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Optimization of critical relative humidity over ice for cirrus cloud formation in Sundqvist parameterisation

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Contrails and cirrus clouds have been identified as being, potentially, the largest effects from aviation on radiative forcing (RF) (IPCC, 1999). This work forms part of a wider investigation to identify the sources of uncertainties in estimating RF from contrails. Cirrus coverage is required to determine what fraction of a grid cell is available for potential contrail formation. In this offline contrail model, the cirrus coverage is calculated from ECMWF ERA-40 specific humidity and temperature data using the Sundqvist parameterisation, Equation 1, where b_{ci} is the fractional cirrus cloud coverage, U_i the relative humidity over ice and U_{ci} the critical value of relative humidity over ice (Sundqvist, 1978).

$$b_{ci} = 1 - \sqrt{\frac{1 - \max(U_i, U_{ci})}{1 - U_{ci}}} \tag{1}$$

The parameterU_{ci} determines whether cirrus clouds will form in a particular grid box, i.e. U_{ci} has to be exceeded for a cirrus cloud to form. Generally, U_{ci} is optimized for a given GCM in order to yield a cloud distribution that leads to an optimal closure of the global annual radiation balance at the top of the atmosphere. In an offline model, an appropriate U_{ci}value for the meteorological dataset used has to be selected. This value may influence the spatial distribution of cirrus coverage calculations and, therefore, the global mean coverage. In this paper, U_{ci} is optimized to the global high cloud field inherent in the ERA-40 dataset. It is also possible to further adjust U_{ci} to produce an optimized cloud distribution for regions with high aircraft movements.

References

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