# Response to comments of Referee 2

## General comments:

It is a little bit bothering me when you use the term “age” in the manuscript. In my understanding, aerosol’s degree of aging should be referred to not only the lifetime in the atmosphere but also how many reactions they involved (both physical and chemical). Or do you simply refer to how many days after aerosol is generated? Could you make it clear in the manuscript?

We agree that there has been some ambiguity regarding the definition of “age” in the introduction of the manuscript. In our case, with “age” we refer to the atmospheric residence time without regard to any chemical or physical aerosol processes. This was now clarified in the introduction (line 69). We decided to keep the term “age” in the manuscript as it is shorter and catchier than “atmospheric residence time”. We can further refer to the work of Deleersnijder and Campin (2001), who also used the term “age” to describe particle residence times.

For equation 2, I do not understand why you remove the source and sink for aging. The aging process of BC in the atmosphere is very complicated (see “Bounding the role of black carbon in the climate system: A scientific assessment”). I suggest adding some discussion about the atmospheric aging processing of BC and why you decide not to include that.

In Section 2.1.1 we included a brief discussion of what simplifications are implicitly assumed with regard to the source and sink terms in equation 2. It is true that we neglected additional source terms that would arise if physicochemical aging processes (e.g., hydrophilic coating) and therefore multiple BC sub-species were considered. Including this additional complexity would, however, be beyond the scope of our paper, which considers BC as a suitable tracer to investigate local air pollutant transport.

This manuscript is too long. Since it is an extension of a previously published work, maybe you can remove common parts and refer to that paper.

We shortened the technical description of the simulation setups in Sections 2.2.1 and 2.2.2 as indeed much of this content is already included in our previous paper. We kept only the parts that are more specific to the present case study. Furthermore, we removed the detailed description of the EOF

methodology in Section 3.4 as it does not fit well into this chapter. Lastly, we decided to create a supplementary pdf file for figures that are not central to the written paper content.

For your equations, could you define all parameters clearly and put their unit? Maybe you can make a table.

We added a Table at the end of the manuscript with all relevant mathematical symbols. Moreover, we checked the entire manuscript to ensure that variables are defined everywhere consistently. We also changed some definitions, e.g., the age concentration is now defined by c_a and not alpha.

When you discuss other models for estimating aerosol aging, I suggest adding a discussion of the FLEXPART and CO tracer method since a recently published paper ("Particle phase-state variability in the North Atlantic free troposphere during summertime is determined by atmospheric transport patterns and sources") used this method to estimate the aging of the aerosol air mass.

We added the FLEXPART part model in our introduction where we introduced the Lagrangian particle dispersion models.

## Specific comments:

I suggest improving the title by mentioning this is a model study and the model name since the current title sounds like a field measurements

The title was changed to "Air pollution trapping in the Dresden Basin from gray-zone scale urban modeling." This title reflects that it is a modeling study and also mentions the addressed spatial scale.

L144-150, "The first two … of their age." You can either mark the terms in the equation or show the terms in the manuscript. It is not very clear to me when I read it.

We added some text labels to the individual terms in the equations for more clarity.

L272-273, "For the air-chemistry … 14km resolution." Could you explain what you mean by air chemistry? Do you mean chemical reactions in the gas phase

or aerosol phase or both (heterogeneous reactions)? Moreover, what reactions you included (e.g., ozonation, aqueous phase reaction, photolysis, NOx reaction, etc.,).

We decided to shorten this part of the manuscript and refer to our previous manuscripts where the mesoscale setup and used air-chemistry mechanism are explained in more detail. Anyways, it was a bit misleading to write air chemistry, because BC is assumed to be chemically inert in our model.

L275, “Domains … respectively.” How do you choose the location and size of D1 to D3? Moreover, I think you should not use the resolution since that means how many ticks per length. Maybe you should use distance.

We replaced “horizontal resolution” with “horizontal grid spacing” as this is exactly what is meant by it. Domain sizes are chosen rather arbitrarily but it is ensured that the relaxation fetch between the inner and outer domain boundaries at each nesting step is sufficient for a relaxation of the lateral boundary conditions. The locations are chosen such that the target area is located close to the domain centers.

Figure 3. Where is D4? It is not clear to me. Also, I think you should label D2. It is not clear to me which box is D1 since D1 is labeled between two boxes.

Figure 3 was improved and split into two plots in order to better show domains D2, D3, and D4. We also used different colors for the boxes such that the relationship between the boxes and labels should be clear now.

Figure 6. I suggest using a color different from the color bar for the mark of Dresden. Moreover, do you have any spots that have MSL pressure below 996 hPa? If not, you can reduce the range of the color bar to cover the min and max of pressure.

We changed the colormap of the figure, adjusted the color of the marks, and restricted the color scale to 996 hPa.

Figure 7. It is not clear to me how you calculate the b and c color bars and why b and c have different Z ranges.

Maybe it was confusing that we placed the color bar labels of (b) and (c) not directly to the left of the color bar but on top of the plot. This was changed accordingly, such that it is clear that (b) shows $u_{||}$ and (c) shows the vertical gradient in virtual potential temperature. We also explained more clearly how $u_{||}$ is defined. We also equalized the z ranges of plots (b) and (c) for better comparison.

Figure 8. I suggest adding a caption even if it will be the same as Figure 7's.

We also included a more detailed caption in Figure 8.

L380-381, "3.3 … concept." Please check all your section numbers.

The double section was removed.

Figure 12. What is the color bar?

"The color bar indicates the horizontal wind speed of the reconstructed wind field patterns in (c-f)." was added to the caption of Figure 12.