



MODIS/VIIRS Surface Reflectance Validation

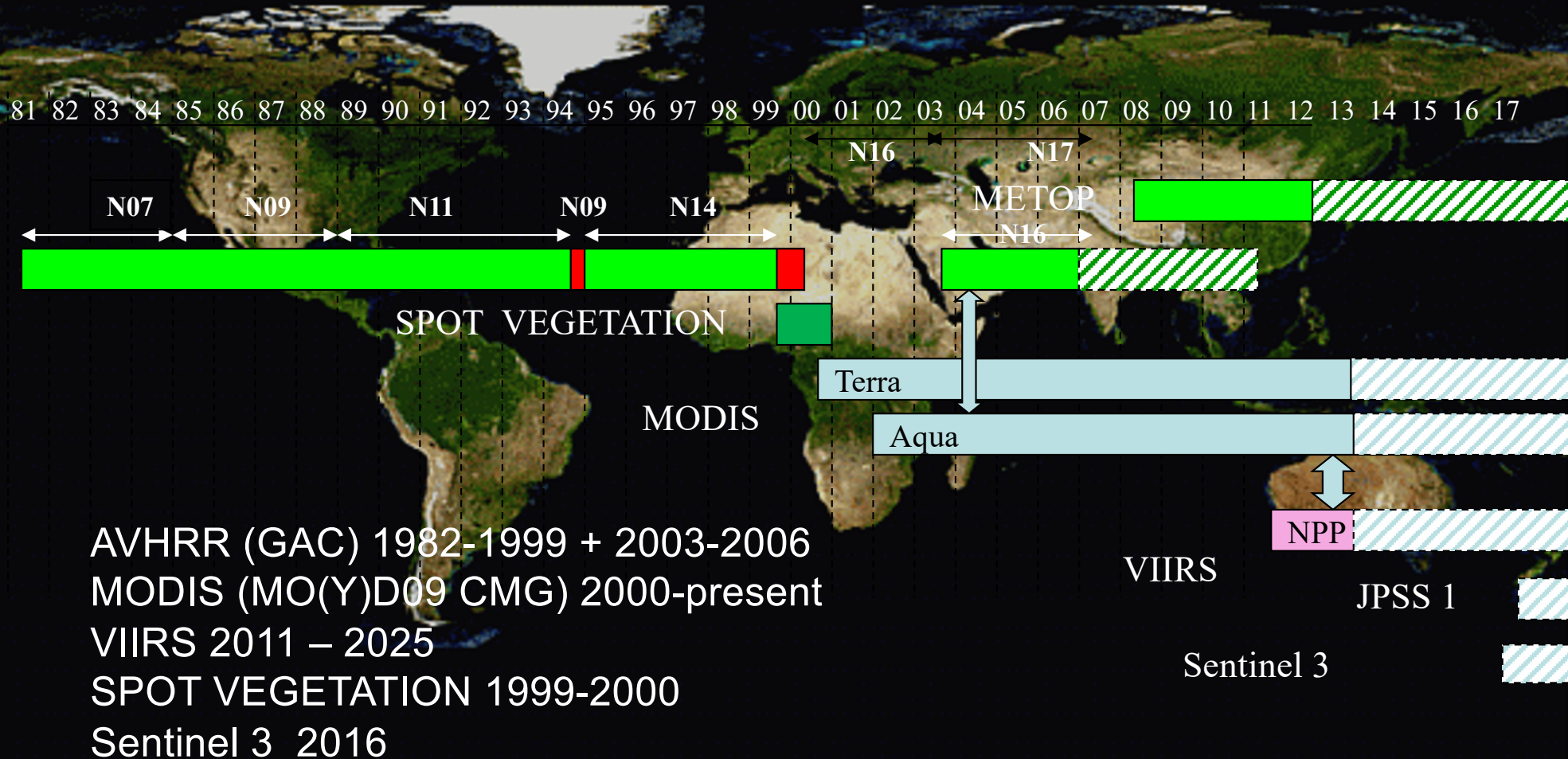
Eric Vermote

NASA/GSFC Code 619, Greenbelt, MD 20771, USA



A Land Climate Data Record

Multi instrument/Multi sensor Science Quality Data Records used to quantify trends and changes



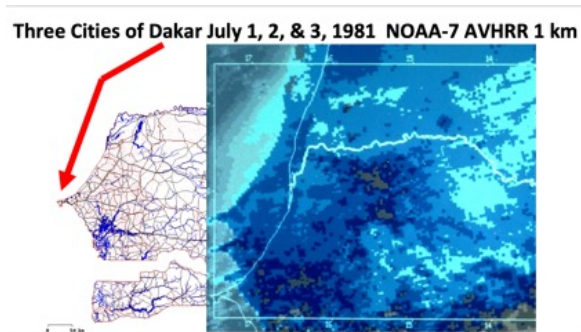
Emphasis on data consistency – characterization rather than degrading/smoothing the data



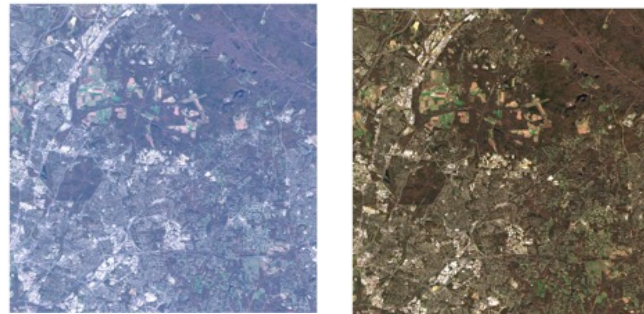
Land Climate Data Record (Approach)

Needs to address geolocation, calibration, atmospheric/BRDF correction issues

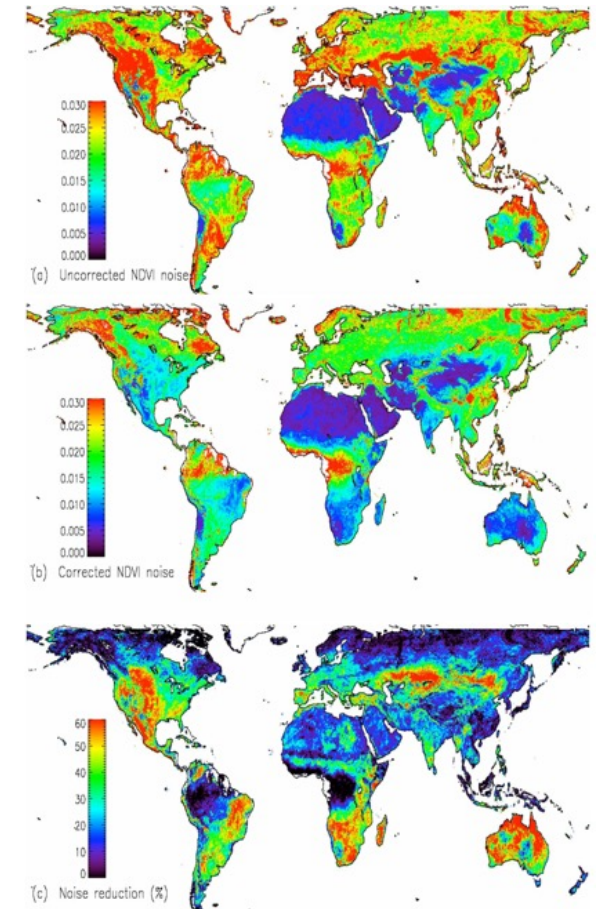
GEOLOCATION



ATMOSPHERIC CORRECTION

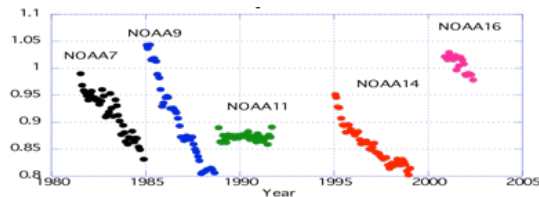


BRDF CORRECTION

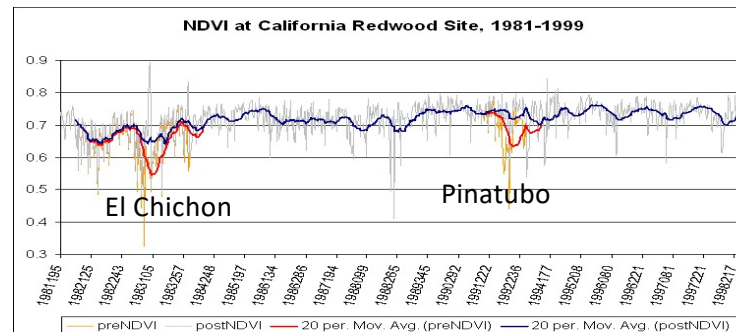
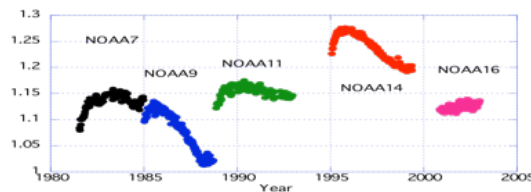


CALIBRATION

Degradation in channel 1
(from Ocean observations)



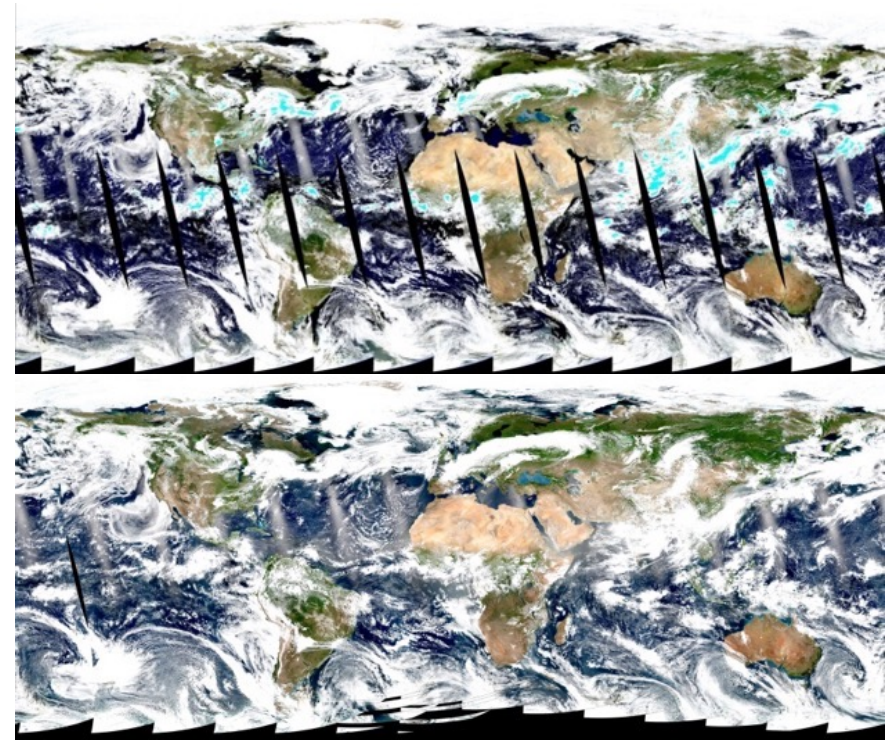
Channel1/Channel2 ratio
(from Clouds observations)



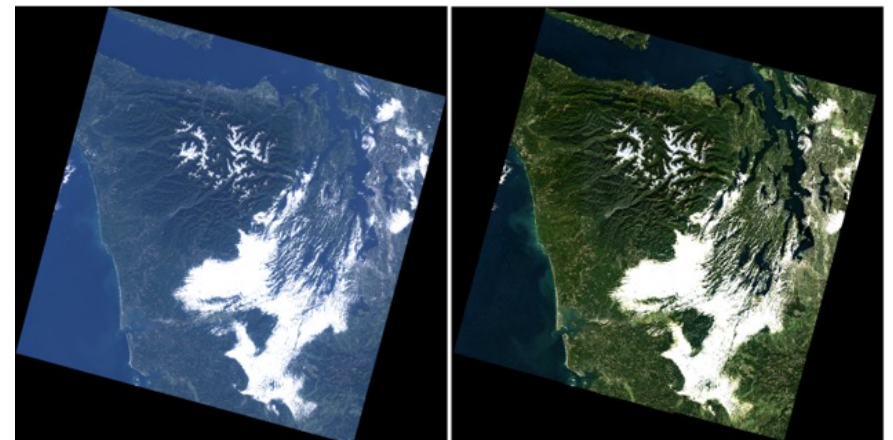


Atmospheric correction (AC)

- Estimate of the **surface spectral reflectance**, as would have been measured at ground level if there were **no atmospheric scattering or absorption**
- Generic approach for AC for multiple sensors
- AC products for EO sensors:
 - MODIS (Terra, Aqua)
 - Products: MOD09, MYD09
 - VIIRS (S-NPP, JPSS1)
 - Products: VNP09
 - OLI (Landsat-8) and MSI (Sentinel-2)
 - LaSRC algorithm/product
 - Harmonization Landsat / Sentinel 2 (HLS) project
 - USGS' on demand SR product for OLI



A true color composite of MODIS/Aqua (*top*) and VIIRS/S-NPP (*bottom*) images acquired on July, 1, 2017



CEOS WGCV Land Product Validation Plenary, 26-27 MAY 2021, Teams
A true color composite of Landsat-8 image without AC (*left*) and with AC (*right*). Image is acquired on October, 14, 2013



Landsat8/OLI and Sentinel 2/MSI Surface Reflectance is largely based on MODIS C6 (LaSRC)

Algorithm reference for L8: Vermote E., Justice C., Claverie M., Franch B., (2016) "Preliminary analysis of the performance of the Landsat 8/OLI land surface reflectance product", Remote Sensing of Environment, 185,46-56.

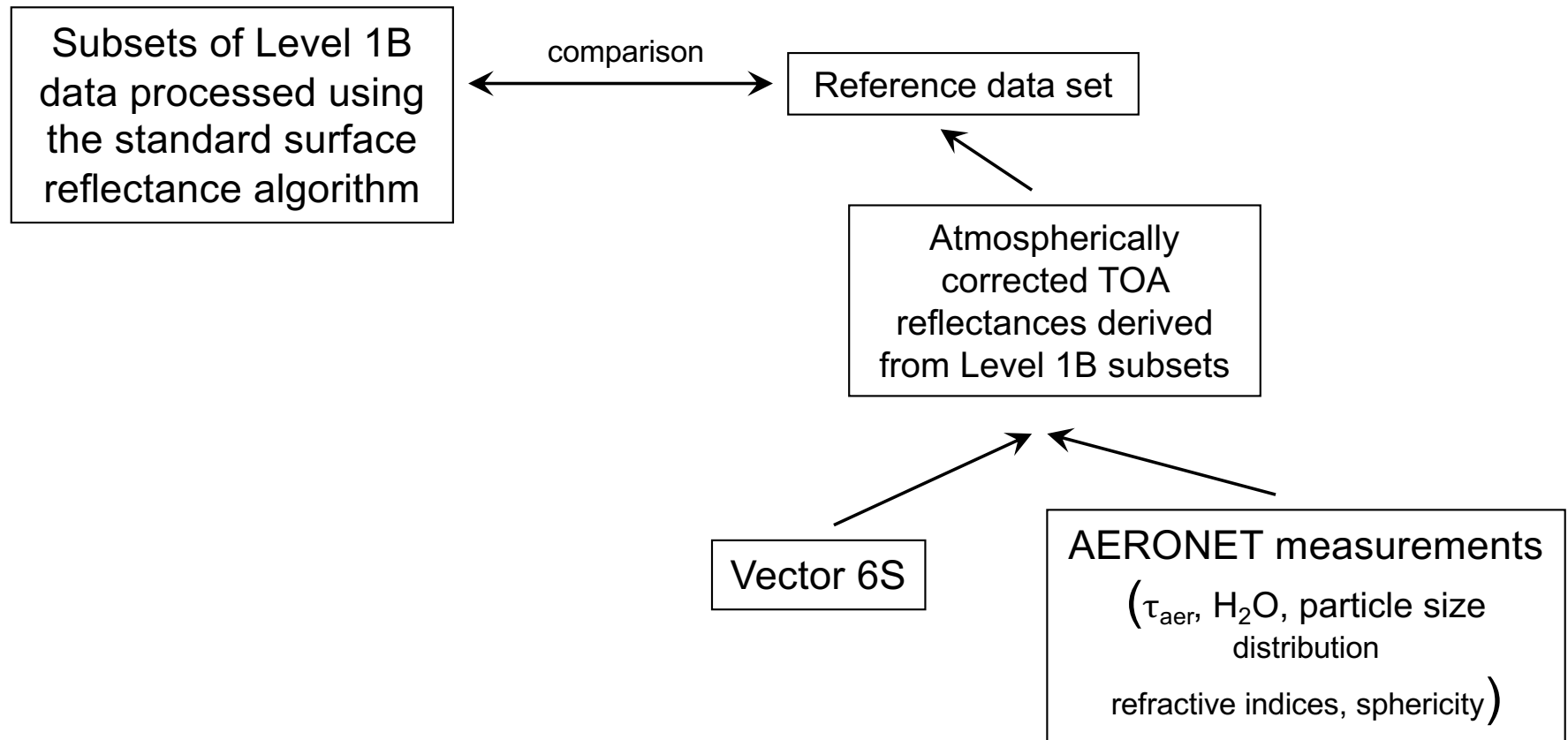
The MODIS **Collection 6 AC algorithm** relies on

- the use of very accurate (better than 1%) vector radiative transfer modeling of the coupled atmosphere-surface system (6S)
- the inversion of key atmospheric parameters
 - ***Aerosols are retrieved from Landsat8/Sentinel 2 images***
 - ***Water vapor and ozone from daily MODIS product.***

Home page: <http://modis-sr.ltdri.org>

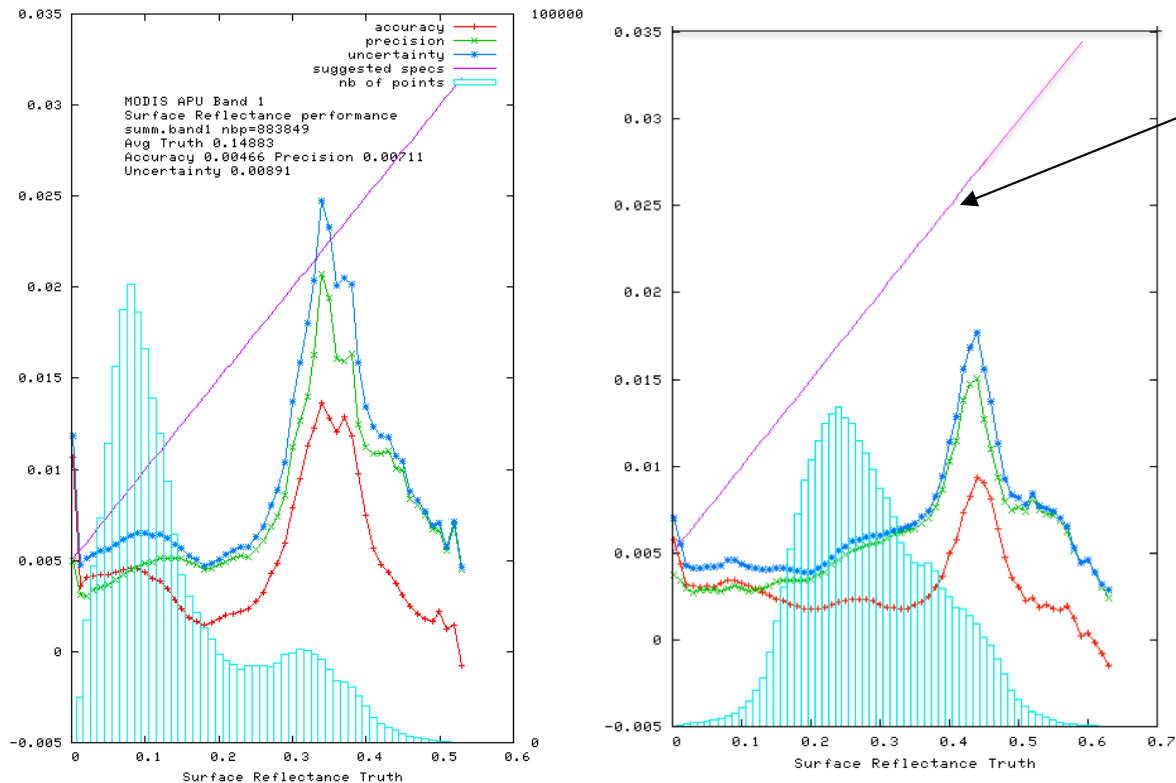


Methodology for evaluating the performance of Landsat8/Sentinel2 LaSRC product





quantitative assessment of performances (APU) for MODIS



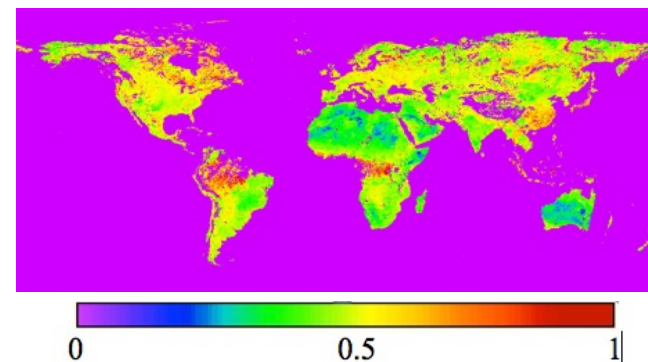
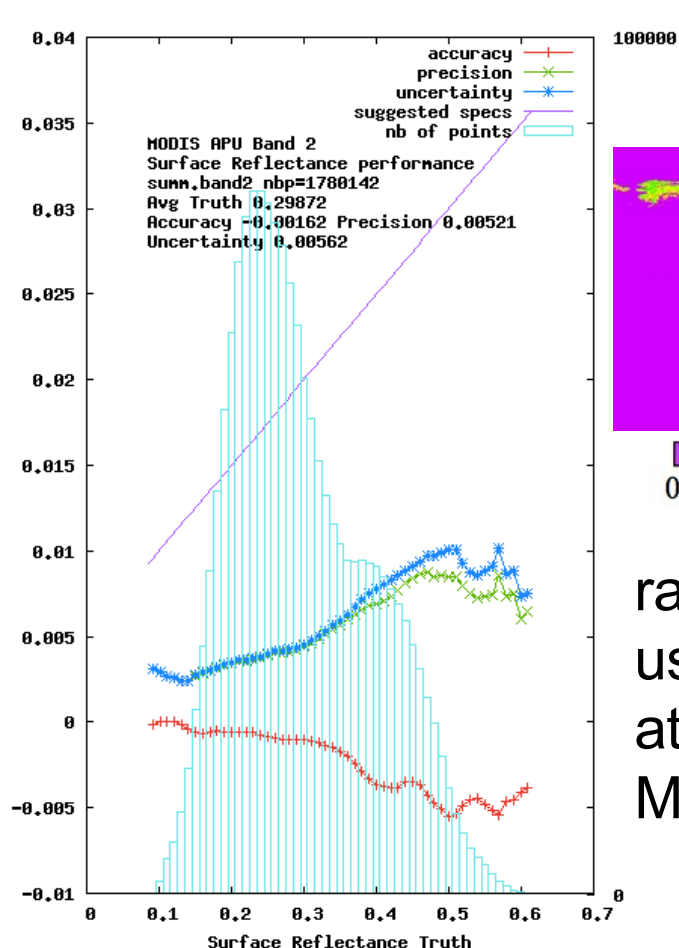
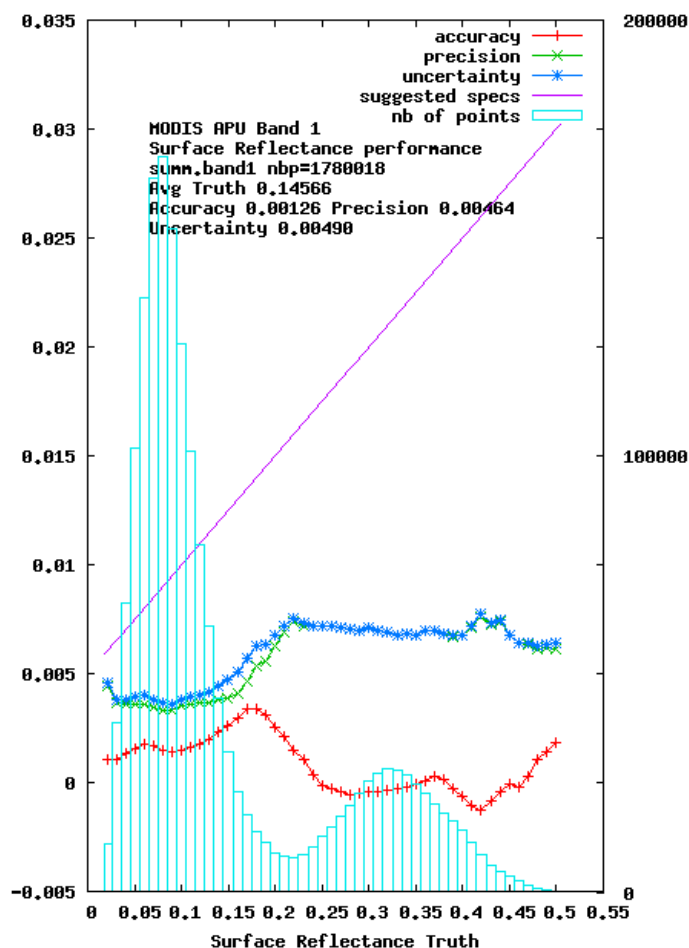
Specification:
Based on error budget for
collection 4

E. Vermote and S. Y. Kotchenova,
MODIS Directional surface
reflectance product: Method, error
estimates and validation. 2011.
Land Remote Sensing and Global
Environmental Change: NASA's
Earth Observing System and the
Science of ASTER and MODIS.
Series: [Remote Sensing and
Digital Image Processing](#), Vol.
11, Springer Verlag. 873p. ISBN:
978-1-4419-6748-0

COLLECTION 5: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification (the line in magenta), that was derived from the theoretical error budget. Data collected from Terra over 200 AERONET sites from 2000 to 2009.



Improving the aerosol retrieval in collection 6 reflected in APU metrics



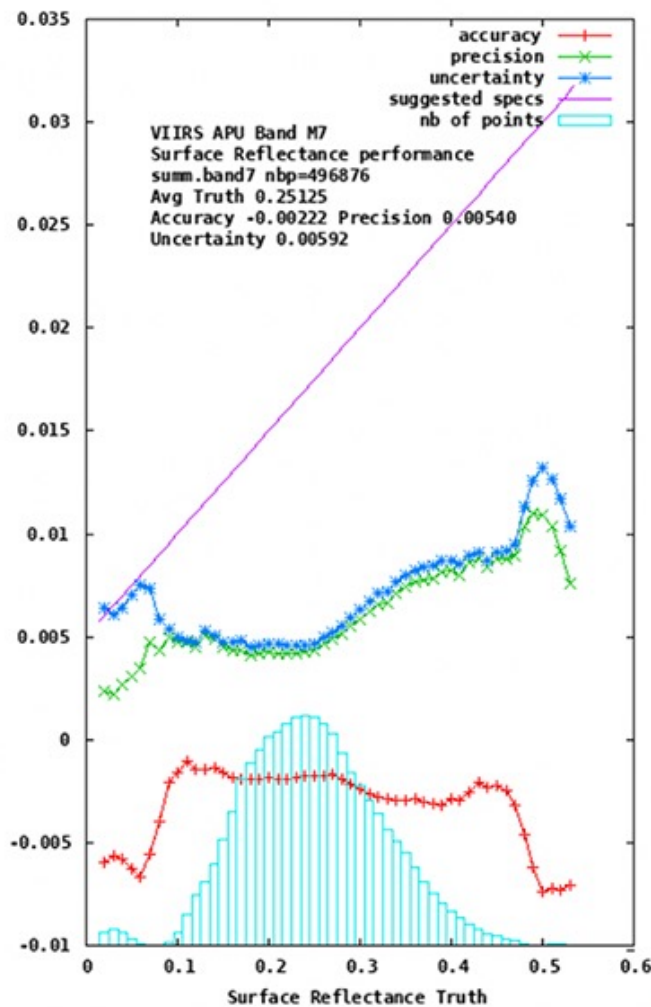
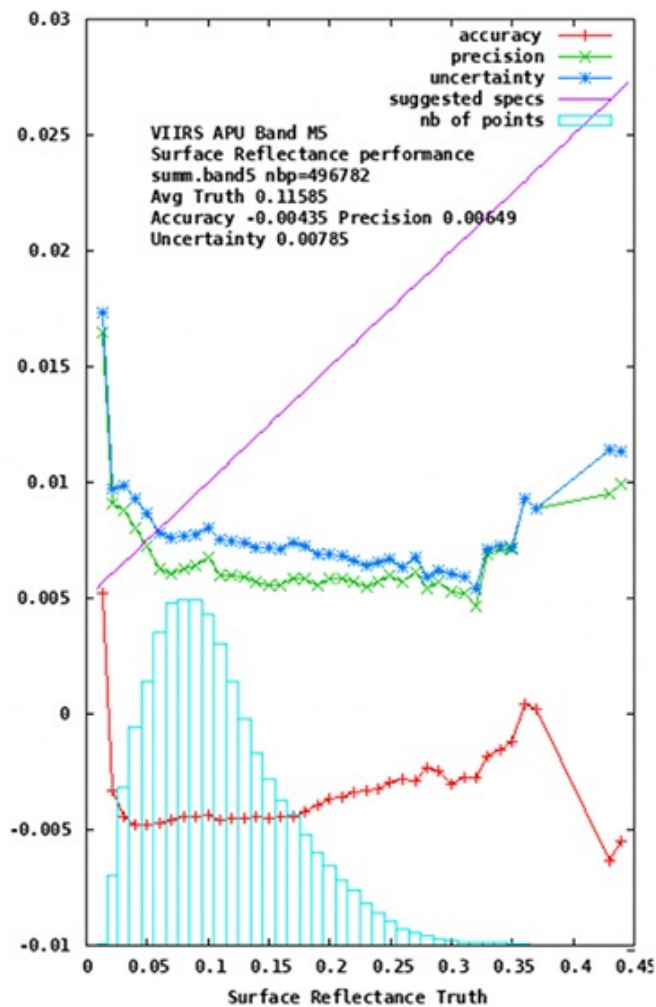
ratio band3/band1 derived using MODIS top of the atmosphere corrected with MISR aerosol optical depth

COLLECTION 6: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification (the line in magenta), that was derived from the theoretical error budget. Data collected from Terra over 200 AERONET sites for the whole Terra mission.

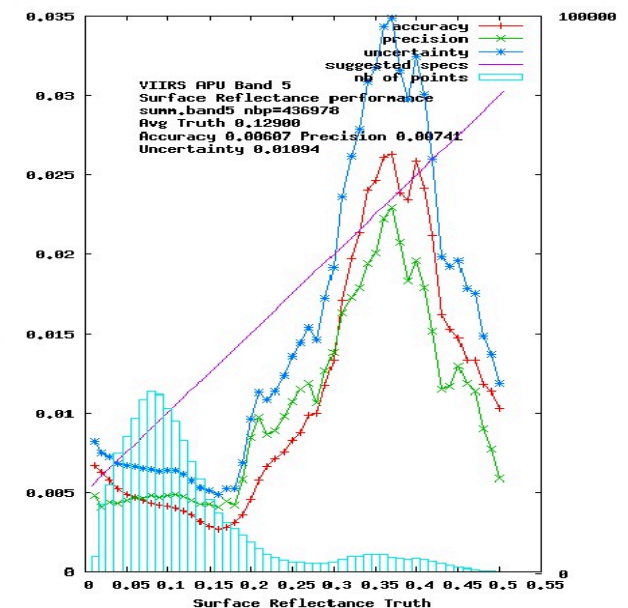


VIIRS Validation follow the same methodology

Current performances M5 (red) M7 (NIR)



Original NASA C1.1
Processing (M5)





BDRF Normalization enables large scale cross comparison

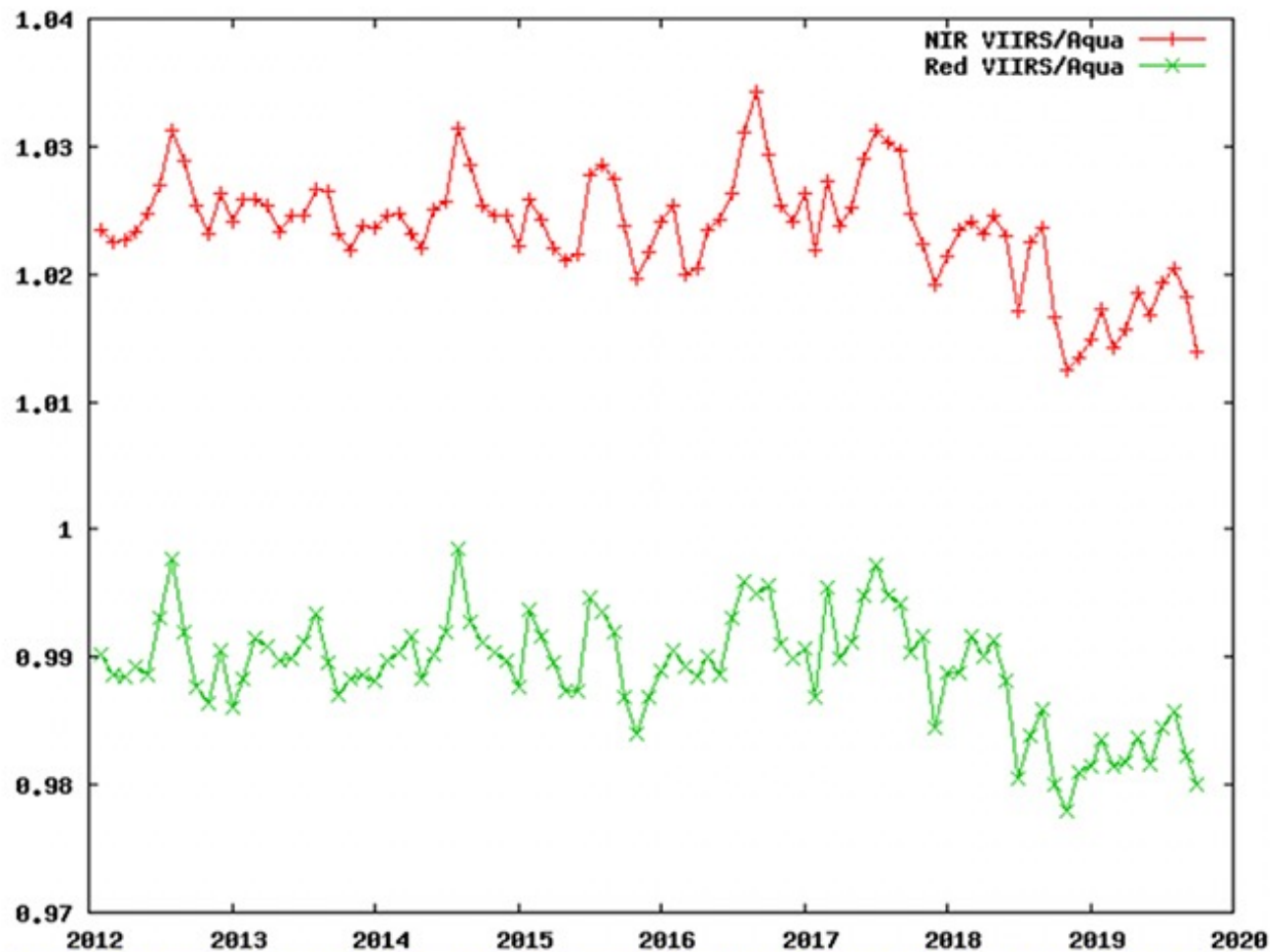
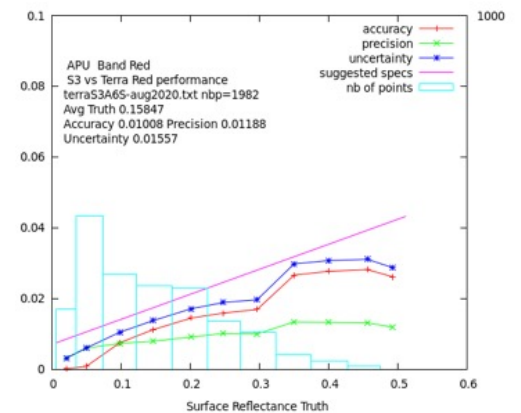
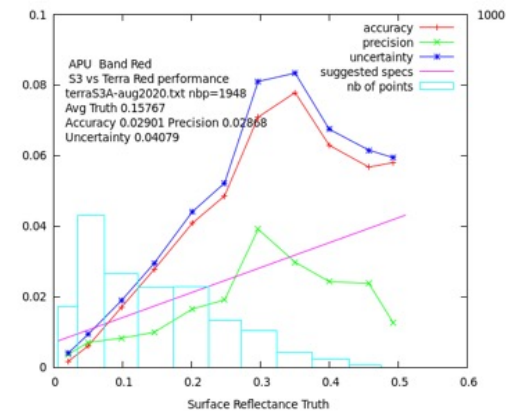
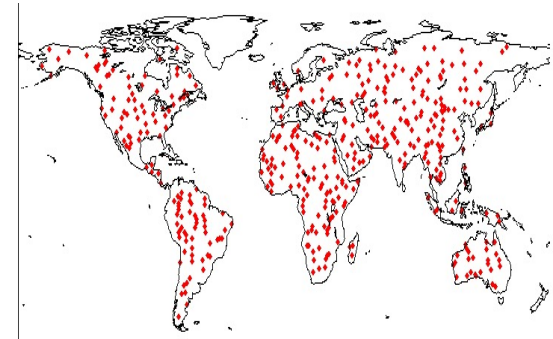
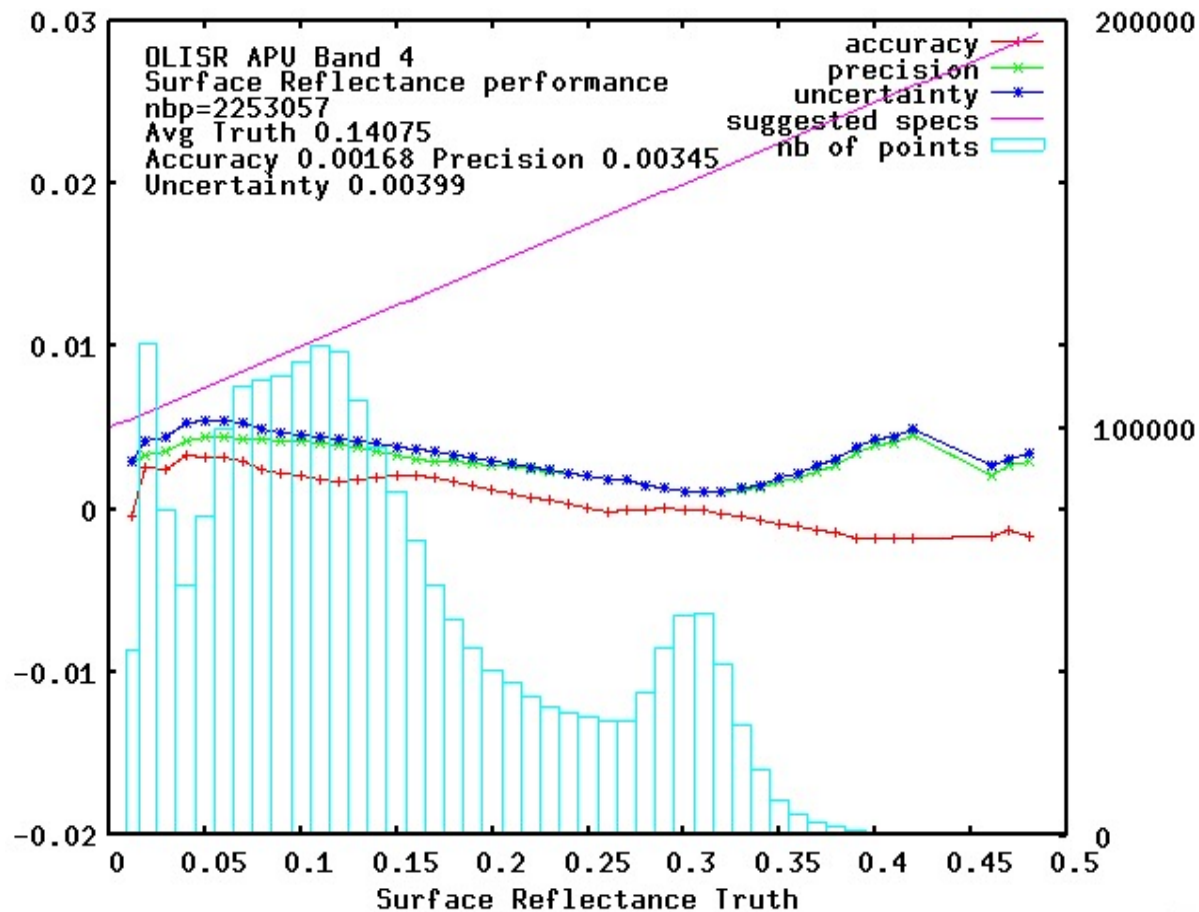


Figure 2. Automated monthly VIIRS surface reflectance cross-comparison with MODIS Aqua from 2012 to 2019. The stability of both VIIRS and MODIS Aqua is excellent in both red and NIR as shown ($\pm 0.5\%$). An update in the VIIRS calibration methodology ($\sim 1\%$) is visible around 2018 that should disappear once collection 2 is produced.





Evaluation of the performance of Landsat8



The “preliminary” analysis of OLI SR performance in the red band over AERONET is very similar to MODIS Collection 6



ACIX-II

Atmospheric Correction Inter-comparison eXercise

ACIX is an international collaborative initiative to inter-compare a set of atmospheric correction (AC) processors for high-spatial resolution optical sensors. The exercise will focus on Landsat-8 and Sentinel-2 imagery over a set of test areas. The inter-comparison of the derived Bottom-of-Atmosphere (BOA) products is expected to contribute to the understanding of the different uncertainty contributors and help in improving the AC processors

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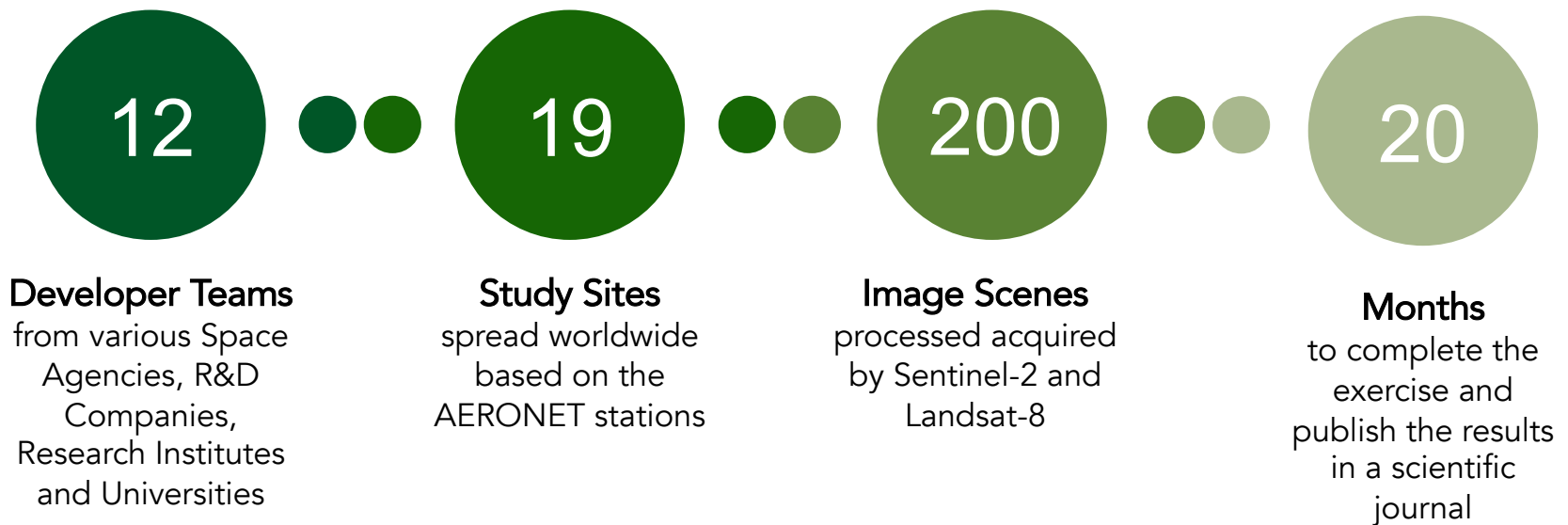
Ferran Gascon | ESA/ESRIN, Ferran.Gascon@esa.int

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Eric Vermote | NASA, eric.f.vermote@nasa.gov

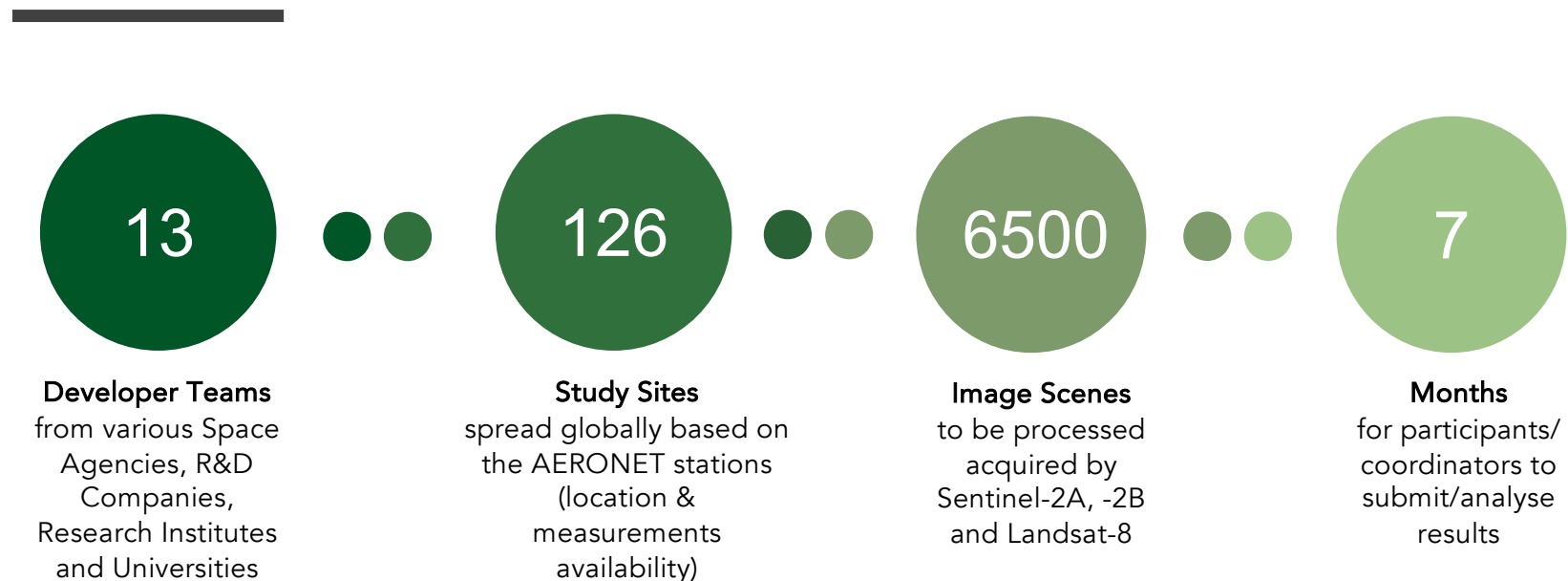


ACIX-I



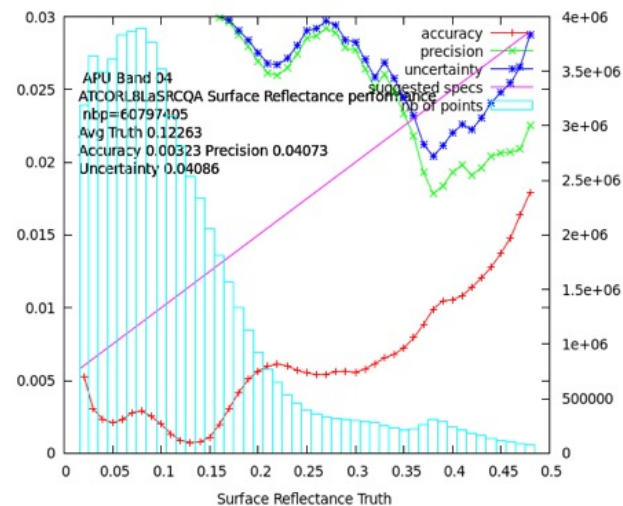
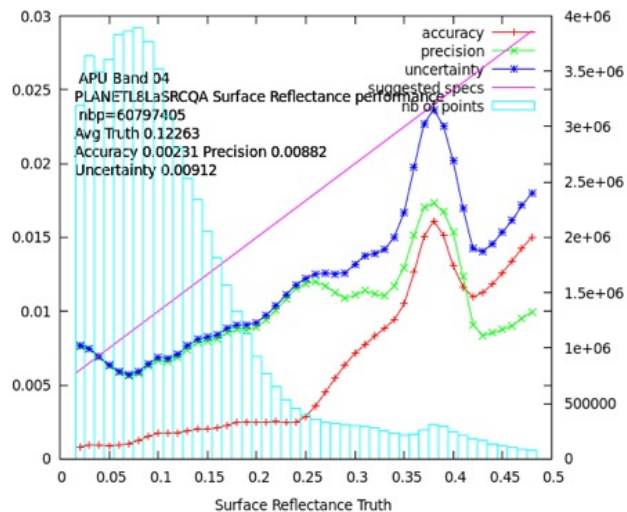
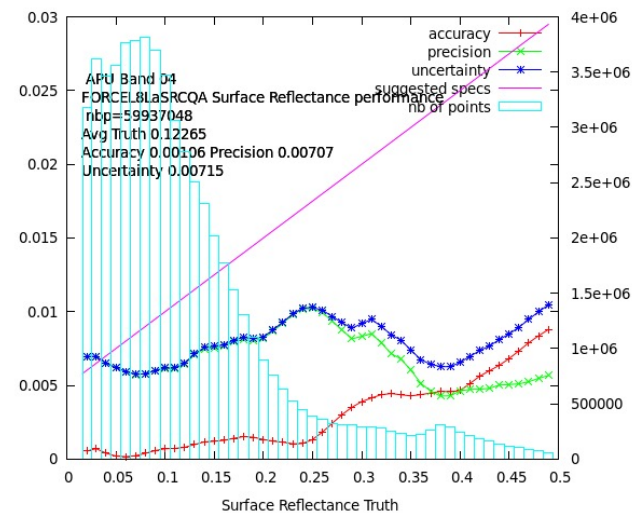
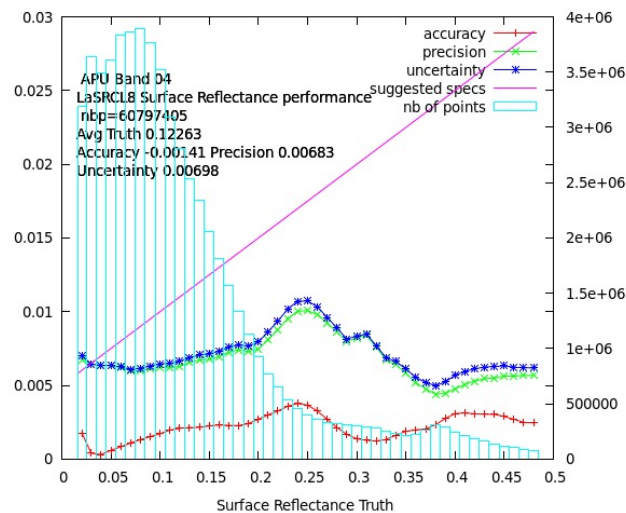


ACIX-II -Land





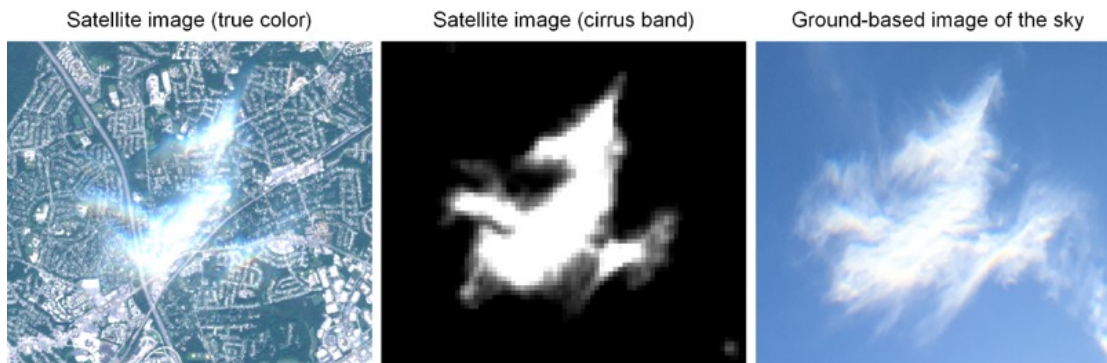
Some APU results in the Red (670nm) Filtered with LaSRC (3.5.5) QA





Cloud validation: SkyCam

- Ground-based skycam
 - For objective validation of satellite-derived cloud masks
 - Proof of concept: manual iphone with fisheye lens over NASA GSFC
 - Current version: automatic, enabling replication over multiple sites
 - Part of validation dataset within CEOS CMIX-1 (Cloud Masking Inter-comparison Exercise)



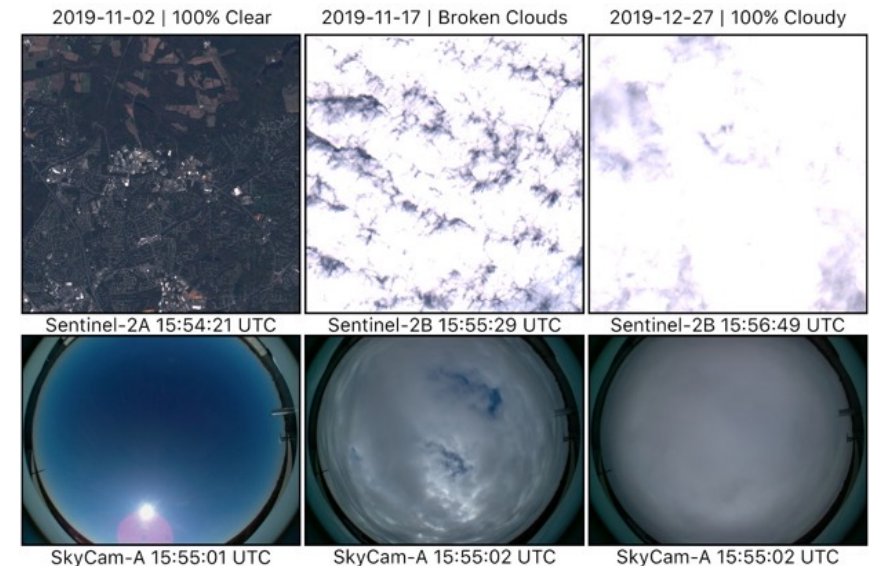
An experimental sky-image-derived cloud validation dataset for Sentinel-2 and Landsat 8 satellites over NASA GSFC

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^a Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA

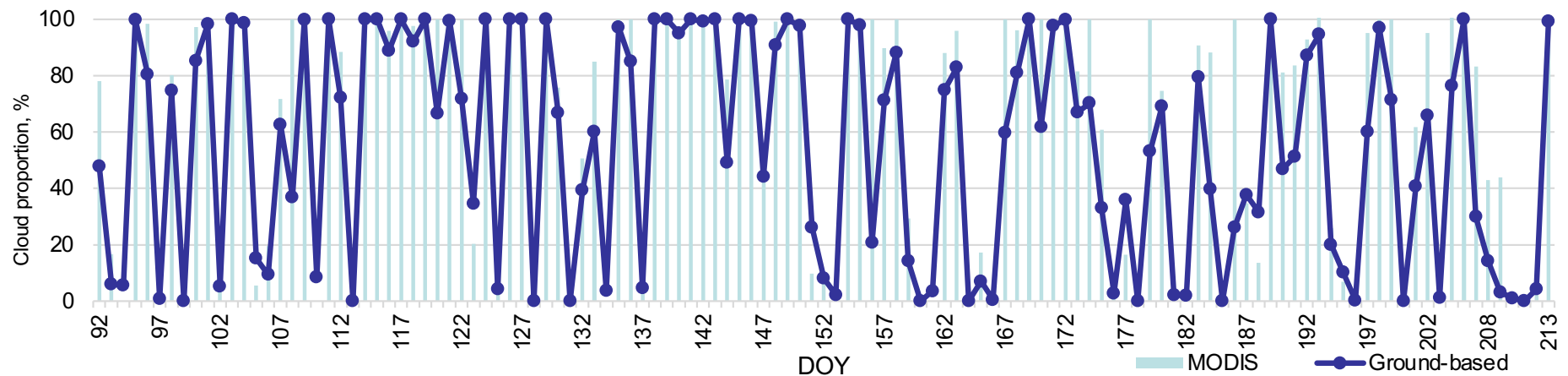
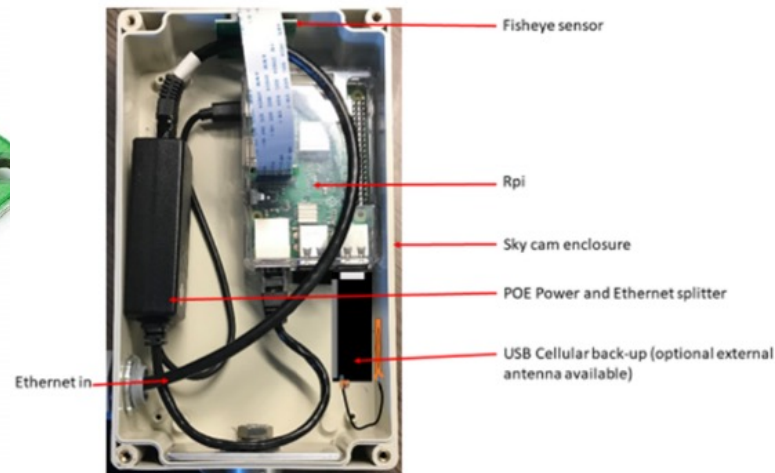
^b College of Information Studies (School), University of Maryland, College Park, MD 20742, USA

^c NASA Goddard Space Flight Center Code 619, 8800 Greenbelt Road, Greenbelt, MD 20771, USA



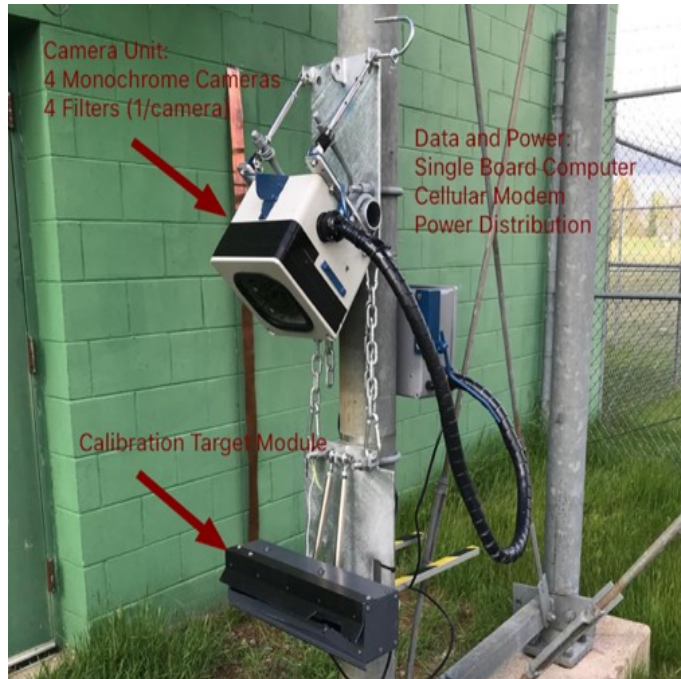


SkyCam system @ NASA/GSFC





Ground Validation is on going



CAMSIS system

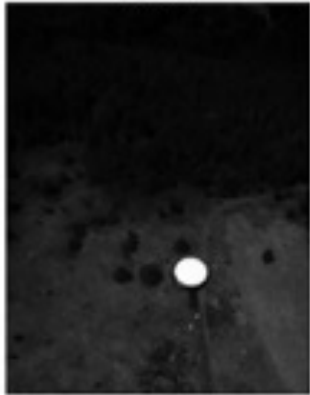


CAMSIS is installed at a height of 123m on a TV tower (WLEF) near Park Falls, WI at the Chequamegon National Forest

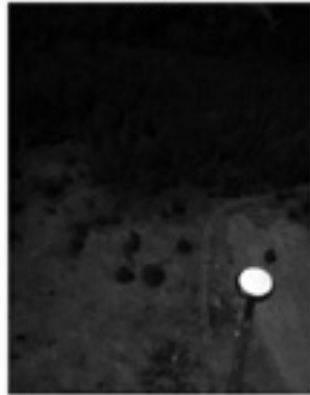


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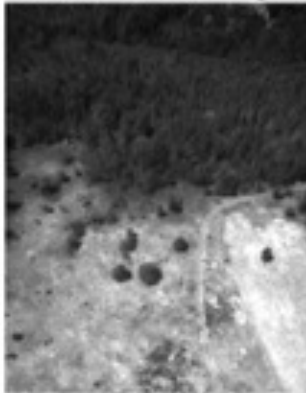
Raw 1



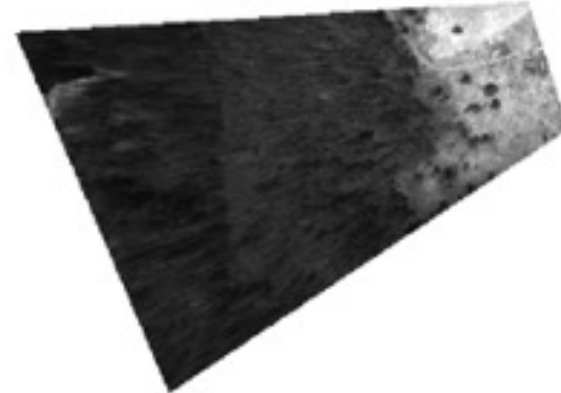
Raw 2



Calibrated and Merged



Georeferenced

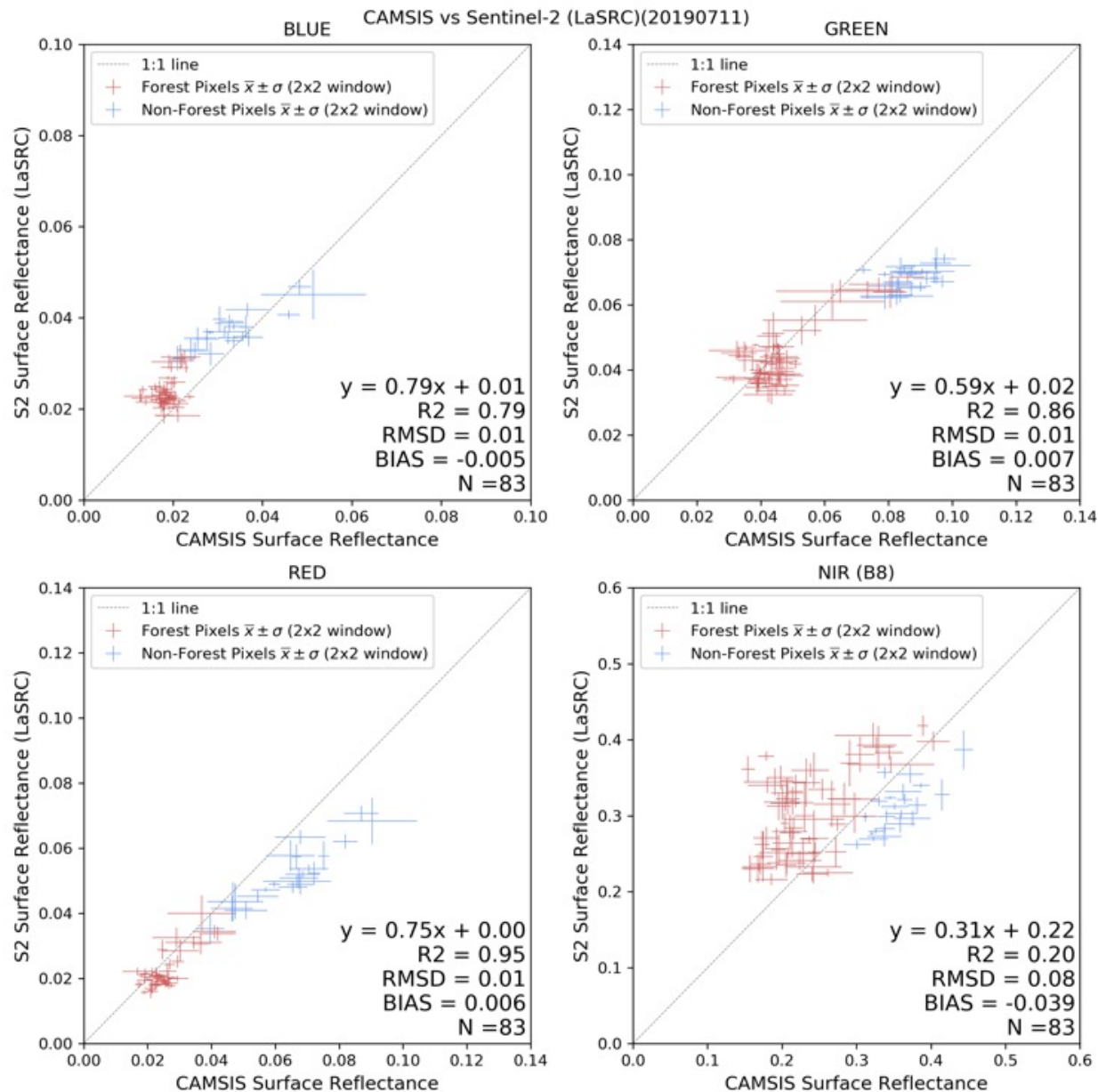


Resampled to 10m



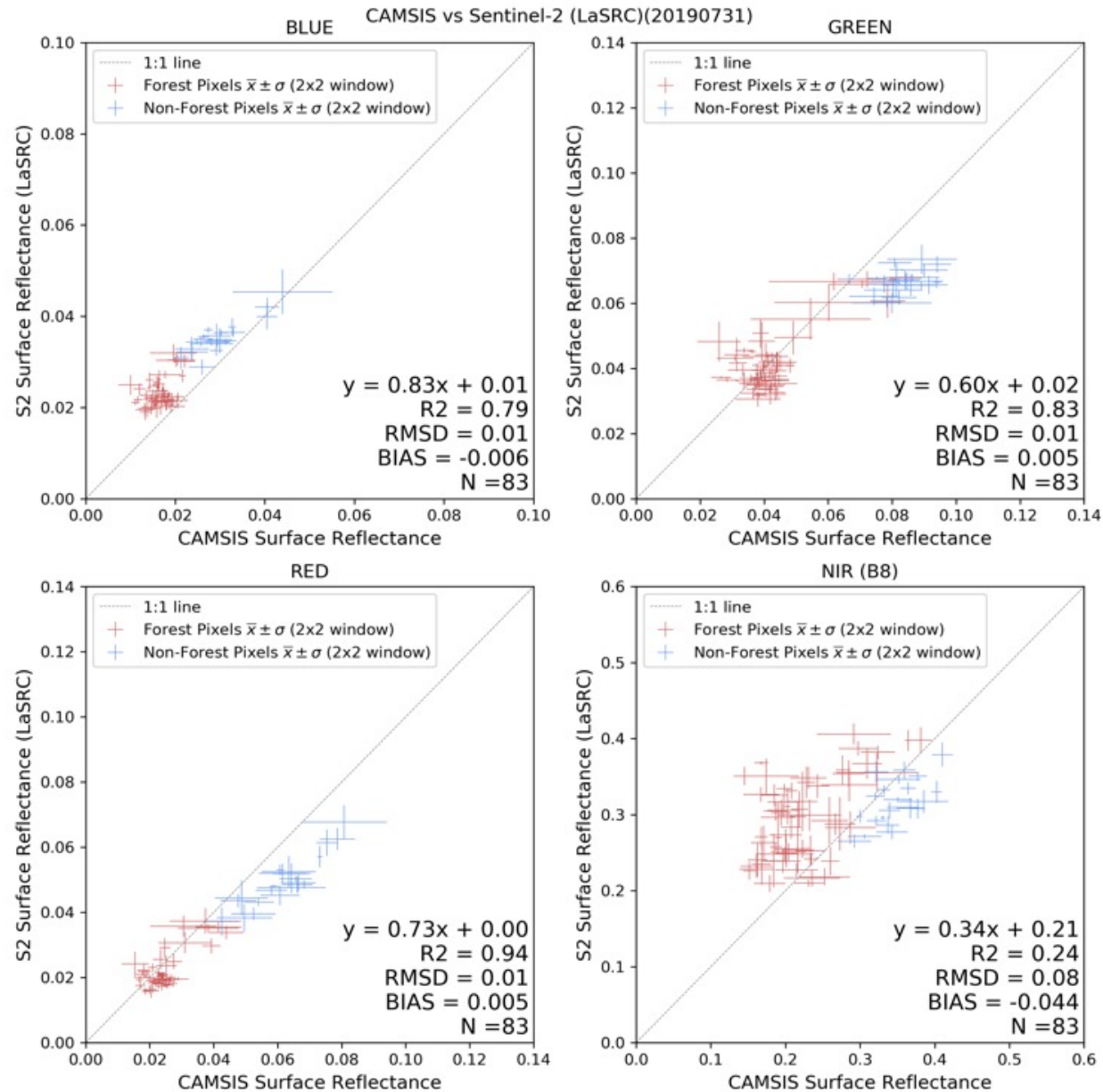


Ground Validation is on going



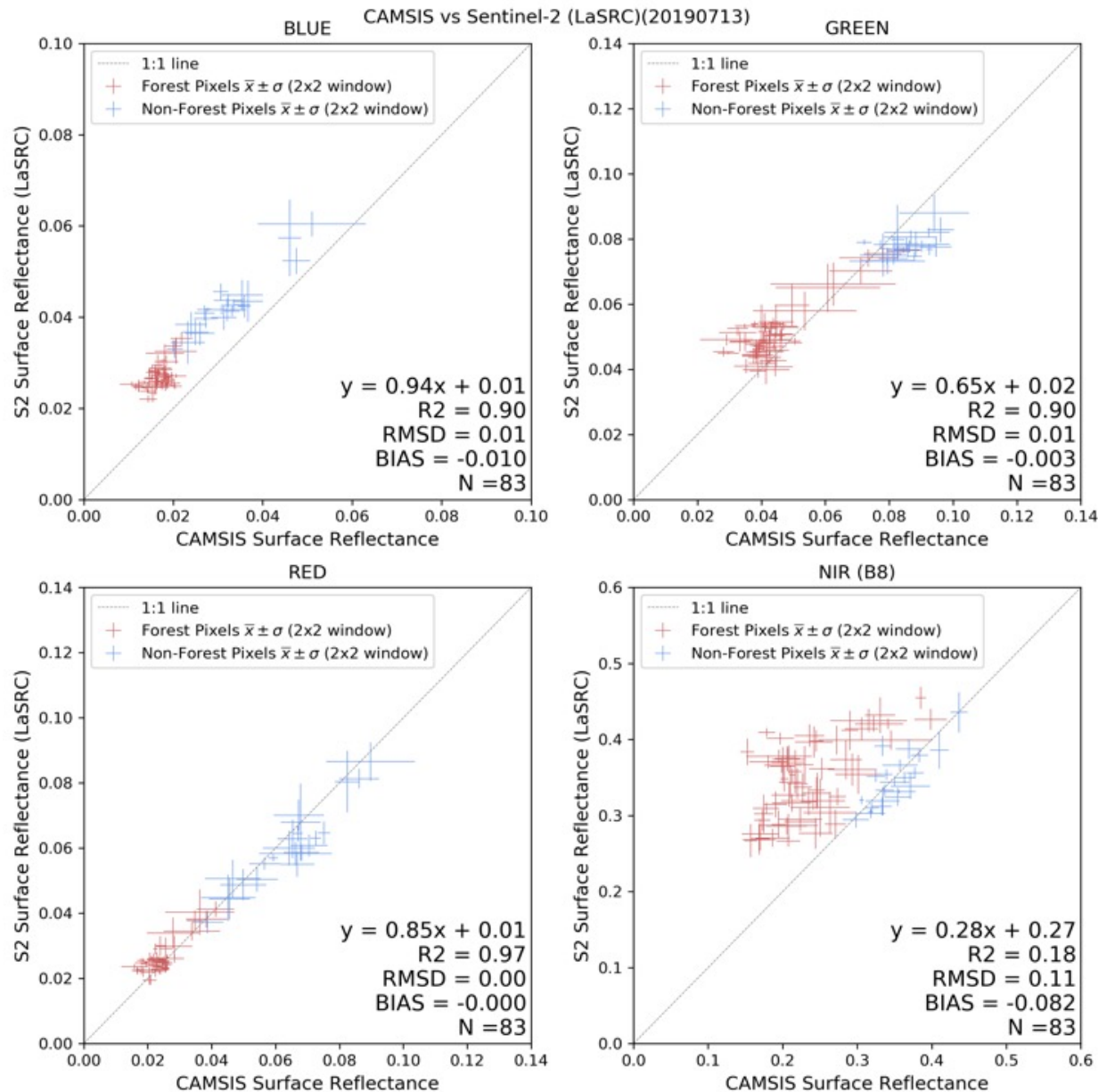


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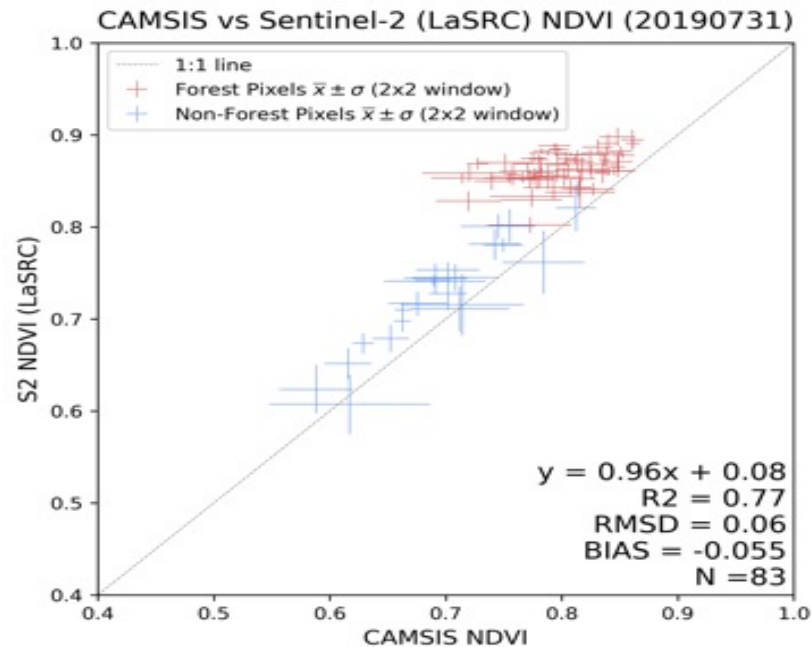
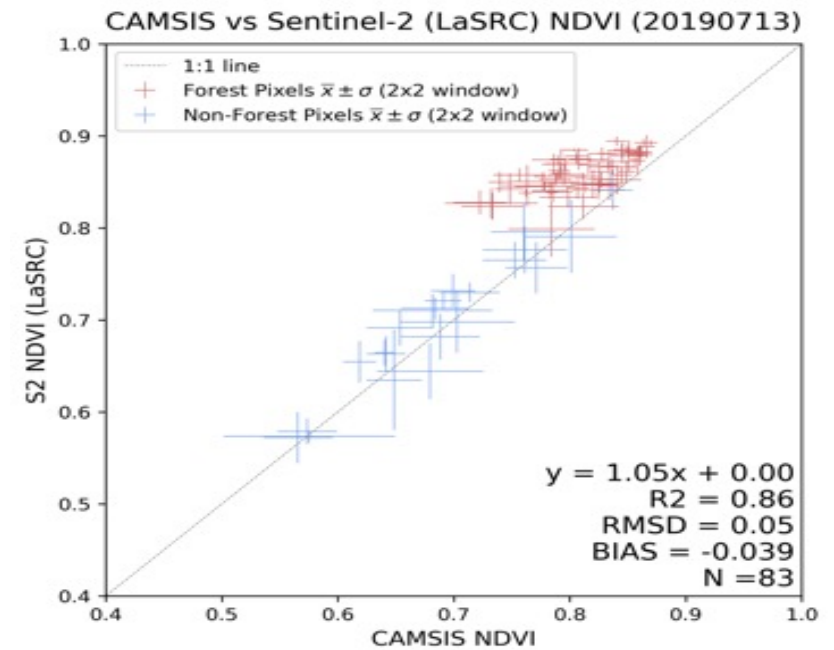
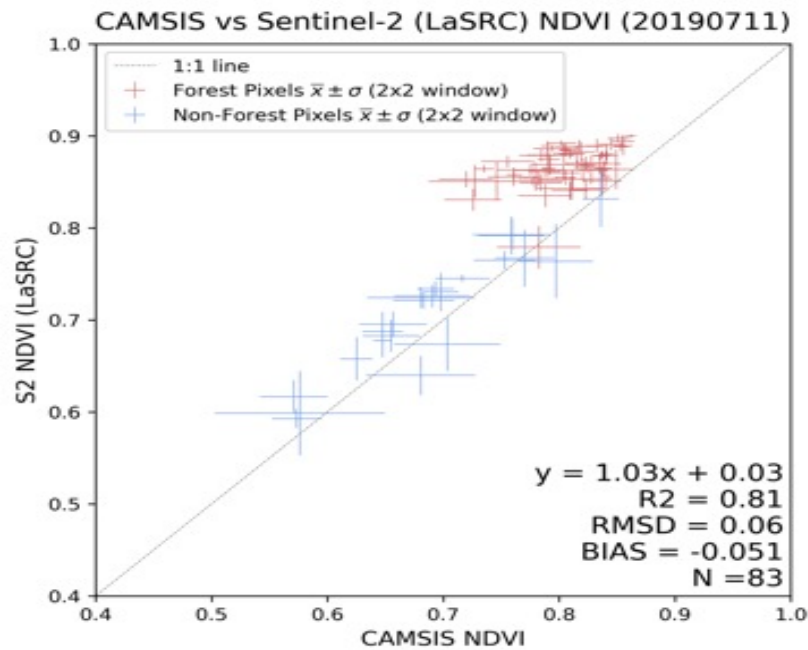


Ground Validation is on going





Ground Validation is on going





Thank You!