

# Harnessing Satellite and Geospatial Data for Fire and Haze Monitoring, Assessment and Early Warning

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# Overview of ASMC

**ASEAN Specialised Meteorological Centre (ASMC), hosted by the Meteorological Service Singapore (MSS), supports the ASEAN region in 3 broad aspects:**

Monitoring and Assessment of Land/Forest Fire, and Provision of Early Warning on Transboundary Haze Occurrence



Regional Weather and Climate Assessment and Outlook, as well as Seasonal Predictions and Climate Projections



Services Delivery, Research & Development, and Capability Building

# History

## Science & Technology Sectoral

- 1993:** Established as regional ASEAN Centre focusing on weather and climate, as well as regional capability development in these areas.
- Coordinate and report on activities at the Subcommittee on Meteorology and Geophysics (SCMG) and Committee on Science, Technology and Innovation (COSTI)

## Environment Sectoral

- 1995:** Designated as the ASEAN Centre to monitor and assess land and forest fires and the occurrence of transboundary smoke haze for the southern ASEAN region
- 1997:** Tasked to operationalize an "intranet" among the relevant ASEAN meteorological service and environmental agencies to improve communications and enhance the effectiveness of existing early warning and monitoring systems.
- 2002:** Area of responsibility extended to include the northern ASEAN region
- Serve as technical advisor at various ASEAN ministerial meetings on the environment, fires and smoke haze

## Disaster Management

- 2013:** 1<sup>st</sup> ASEAN Climate Outlook Forum. Biannual regional consensus outlook for rainfall and temperature during monsoon seasons.
- 2024:** Sharing of high-resolution regional climate projections data for the Southeast Asia region

# ASMC's Mandates

01



## Weather & Climate

Deliver regional weather, climate assessments and future projections, including seasonal forecasts

02



## Fire & Haze Monitoring

Monitor land/forest fires and provide transboundary haze early warning services

03



## Data Management

Process and share satellite and meteorological data for fire and haze detection

04



## Digital Platform

Maintain ASEAN's official website for meteorological and environmental monitoring information

05

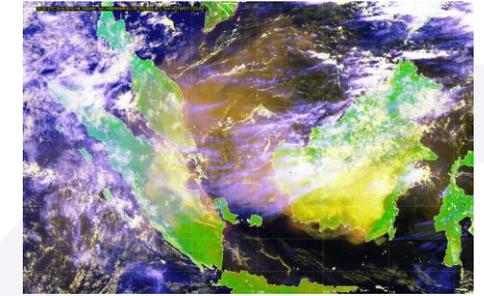
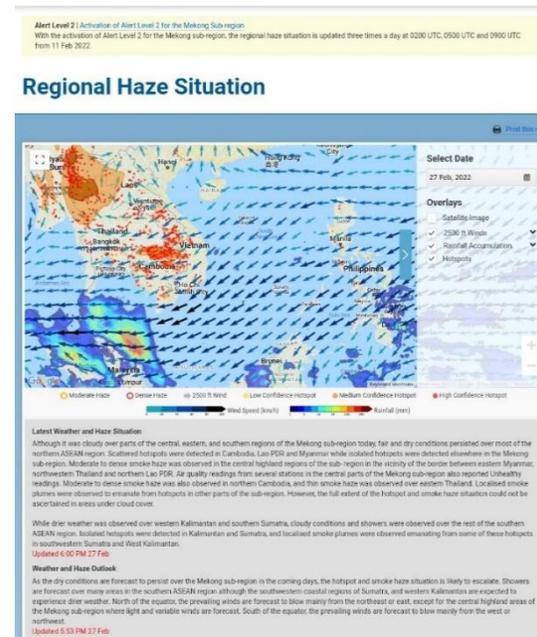


## Capability Development

Enhance regional early warning capabilities through R&D and capacity building initiatives

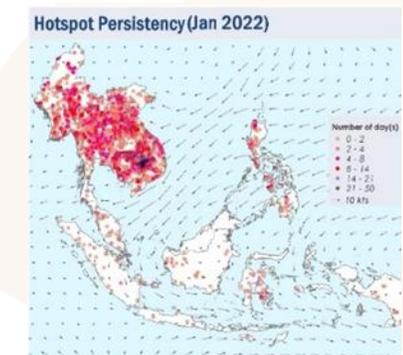
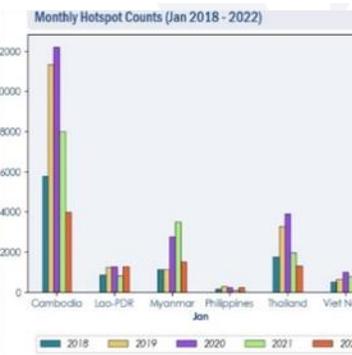
# Key Products and Services

- Operational and regularly updated information and products
  - Daily assessment and forecast of regional weather and haze situation
  - Monthly situation review and assessment
  - Subseasonal and seasonal outlook (up to 3 months ahead)
  - ENSO/IOD assessment and outlook
  - Fire hotspots and Satellite images
  - Alerts Levels for fires/haze and Early Warning
  - Weather observation and Numerical Weather Prediction (NWP)
  - Fire Danger Rating System (from Met Malaysia)
  - WMO Information System (WIS) 2.0 data portal
  - Burnt Area Mapping (in development)



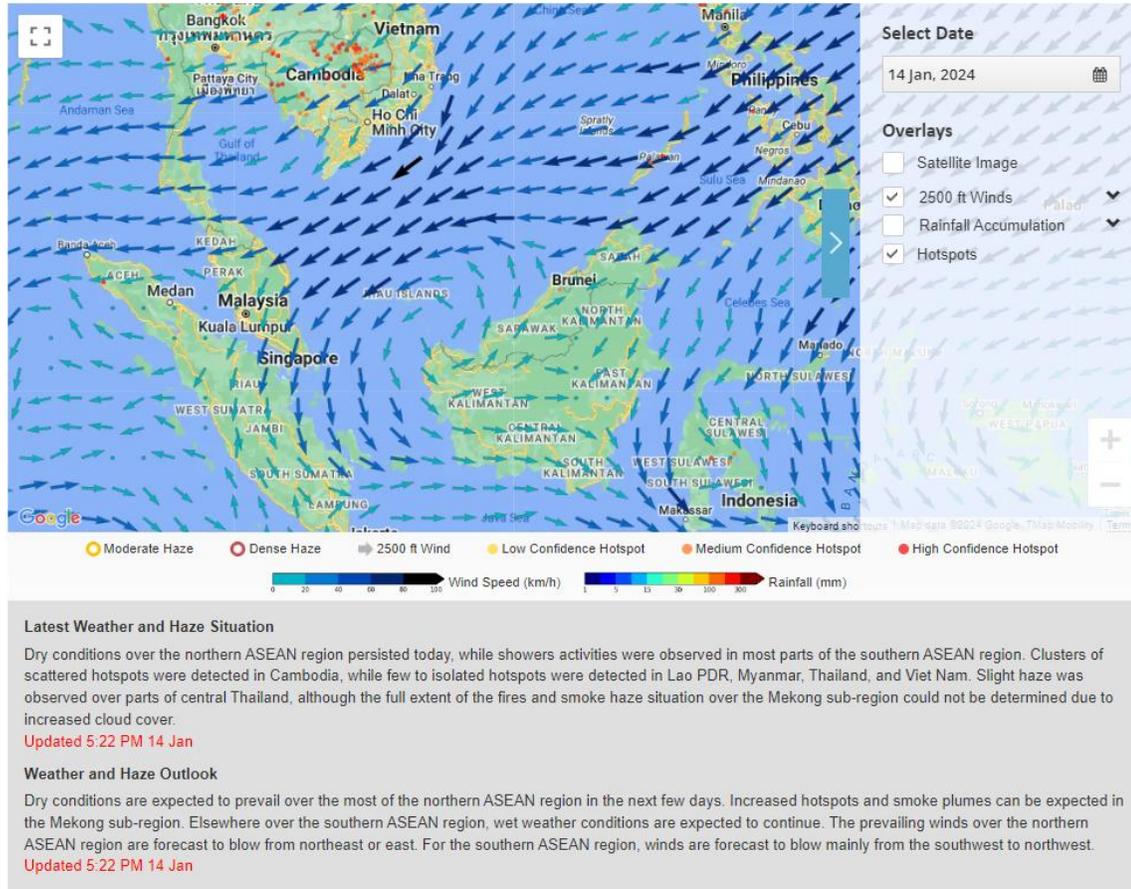
Date of Issue	Alert Level	Details
14 Dec 2023	Level 1	<p><b>Start of Dry Season for the Northern ASEAN Region</b></p> <p>Northeast Monsoon conditions have been firmly established over the northern ASEAN region since early-Dec 2023 with the prevailing winds blowing predominantly from the northeast or east. In recent days, dry weather conditions were observed over the Mekong sub-region with gradually increasing hotspot counts. There were a total of 52 and 43 hotspots detected in the Mekong sub-region on 12 Dec 2023 and 13 Dec 2023 respectively.</p> <p>As the dry conditions over the northern ASEAN region are likely to persist in the coming months, the hotspot and smoke haze situation over the region is expected to deteriorate.</p> <p>ASMC Media Release - Start of Dry Season for the Northern ASEAN Region</p>
14 Nov 2023	Level 1	<p><b>End of Dry Season for the southern ASEAN region</b></p> <p>In recent days, widespread shower activities have helped to further suppress the overall hotspot and smoke haze situation over the southern ASEAN region. Based on surveillance by the NOAA-20 satellite, 18 and 36 hotspots were detected in Sumatra on 12 and 13 November 2023 respectively, and 3 hotspots were detected in Kalimantan on both days.</p> <p>The hotspot and haze situation over the southern ASEAN region is expected to remain subdued as shower activities are forecast to continue in the coming months. However, isolated hotspots and localised smoke plumes may still develop in the prone areas during brief periods of relatively drier weather.</p>
24 Oct 2023	Level 1	<p><b>Downgrade of Alert Level 2 to Alert Level 1 for the southern ASEAN region</b></p> <p>In recent days, increased rainfall has helped to improve the overall hotspot and smoke haze situation over the southern ASEAN region. While this has reduced the risk of transboundary haze occurrence, isolated hotspots and localised smoke plumes may still develop in fire-prone areas during brief periods of dry weather.</p> <p>Based on surveillance by the NOAA-20 satellite, a total of 57 and 47 hotspots were detected in Sumatra, and a total of 8 and 8 hotspots were detected in Kalimantan on 22 and 23 October 2023, respectively. The hotspot and haze situation over the southern ASEAN region is expected to further improve as more rainfall is forecast in the coming weeks.</p> <p>Activation of Alert Level 2 for Sumatra</p>

## Examples of ASMC products/services



# Assessment & Outlook

## Regional Haze Situation and Outlook



- 24/7 Monitoring of regional weather, land and forest fires and smoke haze situation
- Taking into account data from various satellites and observations from weather reports and air quality data
- Risk assessment and early warning on transboundary haze occurrence based on forecast guidance from NWP\* models, dispersion model and climate predictions

\*Numerical Weather Prediction

# Warnings & Alerts

Warnings and advisories are issued to ASEAN Member States and interim \*ACC THPC when there are risks of transboundary haze affecting the respective sub-region (northern/Mekong sub-region and southern ASEAN region)

## Alert Level 1 | [Start of Dry Season for the Northern ASEAN Region.](#)

The upgrade of Alert Level 0 to Alert Level 1 indicates the start of dry season for the northern ASEAN region. The regional haze situation will be updated daily at 0900 UTC.

Alert Banner on the Landing Page of the ASMC website (<https://asmc.asean.org/home>)

Date of Issue	Alert Level	Details
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14 Nov 2023	Level 2	<p><b>End of Dry Season for the southern ASEAN region</b></p> <p>In recent days, widespread shower activities have helped to further suppress the overall hotspot and smoke haze situation over the southern ASEAN region. Based on surveillance by the NOAA-20 satellite, 18 and 36 hotspots were detected in Sumatra on 12 and 13 November 2023 respectively, and 3 hotspots were detected in Kalimantan on both days.</p> <p>The hotspot and haze situation over the southern ASEAN region is expected to remain subdued as shower activities are forecast to continue in the coming months. However, isolated hotspots and localised smoke plumes may still develop in fire-prone areas during brief periods of relatively drier weather.</p>
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	Level 2	<p><b>Activation of Alert Level 2 for Sumatra</b></p>

Alert Levels	Conditions/Trigger Points
Alert Level 0	<ul style="list-style-type: none"> <li>No transboundary smoke haze/ Stand down</li> </ul>
Alert Level 1	<ul style="list-style-type: none"> <li>Dry Season</li> </ul>
Alert Level 2	<ul style="list-style-type: none"> <li>Risk of transboundary haze in the region</li> <li>High hotspot counts detected on 2 consecutive days with dense smoke plumes</li> </ul>
Alert Level 3	<ul style="list-style-type: none"> <li>Extent of transboundary haze</li> <li>Dry weather conditions persisting</li> <li>Prevailing winds blowing towards neighbouring ASEAN countries</li> </ul>

\*ASEAN Coordinating Centre for Transboundary Haze Pollution Control



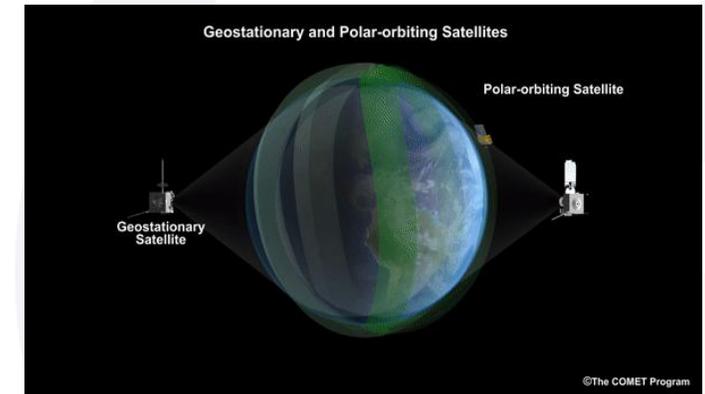
# ASMC Capability Building Programme (ACaP)

- The ASMC Regional Capability Building Programme (ACaP) enhances regional capabilities in four key areas.
- Workshops/fora have been conducted in NWP, fires and haze monitoring using satellites, S2S and climate outlook, as well as on utilising climate change projections



# Satellite Utilization for Hotspot and Haze Monitoring

Types of Satellite	Polar Orbiting	Geostationary
Satellite in use	<ul style="list-style-type: none"> <li>• SUOMI-NPP</li> <li>• NOAA-20</li> <li>• NOAA-21</li> </ul>	<ul style="list-style-type: none"> <li>• Himawari-8/9 (Japan)</li> <li>• GeoKompsat(GK)-2A &amp; 2B (S. Korea)</li> </ul>
Advantages	<ul style="list-style-type: none"> <li>• <b>Higher spatial resolution</b> capable of detecting smaller and lower intensity fires</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Higher frequency</b> of update allows observations over areas previously obscured by clouds</li> <li>• Wider area coverage</li> <li>• GK-2B carries GEMS* sensor for monitoring air pollutants</li> </ul>
Disadvantages	<ul style="list-style-type: none"> <li>• <b>Only 2 images per day</b> (1 day, 1 night)</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Lower spatial resolution</b></li> </ul>
Main Usage	<ul style="list-style-type: none"> <li>• Hotspot detection and reporting (NOAA-20)</li> <li>• Observing smoke haze/plumes areas</li> </ul>	<ul style="list-style-type: none"> <li>• Monitoring smoke plume/haze emission and movements</li> <li>• Hotspot detection over areas cannot be captured by Polar Orbiting Satellite due to obscurations</li> </ul>



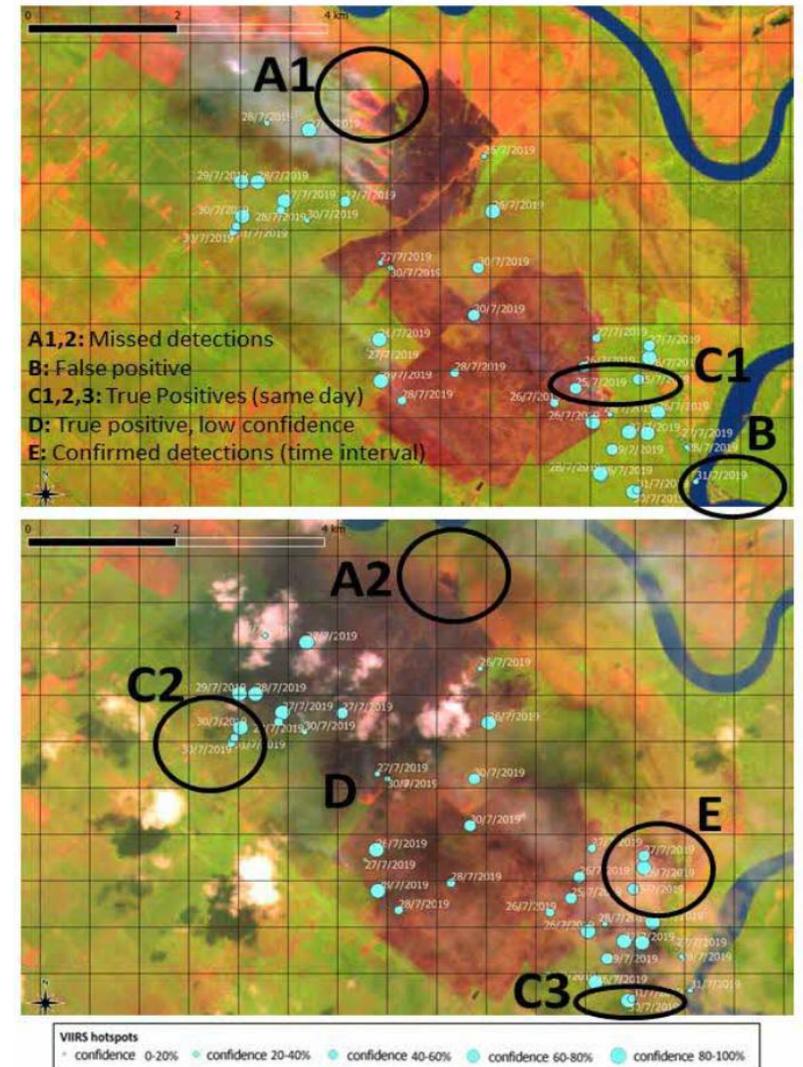
\*Geostationary Environmental Monitoring Spectrometer

# Hotspot Monitoring

- ASMC leverage the \*VIIRS sensor data onboard the NOAA satellites, capable of measuring radiation from Earth
- Not all classified hotspots are true fires on the ground (i.e. False Alarms)
  - Similar signatures might be mistaken as fires by the algorithm (e.g. solar panels, flaring from power stations)
- +NOAA's hotspot algorithm assigns a **Fire Confidence (FC)** parameter to measure how true a hotspot is based on a series of tests ranging from 0% (least likely) to 100% (most likely)
- ASMC assessed hotspot detection over the ASEAN region by comparing with Sentinel-2 imagery due to its high spatial resolution
  - Validation results grouped FC into:

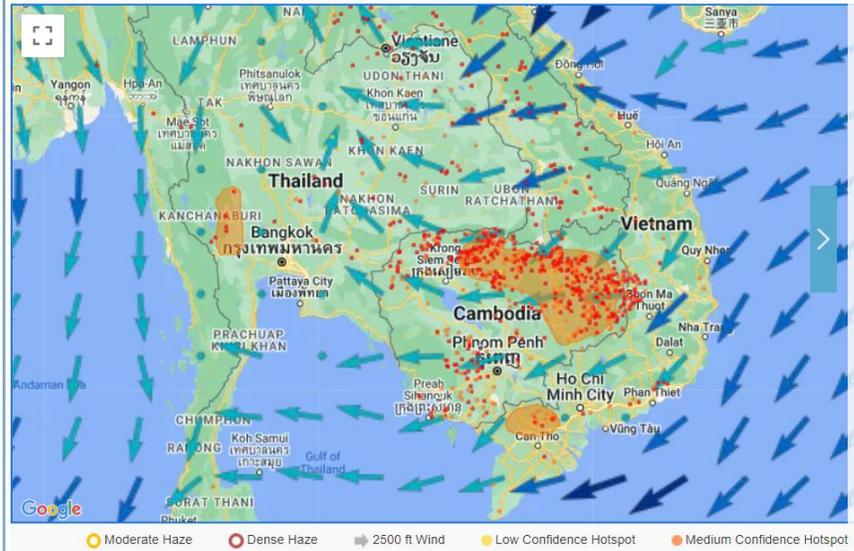
● High    ● Moderate    ● Low

\*VIIRS – Visible Infrared Imaging Radiometer Suite  
+National Oceanic and Atmospheric Administration

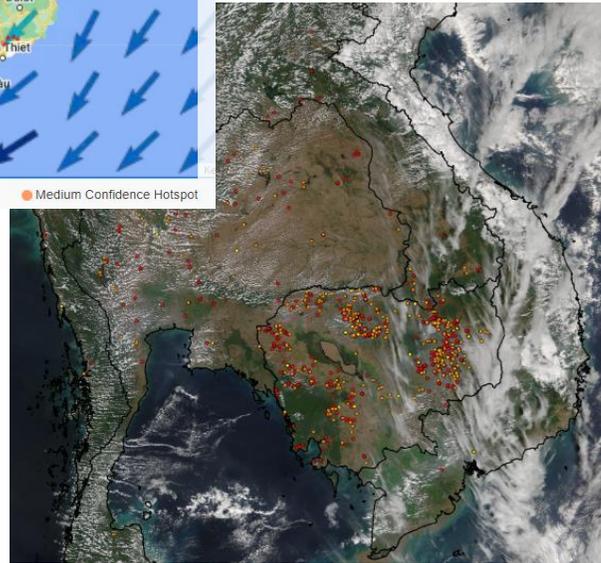


Example of NOAA-20 VIIRS Hotspot Verification in Borneo

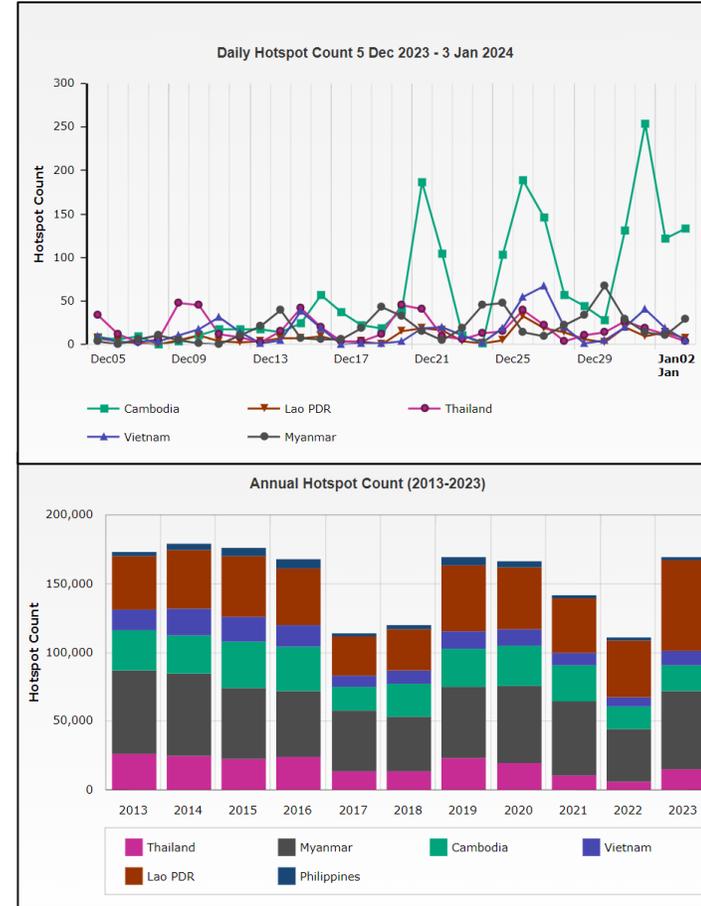
# Hotspot Reporting



Hotspot plotted on Google Map on ASMC landing webpage



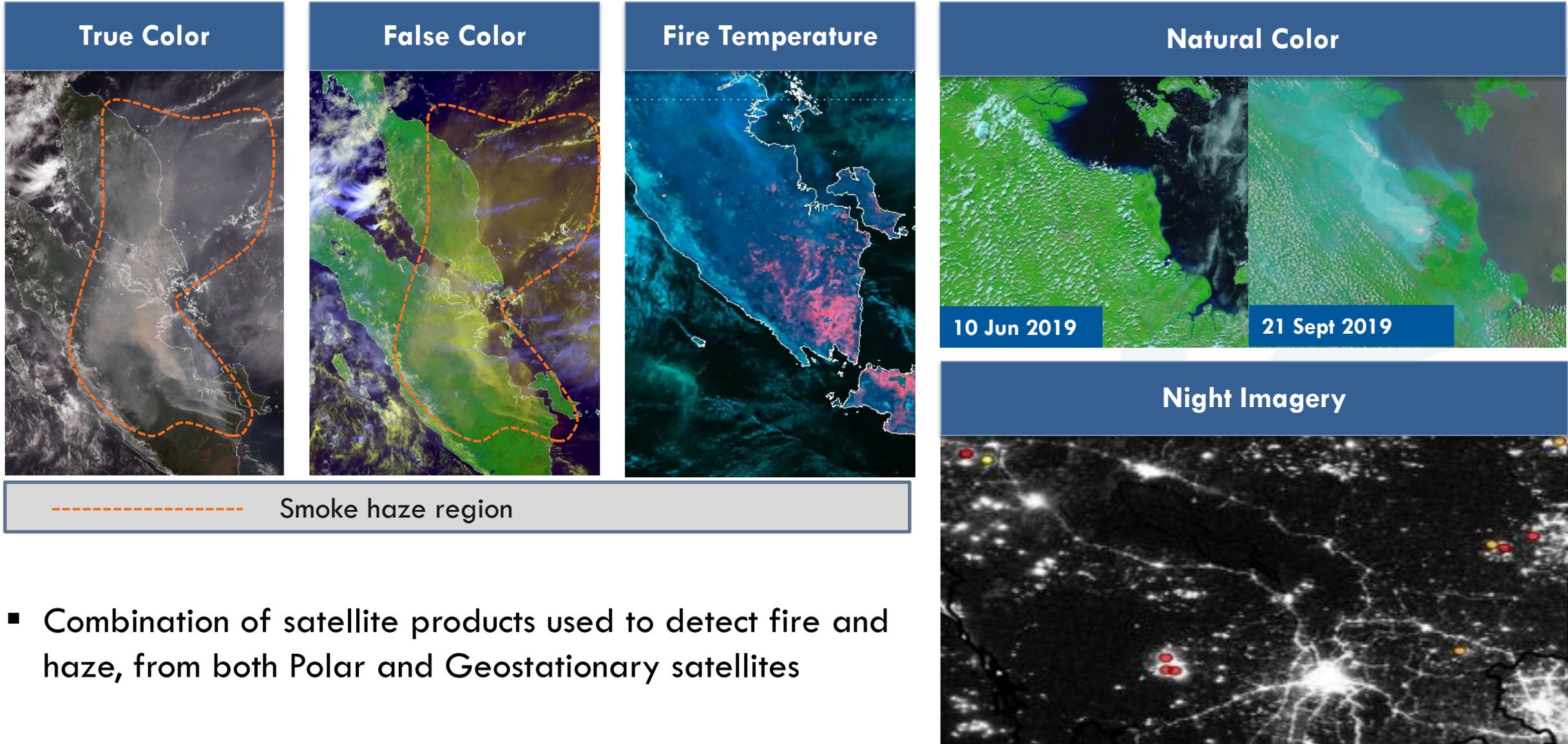
NOAA-20 True Color Imagery with hotspot overlaid



Daily/Monthly/Yearly hotspot counts on ASMC website segmented in regions

- While hotspots across all fire confidences are available on ASMC website (<https://asmc.asean.org/>), only the High Confidence hotspot counts are tracked and reported on ASEAN haze meetings.

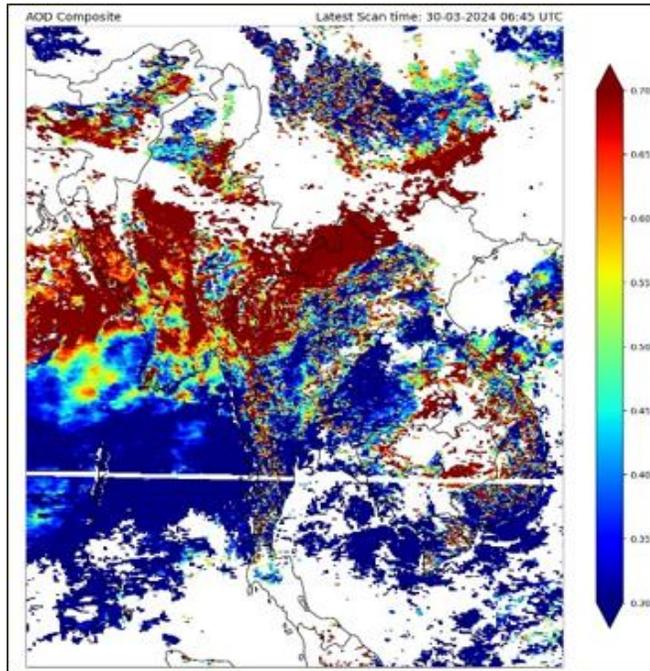
# RGB Satellite Composite for Hotspot and Haze Monitoring



# Satellite Products for Hotspot and Haze Monitoring

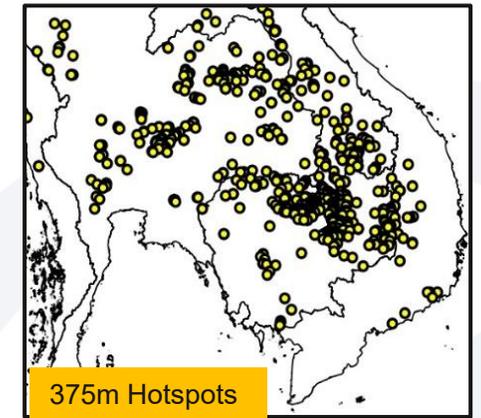
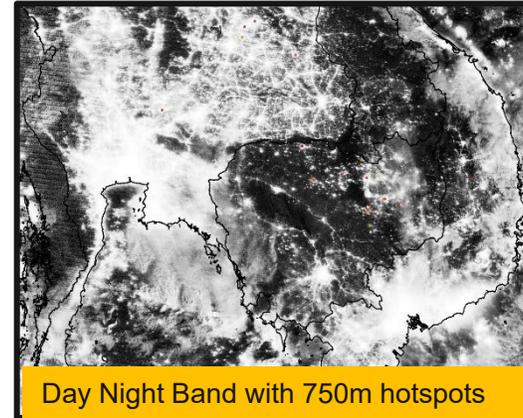
## GEMS Aerosol Optical Depth (AOD)

Describes the aerosol amount in the entire column of atmosphere

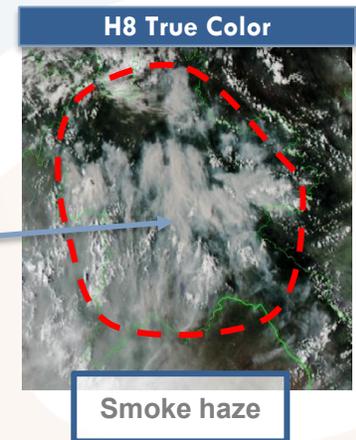
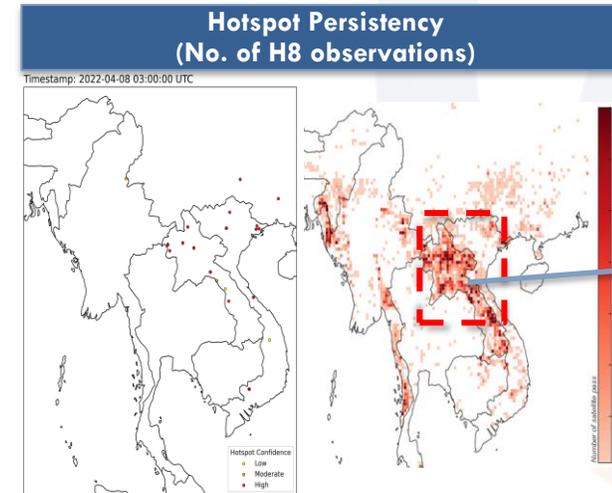


## NOAA I-Band (375m)

Higher resolution (able to detect lower intensity fire and more sensitive than 750m at night)



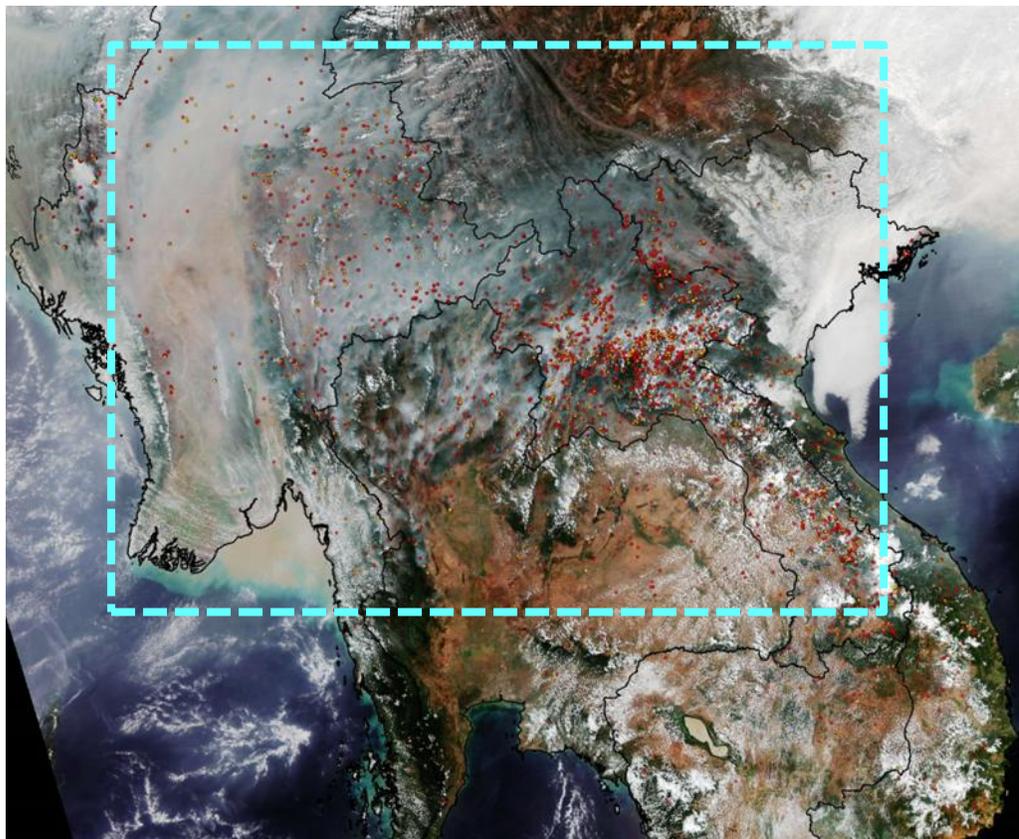
**Himawari-8/9 hotspots**  
Higher frequency, quick assessment of hotspot clusters and high persistency associated with true positives of smoke haze



# Transboundary Haze Occurrence

28 March 2025

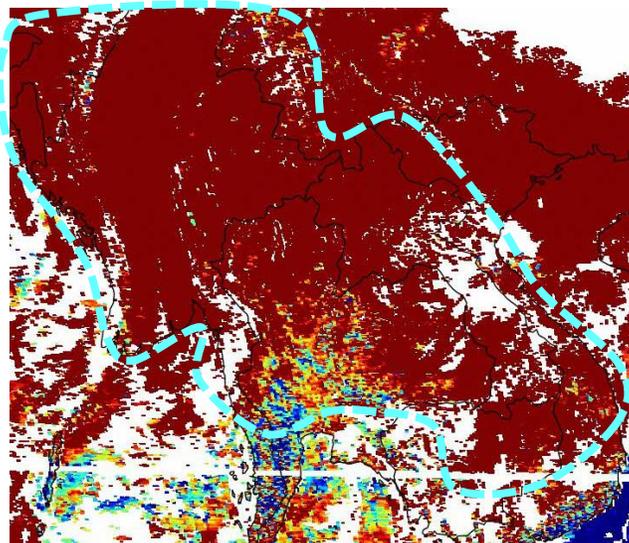
NOAA-20



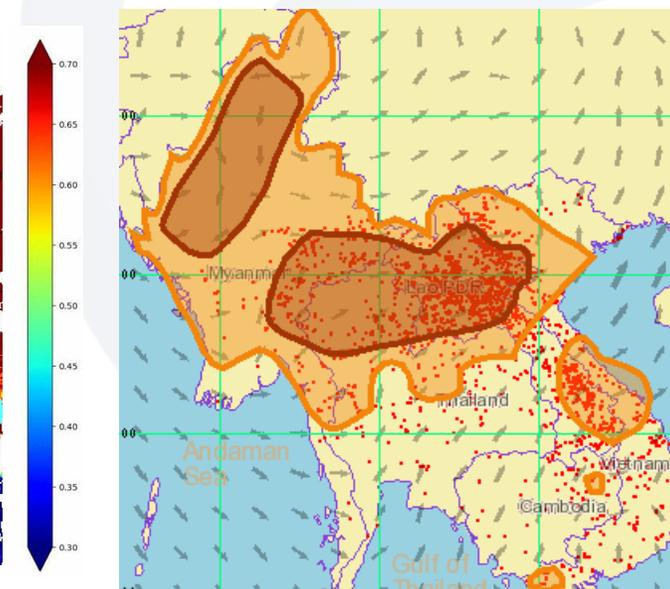
Himawari-9 hotspot and RGB animation



Aerosol Optical Depth GEMS

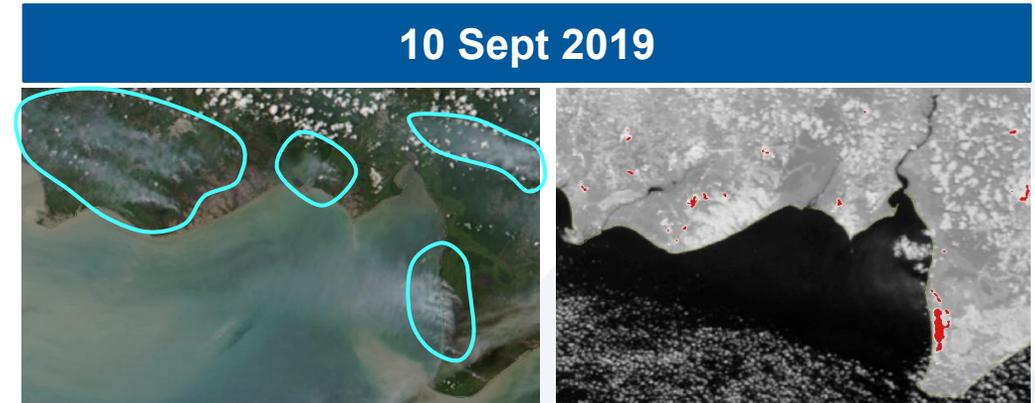


ASMC Assessments



# Burnt Area Mapping (in development)

- Burnt area mapping product for the ASEAN domain to monitor trends in total burnt area estimates
  - As opposed to exact delineation of specific burning areas
- Methodology based on using burn-sensitive Vegetation Index (VI) (Giglio (2009)) with adjustments based on Gaveau et al (2021) and using VIIRS I-band spectral channels (375m resolution).
- Ongoing work:
  - Validation against Sentinel-2 and MODIS, as well as GISTDA (Thailand) Landsat-based burnt area product
  - Calibration to Northern/Southern ASEAN fire seasons



ASMC prototype burnt area over southern Borneo. Left: True Color RGB composite showing smoke plumes. Right: Burnt areas in red.



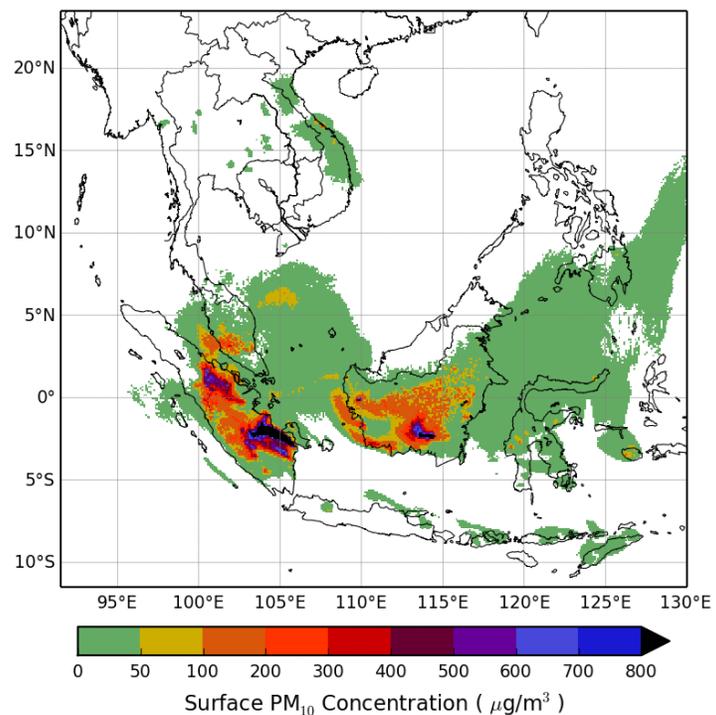
Sentinel-2 observation of Cambodia during 9 Jan 2025 (left) and 19 Jan 2025 (right). ASMC prototype burnt areas (VIIRS) with darker color indicating higher burn severity

# Short-term Smoke Haze Forecasting

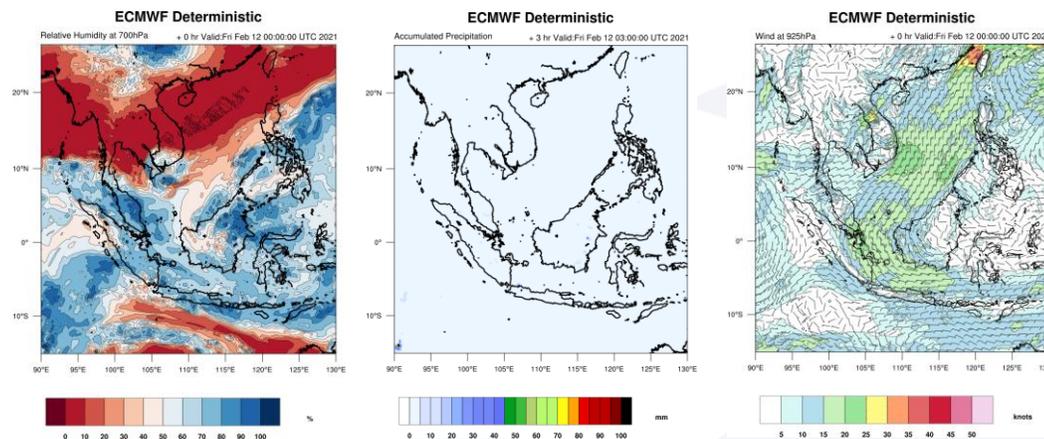
**NAME Dispersion Model (in-house)**  
 Prediction of biomass burning smoke haze affecting the ASEAN region

Surface PM10 Concentration forecast  
 21 – 24 Oct 2015

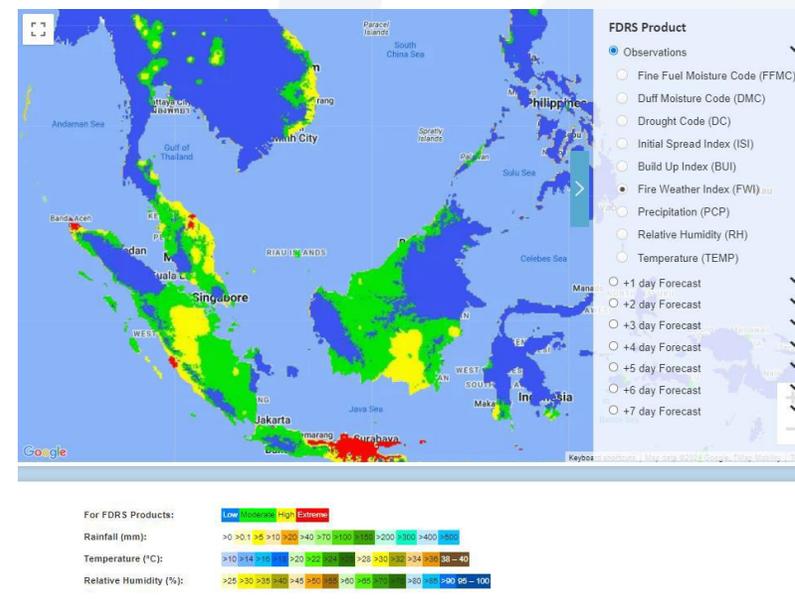
Valid 21 Oct 2015, 00:00 UTC



**ECMWF model forecast**  
 Model forecast of relative humidity, accumulated rainfall and wind direction/speed



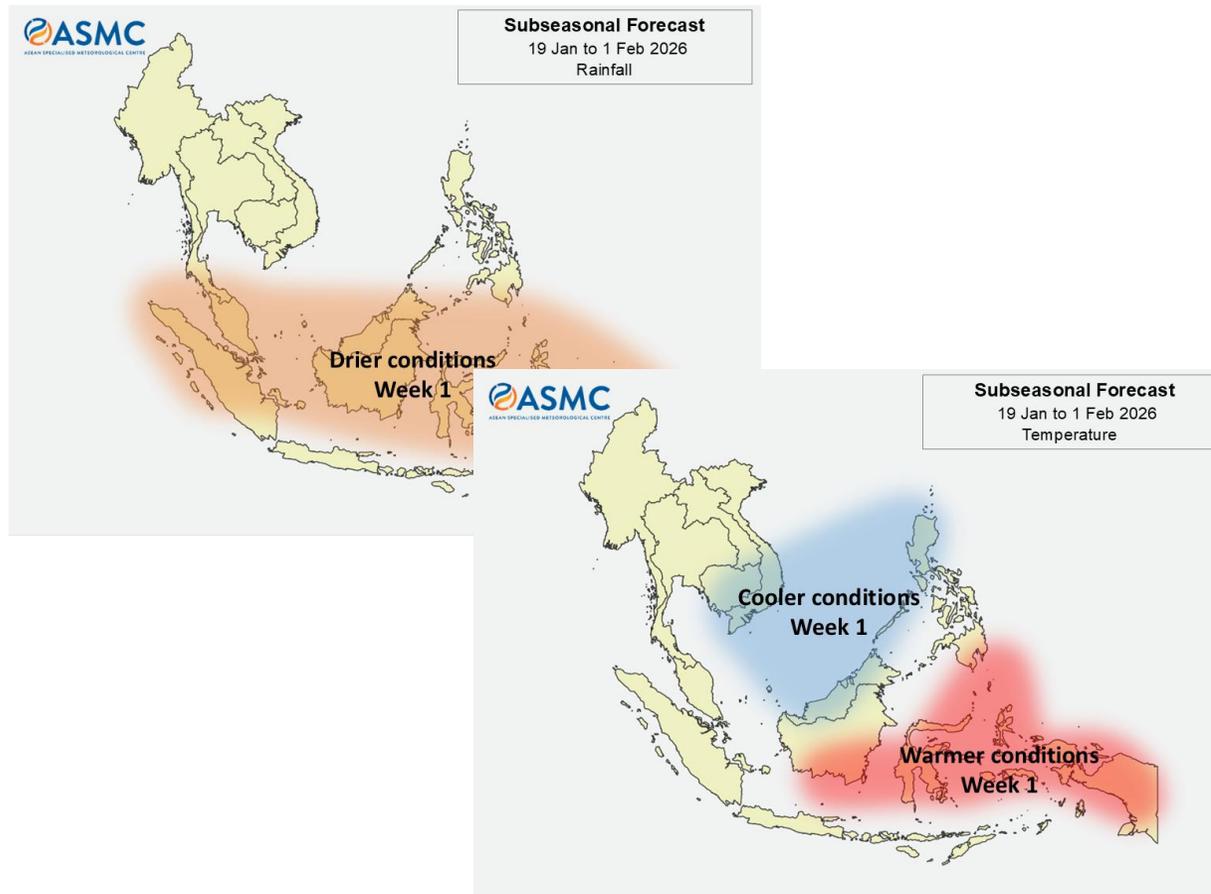
**Fire Danger Rating System**  
 (courtesy of Met Malaysia)  
 Monitors and forecast fire risk (up to 7 days) over the ASEAN region based on meteorological variables



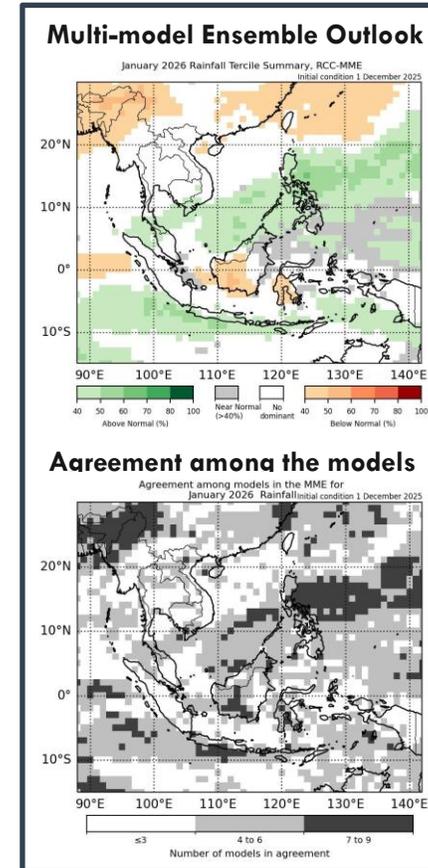
# Longer-Term Outlook: Subseasonal to Seasonal Predictions

- Subseasonal (2 weeks) to seasonal (1-3 months) outlook for rainfall and temperature

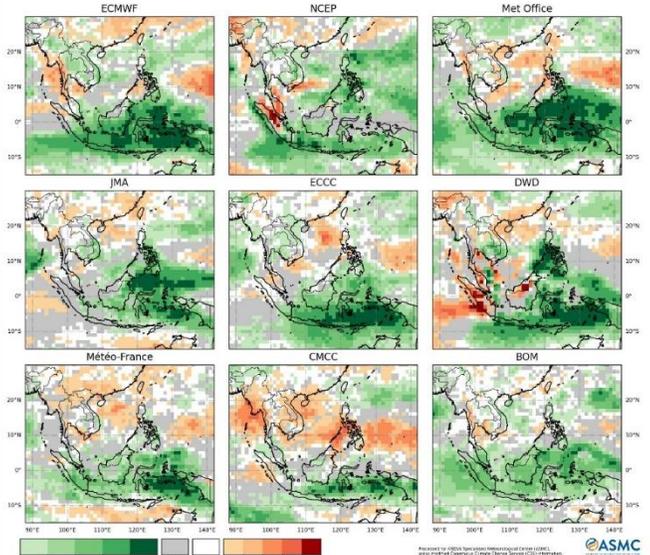
## Subseasonal



## Seasonal



## Nine models' outlook from CDS



ECMWF, NCEP,  
UK Met Office,  
JMA, ECCC, DWD,  
Météo France,  
CMCC, BOM

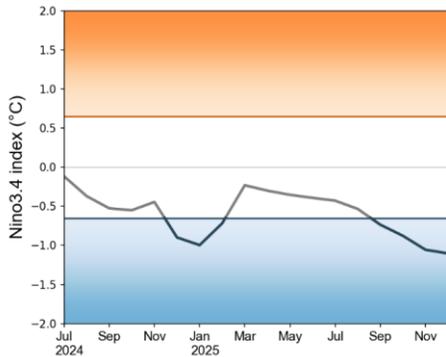
<https://asmc.asean.org/asmc-seasonal-outlook/>

Seasonal multi-model ensemble outlook combines forecasts from 9 models (Copernicus Data Store)

# Longer-Term Outlook: Climate Variability

## El-Niño Southern Oscillation (ENSO)

ASMC In-house monitoring  
(<https://asmc.asean.org/asmc-el-nino/>)

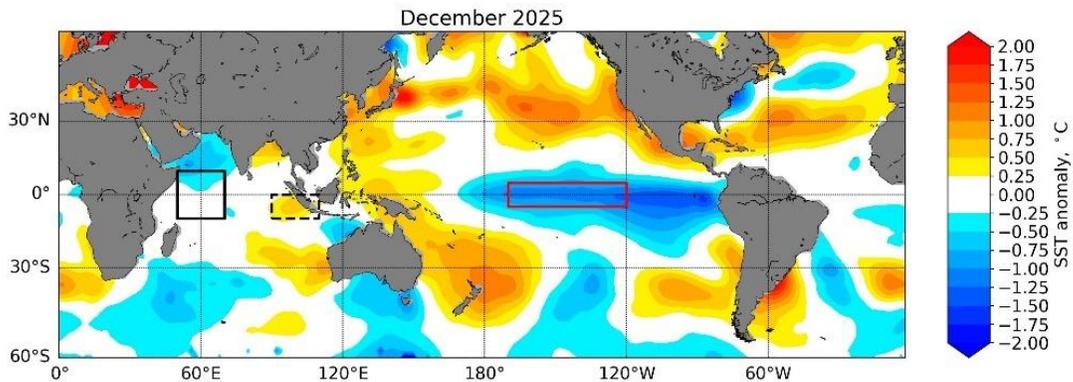


**Current state:** La Niña Conditions

**Outlook:** La Niña conditions are predicted to weaken and then transition to ENSO-neutral conditions in February – March 2026.

Trend of Nino3.4 Index to track ENSO status

Summary description and graphics of the current state and outlook of ENSO

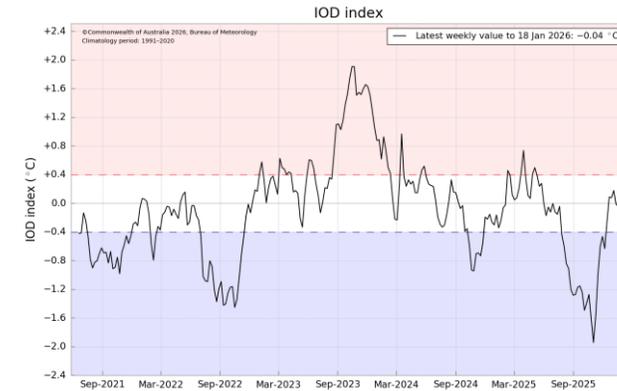


Detrended SST anomalies for December 2025 with respect to 1976-2014 climatology using ERSST v5 data

## Indian Ocean Dipole (IOD)

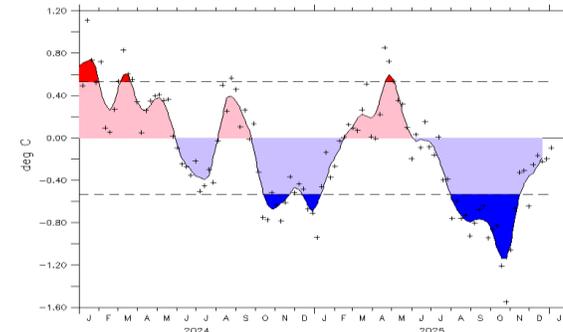
Global Sources

Bureau Of Meteorology, Australia



Bureau Of Meteorology's climate model outlook on IOD

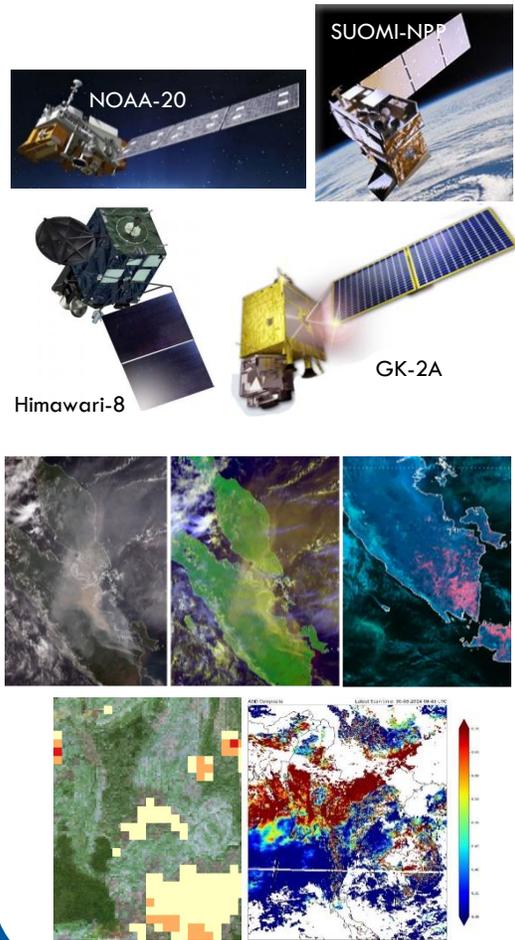
NOAA



Dipole Mode Index (DMI) across the Equatorial Indian Ocean

# Summary

## Monitoring

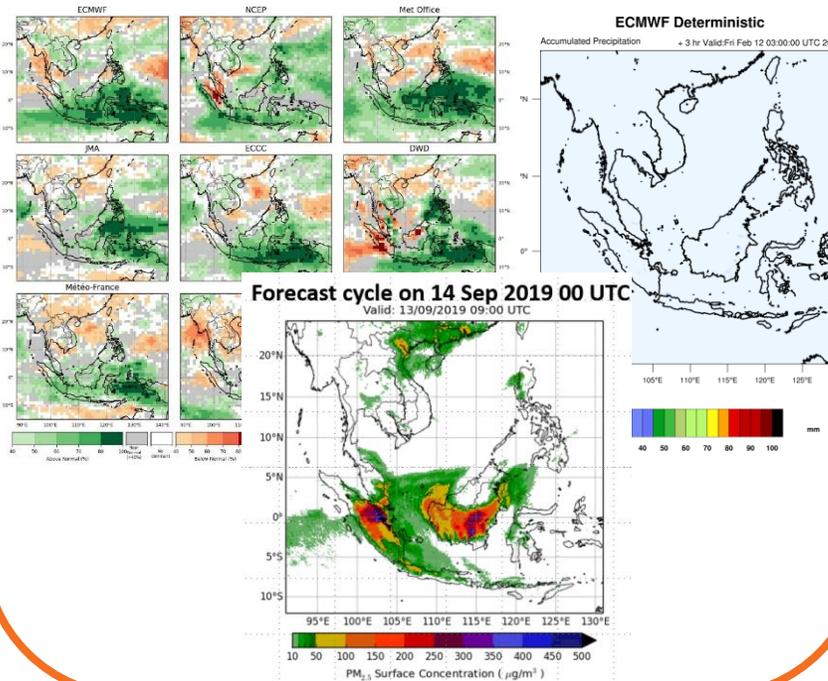


## Forecasting



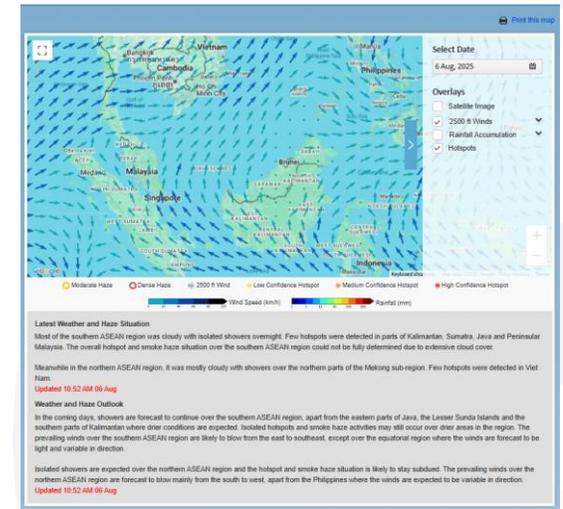
**Current state:** La Niña Conditions

**Outlook:** La Niña conditions are predicted to weaken and then transition to ENSO-neutral conditions in February – March 2026.



## Assessments/Warnings

### Regional Haze Situation



**Alert Level 2 | Activation of Alert Level 2 for the Southern ASEAN Region**  
With the activation of Alert Level 2 for the Southern ASEAN Region, the regional haze situation is updated at 0300 UTC and 0900 UTC.

<b>Level 0</b>	No transboundary smoke haze / Stand down.
<b>Level 1</b>	Dry season.
<b>Level 2</b>	Increasing risk of transboundary haze in the region: <ul style="list-style-type: none"> <li>Escalating hotspot activities with moderate to dense smoke haze observed over 2 or more consecutive days;</li> <li>Dry weather persisting;</li> <li>Prevailing winds blowing smoke haze from the hotspots towards neighbouring ASEAN countries.</li> </ul>
<b>Level 3</b>	High risk of severe transboundary haze in the region. <ul style="list-style-type: none"> <li>Significant and persistent hotspot activities with widespread moderate to dense smoke haze observed over 2 or more consecutive days;</li> <li>Dry weather persisting;</li> <li>Prevailing winds blowing smoke haze from the hotspots towards neighbouring ASEAN countries.</li> </ul>



ASEAN SPECIALISED METEOROLOGICAL CENTRE

