Trending Landsat Calibration Using Libya 4

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Outline

Objective: how precisely can we trend Landsat data using PICS, especially Libya 4?

- PICSIASDA – a Landsat trending database
- Procedure
- Results
  - SDSU (PICSIASDA)
  - GSFC
- Comparison to other desert sites
- Conclusions

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PICSIASDA Overview

- PICSIASDA is an automated trending tool developed for the Landsat Image Assessment System (IAS).
- It allows the user the ability to designate a specific region of interest (ROI) by submitting a ascii shape file into the system.
- After the ROI is established, the user can simply choose the “PICS automation” process in the Landsat Archive Manager (LAM) interface when creating batch scene orders.
- The IAS automatically trends statistical data for all of the pixels within the ROI, and creates a png image capture of each band for visual reference.

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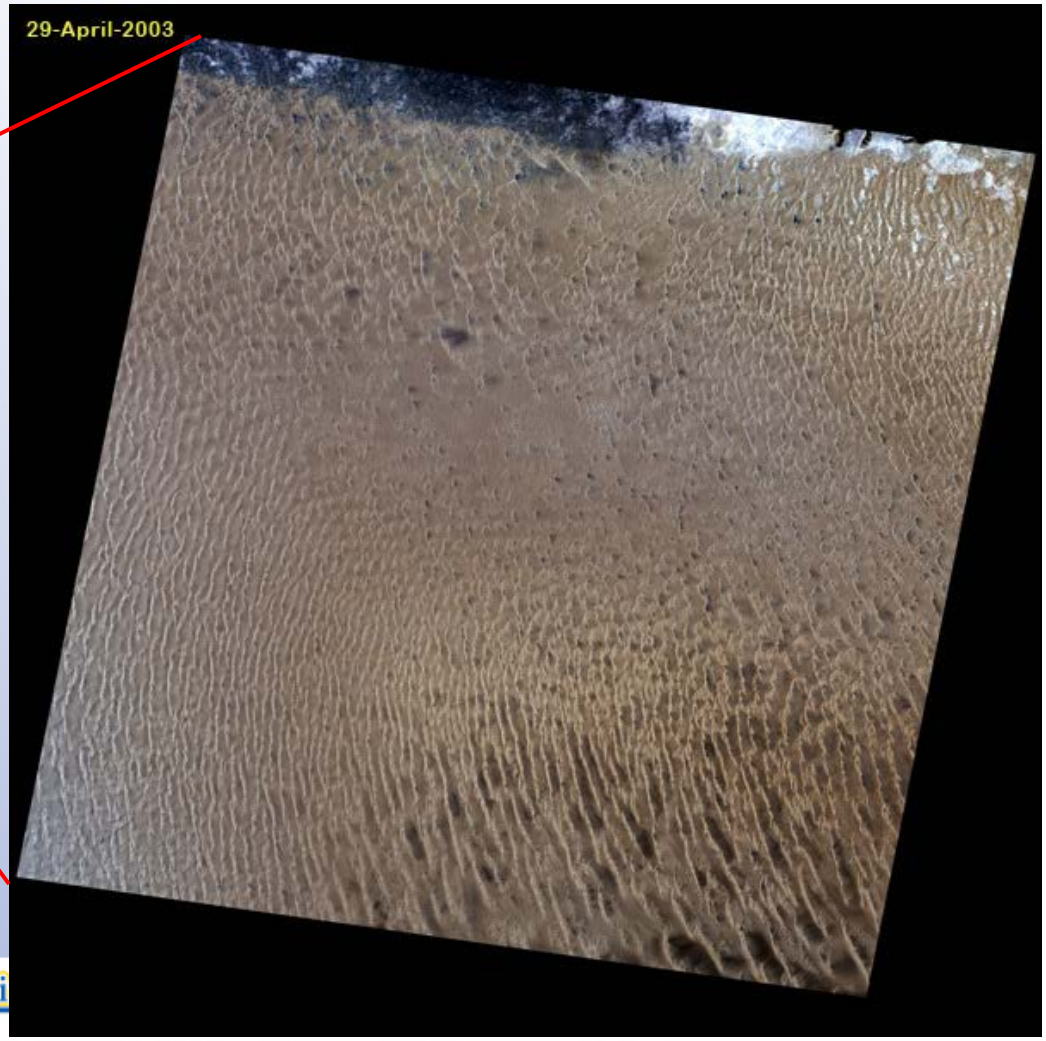
Functionality of PICSIASDA

- The PICSIASDA tool uses a control file that allows for the importation of various ascii shape (shp) files or point locations with a specified radius for both WRS-1 and 2 scenes.
- The system is set up to handle any scene data acquired by Landsat sensors (MSS, TM, ETM+).
- The generic nature of the tool also allows for the inclusion of future Landsat platforms.
- The trending database supplies the user with L0R, L1R, and L1T data to compare side by side.
- Additional data fields include solar geometries, geometric statistics, acquisition quality statistics, and processing logs to help with data point and scene quality assessments.

Libya 4 PICSIASDA Trending Site



Libya 4:
WRS2 Path 181 Row 40
PICSIASDA ROI Dimensions:

LATITUDE	LONGITUDE
29.754	23.127
29.482	24.862
27.991	24.481
28.249	22.751

Landsat TM/ETM+ Temporally Trended Data

- All PICSIASDA scene data has undergone the following calculations and calibrations:
  - ESUN correction
  - Earth/sun distance correction
  - Solar elevation angle correction
  - BRDF correction
    - The BRDF correction factor was derived for each band by plotting the TOA reflectance against solar zenith angle and viewing zenith angle
    - The linear model was used to correct the TOA Reflectance to nadir looks

PICSIASDA Results

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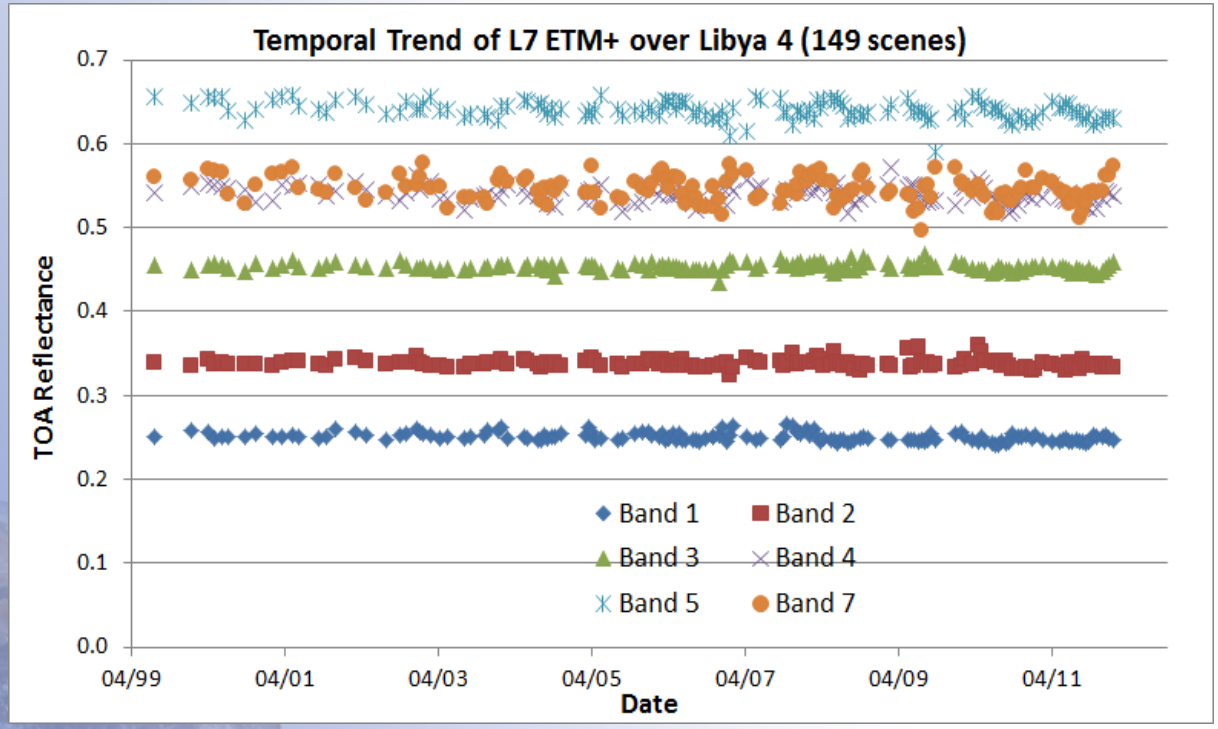
Temporal Trend of L7 ETM+ over Libya 4



Uncertainties	
Band 1	1.94%
Band 2	1.44%
Band 3	0.95%
Band 4	1.83%
Band 5	1.61%
Band 7	2.75%

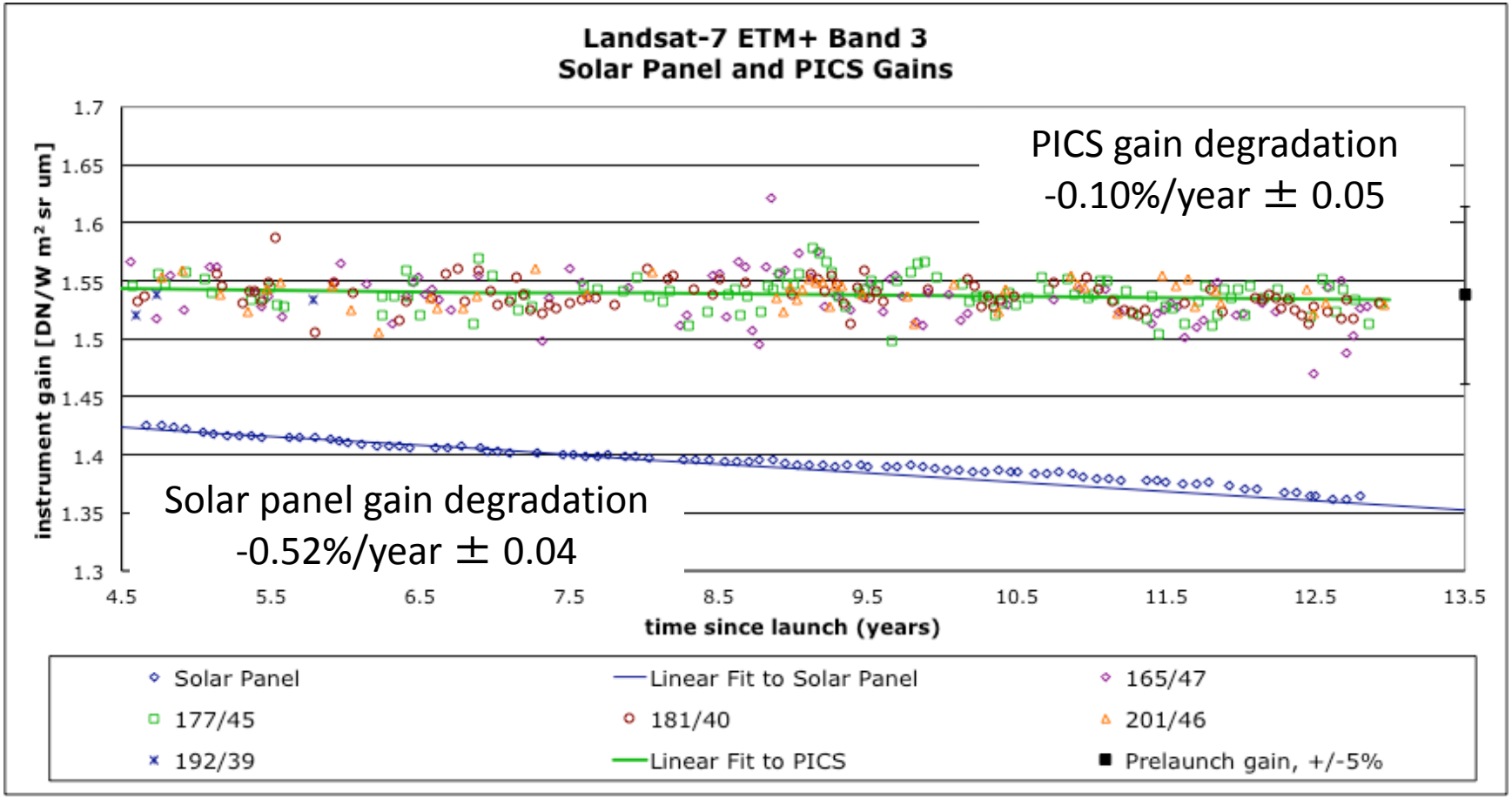
t-test on the slope

Bands	Slope	p-value	Remark
Band 1	-1.5E-06	<0.0001	Reject
Band 2	-3.90E-07	0.239	Fail to Reject
Band 3	-4.81E-07	0.099	Fail to Reject
Band 4	-1.89E-06	0.004	Reject
Band 5	-2.97E-06	<0.0001	Reject
Band 7	-2.86E-06	0.004	Reject

Degradation per year

Bands	%/yr ± 2σ SDSU
1	-0.22±0.09
2	-0.04±0.07
3	-0.04±0.05
4	-0.13±0.09
5	-0.17±0.07
7	-0.19±0.13

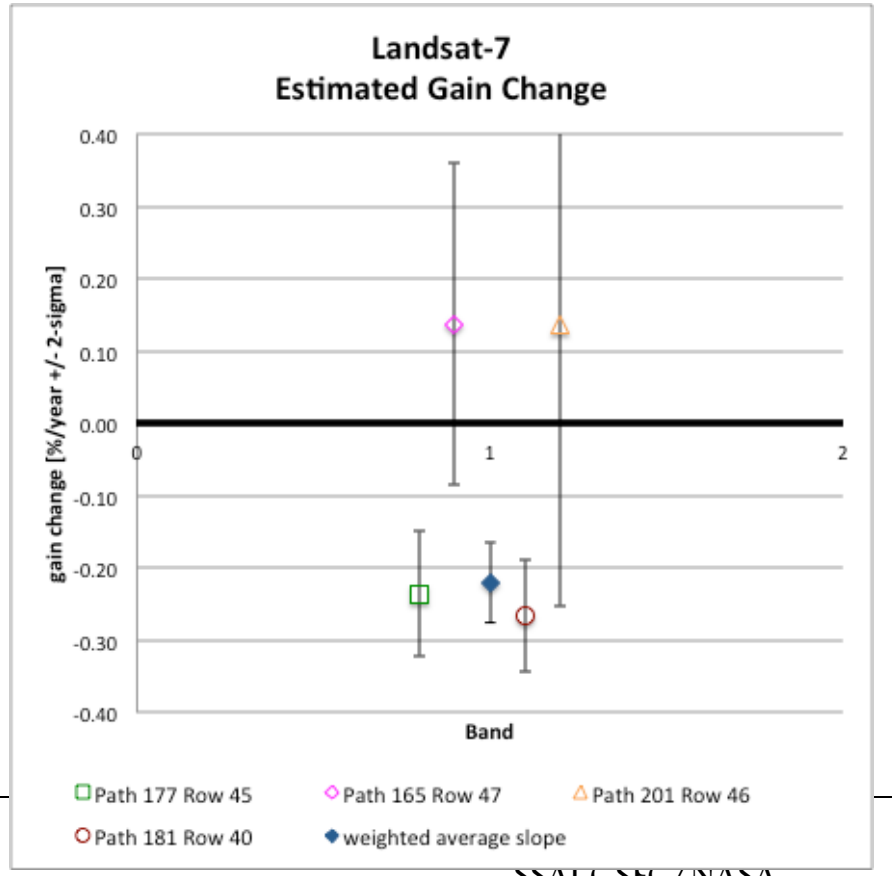
Landsat-7 ETM+ Red Band PICS Relative Calibration Trends



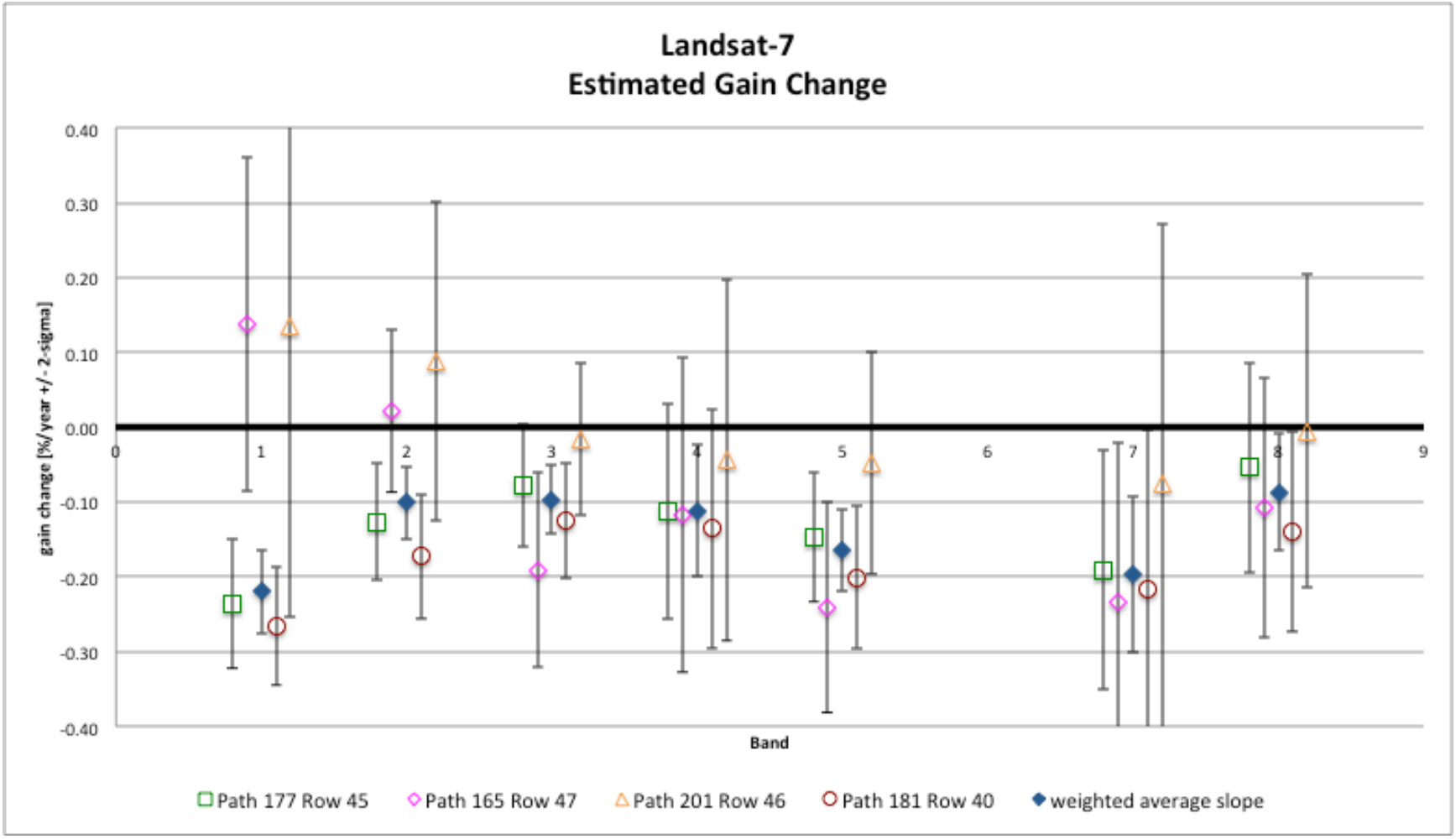
Reduction of data

- Linear fit to each site
- Calculate weighted average of slopes for an estimate of gain change, weighting by uncertainty for each site

	Blue Band Estimated Gain Change [%/year ± 2σ]
177/45	-0.24 ± 0.09
165/47	0.14 ± 0.22
181/40	-0.27 ± 0.08
201/46	0.14 ± 0.39
weighted average slope	-0.22 ± 0.06



Landsat-7 ETM+
Estimated Gain Change



Landsat-7 ETM+ Gain Trending Summary

- Fit is from July 2003 to present
- PICS trend based on weighted average of four sites
- Solar panel is degrading
- PICS degradation is statistically significant in all bands

	Estimated Gain Change [%/year ± 2σ]	
	Solar Panel	PICS
Band 1	-0.51 ± 0.02	-0.22 ± 0.06
Band 2	-0.46 ± 0.02	-0.10 ± 0.05
Band 3	-0.52 ± 0.04	-0.10 ± 0.05
Band 4	-0.68 ± 0.04	-0.11 ± 0.09
Band 5	-0.11 ± 0.01	-0.17 ± 0.05
Band 7	0.13 ± 0.02	-0.20 ± 0.10
Band 8	-0.56 ± 0.02	-0.09 ± 0.08

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Comparison of Landsat 7 Libya 4 Trends

Band	SDSU	GSFC
1 (Blue)	-0.22 ± 0.09**	-0.22 ± 0.06**
2 (Green)	-0.04 ± 0.07	-0.10 ± 0.05**
3 (Red)	-0.04 ± 0.05	-0.10 ± 0.05**
4 (NIR)	-0.13 ± 0.09**	-0.11 ± 0.09**
5 (SWIR 1)	-0.17 ± 0.07**	-0.20 ± 0.10**
7 (SWIR 2)	-0.19± 0.13**	-0.09 ± 0.08**

** denotes statistically significant degradation

Note:
1. Different results with essentially the same data sets.
2. Suggests consistent degree of precision ≥0.2%/yr

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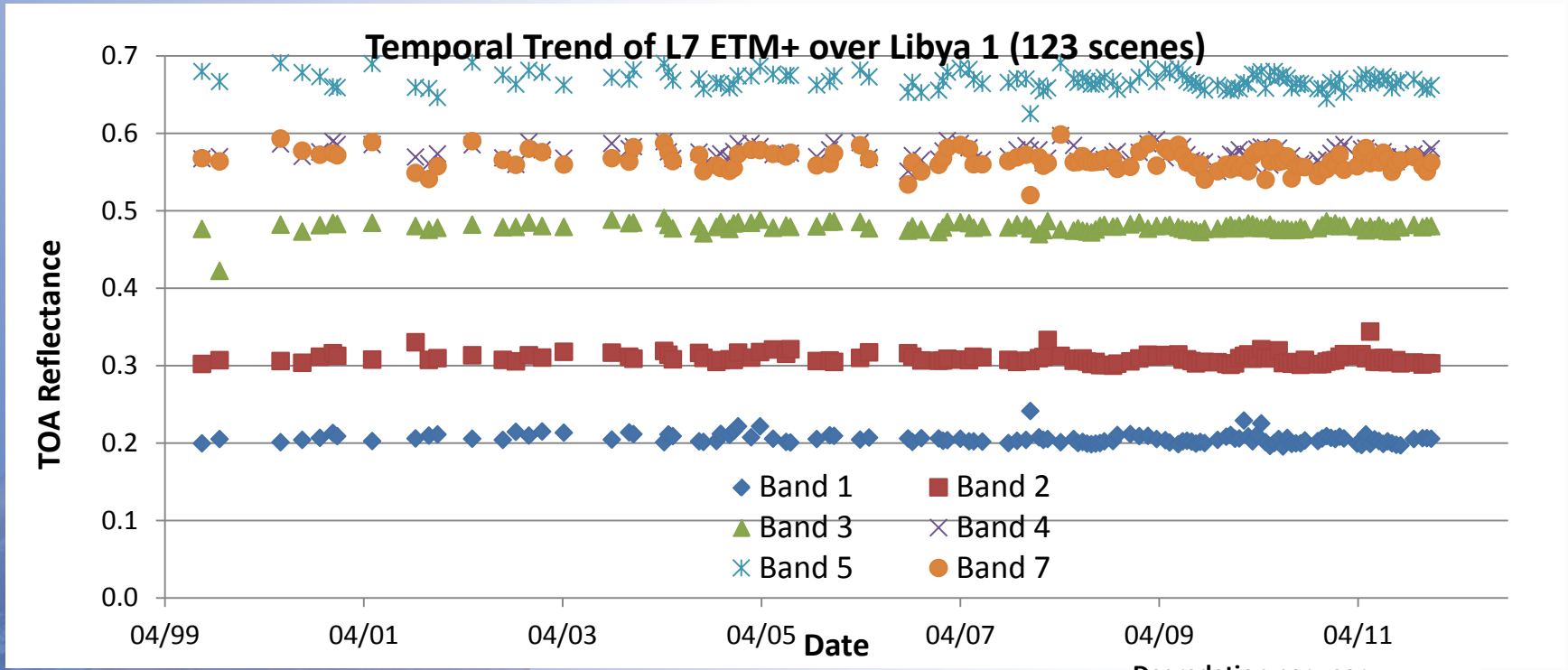
Additional Sahara Site Results

Temporal Trend of L7 ETM+ over Libya 1



Uncertainties	
Band 1	3.17%
Band 2	2.11%
Band 3	1.35%
Band 4	1.65%
Band 5	1.55%
Band 7	2.20%

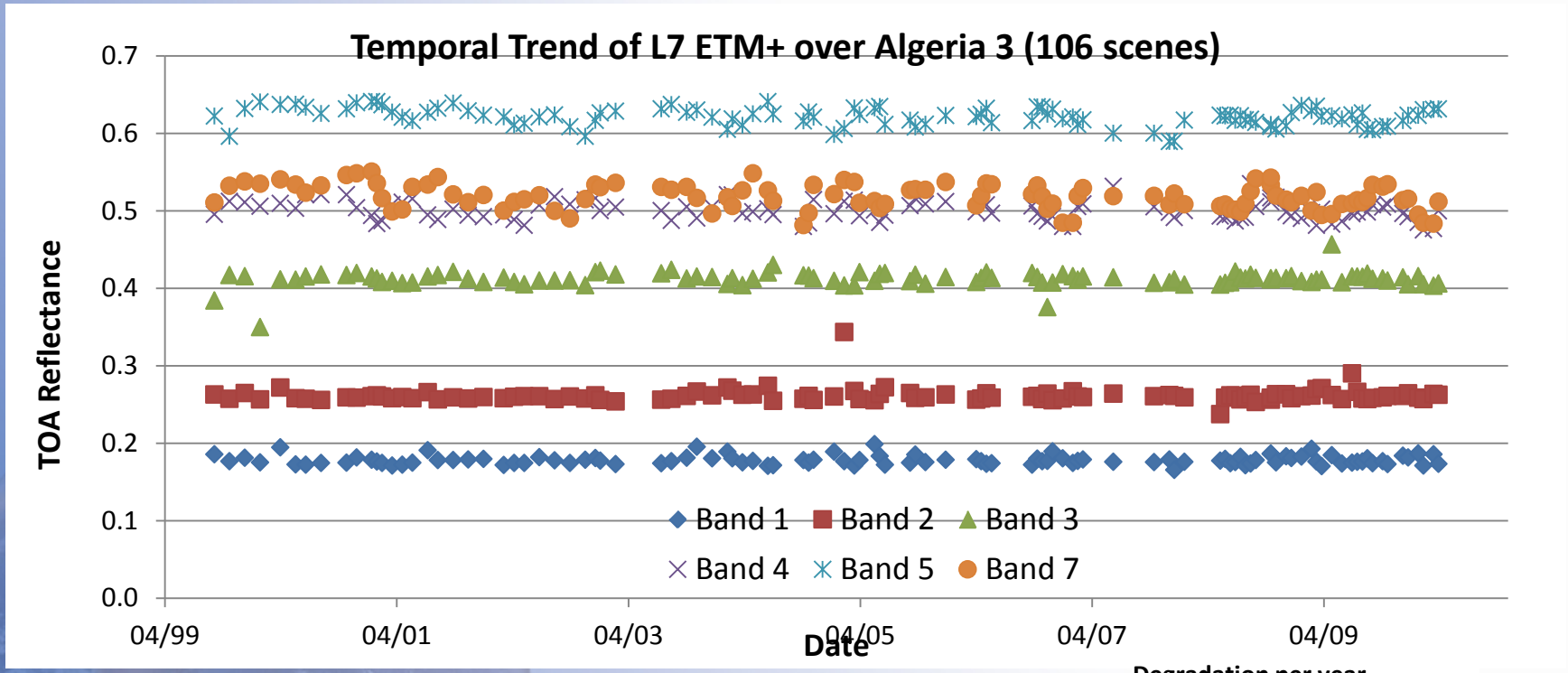
t-test on the slope

Bands	Slope	p-value	Remark
Band 1	-7.74E-07	0.226	Fail to Reject
Band 2	-1.02E-06	0.036	Reject
Band 3	1.83E-07	0.707	Fail to Reject
Band 4	-1.84E-06	0.009	Reject
Band 5	-1.98E-06	0.010	Reject
Band 7	-2.38E-06	0.010	Reject

Degradation per year

Bands	%/yr ± 2σ SDSU
1	-0.14±0.22
2	-0.12±0.11
3	0.01±0.07
4	-0.11±0.09
5	-0.11±0.08
7	-0.15±0.11

Temporal Trend of L7 ETM+ over Algeria 3



Uncertainties	
Band 1	3.26%
Band 2	3.74%
Band 3	2.46%
Band 4	2.40%
Band 5	1.86%
Band 7	3.07%

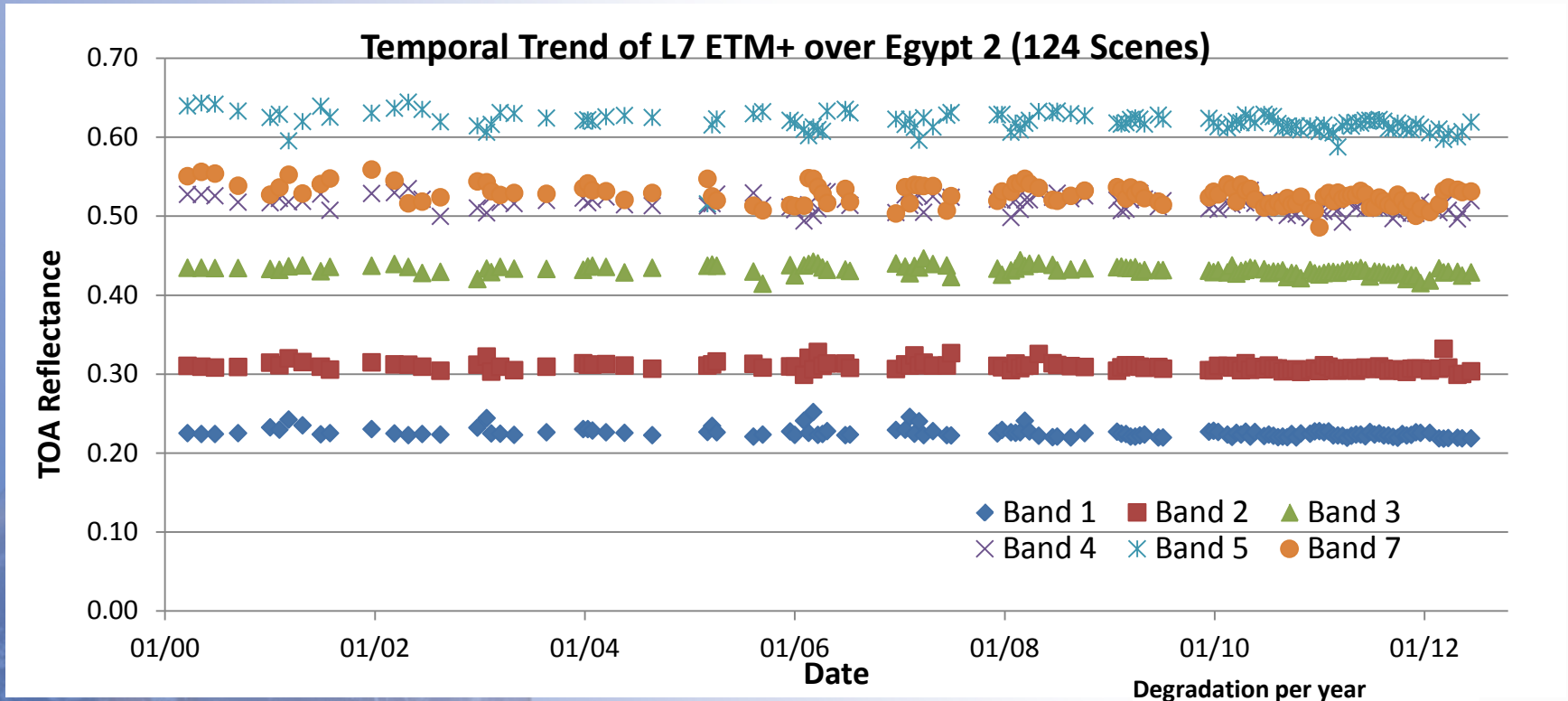
t-test on the slope

Bands	Slope	p-value	Remark
Band 1	6.46E-08	0.89	Fail to Reject
Band 2	2.98E-07	0.71	Fail to Reject
Band 3	8.98E-07	0.29	Fail to Reject
Band 4	-2.26E-06	0.02	Reject
Band 5	-2.96E-06	0.001	Reject
Band 7	-4.54E-06	<0.0001	Reject

Degradation per year

Bands	%/yr ± 2σ SDSU
1	0.01±0.20
2	0.04±0.23
3	0.08±0.15
4	-0.16±0.14
5	-0.17±0.11
7	-0.31±0.17

Temporal Trend of L7 ETM+ over Egypt 2



Uncertainties	
Band 1	2.51%
Band 2	1.73%
Band 3	1.25%
Band 4	1.76%
Band 5	2.24%
Band 7	2.34%

t-test on the slope

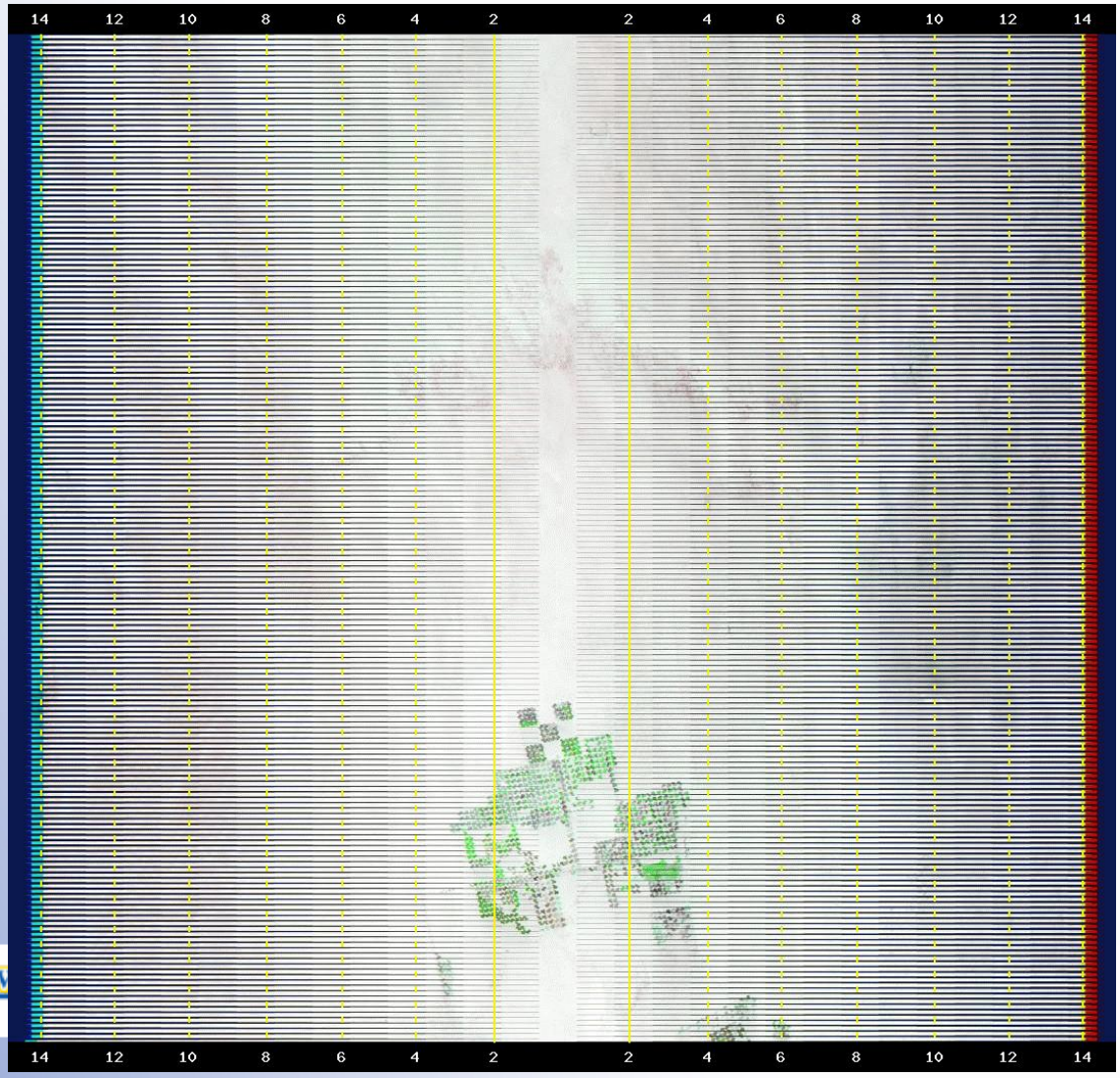
Bands	Slope	p-value	Remark
Band 1	-1.66E-06	<.0001	Reject
Band 2	-1.26E-06	0.0005	Reject
Band 3	-1.55E-06	<.0001	Reject
Band 4	-2.59E-06	<.0001	Reject
Band 5	-3.34E-06	0.0004	Reject
Band 7	-4.64E-06	<.0001	Reject

Degradation per year

Bands	%/yr ± 2σ SDSU
1	-0.26±0.12
2	-0.15±0.08
3	-0.13±0.06
4	-0.18±0.08
5	-0.19±0.11
7	-0.31±0.10

Problem With Egypt 2

- Several irrigated crop circles have popped up in the last four years in the southern part of the Egypt 2 PICS site.
- Unfortunately, the point density of this site is too sparse during the first eight years of collection to do much of a statistical analysis to determine cropland development's effect on this site.



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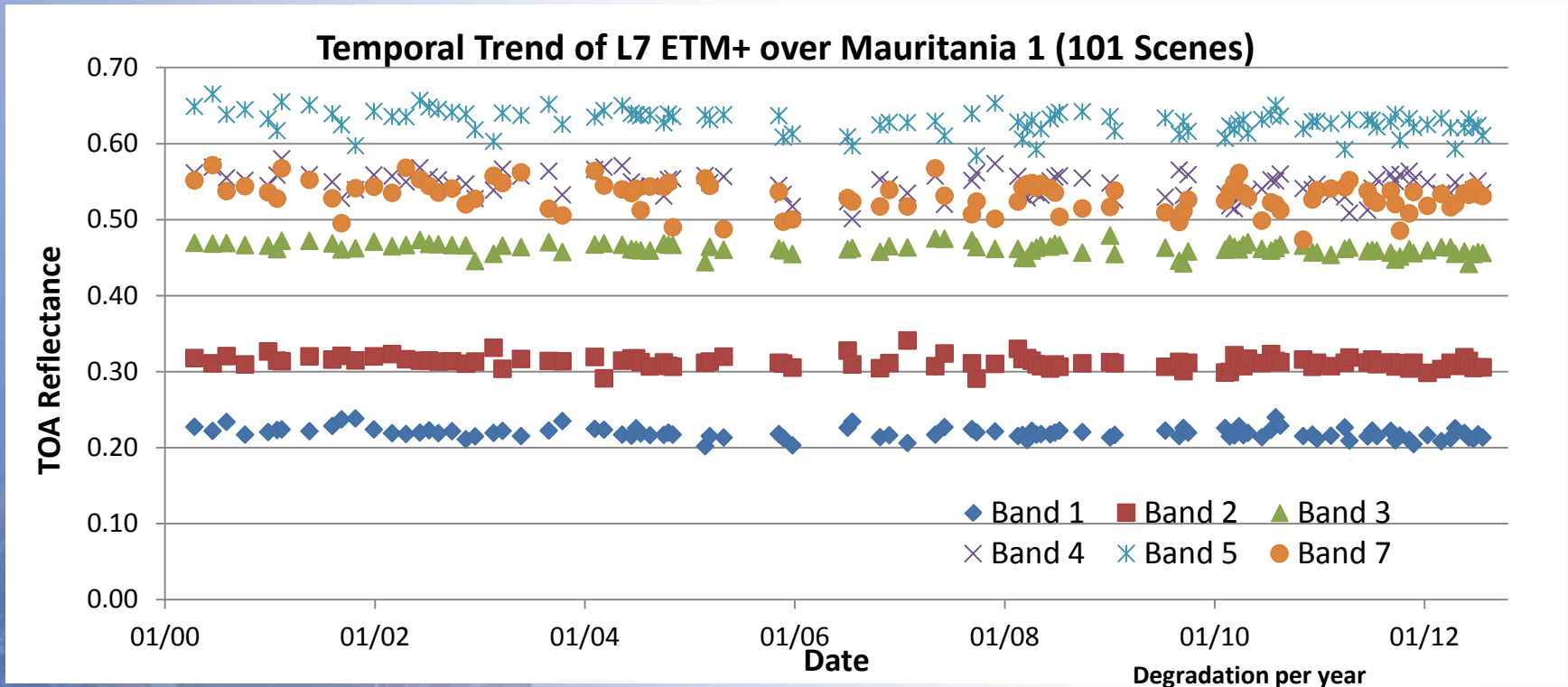
Temporal Trend of L7 ETM+ over Mauritania 1



Uncertainties	
Band 1	3.21%
Band 2	2.41%
Band 3	1.54%
Band 4	2.81%
Band 5	2.45%
Band 7	3.71%

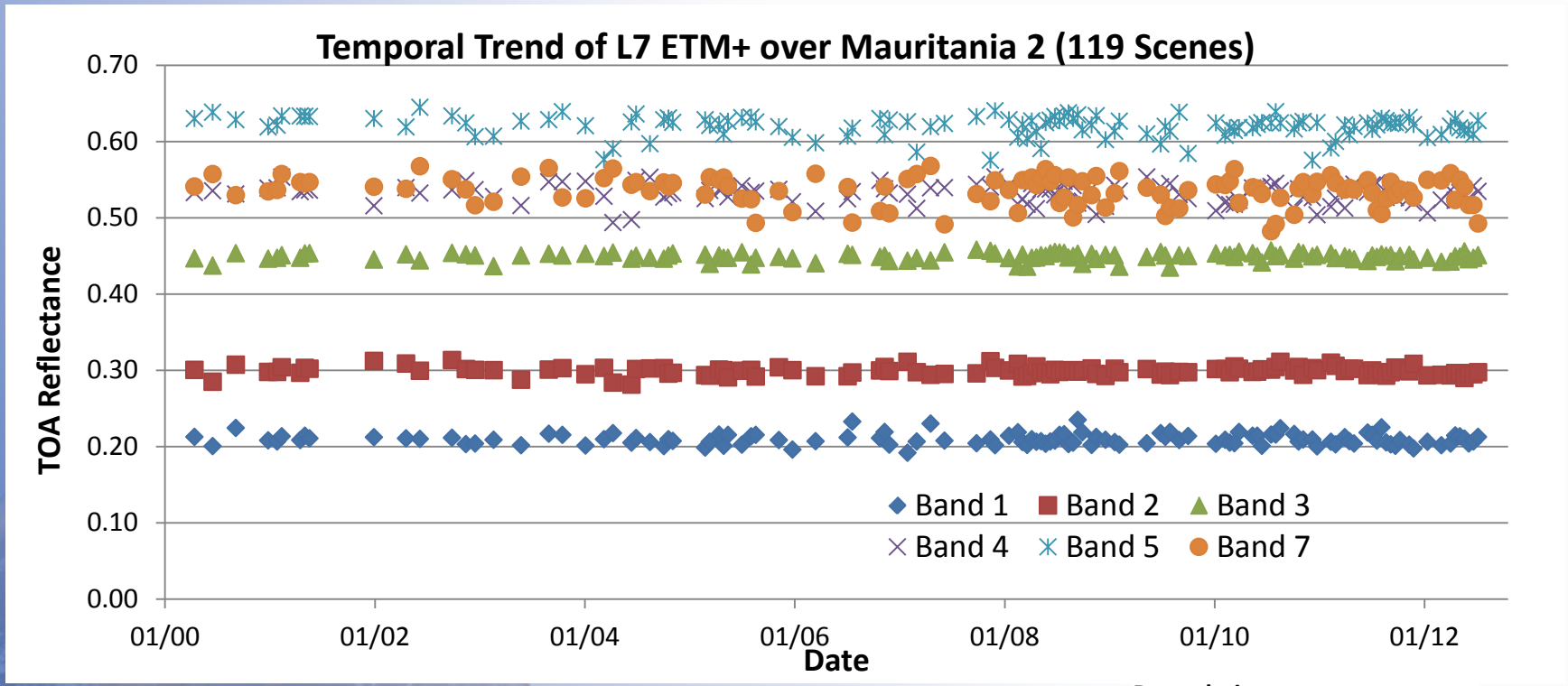
t-test on the slope

Bands	Slope	p-value	Remark
Band 1	-1.54E-06	0.002	Reject
Band 2	-1.60E-06	0.003	Reject
Band 3	-2.09E-06	<.0001	Reject
Band 4	-3.71E-06	0.001	Reject
Band 5	-4.43E-06	<.0001	Reject
Band 7	-4.32E-06	0.002	Reject

Degradation per year

Bands	%/yr ± 2σ SDSU
1	-0.25±0.16
2	-0.18±0.12
3	-0.16±0.07
4	-0.24±0.14
5	-0.25±0.12
7	-0.29±0.18

Temporal Trend of L7 ETM+ over Mauritania 2



Uncertainties	
Band 1	3.43%
Band 2	1.86%
Band 3	1.08%
Band 4	2.29%
Band 5	2.25%
Band 7	3.49%

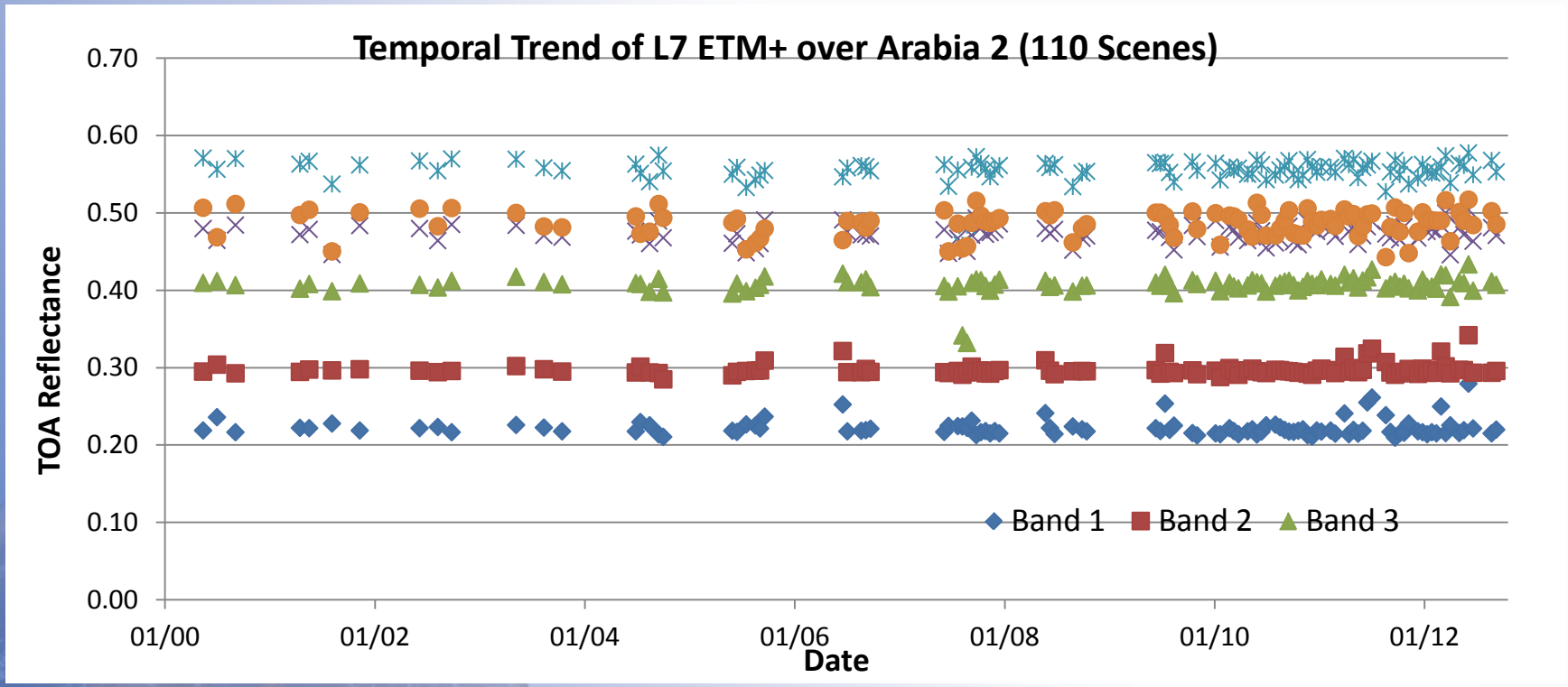
t-test on the slope

Bands	Slope	p-value	Remark
Band 1	-1.21E-07	0.82	Fail to Reject
Band 2	-1.48E-07	0.71	Fail to Reject
Band 3	1.70E-07	0.63	Fail to Reject
Band 4	-1.49E-06	0.09	Fail to Reject
Band 5	-2.00E-06	0.047	Reject
Band 7	-2.99E-06	0.03	Reject

Degradation per year

Bands	%/yr ± 2σ SDSU
1	-0.02±0.18
2	-0.02±0.10
3	0.01±0.06
4	-0.10±0.12
5	-0.12±0.12
7	-0.20±0.18

Temporal Trend of L7 ETM+ over Arabia 2



Uncertainties	
Band 1	4.94%
Band 2	2.68%
Band 3	2.89%
Band 4	2.48%
Band 5	2.77%
Band 7	3.32%

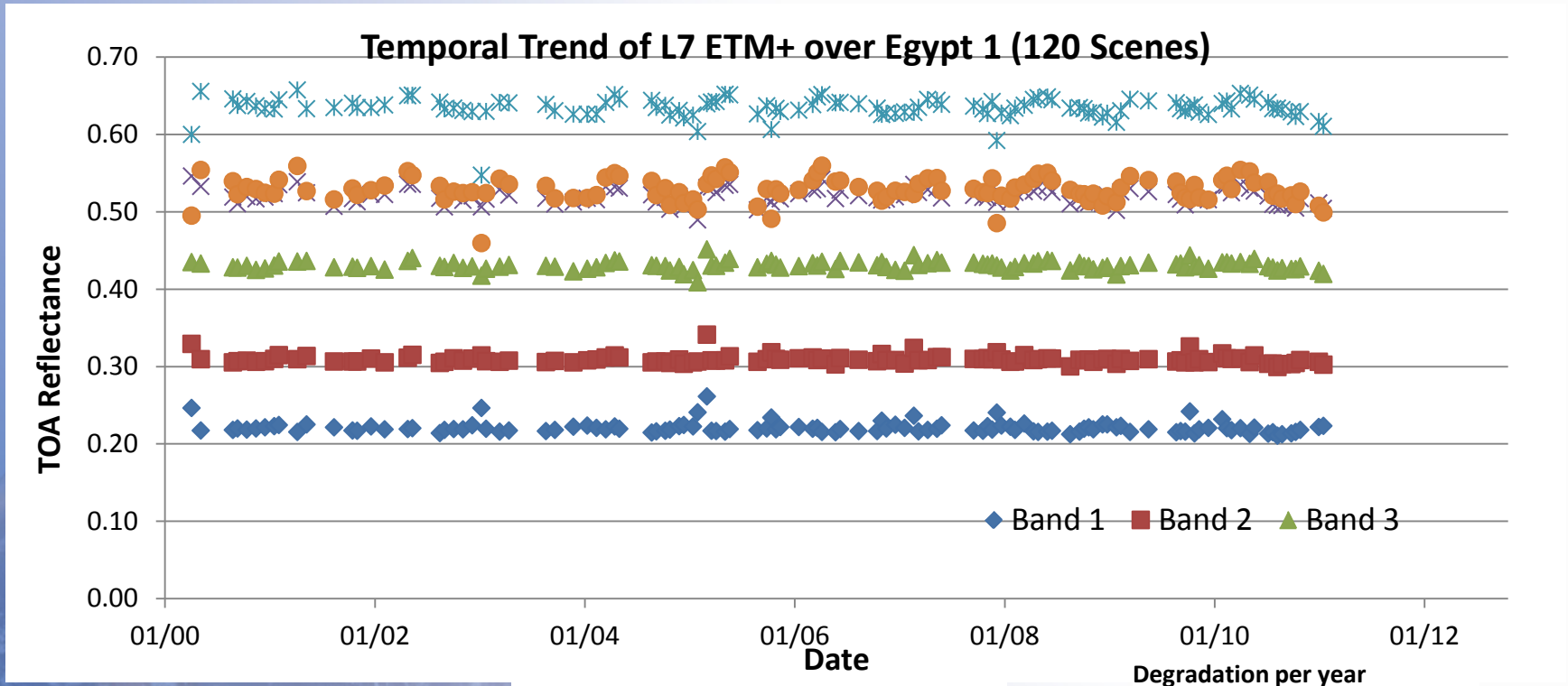
t-test on the slope

Bands	Slope	p-value	Remark
Band 1	3.23E-07	0.6915	Fail to Reject
Band 2	8.53E-07	0.1476	Fail to Reject
Band 3	7.93E-07	0.3623	Fail to Reject
Band 4	8.74E-07	0.3142	Fail to Reject
Band 5	-5.21E-07	0.6475	Fail to Reject
Band 7	-1.10E-07	0.927	Fail to Reject

Degradation per year

Bands	%/yr ± 2σ
	SDSU
1	0.053±0.268
2	0.106±0.145
3	0.072±0.157
4	-0.068±0.134
5	-0.034±0.149
7	-0.008±0.179

Temporal Trend of L7 ETM+ over Egypt 1



Uncertainties	
Band 1	3.36%
Band 2	1.74%
Band 3	1.29%
Band 4	1.86%
Band 5	2.14%
Band 7	2.98%

t-test on the slope

Bands	Slope	p-value	Remark
Band 1	3.15E-07	0.8894	Fail to Reject
Band 2	3.73E-07	0.8112	Fail to Reject
Band 3	4.33E-07	0.6703	Fail to Reject
Band 4	-5.17E-07	0.6112	Fail to Reject
Band 5	-1.95E-06	0.5392	Fail to Reject
Band 7	-1.76E-06	0.538	Fail to Reject

Degradation per year

Bands	%/yr ± 2σ SDSU
1	0.051±0.736
2	0.044±0.365
3	0.037±0.172
4	-0.036±0.141
5	-0.112±0.364
7	-0.122±0.395

Comparison of Saharan Sites

Landsat 7 % Uncertainties (temporal std. dev / temporal mean)								
Landsat Band	Libya 4	Libya 1	Algeria 3	Egypt 1	Egypt 2	Mauri-tania 1	Mauri-tania 2	Arabia 2
1 (Blue)	**1.94**	3.17	3.26	3.36	2.51	3.21	3.43	4.94
2 (Green)	**1.44**	2.11	3.74	1.74	1.73	2.41	1.86	2.68
3 (Red)	**0.95**	1.35	2.46	1.29	1.25	1.54	1.08	2.89
4 (NIR)	1.83	**1.65**	2.40	1.86	1.76	2.81	2.29	2.48
5 (SWIR 1)	1.61	**1.55**	1.86	2.14	2.24	2.45	2.25	2.77
7 (SWIR 2)	2.75	**2.20**	3.07	2.98	2.34	3.71	3.49	3.32
# Scenes	149	123	106	120	124	101	119	110

CONCLUSIONS

- Libya 4 site is most stable in Sahara
  - Based on Landsat 7 observations
  - Libya 1 also very good
  - Not all PICS are invariant! (Egypt 2!)
- Consistent trending possible at approximately 0.2%/year precision
  - Dependent upon data processing and analysis methods
  - Based on nadir looking, multi-spectral observations
  - Not possible at all PICS