IBS Center
for Climate Physics

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Multiyear warming in high latitudes by interannually varying biomass burning emissions

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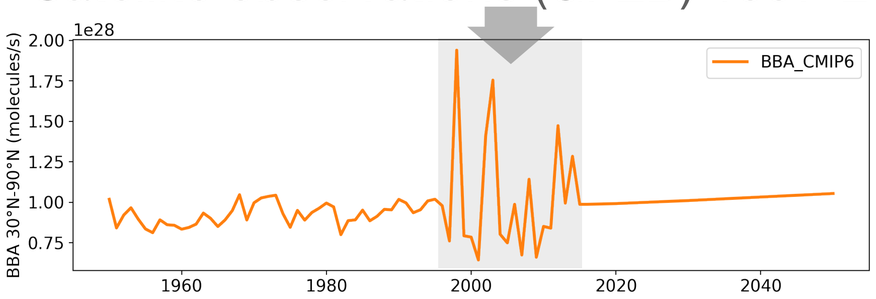
CESM2 Large Ensemble Simulations

- 100 ensemble members
- Focus on ~1990-2020 in this study
- All 100 members are forced by the same CMIP6 forcings, except for slightly modified biomass burning aerosols for 50 members (see next slide).

CMIP6 biomass forcing has strong interannual variability

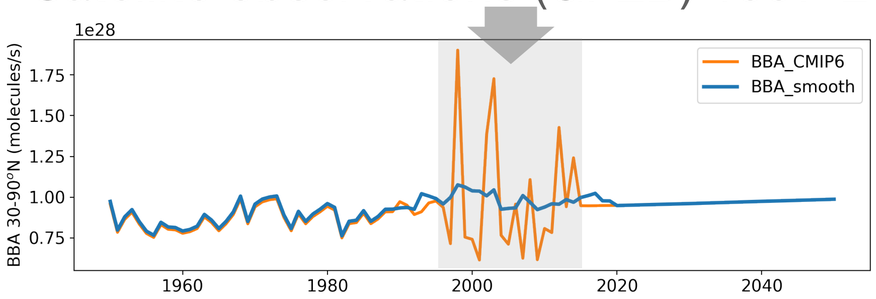
Satellite observations (GFED) 1997-2014



- 50 members are forced with CMIP6 biomass burning aerosols

50 + 50 members divided by biomass burning aerosol variability

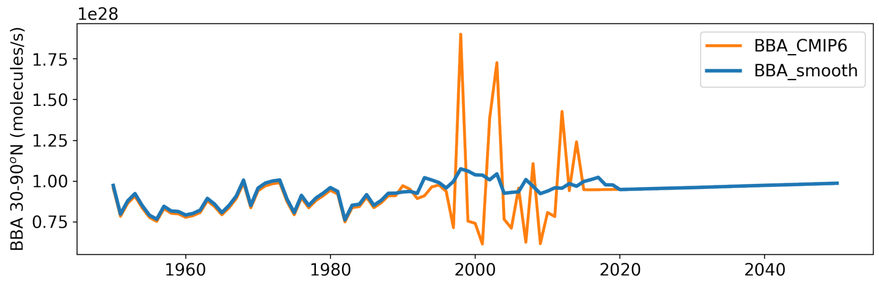
Satellite observations (GFED) 1997-2014



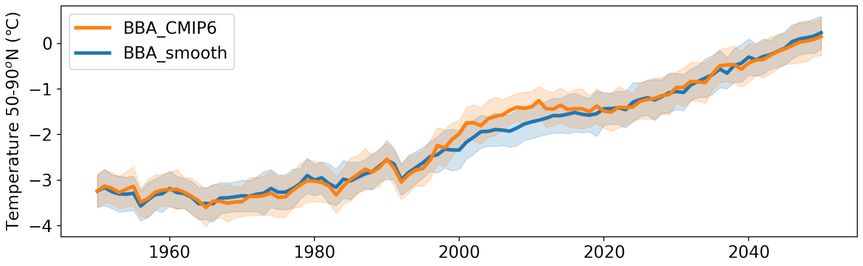
- 50 members are forced with CMIP6 biomass burning aerosols
- The second 50 members are smoothed from the CMIP6 forcing

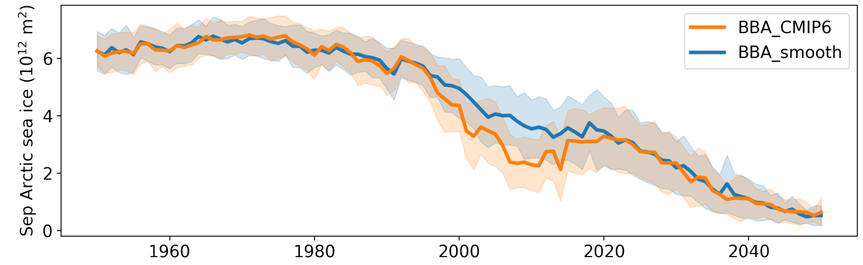
Temperature response to the variable forcing (CMIP6 — Smooth aerosol forcing)

FORCING



CLIMATE RESPONSE





Same mean aerosol flux

- **NH warms**
- **Sea ice melts**

Only differ At interannual scale

- **Response at decadal**

(Atmosphere-only response cannot explain it, because of short aerosol life time -> there is something more!)

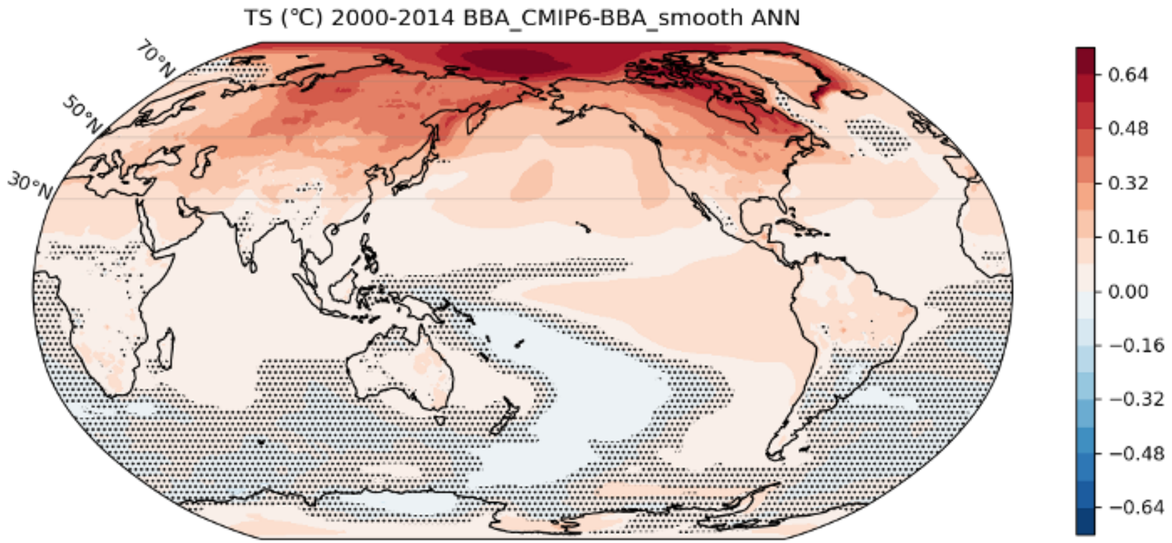
Kim et al., submitted

Also see Fasullo et al., 2021, DeRepentigny et al., 2022, Heyblom et al., 2022

Warming response shows typical Arctic amplification pattern

Annual Mean Difference

CMIP6 — Smooth



Stipple: non-significant

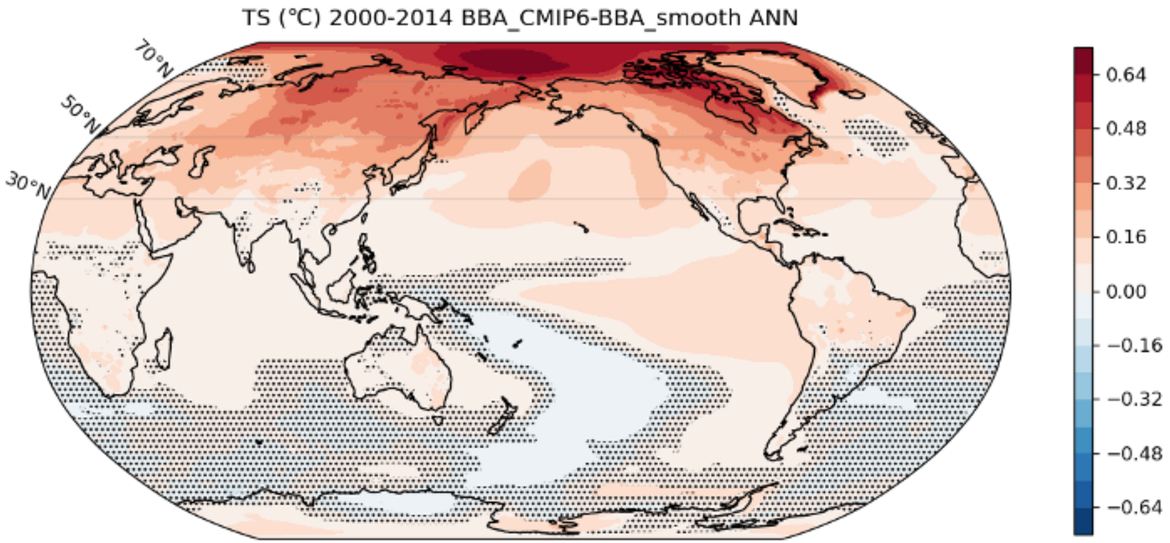
Kim et al., submitted

Also see Fasullo et al., 2021, DeRepentigny et al., 2022, Heyblom et al., 2022

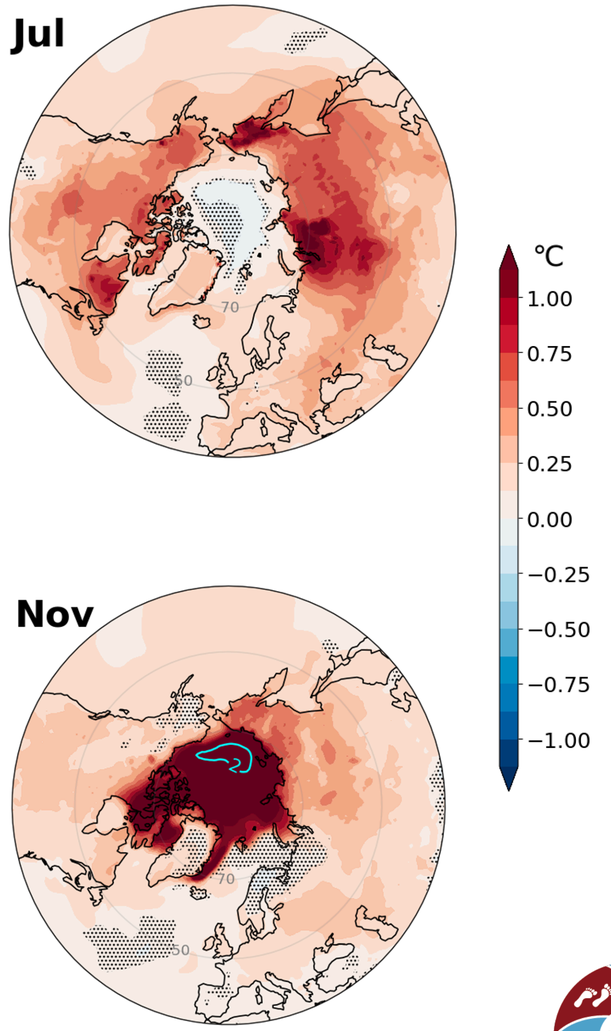
Warming pattern comes from summer and winter responses

Annual Mean Difference

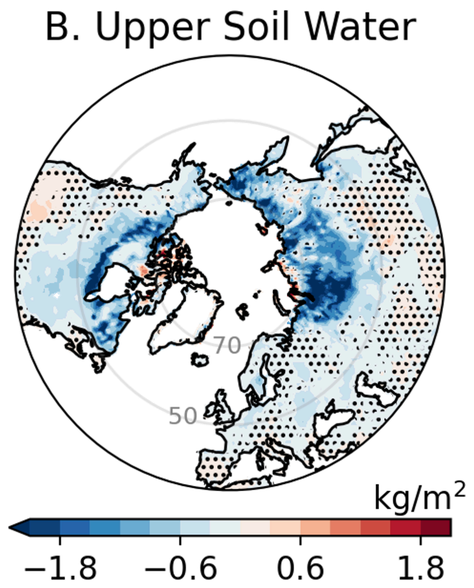
CMIP6 — Smooth

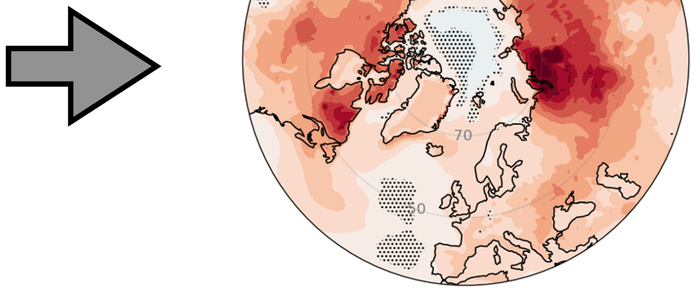


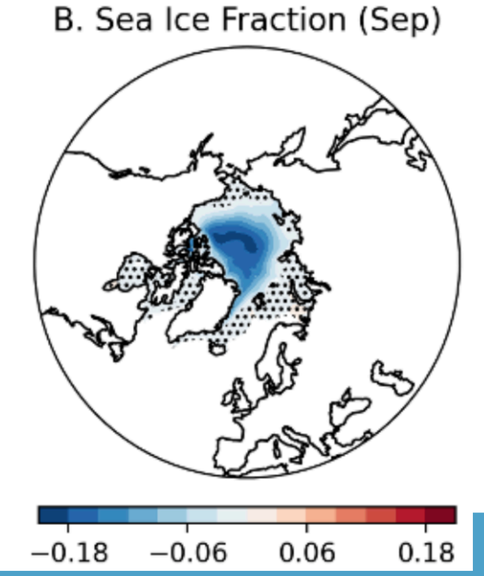
Stipple: non-significant

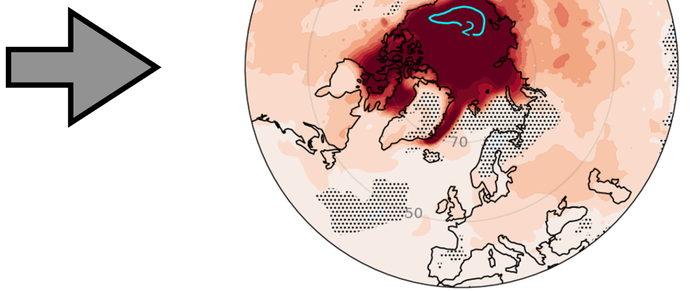


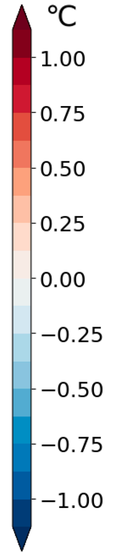
Summer warming from soil water loss, Winter warming from Arctic sea ice loss



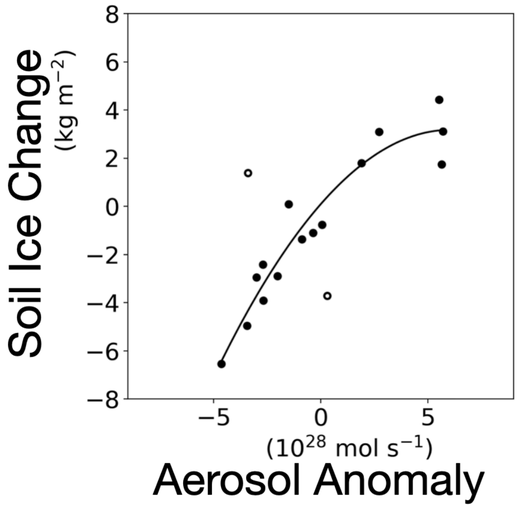


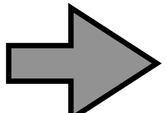


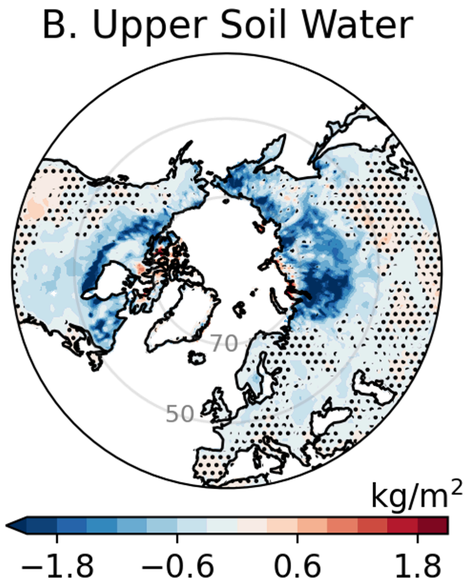


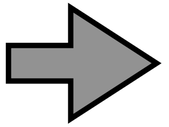


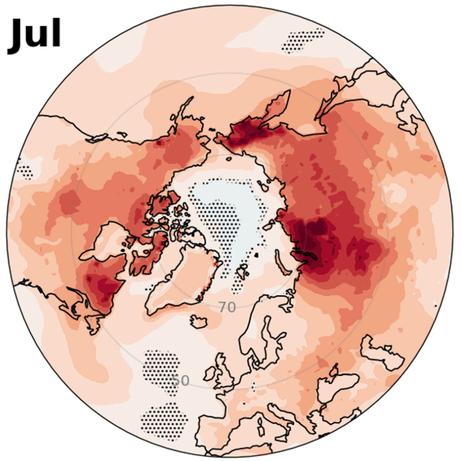
Decadal warming from permafrost loss and Arctic sea ice loss

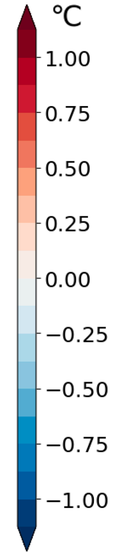


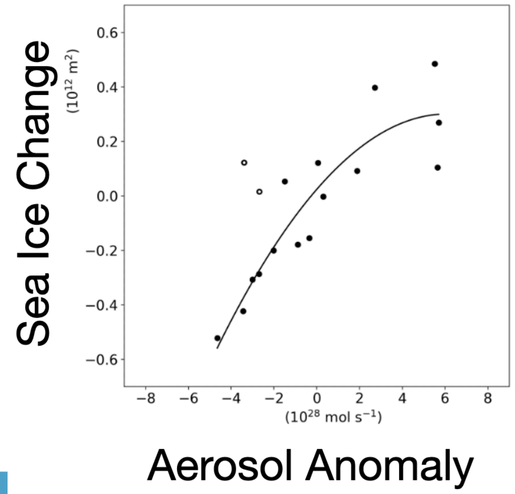


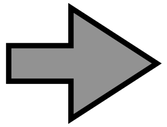


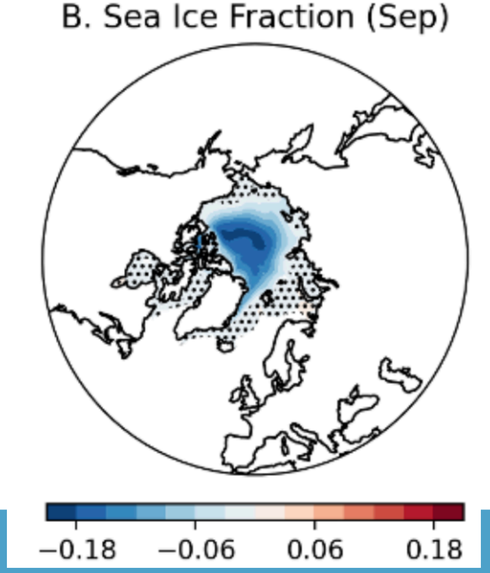


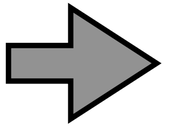


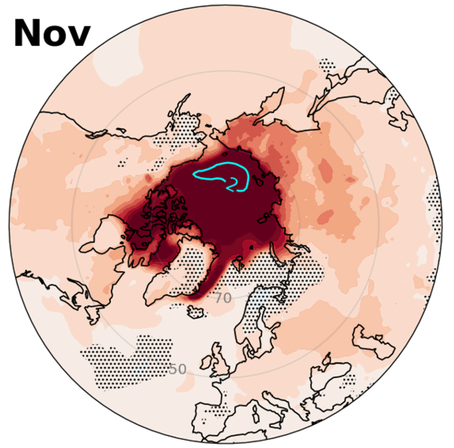




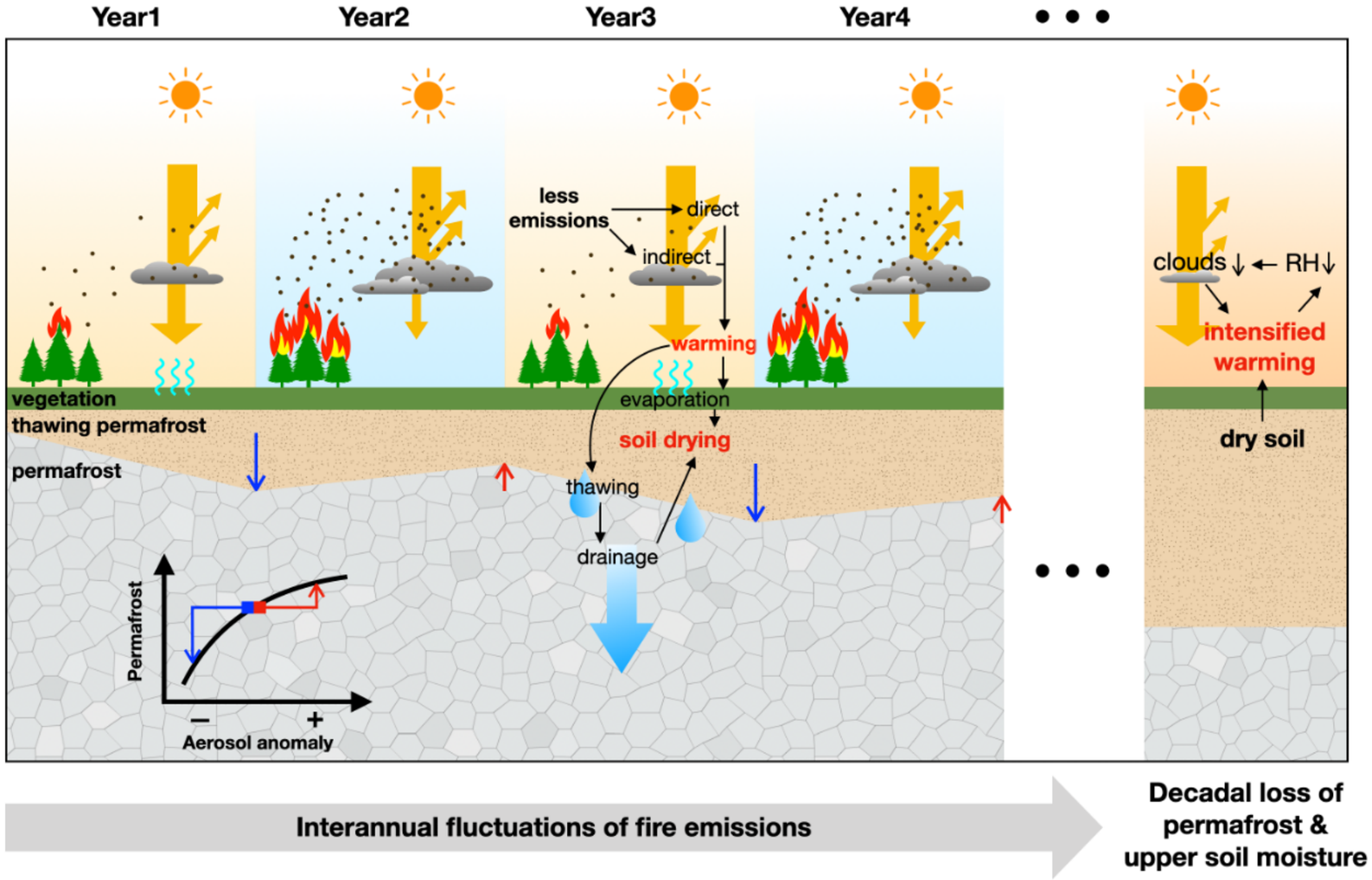








Summary



- We compared CESM2 large ensemble data with two types of aerosol forcing.
- High fluctuation of aerosols induce decadal NH warming.
- The decadal subarctic warming occurs through nonlinear interactions between aerosol-clouds and permafrost soil water processes.
- Similar nonlinear responses occur in the Arctic sea ice, resulting in decadal Arctic warming.