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Reputation Resources Results



Application of an Emission Inventory GIS-Based Tool Across the Michigan/Ontario Border

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Introduction



- Present the application of an Emission Inventory GIS-based software system (EIGIS) across an area containing Detroit, Michigan and south-western Ontario.
- Goal: Determine how EIGIS could be used to improve the current emission inventories for transboundary modelling applications.



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Background



- EIGIS is a software system that computes emission inventories for area and mobile sources using a bottom-up (attribute layer) approach.
- Developed under a multi-phase contract for Environment Canada to aid in the computation of national emission inventories.
- Based upon ESRI ArcGIS technology.



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Background Why?



- In modelling, the spatial allocation of emissions can be as important as the emission themselves.
- Emission processors (e.g., SMOKE), convert national EIs into hourly, spatially allocated (gridded) emissions.
- AQ models (e.g., CMAQ) replicate the transport and chemical transformation of pollutants emitted to the atmosphere.
- These models are only as good as their inputs!

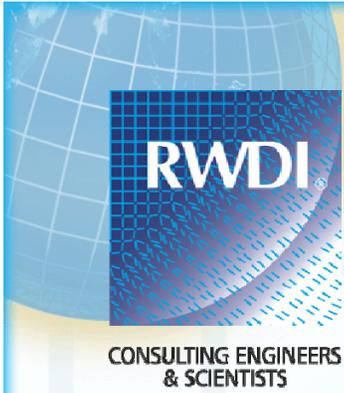


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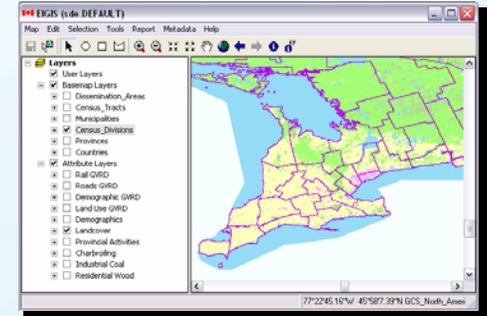
Background



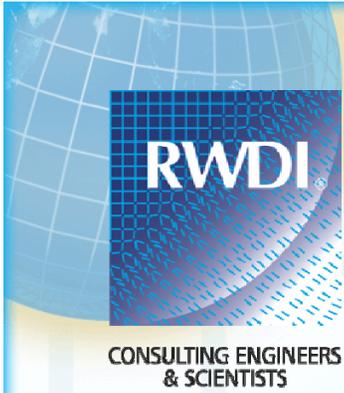
- Work performed under two independent projects that shared a number of common goals.
- US EPA: evaluate different means of computing emissions, with a 2002 NEI benchmark, in three source sectors and 10 counties in Detroit area.
- Environment Canada: assess and improve existing, provincially aggregated 2002 CAC EI for seven sectors and 6 census divisions in SW Ontario.



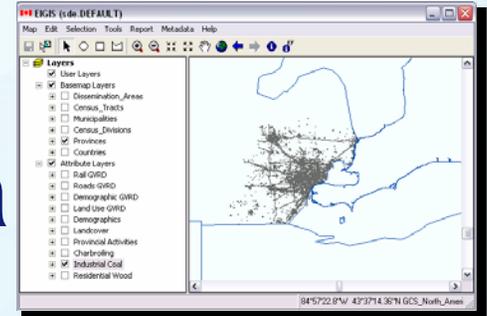
Current Techniques South-Western Ontario



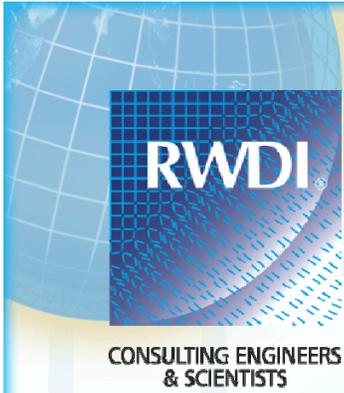
- Asphalt Plants
- Ferrous
- Non-Ferrous Foundries
- Industrial and commercial boilers
- Commercial wood burning
- Agricultural burning
- Residential garbage burning
- Garbage burning at landfills



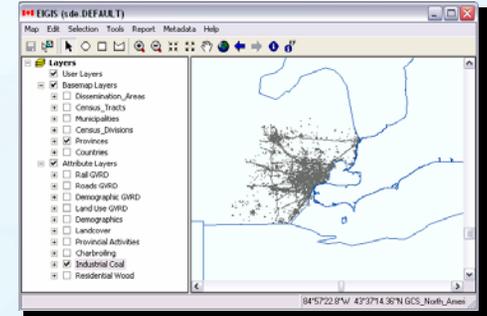
Current Techniques Detroit Metropolitan Area



- Residential Wood Combustion
 - Fireplaces and woodstoves
- Industrial Fuel Combustion – Coal
 - Industrial coal burning of anthracite and bituminous/sub-bituminous coals
- Charbroiling
 - Meat cooking at commercial restaurants



EIGIS Methodology (Detroit Specific)



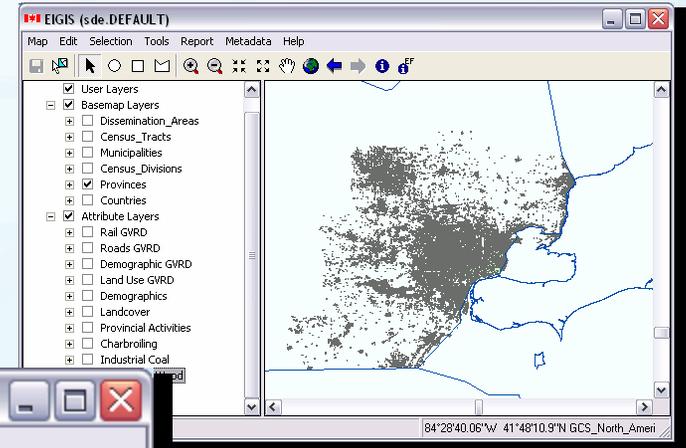
Concentrate on Detroit...

- Step 1: Obtain GIS Data
- Step 2: Obtain Activity Data
- Step 3: Obtain Emission Factors
- Step 4: Input into EIGIS
- Step 5: Have EIGIS Compute the EI
- Step 6: Plot EI in EIGIS for QA
- Step 7: Export to Model-ready Input Files (SMOKE ORL format)



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EIGIS Methodology GIS Data

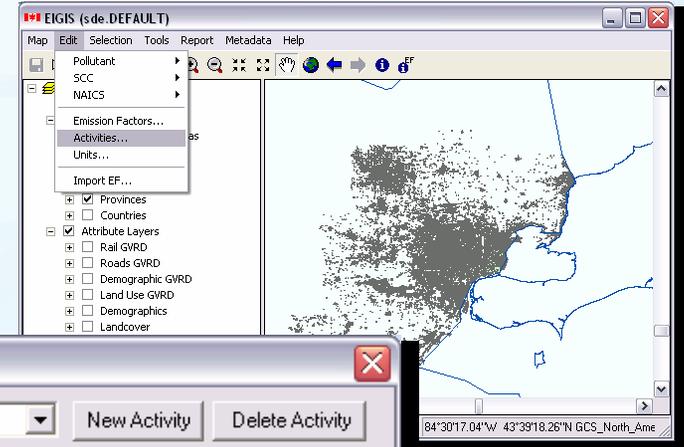


	COUNTY	NAME	Fireplaces	Non_EPA_Fireplac	Non_Catalytic_Fire	Catalytic_Fireplac	Woodstoves	Catalytic_Woods	Non_Catal
▶	049	GENESEE	3765.967	8703.899	539.2633	217.5975	6222.333	155.5583	385.5141
	087	LAPEER	1520.11	7165.805	443.9684	179.1451	12611.19	315.2798	781.3455
	091	LENAWEE	1846.916	8706.37	539.4164	217.6593	15322.45	383.0613	949.3257
	093	LIVINGSTON	1208.337389	2792.70840995	173.02649931	69.81771024	1996.48	49.912	123.695
	099	MACOMB	6568.364460	15180.79870173	940.54948478	379.51996754	10852.61	271.3151	672.3897
	115	MONROE	1158.132702	2676.67537837	165.83749626	66.91688445	1913.529	47.83823	118.5556
	125	OAKLAND	10090.28064	23320.64858448	1444.86627099	583.01621461	16671.71	416.7926	1032.921
	147	ST. CLAIR	1376.261	3180.812	197.0721	79.52031	2273.932	56.8483	140.8849
	161	WASHTENAW	2688.022085	6212.55449998	384.90826793	155.31386249	4441.295	111.0324	275.1672
	163	WAYNE	16942.95375	39158.54120646	2426.12700953	978.96353016	27994.06	699.8515	1734.415



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EIGIS Methodology Activity Data



Activity Editor

Activity Name: Residential Wood Non EPA Fireplaces New Activity Delete Activity

Units: tons New Units

Description: Tons of wood burned within non-EPA fireplaces.

Attribute Layers:	Fields:	Values (first 50 unique):
Demographic GVRD	AREA_KM2	2676.67537837
Land Use GVRD	COUNTY	2792.70840995
Rail GVRD	NAME	3180.812
Roads GVRD	Fireplaces	6212.55449998
Demographics	Non_EPA_Fireplaces	7165.805
Landcover	Non_Catalytic_Fireplaces	8703.899
Provincial Activities	Catalytic_Fireplaces	8706.37
Charbroiling	Woodstoves	15180.79870173
Industrial Coal	Catalytic_Woodstoves	23320.64858448
Residential Wood	Non_Catalytic_Woodstoves	39158.54120646

Populate All Values

Formula:
ACTIVITY = [RESIDENTIAL_WOOD:Non_EPA_Fireplaces]

Clear Formula Check Syntax

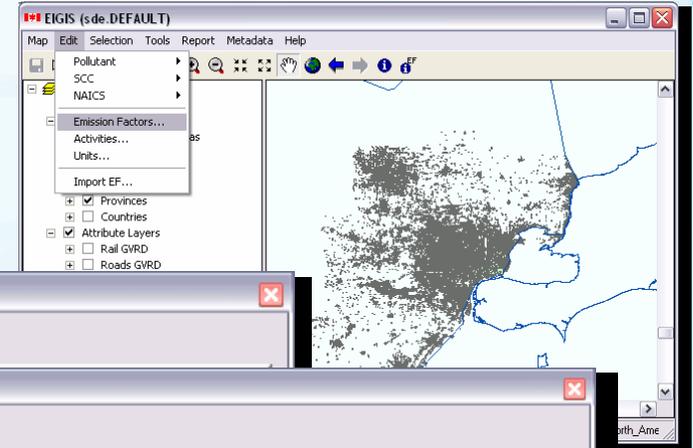
Save Activity Calculate Activity... Close

Calculator buttons: =, !=, >, <, >=, <=, +, -, *, /, IF THEN



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EIGIS Methodology Emission Factors



Emission Factors

Definition Editor

Feature Layer: Residential Wood

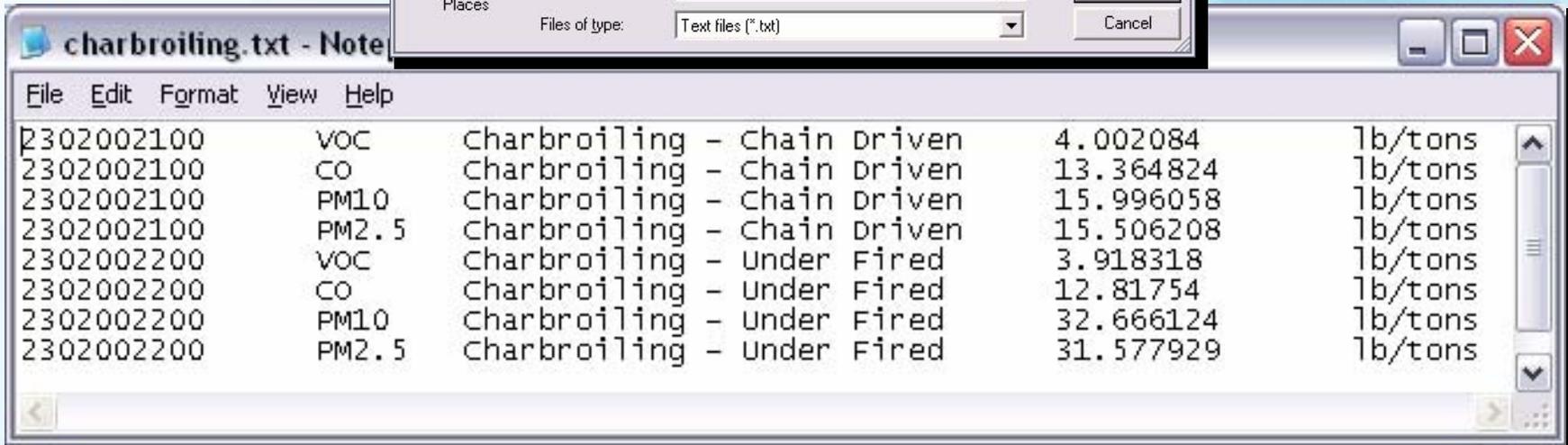
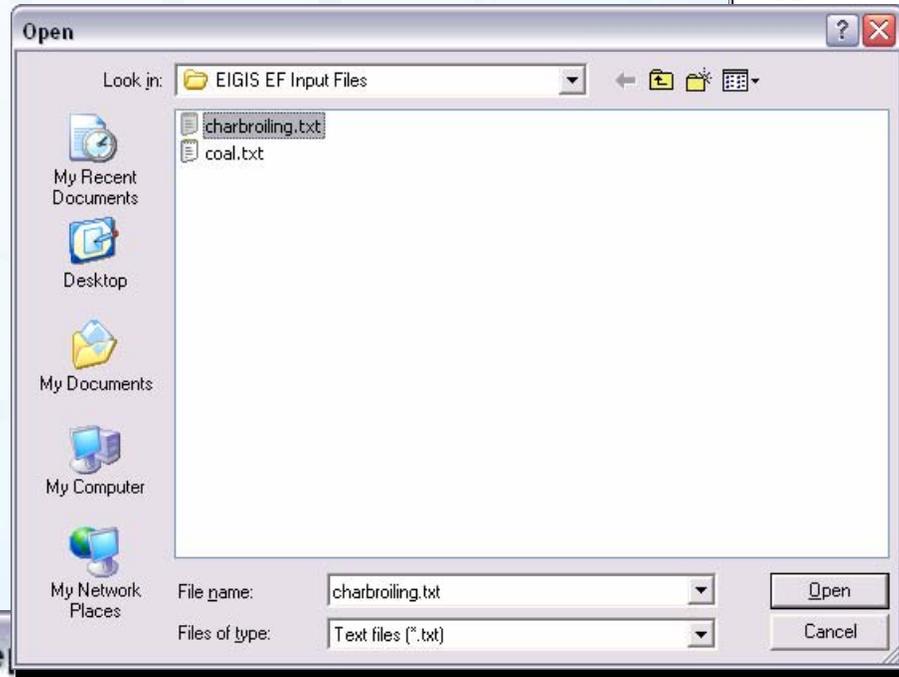
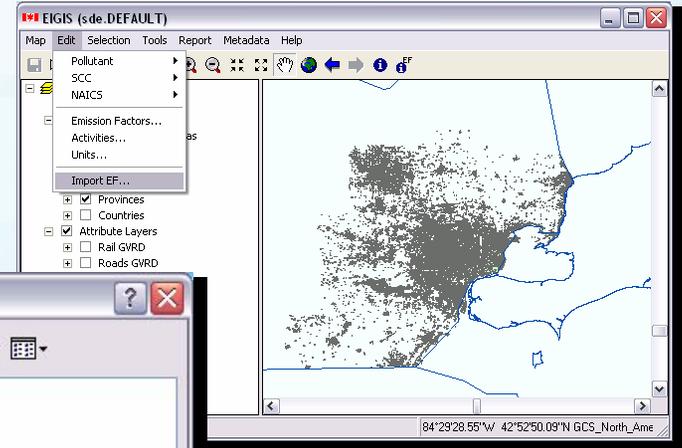
Selected	NAME	Non_EPA_Firepla	Woodstoves	EF	EF Unit	Activity	Pollutant Shortna	SCC Number
<input type="checkbox"/>	GENESEE	8703.899	6222.333	30.6	lb/tons	Residential Wood N	PM10	2104008002
<input type="checkbox"/>	GENESEE	8703.899	6222.333	30.6	lb/tons	Residential Wood N	PM2.5	2104008002
<input type="checkbox"/>	GENESEE	8703.899	6222.333	0.4	lb/tons	Residential Wood N	SOx	2104008002
<input type="checkbox"/>	GENESEE	8703.899	6222.333	53	lb/tons	Residential Wood N	VOC	2104008002
<input type="checkbox"/>	GENESEE	8703.899	6222.333	2.8	lb/tons	Residential Wood N	NOx	2104008002
<input type="checkbox"/>	GENESEE	8703.899	6222.333	230.8	lb/tons	Residential Wood N	CO	2104008002
<input type="checkbox"/>	LAPEER	7165.805	12611.19	30.6	lb/tons	Residential Wood N	PM10	2104008002
<input type="checkbox"/>	LAPEER	7165.805	12611.19	30.6	lb/tons	Residential Wood N	PM2.5	2104008002
<input type="checkbox"/>	LAPEER	7165.805	12611.19	0.4	lb/tons	Residential Wood N	SOx	2104008002
<input type="checkbox"/>	LAPEER	7165.805	12611.19	53	lb/tons	Residential Wood N	VOC	2104008002
<input type="checkbox"/>	LAPEER	7165.805	12611.19	2.8	lb/tons	Residential Wood N	NOx	2104008002
<input type="checkbox"/>	LAPEER	7165.805	12611.19	230.8	lb/tons	Residential Wood N	CO	2104008002
<input type="checkbox"/>	LENAWEE	8706.37	15322.45	30.6	lb/tons	Residential Wood N	PM10	2104008002
<input type="checkbox"/>	LENAWEE	8706.37	15322.45	30.6	lb/tons	Residential Wood N	PM2.5	2104008002
<input type="checkbox"/>	LENAWEE	8706.37	15322.45	0.4	lb/tons	Residential Wood N	SOx	2104008002
<input type="checkbox"/>	LENAWEE	8706.37	15322.45	53	lb/tons	Residential Wood N	VOC	2104008002
<input type="checkbox"/>	LENAWEE	8706.37	15322.45	2.8	lb/tons	Residential Wood N	NOx	2104008002

Show All Columns Edit/New Units Edit/New Activity Export Save Delete Close Help



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EIGIS Methodology Input into EIGIS

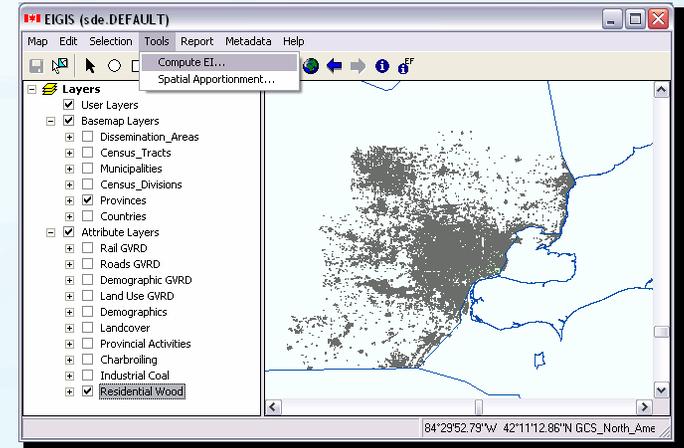




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EIGIS Methodology

Compute the EI



Compute EI

Please select the combination of Pollutants and Source Classification Codes (SCCs) for the selected features to be computed. By default, the pollutants and SCCs selected are those for which emissions do not exist. The pollutants and SCCs listed are those whose emission factors have been defined for the selected features.

Pollutants	SCCs
<input checked="" type="checkbox"/> CO - Carbon Monoxide - 630-08-0	<input checked="" type="checkbox"/> 2104008002 - Stationary Source Fuel Combustion
<input checked="" type="checkbox"/> NOx - Oxides of Nitrogen - n/a	
<input checked="" type="checkbox"/> PM10 - Particulate Matter less than or equal to 10	
<input checked="" type="checkbox"/> PM2.5 - Particulate Matter less than or equal to 2.5	
<input checked="" type="checkbox"/> SOx - Sulfur Dioxides - 7446-09-5	
<input checked="" type="checkbox"/> VOC - Volatile Organic Compounds - n/a	

Select All Deselect All Select Collection Select All Deselect All Select Collection

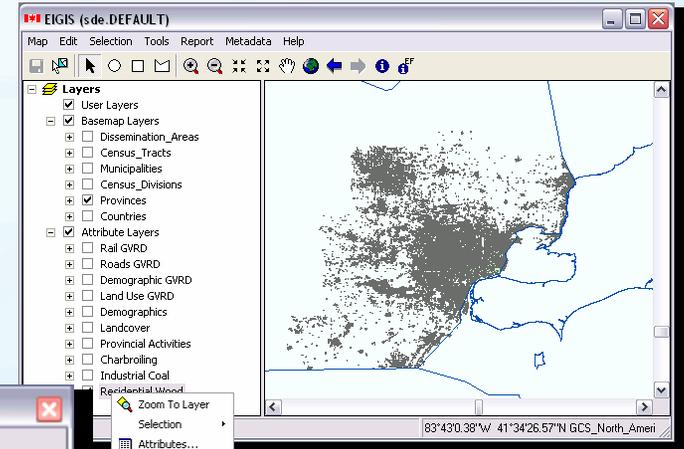
Compute EI Close



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EIGIS Methodology

Plot EI in EIGIS



Plot Emission Estimates

Please select a combination of one Pollutant and one Source Classification Code (SCC)

Pollutants

- CO - Carbon Monoxide - 630-08-0
- NOx - Oxides of Nitrogen - n/a
- PM10 - Particulate Matter less than or equal to 10 micrometers - 7446-09-5
- PM2.5 - Particulate Matter less than or equal to 2.5 micrometers - 7446-09-5
- SOx - Sulfur Dioxides - 7446-09-5
- VOC - Volatile Organic Compounds - n/a

EIGIS (sde.DEFAULT)

Map Edit Selection Tools Report Metadata Help

- Demographic GVRD
- Land Use GVRD
- Demographics
- Landcover
- Provincial Activities
- Charbroiling
- Industrial Coal
- Residential Wood

Emissions (Pollutant: PM10)

37.1520600322102 - 37.1
37.1520600322102 - 38.7
38.7625900911838 - 44.1
44.1494397602813 - 86.2
86.2298056767679 - 99.4
99.4608534491892 - 120.
120.809486565089 - 120.
120.843783865793 - 210.
210.708384461259 - 323.
323.688910206321 - 543.

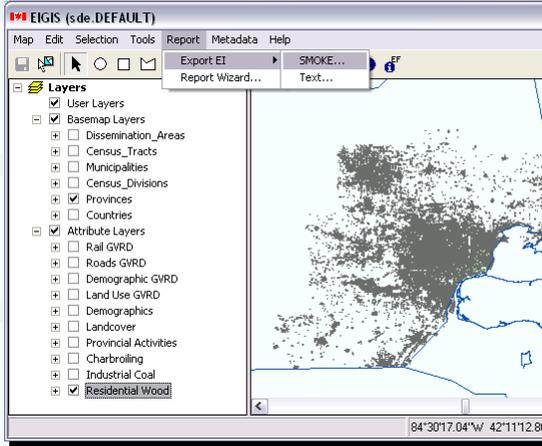
84°30'41.28"W 42°43'8.21"N GCS_North_Ameri



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EIGIS Methodology

Export to Model-ready Input Files



Report - Export EI - SMOKE

Header Information

Year: Description:

Pollutants

Short Name	Full Name	CAS
<input type="checkbox"/> PFC	Perfluorocompound	355-42-0
<input checked="" type="checkbox"/> PM10	Particulate Matter less than or equal t...	n/a
<input checked="" type="checkbox"/> PM2.5	Particulate Matter less than or equal t...	n/a
<input type="checkbox"/> SF6	Sulfur Hexafluoride	2551-62-4
<input type="checkbox"/> SOx	Sulfur Dioxides	7446-09-5

Source Classification Codes

Type	SCC	Level1	Level2	Level3	Level4
<input type="checkbox"/> AREA	2104008000	Stationary Source Fu...	Residential	Wood	Total: Woodst...
<input type="checkbox"/> AREA	2104008001	Stationary Source Fu...	Residential	Wood	Fireplaces: Ge
<input checked="" type="checkbox"/> AREA	2104008002	Stationary Source Fu...	Residential	Wood	Fireplaces: Ins
<input type="checkbox"/> AREA	2104008003	Stationary Source Fu...	Residential	Wood	Fireplaces: Ins
<input type="checkbox"/> AREA	2104008004	Stationary Source Fu...	Residential	Wood	Fireplaces: Ins

Output File

File Format

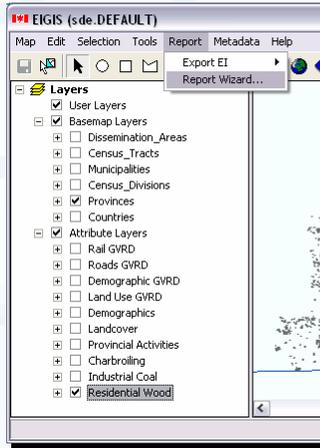
ORL IDA

RWDI

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EIGIS Methodology

Export to Model-ready Input Files



The "Summary" dialog box is displayed, showing the following configuration:

- Summarize Report By: Area Sources
- Report Layer: Provinces
Canada-->26 Michigan
- Layer Fields:
PROVINCE_SHORTNAME
PROVINCE_ID
- SCCs:
2104008002
- Pollutants:
PM2.5
PM10
- Backcast/Forecast Options:
Current Emission Inventory Year: 2000
- Output Units: tonnes

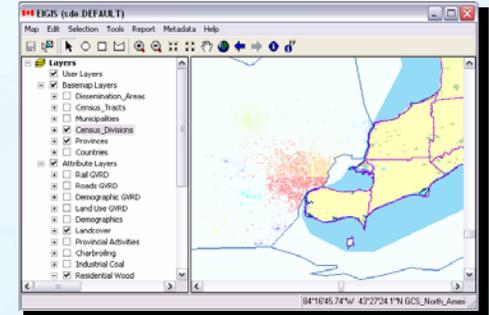
Buttons at the bottom of the dialog include "<< Previous", "Export", and "Close".

Below the dialog box, the software interface shows a list of selected items: WHO-TEQ, World Health, n/a. At the bottom of the window, there are buttons for "Show: Selected", "Unselected", and "All" (selected), along with "Select All", "Deselect All", "Invert Selection", "<< Previous", "Next >>", and "Cancel".



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Conclusions



- EIGIS easily adopted in the US - no code changes!
- EIGIS is effective for both high-resolution bottom-up and simple top-down techniques.
- EIGIS is effective for automating the calculation and exporting of emissions into SMOKE model-ready input files (IDA or ORL).
- Mapping feature a useful QA tool within EIGIS.
- Emissions could be further improved by incorporating higher resolution land use information with a larger number of land use types.



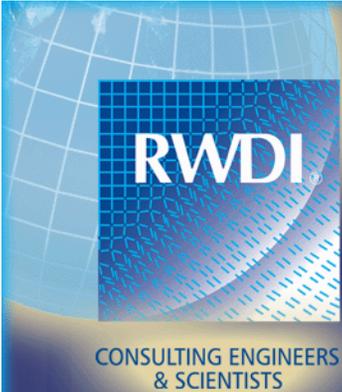
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Ideas for the Future



- Phase III (ongoing development...)
 - Incorporate pre-computed point sources
 - Test more robust distributed environments
 - More post-processing / analysis tools
 - National EI calculations (pre-populated)
 - Integrated reconciliation functionality
- Additional testing for different geographies
- Test ability to improve emission estimates by incorporating higher resolution land use data with a larger number of land use types



Reputation Resources Results



Acknowledgments

- ESRI Canada
- U.S. EPA, Emission Inventory Group
- Environment Canada, Pollution Data Division
- Environment Canada, Pacific & Yukon Region
- Greater Vancouver Regional District
- BC Ministry of Environment

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