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The French-German climate mission MERLIN

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Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have been recognized by the International Panel of Climate Change (IPCC) as the most important of the Earth's greenhouse gases. Measurements on Antarctic ice cores have documented an atmospheric increase of all three gases since the beginning of the industrial revolution. The concentration increase of these three trace gases over the time period spanning the years 1750 to present have induced an additional global annual mean radiative forcing of more than 2 Wm^{-2}. Any prediction of future climate and any policy advice on greenhouse gas avoidance require reliable estimates of the natural and anthropogenic sources and sinks of these gases in terms of location, magnitude, and variability on a global basis.

MERLIN is a small satellite mission, dedicated for the measurement of atmospheric CH_4. Together with appropriate modelling activities, this data can be used to infer CH_4 fluxes on the Earth surface by means of inverse models that describe atmospheric transport and mixing. Atmospheric CH_4 is the 2nd most important anthropogenic greenhouse gas which has a Global Warming Potential (GWP) of about 23 relative to CO2 on a time scale of 100 years. The major anthropogenic sources of CH_4 are the emissions from energy production, landfills, waste treatment, cattle, rice fields, and incomplete biomass burning. In addition there are significant natural CH_4 sources from wetlands. Due to human activities, the concentration of CH_4 in the atmosphere has been multiplied by more than 2.5 over the relevant time period. Thus radiative forcing caused by methane contributes significantly to climate warming of the atmosphere. Due to chemical reactions, CH_4 also increases radiative forcing of tropospheric O_3 and influences the concentration of OH^- which is the major sink of CH_4 in the atmosphere. Including all so-called indirect effects causes a radiative forcing of up to 60% of that of CO_2 despite of a much lower concentration. In addition, global warming in particular in the Arctic regions might foster the melting of permafrost soils which contain significant amounts of carbon in the atmosphere. There exist also very large deposits of CH_4 as hydrates on the ocean shelves that are vulnerable to ocean warming. Paleo records indicate that both processes have been important feedbacks in the climate system. Development and implementation of an observational system for the detection of CH_4 emissions in these vulnerable areas has therefore a high scientific priority.

As a novel feature, the MERLIN payload makes use of the Integrated-Path Differential-Absorption (IPDA) lidar technique. The lidar signals from cloud tops or the Earth surface can be used to measure the spatial and temporal gradients of atmospheric CH_4 columns along the satellite sub-track with high accuracy. Initial impact studies clearly show substantial reduction of the prior methane flux uncertainties in key observational regions when using synthetic MERLIN observations in the flux inversion experiments. Measurement biases that can arise from unknown aerosol scattering or scattering from thin cirrus layers are avoided by range-gated signal detection. The lidar instruments permits all-season and all-latitude coverage as it is not relying on sunlight. As an important milestone, MERLIN has successfully passed the Preliminary Readiness Review (PRR) at the end of Phase A and is now in Phase B. The envisaged launch date will be in the 2017 time frame.

In the presentation I will give an overview on the MERLIN mission concept. Further I report on the results from supporting studies regarding the simulated measurement performance and the impact on flux inversion using simulated MERLIN observations as input data. Finally, I present the status of CHARM-F which is an airborne demonstrator for IPDA lidar measurements of atmospheric CO_2 and CH_4, simultaneously.