Condensation trails from biofuels/kerosene blends scoping study: Summary

- To describe a possible impact of emissions from various fuels on climate, we have to distinguish between **contrail formation** and **contrail properties**.
- Contrail formation is similar to condensation of breath air on cold days. **Transition from kerosene to alternative fuels will merely effect details of the formation process**, but not inhibit it.
- Drop-in biofuels have marginally higher energy content than kerosene and a little more water vapour is emitted per kg of fuel burnt. This leads to **slightly earlier onset of contrail formation** in terms of flight altitude and temperature.
- Burning drop-in biofuels leads to **considerably lower emissions of soot and aerosol particles** compared to kerosene. Even blends show reductions of soot and aerosol emissions. This lowers the initial ice crystal number concentrations of contrails, a beneficial effect for climate.
- **Lower ice crystal number concentrations** lead on average to contrails with reduced optical thickness and lifetimes, thus a **reduced climate effect**.
- The benefit per individual contrail depends strongly on ambient conditions (meteorology, time of the day). **Biofuels should be used in a way that optimises the climate benefit**.
- A large overall benefit **requires a large reduction of soot emissions** (more than 50%).
- It is thus required to **identify** those molecules and chemical groups in the fuel that are main **precursors of soot particles**. In particular, aromatics are known to lead to soot emission, but they are not the only ones.
- Kind and amount of emissions are also controlled by several inter-dependent combustion sub-processes. Simple but detailed **process models,** validated by relevant measurements, are required **to calculate emissions** (in particular soot) for the variety of synthetic jet fuels under a large variety of engine conditions and architectures.
- **Measurements** under laboratory, ground based and in-flight conditions, are required to **provide basic input data** for the models and to test model predictions.
- Apart from alternative fuels and new combustion concepts (lean combustion), the climate effect of aviation can be reduced by **steering clear of sensitive regions and times**, using reliable weather forecasts for flight routing and for **prediction of the individual climate effect of each flight**.

DLR's research aircraft Falcon measuring emissions and contrails from biofuels in the wake of DLR's ATRA (Advanced Technology Research Aircraft) during a measurement campaign in fall 2015.