ASMC BULLETIN

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ASEAN SPECIALISED METEOROLOGICAL CENTRE

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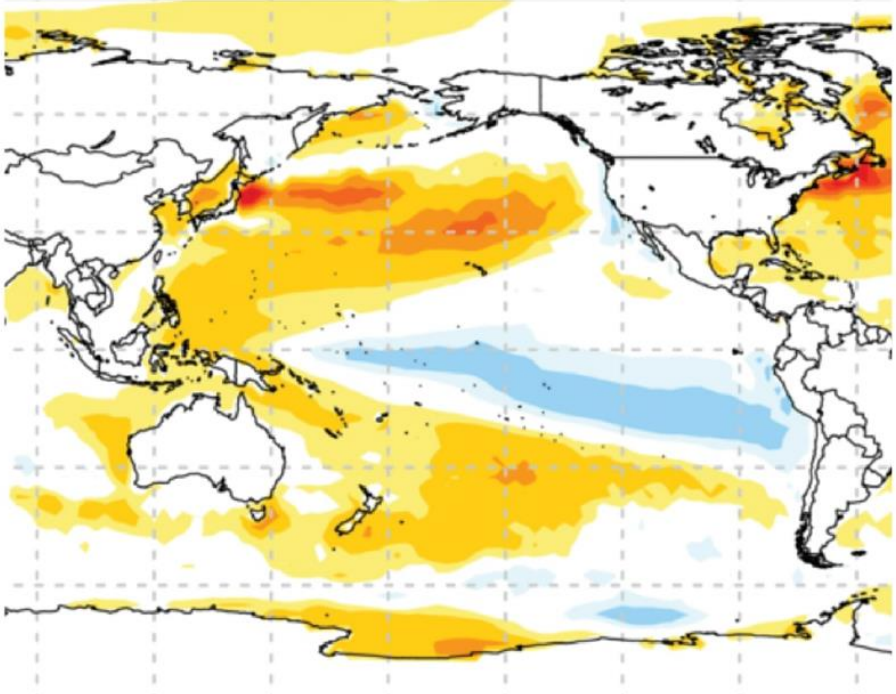

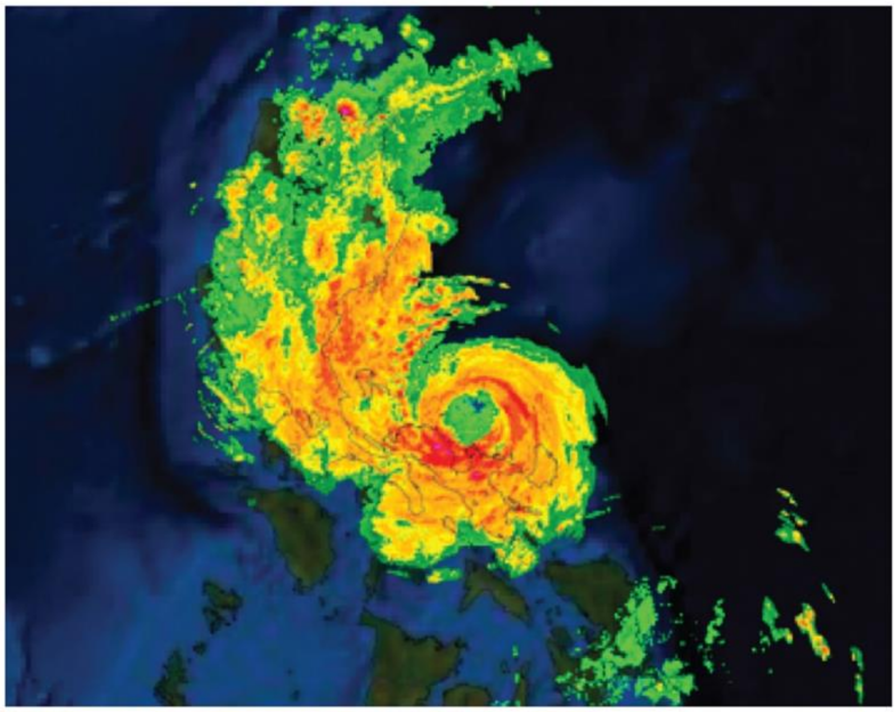

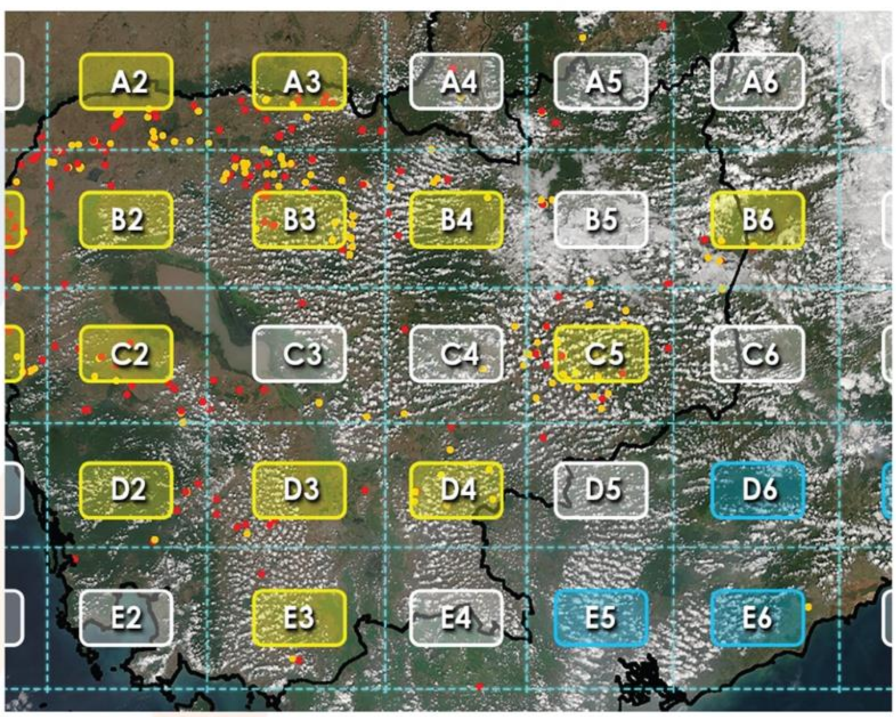

Published annually in March and September, this ASMC bulletin provides a review and outlook of weather and climate phenomena of importance to the region (*e.g.*, ENSO, MJO, and monsoon) as well as their influence on the region's temperature and rainfall conditions.

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Highlights

In 2020, La Niña development brought the focus back to the Pacific:

- Wetter than normal conditions were observed over much of Southeast Asia in the second half of 2020, in line with expectations for a La Niña event.
- Severe rainfall events occurred in Brunei Darussalam, Myanmar, the Philippines, Thailand and Viet Nam. For the Philippines, many of these events were associated with tropical cyclones.
- The dry season for the southern ASEAN region experienced a late onset; the wetter than normal weather contributed in part to subdued hotspot activities in 2020.
- The current La Niña conditions are predicted to transition to ENSO neutral conditions by the middle of 2021.

Beyond the Pacific Ocean:

- The Indian Ocean Dipole (IOD) has been, and is expected to continue in its neutral phase until the middle of 2021.
- The Madden-Julian Oscillation (MJO) interacted with the ongoing La Niña event, contributing to severe rainfall events by promoting tropical cyclogenesis and enhancing convective rainfall.

ASMC continues to build regional capabilities via online channels:

- A webinar on fire and smoke haze monitoring for the northern ASEAN region was held in January 2021.
- The ASEAN Climate Outlook Forum (ASEANCOF) transitioned to an online format in its 15th session.

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CLIMATE REVIEW (JULY – DECEMBER 2020)

The development of La Niña conditions

The second half of 2020 saw the development of La Niña conditions. During this time, observed sea-surface temperature (SST) values over the Nino3.4 region of the Tropical Pacific transitioned from the neutral range into La Niña conditions at the start of the second half of the year (Figure 1). Key atmospheric indicators of the El Niño-Southern Oscillation (ENSO) (*e.g.*, the strength of the trade winds and amount of cloudiness) also started to exhibit La Niña conditions.

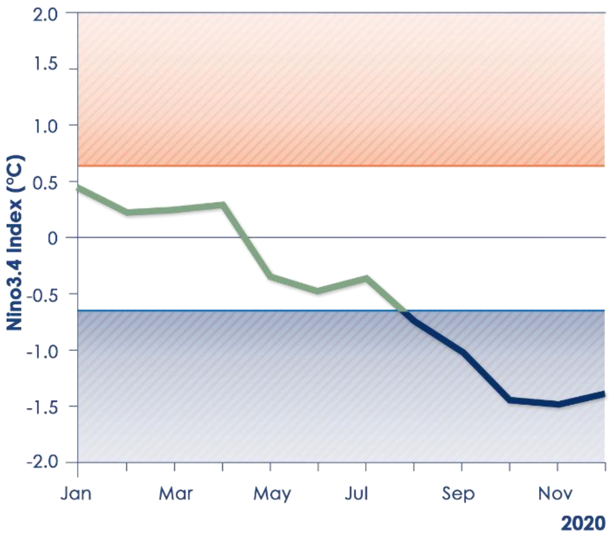

Figure 1: The Nino3.4 index (detrended) using 1-month SST anomalies. Warm anomalies (≥ +0.65; orange) correspond to El Niño conditions while cold anomalies (≤ -0.65; blue) correspond to La Niña conditions, otherwise: neutral (> -0.65 and < +0.65). Reference methodology: Turkington *et al.*, 2018.

In June 2020, models from the Copernicus C3S multi-model system predicted the ENSO conditions to be either neutral or cool for the second half of 2020 (Figure 2). From September 2020, most models predicted La Niña conditions of varying strengths based on the Nino3.4 index. At the same time, the C3S forecasts were predicting La Niña conditions until at least the end of 2020, even though variability in the strength of the conditions had still existed (not shown).

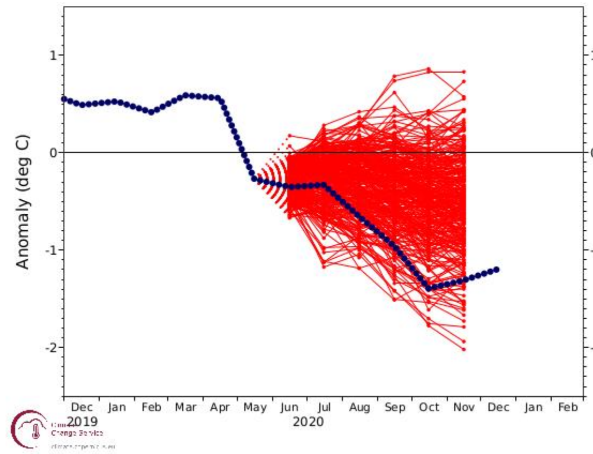

Figure 2: Forecasts of Nino3.4 index's strength (red lines) in June 2020 for the second half of 2020 from various seasonal prediction models from international climate centres. Observed values are in blue. Credit: Copernicus C3S.

The Indian Ocean Dipole (IOD) index was neutral for the second half of 2020 (Figure 3). After briefly positive values in June 2020, which were neither strong nor long enough to indicate another positive IOD event, the IOD index fluctuated within the neutral range around zero (Figure 3).

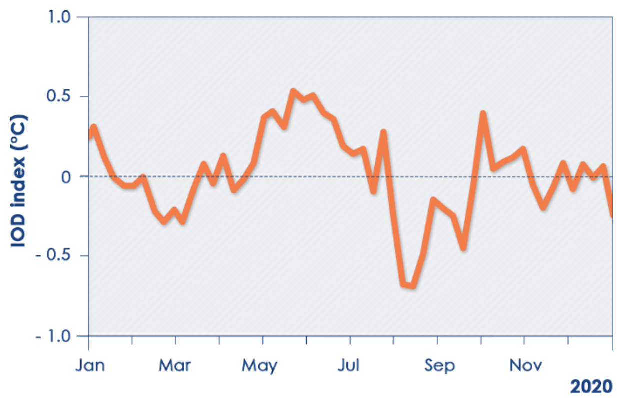

Figure 3: Indian Ocean Dipole (IOD) index showing generally neutral values in 2020. Data: Bureau of Meteorology, Australia.

Warm SST anomalies across, and to the east of the Philippine Sea, were the most notable anomalies around Southeast Asia in the second half of 2020. These warm anomalies in the Western Pacific are a common feature of La Niña events. In the South China Sea and the northern half of the Bay of Bengal, warm SST anomalies in July – September 2020 (Figure 4; top) returned to near average in October – December 2020 (Figure 4; bottom). Around Indonesia, the SSTs were near average for most of the second half of 2020.

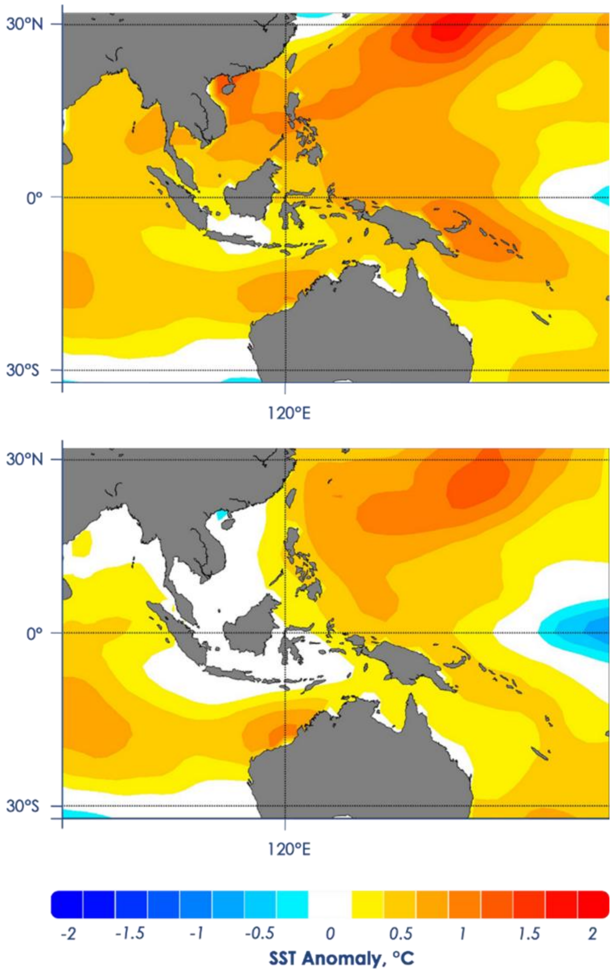

Figure 4: Sea-surface temperature (SST) anomalies (against 1976 – 2014 climatology) for July – September 2020 (top) and October – December 2020 (bottom). SSTs were warmer than average for much of the Southeast Asia region in July – September 2020. In comparison, SSTs were closer to the average for much of the region in September – December 2020, although the La Niña pattern of warmer sea-surface temperatures around the Philippines and cooler equatorial temperatures in the central Pacific were still prominent. Data: IRI Data Library.

Overall, Southeast Asia experienced a mix of near to above average temperatures in the second half of 2020 (Figure 5). Most of Mainland Southeast Asia went from above average temperatures in July – September 2020 (Figure 4; top) to near average in October – December 2020 (Figure 4; bottom), in line with the cooling of SSTs in the South China Sea. The exceptions were Myanmar and northwestern Thailand, which experienced above average temperatures during both periods. The Maritime Continent experienced a mix of near to above average temperatures throughout the second half of 2020 (Figure 5).

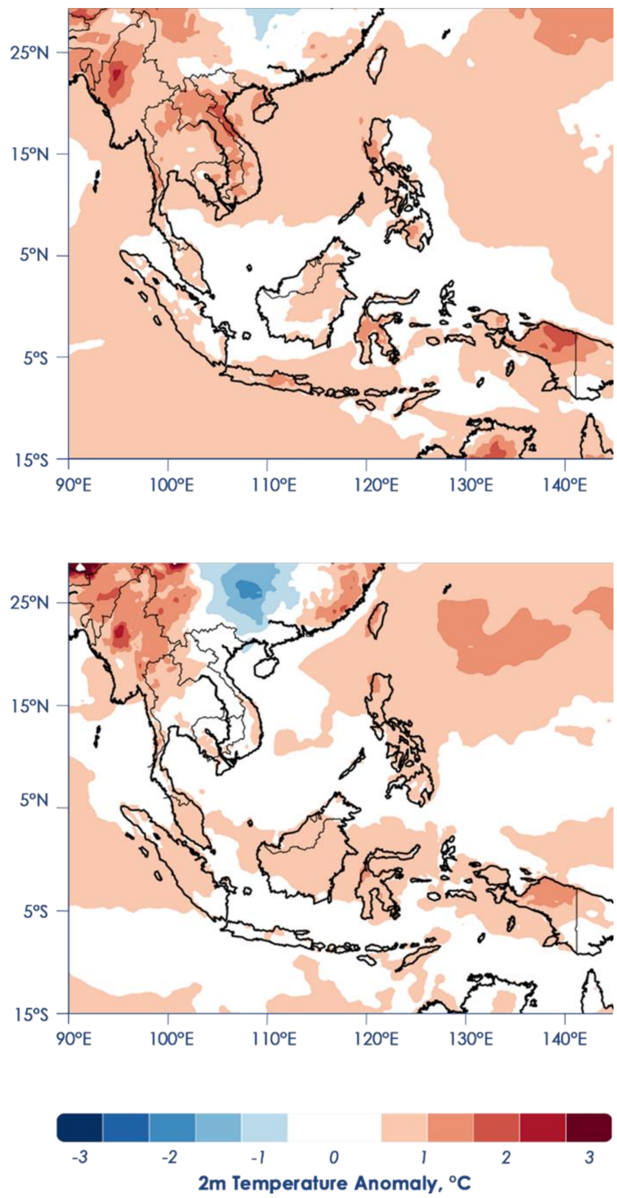

Figure 5: The average 2-metre temperature anomalies (against 1981 – 2010 climatology) for July – September 2020 (top) and October – December 2020 (bottom) show a mix of near to above average temperatures (red and white, respectively) for Southeast Asia in the second half of 2020. Data: ECMWF.

For rainfall, most of the Maritime Continent — apart from the Philippines — recorded above average rainfall for the July – September 2020 period (Figure 6; top). During October – December 2020, much of Mainland Southeast Asia and the Philippines recorded above average rainfall (Figure 6; bottom).

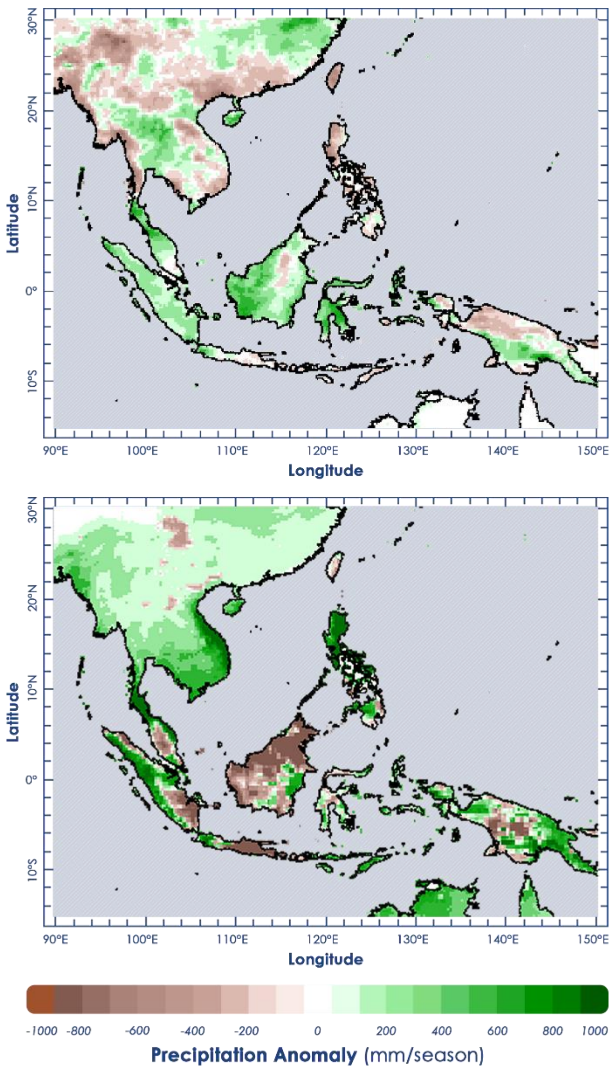

Figure 6: Seasonal rainfall anomaly (against 1981 – 2010 climatology) for July – September 2020 (top) and October – December 2020 (bottom) from the CHIRPS dataset. Areas in green experienced wetter than average conditions, while those in brown experienced drier than average conditions. Data: IRI Data Library.

The rainfall anomaly plots highlight the different impact La Niña events have on Southeast Asia at different times of the year. During the Southwest Monsoon season (typically from June – September), the largest wet anomalies tend to occur in the Maritime Continent, except in the Philippines. This pattern was observed in 2020. Similarly, during the Northeast Monsoon (typically mid-November – March), most of Southeast Asia typically records wetter than average conditions, except in the western Maritime Continent (*i.e.*, parts of Sumatra, the Malay Peninsula and Borneo Island) where the relationship between rainfall and ENSO is poor.

However, there is still variability between La Niña events through which intra-seasonal variability can play a role. At the intra-seasonal timescale, during July – September 2020 Madden-Julian Oscillation (MJO) pulses favoured the Indian Ocean and Western Hemisphere (Figure 7).

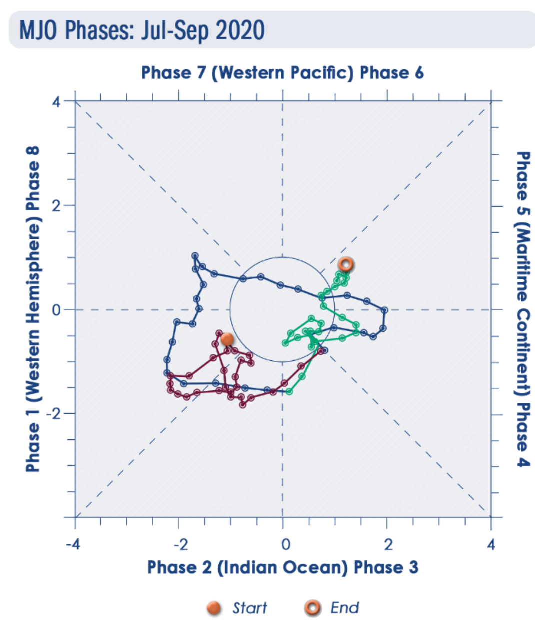

Figure 7: MJO strength and phases during July (red), August (blue) and September (green) 2020. The orange dots mark the start and end of the time series. Data: Bureau of Meteorology, Australia.

An MJO developed over the Indian Ocean in the middle of July 2020, reaching the western Maritime Continent at the beginning of August 2020 before weakening (based on the Real-time Multivariate (RMM) index; Wheeler and Hendon, 2004). Subsequently, in the second half of August 2020, the MJO signal strengthened again in the Western Hemisphere.

This MJO continued moving eastward through the Indian Ocean before weakening at the start of September 2020 prior to reaching the Maritime Continent. During this time of the year, phases 2 and 3 of the MJO tend to bring wetter conditions to the western Maritime Continent, while phases 1, 2, and 8 tend to bring drier conditions to the Philippines as well as southern Mainland Southeast Asia. This rainfall response was somewhat in line with the rainfall anomalies in Figure 6.

In the first half of October 2020, another MJO signal appeared to develop in the Maritime Continent (Figure 8) before propagating eastward into the Western Pacific (phase 6). The signal weakened slightly in phase 7, strengthening again in phase 8 before finally weakening in the Indian Ocean in phase 3 at the end of November 2020.

Wetter conditions in October 2020 can be partly related to the MJO activity, as phases 5 and 6 tend to bring wetter conditions to the regions around 10°N, which also had some of the largest anomalies (Figure 6; bottom).

In the western Maritime Continent, phases 7 and 8 tend to bring drier conditions while phases 2 and 3 bring wetter conditions, making it difficult to discern the influence of the MJO on the October – December 2020 average anomalies (Figure 6; bottom). However, the MJO activity may partly explain the drier conditions over Borneo Island and Java Island, where MJO phases 8 and 1 bring drier conditions. Lastly, there was no discernible MJO signal in phase 4, the phase that tends to bring the wettest conditions to these regions.

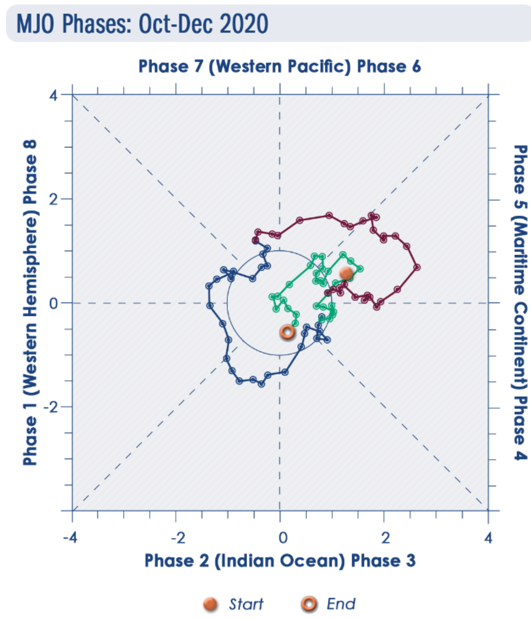

Figure 8: MJO strength and phases during October (red), November (blue) and December (green) 2020. The orange dots mark the start and end of the time series. Data: Bureau of Meteorology, Australia.

REGIONAL FIRE AND HAZE SITUATION (JULY – DECEMBER 2020)

A subdued fire and haze season for the southern ASEAN region (August – October 2020)

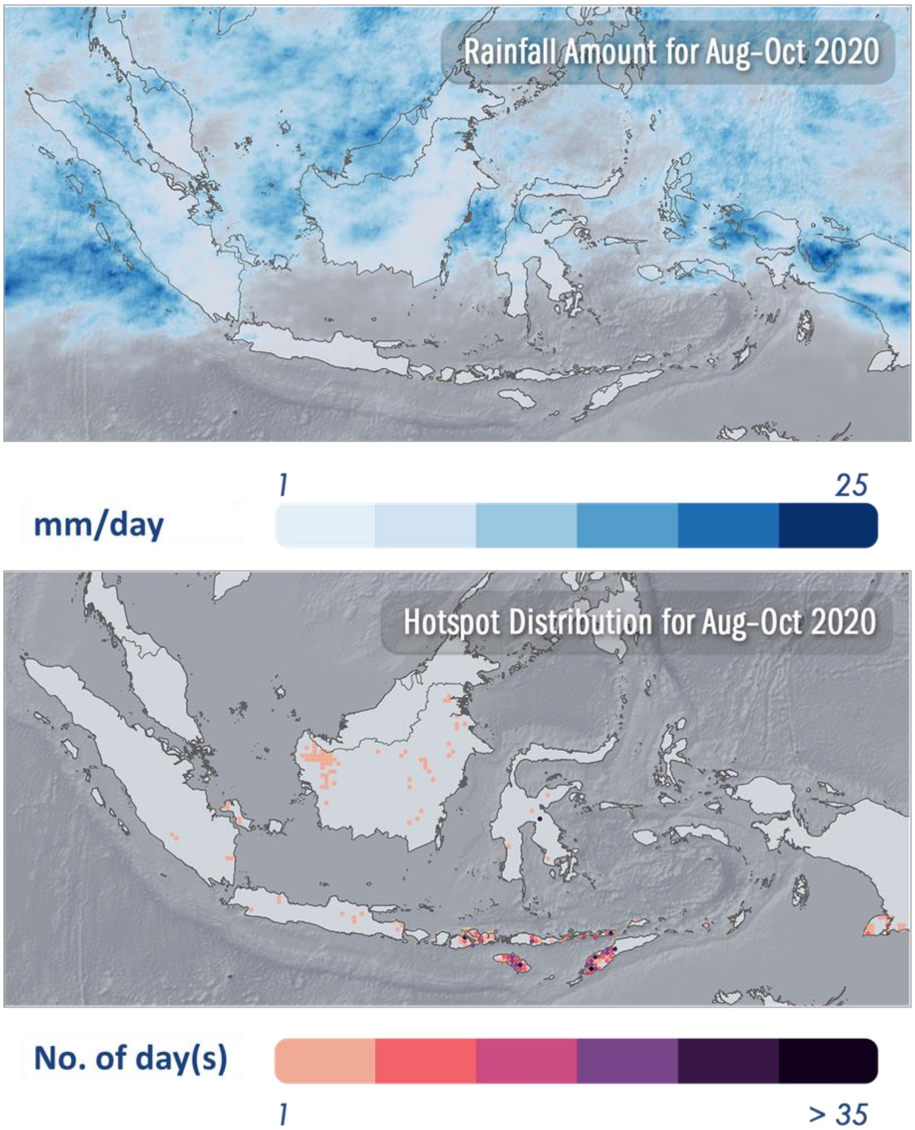

Figure 9: The daily average rainfall (top) and distribution of NOAA-20 hotspots for the southern ASEAN region during August – October 2020 (bottom). Data: Global Precipitation Measurement (GPM).

Traditionally, the dry season for the southern ASEAN region lasts from June – October each year. However, in 2020, rainfall over the region remained relatively high from June – July, and the southern ASEAN region experienced a delayed dry season onset. Dry conditions emerged in August 2020 and the start of the dry season — or Alert Level 1 — for the southern ASEAN region was declared on 3 August 2020.

During the dry season, the region as a whole experienced wetter than normal conditions (Figure 9; top). This was in part due to the development of La Niña conditions during this period (Figure 1).

As the hotspot and haze situation was generally subdued during the 2020 southern ASEAN dry season (Figure 9; bottom), Alert Level 2 and Alert Level 3 were not activated.

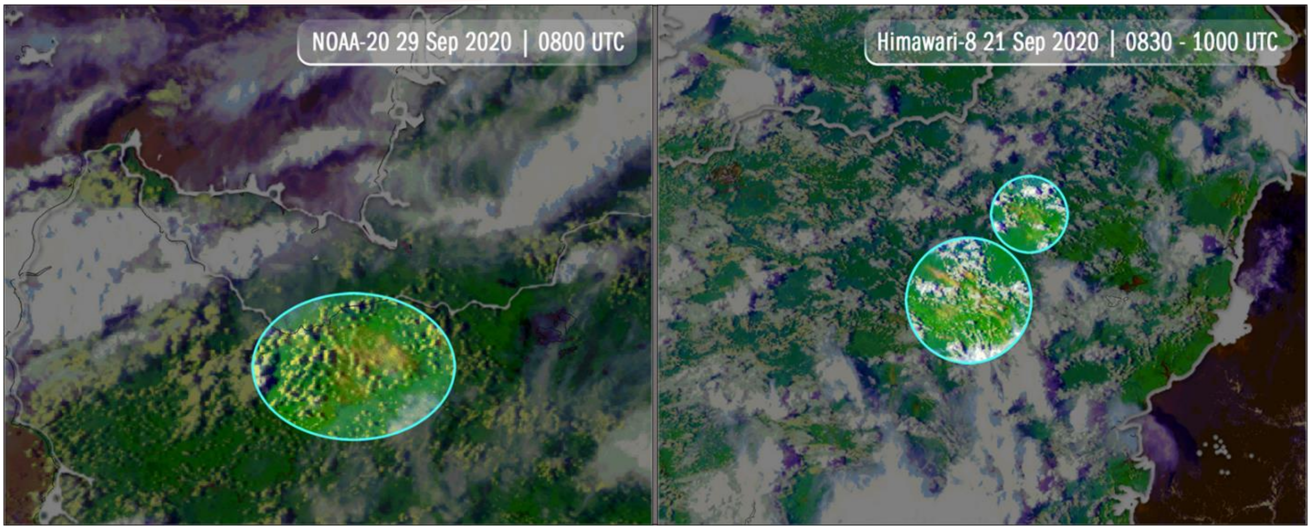

Figure 10: Smoke plumes were observed over the central and eastern parts of Kalimantan on 21 September 2020 (left) but were short-lived, due in part to rainfall activities. Scattered hotspots with smoke plumes were observed on 29 September 2020 during a brief dry period (right).

The relatively high rainfall during the 2020 dry season helped alleviate the hotspot and haze situation in the southern ASEAN region. There were brief periods of drier weather over parts of Kalimantan in September 2020 (Figure 10) which led to the occurrence of scattered hotspots and localised smoke plumes on several days. Nonetheless, rainfall activity continued through most of the dry season and was a contributing factor that helped subdue the hotspot and fire activities in the region.

Overall, the number of hotspots detected in the southern ASEAN region was around 20% of those detected in 2019.

Overall, during the July – December 2020 period, hotspot activities in the southern ASEAN region were much more subdued compared to previous years. Likewise, in the Mekong sub-region, hotspot activities and the smoke haze situation were less intense compared to the same period in 2019.

CLIMATE AND HAZE OUTLOOK (MARCH – AUGUST 2021)

Signs of La Niña decay

La Niña conditions are currently present. Most model outlooks from international centres indicate the negative (cool) anomaly easing through March – April 2021 (Figure 11). From May 2021 onwards, there is a wide spread of possible outcomes ranging from moderate La Niña conditions to ENSO neutral conditions. However, most models predict a transition to ENSO neutral conditions (based on the Nino3.4 index).

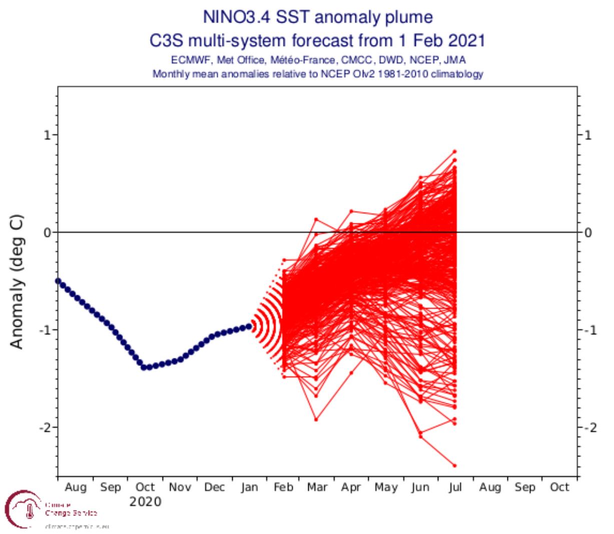

Figure 11: Nino3.4 SST anomaly predictions showing the negative (cool) anomaly easing slightly since end 2020. Accounting for background warming, most models predict La Niña conditions to become neutral from May 2021 onwards. Credit: C3S Copernicus.

In line with the Nino3.4 predictions, the ensemble-mean predictions of sea-surface temperature (SST) anomalies show weaker La Niña-like conditions during March – May 2021 (Figure 12). Under La Niña conditions, cooler SST anomalies are generally observed in the eastern Tropical Pacific Ocean (blue shades) and warmer anomalies in the western Tropical Pacific (red shades). La Niña conditions further require the SST pattern to remain for several months, and to couple with the atmosphere. The latter can be observed through stronger easterly winds in the eastern Pacific Ocean and above average rainfall in the western Pacific Ocean.

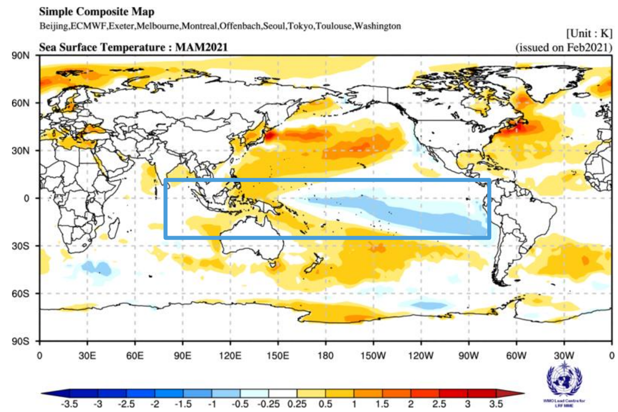

Figure 12: SST anomaly prediction for March – May 2021 showing weaker La Niña-like conditions in the Tropical Pacific Ocean (blue box). Credit: WMO Lead Centre for Long-Range Forecasting.

The IOD is likely to be neutral for March – May 2021. The IOD index is currently positive but within the neutral range with most models predicting the index to slowly decline over the next few months: becoming negative but still remaining in the neutral range (Figure 13). The models predict the IOD index to remain neutral for the first half of 2021, with some models predicting a negative IOD to develop from July 2021 onwards. However, models have limited skill in predicting the IOD at these longer lead times.

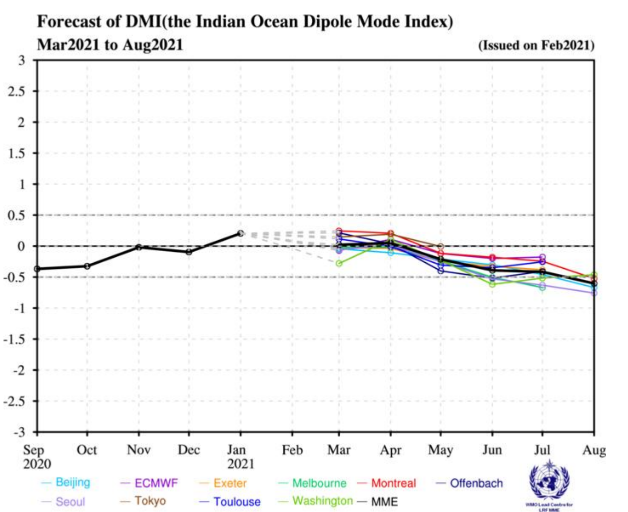

Figure 13: IOD index predictions (from models available on the WMO Lead Centre for Long-Range Forecasting) predict a drop in the IOD index, but are mostly within the neutral range for the first half of 2021. Credit: WMO Lead Centre for Long-Range Forecasting.

In the upcoming March – May 2021 period, model predictions from selected C3S models (SEA RCC-Network Long-range Forecasting Node) indicate enhanced chances of above normal (wetter) conditions over much of Southeast Asia (Figure 14). The areas where above normal rainfall is predicted correspond to those that typically experience wetter than average conditions during a La Niña event.

For parts of Sumatra and the western parts of Borneo Island, model predictions indicate below normal (drier) conditions for March – May 2021. At this time of year, the model skill is good for southern Mainland Southeast Asia, Peninsular Malaysia and the Philippines, and moderate for the rest of Southeast Asia.

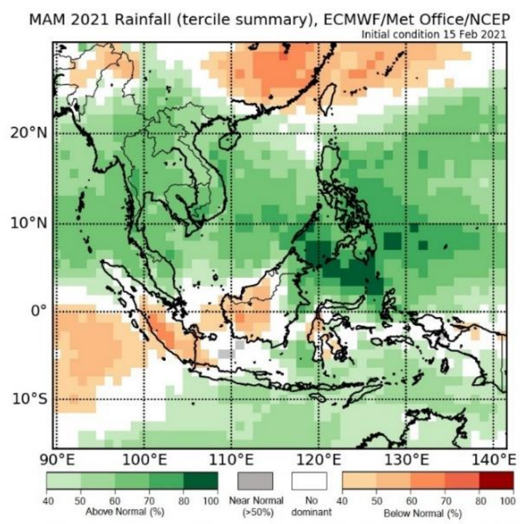

Figure 14: Rainfall tercile summary predictions of multi-model ensemble model for March – May 2021. Brown shades show regions with a higher likelihood of drier conditions, while green shades show regions with a higher likelihood of wetter conditions. Data: Copernicus C3S (modified).

For temperature, most of the Maritime Continent is predicted to continue experiencing above normal (warmer) conditions during March – May 2021 (Figure 15), except for Peninsular Malaysia where near normal conditions are expected. While below normal (cooler) conditions are expected for northeast Thailand and southern Lao PDR, above normal conditions are expected for central and northern Myanmar. Below to near normal temperatures are expected for the rest of Mainland Southeast Asia.

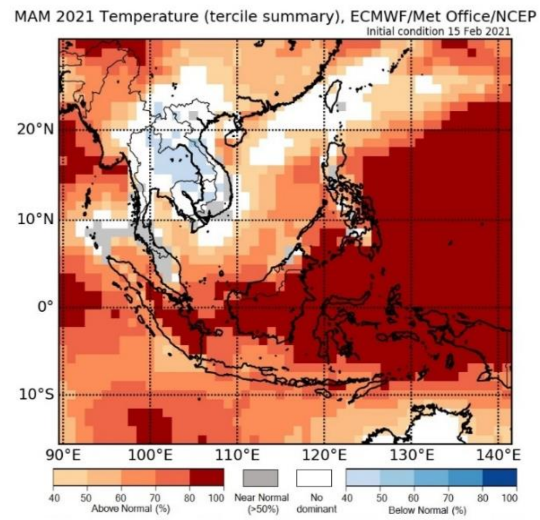

Figure 15: Temperature tercile summary predictions of multi-model ensemble model for March – May 2021. Red shades show regions with a higher likelihood of warmer conditions, while blue shades show regions with a higher likelihood of cooler conditions. Data: Copernicus C3S (modified).

While normal to above normal rainfall is forecast for much of the Mekong sub-region during March – May 2021, these months are the climatologically dry months for the sub-region. Hence, hotspot activities are expected to remain elevated with a risk of transboundary smoke haze occurrence. As we approach the middle of the year, shower activities are expected to return to the Mekong sub-region as the Inter-monsoon sets in and is followed by the Southwest Monsoon. These shower activities are expected to help keep hotspot activities subdued.

For the southern ASEAN region, below normal rainfall is expected for most parts of Sumatra and Kalimantan in March – May 2021, increasing the likelihood of isolated hotspot and smoke haze development in those areas. In the months of June – August 2021, the southern ASEAN region is expected to enter its traditional dry season. The resultant prolonged periods of drier conditions can lead to an escalation of hotspot activities and an increased risk of transboundary smoke haze occurrence.

SIGNIFICANT WEATHER EVENTS IN SOUTHEAST ASIA

Heavy Rainfall over Brunei Darussalam on 10 July 2020

Contributed by Arifin Yussof (Meteorological Officer) and Nurulinani Jahari (Meteorological Officer)

Brunei Darussalam Meteorological Department (BDMD), Brunei Darussalam

On 10 July 2020, Brunei experienced widespread and prolonged rainfall which ultimately caused low-lying areas to be severely flooded. Some roads remained inundated until the next day. This event is anomalous as Brunei typically observes drier conditions during the Southwest Monsoon (June – September).

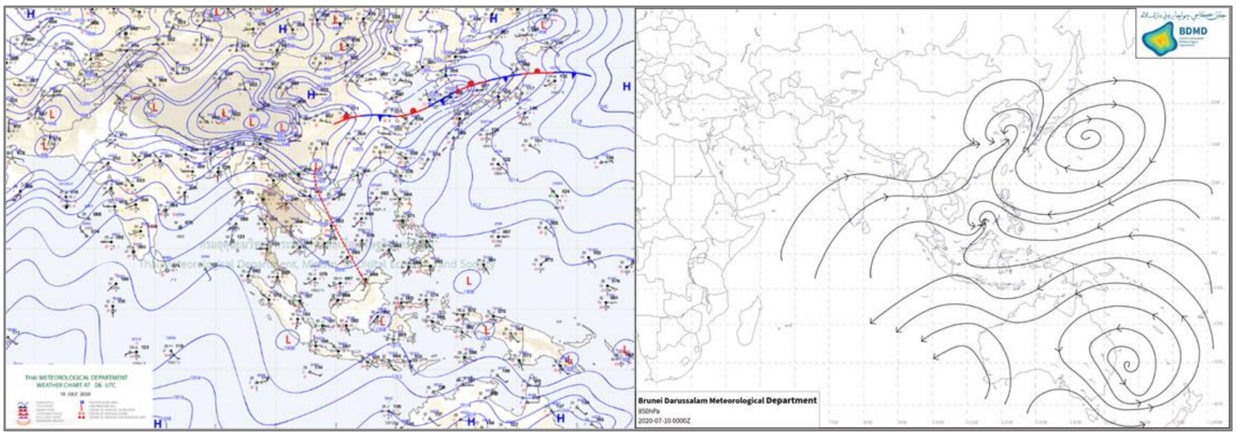

Figure 16: The surface weather chart for 0600 UTC 10 July 2020 (left) and the wind chart analysis for 0000 UTC 10 July 2020 (right). The latter was analysed by BDMD's Duty Forecaster. Credit (left): Thai Meteorological Department (TMD).

Synoptic Overview

The prevailing wind was southwesterly, as observed in the wind chart analysis (Figure 16; left). Southwesterlies tend to bring drier air to Brunei due to moisture being absorbed as the air mass passes over the Sumatra Island. On 10 July 2020, the abundance of moisture came instead from a low-pressure trough extending from Mainland China to the northern parts of Borneo Island (Figure 16; left). Furthermore, based on BDMD's wind chart analysis on 0000 UTC 10 July 2020 (Figure 16; right), a small cyclonic vortex was observed just north of Brunei, which likely triggered the active weather over Brunei. This can be confirmed by the relative vorticity at 850 hPa which shows positive vorticity over the South China Sea (Figure 17).

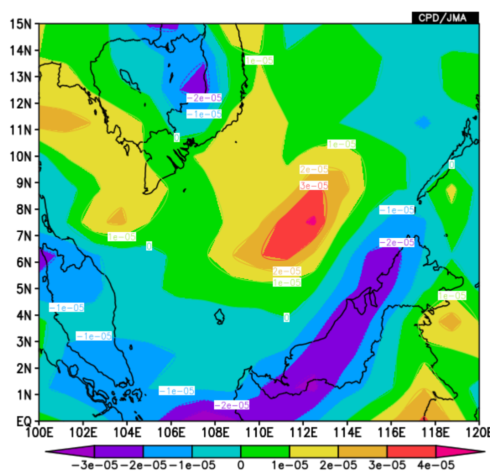

Figure 17: Relative vorticity at 850 hPa for 10 July 2020. Credit: JRA-55.

The unsettled weather started to develop over inland Temburong in the afternoon and propagated towards the coastal region, eventually affecting the whole of Brunei by the evening.

Observations

On 10 July 2020, the Brunei International Airport rain gauge recorded 81.5 mm — the highest daily rainfall amount in 2020. Hourly rainfall data at Brunei International Airport also showed continuous rainfall for five hours (Figure 18) with a peak reading of 40 mm/h at 8 pm LT.

Forecasting the Event

BDMD's forecasters mainly utilise numerical weather prediction (NWP) data from the National Centers for Environmental Prediction's (NCEP) Global Forecast System (GFS), which is then processed by BDMD's NWP Section. Based on the morning GFS model run, the six-hourly rainfall rate ensemble forecast (Figure 19; top), as well as the hourly rainfall rate forecast (Figure 19; bottom), indicated active weather conditions. In this case, the GFS model performed well in terms of the accuracy of its spatial and temporal forecast of the active weather conditions.

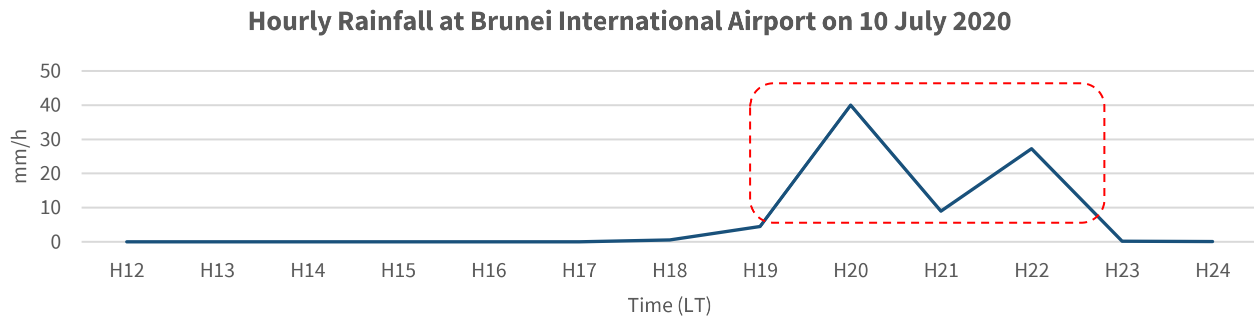

Figure 18: Graph of hourly rainfall at Brunei International Airport on 10 July 2020.

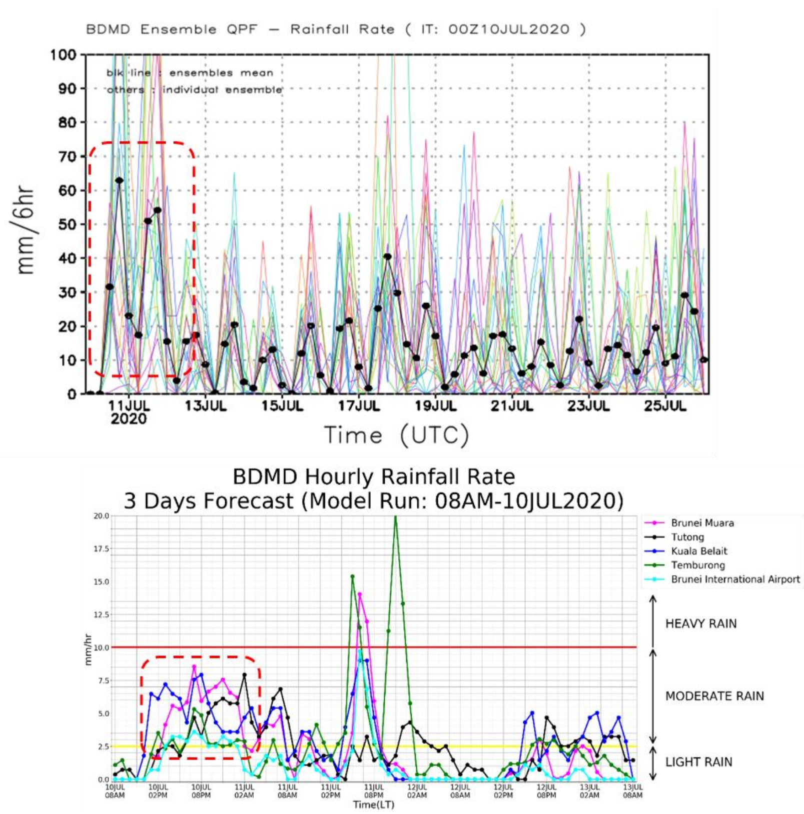

Figure 19: GFS ensemble (top) and hourly (bottom) rainfall forecasts initialised at 8 am (local time) on 10 July 2020. The forecast for the 10 July 2020 event is circled in red. Credit: NCEP GFS.

Warnings Issued

BDMD issued three consecutive yellow stage weather warnings for 10 July 2020 (Figure 20). Yellow stage weather warnings are disseminated to respective government agencies, such as the National Disaster Management Center and Ministry of Defense, to aid them in coordinating the deployment of their resources. The general public also receives these warnings via the Brunei WX App, official BDMD social media accounts, and radio alerts.

Thankfully, no lives were lost that day.

Figure 20: First yellow stage weather warning issued at 3.00 pm (local time) on 10 July 2020 (left) and the subsequent warning extension issued at 6.15 pm (local time) on the same day (right).

Severe Weather Event over the Southern Tip of Myanmar

Contributed by: Ms. Sabai Lwin (Assistant Director)

Agro Meteorological Division, Department of Meteorology and Hydrology (DMH), Myanmar

Myanmar experienced a severe weather event on 19 September 2020 with heavy rainfall, strong winds and significant wave activity causing damage to Bokpyin Township, Kawthoung District in Myanmar (Figure 21). This event wrecked houses, brick wall fences and wooden bridges and was due to Tropical Storm Noul which originated in the Philippine Sea.

Figure 21: Severe weather affected several areas in Myanmar, one of which was Bokpyin Township. Credit: Myanmaalinn via Facebook.

Synoptic Overview

At the time of the event, Myanmar was undergoing the Late-monsoon Season (transition period). Just before the event, Tropical Storm Noul crossed the central coast of Viet Nam and continued moving westwards. Noul reached Southern Myanmar on 19 September 2020, although it had been downgraded to a low-pressure area by this time. From the synoptic mean sea level pressure (Figure 22) and wind chart analysis (not shown), the situation was conducive for strong wind and heavy rainfall over the Southern Myanmar area. The corresponding surface weather chart (Figure 22) showed a low-pressure cell over Myanmar.

Himawari-8 satellite imagery (Figure 23) at 0640 UTC on 19 September 2020 also showed heavy-rain clouds over Southern Myanmar.

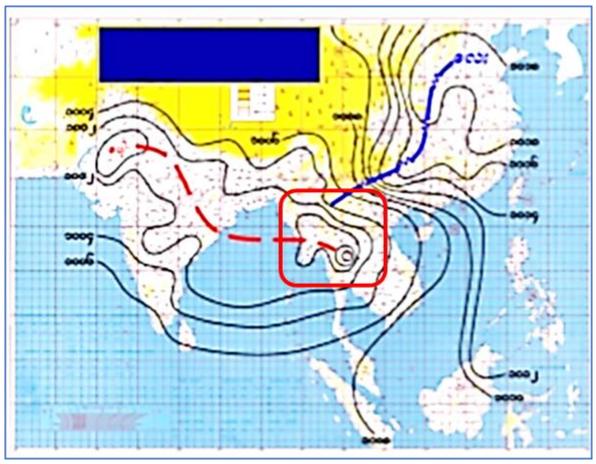

Figure 22: Mean sea level pressure chart (adapted from DMH) for 19 September 2020 (0000 UTC), showing a low-pressure area over Myanmar (red box).

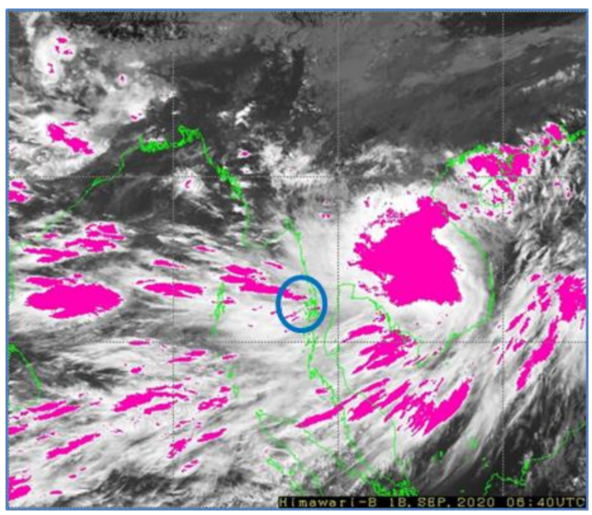

Figure 23: Himawari-8 satellite image on 19 September 2020 at 0640 UTC showing heavy-rain clouds over Southern Myanmar (blue circle). Credit: Japan Meteorological Agency (JMA).

Forecasting the Weather Event

Meteorological forecasters used daily rainfall and wind products from the US National Centers for Environmental Prediction Global Forecast System (NCEP GFS) to make the forecasts. The morning GFS model output (18 September 2020 0300 UTC model run) predicted active weather over the Southern Myanmar area as shown in Figure 24.

Observations

The daily rainfall recorded at Kawthoung Station on 19 September 2020 was 101 mm, which is a heavy rainfall amount (*i.e.*, > 77 mm) for Southern Myanmar. The strong winds, which were the primary cause of damage, blew at speeds of 25 – 30 mph (22 – 26 kt) due to the remnants of Tropical Storm Noul.

Warnings Issued

DMH issued six warnings for Tropical Storm Noul during its westward path from Viet Nam to Myanmar. DMH issued the first "Noul"-related warning on 18 September 2020 when it was over Thailand and had weakened into a depression. It was forecast that Tropical Storm Noul would continue to move westward and likely cross Southern Myanmar as a low-pressure area on 19 September 2020, with surface wind speeds reaching 35 – 40 mph (30 – 35 kt). DMH advised the community that they should be aware of the possibility of heavy rainfall with strong winds, as well as flash floods and landslides near hilly areas and small rivers due to the depression from the remnants of Tropical Storm Noul.

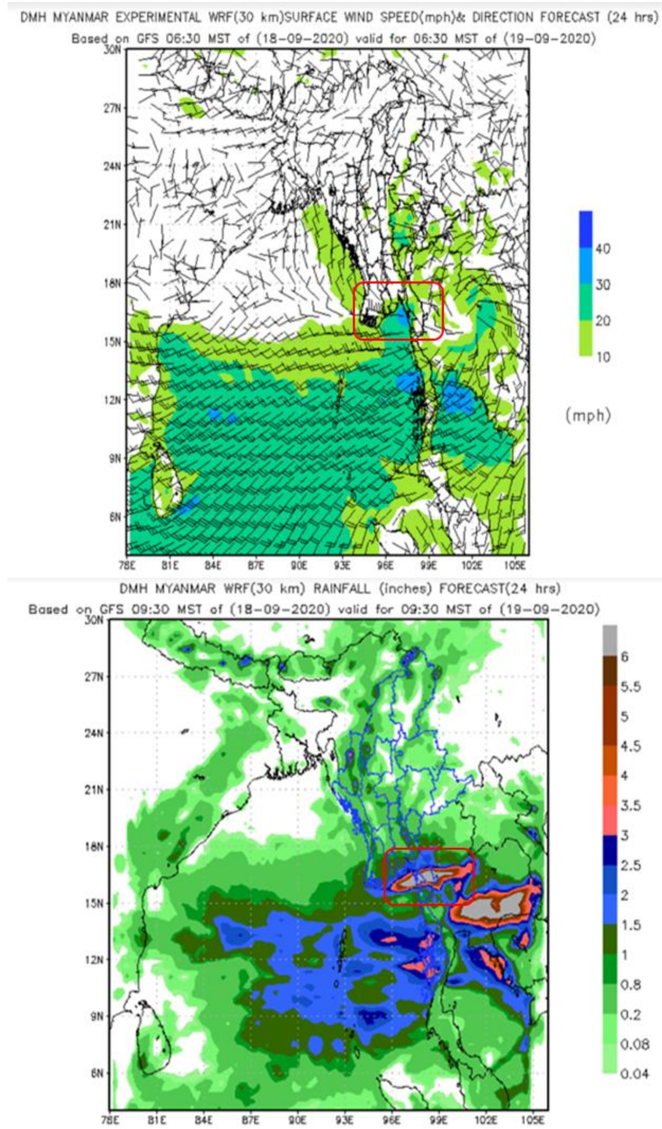

Figure 24: Wind (top) and rainfall (bottom) forecasts from GFS for 19 September 2020 0300 UTC (0930 MST), based on the 18 September 2020 0300 UTC model run, showing heavy rain and strong winds over Southern Myanmar (red boxes). **Credit: NCEP GFS.**

The Destructive Late-Season Philippine Typhoons of the 2020 Season

Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Philippines

The Philippine tropical cyclone season of 2020 was marked by Typhoon Goni (Rolly) and Typhoon Vamco (Ulysses): two late-season tropical cyclones that set several meteorological records in the Philippines. These two events led to 126 lives lost and damages, amounting to PHP 38.2 billion (USD 768 million), to infrastructure and the agricultural sector.

Super Typhoon Goni: Was it the Strongest to Hit the Philippines Post-Haiyan?

Contributed by: Robb P. Gile (Weather Specialist I, Weather Division, DOST-PAGASA)

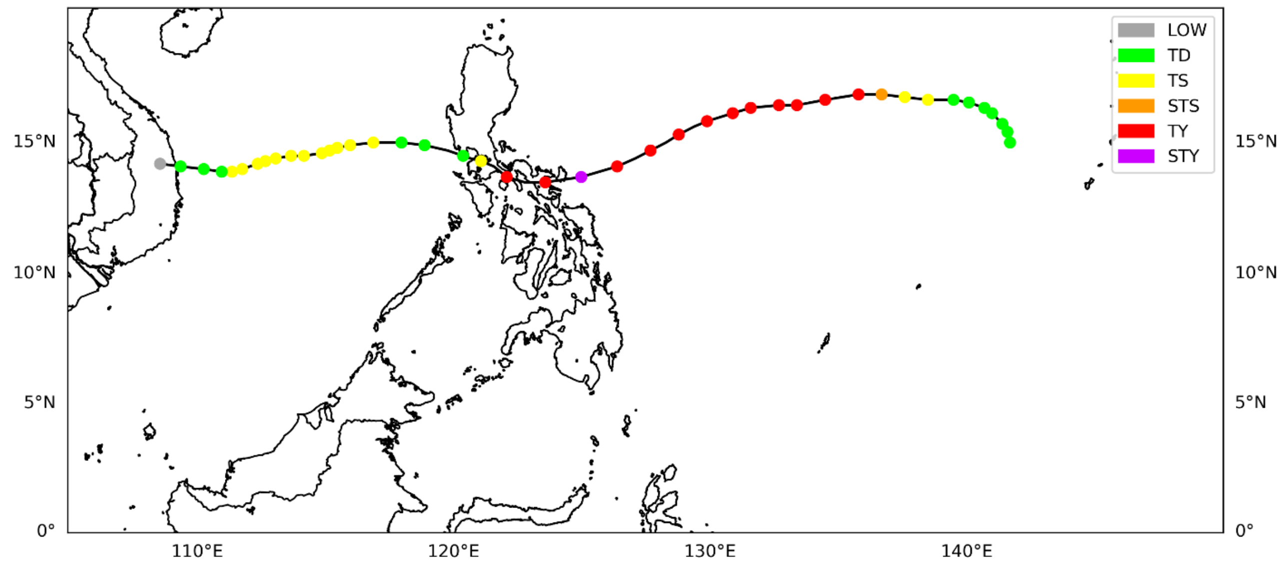

Figure 25: Preliminary best track positions and intensities of Typhoon Goni (Rolly) at standard synoptic times (0000, 0600, 1200, and 1800 UTC) from 26 October – 6 November 2020.

Meteorological History

The strongest typhoon of 2020, Goni, in the Western Pacific originated from an area of low pressure over the Philippine Sea, west of the northern Marianas. It was first tracked as a tropical depression at 1800 UTC on 26 October 2020. After reaching tropical storm category within 48 hours of development, Goni underwent another 48-hour period of rapid intensification, reaching a peak of 40 – 45 kt/24 h. At 1200 UTC on 30 October 2020, it turned southwestwards towards Bicol Region in the southeastern portion of Luzon, reaching 10-minute maximum sustained winds of 115 kt. This intensity was maintained for 24 hours as Goni inched closer to Catanduanes; an island province situated to the east of the Bicol Peninsula. Roughly three hours before landfall, the Dvorak technique yielded T8.0/8.0 for the typhoon's intensity. This meant that Goni reached a maximum wind speed of 120 kt — a super typhoon by PAGASA's tropical cyclone classification scale. At 2050 UTC on 31 October 2020 (4:50 AM on 1 November 2020 local time), the typhoon made landfall over the town of Bato in Catanduanes at its peak intensity (120 kt, 910 hPa). With this, Goni had become the strongest typhoon (in terms of maximum winds) since Typhoon Haiyan (Yolanda) in 2013 to make landfall over any locality in the Philippines.

Throughout 1 November 2020, Goni passed over several provinces in the Southern Luzon area, its track shifting to a westward or west-northwestward direction. The eye of the typhoon made three additional landfalls during its traverse of Luzon — over the towns of Tiwi (Albay), San Narciso (Quezon), and Pagbilao (Quezon). Despite making its initial landfall at peak intensity, the combination of land interaction with the rugged terrain of Luzon as well as the increasing easterly wind shear brought about by an upper-level anticyclone to the northeast of Goni resulted in a rapid weakening phase. Within 24 hours of landfall, the super typhoon had degenerated into a tropical depression. By the time it reached the West Philippine Sea the following day (2100 UTC on 1 November 2020), Goni had weakened by 90 kt from its initial landfall intensity.

Once over the West Philippine Sea, Goni moved westward to west-southwestward with slight intensification. However, the prevailing Northeast Monsoon continued bringing unfavourable conditions that prevented the cyclone from intensifying further. After making landfall over Central Viet Nam, Goni weakened into a remnant low at 0600 UTC on 6 November 2020. Figure 25 shows the preliminary best track positions and intensities of Goni at standard synoptic times.

Figure 26: The last known observation (2030 UTC on 31 October 2020) from Bato weather radar (left). The pink circular band is an indication of the impending failure of the radar antenna. The post-storm aerial survey over the PAGASA weather radar in Bato, Catanduanes, where the pedestal of the radar antenna can still be seen standing on the tower rooftop (centre). The reflectivity image from Daet weather radar when Typhoon Goni (Rolly) made landfall over Bato, Catanduanes, at 2050 UTC on 31 October 2020 (right).

The Search for Goni's Landfall Intensity

Due to the absence of routine aircraft reconnaissance in the western North Pacific, tropical cyclone intensities are estimated primarily using the Dvorak technique (Dvorak 1984; Koba *et al.*, 1991) where estimates of tropical cyclone intensities are obtained using analyses of infrared and visible images from geostationary satellites. Surface observation from manned and unmanned weather stations, and remotely sensed data from Doppler weather radars, microwave imagers/sounders and scatterometres are then used to further refine the Dvorak-based intensity estimate.

In the hours leading up to landfall and the period following its passage over Catanduanes, two weather radars of the state weather bureau (PAGASA) were able to capture the full circulation of Goni, especially its inner core where the strongest winds and heaviest rainfall would be found. Figure 26 (left) shows the last available image generated by the weather radar in the town of Bato, Catanduanes — the same municipality where the eye of Goni made its first landfall. The radar image shows a well-defined, 30 km diameter pinhole eye surrounded by a strong circular band of reflectivity roughly 20 km thick associated with its eyewall region. Due to devastating extreme winds associated with the eyewall of Goni, the radome, antenna, and satellite communications dish of the radar station were completely blown off (Figure 26; centre).

In the hours prior to landfall, intermittent communication with Bato radar due to worsening weather conditions was compensated for by continuous observations from another weather radar station in Daet, Camarines Norte. Just as in Bato, the radar in Daet was able to capture the initial landfall of Goni over Catanduanes and observe the same well-defined pinhole eye and intense eyewall signature of the super typhoon (Figure 26; right). With the failure of the Bato radar, the Daet radar served as the primary surveillance station for PAGASA's meteorologists during the critical hours of Goni's passage over the Bicol Peninsula. For several hours, the Daet radar provided continuous observation until Goni eventually entered the blind sector of the Daet radar in the early afternoon of 1 November 2020 (local time) as it approached the Bondoc Peninsula in Southern Quezon. From thereon, meteorologists relied heavily on a combination of surface and satellite observations to monitor the progress of Goni and issue the appropriate warnings.

The Doppler velocity data captured by both Bato and Daet radars, especially during hours prior and at the time of landfall, will be crucial in providing the best estimate of Goni's intensity before and at initial landfall during the post-season storm reanalysis. Wind fields of the tropical cyclones can be retrieved from the Doppler velocity data using the ground-based velocity tracking display (GBVTD) technique (Lee *et al.*, 1999). From these wind fields, the maximum winds at different altitudes can be determined, thereby allowing a better estimate of maximum near-surface winds using appropriate corrections and minimum central pressure using the method of Shimada *et al.*, (2016) under the assumption of gradient wind balance. Similar investigations have been performed for Typhoon Haiyan (Yolanda) in 2013 (Shimada *et al.*, 2018a) and Typhoon Goni (Ineng) in 2015 (Shimada *et al.*, 2018b). The surface wind estimates from the GBVTD technique will verify if Typhoon Goni (Rolly) in 2020 was indeed the strongest post-Haiyan tropical cyclone, in terms of maximum winds, to make landfall over the Philippines. Aside from the Bato weather radar, the synoptic station in the neighbouring capital municipality of Virac was directly hit by Goni, with the eye of the super typhoon passing directly over the station. This allowed the weather station to observe the violent winds within the inner core of Goni, and the barometric minimum and lull within the eye.

The passage report submitted by station personnel shows that their instruments registered a minimum sea level pressure of 912.1 hPa at 2114 UTC on 31 October 2020, a peak 3-second gust of 38 m/s at 2150 UTC, and a lull lasting 30 minutes beginning at 2100 UTC. However, it must be noted that the wind instrument of the station also suffered a failure due to violent winds, thereby increasing the likelihood that the station did not capture the highest gusts. Nevertheless, if verified and corroborated by the radar-derived minimum central pressure estimate, the barometric minimum from Virac station will be one of the lowest reported by a manned station in the Philippines post-Haiyan. This would thus make Goni the strongest tropical cyclone, in terms of central pressure, to make landfall since Typhoon Mangkhut (Ompong) in 2018.

The Passage of Typhoon Vamco (Ulysses) Over Central Luzon, Philippines

Contributed by: Sheilla Mae R. Reyes (Weather Specialist I, Weather Division, DOST-PAGASA)

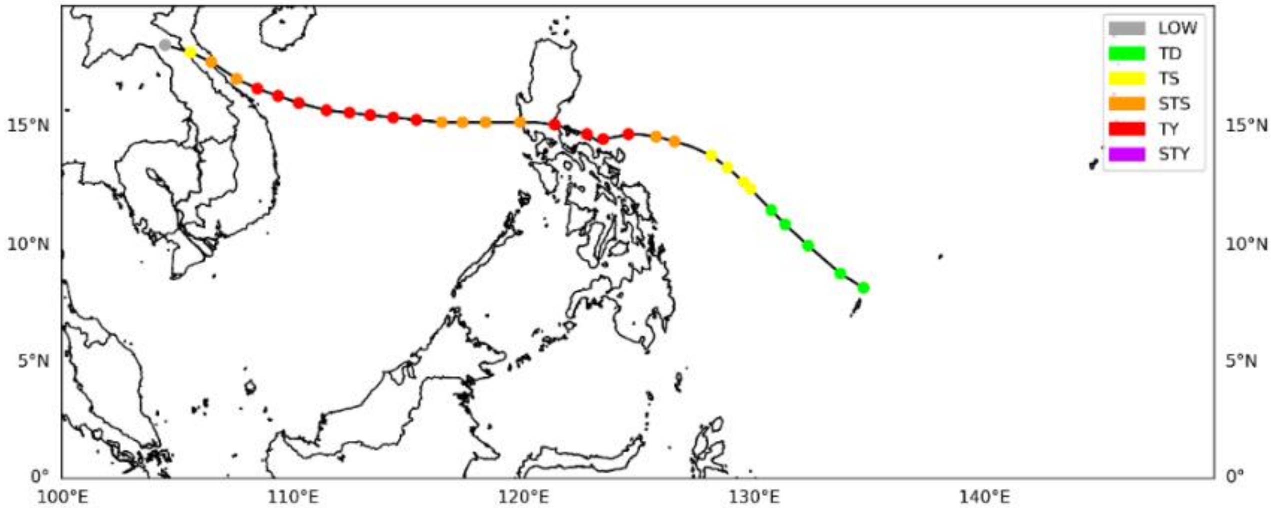

Figure 27: Preliminary best track positions and intensities of Typhoon Vamco (Ulysses) at standard synoptic times (0000, 0600, 1200, and 1800 UTC) from 8 – 15 November 2020.

Synoptic Overview

An area of low pressure located east of Mindanao gained sufficient organised deep convection to be classified as a tropical depression at 0600 UTC on 8 November 2020 (Figure 27).

The disturbance moved generally northwestwards under the steering influence of the subtropical ridge positioned to the northeast. After 24 hours, the disturbance strengthened enough to become a tropical storm, and after further strengthening, at 1200 UTC on 10 November 2020, Vamco became a severe tropical storm. At this time, the subtropical ridge hindered further poleward movement, causing Vamco to turn from a northwestward to a more west-northwestward track. When Vamco was just to the north of Catanduanes, it became more compact with feeder bands wrapped tighter into the central convection signifying continuous intensification. When an eye feature was observed by the PAGASA Daet Doppler radar at 0000 UTC on 11 November 2020, Vamco was upgraded to typhoon intensity and momentarily moved west-southwestwards, brushing the northern coast of Camarines Provinces (Figure 28). By 0900 UTC on the same day, Vamco had started moving west-northwestwards again. Subsequently, it gained strength: reaching an estimated intensity of 75 kt before its first landfall over Patnanungan, Quezon.

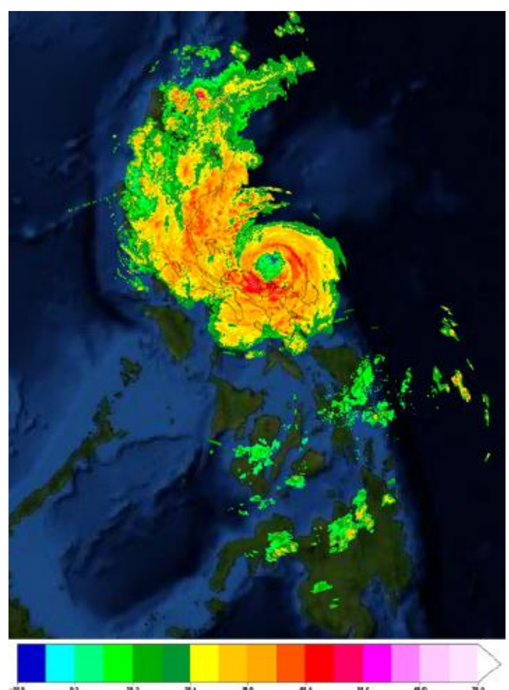

Figure 28: Philippine radar mosaic (column maximum; CMAX) at 0900 UTC on 11 November 2020.

After its second landfall over Burdeos, Quezon, Vamco moved westward and made its third landfall over General Nakar, Quezon (mainland Luzon). It then continued to move inland, traversing Central Luzon. Due to the rugged terrain, Vamco weakened to a severe tropical storm as its centre emerged over the West Philippine Sea on the morning of 12 November 2020. It then regained typhoon strength reaching an estimated peak intensity of 80 kt as it headed towards Central Viet Nam. Vamco weakened into a severe tropical storm just before it made landfall over the Ha Tinh and Thua Thien-Hue provinces and continued to weaken as it moved inland. At 1800 UTC on 15 November 2020, Vamco weakened into a low-pressure area.

Heavy Rainfall and Massive Flooding Event

The passage of Vamco brought excessive rainfall over the Luzon area, causing multiple landslides and flooding incidents that claimed 101 lives and resulted in extensive damages to agriculture and infrastructure totalling PHP 20.2 billion (USD 417 million). As such, Vamco ranked as the sixth-costliest Philippine typhoon on record.

Based on the synoptic rain gauge observations (Figure 29), the eastern section of Luzon, specifically: Rizal and the northern portions of mainland Cagayan, Aurora, and Quezon, received a 6-day rainfall accumulation of more than 360 mm. Metro Manila, Bataan, Catanduanes, Albay, and the rest of Calabarzon received at least 180 mm. It should be noted that some of these aforementioned areas, particularly the Bicol Region where Catanduanes and Albay belong, were still recovering from the impact of Typhoon Goni (Rolly) in 2020.

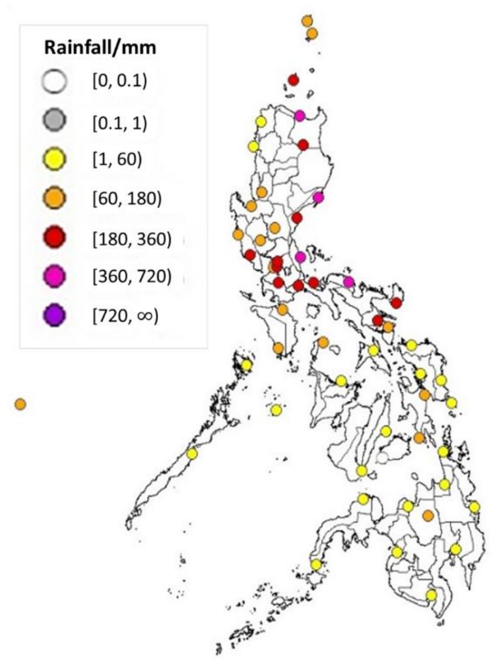

Figure 29: Nationwide accumulated rainfall from 8 – 15 November 2020 based on reports from PAGASA synoptic stations.

Vamco dumped heavy rain as it traversed over Central Luzon, causing massive flooding over the area and nearby provinces including Metro Manila, the capital city. The excessive rainfall caused the Marikina River to overflow, resulting in severe flooding in Marikina City which submerged thousands of households in flood waters. Due to the swelling of rivers, Cagayan and Isabela, located in the northern portion of Luzon, also experienced widespread flooding. In addition, dams over Luzon reached critical levels, forcing the Magat Dam to open seven spillway gates to control the reservoir's flow.

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October 2020's March of Tropical Cyclones and their Impact on Thailand's Rainfall

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In October 2020, Thailand experienced abundant rainfall and flash floods were reported in several areas. Consecutive days of heavy rainfall and gusty winds triggered flooding and landslides in upper Thailand. In total, the heavy rain and winds affected up to 200,000 people from 2,343 villages in 153 districts across 34 provinces around the country.

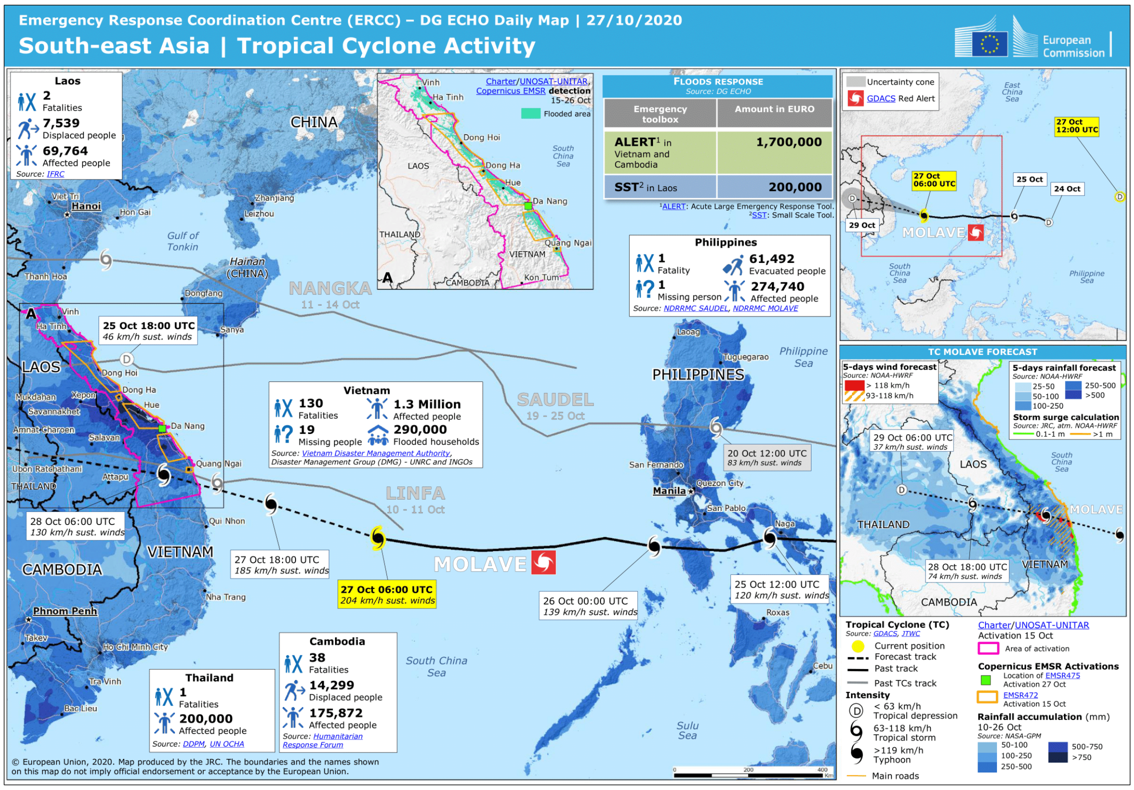

Figure 30: The path of four tropical cyclones over the South China Sea. In October 2020, tropical cyclone activity severely affected people and properties over Southeast Asia. Credit: Emergency Response Coordination Centre (ERCC).

The Impact of Tropical Cyclones

During this month, Thailand was dominated by the active Southwest Monsoon. Moreover, there were six tropical cyclones that affected Thailand in October 2020, five of which passed near or over Thailand. The first of these tropical cyclones was an unnamed tropical depression, which made landfall over Nha Trang, Viet Nam, on 7 October 2020 and then degenerated into an active low-pressure cell before moving through Cambodia and into the upper Gulf of Thailand on 8 October 2020. The second was Tropical Storm Linfa, which intensified from a tropical depression over the middle of the South China Sea on 10 October 2020 and made landfall over Quang Ngai, Viet Nam, on 11 October 2020. It continued moving westward to Lao PDR before being downgraded to a tropical depression over Kon Tam, Viet Nam, and then becoming an active low-pressure cell over Attapu, Lao PDR, the following day. Tropical Storm Nangka, from the South China Sea, made landfall over Ninh Binh, southern Hanoi, Viet Nam, on 14 October 2020 and weakened into a tropical depression over Thanh Hóa, Viet Nam, and subsequently into an active low-pressure cell over Hua Phan, Lao PDR. Lastly, Tropical Depression Ofel, over the central South China Sea, made landfall over Central Viet Nam on 16 October 2020 and degenerated into an active low-pressure cell over Cambodia the next day. The second to last tropical cyclone in October 2020 was Typhoon Saudel that made landfall over Viet Nam, which became a tropical depression on 26 October 2020 and then moved over Lao PDR before dissipating (Figure 30).

Figure 31: Heavy rains triggered flooding in Nakhon Ratchasima province. Credit: Prachachat.

The final tropical cyclone for October 2020 was Typhoon Molave. It made landfall over Quang Ngai, Viet Nam, on 28 October 2020 and was downgraded into a tropical storm over Quang Nam, Viet Nam, in the evening before moving through Lao PDR and being further downgraded to a tropical depression. The storm then passed over the Ubon Ratchathani province, Thailand, and degenerated into an active low-pressure cell over the northeastern part on 29 October 2020 before dissipating the next day. Typhoon Molave brought enhanced, widespread and heavy rainfall in several areas and very heavy rainfall in some areas of Thailand, particularly its northeastern regions. The highest daily rainfall total of 108.5 mm was recorded at Amphoe Na Chaluai in Ubon Ratchathani province on 28 October 2020.

For October 2020, the average rainfall over Thailand was 245.4 mm, or about 31% above the 1981 – 2010 normal, with enhanced rainfall particularly over parts of upper Thailand (Figure 32). The northeastern part was about 81.4 mm (70%) above normal, while the central and eastern parts were 68.3 mm (37%) and 122.1 mm (54%) above normal respectively. Monthly rainfall records were broken from many rain gauge measurements reported in October 2020.

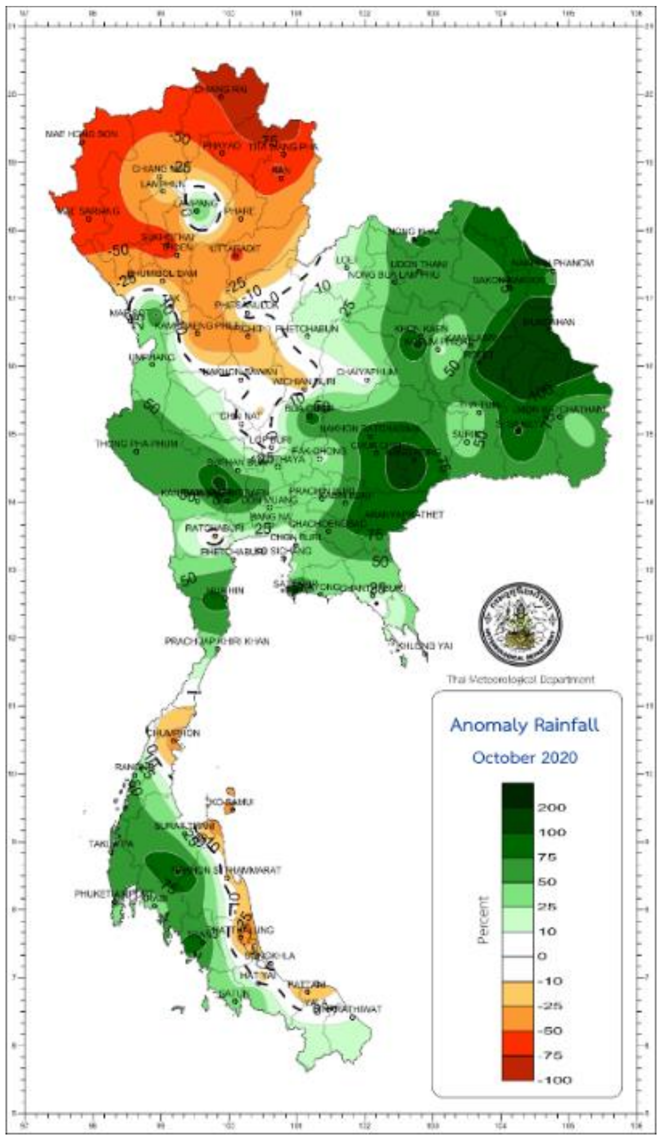

Figure 32: Rainfall anomalies in October 2020 (against 1981 – 2010 climatology). Based on TMD's 75 rain gauge stations.

Madden-Julian Oscillation (MJO) and Equatorial Waves (EW)

In October 2020, an MJO signal started developing over the Maritime Continent and propagated eastward to the western Pacific Basin (Figure 33).

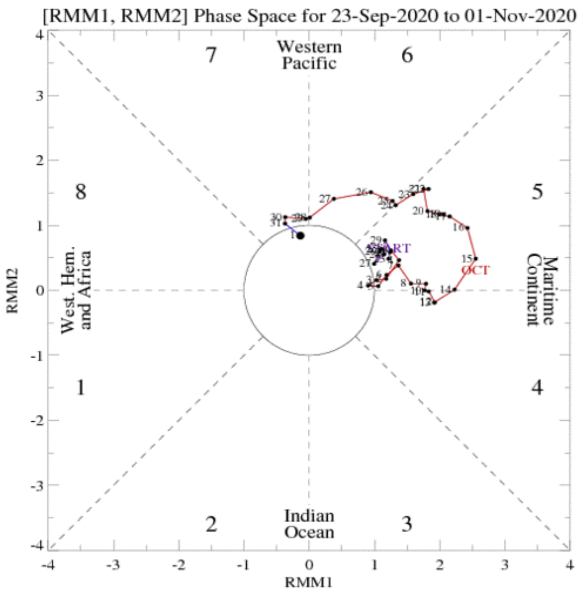

Figure 33: The MJO phases during the heavy rain event in October 2020. Credit: Climate Prediction Center, NCEP.

Anomalous enhanced convection was observed over the Maritime Continent almost the entire month of October 2020, related to both the MJO and La Niña event. Moreover, the activity of Equatorial Rossby and Kelvin waves over the western Pacific basin, together with the La Niña event, seemed to be related to the intensification of tropical cyclone activity during October and November 2020. The active MJO and EW (Equatorial Rossby and Kelvin waves), accompanied with moderate La Niña conditions, enhanced convection over the western tropical Pacific Basin. The MJO and EW also provided a favourable environment for tropical cyclone formation (Figure 34; black box).

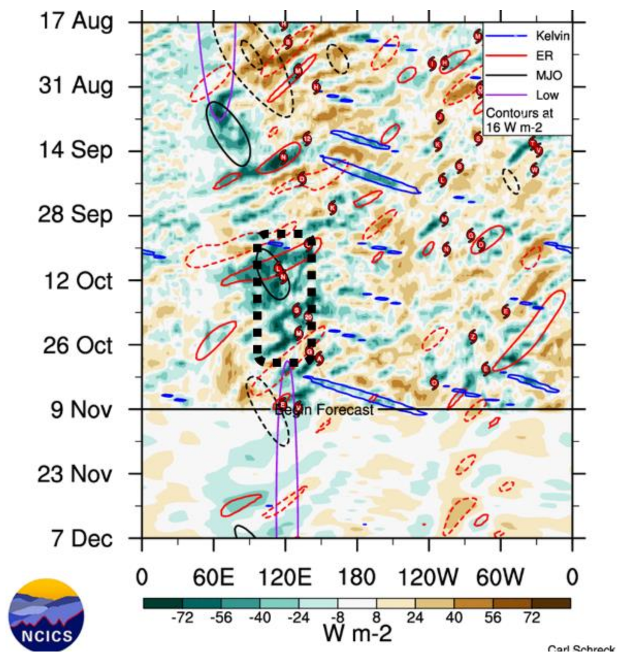

Figure 34: Outgoing Longwave Radiation (OLR) anomalies (shading) and equatorial waves (contours) during August – November 2020 Credit: North Carolina Institute for Climate Studies.

An Extreme Rainfall Event in Central Viet Nam in October 2020

Contributed by: Tran Ngoc Van and Chinh Ta-Huu (Forecasters)

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From October to November 2020, Central Viet Nam experienced heavy rainfall: occurring continuously from 6 October 2020 and lasting into the first 10 days of November 2020. Consequently, floods and landslides caused serious damage to the central provinces (Central Viet Nam). Hundreds of people died and went missing, more than 1,500 houses collapsed, and nearly 240,000 other houses sustained damage such as losing their roofing. Agriculture and aquaculture sectors were also severely affected. The total damage is estimated at about VND 30,000 billion (USD 1.3 trillion).

The highest total rainfall during October 2020 occurred in the middle of Central Viet Nam where 2,000 – 3,500 mm was recorded. This anomalous rainfall (2 – 4 times higher than the climatological norm) is shown in Figure 35 (top) where parts of this region recorded more than 1,000 mm of rainfall more than the average.

The rainfall percentile map (Figure 35; bottom) also shows that the total rainfall reached the 99th percentile (red box). The total rainfall amounts at some observed stations in Central Viet Nam are compared to the climatology and historical maximums in Table 1 where it can be seen that rainfall in October 2020 was around 3 – 4 times higher than climatology (or twice the historical maximum).

A combination of factors, such as tropical cyclones (four tropical storms and one tropical depression in October 2020), cold air intrusions and easterly waves, led to the extreme rainfall, although the occurrence of many tropical cyclones in the South China Sea was likely the most important factor. From August – November 2020, eight of the tropical cyclones that formed in the Philippine Sea made landfall in Viet Nam.

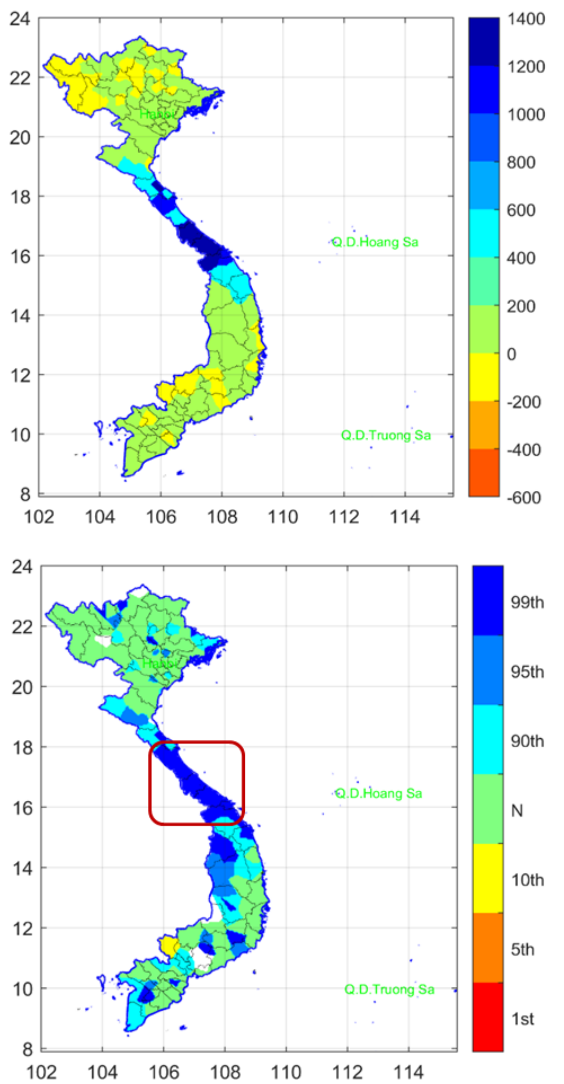


Figure 35: Rainfall anomaly (top) and rainfall percentile map (bottom) for October 2020.

Table 1: Observed rainfall in October 2020 for select stations in Central Viet Nam along with the mean October value for the station (1970 – 2010), and the previous historical October maximum.

Station	October climatology *(mm)*	October 2020 *(mm)*	Historical maximum rainfall *(mm)/year*
Ha Tinh	830	2,367	1,779/2010
Dong Ha	698	2,243	1,132/2011
Khe Sanh	522	2,813	1,115/2010
Hue	833	2,604	1,469/1969
A Luoi	969	3,465	1,974/1990
Nam Dong	1,070	3,268	1,761/2007

Table 2: The Oceanic Niño Index (ONI) in 2020. The values refer to the averages over three-month periods. For example, December – February under 'DJF' and April – June under 'AMJ'.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2020	0.5	0.6	0.5	0.3	0.0	-0.2	-0.4	-0.6	-0.9	-1.2	-1.3	-1.2

It has been well-established that ENSO and MJO play an essential role in controlling tropical cyclone activity in the western North Pacific. La Niña conditions likely occurred in the autumn (the August – October, September – November and October – December periods) of 2020 based on Table 2. During this time, sea-surface temperatures were warmer in the Philippine Sea, which stimulates tropical cyclone formation.

Figure 36 shows that during October 2020, the MJO was in the active phases for the Maritime Continent and Western Pacific (phases 5 and 6, respectively) which favours the development of tropical disturbances in the western North Pacific and the South China Sea.

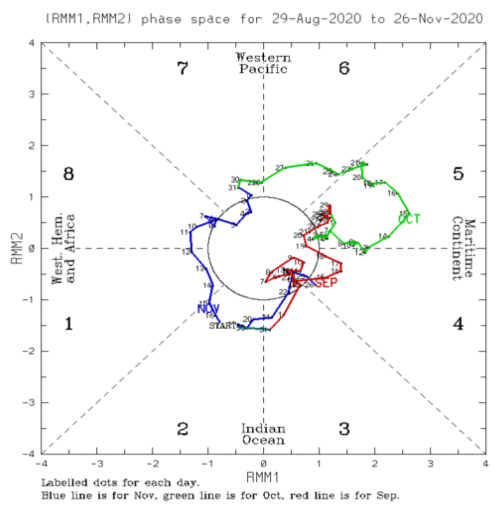


Figure 36: MJO conditions from 29 August – 26 November 2020. Data: Bureau of Meteorology, Australia.

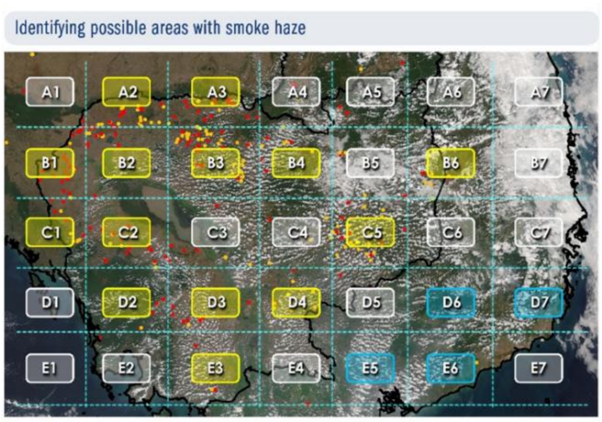
ASMC EVENTS

ASMC Webinar on Fire and Smoke Haze Monitoring and Detection for the Mekong Sub-region

Online, 12 – 13 January 2021

ASMC regularly conducts regional capability building workshops each year for national environment and forestry agencies of ASEAN Member States in both the northern and southern ASEAN regions. Despite restrictions placed on overseas travel due to the global COVID-19 pandemic, ASMC aims to continue its remit to build capability in the ASEAN region via virtual platforms.

To this end, ASMC conducted its first webinar on 'Fire and Smoke Haze Monitoring and Detection for the Mekong sub-region' on 12 – 13 January 2021 with the objective of strengthening the capabilities of national environment and forestry agencies of the Mekong sub-region in the monitoring and assessment of land/forest fires, and the ongoing haze situations. The webinar attracted a total of 15 participants from Myanmar, Cambodia and Thailand.

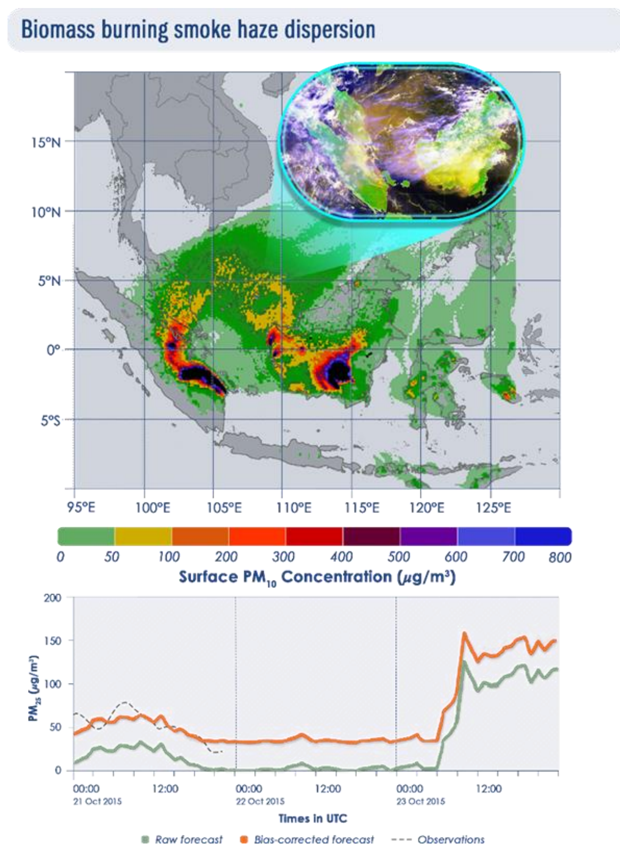


A satellite image overlain with a grid used during the webinar's hands-on session where participants were invited to identify possible areas with smoke haze.

The webinar elaborated upon and explained the key concepts and principles of remote sensing, including the use of geostationary and polar-orbiting satellites to monitor and detect land/forest fires and hotspots as well as smoke haze. The concepts were reinforced through case studies and a virtual hands-on session facilitated by ASMC's trainers. The hands-on session provided participants with an opportunity to experience the preparation of a Haze Analysis Map based on the observed/forecast weather and climate, as well as fire and haze conditions.

ASMC's trainers also shared on the latest satellite systems and its products as well as ASMC-developed analysis tools that tap on satellite data for fire/hotspot, and haze monitoring and detection.

To aid decision-making and operations planning, users would be interested to know the behaviour of the smoke plume/haze — its density and extent in the coming days. ASMC's trainers presented on the mechanisms of land/forest fires and the concepts of smoke haze dispersion modelling.



Sample output of smoke haze in the ASEAN region from ASMC's Smoke Haze Dispersion Model.

The influence of the weather and climate on fire and haze development was also discussed during the lectures on seasonal and sub-seasonal prediction, as well as in the review of the current weather and smoke haze situation, and outlook over the Mekong sub-region.

The webinar closed with a sharing from participants on the challenges in monitoring the regional fire and smoke haze situation following a transition from the NOAA-19 to the NOAA-20 satellites.

The participants expressed appreciation to ASMC for conducting the webinar. They found the webinar interesting and felt that it had given them a better understanding on the monitoring and detection of hotspots and smoke haze.

Ms May Yadanar Oo from the Ministry of Natural Resources and Environmental Conservation (MONREC), Environmental Conservation Department, Myanmar, shared that the topics presented in the webinar were relevant and useful, particularly the lectures on the detection of hotspots and smoke haze using satellites. She expressed hope that future webinars would continue to include similar topics.

A snapshot of some participants and ASMC's trainers at the ASMC webinar on 'Fire and Smoke Haze Monitoring and Detection for the Mekong Sub-region' held on 12 – 13 January 2021.

15th Session of the ASEAN Climate Outlook Forum (ASEANCOF-15)

Online, 23, 25, and 27 November 2020

The 15th Session of the ASEAN Climate Outlook Forum (ASEANCOF-15), coordinated by ASMC, took place online over three days in November 2020. It was attended by over 50 participants from ASEAN Member States' National Meteorological and Hydrological Services (NMHSs), the World Meteorological Organization (WMO), WMO Global Producing Centres (GPCs), other global centres, and representatives from the disaster risk reduction sector. While the November session normally takes place as a physical meeting, due to COVID-19 and the associated travel restrictions, the meeting was held online.

Some participants from the first day of ASEANCOF-15.

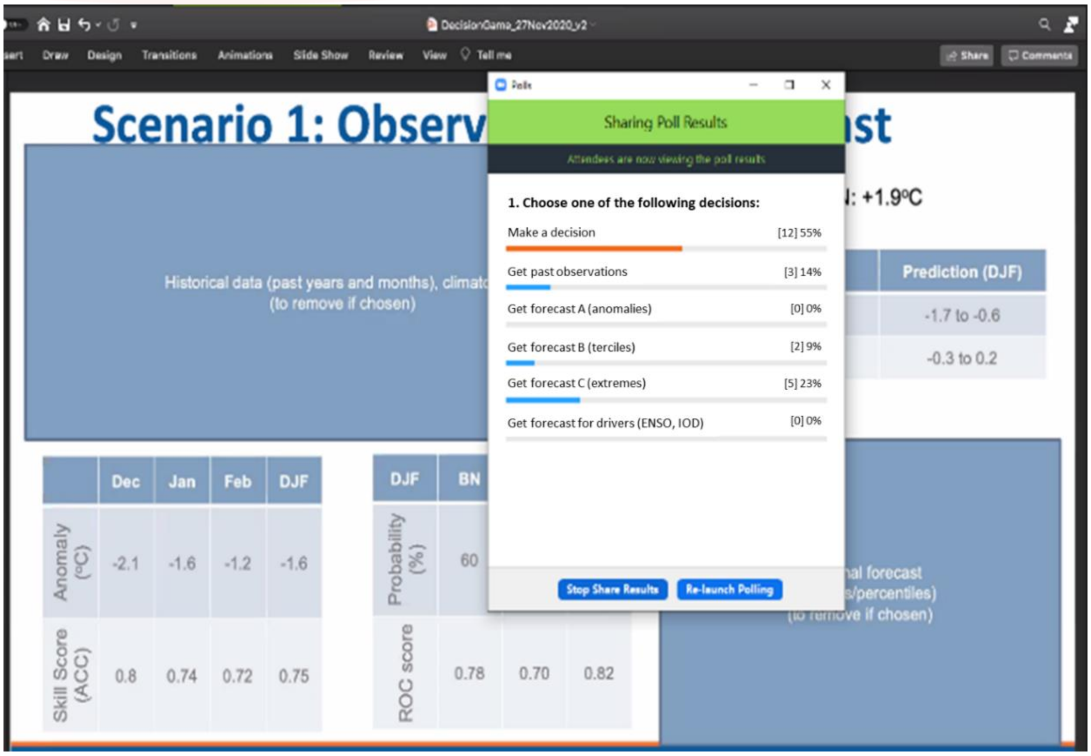
The first day of ASEANCOF-15 covered presentations from the NMHSs and GPCs for the December 2020 – February 2021 season. Making use of the online format, there were presentations not only from the ASEAN region, but also from as far away as Australia and Europe. The common thread through all the presentations was the La Niña conditions that had developed in the second half of 2020. These presentations, and subsequent discussions, formed the basis of the regional consensus discussions that followed.

The focus of the second day was to arrive at the regional consensus for climate drivers as well as the rainfall and temperature outlook. There was also an objective review of the previous outlook, made possible by the new format for the ASEANCOF outlook implemented in May 2020.

Additionally, presentations on the SEA RCC-Network and moving towards objective outlooks also took place on the second day. Ryan Kang (Executive Meteorologist, Meteorological Service Singapore) gave an overview of the new SEA RCC-Network (www.mss-int.sg/sea-rcc-network) and Long-range Forecasting Node pages, and polled the audience on potential new features for the website (the Standardised Precipitation Index was the most popular choice as a new product to be included on the website). Wilfran Moufouma-Okia (Head, Climate Prediction Services Division, WMO) highlighted the steps to make a Regional Climate Outlook Forum (RCOF) more objective and noted how ASEANCOF was a good candidate for implementing these changes.

The final day of the forum focussed on the disaster risk reduction sector, as well as the dissemination of the consensus outlook for the upcoming season. For this day, additional participants from the disaster risk reduction sector joined in, including national representatives from Myanmar, Thailand and the Philippines.

Some participants from the final day of ASEANCOF-15.



Screenshot of the interactive game used as part of ASEANCOF-15. Through engagement with participants, the game aimed to increase their understanding of possible decision-making processes for disaster preparedness

The final day started with an interactive game led by Tan Wee Leng (Research Scientist, ASMC). Participants were tasked to decide on their mitigation strategy for a forecast potential disaster. For this task, they had a limited timeframe for mitigation measures to be put in place.

Individual participants were given the option to access various pieces of information in order to decide on what action to be taken as part of their mitigation plan. Upon deciding that they were ready to make this decision, individual participants were able to initiate a consensus poll; the final action taken by the group was decided by polling all participants.

During the game, participants could request for climate and weather information. However, accessing such information would incur a time penalty and leave less time for their final decision.

Ultimately, most players requested for ENSO as well as tercile and anomaly forecasts — common products used in seasonal outlooks.

Whether they succeeded in mitigating the disaster (or not), the overall feedback from the participants on this session was favourable.

Following the game and the presentation of the consensus forecast, representatives from the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP), the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), and the Food and Agriculture Organization of the United Nations (FAO) shared their experiences working in disaster risk reduction. The participants were then broken into groups to further discuss how climate outlooks could support disaster risk reduction in Southeast Asia.

Overall, ASEANCOF-15 demonstrated that the many aspects of physical ASEANCOF meetings could be translated to an online platform. While there were fewer opportunities for interaction amongst participants as compared to the usual physical meetings, there were more opportunities for people to join with the forum as it had been held virtually.

Upcoming Events

Third Workshop on ASEAN Regional Climate Data, Analysis and Projections (ARCDAP-3)

Online, 15 – 18 March 2021

The Third Workshop on ASEAN Regional Climate Data, Analysis and Projections (ARCDAP-3) will be coordinated by ASMC, with the support of WMO, and conducted online from 15 – 18 March 2021. Through a mixture of presentations and discussions led by scientists with the relevant expertise, the ARCDAP-3 workshop aims to encourage uptake of the latest ensemble of climate simulations from the Coupled Model Intercomparison Project (CMIP6). This will address the need for ASEAN climate change practitioners to upgrade their knowledge of the latest global climate model database and further hone their capabilities in producing robust climate change information.

Weather Prediction by Numerical Methods Module 2 (WPNM-M2)

Online, 3 – 5 May 2021

The Weather Prediction by Numerical Methods Module 2, organised by the Centre for Climate Research Singapore (CCRS) and coordinated by ASMC, will be conducted online from 3 – 5 May 2021. This second training module (WPNM-M2: Physical Parameterisations) aims to equip participants with knowledge on model physics and model parameterisations in weather prediction and climate models. The training module will involve a series of lectures and be accompanied by a few hours of hands-on practical sessions. The lecturers will be delivered by scientists from CCRS, with additional lecturers engaged from local universities.

16th Session of the ASEAN Climate Outlook Forum (ASEANCOF-16)

Online, May 2021

The 16th Session of the ASEANCOF will be conducted online in May 2021. ASEANCOF-16 aims to generate consensus rainfall and temperature outlooks for the June – August 2021 boreal summer monsoon season. The consensus will be provided alongside related information on weather and climate drivers in the Southeast Asia region such as the El Niño/La Niña, Indian Ocean Dipole, and monsoon circulations.

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