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On contrail radiative forcing and climate sensitivity: studies with the ECHAM general circulation model

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The future development of contrails is investigated by means of a contrail parameterization developed for the ECHAM general circulation model, considering changes in air traffic, aircraft technology as well as background climate change. Our best estimate from time slice simulations is an increase of global annual mean radiative forcing from 3.5 mW/m^2 in 1992 to 9.4 mW/m^2 in 2015 and to 14.8 mW/m^2 in 2050. The temporal development of the simulated contrail radiative forcing is most closely related to contrail cover, although the mean optical depth is found to increase in a warmer climate. Uncertainties in contrail radiative forcing mainly arise from uncertainties in microphysical and optical properties such as particle shape, particle size, and optical depth.The results are discussed particularly with regard to the special report on "Aviation and the Global Atmosphere" by the IPCC (1999) and more recent studies on contrail and contrail-cirrus radiative forcing.

In equilibrium climate change simulations with the ECHAM model we find that the climate sensitivity to contrail cirrus is significantly smaller (0.43 K/(Wm^{-2})) than the corresponding value for a CO_2 change (0.73 K/(Wm^{-2})). The pattern of the surface temperature response is much smoother than the forcing contrail pattern with little correlation between both. Together with the finding that the transient response for aircraft impacts to be expected during the 1990ies is markedly delayed behind the equilibrium response, our results do not confirm a recent study suggesting a dominating influence of contrail cirrus on temperature change over the United States of America between 1975 and 1994.