Calibration errors introduced by the linear opacity correction

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The current technique at the 30 m is to linearly interpolate the opacity derived from two successive skydips (and from an atmosphere model). However, situations may occur where the opacity changes rapidly during the observation of a map. If a skydip measurement were available in total power, it would be possible to derive a total-power-to-Kelvin calibration factor. Then, the opacity may be determined record by record from the total power information contained in the data (for the 37 channel bolometer, the total power of three channels is available). But even with a total power skydip, the opacity can only be determined assuming that

1. the mean atmospheric temperature is varying slowly as compared to the opacity variations, allowing for a linear interpolation between two skydips,
2. same with the temperature of the hot load and its corresponding count rate,
3. same with the calibration factor (total-power-to-Kelvin).

The first two assumptions may be relaxed, if the weather data were recorded and analysed (with an atmosphere model) on a record-by-record basis. The same holds for the cabin temperature (assumed to equal the temperature of the hot load). In any case, the formula to derive the zenith opacity from the total power is

$$\tau_{\mathrm{z}} = -\sin\left(\mathrm{airmass}\right) \cdot \ln\left(\frac{T_{\mathrm{atm}} - T_{\mathrm{amb}} + \frac{P_{\mathrm{sky}} - P_{\mathrm{hot\ load}}}{\mathrm{Counts\_to\_Kelvin} \cdot F_{\mathrm{eff}}}}{T_{\mathrm{atm}} - T_{\mathrm{cb}}}\right), \qquad (1)$$

where P are the total power counts (towards the sky and the hot load, respectively), T_{atm} and T_{amb} the mean atmosphere and ambient temperatures, respectively, and T_{cb} the temperature of the cosmic background radiation field. At the *Heinrich-Hertz-Telescope*, the skydips are taken in total power mode at six elevations, followd by a hot-load measurement (subscan 7). The skydip opacities (at 345 GHz) were derived from a least squares fit to the skydip data (total power on sky minus total power from hot load) at different elevations, allowing to fit the zenith opacity and the calibration factor (the data were weighted by the inverse variance of the total power at a given elevation). The opacities towards the sources were then determined using Eq. 1. The results for maps of Saturn, G34.3, and W3OH (data kindly provided by Michael Dumke, SMTO) are summarized in Table 1. The calibration error due to the linear correction does not only depend on the mean opacity itself, but also on the opacity variations (see Fig. 1). In case of rapid variations, it may even be possible to introduce artefacts in the source structure due to a wrong opacity interpolation (a situation not encountered in the test data shown here).

Table 1: Summary of results (in counts/beam at peak position), using the "exact correction" (still depending on the reliability of the atmosphere model), respectively the linear interpolation of the skydip opacities. The corresponding relative calibration errors are also given. Note that the skynoise reduction (for G34.3 and W3OH) introduces a non-linearity in the response of the system to the signal.

	exact correction	linear correction	rel. error	τ_1	τ_2	τ_{mean}
Saturn	1.5201×10^6	1.2548×10^6	17.5 %	0.58	0.60	0.59
G34.3	28409	32608	14.8 %	0.44	0.55	0.51
W3OH	15809	18647	18.0 %	0.84	0.82	0.83

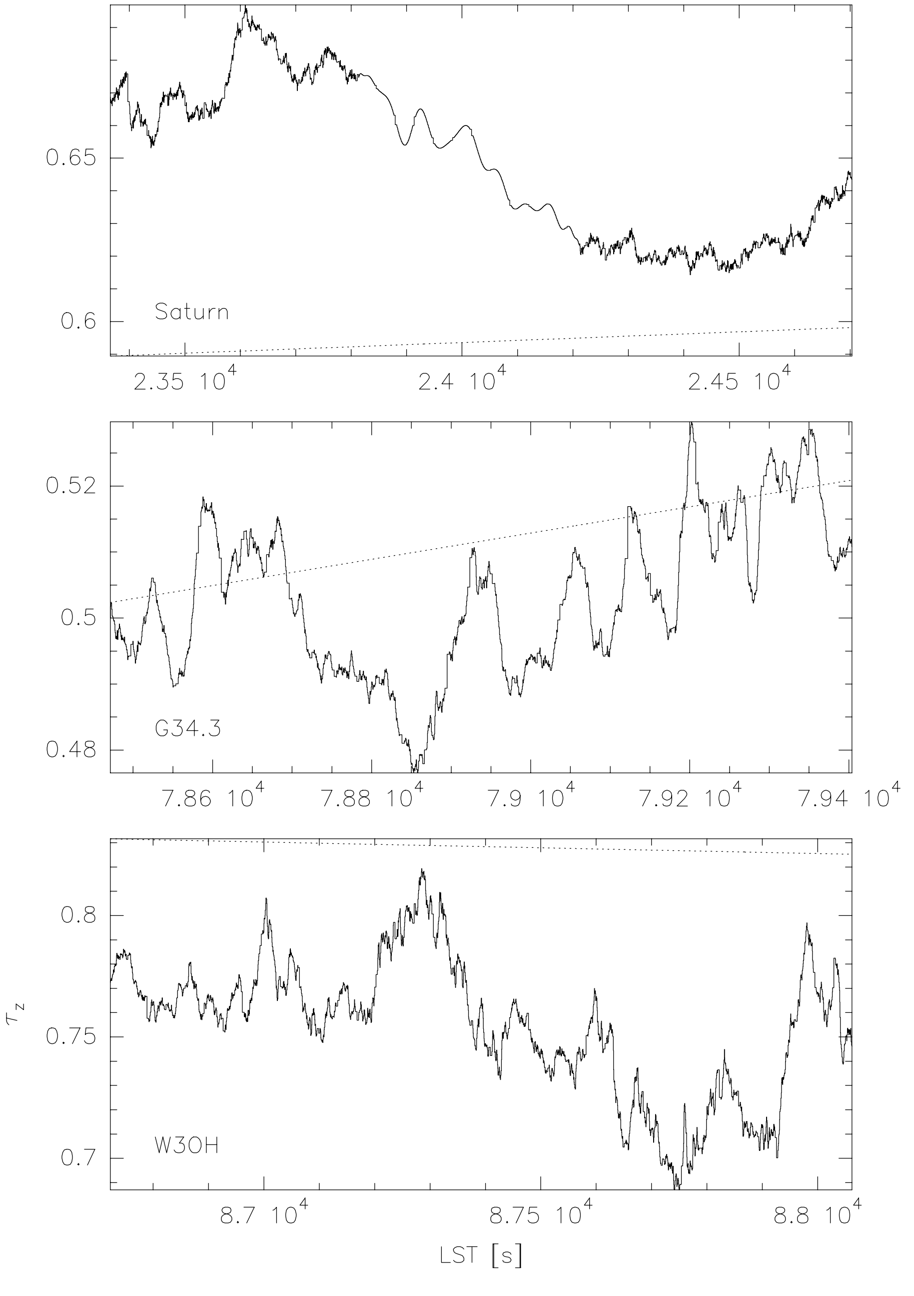

Figure 1: Zenith opacity variations as derived from total power variations. The dashed line is the linear opacity interpolation as derived from the skydip measurements taken before and after the scan. A part of the records of the Saturn data are replaced by a model without the total power contribution of Saturn. HHT 19-channel bolometer data kindly provided by M. Dumke, SMTO.