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Ocean Science
Discussions

Interactive comment on "Electromagnetic characteristics of ENSO" *by* Johannes Petereit et al.

Anonymous Referee #1

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Summary of results

The paper describes an application of established electromagnetic theory to use variations in the tidally-induced magnetic field to potentially identify anomalies in the conductivity in the Equatorial Pacific Ocean, and use these as indicators of incipient El Nino/La Nina (ENSO) events. They show acceptable levels of correlation between these signals and ENSO events with a lead time of several months, and state that this provides a higher level of predictability than observations of surface fields.

General style

The paper is generally well structured and clearly written, and the standard of English is good.

General comments

There are in my opinion some logically important steps missing in sections 2.1 and 2.1, which purport to explain how the interaction between tidal motions, the Earth's magnetic field and the local T/S structure in the tropical Pacific gives rise to measurable magnetic field anomalies.

The results described in the paper from the ocean model are very interesting, but I have some difficulty with the overall message of this work. There is a bald statement in the Conclusions section that the estimated magnetic anomalies are currently too small to measure, which would seem to invalidate the main conclusion (stated directly in the final sentence of the paper) that this technique might be used to predict the onset of an ENSO event. This, in my opinion, demands some discussion of how useful the technique actually is, both at the present and at some time in the future. Firstly, is there a fundamental limit to the smallest measurable magnetic signal in the ocean? How large is the effect of internal waves and other small-scale oceanic motions on the magnetic anomaly, compared with that due to the predictable tidal signal? Are there any foreseeable improvements in technology that would reduce the SNR to enable these signals to be detected? Secondly, as the authors note in the Introduction, upper ocean heat content is already known to be a good predictor of ENSO: surely this is a far easier precursor to measure directly than the admittedly tiny magnetic field anomalies? Are there any real advantages of the technique discussed in this paper over conventional monitoring of standard hydrographic fields (e.g. the TAO/TRITON array)?

Recommendation

Accept with major revisions

Specific comments

Abstract

"Tidally-forced" is more correct than "tidal-forced", which occurs throughout the paper,

particularly in the Abstract.

P1L2: Replace “separable from“ with “distinguishable in”

1. Introduction

P2L9: “thermohaline circulation” does not drive the ocean – replace this with “buoyancy fluxes”?

P2L31: “pacific” should have a capital.

P2L5: What does “variating” mean?

There is usually a short description of the structure of the rest of the paper at the end of the Introduction, but one is lacking here. In the present case I think this would be very helpful, since it would steer the reader through the logical chain of argument from tidal currents to the at least theoretically detectable magnetic anomalies, and hence to correlations between the latter and ENSO events.

2.1 Ocean and tidal induced currents

P3L26: Insert “with” after “linearly vary”.

P3L27: What does “well know for real observation times” mean?

2.2 EMOTS

Perhaps I am not paying enough attention here, but there doesn’t seem to be a clear link between the induced currents jm2 in the previous section and the measurable resulting magnetic field. Specifically, Br is referred in the subsequent section as being defined in the present section, but it is not. There is quite a dense description of the conductivities, but this doesn’t seem to go anywhere – is there some text missing here?

Also, are the EMOTS measurable in the magnetic or electric field? Presumably the magnetic component, since this is referred to several times further on, but this is not stated explicitly here.

Finally, I think this section would be a suitable place for an error analysis of the predicted signals. Specifically, how large is the contribution of the other, more stochastic, flow components (e.g. tropical instability waves, equatorial Kelvin waves, internal waves, etc) relative to the tidal signal? What is the magnitude of variability of the local geomagnetic field? What are the current measurement limits?

3.2 Spatio-temporal anomaly development

P6L5: To make this paragraph make more sense, perhaps state explicitly that Bearth vanishes at the geomagnetic equator. Also, say explicitly how the spatial structure of the tidal flow reduces Br in this region. Presumably this vanishing of the background field implies that equatorial regions are the worst place to use this technique!

P6L8: Figure 2b strictly only shows one anomaly, rather than a robust lead-lag relationship between “anomalies”, as suggested in the text

It would be helpful to discuss here how the computed Br anomalies relate to the noise levels and to instrumental measurement capabilities.

4 Conclusions

P8L18: The statement that the predicted Br anomalies are too small to be detected with current observational techniques is quite startling, but is not discussed further. In fact, the following text then states how potentially useful the results of the paper are in predicting ENSO, despite them being at present totally impracticable! It would be useful here to include something about at least about the possibility of improving the detection threshold – is this at least theoretically possible?

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