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THE IMPACT OF METEOROLOGICAL VARIABILITY ON THE MODELLING OF AIR QUALITY SCENARIOS

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Abstract

The Air Quality Modelling Applications Section (AQMAS) of Environment Canada (EC) uses 2006 as a base year for policy modelling. Evaluation of air quality models starts with the verification of its meterological input. Furthermore, the representativeness of the selected base case year must be verified with respect to climatology. In large scale modelling over long forecast periods, normally several weather extremes are present. Within this period, we analyzed discrepancies relative to climatology (precipitation and temperature) over North America and compared them with those of 2005 and 2007. Also, we scored the modelled meteorology against observations and compared the model uncertainty with that of the operational Global Environmental Multiscale (GEM) model.

This presentation will address some of the uncertainties introduced by meteorological fields in our policy modelling platform for 2006. In particular, using A Unified Regional Atmospheric Modelling System (AURAMS), we will emphasize the influence of meteorological variability (in terms of temperature and precipitation) on the modelling of air quality scenarios.

INTRODUCTION

The New Canadian Modelling Platform (NCMP) uses 2006 as a base year for air quality policy scenarios. In policy modeling the emissions inventory year is generally used as a reference year for generating the meteorological fields.
Before applying meteorological fields, and to avoid possible uncertainty in air quality modelling, various verifications should be performed. The verifications applied in this study contain the following analyses:

- ***Objective scores: model performance verification (against observations) at the surface and on the upper air levels;***
- ***Representativeness of the selected base case year with respect to the climatology;***
- ***Impact of meteorological variability on air quality modelling***

METHODOLOGY

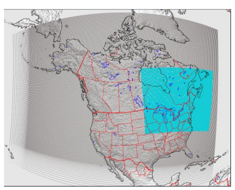

Fig 1. GEM (gray) and AURAMS (bleu) grids used in our experience

Air quality modeling was performed using AURAMS (A Unified Regional Air-quality Modelling System). The meteorological input used was generated by GEM (Global Environmental Multiscale model).

GEM is the operational Canadian forecast model and regional version was applied in our performance. This version has 15km horizontal resolution over North America and decreasing resolution for the rest of domain. The 30-hour forecasts were done on a daily basis, discarding the first six hours as a spin-up period.

AURAMS will be run at 22.5km resolution Before, all required meteorological fields will be interpolated on a same grid.

Representativeness of the selected base case year with respect to climatology

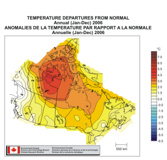

Figure 2 Annual temperature departure in 2006

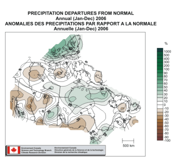

Figure 3 Annual precipitation departures in 2006

On a global and/or national level, 2005 and 2006 had the presence of extreme weather, recording even the standing absolute records. **2006** is recorded as the <u>**second hottest year in Canada**</u> over 1948-2008.

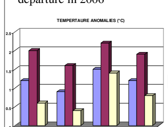

Figure 4 Temperature anomalies in 2005, 2006 and 2007 for Montreal, Toronto and Ottawa

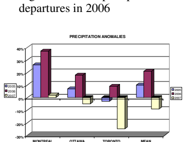

Figure 5 Precipitation anomalies in 2005, 2006 and 2007 for Montreal, Toronto and Ottawa

On the left are presented mean yearly discrepancies for <u>**2005, 2006 and 2007**</u> against climate values (1971-2000) for 3 Canadian cities: Montreal, Toronto and Ottawa. Among these 3 years, 2006 recorded the highest biases for temperature and precipitation with exclusively positives anomalies for temperature and precipitation.

Objective scores

We analyzed objective scores for 2006 generated by two GEM versions: **AQGEM** (Air Quality GEM) and **OPGEM** (OPerational GEM used in 2006 by the Canadian Meteorological Centre). The first version is applied in NCMP for 2006.

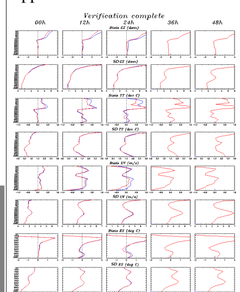

Figure 6 Upper air annual verification for geopotential height (GZ), temperature (TT), wind (UV) and dew points (ES). Red line represents OPGEM and blue AQGEM

Geopotential Height

- Mean monthly anomalies are generally 1dam in the lower atmosphere (1000mb-850mb), and can go up to 6dam in the upper levels (near 10mb).

Temperature

- At the surface, for both models mean monthly SD are generally between 2ºC and 3ºC and the bias between 0ºC and 0.5ºC,
- In the upper air, SD plots are almost identical. Up to 500mb the biases are generally below ±0.5ºC with highest discrepancies ±1.0ºC at top of the model

Wind

- In the upper air the SD are very similar for both models. Some differences are observed for biases, caused by slightly stronger winds predicted by AQGEM,
- The high SD anomalies are generally located near 250mb, the height at which the jet stream is found.

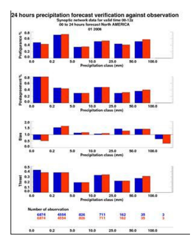

Figure 7 Precipitation verification for January 2006. Bleu color represents OPGEM and red AQGEM

Dew Point Temperature

- At the surface for both models the biases are almost identical: ±0.75ºC. The SD goes up to 4ºC (24h forecast) in some months for both models.
- On the upper air levels, the monthly SD are almost identical for both models with values between 2ºC and 4ºC near ground levels with max discrepancy (for both models) close to 8ºC, around 500mb at 24h forecast). The biases are also similar, with slightly higher dew point values predicted by AQGEM.

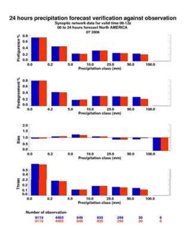

Figure 8 Precipitation verification for January 2006. Bleu color represents OPGEM and red AQGEM

Precipitation

- The models achieved their best performance in the two first bins (0.0– 0.2mm and 0.2 - 0.5mm), which are the most frequent
- The heaviest precipitation rate (≥100mm) has the weakest monthly score (persistently underforcasted) but very weak monthly occurrence (under 0.1%).

Impact of meteorological variability on air quality modeling

August (2006, 2007) and **December** (2005, 2006) served as meteorological input. August was generally warmer and drier in 2007 than in 2006. December 2006 has remarkably higher temperatures than December 2005.

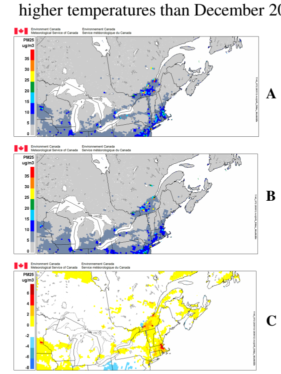

Figure 9 Average daily maximum 24-hour PM2.5 concentrations for December 2005 (A), December 2006 (B) with correspondent difference A-B (C)

December

Predicted average daily maximum 24-hour concentrations of PM2.5 is very similar for both years (figure 9 (A,B)) with PM2.5 concentration generally higher in 2005 (colder month) (figure 9 (C)) The highest discrepancies (up to <u>**6µg/m3**</u>) are in some urban areas, such as Montreal, Boston, Quebec, Sherbrooke and Minneapolis.

August

The predicted ozone concentrations for August 2006 and August 2007 are spatially similar, with 2007 (warmer and drier month) having higher predicted concentrations. On figure 10, we can see that the difference goes up to <u>**6-14ppb**</u>, (figure 10 (C)) which presents an augmentation in predicted ozone concentration of <u>**20-35%**</u> close to some urban areas (figure 10 (D)).

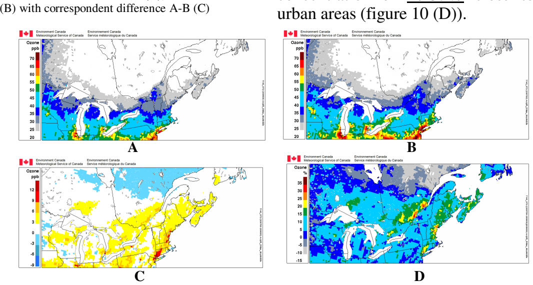

Figure 10 Average daily maximum 8-hour ozone concentrations for August 2006 (A), August 2007 (B) with correspondent difference A-B (C) and relative difference (A-B)/A (D)

CONCLUSION

The objective scores for AQGEM are very similar to OPGEM used in 2006. Comparing a selected base year (2006) with climate averages, we observed that some important meteorological anomalies were present. To examine the impact of meteorological variability we used following months: August (2006 and 2007) and December (2005 and 2006). For winter months, we obtained differences in predicted average 24-hour PM2.5 concentrations of up to 6µg/m3 in some urban areas. For summer months, the difference in average 8-hour ozone concentrations goes up to 10ppb which is equivalent to a 20-35% change in ozone concentrations close to some urban centers.

References

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