Geophysical Research Abstracts,
Vol. 11, EGU2009-13670, 2009
EGU General Assembly 2009
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Precipitation nowcasting from geostationary satellite platforms: Neural network methodology exploiting low-Earth-orbit and ground-based data synergy

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Many severe meteorological events develop at short time scales. The availability of effective rain-rate nowcasting techniques is valuable for Civil Protection purposes. Neural network based nowcasting techniques, exploiting satellite data, have been proven to be more accurate than conventional techniques. Several rain retrieval techniques have been proposed on the basis of multi-satellite imagery, exploiting passive sensor measurements acquired by Geostationary-Earth-Orbit (GEO) and Low Earth Orbit (LEO) platforms. These approaches tend to overcome some inherent limitations due to the use of satellite thermal infrared (IR) radiances, which are measurements poorly correlated with rainfall. In this respect, microwave (MW) radiometric data available from Low Earth Orbit (LEO) platforms can provide more accurate rain estimates. MW brightness temperatures are fairly sensitive to liquid and ice hydrometeors since rain clouds are not optically opaque at microwave frequencies. GEO satellites can ensure Earth coverage with a high temporal sampling, whereas LEO satellites have the drawback of low temporal sampling. Therefore, LEO-MW and GEO-IR radiometry are clearly complementary for monitoring the Earth's atmosphere and a highly variable phenomenon such as precipitation. The IR radiances from geostationary images can be properly calibrated using microwave-based combined algorithms. Microwave data can be extracted from the microwave imager sensors, but any rain estimation source may be, in general, foreseen. Ground based meteorological radar reflectivity can also be exploited.

The objective of this work is to identify guidelines for improving the neural-network approach successfully applied to the rainfall field nowcast from thermal infrared and microwave passive-sensor imagery aboard, respectively, Geostationary-Earth-Orbit (GEO) and Low-Earth-Orbit (LEO) satellites, using infrared (IR) multi-channel data available from Meteosat Second Generation (MSG) and microwave (MW) data from LEO satellites or ground based meteorological Radar. The multi-sensor space-time prediction procedure, being based on the Neural Combined Algorithm for Storm Tracking (NeuCAST), consists of two consecutive steps: first, the infrared radiance fields measured from geostationary satellite radiometer (e.g, MSG) are projected ahead in time (e.g., 30 minutes); secondly, the projected radiance field is used to estimate the rainfall field by means of a MW-IR combined rain retrieval algorithm exploiting GEO-LEO or GEO-Radar observations. The MSG NeuCAST methodology is here illustrated and discussed. Its accuracy is quantified by means of quantitative error indexes, evaluated on selected case studies of rainfall events in Southern Europe between 2003 and 2006.