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Contrail Cirrus Forecasts for the ML-CIRRUS Experiment and Some Comparison Results

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Model simulations with the contrail cirrus prediction model CoCiP driven by numerical weather prediction (NWP) data provided from the European Centre for Medium Range Forecasts (ECMWF) and global aircraft waypoint data show a mean computed cover (for optical depth larger than 0.1) of 0.23% globally, and 5.4% over mid Europe (Schumann and Graf, JGR, 2013). The computed mean longwave radiative forcing (RF) reaches 3 W m-2 over mid Europe (10°W–20°E and 40°N–55°N), and 0.13 W m-2 globally. The global net RF is about 40-60% smaller because of compensating shortwave cooling induced by contrails during daytime. The results depend on several model details such as the number of ice particles forming from aircraft soot emissions, the contrail plume dispersion, ice particle sedimentation etc., all influencing contrail life time and their optical properties. The quantitative results depend also strongly on ambient relative humidity, vertical motion and on ice water content of other cirrus predicted by the NWP model.

In order to test and possibly improve this and other contrail models, high-quality observations are needed to which multi-parameter model output can be compared. The Mid-Latitude Cirrus Experiment ML-CIRRUS was performed (see C. Voigt et al., this conference) with a suite of in-situ and Lidar instruments for airborne measurements on the research aircraft HALO.

Before and during the mission, CoCiP was run daily to provide 3-days forecasts of contrail cover using operational ECMWF forecasts and historical traffic data. CoCiP forecast output was made available in an internet tool twice a day for experiment planning. The one-day and two-day contrail forecasts often showed only small differences. Still, most recent forecasts and detailed satellite observations results were transmitted via satellite link to the crew for onboard campaign optimization. After the campaign, a data base of realistic air traffic data has been setup from various sources, and CoCiP was rerun with improved ECMWF-NWP data (at one-hour time resolution). The model results are included in the HALO mission data bank, and the results are available for comparison to in-situ data. The data are useful for identifying aircraft and other sources for measured air properties. The joint analysis of observations and model result has basically just started. Preliminary results from comparisons with lidar-measured extinction profiles, in-situ measured humidity, nitrogen oxides, and aerosol and ice particle concentrations, and with meteorological observations (wind, temperature etc.) illustrate the expected gain in insight.

The contrail forecasts have been checked by comparison to available data including satellite data and HALO observations. During the campaign, it became obvious that predicted contrail cirrus cover compared qualitatively mostly well with what was found when HALO reached predicted cirrus regions.

From the analysis of the measured data, some examples of significant correlation between model results and observations have been found. However, the quantitative agreement is not uniform. As expected, nature is far more variable than a model can predict. The observed optical properties of cirrus and contrails vary far more in time and space than predicted. Local values were often far higher or lower than mean values. A one-to-one correlation between local observations and model results is not to be expected. This inhomogeneity may have consequences for the climate impact of aviation induced cloud changes.