Anonymous Referee #2 (RC2)
The authors go through the commendable and accurate process of estimating oceanic electric fields from models, to compare with data from 4 submarine cables. The primary results presented are correlations between the observed and modelled electric fields, which are used to infer the suitability of using submarine cables for oceanic velocity. The statistical interpretation of these correlations does not seem methodical enough to be believable in its current state. The conclusions presented are not detailed, and do not advance the field beyond earlier papers on the topic. Even their recommendations for placing cables in strategic points - an easy thing to propose but much harder to actually implement, see the SMART cable effort - does not include the specificity needed to ensure that such cables can provide useful results for inferring ocean circulation, such as resolving meanders, variables subsurface sediment thickness, or flow acceleration/deceleration. This article focuses on just the first step of getting useful cable voltage measurements, obtaining a high correlation between observations and models, but the second step of interpreting why the cable voltages change is just as important and even harder.

Thank you for your very thoughtful comments and review. We address your points below and very much appreciate your recommendations for bringing this study past the first step.

Technical comments:

Intro
lines 41-43: Another confounding factor is that, because longer cables integrate over longer distances, it becomes harder to assign transport or velocity to any single section of the cable.

Very true. We will adjust the sentence to become:

> …however, there are many challenges in using longer cables. These challenges are largely due to the myriad of processes which may also induce marine electromagnetic fields, especially across the length of the cable: secular variation (Shimizu et al., 1998), variations in ionospheric tides (Pedatella et al., 2012; Schnepf et al., 2018), geomagnetic storms or longer period ionospheric/magnetospheric signals (Lanzerotti et al., 1992a, 1995, 2001). Additionally, because the cable voltage is produced from the electric field integrated along the entire cable length, the longer the cable is, the more challenging it is to assign cross-cable ocean transport to any one section of the cable.

lines 44-45: This question has already been addressed in the literature.

Please let us know papers you are thinking of. We were not aware of any prior studies using data from cables spanning more than 1000km.

Data and Data processing
line 65: Also look at Luther publications from BEMPEX for an interpretation of the oceanic EF response at periods from hours to days.

Thank you for this reference recommendation for daily variation signals; we will include this reference in the revised manuscript.

Section 3
lines 86-93: Does elmgTD also include mildly conductive subsurface sediment layers, which vary significantly across ocean basins? These are important for interpreting oceanic EM signals.

elmgTD can include these subsurface sediment layers and our revised numerical work included them. They did significantly change the signal (see above figure on page 4).

Figure 3: What date/time are the ECCO velocities shown for?

Thank you for catching this. The caption will be revised accordingly:

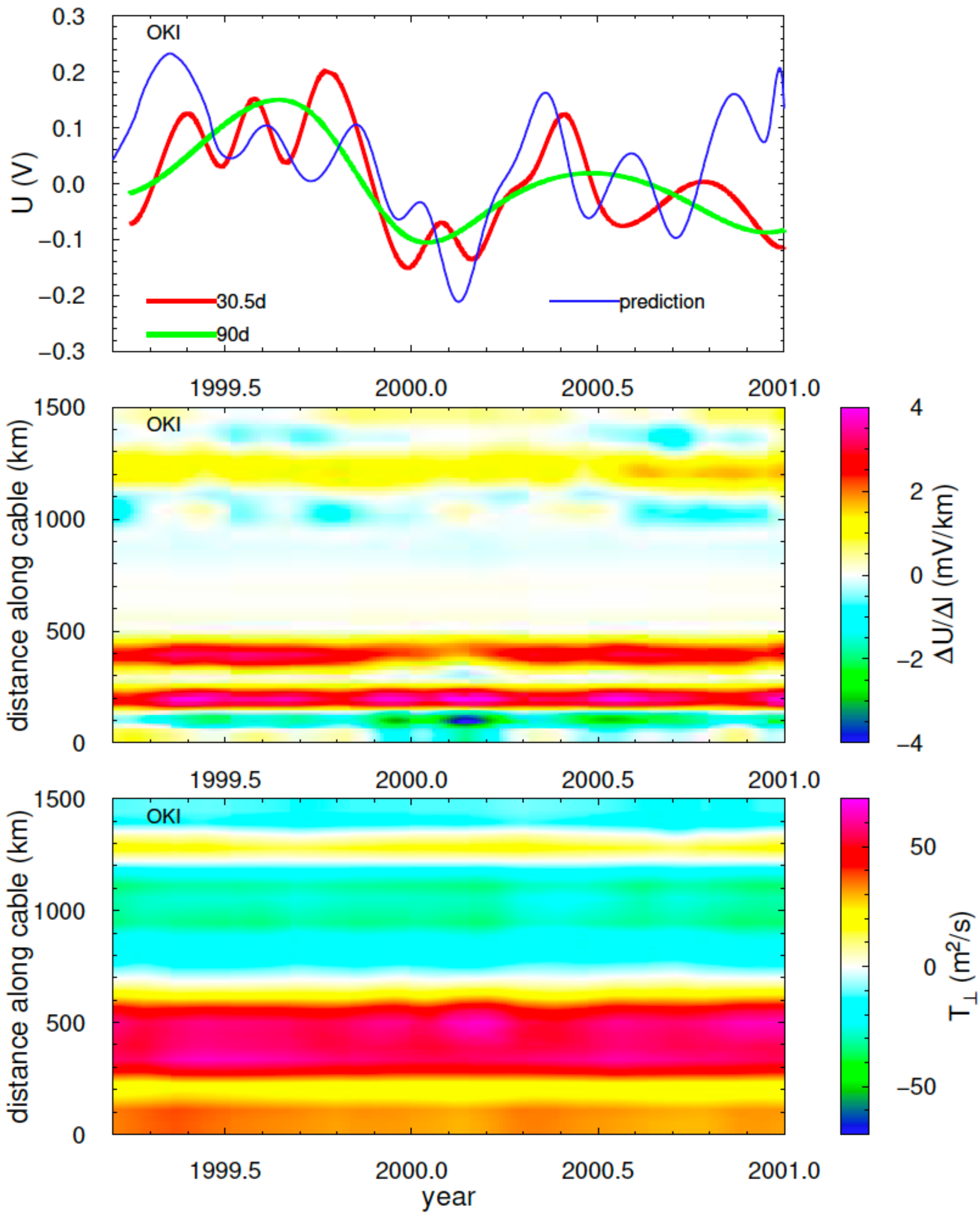
> Figure 3. The surface velocities from ECCOv4r3 are shown in a) for the zonal (U) component and b) for the meridional (V) component. The labelled, thick black lines denote the seafloor voltage cables used in this study. A snapshot of the IGRF vertical main field, Bmainz is illustrated in c) and d) depicts the NOAA World Ocean Atlas seawater electrical conductivity's January climatology in the surface layer. All snapshots represent conditions of January 17, 1997.

Figure 4 comments

We have changed Figure 4 (and have also included similar Figures 5 and 6 for the HAW1NS and HAW3 cables).

> Figure 4. The results for the OKI cable. The top panel shows in red and green the smoothed time series of cable voltages using 30.5-day and 90-day knot separation, respectively. The blue and brown lines correspond respectively to the predictions obtained by the 3-D and 2-D model. The middle panel shows the time-development of voltage gradient along the cable length from the 3-D model. In the bottom panel, we plot in similar way the ECCOv4r4 vertically integrated transport across the cable. The cable orientation follows Table 1, from Honshu to Okinawa.

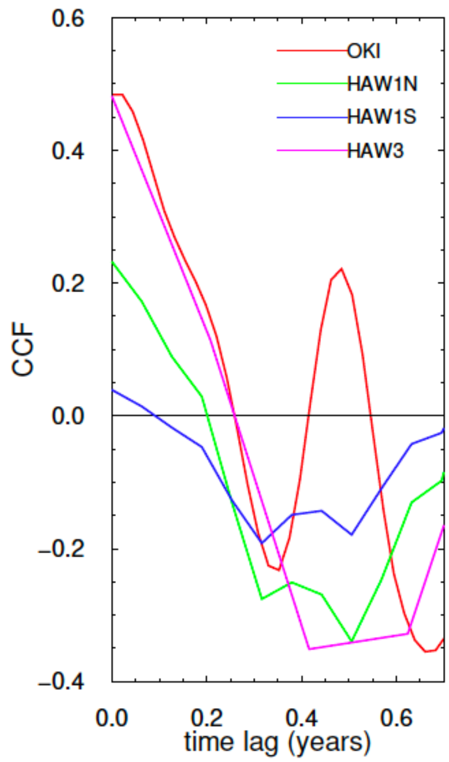
This new figure is shown on the next page.


OKI
U (V)
30.5d
90d
prediction
1999.5
2000.0
2000.5
2001.0
distance along cable (km)
ΔU/Δl (mV/km)
$T_\perp$ (m²/s)
year

Section 4, Results and Discussion comments

We have substantially revised our Results and Discussion section. We also include an additional figure, Figure 7.

Figure 7. The cross-correlations function (CCF) between the observed and predicted voltages for individual cables.



In Figure 7, we calculated the cross-correlation functions (CCF) between the predicted and observed voltages using the 30.5-day knot separation datasets. Because of gaps present in the data, the Gaussian-kernel method (Rehfeld et al., 2011) was applied. All CCFs have their respective peaks at zero phase leg. The OKI, HAW3, HAW1N, and HAW1S signals show respective peak correlations of 0.48, 0.48, 0.23, and 0.04. It is obvious that the discrepancies between the predicted and observed voltages are 160 still large, and significant efforts are required both on the side of data processing and numerical modeling to reconcile the results.

On the side of numerical modelling, one could devise a comparison study between different ocean models. Indeed, we have used our model to predict the magnetic fields of the LSOMG model in the past (Velimský et al., 2019), and we have also attempted the calculation of the cable voltages for the eddy-resolving GLORYS ocean model (not shown here). One problem related to this approach is the volume of computational resources necessary to carry out the calculations. As the cable voltages are sensitive to local electric fields, the usual simplifications of the EM induction solver, based on the thin-sheet approximation, or representing the oceans by a single layer with integrated water transports and electrical conductances, are problematic (Šachl et al., 2019; Vel.mský et al., 2019). The single 5-year calculation of the full physical model presented here, with 50 ocean layers and spherical-harmonic truncation degree 240, required about 105 CPU-hours to complete. Semi-global or regional modelling tools with local refinement ability are needed for more accurate numerical studies.

lines 153-156: This is the crux of successfully using submarine cable voltages: placing it in a region that is conducive to interpreting such measurements. Note also that substantial effort is put into calibrating the Florida Current voltage time-series, see more recent publications by Meinen.

Thank you very much for this reference suggestion.

lines 157-163: Yes, most scientists who work with submarine cables could confirm that these are useful requirements for using such signals to interpret voltages. This point is not, however, substantiated in detail by this paper.

Nowhere do the authors note that their correlations are subject to an important additional source of noise: that the ECCO model might not accurately reflect the actual monthly averaged oceanic velocity field. To my knowledge nobody is able to evaluate ocean models based on their velocity field (for many practical and technical reasons). In light of this, a better approach, see Flosadottir et al 1997, would be to use a "perfect model" approach, so that you don't have to worry about the mismatch between ocean models and actual ocean circulation.

We are familiar with that paper and that certainly is an interesting approach. However, we feel that this first step of using actual (and very imperfect) seafloor cable data on a large (>1000 km) scale is an important aspect of our paper—even if the results only suggest more work is needed.

Also, for understanding the Florida Cable results, important details are presented in Spain and Sanford, J Mar Research, 1987.

Thank you very much for this reference recommendation.