

A surface reflectance standard product from LDCM and supporting activities

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Message from the PI



MONDAY

Rationale for the research activities

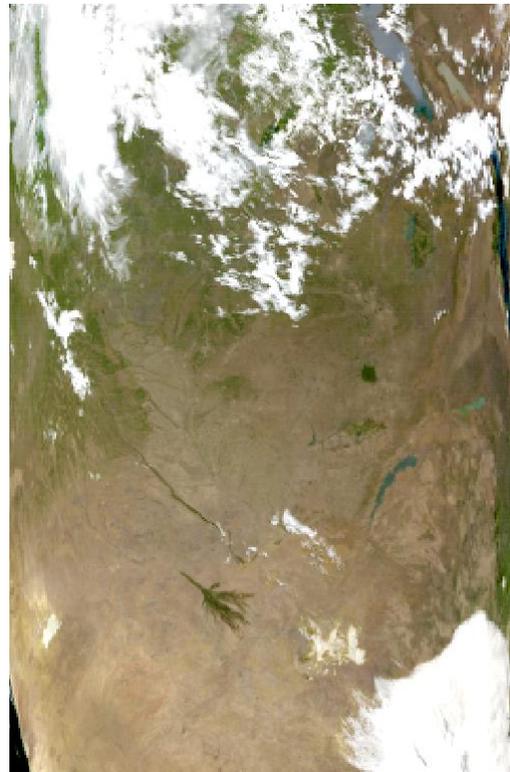
- The Surface Reflectance standard product developed for MODIS provides the basis for a number of higher order land products for global change and applications research
- A similar approach could work for LDCM
- It is possible to implement an operational robust, globally applicable and fully automated correction as part of the LDCM processing chain, with the code made openly available for others to use (e.g. LDCM ground stations).
- The algorithm has already been tested by the NASA LEDAPS project (an operational prototype).

Atmospheric effect has a strong impact on remotely sensed data

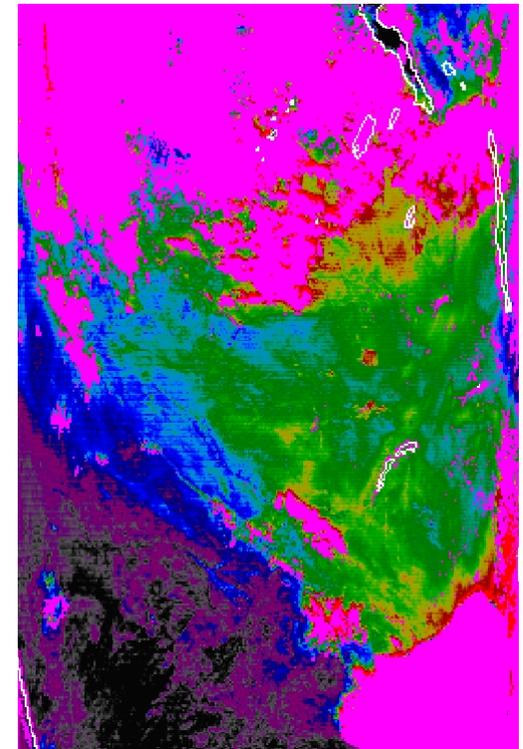
MODIS Granule over South Africa (Sept,13,2001, 8:45 to 8:50 GMT)



RGB no correction
for aerosol effect



RGB surface reflectance
(corrected for aerosol)

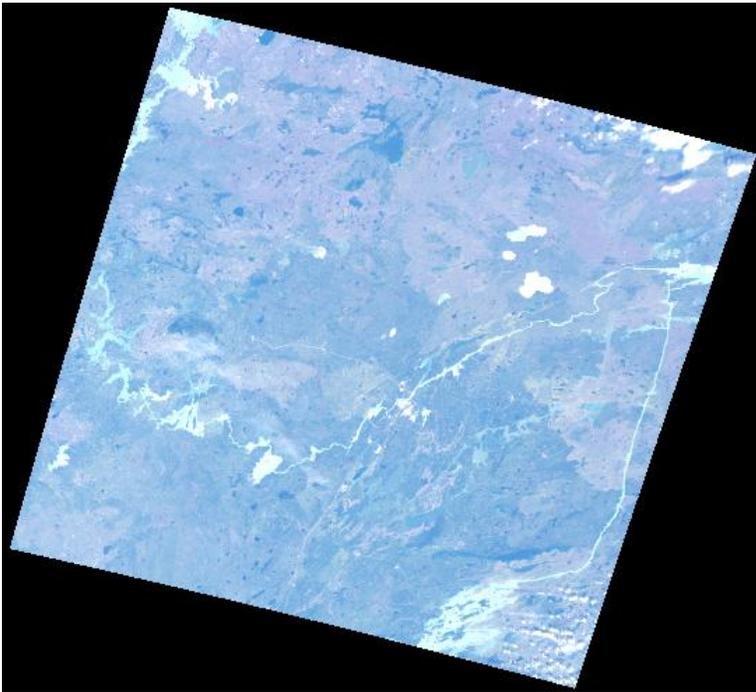


Corresponding aerosol optical
thickness at 670nm (0 black,
1.0 and above red) linear
rainbow scale. Clouds are in
magenta, water bodies are
outlined in white.

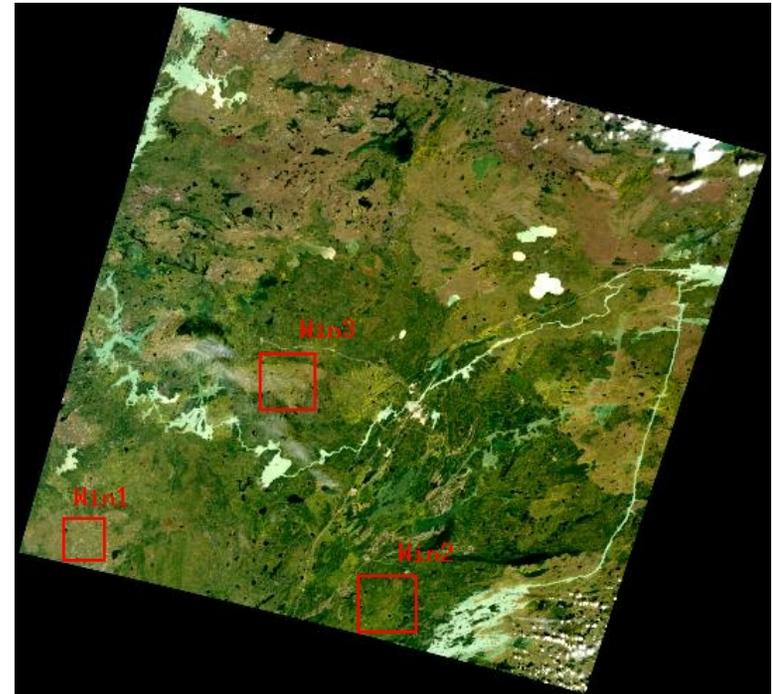
BOREAS ETM+ scene

Scene: p033r021

Date: 09/17/2001



Top-of-atmosphere TOA



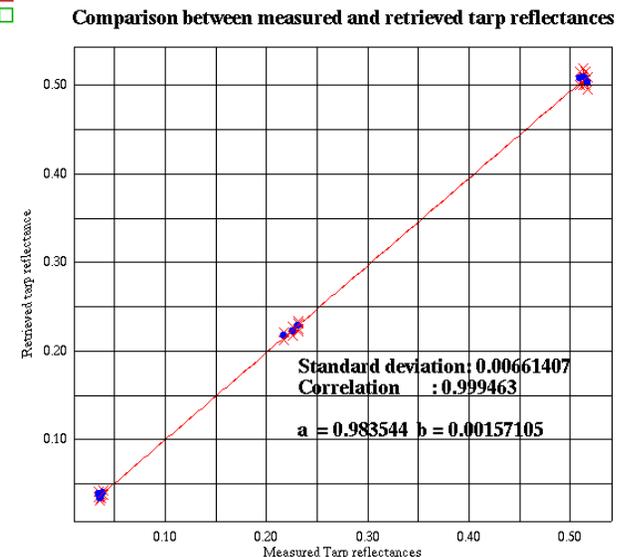
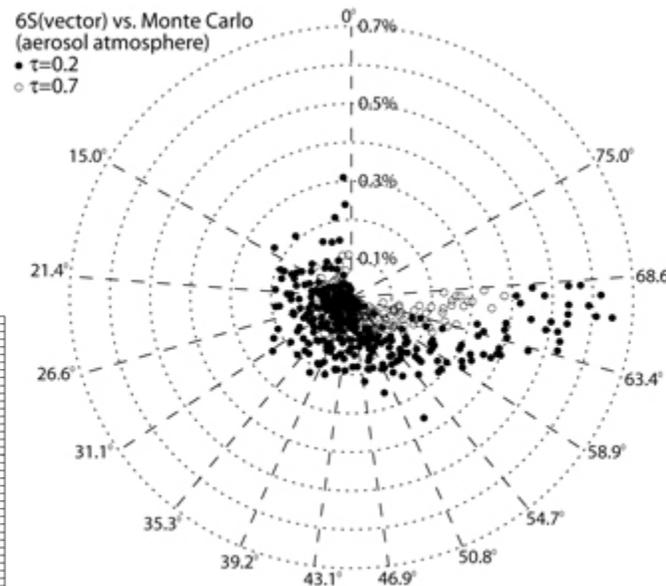
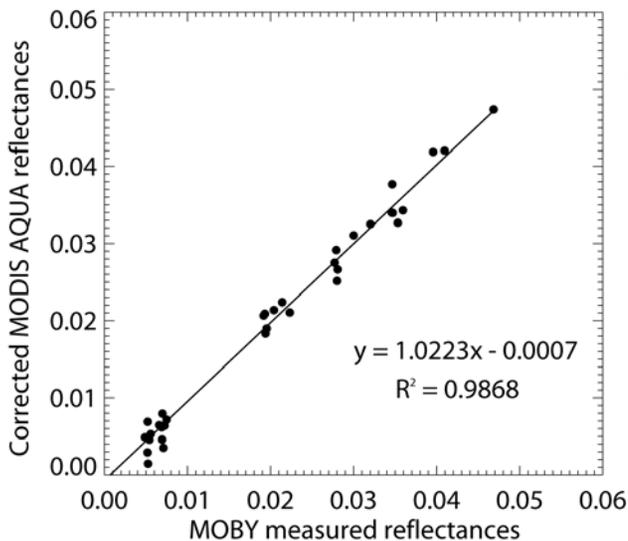
Surface Reflectance

Approach for the surface reflectance product

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

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

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



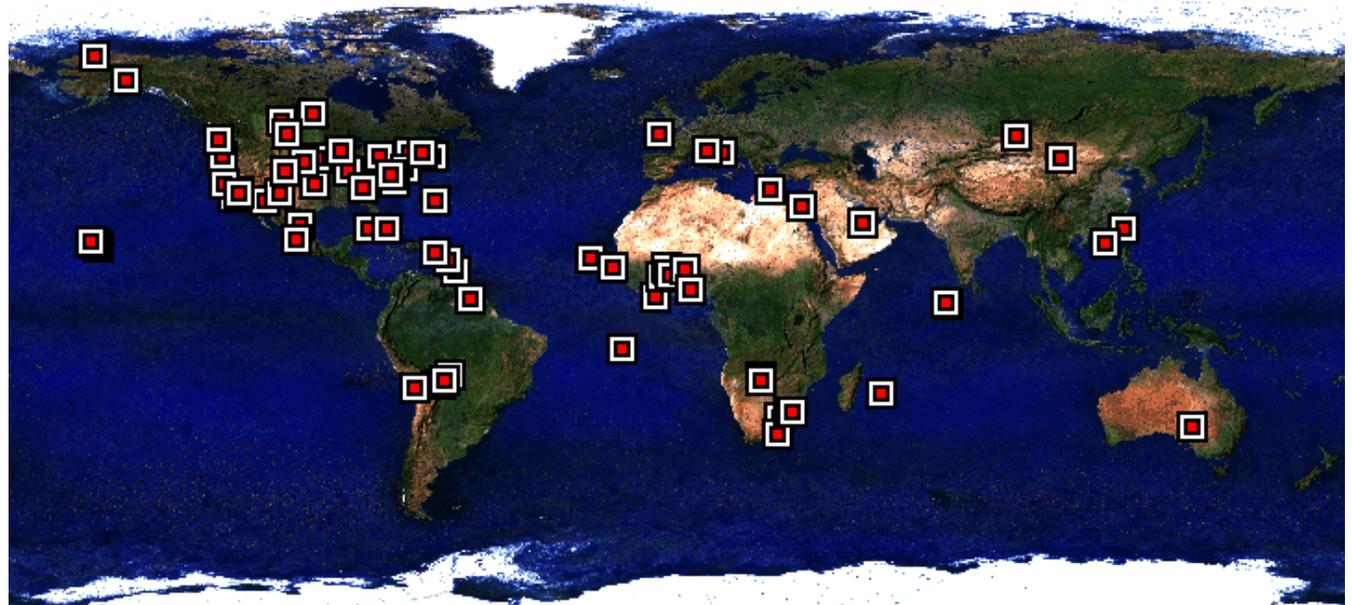
Approach for the surface reflectance product

- **Validation and uncertainty estimates. Theoretical error budget developed, 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		$\Delta\text{NDVI} \times 1000$			NDVIx1000		$\Delta\text{NDVI} \times 1000$			NDVIx1000		$\Delta\text{NDVI} \times 1000$		
849		30	34	40	471		22	28	33	248		11	15	19

Error ~0.5% in reflectance units

AERONET - An Internationally Federated Network



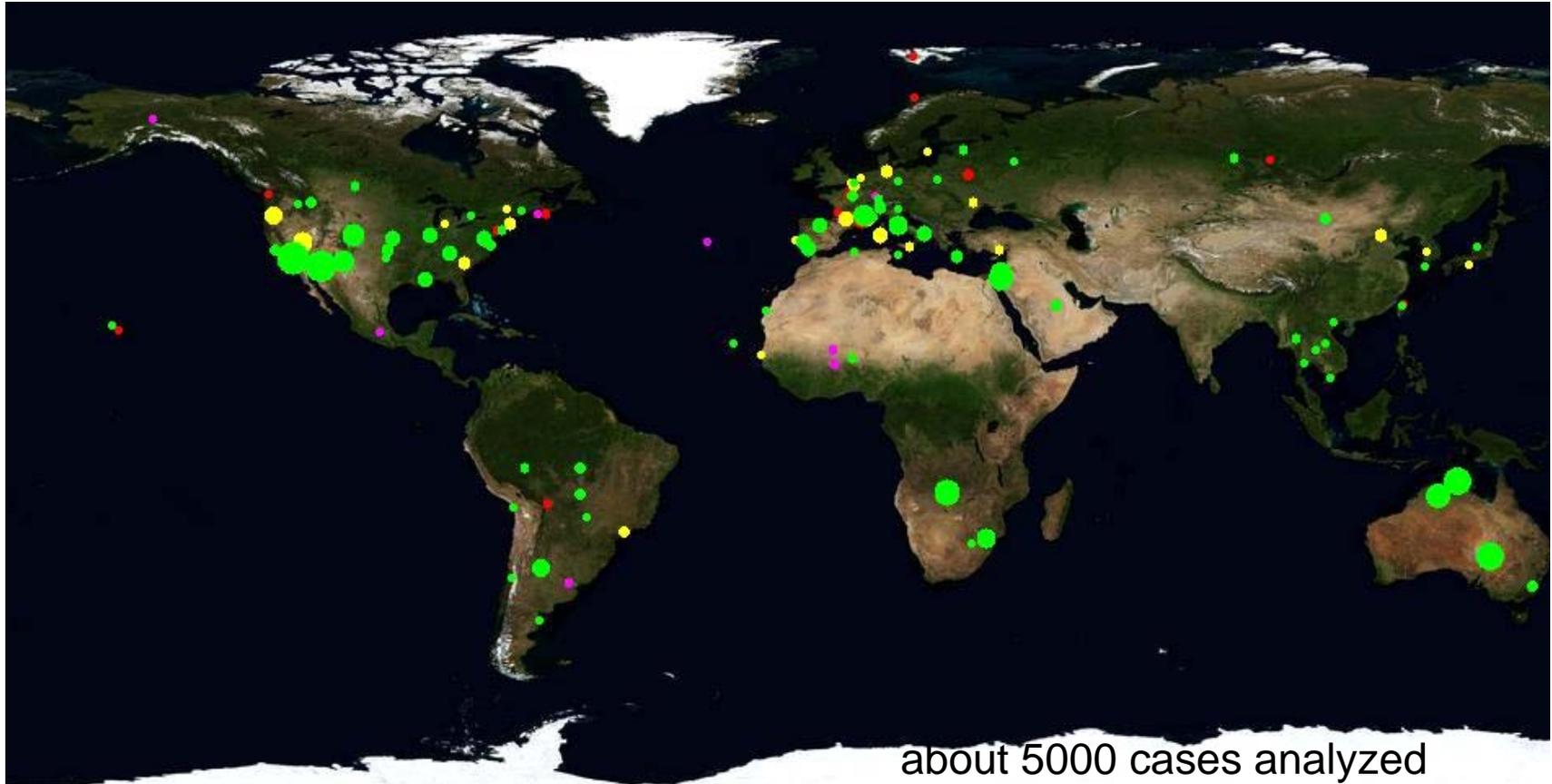
SeaWiFS composite

LDOPE / MODLAND

- Characterization of aerosol optical properties
- Validation of Satellite Aerosol Retrievals
- Near real-time acquisition; long term measurements
- Homepage access <http://aeronet.gsfc.nasa.gov:8080/>

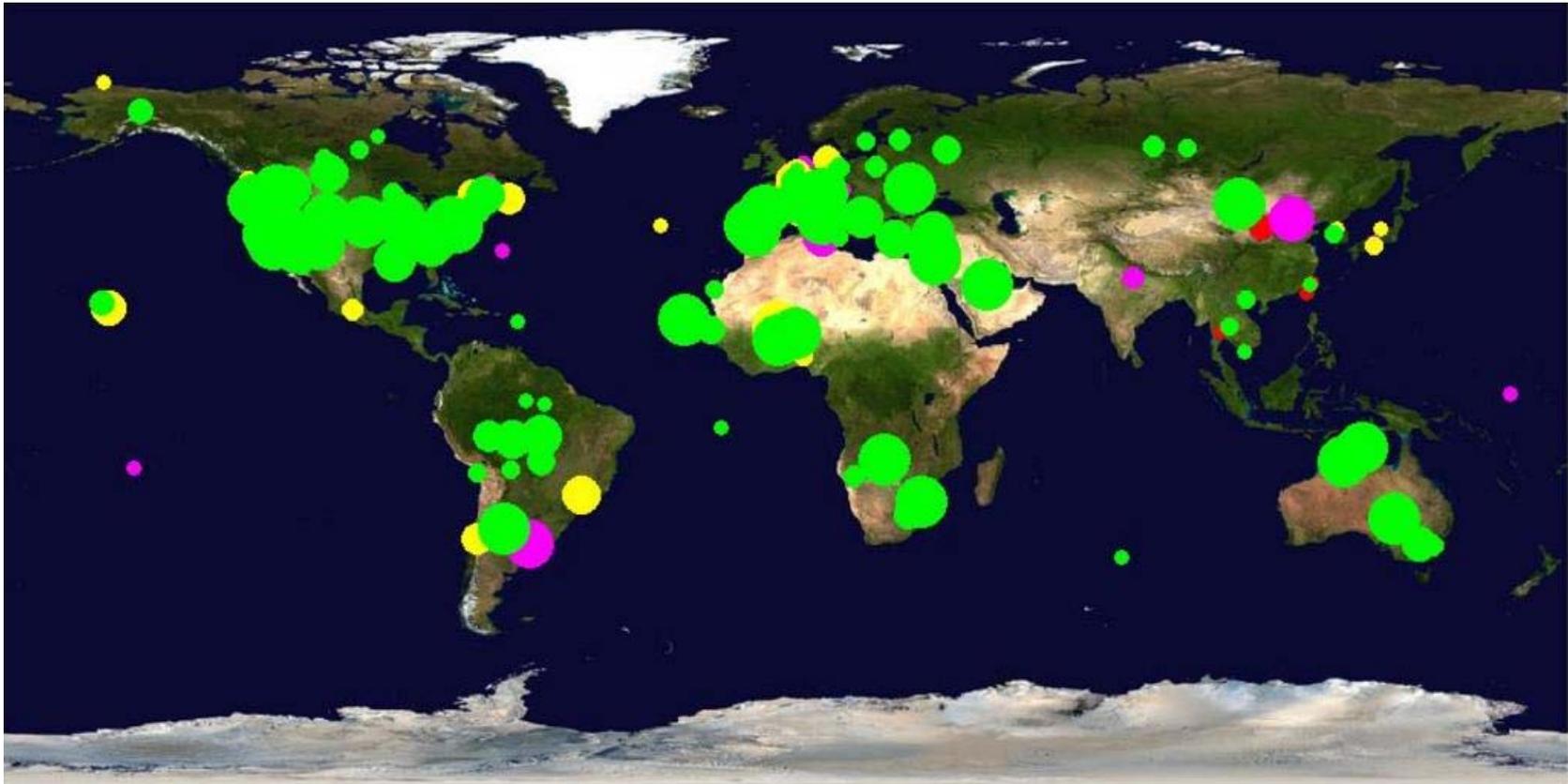
Approach for the surface reflectance product - 2003 AERONET results

Global annual comparison of MODIS band 1 (red) land surface reflectance compared with 6S parameterized with all the available AERONET sun-photometer data for 2003. The circles are centered on AERONET sites. The circle colors indicate the percentage of comparisons that fell within the theoretical MODIS one sigma error bar (green >80%, 65% < yellow < 80%; 55% < magenta < 65%, red < 55%). The circle radii are proportional to the number of observations used in the data comparisons. Globally, 86.6% of the 2003 comparisons fell within the theoretical MODIS one sigma error bar.



2000-2007 Results (25,542 cases)

88.85% of band1 data were within the error bars ($\pm 0.005 + 0.05 \text{ ro}$)



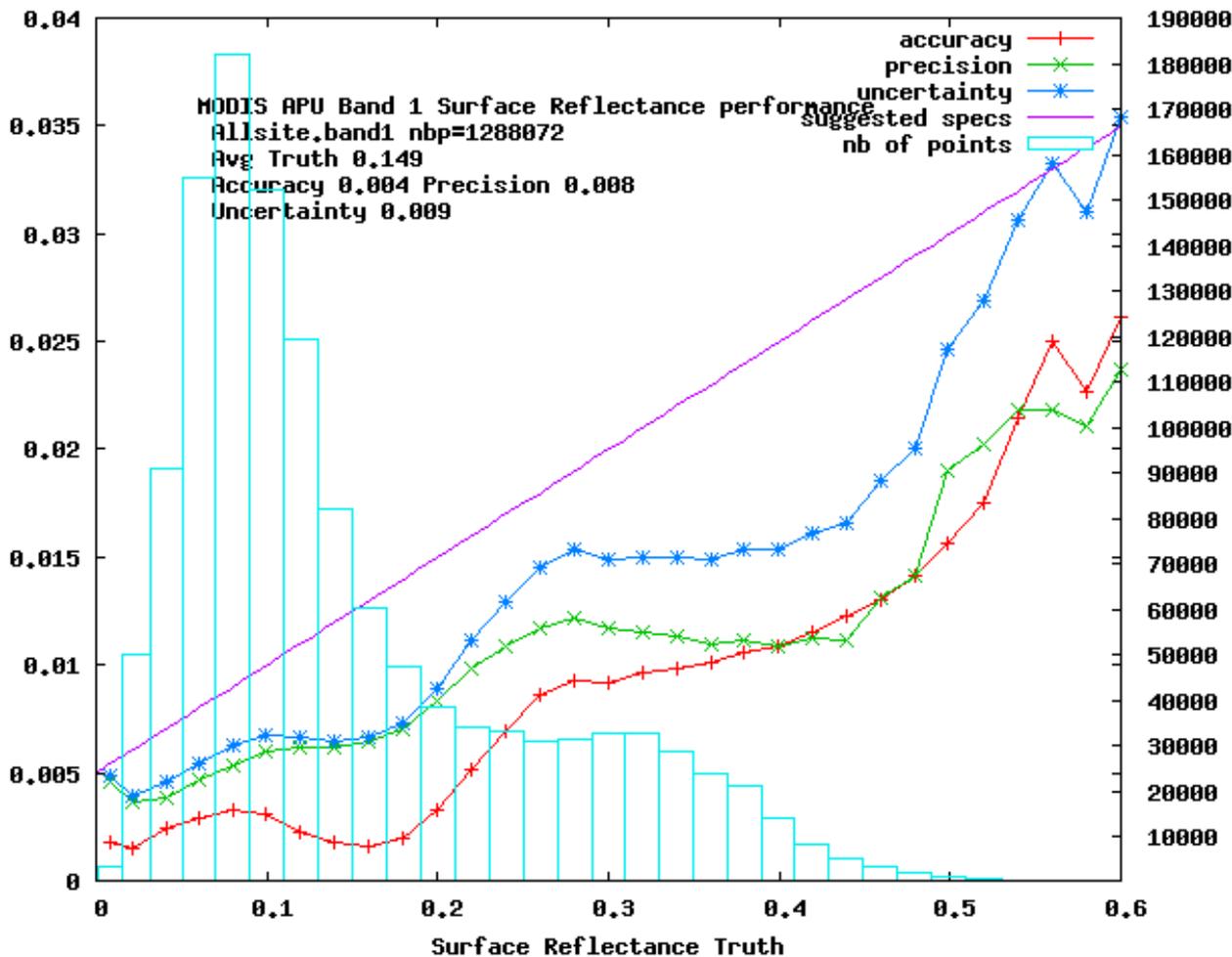
Version 2 AERONET (i.e. with background correction and spheroid)

Toward a quantitative assessment of performances (APU)

1.3 Million 1 km pixels were analyzed for each band.

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

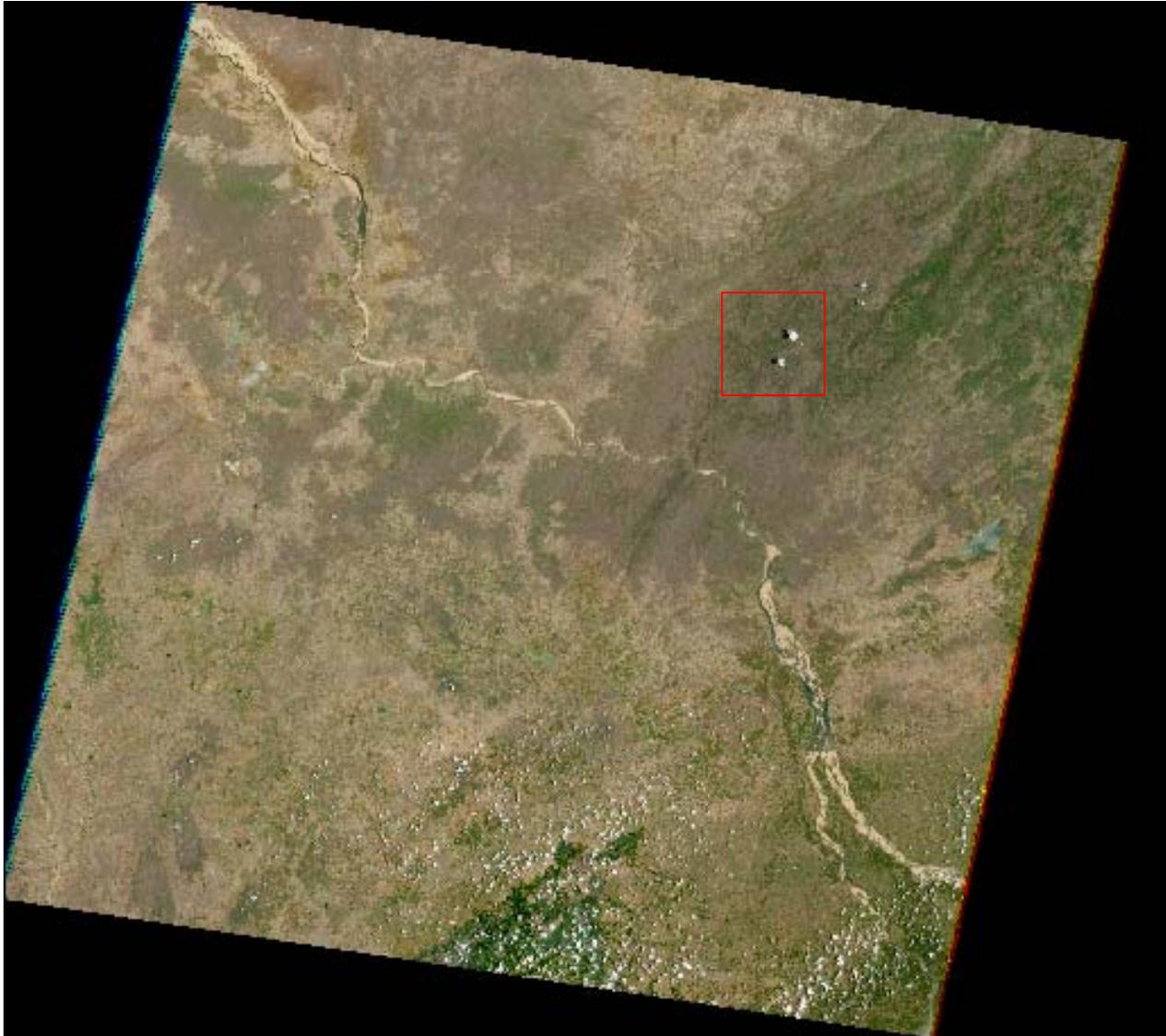
On average well below magenta theoretical error bar



Landsat cloud/cloud shadow mask

- Use the surface reflectance / thermal band (based on MODIS experience)
 - 1) First step cloud and snow mask (visible and thermal) undertaken 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 ($1.6\text{mic} > 0.05$ – water test), additional test (Blue > 0.30 and Temperature $<$ NCEP based Threshold) is performed to account for saturation in the blue.
 - 4) Clear pixel temperature (thermal band) used to compute reference air temperature used in estimate of cloud height, for the shadow mask algorithm, which is based on a hybrid geometric and spectral approach

Example of Landsat cloud/cloud shadow mask

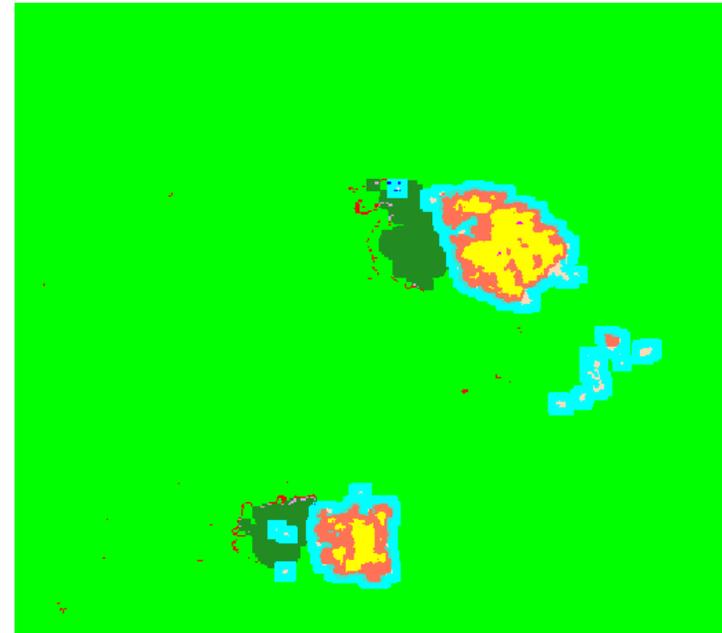
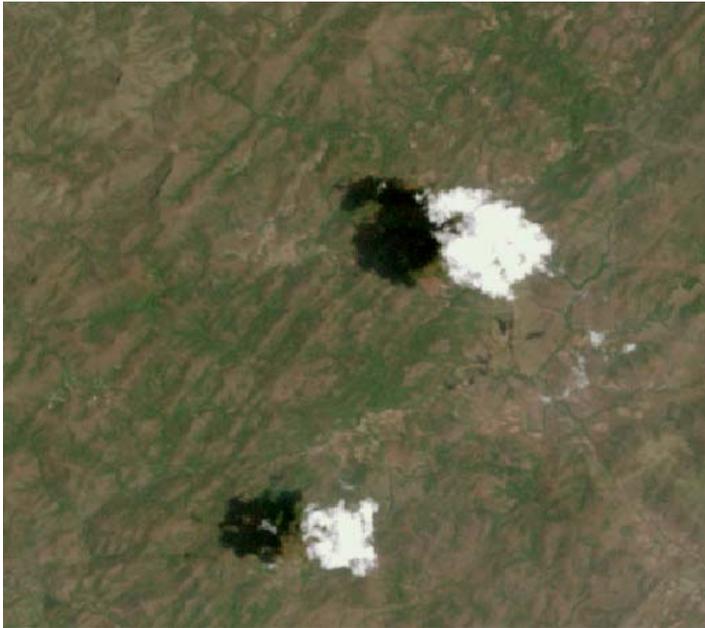


Simple Cloud Mask

Clouds are in yellow



Expanded Detail



Yellow, Orange: clouds

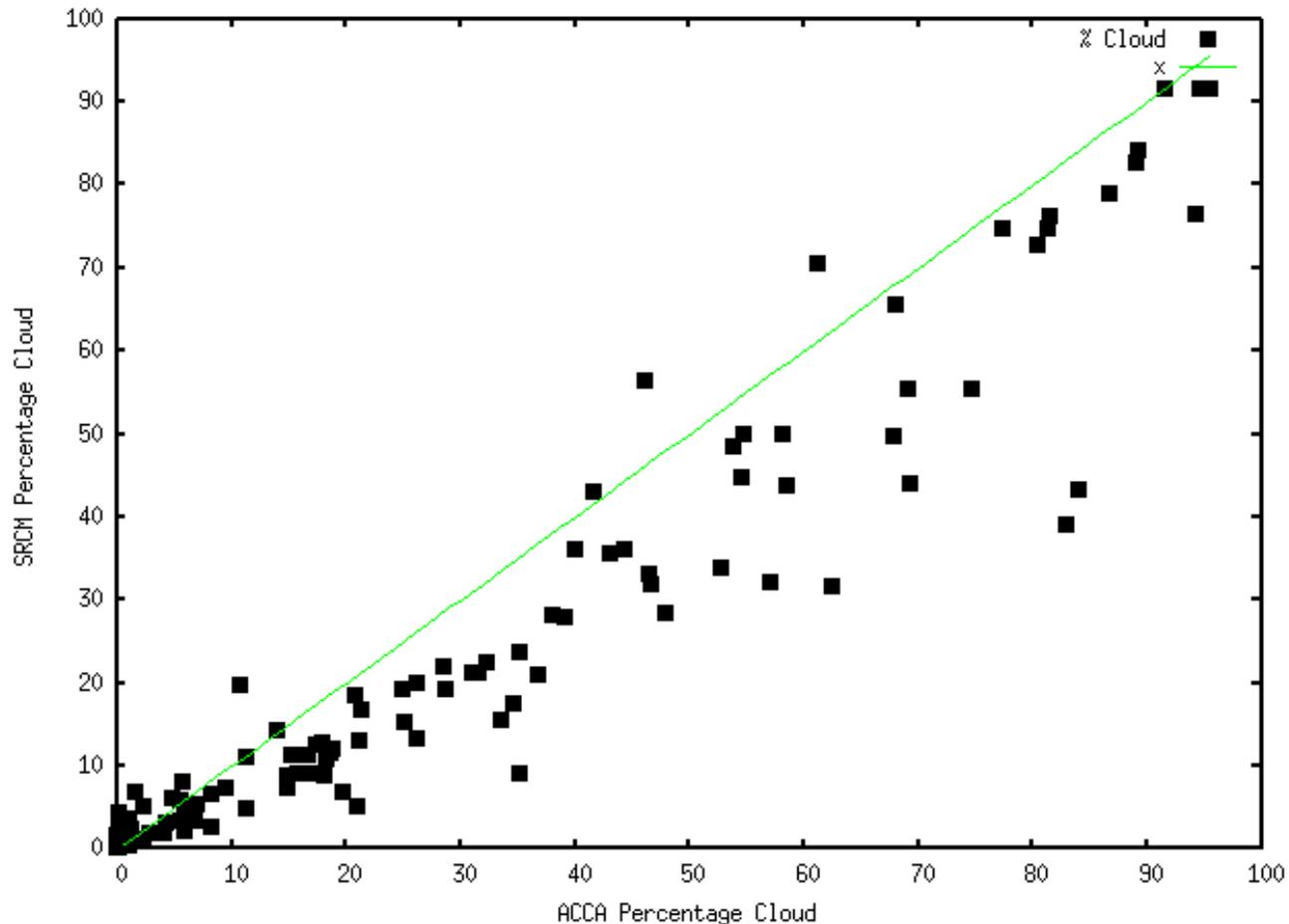
Blue: Adjacent to cloud

Dark Green: Shadow

Light green: Clear

Comparison with ACCA

- First version of simple cloud algorithm run on 2500 scenes (122 scenes, ACCA validation data set)
- Initial result shows good consistency w. ACCA showing slightly more cloud
 - Identifying those scenes with large differences for further evaluation
- Will also compare Landsat scene stats with MODIS cloud stats
- General Issue – how do you evaluate cloud mask accuracy ?



Next Steps on the Atmospheric Correction Work

- Further Evaluation of Landsat SR product
 - Continued comparison with MODIS
 - Develop APU for L7
- Evaluate early prototype OLI SR processing at EDC?
 - Initial version of SR code delivered to EDC
 - Project to develop LDCM 'operational' version, to be tested initially with L7
- Continued Refinement
 - Attention to coastal regions / water
 - Evaluate use of MODIS aerosol models for Landsat
 - Evaluate need for Adjacency Effect correction
 - Determine need for solar zenith angle correction /BRDF effects
- Further Evaluation of Simple Cloud Mask
 - Extend the comparison with ACCA and MODIS
 - Common test scenes with AT ACCA
- More work on testing shadow mask

Recommendations

- Thermal capability on LDCM would certainly enhance the cloud detection with OLI data
 - Will need to address pixel/geometry co-location of data from two instruments
- LDCM should provide a Surface Reflectance product
 - early testing of ‘operational’ code/production suggested w. proxy data
- Greater ST participation desired in evaluation of OLI instrument testing and performance results (e.g. w. attention to band to band registration, cross-talk, saturation levels, SNR etc)
 - Protected web access to data and results as needed / periodic telecons / an updated Testing Schedule
 - Instrument performance through product evaluation SR, NDVI TOC, Cloud Mask (using proxy data)
- Next ST Meeting 1 Day for Topical Working Groups
 - Suggest a cloud/shadow focus group (try to develop consensus approach for standard processing)

Update on Related Developments

- GEOSS Ag 0703 Global Agricultural Monitoring Task
 - New secretariat at ISRO (Ahmedabad)
 - Requirement for 3-5 day repeat, mid-res'n, cloud free coverage during growing season (this should influence NLIP planning beyond another Landsat)
 - Data policy workshop planned for China, Spring 08 (USGS participation will be needed)
- GOFC/GOLD and START African Regional Network Data Initiative (NASA-GOFC funding)
 - Build on the recent USGS Landsat web-enabled data initiative
 - Regional network nodes to provide data to regional scientists without internet
 - EDC requested to host visiting scientists – extraction extract data, take back data on disc, some capacity building on data management
 - Letter of request for participation sent to USGS and UNEP Grid
- Upcoming NASA LCLUC ST Meetings
 - Thailand (w. MAIRS/APN on Tropical Land Use Systems), January 09
 - Washington, March '09 – climate and land use
 - Data issues to be addressed - GLS 2005 and 2010, 1995? and Products
- SAXTA (NASA funded Landsat P2P)
 - Project completed - system developed and tested
 - System available to USGS as needed