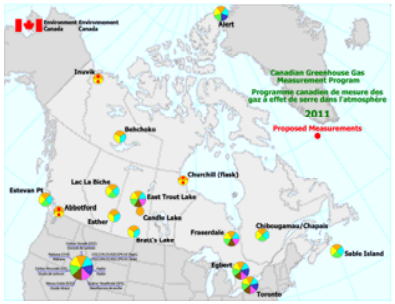
Development of Environment Canada's Carbon Assimilation System

Saroja Polavarapu[1,2], Michael Neish[2], Shuzhan Ren[2], Ray Nassar[1], Douglas Chan[1], Dylan Jones[2], Feng Deng[2], John Lin[3], Myung Kim[3]

[1]Climate Research Division - Environment Canada, [2]University of Toronto, [3]University of Waterloo

1. Why?



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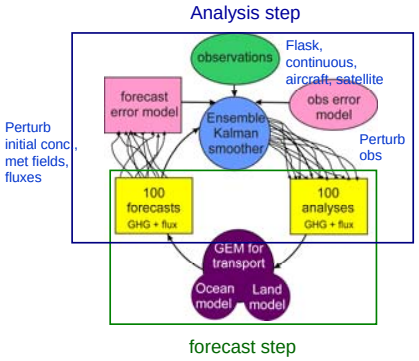
- Monitor CO_2, CH_4 fluxes over Canada
- Address climate mitigation policies related to managed and unmanaged Canadian carbon sources and sinks
- Address adequacy of EC's network of ground-based observations

2. How?



Ensemble Kalman Smoother

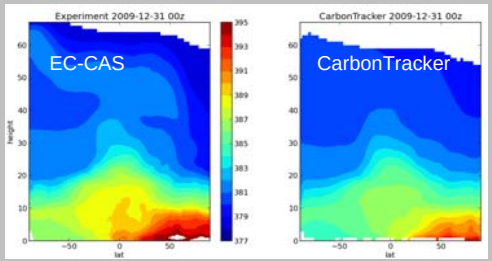
- Model: Global Environmental Multiscale (GEM) model, EC's operational weather forecasting model, Air quality version (GEM-MACH). Global 0.9° x 0.9° .
- Assimilation: Ensemble Kalman Smoother with tracer/flux augmented state, as in Miyazaki (2011) or Kang et al. (2011)
- Observations: Surface, aircraft, GOSAT, OCO-2
- Plan: Build atmospheric model and assimilation first. Later couple to ocean and terrestrial biosphere model, each constrained by observations.

Kang, J.-S., E. Kalnay, J. Liu, I. Fung, T. Miyoshi, and K. Ide (2011), "Variable localization" in an ensemble Kalman filter: Application to the carbon cycle data assimilation, *J. Geophys. Res.*, 116, D09110, doi:10.1029/2010JD014673.

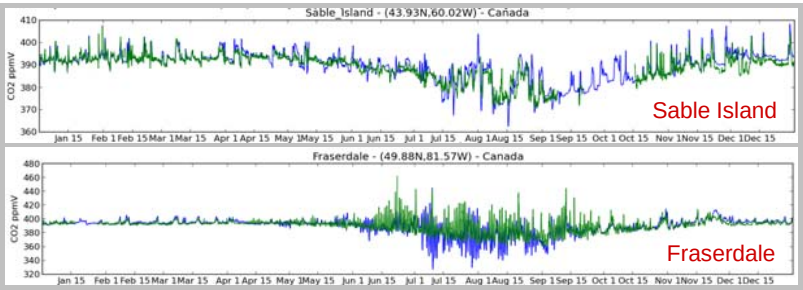
Miyazaki, K., T. Maki, P. Patra, and T. Nakazawa (2011), Assessing the impact of satellite, aircraft, and surface observations on CO2 flux estimation using an ensemble based 4-D data assimilation system, *J. Geophys. Res.*, 116, D16306, doi:10.1029/2010JD015366.

3. Current status

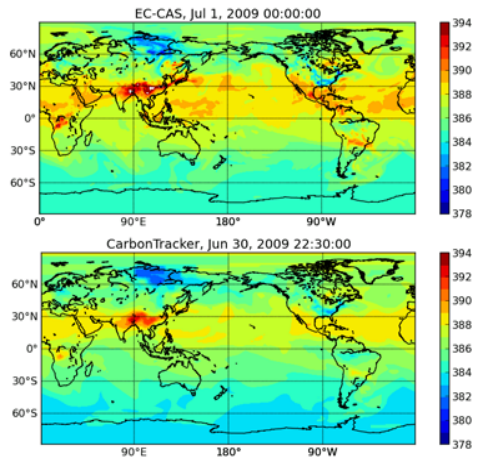
- Testing model transport of CO_2 with known fluxes during 2009
  - Initial condition and input fluxes same as NOAA CarbonTracker-2010
- Assimilation system development underway



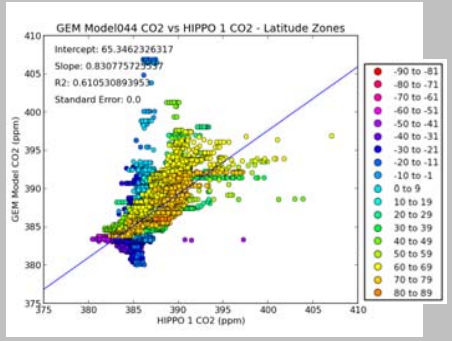
- Global CO_2 mass increase evident by Dec. 2009



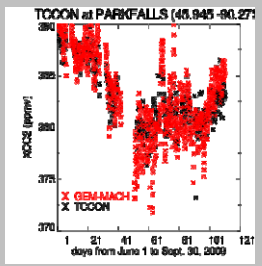
- Comparison to surface observations: long, synoptic scales captured
- Some low CO_2 spikes in summer due to insufficient vertical mixing



- Similar XCO_2 to CarbonTracker on July 1



- Comparisons to HIPPO1 aircraft observations for Jan.8-30, 2009: worse agreement in tropics



- Agreement with TCCON obs in summer 2009

4. Next steps

- Model improvement
  - More realistic boundary layer mixing
  - Better mass conservation
- Assimilation scheme development
  - Adapt EnsKF from meteorology to tracers + fluxes
  - Complete EnsKF, EnsKS and test with surface obs.
  - Test with surface plus GOSAT obs.
- Emissions
  - Update to best available inventories

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