

A surface reflectance standard product from LDCM and supporting activities

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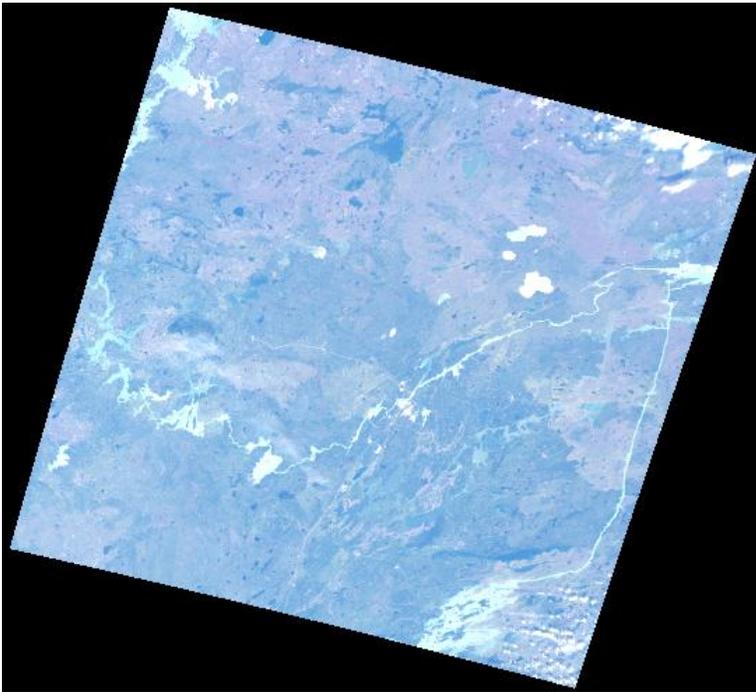
Rationale for the research activities

- A Surface Reflectance standard product developed for MODIS provides the basis for a number of higher order land products for global change and applications research
- It is possible to develop an operational robust, globally applicable and fully automated code for integration into the LDCM processing chain and the code made openly available for others to use (e.g. LDCM ground stations).
- Surface Reflectance an essential standard product from LDCM

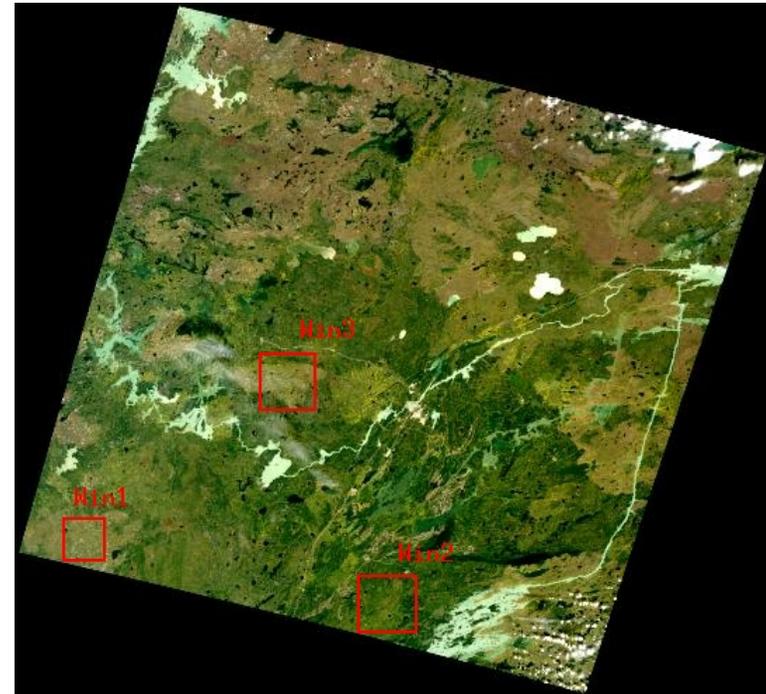
BOREAS ETM+ scene

Scene: p033r021

Date: 09/17/2001



Top-of-atmosphere TOA



Surface Reflectance

Rationale for surface reflectance

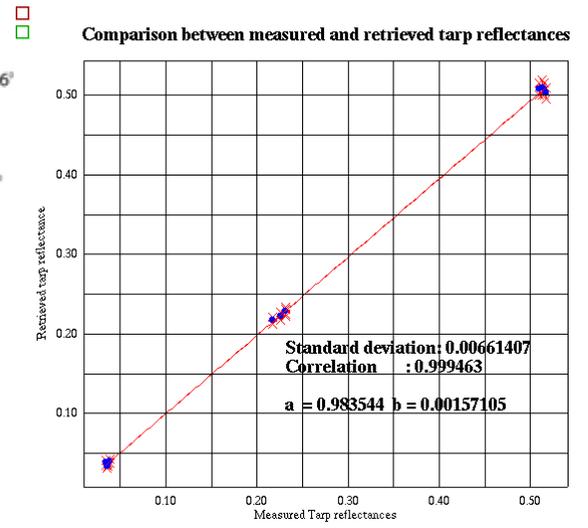
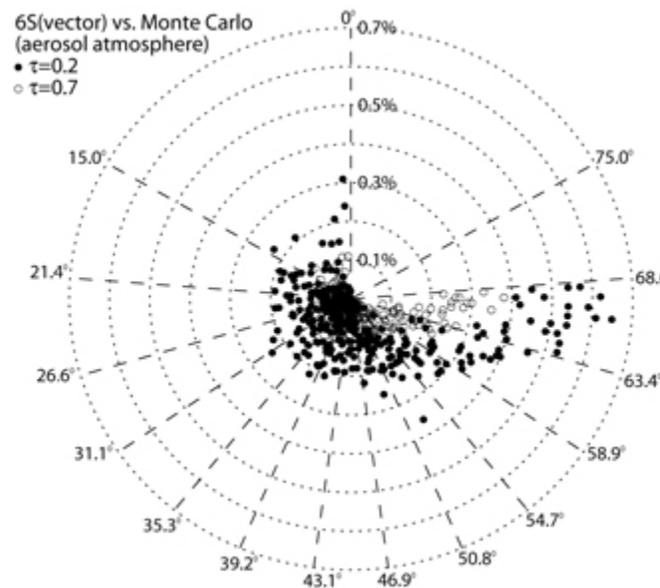
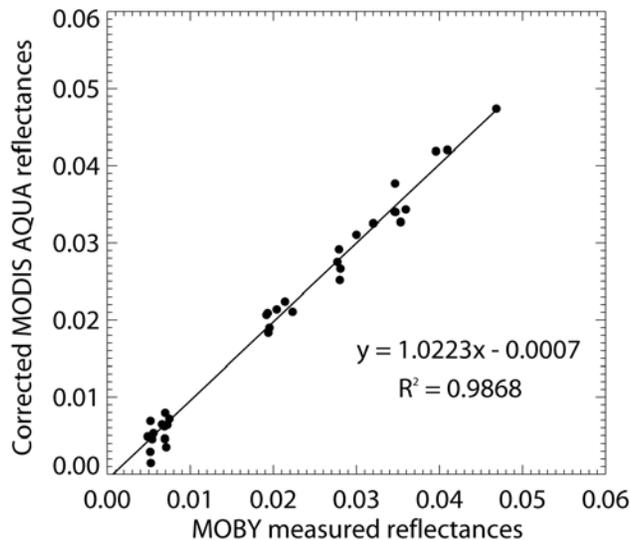
- Science moving from analysis of a few scenes to multi-temporal regional to global studies – open archive - greater need for normalization
- Atm corr first step for all those trying to use the data for science analysis
 - An automated approach > standard product is needed
- Added Rationale
 - SR input seminal to the Essential Climate Variable list (Albedo, LAI etc...)
 - Natural Path for a Climate Data Record
- Also needed is a Cloud/ Cloud Shadow Mask
 - e.g VIIRS product adopted the MODIS cloud shadow approach,

Approach for the surface reflectance product is matured and traceable

- Atmospheric correction consistent with the MODIS, AVHRR and NPP-VIIRS approach, ensuring consistent reflectance data across resolutions based on rigorous radiative transfer

<http://6s.ltdri.org>

<http://rtcodes.ltdri.org/>



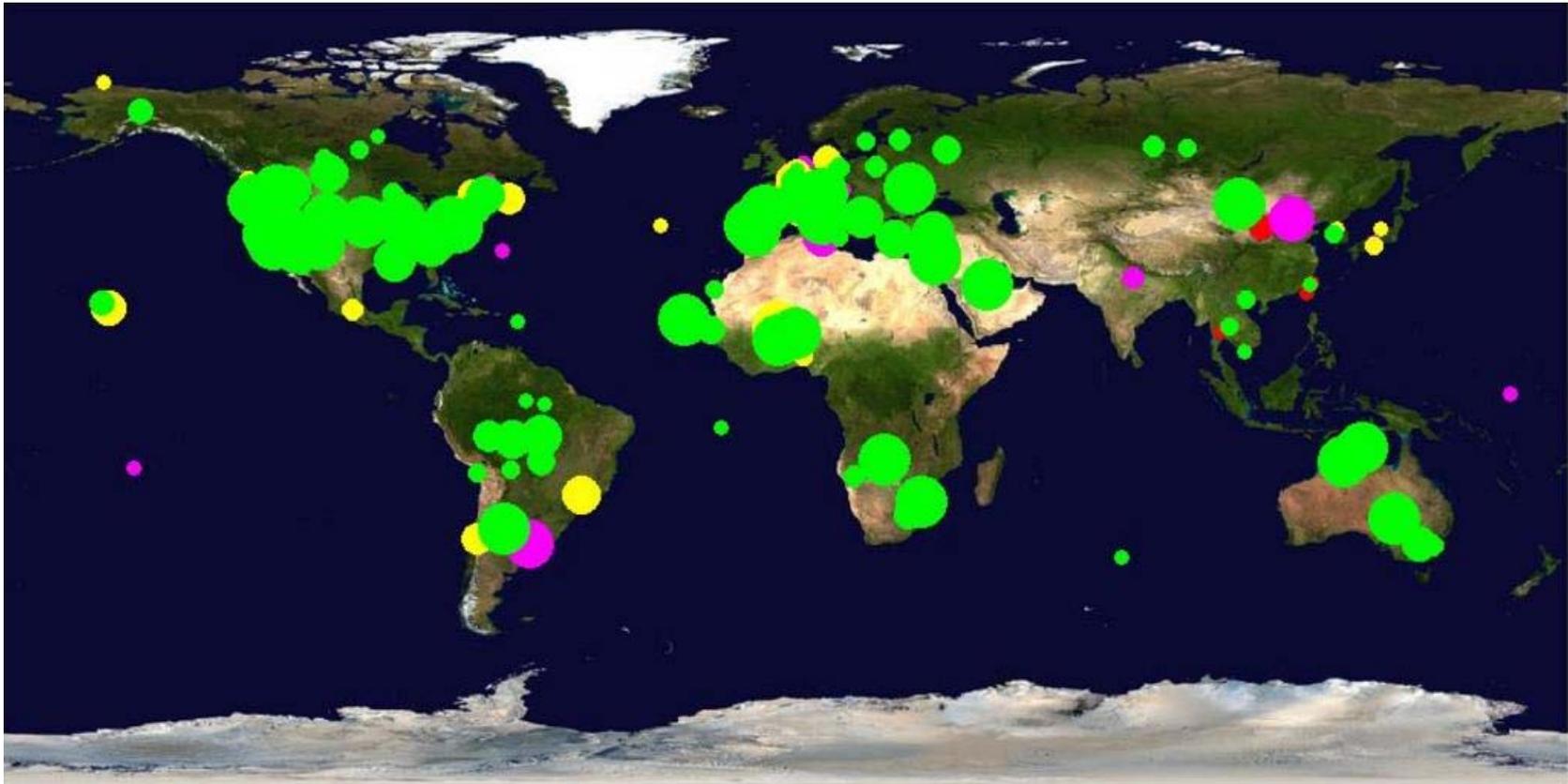
Radiative transfer based error budget

- **Validation and uncertainties estimates. Theoretical error budget, comprehensive evaluation.**

FOREST					SAVANNA					SEMI-ARID				
Belterra					Skukuza					Sevilleta				
λ [nm]	$\rho \times 10000$	Clear	Average	Hazy	λ [nm]	$\rho \times 10000$	Clear	Average	Hazy	λ [nm]	$\rho \times 10000$	Clear	Average	Hazy
		$\Delta\rho \times 10000$					$\Delta\rho \times 10000$					$\Delta\rho \times 10000$		
470	120	52	51	52	470	400	52	52	53	470	700	51	53	55
550	375	49	55	64	550	636	52	58	64	550	1246	51	70	85
645	240	52	59	65	645	800	53	62	67	645	1400	57	74	85
870	2931	40	152	246	870	2226	35	103	164	870	2324	41	95	146
1240	3083	38	110	179	1240	2880	38	97	158	1240	2929	45	93	148
1650	1591	29	52	84	1650	2483	35	66	104	1650	3085	55	81	125
2130	480	41	28	42	2130	1600	40	36	53	2130	2800	56	60	87
NDVIx1000			Δ NDVI x1000		NDVIx1000			Δ NDVI x1000		NDVIx1000			Δ NDVI x1000	
849		30	34	40	471		22	28	33	248		11	15	19

Error in ~0.5% in reflectance unit

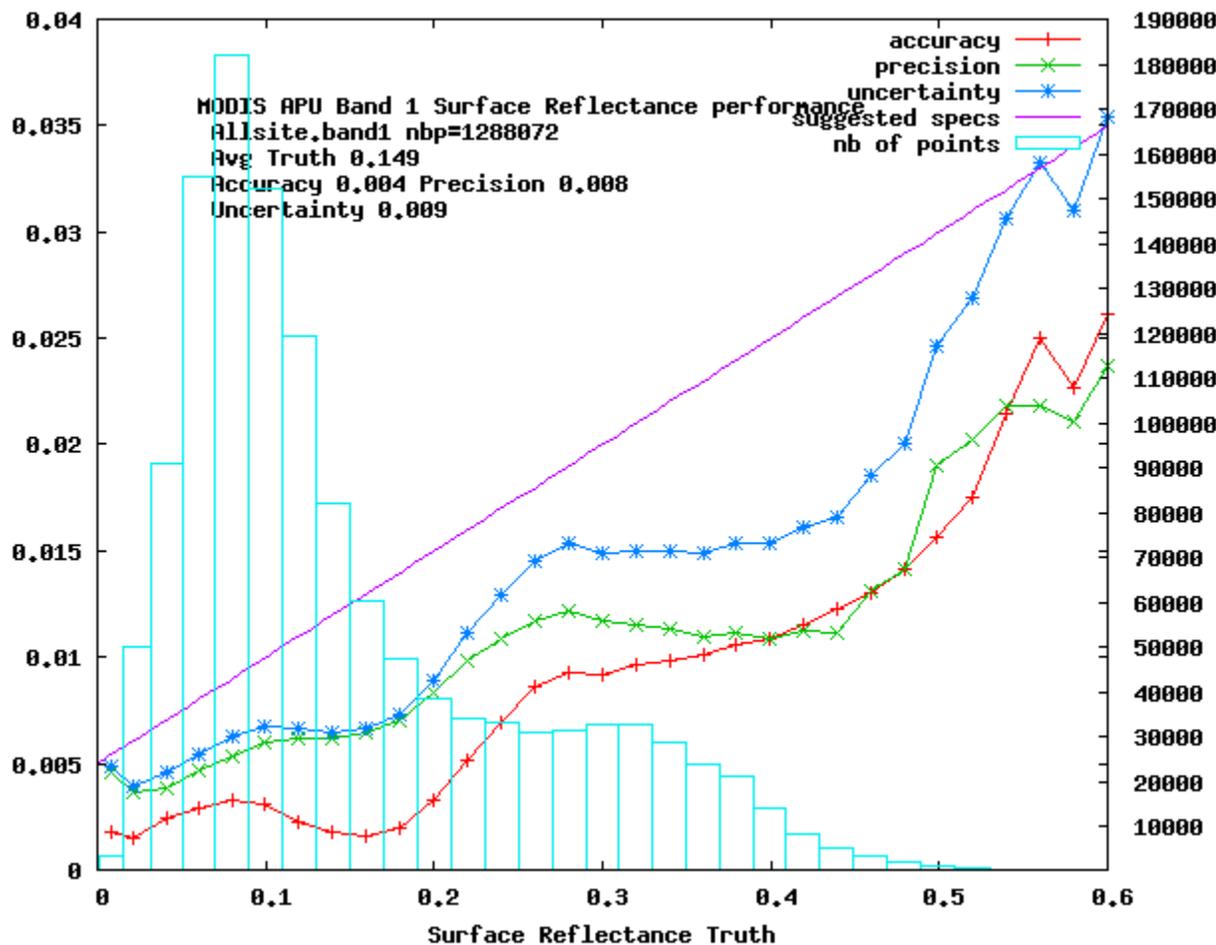
Extensive validation through use of high quality aerosol measurement



Version 2 AERONET (i.e. with Background correction and spheroid)

Toward a quantitative assessment of performances (APU)

1,3 Millions 1 km pixels were analyzed for each band.



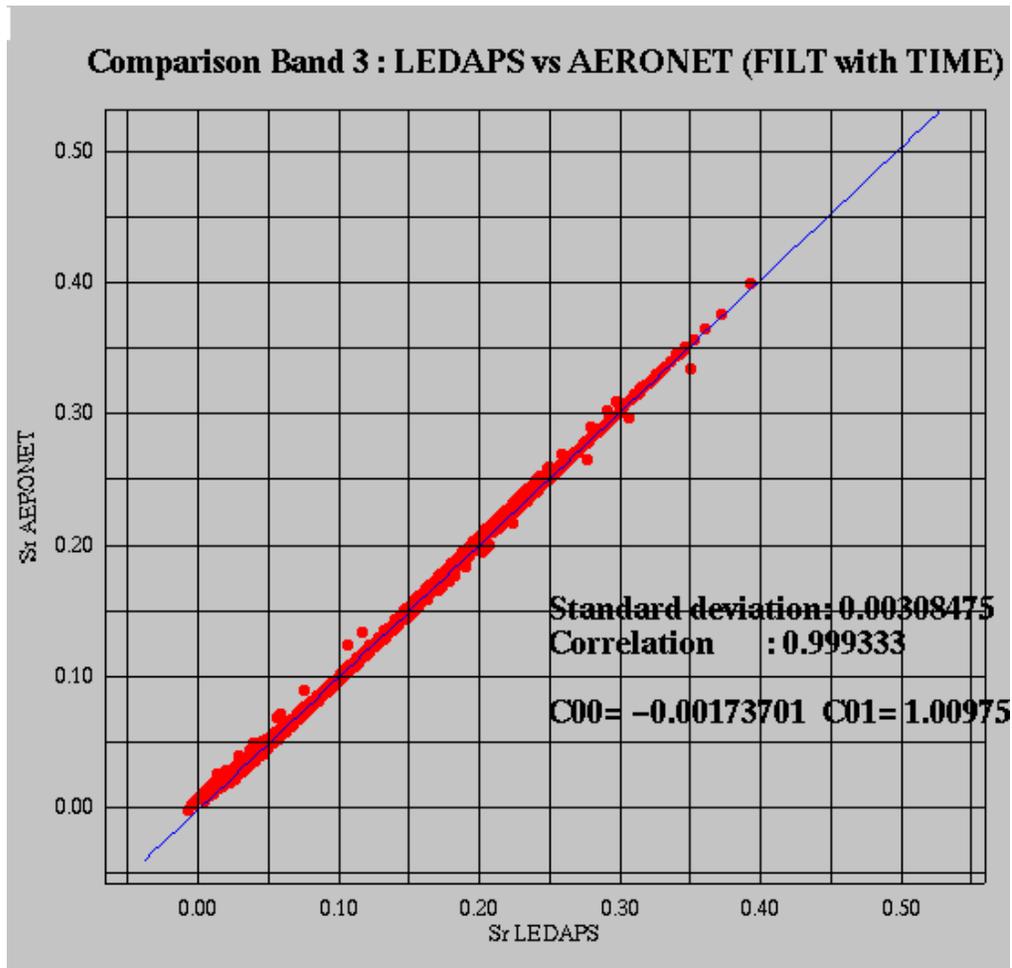
Red = Accuracy (mean bias)
Green = Precision (repeatability)
Blue = Uncertainty (quadratic sum of A and P)

On average well below magenta theoretical error bar

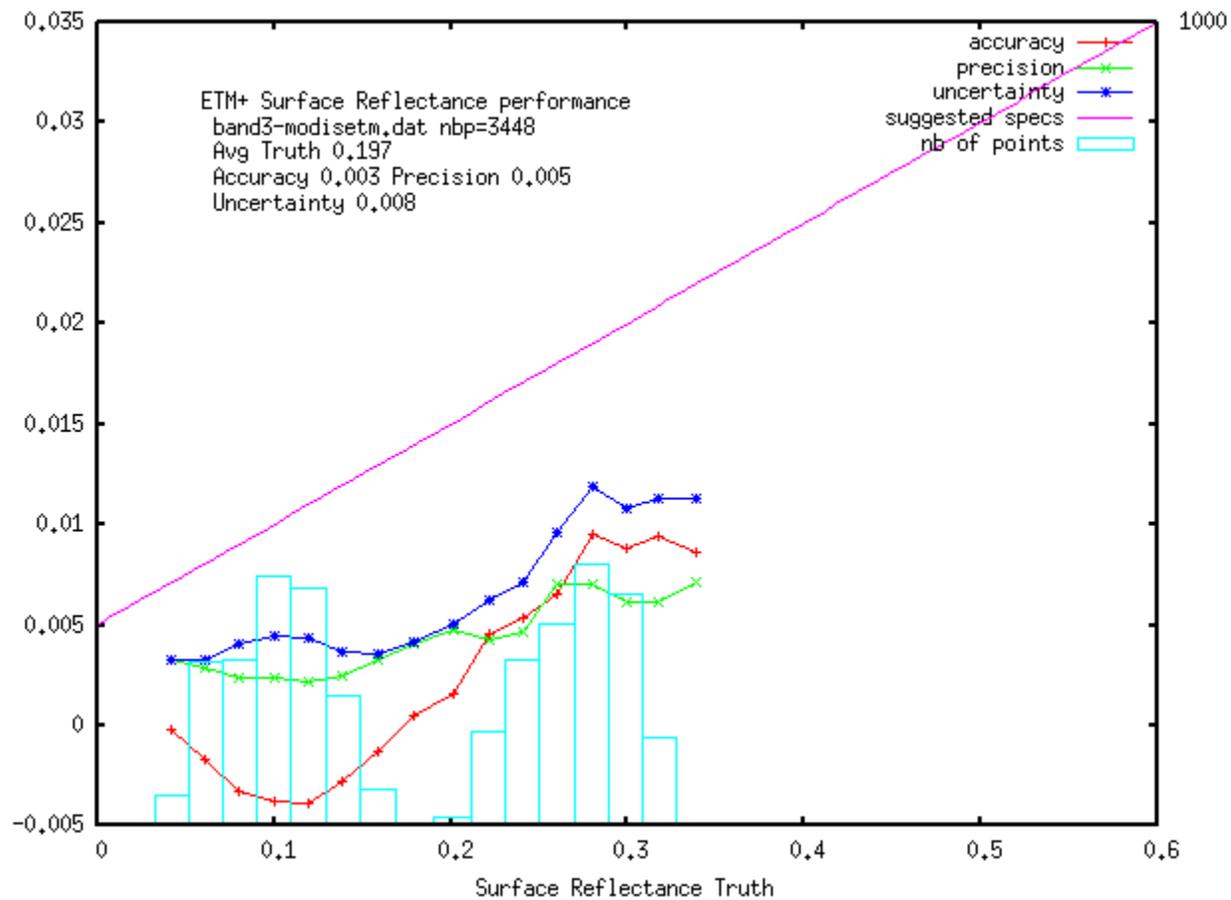
Using MODIS data and lessons learned

- Theoretical basis for atmospheric correction well established
- Error analysis method developed
- Validation methodology – Aeronet
- Dataset inter comparison – MODIS / Landsat
- Much of the MODIS approach can be transferred to Landsat

EVALUATION of Landsat SR product from LEDAPS against AERONET



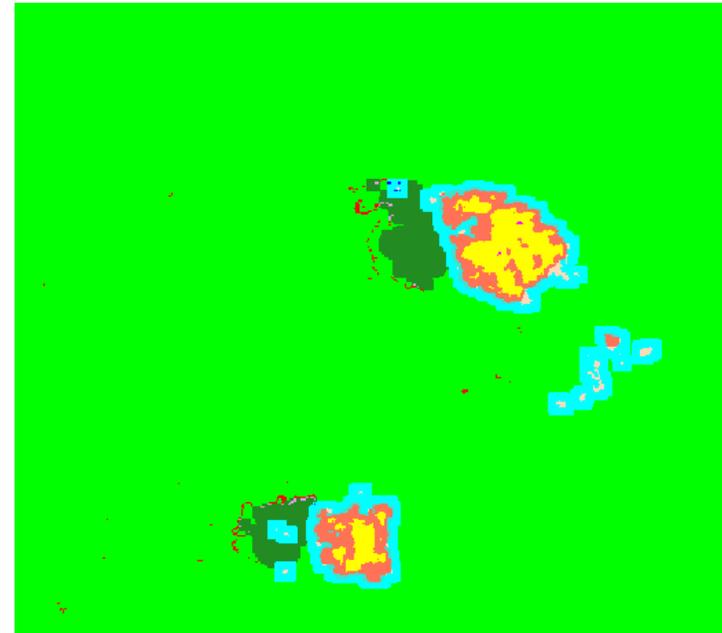
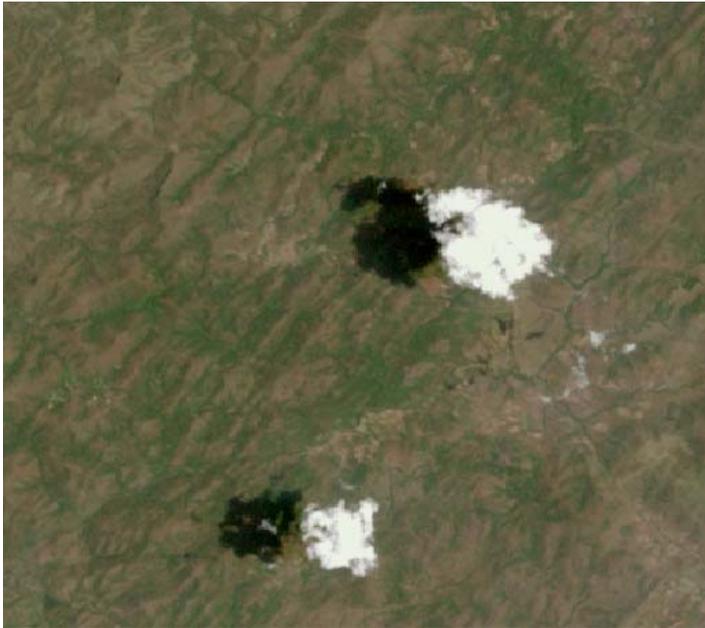
APU results: Band 3 (670nm) using MODIS as Truth



LEDAPS cloud/cloud shadow mask

- Use the surface reflectance /thermal band
 - 1) First step cloud and snow mask (visible and thermal) done prior to aerosol inversion
 - 2) Second step - Aerosol is derived and Surface reflectance product is generated
 - 3) On the corrected data for non snow pixels, clouds are derived from Red-Blue anomaly ($\text{Red-Blue}/2 > 0.03$) (Whiteness) for land pixels ($1.6\text{mic} > 0.05$), additional test ($\text{Blue} > 0.30$ and Temperature $<$ NCEP based Threshold) is performed to account for saturation in the blue
 - 4) Clear pixel temperature is used for the shadow detection algorithm based on a hybrid of geometric and spectral approach.

Details



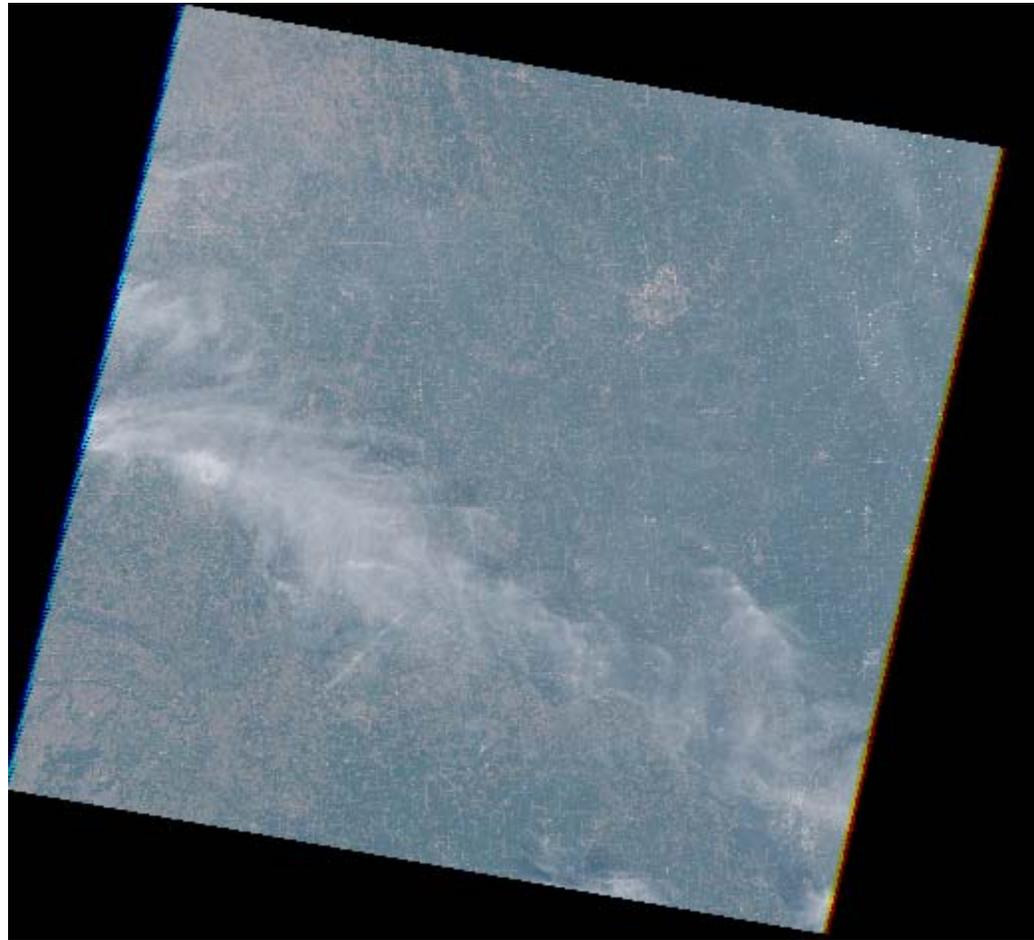
Yellow, Orange: clouds

Blue: Adjacent to cloud

Dark Green: Shadow

Light green: Clear

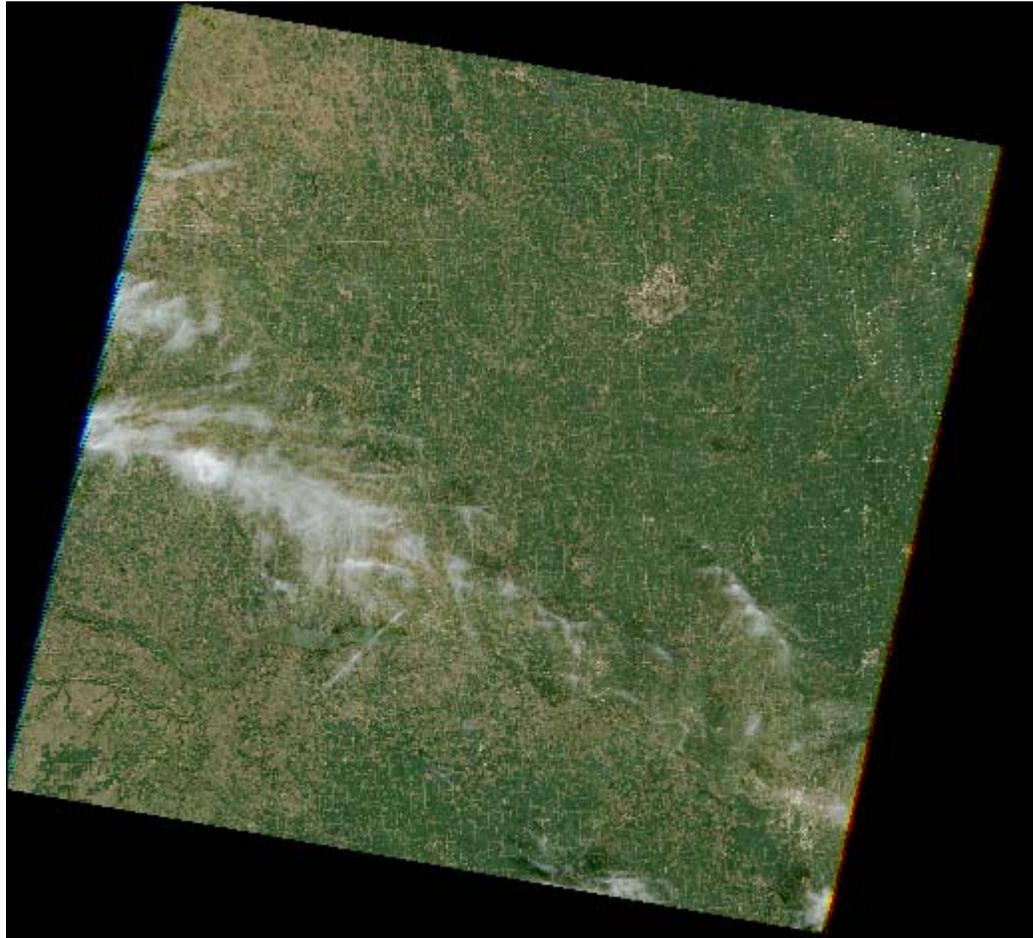
What is a cloud?



ACCA



Surface reflectance



New Cloud Mask



Surface reflectance product what is needed to make it real?

- Flexibility in improving the algorithm
 - Several versions: Standalone (LEDAPS) using MODIS (WELD)
 - Approach adopted needs to be determined as a function of maturity near - Launch
 - Room for incremental improvements post launch
 - Plans for Reprocessing ?
- Need for operational QA and Cal/Val effort
- Keep the scientist who are using the data, involved in the product QA Cal/Val and algorithm tuning -
- Evaluation of Cloud Mask
 - Real problem for MODIS – New approach for VIIRS