Bringing QFED into the VIIRS Era

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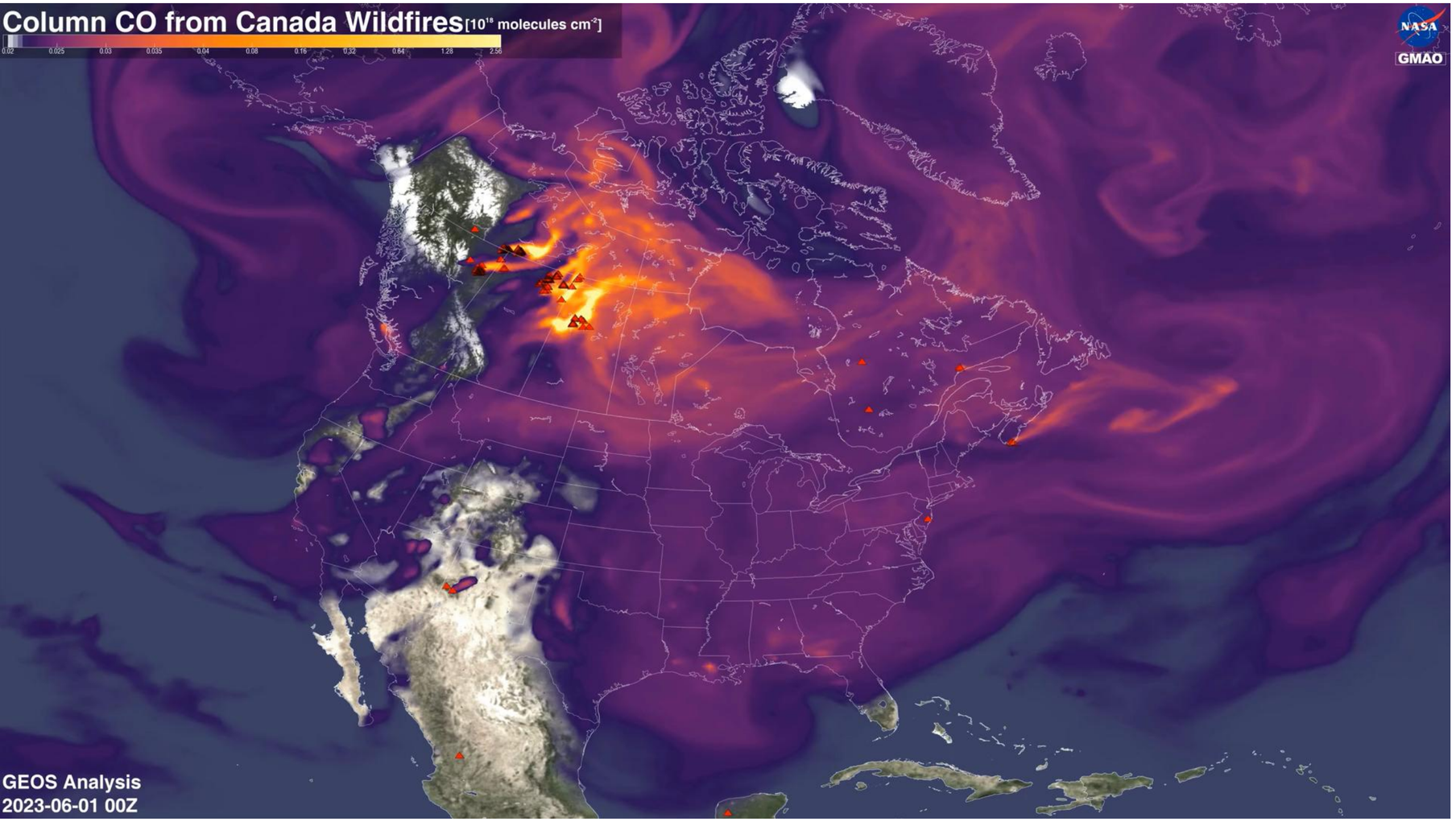
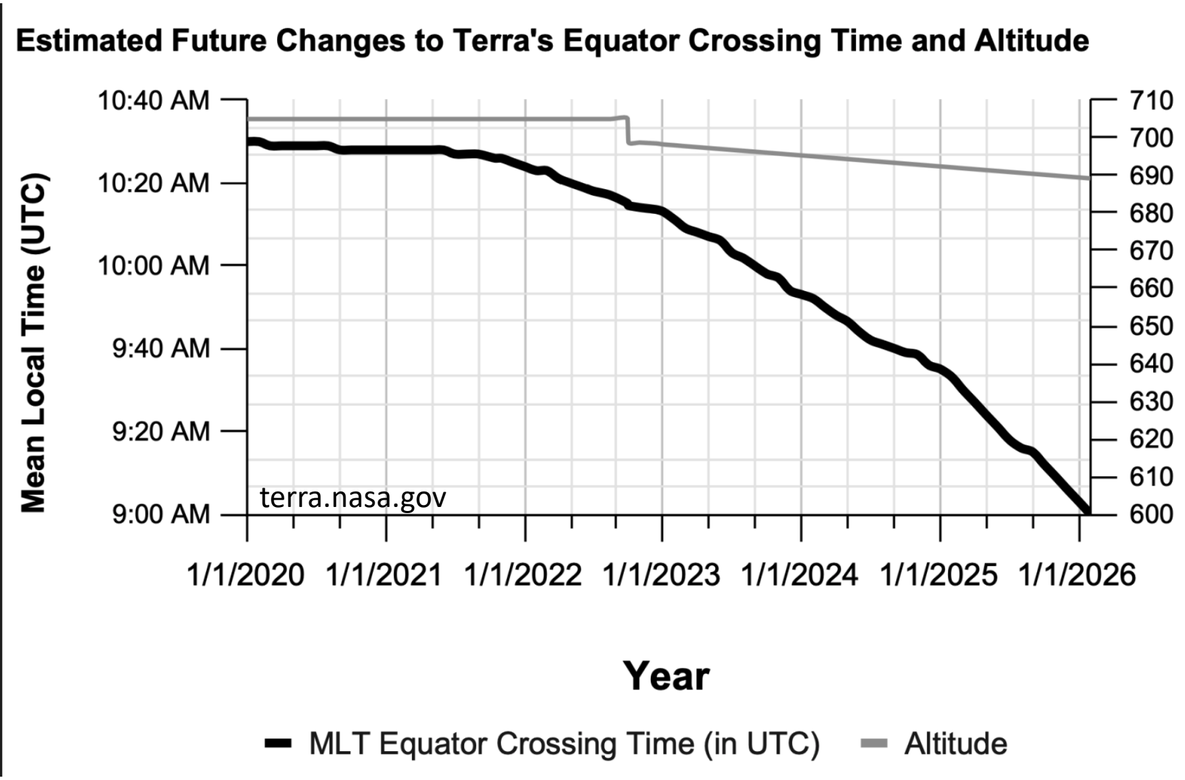
Quick Fire Emissions Dataset (QFED)



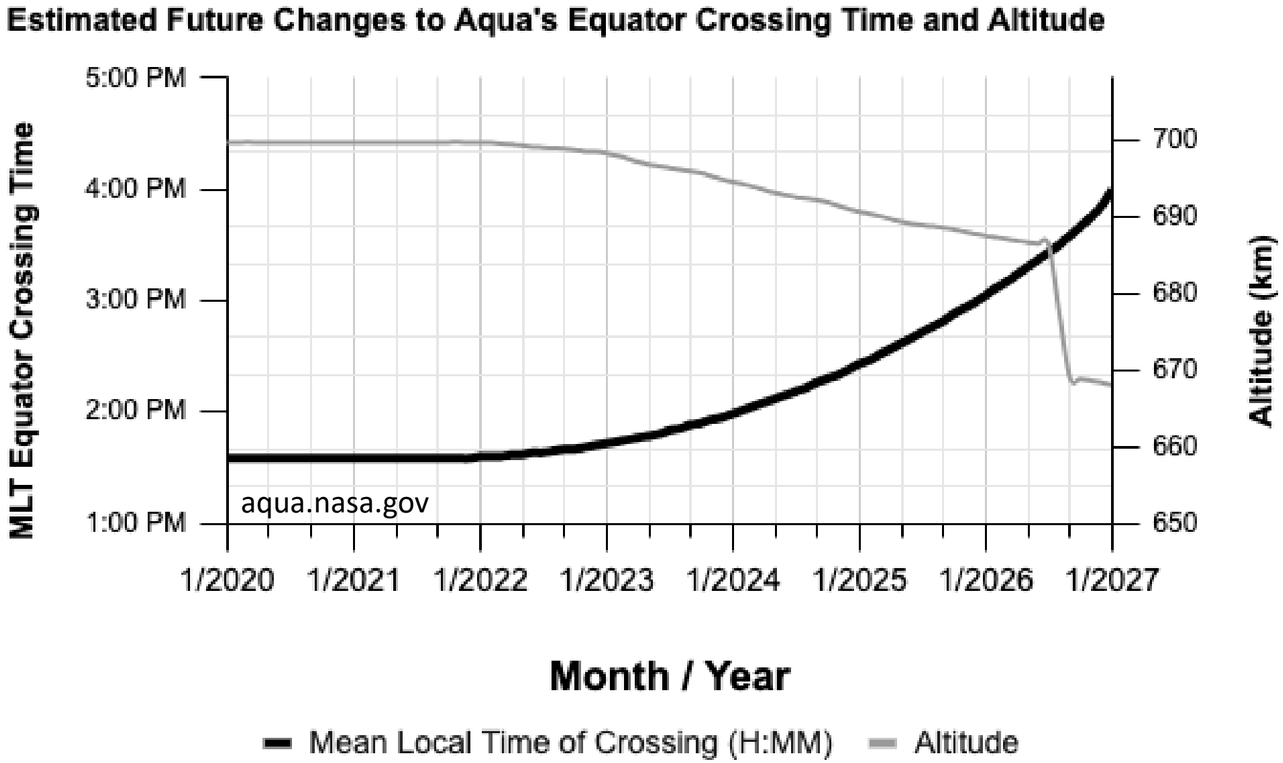
- GMAO product using a top-down approach to provide biomass burning emissions in GEOS systems
- Derived from satellite observed fire radiative power (FRP)
- **Global** aerosol and trace gas emissions with **biome and species level control,** tailored for use in GEOS
- Current operational version is v2.6r1
- QFED 3 is a refactoring of the code, allowing for the addition of new satellites and instruments
- The initial release is QFED v3.2, and is designed for **CONTINUITY**

Terra and Aqua Are Aging and Will Be Decommissioned Soon

- Terra's observation time is getting earlier

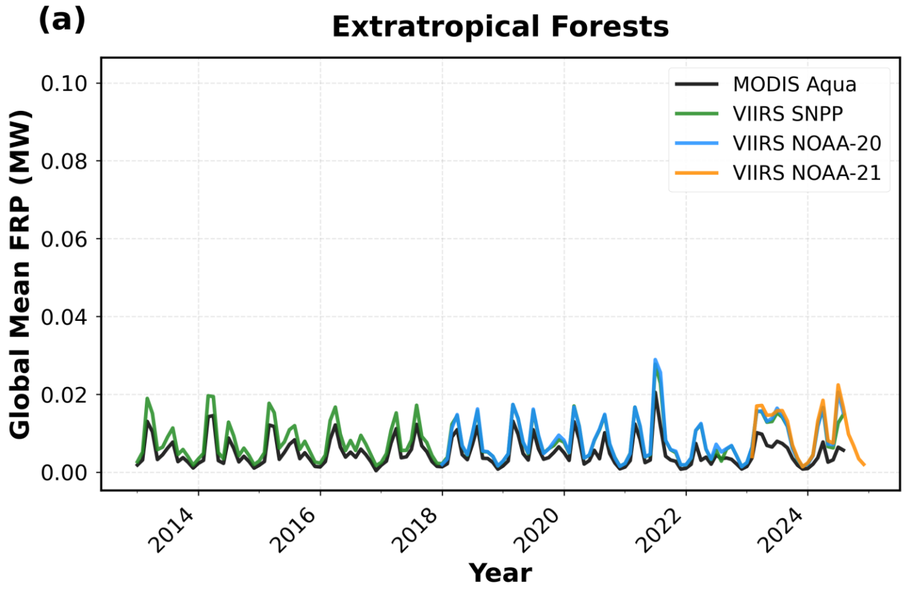


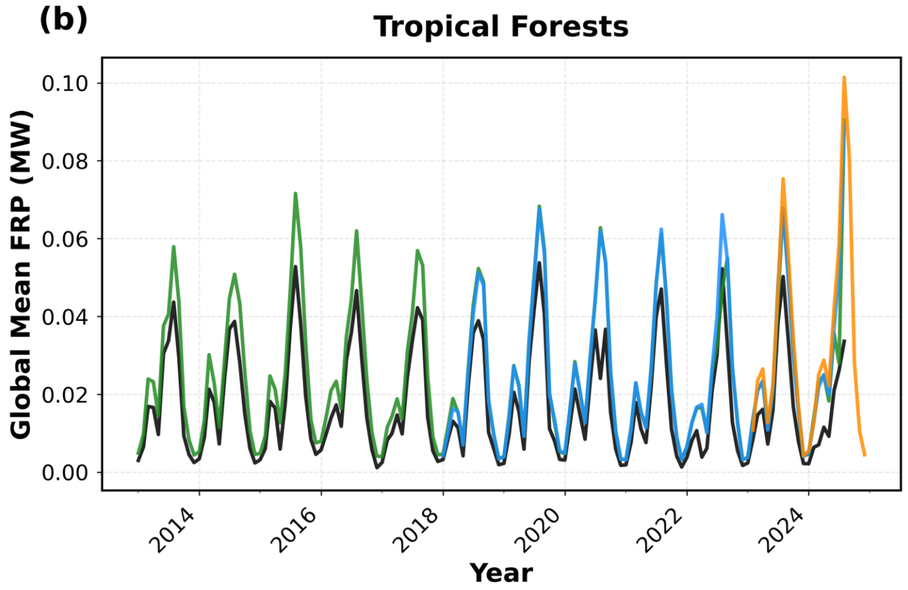
- Aqua's observation time is getting later

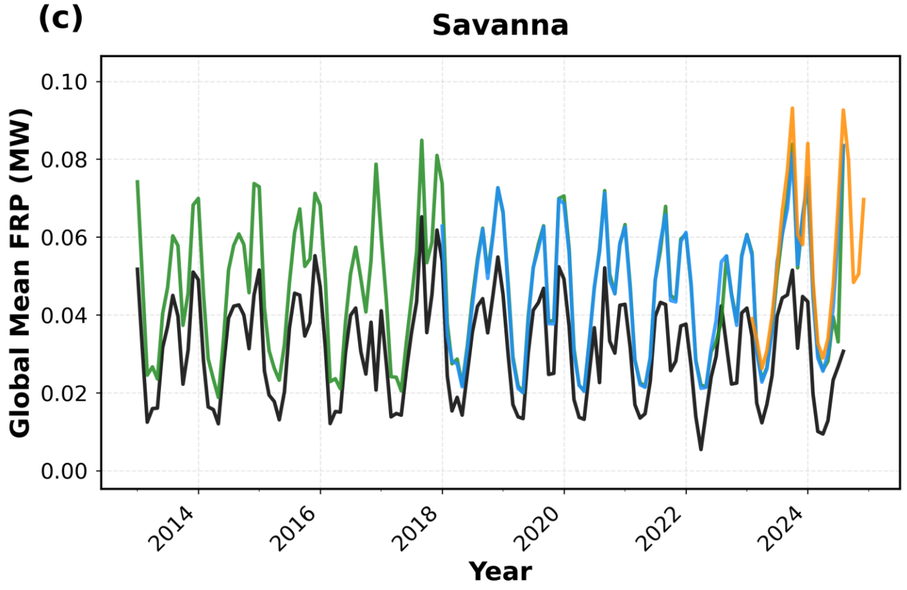


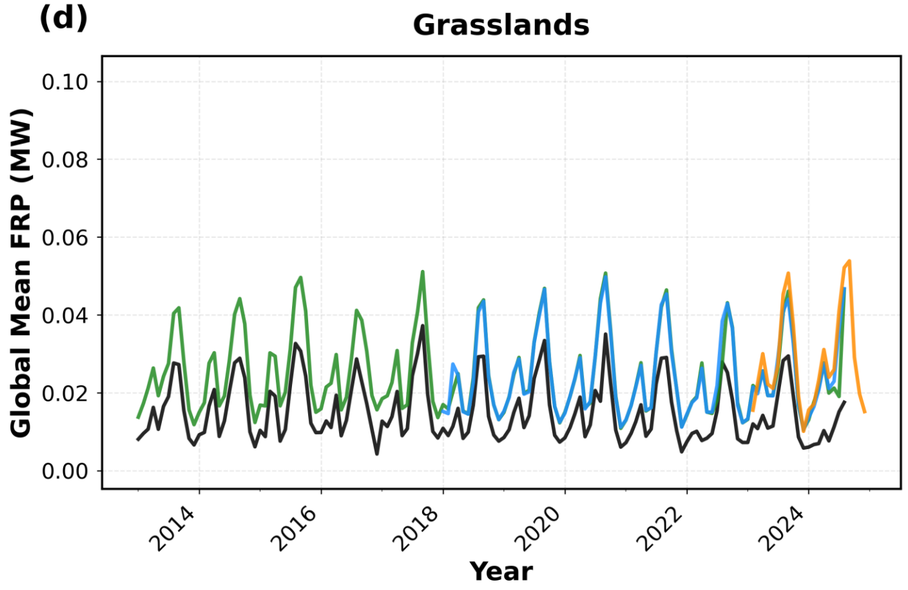
- These orbital changes impact fire detection!
- On average, wildfires peak in the afternoon -> Terra is increasingly underestimating fire activity

Global Mean FRP from VIIRS Compared to Aqua MODIS





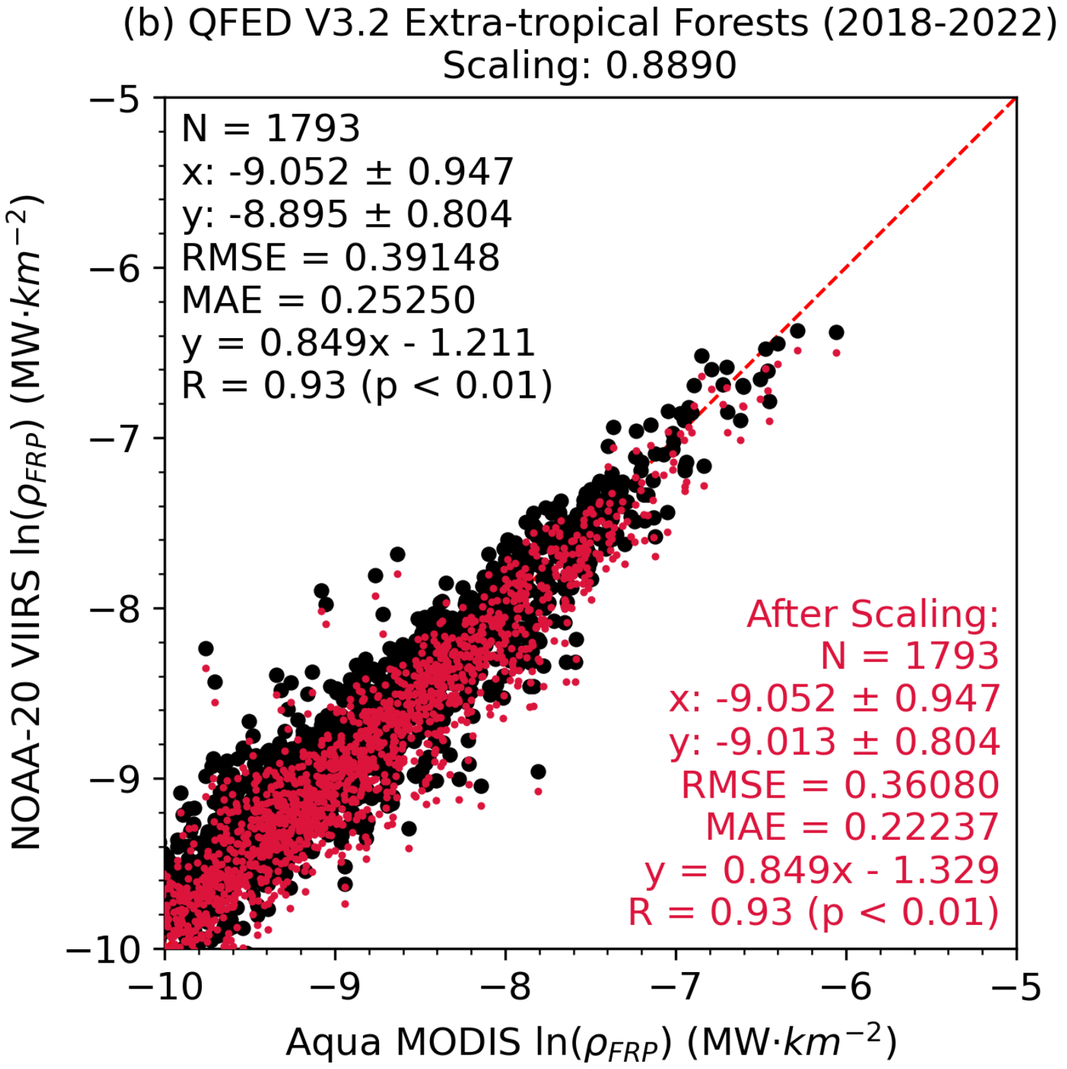




- First step for processing: FRP is gridded and assigned to one of four biomes (consistent with v2.6r1)
- Active Fires 6-Min L2 Swath 375m used for VIIRS (V*14IMG Products)

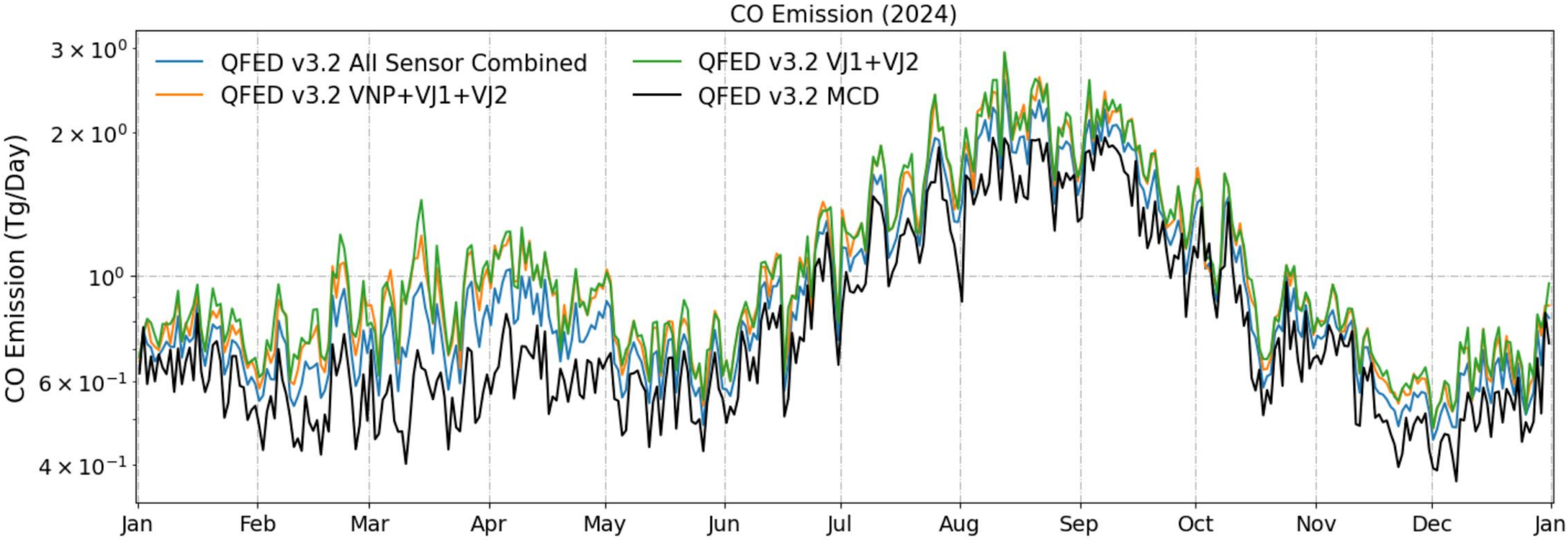
- More data becomes available as new satellites are launched
- FRP from Aqua MODIS is consistently lower than the satellites with VIIRS, but everything is well correlated
- Tropical forest and savannah are the heavy hitters

Establishing Continuity from MODIS to VIIRS FRP



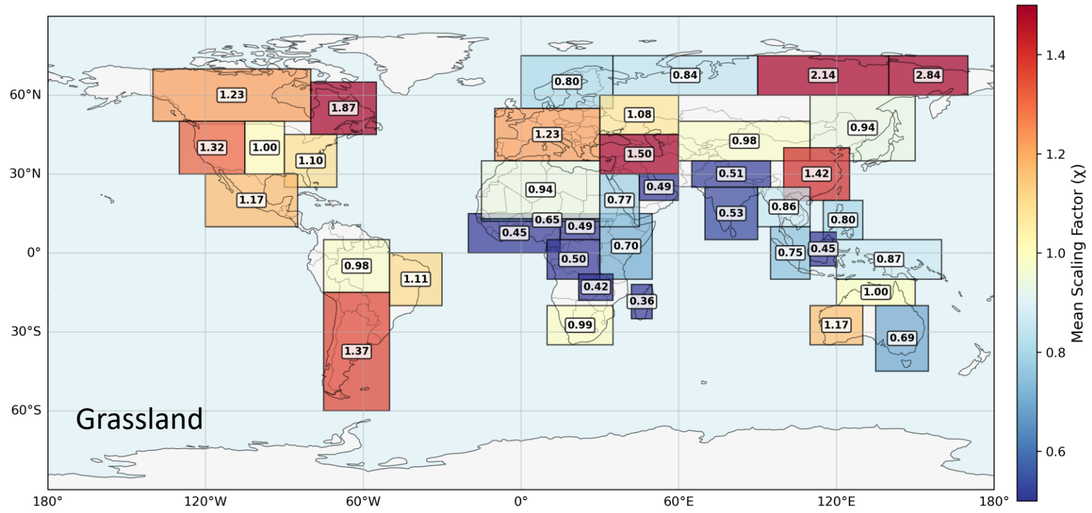
- Scaling factors were determined using a linear regression of global mean FRP density against Aqua MODIS
- Only showing extratropical forests for simplicity but this was done independently for each biome and satellite
- We assessed scaling factors for a 5-year chunk (shown here) but ultimately selected 2024 to take advantage of the launch of NOAA-21 and minimize a jump in the historical record due to Terra's and Aqua's drifting orbits (Terra drifting earlier since 2020, Aqua drifting later since 2022)

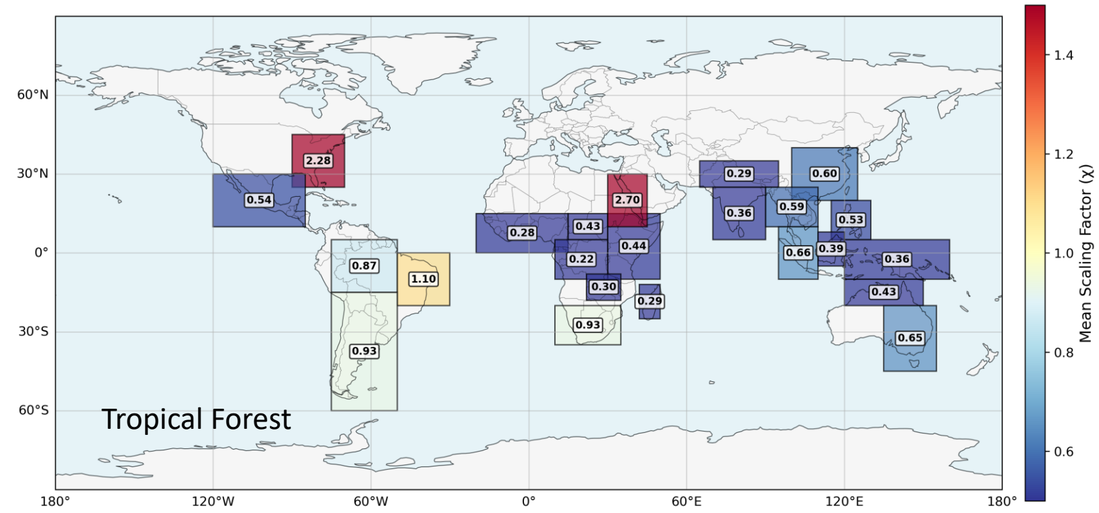
QFED Emissions for 2024

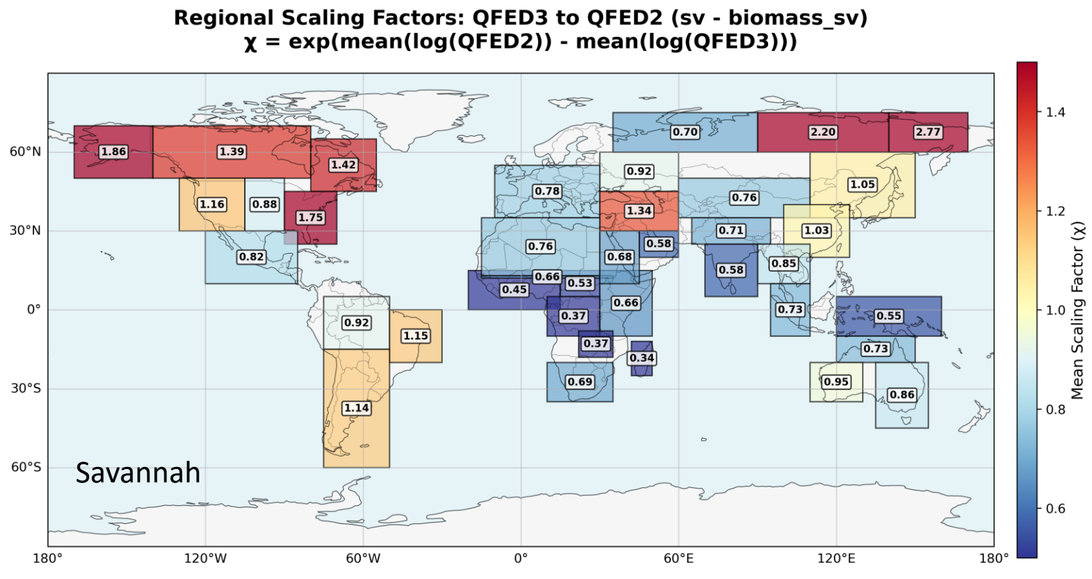


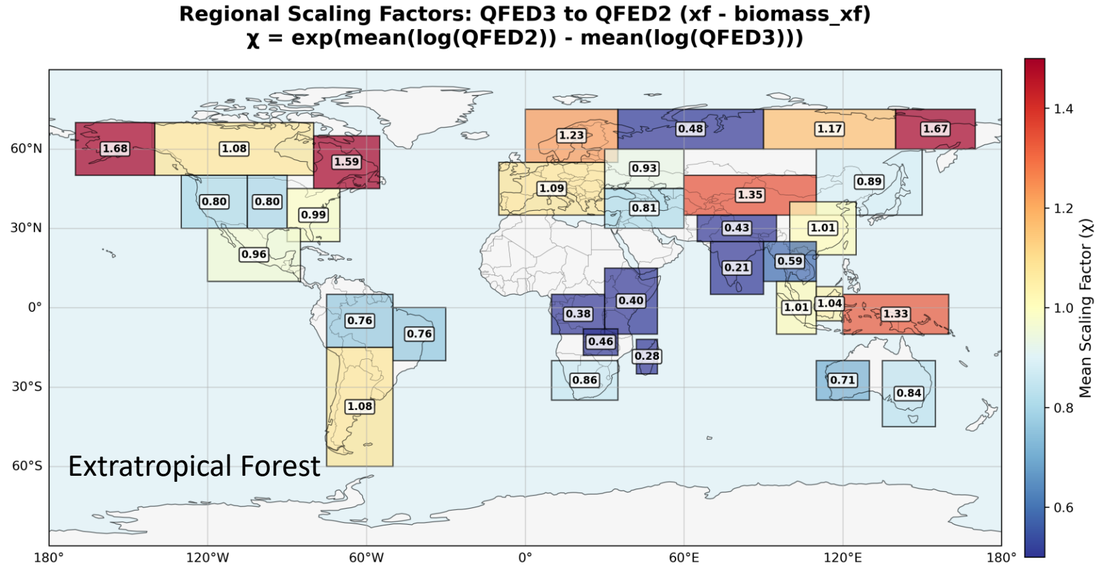
- Terra has been drifting earlier for the past ~5 years -> MODIS based emissions are lower than VIIRS based
- Emissions are relatively stable regardless of whether SNPP is included -> we will move forward without it

Regional Scaling Factors to Fine Tune Continuity with QFED 2.6r1



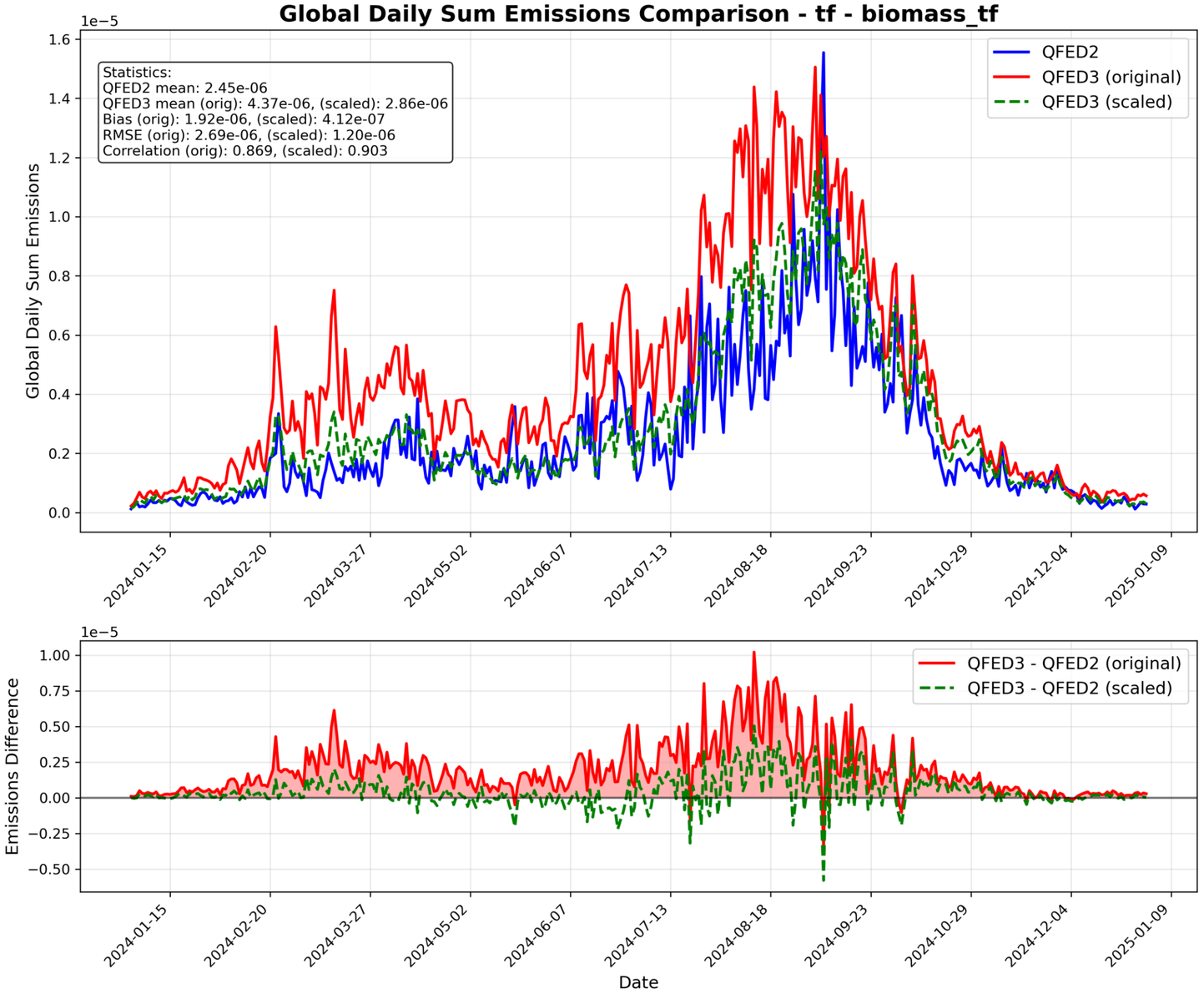






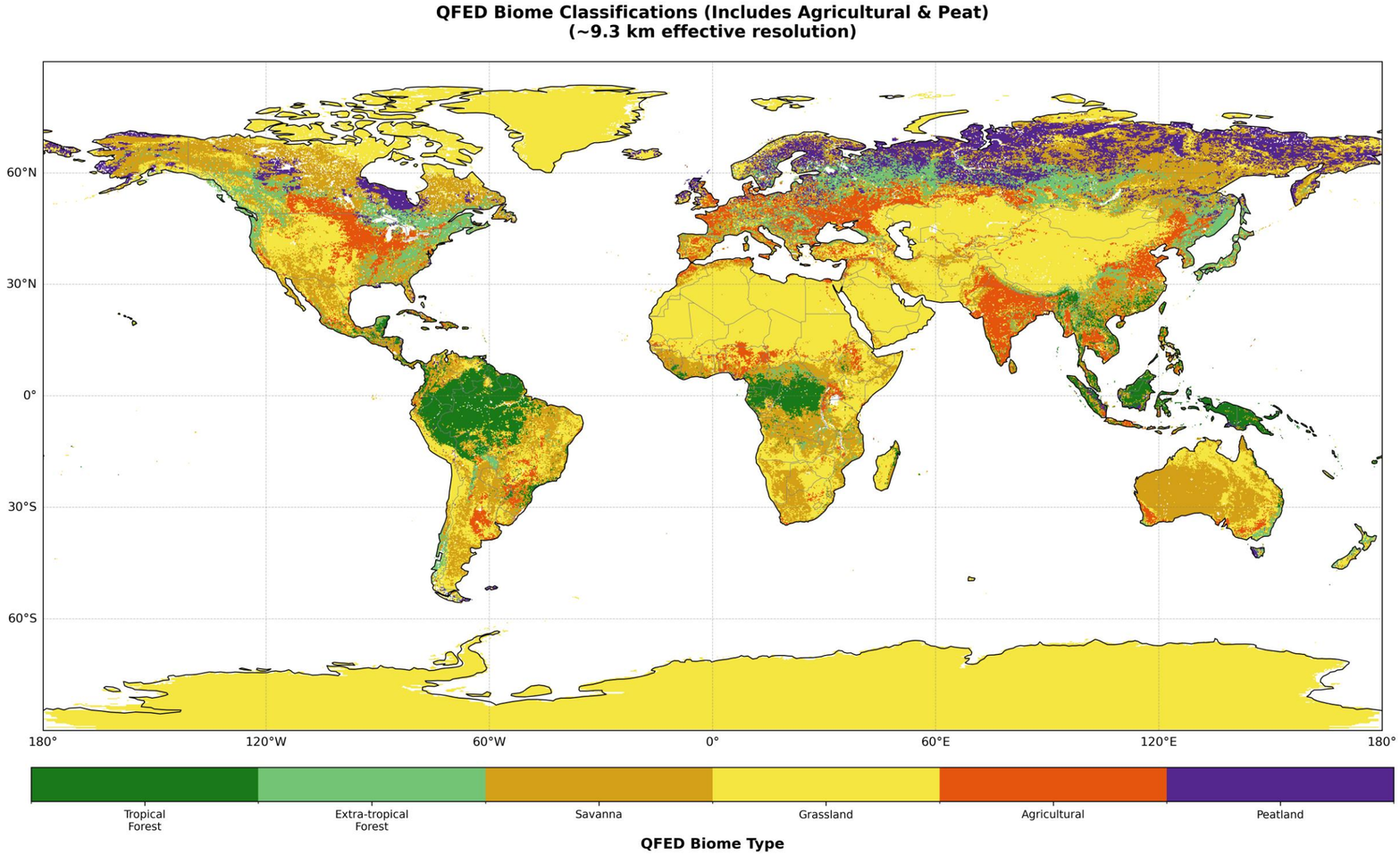
- A linear regression was used to generate biome and region dependent scaling factors for the year 2024 using OC
- 2024 was chosen so that a jump would not be present due to the Terra drift

Impact of Scaling on Global Organic Carbon Emissions: Tropical Forest

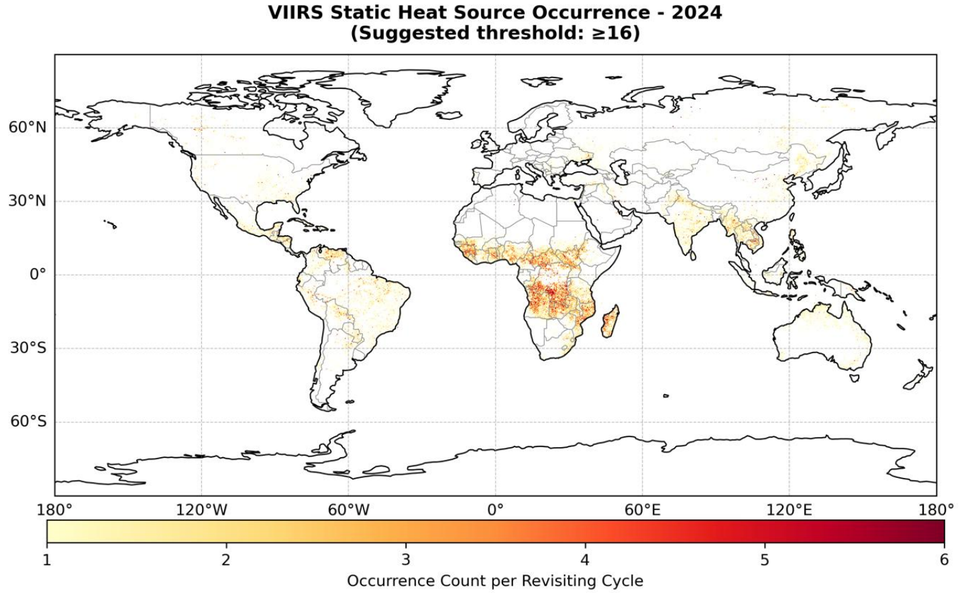


- Only showing tropical forest in the interest of time - biome with the largest impact from scaling
- We want the dashed green line to be closer the the blue in the top panel and hovering around zero in the bottom panel
- The positive bias is greatly reduced and the correlation is improved
- Scaling is applied to all species and works well for years other than 2024 (not shown by figure)

QFED 3.3 will be Anchored to NOAA-20 VIIRS instead of Aqua



- Land surface types have changed over the past decade!
- Regions that were once forest have been reclassified as croplands, savanna, etc.
- QFED previously used a constant surface type map, but this can be dynamic in time for the retrospective period and use the latest available for NRT versions of the emissions



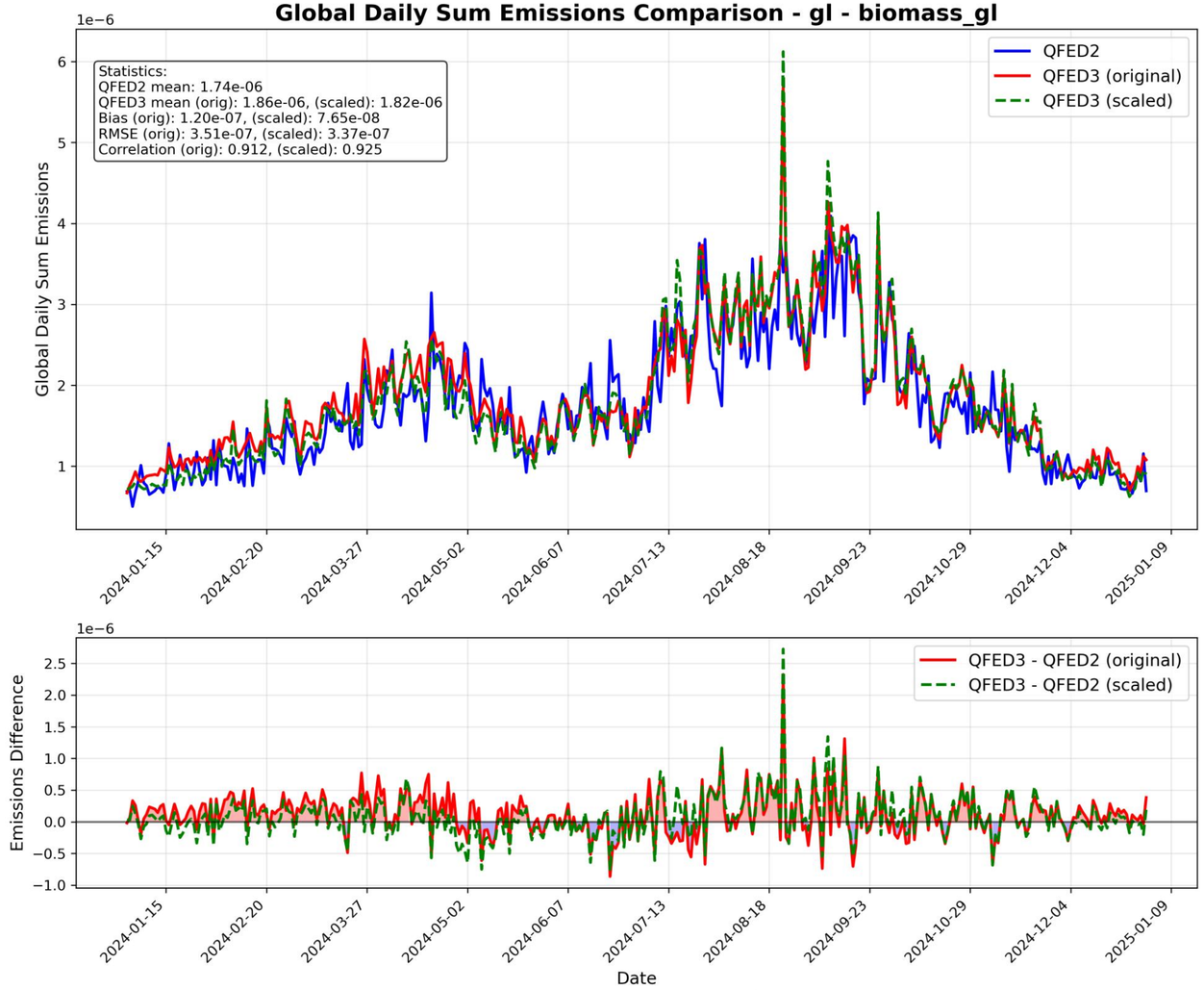
- VIIRS has a habit of misclassifying reflective surfaces like solar farms as “hot spots”
- These can be removed prior to emission calculation along with known volcanic eruptions and gas flaring
- Gas flaring is currently double counted in GEOS by anthropogenic emissions

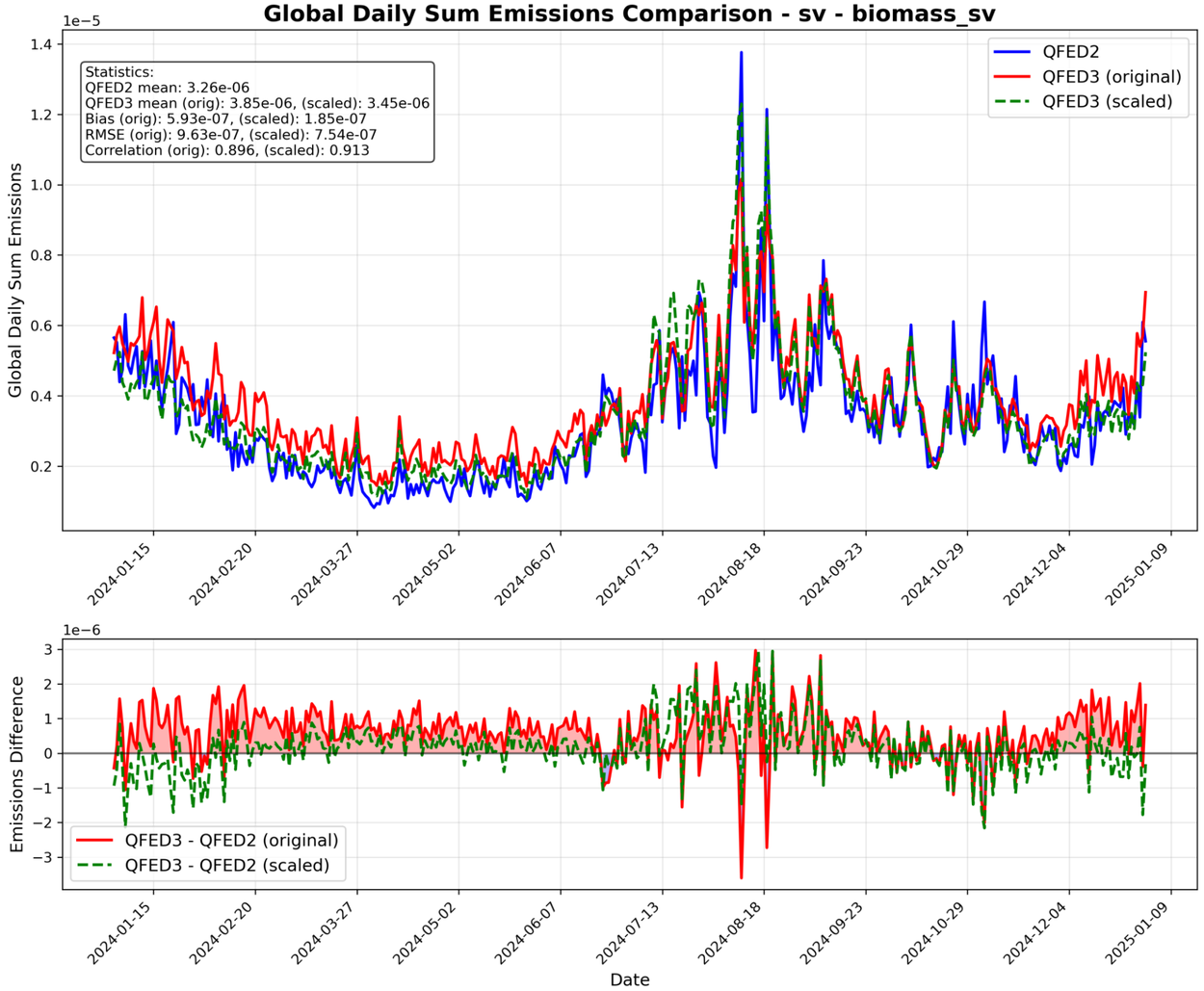
Take Home Messages

- Producing global biomass burning emissions in-house gives us biome and species level control for tailoring products specifically for use in GEOS
- A refactoring of the legacy QFED2 code was completed to enable the use of instruments other than MODIS
- The initial data release for QFED3 is intended to have minimal differences compared to QFED2.6r1 to support continuity in GMAO systems, however VIIRS can see smaller fires not observable by MODIS
- Version 3.2 is undergoing testing in GMAO's operational products and will be released through GES DISC

- Next, we plan to add more biomes, include annually varying land surface characterizations, and remove emissions associated with static heat sources, gas flaring, and volcanoes
- We are currently working on recomputing satellite and biome dependent emission coefficients based on data from VIIRS and GFED5

Impact of Scaling on Global Emissions: Grassland and Savannah

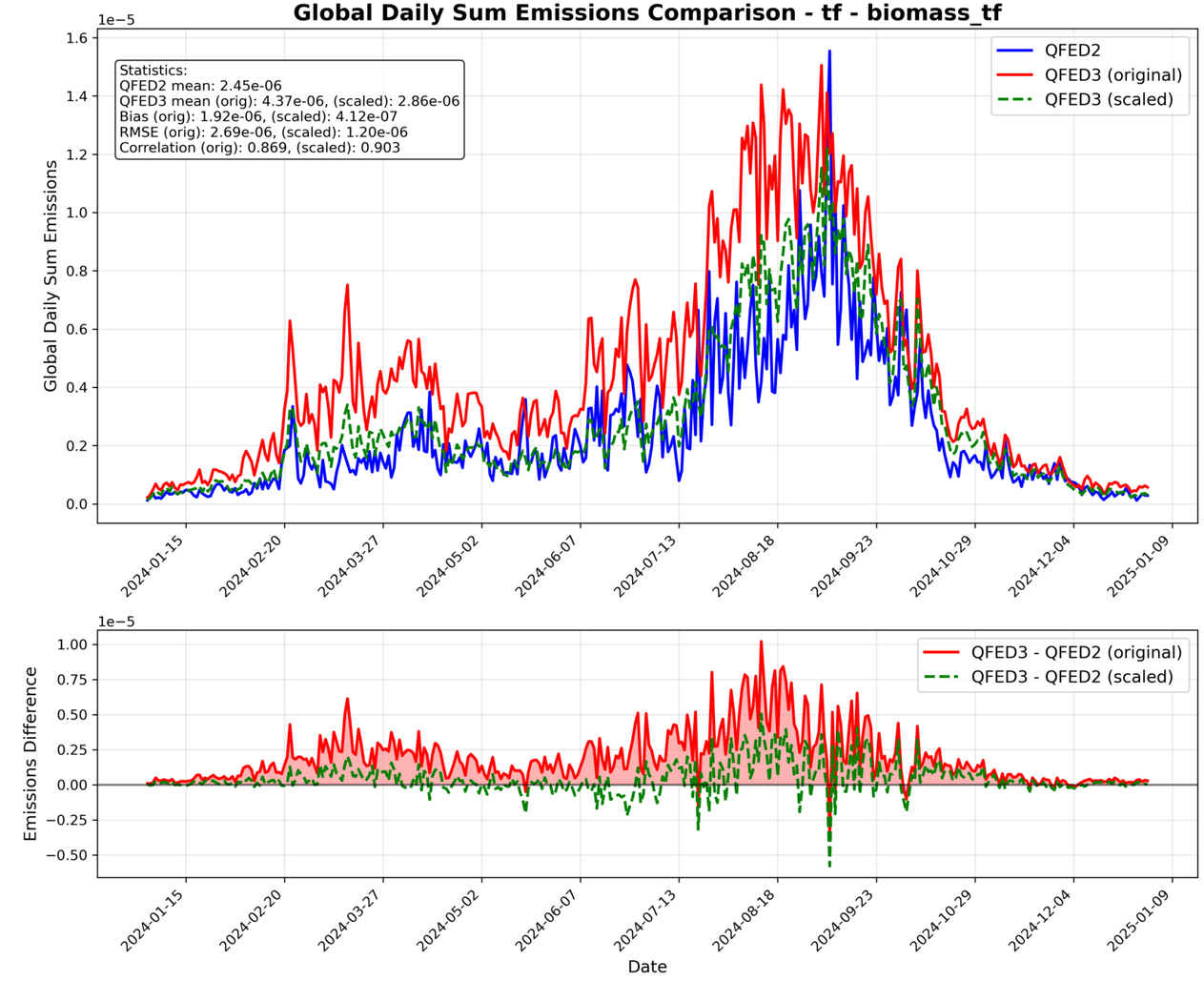


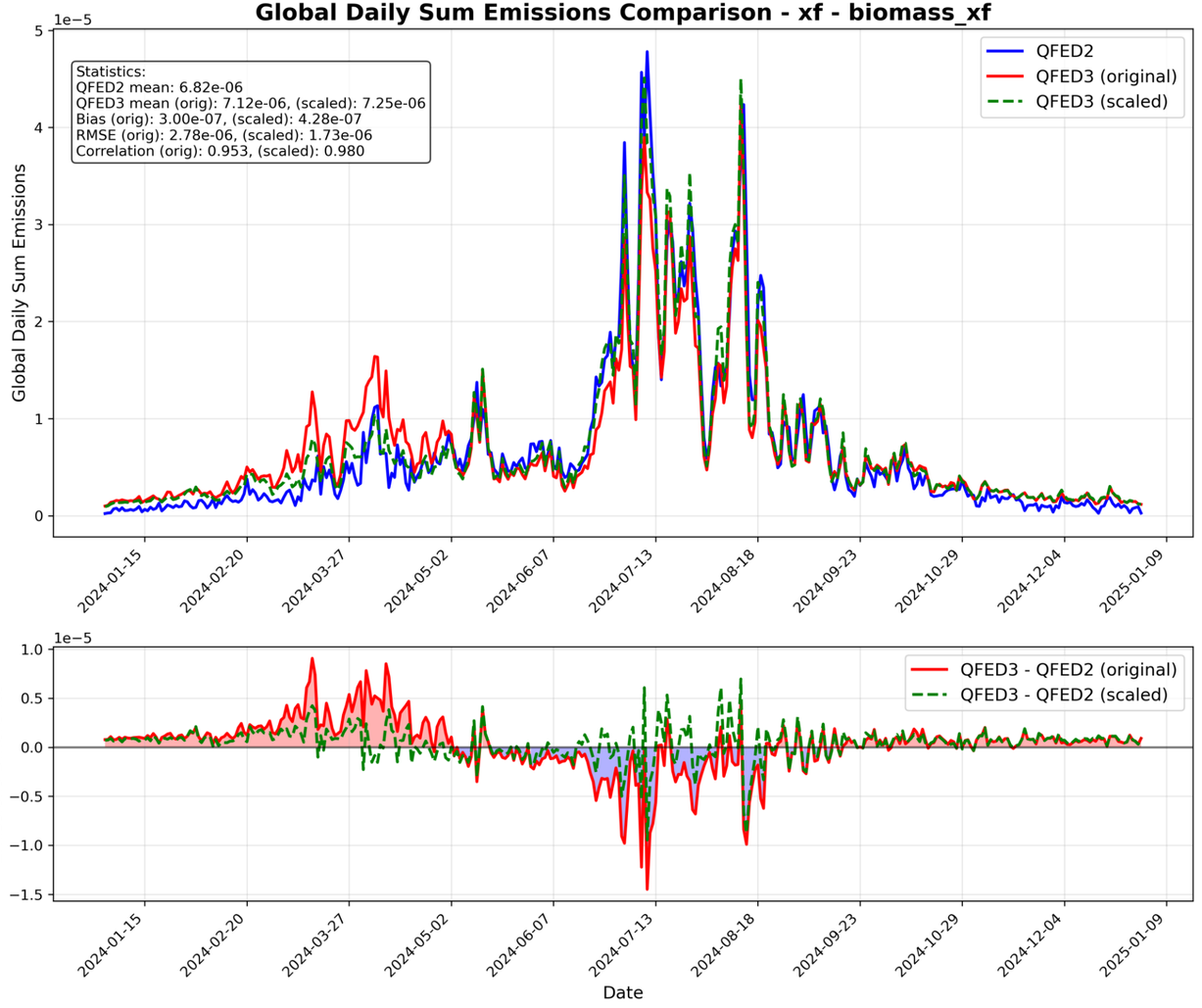


- Global grassland emissions are an order of magnitude smaller than the other biomes
- Scaling does not have a large impact on grassland emissions

- Scaling slightly reduces savannah emissions during the boreal winter months

Impact of Scaling on Global Emissions: Tropical and Extratropical Forest



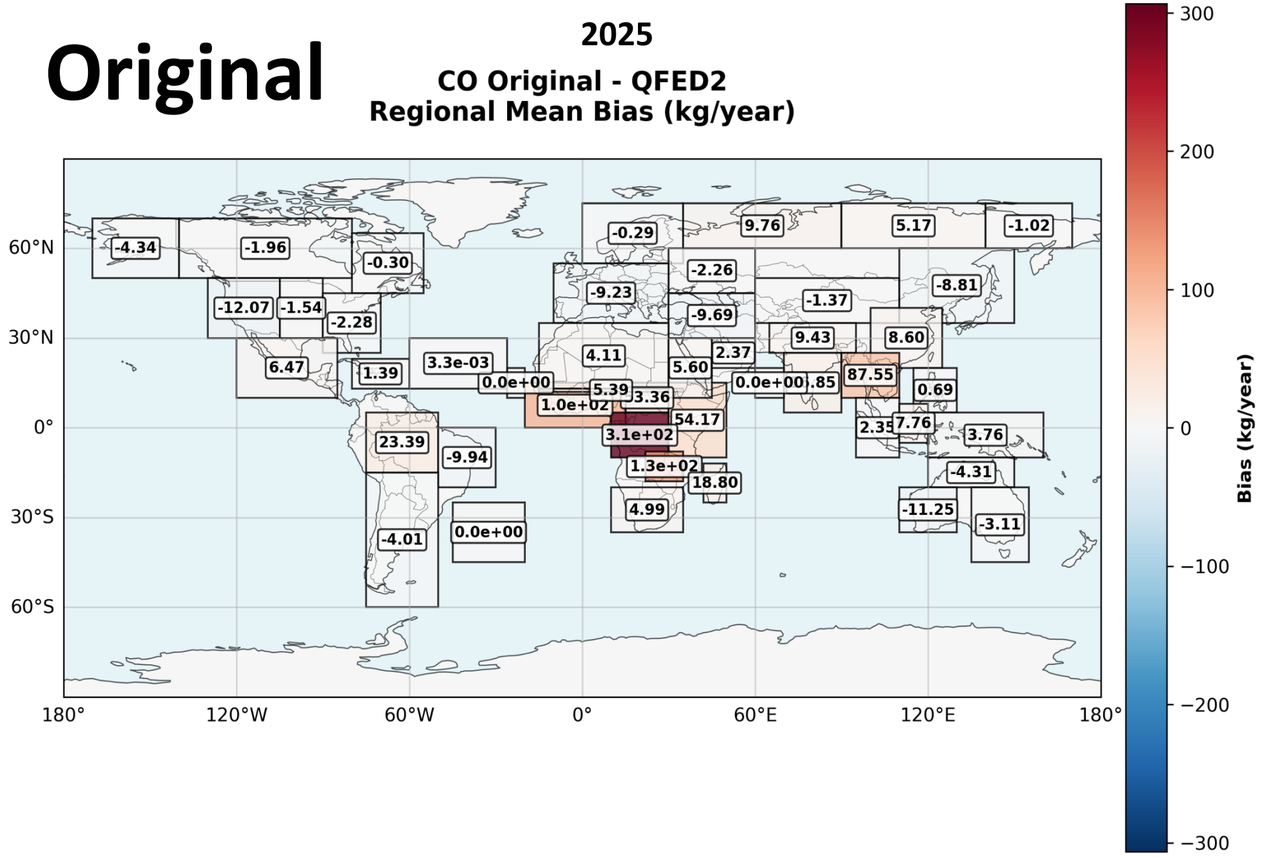


- Scaling has the largest impact on tropical forest emissions
- The positive bias is greatly reduced and the correlation is improved

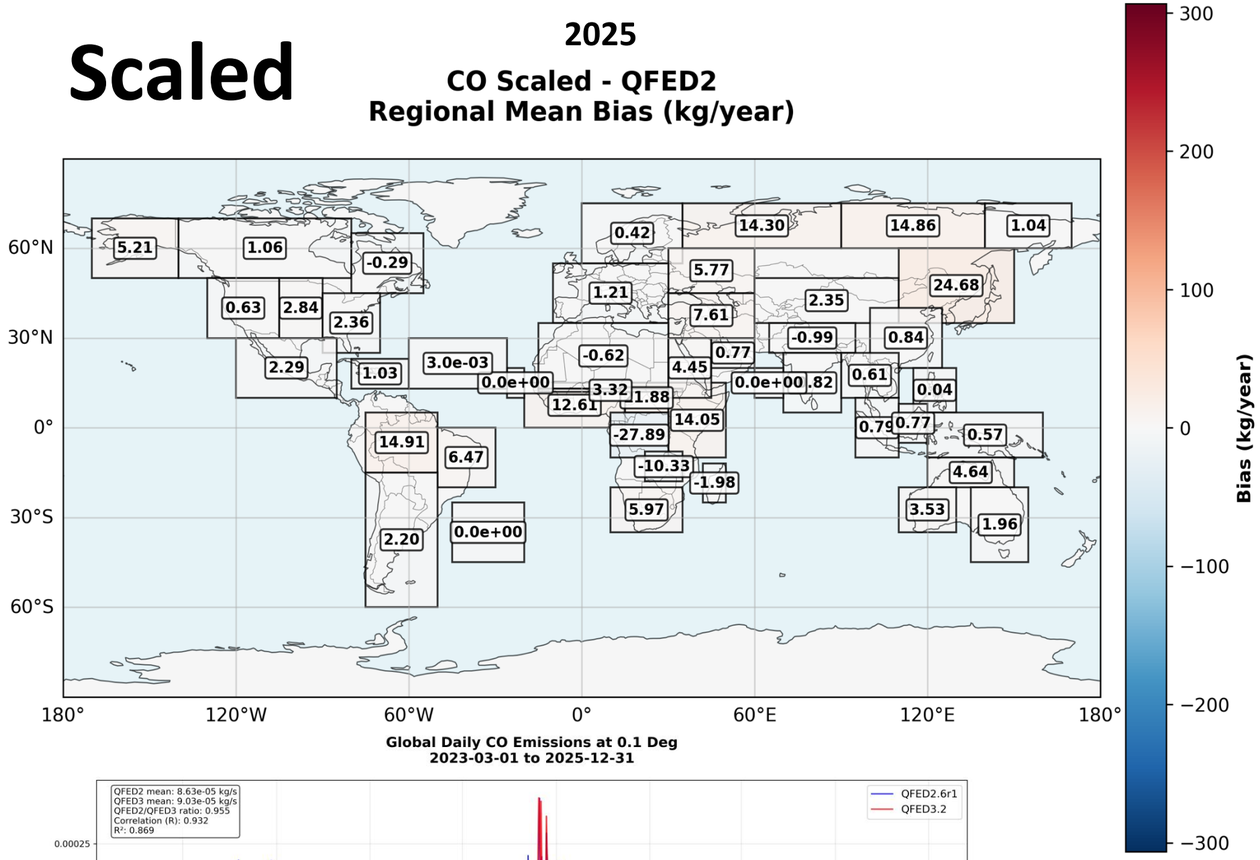
- Indochina was impacted by extratropical emissions, particularly during March and April
- The boreal summertime negative bias is corrected through scaling

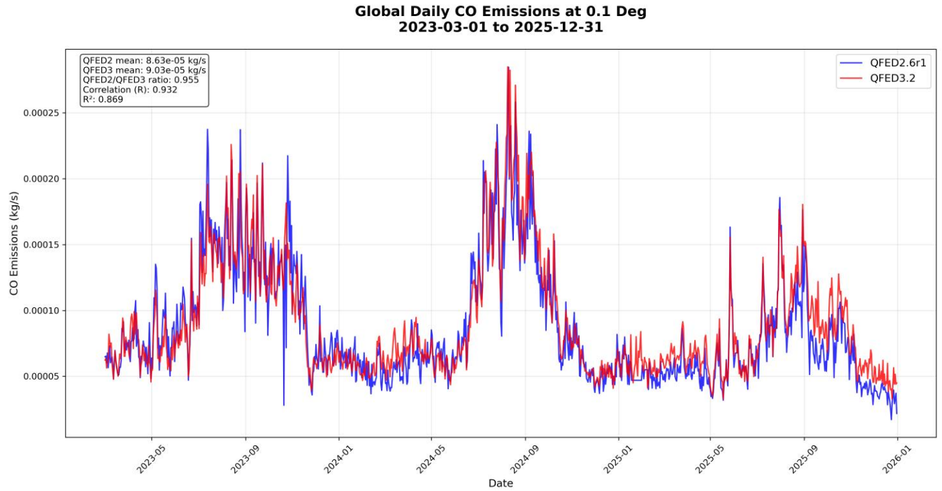
Does Scaling with 2024 Work For Other Years?

Original



Scaled



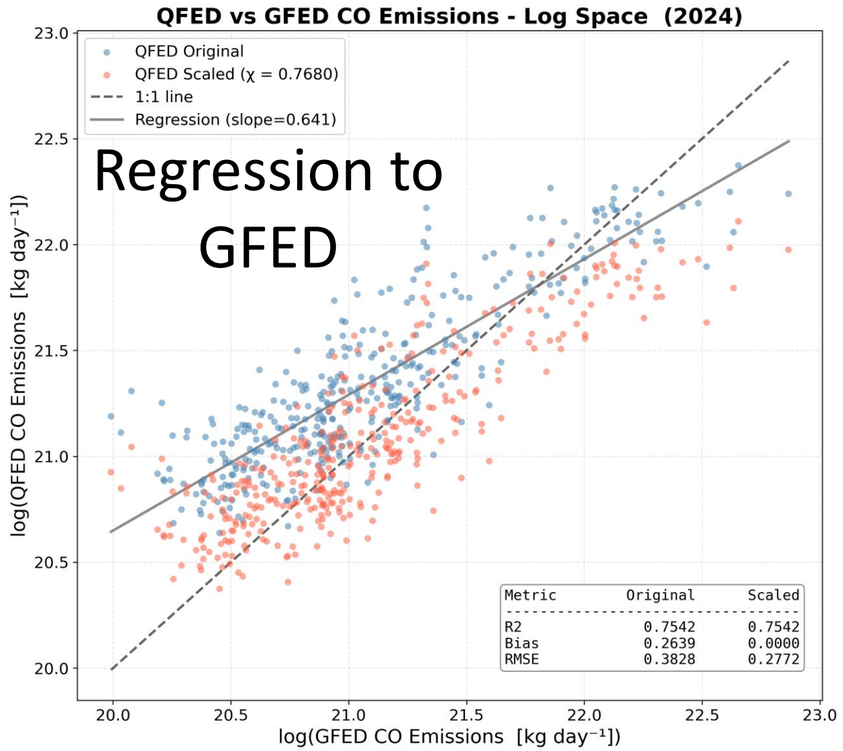


- Yes! These maps are for 2025
- Despite interannual variability in wildfires, the problem areas of central Africa and Indochina are characteristic of the MODIS to VIIRS switch

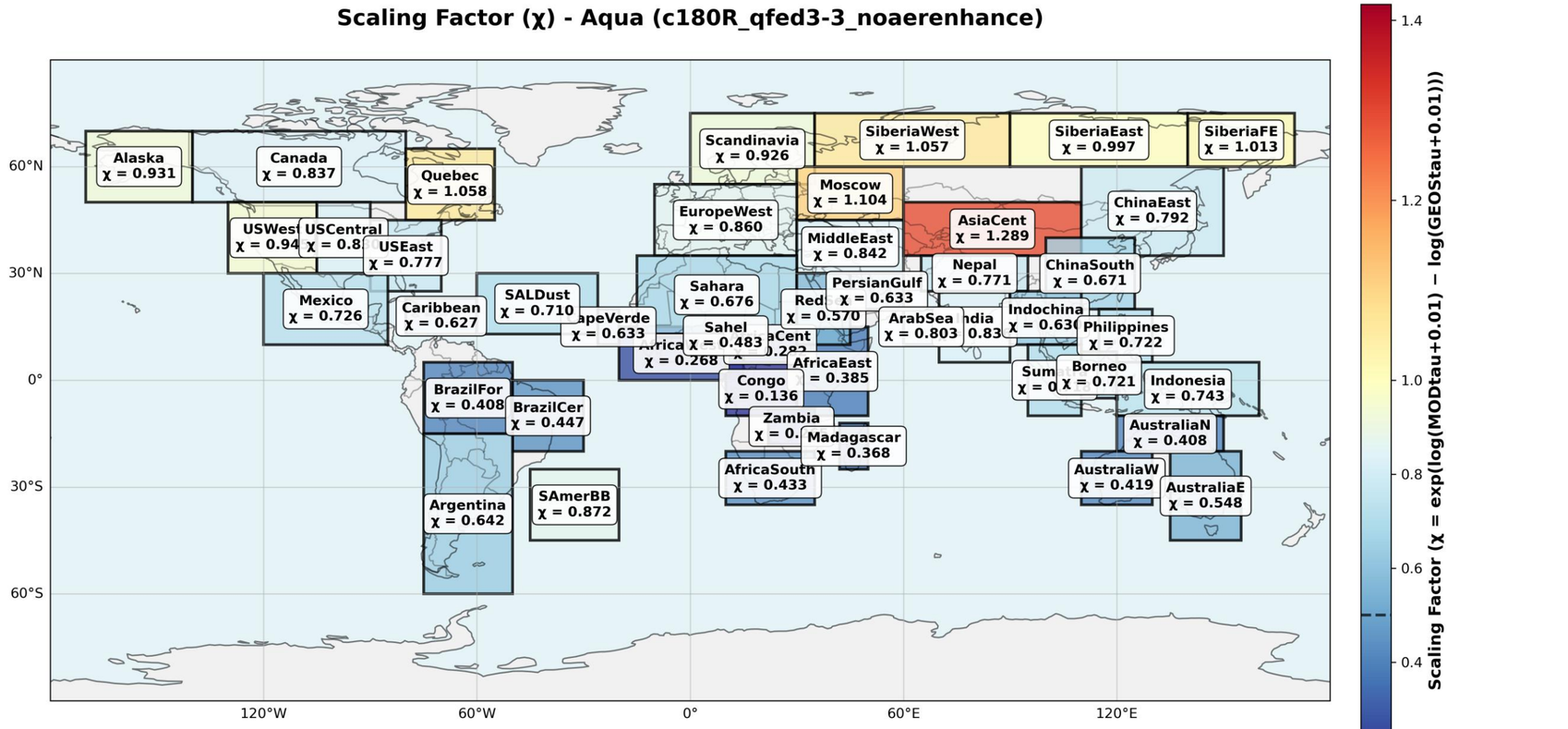
QFED 3.3 Improved Emissions Estimates Currently in Progress

1) Update α_m using the more recent GFED5 dataset
2) Use NOAA-20 as the anchor instead of Aqua
3) Regenerate aerosol enhancement factors

Preliminary Look at Deriving Aerosol Enhancement Factors



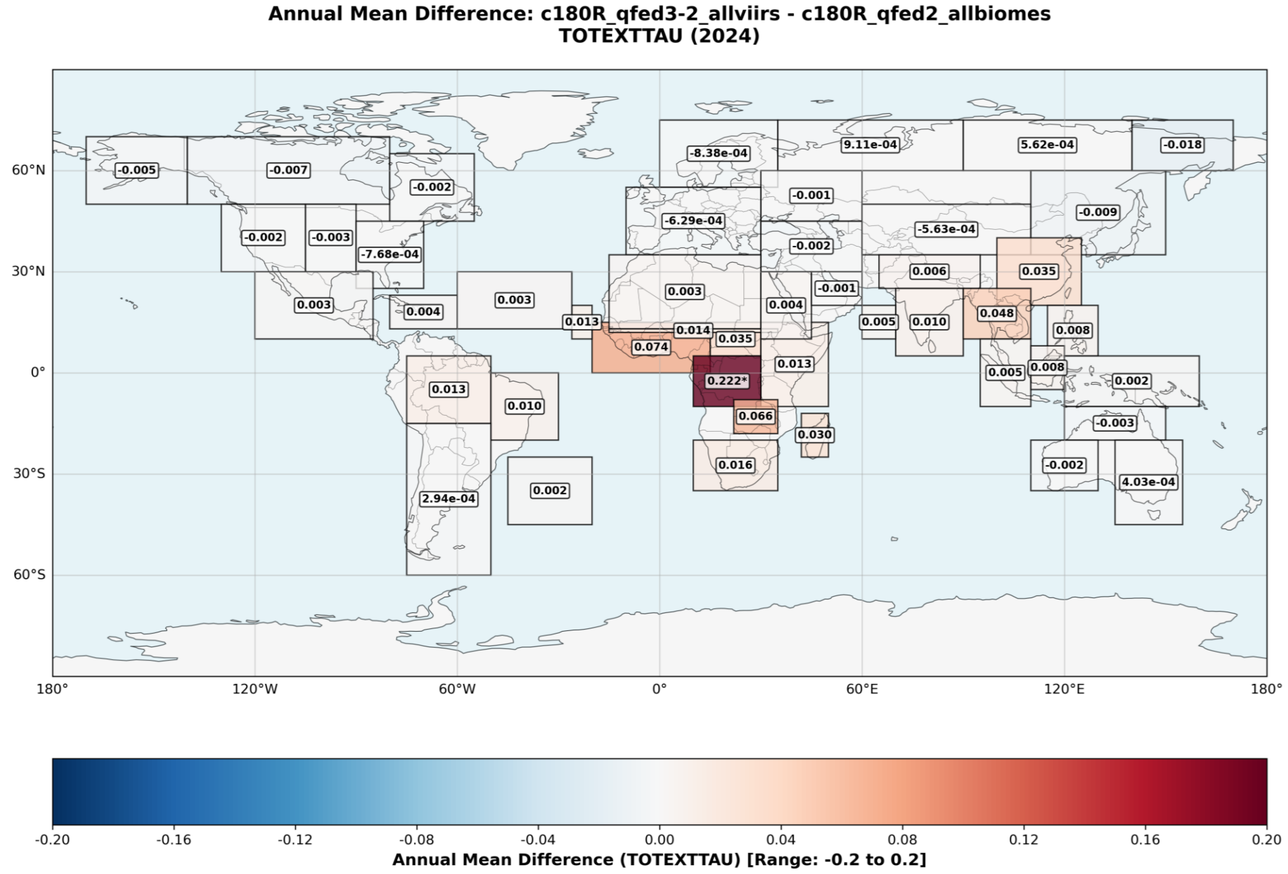
- Lower daily mean emissions (winter) tend to be overestimated by QFED using NOAA-20
- Scaling by 0.768 reduces this bias



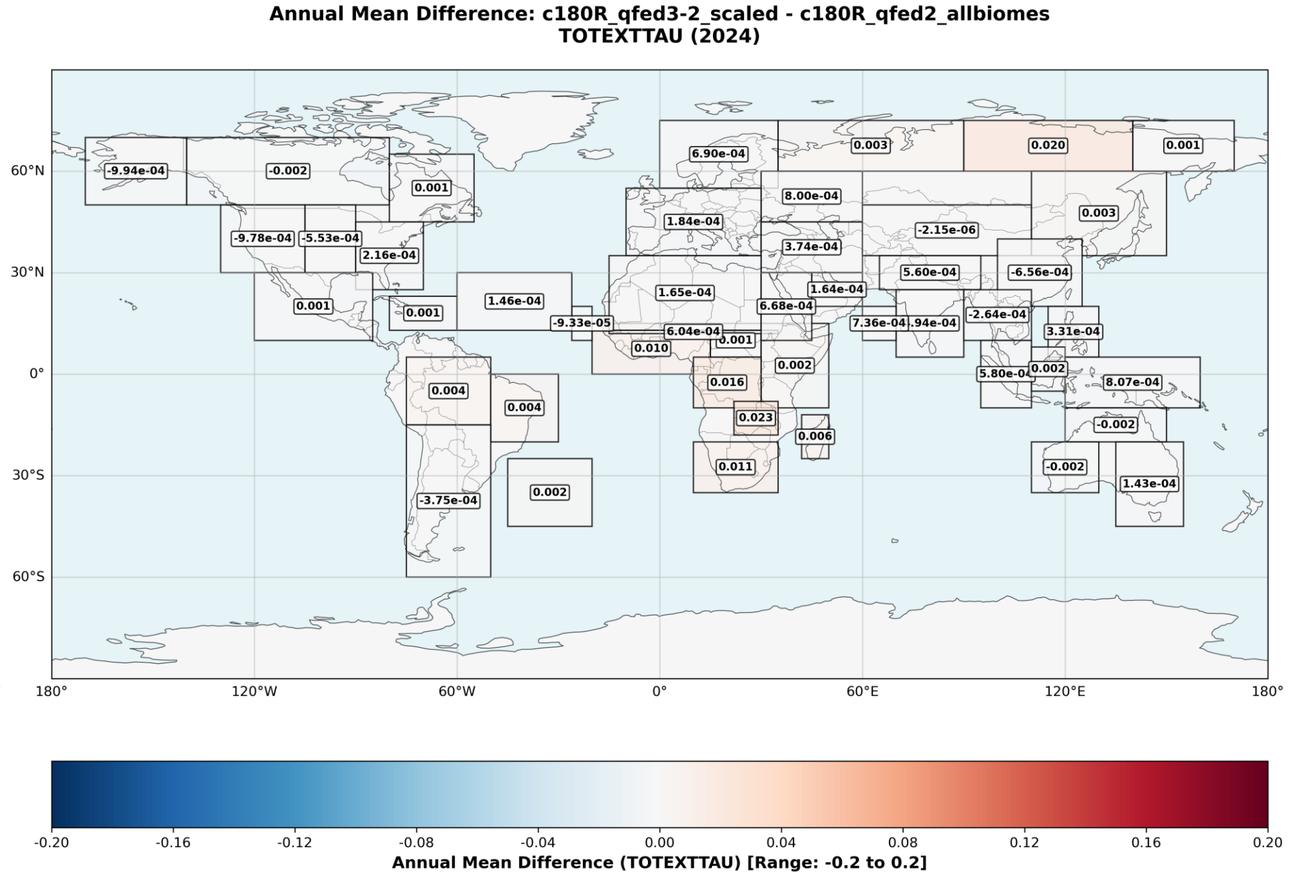
- C180 replay with raw emissions and no scaling by 0.778 in ExtData
- Emissions will need to be reduced rather than enhanced

Impact of Scaled Emissions on Modelled AOD

Original



Scaled



- Three replays with the only difference being biomass burning emissions: 1) QFED2, 2) original QFED3, 3) scaled QFED3
- Positive bias in QFED3 is greatly reduced over central Africa and Indochina
- The seasonal cycle was also investigated on a region-by-region basis, and is much improved with the scaling