

Spatial Quality from Edge target imaged by KOMPSAT-3

(& KARI methodology of MTF Estimation, ver. 2019)
(Jan. 2014 ~ July 2019)

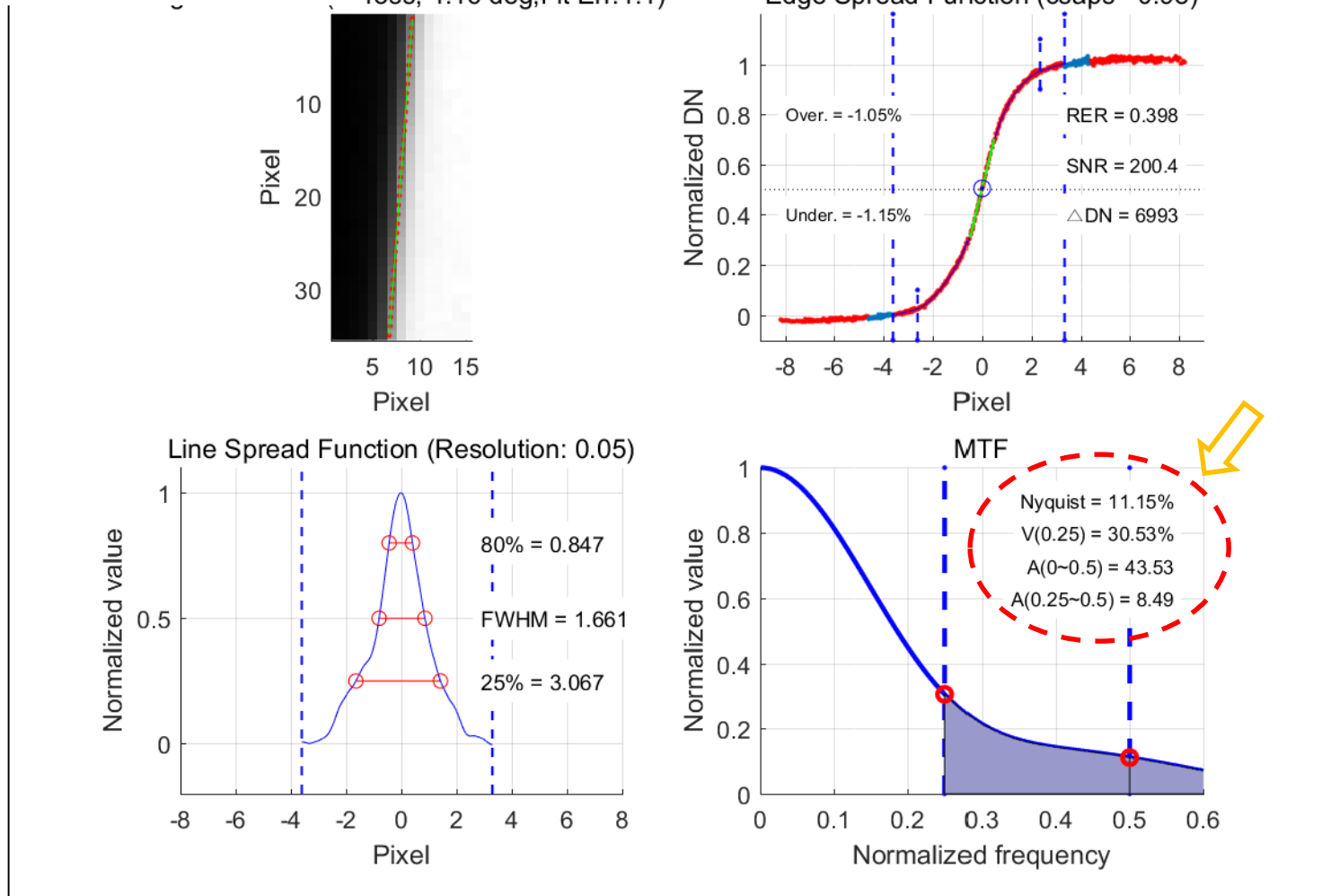
November 19, 2019

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Korea Aerospace Research Institute (KARI)
Image Data System Development Division

(Sample) KARI's MTF Estimation from Edge target

(MTF Code Ver. 2016.12.14)



Additional Estimators \Rightarrow

- $V(0.25)$ = MTF value at a Quarter frequency
- $A(0\sim 0.5)$ = Area from 0~0.5
- $A(0\sim 0.25)$ = Area from 0~0.25
- $A(0.25\sim 0.5)$ = Area from 0.25~0.5

Agenda

1. Status of Edge target in worldwide

2. Spatial Quality of KOMPSAT-3 by KARI methodology

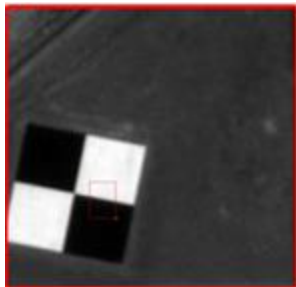
Comparison of Spatial quality Estimators (Draft)

❖ We need fill in this table continuously.

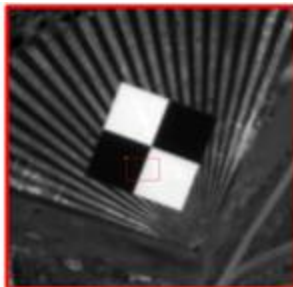
Estimator		Good	Weak	Applicable Targets	Re-commend	Comments
RER		High reliable		Edge	OK	
Edge slope		High reliable	- Need GSD each imaging - Only Edge	Edge		- Difficulty in measuring - Good for big GSD
FWHM		High reliable		Edge, Point	OK	
MTF	@ Nyq.	Popular	Low reliable	Edge, Point, Periodic	Normal	
	@ 0.25		Low reliable			
	Area 0~0.5	High reliable			OK	
	Area 0~0.25	High reliable			OK	
	Area 0.25~0.5		Low reliable			

List of Standard Edge targets

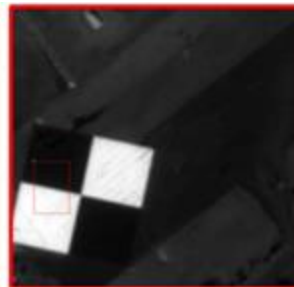
Target	Description and Dimensions	Orientation (to true north)	Lat / Long	Status
Salon de Provence, France	60m x 60m, 2x2 checkerboard, painted tar pad	$\sim -3^\circ / 87^\circ$	43.60583N 5.12028E	Good
Stennis Space Center, USA	45m x 45m (?), 2x2 checkerboard		23.51972N 119.58333W	Need Repainting
Penghu, Taiwan	60m x 60m, 2x2 checkerboard, painted surface	$0^\circ / 90^\circ$	30.38667N 89.62861E	Need Repainting
Big Spring, USA	40m x 40m, 2x2 checkerboard, painted concreted			
Baotou city, China	48m x 48m for a single panel, contrast (W/B) > 5:1	5°	40.85167N 109.62889E	Good
Mongol with KARI	70m x 70m, 2x2 checkerboard, painted surface	-11.19°	47.71049N 106.98953E	Good
Shadnagar, India			16.902709N 78.195753E	Good



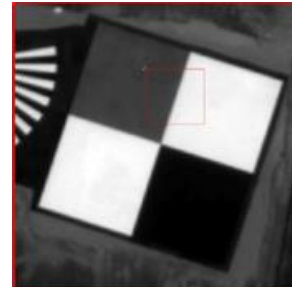
Salon



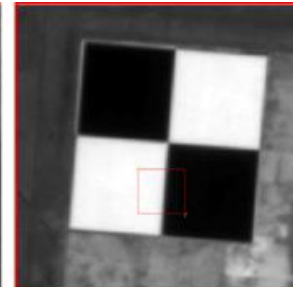
Stennis



Penghu



Baotou

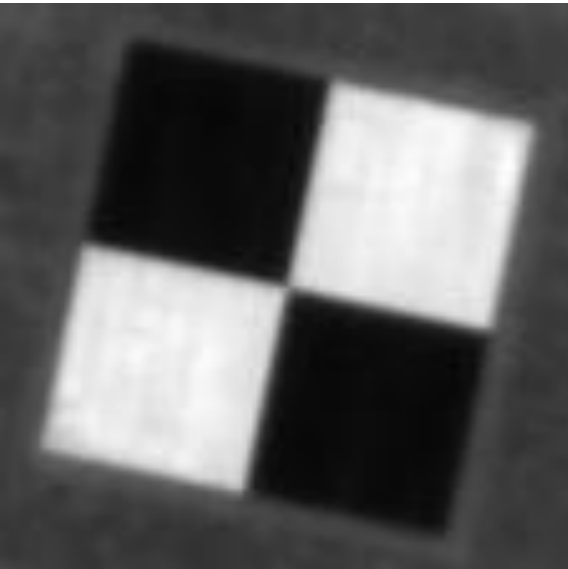


Mongol



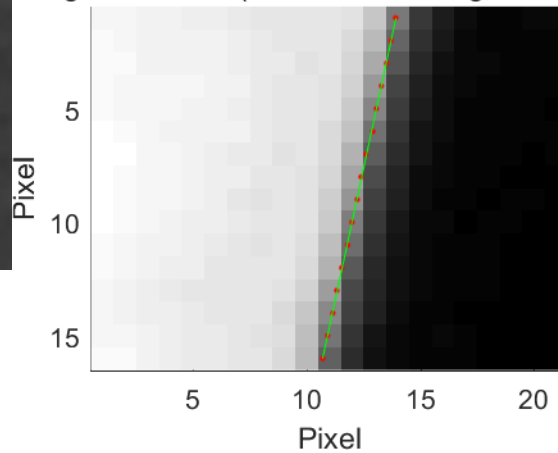
India

Salon de Provence, France

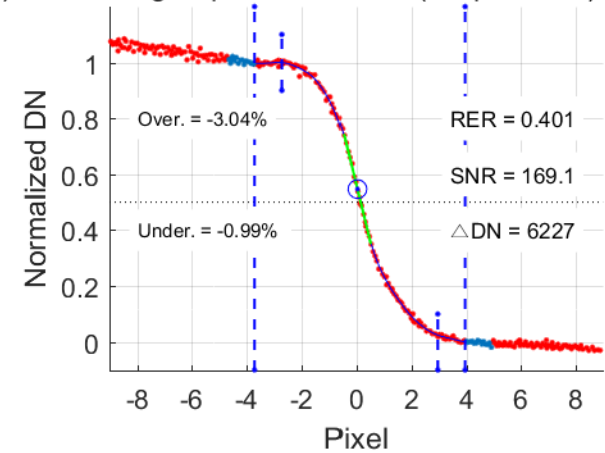


- Imaging date: 2017.08.03
- Tilt angle: -7.42deg

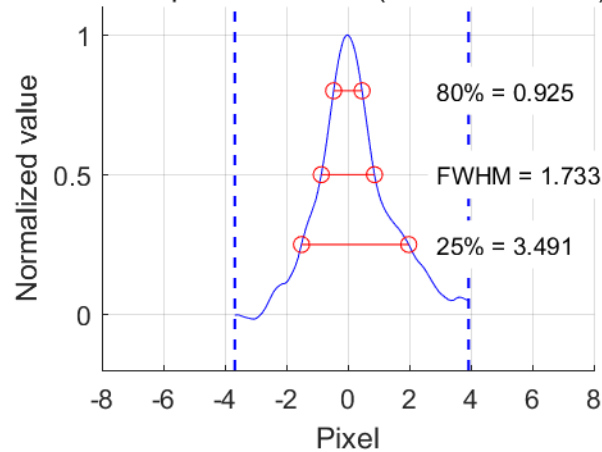
Edge Detection (Across, 12.15 deg, Fit Err:1.6)



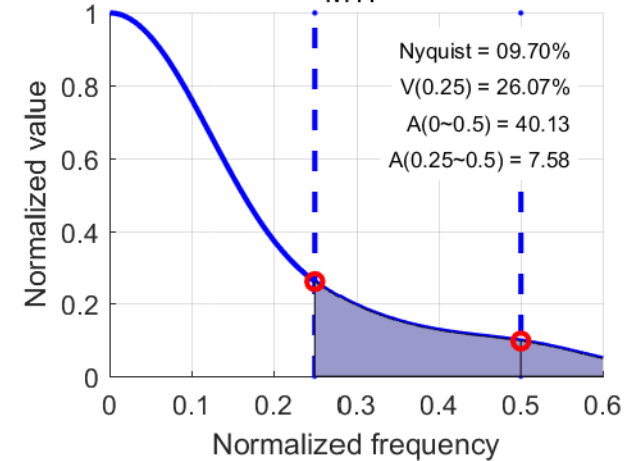
Edge Spread Function (csaps= 0.98)



Line Spread Function (Resolution: 0.06)



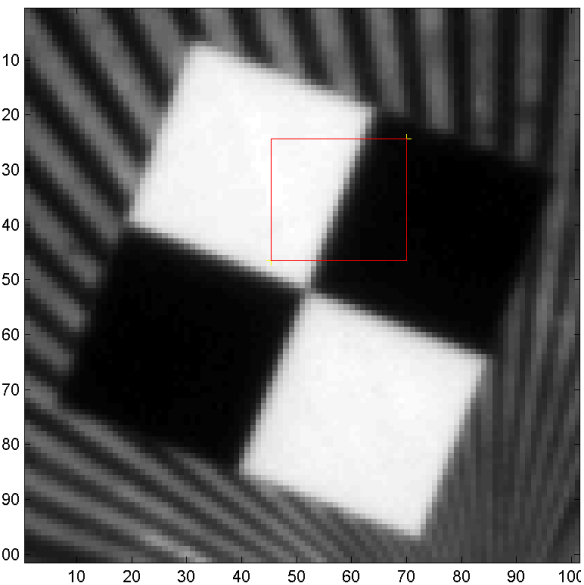
MTF



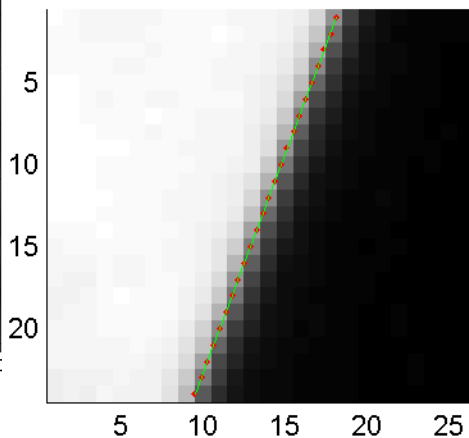
Imaged by KOMPSAT-3
(GSD: 0.7m)

Stennis Space Center, USA

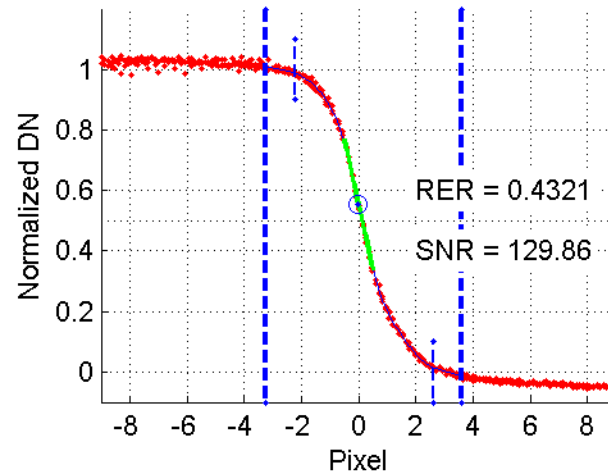
- Imaging date: 2014.04.30
- Tilt angle: 2.11deg



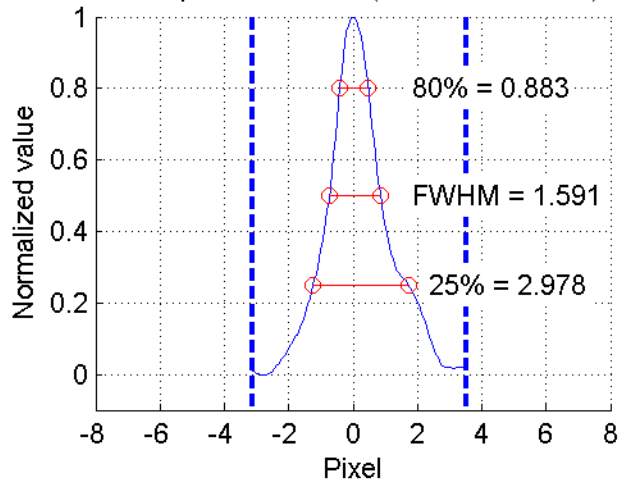
Edge Detection (Across, 20.56 deg)



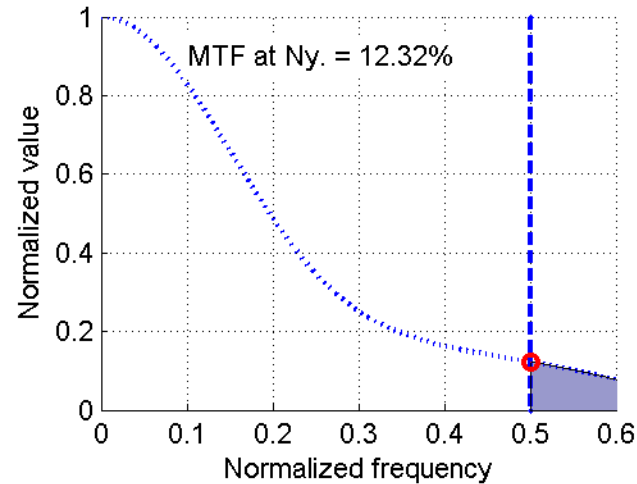
Edge Spread Function (csaps= 0.98)



Line Spread Function (Resolution x 0.05)



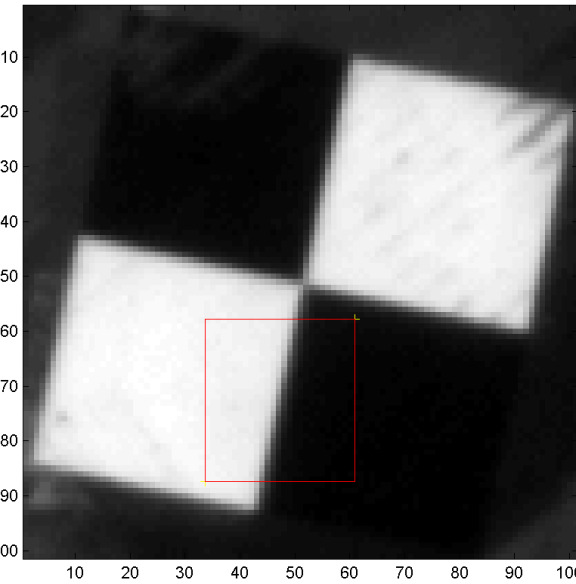
MTF



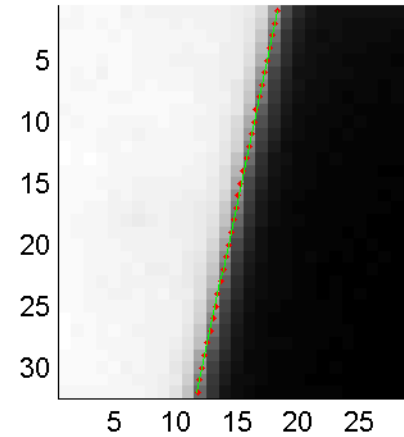
Imaged by KOMPSAT-3
(GSD: 0.7m)

Penghu, Taiwan

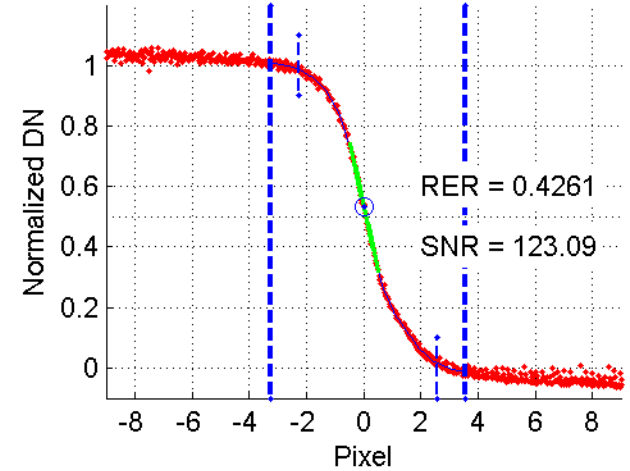
- Imaging date: 2014.04.29
- Tilt angle: 7.29deg



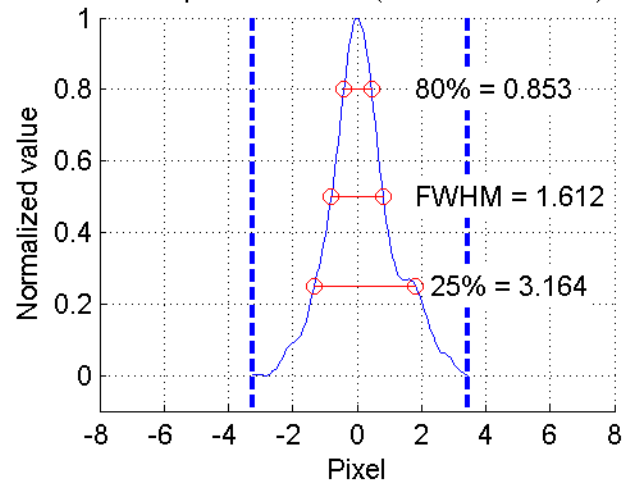
Edge Detection (Across, 11.89 deg)



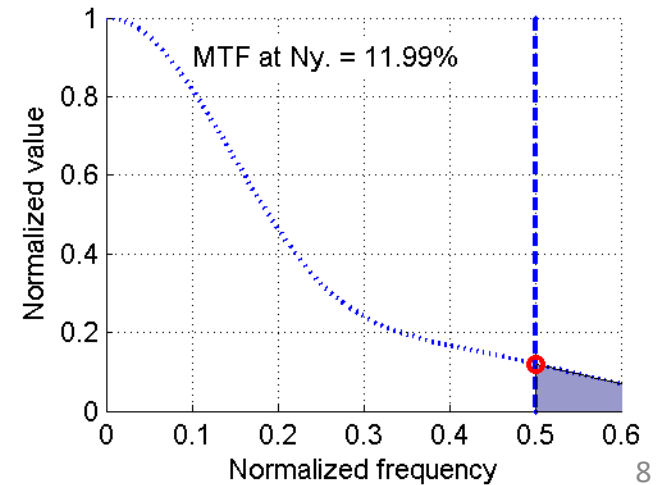
Edge Spread Function (csaps= 0.98)



Line Spread Function (Resolution x 0.05)



MTF



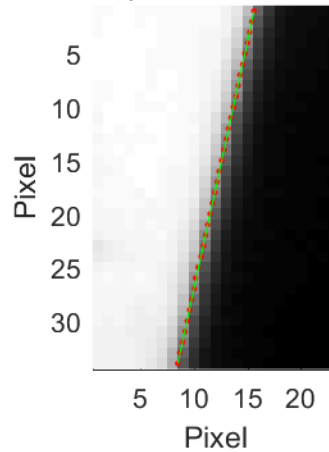
Imaged by KOMPSAT-3
(GSD: 0.7m)

Baotou, China

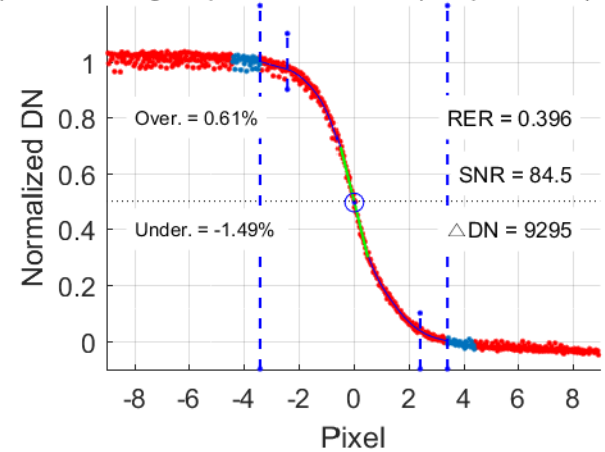


- Imaging date: 2017.08.03
- Tilt angle: 24.22deg

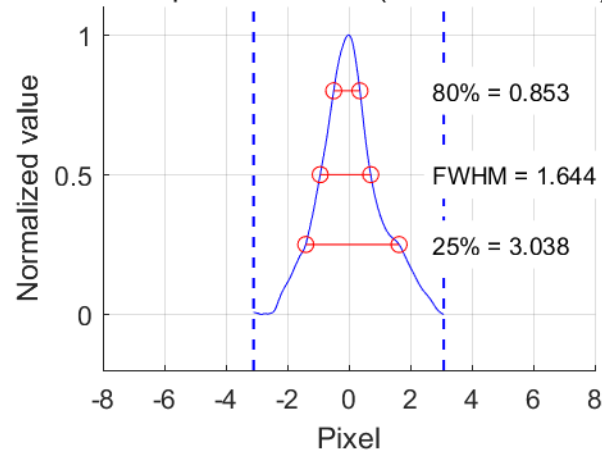
Edge Detection (Across, 12.20 deg, Fit Err:1.7)



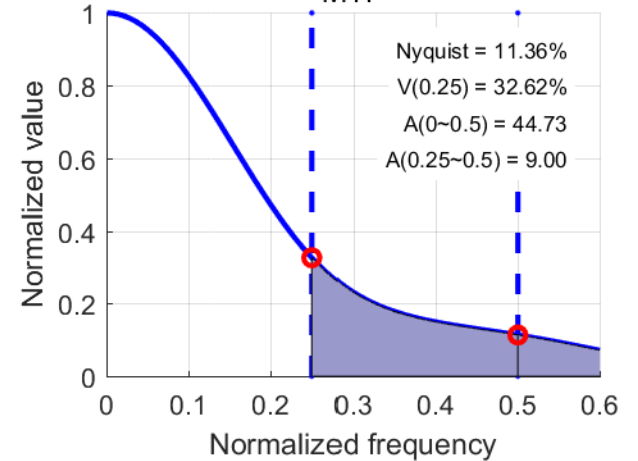
Edge Spread Function (csaps= 0.98)



Line Spread Function (Resolution: 0.05)



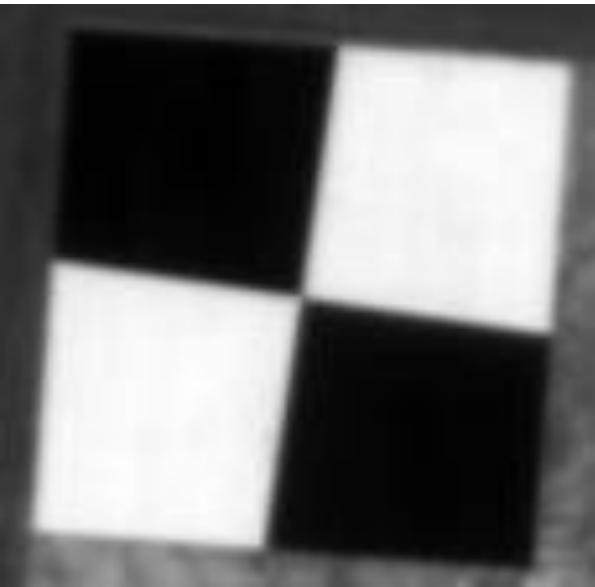
MTF



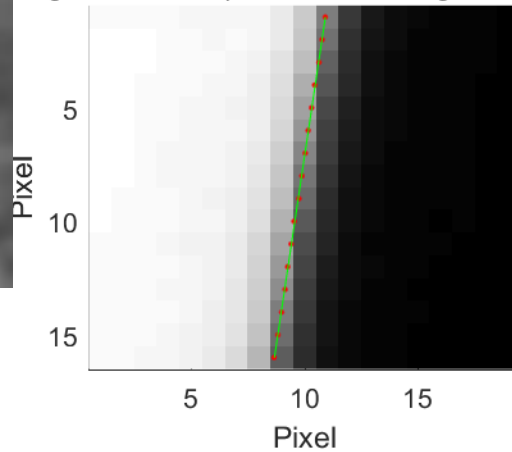
Imaged by KOMPSAT-3
(GSD: 0.7m)

Mongolia

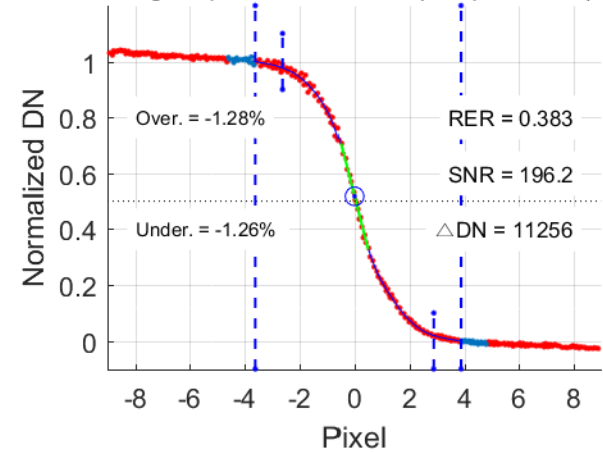
- Imaging date: 2017.07.21
- Tilt angle: 5.42deg



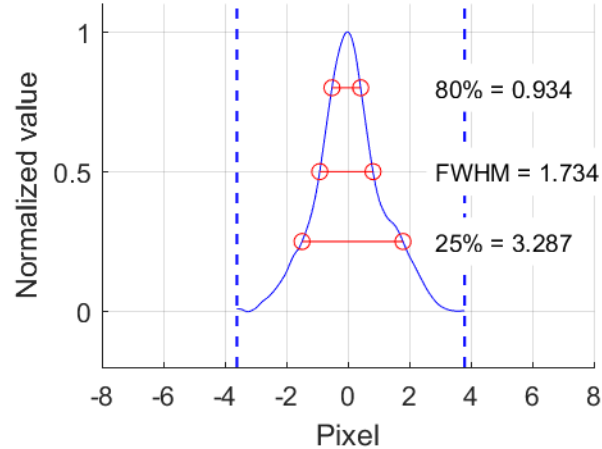
Edge Detection (Across, 8.51 deg, Fit Err:0.9)



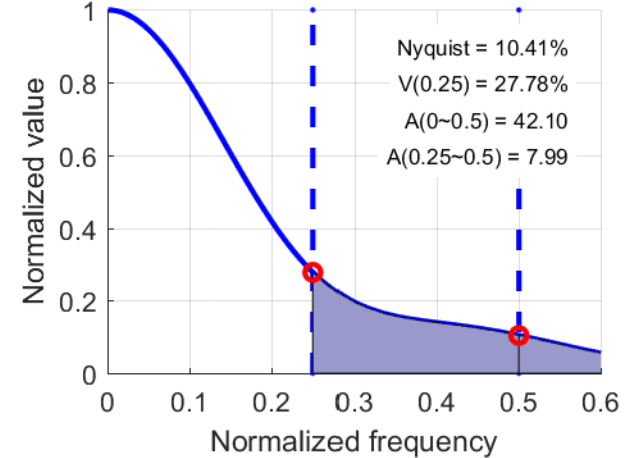
Edge Spread Function (csaps= 0.98)



Line Spread Function (Resolution: 0.06)



MTF



Imaged by KOMPSAT-3
(GSD: 0.7m)

Agenda

1. Status of Edge target in worldwide

2. Spatial Quality of KOMPSAT-3 by KARI methodology

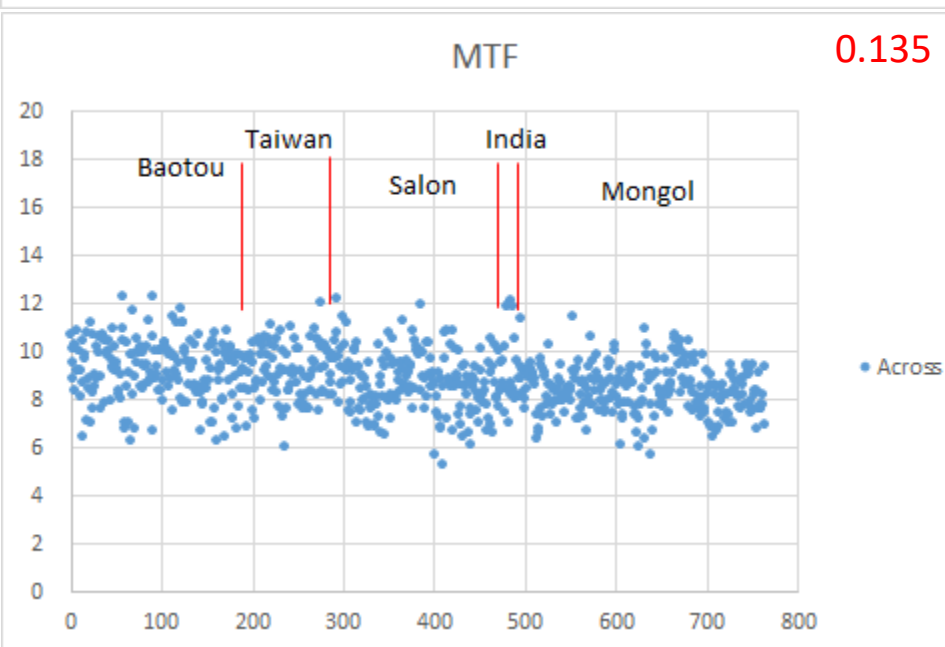
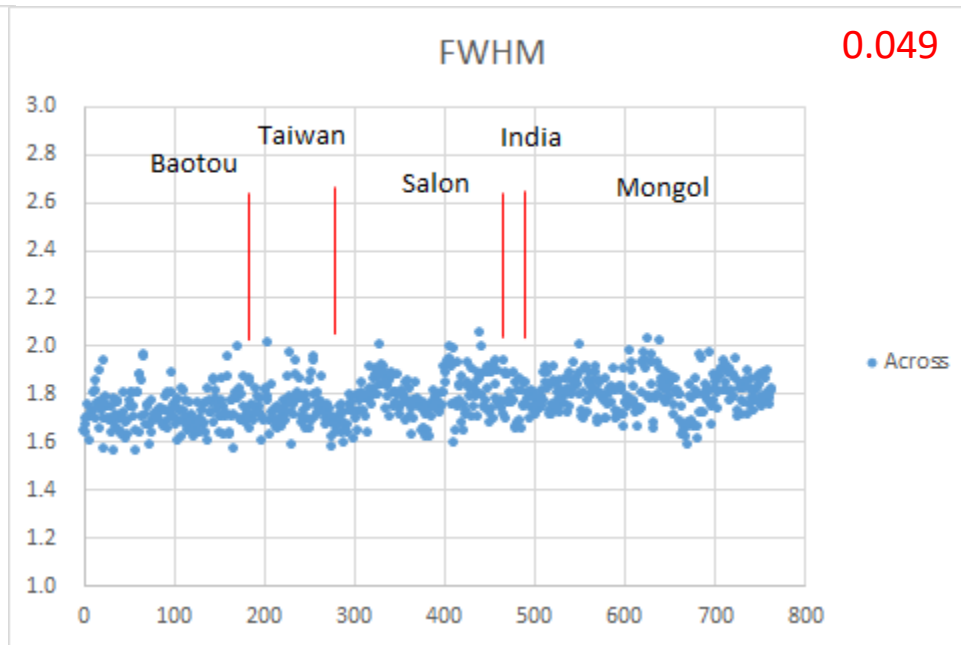
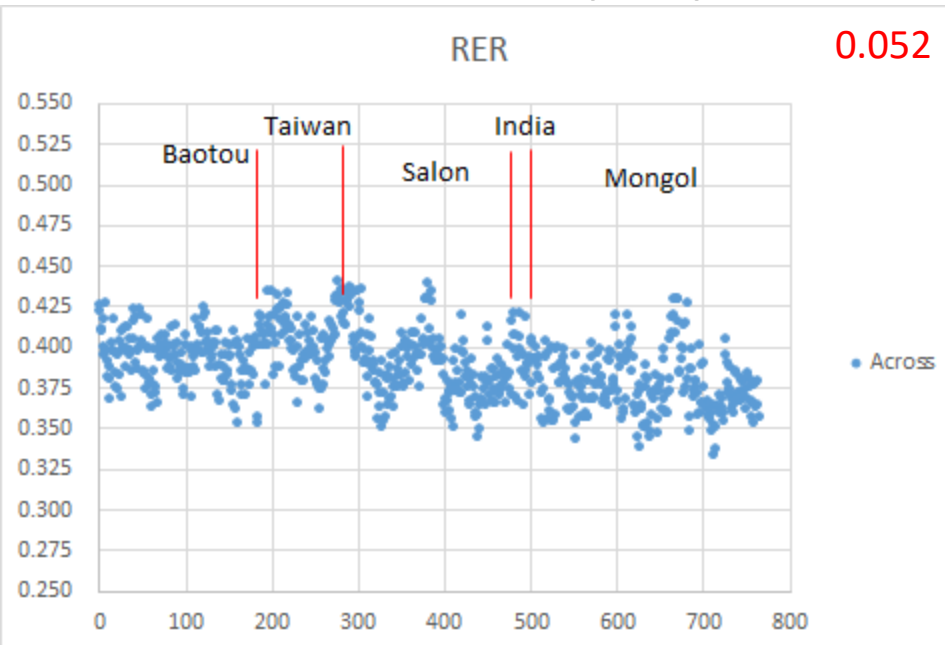
Results from Edge targets with KOMPSAT-3

		No.	RER	FWHM	MTF		MTF Area			SD/Ave		
					Nyq.	0.25	0~0.5	0~0.25	0.25~0.5	RER	FWHM	MTF
Across	Baotou	185	0.394	1.727	9.23	26.59	39.68	31.74	7.94	0.036	0.046	0.134
	Taiwan	21	0.408	1.749	8.94	29.06	40.65	32.58	8.07	0.037	0.047	0.104
	Salon	272	0.393	1.773	8.86	26.77	39.08	31.63	7.45	0.053	0.050	0.137
	India	19	0.396	1.757	9.55	25.10	40.00	32.26	7.73	0.045	0.040	0.168
	Mongol	268	0.377	1.803	8.40	23.89	37.89	30.95	6.93	0.047	0.044	0.115
	Ave	765	0.388	1.771	8.81	25.74	38.87	31.46	7.41			
	Max		0.441	1.558	12.31	35.33	44.34	34.97	9.47			
	Min		0.338	2.056	5.23	17.34	33.66	28.09	5.39			
	StdDev		0.020	0.087	1.19	3.24	1.99	1.25	0.80			
	SD/Ave		0.052	0.049	0.135	0.126	0.051	0.040	0.108			

(Imaging period) Jan. 2014 ~ July 2019

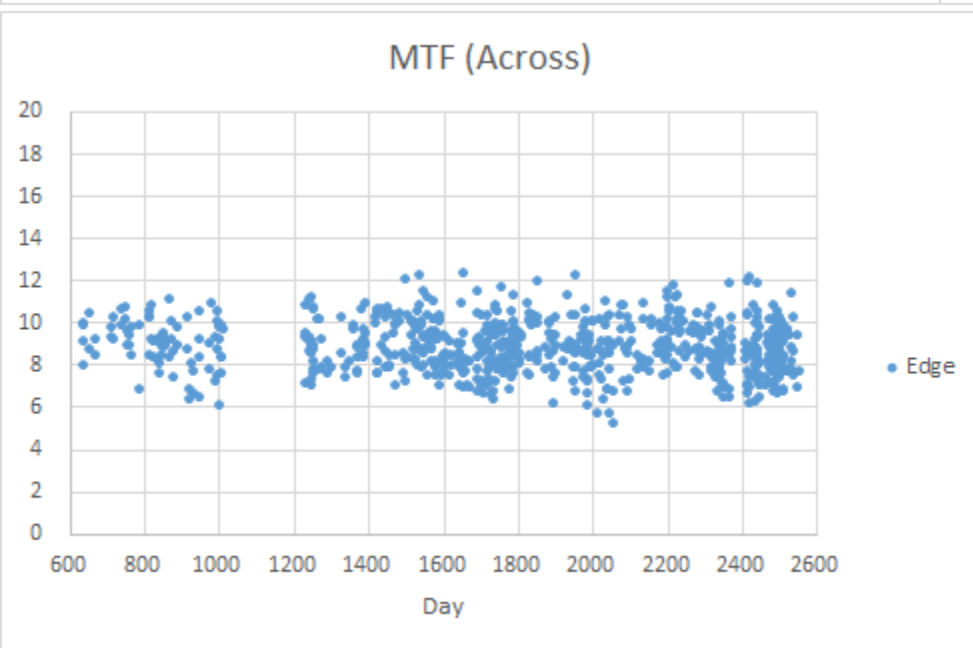
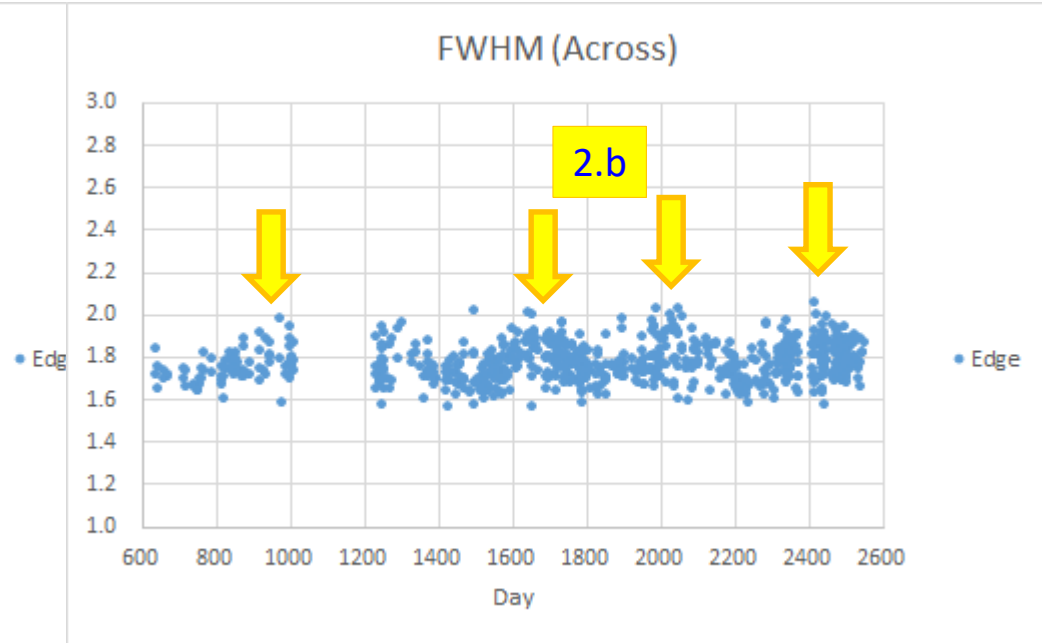
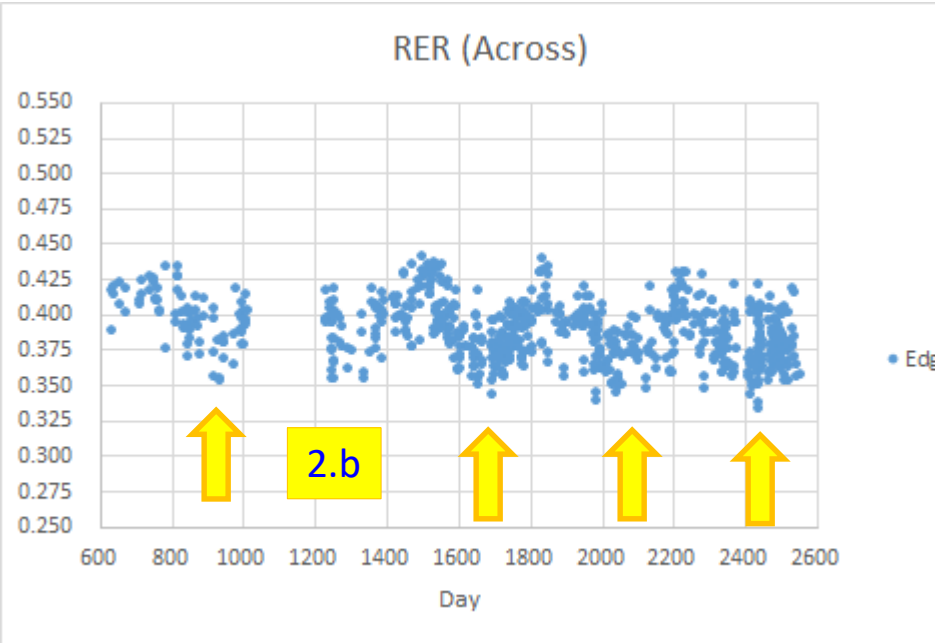
(K3) RER, FWHM, MTF

(Across) Std.Dev / Average



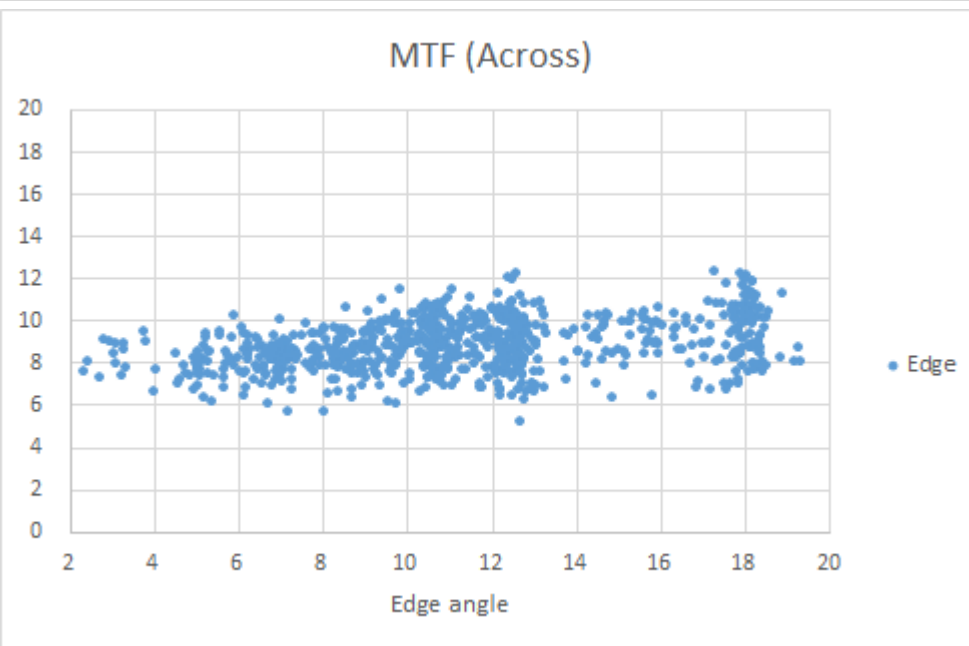
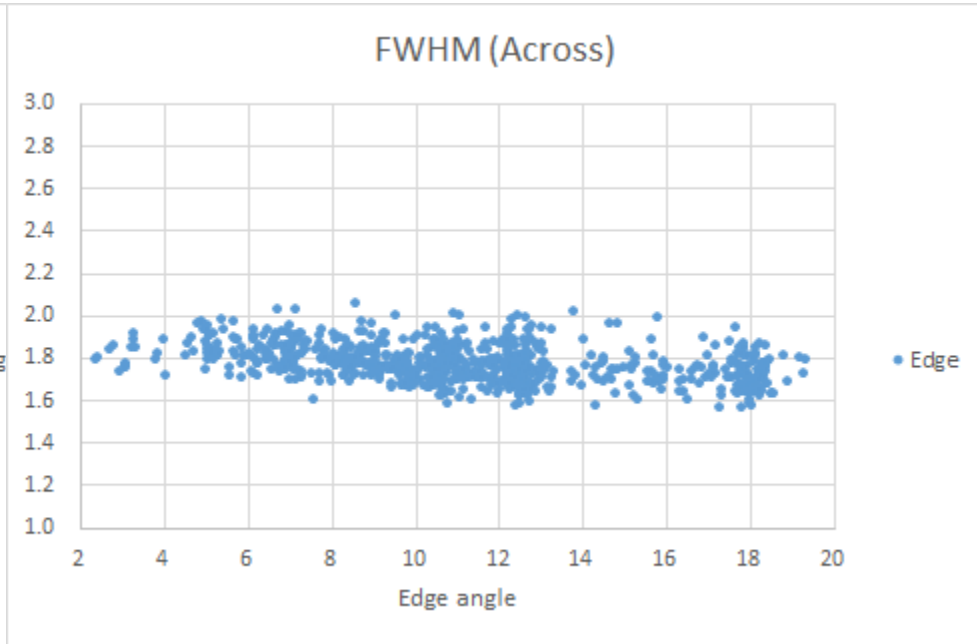
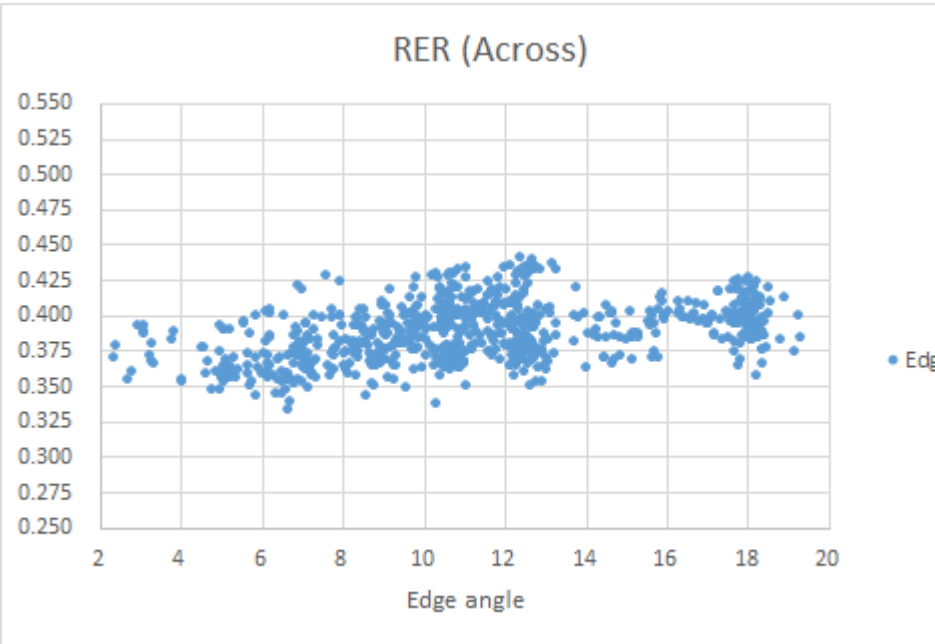
1. RER & FWHM are stable.
2. MTF @ Nyq as estimator is not good.
3. Each of them shows a little different result.
 - a. Status of them may be a little different.
 - ✓ Cleaning, Some condition

(K3) RER, FWHM, MTF (Day)

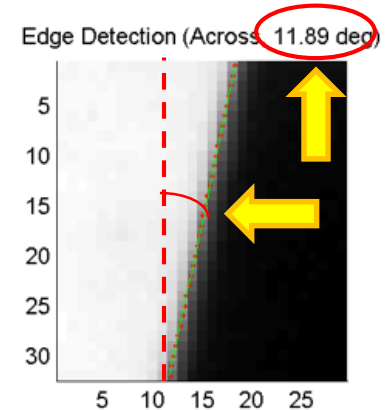


1. 'Day' from KOMPSAT-3 launch
2. RER & FWHM are Fluctuating & Decreasing.
 - a. (Decreasing) Overall
 - b. (Fluctuating) Oct~Feb in 2015,2017,2018, 2019
3. Two possible reasons
 - a. Seasonal variation
 - b. KOMPSAT-3: Reliability down

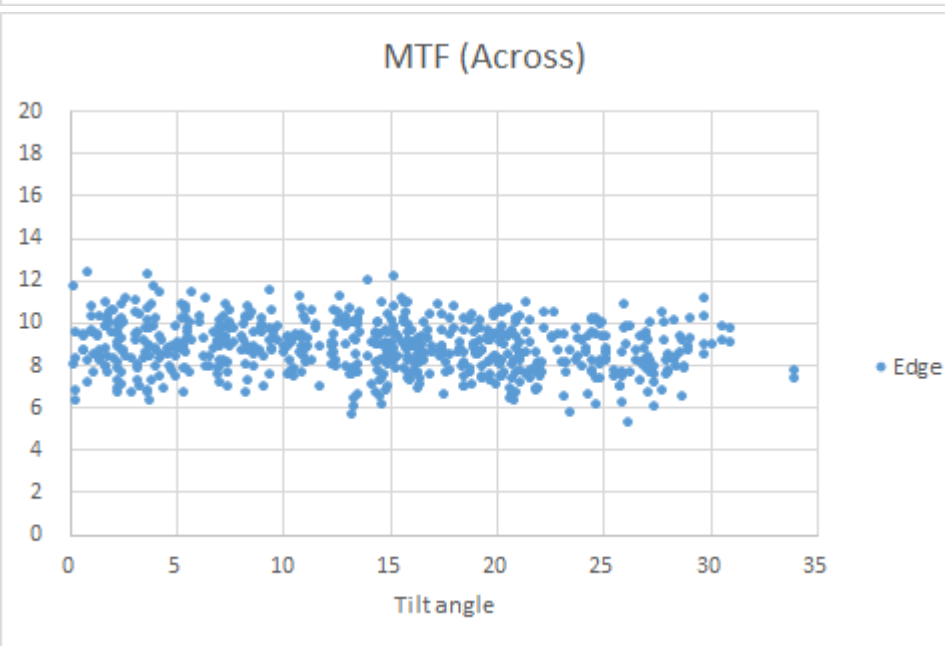
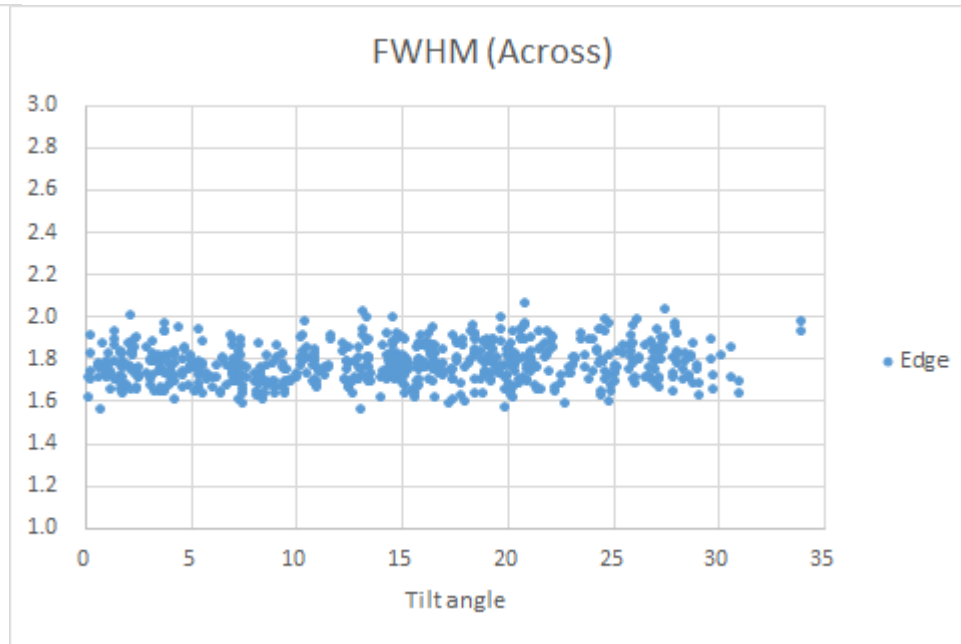
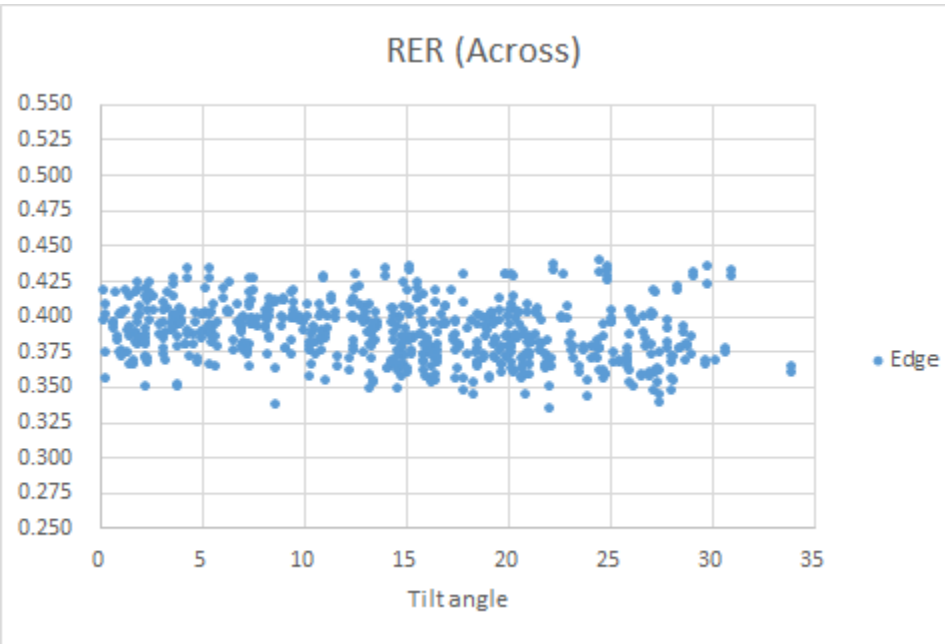
(K3) RER, FWHM, MTF (Edge angle)



1. RER, FWHM & MTF don't depend on Edge angle.
2. A little Slope by Edge target (????)



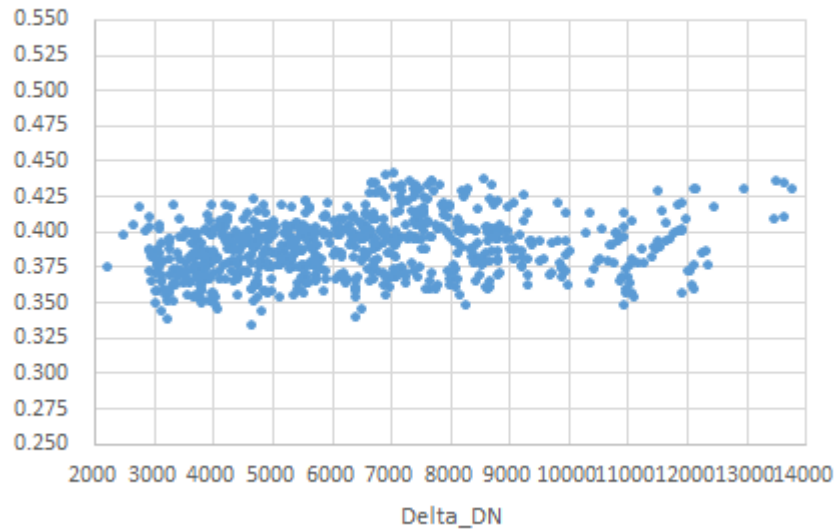
(K3) RER, FWHM, MTF (Roll tilt angle)



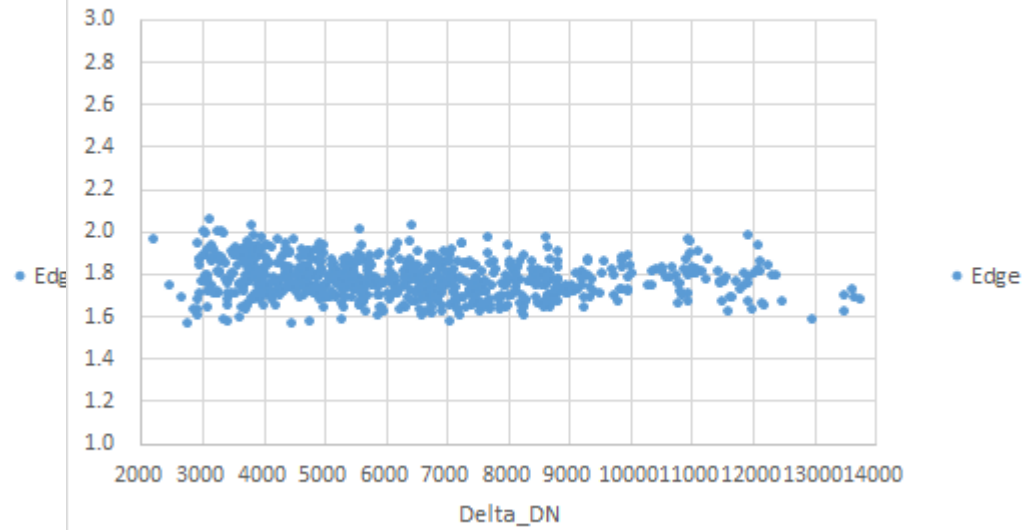
1. RER, FWHM & MTF don't depend on Roll tilt angle.

(K3) RER, FWHM, MTF (Δ DN)

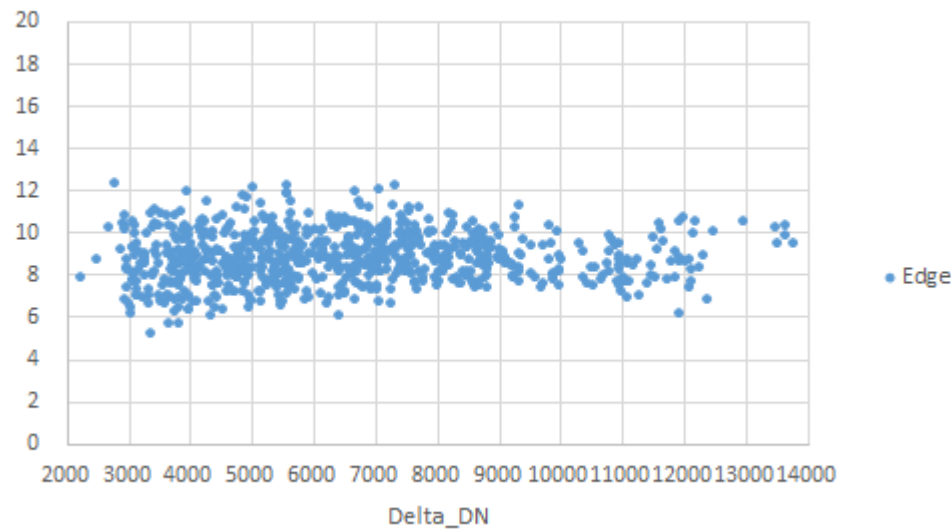
RER (Across)



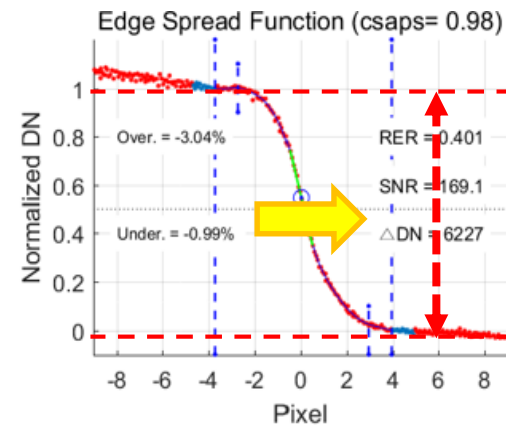
FWHM (Across)



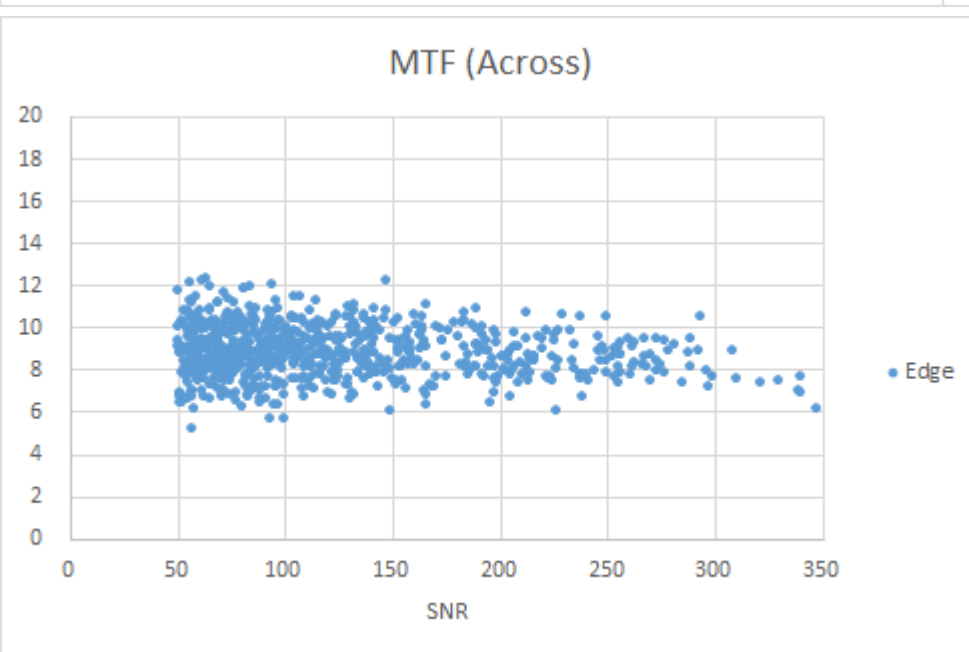
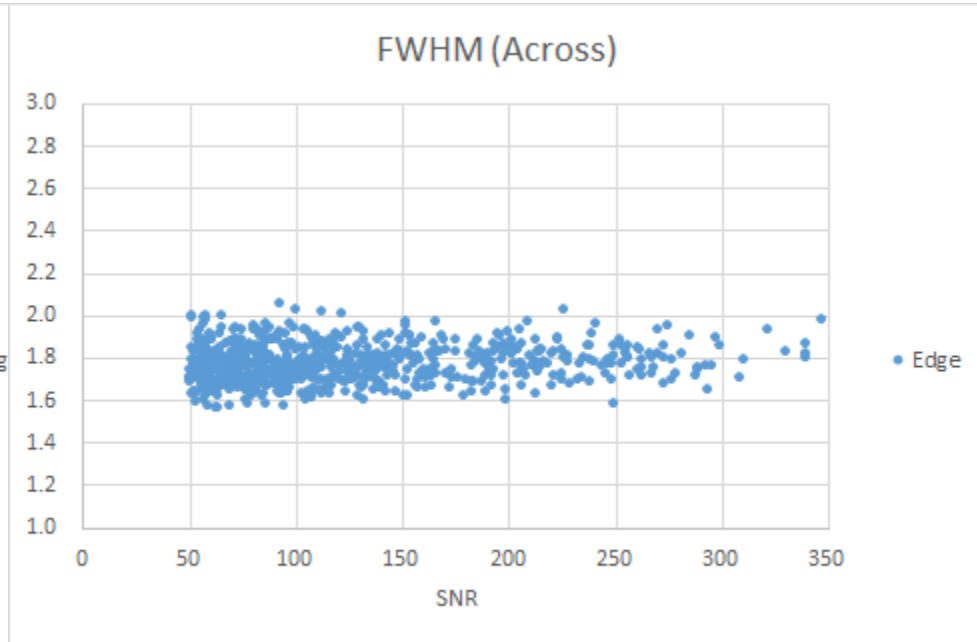
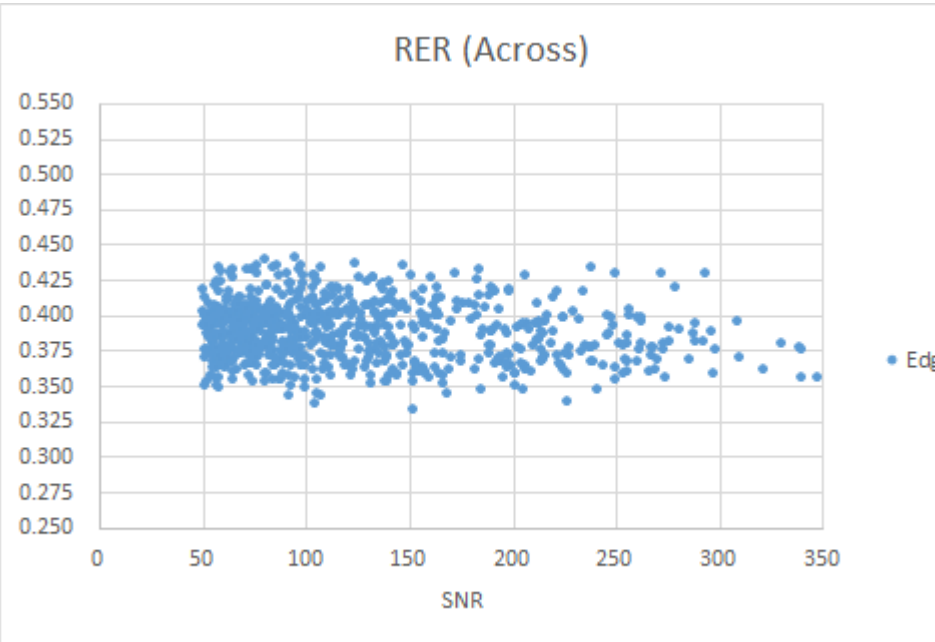
MTF (Across)



1. (K3) 14bit (0~16383 DN)
2. RER, FWHM & MTF don't depend on Δ DN.



(K3) RER, FWHM, MTF (SNR)



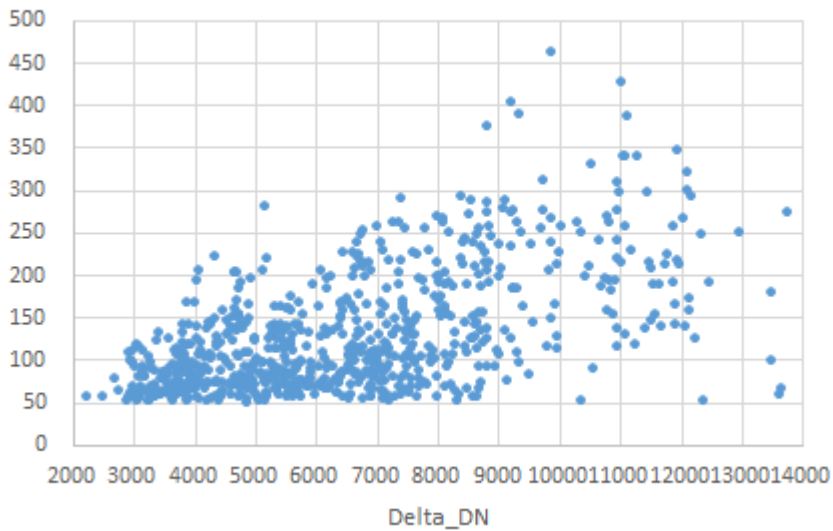
1. RER, FWHM & MTF don't depend on SNR.

❖ Method for measuring SNR has to be Updated~!

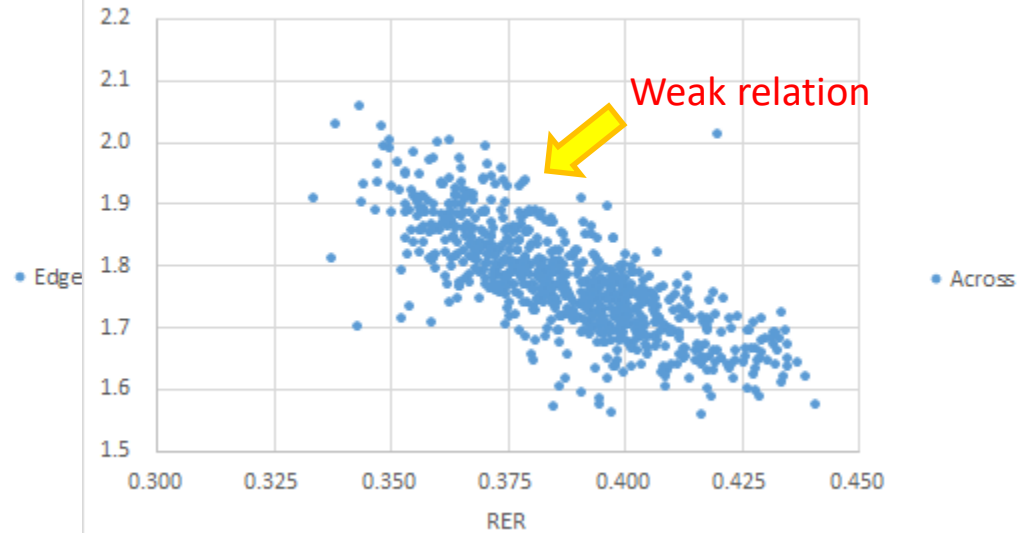
- Edge target is not Uniform. (Need Cleaning, Sweeping & Re-painting)
- SNR of K3 > 100

(K3) SNR vs. Δ DN

SNR vs. Delta_DN (Across)



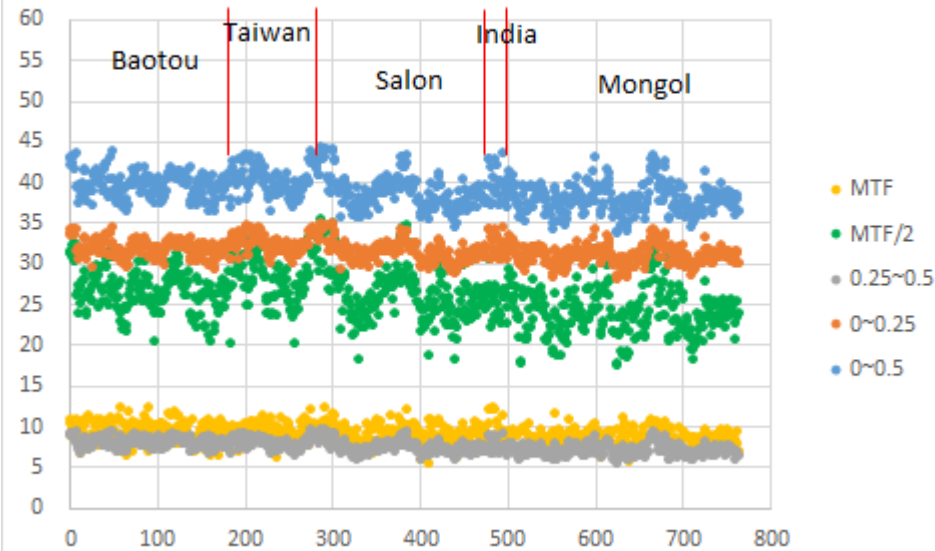
RER - FWHM



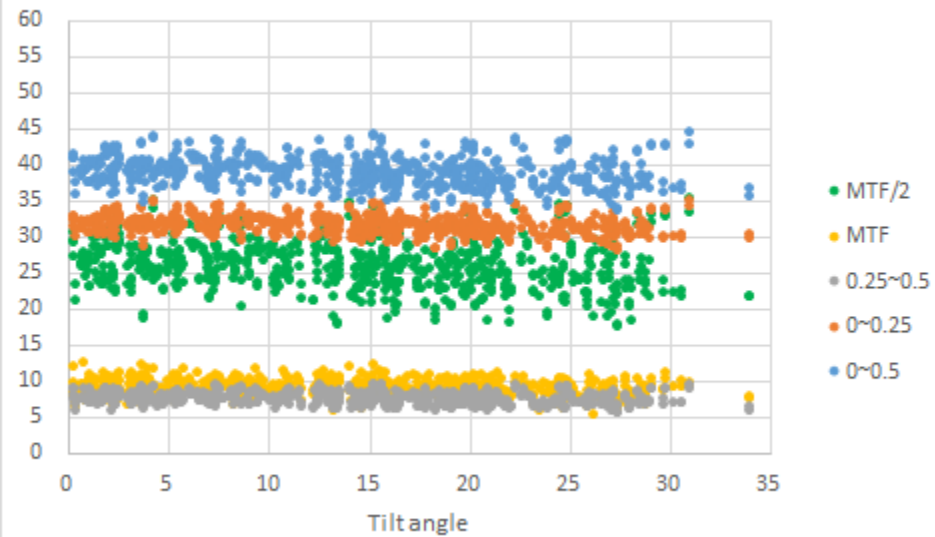
1. Weak relation between RER and FWHM
2. There is a relation between SNR and Δ DN.
 - Plan to change the Reasonable SNR calculation method

(K3) MTF area on MTF curve plot

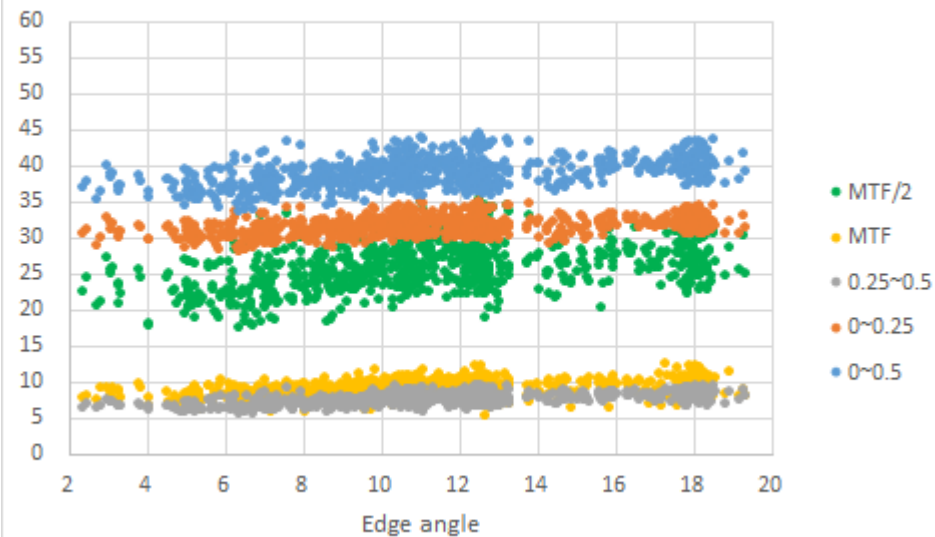
MTF area (Across)



MTF area (Across) - Tilt angle



MTF area (Across) - Edge angle

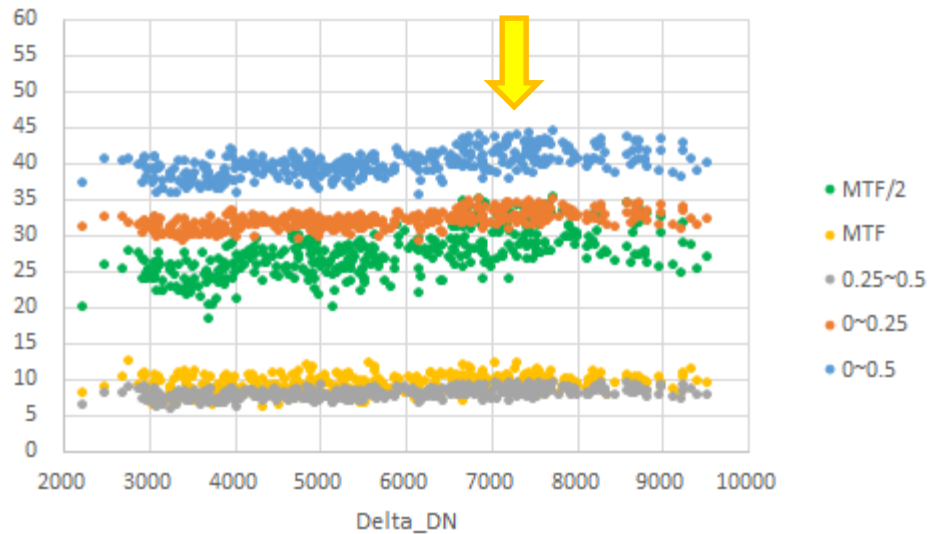


1. MTF area is stable.
2. MTF area don't depend on Roll tilt angle & Edge angle.

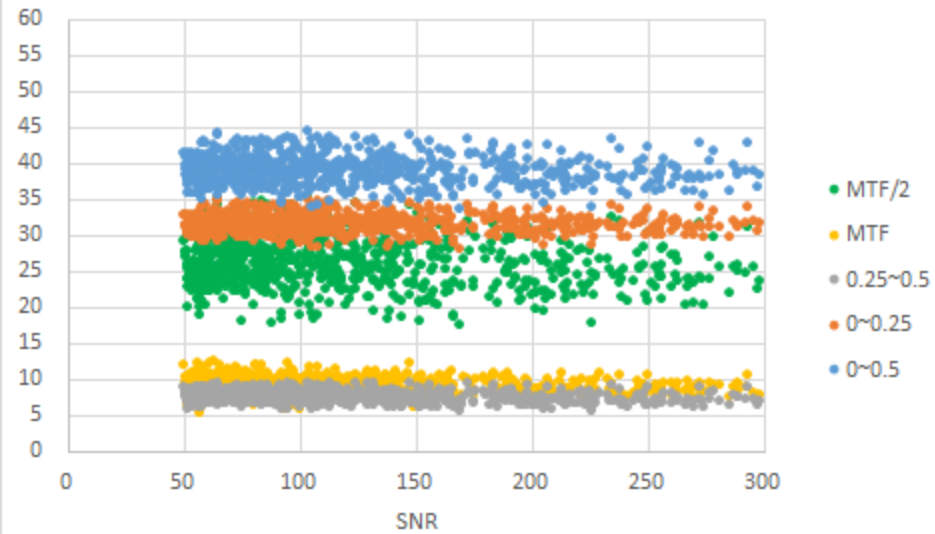
Parameter	SD/Ave	Parameter	SD/Ave
RER	0.051	MTF area 0~0.5	0.051
FWHM	0.049	MTF area 0~0.25	0.040
MTF	0.135	MTF area 0.25~0.5	0.108
MTF 0.25	0.126		

(K3) MTF area on MTF curve plot

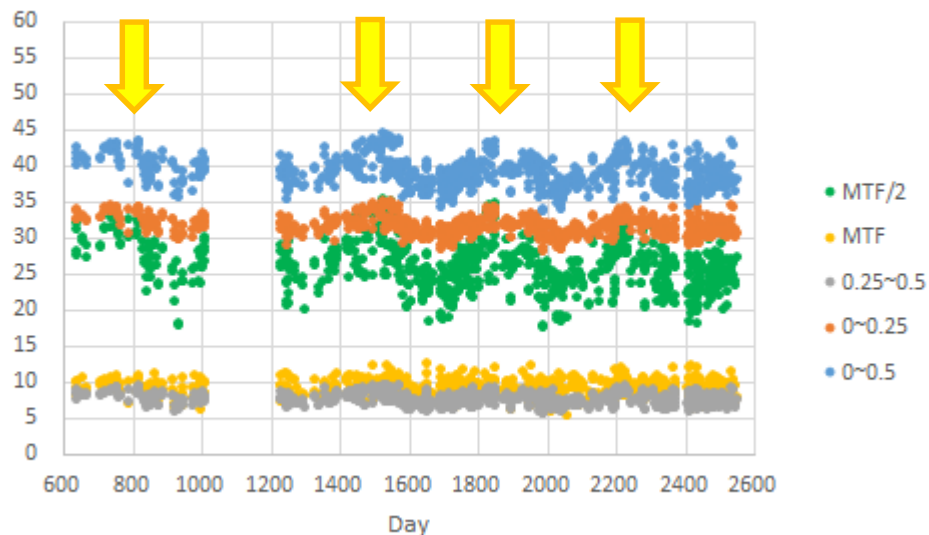
MTF area (Across) - Delta_DN



MTF area (Across) - SNR



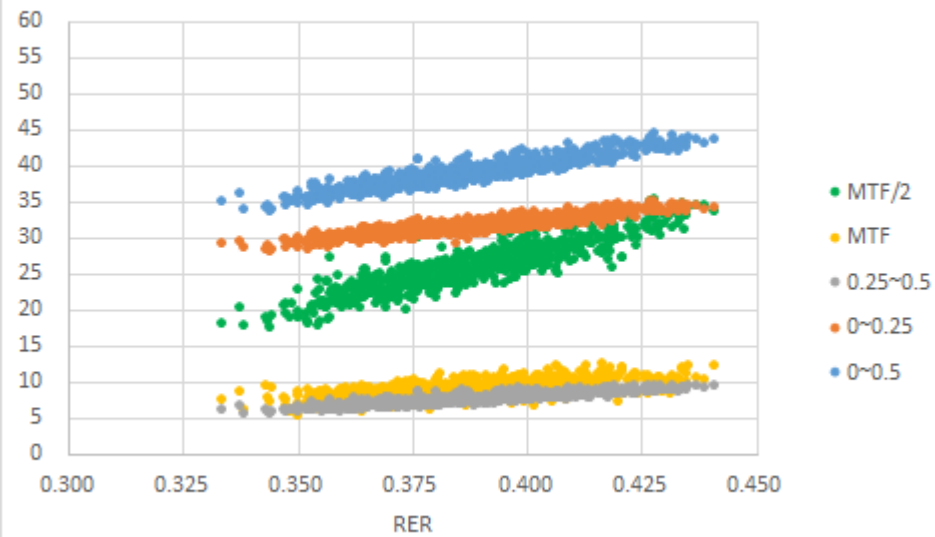
MTF area (Across) - Day



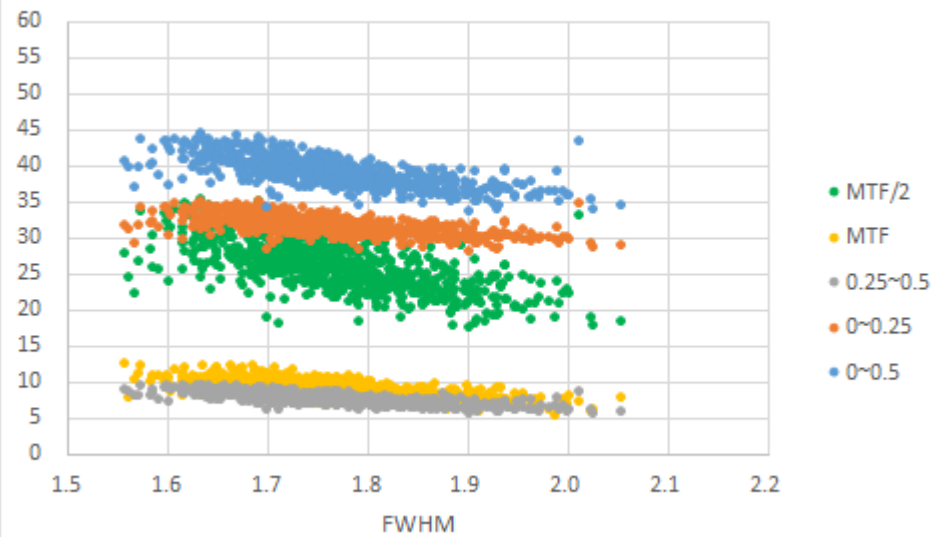
1. MTF area don't depend on Δ DN (????)
2. MTF area don't depend on SNR.
3. (Day) MTF area may be Fluctuating & Decreasing.
 - a. Oct~Feb in 2015,2017,2018, 2019
4. Two possible reasons
 - a. Seasonal variation
 - b. KOMPSAT-3: Reliability down (????)

(K3) MTF area on MTF curve plot

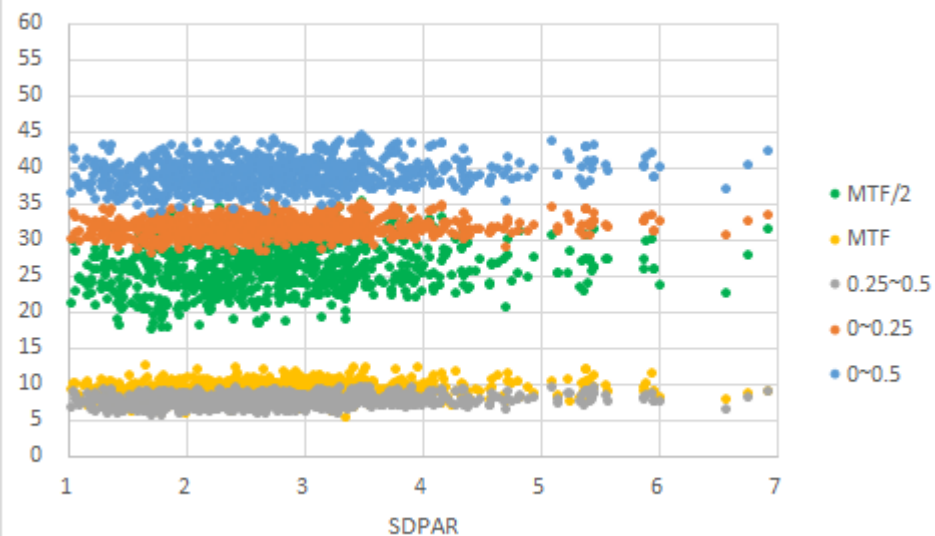
MTF area (Across) - RER



MTF area (Across) - FWHM



MTF area (Across) - SDPAR



1. Good relation between MTF area and RER & FWHM.

Summary and Future works (1/2)

1. Each of Edge target shows a little different result of RER, FWHM & MTF
 - a. Status of them may be a little different. (Cleaning, Some condition, etc.)
2. RER, FWHM may be Fluctuating and Decreasing by two possible reasons (Oct~Feb 2015, 2017, 2018, 2019)
 - a. (Fluctuating) Seasonal variation
 - b. (Decreasing) KOMPSAT-3: Reliability down
3. (Edge angle) RER, FWHM & MTF don't depend on Edge angle.
4. (Roll tilt angle) RER, FWHM & MTF don't depend on Roll tilt angle.
5. (Δ DN) RER, FWHM & MTF may or not depend on Δ DN
6. (SNR) RER, FWHM & MTF don't depend on SNR.
7. As Spatial quality estimator
 - a. MTF @ Nyq. is not good.
 - b. RER & FWHM are Stable.
 - c. MTF Area 0.5 & 0.25 are Stable

Parameter	SD/Mean
RER	0.051
FWHM	0.049
MTF	0.135
MTF 0.25	0.126
MTF area 0~0.5	0.051
MTF area 0~0.25	0.040
MTF area 0.25~0.5	0.108

Summary and Future works (2/2)

8. There is a relation between SNR and Δ DN.
 - a. Edge target is not Uniform. (Need Cleaning, Sweeping & Re-painting)
 - b. SNR of KOMPSAT-3 > 100

9. Maintenance and Monitoring be Needed to;
 - a. Keep and Share the status of the Edge targets (CCTV?)
 - b. Imaging by the several satellites

10. MTF area is stable
 - a. MTF area don't depend on Roll tilt angle, Edge angle, SNR & Δ DN.
 - b. (Day) MTF area also be Fluctuating. (Oct~ Feb in 2017,2018,2019)

11. Good relation between MTF area and RER & FWHM.
 - a. Weak relation between RER and FWHM

< Future work >

- ① KOMPSAT-3A will be added, and Along direction too
- ② CEOS WGCV IVOS, GeoSpatial W/G