

The impacts of biomass burning aerosols on cloud and precipitation

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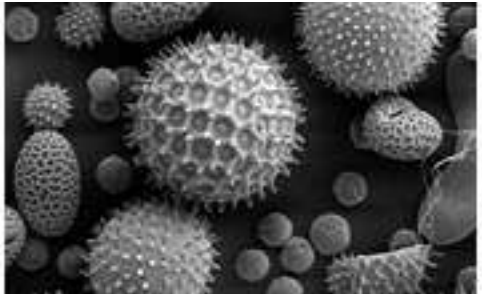
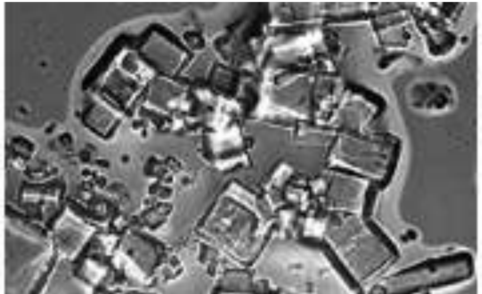
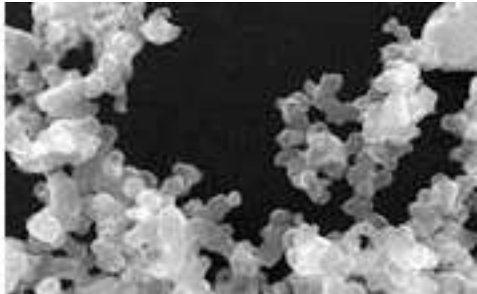
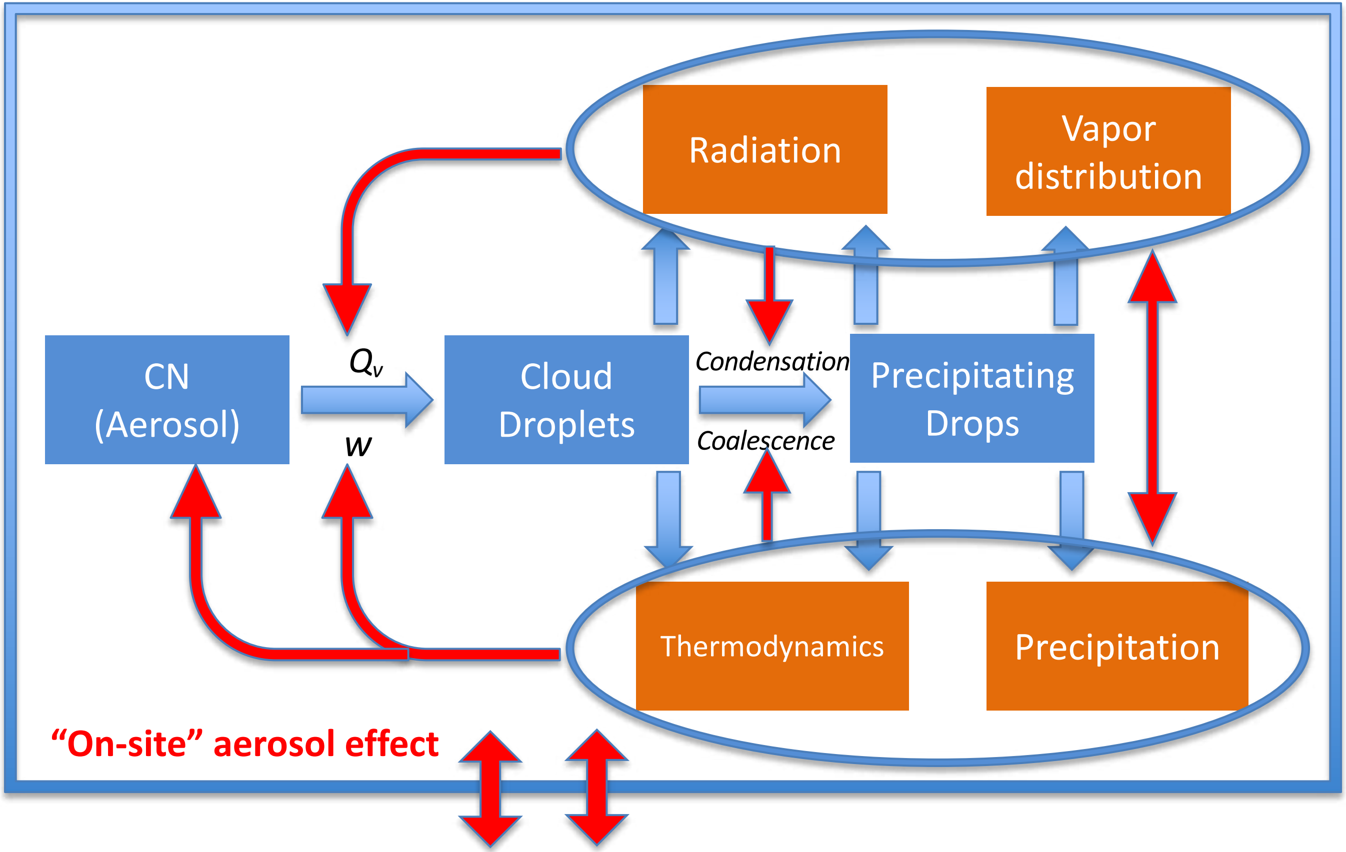
1. LAERO, 2. CNES, 3. CNRM, 4. LATMOS, 5. LMD

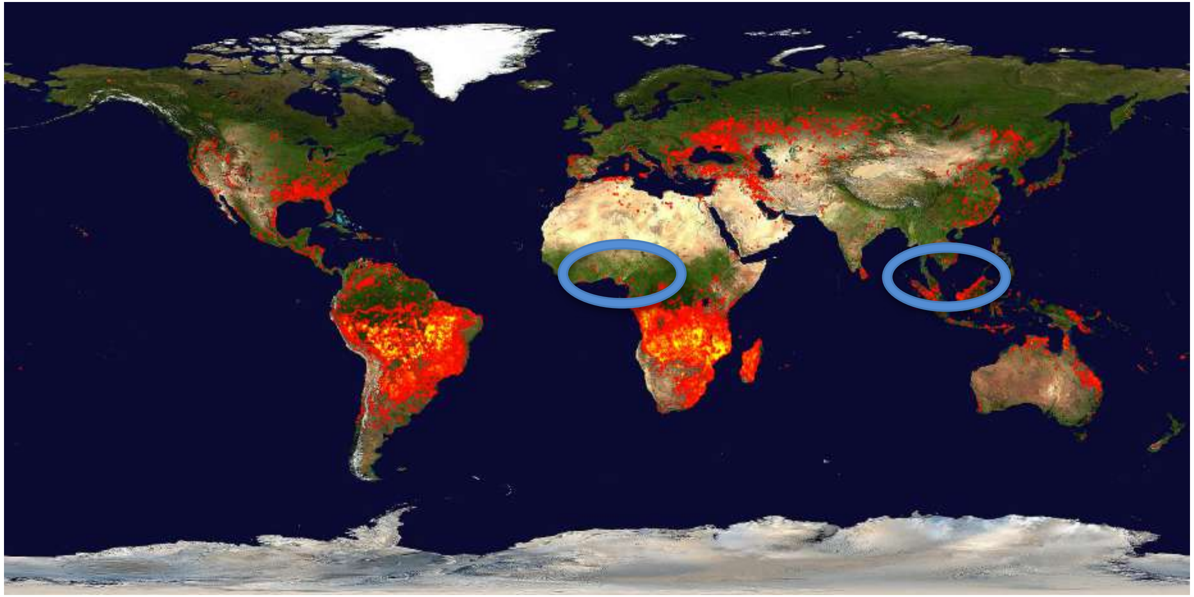
Aerosol-Cloud Interaction and Beyond



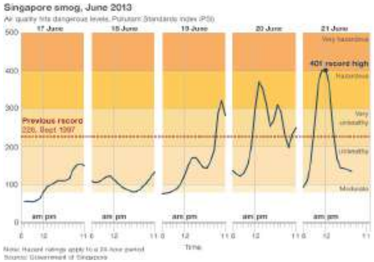
Interaction with larger scales (and potentially remote effects)

A Global Map of Fires

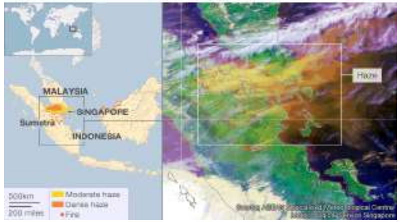
- MODIS on NASA's Terra satellite shows fires around the world.
- Credit: NASA



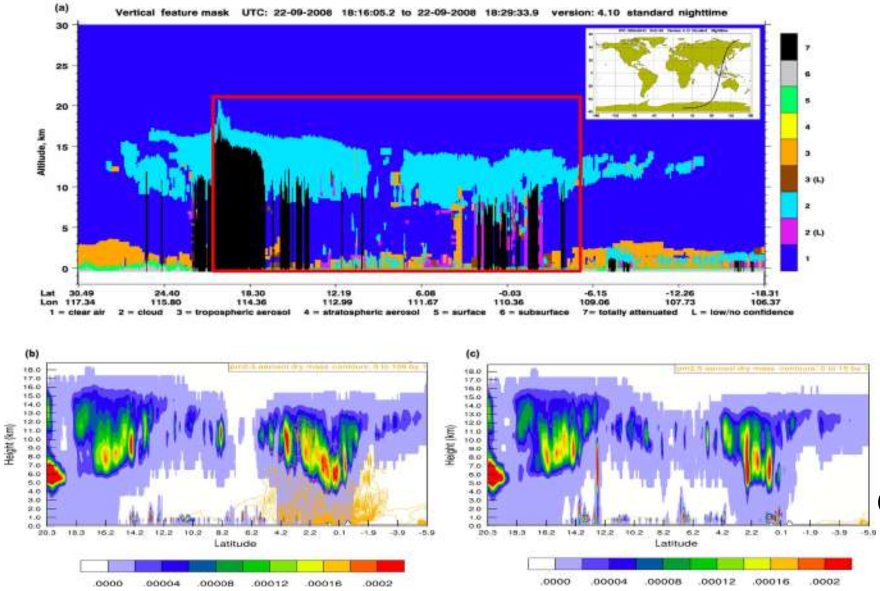
Fire Aerosols and Hazes in Southeast Asia
How would they affect Convection and Precipitation



Map and satellite view of the haze over Singapore



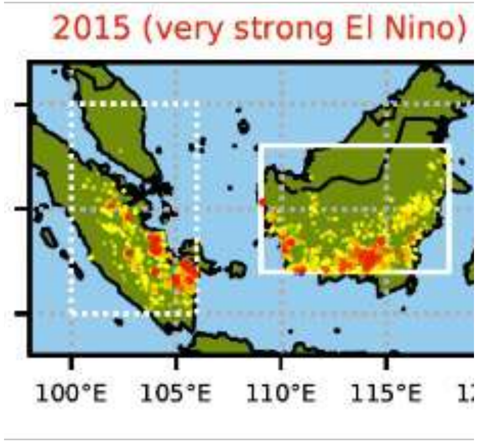
CALIPSO image (a) vs. modeled hydrometeor map derived with (b) or without (c) fire aerosols: 22 September 2008
(Lee and Wang, 2020)

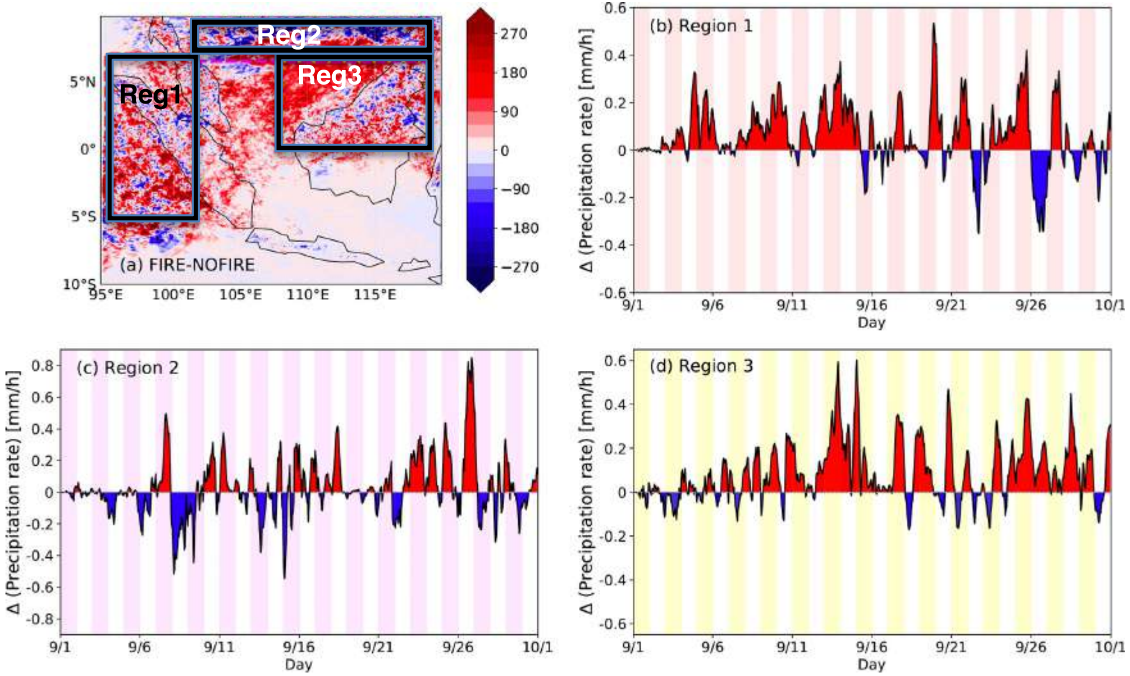


(kg/kg)

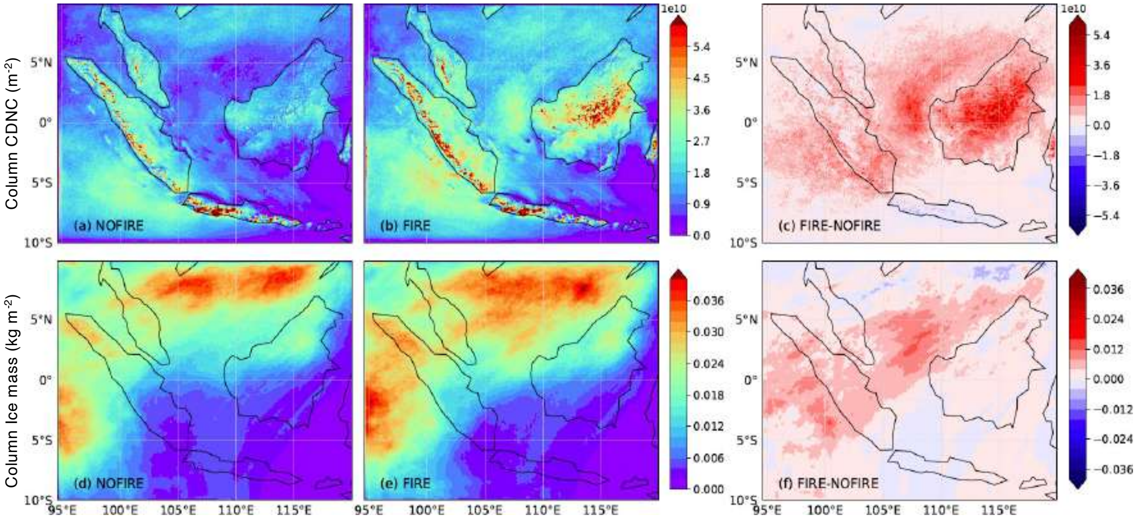
Fire Aerosols on Deep Convection over Maritime Continent

- WRF-Chem model, nested domains
- Inner domain (shown) with a 4-km horizontal resolution
- August 2015
- $\Delta Precip = Precip_{Fire} - Precip_{NoFire}$
- Takeishi & Wang (2022); also Lee and Wang (2020, 2021)





- Aerosols from fires substantially increase the cloud droplet number concentration (CDNC)
- Excessive CNDCs then further increase the ice particle population, initiated from the freezing and riming
- Takeishi and Wang (2022)

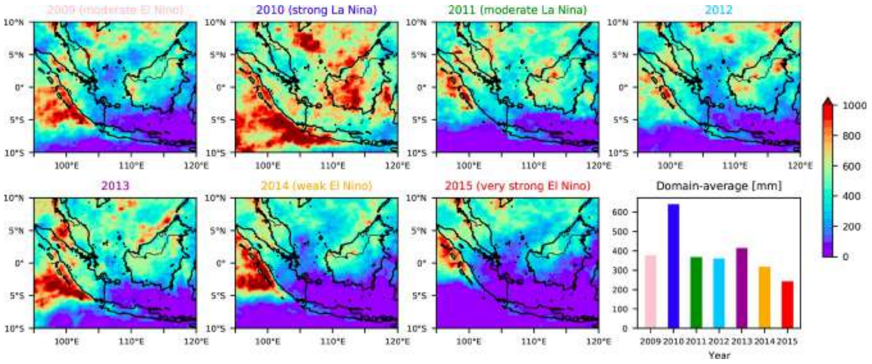


(Shown are monthly mean data)

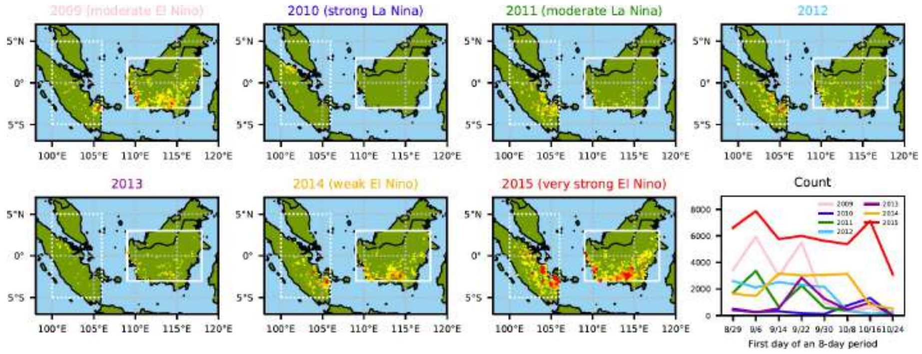
Fire Aerosols on Deep Convection over Maritime Continent: Modulation by ENSO?

- Similar modeling configuration but for different years to examine the potential modulation by ENSO
- Similar enhancement in precipitation due to fire aerosol has been reproduced
- Takeishi & Wang (in preparation)

Accumulated TRMM precipitation (mm) in September and October

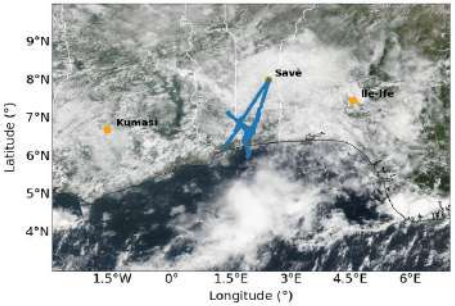


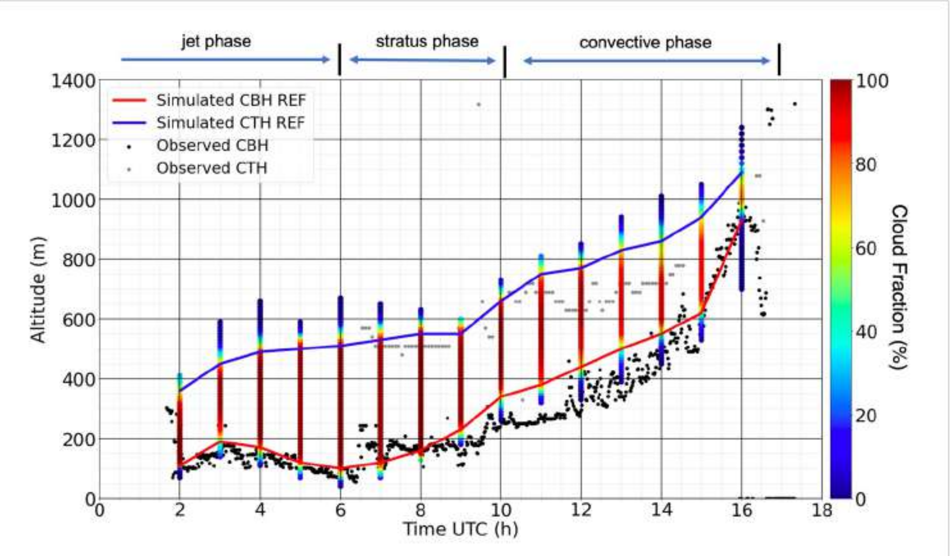
MODIS fire counts

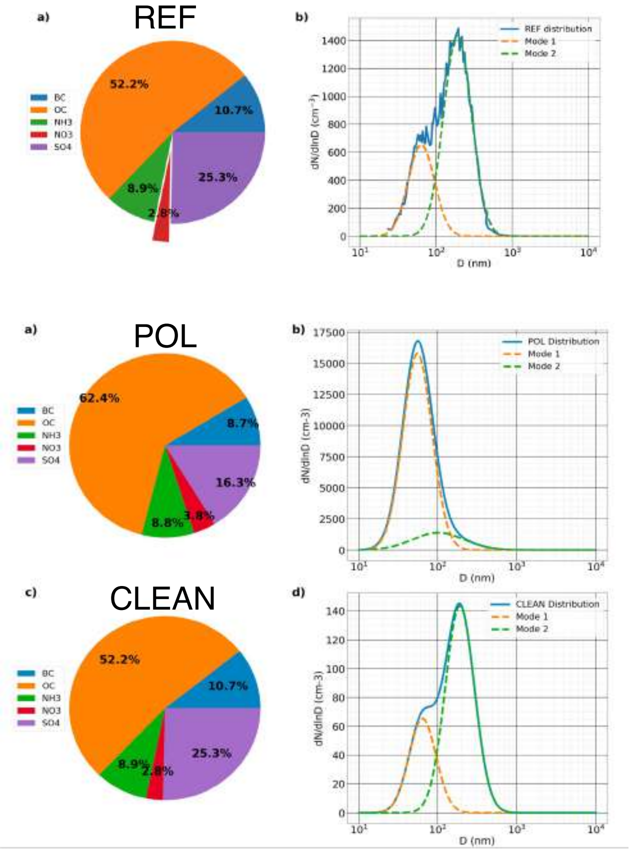


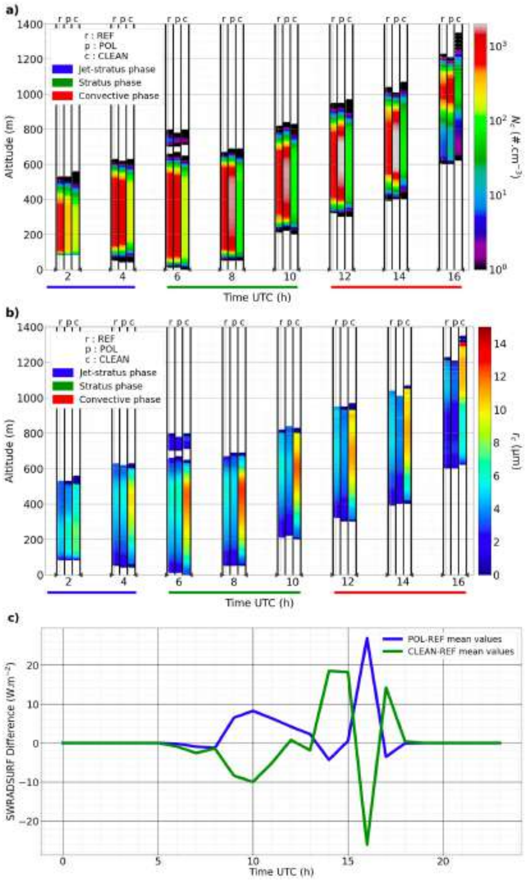
Anthropogenic Aerosols on the Life Cycle of Low Clouds in Southern West Africa
(Delbeke et al., 2022; in review)

- Meso-NH model with interactive aerosols
- Large-Eddy Simulation (LES), 40x40x10 meter resolution
- Observed case with different aerosol profiles: REF, POL, CLEAN and with vs. without BC (semi-direct effect)

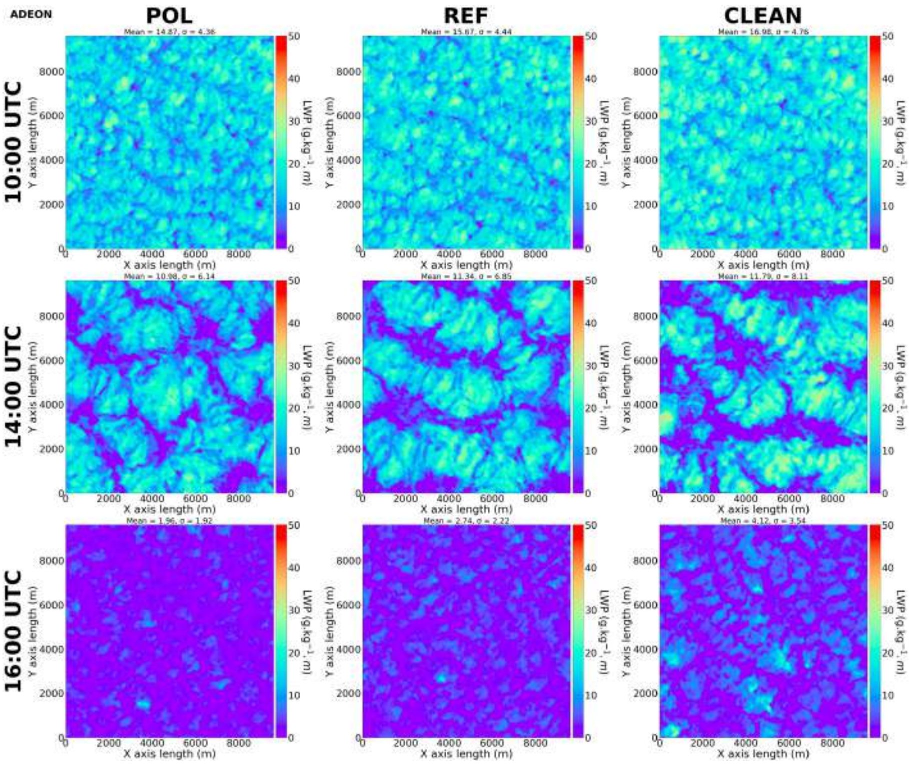




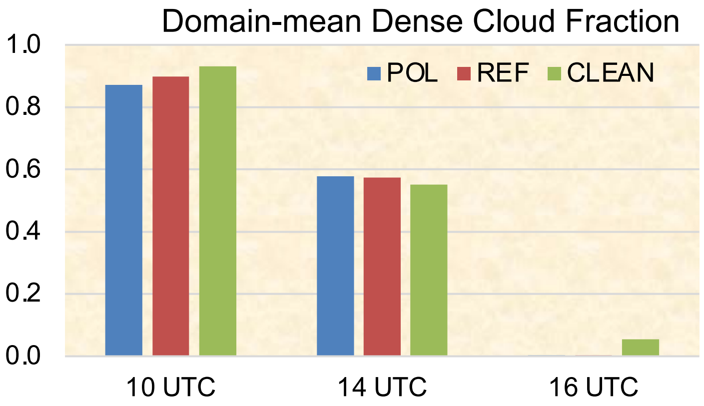


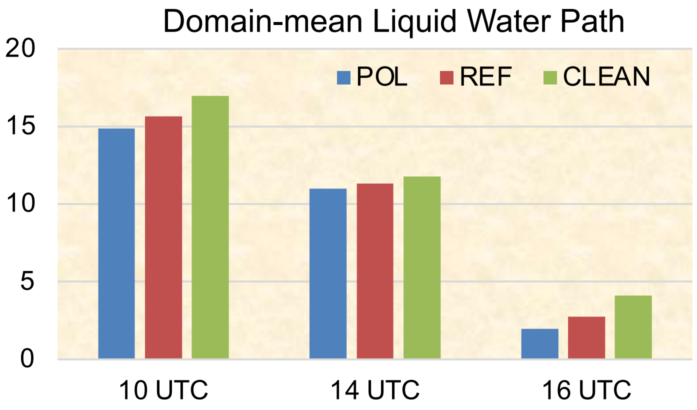


a)
r : REF
p : POL
c : CLEAN
Jet-stratus phase
Stratus phase
Convective phase
Altitude (m)
Time UTC (h)
N_c (#.cm^{-3})
b)
r : REF
p : POL
c : CLEAN
Jet-stratus phase
Stratus phase
Convective phase
Altitude (m)
Time UTC (h)
r_c (µm)
c)
POL-REF mean values
CLEAN-REF mean values
SWRADSURF Difference (W.m^{-2})
Time UTC (h)



ADEON
POL
REF
CLEAN
10:00 UTC
14:00 UTC
16:00 UTC
Mean = 14.87, σ = 4.36
Mean = 15.67, σ = 4.44
Mean = 16.98, σ = 4.76
Mean = 10.98, σ = 6.14
Mean = 11.34, σ = 6.85
Mean = 11.79, σ = 8.11
Mean = 1.96, σ = 1.92
Mean = 2.74, σ = 2.22
Mean = 4.12, σ = 3.54
X axis length (m)
Y axis length (m)
LWP (g.kg^{-1}.m)





- Response of N_C and r_c to aerosol profile is expected
- Response of surface incoming radiation varies with time – not necessarily consistent with N_C so does CF
- Smaller particles evaporate faster in entrainment zone likely to be the reason behind
- LWP inversely related to aerosol abundance
- Feedbacks to turbulent mixing and radiation
- Dense cloud pixels: $LWP > 10\ g\ kg^{-1}\ m$

Impacts of semi-direct effect of absorbing aerosols

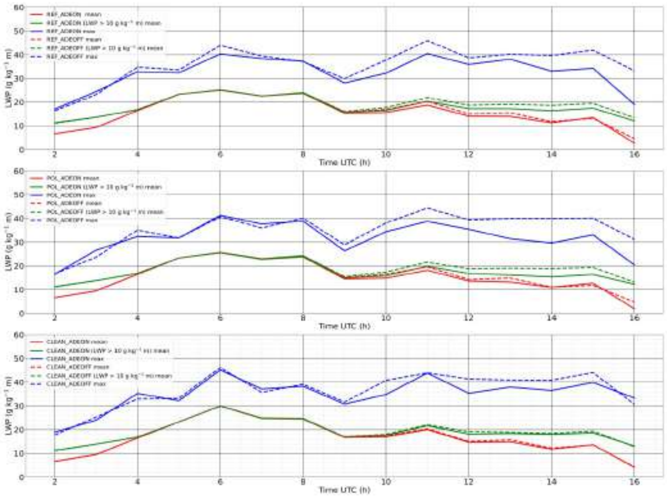
- $LWP_{AODON} < LWP_{AODOFF}$
- $CF_{AODON} > CF_{AODOFF}$ in mid-convection stage
- Absorbing aerosols supress vertical development

Domain-mean LWP

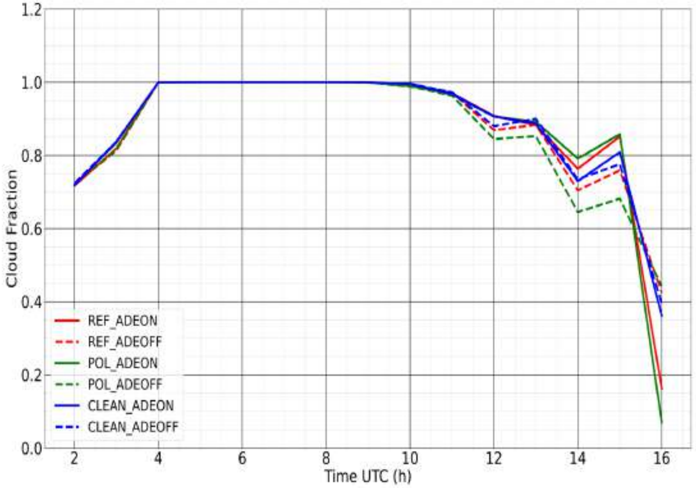
REF

POL

CLEAN



Domain-mean CF



AODON includes while *AODOFF* excludes the semi-direct effect

Summary

- Aerosols emitted from biomass burnings are effective in scattering or absorbing sunlight, and in acting as cloud condensation nuclei and ice nuclei
- Findings obtained from the high-resolution modeling of two different cases both indicate a drastically increase of cloud droplets due to fire aerosols
- Fire aerosols are found to enhance convective precipitation over Maritime Continent through excessive liquid-ice conversion consequent to fire aerosol activation
- Fire aerosols affect life cycle of SWA low clouds through both indirect and semi-direct path
- Dynamical feedback responding to fire aerosols demands more efforts and certain model improvements

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