Center for Disaster Management and Risk Reduction Technology

CEDIM Forensic Disaster Analysis Group (FDA)

Super Typhoon Haiyan / Yolanda – Report

13.11.2013 – Report No. 2, Focus on Philippines – 18:00 GMT

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Official Disaster Name	Date	Landfall UTC	Local	Duration (PHL)
Yolanda (International: Haiyan)	**From 4-11**	**7.11. 20:40**	**+8**	**30 hours**

Preferred Hazard Information:

Path	Speed	Definition	Width (km)	Gust (Peak)	Landfall	Sustained
280W (PH) then 325W (VN)	**30-40kph**	**Category 5**	**Max: 150**	**379kph**	**312kph**	**250kph**
				JTWC		JTWC

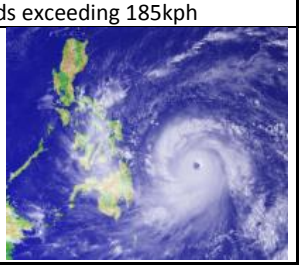
Location Information:

Country	ISO	Provinces/Regions	Most Impact	Economic Exposure	HDI (2012)	Urbanity	Pop. affected
Philippines	**PH**	**IV, V, VI, VII, VIII, X, XI, XIII**	**Leyte, Samar, Tacloban**	**Ca. $104b**	**0.654**	**55%**	**Ca. 14 million**
Vietnam, China	**VN**	**North of Da Nang**	**Coastal regions**	**n/a**	**0.617**	**45%**	**600,000 evac.**

Preferred Hazard Information:

Philippines	Vietnam	China	**Key Hazard Metrics**
Typhoon (Cat. 5)	Category 4	Unk.	Leyte, Dinagat, Samar, Aklan, Capiz, Guimares, Cebu (all on Philippines), with wind speeds exceeding 185kph
Hazard Description (Wind speed etc.)			

The category 5 typhoon made landfall near Guiuan on Eastern Samar at 07.11 at 20:40 UTC and hit with the strongest landfall wind speeds ever observed. Previously, the typhoon had hit the small nation of Palau causing some damage. Wind gust speeds reached a predicted 380 kph shortly before impact.The warm sea water and low wind shear has contributed to the maximum intensity of this typhoon before landfall. The central pressure was estimated 885 hPa (according Joint Typhoon Warning Center), which makes it only the 5th in 25 years in the Western Pacific to do so (Megi 2010, Flo 1990, Ruth 1991, Yuri 1991). The wind speeds have dropped significantly to around 150 kph approaching Vietnam and Southern China (Hainan). Typhoon dissipated 11.11. over China.



Additional hazard information on Haiyan/Yolanda: http://www.wettergefahren-fruehwarnung.de/Artikel/20131108info.pdf

Vulnerability and Exposure Metrics (Population, Infrastructure, Economic)

The capital stock of the affected locations is around $104b with the GDP being around $31b with approximately 17 million inhabitants. Leyte was the first hit with destructive force (1.5 million inhabitants) with Tacloban City worst affected (220,000 inhabitants). Most houses will not withstand winds of over 200 kph, thus destruction in the eye of the typhoon will be close to 70-80 % as confirmed by police officials in the affected regions.

What have been the 2 largest comparable damaging events in the past?

Date - Name	Impact Size (1 min sustained)	Location	Social % or Insured %	Economic Loss in Philippines
2012 Bopha	Typhoon (280 kph)	Southern PH	1146 deaths, 834 missing	$1.04b USD (42b PHP)
1990 Mike	Typhoon (280 kph)	Central PH	748 dead	$879m USD (2013 adj.)

Mike was close to the path of this storm in 1990 – destroyed 117,000 homes and damaged 295,000 others

Preferred Building Damage Information: *(Damage states will be filled in later when more info available)**

160,000 destroyed and 148,000 damaged buildings counted. Northern Leyte: The destruction has been canvassed at 70-80 % of homes destroyed.Panay Island : 127,000 destroyed and approx. 114,000 damaged. All communication systems affected. Tacloban City – 60% destroyed, 30% severely damaged, 10% damaged. Approx. 1,000,000 homes expected to be damaged.	
*total destruction will not be known for weeks. Over 3.5 million houses exposed	UN Rapid Response

Secondary Effect Information:

Type	Impact	Damage %	Social %	Economic %
Storm Surge	Wave heights of 5-6m were seen	Major	High % in Casey, Tacloban	Unk.
Flooding	River flooding and flash flooding	Major	Unk.	Unk.
Landslides	Not as many as predicted	Minor	Unk.	Unk.

Disaggregation will occur during the course of the FDA

Preferred Social Impact Information:

Type	Median	Accepted Range	Description	Source
Deaths	**ca. 13000**	Official: 2275 but many more	Leyte:10000? (Tacloban:1000+), Samar: 3100, Panay: Over 200 dead; Total:22000 missing	PDRRMC, NDRRMC, Red Cross
	***NB: 60000 people are currently being searched for on Person Finder (Google)*			
Injuries	3804	Will increase	Still being counted	NDRRMC
Long term Homeless	**2,100,000**	**estimated**	Based on housing destruction calculations and current PDRRMC data	Daniell, CATDAT
Short term homeless	**4,700,000**	**estimated**	Locations w/o power and damaged houses	Daniell, CATDAT
Affected	**14,000,000**	8.0m	**IV, V, VI, VII, VIII, X, XI, XIII**	Estimates, NDRRMC

Preferred Current Economic Impact Information: $million int. event-day dollars

Type	Median	Accepted Range	Description	Source
Total Cost	**$13.6b**	**$9b-17b**	Total estimate (using rapid loss model combined with damage for range)	CATDAT/ James Daniell
Insured Losses	$1000m	$200m-$2b	According to Bloomberg Analyst citing - % takeout should be lower however	Kinetic Analysis Corp.
Aid	Ca. $150m	n/a	Continually increasing (currently at ca. 1%)	ReliefWeb

Direct Economic Cost (Total) – Summary

- Given the capital stock of the disaster path and the destruction seen in locations of Leyte – a quick estimate can be made. Using the 70-80% destroyed rate for Tacloban and other locations, northern Cebu and parts of Aklan and Iloilo, the MDR (mean damage ratio) comes to around 30% for Leyte. In other locations like Aklan, and MDR of 15% is likely based on the initial estimates of house destruction. MDRs of ca. 15% in Samar. In less affected regions, MDRs of 1-5% are likely.
- Reconstruction costs in the order of $4b (174b PHP) from the 3 provinces, and around **$9.5b total cost** for all affected regions from the first estimate (CATDAT-James Daniell)
- Plantations and crop losses (sugar cane and rice) will be huge, and industry losses of the affected region will probably be at least 40% of GDP – thus around $2b from the 3 provinces and around $2.1b from other locations, totalling **around $4.1b**
- This is in the order of 14 times larger than Typhoon Bopha.

Links and studies

Information Gap Analysis of Trevor Girard (KIT) (click here for analysis)
Social Sensors Project of KIT and GFZ (click here for analysis)

www.wettergefahren-fruehwarnung.de
(Updated storm track)
http://www.earthquake-report.com
(CATDAT data and statistics)
http://google.org/personfinder/2013-yolanda
(Google Person Finder for Yolanda)
http://www.ndrrmc.gov.ph/
(official updates from NDRRMC)
http://www.ssd.noaa.gov
(track and intensity data)

Insured Loss Estimates:

Public infrastructure damage has occurred, as well as total destruction of many industries. Sugar cane and rice production losses will be nearly total through this region – accounting for 50% and 33% respectively of the Philippines. Bloomberg currently estimates around 14% insurance losses as a percentage of total, however less is expected.

Abridged Summary Description:

A catastrophic typhoon has hit Philippines, Palau, and will continue on to Vietnam and China. **Over 13000 are presumed dead** in Philippines **with over 2.1 million homeless and between 3 and 5 million currently displaced (1.18 million on Panay Island)**. The economic cost will be the largest ever in terms of Philippines typhoon losses with around **$13.6b USD or 590 billion PHP** expected losses (which would be 10 times larger than historic typhoon losses).

CATDAT Economic Storm Rank	10: Catastrophic	**CATDAT Social Storm Rank:**	10: Catastrophic

This summary report was produced in conjunction with the CATDAT database, earthquake-report.com, wettergefahren-fruehwarnung.de, NDRRMC and JTWC data. In the second part below is full size documentation of the diagrams shown in the summary above. The data is current as of 13th November 2013 5:00pm European Standard Time.

II. FURTHER INFORMATION AND ANALYSIS

1 Hazard information and description

1.1 Summary

In 2013 the western north Pacific tropical cyclone season was very active and 4 out of five typhoons of the highest category 5 worldwide occurred in this area. The tropical cyclone activity in the western Pacific culminated in super typhoon “Haiyan” that developed into one of the strongest cyclones in worlds history. According to satellite data peak wind gusts were 380 kph. “Haiyan” made landfall shortly after peak intensity and hit the central Philippines on 7 and 8 November 2013. With maximum wind speeds around 300 kph, an extraordinary high storm surge and torrential rain the typhoon devastated in particular the Philippine provinces of Samar and Leyte.

1.2 Evolution of “Haiyan” (Philippine name: “Yolanda”)

"Haiyan" took its origin about 100 kilometers southeast of Pohnpei, the main island of the Federated States of Micronesia. On 3 November 2013 the Joint Typhoon Warning Center (JTWC) issued a warning for an increased likelihood of a storm development for this area of relatively low air pressure. Within a day, the system intensified from a tropical depression into a tropical storm, which was named "Haiyan". Following a west northwesterly track, “Haiyan” was classified as a typhoon on 4 November. Within 36 hours “Haiyan” grew into a typhoon of the highest category 5 on 6 November 2013, 12 UTC. With warm waters of at least 26C that extended into great depth (more than 100 meters), low wind shear, and excellent upper-level outflow conditions, Haiyan could stay at category 5 strength until landfall.

The development of “Haiyan” peaked on 7 November 2013 (18 UTC). The central pressure dropped to a value between 862 hPa (JMA) and 884 hPa (JTWC). The maximum sustained wind speed was 314 kph gusts reached values up to 379 kph (JTWC). A little bit later, at 20:40 UTC, “Haiyan" made landfall as an extremely dangerous category 5 typhoon on the Philippine island of Samar near Guiuan. Even after landfall there was only little weakening at first and "Haiyan" kept its intensity as typhoon of the highest category until 8 November (06 UTC).

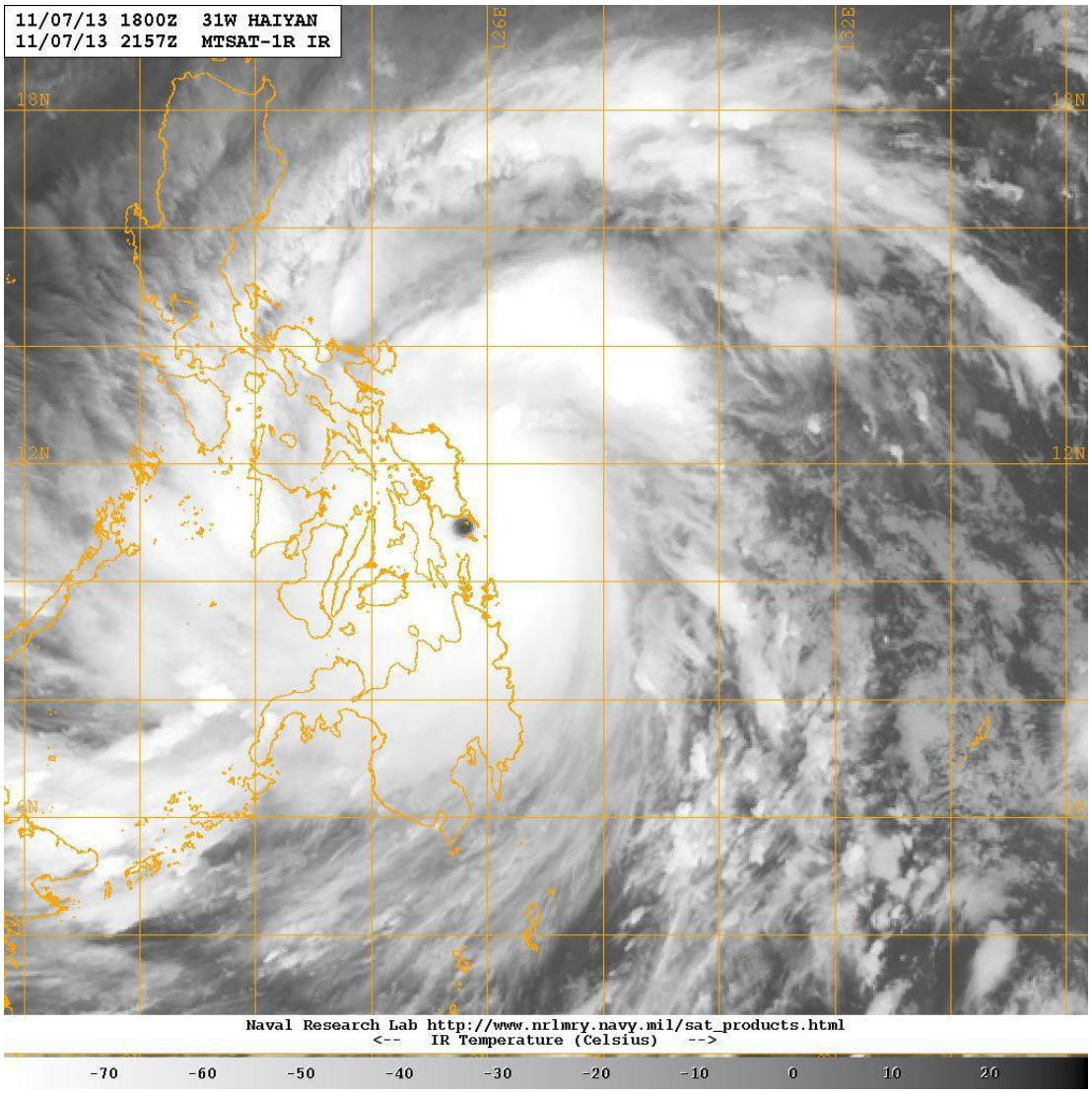


Fig. 1: Satellite image with Haiyan just after making landfall; 13 November 2013, 21:57 UTC. Image credit: Naval Research Lab, http://www.nrlmry.navy.mil/TC.html

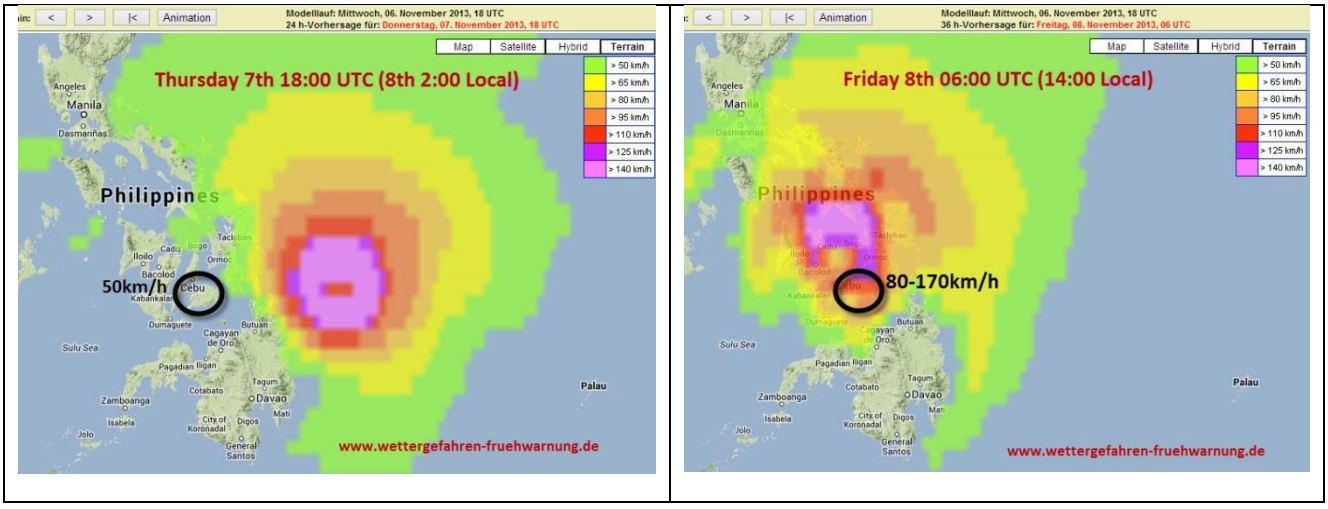


Fig. 2: Forecasted average wind speed and extension of the storm system shortly before land fall at 7 November, 18 UTC, and at 8 November, 06 UTC. (Forecast data: GFS Model). Circled is Bohol – location of the recent earthquake as a reference. Image credit www.wettergefahren-fruehwarnung.de

Over the South China Sea “Haiyan” followed a more northerly track and lost intensity. The storm center passed the Chinese Island of Hainan and made landfall near Haiphong in north eastern Vietnam on 10 November 2013 (21 UTC). At the time of landfall, a central pressure of 970 hPa and sustained wind speeds up to 111 kph were analysed. Due to direct and indirect influence of the boundary layer friction over land, the system quickly weakened and eventually "Haiyan" was a tropical depression on 11 November 2013 over southern China.

Fig. 3: Path of Haiyan/Yolanda and forecasted track (as from 10 November 2013, 06 UTC), Source: JTWC imported into Google Maps(full size version of the figure in part I SUMMARY)

1.3 Impact of “Haiyan” in Vietnam and China

Despite the continuous weakening, the impact of the typhoon "Haiyan" especially over North Vietnam and the far south of China was remarkable. Along the North Vietnamese coast at landfall of typhoon storm surges and high winds were an issue, otherwise heavy rainfall caused flooding.

The TRMM analyses of satellite data show a maximum of rainfall in the central Philippines with locally near 500 mm, another maximum over central Vietnam with 300-500 mm and in Guangxi (southern China) with 200-300 mm. This is in good agreement with precipitation data from surface based weather stations. Behai, a coastal city in Guangxi, recorded a 24-hour rainfall amount of 324 mm until 11 November 2013, 12 UTC. In Lang Son in northern Vietnam the 24 h-rain amount was 147.6 mm on the same day. The heavy rains led to widespread flooding, at least 13 people lost their lives in China, at least 5 in Vietnam.

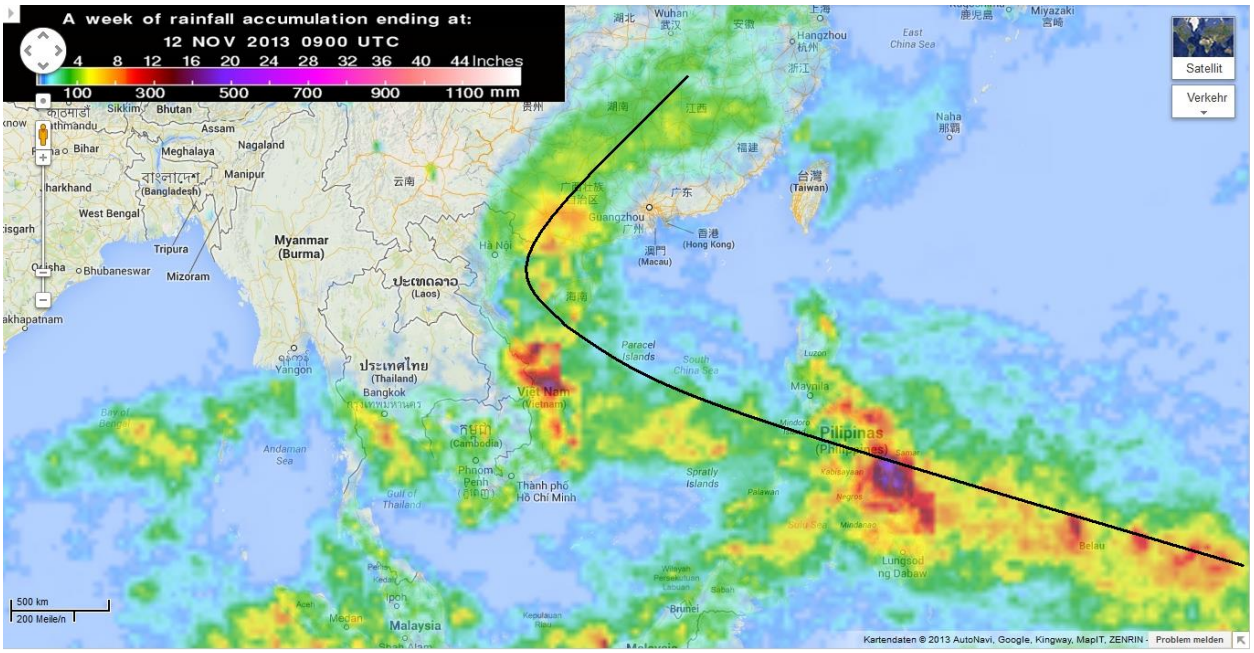


Fig 4: Accumulated rain amount along "Haiyans" track, 5 November – 12 November 2013, 03 UTC. Data source: http://trmm.gsfc.nasa.gov/

1.4 "Haiyan" in the historical context

Regarding recorded or estimated wind speeds during the typhoon this event must be rated as outstanding. The average wind speed - it is a 1-minute average - of 315 kph was the fourth highest ever observed with tropical cyclones. Only typhoons Nancy, Violet and Ida were associated with even stronger winds. The maximum wind gusts were 379 kph (according to JTWC). This value is extraordinary and close to the world record for wind gusts outside of tornadoes, which is held by Cyclone Olivia (1996) with 408 kph. Usually the highest wind speeds occur over open waters; the fact that "Haiyan" fell ashore just 3 hours after peak intensity leads to the conclusion that the super typhoon likely made landfall with sustained winds near 315 kph and therefore was the strongest tropical cyclone on record to make landfall in world history. Similarly high wind speeds (306 kph) at landfall were observed with Hurricane "Camille" in 1969 making landfall near the Mississippi delta.

The minimum central pressure, which is estimated between 858-884 hPa, is also an extremely low value. By comparison, the most intense tropical cyclone in history, typhoon "Tip" (1979), had a record low central pressure of 870 hPa. So it is quite possible that "Haiyan" could set a new record, too.

Table 1: List of 11 strongest Tropical Cyclones 1958-2013

Name	Year	Wind in kph	Central pressure
		kph	hPa
Taifun Nancy	1961	345	882
Taifun Violet	1961	335	895
Taifun Ida	1958	325	877
Taifun Haiyan	2013	315	858-884
Taifun Kit	1966	315	880
Taifun Sally	1964	315	895
Taifun Joan	1959	315	885
Hurricane Allen	1980	305	899
Taifun Tip	1979	305	870
Hurricane Camille	1969	305	905
Taifun Vera	1959	305	895

[1] wind speeds: 1 minute sustained wind
[2] observed or estimated central pressure of the tropical storm system
Data: various sources, table compiled by www.wettergefahren-fruehwarnung.de

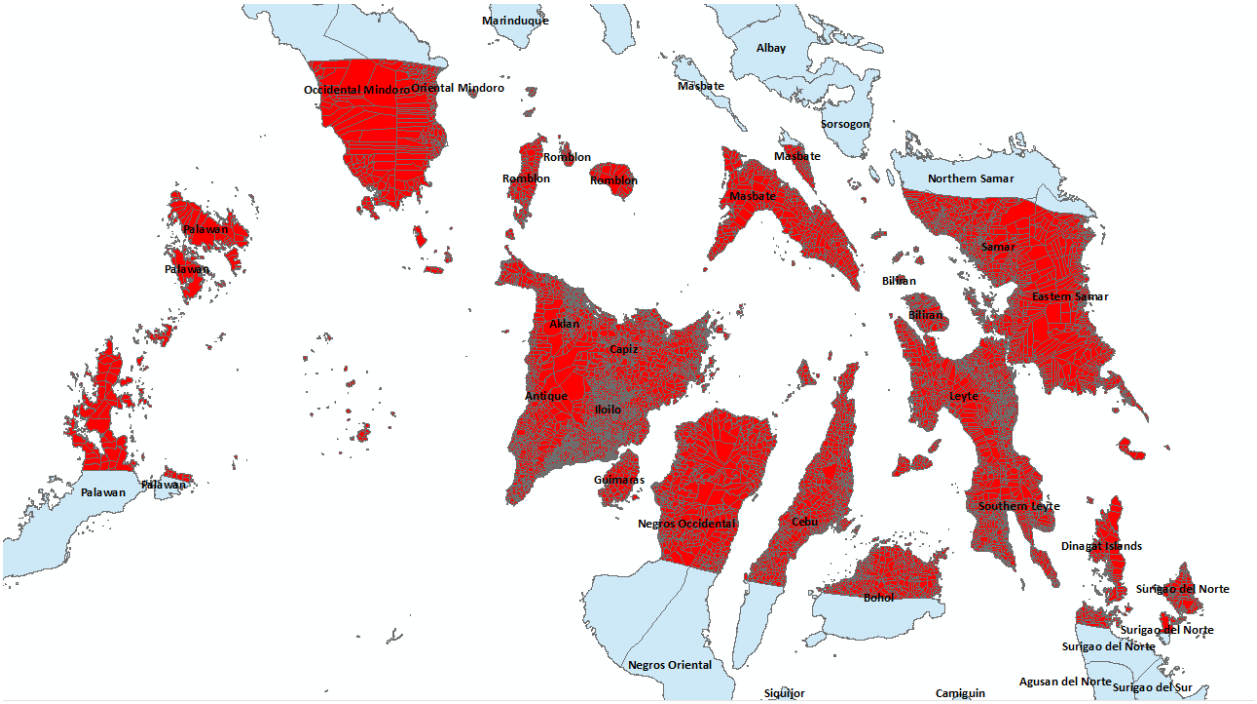


Fig. 5: Main track affected locations in the Philippines comprising of 17 million population exposure.

2 Building damage information

Collating the current damage estimates on a provincial level – the following destroyed and damaged building results with 160,000 buildings currently counted as destroyed and 148,000 currently counted as damaged. It should be noted that these figures do not include any buildings on Leyte, Samar, Eastern Samar and therefore can be expected to increase substantially. It is expected that the final total will be around 400,000 buildings destroyed and around 600,000 buildings damaged combining to 1,000,000 structures needing repairing or reconstruction.

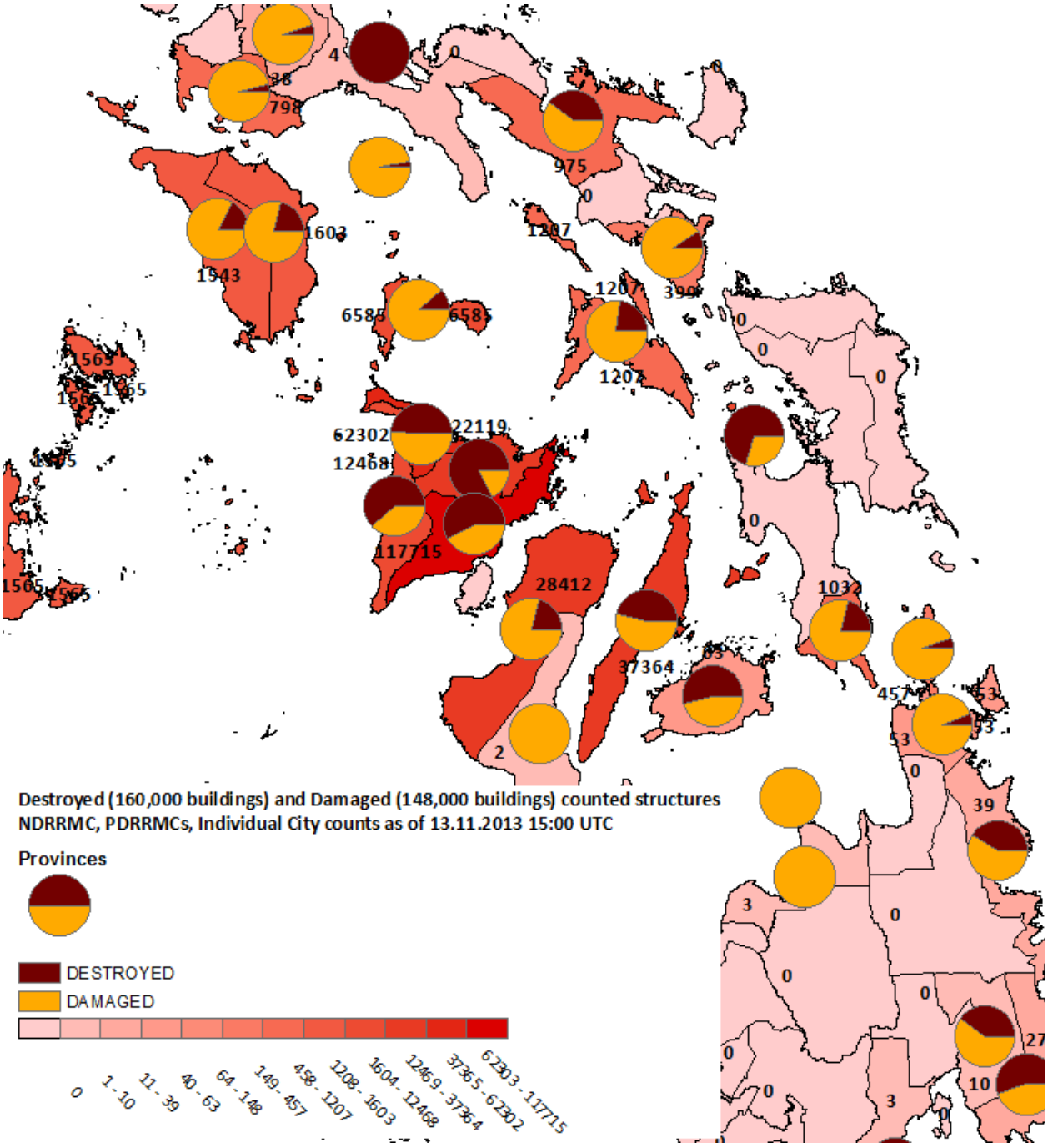


Fig. 6: Province level destroyed and damaged building counts as quantified by various municipalities, provincial disaster response offices (PDRRMC) and national data (NDRRMC) showing over 300,000 buildings currently counted with damage (it is expected this is about 30% of the final total to be counted given that the Eastern Visayas data is currently not in)

Destruction is currently still being counted with only Region VI showing fully collated loss statistics on destroyed and damaged buildings. When looking at a municipality level, it can be seen how few of the municipalities have returned final loss statistics, however each update of the NDRRMC reports and local counts will update this figure.

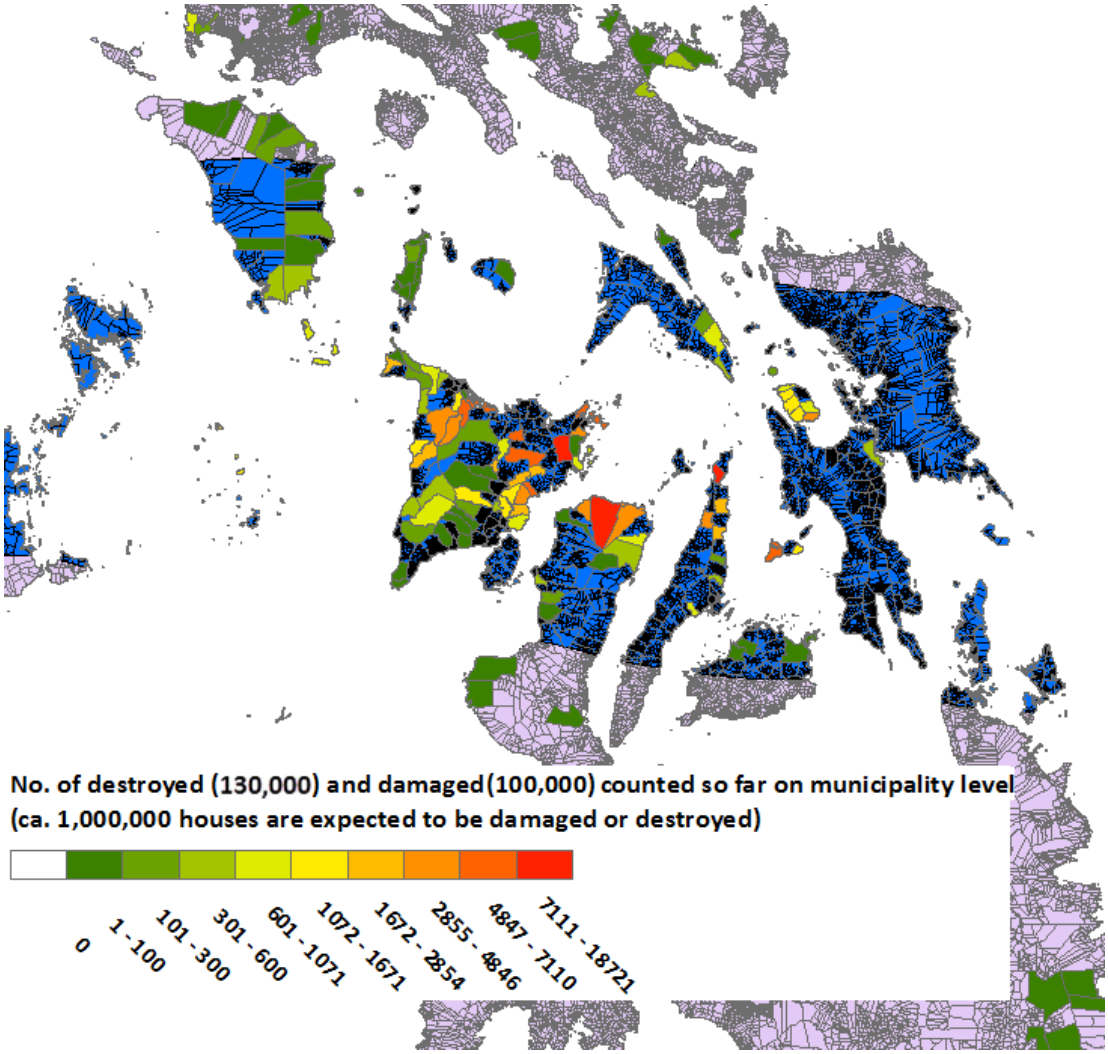


Fig. 7: Municipality level damage counted currently via NDRRMC, PDRRMCs as of 13.11.2013 08:00am UTC

Fig. 8: Destruction as seen from above Tacloban City (estimated 70%-80% destruction rate) – with the official numbers still to be counted and not within the already 308,000 recorded damaged or destroyed buildings on province level or 230,000 municipality level counted (takes longer for them to be placed than the province data), Source: UN Rapid Response Team (full size version of the picture in part I summary)

3 Social impacts

3.1 Homeless Analysis

Homeless data has been collected from NDRRMC reports, PDRRMC reports throughout the region, news articles, comments on specific towns and other data. Currently on the province level, the current data is available however, the collation by NDRRMC should be viewed as the"official" source, and these collations simply used as a modelled estimate of the locations for which no data is available.

Although 600,000 are stated to be displaced from other sources, the NDRRMC (national) has not as yet included much PDRRMC (provincial) data, and no data currently on the worst affected regions of Leyte, Samar and Eastern Samar.

The estimate of 6 million short-term displaced and **2.1 million long-term homeless** correlates with what has been seen and the reports from PDRRMC (not yet reported via NDRRMC)

Currently alone in Region VI (Panay Island etc.), 1.158 million are displaced from official counts with 124117 houses destroyed and 111909 houses partially destroyed totalling to around 235,000 homes damaged or destroyed in Western Visayas, with Aklan and Iloilo worst affected when totalling the provincial data. Around 650,000 of these can be expected to be long-term homeless.

Carrying these displaced figures through to the affected locations in Leyte, Samar and Eastern Samar and northern Cebu, there are reports from various locations coming in of the damage levels, the initial values of 6 million have reduced to around **4.7 million short-term displaced,** however the 2.1 million long-term homeless remains the same. The 4.7 million comes from trending the displaced figures. In all regions affected by the storm, around 13 million people are present. Given food shortages, power outages, the tropical depression Zoraida and other influencing factors, it may be that the actual displaced figure is somewhere between the 4.7 and 13 million figure.

Although only 112,000 have been registered displaced across Region VII (Cebu, Bohol), it is expected that this number will rise to about 450,000 when the affected locations in northern Cebu are counted. It is expected that around **150,000 in Cebu will be long-term homeless.**

Across Leyte, Samar and Eastern Samar around 1.16 million people are presumed to be long-term displaced however the current total of displaced has not been counted.

Leyte will likely have around 600,000 long-term homeless, Eastern Samar around 300,000 homeless and Samar around 260,000.

In other locations, there are expected to be additional homeless, like on Bilaran where around 8000 houses have been destroyed and around 50,000 left homeless.

Summary of official and estimated figures for long-term homeless:

Region VI: Panay Island, Aklan, Capiz, Iloilo, Antique – 650,000 long-term (1.158 milion displaced currently) – official figures.

Region VII: Cebu, Bohol – 150,000 long-term (450,000 estimated to be currently displaced)

Region VIII: Eastern Visayas – E. Samar, Leyte, Samar, Bilaran, S. Leyte – 1,230,000 long-term homeless (unknown currently displaced – possibly 2.2 million)

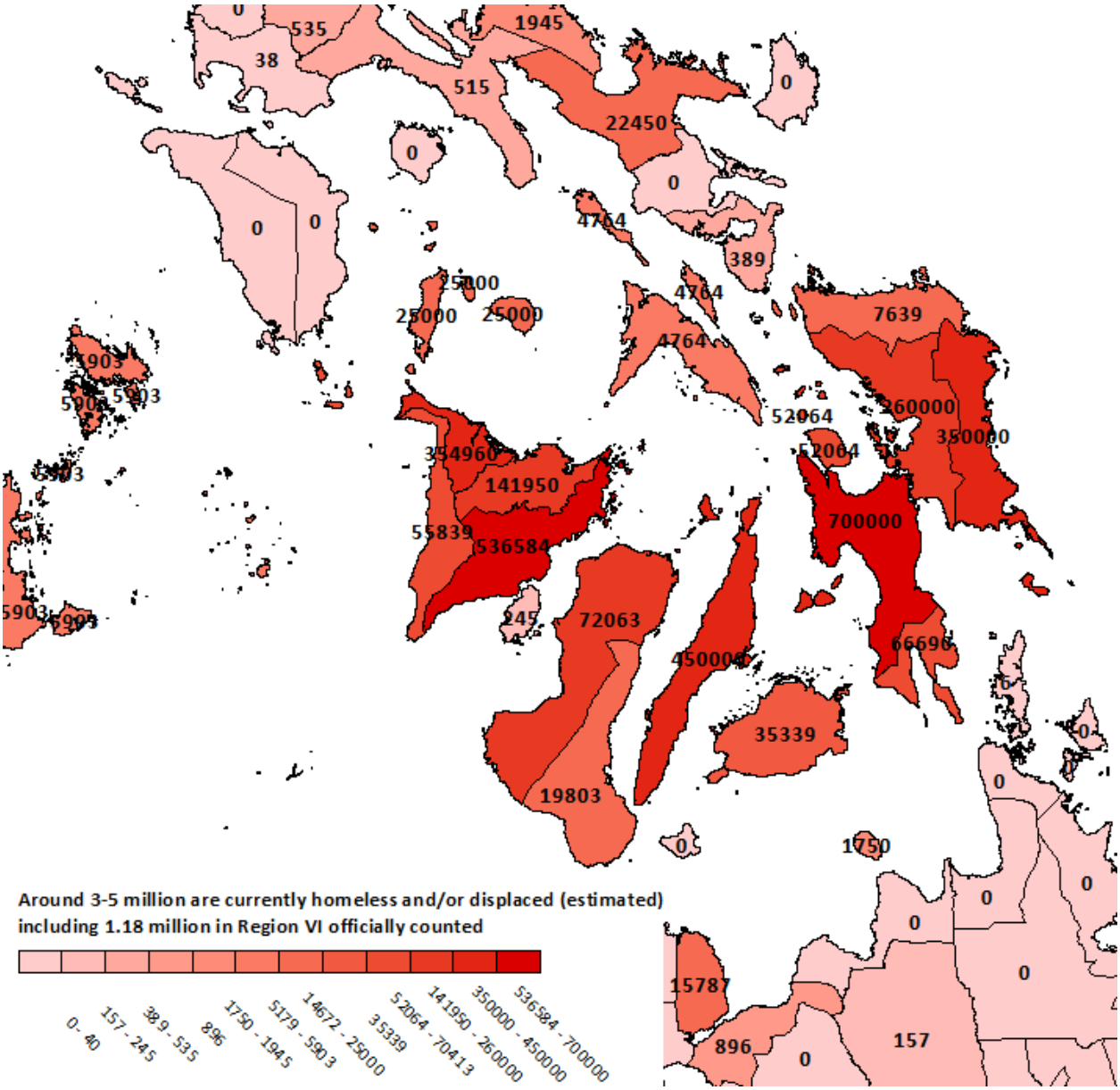


Fig. 9: Currently displaced and homeless from NDRRMC, PDRRMC, news and estimated sources via CATDAT. (estimates are rounded to 1000s, statistics are kept as exact values).

3.2 Casualties

Current fatality estimates from regional sources (NDRRMC should be used for official values – currently 2344 dead and 79 missing). 3804 people are counted to be injured.

Using unofficial sources, the potential fatalities are over 13,000. There are currently 22,000 missing people according to the Red Cross. The numbers are currently unknown in Leyte, hence a value of 10,000 has simply been input, and 785 in Samar and 2400 in Eastern Samar, collating news reports and uncertainties. It should be noted that these are unofficial numbers.

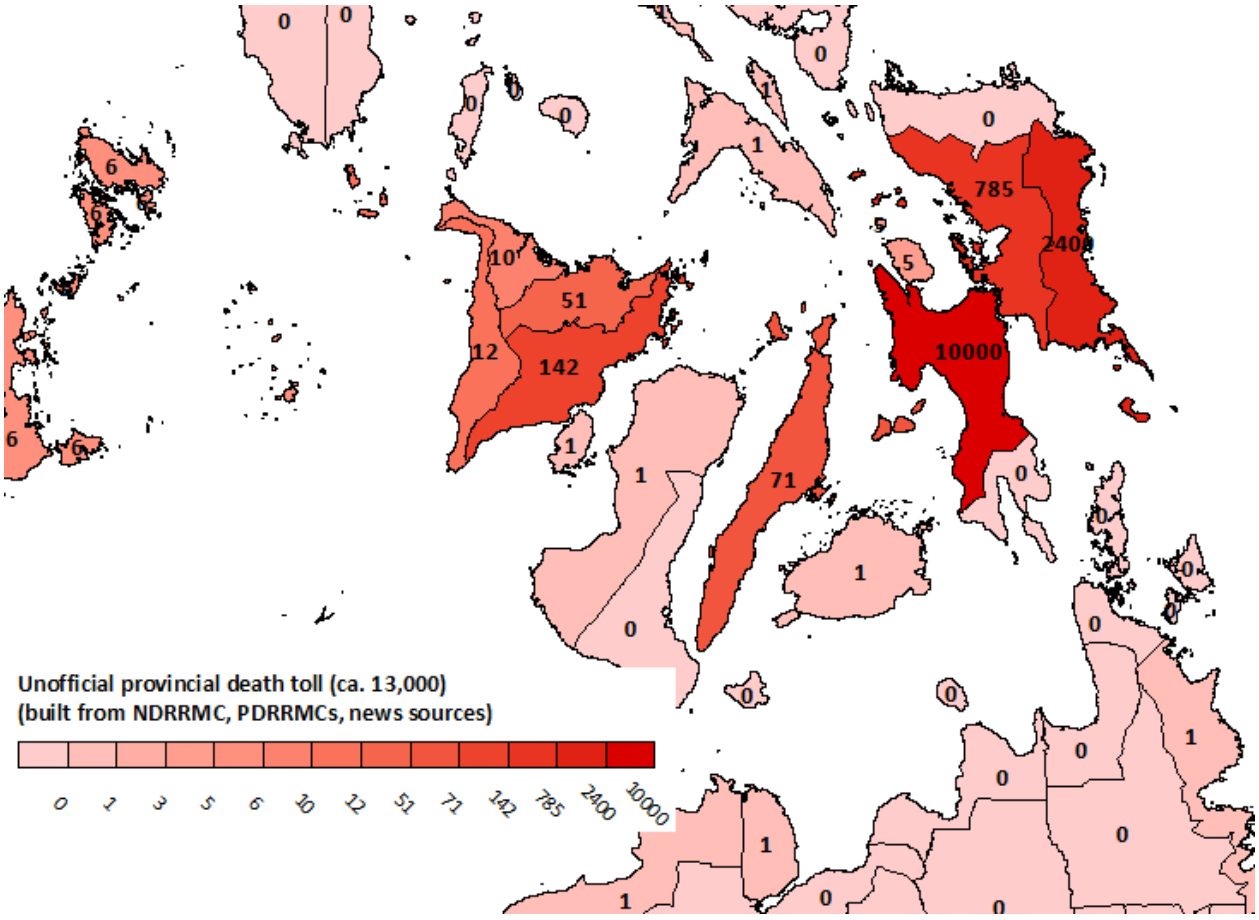
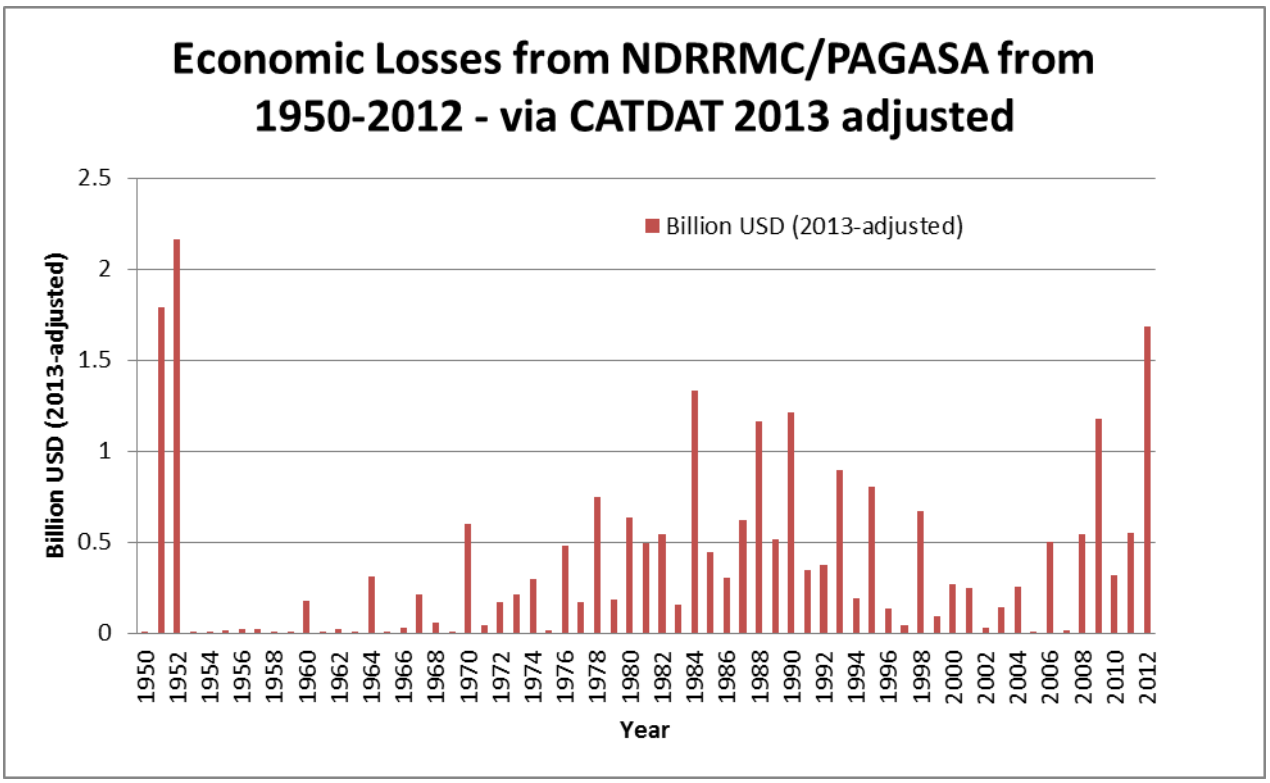


Fig. 10: Unofficial death toll from the Yolanda Typhoon collated from various sources as of 13.11.2013 4:45pm. UTC.

4 Economic impact in a historic context

Using the historic economic losses from the past 63 seasons of typhoons and tropical storms, the following analysis has been undertaken showing the extent of the impact of this disaster as compared to the previous years firstly only for the period of 1950 to 2012. It can be seen that no historic typhoon season has exceeded 2.5 billion USD.



*there is some conjecture as to Typhoon Amy losses in 1951 but the current values of NDCC and Typhoon2000 have been used.

Fig.11: Economic Losses from Typhoons (2013 adjusted dollars) from 1950-2012 (CATDAT; NDCC; NDRRMC; Typhoon2000).

Now including the losses including 2013 (this disaster), pegged at 13.6 billion USD damage, it can be seen that in economic and damage terms this disaster is a magnitude larger than previous events.

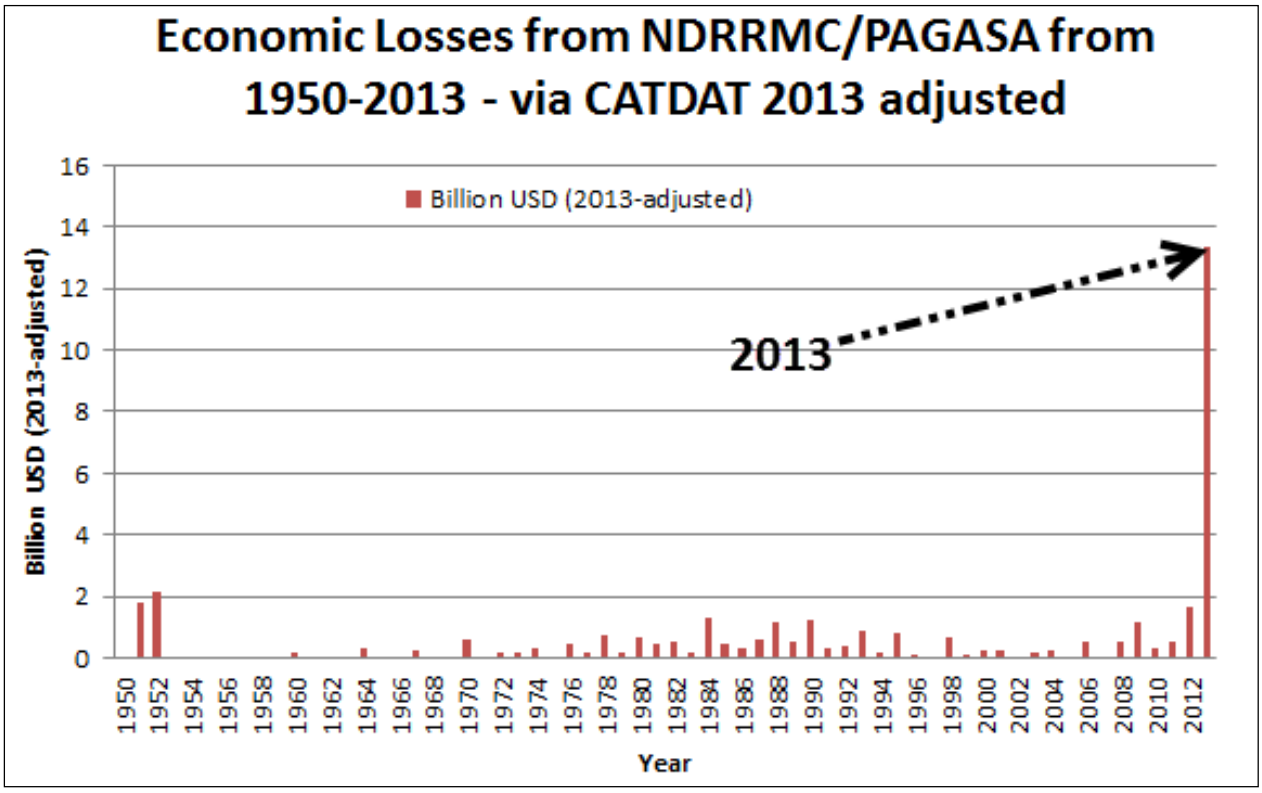


Fig.12: Economic Losses from Typhoons (2013 adjusted dollars) from 1950-2013 (CATDAT; NDCC; NDRRMC; Typhoon2000).

An analysis is now made, by adjusting for the population increase through time to calculate a predicted "as if today" calculation of historic typhoons for the exposure of today. It can be seen that Yolanda is the largest event even when reproducing these historic typhoons.

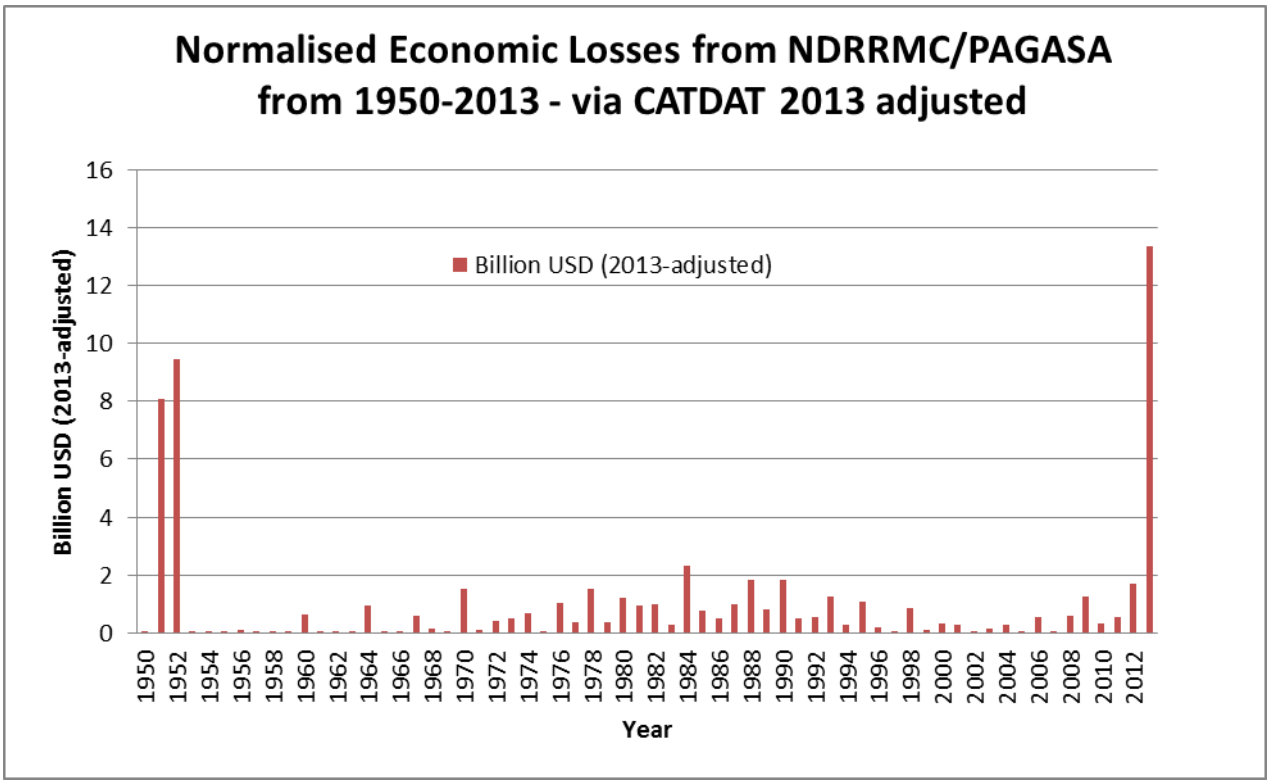


Fig.13: Normalised Economic Losses from 1950-2013 for Philippines typhoons (CATDAT).

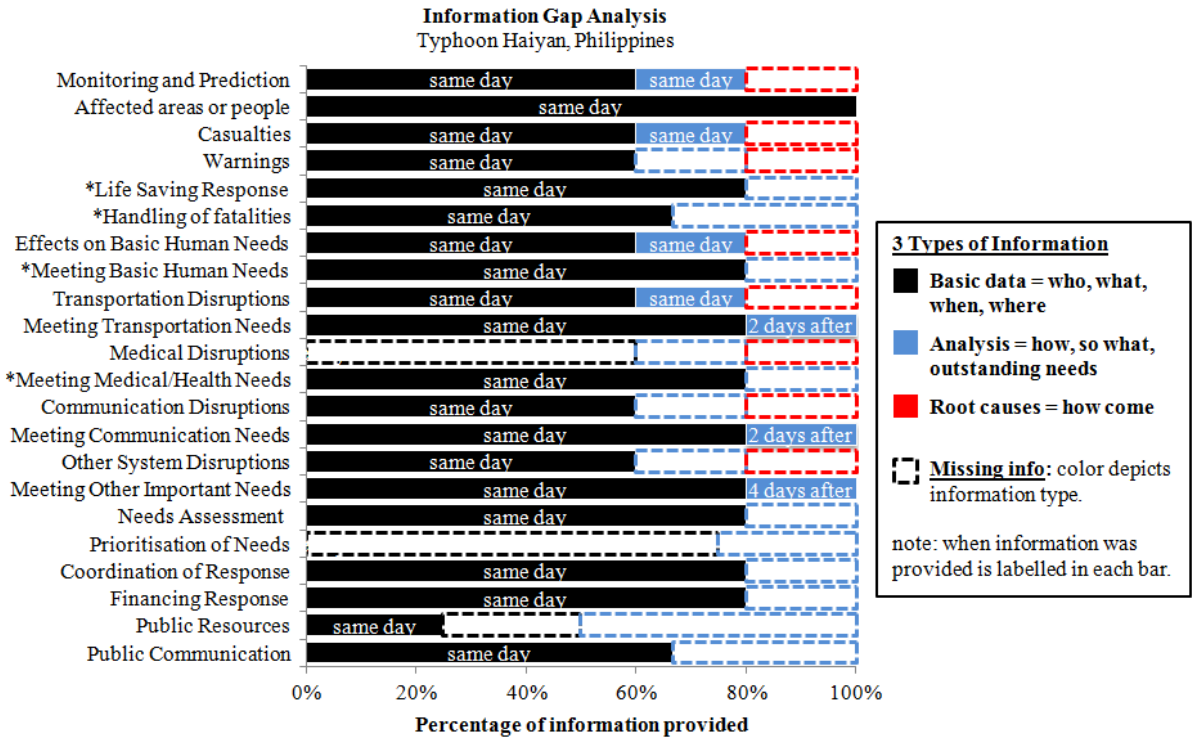
5 Disaster information

5.1 Analysis of information

The chart below in Fig. 14 is the result of an analysis of the information produced within the first 4.5 days of the first landfall of Typhoon Haiyan in Guiuan at 4:40am Local Time on 8 November 2013. The information was retrieved from the situation reports issued by the National Disaster Risk Reduction and Management Council (NDRRMC) website (http://www.ndrrmc.gov.ph/). All information was categorized under the headings listed on the left side of the chart. Each piece of critical information was separated into three types, being basic data (who, what, where, when), analysis (how, outstanding needs), and root causes (how come). The dotted areas identify the missing information. The chart is based on the summarized *Evaluation of the Information* listed in the table 2 below.

Information Gap Analysis:

Super Typhoon Yolanda/Haiyan, the Philippines



*The lack of analysis information in these response areas signifies that the extent to which these actions are meeting the needs of the affected population is unknown.

Fig.14: Information Gap Analysis: Super Typhoon Yolanda/Haiyan, the Philippines

Each of the sections in the table 2 below represents an area of the disaster response for which information is typically disseminated to the public (based on a review of past disasters in different regions). Questions are framed so that information content and timing of delivery can be better understood and standardized.

Table 1: Evaluation of information – detailed overview

Evaluation of the Information (provided as of 12 Nov 2013 by the NDRRMC in response to Super Typhoon Yolanda/Haiyan)	
Information predicting a disaster event, describing an event which has occurred, or describing the current situation	
When is the public made aware of predictions? How soon after is the public informed of details? How often are updates?	**Information detailed and provided within a reasonable time-frame, and updates frequent** Based on: 2 days before 1st landfall: path of typhoon is being tracked and areas expected to be in path identified, which includes what, where and when. Flood and landslide risks discussed. Frequent updates.
Description of affected area(s) or people	
How soon after disaster were areas or people affected identified?	**Information detailed and provided within a reasonable time-frame** Based on: 2 days prior: areas likely to be affected put under BLUE alert and flood prone areas identified. Within hours affected areas identified, and affected families. Updates follow.
Human life safety and potential threats to human life safety (including particularly vulnerable populations)	
How soon after event is the public made aware of the casualties/missing?	**Information is detailed; however, numbers of casualties in earlier reports are not accurate as numbers continue to rise.** Based on: After 1 day state a very low number of casualties (4 dead/ 7 injured), which rises to 255 dead/ 45 injured after 3 days to 1,798 dead/ 2,582 injured after 4.5 days.
When is public made aware of potential dangers?	**Information detailed and provided within a reasonable time-frame** Based on: 2 days before: fishermen warned. 1 day before: warnings against possible flashfloods, landslides, and storm surges.
When did the DM system begin evacuations or Search and Rescue?	**Information detailed and provided within a reasonable time-frame** Based on: 2 days before evacuation is being encouraged, schools prepped as evacuation sites and pre-positioning of SAR assets. 1 day before some evacuations ordered. Updates follow.
When did the DM system begin activities aimed at dealing with fatalities?	**Minimum information provided** Based on: 2 days after 300 cadaver bags are sent to Tacloban city. 4 days after retrieval operations are being conducted in Tacloban City, Eastern Samar, Samar and Leyte.
Basic human needs (water, food, shelter, clean air, sanitation)	
Disruption: When are disruptions to basic human needs identified?	**Information detailed and provided within a reasonable timeframe** Based on: 1 day before numbers provided of evacuated and stranded, and advised public in some areas to start storing water. 1.5 days after identified damaged houses. Updates follow.
Solution: When are activities conducted to meet the basic needs?	**Information detailed and provided within a reasonable timeframe** Based on: 2 Days before pre-positioning of many relief items, includes what, where, who, and value of goods. 1hr20min after description of activities. Updates follow.
Transportation networks (road, air, rail, river/sea)	
Disruption: When are transportation disruptions identified?	**Information detailed and provided within a reasonable timeframe** Based on: 1hr20min after update on stranded passengers, vehicles, and status of roads and bridges provided including where and cause. Updates follow.
Solution: When are activities conducted to meet transport. needs?	**Information detailed and provided within a reasonable timeframe** Based on: 2 days before planning being done for transport and road clearing activities. 2 days after most roads/bridges passable & no more stranded passengers/vehicles. Updates follow.
Capacity of medical/ health services	
Disruption: When are disruptions to medical system identified?	**No detail regarding actual effects to medical system following landfall** Based on: 2 days before alerted DoH representatives in province likely to be affected. DoH activated code blue in all regions, and code white for hospitals with standby response teams.
Solution: When are activities taken to meet medical needs?	**Information detailed and provided within a reasonable timeframe** Based on: 2 days before DoH issued alerts, and begins preparation activities. 1hr20min after update on amount of drugs and medicines prepositioned. Updates follow.

Communication Networks	
Disruption: When are communication system disruptions identified?	**Information detailed and provided within a reasonable timeframe** Based on: 13hrs after communication interruptions identified, no cellphone signal reported in regions VII & VIII, and interruptions in 24 municipalities in northern Cebu. Updates follow.
Solution: When are activities taken to meet communication needs?	**Information detailed and provided within a reasonable timeframe** Based on: 3 days before began preparation activities. 1hr20min after discussed radio communications. 2 days after communications restored in various areas. Updates follow.
Other systems (electricity, agriculture, education, financial, business)	
Disruption: When are other system disruptions identified?	**Information detailed and provided within a reasonable timeframe** Based on: 1 day before disruptions to fishing, education, and gov. work identified. 1hr20min after power outages identified. 1.5 days after agricultural damage identified. Updates follow.
Solution: When are activities taken to meet other important needs?	**Information detailed and provided within a reasonable timeframe** Based on: 2 days before Dep. of Agriculture pre-positioned buffer stocks of seedlings (vegetables), rice and corn. 1 day after power restoration identified. Updates follow.
Assessment of needs of people or response	
When have the various areas affected been assessed?	**Information detailed and provided within a reasonable timeframe** Based on: 2 days before pre-deployment of assessment teams discussed. 1hr20min after NFA IV-B deployed data gathering teams. Assessments continue with each following update.
Establishment of prioritised needs of those affected or needs to improve the response	
When has the DM system established critical needs?	**no information**
Activation/coordination of emergency services, i.e., EOC, medical teams, SAR, police, army	
How quickly has the DM system activated emergency services?	**Information detailed and provided within a reasonable timeframe** Based on: 3 days before directed chairpersons, regional DRRMCs, IV-A, IV-B, V, VI, VII, VIII, X CARAGA and NCR to plan and initiate all necessary actions and alert all responder groups and raise the alert status of RDRRMC Operations Centers. Updates follow.
How often are updates?	
Acquisition of funding and/or dispersal	
When is funding begin to be acquired?	**Information detailed and provided within a reasonable timeframe** Based on: 2 days before prepositioning of standby funds (P36,967,267) and planning for donations underway. Updates follow.
How soon is it dispersed?	
Establishment and identification of resources available to those affected	
When is the public made aware of the various resources available?	**Information detailed and provided within a reasonable time-frame** Based on: 2 days before NDRRMC situation reports begin to be released and act as resource, containing numerous updates on typhoon movement, transportation, evac. centers etc.
Establishment of a system to distribute disaster related information and updates	
When is a system established to distribute disaster information?	**Information detailed and provided within a reasonable time-frame, and system appears to be capable of reaching a very large audience** Based on: 2 days before NDRRMC starts issuing reports and SMS, fax and websites are used.

6 Social sensors

Social networking services like Facebook, Google+ or Twitter allow easy and rapid sharing of information, feelings and observations. During natural disasters, these data can be used to obtain insight into the mood of the population and the extent of damage from the perspective of eye-witnesses.

6.1 Method & Data

To get rapid information on what eye-witnesses report from the affected area, we analyze twitter messages related to the typhoon Haiyan/Yolanda which hit the Philippines at Nov. 7, 20:40 UTC. We extract twitter messages, so called tweets, containing one or more specified keywords from the field of "cyclonic storms" and use them for further analysis shown below. For the time frame of Nov. 4 to Nov. 12 we get a database of 36751 localized tweets of which 5159 are located in our area of interest (Philippines). About 939 to 1602 of these tweets have photos attached.

6.2 When do people twitter?

As storms of these categories are known in advance through weather prediction models, people already start to twitter on the event before it actually takes place. Figure 15 shows the number of localized tweets per hour from Nov. 4 to Nov. 12 on the Philippines. The early increase during the day of Nov. 7 before the event, illustrates the premature reaction of the Twitter users on the announced typhoon. The decay in the number of messages shows the elongated type of the event in time, even exceeding the duration of the event itself (approximately 30 hours, denoted by the grey box in figure 15).

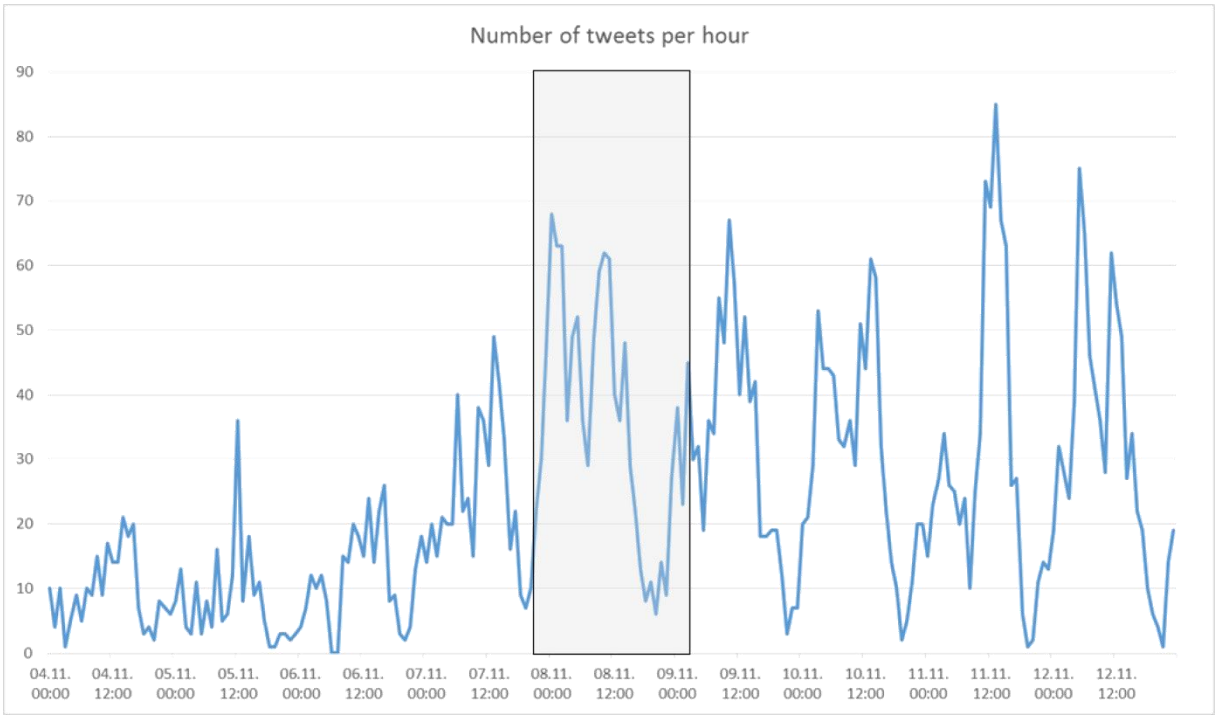


Fig. 15: Number of tweets vs. time from Nov. 4 to Nov. 12. The graph shows the premature reaction of the users on the announced event.

6.3 Where do people twitter?

To see the spatial distribution of the tweets, we created a heat map, shown in figure 16. Apart of the worldwide reaction on the typhoon and its severe consequences, the main concentration of tweets is located on the Philippines Island as one would expect. The hotspot Manila, the country's capital, reflects

the national reaction on the event. Another minor hotspot is located at Cebu City, the city which was strongly affected by the earthquake on Oct. 15.

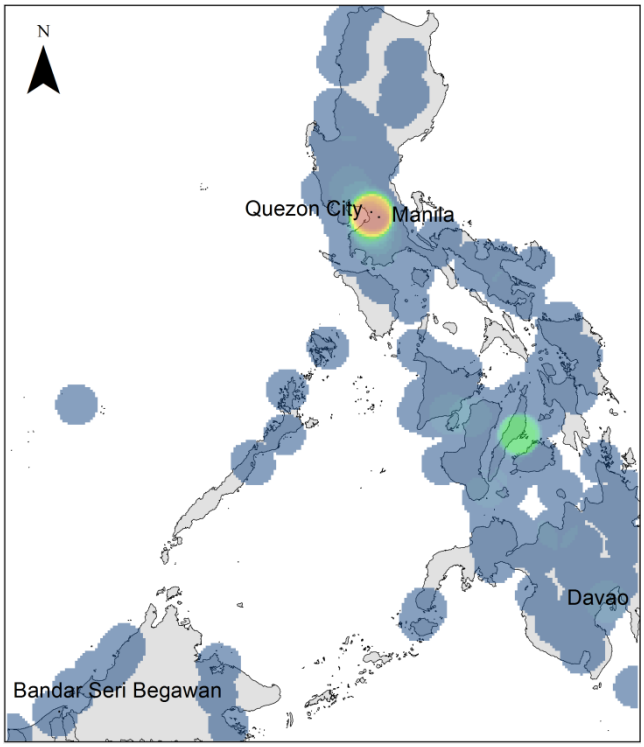


Fig. 16: Spatial distribution of tweets on national level. Two hotspots of Twitter activity Manila and Cebu City are marked clearly.

6.4 What do people twitter?

To gain insight into what people report from the affected area, how eye-witnesses appraise the situation and what they report about damage and losses, we categorize the tweets related to their content. We set up four categories: damage, evacuation, call/pray for help/donations for the victims and not relevant. Messages most interesting for rapid hazard estimation make about 10% of all messages: tweets on evacuations and damages can be used for rapid estimation. The charts in figure 17 show that the majority of the relevant messages belong to the categories of damage or call/pray for help/donations for the victims. In contrast, the topic of evacuation is only present in very few messages.

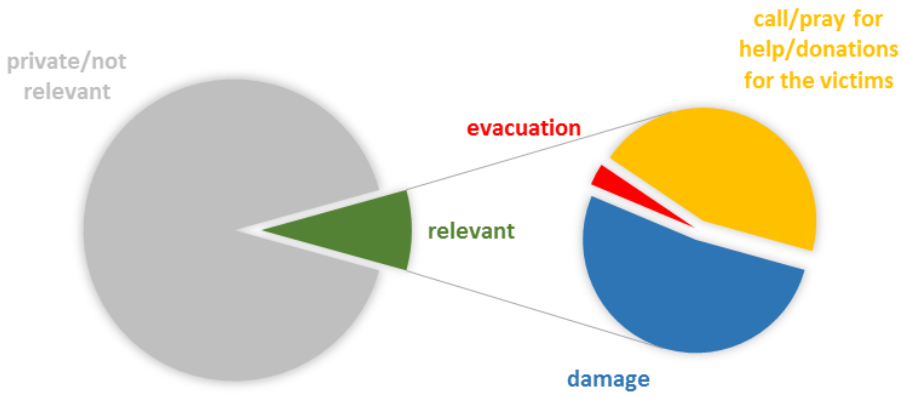


Fig. 17: Shares of categorized messages

Table 3 shows several examples of typical damage reports of Twitter users.

Table 3: Example tweets, representing typical damage reports.

Date	Text	Coordinates [lat, long]
Nov 09 2013 10:42:53	Destroyed homes here in Bogo Cebu bec. of typhoon Yolanda #nofood #helpCEBU #homeless @ABSCBNNews	11.0533, 124.0291
Nov 09 2013 11:12:47	Wow. Just found out that some people I know had their houses destroyed in Capiz... So sad	10.7013, 122.4698
Nov 09 2013 11:24:23	My friend's family in Leyte are safe but their house was destroyed by #YolandaPH fury.	7.0987, 125.6309
Nov 10 2013 06:43:49	Ohmygawd our house in Daan Bantayan got destroyed. Shit. Every house got destroyed even the cemetery. Still can contact anyone :(	10.3164, 123.8811
Nov 10 2013 08:35:12	Got news from brgy captian about the typhoon. Our vacation house in Bogo was severely destroyed. #smh	10.3408, 123.9033

6.5 Summary

Twitter messages related to the typhoon Haiyan/Yolanda facilitate rapid and eye-witness based information. However, compared to the major earthquake in the Philippines three weeks earlier, the number of extracted messages from Twitter is much lower. The result: in the three days after the earthquake, more than 50.000 messages could be extracted towards 36.751 during the nine days of Nov. 4 to Nov. 12. This could be an indication that the communication infrastructure has experienced substantially greater damage during the typhoon than through the earthquake on Oct. 15. Further investigation will be conducted to get a better understanding of the impact of the typhoon and its aftermath.

7 Appendix:

Historic Losses from Typhoons in the Visayas, Leyte and Samar (from the Selga Chronology I and II)

2 August 1620 – "A violent typhoon raged over Samar. The ship San Nicolas, that was returning from Acapulco to Manila, was wrecked near Borongan. The flagship of the expedition foundered near Palapag"

January 1630 – "Toward the beggining of January a strong typhoon, lasting 24 hours, was felt over southern Samar"

7-12 November 1865 – "Samar and Leyte experienced a heavy typhoon. Many houses were destroyed. The crop of Occidental Samar, about to be harvested, was a total loss. The goleta San Roque coming from Cebu was wrecked on the western coast of Samar, with a total loss of its cargo. The same baguio hit the province of Pangasinan; most of the houses were unroofed in Urbiztongo, Mangatarem, and Manaoag. The same typhoon was responsible for heavy flood in the Zamboanga district, Mindanao. The barometric minimum at Manila was 742.64 mm. It was considered as one of the worst typhoons both on account of its intensity and extension."

5 May 1870 – "Samar and Leyte experienced a devasting baguio, which in Leyte alone destroyed 400 houses, more than 15 bridges and many fruit trees. On the night of the same day a terrible storm was felt on the western coast Negros, causing the death of three persons and seriously injuring three others, and 247 houses were destroyed. The courthouses, school buildings and bridges fared ill from the typhoon. One day later, the storm, was felt in Iloilo with excessive rains and violent wind from the N, later veering to the E and SW. The sky was gloomy and the barometric pressure very low. The schooners San Rafael, San Antonio, San Salvador, San Miguel and San Vicente, all dissapeared in the sea. In the brig Januaria, only four persons were saved, the rest of the crew and passengers, 18 in all, being drowned."

9 November 1874 – "The southern part of Samar suffered again from the typhoon of november 9, 1874. The storm destroyed bridges in Borongan, gandara, and Pambujan. The palay, abaca, sugar cane, and camote fields were damaged, either because of the violence of the winds or the excessiveness of the rain. In Almeria, Leyte, seven houses were blown down. The church belfry fell. The biggest trees were bent. The towns of naval, Leyte, and Caraycaray were inundated, resulting in the damage of rice fields and the destruction of the saw mill. Because of this tempest, the brig-schooner Union Bustariana, bound from Iloilo with sibucao to Hongkong, was wrecked on the coast of Antique. No less destruction was suffered by the brig Rafaela, which loaded with timber, was sailing from Zamboanga to Manila."

17 July 1877 – "It seems that a storm of small diameter ocurred in southern Visayas at about middle of July. The authorities of Inopocan, Indang, Hilongos, Matalom, Cajagnaan and Maasin reported that from 17th to 20th, strong rain with violent gusts was felt on the western of Leyte; the damages were considerable. On the 18th, a tempest accompained by strong rain and wind, lasting till the next day, was experienced in Balamban, Cebu."

12 December 1879 – "Terrible was the storm which lashed Leyte at about the middle of December. The rivers of Abuyog swelled to such an extent that the people had to stay in the ridges of their houses, being unableto go tothe mountains. The town of Hinunangan was destroyed. Only 20 houses were left standing. The number of houses destroyed in the province amounted to about 1,000. Churches, courthouses, and convents were blown down. The bridges and culverts gave way to the force of the water"

7-16 October 1897 – "Moving from E of the Western Carolines in a direction near E-W, the typhoon crossed Samar and Leyte and then moved over S Mindoro towards the China Sea. The barometric minimum at Guiuan, Samar, was of 710.0 mm. It caused a tremendous wave which in S Samar and N Leyte destroyed completely several towns and claimed about 1500 human victims. It wrecked numerous boats within the Archipielago and put in great danger of foundering many others in the China Sea, where it inclined to NW."

1-8 June 1903 – "The Capiz typhoon. This typhoon was remarkable for its small diameter, high velocity and intensity. It started a short distance to the east of Mindanao, passed north of Surigao moving WNW, crossed close to the central part of the Island of Leyte and swept across the extreme northern part of Cebu and the whole of northern Panay in a direction parallel to the coast. After passing over Busuanga, it inclined towards the north, crossed the Paracels, passed south of Hainan and struck Indochina, doing enormous damage to Namdink and western Tongking and causing the death of over 2,000 people. In crossing the Archipelago, the velocity of translation was about 12 miles per hour. The diameter was so small that it passed over the China Sea in the direction of Tongking without giving those in Hongkong any suspicion its passage or enabling those in Tongking to predict its approach, until it began to show ruin and destruction over the country. The barometric minimum at Ormoc was 745.0 mm. and at Capiz was 740.0 mm."

2-10 November 1909 – "This typhoon formed between Yap and Palau, moved WNW, crossing Leyte, passing very close to northern Panay and crossing the southern extremity of Mindoro on its course into the China Sea. There it changed to the NW and then W, entering Indochina on a WSW course north of, and very close to, Tourane. The following barometric minima were observed: 728.53 mm. at Tacloban; 730 mm. at Capiz; 738.87 mm. on board the Fathomer anchored at southern Tablas Island; 731.51 mm. on board to Sungkiang and 730.9 mm. at Tourane."

14-18 October 1912 – "This typhoon appeared about 300 miles east of Leyte, moved W, changed to NW as it passed over Cebu Island and entered the China Sea after crossing Mindoro. It then gradually inclined to the west, entering Indochina near Tourane. Leyte and Cebu suffered great destruction to life and property. The following barometric minima were observed: 739.02 mm. at Surigao; 716 mm. at Maasin; 735.06 mm. at Cebu and 740.9 mm. at Capiz."

10-20 October 1919 – "This small typhoon forme in the Pacific, moved almost due W across Leyte, Cebu, Negros, Panay, and Palawan. It then inclined to the N in the China Sea and entered Indochina south of Tourane. Great damage was caused by the rains and floods."

2-5 November 1930 – "This very small typhoon entered the eastern coast of southern Samar at about 9 p.m. of the 2nd: it passed close to Tacloban and after traversing the northern part of Leyte, Cebu and Negros Islands, it passed very near to Iloilo. The typhoon moved from Leyte to Iloilo at the extraordinary rate of over 22 miles per hour. Although the depth of the typhoon was not very great, yet much damage was done to several towns specially to those on the north side ot the track owing to the considerable force obtained by the Nly winds prevailing during this part of the year. Thousands of people were homeless after the storm, particularly in the province of Iloilo. This typhoon seems to be the same which caused heavy loss of life and severe damage, according to Press dispatches, at the beginning of November (probably on the 5th or during the night of the 4th) at Poulo Condore, an island off the Conchinchina coast."

2-5 January 1931 – "It crossed Leyte, Camotes Islands, northern Cebu, northern Negros, central Panay and passed into the China Sea between Mindoro and Busuanga. Barometric minima: 731.0 mm. at Sagay; 730.0 mm. at Dumalag and 738.0 mm. At Baybay. Destructive typhoon. Velocity o the wind at Cebu at the rate of 118.7 kms. Per hour. Total damage in the Philippines was estimated at no less than six million pesos. The National Headquarters of the American Red Cross donated 20, 000: the local chapter spent 15,000 in relief work. Proclamation No. 357 issued by the Governor-general on January 23, 1931, asking all citizens to lend all possible aid to a special Typoon Fund."

24 November – 5 December 1934 – "This typhoon apparently formed on the 24th of November near Truk, passed close to the south of Yap and moving over 17 miles per hour in a WNW direction, it struck Guiuan on the morning of the 29th. Guiua´s barometric minimum was 724.8 mm. and the wind reached full hurricane force. The storm passed close to the south of Tacloban, causing the barometer to fall to 727.2 mm. and gave rise to an unprecedented flood. Continuing its WNW course, the typhoon reached the NE end of Panay, changed then its direction to NW, passed very close to the south of Odiongan, traversed Mindoro and entered the China Sea near Puerto Galea and filled up over the Paracels. The damage done to Leyte, Tablas and Mindoro was considerable."

3-7 December 1934 – "This abnormal typhoon formed in the China Sea west of Palawan, moved very slowly for a considerable time, and approached the northern part of Palawan, passing close to Bacuit. Taking an almost due east course, the storm crossed the northern part of the Sulu Sea, traversed the island of Panay, and decreasing in energy, it crossed central Leyte and passed to the Pacific south of Samar, filling up far to the NW of Yap. The town of Bacuit was practically wiped out: extraordinary floods occurred in Palawan. The barometric minimum at Cuyo was 751.87 mm. and at Iwahig was 748.56 mm."

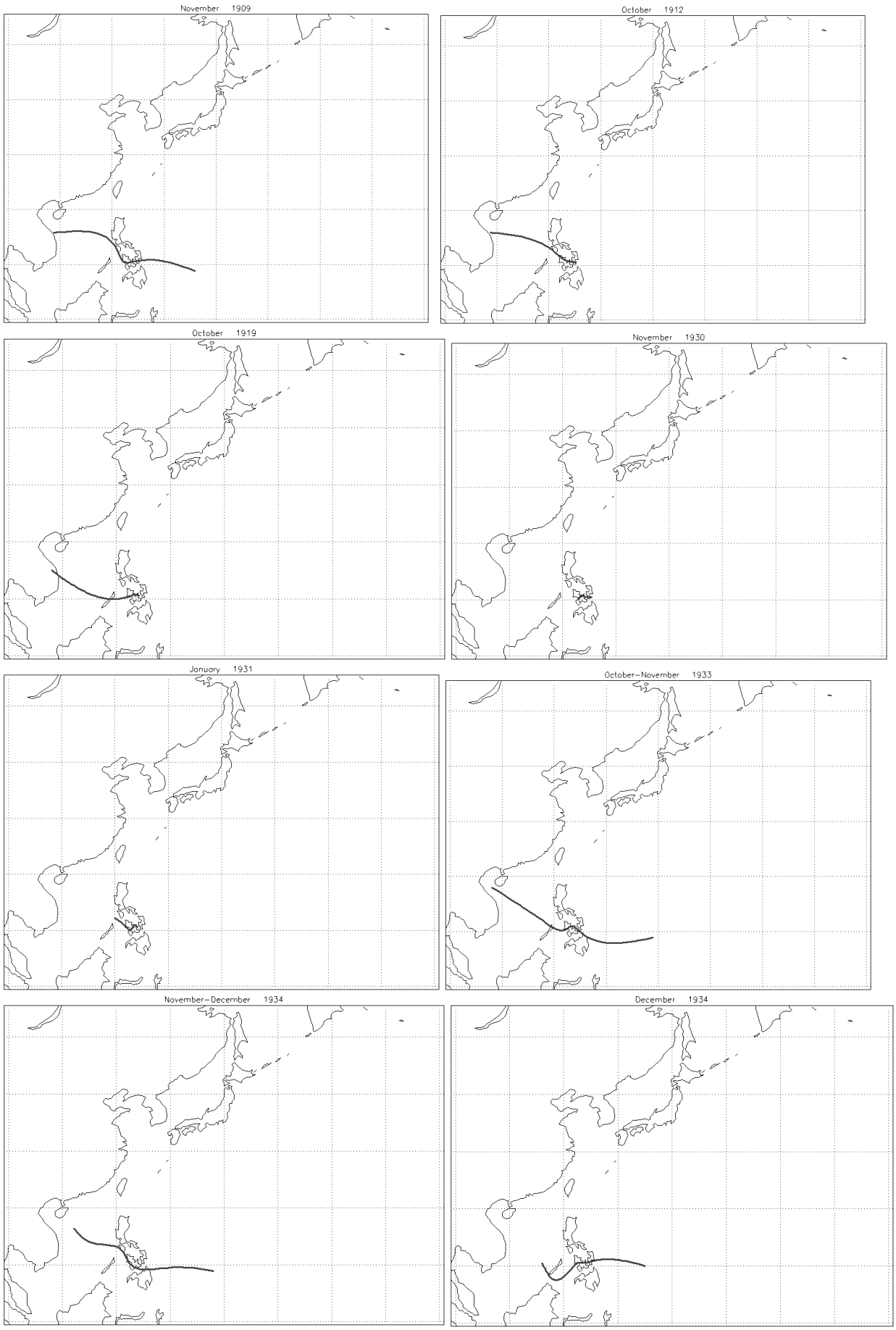


Fig. Storm tracks from **Selga Chronology I and II affecting the same regions as this typhoon (**http://pendientedemigracion.ucm.es/info/tropical/selga-ii.html**)**

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