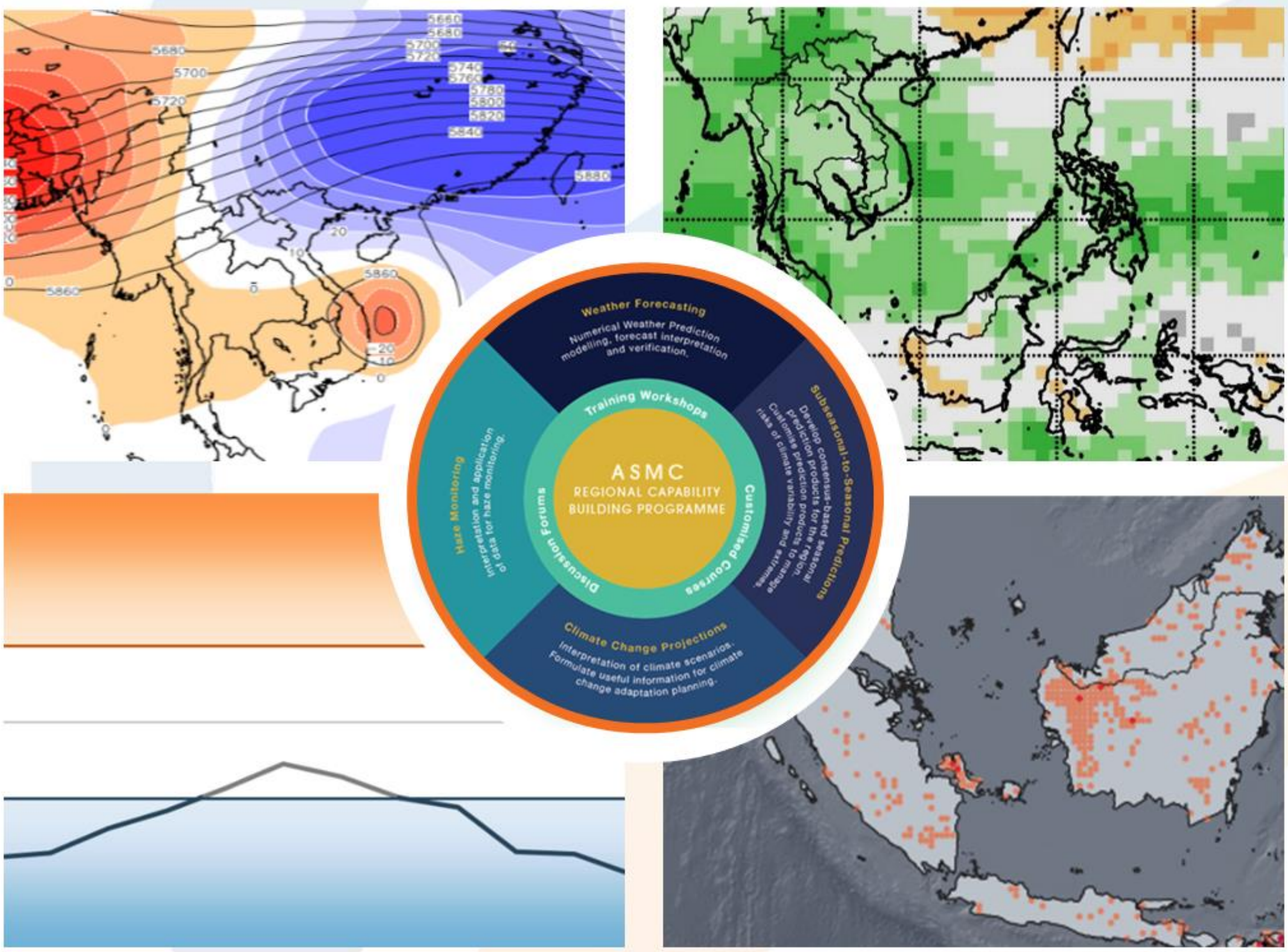
ASMC Bulletin

Issue No.9 (March 2022)



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Published annually in March and September, the ASMC bulletin provides a review and outlook of weather and climate phenomena of importance to the region as well as their influence on the region's weather conditions. For feedback and enquiry, please email: **ASMC_Enquiries@nea.gov.sg**

Summary

In the the second half of 2021,

- A weak negative Indian Ocean Dipole (IOD) prevailed through the second half of 2021.
- La Niña conditions re-emerged in September 2021.
- The Southern ASEAN region experienced a subdued haze season due to a relatively wetter dry season.
- Traditional dry season for the Northern ASEAN region began from December 2021.

Over Southeast Asia,

- Typhoon Rai brought record winds and heavy rainfall to Viet Nam.
- Seasonal variation in June – September 2021 impacted the agriculture sector in Thailand.
- Brunei Darussalam experienced anomalous heavy rainfall in July 2021.
- Intra-seasonal and inter-annual climate variability contributed to extreme events in the Philippines.

Between March and August 2022,

- The current La Niña conditions are predicted to return to ENSO neutral conditions by mid-2022.
- The Indian Ocean Dipole (IOD) is expected to continue in its current neutral phase.
- Models predict wetter conditions over much of Southeast Asia, in line with La Niña conditions.
- Hotspot activity and smoke haze over Mekong sub-region are likely to persist till May 2022.

ASMC Regional Capability-Building Programme (ACaP):

- 17th ASEAN Climate Outlook Forum (ASEANCOF-17) held in November 2021
- ASEAN Hotspot and Haze Assessment (H2A) Workshop held in February 2022
- Upcoming event: ASEANCOF-18 (tentatively May 2022)

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CLIMATE REVIEW (JUL – DEC 2021)

A weak negative IOD event followed by a late re-emerging of La Niña conditions

El Niño Southern Oscillation (ENSO)

The second half of 2021 saw the re-emerging 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 conditions to La Niña conditions in the third quarter of the year (Figure 1). Key atmospheric indicators of ENSO (e.g., trade wind strength and cloudiness) also started to exhibit La Niña conditions towards the end of third quarter.

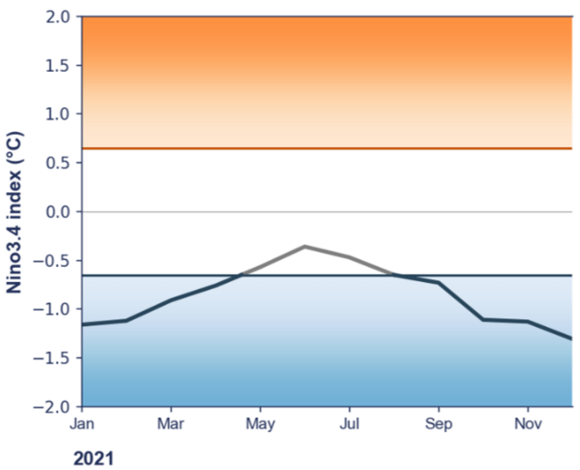


Figure 1. The Nino3.4 index (detrended) using the 1-month SST anomalies. Warm anomalies (⩾ +0.65; orange) correspond to El Niño conditions while cold anomalies (⩽ -0.65; blue) correspond to La Niña conditions, otherwise neutral (> -0.65 and < +0.65). *Reference methodology: Turkington, Timbal, & Rahmat,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

In June 2021, models from the Copernicus C3S multi-model system predicted the ENSO conditions to be either neutral or cool for the second half of 2021 (Figure 2). By September 2021 (not shown), most models predicted La Niña conditions of varying strength based on the Nino3.4 index. Overall, the models' ensemble spread was leaning towards La Niña occurring from the June forecast onwards, and the model predictions were close to the Nino3.4 index observed values.'

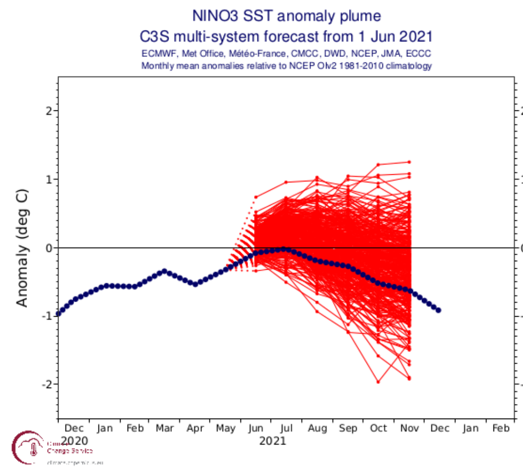


Figure 2. Forecasts of Nino3.4 index's strength (red lines) in June 2021 for the second half of 2021 from various seasonal prediction models of international climate centres. Observed values are in blue. *Credit: Copernicus C3S*.

Indian Ocean Dipole (IOD)

From June 2021 onwards, there were signs of a negative IOD developing, with the negative IOD event established by the third quarter (Figure 3). The strength of the weak negative IOD fluctuated considerably during the second half of the year and returned to neutral by the end of 2021.

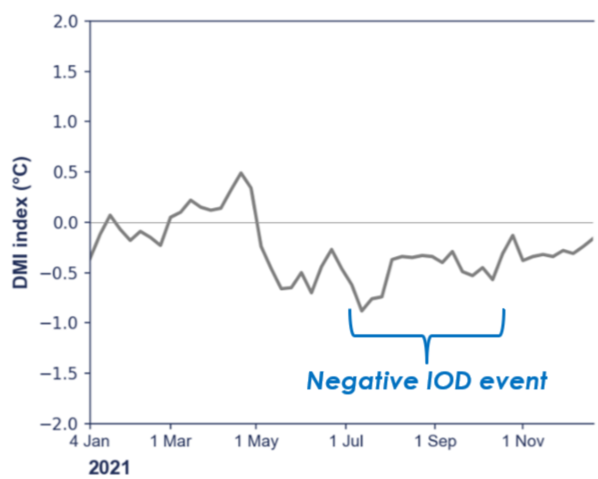


Figure 3. Indian Ocean Dipole (IOD) index showing a brief episode of negative IOD event in the early second half of 2021. *Credit: Bureau of Meteorology, Australia*.

Temperature Conditions

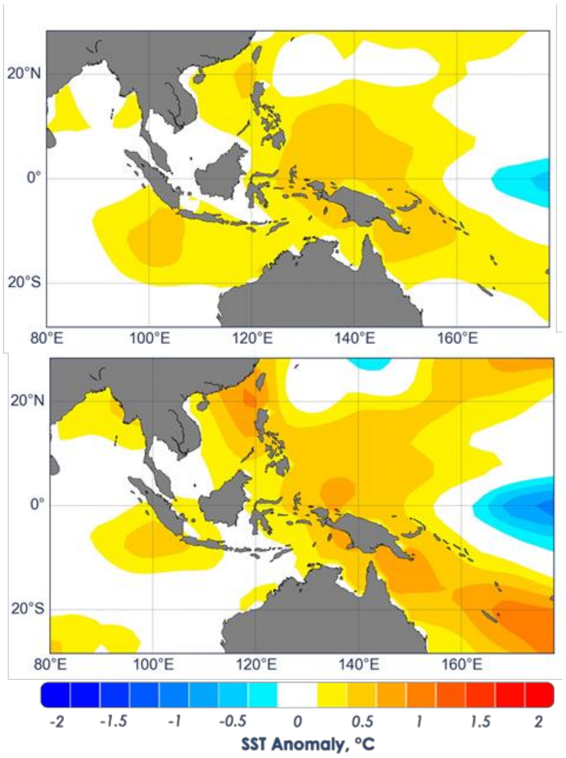


Figure 4. Average sea surface temperature (SST) anomalies for July – September 2021 (upper) and October – December 2021 (lower). SSTs were warmer than average for much of the Southeast Asia region in July – September 2021 with the warm pattern further intensifying in October – December 2021. The reference climatology is from 1991 to 2020). *Data: IRI Data Library*.

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 2021 (Figure 4). These warm anomalies in the Western Pacific are a common feature of La Niña events. Between October and December 2021, these warm anomalies intensified in line with the developing La Niña event (Figure 4; lower). In the South China Sea (SCS) and Bay of Bengal, the SST anomalies were near- to above-average for the second half of 2021. Some intensification of warm SST anomalies, northern of SCS and Bay of Bengal, were also observed between October and December 2021. Around western and central Indonesia, the SSTs were mostly near-average for second half of 2021, with warm SST anomalies confined to eastern tropical Indian Ocean attributed to the negative IOD event.

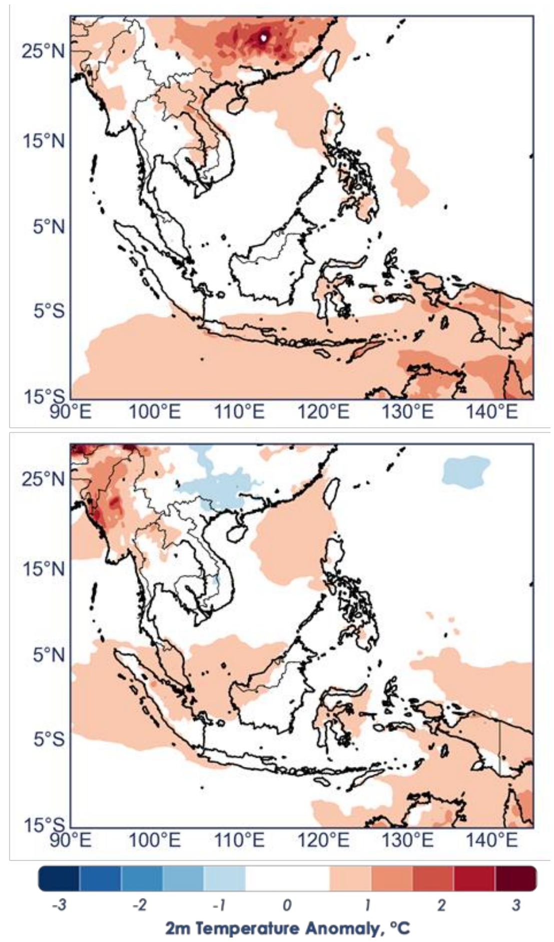


Figure 5. Average 2-metre temperature anomalies (˚C) against 1991-2020 climatology for July – September 2021 (upper) and October – December 2021 (lower) show a mix of near- to above-average temperatures (white and red shades, respectively) for Southeast Asia in the second half of 2021. *Data: ECMWF*.

Overall, Southeast Asia experienced a mix of near- to above-average temperatures in the second half of 2021 (Figure 5). For Mainland Southeast Asia between July and September 2021, above-average temperature was recorded over Lao PDR and parts of Myanmar, Cambodia, and Viet Nam (Figure 5; upper). The above-average temperatures returned to near-average in October to December 2021 (Figure 5; lower). The exception was Myanmar, where the above-average temperature persisted and intensified in October to December 2021, in line with the warming of SSTs in the northern half of the Bay of Bengal. The Maritime Continent experienced a mix of near- to above-average temperatures throughout the second half of 2021.

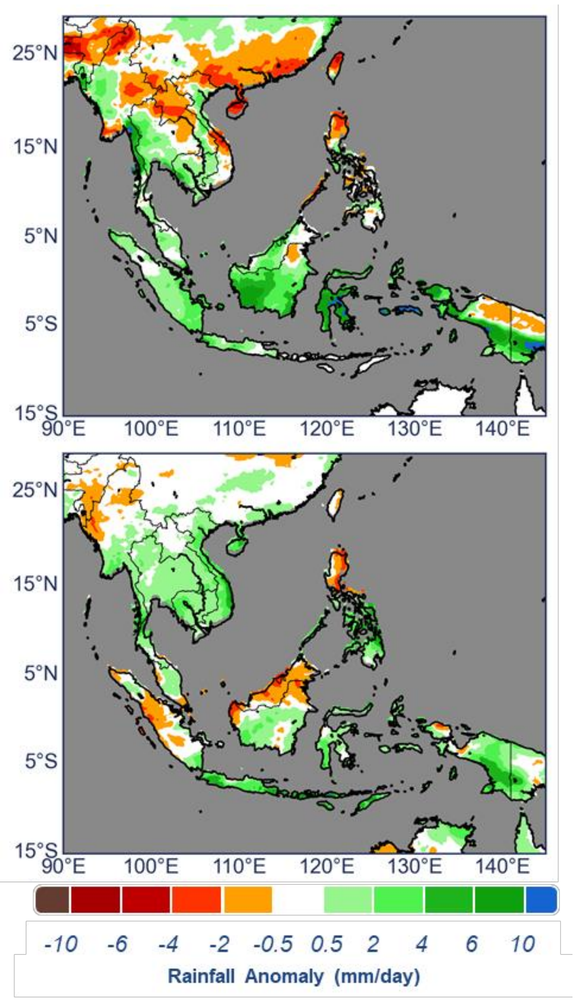


Figure 6. Rainfall anomaly (in mm/day) for July – September 2021 (upper) and October – December 2021 (lower) against 1991-2020 climatology from CHIRPS dataset. Areas in green experienced wetter than average conditions, while those in orange experienced drier than average conditions. *Data: IRI Data Library*.

Rainfall Conditions

During the July to September 2021 period (Figure 6; upper), most of the Maritime Continent – apart from the Philippines – recorded above-average rainfall, which was likely influenced by both the negative IOD event and a developing La Niña event during this time. Mainland Southeast Asia experienced a mix of below- to above-average rainfall. During the October to December 2021 period, much of Mainland Southeast Asia, the southern half of the Philippines and southeastern parts of the Maritime Continent recorded above-average rainfall (Figure 6; lower). This wet pattern is typically observed during La Niña events in the Northeast Monsoon (mid-November to March) period. Elsewhere, a mix of below- to above-average rainfall was recorded.

Madden-Julian Oscillation

While two of the main climate drivers (IOD and ENSO) were active during various times in the second half of 2021, intra-seasonal variability can still play a role in influencing the region's rainfall.

At the intra-seasonal timescale during July to September 2021, the Madden-Julian Oscillation (MJO) signal favoured the Indian Ocean and the Maritime Continent (Figure 7). An MJO signal was present in the Indian Ocean (Phases 2 and 3) in early July 2021, propagated over the Maritime Continent (Phases 4 and 5) in the second week of July before weakening (based on the RMM index). Subsequently, at the end of July 2021, the MJO signal strengthened again in the Western Hemisphere (Phases 8 and 1). This MJO continued moving slowly eastwards through the Indian Ocean (Phase 2), with a rapid strengthening in the RMM plot around the middle of August 2021 before weakening towards the end of the month. Due to the near complete circumnavigation of the MJO signal, it is difficult to discern the influence of the MJO on the region's rainfall in Figure 6, upper. Phases 3 to 4 tend to bring wetter conditions to much of the region, while Phases 7 to 8 tend to bring drier conditions, and Phase 2 and Phase 5 bring a mix of drier and wetter conditions at this time of the year.

For most of September 2021, the MJO signal over the Indian Ocean (Phase 3) appeared incoherent due to interference from other high-frequency waves. In the last week of September 2021, an MJO signal emerged over the Maritime Continent (Phase 4). Phase 3 tends to bring wetter conditions to the western Maritime Continent while Phase 4 tends to bring wetter conditions to much of the Southeast Asia at this time of the year.

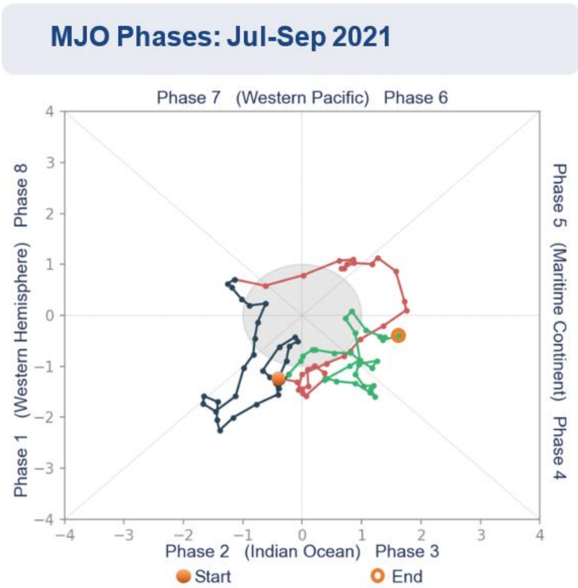


Figure 7. MJO strength and phases during July (red), August (blue) and September (green) 2021. The orange dots mark the start and end of the timeseries. *Data: Bureau of Meteorology, Australia*.

During October to December 2021, the MJO signal favoured the Maritime Continent (Phases 4 and 5) and the Western Pacific (Phases 6 and 7; Figure 8). The MJO signal from the end of September 2021 continued propagating over the eastern Maritime Continent (Phase 5) in early October before weakening rapidly by the second week of the month as it approached the Western Pacific (Phase 6). For the rest of October 2021 and early November 2021, there was no MJO activity based on the RMM index (Figure 8). From second week of November onwards, there were signs of a MJO signal over the Maritime Continent (Phases 4 and 5). However, this signal was not very coherent as it moved very slowly eastwards over the Western Pacific (Phases 6 and 7) in December 2021. Overall, the presence of the La Niña conditions as well as other high-frequency waves may have contributed to the less coherent MJO pulses in October to December 2021 period.

Considering the influence of MJO on the region's rainfall, during October to November Phases 4 and 5 tend to bring wetter conditions to the regions around 10°N. For December, Phase 6 tends to bring wetter conditions to eastern Maritime Continent, while Phase 7 tends to bring drier conditions to the western Maritime Continent at this time of the year. Therefore, the wetter conditions around 10°N for October to December 2021 may have also been influenced by MJO activity, with the MJO activity in December 2021 contributing to the drier conditions in the western Maritime Continent (Figure 6; lower).

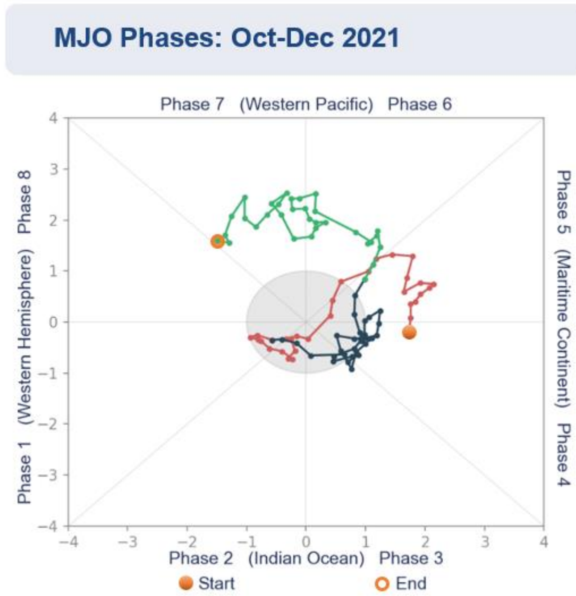


Figure 8. MJO strength and phases during October (red), November (blue) and December (green) 2021. The orange dots mark the start and end of the timeseries. *Data: Bureau of Meteorology, Australia*.

REGIONAL FIRE AND HAZE SITUATION (JUL – DEC 2021)

A subdued haze season over the southern ASEAN region

The dry season in 2021 set in over the southern ASEAN region in July 2021, contributing to an increase in hotspot activity as the monsoon rain band moved north of the equator. La Niña conditions – typically associated with higher rainfall over most parts of the ASEAN region – became established in September 2021. Sporadic rainfall over the region throughout the dry season (Figure 9) helped to suppress the hotspot and smoke haze situation. However, hotspots clusters still developed mainly in southern Sumatra and parts of West Kalimantan on some days (Figure 10).

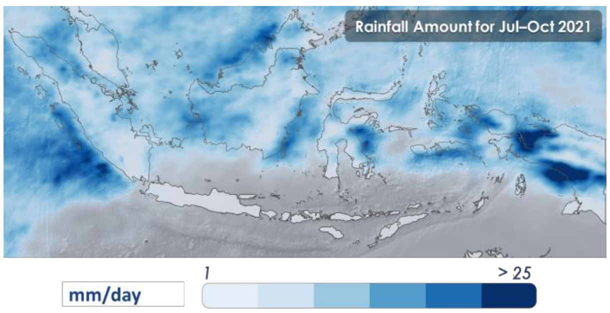


Figure 9: Average daily rainfall over the southern ASEAN region during July – October 2021. *Data: Global Precipitation Measurement (GPM).*

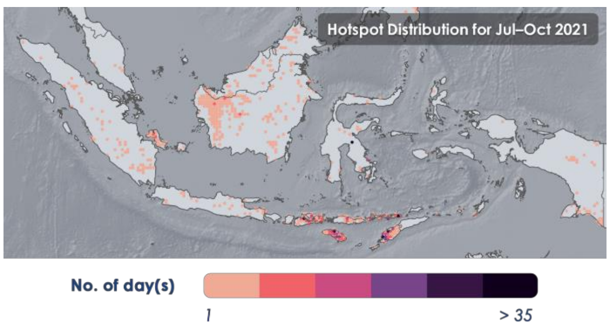


Figure 10: Persistency of hotspots for July – October 2021 in the southern ASEAN region. *Data: NOAA-20 satellite.*

Localised smoke plumes were observed to emanate from hotspot clusters at times during the dry season, particularly in southern Sumatra and West Kalimantan (examples in Figure 11 and Figure 12).

No transboundary haze was observed in the southern ASEAN region during the 2021 dry season.

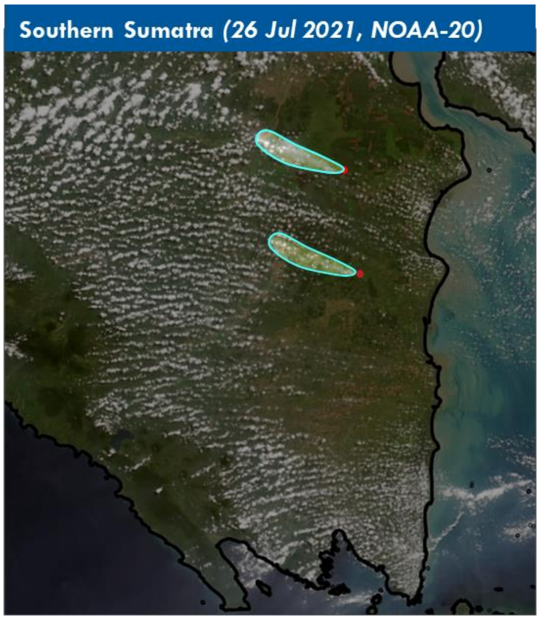


Figure 11: True colour NOAA-20 satellite image of smoke plumes observed over southern Sumatra in July 2021.

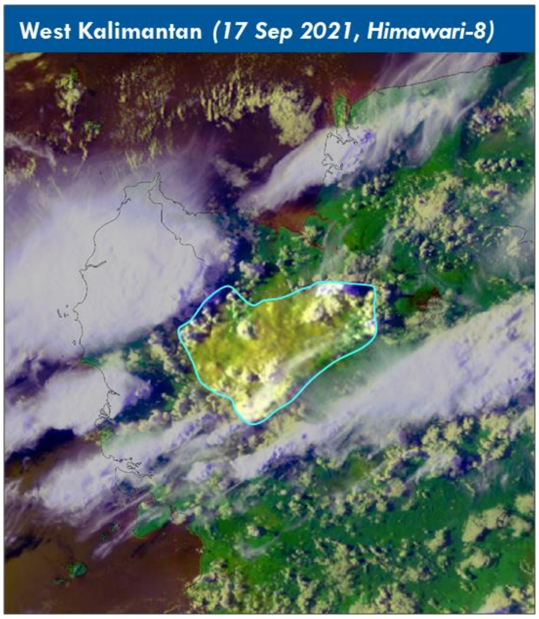


Figure 12: False colour Himawari-8 satellite image of smoke haze observed over West Kalimantan in September 2021.

Towards October 2021, widespread shower activities returned to the southern ASEAN region as the monsoon rain band moved southwards again towards the equator. This brought an end to the dry season over the southern ASEAN region.

Overall, the hotspot counts in the southern ASEAN region were mostly lower than those in previous years for the same period (Figure 13). The total hotspot counts for this region in 2021 were about 10% lower than those in 2020. In the northern ASEAN region, the onset of the Northeast Monsoon towards December 2021 led to the start of the dry season, bringing with it an increase in hotspot activity, particularly in Cambodia and Lao PDR.

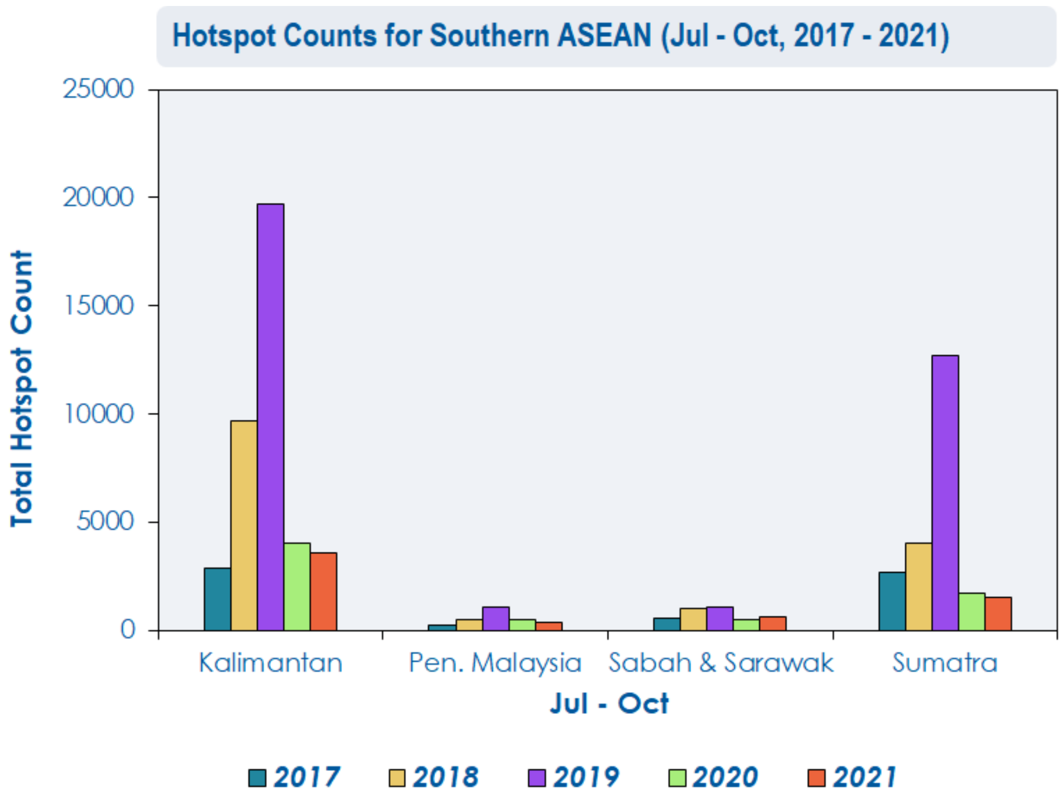


Figure 13: Total hotspot counts for southern ASEAN region in July – October 2021, in comparison with the total hotspot counts for the same period in previous years.

CLIMATE AND HAZE OUTLOOK (MAR – AUG 2022)

Signs of La Niña decay

ENSO Outlook

La Niña conditions are currently present. Most model outlooks from international centres (C3S Copernicus) indicate the negative (cool) anomaly easing through March – May 2022 (Figure 14). From June 2022, there is a wide spread of possible outcomes ranging from La Niña conditions remaining to El Niño conditions developing. However, accounting for background warming, most models predict a transition from La Niña conditions to ENSO neutral conditions (based on the Nino3.4 index) by the middle of 2022.

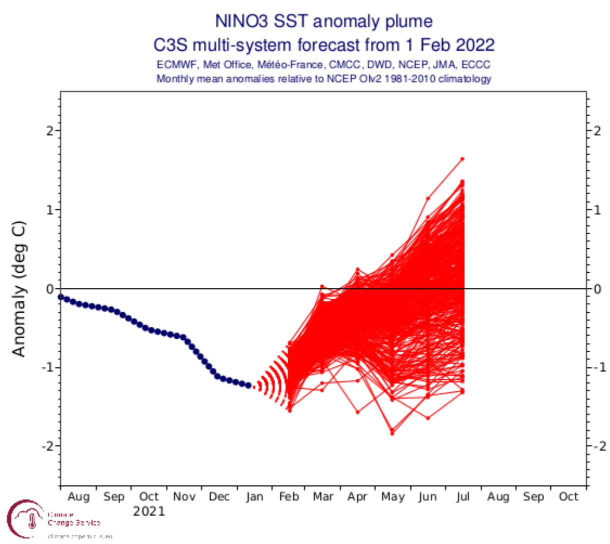


Figure 14. Nino3.4 SST anomaly predictions showing the negative (cool) anomaly easing from start of 2022. *Credit: C3S Copernicus*.

In line with the Nino3.4 predictions, the ensemble-mean predictions of SST anomalies show La Niña-like conditions during March – May (MAM) 2022 (Figure 15). Under La Niña conditions, colder SST anomalies are observed in the eastern and central 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, as well as to couple with the atmosphere through stronger easterly winds in the eastern Pacific Ocean and more rainfall than average in the western Pacific Ocean.

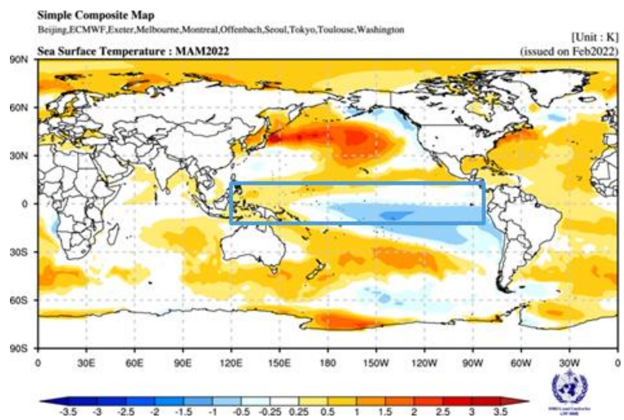


Figure 15. SST anomaly prediction for March – May (MAM) 2022 from WMO showing La Niña like conditions in the Tropical Pacific Ocean (blue box). *Credit: WMO Lead Centre for Long-Range Forecasting*.

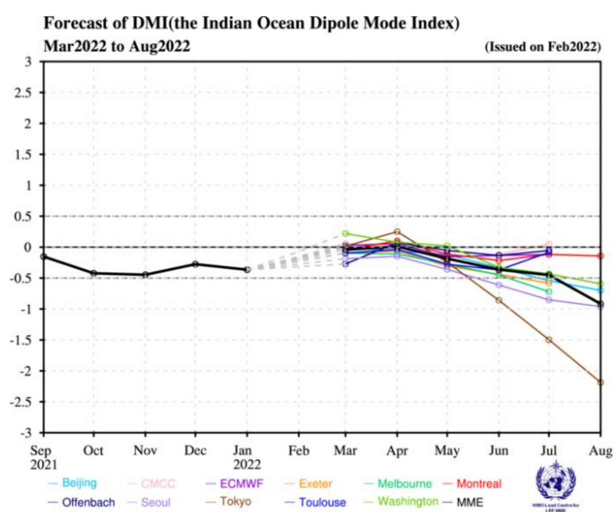


Figure 16. IOD index predictions, from models available on the WMO Lead Centre for Long-Range Forecasting, predict continued neutral phase in the first half of the year, with some models predicting a drop in the index from the middle of 2022. *Credit: WMO Lead Centre for Long-Range Forecasting*.

IOD Outlook

The IOD is likely to continue in its neutral phase for March – May 2022 (Figure 16). The IOD index is currently negative but within the neutral range. The models predict the IOD index to remain neutral for the first half of 2022, with some models predicting a negative IOD to develop from July 2022 onwards. However, models have limited skill in predicting the IOD at these longer lead times.

Rainfall Outlook

In the upcoming March – May 2022 period, model predictions from selected C3S models (SEA RCC-Network Long-range Forecasting Node) indicate enhanced chance of above-normal (wetter) conditions over much of Southeast Asia (Figure 17). The areas where above-normal rainfall is predicted correspond to those that typically experience wetter than average conditions during a La Niña event.

Across the equatorial region, a mix of below-normal (drier) to above-normal conditions are predicted for March – May 2022. 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.

Temperature Outlook

For temperature, most of the Maritime Continent is predicted to experience above-normal (warmer) conditions during March – May 2022 (Figure 18), except for central and northern Philippines where no dominant terciles are predicted, as well as Peninsular Malaysia where near-normal conditions are expected. For Mainland Southeast Asia, below-normal (cooler) conditions are expected for northern Thailand, Lao PDR, as well as central and northern Viet Nam. For the rest of Mainland Southeast Asia, the model predictions indicate either no dominant tercile or near-normal temperature.

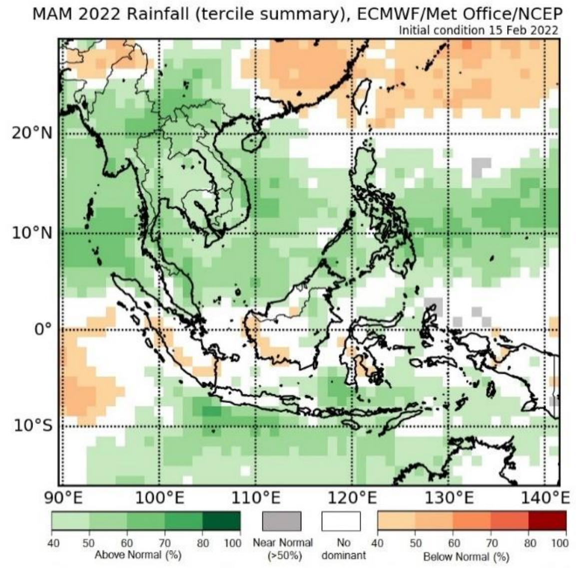


Figure 17. Rainfall tercile summary predictions from the multi-model ensemble for March – May (MAM) 2022. Brown shades show regions with a higher likelihood of drier conditions, while green shades show regions with a higher likelihood of wetter conditions (contains modified Copernicus C3S information).

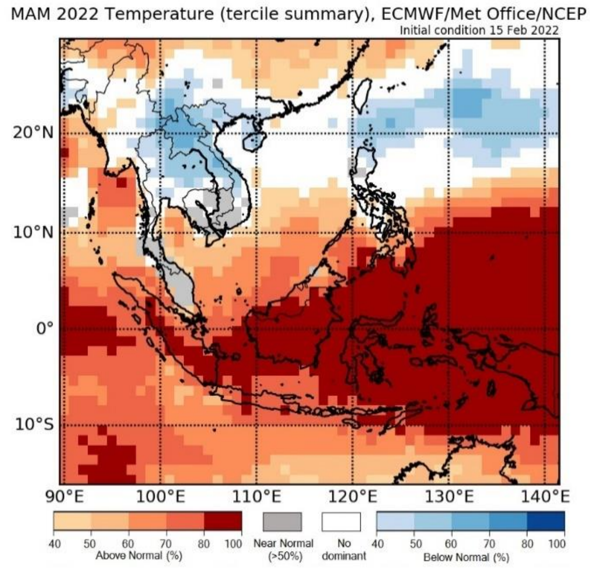
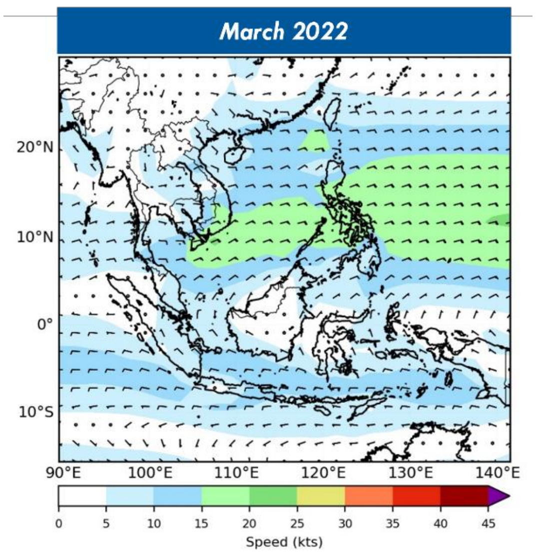
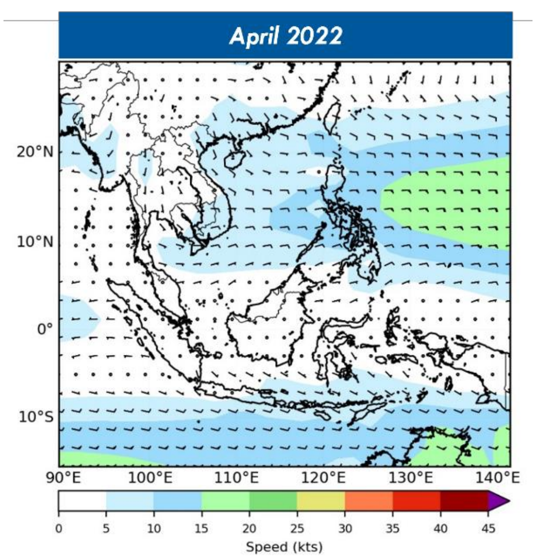


Figure 18. Temperature tercile summary predictions from the multi-model ensemble for March – May (MAM) 2022. Red shades show regions with a higher likelihood of warmer conditions, while blue shades show regions with a higher likelihood of cooler conditions (contains modified Copernicus C3S information).

Haze Outlook

The ongoing dry season for the Mekong sub-region is expected to continue till May 2022 before a transition to wetter conditions brought about by inter-monsoon and subsequently Southwest Monsoon conditions. Escalated hotspot and smoke haze activities are likely for the sub-region during this period, but the overall situation is likely to be moderated by wetter than average conditions brought about by the existing La Niña event. There remains an elevated risk of transboundary haze occurrence in the Mekong sub-region between March – May 2022.





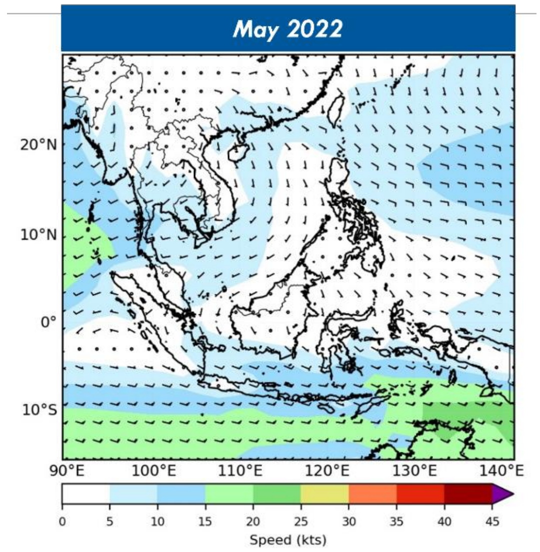


Figure 19. Outlook on seasonal mean wind (925 hPa) for period March – May 2022, showing the northeast monsoon prevailing until May 2022 before a gradual transition to inter-monsoon conditions. *Source: ECMWF*.

For the southern ASEAN region, drier conditions typically start developing in June 2022, when the monsoon rain band moves north of the equator and Southwest Monsoon conditions become established. Hotspot and smoke haze conditions are expected to start intensifying in fire-prone areas of the region between June and October 2022 during periods of drier weather.

SIGNIFICANT WEATHER EVENTS IN SOUTHEAST ASIA

Typhoon Rai over Viet Nam during the 2021 Pacific Typhoon Season

Contributed by Mr Mai Van Khiem, Mr Nguyen Van Huong, Ms Tran Ngoc Van, Ms Hoang Thi Mai, Ms Nguyen Thanh Hoa, and Ms Trinh Thuy Nguyen
National Centre for Hydro-Meteorological Forecasting (NCHMF), Viet Nam

On the evening of 17 December 2021, Typhoon Rai entered the Bien Dong Sea with the highest wind speed recorded at 90 – 99 knots. Although it did not directly hit the land and had weakened over the sea, it still brought significant impact to the coastal areas of Viet Nam. When it passed through the Song Tu Tay Island, the strong winds broke 2 anemometers, 90% of trees, 27 solar panels, and more than 500 m^2 of tiled roofs. At least 1 death was reported while dozens of boats were sunk and crushed. Hectares of vegetables and fruits were spoilt and ruined, and hundreds of shrimp cages were damaged, particularly over the Binh Thuan, Phu Yen, and Quang Ngai provinces.

Based on historical record during the period 1951 till 2021, for the month of December, there were 82 tropical cyclones (TCs) in the Northwest Pacific. Most of these TCs were active outside the Bien Dong Sea while only a few had entered the southern parts of the sea, including Typhoon Rai (2021), Typhoon Lee (1981), Typhoon Norris (1986), Typhoon Axel (1994), Typhoon Faith (1998), and Typhoon Utor (2006) (Figure 20).

NCHMF had issued a total of 64 bulletins on Typhoon Rai, of which 28 were brief bulletins. Forecasts and warnings were regularly updated in the news, providing updates on strong winds, big waves, as well as storm surges with high tides and heavy rains. NCHMF had provided timely and comprehensive forecasting and warning information to national agencies and local authorities, such as the National Committee for Search and Rescue, the Commanding Committee of Natural Disaster Prevention and Control for Ministries, branches, and localities in the Central and South-Central Region, news agencies, and media. This coordination helped disseminate the weather updates and warnings to the public as quickly as possible so that the risk and damages to the loss of life and property could be minimised.

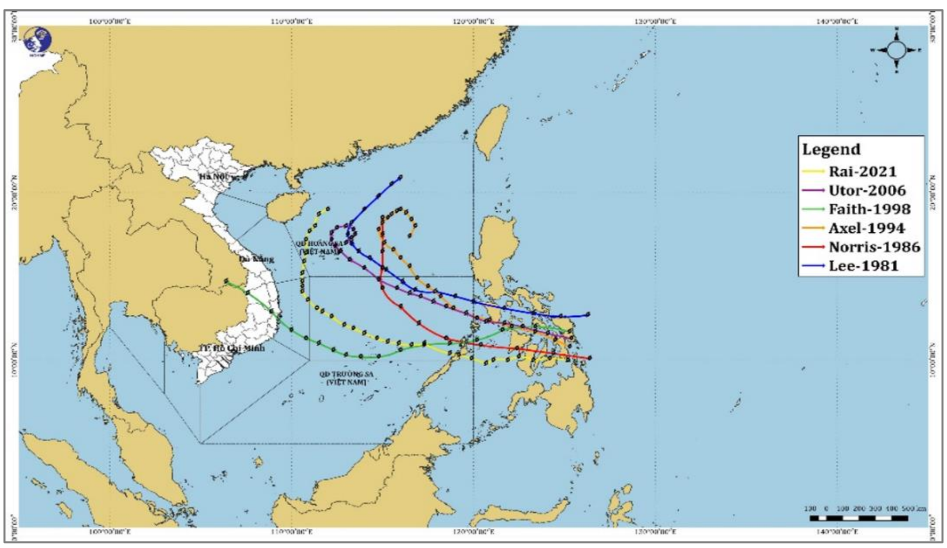
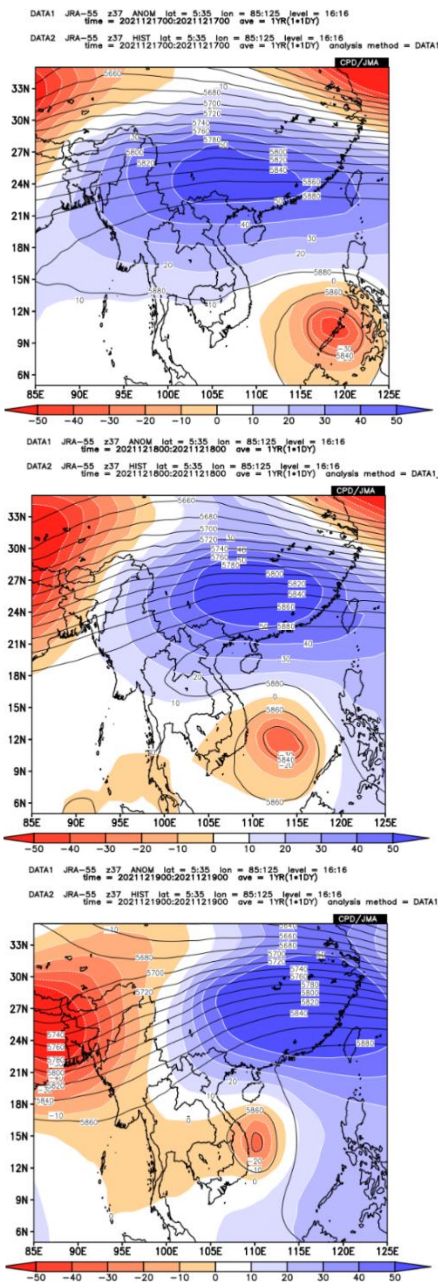


Figure 20: Tracks of the Typhoons over Bien Dong Sea in December (1951-2021)

From 18 to 19 December 2021, Typhoon Rai moved from the north towards the north-northwest. On 20 December 2021, the typhoon tracked toward the northeast and the western Pacific subtropical high (WPSH) entered the longitude of 101°E. After one day, the WPSH retreated to the east and created favourable conditions for Typhoon Rai to move toward the west-northwest and north-northeast. At the same time, the convergence of jet stream at the 500mb level had gradually shifted to the east and resulted in a cold surge at the south (Figure 21).



(a)

(b)

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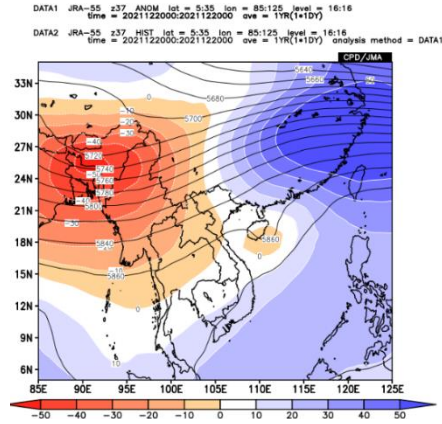

(d)

Figure 21: Geopotential height and anomaly geopotential height at 500 mb from 17 to 20 December 2021 (from a to d). *Credit: Tokyo Climate Center.*

Over the Bien Dong Sea, Typhoon Rai began to weaken into a tropical depression from 20 December 2021, due to the incoming cold air mass from the north which caused a drop in the sea surface temperature (Figure 22).

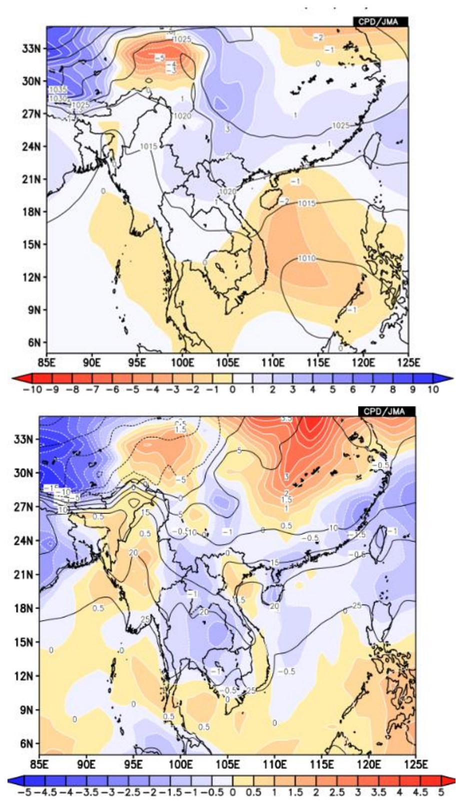

Figure 22: Mean Sea Level Pressure anomaly (top) and average temperature anomaly from 18 to 20 December 2021 (bottom). *Credit: Tokyo Climate Center*.

During the period from 18 to 20 December, moderate to heavy rainfall (ranging from 80 – 180 mm) fell over the areas from the Thua Thien Hue to the Phu Yen provinces under the influence of Typhoon Rai and the presence of a cold surge over the Bien Dong Sea (Table 1).

City / Province	Station	Rainfall Amount
Quang Ngai	Dien Lake Basin	208 mm
	Dien Truong	207 mm
	Sa Huynh	189 mm
Binh Dinh	Can Hau Lake	194 mm

Table 1: Maximum daily rainfall recorded by the weather stations during the Typhoon Rai period.

The meteorological station at the Song Tu Tay Island had detected strong winds at level 14 and wind gusts at level 17, based on the Beaufort scale (Table 2). These wind speed records were the highest in the past 40 years. Over the coastal area of the Binh Dinh province, strong winds at level 6 – 7 and wind gusts at level 8 – 9 were recorded, while the areas from the Quang Ngai to the Khanh Hoa provinces had recorded wind gusts at level 6 – 7 (Figure 23).

Station	Maximum wind speed (and Beaufort wind scale)	Maximum wind gust (and Beaufort wind scale)
Song Tu Tay	45.6 m/s (14)	56.8 m/s (17)
Ly Son	21.0 m/s (9)	28.0 m/s (10)
Quang Ngai	6.0 m/s (4)	14.0 m/s (7)
Hoai Nhon	16.0 m/s (7)	23.0 m/s (9)
An Nhon	12.0 m/s (6)	16.0 m/s (7)

Table 2: Maximum wind speed and gust measured by ground station from 18 to 19 December 2021.

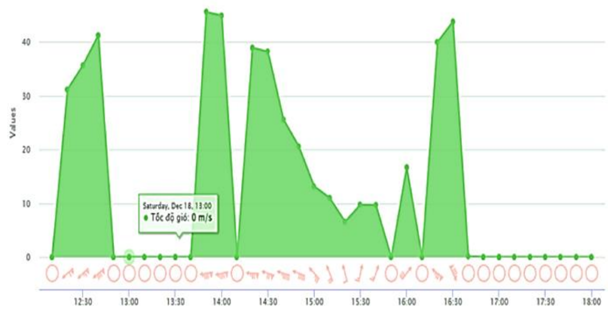

Figure 23: Wind speed and direction measured by ground station on 18 December 2021.

Typhoon Rai was classified as a Super Typhoon with the maximum wind speed of 105 knots and its core was near the central of the Philippines. For typhoons that had entered the Bien Dong Sea from 1981 to 2021, only 3 typhoons had recorded wind speed over 100 knots, i.e., Typhoon Bopha (100 knots), Typhoon Hagupit (115 knots), and Typhoon Nockten (105 knots) (Figure 24).

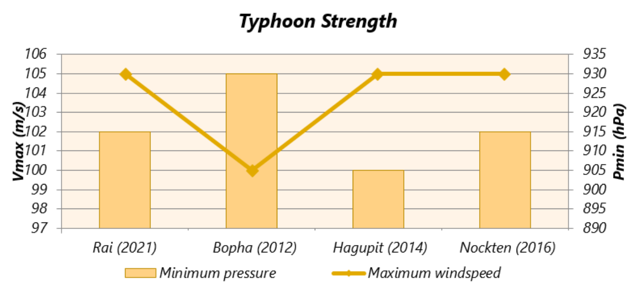

Figure 24: Strength of the typhoons that had entered the Bien Dong Sea from 1981 to 2021.

Overall, Typhoon Rai was the strongest typhoon affecting Viet Nam in the past 30 years, where the wind speed reached level 15 (90 – 99 knots) and wind gusts at level 17 (118 knots). However, it moved quickly out of Viet Nam due to the presence of a cold surge over the sea areas of Viet Nam.

Impact of Seasonal Variation on Agriculture in Thailand

Contributed by Mr Chalump Oonariya and Ms Krittika Suebsak (Meteorologist)
Climate Center, Thai Meteorological Department (TMD), Thailand

Thailand's climate has a high degree of variability and changes in many timescales. The intensity and occurrence of high impact weather and climate events have been increasing. Especially in recent years, Thailand had experienced stronger impacts of seasonal variability particularly dry spells and flood events during the monsoon season. The high degree of seasonal variability poses greater challenges to predicting future weather and climate conditions. To improve the understanding on the variabilities, extra efforts from researchers, scientists, and forecasters in key scientific aspects should be addressed.

In recent years, climate variabilities occurred dramatically at all timescales. Most of the events were typically influenced by monsoon rainfall and tropical storms. There were also influences from large-scale circulations that contributed to rainfall anomalies, in the intensities of the subtropical high and Intertropical Convergence Zone (ITCZ).

Agricultural sector plays a crucial role in Thailand. It is the main commodity for the nation's exports and a major source of staple food for the population. The agricultural sector constitutes 10.5 percent of Thailand's GDP (2014) and provides employment to approximately 25 million people, accounting for 42 percent of the labour force. Climate variability is crucial as it increases the frequency and severity of floods, droughts, and extreme weather events, which directly affects the agricultural sector.

In 2021, Thailand experienced a long dry spell between 18 June 2021 and 5 July 2021, amid a rainy monsoon season. The dry spell was severe and resulted in rainfall deficit across Thailand. Figure 25 illustrates the rainfall anomaly and dryness in June 2021 that caused serious damages to the agricultural sector and water resources. The impact was apparent over most of Thailand, and particularly over northern, northeastern, and central Thailand. The dry spell could be attributed to the subtropical high-pressure over the Pacific Ocean which influenced the extension of a strong cross-equatorial pressure gradient (CEPG) and a weak ITCZ over the Mekong sub-region. The relationship between CEPG and ITCZ is essential to seasonal variability, especially over the Mekong sub-region and the Maritime continent.

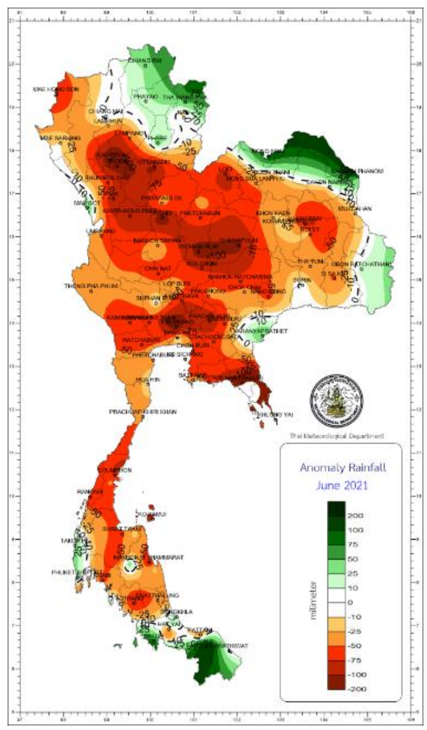

Figure 25: Rainfall anomaly over Thailand in June 2021, recorded by TMD weather stations. Climatological mean was derived from the period of 1991-2020.

The most recent floods in 2021 were triggered by several tropical storms in the ASEAN region, including Tropical Storm Dianmu (in September 2021), as well as Tropical Storm Lionrock and Tropical Storm Kompasu (in October 2021). Heavy rainfall from tropical storms had affected Thailand, causing river overflow, flash floods, and landslides across the country. The floods affected 46,231 farmers and constituted 18 million US Dollars from the government budget of which the agricultural sector had the highest share. Figure 26 illustrates the rainfall anomaly in September 2021 under the influence of tropical storms.

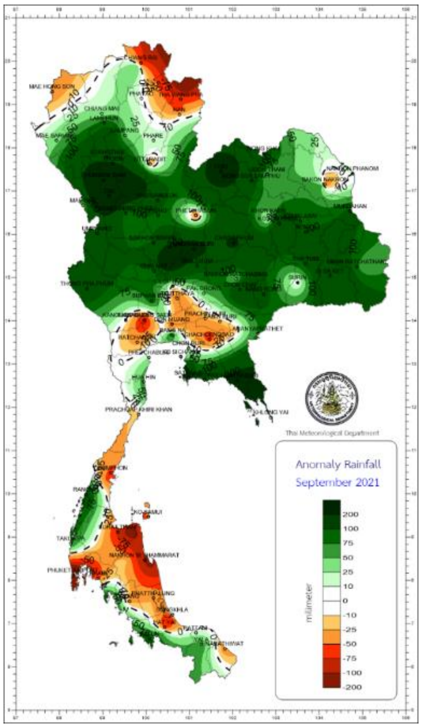

Figure 26: Rainfall anomaly over Thailand in September 2021, recorded by TMD weather stations. Climatological mean was derived from the period of 1991 – 2020.

In particular, Tropical Storm (TS) Dianmu developed in the South China Sea and tracked west-northwestwards toward the Mekong sub-region. The atmospheric conditions were favourable for tropical cyclogenesis with low level vorticity and vertical wind shear, good outflow, and warm sea surface temperature. These resulted in a rapidly organising system, with the depression steered west-northwestwards by the southern periphery of a low- to mid-level subtropical ridge to the north and eventually made landfall in Viet Nam on 23 September 2021. TS Dianmu then weakened into a tropical depression (TD) as it moved over central Viet Nam and southern Lao PDR (Figure 27). During 24 – 26 September 2021, the remnants of TS Dianmu tracked across northeastern Thailand into the Bay of Bengal, where it intensified to a low-pressure area before it moved inland for the second time over West Bengal. Thailand's Department of Disaster Prevention and Mitigation (DDPM) reported that TS Dianmu brought flash floods which affected 71,093 households (or 355,465 persons) across several provinces in Thailand.

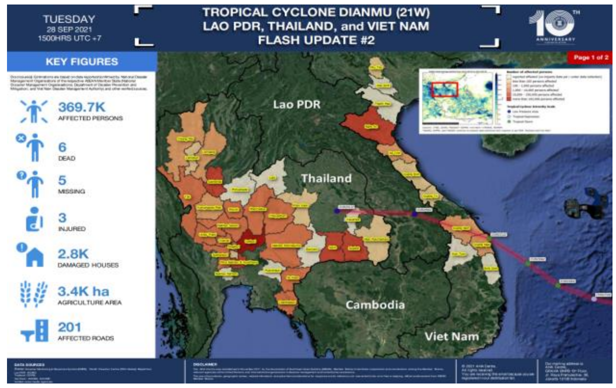

Figure 27: Impact of Tropical Storm Dianmu over the Mekong sub-region. *Credit: reliefweb.int by United Nations Office for the Coordination of Humanitarian Affairs (OCHA).*

The impact of heavy rainfall in September 2021 was significant. The Ministry of Agriculture and Cooperatives (MOAC) reported that during the period 1 September 2021 to 15 October 2021, over 8,528 km^2 of agricultural areas in several regions of Thailand were damaged by floods. Plantation areas in 48 provinces and 463,615 farmers were also affected. Based on statistics from the Centre for Agricultural Disaster Mitigation, these agricultural lands included 5,776 km^2 rice paddy fields, 2,672 km^2 crops fields, and 63.2 km^2 fruit plantations. In addition, the floods also spoilt the fishery businesses (92.16 km^2 damaged areas in 38 provinces and 40,900 farmers) and livestock businesses (11.1 km^2 damaged farms in 15 provinces, 44,600 farmers, and 6.74 million livestock).

Heavy Rainfall over Brunei Darussalam in July 2021

Contributed by Mr Arifin Yussof (Meteorological Officer) and Ms Nurulinani Jahari (Meteorological Officer)
Brunei Darussalam Meteorological Department (BDMD)

During the period 10 – 14 July 2021, Brunei Darussalam experienced increased rainfall which caused many areas in the country to be flooded and inundated, and eventually resulted in disruptions to the smaller rural villages in the inland areas. The floods submerged the roads and cut off the access to these villages for a few days.

Synoptic Overview

Typically, during the month of July, Brunei Darussalam experiences Southwest Monsoon conditions which bring drier conditions and dry southwesterly winds over the country. However, the heavy rainfall during 10 – 14 July 2021 was a particularly anomalous event. The increased rainfall was likely due to the interaction between the Rossby Waves, which dominated over the Indian Ocean during the period 6 – 10 July 2021 (Figure 28), and the prevailing southwesterly equatorial flow in the same period (Figure 29). As a result, there was wind convergence over much of the coastal areas of Borneo, including Brunei Darussalam. The Rossby Wave and the southwesterly equatorial flow could also be associated with the formation of an active low-pressure development over the South China Sea (Figure 30).

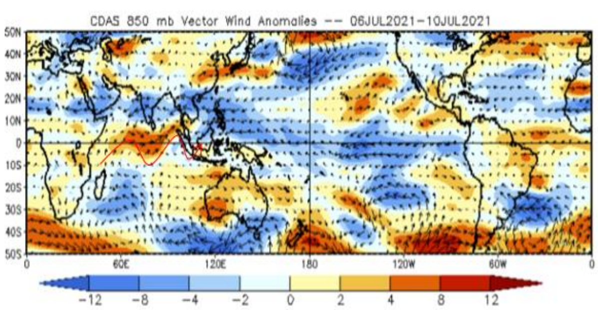

Figure 28: Wind anomalies at 850 mb for 6 – 10 July 2021. The red line represents the Rossby Wave. *Credit: NOAA CPC/NCEP.*

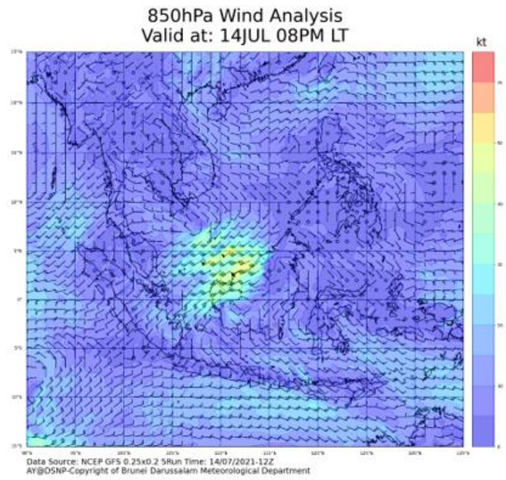

Figure 29: Wind analysis at 850 hPa on 14 July 2021. *Credit: NCEP GFS.*

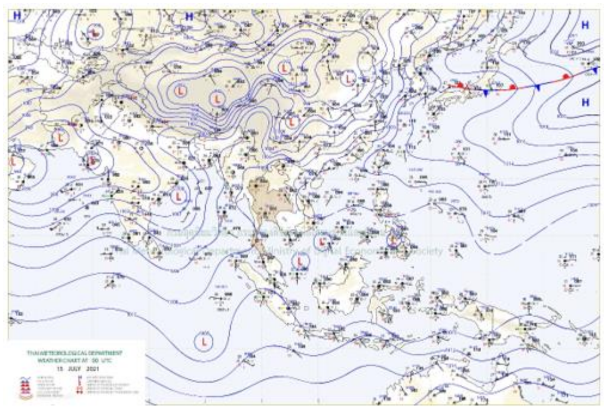

Figure 30: The surface weather chart on 13 July 2021. *Credit: Thai Meteorological Department (TMD).*

Observations

Based on the CHIRPS dataset, which was derived from satellite estimates, most of the rainfall fell over the coastal areas of Tutong and Brunei Muara Districts, and the inland Tutong District. These data corresponded well with the flash floods reported by the public. The rainfall accumulation data from CHIRPS (Figure 31) also showed good agreement with the total rainfall of 174.3 mm (10 – 14 July 2021) recorded by the observation station at Brunei International Airport (Figure 32).

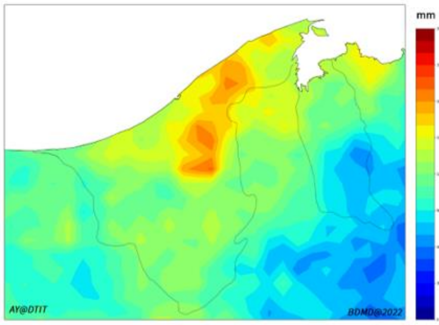

Figure 31: Rainfall accumulation during 10 – 14 July 2021. *Credit: IRI Data Library, CHIRPS.*

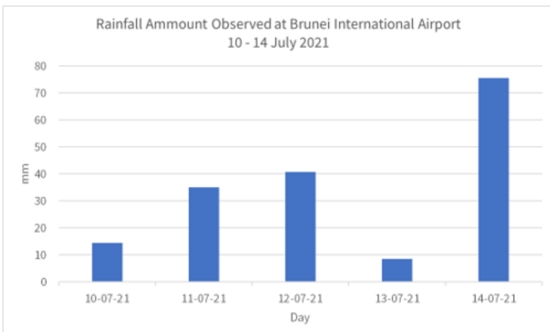

Figure 32: Daily rainfall from 10 – 14 July 2021 recorded by observation station at Brunei International Airport.

Forecasting the Event

The primary forecasting tools used by BDMD Forecasters are products from the NCEP GFS (Global Forecast System) model, which performed very well during the event. The model runs of the ensemble forecast products on 9 July 2021 (Figure 33) and 10 July 2021 (Figure 34) had shown early indications on the impending severe weather conditions.

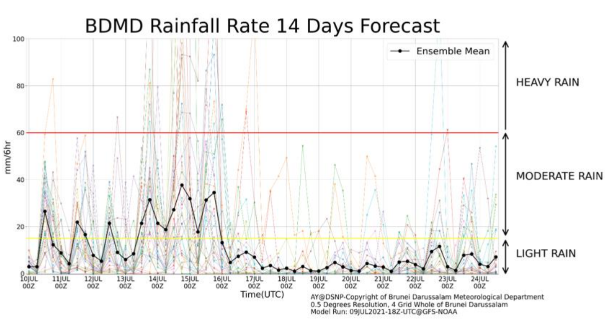

Figure 33: 14-Day rainfall rate forecast from the ensemble mean showing increased rainfall for 10-16 July 2021. *Credit. NCEP GFS.*

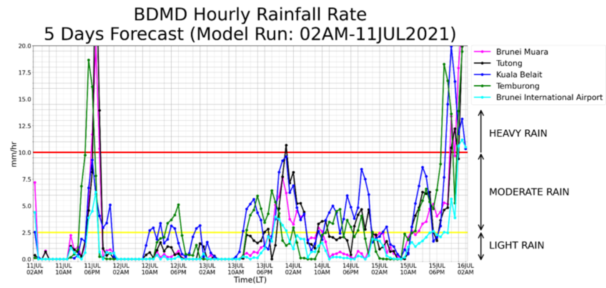

Figure 34: Hourly rainfall rate forecast showing increased rainfall for 11 – 16 July 2021 over much of Brunei Darussalam. *Credit. NCEP GFS.*

Warnings Issued

Over the five-day period 10 – 14 July 2021, BDMD had issued 8 Weather Warnings (Figure 35) and 1 Weather Advisory to help the public and relevant government agencies in early preparations ahead of the impending severe weather conditions. This valuable weather information was also made available to the public through various channels, such as radio, television, social media, as well as via real-time update in the Brunei Weather mobile application. It was fortunate that no lives were lost during this heavy rainfall event.

Figure 35: The Weather Advisory issued by BDMD Forecast Office on 14 July 2021 on the adverse weather conditions.

Weather Review of July to December 2021 in the Philippines

Contributed by Mr Joey Figuracion and Ms Ana Liza Solis
Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA)

Introduction

In general, the Philippine's climate is referred to as hot and humid due to Maritime Tropical airmass (Flores & Balagot, 1969). As an archipelago near the equator, the weather and climate situation in the country during the July to December period are highly susceptible to the variability and extremes of multiple climate drivers (e.g., monsoon, tropical cyclones (TCs), El Niño Southern Oscillation (ENSO), trade winds, Inter-Tropical Convergence Zone (ITCZ), intra-seasonal to inter-annual modes, and equatorial waves). The July to December period also covers two monsoons: The Southwest Monsoon (SWM) and the Northeast Monsoon (NEM). These monsoons have significant influence on the rainfall patterns and tropical cyclone variability over the country. Typically, the July-August-September (JAS) period is characterised by hot and humid conditions and the SWM brings higher rainfall to the western parts of the Philippines (Type I) compared to other parts of the country (Figure 36).

Conversely, the eastern section of the country (Type II) receives more rainfall during the October-November-December (OND) period, which coincides with the NEM season and the combined associated rainfall from tropical cyclone influx, shear line, and equatorial waves in contrast to other parts of the country. During the surge of NEM, there is typically a decrease in environmental temperature (Figure 40) and humidity, from October to February the following year. This is usually due to the advected continental polar airmass which eventually reaches the country as modified maritime tropical airmass (Flores & Balagot, 1969; Williams & Jung, 1993). The Philippine domain is also located in the typhoon belt which experiences an average of nineteen tropical cyclones in a year. About 70 – 80% of these TCs occur during the July to December period when their paths veer more towards the Philippine landmass.

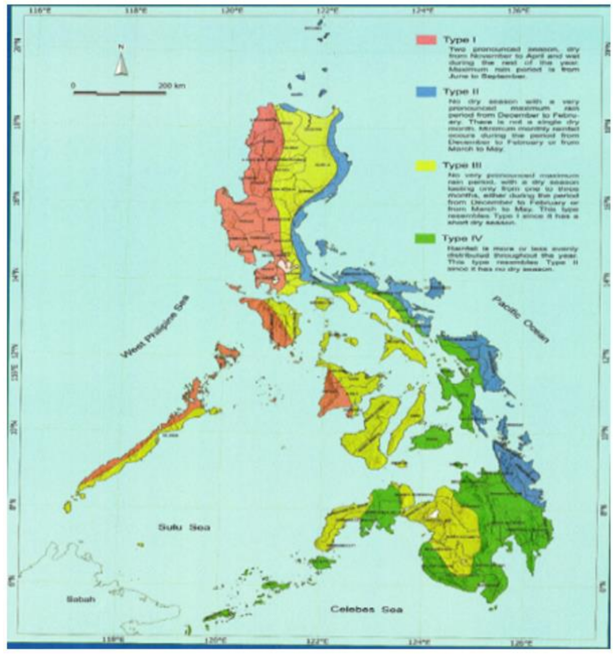

Figure 36: Climate map of the Philippines based on rainfall distribution, showing four different types of climates:

- Type I – two pronounced seasons: dry from November to April, wet during rest of the year,
- Type II – no dry season with a very pronounced rainfall from November to April,
- Type III – no pronounced seasons, relatively dry from November to April, and
- Type IV – rainfall is generally evenly distributed throughout the year.

Precipitation

The total rainfall in the second half of 2021 accounted for 62.6% of the average annual rainfall in the country. As shown in Figure 37, the pattern of SWM precipitation amount in the western parts of Luzon Island was near-normal to above-normal, and similar to the rainfall in some parts of Mindanao and Visayas areas.

On the other hand, the OND period recorded near-to above-normal rainfall in most parts of the country and was ranked as the 17th wettest OND period since 1961. The significant surplus of rainfall in parts of Palawan, Visayas, and Mindanao was associated with TCs during the period. The 2021 La Niña event had insignificant impact on the rainfall, as compared to the same period in 2020 (Figure 37). Generally, the July to December period observed a positive anomaly as shown in the temporal variability (Figure 38). However, brief periods of rainfall deficit were also experienced in some parts of the country. The spatial variability showed that the deficits were observed in the river basins and tributaries of major dams, which supplied most of the water to the Luzon areas (Figure 39).

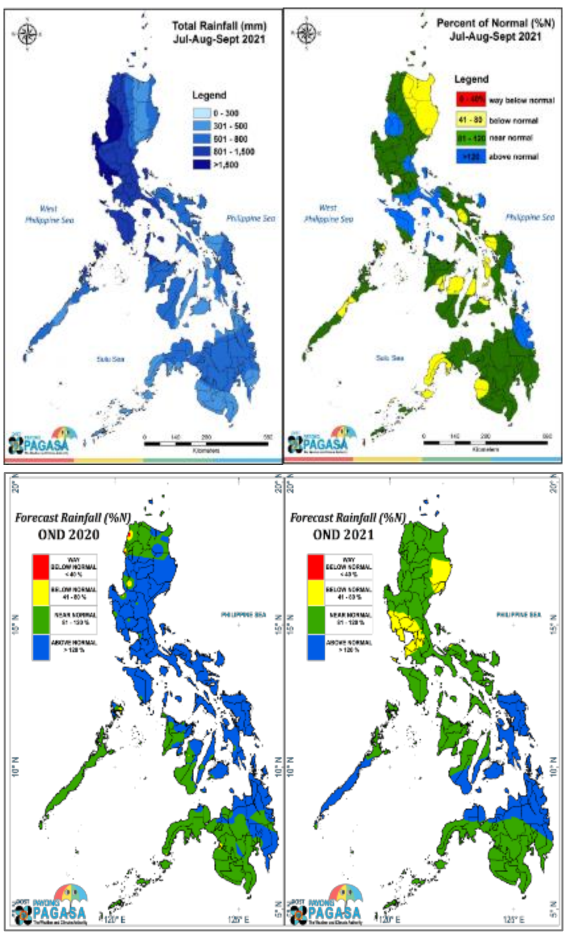

Figure 37: Total rainfall and anomaly for July-August-September 2021 period (top) and the 2020 – 2021 comparison of precipitation forecast for October-November-December period (bottom).

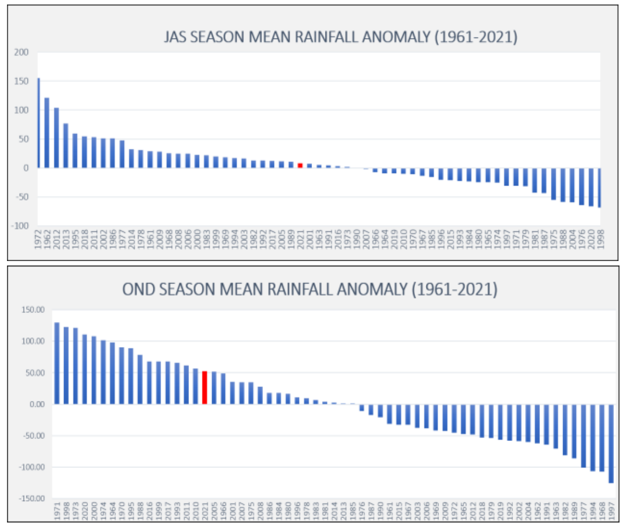

Figure 38: Seasonal mean rainfall anomaly for July-August-September (top) and October-November-December (bottom) from 1961 – 2021. The red bar represents the value for 2021.

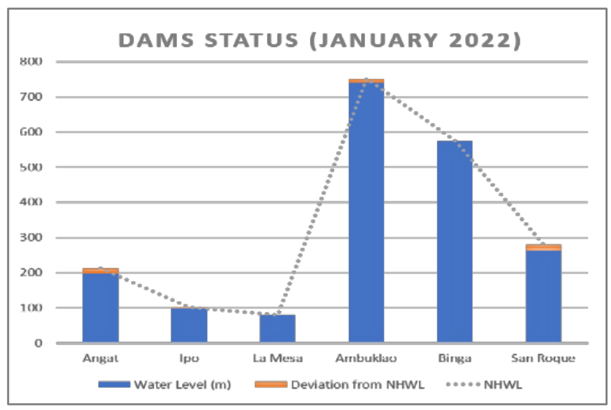

Figure 39: Spatial variability of rainfall distribution across different dams at Luzon.

Global analysis has put 2021 as one of the warmest years in the history. Over the Philippines, the annual mean temperature anomaly was ranked as the 11th highest, based on preliminary analysis using the data from 1961 – 2021 (Figure 40). The formation of tropical cyclones is known as an effective heat absorber due to the cooling effect of its convection and rainfall. This was evident in November 2021, where the absence of tropical cyclones in the Philippine region contributed to a positive mean temperature anomaly. On the contrary, strong NEM conditions contributed to cold surges and several frost events over the mountainous areas in Luzon in December 2021, with the lowest temperature recorded at 7.7°C (the historical lowest temperature is 6.3°C in 1961).

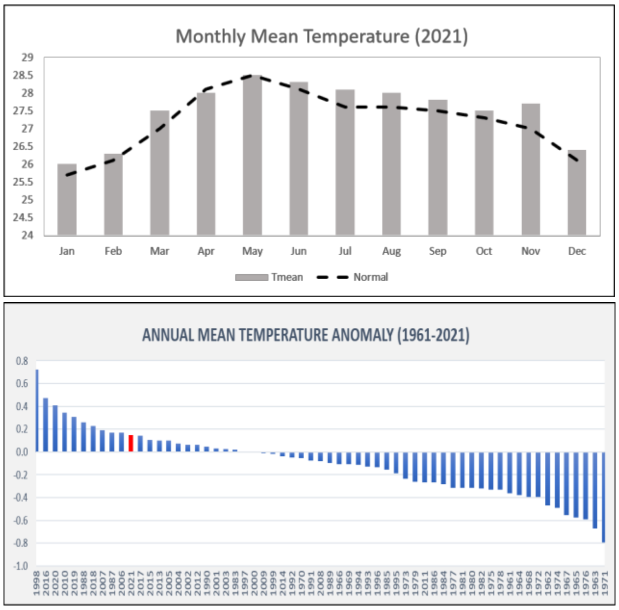

Figure 40: Monthly mean temperature in 2021 (top) and the annual mean temperature anomaly from 1961 – 2021 (bottom).

Tropical Cyclone and Its Impacts

The tropical cyclones development within the Philippine Area of Responsibility (PAR) had a slight decrease in 2021. A total of fifteen tropical cyclones were recorded over the PAR, which was about 79.1% of the long-term average. In 2021, the July to December period contributed to 73.3% of the total TCs in the year (Figure 41 and Figure 42). In particular, four TCs had crossed the landmass of the Philippines within the period. These included Typhoon Conson, Tropical Storm Lionrock, Severe Tropical Storm Kompasu, and Typhoon Rai. The TCs damaged infrastructure and agriculture and resulted in an estimated loss of 39 billion PHP and 478 casualties (Table 3).

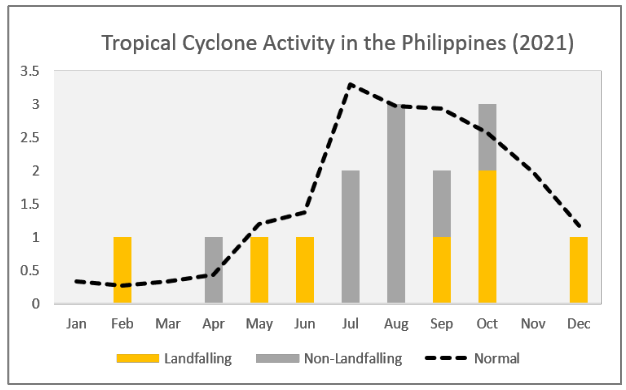

Figure 41: Monthly tropical cyclone activity in 2021 and the climatological average.

MONTH	NUMBER OF TC	TC NAMES AND DATE	ESTIMATED COST OF DAMAGE		AFFFECTED FAMILIES	DEAD	MISSING	INJURED
			COST OF DAMAGE TO AGRICULTURE	COST OF DAMAGE TO INFRASTRUCTURE				
JULY	2	TD EMONG JUL 04 - 06	-	-	-	-	-	-
		TY FABIAN (INFA) JUL 16-23	₱ 743,220,278.41	₱ 459,799,355	78,773	6	1	7
AUGUST	3	TD GORIO AUG 07	-	-	-	-	-	-
		TS HUANING (LUPIT) AUG 07	-	-	-	-	-	-
		TD ISANG (OMAIS) AUG 19 - 22	-	-	-	-	-	-
SEPTEMBER	2	TY JOLINA (CONSUN) SEP 6-9	₱ 1,349,221,036.1	₱ 63,676,053	90,835	20	4	33
		TY KIKO (CHANTHU) SEP 7-12	₱ 37,354,667.52	-	12,132	-	-	27
OCTOBER	3	TD LANNIE OCT 4-6	₱ 12,225,109.47	-	1,701	3	-	-
		STS MARING (KOMPASU) OCT 8-12	₱ 3,267,218,527.47	₱ 3,120,025,133.35	297,046	43	16	5
		TD NANDO OCT 9	-	-	-	-	-	-
NOVEMBER	0	-	-	-	-	-	-	-
DECEMBER	1	TY ODETTE (RAI) DEC 14-18	₱ 12,756,850,556.944	₱ 17,190,395,003.78	2,336,249	406	65	1265

Table 3: Tropical Cyclones that had entered the Philippine Area of Responsibility (PAR) during July to December 2021.

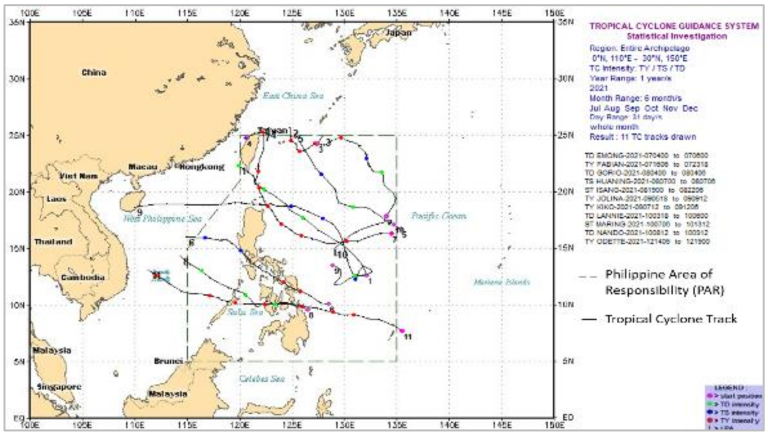

Figure 42: Tracks of the tropical cyclones (TCs) in 2021 over the Philippine Area of Responsibility (PAR).

Typhoon Rai (14 – 18 December 2021) was the strongest TC which made landfall in 2021 with the recorded maximum wind gusts of 209 km/h. Typhoon Rai dumped large amount of rainfall over a period of five days and the total rainfall exceeded the average monthly total, causing widespread flooding, multiple landslides, 406 casualties, and about 30 billion PHP in damages. There were also disruptions to the infrastructure, agricultural farms, communication, and transportation for the 2.34 million population in Palawan, Visayas, and Mindanao (Figure 44).

Climate Drivers

The monitoring over the Central and Eastern Pacific Ocean basin showed the La Niña conditions began to prevail from October 2021 (Figure 43). However, its effect on rainfall in the Philippines was not significant, as compared to the La Niña episode in 2020, where most parts of the country recorded above-normal rainfall. In addition, the intra-seasonal active mode of Madden-Julian Oscillation (MJO) was present in the maritime continent and eventually moved to the Western Pacific (Figure 45) during the July to December 2021 period. The interaction of these climate drivers changed the environmental condition and influenced the timing and frequency of tropical cyclone development in the country – no TC in November 2021 and less TC formation in general due to westerly wind anomaly in the Northwestern Pacific basin.

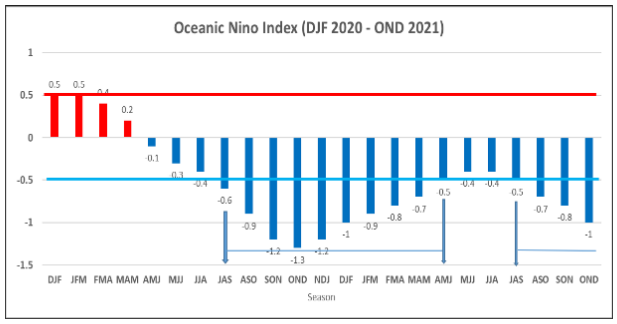

Figure 43: Oceanic Niño Index from December-January-February 2020 to October-November-December 2021. *Credit: NCEP/NOAA CPC.*

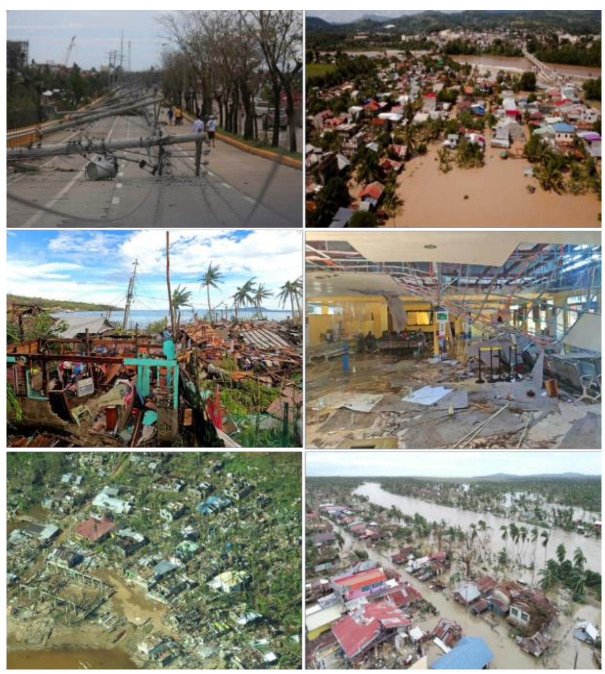

Figure 44: Impacts of Typhoon Rai in the Philippines.

Summary

Climate variability in the Philippines is typically influenced by the different climate drivers and its teleconnection and base state responses. During the July to December 2021 period, these were evident in the observed rainfall amount, mean temperature, and TC frequency and intensity in the country. Overall, the country's rainfall during this period recorded a surplus but a few locations near the river basins and major dams in Luzon had experienced rainfall deficits. This spatial disparity of rainfall distribution and positive anomaly of the Outgoing Long-wave Radiation (OLR) could be attributed to the decline of the seasonal TC frequency in the surrounding. Moreover, the decrease in cooling effect from convection activity and rainfall from tropical cyclones contributed to an above-normal temperature anomaly which was in line with the global trend analysis. A few exceptions were observed in the mountainous area of Northern Philippines where cold surges brought a cooler environment and frosts.

In summary, the July to December 2021 period showed that rainfall distribution, temperature, and TC characteristics remained closely related and responsive to the intra-seasonal and inter-annual climate drivers such as La Niña and MJO. This variability was also the main contributor to extreme weather events and natural disasters that affect the Philippines.

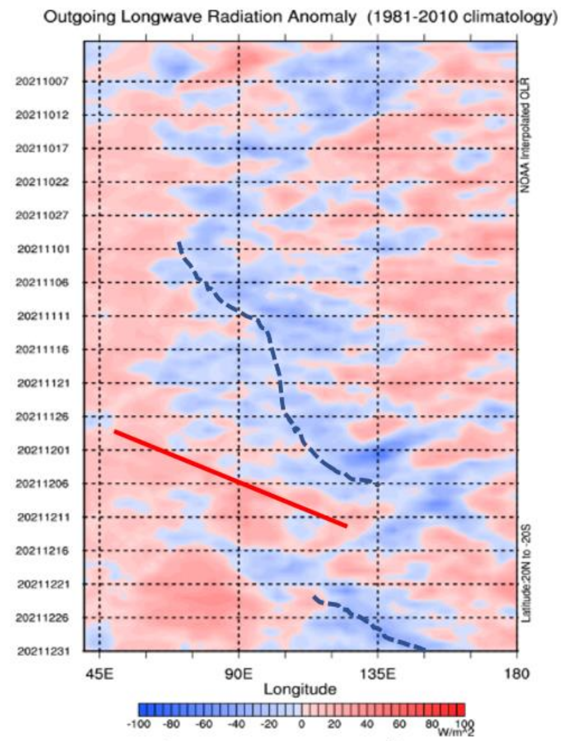

Figure 45: The Hovmöller diagram from November to December 2021. *Credit: NOAA Physical Sciences Laboratory (PSL).*

ASMC EVENTS

Seventeenth Session of the ASEAN Climate Outlook Forum (ASEANCOF-17) (Online: 22-26 November 2021)

The Seventeenth Session of the ASEAN Climate Outlook Forum (ASEANCOF-17), coordinated by ASMC, took place online on 22 – 26 November 2021. Overall, there were more than 70 participants for ASEANCOF-17 from ASEAN National Meteorological and Hydrological Services (NMHSs), the World Meteorological Organization (WMO), ASEAN Secretariat (ASEC), Regional Integrated Multi-Hazard Early Warning System (RIMES), as well as other international organisations.

The session started with opening remarks from the Head of the WMO Regional Office for Asia and the South-West Pacific (WMO RAP), Mr Benjamin Churchill and ASMC Deputy Director of Operations, Mr Raizan Rahmat. For the rest of the first day, representatives from NMHSs of ASEAN Member States and Global Producing Centres (GPCs) presented their outlook for December-January-February (DJF) 2021/2022. The presentations comprised of eight ASEAN NMHSs and five GPCs, which were Australia Bureau of Meteorology (BoM), Japan Meteorological Agency (JMA), APEC Climate Center (APCC) on behalf of WMO LRF, the European Centre for Medium-Range Weather Forecasts (ECMWF), and the UK Met Office.

The second day was an introductory session to NextGen, a new set of high-quality, flexible, and tailored seasonal climate forecasts created by IRI, Columbia University. This introductory session provided an opportunity to share with NMHSs one of the approaches for developing objective outlooks and to gauge interest in setting up NextGen for the region. The session was led by Ángel Muñoz and Andrew Robertson from IRI, Columbia University.

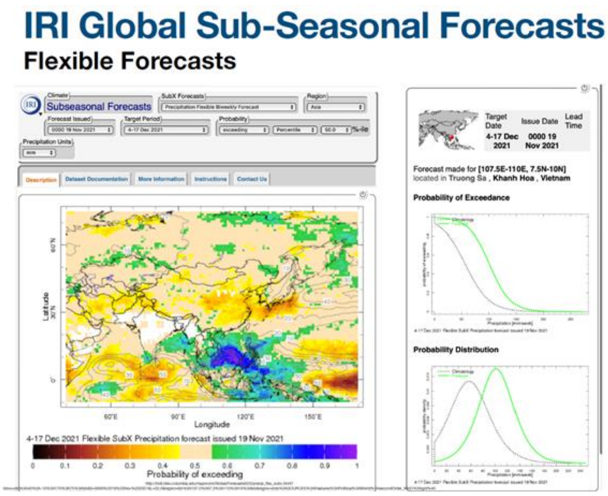

Figure 46: Example of the Flexible Forecasts from IRI, Columbia University, a possible component of NextGen

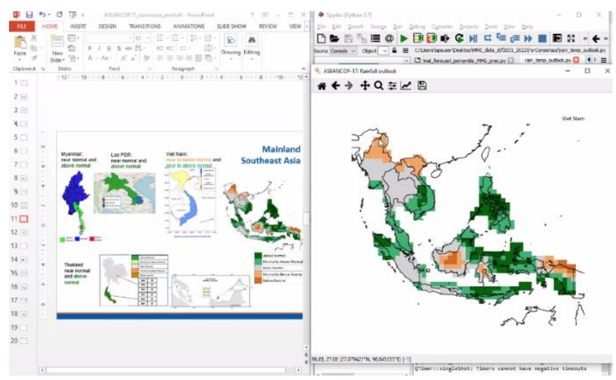

Figure 47: Screenshot of consensus discussion for the rainfall outlook – comparing the MME with the outlooks from the NMHSs in Mainland Southeast Asia.

The focus of the third day was to arrive at the regional consensus for climate drivers, as well as the rainfall and temperature outlooks. Also on the third day were presentations from two of the three SEA RCC-Network nodes, with Mr Ryan Kang providing updates from the Long-Range Forecasting Node, and Ms Junie Ruiz providing updates from the Climate Monitoring Node. Dr Thea Turkington also provided updates from the ASEANCOF Working Group. During Dr Thea's presentation, she highlighted ASEANCOF's focus on training to support ASEAN NMHSs.

The final day comprised of the presentation of the consensus and the discussion session on seasonal outlooks and other climate services for Disaster Risk Reduction (DRR). This day was held as a webinar and marked the first time that an open call was made for ASEANCOF registration.

The session started with an interactive game led by Mr Tan Wee Leng, to highlight how interpretation of messages or information is not straightforward. Next, the climate review and consensus were presented. This was followed by a series of presentations from NMHSs on national outlooks for extreme events at seasonal and subseasonal timescales. The final section was a panel discussion on the use of climate services for DRR.

Overall, it was a successful ASEANCOF-17. The interest in the webinar suggested that future consensus report and discussion sessions on the final day should be open to a wider audience – at least when this is held in a virtual format. It is expected that the participant rate for this component would also increase as more people and user agencies become aware of ASEANCOF.

Figure 48: Participants in ASEANCOF-17

Hotspot and Haze Assessment (H2A) Workshop for the ASEAN Region (Online: 22-23 February 2022)

ASMC has conducted six workshops on hotspot and haze assessment since 2018 under its Regional Capability Building Programme for ASEAN Member States. A combined workshop was held this year for both the Mekong sub-region and southern ASEAN region, bringing together participants from both regions to discuss and share on regional issues in fires and haze monitoring, mitigation, and control.

The H2A 2022 workshop for the ASEAN region was held online over two days on 22 – 23 February 2022 and welcomed more than 42 participants from environment and disaster management sectors in countries around the ASEAN region, including Brunei Darussalam, Cambodia, Lao PDR, Malaysia, Myanmar, Thailand, and Viet Nam. Representatives from the Environment Division of the ASEAN Secretariat (ASEC) were also in attendance.

During the workshop, there were engaging discussions by participants on local issues in fires management, monitoring, and suppression, as well as air quality and haze conditions in 2021. Participants also actively partook in quizzes and activities during the lectures on the interpretation of satellite imagery, satellite technologies and products, seasonal and subseasonal predictions, and dispersion modelling. The workshop participants were updated on the review and outlook of regional weather, climate, and haze situation to help them better prepare for the possibility of fires and smoke haze development in their respective countries in upcoming months.

Dr Vong Sok, Head of Environment Division at ASEC, expressed his appreciation to the workshop organisers and speakers at the end of the session and welcomed the opportunity to learn about the technical analyses and assessments at the ASMC, which is useful to support their work in the region.

Ms Naila Athifa, Environmental Officer from Department of Environment, Brunei Darussalam, also opined that the quizzes were a nice touch to allow interaction and check the understanding of participants.

Figure 49: Participants in H2A 2022

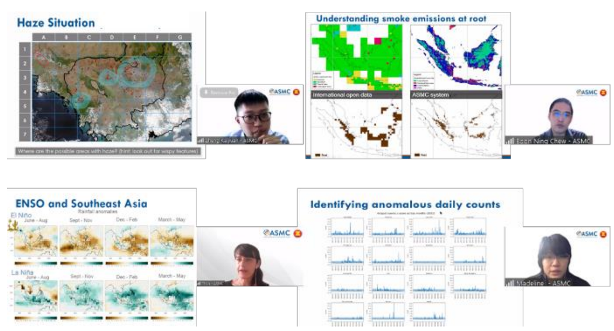

Figure 50: Lecturers introduced participants to a range of topics relevant to fires and smoke haze monitoring and assessment in the ASEAN region.

Going forward, ASMC will plan further workshops in numerical weather prediction, climate change projections, seasonal and subseasonal predictions, as well as haze monitoring to further advance regional capabilities in issues relating to weather, climate, and transboundary smoke haze.