Unfiltering of the GERB2 Data

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Introduction

- GERB-2 started but SEVIRI still in commissioning -> no spectral information at this time for unfiltering.

- This talk presents the direct unfiltering method, parameters and results for:
  - shortwave and longwave unfiltering,
  - estimation of the small contaminations: $\mathrm{L}_{sw,th}$ and $\mathrm{L}_{lw,sol}$

- Annexes about the improvements that will be possible with SEVIRI.

Related Documentation

- CERES direct unfiltering described in: "Determination of Unfiltered Radiances from the Clouds and Earth's Radiant Energy System Instrument", Loeb et al., 2001, J. App. Met., 40, 822-835.
- "Generation of a Data Base of TOA Spectral Radiance Fields", MSG-RMIB-GE-TN-0030.
- "Correction of the dispersion in the GERB's detector spectral response curves", MSG-RMIB-GE-TN-0031.
- "Direct Unfiltering of GERB Data", MSG-RMIB-GE-TN-0035.

Definitions

$$L(\lambda) = L_{sol}(\lambda) \, + \, L_{th}(\lambda)$$
$$L_{sw} = \int L(\lambda) \, \phi_{sw}(\lambda) d\lambda \, = \, L_{sw,sol} + L_{sw,th}$$
$$L_{lw} = \int L(\lambda) \, \phi_{lw}(\lambda) d\lambda \, = \, L_{lw,sol} + L_{lw,th}$$

To be transformed in

$$L_{sol} = \int L_{sol}(\lambda) \, d\lambda$$
$$L_{th} = \int L_{th}(\lambda) \, d\lambda$$

Not trivial because : (i) not totally flat spectral responses $\phi_{sw}(\lambda)$ and $\phi_{lw}(\lambda)$ and (ii) overlap of $L_{sol}(\lambda)$ and $L_{th}(\lambda)$

Direct Unfiltering Method

1.Estimation of the small contributions $L_{sw,th}$ and $L_{lw,sol}$ and their elimination from the measurements

$$L_{sw,sol} = L_{sw} - L_{sw,th}$$
$$L_{lw,th} = L_{lw} - L_{lw,sol}$$

2. Estimation of factors α_{sw} and α_{lw} and unfiltering

$$L_{sol} = \alpha_{sw} L_{sw,sol}$$
$$L_{th} = \alpha_{lw} L_{lw,th}$$

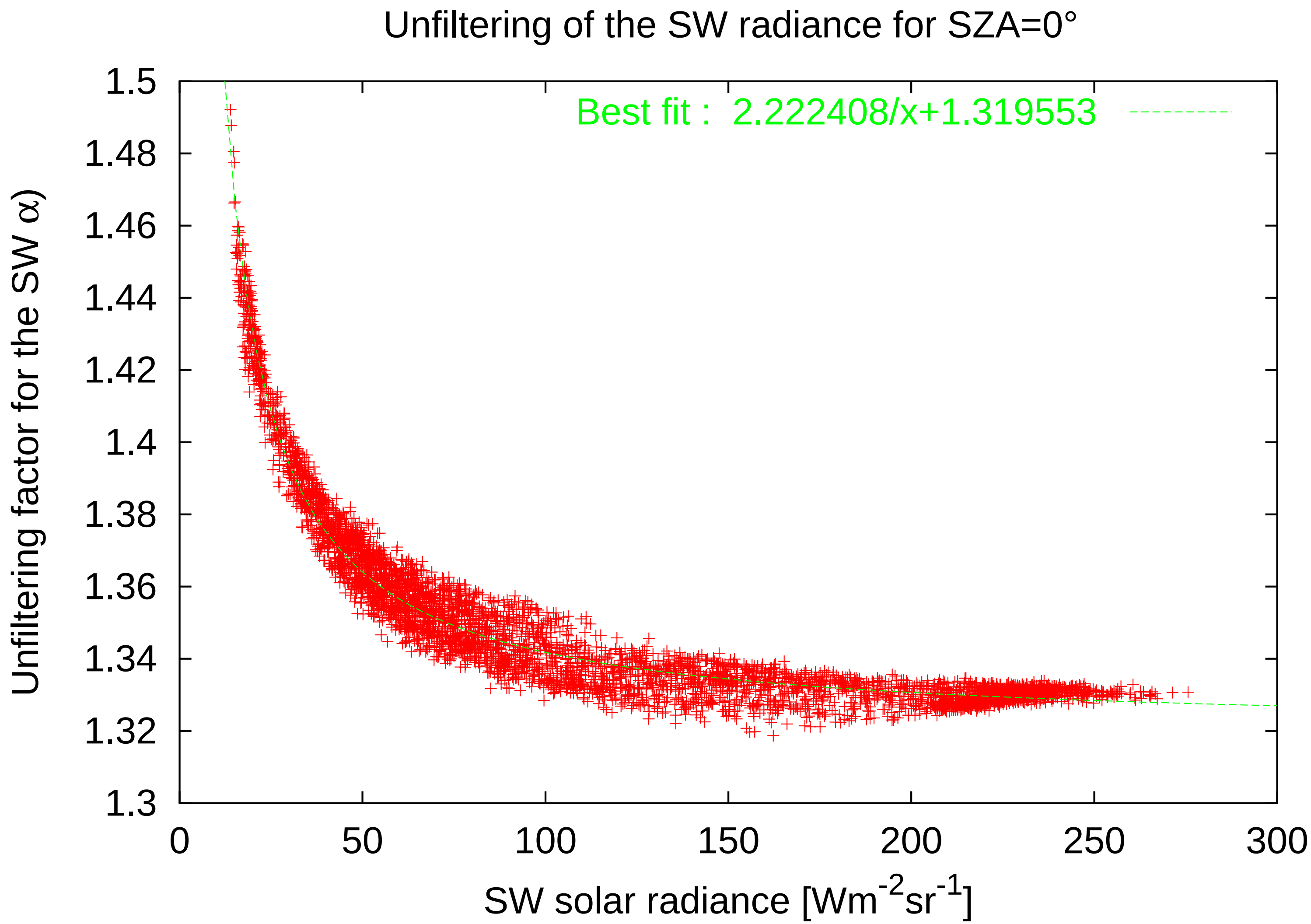
Estimation of α_{sw} (shortwave unfiltering)

$$\alpha_{sw} = \frac{a(\theta_s)}{L_{sw,sol}} + b(\theta_s) \quad \Rightarrow \quad L_{sol} = a(\theta_s) + b(\theta_s)\, L_{sw,sol}$$

Example, best fit for a nadir Sun:

$$\alpha_{sw} = \frac{2.222}{L_{sw,sol}} + 1.3196 \quad \Rightarrow \quad L_{sol} = 2.222 + 1.3196\, L_{sw,sol}$$

and RMS error on α_{sw} at 1σ is 0.38% (LIMITED).



Unfiltering of the SW radiance for SZA=0°
Best fit : 2.222408/x+1.319553
Unfiltering factor for the SW α)
SW solar radiance [Wm-2sr-1]
1.5
1.48
1.46
1.44
1.42
1.4
1.38
1.36
1.34
1.32
1.3
0
50
100
150
200
250
300

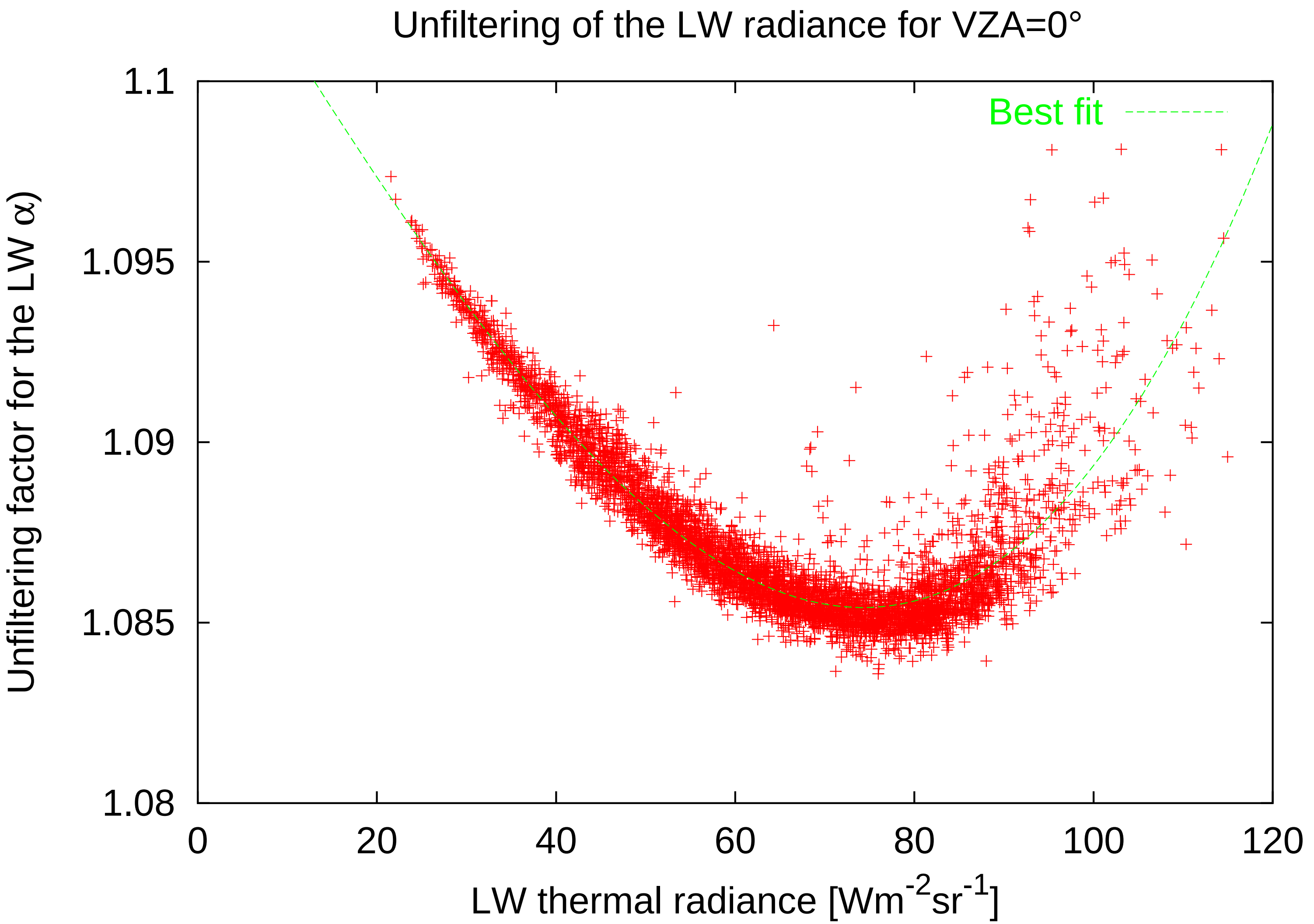
Estimation of α_{lw} (longwave unfiltering)

Use of polynomial regression:

$$\alpha_{lw} = a(\theta_v) + b(\theta_v)\, L_{lw,th} + c(\theta_v)\, L_{lw,th}^2 + d(\theta_v)\, L_{lw,th}^3$$

$$\Rightarrow \; L_{th} = a(\theta_v)\, L_{lw,th} + b(\theta_v)\, L_{lw,th}^2 + c(\theta_v)\, L_{lw,th}^3 + d(\theta_v)\, L_{lw,th}^4$$

For example, for nadir observation, the RMS error on α_{lw} at 1σ is 0.08% (EXCELLENT).


Unfiltering of the LW radiance for VZA=0°
Best fit
Unfiltering factor for the LW α)
LW thermal radiance [Wm-2sr-1]
1.1
1.095
1.09
1.085
1.08
0
20
40
60
80
100
120

Shortwave Thermal Contamination $L_{sw,th}$

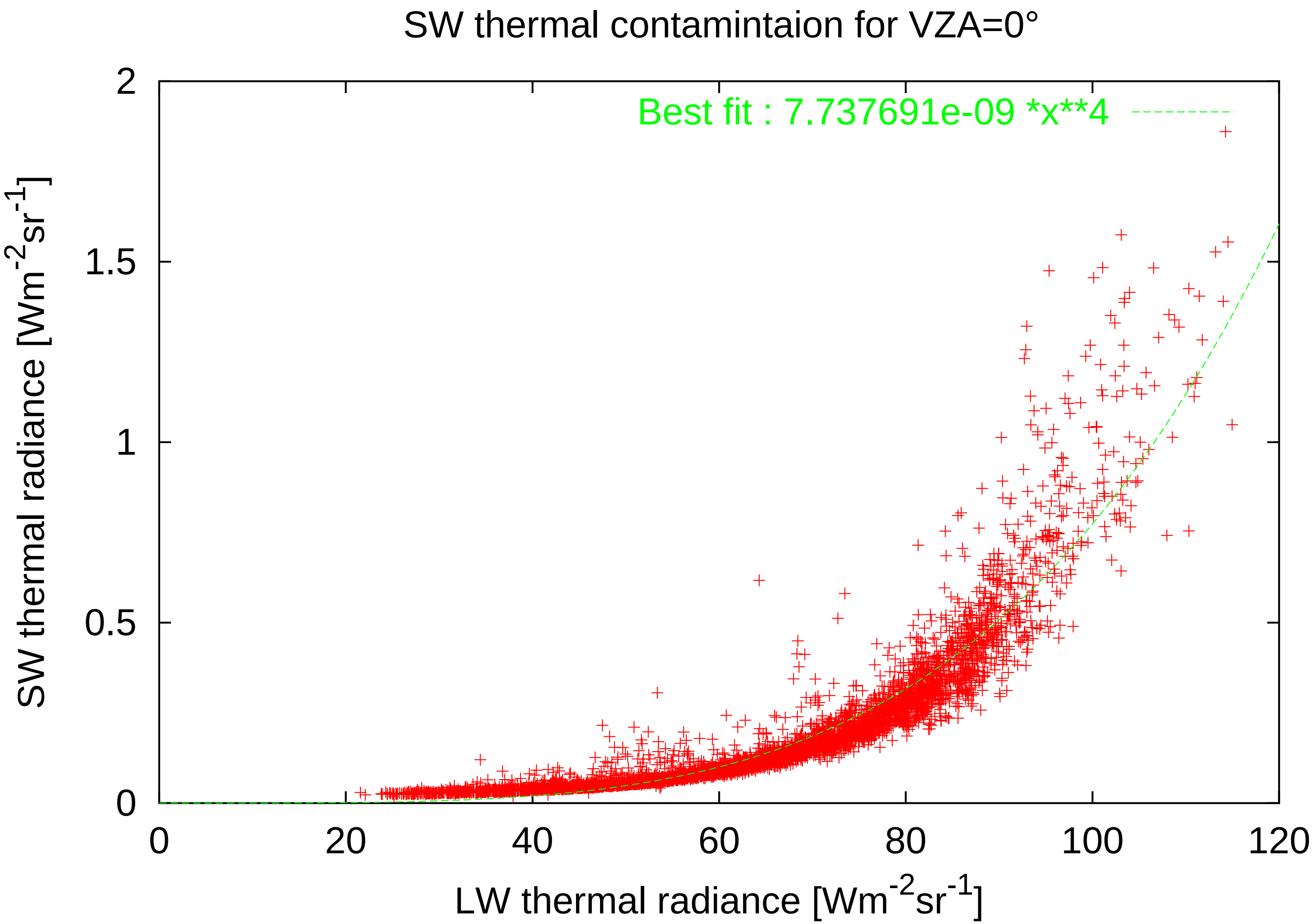
In average, very small: $\langle L_{sw,th} \rangle = 0.2\,Wm^{-2}sr^{-1}$ at $\theta_v = 0^o$
Exponential shape, May be estimated as:

$$L_{sw,th} = a(\theta_v)\,L_{lw,th}^4$$

For example, best fit for a nadir observation:

$$L_{sw,th} = 7.74\,10^{-9}\;\; L_{lw,th}^4$$

and the RMS error on $L_{sw,th}$ at 1σ is $0.07\,Wm^{-2}sr^{-1}$ (EXCELLENT)
Note: this can be tested using night-time GERB data.


SW thermal contamintaion for VZA=0°
Best fit : 7.737691e-09 *x**4
SW thermal radiance [Wm-2sr-1]
LW thermal radiance [Wm-2sr-1]
0
0.5
1
1.5
2
0
20
40
60
80
100
120

Longwave Solar Contamination $L_{lw,sol}$

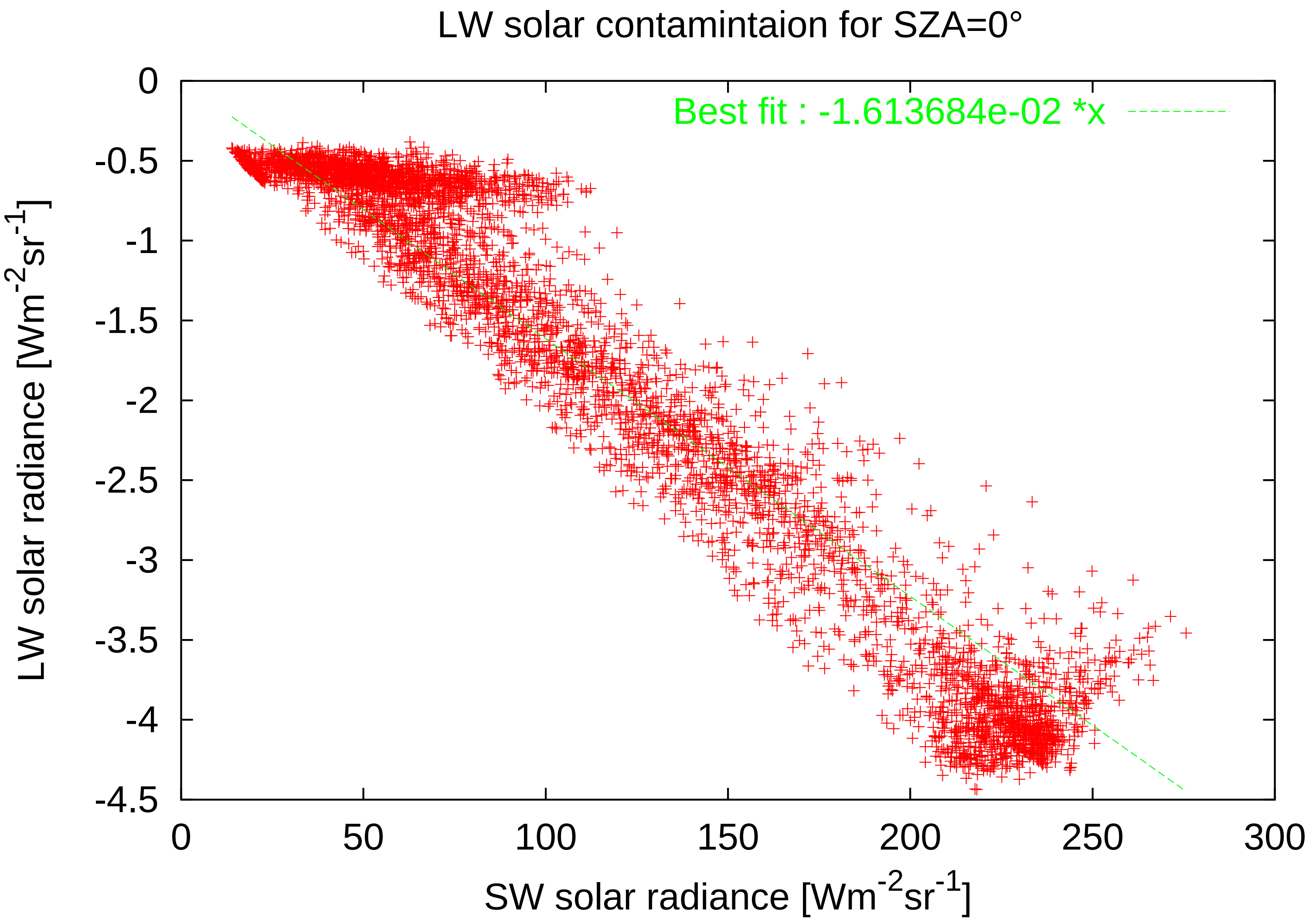
In average important values: $\langle L_{lw,sol} \rangle = -2\, Wm^{-2}sr^{-1}$ (at $\theta_s = 0^o$).
Up to $-4.5\, Wm^{-2}sr^{-1}$ (!) for reflective clouds -> great contribution to the LW measurement.
May be estimated as:

$$L_{lw,sol} = a(\theta_s)\, L_{sw,sol}$$

For example, best fit for $\theta_s = 0^o$:

$$L_{lw,sol} = -0.0161 \;\; L_{sw,sol}$$

and the RMS error on $L_{lw,sol}$ at 1σ is $0.35\, Wm^{-2}sr^{-1}$ (LIMITED)



LW solar contamintaion for SZA=0°
Best fit : -1.613684e-02 *x
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
0
50
100
150
200
250
300
LW solar radiance [Wm-2sr-1]
SW solar radiance [Wm-2sr-1]

Summary

1. Relatively important error introduced by unfiltering of the shortwave channel (estimation of α_{sw}): 0.38% at 1σ.

2. Accurate unfilt. of the longwave channel (estimation of α_{lw}): 0.1% at 1σ.

3. Accurate estimation of the small shortwave thermal contamination $L_{sw,th}$, estimation error $< 0.1\, Wm^{-2}sr^{-1}$ at 1σ.

4. Important error introduced when estimating the longwave solar contamination $L_{lw,sol}$: about $0.35\, Wm^{-2}sr^{-1}$ at 1σ (main problem for reflective high level clouds).

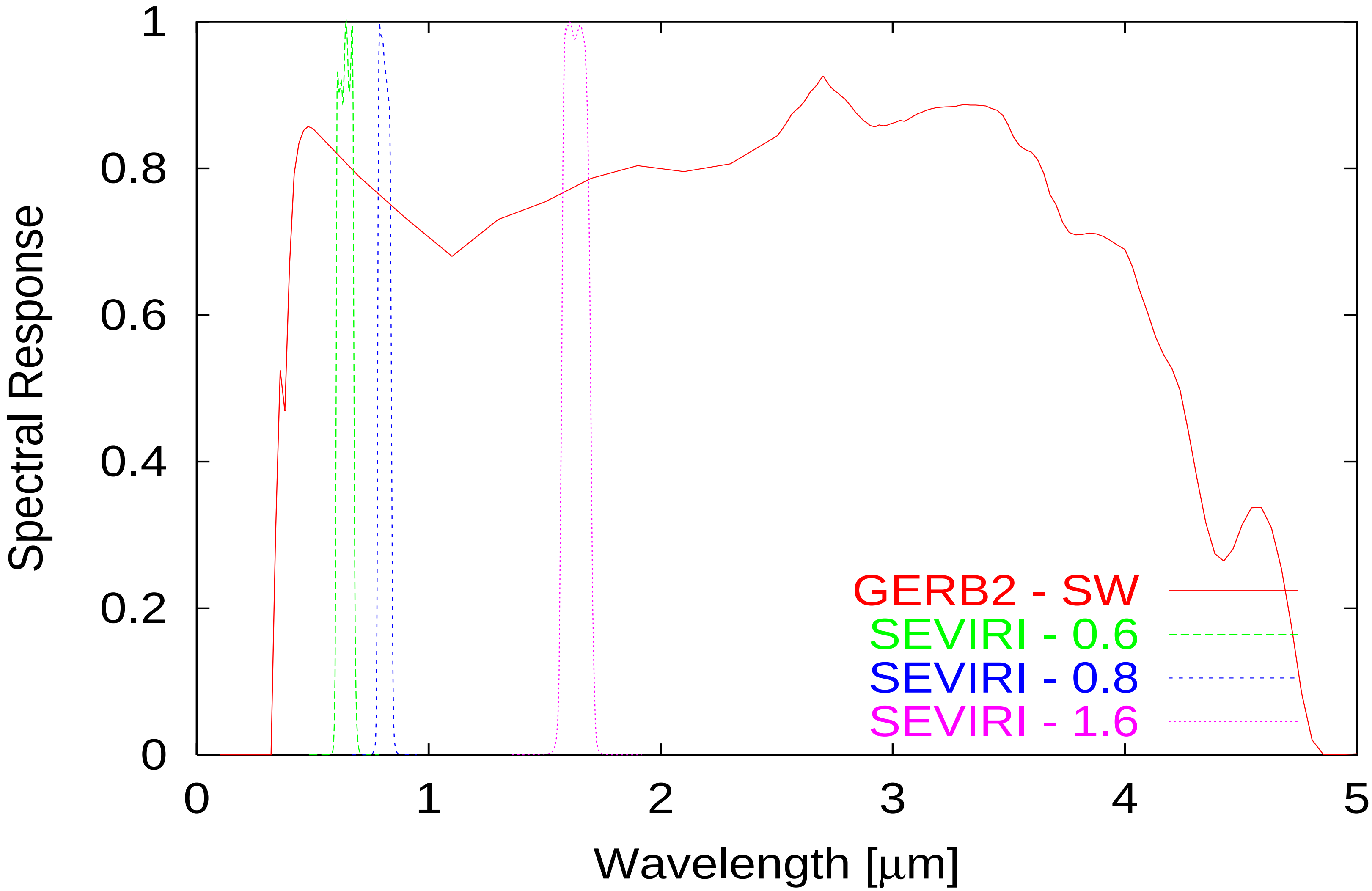
Annex: use of SEVIRI solar channels (0.6, 0.8 and 1.6 microns) to improve (1) and (4)?

SEVIRI for α_{sw} estimation

$\alpha_{sw} = \frac{a}{L_{sw}} + b \quad \Rightarrow \quad 0.38\%$

$\alpha_{sw} = \frac{a}{L_{sw}} + b + \frac{c}{L_{0.6}} + d\,L_{sw} + e\,L_{0.6} + f\,L_{0.8} + g\,L_{1.6} \quad \Rightarrow \quad 0.21\%$

RMS error of 0.21% may be obtained using SEVIRI information -> SEVIRI is not so informative to help in estimate of α_{sw}.



Spectral Response
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
Wavelength [μm]
GERB2 - SW
SEVIRI - 0.6
SEVIRI - 0.8
SEVIRI - 1.6

SEVIRI for $L_{lw,sol}$ estimation

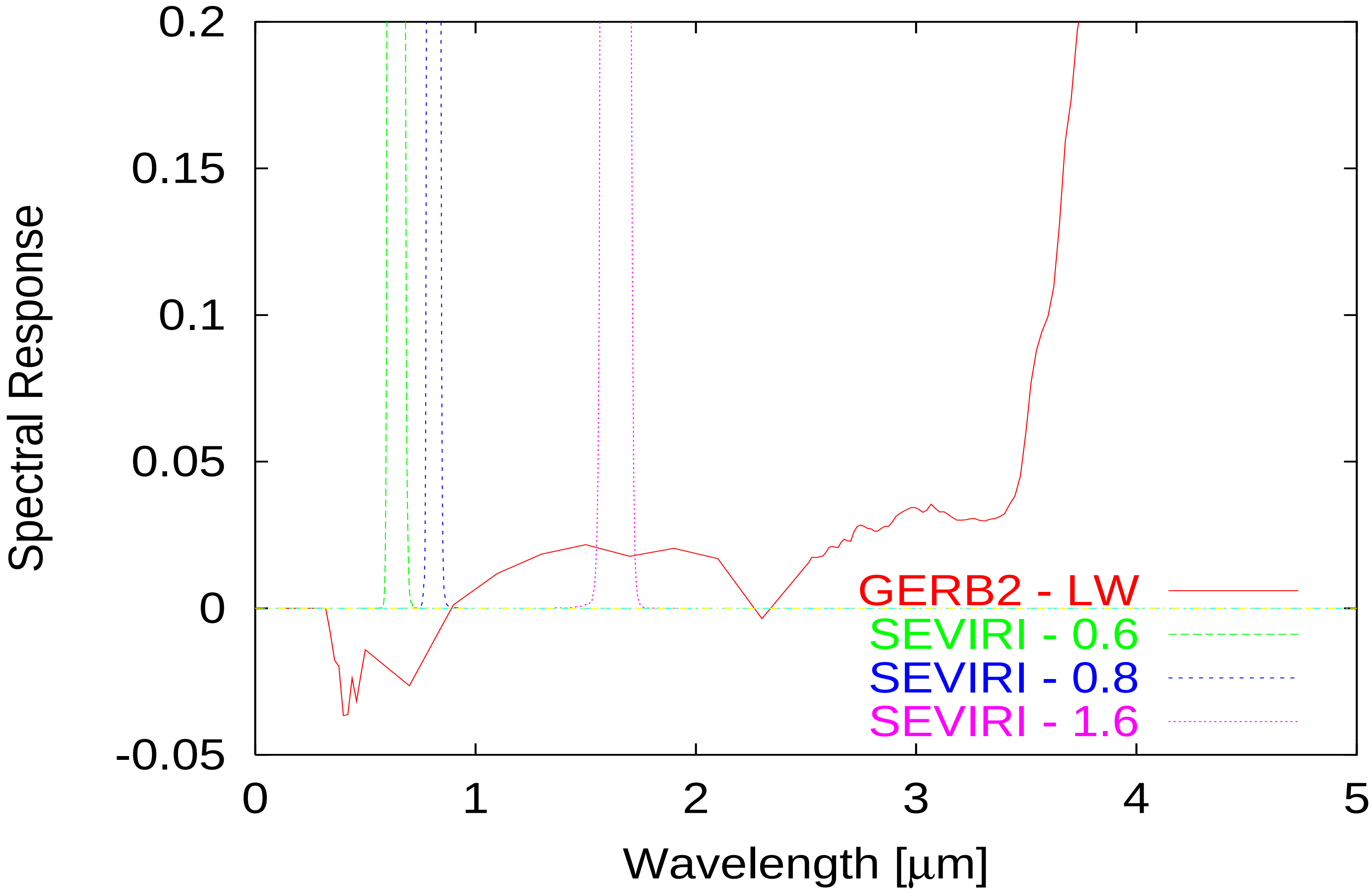
$L_{lw,sol} = a\,L_{sw,sol} \;\Rightarrow\; 0.35\,Wm^{-2}sr^{-1}$

$L_{lw,sol} = a + b\,L_{sw,sol} \;\Rightarrow\; 0.32\,Wm^{-2}sr^{-1}$

$L_{lw,sol} = a + b\,L_{sw,sol} + c\,L_{0.6\mu m} + d\,L_{0.8\mu m} + e\,L_{1.6\mu m} \Rightarrow 0.07\,Wm^{-2}sr^{-1}$

Significant improvement!

The residual error is small according to the mean value $L_{lw,th} = 64\,Wm^{-2}sr^{-1}$


0.2
0.15
0.1
0.05
0
-0.05
Spectral Response
0
1
2
3
4
5
Wavelength [µm]
GERB2 - LW
SEVIRI - 0.6
SEVIRI - 0.8
SEVIRI - 1.6

Conclusions

- Acceptable direct unfiltering error.

- SEVIRI does not help much the unfiltering of the shortwave channel (RMS error: 0.38% -> 0.21%) but is very interesting for the estimate of the longwave solar contamination.

- In the RMIB GERB processing implementation, the unfiltering is done by estimation of the unfiltered and filtered quantities as for example:

$$L_{sol} = \frac{\widetilde{L_{sol}}}{\widetilde{L_{sw,sol}} + \widetilde{L_{sw,th}}} L_{sw}$$