Derivation of Top-Of-the-Atmosphere Radiative Fluxes from SEVIRI: Methodology, Accuracy and Perspectives

Royal Meteorological Institute of Belgium

Nicolas Clerbaux, Steven Dewitte, Bogdan Nicula, Luis Gonzalez, Alessando Ipe

email : gerb@oma.be

1. Introduction

Within the GERB data processing at RMIB, the solar and thermal fluxes at the TOA are, in a first step, estimated from the SEVIRI instrument. In a second step, those fluxes are "corrected" using the GERB instrument data.

The SEVIRI estimates are less accurate than the final fluxes. Nevertheless, these "uncorrected" fluxes may be of interest due to the difference of nominal life-span for the 2 instruments (SEVIRI=7 years > GERB =3 years).

This poster presents the methodology (measurement, NB-to-BB and radiance-to-flux conversions) to derive the SEVIRI fluxes estimates and their expected accuracy.

2. SEVIRI Measurements

- Temporal sampling 15' -> good resolution of the diurnal cycle, easy temporal integration.

- Field of view : 40% of the Earth (reduced to 20% if θ_v is limited to 60°).

- Use of Level 1.5 data (after EUMETSAT rectification) -> simplifies the processing (geolocation, clear sky quantities, ...).

- Noise level : depending on the channel but always small.

- Calibration error (this propagates up to the final product!):

Solar channels	(VIS0.6, VIS0.8, NIR)	5%	(vicarious calibration)
Thermal channels	(IR3.9, WV6.5, ..., CO2)	0.5%	(blackbody)

3. NB-to-BB conversion

In this step, the broadband unfiltered solar and thermal radiances must be estimated from the SEVIRI NB radiances:

$$\{\, L_{nb} = \int (L_{sol}(\lambda) + L_{th}(\lambda))\, \phi_{nb}(\lambda)\, d\lambda \,\} \quad -> \quad \left\{ \begin{array}{c} L_{sol} = \int L_{sol}(\lambda)\, d\lambda \\ L_{th} = \int L_{th}(\lambda)\, d\lambda \end{array} \right.$$

This is done using second order polynomial regression on the SEVIRI NB radiances. Parameterization is done using best fit on a large database of realistic spectral signature $L_{sol}(\lambda)$ and $L_{th}(\lambda)$ generated using a radiative transfer model (SBDART).

– Good accuracy for thermal radiation (large number of channels).

– Limited accuracy for solar radiation (few channels and great dispersion of spectral signature).

4. Radiance-to-flux conversion - Solar

– Method : use of angular dependency models $R(\theta, \phi)$ for the radiation at the TOA:

$$F_{sol} = \frac{\pi}{R(\theta, \phi)} L_{sol}(\theta, \phi)$$

– State-of-the-art models: CERES-TRMM ADMs (for about 200 scene types). About 30% more accurate than the ERBE models (depending on the kind of scene).

– ADM selection needs scene characterization in term of: surface IGBP geotype and snow cover, cloud fraction, cloud optical depth and cloud phase. In addition: the surface wind for the ocean sun-glint area.

5. Scene identification (only day time)

– Estimation of clear sky reflectance for the VIS0.6 and VIS0.8 channels (statistical estimation on the last 60 days),

– For each SEVIRI pixel, estimation of the cloud optical depth using the VIS0.6 (land) or VIS0.8 (ocean) channel and the corresponding clear sky value, thresholding on the cloud optical depth -> cloud mask at full resolution.

– cloud fraction estimated on 3*3 pixels boxes,

– cloud optical depth averaged on the cloudy pixels in the boxes

– cloud phase estimated using the NIR1.6 channel.

6. Radiance-to-flux conversion - Thermal

– Method: use of limb darkening model $R(\theta)$

$$F_{th} = \frac{\pi}{R(\theta)} L_{th}(\theta\,\phi)$$

– Limb darkening model $R(\theta)$ dependent on spectral signature in the thermal channels (does not need explicit scene identification):

$$R(\theta) = R(\theta, L_{6.2\mu}, ..., L_{13.4\mu})$$

– Bottleneck: important overestimation of the OLR in case of optically thin ($\tau \sim 1.5$) and cold (cirrus) clouds in the “nadir region” ($\theta_v < 40^o$) .

7. Accuracy table

steps	**solar**	**thermal**
NB measurement	5%	0.5%
NB-to-BB conversion	3.2%	0.7%
radiance-to-flux conversion	$6^{(1),(2)}$%	$2^{(1)}$%
total	**14.2%**	**3.2%**

Notes:

(1). strong angular dependency of the radiance-to-flux conversion and hence regional pattern for the fluxes accuracy. The best accuracies are obtained for viewing angle close to 50° (e.g. Southern Europe),

(2). this is **instantaneous error** using the CERES-TRMM ADMs (the temporal averaging reduces the angular conversion error). Preliminary validation has shown better results (4% instead of 6%, except for clear ocean).

8. Perspectives

Synergetic use of GERB data:

– reduction of the measurement error and the NB-to–BB conversion error, especially for the solar radiation. GERB does not improve the radiance-to-flux conversion.

– Validation/improvement of the NB-to-BB conversion using the GERB data.

– Possible use of GERB data to calibrate the SEVIRI channels.

Synergetic use of CERES data (on the EOS satellites):

– Validation of the SEVIRI derived fluxes (a software has been implemented at RMIB and tested using CERES-TRMM and Meteosat-7 data).

– Possibility to extend the spatial coverage to Northern Europe (CM-SAF activities).

9. Conclusions

- The methodology to derive TOA radiative fluxes from weather satellite imagers is well-known and has been widely applied (Meteosat, GOES, AVHRR, ...). No particular problem in the application to SEVIRI.

- Strong interest of GERB, especially for the solar flux estimation.

- Interest for dissemination to the user community only if GERB is not available. Nevertheless, interest to archive the SEVIRI fluxes for long-term analysis of the ERB.

- The method is currently running at RMIB using Meteosat-7 data (full disk and european sector).

10. Additional information

- Section “Documentation” at the RMIB GERB web site:

http://gerb.oma.be

- Near real-time TOA fluxes from Meteosat-7 available on the ftp site:

ftp://gerb.oma.be

- For the radiance-to-flux conversion for solar radiation see the CERES ADM group web site :

http://asd-www.larc.nasa.gov/Inversion/

- For the radiance-to-flux conversion for thermal radiation using SEVIRI spectral signature see: “Estimation of TOA Braodaband Flux Errors Using a Coupled Radiometer-Imager. Part II: Longwave Radiation.” (to be published,available at RMIB).

- Spectral radiance curves at the TOA (solar and thermal) available at:

http://gerb.oma.be/nic/SpectralRadianceTOA/