Space-borne remote sensing with active optical instruments for the measurement of temperature, pressure, ozone and the greenhouse gases CO_2, CH_4, and N_2O

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Lidar (Light Detection and Ranging) is regarded as an innovative component of the global observing system. It offers the possibility to directly sample the four-dimensional variability of the atmosphere with unprecedented accuracy and spatial resolution. In Europe, space-borne lidar systems have been the subject of extensive investigations since mid 1970's resulting in mission and instrument concepts such as ATLID a backscatter lidar for aerosol and clouds for the EarthCARE mission or ALADIN, a Doppler wind lidar considered for the ADM/Aeolus mission. Major advances, particularly in humidity profiling, are expected from the space-borne Differential Absorption Lidar (DIAL) being the Core instrument of the WALES (Water Vapour Lidar Experiment in Space) mission which was studied up to a level of Phase A.

In this presentation we report on the background definition of a future lidar system capable of monitoring the greenhouse gases carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), stratospheric and tropospheric ozone (O_3) and the meteorological parameter pressure (p) and temperature (T). The idea of this study which was initiated by the European Space Agency (ESA) was to select one or two candidate instruments for follow-on activities on sensor and mission level. For each parameter appropriate performance models of active optical instruments either for range-resolved or for total column measurements were defined and implemented as computer codes for parametric analysis. The sampling strategy and error characteristics for the individual species have been investigated in great detail by comprehensive computer simulations along the scientific needs and observational requirements which were defined by representatives of the user community for the timeframe beyond 2012. The results have been compared to the performance of already existing or planned passive sensors for identification of possible sensor synergy or data gaps in the global observing system. As a remarkable result it was found that the total column content of CO_2 can be precisely measured by space-borne Path-integrated Differential Absorption Lidar (IPDA) applied in the 1.6μm or 2 μm spectral region. IPDA instruments are expected to meet the stringent target observational requirements for the random error of CO_2 as derived from forward simulation and inverse modelling. The target requirements can also be achieved for CH_4. In case of N_2O the threshold requirements can be met, only. Range-resolved atmospheric backscatter DIAL would require a considerable larger instrument for both CO_2 and CH_4 which is not available from current technology. After trading-off pros against cons which included the results of all investigated parameter, the greenhouse gas CO_2 was finally selected as potential candidate worthwhile to be further studied on instrument and mission level.