



# Status of the Landsat and Sentinel 2 Surface Reflectance Product

Eric Vermote<sup>1</sup>, Chris Justice<sup>2</sup>, Jean-Claude Roger<sup>1,2</sup>, Sergii Skakun<sup>1,2</sup>  
and Belen Franch<sup>1,2</sup>

<sup>1</sup> NASA Goddard Space Flight Center Code 619

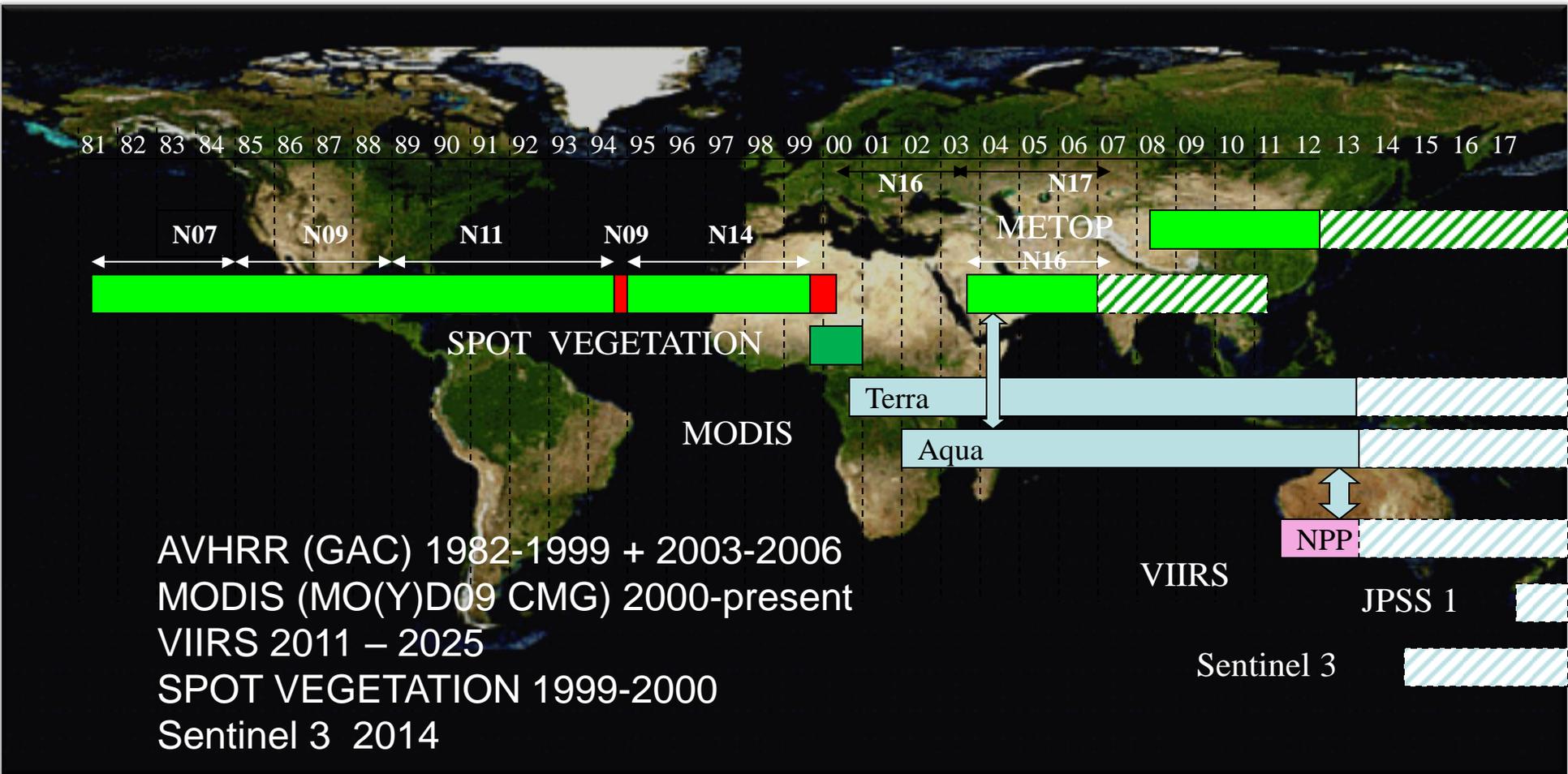
<sup>2</sup> University of Maryland Department of Geographical Sciences

**[Eric.f.vermote@nasa.gov](mailto:Eric.f.vermote@nasa.gov)**



# 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*

Landsat Science Team Meeting, 26-28 July 2016, Brookings, SD



# Generic Surface reflectance algorithm

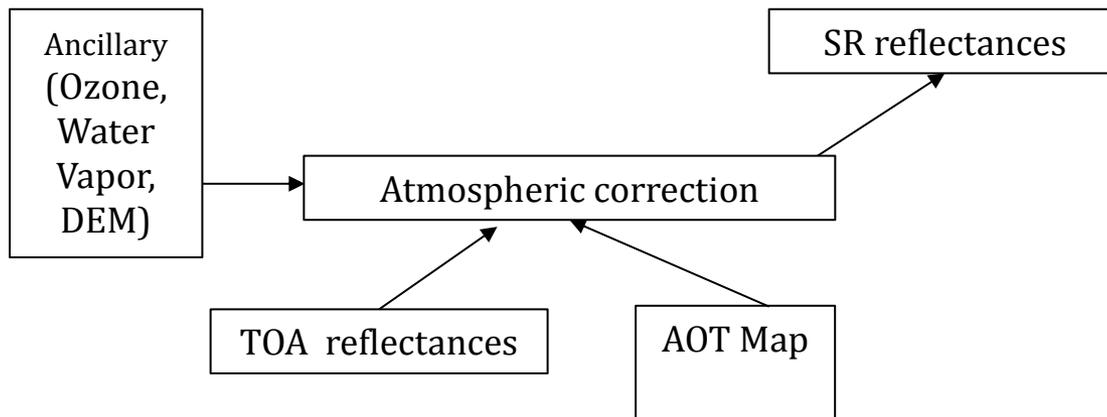
The Surface reflectance algorithm relies on

- 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>



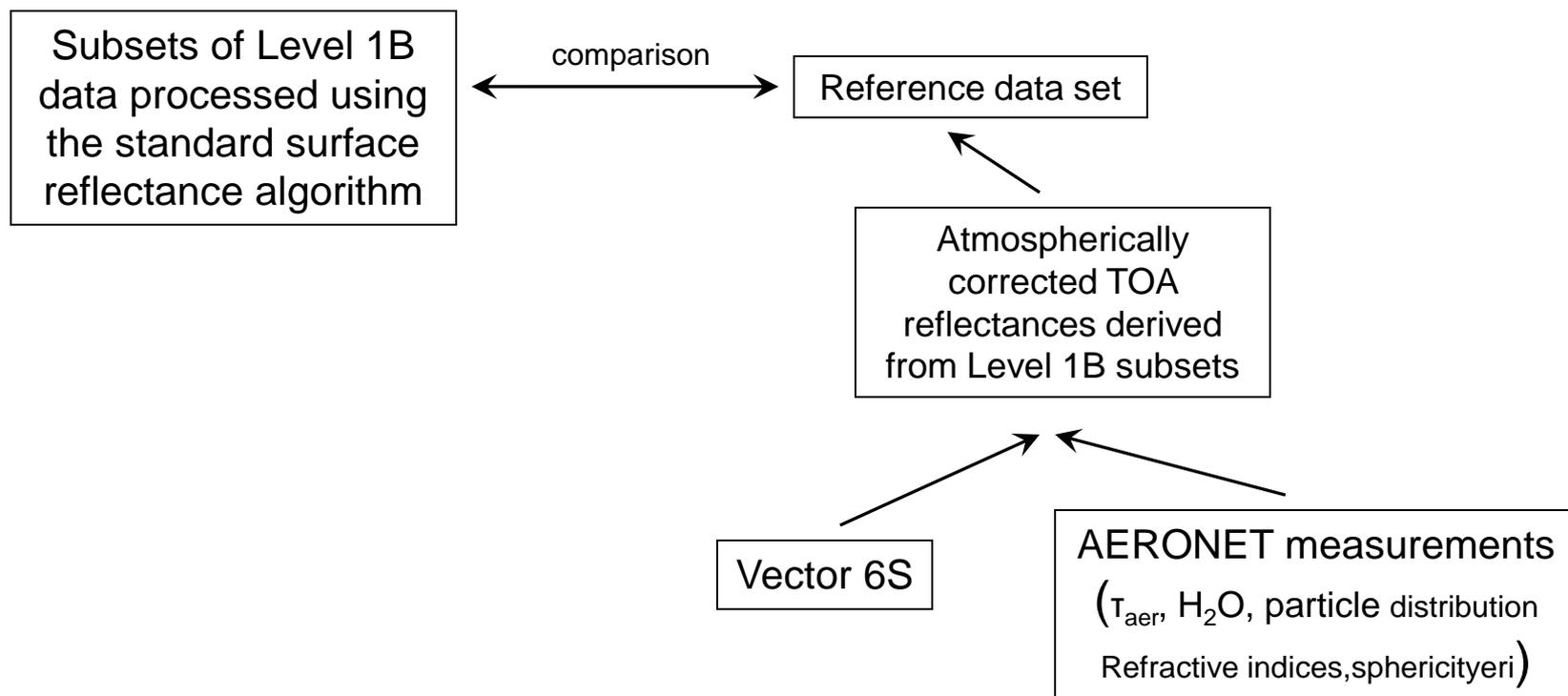
# Generic flowchart for atmospheric correction





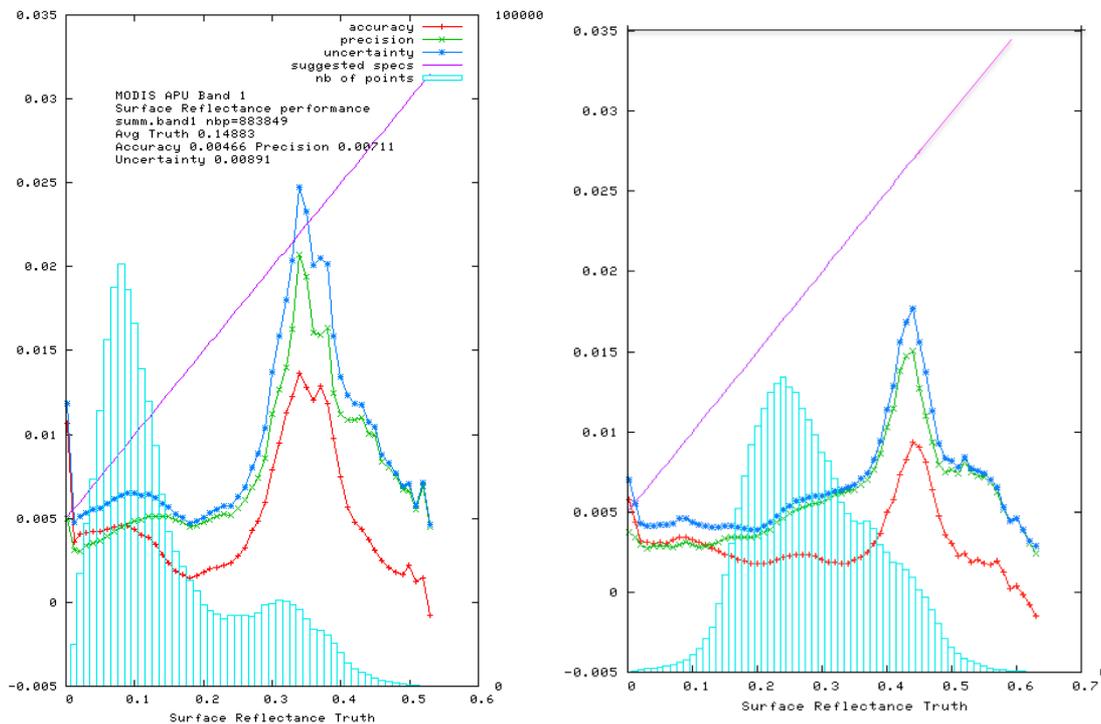


# Methodology for evaluating the performance of surface reflectance





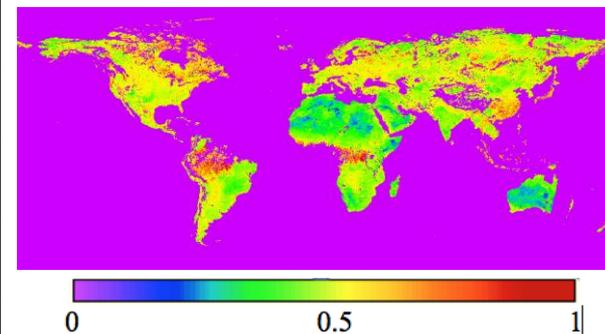
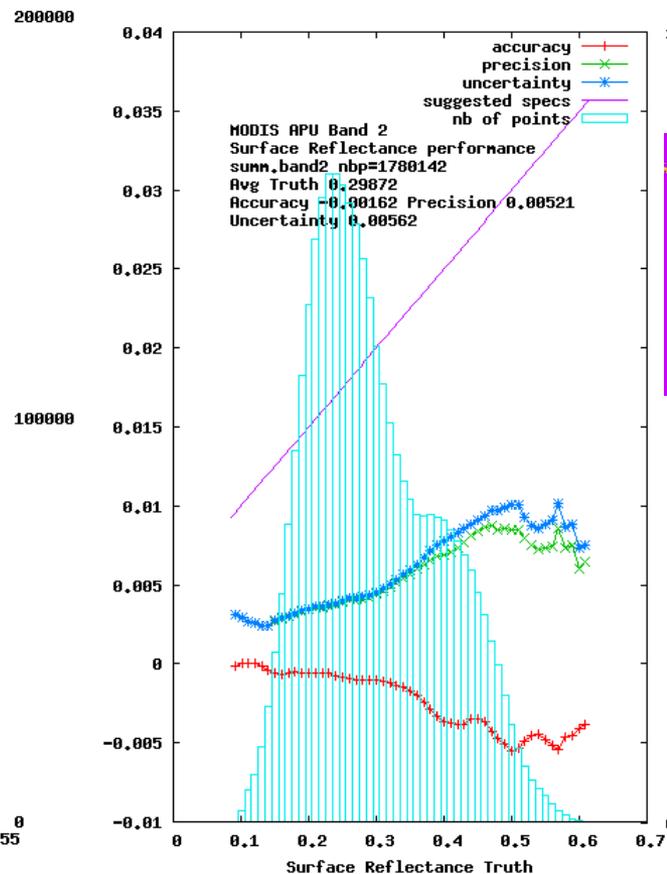
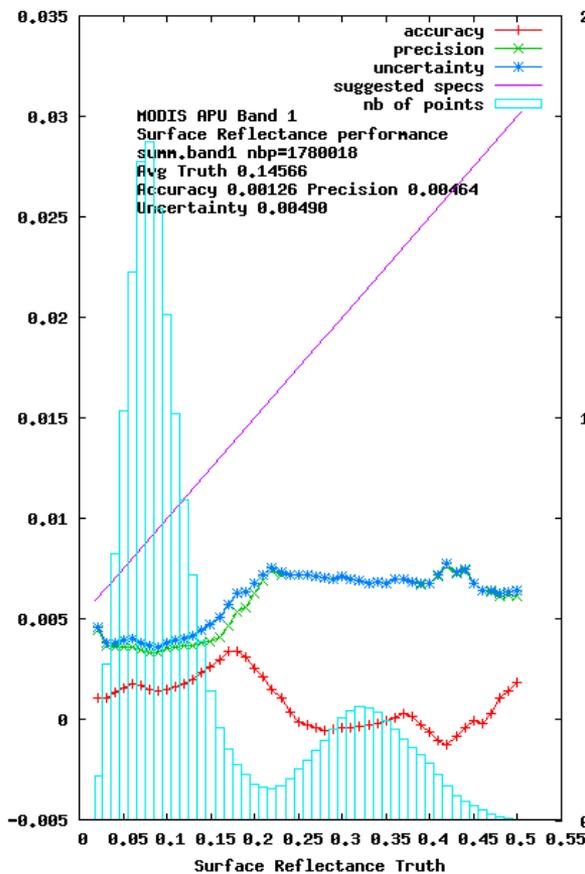
# quantitative assessment of performances (APU) for MODIS



**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

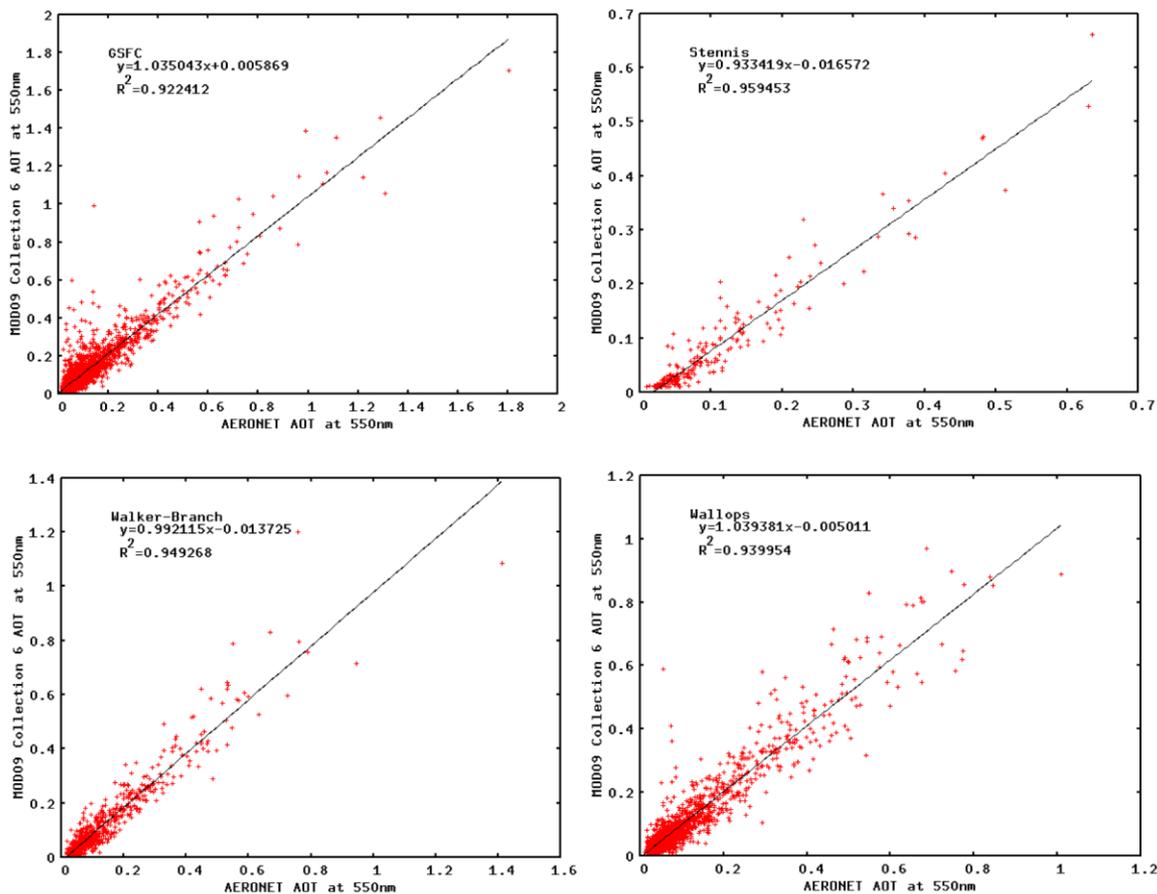


ratio band3/band1 derived using MODIS top of the atmosphere corrected with MISR aerosol optical depth

**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.



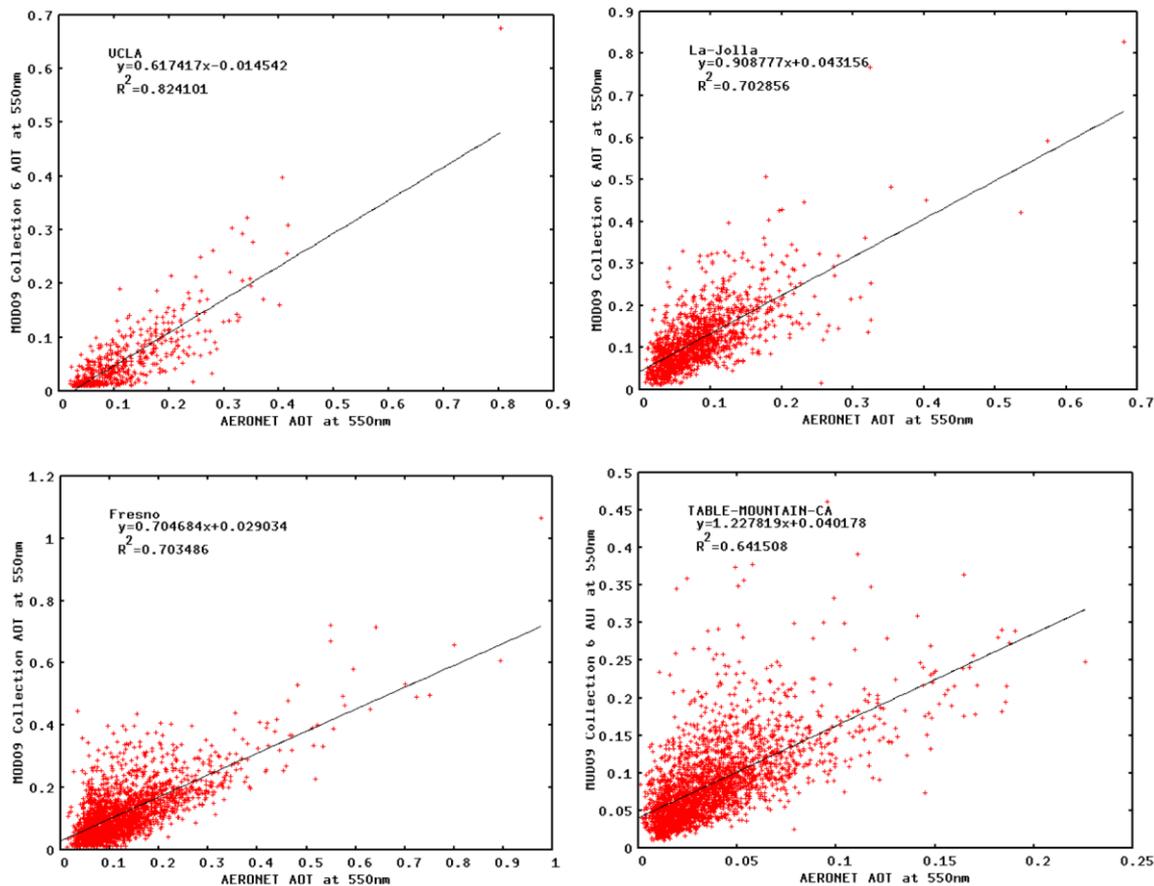
# Aerosol retrieval also shows improvement



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).



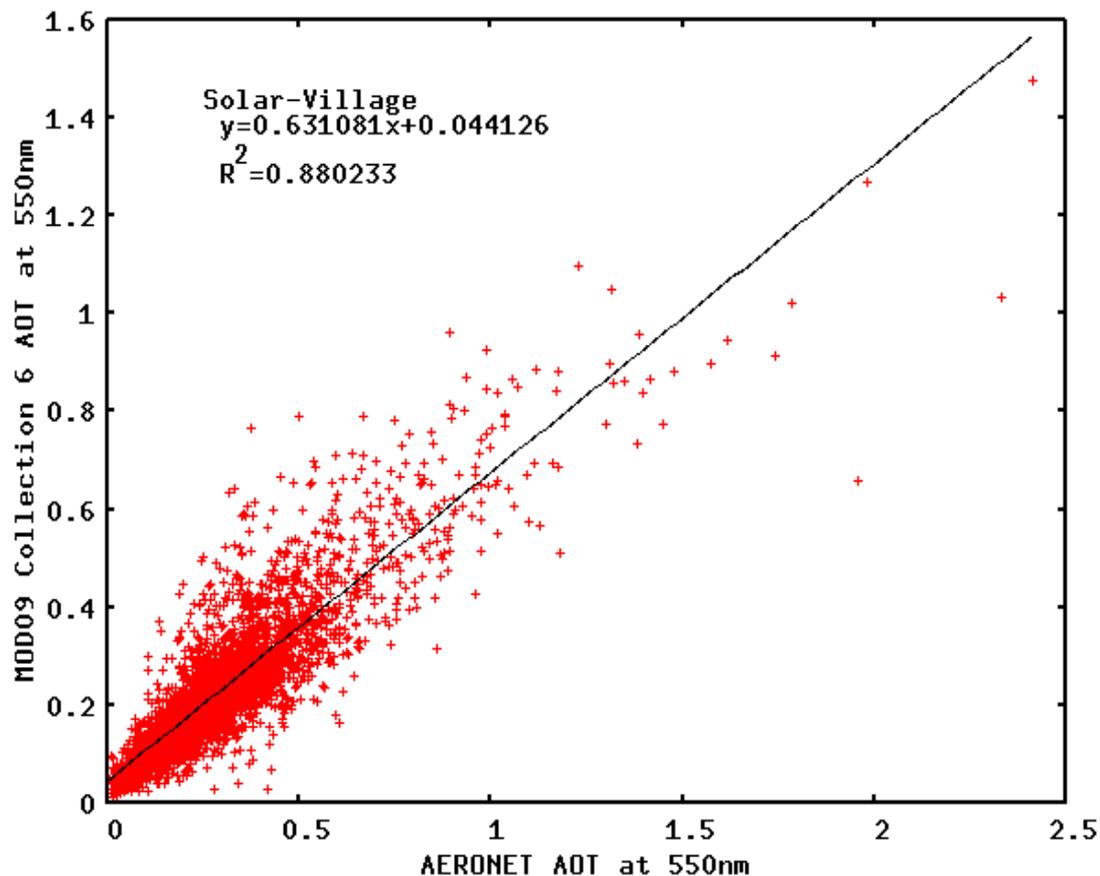
# Aerosol retrieval also shows improvement



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)



# This Surface Reflectance is applied to Landsat8/OLI and Sentinel 2

**Algorithm reference for L8:** Vermote E.F., Justice C., Claverie M. and Franch B., “Preliminary analysis of the performance of the Landsat 8/OLI land surface reflectance product” Remote Sensing of Environment. In Press.

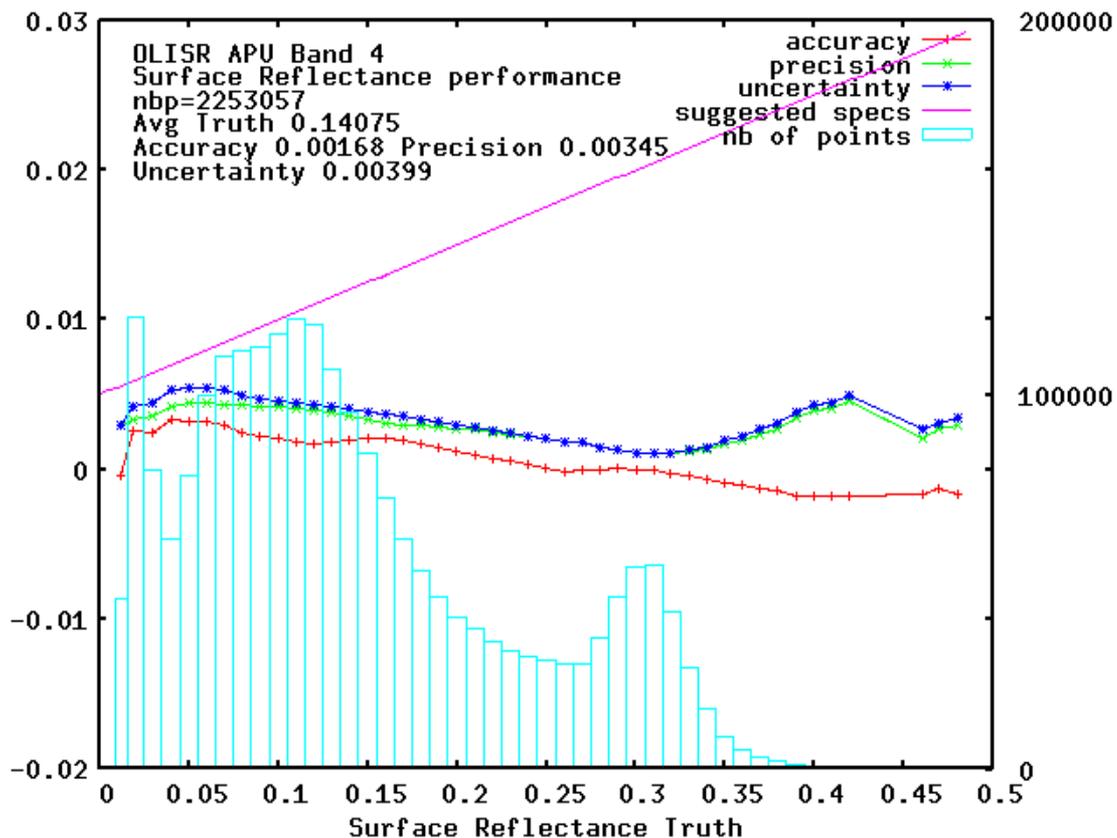
The MODIS **Collection 6 AC algorithm** relies on

- 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 OLI/Sentinel 2 images***
  - ***Water vapor and ozone from daily MODIS product.***

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



# 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



# This is confirmed by comparison with MODIS

OLI Band	TM LEDAPS (Claverie et al., 2015)			ETM+ LEDAPS (Claverie et al., 2015)			OLI (Vermote et al., 2016)		
	A	P	U	A	P	U	A	P	U
2	7?	9?	<b>11?</b>	9?	7?	<b>12?</b>	2?	6?	<b>6?</b>
3	1?	9?	<b>9?</b>	6?	9?	<b>11?</b>	3?	6?	<b>7?</b>
4	9?	10?	<b>14?</b>	1?	9?	<b>9?</b>	1?	6?	<b>6?</b>
5	5?	17?	<b>17?</b>	3?	14?	<b>15?</b>	2?	12?	<b>12?</b>
7	1?	14?	<b>14?</b>	5?	15?	<b>16?</b>	9?	11?	<b>14?</b>

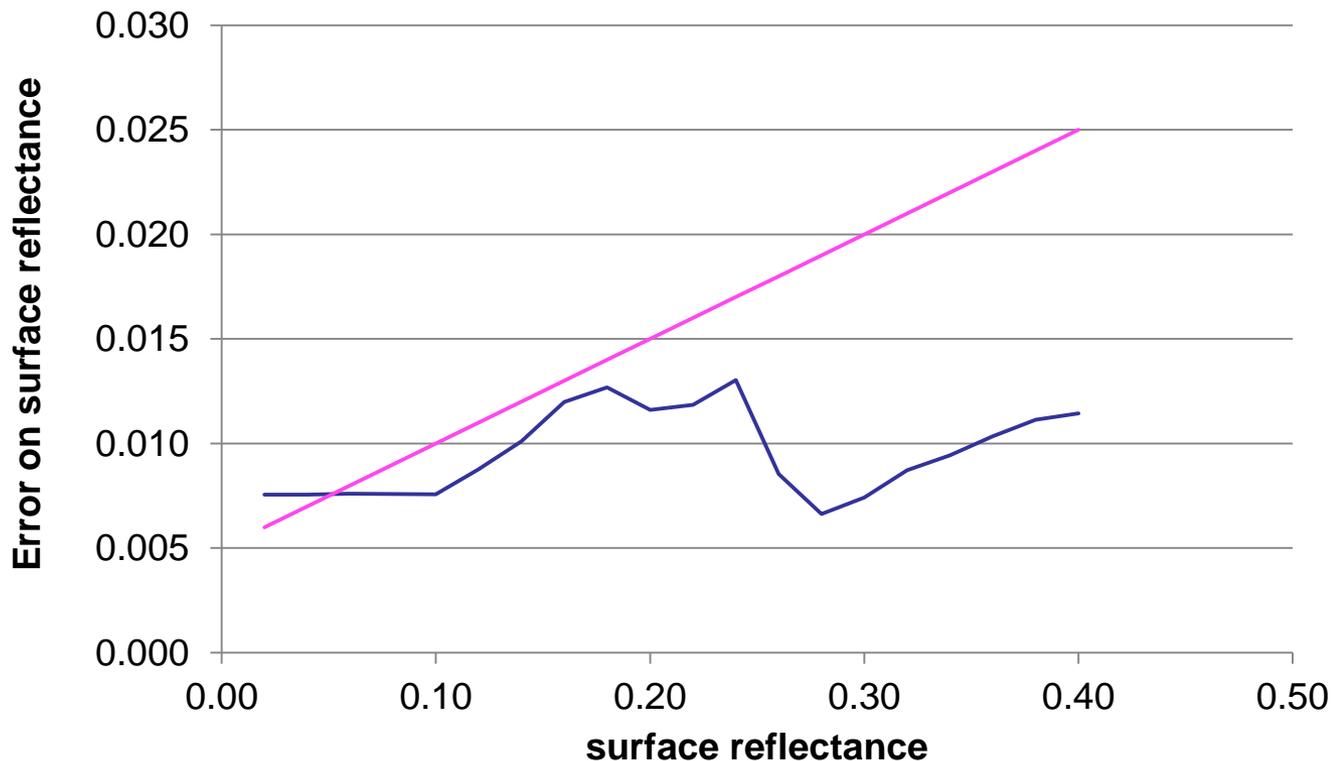
OLI surface reflectance APU scores expressed in  $10^{-3}$  reflectance (compared to TM and ETM+ surface reflectance APU by Claverie et al. (2015) using Aqua MODIS BRDF and spectrally adjusted surface reflectance CMG product as reference, the OLI surface reflectance was aggregated over the CMG. Band number corresponds to OLI band number designation and equivalent TM/ETM+ bands were reported.



# Sentinel 2 SR “validation” (6 scenes only)



**For the Red channel (Band 4 @ 665nm)**

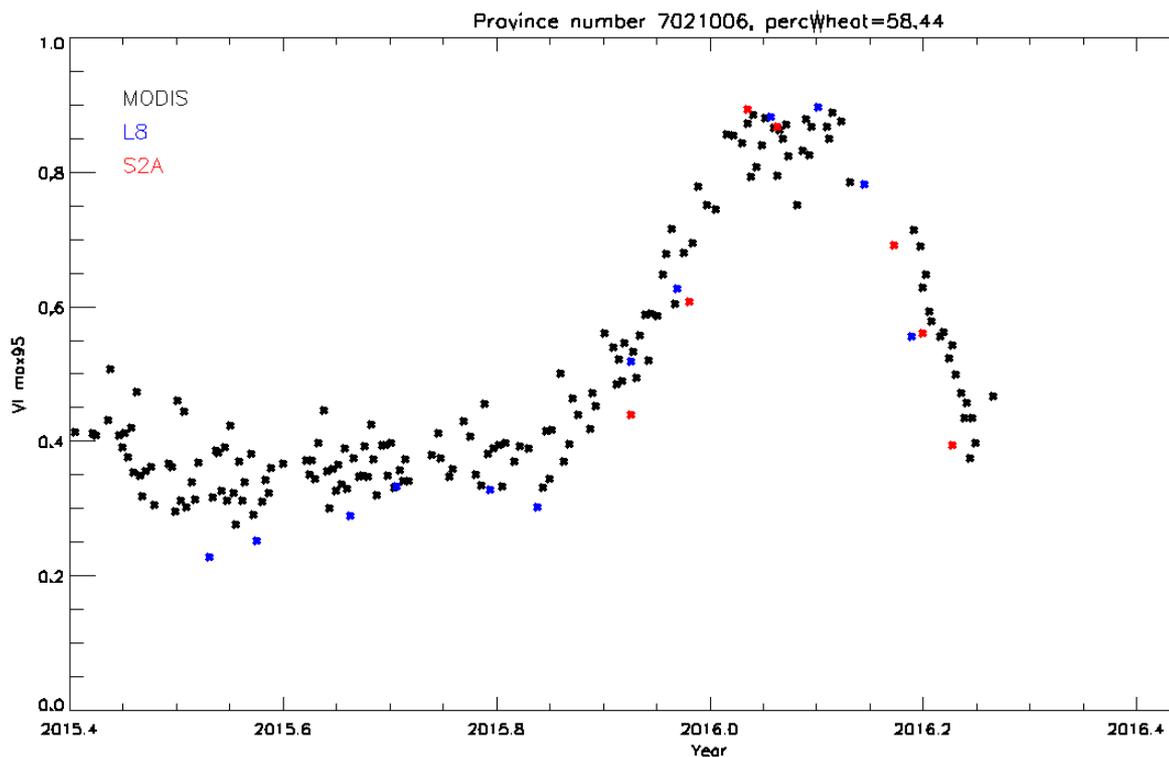




# Comparison of L8/S2 with MODIS

## CMG MODIS product

NDVI aggregated at **CMG resolution**.  
summer crops (maize-soy)



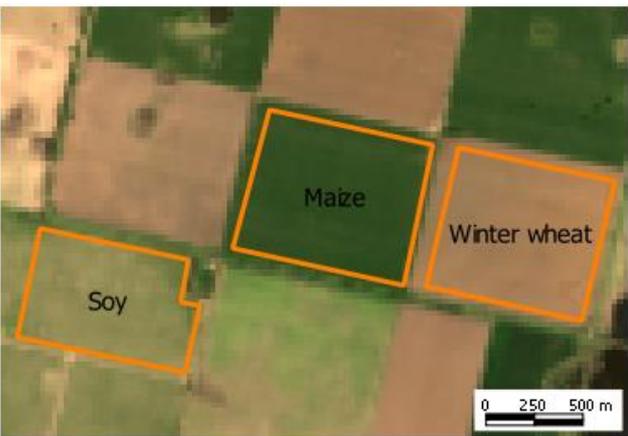


# Temporal information is now available at the field level

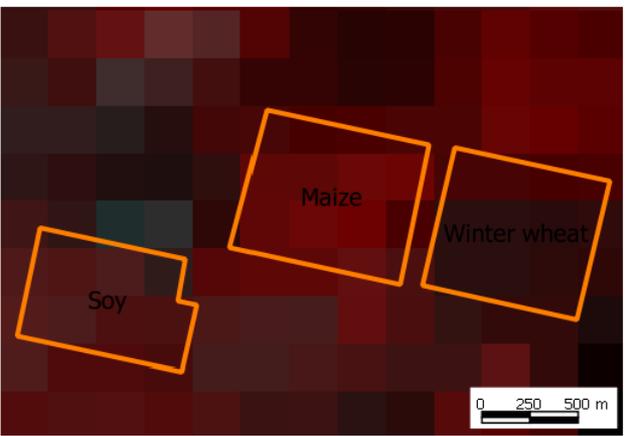
NDVI aggregated at field level (Argentina, S2A tile 20HNNH).



Sentinel-2A image acquired on 04-Dec-15, 10m, true color B04-03-02 (SR, scaled 0-0.15)



Landsat-8 image acquired on 04-Dec-15, 30m, true color B4-3-2 (SR, scaled 0-0.15)



MOD09GQ image acquired on 04-Dec-15, 250m, false color B2-1-1, SR



Sentinel-2A image acquired on 23-Jan-16, 10m, true color B04-03-02 (SR, scaled 0-0.15)

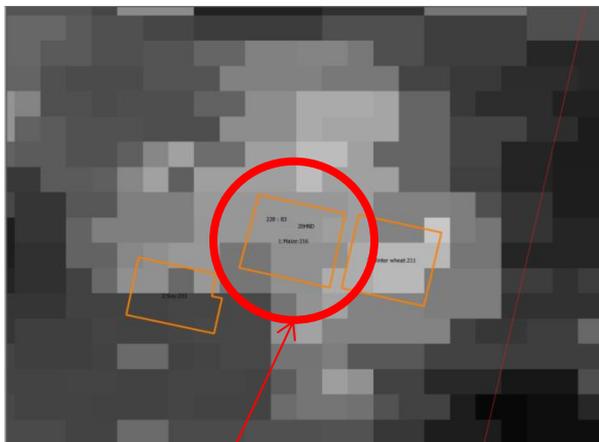


Landsat-8 image acquired on 21-Jan-16, 30m, true color B4-3-2 (SR, scaled 0-0.15)



# Temporal information is now available at the field level

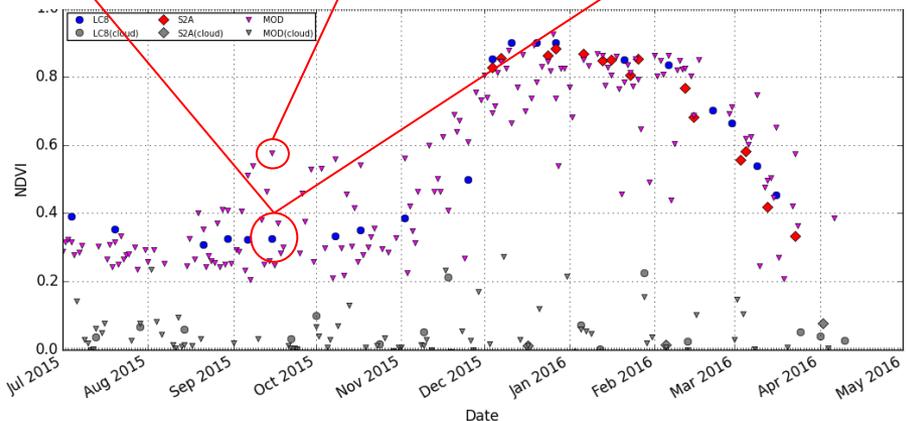
NDVI aggregated at field level (Argentina, S2A tile 20HNNH).



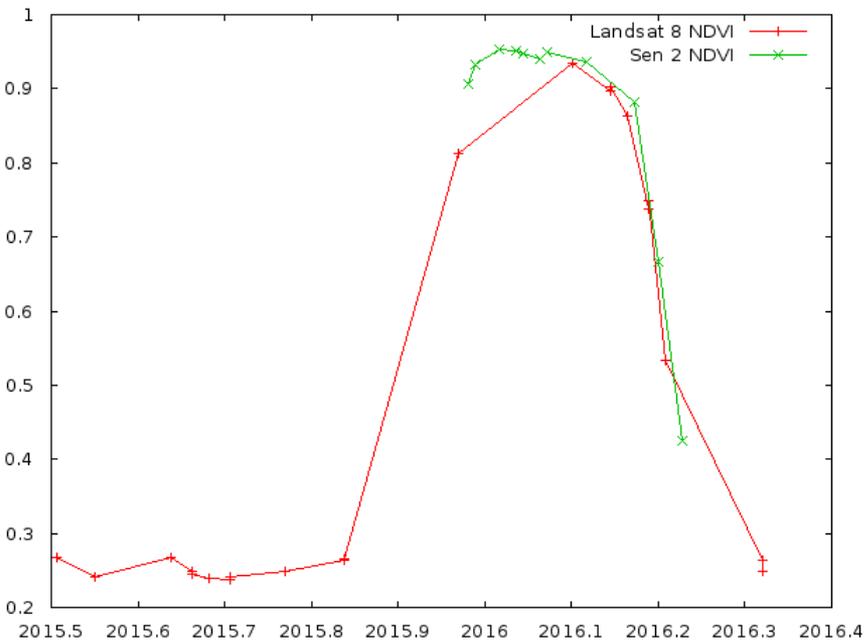
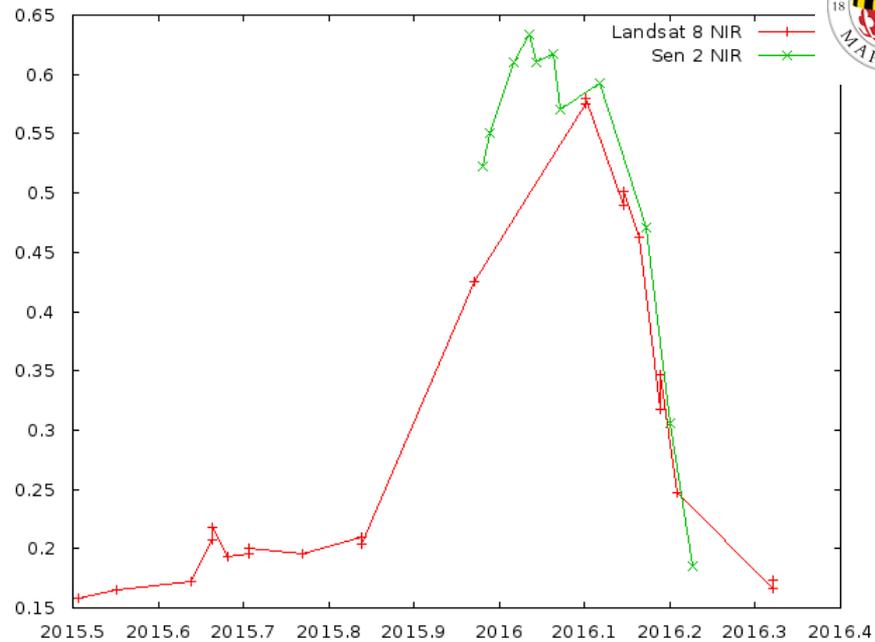
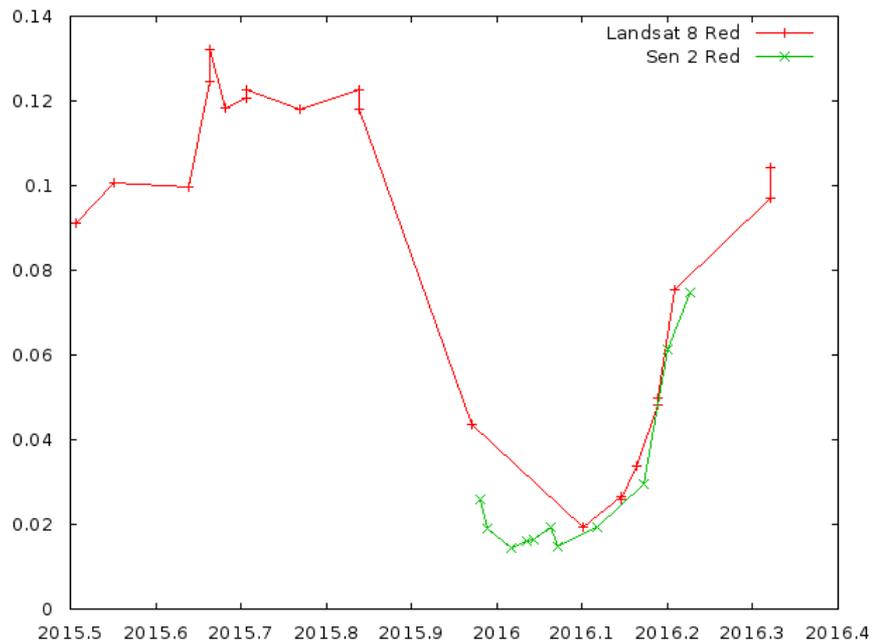
LC8 acquired on **15-Sep-2015** (30m). SR NIR band scaled 0.05-0.55

MODIS/Terra (MOD09GQ) acquired on **15-Sep-2015** (250 m). SR NIR band scaled 0.05-0.55

MODIS/Terra (MOD09GQ) acquired on **16-Sep-2015** (250 m). SR NIR band scaled 0.05-0.55



Maize





# 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

\* 1<sup>st</sup> Workshop in June 21<sup>st</sup>-22<sup>nd</sup> @ 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 30<sup>th</sup> (available on the web site for eventual end users feedbacks)

\* 2<sup>nd</sup> 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, Landsat, Sentinel 2, Sentinel 3...)
- Preliminary Sentinel 2 surface reflectance validation shows good performance but needs a more extensive study