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

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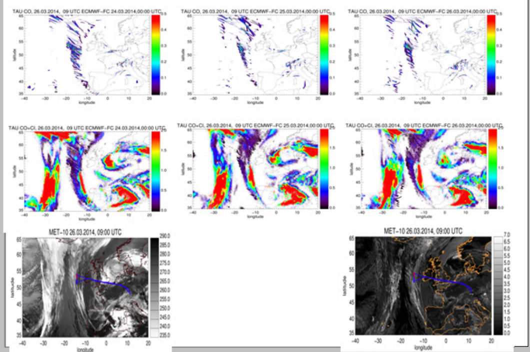
DLR

Introduction

- Contrail cirrus are responsible for a large share of aviation climate impact (IPCC 5AR, 2013)
- Accurate assessment requires data on microphysics (Graf et al., GRL, 2012; Schumann&Graf, JGR, 2013)
- Aviation climate impact may be mitigated by route changes based on reliable contrail predictions
- Contrail cirrus can be predicted (Schumann, 2012)
- Contrail cirrus has been observed during ML-CIRRUS (Voigt et al., EGU 2015 - Session AS3.5)
- Here, results are compared for a subset of measured data (preliminary data analyses).

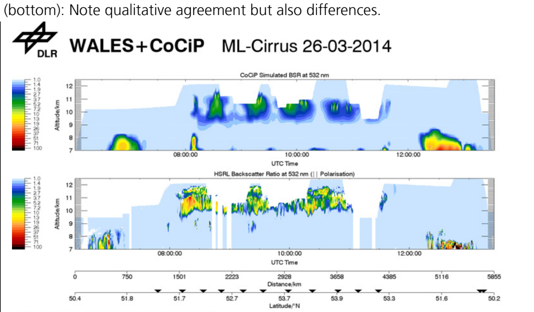
3-, 2-, and 1-day forecast of optical depth of contrails (top panel) and contrail cirrus (middle), compared to Meteosat SEVIRI IR brightness temperatures at 10.8 µm and from 10.8-12 µm difference (bottom) at 0900 UTC 26 March 2014: Note: Generally good structural agreement.



Contrail Cirrus Prediction Method (CoCiP)

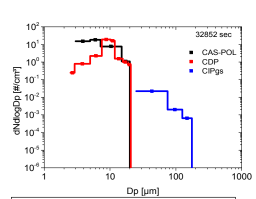
The Contrail Cirrus Prediction method (CoCiP) simulates the properties of an ensemble of contrails for given air traffic and meteorology (Schumann, GMD, 2012).
The DLR Mission-Support Tool includes CoCiP products.
CoCiP uses ECMWF IFS 1-h forecast data at 0.5° resolution and ACCRI traffic data (Wilkerson et al., ACP, 2010) for 60°W-20°E, 20°N-70°N. Forecast started every 12 h for the next 4 days.
Two standard products are provided from the forecast output:
1) maps of optical depth of contrails at 5-km resolution and
2) similar maps of optical depth of contrail-cirrus
ECMWF and CoCiP output along flight paths is available with the observations from the HALO data bank.

Vertical cross-section along flight path of HALO 26 March of 532 nm backscatter ratio: CoCiP-computed (top) and WALES-Lidar-observed (bottom): Note qualitative agreement but also differences.



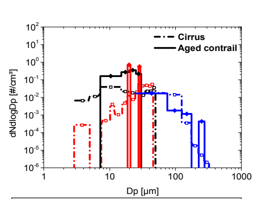
In-situ observations of contrail and cirrus of 26 March 2014:
Ice particle number concentration size spectra for young contrails, aged contrails and cirrus. Contrails and their age are derived from NOx concentrations. The size spectra data are from
CAS-DPOL (Huber, Schlage, Jurkat, Voigt, Minikin, DLR) and
CDP/CIP (Weigel, Borrmann, Uni-Mainz)

Left: 2-4 h old contrails



226 hPa, 213 K, RHi 96 %
N_CAS > 3 µm 8 #/cm³

Right: ~10 h old contrails

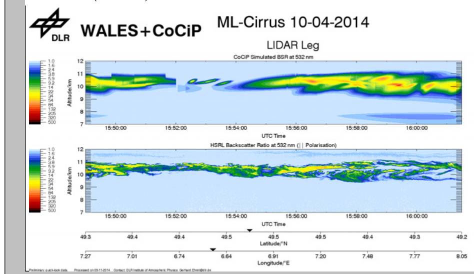


226 hPa,213 K, RHi 101 %
N_CAS > 3 µm 0.1 #/cm³

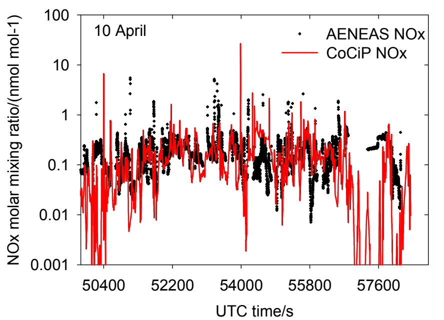
Forecast quality

- Four-day contrail-cirrus forecasts are useful for mission planning
- Partly because of excellent ECMWF performance, the 1-day and 2-day contrail forecasts show small differences.
- The predicted contrail cirrus cover compares qualitatively well with what was found when HALO reached predicted cirrus regions.
- Differences exist because of deviations in the forecast meteorology and traffic data, and because of model deficiencies.

Vertical cross-section along flight path of HALO 10 April of 532 nm backscatter ratio: CoCiP-computed (top) and WALES-Lidar-observed (bottom): Note: Most of the cirrus is contrail induced.



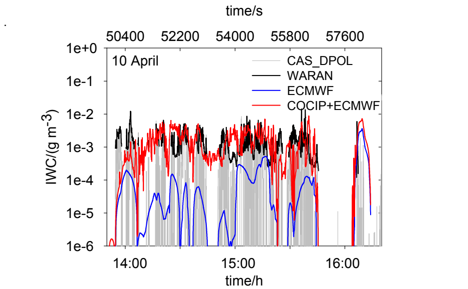
Nitrogen oxides mixing ratio along flight path of HALO 10 April. Black: data deduced from measured NO, O_3 and temperature, and from estimated photolysis rates.: Red: computed from passive tracer aircraft emissions during last 24 hours (assumed NO_2 EI: 20 g/kg). Note Agreement is a measure for how good CoCiP simulates plume dilution.



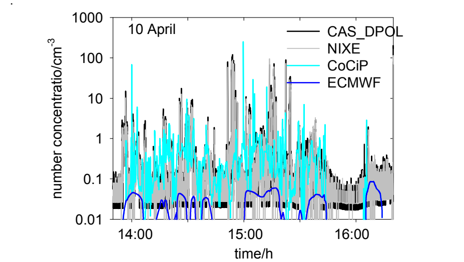
Comparisons to Lidar and in-situ data

- The in-situ data are from preliminary data analysis
- The comparison to lidar is better for 10 April than for 26 March, partly because of better traffic data but mainly because of higher predicted relative humidity.
- Quantitative agreement for NOx, IWC, ice particle number concentration and – in some cases – backscatter ratio, contribute to CoCiP model validation
- As to be explained in more detail in a coming paper: Some of the observed cirrus could not be explained without contrail contributions

Ice water content (IWC) deduced from ice particle size spectra CAS-DPOL data (~0.5-50 µm), from WARAN difference between measured humidity above saturation, from ECMWF forecasts and from CoCiP model: Note that most of the measured IWC results from contrails in this case.



Number concentration of ice particles as measured by CAS.-DPOL and NIXE (both ~0.5-50 µm), as derived from ECMWF IWC and temperature forecast, and as computed by CoCiP. Note that the data agree with the forecast only when contrail contributions are taken into account for this case.



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