Interaction between biomass-burning aerosol and clouds under different climate/weather regimes

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1. Motivation

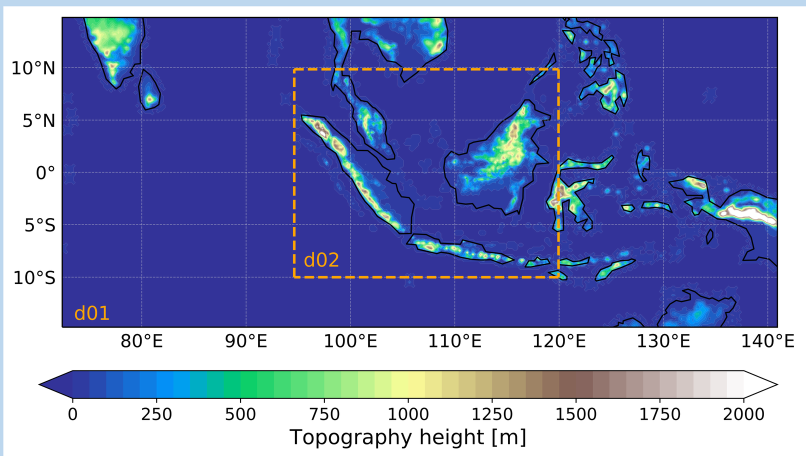
Impacts of biomass burning particles on weather and climate remain uncertain. Although emissions of biomass burning particles are seasonal and quite heterogeneous in space and time, they can be a dominant source of particles in some regions, and their impacts on the local weather and regional climate through radiation and clouds need to be assessed. Therefore, this study focuses on the impacts of aerosols emitted by biomass burnings over Southeast Asia (SEA) and aims to answer the following questions:
(a) How are cloud properties and surface precipitation affected by varying emissions of biomass burning aerosols?,
(b) How are the above processes represented in models?, and
(c) What is their long-term significance of biomass-burning aerosols in regional climate?

SEA typically observes two peaks in the emissions of biomass-burning particles each year: March-April over the Indo-China peninsula, and September-October over Maritime Continent (MC). We focus on the latter, as the geographical configuration of MC makes it possible for us to isolate the biomass burning effects aside from other particles' impacts. Due to its location, however, MC is also impacted by multiple climate variabilities such as ENSO.

There have been some modeling studies focusing on aerosol-cloud interaction over MC, but most have used relatively coarse horizontal resolutions. This study uses cloud-resolving simulations over MC and further examines the detailed mechanisms of aerosol-cloud interaction over MC suggested by Lee & Wang (2020).

2. WRF-CHEM Simulations

- Weather Research and Forecasting (WRF) model [Skamarock et al., 2008] coupled with Chemistry [Grell et al., 2005]
- Simulation settings:
  - Period: September 2015, preceded by a month-long spin-up period
  - Domain:

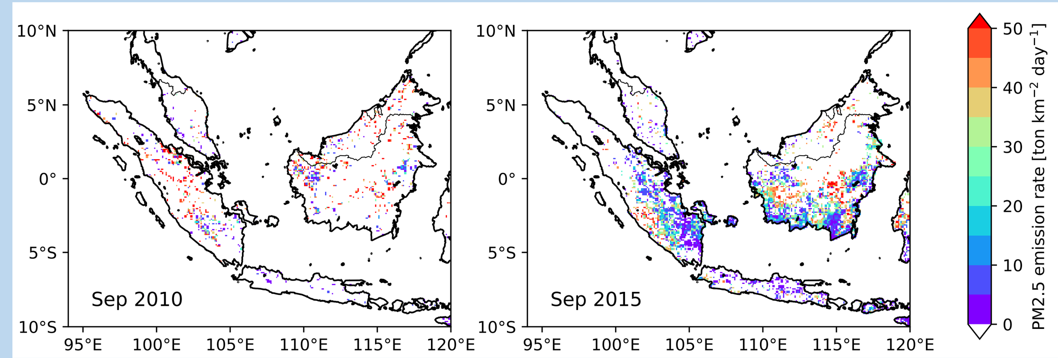


◂ Figure 1:
Terrain height [m] over the parent (d01) and nested (d02) domains for our WRF-CHEM simulations.

  - Resolution: 20 km (d01), 4 km (d02)
- Meteorology input: NCEP-FNL, 1° × 1°
- Anthropogenic emission data: Regional Emission inventory in ASia (REAS) version 2.1 [Kurokawa et al., 2013], 0.25° × 0.25°
- Four Dimensional Data Assimilation (FDDA)
- Morrison two-moment microphysics scheme [Morrison et al., 2009]
- Fire Inventory from NCAR (FINN) [Wiedinmyer et al., 2011], 1 km × 1 km

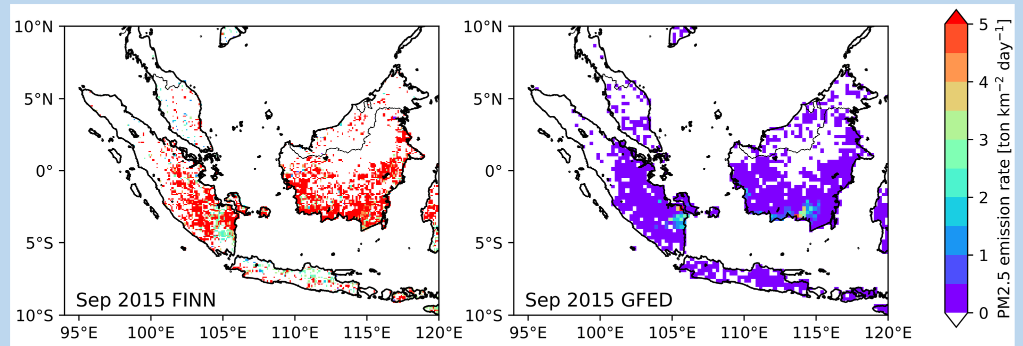
3. Variabilities

How long particles remain in the atmosphere depends on <u>variability in wash-out (i.e., precipitation)</u>
→ **variability in climate/weather regimes**
But emissions of biomass-burning particles also vary, depending on month, year, emission estimates, etc.
Comparison of simulations with…
1. FIRE vs. NOFIRE
   e.g., How are cloud properties different, if there were no fires?
2. Same month (September), different years
   e.g., 2010 vs 2015 FINN…? (Figure 2)



◂ Figure 2:
PM2.5 emission rates [ton/km²/day] in FINN for September 2010 (left) and 2015 (right). These are the simple averages of all daily emission rates observed in 9/1 - 9/30 within each 0.1° × 0.1° box.

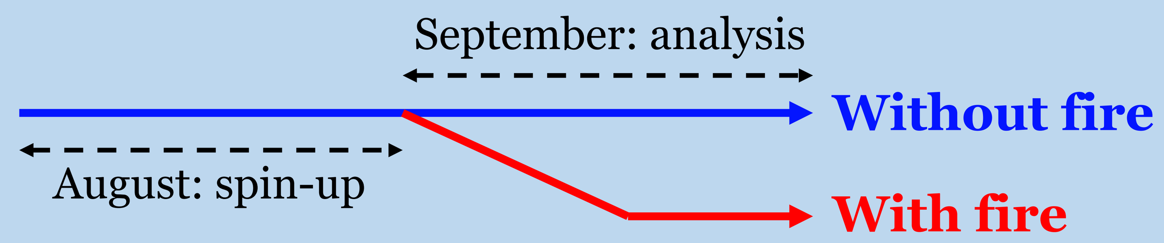
3. Other biomass-burning emission data for the same month & year
   e.g., FINN vs. Global Fire Emission Database (GFED, 0.25° × 0.25°) [Giglio et al., 2013] (Figure 3)



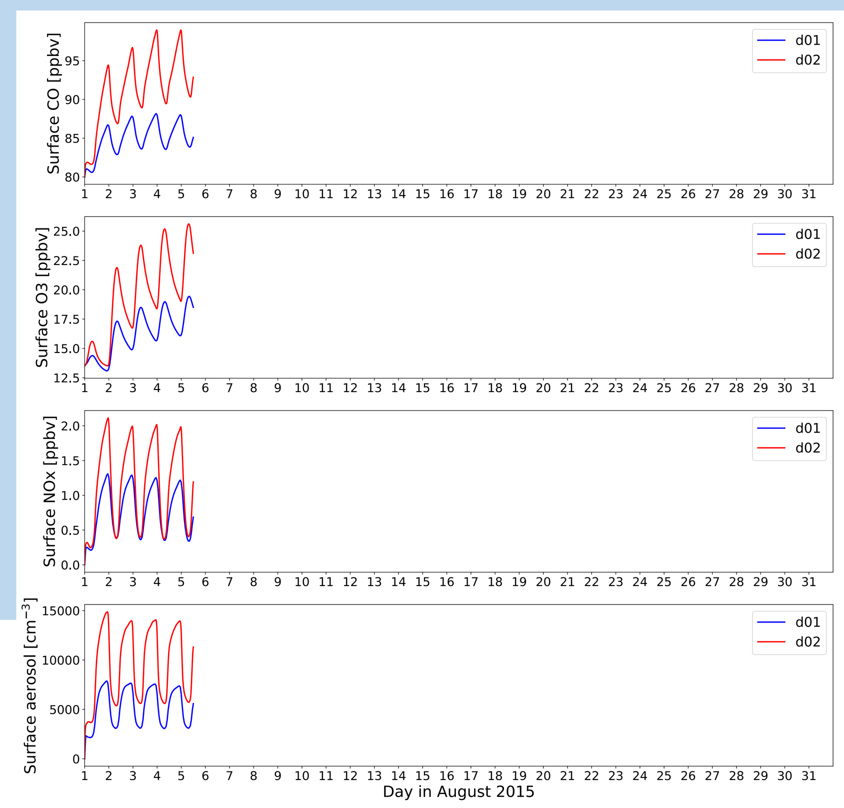
◂ Figure 3:
PM2.5 emission rates [ton/km²/day] in FINN (left) and GFED (right) for September 2015. For FINN, all daily emission rates observed in 9/1 - 9/30 were averaged within each 0.1° × 0.1° box. For GFED, monthly emission rates were split by 30 to obtain approximate mean daily emission rates. Note the difference in resolution.

4. Preliminary Simulation Results (<u>still spinning up</u>)

Our simulation is **still spinning up** chemistry (~20% done):



Approximate time to spin up:
CO: ~2 months
O_3: ~3 weeks
NO_x: ~day
Aerosols: a few days - 2 weeks



▸ Figure 4:
Time series of surface-level mean CO [ppb], O_3 [ppb], NO_x [pbb] and aerosol concentration [cm⁻³] averaged over the parent (d01) and nested (d02) domains.

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