Calibration of a multispectral polarimeter and calculation of the complete Stokes vector from radiance measurements in the Arctic

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The uncertainty of the effect of aerosol on the radiative transfer and therefore on the change of the temperature at the earth surface is still very large [1]. New satellite programs such as 3MI or HARP2 and SPEXone on the PACE satellite can provide aerosol properties with global polarisation information of the light which help to determine their effect on the climate [2]. The airborne multispectral sunphotometer and polarimeter (AMSSP) which was developed at the Institute for Space Science (Freie Universität Berlin) can be used for the validation of those new satellites in order to improve the basis for aerosol retrievals [3]. The polarimeter can cover all measurement geometries due to its universal entrance optic system and covers a large spectral range of wavelengths between 250 and 780 nm.

The AMSSP measures the complete Stokes vector and provides the complete polarisation information of the light that travelled through the atmosphere. The instrument is built up of four optical paths with a waveplate, a polarizer and a spectral sensor each. Thus, a set of four intensities are measured simultaneously. Using the Mueller matrix formalism, the complete Stokes vector can be calculated from these intensity measurements.

The information about the set up of the optical components is crucial in order to calculate the Stokes vector. Thus, sophisticated calibration measurements are necessary to determine the instrument parameters, namely the angles of the waveplates and the polarizers and the retardation of the waveplates. The laboratory setup for the calibration of the instrument was improved and developed further in the last years. The accuracy of the determined parameters can be shown by reproducing a given Stokes vector from the intensity measurements correctly. For the first time, the instrument parameters could be determined during calibration measurements so that the accuracy of the calculated Stokes vector is better than 0.5% for the linear polarisation parameters Q and U and better than 2% for the circular polarisation parameter V.

The same information about the instrument was used to calculate the Stokes vector from intensity measurements during a field campaign on the Polarstern in May–July 2017. The retrieved polarisation information showed reasonable results. Further campaigns with other polarimeters are planned to validate the measurement setup.

References

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