Reviewer 2

The manuscript is based on ASIM observation (BLUEs over cloud top) and make the parameter (CTH, CAPE, TP, CLWC, CSWC) fitting algorithm for BLUE occurrence rate using ECMWF ERA5 data. Then, authors used ASIM BLUEs occurrence rate to validate the adopted parameterization. Finally, they predict results with EMAC models and conclude that 17-28% large than present day model. The in-cloud corona schemes can help to understand the contribution of greenhouse gas and oxidant species from BLUEs.

I thoroughly enjoyed reviewing this manuscript and only have some minor requests for revision.

Thank you very much for your constructive and encouraging comments that we appreciate. Please find below answers to your particular points.

ASIM only recorded BLUEs at nighttime. Hence, the corona parameterizations with CAPE, TP, CLWC and CSWC were only validated at nighttime. In general, thunderstorm activity is expected to be more intense in the afternoon than nighttime since updraft are weaker without heating by sunlight. Are there any assumptions for BLUEs occurrence rate for nighttime or daytime?

The referee is completely right in that thunderstorm activity is expected to be more intense in the daytime and afternoon than in nighttime. Please consider that we calculated the synthetic annual global average by accounting for all time steps throughout the diurnal cycle assuming that daytime coronas in thunderclouds causing BLUEs are equally probable as those occurring at nighttime (see section 4.1). In fact, we believe that our BLUE parameterization are completely valid for daytime (including afternoon) because during daytime, when updraft are stronger than during nighttime, the parameterization will use daytime values of the considered meteorological variables like CAPE, TP, CTH, CLWC and CLWC. However, since data of BLUE rates and geographical distribution are still missing (ASIM only measures during nighttime), we still cannot compare with BLUE daytime distribution. In the revised manuscript we have used the units of "Blues km-2 h-1" instead of "Blues km-2 night-1" or "Blues km-2 day-1" so that all figures become more consistent among them.

The flash occurrence rate are several times larger than BLUEs. Is any significant difference between flash and BLUEs occurrence rate?

This is an important question and a possible answer may come from looking at Fig 5b of a recent paper by Husbjerg et al. GRL 2022 (doi: e2022GL099 064), ***cited in our manuscript****, showing that the CAPE associated to thunderstorms producing lightning flashes have a median value of 1000 J/Kg while thunderstorms producing BLUEs require stronger convection than needed from lightning alone. The CAPE found in the scenarios of thunderstorms that produce BLUEs range median values between 1280 J/Kg (slow BLUES, that is, those buried in the thunderclouds) and 1570 J/Kg (fast BLUES, that is, those appearing in the top of thunderclouds). As indicated in Husbjerg et al. GRL 2022, A CAPE greater than 2000 J/Kg usually indicates deep convection. Cells generating fast blue discharges have 25% occurrence in the region of deep convection. For cells generating only slow blue discharges it is 17%* ***while for regular lightning, only 10% of the events have a CAPE greater than 2000 J/Kg****. Therefore, there is a strong link between deep convection and the generation of blue discharge events. Another consequence is that it is then more probable that lightning occurs since they do not so much require the presence of deep convection to occur.*

Do you explain more about the contribution of greenhouse gas and oxidant species for BLUEs? Authors are encouraged to claim more important effects on the future weather system.

Thanks for raising this point. However, that would be the subject of another paper in preparation so we prefer just to mention the possible influence of BLUEs in greenhouse and oxidant atmospheric gases.

It is unclear that how the RCP6.0(Representative Concentration Pathway 6.0) affect the BLUEs occurrence rate? What is the important implication of climate changes for BLUEs rates?

Figure S9 in the revised supplementary material shows the projected annual variation of the variables used to parameterize BLUEs under the RCP6.0 scenario. CAPE, total precipitation, and the cloud content of liquid and snow water are projected to increase in the regions (among others) with the higher occurrence of thunderstorms, such as Middle Africa, North America and Southeastern Asia. As a consequence, the global occurrence of BLUEs is projected to increase.

Solar activity and aerosol from human activity may be related with climate change. In your modeling results, do you consider other external factors, e.g., solar radiation or aerosols and their relation to climate change. Bedsides, volcanic eruption or human activity will be the unexpected factors in your models.

As detailed by Jockel et al. (2016), the future solar forcing has been prepared according to the solar forcing used for CMIP5 simulation of HadGEM2-ES, where the SSTs and SICs are taken from Jones et al. (2011; see also Sect. 3.3). It consists of repetitions of an idealized solar cycle connected to the observed time series in July 2008. Here, we deviate from the CCMI recommendations consisting of a sequence of the last four solar cycles (20–23).

Anthropogenic emissions are incorporated as prescribed emission fluxes following the CCMI recommendations (Eyring et al., 2013b). Troposheric and stratospheric aerosols are prescribed. In the case of RCP 6.0, anthropogenic emissions are taken from the RCP 6.0 data by Fujino et al., (2006). The anthropogenic emissions are prescribed from monthly values, which have been linearly interpolated from annual emission fluxes.

We acknowledge that volcanic eruptions and human activities are unexpected factors in the model. In fact, limiting our projections to the RCP 6.0 scenario is already a strong limitation, as other scenarios have been proposed, such as the RCP 2.6, RCP 4.5, RCP 8.5. More recently, the Shared Socioeconomic Pathways (SSP) SSP1, SSP2, SSP3, SSP4 and SSP5. However, we did not count with enough computational resources to simulate all the possible future scenarios.