cnes CENTRE NATIONAL D'ÉTUDES SPATIALES	**Centre National d'Etudes Spatiales**	megha tropiques
SCA _RAD_08 TRO-34-NT-2786-CNES	**Activity : CAL/VAL** **Level A1/A2 comparison**	**Prepared by : CNES Team** **Verified by : N Karouche**

Contents

1. OBJECTIVE

The two main Channels are Channel 2 (solar channel, 0.2-4µm) and Channel 3 (total channel, 0.2-200µm). Channel 2 is dedicated to measure solar radiance (L_{sw}). Channel 3 measures total radiance (L_{tot}). Long wave radiance (L_{lw}) is computed by the difference between total channel and solar channel : $L_{lw} = L_{tot} - A' L_{sw}$

A' represents the difference of sensibility in the SW domain, between Channel 2 and Channel 3.

To compute L_{lw}, it is absolutely necessary that Channel 2 (L_{sw}) and Channel 3 (L_{tot}) aim exactly at the same location. The difference of location between the two channels is called registration.

In-flight Scarab registration performances are very close to the requirements for L1A1 product.

However, the small difference of location between Channel 2 and Channel 3 can be reduced by resampling the Channel 3 over the Channel 2. This is done for the L1A2 product.

Resampling can bring artefacts, however, as Scarab spatial sampling respects Shannon theorem, these artefacts should be negligible.

The object of this study is to compare L1A1 and L1A2 products, in term of radiometry, and to see if L1A2 is significantly better than L1A1.

In nominal mode, Channel 2 (solar filter) and Channel 3 (no filter) images are too different to be compared.

But with MS mode, both channels have the same solar filter. If they aim exactly at the same location, they should give almost exactly the same result.

If not, this can be assign to several factors:

+A' factor (the proportional factor between Channel 2 and 3). This factor is easily determined in MS mode.

+A' spectral sensibility. A' is not constant and depends on spectral signature of the scene.

+Registration (both channels don't aim exactly at the same location).

By comparing Channel 2 and 3 in MS mode, we can assess all these elements.

2. METHODS

L_{sw}^{2} represents the luminance measured by Channel 2. As Channel 2 has a filter, it is a Short Wave (sw) luminance.

L_{sw}^{3} represents the luminance measured by Channel 3. As Channel 3 has a filter, in this MS mode, it is also Short Wave (sw) luminance.

1/ Calculate the A' factor for this image in MS mode.

$$A'_{MS} = \text{mean}(L_{sw}^{3}) / \text{mean}(L_{sw}^{2})$$

2/ Calculate C5 Channel

$$L^{5} = L_{sw}^{3} - L_{sw}^{2} * A'_{MS}$$

In this case, C5 is not the infrared channel. C5 should be equal to 0, as Channel 2 and Channel 3 are in solar mode.

L^{5} can be calculated for level A1 and level A2 products.

Standard deviation of L^{5} measures directly the error mainly due to registration.

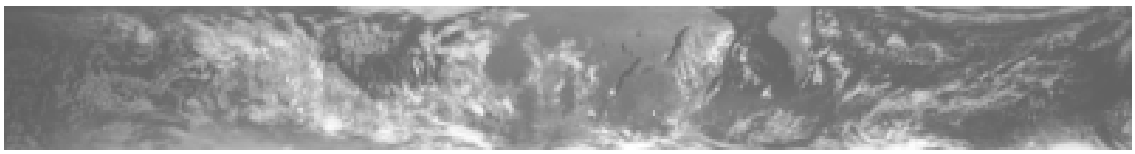
3. PRODUCTS USED

See table

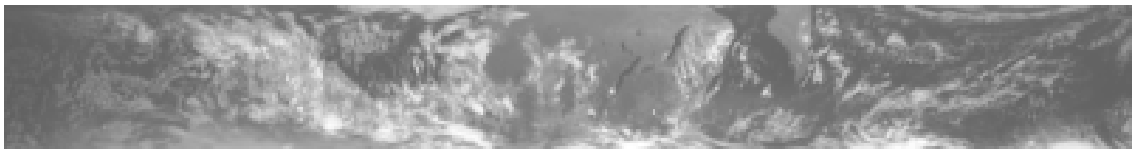
4. RESULTS

4.1. MS MODE ORBIT NUMBER 3775

4.1.1. IMAGE

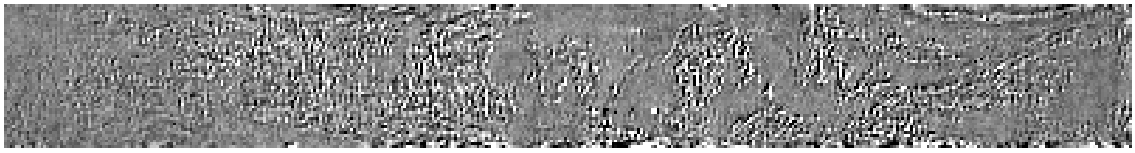


C2 channel



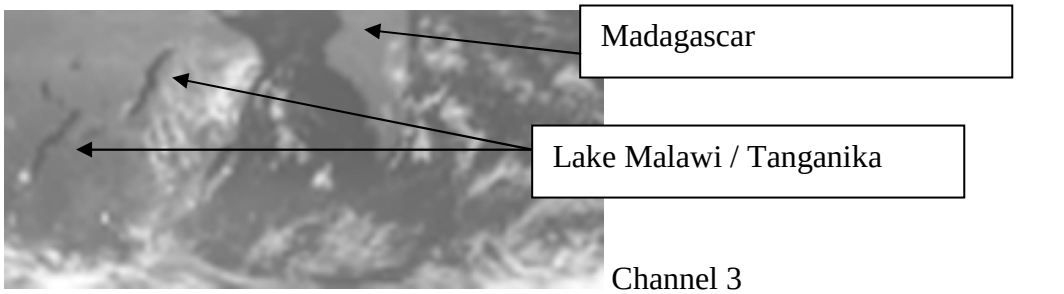
C3 channel

C5 from level A1

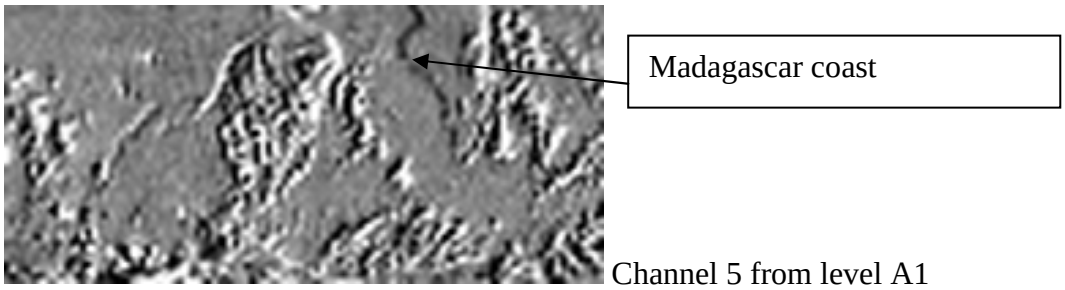


C5 from level A2

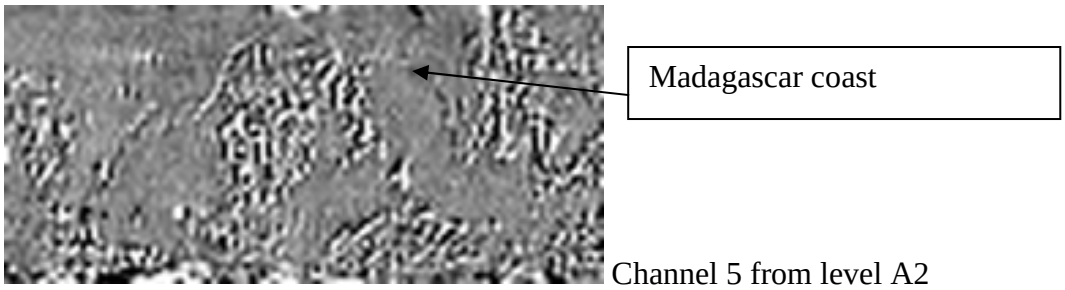
Zoom :



Channel 3



Channel 5 from level A1



Channel 5 from level A2

On level A2, Madagascar coast is almost fainted.

4.1.2. RADIOMETRIC ERROR

For each image, we can compute standard deviation, min and max of the error of the Channel 5. We can also compute the mean value of the original scene Channel 2.

	Standart deviation W/m²/sr	Min W/m²/sr	Max W/m²/sr	Mean W/m²/sr
C2				48
C5_A1	0,57	-3,8	7,8	
C5_A2	0,41	-2,9	7,6	

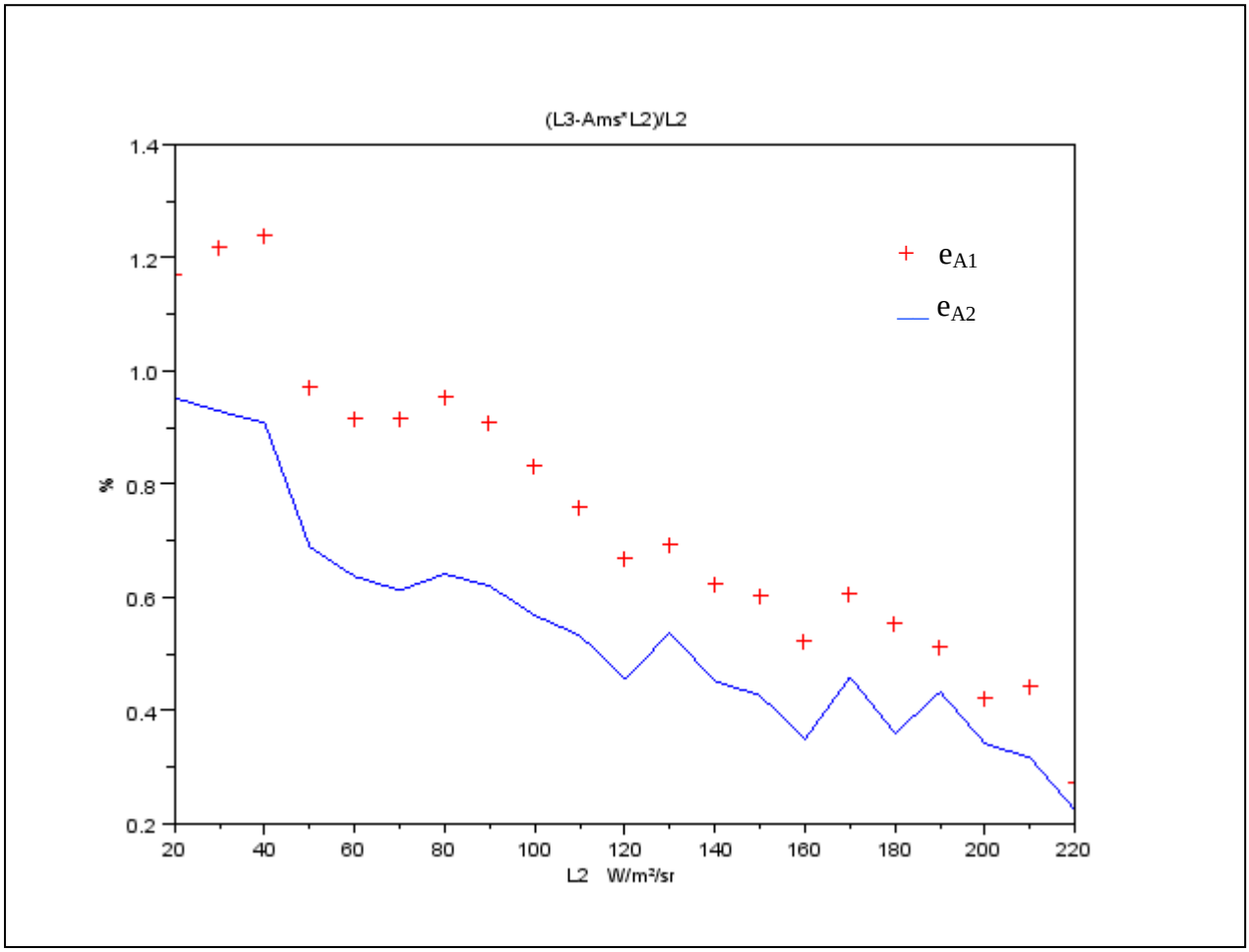
This table shows that resampling reduce the RMS error by a factor 1.4. The maximum error is slightly decreased by this treatment.

For this image, the radiometric error can be computed with:

$$e_{A1} = \frac{\sigma_{C5\_A1}}{\overline{L_{sw}^2}} = 1.1\%$$

$$e_{A2} = \frac{\sigma_{C5\_A2}}{\overline{L_{sw}^2}} = 0.85\%$$

It means that the final error on the luminance of the Channel 5, due to registration, will be roughly 0.85% of the luminance of Channel 2. As the mean luminance (for the day part of this image) is about 48 W/m²/sr, it means that the mean error on the Channel 5 will be 0.4W/m²/sr.



This radiometric error can be evaluated for each luminance level of L2 :

Roughly, the radiometric error follow the law:

For L1A1 : 0.4% at 220 W/m²/sr to 1.2% at 20 W/m²/sr $e = 0.4\% + 1.2\%/200*(220-L^2_{sw})$

For L1A2 : 0.3% at 220 W/m²/sr to 0.9% at 20 W/m²/sr $e = 0.3\% + 0.6\%/200*(220-L^2_{sw})$

4.1.3. ABSOLUTE RADIOMETRIC ERROR ON CHANNEL 5

Long wave radiance (L_{lw}) is computed by the difference between total channel and solar channel for nominal image: $L_{lw} = L_{tot} – A' L_{sw}$

The radiometric error that we should have on L_{lw}, due to registration, can be evaluated on MS image by:

$$\frac{dL_{lw}}{L_{lw}} = \frac{d(L_{sw}^3 - A'_{ms}\, L_{sw}^2)}{L_{lw}}$$

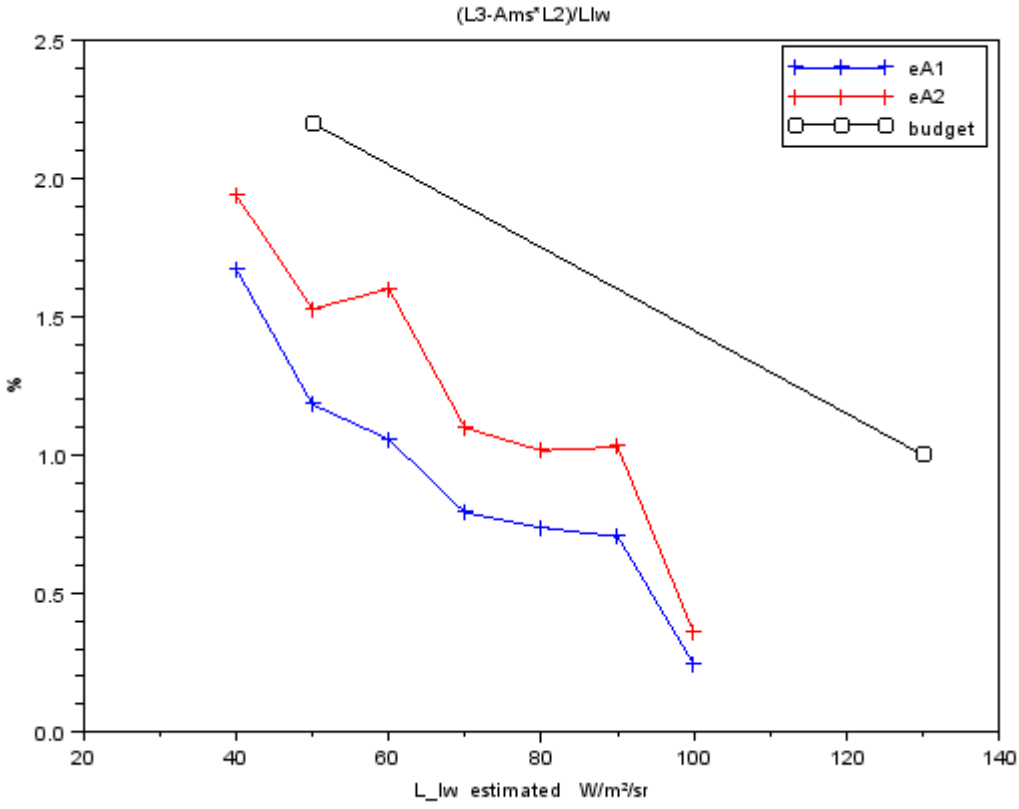
In MS mode, Channel 3 has a solar filter. It is not possible to calculate exactly L_{lw}. But this value can be estimated with the luminance L_{ir} of Channel 4 (infrared window) with polynomial interpolation. This polynomial P can be calculated on night scene, where Channel 3 receives only thermal radiance.

$L_{lw} = P(L_{ir})$

The radiometric error can be estimated by :

$$e'_{A1}(L_{lw\_estimated}) = \frac{\sigma_{C5\_A1}(L_{lw\_estimated})}{L_{lw\_estimated}}$$

$$e'_{A2}(L_{lw\_estimated}) = \frac{\sigma_{C5\_A2}(L_{lw\_estimated})}{L_{lw\_estimated}}$$

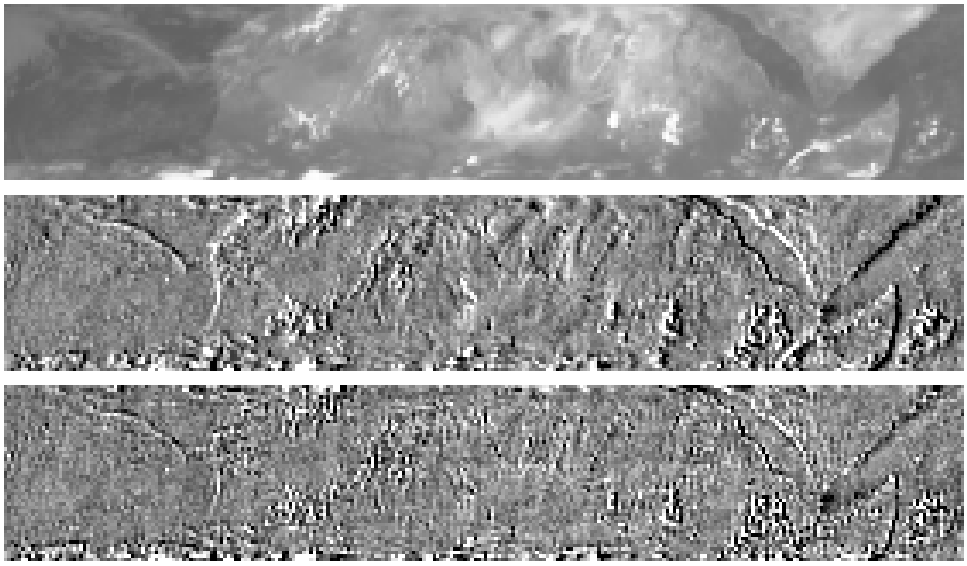


High level of luminance for L_{lw} corresponds to hot temperature and lower luminance for L_{sw}.

Low level of luminance for L_{lw} corresponds to cold temperature and higher luminance for L_{sw} (white clouds).

The black line represents the radiometric budget. L1A2 product generates good margins.

4.2. MS MODE ORBIT NUMBER 5061



4.3. STATISTICAL APPROACH

Level A1 product

Orbit	MIN	MAX	STD <C3-AC2>	<C3>	STD<C3>
	W/m²/sr	W/m²/sr	W/m²/sr	W/m²/sr	(%)
315	-6,2	5,5	0,72	66	1,1
329	-3,9	4,1	0,64	50	1,3
809	-7,1	5,5	0,76	65	1,2
1007	-6,3	7,2	0,88	82	1,1
1303	-4,3	3,6	0,34	43	0,8
1304	-3,0	2,5	0,35	55	0,6
2277	-5,6	7,9	0,44	50	0,9
2986	-1,4	1,1	0,20	19	1,0
3380	-4,3	4,2	0,48	45	1,1
mean					**1.0**

Level A2 product

Orbit	MIN	MAX	STD <C3-AC2>	<C3>	STD<C3>
	W/m²/sr	W/m²/sr	W/m²/sr	W/m²/sr	(%)
315	-4,2	2,9	0,51	66	0,8
329	-2,6	2,2	0,43	50	0,9
809	-4,0	4,3	0,52	65	0,8
1007	-5,2	4,3	0,62	82	0,8
1303	-2,7	3,7	0,25	43	0,6
1304	-3,0	2,0	0,27	55	0,5
2277	-3,9	7,1	0,34	50	0,7
2986	-1,0	1,1	0,16	19	0,8
3380	-3,4	3,5	0,34	45	0,8
mean					**0.73**

This study confirms the figure found on orbit 3775.

5. CONCLUSION

Here is the absolute radiometric budget for Channel 5 L1A2.

The registration figure is updated with the analysis presented here.

L1A2			Bright cold clouds	Hot / bright scene	Night scene
			250 SW + 50 LW	210 SW + 130 LW (20°)	0 SW + 80 LW
Instrumental noise	Random		0,21%	0,11%	0,14%
Calibration CALM	Bias		0.12%	0.12%	0.12%
A' factor	Random	0.2%	1%	0.3%	0%
Registration	Random	e = 0.3% + 0.6%/200*(220-L^2_{sw})	1.5%	0.55%	0%
Location	Random		0,4%	0,40%	0,40%
Budget @1σ %			**1.9%**	**0.8%**	**0.45%**
Budget @1σ W/m²/sr			**0.95 W/m²/sr**	**1.0 W/m²/sr**	**0.35 W/m²/sr**