THE TELECOVER TEST:
A QUALITY ASSURANCE TOOL FOR THE OPTICAL PART OF A LIDAR SYSTEM.

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ABSTRACT

A test is described, which serves as a self-check of the optical part of a lidar system. Several lidar signals using different parts of the lidar telescope are compared. Differences in these signals indicate range dependent transmisson changes of the optical receiver, resulting in signal distortion. A systematic approach including comparision with ray tracing simulations of the optical system can point out causes of the deviations.

1. THE TELECOVER TEST

The backscattered photons collected by different parts of the telescope of a lidar system reach the signal detector using different paths in the optical receiver and hit the optical components under different incident angles. Comparing lidar signals from different parts of a lidar telescope enables us to detect range dependent transmission changes of the receiver optics, which distort the lidar signal. We call this lidar test tool the telecover test. The overlap function is just the most obvious feature producing differences in different telecover signals. In a first attempt the telescope can be covered in a way that just quarters of the telescope are used, which we call the quadrant test (figure 1), or using only an inner and outer ring of the telescope, i.e. the ring test. For the ideal lidar system, the normalized signals from all different telecover tests must match apart from the overlap range, which can be therewith assessed, assuming constant atmospheric conditions during the test. Causes of deviations might be laser tilt, telescope misalignment, displacement of field and aperture stops (vignetting), optical coating effects of e.g. beamsplitters and interference filters like spatial inhomogeneity or transmission depending on the angle of incident, or spatial inhomogeneity of the detector sensitivity [1][2]. In case of differences between different telecover signals, a comparison with ray tracing simulations of the system can help to narrow down possible causes. The telecover test can be applied to monoaxial and biaxial lidar systems with Newtonian or Cassegrainian telescopes. This test is one of the quality assurance tools of EARLINET [3], implemented during EARLINET-ASOS [4]. Figure 2 shows the used nomenclature for the telecovers relative to the laser-position with respect to the telescope axis. For mono-axial systems the reference could be chosen with respect to the receiving optics.

Examples and results of the telecover test will be shown as well as comparisons with ray tracing simulations.

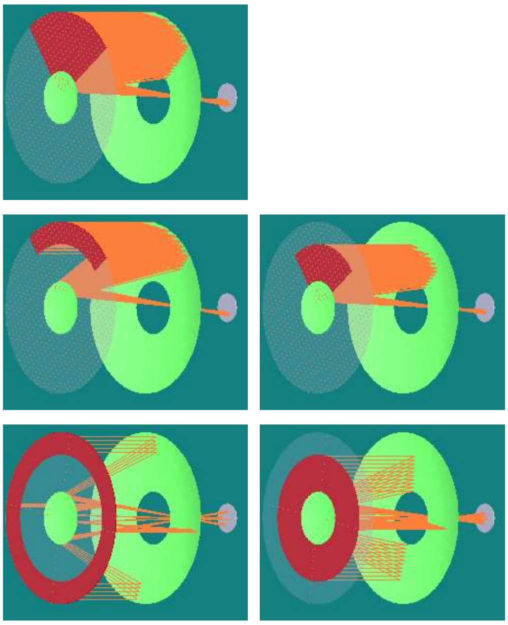

Figure 1. Parts of a Cassegrainian lidar telescope used for the telecover measurements: the quadrant- (top) and octant-parts (middle) are successively rotated in 90° steps, and the ring-test (bottom).

2. TELECOVER EXAMPLE

Figure 3 shows a range-corrected and normalized telecover examples for the lidar system shown in figure 2, bottom. The telescope diameter is 300 mm and the laser-telescope distance amounts to 400 mm. The comparison between the first and second east qudrant measurement (E and E2) shows that the atmosphere was stable enough during the test. The north-signal is very different from the other quadrants. A further inspection of the telescope showed that the imaging of the north sector is very distorted due to mechanical stress of one of the telescope mirrors leading to a loss of signal strength of the north-quadrant in the far range. As a result the north-quadrant has been permanently covered (excluded) for the lidar measurements. For a perfect aligned system, the east and west quadrants should give the same signals with the same overlap function, the south quadrant full overlap should be at a farther range and for the north quadrant at an earlier range. The north and south overlap functions are as expected, and the full overlap of the whole telescope is not earlier than about 400 m, where the east, south and west signals merge. But the east quadrant shows an earlier full overlap than the west quadrant, indicating a small laser tilt in west-east direction.

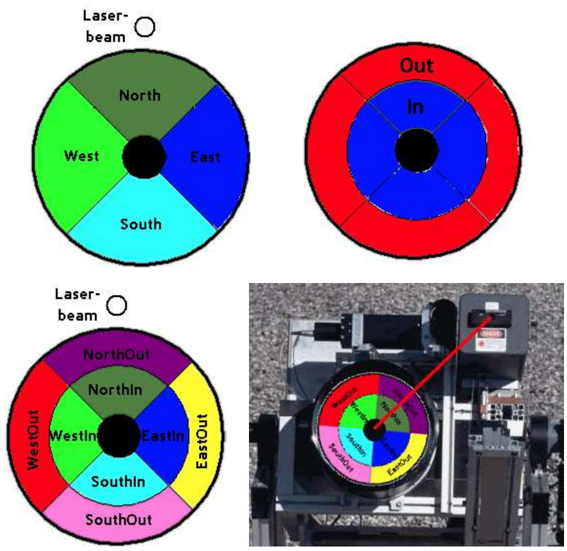

Figure 2. Nomenclature for the telecover parts with respect to the laser position. The red line indicates the direction from the telescope to the laser axis.

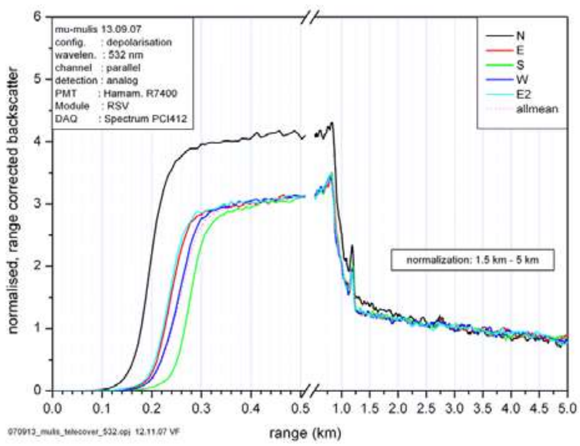

Figure 3. Range corrected quadrant-telecover signals of the lidar system shown in figure 2, normalized between 1.5 to 5 km range. The east quadrant (E) is measured twice to estimate the atmospheric stability during the test measurements. "Allmean" is the mean of the east, south and west signal.

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