# Lunar Night at DL0SHF

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## Why?

Determination of the positional errors of an antenna requires measurements of true and predicted positions of celestial objects, ideally covering the entire sky as evenly as possible. A good object is the Sun which gives a strong signal. However, it will cover only a certain path in the sky during one day, and in particular, in winter this path is at low elevation and rather short. Moreover, to reach all the declinations from -23 to +23º possible for the Sun, one would have to take measurements over half a year!

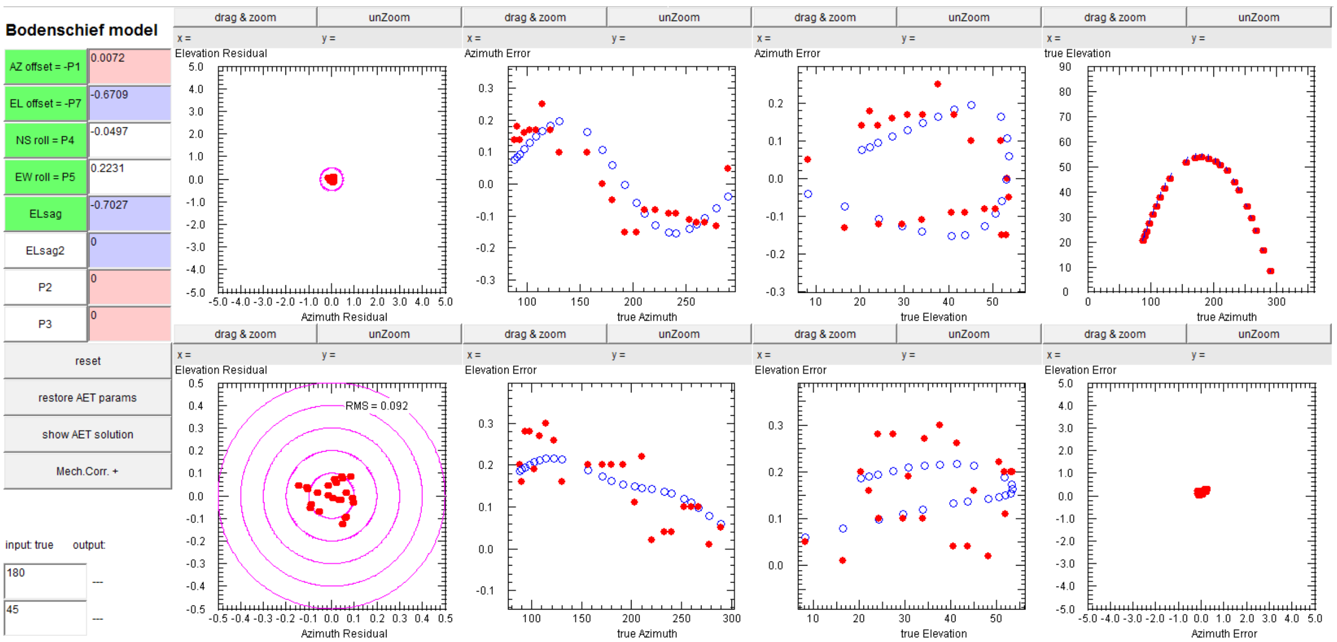
The Moon is the next best choice, as it performs its cycle of declinations within one month, so that a complete set of observations could be done within two weeks.

Circumpolar sources, such as Cas A and Cyg A, would map the northern directions, but due to their flux falling with frequency, they are suitable only for the lower frequencies, such as 1.3 GHz. For 10 and 24 GHz they are unsuitable because of the poor signal-to-noise ratio and undetectable signal levels, respectively.

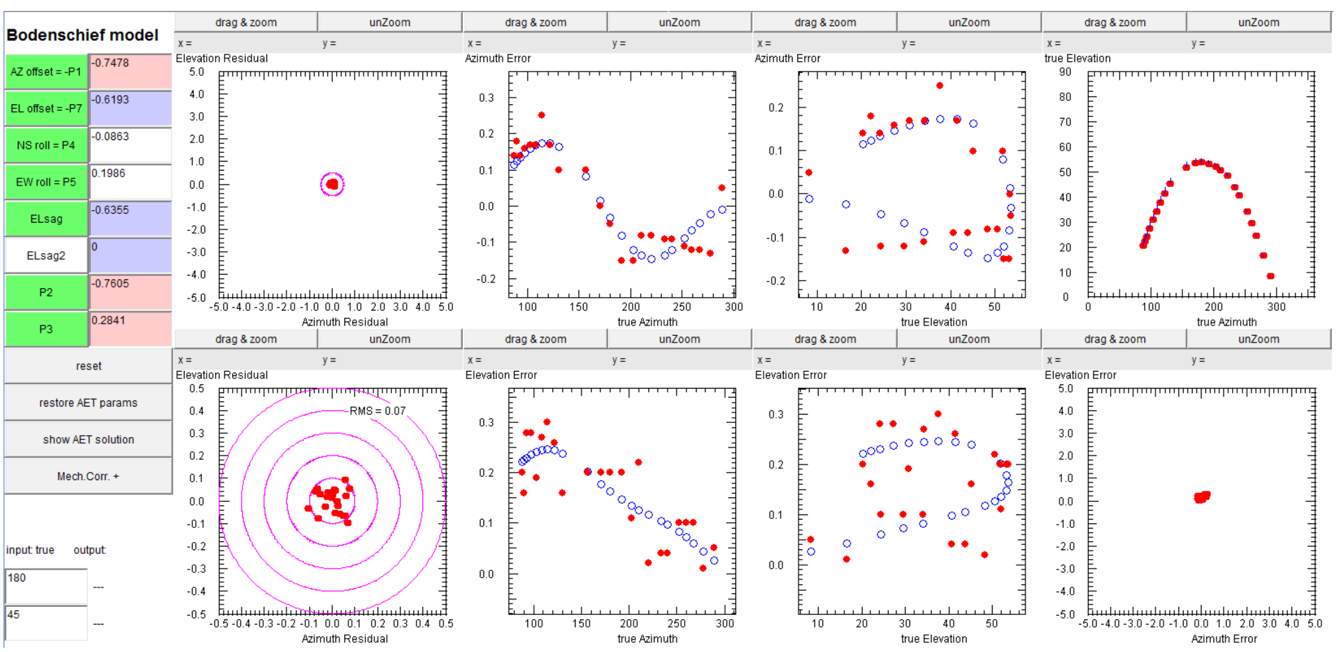
Thus in the night of 6/7 dec an attempt is made to get position corrections for three antennas of DL0SHF applying the Bodenschief approach to the Moon. In this night it would culminate at about 54º elevation. The measurements start shortly after moonrise, as to cover positions throughout the ascending branch of the lunar path, and getting various elevations.

# 1.3 GHz

The measurements yield a consistent data set which leads to a very satisfactory fit of the Bodenschief optimization:



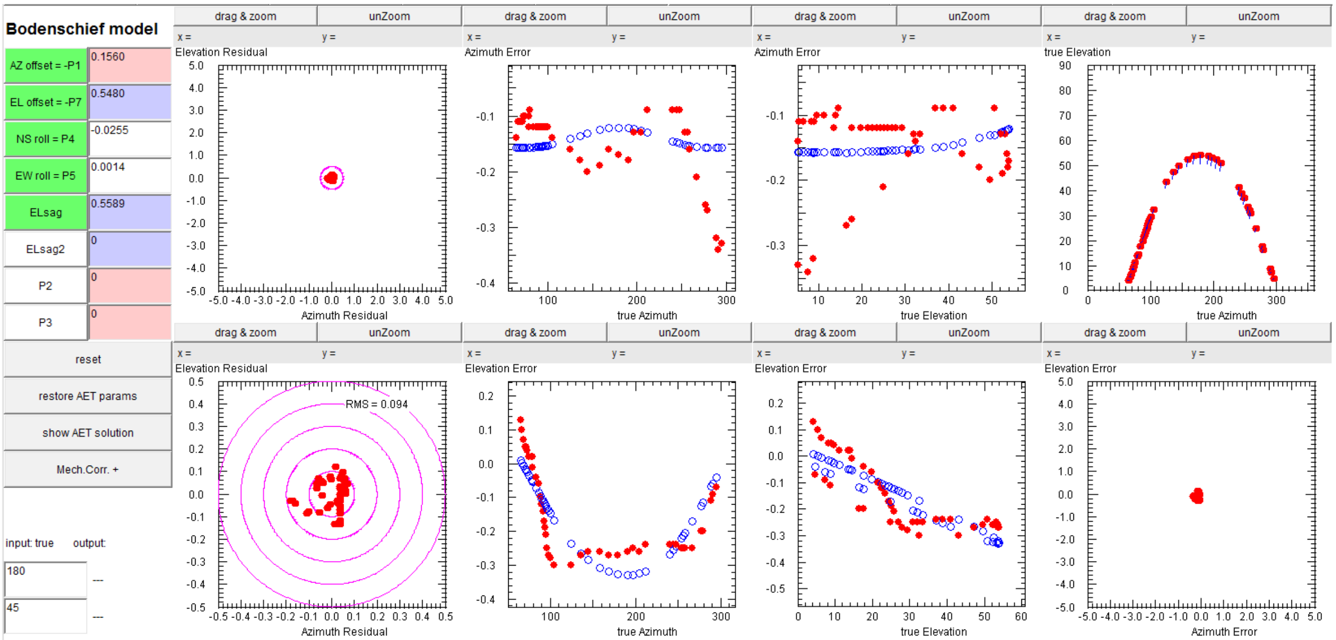

If we take also the P2 and P3 parameters into account, the fit is slightly improved:



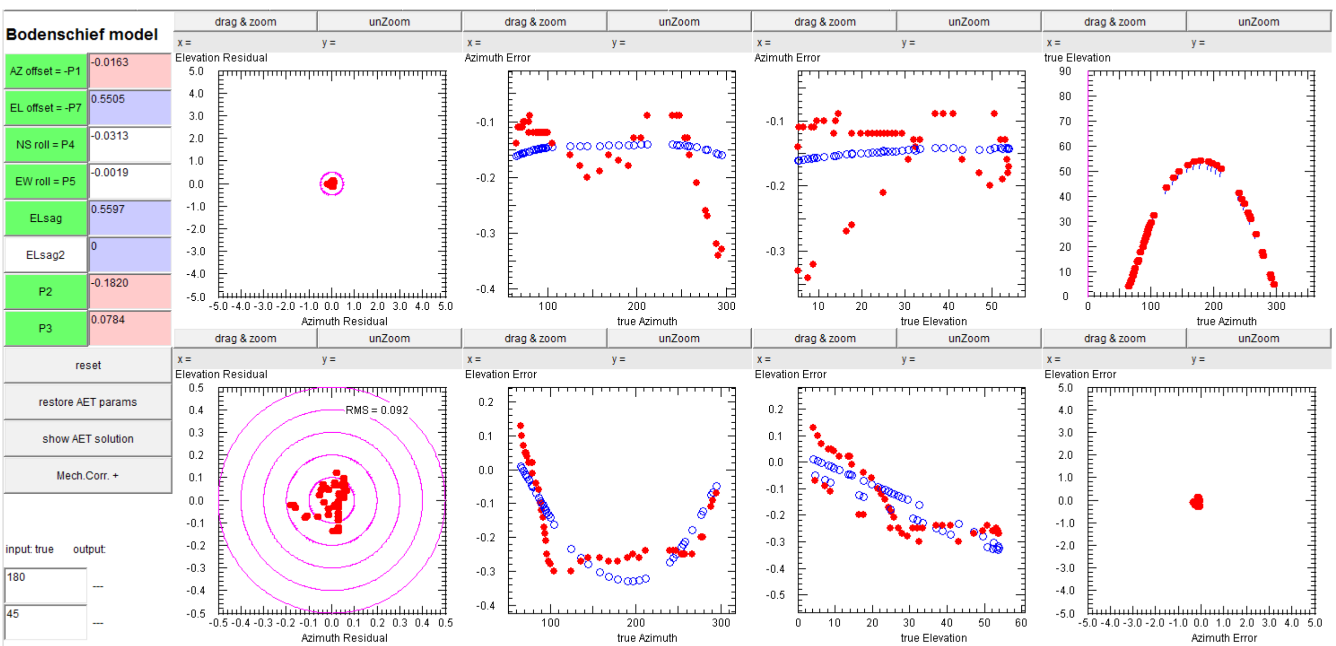

Thus, for this antenna Bodenschief does not need any modification.

# 10 GHz

Interpretation with the original Bodenschief model gives a satisfactory fit, except for the western edge:




which is only very slightly improved, if we take also the P2 and P3 parameters into account:

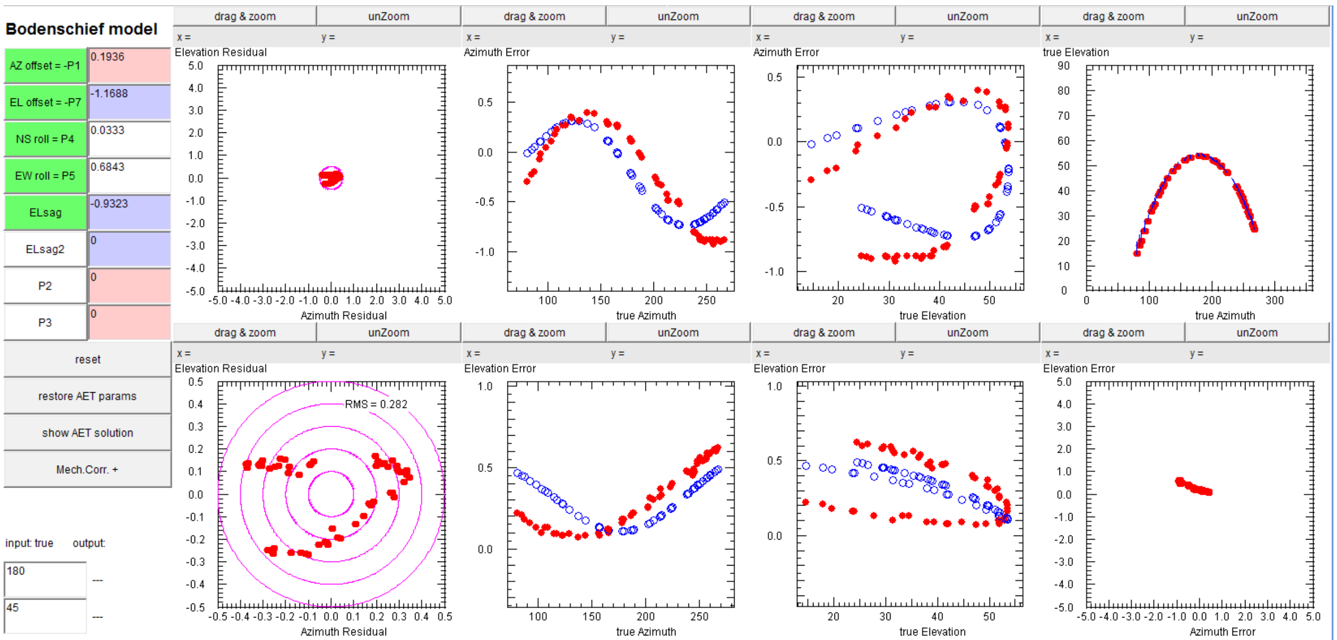



This indicates that also for this antenna no modification of Bodenschief is required.

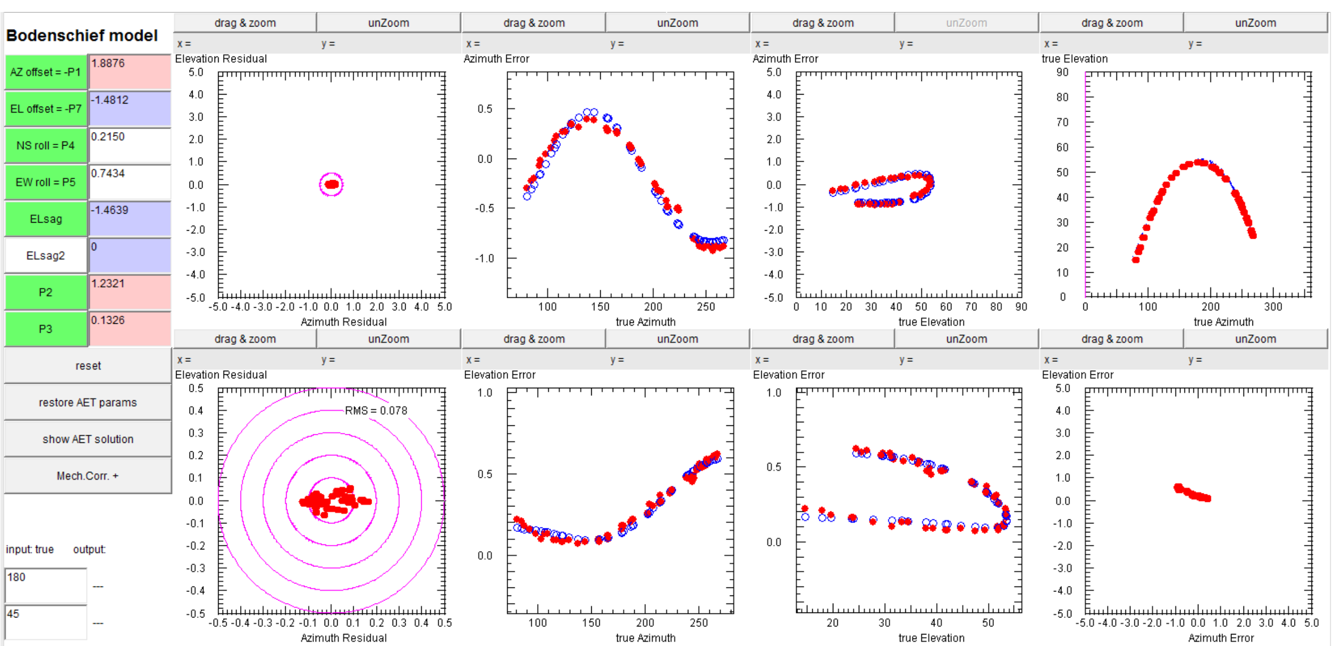
# 24 GHz

To guarantee that data are independent of the last entry, every measurement is done after the antenna is moved slightly off the last offset position, and the Moon is searched anew. At several position a series of three measurements is done.

Interpretation with the original Bodenschief model gives a very poor fit. As had been found from earlier measurements, the azimuth-dependence of azimuth and elevation errors is poorly matched:




If the P2 and P3 parameters are added, the fit is greatly improved, and become quite satisfactory:




For this antenna the additional parameters are essential.

## Conclusions

If one compares the interpretation of the three data sets with various models:

| | 1.3 GHz | 10 GHz | 24 GHz |
|---|---|---|---|
| Bodenschief | 0.092 | 0.095 | 0.283 |
| Bodenschief+P2+P3 | 0.070 | 0.092 | 0.078 |
| P-model | 0.074 | 0.097 | 0.078 |
| Q-model (10 param.) | 0.064 | 0.071 | 0.053 |
| Q-model (18 param.) | 0.055 | 0.029 | 0.033 |

one may draw these conclusions:

- the original Bodenschief model is entirely satisfactory for the 1.3 and 10 GHz antennas.
- the 24 GHz antenna clearly requires the addition of the P2 and P3 terms, which indicates that this antenna suffers from a collimation error, viz. the optical axis is offset from the centre of movement of the positioning system. It might be this aspect that caused the unsatisfactory positioning of this antenna ...
- while interpretation with more sophisticated models gives a better fit of the data, there are differences:
    - 1.3 GHz shows the least improvement. This is due to larger width of the antenna lobe (1.9º)
    - 10 GHz: with the Q18 model the tracking accuracy of the system is reached
    - 24 GHz: Q18 model reaches almost the system's tracking accuracy. It is possible that among this large data set are less accurate.

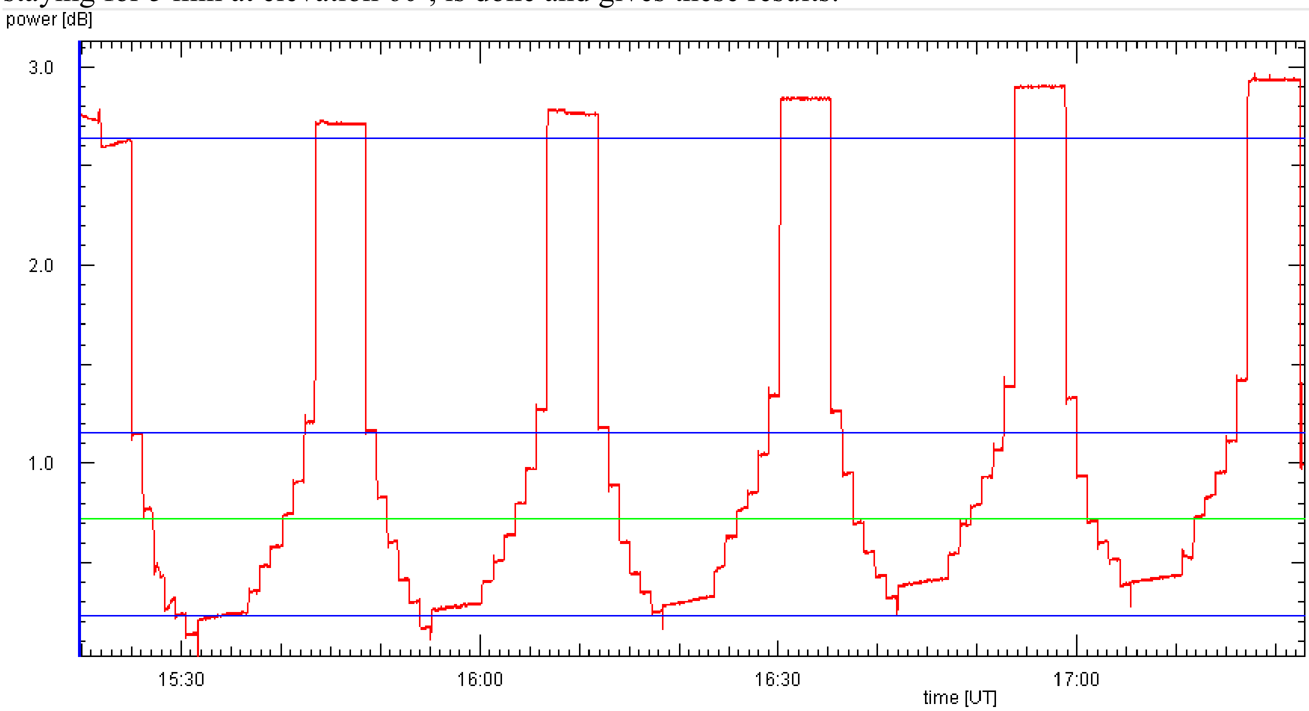
## Next Steps

Since the position corrections for 24 GHz pertain only to the path of an object at about 20º declination, the measurements will be continued at other, lower lunar positions. Next convenient opportunity will be next weekend or slightly later, when the Moon culminates at about 30..40º.

## Something else about the 24 GHz antenna

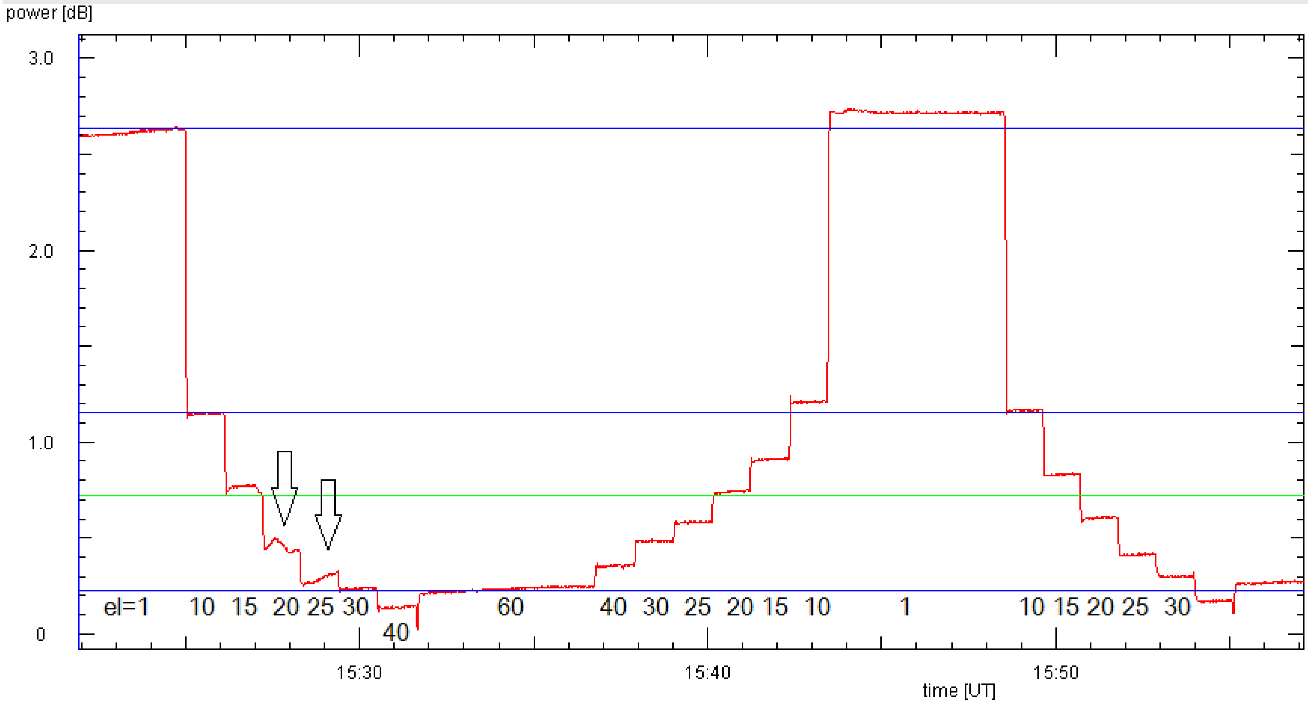
It had been noticed before that sky profiles taken by moving up in elevation differ systematically from those taken while moving down. As this occurs repeatedly and in a reproducible manner, this cannot be due to changes in the sky like passing clouds. Errors in the positioning system can also be safely excluded....

Since the sky was clear and cloudless in the afternoon and evening of Dec.6th this was a good chance to further investigate this problem. Under this conditions of a still and settled atmosphere a sequence of five profiles, done upwards and downwards, along with 5 min long flux calibrations at elevation 0º and staying for 5 min at elevation 60º, is done and gives these results:




- the observation starts at elevation 1º, followed by measurements at 10, 15, 20, 25, 30, 40, and 60º where data are taken for 5 min. After this measurements are taken in the opposite sequence, leading down again to the flux calibrator
- there is a slow and systematic rise of the level by about 0.3 dB over almost 2 hours. This is most probably a drift of the receiving system, as the atmosphere would not expected to warm up during sunset!
- as the sky profiles are all done at the same sequence of elevations, one notes that the profiles done in the same sense correlate very well …
- but differ significantly from the profile done in the opposite sense. The measured values of the profile going downward are higher by about 0.05 dB
- the values at 60º are always higher than at 40º, very probably due to spill-over. However I had noticed that this had been different in observations done earlier this year. I have to look into this more closely!

While the individual steps of every profile look rather flat – which would be as expected from a still atmosphere – during the first profile some changes can be seen at 20 and 25º:




This zoomed view also shows the differences between upwards and downwards profiles and the closel similarity of the two upwards profiles.

Interpretation: Since changes in the atmosphere as well as errors in the positioning system can be excluded, one is left with the hypothesis that the receiver characteristics are altered when the antenna moves upwards instead of downward. Tests have shown that this behaviour is not due to moving the antenna beyond a certain elevation. As the upward profiles seem to have a constant offset from the downward profiles – this needs further verification! – this behaviour is not simplt elevation-dependent, but it shows a memory (or hysteresis).
My suspicion is that some part in the receiver front-end is mechanically displaced when the antenna is pointed upwards, and regains its normal position only when the antenna points horizontally …
This effect is small – only about 0.05 dB – but well measurable with this receiving system, and it might affect the interpretation of any data.