





Air Quality Forecast at the Meteorological Service of Canada: What's up in 2013

NOAA's AQ Forecaster Focus Group Workshop, 2013 Mike Howe, Didier Davignon MSC-WEPS-NPO 2013-09-26

Summary

- The Air Quality Health Index: status and new initiatives
- The Canadian Air Quality Modelling System
 - Latest updates
 - Evaluation
 - In development
- Forest Fire smoke emissions modelling: the FireWork-GEMMACH system
 - Evaluation
 - Path forward



Page 2 – 8 juillet 2016



Update on the Canadian Air Quality Health Index (AQHI) Forecast Program

Speaker: Mike Howe

Shown: Air Quality Health Index on Weather.gc.ca

Environnement

Canada

Environment

Canada

Governm of Canad	ent Gouvernemenl a du Canada						Canada.g	c.ca Serv	ices Depar	tments Français					
Weather Ale	rts Marine /	Air Quality	• Techni	cal Pa	st Weath	her			(Canad'ä Search					
Home > Air Quality	/ > Air Quality Heal	th Index a O	Intario												
Toronto - A	ir Quality H	lealth li	ndex												
	Current Observed at: 1: 2	23 Septe	mber 201	Past 24 hr AQHI by Station											
			4	F	6	-		10							
	1 2 3 4 5 Low Risk Moderate Risk (1-3) (4-6)					1	High Risk (7-10)	> 9 10 High Risk (7-10) Hi							
	At-Risk Population • Enjoy your of • Find out if y	on: usual outdo rou are at r	oor activitie isk	:5,	Gener: • I	al Popul Ideal air	ation: quality for (outdoor acti	ivities.						
	Forecast Maximums Heal							alth Message							
	Issued at: 6:00	AM EDT M	onday 23 S	Septembe	er 2013										
	Monday	3 - L	ow Risk			•									
	Monday night 3 - Low Risk Tuesday 3 - Low Risk					-									
						•									
	Who is at risk?	,			Did y	you kn	ow?			-					
	People with heart and lung conditions are most affected by air pollution.					You should avoid spilling gas when filling cans and tanks.									
	To find out if you <u>quide</u> , your physi <u>authority</u> .	<u>he health</u> alth													
	Visit the <u>national</u> about the AQHI.	AQHI Web	<u>site</u> to lea	irn more											

Page 3 – 8 juillet 2016





Environnement

Canada

Environment

Canada

Canada

Implementation Status

- AQHI reaches approximately 65% of Canadians
 - 76 forecast locations (Wx Office)
- AQHI forecasts available in all provinces, all SPCs participate in forecasting
 - Fully adopted in 7 provinces
 - Retirement of their provincial AQI's
 - Remaining provinces "pilot testing" (includes major cities)
 - Quebec, Ontario and New Brunswick (paths forward identified for former 2)

• North

- Yellowknife June/2013
- Iqaluit and Inuvik Summer /2014
- Data delivery/integrity remains the primary obstacle to moving forward in other locations

International

- Delegation from Shanghai Envir Monitoring Centre June 2013
- Hong Kong implementation of AQHI progressing
- Ongoing engagement with Mexico and the US through the CEC
- Requests from India, UK and New Zealand



Page 5 – 8 juillet 2016



AQHI Enhancement for Pan Am Games 2015

- Raise visibility of individual AQHI locations in the (6 in Toronto and 2 in Hamilton)
- Forecasts for individual locations at 3 hour increments Tor for Day 1 (Trend Forecasts)
- Continue to use community value with Weather Network and other media
- New 2.5km grid GEM-MACH demonstration output planned
 - New emissions scheme





Page 6 – 8 juillet 2016



Showcasing research products for AQHI forecasting: High-resolution window

Capacity tested with predecessor to GEM-MACH

- 42-km → 15-km → 2.5km nests
- 42- and 15-km AURAMS driven by 15km GEM
- 2.5-km AURAMS driven by 2.5-km GEM.

GEM-MACH2.5 cascade currently in development



15-km GEM-LAM, 42-km, 15-km, and 2.5-km AURAMS domains (from BAQSMet study, Makar et al.) Page 13 -





Environnement

High Resolution Grid, Spacing at 2.5-km 250 x 300 based on GEM4



Road Link-Based Pollutant Emissions McMaster University Traffic Flow Model v1



Showcasing New AQHI Modelling @ High-resolution for Pan Am

O₃ model predictions for 8 July, 2007 1pm local time



The model captured the transport of ozone along the <u>lake breeze frontal</u> <u>convergence zone</u> better at 2.5-km resolution than at 15-km resolution Page 10 – 8 juillet 2016



Environnement Environment Canada Canada

The Canadian AQ Modelling System

Speaker: Didier Davignon

In this section:

- Latest updates to the RAQDPS
- Model evaluation
- Future developments

For reference:

- RAQDPS = Regional Air Quality Deterministic Prediction System
- GEM-MACH10: AQ model at the core of the RAQDPS



Page 11 – 8 juillet 2016



The Canadian AQ Modelling System



Latest implementation, February 2013

- New version of GEM NWP model source code
- New GEM-MACH grid configuration (\rightarrow ~5X more Flops):
 - domain virtually unchanged,
 - horizontal grid spacing reduced (15 km to 10 km),
 - number of σ -p vertical levels increased (58 to 80),
 - met time step reduced (450 s to 300 s),
 - chemistry time step unchanged (900 s)
- Change in meteorological piloting model from GEM-LAM15/3D-Var to GEM-LAM10/4D-Var
- Mostly same emissions inventories but improved emissions processing, especially for Canadian emissions



Page 13 – 8 juillet 2016



Changes to Emissions

- Emissions inventories used:
 - Canada: new version (2006 base year)
 - USA: no change (projection to 2012)
 - Based on EPA 2005 v4.2
- Mexico & biogenics: no change





Changes to Emissions

- Corrected and optimized boundary shapefiles
- Corrections and improvements to some spatial surrogate fields, including new surrogates for Canadian on-road mobile emissions
- Updates to some Canadian temporal profiles
- New library of PM speciation profiles and addition of some VOC speciation profiles
- Land-use-dependent transportable fraction used to scale fugitive dust emissions
- Removal of emissions from shut-down facilities (e.g., Flin Flon, MB)



Canada

Callada

Model evaluation: ozone

Summer hourly scores

- Small improvement in correlations, bias improved
- Bias reduced in Canada (<1ppbv)
- Bias in USA: West is negative (~ -7ppbv), East is positive (~ 3ppbv)
- Winter hourly scores
 - Small improvement in correlations, neutral for bias
 - Bias generally negative:
 - Canada West/East: about -1/-4 ppbv
 - USA West/East: about -4/-3 ppbv



Page 16 – 8 juillet 2016



Model evaluation: PM2.5

Summer hourly scores

- Small improvement in correlations & bias
- Correlations improved in USA also
- Bias in USA: West is negative (~ -2ug/m3), East is positive (~ 4ug/m3)
- Winter hourly scores
 - Small improvement in correlations, neutral for bias
 - Bias improved in Canada (near zero)
 - URMSE improved across domain
 - Bias in USA: West/East: about 0/-1 ug/m3
- (Used winter/summer 2012)



Page 17 – 8 juillet 2016



Future developments

- Working on a new GEM-MACH v2 based on an updated version of the GEM weather model
 - New vertical staggering of variables has a large impact on surface AQ
 - Will be piloted by a global weather model instead of a regional
 GDPS at 15km
 - Potential for piloting from the lid, may allow to lower model lid
 - Preliminary results very promising
- AQ forecast at 2.5km is being evaluated (PanAm, etc)
- Longer-term plans to extend forecast lead time beyond 48 hours
- Long-term plan for AQ data assimilation was developed



Environnement Environment Canada Canada Page 18 – 8 juillet 2016



FireWork-GEMMACH: including forest fire emissions in AQ forecast

- Brief description of FireWork-GEMMACH
- Preliminary evaluation
 - Objective scores
 - One case study
- Next steps





Approach

FireWork framework





Environnement Environment Canada Canada Page 20 – 8 juillet 2016



Current Firework Modelling strategy

- The experimental set-up uses the same configuration of the operational 10 km GEM-MACH to execute a separate run that takes into accound fire emissions.
- Run in parallel with forest fire emissions:
 - Run twice a day
 - Inclusion of "old smoke" from the previous run
- Products
 - PM_{2.5} Maps and animations based on the difference between Firework and the operational run to isolate plumes
 - Alternate AQHI with Firework





Average PM_{2.5} Concentrations and Differences for July 2013

Operational forecast

Difference when wildfire emissions are included



50.0 40.0 30.0 20.0 10.0 5.0 1.0 0.5 -0.5 -1.0 -5.0 -10.0 183 -20.0 -30.0 -40.0 -50.0 100.0

Difference: GM_withWildFire – GM_withoutWildFire



Environnement Environment Canada Canada Page 22 – 8 juillet 2016



Average O₃ Concentrations and Differences for July 2013

Operational forecast

Difference when wildfire emissions are included



Difference: GM_withWildFire – GM_withoutWildFire



Environnement Environment Canada Canada Page 23 – 8 juillet 2016



The Average NO₂ Concentrations and Differences for July 2013

Operational forecast

Difference when wildfire emissions are included





Difference: GM_withWildFire – GM_withoutWildFire



Environnement Environment Canada Canada Page 24 - 8 juillet 2016



Objective Scores for Summer 2013 Period: June 6th – July 31st

		Region											
BOOTSRAPPING		Canada		West Canada		East Canada		USA		West USA		East USA	
Pollutant	Statistic	OPS	Forest Fire	OPS	Forest Fire	OPS	Forest Fire	OPS	Forest Fire	OPS	Forest Fire	OPS	Forest Fire
NO2	MB	1.32	1.34	0.40	0.41	2.24	2.27						
	R	0.48	0.48	0.51	0.51	0.47	0.47						
	URMSE	7.29	7.31	5.78	5.79	8.43	8.46						
O 3	MB	0.88	1.20	0.12	0.31	1.30	1.70	2.46	2.72	-5.21	-4.83	5.23	5.45
	R	0.59	0.60	0.59	0.60	0.58	0.59	0.64	0.64	0.68	0.69	0.67	0.67
	URMSE	10.99	10.98	9.63	9.64	11.66	11.63	14.06	14.05	13.86	13.92	13.07	13.06
PM _{2.5}	MB	-0.66	-0.31	-1.40	-1.20	-0.05	0.43	1.08	1.74	-2.11	-1.07	2.93	3.36
	R	0.31	0.35	0.16	0.17	0.26	0.32	0.31	0.34	0.22	0.29	0.30	0.31
	URMSE	10.51	10.26	6.39	6.44	12.94	12.52	11.30	12.39	8.12	11.62	12.42	12.53
	Legend												
	OPS (Base C	ase) is better	•										
	Forest Fire Ve	rest Fire Version is better											
	Statistically not significant												
	N/A												

- Main impact is to improve correlations for PM in Canada
 - Adds ozone were model bias was already positive
- The experimental 2013 version of FireWork tends to add too much PM in USA
 - Got worse in August, not included here.



Page 25 – 8 juillet 2016



Case Study: Forest Fire in Northern Quebec



Page 26 – 8 juillet 2016



Aqua/MODIS (2013/181; 06/30/2013 18:00 UTC) image showing forest fires in Quebec



Source: http://rapidfire.sci.gsfc.nasa.gov/gallery/



Environnement Environment Canada Canada



PM_{2.5} Correlations (observations vs forecasts)

PM_{2.5} correlations (OBS & forecasts) at station locations. Considered period: June 28th – July 4th 2013.

	CORRELATION							
Station ID	GM_OPS	GM_with_Wildfires						
53201	-0.17	0.70						
55001	0.30	0.66						
53901	-0.13	0.68						
50604	0.28	0.27						
53301	-0.13	0.41						
51201	-0.15	0.60						
52001	0.01	0.53						
50504	-0.10	0.43						
52710	0.77	0.56						
MTL (12 stations)	-0.04	0.21						
AVG	0.07	0.50						

Significant improvements in PM_{2.5} correlations for analyzed 21 stations.

In general, the average summertime $PM_{2.5}$ correlation per region is around 0.30. Model version with wild fire emissions improved average correlation to **0.50** for analyzed stations.



Page 28 – 8 juillet 2016



Objective Scores

Period: June 30th – July 3rd 2013 (Wildfires in Quebec)

4 days only

		Region											
BOOTSRAPPING		Canada		West Canada		East	East Canada		USA		West USA		USA
Polluant	Statistique	OPS	Forest Fire	OPS	Forest Fire	OPS	Forest Fire	OPS	Forest Fire	OPS	Forest Fire	OPS	Forest Fire
	MB	1.58	1.67	0.70	0.71	2.49	2.65						
NO ₂	R	0.48	0.48	0.48	0.48	0.48	0.47						
	URMSE	7.60	7.70	6.25	6.25	8.68	8.84						
_	MB	2.25	3.68	3.16	3.21	1.73	3.94	1.79	2.38	-3.51	-3.15	3.66	4.32
O_3	R	0.54	0.56	0.62	0.62	0.49	0.52	0.63	0.64	0.63	0.64	0.63	0.64
	URMSE	11.73	11.30	11.16	11.14	12.01	11.39	14.08	13.94	16.68	16.54	12.51	12.32
554	MB	-7.99	-6.33	-2.41	-2.36	-12.64	-9.65	-0.88	-0.07	-2.62	-2.07	0.09	1.05
PIVI _{2.5}	R	0.13	0.32	0.07	0.09	0.03	0.20	0.25	0.28	0.17	0.18	0.24	0.28
	URMSE	18.06	16.52	8.84	8.76	22.03	20.30	10.42	10.51	7.87	8.25	11.49	* 11.43
			\backslash									/	
												/	
	Legend												
	OPS (Base Case) is better												
	Forest Fire Ve	ersion is better		<u> </u>								_/	
	Statistically no	ot significant		\mathbf{i}								/	
	N/A												
100												vod	
												veu	
												-	
						DM	coor	oc im	nrovo	4			
	O3 (R, URMSE) scores improved also												
						Dame		040					



Environnement Environment Canada Canada

Page 29 – 8 juillet 2016



Next Steps

- FireWork-GEMMACH 2014 to be run in operations starting in May.
 - Include improvements to US fire emissions (Fire evolution)
- Work in progress:

. . .

- Implement Fire growth algorithm
- Implement plume rise algorithms
- Improve emission data feed (additional data sources)
- Implement a passive tracer stragegy





Sample product





Environment Environnement Canada Canada

Page 31 - 8 juillet 2016

Thank you!

Didier Davignon

Chief, Air Quality Modeling Applications Section (AQMAS) National Prediction Operations Meteorological Service of Canada, Environnement Canada

Mike Howe Manager, Client Services Health and Air Quality Forecast Services Meteorological Service of Canada, Environnement Canada



Page 32 – 8 juillet 2016

