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

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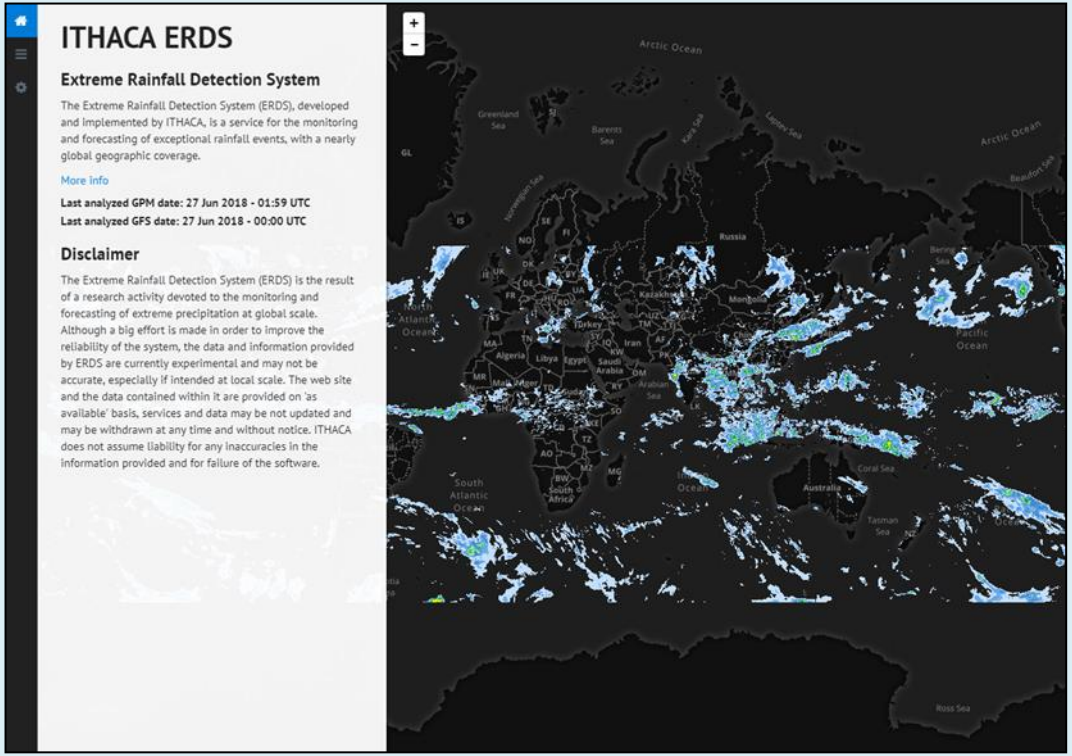
ERDS

(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

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RAINFALL AMOUNT EVALUATION

(12 – 24 – 48 – 72 – 96 hours aggregation interval)

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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

TEMPORAL COVERAGE

from 12 March 2014 to nowadays

SPATIAL COVERAGE

60° N – 60° S

TEMPORAL RESOLUTION

30 minutes

SPATIAL RESOLUTION

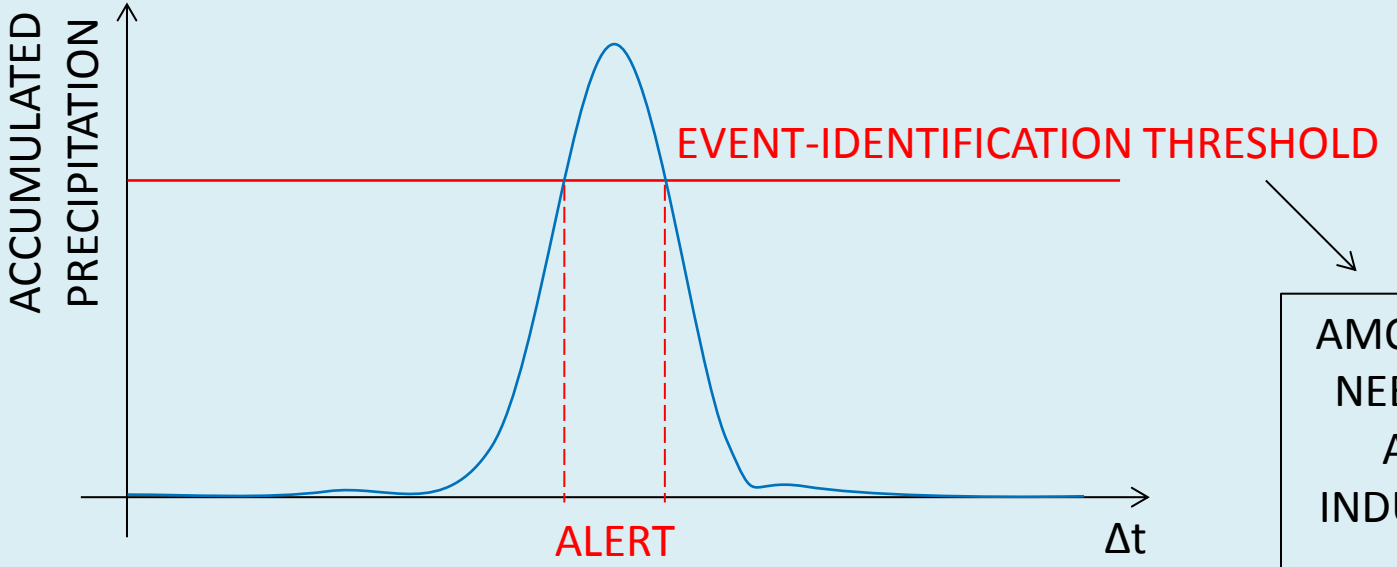
0.1° x 0.1°

LATENCY

4 hours

EXTREME RAINFALL DETECTION

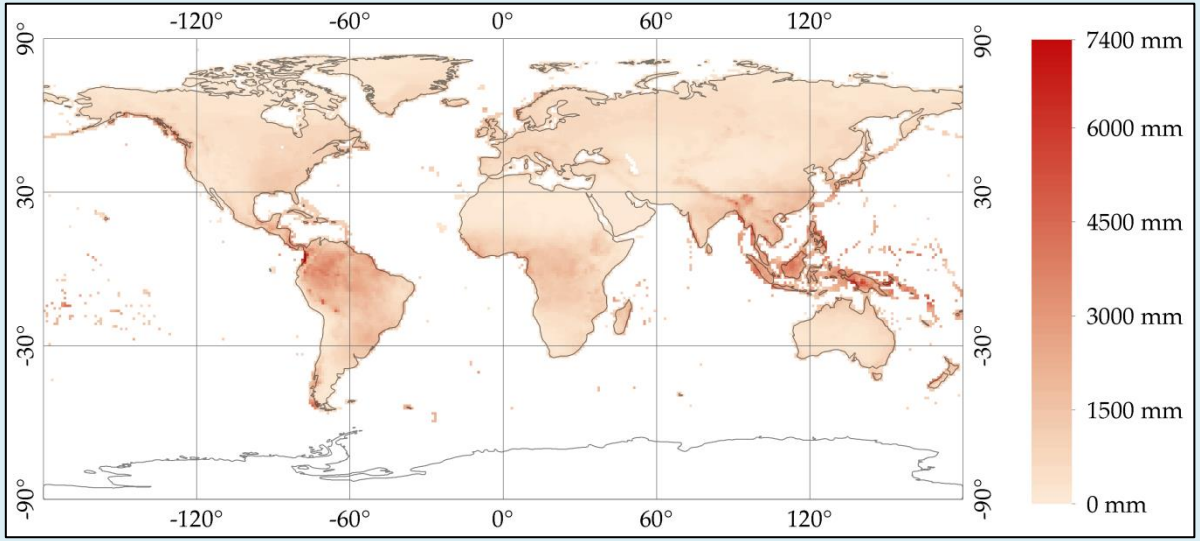
The extreme rainfall detection is based on the concept of event-identification threshold: an alert is provided if the accumulated rainfall exceeds the threshold.



AMOUNT OF RAINFALL NEEDED TO TRIGGER A FLOOD EVENT INDUCED BY EXTREME RAINFALL

EXTREME RAINFALL DETECTION

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".



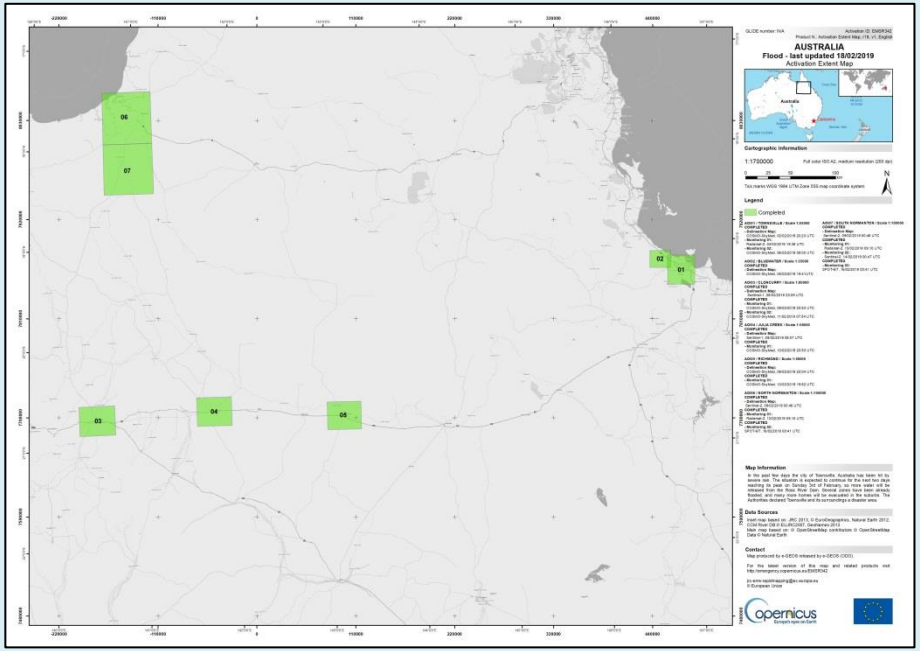
MORE INFO ON:

Mazzoglio, P.; Laio, F.; Balbo, S.; Boccardo, P.; Disabato, F. Improving an Extreme Rainfall Detection System with GPM IMERG data. Remote Sens. 2019, 11, 677. doi.org/10.3390/rs11060677

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.



Copernicus Emergency Management Service (© 2019 European Union), EMSR342

QUEENSLAND CASE STUDY

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.

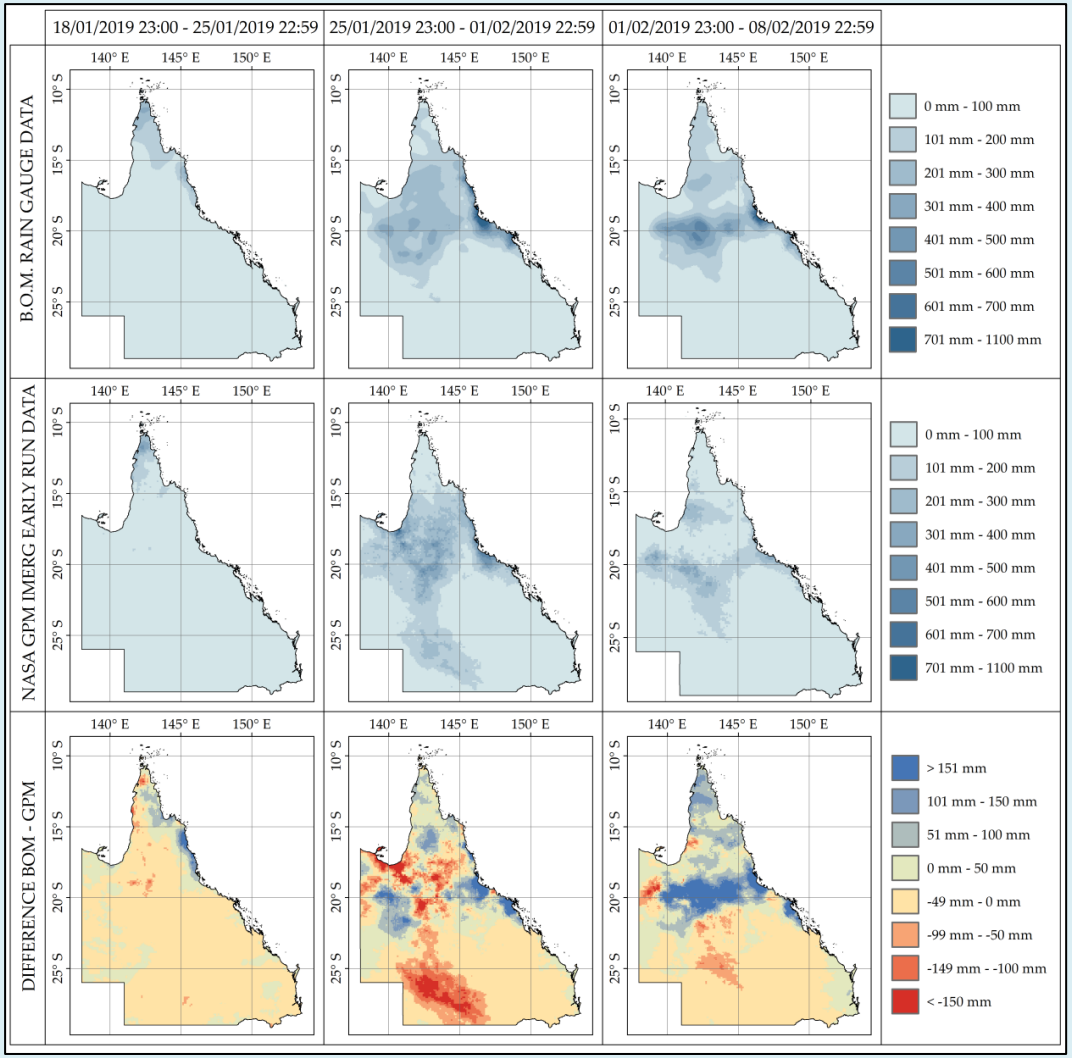
ANALYSIS OF AVAILABLE RAINFALL MEASUREMENTS

NASA GPM IMERG HALF-HOURLY EARLY RUN DATA

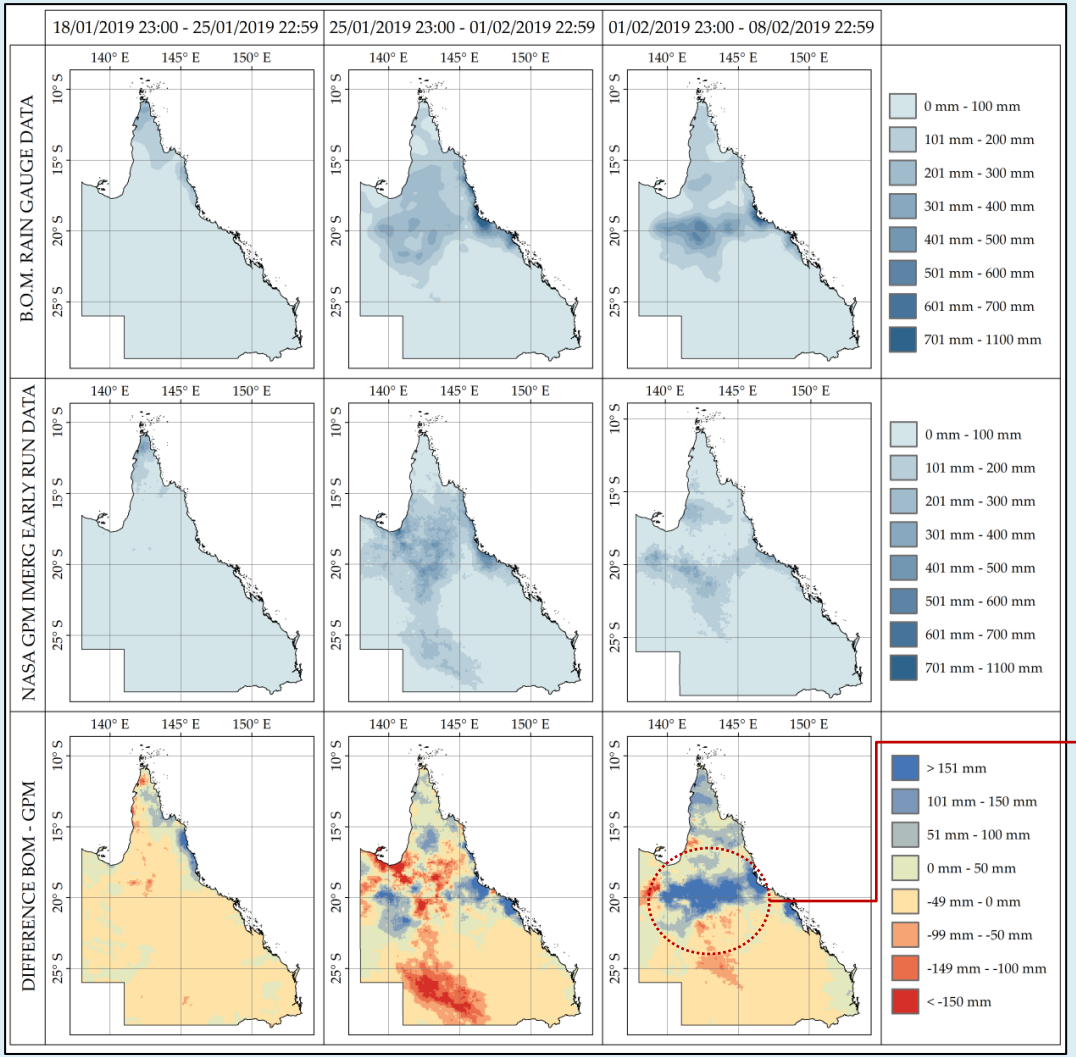
DAILY RAINFALL MEASUREMENTS CONTAINED IN THE BUREAU OF METEOROLOGY CLIMATE DATABASE (AUSTRALIAN DATA ARCHIVE FOR METEOROLOGY – ADAM)

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

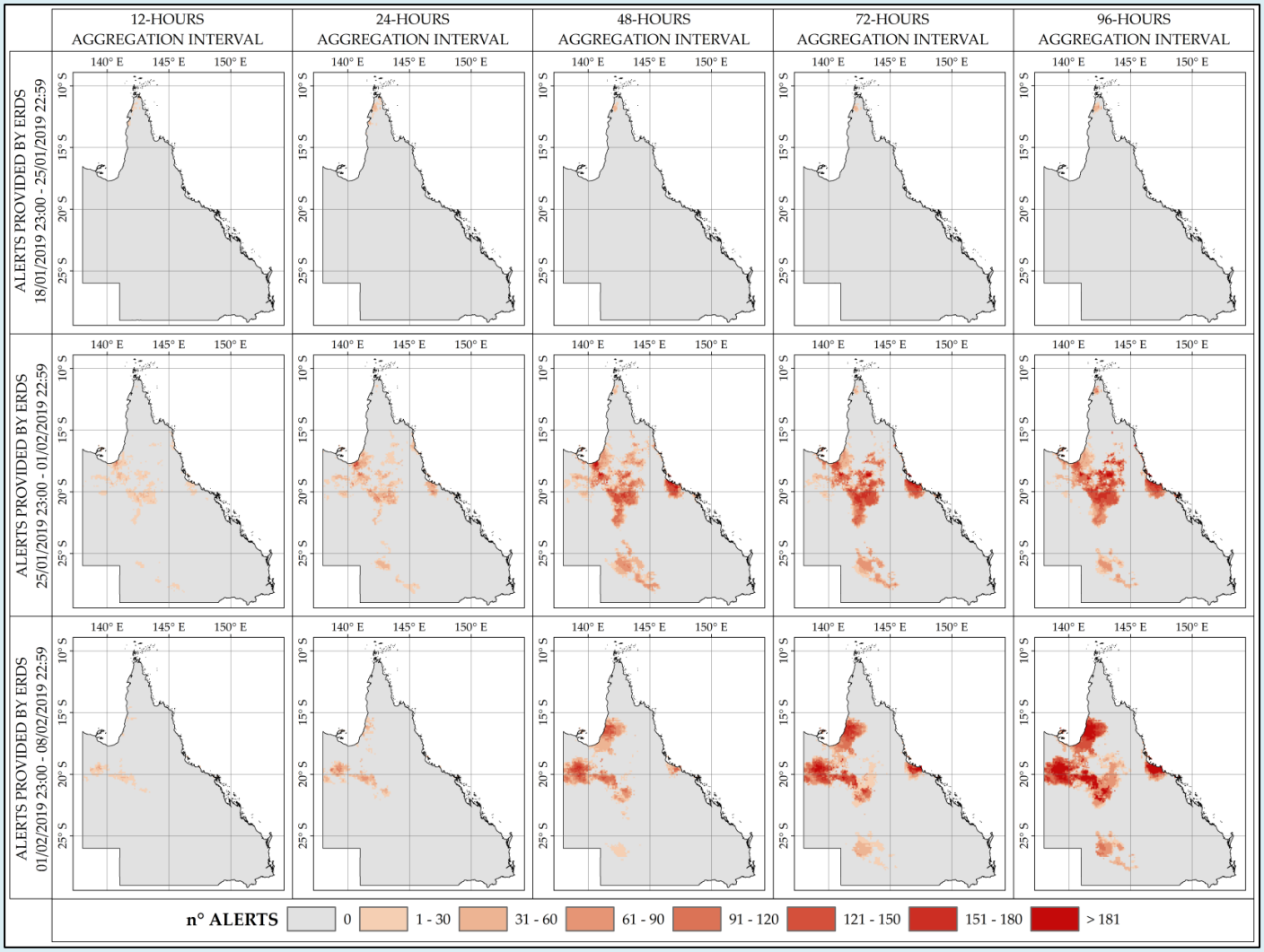


MAXIMUM POSITIVE WEEKLY DIFFERENCE RECORDED DURING THE THIRD WEEK (741 mm) NEAR TOWNSVILLE

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)



OVERVIEW OF THE AREAS AFFECTED BY HEAVY RAINFALL (ACCORDING TO ERDS NEAR REAL-TIME ALERTS)

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.

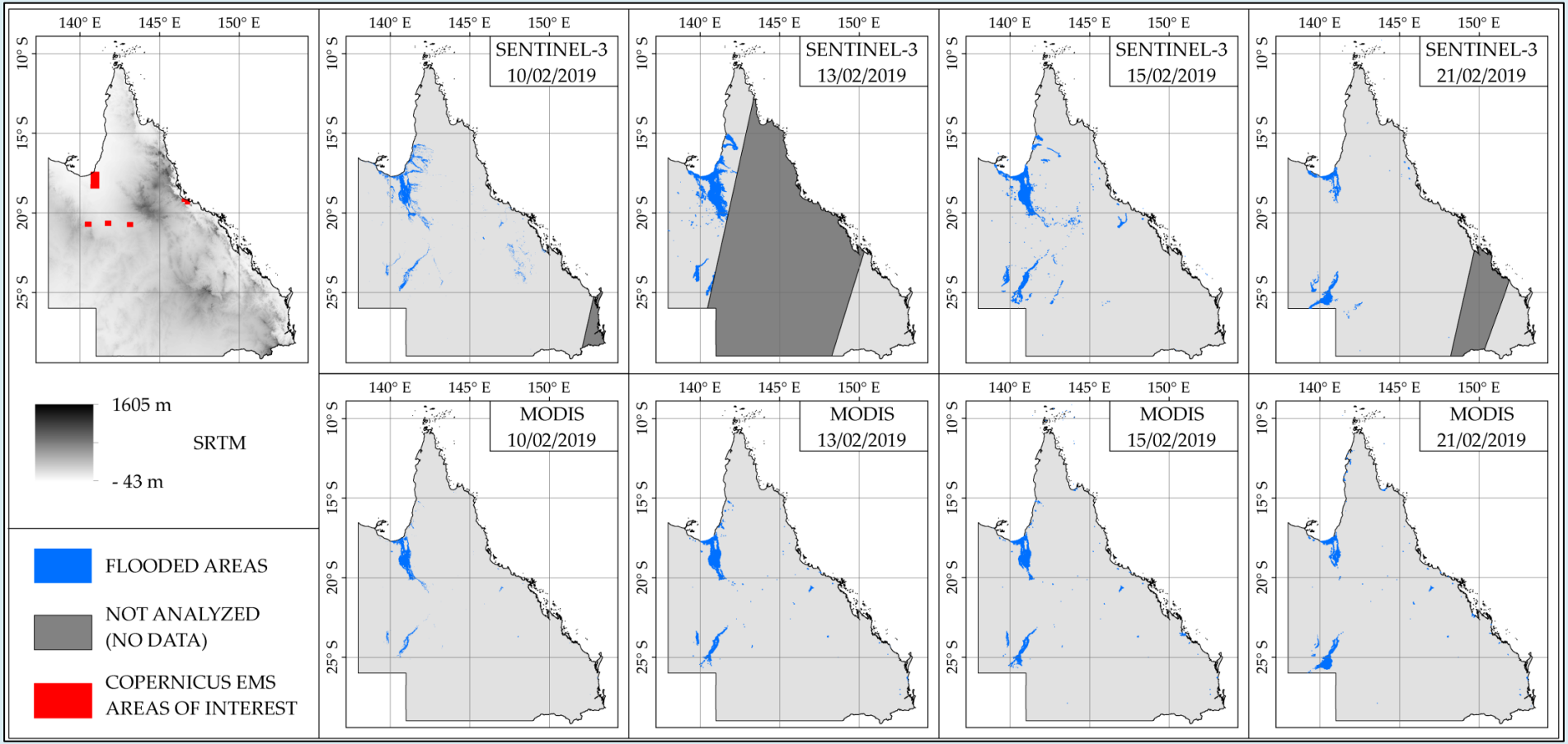
$$\mathrm{NDWI} = \frac{\mathrm{G} - \mathrm{NIR}}{\mathrm{G} + \mathrm{NIR}}$$

NDWI ≥ 0.1 -> WATER
NDWI < 0.1 -> NO WATER

	SENTINEL-3 (300 m resolution)	**MODIS (500 m resolution)**
G – GREEN BAND	B06 (λ centre = 560 nm)	B04 (545 – 565 nm)
NIR – NEAR INFRARED BAND	B19 (λ centre = 900 nm)	B05 (1230 – 1250 nm)

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.

FLOODED AREAS EXTRACTION



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 were 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.