The Effect of Temperature Inversions on NO$_2$ using Temperature Profiles from AIRS

A community level application

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Study Area

Source: Google Maps
Population of Hamilton 500,000
Industry + traffic => poor air quality
Inversions occur frequently
Respiratory diseases – common
- Asthma
- Coughs
Temperature Inversions

- Nighttime radiation inversions most common
- Daytime – advective, subsidence
- Surface or elevated
  - Elevated – recirculation of pollution progressively increasing the pollutant loading over time
Niagara Escarpment

- Influenced by Niagara Escarpment
- Proximity to Great Lakes
Topography
Determining Temperature Profiles

- Local meteorological tower, 91 m high
- Nearest WMO Radiosonde Station at Buffalo International Airport - 100 km south
- 3 air quality monitors
AIRS

- Data from GIOVANNI
  - Ease of download and ease of use
  - Minimal processing
  - Limitations in horizontal and vertical resolution

- AIRS Level 3, version 5, daily AM/PM temperature profiles 2003-2007 (1826 days)
AIRS Data

- Temperature profiles up to 925 hPa level

<table>
<thead>
<tr>
<th>PM Crossing</th>
<th>AM Crossing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1450 valid PM profiles</td>
<td>1436 valid profiles</td>
</tr>
<tr>
<td>Normal</td>
<td>Inversion</td>
</tr>
<tr>
<td>1120</td>
<td>330</td>
</tr>
<tr>
<td>Normal</td>
<td>Inversion</td>
</tr>
<tr>
<td>1000</td>
<td>436</td>
</tr>
</tbody>
</table>

- Strength of inversions
  - Day: 2.8 C
  - Night: 2.4 C
Inversion Frequency

![Bar chart showing inversion frequency by season and time of day. The y-axis is labeled 'Frequency 2003-2007' ranging from 0 to 200. The x-axis is labeled with seasons: Spring, Summer, Fall, Winter. The chart includes two sets of bars for each season, representing AIRS 0200hrs and AIRS 1400hrs. The highest frequency is observed in Spring for AIRS 0200hrs, with a peak near 150, followed by Winter and Summer, and the lowest in Fall. The bars for AIRS 1400hrs are generally lower than those for AIRS 0200hrs.]
Results - NO$_2$ DAYTIME

AIRS – 11% increase

LOCAL – 48% increase
NO$_2$ - NIGHTTIME

AIRS – 49% increase

LOCAL – 40% increase
SEASONAL NO$_2$ - DAY

AIRS

LOCAL

Graph showing seasonal NO$_2$ concentrations.
SEASONAL NO$_2$ - NIGHT

AIRS

LOCAL
Wind Direction – AIRS Daytime

Normal

Inversion

Long-range transport
Wind Direction - Nighttime

Normal

Inversion
Health Impact
Human Respiratory Response

- Neutrophil cell types in respiratory tract
- Respond to infection and inflammation
  - count increases after exposure to air pollution
Human Respiratory Response
### Multivariate Statistical Regression

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>95.0% Confidence Interval for B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Day Inversion</td>
<td>.124</td>
<td>.049</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Neutrophil Counts ArcSin Transformation

- Controlling for age, smoking, medication, surface temperature, humidity
Conclusions

- AIRS temperature profiles useful in assessing changes in air quality resulting from inversions
- Suitable for studies of the city and neighboring areas
- Can be incorporated into health studies
References

Daytime Frequency

**Day**

**Night**

MT

- DJF: [Height]
- MAM: [Height]
- JJA: [Height]
- SON: [Height]
PM2.5 AIRS

DAY

NIGHT

A

B

C

D
PM2.5 MT

DAY

NIGHT
PM2.5 WIND DIRECTION

NORMAL

INVERSION

1400 hrs

1400 hrs

0200 hrs

0200 hrs

PM2.5 (µg/m³)

30-51  
20-30  
10-20  
0-10

PM2.5 (µg/m³)

20-45  
20-30  
10-20  
0-10

PM2.5 (µg/m³)

30-48  
20-30  
16-20  
0-10

PM2.5 (µg/m³)

7.9%  
6.9%  
6.3%  
7.1%
Validation