Environment Canada Environnement Canada

Canada

National Air Quality Health Index and Forecast Program: Program Update

September 18, 2007

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Overview

- Air Quality Health Index (AQHI) Status Report
  - What is the AQHI?
  - Why do we need a new index?
  - Transition
  - National Pilot
  - Next Steps
- Canadian Air Quality Modelling System
- Questions

What is the AQHI?

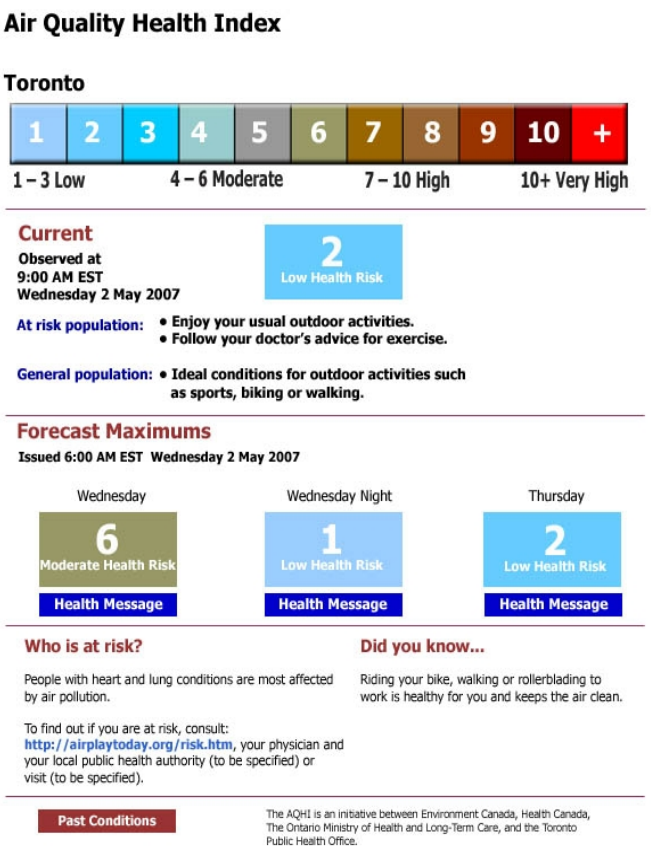
- The AQHI is a *personal health protection tool* that is designed to help individuals make decisions on limiting short-term exposure to air pollution
  - Sum of risk from multiple pollutants (O_3, PM and NO_2)
  - Rolling 3-hour concentrations
  - Uses a 1-10+ scale similar to the UV Index
  - Decouple air quality regulation from provision of health advice

- Environment Canada, Health Canada and the provinces have been developing the AQHI over the past 6 years. The AQHI formulation has been agreed upon:

AQHI = 10/10.4*(100*(EXP(0.000871*NO2)-1+EXP(0.000537*O3)-1 +EXP(0.000487*PM2.5)-1))

AQHI Presentation: UV Index-Like

- Illustrates level of health risk with **colour & number scale** of 1-10+
- **Labels the level of HEALTH risk** as “low”, “moderate”, “high” or “very high”
- **Forecasts** local air quality for the current and next day
- **Empowers individuals** to decide how they might be at risk
- Provides **health messaging** to tell Canadians—both general & at-risk populations—how to minimize that risk



Why do we need a new index?

- Existing AQIs do not reflect current scientific evidence:
  - Additive effects of multiple pollutants
  - effects at low levels of exposure (no-threshold)
- Unevenly applied across Canada
  - Formulations (pollutant averaging times, pollutants included, thresholds)
  - Health protective advice
- Public misperceptions of air quality and health
  - Confirmed by Public Opinion Research

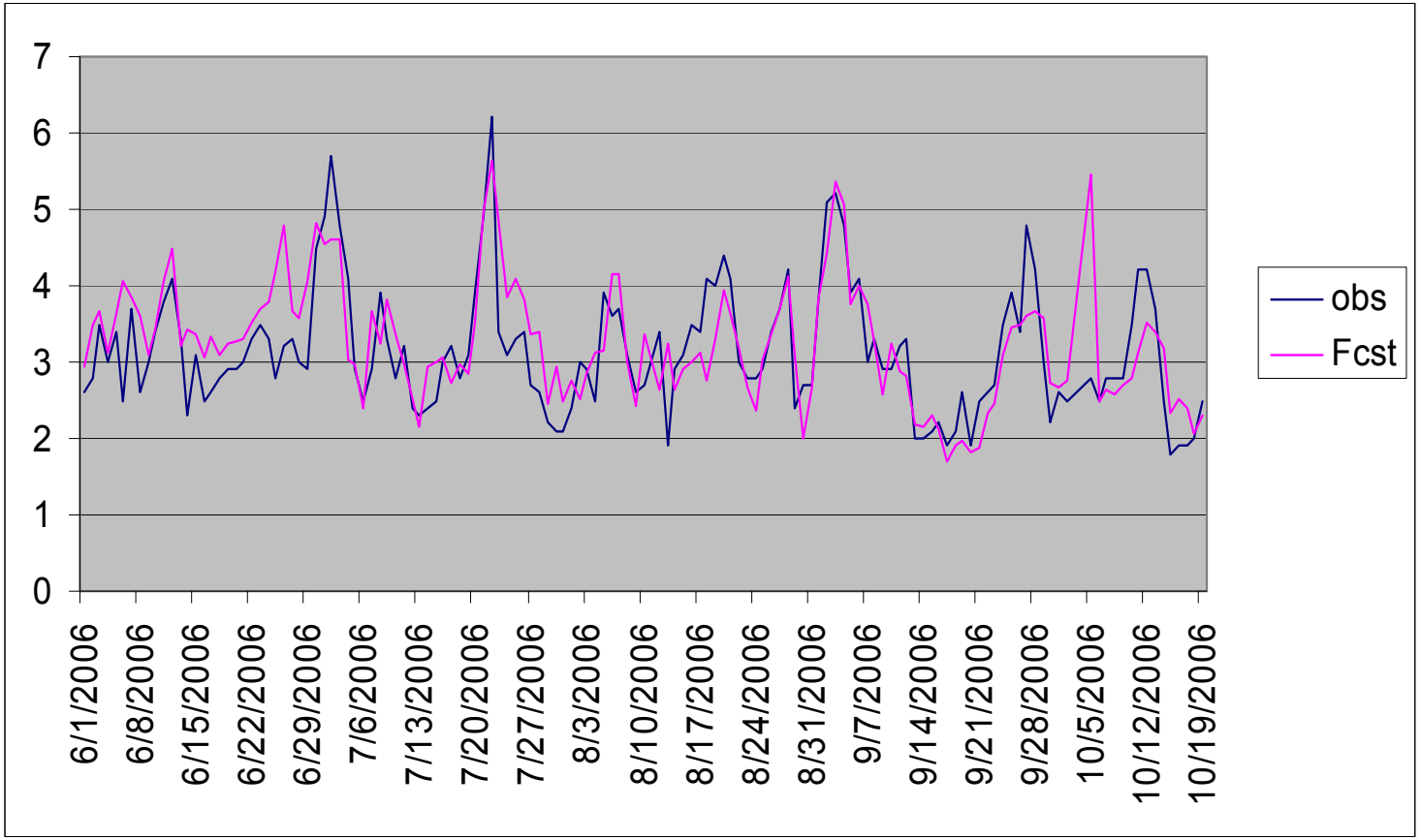
Transitioning to the AQHI

Priority is to *"transition"* the AQFP from the current single-pollutant AQI program to the new multi-pollutant AQHI Forecast Program

- AQHI Tests
  - 2005 in British Columbia (9 locations)
  - 2006 in British Columbia (14 locations)/Nova Scotia (3 locations)
  - Evaluation
- Development and testing period ended on March 31, 2007
  - Decision taken by EC and partners to begin initial implementation beginning summer 2007

Can We Forecast the AQHI?

Burrard Inlet BC Forecast Region – Summer/Fall 2006

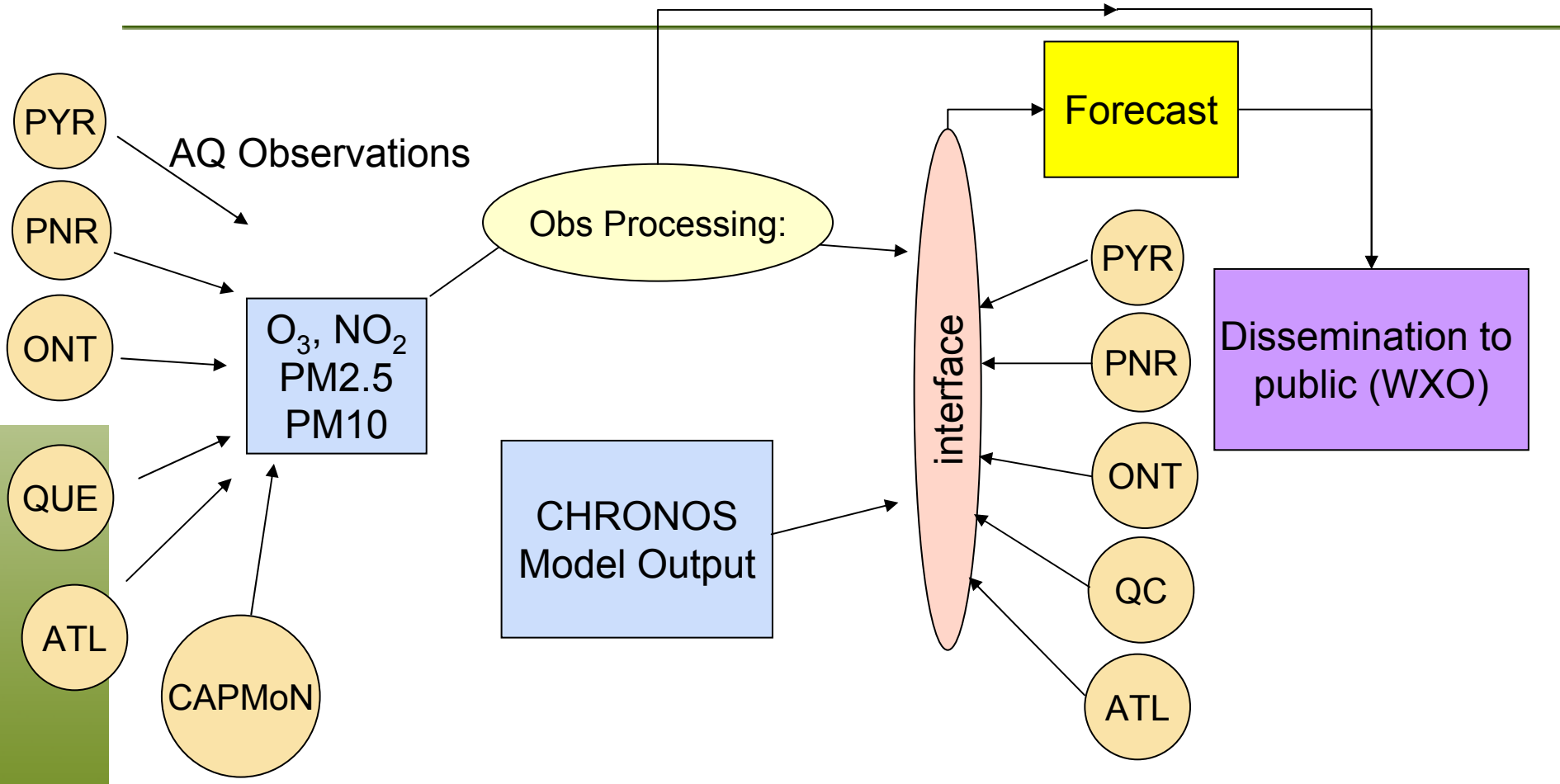


National Pilot

Agreement reached to begin national pilot in select locations across Canada

- Requirement to verify AQHI behavior in areas with larger variability in air pollution concentrations
  - City of Toronto – July 2007
  - Greater Vancouver –October 2007
  - City of Montreal – December 2007
  - Other jurisdictions to be added as they become ready with pilot cities available from each province by spring 2008
- Requirement to train forecasters
  - Three 1-week training sessions in Toronto (April-June2007)
    - MSC, NOAA, provincial and private sector forecasters
- Requirement to develop a new suite of forecaster prediction tools
  - Developed by the Canadian Meteorological Centre (CMC), Dorval QC
  - Centralization of all real-time data through CMC

National Pilot: Issuing the AQHI



AQHI = 10/10.4 * (100 * (EXP(0.000871*NO2)-1 + EXP(0.000537*O3)-1 + EXP(0.000487*PM2.5)-1))

National Pilot

- Requirement to develop new dissemination capability
  - Extensive revamping of EC's *Weather Office* website to handle all "dynamic data" ie forecasts and observations
    - www.weatheroffice.ec.gc.ca
  - Development of new AQHI website for "static" information
    - http://www.cas-aqhi.gc.ca
- Develop deliver new AQHI communications plans
- Brief EPA/NOAA due to potential communications problems in border communities

Next Steps

- Evaluation of the AQHI performance is ongoing
- 27 largest municipalities or 80% of Canadian population to have access to AQHI by 2010
  - Plan a phased implementation as jurisdiction are ready
  - Requires necessary supporting monitoring infrastructure
- Ongoing training to forecasters
- Integration of AQ forecast production into the MSC forecast workstation suite ie SCRIBE
- Agreement to review AQHI formulation on a regular basis and adjust as required ie every 3 years
- Enhanced dissemination capability – ATADS/Wx RDO/Internet/ “push technology”, etc

Status of the New EC Operational AQ Forecast Model: GEM-MACH15

- **GEM-MACH:**
  - **Global Environmental Multiscale model - Modelling Air quality and CHemistry**
- **Objective: To replace in 2008 CHRONOS, the current EC operational regional AQ forecast model for O_3, $PM_{2.5}$, and PM_{10}, with a new GEM-based operational AQFM that includes a science package equivalent to the one in AURAMS**
  - **GEM: Canada Weather Forecast model**
  - **AURAMS: Environment Canada research and policy support air quality model (~ EPA's CMAQ)**

GEM-MACH Development Motivation

- **CHRONOS has been operational since 2001 (experimental program since 1999)**
  - **Produces numerical guidance for O_3 and $PM_{2.5}$**
  - **Runs twice a day (00Z and 12Z)**
  - **Available to forecasters and public**
- **CHRONOS limitations:**
  - **CHRONOS science needs to be upgraded to improve performance**
  - **CHRONOS code is OpenMP'ed but is not MPI'ed → 16 CPU limit and no room to grow**
  - **Interpolation between GEM and CHRONOS is time-consuming and introduces errors.**
- **GEM-MACH**
  - **Chemistry and emissions packages will be embedded in GEM (i.e., "on-line" chemistry)**
  - **Embedded AQ package will benefit from GEM infrastructure, which is Message Passing Interface (MPI)-capable**

GEM-MACH: model characteristics

CHARACTERISTIC / MODEL	CHRONOS	GEM-MACH
Meteorological Driver	GEM (off-line)	GEM (**on-line**)
PM Size Distribution Representation	Sectional method (2 bins: PM2.5 and PMc)	Sectional method (flexibility to allow **different number of size bins (2-12)** based on **C**anadian **A**erosol **M**odule (Gong et al., 1997a,b, 2000)
PM Composition Representation	4 species: sSO4, sOC, H2O, primary PM	**9 species**: SO4, NO3, NH4, EC, pOC, sOC, CM, SS, H2O
Emissions	PM2.5 and PMc emission are assumed to be bulk emissions (no speciation, no further size disaggregation); 17 gas-phase species emitted	PM2.5 and PMc emissions **speciated** to 7 species and size **disaggregated** to 2-12 bins by primary source type (major and minor point, area, mobile); 17 gas-phase species emitted
Advection	Positive-definite, nonoscillatory, semi-Lagrangian method (Smolarkiewicz and Pudykiewicz, 1991)	Semi-Lagrangian method (Côté et al, 1993…)
Vertical Diffusion	Based on prognostic equation for TKE with the values of the vertical diffusion coeff. derived from GEM	Based on prognostic equation for TKE
Subgrid Convective Mixing	Not included	Not included

GEM-MACH: model characteristics (cont')

CHARACTERISTIC / MODEL	CHRONOS	GEM-MACH
Gas-Phase Chemistry Mechanism **Chemical Solver** **Photolysis**	ADOM-2 mechanism (Stockwell and Lurmann, 1989); 47 advected species Vectorized version of Young and Boris (1977): Makar (1995) Table lookup	ADOM-2 mechanism (Stockwell and Lurmann, 1989) with 1) **p-SO4 replaced by H2SO4**, 2) **N2O5 + H2O** "heterogeneous nitrate formation" rate enhancement **switch=off**. Vectorized version of Young and Boris (1977): Makar (1995) Table lookup
Aqueous-Phase Chemistry Mechanism **Solver**	None	**Based on ADOM mechanism** (Young and Lurmann, 1984); nucleation scavenging reactions replaced by **explicit particle activation**; **20 reactions, 7 gas and 13 aqueous species** (Gong2001) Vectorized Young & Boris (based on Makar, 1995)
Aerosol Dynamics	Sedimentation	**Nucleation, Condensation Coagulation, Sedimentation**
Heterogeneous Chemistry	HETV (vectorized inorganic heterogeneous chemistry based on the [Halogens excluded] ISORROPIA metastable option).	HETV (vectorized **inorganic heterogeneous chemistry** based on the [Halogens excluded] ISORROPIA).

GEM-MACH: model characteristics (cont')

CHARACTERISTIC / MODEL	CHRONOS	GEM-MACH
Secondary Organic (SOA) Yields	Based on Pandis et al. (1992)	**IAY scheme** Based on Jiang (2004)
Cloud (Physical) Processes	Cloud attenuation and enhancement photolysis rates, based on ADOM algorithm.	Cloud attenuation and enhancement photolysis rates, based on ADOM algorithm. **1)** Aerosol activation (based on Jones et al., 1994) **2)** Droplet scavenging of interstitial aerosol
Dry Deposition	New resistance-based methods for gases (Zhang et al., 2002)) and size-segregated model for particles (Zhang et al., 2001); 15 land-use categories.	New resistance-based methods for gases (Zhang et al., 2002)) and size-segregated model for particles (Zhang et al., 2001); 15 land-use categories
Wet Deposition	Distribution of LWC is used to calculate the wet scavenging term by applying Sundqvist formulae for the rate of release of precipitation	Transfer of tracers from cloud to rain water based on **precipitation production**. **In-cloud and below cloud scavenging of particles size dependant and soluble.**
Initialization	Fixed initial conditions (cold start) From previous run (warm start)	Fixed initial conditions (cold start) From previous run (warm start)
Chemical boundary conditions	zero gradient inflow, open boundary out-flow	**climatological profiles**

GEM-MACH: Recent Milestones

GEM v3.3.0 released May 2007

- **First official version of GEM to include the new chemistry interface needed by GEM-MACH**

GEM-MACH v1.1.2 released July 2007

- **First version to include treatments of gas-phase chemistry and secondary organic aerosol formation**
- **First version with a complete implementation of the new emissions interface, including surface and elevated anthropogenic emissions and surface biogenic emissions**

GEM-MACH: next milestones

GEM-MACH v1.2.0 (Sept 2007)

- **Complete connection with GEM 3.3.0**

GEM-MACH v1.2.1 (target: October 2007)

- **First version with <u>full ozone chemistry package</u> (vertical diffusion of tracer species and dry deposition added in this version)**
- **Equivalent to CHRONOS for ozone**

GEM-MACH v1.2.x (target: Before Christmas)

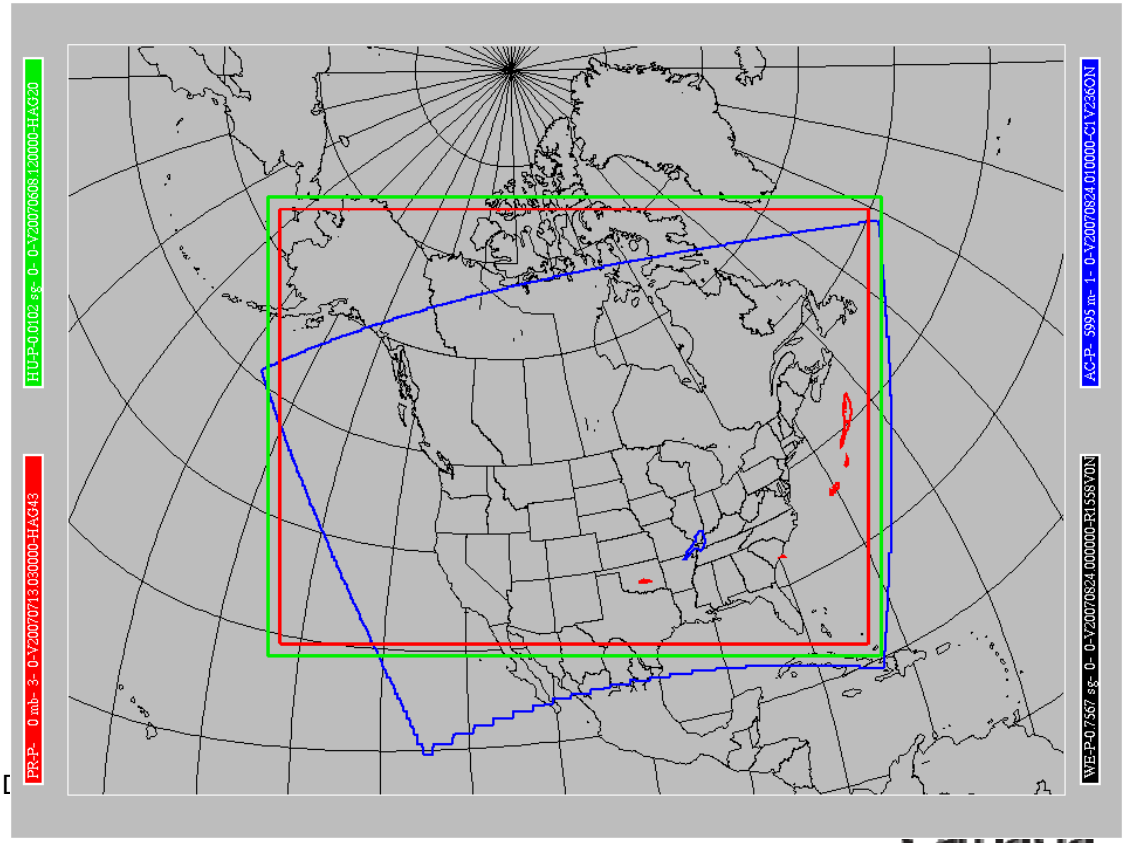
- **2 bins for PM as in CHRONOS**

GEM-MACH15 Configuration: Op. version

Have chosen GEM-LAM to be the operational grid configuration

GEM-MACH15: dx 15km
348x465 58 eta levels
8 time steps per hour
(36 times bigger)

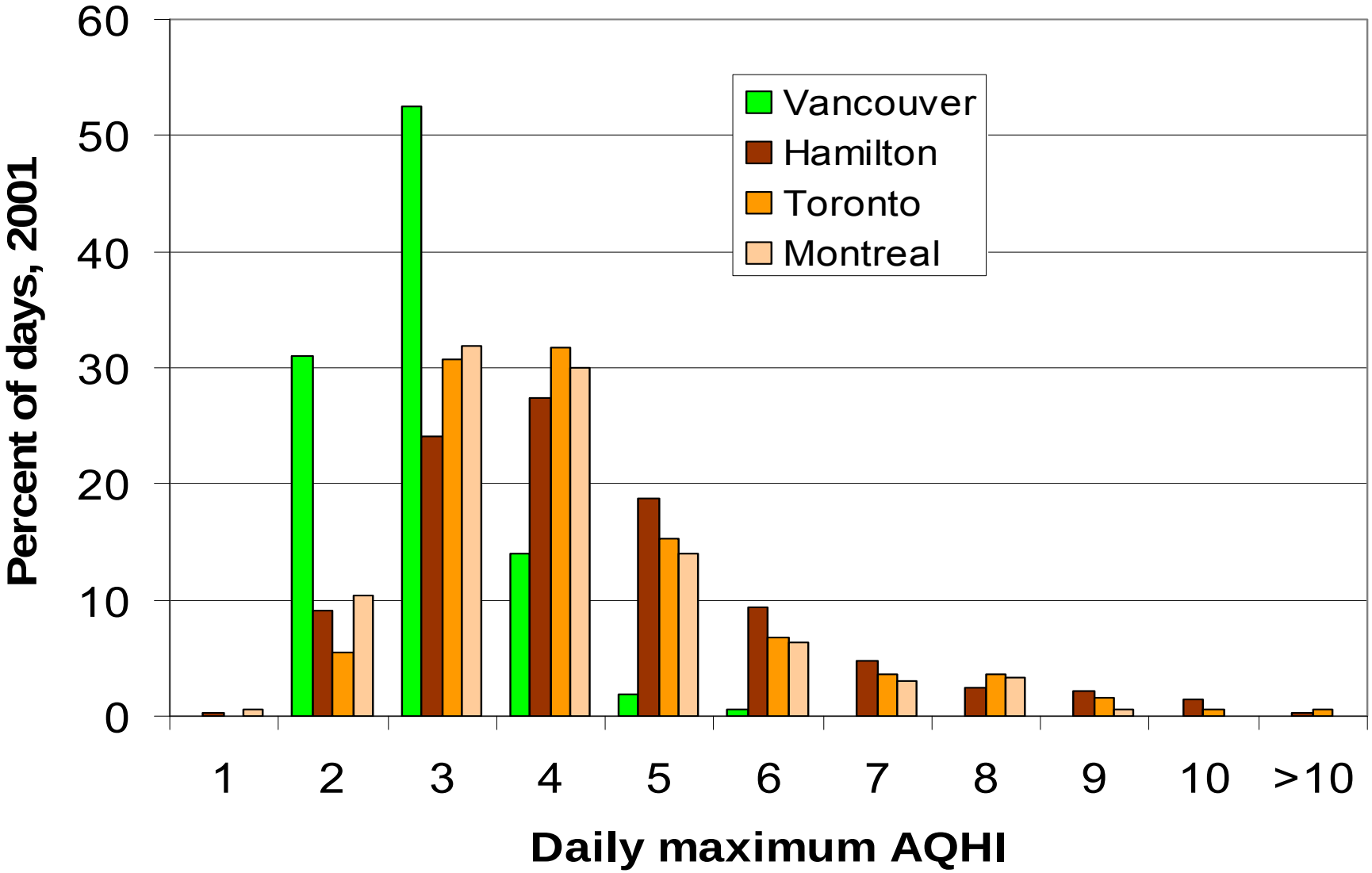
CHRONOS: dx 21km
350x250 24 Gal-Chen levels
1 time step per hour



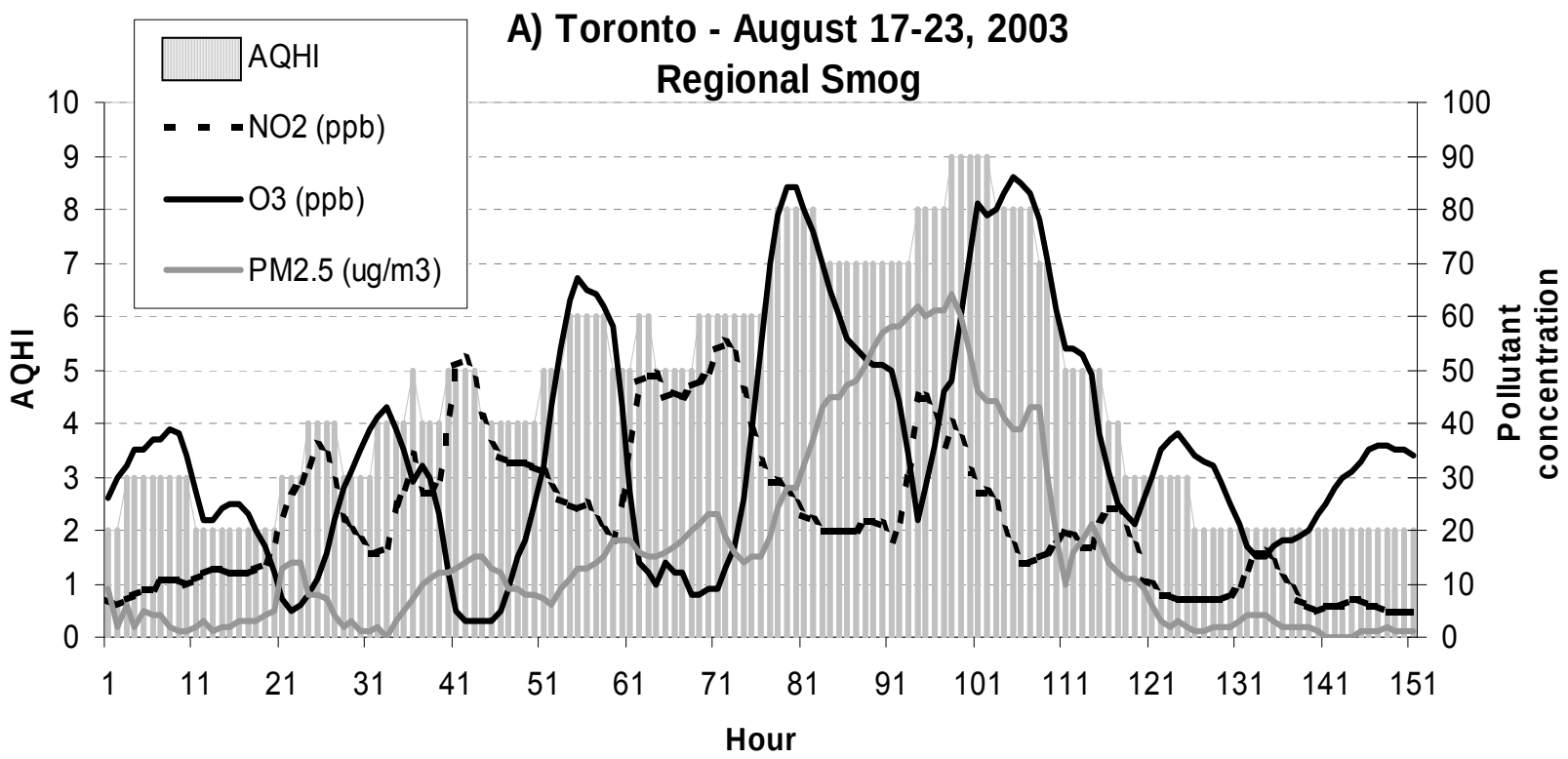
GEM-MACH 15 schedule

- **Until March 08:**
  - **verification of series, case studies, evaluation with the Regions, impacts of different processes, code optimization, 3D structure of new model with r.diag**
- **April 08:**
  - **scores for final series on multi-seasons**
- **May 08:**
  - **CPOP (for GEM-MACH15, nothing for CHRONOS)**
- **June 08:**
  - **→ in parallel for the whole summer 2008 (Availability outside EC?)**
- **Sept 08:**
  - **first implementation of GEM-MACH15**

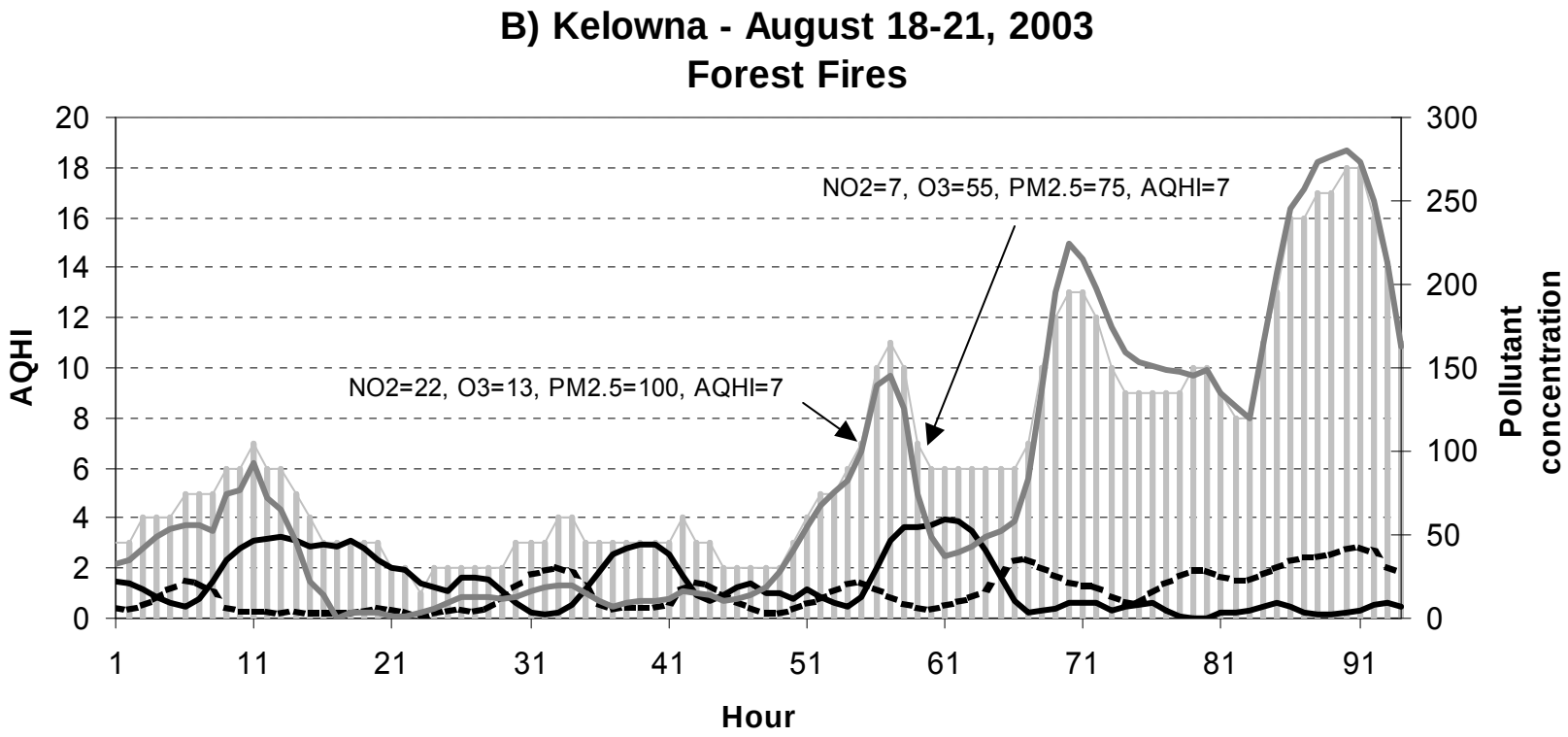
Questions?


Percent of days, 2001
60
50
40
30
20
10
0
Vancouver
Hamilton
Toronto
Montreal
1
2
3
4
5
6
7
8
9
10
>10
Daily maximum AQHI

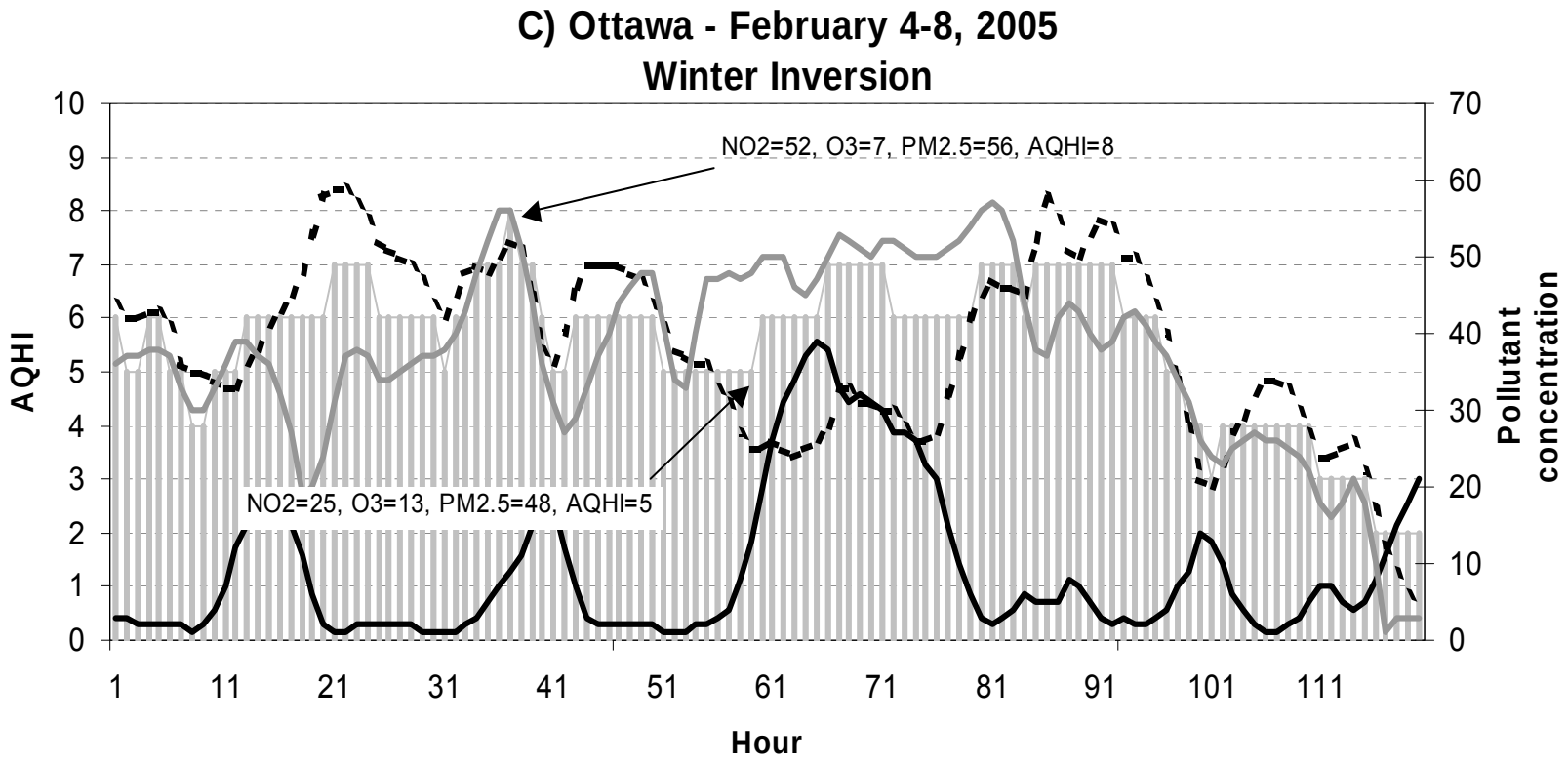
Multi-Pollutant Performance

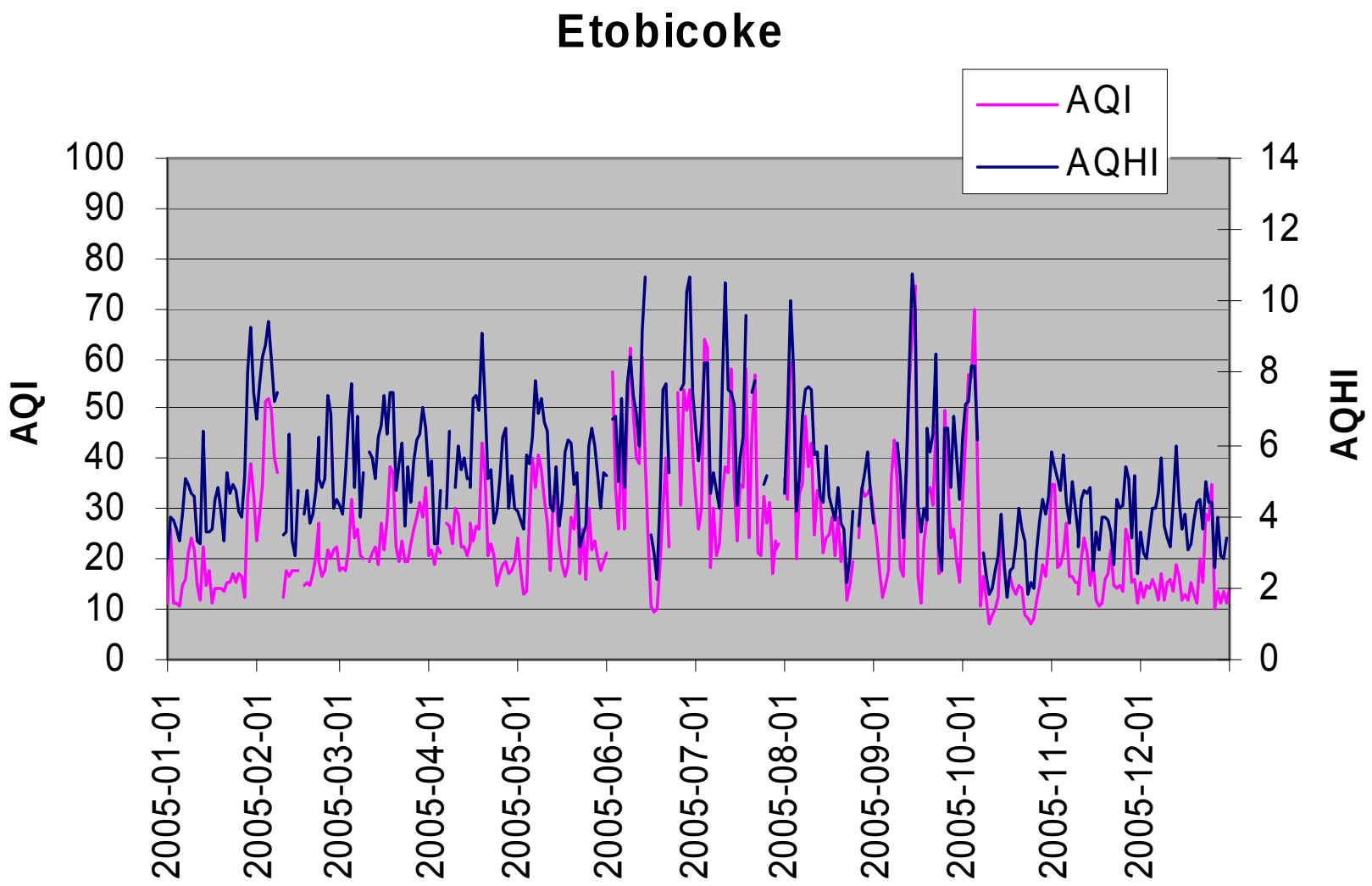


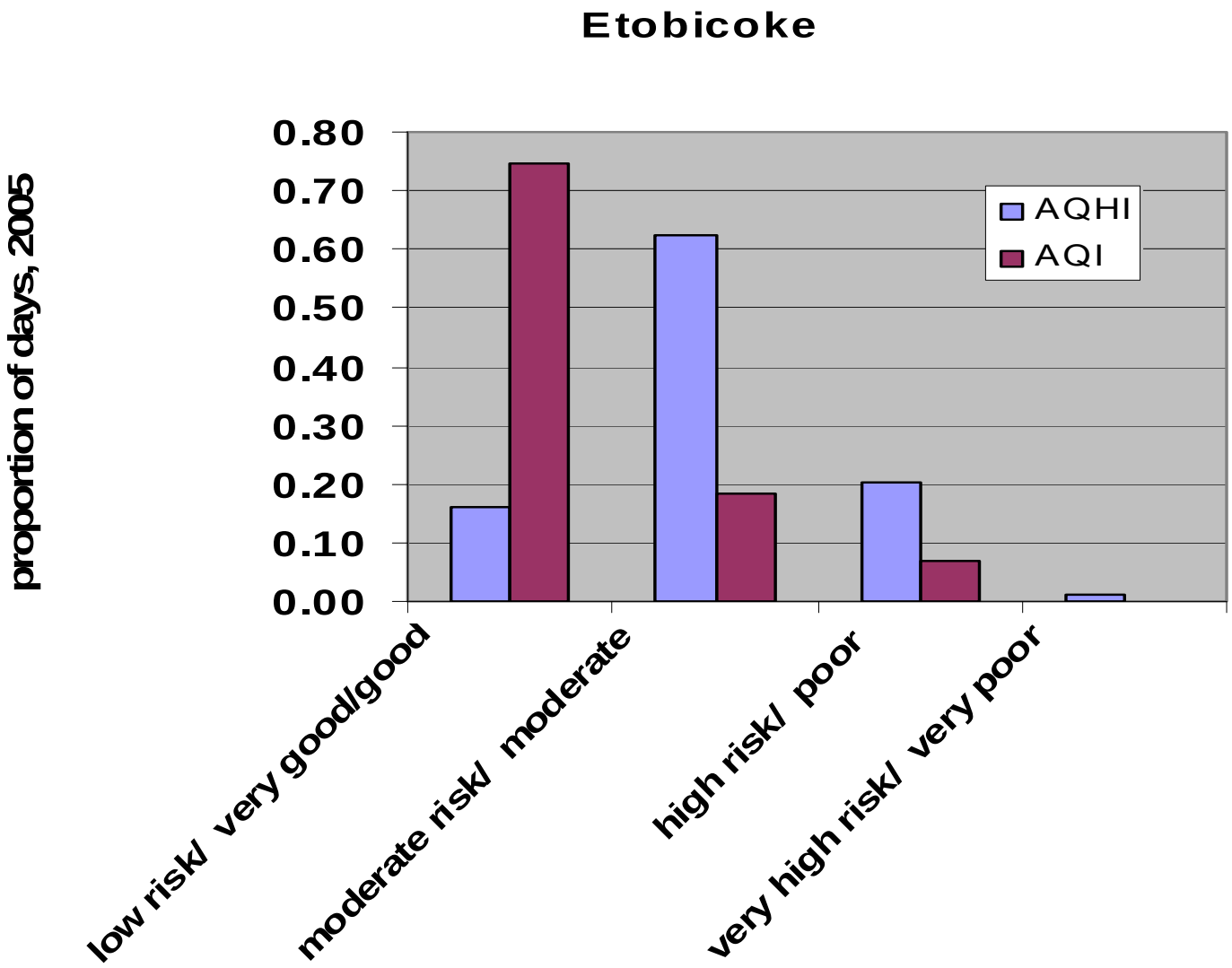
Single Pollutant Performance



Winter Air Pollution Event




Etobicoke
AQI
AQHI
100
90
80
70
60
50
40
30
20
10
0
14
12
10
8
6
4
2
0
2005-01-01
2005-02-01
2005-03-01
2005-04-01
2005-05-01
2005-06-01
2005-07-01
2005-08-01
2005-09-01
2005-10-01
2005-11-01
2005-12-01


Etobicoke
proportion of days, 2005
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
AQHI
AQI
low risk/ very good/good
moderate risk/ moderate
high risk/ poor
very high risk/ very poor

AQHI Health Messages

Level of Risk	Index Reading	What You Should Do	
		At Risk Population	**General Population**
Low	**1 – 3**	▪Enjoy your usual outdoor activities. ▪Follow your doctor's advice for exercise.	▪Ideal conditions for outdoor activities: sports, biking or walking.
Moderate	• **4 – 6**	▪If you have heart or breathing problems and experience symptoms, consider reducing physical exertion outdoors or rescheduling activities to times when the index is lower. ▪Follow your doctor's usual advice about managing your condition.	▪No need to modify your usual outdoor activities.
High	**7-10**	▪Children, the elderly and people with heart or breathing problems should reduce or reschedule physical exertion outdoors to periods when the index is lower, especially if you experience symptoms. ▪Follow your doctor's usual advice about managing your condition.	▪Anyone experiencing discomfort such as coughing or throat irritation should consider reducing or rescheduling strenuous outdoor activities to periods when the index is lower.
Very High	**Above 10**	▪Children, the elderly and people with heart or breathing problems should avoid physical exertion outdoors. ▪Follow your doctor's usual advice about managing your condition.	▪Everyone should consider reducing or rescheduling strenuous outdoor activities to periods when the index is lower, especially if you experience symptoms.

Self-calibration

At Risk Population:
People with heart or lung disease (including asthma) should monitor symptoms as the index reading increases.

General Population:
Even healthy people may have more difficulty breathing as air pollution increases.

- Paying attention to the index and your symptoms
- What does a particular index reading mean to you