

## ***Interactive comment on “On the Approximation of Spatial Structures of Global Tidal Magnetic Field Models” by Roger Telschow et al.***

### **Anonymous Referee #2**

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#### GENERAL COMMENTS:

This paper discusses the construction and use of customized basis functions for the purpose of modeling or representing global tidal magnetic fields. These functions include the temporal periodicities, but also take into account the spatial patterns of the tides by confining their variation within ocean basins. Three types of functions are considered, including traditional solid harmonics, radial basis functions, and physically motivated functions that solve Maxwell's equations, but are restricted to ocean basins via Slepian functions. They apply these to the CM5 M2 field as well as a synthetic field and find that there are discrepancies between the CM5 model and the physics-based functions over the continents. The conclusion is that these physical functions could be a more appropriate set of basis functions for modeling tidal magnetic fields. I believe

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the paper is acceptable for publication in the present form after some minor revisions listed below, but it would be much improved after addressing the major concerns I discuss below.

#### SPECIFIC COMMENTS:

I find the paper to be technically very good, but the reduction of noise over the continents does not seem so important. CM5 was based upon CHAMP data only, but newer M2 models from Swarm (see Sabaka et al., 2018) show much less noise contamination in general, which will probably also be reduced over continents. The M2 signal is small and the models are not usually interpreted over the continents anyways, so this problem is even more secondary. In fact, the residuals for the trial functions in figure 6 (CM5) are over a smaller range of 0.0-0.3 than those of the figure 7 (synthetic) range 0.0-0.6, which makes me wonder if the appearance of the residuals for CM5 look more exaggerated than they really are.

However, what I find very important about this work are the physical based trial functions themselves because they allow a direct connection between the data and the ocean velocity and conductivity parameters. I think the most important part of the paper would be an added section that addresses solving the inverse problem of inferring these parameters from the data, that is, CM5, using these trial functions. The section should include discussions on:

- 1) How does the  $u$  field corresponding to figure 6 from CM5 compare with the TPX08-ATLAS model?
- 2) Can you solve for the 1D conductivity  $\sigma$  in the ball  $B_a$  like was done in Grayver et al. (2016)? Even if you cannot do this at least discuss the issues like sensitivity, observability, regularization, etc.
- 3) By fixing  $u$  to TPX08-ATLAS, can you say anything about the sensitivity or observability of  $\sigma$  in the shell  $S_a$ ?

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If this discussion is added, then I think the paper would be much more useful.

TECHNICAL CORRECTIONS:

- 1) Define  $E$  and  $\mu_0$  in equation 1.
- 2) Perhaps you could give some more detail about the Regularized Orthogonal Functional Matching Pursuit algorithm.
- 3) What is the meaning of the norm with respect to  $H$  in equation 2?
- 4) Should  $d$  have a subscripted  $i$  or  $i-1$  in equation 2?
- 5) Define  $\lambda$  in equation 2.
- 6) On page 4 you say  $y_{\{0,0\}}^{(2)} = y_{\{0,0\}}^{(3)} = 0$  for convenience, but the real reason is to ensure uniqueness?
- 7) In the context of eigenvalue equation (not numbered) on page 6, you should state that the denominator of equation 8 is equal to  $\hat{g}^T \hat{g}$ . If this is not correct, then please explain the eigenvalue equation more thoroughly.
- 8) What model does  $B_{\{main\}}$  come from?
- 9) What are the units of the map in figure 4a?
- 10) On page 9 you define  $D_1$  from  $n = 0, \dots, 20$ , but if these functions are the solid harmonics, then should you be starting at  $n = 1$  instead?
- 11) Define a Reuter grid or give a reference.
- 12) What altitude are the maps in figure 5?
- 13) In all global map figures you should outline the continents so they can be seen.
- 14) Figures 6 and 7 should be combined such that each corresponding map uses the same scale and can be seen simultaneously. As stated earlier, it appears that the residuals for the CM5 fits are over a smaller range, which amplifies the features relative

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to that of X3DG.

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