26th International Congress on Modelling and Simulation, Adelaide, SA, Australia, 30 Nov–4 Dec 2025
mssanz.org.au/modsim2025

Biogenic and anthropogenic contributions to air quality extreme events in urban centres in Southeast Asia

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Abstract: Southeast Asian countries suffer from high levels of air pollution which often becomes particularly severe during wildfire season. The common practice of land clearing through fire for agriculture, combined with the dry conditions of the southwestern monsoon, leads to an increase in forest fires across the region. This results in hazy conditions almost every summer, posing severe consequences for human health. Southeast Asia experienced especially severe episodes of wildfire induced haze in 2019. Climate change is projected to exacerbate these episodes of poor air quality, as weather conditions favouring the ignition and spread of wildfires are expected to occur more frequently and intensely.

With the atmospheric chemistry transport model EMEP MSC-W (Simpson et al, 2012) coupled with the weather and research forecast model (WRF, Skamarock et al., 2019) applied to Southeast Asia we can determine the relative impact of different sources of air pollution, both for current and projected future conditions. For current conditions we use the EDGAR 6.1 global air pollutant emissions dataset (Monforti Ferrario et al., 2022) and for wildfire emissions the data from the FINN2.5 earth-observation based fire emissions inventory (Wiedinmyer et al., 2023). For future wildfire conditions, we develop wildfire emission projections for several pollutants including CO_2, CO, NO, NO_2, SO_2 NH_3, CH_4, $PM_{2.5}$ and VOCs based on the SSP5-RCP8.5 scenario calculations of the ISIMIP3b models. We analyse the emergence, development and dissolution of air quality extreme events during the September 2019 wildfires in three major cities in Southeast Asia – Kuala Lumpur, Singapore and Jakarta – using the following emission scenarios for Southeast Asia:

- **Anthropogenic + biomass burning** – representing the most realistic reconstruction of atmospheric conditions for the year 2019.
- **Anthropogenic only** – biomass burning excluded, to isolate the impact of fire emissions.
- **Biogenic only** – both anthropogenic and biomass burning excluded, retaining only natural background sources.

The study demonstrates that episodes of extreme air quality are well captured, considering the limitations of horizontal resolution and the accuracy of the input data.

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Keywords: *Atmospheric chemistry transport modelling, Air Quality, Air Pollution, wildfire, biomass burning, climate change*