AQHI Program Status and Future Developments

NOAA Air Quality Forecaster Focus Group Workshop
College Park, Maryland

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Meteorological Service of Canada, September 27-28, 2018
Part 1 - Overview

- AQHI Current Status
- AQHI+
- AQHI Advisory Program
- $SO_2$ Exceedances and Notes
- Future Developments
AQHI Current Status

• Multi-pollutant health based index (O₃, PM₂.₅, NO₂)

\[ AQHI_{PM2.5} = \frac{10}{10.4} \times \left(100 \times \left[ \left(e^{0.000871 \times NO₂} - 1\right) + \left(e^{0.000537 \times O₃} - 1\right) + \left(e^{0.000487 \times PM2.5} - 1\right) \right] \right) \]

• As of Sept 25th, 2018 AQHI forecasts available for:
  • 110 Communities across Canada
  • 11 additional station forecasts in larger cities
  • This covers approximately 80% of the Canadian population
  • **Special focus on sensitive population**
  • Continue to support the Info-Smog program in Quebec
AQHI+

- Activates based on single pollutant thresholds
  - Set by province/territory
  - Single pollutant AQHI formulation used while above threshold
  - Threshold linked to high risk AQHI category (7 or more)
  - Exception for PM$_{2.5}$ in BC, activates based on formula when it exceeds regular AQHI value
  - Usually based on provincial regulations for specific pollutants
  - Can be used for non-AQHI pollutants (not ideal)
- Generally based on 1-hr average
  - More responsive to changing conditions
  - More vulnerable to bad data
- Acts as a support to health messaging during single pollutant events (e.g. Forest fires)
## AQHI+ Pollutant Thresholds

<table>
<thead>
<tr>
<th>AQHI+ Pollutant</th>
<th>Alberta</th>
<th>British Columbia</th>
<th>Ontario</th>
<th>Northwest Territories</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO (ppb)</td>
<td>13500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO₂ (ppb)</td>
<td>159.5</td>
<td>201</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>O₃ (ppb)</td>
<td>82.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM₂.₅ (µg/m³)</td>
<td>80.5</td>
<td>Ceiling(PM₂.₅/10)</td>
<td>80.5</td>
<td></td>
</tr>
<tr>
<td>SO₂ (ppb)</td>
<td>172.5</td>
<td>36/71*</td>
<td>251</td>
<td></td>
</tr>
<tr>
<td>H₂S (ppb)</td>
<td>1000.5</td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>TRS (ppb)</td>
<td>1000.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*proposed
Advisory Programs

- Ontario:
  - Smog and Air Health Advisory for AQHI 7 or more (incl. AQHI+)
- Alberta/Northwest Territories
  - Special AQ Statement for AQHI 7 or more (incl. AQHI+)
- British Columbia
  - Advisories issued by province
  - Provincial advisories disseminated by ECCC via Special AQ Statement
- Quebec
  - Smog Warning based on AQI
  - Triggered by:
    - $O_3$ (82 ppb) for at least 3 consecutive hours
    - $PM_{2.5}$ (35 $\mu$/m$^3$) 3 hour rolling average
SO$_2$ Exceedances

- SO$_2$ is not part of the AQHI formulation.
- British Columbia (and Ontario) wants additional messaging for SO$_2$
- Nature of the pollutant is such that exceedances occur with very little warning and are often short lived
- Pollutant is detectable by public due to pungent smell, but is not reflected in the AQHI
  - The observed AQHI does not reconcile with user experience
- Proposal:
  - Pre-defined SO$_2$ thresholds will trigger the appearance of a canned message that will be displayed on AQHI page
  - Message will be short, not too technical and direct users to another website for further information
Sample of AQHI Page with Note

Kitimat - Air Quality Health Index

Observed Conditions

Calculated at: 2:00 PM PDT Monday 10 September 2018

1

Past 24 hr

6

1 2 3 4 5 6 7 8 9 10 +

Low Risk (1-3) Moderate Risk (4-6) High Risk (7-10) Very High Risk

Please Note: 2:00 PM PDT Monday 10 September 2018

- Elevated levels of sulphur dioxide have been reported. For more information, visit B.C.’s Ministry of Environment and Climate Change Strategy.
- This is a second message to test special notes.
- This is a third message to test special notes.

At-Risk Population:
- Consider reducing or rescheduling strenuous activities

General Population:
- No need to modify your usual outdoor activities unless


Future Developments

• Note functionality was designed to be adaptable to use with any pollutants and/or hazards
• Note functionality may be used for forest fire smoke:
  • How to differentiate between forest fire smoke and other PM$_{2.5}$ events?
• As GEMMACH model run extends to 72-84 hours:
  • Forecast period can be expanded to include Day 3
• Customizable email alerts based on user defined AQHI thresholds
• Future version of Weather Office website will include customizable maps with selectable layers:
  • Planned layers will include AQHI Nationally, AQI in Quebec
Future Developments (cont.)

• Continuing to evaluate the feasibility of staffing a smoke desk that would monitor forest fire smoke
  • Regionally dependent, but coverage would be national
• Small sensor project:
  • Launched study to evaluate the reliability/feasibility of various sensors for potential integration into observation network, complementing existing monitors
  • Focus on rural and remote northern locations
  • Rapid deployment for emergency data collection (Forest Fires)
• Longer term: Integration into Weather App
Part 2 - Overview

• Status and recent updates to operational AQ systems
• Performance
• Next steps
2018 British Columbia Wildland Fires

Fire season started late July only, but...
Record number of hectares have burned: estimated 1,252,000 hectares, previous record 1,216,000 hectares in ... 2017

Since April 1, BC Wildfire has responded to 2,015 fires
More than 4,500 personnel fighting fires, including 850 out-of-province personnel, including 51 firefighters from Washington state
More than 1,400 contractors from the B.C. forestry industry assisting
230 aircrafts flying in support of ground crews
770 RCMP members or civilian members deployed in support of B.C. wildfires, including Alberta RCMP tactical officers
Canadian Operational Air Quality Forecast Systems

- **Systems run by ECCC Operations**
  
  **1) RAQDPS** *(Regional Air Quality Deterministic Prediction System)*
  
  - GEM-MACH
  - Emissions & boundary conditions
  - Statistical model (UMOS-AQ)
  - Operational Products
  - Regional Deterministic Air Quality Analysis (RDAQA)

Different PM$_{2.5}$, PM$_{10}$, and O$_3$ charts are available
Systems run by EC CC Operations

2) FireWork (RAQ DPS with wildfire emissions)
   - Emissions
   - Statistical model (UMOS-AQ)
   - Experimental Products
   - Regional Deterministic Air Quality Analysis connected to FireWork (RDAQA-FW)

http://weather.gc.ca/firework/index_e.html

Hourly, max and average fire-PM$_{2.5}$ concentrations over FireWork domain and/or zoomed Canadian sub-domains

Exemple: MAX hourly PM$_{2.5}$ (ug/m$^3$)
Period covered: 2017 Sept 2$^{nd}$ 00-24UTC
Canadian Operational Air Quality Forecast Systems

• **Systems run by ECCC Operations**

  2) **FireWork** (products available via password-protected web page)


  Many additional products and tools such as:

  • **Objective Analysis**
  • **Wildfire event related products**
  • **Client-specific products**
  • **Interactive Webmap**
  • **UMOS-AQ/MIST 2D fields**
  • **Etc.**
Recent updates to RAQ DPS and FireWork

• RAQ DPS:
  • Inheriting updates to weather data assimilation in RDPS
  • Incremental Analysis Update (IAU)
  • Updated GEM-MACH core. Main features:
    • Improves dry deposition over snow/ice
    • Deactivation of aerosol chemistry in stratosphere
    • Code optimisation
  • New emissions

• FireWork:
  • Adjusted fire area estimates

Operational as of September 18th 2018

<table>
<thead>
<tr>
<th></th>
<th>SRPDQA019</th>
<th>SRPDQA020</th>
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</thead>
<tbody>
<tr>
<td>Canada</td>
<td>2010</td>
<td>2013</td>
</tr>
<tr>
<td>USA</td>
<td>2011</td>
<td>2017*</td>
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<tr>
<td>Mexico</td>
<td>1999</td>
<td>2008</td>
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</table>

* Projected from 2011
New Performance Indicators – Mai 2018 AQPI

**MAY 2018**

<table>
<thead>
<tr>
<th></th>
<th><strong>O₃</strong></th>
<th><strong>NO₂</strong></th>
<th><strong>PM₂.₅</strong></th>
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<tbody>
<tr>
<td>Current</td>
<td>86</td>
<td>68.7</td>
<td>59.3</td>
</tr>
<tr>
<td>5 Year Average</td>
<td>86.1</td>
<td>71</td>
<td>59.2</td>
</tr>
</tbody>
</table>

AQPI formulation for each pollutant:

\[
AQPI(O₃, NO₂, PM₂.₅) = 100 \times \text{AVG} \left[ \text{FAC2} + R + (1 - \text{ABS}\left(\frac{MFB}{2}\right)) \right]
\]

Conclusions for this month:

RAQDPS performance similar to 5 year average

- **O₃** – AQPI: **equivalent** to the 5y average for this month. Slight improvement over Eastern Canada
- **NO₂** – AQPI: **slightly degrading** due to actual emissions decreasing while our emission inventories have not been updated yet.
- **PM₂.₅** – AQPI: **equivalent** to the 5y average for this month.

Note: SRPDQA is French for RAQDPS
Conclusions:
The 3 models have similar performance as measured with AQPI, except for CAMS overpredicting PM.

To be addressed for the RAQDPS:
NO\textsubscript{2} – updated emissions (next update this fall)
PM\textsubscript{2.5} – Diurnal profile shifted in Eastern Canada – to be investigated
Next Steps

- **RAQ DPS**
  - 72h forecasts (late 2019)
  - New, improved GEM core dynamic library (late 2019)
  - Developing 2.5km subdomains (experimental)

- **FireWork**
  - Improved plume height and wildfire emissions estimates through the Canadian CFFEPS module (tested this year, delivery planned for 2019 wildfire season)
  - Experimental 2.5km runs over a western domain (supporting FireEx-AQ)
RDAQAv2 Planned Innovations (Spring 2019)

- Like current version 1, version 2 will produce off-line hourly surface analyses of O$_3$, NO$_2$, SO$_2$, PM$_{2.5}$, PM$_{10}$, and AQHI and will use the same Choleski solver to perform the analysis.

- v2 has important structural changes to:
  - improve the quality of the analyses
  - ease the transition towards data assimilation cycling

- RDAQA is an end product: GEM → GEM-MACH → RDAQAv2, and thus has no impact on other systems (reduced risk)

- Computational cost at execution time is about same as version 1

- Structural changes:
  - Analysis module, Error statistics (input), Improved verification
Error Statistics (Input)

- Observation error variance to minimize the analysis error variance using cross-validation (Ménard and Deshaies-Jacques, Atmosphere, 2018a,b)

- Background error variance is state-dependent (2-month climatology) meeting the variance innovation consistency (Ménard, QJRMS, 2016)

- Anisotropic error correlations based on off-line ensembles (EnOI)
Global $O_3$ Assimilation and UV Forecasting (exp. 2019)

Sample summer time UV Index forecast image for 24 Aug, 2015, at 18 UTC generated by an earlier version of the proposed system.

Reduction of UV Index by clouds

Very high to extreme UV Index ($\geq 8$) from prognostic column ozone near midday
Questions?