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Multisensor analysis of an impressive hail storm: observations by GPM of extremely rare features over the Mediterranean region

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On September 05, 2015 a violent hail storm hit the Gulf and the city of Naples in Italy. The storm was caused by a southward plunge of the jet stream that carved into Western Europe, sending an upper disturbance into the Italian peninsula. That instability, associated with high Sea Surface Temperature (SST), and low-level convergence, stirred up an impressive severe thunderstorm with intense lightning activity and strong winds, that started developing around 0600 UTC over the Tyrrhenian Sea off the coast of Naples, and reached maturity by 0637 UTC, hitting the coast around 0900 UTC, moving inland afterwards, until its complete dissipation around 1200 UTC. The storm dropped 7-10 cm diameter hailstones along its path over the sea, and in Pozzuoli, near Naples. During its mature phase, at 0845 UTC, the hail storm was captured by one overpass of the Global Precipitation Measurement mission Core Observatory (GPM-CO), launched in February 2014, and equipped with the GPM Microwave Imager (GMI) (the most advanced multichannel conical-scanning microwave radiometer available), and with the Ka/Ku band Dual-frequency Precipitation Radar (DPR). In this study GPM-CO observations are thoroughly analyzed and discussed, along with the analysis of other spaceborne and ground-based measurements. The LINET ground based lightning detection network registered over 37000 strokes between 0500 and 1200 UTC in the areas hit by the storm throughout its evolution. Meteosat Second Generation (MSG) SEVIRI VIS/IR images show the extremely rapid development of the storm, with cloud-top temperatures (at 10.8 μm) dropping from 270 K at 0657 UTC to the extremely low value of 205 K at 0637 UTC (65 K in 40 minutes). The occurrence of a very well defined convective overshooting top is evidenced by the VIS images and by the analysis of the brightness temperature (TB) differences in the three 183 GHz water vapor channels of AMSU/MHS (MetOp-A overpass at 0834 UTC and MetOp-B overpass at 0929 UTC), usually applied to tropical convective clouds. DPR shows vertical extension of more than 16 km a.s.l., with top height reflectivity values up to 40 dBZ at 14 km and 20 dBZ at 16 km, signs of strong updraft, supporting large ice hydrometeors, and confirming the presence of the deep overshooting above the 13.5 km tropopause. GMI observations show strong TB depressions with 19 GHz (V-Pol) TBs values as low as 158 K, while at 37GHz, 89GHz, and 166 GHz TBs are as low as 97K, 67K, and 87K, respectively. Such low values, similar in both V and H polarization channels, indicate the presence of high density, round shaped and/or tumbling, large iced hydrometeors. In almost two years of GPM global observations, due to the remarkable low TBs, the storm ranks as third in terms of 37 GHz polarization-corrected temperature (PCT) values (100 K), and first in terms of 19 GHz V-Pol TB values. The comparative use of measurements from GMI and DPR with those available from other sensors provides observational evidence of extremely rare features of such severe hail storm, and demonstrates the potentials of the GPM-CO in providing unique spaceborne measurements of 3-D structure of precipitation.