Dynamic estimation of open biomass burning emissions by using fused fires detected by polar-orbiting and geostationary satellites in mainland China

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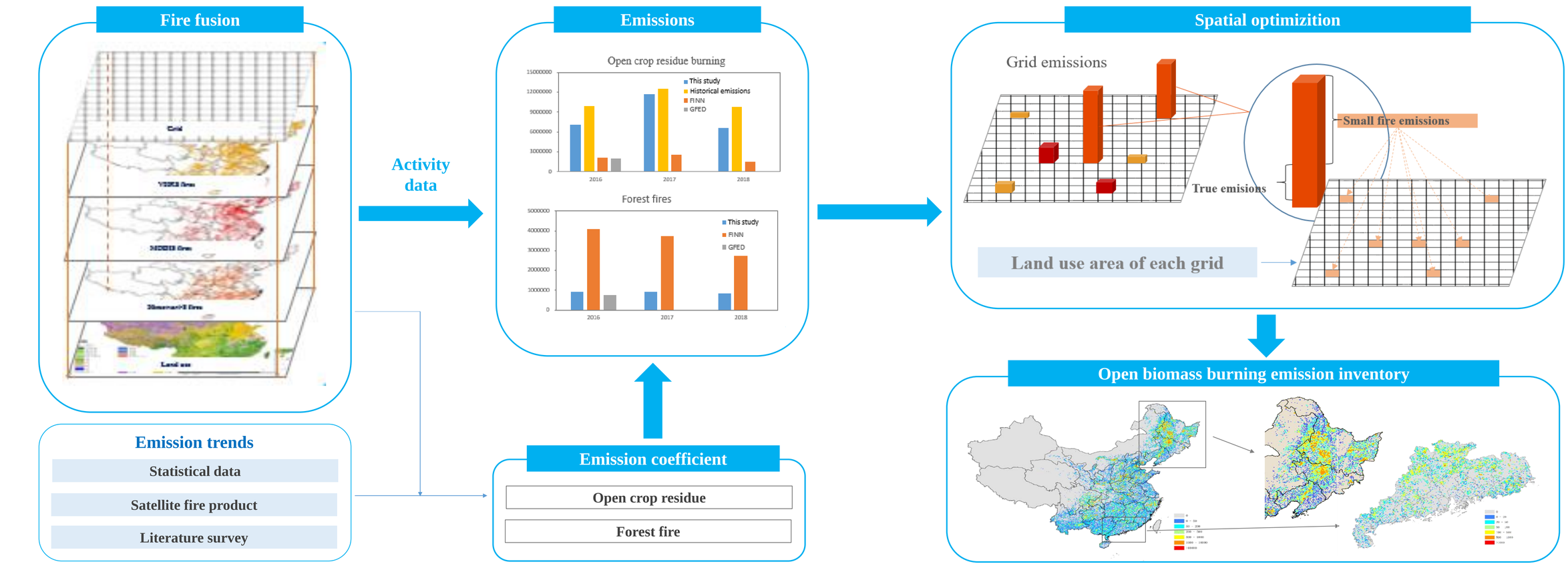
Introduction

Open biomass burning (OBB), which has adverse effects on air quality, climate and human health, is an important emission source of gaseous pollutants and particulate matter (PM) in China. The timely estimation of OBB and characterizing their temporal and spatial distributions are beneficial to promote air quality simulation and management. Several daily OBB emission products, such as GFED, FINN, and GFAS, based on MODIS observations had been developed. However, MODIS observations typically miss small or short-term fire events due to their rough spatial resolution and limited monitoring times, which could consequently lead to the underestimation of OBB emission. In this study, we developed a new method for dynamic estimation of OBB emission by using a fused fire data based on polar orbit satellites (MODIS and VIIRS) and geostationary satellite (Himawari-8) observations. Compared with MODIS observations (1km, four times a day), the VIIRS observations have a higher spatial resolution (375m), and the Himawari-8 can observe the 24-hour variability of fires. Thus, the grid number with fused fire covered increased about 8 times for open crop residue burnings and 6 times for forest fires compared to grid number with only MODIS fire covered in Guangdong province in the year of 2017. Meanwhile, open biomass burning emissions in mainland China calculated by fused fires were about 0.7 times higher than FINN and 2.2 times greater than GFED and GFAS, owing to the supplementation of fires missed by MODIS observations. More importantly, emissions derived from fused fire-based may increase the temporal resolution to 1 hour with a time delay of only 1 to 2 days.

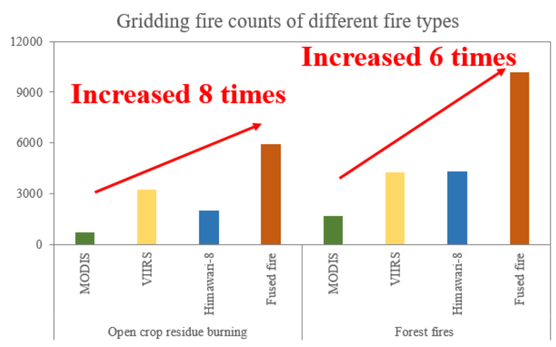
Methodology

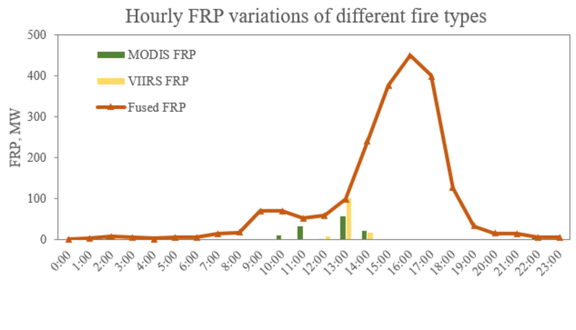


1) **Fire fusion**: Based on geographical location and occur time of fires detected by MODIS, VIIRS and Himawari-8 to improve fire monitoring ability.
2) **FRE-based emission coefficients**: According to the relationship between daily emissions and fused FRE for open crop residue burning, and FRE biomass combustion coefficient for forest fires to reflect the regional discrepancies of emission factor.
3) **High spatiotemporal resolutions**: hourly, 9km×9km or 3km×3km

Emission improvement and assessment

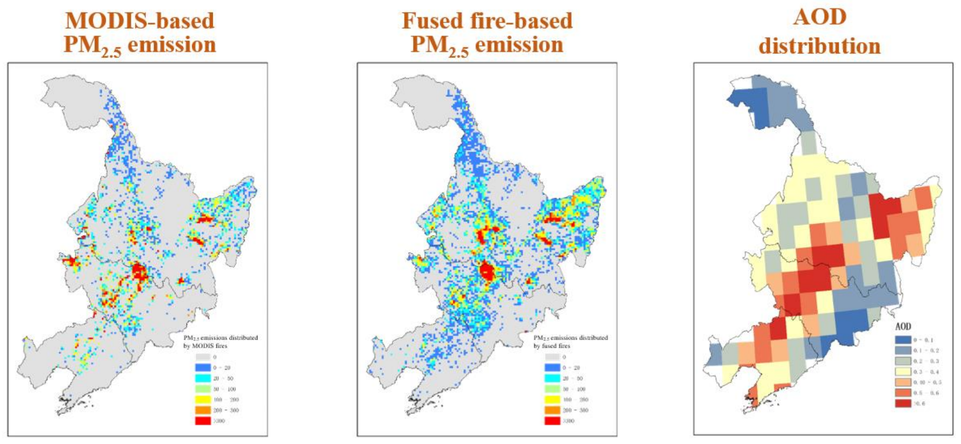
Fire monitoring ability





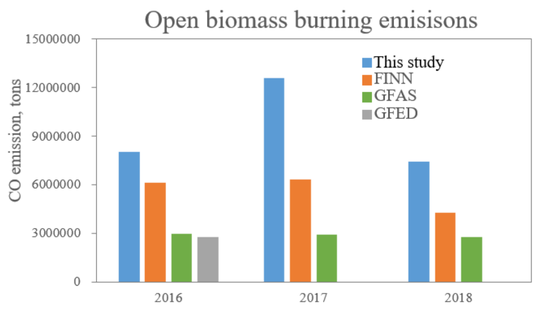
Taking Guangdong province in 2017 as an example:
1) After the fusion, the grid number with fire covered increased 8 times and 6 times for open crop residue burning and forest fires.
2) FRP can be hourly observed instead of several times in one day.

Spatial distribution



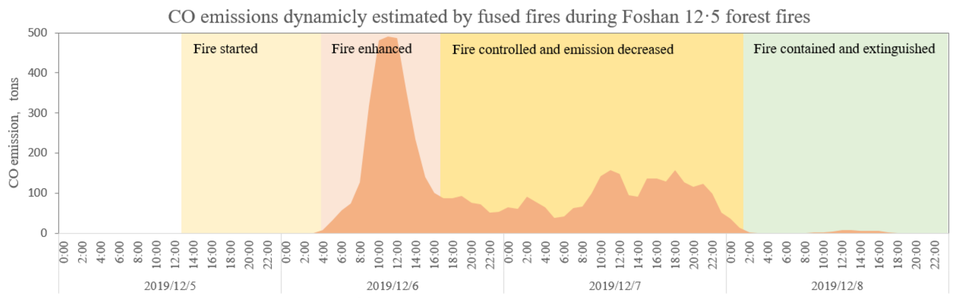
Taking $PM_{2.5}$ emissions from Northeast China in October 2017 as examples, $PM_{2.5}$ emissions allocated by fused fires are more widespread and correlated with AOD than that distributed by MODIS fires.

Annual emissions in mainland China



Emissions from open biomass burning are larger than FINN, GFAS and GFED due to the supplementation of missing fires detected by MODIS.

Dynamic estimation



The dynamic estimation of open biomass burning emissions could reflect the cycle variation during a forest fire effectively and timely.

Conclusions

1) Fires detected by polar orbit satellite (MODIS and VIIRS) and geostationary satellite (Himawari-8) were fused; 2) Open biomass burning emissions were dynamically estimated by using fused fire radiative energy and FRE-based emission coefficient; 3) Fused fires showed higher spatial coverage and temporal resolution; 4) Emissions based on fused fires could decrease the underestimation of open biomass burning emissions caused by fire missing; 5) The dynamic estimation of open biomass burning emissions had high spatial representativeness and timeliness.

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