generated using LDCM bands 2,3,4. The surface reflectance product shows coverage of cirrus clouds over the scene.

Landsat 8 results (cont.)



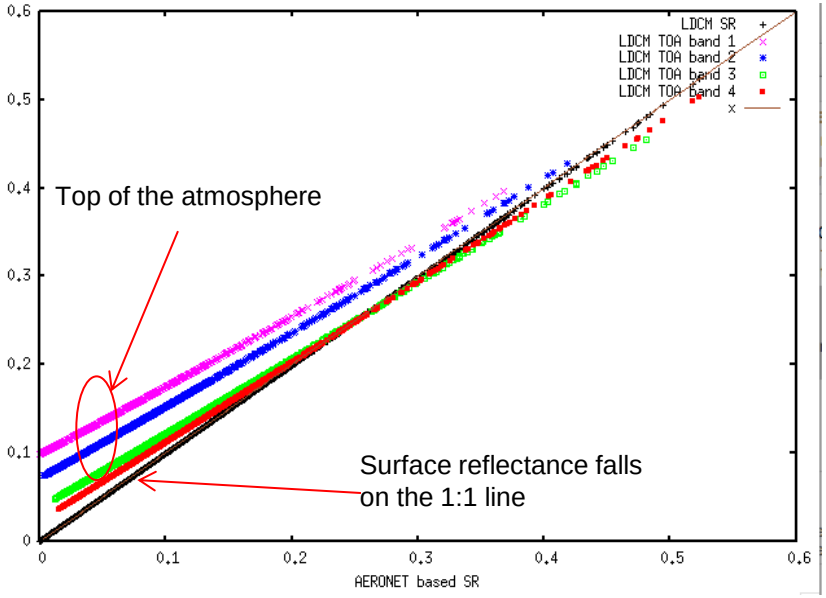
Top of the atmosphere image acquired on April 21 2013. This true-color composite was generated using LDCM bands 2,3,4.

Landsat 8 results (cont.)



The coverage of cirrus cloud is very well captured by LDCM band 8.

Landsat 8 results (cont.)



Validation of the LDCM surface reflectance over GSFC AERONET site. The red square points to the the area used for comparison

Conclusions

- Surface reflectance algorithm is mature and pathway toward validation and automated QA is clearly identified.
- Algorithm is generic and tied to documented validated radiative transfer code enabling easier inter-comparison and fusion of products from different sensors (MODIS,VIIRS,AVHRR, LDCM, Landsat, Sentinel 2 …)
- SPOT4 Take5 Surface reflectance dataset
  - Good consistency with MODIS SR after BRDF correction
  - Good overall consistency S4 Time series
  - Some differences remain around cloudy area
- preliminary LDCM correction results are promising…