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Background Subtraction in sharp_combine

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1.

Let the measured signal be given by

$$M_o'(i,t) = G(i)[A(t)S(i) + B(t)] \tag{1}$$

where i denotes a constant point on the sky or an array pixel, and t denotes time.

$$\begin{aligned} B(t) &= \text{background: changes with time, constant across array} && (2)\\ A(t) &= \text{atmospheric attenuation: changes with time, constant across array} && (3)\\ S(i) &= \text{source intensity: varies across the array, constant in time} && (4)\\ G(i) &= \text{detector gain: varies across the array, constant in time} && (5)\end{aligned}$$

Assuming we have already accurately corrected the data for $A(t)$ (airmass and tau) and $G(i)$ (the rgm) we have

$$M_o(i,t) = \frac{M_o'(i,t)}{G(i)A(t)} = S(i) + D_o(t) \tag{6}$$

where the dc offset is $D_o(t) = B(t)/A(t)$.

The main sharp_combine algorithm time averages this quantity:

$$\langle M_o(i,t)\rangle = S(i) + \langle D_o(t)\rangle \tag{7}$$

where $\langle\rangle$ denotes a time average. While one expects $\langle B(t)\rangle = 0$ for long times, it is not necessarily true that $\langle D_o(t)\rangle = 0$, especially if $A(t)$ has large time variations. Kirby et al. (2005) dealt with this problem for Hertz data. Here we deal with it by apprpriately lowering $D(t)$ at each time step so that after many iterations we get $\langle D(t)\rangle \to 0$; or equivalently $\langle D(t)^2\rangle$ approaches the measured flux uncertainties (measured how?).

The difference between the average and any single file is the difference between equations (6) and (7)

$$d(i,t) = M_o(i,t) - \langle M_o(i,t)\rangle = D_o(t) - \langle D_o(t)\rangle \tag{8}$$

where we have used nearest-neighbor sampling to align the individual array measurements $M(i,t)$ with the re-gridded data $\langle M(i,t)\rangle$. This difference $d(i,t)$ provides a measure of the dc offset for each array pixel so we take

$$\overline{d(i,t)} = D_o(t) - \langle D_o(t)\rangle \tag{9}$$

where the over-bar denotes spatial averaging across the array.

Combining equations (6) and (9) yields an estimate of the background subtracted source intensity in each file

$$\begin{aligned} M_1(i,t) &= M_o(i,t) - \overline{d(i,t)} && (10)\\ &= S(i) + D_o(t) - (D_o(t) - \langle D_o(t)\rangle) && (11)\\ &= S(i) + \langle D_o(t)\rangle && (12) \end{aligned}$$

If $\langle D_o(t)\rangle \ll S(i)$ then $M_1(i,t)$ is a good estimate of $S(i)$ and we are done. If not we start over with equation (12) in place of equation (6) with $D_1(t) = \langle D_o(t)\rangle$.

REFERENCES

Kirby, L., Davidson, J. A., Dotson, J. L., Dowell, C. D., & Hildebrand, R. H. 2005, PASP, 117, 991
