

TROPICAL CYCLONE 101

FOUNDING PARTNERS



ISTA LAND

PLATINUM DONORS



NICKEL ASIA





weather philippines My Philippines. My Weather.



- An average of 20 tropical cyclones enter the Philippine Area of Responsibility (PAR).
- Only 10 cross or affect the country.

*Based from PAGASA's 1948-2010 mean.





Tropical Cyclone (TC)

- an intense circulating weather system over tropical seas and oceans, and is characterized by low atmospheric pressure, strong winds and heavy rains.

Winds around a TC rotate Counter-clockwise in the Northern Hemisphere and Clockwise in the Southern Hemisphere.











Tropical cyclone basins

Almost all tropical cyclones form and travel toward land in the seven ocean "basins" shown on the map. The number in each basin is the yearly average of tropical storms with 39 mph or faster winds. The words "hurricane," "typhoon," or "cyclone" are the names used for storms with 74 mph or faster winds. City names are locations of major tropical cyclone forecasting centers.







Tracks and Intensity of Tropical Cyclones, 1851-2006





Conditions for a Tropical Cyclone to form:

- 1. Warm sea surface temperature (sst) of at least 26.5°C with a depth of 150 ft and high moisture present in the air. The heat from the sea is the main energy source for TCs.
- 2. Presence of ITCZ.
- 3. Existence of LPA or Tropical Disturbance.
- 4. Weak vertical wind shear or light winds in the upper troposphere.







Cooler Air

Light winds

Heat

Moisture

Ocean temperature warmer than 80°F

©The COMET Program



Warmer Air



Effects of Vertical Wind Shear (Vz) on Tropical Cyclones













SEASONAL MIGRATION OF THE INTER-TROPICAL CONVERGENCE ZONE (ITCZ)







Monthly frequency of T.C. entering the PAR and crossing the Philippines Period: 1948-2010





Three LPAs within the ITCZ







Conditions for a Tropical Cyclone to weaken and dissipate:

TCs weaken and die when:

- 1. They travel over cooler sea surface temperatures or enter an environment of cool dry air.
- 2. They move over a large land mass.
- 3. They travel across an environment of strong vertical wind shear.





Energy of a Tropical Cyclone

- In an <u>average afternoon thunderstorm</u>, the energy released amounts to about 20-kiloton atomic bombs.
- A small typhoon carrying winds of 120 kph has an energy almost equivalent to exploding 500,000 atomic bombs per day or about 6 atomic bombs per second.





Movement and Speed of Tropical Cyclones

- TCs tend to move under the influence of the Trade Winds known technically as *"Steering Flows"* that originate from Strong High Pressure Areas that surround the TC, and "carry it along" like "a cork floating in the river stream."
- In the Philippine Sea, TCs tend to move on a general westnorthwest (WNW) direction with an average speed of 19-20 kph.





Other factors that influence the movement of TCs:

- 1. Passage of an Eastward propagating Frontal System along the sub-tropics which pulls a TC poleward.
- 2. Interaction between two or more TCs within its periphery (Binary Interaction aka. Fujiwhara Effect).
- 3. Interaction with Land (esp. with mountainous terrain).







Figure 1 Standard Pattern



Source: JTWC's 1996 Annual Tropical Cyclone Report (ATCR) p. 9







Source: JTWC's 1996 Annual Tropical Cyclone Report (ATCR) p. 9



Binary interaction between Pepeng and Quedan:













1,600 km. from each other

4.1

Pepeng

Quedan



Dry air from China weakens Pepeng

Pepeng

1,400 km. from each other

Direct Cyclone Interaction (aka. Fujiwhara Effect) begins Quedan

OCL02







Nepartak

Pepeng

9



Nepartak

Pepeng

3





Classification of Tropical Cyclones:

TROPICAL DEPRESSION (TD)







• TROPICAL STORM (TS)



Maximum Sustained Winds Range: 62 to 117 kph

Haiyan (Yolanda) shown here as a developing TS.





TYPHOON (TY)



Maximum Sustained Winds Range: 118 to 219 kph

Rammasun (Glenda) as a 185-kph Typhoon.

MTSAT-FLOATER RGB IMAGE [VIS,VIS,IR] - JUL 15 14 05:32 UTC MeIDA





SUPER TYPHOON (STY)



Maximum Sustained Winds Range: 220 kph or more

Haiyan (Yolanda) as a Super Typhoon, 24 hours before it made landfall.





BASYANG (Conson) becoming a 120 kph TYPHOON










EIR SATELLITE IMAGERY OF RAMASSUN (GLENDA)





MTSAT-FLOATER RBTOP IR - JUL 15 14 11:01 UTC



2

VISIBLE SATELLITE IMAGERY OF HAIYAN (YOLANDA)







My Philippines. My Weather.



Summary of Tropical Cyclone Classification







Atlantic Hurricane Season

BBC





Parts of Typhoon







Associated weather in each part:

1. OUTER RAINBANDS

- Severe Thunderstorms, Light to Moderate On and Off Rainfall with winds not exceeding 62 kph occurring occasionally.

2. INNER RAINBANDS

- Moderate to Heavy Rainfall with increasing winds of 63 to 117 kph occurring frequently.

3. EYEWALL

- Heavy to Extreme Rainfall with violent winds of greater than 118 kph occurring intermittently or continuously.





4. THE "EYE"

- The calm part of a Typhoon, with sometimes light winds of up to 20 kph.
- Lowest Atmospheric Pressure.
- The Sky may be Cloudy or Clear.
- Average "eye" diameter is about 30 km across.





Typhoon's Size

- Vertical Extent: a typhoon's vertical size can reach a height of 40,000 to 50,000 feet above sea level.
- Horizontal Extent: a typhoon's horizontal size can reach a maximum of 1,500 km in diameter and a minimum of 150 km. Avg size is about 600 km.

Examples: largest ever recorded STY TIP (Oct 1979) – 2,200 km in diameter. Smallest was TC TRACY in Australia – 100 km.





Horizontal view of a Typhoon







Hurricane Floyd September 14, 1999 @ 1244 UTC Hurricane Andrew August 23, 1992 @ 1231 UTC



NOAA

The spiral rainbands of Hurricane Floyd (left, 1999) versus the more compact Hurricane Andrew (right, 1992)





Hurricane Katrina Storm diameter (400 mi / 650 km)

Hurricane Charley Storm diameter (150 mi / 240 km)



NOAA-NASA GOES Project; NASA





Typhoon's Radar View (Loop)







Aircraft Reconnaissance:













Typhoon Hazards

STORM SURGE – are ocean waves being pushed towards the shore by the force of the winds and the intense low pressure of the storm.

A Super Typhoon can generate storm surge of a height of more than 20 feet (6 meters).





Wind and Pressure Components of Hurricane Storm Surge

Eye



Wind-driven Surge

Pressure-driven Surge (5% of total)

Water on ocean-side flows away without raising sea level much

As water approaches land it "piles up" creating storm surge

©The COMET Program





Hurricane Intensity Scale (Storm Surge)



©The COMET Program





Surge in shallow water close to shore

Water from braking waves moves inland faster than it can flow back to the ocean, causing wave set-up that adds to water depth. Wave set-up can begin causing coastal flooding several hours before the surge brings a quick rise in water level. Normal high tide

Surge height

A shallow ocean bottom blocks water from flowing back to sea, making the surge higher.





Storm Surge at Shallow Coastline or Beach-Front Areas



©The COMET Program











Storm Surge at Steep Coastline



©The COMET Program











A fast-moving, strong typhoon like **Haiyan** (Yolanda) which moved 28 to 42 kph can generate a sudden and devastating (Tsunami-like waves) storm surge called as **METEOTSUNAMIS**¹



¹ http://www.usno.navy.mil/NOOC/nmfc-ph/RSS/jtwc/atcr/2013atcr.pdf

MeteoTsunami on STY Haiyan 📣 MeteoGroup





Storm Surge Damage









Kimberly King

The home of David and Kimberly King before and after Hurricane Katrina, Waveland, MS





Aftermath of Hurricane Ike in Galveston, Texas



U.S. Geological Survey





STRONG / HIGH WINDS – Typhoons with winds of more than 185 km/hr are considered catastrophic, capable of destroying even concrete homes or buildings if exposed.







STY REMING (DURIAN) prepares to make landfall...11 AM Nov 30, 2006





























EXTREME RAINFALL / FLOODING – Intense rainfall can result in all kinds of flooding and can be devastating especially if brought about by a Super Typhoon, when an affected location is within the typhoon's most intense rain clouds. The most number of deaths during a tropical cyclone event are attributed to this type of hazard.

Intense rainfall of past notable typhoons were located mostly on the southern portion of the "Eyewall" particularly during the months of October thru December – with 24-hour rainfall amount of more than 300 mm.







STY REMING (DURIAN) prepares to make landfall...11 AM Nov 30, 2006




24W: 30-Nov-2006 00:00:00 00:03 away Vmax: 120 kts Brightness Temp - Horizontal Polarization **%**> Nada latitude Heaviest Rain of Ъí REMING Ŋ CIMSS longitude





TS 'KETSANA' (ONDOY)

DAY 03 (Sep 25): The day before the flood...







DAY 04 (Sep 26): ONDOY makes landfall









































































Eyewall Mesovortices – these are also known as "miniswirls" or micro tornadoes found within the eyewall of an intense typhoon. These small twisters can reach winds of more than the existing horizontal wind speeds of the typhoon.

Example: If existing typhoon wind speeds are 240 kph over a specific location, **Mesovortices** can double it to 440-600 kph – capable of uprooting trees and carrying weak houses a few meters off the ground.







Figure 307. Mini-swirls in a hurricane According to Professor Fujita, mini-swirls and microbursts both occur within the eye wall of hurricanes and typhoons. Details of this idea are presented in a <u>National Geographic Magazine</u> article on Hurricane Andrew in the April, 1993 issue, on pages 2-37. Drawing courtesy of Professor Ted Fujita.







Hurricane Jeanne

Extreme local wind damage tied to intense convective element in eyewall mesovortex.







Lahars/Mudflows or Landslides – these hazards are common along steep slopes and low-lying areas of active volcanoes and mountains.

Intense Typhoons can release more than 20 billion cubic tons of rain within its circulation, capable of sweeping off lahars or muds.





Buys Ballot's Law (Wind Shifting)

This law was first formulated in 1857 by the Dutch meteorologist, <u>Buys Ballot</u>, and bears his name.

 a law describing the relationship of the horizontal wind direction in the atmosphere to the pressure distribution.







If one stands facing the wind in the Northern Hemisphere, the storm (low pressure system) will always be to the right. In the Southern Hemisphere, if one stands facing the wind, the storm will always be to the left.





Wind Shifting Counter Clockwise (BACKING)...







Wind Shifting Clockwise (VEERING)...







Lull or Calm Conditions – DIRECT HIT







Typhoon Tracking

• To track a typhoon, one must have a Tracking Chart to plot its location and to know when and where it is going to strike.





Step 1: Download & Print a Tracking Chart







Step 2: Learn How To Use the Tracking Chart







Step 3: Locate the Coordinates of the Storm

- In locating the coordinates of a typhoon, one must grab the latest bulletin from any weather agencies where coordinates are available.
- You can get it through the radio, TV, & internet thru the various typhoon sites, like: <u>www.weather.com.ph</u>, <u>www.pagasa.dost.gov.ph</u>, <u>www.typhoon2000.ph</u>







Frequency of TCs in the Philippines

- 1. NORTHERN LUZON: 32% (Very Frequent)
- 2. BATANES GROUP: 25% (Very Frequent)
- 3. SOUTHERN BICOL, MINDORO, MASBATE, NORTHERN PANAY, SAMAR & NORTHERN LEYTE: 19% (Frequent)
- 4. CENTRAL LUZON, NORTHERN BICOL, SOUTHERN TAGALOG PROVINCES & NCR: 16% (Frequent)
- 5. PALAWAN, SOUTHERN PANAY, NEGROS, CEBU, BOHOL, NORTHERN MINDANAO & SOUTHERN LEYTE: 7% (Less Frequent)
- 6. CENTRAL & SOUTHERN MINDANAO: 1% (Rare)



Tracks of Tropical Cyclones in the Western North Pacific Period: (1948-2010)





North Pacific (WNP) during the period 1948-2010 (1641 TC, 1154 or 70% entered or formed in the Philippine Area of Responsibly (PAR) (Data used: JMA Data set).



Tropical Cyclone Frequency using 1°x1° (1948-2010) □







MeteoGroup

Tropical Cyclone Names

RSMC Tokyo Typhoon Center will assign name from this list to tropical cyclones in Western North Pacific and South China Sea of tropical storm strength or above.

	I	11	111	IV	v
Contributed by	Name	Name	Name	Name	Name
Cambodia	Damrey	Kong-Rey	Nakri	Krovanh	Sarika
China	Haikui	Yutu	Fengshen	Dujuan	Haima
Dpr Korea	Kirogi	Toraji	Kalmaegi	Mujigae	Meari
Hong Kong	Kai-Tak	Man-Yi	Fung-Wong	Choi-Wan	Ma-On
Japan	Tembin	Usagi	Kammuri	Koppu	Tokage
Lao Pdr	Bolaven	Pabuk	Phanfone	Champi	Nock-Ten
Macau	Sanba	Wutip	Vongfong	In-fa	Muifa
Malaysia	Jelawat	Sepat	Nuri	Melor	Merbok
Micronesia	Ewiniar	Mun	Sinlaku	Nepartak	Nanmadol
Philippines	Maliksi	Danas	Hagupit	Lupit	Talas
Ro Korea	Gaemi	Nari	Jangmi	Mirinae	Noru
Thailand	Prapiroon	Wipha	Mekkhala	Nida	Kulap
U.S.A.	Maria	Francisco	Higos	Omais	Roke
Viet Nam	Son Tinh	Lekima	Bavi	Conson	Sonca
Cambodia	Ampil	Krosa	Maysak	Chanthu	Nesat
China	Wukong	Bailu	Haishen	Dianmu	Haitang
Dpr Korea	Jongdari	Podul	Noul	Mindulle	Nalgae
Hong Kong	Shanshan	Lingling	Dolphin	Lionrock	Banyan
Japan	Yagi	Kajiki	Kujira	Kompasu	Hato
Lao Pdr	Leepi	Faxai	Chan-Hom	Namtheun	Pakhar
Macau	Bebinca	Pelpah	Linfa	Malou	Sanvu
Malaysia	Rumbia	Tapah	Nangka	Meranti	Mawar
Micronesia	Soulik	Mitag	Soudelor	Rai	Guchol
Philippines	Cimaron	Hagibis	Molave	Malakas	Talim
Ro Korea	Jebi	Neoguri	Goni	Megi	Doksuri
Thailand	Mangkhut	Rammasun	Atsani	Chaba	Khanun
U.S.A.	Barijat	Matmo	Etau	Aere	Lan
Viet Nam	Trami	Halong	Vamco	Songda	Saola
Past Name	es Of 2014	Used/Activ	e Names Of 2015	Inact	ive Names





PAGASA Tropical Cyclones Names

PAGASA retires the names of significant tropical cyclones, when they have caused at least ₱1 billion in damage and/ or have caused at least 300 deaths.

I	п	111	IV
2009	2010	2011	2012
2013	2014	2015	2016
2017	2018	2019	2020
2021	2022	2023	2024
Auring	Agaton	Amang	Ambo
Bising	Basyang	Betty	Butchoy
Crising	Caloy	Chedeng	Carina
Dante	Domeng	Dodong	Dindo
Emong	Ester	Egay	Enteng
Fablan	Florita	Falcon	Ferdie
Gorio	Gardo*	Goring	Gener
Huaning	Henry	Hanna	Helen
Isang	Inday	Ineng	Igme
Jolina	Josie*	Jenny	Julian
Kiko	Karding	Kabayan	Karen
Lannie	Luis	Lando	Lawin
Maring	Maymay*	Marilyn	Marce
Nando	Neneng	Nonoy	Nina
Odette	Ompong	Onyok	Ofel
Paolo	Paeng	Perla	Pepito
Quedan	Queenie	Quiel	Quinta
Ramil	Rosita*	Ramon	Rolly
Salome	Samuel*	Sarah	Siony
Tino	Tomas	Tisoy	Tonyo
Urduja	Usman	Ursula	Ulysses
Vinta	Venus	Viring	Vicky
Wilma	Waldo	Weng	Warren
Yasmin	Yayang	Yoyoy	Yoyong
Zoralda	Zeny	Zigzag	Zosimo





PAGASA auxiliary list of Tropical Cyclone names.

Auxilliary List						
Alamid	Agila	Abe	Alakdan			
Bruno	Bagwis	Berto	Baldo			
Conching	Chito	Charo	Clara			
Dolor	Diego	Dado	Dencio			
Ernie	Elena	Estoy	Estong			
Florante	Felino	Felion	Felipe			
Gerardo	Gunding	Gening	Gardo			
Hernan	Harriet	Herman	Heling			
Isko	Indang	Irma	Ismael			
Jerome	Jessa	Jaime	oiluC			





Tropical Cyclone Tracks (1998-2015)

Source of Info: NASA/JAXA/EORC Tropical Cyclone Database








































JOHN'S WEATHER FORECASTING STONE

CONDITION

FORECAST

Stone is Wet Stone is Dry Shadow on Ground White on Top Can't See Stone Swinging Stone Stone Jumping Up & Down Stone Gone Rain Not Raining Sunny Snowing Foggy Windy Earthquake Tornado

quitor.com



weather philippines My Philippines. My Weather.



Thank you very much.

