ADVANCES IN BRDF FIELD MEASUREMENT: NEW PRINCIPLE AND INSTRUMENT

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1. INTRODUCTION

The advances in the capabilities of sensors and methods used for remote sensing the earth call for taking into account angular effects. The effect is described through the "bi-directional reflectance distribution function" (BRDF). For most applications BRDF models are used. To validate such models and for in flight calibration purposes the measurement of BRDF of natural surfaces is necessary.
Most of the methods used to measure angular reflection properties in the past had to use interpolation or smoothing algorithms in the data processing [1,2]. These computations influence the resulting BRDF. We present the instrument GRADIS (Ground Reflectance Angular Distribution Investigation System) which avoids this problem by using a new principle for acquiring the data. Several measurement campaigns were conducted for basic measurements of different surfaces and for calibration measurements of airborne instruments.

2. BRDF MEASUREMENT

The BRDF describes the reflectance depending on the illumination and viewing geometry. Since the definition of the BRDF assumes a punctual light source, when measuring under natural conditions the additional diffuse radiation leads to the measurement of the HRDF (hemispherical reflectance distribution function). This can later be converted to a BRDF [3].

2.1. Measurement concept

As specified by the description of BRDF, a reflection factor must be obtained for every reflection angle. In general this can be realised in two ways. A sensor can be moved to all angular positions for measurement (goniometer) or a central sensor scans the surface in a circle around itself. A single point measurement with small field of view (FOV) will not directly provide the desired result. Depending on the scale of uniformity of the surface the FOV of an instrument must be adapted to eliminate macroscopic influences.

In the presented method, we use the central sensor approach and take several hundred measurements of the same angle at different sensor locations and later sum up these values to one reflection factor. With this principle, a high resolution measurement of BRDF is possible. As with other measurements working with a central mounted sensor, the basic requirement is an equal surface around the sensor in the sensor range.

The central element of the device is a stand which can be extended from 2m to 6m depending on the measured surface. Mounted on top is a motor to rotate a 1,5m boom holding the sensor. The sensor is a digital CCD camera with a wide angle lens. One measuring sequence takes about 2 minutes, so changes of the position of the sun can be neglected.
The camera itself is sensitive throughout the visual and near infrared spectrum. Glass filters are used as front end filters to define the needed spectral range.
The setup was also designed to allow an easy transport, setup and use. A station wagon is sufficient for the transport of the whole system. Two persons are able to handle the assembly in 30 minutes. The measurements can be performed by one person alone.

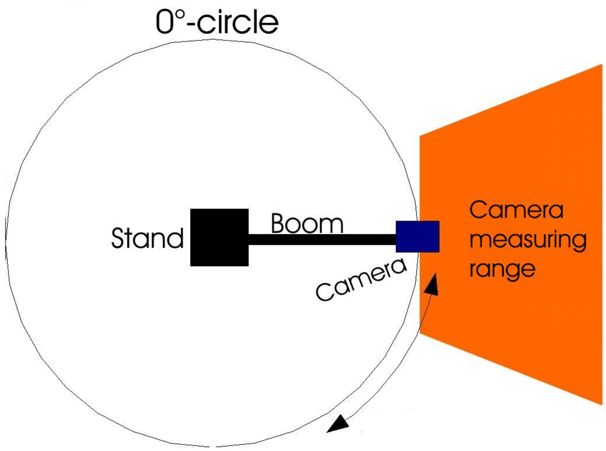

figure 1: **Top view of measuring principle**

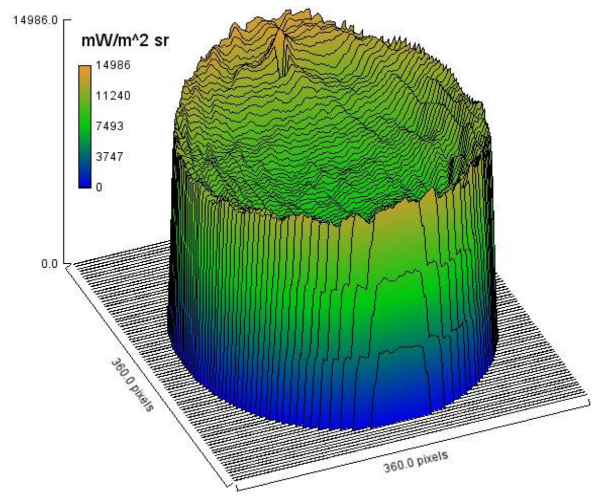

figure 2: Angular reflection of grass in absolute values

2.2. Data processing

Since the processing of the images requires radiance values for each measured pixel, the camera is calibrated in advance of the measurements. An ulbricht-sphere traceable to a PTB-standard is used for this task. For each filter a calibration factor is determined for every pixel. To exclude noise effects, a series of images is recorded and combined.
The geometric calibration of the optical system uses images of known points to calculate the distortion by the lenses and misalignment of the CCD.
The measured data, additional information about measurement geometry and the calibration files are fed into special analysis software for processing. The work left is to specify the regions of the surface which will not be used as data points. These are especially the shadow of the device itself and the path to get to it. Other regions can also be excluded, for example if they do not match the criteria for equal surface.
Until this stage, the measured data only shows the reflection in absolute radiance values. To calculate reflectance factors, the incoming light from the sun and sky has to be known. We use a sun-photometer to measure the aerosol optical thickness in different spectral bands and use radiance transfer codes to calculate the incident radiation.

3. RESULTS

The calculated values can be plotted in different ways, depending on the further use. The visualization as a three dimensional plot allows a good evaluation of the results (figure 2). For comparison to other measurements the data of the principal plane is normally used. The angular resolution is selectable in the software. The usable range depends on the measured surface. For relatively homogeneous targets like asphalt or soil, a resolution of 0,5° has shown good results.

4. CONCLUSION

The GRADIS instrument is operational for over a year now and several measurements have been performed. Different types of surface could be observed. The resulting reflectance data shows the expected characteristics.
To evaluate the data, a comparison to previous measurements with other devices [2] was performed. Unfortunately, the limited number of available data and the challenge of finding a suitable pair of measurements allowed only a small number of quantitative comparisons. However, these showed a good reproducibility.
Parallel measurements to airborne sensors have also been performed [4] as preparation for atmospherical science missions.

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