

Response to Vincent Meijer (Editor)

We would like to thank the Editor Vincent Meijer for their careful review. The remarks helped to substantially improve the clarity and language of the manuscript. Below is our response to the comments on a point-by-point basis. The following convention for text fonts is used:

- Review comments in black color
- Our answers in blue color
- *Pieces of text taken from the revised manuscript in red color and in italic font*

Dear authors and reviewers,

Firstly, I would like to thank the authors for this very interesting manuscript, and the reviewers for dedicating time and effort to improve it. In addition to the reviews by the referees, I have gone over the manuscript as well, and have found a couple of points that should be addressed before final publication. These mostly concern language, grammar, and/or typos. You can find a list of these line-by-line comments below. I do have one general point that I would like to discuss with you.

Let me start by saying that I very much agree with your statement near L121 of the paper: the contrail climate impact predictions utilizing the ensemble members cannot be verified at this point. However, I do think the paper could include a more extensive discussion on the possibility that the uncertainty in the predicted meteorological variables obtained by considering the spread of the ensemble members is not representative of the "true" deviation between the prediction and actual value. Platt et al. (2024) already accounted for this in the predictions of the RHi by the ERA5 ensemble. I think the paper could emphasise this more strongly as a limitation of the study and discuss how it can affect the results presented here. Perhaps you could compare the spread in predicted climate impact of contrails for individual flights that you find with those from Platt et al. (2024)?

Sincerely,

Vincent Meijer

Thank you for this important comment. We modified and emphasized the part of the conclusion that was discussing this matter. The new paragraph now reads: *A subsequent limitation is that our risk-aware decision-making is valid only if the actual climate benefit of a rerouting is reliably predicted. In this context, we define reliability as the capability of the probabilistic prediction to be representative of the actual uncertainty of the climate benefit. Using ensemble weather forecasting and variable model parameters is a standard practice to estimate uncertainties, but extensive comparisons between models and observations are needed before this method can be fully validated. Such comparisons can be done using for example rank histograms,*

that are commonly used to assess the reliability of ensemble forecasting systems (Bröcker and Ben Bouallègue, 2020). We strongly advocate for additional research in evaluating and verifying CoCiP and similar models against observations, before they are used for operational contrail avoidance. Until then, a first step would be to assess whether the climate benefit estimated using reanalysed meteorological data falls within the estimated variability from ensemble weather forecasts, which will be the subject of future work.

However, we do not think that an additional analysis is possible in this case. The main issue is that we do not know the actual climate benefit (and the actual uncertainty associated with it), thus comparisons at this stage could not help us to conclude on the issue. While we agree that an analysis of the spread of predicted climate benefits can indicate the level of self-agreement between ensemble members, we think that such an analysis would not add much to the paper, as the information on the spread is indirectly already contained in the risk value.

Line-by-line comments:

L6: "optimising trajectories" sentence very hard to read, could you perhaps reformulate it?

Reformulated as: *A first strategy consists in optimising trajectories around a best estimate of contrail radiative forcing, then using weather and parametric uncertainties to estimate the risk. In that case, 55% of the reroutings have a higher-than-5% risk of unintentionally damaging the climate compared to a standard risk-unaware avoidance strategy.*

L30: Smith et al. was published in 2026

Corrected.

L46: Technically, only the aCCFs and CoCiP are capable of predicting the contrail's impact on the Earth's energy balance directly: the other models mentioned would still require a separate radiative transfer model. I leave it up to you to decide on whether it is worth pointing this out.

Indeed, thanks for spotting the mistake. It's corrected as: *Different models have been developed to predict the evolution of potentially formed contrails (Fritz et al., 2020; Jafarimoghaddam and Soler, 2025), but not all also provide the forcing of such contrails (Yin et al., 2023).*

L64: "minimise" → "minimises"

Corrected.

L86: "in consequence". It is not clear to me whether the authors want to convey that they call this strategy the "risk-unaware" one because of the reasons stated (e.g. "as a consequence") or whether they want to convey that they will refer to this particular strategy as the "risk-unaware" one in the remainder of the manuscript.

Reformulated with "as a consequence"

L92: "Else" would replace this with "If the risk is above the threshold" to be extra clear.

Corrected.

L94: "mostly of" I would leave this out.

Corrected.

L98: ensemble forecasts are not exclusively generated by perturbations in the initial conditions, but also by perturbing the model physics and possibly boundary conditions. The IFS ensemble system has been using perturbed model physics for several decades:

<https://www.ecmwf.int/en/newsletter/181/earth-system-science/improving-physical-consistency-ensemble-forecasts-using-spp>

Thanks for spotting this mistake. The sentence now reads: [...] *ensemble-based prediction system, which consists of an ensemble of forecasts generated by perturbing initial conditions and model parameters.*

L110: "maximum" → "maximised".

Corrected.

L162: "the ensemble prediction system"

Corrected.

L173: the authors may be interested in citing the final version of the Hildebrandt et al. paper, which was recently published.

Corrected.

L179: "is not" → "it is not"

Corrected.

L180: I think the motivation for not re-deriving a humidity correction for the IFS ensemble system and using one for ERA5 is not the strongest. Is there no data /literature available to support the idea that the mismatch between ERA5 and observations is similar to that of IFS and observations?

We rewrote the sentence as: *Although the correction was derived for the reanalysis data, it is not re-tuned for the forecast data because the underlying parameterisation of upper cloud physics is the same between the two models, and the resolution of the forecast we use is the same as that of the reanalysis.*

We agree though that operational contrail avoidance would require constant monitoring of the forecast data against reference data (such as radiosondes or aircraft in situ observations).

L207: "contrarily to" → "in contrast to".

Corrected.

L293: "while changing its cruise altitude once as it gets lighter"

Corrected.

L294: "using from" → "using"

Corrected.

Figure 3: Figure titles should be corrected as they state "flightplans" instead of "flight plans". it would be helpful to state the altitude/pressure level at which the wind fields are shown.

Corrected. We chose not to indicate the altitude on the plots because it is selected dynamically, being set to the altitude of the closest waypoint of the trajectory for each cell.

L298: "flying below" → "flying below it"

Corrected.

L302: "flightime" → "flight time"

Corrected.

L311: "vertically on" → "vertically across"

Corrected.

L314: "optimum" → "optimal".

Corrected.

L350: "Contrarily" → "In contrast to"

Corrected.

L368: "therefore of 0%" → "therefore 0%"

Corrected.

L368: "flown" should this not be "flies" ? or "had flown"?

Corrected for "had flown".

L371: "risk of damaging" → "risk of damage"

Corrected.

L402: "ice supersaturated regions are globally well predicted by weather forecasts" I think this statement needs to be made more specific for it to not contradict findings on the limited skill of weather forecasts in predicting ice supersaturation when compared to in-situ observations (e.g. Gierens et al. 2020)

We adapted the text accordingly, which now reads: *This is because, although the pointwise prediction of ice supersaturated regions by weather forecasts is poor (e.g., Hofer et al., 2024), the existence of such regions is globally well predicted but their locations are often slightly shifted in space or time compared to their actual location (Dean et al., 2025).*

L405: "with a relatively low-level risk" → "with a relatively low level of risk".

Corrected.

L408: "values" → "value"

Corrected.

L414: "not too different to" → "not too different from"

Corrected.

L417: "allows to use" → "allows one to use"

Corrected.

L428: "in 55% of" → "of 55% in", "in 13% of" → "of 13% in"

Corrected.

L433: "role on" → "effect on"

Corrected.

L436-L438: "used to both increase..., as for..., while avoiding..." is hard to parse. Consider splitting into two sentences.

The new sentences now read: *In this section, we investigate how the risk-optimised strategy can increase the confidence that single reroutings will not unintentionally damage the climate, similarly to the risk-informed avoidance strategy. However, it does so while avoiding the large decrease in potential climate benefit observed when adopting a no-regret avoidance policy.*

L444: "Altitude descent" → "amount of descent"

Corrected.

L445: "weather forecasts variability" → "weather forecast variability".

Corrected.

L446-L447: "avoiding ... by the south/by the north" → "avoiding ... to the south/to the north".

Corrected.

L451-L452: "roughly increasing with increasing average" is unclear. Specify what the average refers to, e.g. "roughly increases with average climate benefit."

Corrected.

L458: "such a that route" → "such a route".

Corrected.

L463: "fuel consumptions" → "fuel consumption".

Corrected.

L465: "a significant higher additional fuel consumption" → "significantly higher additional fuel consumption"; "globally located" → "generally located".

Corrected.

L470-L471: "compared to that adopting the risk-informed avoidance strategy" → "compared with those of adopting the risk-informed avoidance strategy"; "risk-unaware" → "risk-unaware".

Corrected.

Figure 8: "optimisation ran" → "optimisation run" or "optimisation performed".

Corrected.

Figure 9: "mininum" → "minimum"

Corrected.

Figure 10: "weather forecasts variability" → "weather forecast variability".

Corrected.

L477-L478: The sentence beginning "This is shown by the higher number..." is repetitive and appears to contain a missing space in "strategywhen".

We could not spot the issue with this comment, if the mistake is still present please tell us so.

L479: "On the contrary" → "In contrast".

Corrected.

L501: "less flights" → "fewer flights".

Corrected.

L501-L503: "riskiest"; "risks of damaging the climate" → "risks of climate damage" or "the risk of damaging the climate".

Corrected.

L512: "uncertainties on the prediction" → "uncertainties in the prediction".

Corrected.

L514-L515: "which each estimate being very different one from another" → "with the estimates differing substantially from one another".

Corrected.

L516: "major role on" → "major effect on".

Corrected.

L520: "needed to fly these deviations" → "needed to fly these alternative routes" or "needed for these deviations".

Corrected.

L522: The manuscript otherwise uses British spelling, so "emphasizing" should probably be "emphasising".

Corrected.

L525: "Other models are also modelling" → "Other models are also used to model".

Corrected.

L540-L543: "dependences" → "dependencies".

Corrected.

L543: "These aCCFs had been used" → "These aCCFs have been used".

Corrected.

L547: "models able to estimate" → "models capable of estimating".

Corrected.

L548: "sources of uncertainties" → "sources of uncertainty".

Corrected.

L554-L555: "provide a crucial additional time" → "buy the aviation sector crucial additional time"; "decarbonation strategy" → "decarbonisation strategy".

Corrected.