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CIRES

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

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

- Impacts occur over range of temporal and spatial scales

- Emissions estimates essential for air quality planning and management and human exposure assessment

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

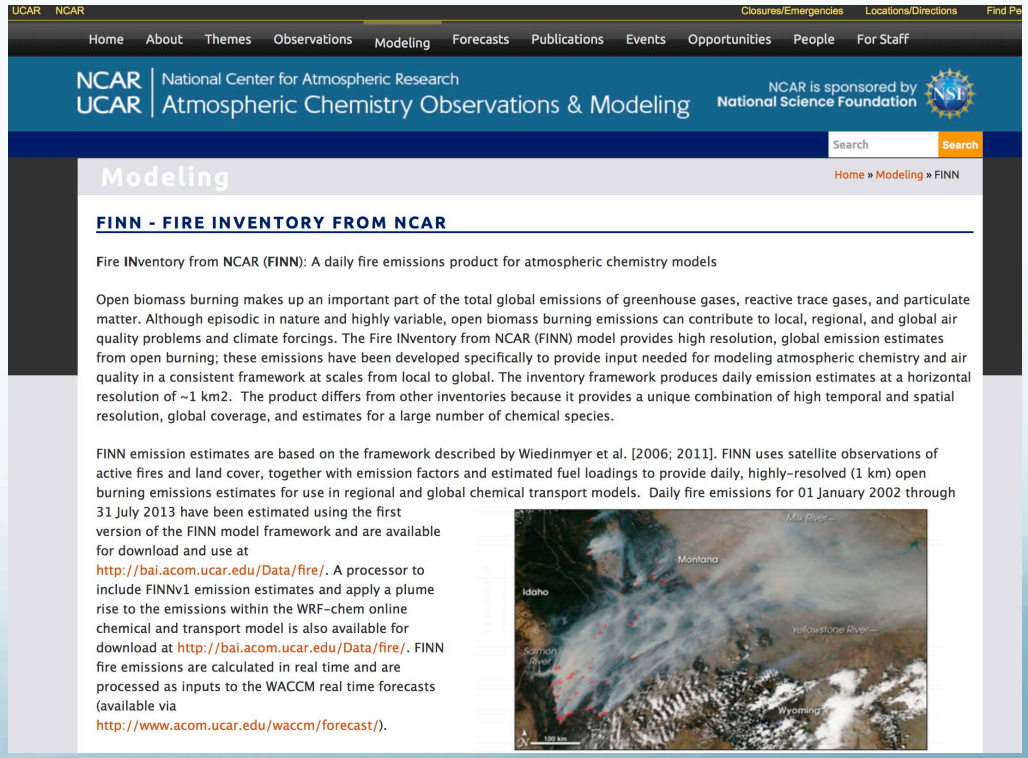
Biomass Burning – Southern Mexico and Central America: May 9, 2003

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

FINN Fire Emissions Model

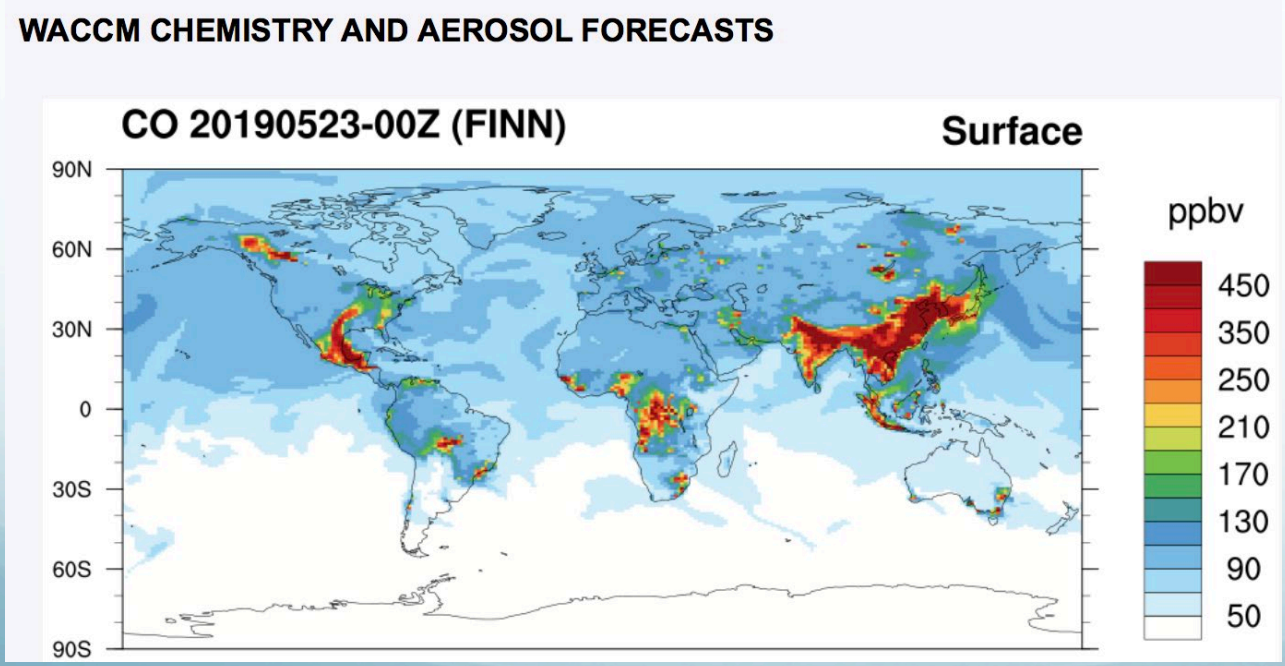
- Designed for atmospheric chemical transport modeling:
  - Emissions estimates for particulate matter and trace gases with high spatial/time resolution across local to global scales
  - Speciation of NMOCs for chemical mechanisms
- FINNv1 released in 2010
- FINNv1.5 released in 2014

NCAR hosts central repository for global FINN v1.5 emissions files spanning 2002-2018: https://www2.acom.ucar.edu/modeling/finn-fire-inventory-ncar



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



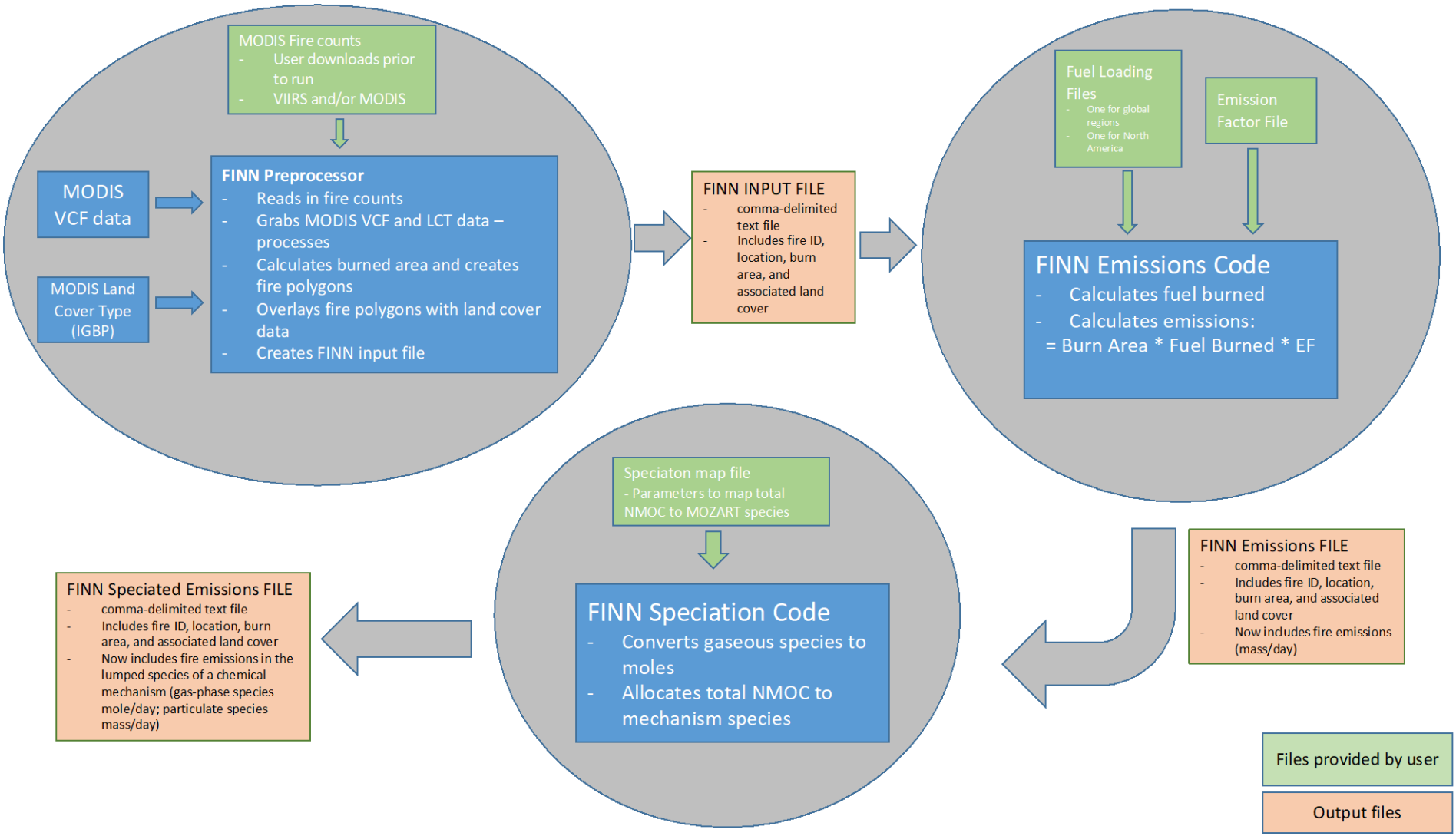
Whole Atmosphere Community Climate Model (WACCM) real-time forecasts http://www.acom.ucar.edu/waccm/forecast/

*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)**

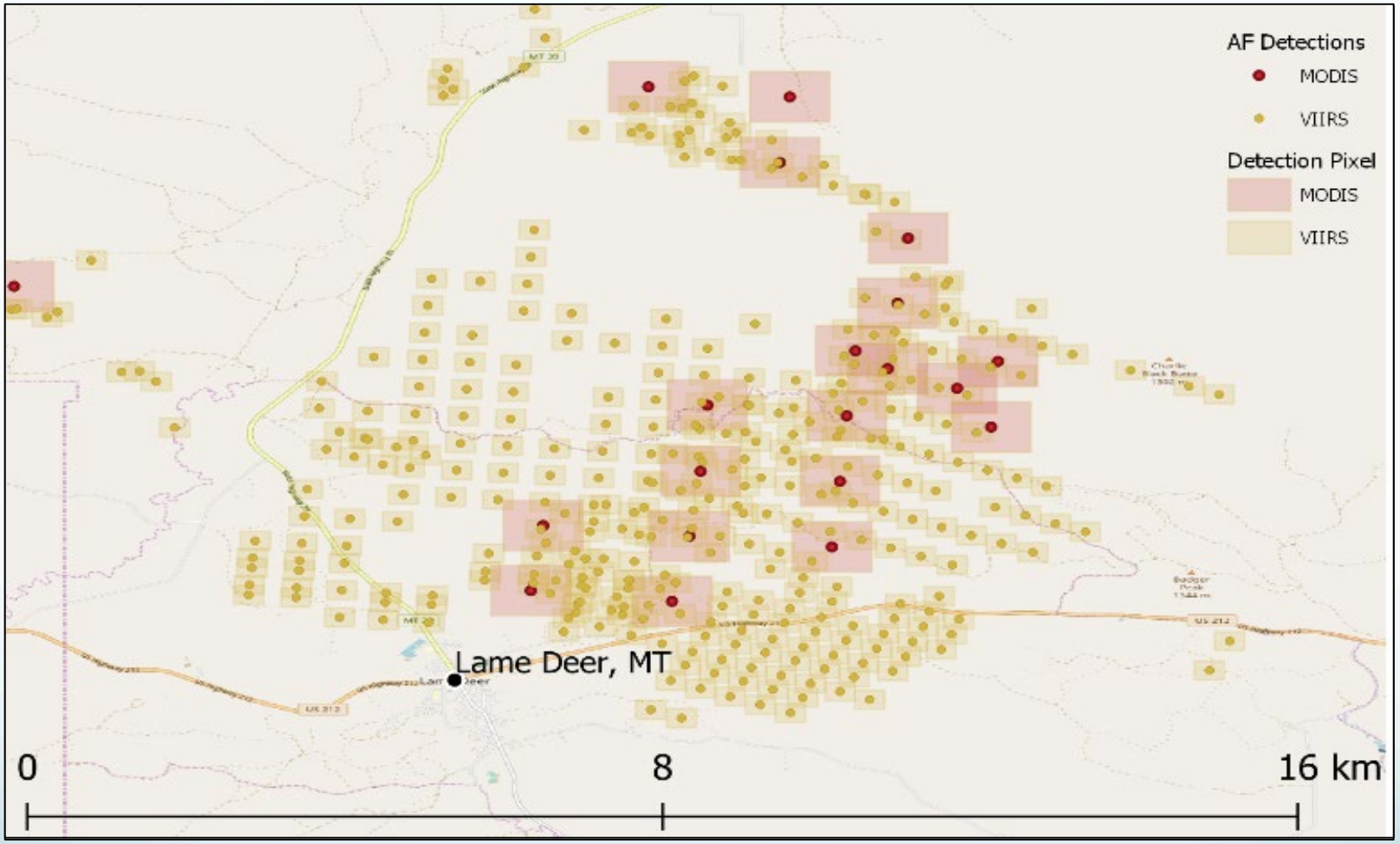
FINN v2.2 Modeling System Components



Preprocessor: Active Fire Detections

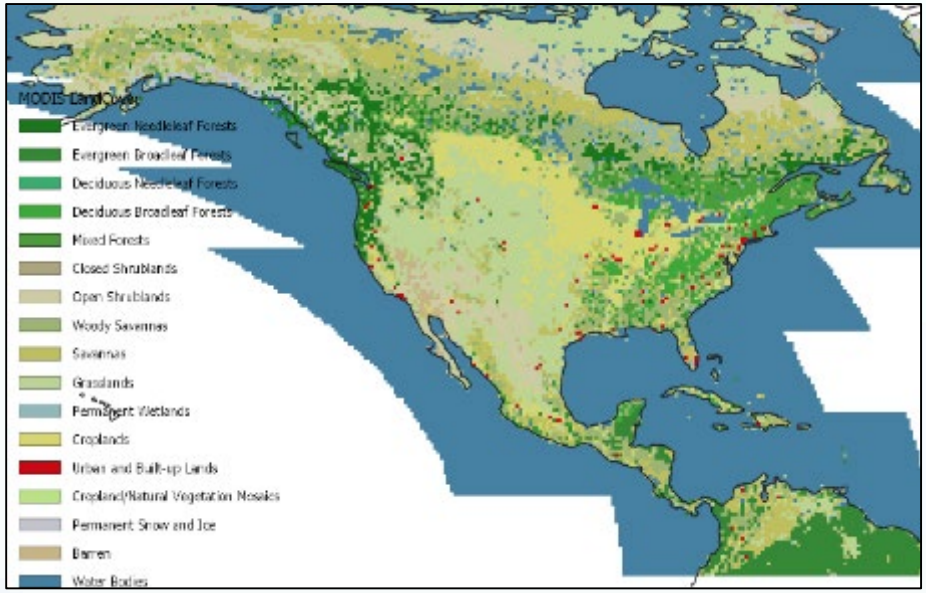
- Preprocessor estimates burned area from daily satellite detections of active fires and characterizes underlying land cover
- Previous versions used MODIS active fire products as default
- Added **option to use VIIRS (375m) active fire product** alone or in combination with MODIS Collection 6 (MCD14DL)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

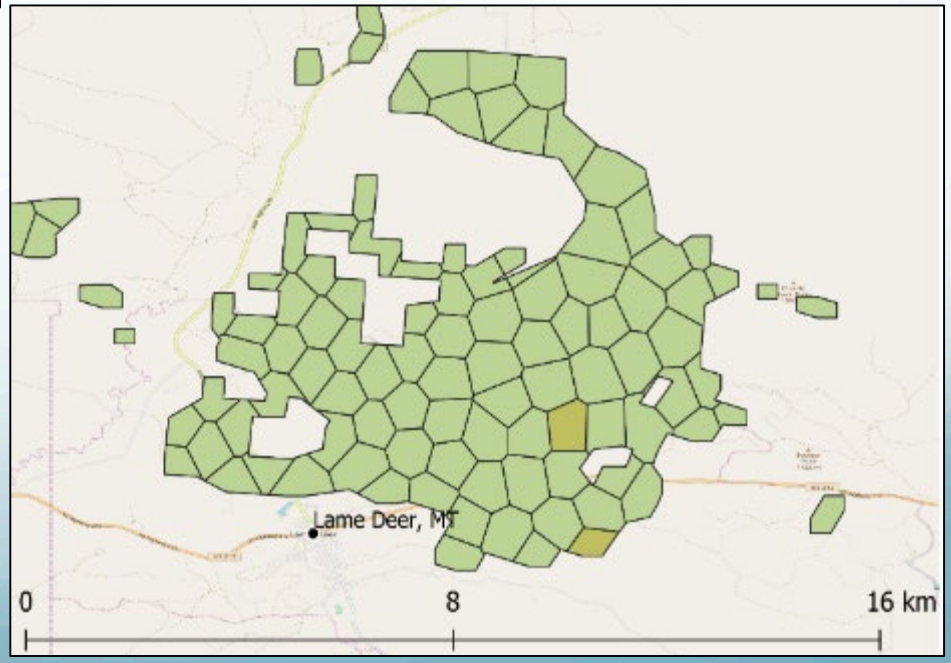
Preprocessor: New Approach for Land Cover Characterization



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



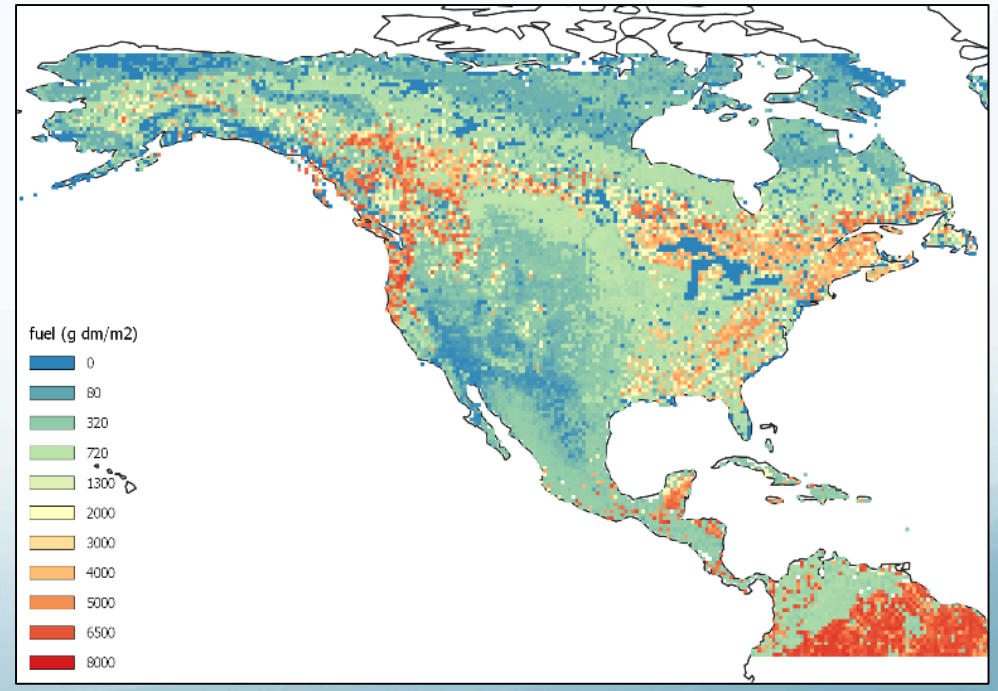
Emissions Model and Chemical Speciation: Highlights

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**



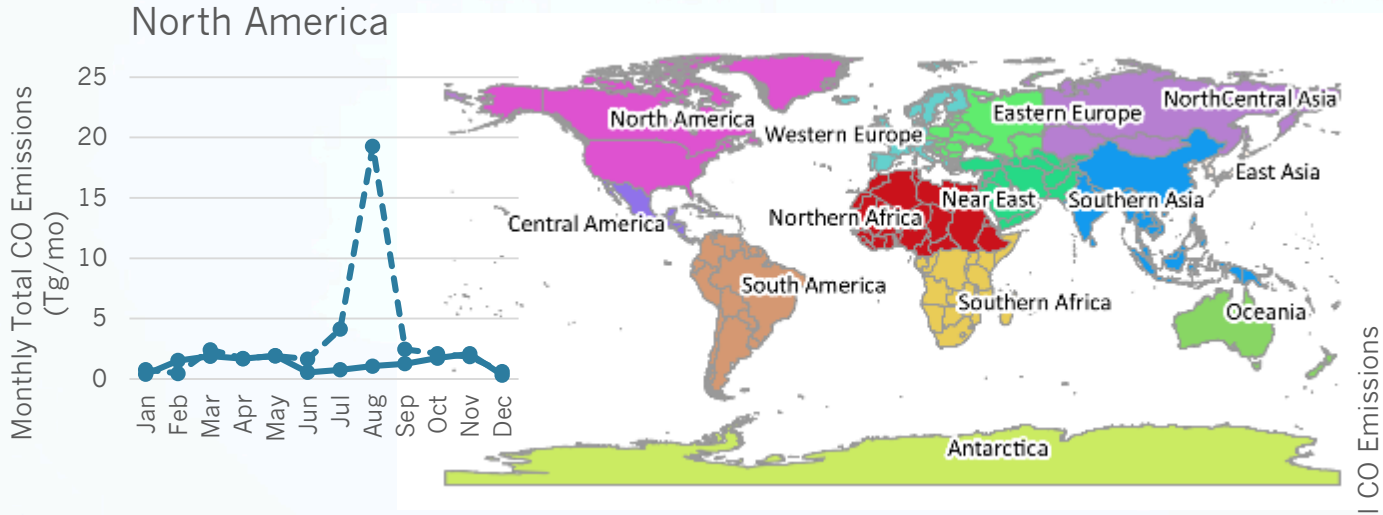
*Liu et al (2017), Urbanski (2014), and Paton-Walsh (2014); Liu et al (2017), Fang et al. (2017), Santiago De La Rosa et al. (2018), Stockwell et al. (2015)

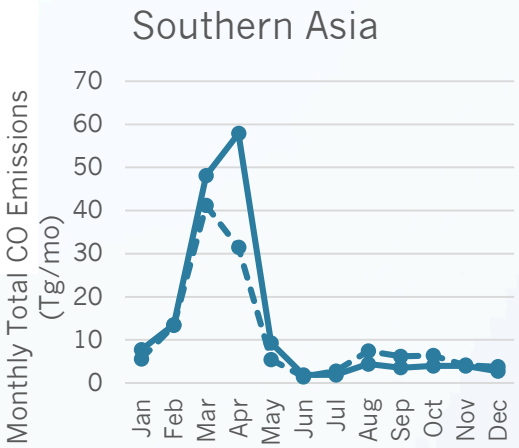
†Hoelzemann et al. (2004); van Leeuwen et al. (2014); Akagi et al. (2011); Pouliot et al. (2017)

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

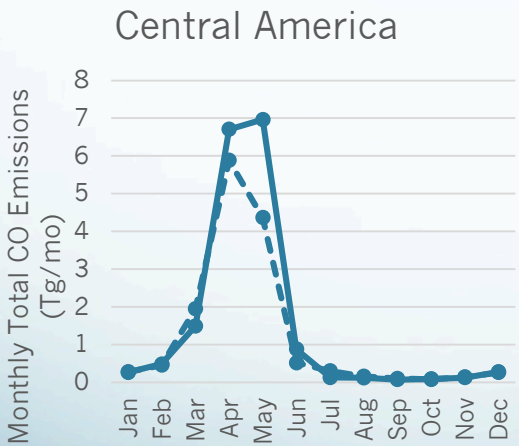
FINN v2.2 Global Simulations: 2016 and 2018

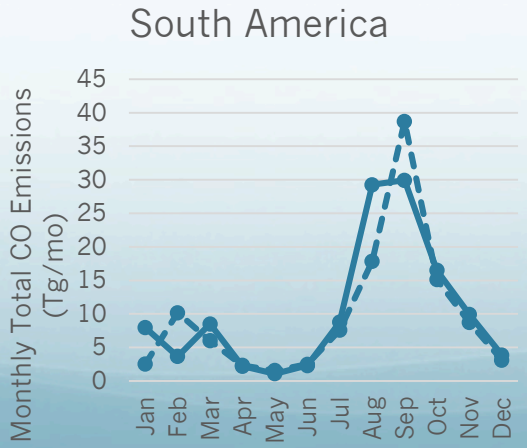


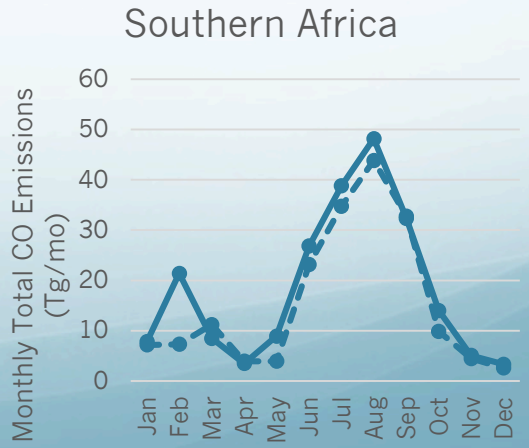


Monthly Total CO Emissions (MODIS+VIIRS Fire Detections)

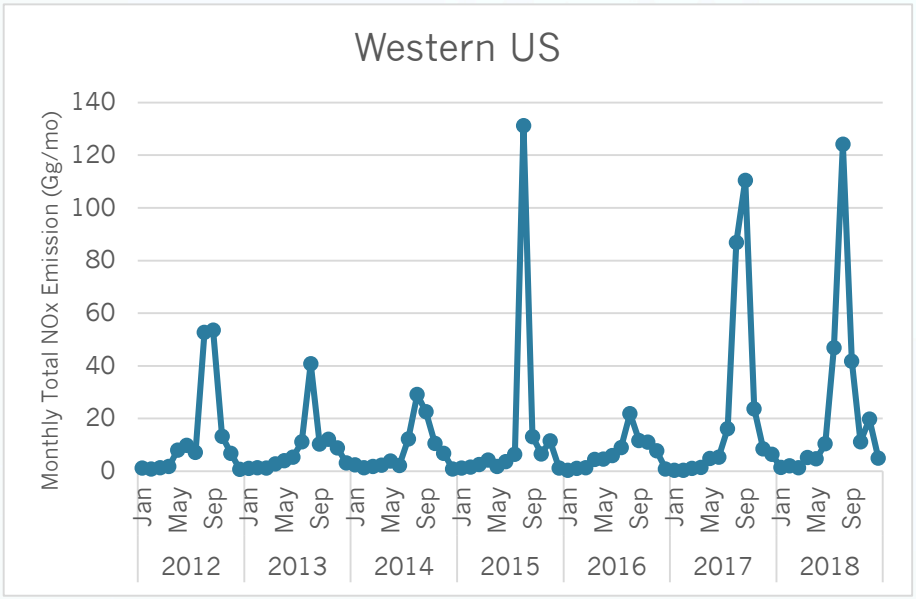
CO 2016 CO 2018

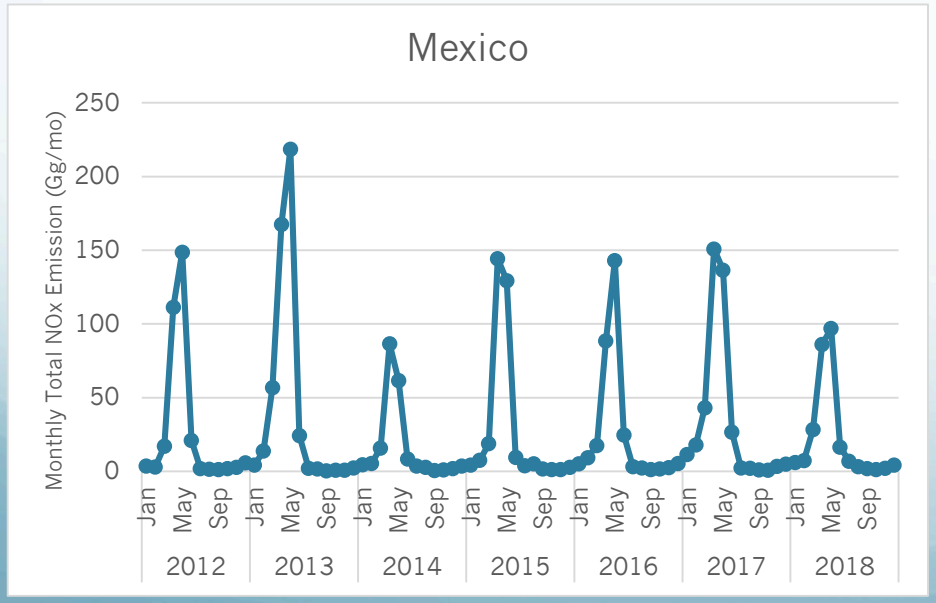




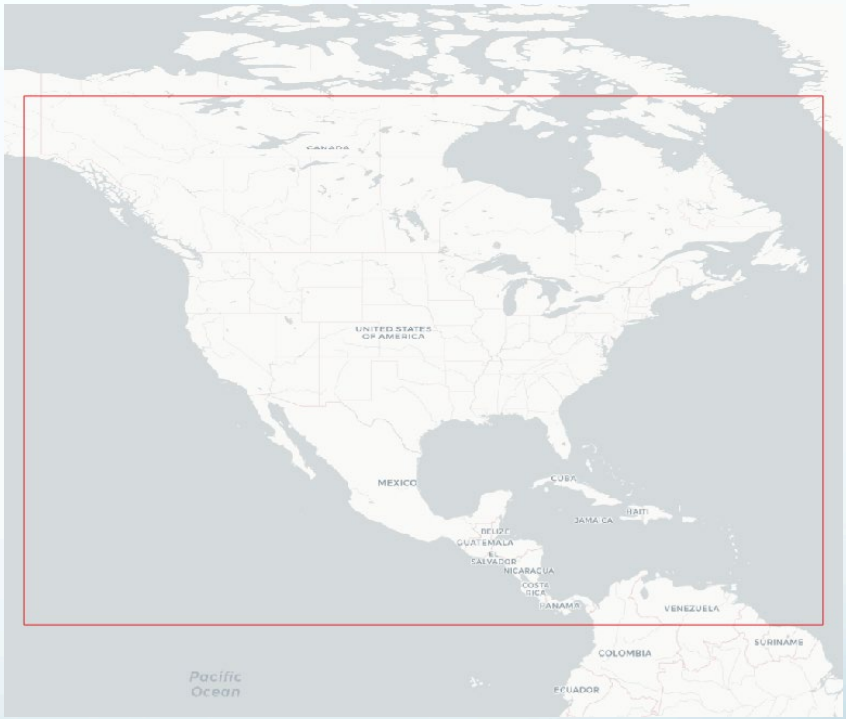


FINNv2.2 North American Simulations: 2012-2018

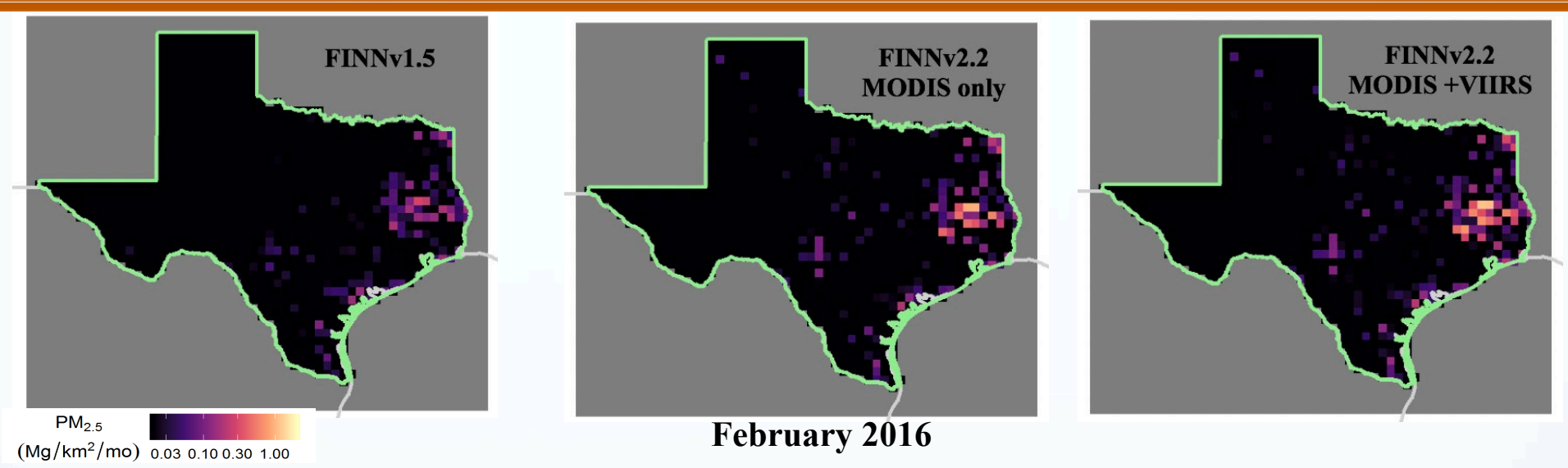


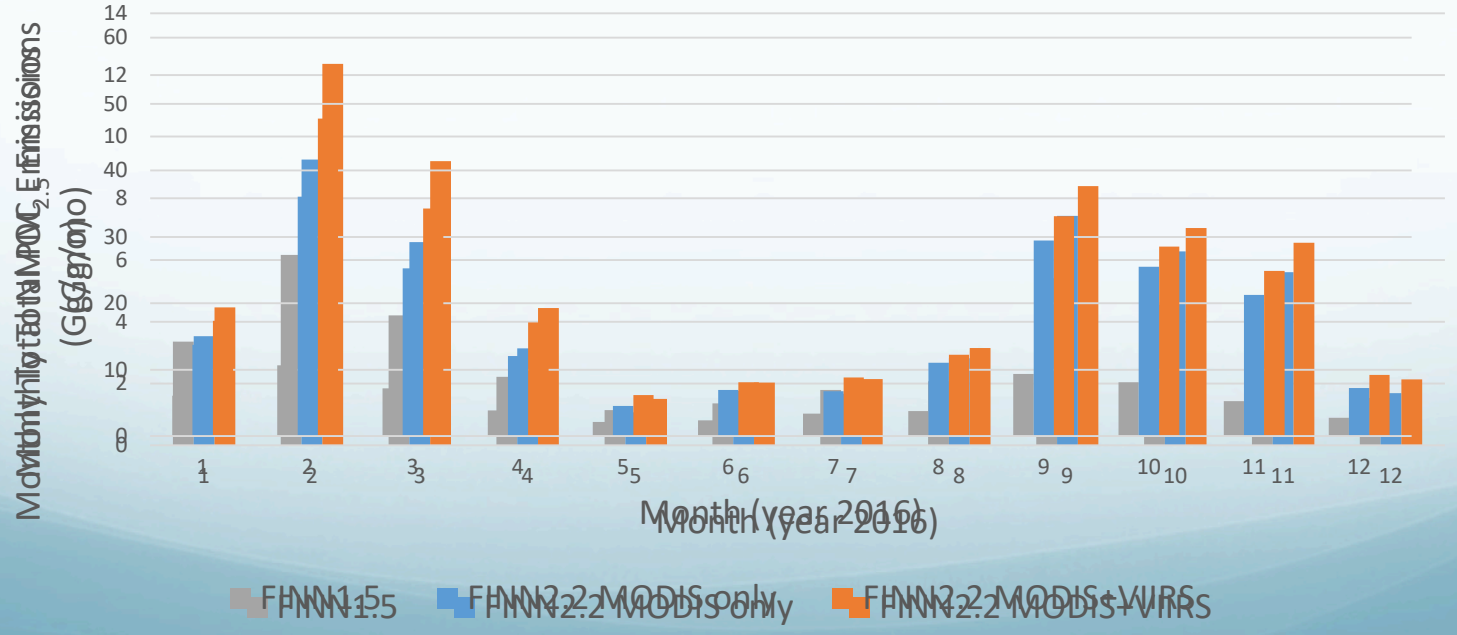


Monthly Total CO Emissions
(MODIS+VIIRS Fire Detections)

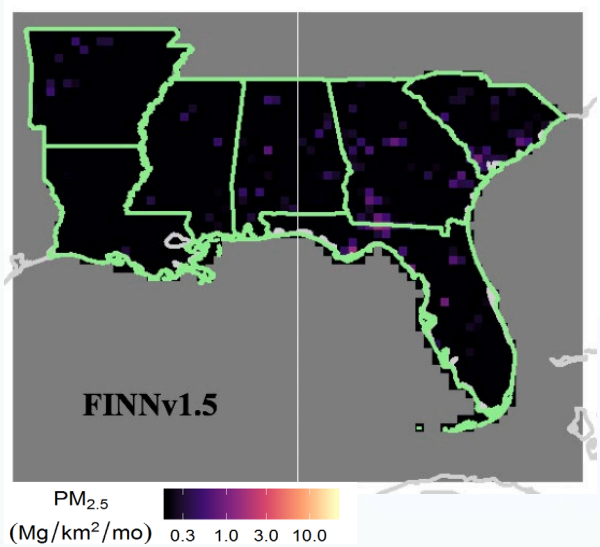


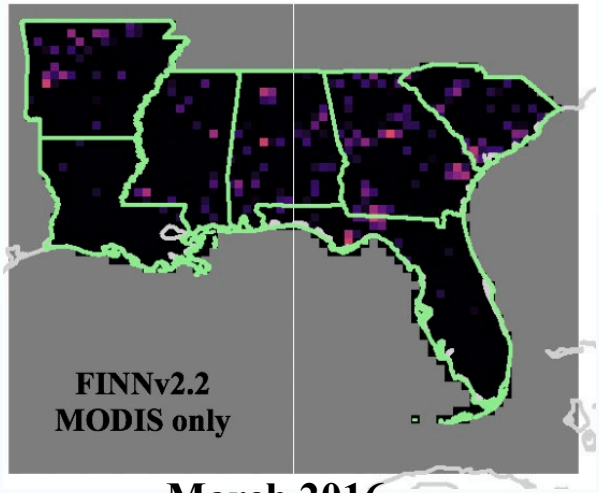
Monthly Total $PM_{2.5}$ and NMOC Emissions in Texas in 2016: FINN 1.5, FINN v2.2 (MODIS only, MODIS+VIIRS)

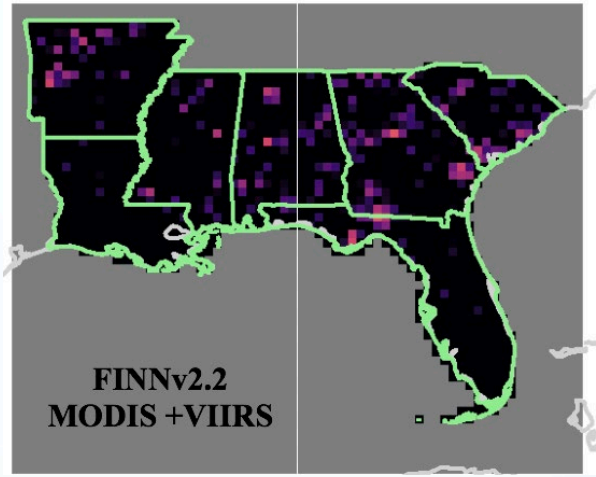




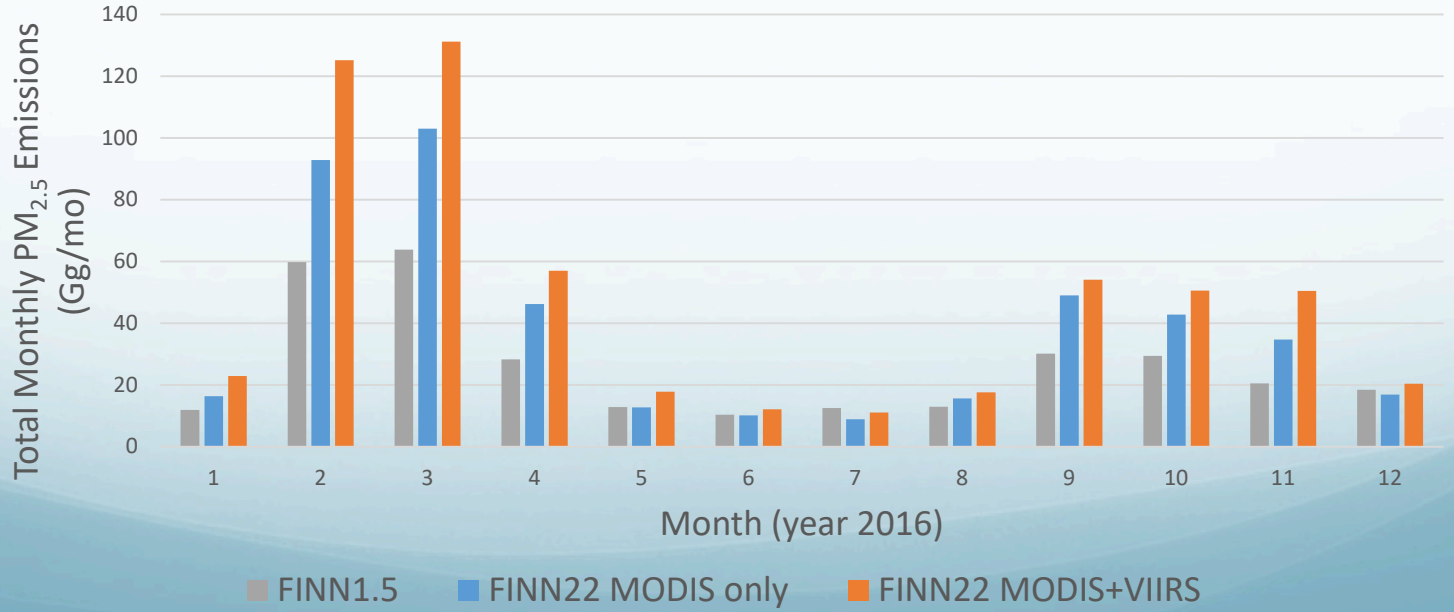
Monthly Total $PM_{2.5}$ Emissions in Southeast U.S. and Lower Mississippi Valley in 2016: FINN 1.5, FINN v2.2 (MODIS only, MODIS+VIIRS)



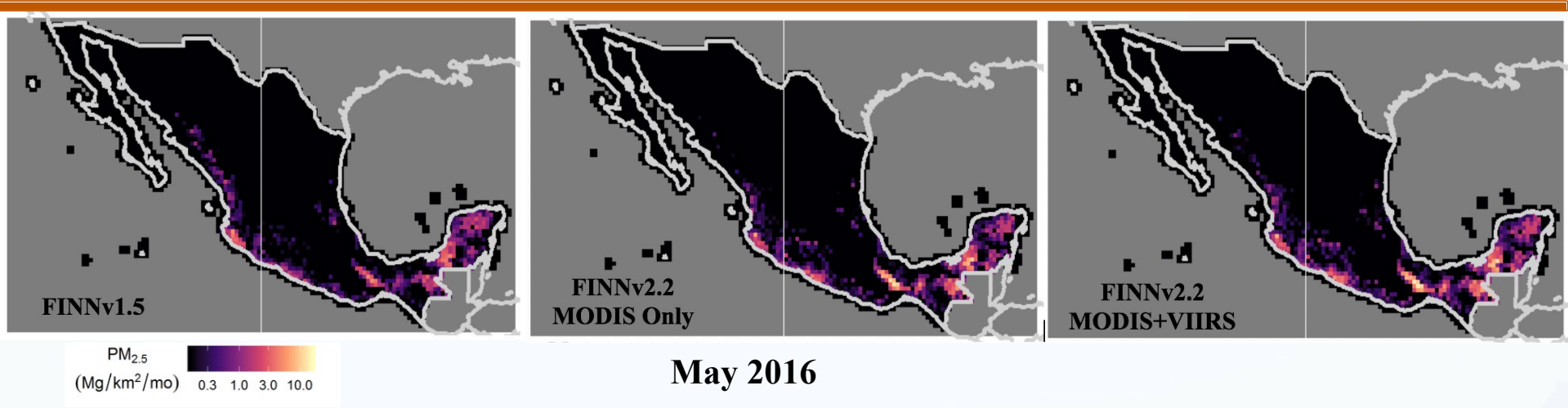


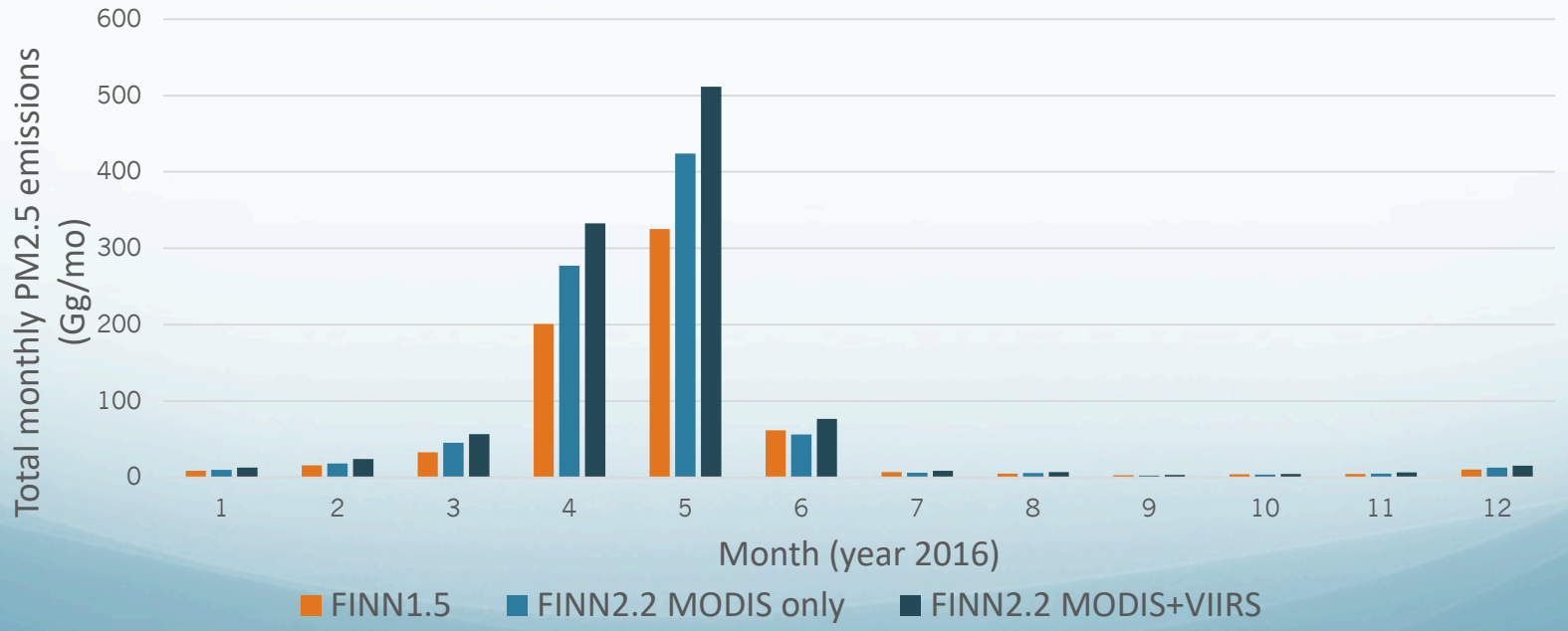


March 2016



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





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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