Matched filtering for EASIER data

Abstract

We introduce in this note the method of matched filtering to EASIER data.

1 temperature measurement

We describe here some details on the analysis to measure the temperature with the sun flux. This analysis is being carried out by Corinne in Grenoble and Romain in Paris.
The basic idea is to use the monitoring data to measure the raise of the baseline upon the passage of the sun in the field of view of GIGADuck's antenna. This raise is used to estimate the noise temperature of the GIGADuck system. The main steps of the analysis are:

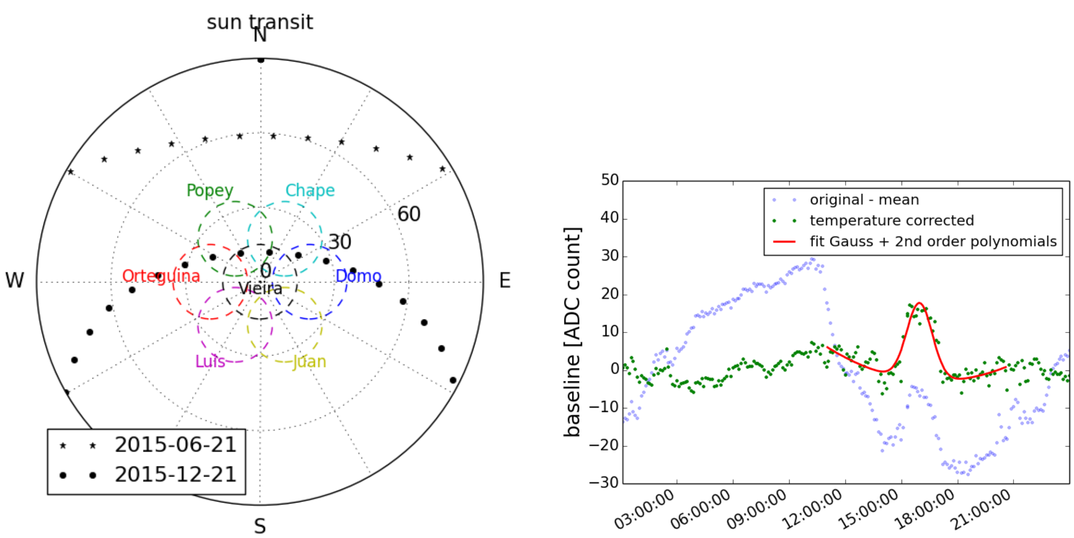

Figure 1 Left: Sun transit for the two solstices. The colored circles represent the field of view of the GIGADuck antennas. Right: Example of the baseline during one day. In blue is the orignal baseline when the mean is subtracted, in green after it was corrected from temperature dependence and in red is a gaussian fit of to extract the signal from the sun.

- produce the monitoring data
- choose a period when the expected sun signal is large
- cut the rainy periods
- find the dependence of the radio baseline with the outside temperature during this period
- correct the baseline for the outside temperature dependence
- fit the radio baseline with a Gaussian plus a second order polynomial.

The figure 1 (left) shows the path of the sun for two different dates and the field of view of the GD C-band antennas. The sun signal will be maximum in summer when the sun is higher in the sky. The plot on the right in the figure 1 (right) shows the raw baseline of one antenna during one day in blue, the same baseline corrected by the tempereature dependence and the fit of the sun bump in red. In Corinne's analysis, the fit is done with a constant instead of a polynomials and it is done on the several (around three) consecutive days. The two methods have shown very similar results. They show differences between antennas but also differences for the same antenna at different time of the year. We intend in the next section of this note to estimate the uncertainties on this measurement to quantify the consistency of these results.

2 Temperature measurement uncertainties

The formula we use to retrieve the temperature is:

$$\mathrm{T_{sys}}(\mathrm{F_{sun}}, \mathrm{A_{eff}}, \Delta\mathrm{P}) = \frac{\frac{1}{2}\mathrm{F_{sun}}\mathrm{A_{eff}}}{10^{\frac{\Delta \mathrm{P}}{10}} - 1} \tag{1}$$

Where $\mathrm{F_{sun}}$ is the sun flux measured by other observatory, $\mathrm{A_{eff}}$ is the effective area in the sun's direction, ΔP is the power difference in dB (with 1dB = 50 ADC count) and the factor $\frac{1}{2}$ is the polarization factor (we only observe one of the two polarizations). The uncertainties on $\mathrm{T_{sys}}$ is then:

$$\sigma^2_{\mathrm{T_{sys}}} = \frac{\mathrm{T^2_{sys}}}{\mathrm{F^2_{sun}}}\sigma^2_{\mathrm{F_{sun}}} + \frac{\mathrm{T^2_{sys}}}{\mathrm{A^2_{eff}}}\sigma^2_{\mathrm{A_{eff}}} + \mathrm{T^2_{sys}}\left(\frac{\frac{\ln(10)}{10}10^{\frac{\Delta\mathrm{P}}{10}}}{10^{\frac{\Delta\mathrm{P}}{10}} - 1}\right)^2 \sigma^2_{\Delta\mathrm{P}} \tag{2}$$

2.1 Sun flux uncertainties

Here we check the precision we have on the sun flux. Up to now, we get data at 2.8 GHz (commonly called f107) and extrapolate the value at 3.8 GHz with parameterisation of the quiet sun and the slowly varying sun. We can compare our results with the Nobeyama observatory data, which collects data on the sun flux at 2 and 4 GHz (we don't use their data yet because they don't release them on the web). The figure 2 shows different fluxes:

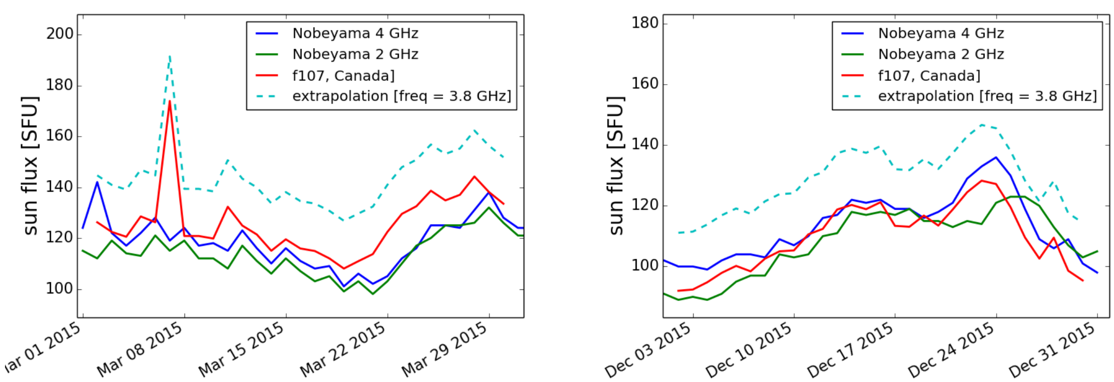

Figure 2 sun flux for at different frequencies

The value reported on the plots for the Nobeyama observatory are taken from what is displayed on their daily curves. I don't really know if this is an average or the minimum value. In any case, the values at 2 and 4 GHz are lower than what is measured at the Canadian site [1, 2] by around 20%. Since I am still not sure of the meaning of the value for the Nobeyama data, I will account for an uncertainty of 20% in the temperature calculation (**this has to be improved either by taking the data of Nobeyama or by determining a precise uncertainty.**). This number of 20% corresponds also to what is given in the website [3] where we found the parameterisation.

2.2 Effective area uncertainties

We do have also some uncertainties on the effective area, be it because of the pointing direction or our knowledge of the gain. We estimate the possible shift in pointing to 2°. The resulting uncertainty on the gain depends on the zenith angle at the sun maximum. The figure 3 shows the effective area and a gaussian fit as a function of the zenith angle and the uncertainties on the effective area based of the gaussian fit.

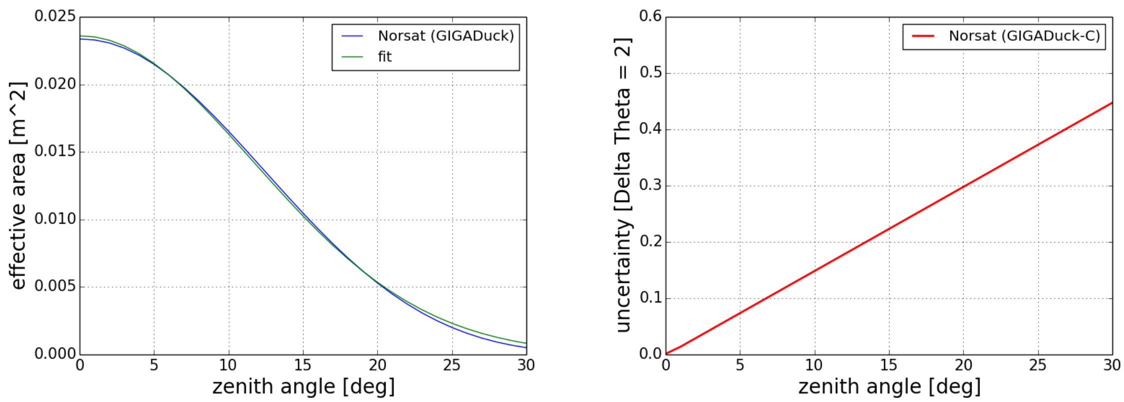

Figure 3 Effective area of the AInfo antenna from HFSS simulation (blue), gaussian fit (green). Right: relative uncertainty on the effective area

We perform the temperature measurement only during the months when a significant signal from the sun is expected, that means when it is high in the sky. The zenith angle at which the sun signal is maximum (in the simulation) is shown in the figure]4 for three antenna: Vieira the central detector that points up to the zenith, Chape and Orteguina (see figure 1 for their field of view).

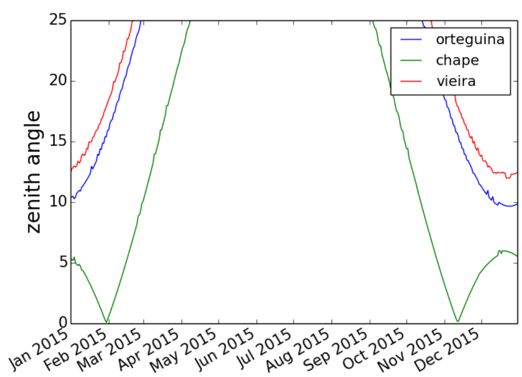

Figure 4 Zenith angle when the sun signal is maximum as a function of the date

[1] http://omniweb.gsfc.nasa.gov/form/dx1.html.

[2] http://www.spaceweather.gc.ca/solarflux/sx-5-en.php. 64

[3] http://www.spaceacademy.net.au/spacelink/solrfi/solrfi.htm.