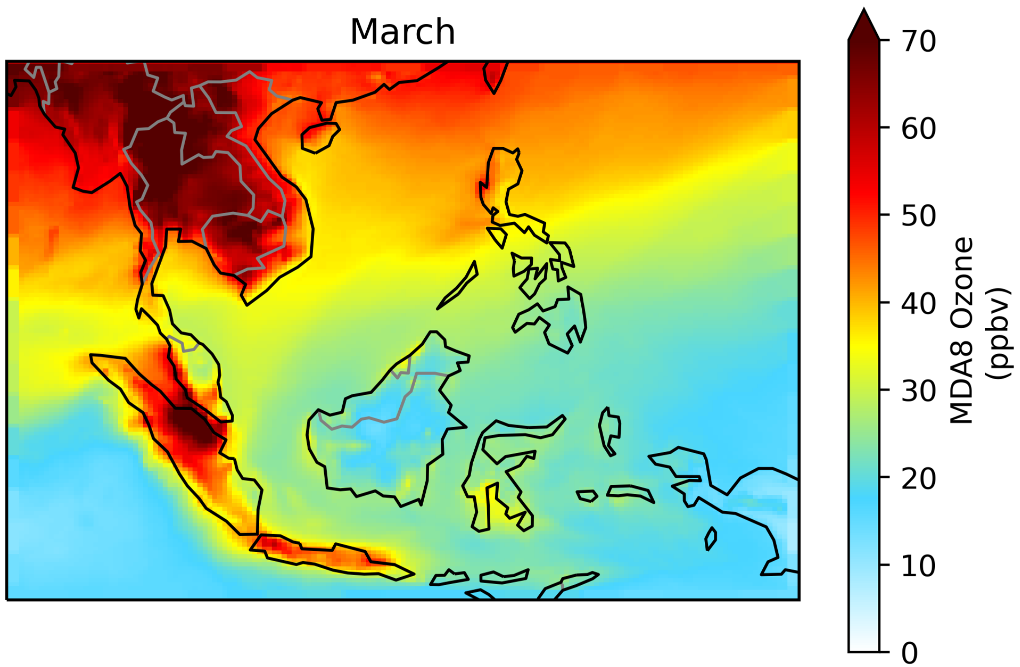
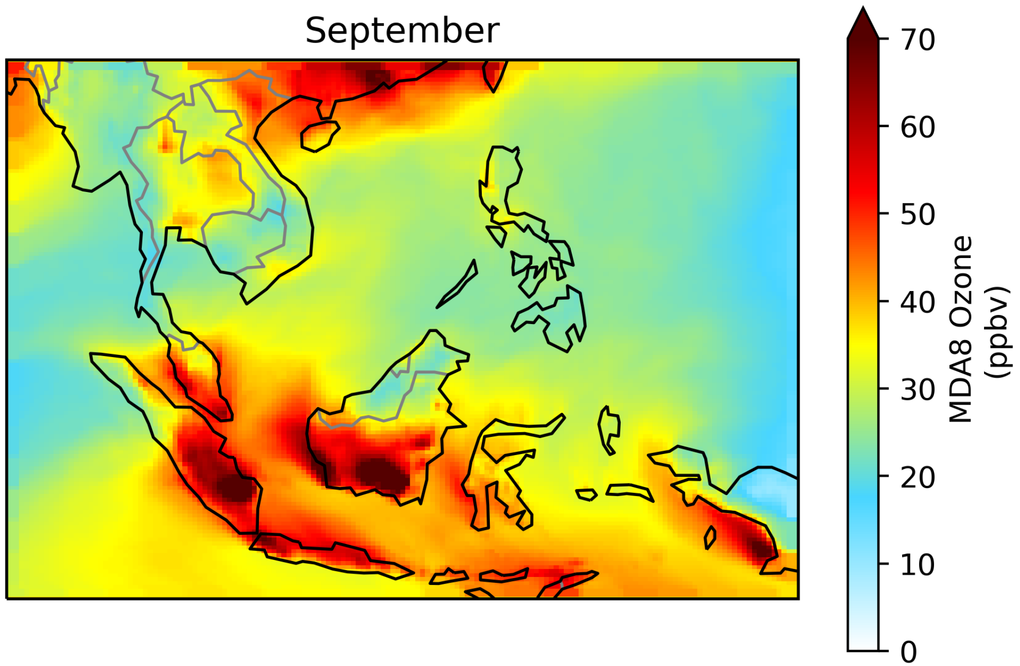
Seasonal impacts of biomass burning on ozone across Southeast Asia in 2014

EGU Session B3.17: Fire in the Earth System

Margaret Marvin[1,2] (mmarvin@ed.ac.uk), Paul Palmer[1,2], Barry Latter[3], Richard Siddans[3], Brian Kerridge[3]

[1]NCEO, University of Edinburgh, UK; [2]School of GeoSciences, University of Edinburgh, UK; [3]NCEO, RAL, UK





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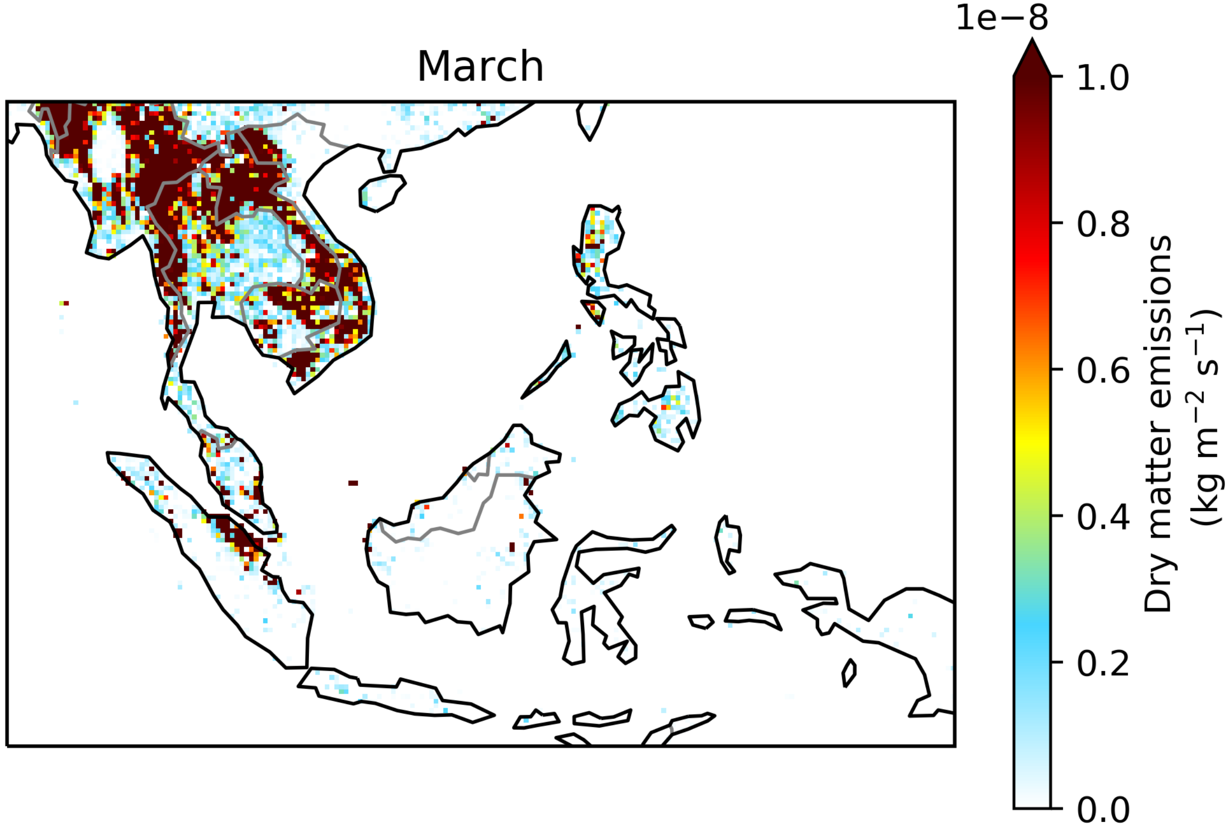
Ozone exposure guideline (WHO, 2006):
100 µg m^{-3} (≈ 50 ppbv)

NERC SCIENCE OF THE ENVIRONMENT

Two distinct biomass burning regimes

Latitude-based differences in dry season timing and land use distinguish two regional biomass burning regimes:

1. Burning of grasslands on mainland Southeast Asia peaking in March
2. Burning of peatlands in maritime Southeast Asia peaking in September



Margaret Marvin | mmarvin@ed.ac.uk | University of Edinburgh

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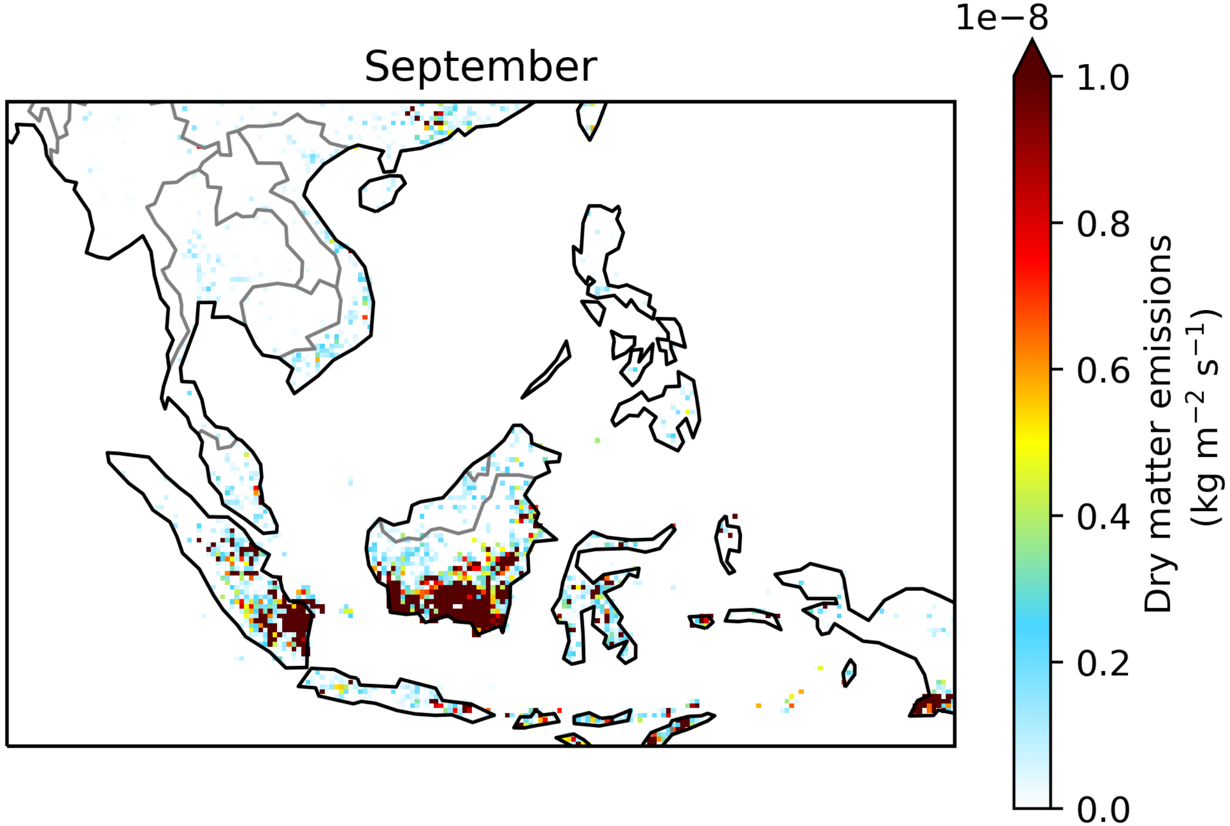

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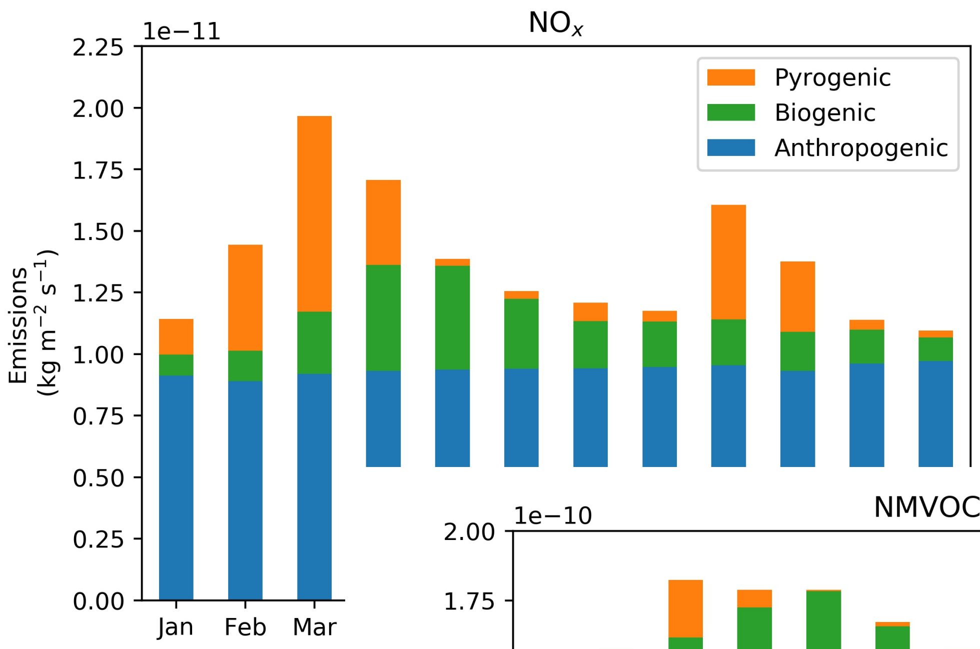
Model and emissions

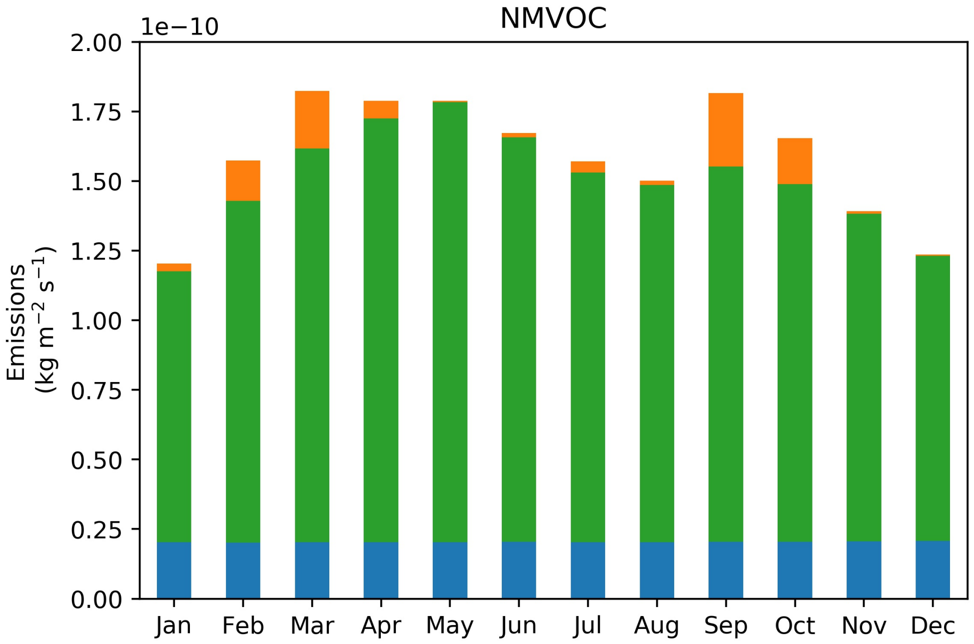
Atmospheric Chemistry Model

- GEOS-Chem v12.5.0 (geos-chem.org)
- Global and nested model
- Nested resolution: 0.25°x0.3125°
- Meteorology from GEOS-FP
- Full gas and aerosol chemistry

Emission Inventories

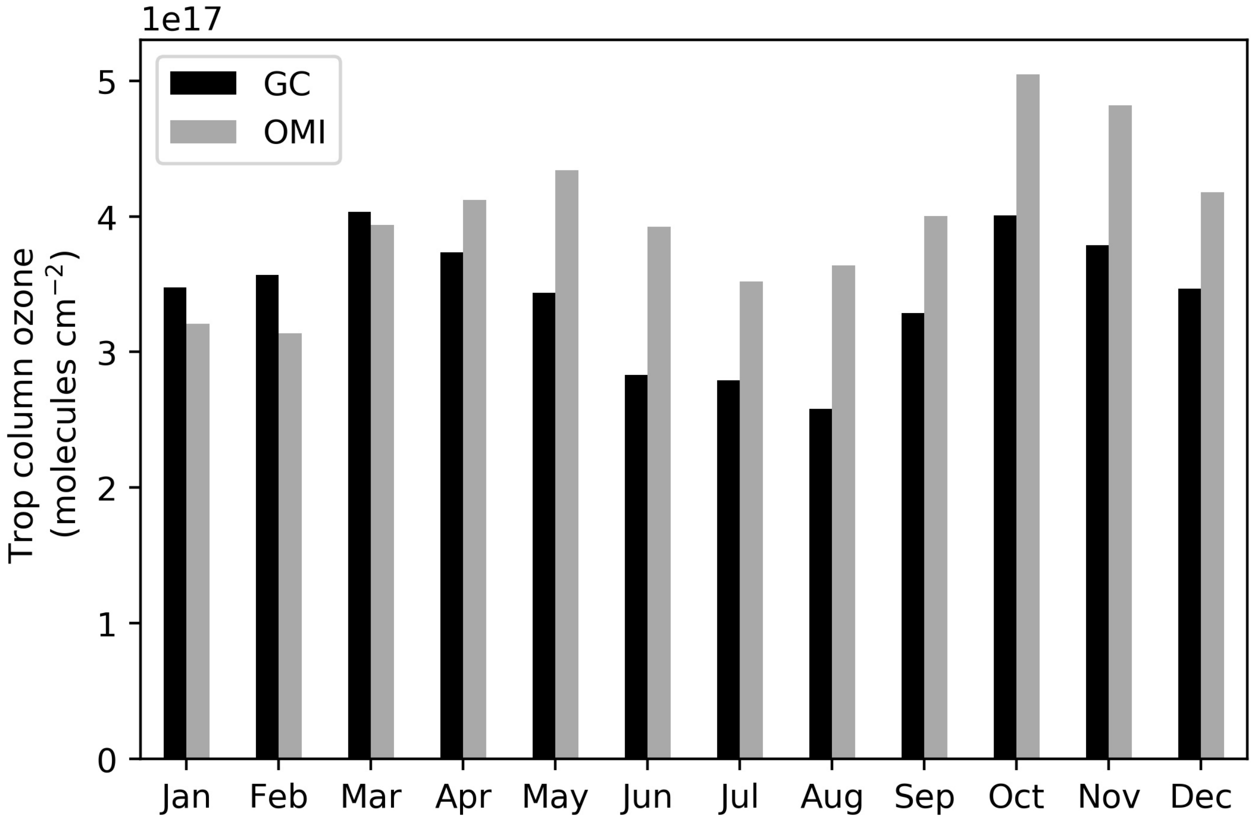
- Anthropogenic: MIX 2010 (Li et al., 2017)
- Biogenic: MEGAN v2.1 (Guenther et al., 2012)
- Pyrogenic: GFED v4.1 (van der Werf et al., 2017)





Seasonal variation in ozone precursors is driven by pyrogenic and biogenic emissions

Seasonal trends in tropospheric ozone reflect variation in precursor emissions



Satellite Observations

- RAL OMI fv0214 lvl2
- Gridded to match model
- Daily overpass at 13:30 LT
- Filtered for good data

Strong seasonal trends in ozone demonstrated by both model (GC) and observations (OMI)

Agreement is best in March, but the model tends to underestimate observations for most of the year

Margaret Marvin | mmarvin@ed.ac.uk | University of Edinburgh

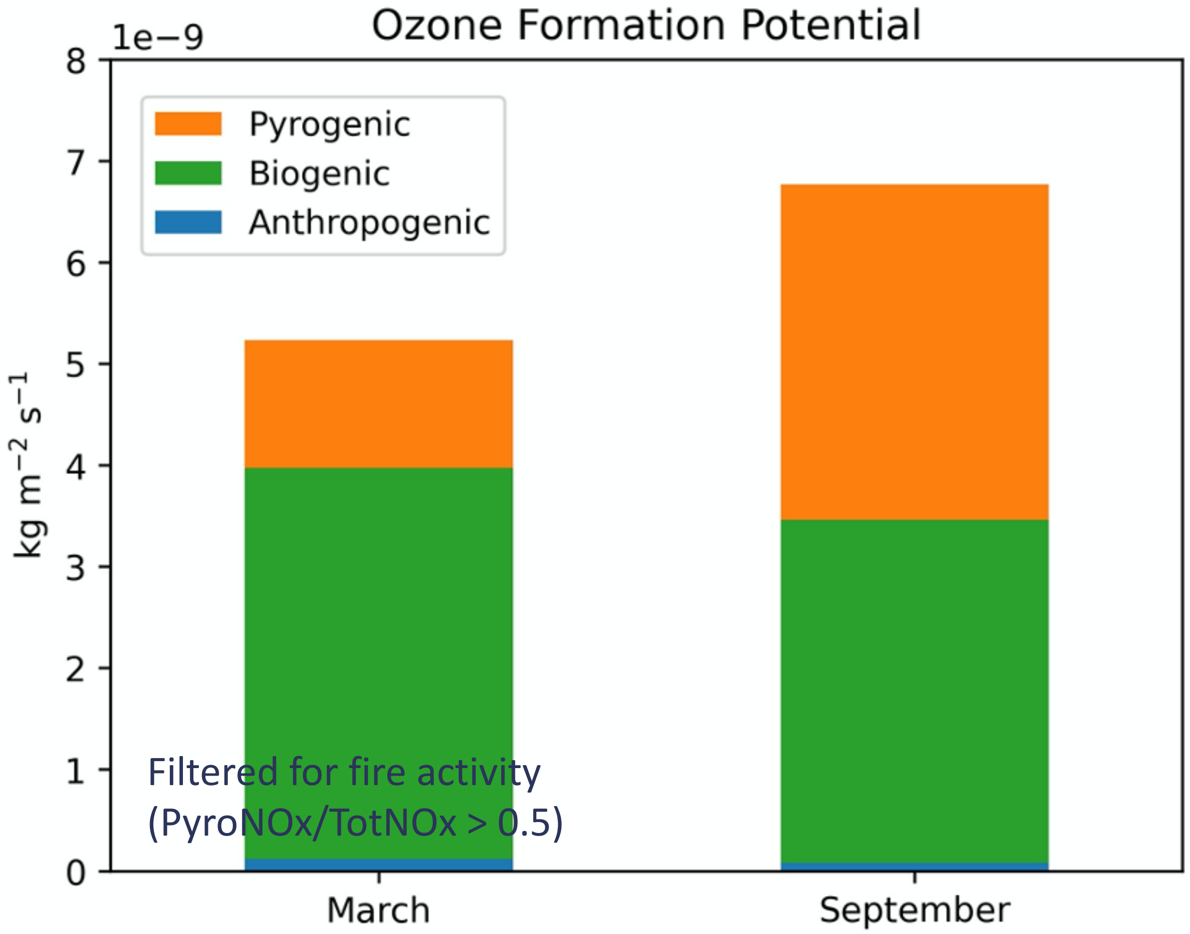
Ozone Formation Potential (OFP) links ozone directly to precursor emissions

$$OFP_{VOC} = E_{VOC} * MIR_{VOC}$$

E: Emission rate (kg m^{-2} s^{-1})
MIR: Maximum Incremental Reactivity

Top Contributing VOC	MIR*
Isoprene (C5H8)	10.61
Propene (C3H6)	11.66
Acetaldehyde (CH3CHO)	6.54
Formaldehyde (HCHO)	9.46
Monoterpenes (C10H16)	4.04
Toluene (C7H8)	4.00

*g ozone per g VOC emitted
Carter (2010)



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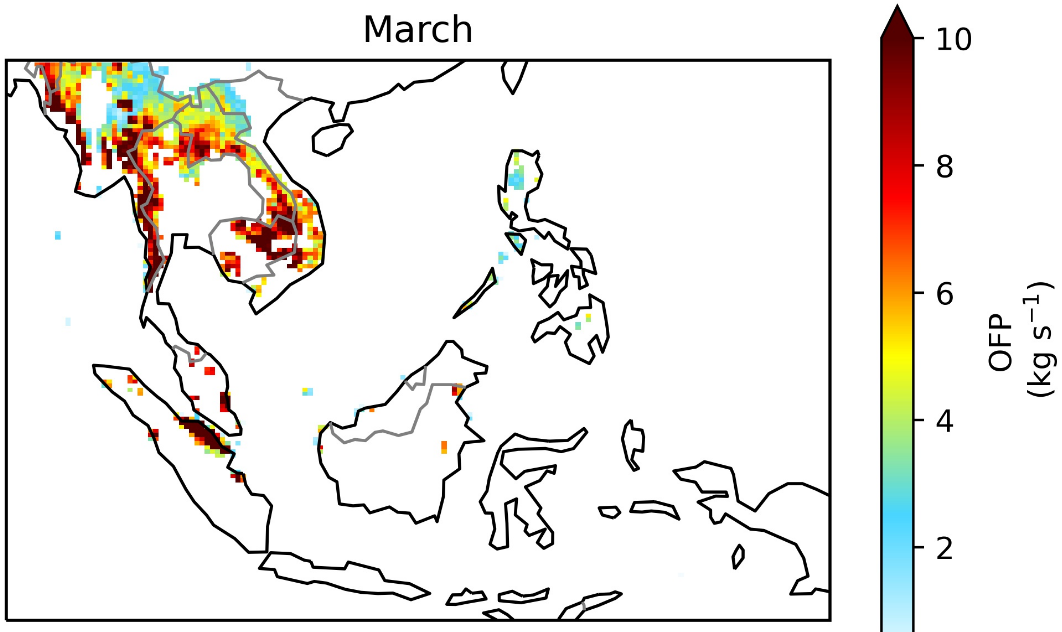
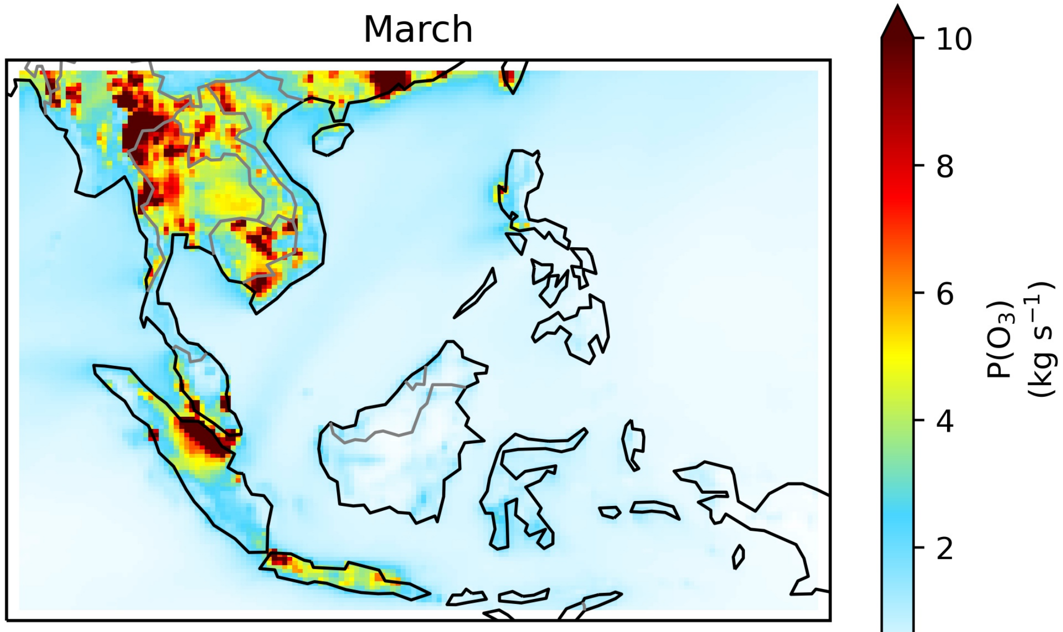
Biomass burning accounts for 33% of regional ozone production in March



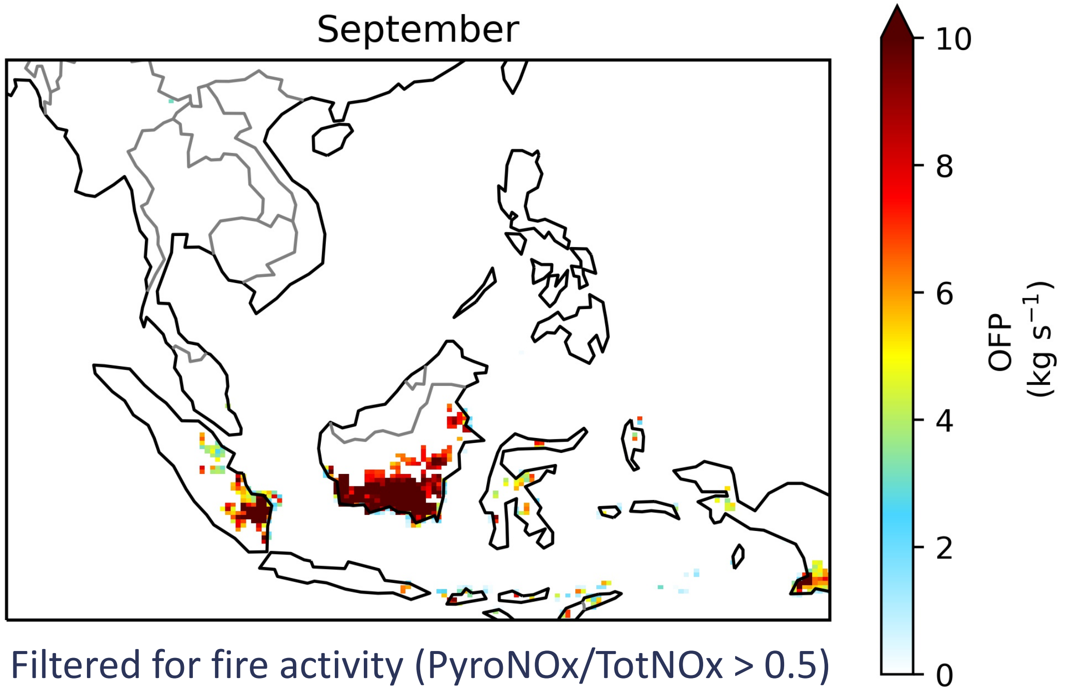
Filtered for fire activity (PyroNOx/TotNOx > 0.5)



Integrated over PBL (alt < 1500 m)

- OFP provides an <u>upper limit</u> on regional ozone production
- Pyrogenic sources could contribute significantly to ozone exposure over mainland Southeast Asia

Biomass burning accounts for 28% of regional ozone production in September



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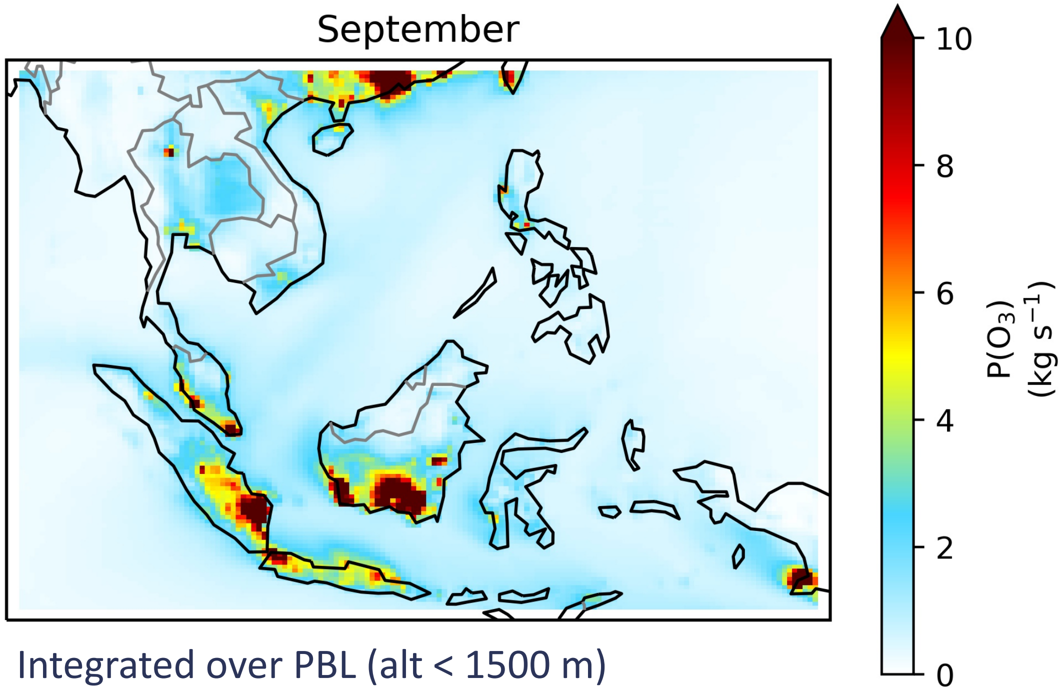

Integrated over PBL (alt < 1500 m)

- OFP provides an <u>upper limit</u> on regional ozone production
- Pyrogenic sources could contribute significantly to ozone exposure over maritime Southeast Asia

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Conclusions

- Differences in the dry season and the type of land burned distinguish two different biomass burning regimes in Southeast Asia
- Each regime has a unique distribution of precursors that drives regional ozone production
- Pyrogenic precursors may produce ozone directly or indirectly through interactions with the biogenic sector
- OFP suggests that biomass burning accounts for 33% and 28% of regional ozone production in March and September, respectively
  - This is an upper limit but shows potential to make the difference between “healthy” and unhealthy ozone exposure for millions of people throughout the region in 2014

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References

Carter, W. P. L. Updated maximum incremental reactivity scale and hydrocarbon bin reactivities for regulatory applications. Prepared for Californian air resources board contract 07-339; 2010. https://ww3.arb.ca.gov/regact/2009/mir2009/mir10.pdf

Guenther, A. B., et al.: The Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2.1): an extended and updated framework for modeling biogenic emissions, Geosci. Model Dev., 5, 1471–1492, https://doi.org/10.5194/gmd-5-1471-2012, 2012.

Li, M., et al.: MIX: a mosaic Asian anthropogenic emission inventory under the international collaboration framework of the MICS-Asia and HTAP, Atmos. Chem. Phys., 17, 935–963, https://doi.org/10.5194/acp-17-935-2017, 2017.

van der Werf, G. R., et al.: Global fire emissions estimates during 1997–2016, Earth Syst. Sci. Data, 9, 697–720, https://doi.org/10.5194/essd-9-697-2017, 2017.

World Health Organization. Occupational and Environmental Health Team. (2006). WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide : global update 2005 : summary of risk assessment. World Health Organization. https://apps.who.int/iris/handle/10665/69477