Variability of contrail formation conditions and the implications for policies to reduce the climate impacts of aviation

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3.5% of human radiative forcing of climate due to aviation in 1990
- Predicted to increase to 5-10% by 2050
Contrails: Threshold Temperature
Contrails: Parameterisation for larger areas

• Very high resolution atmospheric data is needed to predict whether an individual aircraft will produce a contrail at each point along its route

• Only persistent contrails are likely to play a significant climate role

• Parameterisation is needed to describe persistent contrail formation on larger scales (e.g. the grid box of a GCM)

• For a given area, Potential Contrail Fraction describes the fraction of that area in which a persistent contrail will form
  - The maximum possible contrail coverage
  - Calculated from mean atmospheric temperature and relative humidity over a grid box
European 5 States region
Calculating contrail sensitivity

- Contrail grids using product of potential contrail and distance travelled
- Total contrail (summed over all grid boxes)
- Total traffic distance (over all grid boxes)

Contrail sensitivity = \frac{\text{total contrail}}{\text{total distance}}
January 2000

- Time series of contrail sensitivity
- 4 records per day
- 1 time series for each month and year
In January, reducing cruise altitude can increase average contrail.

Variability is very high, especially for FL240 altitude restriction.
July 6:00-11:59am

- In July, contrail production is consistently lower than in January

- Reducing cruise altitude reduces the mean contrail sensitivity
Selecting cruise altitude restrictions

- Calculate contrail formation for the traffic sample
- Recalculate contrail formation for each of four cruise altitude scenarios
- Calculate the fuel increase associated with each cruise altitude restriction
- For each time step, select the cruise altitude restriction that offers the greatest contrail reduction per unit of additional CO₂ emitted
Cruise altitude restrictions selected
January

- 3 of the fixed altitude restrictions would increase contrail
- Variable restrictions could remove between 65 and 95% of contrail
- Fuel increase incurred is less than that for FL 240 restriction
• All of the fixed altitude restrictions would reduce contrail

• Variable cruise altitude restrictions would reduce contrail more for the same fuel burn increase
Conclusions

• Conditions for contrail formation are highly variable

• Cruise altitude restrictions could reduce contrail coverage
  – Variable restrictions are more effective at reducing contrail than monthly fixed restrictions
  – Variable restrictions would require radical changes in air traffic management and safety must not be compromised

• For air transport – clean technology does not just mean aircraft, engine or fuel technology