ccast nonlinearity corrections

*** draft ***

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parameters

- r_{in} is scene count spectra
- r_{sp} is space-look count spectra
- n is the number of decimated points
- d is the decimation factor
- c_{m} is modulation efficiency
- c_{p} is PGA gain
- c_{a} is A/D gain
- v_{inst} instrument contribution to DC level
- v_{dc} is estimated DC level
- f_{N} is the numeric filter at the sensor grid
- a_2 are the correction parameters

nonlinearity correction

- let / be pointwise division, and

$$r_{\mathrm{in}}^{\mathrm{s}} = r_{\mathrm{in}} / f_{\mathrm{N}}$$

$$r_{\mathrm{sp}}^{\mathrm{s}} = r_{\mathrm{sp}} / f_{\mathrm{N}}$$

- the DC level is given by

$$v_{\mathrm{dc}} = v_{\mathrm{inst}} + \frac{2 \cdot \sum_{i=1}^{n} \left| r_{\mathrm{in}}^{\mathrm{s}} - r_{\mathrm{sp}}^{\mathrm{s}} \right|}{c_{\mathrm{m}} \cdot c_{\mathrm{a}} \cdot c_{\mathrm{p}} \cdot d \cdot n}$$

- corrected radiances (scaled by f_{N}) are

$$r_{\mathrm{out}}^{\mathrm{s}} = r_{\mathrm{in}}^{\mathrm{s}} \cdot (1 + 2 \cdot a_2 \cdot v_{\mathrm{dc}})$$

f_{N} normalization

- now suppose we have a scaling factor w for f_{N}, so that

$$r_{\mathrm{in}}^{\mathrm{s}}{}' = r_{\mathrm{in}}/(w \cdot f_{\mathrm{N}})$$

$$r_{\mathrm{sp}}^{\mathrm{s}}{}' = r_{\mathrm{sp}}/(w \cdot f_{\mathrm{N}})$$

- then the DC level is

$$v_{\mathrm{dc}}{}' = v_{\mathrm{inst}} + \frac{2 \cdot w \cdot \sum_{i=1}^{n} |r_{\mathrm{in}}^{\mathrm{s}} - r_{\mathrm{sp}}^{\mathrm{s}}|}{c_{\mathrm{m}} \cdot c_{\mathrm{a}} \cdot c_{\mathrm{p}} \cdot d \cdot n}$$

- and the corrected radiances (scaled by f_{N}) are

$$r_{\mathrm{out}}^{\mathrm{s}}{}' = r_{\mathrm{in}}^{\mathrm{s}} \cdot (1 + 2 \cdot a_2 \cdot v_{\mathrm{dc}}')$$

- note that $v_{\mathrm{dc}}{}'$ and $r_{\mathrm{out}}^{\mathrm{s}}{}'$ are both functions of w

discussion

- the formulas here were reverse engineered from the UW code
- early versions of both UMBC and UW CCAST used a frequency domain representation of f_{N} from UW
- after the Aug 2013 high res test UMBC switched to a time domain representation, with transform to the sensor grid from Dan Mooney
- this did not work correctly until we scaled the new filters to match the norms of the old UW filters,

$$\begin{aligned} \text{LW:}\quad f_{\mathrm{N}} &= 1.6047 \cdot f_{\mathrm{NM}} / \max(f_{\mathrm{NM}}) \\ \text{MW:}\quad f_{\mathrm{N}} &= 0.9826 \cdot f_{\mathrm{NM}} / \max(f_{\mathrm{NM}}) \\ \text{SW:}\quad f_{\mathrm{N}} &= 0.2046 \cdot f_{\mathrm{NM}} / \max(f_{\mathrm{NM}}) \end{aligned}$$

  Here f_{NM} was the transform from the time domain, before any scaling