P5_GMAC2018

Aerosol Elemental Carbon Observations over Canada (2006-2015): Constraining Regional Emissions in North America

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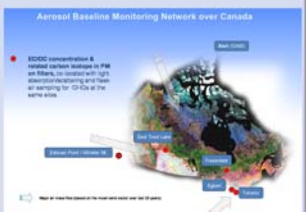
Introduction

Although lots of attention has recently been paid to Black Carbon (BC) due to its important role in climate system, there are still large knowledge gaps in quantifying their emission sources and estimating their climate impacts at regional and global scale. Because of the short atmospheric life-time of BC, thus, changes in its atmospheric concentrations could reflect the corresponding changes in its source emissions. In this work, we are going to show using long-term atmospheric observations of elemental carbon (EC), as BC mass concentrations, to potentially constrain its regional emission sources in North America.

Observation sites

❖ An observation network of EC has been strategically established across Canada since 2006. The sites represent different geographic regions with various continental source influences, including: urban (Toronto, ON), rural (Egbert, ON), boreal forest (Fraserdale, ON, East Trout Lake, SK), high elevation (Whistler Mt., BC), and a remote Arctic region (Alert, NU).

❖ Weekly integrated quartz filter samples collected at the sites have been analysed for EC concentrations over the period of 2006 to 2015 via a thermal method, i.e., EnCan-Total-900 (Huang et al., 2006).



References

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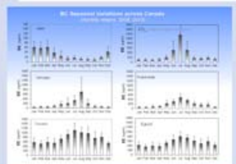
- van Marle et al., Historic global biomass burning emissions for CMIP6 (BB4CMIP) based on merging satellite observations with proxies and fire models (1750–2015), Geosci. Model Dev., 10, 3329–3357, 2017, https://doi.org/10.5194/gmd-10-3329-2017
- Hoesly et al., Historical (1750–2014) anthropogenic emissions of reactive gases and aerosols from the Community Emissions Data System (CEDS), Geosci. Model Dev., 11, 369–408, 2018, https://doi.org/10.5194/gmd-11-369-2018

Results

❖ Downwards trends (2006-2015) are observed in both annual & seasonal means at sites (i.e., Toronto & Egbert) in eastern Canada

❖ Upwards trends (2006-2015) in summertime are observed at a boreal forest site (East Trout Lake, SK) in western Canada.

❖ Seasonal patterns, with relatively higher concentrations in summer-fall months and relatively lower concentrations in winter-spring months, were observed at all sites except for Alert (the Arctic site).

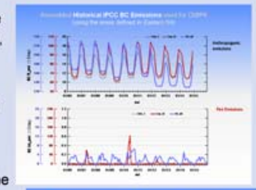


❖ Mann Kendall Test confirmed the trend analysis (suitable to small datasets with no normal distribution required).

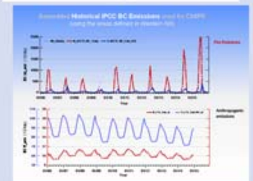
Possible areas influencing our measurements in the Eastern and Western North America.

Constraining Regional Sources

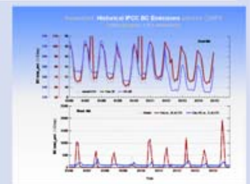
❖ In comparison with BC emission inventories (van Marle et al. 2017; Hoesly et al., 2018), it is shown that the trends observed in eastern Canada (e.g., Toronto, and Egbert, ON) are dominated by the changes anthropogenic emissions over the same period and the influence of US emissions on the trends may be more significant than Canadian emissions.

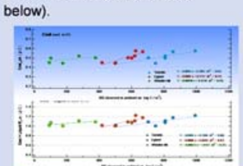


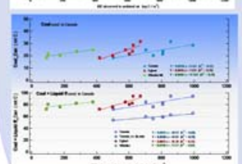
❖ Whereas that the seasonal pattern and inter-annual variability observed in western Canada have been influenced much more by biomass burning events.



❖ The decreasing trends (2006-2015) in eastern Canada would imply beneficial effects from clean air policies both in the US (Clean Air Act) and Canada (Clean Air Regulatory Agenda), supporting by the correlations between the fossil fuel emissions and BC mass in annual averages (see plots below).







❖ However, there are inconsistencies in seasonal profiles / patterns between the observations and the regional emissions inventories in Eastern North America. That raises questions and suggests a possible approach on constraining the seasonal profile of BC emissions in North America via atmospheric observations.