A Note on Interferometric Calibration

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We derive the UW definition of reference truth convolved with responsivity. Note that this does not prove the definition is "correct" in any particular way. The definition is just an approximation to a more accurate representation. It may suggest why the UW definition is easier to use as a specification for some forms of the calibration equation.

Calibration of the on-axis optical path of a Michaelson interferometer can be represented as

$$r_{\text{cal}} = r_{\text{ICT}} \frac{ES - SP}{IT - SP} \tag{1}$$

where r_{cal} is calibrated radiances, r_{ICT} is expected radiance from the internal calibration target, and ES, IT, and SP are uncalibrated spectra for earth scene, internal calibration target, and space looks, respectively. We can approximate instrument responsivity as

$$\rho = \frac{IT - SP}{r_{\text{ICT}}} \tag{2}$$

Substituting (2) in (1) gives

$$r_{\text{cal}} = \frac{ES - SP}{\rho} \tag{3}$$

We can represent ES, IT, and SP as $ES = F\rho\, r_{\text{ES}}$, $IT = F\rho\, r_{\text{ICT}}$, and $SP = F\rho\, r_{\text{SP}}$, where r_{ES}, r_{ICT}, and r_{SP} are high resolution approximations to the true radiances, F is resampling from the high resolution to $dv = 1/(2\,\text{OPD})$, and OPD is the optical path difference. Substituting this into (3) gives

$$r_{\text{cal}} = \frac{F\rho\, r_{\text{ES}} - F\rho\, r_{\text{SP}}}{\rho} \tag{4}$$

The space look radiances are very small in comparison with earth scene radiances. If we drop the space look term in (4) we have

$$r_{\text{cal}} \approx r_{\text{resp}} = \frac{F\rho\, r_{\text{ES}}}{\rho} \tag{5}$$

This is the UW definition of "reference truth with responsivity".

A more conventional and user-friendly definition of reference truth is

$$r_{\text{flat}} = F r_{\text{ES}} \tag{6}$$

In practice we find the UMBC CCAST reference calibration equation (a "ratio first" form) has smaller residuals when compared with r_{flat}, while the NOAA 4 algorithm (an "SA^{-1} first" form) has smaller residuals with r_{resp}. It seems to us the proper focus for calibration algorithm development should be minimizing residuals in comparison with r_{flat}.