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Lightning channels emerging from the top of thunderstorm clouds

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In recent years, research of transient luminous events is shifting from the rather common elves and sprites high above thunderclouds to the much less frequently observed phenomena issued by the storm cloud itself: gigantic jets (GJ) connecting to the ionosphere, and high-energy terrestrial gamma-ray flashes (TGFs) recorded at spacecraft. These phenomena both are observed more often at tropical latitudes, and a link may or may not exist between the two. It is likely that both share the requirement of high-altitude leaders of negative polarity, which in the case of a GJ escapes from the cloud top and transforms into a long streamer discharge. While this should be easier at lower air densities (higher altitude), previous studies showed that GJs need not be produced by storms with the highest tops. TGFs have still unclear origins, but may be related to production in negative leaders or other regions with strong vertically directed electric fields by runaway electron mechnisms.
In December 2009, a gigantic jet was observed in the Mediterranean Sea region. During the same night, a nearby storm produced repeatedly multiple leaders piercing through the cloud top, without any sign of streamers reaching higher altitudes (unlike jets or starters). Similar observations of upward cloud-to-air lightning have been obtained recently by low-light cameras over storms near the Catalonian coast in different seasons. The production conditions are currently being investigated, with a focus on optically determined altitudes of lightning and evolution of storm tops (and their temperature level). The initial impression is that cloud flashes escape into the air above during stages when the growing convective cloud top is very close to the main charge production region. Upward cloud-to-air lightning has also been mapped by the Ebro Lightning Mapping Array, exhibiting inverse bolt-from-the blue characteristics, and as a by-product of a bolt-from-the-blue lightning strike to ground, recorded by a high-speed camera.