Environment Canada Environnement Canada

Improvements to the Regional Deterministic Operational Air Quality Analysis System for Surface Pollutants including AQHI at the Canadian Meteorological Center

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INTRODUCTION

In February 2013, in collaboration with the Air Quality Research Division, the Canadian Meteorological Centre (CMC) implemented into operations a new surface analysis (RDAQA) for air quality species (ozone and $PM_{2.5}$). Since 2013 RDAQA has been upgraded by including new objective analysis (OAs): nitrogen dioxide (NO_2), coarse particulate matter (PM_{10}), sulfate dioxide (SO_2) and air quality health index (OA-AQHI). The RDAQA System is connected to two slightly different configuration of the same model (operational GEM-MACH and FireWork – GEM-MACH respectively).The two RDAQA analyses are produced hourly using the two model configuration (trial fields), surface observations (from Canadian regional data providers and the US EPA/AIRNow Program). The solver which blends model and observations is an improved version based on the classical optimal interpolation approach with a semi-empirical bias correction algorithm.

FLOWCHART OF AIR QUALITY SURFACE OBSERVATIONS PROCESSING

RAWDATA
- AQ surface observations from Canadian data providers:ASCII format AIRNow 'OBS' realtime
- AQ surface observations from US stations (EPA): real-time files from AIRNow Gateway

REAL TIME → DBASE
- ADE decoder 6hour SQLite files + Basic Quality Control

MAESTRO Operational Run Task Sequencer
- **CUTOFF**: First cut-off: valid hour+65 min; Second cut-off: valid hour+130m
- **DERISFC**: Processing of corrections, selection and blacklisting
- **BGCKSFC**: Trial field interpolated to each point, Quality Control (Bgck), selection of (O-P)+Bgck-QC flags
- **AQHI**: Mapping AQHI over Canada and USA (derived product from OA for ozone, $PM_{2.5}$ and NO_2)
- **POSTSFC**: Final selection, data with O, O-P, O-A, observation and first-guess errors, QC OA flags
- Generation of statistics, maps, monthly reports, statistics and graphs on website

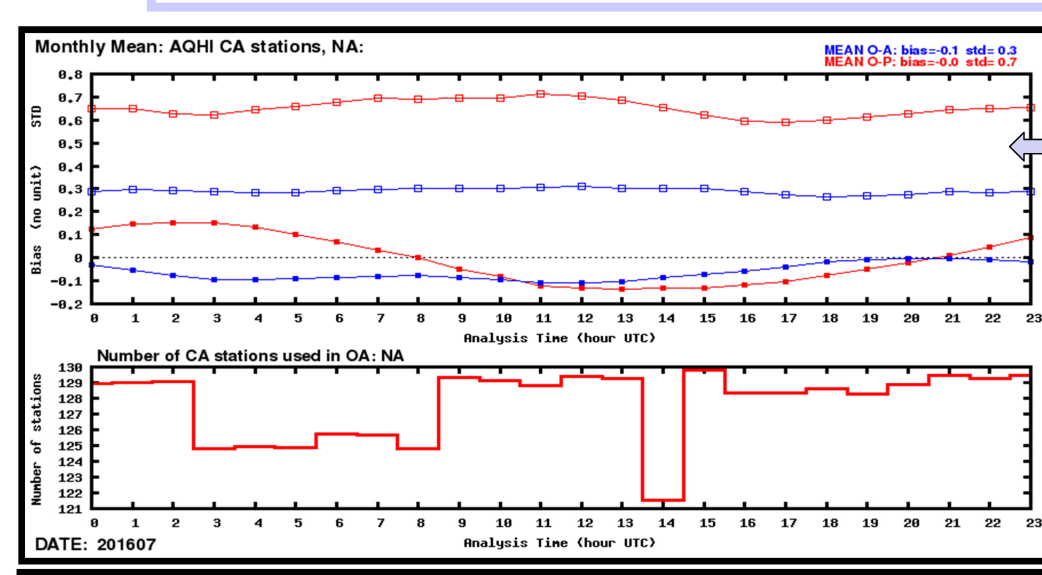
The Operational run task sequencer (MAESTRO) was used to create a modular suite for the RDAQA and RDAQA-FW as part of the larger ensemble of operational suites currently running at the CMC. Each module represents a particular process in the RDAQA system for supporting and developing the air quality database (in SQLite format) for the observations and the gridded files containing the trial fields, analyses and increments. Various flags, indicating the quality and validity of the observations, have been added to the database as well as processed quantities., such as observations minus first-guess values (O-P), observation minus analyses values (O-A), observation errors, first-guess errors and correlation length.

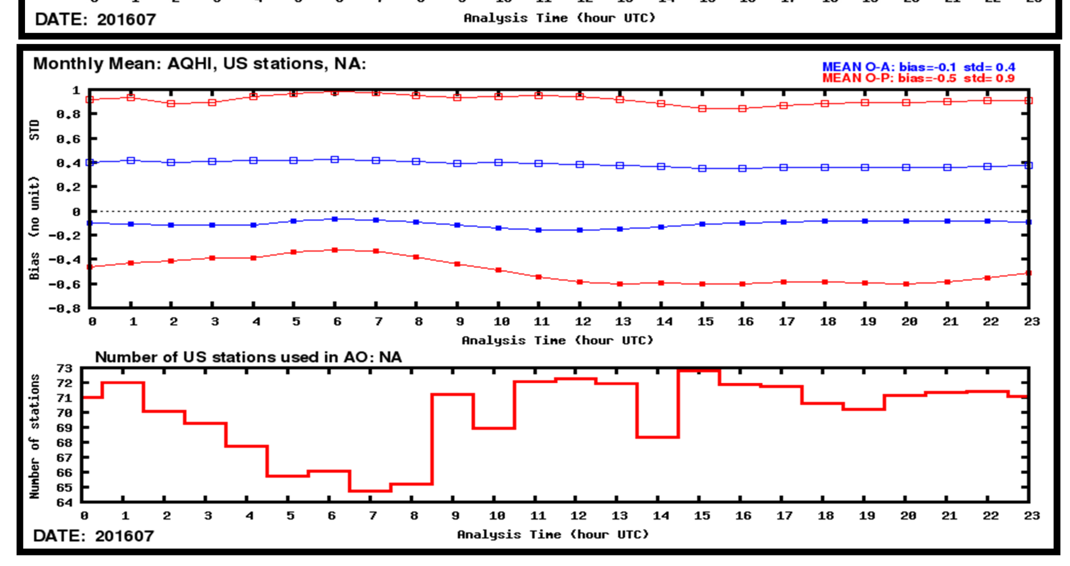
METHODOLOGY AND VERIFICATION

Optimal interpolation is an objective analysis method that uses a linear combination of the background fields and observations and is optimized by minimizing the error variance using hourly varying error statistics. The observations are acquired in real-time and passed through a series of quality control tests as follows: exceedances of max and min concentration values, dubious jump detection and background check of observed-minus-forecast increments. The background field is provided by the operational regional air quality model. A regional bias correction is applied for some pollutants (Robichaud and Menard, 2014). The production of objective analysis is done in the module "analsfc" and is output as a four-panel product (see below). The module OA-AQHI computes the air quality index using the formula developed by Stieb et al. 2008:

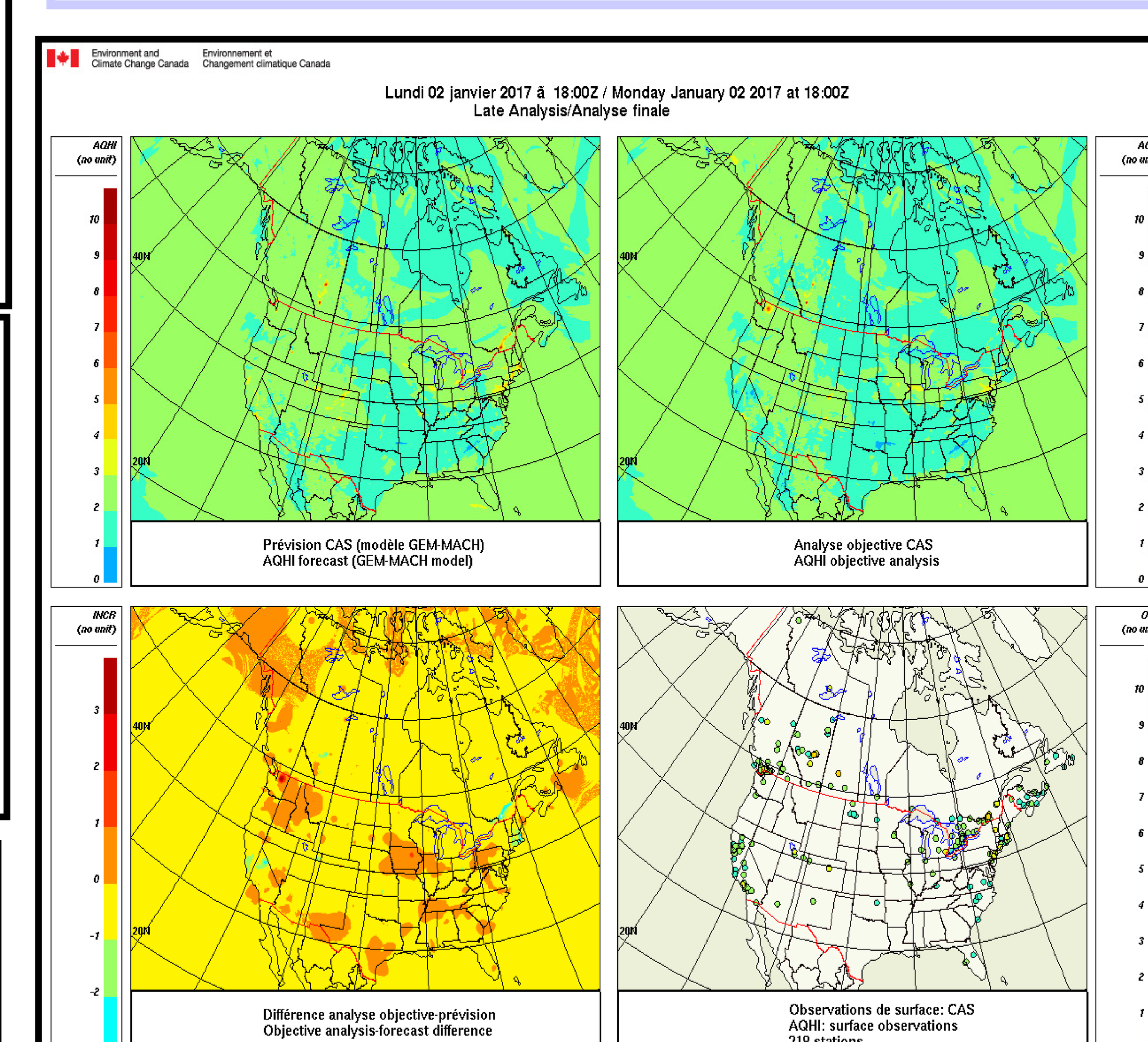
$$AQHI = (10/10.4)*[100*((\exp(0.000871*NO_2)-1)+((\exp(0.000537*O_3)-1)+((\exp(0.000487*PM_{2.5})-1)]$$

Where OAs for 3 pollutants are used instead of observations. The validation of OA-AQHI was done using the two sets of values for O-P (model) and O-A (OA-AQHI). The O-A biases and RMSE (root mean squared error for AQHI) are significantly reduced comparing to O-P (Robichaud and Menard, 2016). A bias correction is applied to NO_2, NO, $PM_{2.5}$, PM_{10}, SO_2 observations to improve performance. Two types of verification scores have been computed: internal and external. The results for all species indicate that the analysis provides a substantial reduction in standard deviation and bias for all analysis hours.



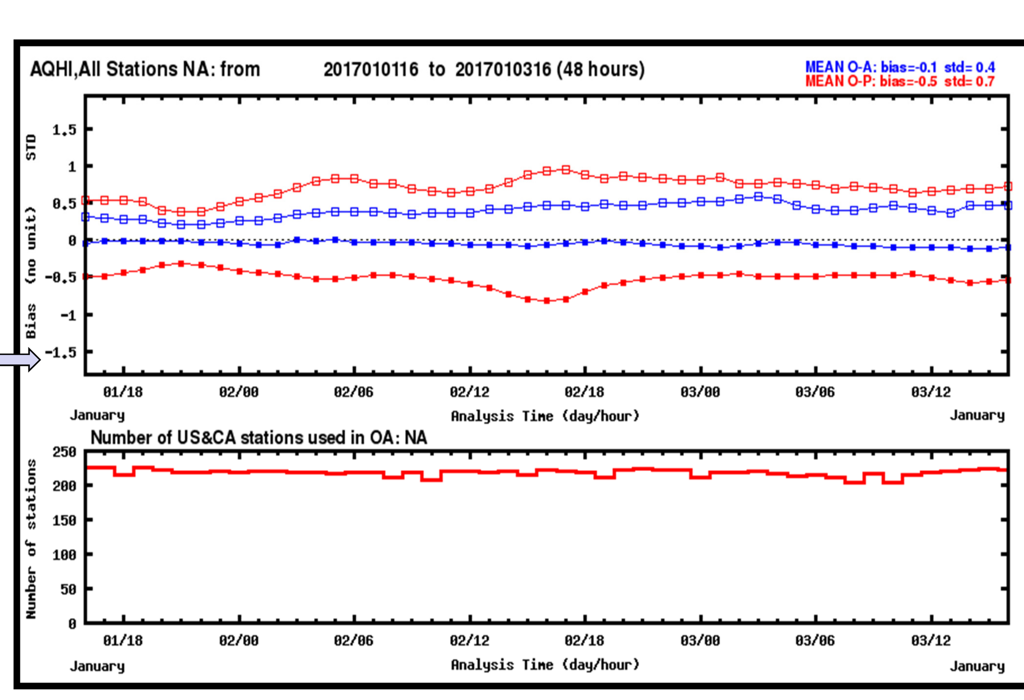


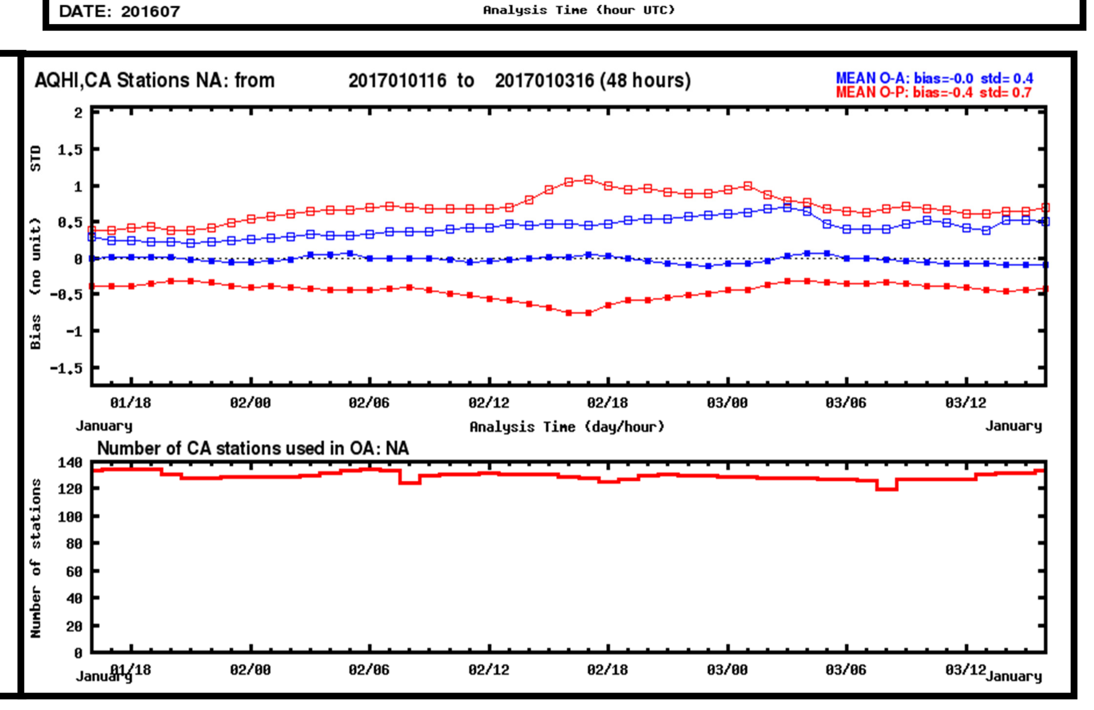
Examples of monthly mean O-P & OA AQHI statistics which include the bias, standard deviation and average number of stations per UTC hour for July 2016 (RDAQA system): in the top for CA stations in the bottom for US stations



Example of the final product from the RDAQA system for AQHI (winter case) The product contains 4 images: model trial field in the top left corner, objective analysis in the top right, analysis increments (or correction to the model) in the bottom left corner, and observations used to generate the analysis in the bottom right.

Two examples of daily monitoring ofAQHI for the RDAQA, available in real-time for all (CA + US) stations (left) and CA stations (right).The verification scores of bias & std for O-P and O-A appear as a function of hour, as well the number of stations assimilated is plotted in the bottom panel.





FUTURE

The high value of the objective analysis products has become well known over the past several years and regional forecasters have expressed a strong interest in having full support for these products. The mapping of AQHI provides real-time information of evaluation of environmental risk anywhere anytime for Canada and USA. AQHI values are highest in spring and summer and are sensitive and also impacted by meteorological short-term and inter-annual fluctuations. The future development includes using the analysis to initialize the GEM-MACH and FireWork-GEM-MACH models as well as adding other species to the RDAQA & RDAQA-FW systems

REFERENCES

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Stieb DM et al. 2008. A new multipollutant, no-threshold air quality health index based on short-term associations observed in daily time-series analyses. J Air Waste Manage Assoc 294:1599-1608.

Objective Analysis of Ozone and PM2.5 (experimental web site, available from internal AQMAS/AQHI: http://aqhi.cmc.ec.gc.ca)

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