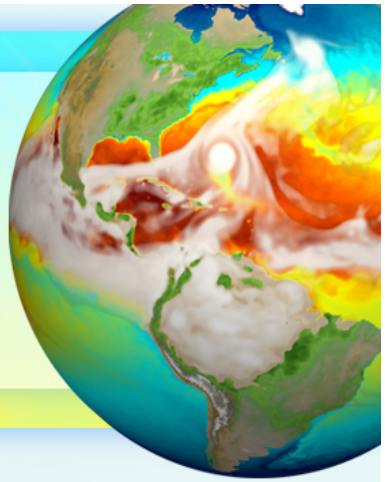

Wildfire aerosol climate effect using online fire emission coupling in E3SM

Li Xu[1], Stijn Hantson[1], Yang Chen[1], William J. Riley[2], Qing Zhu[2], Natalie M. Mahowald[3] and James T. Randerson[1]

Virtual E3SM PI meeting, October 29, 2020

[1]University of California, Irvine, [2]Lawrence Berkeley National Laboratory, [3]Cornell University.

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BIOLOGICAL AND ENVIRONMENTAL RESEARCH

Earth and Environmental Systems Sciences

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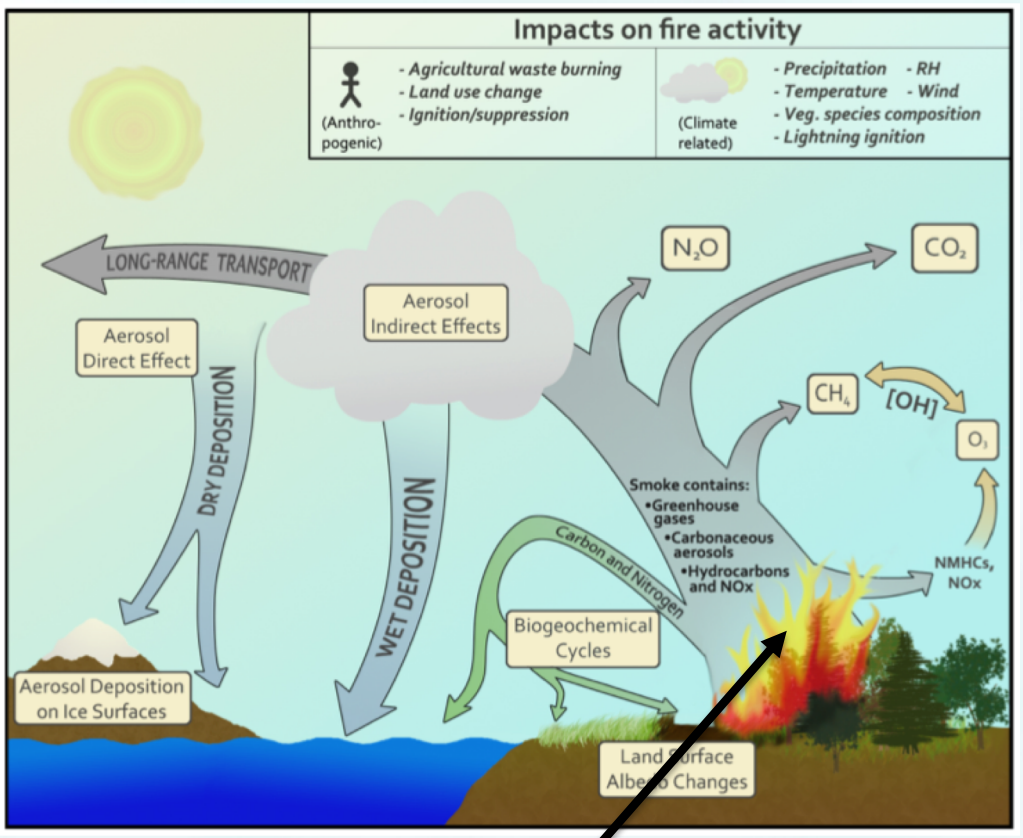
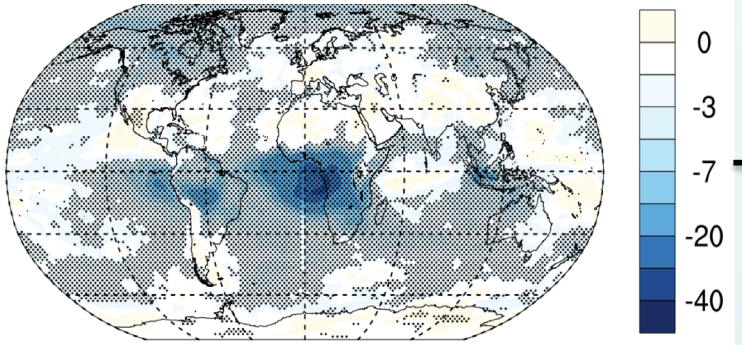
Climate effect of wildfires



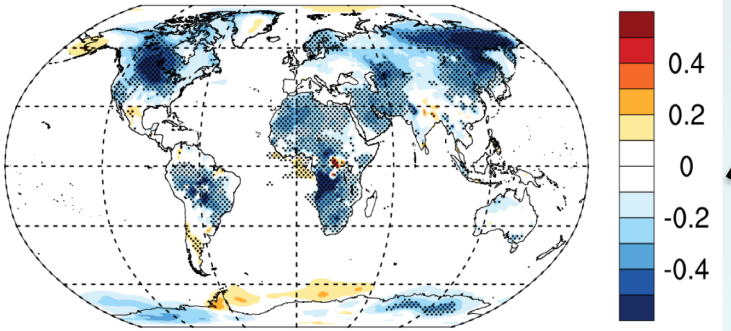
Ward et al. (2012)

Fire aerosols significantly change near-surface climate and primary productivity in many regions

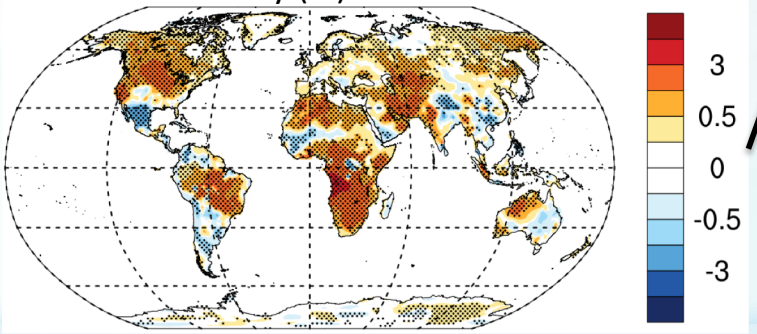
Downwelling solar radiation at surface (W m^{-2})



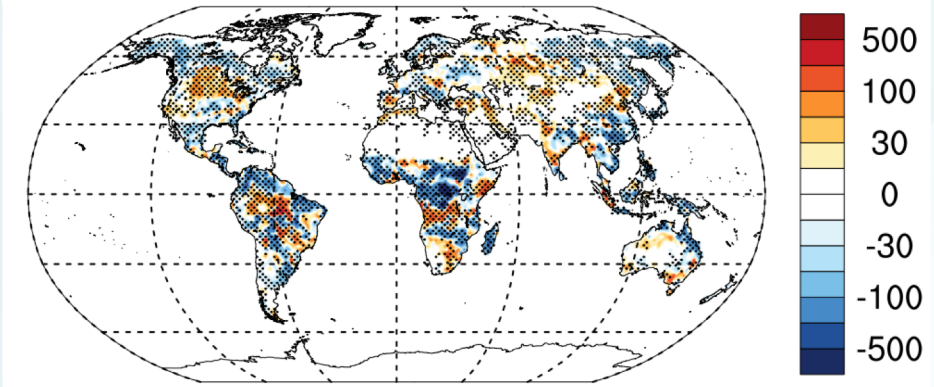
Surface air temperature (°C)



Relative humidity (%)



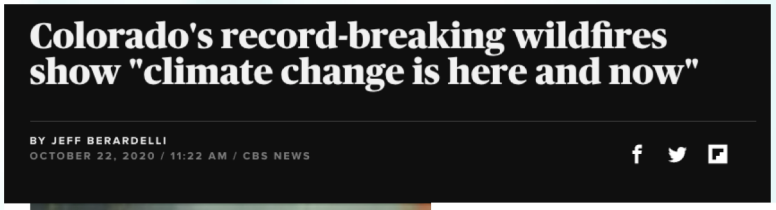
Gross Primary Productivity (gC m^{-2} yr^{-1})

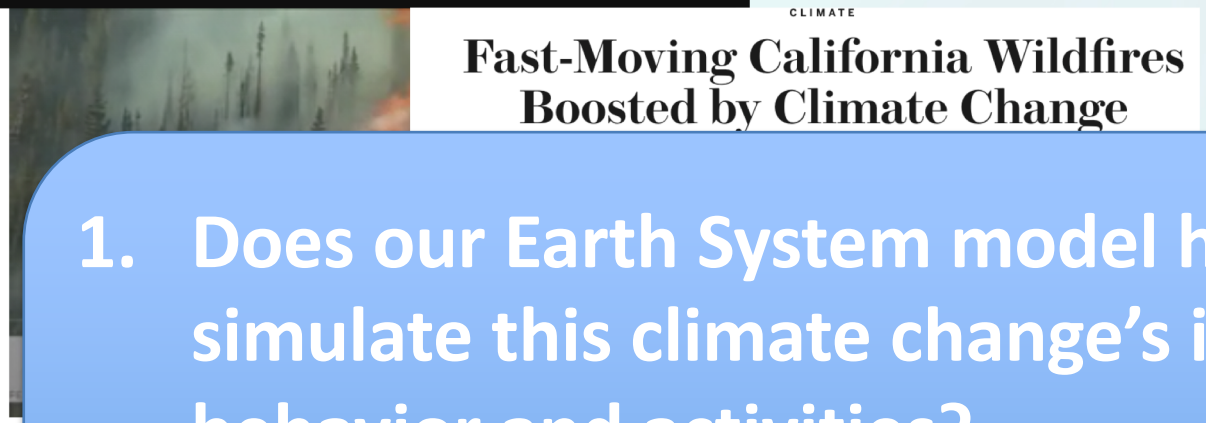


Variables	Fire – No Fire
Downward solar radiation at land surface (W m^{-2})	-2.8±0.7*
Land surface air temperature (°C)	-0.18±0.15*
Land relative humidity (%)	0.39±0.31*
Gross primary productivity (Pg C yr^{-1})	-3.0±1.7*

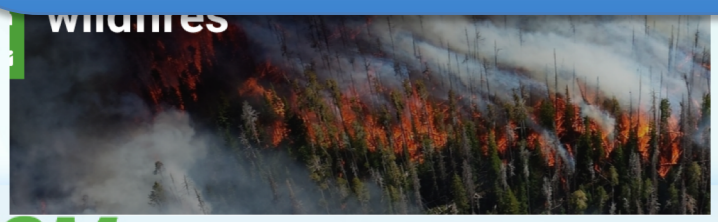
Xu et al., in prep.

Climate change's influence on wildfires



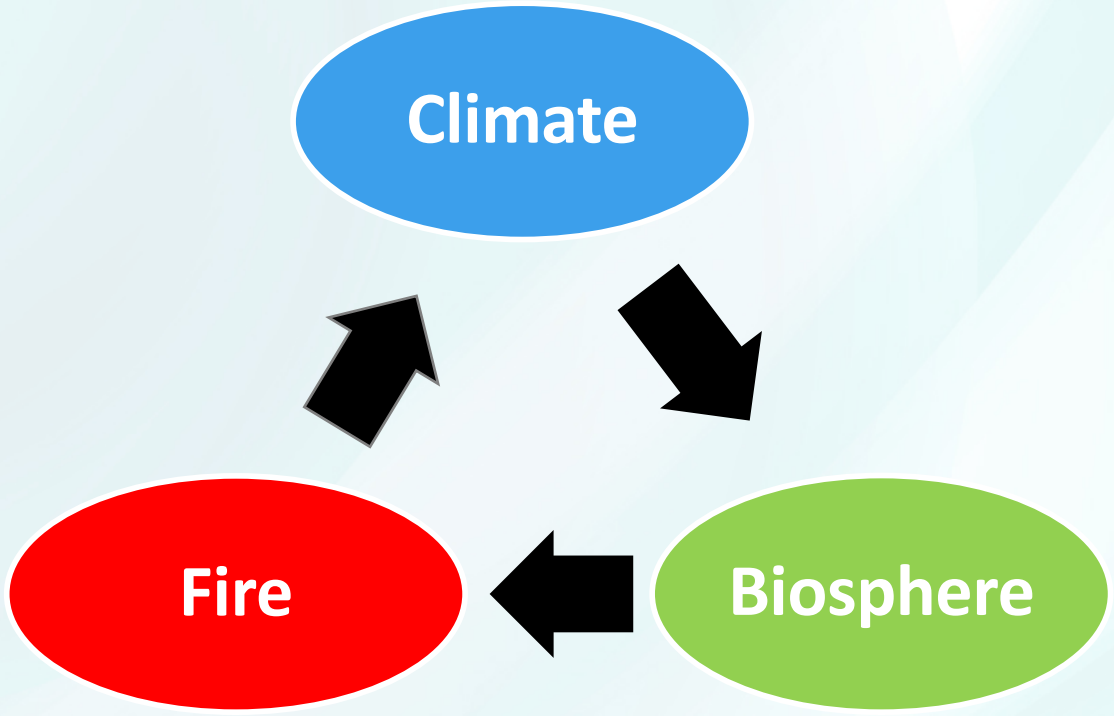


1. Does our Earth System model have capability to simulate this climate change's influence on fire behavior and activities?
2. How do wildfires respond to the changing climate in a regional or global scale?

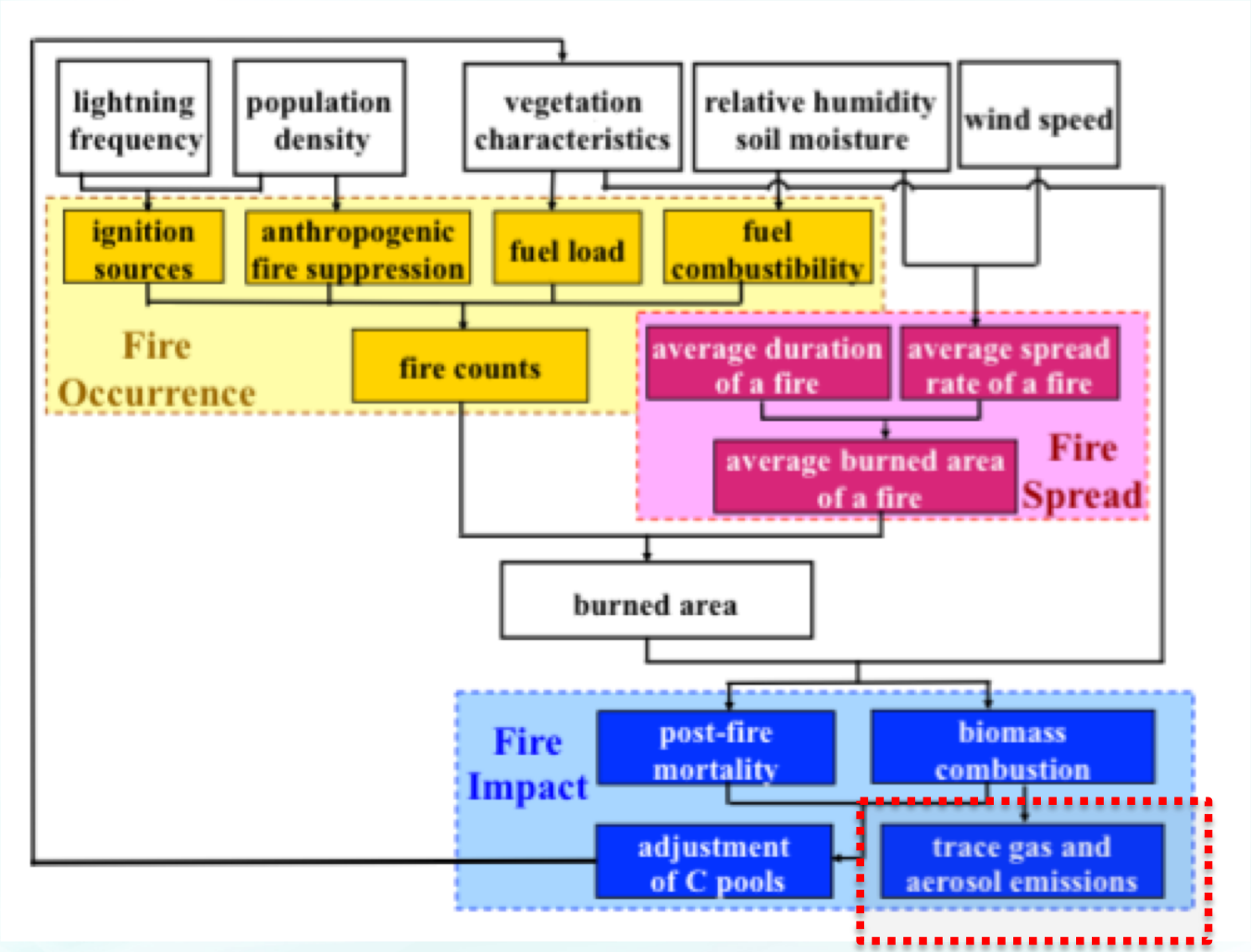


Objectives

- Couple online fire emissions from ELM to EAM *that is not available in E3SM*
- Provide a tool to study the fully-coupled fire-climate interaction in E3SM

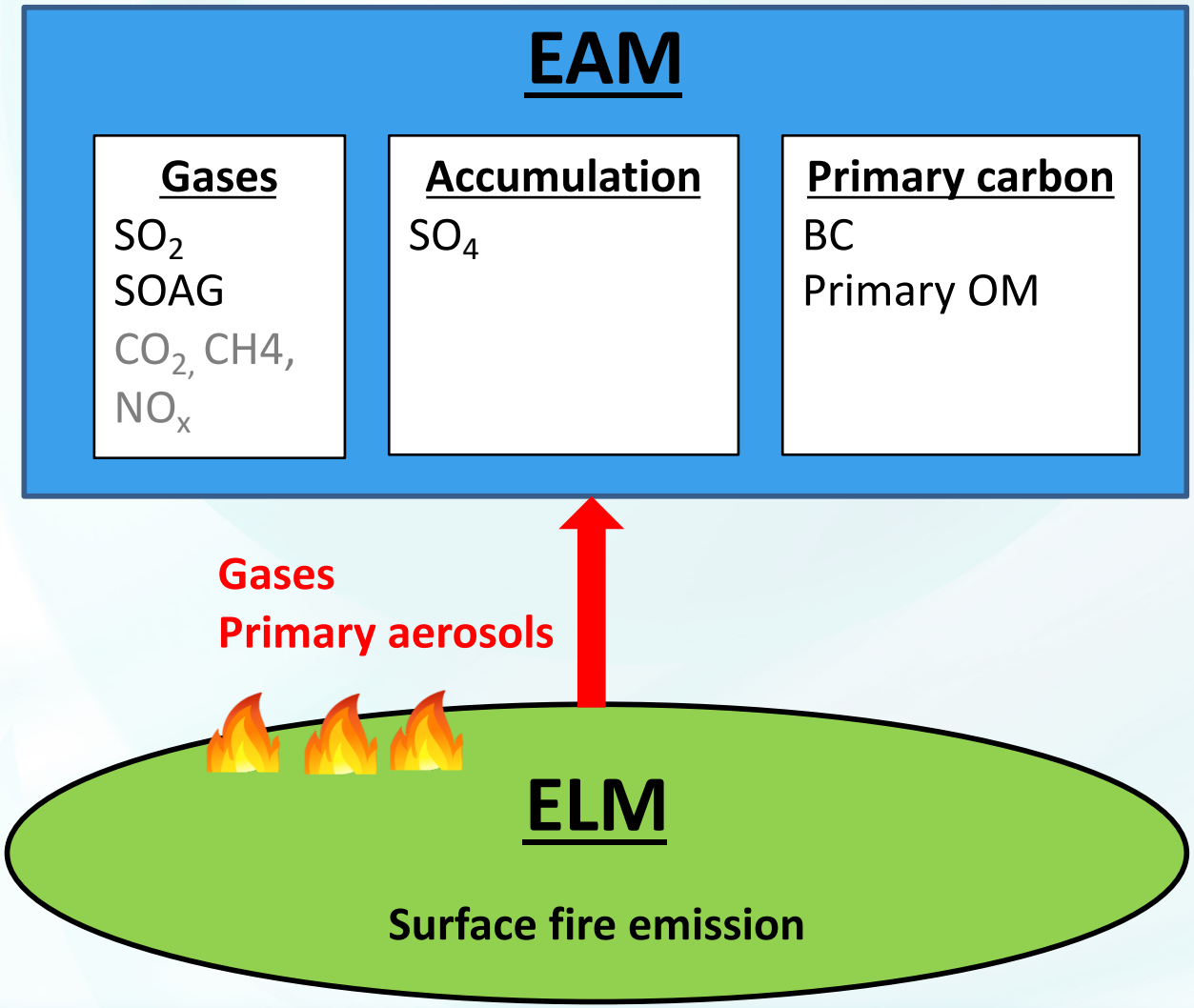


Fire Model in E3SM (adopted from CLM4)



Li et al., 2012, *Biogeosciences*

Coupled fire emission module in E3SM



EAM feature:

- Choice of surface or elevated vertical fire emission
- Timestep: 30 minutes

ELM features:

- PFT-dependent emission factor for each species and DM/C ratio
- Consideration of peat fire emission factor in the equatorial Asia

#	Plant Function Type	Emission Factor Source
0	Not vegetated	0
1	NET Temperate	S3
2	NET Boreal	S2
3	NDT Boreal	S2
4	BET Tropical	S4
5	BET Temperate	S3
6	BDT Tropical	S4
7	BDT Temperate	S3
8	BDT Boreal	S2
9	BES Temperate	S3
10	BDS Temperate	S3
11	BDS Boreal	S2
12	C3 Arctic Grass	S2
13	C3 non-Arctic Grass	S1
14	C4 Grass	S1
15	Crop 1	S5
16	Crop 2	S5

Emission factor references:
Andreae, 2019, *ACP*

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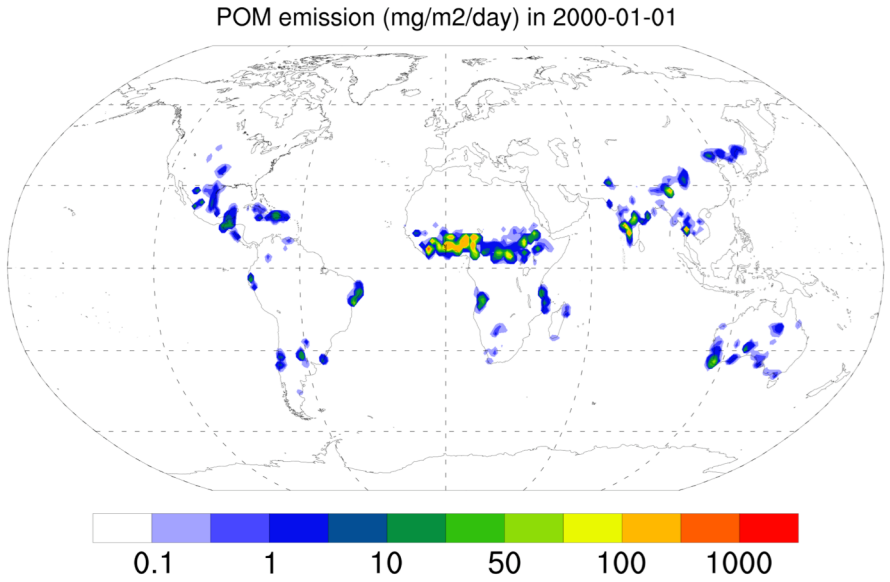
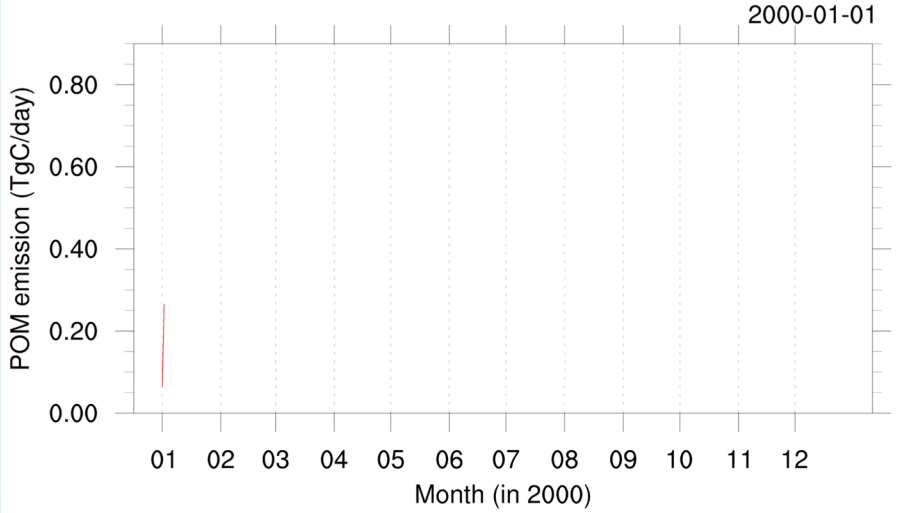




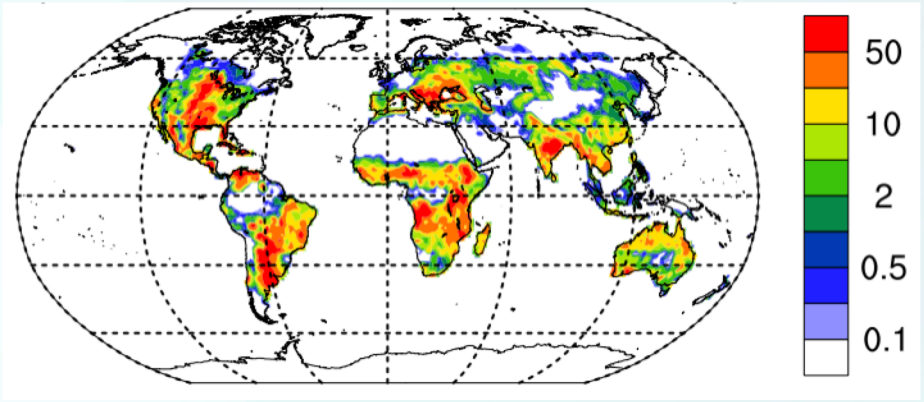
Experiment	Description
No fire	Non-fire aerosol sources
Cpl. fire	Non-fire aerosol sources + online fire emissions from ELM
GFED fire	Non-fire aerosol sources + prescribed monthly optimized fire emissions from GFED

Duration: 20 years (1997-2016)

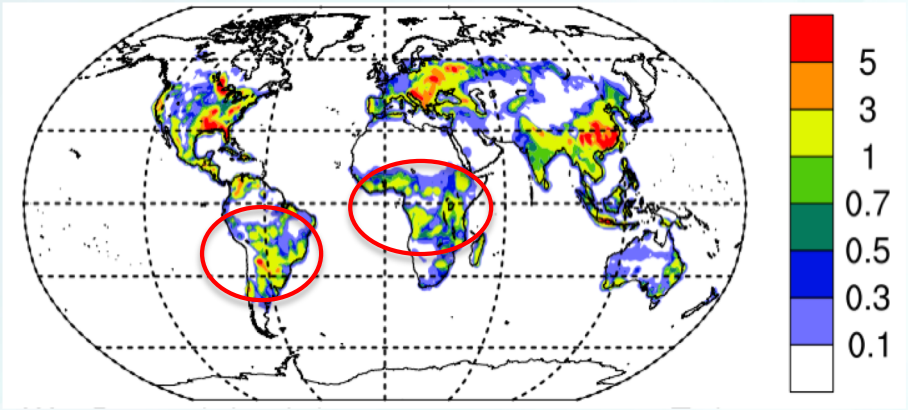
Preliminary results

The atmospheric primary organic matter (POM) burden and aerosol optical depth from fires appears low bias in tropical fire regions and high bias in northern hemisphere forest regions in accordance with burned area.

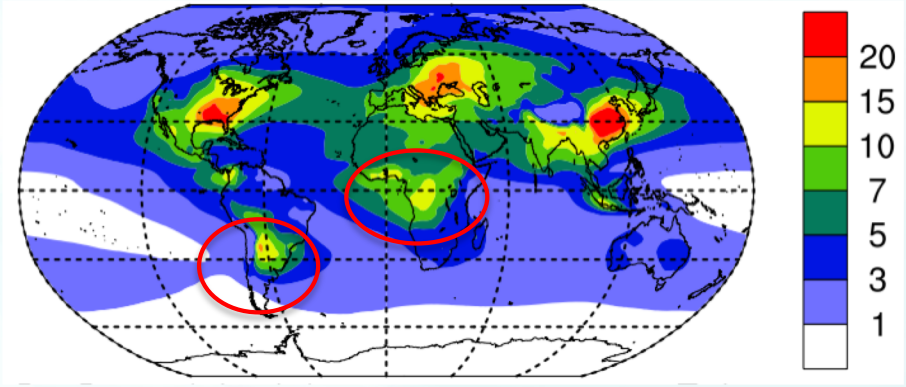
Burned Area (% yr^{-1})



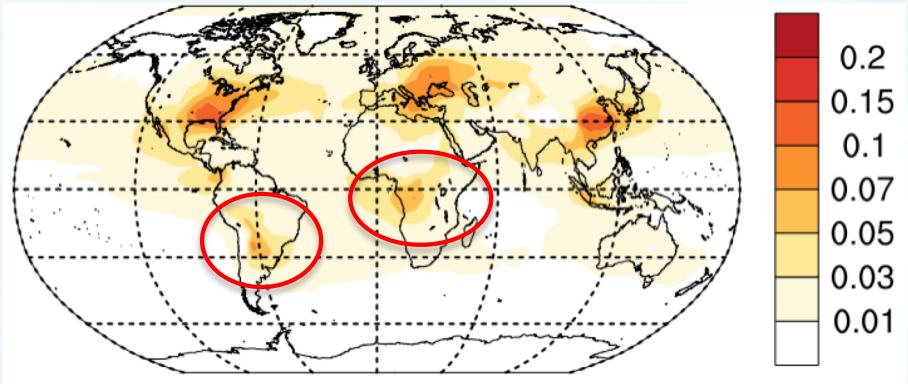
POM Emission (g m^{-2} yr^{-1})



POM Burden (g m^{-2} yr^{-1})



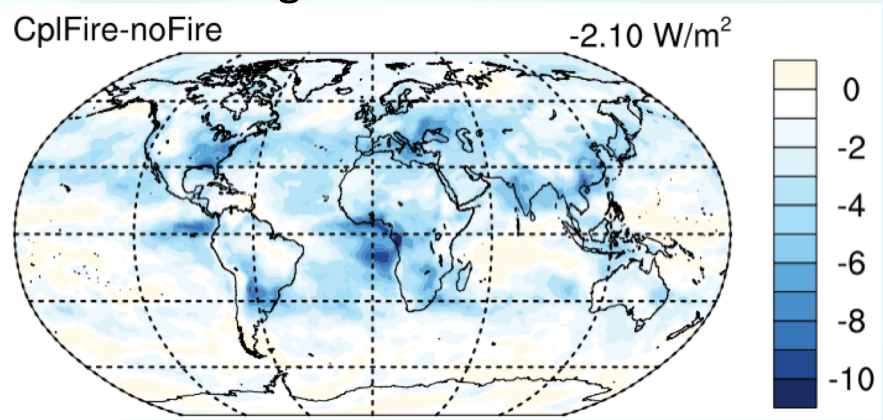
Aerosol Optical Depth



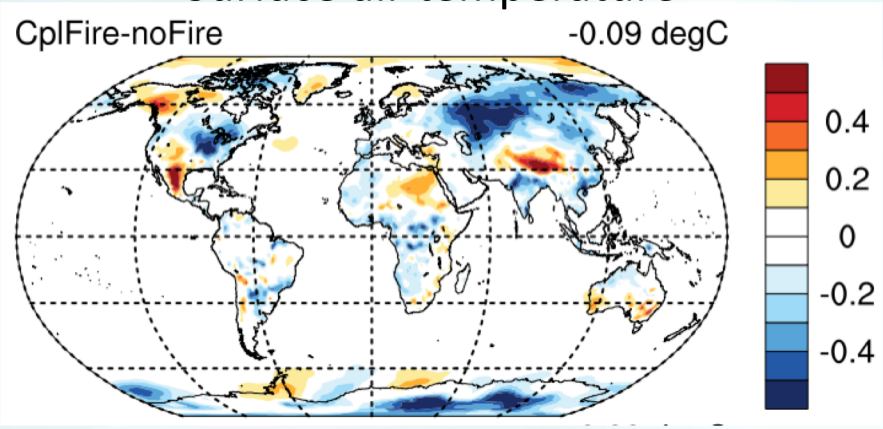
Preliminary results:

Fire aerosols change near-surface climate in many regions

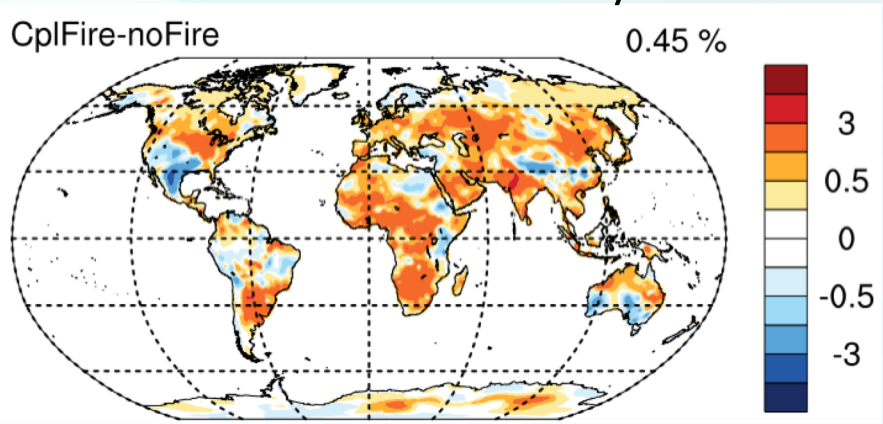
Downwelling solar radiation at surface



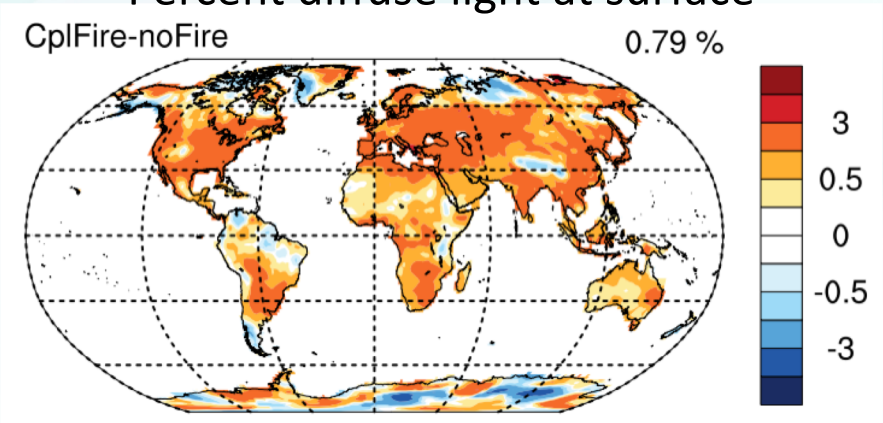
Surface air temperature

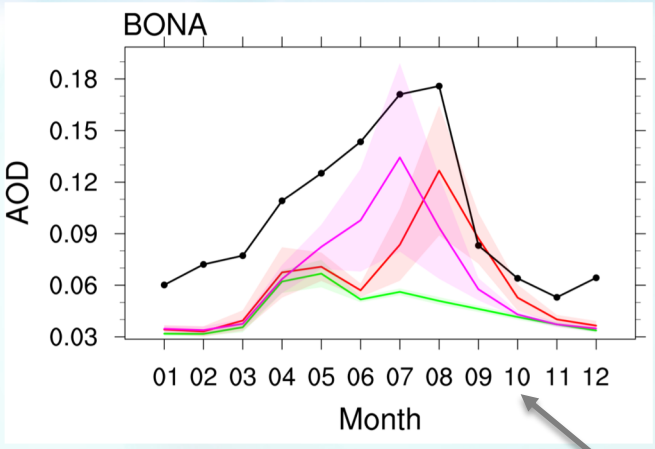


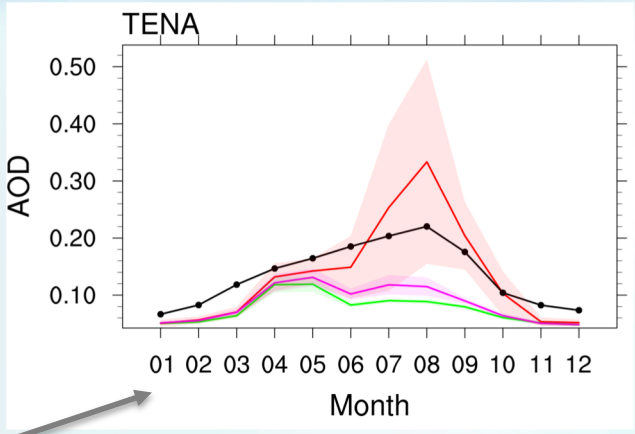
Relative humidity

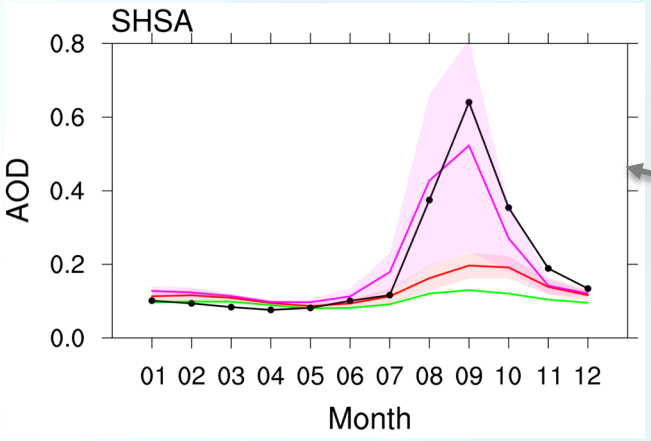


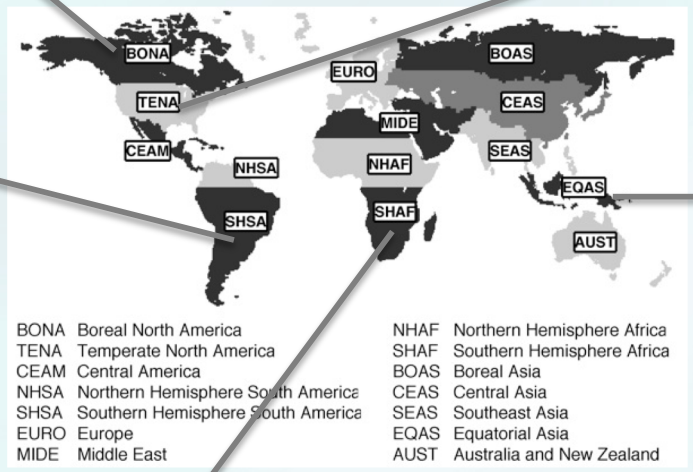
Percent diffuse light at surface

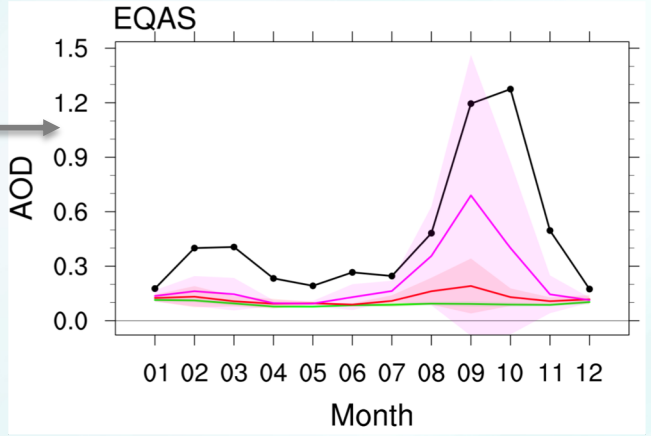


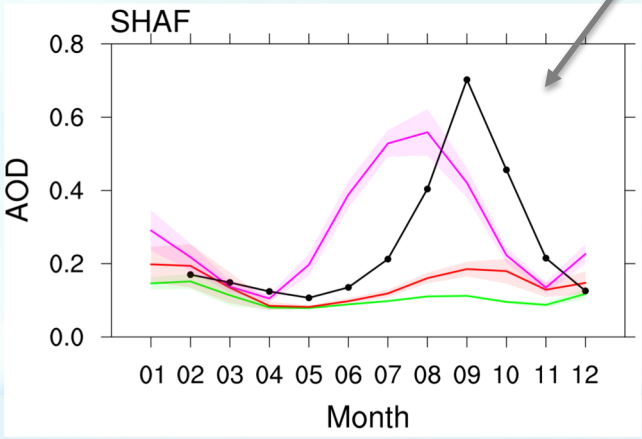












No fire
Cpl. fire
GFED fire
AERONET

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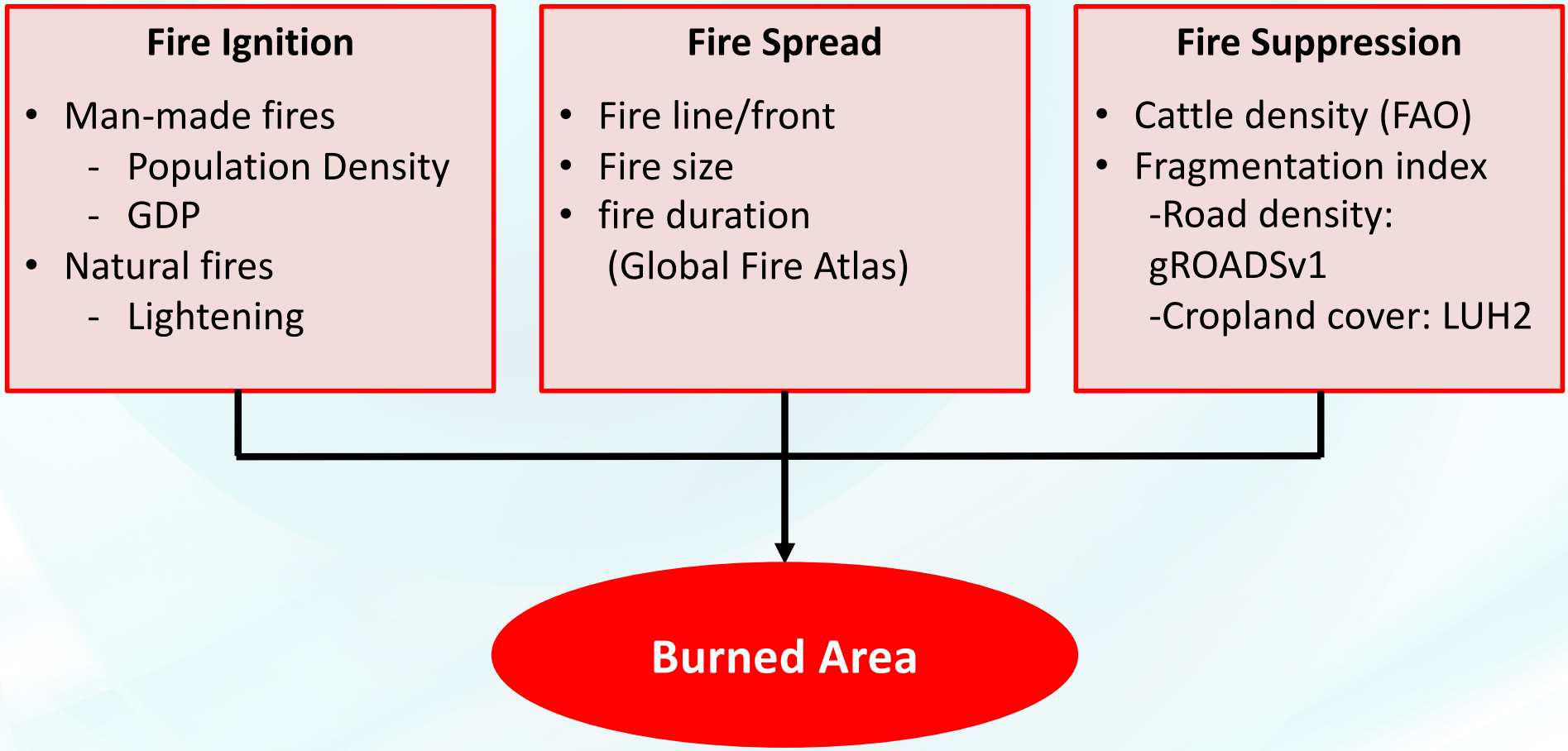
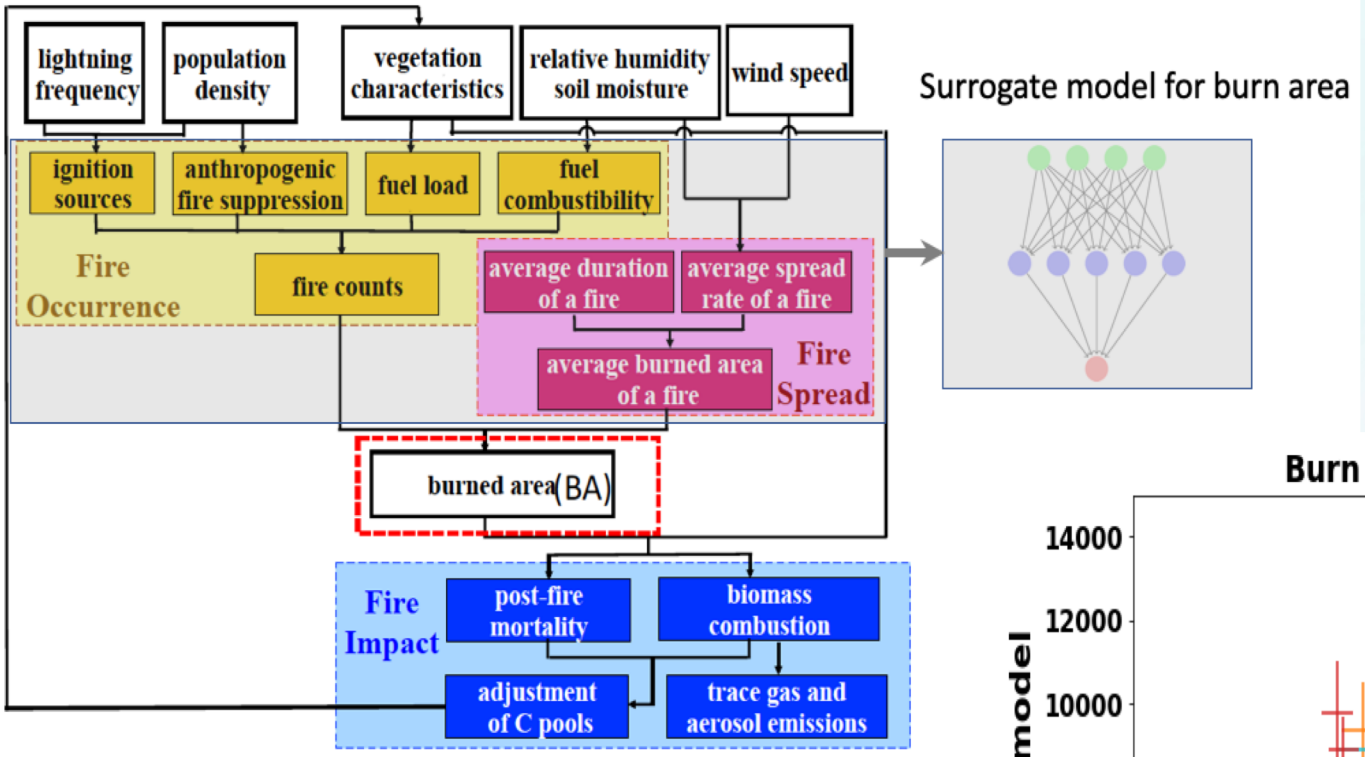
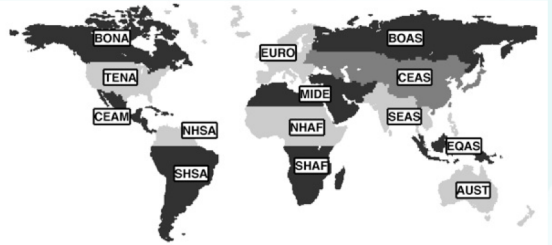
Ongoing: Developing a new semi-mechanic fire model



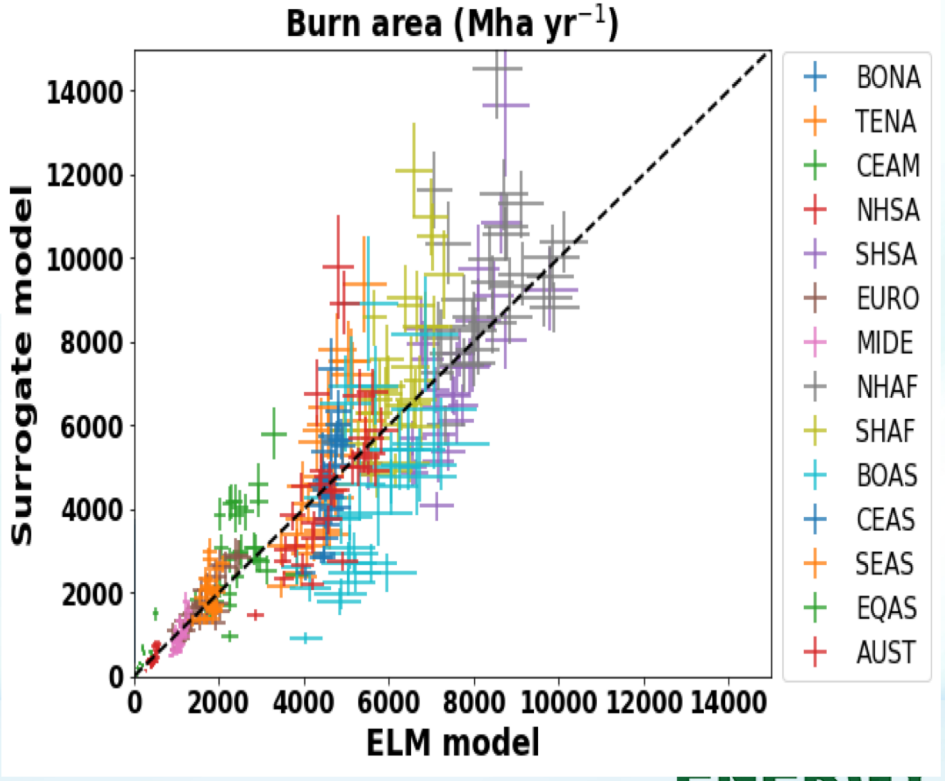
Development of a Machine Learning Fire Model in E3SM



Surrogate model for burn area



14 GFED regions

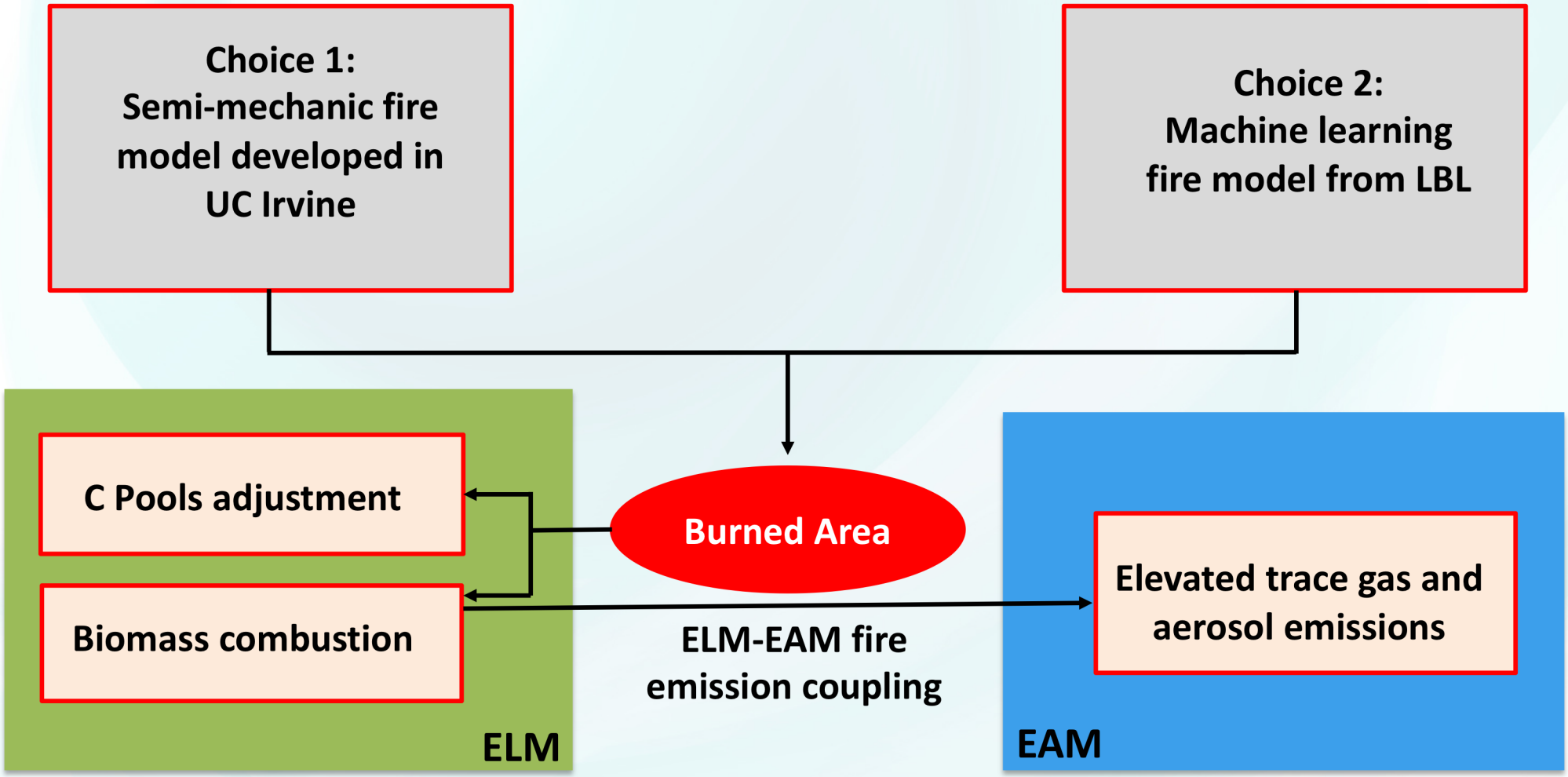


Li et al., 2012

Slide courtesy of Dr. Qing Zhu (LBL)

Check “E3SM wildfire fire surrogate model based on machine learning” (**#D4S2-BR#2)**

Ongoing: Integration of the fire-climate coupling in E3SM



Summary

- We developed an online fire emission coupling module in E3SM.
- The atmospheric aerosol loading from the coupled fires appears reasonable with a low bias in tropical fire regions.
- The new feature of the online fire emission coupling provides a useful tool to study the fire-climate interaction in the near future.

Thanks!