FIRST OPERATIONAL RESULTS OF RELASE (RAINFALL ESTIMATION FROM LIGHTNING AND SEVIRI DATA) SOFTWARE AT CNMCA

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I. INTRODUCTION

For the next generation of geostationary meteorological satellites (Meteosat Third Generation - MTG) an optical Lightning Imaging (LI) mission is planned. Together with the GLM (Geostationary Lightning Mapper), that will be flown on the next generation of GOES (Geostationary Operational Environmental Satellite) series, there will be an almost global coverage for lightning detection from space. These continuous flow of lightning data will be crucial and critical in many applications as in nowcasting, climatology and atmospheric research.

The collaboration between CNMCA (Centro Nazionale di Meteorologia e Climatologia Aeronautica - Italy) and SELEX-GALILEO (a Finmeccanica company) aims to study a possible use of lightning data in hydrological field. A rainfall retrieval technique that uses geostationary satellite Infrared (IR) observations and lightning information retrieved from LAMPINET (lightning network of the Italian Air Force Meteorological Service) is presented in this paper.

A comparison with products of HSAF (EUMETSAT Satellite Application Facility on Support to Operational Hydrology and Water Management) is also presented.

II. PRESENTATION OF RESEARCH

One of the objectives of the "EUMETSAT Satellite Application Facility on Support to Operational Hydrology and Water Management (H-SAF)" is to provide new satellite-derived products from existing and future satellites with sufficient time and space resolution to satisfy the needs of operational hydrology. A possible contribution to improve the liquid precipitation products using lightning data is presented.

Polar satellites alone present some problems to identify convective rain because of their low spatial and temporal resolution. It's even possible that a severe storm can start and finish between two passages of satellites.

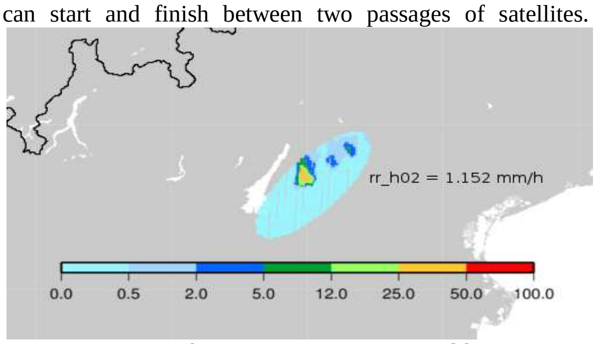

Fig. 1 - Comparison between precipitation retrieval by microwave sensor on polar satellite (AMSU) and radar.

On the other hand geostationary satellites offer a better spatial e temporal resolution but sensors onboard (VIS and IR) are not the best to retrieve precipitation. Therefore lightning detection, and the correlation between number of lightning and rainfall, can be very useful to improve satellite retrieval of precipitation.

For this purpose a software named RELASE (Rainfall Estimation from Lightning And Seviri data) has developed at CNMCA. This software works on Italian area because now it can use only LAMPINET data, but it can be easy modified to work with others lightning detection networks or (in the future) with LI data.

Flux diagram of the software is in figure 2.

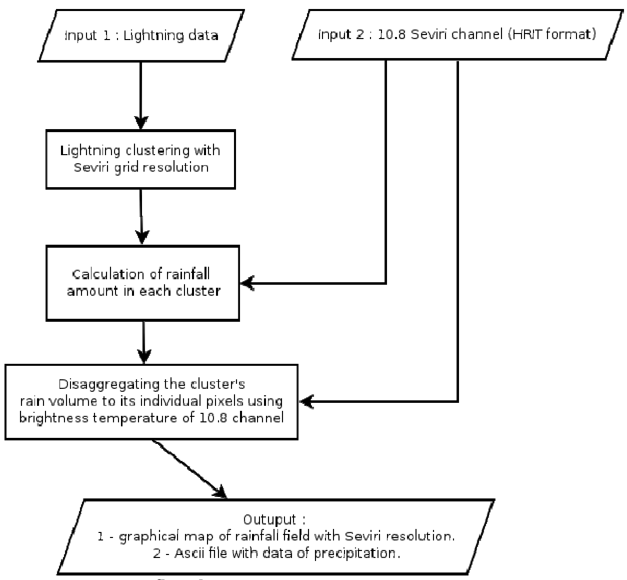

Fig. 2 - RELASE flux diagram

To determine a quantitative relationship for rainfall estimation using lightning and Seviri data a bivariate linear regression for the cluster's rain volume has been employed:

$$RR = (b_0 + b_1 S/N + a_2 T)N$$

where RR is the cluster's rain volume in mm h^{-1} km^2 (from Italian weather radar network), S is the number of the flashes (from Lampinet), T in °K is the minimum 10.8 µm brightness temperature in the cluster and N is the number of pixels in the cluster. The coefficients b_0 , b_1 , and b_2 are determined using a least squares regression.

To disaggregate the cluster's rain volume to its individual pixel the histogram of the IR temperature (constructed from all pixels associated with lightning that exist in the dataset) has been used (Fig. 3).

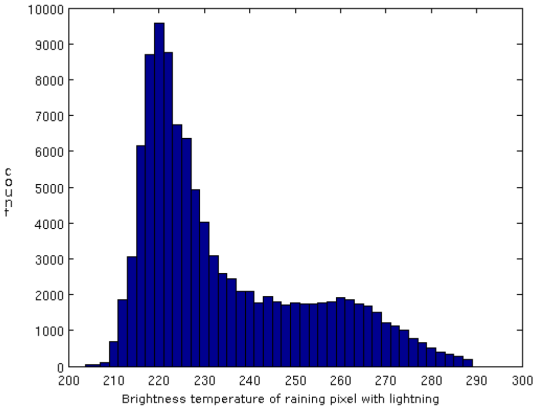

Fig 3 - Histogram of britghtness temperature of raining pixels with lightning

The probabilities

$P(T_i)$ = P(a raining pixel has temperature > T_i)

is calculated from the histogram. The disaggregation procedure uses these IR temperature probabilities to compute weights for each individual pixel of a convective cluster. A pixel's weight is defined as the ratio of the pixel's probability to the sum of probabilities of all pixels located within the same convective cluster. The proposed combined IR–lightning algorithm for convective rainfall estimation can be summarized as follows:

1. read an IR image (software can read HRIT seviri raw format directly);
2. determine the lightning strikes within a 15 minutes window, centred around the IR sampling time;
3. determine the lightning clusters;
4. determine the rain volume of each cluster with the equation above;
5. allocate the rain volume of each cluster to pixels based on histogram and probability written above;

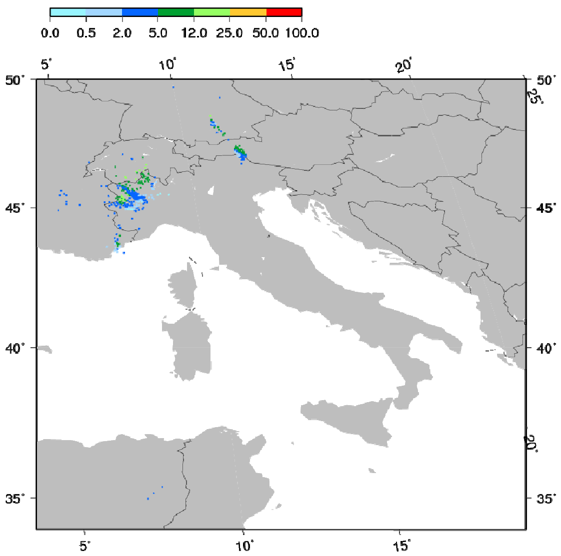

Fig 4 - An image output of RELASE

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III. RESULTS AND CONCLUSIONS

Dataset is composed by 27 days of gathered data (radar rainfall rate, 10.8 µm Seviri images, LAMPINET data) from 3rd March 2011 to 30th June 2011. In each of these days there are multiple storms. Dataset contains 4703 lightning's clusters. This dataset has been used for the calibration of software (i.e. least squares regression to determinate the coefficients b_0 , b_1 , and b_2). The mean values of parameters identified by this calibration are b_0 = 0.5131, b_1 = 0.2373 and b_2 = -0.0014.

From 1st July RELASE is in operative chain at CNMCA and works h24. In this first period of evaluation, to characterize statistically the agreement between radar rainfall rate (considered as "true" value) and lightning observations three performance scores has been used: the probability of detection (POD), the false alarm rate (FAR), and the critical success index (CSI), defined as

where $n_{success}$, $n_{failure}$ and $n_{false\ alarm}$ are the numbers of successes, failures, and false alarms, respectively, in the comparison. A comparison yields a success when there is lightning and a radar rainfall rate greater than 10 mm/h, a false alarm when there is lightning but not rainfall, and a failure when there is rainfall greater than 10 mm/h with no lightning indications.

The software has been tested on 873 lightning's clusters and the results are:

POD = 0,48 FAR = 0.34 CSI = 0.30

The general conclusion of this study is that lightning data contain useful information for satellite rainfall estimation, mainly in convective phenomena where MW retrivial can presents some problems. Good scores of RELASE software suggests a possible use as product in HSAF project to improve rainfall estimation of MW and IR techniques.

V. REFERENCES

Grecu M., Anagnostou E., 2000: Assessment of the Use of Lightning Information in Satellite Infrared Rainfall Estimation, *J. Hydrometeor*, **1**, 211–221

Rosenfeld D., 2008: Assessment of the added application capabilities of LI to the planned MTG mission, *EUMETSAT*

Tapia, A., Smith, J. A., and Dixon, M, 1998: Estimation of convective rainfall from lightning observations, *J. Appl.Meteorol.,* 37, 1497–1509