A novel method for accurate calibration of high spectral resolution infrared measurements of surface solar radiation

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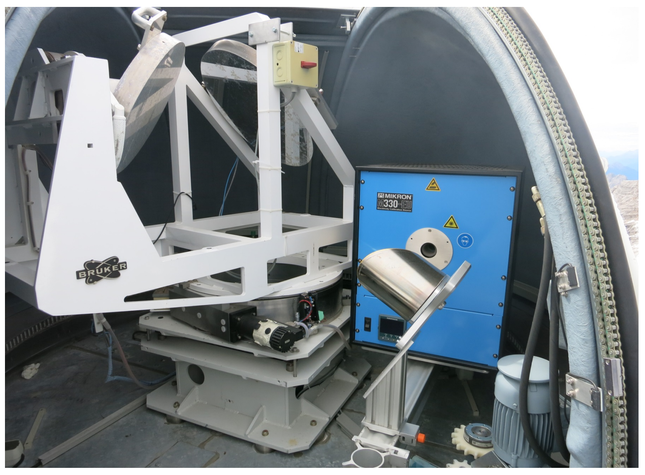
Abstract

- Solar absorption spectra in the near infrared (NIR) can be used to quantify absorption processes via radiative closure, e.g. the water vapor continuum
- Radiometric calibration of spectra is required for closure experiments
- No standard calibration method with sufficient accuracy was available for the NIR
- We present a novel calibration scheme that relies on a combination of the Langley technique and measurements of a medium-temperature blackbody source
- A calibration accuracy of 1 -1.7 % is achieved in the 2500-7800 cm^{-1}-range, which enables the quantification of water vapor continuum absorption in the Zugspitze closure setup

Instrumental setup

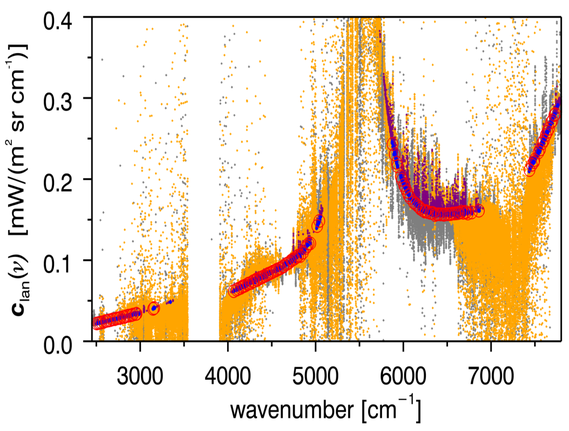


← NIR spectral radiance measurements: **Solar FTIR** (2500-7800 cm^{-1}, Bruker IFS125HR interferometer)

High-temperature blackbody calibration source (1973 K, MIKRON M330-EU) in the Zugspitze FTIR dome and additional 90° off-axis mirror for blackbody measurements

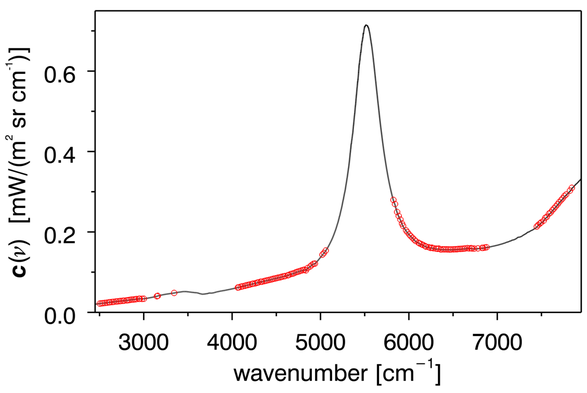
Calibration method

- **Langley method:** enables highly accurate calibration in selected spectral windows



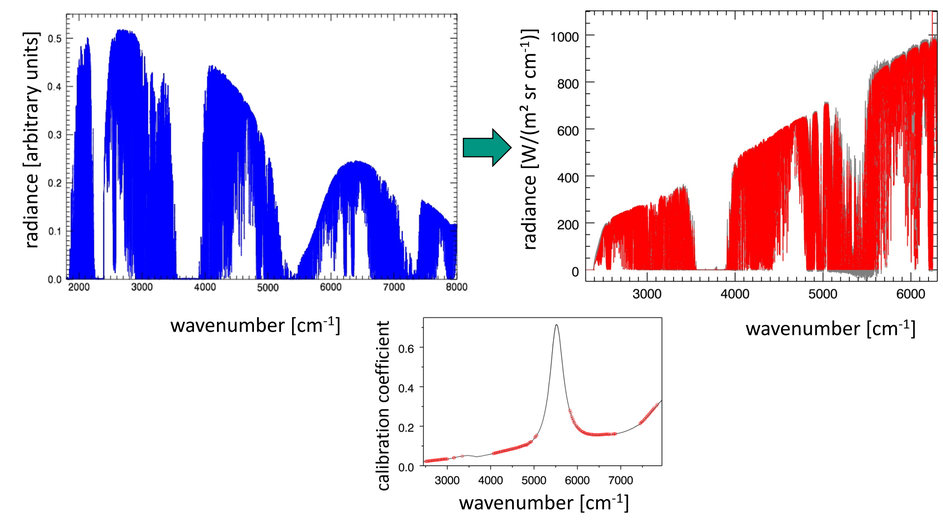
← Selection of suitable spectral points from initial Langley calibration results (grey). Selection based on avoiding solar lines (orange), low fit uncertainty (purple) and stability of fit result (blue). Final Langley results are averaged over 10 cm^{-1}-bins (red circles)

- **Blackbody radiance measurements:** constrain the shape of the calibration curve between Langley points

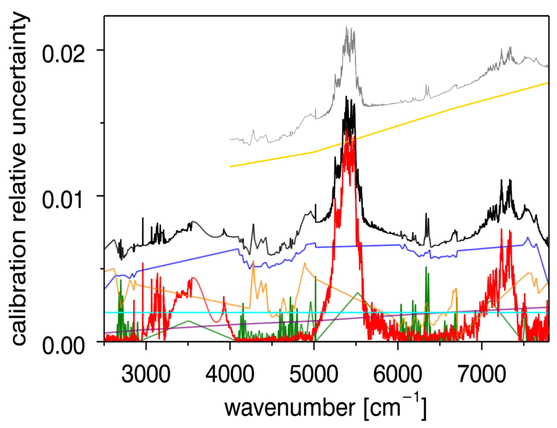


← Combined calibration curve constructed from Langley fit results in suitable windows (red circles) in combination with blackbody measurements (black line)

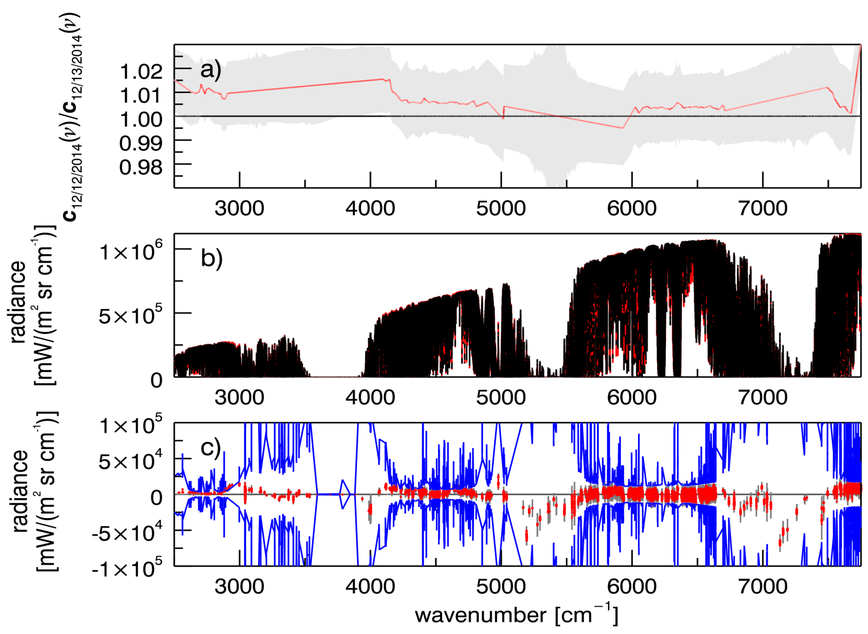
Results



↑ Solar FTIR measurement (blue), calibration coefficients (middle panel) and comparison of calibrated spectrum (grey) with LBLRTM calculation (red)



↑ Calibration uncertainty estimate (2 σ). Blue: Langley fit uncertainty, red: blackbody uncertainty, green: shape error uncertainty, orange: airmass uncertainty, purple: mispointing uncertainty, cyan: FOV uncertainty, yellow: ESS uncertainty, grey: total uncertainty, black: total uncertainty relevant for radiative closure experiment (not including ESS contribution).



↑ Validation of calibration results and uncertainty estimate assessing reproducibility of calibration results (a) and via a closure with synthetic radiance spectra (b +c). Both efforts indicate validity of the 1 - 1.7 % uncertainty estimate.

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