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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Correcting for Model Changes in Statistical Post-Processing – An approach based on Response Theory" *by* Jonathan Demaeyer and Stéphane Vannitsem

Anonymous Referee #2

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General Comments:

The discussion paper presents a method for adapting a post-processing approach after a (small) change in the forecast model, as is often the case in operational weather forecasting. The innovative idea of this paper is to base the approach on response theory. Using a tangential linear model, transient response theory represents a correction method of a post-processing approach as long as the changes in the forecast model are small. Since the consideration of small changes in the prediction model is of great importance, the paper represents a potentially valuable contribution. I particularly congratulate the authors for the courage to base their approach on physical theory, in this

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Discussion paper

case transient response theory.

The general structure of the paper is clear and the paper is generally well written. The paper contains quite some mathematical derivations in the appendix and in the supplementary material. As such, it is a challange to understand the theory and may discurrage interested readers. The impact of the paper may be largely increase with some additional – simplified – explanation. I have added some ideas in this respect in the specific comments. Further, the description of the figure is held very short. I prefer to be guide through the figures, instead of just been given the main conclusion.

A carefull proofreading should be performed in terms of language and formulas (see a non-exhaustive list in the technical corrections).

Specific Comments:

The information in Eq. (13)-(14) and (16)-(17) is very redundant, since one only has to exchange the parameters. I suggest to compress this a little bit.

The application of the concept to the OU-processes is quite helpful. I would suggest to first formulate the response theory in general, and then in a separate section apply and explain the formulas for the OU case, followed by the post-processing. It would further be helpful to maybe see a figure of $\alpha(\tau)$ and $\beta(\tau)$.

With respect to the QG model it would be helpful to, on the one hand, see the model equations probably in the Fourier space, but, on the other hand, simplify the Fourier expansion (e.g. using complex expansion), since this is a quite standard Galerkin approach (you have to mention the boundary conditions).

The application of the response theory here is very not very clear to me, and I still do not quite see, where and how the tangent model comes into play.

Regarding Fig. 2 (b) you may guide the reader a little bit, e.g., mention, that ψ_2 and ψ_3 represent the strength of the zonal wavenumber 1 anomalies, which are both small in the dashed line ellipse, and large in the dashed-dot ellipse, which also seems to have a strong zonal mean ψ_1 component. What is the relevance of the equilibrium ploints?

Technical Corrections:

page 1, line 2: "... cope with slight model change" -> "... cope with slight model changes"

p. 1, l. 3: "The response theory allows then to ..." -> Response theory allows us to ...". The usage of "allow" throughout the paper is incorrect. Please check with native speaker.

p. 1, l. 5: "averages involved": I only understood after reading the paper, what is meant by this.

p. 1, l 7: "... the application to the latter provide a proof-of-concept of the potential performance of response theory ..." -> "... the application to the latter provides a proof-of-concept and assesses the potential performance of response theory ..."

p. 1, l. 9: What is "in a more operational environment"? Maybe "in an environment more similar to the operational environment"

p. 2, l. 15: "These operational models, ...": Remove "these", since reference is not clear.

p. 2, l. 16: "... behaviours" -> "... behaviour" or maybe just "... processes".

p. 2, l. 17: "past forecasts" -> "forecasts in the past"

p. 2, l. 22ff: "Recent research have studied non-homogeneous regression with time-adaptative training scheme, where a trade-off have to be considered between large training data sets for stable estimation and the benefit of shorter training periods to adjust more rapidly to changes in the data (Lang et al., 2019). ": Language editing needed, e.g. "Recent research has investigated non-homogeneous regression with a time-adaptive training scheme, where a trade-off between a large training data set for stable estimates and the benefit of a shorter training period for faster adaptation to data changes must be considered. (Lang et al., 2019). “

p. 2, l. 31: “... parameters variations as well as new terms in the tendencies are potential model change.” -> “... parameter variations as well as new terms in the tendencies are potential model changes.”

p. 3, l. 17: square bracket “< >” are not explained here, only later on. In general I find it confusing to refer here to averages, as these are to my understanding expectation values (which are indeed estimated via ensemble averages).

p. 3, eqs. (1), (2), (3): add (τ) to $\dot{x}$, $\dot{y}$, $\ldots$

Eq. (5): remove $\cdot$, since this is not a scalar product.

Eq. (6): the numerator should be with a quare (I guess you’re doing least quares).

p. 3, l. 29: “Note that if $\kappa = 1$, the correction is perfect.”: Not absolutely true, since forecast and model still differ in λ.

p. 4, l. 20: “for correct ...” -> “for a correct ...”

p. 4, l. 25: “... of infinite number of ...” -> “... of an infinite number of ...”

Eq. (20): Remove ˆ from β in denominator.

p. 6, l. 8: “... over model the y forecasts” -> “... over the model y forecasts”

p. 6, l. 19: “It is also assumed that there is no interference due to initial condition errors in the problem.”: Please clarify, what you mean by this.

Eq. (23): $f^{\tau}()$ is only given later and specific for the OU process. Please state here, what this is.

Also Eq. (23): The term in the square brackes may be a scalar product in general, but as you have formulated ψ_y, it is not. Later on you use bold letters for vectors, right?

p. 7, l. 1: “its stochastic integrals ...”> This may need some explanation.

Eq. (28): Check formula: Isn't there missing $A(f^{\tau'}(x_o))$ and $A(f^{\tau}(x_o))$ should be$A(f^{\tau''}(x_o))$? Again is this really a scalar product?

p. 7, l. 23ff: You put σ_y^2 into square brackets, although these are already expected values, so the brackets make no sense here.

p. 8, l. 8+9: I assume, that the n in the sine and cosine should not be there.

Section 3: The notation in Eqs. (31)-(33) and (34) may be misleading, since x is a coordinate, while $\mathbf{x}$ is the vector of the coefficients of the spectral expansion. Further, $\mathbf{F}$ is not given.

p. 9, l. 13,14: Should be Fig. 2(c) and Fig. 2 (d).

p. 12, Eq. (39): Use either scalar product or transpose ^{T}.

Eq. (40): Since it is an approximation, use $\approx$ instead of $=$ here.

p. 14, l. 8: "... the averages of the model $\hat{y}$ (model 1) averages ...": Is this correct?

p. 14, l. 12: Figures should always be given (numbered) in the same order as they appear in the text. Please check.

p. 14, l. 25: "... to avoid rare and unrealistic extreme response of ..." -> "... to avoid rare and unrealistic extreme responses of ..."

p. 14, l. 25: "... (set to 3. adimensional unit) ...": Please check.

p. 21, l. 2: "… which can in some circumstances limit of the applicability ..." -> "… which can in some circumstances limit the applicability ..."

p. 21, l. 6ff: Please revise paragraph.

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