Article

Meteorological Conditions Associated with Lightning Ignited Fires and Long-Continuing-Current Lightning in Arizona, New Mexico and Florida

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1. Introduction

This supplement includes detailed plots (Fig.S S1 to Fig. S4) of the meteorological conditions that favor the occurrence of LCC(>18 ms)-lightning in the Western Mountains and Arid West (WMAR) and in the Atlantic and Gulf Coastal Plain (AGCP).

2. Meteorological conditions of LCC(>18 ms)-lightning

2.0.1. Western Mountains and Arid West

In this section, we investigate the meteorological conditions of thunderstorms producing LCC(>18 ms)-lightning over the WMAW (between 93.5°W and 114°W longitude degrees and 31.5°N and 38°N latitude degrees) during the fire season (from June to September) and between 1998 and 2014. We use optical observations reported from the space-based instrument Lightning Imaging Sensor (LIS) onboard the TRMM satellite between 1998 and 2014 [1–6]. Meteorological data are obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF) fifth generation reanalysis (ERA5) [7].

We analyze in Fig. S1 the value distribution of several meteorological parameters during the occurrence of typical and LCC(>18 ms)-lightning flashes over the WMAW. We have selected the same meteorological variables as shown in Fig.4 for the case of LIW in Arizona & New Mexico (ANM). According to Fig. S1(a, c), there are not significant differences in the median values of the 1-hourly accumulated precipitation and the CBH for LCC(>18 ms)-lightning and typical lightning (p-value higher than 0.05). However, there are some preferential meteorological conditions for the occurrence of LCC(>18 ms)-lightning in the area. Fig. S1(b) shows that thunderstorms producing LCC(>18 ms)-lightning tend to occur at colder air temperature at surface than the climatological median. Figures Fig.S S1(d-f) indicate, respectively, that the preferential conditions for the occurrence of LCC(>18 ms)-lightning are higher wind shear, lower temperature difference between 700 hPa and 450 hPa pressure levels and higher total totals index. Lower temperature difference between vertical levels and higher total totals index than the climatological medians suggest that LCC(>18 ms)-lightning tend to occur in thunderstorms that are more humid than the climatological median.

We plot in Fig. S2 the median vertical profile of some meteorological parameters during the occurrence of typical and LCC(>18 ms)-lightning flashes, following the same approach as in Fig.5 for LIW. Fig. S2(a-c) suggest that LCC(>18 ms)-lightning flashes tend to occur in thunderstorms with median values of relative humidity, specific cloud ice water content and specific rain water content that are higher than the climatological median, confirming that the total totals index are higher than the climatological median due to higher moisture. Fig. S2(d) indicates that the updraft is lower than the climatological median at altitudes below the 600 hPa pressure level and higher at higher altitudes. Finally, Fig. S2(e) shows that the median vertical profile of the temperature is significantly lower than the climatological median for thunderstorms producing LCC(>18 ms)-lightning. High convection and ice

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content coincide with the characteristics of typical supercells, while similar accumulated precipitation suggest that LCC(>18 ms)-lightning-producing thunderstorms are not low precipitation thunderstorms.

2.0.2. Atlantic and Gulf Coastal Plain

The meteorological conditions of thunderstorms producing LCC(>18 ms)-lightning over the AGCP region during the fire season (from May to September) and between 1998 and 2014 are investigated in this section. We exclude lightning flashes taking place over ocean.

Fig. S3(a) shows that LCC(>18 ms)-lightning flashes tend to occur in thunderstorms with a lower median precipitation accumulated in 1 hour than the climatological median, while Fig. S3(b, c) show that the median temperature at surface and CBH are lower than the climatological median. Fig. S3(d, e, f) suggest that the instability of thunderstorms producing LCC(>18 ms)-lightning is higher than the climatological median, since the wind shear, the temperature difference between 700 hPa and 450 hPa pressure levels and the total totals index are higher than the climatological median.

We plot in Fig. S4 the vertical profile of the median values of some selected meteorological variables. Fig. S4(a-c) show that the relative humidity, the specific cloud ice water content and the specific rain water content tend to be higher than the climatological median for thunderstorms producing LCC(>18 ms)-lightning. Furthermore, Fig. S4(d) suggests that there are not significant differences in the vertical velocity between thunderstorms producing LCC(>18 ms)-lightning and typical thunderstorms. Finally, similarly as in the WMAW, Fig. S4(e) shows that the median vertical profile of the temperature is significantly lower than the climatological median for thunderstorms producing LCC(>18 ms)-lightning.

Data Availability Statement: TRMM-LIS data can be freely downloaded from https://ghrc.nsstc.nasa.gov/lightning/data/data_lis_trmm.html. NLDN data can be obtained upon request to Vaisala. The ERA5 meteorological data are freely accesible through Copernicus Climate Change Service (C3S) (2017): ERA5: Fifth generation of ECMWF atmospheric reanalyses of the global climate . Copernicus Climate Change Service Climate Data Store (CDS) https://cds.climate.copernicus.eu/cdsapp. Fire data can be freely downloaded from https://www.fs.usda.gov/rds/archive/Catalog/RDS-2013-0009.5.

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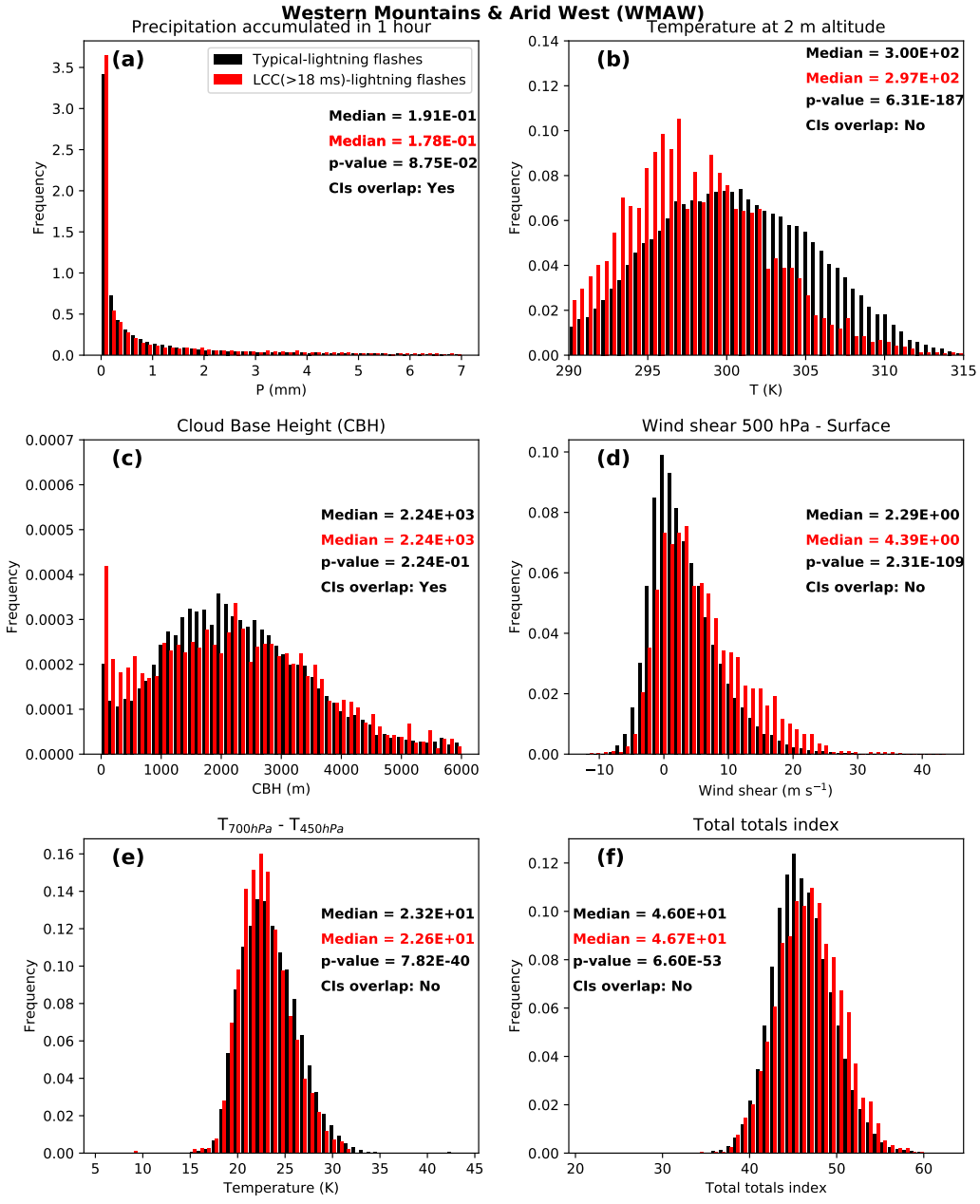

Figure S1. Frequency distribution of hourly accumulated precipitation (a), air temperature at 2 m altitude (b), CBH value (c), wind shear between 500 hPa pressure level and surface (d), temperature difference between 700 hPa and 450 hPa pressure levels (e) and total totals index (f) for typical lightning flashes (black) and the LCC(>18 ms)-lightning (red) in WMAW during the fire season between 1998 and 2014. he p-values have been obtained from the Kruskal-Wallis H-tests [8]. The results of the analysis of the overlap between 95% bootstrap CI of medians is included.

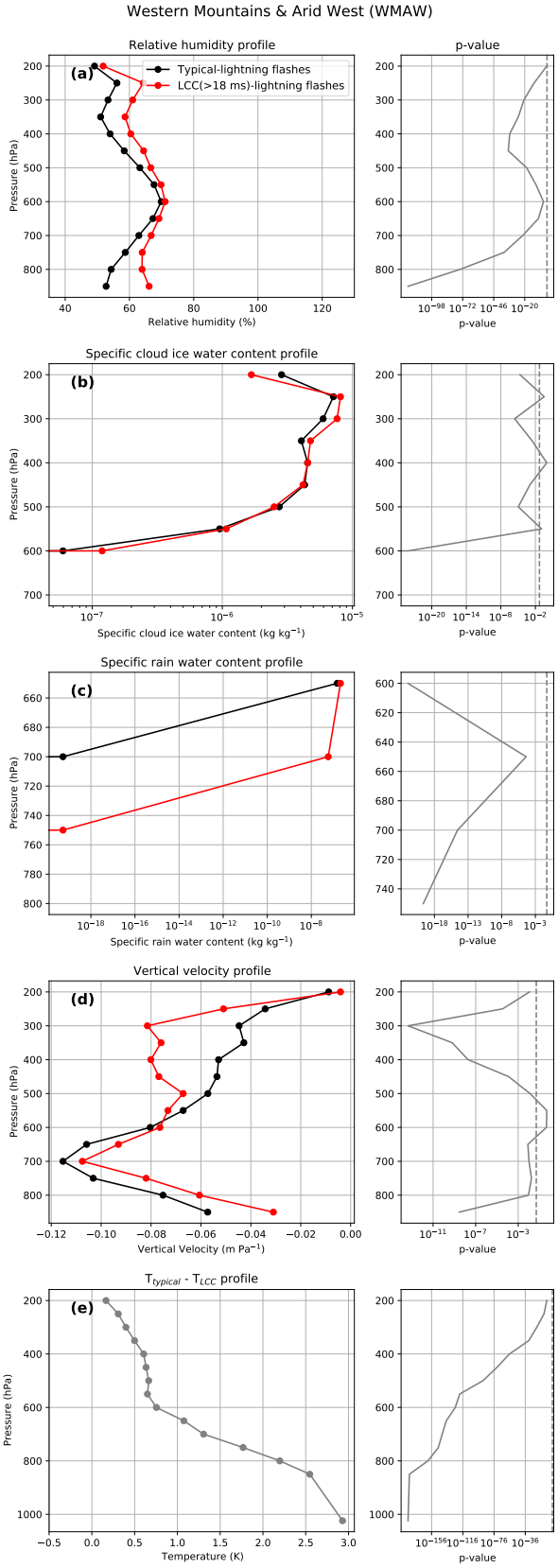

Figure S2. Vertical profiles of the most important meteorological conditionsor typical lightning flashes (black) and the LCC(>18 ms)-lightning (red) in WMAW. The first column shows the vertical profiles of the relative humidity (a), specific cloud ice water content (b), specific rain water content (c), vertical velocity (d) and temperature difference (e) for typical lightning flashes (black) and the LCC(>18 ms)-lightning (red) climatologies during the fire season in the WMAW between 2009 and 2013. The second column shows the $p-value$ (solid line) for each vertical level representing the probability of equal median between both distributions and a mark showing the limit at 0.05 (dashed line). The p-value has been obtained by the Kruskal-Wallis H-test [8].

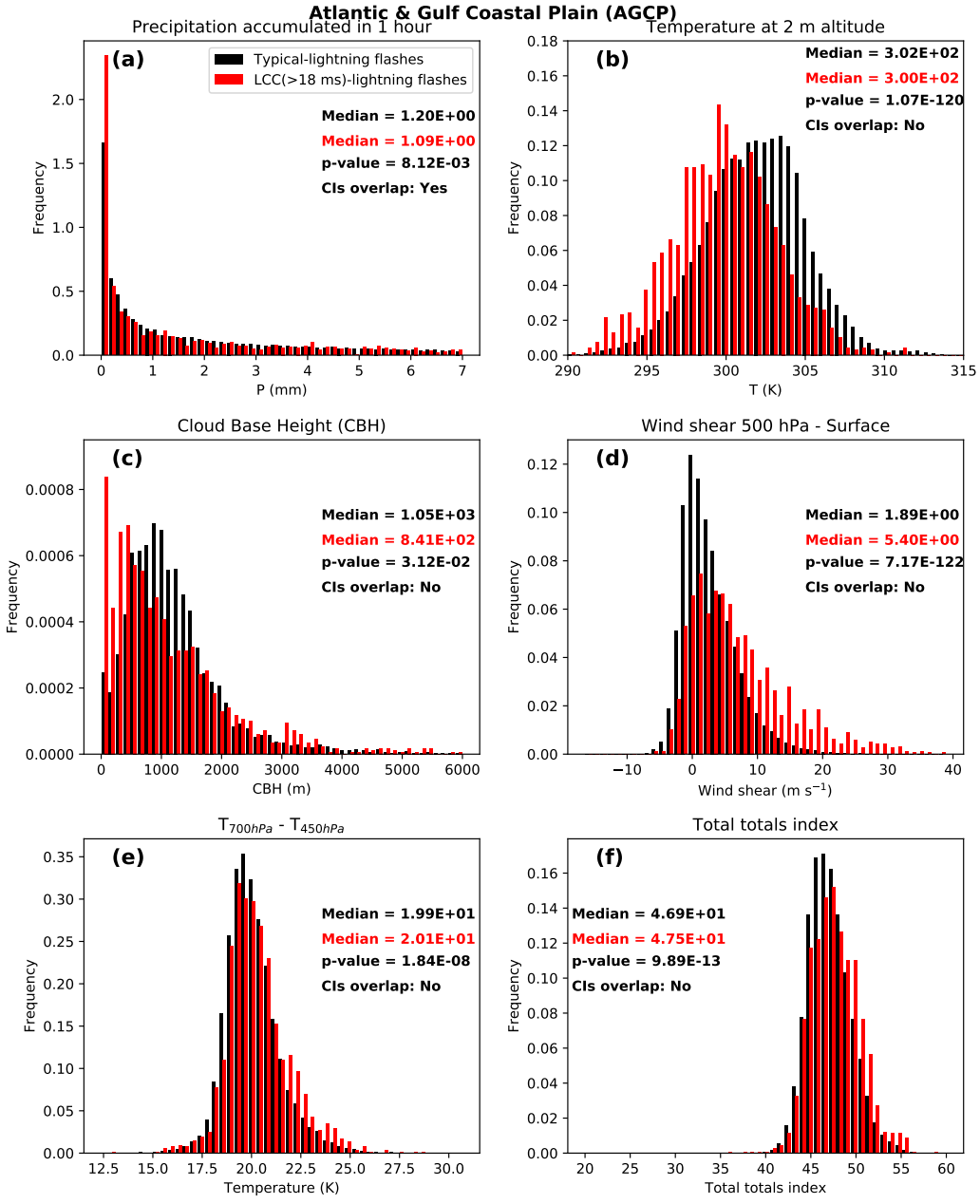

Figure S3. Frequency distribution of hourly accumulated precipitation (a), air temperature at 2 m altitude (b), CBH value (c), wind shear between 500 hPa pressure level and surface (d), temperature difference between 700 hPa and 450 hPa pressure levels (e) and total totals index (f) for typical lightning flashes (black) and the LCC(>18 ms)-lightning (red) in AGCP during the fire season between 1998 and 2014. he p-values have been obtained from the Kruskal-Wallis H-tests [8]. The results of the analysis of the overlap between 95% bootstrap CI of medians is included.

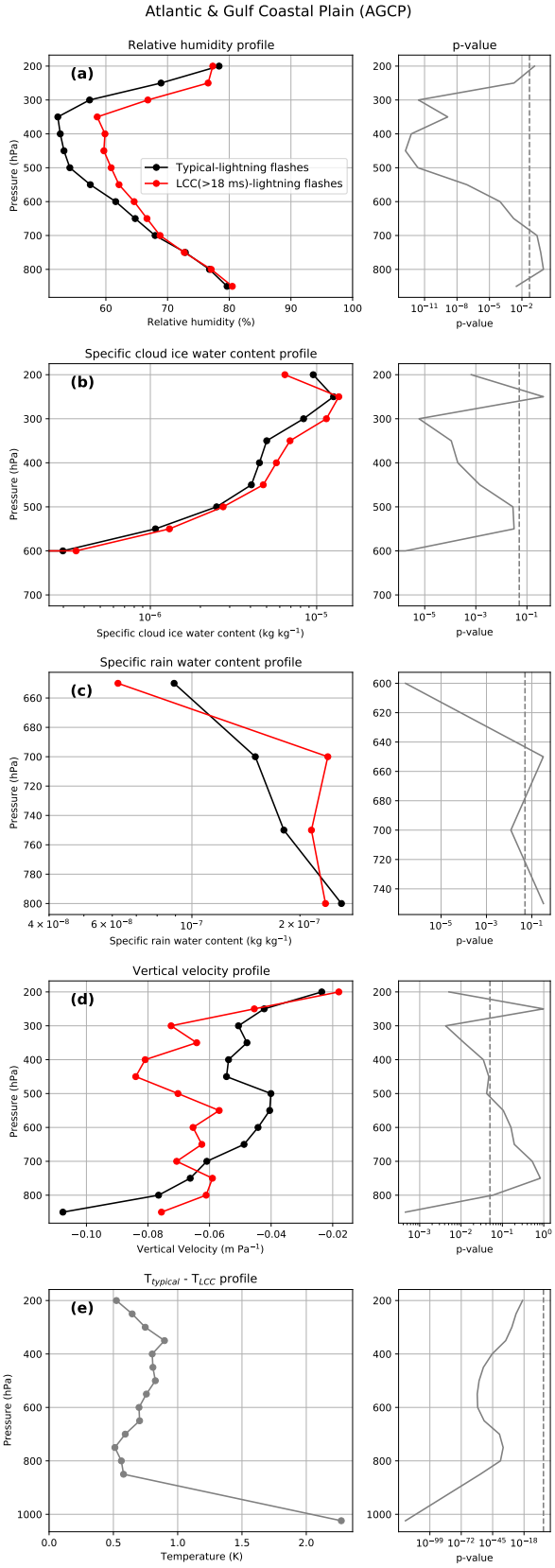

Figure S4. Vertical profiles of the most important meteorological conditionsor typical lightning flashes (black) and the LCC(>18 ms)-lightning (red) in AGCP. The first column shows the vertical profiles of the relative humidity (a), specific cloud ice water content (b), specific rain water content (c), vertical velocity (d) and temperature difference (e) for typical lightning flashes (black) and the LCC(>18 ms)-lightning (red) climatologies during the fire season in the AGCP between 2009 and 2013. The second column shows the $p-value$ (solid line) for each vertical level representing the probability of equal median between both distributions and a mark showing the limit at 0.05 (dashed line). The p-value has been obtained by the Kruskal-Wallis H-test [8].

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