# Improving the simulations of biomass burning smoke and anthropogenic dust in E3SM

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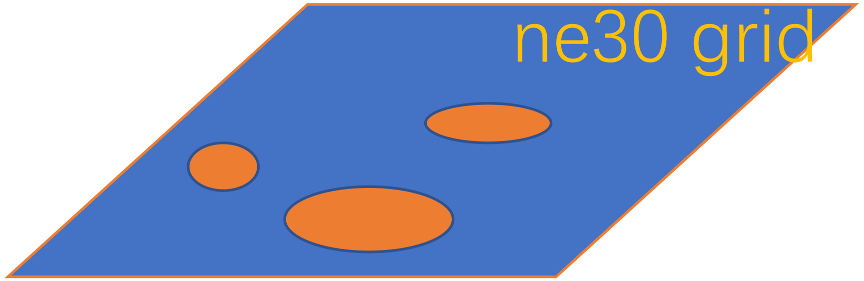
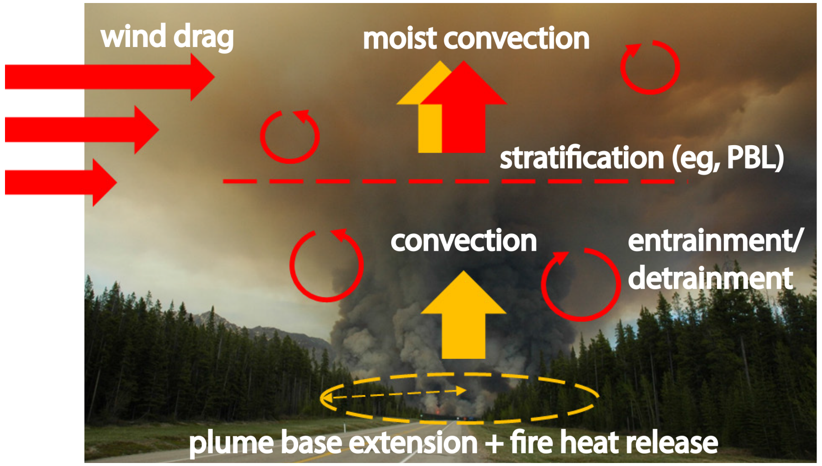
# Motivation

- Goal: to interactively calculate fire plume injection heights based on fire properties and ambient meteorological conditions in the model.
- For ne30 res. application
  - In one ne30 grid, difference in fire intensities of many fires (fire size, heat release) leads to different injection heights – the need for describing the fire intensity distribution.



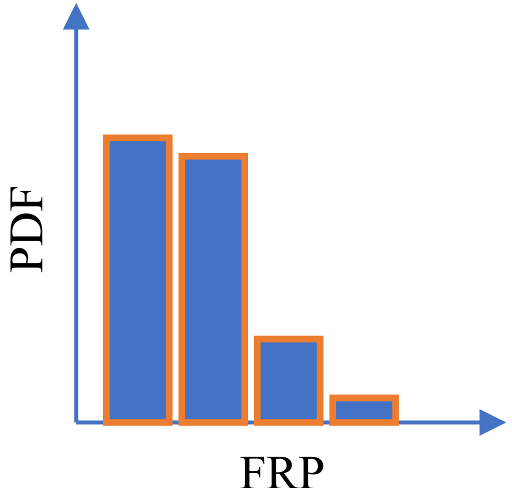

- Physics of 1D plumerise model
  - Embedded in host model (WRF-Chem, E3SM, etc.)
  - Solving 6 governing equations of $\omega$, T, and m.m.r. of cloud hydrometeors.
  - Inputs for initial conditions: fire size and fire heat release, and ambient conditions (T, $\rho$, $\omega$, U, V, qv)




Paugam et al., 2016

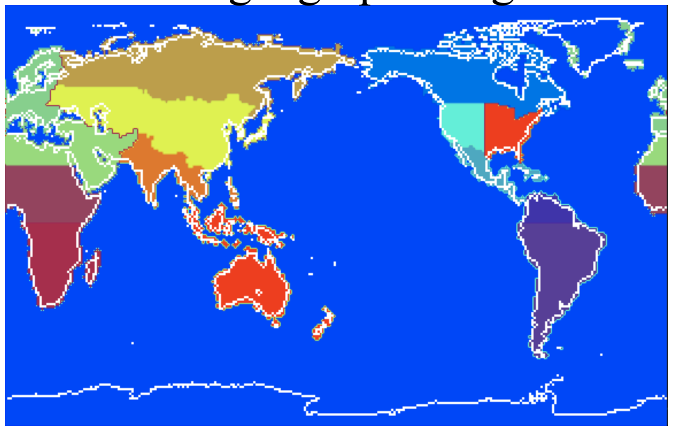
# Approach – Scaled-FRP and FRP×10 in this study

- Four FRP bins + MODIS observations
  - 0~10MW : 14% of BB emis.
  - 10~100MW: 66% of BB emis.
  - 100~500MW: 17% of BB emis.
  - >500MW: 3% of BB emis.
- New emission files
  - Total emissions of BC and POM are partitioned to these four FRP bins as four sectors (emission∝ total FRP, Ichoku and Kaufman, 2005 ).
  - Note: vert. dist. of BB aerosols are still prescribed in the files.



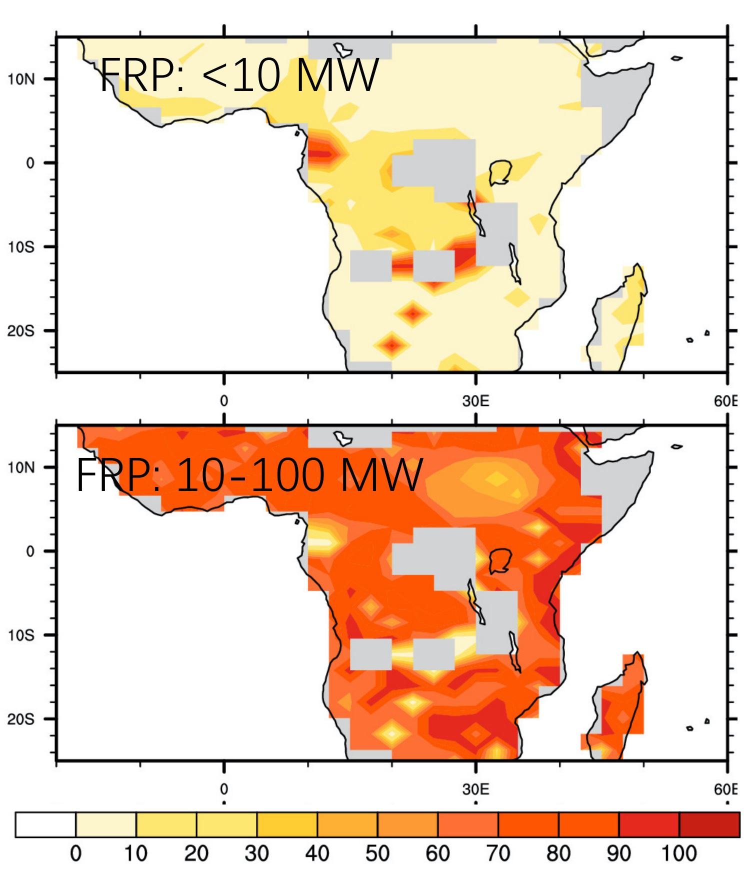

- In scaled-FRP method, we need to find maximum FRP over a certain area or biome and long periods (Val Martin et al., 2012). MaxFRP corresponding to 1 $km^2$ of fire size
- In our study, MaxFRP is a function of (GFED regions, PFTs, months)
- We incorporate the LUT in the code and calculate MaxFRP before the plumerise calculation.

GFED geographic regions

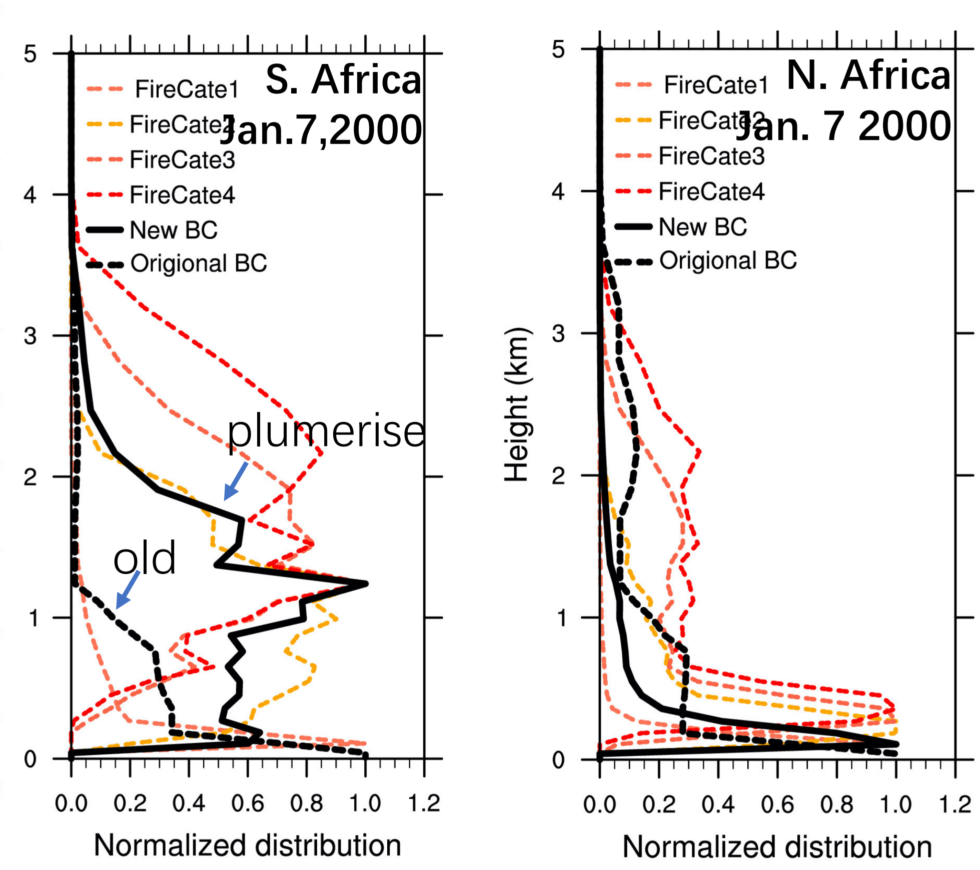


# Preliminary results

## Fire emissions % of four categories

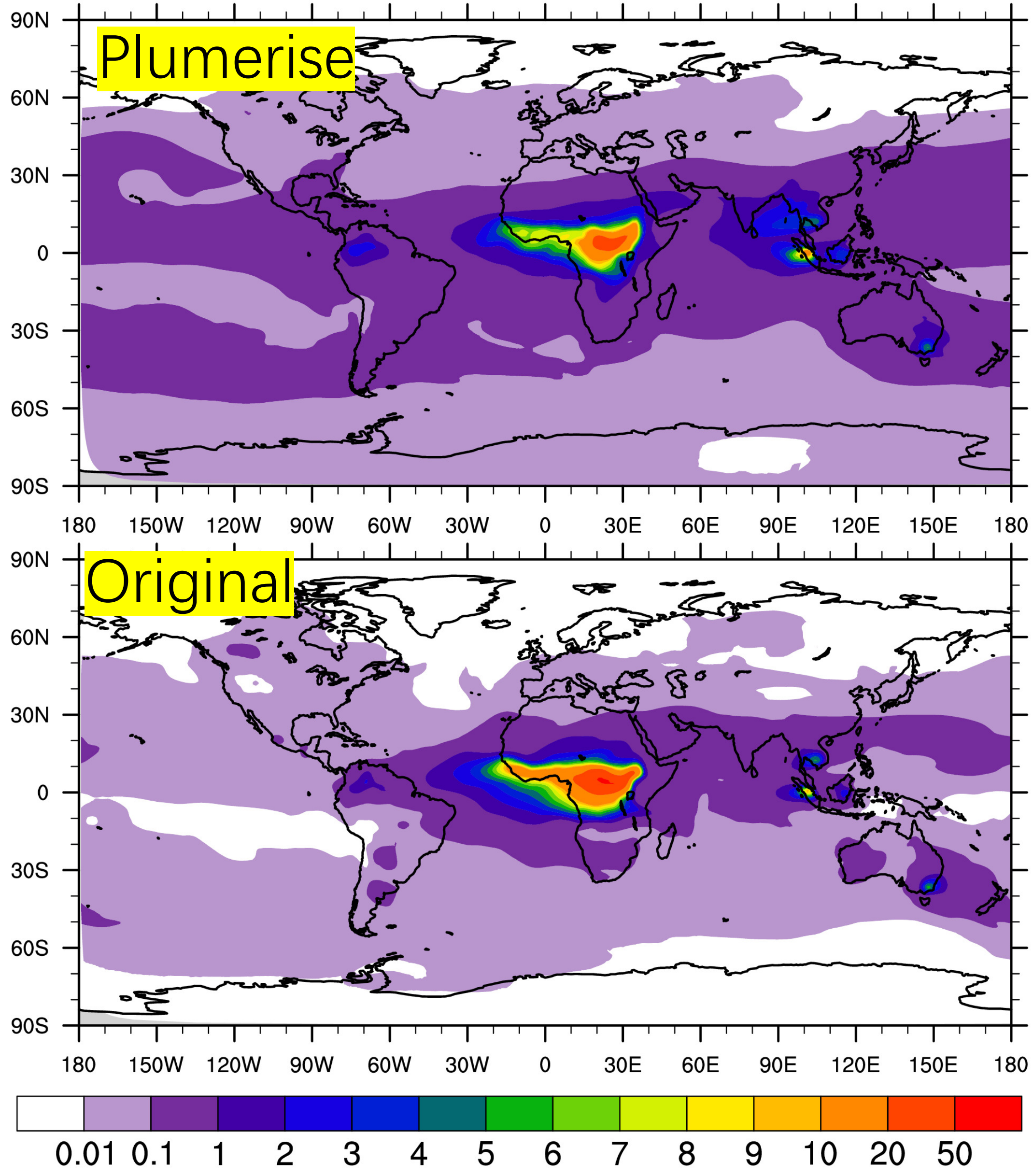



## Calculated and prescribed BC profiles



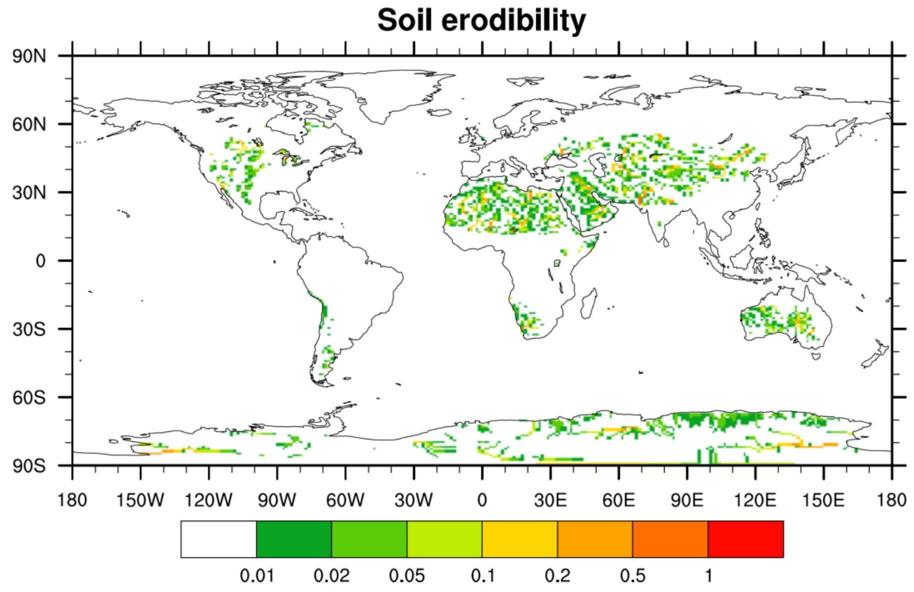
# Preliminary results

- Burden of mode 4 (mg/m$^2$)
- Surface BC/POM emissions are turned off
- Higher burden over SE. Asia, Australia, and Southern Africa.
- Lower burden over N. Africa

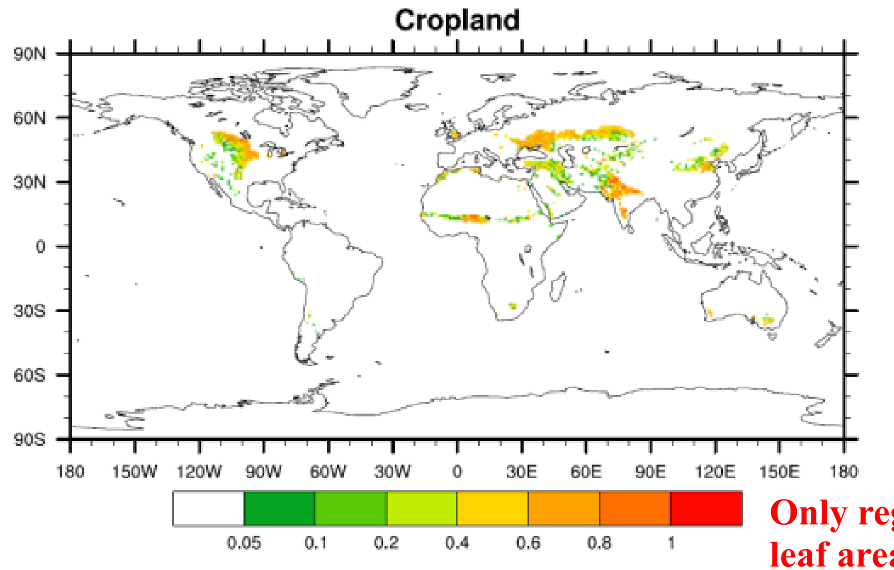


# Anthropogenic dust emission

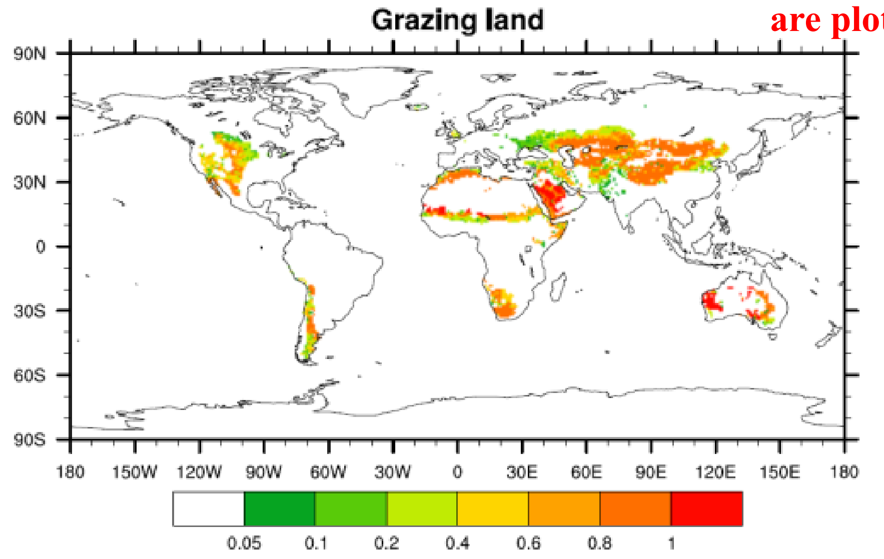
## Only at bare soil (Zender et al. 2003 )




## Landuse (year 2010, from HYDE 3.2.1)




Only regions with leaf area index<0.5 are plotted




**Approach to account for dust emissions due to land use (anthropogenic dust) by modifying the soil erodibility S in dust emission parameterization:**

$$S_{new} = S_{default} + C * f_{land\_use}$$

$f_{land\_use}$: **landuse fraction** from Goldewijk et al. (2017): Historical Database of the Global Environment (HYDE version 3.2). Resolution at 0.0833 degree (~9 km), 10,000 BCE to 2015 CE

# Experimental design

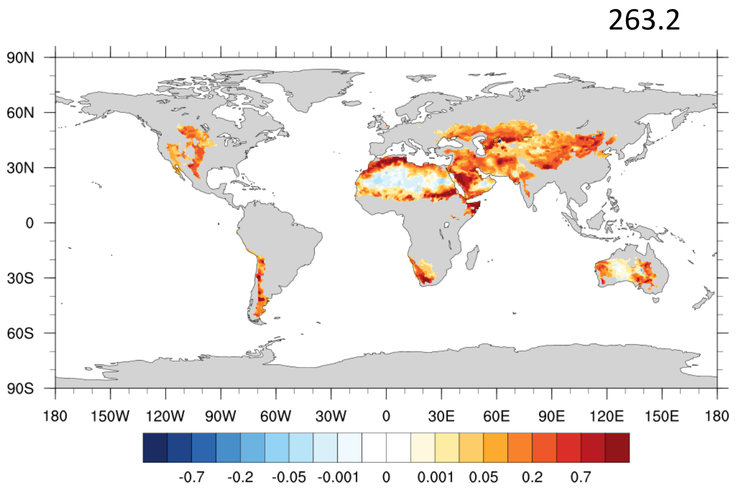
- Zender et al. (2003) dust emission scheme is used, with SST and sea ice prescribed

| Experiments | Soil erodibility (S)[a] | Leaf and stem area index threshold $(L+S)_t$ | Threshold of S $(S_t)$ |
|---|---|---|---|
| **Default** | Geomorphic S (natural) | 0.3 | 0.1 |
| **Baseline** | Geomorphic S (natural) | 0.5 | 0.001 |
| **LU_1** | Geomorphic S (natural) plus land use fraction (C=1) | 0.5 | 0.001 |
| **LU_001** | Geomorphic S (natural) plus land use fraction (C=0.01) | 0.5 | 0.001 |

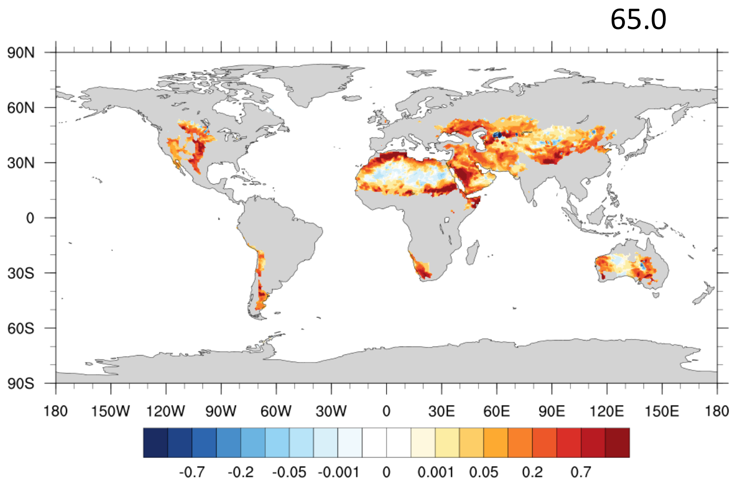
- Where C represents tuning factor for anthropogenic vs. natural dust emissions

- Model results are 2010-2012 averages with 2009 as spin-up

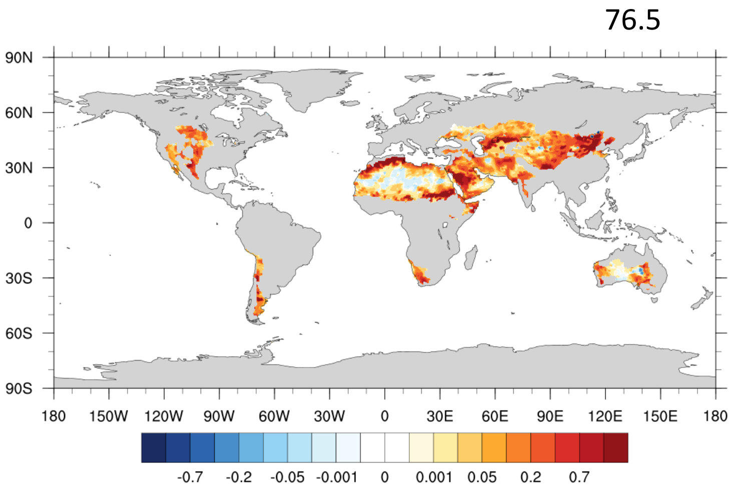
# Emissions Difference between LU_001 and Baseline



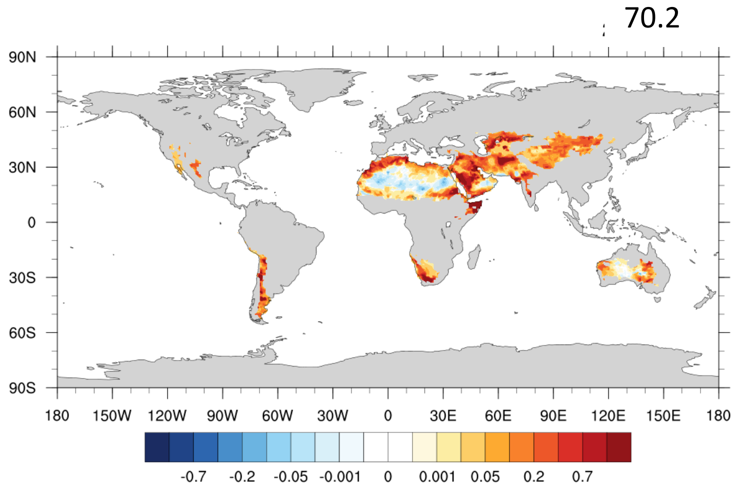

Annual



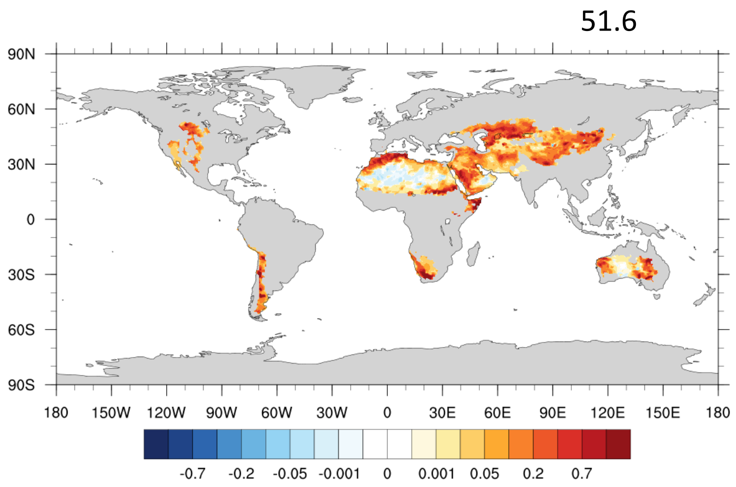

Dec/Jan/Feb



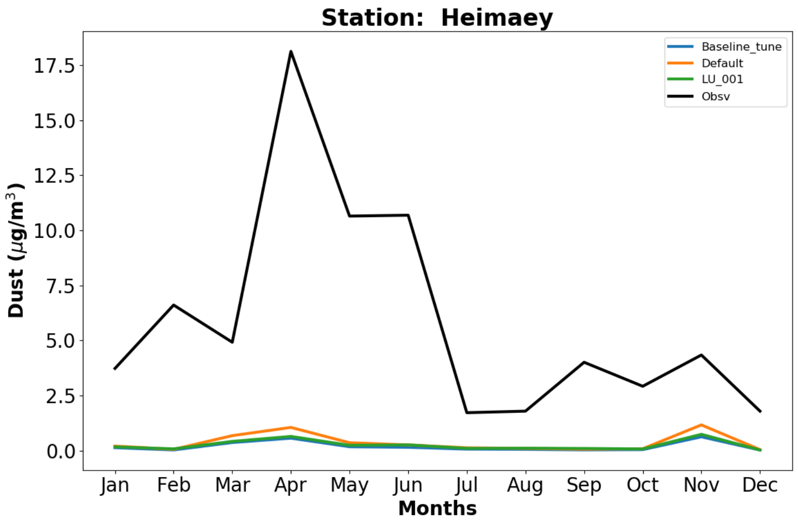

Mar/Apr/May



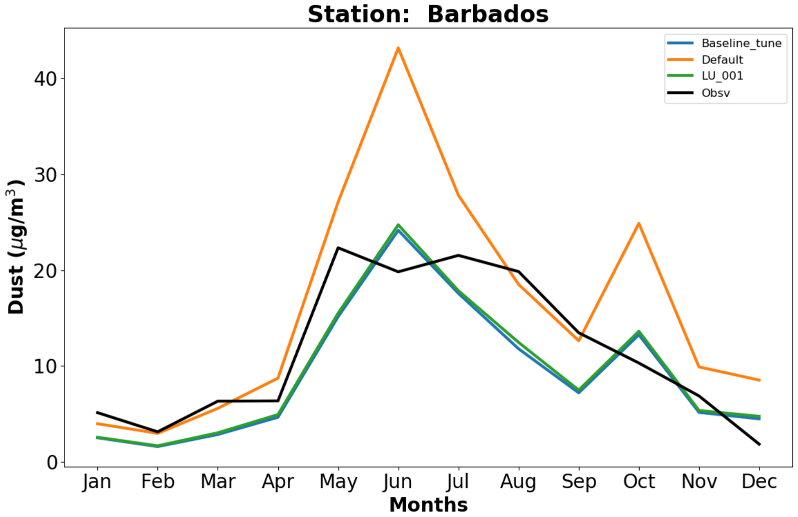

Jun/Jul/Aug



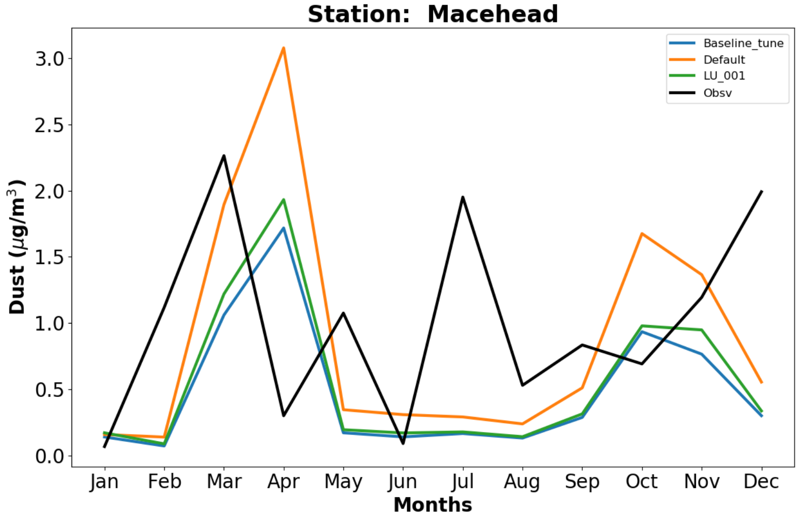

Sep/Oct/Nov



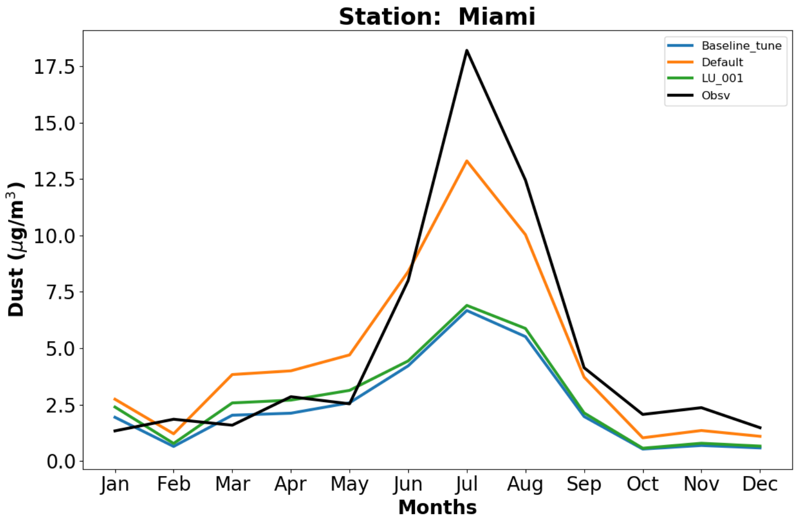

63.4°N, 20.3°W



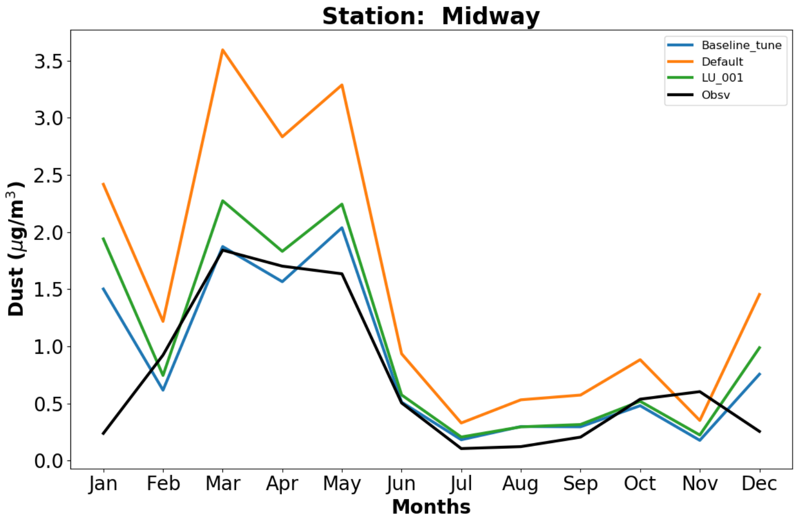

13.2°N, 59.4°W



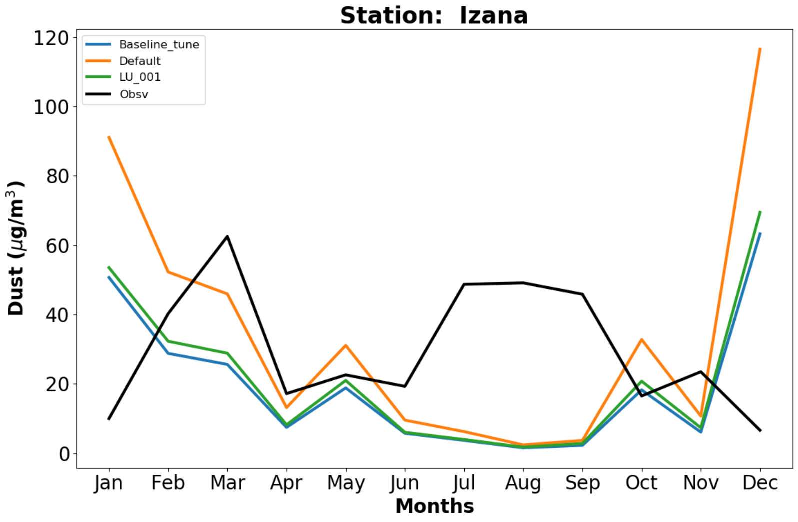

53.3°N, 9.9°W




25.8°N, 80.3°W




28.2°N, 177.4°W




28.3°N, 16.5°W