HYDROMETEOROLOGICAL HAZARDS

LESSON 1: TYPHOON

A **tropical cyclone** is a system of clouds and storms that starts over warm tropical waters. Depending on where it forms, it's called different names. In the northwest Pacific, it's called a **typhoon**; in the Atlantic and east Pacific, it's a **hurricane**; while in the Indian and south Pacific, it's simply called a **tropical cyclone**.

PARTS OF A TYPHOON

A **tropical cyclone** has a center called **the eye**, which is the calmest part of the storm where winds rotate. Winds heading towards the center are affected by the **Coriolis force**, caused by the Earth's rotation. This force deflects winds to the right in the northern hemisphere and to the left in the southern hemisphere. The strongest winds, known as **maximum sustained winds**, are found closest to the eye in the **eyewall or wall cloud.** These wind speeds determine the cyclone's classification.

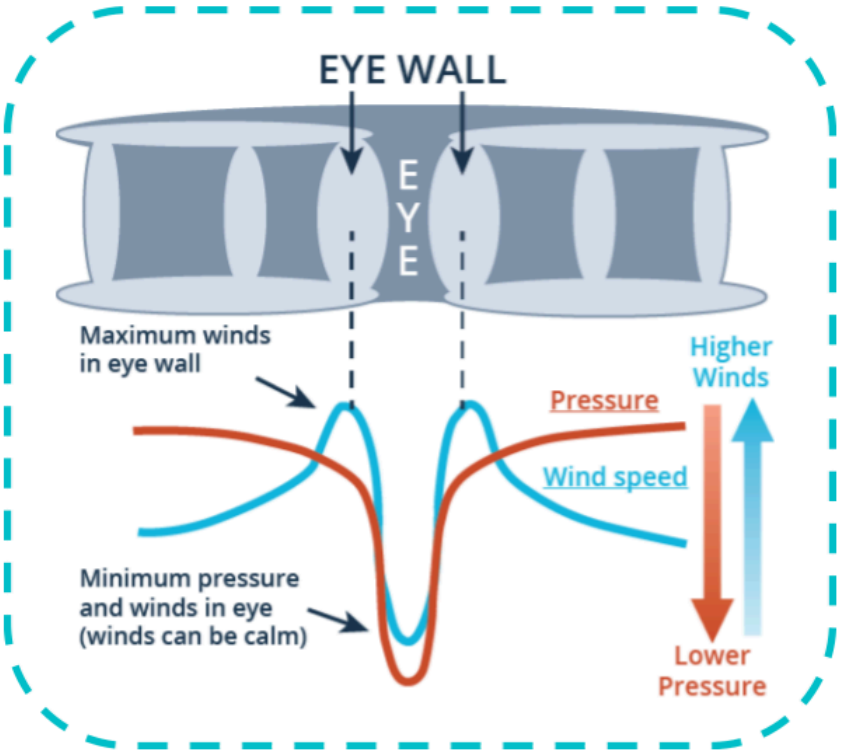


Fig. 2. Cross section of a cyclone.

TROPICAL CYCLONE INTENSITY SCALE

The **Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA)** classifies tropical cyclones into five categories**: tropical depression, tropical storm, severe tropical storm, typhoon, and super typhoon**. These storms can cause damage through **torrential rainfall, strong winds, thunderstorms, and storm surges**. The Philippines experiences about 20 tropical cyclones annually, ranging from mild depressions to powerful super typhoons. Notable cyclones include **Tropical Storm Ondoy, Typhoon Pablo, and Super Typhoon Yolanda.**

Category	Sustained Winds (kilometers per hour)
Super Typhoon	> 220
Typhoon	118 - 220
Severe Tropical Storm	89 - 117
Tropical Storm	62 - 88
Tropical Depression	≤ 61

PUBLIC STORM WARNING SIGNAL

PAGASA monitors tropical cyclones and low-pressure areas (LPA's) **as soon as these enter the Philippine Area of Responsibility (PAR)**. After compiling data from concerned weather stations and monitoring agencies, they release forecasts and weather bulletins. **A Public Storm Warning Signal (PSWS) is** issued in the affected areas to inform the public on the projected impacts of the storm and how soon these are expected to be felt. Similar to the aforementioned new tropical cyclone categories, **PSWS no. 5** was also recently added. It is raised when a **super typhoon** is affecting the area.

PSWS	Lead Time from the First issuance of the signal	Sustained Winds	Expected Damages due to Winds
1	36 hours	30-60 km/h	none to very little
2	24 hours	61-120 km/h	light to moderate
3	18 hours	121-170 km/h	moderate to heavy
4	12 hours	171-220 km/h	heavy to very heavy
5	12 hours	more than 220 km/h	very heavy to widespread

PRECAUTIONARY MEASURES FOR A TYPHOON

- Stay informed about the typhoon's location and expected impacts using any available device.
- Remain indoors and secure windows and doors.
- Bring inside any items that could be blown or washed away by the typhoon.
- If you're in a coastal area, move to higher ground, particularly if a storm surge is expected.
- Only venture outdoors once authorities declare it safe to do so.

LESSON 2: THUNDERSTORM

A **thunderstorm** is a **weather condition characterized by heavy rain and wind accompanied by lightning, thunder; sometimes with hail and tornadoes.** It can last for **30 minutes to several hours.** Thunderstorms require **moisture and rapidly rising warm air**, which is why they are common in humid areas. They are frequently observed **near the equator and rarely in the polar regions.**

THUNDERSTORM FORMATION

Convection drives the formation of thunderstorms. **Warm air rises while cooler air sinks**, creating updrafts and downdrafts respectively. Thunderstorms occur when **there's a balance between these upward and downward air movements**. As warm air rises, it cools and condenses, forming cumulonimbus clouds with millions of water droplets and ice particles. Collisions within these clouds generate electrical charges, with electrons moving to the lower portion, creating **a negative charge**, and **positive charges** accumulating at the top.

Below-freezing temperatures at the cloud top cause droplets to **freeze and become negatively charged.** These frozen droplets may fall, further enhancing the negative charge, or continue downward to the ground. This buildup of negative charge repels the existing negative charge on the Earth's surface, **giving objects on the ground a positive charge.** When air becomes sufficiently ionized, it turns into electrically conductive plasma, **enabling lightning.**

As **ionization** and **plasma formation** occur above, objects on the ground **produce electrical discharges** called **streamers**, reaching towards the clouds. Even human bodies can generate streamers, making it unsafe to be outdoors during a thunderstorm.

LIGHTNING AND THUNDER

Plasma, created by ionization, descends **to establish a path for electric current**. Electrons rush downwards to connect with the streamers, resulting in lightning**. The core of a lightning bolt generates intense heat, hotter than the sun's surface, producing a bright white or blue flash**. This heat rapidly expands the surrounding air upon impact, causing an **explosive release known as thunder**, heard as a booming sound.

Lightning strikes can occur successively and repeatedly hit the same location. For instance, **the Empire State Building**, standing at 444 meters tall**, experiences 25 to 100 lightning strikes annually**. Despite its height, lightning effortlessly targets the building due to its prominence amidst the skyline.

TYPES OF THUNDERSTORMS

Thunderstorms are categorized based on **severity or structure**. According to the U.S. National Weather Service, a severe thunderstorm exhibits wind gusts **of at least 94 km/h, hail with a diameter of at least one inch, or a tornado**. Thunderstorms can take the form of single-cell, multi-cell, supercell, or squall line formations.

A **single-cell thunderstorm** is a brief storm characterized by a single updraft-downdraft couplet, capable of producing heavy rainfall and lightning.

Multi-cell thunderstorms consist of multiple individual cells, with each cell typically lasting 30 minutes to an hour. These systems can persist for hours and may bring hail, flooding, and brief tornadoes.

Supercell thunderstorms are highly organized, featuring a large rotating updraft up to 20 km in diameter and 15 km in height. These storms can last for several hours and often generate violent tornadoes.

A squall line is a linear group of storms, shorter-lived than multi-cells and supercells. They are less likely to produce tornadoes and typically span 15 to 20 km in length, although they can extend for hundreds of kilometers.

THUNDERSTORMS IN THE PHILIPPINES

Most thunderstorms in the Philippines **occur in connection with typhoons**. In 2013, a thunderstorm triggered by **tropical depression Wilma** spawned a **waterspout**, a tornado originating from a body of water. This event affected north Bohol and Cebu with winds reaching **80 km/h**. **Another tornado, with winds of 200 km/h**, struck Leyte a week later. While tornadoes are not rare in the Philippines, they are less frequent and severe compared to countries like the U.S. In 2016, lightning during a thunderstorm caused a house fire that led to two fatalities in Davao, attributed to typhoon Marce. Heavy rains and thunderstorms associated with the typhoon likely caused lightning to strike the main electricity line, igniting the house.

SIGNS OF APPROACHING THUNDERSTORM

Signs of an approaching thunderstorm include **sudden changes in temperature, strong winds, lightning, and heavy rain.** Additionally, forecasts and weather bulletins provide advance notice of potential thunderstorms.

PAGASA initiates a thunderstorm watch when thunderstorm formation is expected within twelve hours. Updates are provided through media outlets and the PAGASA website. **If a thunderstorm is anticipated in a particular area within the next two hours, PAGASA issues a thunderstorm advisory.**

PRECAUTIONARY MEASURES BEFORE AND DURING A THUNDERSTORM

When a thunderstorm is approaching, take these precautions:

- Stay indoors and ensure all windows, doors, and openings are securely closed.
- Seek shelter, preferably in a car, as its metal frame helps deflect lightning. However, the rubber tires do not prevent lightning strikes.
- Unplug electrical devices and avoid using corded phones or devices connected to outdoor wires. It's safe to use cell phones and remote controls.
- Avoid contact with water, including bathing and washing hands.
- If on water, head to land immediately.
- If outdoors, keep away from trees or high points, as they are more likely to be struck by lightning.

LESSON 3: FLOODING

Flooding is when areas usually not covered by water are engulfed or submerged. It is **usually caused by a temporary rise in or overflowing of streams, rivers, or confined bodies of water.** It may also be caused by **heavy and prolonged rainfall, tsunamis, and storm surges**. **Failure of manmade structures such as dams and clogging of drainage systems** are also common causes of flooding. Floods typically develop in a span of hours to a few days. In cases wherein there is rapid inundation (less than six hours), it is considered a **flash flood**.

FACTORS THAT INFLUENCE FLOODING

Several factors influence the occurrence of flood. These include **rainfall intensity and duration, topography, soil conditions, and ground cover.** Most **flash flooding** is the result of prolonged, heavy rainfall from typhoons or slow-moving thunderstorms. Flooding is **more common** in low-lying areas such as **plains and deltas** which stream networks naturally drain water to. Surface runoff, or the water that does not enter the soil and moves downslope**, is more dominant in impermeable materials such as clay, or in cases where the soil is too saturated to allow infiltration**. **Runoff** (and consequently, the likelihood of flooding) is high in urban areas since much of the ground is covered by concrete and such places are often situated in flat, low-lying topographies. Vegetation lessens runoff, as it absorbs water and improves the ability of the ground to take in more moisture.

Typhoon “Ondoy” (Ketsana) brought record-breaking rainfall to the northern Philippines, 25 with the highest recorded amount having been 455 mm of rain in 24 hours in Metro Manila. This is equivalent to a month’s worth of rainfall in the area! Rainfall-induced floods affected over 400,000 people in Manila and surrounding areas, submerging entire streets and stranding pedestrians and vehicles. Marikina City, in particular, experienced floodwaters from the waist level to about two storeys high, which can be attributed to the 10.99 m rise in the water level of Marikina River. Flooding can also occur in coastal areas due to tsunamis and storm surges, which will be discussed in the next lesson.

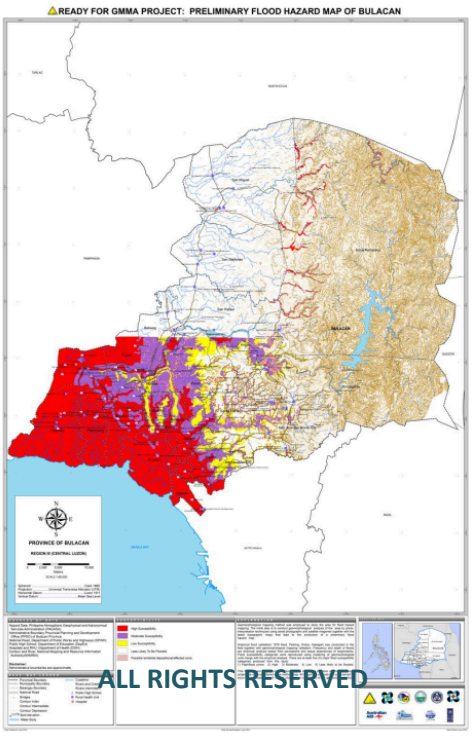


Fig. 3. Flood hazard map of the province of Bulacan

LESSON 4: STORM SURGE

A **storm surge** is an abnormal rise in seawater level during a storm, much like the formation of a tsunami. Water piles up near the shore due to friction with the seabed, driven by the force of storm winds. This excess water **can lead to flooding and contamination of freshwater sources**. In low-lying islands or coastal areas, **storm surges can sweep inland, eroding land, and causing destruction to buildings and roads.**

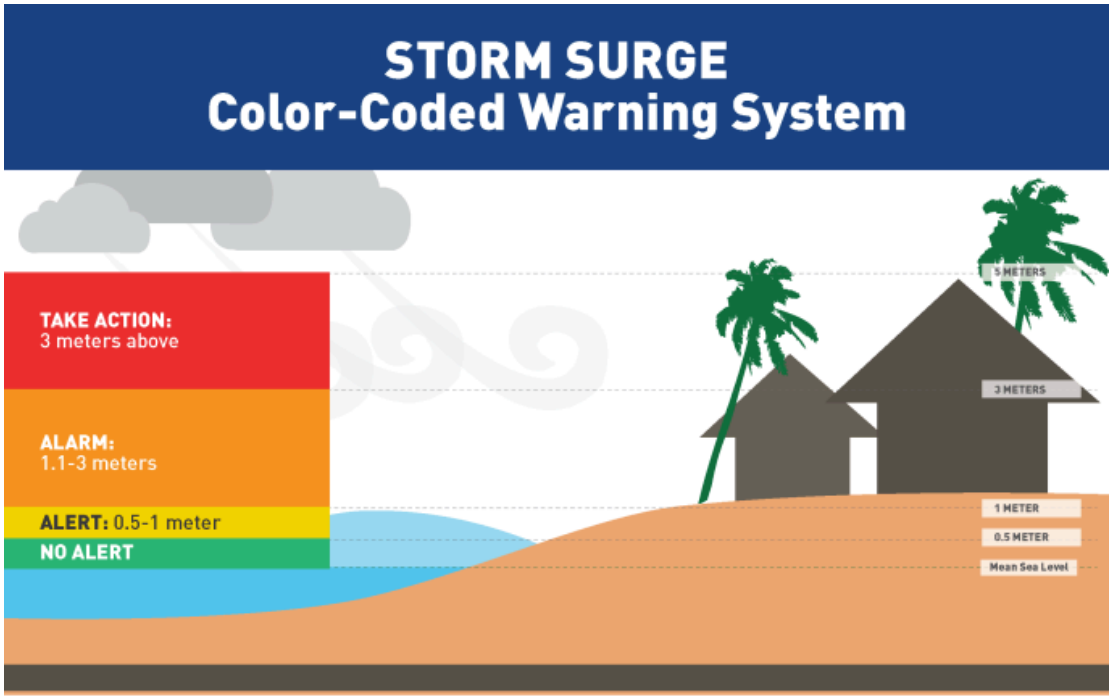
FACTORS THAT AFFECT OCCURRENCE AND SEVERITY OF A STORM SURGE

The intensity of a storm surge depends on various factors**, including the storm's strength and speed, the shape and features of the coastline, its angle of approach, and the continental shelf's width and slope.** Stronger storms typically result in more destructive surges. Fast-moving storms generate larger surges along straight coastlines, while slower ones affect bays and estuaries more. Inward-bowing bays and coasts are more prone to significant surges than outward-bowing ones, as they concentrate water accumulation in a smaller area.

Fig. 3. Flooding induced by storm surges is more likely in a gently sloping continental shelf (left) than one with a steep slope.

STORM SURGE PREPAREDNESS

Storm surges are forecastable. Project NOAH's Storm Surge Hazard Mapping Team conducted simulations to predict surge heights and affected areas during Typhoon Yolanda. Initial estimates indicated flooding of approximately 98 km in Leyte and 93 km in Samar. PAGASA employs a color-coded storm surge warning system based on wave heights, with increasing danger levels from green to red.



STORM SURGE WARNING LEVEL	EXPECTED HEIGHT	ACTION TO BE TAKEN
RED **TAKE ACTION**	3 meters above	**Storm surge is CATASTROPHIC.** There is significant threat to life. Mandatory evacuation is enforced.
ORANGE **ALARM**	1.1 to 3 meters	**Storm surge is EXPECTED.** Conditions could become life threatening. All marine activities must be cancelled. Follow evacuation guidelines from local authorities.
YELLOW **ALERT**	0.5 to 1 meter	**Storm surge is POSSIBLE.** Stay away from the coast or beach. Preparation measures must be carried out.
GREEN **NO ALERT**		**No action required.**

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IN CASE OF AN APPROACHING TYPHOON OR STORM SURGE, TAKE THESE STEPS:

- Monitor storm signals and surge warnings, and heed related announcements.
- Avoid low-lying areas and steep coastal regions vulnerable to landslides.
- Develop evacuation plans and procedures in advance.

LESSON 5: EL NINO AND LA NINA

El Niño and La Niña represent the **warm and cold phases of the El Niño-Southern Oscillation (ENSO) cycle**, which involves changes in oceanic and atmospheric temperatures across the Equatorial Pacific. This cycle significantly impacts oceanic processes, rainfall, wind patterns, and the formation of tropical cyclones. **Monsoons**, on the other hand, **are seasonal shifts in prevailing wind direction caused by uneven heating of land and ocean**. There are two types: **the southwest or summer monsoon, known as Habagat, bringing warm, moist air and heavy rainfall, and the northeast or winter monsoon, known as Amihan, bringing cooler temperatures and minimal rainfall from Mongolia and northwestern China.**

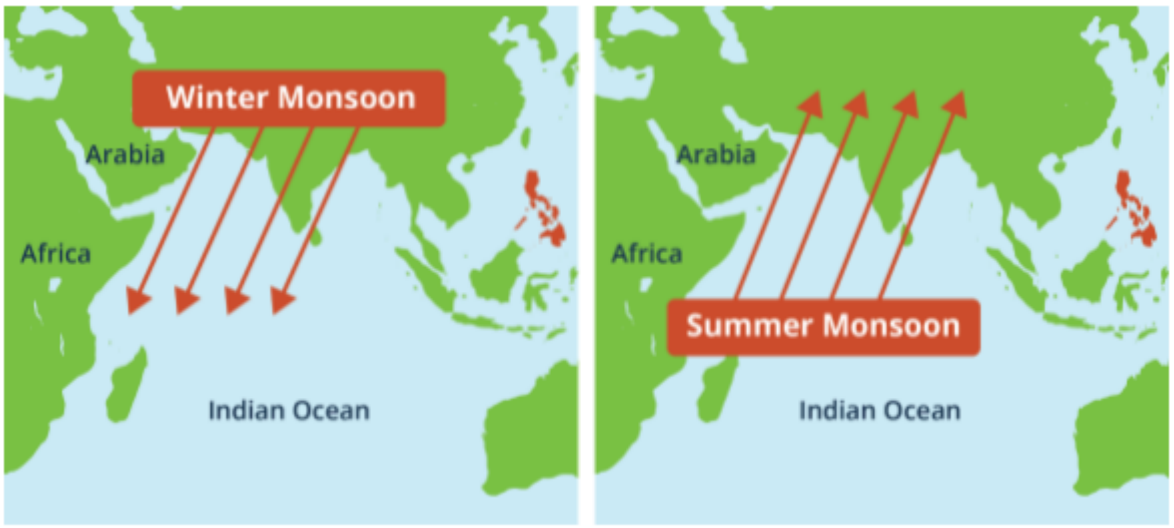

Fig. 1. Direction of seasonal winds that affect the Philippines annually.

EL NIÑO

El Niño, meaning **"The Little Boy" or "Christ Child"** in Spanish, refers **to abnormally warm seawater** first observed in South America, **often coinciding with Christmas**. In the Philippines, El Niño typically occurs from **December to February**, marked **by delayed or shortened rainy seasons and reduced monsoon and cyclone activity**. Although it brings fewer and milder storms, El Niño is also linked to **severe droughts**, which can be equally destructive. During El Niño episodes, drought assessment maps and advisories are issued to aid in mitigation efforts.

During El Niño, water supply becomes critical. It's essential to conserve and minimize the impact of shortages. Here's how:

- Stay hydrated.
- Use a set amount of running water for brushing or bathing.
- Collect rainwater when available, ensuring containers are covered to prevent mosquito breeding.

Reuse water from laundry or cooking for cleaning, car washing, or watering plants.

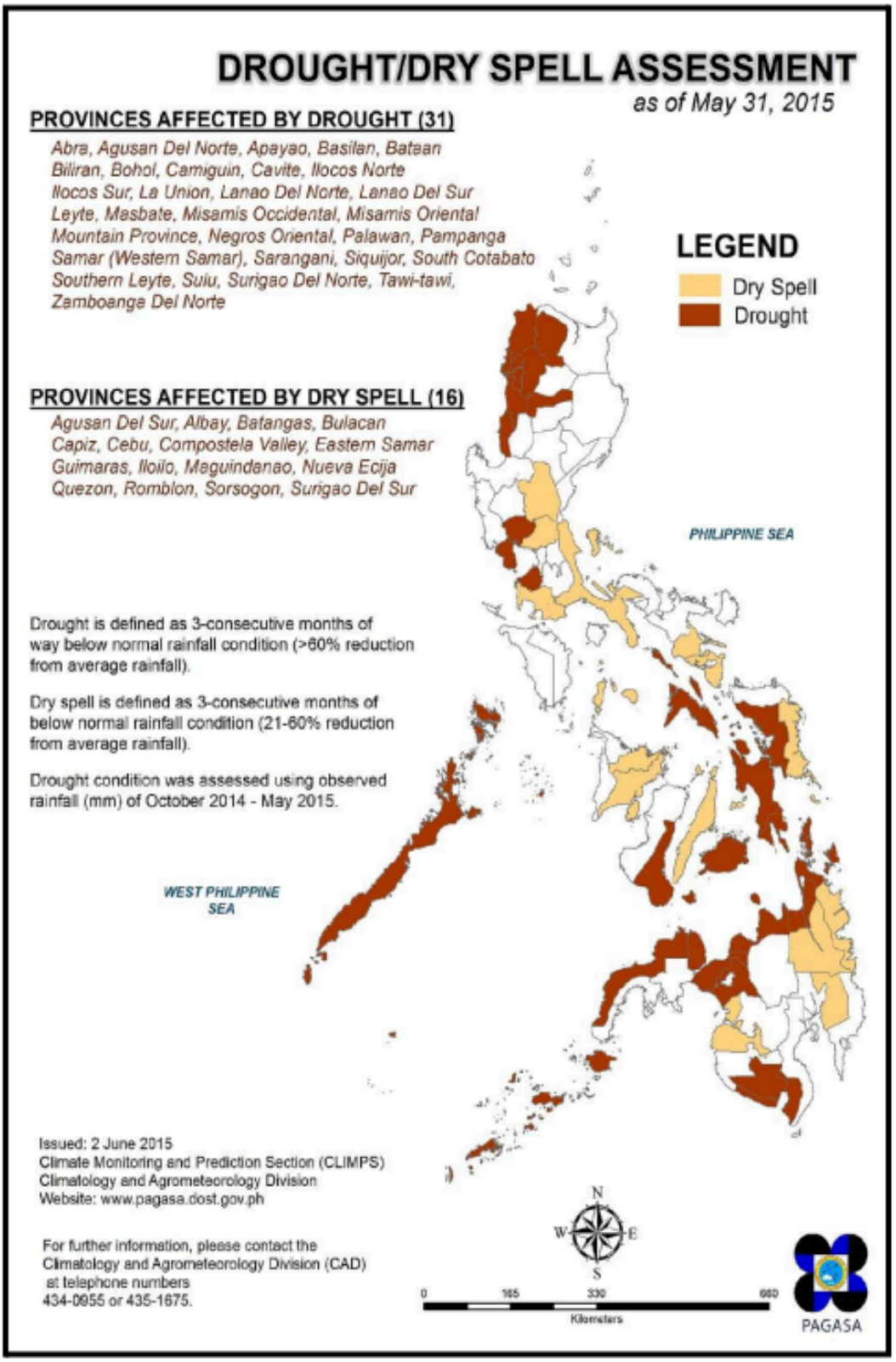

Fig. 3. Drought/dry spell assessment by PAGASA (as of May 2015)

LA NIÑA

La Niña, translating to **"The Little Girl,"** features **cooler-than-average sea surface temperatures.** Often called **El Viejo (The Old Man) or anti-El Niño**, its local weather effects typically oppose those of El Niño. La Niña occurs when **strong trade winds and ocean currents cause cold water to rise, a process known as upwelling**. This brings nutrient-rich waters to the surface, benefiting the fishing industry.

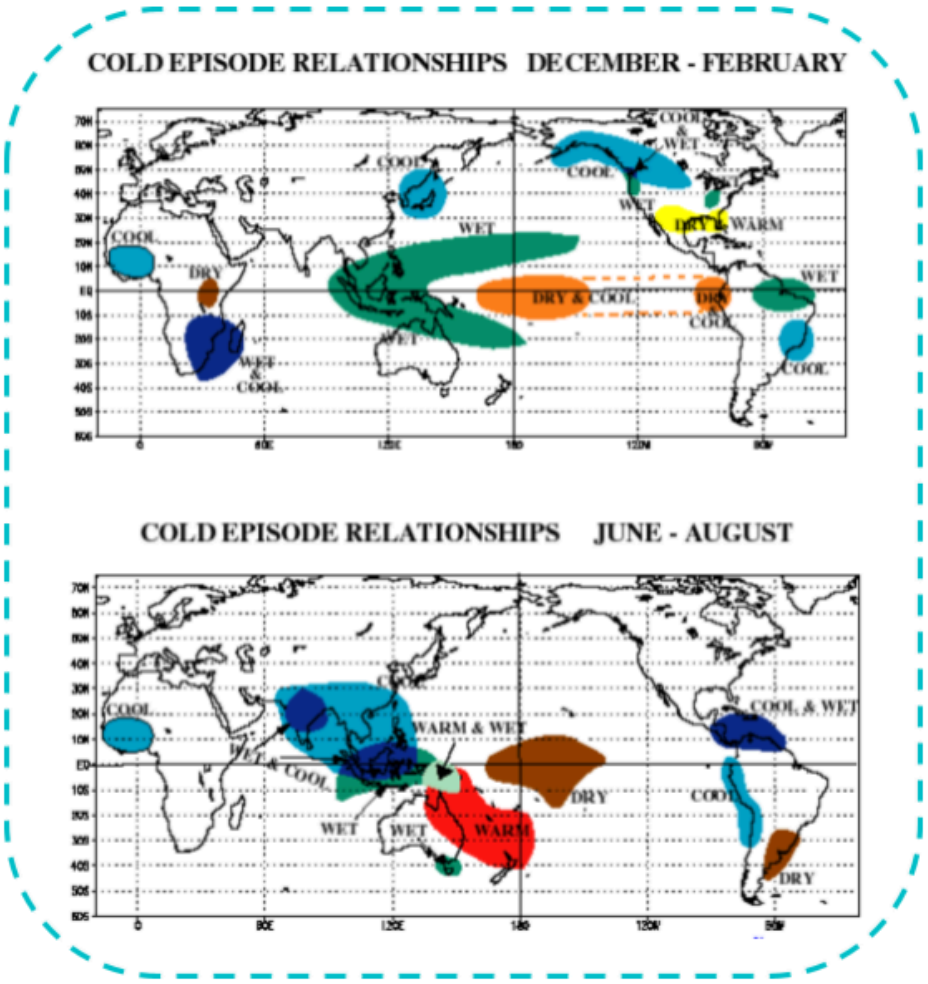

Fig. 4. Regional effects of La Niña throughout the world

During La Niña, higher-than-usual air pressure in the central and eastern Pacific leads to reduced cloud formation and rainfall, resulting in drier conditions, notably affecting South America and the U.S. Gulf Coast.

Conversely, lower air pressure in the western Pacific triggers increased rainfall in Southeast Asia, particularly benefiting agricultural regions like Northwest India and Bangladesh during the summer monsoon. However, in Australia, severe La Niña events have caused devastating floods.

In the Philippines, La Niña typically boosts rice production but also correlates with destructive typhoons, heavy rainfall, and consequent landslides and floods.

ENSO MONITORING

El Niño and La Niña are monitored and forecasted using the **Ocean Niño Index (ONI)**, which tracks deviations in **sea surface temperatures (SSTs)** over three months in the Niño region. **El Niño is signaled by a positive ONI of +0.5ºC or higher**, **while La Niña is indicated by a negative ONI of -0.5ºC or lower**. **ONI values between +0.5ºC and -0.5ºC signify ENSO-neutral conditions**. Forecasters predicted a transition from La Niña to ENSO-neutral conditions in the northern hemisphere from March to May 2018, with ENSO-neutral conditions likely in the latter part of the year. La Niña was officially declared in the Philippines by PAGASA in November 2017 and was expected to persist until February 2018.

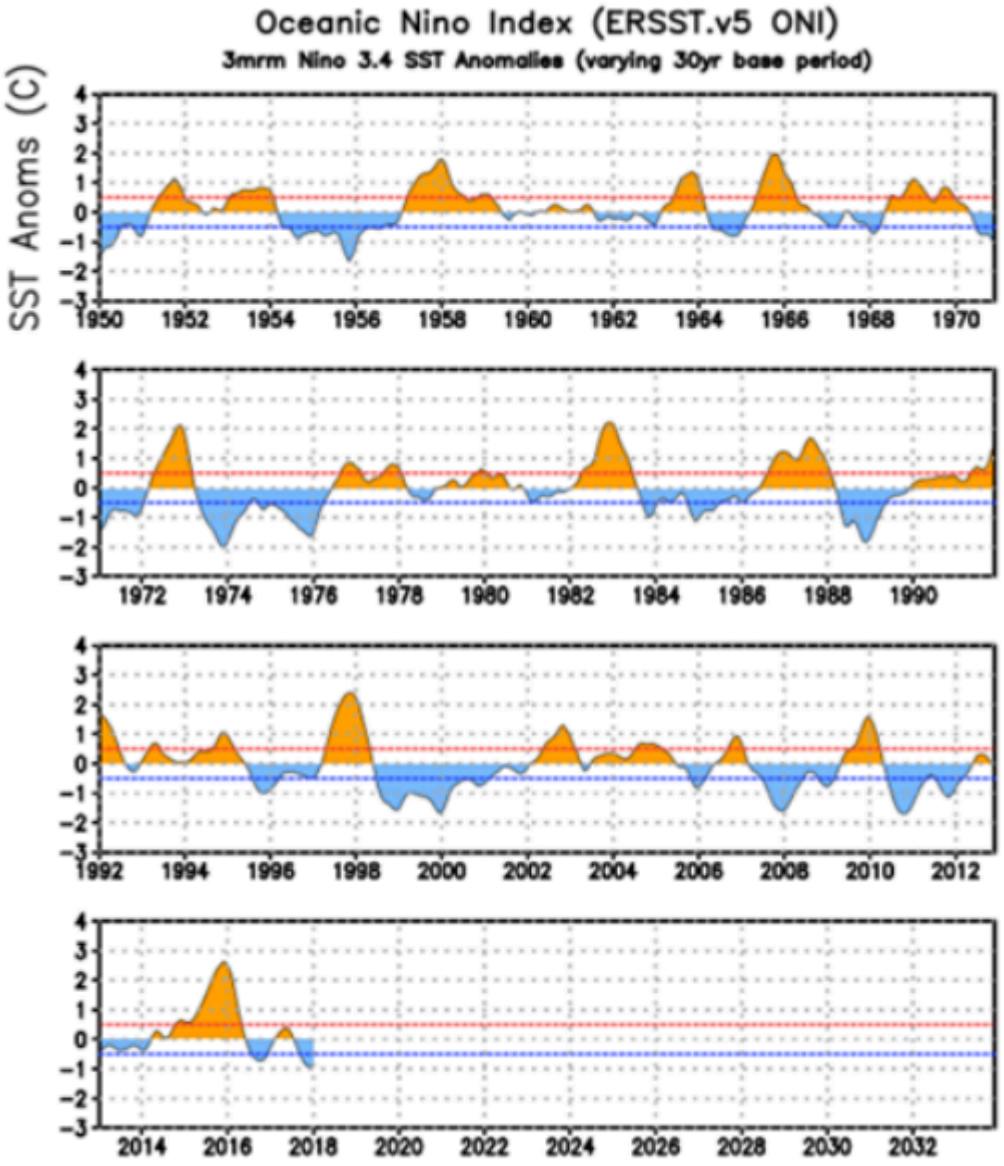

Fig. 5. Ocean Niño Index (ONI) from 1950 to 2018. Portions of the graph that fall above the red line indicate El Niño; those below the blue line indicate La Niña. The area between the two lines is considered ENSO-neutral.