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Reconstruction of high-resolution time series from slow-response atmospheric measurements by deconvolution

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Measurements of high temporal resolution are often needed to study the spatial or temporal variation of atmospheric parameters. An efficient method to enhance the temporal resolution of slow-response measurements is introduced. It is based on the deconvolution theorem of Fourier transform to restore amplitude and phase shift of high frequent fluctuations. It is shown that the quality of reconstruction depends on the instrument noise, the sensor response time and the frequency of the oscillations. The method is demonstrated by application to measurements of broadband terrestrial irradiance using pyrgeometer and temperature and humidity measurements by drop sondes. Using a CGR-4 pyrgeometer with response time of 3 s, the method is tested in laboratory measurements for synthetic time series including a boxcar function and periodic oscillations. The originally slow-response pyrgeometer data were reconstructed to higher resolution and compared to the predefined synthetic time series. The reconstruction of the time series worked up to oscillations of 0.5 Hz frequency and 2 W m^{-2} amplitude if the sampling frequency of the data acquisition is 16 kHz or higher. For oscillations faster than 2 Hz, the instrument noise exceeded the reduced amplitude of the oscillations in the measurements and the reconstruction failed. The method was applied to airborne measurements of upward terrestrial irradiance and drop sonde profiles from the VERDI (Vertical Distribution of Ice in Arctic Clouds) field campaign. Pyrgeometer data above open leads in sea ice and a broken cloud field were reconstructed and compared to KT19 infrared thermometer data. The reconstruction of amplitude and phase shift of the deconvoluted data improved the agreement with the KT19 data and removed biases for the maximum and minimum values. By application to temperature and humidity profiles measured by drop sonde profiles, the resolution of the cloud top inversion cloud be improved.