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Investigating the limiting aircraft-design-dependent and environmental factors of persistent contrail formation

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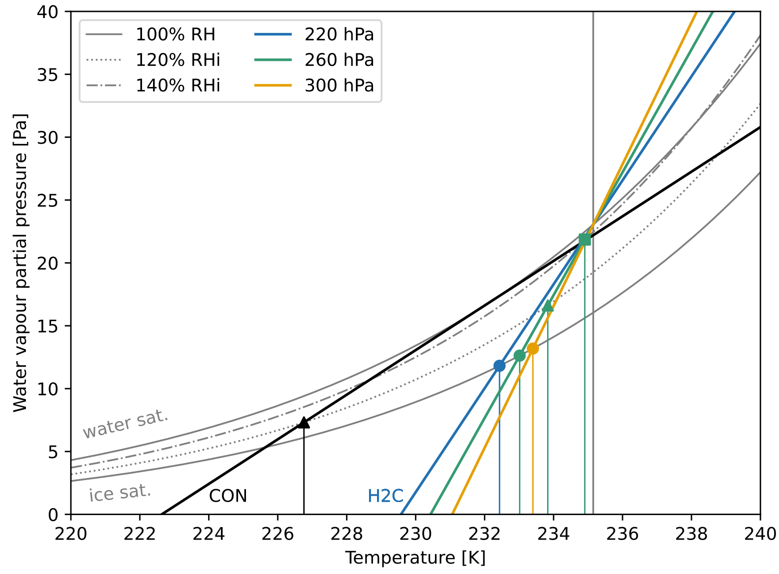

Figure S1. Ambient temperature vs. water vapour partial pressure diagram with threshold mixing lines for a conventional, kerosene-powered aircraft (CON, black line for 240 hPa) and a hydrogen combustion aircraft (H2C, coloured lines for different pressure levels). The ice and water saturation curves are shown for 100 % (gray lines), as well as the curve for ice supersaturations of 120 % (dotted gray line) and 140 % (dash-dotted gray line). The intersection of the threshold mixing lines with these curves are marked for comparison with Bier et al. (2022) and Bier et al. (2024) - see main text.

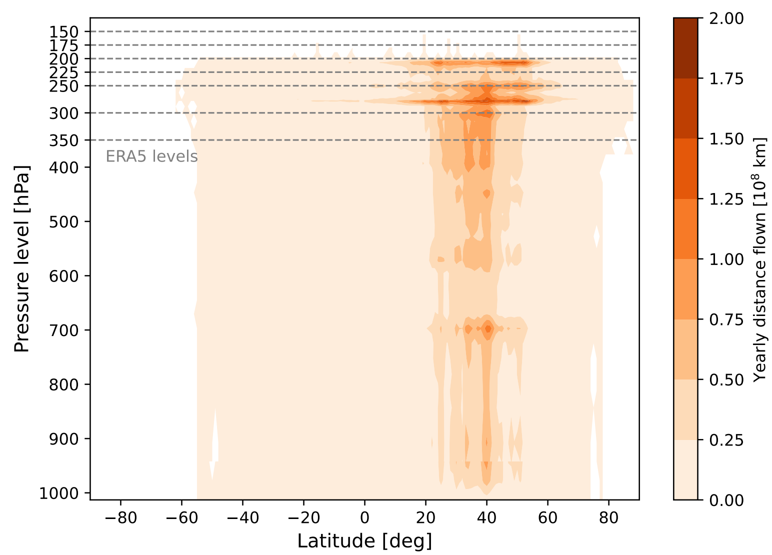

Figure S2. DEPA 2050 progressive scenario for the year 2050 used to weight the potential persistent contrail formation. Also shown are the ERA5 pressure levels considered in the study.

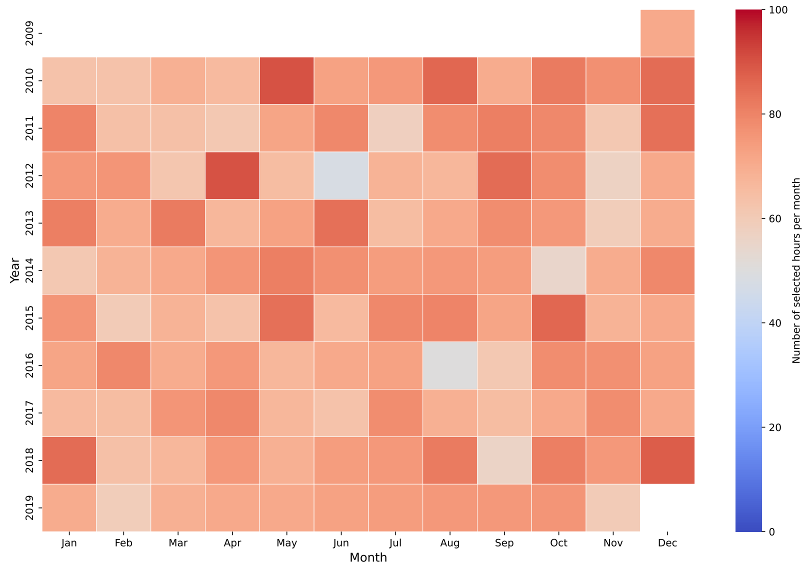

Figure S3. Number of hours randomly selected in ERA5 within the 2010 decade.

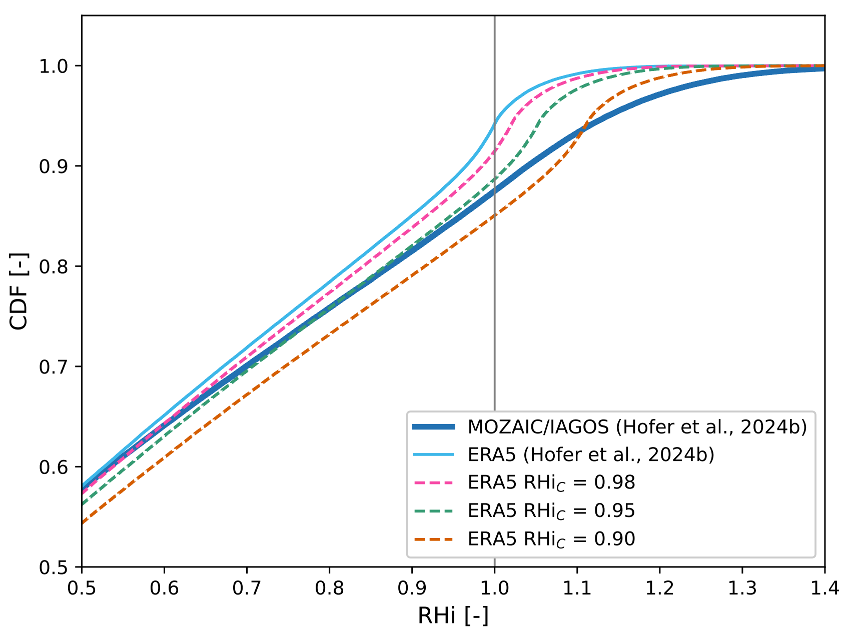

Figure S4. Comparison of the cumulative distribution functions of ERA5 and MOZAIC/IAGOS from (Hofer et al., 2024). We enhance the ERA5 relative humidity by applying simple factors and find that $\mathrm{RHi_C} = 0.95$ provides a good fit against MOZAIC/IAGOS data for $\mathrm{RHi} \leq 1.0$.

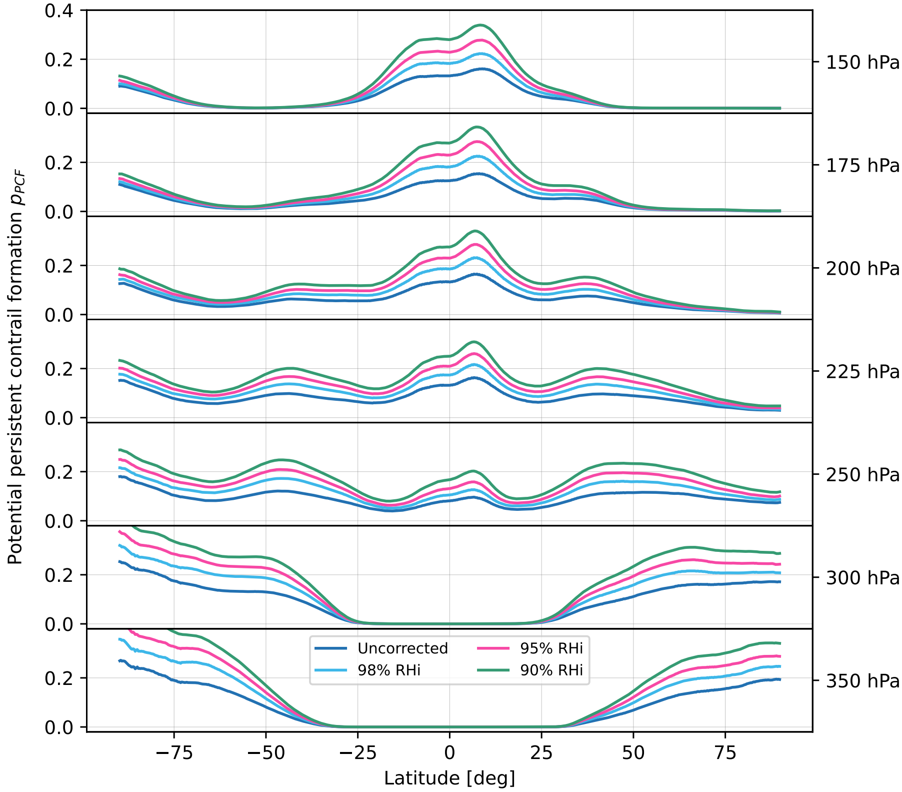

Figure S5. Potential persistent contrail formation as a function of latitude (x-axis) and altitude (secondary y-axis) for different relative humidity enhancements.

References

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Hofer, S., Gierens, K., and Rohs, S.: How Well Can Persistent Contrails Be Predicted? An Update, Atmospheric Chemistry and Physics, 24, 7911–7925, https://doi.org/10.5194/acp-24-7911-2024, 2024.

Table S1. Potential persistent contrail formation p_{pcf} and DEPA 2050 distance-weighted p_{pcf} for the pressure levels 300 and 250 hPa and all considered pressure levels, averaged over four latitude bands: the southern extratropics (xtropS), tropics (trop), nothern extratropics (xtropN) and all latitudes. Percentage changes are provided for the globally-averaged values for simple comparison. The full data is available within the linked dataset.

Aircraft	Pressure level	p_{pcf}				Distance-weighted p_{pcf}			
		xtropS	trop	xtropN	all	xtropS	trop	xtropN	all
WET-75	300 hPa	0.057	0.000	0.028	0.028 (37.1 %)	0.000	0.000	0.002	0.001 (10.1 %)
	250 hPa	0.061	0.000	0.030	0.031 (45.4 %)	0.000	0.000	0.003	0.001 (16.2 %)
	all	0.044	0.015	0.019	0.026 (43.4 %)	0.000	0.000	0.001	0.000 (14.9 %)
WET-50	300 hPa	0.096	0.000	0.064	0.053 (69.6 %)	0.000	0.000	0.008	0.003 (40.6 %)
	250 hPa	0.086	0.000	0.064	0.050 (74.7 %)	0.000	0.000	0.009	0.003 (53.1 %)
	all	0.065	0.029	0.040	0.044 (74.0 %)	0.000	0.000	0.004	0.001 (48.3 %)
HYB-80	300 hPa	0.104	0.000	0.075	0.060 (78.3 %)	0.000	0.000	0.011	0.004 (53.8 %)
	250 hPa	0.093	0.000	0.073	0.055 (82.6 %)	0.000	0.000	0.011	0.004 (66.3 %)
	all	0.069	0.033	0.045	0.049 (81.7 %)	0.000	0.000	0.004	0.002 (61.7 %)
CON-30	300 hPa	0.119	0.000	0.100	0.073 (95.3 %)	0.000	0.000	0.017	0.006 (88.0 %)
	250 hPa	0.104	0.004	0.086	0.065 (96.3 %)	0.000	0.001	0.015	0.005 (92.6 %)
	all	0.076	0.043	0.055	0.058 (96.5 %)	0.000	0.001	0.006	0.002 (91.5 %)
CON-37	300 hPa	0.124	0.000	0.105	0.076 (100.0 %)	0.000	0.000	0.020	0.007 (100.0 %)
	250 hPa	0.106	0.007	0.089	0.067 (100.0 %)	0.000	0.001	0.016	0.006 (100.0 %)
	all	0.078	0.045	0.057	0.060 (100.0 %)	0.000	0.001	0.007	0.003 (100.0 %)
CON-40	300 hPa	0.126	0.000	0.108	0.078 (102.1 %)	0.000	0.000	0.021	0.007 (105.9 %)
	250 hPa	0.107	0.008	0.090	0.068 (101.7 %)	0.000	0.001	0.016	0.006 (103.3 %)
	all	0.079	0.047	0.058	0.061 (101.7 %)	0.000	0.001	0.007	0.003 (104.0 %)
H2C-40	300 hPa	0.142	0.003	0.128	0.091 (119.3 %)	0.001	0.001	0.032	0.011 (164.8 %)
	250 hPa	0.111	0.063	0.098	0.091 (134.8 %)	0.001	0.006	0.019	0.009 (149.0 %)
	all	0.084	0.064	0.065	0.071 (118.3 %)	0.000	0.002	0.009	0.004 (146.5 %)
H2FC-HV	300 hPa	0.145	0.004	0.131	0.093 (122.4 %)	0.001	0.002	0.034	0.012 (177.2 %)
	250 hPa	0.111	0.078	0.099	0.096 (142.8 %)	0.001	0.007	0.019	0.009 (157.5 %)
	all	0.085	0.066	0.067	0.073 (120.8 %)	0.000	0.003	0.009	0.004 (154.7 %)

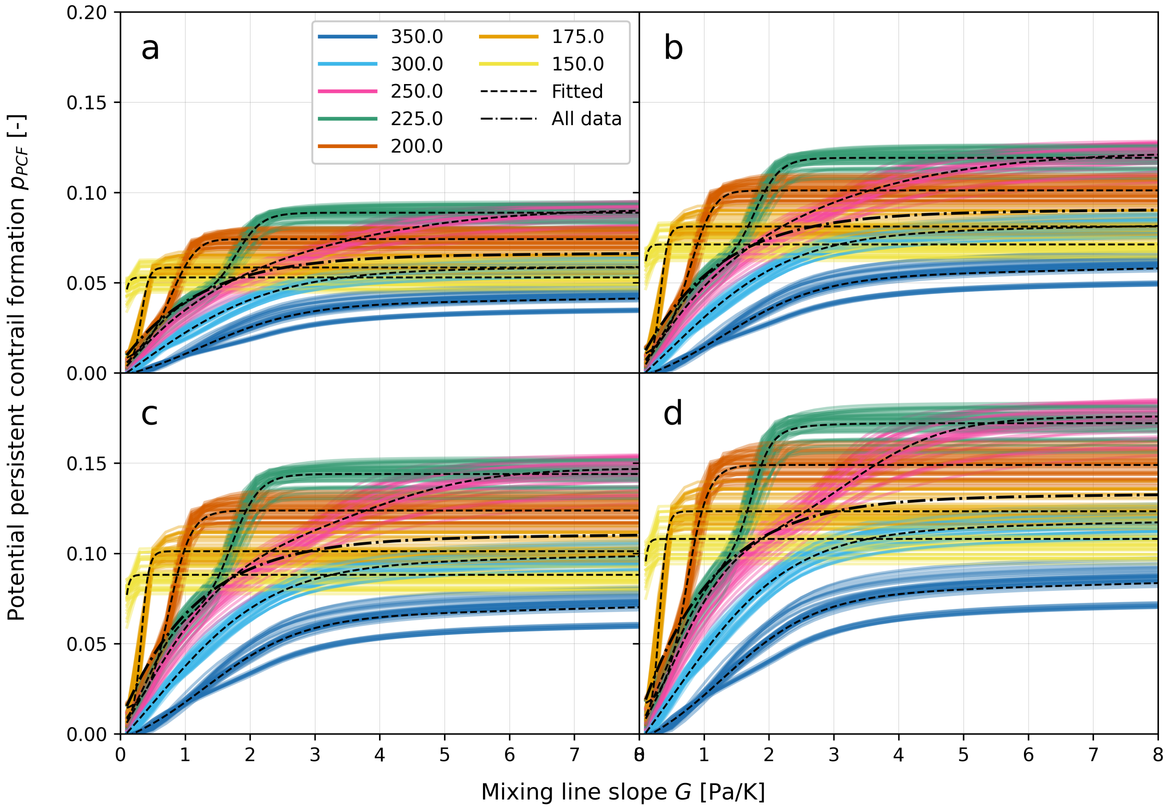

Figure S6. Potential persistent contrail formation p_{pcf} as a function of the mixing line slope G on a climatological timescale for pressure levels 350 to 150 hPa. We enhance the relative humidity by applying simple factors 1/RHi$_C$: **(a)** no correction, **(b)** RHi$_C$ = 98 %, **(c)** RHi$_C$ = 95 %, **(d)** RHi$_C$ = 90 %. Each coloured line corresponds to a single season within the 2010 decade. The dashed lines are the fitted responses using a modified logistic function, for each pressure level individually ("fitted") and for all pressure levels together ("all data").

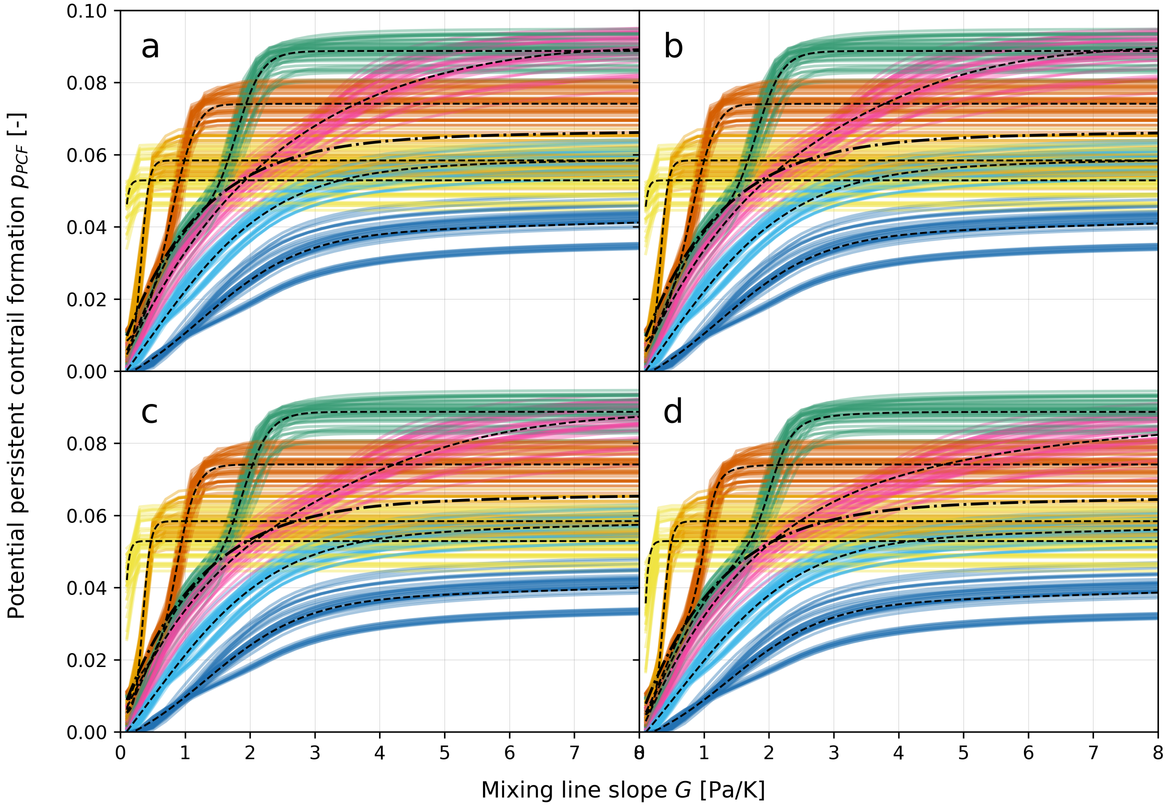

Figure S7. Potential persistent contrail formation p_{pcf} as a function of the mixing line slope G on a climatological timescale for pressure levels 350 to 150 hPa. We increase all ambient temperatures by **(a)** 0 K, **(b)** 0.1 K, **(c)** 0.5 K, **(d)** 1.0 K. Each coloured line corresponds to a single season within the 2010 decade. The dashed lines are the fitted responses using a modified logistic function, for each pressure level individually ("fitted") and for all pressure levels together ("all data"). There is very little discernible difference between the uncorrected and corrected results. Most notable is the slight reduction in p_{pcf} at 250 hPa at high G.