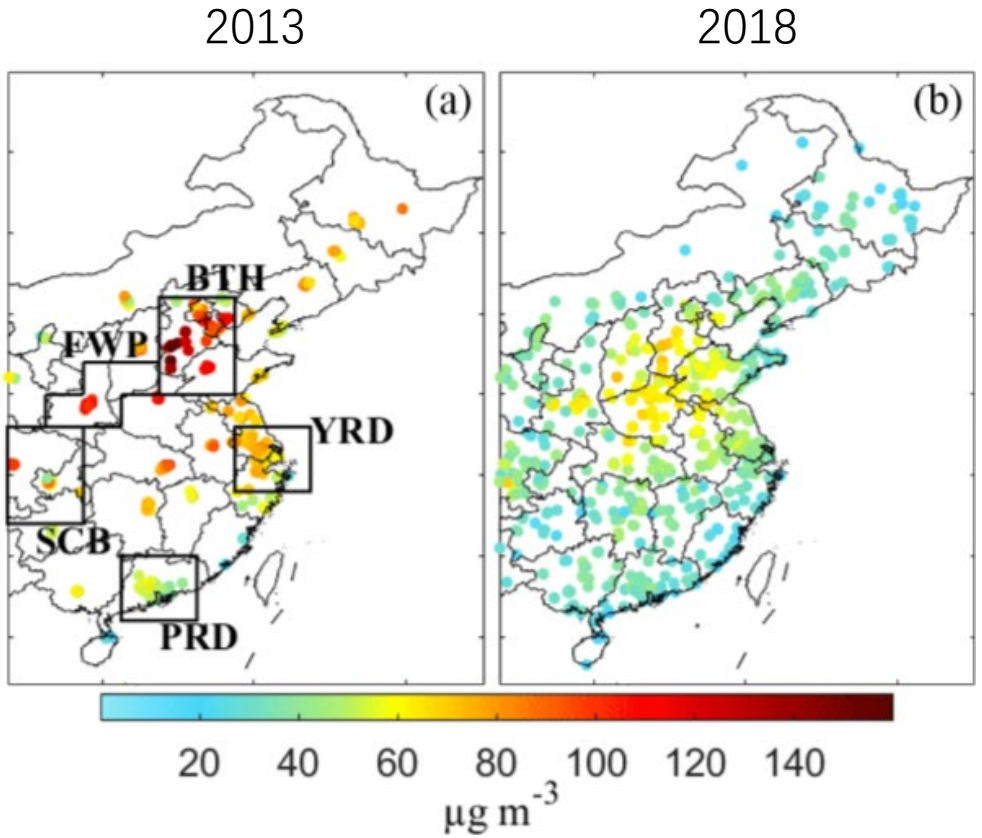
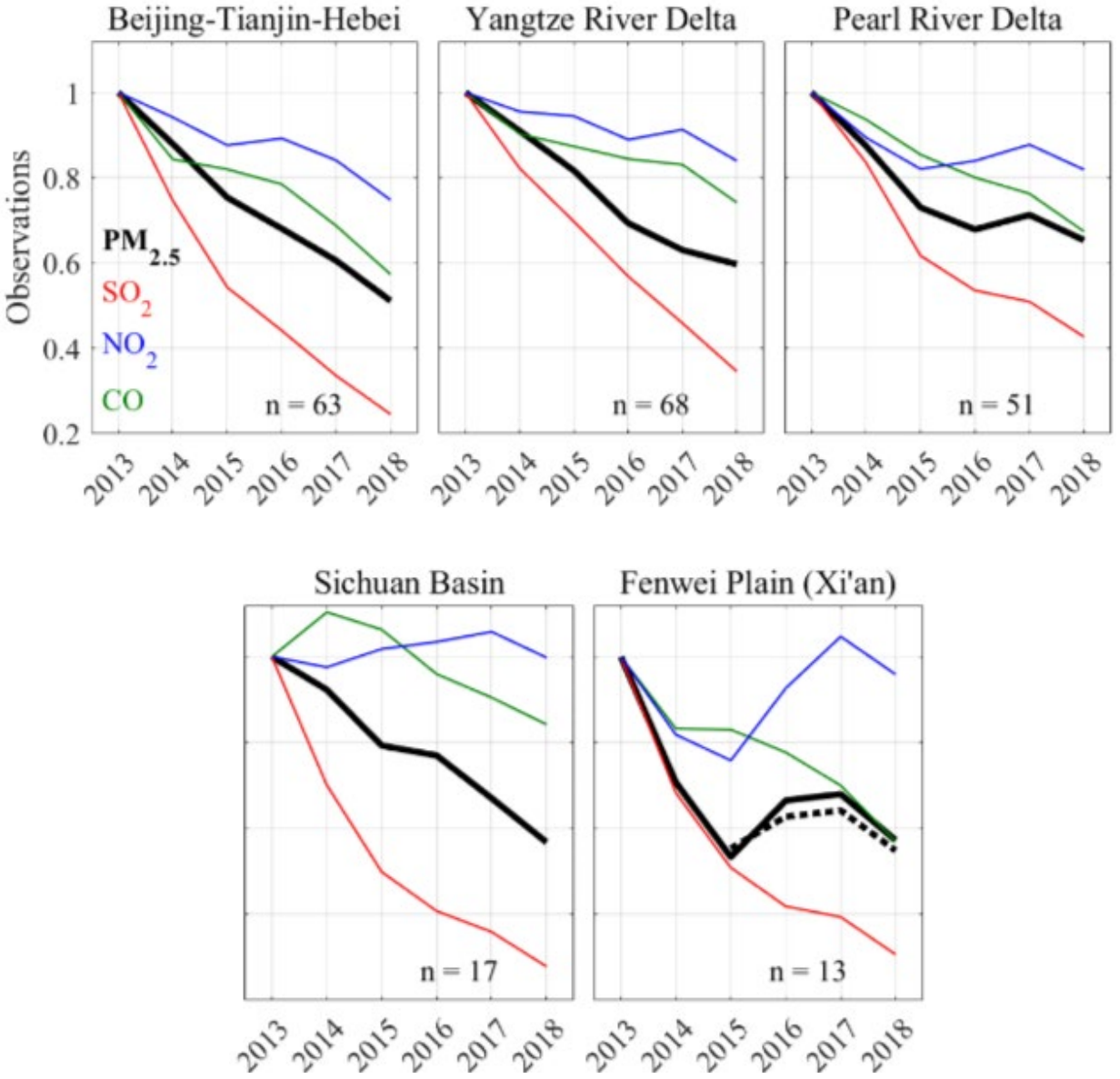
WESTLAKE UNIVERSITY

Extreme Haze Episodes in Northeast China Driven by Straw Burning Emissions

Xinchun Xie, Yuzhong Zhang, Ruosi Liang, Wei Chen, Peixuan Zhang, Xuan Wang, Ying Zhou, Yuan Cheng, and Jiumeng Liu

Improvement of $PM_{2.5}$ pollution across eastern China

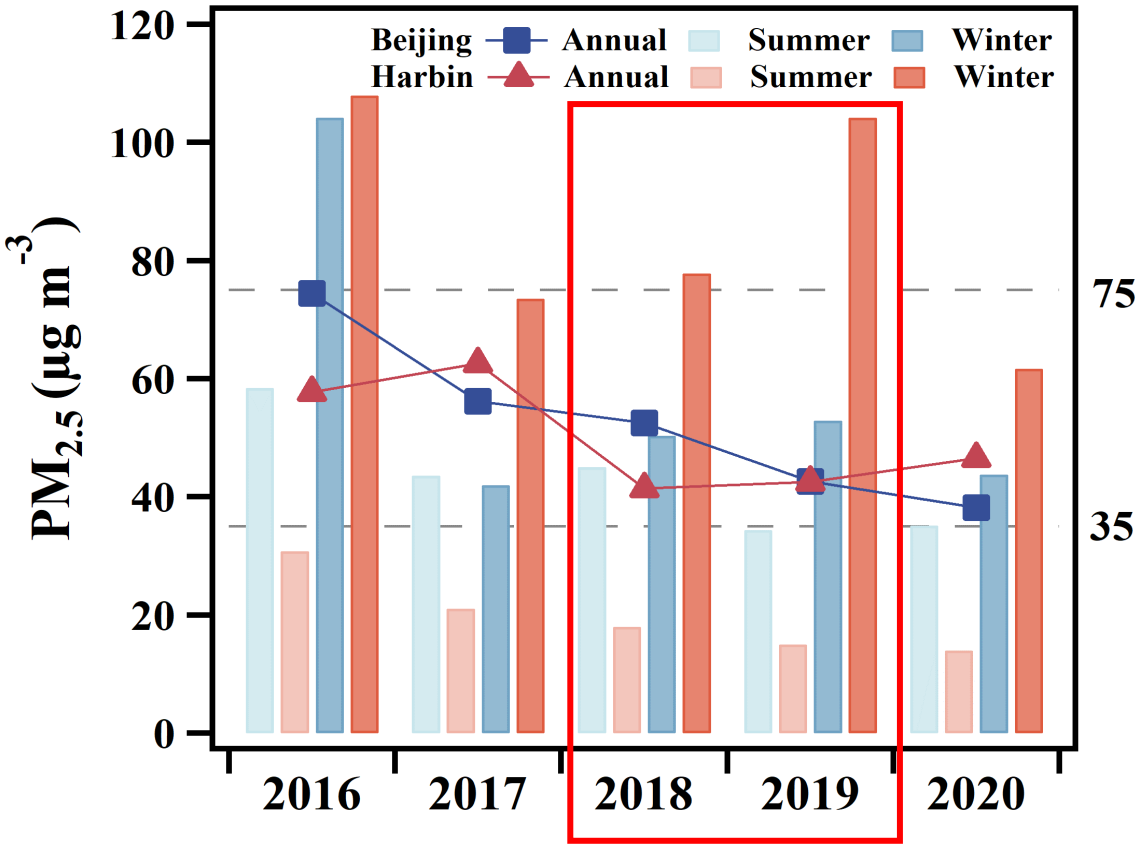




Zhai et al., 2019

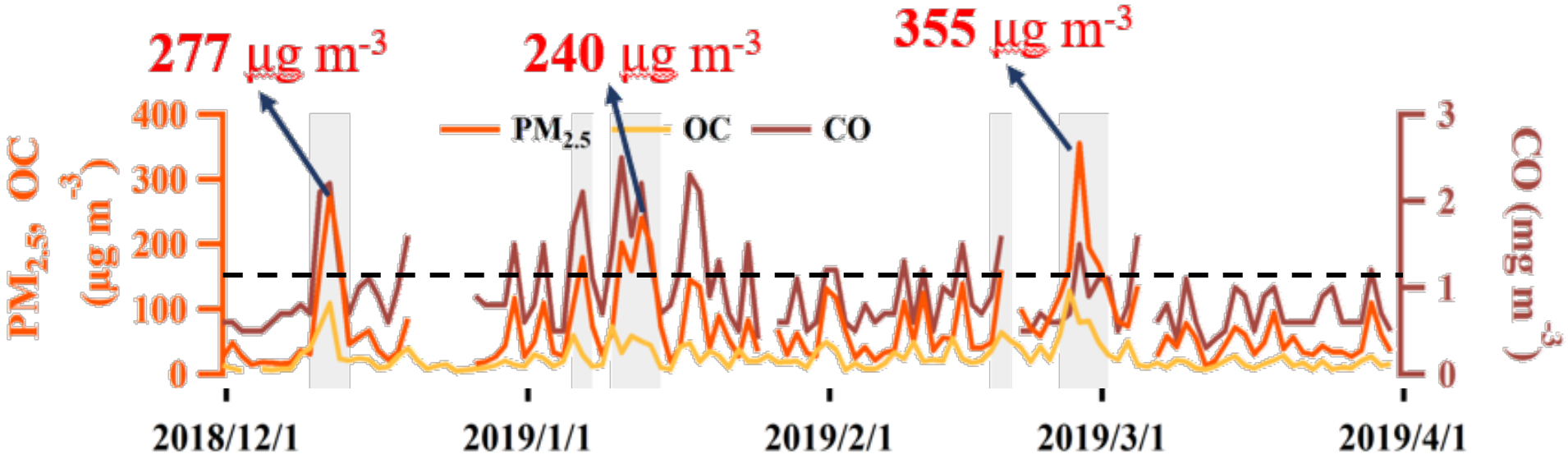
$PM_{2.5}$ pollution in Northeast China

- The decrease of PM2.5 in Northeast China is slower than other regions such as North China
- PM2.5 pollution in Northeast China is a winter problem



Extreme haze in 2018-2019 winter

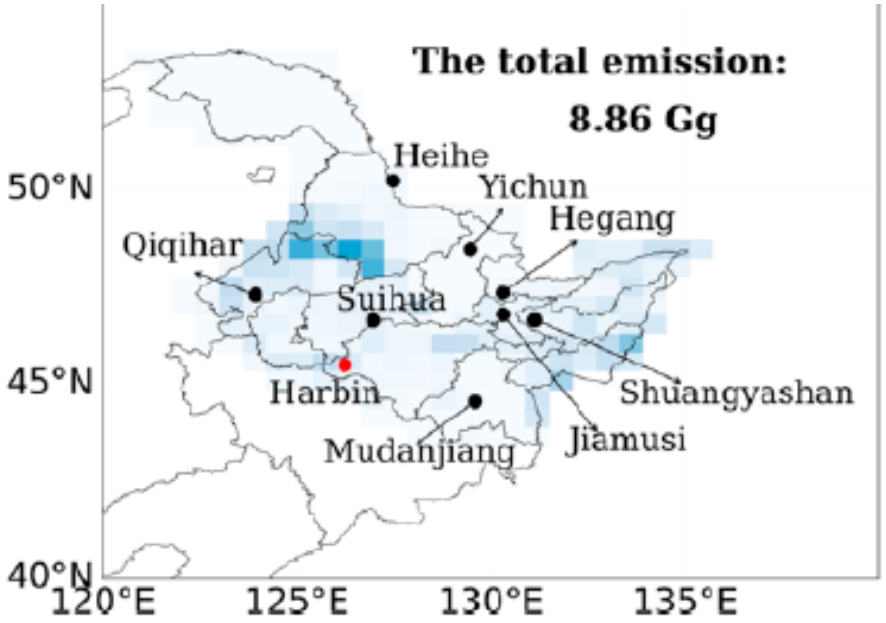
Measurements at Harbin



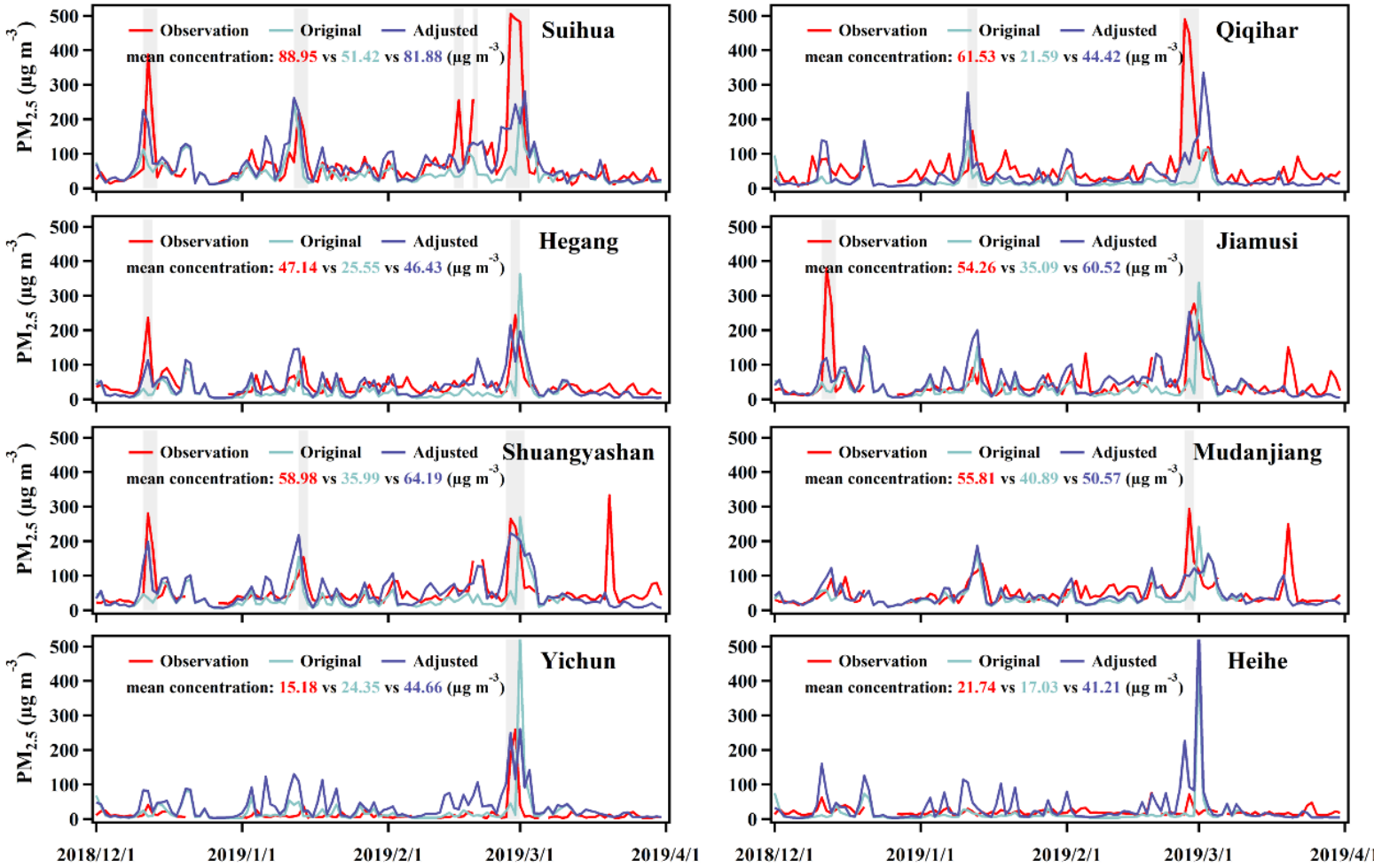
Heavy pollution days	Harbin	Suihua	Qiqihar	Jiamusi	Shuangyashan	Mudanjiang	Hegang	Yichun	Heihe
Observation	13	10	4	5	6	1	2	2	0

Xie et al., 2024

Extreme haze in 2018-2019 winter



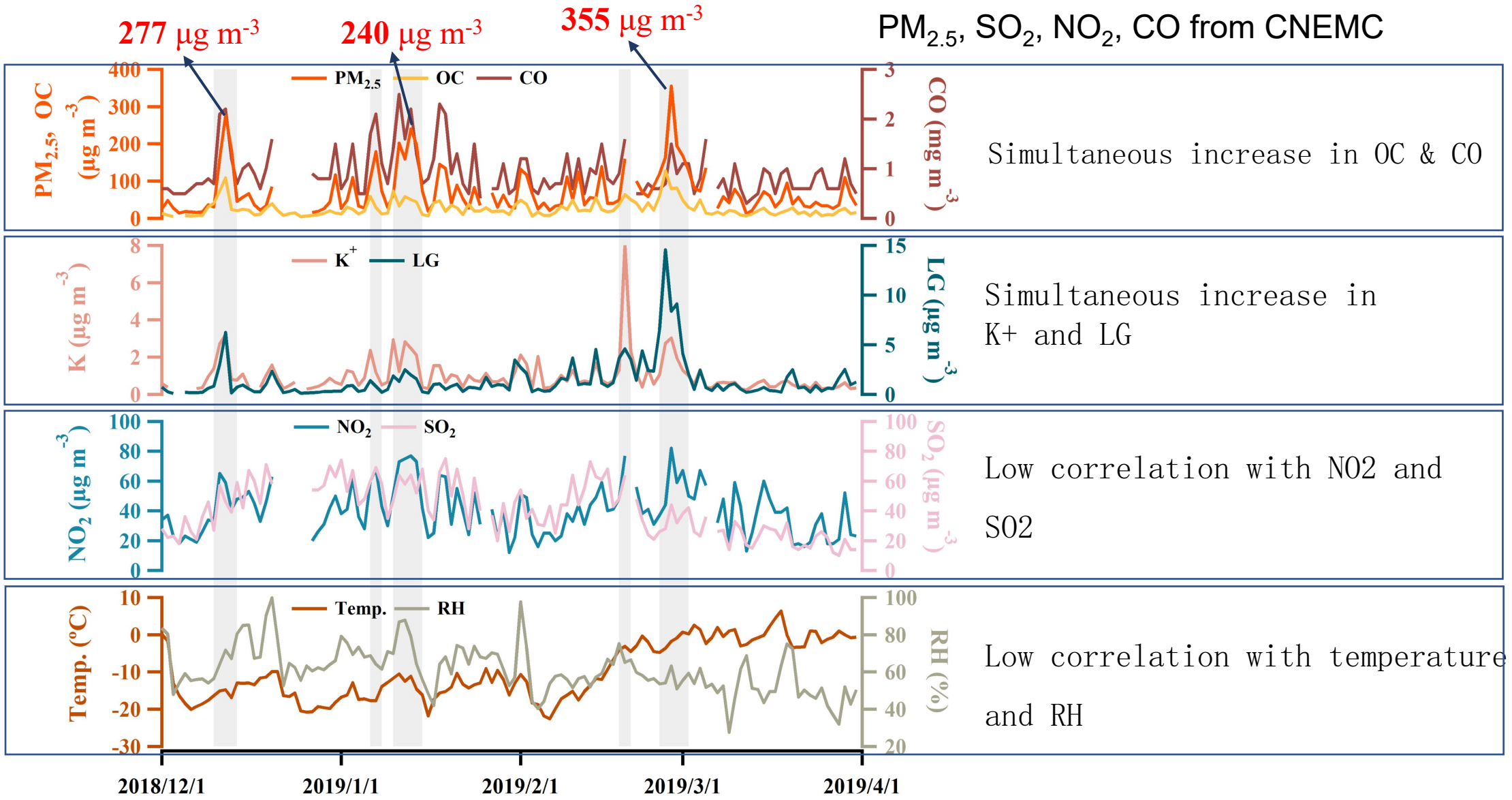
550 μg m^{-3}



Biomass burning as main cause of heavy haze episodes

OC, BC, K+, LG from Cheng et al., 2021

$PM_{2.5}$, SO_2, NO_2, CO from CNEMC



Agricultural fires as main cause of heavy haze episodes

黑龙江省人民政府办公厅关于印发黑龙江省禁止野外焚烧秸秆改善大气环境质量实施方案的通知

2017年02月13日14:52

9月至11月和次年4月至6月是我省秸秆野外禁烧的重点时段。

我省禁止秸秆露天焚烧工作奖惩暂行规定将出台 两时间段出现“第一把火”直接扣拨50万

2018年08月23日15:01 来源：省环保厅

2018/12/11~2019/3/9

从省环保厅获悉，为严格控制秸秆露天焚烧，我省近期将出台《黑龙江省禁止秸秆露天焚烧工作奖惩暂行规定》。每年9月15日至12月10日，翌年3月10日至5月15日期间，出现第一个火点的，省财政直接扣拨50万元财政拨款。

黑龙江省全域全时段全面禁烧秸秆

2020年03月23日15:50 来源：省生态环境厅

来自省政府新闻办举行我省新冠肺炎疫情防控工作第三十六场新闻发布会上的消息，当前正值备春耕的关键期，我省要求坚定不移贯彻“全域全时段全面禁烧”，一旦发现露天焚烧秸秆的行为，将予以严厉处罚。

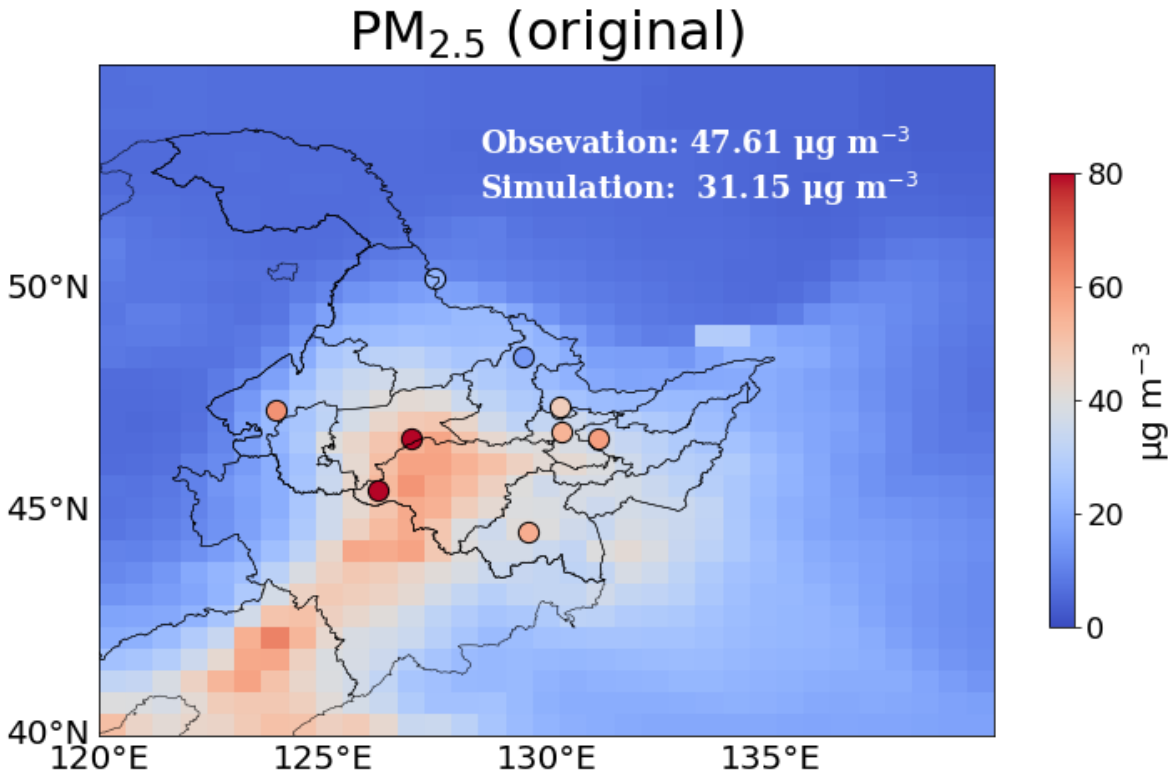
9月15日至明年5月15日 禁止秸秆露天焚烧

2020年09月16日13:53 来源：黑龙江省人民政府网

根据《黑龙江省禁止秸秆露天焚烧工作奖惩暂行规定》，2020年9月15日至2021年5月15日，为2020-2021年秸秆禁烧期。

- Large amount of straw residue
- Changes in policies

GEOS-Chem model underestimates during the episodes



Model: GEOS-Chem version 12.8.2

Horizontal resolution: 0.5° × 0.625°

Vertical layers: 47 vertical levels

Anthropogenic emissions: MEIC

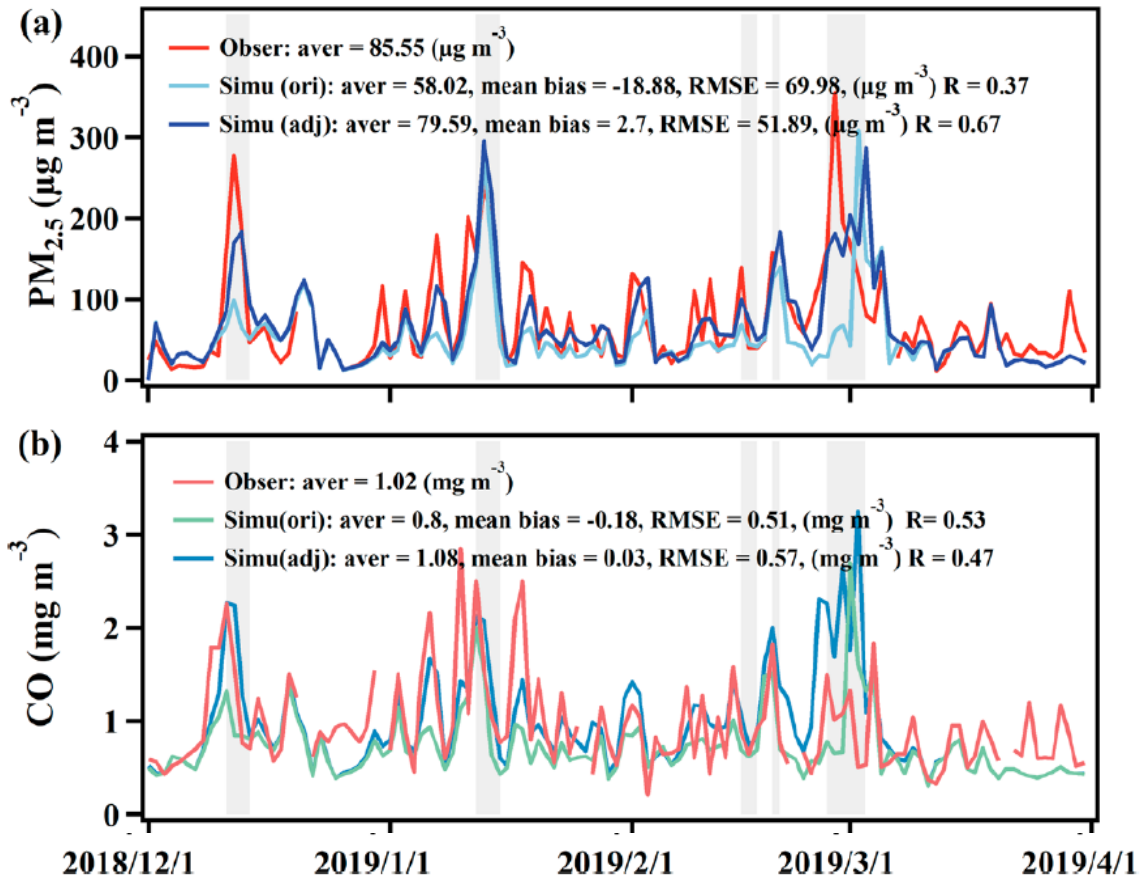
Fire emissions: GFED4s

SAVA: Savanna, grassland, and shrubland fires
BORF: Boreal forest fires
TEMF: Temperate forest fires
DEFO: Tropical deforestation & degradation
PEAT: Peat fires
AGRI: Agricultural waste burning

GEOS-Chem model underestimation in Northeast China

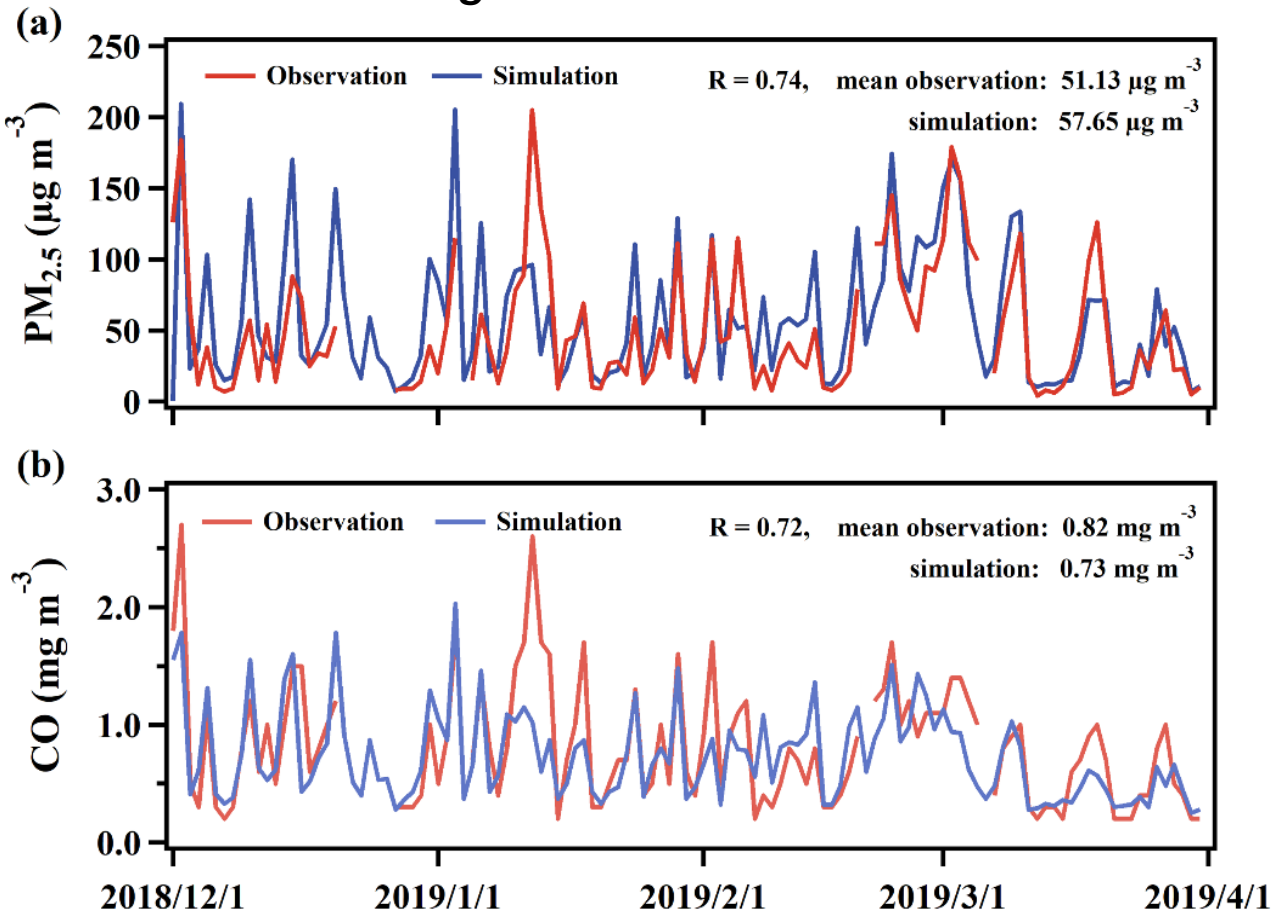
Harbin

Underestimation of PM2.5 in Northeast



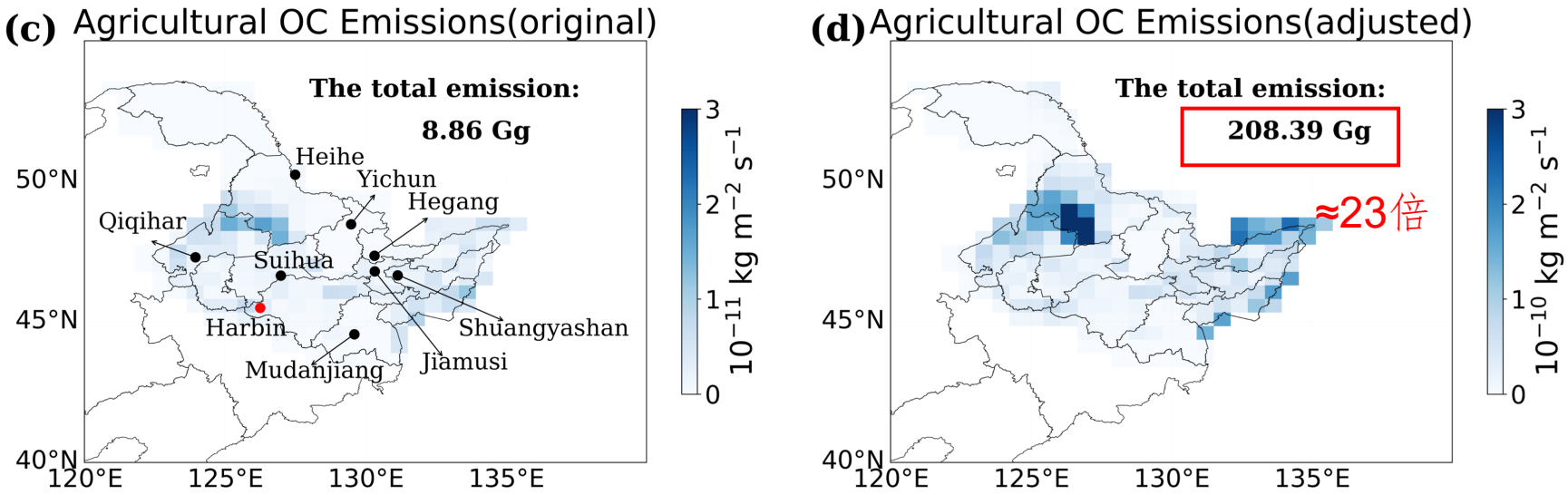
Beijing

Good agreement in North China



The Emission Inventory Underestimates Agricultural Fire Activities

Agricultural fire emissions are very low in GFED4s during the period



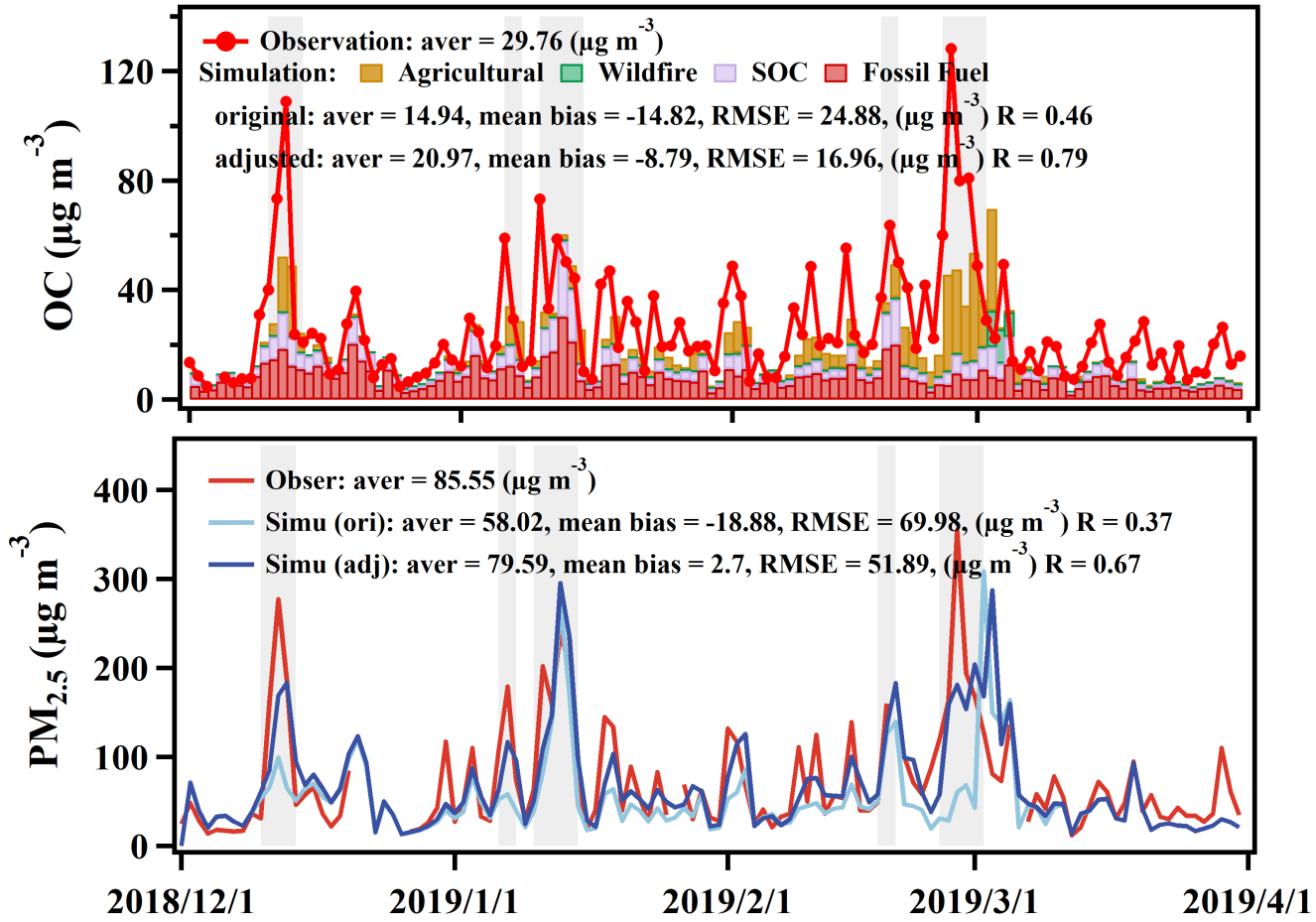
Regional underestimation of agricultural fire activity

- Uniform scaling of agricultural fire emissions based on OC observations in Harbin
- Same scaling factor for all species from agricultural fires (including OC, CO, and BC)

Increased agricultural fire emissions in simulations

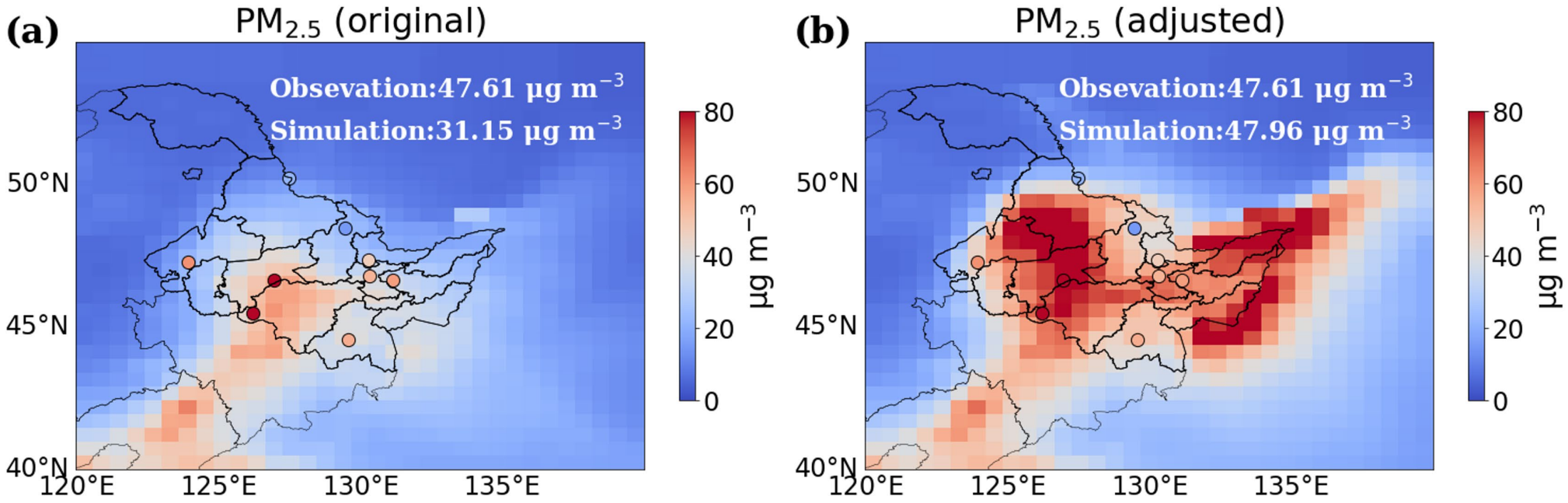
➢ Better agreement in Harbin after increasing fire emissions

- **Observed average $PM_{2.5}$**: 72.78 μg m^{-3}
- **Simulated average (adjusted):** 67.95 μg m^{-3}
- **Simulated average (original):** 51.84 μg m^{-3}



Increased agricultural fire emissions in simulations

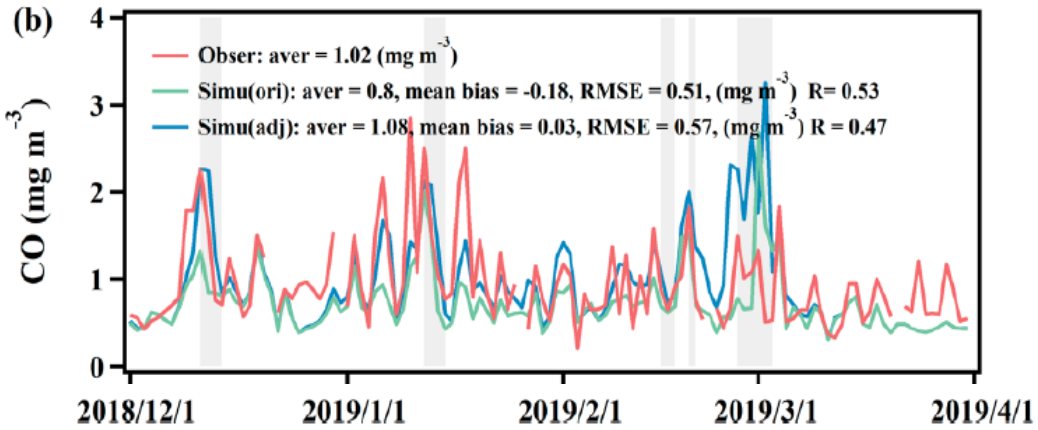
- Better agreement across most cities in Heilongjiang



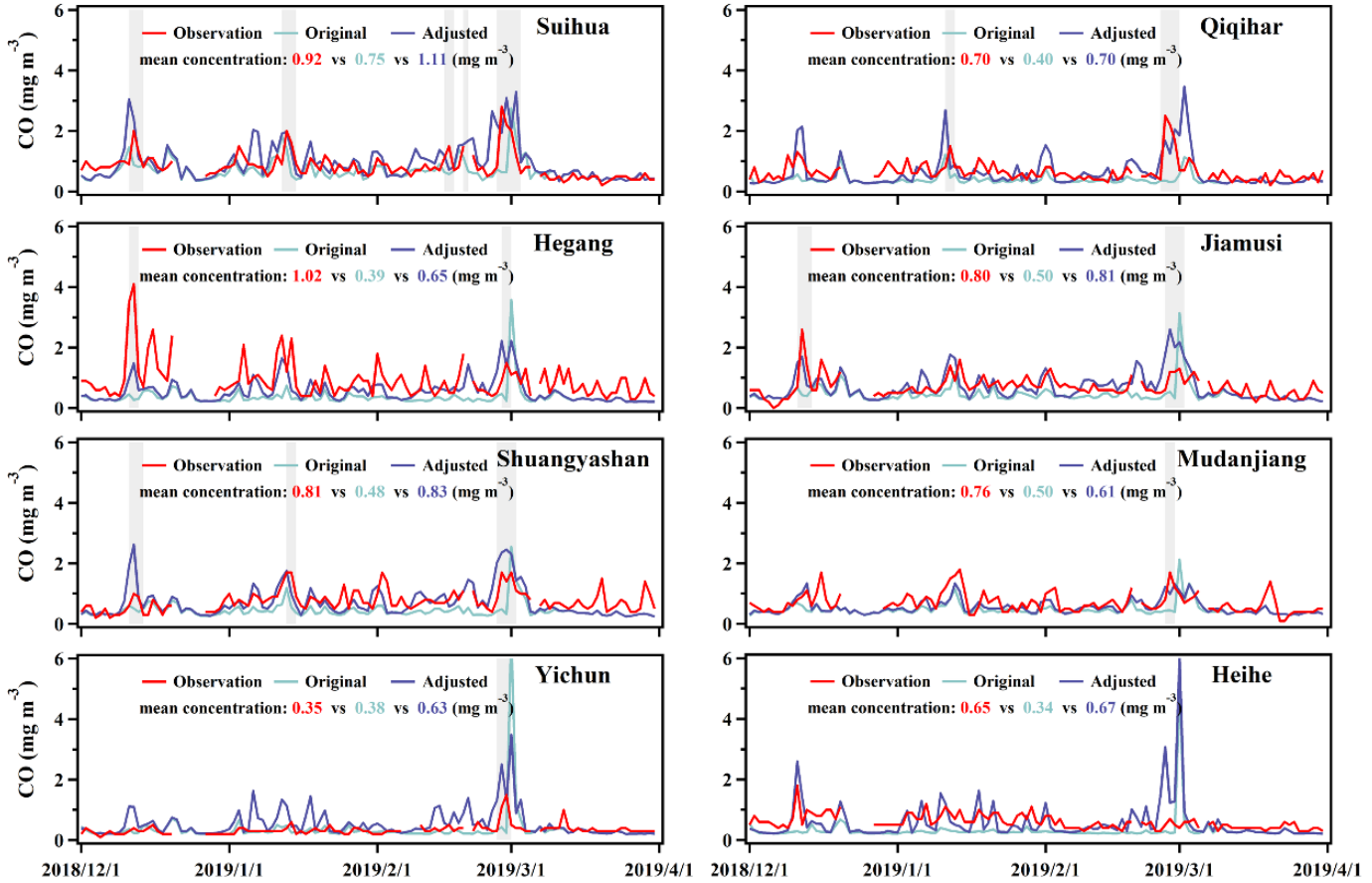
The underestimation of agricultural fire activity is regional and systematic

Increased agricultural fire emissions in simulations

- Better agreement for CO simulations

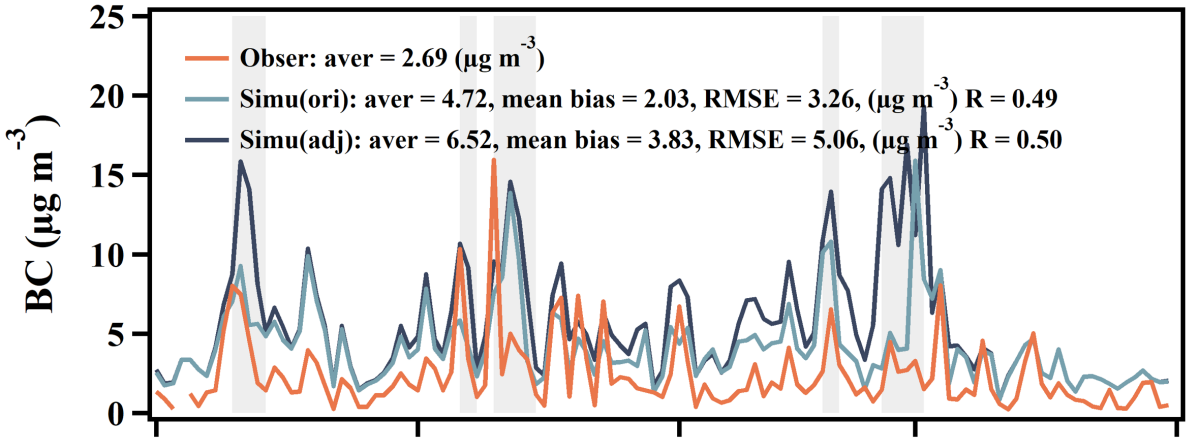


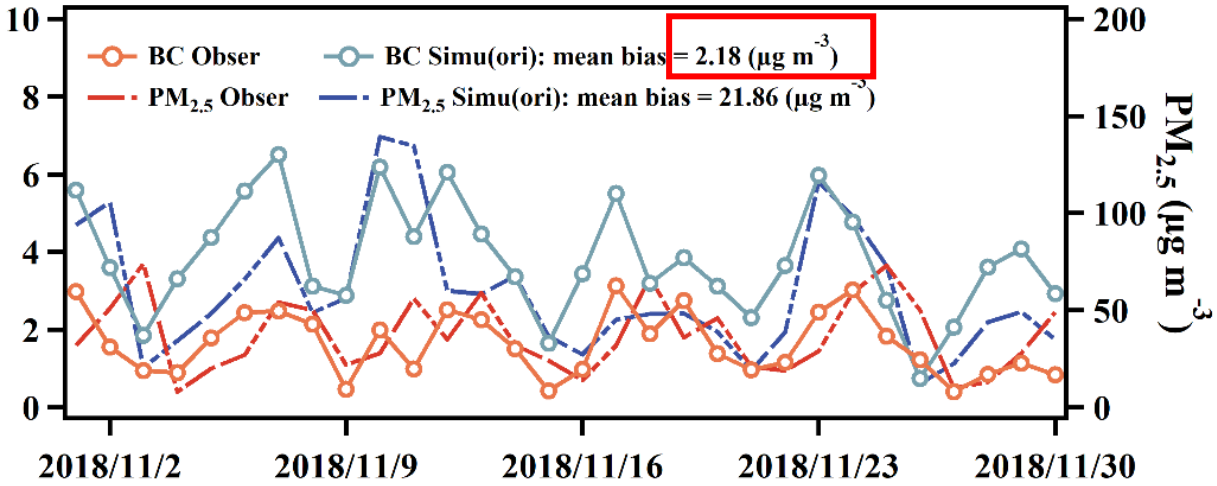
The underestimation is due to agricultural fire activity rather than OA emission factors

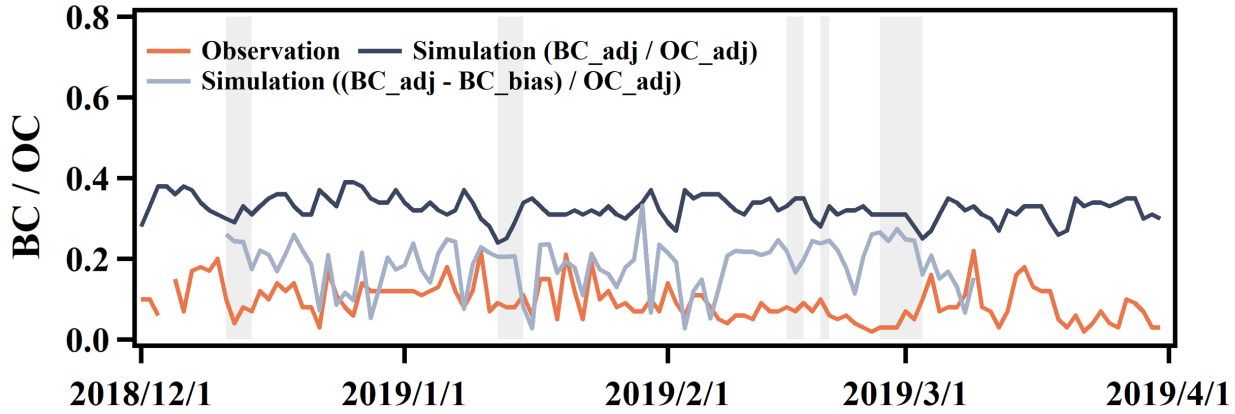


The Emission Inventory Assumes an Excessive Combustion Efficiency

- GFED4s overestimate the emission ratio of BC/OC

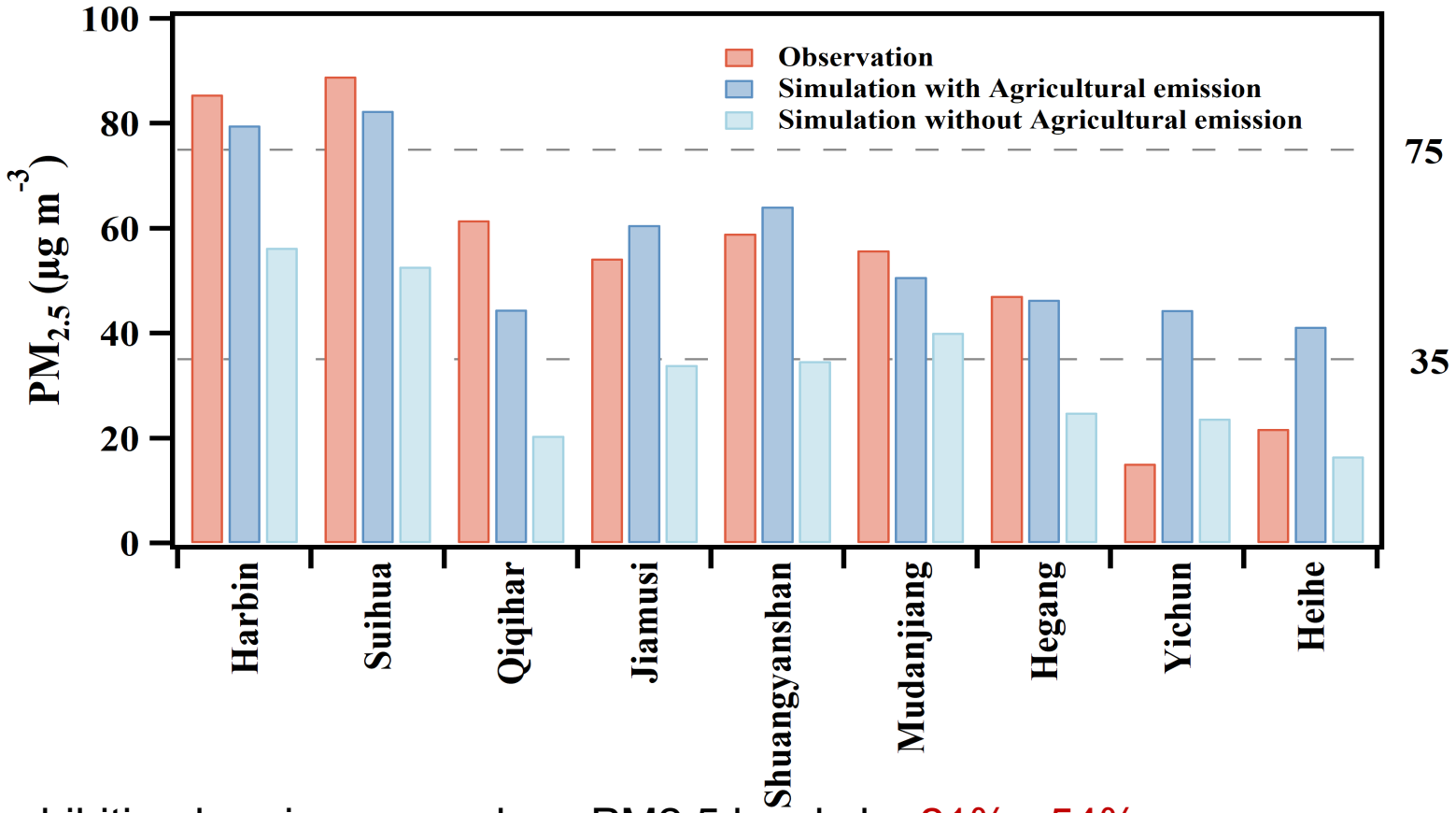






	BC/OC
Observation-adjusted	0.18
GFED4s	0.33

Implication for PM2.5 Control



- Strictly prohibiting burning can reduce PM2.5 levels by 21% - 54%
- Especially a 29% reduction in Harbin, a 46% reduction in Shuangyashan).
- Based on the Integrated Exposure-Response (IER) model, strict prohibition of burning can reduce premature deaths due to PM2.5 exposure by 13.9%.

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Letter

Wintertime Heavy Haze Episodes in Northeast China Driven by Agricultural Fire Emissions

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https://pubs.acs.org/action/showCitFormats?doi=10.1021/acs.estlett.3c00940&ref=pdf

Summary

- From December 9, 2018, to March 11, 2019, emissions from straw burning were the main cause of severe particulate pollution in Heilongjiang Province.
- The Global Fire Emissions Database (GFED4s) underestimates agricultural fire emissions and overestimates the BC/OC emission ratio in Northeast China.
- Banning straw burning can effectively improve air quality in Heilongjiang Province and reduce premature deaths caused by particulate exposure.