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Earth System Dynamics
Discussions

# *Interactive comment on* "Historical and future anthropogenic warming effects on the year 2015 droughts, fires and fire emissions of $CO_2$ and $PM_{2.5}$ in equatorial Asia" *by* Hideo Shiogama et al.

**Anonymous Referee #2**

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General comments:

The authors present a policy-relevant study of changes in precipitation deficits and fire metrics in equatorial Asia (EA) during a 2015-like El Niño event and in a decadal-average sense at 1.5°, 2°, and 3°C warming levels. Results are based on a factual-counterfactual probabilistic event attribution approach in a MIROC5 AGCM large ensemble framework. The following questions are explored:

- Did historical climate change increase the probability of the 2015 event?
- How will probabilities of drought, fire and fire emissions change when a major El



Niño event similar to the one in 2015 occurs in 1.5°C, 2.0°C, 3.0°C climate.

Authors find that historical anthropogenic forcing has increased the likelihood of a drier-than-2015 El Niño-driven precipitation deficit in the EA from 2% to 9%. At 1.5°C of warming, a drier event is 82% likely to occur. At 2°C of warming, the probability of a drier event drops to 67% likely (for reasons that are not entirely clear) but increases to 93% at 3°C of warming. This increased risk of drier conditions during El Niño events has ramifications for burned area extent, CO2 and particulate emissions in the regions.

The paper could be a valuable addition to the current body of literature on extreme events in warmer climates and the figures presented are clear and easy to interpret. There is care taken to connect findings to policy considerations whenever possible, particularly possible underestimates of EA $CO_2$ emissions under climate change scenarios. However, the interesting findings would benefit from additional detail on the method, model experimental framework, relationships between relevant processes, and, most critically, on the value-add gained by using a 100-member large ensemble as opposed to 10-member ensembles. Addressing the specific comments below should more than adequately clarify and strengthen conclusions.

Specific comments:

I recommend omitting the phrase: "the year" from the title.

Abstract On what is the statement "caused" based on? [L14] What is the dry season in Equatorial Asia (i.e., in terms of months)? [L15] The acronym PM2.5 is not yet defined [L21]

Introduction It would be helpful to explicitly define when EA dry season occurs. . . Is the EA region the same as the SEA SREX region? If not, the specific latitude and longitude boundaries should be given. [L32-34]

Could you explain the ENSO phenomenon and how and why it "enhanced severe drought" to help guide readers? How did the 2015 drought compare to other ENSO

events? This can be done through an explanation of the relationship between Walker circulation and convection and by including relevant citations on how the 2015 event compares to other El Nino in terms of effect on EA climate. [L32-34]

Is the whole EA region considered tropical peatland? Can that qualification be defined (i.e. what is tropical peatland) and can it be explained why the region is susceptible to biomass burning? [L33]

Can you elaborate more on the findings of Lestari et al. 2014? It will help readers understand how this new study extends the findings. [L43]

Question 1: Did historical climate change increase the probability of the 2015 event? How is historical climate change defined? Is it with respect to a certain base period? How is “change" defined in the presence of natural variability? [L47]

Can you elaborate on the probabilistic event attribution approach used in this study? It will help readers who are not familiar with detection and attribution techniques understand the opportunities and limitations of these approaches. How were they used in these cited papers? What were some of the key findings? [L48-54]

I also recommend the following edit: “We use a probabilistic event attribution approach similar to Lestari et al. (2014), but our results are based on 100-member large ensembles of the MIROC5 AGCM with and without anthropogenic warming as opposed to 10-member ensembles." Then, a statement should be made about why the large ensembles were necessary and important to use. Justifying and highlighting the importance of large ensembles is a key point, especially for a special journal edition dedicated to large ensembles. [L48-50]

Question 2/3: Could these two sections be combined into one section about risk at 1.5, 2.0, and 3.0°C warming? [L55]

Just a small comment but can the connection between the initiation of the HAPPI project and the Paris agreement be smoothed out a little? Was the HAPPI project



initiated in response to or to inform the Paris agreement? [L56-61]

In regards to “Although socio-economic factors (e.g., conversions of forest and peatlands to agriculture and plantations of oil palm) are also important for fire activities (Marlier et al., 2013, 2015; Kim et al., 2015), we only examine the effects of climate change in this study.” Does this mean land-use change is not considered? What are the relevant “effects of climate change” on these events (i.e. warmer mean temperature, circulation changes, changes in ENSO?)

Empirical functions: Can you elaborate on your observational dataset choices? Why did you choose the reanalysis products you use? How are the enhanced fire fraction, fire CO2 emissions and fire $PM_{2.5}$ emissions computed in the Global Fire Emissions Database?

Could a figure demonstrating the relationship between burned area, CO2 emissions, and particulate emissions be included? Is there a linear relationship between burned area and emissions?

What are the empirical functions used for in this study?

Model simulations: Can you provide a further description of the MIROC5 AGCM? I.e. what is the horizontal resolution of the atmosphere? What observed SSTs specifically were used, particularly for the “natural" SST? How was the “long-term anthropogenic signal" defined and removed? Most importantly, what fire model is used? How is it related to the land surface state and coupled to the atmosphere? What triggers a fire in the model? How are CO2 and $PM_{2.5}$ concentrations determined for a given event? [L103-121]

What are the “corresponding standard deviation values”? [L108]

Throughout the study, the descriptions of the figures are a little brief. In this case: "The precipitation and vertical motion anomalies are closely related to the Nino 3.4 SST (an index of El Niño Southern Oscillation) in the observations, and the MIROC5 model

represents these relationships well (Figs. 3c-e).” How are they related (i.e., subsidence and reductions in rainfall during an El Niño)? What does “represent these relationships well" mean (i.e., significantly correlated with observations)? [L108-110]

How were “prescribed long-term warming anomalies in SST” defined? From Figure 4, I can see that there are spatial differences in warming, where do they come from? These details are likely important to the overall interpretation of the results and it would benefit the reader not to have to search for methodological descriptions in other studies or elsewhere in the paper. [L125-126]

The colorbar seems to be saturated in the bottom panel of Figure 4 over much of the Northern hemisphere, could the scale be adjusted to accommodate the 3°C mean difference? Is there a difference between the respective Figure 5 top and middle panels? Could you detail how these results were reached using the cumulative density functions? Particularly, how did the use of large ensembles affect the results? Does the “chance of exceedance” change with fewer members? [L154-158]

Can you comment on why the chance of precipitation reduction exceedance more probable in the 1.5° scenario than the 2° scenario? [L157]

“2015 CO2 emission of Japan due to fossil fuel consumptions" is a missing a citation [L168-169]

I am sorry I may have missed something, but what is the AIM/CGE model used for? Was it introduced in the methods section? [L179-180]

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