Supporting Information for

The Fire Inventory from NCAR version 2.5: an updated global fire emissions model for climate and chemistry applications

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Introduction

This supporting information provides additional details about the specific incremental updates to the Fire Inventory from NCAR (FINN) model that led to the version presented in the manuscript. Additional information describing the code is provided. Figures showing more detailed comparisons of FINNv2.5 with previous versions of FINN and other inventories are provided.

Text S1. Description of incremental updates to FINN2

Here we summarize the advances in the timeline of producing the updated FINN wildfire emission inventory, moving from the FINN1 framework to the FINN2 framework. Although we recommend using FINNv2.5 in all future studies, during the update process FINN emissions were being used in several studies, so we record the main updates for various versions here. Large advances in code and processing are denoted by a change in the first version number; smaller changes and bug fixes are denoted by decimal numbers. FINN2.2 was the first updated inventory released for use and included VIIRS detections as well as the new aggregated polygon method of fire area calculation. FINN2.3 was updated for a bug fix to ensure consistent 2-day tropical region persistence of fires when satellite overpasses miss detections. For FINN2.4, we re-wrote the IDL

code that creates chemical species for model input and we corrected vegetation types in the NMOG speciation tables used for the MOZART chemical mechanism (specifically Temperate and Boreal were swapped). When assessing FINN2.4 in grass/savanna regions, we found a large overestimation and identified that fire behavior in this vegetation type did not require burned area polygons to be connected as rigorously as for other vegetation types. Consequently, in FINNv2.5 we altered the processing in grass/savanna to aggregate burned area polygons into larger areas in a more conservative way, because we do not expect to miss detections of small understory fires as much as in say forest vegetation types. Our threshold for changing this polygon processing is: more than 50% tree type will use the original large polygon method and less than 50% tree cover will use aggregation only if the instrument footprint polygons touch (see section 2.1). Figure S1 shows the comparison of emissions for all the updates in FINN2.X compared to FINN1.5, and Figure S2 shows the comparison of CO emissions for the different global regions. We also show MODIS-only fires versus MODIS and VIIRS files for some versions to highlight the impact of including more fire detections from VIIRS (discussed in the main manuscript, section 4.1).

Versions that use both MODIS and VIIRS detections are default. Versions that use MODIS-only detections have an 'm' suffix or (MODIS), e.g. FINNv2.5m or FINNv2.5(MODIS). To cite the use of FINN emissions, use the appropriate version number and the appropriate annotation to identify if the version driven by MODIS only or MODIS and VIIRS detections.

Text S2. Detailed code description
There are three components to the FINNv2 model: A preprocessor, the emissions code, and the speciation code. Here, each component is described.

S2.1 Preprocessor
Previously done with proprietary GIS software, the preprocessor code was converted to Python and is available for download. In this code, the active fire data, the VCF data, and the LCT data are obtained and processed for a selected region. The preprocessor then follows the steps outlined in Sections 2.1-2.3 above to create a text file. The preprocessor code can be accessed via GitHub at: https://github.com/NCAR/finn-preprocessor. README.md describes the process by which a user can run the code. The output from the preprocessor is a comma-delimited text file that is to be used as input to the emissions code. This file contains the following fields: a polygon identifier, a fire identifier, the associated latitude and longitude of each polygon, date, polygon (fire point) area, land cover type, fraction of land cover type, fraction of VCF tree cover, fraction of VCF herbaceous cover, fraction of VCF bare cover, and global region. This file is used as an input to the emissions model (Section 2.4).

S2.2 Emissions Code
The emissions code takes the file created by the pre-processor and develops emission estimates of CO2, CO, NMOG, NOx(as NO), NO, NO2, SO2, PM2.5, PM10, OC, BC, NH3. The code here follows the basic outline described in equation 1. The code

reads in four files: The preprocessor-created input file, the fuel loading file that defines the fuel loadings of generic vegetation codes based on global location (Tables 2 and 3), and an emissions factors file that assigns emission factors based on generic vegetation code (Table 4). The code first ensures that the vegetation cover fraction for each polygon totals 1.0. The code addresses any polygons with 100% bare cover, and reassigns the herbaceous/tree cover based on the land cover type if the land cover is assigned as urban (as described by Wiedinmyer et al. 2011). The land cover type is then mapped to the generic vegetation assignment (based on Table 1). Fuel loading is assigned based on vegetation type and global region. The fraction burned for each polygon is assigned based on land cover type and vegetation coverage following Wiedinmyer et al. 2011. Finally, the emissions are calculated for all species in the emissions factor table. The output from this file is a comma-delimited text file with the following fields: Longitude, Latitude, polygon id, fire id, day of the year, land cover type, generic vegetation code, percent tree cover, percent herbaceous cover, percent bare cover, burned area, biomass burned per area burned, CO_2, CO, NOx, NO, NO_2, NH_3, SO_2, NMOG, PM2.5, PM10, OC, BC.

S2.3 Speciation Code
The code to speciate the NMOG to a specific chemical mechanism reads in the emissions file created output from the process described in Section S2.2 and a table with conversion factors (e.g., Table 5). The code calculates the moles of individual emission species. The output can be either a comma-delimited text file with the daily emissions, or a gridded NetCDF file with daily emissions estimates.
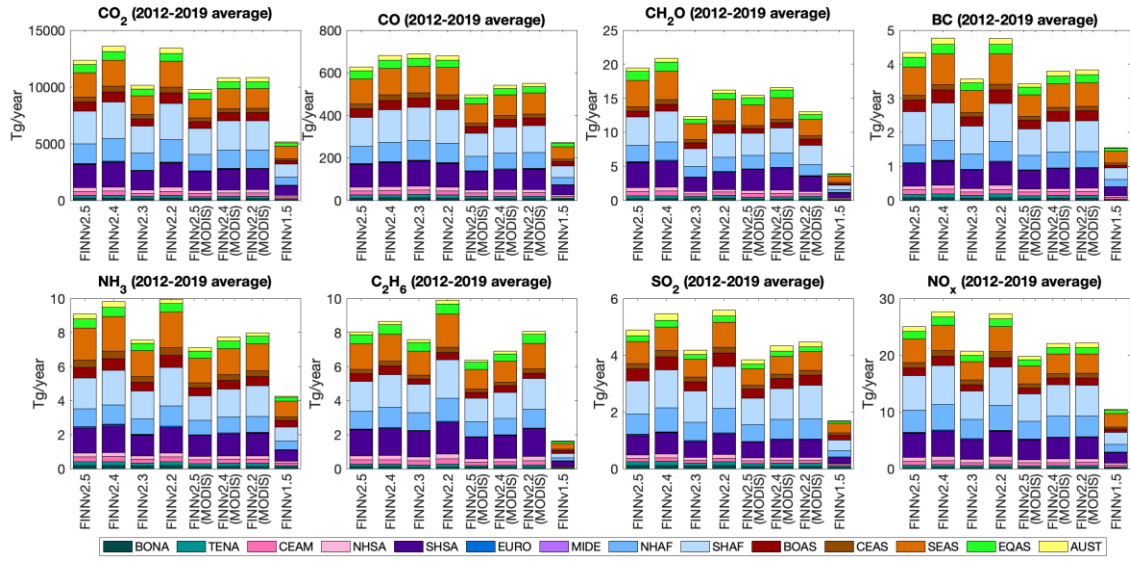
Figure S1. Annual total emissions (averaged for 2012-2019) of CO2, CO, CH2O, black carbon (BC), NH3, C2H6, SO2, and NOX from the Fire Inventory from NCAR version 2.5 (FINNv2.5), FINNv2.4, FINNv2.3, FINNv2.5 MODIS-only version, FINNv2.2 MODIS-only version, and FINN version 1.5.
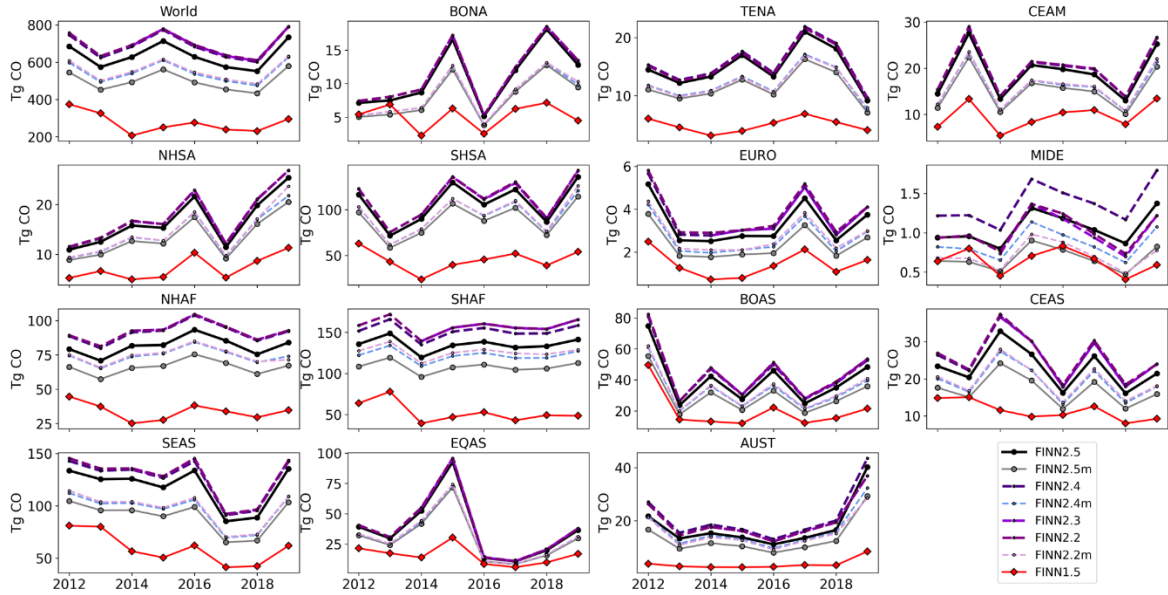
Figure S2. Comparison between regional CO emissions from all FINN versions.
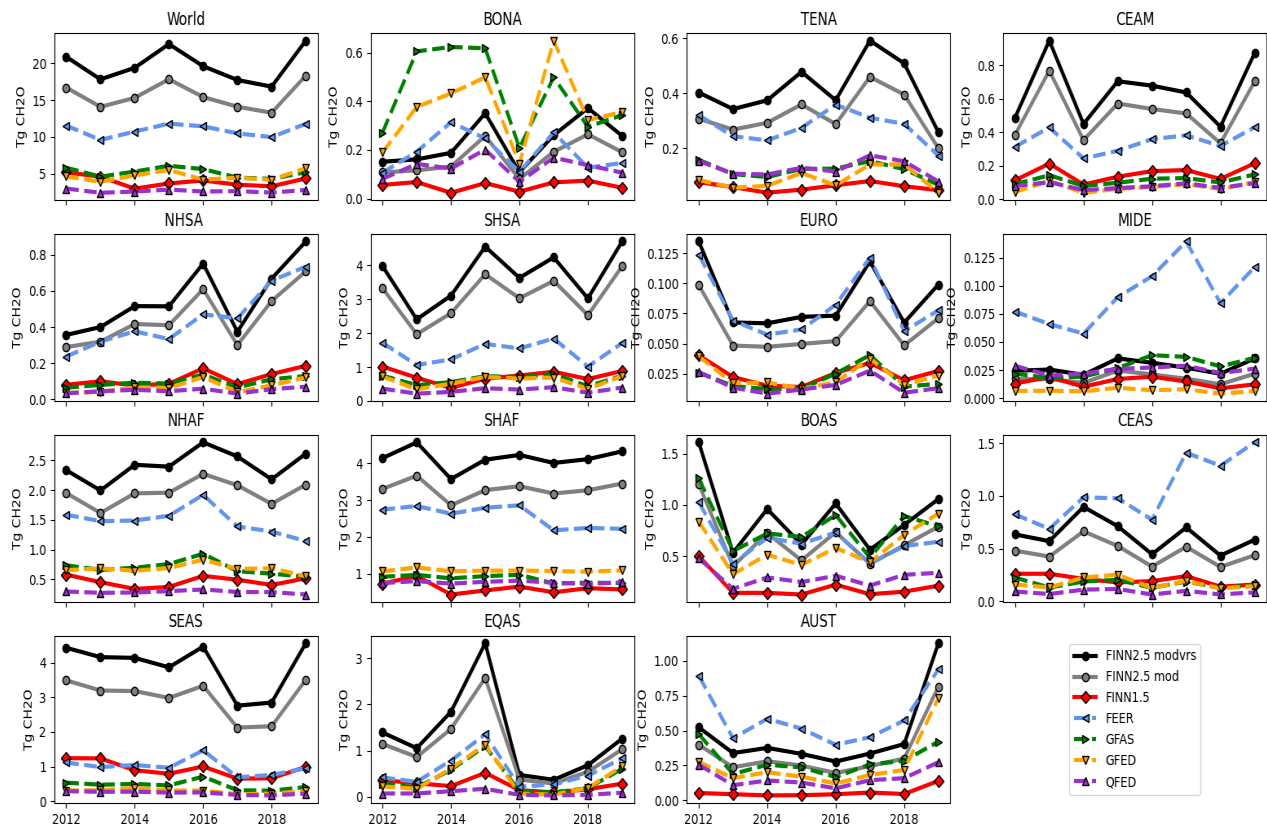
Figure S3. Yearly regional fire CH2O emissions with different inventories, showing interannual variability.
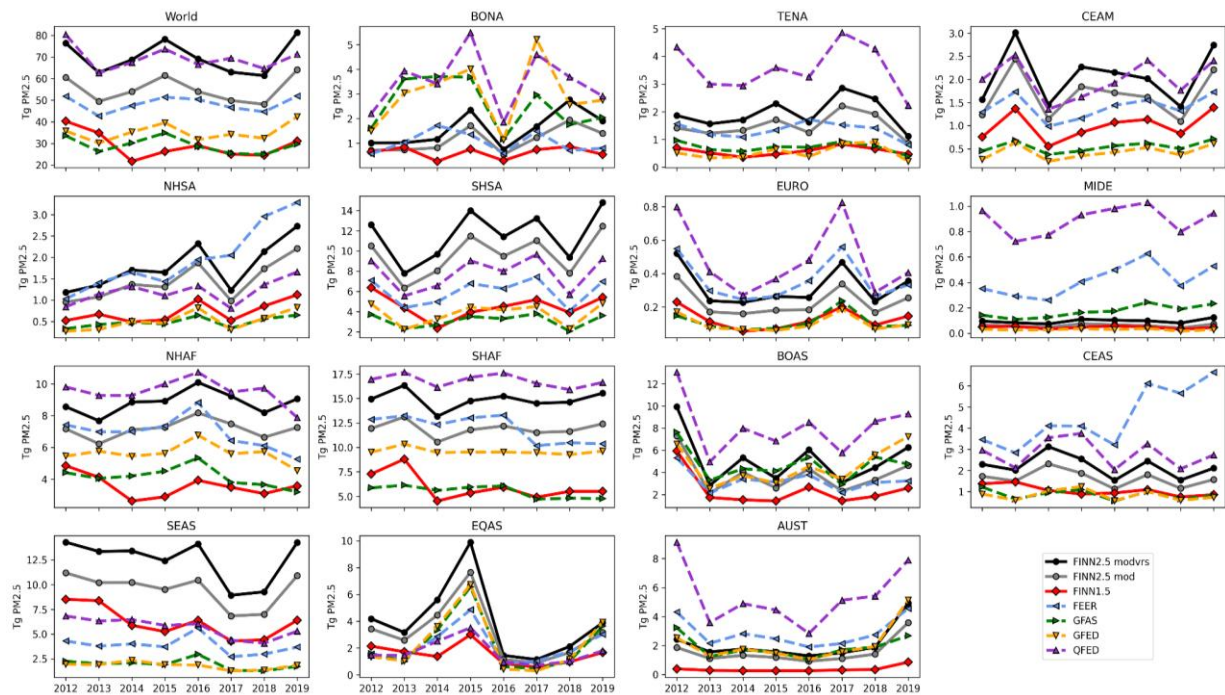
Figure S4. Yearly annual regional fire PM2.5 emissions comparison between different inventories showing interannual variability.
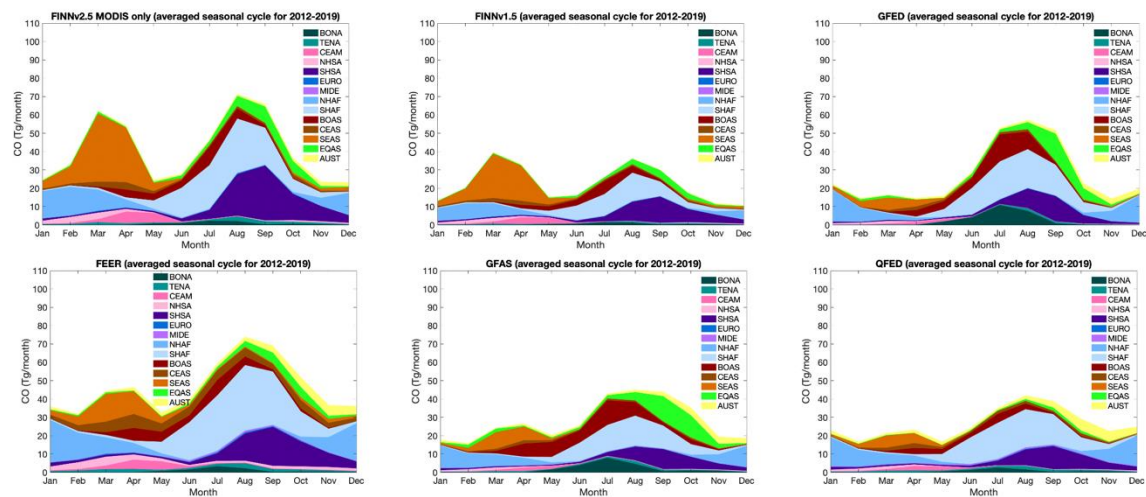
Figure S5. Same as Figure 6 but for FINNv2.5 MODIS only version, FINNv1.5, GFED, FEER, GFAS, and QFED.