



Figure 8. Analogous to Fig 3, but for Case #4 at 18:42 UT.

The tropopause is found between 10 and 15 km at mid-latitudes in summer but can descend below 10 km in winter, limiting the vertical extent of convection [12]. Climatology from the closest sounding station (Barcelona, 250 km NE of the region of study) of the last 15 years shows the tropopause moving around 12.5-13.0 km in summer months, and between 10.5 and 11.5 km from December to April.

Focusing on the case study, the three analysed days had the following vertical profile: The 0°C isotherm was below 3.0 km, the -20°C around 6.0 km, the -40°C around 8.0 km and the tropopause between 10.0 and 11.0 km. Analysing the lightning activity throughout those days, it is interesting to note that there is activity in the LMA only when radar reflectivity >12 dBZ is reported above the -40°C isotherm height (around 8.0 km). Besides, radar reflectivity > 35 dBZ is above the -20°C isotherm height, indicating sufficient conditions for electrification. On the analysed days, the TOP-35 radar product (maximum height of 35 dBZ) hardly reached 7 km,

The bulk of the LMA sources were distributed around 4 km, just above the melting layer. In fact, the melting layer can be inferred in Fig. 6, where the “bright band” radar signal is visible and occurs in the layer where snowflakes are melting into rain [13].

Lightning occurrence displays a marked seasonality in Catalonia, with about 50% of the activity taking place in July

and August, according to the last ten years average. 83% of lightning occur from June to September, and 94% from May to October. The months of the present case studies, April and November, account 3.7% and 1.3% of the annual activity, respectively. Therefore, the storms analysed here can be considered “out of season”. Regarding risk assessment, even if downward lightning to wind turbines can be more common in relation to deep convective situations, results suggest that “out of season” thunderstorms, showing limited vertical extent, may also be a threat to wind turbines.

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