Review

The paper discusses applying a system identification technique to find the responses of climate models to small perturbations using a single simulation. The objectives and the methodology are well described in sections 1 and 2. The method is then applied in section 3 to find how low cloud fraction and latent heat flux change globally in response to a +1K perturbation of the near-surface temperature over the Northwest Indian Ocean. The results are compared with the results of a step response simulation. The results and the potential applications of the technique are discussed in section 4.

I find the technique very interesting and I believe that it can be a powerful tool in studying the climate system and that it has various potential applications (as some described in section 4). However, the manuscript should be first improved in several ways before it is considered for publication:

1) It helps the reader and potential users of the technique if the paper presents a quantitative evaluation of how well the proposed technique works in the single example shown

2) Further discussions on how the range of the magnitude of the normalized sequences is chosen (Line 200) and how SNR and nonlinearity can be quantified are needed.

3) There are few other techniques proposed in the literature to characterize the linear response of climate models. They should be briefly mentioned in section 1.

Here are some details regarding 1-3:

1) Fig. 1 shows that the system identification technique underestimates (overestimates) the magnitude of the low cloud fraction (latent heat flux) response. The patterns of the response, which are simple and local, look similar. The errors in the magnitude and pattern (e.g. pattern correlation in the region of interest) should be quantified. That way how changing parameters such as the frequencies of the band-pass filtering affects the accuracy can be quantified. Among the two reasons offered for the discrepancies, contribution from nonlinearity can be eliminated by reducing the amplitude of the forcing in the step function simulation and using a pair of heating and cooling simulations. Finding the "true" linear response using the step function simulations against which the system identification technique can be verified might take some effort, but given that evaluating the performance of the technique is crucial, I think it is worth the effort to demonstrate how well the technique captures the linear response. As for the second reason, again, it would be nice to quantitatively show which range of band-pass filtering yields the best agreement with the linear response of the step function simulation at least for this specific example. I am also wondering why the response to this specific region (Northwest Indian Ocean) and in these specific variables have been chosen.

2) How is the [-1K,+1K] range is chosen for the normalized sequence? (Line 200). In problems concerning linear responses, a major difficulty is obtaining good SNR without violating linearity. Does this problem exist in this technique as well? If so, how the SNR and nonlinearity in depend on the magnitude of this range should be explored (and this likely vary across different regions), which requires quantifying the SNR and degree of nonlinearity. I am not suggesting that this should be done for this paper, but these issues should be (at least briefly) discussed.

3) Other methods have been proposed in the literature which share closely some of the objectives of the current study. One example is the fluctuation-dissipation theorem (some recent examples: Gritsun and

Branstator 2007, Ring and Plumb 2008, Cooper and Haynes 2011, Fuchs et al 2015). Another example is the Greens function method of Hassnazadeh and Kuang 2016. Note that these methods too can determine (at least theoretically) the full dynamic behavior of the system as they provide the linear response function of the model. I suggest to briefly mention other methods such as these two to better connect the current paper with the literature.

Gritsun, A. and Branstator, G., 2007. Climate response using a three-dimensional operator based on the fluctuation-dissipation theorem. Journal of the Atmospheric Sciences

Ring, M.J. and Plumb, R.A., 2008. The response of a simplified GCM to axisymmetric forcings: Applicability of the fluctuation-dissipation theorem. Journal of the Atmospheric Sciences

Cooper, F.C. and Haynes, P.H., 2011. Climate sensitivity via a nonparametric fluctuation-dissipation theorem. Journal of the Atmospheric Sciences

Fuchs, D., Sherwood, S. and Hernandez, D., 2015. An exploration of multivariate fluctuation dissipation operators and their response to sea surface temperature perturbations. Journal of the Atmospheric Sciences

Hassanzadeh, P. and Kuang, Z., 2016. The linear response function of an idealized atmosphere. Part 1: Construction using Green's functions and applications. Journal of the Atmospheric Sciences

Minor comments:

Simulation details: it helps if some details about the model setup (e.g. horizontal and vertical resolutions in the atmosphere and ocean etc.) are included following line 178.

End of line 264: ")" missing

Line 315: Figure's label missing

Fig 1a: dashed lines are visible on the pdf but do not show when printed

Line 205-215: z^A_i is uniform across each of the 22 regions (right?). But that means there would be discontinuities in the heat source profile at the boundaries of these regions. That might cause problems if the model uses spectral methods.

Is there a statistically significant difference between the climatology (eg. time mean latent heat flux or zonal wind field) of the pre-industrial control simulation and the climatology of the system identification (perturbed) simulation?

I am very curious to see how this interesting technique performs for a range of problems and especially for regions that excite teleconnection patterns, as the authors discussed in section 4. To evaluate the technique, it might be a good idea (for future) to use a simpler climate model (e.g. an atmospheric GCM with coarse grid) which is cheaper to run and can be used to explore more examples.