General comments on corrections done

We would like to thank all five reviewers for their valuable input. A major revision of the structure of the document has been done as suggested by most. The technical details related to the code were moved to the Appendix.
Also, their remarks lead to the rephrasing of three paragraphs and the discussion part in the conclusions was extended. More details have been provided on the setup of the experiments with different modeling of B. Some plots and captions have been corrected and completed. The first part of this document gives an overview of the modifications done, followed by the answers to the comments of each reviewer.

(1) Modifications of the structure of the document.

Reviewers asked modifications of the structure of the document:

In Sect. 2.0, Sect. 2.2.3 doesn't exist anymore.

As asked by different reviewers, the technical details of Sect 3. has been moved in Appendices. Thus, Sect 3. is renamed "Five stages to generate the background error covariance statistics (GEN_BE code version 2.0). and subsections from 3.1.1 to 3.1.4 renumbered from 3.1 to 3.4.
The previous Sect. 3.2 does not exist anymore:

- Sect. 3.2.1 have been included in the Appendix A (FORTRAN code and input/output description)
- The first part of the Sect. 3.2.2 has been merged to the new Sect 3.2.
- Section 3.2.3 becomes Appendix C (Installation, compilation, set up and visualization).
- The description of the namelist options goes in Appendix B (Description of the namelist options)

Section 5.0 includes now the results related to chemistry data assimilation previously shown in Appendix A. Sect. 5.0 is renamed "Cloud and chemistry variational data assimilation"

- Sect. 5.1 is named "Generation of a multivariate background error covariance for hydrometeors.
- Sect. 5.1.1 is added and is composed by the part related to the balance operator previously presented in Sect. 3.2.2. Section 5.1.1 is named "Generation of a multivariate background error covariance for hydrometeors.
- Previous Sect 5.1, and 5.2 becomes 5.1.2 and 5.1.3
- Previous Appendix B becomes Sect. 5.2 and is named "Background Error for Chemical Species"

(2) Modification Equations

Some Equations has been corrected, added and renumbered. We give an update below of the different modifications done.

- Eq. (1) J_b and J_o terms are added
- Eq. (2) new equation added to present a general definition of B
- Eq. (3) the definition of $\delta x=(x_b-x)$ added and renumbered
- Eq. (4) renumbered
- Eq. (5) $B^{1/2}$ is presented instead of δx
- Eq. (6) new equation to present the calculation of the regression coefficient.
- Eq. (7) presents of the calculation of the unbalanced part of the perturbations δt_u
- Eq. (8a) presentation of the Daley's formula that define the vertical length scale for one dimension along the vertical (z).
- Eq. (8b) presentation of an approximation of the formula of Daley along the vertical
- Eq. (9a) presentation of the Gaussian formula that define the vertical length scale for one dimension along the vertical (z).
- Eq. (9b) inverted expression of 9(a)
- Eq. (10a) corrected and renumbered
- Eq. (10b) corrected and renumbered
- Eq. (11) corrected and renumbered
- Eq. (12a-c) Identical

(3) Modification Figures

Previous Fig. 14, that shows the distribution of the vertical model level in function of pressure level, is presented earlier in the document (in the first paragraph of section 3.0 and becomes Fig. 3).
It allows visualizing the density of the vertical model in function of pressure and switch from vertical model level to pressure accurately when results are presented in sect 3.0, 4.0 and 5.1.

Fig. 9, 10,11,12,13,15,16,18a added right vertical axis in hPa pressure levels.

(4) Modification Tables

Table are renumbered:
Table 4 becomes Table 1
Table 2 is created to gather the setup information about the different modeling of B.
The other Tables are moved into the appendix:
- Previous Tables B1, B2, and B3 become Tables A1, A2 and A3.

- Previous Tables 1, 2, 3, 6, 7 and 5 become respectively Tables B1, B2, B3, B4, B5, and B6.

(5) Major revision in the text

Description of the experiments:

(a) The description of the D-ensemble dataset (50 members over the CONUS domain) coming from DART is done in the second paragraph of Sect. 3. : "Figures shown in … Romine et al. (2014) to generate the ensemble and … Table contains detailed information setup of the data assimilation experiment."

Reference about DC3 experiment of Romine et al. 2012 is replaced by: Romine G., S., Schwartz C., S., Berner J., Fossell, R., K., Snyder C., Anderson J. and Weisman M., L.: Representing forecast error in a convection-permitting ensemble system, Mon. Weather Rev., doi: http://dx.doi.org/10.1175/MWR-D-14-00100.1, 2014.

(b) A new table 2 is presented Section 4.0, to give details about the benchmark performed.

Table 2: Description of the setup of the background error matrix modeling diagnosed over the CONUS Domain. $\mathbf{B}_{eof}$ and $\mathbf{B}_{rcf}$ are diagnosed using GEN_BE code version 2.0 and the D-Ensemble method while $\mathbf{B}_{nam}$ is performed by NCEP using the NMC method.

Paragraphs rephrased:

(a) In the introduction, the first paragraph has been corrected, the second and the third rephrased following the remarks of the different reviewers.
(b) Section 2.2.2, the order of the description of the different transform match the Eq. 5:
- The $\mathbf{U}_p$ matrix, called physical transform or balance operator, …
- The $\mathbf{S}$ matrix is …
- The $\mathbf{U}_v$ matrix, called vertical transform, …
- The $\mathbf{U}_h$ matrix, called horizontal transform, …

(c) First paragraph of Section 3.0 has been rephrased.
(d) Section 3.2 has been rephrased (merge of previous sections).
(e) First paragraph of Sect 4.0 is rephrased and additional information is given to the general setup of the different modeling of B ($\mathbf{B}_{eof}$, $\mathbf{B}_{rcf}$ and $\mathbf{B}_{nam}$). References have been added: Romine et al. 2014, Rogers et al. 2009 and Wu 2005.
(f) Section 4.2 has been rephrased
(g) Section 5.1.1 coming from the previous Sect. 3.2.2 is partially rephrased to become independent.

(h) The discussion has been extended in Section 6, which is partially rephrased.

(6) Direct answers are given on the different referee below, in the following document.

Corrections Referee 2: R. Bannister (waiving anonymity),

1 General comments

This paper provides scientific and technical documentation for v2.0 of the GEN_BE system for modelling background error covariances in meteorological data assimilation. The paper gives a general background to the steps that make up the change of variable (control variable transform) used to rep- resent compactly the B-matrix in 3D-VAR and summarizes the options that GEN_BE v2.0 provides. A selection of statistics (e.g. correlations, length-scales, eigenmodes) and pseudo observation tests are shown to demonstrate the performance and capabilities of the suite of code.
The methods themselves used in the control variable transform are not new - most are used in other systems (like empirical orthogonal function decompositions, digital filters and statistical regressions), but the flexible way that they are adopted in this system is innovative and potentially useful to many forecasting systems other than the ones used in this paper. The flexibility includes the extension of the control vector to include hydrometeors like snow, rain, ice and cloud, which will inevitably be useful to other data assimilation researchers across the world who work in, e.g., radar assimilation or convective-scale data assimilation in general.
The presentation in general requires some attention. There are far too many grammatical errors, spelling errors, and mathematical errors. I have highlighted in Section 3 of this report as many errors as I can. There is sometimes a lack of consistency in presenting information throughout the paper (e.g. in representing elevation in the atmosphere, sometimes model level is used, other times pressure is used - this makes it difficult to compare plots even with the pressure/level plot - Fig. 14, which in any case appears far too late in the paper). It should be clear from each Fig. that shows statistics, the source of the data used, its type (ensemble or NMC), the averaging done (over how many days), and the modelling method used to produce the plot (e.g. EOFs or recursive filters). This is not always done in the current version. There is scope to discuss any obvious limitations of the software suite, e.g. can it deal with models on different grids, can it cope with reversal of order of the transforms (e.g. the transforms Uv and Uh). These points are raised in more detail in section 2.

Answers:

We want to thank R. Bannister for his review and advice to improve the discussion about the limitations and future of the GEN_BE code version 2.0, and the presentation of the document.

- *The figures that show statistics contained additional information: the source of the data used (WRF-ARW/WRF-NMM/WRF-CHEM), its type (D-ensemble or NMC), the averaging done (over how many days), and the modelling method used to produce the plot (e.g. EOFs or RFs)*

- *In Sect. 6.0, one paragraph has been added to discuss obvious limitations of the software and suite: it deals with models on different grids.*

- *Corrections has been done following the remarks mentioned in the specific comments*

2 Specific comments

1. In Section 1 of the paper the flexible nature of the suite is discussed, especially that it allows input from a range of models. Firstly, what computational grid does the system use (e.g., Arakawa A, B, C, Lorenz, Charney-Phillips, an irregular grid, etc.)? How does the software deal with input data held on grids different to the one used?

The answer is contained in a paragraph added in Sect 6.0:
"In these previous examples, GEN_BE code version 2.0 can handle input datasets coming from WRF, a model defined on a C-Arakawa grid, and the background error statistic outputs are computed on unstaggered A-Arakawa grid. Within minor modifications, the code would be able to handle other horizontal grids. Also, statitics could easily be done on models with different vertical grid definition. If we consider performing the background errors statistics on an unstructured grid, the structure of the code can remain the same but few mathematical operators, such as differential and laplacian, and estimation of the distance between two grid points, would need to be re-defined according to the grid. In fact, the Up transform needs to be performed in the unstructured grid according to the user's choice of control variables. Uv transform will remain identical and Uh transform would be modified according to the mathematical operators. Another option would be to interpolate first the input dataset on a regular grid according to the data assimilation system used and then compute the statistics. Thus, implementation of models with different grid can be done in the GEN_BE v2.0 code based on its general framework and may be completed by adding new diagnostics."

We are currently implementing a Model with an unstructured grid (MPAS-GLOBAL) into GSI. We performed the data assimilation process interpolating the meteorological field on a unstaggered A-Arakawa Gaussian grid. In this case, the calculations to perform the statistics that model B using GEN_BE are straightforward.

2. I was wondering if the suite has the capability of dealing with the following:

(a) In Section 2.2.2 the control variable transform is shown. If a user wishes to experiment with alternative orderings of the transforms, e.g. $\delta x = SUpUhUvu$ instead of $\delta x = SUpUvUhu$, is this possible?
The actual order of the transforms are $\delta x = UpSUvUhu$ (equation 4 is UpSUvUhu and not SUpUhUvu as previously written, see modification p4296, Eq 4). It is possible for a

user to invert the order of the Uh and Uv transforms. (Wlasak and Cullen 2014 study the impact of the defined order of vertical and horizontal operators).

(b) Can the suite deal with other methods of modelling horizontal correlations such as spectral methods or diffusion operators?
The original version GEN_BE V1.0 contained spectral method for global applications. The code can be provided and minor update need to be according to the new framework. We can provide it as it is if necessary.
We have no particular plan to use diffusion operators yet.

(c) Can the suite deal with dynamical balance operators instead of purely statistical ones?
We do not have plan in next future to use balance operators. Variational-Ensemble hybrid methods will be used to add some flow dependence in the background error covariances.

(d) Is the user tied to stream function, potential and temperature (e.g. vorticity/divergence/pressure/PV, etc. might be desired)?
The GEN_BE V.2 code has been designed to handle various control variables defined by the user (Table 4). Vorticity/divergence are already implemented. Adding new control variables is a minor development. In this case, the user has to define in the module io_input_model.f90 how to compute this variable according to the model variables. All the stages of GEN_BE can be applied directly and the user can define linear correlated errors with other control variable via the namelist.input file.

(e) What about background errors that are distributed in time as might be used in weak constraint 4D-Var (so that δx and u are 4-D fields instead of 3-D)?
For example, it would be possible to apply GEN_BE on the tendency of the fields too to have an estimate.

(f) Note: I realise that the above might be beyond the objectives of GEN_BE v2.0, but these issues are worth nothing (at least to state the limitations of the software and/or any future development work that might be planned).
We have extended the discussion part in Sect. 6 including some answers of the previous remarks

3. P.8, 2nd bullet: an ensemble can be worse than NMC due to incorrect spread of the ensemble.
We agree: an incorrect low spread of the ensemble method will give to much confidence on the background error covariance and likely less observations would be assimilated. Adaptative inflation is used in the DART-EAKF D-ensemble. Moreover, the spread and the correlations in the NMC method, may be inappropriate specially in the area poorly observed.
Also, we add the reference Fisher (2003) in this paragraph and refer about some drawbacks of the D-ensemble method in the sentence: "However, more computational resources are required to run an ensemble simulation and it may not provide automatically the optimum B for a particular system (Fisher 2003)."

4. Section 3.1.1 in general: It's not immediately clear what distinguishes stages 0 and 1. Fig. 2 says that stage 0 computes error perturbations and stage 1 remove mean. This should be made absolutely clear in the text.
An other reviewer asked us to introduce clearly the goal of each stage before going further. It has been done before section 3.1 writing "Stage 1 removes the mean of these perturbations and defined the binning applied."

5. P.10: ... and then directly calculates the regression coefficient as a product - a product of what with what?
Section 3.2, Eq. 6 has been added and commented.

6. Equation 6: I would say that this equation comes from the finite difference formula rather than Taylor development. It also relies on symmetry of ρ about the origin.

After introducing the Daley's formula, previous version has been changed by:
"Approximating Eq (7a) with finite difference to the second order derivatives of $\rho(\delta z)$ *and assuming ρ symmetric around the origin results in:"*

7. Last equation on P.11: presumably ρ(x) should be ρ(δx), and the Lvg should be L2vg.
Corrected in the text

8. Equation 6 is just the previous equation rearranged.
(see correction 6)

9. P. 12: last para.: the EOF representation of the vertical covariance matrix is exact if all EOFs are used (they will include inhomogeneity e.g.).

10. P.12, L.22: sparse repartition - what does this mean?
The sentence :
"Hydrometeors mixing ratio show even more local structures due to their sparse repartition on the horizontal and the vertical" is replaced by
"Hydrometeors mixing ratio show even more local structures due to sparse locations"

11. Equation 8: what is the significance of the factor of 8 in the denominator?
The formula has been replaced by $\rho(r) = \exp(-\frac{r^2}{2L})$

12. Equation 10: shouldn't the right hand side be square-rooted?
It should be square rooted. Corrected.

13. P.15, L.16: precising ?
This sentence has been rephrased in the text: "The parameters equal to ... by subtracting their balanced part coming from the stream function (psi).

14. Notes on Figures that involve model level: where does the boundary layer top and tropopause relate to the model levels? What is the data used to compute them (ensemble? NMC? time period?).
Table 2, presented section 4.0, has been created to gather the information of the set up of the different modeling of B. Also, we add some information at the end of captions to reference the method used:
According to the renumbered figures:
Fig3: added "(WRF, Res. 15 km)."
Fig4: added "(WRF, Res. 15 km, D-ensemble)"
Fig5: added "(WRF, Res. 15 km, D-ensemble)."
Fig6: added "(WRF, Res. 15 km, D-ensemble, EOFs)"
Fig7: added "(WRF, Res. 15 km, D-ensemble, EOFs)"
Fig8: added "(WRF, Res. 15 km, D-ensemble, EOFs)."
Fig9: added "(WRF, Res. 15 km, D-ensemble, RFs)."
Fig10: added "(WRF, Res. 15 km, D-ensemble, RFs)."
Fig11: added "(Beof: WRF Res. 15 km, D-ensemble, EOFs)"
Fig 12: added "(Brcf: WRF Res. 15 km, D-ensemble, RFs)."
Fig 13: added "(Bnam:WRF-NMM Res. 12 km, NMC, RFs)."
Fig 14: added "(WRF, Res. 15 km, D-ensemble)."
Fig 15: added "(WRF, Res. 15 km, D-ensemble)"
Fig 16: added "(WRF, Res. 15 km, D-ensemble)"
Fig 17: added "(WRF, Res. 15 km, D-ensemble, RFs)"
Fig 18: added "(WRF, Res. 15 km, D-ensemble)"
Fig19: added "(WRF-CHEM, Res. 36 km, D-ensemble)"
Fig20: added "(WRF-CHEM, Res. 36 km, D-ensemble)"
Fig21: added "(WRF-CHEM, Res. 36 km, D-ensemble)"

15. P.16, L.19: What is nebulosity?
Nebulosity is a parameter diagnosed to define the presence of cloud in the low atmosphere. In the study of Ménétrier et al. 2011, the authors estimate the nebulosity based on the cloud fraction calculation of AROME coming from the first vertical model levels.

16. P.16, L.21 and P.17, L.9: what is the relative humidity rate?
P16 L21
In the new paragraph, "relative humidity rate" is replaced by "humidity"

P.17, L.9 Replaced by "as their presence or absence is directly related to the humidity rate" by
"as their presence or absence is directly related"

17. P. 17, description of covar6: there seems to be 0, 1, and 2, meaning 'no regression', 'full regression' and 'diagonal only'. The last one I assumed to be the meaning. The key should be pointed out explicitly, perhaps in one of the tables. Are there any other options beyond 2?
No other option beyond 2 are available at present.
Table 6: added "At present, the parameter covar can take three values: 0, 1, and 2, meaning "no regression", "full regression" and "diagonal only". "

18. P.21, 1st para.: This needs to be written in a more lucid style.
The paragraph has been rephrased.

19. Fig. 14 (pressure vs. level) is out of place - this should be placed earlier in the paper (e.g. immediately after Fig. 3).
This figure is now presented just after the figure of the CONUS domain.

20. It would be useful to show statistics that come directly from the sample (i.e. not the statistics implied by the transforms) for comparison with Figs. 11-13. Also on these Figs. please include axis labels.
Some information have been added to compare horizontal length scale coming from NAM in Sect 4.1.2 : "Direct comparison of … compare statistics from forecast of different length."
We redid the Figs (11-13) adding the axis.

21. P.23, L.24: The text refers to 1-D variance in connection with Fig. 18a, but this Fig. looks to me like a slice through 2-D data.
The order of the figures has been inverted. The legend is replaced by:
"(a) Profile of standard deviation of liquid water condensate mixing ratio (qcloud in g kg-1) averaged along the vertical and (b) horizontal cross-section of standard deviation of qcloud at the vertical model level 5 (950 hPa). Both plots indicate the presence of low maritime clouds noted by high standard deviation."

22. P.24, L.23: Methods that combine general statistics of the background errors and local balance are found to perform better when the ensemble size is small. As it reads this statement says that these hybrid techniques do better with smaller ensembles than with larger ensembles. Is this what the authors want to say? Do they mean, When the ensemble size is small, methods that combine general statistics of the background errors and local balance are found to perform better.
The sentence "Methods that combine general statistics of the background errors and local balance are found to perform better when the ensemble size is small"

is replaced by "When the ensemble size is small, methods that combine general statistics of the background errors and local balance are found to perform better"

23. P.25, L.21 onwards: The authors talk about the ensemble of the day. Does this mean that regression coeffcients have to be recalculated each time as new ensemble is used?
Only the geographical mask could be updated and the variance 3-D. If the goals of DA and the meteorological situation remain the same (same specific event) for the next cycle of analysis, we can keep these regression coefficients. Moreover, it should be possible to re-computed every cycle these coefficients are they are not in the critical path for operational center: these statistics are not so CPU time expansive and can be launched as soon the forecast is available.

In Sect. 6 renamed summary and discussions the following sentences have been added: "The regression coefficients calculated, can be conserved for a next cycle analysis as they are averaged by bins or recalculated as they are not so expansive with regard to CPU (central processing unit) time."

24. Table 4 (and text that refers to this table): Given that qcloud and qice are two separate variables, does this mean that the former refers only to liquid water?
In table 4, I replaced "Cloud mixing ratio" by "Cloud water mixing ratio" and "Rain mixing ratio by "Rain water mixing ratio"

25. Please include in each Fig. that shows statistics the following: the source of the data used, its type (e.g. the model and ensemble or NMC), the averaging done (e.g. over how many days), and the modelling method used to produce the plot (e.g. EOFs or recursive filters).
Done and show in remark (14)

3 Technical corrections Things crossed out should be removed and things

1. P.3, L.4: *The sentence has been split and rephrase: "The probability errors are supposed to be normally distributed"*

2. P.3, L.23: this → these .
"these different efforts" replaced by "this different efforts"

3. P.4, L.10: please define CONUS - this might not be known outside of N.America.
Replaced by CONUS (CONtiguous United States) and moved in the first paragraph of Sect 3.0

4. P.4, L.13: Test→ Testbed .
Replaced

5. P.5, L.1: mapper → map.

Replaced

6. P.5, L.6: In general → Often .
Replaced

7. P.5, L.10: B matrix, is comprised.
Changed by Replaced "B matrix, being comprised of nearly 10^8 x 10^8 = 10^{16} entries, is too."

8. P.6, L.20: applications of a recursive filter.
Add a before recursive filter.

9. P.7, L.8: modeling of a .
The paragraph has been merged to another section and this sentence doesn't exist anymore.

10. P.7, L.19: In version 2.0 .
The all paragraph has been re-written.

11. P.10, L17: balanced part for from each other variable.
The sentence has been replaced by "Linear regressions are performed to derive uncorrelated (i.e. unbalanced) perturbations by removing the balanced part from each other perturbation variable"

12. P.10, L19: block.
Corrected to block

13. Equation 5: It is unusual that $\nabla 2$ is used here for a 1-D vertical derivative. It would be more informative to have $\partial 2\rho/\partial z2$ (or whatever the derivative is respect to).
We corrected the equation.

14. P.11, L.15: subsisting -> substituting .
The sentence has been rephrased (see point 6 of the specific comments)

15. P.12, L.16: grib-> grid .
Changed grib to grid

16. P.12, L.19 and P.19, L.18: potential velocity change to velocity potential .
Done

17. P.12, L.25: plane.
"Plan" changed to "plane"

18. P.13, L.1: points.

Point changed to points

19. P.13, Ls.7 and 12: the .
Removed "the" before Eq.

20. P.14, L.16: controls variables.
"controls variables" replaced by "control variables"

21. P.15, L.25: with and .
These sentences have been rephrased in the new section 3.2.

22. P.16, L.18: statically→statistically .
These sentences have been rephrased in the new section 3.2.

23. P.18, first para.: add the before each compiler name.
Done

24. P.19, Ls. 1 and 3: of resolution .
Replaced by "domain at 15 km resolution"

25. P.20, L.26: ... horizontal slice done at the 500hPa level for the temperature ... .
Replaced by "horizontal cross-section at the 500hPa level for temperature"

26. P.21, L.2: is employed in the .
The sentence is replaced by "When the operator (Uv) employs EOF decomposition, the Jb term of the cost function is weighted by the variance coming from the eigenvalues of Beof"

27. P.21, L.11: ... is spreaded out by the recursive filter EOF decomposition ... . [At least the caption of Fig. 11 refers to EOF.]
We removed it in the new paragraph.

28. P.21, L.20: This→ These
The all sentence has been replaced by "These ensemble based background error statistics have potentially more skill to estimate correlated errors related to the present meteorological event."

29. P.22, L.4: Modifiations code change to Code modifcations
Done

30. P.23, L.26: It is used most of the time used ... .
Sentence replaced by "It is most of the time used when the perturbations come from the NMC method or when the variance is not diagnosed at the analysis time".

31. P.24, L.7: ... the possibility of adding

The sentence has been replaced by :" The covariance between mixing ratio of cloud water condensate and relative humidity, described in Sect. 5.1.1, can reinforce the ability of adding clouds in the dry area or removing clouds in the cloudy area."

32. P.24, L.9: "is beneficial at the analysis time as it allows including increments of hydrometeors directly at the analysis time"
Replaced by "The univariate version of the balance operator for hydrometeors may be beneficial at the analysis time as hydrometeors can be directly assimilated"

33. P.26, L.14: amount → number .
Amount replaced by number

34. P.26, L.19: The Barré et al. reference does not appear in the reference list.
The reference has been added.

35. P.26, L.26: aerosols .
The reference of Benedetti and fisher 2007 and the sentence about aerosols has been removed.

36. P.27, L.1: the optical depth .
Sentence removed

37. Table 1: Allows GEN_BE to read ... .
The all sentence is corrected as follow "Set up the acronym for the model input allows GEN_BE to read different input model in the stage 0."

38. Table 1: ... historical date data available, defined in hours ... .
Replaced date available by "date data available"

39. Table 2: ... hgt defined the width ... .
I replaced "binwidth_hgt defined the width that splits the bins" by "binwidth_hgt define the width that splits the bins"

40. Table 2 (two occurrences): level model change to model level.
Line bin_type 3: I replaced "vertical level model" by "vertical model level"
Line bin_type 4: I replaced "model vertical level" by "vertical model level"
Line bin_type 5: I replaced "vertical level model" by "vertical model level"
Line_bin_type 7 : I replaced "vertical levels" by "vertical model level"

41. Table 3: In the rst item in this table, should 1-8 be 0-7 ?
Yes, we corrected the line bin_type to 0.

42. Table 6: First variable do →does not ... .
Line covar1, we replaced do by does.

43. Table 7, last three rows: is there a reason for upper case in Cov?
All has to be lower case. We corrected.

44. Fig. 16: The caption and Fig. itself don't match (horizontal shown instead of vertical)
It has been corrected.