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The combined use of partial and total column measurements of atmospheric methane to better constrain sources and sinks

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Active remote sensing of trace gases from aircraft or satellite using lidar facilitates the retrieval of meaningful data even under conditions of broken clouds, due to the small footprint of the lidar. Given sufficient optical thickness, retrieval of partial columns from cloud tops is also possible. This has also been demonstrated for airborne measurements from the CHARM-F differential absorption lidar, which measures both methane and carbon dioxide. This study examines the use of these partial columns for the derivation of both sources and sinks of methane. CHARM-F measurements from flight campaigns, including 2018's CoMet mission, are used to characterize these measurements. CHARM-F is an airborne demonstrator for the planned DLR/CNES methane missions MERLIN, and the principle focus of this study is on the interpretation of the partial column satellite lidar measurements that will be provided by this mission. Cloud heights and optical depths measured by the aerosol lidar CALIPSO can provide information about when and where we expect to be able to make such measurements, but this has to be adjusted to take into account a different overpass times, with MERLIN in a dawn-dusk orbit and CALIPSO in the A-Train. Thus measurements from the aerosol lidar mission CATS on the International Space Station with a variable overpass time are also used. In addition to attempting to isolate the boundary layer signal by combining total and partial column measurements going down to low clouds, the possibility of deriving coarse-resolution information about methane vertical distributions from different cloud heights is also examined. For methane this proves to be particularly interesting, as it provides an additional constraint on the vertical distribution brought about by both the distribution of the tropospheric chemical sink as well as the stratospheric component. The impact of uncertainties in the vertical mixing when interpreting partial columns is also examined.