Defining Common Reference Channels for Geostationary Infrared Imagers

This article follows up the theoretical considerations presented above with an example applied to the infrared channels of geostationary imagers. The uncertainties, $u(\delta L_r)$, introduced by the process of spectral conversion to *Common Reference Channels* (CRCs) are evaluated and discussed. These are referred to *Spectral Mismatches.*

There are various ways to define CRCs for geostationary imagers. For example, it is possible to select one particular instrument as a reference – either in Geostationary or Low Earth Orbit. For example, defining a High-resolution InfraRed Sounder (HIRS) instrument allows the possibility of using a homogenised series of HIRS observations as inter-calibration references for historic archives of all geostationary imagers.

Another method is also investigated here, based on the definition of a synthetic CRCs, derived from the characteristics of combinations of the current geostationary imagers, comprising FY-2C, GOES-12, Meteosat-8 and MTSAT-1R. Synthetic CRCs are defined in bands where more than one of these instruments have channels. The CRCs are defined here to have simple, rectangular Spectral Response Functions (SRFs), whose limits are calculated as the mean wavelength at which the normalised SRFs of the constituent instruments cross 0.5. An example of this definition is shown in Figure 1.

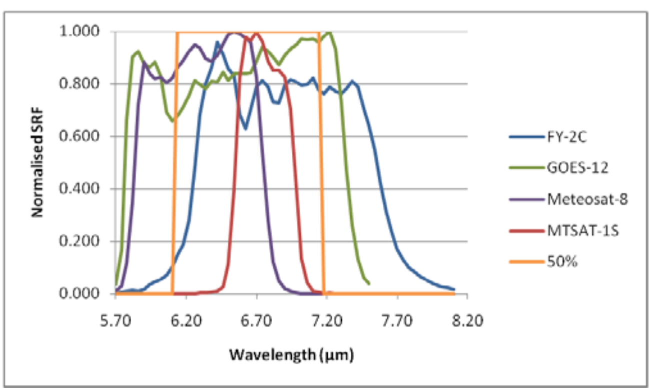

Figure 1: Spectral Response Functions of water vapour channels used to define rectangular *Common Reference Channel*, shown in orange as "50%"

Although this process is objective, the initial selection of the instrument/channel combinations introduces a subjective element in the analysis and the results will depend on this choice. For example, it would also be possible to combine multiple channels of a single instrument. However, the definitions should remain static for a given inter-calibration product.

To estimate the uncertainty introduced by the process needed to convert the radiances of the monitored instruments' channels to the CRCs, $u(\delta L_r)$, we evaluate the difference in radiances seen by these channels over a representative range of scenes. This is achieved by comparing a set of radiance spectra observed by the Infrared Atmospheric Sounding Interferometer (IASI) convolved with the monitored instrument's SRF and that of the CRC.

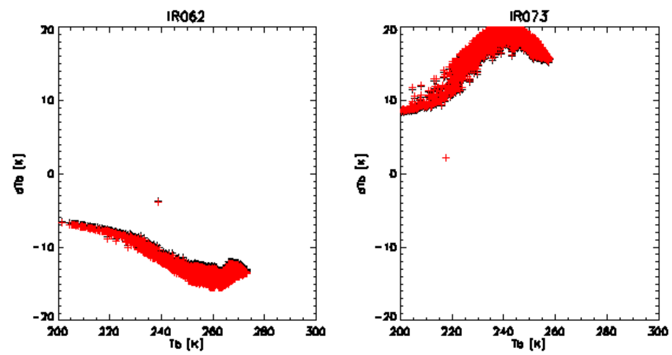

Figure 2: Spectral mismatches, δL_r, shown as brightness temperature differences [K] between water vapour channels of Meteosat-8 (black) and -9 (red) and Common Reference Channels.

The differences are plotted in Figure 2 for the two water vapour channels of Meteosat-8 and Meteosat-9. It can be seen that there are large differences (~10 K) between the radiances observed in these channels and those of the CRC. Although a spectral conversion process can account for the mean differences, a residual error remains, the *Uncertainty* associated with the *Spectral Mismatch* $u(\delta L_r)$, which introduces uncertainty into the inter-calibration product. The magnitude of this uncertainty is estimated in Table 1 as the standard deviation of the residuals from a quadratic fit through the radiances shown in Figure 2.

Table 1 - Residual errors introduced converting Meteosat/SEVIRI IR channels to *Common Reference Channel* and HIRS Channel - Spectral Mismatch Uncertainty, $u(\delta L_r)$.

Meteosat Second Generation Channel	CRC Wavelength Limits (µm)	CRC Spectral Mismatch Uncertainty, $u(\delta L_r)$	MetopA/ HIRS/4 Channel	HIRS Spectral Mismatch Uncertainty, $u(\delta L_r)$
IR3.9	3.619 - 4.072	0.72 K	17 19	1.12 K 1.02 K
IR6.2	6.101 - 7.152	0.73 K	12	0.88 K
IR7.3	6.383 - 7.493	1.10 K	11	0.16 K
IR8.7	(Meteosat Only)	(0.06 K)	N/A	N/A
IR9.7	(Meteosat Only)	(0.05 K)	9	0.06 K
IR10.8	10.301 - 11.336	0.03 K	8	0.42 K
IR12.0	11.461 - 12.521	0.10 K	8	0.87 K
IR13.4	12.801 - 13.870	0.08 K	7	0.29 K

Table 1 confirms our expectations that relatively large uncertainties are introduced by the spectral conversion process required when using these CRCs for channels in strongly absorbing parts of the spectrum, while minimal uncertainties are introduced for window channels. Table 1 also shows relatively large uncertainties introduced when using HIRS as reference channels – even in window regions, due to SRF differences. However, these may be sufficient quality for some applications, such as generating composite images from multiple GEO imagers.

More sophisticated definitions could be based on SRFs containing a certain fraction of the total radiance seen by each channel, or matching weighting functions, to more accurately reflect the response of channels in absorption bands. It may also be possible to define CRCs based by minimising the uncertainty associated with the spectral mismatch.

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