

Interactive comment on “The Dynamical Impact of Rossby Wave Breaking upon UK PM10 Concentration” by C. P. Webber et al.

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Response to the minor comments made by Anonymous Referee 3

1. P2, L54-55: "The pressure dipole results from the meridional advection of upper level air masses with anomalous potential vorticity (PV) characteristics." I think that the link between upper-level PV and the pressure dipole is not immediately clear. A clarifying sentence might help.

A clarification section has been added prior to this sentence, it reads:

"A region characterised by anomalously low PV, i.e. cyclonic motion, is associated with upper tropospheric divergence and subsequent convergence in the lower troposphere. Such a pattern is associated with anomalously low MSLP at the surface. The opposite

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signal can be seen for anomalously high PV or anticyclonic motion."

2. Section 2.1: Please move the formulas to the place in the text where they are referred to. At the moment, for instance, formula (6) is appended at the end of the section, but discussed at the top of page 4.

Formulae (4) and (5) have been moved, to follow the text:

"resulting in CRWB/ACRWB occurring respectively".

We feel that formula (6) is presented most clearly in its current positioning.

3. P4, L41: At the three measurement sites, being classified by DEFRA as urban background sites, are 'justified' (motivated) by the fact that the majority of the UK's population live in urban areas. Further down (L44-48) it is discussed that the sites are influenced by 'urban' activities, and that, therefore the three stations are combined to remove local spikes. How does this fit together with the motivation? By the way: What is DEFRA?

P4 L41 has been altered to:

"The three sites used are all classified by the Department of Environment, Farming and Rural Affairs (DEFRA) as urban background sites, each representative of their urban environment, away from direct anthropogenic sources (DEFRA, 2014). "

It has been clarified on P4 L44 how the spikes removed are related to the influence of direct PM10 point sources on each urban background air quality monitoring station, which are placed to avoid direct influence from individual point sources (DEFRA, 2014).

4. P5, L53 and L61: "A daily mean [PM10] ([PM10]) exceedance has been defined in this study, when [PM10] exceeds the threshold of $29.72 \mu\text{g m}^{-3}$ ($\log_e[\text{PM10}] = 3.39$)" "The tri-site [PM10] is $19.72 \mu\text{g m}^{-3}$ or $\log_e[\text{PM10}] = 2.98$, resulting in an impact threshold of $29.72 \mu\text{g m}^{-3}$ or $\log_e[\text{PM10}] = 3.39$ ": Repetitive?! Further, why does this, in the

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second sentence, result in an impact value?

In the sentence beginning: "The tri-site" the dependent clause following "2.98," has been removed. The following sentence has been added:

"Therefore we use a threshold for daily mean [PM10] of $29.72 \mu\text{g m}^{-3}$ or $\ln[\text{PM10}]=3.39$ to define an exceedance. "

Furthermore $\log_e[\text{PM10}]$ is replaced by $\ln[\text{PM10}]$ throughout the whole text, following a suggestion from anonymous reviewer 1 (See review 7).

5. P5, L62-70: Here the time-lag issue is discussed. It is argued that a time lag between [PM10] and RWB makes sense. But, no time lag is used for negative BI and [PM10]. Finally, the whole paragraph starts with the finding that the best correlations result if no time lag is used between RWB and MSLP. The reader can easily get lost in these many different cases! A little remedy could be if the link between MSLP and RWB is not discussed. To me it sounds rather obvious that the best correlation occurs if no time lag is used. And, by the way, I don't see a need to motivate the RWB time lag by a corresponding MSLP time lag. In short: Simplify the paragraph a little!

Discussion of the temporal lag between RWB and MSLP has been removed. What remains is an explanation for the 1-day lag between positive BI values and UK [PM10] and the 0-day lag between negative BI values and UK [PM10].

The paragraph now reads:

"The concept of a temporal lag between RWB and UK [PM10] is explored during the analysis. The greatest UK [PM10] is found when using a one-day lag following $BI > 0 \text{ K km}^{-1}$. The lag accounted for the time taken for European PM10 to advect into the UK and for the UK to subsequently be exposed to a new air mass. In events where RWB was not diagnosed ($BI < 0 \text{ K km}^{-1}$), it was found that a 0-day lag provided the best relationships between RWB and [PM10]. Negative BI values are associated with westerlies entering the UK, providing the most efficient [PM10] removal processes.

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These removal processes reduce surface [PM10] on timescales of less than a day and hence there is a lag of 0 days between negative BI values and resultant UK [PM10]. Therefore in Sect. 3.1 and 3.2, when a day is not indicating RWB ($BI > 0 \text{ K km}^{-1}$), no temporal lag was applied."

5.1: To me it sounds rather obvious that the best correlation occurs if no time lag is used

In the case of high pressure it is seen that the greatest UK [PM10] is found using a one-day lag following $BI > 0 \text{ K km}^{-1}$. This temporal lag allows for the time taken to transport PM10 from mainland Europe into the UK.

6. Section 3: This section contains the main results from the study. All in all, the discussion is clear and the results are well supported by the data. However, while reading from subsection 3.1 to 3.2, to 3.3 and finally 3.5 I got a little lost. Many aspects of the link between [PM10] and RWB, positive and negative BI, CRWB and ACRWB, the exceedances of [PM10]... are discussed. I think it would be great to start the whole section 3 with a (rather short) introductory paragraph that, from the beginning, tells the reader here the journey will go to. In short: Give the reader some guidance what he can expect from this section and how the different subsections are connected.

An introductory paragraph has been added to Sect. 3, which will act to aid the reader through the results section of this study.

"Section 3 presents the main results from this study. Section 3.1 begins by analysing the relationship between BI and UK Midlands [PM10]. Section 3.2 presents regions where RWB occurrences result in significantly elevated UK [PM10]. This analysis is undertaken for four RWB subsets; Warm Anticyclonic, Cold Anticyclonic, Warm Cyclonic, and Cold Cyclonic RWB. Section 3.3 analyses the MSLP response to both ACRWB and CRWB. The most important result from this study is presented in Sect. 3.4 and refers to the probability that days on which RWB occurs, lead to hazardous PM10 threshold exceedances. A RWB subset that results in the greatest probability of exceeding a

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hazardous UK [PM10] threshold is examined in more detail in Sect. 3.5. The mechanism dictating the occurrence of Northeast Atlantic/ European CRWB is presented in Fig. 6 and discussed from Sect. 3.5 onwards."

7. **P6, L20:** move formula (7) and (8) to the place in the text where they are referred to.

We feel like the current placement of formula (7) and (8) present the clearest possible presentation.

8. **Figure 2 and corresponding text:** In panel b) and c) there are some data points at rather low BI values. I wonder whether these data points, with a considerable leverage, influence the overall fit of the least-square fit? How does the correlation change if these points are omitted? I am also not perfectly convinced that it is reasonable to look at BI> 0 points only (red points and curve fitting) and to deduce that, for instance in panel b), the BI>0 has no impact on [PM10]. Finally, it might be better to use for all four panels the same range for the x axes. This would allow the different locations (GP1-4) to more easily be compared.

A sensitivity analysis was undertaken, to analyse the impact of the outliers. Any BI values < 30 K km⁻¹ were masked out of this analysis and the correlation coefficients obtained from this analysis. This sensitivity analysis has been described within the text on P6L96:

"Fig. 2 b) and c) are influenced by very low BI values, which appear as outliers in the general distribution. It was shown that by removing BI values < -30 K km⁻¹, there was very little impact on the overall CC values obtained from Fig, 2 b) and c). In Fig. 2 b) and c) the Correlation coefficient increases from 0.42 to 0.43 and from 0.32 to 0.33 respectively, following the removal of the outliers."

The red points in all subplots in Fig. 2 provide a data subset that is independent from the blue dots. Therefore it is reasonable to analyse this dataset separately from the blue dots. If this step is taken a correlation coefficient of 0.04 exists between BI and

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UK [PM10] for $BI > 0 \text{ K km}^{-1}$ in Fig. 2b). Therefore in this analysis, the magnitude of $BI > 0 \text{ K km}^{-1}$ has very little, if any impact on UK [PM10].

The x-axis scales in Fig. 2 have been altered as to be consistent throughout all four subplots.

9. P7, L24-25: "the following longitudinal filter has been applied: $277.5^\circ\text{E} < \text{longitude} < 77^\circ\text{E}$ in order to focus on regions influential upon UK [PM10]." I do not clearly understand what you mean with longitudinal filter? Do you simply neglect all RWB events in this domain?

The sentence has been re-phrased to read:

"To focus on the regions that are shown to be influential to UK [PM10], a longitudinal mask has been applied so that only longitudes east of 277.5°E and west of 77°E are included in this analysis."

For clarification, only RWB events that have occurred within the selected domain have been analysed.

10. P7, L30-31: Incomplete sentence

This has been addressed to read:

"Figure 3 shows that warm and cold CRWB significantly raise UK [PM10], predominantly in the Northeast Atlantic/ European region and not in the Northwest Atlantic region."

11. P10, L33-35: Repetitive?! Is it the same 10-grid point criterion used before? If so, I would prefer this criterion is introduced only once in the text.

The sentence re-iterating the 10 grid point threshold has been removed. P10 L33-35

12. P12, L10: "[PM10]>[PM10] + $10 \mu\text{g m}^{-3}$ " Unclear!

The overbar has been added to the first term on the left hand side. This now reads:

"[PM10]> $\overline{[PM10]}$ + 10 $\mu\text{g m}^{-3}$ "

13. P12, L15: "The greatest probability of exceeding this studies hazardous [PM10] threshold was associated with a synoptic mechanism identified by an Omega Block (probability 0.383)" Complicated sentence! Please rephrase.

The sentence was rephrased to read: "In this study, the Omega Block mechanism resulted in the greatest probability of exceeding a hazardous [PM10] threshold."

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