Author's response to Referee #2 (gmd-2023-88)

We are grateful to referee #2 for the positive and constructive feedback. Below, we list all comments from the referee (in *italic*) and our point-by-point response.

Referee: *This manuscript presents the SolFinder tool, a multi-criteria decision making (MCDM) application designed to identify eco-efficient aircraft trajectories. It accomplishes this by solving a bi-objective optimization problem aimed at minimizing both climate impact and operating costs. The development of the MCDM tool, along with the results it yields, appears to be of interest to the readership of Geoscientific Model Development. Overall, the manuscript is clearly written and generally well-structured. I recommend only minor revisions to address the points listed below before accepting it for publication.*

1. *The terms "Pareto-optimal solutions" and "Pareto optimal solutions" are both accepted in the literature; however, consistency within your manuscript would enhance its presentation. Please choose one format and use it uniformly throughout the paper.*
   Author's response: Thank you for pointing this out, we adopted "Pareto-optimal solutions" consistently in the revised version of the manuscript.

2. *On line 156, the authors write, "If the VIKOR method identifies more than one recommended solution, i.e., the solutions p_v (v = 1,2,...,M) are equally recommended, the model selects the one with the minimum value of the objective function assigned to the lowest weight w_n", justify why it opts for the solution with the minimum value of the objective function corresponding to the lowest weight. Would it be more logical for the final selection to be based on the objective with the highest weight since it represents the most important criterion?*
   Author's response: We thank the referee for highlighting the need of clarifying this point. This criterion was chosen so that, in the following situation:
   - bi-objective optimization problem, aiming to minimize operating costs and climate impact
   - weight assigned to operating costs is higher than weight assigned to climate impact

   we find a way to translate in mathematical terms our definition of "eco-efficient" aircraft trajectories, i.e., a compromise solution between cost-optimal and climate-optimal solutions, such that the largest possible climate impact reduction is achieved, while keeping the operating costs nearly unchanged with respect to the cost-optimal solution. Using the VIKOR method, a subset of Pareto-optimal solutions is identified, according to the relative importance of the two optimization objectives. Therefore, if the highest weight is assigned to the objective function representing operating costs, the VIKOR method equally recommends a subset of Pareto-optimal solutions close to – or, possibly, including - the cost-optimal extreme point of the Pareto-front. Among this subset of equally recommended solutions, we choose the point leading to the largest climate impact reduction, i.e., "the minimum value of the objective function assigned to the lowest weight" (line 156). Therefore, the objective with the highest weight plays a dominant role in the selection of the subset of equally recommended solutions (VIKOR method), while the objective with the lowest weight becomes dominant in the selection of a single solution among this subset. We clarify this motivation in the revised version of the manuscript, with the support of Figure 2.

3. *Figure 2 could be enhanced for clarity and visual appeal. Firstly, it would be beneficial to use a single color and symbol to denote the Pareto-optimal solutions—currently, there is a mix of*

red dots and gray crosses, which can be confusing. Secondly, adopt a consistent color and symbol for the solutions recommended by VIKOR, which are presently indicated by both red dots and green crosses. Lastly, I suggest using a distinctly different color and symbol to highlight the final selected solution in Figure 2d. A blue star or another distinctive marker could be effective in clearly indicating the chosen solution to the audience.

Author's response: We agree with the suggestion of improving the readability of Figure 2. Below, we include the updated figure, using consistent indicators for the different solutions (Pareto-optimal solutions, solutions selected by VIKOR, final selected solution) across the four panels. Symbols and colours used for different categories of optimal solutions are now also consistent between Fig. 2 and Fig. 3.

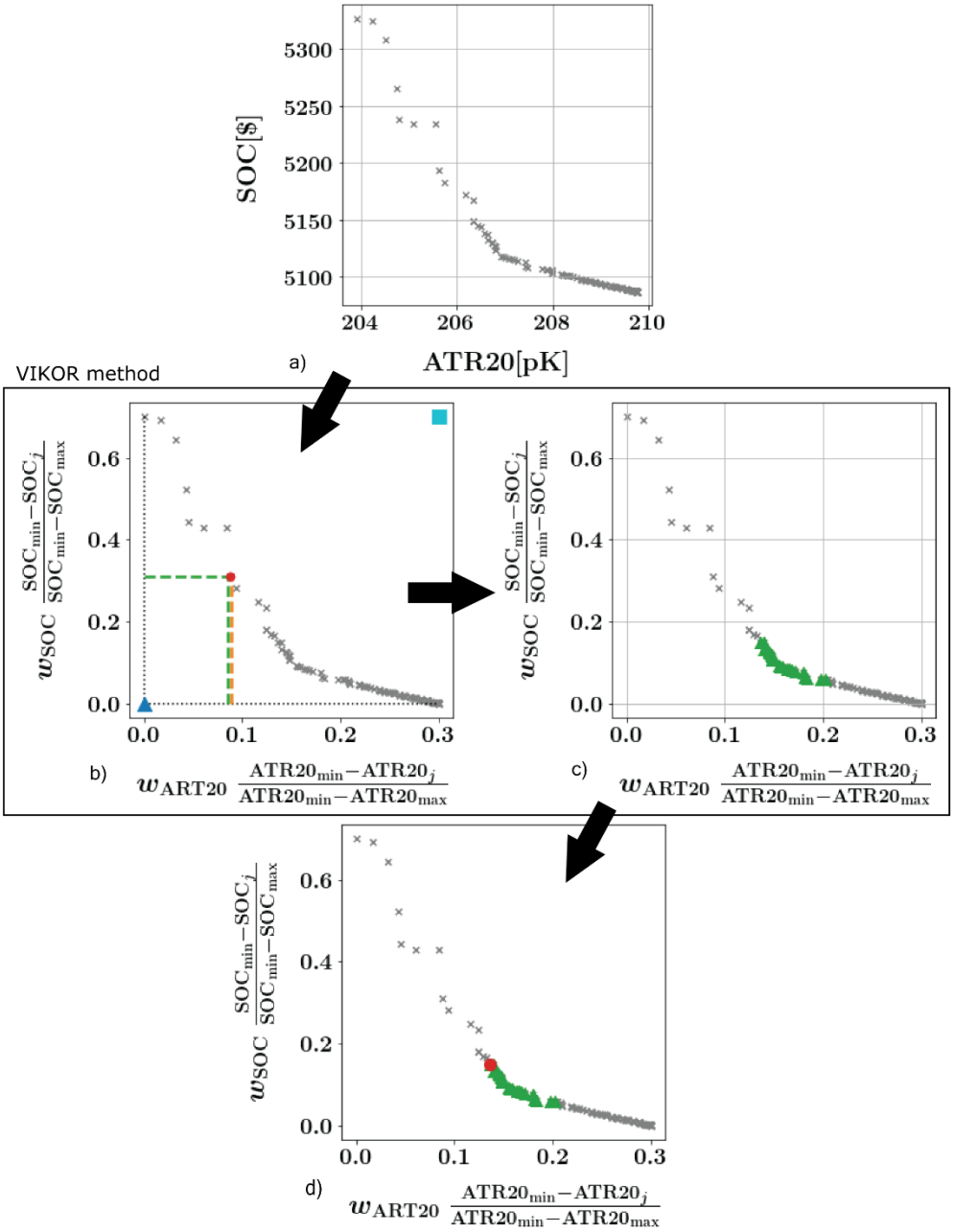

Figure 2 - Illustration of the steps performed by the eco-efficient decision-making strategy relying of VIKOR. The aircraft trajectories are optimized to minimize SOC and ATR20, resulting in a set of Pareto-optimal solutions (grey crosses). We set w_{SOC} = 0.7, w_{ATR20} = 0.3, γ = 0.5. Panel a) shows the Pareto-optimal solutions (grey crosses) collected before applying the decision-making strategy. Panel b) illustrates the application of the VIKOR method, thus the axes are scaled as in Fig. A1. This

step results in the identification of the subset of recommended solutions, represented by the green triangles in panel c). Panel d) shows the selected solution (red dot) among the subset of recommended solutions (green triangles).

4. *Ensure consistency in your manuscript by using either "decision-maker" or "decision maker" throughout the paper.*
   Author's response: Thank you for highlighting this inconsistency. In the revised manuscript, we only use the option "decision-maker".

5. *The manuscript mentions that decision-makers must configure the values for gamma (γ) and weights when using the VIKOR method implemented within SolFinder. While determining weights may be more intuitive for decision-makers, selecting an appropriate gamma (γ) value could pose a challenge for those less familiar with the subject of the MCDM or VIKOR method. I recommend that the authors include a brief, accessible explanation of how varying gamma (γ) values influence the outcomes. For example, elucidate the implications of a gamma (γ) value near 1 versus one closer to 0, and clearly state the default gamma value used in your program, such as 0.5, if applicable. This explanation would benefit both the paper and the SolFinder tool itself, leveraging insights from your good sensitivity analyses.*
   Author's response: The impact of using different values of the parameter gamma (γ) has been addressed in the revised version of the manuscript, by extending the text in the "Sensitivity of VIKOR parameterization" section (Sect. 2.3.1.). We use Figure 3 to explain how, as explained in Opricovic and Tzeng (2004):
   - with $\gamma < 0.5$, the veto principle is applied, i.e., if one of the objectives is heavily penalized by selecting a certain Pareto-optimal solution, then such solution will have a low likelihood of being recommended. Therefore, setting $\gamma = 0.25$ (as in Fig.s 3a, 3d, 3g, 3j) leads to excluding elements located in the external sections of the Pareto-front, because of their distance to the opposite extreme of the Pareto front.
   - with γ larger than 0.5, the priority is given to achieving the greatest overall benefit, accepting the possibility of large penalties for one of the objectives. As a result, the set of recommended solutions (green triangles in Fig.3) can include the solution minimising the objective with the highest relative weight. For example, when $w_{SOC}= 0.8$ and $\gamma = 0.75$, the solution with minimum SOC is included in the set of Pareto-optimal solutions (Fig. 3l).
   - with $\gamma = 0.5$, the same relative importance is assigned to avoiding large penalties in one of the objectives, and to achieving the greatest overall benefit. This is the default value in our experiments, and all results presented in Section 3.2 were obtained setting $\gamma = 0.5$.

   This revised text aims at clarifying what the user should expect when changing the value of the group utility weight γ. In this passage, we also added references to the definition of γ in Sect. 2.3, and to the formula included in Appendix A.

References:

- Opricovic, S. and Tzeng, G.-H.: Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS, European Journal of Operational Research, 156, 445–455, https://doi.org/10.1016/S0377-2217(03)00020-1, 2004