EUROPEAN COMMISSION
JOINT RESEARCH CENTRE

28 Sep 2018 18:00 UTC

Mw 7.5 Earthquake in Indonesia, 28 Sep 2018

GDACS Earthquake RED Alert

GDACS Tsunami ORANGE Alert

28 Sep 2018 - Emergency Report

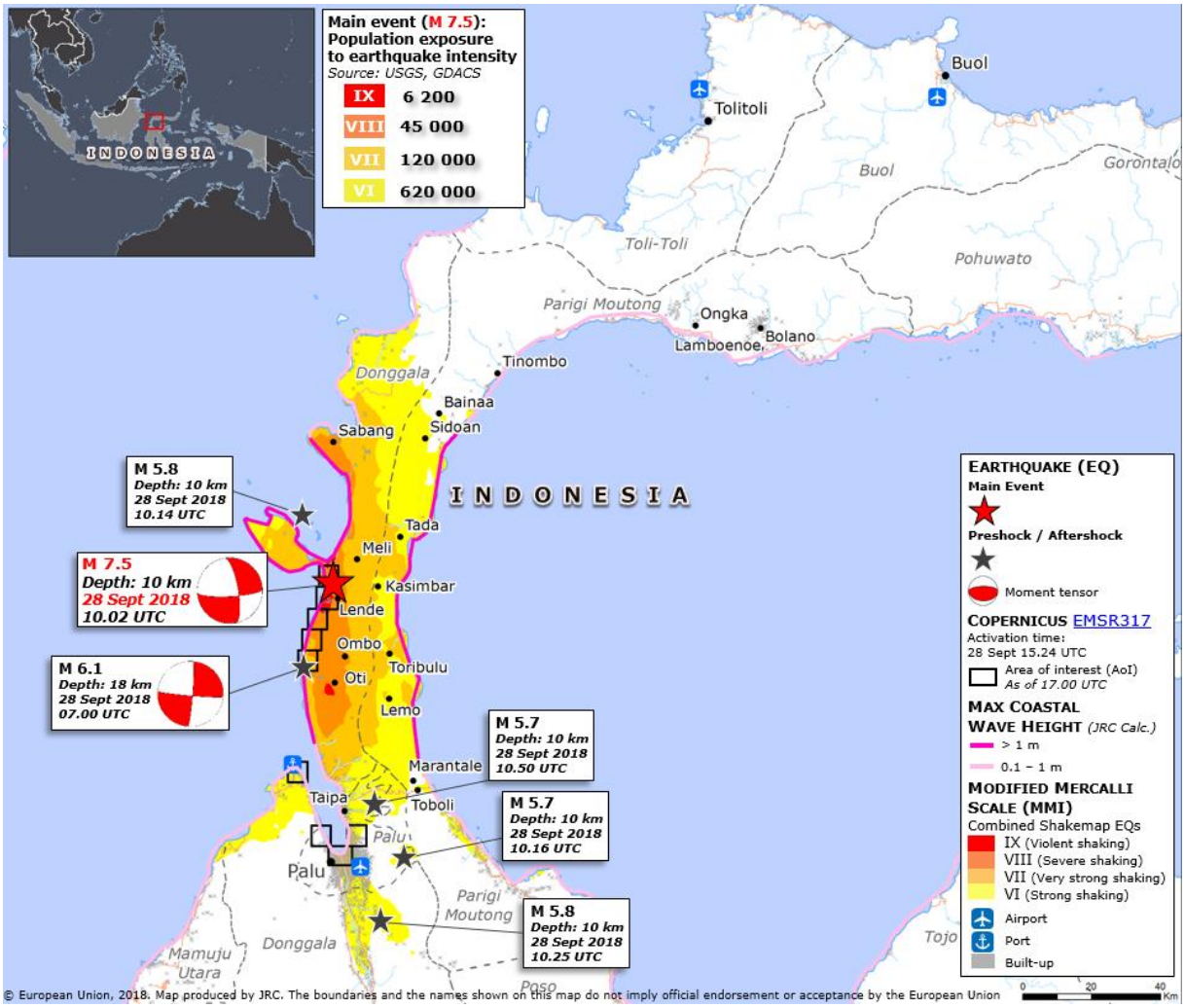


Figure 1 *- Location of the Mw 7.5 Earthquake event and the other 6 earthquakes in Indonesia, with the overall shakemap of all the earthquakes.*

1 Executive Summary

- Seven main earthquakes of magnitude **Mw between 7.5 and 5.7** hit the the island of **Sulawesi** (Sulawesi Tengah province/Central Sulawesi, Indonesia) on **28 September,** within 7 hours and in 100 km**.** The main shock of magnitude 7.5 Mw was **at 10:02 UTC** at a depth of **10 km** .
- All the earthquakes affected the Sulawesi Tengah province in the island of **Sulawesi**, in an area close to the city of **Palu** (280 000 people), which is around 70 km far from the epicentre of the main shock. The affected region is a low density populated area, mostly localised in the city of Palu and in villages along the coasts.
- For the 7.5 Mw event, USGS PAGER estimated a shaking up to “Violent” for 10 000 people, "Severe" for 44 000 people and "Very Strong" for 129 000, with a **Yellow** alert for fatalities and economic losses. Considering all the earthquakes, the city of Palu is exposed to a shaking intensity “Strong”.
- GDACS issued **Orange Aler**t for the potential humanitarian consequences about **20 min** after the 7.5 Mw and 5.8 Mw events, issuing SMS and email alerts. The other 5 earthquakes have been classified as Green Alert. After new data became available, the alert level for the 7.5 Mw became **Red** while the other alert levels are still confirmed.
- GDACS issued an Orange alert for tsunami threat occurred by this event (1.6 m). A tsunami warning was issued by national authorities, and was lifted later. A tsunami was recorded along the coast up to Palu. Media report wave up to 2 m.
- As of 28 September afternoon, **1 person** is reported **dead,** around 10 injured, dozens buildings damaged and several houses suffered power outages. Search and rescue operations are still on-going and, so far, no international assistance has been requested.
- About one month ago, on the 28 July and 5 August, the island of Lombok in Indonesia was affected by 2 strong earthquakes of magnitude 6.4Mw and 6.9Mw, causing around 400 deaths and which required the international support.
- Over the next three days, cloudy conditions with the possibility of light rainfall in the area of Palu, and moderate to heavy rains in some areas of central and western Sulawesi.

2 Situation Overview

2.1 Situation

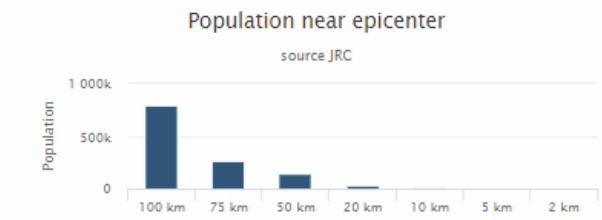
- An earthquake of magnitude **7.5 Mw** at a depth of **10 km** hit the the island of **Sulawesi** (Sulawesi Tengah province/Central Sulawesi, Indonesia) on **28 September at 10:21 UTC** (780 000 people in the 100 km radius from the epicentre, GDACS), causing some damages and the deaths of 1 people. Search and rescue operations are still on-going (see Section 2.2).
- A pre-shock of magnitude 6.1 Mw at a depth of 18 km occurred at 07:00 UTC and 5 aftershocks between 5.7 and 5.8 at a depth of 10 km occurred up to 13:35 UTC. The total of 7 earthquakes occurred within 7 hours within the distance of the epicentres of 100 km.
- The epicenter of the main shock was located in central Sulawesi island, around 70 km northeast of Palu city.
- For the main earthquake, USGS PAGER estimated a shaking up to “Violent” for 10 000 people, "Severe" for 44 000 people and "Very Strong" for 129 000, with a **Yellow** alert for fatalities and

economic losses. Considering all the earthquakes, the city of Palu is exposed to a shaking intensity “Strong”.

- For the main shock, GDACS issued an **Orange Alert** for the potential humanitarian consequences about **21 min** after the event, issuing SMS and email alerts, and increased this alert to **RED** after around 3 hours, after a new shakemap became available. Another Orange alert was issued for the 5.8 Mw at 10:25 UTC, while the other earthquakes are all classified as Green Alert.
- GDACS issued an Orange alert for tsunami threat occurred by this event (1.6 m). A tsunami warning was issued by national authorities, and was lifted later. A tsunami was recorded along the coast up to Palu. Media report wave up to 2 m.
- Only about one month ago, on the 28 July and 5 August, the island of Lombok in Indonesia was affected by 2 strong earthquakes of magnitude 6.4Mw and 6.9Mw, causing around 400 deaths and which required the international support.

Exposed population

The earthquake happened in **Indonesia** , Province of **Sulawesi Tengah** (population 1,832,441) . The nearest places are Lende, Magapa, Ombo, Meli, Potomoea, Kasimbar, Baja, Toribulu, Oti, Popodi, and Bainaa.



Radius	Population
100 km	780000 people
75 km	260000 people
50 km	130000 people
20 km	27000 people
10 km	13000 people
5 km	5300 people
2 km	<1000 people

Figure 2 - *GDACS - Impact Estimation: population near the epicenter of the M 7.5 Earthquake event in Indonesia.*

2.2 Humanitarian impact and response

The preliminary humanitarian impact (as of 28 September at 17:00 UTC) is shown in the table below. Search and rescue operations are still on-going, the full scale of damages and humanitarian needs are not yet known. So far, no international assistance has been requested.

Indonesia - Situation *(as of 28 Sept)*	
Dead / missing	**At least 1** dead in Donggala Regency Search and rescue operations are ongoing. (https://ahacentre.org/flash-update/flash-update-no-01-m-7-4-earthquake-minahassa-peninsula-sulawesi-indonesia-28-sep-2018/) Media reported at least 5 deaths (https://www.bbc.com/news/world-asia-45683630)
People Injured	At least 10 people
Damaged houses/ infrastructures	Dozens houses damaged Several roads damaged Power outages Palu airport closed
Areas mostly affected	**Central Sulawesi (Sulawesi Tengah),** - *Donggala Regency* - *Palu City* - *Parigi Moutong Regency.*

Table 1 *- Indonesia - Situation (as of 28 September afternoon)*
Sources:https://www.bnpb.go.id/gempa-berkekuatan-magnitudo-77-peringatan-dini-tsunami-sempat-diaktifkan-namun-sudah-berakhir, https://ahacentre.org/flash-update/flash-update-no-01-m-7-4-earthquake-minahassa-peninsula-sulawesi-indonesia-28-sep-2018/, *media*

A tsunami warning was issued by national authorities, but was lifted later. WATCH warning and evacuation order was released for coastal residents in northern part of Donggala Regency, Palu City, and northern part of Mamuju Regency (BNPB).
National authorities reported that a tsunami hit the coast up to Palu.
https://www.bnpb.go.id/tsunami-terjang-pantai-palu-penanganan-darurat-terus-dilakukan

Video of the tsunami:

https://www.youtube.com/watch?v=bQXuJHQs2WY

https://www.youtube.com/watch?v=F05edMisEJE

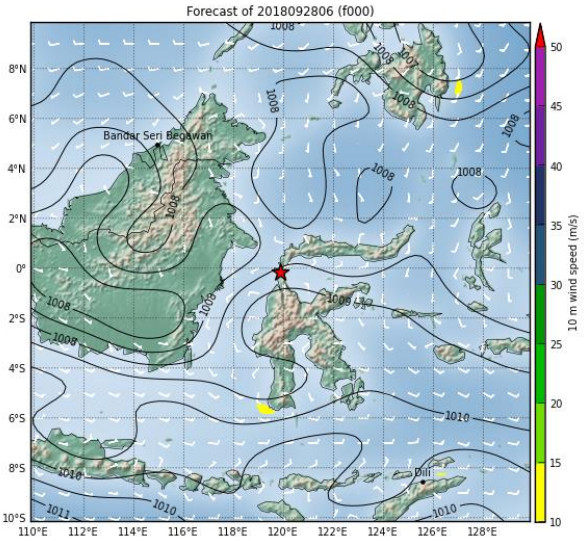
Figure 3 and 4 - *Tsunami impact for the M 7.5 Earthquake event in Indonesia (sorce: twitter **@ChannelNewsAsia**.)*

Figure 5 - *Earthquake impact in Indonesia (sorce: twitter **@ChannelNewsAsia**.)*

2.3 Meteorological Situation

Current Condition: In Palu, partly cloudy to cloudy, with the possibility of local thunderstorms in some areas of central, western and southern Sulawesi. Details on the current weather are shown in the figure on the right, containing the surface weather map - isobars and winds - valid for 28 Sep 06 UTC; the areas of wind speeds higher than 35 km/h are shaded by yellow colour (data source: NOAA-GFS, see GDACS. The current weather radar image is shown below, as of 28 Sep, 12:00 UTC, source: BMKG)

More information on the current weather in Palu: http://www.bmkg.go.id/cuaca/prakiraan-cuaca.bmkg?Kota=Palu&AreaID=1200106&Prov=29



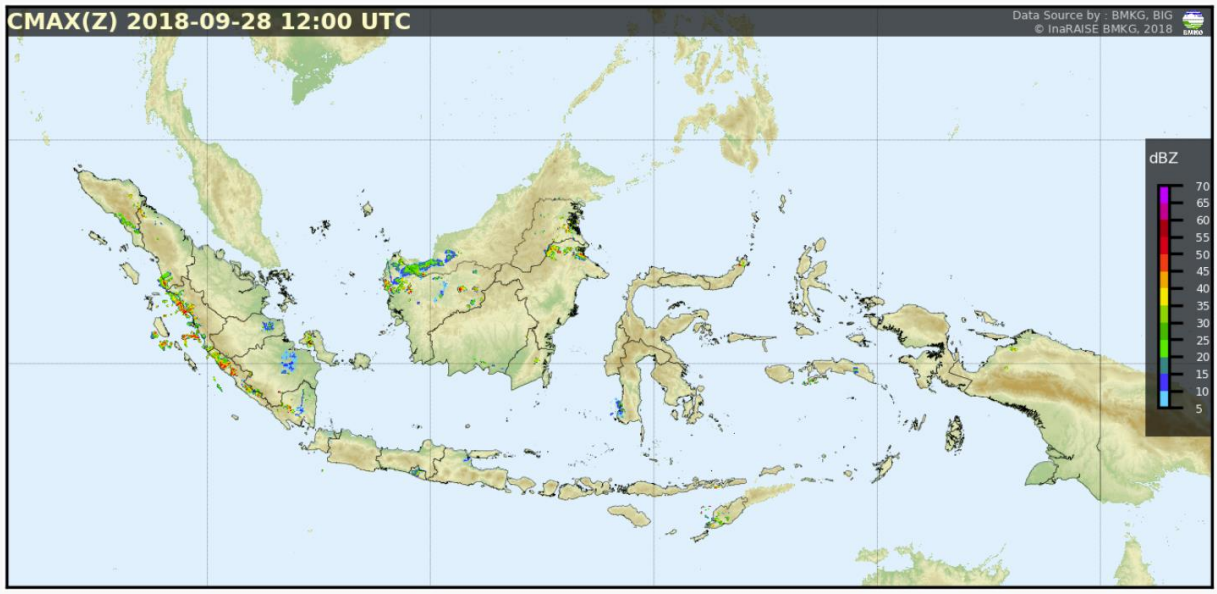
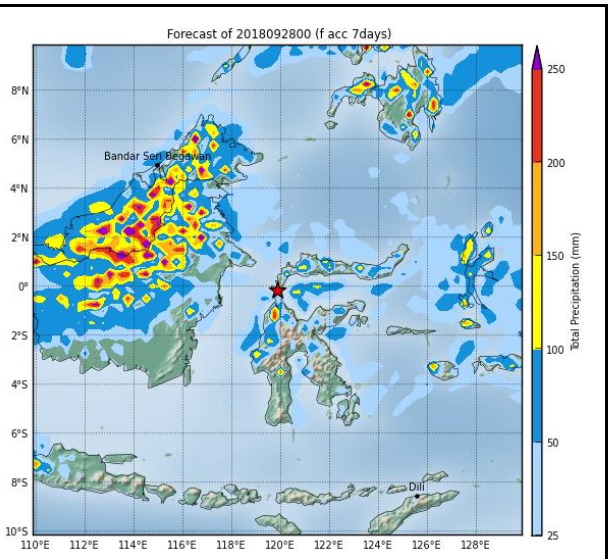


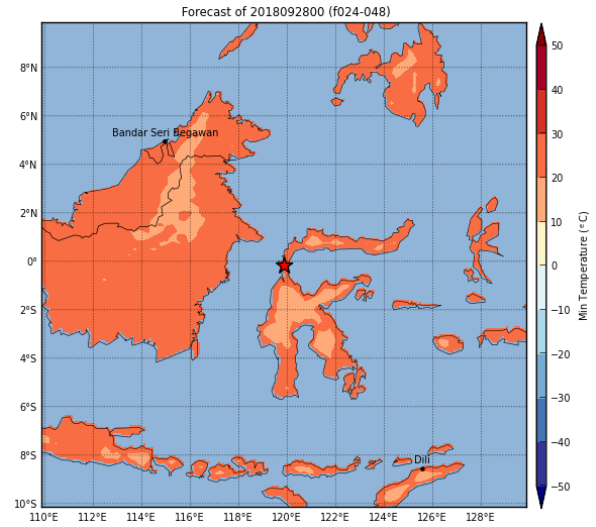
Figure 6 - 7 *- TOP-RIGHT: Surface weather analysis map (isobars and winds) valid for 28 Sep 06 UTC Data Source: GFS (Global Forecast System of NCEP / NOAA, as of 28 Sep, 06 UTC), see GDACS. BOTTOM: current weather radar image, as of 28 Sep, 12:00 UTC (source*: BMKG)

Forecast: Over the next 7 days, moderate to locally heavy rain and strong winds with possible thunderstorms could affect parts of Indonesia, including some areas of Sulawesi (see next 7 days rainfall accumulation in the image on the right).

In **Palu** (29-30 Sep), partly cloudy to cloudy, with the possibility of light rain. The temperature could reach 36°C (maximum temperature) during the day, dropping during early morning hours to 22°C (minimum temperature). Winds from south-southeast direction with speeds up to 5 km/h (see BMKG and WMO).

3-days weather warnings:
http://www.bmkg.go.id/cuaca/prakiraan-cuaca-tigaharian.bmkg?lang=EN





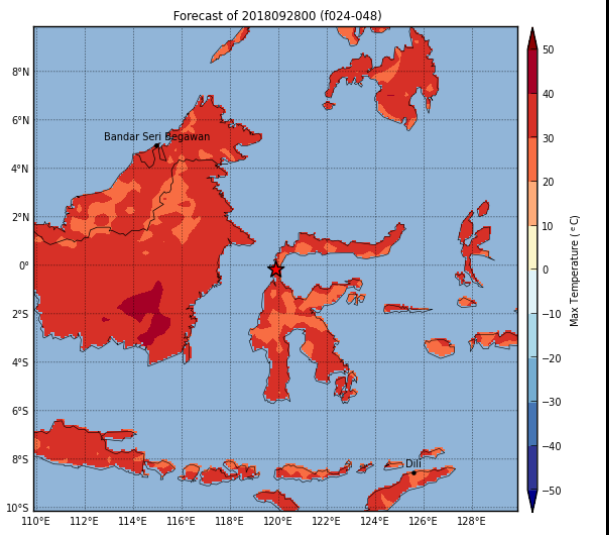


Figure 8-10 *- 7-days precipitation accumulation forecast, Minimum temperature (Bottom-LEFT) and maximum temperatures (Bottom-RIGHT) valid for 29 Sep (00 to 24 UTC).*
Data Source: GFS (Global Forecast System of NCEP / NOAA, as of 28 Sep, 06 UTC), see GDACS

2.4 Seismotectonic of the area

According to USGS, the September 28, 2018, M 7.5 earthquake near Sulawesi, Indonesia occurred as a result of strike-slip faulting at shallow depths within the interior of the Molucca Sea microplate, part of the broader Sunda tectonic plate. Focal mechanism solutions for the earthquake indicate rupture occurred on either a left-lateral north-south striking fault, or along a right-lateral east-west striking fault. Eastern Indonesia is characterized by complex tectonics in which motions of numerous small microplates are accommodating large-scale convergence between the Australia, Sunda, Pacific, and Philippine Sea plates. At the location of the September 28th earthquake, the Sunda plate moves south with respect to Molucca Sea plate at a velocity of about 30 mm/year.

Shallow earthquakes of this size can often have a deadly impact on nearby communities. Historically, this region has hosted several large earthquakes, with fifteen events of M 6.5 and larger within 250 km of the September 28th earthquake over the preceding century. The largest of these was a M 7.9 earthquake in January 1996, about 100 km to the north of the September 28, 2018 event. The 1996 earthquake – a shallow thrust faulting earthquake likely to have occurred on the regional subduction zone system at depth beneath the shallow crust - resulted in approximately 10 fatalities, over 60 injuries, and significant building damage in the local region. (source: USGS).

It is expected that earthquakes of this magnitude and this system, will produce significant aftershock activity.

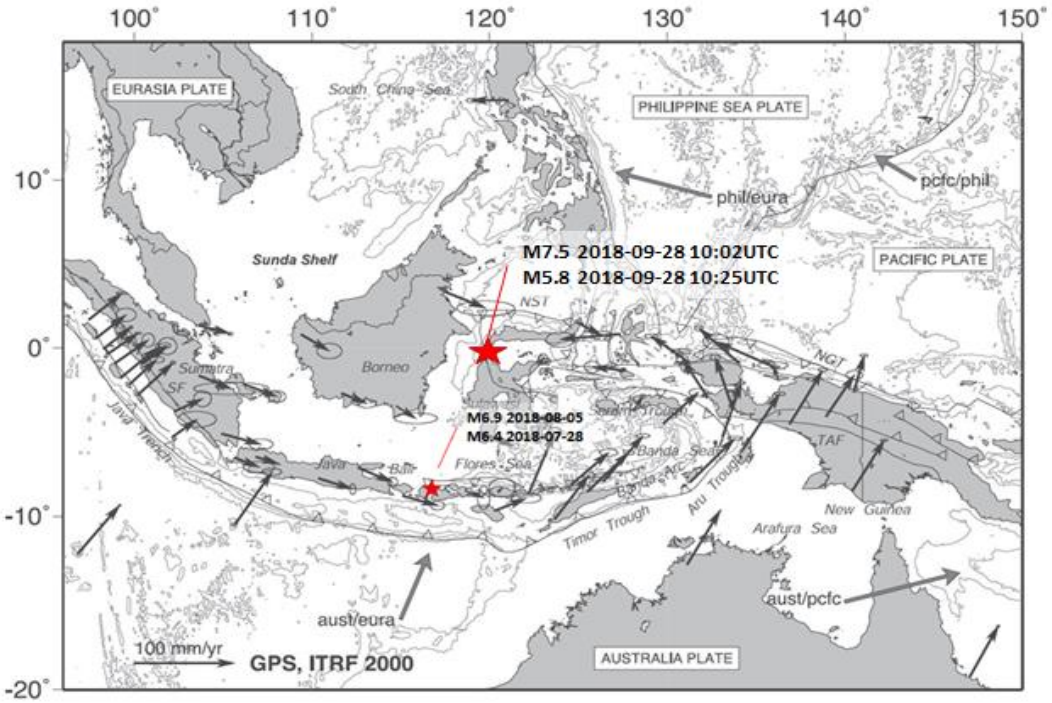


Figure 11 *- Tectonic map of the Indonesian archipelago and surrounding region (Bock et al., 2003, modified. Big red star: the last 2 relevant earthquakes; small red star: the 2 main earthquakes that caused extensive damages about two month ago).*

2.5 Historical events

The list below indicates the events, the hazard (earthquake and tsunami), the date and the international humanitarian support in the area close to these events.

None of the recent earthquakes in the Island of Sulawesi required the humanitarian support.

Date	Hazard	Magnitude	Humanitarian intervention
11-Apr-12	EQ+TS	8.6	ERCC activation (Pre-alert)
25-Oct-10	EQ+TS	7.8	OCHA
12-Sep-09	EQ	7.6	OCHA+ERCC activation (RfA)
12-Sep-07	EQ	8.4	OCHA
06-Mar-07	EQ	7.6	OCHA+ERCC activation (Monitoring)
17-Jul-06	EQ+TS	7.7	OCHA
27-May-06	EQ	6.3	OCHA
28-Mar-05	EQ	7.1	OCHA
26-Dec-04	EQ	7.2	OCHA
11-Nov-04	EQ	7.5	OCHA
2004	EQ	n.a.	OCHA

06-Oct-02	EQ	6.3	OCHA
2000	EQ	n.a.	OCHA
2000	EQ	n.a.	OCHA

Table 2 *- Past earthquake and tsunami events, in the affected tectonic area, which required the international humanitarian support (source: https://fts.unocha.org/data-search/ and ECHO/ERCC). The events from 2007 are reported in the map below.*

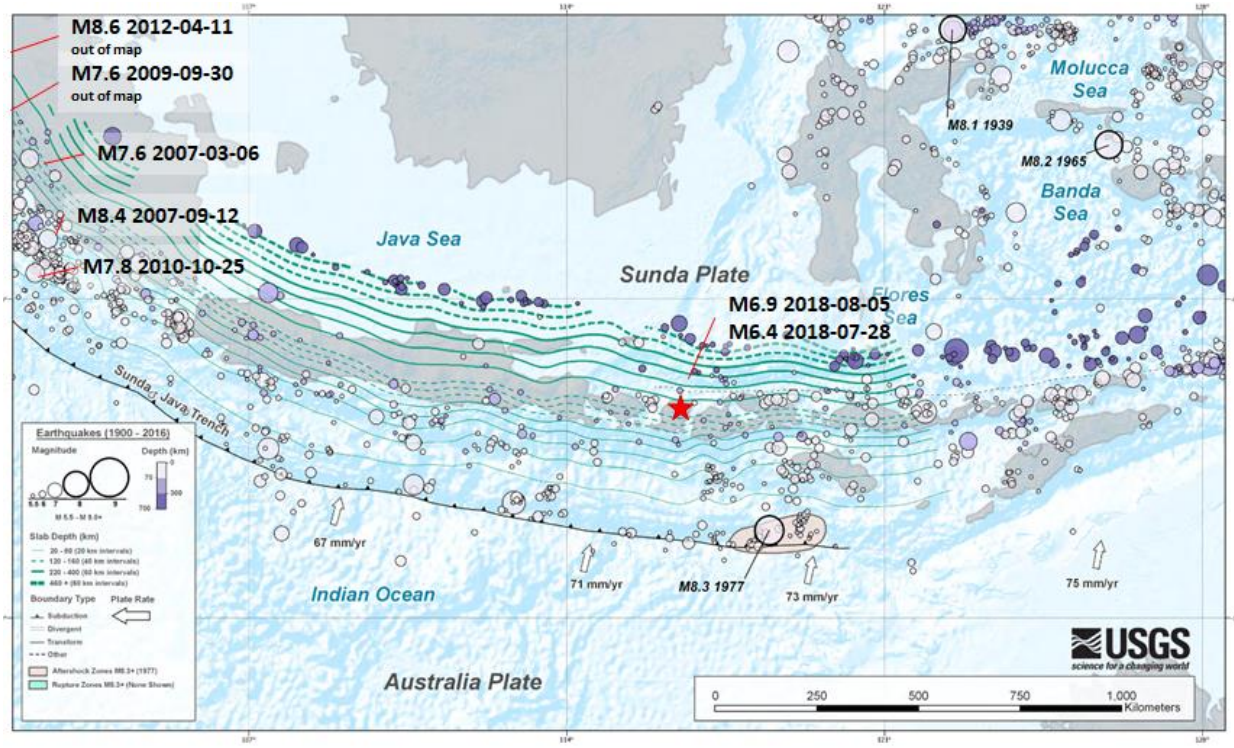


Figure 12 - *Map of tectonic summary regions (USGS, modified with Earthquake and tsunami events which required the OCHA and/or ERCC humanitarian intervention from 2007. Red star: the recent relevant earthquakes occurred on July and August 2018).*

3 JRC contributions

In the period after the end of ARISTOTLE services and the beginning of the new 24 h service that is being prepared, JRC supplies ERCC with a similar service during working hours. ERCC requested an emergency report for this event.

3.1 GDACS System

The Global Disasters Alerts and Coordination System (GDACS) identified the seven main earthquakes of magnitude Mw between 7.5 and 5.7 that hit the island of Sulawesi (Sulawesi Tengah province, Indonesia) on 28 September, within 7 hours and in 100 km. The alert level, magnitude and time of the GDACS EQ alerts for these seven events are shown in the figure on the right, while in this section only the results for the major event (7.5 Mw) are reported (see www.gdacs.org)

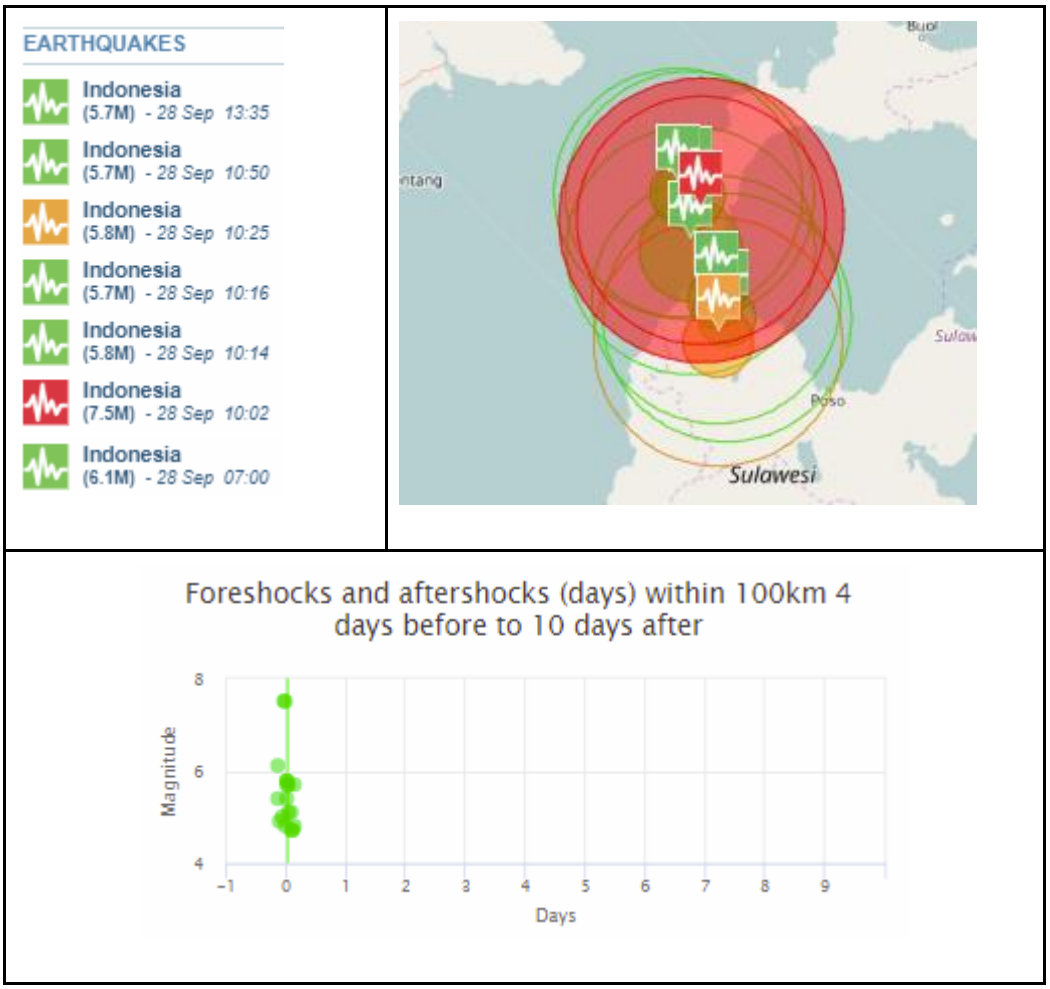


Figure 13 *- GDACS List of major earthquakes in Indonesia on 28 Sep*

GDACS identify the 7.5 Mw earthquake 6 minutes after the event but, according to the new procedure implemented in the site, waited the arrival of the USGS shakemap to provide a better alert[1]. Using the shakemaps the event was first classified as **Earthquake ORANGE alert** after 21 minutes. After a new revised USGS shakemap (3h42min after the 7.5 Mw), the Earthquake alert level was increased to **RED** on 28 Sep at 13:45 UTC. The **Tsunami alert level is ORANGE**.

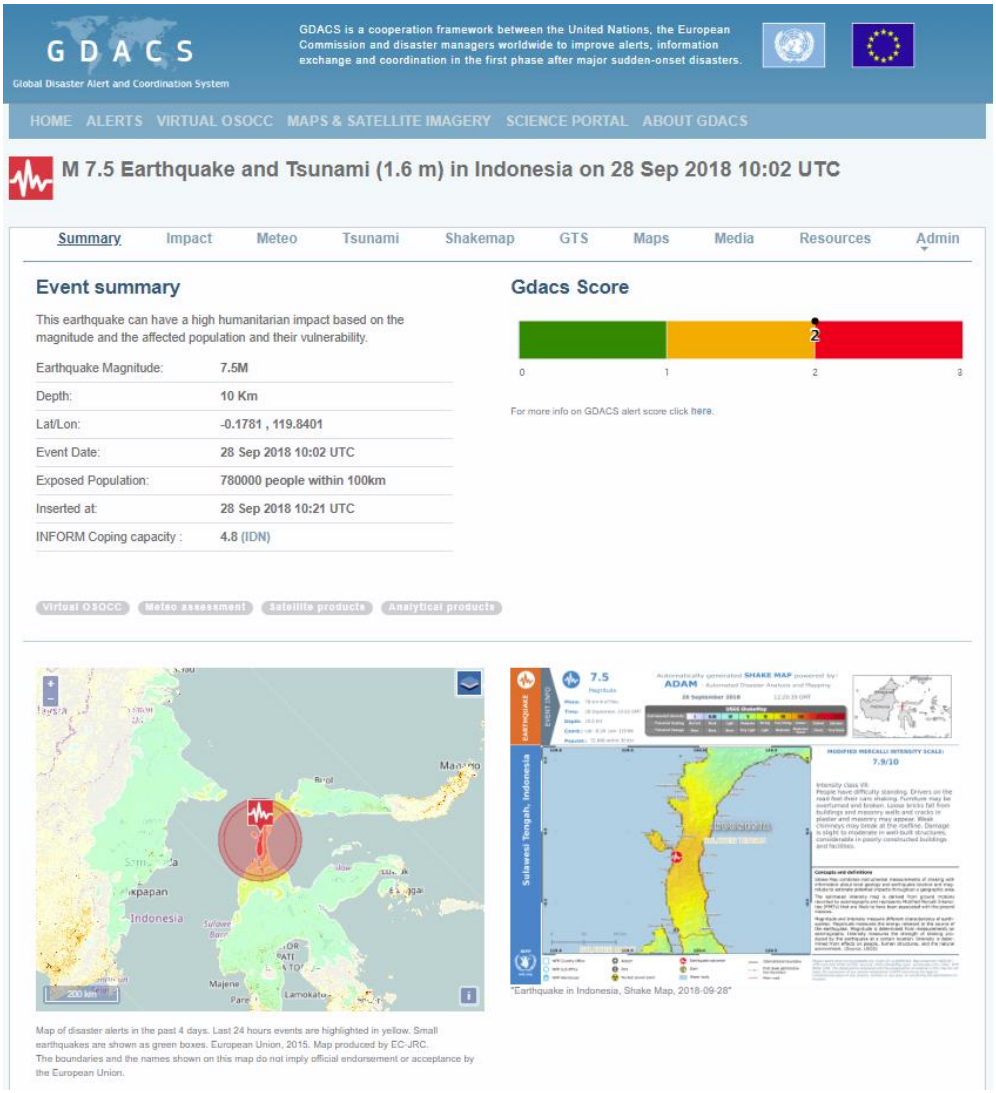


Figure 14 *- GDACS report page*

[1] *As of 1st Sept 2017, GDACS includes a new algorithm to assess the overall impact of earthquakes and the potential need of humanitarian intervention. The new model draws on a combination of earthquake intensity calculation (using the USGS shakemap) and a new empirical model by JRC, when the shakemaps are not available. Furthermore, the Coping Capacity indicator from the set of INFORM indices is now included in the final GDACS Alert Score. Through the new GDACS Earthquake Algorithm system we aim at reducing false alerts and at providing a better estimation of the impact. The ultimate goal is to improve the service for the Humanitarian community*

3.1 Earthquake impact

The USGS shakemap of the event has been updated three times on 28 Sep 2018 at 10:24 UTC, at 12:06 UTC and at 13:45 UTC (see figure below). The maximum value of MMI from the first two estimations was **7.93**, then it was increased to the actual estimation of **8.79**. The increase of the maximum shaking intensity has change the type of alert, from ORANGE (initial estimation) to **RED** (final estimation).

Shakemaps Timeline

Alert	Shake id #	Score	episodeid	Lat/Lon	Magnitude	Depth	Max MMI	Date shake (UTC)	Delay (hh:mm)	
★	1	1.52	1229845	-0.178/119.84	7.5	10	7.93	28 Sep 2018 10:24	00:21	(new episode)
★	2	1.52	1229845	-0.178/119.84	7.5	10	7.93	28 Sep 2018 12:06	02:04	(upd of #1)
★	3	2.05	1229845	-0.178/119.84	7.5	10	8.79	28 Sep 2018 13:45	03:42	(upd of #2)

Table 3 *- GDACS Shakemaps Timeline*

According to the latest GDACS automatic impact estimation based on the third shakemap, **6200 people** have been subject to an intensity **IX (VIOLENT)** of the Modified Mercalli Intensity scale, 45000 people to an intensity VIII (SEVERE) and 120000 to an intensity of VII (VERY STRONG), with the largest impact in the area north of Palu (Central Sulawesi / *Sulawesi Tengah*). The provinces potentially mostly affected are indicated below, while the locations and critical infrastructure in the tables on the next page.

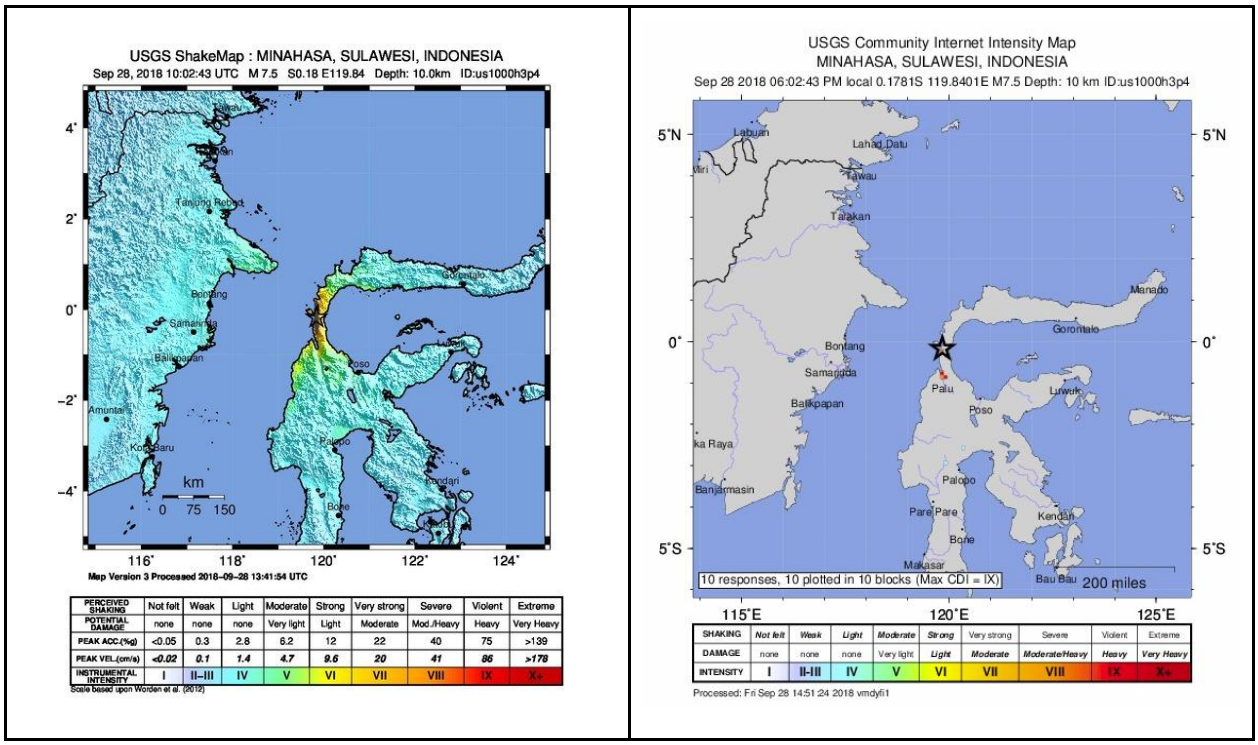
Exposed population

The earthquake happened in **Indonesia** ,of **Kalimantan Timur** (population 2,017,158) .

Intensity	Population
IX	6200 people
VIII	45000 people
VII	120000 people
VI	620000 people
V	1.1 million people

PERCEIVED SHAKING	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	None	None	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
INTENSITY	≤ III	IV	V	VI	VII	VIII	IX	X+

Table 4 *- GDACS - Population in MMI (MMI≥ V)*



Figures 15-16 *- The shakemap (estimated intensity, left figure above) is complemented by "Did you feel it" map (on the right), based on the calling by the citizens reporting felt consequences.*

Affected Provinces

Intensity	Region Province	Country	Population
VIII	Sulawesi Tengah	Indonesia	42000 people
VII	Sulawesi Tengah	Indonesia	75000 people
VI	Sulawesi Tengah	Indonesia	500000 people
VI	Sulawesi Selatan	Indonesia	7400 people
V	Sulawesi Tengah	Indonesia	890000 people
V	Sulawesi Selatan	Indonesia	200000 people
V	Kalimantan Timur	Indonesia	4300 people
V	Sulawesi Utara	Indonesia	2300 people

Table 5 *- GDACS - Affected Provinces (MMI≥ V)*

Affected populated places

Intensity	Name	Region Province	Country	City class	Population	Distance
VIII	Lende	Sulawesi Tengah	Indonesia	Village5	-	2 km
VIII	Magapa	Sulawesi Tengah	Indonesia	Village5	-	8 km
VIII	Ombo	Sulawesi Tengah	Indonesia	Village5	-	13 km
VIII	Baja	Sulawesi Tengah	Indonesia	Village5	-	23 km
VIII	Oti	Sulawesi Tengah	Indonesia	Village5	-	23 km
VIII	Sipoeroe	Sulawesi Tengah	Indonesia	Village5	-	33 km
VII	Kasimbar	Sulawesi Tengah	Indonesia	Village5	-	20 km
VII	Toribulu	Sulawesi Tengah	Indonesia	Village5	-	23 km
VII	Popodi	Sulawesi Tengah	Indonesia	Village5	-	25 km
VII	Lemo	Sulawesi Tengah	Indonesia	Village5	-	37 km
VII	Ladang Kolawi	Sulawesi Tengah	Indonesia	Village5	-	46 km
VII	Towaja	Sulawesi Tengah	Indonesia	Village5	-	47 km
VII	Sabang	Sulawesi Tengah	Indonesia	Village5	-	50 km
VII	Labua	Sulawesi Tengah	Indonesia	Village5	-	54 km
VII	Dongala	Sulawesi Tengah	Indonesia	Village5	-	57 km
VII	Lemokosumba	Sulawesi Tengah	Indonesia	Village5	-	57 km
VII	Tawaeli	Sulawesi Tengah	Indonesia	Village5	-	61 km
VI	Tada	Sulawesi Tengah	Indonesia	Village5	-	29 km
VI	Sigentio	Sulawesi Tengah	Indonesia	Village5	-	46 km
VI	Pambero	Sulawesi Tengah	Indonesia	Village5	-	62 km
VI	Sidoan	Sulawesi Tengah	Indonesia	Village5	-	64 km
VI	Toboli	Sulawesi Tengah	Indonesia	Village5	-	66 km
VI	Taipa	Sulawesi Tengah	Indonesia	Village5	-	66 km
VI	Bainaa	Sulawesi Tengah	Indonesia	Village5	-	70 km
VI	Ou	Sulawesi Tengah	Indonesia	Village5	-	72 km
VI	Rilanta	Sulawesi Tengah	Indonesia	Village5	-	73 km
VI	Munte	Sulawesi Tengah	Indonesia	Village5	-	74 km
VI	Taipa	Sulawesi Tengah	Indonesia	Village5	-	74 km
VI	Siboa	Sulawesi Tengah	Indonesia	Village5	-	78 km
VI	Palu	Sulawesi Tengah	Indonesia	City	280000 people	80 km

Table 6 *- GDACS - Affected Populated places, only only the first 30 places (GDACS full list)*

Critical infrastructure

Airports, ports, nuclear plants and hydrodams at risk, if affected, are listed below.

Airports

Intensity	Name	IATA Code	Elevation (m)	Usage	Runway type	IFR	Runway Length (ft)
VI	Mutiara	PLW	87	Civ.	Paved	No	6700
V	Kasiguncu		53	Civ.	Paved	No	3600

Ports

Intensity	Name	LOCODE	Country
VII	Donggala		Indonesia
VII	Pantoloan	IDPTL	Indonesia
VI	Toboli		Indonesia
VI	Palu		Indonesia
V	Tomoni		Indonesia

Table 7 *- GDACS - Affected Airports and Ports (MMI≥ V)*

3.2 Tsunami impact

GDACS issued an **Orange alert** for tsunami using the JRC “Realtime-Fast calculations” (HYSEA) with a maximum Tsunami of **1.5 m** and this alert level was confirmed by the online JRC tsunami calculations, with a maximum tsunami calculated of **1.6 m** along the coasts of Sulawesi in the area north of Palu on 28 Sep at 10:25 UTC (see figures below).

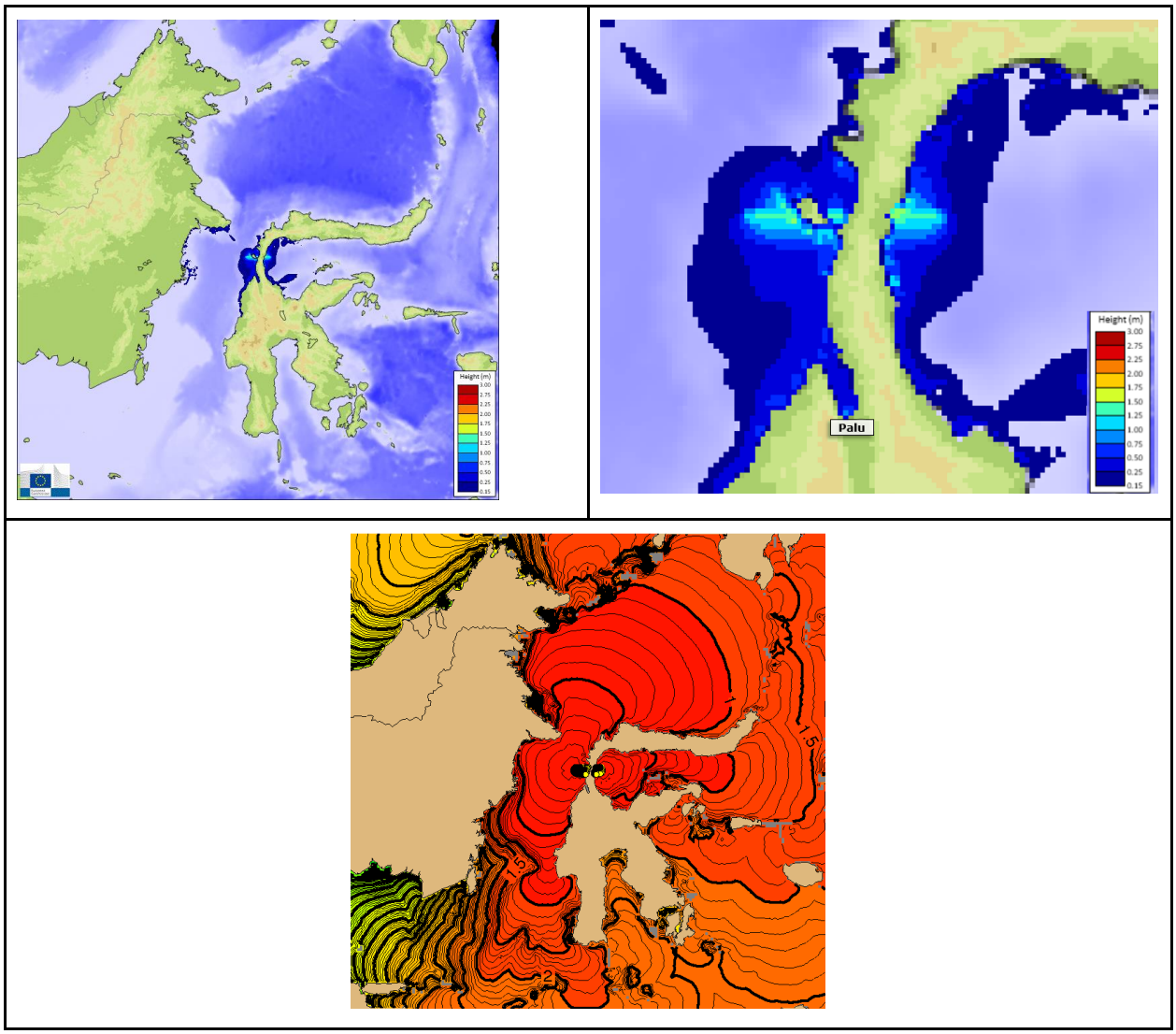


Figure 17 *- JRC tsunami calculations.*

Tsunami affected locations

Date	Name	Country	Alert	Tsunami wave height (m)
28-Sep-2018 10:25:23	Panowang	Indonesia		1.6m
28-Sep-2018 10:03:03	Palu	Indonesia		1.2m
28-Sep-2018 10:18:26	Marantale	Indonesia		1.0m
28-Sep-2018 10:50:18	Lemokosumba	Indonesia		0.8m
28-Sep-2018 10:34:22	Luuk Datan	Philippines		0.7m
28-Sep-2018 10:11:74	Dongala	Indonesia		0.6m
28-Sep-2018 10:16:76	Laboean	Indonesia		0.6m
28-Sep-2018 10:40:53	Tiempae	Indonesia		0.5m
28-Sep-2018 10:09:25	Pagasinan	Philippines		0.5m
28-Sep-2018 10:24:66	Oti	Indonesia		0.5m

***Table 8** - GDACS Table tsunami affected locations (max height≥0.5)*

3.2 Copernicus activation

The Copernicus Emergency Management Service was activated by DG ECHO-ERCC on 28 September at 13:25 UTC (EMSR317). The request is for damage assessments (grading maps) for 9 areas of interest of ca. 6 x 6 km derived from the initial area requested by ECHO ca 20x30 km (see figures below). At the time of writing this report the definition of the production plan was ongoing.

Figure 18 *- Areas for which DG ECHO-ERCC has requested grading maps (EMSR317).*

Figure 19 *- Areas of Interested refined by CEMS (EMSR317).*

4. Other Information

4.1 Virtual OSOCC Activation

A new breaking emergency discussion has been initiated in VOSOCC web site on 28 September early afternoon.

4.2 International Charter activation

The International Charter has not been activated so far.

4.3 Volcanic Hazard

Volcanic Hazard is here reported only because it could affect the transport of Humanitarian goods to the area and because of the Rinjani volcano located on the affected island of Lombok.

Indonesian volcanoes interested by Volcanic Ash Advisories from Darwin Volcanic Ash Advisories are the Dukono, Krakatau, Ibu, Kadovar, Kerinci are the only ones in Indonesia interested by recent Advisories. As of todays's 28 September 2018: http://www.bom.gov.au/aviation/volcanic-ash/darwin-va-advisory.shtml

No ongoing significant eruptions.

5 Expected Updates

Further update will be provided if needed.

6 References and contact points within JRC

Contact points within JRC: Disaster Risk Management Unit
- Alessandro Annunziato, alessandro.annunziato@ec.europa.eu
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- Pamela Probst, pamela.probst@ec.europa.eu

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For updated information on the disaster, please consult the following web sites:

- GDACS: http://www.gdacs.org/report.aspx?eventid=1157757&episodeid=1229845&eventtype=EQ
- Copernicus EMS: http://emergency.copernicus.eu/mapping
- BNPB: https://www.bnpb.go.id/
- BMKG: http://www.bmkg.go.id