TECHNICAL MEMORANDUM

AIR SCIENCES INC.
DENVER • PORTLAND

MODIFICATIONS TO THE DEASCO$_3$ FIRE EMISSIONS INVENTORY METHODOLOGY

PREPARED BY: Matthew Mavko, Air Sciences Inc.

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This technical memorandum summarizes the changes made to the fire emissions inventory (EI) methodology from the DEASCO$_3$ project[1]. Modifications included corrections to activity processing and acreage estimations for satellite-detected fires, as well as enhancements to the emissions calculations.

Fire Activity Modifications

Domain Boundary Correction

The CAMx model[2] for this project uses a gridded domain in projected space that covers all of the Contiguous United States (CONUS), southern Canada, and Northern Mexico. For version a of the 2008 EI, coordinates for this domain were stored in the WRAPTools database only at the four corners in unprojected space. When converting to the modeling domain projection to classify burns as inside or outside the domain boundary, therefore, it drew virtual curved lines following the lines of latitude and longitude of the corner coordinates. This resulted in burns being erroneously excluded from Canada and included from Mexico (the longitudinal errors did not make a difference as they were well off the coasts of North America).

This problem was corrected in version b of the 2008 EI and version a of the 2011 EI by defining coordinates at a regular spacing along the entire boundary of the domain, such that projecting the coordinates correctly defined a rectangle.

Minimum Fire Size Modification

Minimum fire sizes for satellite-detected fires were defined for several areas of the CONUS based on ground-reported burns for those regions. The minimum size was adjusted upward (from 10 to 40 acres) based on a further review of detection limits of the remote sensing instruments used for fire detection.

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[1] https://wraptools.org/pdf/ei_methodology_20130930.pdf

[2] https://wraptools.org/pdf/DEASCO3_Model_RunSpec_CAMx_SA_Base08c_03_11_2013.pdf

Orphaned Fires Reconciliation

Final QA/QC of the 2008 EI revealed some minor inconsistencies in the way the final inventory files were queried from the WRAPTools database, which caused burns included in the daily files to be excluded from the hourly files. These queries were reconciled to prevent this "orphaning" from happening.

Fire Emissions Calculations Modifications

NO_2 Emission Factor Assignment

Emission factors for several trace gases are assigned by biomass type (as defined in Akagi et al., 2011)[3] to fire events. During the final QA/QC of fire EI 2008b, a coding error was discovered in the database that prevented NO_2 emission factors from assigning properly (all fire events were assigned the EF for biomass type 3, crop residue). This error was corrected, which resulted in a slight decrease in NO_2 emissions for wildland fires in the 2008 EI (the correction was applied prior to exporting the 2011a EI).

Levoglucosan

Emission estimates for levoglucosan were developed for the PMDETAIL project, and were included in fire EIs 2008b and 2011a.

Akagi et al. (2011) includes the most comprehensive list of emission factors (EFs) for trace gases related to biomass burning. EFs were reported by seven major biomass types, which were preserved in the WRAPTools emissions database and are used to classify fire events.

EFs for levoglucosan are available in recent literature from laboratory experiments. Sullivan et al (2008)[4] reported the most recent and comprehensive set of EFs for levoglucosan to date, synthesizing chamber and stack measurements, reported as a ratio to organic carbon (OC). This table is copied as Table 2 at the end of this section, for reference. Data from this table were assigned a biomass type in addition to the fuel type assigned by Sullivan. EFs from both stack and chamber studies were averaged according to biomass type or by fuel type, as follows:

- For savanna (grassland) and crop residue/pasture, all EFs with fuel type "G" (grasses) were averaged (both stack and chamber EFs)

[3] Akagi, S. K., Robert J. Yokelson, C. Wiedinmyer, M. J. Alvarado, J. S. Reid, T. Karl, J. D. Crounse, and P. O. Wennberg. "Emission factors for open and domestic biomass burning for use in atmospheric models." *Atmospheric Chemistry and Physics* 11, no. 9 (2011): 4039-4072.

[4] Sullivan, A. P., A. S. Holden, L. A. Patterson, G. R. McMeeking, S. M. Kreidenweis, W. C. Malm, W. M. Hao, C. E. Wold, and J. L. Collett. "A method for smoke marker measurements and its potential application for determining the contribution of biomass burning from wildfires and prescribed fires to ambient PM2. 5 organic carbon." Journal of Geophysical Research: Atmospheres (1984–2012) 113, no. D22 (2008).

- For peatland, all EFs with fuel type "D" (duff) were averaged (both stack and chamber EFs)
- For all other biomass types, all EFs of the same "code" (Table 2, column 1) were averaged (both stack and chamber EFs)

Table 1 below summarizes the resulting averaged EFs by biomass type. Note that there is no distinction made between flaming and smoldering combustion phases; the same EFs were applied to all combustion phases in the EI.

Table 1. Summary of levoglucosan emission factors from Sullivan et al (2008) mapped to biomass types as defined by Akagi et al (2011).

	code	**biomasstypeid**	**biomasstypename**	**mg levoglucosan / mg OC**
	r	1	Tropical Forest	-
**	G	2	Savanna	0.069
**	G	3	Crop Residue	0.069
**	G	4	Pasture Maintenance	0.069
	b	5	Boreal Forest	0.098
	t	6	Temperate Forest	0.085
	x	7	Extratropical Forest	0.063
**	D	8	Peatland	0.114
	c	9	Chaparral	0.064
		0	Non-fuel area	0.000

** Uses Fuel Type in Table 2, column 5 instead of Code in column 1

Table 2. Levoglucosan to OC Ratios for all the Experiments Involving the Burning of an Individual Component of a Fuel (adapted from Sullivan et al, 2008)[5]

Code	Fuel	Stack Levoglucosan/OC (mg levoglucosan/mg OC)	Chamber Levoglucosan/OC (mg levoglucosan/mg OC)	Fuel Type
b	Alaskan Duff	0.131	0.113266667	D
x	Black Needle Rush (FL)		0.079	G

[5] The ratios are presented in units of mg levoglucosan/mg OC. The ratios have been separated into stack and chamber burns. If available, in parenthesis by the fuel name is the location from where the fuel was obtained.

Code	Fuel	Stack Levoglucosan/OC (mg levoglucosan/mg OC)	Chamber Levoglucosan/OC (mg levoglucosan/mg OC)	Fuel Type
b	Black Spruce (AK)		0.072	N
b	Black Spruce, dried (AK)	0.083		N
b	Black Spruce, fresh (AK)	0.079		N
c	Ceanothus (CA)	0.054	0.052	L
c	Chamise (CA)	0.043	0.0405	L
c	Chamise, dried (CA)	0.063		L
c	Chamise, dried (CA)	0.106		B
c	Chamise, fresh (CA)	0.059		L
c	Chamise, fresh (CA)	0.104		B
t	Fir, dried (MT)	0.027		N
t	Fir, dried (MT)	0.072		B
t	Fir, fresh (MT)	0.050		N
x	Gallberry (MS)	0.036	0.029	L
s	Grass, dried (MT)	0.041		G
s	Grass, fresh (MT)	0.020		G
x	Hickory (NC)	0.038		L L
c	Juniper (UT)		0.016	L
x	Kudzo (GA)	0.025		L
t	Lodgepole Pine Needle Duff (MT)	0.135		D
t	Lodgepole Pine, dead/small (MT)	0.187		B
t	Lodgepole Pine, fresh (MT)	0.054		N
x	Longleaf Pine (MS)	0.072		N
c	Manzanita (CA)	0.088	0.081	L
c	Manzanita, dried (CA)	0.032		L
c	Manzanita, fresh (CA)	0.050		L
c	Manzanita, fresh (CA)	0.113		B
x	Oak (NC)	0.063		L
x	Palmetto (FL)	0.038	0.068	L

Code	Fuel	Stack Levoglucosan/OC (mg levoglucosan/mg OC)	Chamber Levoglucosan/OC (mg levoglucosan/mg OC)	Fuel Type
x	Palmetto (FL coastal)	0.074	0.025	L
x	Palmetto (FL inland)	0.047		L
x	Palmetto (MS)	0.079	0.059	L
x	Phragmites (LA)	0.074		G
t	Ponderosa Pine Duff	0.077	0.061	D
t	Ponderosa Pine, dead/large (MT)	0.128		B
t	Ponderosa Pine, dead/small (MT)	0.076		B
t	Ponderosa Pine, fresh (MT)	0.036		N
t	Ponderosa Pine, fresh/large (MT)	0.090		B
t	Ponderosa Pine, fresh/small (MT)	0.088		B
	Puerto Rican Fern		0.070	L
	Puerto Rican Mixed Woods		0.128	B
x	Rhododendron (NC)		0.101	L
	Rice Straw (Taiwan)	0.0748	0.079	S
c	Sage (MT)	0.041		L
c	Sage (UT)	0.016		L
x	Saw Grass (LA)	0.041		G
	Southern Pine, dried		0.099	N
x	Titi (FL)	0.050		L
x	Turkey Oak (NC)	0.047		L
x	Wax Myrtle (FL)		0.056	L
x	Wax Myrtle (MS)	0.059		L
b	White Spruce (AK)		0.133	N
x	Wiregrass (FL)		0.200	G
x	Wiregrass (MS)	0.171		G