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Interactive comment on "Evaluating the use of Facebook's Prophet model v0.6 in forecasting concentrations of NO$_2$ at single sites across the UK and in response to the COVID-19 lockdown in Manchester, England" *by* David Topping et al.

Anonymous Referee #2

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Overall Comments: The analysis needs to be extended as the whole forecast workflow to understand the human impact on NO2 concentrations and forecasting seems to be procrustean to Facebook's Prophet model.

The work that needs to be done for this contribution is major, as relevant forecast diagnostics need to be included, regardless of whether they are implemented by Facebook or not.

The novelty of the paper is the workflow that involves resolving multiple data sources,

that is then used in forecasting and clustering. The workflow does not exist in the write-up (methodology section).

In addition, exploratory data analysis to drive the type of model used (referred to as vanilla without any mathematical description) needs to be provided. Authors need to provide motivations behind models they select and this is not possible without exploratory data analysis. Missing are general approaches such as partial autocorrelation analysis of time series, methods used for resolving different spatial scales of input data, the type of forecast method used (including the trend and seasonality model), and why Prophet model is chosen.

A new section on exploratory data analysis with concrete mathematical motivations to use a specific model is a must for this paper. Prophet model needs to be explained in the context of the problem.

Comments on Sections:

2.1 needs to be extended. In its current form this section is not informative about the model being used. The prophet model has many models, pre and post processing steps. Models used in the study need to be clearly discussed.

2.2 Similar problem as 2.1 This section contains an overly abridged description of the method followed by details regarding application. This section needs to be rewritten.

The methodology requires a workflow section that describes the overall workflow built for this study.

Table 1 shows differing spatial resolutions, authors need to clearly present how this disparity is resolved (interpolation, sampling, etc.)

2.4 THis section contains no information on data. If the only purpose of this section is state the changes to mobility patterns after March 12th, this can be done in the section on data sources.

Interactive comment

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The prophet model is a general additive model for time series, where seasonanlity, trend, and cyclicity are linearly superimposed. There is no motivation in the paper why such additive model will be appropriate for NO2 concentrations. It is customary to provide at least a partial autocorelation function plot of the signal in question and performing statistical tests on these components to understand whether an additive model would be appropriate to start with.

Specific Comments:

Line 2: Missing comma after In this study Line 12: "the nature of local traffic": artificial constructs do not possess natural qualities. If you mean historic patterns, please write so. Line 13: Why is HGV abbreviation in square brackets? Line 16: Overall missing comma Line 56-60 belongs in the introduction section. Line 62: "The internal cross-validation methods provided by Prophet are used to arrive at a set of performance metrics applied across all sites." This is not specific enough, you need a subsection under methodology for diagnostics and discuss why they are relevant. Line 63-64: 'this process includes fitting to historical data over a specified period", does this imply you are using an autoregressive forecasting method. If so, this does not imply novelty as these methods have been studied intensively for a long time. Line 65 - 74: These descriptions have nothing to do with the Prophet model but the problem definition. Please distinguish the method from the application.

Line 82-91: Here application is discussed, this section is not related to the method. EMEP model is an integral piece of this work, please describe the system being solved with this model here.

'Line 94: need to be carried over to notes or the appendix

Line 98: "meteorological data on wind speed, direction and temperature provided by the UK Met Office." Please elaborate which model, data product, whether it is reanaly-sis data. In addition, please introduce

Line 116: "this method captures between 8 % – 15 % of vehicles making a journey between two sensors,". Does this mean the traffic data captures up to 15% of actual traffic. If so the sampling bias, and portion of the traffic needs to be discussed in extenso.

Line 156-157: "The multi-modal behaviour of percentage deviation by site type may be indicative of local interventions not captured by the default change-points used during the fitting process." This seems to be a speculation rather than a result. This can be an important point to bring up in the discussions.

Line 157-158: "Specifically, Prophet is designed to detect change-points of the sampled trend in observations."

Line 158 - 160: "One can alter the weighting given to such changes. A manual analysis on an individual site level might identify significant changes in local activity that would be expected to change the seasonality in measured NO2 and thus define change-points that need to be captured during the fitting process." This is a use tip about Prophet, I don't think this relates to results.

Line 164: Vanilla prophet is not discussed methodologically. This must be expanded in the methodology section.

Line 169: Improvement in forecast from 18% to 10% deviation can be quite misleading. Authors need a transform bias correction scheme for the Yeo-Johnson transform to address this. Please see the seminal work of Beauchamp and Olson (1973) on pitfalls of using transformations. Secondly, a transformation is applied to data without being introduced in the methodology. There is no discussion of why this transformation is chosen over Box-Cox transform or a log transform.

Line 220: HYSPLIT model is introduced for the first time under results. This is a major part of the method yet not discussed in methodology.

Line 225: Ward's Method is introduced for the first time in results without discussion

under methodology

Line 227- 229: "Discrepancies between forecasts that incorporate traffic and measured values could arise from errors associated with a number of factors, but data on vehicle traffic type suggests this could also be due to an increase in the ratio of Heavy Goods Vehicles [HGVs]." This statement is not possible to make with current metrics and the level of exploratory analysis of variables. Bias residuals, in addition to very common forecast metrics such as MAPE and MASE are missing in the analysis. If NO2 concentrations have strong seasonality, then observing bimodal deviance (such Figure 1 is not surprising, that is just an indication that there are two regimes where model does significantly bad compared to others).

Figure 4: On average, the model consistently over-estimates measured values. This needs to be discussed.

References: Beauchamp, J. J., & Olson, J. S. (1973). Corrections for bias in regression estimates after logarithmic transformation. Ecology, 54(6), 1403-1407.

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-270, 2020.