Haze Monitoring and Early Warning for ASEAN
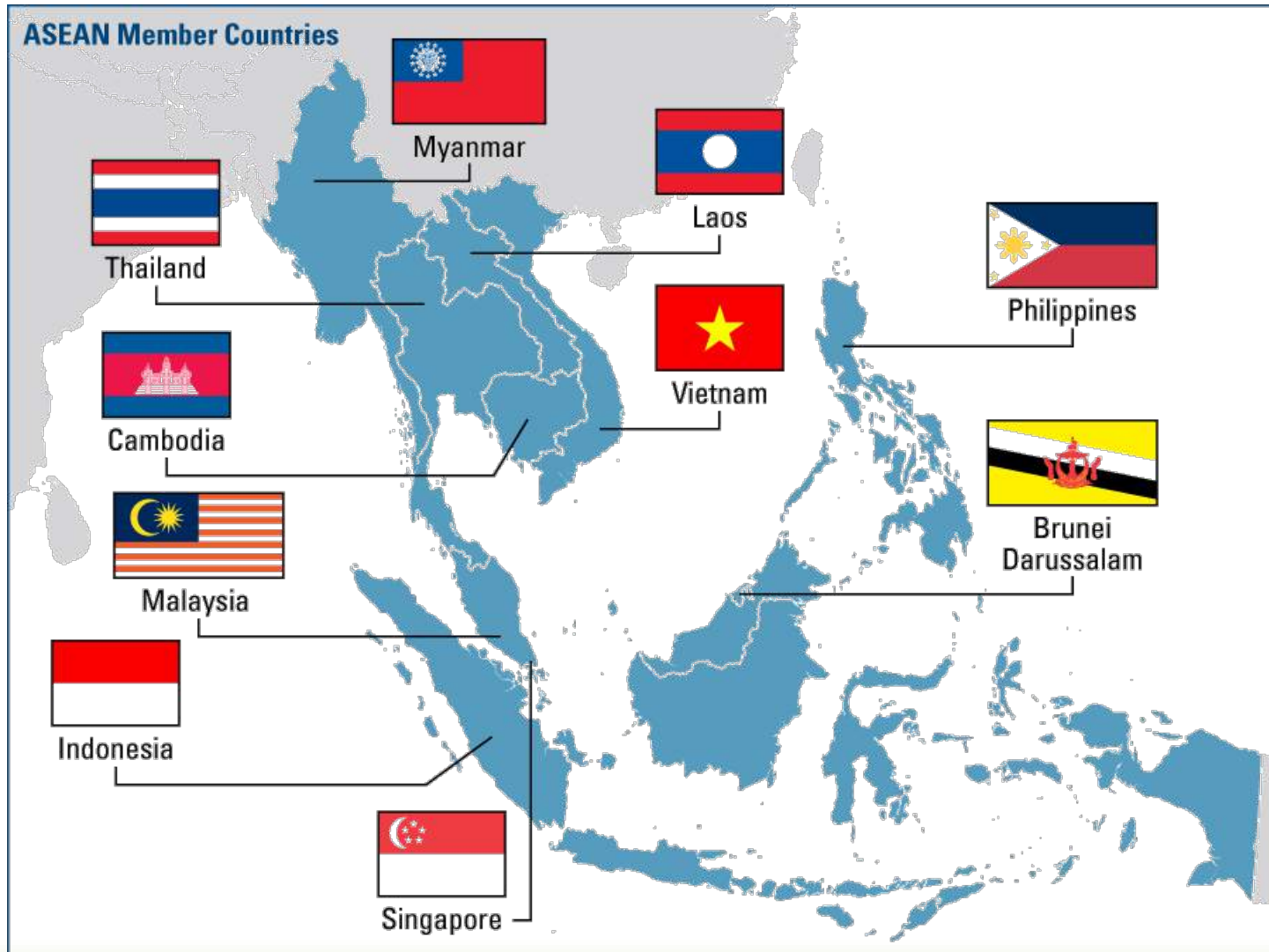
Christopher Gan

ASEAN Specialised Meteorological Centre

2017 IBBI Workshop, 10-11 July 2017, Boulder, CO, USA

Outline

i.   Background

ii. ASMC's Dispersion Modelling System

iii. Forecasting Challenges

iv. Key Initiatives and Research Activities

The Association of SE Asian Nations (ASEAN)

ASEAN Member Countries

A burning issue in Southeast Asia

- Haze has recurrently plagued the region since the early 1970s, arising from the common practice of open burning to clear land for agricultural purposes

- Fires typically occur during the traditional dry season of Jan – Apr in northern ASEAN and Jun – Oct in southern ASEAN

- Most severe haze episodes are due to peatland fires in Southern ASEAN

- Haze pollution is usually worsened by an El Niño event (e.g. 1997, 2015)
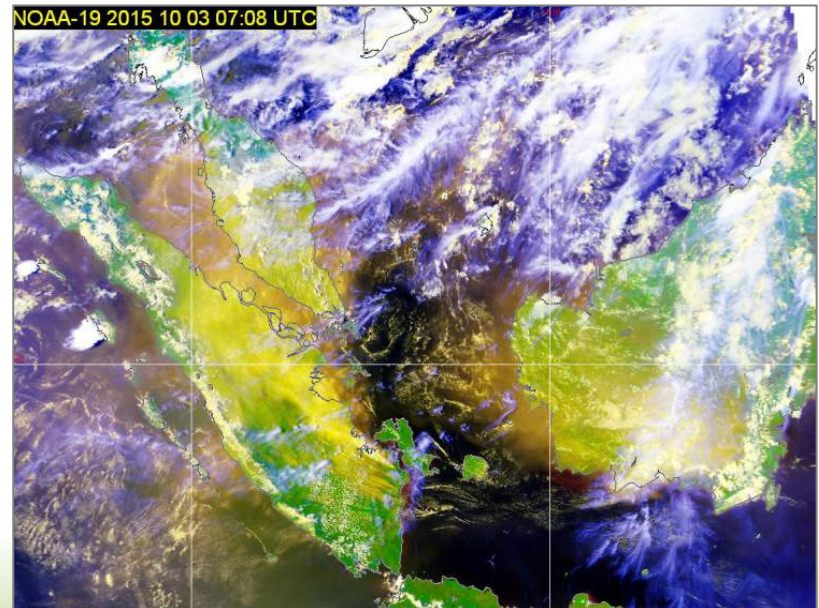
Introduction to ASMC

- Concept of the Centre first broached under WMO, in discussion with National Meteorological Services (NMSs) in ASEAN

- Officially established in 1993 as a regional collaboration programme among the NMSs of ASEAN

- Under the ASEAN Regional Haze Action Plan endorsed by the ASEAN Ministers of the Environment and implemented in 1997, ASMC was appointed to monitor and assess land and forest fires and the occurrence of transboundary smoke haze

- The area of responsibility initially covered the southern ASEAN region and was extended in 2003 to include the northern ASEAN region

ASMC's role in fire & haze monitoring

- ASMC's remit include the following:

  - Monitor and assess the occurrence of land and forest fires, and transboundary smoke haze for the ASEAN region

  - Provide alerts/warnings of transboundary smoke haze to ASEAN member states

- ASMC therefore provides operational and regularly updated information and products on the weather and smoke haze situation in the ASEAN region. Complementarily, ASMC also:

  - Conducts seasonal and climate predictions for the ASEAN region

  - Serves as a technical advisor for various inter-agency/ministerial committees, providing information related to forest fires and smoke haze

  - Provides training such as interpretation of satellite images to agencies in the region

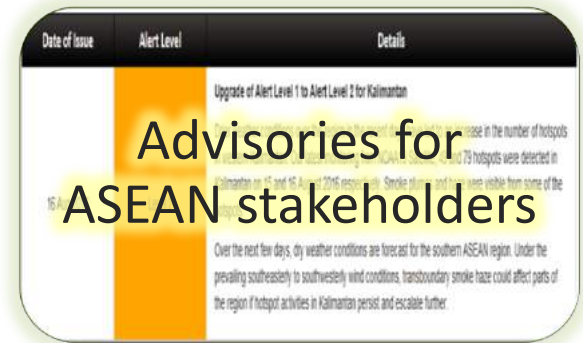- End users include the environment, forestry, meteorological and related agencies of ASEAN member states

Snapshot of *asmc.asean.org*

Regional Fire & Haze Situation

Satellite Images
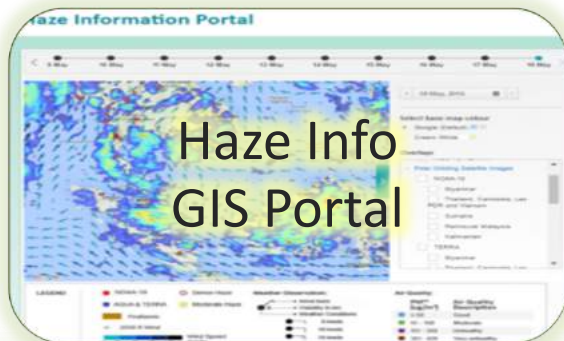
Advisories for ASEAN stakeholders

Regional Weather/ Air Quality

Fire Danger Rating System

Monthly Weather & Haze Review

Haze Info GIS Portal

Seasonal Forecast/ ENSO Outlook

ASEANCOF

Example advisories issued in 2015
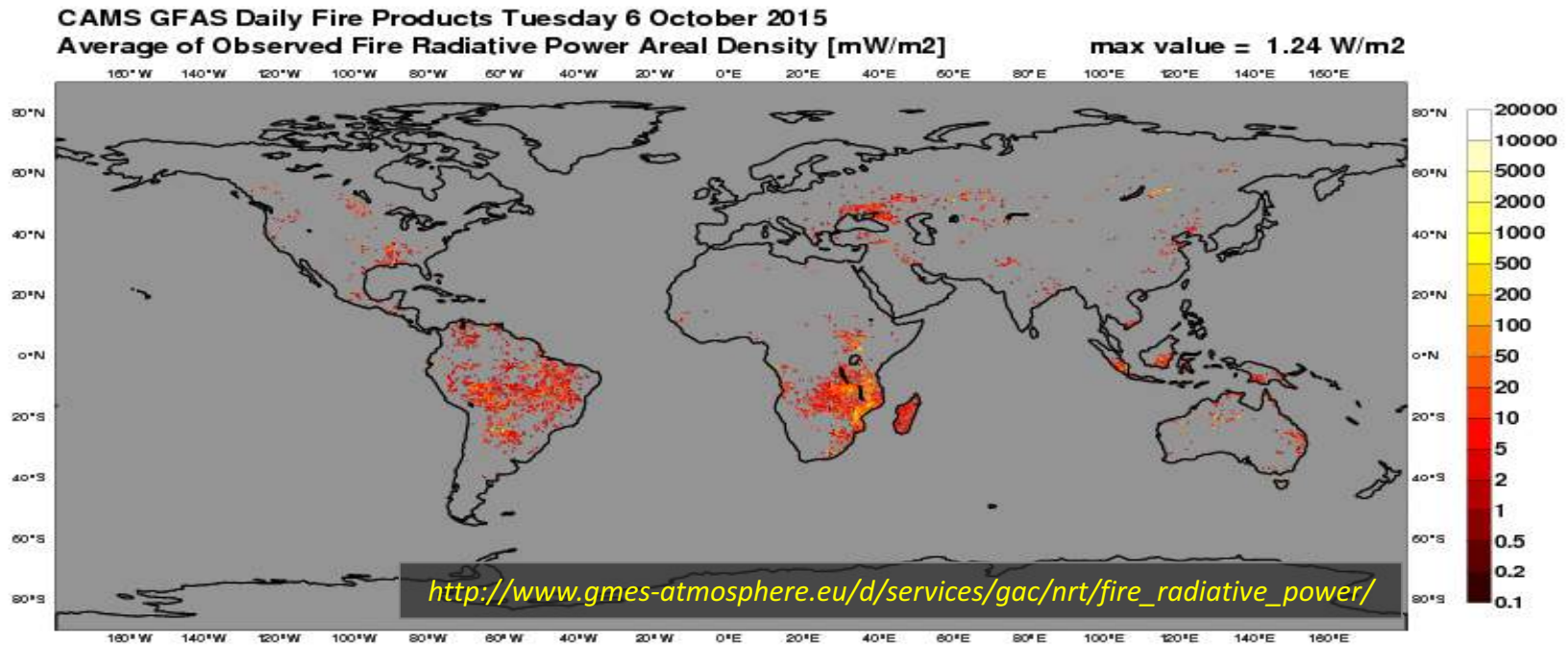
02 Sep 2015	Level 3	***Upgrade of Alert Level 2 to Alert Level 3 for Sumatra*** In the past week, the prevailing dry weather has led to a further escalation of hotspot activities over Sumatra. Increasing hotspot clusters and widespread moderate to dense smoke haze have been detected in southern and central Sumatra. Based on surveillance by the NOAA-18 satellite, 222 and 380 hotspots were detected in Sumatra on 31 August and 1 September respectively. In recent days, the smoke haze from Sumatra has spread to some parts of the region including western Peninsular Malaysia and affected the air quality there. In the coming days, the current dry weather conditions over southern and central Sumatra are expected to persist. Under the prevailing southeasterly to southerly wind conditions, transboundary smoke haze could continue to spread to some parts of the region.
18 Aug 2015	Level 2	***Upgrade of Alert Level 1 to Alert Level 2 for Sumatra and Kalimantan*** Drier weather conditions over the region in the past few days have led to an escalation in the number of hotspots in Jambi and South Sumatra, as well as in West and Central Kalimantan. 42(116) and 242(146) hotspots were detected in Sumatra and Kalimantan on 18(17) August. Smoke plumes and moderate haze were visible from some of the hotspots. Dry weather conditions are likely to persist in Sumatra and Kalimantan. Under the prevailing southeasterly or southwesterly wind conditions, transboundary smoke haze is likely to affect other parts of the region should the hotspot activities continue to persist.
23 Jun 2015	Level 1	***The dry season for the southern ASEAN region has started*** The Southwest Monsoon has onset in the region in early June 2015. In recent days, the region including Sumatra and Kalimantan have been experiencing dry weather conditions, signalling the start of the traditional dry season in the southern ASEAN region. The prevailing Southwest Monsoon is expected to persist over the next few months. The prevailing El Nino could also exacerbate the dry season. During this period, extended periods of drier weather can be expected, which could lead to elevated hotspot activities in the fire-prone areas.

ASMC's Dispersion Modelling System

ASMC's Dispersion Modelling System

- ASMC routinely runs a dispersion model to inform advisories and aid our many stakeholders to hone their risk assessment and response

- **ATLAS** – ASEAN Tropical Lagrangian Atmospheric System
  - Integrates latest available regional land cover and peatland map information for emissions estimation
  - Customised modules aimed at improving representation of atmospheric dispersion processes for tropical ASEAN region

- Developed in collaboration with the UK Met Office and various centres, and draws inputs from the Global Fire Assimilation System (GFAS) of the Copernicus Atmospheric Monitoring Service (CAMS)
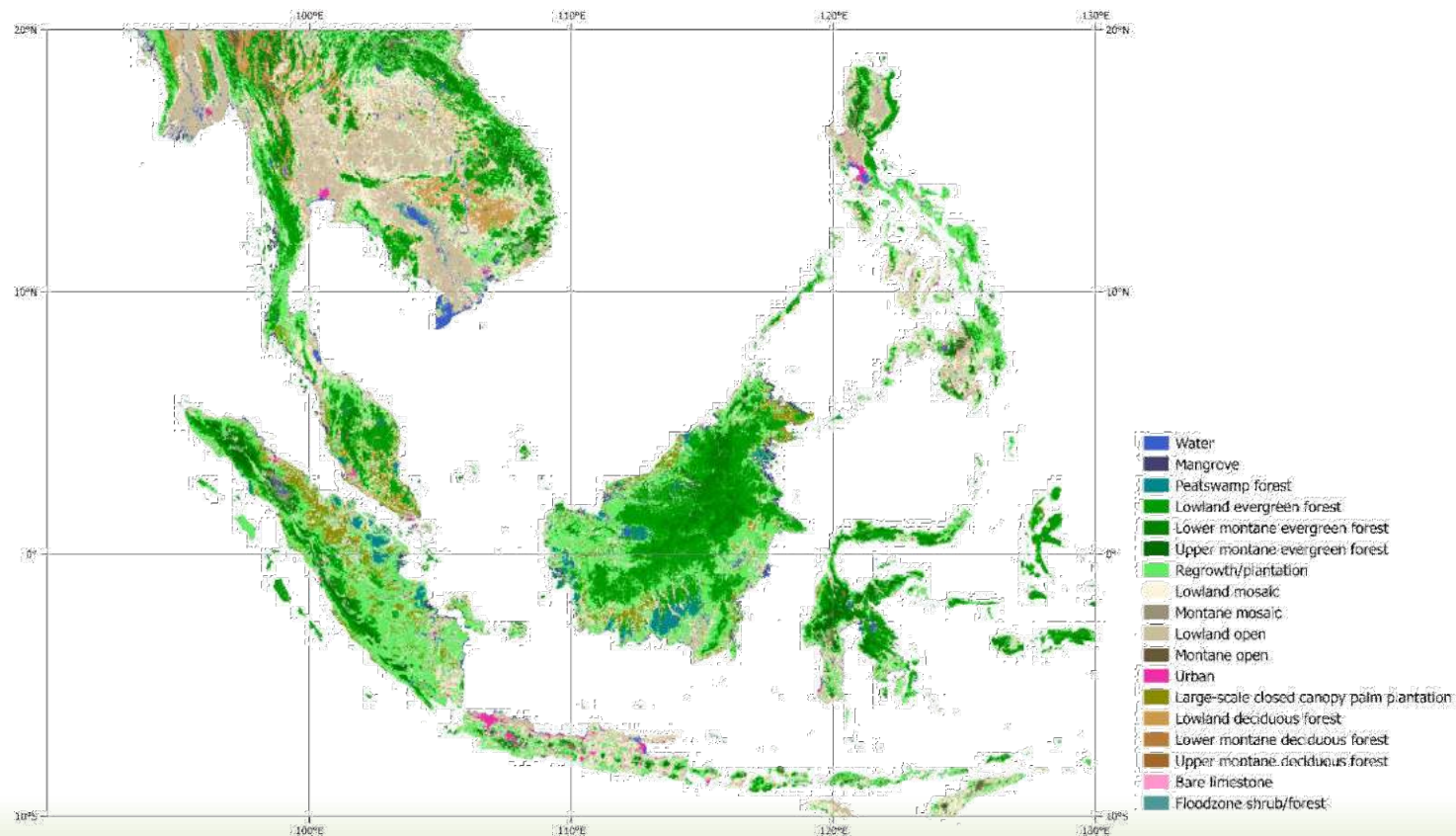
Emissions Estimation

CAMS GFAS Daily Fire Products Tuesday 6 October 2015
Average of Observed Fire Radiative Power Areal Density [mW/m2]   max value = 1.24 W/m2

http://www.gmes-atmosphere.eu/d/services/gac/nrt/fire_radiative_power/

- Fire radiative power (FRP) fields and plume height information are derived from the Global Fire Assimilation System (GFAS) of the Copernicus Atmospheric Monitoring Service (CAMS) (*Kaiser et al., 2012*)

- GFAS fields are available at 0.1° spatial resolution and values are assumed to be constant within each 24-hour window

- In the modelling system, the latest available fire information is assumed to persist into the prediction period the next day

Land cover information

- Emissions of particulate matter are derived from FRP using land cover specific conversion and emission factors
- Land cover information from public domain sources and satellite analysis, developed by the Centre for Remote Imaging, Sensing and Processing (CRISP)
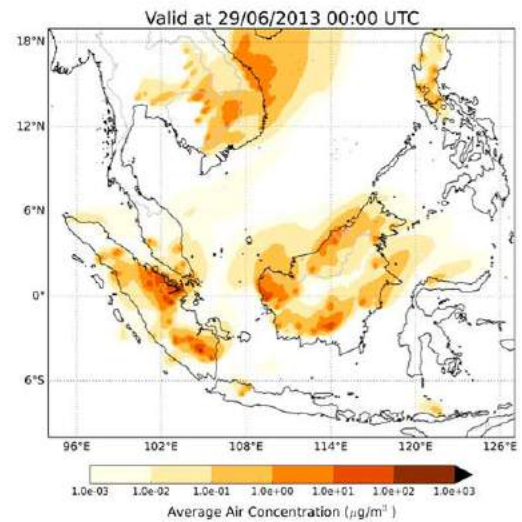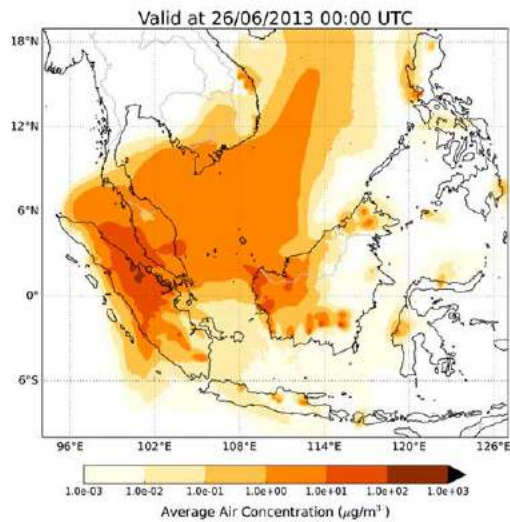

Legend:
- Water
- Mangrove
- Peatswamp forest
- Lowland evergreen forest
- Lower montane evergreen forest
- Upper montane evergreen forest
- Regrowth/plantation
- Lowland mosaic
- Montane mosaic
- Lowland open
- Montane open
- Urban
- Large-scale closed canopy palm plantation
- Lowland deciduous forest
- Lower montane deciduous forest
- Upper montane deciduous forest
- Bare limestone
- Floodzone shrub/forest

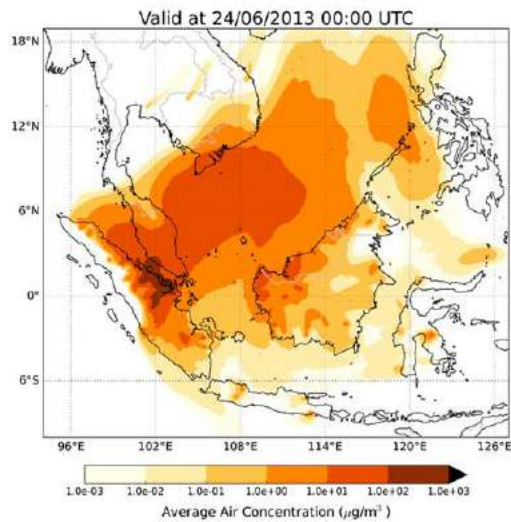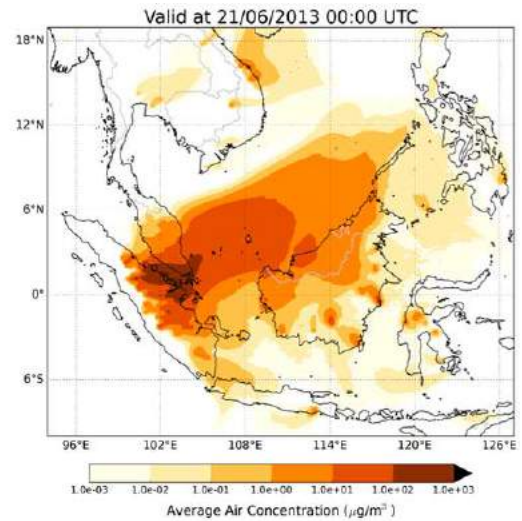*Miettinen et al., 2016*
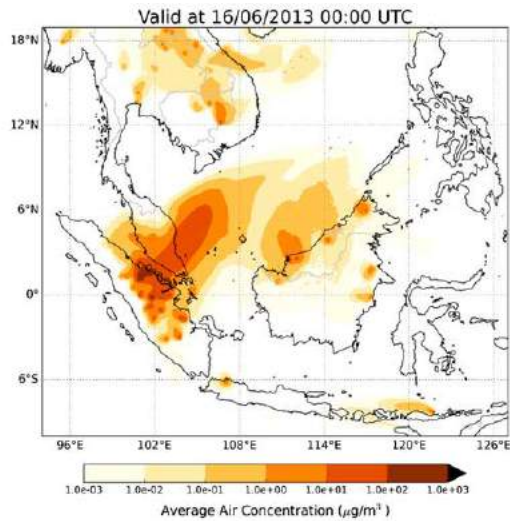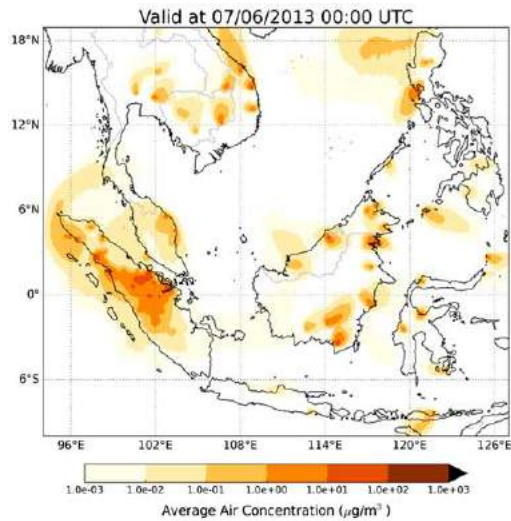
Prototype output

- Prediction of biomass burning smoke haze affecting the ASEAN region

- Estimated surface PM_{10} concentration over a 24-hour period from 00 to 24 UTC at 3-hourly intervals

- Product generally updated by 00 UTC each day, depending on number of fires and available inputs

Biomass Burning Smoke Haze Dispersion
Valid 15 Mar 2017, 00:00 UTC

Surface PM_{10} Concentration ($\mu g/m^3$)

http://www.weather.gov.sg/files/msscommunity/asmc/index.html
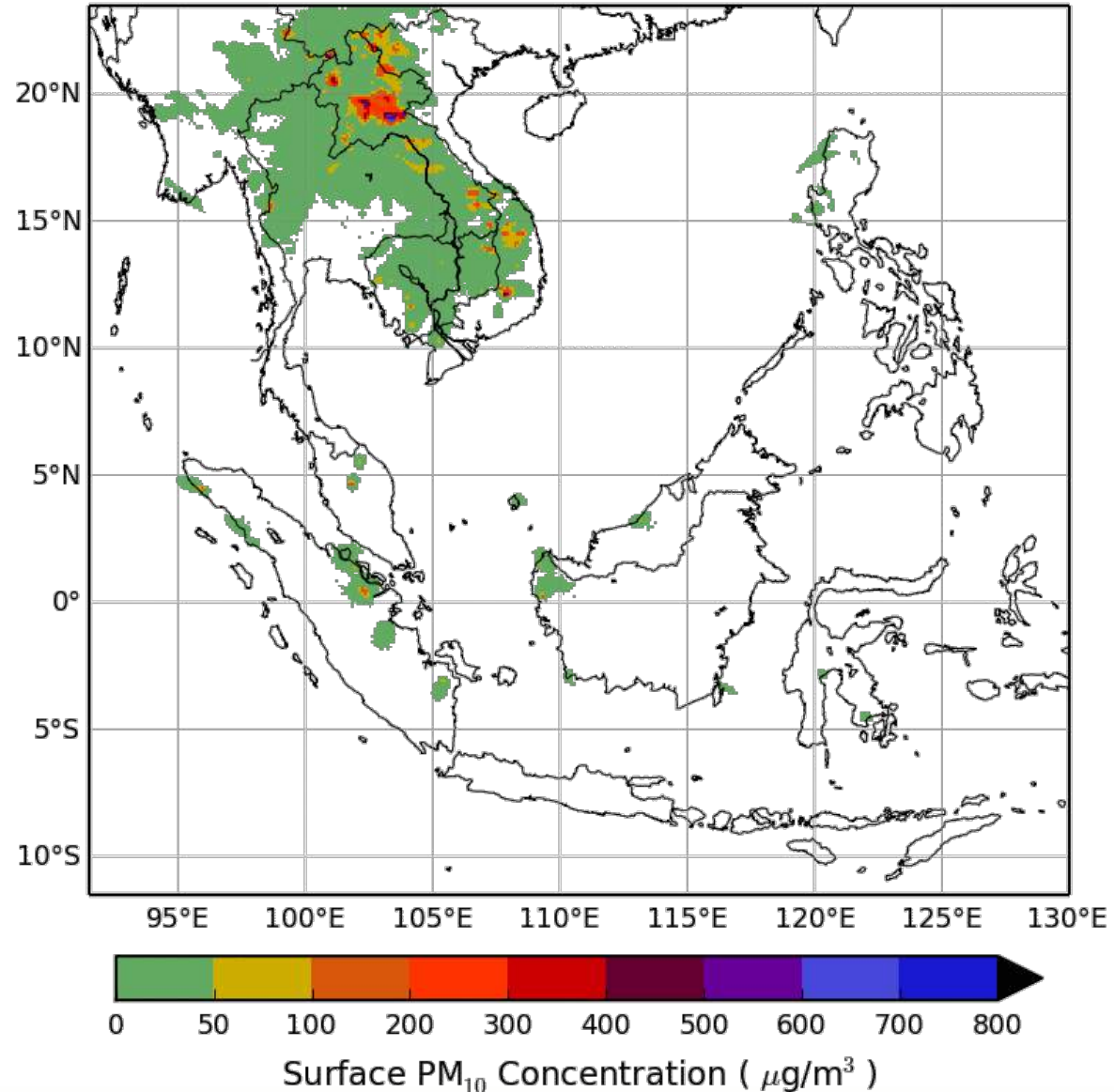
Jun 2013 validation study

Hertwig et al. 2015

Smoke haze episodes in North Thailand during early 2013 (left column) and 2014 (right column) at four observation sites

Modelled and observed PM$_{10}$ concentrations represent daily averages

Site-specific scaling factors have been applied to the modelled outputs

Hertwig et al., 2015
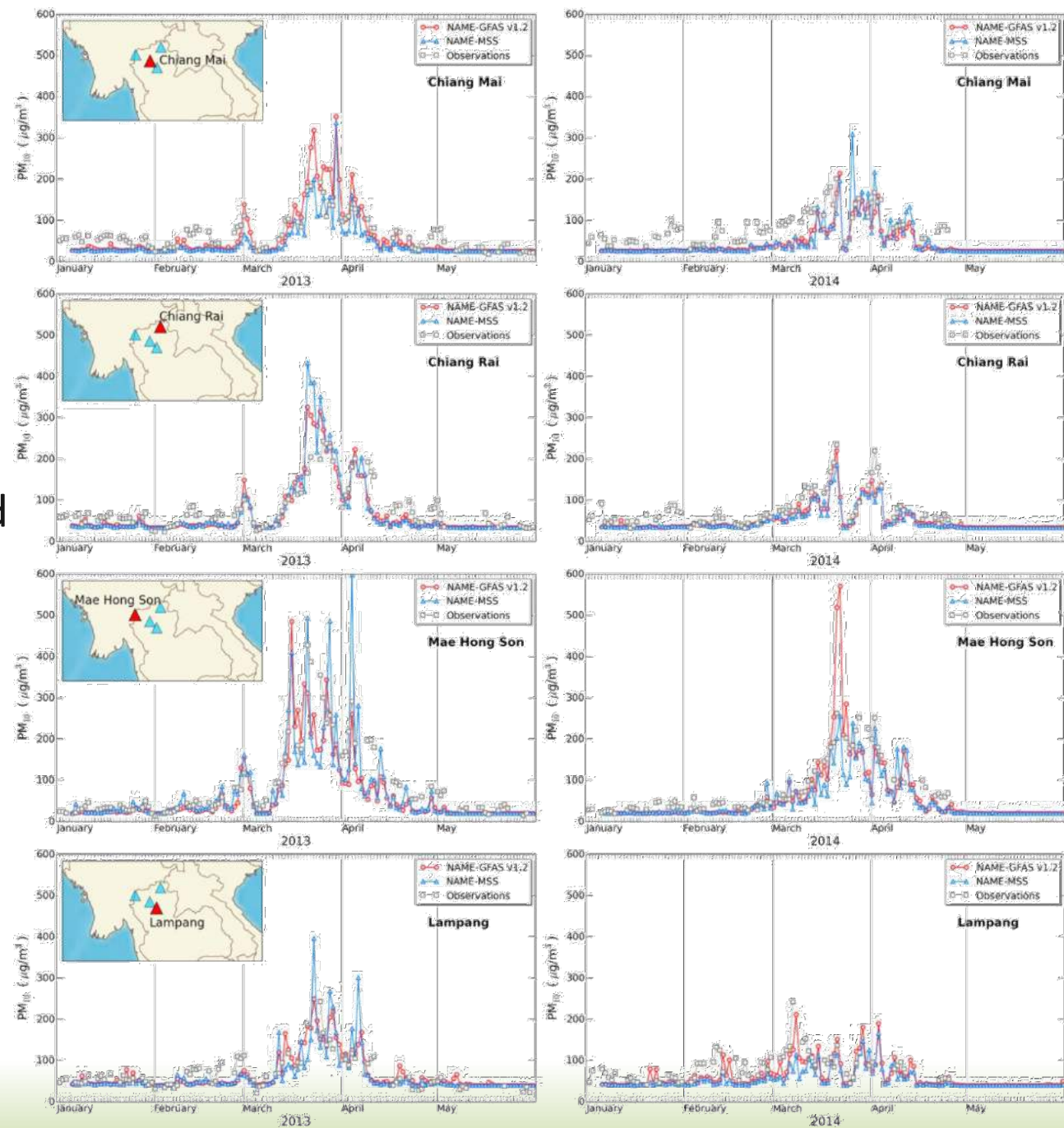
Forecasting Challenges

Nature of fires

- Fires can sometimes be underestimated due to obscuration by cloud cover and thick smoke haze, or when more recently ignited fires are not captured by satellites during their pass

- Smouldering peat fires can also emit large quantities of smoke but can be difficult to detect as they have low thermal signatures and often burn beneath the ground surface

- Propagation of land and forest fires in the region is not well understood and difficult to quantify
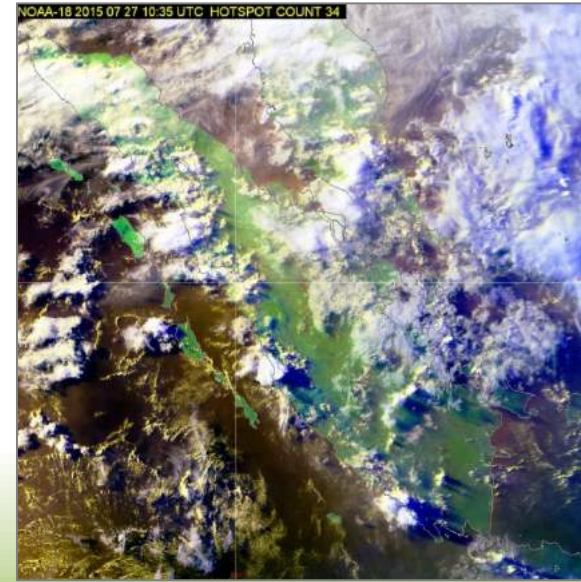
Tropical dynamics

- The tropics poses challenges for prediction; in the form of local wind flows (e.g. land-sea interactions), and transient, small-scale weather systems such as localised thunderstorms

- Modelling of atmospheric chemistry in the region is not well established and requires calibration of schemes originally designed for mid-latitudes

Key Initiatives and Research Activities

ASEANCOF

- Part of WMO Global Framework for Climate Services (GFCS)

- Key output: **Consensus** climate outlooks

- RCOFs provide platforms for climate experts/information users to discuss
  - Climate status
  - Scientific developments
  - End-user requirements

- 8 ASEANCOFs conducted
  - Coordinated by ASMC and host country
  - 1st (Nov 2013), 3rd and 5th in Singapore
  - 4th in Jakarta
  - 2nd, 6th and 8th online (Skype, email)
  - 7th in Manila (Nov 2016)

Image credit: WMO

E.g. tercile probabilistic forecasts for rainfall and temperature
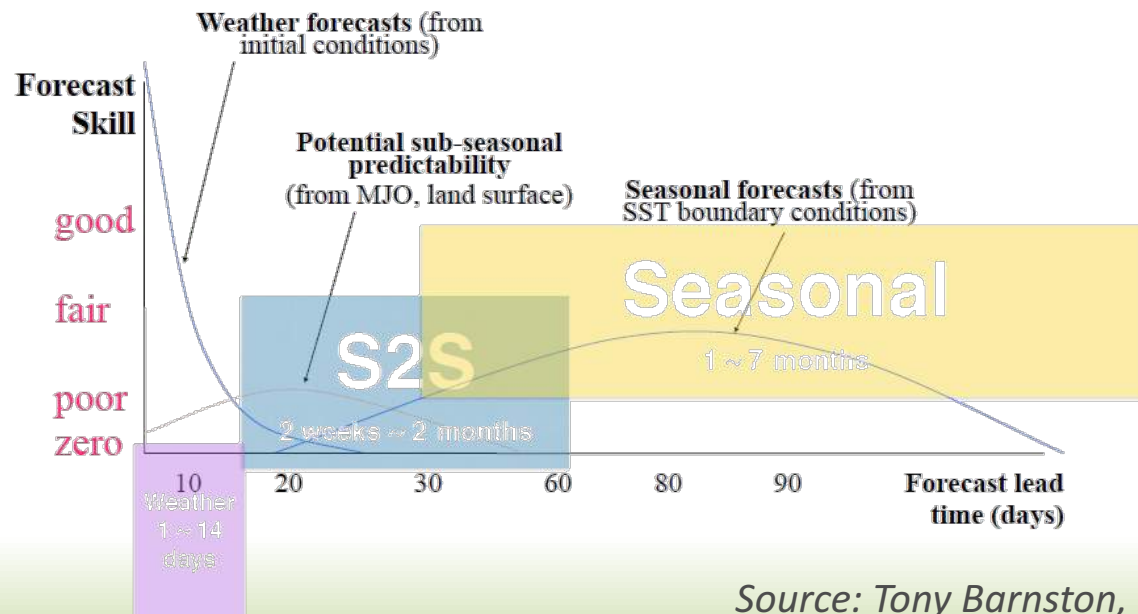
S2S Project

- Subseasonal-to-Seasonal (S2S) prediction project
  - WMO WWRP/WCRP joint research initiative aimed at improving forecasts and understanding on the S2S scale
  - Important applications in water resources, agriculture, disaster-risk reduction, and health where decision-making processes depend on forecasts that span the timescale

Source: Tony Barnston, IRI

S2S-SEA

- S2S capability building programme for ASEAN led by ASMC
  - First of four workshops held in Mar 2017, with participation from all ten ASEAN countries and S2S international experts

- **Potential S2S applications for haze:**
  - The timing and severity of SE Asia haze events have been shown to be influenced by MJO & ENSO – two key drivers of S2S predictability
  - Improve lead time for early warning to stakeholders of potential escalations in fire activity
  - Enable better planning, mitigation and response to fire occurrence and haze events

Product Development

S2S-SEA IV

S2S-SEA III

S2S-SEA II

S2S-SEA I (Mar 2017)

Research

Cutting-edge NWP for the tropics

- Light and variable winds in the tropics, and the dominant short-lived and small-scale thunderstorms pose a significant challenge to NWP models

- Ongoing research programme to build a **tropical convective-scale** NWP system for improving weather forecasts over Southeast Asia

- New system will lead to enhancements in severe weather warnings, risk management for water resource and air traffic management, and provide **high-resolution meteorological inputs for dispersion modelling**

- Two significant future developments
  - Data Assimilation: Improves model initial conditions and forecasts
  - Ensemble forecasting: Provides forecast uncertainty estimates