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The Impact of Mesoscale Convective Systems in Increasing the Upper Tropospheric Water Vapor: Evidence from WMO announced Lightning Megaflash Events

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We have studied five extraordinary lightning flashes recognized by the World Meteorological Organization (WMO) and recorded with the Geostationary Lightning Mappers (GLMs) on the R-series Geostationary Operational Environmental Satellites (GOES-16 and 17) data. The five special events are:
(1) The greatest duration flash of 17.102 ± 0.002 seconds over Uruguay and northern Argentina on 18 June 2020,
(2) The longest single flash that covered a horizontal distance of 768 ± 8 km (477.2 ± 5 miles) across parts of the southern United States on 29 April 2020,
(3) A single lightning flash is 16.730 ± 0.002 s from a flash that developed continuously over northern Argentina on 4 March 2019,
(4) A single flash that covered a horizontal distance of 709 ± 8 km (441 ± 5 mi) across parts of southern Brazil on 31 October 2018,
(5) The 2017 Oklahoma MCS having an LMA-derived length of 321 km.

This paper investigates the influence of Mesoscale Convective System (MCS) thunderstorms on the Upper Tropospheric Water Vapor (UTWV) concentration. We have used independent data sets of water vapor, lightning activity and cloud radiance to investigate this relationship. We have found that the maximum concentrations of UTWV may reach ~ 9 micro-grams/kg of air, or 9 ppmv at the event time. We observed an average of one order of magnitude increase of UTWV at 300hPa pressure level at the event time of all megaflashes we are reporting. It is evident from our analysis that a single megaflash event exceeds the threshold area for a Mesoscale Convective Complex (MCC) of ≥ 50,000 km². If MCCs were circular, the threshold diameter of the cloud is 179 km and of the cold cloud 252 km (Maddox et al., 1980). These two megaflashes have horizontal extents much greater than both these numbers. We have recognized these giant convective complexes as exceptional Mesoscale Convective Systems (MCS) (Jirak et al., 2003) having cloud shield area >= 100,000 km² and cloud top temperature (interior) <= -52°C. The impact of megaflashes in increasing the UTWV may be a useful diagnostic for climate change as it is an intense greenhouse agent which traps the additional heat released from the Earth's surface.

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