

Characteristics of North European winter lightning related to a high positive mode of the North Atlantic Oscillation

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Abstract

In this study, we use the World Wide Lightning Location Network data and investigate properties of more than ninety thousand lightning strokes which hit Northern Europe during an unusually stormy winter 2014/2015. Thunderstorm days with at least two strokes hitting an area of $0.5^\circ \times 0.5^\circ$ occurred 5-13 times per month in the stormiest regions. Such frequency of thunderstorm days is about five times higher than a mean annual number calculated for the same region over winter months in 2008-2017. The number of individual winter lightning strokes was about four times larger than the long-term median calculated over the last decade. In colder months of December, January and February, the mean energy of detected strokes was by two order of magnitude larger than the global mean stroke energy of 1 kJ. We show for the first time that winter superbolts with radiated electromagnetic energies above one mega joule appeared at night and in the morning hours, while the diurnal distribution of all detected lightning was nearly uniform. We also show that the superbolts were often single stroke flashes and that their subsequent strokes never reached MJ energies. The lightning strokes were concentrated above the ocean close to the western coastal areas. All these lightning characteristics suppose an anomalously efficient winter thundercloud charging in the eastern North Atlantic, especially at the sea-land boundary. We found that the resulting unusual production of lightning could not be explained solely by an anomalously warm sea surface caused by a positive phase of the North Atlantic Oscillation and by a starting super El Nino event. Increased updraft strengths, which are believed to accompany the cold to warm transition phase of El Nino, might have acted as another charging driver. We speculate that a combination of both these large-scale climatic events might have been needed to produce observed enormous amount of winter lightning in winter 2014/2015.

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