some notes on the ccast nonlinearity correction

H. E. Motteler

UMBC Atmospheric Spectroscopy Lab
Joint Center for Earth Systems Technology

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nonlinearity correction

- let $/$ be pointwise division, and

$$r^{s}_{in} = r_{in} / f_N$$

$$r^{s}_{sp} = r_{sp} / f_N$$

- the DC level is given by

$$v_{dc} = v_{inst} + \frac{2 \cdot \sum_{i=1}^{n} |r^{s}_{in} - r^{s}_{sp}|}{c_m \cdot c_a \cdot c_p \cdot d \cdot n}$$

- the corrected radiances (scaled by f_N) are

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

f_{N} scaling

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

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

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

- then the DC level is

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

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

$$r^{s}_{\mathrm{out}}{}' = r^{s}_{\mathrm{in}} \cdot (1 + 2 \cdot a_2 \cdot v'_{\mathrm{dc}})$$

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

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

discussion

- the formulas here were reverse engineered from 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 weights (I think) from Joe Predina and transform to the sensor grid from Dan Mooney
- the nonlinearity correction did not work correctly until we scaled the new filters to match the norms of the 2008 UW filters,

$$\begin{aligned} \text{LW:} \quad f'_N &= 1.6047 \cdot f_N / \max(f_N) \\ \text{MW:} \quad f'_N &= 0.9826 \cdot f_N / \max(f_N) \\ \text{SW:} \quad f'_N &= 0.2046 \cdot f_N / \max(f_N) \end{aligned}$$

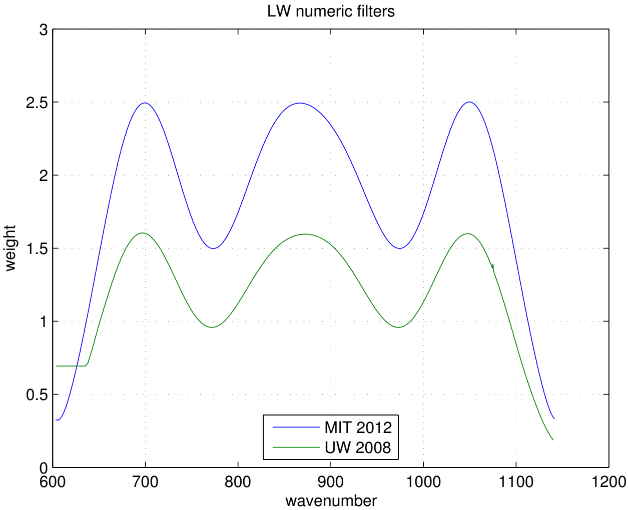
  Here f_N was the transform from the time domain, before any scaling

discussion

- the transform from time to frequency preserves any scaling factor
- so our problem was probably just that the weights we were starting from did not have the correct scaling or normalization
- the following figures show the filters before any scaling
- the following Matlab code is Dan's filter transform demo. `filt` is the time and `sfilt` the frequency representation at the sensor grid

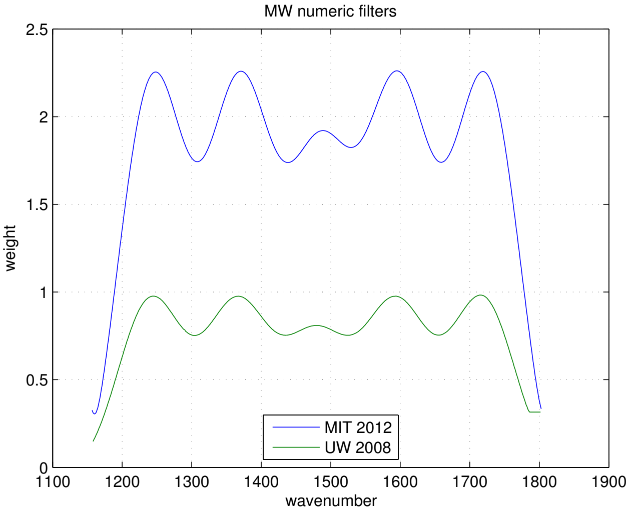
```
S = fft(filt, inst.npts * inst.df);
I = ifft(S);
S1 = fft(I(1 : inst.df : inst.npts * inst.df)) * inst.df;
S2 = circshift(S1, [-inst.cutpt, 0]);
sfilt = abs(S2);
```

LW numeric filters



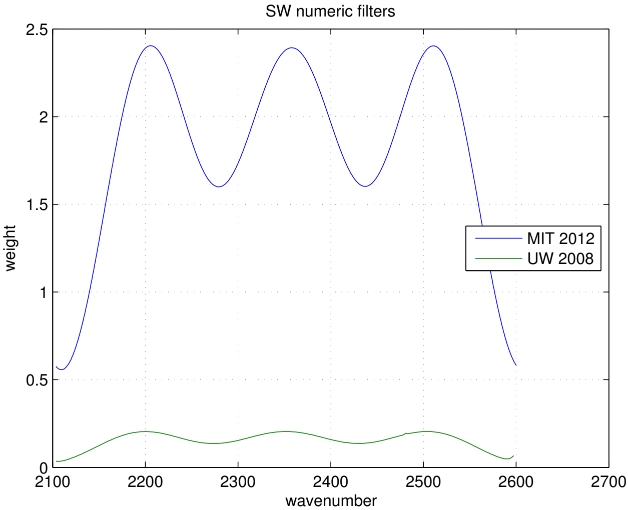
LW filters from UW 2008 frequency domain and MIT 2012 time domain representations

MW numeric filters



MW filters from UW 2008 frequency domain and MIT 2012 time domain representations

SW numeric filters



SW filters from UW 2008 frequency domain and MIT 2012 time domain representations