Future fires in the Coupled Model Intercomparison Project phase 6 (CMIP6)

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Fire impacts on the Earth system

- Fire impacts all Earth system components including vegetation, atmosphere, ocean and cryosphere
  → Need to represent fire in global vegetation and Earth system models
Area burned: 3 models historical, 2 models with several future scenario

Fire emissions: 12 models historical, 6 models with several future scenarios

→ As burned area is available for only few models we focus on fire emissions so far

Changes in data availability are still expected in the next months
## Information on models used

### Historical + SSP

<table>
<thead>
<tr>
<th>Coupled Model</th>
<th>CESM2-WACCM</th>
<th>CNRM-ESM2-1</th>
<th>EC-Earth3-Veg</th>
<th>MPI-ESM1-2-LR</th>
<th>NorESM2-LM</th>
<th>NorESM2-MM</th>
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</thead>
<tbody>
<tr>
<td>Institution</td>
<td>NCAR</td>
<td>CNRM-CERFACS</td>
<td>EC-Earth-Consortium</td>
<td>MPI-M AWI</td>
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<tr>
<td>Land Model</td>
<td>CLM5</td>
<td>ISBA-CTRIP</td>
<td>LPJ-GUESS</td>
<td>JSBACH3.2</td>
<td>CLM5</td>
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<td>yes</td>
<td>yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Burned Area</td>
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<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>No</td>
</tr>
<tr>
<td>Human fire ignition/suppression</td>
<td>Yes</td>
<td>Not allowed on crop and pasture</td>
<td>Suppression on crop and pasture</td>
<td>Yes/ no burning on croplands</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>SSP(126,245,370,585)</td>
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<td>all</td>
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</table>

### Historical only

<table>
<thead>
<tr>
<th>Coupled Model</th>
<th>MPI-ESM-1-2-HAM</th>
<th>TaiESM1</th>
<th>CESM2</th>
<th>SAM0-UNICON</th>
<th>NorCPM2</th>
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<td>CLM5</td>
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</table>
Present day spatial patterns (1997-2014)
Present day spatial patterns (1997-2014)

- Many models show good spatial patterns
- One outlier requires further investigation
Global emissions from preindustrial to 2100

- Uncertainty is still big with respect to the global totals of fire emissions, but also the trends
- Slightly stronger convergence between models for future compared to the past
- Models with peaks use CLM5 as vegetation model
Spatial patterns of future changes

- In colored grid cells all models show the same direction of change.
- Percentage indicates the models with significant change, sign indicates the direction of change.
- For vast areas in the extra tropics all models indicate an increase in fire emissions.
- In the tropics the model trends diverge, only for SSP3 a clear decrease in West Africa.
Changes of potential drivers of fire

Population density
Contributes to decreases in West Africa in SSP3

Temperature
Increases everywhere

Precipitation
Increases can mitigate effects of increasing temperature

Litter pools
Changes driven by climate and CO2 effects on vegetation
How do these drivers affect fire?

Population increase
- Remote areas
  - Increase in ignitions / number of fires
  - Land conversion to open landscapes
  - Increased flammability
- Populated areas
  - Stronger suppression
  - Reduced burned area
  - Increased flammability
- Temperature increase / Precipitation decrease
  - Fire limited by dryness
    - Drier fuels
    - Increased flammability
    - Larger fires / higher fire spread rate
  - Fire limited by fuel loads
    - Lower fuel loads
    - Lower probability of fire spread
- CO2 increase
  - Higher water use efficiency
  - Higher productivity
  - Fuel loads
  - Higher coarse fuel loads
  - Increase tree fraction
  - Coarser fuel
  - Lower flammability

Fire limited by dryness
- Higher moisture content
- Higher productivity
- Lower flammability

Fire limited by fuel loads
- Higher fuel loads
- Higher fire intensity
- Lower flammability
Conclusions

- Analysis is still in exploratory phase
- High uncertainty in global totals
- Increases in fire emissions in the extratropics are consistent across all model