SAMUM Project #2: Airborne Spectral Radiation Measurements in the Saharan Dust Plume

Deutsche Forschungsgemeinschaft DFG

Leibniz Gemeinschaft

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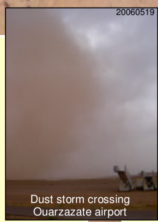
1. Introduction

Goals of the project:

- Airborne, spectral measurement of the **surface albedo** which is needed:
  - as input parameter for modelling
  - as boundary condition for satellite retrievals of aerosol properties
- Assessment of the radiative **forcing** of Saharan dust at the surface
- Improve satellite retrievals of aerosol optical properties



Dust storm crossing Ouarzazate airport

Realisiation:

- SAMUM experiment in South-East **Morocco** from May 19 to June 6, 2006
- **Airborne** measurement of upwelling and downwelling spectral irradiances and actinic flux density aboard the Partenavia aircraft D-GERY
- **Ground-based** measurement of spectral downwelling irradiance, radiance, actinic flux density, and thermal infrared (IR) radiation at Ouarzazate airport

2. Instruments

	Tot.	Measured quantity	Spectral range	Resolution	Remarks
Airborne	2	Irradiance F_λ	290-970 nm	2-3 nm	Temperature-controlled housing. Optical inlets horizontally stabilised [1,2].
Airborne	2	Irradiance F_λ	970-2200 nm	9-16 nm	
Airborne	2	Actinic flux density F_λ^{act}	280-700 nm	2-3 nm	
Ground-based	1	Irradiance/Radiance*, Actinic Flux Density	280-1050 nm	2-3 nm	Switch for 2 inlets. * depends on 2nd optical inlet
Ground-based	2	Thermal broadband radiation F^{IR}	4-42 µm	n/a	Ground emission and atmospheric reflection

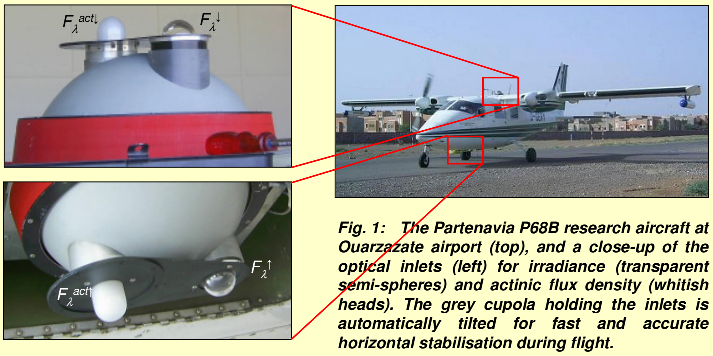
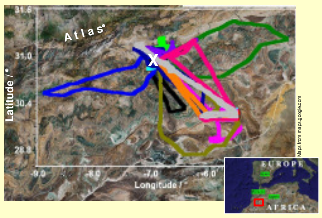


Fig. 1: The Partenavia P68B research aircraft at Ouarzazate airport (top), and a close-up of the optical inlets (left) for irradiance (transparent semi-spheres) and actinic flux density (whitish heads). The grey cupola holding the inlets is automatically tilted for fast and accurate horizontal stabilisation during flight.

Fig. 2: Overview of the 13 different flight patterns flown during the SAMUM campaign. Ouarzazate airport (marked X) is in the center.



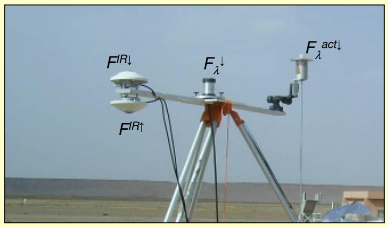


Fig. 3: The surface spectrometer inlets. From left to right: Thermal broadband sensors, irradiance inlet, actinic flux density inlet.

3. Data processing

- Instrumental calibration and corrections
- Iterative algorithm for the derivation of the surface albedo from flight-level measurements
- Atmospheric correction based on available parameters, such as atmospheric profiles from radiosondes and aerosol information (extinction profile from LIDAR, A.O.D. and Ångström parameters from sun photometers)

$$\text{Albedo } \rho(z) = \frac{F\uparrow(z)}{F\downarrow(z)}$$

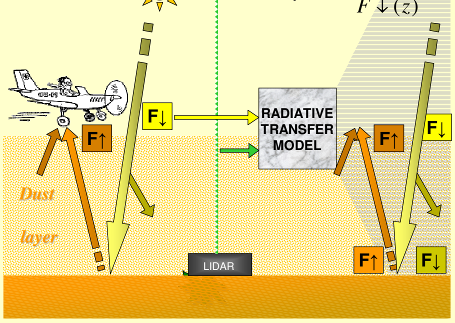


Fig. 4: Illustration of the atmospheric correction algorithm, as described in [1]. Irradiance (F) measurements at flight altitude (left) and aerosol information are put into a model that calculates an irradiance field (right) and yields the surface albedo iteratively.

4. Results

Examplarily, results for May 19 are presented here. There were moderate dust conditions ($\tau_{aer,500nm}$ = 0.4), no clouds, and both satellites (MISR, MERIS) overpassing.

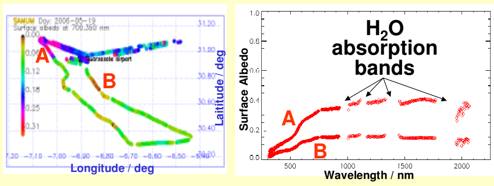
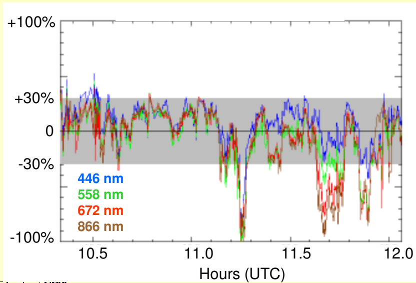
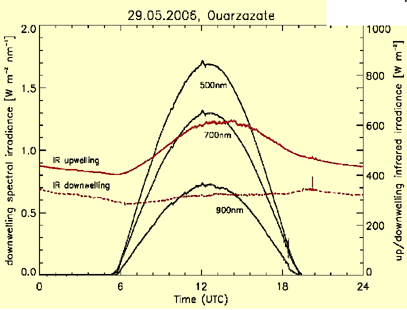


Fig. 5 (left): Surface-albedo map around Ouarzazate at 700 nm as measured on the flight on 19 May, 2006. The surface albedo at the points A and B is plotted spectrally on the right panel. Around 2000 nm the signal is noisier due to low signals there. The gaps are caused by water-vapour absorption bands.

Fig. 6 (right): The difference between our measured surface albedo and that derived from the MISR satellite data on 19 May, 2006. The four MISR wave-lengths have been chosen. MISR overpass has occurred at 11:11 UTC. Agreement to within 30% is mostly found, while differences >30% may be caused by different spatial resolutions or certain assumptions in either retrieval algorithm.





MISR Multi-angle Imaging SpectroRadiometer

Fig. 7 (left): The diurnal course of the irradiance (black lines) and of the thermal IR radiation (red lines) at the surface on Ouarzazate airport. The irradiance peak near noon is due to a small cloud passing the zenith area, while the rest of the day was cloud-free.

5. Outlook

- Comparison to the surface-albedo product of other satellite instruments, such as MODIS, MERIS, and OMI
- Evaluate the **accuracy** of the satellite-retrieved surface albedo
- Use the detailed surface-albedo measurement from SAMUM for improvement of **satellite aerosol retrievals** (e.g., **MERIS** data) in collaboration with the Institute of Environmental Physics at Bremen University (SAMUM Project #7)
- Estimate top-of-atmosphere **forcing** along the flight track in dependence on the surface albedo and aerosol optical parameters encountered during SAMUM
- Investigate the significance of surface-albedo **inhomogeneities** for the top-of-atmosphere radiance and forcing

[1] Wendisch M., P. Pilewskie, E. Jäkel, S. Schmidt, J. Pommier, S. Howard, H. Jonsson, H. Guan, M. Schröder, B. Mayer (2004), Airborne measurements of areal spectral surface albedo over different sea and land surfaces, *J. Geophys. Res.*, *109*, D08203, doi:10.1029/2003JD004392.
[2] Wendisch M., B. Mayer, Geophys. Res. Lett., Vol. 30, No. 4, 1183, doi:10.1029/2002GL016529, 2003

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