Terra AM Observations and Product continuity

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Terra and Aqua Towards End of Life

- Terra launched Dec. 1999, Aqua launched May 2002.
- The combined use of Terra (10.30 am) and Aqua (1.30 pm) MODIS data has been applied to a number of important land surface products (GCOS Essential Climate Variable) e.g., fire, albedo, LAI/FPAR, DSR/PAR, land surface temperature, snow and ice.
- Give climate change – a continuing global climate data record is high desirable
- Following its final inclination maneuver in March 2020, Terra is currently drifting. In September 2022, the Terra-MODIS orbital overpass will reach its lower limit (10.15am), and will exit the 705 km AM constellation (Phase F). If kept on Terra would reach a 9.00am overpass in 2026.
- For Land science, Aqua PM observation continuity assured through VIIRS (S-NPP (2011), NOAA 20 (2017), NOAA 21 (Sept 2022)……..
- For AM there are no US observations to provide continuity with Terra.

Options for Developing AM Continuity

1. Sentinel 3 OLCI/SLSTR

- (i) The Ocean and Land Colour Instrument (OLCI), provides 300m data with 21 bands in the VIS-NIR spectrum, and (ii) the Sea and Land Surface Temperature Radiometer (SLSTR), which has 11 bands at 500m (VIS, SWIR) and 1km mid-long wave IR, and includes bands designed for fire detection and characterization and Land Surface Temperature (LST) generation. (Neither carry a DNB)
- Sentinel 3a (launched 2016) and 3b (launched 2018) have a 10am overpass.
- The follow-on Sentinels 3c and 3d are due for launch in 2023 and 2025, respectively, with planned observation through 2031.
- NASA GSFC receives the S3 data feed from ESA.
- ESA Synergy Surface Reflectance algorithm under-performs compared to MODIS SR (Vermote et al.)

ESA Product Performance – Does not meet suggested specification

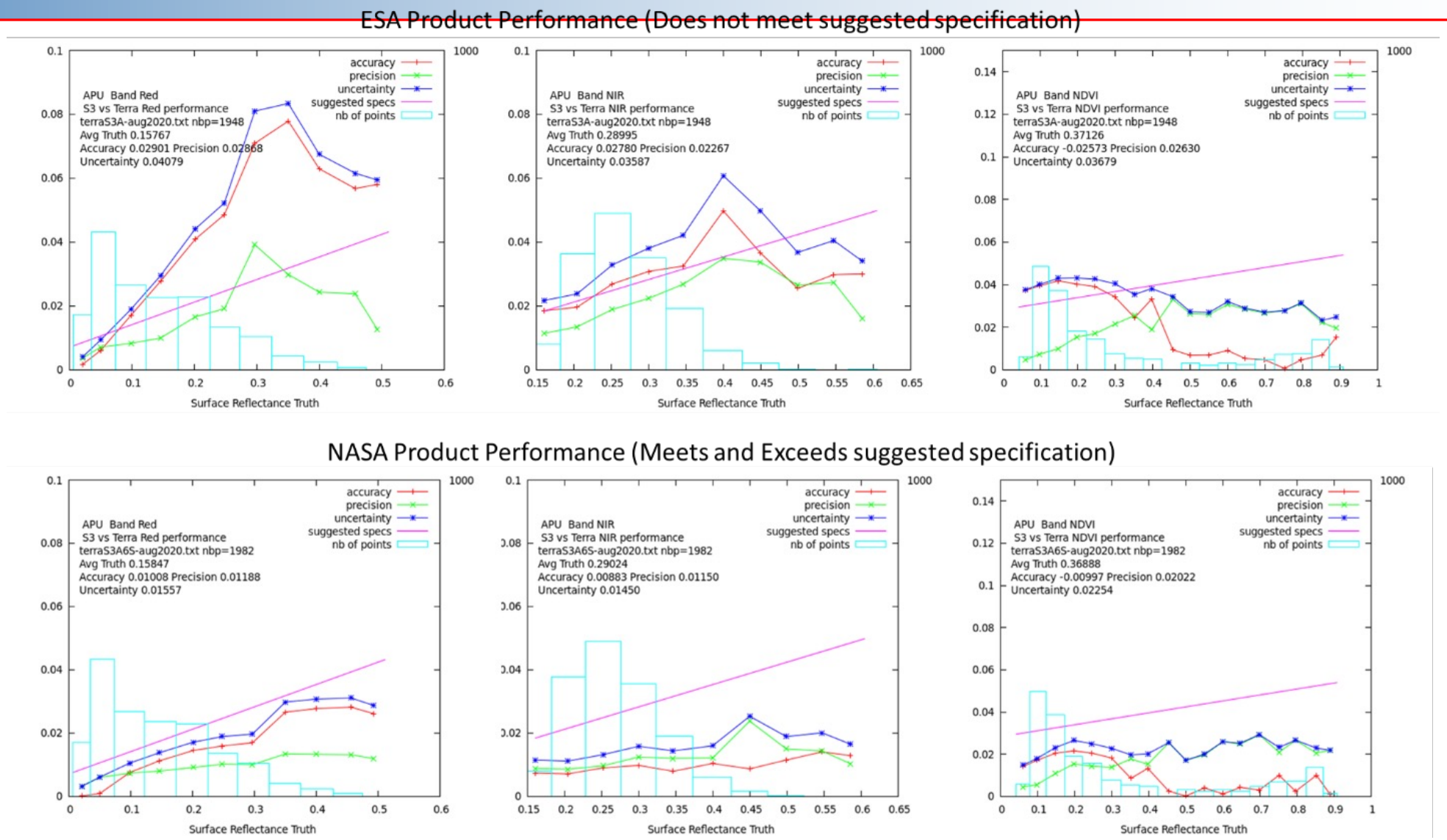

Figure 1: Accuracy, Precision, and Uncertainty metrics comparing the performance of Sentinel 3 Surface Reflectance against Terra-AM MODIS Surface Reflectance using (top) ESA- algorithm and (bottom) NASA-algorithm for August 2020 (Vermote et al.).

Options for Developing AM Continuity

2. MetOp-SG/METImage

- MetOp-C (AVHRR/3) will be replaced in late 2023 by the second generation MetOp (MetOp-SG), which will include METimage, a VIIRS-like instrument, initially conceptualized as the Visible Infrared Imager (VII).
- METimage has 20 bands at 500m spatial resolution with a swath width of +/- 54 degrees (c. 2,670km).
- The MetOp-SG series is planned for operation from 2024-2031 with a 9:30am overpass.
- Note that METimage: i) will not include the VIIRS Day/Night Band, ii) does not include the VIIRS (412nm) blue band used for atmospheric correction, iii) has a lower saturation than VIIRS for the 3740 nm band which will impact fire detection, iv) does not aggregate pixels across the scan like VIIRS.

Comparison of VIIRS, MODIS, METimage, Sentinel 3 SLSTR, OLCI,VIIRS, and AVHRR/3 bands

VIIRS			MODIS			METimage MetOp - SG			Sentinel 3 SLSTR			Sentinel 3 OLCI			AVHRR-3		
Band DNB	ntral Range .500 - 0.900	dir HSR	MODIS Band	Range	HSR	Band NO DNB	Spectral Range	HSR (m)	Band	Range	HSR	Band	Range	HSR	Band	Range	HSR
M1	.402 - 0.42	750	8	0.405 - 0.420	1000								412.5 (10nm)	300m			
M2	.436 - 0.45	750	9	0.438 - 0.448	1000	1 (VII 4)	443 (30nm)	500					442.5 (10nm)	300m			
M3	.478 - 0.49	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000	2 (VII 4)							490 (10nm)	300m			
M4	.545 - 0.58	750	4 or 12	0.545 - 0.565 0.546 - 0.556	500 1000	3 (VII 4)	555 (20nm)	500		0.555 (20nm)	500m		510 (10nm),560 (10nm	300m			
I1	.600 - 0.68	375	1	0.620 - 0.670	250	4 (VII 4)							620 (10nm)	300m	1	0.572 - 0.703	1100
M5	.662 - 0.68	750	13 or 14	0.662 - 0.672 0.673 - 0.683	1000 1000	5 (VII 4)	670 (20nm)	500		0.669 (20nm)	500m		665 (10nm),673, 68	300m	1	0.572 - 0.703	1100
						6 (VII 4)	752 (10nm)	500					708,753,761,764	300m			
M6	.739 - 0.75	750	15	0.743 - 0.753	1000	7 (VII 4)	763 (10nm)	500					767, 778	300m			
I2	.846 - 0.88	375	2	0.841 - 0.876	250	8 (VII 4)	865 (20nm)	500							2	0.720 - 1.000	1100
M7	.846 - 0.88	750	16 or 2	0.862 - 0.877 0.841 - 0.876	1000 250	9 (VII 4)				0.865 (20nm)	500m		865 (20nm)	300m	2	0.720 - 1.000	1100
						10 (VII 4)	914 (20nm)	500					885,900,940 (10nm)	300m			
M8	.230 - 1.25	750	5	SAME	500	11 (VII 4)	1240 (20 nm)	500					1020 (40nm)	300m			
M9	.371 - 1.38	750	26	1.360 - 1.390	1000	12 (VII 4)	1375 (40 nm)	500		1.375 (15nm)	500m						
I3	.580 - 1.64	375	6	1.628 - 1.652	500	13 (VII 4)	1630 (20 nm)	500		1.61 (60nm)	500m						
M10	.580 - 1.64	750	6	1.628 - 1.652	500	14 (VII 4)									3a	SAME	1100
M11	.225 - 2.27	750	7	2.105 - 2.155	500	15 (VII 4)	2250 (50 nm)	500		2.25 (50nm)	1000						
I4	.550 - 3.93	375	20	3.660 - 3.840	1000	16 (VII 4)	3740 (180nm)	500							3b	SAME	1100
M12	.660 - 3.84	750	20	SAME	1000	17 (VII 4)				3.74 (380nm)	1000				3b	3.550 - 3.930	1100
M13	.973 - 4.12	750	21 or 22	3.929 - 3.989 3.929 - 3.989	1000 1000	18 (VII 4)	3959 (60 nm)	500		3.74 Fire(380nm)	1000						
						19 (VII 4)	4040 (60 nm)	500									
						20 (VII 4)	6725 (370nm)	500									
						21 (VII 4)	7325 (290nm)	500									
M14	.400 - 8.70	750	29	SAME	1000	22 (VII 4)	8540 (290nm)	500									
M15	.283 - 11.2	750	31	10.780 - 11.280	1000	23 (VII 4)	10690 (500 nm	500		10.85 (900nm)	1000				4	10.300 - 11.300	1100
I5	.500 - 12.4	375	31 or 32	10.780 - 11.280 11.770 - 12.270	1000 1000	24 (VII 4)				10.85Fire (900nm)	1000				4 5	10.300 - 11.300 11.500 - 12.500	1100 1100
M16	.538 - 12.4	750	32	11.770 - 12.270	1000	25 (VII 4)	12020 (500 nm	500		12.0 (1000nm)	1000				5	11.500 - 12.500	1100

Recommendation for AM Land Product Continuity
(submitted to HQ September 2021)

- Complete the preparation of Sentinel 3 'Tier-1' Land Products (e.g., Surface Reflectance, Land Surface Temperature, and Active Fires), as an interim solution to data continuity in the event that MODIS Terra data be discontinued (Start now). Adapt merged downstream products of Albedo, LAI/FPAR, Snow and Ice once the input data are established (late 2022) and evaluate the utility of Sentinel-3 to replace Terra.
- Discuss with European partners (DLR/JRC/Eumetsat) for access, download and storage of METimage L1 data (Start discussions now).
- Establish a partnership/agreement with Europe and NOAA for METimage instrument calibration and characterization using NASA MCST/VCST as appropriate.
- Designate a technical/discipline POC to the CEOS-WGCV to foster early-AM cal/val efforts, including product intercomparison and validation activities, consistent with the CEOS-WGCV.
- Evaluate if there is any advantage/value-added of generating NASA products from METimage.

A back-of-the-envelope strawman budget was developed.

Next Steps

- Switching off Terra/Aqua in June-July 2023 needs an impact evaluation by the land team.
  - Terra is particularly important as there is currently no plan for continuity – how useful would Terra data be, beyond 2023 with a drifting overpass?
  - The case for Aqua is less so for land (given VIIRS pm coverage)

  (NB. - the operation costs are surprisingly high ($70M pa))
- The Land Team will need to develop a Phase-F plan for the Terra/Aqua Products (for the final 2 years of SR funding)
  - Plans for Long Term Data Access and DAAC Archive also needed
- Increased attention is needed to VIIRS Land Data Continuity Products
- A strong case for land data AM continuity needs to be made
  - Users (particularly USG users) need to be notified and any concerns need to be voiced for example to the Science Data Needs WG.