MODIS/VIIRS Surface Reflectance

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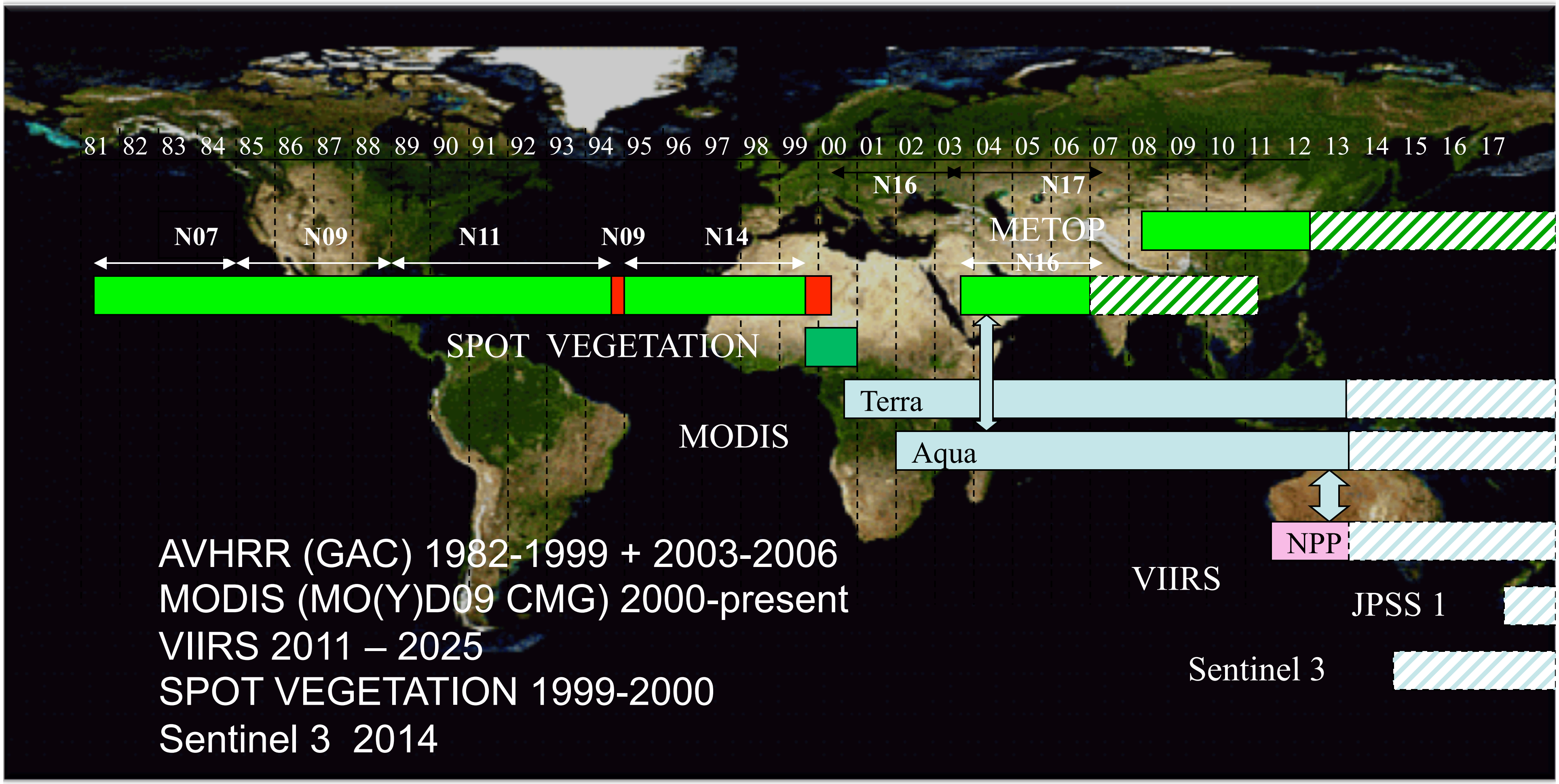
MODIS/VIIRS Science Team Meeting, June 6-June 10, Silver Spring, MD

A Land Climate Data Record

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



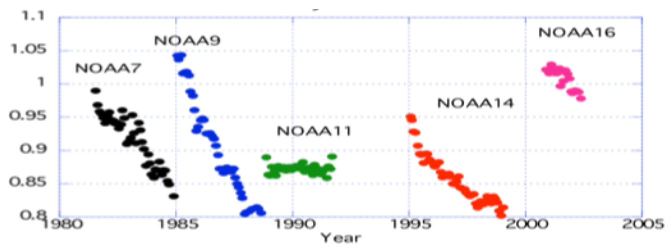
Emphasis on data consistency – characterization rather than degrading/smoothing the data

Land Climate Data Record (Approach)

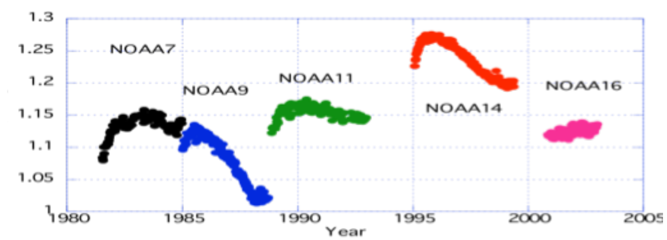
Needs to address geolocation,calibration, atmospheric/BRDF correction issues

CALIBRATION

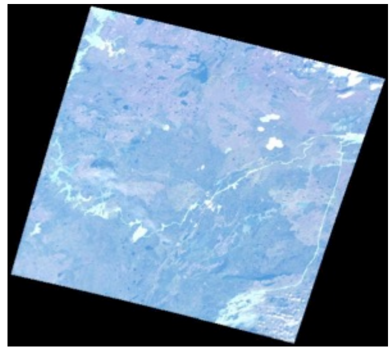
Degradation in channel 1
(from Ocean observations)

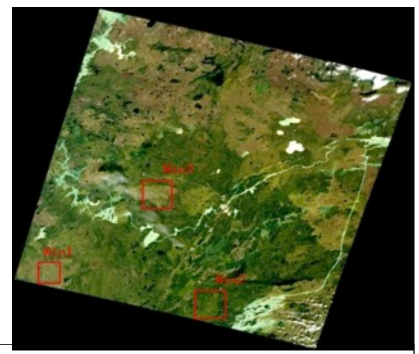


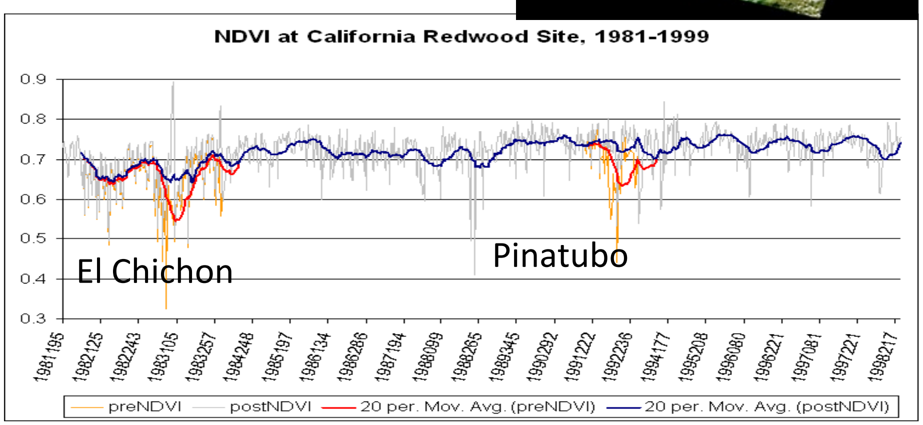
Channel1/Channel2 ratio
(from Clouds observations)



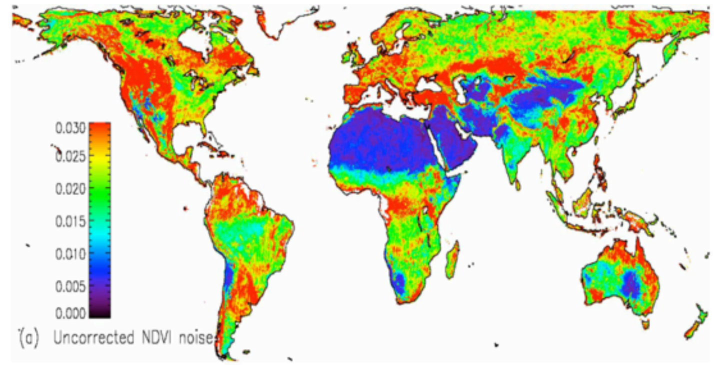
ATMOSPHERIC CORRECTION

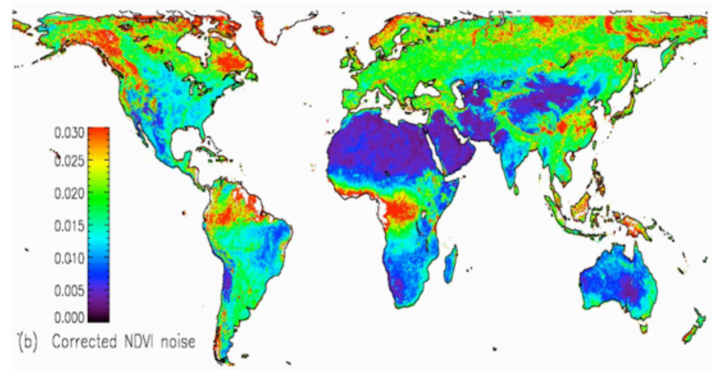


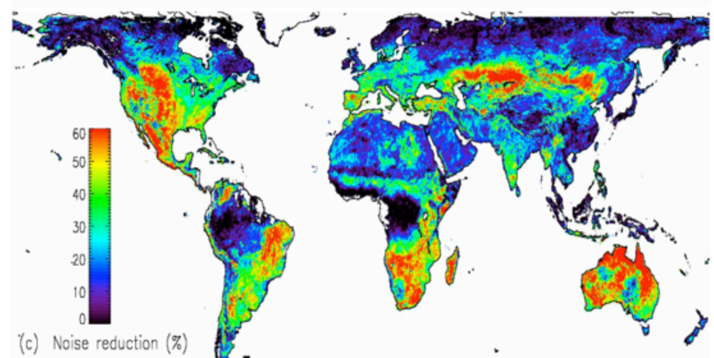




BRDF CORRECTION







At Launch VIIRS Surface Reflectance based MODIS C5

The MODIS **Collection 5 AC algorithm** relies on

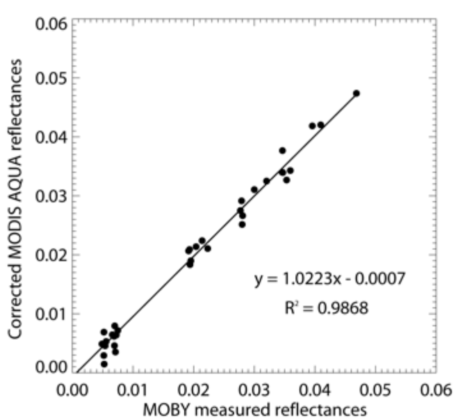
- the use of very accurate (better than 1%) vector radiative transfer modeling of the coupled atmosphere-surface system
- the inversion of key atmospheric parameters (aerosol, water vapor)

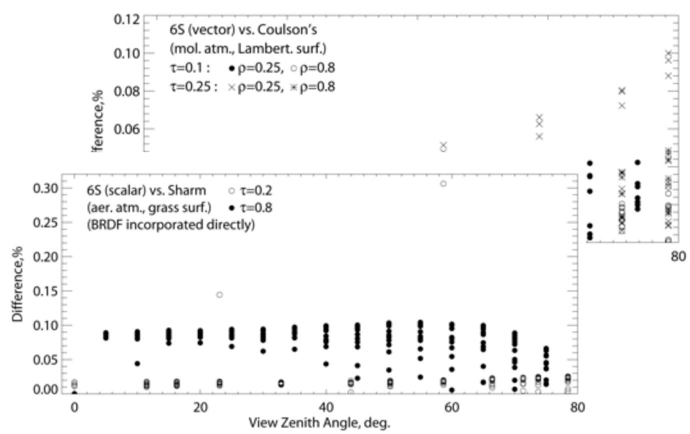
Home page: http://modis-sr.ltdri.org

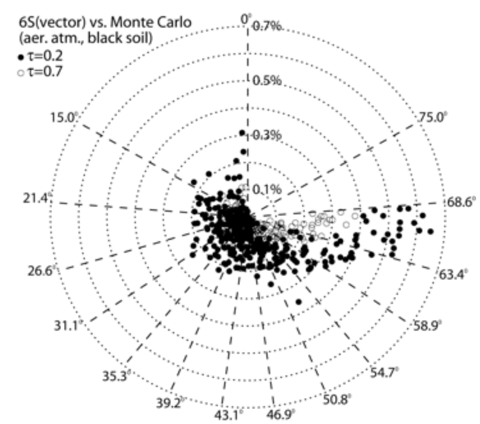
6SV Validation Effort

The complete 6SV validation effort is summarized in three manuscripts:

- Kotchenova, S. Y., Vermote, E. F., Matarrese, R., & Klemm Jr, F. J. (2006). Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part I: Path radiance. *Applied Optics*, *45*(26), 6762-6774.
- Kotchenova, S. Y., & Vermote, E. F. (2007). Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part II. Homogeneous Lambertian and anisotropic surfaces. *Applied Optics*, *46*(20), 4455-4464.
- Kotchenova, S. Y., Vermote, E. F., Levy, R., & Lyapustin, A. (2008). Radiative transfer codes for atmospheric correction and aerosol retrieval: intercomparison study. *Applied Optics*, *47*(13), 2215-2226.



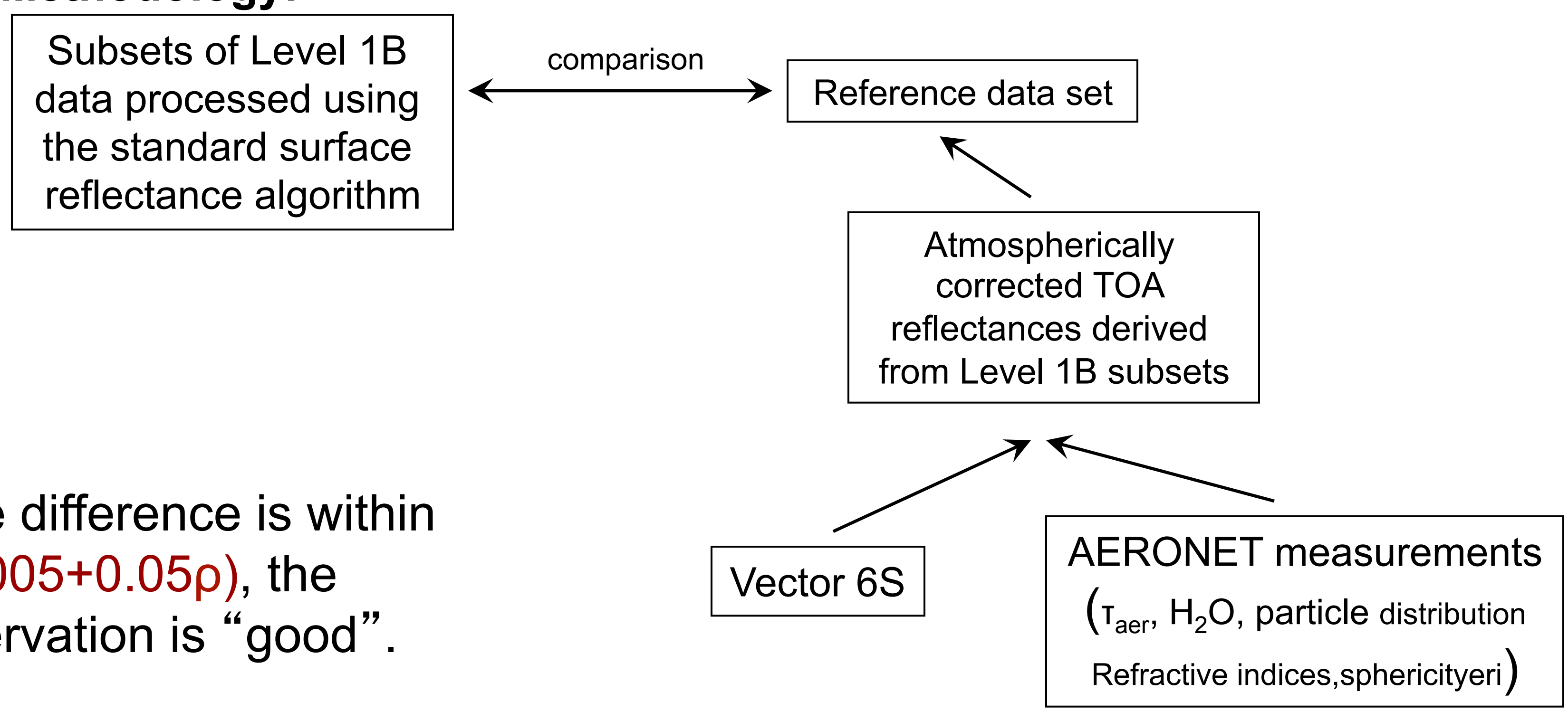




Methodology for evaluating the performance of VIIRS/MODIS

To first evaluate the performance of the MODIS Collection 5 SR algorithms, we analyzed 1 year of Terra data (2003) over **127** AERONET sites (**4988** cases in total).

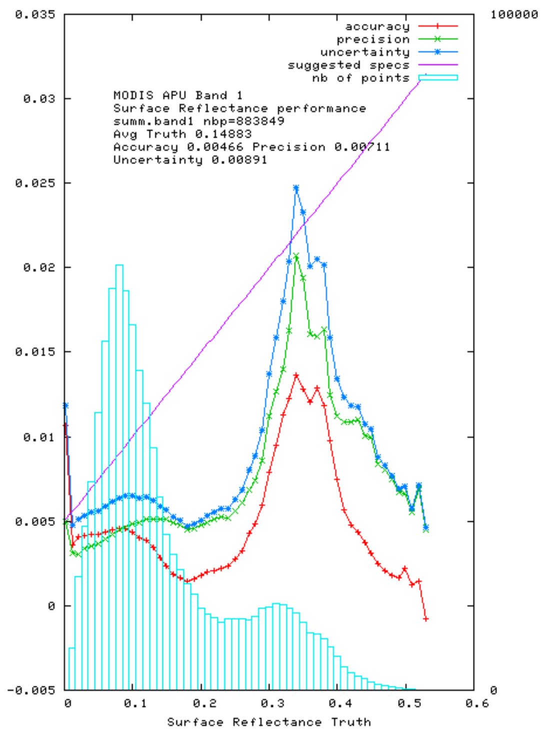
Methodology:

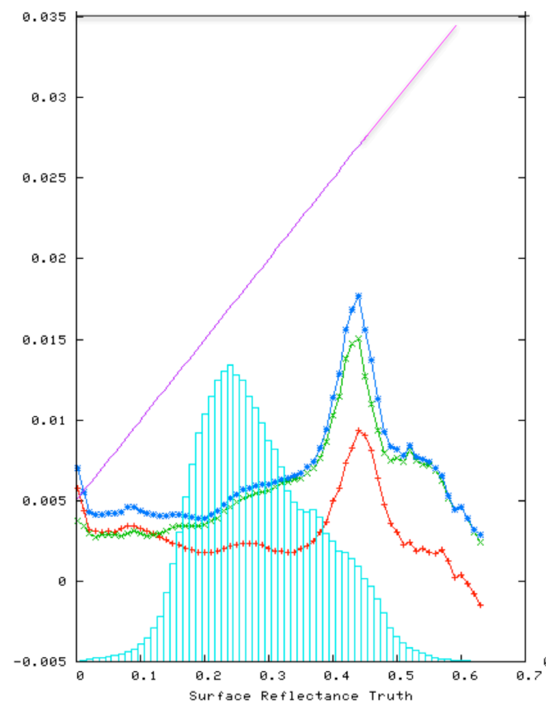


If the difference is within ±(0.005+0.05ρ), the observation is "good".

http://mod09val.ltdri.org/cgi-bin/mod09_c005_public_allsites_onecollection.cgi

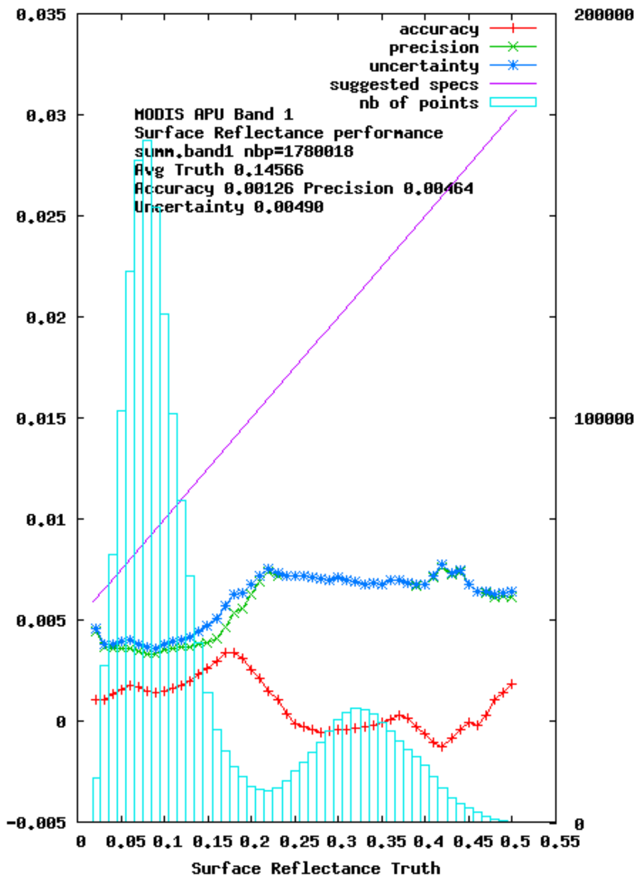
quantitative assessment of performances (APU)

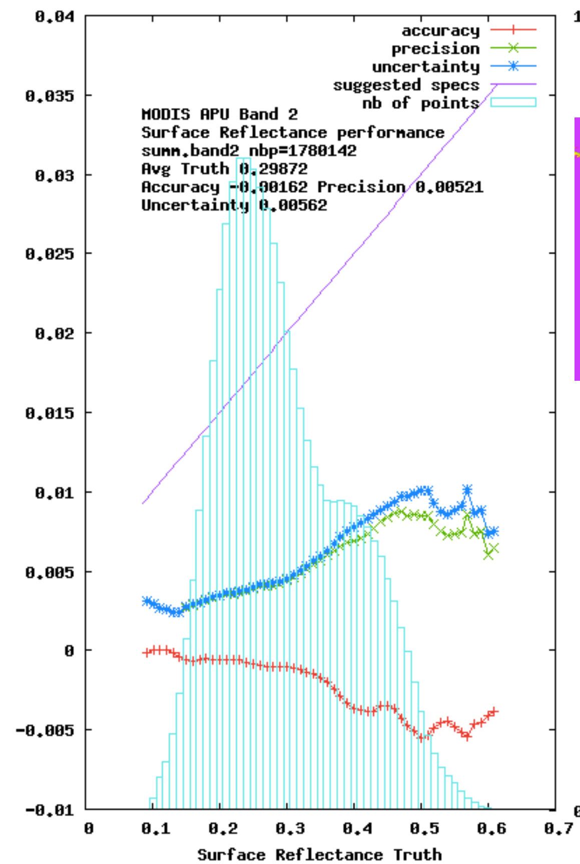


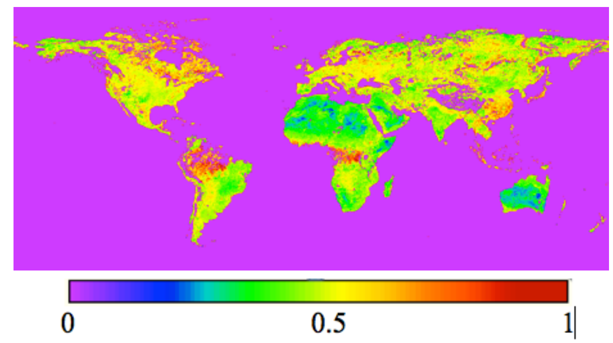


COLLECTION 5: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification (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



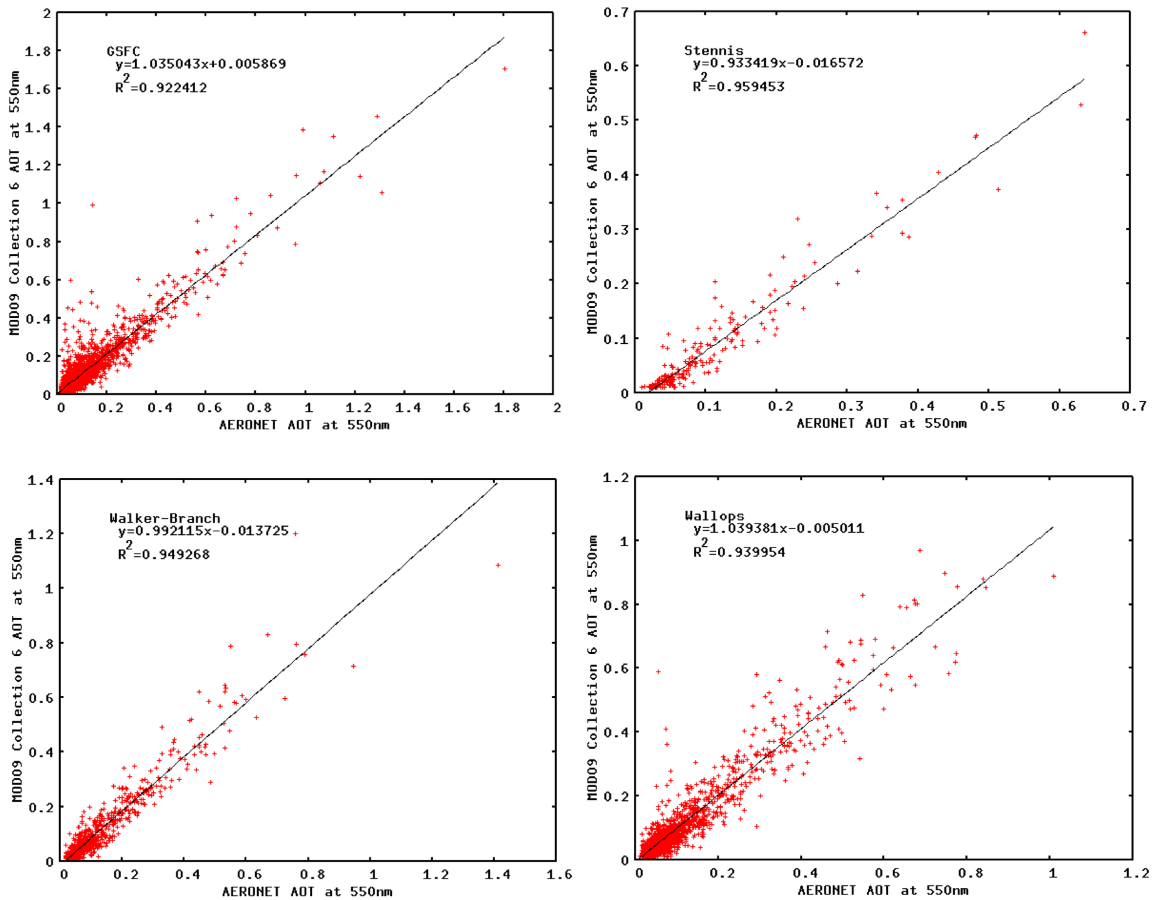




ratio band3/band1 derived using MODIS top of the atmosphere corrected with MISR aerosol optical depth

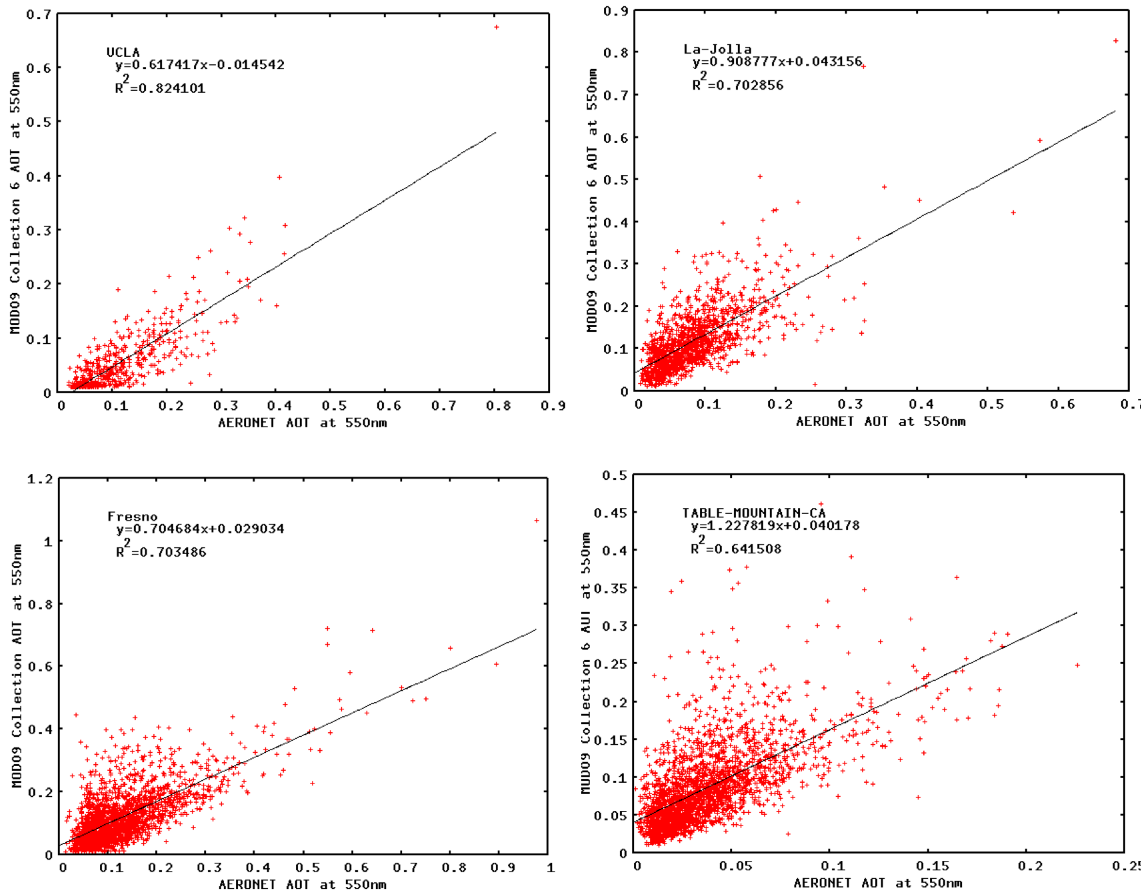
COLLECTION 6: accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification (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.

Aerosol retrieval also shows improvement



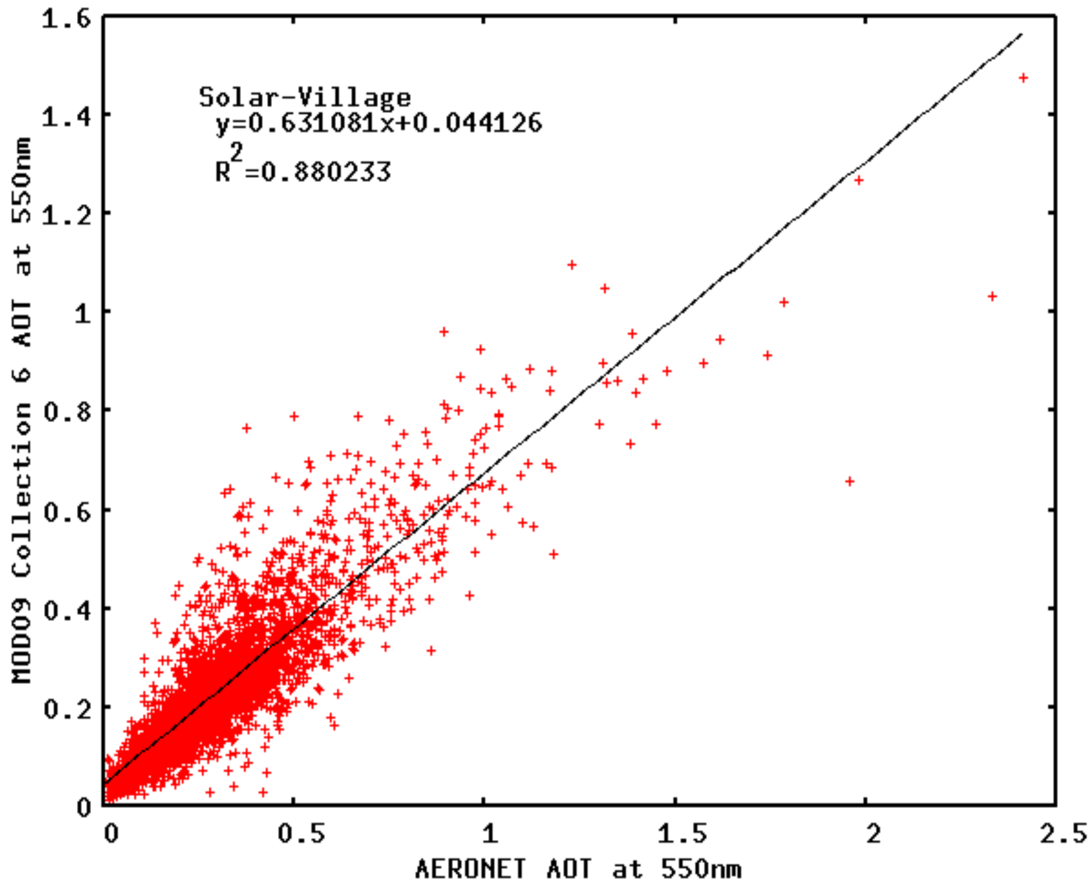
Scatterplot of the MOD09 AOT at 550nm versus the AERONET measured AOT at 550nm for East Coast sites selection: GSFC (top left), Stennis (top right), Walker Branch (bottom left) and Wallops (bottom right).

Aerosol retrieval also shows improvement



Scatterplot of the MOD09 AOT at 550nm versus the AERONET measured AOT at 550nm for the West Coast sites selection: UCLA (top left), La Jolla (top right), and Fresno (bottom left) and Table Mountain (bottom right).

Aerosol retrieval also shows improvement



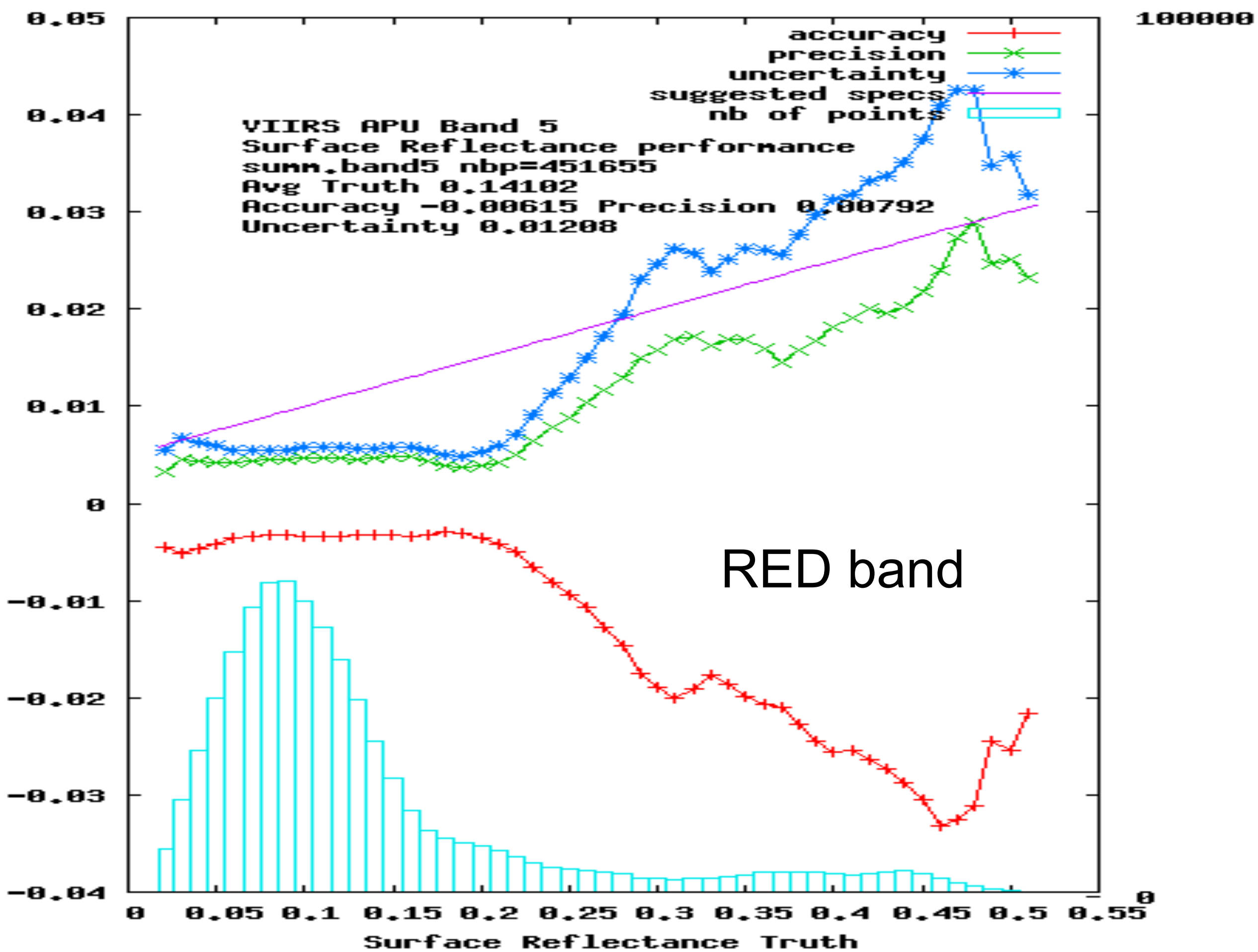
Scatterplot of the MOD09 AOT at 550nm versus the AERONET measured AOT at 550nm for for a very bright site in Saudi Arabia (Solar Village)

VIIRS Surface reflectance

- the VIIRS SR product is directly heritage from collection 5 MODIS and that it has been validated to stage 1 (Land PEATE adjusted version)
- MODIS algorithm refinements from Collection 6 will be integrated into the VIIRS algorithm and shared with the NOAA JPSS project for possible inclusion in future versions of the operational product .

Evaluation of Algorithm Performance

VIIRS C11 reprocessing (MODIS C5 algorithm)



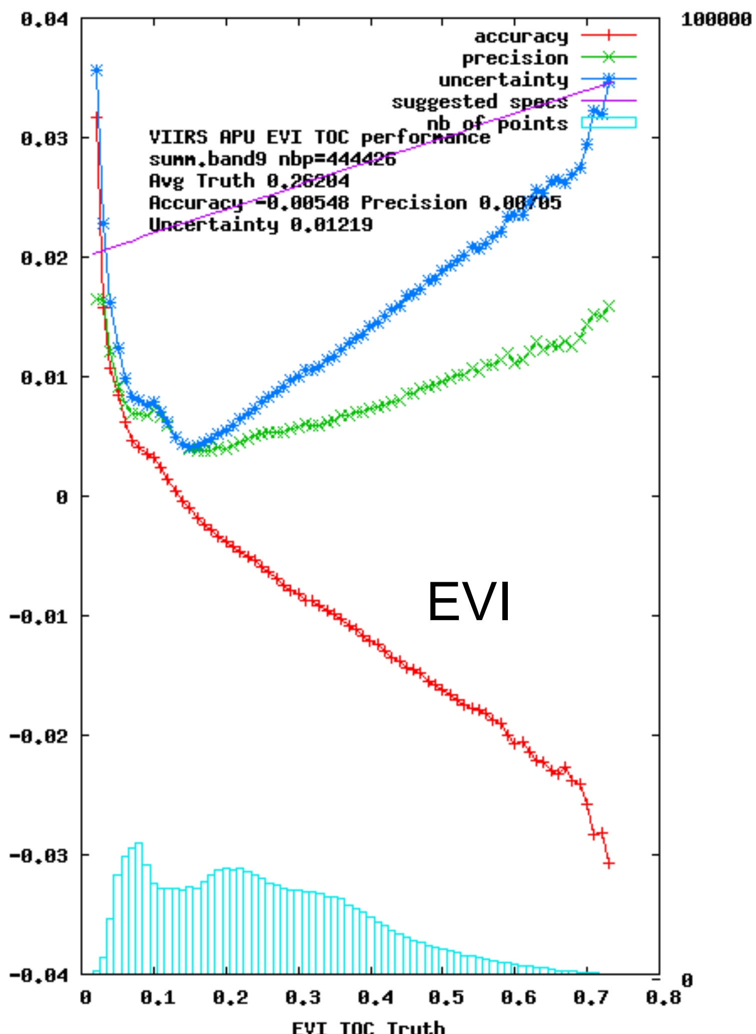
450000 pixels were analyzed for each band.

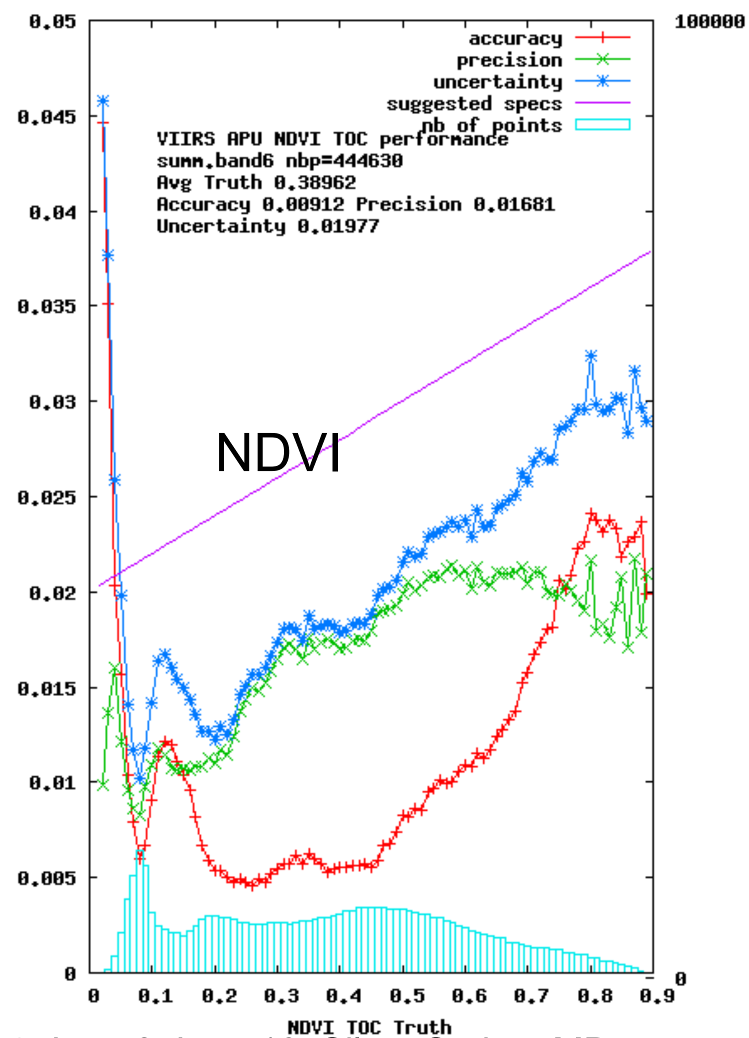
Red = Accuracy (mean bias)
Green = Precision (repeatability)
Blue = Uncertainty (quadatric sum of A and P)

On average well below magenta theoretical error bar

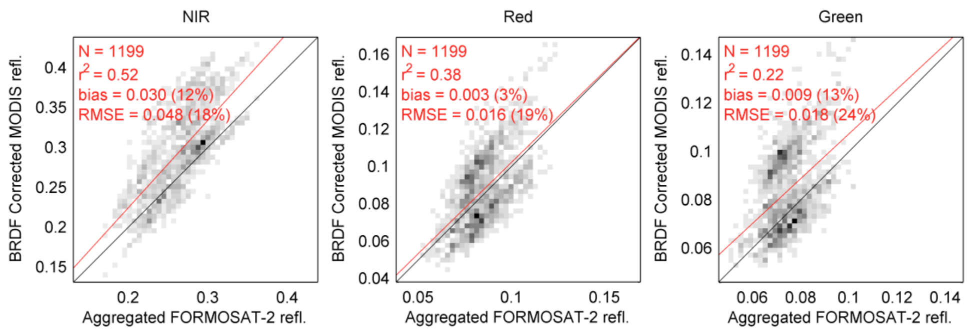
Evaluation of Algorithm Performance

VIIRS C11 reprocessing

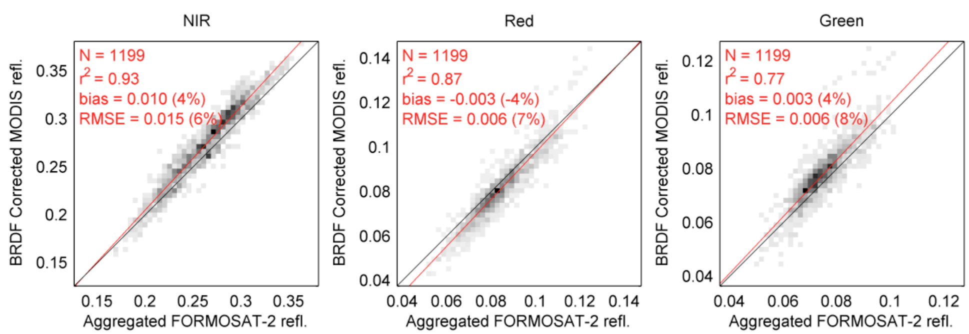




Use of BRDF correction for product cross-comparison



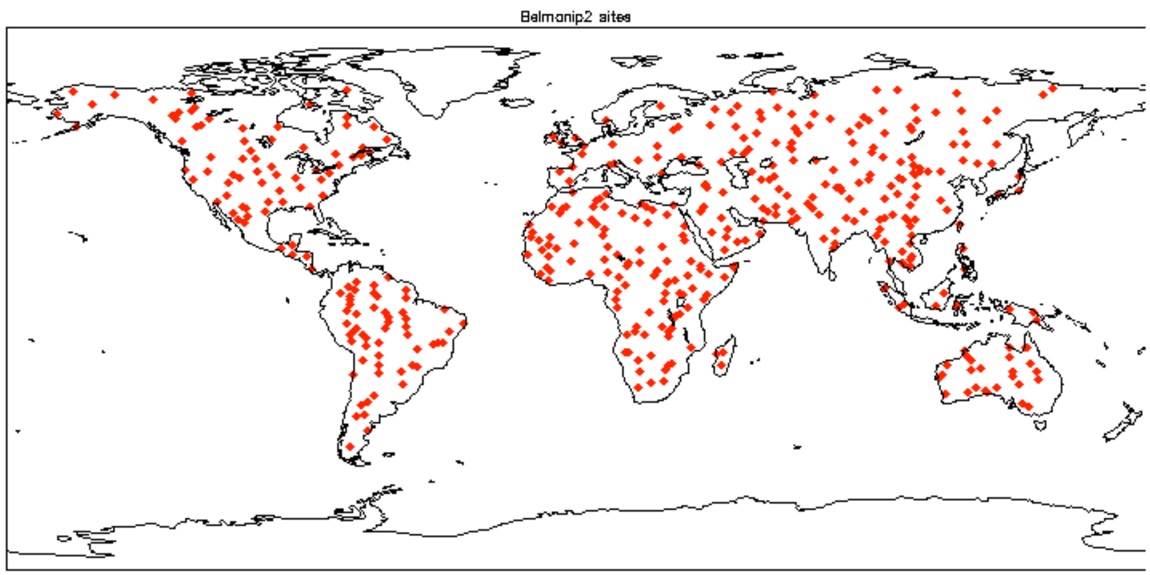
Comparison of aggregated FORMOSAT-2 reflectance and MODIS reflectance. No BRDF correction. Density function from light grey (minimum) to black (maximum); white = no data.



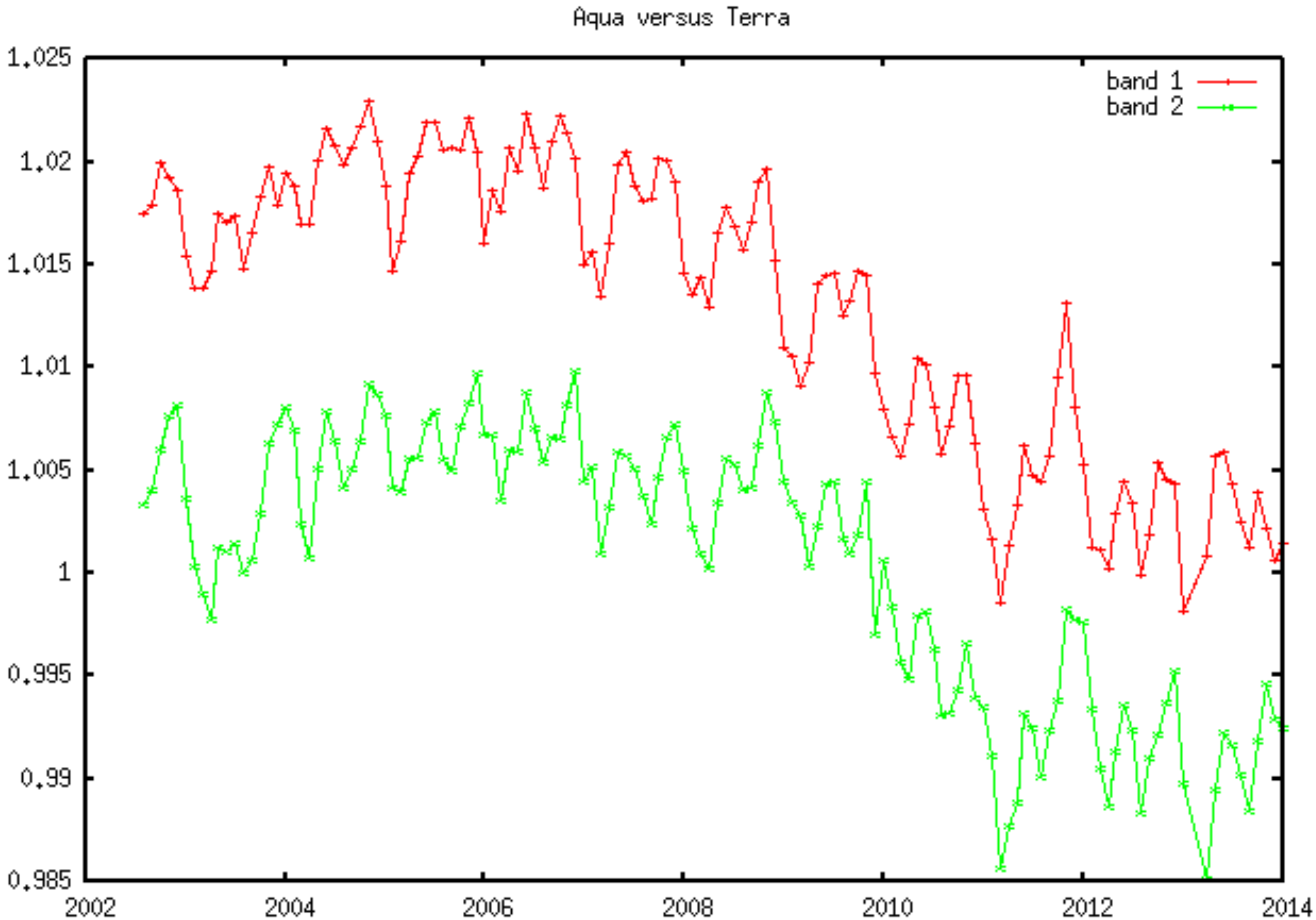
Comparison of aggregated FORMOSAT-2 reflectance and BRDF corrected MODIS reflectance. Corrections were performed with Vermote al. (2009) method using for each day of acquisition, the angular configuration of FORMOSAT-2 data.

Cross comparison with MODIS over BELMANIP2

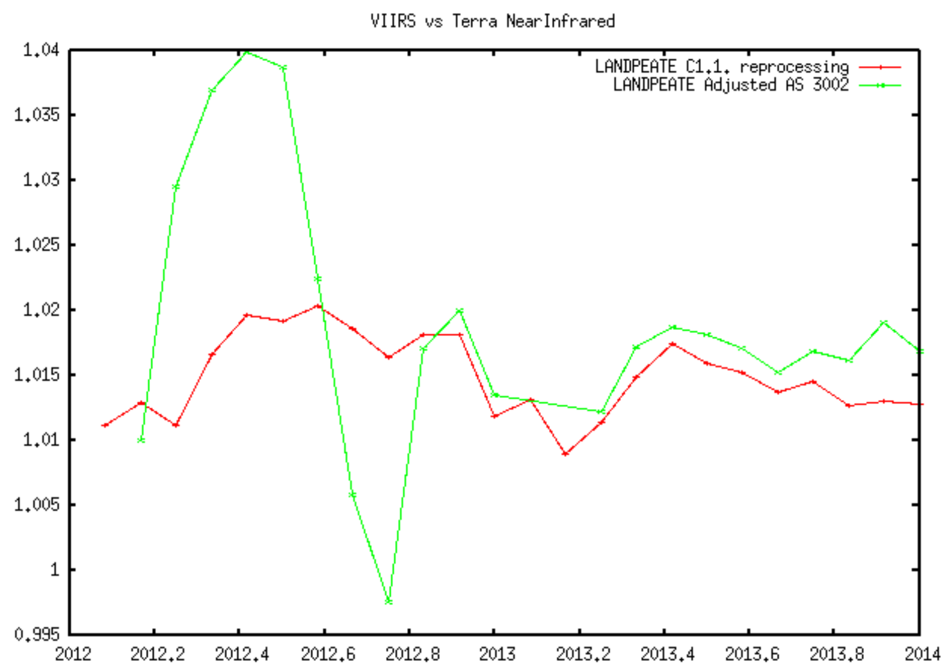
The VIIRS SR is now monitored at more than 400 sites (red losanges) through cross-comparison with MODIS.

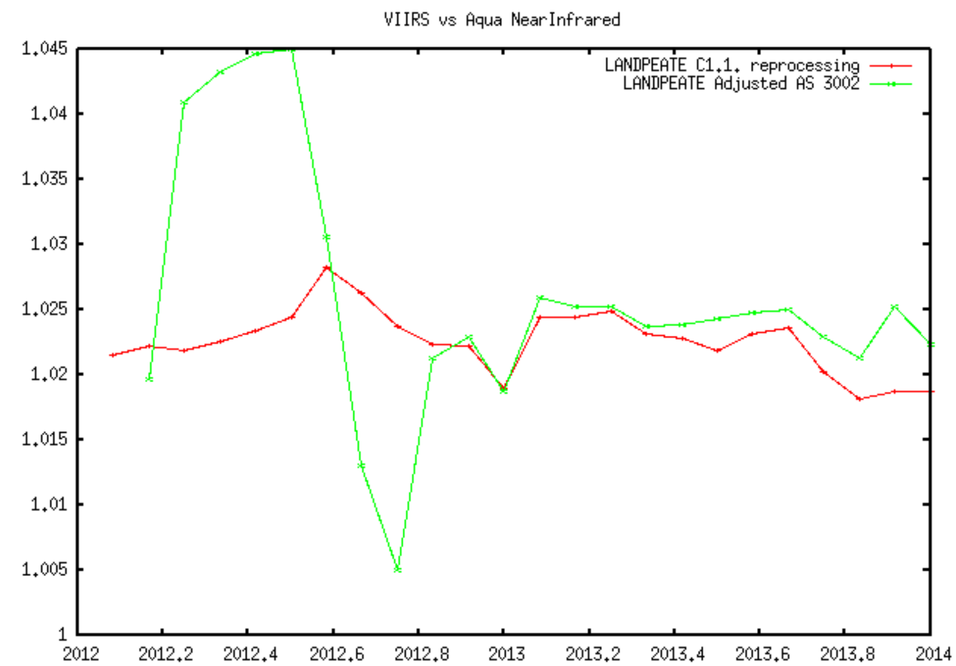


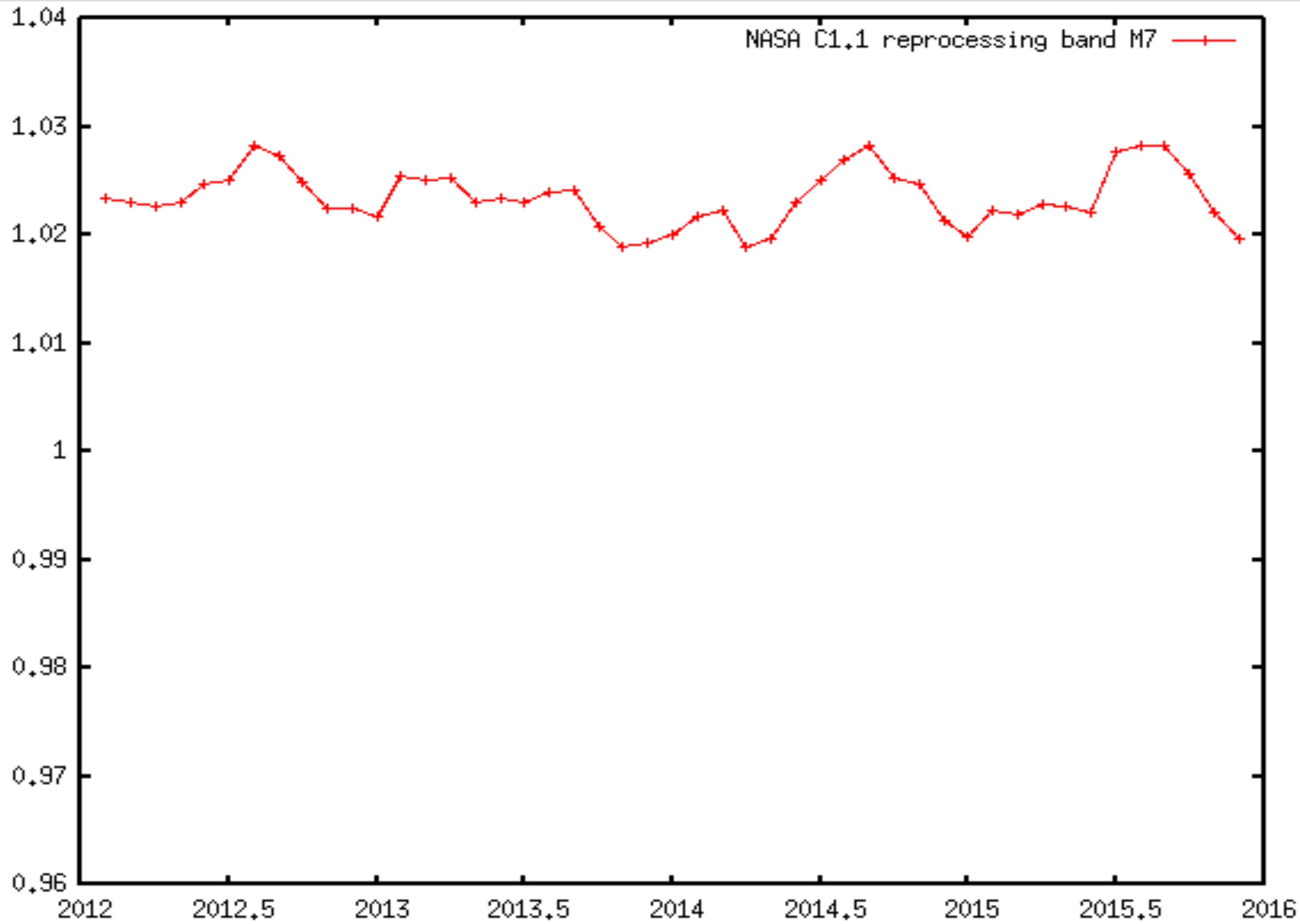
Terra/Aqua Red/NIR Collection 5



VIIRS C11 and VIIRS "operational" AS3002

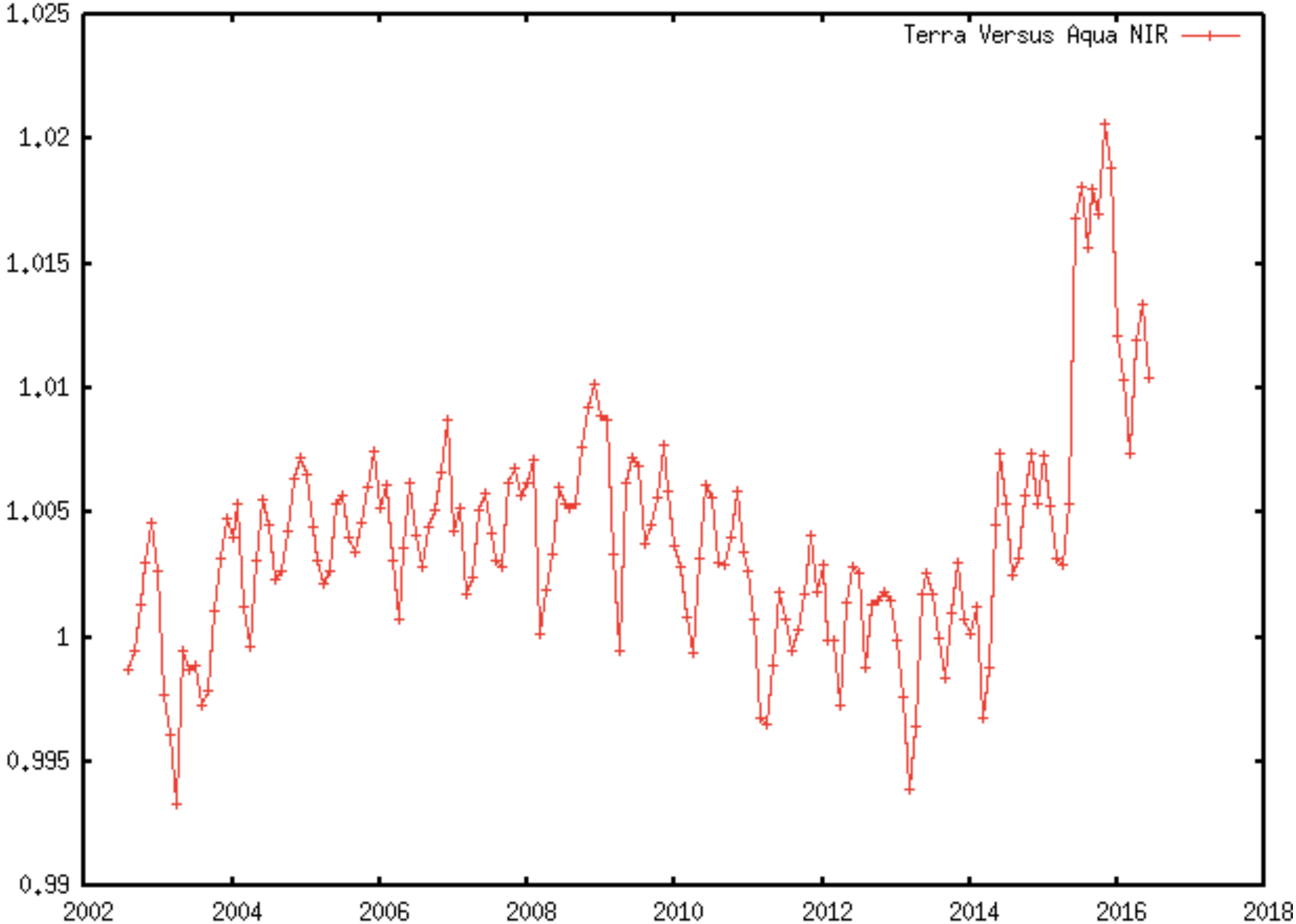




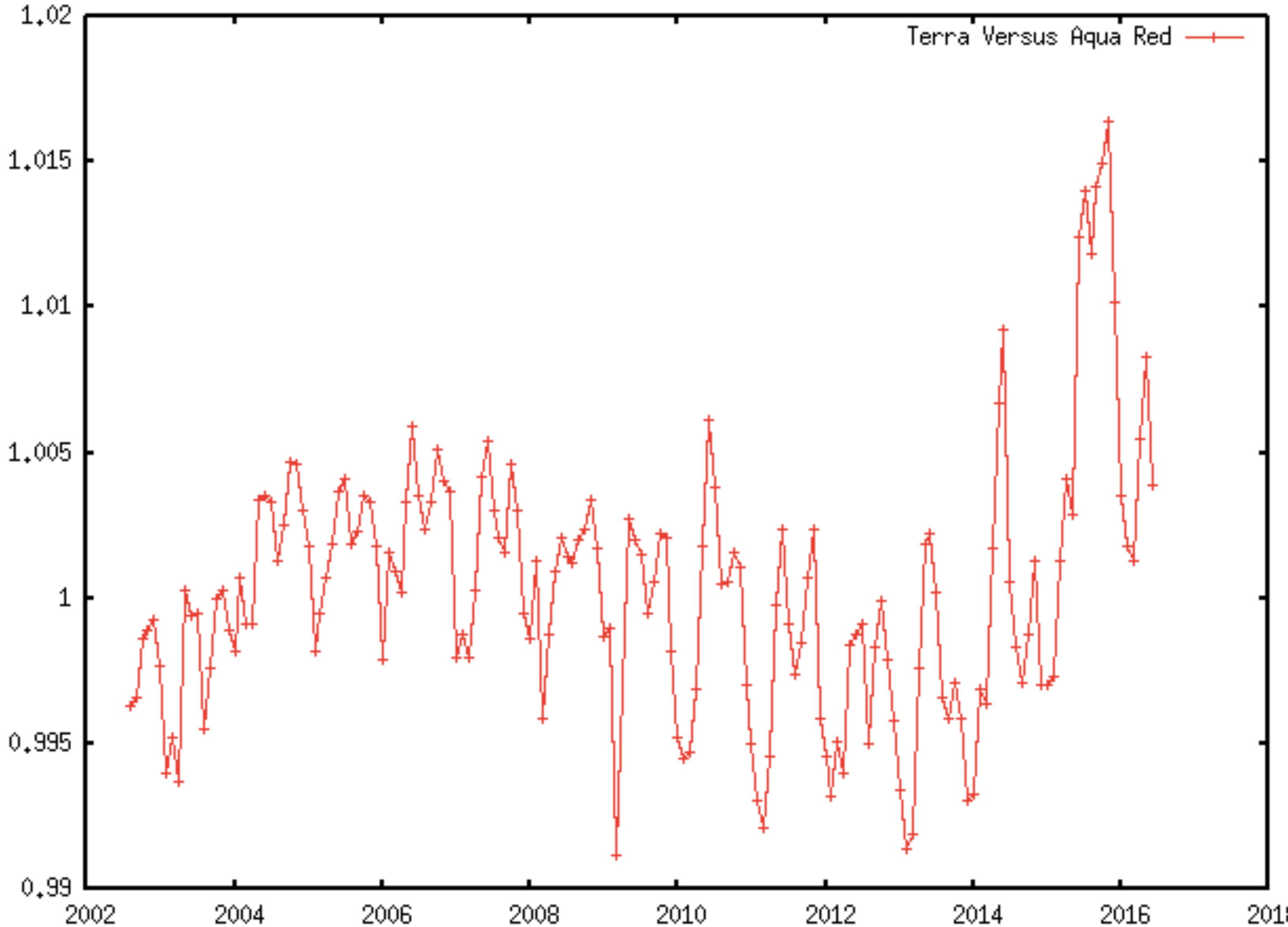


Cross comparison results of the VIIRS and MODIS-Aqua SR product on a monthly basis for the BELMANIP sites reprocessed version (C1.1) for the near infrared band (M7).

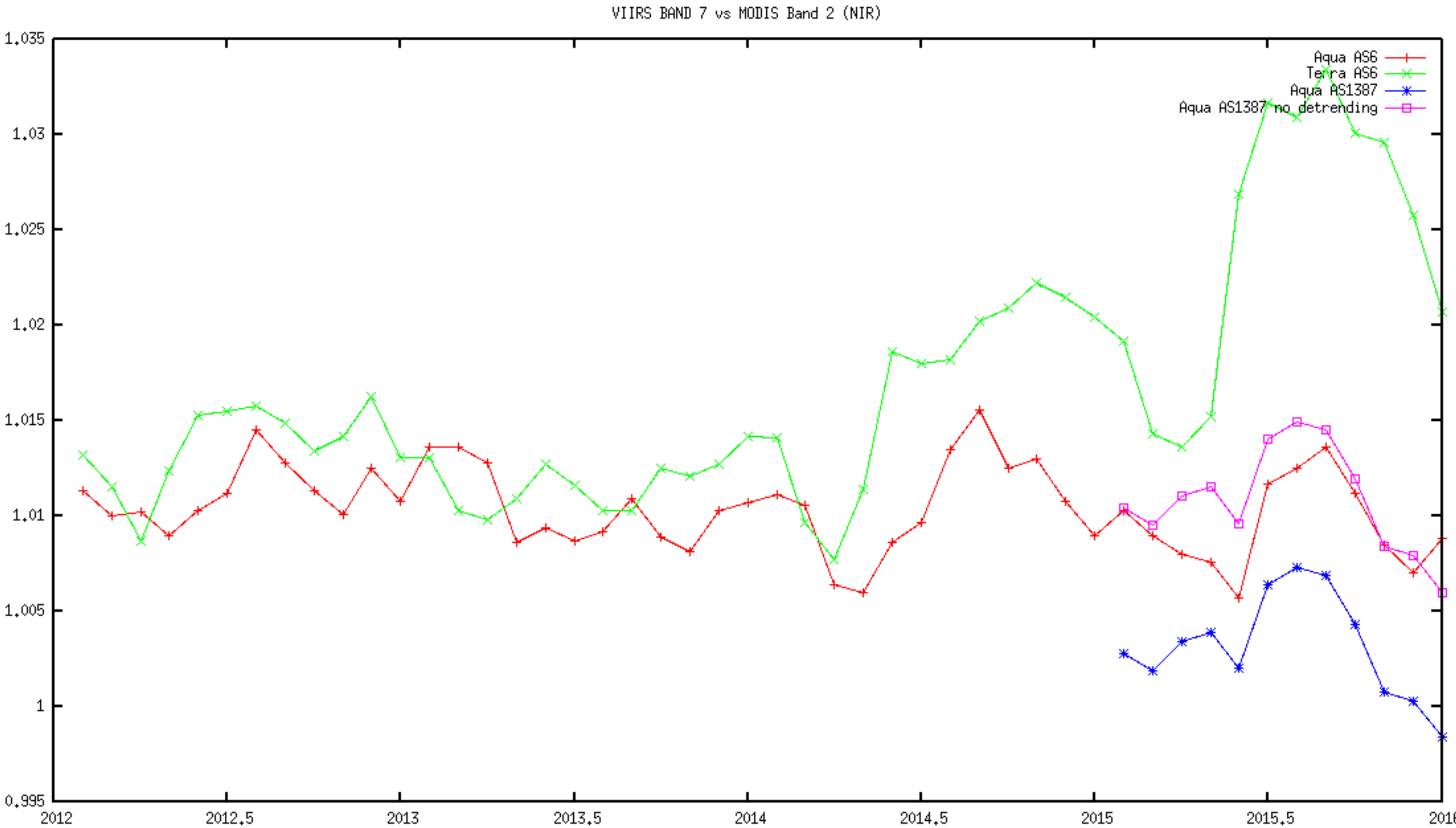
Terra/Aqua NIR Collection 6



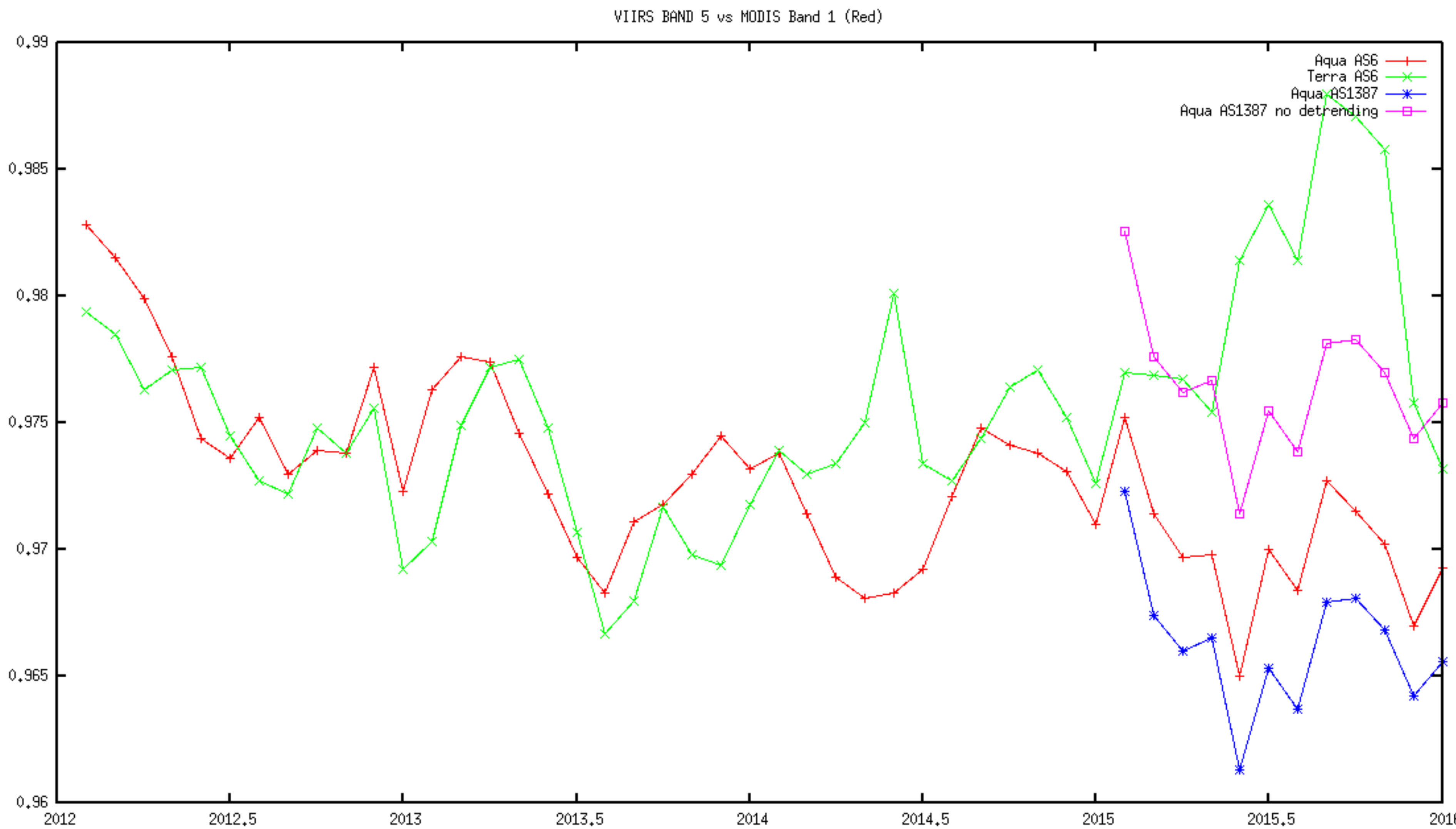
Terra/Aqua Red Collection 6



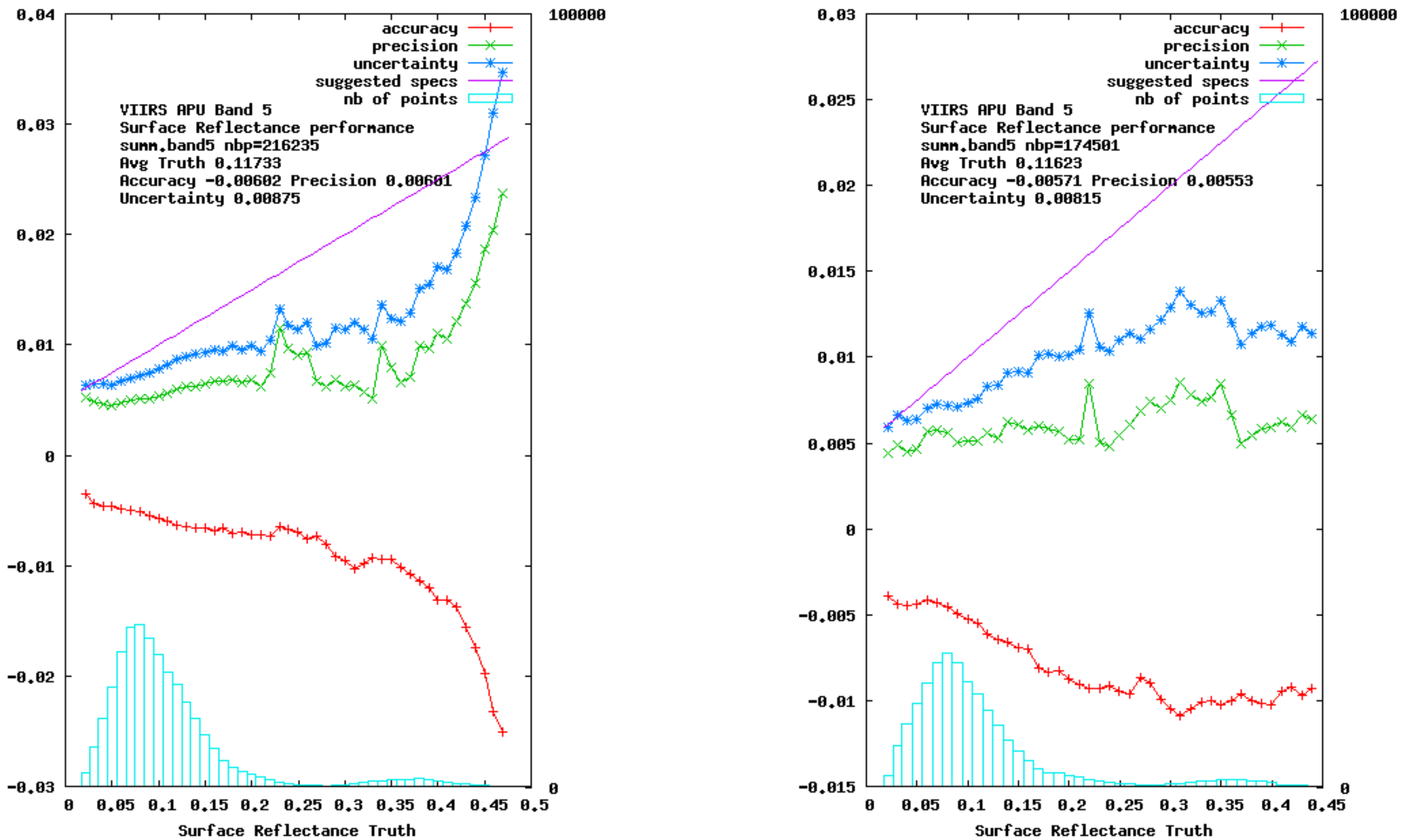
MODIS/VIIRS Results NIR



MODIS/VIIRS Results Red



Testing of MODIS Collection 6 implementation for VIIRS (coming up in AS 5000)



Performances of the VIIRS surface reflectance in the red band derived over AERONET sites for 2012 (Left side)and 2013 (right side).

The need for a protocol to use of AERONET data

To correctly take into account the aerosols, we need the **aerosol microphysical properties** provided by the AERONET network including size-distribution ($\%C_f$, $\%C_c$, C_f, C_c, r_f, r_c, σ_r, σ_c), complex refractive indices and sphericity.

Over the 670 available AERONET sites, we selected **230 sites** with sufficient data.

To be useful for validation, the aerosol model should be readily available anytime, which is not usually the case.

Following *Dubovik et al.*, 2002, JAS,*[2] one can used regressions for each microphysical parameters using as parameter either τ_{550} (aot) or τ_{440} and α (*Angström* coeff.).

The protocol needs to be further agreed on and its uncertainties assessed

ACIX: CEOS-WGCV Atmospheric Correction Inter-comparison Exercise (ESA/NASA/UMD)

The exercise aims to bring together available AC processors (**actually 14 processors including SEN2COR, MACCS, L8-S2-6SAC, …**) to generate the corresponding SR products.

The input data will be **Landsat-8 and Sentinel-2 imagery** of various test sites, i.e. coastal, agricultural, forest, snow/artic areas and deserts.

Objectives
- To better understand uncertainties and issues on L8 and S2 AC products
- To propose further improvements of the future AC schemes

* 1st Workshop in June 21st-22nd @ University of Maryland (by invitation): to elaborate concepts, protocols and guidelines for the inter-comparison and validation of SR products

Program (with first suggestions) will be provide April 30th (available on the web site for eventual end users feedbacks)

* 2nd workshop in January 2017 (open)

https://earth.esa.int/web/sppa/meetings-workshops/acix

Conclusions

- Surface reflectance (SR) algorithm is mature and pathway toward validation and automated QA is clearly identified.
- Algorithm is generic and tied to documented validated radiative transfer code so the accuracy is traceable enabling error budget.
- The use of BRDF correction enables easy cross-comparison of different sensors (MODIS,VIIRS,AVHRR, LDCM, Landsat, Sentinel 2 ,Sentinel 3…)
- AERONET is central to SR validation and a “standard” protocol for its use to be defined (CEOS CVWG initiative)