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Atmospheric Chemistry and Physics Discussions

Interactive comment on "North Atlantic Oscillation and tropospheric ozone variability in Europe: model analysis and measurements intercomparison" *by* F. S. R. Pausata et al.

Anonymous Referee #2

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Overall Comments

The paper ties surface ozone variability over Europe to fluctuations in the NAO, nicely connecting air quality with a leading atmospheric mode of variability. This finding raises the possibility of predictive power on a 3-6 week time scale. If future shifts in this atmospheric mode can be predicted, then the air quality implications, at least in a seasonal mean sense, follow. It raises an important point that long-term ozone trends need to be interpreted in light of considerable variability, such as that driven by the NAO. The paper should be publishable after addressing the points below, which suggest additional work to set appropriate context as well as to clarify some of the methods and

intepretations.

General Comments

Throughout the text, there are attributions of enhanced or depleted surface O3 during NAO phases to specific transport pathways. The basis for these attributions is not always obvious. For example, why is the enhanced wintertime surface ozone during positive NAO phases necessarily advected from the marine lower troposphere as opposed to subsiding from aloft around the anticyclone?

How do the findings here differ from those in Hess and Lamarque (2007, JGR, doi:10.1029/2006JD007557) who examined contributions of regional emissions and stratospheric ozone using sensitivity simulations and tracers in their model (similar to the approach recommended by the authors on p 3149)? A clear description of the advances made here is needed.

The paper should be strengthened by including more evaluation of the model with observations (e.g., in Figure 2). P3137 mentions an ozone bias in some regions. Is this year-round? It would be better to show how the model compares with the observations at the sites in Table 1. Statistics should be included to support statements like, "model captures the observed range of interannual o3 variability" and those on top of P3138, on P3140 (seasonal and spatial variability in surface and tropospheric column ozone), etc.

Specific Comments

The abstract could be clearer in places. Some questions: Over what region is surface ozone examined (lines 6-7)? Is the NAO much weaker in fall and thus does not have much impact on surface ozone in this season? What kind of lead time is possible for using the SLP PC1 to predict surface ozone? What period is the 1990s increase relative to (1980s?) or is there an increase over the 1990s? How does the NAO affect this (e.g., a shift from negative to positive over the period) ?

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P3133 L4-5 Some early papers could be included – Wild et al. 2001, Yienger et al., 2000, both in JGR.

P3133 L10-17 The point here is not clear as to whether the authors are suggesting that STT is important for the local-to-regional elevated ozone (e.g., specific events) or baseline levels. In general, it could be clearer that the majority of O3 production, at least in summer, is produced from local-to-regional precursor emissions.

P3134 L5 The intercontinental transport is occurring in the westerly flow, correct? L18-19. Are the droughts and smog associated with positive or negative NAO phases? Elsewhere, please specify sign of NAO and associated impact wherever possible. L20-24. Is this the same as the northern annular mode definition? If so, there is a lot of literature on these modes that should be cited for context here.

P3136 L8-10 Hess and Lamarque, JGR, 2007 study 1980-2001 so there is some precedent for analysis of AO, O3 variability over multiple decades.

P3136 L13-16. Stronger support for stratospheric influence could be made by using a stratospheric tracer in the model, a commonly used approach [e.g., Wang et al. JGR 1998, doi:10.1029/98JD00156. In the absence of such a tracer, water vapor or CO distributions should provide additional evidence.

P3137 L12-15. Which meteorological variables are nudged? How is stratospheric ozone simulated in the model?

P3137 L20. It would help to briefly summarize the emissions used. For example, is biomass burning varying inter-annually in these simulations? Do fires vary with NAO (e.g., drier regions) and thus affect O3? Same for natural emissions (lightning, biogenic) –is NAO-driven variability in these included?

P3139. Clarify in text that Figure 1 is the EOF of the SLP.

P3143 L3-5. “More storms in the Mediterranean sea”: from observations or model? L11-16 is out of place in a “winter” section. “Spring” section discussion could be sharp-

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ened to clarify the main point, I found the discussion here confusing.

P3145 The case for stratospheric influence is not particularly compelling in Figure 7 and 8 and could perhaps be strengthened by considering the three-dimensional nature of intrusions (see for example Langford et al., 2012, JGR, doi:10.1029/2011JD016766 who also show that STT events can impact surface air on a short-term basis)

P3146. The discussion of long-term trends being associated with NAO phasing is confusing. Has there been a trend in NAO phasing or is variability driven by NAO mistakenly being interpreted as a long-term trend?

P3147 Can a new pair of sites be proposed to better capture the centers of action for NAO in summer or is it always necessary to do the full PC analysis?

P3148 The model and observations look like they are trending different directions in MAM in Figure 9. JJA does not look well captured either.

Figure 2. Do observations support the simulated higher ozone levels over the Atlantic than over the continents?

It would help to place modeled and observed correlations in Figures 4 and 5 together for easier comparison, perhaps by superimposing the circles in Figure 4 on the modeled correlations.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 3131, 2012.