A review of “Inter-calibration of polar imager solar channels using SEVIRI” by Meirink et al.

Summary

Although many SNO and ray-matching satellite sensor inter-calibration results have been published, this paper provides a detailed sensitivity analysis of the band spectral atmospheric corrections and SEVIRI/MODIS and other GEO/LEO inter-calibration angular and other thresholds making it a worthwhile paper to publish. The resulting regression slopes based on various combinations of threshold provided the uncertainty of the inter-calibration method. It also makes the case that a 3rd satellite can be used as a transfer medium to compare the calibration between two satellite sensors.

General Comments:

Page 7 line 5, Page 12 line 24. “nominal” usually refers to the at launch calibration in a lot of the AVHRR papers published. I would persuade the authors from using this term to describe the existing calibration used to compare the inter-calibrations used in this study. I suggest the following.

1) “For MODIS the nominal calibration” replace with “For MODIS the collection 5 calibration is provided …”
2) “For AVHRR we use the Heidinger et al. 2010 calibration referred to in this study as the “Heidinger calibration”
3) “For SEVIRI the operational calibration by EUMETSAT is used and referred to as in this study as the EUMETSAT calibration”

Page 7 line 19 and Page 12 line 18. The word “re-calibration” to identify the regression slopes defined in this paper is confusing. It implies an iterative process. Also many papers define calibration as an absolute calibration method, such as deserts, and inter-calibration as the calibration referenced to a well-calibrated contemporary sensor. I suggest to use the word “inter-calibration” to describe the calibration method and the calibration slopes in this paper. Some sections of the text already follow this standard, for example section 4 heading is “Inter-calibration of SEVIRI and MODIS” in section 6.

Section 3.1. The correcting for differences in spectral response. In this description the first paragraph has to mention clearly that the only spectral correction being made is the atmospheric correction. Also state that the spectral correction is derived from two components, surface spectral signature and atmospheric absorption. The underlying surface is assumed to be Lambertian and a constant spectral reflectance based on the measured reflectance with the atmospheric absorption removed. The absorption is only computed above either the cloud effective radiating temperature or surface. Essentially Page 10 line 20 paragraph and page 15 line 22 sentence, should go first to divide the spectral correction into two components, surface spectra and atmospheric spectra.

I am confused about the TCWV. The description indicates that the water vapor absorption was computed in a look up table (Page 9 line 15). Yet in the next paragraph

(Page 9 line 23) the TCWV was computed using ERA-Interim climatology. Then the water vapor above the cloud was determined from the McClatchey tropical profile (Page 9 line14). Please clarify how the water vapor absorption was determined.

Page 10 and line 14 then the MODIS ch18/ch17 ratio is well correlated to the water vapor absorption in Figure 2. Please clearly state the intent of the sentence on Page 10 line 14 "Indeed, a good linear correlation is obtained, demonstrating the validity of the water vapour correction both for clear and cloudy pixels." Is the spectral atmospheric correction algorithm used in this study validated by Figure 2. Or was this a separate study of simulated MODIS SEVIRI ch2 reflectance ratios? Or was it used in Figure 3,4,5? Please clarify.

Page 10 line 18. "This also gives confidence in the atmospheric correction method for other sensors, such as AVHRR, that do not carry channels with additional information on atmospheric water vapour." AVHRR channels do carry additional information. IR channels 4 and 5, 11 and 12μm can be used to determine the water vapor column. Even SEVIRI has these channels and are probably used operationally to compute TCWV. Here are some references.

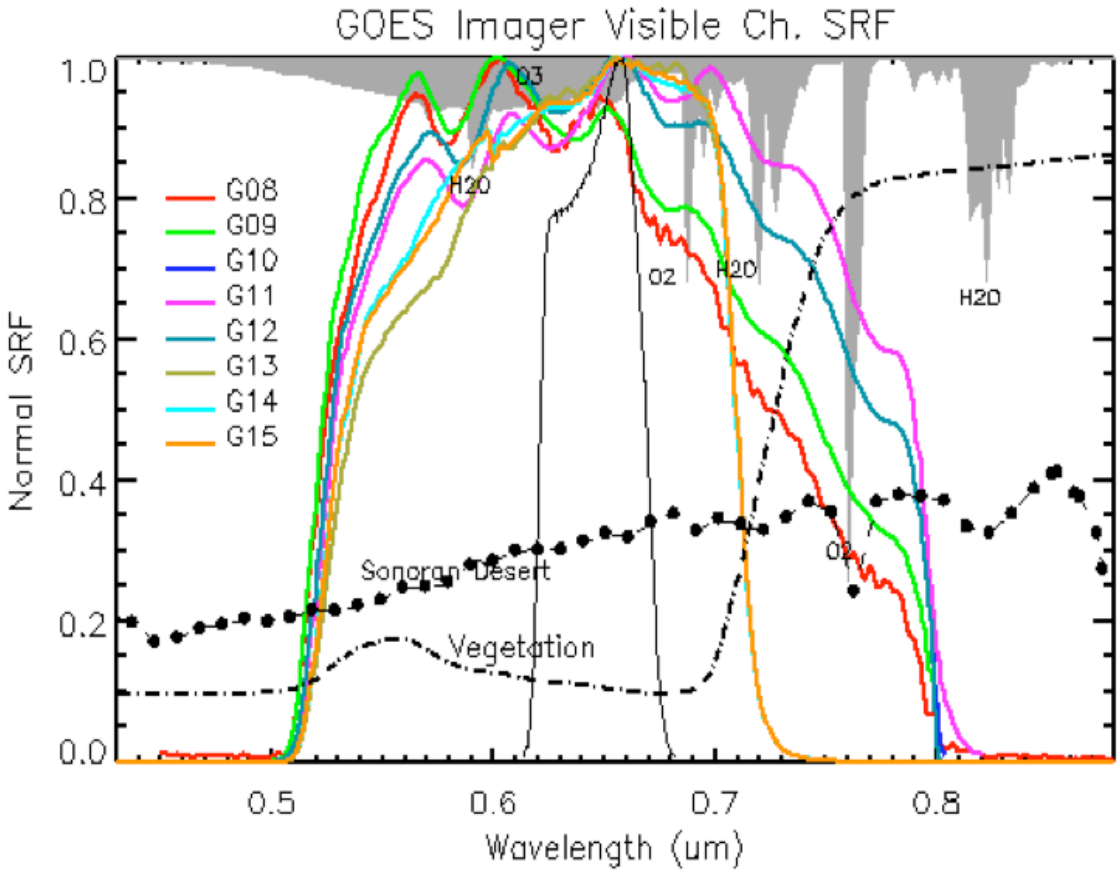
> Wu, A. ; Xiong, X. ; Angal, A., 2013, Derive a MODIS-Based Calibration for the AVHRR Reflective Solar Channels of the NOAA KLM Operational Satellites, Geoscience and Remote Sensing, IEEE Transactions on , Volume: 51 , Issue: 3 , Part: 1, DOI, 10.1109/TGRS.2012.2220780 (fig 2)
>
> M. Schroedter-Homscheidt, A. Drews, S. Heise , 2008, Total water vapor column retrieval from MSG-SEVIRI split window measurements exploiting the daily cycle of land surface temperatures, Remote Sensing of Environment 112 (2008) 249–258

Page 11 MODIS band 2 saturation. Is there not a flag in the MODIS read code to filter the individual pixel level saturated radiances as not to contaminate the gridded level MODIS/SEVIRI reflectance pairs. This is a much cleaner approach then to have an arbitrary MODIS radiance threshold. The saturation of the land use channels is well known and the saturated pixels are simply filtered. I am concerned this might set a precedent to compare MODIS band 2 without removing the saturated pixels among novice researchers. I strongly suggest the authors to filter the MODIS saturated pixels and redo Fig 4,5, and Table 2.

I am very surprised that land in the SEVIRI inter-calibration domain does not change the regression slope of the 0.86 channel inter-calibration especially between AVHRR or MODIS and SEVIRI. A typical vegetation spectra is available https://gsics.nesdis.noaa.gov/wiki/Development/20130304 under Fanfang Yu GSICS 2013 presentation on Thursday and shown here.

1) The gain difference between land/ocean and ocean-only is1.2% in Table 2. Could it be the case the SEVIRI inter-calibration domain is dominated by ocean, so the difference is smaller? Or is land mostly dominated by bright clouds obscuring land? Please add another row in Table 2 that includes land only.

2) The Terra overpass time also has greater probability of clear-sky land than Aqua-MODIS. Is the Fig4c MODIS/SEVIRI scatter plot similar for Terra and Aqua?
3) There is a secondary concentration of reflectance pairs in Figure 4c that does not seem to be present in the other bands. Could the authors please comment where these points come from? It also seems there is a greater concentration of points to the left of the diagonal of Fig 4c, due to the MODIS saturation issue that would skew the slope. This paper almost makes the statement that the surface reflectance is irrelevant in inter-calibration, however the atmospheric correction can cause a considerable bias.
4) Can the authors please comment if this method could work to inter-calibration the 0.65μm and 0.86μm channels or broadband imagers such as Meteosat-7. Is it simply fortuitous that the 0.86μm bands inter-calibrated in this paper seem to be independent of surface spectra? See
Doelling, D. R., C. Lukashin, P. Minnis, B. Scarino, and D. Morstad, 2011: Spectral reflectance corrections for satellite intercalibrations using SCIAMACHY data. Geosci. Remote Sens. Lett., **8**, doi:10.1109/LGRS.2011.2161751
5) The AVHRR spectral response function begins at 0.70μm, whereas SEVIRI at 0.77μm. Page 16 line 21. In this case the AVHRR SRF is very broad. Could this explain the AVHRR/SEVIRI channel 2 Fig 7 result? Have you compared the ocean only and land only slopes for AVHRR and Meteosat? Is the gain difference between land/ocean and ocean different by only 1.2% as is the case with MODIS? I would like to see an equivalent Fig 4c for this pair for land only and also for ocean only.
6) I would urge the authors to add in the conclusion that the spectral correction used is only an atmospheric correction and that caution must be used when inter-calibrating clear-sky land.



Specific Comments:

• Abstract line 20. The replace the word existing with Heidinger et al 2010 AVHRR calibration.

• Abstract Page 2 line 10. Replace “off” by “offset”

• Page 3 line3. Replace “using carefully selected targets” with using well-characterized targets”

• Page 6 line 29. Replace “AVHRR observations” with “AVHRR nominal observations” (see general comments)

• Page 7 line 8. Is there a reference for the official EUMETSAT calibration?

• Page 8 line 15. How are the slope-only fits with fixed offsets performed? For example Figure 3.

• Figure 3. I would suggest to title the reflectance pair scatter as all “without angle matching” and “angle matched”, to allow the user to easily identify the difference between the two plots.

• Figure 3. I suggest also providing standard error about the fit to qunatify the regression improvement in the plot statistics. All of the correlation coefficients are above 97% used in the paper.

• Page 13 line 14. Is the residual seasonal cycle in the monthly slopes perhaps due to a seasonal variation of the dynamic range, where some seasons do not have many bright high clouds. The Meirink 2009 (fig 3) paper mentions that large SRF corrections are for low clouds, whereas smaller SRF corrections are needed for high clouds.

• Page 13 line 19 “The SEVIRI EUMETSAT reflectance is found .. “
• Fig 5. Please clarify is the standard deviation the standard error about the fit? If the monthly slopes dropped rapidly due to instrument sensor degradation then the standard deviation would be large and not accurately assess the uncertainty of the trend as in the bottom panel of figure 6.
• Table 2. It seems the results for geom. Criteria of channel 1, for $\Delta\theta < 20°$ and $\Delta\theta < 5°$ are reversed in the table. The greater angle limit should have more N than the restricted angle fit.
• Table 2. add sunglint criterion, add rainbow criterion and add glory criterion, implies that the sunglint criterion is added to the previous row, etc. Yet the number of matches increases, indicating only one criterion is performed at a time. Please clarify.
• Table 2 The last column is the standard deviation of the monthly correlation coefficients. It is very difficult to quantify uncertainty with a correlation coefficient. I would rather have the standard error of the linear trend of the monthly slopes, similar to the standard deviations in Figure 5.
• Page 14 line 21. It seems the scattering angle ranges listed are not to be avoided but are the valid domains, please recheck.
• Page 14 line 26. “the drawback is the number of grid points…” I do not know what this sentence means. With the standard criterion you get the same number of reflectance pairs monthly over the year? With the application of scattering angle the number of monthly grid points varies greatly?
• Page 14 line 27. “For satellites with different overpass time” does this imply the AVHRR/SEVIRI inter-calibration pairs, since the NOAA satellite orbit is degrading in local time? Please clarify
• Page 15 line 8. Why is this as expected? Is this a result of satellite navigation error or aggregation is now nearing a pixel or two per region? Please elaborate.
• Page 15 line 16. The decreased dynamic range is only an issue with the $Rn<0.5$, since the average standard deviation of the $Rn>0.1$ is 0.0038 and is less than 0.0040 of the standard settings. (see comment above concerning the use of correlation coefficients)
• Page 15 line 22. The explanation of the how clear-sky is treated should be addressed in full in page 9 and then referred to here. (see general comments)
• Page 16 line 10 and Page 18 line 25. It should be made clear here that the uncertainty is the inter-calibration methodology, based on sensitivity studies and not the overall inter-calibration slope. The sentence that begins with “It needs to be emphasized” should mention specific systematic errors, such as the MODIS calibration uncertainty, the surface spectral signature, errors in the spectral response function, Met-9 solar constant estimate, etc. Could the authors please elaborate how the 1% and 1.5% uncertainties were derived?
• Page 18 line 1 Could this be a result of the degrading NOAA orbits as to alias the solar zenith angle dependencies into the inter-calibration results.
• Page 18 line 10. Could the authors elaborate if the inter-calibration method uncertainties mentioned above are applicable to the AVHRR/SEVIRI regression slopes?
• Page 19 line 1. Replace defect with defective.