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Interactive comment on "Sensitivities of the MJO Forecasts on Configurations of Physics in the ECMWF Global Model" *by* Jun-Ichi Yano and Nils P. Wedi

Jun-Ichi Yano and Nils P. Wedi

jiy.gfder@gmail.com

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We would like to thank the Editor for his considerate comments. We apologise again for the delay, partially this was due to Covid-19 as one of the authors had difficulties to access the relevant infrastructure and data. Having said this, we much appreciate the opportunity provided by the Editor to respond in full. We understand that it is not easy to give specific recommendations as an editor, when the main issue is in the presentation of difficult and unexpected results. We *do* believe that the results should be recorded to illustrate, for example, the contrast of friction formulations in operational models with those in idealised studies of the MJO. The latter are often based on a

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Discussion paper

rather simple Rayleigh–friction formulation, taking a dichotomy of with or without. Unfortunately, existing theoretical models are too limited to explain corresponding MJO sensitivities simulated by operational models.

We agree that no simple theoretical interpretation of the results are possible from the present study. Originally, we started to explore a possibility of interpreting the MJO as a nonlinear free wave under active interactions with Rossby waves from and to higher latitudes. A main strategy has been to remove the constraints to the free dynamics in an operational model by selectively turning off the tendencies of different physical parametrisations.

In spite of a substantial number of sensitivity experiments performed, it turns out to be difficult to draw firm conclusions. However, such a work should not simply be considered a failure. Here, we disagree with the Editor's comment that "the current state (of manuscript) is not useful", if what it means is a lack of positive results. Notably, in a recent comment in the journal Nature, Mehta (2019) argues why a negative result is crucial for a healthy progress of science.

It would be important to emphasise that our methodology is sound, and we have set out with a clear hypothesis as stated in the manuscript. More specifically, individual sensitivities of momentum diffusion are examined, with a hope of distilling specific impacts that either deteriorate or improve MJO forecasts. As it turns out, such an investigation is difficult, because other processes, that are not eliminated, compensate with a nonlinear response. We agree with the assessment that the results are complicated. However, it is unethical to simplify what we actually obtained. We further agree with the Editor and the Reviewers about the (lack of) presentation style of these complicated results. We will revise the manuscript to better present the unexpected complexity of the results. We will also clearly state in revision that we do not find any clear-cut interpretations in terms of the nonlinear free-Rossby wave dynamics as we originally envisioned. Nevertheless, this is an important negative finding, that should inspire further experimental studies while avoiding repeating the same mistakes made

here.

As recommended by Mehta (2019), the present manuscript will become a showcase that established researchers with a good background on the MJO fail to prove their hypothesis. It will further send a strong message to younger and aspiring scientists bombarded with success stories. It is our view that the Reviewers and the Editor read the present manuscript with 'success' in mind.

More specifically, in revision, we have realised that it is difficult to extract any firm conclusions for readers from the original manuscript for two related reasons. First, the basic nature of the present study is exploratory. The main goal is an extensive sensitivity study of MJO forecasts on physics, that call for theoretical studies more closely tied to the actual physics of operational models. Urgent needs for such a new type of theoretical studies will be more explicitly emphasised in revision (L468–469). Second, we have failed to state this actual main goal of the work in the original manuscript. The motivation of the study to investigate a possibility of interpreting MJO as a nonlinear free wave in operational models is wrongly stated as a main purpose. This will also be corrected in revision so that readers will be better guided through the revised manuscript.

We still personally believe that the free nonlinear Rossby-wave theory remains a viable idea. However, clearly, we have failed to obtain any firm support to this theory by the present sensitivity study. It simply demonstrates how hard it is to emulate free dynamics within a global forecast model without deteriorating the basic state of the model that so crucially depends on these physical parametrisations. This point has already been made in the original manuscript. However, we have failed to extend its implications.

In contrast, we have obtained firm evidence for interactions of the MJO with extratropical waves by the present sensitivity study: the behaviour of the model is relatively insensitive to the choice of physics in representing this aspect of the MJO dynamics. This very point, that was failed to be remarked in the original manuscript, will clearly be

pointed out in revision.

The Editor suggests that finding sensitivities themselves do not constitute anything original. However, we disagree on this point in the context of MJO studies: these studies are strongly driven by a paradigm of MJO driven by convection, thus almost any global modelling studies of the MJO are also exclusively focused on sensitivities to convection parametrisation. A recent paper by Pilon et al (2016) and Jiang et al (2020) are a good example. The originality of the present paper is to explicitly point out that MJO forecasts do not sensitively depend on convection parametrisations only but also on other physics, especially the momentum dissipation processes. Probably, pointing out this very simple fact is already a very important contribution of the present work. Unfortunately, we had failed to emphasise such a basic point in the original manuscript.

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