Seminar “Ocean, Ice and Atmosphere”

Institute of Environmental Physics (IUP), University of Bremen

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What is the surface altitude representative for trace gas retrievals from passive satellite instruments?

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Satellite retrievals of atmospheric greenhouse gas concentrations are used to obtain information on their sources and sinks via inverse modelling. Such an application requires very high accuracy as even small biases of the retrieved concentrations may result in large errors of the inferred emissions or sink strength. For example, for the upcoming Copernicus satellite mission dedicated to carbon dioxide monitoring (CO2M) the accuracy of the dry-air column-averaged CO2 mole fraction (XCO2) is required to be better than 0.5 ppm. Here we investigate a potentially important systematic error source, namely XCO2 biases due to sub-pixel variability of surface reflectivity (albedo) and altitude. We show that the XCO2 bias can be large especially if surface albedo and altitude are spatially correlated within single ground pixels. To minimize this error source we motivate that the use of albedo-weighted surface altitude better represents the satellite’s spatial sample than the unweighted average. We use Copernicus Sentinel-2 data combined with Copernicus Digital Elevation Model (DEM) data and the Fast atmOspheric traCe gAs retrievaL (FOCAL) algorithm and create a variety of self-consistent experiments to test this theory. First we conduct experiments with defined conditions and second we apply the methodology to some real-world examples. In all these examples, we find that using the albedo-weighted average of the surface altitude is needed to reduce biases at locations with heterogeneous surface structure to values below the requirements for future satellite missions. Therefore, we show that the use of the albedo-weighted surface altitude in the retrieval process results in significant reduction of the XCO2 bias compared to the use of the unweighted mean altitude, as currently used in most retrieval schemes.