Environment Canada Environnement Canada

ONTARIO AIR QUALITY FOR SUMMER 2009

WITH SPECIFIC FOCUS ON MODEL PERFORMANCE FOR AUG 15-17TH

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Abstract

The months of June and July were so cold and rainy that most Ontarians were left wondering when summer would start. A persistent upper level low brought highly localized and intense thunderstorms over many parts of southern Ontario with a few notable precipitation records made. This created few opportunities for significant local fine particulate matter ($PM_{2.5}$) build-up over southern Ontario and even fewer chances for long-range transport of $PM_{2.5}$ from non-local emission point sources. Ozone (O_3) values also rarely exceeded 80 ppb in southern Ontario as more cloud cover was evident during peak ozone times as a result of the upper-low residing over Ontario. The long-awaited hot weather finally arrived in August as a dominate ridge of high pressure resided over the lower Great Lakes. August 15-17th had a spell of higher $PM_{2.5}$ values near 40 ug/m³ and also peak ozone values near 80 ppb over southern Ontario.

An evaluation of several air quality models was conducted for the summer with a closer look at the August 15-17th event. A comparison was made for O_3 and $PM_{2.5}$ between the Canadian operational air quality forecast models, CHRONOS and GEM-MACH15, as well as the US model, CMAQ. Furthermore, nitrogen dioxide (NO_2) predictions from CHRONOS and GEM-MACH15 were also analyzed in order to evaluate the models' capabilities to forecast the Air Quality Health Index (AQHI) which is based on the interactions between NO_2, O_3 and $PM_{2.5}$.

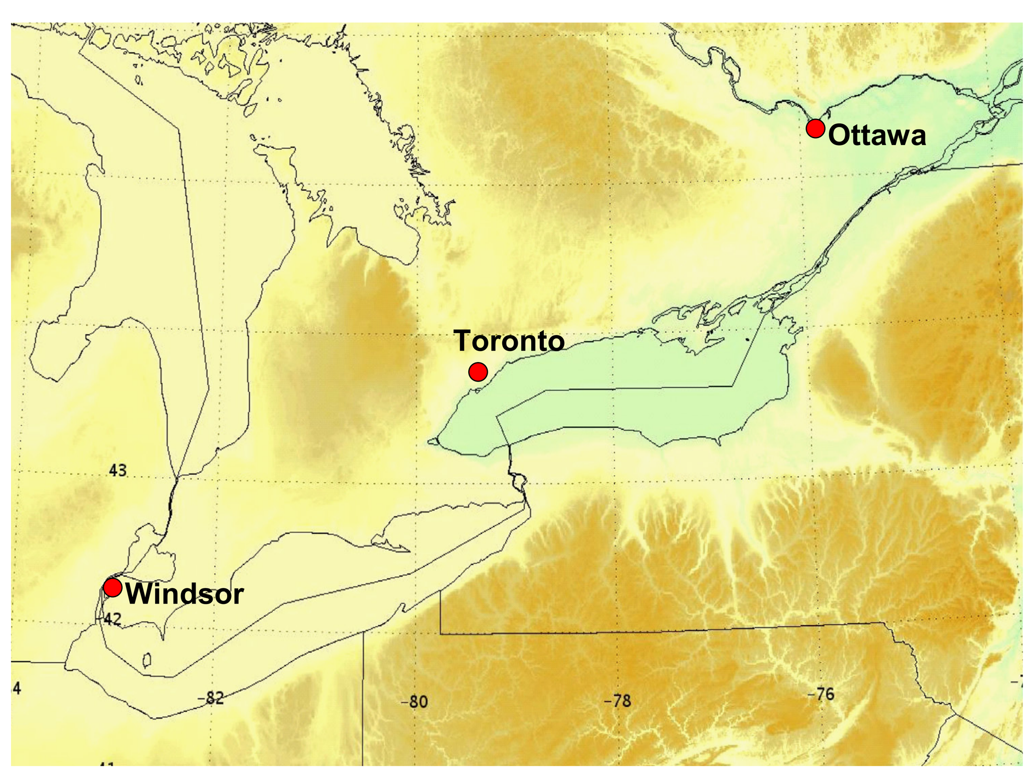
Background

The Air Quality Health Index (AQHI) developed by Health Canada and Environment Canada is among the first of its kind in the world. It links the health risks with a mixture of air pollutants. The AQHI is calculated based on three specific pollutants: ground-level O_3, $PM_{2.5}$ and NO_2. These three pollutants will be evaluated for three sites (Windsor, Toronto and Ottawa) located in southern Ontario for the summer of 2009.

Forecasters at the Ontario Storm Prediction Centre use guidance from CHRONOS and the newly developed operational air quality model GEM-MACH15 as a tool to forecast each pollutant concentration for the AQHI. This year, Ontario Region has also participated in the evaluation of performance and utility of the US numerical air quality forecast guidance. Hourly O_3 and $PM_{2.5}$ outputs from CMAQ are compared with the Canadian models and against the measurements for the study sites. Results from each of the models' performances for August 15-17th 2009, is presented in this poster.

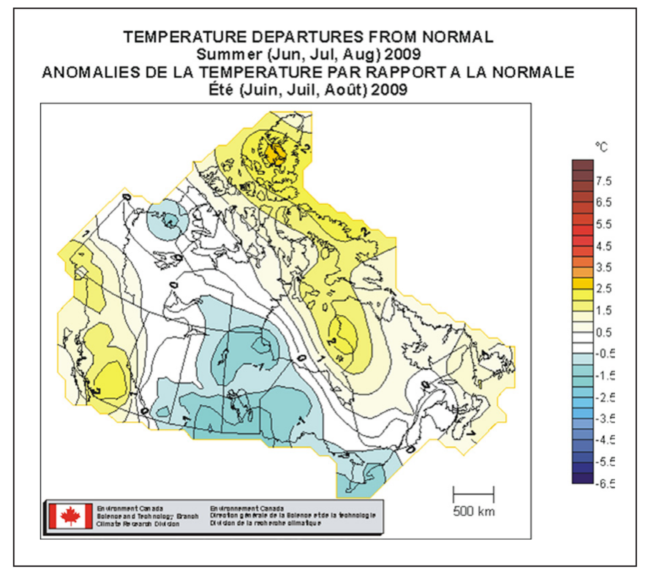
Objective

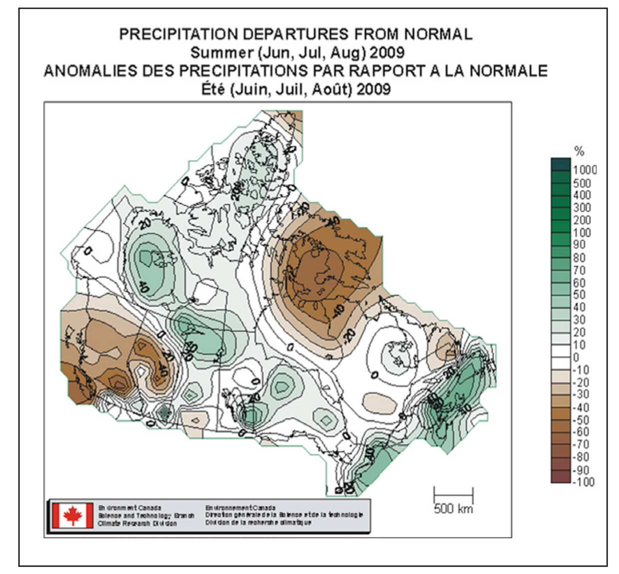
Mean concentrations of NO_2, O_3 and $PM_{2.5}$ for the summer of 2009 will be compared to multi-year summer season averages. It will be seen how the summer weather pattern this year affected each of the pollutant concentrations in Windsor, Toronto and Ottawa. A more intense evaluation of the three pollutants will be conducted for the August 15-17 period when southern Ontario did receive an episode of poorer air quality.



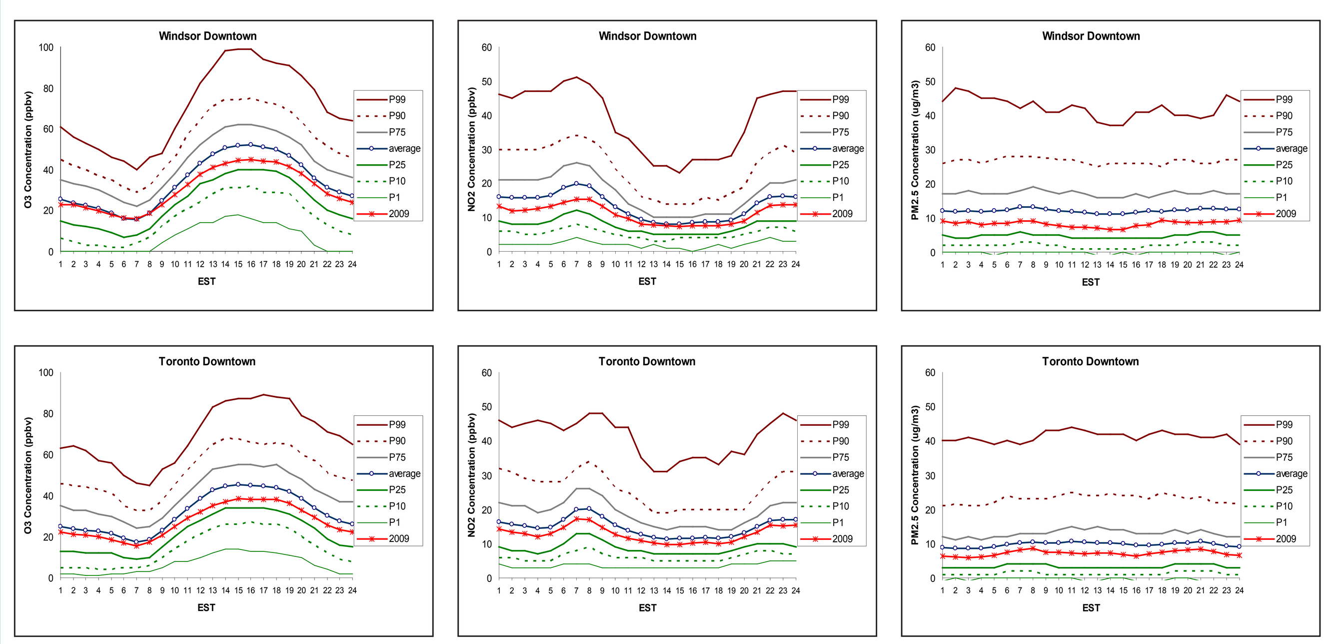
Analysis

For Ontario, the summer of 2009 was much cooler and wetter than normal as a persistent upper-level cold low resided over the area for most of the season. Most of Ontario was on average 1.5°C below normal. With respect to precipitation, southern Ontario was significantly wetter than usual with some areas around the lower Great Lakes receiving 20-40% more precipitation than normal.



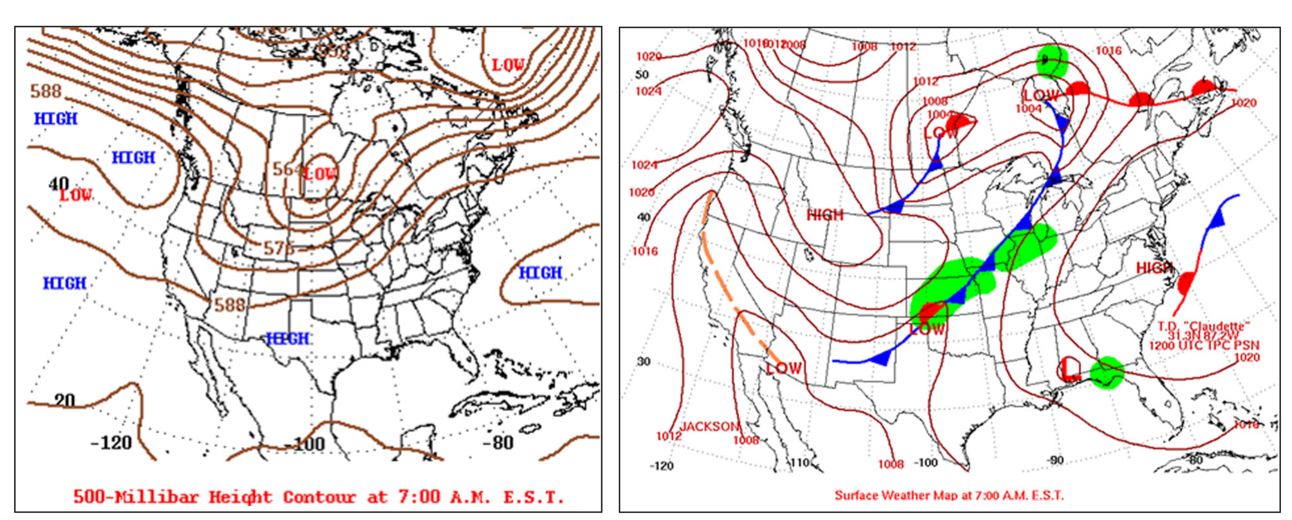


The persistent advection of colder and cleaner air from the north which was ushered in by the upper-level low decreased the frequency of long-range transport of pollutants from the US as well as build-up from local area point sources. Furthermore, summertime high pressure systems shifted well south of the lower Great Lakes as the low gave way to cloudier and wetter conditions. This resulted in decreased ozone concentrations due to less photochemistry production, as well as increased wet deposition of all three pollutants which contributed to their overall decrease below normal values.



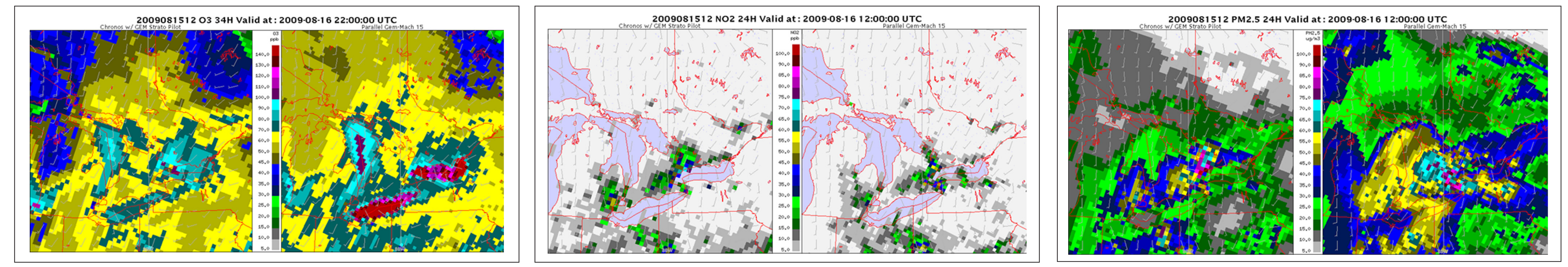
Summer Climate Values from 2004-2009 with 2009 summer average values highlighted in red.

An episode of higher pollutant values occurred on Aug 15-17th as a strong high pressure system dominated across the Eastern US seaboard. Persistent southwest flow developed over southern Ontario and extended from the surface to 500 mb.

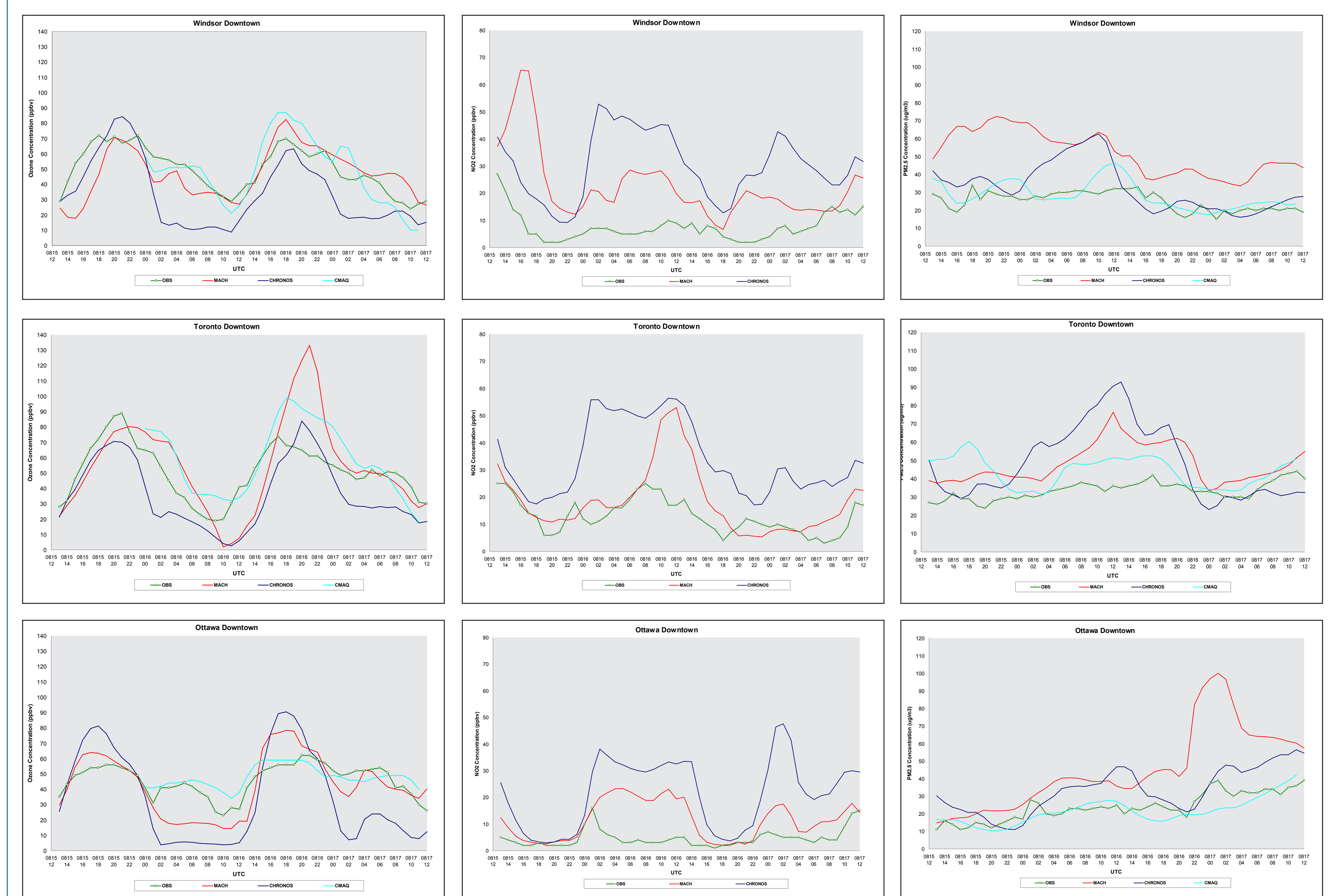


500 mb height contour and surface pressure maps for Monday August 17th 2009)

Here is a spatial display of NO_2, O_3 and $PM_{2.5}$ at peak times during the 20090815 12Z model run for CHRONOS and GEM-MACH15.



Both GEM-MACH15 and CMAQ fit the Ozone diurnal curve better for all three sites although GEM-MACH15 showed larger diurnal variability. CHRONOS consistently under-predicted the diurnal O_3 pattern. GEM-MACH15 did a better job in forecasting the diurnal pattern for NO_2 whereas CHRONOS over-predicted for this event. CMAQ was the clear winner in forecasting PM2.5 in which it modelled the diurnal trend very well with no significant bias. GEM-MACH15 had a larger positive bias for $PM_{2.5}$ than CHRONOS for all three cities, especially for Windsor.



Conclusions

The upper-level cold low had a direct impact on O_3, $PM_{2.5}$ and NO_2 summertime values which were well below normal levels for southern Ontario. The newly developed operational Canadian air quality model, GEM-MACH15, did show an improvement over CHRONOS in predicting O_3 and NO_2 during the Aug 15-17th event but performed poorly with $PM_{2.5}$. CMAQ appeared to be the best model in forecasting the pattern and concentrations for $PM_{2.5}$ in this case study. Learning from this case study, forecasters at the Ontario Storm Prediction Centre can apply this knowledge in a similar situation for the AQHI forecast.

Reference

www.smc-msc.ec.gc.ca/ccrm/bulletin/national_e.cfm
www.climatelogic.com/forecasts/review-summer-2009-north-america.html

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