Transient synchronization and coupling of lightning activity in severe Mediterranean winter thunderstorms

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Analysis of space-shuttle video footage of 6 storm systems with different flash rates, obtained during the STS-107 mission in January 2003, showed that when the storm flash rate is high, lightning activity in separate thunderclouds becomes clustered, with bursts of nearly simultaneous activity separated by quiet periods [Yair et al., *JASTP*, 2006]. The analysis was expanded to sequences of lightning flashes in Mediterranean winter thunderstorm, based on data obtained during the 2004/5 and 2005/6 seasons from ground-based lightning location systems. We found similar patterns of clustering and synchronicity of flashes in individual clouds, separated by tens to hundreds of kilometers, hinting at a possible mutual electromagnetic coupling of remote thunderstorms. We developed a theoretical model that is based on the "fire and integrate" concept of Mirrolo and Strogatz [1990], in order to simulate the flashing behavior of a weakly coupled network of thunderstorm cells. In this type of coupling, the intensity of the electric field in a thunderstorm (i) grows with time, reaches the critical breakdown value, generates a lightning flash and its field drops to zero, while adding a ΔE to the intensity of the internal electric field in all thunderclouds (j) that are linked to it. The value of ΔE is inversely proportional to the distance between clouds i and j. Several topologies of the thunderstorm network were tested with varying degrees of coupling, assuming a fixed probability of links between active cells. The results suggest that when a critical value of coupling is surpassed, all thunderstorm cells will flash in a synchronized manner. The physical mechanisms that are possibly interacting will be discussed.