

We would like to thank Reviewer#1 for his/her feedback and the constructive comments. We reply to these comments individually below. In our response, we are referring to the new manuscript with highlighted changes, in the following just denoted as 'new manuscript'.

Review 1, Anonymous Referee #1

The paper demonstrated singular vector analysis using EURAD-IM-SVA based on ZEPTER-2 campaign measurements. It provided sufficient description of the system and results are well presented.

Comment 1: While the paper focus on the leading singular value and its corresponding singular vector, it is worthwhile to present the other singular vectors since the second largest singular value can be very close to the first one.

Response 1: We fully accept the comment and modified the text and figures in order to present also other singular vectors for singular value analysis with respect to initial values. In particular, we added a table (Table 1 in the new manuscript) that lists the magnitudes of the five largest singular values with respect to initial values for each considered case. Further, we illustrated the vertical and horizontal placement for the second largest singular vector with respect to initial values (Figures 3, 4 and 5 in the new manuscript) as well as its relative rankings (Figure 6 in the new manuscript) and extended the explanations in the main text accordingly.

For singular vector analysis with respect to emission factors however, only the first singular vector has been calculated due to the current implementation that features only the Power method for this task. We clarified this in the new manuscript on page 9, lines 269-270: *“For singular vectors with respect to emission factors, however, only the power method is implemented in the current model version”* as well as on page 11, lines 351-354: *“Please note, that the analysis of initial value uncertainties includes results of several leading singular vectors, while the analysis of emission factor uncertainties is only concerned with the leading singular vector. The latter is due to different implementations of eigenvalue problem solvers (see Sect. 3.2)”* and on page 14/15, lines 463-464: *“The subsequent analysis in Sect. 5.2.1 and Sect. 5.2.2 discusses only results for the first singular vector as further singular vectors are not available (see Sect. 3.2).”* We hope that this finds the approval of the reviewer.

Comment 2: There are quite many papers on the optimal positioning of the observations or the adaptive observations. The authors should add more of those previous work to their paper.

Response 2: We followed this advice and added the following references to our introduction: Baker and Daley, 2000; Bishop and Toth, 1998; Buizza and Palmer, 1993; Daescu and Carmichael, 2003; Daescu, and Navon, 2004; Gelaro et al., 1999; Kim et al., 2011; Langland et al., 1999; and Toth and Kalnay, 1993 (pages 2-3 in the new manuscript).

References:

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2. Bishop, C. H. and Toth, Z.: Ensemble Transformation and Adaptive Observations, *J. Atmos. Sci.*, 56, 1748–1765, 1998.
3. Buizza, R. and Palmer, T. N.: The Singular-Vector Structure of the Atmospheric Global Circulation, *J. Atmos. Sci.*, 52, 1434–1456, 1993.
4. Daescu, D. N., and Carmichael, G. R.: An Adjoint Sensitivity Method for the Adaptive Location of the Observations in Air Quality Modeling, *J. Atmos. Sci.*, 60, 434-450, 2003.
5. Daescu, D. N., and Navon, I. M.: Adaptive observations in the context of 4D-Var data assimilation, *Meteorol. Atmos. Phys.*, 85, 4, 205–226, 2004.
6. Gelaro, R., Langland, R., Rohaly, G. D. and Rosmond, T. E.: An assessment of the singular vector approach to targeted observations using the FASTEX data set, *Quart. J. Roy. Meteor. Soc.*, 125, 3299-3327, 1999.
7. Kim, H. M., Kim, S.-M., and Jung, B.-J.: Real-Time Adaptive Observation Guidance Using Singular Vectors for Typhoon Jangmi (200815) in T-PARC 2008, *Wea. Forecasting*, 26, 634-649, 2011.
8. Langland, R. H., Toth, Z., Gelaro, R., Szunyogh, I., Shapiro, M. A., Majumdar, S. J., Morss, R. E., Rohaly, G. D., Velden, C., Bond, N., and Bishop, C. H.: The North Pacific Experiment (NORPEX-98): Targeted Observations for Improved North American Weather Forecasts, *Bull. Amer. Meteor. Soc.*, 80, 1363–1384, 1999.
9. Toth, Z. and Kalnay, E.: Ensemble forecasting at NMC: The generation of perturbations, *Bull. Am. Meteorol. Soc.*, 74, 2317–2330, 1993

Specific:

Comment 3: p6271, line 9: initial uncertainties -> initial concentration uncertainties

Response 3: This has been corrected accordingly (page 3, line 87 in the new manuscript).

Comment 4: p6282, line 5: SO2O3 -> SO2, O3

Response 4: This has been corrected accordingly (page 11, line 346 in the new manuscript).

Comment 5: p6292, Equation A3: Indices "i,j" should appear at left hand side as well to be consistent with Equation A1.

Response 5: In contrast to Equation A1, the results of Equation A3 are not dependent on indices "i,j". This can be seen by comparing results of Equation A3 (as depicted in Figures 6 and 8) with results of Equation A1 (as depicted in Figures 4, 5 and 7). Therefore, we would like to not change Equation A3. However, we tried to be more specific in the explanation (page 19, lines 610-626). Please note that we followed the recommendation of the journal to utilize the program "latexdiff" to highlight changes. Therefore changes that are made in the "equation environment" are not easy to see. Here, the color red marks deleted terms even though the terms are not crossed.

Comment 6: p6298, Table 2: Please remove the last two digits from the heights.

Response 6: This has been corrected accordingly (page 30, Table 2 in the new manuscript).

Comment 7: p6300, Figure 1: The units of the emission source strength indicate that the emissions are dependent on the height of the first layer. It is better to be converted them to flux types.

Response 7: We adjusted Figure 1 so that the emission source strength is no longer dependent on the height of the first layer, but is denoted in $\text{mg}/\text{m}^2/\text{s}$ (page 24, Figure 1, in the new manuscript)

Comment 8: p6303, Figure 4: The position of the two panels are inconsistent with text (p6284 line 8).

Response 8: This has been corrected accordingly in the text (page 13, line 415 in the new manuscript).