



New Developments with the Fire INventory from NCAR (FINN) Emissions Model

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Fire Emissions Modeling

- Transport and chemical processing of emissions from biomass burning influence air quality, climate, human health
- Impacts occur over range of temporal and spatial scales
- Emissions estimates essential for air quality planning and management and human exposure assessment



Vermote, 2015 via <https://worldview.earthdata.nasa.gov>



http://www.nasa.gov/vision/earth/environment/central_am_fires.html

Hidden Pines Fire,
Bastrop, Texas:
October 14, 2015

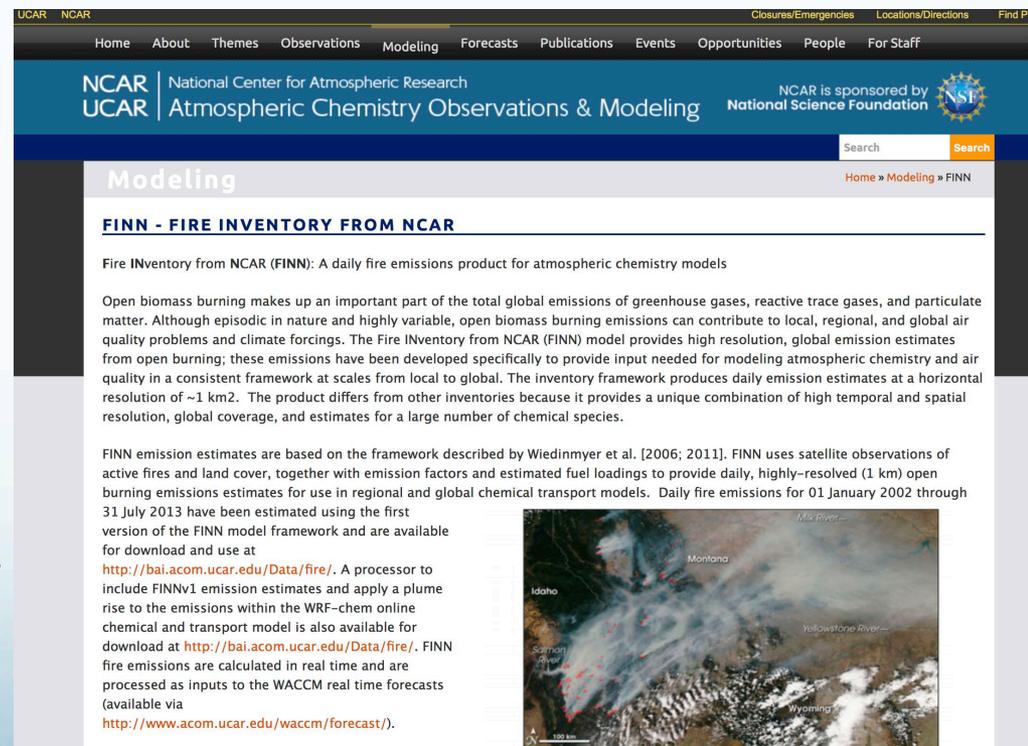
Biomass Burning –
Southern Mexico
and Central America:
May 9, 2003

FINN Fire Emissions Model

- Designed for atmospheric chemical transport modeling:
 - Emissions estimates for particulate matter and trace gases with high spatial/time resolution across local to global scales
 - Speciation of NMOCs for chemical mechanisms
- FINNv1 released in 2010
- FINNv1.5 released in 2014

NCAR hosts central repository for global FINN v1.5 emissions files spanning 2002-2018:

<https://www2.acom.ucar.edu/modeling/finn-fire-inventory-ncar>



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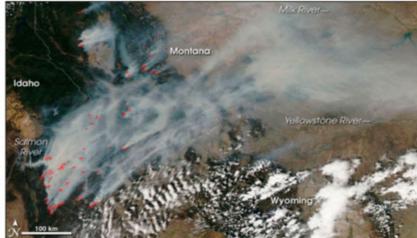
Modeling

FINN - FIRE INVENTORY FROM NCAR

Fire INventory from NCAR (FINN): A daily fire emissions product for atmospheric chemistry models

Open biomass burning makes up an important part of the total global emissions of greenhouse gases, reactive trace gases, and particulate matter. Although episodic in nature and highly variable, open biomass burning emissions can contribute to local, regional, and global air quality problems and climate forcings. The Fire INventory from NCAR (FINN) model provides high resolution, global emission estimates from open burning; these emissions have been developed specifically to provide input needed for modeling atmospheric chemistry and air quality in a consistent framework at scales from local to global. The inventory framework produces daily emission estimates at a horizontal resolution of ~1 km². The product differs from other inventories because it provides a unique combination of high temporal and spatial resolution, global coverage, and estimates for a large number of chemical species.

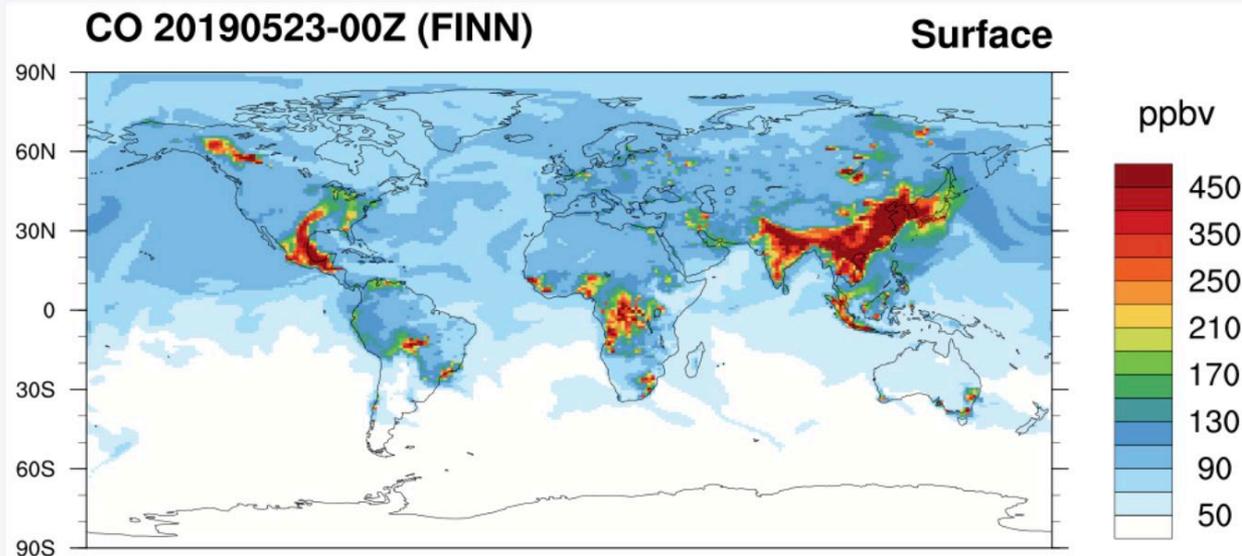
FINN emission estimates are based on the framework described by Wiedinmyer et al. [2006; 2011]. FINN uses satellite observations of active fires and land cover, together with emission factors and estimated fuel loadings to provide daily, highly-resolved (1 km) open burning emissions estimates for use in regional and global chemical transport models. Daily fire emissions for 01 January 2002 through 31 July 2013 have been estimated using the first version of the FINN model framework and are available for download and use at <http://bai.acom.ucar.edu/Data/fire/>. A processor to include FINNv1 emission estimates and apply a plume rise to the emissions within the WRF-chem online chemical and transport model is also available for download at <http://bai.acom.ucar.edu/Data/fire/>. FINN fire emissions are calculated in real time and are processed as inputs to the WACCM real time forecasts (available via <http://www.acom.ucar.edu/waccm/forecast/>).



Example Applications*

- Air quality and population exposure in regions with high fire activity
- Influences of changing climate and development patterns on wildfires
- Complement surface, aircraft, satellite observations

WACCM CHEMISTRY AND AEROSOL FORECASTS



Whole Atmosphere
Community Climate
Model (WACCM) real-
time forecasts

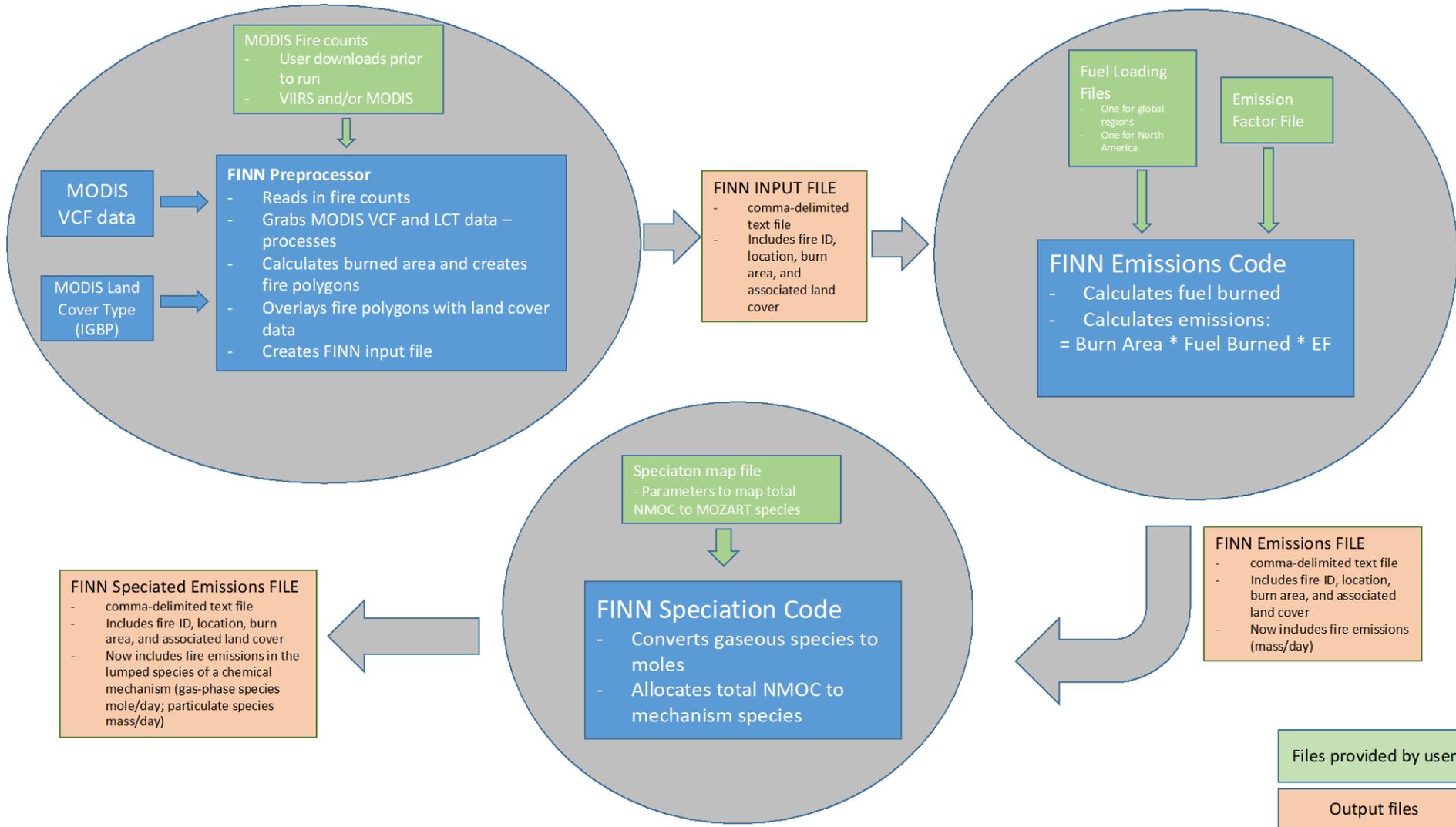
<http://www.acom.ucar.edu/waccm/forecast/>

*e.g. Nuryanto, 2015; Crippa et al., 2016; Ivey et al., 2014; Pimonsree et al., 2018; Hurteau et al., 2014; Stavrakou et al., 2016; Reddington et al., 2018; Larkin et al., 2014, Pereira, 2016; Urbanski et al., 2018.

Development Efforts

- On-going collaboration since 2012
- Assistance from Ramboll, National Center for Atmospheric Research (NCAR), Texas Commission on Environmental Quality (TCEQ)
- Texas Air Quality Research Program sponsored three projects:
<http://aqrp.ceer.utexas.edu> (12-018, 14-011, 18-022)
- Culminated in development of **FINNv2.2**
- Sonoma Tech, Inc (STI) is evaluating FINNv2.2 using the Multi-Angle Implementation of Atmospheric Correction (MAIAC) AOD product
(Pavlovic et al. presentation in this session)

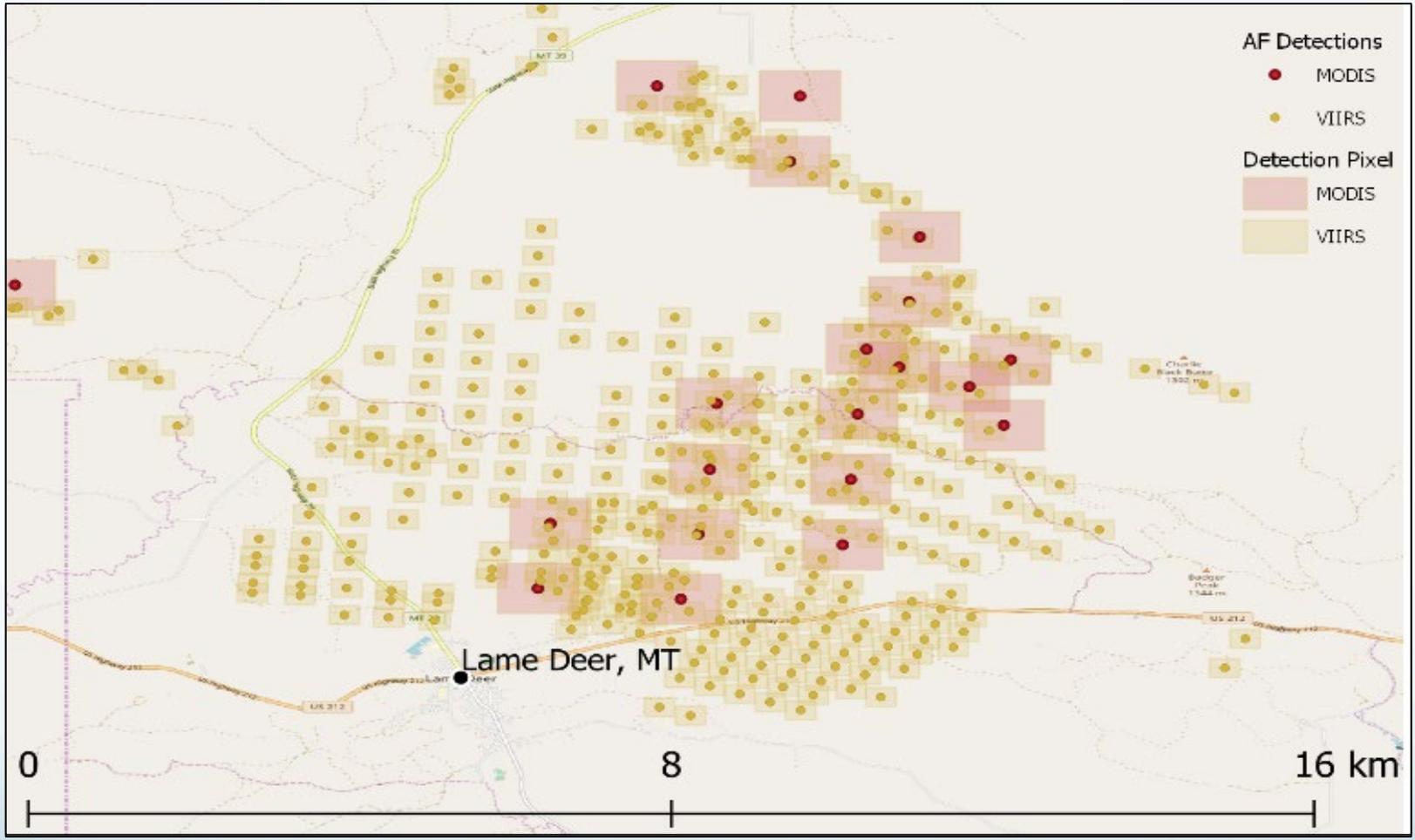
FINN v2.2 Modeling System Components



Preprocessor: Active Fire Detections

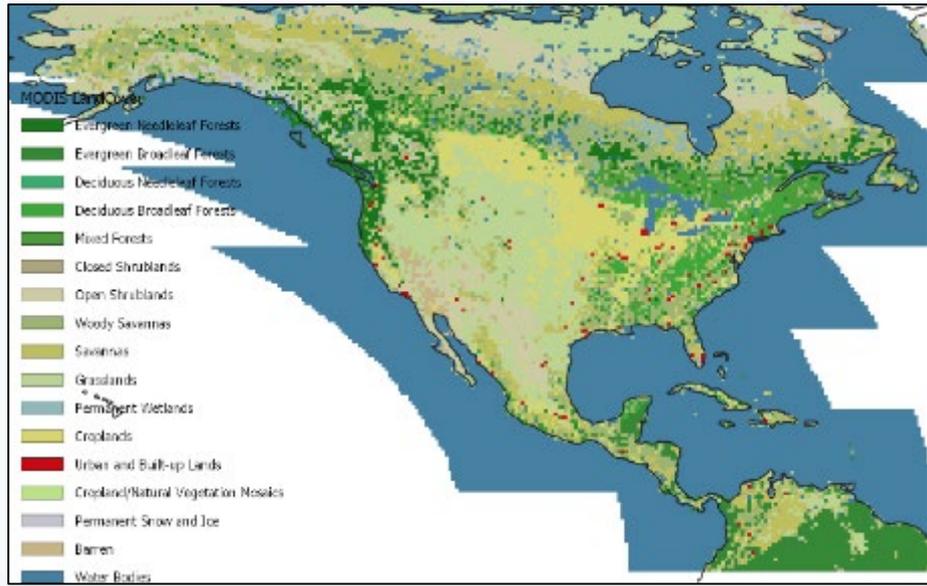
- Preprocessor estimates burned area from daily satellite detections of active fires and characterizes underlying land cover
- Previous versions used MODIS active fire products as default
- Added **option to use VIIRS (375m) active fire product** alone or in combination with MODIS Collection 6 (MCD14DL) product
- Uses **local time** to specify date of fire detection for easier comparisons with observations

Preprocessor: New Approach for Burned Area Estimation



Each detection assigned square area (0.14 km^2 VIIRS or 1 km^2 MODIS)
Detection rectangles formed from scan and track sizes of satellite pixel
Convex hulls from detection clusters joined to form “**fire polygon**”

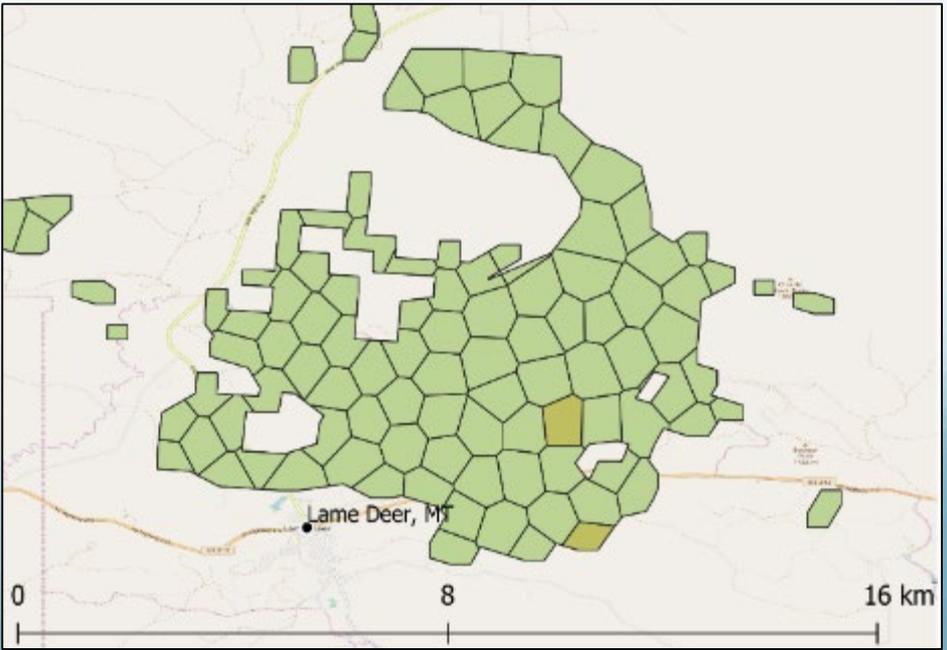
Preprocessor: New Approach for Land Cover Characterization



Terra and Aqua combined MODIS Land Cover Type (MCD12Q1) Version 6 data product with the International Geosphere-Biosphere Programme (IGBP) classifications

Fire polygon subdivided to analyze underlying land cover

MOD44B v006 MODIS/Terra Vegetation Continuous Fields (VCF) yearly product used to determine tree, grass, and bare cover



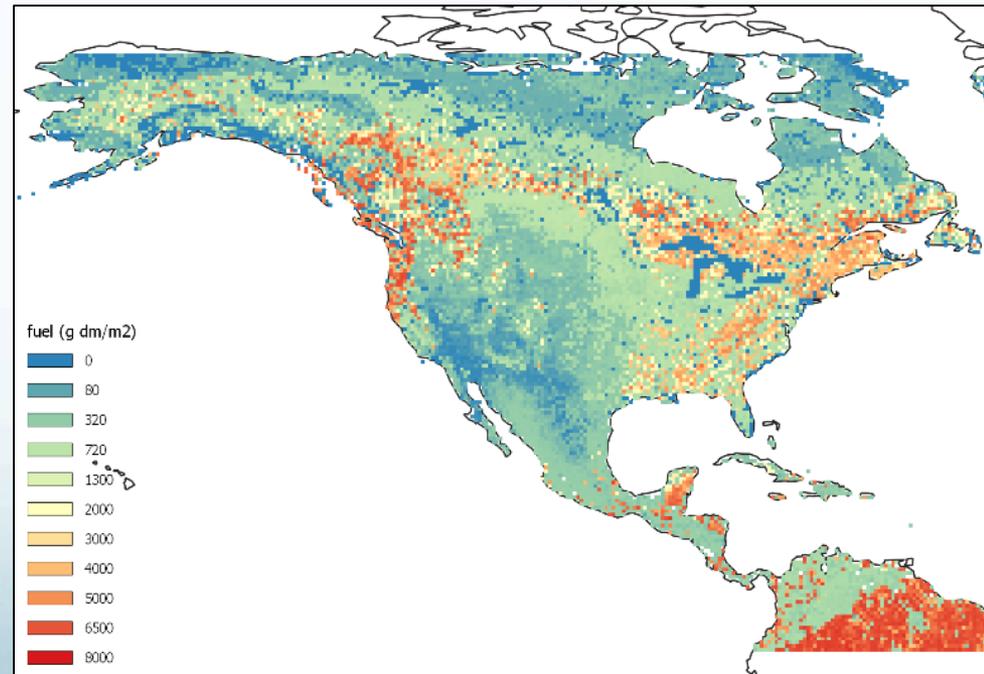
Emissions Model and Chemical Speciation: Highlights

Emission Factors

- 16 IGBP classes mapped to seven vegetation types
- Akagi et al (2011) and updates in 2015
- New studies* between 2014-2018 for **forests and croplands**
- **NMOC** includes identified and unidentified compounds; new NMOC emissions mapping for MOZART-T1 chemical mechanism

Biomass Loadings

- Updated regional defaults†
- USFS Fuel Characteristic Classification System (**FCCS**) supersedes regional defaults for **North America**



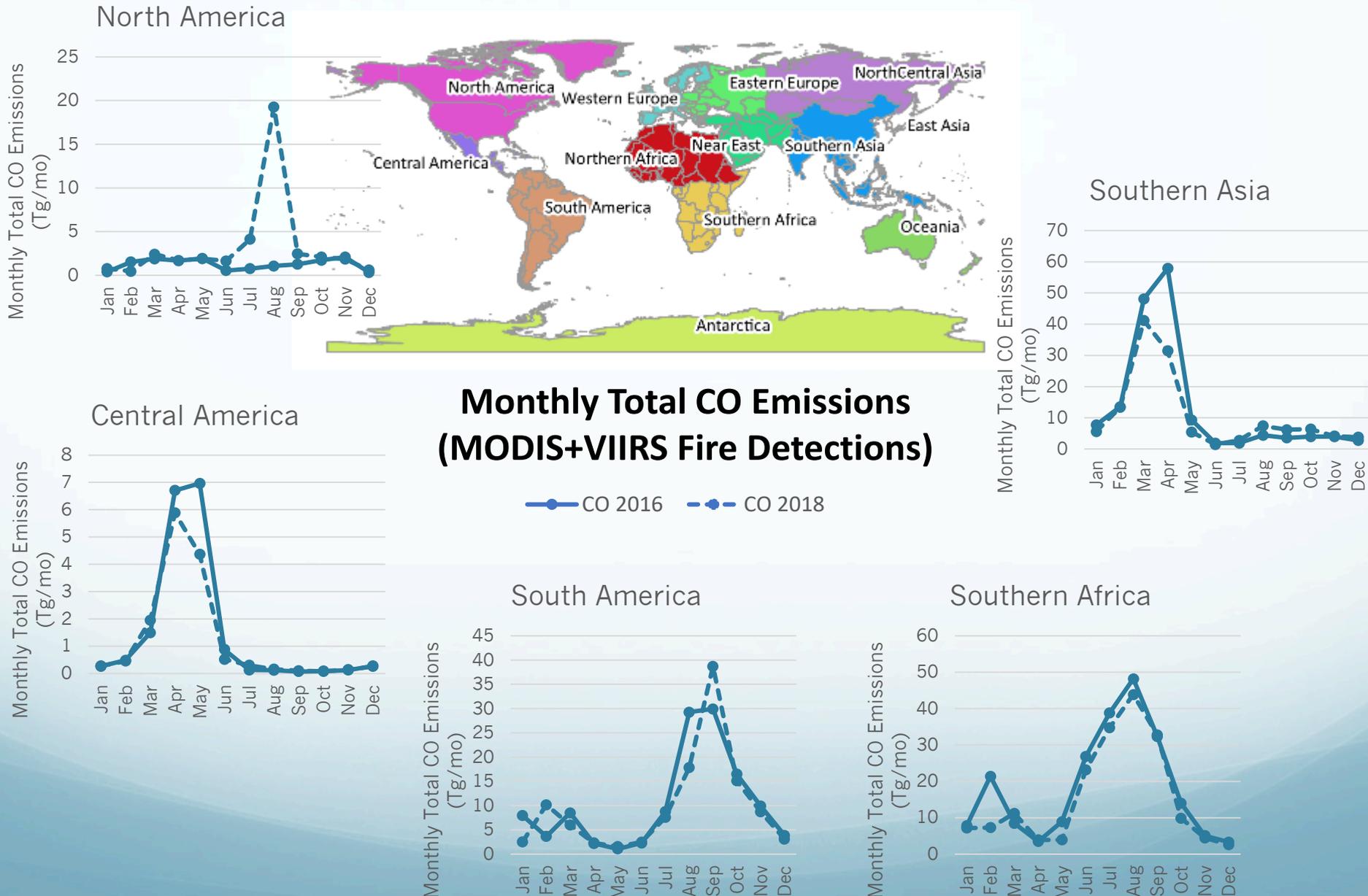
*Liu et al (2017), Urbanski (2014), and Paton-Walsh (2014); Liu et al (2017), Fang et al. (2017), Santiago De La Rosa et al. (2018), Stockwell et al. (2015)

†Hoelzemann et al. (2004); van Leeuwen et al. (2014); Akagi et al. (2011); Pouliot et al. (2017)

FINN v2.2 Computing Environment

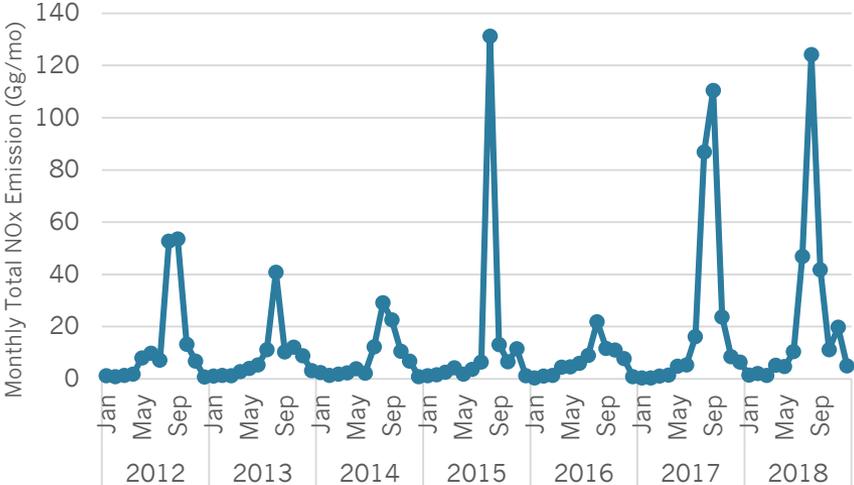
- Open source
- Preprocessing algorithm implemented in PostGIS to improve performance (i.e., shorter execution time)
- Docker environment houses FINN preprocessor tools
- Emissions model and chemical speciation codes written in IDL language, but new versions in Python have been developed

FINN v2.2 Global Simulations: 2016 and 2018

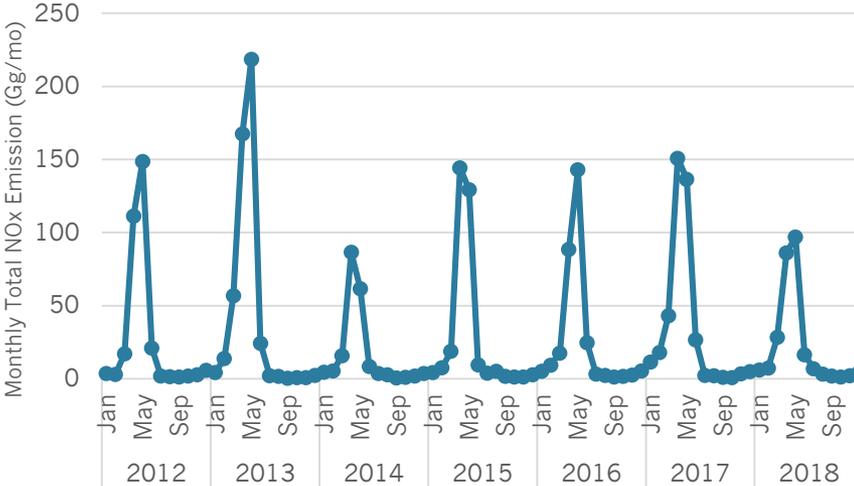


FINNv2.2 North American Simulations: 2012-2018

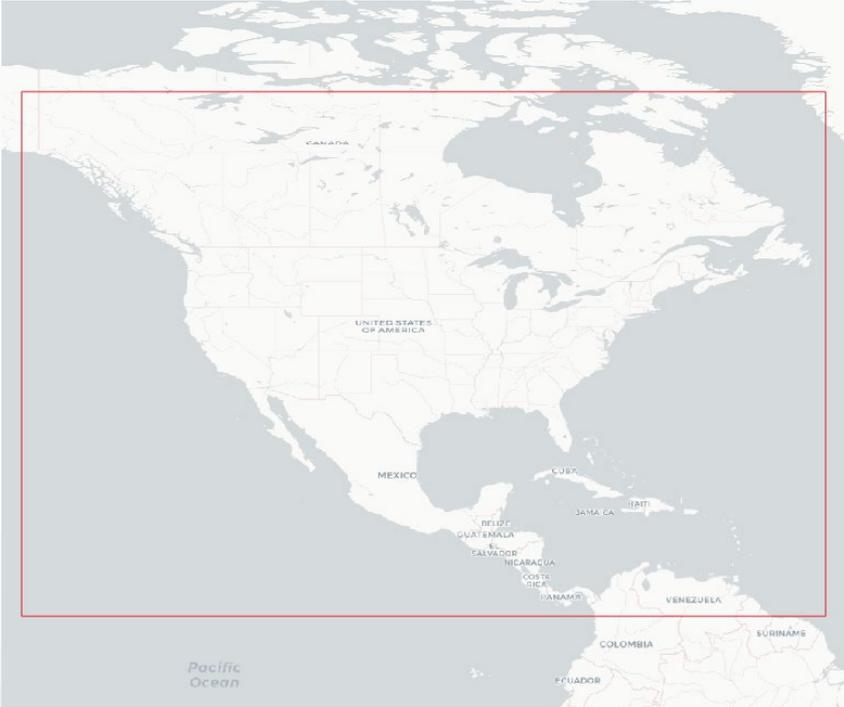
Western US



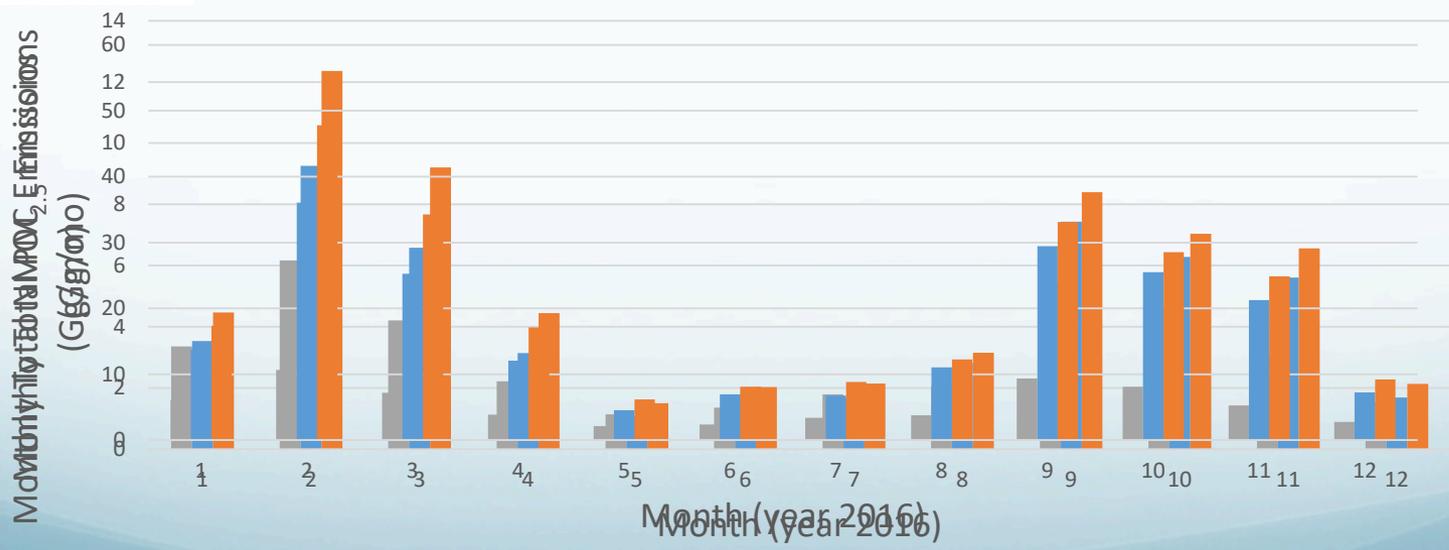
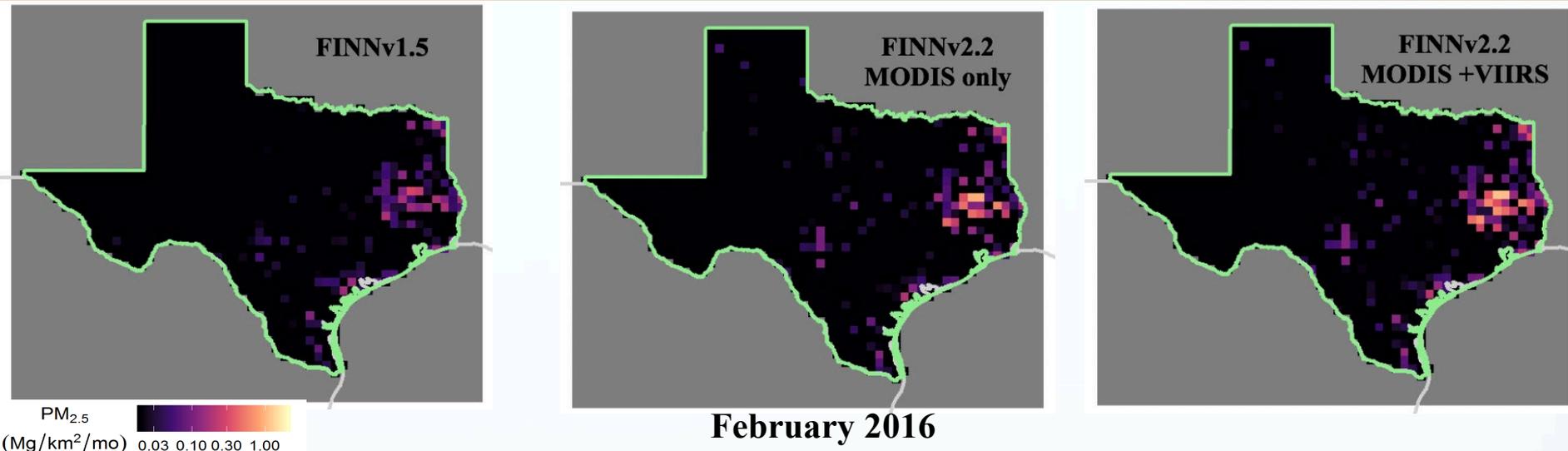
Mexico



Monthly Total CO Emissions (MODIS+VIIRS Fire Detections)

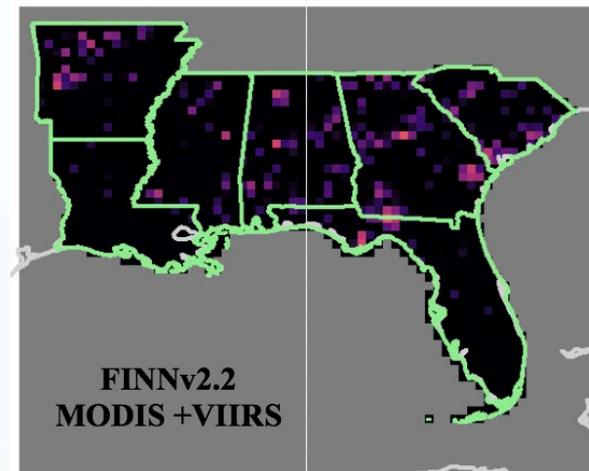
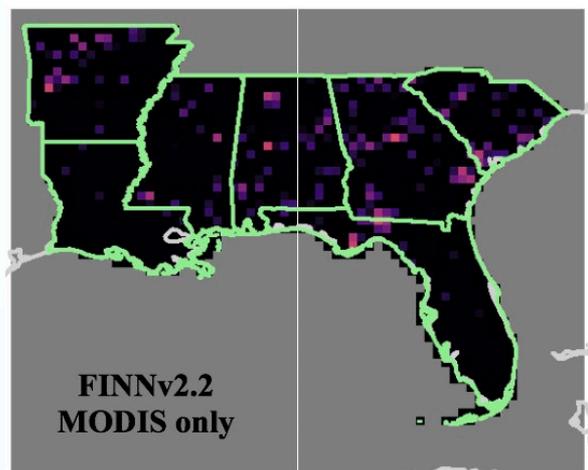
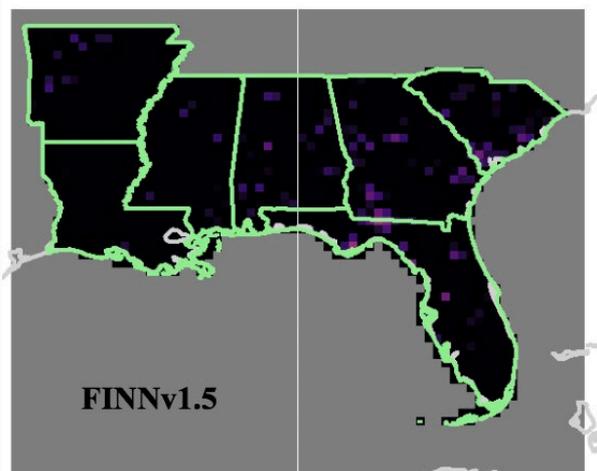


Monthly Total PM_{2.5} and NMOC Emissions in Texas in 2016: FINN 1.5, FINN v2.2 (MODIS only, MODIS+VIIRS)



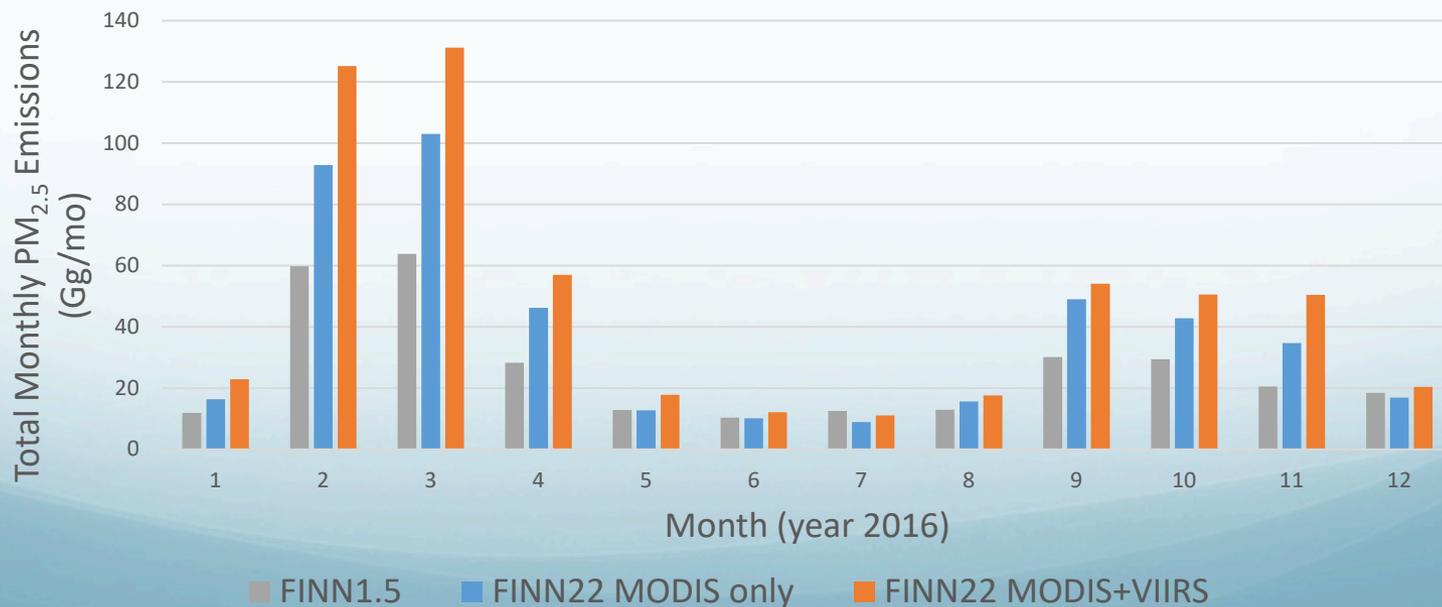
■ FINN1.5
 ■ FINN2.2 MODIS only
 ■ FINN2.2 MODIS+VIIRS

Monthly Total PM_{2.5} Emissions in Southeast U.S. and Lower Mississippi Valley in 2016: FINN 1.5, FINN v2.2 (MODIS only, MODIS+VIIRS)

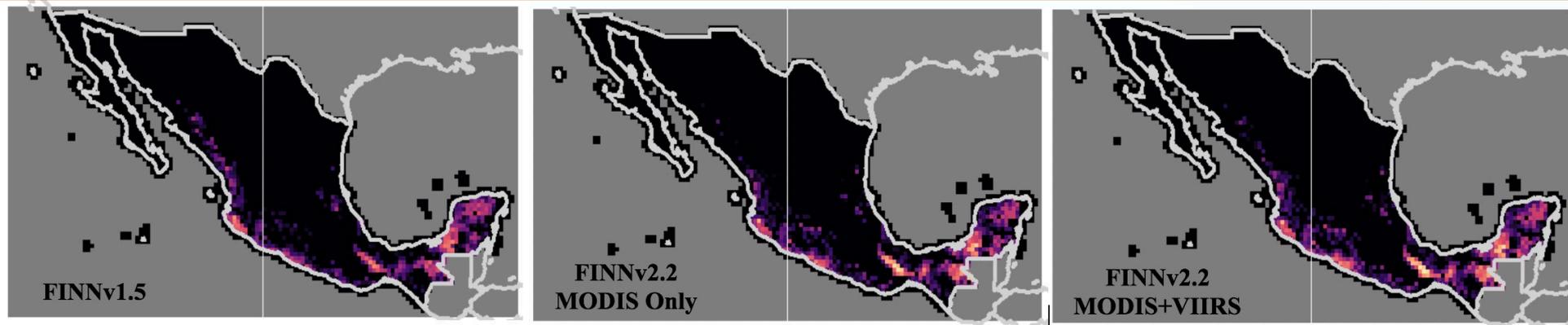


PM_{2.5}
(Mg/km²/mo) 0.3 1.0 3.0 10.0

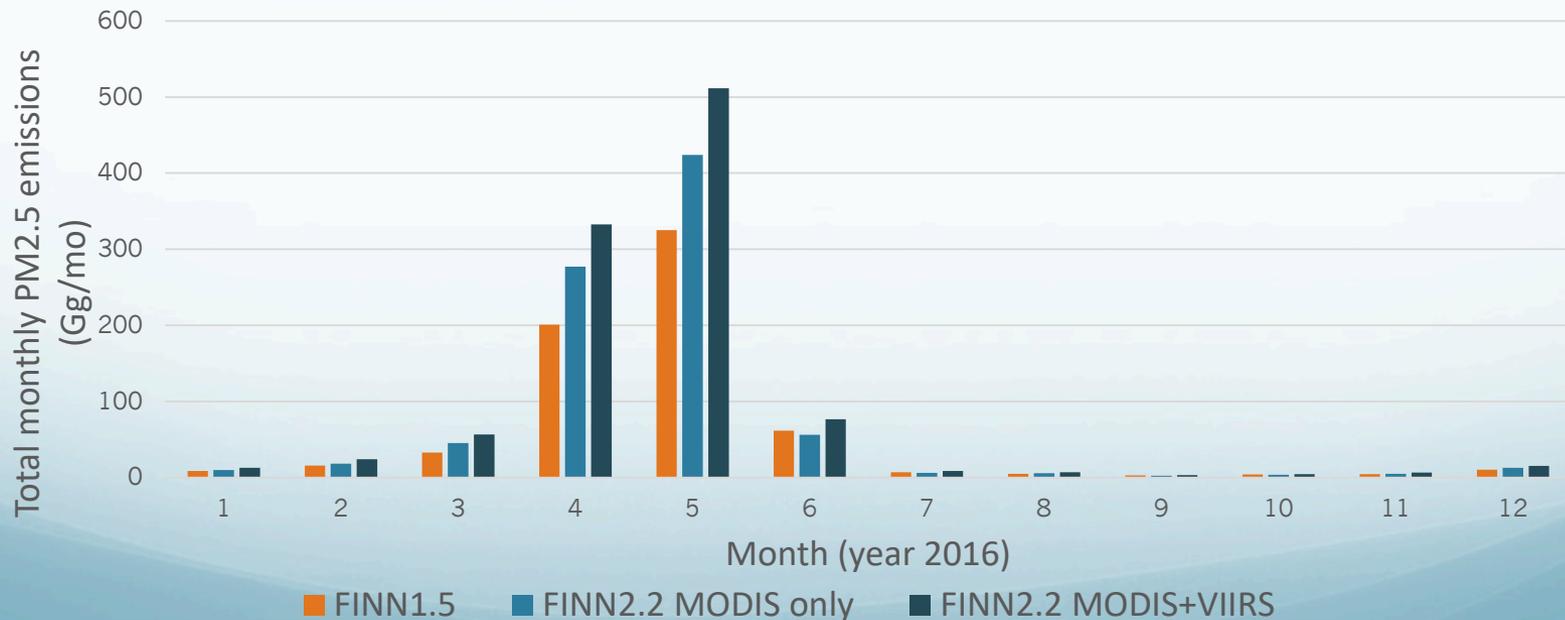
March 2016



Monthly Total PM_{2.5} Emissions in Mexico Valley in 2016: FINN 1.5, FINN v2.2 (MODIS only, MODIS+VIIRS)



May 2016



Summary

- FINN v2.2 development:
 - Addresses improvements to earlier versions (e.g. burned area estimates, detection of smaller fires)
 - Incorporates recent data (e.g., land cover, fuel loading, emission factors, chemical speciation)
- Open source code: Available links to GitHub development platform and user's guide
- Global-scale simulations will be released via the NCAR data portal currently serving as repository of FINNv1.5 files
- **We encourage community feedback**

Acknowledgment

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