Mapping Methods

Environmental exposures

CAREX CANADA

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General overview of methods for outdoor air quality maps

Ambient air concentrations were estimated for each residential census block in Canada using publicly available data. Background concentrations in outdoor air were estimated based on data from the National Air Pollution Surveillance (NAPS) monitoring stations. Depending on the substance, the background concentrations were modified based on source concentrations from known emitters such as airplanes, trains, cars & trucks, and industry. Substance specific details are reported in the following section as data and potential concentrations vary by substance.

All maps were created using data at the census block level. Mean values within the census blocks were aggregated for each health region. This provides an average exposure value for each health region in Canada.

General overview of methods for pesticides and radon

For our pesticide and radon maps, alternate methods were used to more appropriately estimate their concentrations in the environment.

Pesticides (2,4-D, chlorothalonil, and glyphosate)

The potential population-level exposure in Canada was estimated for three commonly applied pesticides that are suspected carcinogens (2,4-dichlorophenoxyacetic acid (2,4-D), glyphosate, and chlorothalonil). Pesticide exposure was estimated for every census subdivision in Canada and reports the kilograms of pesticides applied per square kilometre of agricultural land. Residents living near agricultural areas may have a higher potential pesticide exposure.

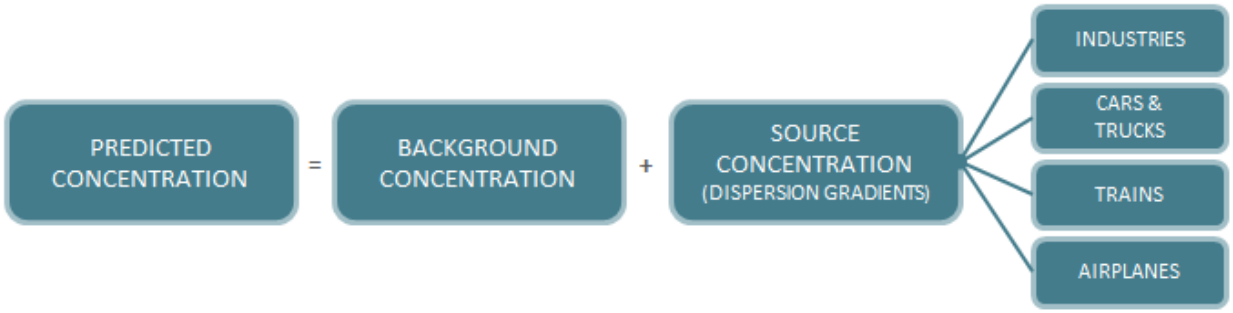
Radon

The radon map uses data from the Cross Canada Radon Survey (Phase I & II) and displays the percentage of homes that tested about the guideline of 200 Bq/m^3 by health region.

More details on the methods and data for all substances can be found in the following section.

1,3-Butadiene

Concentrations of 1,3-butadiene in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of 1,3-butadiene emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
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Identifying Dispersion Gradients for Roads, Rails, Large Industries and Airports

INDUSTRIES

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TRAINS

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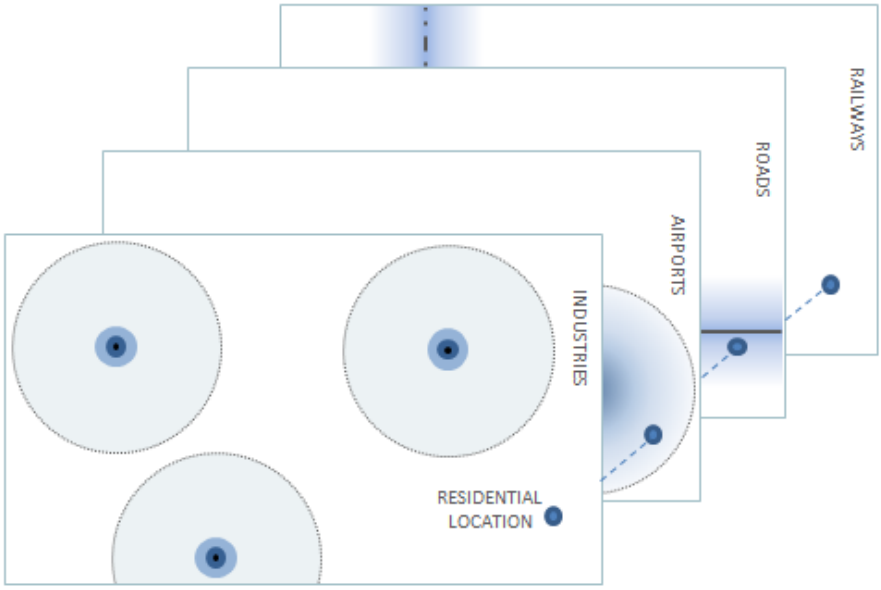
Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Benzene	Highways/Major roads	3.25[1,2,3,4]	50[3,5,6]
	Local Roads	1.5[1,2,3,4]	50[3,5,6]
1,3-Butadiene	Highways	4.0[6]	75[6]
Ethylbenzene	Highways	3.7[2,7,8]	300[8]
	Major Roads	2.2[2,7,8]	300[8]
	Local Roads	1.4[2,7,8]	300[8]

References:
1. Hellen H, Hakola H, Pirjola L, Laurila T, Pystynen KH. (2006). Ambient air concentrations, source profiles, and source apportionment of 71 different C2â^' C10 volatile organic compounds in urban and residential areas of Finland. Environ Sci Technol 40(1):103-108.
2. Parra M, Elustondo D, Bermejo R, Santamaria J. (2009). Ambient air levels of volatile organic compounds (VOC) and nitrogen dioxide (NO2) in a medium size city in northern Spain. Sci Total Environ 407(3):999-1009.

3. Thorsson S, Eliasson IÄ. (2006). Passive and active sampling of benzene in different urban environments in Gothenburg, Sweden. Water, Air, & Soil Pollution 173(1):39-56.
4. Vardoulakis S, Gonzalez-Flesca N, Fisher B. (2002). Assessment of traffic-related air pollution in two street canyons in Paris: Implications for exposure studies. Atmos Environ 36(6):1025-1039.
5. Beckerman B, Jerrett M, Brook JR, Verma DK, Arain MA, Finkelstein MM. (2008). Correlation of nitrogen dioxide with other traffic pollutants near a major expressway. Atmos Environ 42(2):275-290.
6. Venkatram A, Isakov V, Seila R, Baldauf R. (2009). Modeling the impacts of traffic emissions on air toxics concentrations in Paris: implications for exposure studies. Atmos Environ 43 (20): 3191-3199. 7. Roukos J, Riffault V, Locoge N, Plaisance H. (2009). VOC in an urban and industrial harbor on the French North Sea coast during two contrasted meteorological situations. Environmental Pollution 157(11):3001-3009.
8. Wang P, Zhao W. (2008). Assessment of ambient volatile organic compounds (VOCs) near major roads in urban Nanjing, China. Atmos Res 89(3):289-297.

Applying Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby airport and road. There are no industries or railways close enough to add to the predicted concentration.

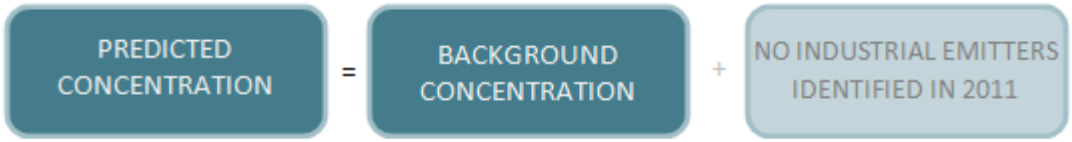
Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations , for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
- No independent monitoring was available or conducted to evaluate how well the predicted concentrations match actual measured levels. The results presented are best used to make regional comparisons, and should not be used to assess regulatory compliance.
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

2,3,7,8-Tetrachlorodibenzo-para-dioxin

Concentrations of 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD) in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors. No industrial emitters for 2011 were identified. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.

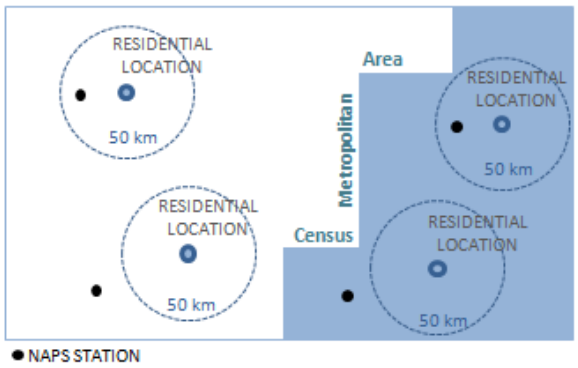


Other sources of TCDD emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Determining Concentrations at Residential Locations

No industries reporting emissions of 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD) to air were identified in the National Pollutant Release Inventory (NPRI) for 2011.

Concentrations at residential locations are assigned using measured levels from National Air Pollution (NAPS) monitors using the following rules:



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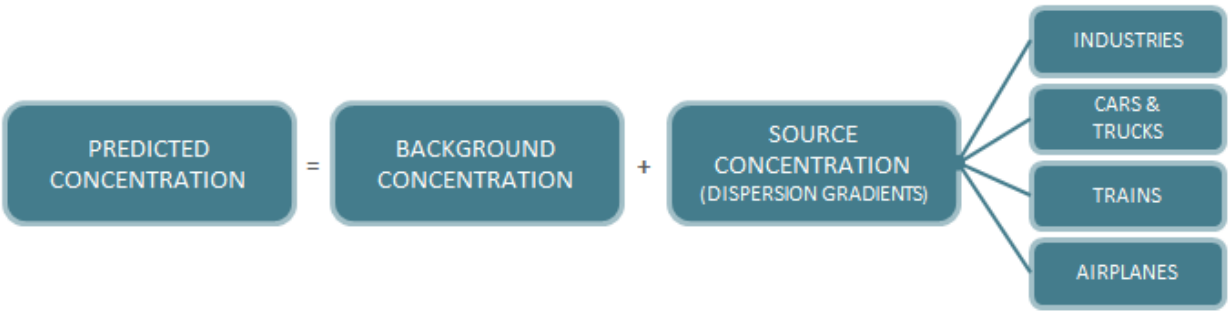
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.

Acetaldehyde

Concentrations of acetaldehyde in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of acetaldehyde emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

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Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
	Major roads	2.6 [2]	200
	Rail	1.15	200 [3]
Formaldehyde	Highways	2.0 [1,4]	200 [1]
	Major roads	1.4 [2]	200 [1]
	Rail	1.15	200 [3]
Diesel Exhaust [5]	Highways	4.0 [4]	189 [4]
	Major roads	2.8 [2]	189 [4]
	Rail	1.15	200 [3]
Metals	Highways	2.9 [4]	161 [4]
Arsenic	Major roads	2.0 [2]	161 [4]
Cadmium,	Rail	1.15	200 [3]
Hexavalent Chromium			
Lead			
Nickel			
Polycyclic Aromatic Hydrocarbons [6]	Highways	4.0 [4]	189 [4]
Benz[a]anthracene	Major roads	2.8 [2]	189 [4]
Benzo[b]fluoranthene	Rail	1.15	200 [3]
Benzo[k]fluoranthene			
Benzo[a]pyrene			
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Indeno(1,2,3-cd)pyrene			

References:

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6. We assume polycyclic aromatic hydrocarbons are mainly bound to ultra-fine particles in outdoor air, based on: Miguel et al (2004). Seasonal variation of the particle size distribution of polycyclic aromatic hydrocarbons and of major aerosol species in Claremont, California. Atmosphere Environment 38 (20) pp 3241-3251.)) Gradients are therefore based on those identified for ultrafine particles.

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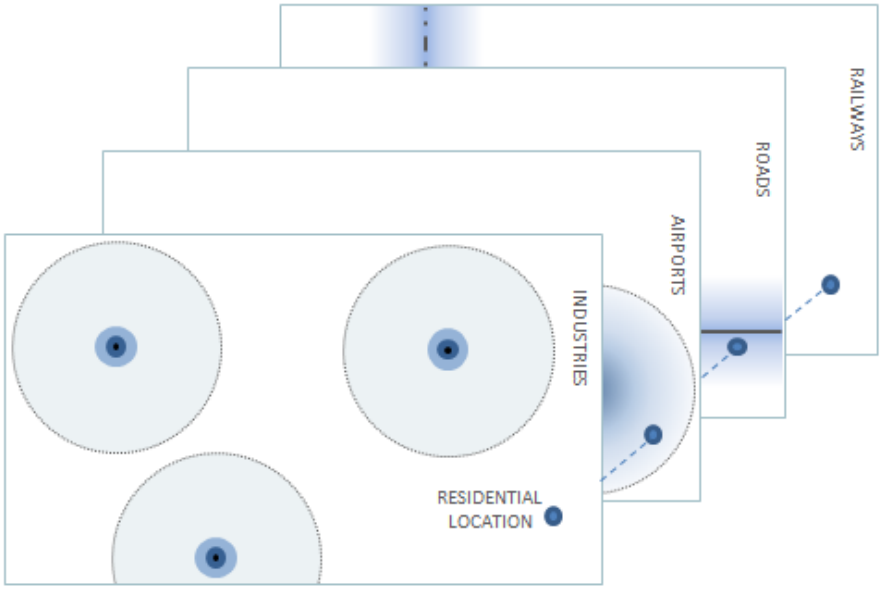

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Arsenic

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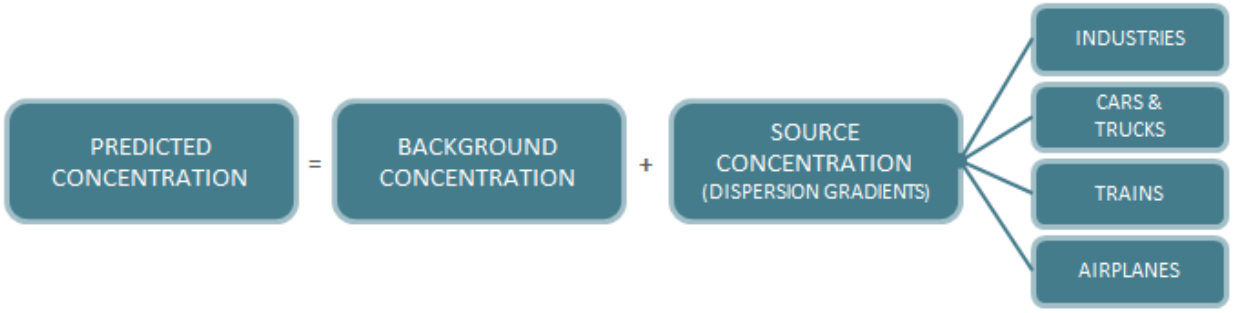

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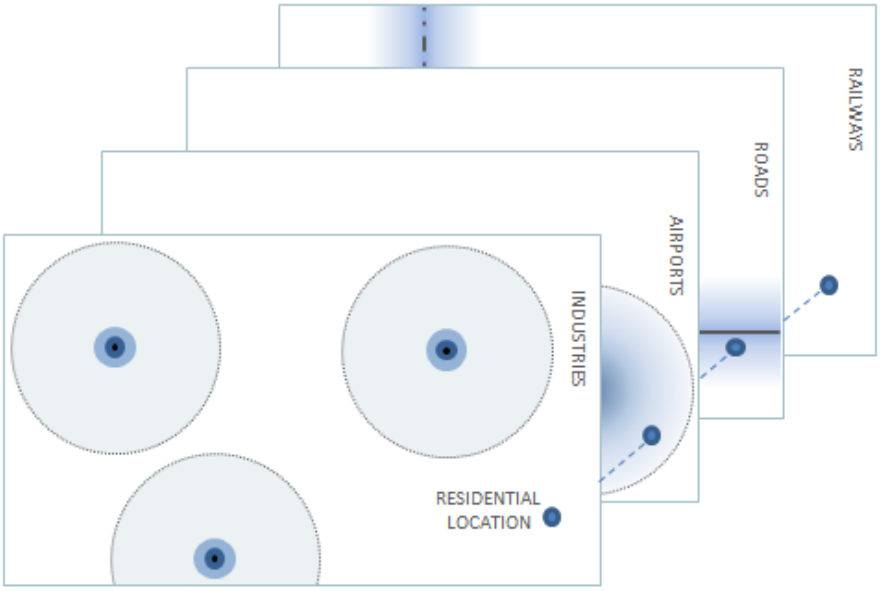

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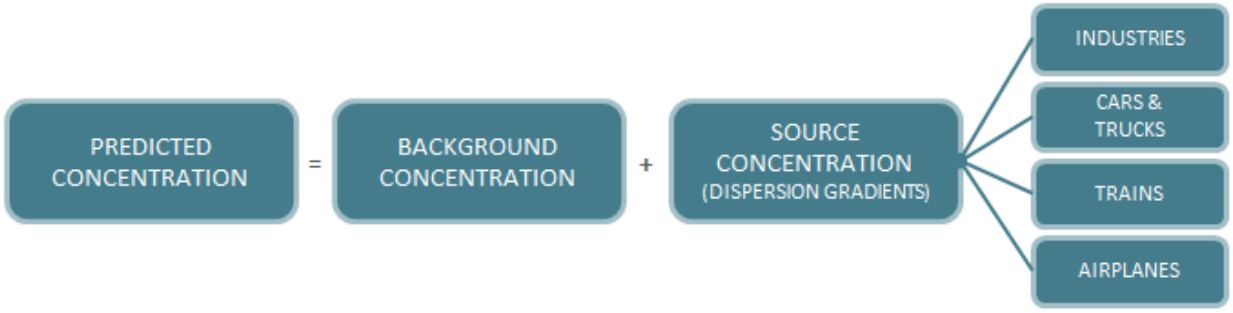

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CARS & TRUCKS

We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS

We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

AIRPLANES

We used a screening level dispersion model (SCREEN3), to estimate concentrations around medium and large airports based on estimated emissions. The model estimates worst-case ground level concentrations from emissions. Estimates were produced up to 5000m from airports. Emissions from airports were estimated using landing/take-off volumes at each airport and aircraft emission factors specific to each substance.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Benzene	Highways/Major roads Local Roads	3.25[1,2,3,4] 1.5[1,2,3,4]	50[3,5,6] 50[3,5,6]
1,3-Butadiene	Highways	4.0[6]	75[6]
Ethylbenzene	Highways Major Roads Local Roads	3.7[2,7,8] 2.2[2,7,8] 1.4[2,7,8]	300[8] 300[8] 300[8]

References:

1. Hellen H, Hakola H, Pirjola L, Laurila T, Pystynen KH. (2006). Ambient air concentrations, source profiles, and source apportionment of 71 different C2âˆ’ C10 volatile organic compounds in urban and residential areas of Finland. Environ Sci Technol 40(1):103-108.
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3. Thorsson S, Eliasson IÄ. (2006). Passive and active sampling of benzene in different urban environments in Gothenburg, Sweden. Water, Air, & Soil Pollution 173(1):39-56.
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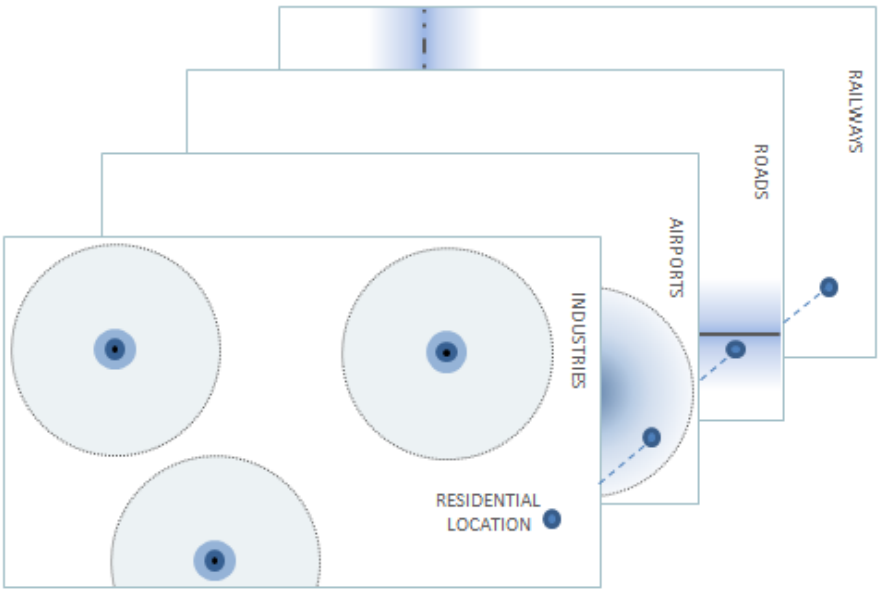
5. Beckerman B, Jerrett M, Brook JR, Verma DK, Arain MA, Finkelstein MM. (2008). Correlation of nitrogen dioxide with other traffic pollutants near a major expressway. Atmos Environ 42(2):275-290.
6. Venkatram A, Isakov V, Seila R, Baldauf R. (2009). Modeling the impacts of traffic emissions on air toxics concentrations in Paris: implications for exposure studies. Atmos Environ 43 (20): 3191-3199. 7. Roukos J, Riffault V, Locoge N, Plaisance H. (2009). VOC in an urban and industrial harbor on the French North Sea coast during two contrasted meteorological situations. Environmental Pollution 157(11):3001-3009.
8. Wang P, Zhao W. (2008). Assessment of ambient volatile organic compounds (VOCs) near major roads in urban Nanjing, China. Atmos Res 89(3):289-297.

Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby airport and road. There are no industries or railways close enough to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations , for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
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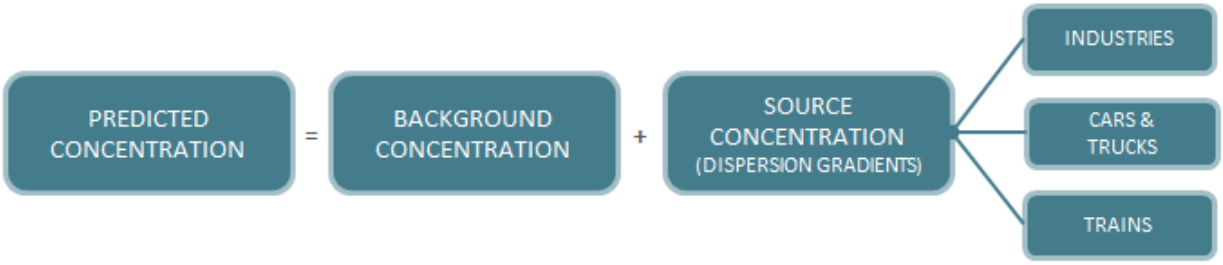
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Benzo[a]pyrene

Concentrations of benzo[a]pyrene in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of benzo[a]pyrene emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
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Identifying Dispersion Gradients for Roads, Rails and Large Industries

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

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TRAINS

We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

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Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
	Major roads	2.6 [2]	200
	Rail	1.15	200 [3]
Formaldehyde	Highways	2.0 [1,4]	200 [1]
	Major roads	1.4 [2]	200 [1]
	Rail	1.15	200 [3]
Diesel Exhaust [5]	Highways	4.0 [4]	189 [4]
	Major roads	2.8 [2]	189 [4]
	Rail	1.15	200 [3]
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Arsenic	Major roads	2.0 [2]	161 [4]
Cadmium,	Rail	1.15	200 [3]
Hexavalent Chromium			
Lead			
Nickel			
Polycyclic Aromatic Hydrocarbons [6]	Highways	4.0 [4]	189 [4]
Benz[a]anthracene	Major roads	2.8 [2]	189 [4]
Benzo[b]fluoranthene	Rail	1.15	200 [3]
Benzo[k]fluoranthene			
Benzo[a]pyrene			
Chrysene			
Indeno(1,2,3-cd)pyrene			

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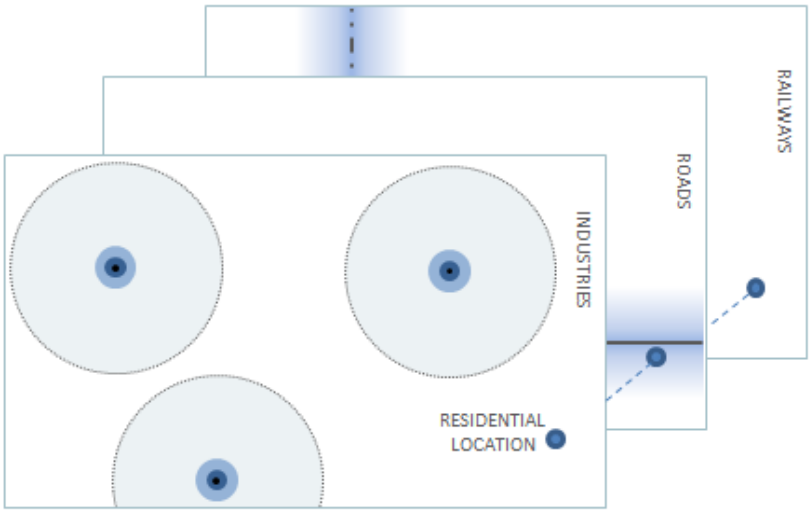
Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby road. There are no industries or railways close enough to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

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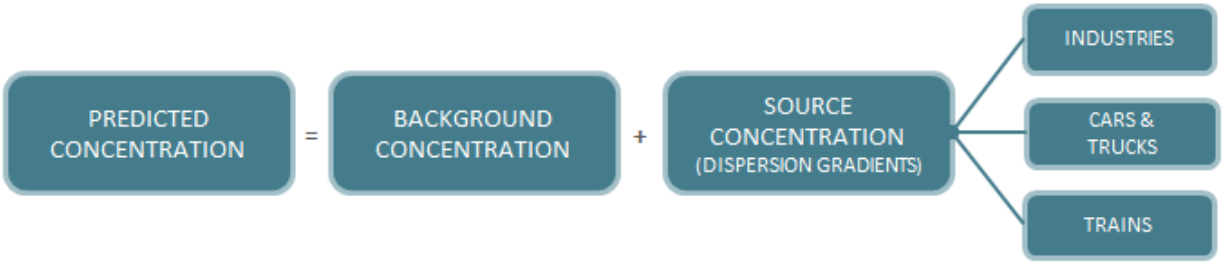
Benzo[b]fluoranthene

Concentrations of benzo[b]fluoranthene in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of benzo[b]fluoranthene emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

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Identifying Dispersion Gradients for Roads, Rails and Large Industries

INDUSTRIES

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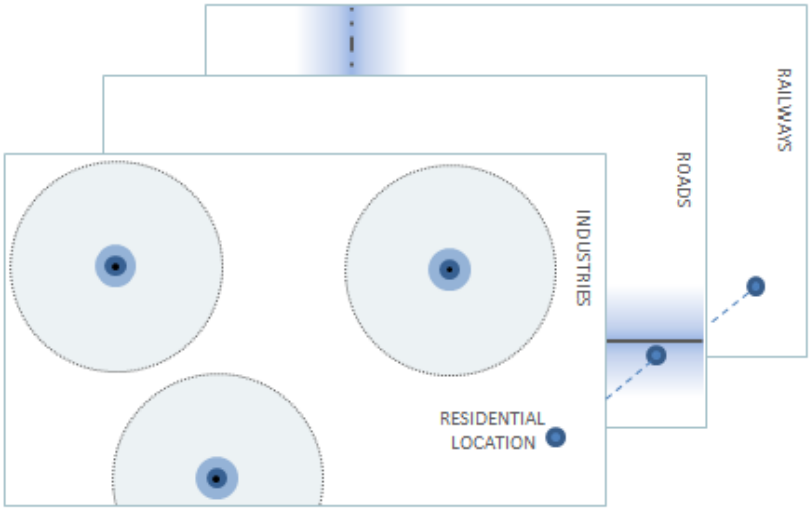
Applying the Dispersion Gradients to Residential Locations



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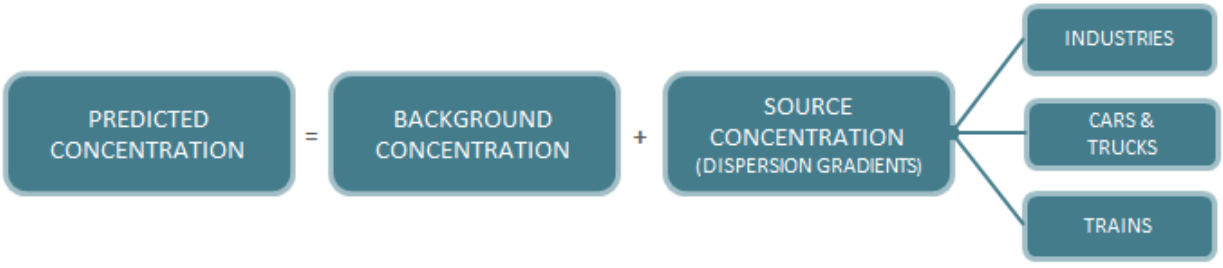

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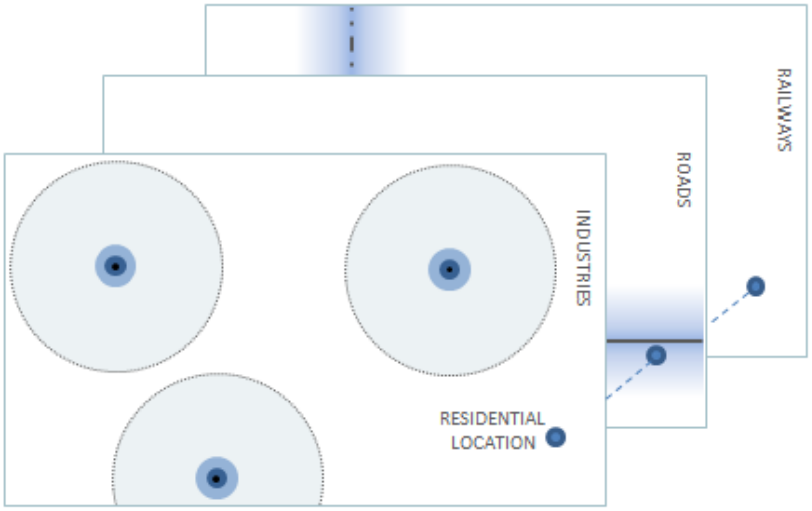

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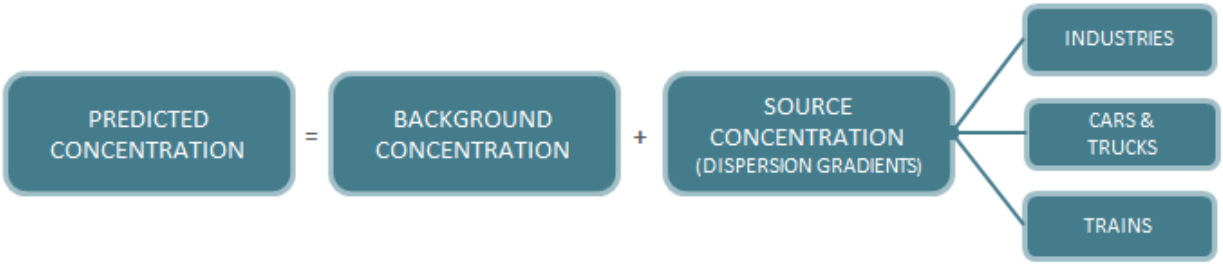
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Benz[a]anthracene

Concentrations of benz[a]anthracene in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of benz[a]anthracene emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
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Identifying Dispersion Gradients for Roads, Rails and Large Industries

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

CARS & TRUCKS

We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS

We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
	Major roads	2.6 [2]	200
	Rail	1.15	200 [3]
Formaldehyde	Highways	2.0 [1,4]	200 [1]
	Major roads	1.4 [2]	200 [1]
	Rail	1.15	200 [3]
Diesel Exhaust [5]	Highways	4.0 [4]	189 [4]
	Major roads	2.8 [2]	189 [4]
	Rail	1.15	200 [3]
Metals	Highways	2.9 [4]	161 [4]
Arsenic	Major roads	2.0 [2]	161 [4]
Cadmium, Hexavalent Chromium	Rail	1.15	200 [3]
Lead			
Nickel			
Polycyclic Aromatic Hydrocarbons [6]	Highways	4.0 [4]	189 [4]
Benz[a]anthracene	Major roads	2.8 [2]	189 [4]
Benzo[b]fluoranthene	Rail	1.15	200 [3]
Benzo[k]fluoranthene			
Benzo[a]pyrene			
Chrysene			
Indeno(1,2,3-cd)pyrene			

References:

1. Viskari, E., Vartiainen, M., Pasanen, P. (2000). Seasonal and diurnal variation in formaldehyde and acetaldehyde concentrations along a highway in Eastern Finland. Atmospheric Environment; 24(6): 917-923.

2. When gradients were not available for major roads, the gradient increase was set at 70% of the associated pollutant increase documented at highways. This percentage was based on the ratio of average traffic volumes for major roads and highways. (Setton et al (2005). Road Classification Schemes – Good Indicators of Traffic Volume? UVIC SSL Working Paper 05-014 http://www.cher.ubc.ca/UBCBAQS/SSL05-014-TRAFFIC.pdf)

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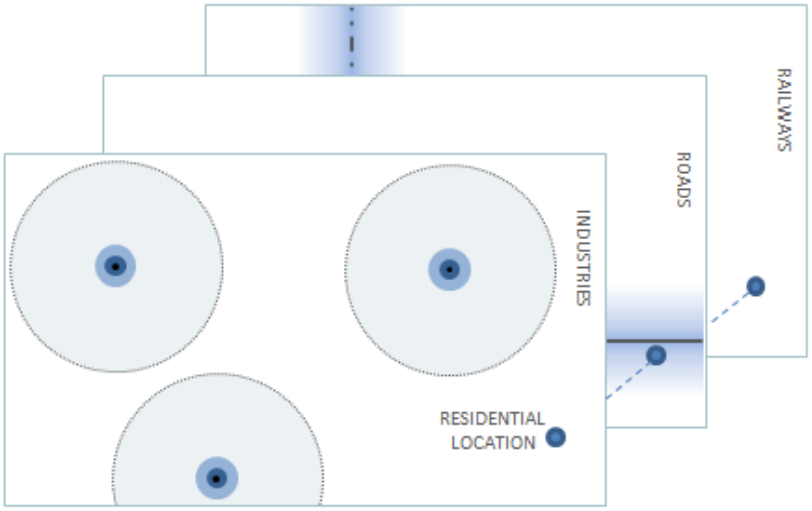
apportionment of fine particle air pollutants in Southeastern United States using solvent-extractable organic compounds as tracers. Environmental Science and Technology, 36(11):2361-2371. (d) Wu, C.F., Wu, S.Y., Wu, Y.H. et al. (2009). Cancer risk assessment of selected hazardous air pollutants in Seattle. Environment International, 35(3), 516-522.
6. We assume polycyclic aromatic hydrocarbons are mainly bound to ultra-fine particles in outdoor air, based on: Miguel et al (2004). Seasonal variation of the particle size distribution of polycyclic aromatic hydrocarbons and of major aerosol species in Claremont, California. Atmosphere Environment 38 (20) pp 3241-3251.)) Gradients are therefore based on those identified for ultrafine particles

Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby road. There are no industries or railways close enough to add to the predicted concentration.

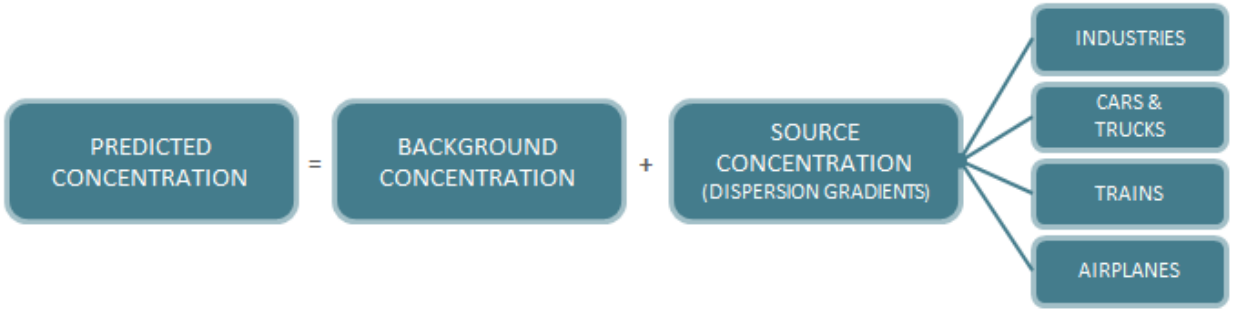
Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations , for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
- No independent monitoring was available or conducted to evaluate how well the predicted concentrations match actual measured levels. The results presented are best used to make regional comparisons, and should not be used to assess regulatory compliance.
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Cadmium

Concentrations of cadmium in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of cadmium emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
- For all locations in Non-Census Metropolitan Areas and more than 50 km from a NAPS monitoring station, the overall annual average from all rural NAPS stations in Canada is assigned as background.

Identifying Dispersion Gradients for Roads, Rails, Large Industries and Airports

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

CARS & TRUCKS

We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS

We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

AIRPLANES

We used a screening level dispersion model (SCREEN3), to estimate concentrations around medium and large airports based on estimated emissions. The model estimates worst-case ground level concentrations from emissions. Estimates were produced up to 5000m from airports. Emissions from airports were estimated using landing/take-off volumes at each airport and aircraft emission factors specific to each substance.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
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Cadmium, Hexavalent Chromium	Rail	1.15	200 [3]
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Nickel			
Polycyclic Aromatic Hydrocarbons [6]	Highways	4.0 [4]	189 [4]
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Benzo[b]fluoranthene	Rail	1.15	200 [3]
Benzo[k]fluoranthene			
Benzo[a]pyrene			
Chrysene			
Indeno(1,2,3-cd)pyrene			

References:

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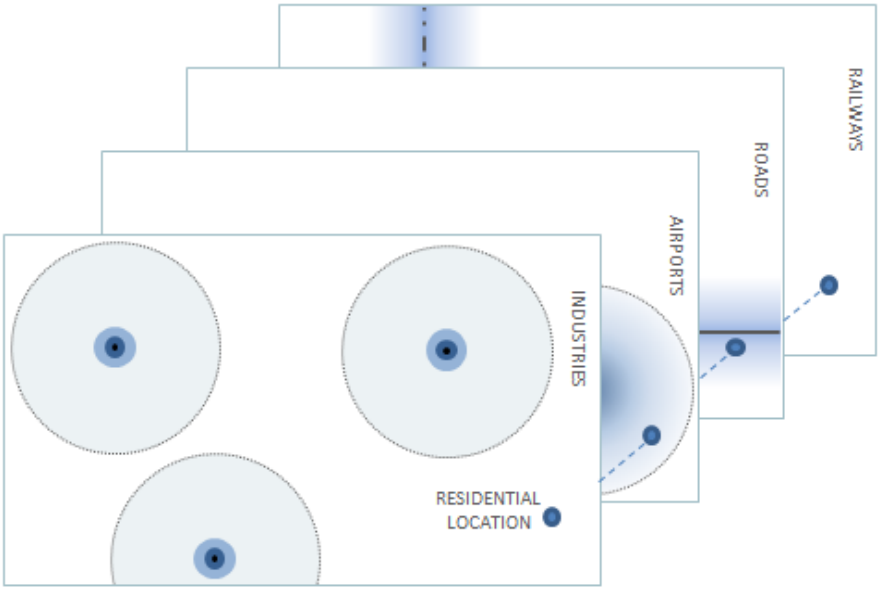
apportionment of fine particle air pollutants in Southeastern United States using solvent-extractable organic compounds as tracers. Environmental Science and Technology, 36(11):2361-2371. (d) Wu, C.F., Wu, S.Y., Wu, Y.H. et al. (2009). Cancer risk assessment of selected hazardous air pollutants in Seattle. Environment International, 35(3), 516-522.
6. We assume polycyclic aromatic hydrocarbons are mainly bound to ultra-fine particles in outdoor air, based on: Miguel et al (2004). Seasonal variation of the particle size distribution of polycyclic aromatic hydrocarbons and of major aerosol species in Claremont, California. Atmosphere Environment 38 (20) pp 3241-3251.)) Gradients are therefore based on those identified for ultrafine particles.

Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby airport and road. There are no industries or railways close enough to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations , for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
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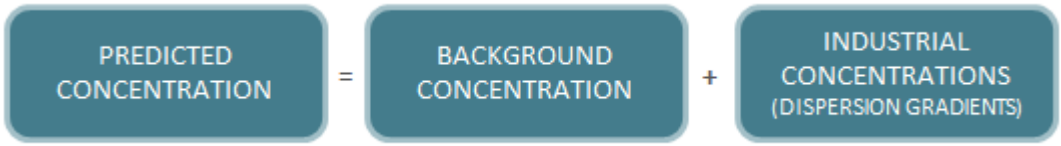
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Chloroform

Concentrations of chloroform in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of chloroform emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
- For all locations in Non-Census Metropolitan Areas and more than 50 km from a NAPS monitoring station, the overall annual average from all rural NAPS stations in Canada is assigned as background.

Identifying Dispersion Gradients for Industries

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

Applying the Dispersion Gradients to Residential Locations

A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients of industrial emitters.

In this example, two residential locations would be assigned a background concentration plus additional amounts from the nearby industry. There are no industries close enough to the third residential location to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations, for example: prevailing wind patterns due to local topography may affect gradient shape and distances.
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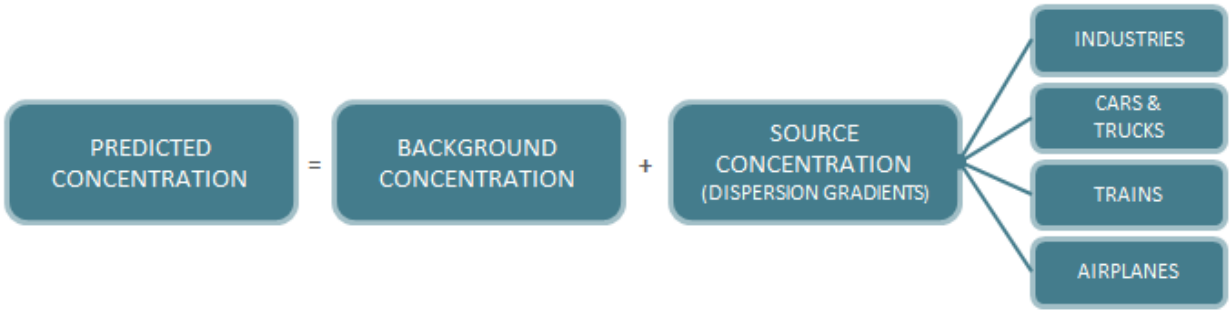
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.

Chromium (Hexavalent)

Concentrations of hexavalent chromium in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of hexavalent chromium emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
- For all locations in Non-Census Metropolitan Areas and more than 50 km from a NAPS monitoring station, the overall annual average from all rural NAPS stations in Canada is assigned as background.

Identifying Dispersion Gradients for Roads, Rails, Large Industries and Airports

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

CARS & TRUCKS

We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS

We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

AIRPLANES

We used a screening level dispersion model (SCREEN3), to estimate concentrations around medium and large airports based on estimated emissions. The model estimates worst-case ground level concentrations from emissions. Estimates were produced up to 5000m from airports. Emissions from airports were estimated using landing/take-off volumes at each airport and aircraft emission factors specific to each substance.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
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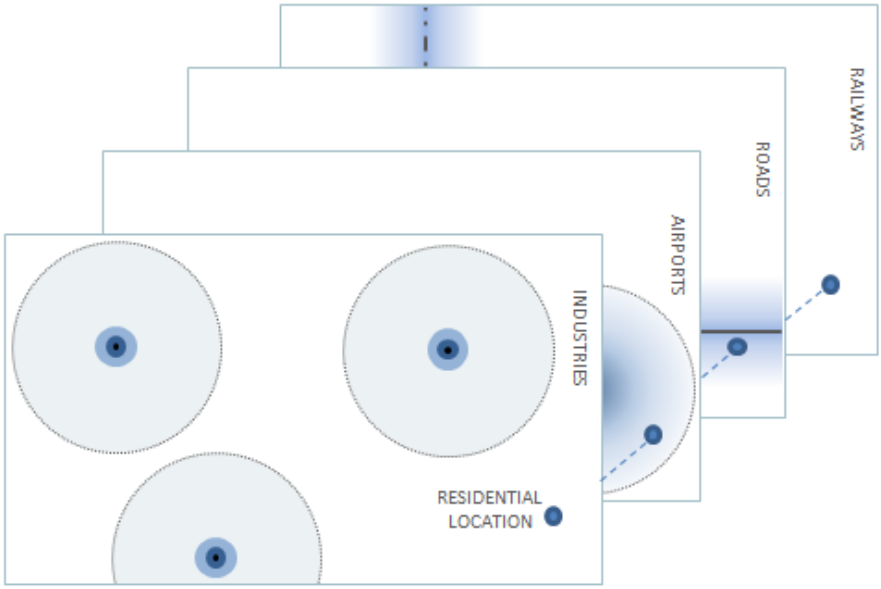
Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby airport and road. There are no industries or railways close enough to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

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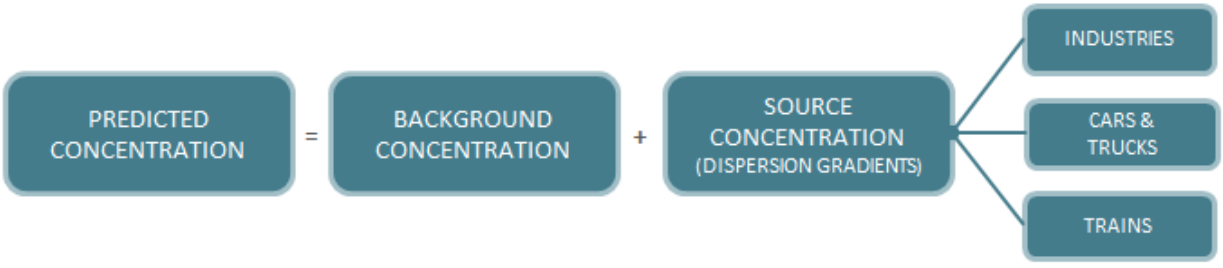
Chrysene

Concentrations of chrysene in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of chrysene emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

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Identifying Dispersion Gradients for Roads, Rails and Large Industries

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We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

CARS & TRUCKS

We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS

We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
	Major roads	2.6 [2]	200
	Rail	1.15	200 [3]
Formaldehyde	Highways	2.0 [1,4]	200 [1]
	Major roads	1.4 [2]	200 [1]
	Rail	1.15	200 [3]
Diesel Exhaust [5]	Highways	4.0 [4]	189 [4]
	Major roads	2.8 [2]	189 [4]
	Rail	1.15	200 [3]
Metals	Highways	2.9 [4]	161 [4]
Arsenic	Major roads	2.0 [2]	161 [4]
Cadmium, Hexavalent Chromium	Rail	1.15	200 [3]
Lead			
Nickel			
Polycyclic Aromatic Hydrocarbons [6]	Highways	4.0 [4]	189 [4]
Benz[a]anthracene	Major roads	2.8 [2]	189 [4]
Benzo[b]fluoranthene	Rail	1.15	200 [3]
Benzo[k]fluoranthene			
Benzo[a]pyrene			
Chrysene			
Indeno(1,2,3-cd)pyrene			

References:

1. Viskari, E., Vartiainen, M., Pasanen, P. (2000). Seasonal and diurnal variation in formaldehyde and acetaldehyde concentrations along a highway in Eastern Finland. Atmospheric Environment; 24(6): 917-923.

2. When gradients were not available for major roads, the gradient increase was set at 70% of the associated pollutant increase documented at highways. This percentage was based on the ratio of average traffic volumes for major roads and highways. (Setton et al (2005). Road Classification Schemes – Good Indicators of Traffic Volume? UVIC SSL Working Paper 05-014 http://www.cher.ubc.ca/UBCBAQS/SSL05-014-TRAFFIC.pdf)

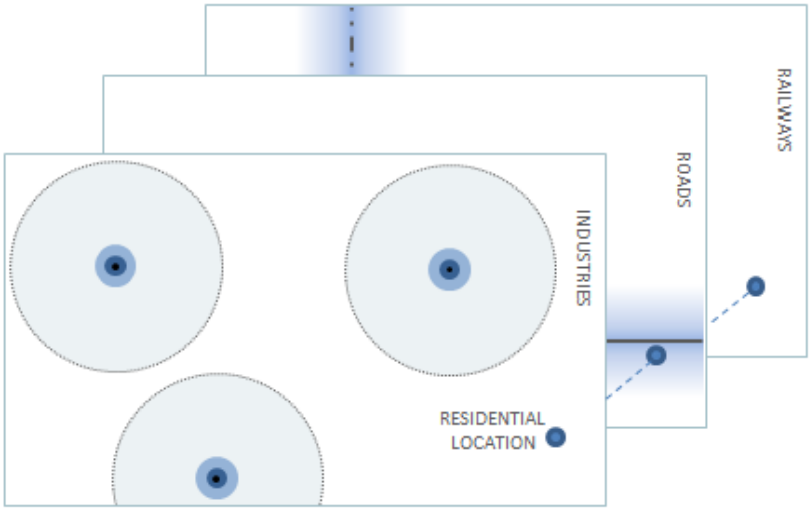
3. Hamid, R. (2008) Development of an exposure model for diesel locomotive emissions near the Alameda Corridor. http://www.metrans.org/research/final/AR%2005-03%20Final.pdf. Accessed July 28 2011.

4. Karner, A., Eisinger, D.S., Niemeier, D.A. (2010). Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data. Environ. Sci. and Technol.; 44(14), 5334-5344.

5. We assume 12 percent of total fine particulates measured are of diesel origin based on: (a) Brook, J.R., Poirot, R.L., Dann, T.F. et al. (2007). Assessing sources of PM2.5 in cities influenced by regional transport. Journal of Toxicology and Environmental Health Part A, 70:3-4: 191-199. (b) Keill, L., Maykut, N. (2003). Final Report: Puget Sound Air Toxics Evaluation. In: Seattle:Puget Sound Clean Air Agency. (c) Zheng, M., Cass, G.R., Schauer, J.J. et al. (2002). Source

apportionment of fine particle air pollutants in Southeastern United States using solvent-extractable organic compounds as tracers. Environmental Science and Technology, 36(11):2361-2371. (d) Wu, C.F., Wu, S.Y., Wu, Y.H. et al. (2009). Cancer risk assessment of selected hazardous air pollutants in Seattle. Environment International, 35(3), 516-522.
6. We assume polycyclic aromatic hydrocarbons are mainly bound to ultra-fine particles in outdoor air, based on: Miguel et al (2004). Seasonal variation of the particle size distribution of polycyclic aromatic hydrocarbons and of major aerosol species in Claremont, California. Atmosphere Environment 38 (20) pp 3241-3251.)) Gradients are therefore based on those identified for ultrafine particles.

Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby road. There are no industries or railways close enough to add to the predicted concentration.

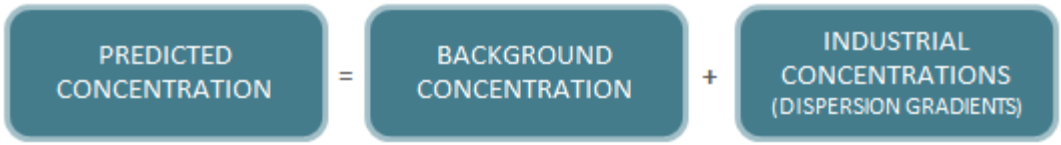
Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations, for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
- No independent monitoring was available or conducted to evaluate how well the predicted concentrations match actual measured levels. The results presented are best used to make regional comparisons, and should not be used to assess regulatory compliance.
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Dichloromethane

Concentrations of dichloromethane in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of dichloromethane emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
- For all locations in Non-Census Metropolitan Areas and more than 50 km from a NAPS monitoring station, the overall annual average from all rural NAPS stations in Canada is assigned as background.

Identifying Dispersion Gradients for Industries

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
	Major roads	2.6 [2]	200
	Rail	1.15	200 [3]
Formaldehyde	Highways	2.0 [1,4]	200 [1]
	Major roads	1.4 [2]	200 [1]
	Rail	1.15	200 [3]
Diesel Exhaust [5]	Highways	4.0 [4]	189 [4]
	Major roads	2.8 [2]	189 [4]
	Rail	1.15	200 [3]
Metals Arsenic Cadmium, Hexavalent Chromium Lead Nickel	Highways	2.9 [4]	161 [4]
	Major roads	2.0 [2]	161 [4]
	Rail	1.15	200 [3]
Polycyclic Aromatic Hydrocarbons [6] Benz[a]anthracene Benzo[b]fluoranthene Benzo[k]fluoranthene Benzo[a]pyrene Chrysene Indeno(1,2,3-cd)pyrene	Highways	4.0 [4]	189 [4]
	Major roads	2.8 [2]	189 [4]
	Rail	1.15	200 [3]

References:

A) Viskari, E., Vartiainen, M., Pasanen, P. (2000). Seasonal and diurnal variation in formaldehyde and acetaldehyde concentrations along a highway in Eastern Finland. Atmospheric Environment; 24(6): 917-923.
B) When gradients were not available for major roads, the gradient increase was set at 70% of the associated pollutant increase documented at highways. This percentage was based on the ratio of average traffic volumes for major roads and highways. (Setton et al (2005). Road Classification Schemes – Good Indicators of Traffic Volume? UVIC SSL Working Paper 05-014 http://www.cher.ubc.ca/UBCBAQS/SSL05-014-TRAFFIC.pdf)
C) Development of an exposure model for diesel locomotive emissions (2008) http://www.metrans.org/research/final/AR%2005-03%20Final.pdf
D) Karner, A., Eisinger, D.S., Niemeier, D.A. (2010). Rear-Roadway Air Quality: Synthesizing the Findings from Real-World Data. Environ. Sci. and Technol.; 44(14), 5334-5344.
E) We assume 18 percent of total fine particulates measured is of diesel origin based on: Keill L, Maykut N. 2003. Final Report: Puget Sound Air Toxics Evaluation. In: Seattle:Puget Sound Clean Air Agency.
F) Polycyclic aromatic hydrocarbons are mainly bound to ultra-fine particles in outdoor air (Miguel et al (2004). Seasonal variation of the particle size distribution of polycyclic aromatic hydrocarbons and of major aerosol species in Claremont, California. Atmosphere Environment 38 (20) pp 3241-3251.)) Gradients are therefore based on those identified for ultrafine particles.

Additional References:

Hamid, R. (2008) Development of an exposure model for diesel locomotive emissions near the Alameda Corridor. http://www.metrans.org/research/final/AR%2005-03%20Final.pdf. Accessed July 28 2011.
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Roorda-Knape MC, Janssen NAH, De Hartog JJ, Van Vliet PHN, Harssema H, Brunekreef B. 1998. Air pollution from traffic in city districts near major motorways. Atmos Environ 32(11):1921-1930.
Roukos J, Riffault V, Locoge N, Plaisance H. 2009. VOC in an urban and industrial harbor on the French North Sea coast during two contrasted meteorological situations. Environmental Pollution 157(11):3001-3009.
Smargiassi A, Baldwin M, Pilger C, Dugandzic R, Brauer M. 2005. Small-scale spatial variability of particle concentrations and traffic levels in Montreal: A pilot study. Sci Total Environ 338(3):243-251.
Thorsson S, Eliasson IÄ. 2006. Passive and active sampling of benzene in different urban environments in Gothenburg, Sweden. Water, Air, & Soil Pollution 173(1):39-56.
Tiitta P, Raunemaa T, Tissari J, Yli-Tuomi T, Leskinen A, Kukkonen J et al. 2002. Measurements and modeling of PM2.5 concentrations near a major road in Kuopio, Finland. Atmos Environ 36(25):4057-4068.
Vardoulakis S, Gonzalez-Flesca N, Fisher B. 2002. Assessment of traffic-related air pollution in two street canyons in Paris: Implications for exposure studies. Atmos Environ 36(6):1025-1039.
Wang P, Zhao W. 2008. Assessment of ambient volatile organic compounds (VOCs) near major roads in urban Nanjing, China. Atmos Res 89(3):289-297.

Applying the Dispersion Gradients to Residential Locations

A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients of industrial emitters.

In this example, two residential locations would be assigned a background concentration plus additional amounts from the nearby industry. There are no industries close enough to the third residential location to add to the predicted concentration.

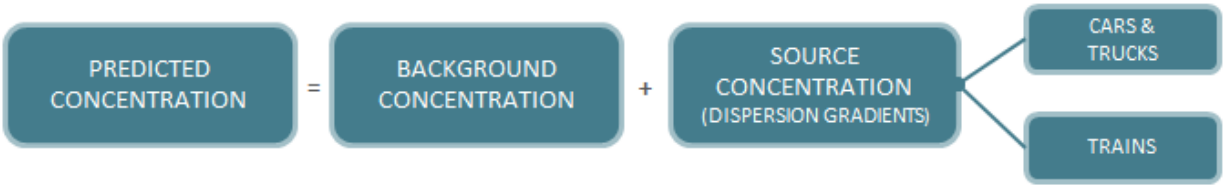
Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations, for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
- No independent monitoring was available or conducted to evaluate how well the predicted concentrations match actual measured levels. The results presented are best used to make regional comparisons, and should not be used to assess regulatory compliance.
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Diesel Engine Exhaust

Fine particulates from diesel exhaust are not measured directly in Canada. Concentrations of diesel exhaust in outdoor air were predicted for residential locations in 2011 by assuming that 12 percent of total fine particulates measured at National Air Pollution Surveillance (NAPS) monitors originate from diesel exhaust. Estimates of concentrations from cars, trucks, and trains are also included. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of diesel exhaust emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
- For all locations in Non-Census Metropolitan Areas and more than 50 km from a NAPS monitoring station, the overall annual average from all rural NAPS stations in Canada is assigned as background.

Identifying Dispersion Gradients for Roads and Rail

CARS & TRUCKS

We estimated the influence of motor vehicles emissions using gradients applied to highways, major roads and minor roads. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS

We estimated the influence of diesel locomotive emissions to substance using gradients applied to all operating railways in Canada (not including light rail transportation. There are few published studies documenting increases in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
	Major roads	2.6 [2]	200
	Rail	1.15	200 [3]
Formaldehyde	Highways	2.0 [1,4]	200 [1]
	Major roads	1.4 [2]	200 [1]
	Rail	1.15	200 [3]
Diesel Exhaust [5]	Highways	4.0 [4]	189 [4]
	Major roads	2.8 [2]	189 [4]
	Rail	1.15	200 [3]
Metals	Highways	2.9 [4]	161 [4]
Arsenic	Major roads	2.0 [2]	161 [4]
Cadmium,	Rail	1.15	200 [3]
Hexavalent Chromium			
Lead			
Nickel			
Polycyclic Aromatic Hydrocarbons [6]	Highways	4.0 [4]	189 [4]
Benz[a]anthracene	Major roads	2.8 [2]	189 [4]
Benzo[b]fluoranthene	Rail	1.15	200 [3]
Benzo[k]fluoranthene			
Benzo[a]pyrene			
Chrysene			
Indeno(1,2,3-cd)pyrene			

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1. Viskari, E., Vartiainen, M., Pasanen, P. (2000). Seasonal and diurnal variation in formaldehyde and acetaldehyde concentrations along a highway in Eastern Finland. Atmospheric Environment; 24(6): 917-923.

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4. Karner, A., Eisinger, D.S., Niemeier, D.A. (2010). Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data. Environ. Sci. and Technol.; 44(14), 5334-5344.

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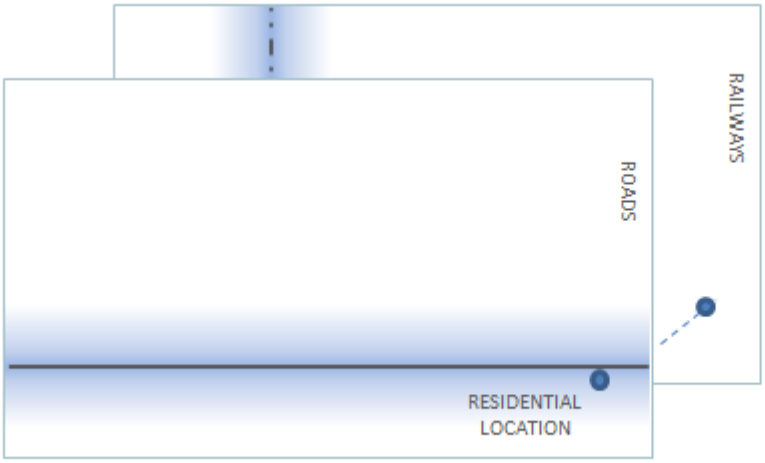
apportionment of fine particle air pollutants in Southeastern United States using solvent-extractable organic compounds as tracers. Environmental Science and Technology, 36(11):2361-2371. (d) Wu, C.F., Wu, S.Y., Wu, Y.H. et al. (2009). Cancer risk assessment of selected hazardous air pollutants in Seattle. Environment International, 35(3), 516-522.
6. We assume polycyclic aromatic hydrocarbons are mainly bound to ultra-fine particles in outdoor air, based on: Miguel et al (2004). Seasonal variation of the particle size distribution of polycyclic aromatic hydrocarbons and of major aerosol species in Claremont, California. Atmosphere Environment 38 (20) pp 3241-3251.) Gradients are therefore based on those identified for ultrafine particles.

Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby road. There are no railways close enough to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations , for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
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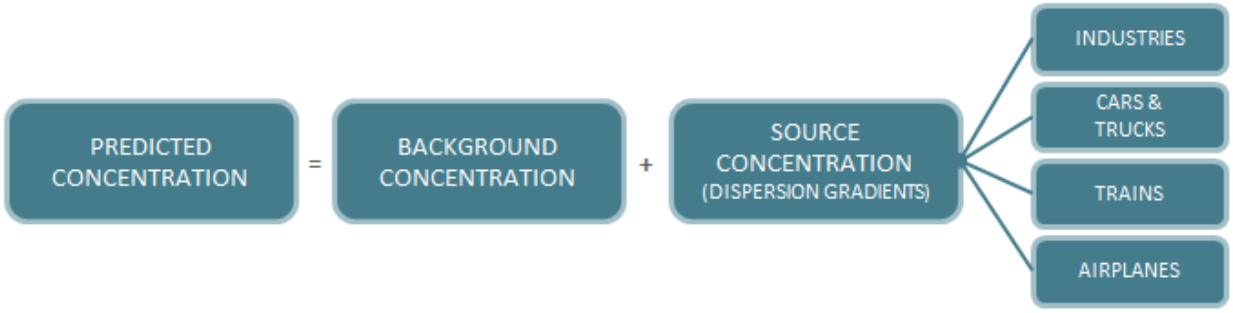
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Ethylbenzene

Concentrations of ethylbenzene in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of ethylbenzene emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
- For all locations in Non-Census Metropolitan Areas and more than 50 km from a NAPS monitoring station, the overall annual average from all rural NAPS stations in Canada is assigned as background.

Identifying Dispersion Gradients for Roads, Rails, Large Industries and Airports

INDUSTRIES We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

CARS & TRUCKS We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

AIRPLANES We used a screening level dispersion model (SCREEN3), to estimate concentrations around medium and large airports based on estimated emissions. The model estimates worst-case ground level concentrations from emissions. Estimates were produced up to 5000m from airports. Emissions from airports were estimated using landing/take-off volumes at each airport and aircraft emission factors specific to each substance.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Benzene	Highways/Major roads	3.25[1,2,3,4]	50[3,5,6]
	Local Roads	1.5[1,2,3,4]	50[3,5,6]
1,3-Butadiene	Highways	4.0[6]	75[6]
Ethylbenzene	Highways	3.7[2,7,8]	300[8]
	Major Roads	2.2[2,7,8]	300[8]
	Local Roads	1.4[2,7,8]	300[8]

References:
1. Hellen H, Hakola H, Pirjola L, Laurila T, Pystynen KH. (2006). Ambient air concentrations, source profiles, and source apportionment of 71 different C2â^' C10 volatile organic compounds in urban and residential areas of Finland. Environ Sci Technol 40(1):103-108.
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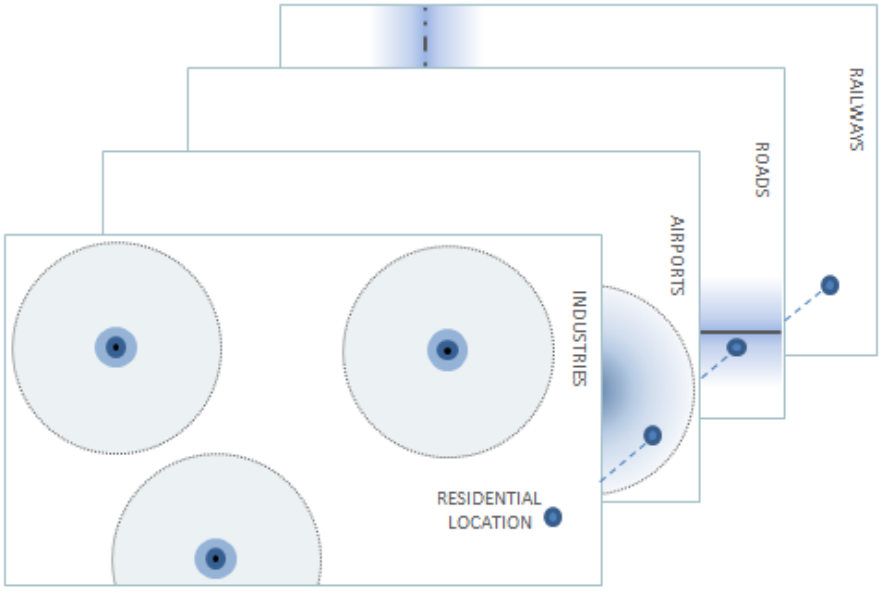
6. Venkatram A, Isakov V, Seila R, Baldauf R. (2009). Modeling the impacts of traffic emissions on air toxics concentrations in Paris: implications for exposure studies. Atmos Environ 43 (20): 3191-3199. 7. Roukos J, Riffault V, Locoge N, Plaisance H. (2009). VOC in an urban and industrial harbor on the French North Sea coast during two contrasted meteorological situations. Environmental Pollution 157(11):3001-3009.
8. Wang P, Zhao W. (2008). Assessment of ambient volatile organic compounds (VOCs) near major roads in urban Nanjing, China. Atmos Res 89(3):289-297.

Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby airport and road. There are no industries or railways close enough to add to the predicted concentration.

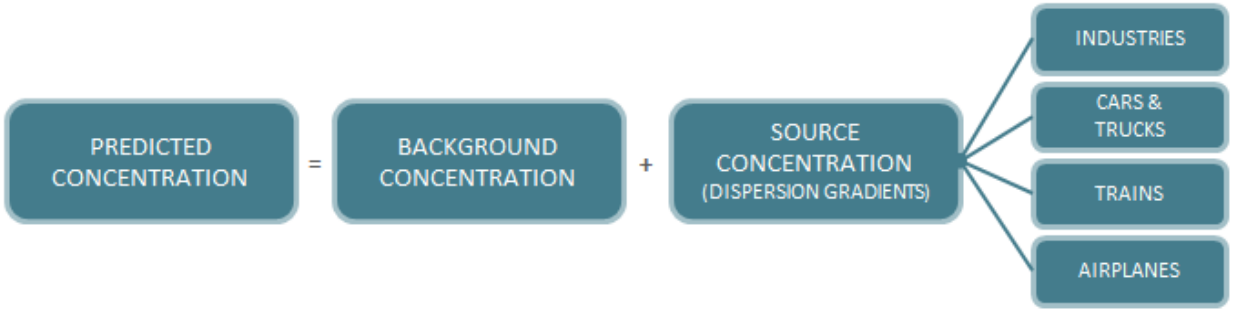
Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations , for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
- No independent monitoring was available or conducted to evaluate how well the predicted concentrations match actual measured levels. The results presented are best used to make regional comparisons, and should not be used to assess regulatory compliance.
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Formaldehyde

Concentrations of formaldehyde in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of formaldehyde emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
- For all locations in Non-Census Metropolitan Areas and more than 50 km from a NAPS monitoring station, the overall annual average from all rural NAPS stations in Canada is assigned as background.

Identifying Dispersion Gradients for Roads and Rail, Large Industries and Airports

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

CARS & TRUCKS

We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS

We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

AIRPLANES

We used a screening level dispersion model (SCREEN3), to estimate concentrations around medium and large airports based on estimated emissions. The model estimates worst-case ground level concentrations from emissions. Estimates were produced up to 5000m from airports. Emissions from airports were estimated using landing/take-off volumes at each airport and aircraft emission factors specific to each substance.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
	Major roads	2.6 [2]	200
	Rail	1.15	200 [3]
Formaldehyde	Highways	2.0 [1,4]	200 [1]
	Major roads	1.4 [2]	200 [1]
	Rail	1.15	200 [3]
Diesel Exhaust [5]	Highways	4.0 [4]	189 [4]
	Major roads	2.8 [2]	189 [4]
	Rail	1.15	200 [3]
Metals	Highways	2.9 [4]	161 [4]
Arsenic	Major roads	2.0 [2]	161 [4]
Cadmium, Hexavalent Chromium	Rail	1.15	200 [3]
Lead			
Nickel			
Polycyclic Aromatic Hydrocarbons [6]	Highways	4.0 [4]	189 [4]
Benz[a]anthracene	Major roads	2.8 [2]	189 [4]
Benzo[b]fluoranthene	Rail	1.15	200 [3]
Benzo[k]fluoranthene			
Benzo[a]pyrene			
Chrysene			
Indeno(1,2,3-cd)pyrene			

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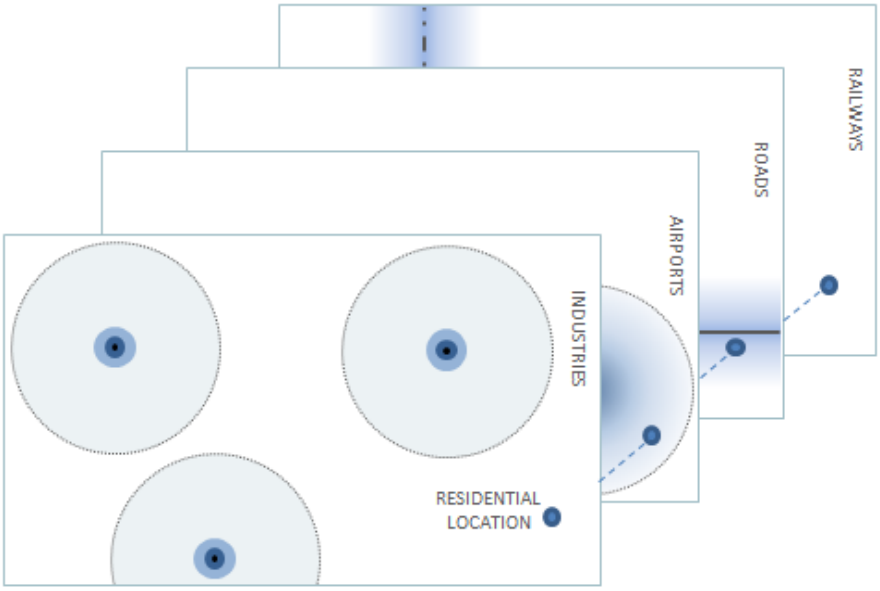
Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby airport and road. There are no industries or railways close enough to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations, for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
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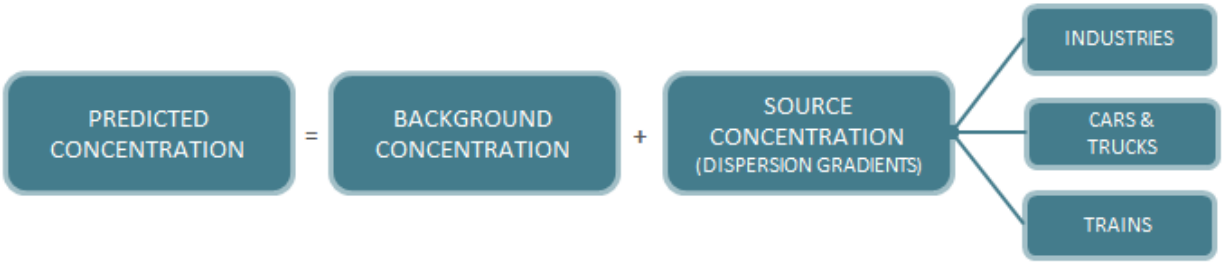
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Indeno[1,2,3-cd]pyrene

Concentrations of indeno(1,2,3-cd)pyrene in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of indeno(1,2,3-cd)pyrene emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
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Identifying Dispersion Gradients for Roads and Rails and Large Industries

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

CARS & TRUCKS

We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS

We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Acetaldehyde	Highways	3.7 [1]	200 [1]
	Major roads	2.6 [2]	200
	Rail	1.15	200 [3]
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Metals	Highways	2.9 [4]	161 [4]
Arsenic	Major roads	2.0 [2]	161 [4]
Cadmium, Hexavalent Chromium	Rail	1.15	200 [3]
Lead			
Nickel			
Polycyclic Aromatic Hydrocarbons [6]	Highways	4.0 [4]	189 [4]
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Benzo[b]fluoranthene	Rail	1.15	200 [3]
Benzo[k]fluoranthene			
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References:

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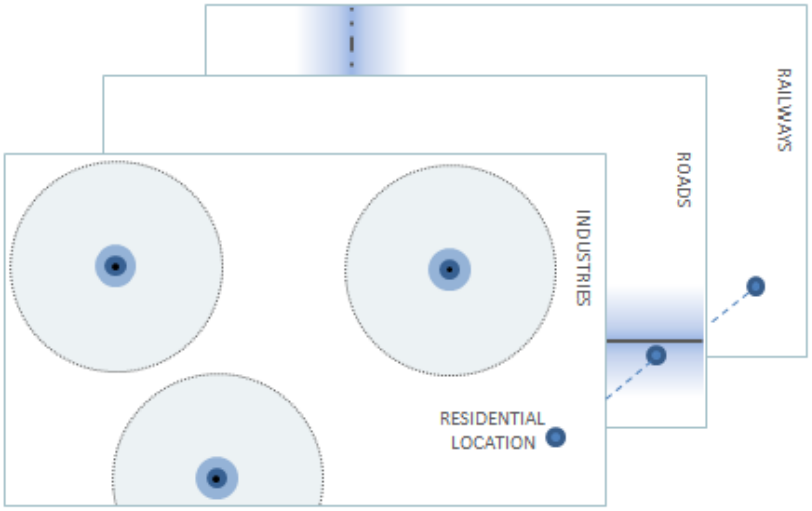
Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby road. There are no industries or railways close enough to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations, for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
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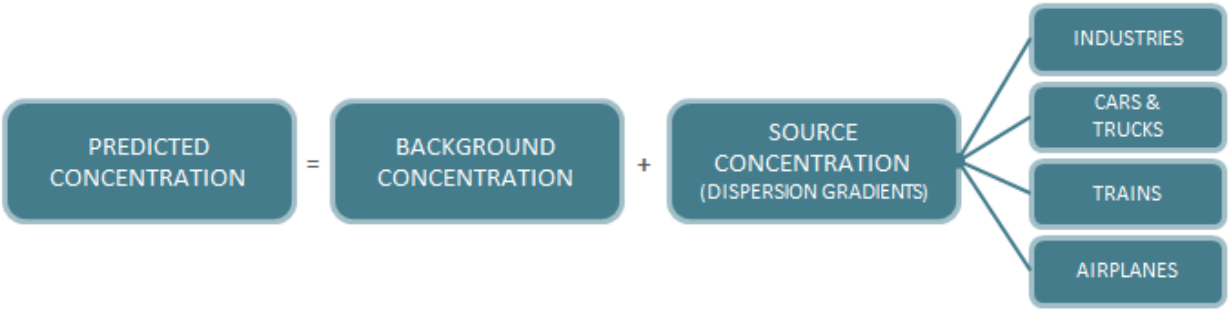
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Lead

Concentrations of lead in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of lead emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
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Identifying Dispersion Gradients for Roads and Rail, Large Industries and Airports

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

CARS & TRUCKS

We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS

We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

AIRPLANES

We used a screening level dispersion model (SCREEN3), to estimate concentrations around medium and large airports based on estimated emissions. The model estimates worst-case ground level concentrations from emissions. Estimates were produced up to 5000m from airports. Emissions from airports were estimated using landing/take-off volumes at each airport and aircraft emission factors specific to each substance.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
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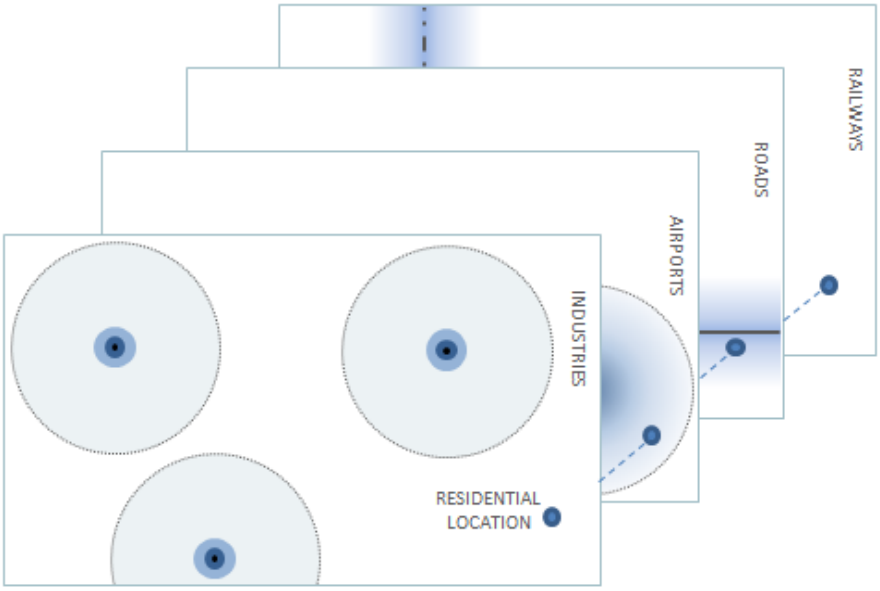

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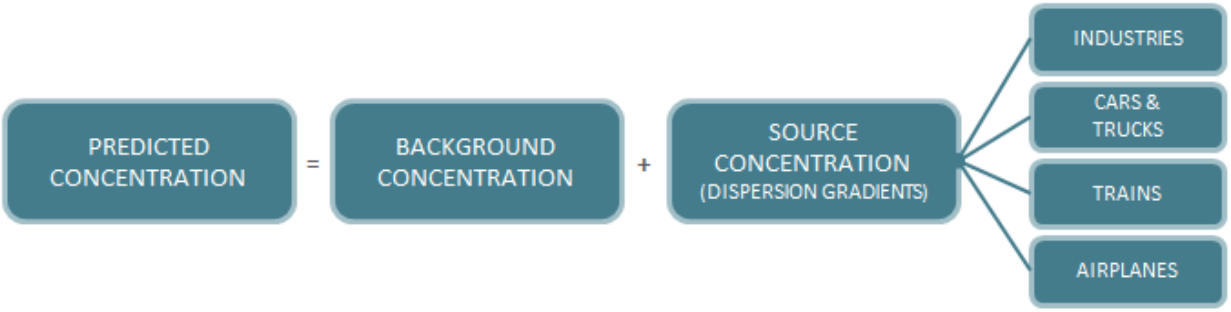

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Indeno(1,2,3-cd)pyrene			

References:

1. Viskari, E., Vartiainen, M., Pasanen, P. (2000). Seasonal and diurnal variation in formaldehyde and acetaldehyde concentrations along a highway in Eastern Finland. Atmospheric Environment; 24(6): 917-923.

2. When gradients were not available for major roads, the gradient increase was set at 70% of the associated pollutant increase documented at highways. This percentage was based on the ratio of average traffic volumes for major roads and highways. (Setton et al (2005). Road Classification Schemes – Good Indicators of Traffic Volume? UVIC SSL Working Paper 05-014 http://www.cher.ubc.ca/UBCBAQS/SSL05-014-TRAFFIC.pdf)

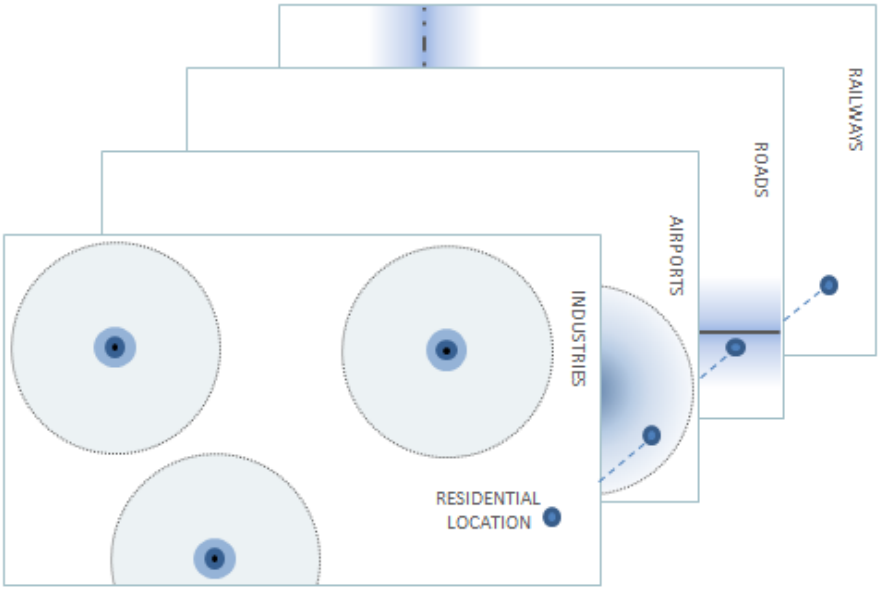
3. Hamid, R. (2008) Development of an exposure model for diesel locomotive emissions near the Alameda Corridor. http://www.metrans.org/research/final/AR%2005-03%20Final.pdf. Accessed July 28 2011.

4. Karner, A., Eisinger, D.S., Niemeier, D.A. (2010). Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data. Environ. Sci. and Technol.; 44(14), 5334-5344.

5. We assume 12 percent of total fine particulates measured are of diesel origin based on: (a) Brook, J.R., Poirot, R.L., Dann, T.F. et al. (2007). Assessing sources of PM2.5 in cities influenced by regional transport. Journal of Toxicology and Environmental Health Part A, 70:3-4: 191-199. (b) Keill, L., Maykut, N. (2003). Final Report: Puget Sound Air Toxics Evaluation. In: Seattle:Puget Sound Clean Air Agency. (c) Zheng, M., Cass, G.R., Schauer, J.J. et al. (2002). Source

apportionment of fine particle air pollutants in Southeastern United States using solvent-extractable organic compounds as tracers. Environmental Science and Technology, 36(11):2361-2371. (d) Wu, C.F., Wu, S.Y., Wu, Y.H. et al. (2009). Cancer risk assessment of selected hazardous air pollutants in Seattle. Environment International, 35(3), 516-522.
6. We assume polycyclic aromatic hydrocarbons are mainly bound to ultra-fine particles in outdoor air, based on: Miguel et al (2004). Seasonal variation of the particle size distribution of polycyclic aromatic hydrocarbons and of major aerosol species in Claremont, California. Atmosphere Environment 38 (20) pp 3241-3251.)) Gradients are therefore based on those identified for ultrafine particles.

Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby airport and road. There are no industries or railways close enough to add to the predicted concentration.

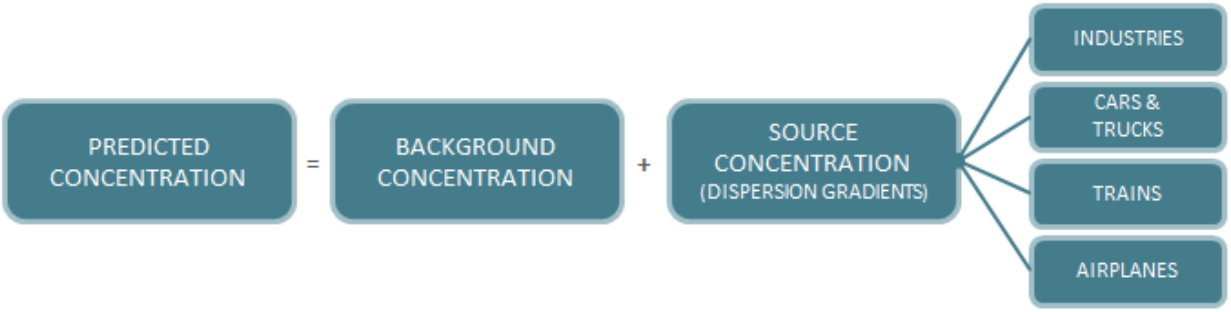
Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations, for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
- No independent monitoring was available or conducted to evaluate how well the predicted concentrations match actual measured levels. The results presented are best used to make regional comparisons, and should not be used to assess regulatory compliance.
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Outdoor Air Pollution

Concentrations of fine particulates ($PM_{2.5}$) in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of $PM_{2.5}$ emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
- For all locations in Non-Census Metropolitan Areas and more than 50 km from a NAPS monitoring station, the overall annual average from all rural NAPS stations in Canada is assigned as background.

Identifying Dispersion Gradients for Roads and Rail, Large Industries and Airports

INDUSTRIES We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

CARS & TRUCKS We estimated the influence of motor vehicle emission on outdoor air concentrations using gradients applied to highways, major roads and minor roads in Canada. Dispersion gradients were determined from a comprehensive search of the published literature. Gradients are created from two key components: 1) the typical increase in substance concentrations at a road compared to background pollutant levels, and 2) the distance from a road at which concentrations return to background levels.

TRAINS We estimated the influence of diesel locomotive emissions on outdoor air concentrations using gradients applied to all operating railways in Canada (not including light rail) transportation. There are few published studies documenting increase in pollutant concentrations near railways; therefore, we applied a 15% increase at railways to all pollutants and a linear decrease reaching background levels at 200m.

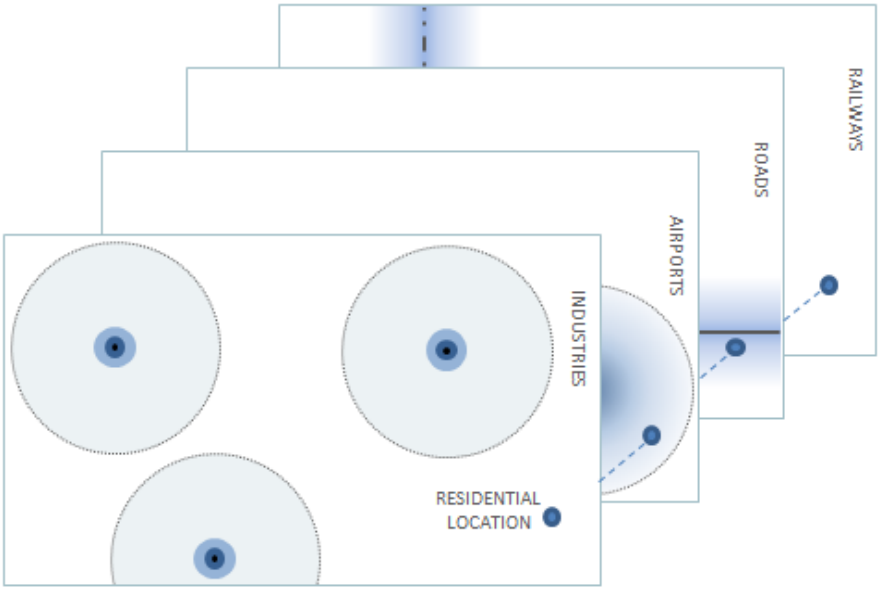
AIRPLANES We used a screening level dispersion model (SCREEN3), to estimate concentrations around medium and large airports based on estimated emissions. The model estimates worst-case ground level concentrations from emissions. Estimates were produced up to 5000m from airports. Emissions from airports were estimated using landing/take-off volumes at each airport and aircraft emission factors specific to each substance.

Summary of Gradients Identified for Roads and Rails

Pollutant	Source	Elevated at Source by a Factor of:	Gradient Distance (meters)
Fine particulates ($PM_{2.5}$)	Highways	1.25[1]	75[2,3,4,5]
	Major roads	1.10[1]	75[2,3,4,5]

References:
1. Smargiassi A, Baldwin M, Pilger C, Dugandzic R, Brauer M. 2005. Small-scale spatial variability of particle concentrations and traffic levels in Montreal: a pilot study. Sci Total Environ 338(3):243-251.
2. Beckerman B, Jerrett M, Brook JR, Verma DK, Arain MA, Finkelstein MM. (2008). Correlation of nitrogen dioxide with other traffic pollutants near a major expressway. Atmos Environ 42(2):275-290.
3. Hitchins J, Morawska L, Wolff R, Gilbert D. 2000. Concentrations of submicrometre particles from vehicle emissions near a major road. Atmos Environ 34(1):51-59.
4. Roorda-Knape MC, Janssen NAH, De Hartog JJ, Van Vliet PHN, Harssema H, Brunekreef B. 1998. Air pollution from traffic in city districts near major motorways. Atmos Environ 32(11):1921-1930.
5. Tiitta P, RRaunemma T, Tissari J, Yli-Tuomi T, Leskinen A, Kikkonen J, et al. 2002. Measurements and modeling of PM2.5 concentrations near a major road in Kuopio, Finland. Atmos Environ 36(25):4057-4068.

Applying the Dispersion Gradients to Residential Locations



A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients.

In this example, the residential location would be assigned a background concentration, plus additional amounts from the nearby airport and road. There are no industries or railways close enough to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations , for example: road and rail estimates are based only on road type or presence of a railway, not actual vehicle or train volume; and prevailing wind patterns due to local topography may affect gradient shape and distances.
- No independent monitoring was available or conducted to evaluate how well the predicted concentrations match actual measured levels. The results presented are best used to make regional comparisons, and should not be used to assess regulatory compliance.
- National air pollution surveillance (NAPS) monitors were used to represent concentrations for all block points within 50km, regardless of monitor siting criteria. Different monitor siting characteristics and representativeness will therefore affect the accuracy of this assumption.
- The estimates produced represent a 'worst-case scenario', as the screening level dispersion model calculates maximum expected concentrations given emissions levels.
- Limited / no information was available on industrial facility operating parameters required to do more exact dispersion modelling. Industrial facilities were grouped into small, medium and large by emission amounts and assigned standard operating parameters by category.
- Specific gradients developed from the literature for roads and railways were often based on limited amounts of studies, especially for railways where one gradient was applied to all diesel combustion related substances.

Pesticides (2,4-D, chlorothalonil, and glyphosate)

2,4-D

Data sources

Actual pesticide application rates were not available for Canada, so pesticide usage was estimated based on crop types grown and typical application rates for these crops in North America. Data were obtained on the distribution and acreage of different crop types, 2,4-D application rates, and the number of people living in each area. Data on agricultural crops were obtained from Agriculture and Agri-Food Canada's Annual Crop Inventory for 2016, which are digital images (raster datasets) that produce an average crop accuracy of 89%.

Data on pesticide usage came from the United States Department of Agriculture's Agricultural Chemical Use Program and the Government of Ontario's Ministry of Agricultural, Food and Rural Affairs. These datasets summarize how much 2,4-D was applied to crops along with the average yearly application rates. Group averages were applied if specific crop data were not available. For instance, we averaged the 2,4-D application rates for pears, peaches, and apples to estimate the application rate for "orchard fruits", which was a crop type captured by the Annual Crop Inventory. Average annual 2,4-D application rates for all crops were obtained.

Population data from Canada's 2016 Census of Population were used to estimate the number of people potentially exposed. Population estimates are based on the number of people living within the census subdivision (CSD).

Methods and analysis

Estimates were calculated at the CSD level (n=5,054). Specifically, we calculated the total area (in km^2) of land within each CSD for each crop type. Total areas were then multiplied by the average 2,4-D application rate data for each crop. Finally, the total was summed together to obtain an estimate of 2,4-D use in kilograms for each CSD. Results were weighted in square kilometres to illustrate the kilograms of 2,4-D applied per square kilometre in each CSD. CSDs with less than 0.2 kg/km^2 were classified as having no exposure to account for very small agricultural activity within the CSD. Data are presented in quartiles and integrated with population data to show potential exposure and variations across the country.

Chlorothalonil

Data sources

Actual pesticide application rates were not available for Canada, so pesticide usage was estimated based on crop types grown and typical application rates for these crops in North America. To estimate potential environmental exposure for chlorothalonil, data were obtained on the distribution and acreage of different crop types, chlorothalonil application rates and the population or number of people living in each area. Data on agricultural crops were obtained from Agriculture and Agri-Food Canada's Annual Crop Inventory for 2016, which are digital images (raster datasets) that produce an average crop accuracy of 89%.

Data on pesticide usage came from the United States Department of Agriculture's Agricultural Chemical Use Program and the Government of Ontario's Ministry of Agricultural, Food and Rural Affairs. These datasets summarize how much chlorothalonil was applied to crops along with the average yearly application rates. Group averages were applied if specific crop data were not available. For instance, we averaged the chlorothalonil application rates for pears, peaches, and apples to estimate the application rate for "orchard fruits", which was a crop type captured by the Annual Crop Inventory. Average annual chlorothalonil application rates for all crops were obtained.

Population data from Canada's 2016 Census of Population were used to estimate the number of people potentially exposed. Population estimates are based on the number of people living within the census subdivision (CSD).

Methods and analysis

Estimates were calculated at the CSD level (n=5,054). Specifically, we calculated the total area (in km^2) of land within each CSD for each crop type. Total areas were then multiplied by the average chlorothalonil application rate data for each crop. Finally, the total was summed

together to obtain an estimate of chlorothalonil use in kilograms for each CSD. Results were weighted in square kilometres to illustrate the kilograms of chlorothalonil applied per square kilometre in each CSD. CSDs with less than 0.2 kg/km^2 were classified as having no exposure to account for very small agricultural activity within the CSD. Data are presented in quartiles and integrated with population data to show potential exposure and variation across the country.

Glyphosate

Data sources

Actual pesticide application rates were not available for Canada, so pesticide usage was estimated based on crop types grown and typical application rates for these crops in North America. Data were obtained on the distribution and acreage of different crop types, glyphosate application rates, and the number of people living in each area. Data on agricultural crops were obtained from Agriculture and Agri-Food Canada's Annual Crop Inventory for 2016, which are digital images (raster datasets) that produce an average crop accuracy of 89%.

Data on pesticide usage came from the United States Department of Agriculture's Agricultural Chemical Use Program and the Government of Ontario's Ministry of Agricultural, Food and Rural Affairs. These datasets summarize how much glyphosate was applied to crops along with the average yearly application rates. Group averages were applied if specific crop data were not available. For instance, we averaged the glyphosate application rates for pears, peaches, and apples to estimate the application rate for "orchard fruits", which was a crop type captured by the Annual Crop Inventory. Average annual glyphosate application rates for all crops were obtained.

For canola, where different strands are grown with or without glyphosate application, exposure rates were estimated based on the proportion of each strand grown in that particular province. For instance, in Quebec, approximately 50% of the canola grown is glyphosate ready, while 50% has no glyphosate applied. For Quebec, an application rate of 50% of glyphosate was applied to canola (i.e., if canola has a glyphosate application rate of 146 kg/km^2, in Quebec the rate would be 73 kg/km^2 or 50% of the actual rate).

Population data from Canada's 2016 Census of Population were used to estimate the number of people potentially exposed. Population estimates are based on the number of people living within the census subdivision (CSD).

Methods and analysis

Estimates were calculated at the CSD level (n=5,054). Specifically, we calculated the total area (in km^2) of land within each CSD for each crop type. Total areas were then multiplied by the average glyphosate application rate data for each crop. Finally, the total was summed together to obtain an estimate of glyphosate use in kilograms for each CSD. Results were weighted in square kilometres to illustrate the kilograms of glyphosate applied per square kilometre in each CSD. CSDs with less than 0.2 kg/km^2 were classified as having no exposure to account for very

small agricultural activity within the CSD. Data are presented in quartiles and integrated with population data to show potential exposure and variations across the country.

Radon

Data sources

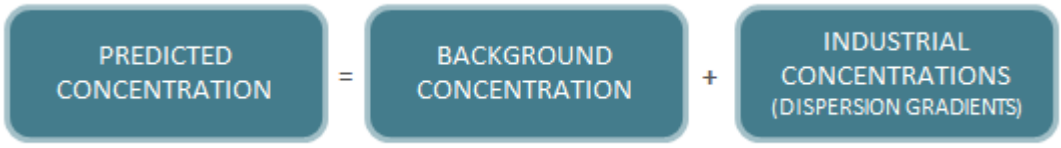
The map was created using radon measurements from the Cross Canada Radon Survey (Phase I & II).

Methods and analysis

The map displays the percentage of home radon measurements in each health region above the current Canadian guideline of 200 Bq/m^3. A total of 13,755 houses were tested with the Cross Canada Radon Survey and the number of tests varies by province. Radon levels can vary significantly, even within health regions.

Tetrachloroethylene

Concentrations of tetrachloroethylene in outdoor air were predicted for residential locations in 2011 using levels measured at National Air Pollution Surveillance (NAPS) monitors and estimates of concentrations from known emitters. Residential locations are represented by the geographic coordinates for all street blocks in Canada in 2011, as provided by Statistics Canada.



Other sources of tetrachloroethylene emissions to outdoor air may be present, but are not included due to a lack of suitable data.

Setting the Background Level

The background concentration is assigned using measured levels from National Air Pollution Surveillance (NAPS) monitors using the following rules:

- For all locations within 50 km of a NAPS monitoring station, the annual average concentration measured at that station is assigned as background.
- For all locations within Census Metropolitan Areas (defined by Statistics Canada) and more than 50 km from a NAPS monitoring station, the overall annual average from all urban NAPS stations in Canada is assigned as background.
- For all locations in Non-Census Metropolitan Areas and more than 50 km from a NAPS monitoring station, the overall annual average from all rural NAPS stations in Canada is assigned as background.

Identifying Dispersion Gradients for Industries

INDUSTRIES

We used a screening level dispersion model (SCREEN 3) to estimate concentrations around industries reporting emissions to air to the National Pollutant Release Inventory (NPRI). The model estimates worst-case ground level concentrations from total emissions. Estimates were produces from 500m, 1000m, and 5000m from each industrial facility categorized into small, medium and large, based on emissions amounts.

Applying the Dispersion Gradients to Residential Locations

A geographic information system was used to overlay residential locations (represented by street block centre points) with the modelled or estimated concentration gradients of industrial emitters.

In this example, two residential locations would be assigned a background concentration plus additional amounts from the nearby industry. There are no industries close enough to the third residential location to add to the predicted concentration.

Limitations

This high-level approach was used to estimate spatial variation in outdoor air concentrations across Canada. Only national, readily available data were used to enable future mapping using the same approach as a means of identifying trends.

- Although we estimated concentrations for all street block centre points in Canada, many local factors are not included that could influence concentrations, for example: prevailing wind patterns due to local topography may affect gradient shape and distances.
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