

Spectral Surface Reflectance Fields Over Megacities

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1. Introduction

Megacities are a major source of particulate matter in the atmosphere. These aerosol particles have an influence on the health of people living in Megacities because they can affect the respiratory systems through inhalation. It is important to include aerosol particles in climate models. For this reason maps of the aerosol optical depth (AOD) over megacities are desired. Such maps of AOD can be derived from MODIS (MODerate Resolution Imaging Spectroradiometer) satellite measurements.



As the satellite cannot distinguish between surface and atmospheric signal the retrieved AOD significantly depends on the accuracy of the surface reflectance fields which are used for the retrieval. The combination of the spectral highly resolved SMART – Albedometer (Spectral Modular Airborne Radiation measurement sysTem) and a 3-chip CCD-camera with high spatial resolution will provide spectrally and spatially high-resolved maps of surface reflectance. Airborne and ground-based measurements were performed over Leipzig in September 2007 to test the instrumental setup and the development of the analysis tools with low logistic efforts. The measurement and analysis methodology will then be applied to a field campaign in the Pearl River Delta (PRD) in southern China.

2. Instruments & Methodology

A Airborne



Figure 1

The airborne measurements were performed with the Partenavia P68B research aircraft. Figure 1 (center) shows the aircraft at the airport Halle Oppin and a close-up of the optical inlets (left and right). The instrumentation with some technical details is presented in Table 1.

	Measured quantity	Spectral range	Resolution	Remarks
Aircraft top	irradiance $F_{\lambda\downarrow}$	300–950 nm	2-3 nm	- Temperature-controlled Housing - Optical inlet (aircraft top) horizontally stabilized [1,2]
		950-2200 nm	9-16 nm	
Aircraft bottom	irradiance $F_{\lambda\uparrow}$	300-950 nm	2-3 nm	
		950-2200 nm	9-16 nm	
	radiance $I_{\lambda\uparrow}$	300-950 nm	2-3 nm	
		950-2200 nm	9-16 nm	
Images	3 spectral bands (green, red, NIR)	50-70 nm		- Calibrated in radiance values 1920x1080 pixel

Table 1

B Ground-based

Ground-based measurements of the angular dependent reflection of different surface types were performed with a self-built instrument of the IRS. It enables the usage of different sensors by a rotating stage as a universal platform. The measurements for the presented field experiment were performed with a matrix camera in the green and near infrared spectral channel. Figure 2 shows the working principle (left) and a photo (right) of the instrument.

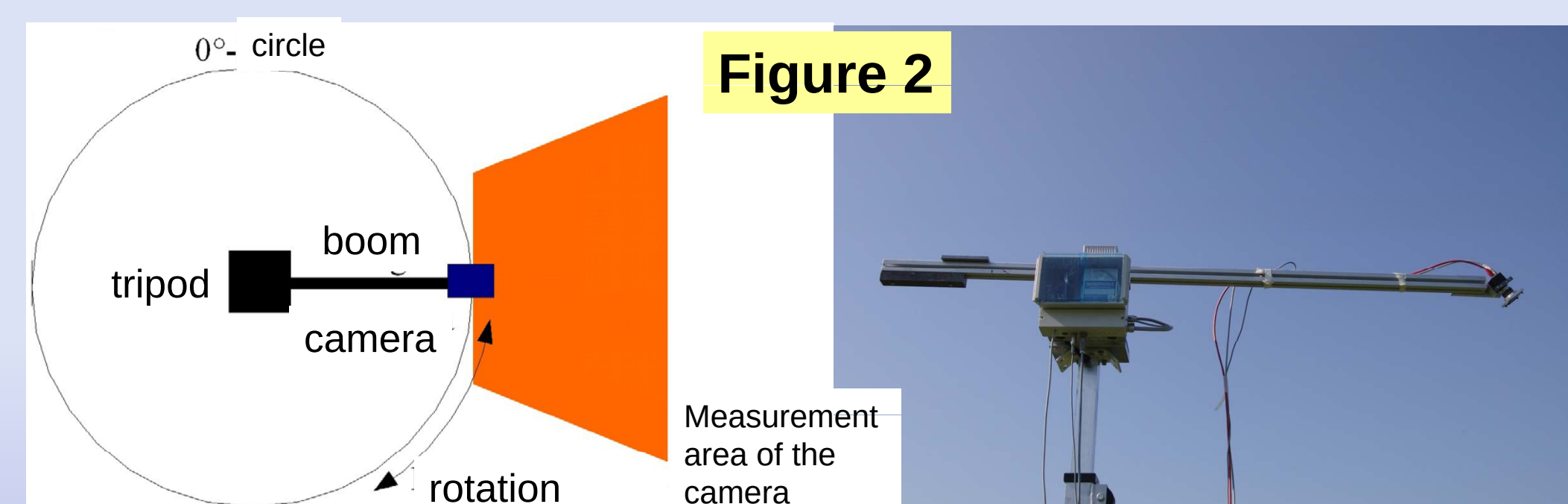


Figure 2

In addition, measurements with a small compact Raman lidar were performed in Leipzig to obtain the aerosol extinction coefficient, as well as Sun photometer measurements, which are performed regularly at IfT in the frame of the aerosol robotic network (AERONET).

C Methodology

Consecutive images and timeseries of spectral downwelling irradiances and upwelling irradiances and radiances were recorded. Flight pattern and flight velocity were chosen to enable an overlap of two consecutive images of at least 1/3. In Figures 3 and 4 schematics of the image acquisition is displayed. With this flight strategy each pixel is visible in at least five consecutive images.

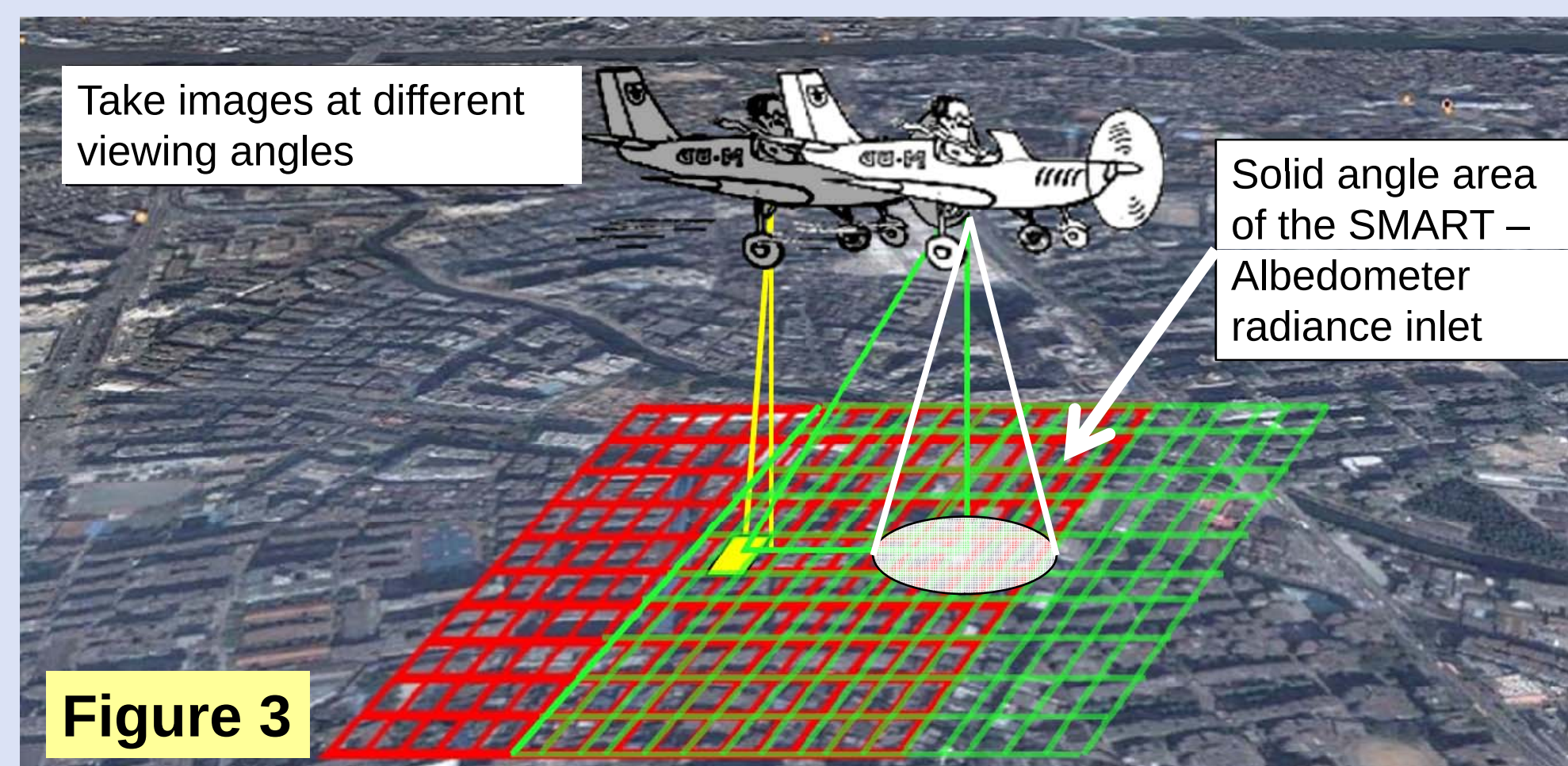
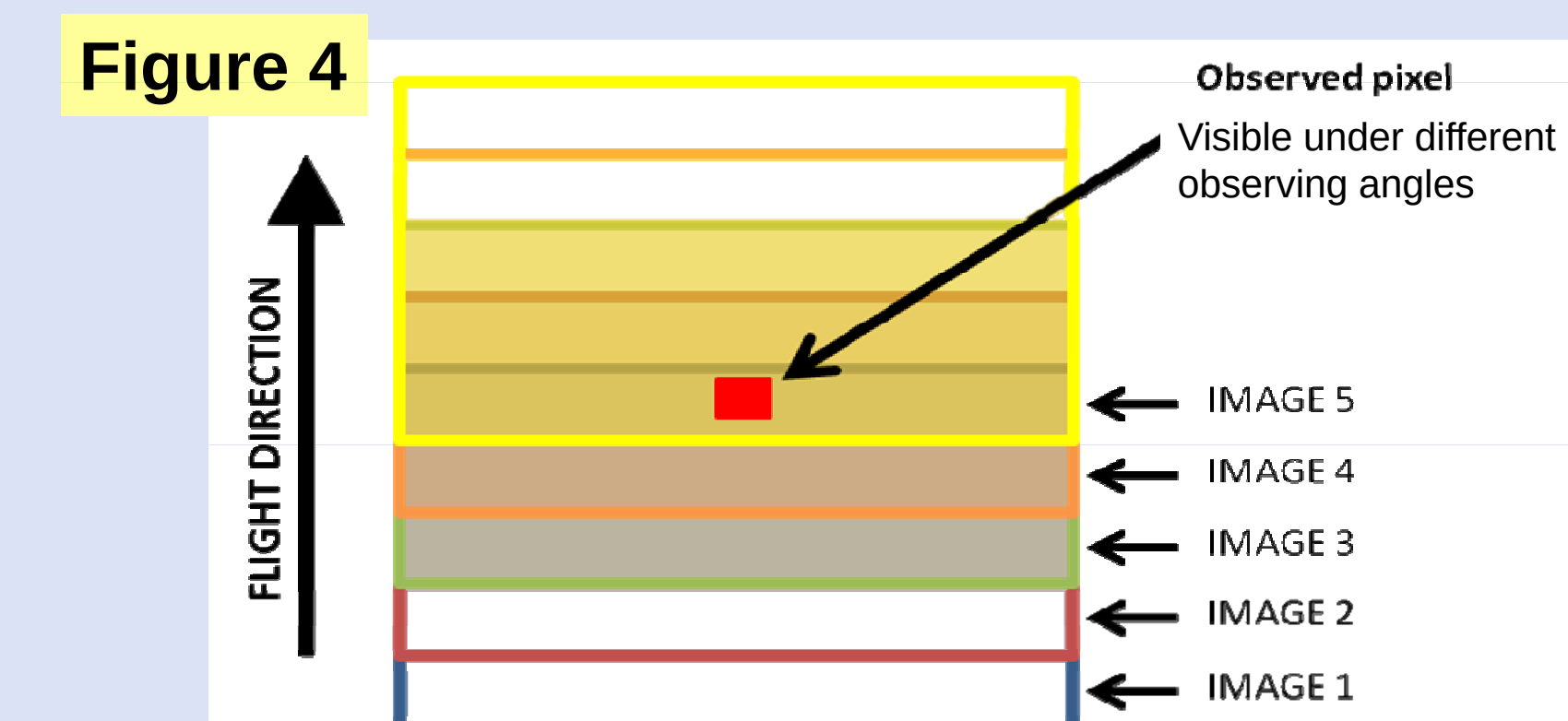


Figure 3



The pixels are analyzed with regard to the dependency of the radiance for different viewing angles. To obtain radiance values out of the raw image data calibrations are necessary.

Therefore the spectral behaviour of the camera was analyzed with a monochromator and a geometric calibration was performed to obtain the distortion parameters. By combining the spectrally-resolved radiance data of the SMART – Albedometer with the spatially-resolved camera data radiance values for each pixel covered by the solid angle of the radiance inlet are derived. To obtain surface reflectances the measured quantities have to be nonlinearly extrapolated to the surface level. Herefore lidar and AERONET data is used as input for the radiative transfer model calculations.

3. Results

In Figure 5A a timeseries of the airborne measured albedo α and reflectance R at flight level is shown. Differences are obvious between heterogeneous anisotropic reflecting surfaces (B) and nearly homogeneous isotropically reflecting surfaces (C) in the timeseries as well as in the corresponding images of the CCD – camera (airborne measurements). For isotropically reflecting surfaces the reflectance is equal to the albedo

$$(R = \alpha \text{ with } R = \frac{\pi L^\uparrow}{F^\downarrow} \text{ and } \alpha = \frac{F^\uparrow}{F^\downarrow})$$

and the graphs are nearly identical. For anisotropic reflecting surfaces the graphs show differences and R is usually smaller than α (except for specular reflectance).

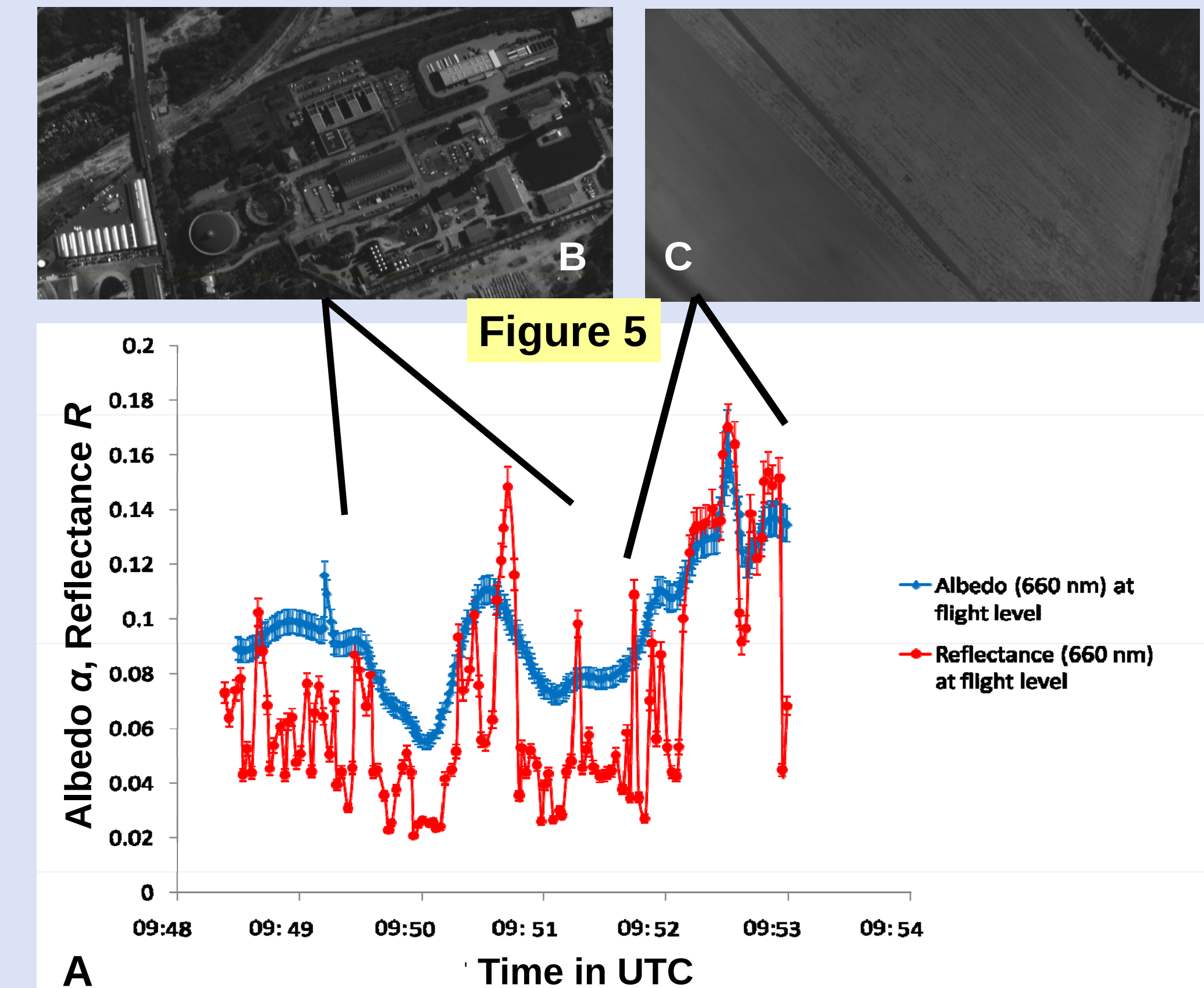


Figure 5

The analysis of the ground based measurements with the CCD – camera focuses on the angular dependence of the reflection and the retrieval of the Bidirectional Reflection Distribution Function (BRDF). Figure 6 presents a qualitative 3D-Plot of the reflected radiation without consideration of the incident solar radiation for the surface type grass. Qualitatively, the typical reflection characteristic of green vegetation in a bowl shape is visible. This means that the reflection is stronger for small angles than in nadir direction.

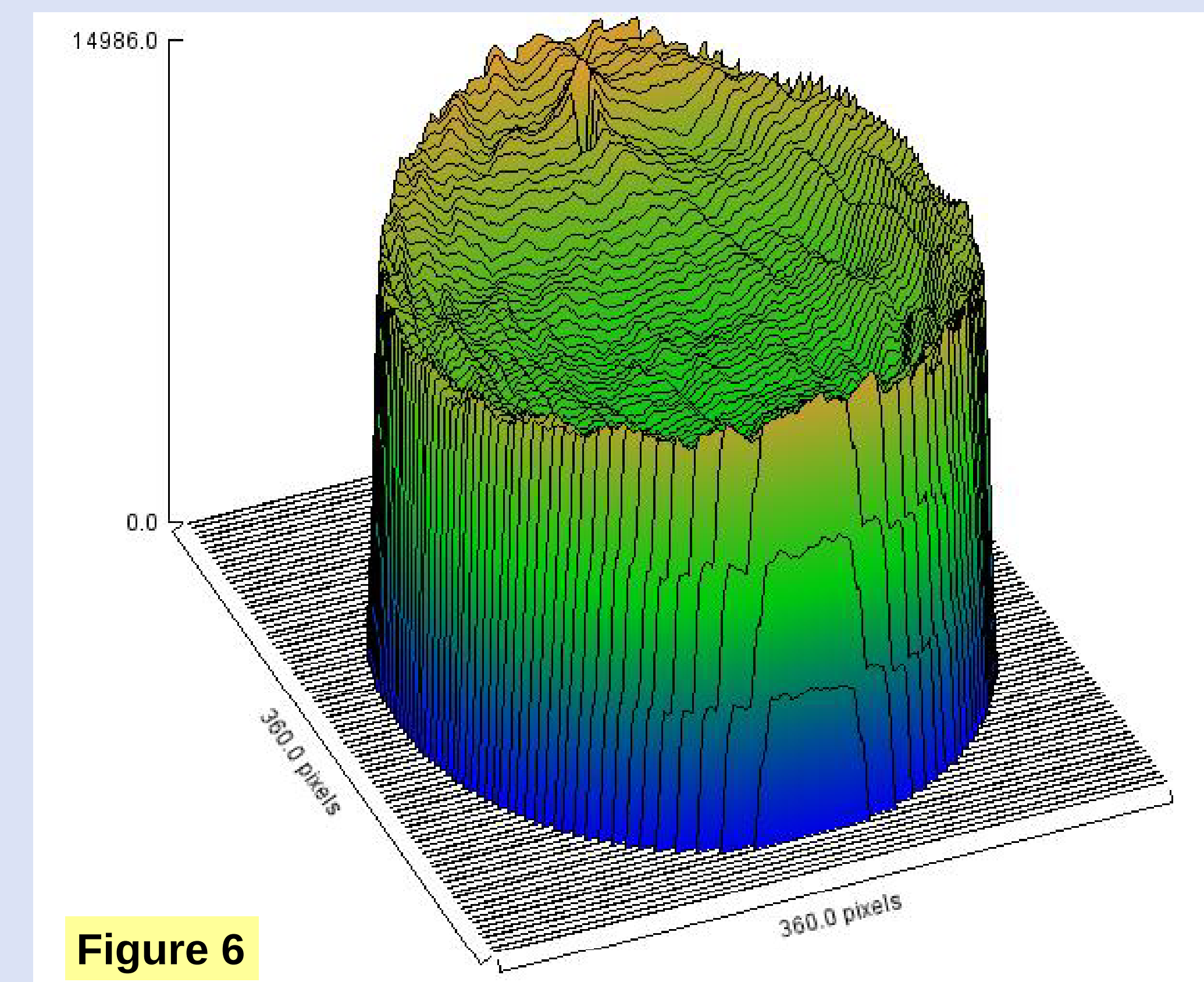


Figure 6

4. Outlook

- Measured albedo and reflectance will be nonlinearly extrapolated to surface values on the basis of an existing routine for albedo extrapolation.
- Pixel values of the CCD camera (airborne) will be converted to surface reflectance values.
- Comparison of obtained reflectance fields with those used for satellite aerosol retrieval
- Application of the measurement and analysis strategy to a field experiment in Guangzhou (PRD, PR China).