

# A Canadian OSSE Data Assimilation facility for Atmospheric Composition satellite missions (CODAAC)

14th Meeting of the CEOS Atmospheric Composition Virtual Constellation (AC-VC-14)  
NOAA Center for Weather and Climate Prediction (NCWCP)  
2-4 May 2018

# CODAAC Objectives

- There has been on-going work developing the modeling and data assimilation capabilities at Environment and Climate Change Canada (ECCC) and the universities.
- The CODAAC will leverage this on-going work and provide more sustained resources to implement a more comprehensive and coordinated chemical data assimilation facility (for AQ and GHG) to support short-term and long-term missions.

# CODAAC Members

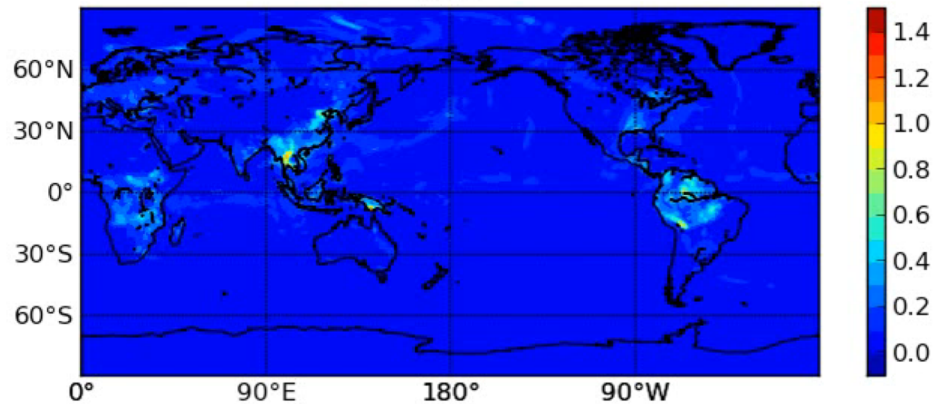
- Dylan Jones (Co-PI, University of Toronto) – Carbon cycle and air quality data assimilation, OSSEs
- Saroja Polavarapu (Co-PI, ECCC) – Carbon cycle data assimilation
- Louis Garand (ECCC) – Meteorological data assimilation, OSSEs
- Jean de Grandpré (ECCC) – Air quality data assimilation, OSSEs
- Amir Hakami (Carleton University) – Air quality data assimilation and health impacts
- Randall Martin (Dalhousie University) – Air quality data assimilation and health impacts, OSSEs
- Richard Ménard (ECCC) – Air quality data assimilation, data retrieval, OSSEs
- Yves Rochon (ECCC) – Air quality data assimilation, data retrieval, OSSEs
- Douglas Chan (ECCC) – Carbon cycle data assimilation
- Pierre Gauthier (Université du Québec à Montréal) – Meteorological data assimilation
- Sylvie Gravel (ECCC) – Air quality modeling
- Michael Moran (ECCC) - Air quality modeling
- Felix Vogel (ECCC) - Carbon cycle data assimilation

# Status of Modeling Capabilities

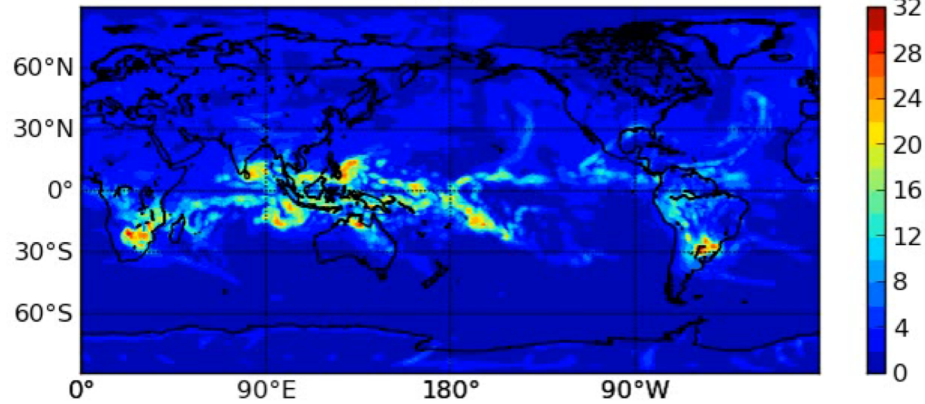


- Joint CO<sub>2</sub>-CH<sub>4</sub>-CO simulation using the GEM-MACH-GHG (Polavarapu et al., 2016)
- Uses prescribed monthly mean OH fields for CO and CH<sub>4</sub> loss
- Resolution: 0.9° x 0.9° with 80 level from the surface to 0.1 hPa

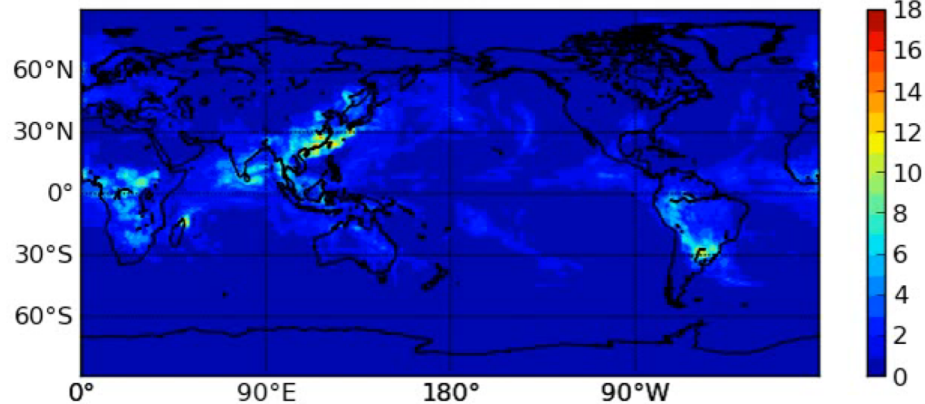
Forecast ensemble spread - 2014-12-27 21:00  
CO<sub>2</sub>



CH<sub>4</sub>



CO



## Environment and Climate Change Canada Carbon Assimilation System (EC-CAS)

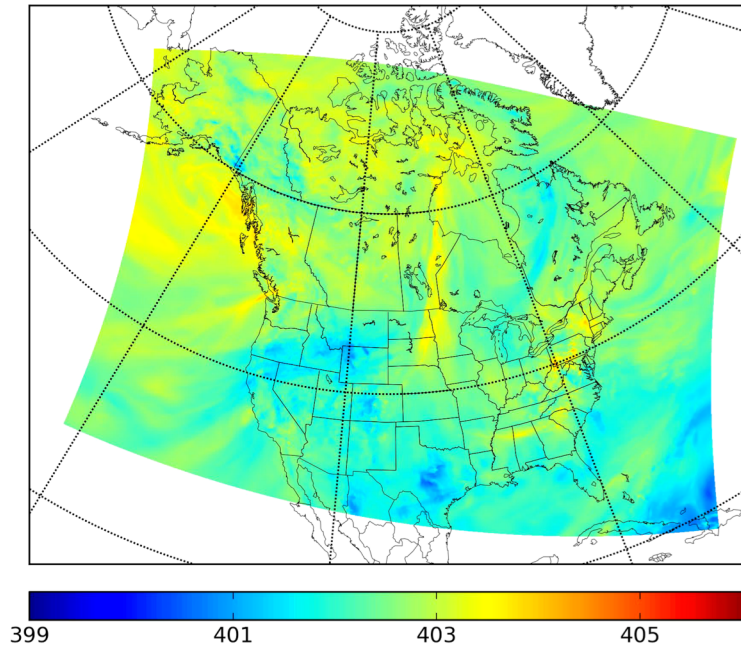
The ensemble spread of 64 forecasts for column mean CO<sub>2</sub> (top), CH<sub>4</sub> (middle), and CO (bottom).

[Saroja Polavarapu, ECCC;  
Vikram Khade, U. Toronto]

# EC-CAS goals: regional flux estimates over Canada

## Regional 10 km grid

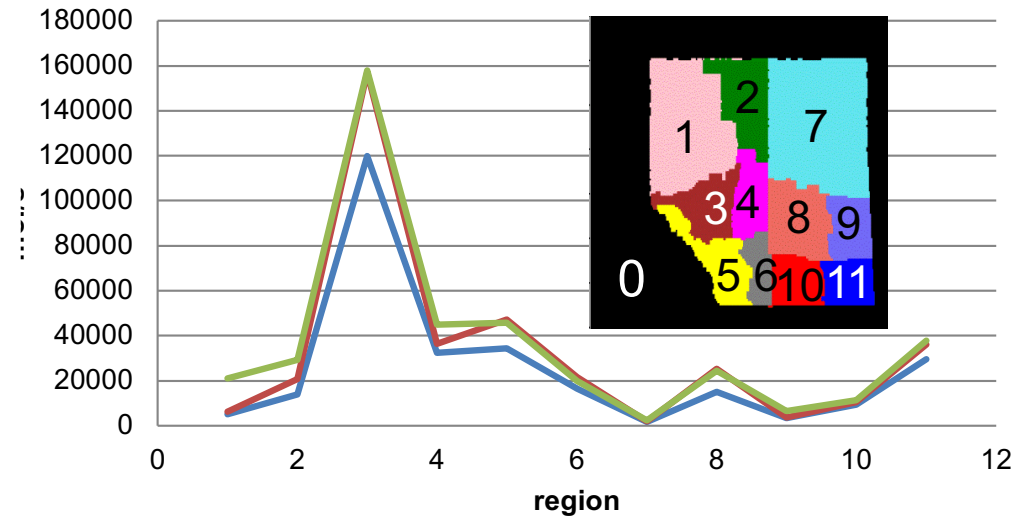
XCO<sub>2</sub> (in ppm) 2015-05-01 03:00



[Jinwoong Kim, ECCCC]

Regional EC-CAS model reduces representativeness errors allowing higher resolution flux estimates

## Flux (Prior Post Target(GEM))



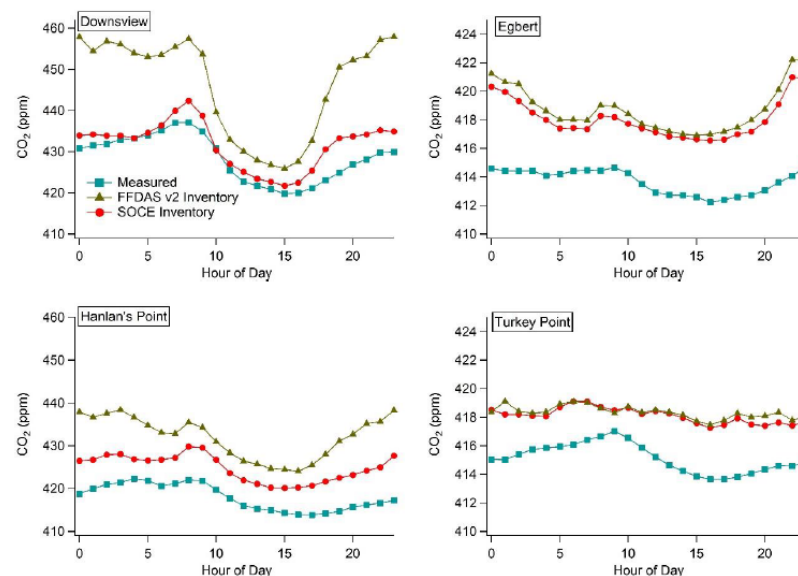
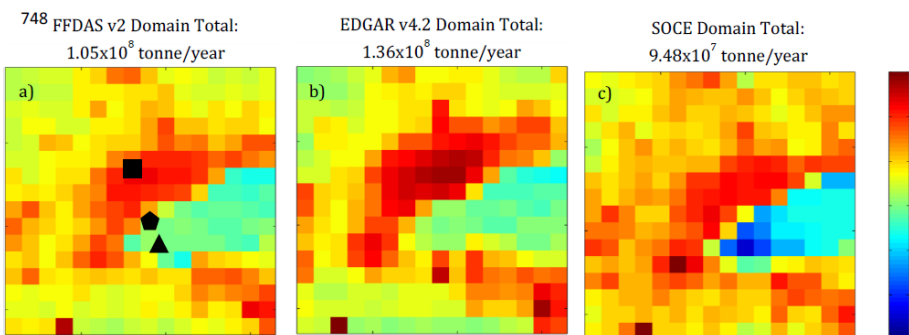
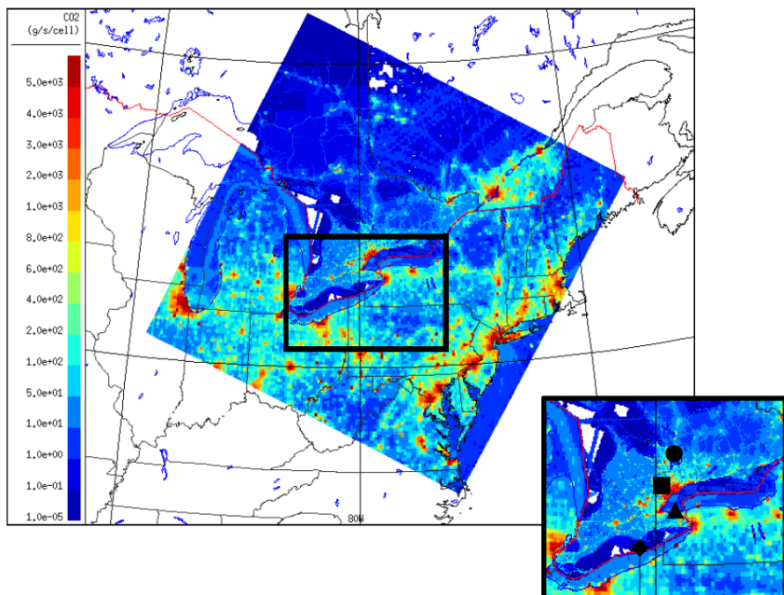
[Douglas Chan, ECCCC]

Preliminary flux estimates with Bayesian inversion for Western Canada with perfect transport

Regional GHG simulations → lateral boundary conditions for urban scale flux estimates by Felix Vogel

# Canadian work – so far:

Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2017-678>  
 Manuscript under review for journal Atmos. Chem. Phys.  
 Discussion started: 26 July 2017  
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- + Assessment of regional emissions of CO<sub>2</sub>
- + temporal emission factors
- + sectorial emission inventory
- + prototype modelling system

[Felix Vogel, ECCCC]



Environment and  
Climate Change Canada

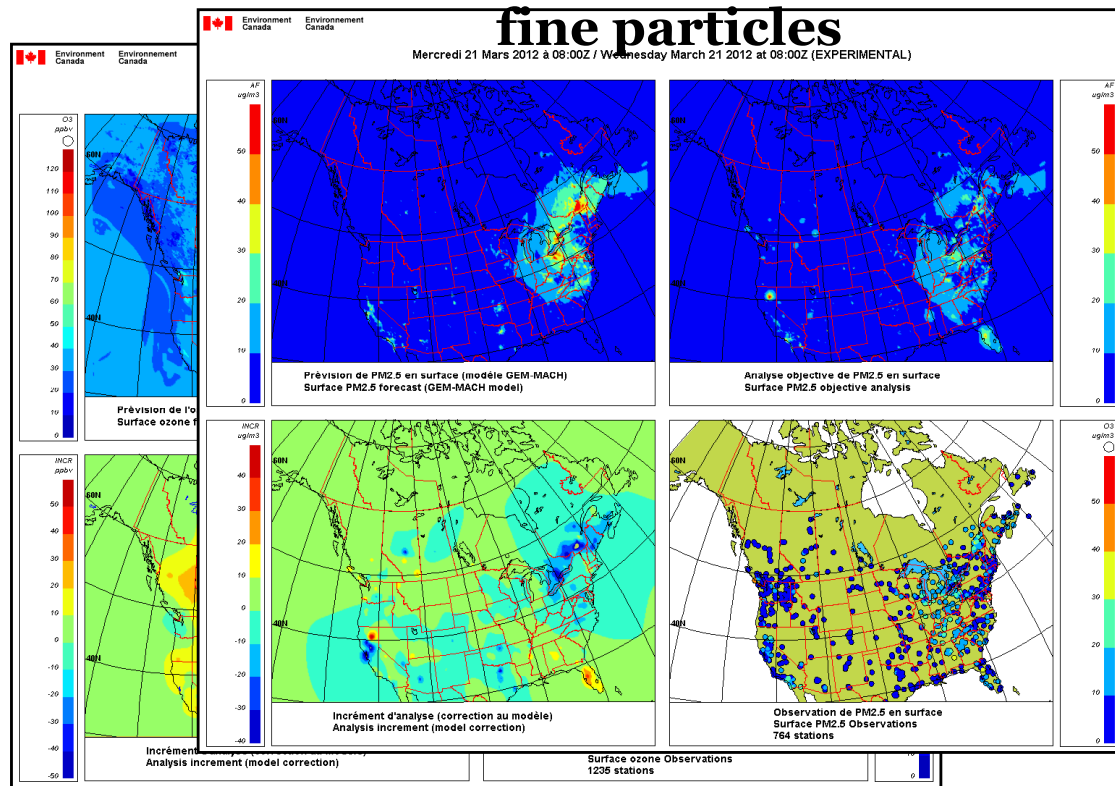
Environnement et  
Changement climatique Canada



# Operational objective analysis

Analysis of  $O_3$ ,  $NO_2$ ,  $SO_2$ ,  $PM_{2.5}$ ,  $PM_{10}$  each hour

*experimental since 2002, operational since Feb 2013*



[Richard Ménard, ECCC]

- 2D Optimum Interpolation, offline
  - FOAR correlation functions
  - error stat in obs. space only
  - chi2 adjusted statistics
  - 3-month diurnal bias correctionMénard and Robichaud 2005  
*ECMWF Proceedings*

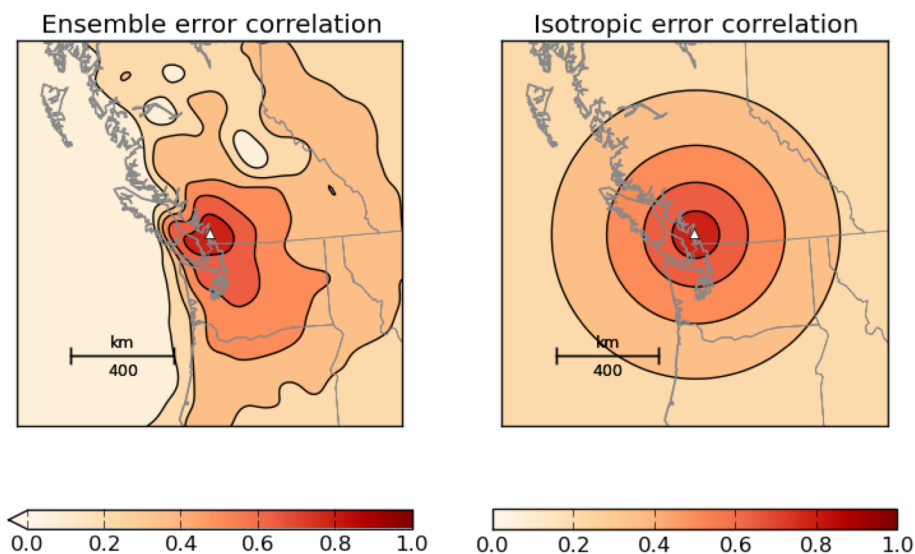
## History

- $O_3$ ,  $PM_{2.5}$  – using CHRONOS 2002-2009
- $O_3$ ,  $PM_{2.5}$  – using GEM-MACH 2009-2015
- $O_3$ ,  $PM_{2.5}$ ,  $NO_2$ ,  $SO_2$ ,  $PM_{10}$  since April 2015 (Robichaud et al. 2015, *Air Qual Atmos Health*)
- Multi-year data set (2002-2012) Robichaud and Ménard 2014, *ACP*

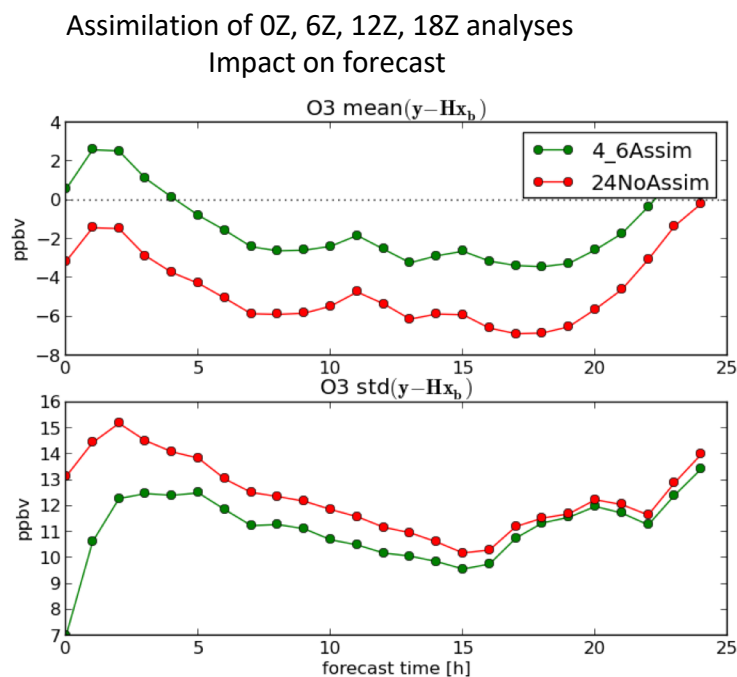


# Collaborations and next implementations

- The Canadian Urban Environmental (CANUE) Health Research Consortium *Jeff Brook* (PI) (ECCC and U of T)

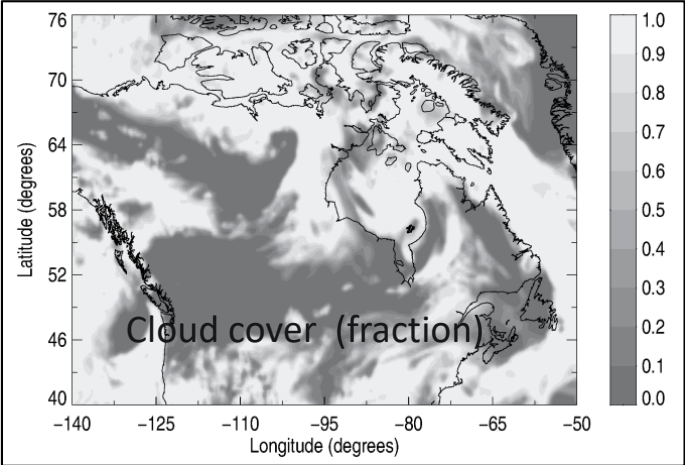
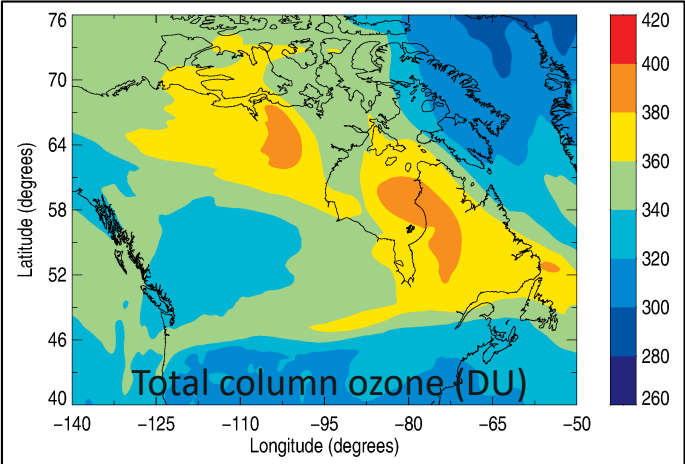
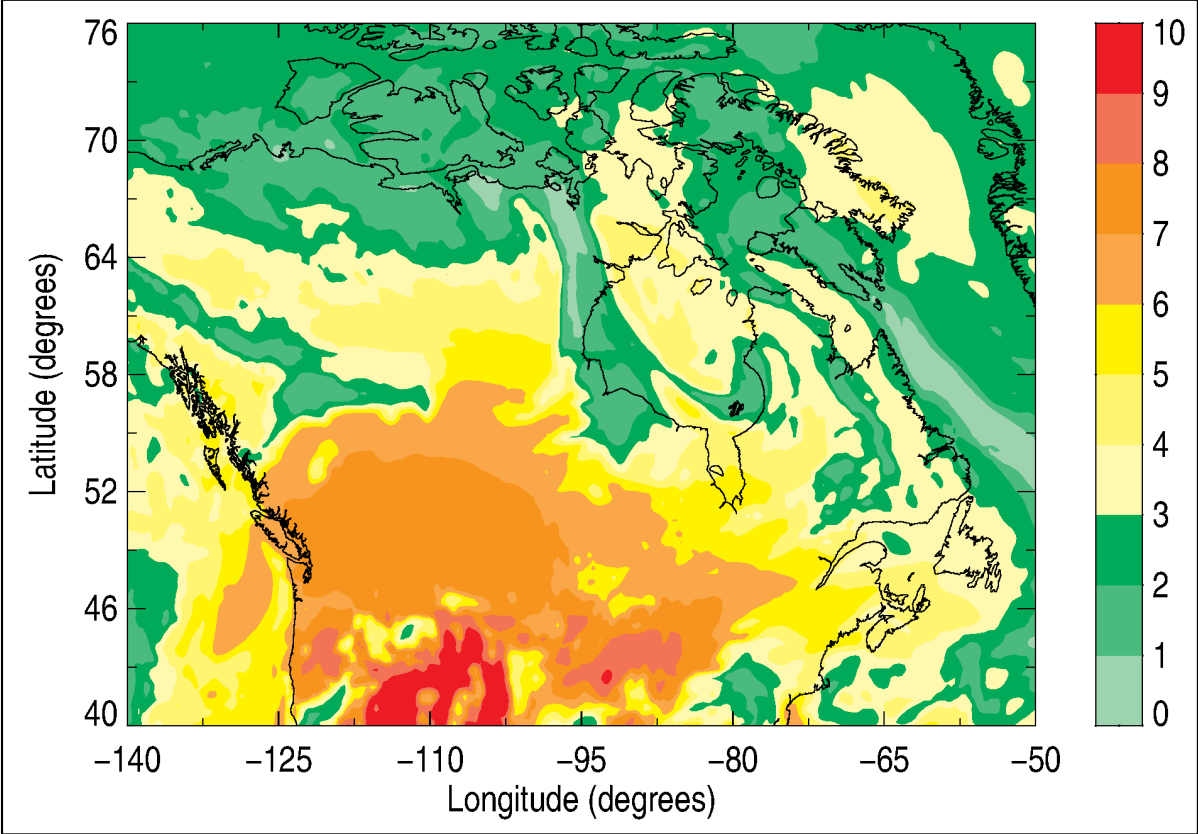


- Regional chemical data assimilation (Fall 2018)



[Richard Ménard, ECCC]

Sample image of UV index day four forecast over Canada from ozone assimilation and forecasting July 11<sup>th</sup>, 2015, 15:00 EDT



[Yves Rochon, ECCC]

# Summary

- CODAAC will provide a state-of-the-art facility to assess the added value of new composition missions such as the Atmospheric Imaging Mission for Northern Regions (AIM-North).
- CODAAC will enable Canada to better exploit complementary observations from other missions, e.g., TROPOMI, GOSAT-2, OCO-3, TEMPO, GEMS, and Sentinel-4.
- Enable Canada to contribute to international efforts to coordinate AQ and GHG OSSEs.