

General comments

In this study, Sporre et al. investigate fog trends at 12 Swedish airports, from the 1970s until 2022. They further analyse trends of meteorological variables and sulphur dioxide emissions and their potential effects on the observed fog trends. By testing for statistically significant differences of two temporal groups of observations (from 1970–1999 and from 2000–2022) and by using 2D-Histograms, Sporre et al. conclude that fog occurrence changes are primarily driven by changes in aerosol emissions, while changes in temperature and moisture availability have an impact on fog occurrence as well.

Overall the paper is well structured and is, for the most part, well written. The topic of analysing and attributing fog trends is highly relevant for the fog community. Nevertheless, the current conclusions rely mainly on qualitative observations (e.g. description of patterns in the line plots and the 2-D histograms). Quantitative backing is needed to make the findings robust. My major concerns are the following:

1. Insufficient quantitative results: Only the differences in fog occurrence between two temporal groups are reported with statistical significance. No explicit slopes, confidence intervals, or p-values are provided for the observed trends, even though a large part of the Result & Discussion section refers to these trends.
2. Inconsistent handling of missing data: Some stations have substantial gaps, while others don't, yet the two group comparison is applied to all sites.

I suggest the following steps to improve the quality of the manuscript:

1. Perform a full trend analysis (e.g. linear regression) for each station, or for those stations where the data amount is sufficient. Report slopes and p-values. If data gaps are too large consider calculating trends before and after the gap. Back up the statements on increasing / decreasing fog occurrences (and meteorological conditions) in the text with quantitative results.
2. Extend the quantitative approach to all variables: Apply the trend estimation and the comparison of the two groups to the meteorological parameters and aerosol emissions.
3. Focus on stations with significant changes.

In addition, a lot of the Results and Discussion section is based on results shown in the plots that are currently in the Appendix. Consider moving them to the result section as they seem to be an integral part of the analysis.

I would enjoy reading a revised version of the manuscript, after the general comments and specific comments below have been addressed. The specific comments are ordered by section and line numbers or figure numbers are given to make clear what the comment refers to.

Specific comments

Abstract

First paragraph: It would be further useful to read about the aim of the study in the Abstract, not just what was done.

Line 12-13: “For the third airport, warmer air temperatures, coupled to climate change, can explain the weak increase in the fog frequency.”: Without reading the full paper, this statement sounds a bit counter-intuitive, as temperature increases can lead to decreases in fog frequency due to related decreases in relative humidity (without additional humidity sources). It would be useful to provide additional context, saying that global warming leads to an increase in the occurrence of temperature ranges that are related to fog occurrence at that specific airport.

Introduction

Line 38-40: “Fogs form similarly to other clouds, but studies have found that fog can consist of unactivated aerosol particles that have grown enough through condensation to substantially reduce visibility but not to pass the critical diameter of activation”.: Can you specify the difference to haze here? Would fog only be present (or visibility be less 1000m) if enough aerosol particles are activated?

2 Method

Line 86 Section heading: I think it would be more fitting to call this section Data & Methods as you describe both the data and (multiple) methods in the section not just a single method

Line 92: “we required each airport to have at least 40 years of visibility data with a substantial amount of data from both the early and late time span of the investigation.”: what does “substantial amount” mean? Have you defined a threshold, that a specific fraction in both time groups needs to be available?

Line 107: missing data from airports: I was wondering if you also checked other data sources concerning the airport observations? E.g. METAR observations can be downloaded from a site by the Iowa State University:

https://mesonet.agron.iastate.edu/request/download.phtml?network=SE__ASOS

I think the paper and your analysis would greatly benefit from a trend quantification based on (mostly) uninterrupted data.

Additionally, if known, can you state the reason for the missing data?

Line 118: “substantial amount”.: Can you put a number to “substantial”? What data amount (e.g. in % or number of years...) do you require before and after 1995?

Line 123: “a linear trend could not be validated from observations.”.: What exactly do you mean by this? Was it not significant? If so, please provide the statistics of the trend analysis to the paper (or in the appendix), as this is your justification for your approach with the two groups.

Line 135-136: “Annual means were used in order to reduce the effects of serial correlation in the underlying time series.”.: I don’t understand what you are talking about here. On what exactly should the series correlation (I guess you mean autocorrelation?) should have an effect? On the trends? Can you specify on which step in your analysis the

autocorrelation would impact if you would use e.g. monthly means, which is frequently done in trend analysis?

Line 136-137: "Model validation confirmed that the assumptions of independent errors and normality were satisfied.": About which model are you talking here? Please specify.

Results and Discussion

Figure A1 and A5:

- Why don't you combine figure A1 and A5 into one figure with two subplots? Then it would be possible to directly compare advection and radiation fog trends and occurrence at both airports.
- In addition, add a description in both captions of A1 and A5 on what the subplots (a-c) are showing

Figure 2: Currently it is quite hard to understand how these plots are generated, can you explain the plots a bit more thorough in the text or the caption? As I understand it, one looks e.g. at the hourly RH values and then counts for how many hours fog occurs in that bin under these conditions? So these plots show, under which meteorological and temporal conditions fog occurs how often? Also maybe consider calling it a 2-D histogram or a heatmap.

Figure 2 "fog hours per year": be careful that subplot g is showing the number of fog events.

Line 170: Here you say that "fog at Göteborg-Landvetter Airport is particularly common during south westerly winds.": Does this align with your advection fog hypothesis, i.e. is this where moist air would come from?

Line 174-177: "... become common earlier in autumn and last longer into spring (Fig A2f)." What do you mean by "become earlier" here? Maybe that it is earlier (compared to the southern airports)?

Figure A2: Can you specify what relative distribution means? Relative to what?

Line 182-183: "... at the bottom to the northernmost at the top,...": specify a)-c) here?

Line 184: fog data over winter seasons: You could also consider analysing the trends separately for the seasons. By looking at annual means only, you might miss fog occurrence changes in seasons (e.g. a decrease in winter but an increase in spring could lead to no changes at all in the annual averages)

Line 191: "it is hard to do a trustworthy trend analysis": Again, I would suggest you do the trend analysis and report the slopes and p-values anyway. Thereby, you still report on the results with the data you have. You are also showing the results as line plots and talking about increasing and decreasing values. Therefore you should provide actual numbers, specifying by how much fog is increasing or decreasing, in your result section.

Line 192: “estimated changes in fog frequency”: Please specify if you are talking about the trend analysis or the comparison of the two groups.

Line 201: Changes in meteorological parameters: Please also specify the decrease by calculating the slopes of the linear regression and providing the p-values. As I see it, most of the stations actually have complete time series so there is no reason not to do it.

Line 205: “slightly larger temperature increase” → quantify

Figure 3: add description of subplots a)-c), these are currently not described in the captions

Line 206: Trend in wind speed: Also quantify the trends in wind speed and add the slope / p-value when you are talking about increases or decreases.

Line 210: Trend in pressure values: Can you add this plot to the review file or to the appendix? Instead of looking at the annual averages in pressure, you could see if there are more days with high pressure situations as these are connected specifically to radiation fog occurrences.

Line 212: “decrease in SO_4^{2-} aerosol concentrations”: Again please quantify this decrease!

Table 1: Maybe mark the rows with significant ($p < 0.05$ or 0.01) differences between the two groups as bold, so it is easier to see which stations report significant changes?

Line 239: For me it was unclear at first what “bin” refers to: Maybe include that the bin refers to the meteorological condition bin?

Line 242-248: This paragraph is quite hard to understand. Consider rewriting it explaining why fog frequencies would stay constant at rising temperatures but fog occurrence increases. Maybe you can quickly describe the difference between fog occurrence and frequency again? Wouldn't a possible explanation be the one you provided with the wind speed? → As temperature is increasing everywhere, but fog occurrence is not decreasing everywhere, temperature can not be solely responsible?

Line 256: “Advection fog events often last longer than radiation fog,”: Do you have statistics to back up this statement, e.g. by how much do advection fog events last longer? Or is there a plot that shows this?

Line 257: I see in figure 8 that the duration of fog events has been decreasing (on average) but how do you know which kind of fog events (radiation or advection) have decreased their duration?

Figure 8 caption description: As I understand it, figure 8 is the result of subtracting the 2-D histogram over one time period from the other, so that then the difference in fog occurrence across the bins of the meteorological variables are shown, correct? If so, I think it would help to include this description into the figure caption or in the text.

Figure A3: As in Figure A2, please specify what the relative distribution is. Also consider updating the caption to explain the plot more thoroughly as described in the previous comment.

Line 281: If the logic of the wind speed decrease is applied here then wouldn't an overall decrease of aerosols imply that fog should decrease everywhere? However it doesn't, so the fog trends are still the result of aerosols and meteorological drivers?

Line 285: Again please quantify the decrease in radiation versus advection fog to back up your statement.

Line 287 and following: Wouldn't warmer air temperatures (and sea temperatures) lead to a higher evaporation over the ocean and therefore more moisture availability potentially leading to an increase in advection fog? Also because more aerosols could be activated and moisture wouldn't be limited?

Line 283-285: How do you know that the increase in radiation fog is not due to an increase in synoptic conditions that favour radiation fog?

Line 298-300: But in addition, warmer daytime temperatures could heat the ground up more, making it harder for radiation fog to form as the air needs longer to cool down?

Line 317: Doesn't the radiation fog frequency for Mid-Sweden decrease as well after the year 2000? The increase at Uppsala is only present until 2005, then there is a decrease too.

Line 335: Why is more moisture supply not favourable for advection fog too?

Conclusions

Line 353: "indicating a stronger influence of advection fog..." influence on what? Or do you mean that it indicates a higher presence of advection fog?

Line 355 and following: As before, the decrease or increase in radiation versus advection fog should be backed up with numbers. Please provide:

- what are the trends in advection versus radiation fog at the airports
- is advection fog more common in general and therefore are the lower frequencies caused by the lower advection fog occurrence?

Technical comments

Line 8: "Our investigation indicate" → "s" missing → indicates

Line 87: "which is described in the first" → which is described first

Line 119-121: "One of the datasets used is a combination of data from two measurement stations. Measurements were taking place at the Rörvik measurement site from 1977 to

2001 and were then continued 3 km south of Rörvik at Råö measurement site.”: I think there should be a “:” between the two sentences instead of a “.” so it is clear that the second sentence provides the detail on the first sentence.

Line 122-123: “Southern Sweden have a better coverage by these stations compared...” → “Southern Sweden has better station coverage compared...”

Line 128: “Emission dataset”: To be consistent, can you also provide the link to the emission data here, as you did with the station measurements?

Line 143-144: “Figure 2 displays the average number of fog hours per year for different values of meteorological and temporal variables.”: Description is not clear, maybe rewrite it similar to the caption text?

Line 146: “fogs are” → fog is

Line 161: “ocean hinder” → ocean hinders

Line 191: “Fig 3c” → in brackets?

Line 240: Fig. S4 → I guess you mean Fig. A4?

Line 261: “Fog in southern Sweden shows a decrease for all wind directions” → Fog in southern Sweden decreases for all wind directions

Line 272: Sentence starting with “As the instruments may have had...” Is there a word missing? The sentence is unclear, particularly towards the end.

Line 279: “The results coupling...” is there a comma missing in this sentence? It is quite long and hard to understand.

Line 316: “This indicate” → “This indicates”

Line 317: “fog post the year 2000” → “fog past the year 2000”

Line 348: “We have investigated fog frequency” → the fog frequency