ATMOSPHERIC NOISE CONTRIBUTION TO COSMIC MICROWAVE BACKGROUND MEASUREMENTS

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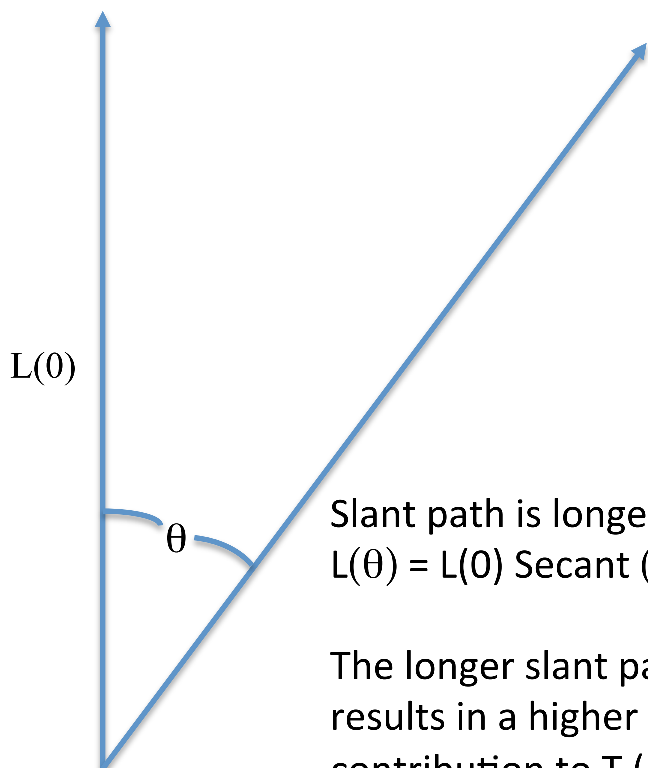
ATMOSPHERIC EMISSION

- When pointing at the CMB through the atmosphere, we see the glow of atmospheric gases added to the sky temperature.
- The emission is principally from oxygen and water vapor.
- The table below shows the range of added noise temperature under different conditions.
- The atmospheric contribution at 10 GHz at sea level is 5 K – 15 K, depending on the level of moisture.
- It is a substantial correction to the sea level measurement for amateurs, who typically are not using a balloon or a satellite platform.
- Note that the temperature decreases significantly at higher altitudes.

Method	LOCATION	Altitude (Ft)	CLOUDS	ATMOSPHERIC NOISE (K)	AUTHOR YEAR
Measured	Germany	0	Clear	5.2	Stein & Forster (2008)
Modeled	Std Atmosphere	0	Clear	6.9	Weger (1959)
Modeled	Std Atmosphere	0	Moderate clouds	8.5	"
Modeled	Std Atmosphere	0	Moderate rain	14.8	"
Measured	White Mtn, CA	12,500	Clear	1.1 - 1.27	Bersanelli et al. (1995)

MEASURING ATMOSPHERIC EMISSION

We can isolate the atmospheric contribution to the measured sky temperature by measuring the sky temperature at different angles, sometime called tipping.



Slant path is longer
$L(\theta) = L(0)$ Secant (θ)

The longer slant path results in a higher contribution to T (Atm).

At pointing angles of 0 degrees (zenith) and θ degrees from the zenith we have,

1) T(sky, 0) = T(CMB) + T (atm,0)*Sec 0
2) T(sky, θ) = T(CMB) + T (atm, θ)*Sec θ

Where T(sky, θ) = Sky temp at angle θ
T(CMB) = cosmic microwave background
T (atm, θ) = atm contribution at θ

Note that T(CMB) is the same at all angles.

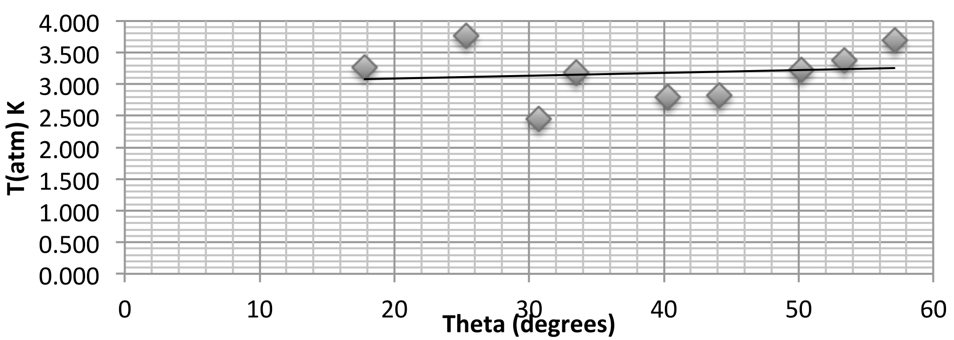
We can determine T(atm) for the zenith by subtracting Eq 1 from Eq 2.

T(sky,θ) - T(sky, 0) = T(atm,0) * (Sec θ - Sec 0)
[T(sky,θ) - T(sky, 0)] * 1/(Sec θ – 1) = T(atm,0)

ATMOSPHERIC NOISE EXAMPLE

- This method involves measuring the sky temperature at various angles, theta, from the vertical.
- Note that the measured sky temperature increases with angle due to a longer atmospheric path.
- The factor, Sec θ, used in the computation of T(Atm, 0) compensates for the increase in path.
- In principal one only needs one measurement at one angle to determine T(Atm,0).
- It is common to create a graph similar to the one below with data taken at numerous angles.
- This should result in a horizontal line fitting the points.
- If calculated T(Atm,0) gets higher as theta goes up, there is ground leakage as horn is tilted.
- The data used below is from a literature reference.

Theta	Secant	T(Sky)	T(Atm)
0.00	1.00	5.70	
17.80	1.05	5.87	3.26
25.30	1.11	6.10	3.77
30.70	1.16	6.10	2.46
33.50	1.20	6.34	3.19
40.30	1.31	6.57	2.80
44.10	1.39	6.81	6.81
50.20	1.56	7.51	3.22
53.40	1.68	7.99	3.37
57.10	1.84	8.81	3.69



HORN ANTENNA EXTENSION

- The angle measurement requires a much narrower beamwidth than the original horn beamwidth of 75 degrees.
- Horn extension optimized for beamwidth of 10 degrees.
- Horn extension made from .010 brass sheet.
- I chose to use an extended horn because it has less scatter than using a dish.

POINTING AT ZENITH AND 45 DEGREES

At the present time I am still having problems with ground radiation. Stay tuned.