

## ***Interactive comment on “The role of aerosol in altering North Atlantic atmospheric circulation in winter and air-quality feedbacks” by F. S. R. Pausata et al.***

**Anonymous Referee #1**

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This is an interesting paper. Through a set of coupled climate chemistry simulations the authors show the impact of future aerosol reductions on the NAO, the blocking frequency over Europe and the distribution of pollutants. They find that in some locations the reduction of aerosol emissions changes the circulation so as to aggravate local pollutant conditions.

While this is an interesting premise, the paper doesn't really convince me. Each aspect of the paper is reasonably presented: the impact of aerosols on the NAO, the impact of aerosols on the coherence index over the Atlantic basin, the impact of aerosols on changes in blocking and on changes in the local pollutant distribution over Europe.

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However, the connection between these various aspects of the paper is not convincingly demonstrated. Unless the authors can clearly present a convincing argument how these various aspects of the paper are connected I cannot recommend publication.

Major Comments.

1) The paper shows that shape of the aerosol distribution changes over Europe depending on the aerosol forcing. In some regions the skewness of the distribution is increased, in others it decreases. The paper goes on to attribute these differences to changes in blocking. I really do not see any convincing demonstration that this is indeed the case. While changes in blocking may impact aerosol distributions there could be a multitude of reasons for the change in shape of the simulated aerosol distributions. This change may or may not be directly related to changes in blocking. For example changes in the mean precipitation, changes in the structure of the boundary layer etc may be responsible for the change in the skewness of the aerosol distribution. For this paper to work the authors need to show the changes in the aerosol distribution can be attributed to changes in blocking. (Indeed it would appear that the situation is slightly more complicated than can be explained by changes in blocking alone. Although it is somewhat difficult to say, it appears the changes in the aerosol distributions do not directly correlate with the changes in the blocking. For example, the 2030AER simulation appears to have less change in blocking than the 2000MFR simulation in the Western Mediterranean region, but approximately the same change in skewness.)

2) The paper suggests that changes in blocking over Europe can be attributed to changes in the NAO. If I understand the paper correctly, the scientific literature suggests that changes in high latitude blocking are associated with changes in the NAO, but it is not clear to me how changes in lower latitude blocking over Europe relate to the NAO. The authors need to conclusively show that the changes in the NAO are associated with the changes in lower latitude blocking over Europe.

3) The relationship between the coherence index, the NAO and blocking over Europe is

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not clear to me. Are the authors claiming that shifts in the coherence index are related to shifts in the NAO? Can the authors prove this? How do shifts in the coherence index relate to blocking? These links need to be shown statistically and conclusively in the paper.

4) The authors seem to want to make the broad claim that changes in the aerosol emissions are primarily causing shifts in the NAO index and in the coherence index. The case for this seems to me to be somewhat shaky. If the authors are not making this claim they need to clearly state the features for which they believe the role of aerosol forcing is most dominant (versus the forcing due to GHGs), and for which features they can not make a clear determination.

(i) If I understand the paper correctly, neither changes in GHG or in aerosols alone can be shown to statistically result in the shift in the NAO. It is only the combination of both these forcings that results in the shift in the NAO. Therefore, it is difficult to attribute difference in the NAO predominantly to differences to aerosol forcing.

(ii) Both the 2030GHG and the 2030AER simulations stretch the coherence index towards Southern Europe. Although the 2030AER distribution “looks” somewhat more like the 2030MFR distribution (thus suggesting the final distribution is forced more by the aerosols than GHGs) it is somewhat unclear that this is really statistically significant.

5) The authors should show the difference in the radiative forcing for both aerosols and greenhouse gases between 2030 and 2000.

6) Is Figure 4 based on monthly mean values (as implied in the figure caption)? This figure really should be based on daily maximum values. Air pollution regulations are based on daily values, as the authors are aware. If they based their statistics on monthly values this needs to be clearly stated and rationalized.

Minor Comments. -P22481, I18-19 extension → extent Is this a reduction to the maxi-

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mum feasible extent of aerosol emissions everywhere or just over Europe?

-P22481, I22-23: While in the first sentence here the authors state aerosol emissions change between simulations in the 2nd sentence they state that the emission scenarios used to force the model are constant. Please clarify.

-P22482-22483: Please state whether the model setup includes a simulation of the indirect effects?

-P22484: Are these simulations in climate equilibrium?

-P22484, I7-12: It might be clearer here if you listed all experiments together instead of omitting the control experiment.

-P22484: I find the names of the experiments somewhat confusing. 2030MFR refers to the simulation where both GHG and aerosol were set to 2030 levels, while 2030AER also uses 2030 MFR aerosols, but 2000 GHGs. Maybe 2030MFR should be referred to simply as 2030?

-Figure 1 and discussion on the coherence maps. The statistical significance of these changes in the coherence is unclear to me. The authors need to make clear the changes that are significant.

-I find Figure 2 somewhat misleading. The control experiment is 60 years, the others 30 years. While this makes plotting easier it makes it more difficult to compare the distributions. The authors should probably normalize these plots to the same number of years or make them frequency plots to facilitate better comparisons.

-P22487, I16-18 This statement is really not accurate as stated. A more accurate statement would be “Neither the 2030GHG or the 2030AER play a statistically significant role in changing the NAO state. . . .”. If I understand the authors here neither the 2030GHG or the 2030AER simulations are statistically different than the control simulation.

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-P22487, I20-21. This statement is only technically accurate: "In conclusion, whereas both GHG and aerosol changes have similar impacts on the NAOI frequency shift. . ." They are both similar because neither of them is statistically significant.

-Figure 3. Blocking frequency is given in percent, but percent of what? Percent of time during the winter months a block occurs at any gridpoint?

-Table 2 states all changes are significant at the 95% level. Is this change from the control? (The text implies not, but the figure caption should be clarified)

-Figure 3. Can you mark the regions evaluated in Table 2 in Figure 3?

-P22490, I4. "Extreme" doesn't really belong here. Skewness implies positive values are more likely than negative values.

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