Landsat Science Products Status Report: Surface Reflectance

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Science Products from LDCM

- Science and applications using Landsat data have been hampered by the absence of standard products.
- LDCM provides an opportunity to move moderate resolution remote sensing to a new era of product generation (as was done for MODIS).
- Standard products from LDCM can also pave the way for standardized products from other Landsat-like sensors, improving utility of EO data to a broader community (as AVHRR and MODIS did for coarse resolution data)
- A standard Surface

Basis/Rationale for the Landsat Surface Reflectance Product

- The Surface Reflectance standard product developed for MODIS provides the basis for a number of higher order MODIS land products for global change and applications research
- The fully automated and robust approach used for MODIS has been adapted for Landsat missions
- The code (LEDAPS variation) has been applied Landsat data and made available to a large community of users
- The Code could also be delivered to LDCM ground stations – in a move towards standard Landsat processing
- Improvements have been implemented (or are underway) in an optimized version of the original code (WELD, Google Earth Engine) using an aerosol model and lookup tables

Basis/Rationale for the Landsat Surface Reflectance Product

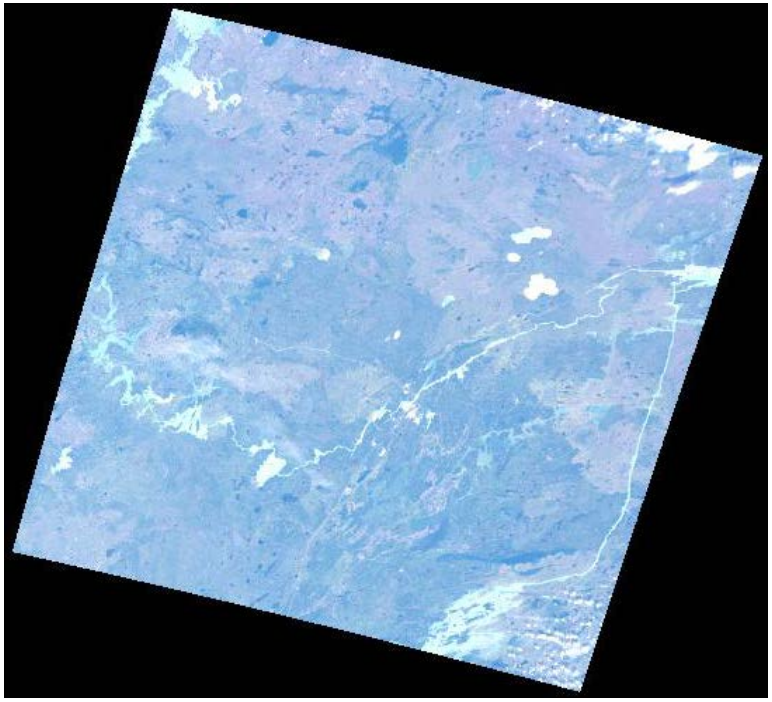
- Higher order products (LAI/FPAR, Forest Cover Change, SIAM Automatic First Stage Classification) have already been generated from SR products.
- A Validation/Evaluation plan is clearly defined and underway (using the global distribution of AERONET sites)
- Automatic Quality Assessment and accuracy verification has also been implemented (GFCC project)
- The same SR approach developed for MODIS and proposed for LDCM is also being implemented for NPP VIIRS providing continuity with MODIS and facilitating data interuse

The need for Surface Reflectance

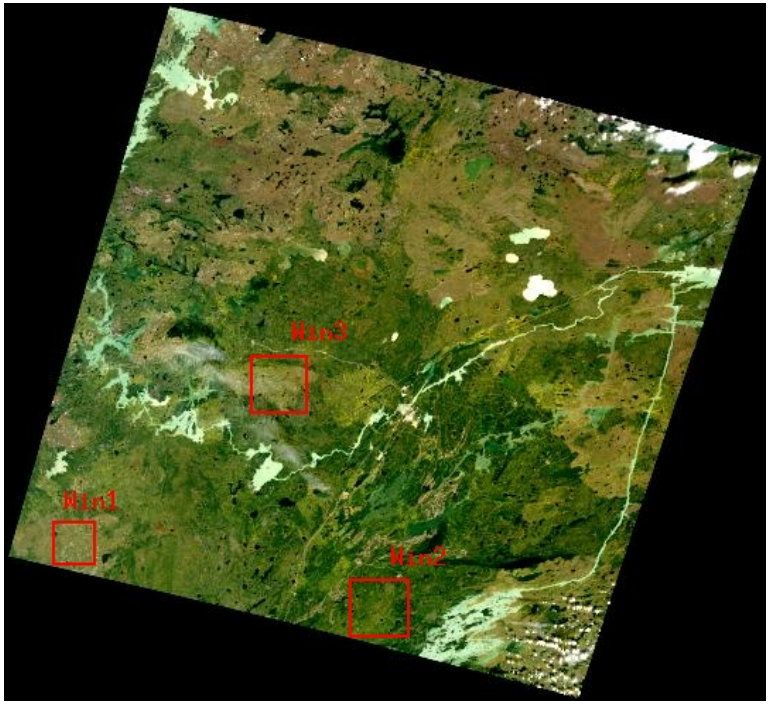
BOREAS ETM+ scene

Scene: p033r021

Date: 09/17/2001



Top-of-atmosphere TOA



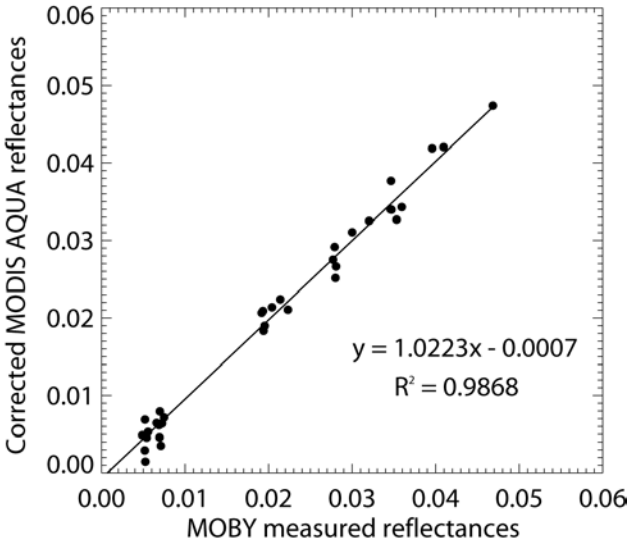
Surface Reflectance

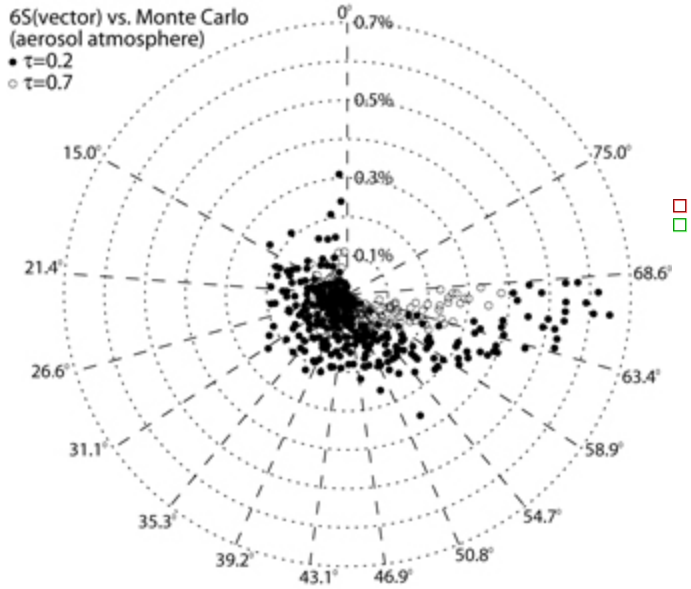
Approach for a Surface Reflectance product

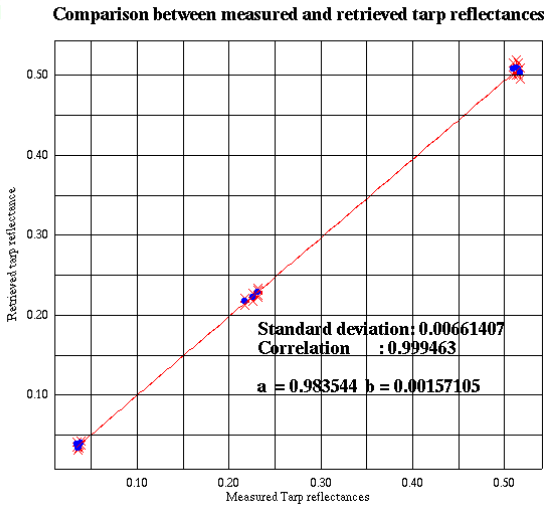
- **Atmospheric correction consistent with the MODIS, AVHRR and NPP-VIIRS approach, ensuring consistent reflectance data across resolutions based on rigorous radiative transfer**

  http://6s.ltdri.org

  http://rtcodes.ltdri.org/







Approach for the surface reflectance product

- **Examples of validation and uncertainties estimates. Theoretical error budget, comprehensive evaluation.**

FOREST

Belterra

λ [nm]	ρ x10000	Clear	Average	Hazy
			Δρx10000	
470	120	52	51	52
550	375	49	55	64
645	240	52	59	65
870	2931	40	152	246
1240	3083	38	110	179
1650	1591	29	52	84
2130	480	41	28	42
NDVIx1000			ΔNDVI x1000	
849		30	34	40

SAVANNA

Skukuza

λ [nm]	ρ x10000	Clear	Average	Hazy
			Δρx10000	
470	400	52	52	53
550	636	52	58	64
645	800	53	62	67
870	2226	35	103	164
1240	2880	38	97	158
1650	2483	35	66	104
2130	1600	40	36	53
NDVIx1000			ΔNDVI x1000	
471		22	28	33

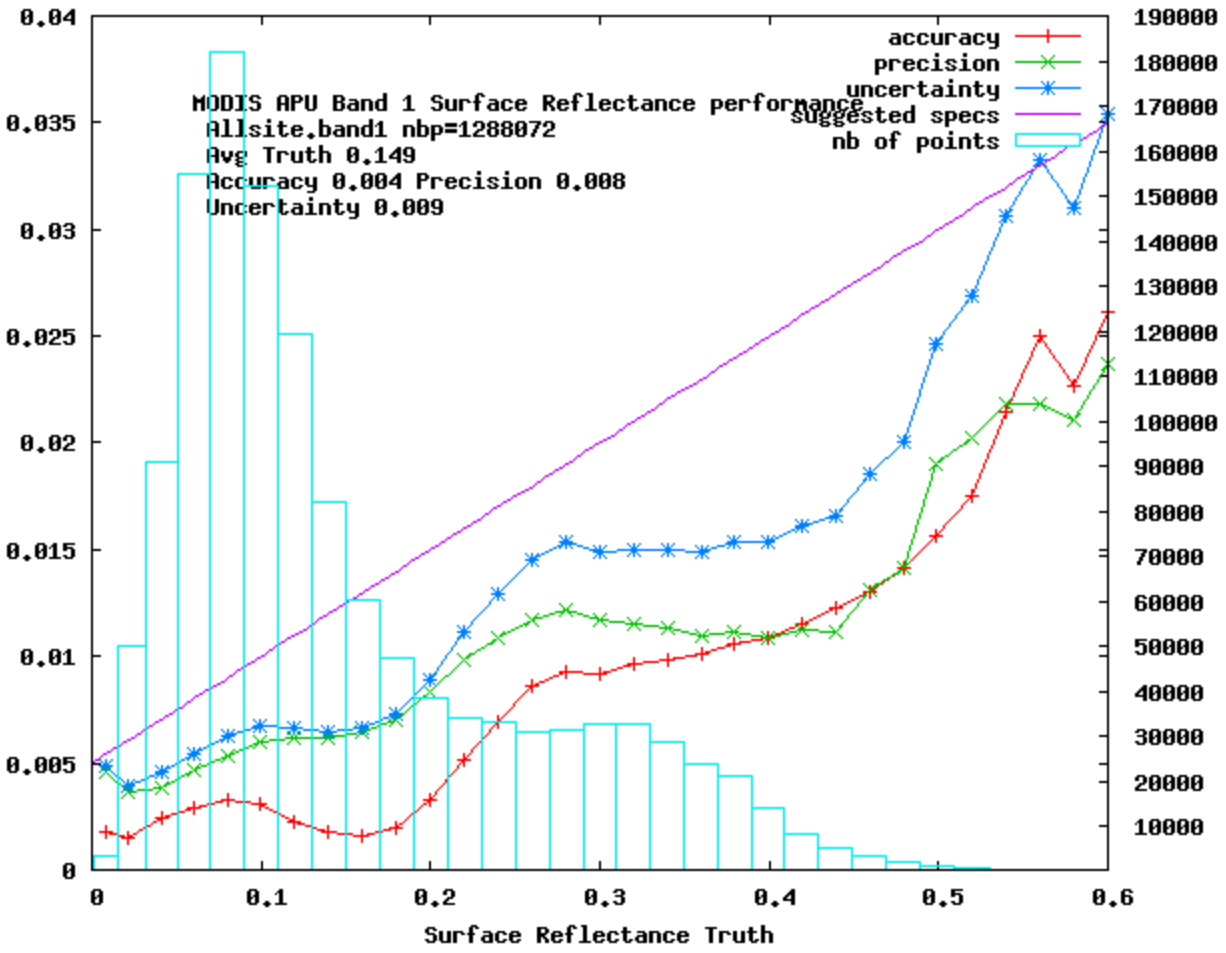
SEMI-ARID

Sevilleta

λ [nm]	ρ x10000	Clear	Average	Hazy
			Δρx10000	
470	700	51	53	55
550	1246	51	70	85
645	1400	57	74	85
870	2324	41	95	146
1240	2929	45	93	148
1650	3085	55	81	125
2130	2800	56	60	87
NDVIx1000			ΔNDVI x1000	
248		11	15	19

Error in ~0.5% in reflectance unit

Toward a quantitative assessment of performances (MODIS APU)



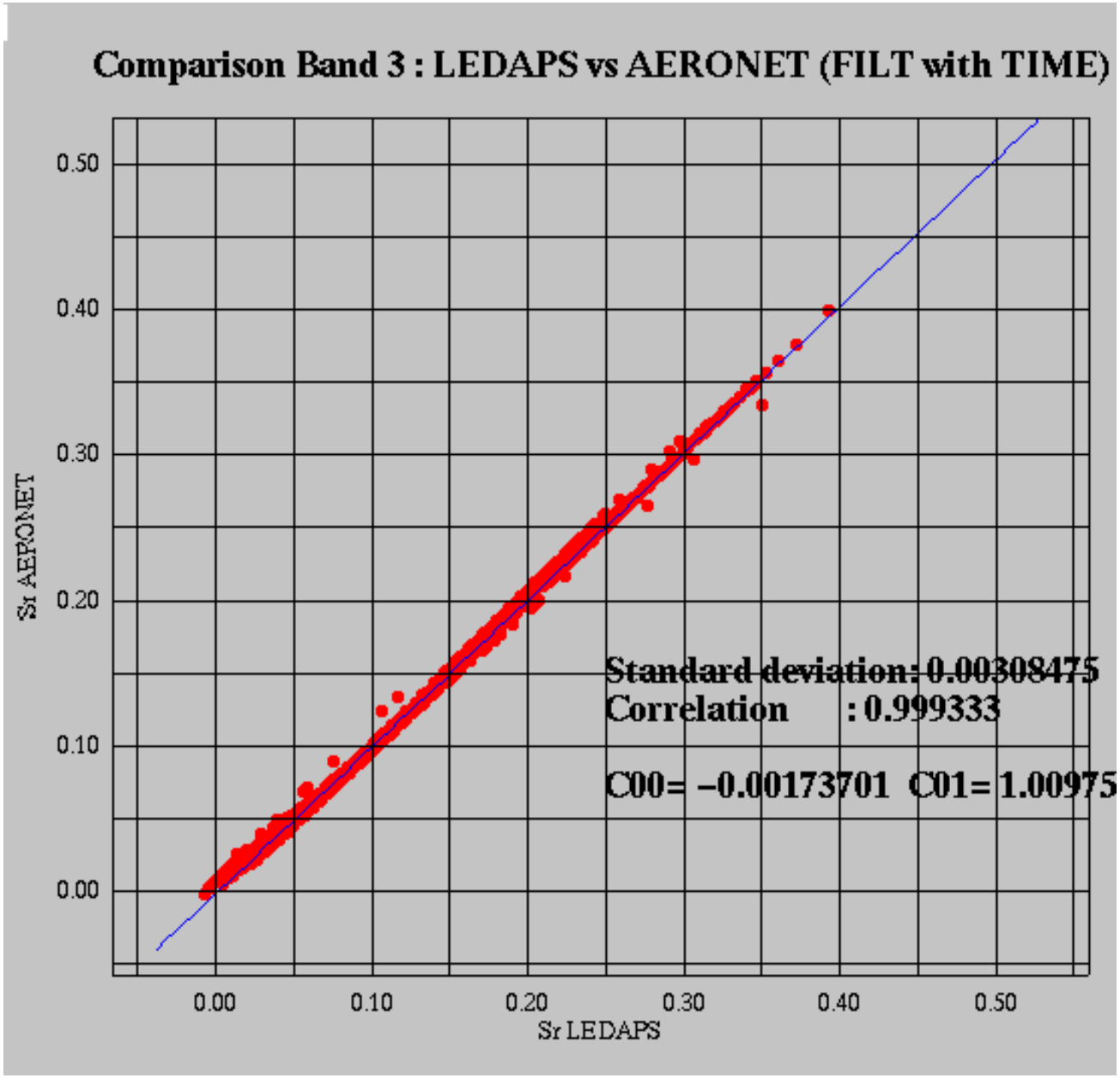
1,3 Millions 1 km pixels were analyzed for each band.

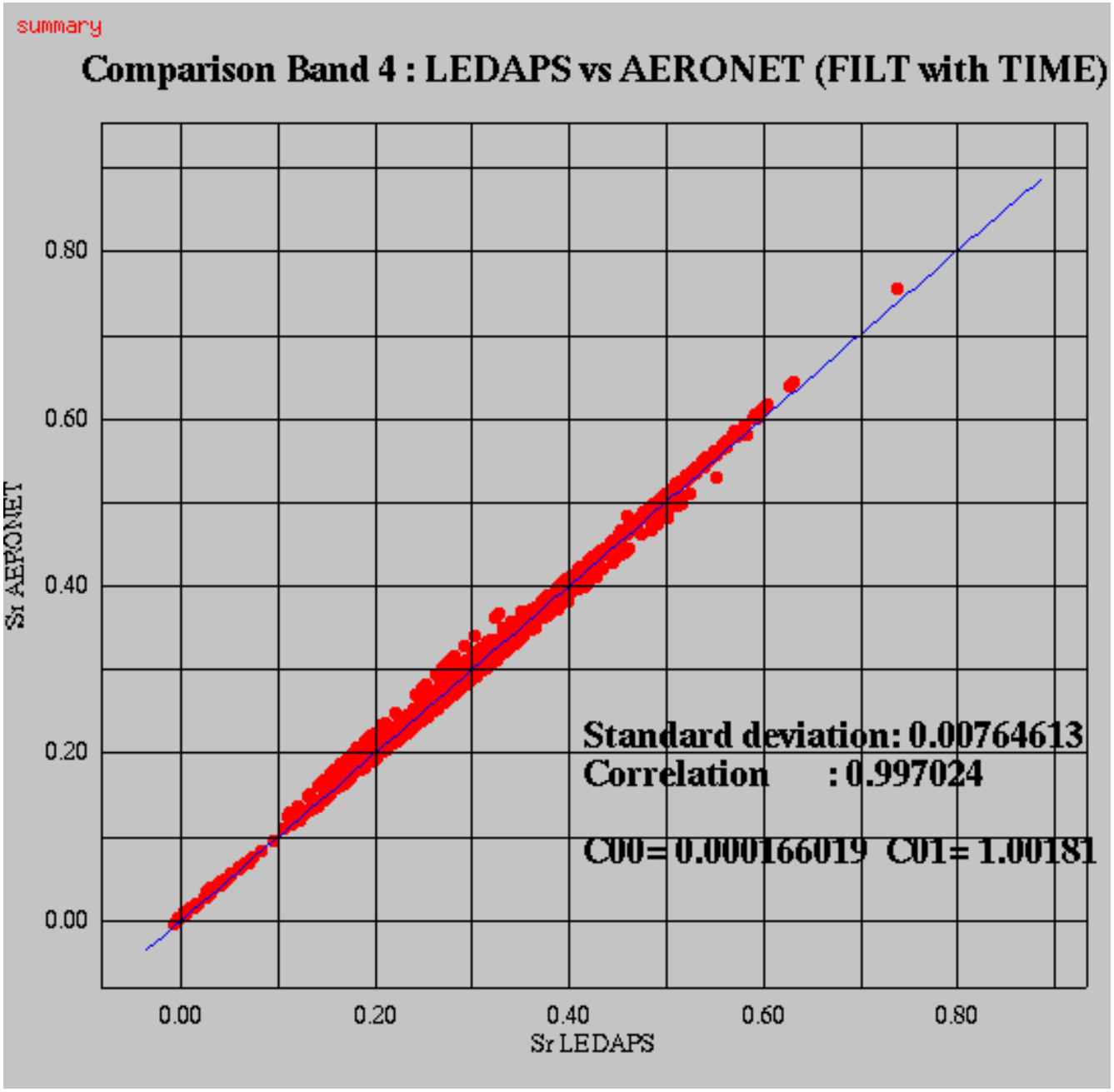
Red = Accuracy (mean bias)
Green = Precision (repeatability)
Blue = Uncertainty (quadatric sum of A and P)

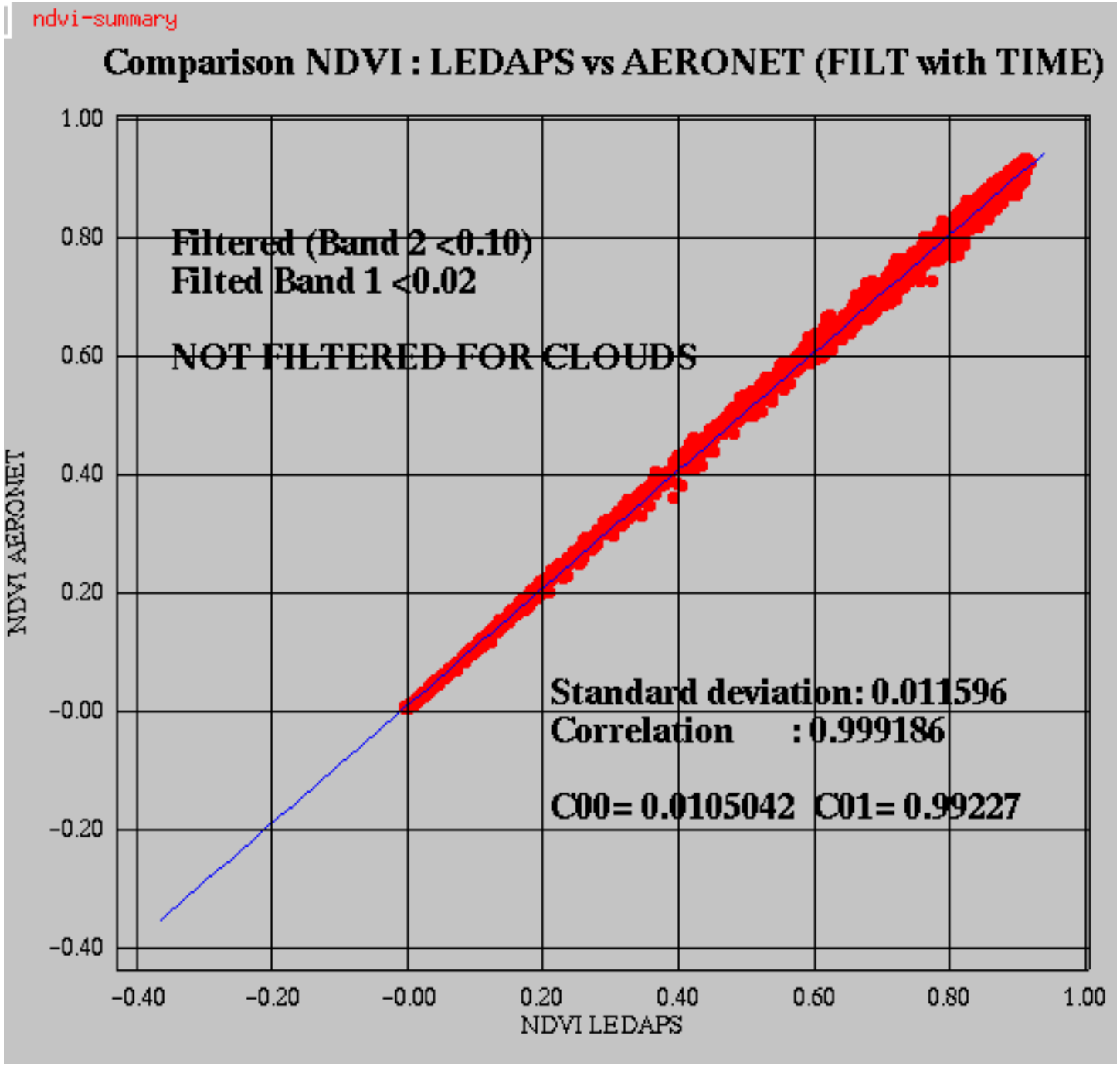
On average well below magenta theoretical error bar

Preliminary evaluation of the LEDAPS ETM+ surface reflectance product

DATE.PATH/ROW	AOT	TIMEDIFF	AERONET SITE
a2000122.w2p041r036	0.0932345	15	Rogers_Dry_Lake-001221821.mie
a2000122.w2p041r037	0.162749	15	UCLA-001221823.mie
a2000170.w2p009r029	0.0449007	60	Kejimkujik-001701451.mie
a2000191.w2p028r035	0.0858729	30	Cart_Site-001911659.mie
a2000247.w2p036r038	0.0365191	205	Tucson-002471753.mie
a2000261.w2p022r039	0.0722956	14	Stennis-002611628.mie
a2000267.w2p048r026	0.0727889	14	Saturn_Island-002671842.mie
a2001155.w2p034r036	0.105914	29	Sevilleta-011551737.mie
a2001216.w2p029r030	0.133025	14	Sioux_Falls-012161656.mie
a2001217.w2p036r025	0.0797376	188	Bratts_Lake-012171728.mie
a2001218.w2p043r028	0.0735507	254	Rimrock-012181817.mie
a2001267.w2p034r032	0.0717833	14	BSRN_BAO_Boulder-012671730.mie
a2001278.w2p015r033	0.147011	15	GSFC-012781537.mie


Comparison Band 3 : LEDAPS vs AERONET (FILT with TIME)
Sr AERONET
Sr LEDAPS
0.00
0.10
0.20
0.30
0.40
0.50
Standard deviation: 0.00308475
Correlation : 0.999333
C00= −0.00173701 C01= 1.00975


summary
Comparison Band 4 : LEDAPS vs AERONET (FILT with TIME)
Sr AERONET
0.00
0.20
0.40
0.60
0.80
Sr LEDAPS
0.00
0.20
0.40
0.60
0.80
Standard deviation: 0.00764613
Correlation : 0.997024
C00= 0.000166019 C01= 1.00181


ndvi-summary
Comparison NDVI : LEDAPS vs AERONET (FILT with TIME)
Filtered (Band 2 <0.10)
Filted Band 1 <0.02
NOT FILTERED FOR CLOUDS
Standard deviation: 0.011596
Correlation : 0.999186
C00= 0.0105042 C01= 0.99227
NDVI AERONET
NDVI LEDAPS
1.00
0.80
0.60
0.40
0.20
-0.00
-0.20
-0.40
-0.40
-0.20
-0.00
0.20
0.40
0.60
0.80
1.00

On going assessment of LEDAPS ETM+ surface reflectance product

- WELD (D. Roy) 120 acquisitions over 23 AERONET sites (CONUS) – in Review
- Google Earth Engine: Acquisitions over 120 AERONET sites (global) – in Progress
- GFCC: Comparison with MODIS SR products
  - GLS 2000 demonstration (in press)
  - GLS 2005 (TM and ETM+) – In progress
- Both LEDAPS and WELD are being tested for global Landsat applications at NASA/Ames

CONCLUSIONS

- The SR Algorithm is mature and ready for production
- A Landsat Surface Reflectance product can be implemented for LDCM, the 412nm should improve the performance of aerosol retrieval
- LDCM SR development should be gradual as the instrument is new. SR should follow different stages (Beta, Provisional, Validated – Stage 1,2,3)
- A system for Operational QA for LDCM/Landsat needs to be developed and implemented
- Further discussion is needed on plans for implementation