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Impact of transmitter frequency selection on the quality of A-SCOPE observations employing the Integrated Path Differential Absorption Lidar technique

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Assessment studies in the frame of the mission evaluation for A-SCOPE (Advanced Space Carbon and Climate Observation of the Planet Earth) reveal that the method of Integrated Path Differential Absorption (IPDA) Lidar will provide the column-weighted dry-air mixing ratio XCO2 with unprecedented accuracy. The unique dataset with sampling twice daily and with all-season and all-latitude coverage will allow inferring sources and sinks of CO2 by means of inverse modelling and will help to improve terrestrial biosphere models. Selection of an appropriate frequency-pair for the on- and off-line measurements either in the 1.6 μm or 2 μm wavelength region is of key importance in order to fulfil the stringent observational requirements for A-SCOPE. It is shown that IPDA lidar instruments using an on-line frequency which is tuned to the line centre of a CO2 absorption line would lead to a weighting function behaviour which favours CO2 observations in the upper troposphere and above. Focussing in the lower troposphere, where the sources and sinks reside, requires a well-defined detuning of the transmitter frequency from line centre. Further constraints arise from the fact that the differential atmospheric optical depth (DAOD) should be close to unity. In addition, the impact from uncertainties in the geophysical parameters temperature, water vapour and surface pressure should contribute as little as possible to the overall error budget. The individual error patterns are frequency dependent and need to be considered in an optimum way in the process of frequency selection. Using state-of-the-art NWP error covariance matrices as model input for the analysis of the temperature and humidity uncertainties, we show that the expected impact on the random error performance can generally be kept very small: about 0.3 ppm at 1.6 μm and 0.7 ppm at 2 μm. Thanks to the more favourable weighting function at 2 μm, the error margin is relaxed by about a factor of two in the latter case. This helps to compensate for the increased impact from uncertainties in the geophysical parameters for A-SCOPE observations at 2 μm.