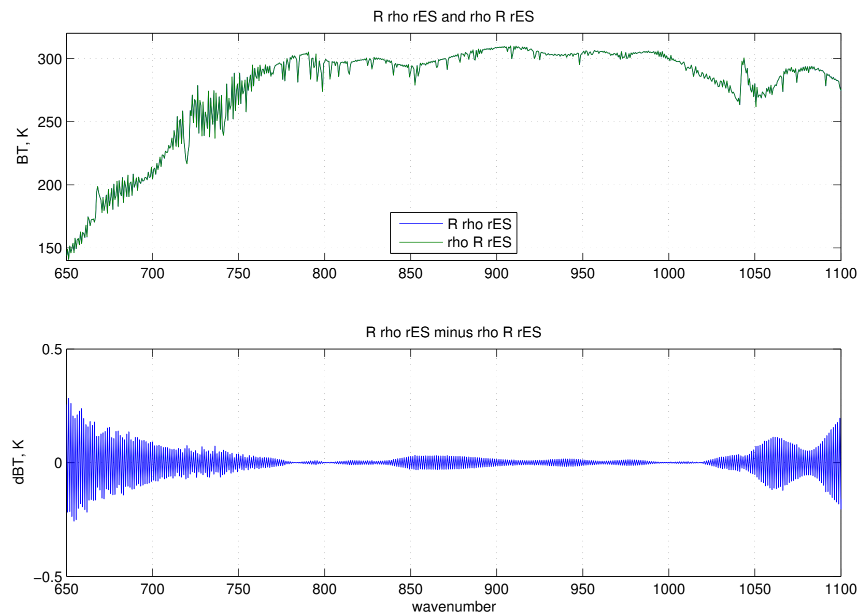

Figure 2: $R\rho\, r_{\mathrm{ES}}$ and $\rho\, R\, r_{\mathrm{ES}}$

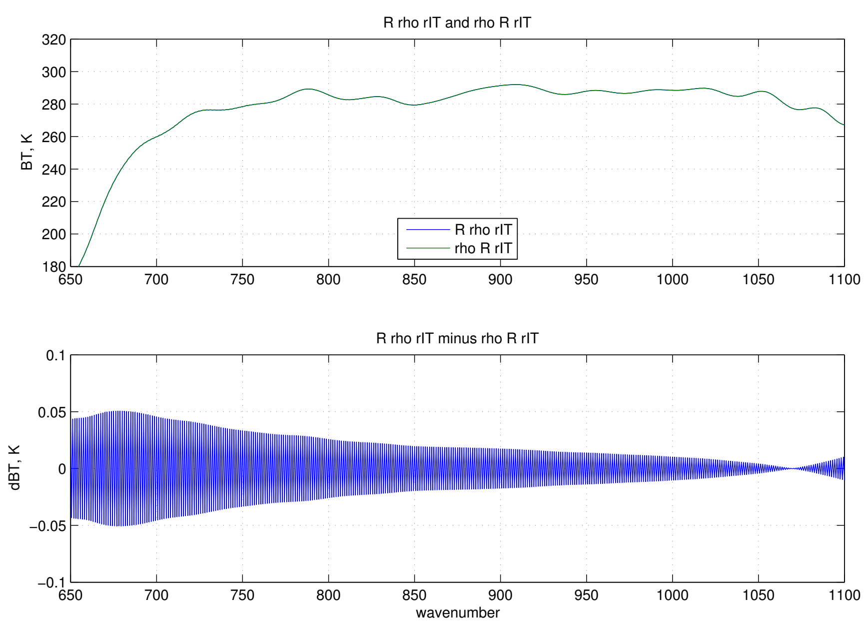

Figure 3: $R\rho\, r_{\mathrm{ICT}}$ and $\rho\, R\, r_{\mathrm{ICT}}$

2 CrIS reference truth

We can a derive a definition of reference truth from a basic form of the CrIS calibration equation, with details depending on assumptions about instrument behavior. Suppose r_{ES} is high resolution earth scene radiance, r_{ICT} high resolution black-body radiance from the internal calibration target, ρ instrument responsivity, and R resampling from high resolution to the instrument sensor grid, $dv = 1/(2\,\text{OPD})$, where OPD is the maximum optical path difference.

If r is some arbitrary high resolution radiance, we might expect that $R\rho\, r \approx \rho\, R\, r$. Figure 2 shows the difference for a typical earth scene, and figure 3 the difference for an ICT (black body) look. Suppose we interpret this as $R\rho\, r_{\text{ICT}} \approx \rho\, R\, r_{\text{ICT}}$ for ICT looks, but $R\rho\, r_{\text{ES}} \neq \rho\, R\, r_{\text{ES}}$ for earth scenes. Calibration of the on-axis optical path of a Michaelson interferometer can be represented as

$$r^{\text{LR}}_{\text{cal}} = r^{\text{LR}}_{\text{ICT}} \frac{ES - SP}{IT - SP} \tag{7}$$

where $r^{\text{LR}}_{\text{cal}}$ is calibrated radiances, $r^{\text{LR}}_{\text{ICT}}$ 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. Note that all values in equation 7 are at the "sensor grid" $dv = 1/(2\,\text{OPD})$.

Let $ES \approx R\rho(r_{\text{ES}} + r_{\text{SP}})$, $IT \approx R\rho(r_{\text{ICT}} + r_{\text{SP}})$, and $SP \approx R\rho\, r_{\text{SP}}$, where r_{ES}, r_{ICT}, and r_{SP} are high resolution approximations to the true radiances, ρ is responsivity, and R is resampling from the high resolution to the sensor grid dv. Let $r^{\text{LR}}_{\text{ICT}} = R(r_{\text{ICT}})$. Substituting this into (7) gives

$$\begin{aligned}
r^{\text{LR}}_{\text{cal}} &\approx r^{\text{LR}}_{\text{ICT}} \frac{R\rho(r_{\text{ES}} + r_{\text{SP}}) - R\rho\, r_{\text{SP}}}{R\rho(r_{\text{ICT}} + r_{\text{SP}}) - R\rho\, r_{\text{SP}}} \\
&= r^{\text{LR}}_{\text{ICT}} \frac{R\rho\, r_{\text{ES}}}{R\rho\, r_{\text{ICT}}} && (8) \\
&\approx r^{\text{LR}}_{\text{ICT}} \frac{R\rho\, r_{\text{ES}}}{\rho\, R\, r_{\text{ICT}}} && (9) \\
&= \frac{R\rho\, r_{\text{ES}}}{\rho} = r_{\text{resp}} && (10)
\end{aligned}$$

We go from equation 8 to 9 because we have assumed responsivity commutes at least approximately with resampling for the ICT look. Equation 10 is the

UW definition of “reference truth with responsivity”.

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

$$r_{\text{flat}} = R r_{\text{ES}} \tag{11}$$

If we assume $R\rho\, r_{\text{ES}} \approx \rho\, R\, r_{\text{ES}}$ then we get “flat” reference truth. In practice we find the “ratio first” UMBC CCAST reference calibration equation has smaller residuals when compared with r_{flat}, while the “SA^{-1} first” NOAA 4 algorithm 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}.