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Perspectives of Air Quality Forecasting in Canada

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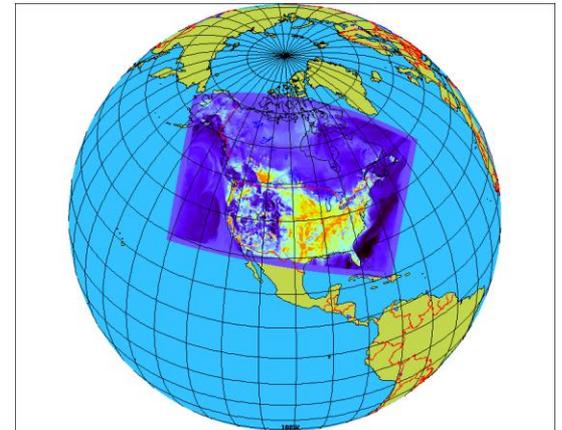
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Environment Canada

**4th International Workshop on Air Quality Forecasting Research
Geneva, Switzerland, 12 - 14 December 2012**

Current Operational Air Quality Forecast System

- Regional system with a domain covering North America
 - 10 km horizontal grid spacing
 - 80 vertical levels with lid at 0.1 hPa (~10 levels in 1st km of the atmosphere)
- On-line coupled meteorology and chemistry model GEM-MACH
 - One-way coupling (meteorology affects chemistry)
 - Full process representation of oxidant and aerosol chemistry:
 - gas-, aqueous- & heterogeneous chemistry mechanisms
 - aerosol dynamics
 - dry and wet deposition (including in- and below-cloud scavenging)
 - 2-bin sectional representation of PM size distribution (i.e., 0-2.5 and 2.5-10 μm) with 9 chemical components



Current Operational Air Quality Forecast System (cont'd)

- Initial Conditions for GEM-MACH
 - Regional 4DVar analysis for meteorological variables
 - No assimilation for chemical constituents
 - Perpetual forecast mode where the 12-hour forecast from previous integration is used to initialize the next forecast
- Boundary Conditions for GEM-MACH
 - From Regional Deterministic (Weather) Prediction System for meteorological variables
 - Climatology for chemical constituents
- Emissions Inventories
 - Canada (2006)
 - US (2012 projection of 2005 NEI)
 - Mexico (1999)

Current Operational Air Quality Forecast System (cont'd)

- Products
 - Twice daily 48-hour forecasts initiated at 00 UTC and 12 UTC
 - Forecast communicated in most areas as an Air Quality Health Index (AQHI): hourly, multi-pollutant, additive, no-threshold, health-based

$$\text{AQHI} = 10/10.4 * 100 * [(\exp(0.000871 * \text{NO}_2) - 1) + (\exp(0.000537 * \text{O}_3) - 1) + (\exp(0.000487 * \text{PM}_{2.5}) - 1)]$$

**More information on the AQHI at the poster sessions: "Evaluation of time series modelling techniques to improve the Air Quality Health Index", Sean Perry*

Recent Changes in the Operational Air Quality Forecast System

- Current system became operational on 3 October 2012
- Improvements to GEM-MACH in current version include:
 - Increase horizontal grid spacing from 15 to 10 km
 - Increase resolution in the stratosphere
 - Number of levels above 100 hPa increased from 12 to 34
 - Total number of levels increased from 58 to 80
 - 4DVar instead of 3DVar assimilation for meteorological variables
 - New set of hourly gridded anthropogenic emissions fields based on a new version of the 2006 Canadian emissions inventory, plus the 2012 projected US and 1999 Mexican inventories.

**For more information on the validation of the current operational system: Presentation by Sophie Cousineau, 'Model Evaluation and post processing' Session, Thursday afternoon*



Future Development

- Context:
 - Current and previous versions of GEM-MACH were highly dependent on the Regional (weather) Deterministic Prediction System (RDPS):
 - Both use the same grid resolution
 - Both use same the meteorological parameterizations
 - GEM-MACH uses RPDS for the initial and boundary conditions for the meteorological variables
 - Planned development for the RDPS is to increase the horizontal grid spacing from 10 to 2.5 km
 - The development thrust for the air quality forecast system is to improve the lead time and quality of the forecast yet keep the grid spacing constant at 10 km

Future Development (cont'd)

- Extending forecast lead time beyond 48 hours
 - Requested by Users;
 - Extension to 72 or 96 hours, depending on computer resources;
 - Will be made possible by adopting the global medium-range weather forecasting system (aka GDPS) to provide GEM-MACH with initial and boundary conditions;
 - Resolution of GDPS to be updated within a year from its current 25 km to 15 km.



Future Development (cont'd)

- Other benefits of targeting longer lead time
 - To maximize compatibility between GDPS and GEM-MACH, the latest meteorological developments of the GDPS, including its new dynamical core, will be integrated in GEM-MACH
 - New dynamical core allows for piloting from side boundaries and lid, allowing for a reduction in the vertical extent of GEM-MACH domain,
 - Desirable since model does not include stratospheric chemistry
 - Lower model lid will allow substantial increase in vertical resolution for equivalent computing time or decrease in computing time for an equivalent resolution
 - In current system with lid at 0.1 hPa, 34 of the 80 levels are above 100 hPa

Future Development (cont'd)

- Improving the quality of the forecasts
 - Emissions:
 - Presentation by Mike Moran, 'Emissions Forecasting Development' Session, Thursday morning*
 - Inclusion of wildfire emissions

Future Development (cont'd)

- Improving the quality of the forecasts
 - Initial conditions for chemical constituents:
 - Long term goal is to have a regional 3D assimilation, but an operational implementation is not expected to be available before 2017;
 - Medium term goal aims the development of a global assimilation system based on a coarse resolution global version of GEM-MACH
 - Short term goal aims to transform the current surface objective analysis of O₃ and PM_{2.5}. (and soon NO₂) into a 3D analysis via the introduction of a vertical correlation model for the analysis increments;

Future Development (cont'd)

- Improving the quality of the forecasts
 - Boundary conditions for chemical constituents:
 - Current operational system uses chemical climatology constructed from an array of sources
 - Short term goal aims to replace the boundary conditions by a climatology obtained from a seasonally-averaged 1-year run of a global configuration of GEM-MACH;
 - Medium term goal aims to use chemical constituents concentrations provided by coarse resolution global GEM-MACH system which will have also provided the initial conditions.

Future Development (cont'd)

- Improving the quality of the forecasts
 - Process representations:
 - Performance analysis will be performed against validated data
 - Gas-phase chemistry:
 - ADOM-II with addition of IVOCs
 - SAPRC-CS07A
 - Organic aerosol chemistry
 - Update SOA yields for monoterpenes, isoprene, alkanes & alkenes
 - Module for uptake of organic gases from gasoline combustion into aqueous sulphate aerosol;
 - Module for update of water-soluble organic gases to cloud phase;
 - Etc...
 - Interactive chemistry

Presentation by Wanmin Gong, 'Process representations and interactions with meteorology' Session, Thursday morning

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Summary

- A new development cycle has begun for the Canadian operational air quality forecast system;
- The goal is to develop a system that will include a regional 10 km-resolution limited-area on-line model and global 1°-resolution on-line model;
- Improvements will include
 - A better dynamical core;
 - Better initial conditions (regional and global assimilation efforts);
 - Better lateral boundary conditions (piloting by a global model with chemistry);
 - Improved process representation; and
 - Improved emissions representation.



Thank you

http://www.weatheroffice.gc.ca/aqfm/index_e.html

