Polarimetric Calibration of Weather Radar using the Sun

Introduction

Measurements of the sun are often used to determine and track receiver stability and to derive the absolute radar calibration factor. Furthermore, it is used to check the alignment of the radar antenna.

It will be shown, how high resolution polarimetric box scans of the sun can give a detailed insight into the radar antenna pattern.

The measurements are performed on the scientific polarimetric weather POLDIRAD, located at the DLR site Oberpfaffenhofen, near Munich. Beside it's large offset parabolic antenna, it features a unique polarization network, which allow to create any polarization state. The access to the flexible signal processing enables custom-build algorithms for different measurement setups.

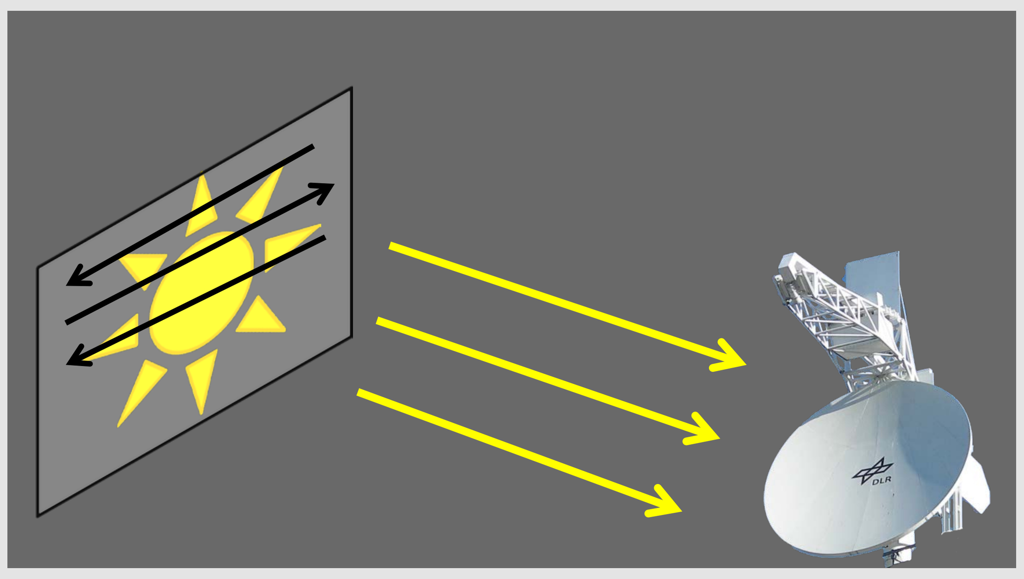


Figure 1: Passive box scan performed to retrieve two-dimensional sun-antenna pattern

Measured Parameters

Several parameters can be estimated from the measured radiation of the sun:

- Absolute power: $P_{Co} + P_{Cx}$
- Differential power: $P_{Cx} - P_{Co}$
- Modulus of co/cx-channel-correlation
- Argument of co/cx-channel-correlation

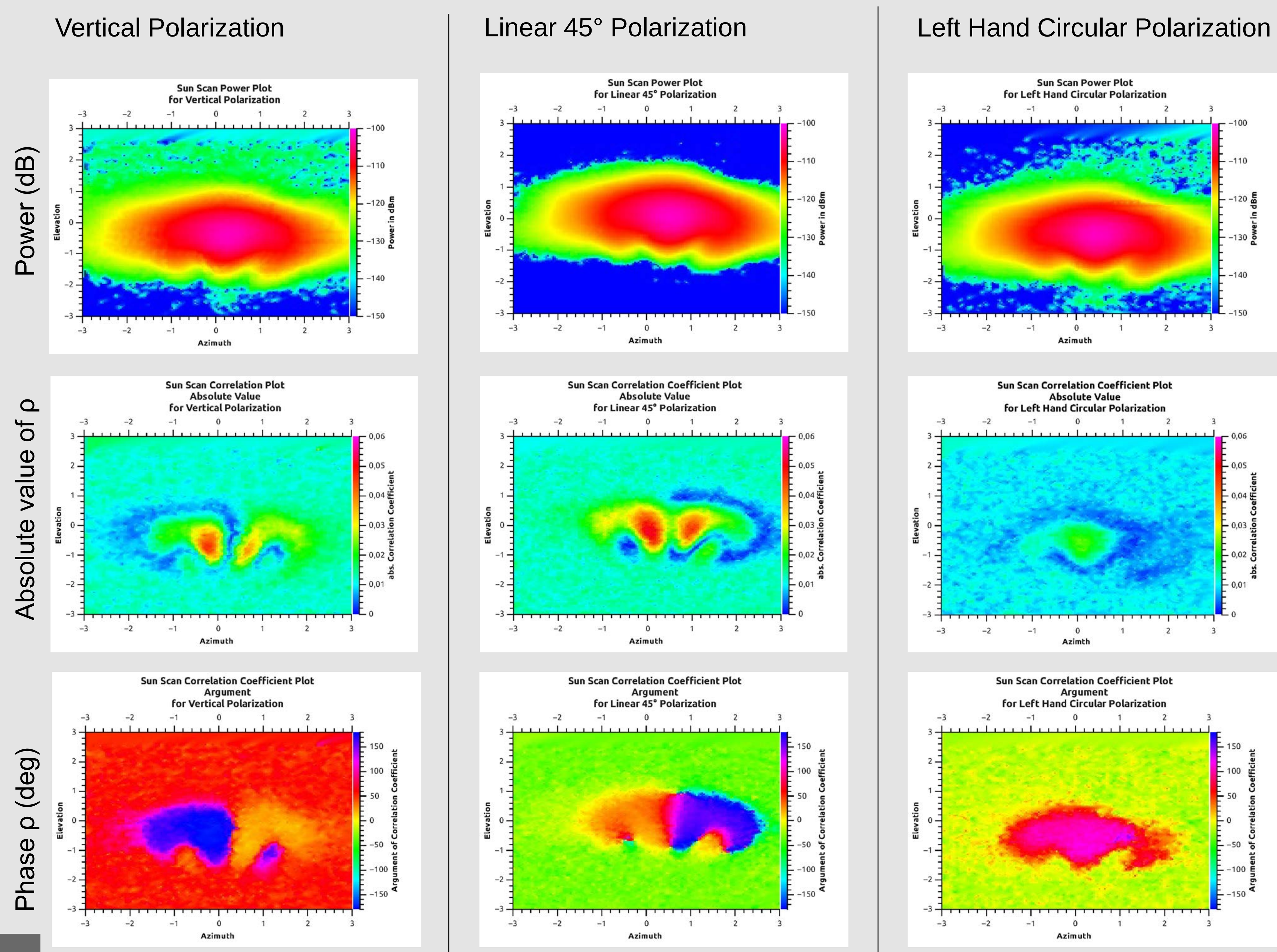
The co/cx-channel-correlation can be defined as:

$$\rho = \frac{\Sigma S_{Co} \cdot S_{Cx}^{*}}{\sqrt{\Sigma |S_{Co}|^2 \cdot \Sigma |S_{Cx}|^2}} \qquad (1)$$

and the logarithmic value as:

$$P = 20 \log(|\rho|) \qquad (2)$$

The expected value $\bar{\rho}$ of the co/cx-channel-correlation is zero since the sun radiates uncorrelated, non-polarized noise in C-Band. Low isolation in the antenna aperture can cause the correlation coefficient to rise giving a figure of merit of the polarimetric antenna pattern (see figures on the right).



Polarimetric Antenna Pattern

The analyzed radar POLDIRAD uses an offset parabolic antenna, whose pattern is polarization dependent. Theoretical work shows, that there is not cross-polarization in the antenna for circular polarization, but a small squinting.

Using the unique polarization network of POLDIRAD allows to determine the polarization dependent antenna pattern, that is shown above.

The absolute received power shown in the first row is similar for all polarizations. For linear (vertical and 45°) polarization there are two areas of high correlation and hence low isolation, which match with the excepted cross-polar lobes of the antenna. It can also be seen, that there is a expected 180° phase shift between the two cross-polar lobes. The absolute phase changes are due to phase shifts in the polarization network.

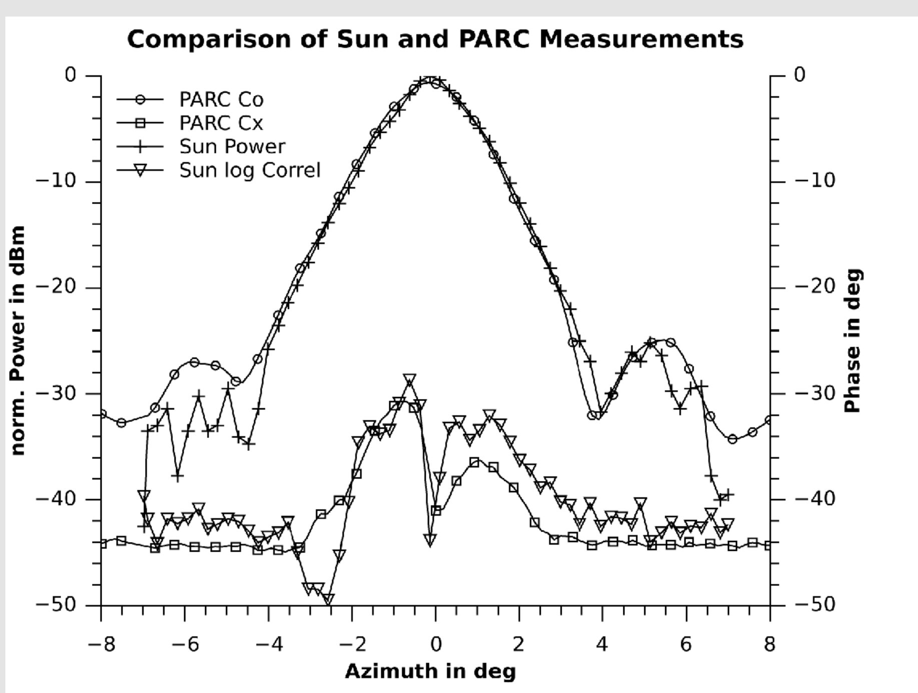


Figure 2: Comparison of the antenna pattern retrieved from the sun and measured using a point source.

Comparison to point source

To verify the antenna pattern measured by sun scans, tests using a point source were performed (see Figure 2).

Keeping in mind, that the sun is not a point source, but a disc with approx. 0.57° electric width - the pattern match well even at the 1st side lobe level below -25dB.

The logarithmic value of the co/cx-correlation from eq. (2) fit well with the logarithmic cross-polar pattern of the antenna.

Summary

High resolution polarimetric sun scans using long integration times can be used to derive the polarimetric antenna pattern of a radar system. The co/cx-channel-correlation can give a figure of merit for the isolation within the antenna and hence the cross-polar pattern.

For polarization dependent antennas like offset parabolic antennas the polarimetric pattern can be used to check the polarization state of the whole radar.

References

- Reimann, J., 2013: *On fast, polarimetric non-reciprocal calibration and multi-polarization measurements on weather radars*. Thesis, TU-Chemnitz, URL http://nbn-resolving.de/urn:nbn:de:bsz: ch1-qucosa-132088, May 2014.

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