Sentinel 3 Science Products: A US Contribution

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Annual Report

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A. Sentinel 3 Cooperation

The PI and Team are in communication with Olivier Arino (ESA) and his staff at ESA ESRIN concerning the status of the Sentinels, taking advantage of different meeting venues to share experience gained with MODIS and VIIRS and better understand the preparation for and characteristics of the Sentinel 3 instrument. The team has also contacted ESA funded PI's who are working on the ESA Land CCI products, which are precursors to products to be generated from Sentinel 3. The team has also been working with the CEOS LPV to ensure that international protocols for product validation are in place.

B. Calibration, Atmospheric Correction / Surface Reflectance Product- Eric Vermote:

In preparation for the Sentinel 3 mission, the activities related to calibration, atmospheric correction and cloud/cloud shadow mask have continued using data from the MODIS sensor but also from the VIIRS recently launched. These results are being shared with European scientists involved in the Sentinel 3 Mission.

1. Calibration

The VIIRS, Aqua and Terra data have been used in an algorithm to inter-compare the calibration of VIIRS and Terra. In this activity the near coincidence of Aqua and VIIRS observation (about 8 minutes) and the similar geometry of observations of Terra and VIIRS (more near nadir coincident observations) have been used to derive a successful inter-calibration approach. Aqua is providing a cloud mask for VIIRS data (VIIRS cloud mask is not operational due to the on-going cooling of the thermal bands), and Terra is acquired in a similar geometry of observations that enables a quasi-direct comparison. This exercise will be very profitable for SENTINEL 3 which might operate in a different orbit. Figure 1 gives an illustration of the inter-calibration for the red band on a particular day (note that all the days acquired have been processed).

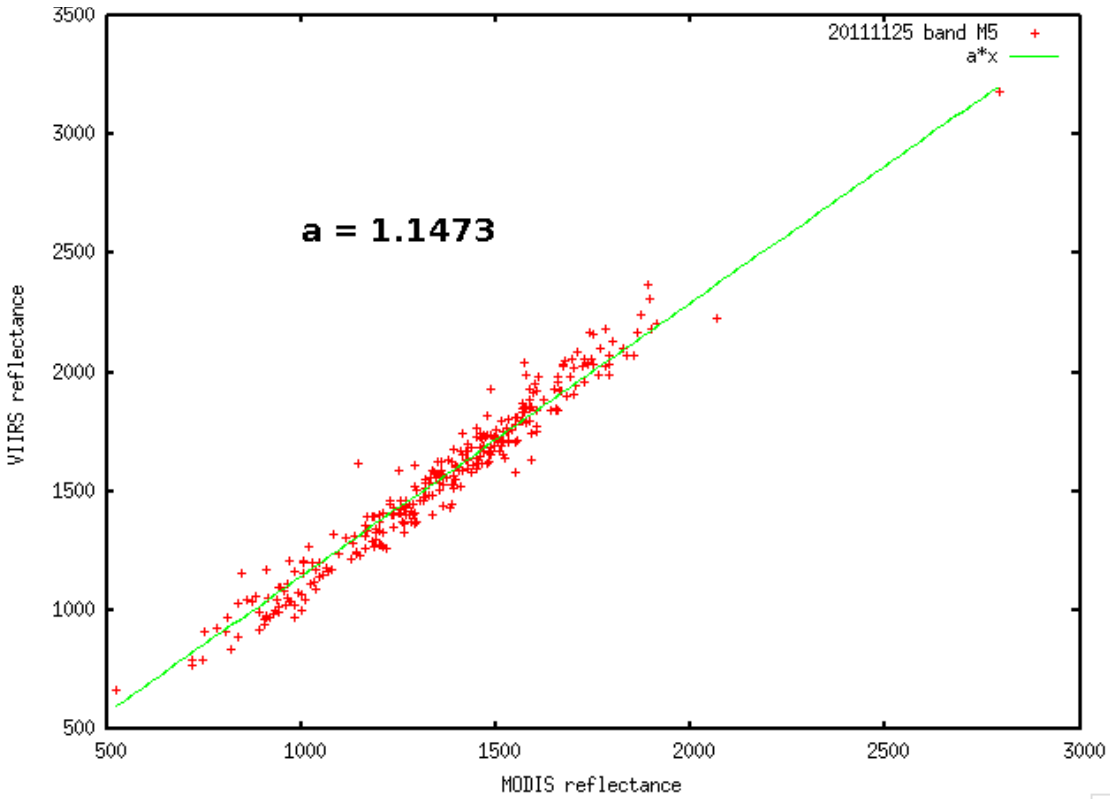

Figure 1: Comparison of VIIRS reflectance in the red (Band M5) preflight calibrated with the MODIS Terra equivalent band (band 1) on November 25 2011. Note that the observations are not coincident in time but just in geometry, Aqua data coincident in time but not geometry is used to adjust for this.

2. Atmospheric correction / Surface reflectance product

We have continued to prototype methods for early evaluation of surface reflectance products in preparation for SENTINEL 3. Two methods have been developed, (a) the comparison to the near coincident reflectance product, (b) the independent assessment at the AERONET sites. The analysis of (a) has been global and multiyear and has successfully shown the promise of atmospheric correction of a SENTINEL 3 type sensor. In this approach we have been comparing the surface reflectance product from Terra and Aqua and applied a common BRDF correction so they can be inter-compared. We are planning in the future to use VIIRS as well which will be useful with respect to the preparation for SENTINEL 3, by allowing us to prototype how the slightly different spectral bands on MODIS/VIIRS affect the comparison. Approach (b) has confirmed the results of approach (a) and is still being refined with respect to the use and filtering of AERONET aerosol model inversions.

B. Fire Monitoring

In the first year of the activities the proposal team in charge of MODIS fire products (Dr. Justice, Dr. Boschetti, Dr. Giglio) have:

1) cooperated with the European team in charge of the development of the ESA contribution to the Fire Essential Variable (FIRE CCI project)

2) maintained contact with ESA ESRIN regarding the possible development of a Sentinel 2 fire product.

The following paragraphs describe in detail the activities carried out:

1) **Cooperation with ESA Fire CCI project**

   To respond to the need for consistent long term monitoring needs highlighted by the IPCC and UNFCC reports, ESA launched the Climate Change Initiative (CCI), aimed at the global monitoring of the Essential Climate Variables (ECVs). Fire is among the ECVs included in the CCI initiative. The project, with a two year duration, is carried out by a large consortium composed of academic and research institutions as well as private enterprises, coordinated by Dr. Emilio Chuvieco (University of Alcala, Spain) and overseen by ESA program manager, Dr. Stephen Plummer.

   In the two years of the project, the consortium will develop and test the processing chain necessary to process a time series of ATSR, SPOT-VGT and MERIS data, which will eventually cover the full 1998- present date time series. The processing chain will be only tested on three (non consecutive) years of data, and for the whole time series for sub-continental windows of limited extent. A subsequent, recompeted consortium will process the whole dataset and it is expected that future expansions of the product will cover the Sentinel 3 time frame.

   Drs. Justice, Boschetti and Giglio were invited to the Fire CCR coordination meeting, held in Stresa in October 2011 in conjunction with the GOFC-GOLD fire implementation team; the objective of the US participation in the discussion has been to ensure that the forthcoming ESA products will be compatible with the NASA products for joint analysis, and that the validation datasets will be produced using a compatible methodology. The discussion in Stresa focused on:

   - Combination of the algorithms which will process the various data sources – the three data streams will be processed independently, and the initial plan of the fire CCI consortium was to release three independent products. The opinion of the MODIS team is that they should be combined.
   - Spatial resolution of the combined product: the three sensors have different spatial resolutions (300m – 1km) and the MODIS team is pushing for a combined product at constant resolution
   - Validation strategy, validation metrics and validation datasets: the details of the strategy have been discussed (CEOS LPV endorsed), to ensure the compatibility with the MODIS validation datasets.

2) **Contacts with ESA regarding Sentinel 3 active fire product**

The Infrared instrument onboard the Sentinel 3 platform will have a dedicated fire channel. From a theoretical point of view, Sentinel 3 is suitable for the production of an active fire product with characteristics similar to MODIS and VIIRS. This would be a major improvement over the current ATSR/AATSR ESA fire product where, due to the limitations of the instrument, only nighttime observations are used (see table 1).

Table 1. Comparison of SLSTR performance with respect to previous AATSR and ATSR-1/2 instrument missions.

		SLSTR	AATSR & ATSR1-2
Swaths	Nadir view	1400 km	500 km
	Dual view	740 km	500 km
Global coverage revisit time	1 S/C (dual view)	1.9 days	7–14 days
	2 S/C (dual view)	0.9 days	–
	1 S/C (nadir view)	1 day	7–14 days
	2 S/C (nadir view)	0.5 days	–
SSI at SSP (km)		0.5 km VIS-SWIR 1 km IR-fire	1 km
Spectral Channels Center λ (μm)	VIS (no ATSR1):	0.555;0.659;0.865;	0.555;0.659;0.865;
	SWIR:	1.375;1.610;2.25;	1.610;
	MWIR/TIR:	3.74;10.85;12;	3.74;10.85;12;
	Fire1/2:	3.74;10.85	
Radiometric resolution	VIS(a = 0.5%):	SNR > 20	SNR > 20
	SWIR(a = 0.5%):	SNR > 20	SNR > 20
	MWIR(T = 270 K):	NeΔT < 80 mK	NeΔT < 80 mK
	TIR(T = 270 K):	NeΔT < 50 mK	NeΔT < 50 mK
	Fire1(< 500 K):	NeΔT < 1 K	
	Fire2(< 400 K):	NeΔT < 0.5 K	
Radiometric accuracy	VIS-SWIR:	<2% (BOL)	
	(a = 2–100%)	<5% (EOL)	<5%
	MWIR-TIR		
	(265–310 K):	<0.1 K (goal)	<0.1 K
	Fire(<500 K):	<3 K	
Life time (in orbit)		7.5 years	AATSR 5 years design, operative since 2002; ATSR2 3 years design, operating from 1995 to 2008; ATSR1 3 years design, operating from 1991 to 2000.

SSI is the spatial sampling interval at sub-satellite point (SSP), λ is central wavelength, a is top of atmosphere albedo, T is top of atmosphere brightness temperature, SNR is signal-to-noise ratio, and NEΔT is noise equivalent difference temperature.

(From Coppo et al, 2010, SLSTR: a high accuracy dual scan temperature radiometer for sea and land surface monitoring from space, Journal of Modern Optics, DOI: 10.1080/09500340.2010.503010)

Fire is not currently included in the list of geophysical products that will be operationally generated by Sentinel 3 and distributed in partnership with EUMETSAT. Considering the presence of the SLSTR instrument, the MODIS team is highlighting the need for a Sentinel 3 active fire product.