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Mechanisms of the global electric circuit and lightning variability on the ENSO time scale

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Many studies of lightning activity on the El Niño–Southern Oscillation (ENSO) time scale show increased activity over tropical land areas during the warm El Niño phase (e.g., Satori et al., 2009; Price, 2009). The mechanisms of this variability—particularly in terms of its role in the global electric circuit (GEC)—are still under debate (e.g., Williams and Mareev, 2014). In this study a general circulation model of the atmosphere and ocean INMCM4.0 (Institute of Numerical Mathematics Coupled Model) is used for modelling the GEC variability on the ENSO time scale. The ionospheric potential (IP) and the lightning flash rate are calculated to study regional peculiarities and possible mechanisms of lightning variation. The IP parameterisation is used (Mareev and Volodin, 2014) which takes into account quasi-stationary currents of electrified clouds (including thunderstorms) as principal contributors into the DC global circuit. The account of conductivity variation in the IP parameterisation is suggested based on the approach realised in (Slyunyaev et al., 2014). Comparison of simulation results with the observational data on lightning activity on the ENSO time scale is discussed.

Numerical simulations suggest that the inter-annual IP variability is low and does not exceed 1% of the mean value, being tightly correlated with the mean sea surface temperature (SST) in the Pacific Ocean (180W–100W, 5S–5N—El Niño area). The IP maximum corresponds to the SST minimum. This result can be explained taking into account that during El Niño (positive temperature anomaly) precipitations in the equatorial part of the Pacific increase while in other tropic zones including the land areas they decrease.

Comparison of simulation results with the observational data on lightning activity on the ENSO time scale is discussed. During the El Niño period in the model, the mean aerosol content in the atmosphere decrease, which is caused by the weakening of the winds over Sahara and South-West Asia lifting dust into the atmosphere. Taking into consideration the decrease in the number of thunderstorms, this does not explain the observed global lightning variation. As another possible explanation for the enhanced El Niño lightning activity, the variation of the atmospheric aerosols and cloud condensation nuclei due to fires is discussed.

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