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EDITORIAL

Reviews and responses for

Fast contrail estimation with OpenSky data

Authors: Junzi Sun and Esther Roosenbrand

Reviewers: Benoit Figuet, Thomas Dubot, Manuel Waltert

Editor: Xavier Olive

Original paper

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1. Review - round 1

We would like to thank the reviewers for their comments. The manuscript has been updated, and our responses are list below together with the comments and questions.

1.1 Reviewer 1

General comments:

I believe this work holds significant value, not only for estimating contrails but also for anyone integrating flight trajectory data with weather data. The primary contribution of this research seems to lie in the development of the fastmeteo library rather than solely its application to contrail estimation. However, the title and abstract only focus on contrail estimation. In my opinion, highlighting the introduction of the fastmeteo library within the abstract and title (not just in the conclusion) would be more appropriate. In Section 2.1 discussing weather data, the article lacks information on the time resolution. For a layperson, it would be beneficial to include a brief explanation of how temperature and relative humidity data are obtained, especially if it involves aviation data. I would also suggest referencing the ERA5 documentation.

Section3: I really like the short overview and the code snippet. It would be helpful to include the content of "flight_new" dataframe.

Section 4: It should be reviewed by a "meteorologist" as I don't have the necessary knowledge Figures: Make sure that the caption punctuation is consistent, I would also extend some of them to be self-explanatory.

- Figure 2: What does the blue area of the right plot represent?

- Figure 4: the description is incomplete.

- Figure 5: I imagine that the color is linked to the number of observations but having a color scale would give me more confidence.

The article is lacking from a discussion section. Questions regarding the accuracy of weather data, its potential impact on contrail estimation, and scenarios where the tool might perform sub-optimally should be explored. It might go beyond the scope of this paper but I would be interested to see how sensitive is the contrail estimation with respect to the weather data.

Grammar:

Use of contraction on line 176.

FastMeteo os fastmeteo?

1.2 Reviewer 2

This paper demonstrates a rapid method for identifying segments of flight trajectories where persistent contrails may have formed, based on contrail formation models. As the trajectory data are sourced from the OpenSky Network, the focus is put on the introduction of a new library called "fastmeteo." This library has been developed to efficiently retrieve meteorological data and subsequently facilitate efficient data interpolation.

The code associated with this paper is outstanding. The fastmeteo library proves to be invaluable for quickly acquiring all the necessary information for the contrail use case, and it is likely to be equally beneficial for other ATM (Air Traffic Management) and environmental applications. The accompanying notebooks, which are linked to the contrail use case, clearly demonstrate how this new library can be readily integrated with other well-known libraries such as Traffic and openap, which are already familiar to the OpenSky Network community. The paper is well-written and clear, but I would like to suggest two main areas for improvement.

Firstly, with regard to the fastmeteo tool (Section 3), while you demonstrate its ease of use, it would be beneficial to provide more explicit explanations for the exceptional results achieved in the benchmarks. Did the results stem from local caching (Section 3)? Or were they due to the vectorized interpolation capabilities, as indicated in the conclusion?

Secondly, when describing your contrail formation model, it would be helpful to clarify novelties introduced in this study. Did you employ standard models, previously developed models, or introduce specific modifications? In particular, for Equation (4), please provide a reference or offer an explanation for its selection.

Additionally, I recommend considering the following minor corrections and improvements:

Line 16: speed -> groundspeed
Line 27: important
Line 28: at a given flight altitude
Line 72: In the contrail use case,… (clarify that levels exclusion is only for this use case)
Line 85: Machine Learning?
Line 92: an essential part or a prerequisite?
Line 102: two lines
Line 150 (L. 154): FastMeteo versus fastmeteo
Line 162: estimated persistent contrails
Line 172: in Table 2, please specify in the title that the data pertain to a very large geographic zone.

1.3 Reviewer 3

In their paper, the authors present a Python method called fastmeteo, which can be used to download weather data for aircraft trajectories in an computationally efficient manner. Subsequently,

fastmeteo is applied by the authors in a practical example on the topic of contrail estimation.

In particular, fastmeteo is very innovative and represents an valuable contribution to science. Thanks to inputs from subject matter experts in the field of meteorology, I came across a few inconsistencies in Section 4 which, in my view, require a major revision. I also found a few minor issues (mainly typos) which I categorized as minor.

Major:

Equation 2: Why do you employ the Goff-Gratch Equation? It is based on old data and only proven to be valid for temperatures above -50°C. There are more accurate formulas based on more recent research, see e.g., Murphy and Koop (2004): https://rmets.onlinelibrary.wiley.com/doi/abs/10.1256/Qj.04.94

The corresponding code, figures, and repository are also updated to reflect these changes.

Line 140: The statement "Unlike water vapor supersaturation, which often results in immediate condensation…" is not true. Without condensation nuclei present, the environment can also be supersaturated with respect to water (e.g., Köhler Theory).

Line 140: At temperatures below -38°C homogenous freezing is likely to occur and thus supersaturation is unlikely.

Line 143, Equation (4): Why do you use this equation. Where does it come from?

Figure 2 (diagram on the right): Why do you keep the blue area?

Figure 2 (diagram on the left): The label 'ice super saturation' is a bit misleading. All of the box above the 'over ice' line is supersaturated with respect to ice, the blue area is just where the air is supersaturated with respect to ice, but subsaturated with respect to water.

Minor:

I suggest using a consistent way of writing "fastmeteo" throughout the entire paper.

Line 16: I'd be more specific on the type of speed presented/contained in ADS-B messages.

Line 27: Typo: "Important" should be "important"

Line 80/81: Acronym ARCO has already been introduced and must not be written out again.

Line 96: Typo "We employs…"

Line 97: Period missing at the end of the sentence.

Line 97: Typo "…performance is further improved." (besides, this sentence repeats the statement of the sentence before.

Caption of Figure 1: I'd mention that the figure refers to fastmeteo.

Line 102: Typo "… it only takes two lines of code..."

Is there a way to add a caption to software code? This way you could refer in your text (e.g. in Line 105) to the corresponding code snippet.

Figure 2: The label for the red lines is missing

Section 5.1: If you label the subfigures in Figure 3 (e.g. with (a), (b), etc.), you could directly refer to these subfigures in the text of Section 5.1

Line 158: (At first glance) It is not clear to which figure you are referring to. Besides, I'd suggest to add labels (e.g. (a), (b), etc.) to Figure 4 as well.

2. Response - round 1

> We would like to thank the reviewers for their comments. The manuscript has been updated, and our responses are list below together with the comments and questions.

2.1 Response to reviewer 1

General comments: I believe this work holds significant value, not only for estimating contrails but also for anyone integrating flight trajectory data with weather data. The primary contribution of this research seems to lie in the development of the fastmeteo library rather than solely its application to contrail estimation. However, the title and abstract only focus on contrail estimation. In my opinion, highlighting the introduction of the fastmeteo library within the abstract and title (not just in the conclusion) would be more appropriate. In Section 2.1 discussing weather data, the article lacks information on the time resolution. For a layperson, it would be beneficial to include a brief explanation of how temperature and relative humidity data are obtained, especially if it involves aviation data. I would also suggest referencing the ERA5 documentation.

> Time resolution of 1-hour is added now.

> reference to ECMWF5 is also added now.

Section3: I really like the short overview and the code snippet. It would be helpful to include the content of 'flight_new' dataframe.

> An example of a dataframe snippet is added now

Section 4: It should be reviewed by a "meteorologist" as I don't have the necessary knowledge Figures: Make sure that the caption punctuation is consistent, I would also extend some of them to be self-explanatory. - Figure 2: What does the blue area of the right plot represent?

> This blue area is removed for clarity.

- Figure 4: the description is incomplete.

> The caption is updated.

- Figure 5: I imagine that the color is linked to the number of observations but having a color scale would give me more confidence.

> The color scale represents the density of the data points, this is clarified in the figure caption now.

The article is lacking from a discussion section. Questions regarding the accuracy of weather data, its potential impact on contrail estimation, and scenarios where the tool might perform sub-optimally should be explored. It might go beyond the scope of this paper but I would be interested to see how sensitive is the contrail estimation with respect to the weather data.

> A discussion is added to the paper, addressing these concerns from the reviewer.

Grammar:

Use of contraction on line 176.

FastMeteo os fastmeteo?

> Those are corrected in the update manuscript.

2.2 Response to reviewer 2

This paper demonstrates a rapid method for identifying segments of flight trajectories where persistent contrails may have formed, based on contrail formation models. As the trajectory data are sourced from the OpenSky Network, the focus is put on the introduction of a new library called "fastmeteo." This library has been developed to efficiently retrieve meteorological data and subsequently facilitate efficient data interpolation.

The code associated with this paper is outstanding. The fastmeteo library proves to be invaluable for quickly acquiring all the necessary information for the contrail use case, and it is likely to be equally beneficial for other ATM (Air Traffic Management) and environmental applications. The accompanying notebooks, which are linked to the contrail use case, clearly demonstrate how this new library can be readily integrated with other well-known libraries such as Traffic and openap, which are already familiar to the OpenSky Network community. The paper is well-written and clear, but I would like to suggest two main areas for improvement.

Firstly, with regard to the fastmeteo tool (Section 3), while you demonstrate its ease of use, it would be beneficial to provide more explicit explanations for the exceptional results achieved in the benchmarks. Did the results stem from local caching (Section 3)? Or were they due to the vectorized interpolation capabilities, as indicated in the conclusion?

> This a great point that we overlooked. both zarr indexing and vectorized computation using xarray are the causes of improved efficiency.

Secondly, when describing your contrail formation model, it would be helpful to clarify novelties introduced in this study. Did you employ standard models, previously developed models, or introduce specific modifications? In particular, for Equation (4), please provide a reference or offer an explanation for its selection.

> We used existing models to demonstrate the use case. This has been clarified in the paper now at the start of section 4.

Additionally, I recommend considering the following minor corrections and improvements:

Line 16: speed - groundspeed

Line 27: important

Line 28: at a given flight altitude

Line 72: In the contrail use case,… (clarify that levels exclusion is only for this use case)

Line 85: Machine Learning?

Line 92: an essential part or a prerequisite?

Line 102: two lines

Line 150 (L. 154): FastMeteo versus fastmeteo

Line 162: estimated persistent contrails

Line 172: in Table 2, please specify in the title that the data pertain to a very large geographic zone.

> All aboved issues are fixed in the updated manuscript.

2.3 Response to reviewer 3

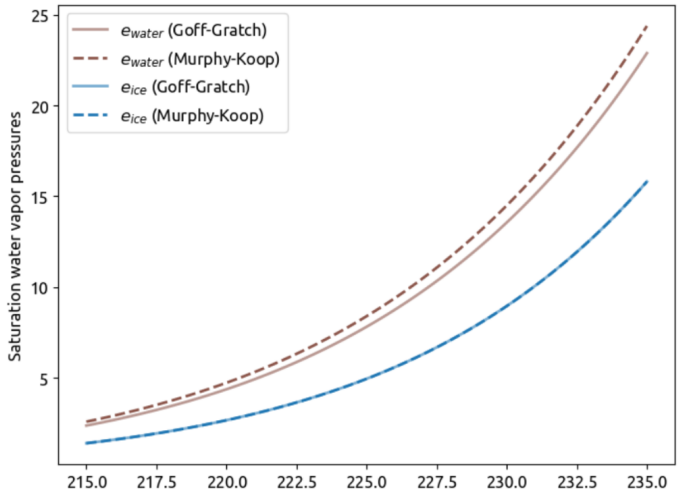
In their paper, the authors present a Python method called fastmeteo, which can be used to download weather data for aircraft trajectories in an computationally efficient manner. Subsequently,

fastmeteo is applied by the authors in a practical example on the topic of contrail estimation. In particular, fastmeteo is very innovative and represents an valuable contribution to science. Thanks to inputs from subject matter experts in the field of meteorology, I came across a few inconsistencies in Section 4 which, in my view, require a major revision. I also found a few minor issues (mainly typos) which I categorized as minor.

Major:

Equation 2: Why do you employ the Goff-Gratch Equation? It is based on old data and only proven to be valid for temperatures above -50°C. There are more accurate formulas based on more recent research, see e.g., Murphy and Koop (2004):
https://rmets.onlinelibrary.wiley.com/doi/abs/10.1256/Qj.04.94

> Thank for this recommendation, in the update manuscript, the Murphy-Koop model is used to replace the older Goff-Gratch model. For the reference, the following image shows the difference between these two model.



The corresponding code, figures, and repository are also updated to reflect these changes.

Line 140: The statement "Unlike water vapor supersaturation, which often results in immediate condensation…" is not true. Without condensation nuclei present, the environment can also be supersaturated with respect to water (e.g., Köhler Theory). Line 140: At temperatures below -38°C homogenous freezing is likely to occur and thus supersaturation is unlikely.

> Thanks for pointing this out. The original text is indeed not accurate, and we have corrected this.

Line 143, Equation (4): Why do you use this equation. Where does it come from?

> The derivation of the equation is added now.

Figure 2 (diagram on the right): Why do you keep the blue area?

Figure 2 (diagram on the left): The label 'ice super saturation' is a bit misleading. All of the box above the 'over ice' line is supersaturated with respect to ice, the blue area is just where the air is supersaturated with respect to ice, but subsaturated with respect to water.

> The figure 2 has been updated now.

Minor:

I suggest using a consistent way of writing “fastmeteo” throughout the entire paper.

> The terms has been homogenized, FastMeteo is used except in the python code snippet.

Line 16: I’d be more specific on the type of speed presented/contained in ADS-B messages.

> Ground speed is specifically mentioned now.

Line 27: Typo: “Important” should be “important”

Line 80/81: Acronym ARCO has already been introduced and must not be written out again.

Line 96: Typo “We employs…”

Line 97: Period missing at the end of the sentence.

Line 97: Typo “…performance is further improved.” (besides, this sentence repeats the statement of the sentence before. Caption of Figure 1: I’d mention that the figure refers to fastmeteo.

> Above errors are corrected in the updated manuscript.

Line 102: Typo “… it only takes two lines of code...” Is there a way to add a caption to software code? This way you could refer in your text (e.g. in Line 105) to the corresponding code snippet.

> We have added more explanations for the code snippet and also added captions for the code snippets.

Figure 2: The label for the red lines is missing

> the label of isobaric mixing line has been added now.

Section 5.1: If you label the subfigures in Figure 3 (e.g. with (a), (b), etc.), you could directly refer to these subfigures in the text of Section 5.1

Line 158: (At first glance) It is not clear to which figure you are referring to. Besides, I’d suggest to add labels (e.g. (a), (b), etc.) to Figure 4 as well.

> subfigure makes it hard to generate a consistent HTML version of the JOAS paper. Hence we chose to keep the the layout as is for now.