西湖大學
WESTLAKE UNIVERSITY

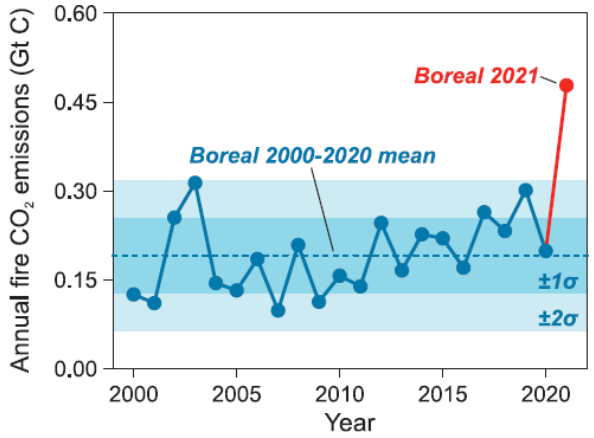
大气化学放大森林野火的气候反馈效应

陈维 张羽中* 邹宇飞 张臻

近年来极端野火事件频发

Los Angeles 2025 fire

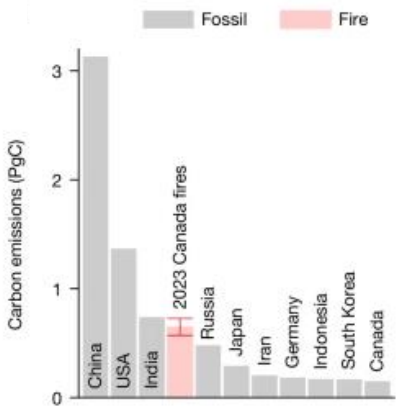
Canada 2021 fire



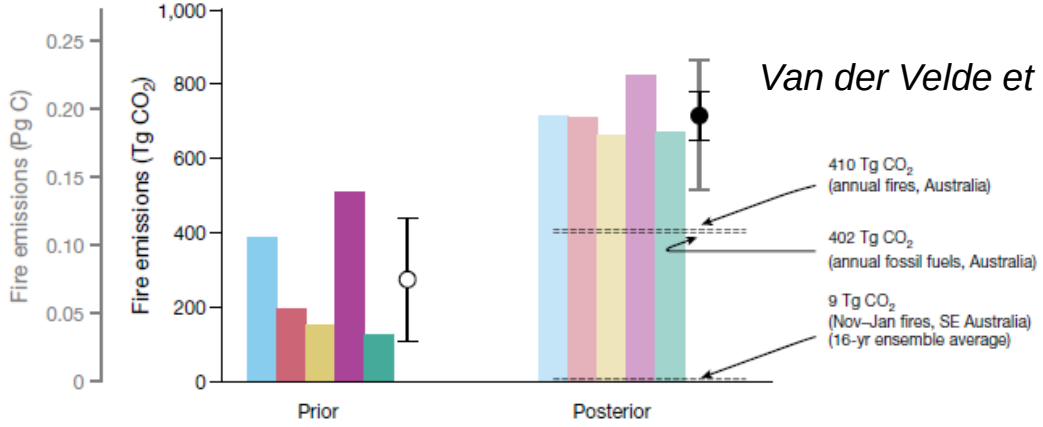
Zheng et al., Science 2023

Canada 2023 fire

Byrne et al., Nature 2023



Australia 2020 fire

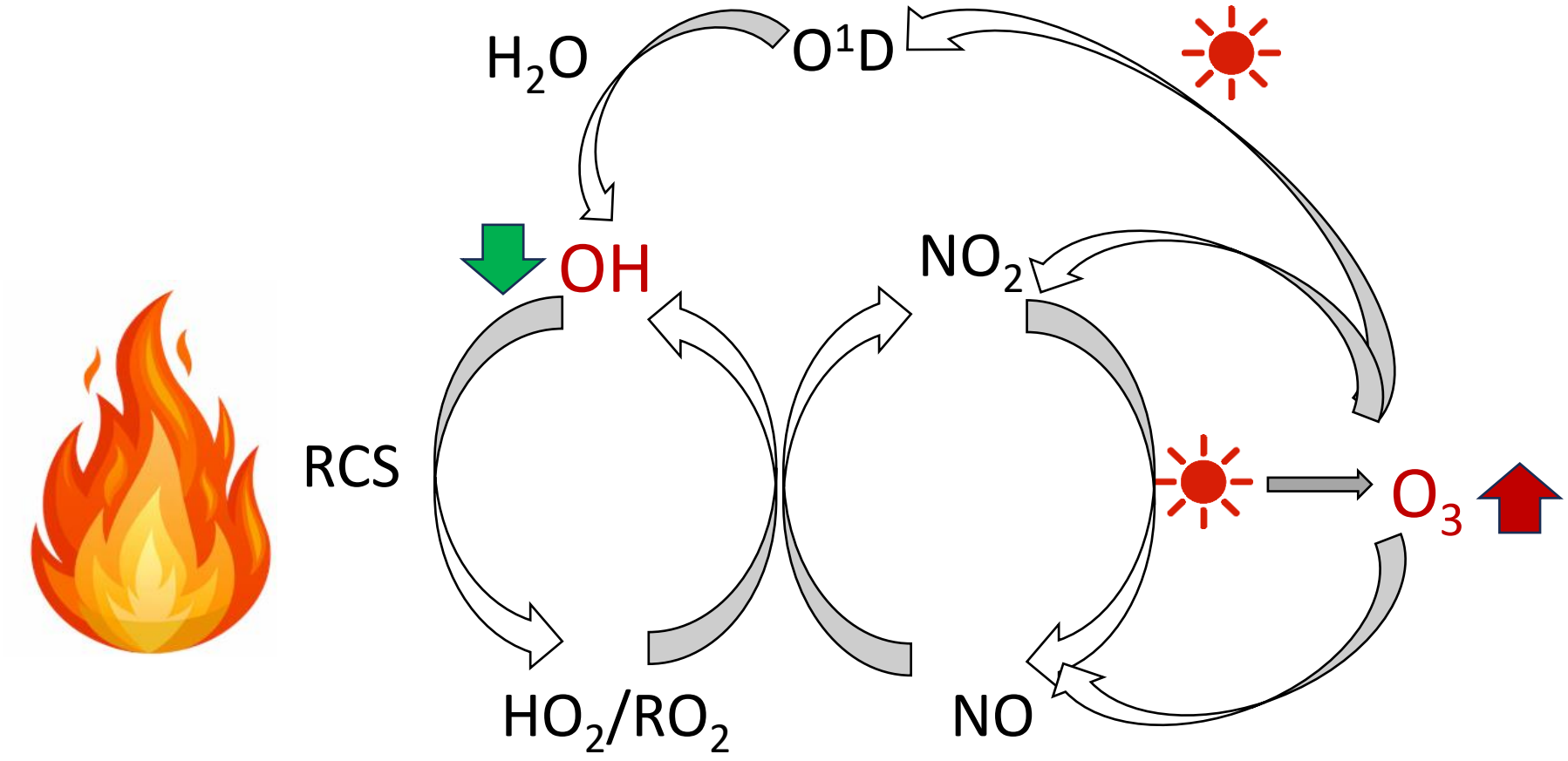


Van der Velde et al., Nature 2021

✓ Fire impacts on society and economy ✓ Fire release large amounts of greenhouse gas CO_2

✓ Forest fires also release reactive carbon species (RCS), perturbing atmospheric chemistry

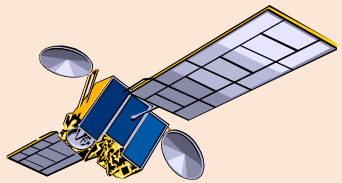
Simplified background atmospheric chemistry mechanism



Forest fires **consume OH** and **promote O_3** production through chemical reactions.

Fire emissions

Recent case study



Satellite observation **Fire emissions**

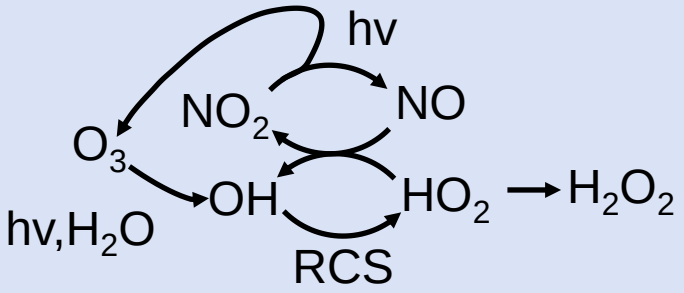
Future prediction

Interaction

Anthropogenic Perturb **Ecosystem Feedback** **Climate Change**

Chemistry simulation

GEOS-Chem model



Atmospheric chemistry

Assessing fire-chemistry-methane feedback with fire emissions and atmospheric chemistry model

澳洲大火(自然源)和新冠(人为源)都导致OH下降

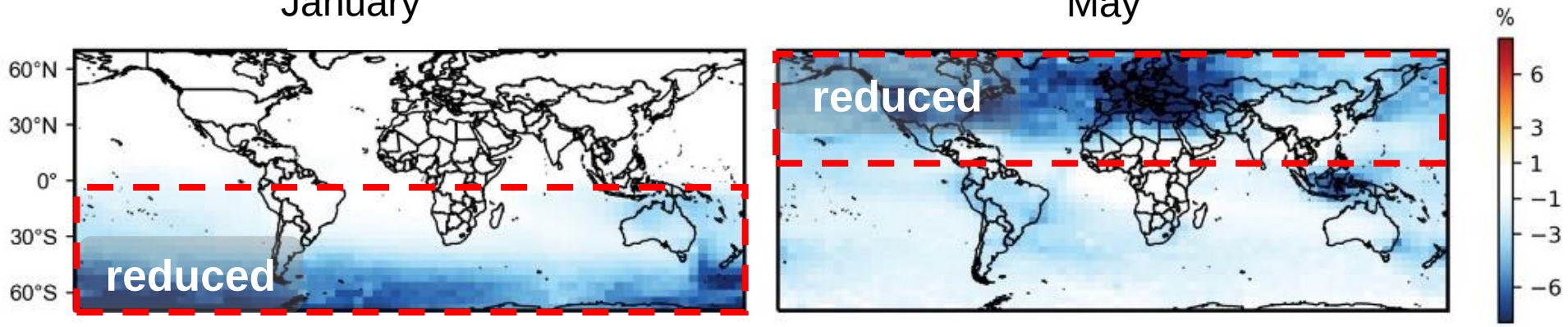
Extreme Australia fire

COVID-19 lockdowns

January

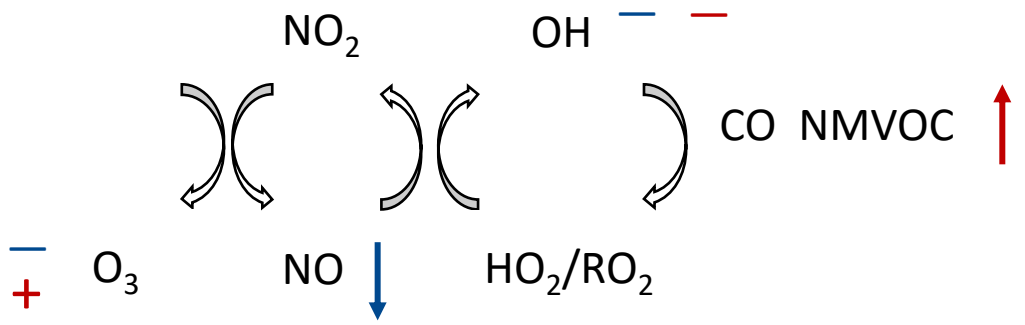
May

model ΔOH



NH COVID-19 lockdowns

SH Extreme Australian fires



Miyazaki et al., Sci. Adv.. 2021

Laughner et al., PNAS. 2021

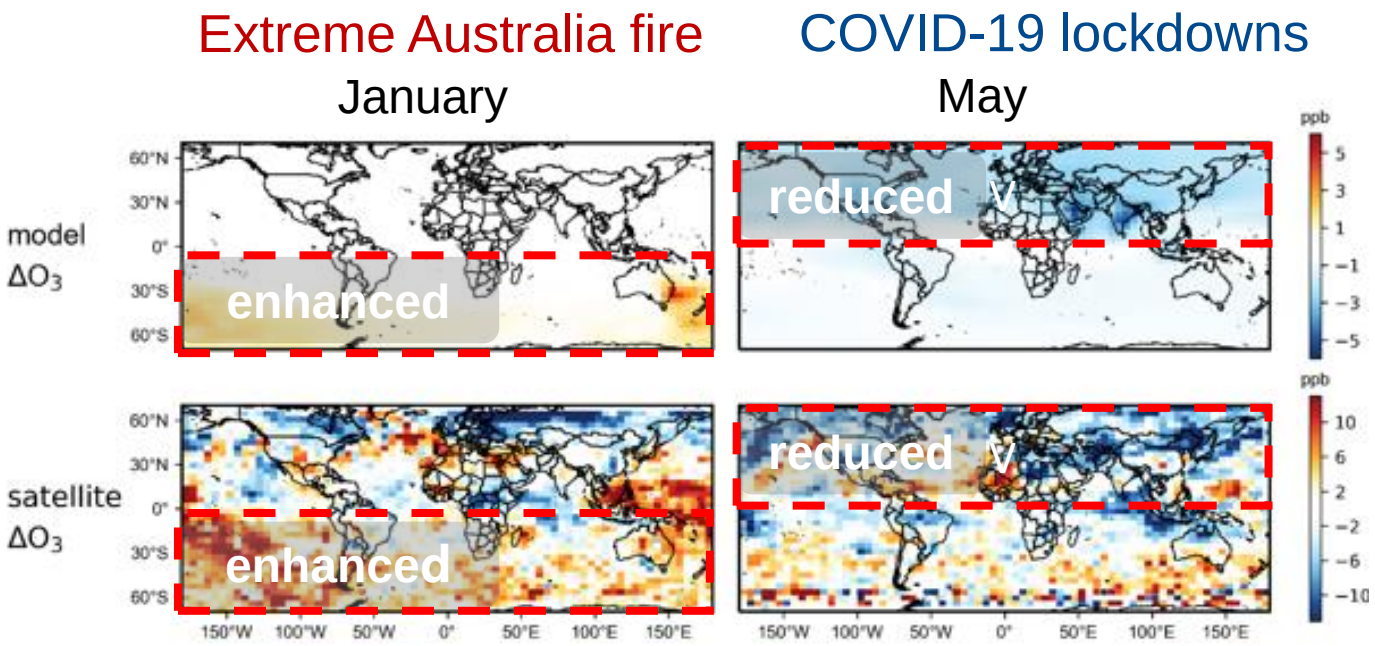
Stevenson et al., Atmos. Chem. Phys. 2022

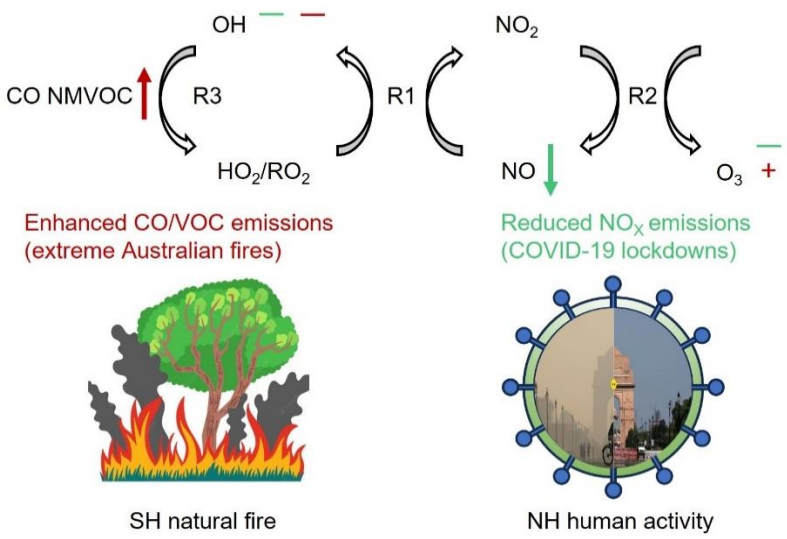
Peng et al., Nature. 2022

Australia fire and **COVID-19 lockdowns** **both lead OH decrease**

野火和人为源不同的 $OH-O_3$ 关系

The opposite O_3 responses serve as **chemical fingerprints** of OH decline due to fire and human activity





- ✓ **Reduced OH** is associated with reduced O_3 in the NH but enhanced O_3 in the SH
- ✓ Consistent with the chemical response to perturbations of anthropogenic **and** fire emissions
- ✓ **O_3 observations** support the attribution of 2020 **OH reduction in both** NH **and** SH

大气氧化性波动的观测证据

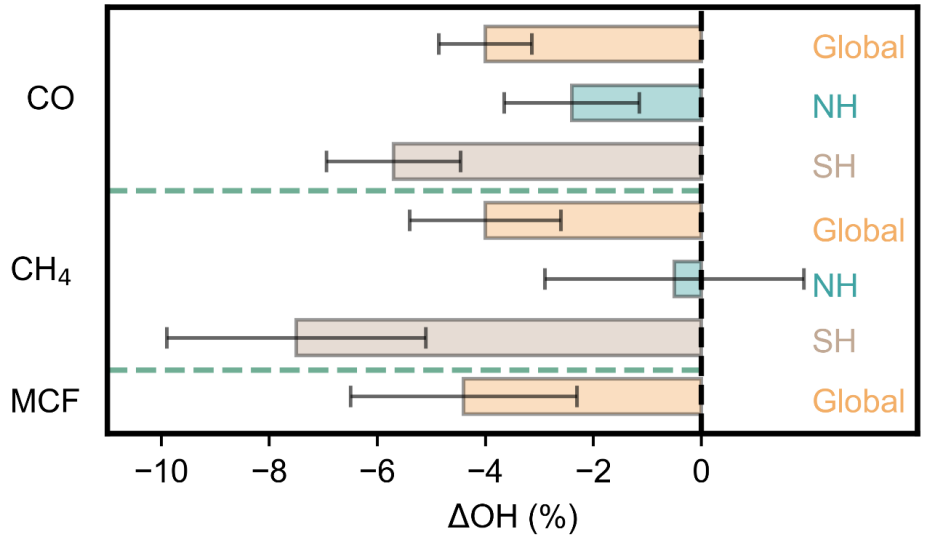
Observational evidence supports the proposed fire-chemistry-methane feedback mechanism

Top-down estimate

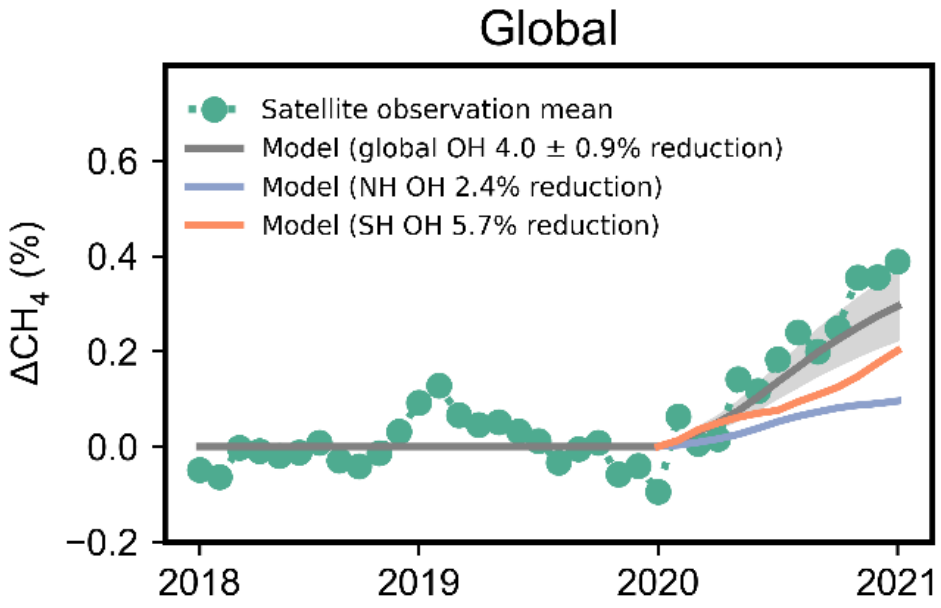
OH

Proxy

Tropospheric OH in 2020 relative to 2018-2019



Implication for methane growth



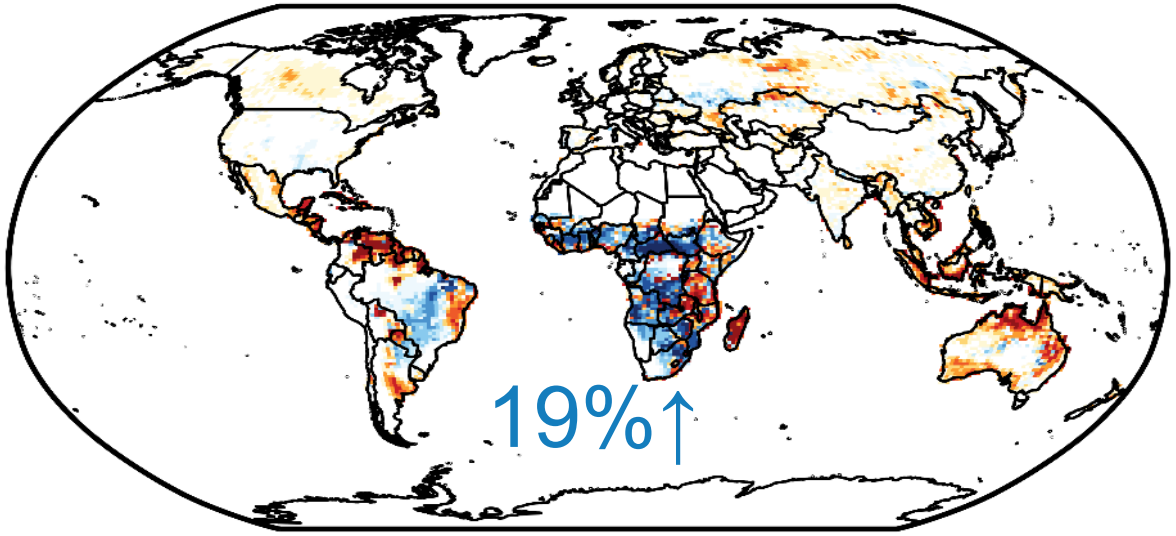
- ✓ **Proxy gases** support the attribution of **OH reduced in both** NH **and** SH
- ✓ Substantial **OH reduction in both hemispheres** can largely explain the methane surge in 2020

气候变化下野火活性物种排放对未来甲烷浓度影响

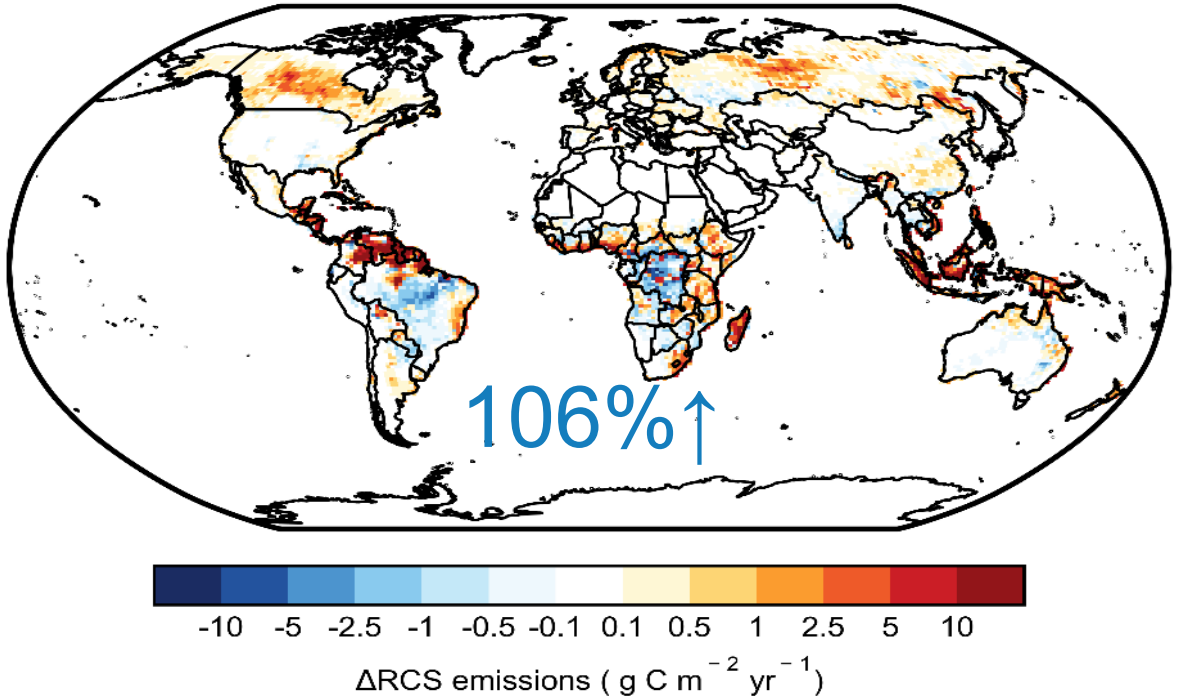
CESM-RESFire-model (full interaction between climate-fire-ecosystem)

Between 2000s and 2050s

Burned area



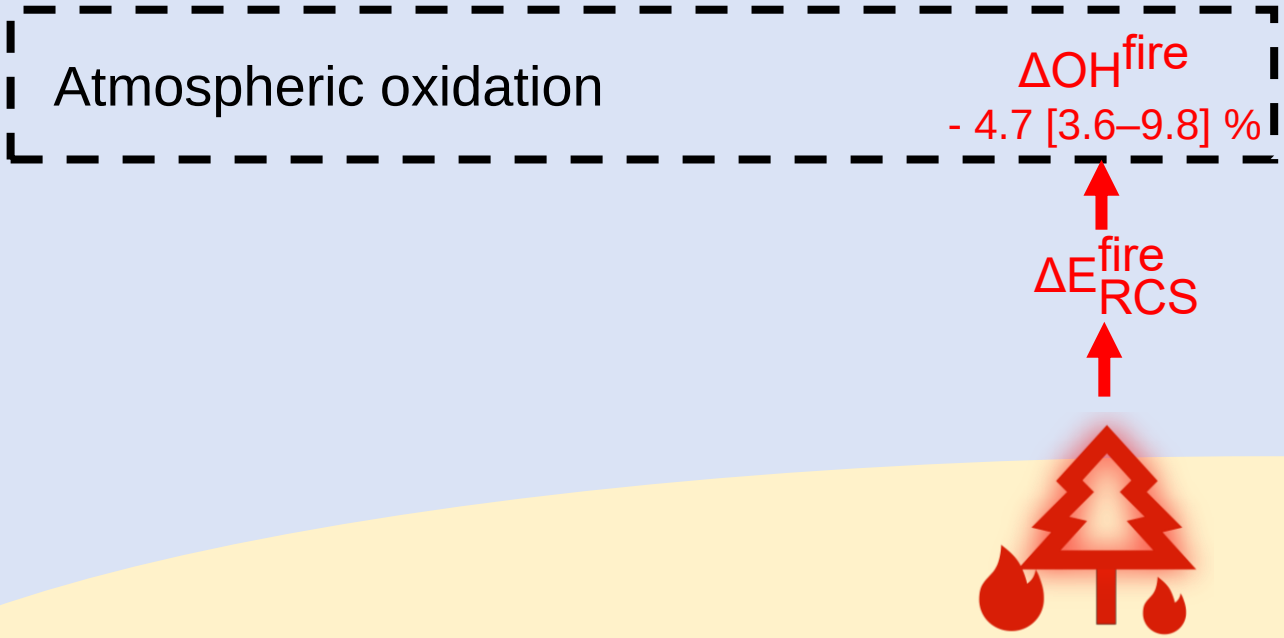
Reactive carbon species emissions



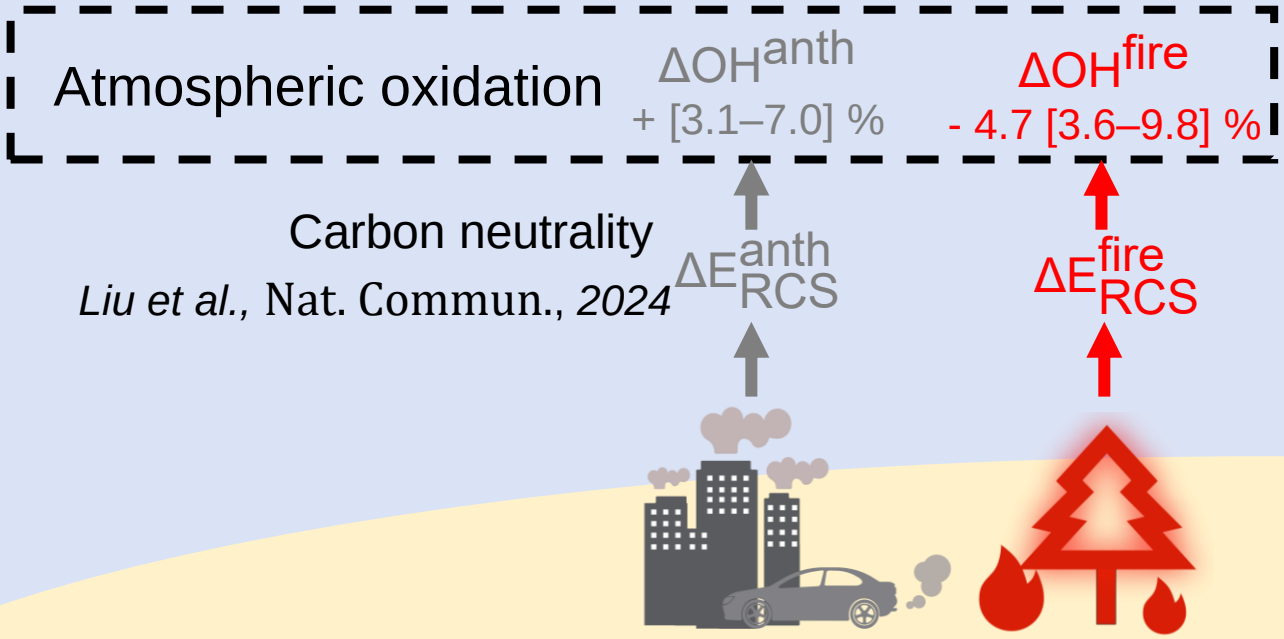
✓ The projected increase is primarily concentrated in **forest-dominant** regions

Zou et al, J. Adv. Model. Earth Syst. 2019; Zou et al., Atmos. Chem. Phys. 2020

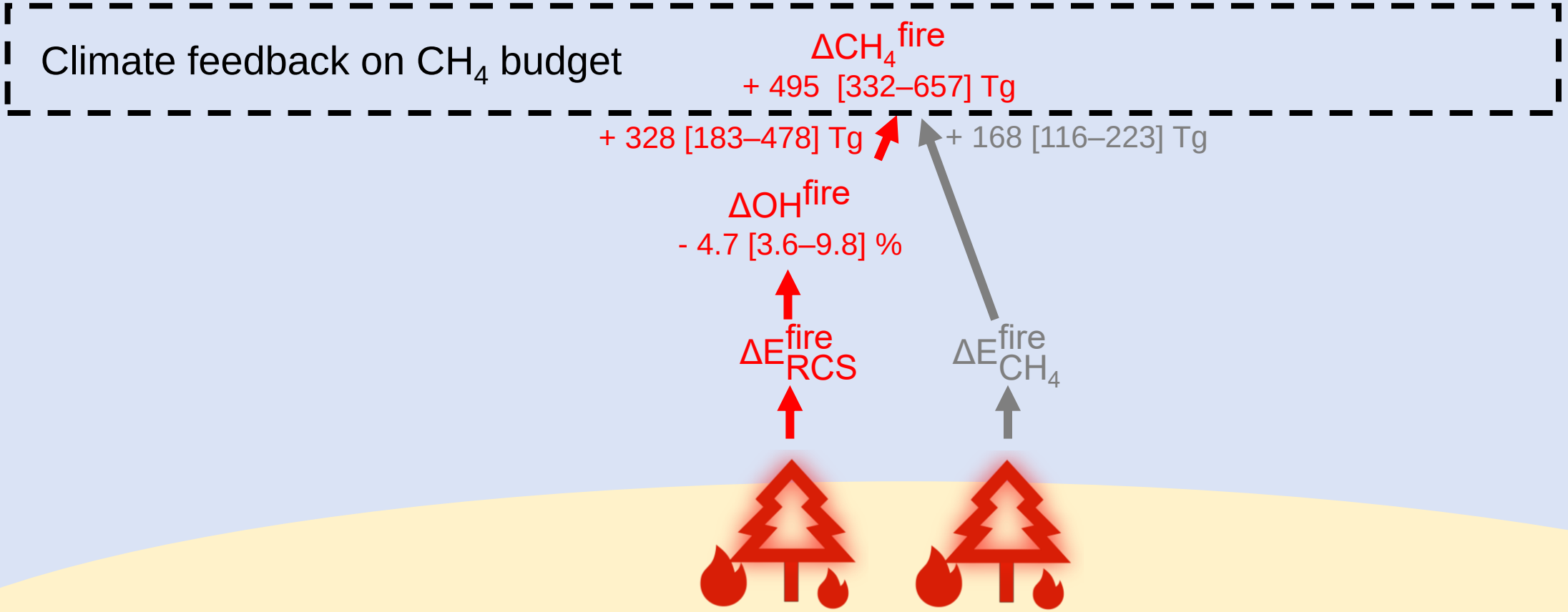
气候变化→野火→大气氧化性



气候变化→野火→大气氧化性

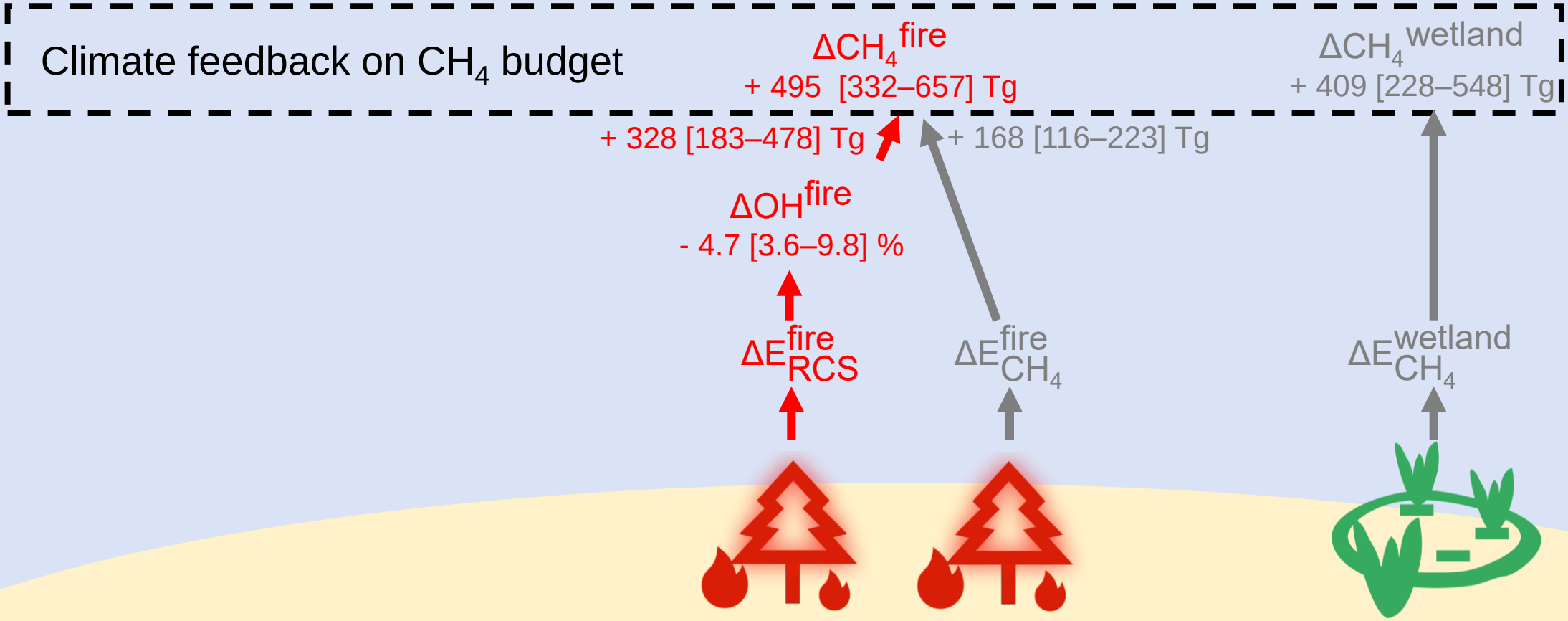


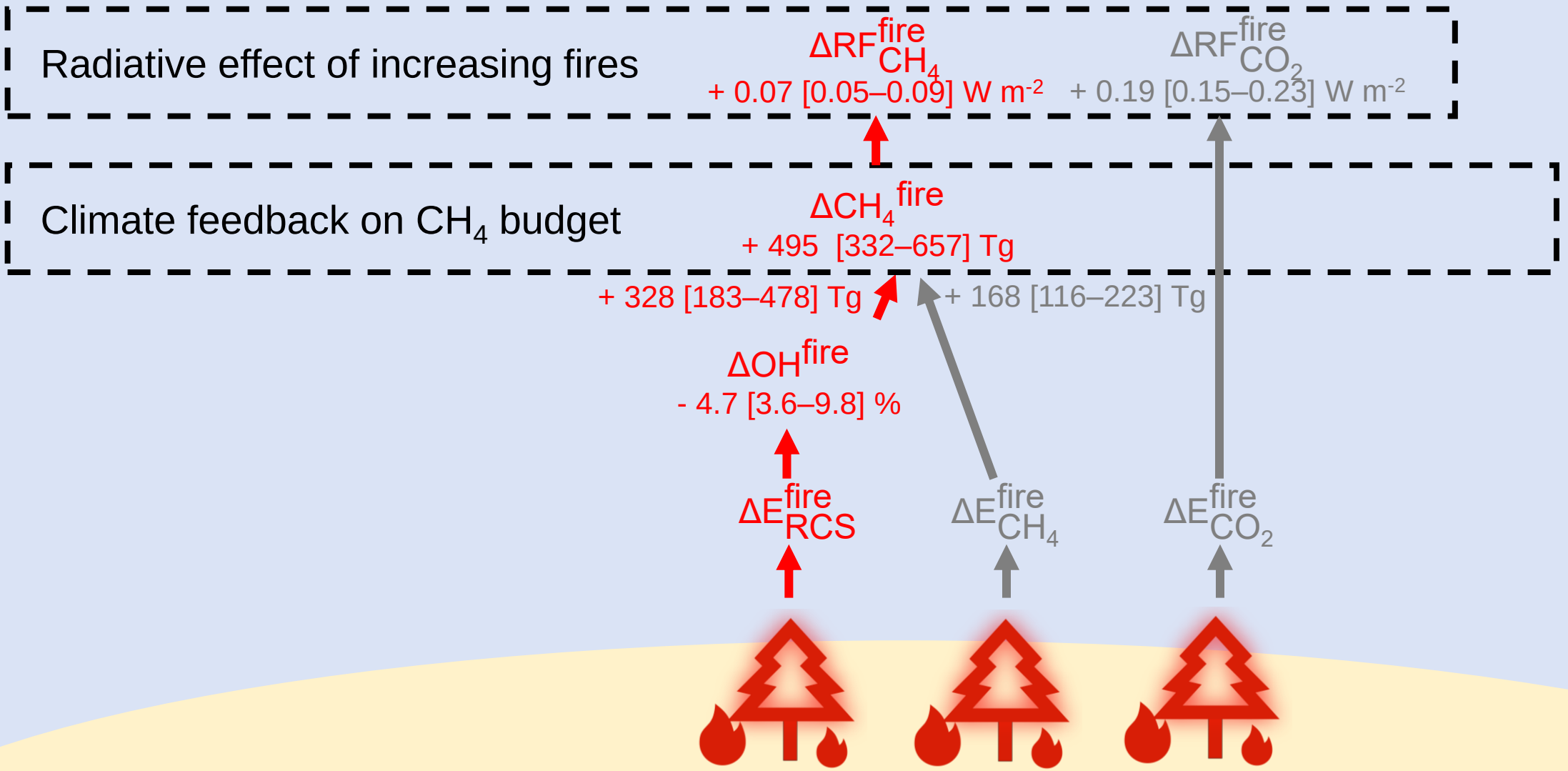
气候变化→野火→大气氧化性→甲烷浓度



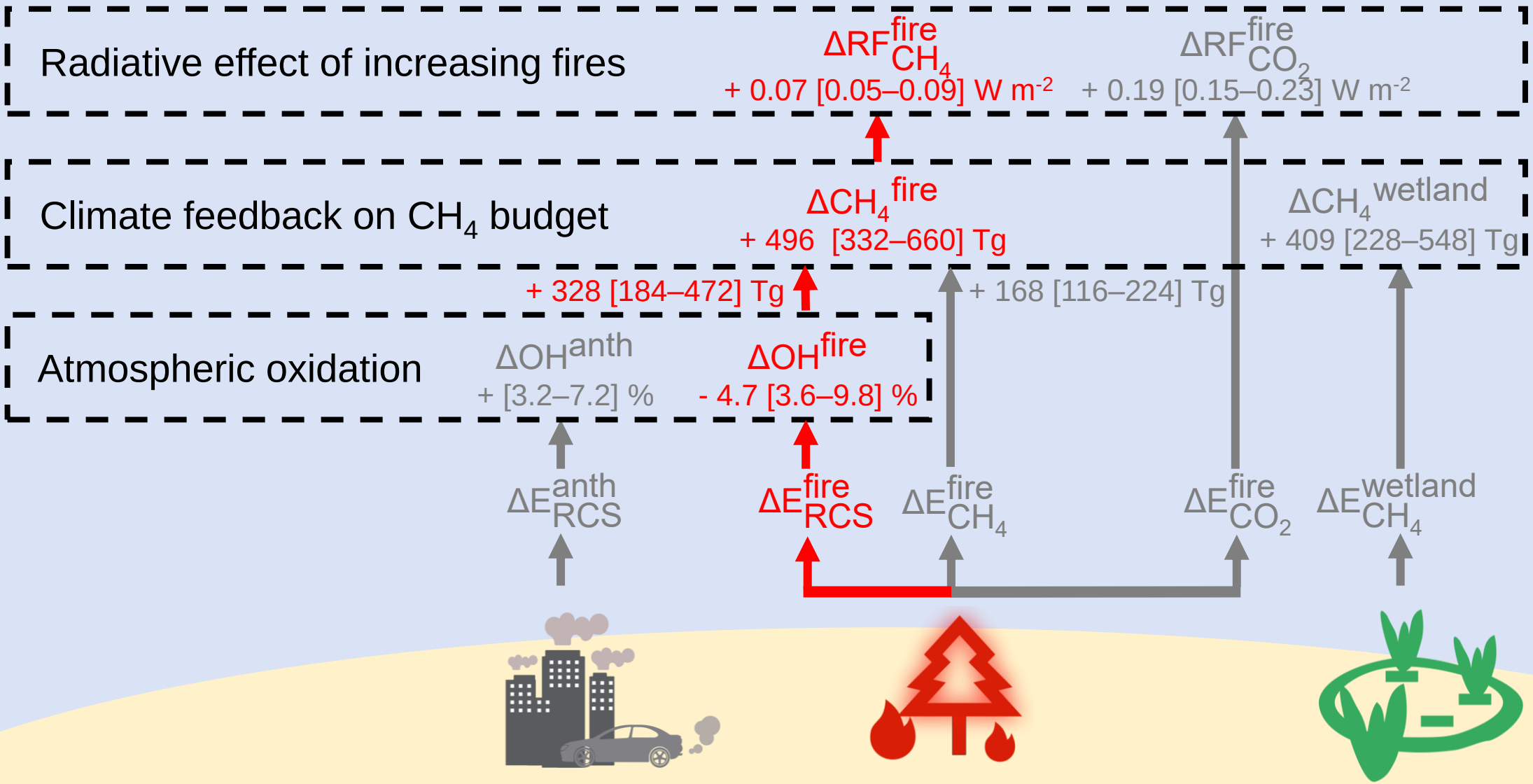
气候变化→野火→大气氧化性→甲烷浓度

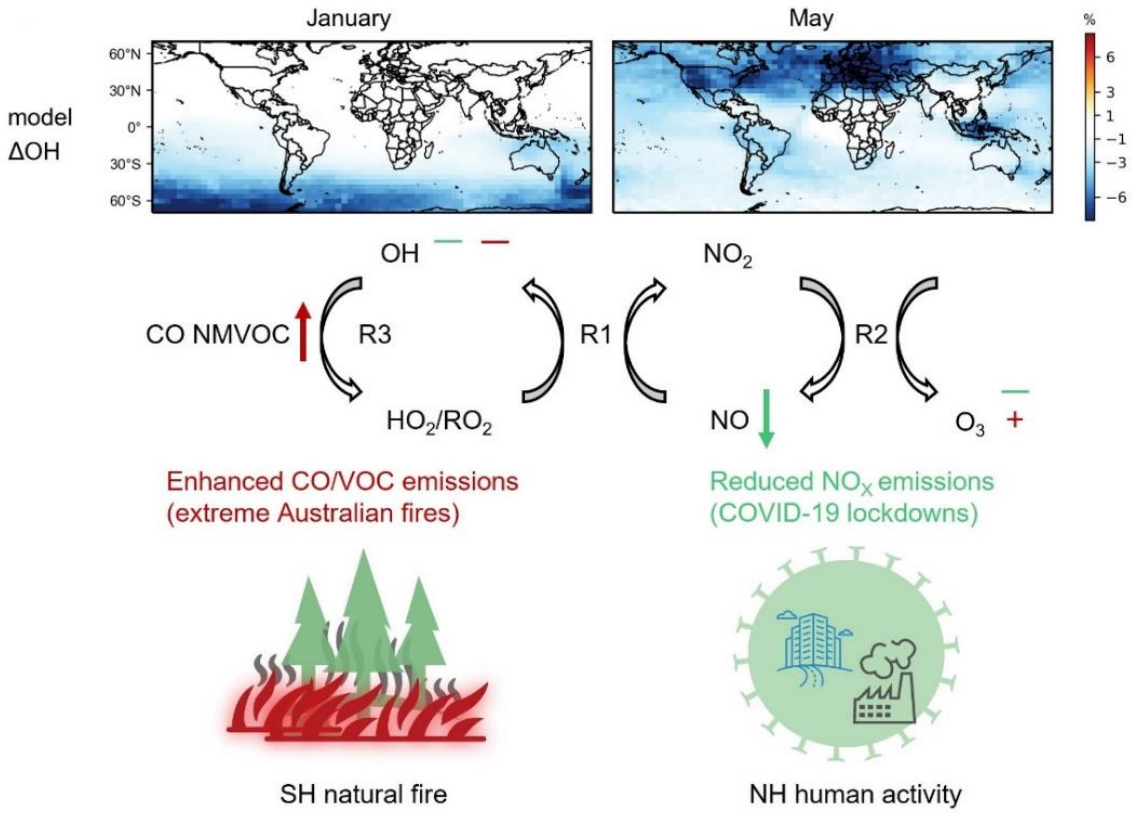
Zhang et al., PNAS 2017
Zhang et all, Nat. Clim. Change 2023



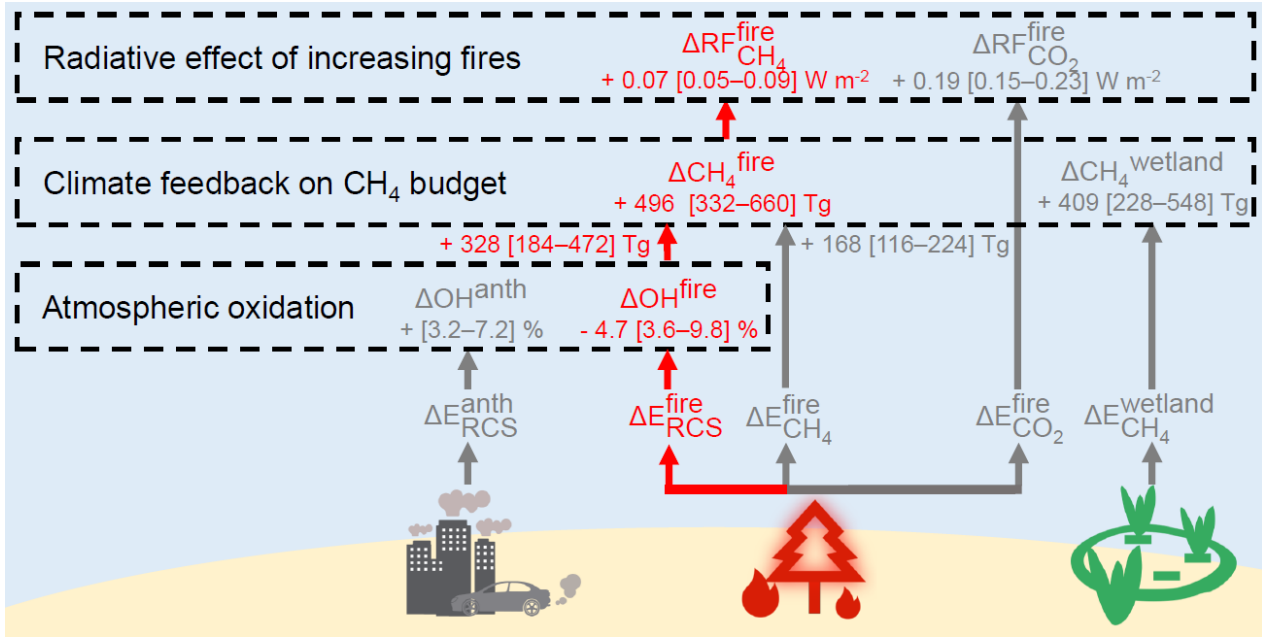

Radiative effect of increasing fires
ΔRF fire CH4
+ 0.07 [0.05–0.09] W m-2
ΔRF fire CO2
+ 0.19 [0.15–0.23] W m-2
Climate feedback on CH4 budget
ΔCH4 fire
+ 495 [332–657] Tg
+ 328 [183–478] Tg
+ 168 [116–223] Tg
ΔOH fire
- 4.7 [3.6–9.8] %
ΔE fire RCS
ΔE fire CH4
ΔE fire CO2

气候反馈机制


Radiative effect of increasing fires
ΔRF fire CH4
+ 0.07 [0.05–0.09] W m-2
ΔRF fire CO2
+ 0.19 [0.15–0.23] W m-2
Climate feedback on CH4 budget
ΔCH4 fire
+ 496 [332–660] Tg
ΔCH4 wetland
+ 409 [228–548] Tg
+ 328 [184–472] Tg
+ 168 [116–224] Tg
Atmospheric oxidation
ΔOH anth
+ [3.2–7.2] %
ΔOH fire
- 4.7 [3.6–9.8] %
ΔE anth RCS
ΔE fire RCS
ΔE fire CH4
ΔE fire CO2
ΔE wetland CH4



Recent



Future

Recent intensification and future prediction of fire-chemistry-methane feedback