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Geoscientific Model Development Discussions

Interactive comment on "System identification techniques for detection of teleconnections within climate models" *by* Bethany Sutherland et al.

Anonymous Referee #2

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In this study, the authors propose using transfer functions to identify teleconnections in climate models. They demonstrate the use of transfer functions in this way with a comparison between two CESM runs: a control run configuration and run with perturbed temperature in the Nino3.4 region. They try to identify the ENSO teleconnections in temperature and precipitation with their method. I very much want to like this paper, but unfortunately there are significant fundamental issues with the conception, execution, and explanation of this study. It is possible that this last pieceâĂŤthe explanationâĂŤis the major problem and that an improved presentation of the work might alleviate the concerns about the conception and execution. In order for this to be a good contribution to the literature, the study needs to address the following questions:

1. Why would transfer functions add value to model analysis of teleconnections? The

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current first explanation, i.e. that they can identify relationships at a range of frequencies while standard methods assume timescales, is an unsatisfactory answer. Such a statistical tool must be used in a way that is physically motivated and therefore particular frequencies are necessary to understand it. This is why transfer functions have been usefully applied to quasi-periodic geophysical phenomena in the past (e.g. ENSO). The second motivation for using transfer functions, namely that there is not a presupposition of the existence of a teleconnection, is concerning. If this is true, then you may well find an apparent relationship between your "input" and your "output", but have them both be driven by some third forcing (e.g., from MacMynowski and Tziperman 2010, wind anomalies excite both Kelvin and Rossby waves). Applying a statistical tool such as this without a particular motivating process is liable to produce spurious relationships or at the very least, uninterpretable ones.

2. If the focus of this study is validating the use of transfer functions for identifying teleconnections by recreating known ENSO teleconnections, why is the experiment designed in this way? There are a few pieces to this that are confusing: a. As the authors themselves note, their perturbation method is not triggering an ENSO event. Because of the atmosphere-ocean coupling and numerous physical processes at play in an El Nino or La Nina event, they rightly recognize that they can't be expected to obtain accurate ENSO teleconnections. So why do this? Why not just calculate the teleconnections in a long, unperturbed CESM model run with the input as the Nino3.4 index? b. 20 years is not enough to resolve responses on either the climate change timescales referred to in line 95 or at ENSO timescales. To the extent that they find relationships that are the same as those for climate change or for ENSO, they have identified relationships that have no frequency dependence for which standard correlations should work equally well. c. The phase information is one of the main advantages of this method, so neglecting it because the solution method doesn't have a nice method for regularization between +/- 180 is not really acceptable. The authors could add some sort of regularization method that penalizes large jumps from one frequency to the next. The phase is an excellent reason to use transfer functions. One can iden-

tify the form of physical relationships (e.g. 2nd order ODE) based on the shape of the magnitude and phase. Incidentally, doing this piece of optimization of transfer function calculation and providing the code would be a valuable contribution to the community.
d. Use of a constant window length for the entire frequency range dramatically decreases the utility of the method, since this is another reason the phase information can be very noisy. There's no reason to keep the same window length for the whole frequency range (c.f. Linz et al. 2014).

3. How should we interpret these results? Currently, the results are extremely confusing. This might be partially because of the definition of "significant"âĂŤthe authors state that there will be some number of false positives, but do not characterize how many. Which of these points are still significant if the definition is that the 2sigma error bars do not overlap? What is the proposed mechanism by which the temperature above the ACC responds to equatorial perturbations at a timescale of 2 days? This spatially-coherent, unphysical response should be a major red flag for the analysis method. In addition, the timescale identified in Figures 5 and 6 is a singular timescale, but there can be coherence between input and output over a large range of frequencies, so what is actually plotted here? The explanation of the propagation is confusing; the period of response in Baja seems to be somewhere around 3 years (Figure 5), so what is this description of the 1 week timescale?

4. What was actually done for the calculations? What window length is used for FFTs and what is the smoothing? What exactly is the input time series? (A plot of this would be useful.) Was there a spin-up for the perturbed model run and if not, why is it not necessary? As currently presented, there is not nearly enough information to reproduce this work.

5. R.e. future work and application to the real world: The suggestion of large scale perturbations to test this in the real world is ludicrous. One can do calculations of transfer functions with existing dataâĂŤe.g. TAO Array in MacMynowski and Tziperman 2010. The realistic way to use transfer functions to identify or characterize ENSO

teleconnections using real world data would be to use the existing Nino3.4 index and compare it to the local temperature and precipitation observations. The index goes back at least until 1950 and many surface stations have records that long.

All told, I think that transfer functions are a very useful tool for geophysical analysis. Transfer function analysis could be useful for teleconnection analysis and identification. However, I do not see how this paper does what it sets out to doâĂŤnamely to demonstrate this.

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