# Measurement of Mixed Biomass Burning and Mineral Dust Aerosol in the Thermal Infrared

C. H. Koehler, E. Lindermeir, T. Trautmann

Remote Sensing Technology Institute, German Aerospace Center, Oberpfaffenhofen, Germany

Introduction

From January 19th to February 6th, 2008, we installed a Fourier transform infrared spectrometer (FTIR) at Praia Airport on the island of Santiago, Cape Verde. Our goal was to measure the combined radiative effect of biomass burning aerosol with mineral dust usually observed here at this time of the year, when mineral dust emerging from the Sahara mixes with biomass burning aerosol transported north-westwards from the Sahelian region. Our measurements were part of the **Sa**haran **M**ineral D**u**st Experi**m**ent 2 (SAMUM 2) funded by the German Research Foundation (DFG) as continuation of the SAMUM 1 field experiment conducted in Morocco in 2006. SAMUM 2 is a joint venture of several German research institutes and universities and included ground based measurements with spectrometers (visible to thermal infrared), LIDAR and sun photometers. Furthermore samples were taken from the aerosol both at the ground and directly from the aerosol layers with the DLR Falcon research aircraft. We will present our measurements here for the first time along with first results obtained during SAMUM 2.
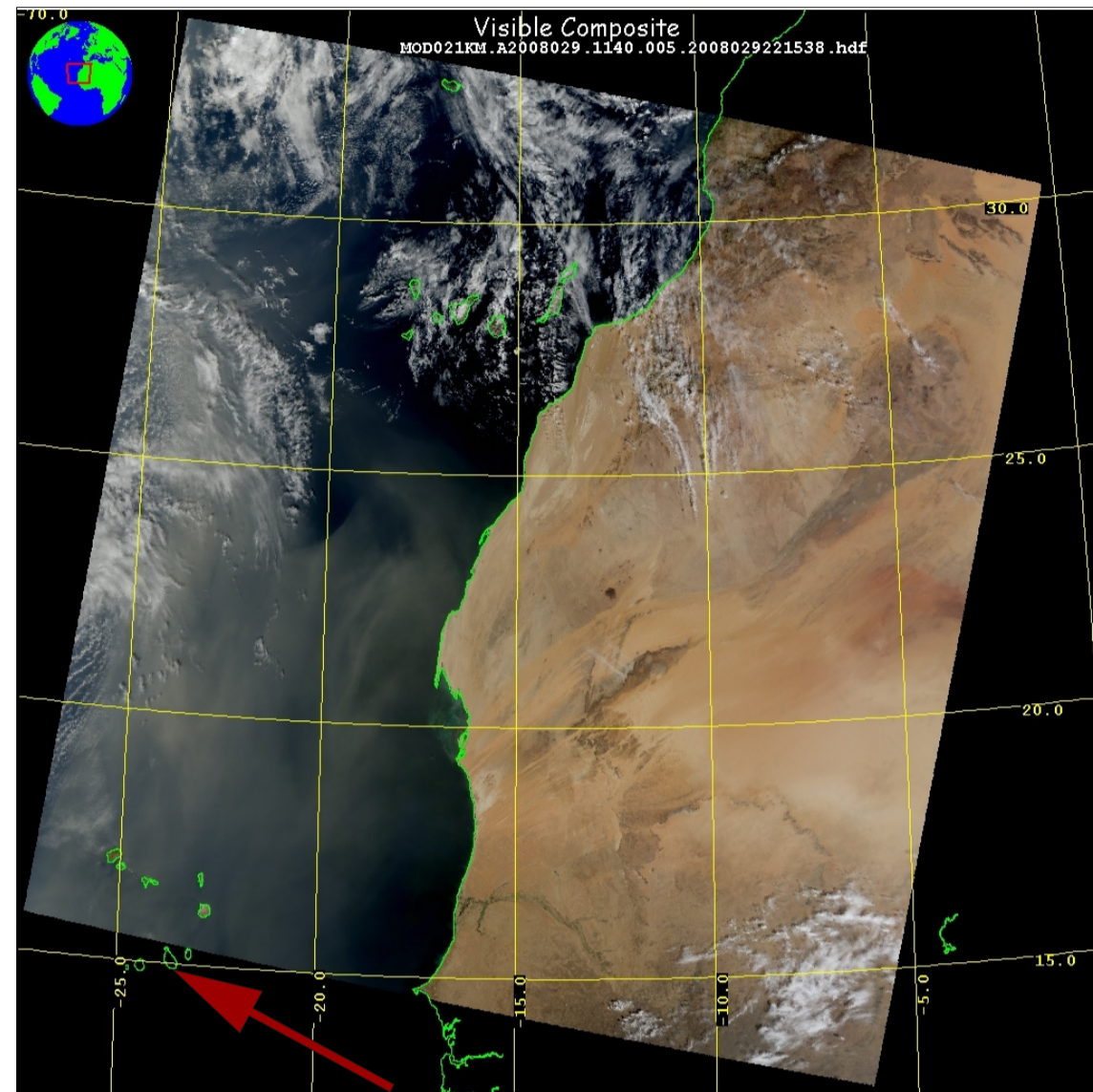
First Results

MODIS Image taken January 29th, 2008 at 11:40 UTC: Mineral dust originating from the Sahara moving westward over the Atlantic and Cap Verde. The red arrow marks Praia Airport, where the instrument was set up.

http://ladsweb.nascom.nasa.gov/

Dust front passage between January 28th and January 29th (see MODIS image on the left):

Line-by-line radiative transfer simulation of clear-sky scenario with radiative transfer code TRAVIS described in [1] including
→ Pressure, temperature and humidity profiles from radio sonde data
→ Ozone column density from GOME 2
→ Remaining data from standard tropical atmosphere

→ Reduced spectral resolution to 10 cm^{-1} to smoothen spectra
→ Calculate brightness temperature difference between measurement and simulation (right)

→ Significant difference between clear-sky measurements and measurements during dust passage in the atmospheric window region from 800 to 1200 cm^{-1} (8 - 12 μm)

→ No significant contribution of biomass burning aerosol in the atmospheric window region
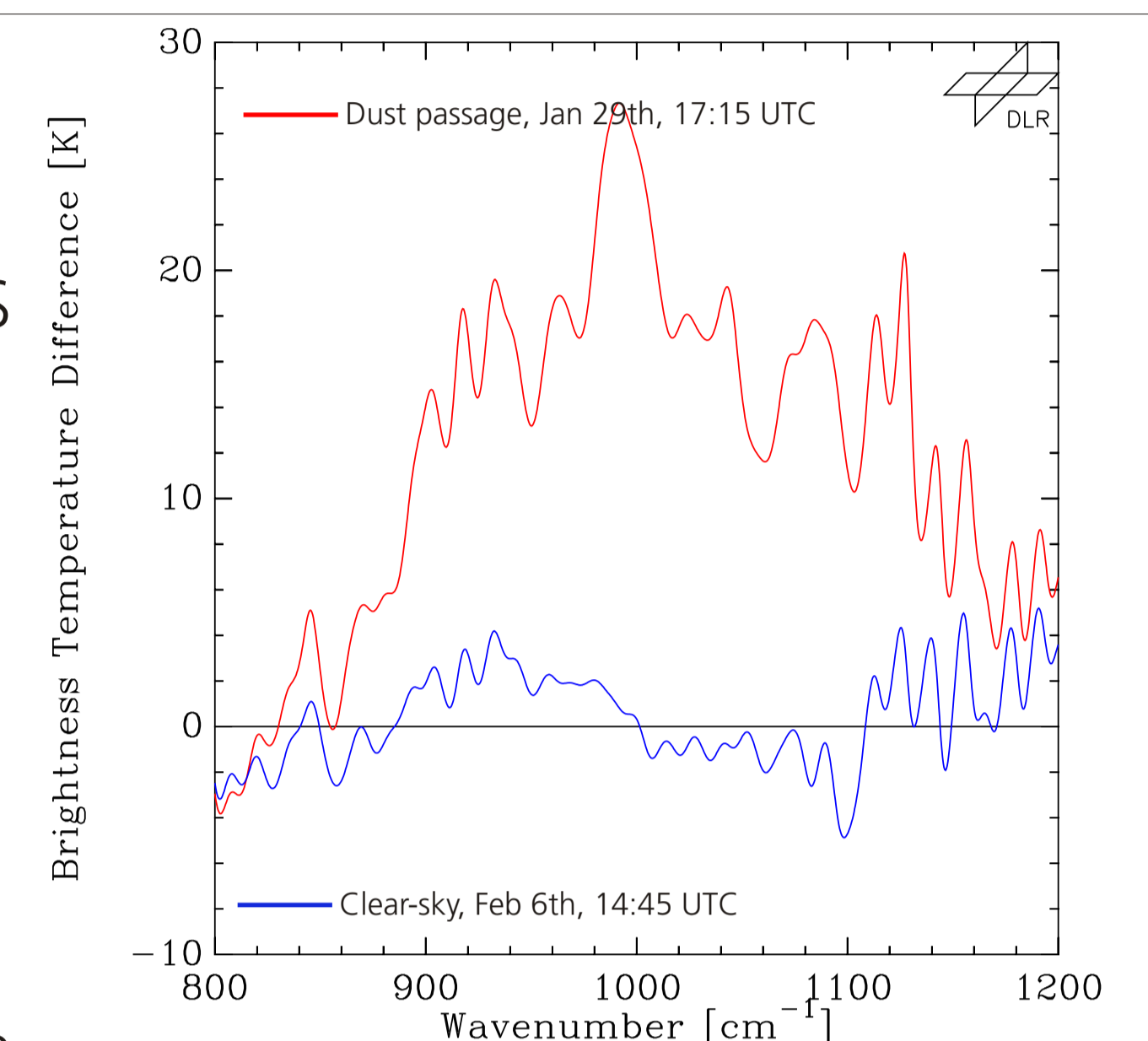
Brightness temperature difference between measured downwelling radiance and simulated clear-sky downwelling radiance. The red curve is the result for a dust loaded atmosphere, while the blue curve was obtained during a clear-sky scenario.

Instrument
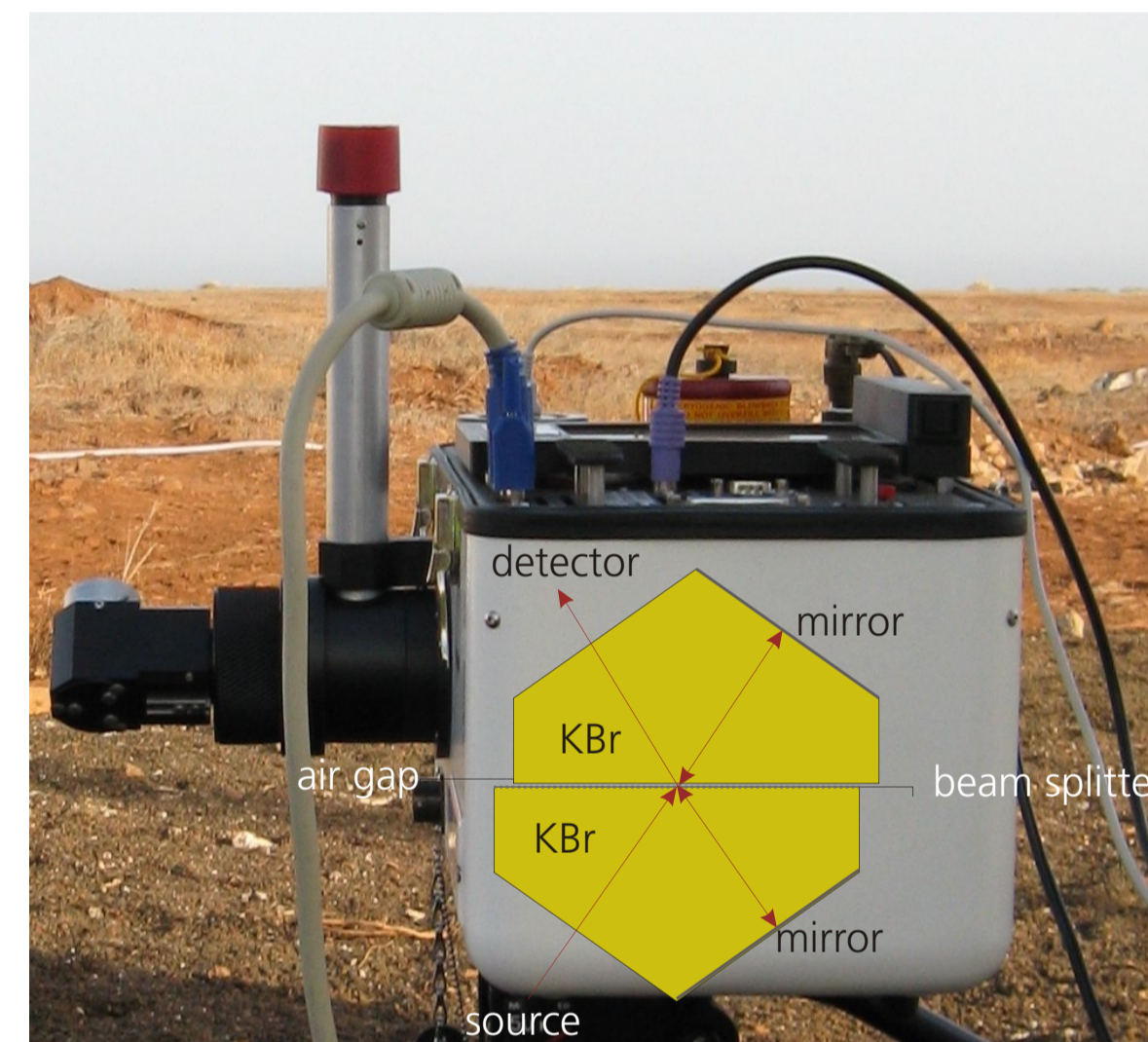
→ Design and Prototypes Model 102 micro FTIR [2]
→ Spectral resolution: 6 cm^{-1}
→ Spectral range: 650 - 3000 cm^{-1} (3.3 - 15 μm)
→ Sandwich type InSb / MCT detector
→ Optical path difference created by relative translation of two KBr prisms
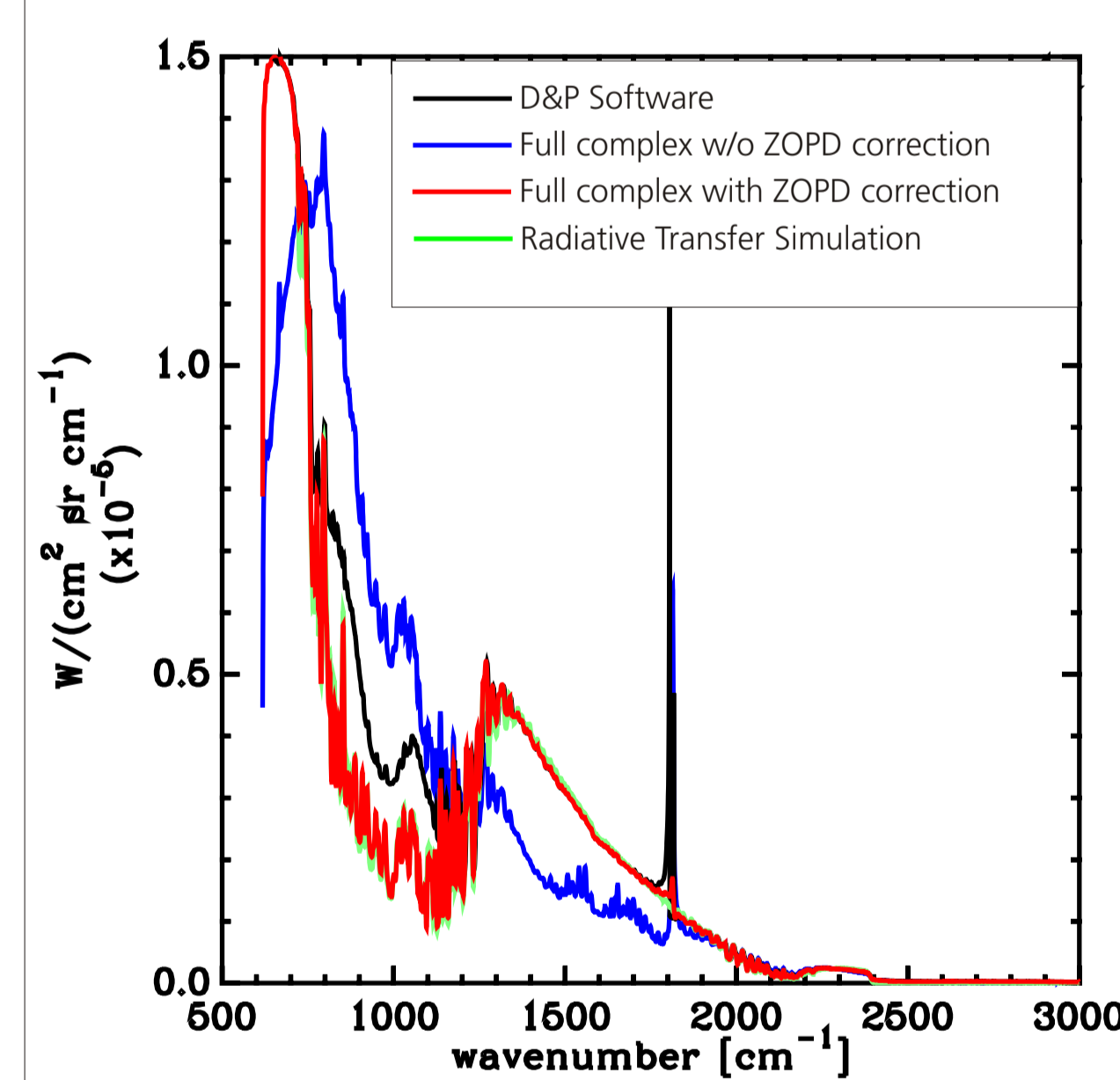→ Very compact design
→ Dispersion of KBr causes zero optical path difference (ZOPD) to vary with wavenumber
→ Dispersion of KBr causes wavenumber dependent phase shift between radiation entering the spectrometer from detector side and radiation entering the spectrometer from source side
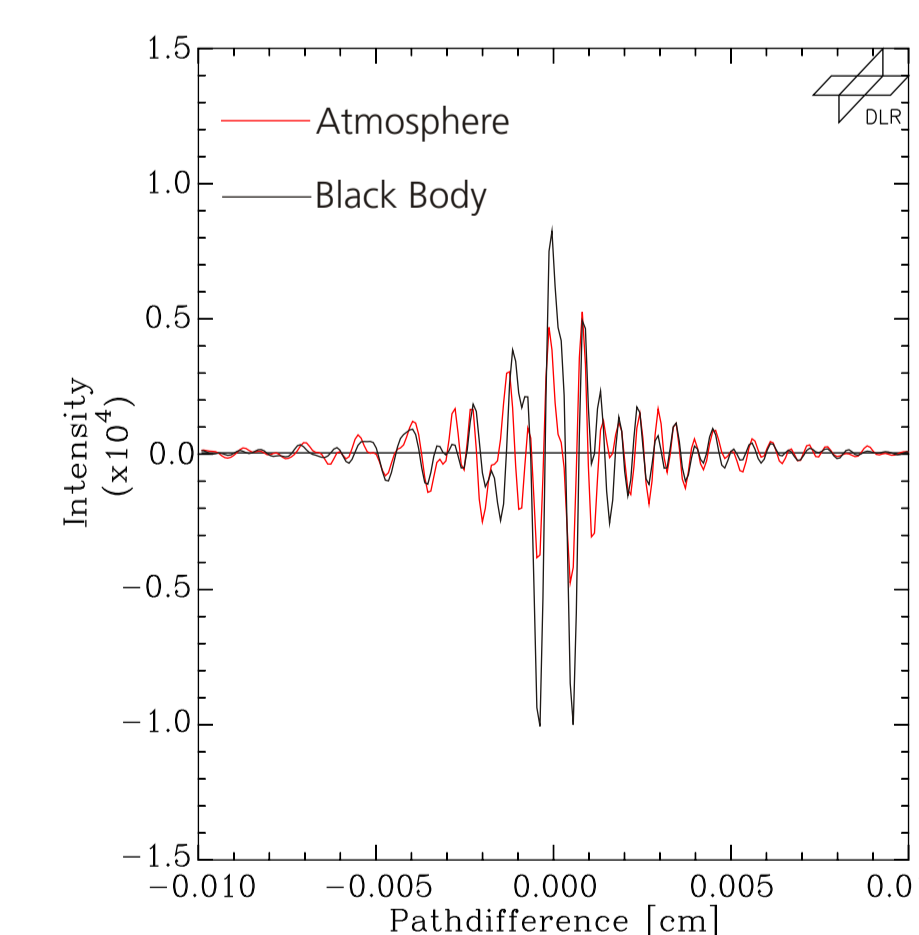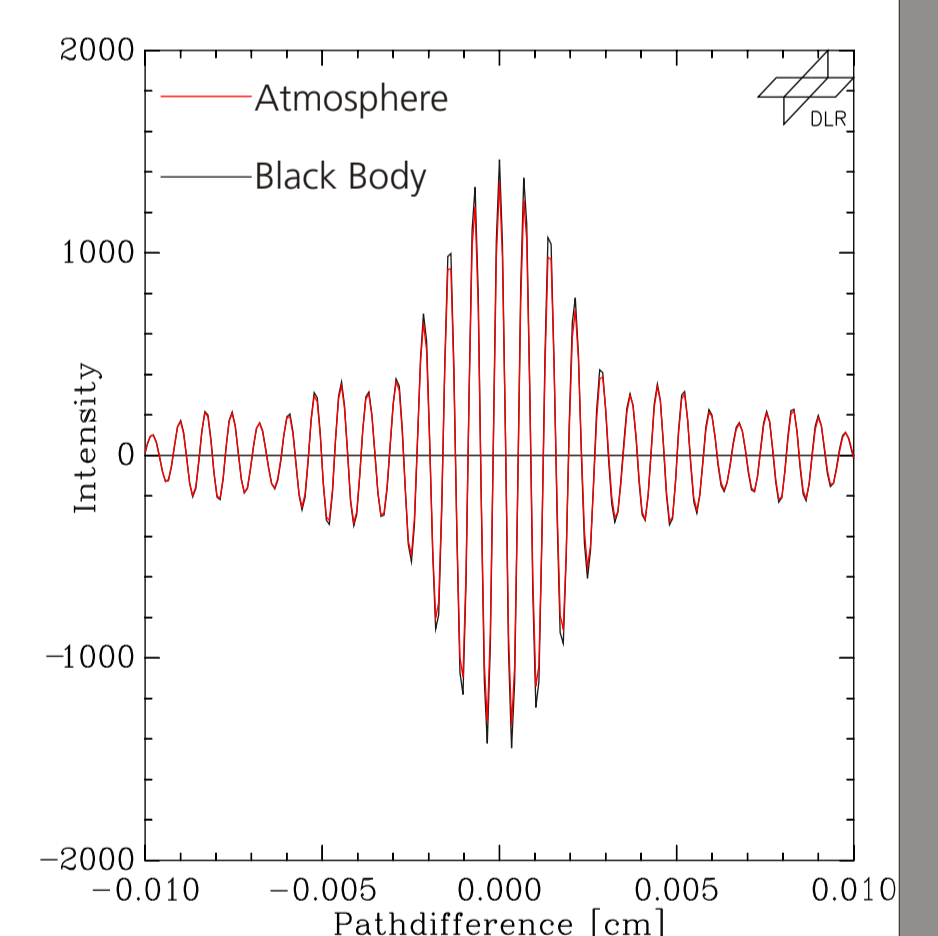
Calibration

A comparison of radiance spectra obtained via different calibration methods and a line-by-line radiative transfer simulation of the downwelling radiance. The results obtained from the instrument software (black) and the full complex calibration without ZOPD correction via narrow-band filtering (blue) lead to considerable deviation in the resulting spectra. In contrast to that, the radiance obtained through full complex calibration for the ZOPD corrected interferograms (red) and the simulated downwelling radiance (green) agree quite well.

In order to improve the results for spectra with large dynamic range, we use the following calibration procedure:

→ Create broadband interferogram with FIR digital filter 600-3000 cm ⇒ remove noise
→ Create narrow-band interferogram with FIR filter 1300 - 1600 cm ⇒ reduce influence of dispersion
→ Set ZOPD of broadband interferogram to center burst of narrow-band interferogram
→ Calibration method described by Revercomb [3] with complex-valued instrument radiance and complex-valued instrument response
→ Use 3 black body temperatures at 3°C, 13°C and 23°C instead of the usual 2 as described by Lindermeir [4]
→ Downwelling radiances agree well with radiative transfer simulation compared to other calibration methods (left)

Comparison of broadband (left) and narrow-band (top) interferograms: ZOPD is set to the center burst of the narrow-band interferogram in each case. Observe the difference between the center bursts for the 23°C black body measurement and the clear-sky atmospheric measurement in the broadband interferograms. This shift would result in a phase error and thus erroneous results after calibration, if the ZOPD was inferred from the broadband interferogram.

References

[1] S. Otto et al, "Solar radiative effects of a Saharan dust plume observed during SAMUM assuming spheroidal model particles",Tellus, 61B, 2009, accepted
[2] A. R. Korb, P. Dybward, W. Wadsworth, J. Salisbury, "Portable Fourier transform infrared spectroradiometer for field measurements of radiance and emissivity", Applied Optics, Vol. 35, No. 10, 1 April 1996
[3] H. E. Revercomb et al, "Radiometric calibration of IR Fourier transform spectrometers: solution to a problem with the High-Resolution Interferometer Sounder", Applied Optics, Vol. 27, No. 15, 1 August 1988
[4] E. Lindermeir et al, "Calibration of a Fourier transform spectrometer using three blackbody sources", Applied Optics, Vol. 31, No. 22, 1 August 1992

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft
DLR

Remote Sensing Technology Institute
P.O. Box 1116
82234 Wessling, Germany
Contact: claas.koehler@dlr.de
http://www.dlr.de/caf