Responses to Reviewers

We thank both Reviewers for the careful reading of the manuscript and helpful comments.

Response to the comments made by Earle Williams, the Reviewer #1, in the second review:

On the occasion of the Workshop on the Global Electrical Circuit in Warsaw, Poland earlier this month, I had good opportunity to meet with the coauthors of this manuscript to learn from them and to share my thoughts. I am attaching (after the main review) here a copy of the comments I had put together on first looking at the revision. That revision is much improved, reinforcing my earlier view that the paper is much improved and eventually deserves to be published. But for the moment, I have some very specific suggestions for a path to that publication.

Suggestions for addressing remaining loose ends:

(1) Need for bipolar conductivity

A big step forward was the accessing of the Swider positive conductivity. But the very best quantity for treating the seasonal issue and the highly polluted Swider boundary layer in winter, one really wants the bipolar (total) conductivity, and based on my separate discussion with Marek Kubicki, these bipolar data are available in the Swider archive. The authors should get them and include them and come up with the best explanation for the seasonal variation of the electric field, and then make a firm judgment about local versus global influence/manifestation. In the present version, the conclusions are not firm.

Response: According to your suggestion, in addition to the conductivity data from 1965-2005, we also used bipolar (total) conductivity for the periods: 1957-1964 and 2005-2015. The annual variation of the total conductivity (TC) is shown in Figure 13.

(2) The expansion ratio threshold for the CN counter

Wilson (1897) showed (in work that eventually won him the Nobel Prize in physics) that when the expansion ratio of 1.25 was exceeded, a rainlike condensation on small ions appeared in his cloud chamber. This is essentially the threshold the authors have provided in supplying valuable new information about their CN counter. But they need to try to establish whether the counter was designed with the CTR Wilson finding in mind, so that they were just short of activating on small ions. I am not quite sure how that can be accomplished, but some effort should be made. At the very least, the Wilson (1897) work and threshold should be mentioned in the revised text.

Response: After consultations we can state that the counter was designed to be as close as possible to CTR Wilson. According to your comment Wilson's publication and the threshold value were mentioned in the revised text.

(3) The CN threshold of 10,000 per cc

Through the response to initial reviews, and through discussion in Warsaw, the authors have conveyed to me their general strategy in their selection of this CN threshold: an effort to achieve conditions sufficiently clean so as to achieve a globally representative measurement at Swider. (In their response to the reviews, they cited Landsberg (1938), Schonland (1953) and Mohnen and Hidy (2010), and now I have had a chance to consult the latter two references. Perhaps the best information in this context is contained in Table 2 of Mohnen and Hidy, and I encourage them to continue to focus on this information.

Having considered all of this information, my general reaction is that the value of 10,000 per cc is still quite large given the perceived objective of the authors. To be more specific, 10,000 per cc is large than the average values for 7 of 9 categories listed in Table 2. So the authors can say that they have selected a threshold value less than the means for "Town" and "City" in Table 2, but they need to say that this general level is still "polluted" and that the finding that they are still unable to make globally representative measurements of the global electrical circuit from Swider is very believable. Remember the initial success of the Carnegie Institution ocean measurements of electric field (and CN!) in achieving global representativeness, but their values for CN were of the order of 100 per cc, and so two orders of magnitude less than the authors' selected threshold. More discussion in the manuscript is needed about the full range of CN conditions one can have.

Response: You are right that the threshold value of 10,000 per cc is a value that still reflects polluted conditions, however taking into account the Świder location (near the Warsaw) and possible emission, the CN concentration about 10,000 per cc are very probable. It is worth mention that it is the upper threshold of CN concentration analyzed in the article. To show "cleaner" conditions we used also threshold of 8,000 and 6,000, and 4,000 per cc (see Table 1). However, as we reduced the CN concentration the number of PG values decreases to some extent.

(4) Reference to Adlerman and Williams (1996)

The authors have been interested in checking on the role of aerosol variation on the seasonal variation of the global circuit. It would be valuable, after they checked carefully the seasonal variations of the Gerdien bipolar conductivity at Swider, to ascertain whether the inferences made by Adlerman and Williams (1996) are valid.

Response: We have additionally digitsed dat from period 1957-2005 and reworked data from 2005-2015 to analyse the bipolar conductivity changes.

(5) Globally representative measurements at Swider

This issue came up at the recent Workshop on the Global Electrical Circuit and is deserving of some additional discussion in the present context. Two key points are worthy of discussion. First, Marek Kubicki informed me about days in which the Gerdien bipolar conductivity is essentially constant over 24 hours. This evidence for a fixed medium (yes, in polluted conditions and low values of conductivity) may provide an advantage to seeing global signals, and deserves additional attention. (The more common behavior at Swider is for highly diurnally variable conductivity.) Second, the boundary layer over land is often stabilized at nighttime by virtue of temperature inversions. This situation, well known to meteorologists but not exploited by atmospheric electricians in earlier work, might also provide a condition when convective transport of electric space charge is zero, and for which Ohm's law is fulfilled. This makes it more likely that a measurement in this special time interval would be globally representative, because local perturbations are strongly suppressed.

Response: we agree but resolving the issue needs at least continuous measurements of CN, dust concentrations and particle size distributions. Perhaps some other type of analysis with selection of special conditions would be more useful.

We would like to thank you for the valuable discussions during the workshop, for all comments and suggestions regarding the manuscript.

In addition to the problems indicated above, we have corrected some presented numbers after we made a small correction to our dataset. We have also tried to improve spelling and grammar.