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# Enhancements of ozone-depleting substances in the lower stratosphere from Asian Monsoon outflow

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The success of the global treaty commonly referred to as the Montreal Protocol has led to decreasing emissions and mixing ratios of many long-lived ozone-depleting substances (ODSs) in the atmosphere. Recent research has focussed on the impacts of short-lived ODSs that have atmospheric lifetimes of six months or less and are not currently controlled through the Montreal Protocol. Recent studies show that the Asian summer monsoon could transport emissions from the rapidly industrialising nations in East and South Asia into the tropical upper troposphere. Further, air masses from the region of the Asian monsoon anticyclone have a significant impact on the chemical composition of the lower stratosphere of the Northern Hemisphere with transport times of a few months.

For this study, almost 100 air samples have been collected on multiple flights on the M55 Geophysica high altitude research aircraft over the Indian Ocean and subcontinent as well as the Himalaya during the summer of 2017 as part of the StratoClim EU project. These air samples have been measured for 30-50 trace gas species most of which are ODSs. We found that mixing ratios of many ODSs were enhanced above background conditions, in particular those of several short-lived species such as dichloromethane ($CH_2Cl_2$) and 1,2-dichloroethane ($CH_2ClCH_2Cl$). Most samples were collected at altitudes where the air is likely to continue to rise and therefore the contained ODSs are likely to contribute to stratospheric ozone destruction. The Equivalent Effective Stratospheric Chlorine (EESC) is calculated and compared to other estimates in the literature in order to assess the impact on the ozone layer. Backward trajectories calculated with the trajectory module of the CLaMS model are used to identify the likely source regions of the air masses. Policy implications of these observations are a delay of the recovery of the ozone layer and a reduction of the impact of the Montreal Protocol.