Burning season emissions of reactive nitrogen from fires in subtropical southern Africa determined with TROPOMI and IASI

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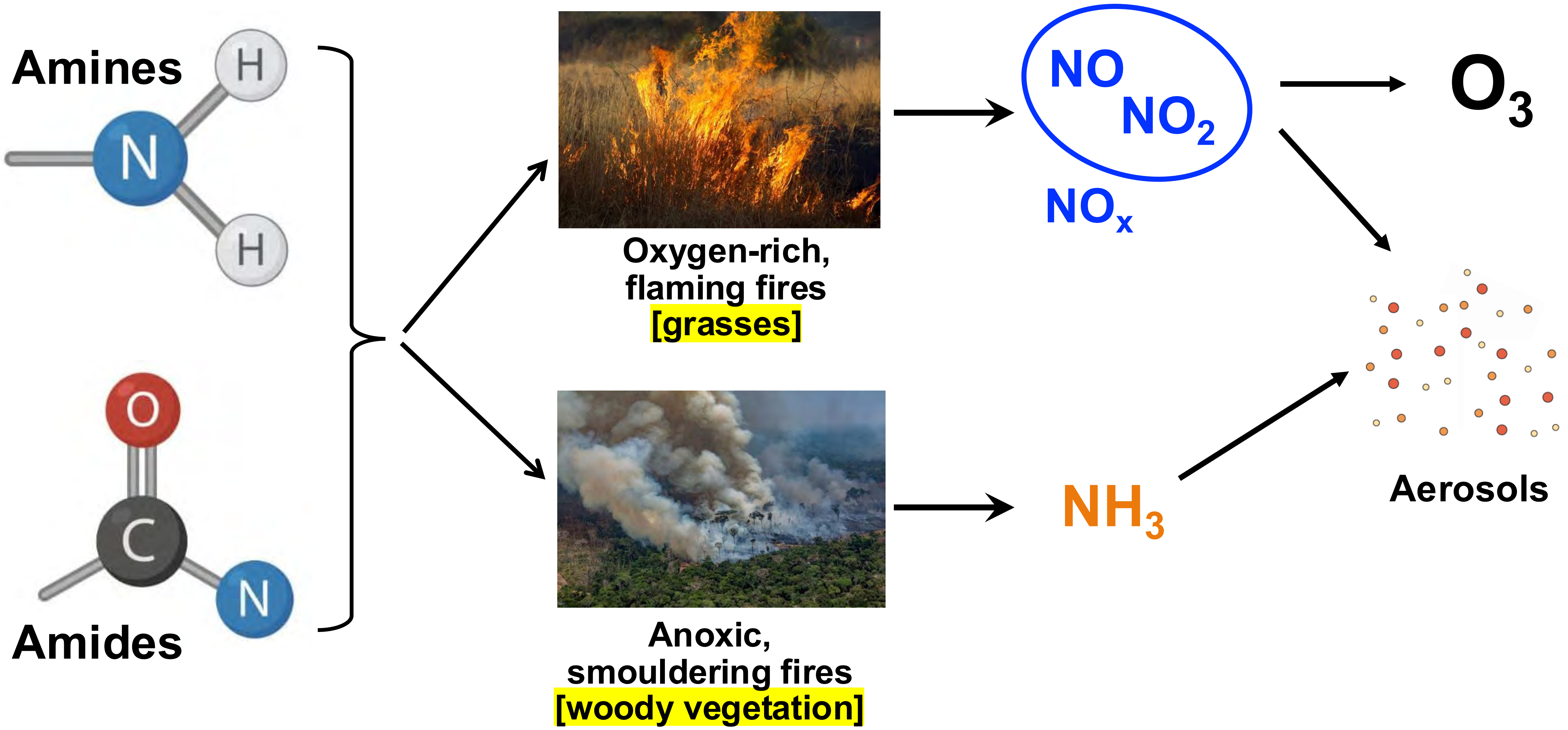
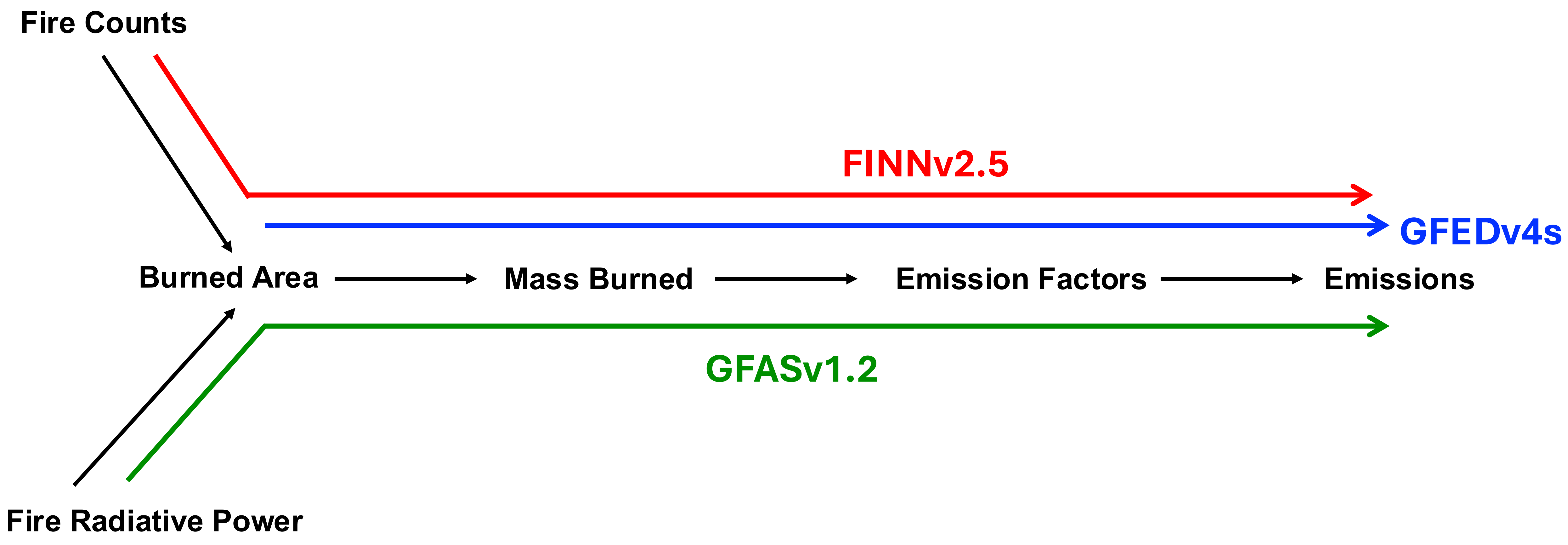
Reactive Nitrogen Emissions from Fires



Reactive nitrogen emissions affect local air quality and regional climate

Reactive Nitrogen Emissions in Bottom-up Inventories



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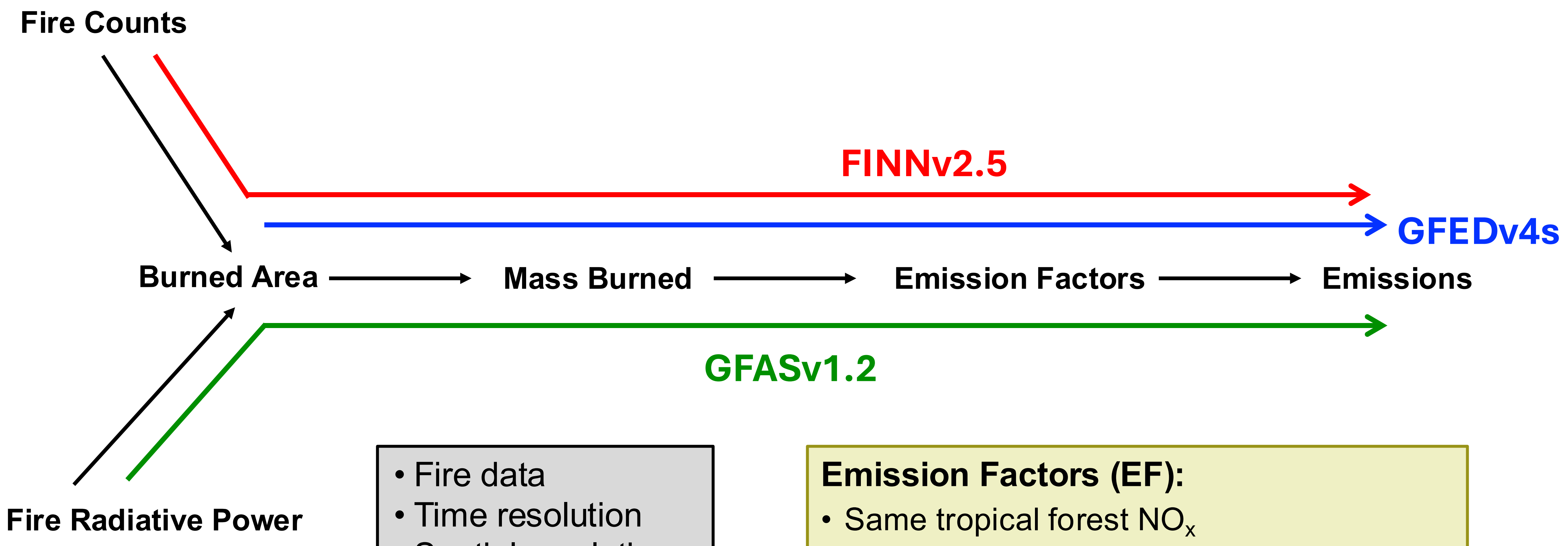


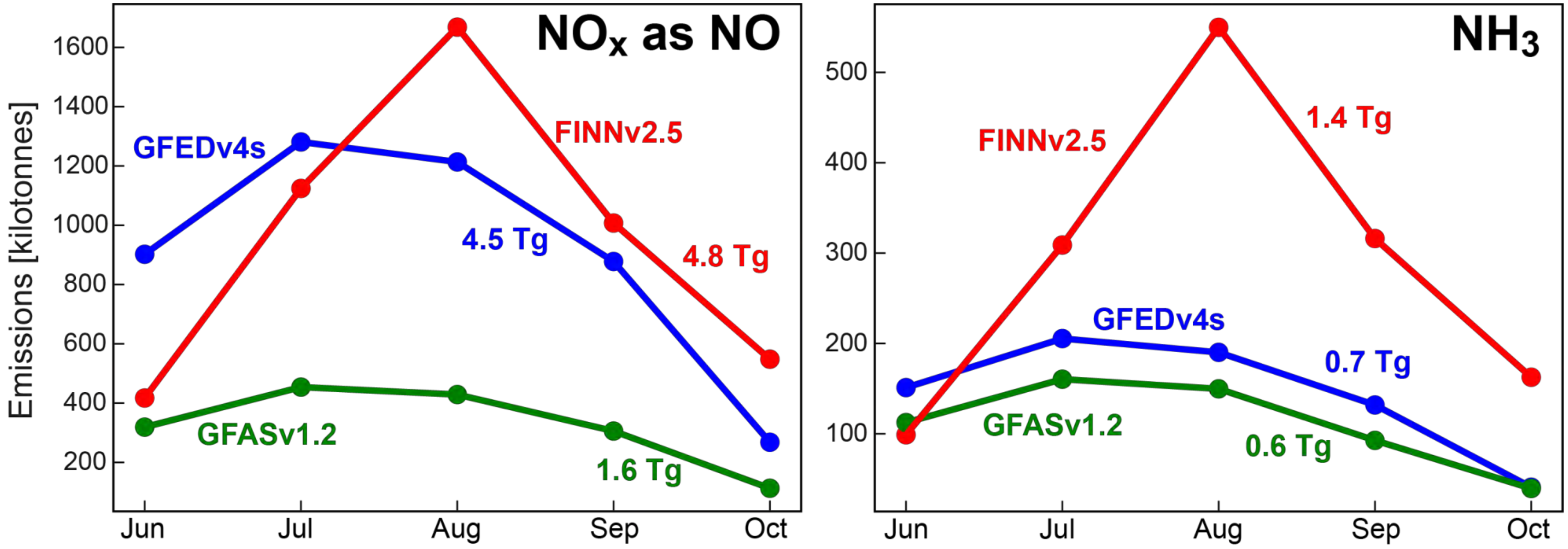
- Fire data
- Time resolution
- Spatial resolution
- Injection height
- Small fires
- Landcover classes

Emission Factors (EF):

- Same tropical forest NO_x
- Same savanna NH_3
- GFAS NO_x EF for savanna half the others
- GFAS NH_3 EF for tropical forest < others
- FINN emits NO_x and NO and NO_2

Reactive Nitrogen Emissions in Southern Africa

Monthly bottom-up June-October 2019 emissions



MODIS Landcover

Mostly savanna fires. Some tropical forest fires.

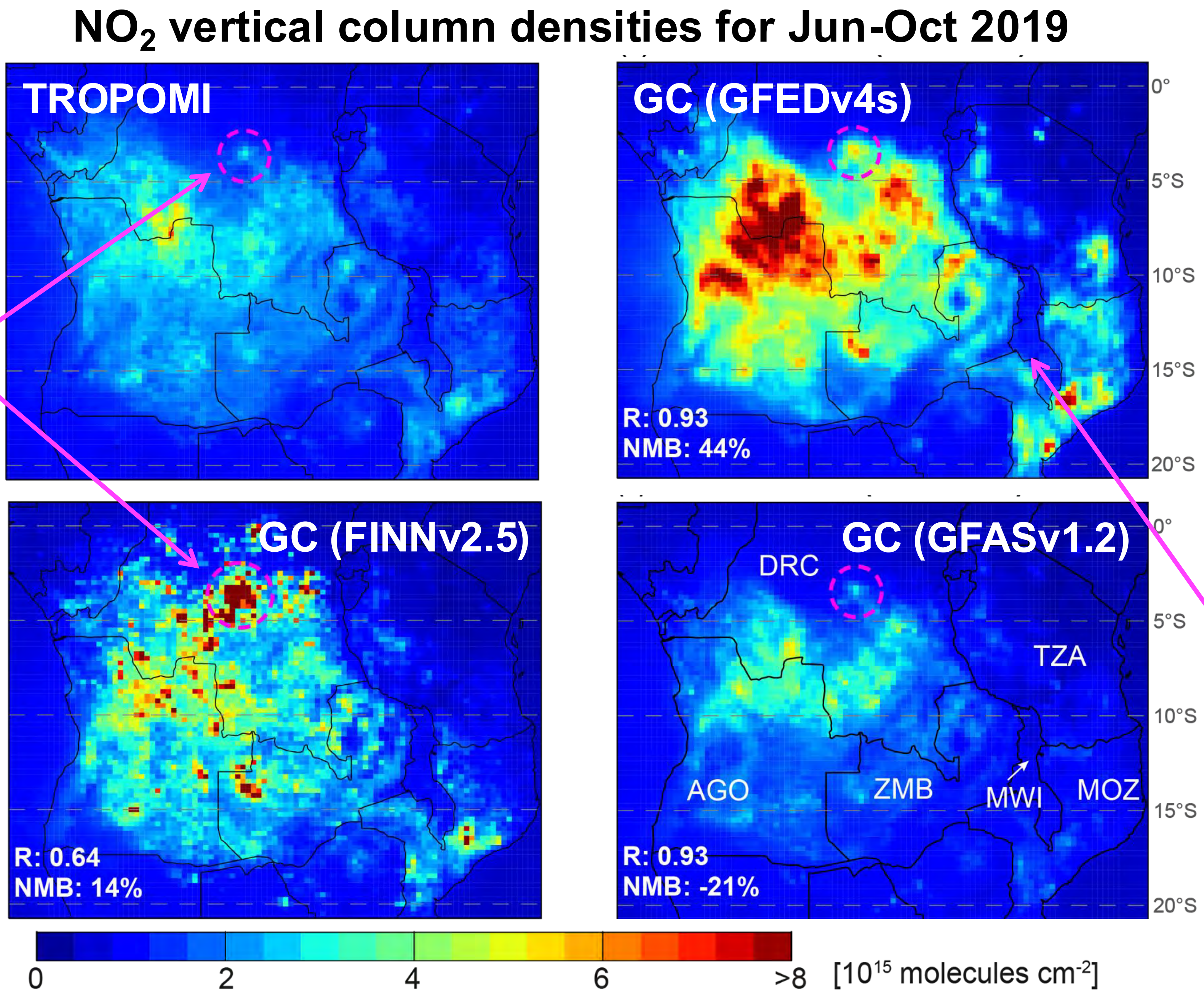
Apply all 3 inventories to GEOS-Chem to compare to IASI for NH_3 and TROPOMI for NO_2

Very different ozone production efficiencies (OPEs): GFAS more sensitive to NO_x than others.

According to GEOS-Chem, FINN OPE > GFED OPE, as far more VOCs and CO than others:

FINN: 108 Tg CO and 13 Tg C for 21 NMVOCs
GFED: 82 Tg CO and 2 Tg C for 13 NMVOCs

Evaluation of Inventories with Satellite Observations



Far more NO_x from tropical forests in FINN (fuel load)

GC: GEOS-Chem

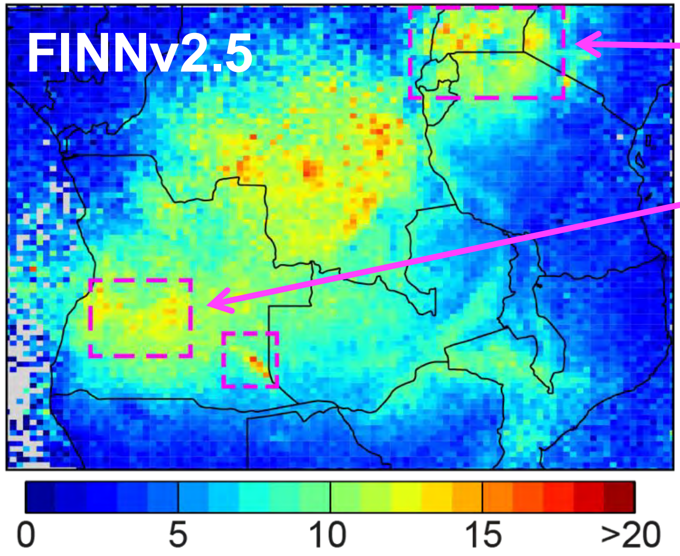
GFED and GFAS NO_2 spatially similar, but >50% difference due to emission factors

Low emissions in Malawi, as spread of fire suppressed by dense population

Evaluation of Inventories with Satellite Observations

NH_3 vertical column densities for Jul-Oct 2019 [10^{15} molecules cm^{-2}]

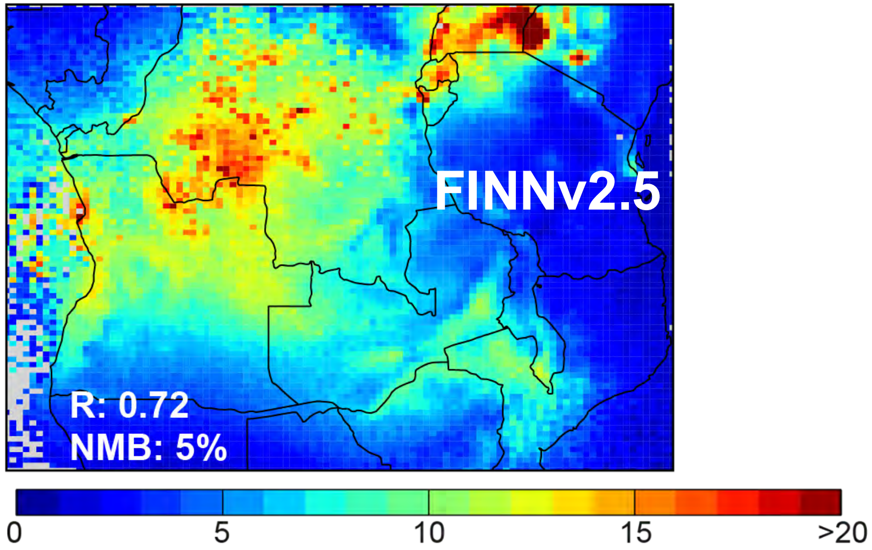
IASI with GEOS-Chem prior:

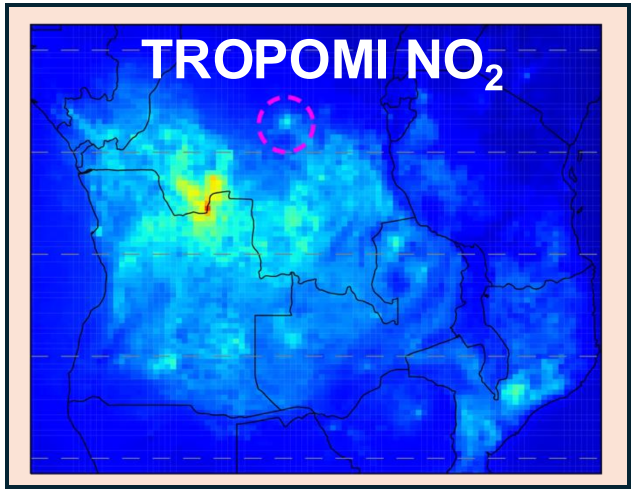


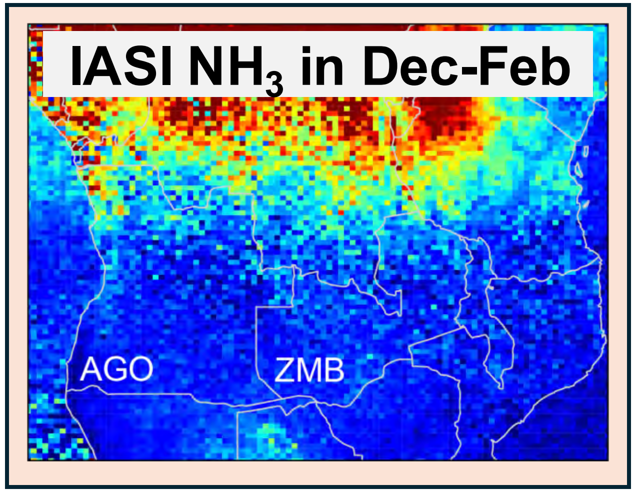
Anthropogenic NH_3 in the Lake Ukerewe Basin

Fire NH_3 in Angola that no inventory reproduces

GEOS-Chem:







June excluded, as no inventories consistent with IASI observations (R < 0.5)

Evaluation of Inventories with Satellite Observations

NH_3 vertical column densities for Jul-Oct 2019 [10^{15} molecules cm^{-2}]

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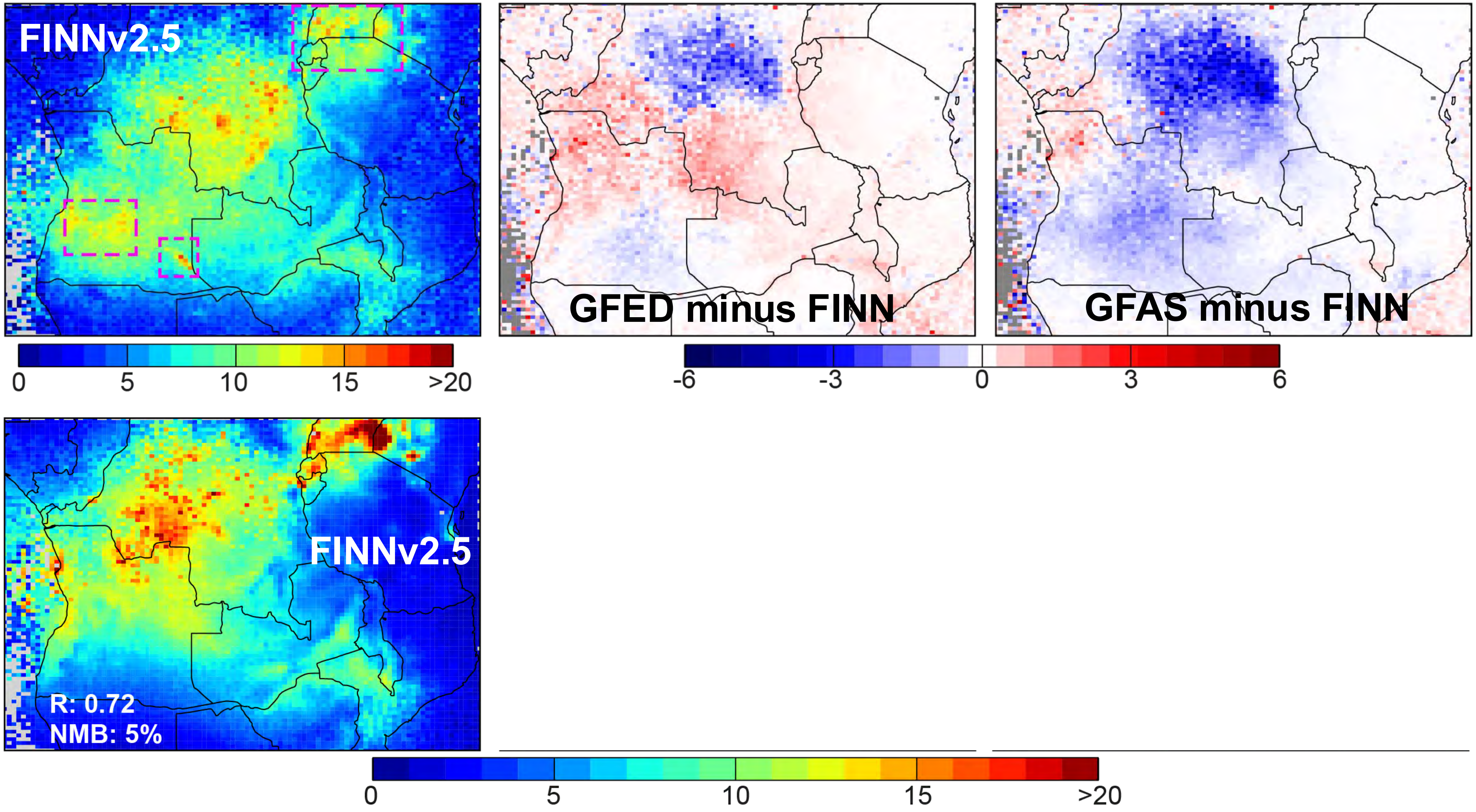
GEOS-Chem:



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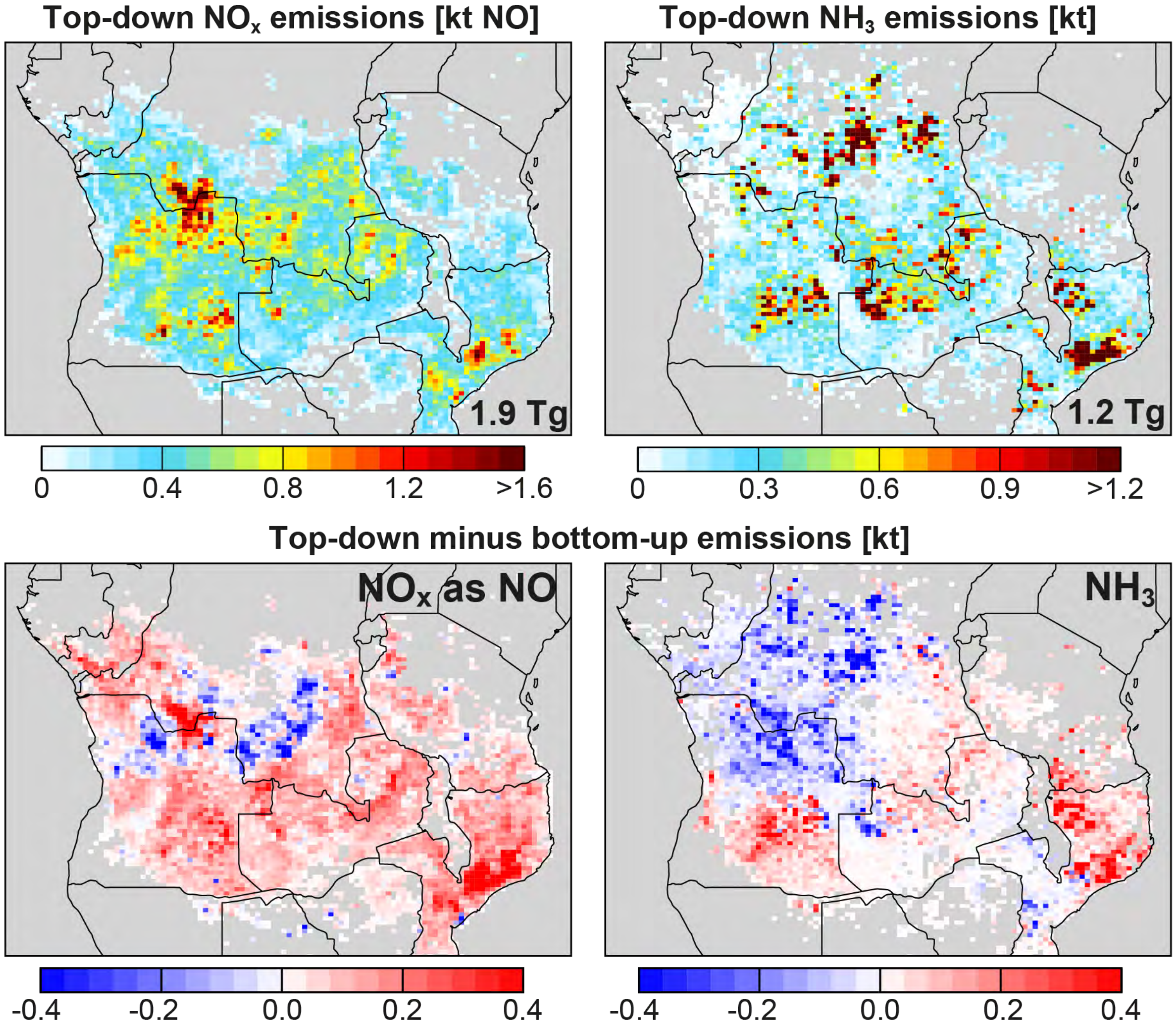
Top-down Emissions with Best Performing Inventories



Mass-balance approach: convert satellite columns to 24-h monthly emissions using GEOS-Chem

Uses GFAS for NO_x, FINN for NH_3 if biomass burning > 50% total

Distribution normal for NO_x, long-tailed for NH_3

Individual inventories correlate NO_x and NH_3 ($R > 0.8$), but top-down is not ($R < 0.4$)

Emissions peak in similar month to bottom-up: July and August for NO_x and August in NH_3

Observationally constrained OPE of **13 Tg O_3 per Tg NO**

Concluding Remarks

Top-down approach could be further refined with more complex inverse modelling methods or with iteration. Regardless, highlights the large disparities between top-down and bottom-up emissions.

Inventories collocate NH_3 and NO_x emissions (smouldering and flaming fires), but these are mostly separate in the top-down estimates

With current biomass burning inventory architecture, could use FINN approach for smouldering fire emissions of NH_3, VOCs, CO, organic aerosols and methane and GFAS or GFED approach for flaming fire emissions of NO_x, black carbon and CO_2

Choice of emission factors remains an issue

Need independent observations. Ideally in National Parks, to validate GEOS-Chem and satellite observations of fire pollution

These till be crucial to confidently use future geostationary 30-minute resolution Sentinel-4 observations of NH_3 and CO (both markers of smouldering fires)

Invited contribution in review in RSC's *Environmental Science: Atmospheres* journal