Clear Ocean Correction for SEVIRI NB-to-BB Conversion

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Abstract

This technical note describes a method to correct the SEVIRI NB–to–BB estimation for clear ocean pixel. This correction is implemented in the SEVIRI processing part of the RGP.

Contents

1 Introduction

The estimation of broadband (BB) shortwave radiance from the narrowband (NB) measurements of the SEVIRI instrument is affected by a relativelly important relative error (typically 10%) for clear sky ocean condition when simple NB–to–BB regression is involved, which is the case in the RMIB GERB Processing. This error is dependent on the angular geometry: Solar Zenith Angle (SZA), Viewing Zenith Angle (VZA) and Relative Azimuth Angle (RAA) and exhibits therefore a kind of diurnal "asymmetry" (for a same SZA, the albedo is not the same the morning and the afternoon). This technical note describes a method to correct the clear ocean NB–to–BB estimation which can be implemented in the RGP SEVIRI processing.

The methodology is presented in section §2. Sections §3 and §4 present the application of the method to the "V999" and "Dubrovnik" [2] SEVIRI NB–to–BB.

The method is then validated in 2 ways:

- in section §5 using a database of couples of coangular SEVIRI NB and CERES BB observations,
- in section §6 by analysis of the ratio between the estimated BB radiance and the CERES TRMM model of BB radiance (Cedric's method)

2 Methodology

The correction takes the form of an additive term C to be added to the BB radiance estimation . This correction C is dependent on the 3 angles:

$$L_{nb2bb,corr} = L_{nb2bb} + C(SZA, VZA, RAA) \tag{1}$$

where L_{nb2bb} and $L_{nb2bb,corr}$ are the estimated BB radiances, in $[Wm^{-2}sr^{-1}]$, before and after correction, respectively.

The value of the correction $C(SZA, VZA, RAA)$ is estimated from the RMIB's "second version of the database of spectral radiance curves" which is based on SBDART version 2.4 radiative transfer simulations. This second version is not yet documented, the first version is documented in [1]. The database contains 153 clear ocean simulations for different wind speed, pigment concentration (chlorophyl), aerosol type and optical depth, atmospheric profile (McClatchey) and Rayleigh scattering factor.

For each angular geometry in $SZA = 0, 10, 20, ..., 80$, $VZA = 0, 5, 10, 15, ..., 85$ and $RAA = 0, 10, 20, ..., 180$, the simulated spectrums $L(\lambda)$ are convoluted with the spectral response filters of the 3 SEVIRI channels used for the shortwave NB–to–BB (i.e. the VIS006, VIS008 and IR_016 channels) to simulate the NB radiances. A simple integration (without filter) provides the corresponding broadband unfiltered radiance L_{sim}. The L_{nb2bb} are then estimated by applying the NB–to–BB regression to the simulated NB radiances. This quantity may differ slightly from the actual BB radiance L_{sim} due to NB–to–BB error.

The correction C_{sim} is obtained as the difference between the median (i.e. percentile at 50%) actual BB radiances L_{sim} and the same quantity but derived through the NB–to–BB regression L_{nb2bb}:

$$C_{sim}(SZA, VZA, RAA) = L_{sim,50\%}(SZA, VZA, RAA) - L_{nb2bb,50\%}(SZA, VZA, RAA) \quad (2)$$

An alternative approach consists in replacing the simulated BB radiance L_{sim} in Equation (2) by the BB radiance L_{ceres} from the CERES TRMM clear ocean model 3:

$$C_{mod}(SZA, VZA, RAA) = L_{ceres}(SZA, VZA, RAA) - L_{nb2bb,50\%}(SZA, VZA, RAA) \quad (3)$$

The 2 approaches are investigated.

3 Correction for the V999 NB–to–BB

For the GERB trial reprocessing V999, very (too!) simple NB–to–BB regressions have been used. The regressions are then good "case study" to test the correction. The V999 regressions [1] are given in term of reflectance and for the ocean takes the form:

$$\rho_{bb} = 0.021207 + 0.285784\rho_{0.6} + 0.488124\rho_{0.8} + 0.003013\rho_{1.6} + 0.000503\ SZA \quad (4)$$

where SZA is the solar zenith angle in degree. The correction $C_{sim}(SZA, VZA, RAA)$ and $C_{mod}(SZA, VZA, RAA)$ corresponding to the regression (4) are stored in the file "clearocean_correction_V999.adm" and "clearocean_correction_V999_model.adm" and are illustrated on the figures (1) and (2), respectively.

4 Correction for the Dubrovnik NB-to-BB

The method is applied to the GERB "Dubrovnik" ocean NB–to–BB regression. The name "Dubrovnik" cames from the fact the regressions have been presented during the EUMETSAT 2005 Conference [2]. The regression to be used over an ocean surface is:

$$\begin{aligned}\rho'_{bb} = \quad & 0.015985 \quad +0.247134\rho_{0.6} + 0.004561\rho_{0.6}^2 + 0.518540\rho_{0.8} + \\ & 0.015142 \quad \rho_{1.6} + 0.000129\ SZA + 0.000265\alpha\end{aligned} \quad (5)$$

where α is the sun-glint angle in degree. The correction $C_{sim}(SZA, VZA, RAA)$ and $C_{mod}(SZA, VZA, RAA)$ corresponding to the regression (6) are stored in the file "clearocean_correction_dub.adm" and "clearocean_correction_dub_model.adm" and are illustrated on the figures (3) and (4), respectively.

[1] a detailed description of those ergressions is given at http://gerb.oma.be/nic/SEV_NB2BB/SEV_NB2BB.html

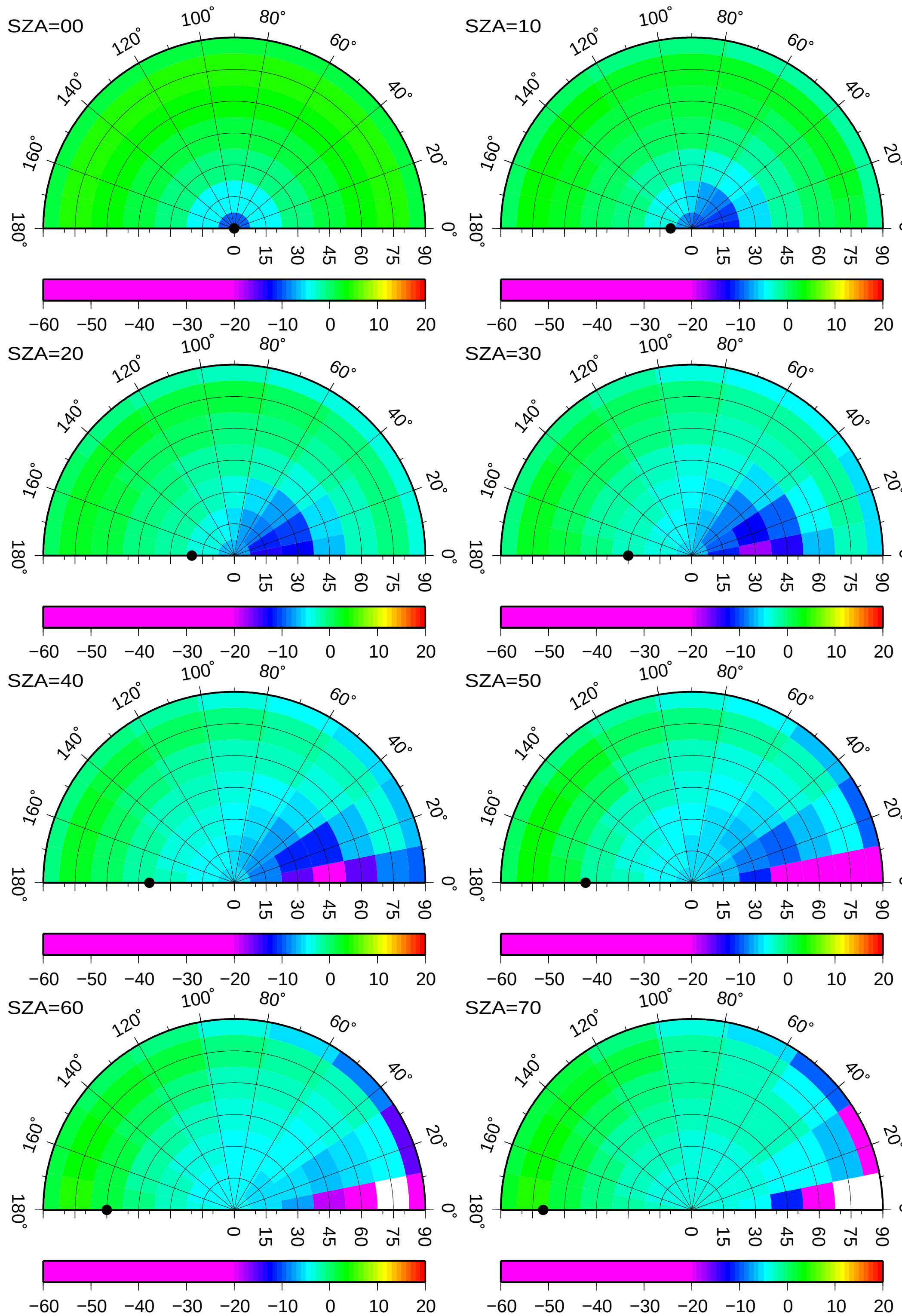

Figure 1: Clear ocean correction $C_{sim}(SZA, VZA, RAA)$ to be used with the V999 ocean regression.

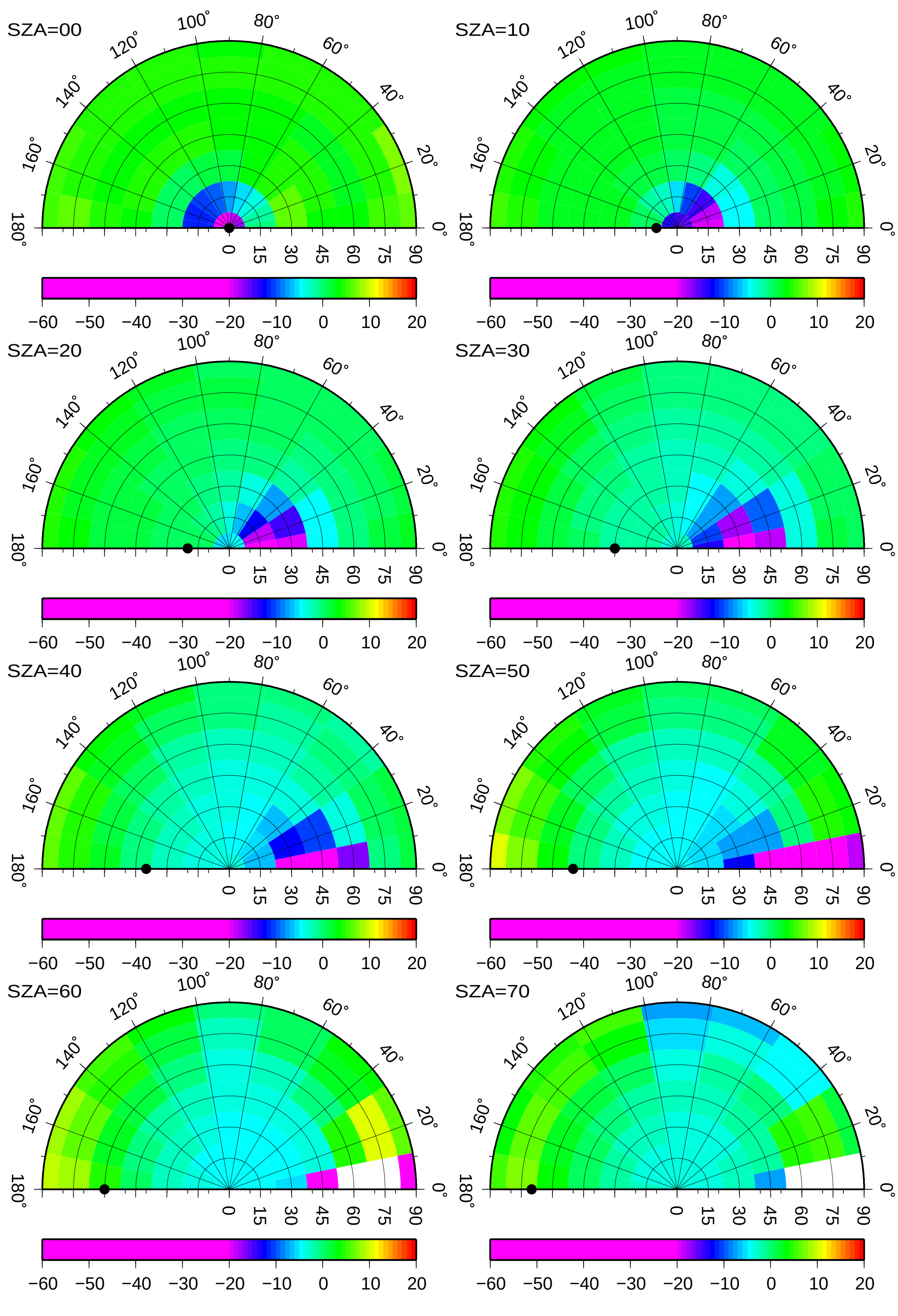

Figure 2: Clear ocean correction $C_{mod}(SZA, VZA, RAA)$ to be used with the V999 ocean regression.

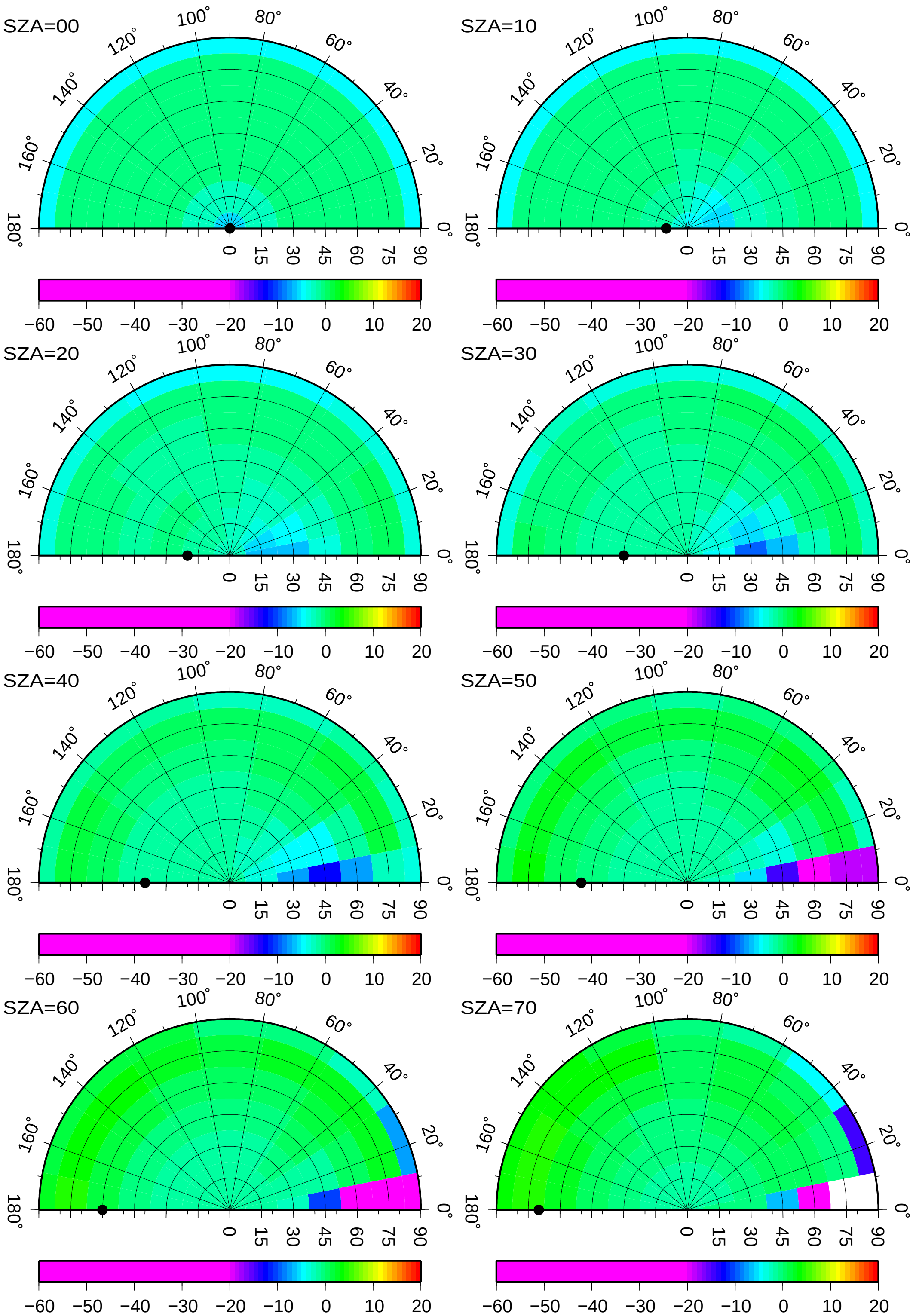

Figure 3: Clear ocean correction $C_{sim}(SZA, VZA, RAA)$ to be used with the "Dubrovnik" ocean regression.

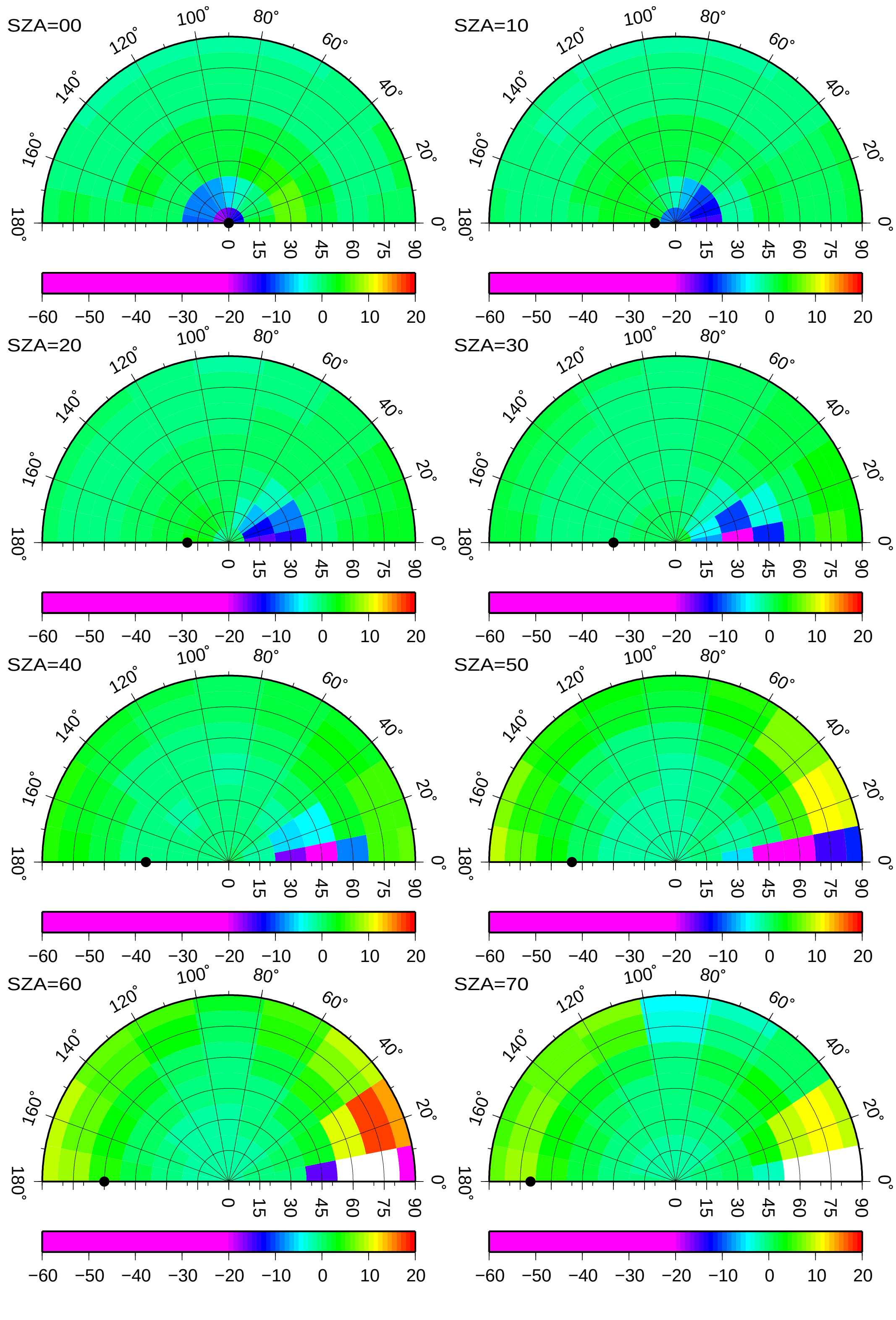

Figure 4: Clear ocean correction $C_{mod}(SZA, VZA, RAA)$ to be used with the "Dubrovnik" ocean regression.

method	$< \rho >$	**slope**	ρ **bias**	**RMS** ρ	**RMS %**
CERES model 3	0.0648	0.9828	0.0004	0.0117	18.2 %
V999	0.0665	0.9749	0.0021	0.0107	16.7 %
V999 + C_{sim}	0.0600	1.0708	-0.0044	0.0084	13.1 %
V999 + C_{mod}	0.0634	1.0159	-0.0010	0.0084	13.0 %
Dub	0.0645	1.0039	0.0001	0.0091	14.1 %
Dub + C_{sim}	0.0616	1.0429	-0.0028	0.0084	13.0 %
Dub + C_{mod}	0.0650	0.9907	0.0006	0.0083	12.9 %

Table 1: Comparison of 7 different BB estimation sur clear ocean. The average CERES observation is $\rho = 0.0644$

5 Validation using coangular BB observations

The database of coangular CERES and SEVIRI observations that was used to parameterize the NB-to-BB regression is used here to quantify the improvement obtained with the correction. The following selection criteria are used: the ERBE class should be 1 (clear ocean), no sun glint condition for CERES and SEVIRI (35°criteria), $VZA < 70$, $SZA < 70$, water fraction of 100%, spatial homogeneousness test $\sigma < 0.05$. This leads to a selection of 80489 useful coangular observations.

The table (1) gives the average reflectance $< \rho >$, the slope, bias $< \rho - \rho_{obs} >$ and the residual error on the BB reflectance for 7 different estimations of the clear ocean BB radiance: the CERES TRMM model number 3, the V999 and Dubrovnik regressions without and with the C_{sim} and C_{mod} corrections.

The use of the CERES model instead of the observations leads to relativelly important residual error (18%) even is in average the performence are good (slight overestimation the BB radiance[2]). The NB radiance with the correction allows to reduce the residual error to about 13%. The improvement is really significant when the simple V999 regressions are used. For the more elaborated Dubrovnik regressions, the improvement is less significant.

Both for V999 and Dubrovnik regressions, better performences are observed with the correction C_{mod} than with C_{sim}, specially in term of bias (in average the correction C_{sim} leads to overestimation of the BB).

6 Validation using model of BB radiance

For this validation, the NB–2–BB estimation (with and without the correction) are analyzed according to the CERES TRMM clear ocean models. The ratio of these 2 quantities is estimated for each clear ocean footprint for the hourly repeat cycles of SEVIRI (06:00, 07:00, ..., 18:00) and this for 12 days in March and April 2004 (1 day out of 5 starting at 1st March). This leads to a database of about 3665135 ratios, without or with the correction scheme, which allows the analysis the improvement gained in the clear ocean BB estimation. The

[2] this may be due to the normalisation of the ADM whih is not included

Figure (5) shows the angular dependency of the ratio according to the SZA, VZA and RAA. In practice, the database is undersampled by a factor 100.

The improvement is well visible on Figure (5) which shows a decrease of angular dependencies, specially the one with SZA. The ratio exhibits the following angular dependency (best linear fits):

$$\begin{aligned}
\frac{L_{nb2bb}}{L_{TRMMADM}} &= 1.070119 - 0.002334 * SZA \\
\frac{L_{nb2bb} + C_{mod}}{L_{TRMMADM}} &= 0.976221 - 0.000333 * SZA \\
\frac{L_{nb2bb}}{L_{TRMMADM}} &= 1.012313 - 0.001242 * VZA \\
\frac{L_{nb2bb} + C_{mod}}{L_{TRMMADM}} &= 1.008855 - 0.001135 * VZA \\
\frac{L_{nb2bb}}{L_{TRMMADM}} &= 1.033652 - 0.000619 * RAA \\
\frac{L_{nb2bb} + C_{mod}}{L_{TRMMADM}} &= 1.010065 - 0.000414 * RAA
\end{aligned} \tag{6}$$

7 Conclusions

A correction scheme is proposed to improved the NB–to–BB conversions for the clear ocean SEVIRI pixel (or ARCH pixels). The methodology is quite simple and seems to work correctly. However, as it is based on DISORT radiative transfer computation with a limited number of streams, the correction should not be used for high solar and/or viewing zenith angles. Furthermore, the correction should not be used in Sunglint conditions where the NB–2–BB regression seems work relativelly correctly (the spectrum is more or less similar to the one of a cloud).

Finally, the analysis suggests that, at least for clear ocean, the "Dubrovnik" regression with the C_{mod} correction should be use in the RGP to reduce the asymmetry problem.

References

[1] N. Clerbaux. Generation of a data base of TOA spectral radiance fields. Technical Note MSG-RMIB-GE-TN-0030, RMIB, December 1999.

[2] N. Clerbaux, C. Bertrand, D. Caprion, B. Depaepe, S. Dewitte, L. Gonzalez, and A. Ipe. Narrowband-to-broadband conversions for seviri. In *Proc. of the 2005 EUMETSAT Meteorological Satellite Conference*, 2005.

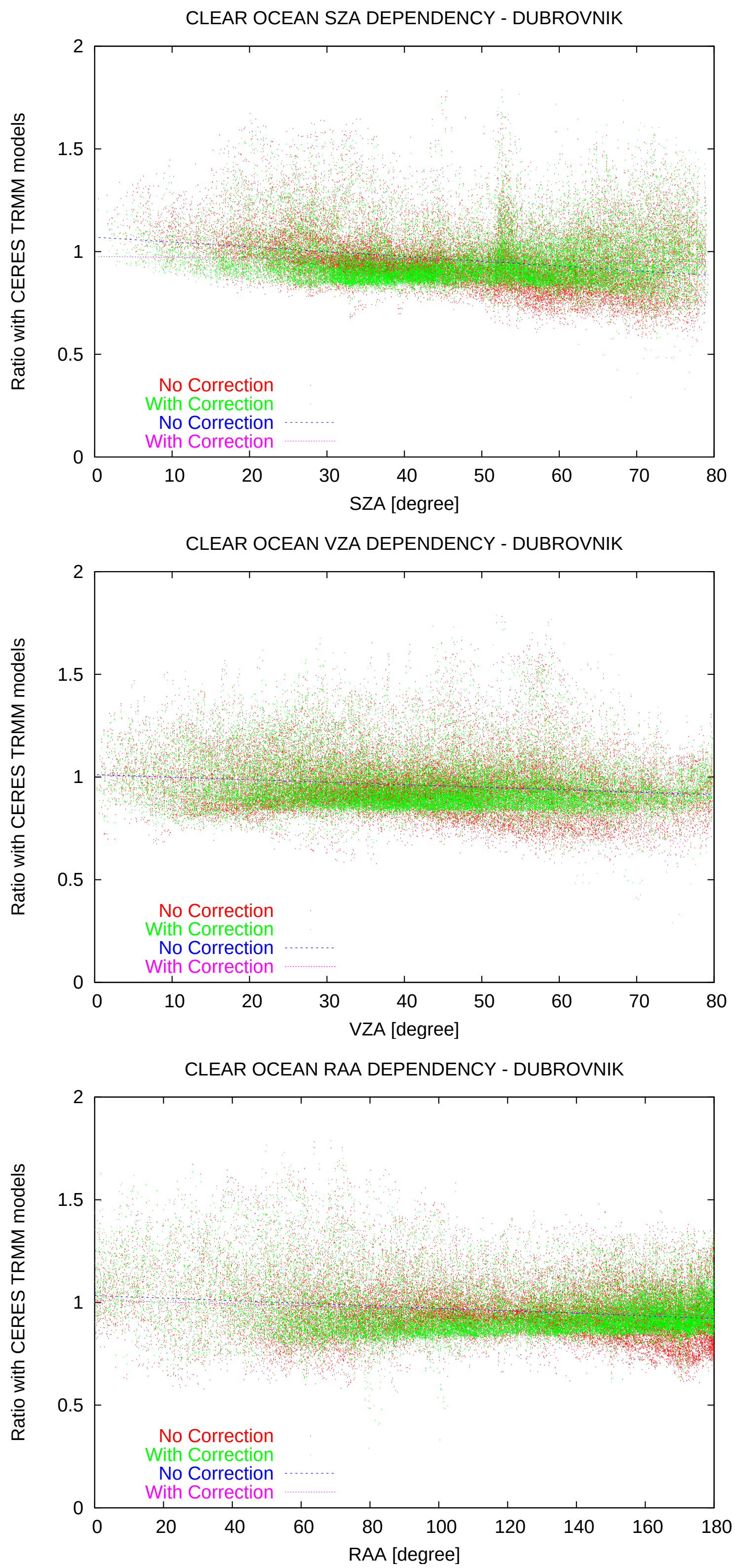

Figure 5: Scatter plots of the ratio between NB-2-BB estimate (with and without correction) and the CERES TRMM clear ocean model.