Assessing the climate impact of formation flights

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WEATHER AND LOCATION DEPENDENCY OF AVIATION CLIMATE EFFECTS: 4-D-CLIMATE-CHANGE-FUNCTIONS

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Abstract. Emissions of aviation include CO_2, H_2O, NO_x and particles. While CO_2 has a long atmospheric residence time and is uniformly distributed in the atmosphere, non-CO_2 gases, particles and their products have short atmospheric residence times and are heterogeneously distributed. Their climate effects depend on chemical and meteorological background conditions during emission, which vary with geographic location, altitude, time, local insolation, actual weather, etc. This spatial and temporal variability can be utilized for aviation climate impact mitigation by identifying aircraft trajectories which avoid climate-sensitive regions. To determine the climate change contribution of individual emissions as function of 3-dimensional position, time and weather situation, contributions of local emissions to changes in O_3, CH_4, H_2O and contrail-cirrus were computed by means of the ECHAM5/MESSy Atmospheric Chemistry model and four-dimensional climate change functions (CCFs) were derived thereof. Typical weather situations in the North Atlantic region were considered for winter and summer. For all non-CO_2 species included in the study, we found distinct weather related differences with respect to their climate impact. Depending on the species, we found enhanced significance of the position of emission release in relation to high pressure systems, in relation to the jet stream, in relation to polar night and in relation to the tropopause altitude. The dominating parameters were found to be contrail-cirrus and total NO_x. The results of this study represent a comprehensive basis for weather dependent flight trajectory optimization studies. Furthermore it constitutes the groundwork for the development of more generally applicable algorithmic CCFs.

Keywords: non-CO_2 emissions, weather dependency, climate optimal trajectories