Investigating global fire behavior, variability, trends, and driving factors using an interactive fire module coupled with CESM2

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David Lawrence, CGD, NCAR

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NCAR
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Fire module in CESM/CLM

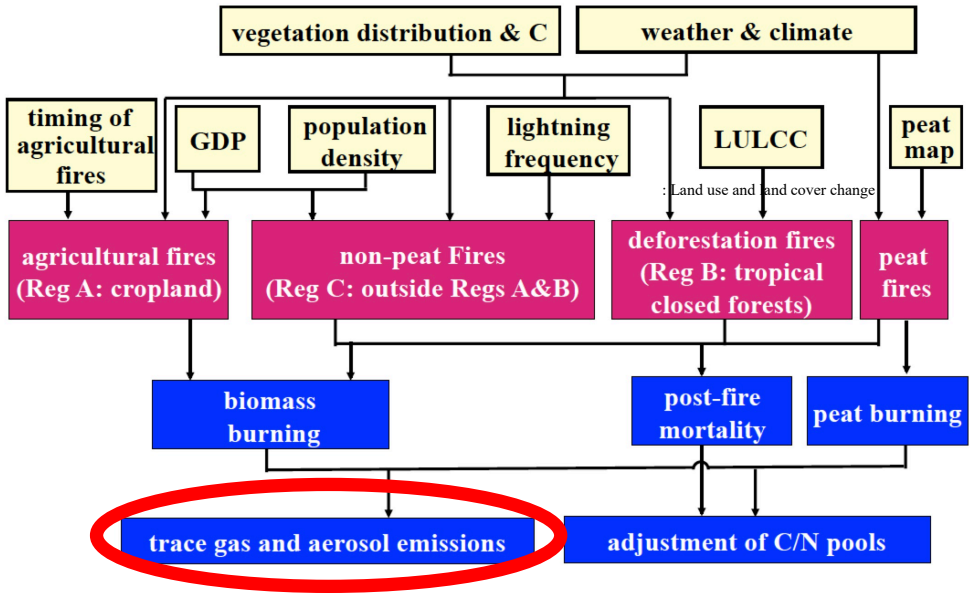


Fig. 2. Structure of new fire parameterization. Fire scheme described in Li et al. (2012a, b) is used in Region C with modifications by mainly adding the economic influence in the fire occurrence component and the socioeconomic influence in the fire spread component.

Li et al., 2013

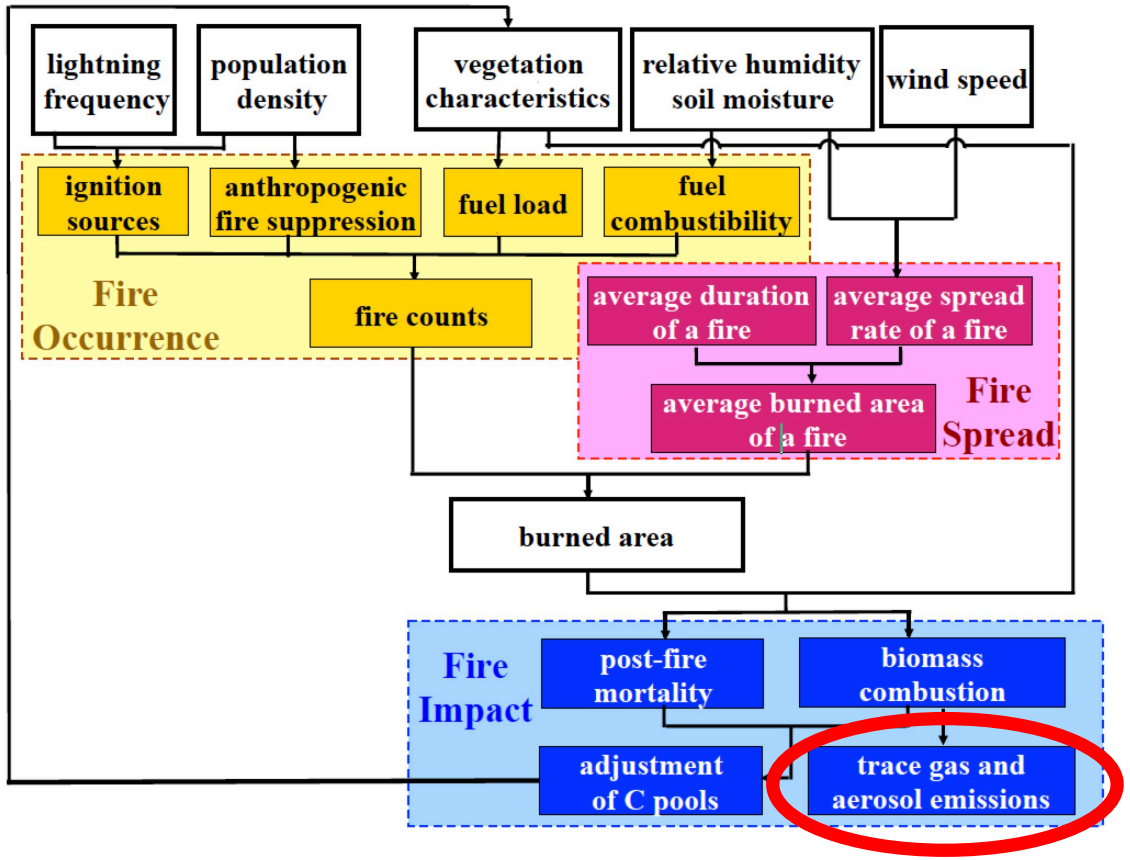
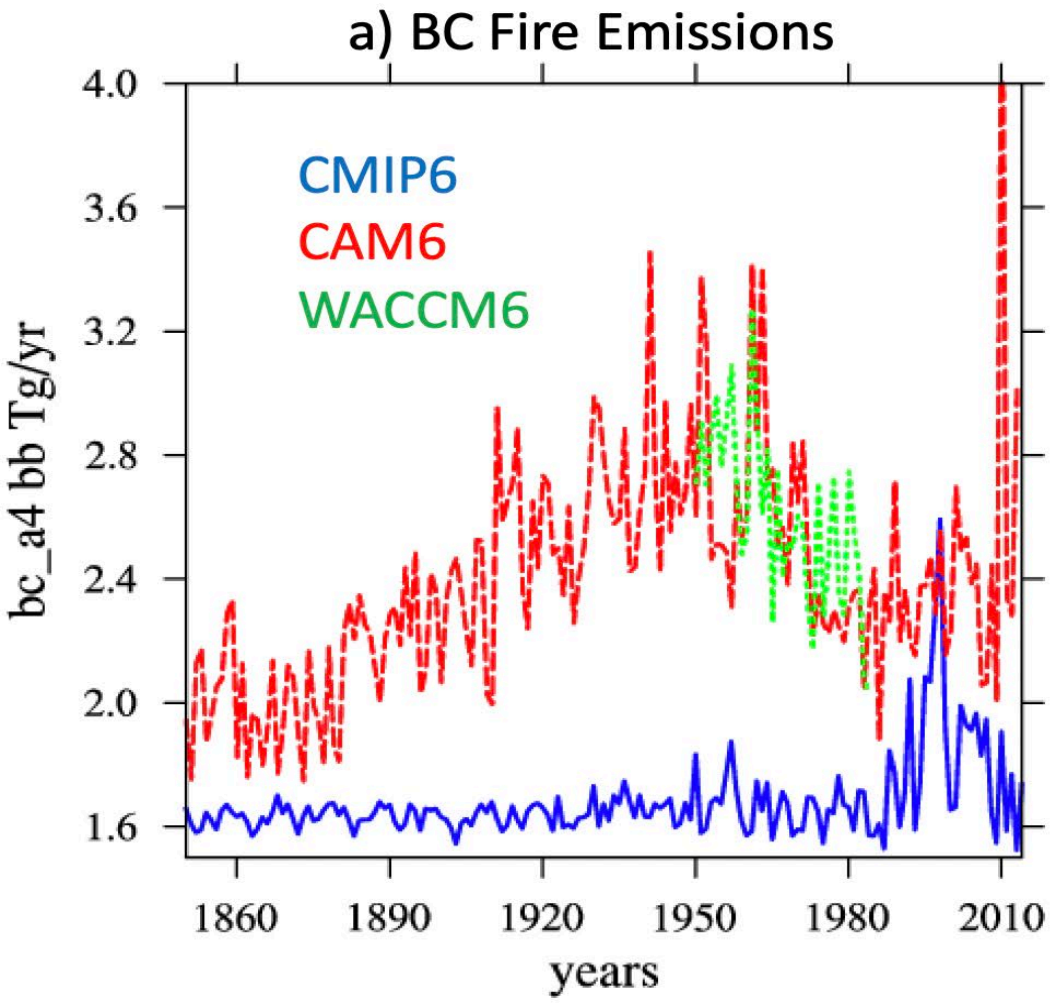


Fig. 1. Fire parameterization of Li et al. (2012a, b). It contains three components: fire occurrence, fire spread, and fire impact.

Li et al., 2012

Disagreement with CMIP6 in fully coupled CESM run



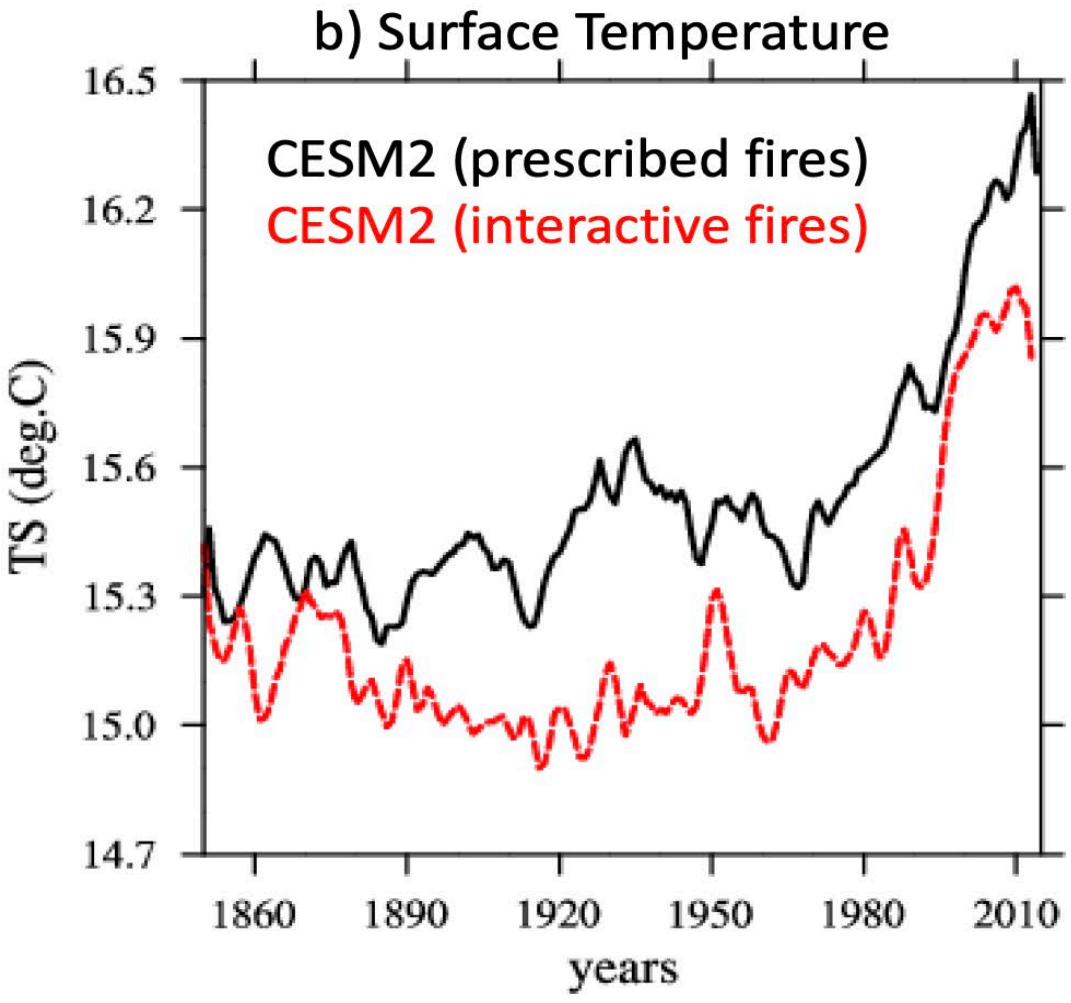


Figure from Simone Tilmes

Updates in the code

1. Recalibrating the relationship between tropical deforestation rate and deforestation and degradation fires

2. Changing BTRAN2 to root-zone soil moisture

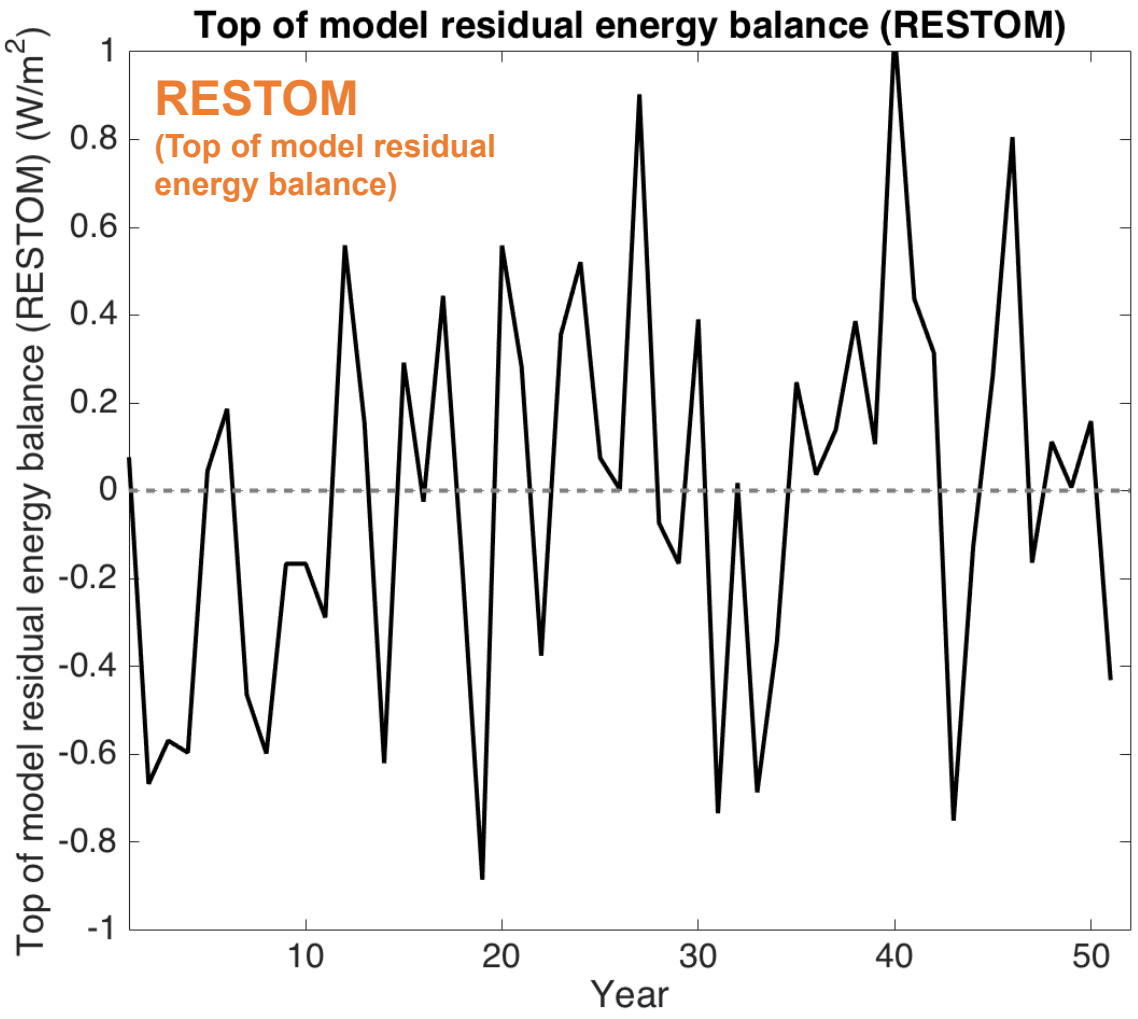
3. Bugs on lightning and ignition identified several months ago is fixed

(https://github.com/ESCOMP/CTSM/issues/889)

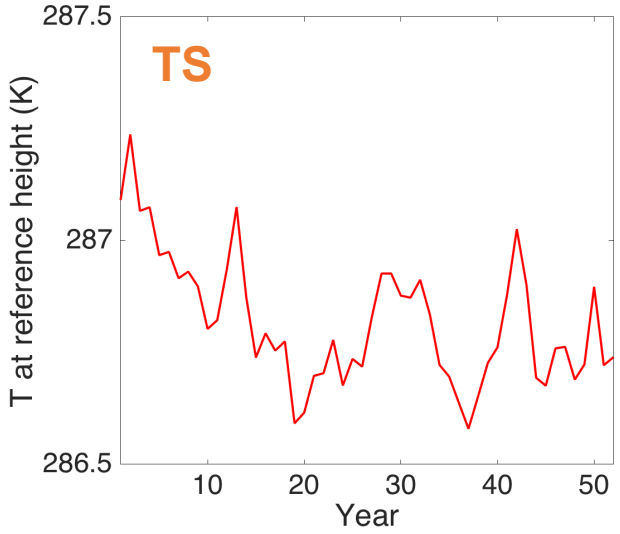
CESM2 simulations with the updated fire module

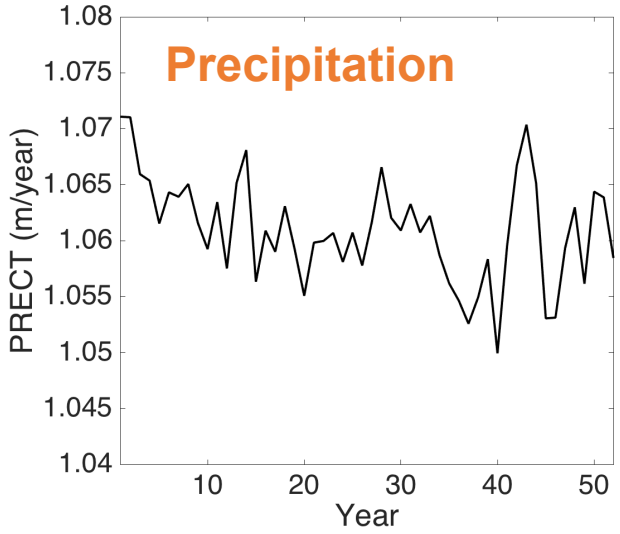
Pre-Industrial Control (PI Control; B1850) run

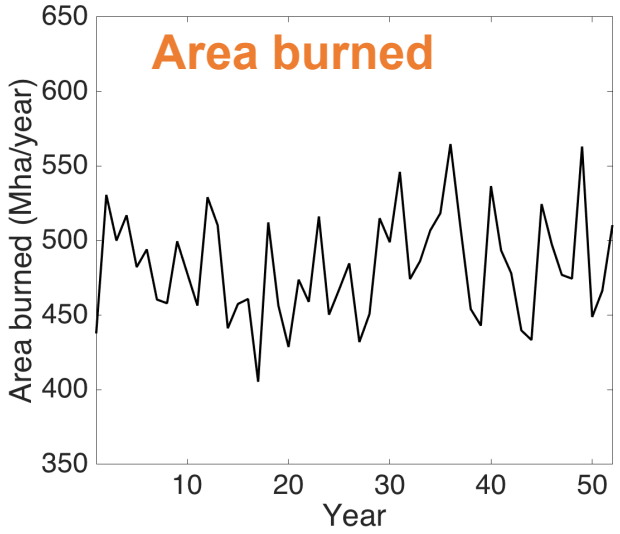
updated fire module code, and fire emissions from the fire module

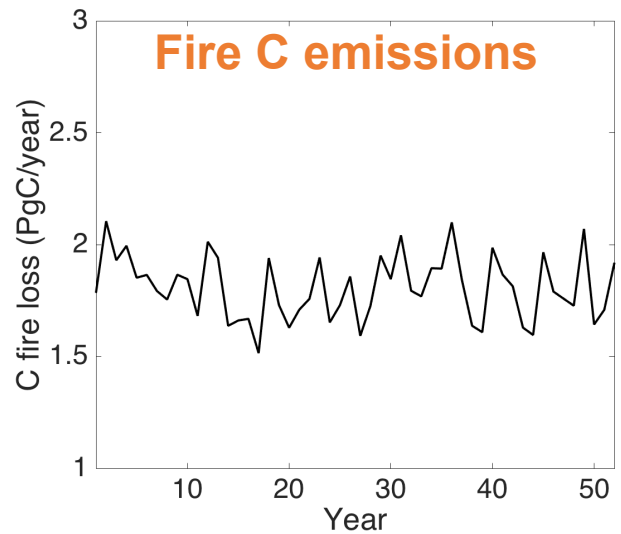


Averaged RESTOM = -0.0037 W/m^2 < 0.05 W/m^2









CESM2 simulations with the updated fire module

Historical simulation (BHIST) runs

We have run an ensemble of **4 BHIST simulations with fire emissions from the fire module**.

- 1850-present
- With-updated fire code
- All have the same setup but different initial conditions:
  - Ensemble.1: using CMIP6 PI Control year 501
  - Ensemble.2: using CMIP6 PI Control year 601
  - Ensemble.3: using CMIP6 PI Control year 631
  - Ensemble.4: using Our PI Control year 42

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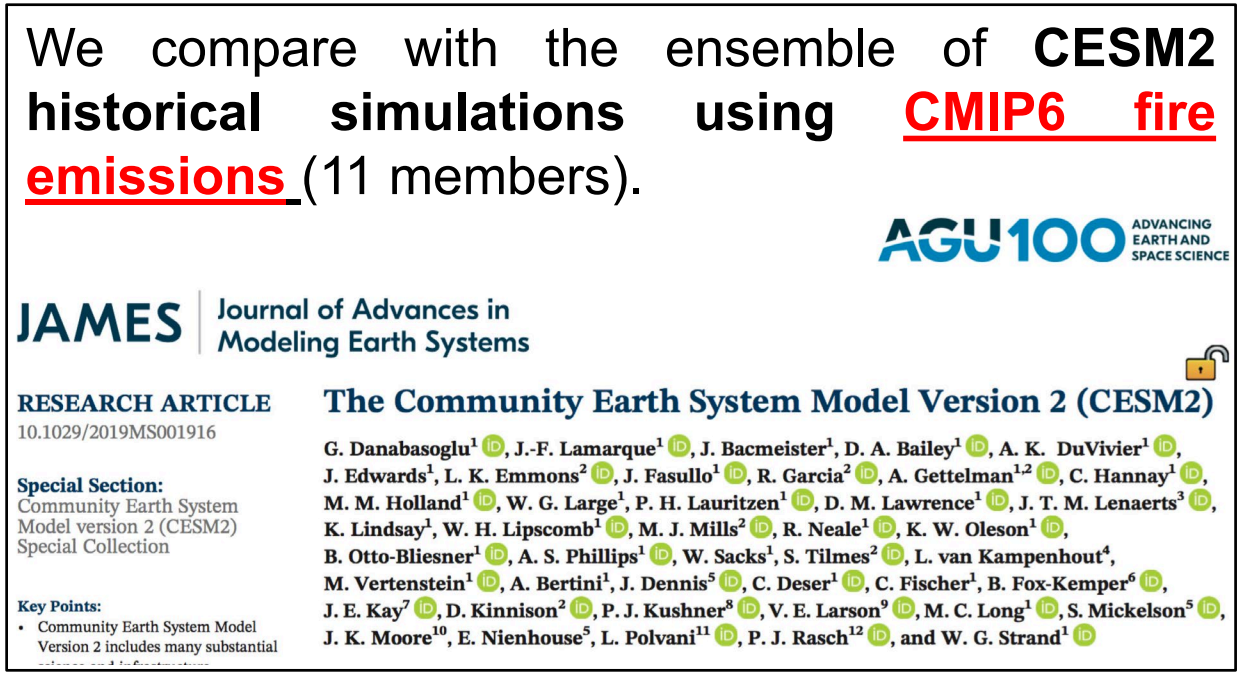
We compare with the ensemble of **CESM2 historical simulations using CMIP6 fire emissions** (11 members).



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JAMES | Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE
10.1029/2019MS001916

Special Section:
Community Earth System Model version 2 (CESM2) Special Collection

Key Points:
- Community Earth System Model Version 2 includes many substantial

The Community Earth System Model Version 2 (CESM2)

G. Danabasoglu[1], J.-F. Lamarque[1], J. Bacmeister[1], D. A. Bailey[1], A. K. DuVivier[1], J. Edwards[1], L. K. Emmons[2], J. Fasullo[1], R. Garcia[2], A. Gettelman[1,2], C. Hannay[1], M. M. Holland[1], W. G. Large[1], P. H. Lauritzen[1], D. M. Lawrence[1], J. T. M. Lenaerts[3], K. Lindsay[1], W. H. Lipscomb[1], M. J. Mills[2], R. Neale[1], K. W. Oleson[1], B. Otto-Bliesner[1], A. S. Phillips[1], W. Sacks[1], S. Tilmes[2], L. van Kampenhout[4], M. Vertenstein[1], A. Bertini[1], J. Dennis[5], C. Deser[1], C. Fischer[1], B. Fox-Kemper[6], J. E. Kay[7], D. Kinnison[2], P. J. Kushner[8], V. E. Larson[9], M. C. Long[1], S. Mickelson[5], J. K. Moore[10], E. Nienhouse[5], L. Polvani[11], P. J. Rasch[12], and W. G. Strand[1]

CESM2 simulations with the updated fire module

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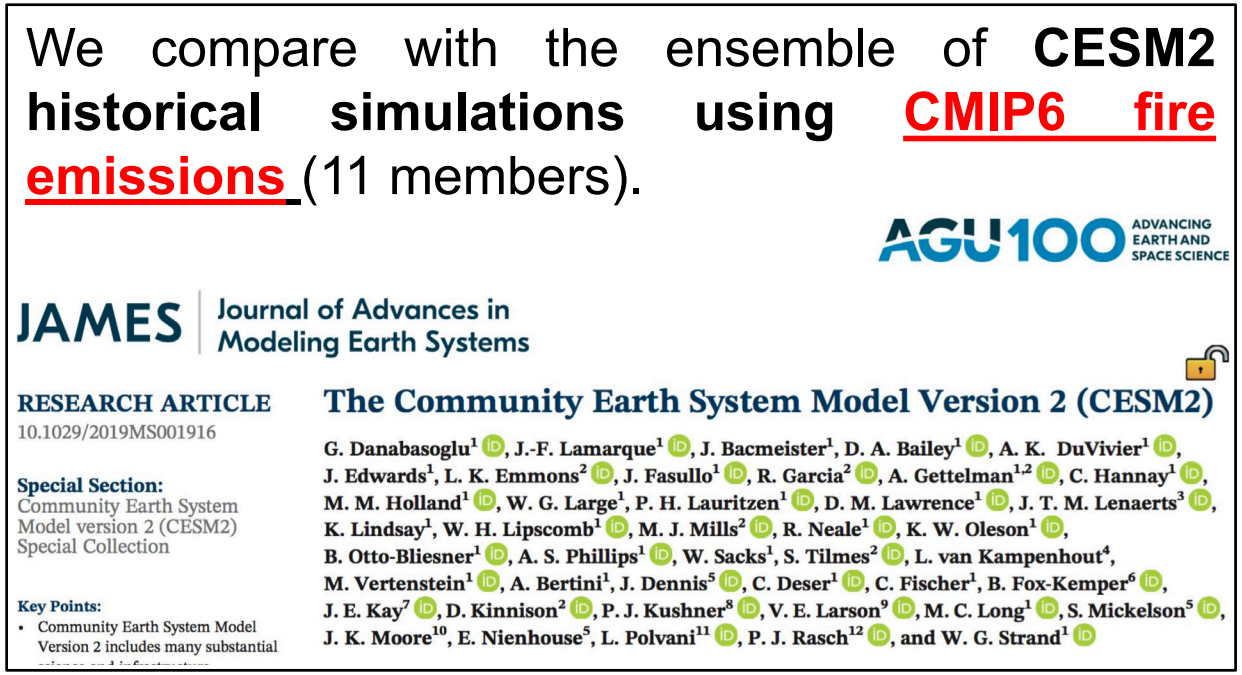
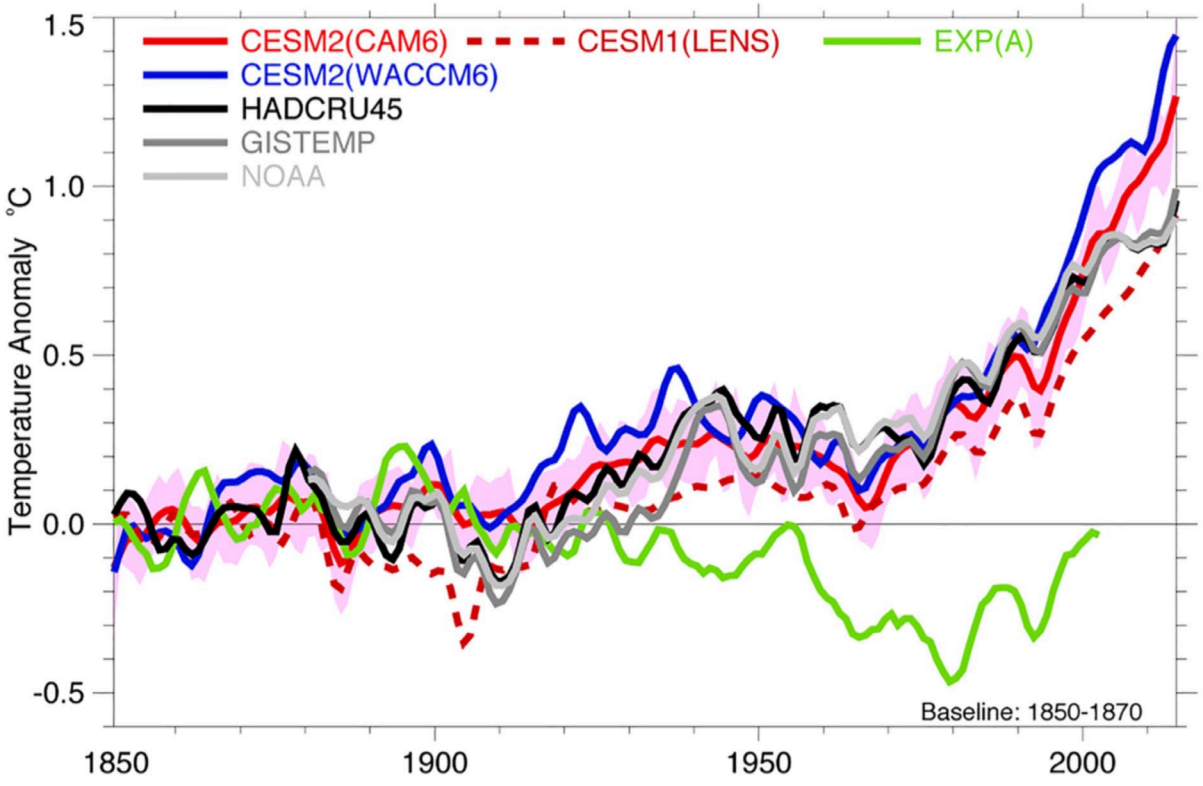


We compare with the **previous BHIST simulation that uses an old version of fire module code and fire emissions from the fire module**.

CESM2 simulations with the updated fire module

Historical transient simulation (BHIST) runs

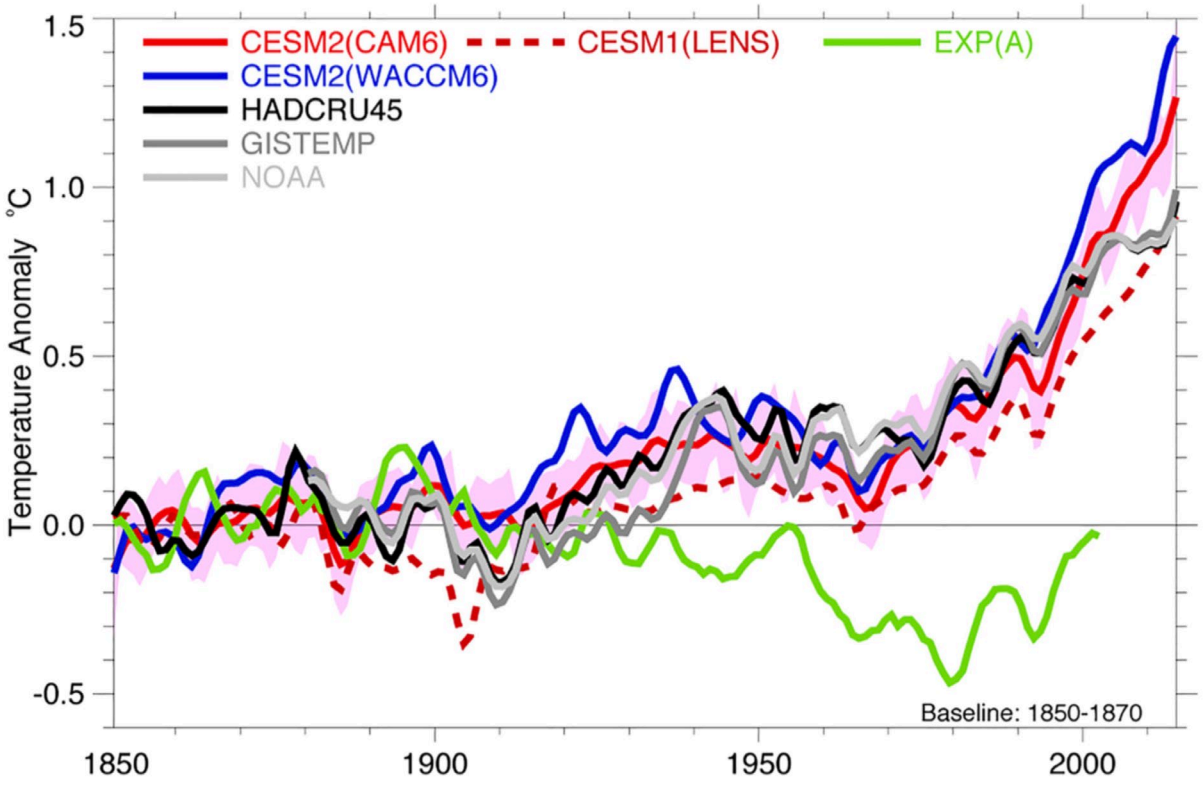
Danabasoglu et al., 2019

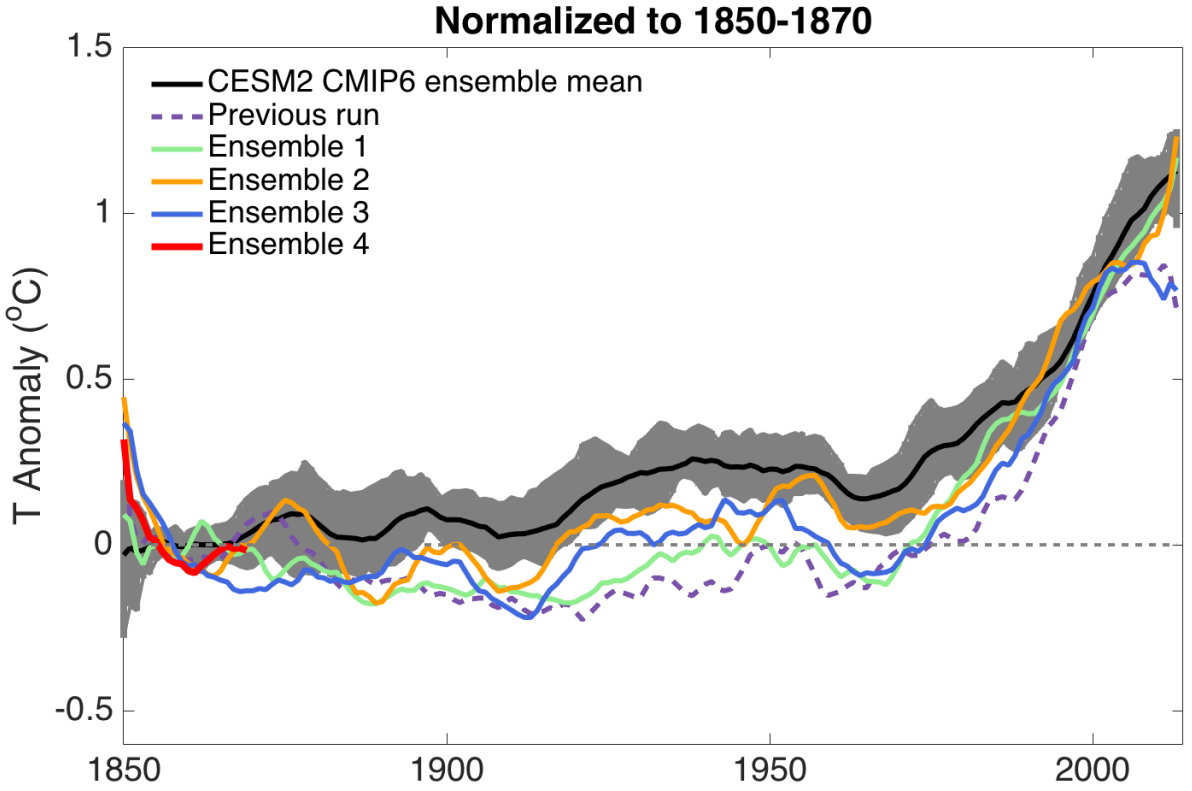


CESM2 simulations with the updated fire module

Historical transient simulation (BHIST) runs

Danabasoglu et al., 2019





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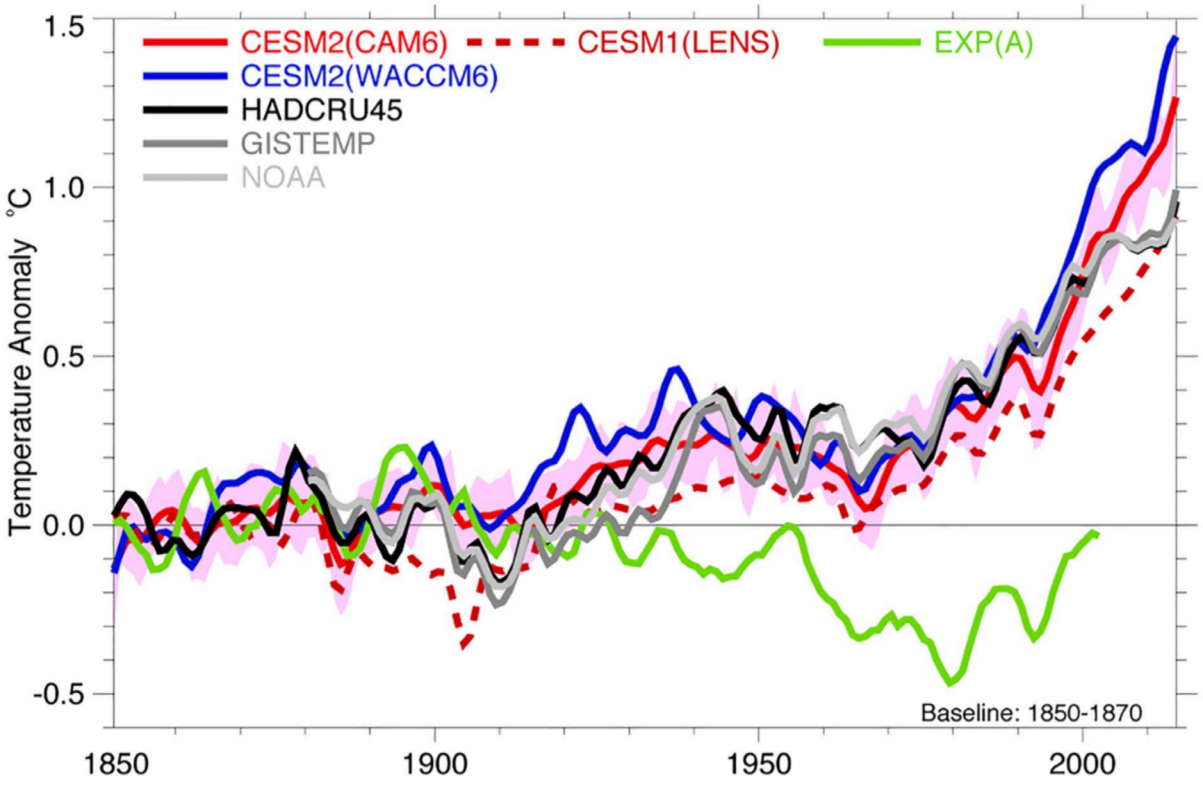
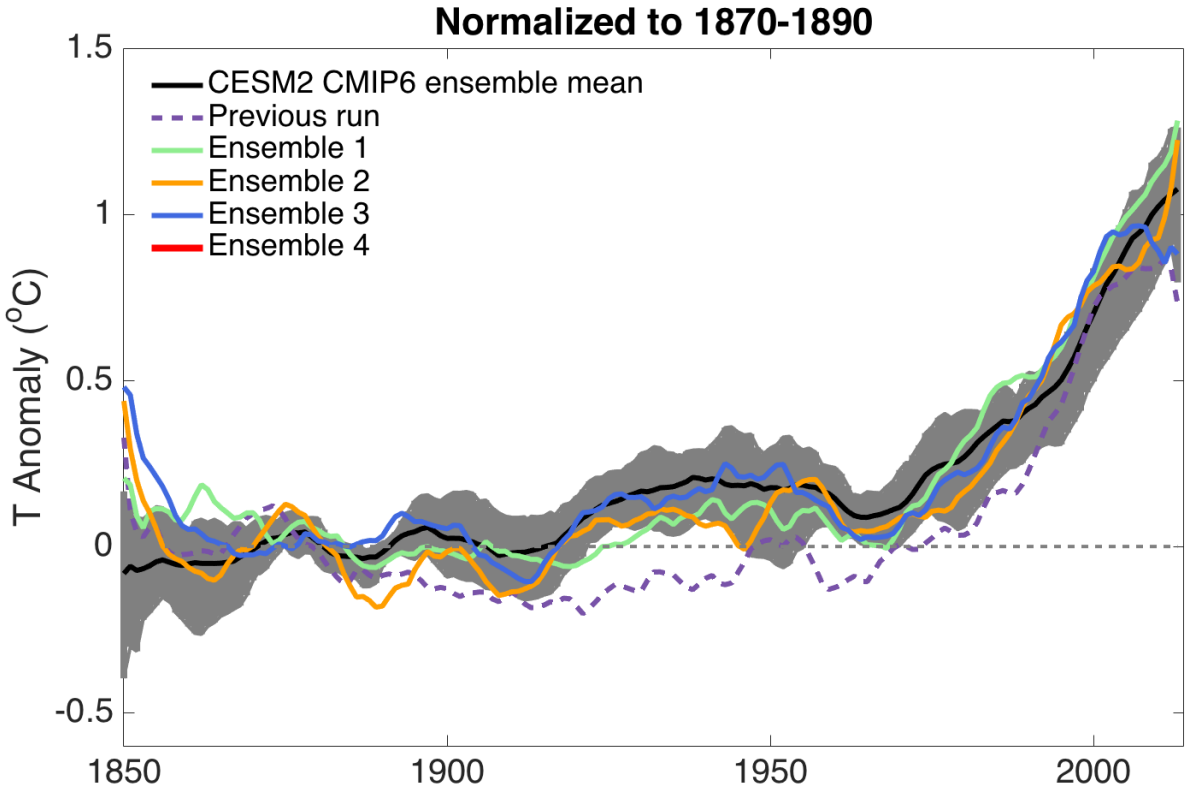
Danabasoglu et al., 2019





CESM2 simulations with the updated fire module

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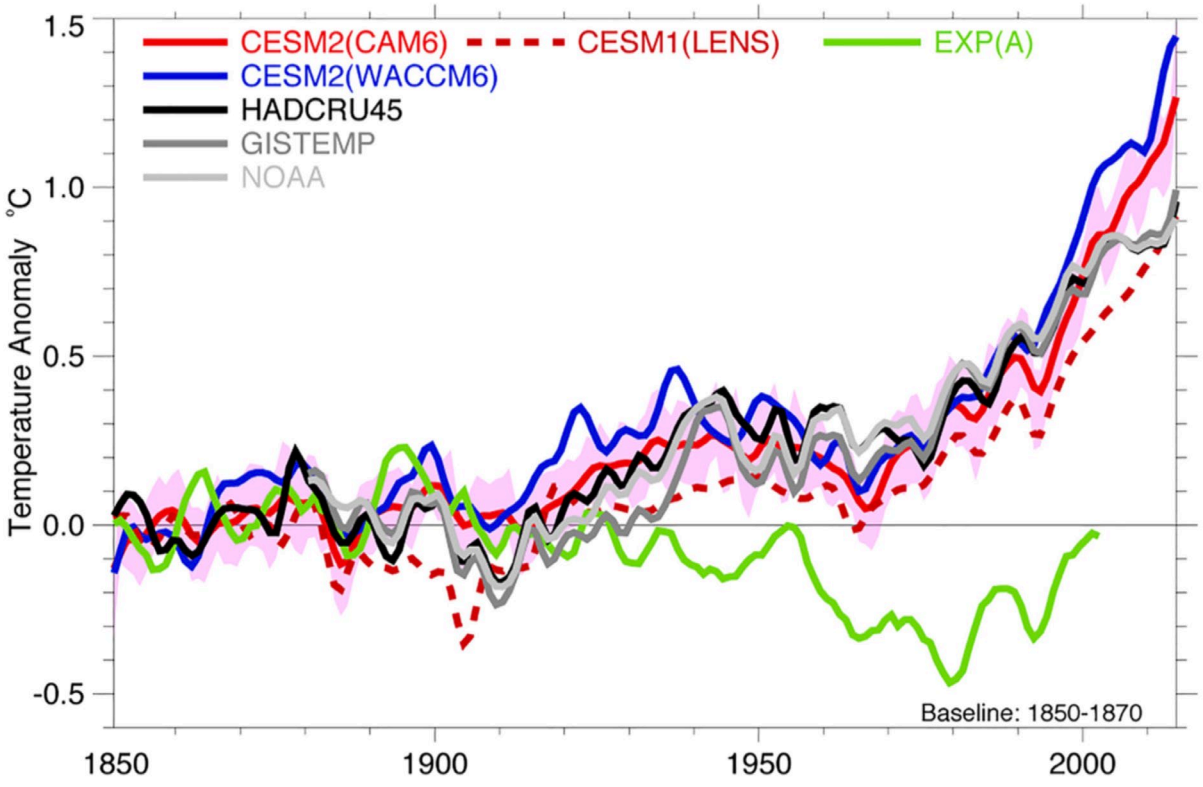
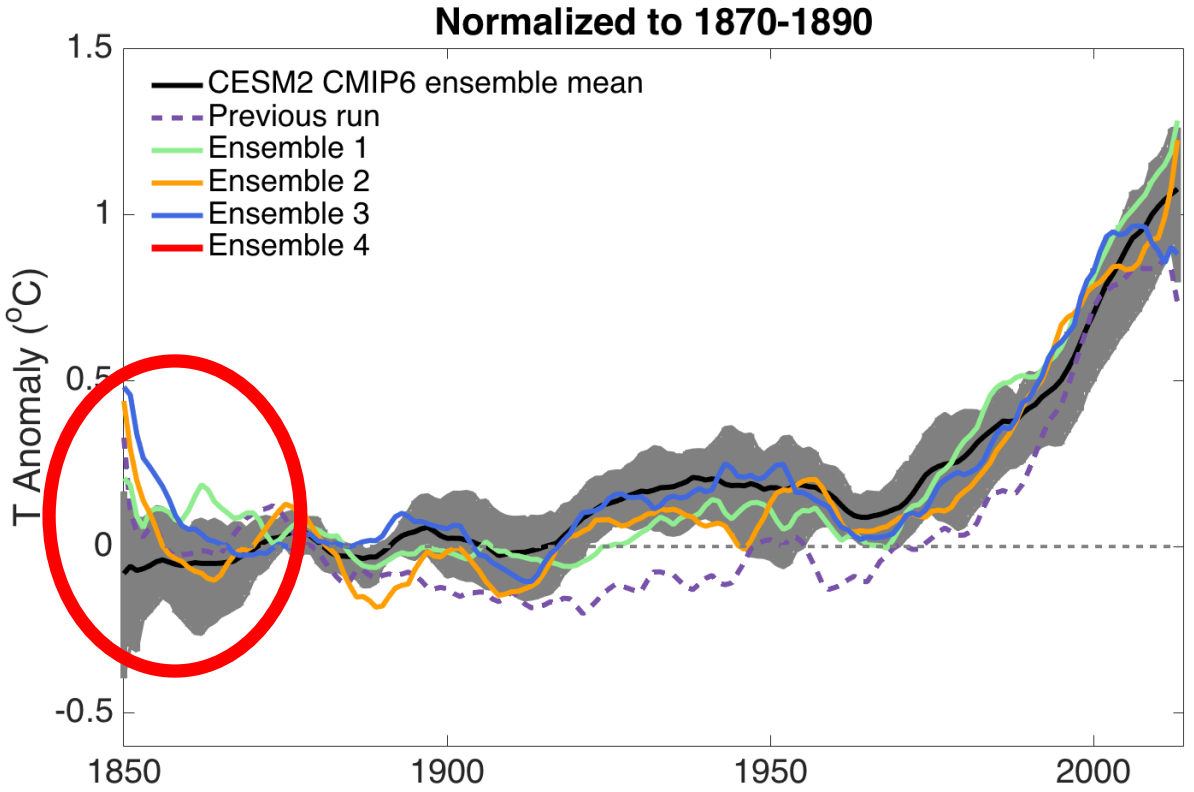
Danabasoglu et al., 2019





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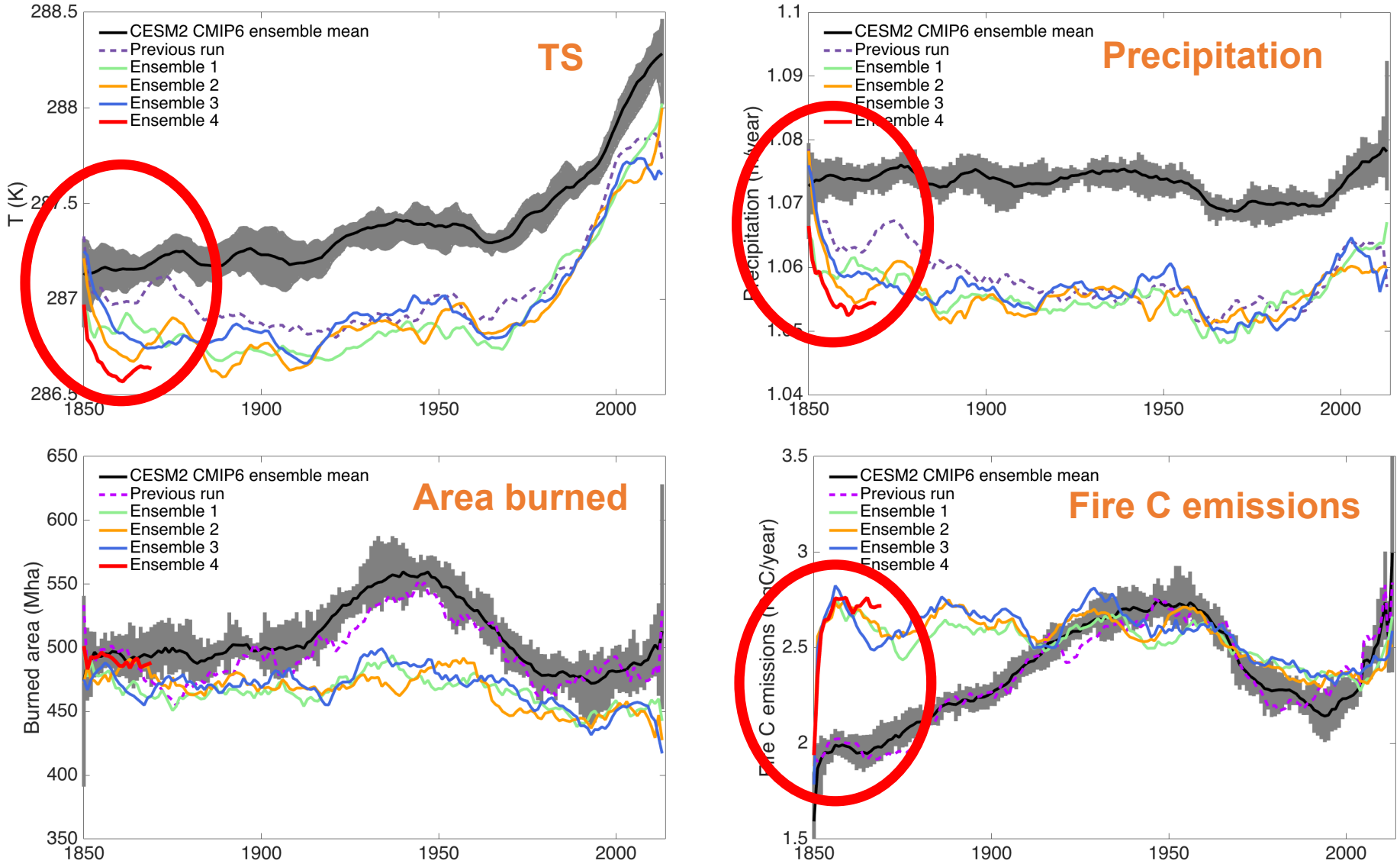

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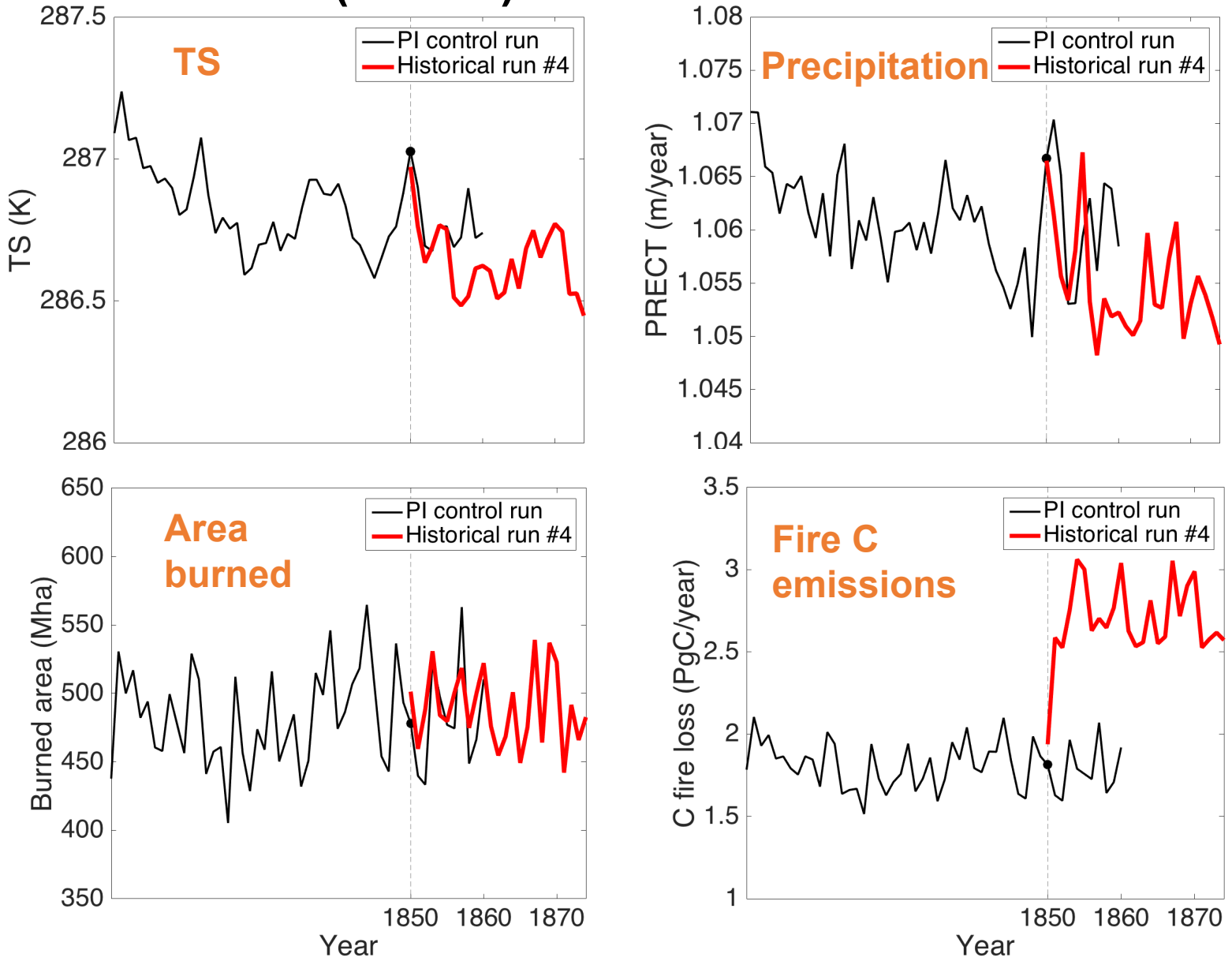

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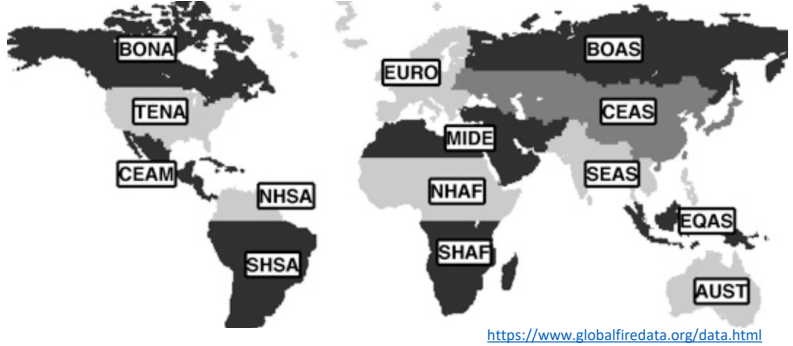
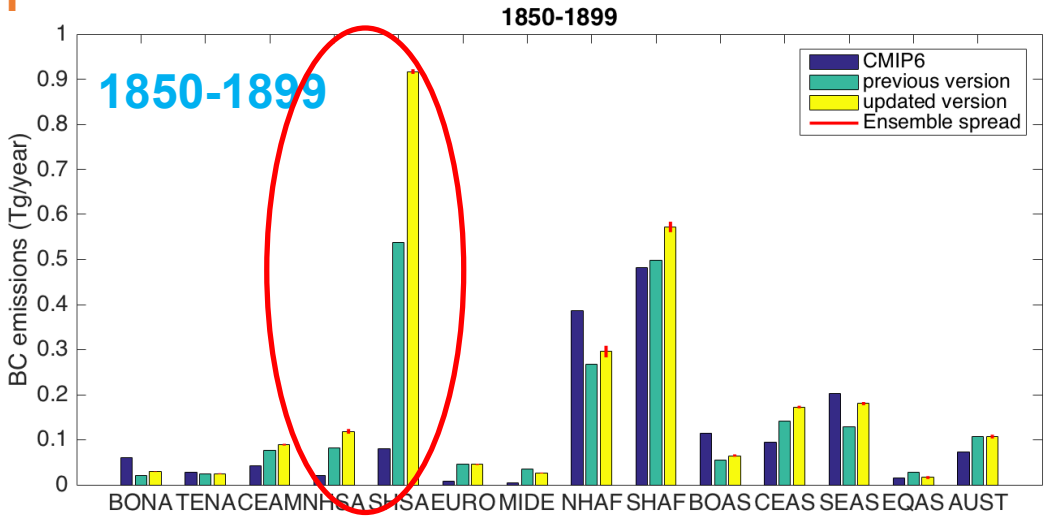
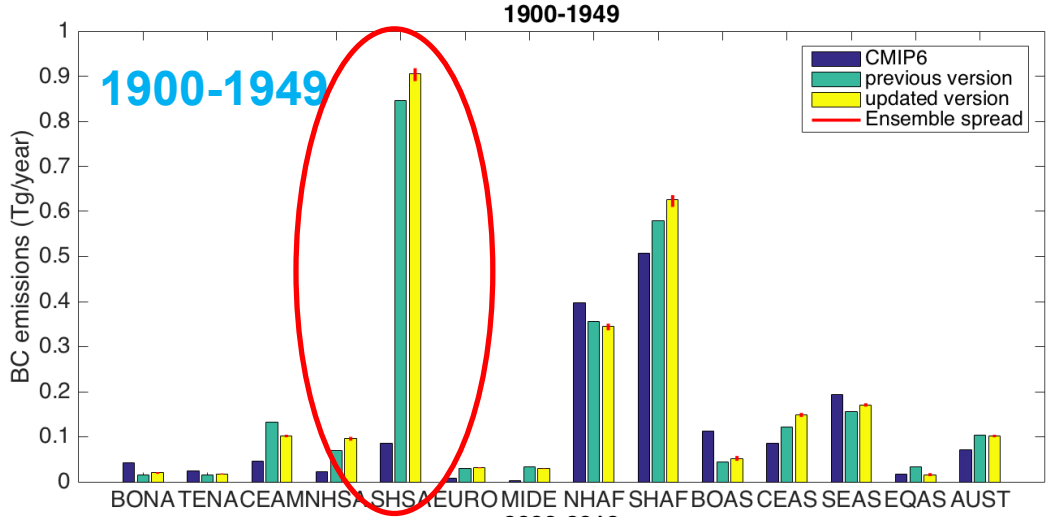
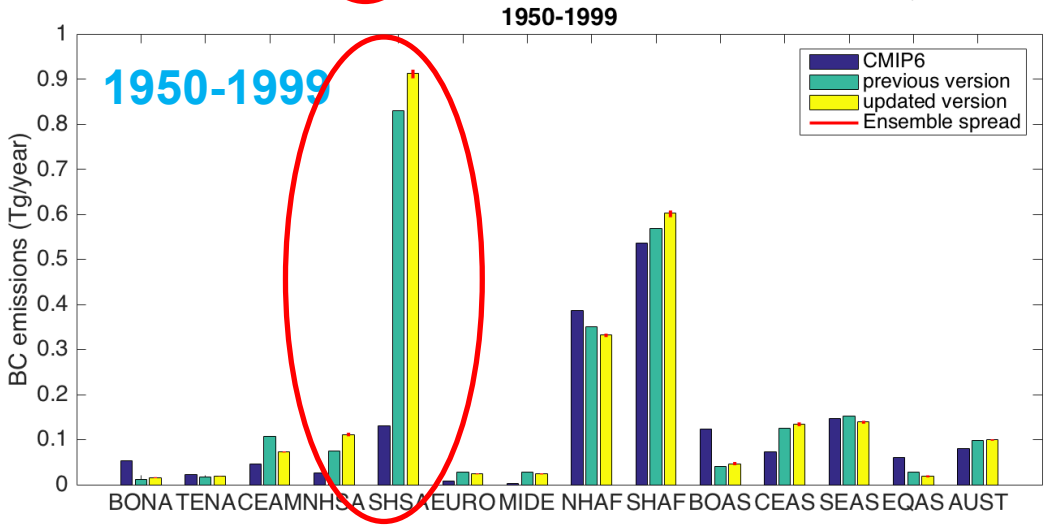


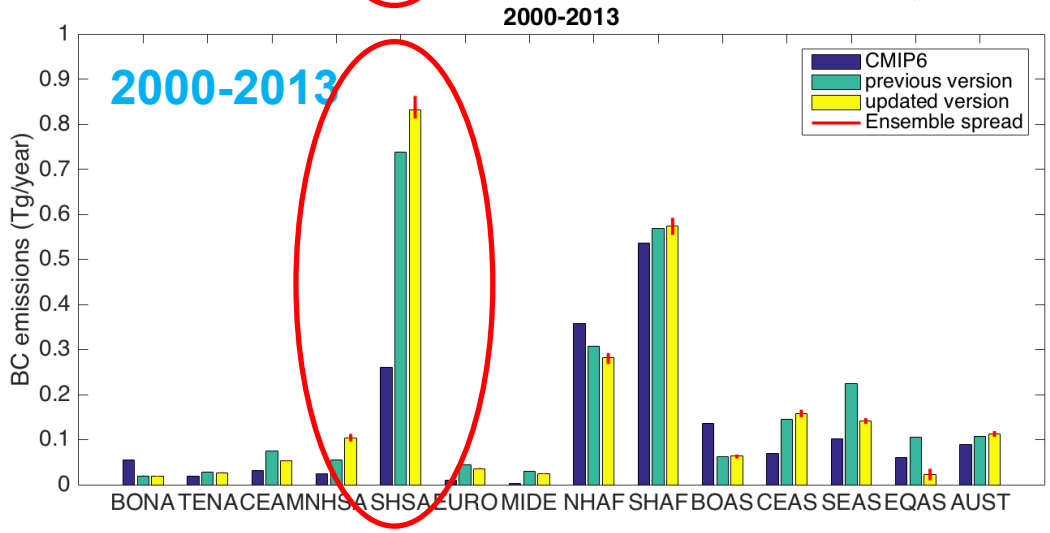
https://www.globalfiredata.org/data.html

Black Carbon emissions:









CESM2 simulations with the updated fire module

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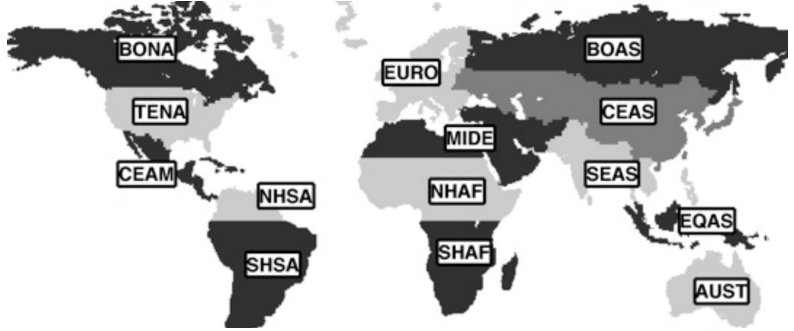
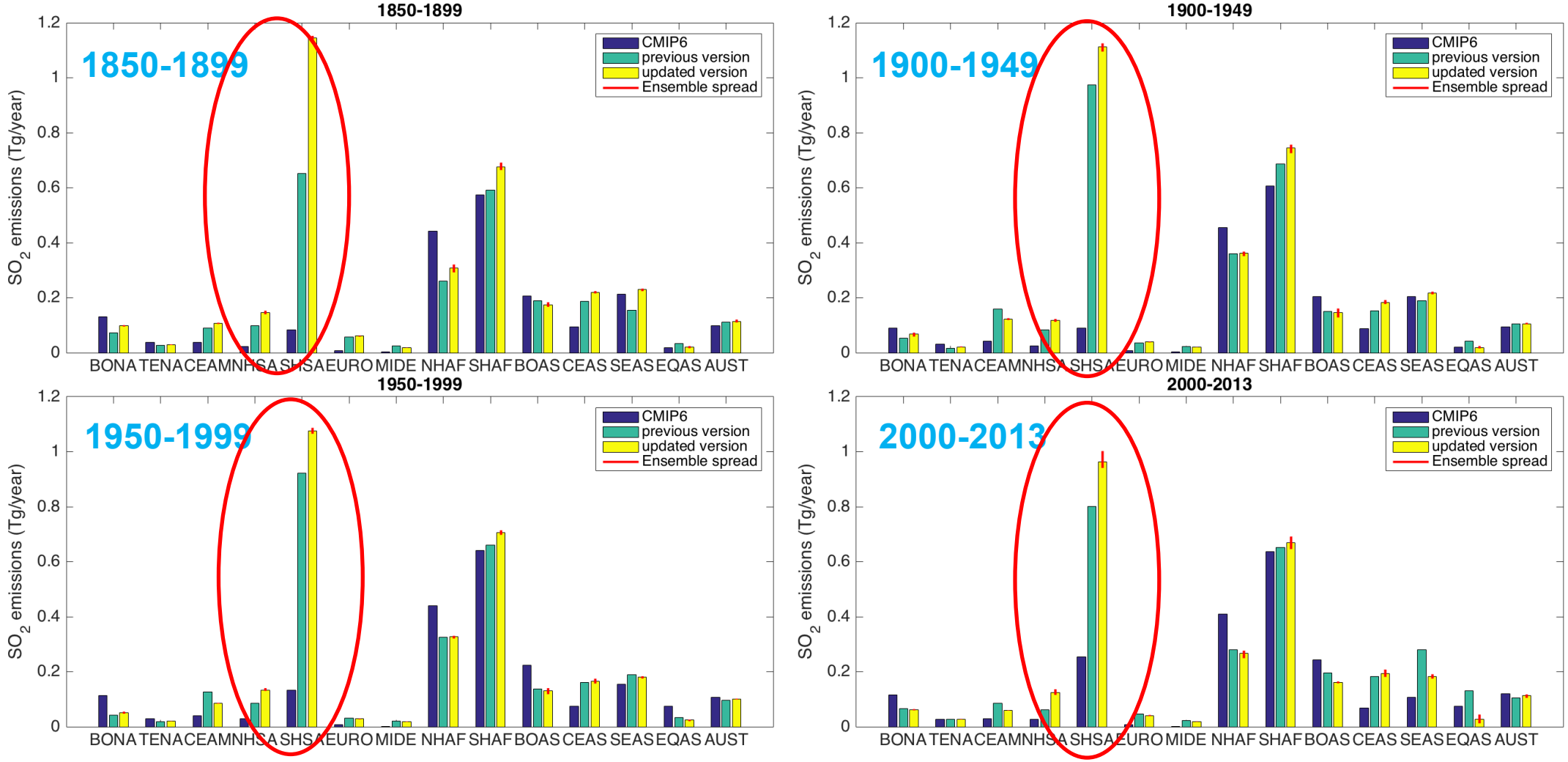


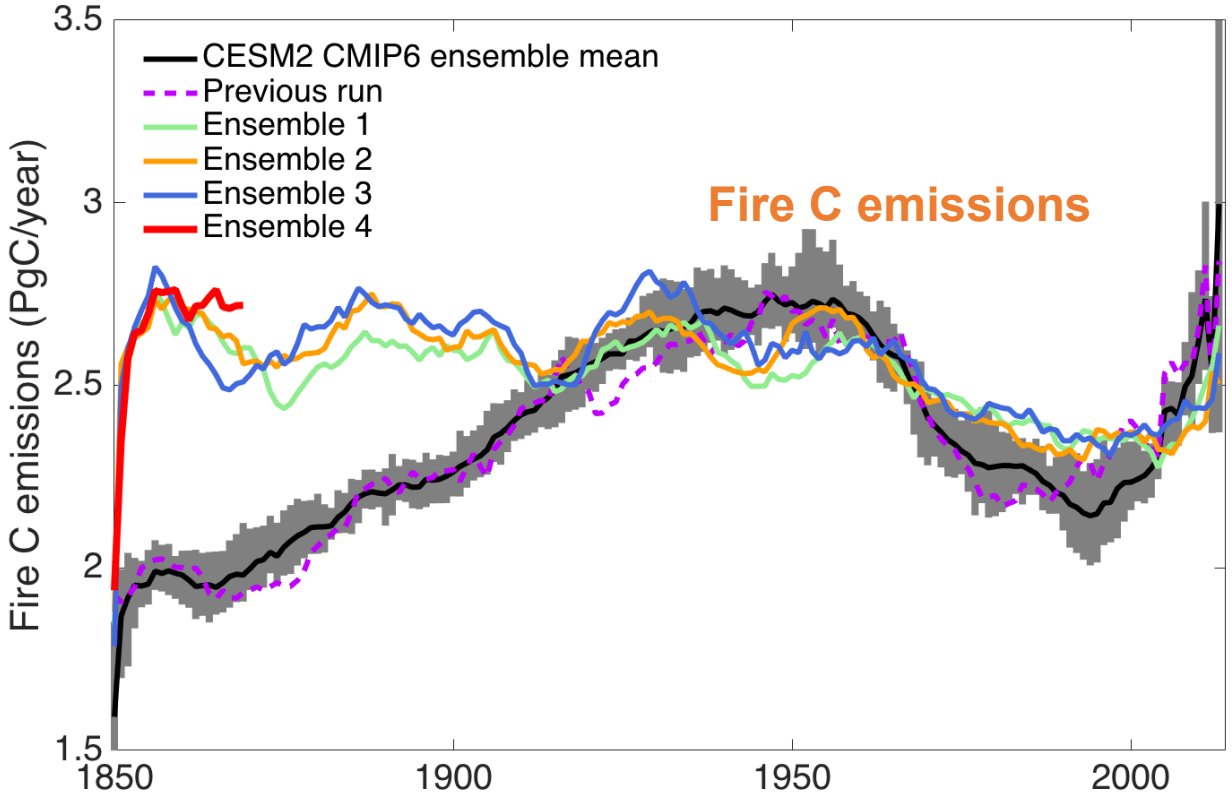
SO_2 emissions:



Two issues:

(1) Initial jump in fire emissions in 1850 => Lack of land use in PI control

(2) Fire emissions generated by CESM interactive fire simulations being lower than CMIP6 fire emissions => ?



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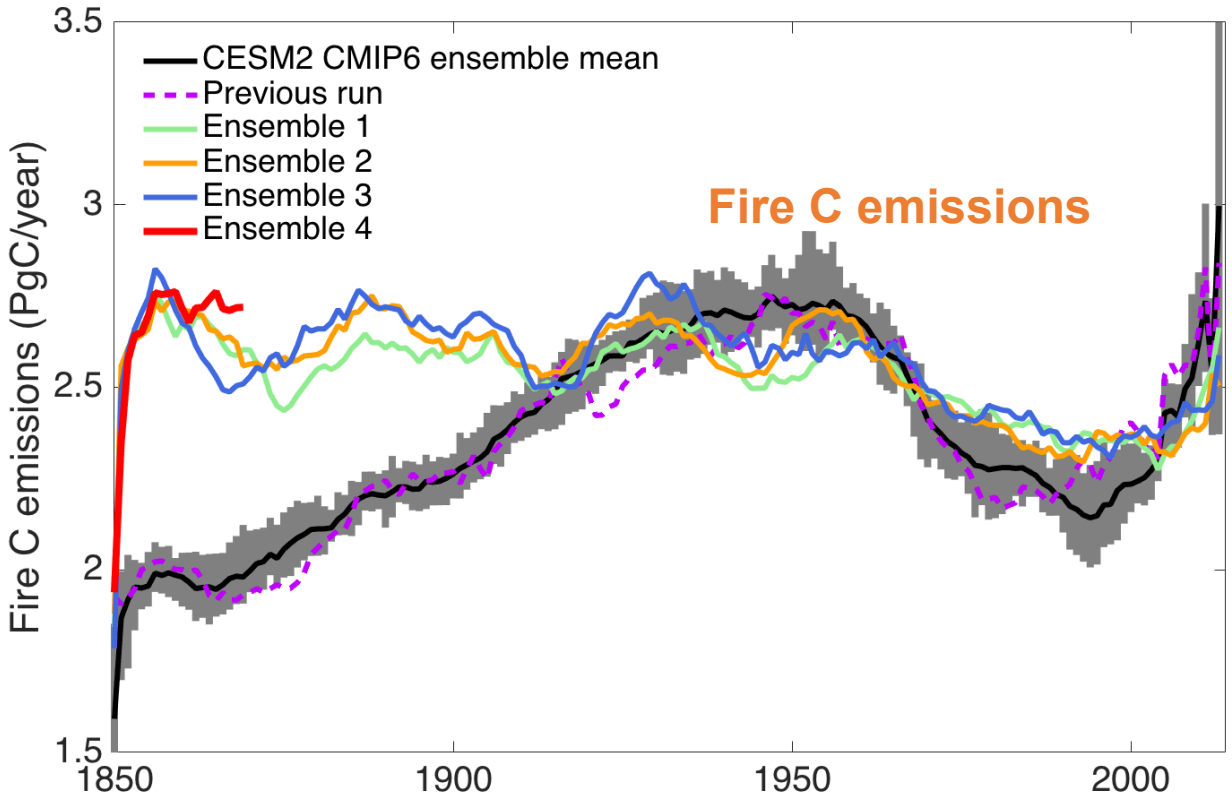

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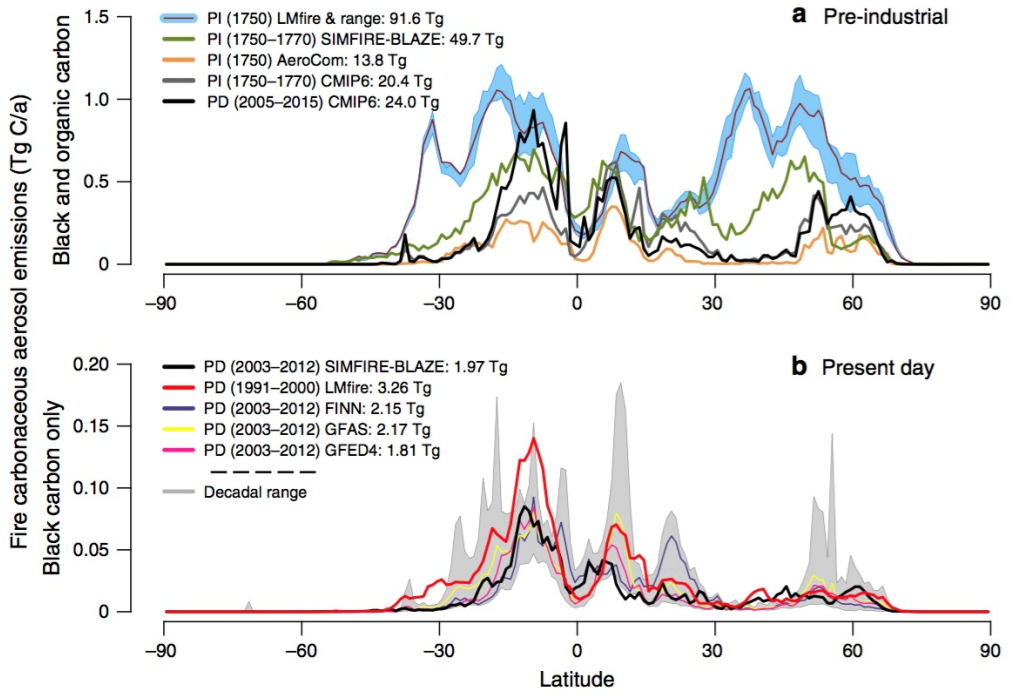
ARTICLE

DOI: 10.1038/s41467-018-05592-9 OPEN

Reassessment of pre-industrial fire emissions strongly affects anthropogenic aerosol forcing

D.S. Hamilton[1,2], S. Hantson[3,4], C.E. Scott[1], J.O. Kaplan[5,6,7], K.J. Pringle[1], L.P. Nieradzik[8,9], A. Rap[1], G.A. Folberth[10], D.V. Spracklen[1] & K.S. Carslaw[1]



Depending on the emitted species, modelled total global fire emissions in the PI are estimated to be between approximately two-and-a-half and five times higher than those in the CMIP6 dataset (Supplementary Table 2), reflecting the large contribution

Summary

1. The updated fire module code is improved from the previous version.

2. The initial drop of global mean surface temperature is likely due to the jump of fire emissions in 1850.

3. The initial jump of fire emissions in 1850 is mainly due to the unburned carbon accumulation as there are no land use in PI Control run.

4. Emissions generated by the fire module in the CESM2 simulations is higher than CMIP6 fire emissions, however CMIP6 fire emissions for PI may be too low.

5. Next: The PI control run needs to be fixed. I will try start the run earlier (e.g., 1750) and/or include land use during 1850 to the PI control run.

6. Next: Run CESM2 with atmospheric chemistry using chemical species emitted from the fire module.

Thank you!