Atmospheric Fluctuation Noise for Single Dish Measurements

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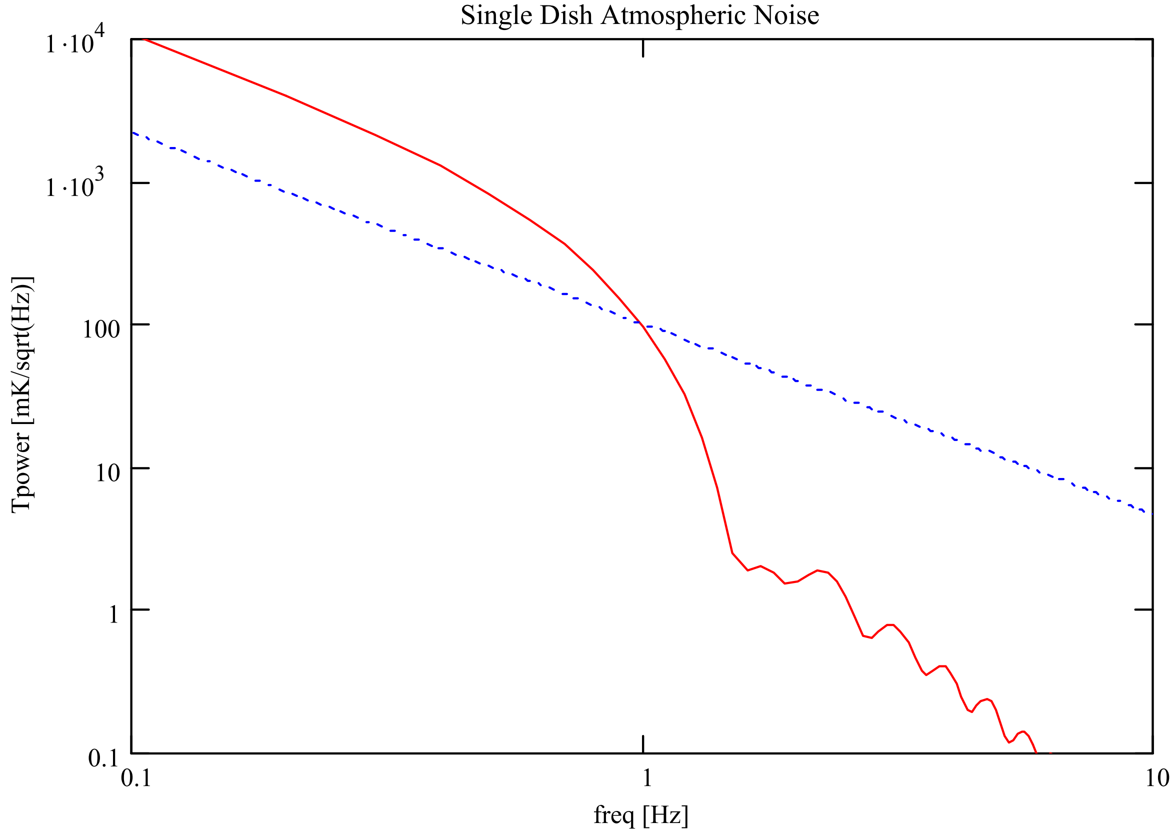

Calculation of the atmospheric noise for a single dish staring at the sky using the same assumptions as ALMA Memo 422; 250 micron RMS noise from the 300 m baseline phase monitor and a conversion of 20mK/micron from delay to sky brightness.

This was calculated using the approach developed by Oliver Lay [Lay, O., "The temporal power spectrum of atmospheric fluctuations do to water vapor", Astronomy & Astrophysics Suppl. Ser. 122, 1997, pp. 535-545.]. The phase monitor data gives the structure function at a particular baseline length. This actually the integral of the 2-D wavefront delay power spectrum filter by the interferometer. To calculate the effect of any other type of measurement is best done by working with this 2-D wavefront delay power spectrum since most instruments just act as filters on this power spectrum. The expected power law for this spectrum is $(qx^2+qy^2)^{-11/6}$ where qx and qy are inverse lengths in the x and y directions. The details of the interferometer filtering are in Lay's paper. The phase monitor data was used to calculate the magnitude of the power spectrum, i.e. the coefficient in front of $(qx^2+qy^2)^{-11/6}$ taking proper account of the interferometer filtering. The single dish filtering function corresponding to a Gaussian illumination function with 10 dB edge taper was calculated and the power spectrum was multiplied by this filter. The inverse length axis was then converted to frequency using the Taylor model, ie. multiplying by the wind speed.

The noise power scales as $f^{4/3}$ for long time scales, or slow chopping, and that there is a rapid decrease for frequencies faster than the wind crossing time. The antenna is a very effective low pass filter. The effect of chopping the calibration load and synchronously demodulating the output is actually just applying an additional filter to the above spectrum. Chopping at 3 Hz and integrating for 10 sec multiplies the spectrum by a narrow window centered at 3 Hz that is ~0.1Hz wide.

I conclude that chopping between the two loads at 3 Hz and certainly at 10 Hz should make the atmospheric fluctuation noise negligible for the dual-load calibration scheme.