Scope of Work For

Project 14-011
Targeted Improvements in the Fire INventory from NCAR (FINN) Model for Texas Air Quality Planning

Prepared for

Air Quality Research Program (AQRP)
The University of Texas at Austin

by

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Overview

Wildland fires and open burning can be substantial sources of ozone precursors and particulate matter. The influence of fire events on air quality in Texas has been well documented by observational studies. During the 2012-2013 fiscal year of the Air Quality Research Program (AQRP), Dr. Elena McDonald-Buller, Dr. Christine Wiedinmyer, and Mr. Chris Emery led a project (#12-018) that evaluated the sensitivity of emissions estimates from the Fire INventory from NCAR (FINNv1; Wiedinmyer et al. 2011) to the variability in input parameters and the effects on modeled air quality using the Comprehensive Air Quality Model with Extensions (CAMx; ENVIRON, 2011). The project included an analysis of the climatology of fires in Texas and neighboring regions, comparisons of fire emission estimates between the FINN and BlueSky/SmartFire (Larkin 2009; Chinkin et al., 2009) modeling frameworks, evaluation of the sensitivity of FINN emissions estimates to key input parameters and data sources, and assessment of the effects of FINN sensitivities on Texas air quality. Among the many findings of the study were the needs for targeted improvements in land cover characterization, burned area estimation, fuel loadings, and emissions factors. These needs were particularly pronounced in areas with agricultural burning. This project addresses specific improvements in FINN that will support fire emissions estimates for Texas and the next public release of the FINN model. Fire emissions and air quality modeling will focus on 2012 to support TCEQ's air quality planning efforts.

Technical Context and Motivation

The influence of fire emissions on ozone and particulate matter concentrations in Texas has been documented in previous observational studies by Junquera er al., 2005; Morris et al., 2006; McMillan et al., 2010; Villanueva-Fierro et al., 2009. Fire emissions are often transported over regional or longer spatial scales and can contribute to exceedances of air quality standards. Accurate characterization of these events is necessary for understanding their influences on measured ambient concentrations, providing a weight of evidence for exceptional event exclusions, conducting air quality modeling for planning and attainment demonstrations, and estimating North American Background (NAB) ozone concentrations used to inform policy decisions regarding the National Ambient Air Quality Standards (NAAQS). Most climate models suggest that droughts will become more severe in the southwestern United States as climate changes in response to increased concentrations of greenhouse gases and other radiative forcing species in the atmosphere (U.S. Global Change Research Report, 2009). An increase in future drought frequency in Texas and the southwestern United States may have complex and profound effects on the occurrence of fires.

During the 2012-2013 AQRP fiscal year, our team completed a project, entitled *The Effects of Uncertainties in Fire Emissions Estimates on Predictions of Texas Air Quality*, which evaluated the sensitivity of emissions estimates from FINN to variability in input parameters and effects on modeled ozone and particulate matter concentrations during the spring and late summer/fall of 2008 using CAMx v5.41. The project included: (1) analysis of an 11-year climatology of fires in Texas, the central and western United States, Mexico and Central America, and western Canada using FINN; (2) comparison of fire emissions estimates between the FINN and BlueSky/SmartFire modeling frameworks; (3) evaluation of the sensitivity of FINN emissions estimates to emission factors, land cover classification, fuel loadings, and fire detection and area burned estimates; and (4) evaluation of FINN sensitivities on air quality using CAMx. Sensitivity studies conducted using different input data sources for FINN highlighted the potential variability in predictions of fire emissions; effects were season and region dependent, could exceed a factor of two, and have substantial impacts on CAMx predictions of ozone and fine particulate matter concentrations.

Objectives

This project will make specific improvements in FINN that will support fire emissions estimates for Texas air quality planning and the next public release of the FINN model. The project has four major objectives:

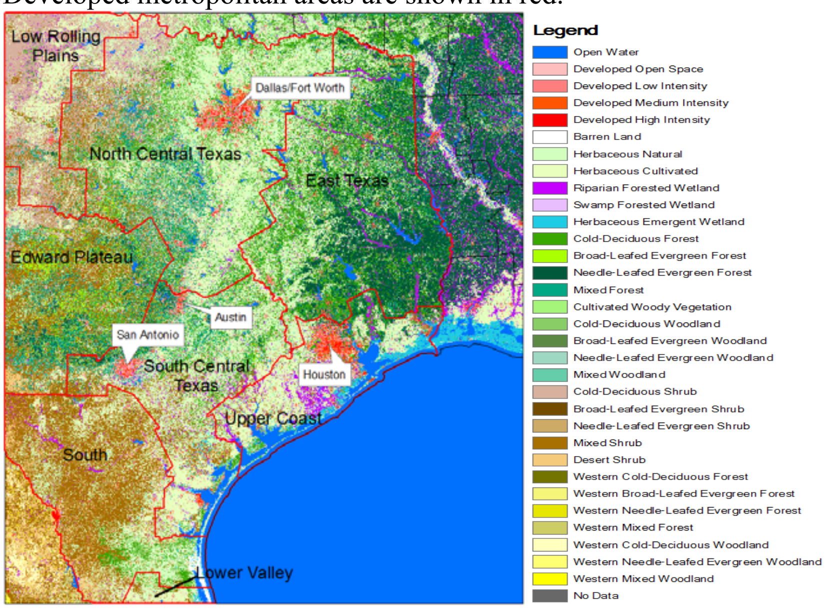
(1) Application of regionally-specific land cover data for Texas and its neighboring states;
(2) Mapping of croplands and assignment of fuel loading estimates and emissions factors;
(3) Investigation of an emerging data resource for fire detection and burned area estimation;

(4) Investigation of the partitioning of NO_x emissions to NO_z to account for rapid NO_x oxidation in hot, rising fire plumes at sub-grid scales.

The effects of the improvements in the FINN model on ozone and fine particulate matter concentrations will be evaluated using CAMx. Project tasks are described below.

Task 1. Regional Land Cover Characterization (UT with peer review from ENVIRON)
This work will apply land cover data specific to Texas, as an alternative to global scale land cover mapping from the MODIS LCT product, which is the FINN default, or the GlobCover product, which was investigated in AQRP project #12-018. We anticipate using a database from Popescu et al. (2011), shown in Figure 1, which has been developed for biogenics emissions modeling in Texas. To the extent possible, regional land cover data for neighboring states will also be applied in FINN. We expect to work in collaboration with the Texas Commission on Environmental Quality (TCEQ) to ensure that the most recent land cover data development efforts in Texas are considered and to establish potential land cover data resources and contact information for appropriate agencies in other states.

Figure 1. Thirty-six land cover/land use types in eastern Texas (Source: Popescu et al., 2011) with boundaries of Texas climate divisions (Source: National Oceanic and Atmospheric Administration). Developed metropolitan areas are shown in red.



Task 2. Mapping of Croplands (UT with peer review from ENVIRON)
The current representations of croplands in FINN and other global fire models lack specificity in distinguishing crop types and assignment of parameters important for fire emissions estimates. A mapping of crop types will be developed for incorporation in the FINN land cover database for the United States and to the extent possible neighboring countries. A literature search along with direct contact of individuals in the research community will be used to identify relevant data resources for cropland characterization and assignment of crop-specific emissions factors and fuel loadings in FINN. A promising candidate is the publicly available EarthStat (http://www.earthstat.org/) initiative. EarthStat is a collaborative effort between the University of Minnesota's Institute on the Environment-Global Landscapes Initiative and McGill University's Land Use and the Global Environment Laboratory that focuses on global agricultural landscapes.

Task 3. Estimation of Burned Area (UT and ENVIRON)

FINN currently assumes an upper limit of 1 km^2 for area burned in its default configuration, except for fires located in grasslands and savannas, which are assigned a burned area of 0.75 km^2 (Wiedinmyer et al., 2006; Al-Saadi et al., 2008). This burned area is scaled in accordance with the percent bare cover in the MODIS Vegetation Continuous Fields (VCF) product (e.g., in a forested area with 10% bare cover, the area burned is assumed to be 0.9 km^2). This work will consider two alternative resources. A potential source of fire activity data may be available from the Western Regional Air Partnership (WRAP) Fire Emissions Tracking System (FETS; http://deasco3.wraptools.org/), a web-enabled database tool for planned and unplanned fire events, which is intended for daily smoke management coordination and retrospective analyses such as emission inventories and regional haze air quality planning tasks. The team will investigate the availability of fire activity data from FETS for the 2012 year. An emerging data resource is the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor onboard the National Aeronautics and Space Administrations (NASA's) National Polar-orbiting Operational Environmental Satellite System Preparatory Project (NPP) platform that launched on October 28, 2011. The VIIRS active fire product will be explored as a resource for fire detections (http://npp.gsfc.nasa.gov/viirs.html). The VIIRS product is currently available for September through December of 2012; this resource may become useful should TCEQ wish to expand the time period of its current CAMx modeling in 2012 and for future air quality modeling efforts.

Task 4. Sub-grid scale Partitioning of NO_x Emissions to NO_z in Fire Plumes (ENVIRON)

Observational research via surface and aircraft monitoring indicate mixed ozone impacts from fires (Jaffe and Wigder, 2012). Yet, chemical transport models, including CAMx and the CMAQ, consistently show large surface ozone impacts from fire sources; a factor that may contribute to discrepancies between modeled and observed ozone impacts includes the representation of chemical processes from the immediate injection of fresh fire emission to large grid cells. In some modeling applications (Alvarado et al., 2010), direct local ozone impacts from large fires have been addressed by partitioning fresh NO_x emissions to aged (oxidized) NO_z forms (e.g., HNO_3 and PAN) to account for rapid NO_x oxidiation in fire plumes when their sizes are well below grid scales. In this project, photochemical modeling will be used to investigate ozone sensitivity to various approaches to partition NO_x emissions to NO_z compounds. Approaches will include simple proportions of NO_x to various forms of NO_z across all fire types and sizes, stratifying NO_x partitioning by fire type to account for different relative levels of NO_x and VOC emissions, and stratifying NO_x partitioning by fire size to account for different time scales for plume rise prior to injection into the grid system. On the basis of these results, recommendations will be developed for future fire plume speciation techniques and/or explicit chemistry modeling, such as those necessary for plume-in-grid techniques currently in use for large anthropogenic NO_x point sources.

Task 5. CAMx Sensitivity Studies (UT and ENVIRON)

In order to support TCEQ's air quality planning efforts, fire emission estimates will be developed for the entire year of 2012. Sensitivity studies will be conducted using CAMx v6.10 (ENVIRON, 2014) for the June 2012 episode consistent with current TCEQ developments. The success of the CAMx simulations will be contingent on communication with and assistance from the TCEQ, as well as transfer of all necessary data files and scripts for predictions of ozone and fine particulate matter concentrations from the TCEQ to the project team. Model performance evaluation for this newly developed modeling episode is beyond the scope and will not be considered in this effort.

Schedule

The project is composed of 6 major components. The proposed project schedule is presented in Table 1.

Table 2. Schedule of project activities

ID	Task	Apr-May 2014	June-July 2014	Aug-Sept. 2014	Oct.-Nov. 2014	Dec. 2014-Jan-2015	Feb.-Mar. 2015	Apr.-May 2015	June 2015
1	Regional Land Cover Characterization	X	X	X					
2	Mapping of Croplands		X	X	X	X			
3	Fire Detection and Estimation of Burned Area		X	X	X	X			
4	Sub-grid scale Partitioning of NO_x Emissions to NO_z in Fire Plumes			X	X	X			
5	CAMx Sensitivity Studies				X	X	X	X	
6	Reporting	X	X	X	X	X	X	X	X

Deliverables

AQRP requires certain reports to be submitted on a timely basis and at regular intervals. A description of the specific reports to be submitted and their due dates are outlined below. One report per project will be submitted (collaborators will not submit separate reports), with the exception of the Financial Status Reports (FSRs). The lead PI will submit the reports, unless that responsibility is otherwise delegated with the approval of the Project Manager. All reports will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. Report templates and accessibility guidelines found on the AQRP website at http://aqrp.ceer.utexas.edu/ will be followed.

Executive Summary

At the beginning of the project, an Executive Summary will be submitted to the Project Manager for use on the AQRP website. The Executive Summary will provide a brief description of the planned project activities, and will be written for a non-technical audience.
Due Date: Friday, May 30, 2014

Quarterly Reports

The Quarterly Report will provide a summary of the project status for each reporting period. It will be submitted to the Project Manager as a Word doc file. It will not exceed 2 pages and will be text only. No cover page is required. This document will be inserted into an AQRP compiled report to the TCEQ.

Due Dates:

Report	Period Covered	Due Date
Quarterly Report #1	June, July, August 2014	Friday, August 30, 2014
Quarterly Report #2	September, October, November 2014	Monday, December 1, 2014
Quarterly Report #3	December 2015, January & February 2015	Friday, February 27, 2015
Quarterly Report #4	March, April, May 2015	Friday, May 29, 2015
Quarterly Report #5	June, July, August 2015	Monday, August 31, 2015
Quarterly Report #6	September, October, November 2015	Monday, November 30, 2015

Technical Reports
Technical Reports will be submitted monthly to the Project Manager and TCEQ Liaison as a Word doc using the AQRP FY14-15 MTR Template found on the AQRP website.
Due Dates:

Report	Period Covered	Due Date
Technical Report #1	Project Start – July 31, 2014	Friday, August 8, 2014
Technical Report #2	August 1 - 31, 2014	Monday, September 8, 2014
Technical Report #3	September 1 - 30, 2014	Wednesday, October 8, 2014
Technical Report #4	October 1 - 31, 2014	Monday, November 10, 2014
Technical Report #5	November 1 - 30 2014	Monday, December 8, 2014
Technical Report #6	December 1 - 31, 2014	Thursday, January 8, 2015
Technical Report #7	January 1 - 31, 2015	Monday, February 9, 2015
Technical Report #8	February 1 - 28, 2015	Monday, March 9, 2015
Technical Report #9	March 1 - 31, 2015	Wednesday, April 8, 2015
Technical Report #10	April 1 - 28, 2015	Friday, May 8, 2015
Technical Report #11	May 1 - 31, 2015	Monday, June 8, 2015

Financial Status Reports
Financial Status Reports will be submitted monthly to the AQRP Grant Manager (Maria Stanzione) by each institution on the project using the AQRP FY14-15 FSR Template found on the AQRP website.
Due Dates:

Report	Period Covered	Due Date
FSR #1	Project Start – July 31, 2014	Friday, August 15, 2014
FSR #2	August 1 - 31, 2014	Monday, September 15, 2014
FSR #3	September 1 - 30, 2014	Wednesday, October 15, 2014
FSR #4	October 1 - 31, 2014	Monday, November 17, 2014
FSR #5	November 1 - 30 2014	Monday, December 15, 2014
FSR #6	December 1 - 31, 2014	Thursday, January 15, 2015
FSR #7	January 1 - 31, 2015	Monday, February 16, 2015
FSR #8	February 1 - 28, 2015	Monday, March 16, 2015
FSR #9	March 1 - 31, 2015	Wednesday, April 15, 2015
FSR #10	April 1 - 28, 2015	Friday, May 15, 2015
FSR #11	May 1 - 31, 2015	Monday, June 15, 2015
FSR #12	June 1 - 30, 2015	Wednesday, July 15, 2015
FSR #13	Final FSR	Wednesday, August 15, 2015

Draft Final Report
A Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will include an Executive Summary. It will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources.
Due Date: Monday, May 18, 2015

Final Report
A Final Report incorporating comments from the AQRP and TCEQ review of the Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources.
Due Date: Tuesday, June 30, 2015

Project Data
All project data will be submitted to the AQRP Project Manager within 30 days of project completion. This archive for the project will include all land cover data, fire detection/burned area data, input/job scripts/output for fire emissions modeling with FINN, input/job scripts/output for air quality modeling with CAMx, and software files associated with the analysis and presentation of results in the final report. The data will be submitted in a format that will allow AQRP or TCEQ or other outside parties to utilize the information. All data will be submitted for inclusion in the AQRP archive at the Texas Advanced Computing Center (TACC) and retained for seven years.

AQRP Workshop
A representative from the project will present at the AQRP Workshop in June 2015.

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