Assessment of an Extreme Rainfall Detection System for flood prediction over Queensland (Australia)

Paola Mazzoglio*, Francesco Laio, Constantin Sandu and Piero Boccardo

* paola.mazzoglio@ithaca.polito.it

© Contains modified NASA MODIS data [2019] processed by Sentinel Hub
ERDS
(EXTREME RAINFALL DETECTION SYSTEM - erds.ithacaweb.org)

ERDS is a service for the monitoring and forecasting of exceptional rainfall events, with a nearly global spatial coverage. ERDS is also an alert system designed to identify hydrometeorological events, such as hurricanes, tropical storms, convective storms, flash floods and heavy rainfall that could lead to flood events or landslides.

The information is accessible through a WebGIS application, developed in a complete Open Source environment.
ERDS NEAR REAL-TIME RAINFALL MONITORING

INPUT DATA
NASA GPM IMERG half-hourly data

RAINFALL AMOUNT EVALUATION
(12 – 24 – 48 – 72 – 96 hours aggregation interval)

EXTREME RAINFALL DETECTION
IDENTIFICATION OF AREAS POTENTIALLY AFFECTED BY HYDROLOGICAL DISASTERS
## INPUT DATA

NASA GPM (Global Precipitation Measurement) 
IMERG (Integrated Multi-satellite Retrievals for GPM) early run products

<table>
<thead>
<tr>
<th>TEMORAL COVERAGE</th>
<th>SPATIAL COVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>from 12 March 2014 to nowadays</td>
<td>60° N – 60° S</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TEMPORAL RESOLUTION</th>
<th>SPATIAL RESOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 minutes</td>
<td>0.1° x 0.1°</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LATENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 hours</td>
</tr>
</tbody>
</table>
The extreme rainfall detection is based on the concept of event-identification threshold: an alert is provided if the accumulated rainfall exceeds the threshold.
The threshold methodology is based on threshold values equal to a percentage of the mean annual precipitation. The mean annual precipitation was calculated using 10 years of GPCC monthly “Monitoring Product”.

MORE INFO ON:
Mazzoglio, P.; Laio, F.; Balbo, S.; Boccardo, P.; Disabato, F.
Improving an Extreme Rainfall Detection System with GPM IMERG data.
QUEENSLAND CASE STUDY

According to the Australian Government Bureau of Meteorology (BOM), heavy rainfall affected Queensland (Australia) from 26th January 2019 until 9th February 2019.

Several localities received more than four times their February average rainfall. The massive amount of rainfall led to moderate to major flooding. Several cities were also partially affected and Copernicus Emergency Management Service was activated with the aim of providing an assessment of the impact of the event.
This study aims to evaluate NASA GPM (Global Precipitation Measurement) IMERG (Integrated Multi-satellite Retrievals for GPM) early run half-hourly data in the detection of the extreme rainfall that led to this massive flood event by comparing the weekly accumulated rainfall with in-situ rainfall measurements.

Alerts provided by ITHACA Extreme Rainfall Detection System (ERDS) were analyzed in order to estimate the most affected areas.

ERDS outputs were also validated using an automatic flooded areas extraction performed both on Sentinel-3 and on MODIS (Moderate-resolution Imaging Spectroradiometer) optical images acquired after the end of the rainy period.
ANALYSIS OF AVAILABLE RAINFALL MEASUREMENTS

NASA GPM IMERG HALF-HOURLY EARLY RUN DATA

DAILY RAINFALL MEASUREMENTS CONTAINED IN THE BUREAU OF METEOROLOGY CLIMATE DATABASE (AUSTRALIAN DATA ARCHIVE FOR METEOROLOGY – ADAM)

Rainfall data were analyzed in the following three different time periods:

• from 18th January 2019 23:00 UTC to 25th January 2019 22:59 UTC;
• from 25th January 2019 23:00 UTC to 1st February 2019 22:59 UTC;
• from 1st February 2019 23:00 UTC to 8th February 2019 22:59 UTC.
MAXIMUM ACCUMULATED RAINFALL Recorded in the Second Week
MAXIMUM POSITIVE WEEKLY DIFFERENCE
RECORDED DURING THE THIRD WEEK
(741 mm) NEAR TOWNSVILLE

MAXIMUM NEGATIVE WEEKLY DIFFERENCE
RECORDED DURING THE SECOND WEEK
(- 599 mm) NEAR NORMANTON

UNDERESTIMATION IN THE CENTRAL PART
OF QUEENSLAND DURING THE THIRD WEEK
(blue zones reported in the third row of the figure)
In the first week, alerts were provided only in the northern areas of Queensland.

During the second and third weeks, instead, alerts were issued also in the central part of Queensland.
FLOODED AREAS EXTRACTION

An automatic flooded areas extraction was performed both on Sentinel-3 and on MODIS images acquired on 10th, 13th, 15th and 21st February using the Normalized Difference Water Index (NDWI) for the identification of water features.

\[
NDWI = \frac{G - \text{NIR}}{G + \text{NIR}}
\]

- \( NDWI \geq 0.1 \rightarrow \text{WATER} \)
- \( NDWI < 0.1 \rightarrow \text{NO WATER} \)

<table>
<thead>
<tr>
<th>SENTINEL-3 (300 m resolution)</th>
<th>MODIS (500 m resolution)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G – GREEN BAND</td>
<td>B06 (( \lambda ) centre = 560 nm)</td>
</tr>
<tr>
<td>NIR – NEAR INFRARED BAND</td>
<td>B19 (( \lambda ) centre = 900 nm)</td>
</tr>
</tbody>
</table>

A manual refinement of the water mask by means of visual interpretation proved to be necessary in order to remove false alarms induced by the presence of clouds in some portion of the images.
CONCLUSIONS

Both GPM data and ERDS outputs proved to be a reliable source of information for the evaluation of areas affected by heavy rainfall. These findings have important applications for countries where an appropriate network of measurement instruments is still missing.

Due to the coarse spatial resolution (0.1°), local scale validation is recommended. Modest underestimations/overestimations are reported in different localities, especially when high rainfall rate is measured.

Obtained results highlighted that ERDS was able to detect the most affected areas. The discrepancies between flooded areas and ERDS alerts location are mainly induced by the characteristics of the early warning system. The system, in fact, provides alerts about heavy rainfall.

No analysis regarding the areas that will be affected by flood events is performed. Further studies could be conducted in order to implement information about the morphology of the territory with the aim of providing information about where the flood events will occur.