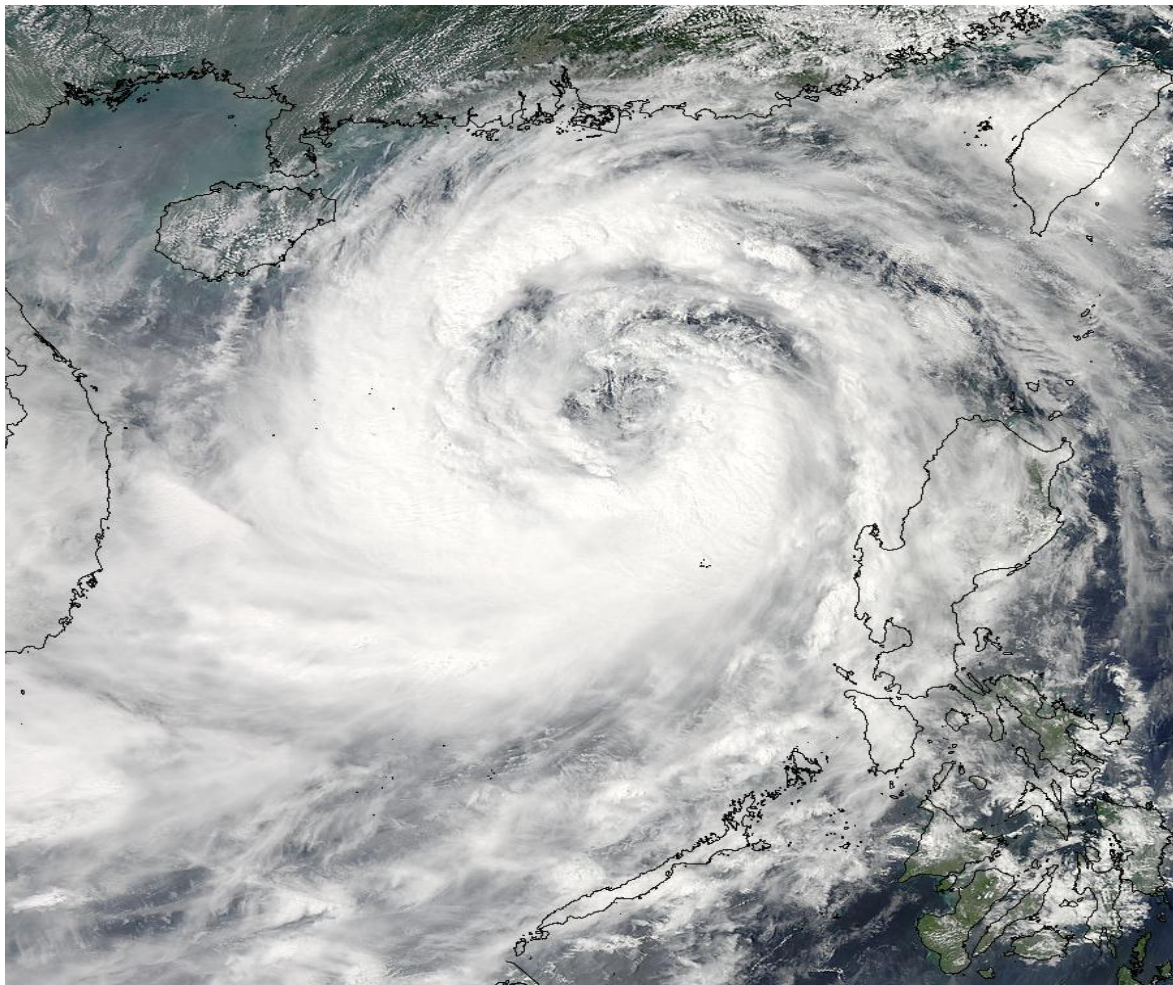


Initial Assessment on the Development of Typhoon Pedring (Nesat) over the Philippines

September 25-29, 2011



Satellite image of Pedring (Nesat) on September 28, 2011 (Source: <http://rapidfire.sci.gsfc.nasa.gov/cgi-bin/imagery/single.cgi?image=Nesat.A2011271.0535.2km.jpg>)

On September 27, 2011, The Philippines was struck by typhoon Pedring (Nesat). After gaining strength over the open ocean since September 21, it moved west north-west and made landfall over the boundary of Aurora and Isabela. At that moment, the central portion of the storm's eye was located at 40 km east of Casiguran, Aurora (16.4°N, 122.7°E), and showed maximum sustainable winds of 140 km/h near the centre and gustiness of up to 170 km/h. Pedring (Nesat) has caused 66 confirmed casualties and 28 missing persons. More than 2,846,000 persons have been affected in 34 provinces (300 municipalities) and 43,112 houses have been damaged as reported by the National Disaster Risk Reduction & Management Council (NDRRMC). The estimated agricultural, infrastructure and school building damage amounts to more than 9,436 million PhP.



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1 Chronology of the Tropical Cyclone Pedring (Nesat)

A low pressure area (LPA) was detected to the East-south-east of Palau on the evening of September 21, 2011. The LPA gradually drifted westwards, becoming better organized and prompting the Joint Typhoon Warning Center (JTWC) to issue a Tropical Cyclone Formation Alert. Subsequently, as the LPA became well organized with flaring deep convection developing around it, the Japan meteorological Agency (JMA) started monitoring it. On September 24, 2011, the JMA further upgraded this LPA to a tropical storm and named it Nesat. The Philippine Atmospheric, Geophysical & Astronomical Services Administration (PAGASA) named it Pedring.

Pedring (Nesat) continued to drift west with an expanding deep convection around the entire system and a consolidating convection around the centre. The mid-level warm anomaly near the system continued to intensify and the convective banding near the centre became more and more tight. As a result, JMA upgraded Pedring (Nesat) to a severe tropical storm on September 25, 2011. Late on the same day, JMA further upgraded Pedring (Nesat) to a typhoon. The system rapidly deepened and quickly developed a 30 nautical miles (56 km) ragged eye and mesoscale anticyclone aloft generating an exceptionally excellent all-around outflow.

According to PAGASA weather bulletin, issued on September 27, 2011 at 5:00 a.m., the large core of Typhoon Pedring (Nesat) made landfall over the boundary of Aurora and Isabela (see track in Figure 1.1). At that moment, the central portion of the storm's eye was located at 40 km east of Casiguran, Aurora (16.4°N, 122.7°E), as deduced from radar, satellite and surface data. It showed maximum sustainable winds of 140 km/h near the centre and gustiness of up to 170 km/h.

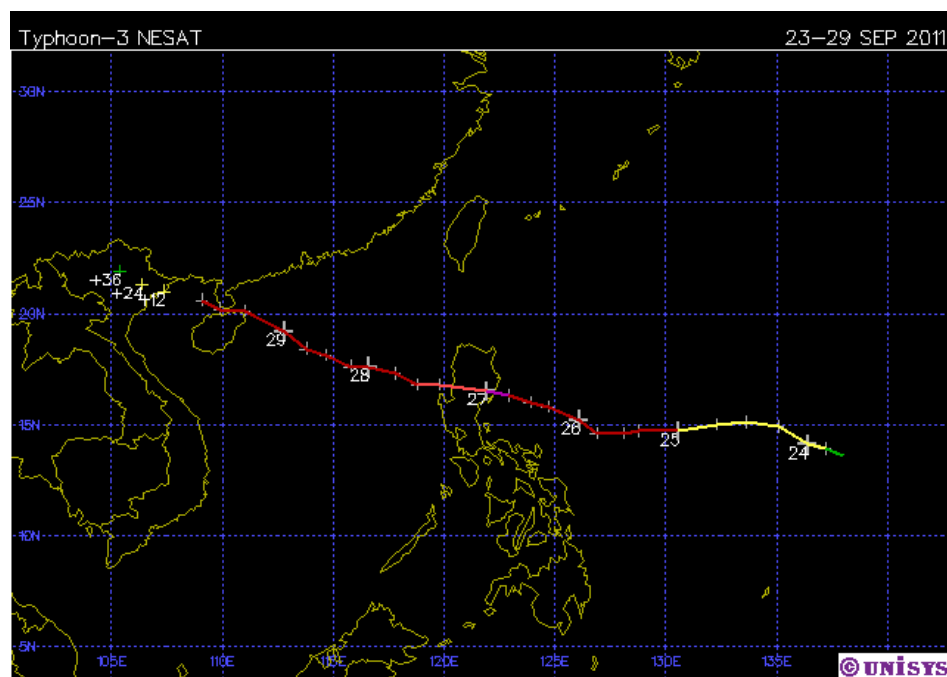


Figure 1.1 Typhoon Track (Source: <http://weather.unisys.com/>)

Typhoon Pedring (Nesat) caused many power breakdowns in up to 11 provinces due to strong winds and floods. It enhanced the Southwest Monsoon, bringing scattered to widespread rains over Southern Luzon and Western Visayas. Areas along Manila Bay suffered the worst flooding in many years.



According to PAGASA weather bulletin issued on September 29, 2011 at 5:00 a.m., Typhoon Pedring (Nesat) continued to move away from the country – at that moment it had already left the Philippine Area of Responsibility (PAR). However, it continued to enhance the Southwest Monsoon and bring rains (scattered to widespread) over Western Luzon.

Pedring (Nesat) has caused 66 confirmed casualties, while 28 persons are still missing. More than 2,832,000 persons have been affected in 34 provinces (300 municipalities) and 44,072 houses have been damaged as reported by the National Disaster Risk Reduction & Management Council (NDRRMC). The estimated agricultural, infrastructure and school building damage amounts to more than 9,436 million PhP.

2 Setup of the Typhoon Trigger and Assessment of Monitored Data

2.1 Assessment of Monitored Data

A novel insurance product aims to protect cooperatives in the Philippines from insolvency following typhoons. DHI Water & Environment (S) Pte. Ltd. (DHI) provides online real-time monitoring of weather events all over the country, serving as the basis for the insurer's payout scheme.

Wind and rainfall were previously identified by DHI as the two major causes of insurance loss and threshold values – so called triggers – set up for these two parameters. That enables DHI to categorize the severity of a weather event into a 10-year, 15-year or 20-year event.

In order to supply the most accurate information, DHI's so-called 'Typhoon Trigger' integrates different kinds of independent data, thereby forming a coherent picture of the actual weather situation in the Philippines.

The Typhoon Trigger recognizes a typhoon event from the moment a tropical depression hits the PAR with maximum wind speeds superior to 30 knots (55.6 km/h).

2.1.1 Rainfall Data

The rainfall trigger is based on satellite data provided by the Tropical Rainfall Measuring Mission (TRMM), a joint mission of National Aeronautics and Space Administration (NASA) and the Japan Aerospace Exploration Agency (JAXA) designed to monitor and study tropical rainfall. Data are available on a three-hour basis in grids of 0.25°, which are approximately squares of 27x27 km. Hence, the Philippines are covered by 852 data squares, each containing the level of rain for this area. Thereby, TRMM offers a dense coverage of the Philippines, both in time and space.

Raw data from the TRMM satellite use eight different stations to validate local data and make the necessary calibration. The closest validation station for the Philippines is located in Taiwan. After quality control operations, TRMM data are regarded as a reliable qualitative and totally independent data source useful to the hazard analysis and the development of the trigger.

It is important to keep in mind that the direct comparison between rain gauges and the TRMM rainfall data is very difficult due to the different approaches in the measurement of rainfall.

2.1.2 Categorisation and Triggering

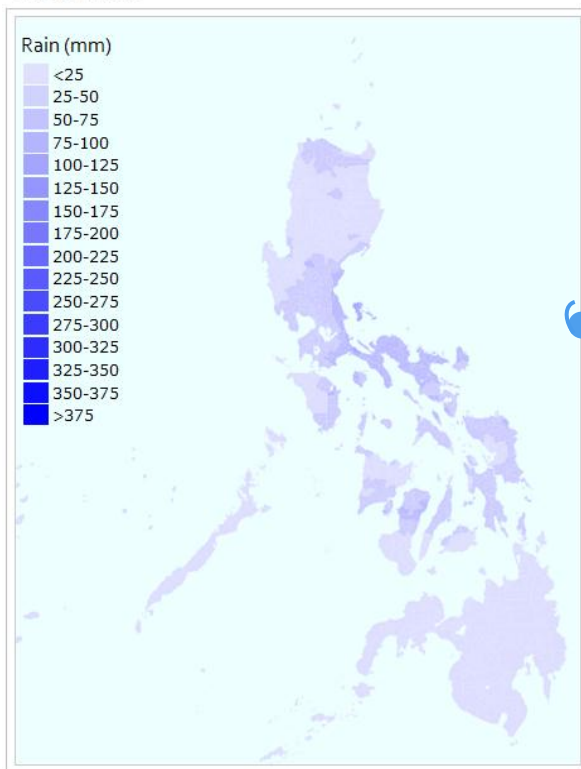
In order to evaluate the rain trigger, an extreme value analysis is carried out on the 24-hour TRMM rainfall data for each municipality. Comparing the maximum 24-hour rainfall to the calculated 10-year, 15-year or 20-year rain events, the event return period is calculated for each of the municipalities. Finally, checking each of the municipalities against the trigger criteria, the triggered municipalities are sought out.

2.1.3 Tracking Typhoon Pedring (Nesat)

DHI's system was able to track Pedring's (Nesat's) precipitation and wind over the affected areas of the Philippines during the evolution of the Typhoon.

As shown in Figure 2.1 and Figure 2.2, the monitoring system clearly reveals the areas that have been affected by the rains during the approach of Pedring (Nesat) on September 25 and 26, 2011 and the following landfall on September 27, 2011 over the boundary of Aurora and Isabela provinces.

Daily Event 2011-09-25



Daily Event 2011-09-26

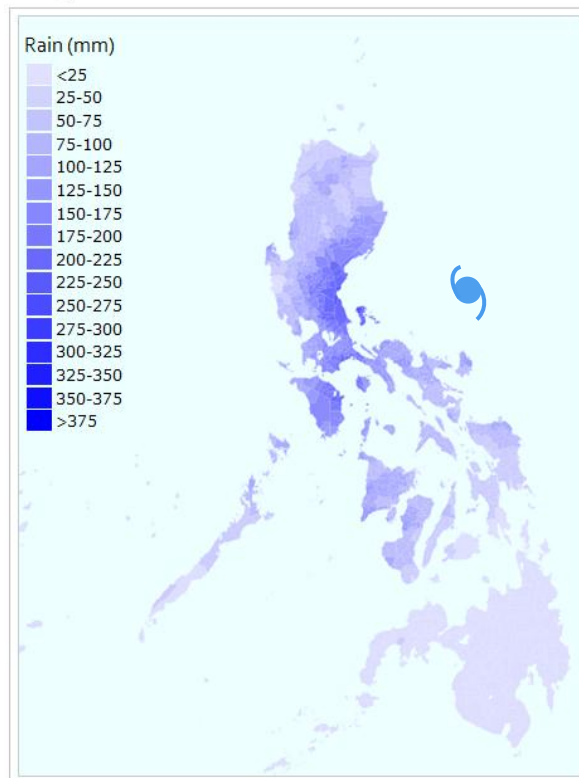
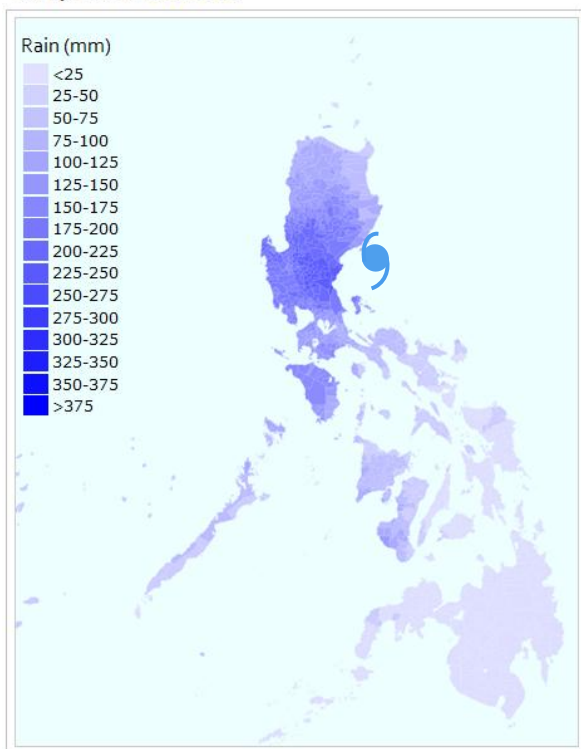


Figure 2.1 DHI's rainfall real-time monitoring system on September 25 (left panel) and 26 (right panel), 2011. Heavy rainfall is represented in dark blue. The legend displays the maximum 24-hr rainfall values measured by satellite TRMM. Approximate location of Pedring (Nesat) for each day.

Daily Event 2011-09-27



Daily Event 2011-09-28

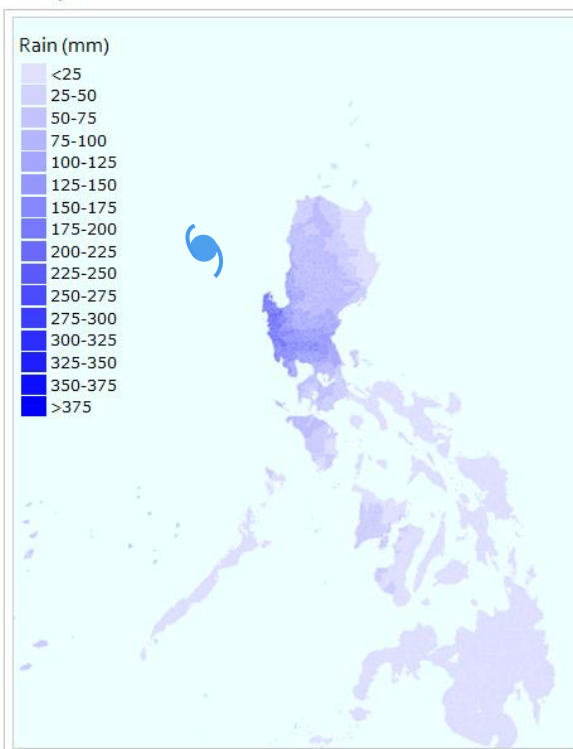


Figure 2.2 DHI's rainfall real-time monitoring system on September 27 (left panel) and 28 (right panel), 2011. Heavy rainfall is represented as dark blue areas. The legend displays the maximum 24-hr rainfall values measured by satellite TRMM. Approximate location of Pedring (Nesat) at landfall, on September 27 and 28, 2011.

3 Linking Damage to Triggered Municipalities/Provinces

During September 26 and 27, 2011, the areas of Cagayan, Isabela, Quirino, Batanes, Nueva Vizcaya, Ilocos Norte, Bataan, Nueva Ecija, Zambales, Benguet and Laguna received between 150 and 200 mm of rain over 24 hours, experiencing several types of flood and landslide casualties including many power breakdowns as reported by NDRRMC (see Figure 3.1 for a close up on the region).

No rain events have been triggered during the passage of typhoon Pedring (Nesat), as no municipality overpassed the amounts of around 260 mm and higher precipitation necessary to trigger a 10-year precipitation event. However, high amounts of precipitation have been measured by TRMM in several municipalities, reaching amounts of 219 mm/24 hr in Lupao and San Leonardo (Nueva Ecija) and 219 mm/24 hr in Panukulan (Quezon).

Daily Event 2011-09-27

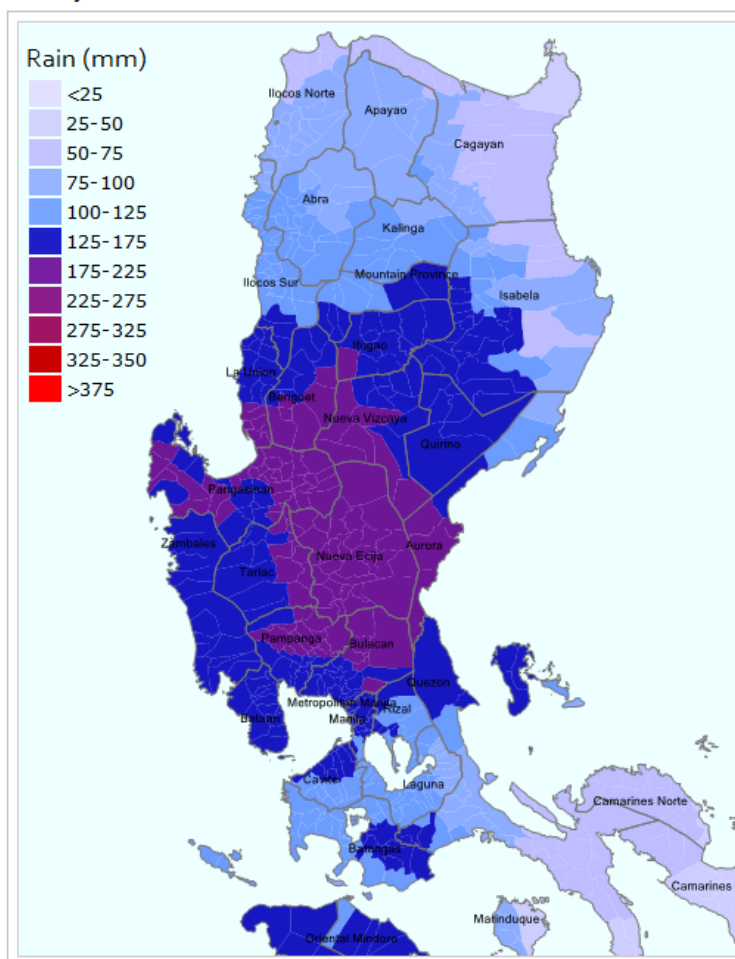


Figure 3.1 DHI's rainfall real-time monitoring system on September 27 (left panel) and 28 (right panel), 2011. Heavy rainfall is represented as dark blue areas. The legend displays the maximum 24-hr rainfall values measured by satellite TRMM.

The Table 3.1 shows several municipalities mentioned in the NDRRMC report where different casualties has been reported. The table also shows, for better comparison, the maximum values estimated by DHI's monitoring system, from TRMM satellite over 24 hours, and the corresponding trigger for a 10-year event (values estimated on September 26 and 27, 2011).

Table 3.1 List of affected municipalities (as reported by NDRRMC) and corresponding rainfall and 10 -year event trigger values.

Municipality (Province)	Measured Rainfall (mm/24 hr)	Trigger Value for a 10-year Rainfall Event (mm/24 hr)
San Leonardo (Nueva Ecija)	219	267
Pantabangan (Nueva Ecija)	205	279
Lupao (Nueva Ecija)	219	267
San Antonio (Nueva Ecija)	217	268
Cabanatuan city (Nueva Ecija)	206	270
Quezon (Nueva Ecija)	204	267
Baler (Aurora)	200	348
San Ildefonso (Bulacan)	199	279
Umingan (Pangasinan)	217	282
Panukulan (Quezon)	215	360

The Typhoon Trigger covers the Philippines at municipal level based on the probability of both rain and wind exposures during a typhoon event. The real-time monitoring system updates the data every three hours, at the same time adjusting the affected municipalities and well as the event category for each of them. Table 3.2 lists the 13 municipalities triggered by DHI's system for the passage of typhoon Pedring (Nesat) on September 26 and 27, 2011, due to strong winds. They have all been triggered by a 10-year event.

Table 3.2 List of triggered municipalities with their corresponding estimated surface wind values and type of event with the according trigger wind values

Municipality (Province)	Estimated Surface Winds (knots)	Event-Return Period in Years (Trigger Value)
BACNOTAN (La Union)	68	10 (67.6)
BAGULIN (La Union)	70	10 (68.3)
BAUANG (La Union)	69	10 (68.1)
BURGOS (La Union)	70	10 (68.4)
CITY OF SAN FERNANDO, Capital (La Union)	69	10 (68.3)
KAPANGAN (Benguet)	70	10 (69.9)
LA TRINIDAD, Cap. (Benguet)	70	10 (69.4)
NAGUILIAN (La Union)	70	10 (68.7)
SABLAN (Benguet)	70	10 (68.4)
SAN GABRIEL (La Union)	69	10 (68.5)
SAN JUAN (La Union)	69	10 (67.8)
SANTOL (La Union)	68	10 (67.9)
TUBLAY (Benguet)	70	10 (68.5)

Figure 3.2 displays DHI's wind surface estimation for the passage of typhoon Pedring (Nesat). It clearly shows the area where the typhoon has made landfall and entered the Philippines, becoming weaker as the typhoon loses energy crossing west north-west over land.

Event PEDRING (2011 Sep)

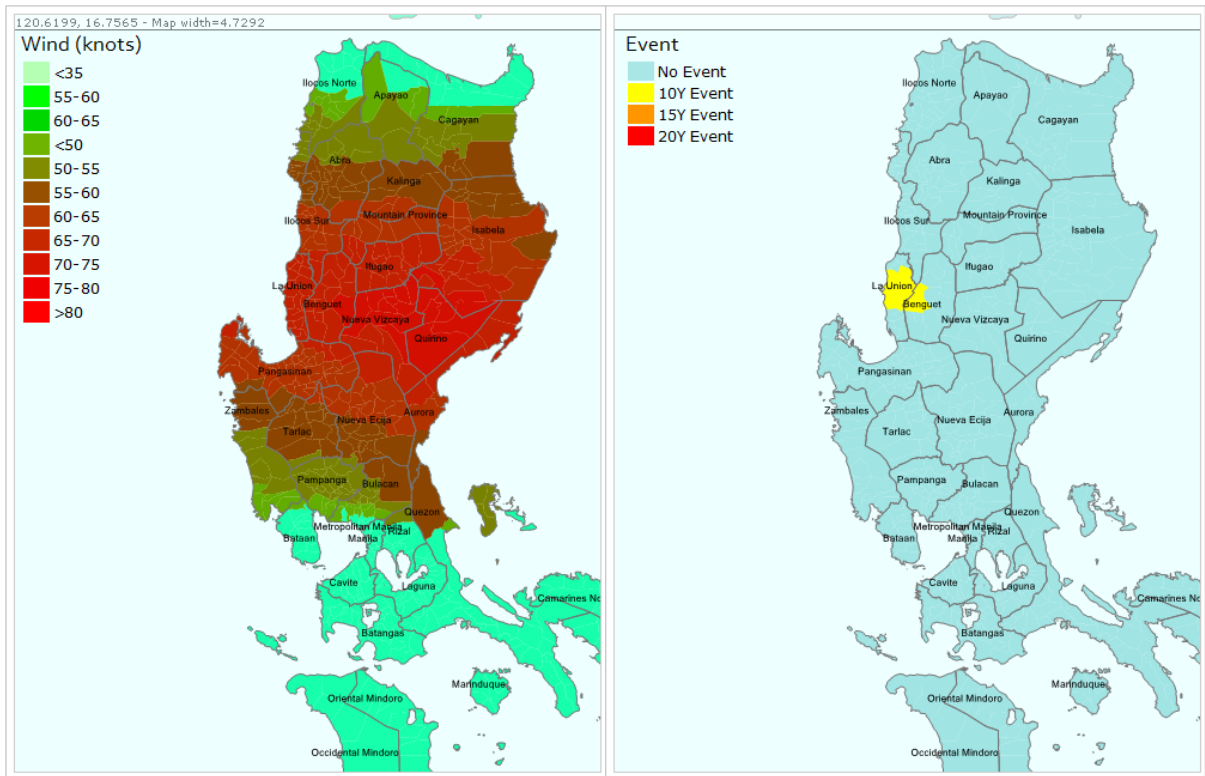


Figure 3.2 DHI's surface wind monitoring system after the passage of Pedring (Nesat). Strong surface winds, represented as dark areas (left panel, intensity described in the legend), and the corresponding triggered areas (right panel).

4 State of Calamity Reported by NDRRMC

The NDRRMC has reported several areas under a state of calamity (see Table 4.1) due to the passage of typhoon Pedring (Nesat), as follows from the report of October 5, 2011, 6:00 a.m (Sitrep No. 20).

Table 4.1 List of areas declared under state of calamity (as of October 1, 2011)

Region	Areas Declared		
	City	Municipality	Province
II	Amulung, Cagayan	Santiago City, Isabela Tuguegarao, Cagayan	Quirino Isabela
III	Obando, Bulacan Calumpit, Bulacan Dinalupihan, Bataan	Mecaguayan City, Bulacan Olongapo City, Bulacan Tarlac City, Tarlac	Nueva Ecija
IV-A	Noveleta, Cavite		Cavite
NCR		Malabon, Navotas, Marikina	
Total	5	8	4

The following table shows the estimated values of rainfall and surface wind by DHI's monitoring system for all the municipalities mentioned in the NDRRMC report.

Table 4.2 List of areas declared under state of calamity

Declared Area Municipality (Province)	Max. Measured Rainfall (10-year Event Trigger Value in mm/24 hr)	Estimated Surface Wind (10- year Event Trigger Value in knots)
Santiago City (Isabela)	159.6 (296)	71 (78.3)
Amulung (Cagayan)	70.3 (298)	53 (82.3)
Tuguegarao (Cagayan)	79.28 (316)	56 (83.1)
Obando (Bulacan)	150 (292)	>50 (68.7)
Calumpit (Bulacan)	167.8 (297)	50 (69.3)
Dinalupihan (Bataan)	159 (337)	50 (67.5)
Tarlac City (Tarlac)	177 (261)	58 (73.7)
Meycauayan City (Bulacan)	151.9 (294)	>50 (69.7)
Noveleta (Cavite)	132 (351)	>50 (66.4)
Malabon (Metropolitan Manila)	148.8 (292)	>50 (68.9)
Navotas (Metropolitan Manila)	150 (292)	>50 (68.4)
Marikina (Metropolitan Manila)	144 (322)	>50 (71.1)