The issue of **harmonizing** the methodologies for emission inventories of GHGs with those of SLCFs
(In terms of measurement perspective)

GHGs: 1) Bottom up report (Activities * EFs)
2) *Top-down inverse modeling technique*
which has been a widely used approach for constraining/verifying GHGs emission inventory at regional and global scales, i.e., using atmospheric measurements in conjunction with lagrangian particle dispersion model.

SLCFs (e.g., BC) :
1) Bottom up report (Activities* EFs)
2) *Top down (??)*

Is it possible to using Top-down method to constrain BC emissions or emission trends? What are required?

The short answer:
- It is possible !
- Long term robust and traceable atmosphere measurements are required !

Constraining Uncertainties of BC in the Climate Forcing

Via robust and traceable measurements

$$\mathbf{DRF\_BC} = \mathbf{E}\text{mission} \times \text{Lifetime} \times \mathbf{MAC_{BC}} \times \mathbf{AFE}$$

(Eqn. 6.1, in Bond, et al, 2013)

Where

Emission = **A**ctivity * **E**mission **F**actor

AFE = **A**bsorption **F**orcing **E**fficiency

MAC = σ_{ap}/C (factor converting Absorption to Mass)

where: MAC = **M**ass-specific **A**bsorption **C**oefficient [m^2/g]

σ_{ap} = light absorption coefficient [m^2 absorption / m^3 air]

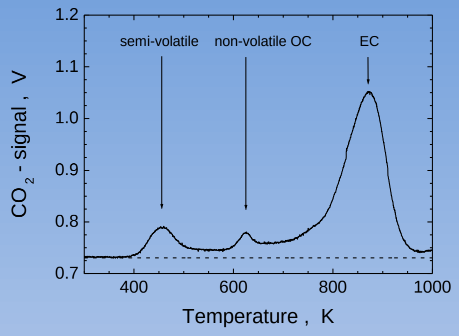
C = BC mass concentration [gC / m^3 air]

Reducing uncertainties of EFs and MAC values would reduce the uncertainties of directive radiative forcing of BC !

"BC" Measurement Methods
(Commonly used)

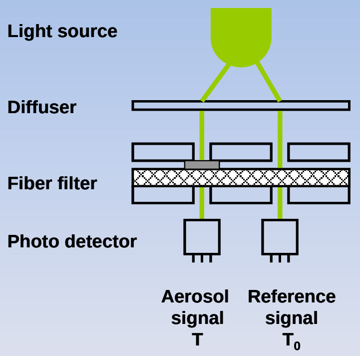
By Evolved Carbon --- Elemental Carbon (EC)

- CO_2 evolved from carbonaceous aerosols via thermal or thermo-optical methods: e.g., IMPROVE / EUSAAR /NIOSH/ EnCan-total-900
- BC properties: composition, volatility
- Pros: links to primary calibration via gravimetric approach
  Cons: charring from the analysis may contribute to EC



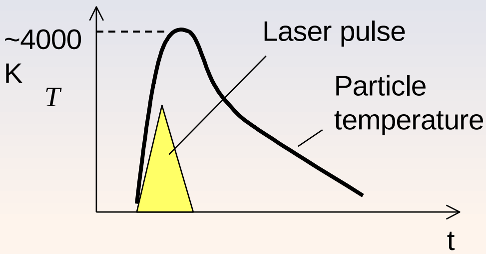
By Light Absorption --- Equivalent Black Carbon (EBC)

- Filter-based: Aethalometer, PSAP, MAAP, COSMOS
- In situ: photo-acoustic, ext. minus scat.
- BC properties: light absorption
- Pros: semi-continuous or continuous measurements
- Cons: measuring total attenuation (not specifying "BC" contribution); require MAC to link light abs. to mass con.



By Laser Incandescence --- Refractory Black Carbon (rBC)

- Laser heating of particles, e.g., SP2, LII
- BC Properties: volatility, composition
- Pros: measuring graphitic-like carbon
- Cons: size dependent sensitivity (~ 70nm – ~ 500 nm)



Courtesy to John Ogren , GMAC2013 presentation, 2013-05-2111

http://www.atmos-chem-phys-discuss.net/13/9485/2013/acpd-13-9485-2013.html

Characteristics of Black Carbon ?

Based on the recommended terminology proposed by the members of WMO_SAG
(www.atmos-chem-phys.net/13/8365/2013/ doi:10.5194/acp-13-8365-2013)

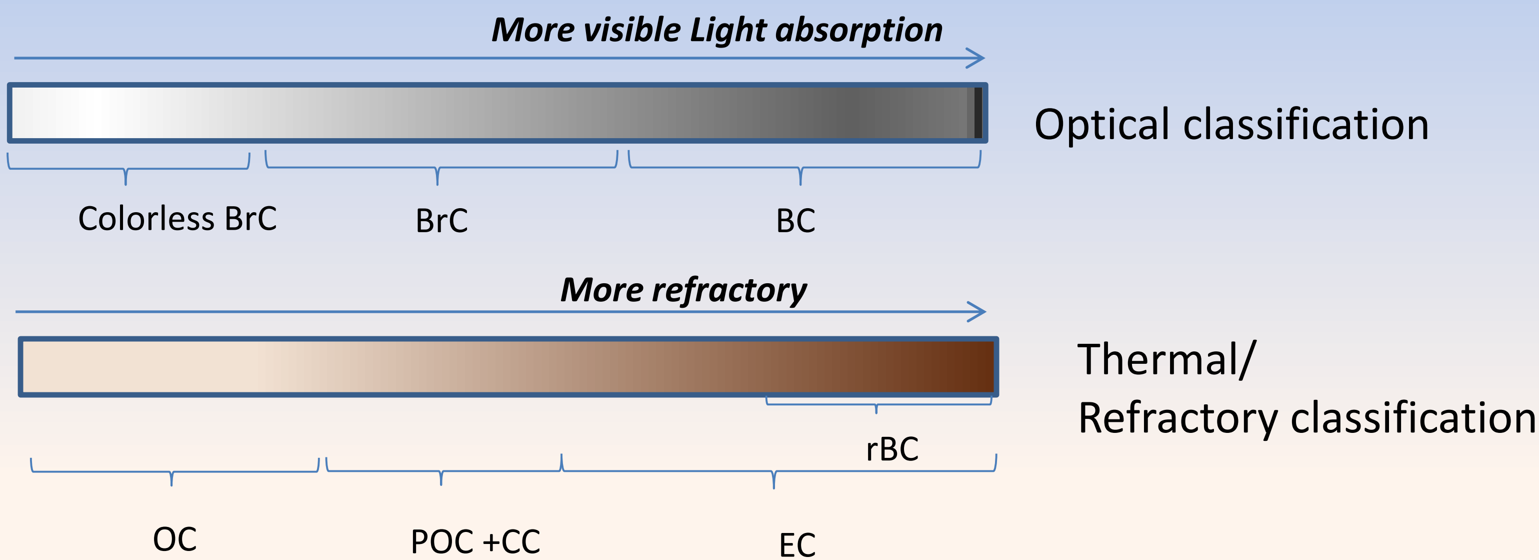
Defined by 5 essential properties

- Composition
- Morphology
- Volatility
- Solubility
- Light absorption

Microcrystal structure determines the properties of **BC**

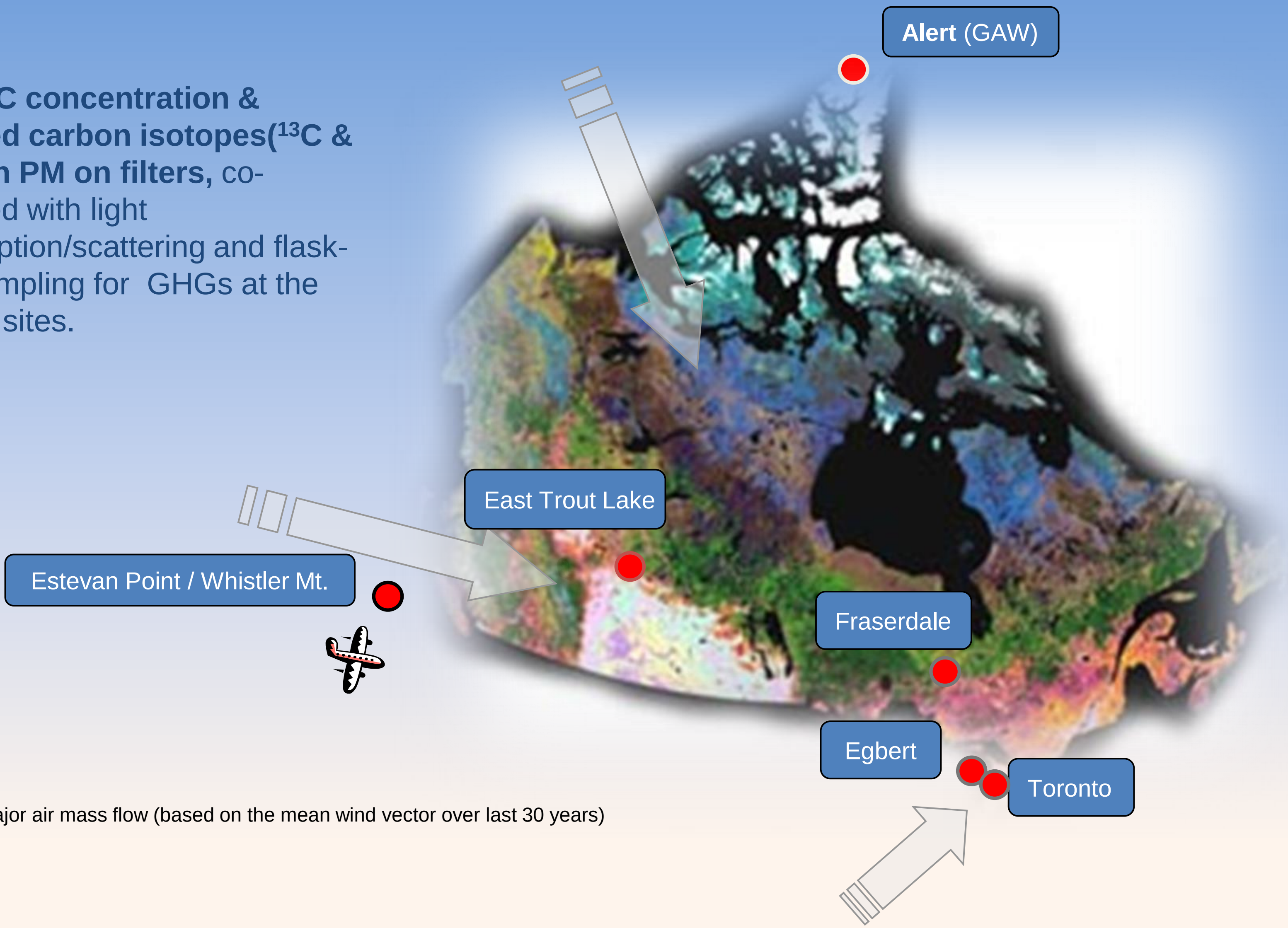
A continuous spectrum of changing in all the properties *(e.g., optical & thermal properties)* ***!***

There is no one to one clearly fixed relationship !



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

- **EC/OC concentration & related carbon isotopes(^{13}C & ^{14}C) in PM on filters,** co-located with light absorption/scattering and flask-air sampling for GHGs at the same sites.



Major air mass flow (based on the mean wind vector over last 30 years)

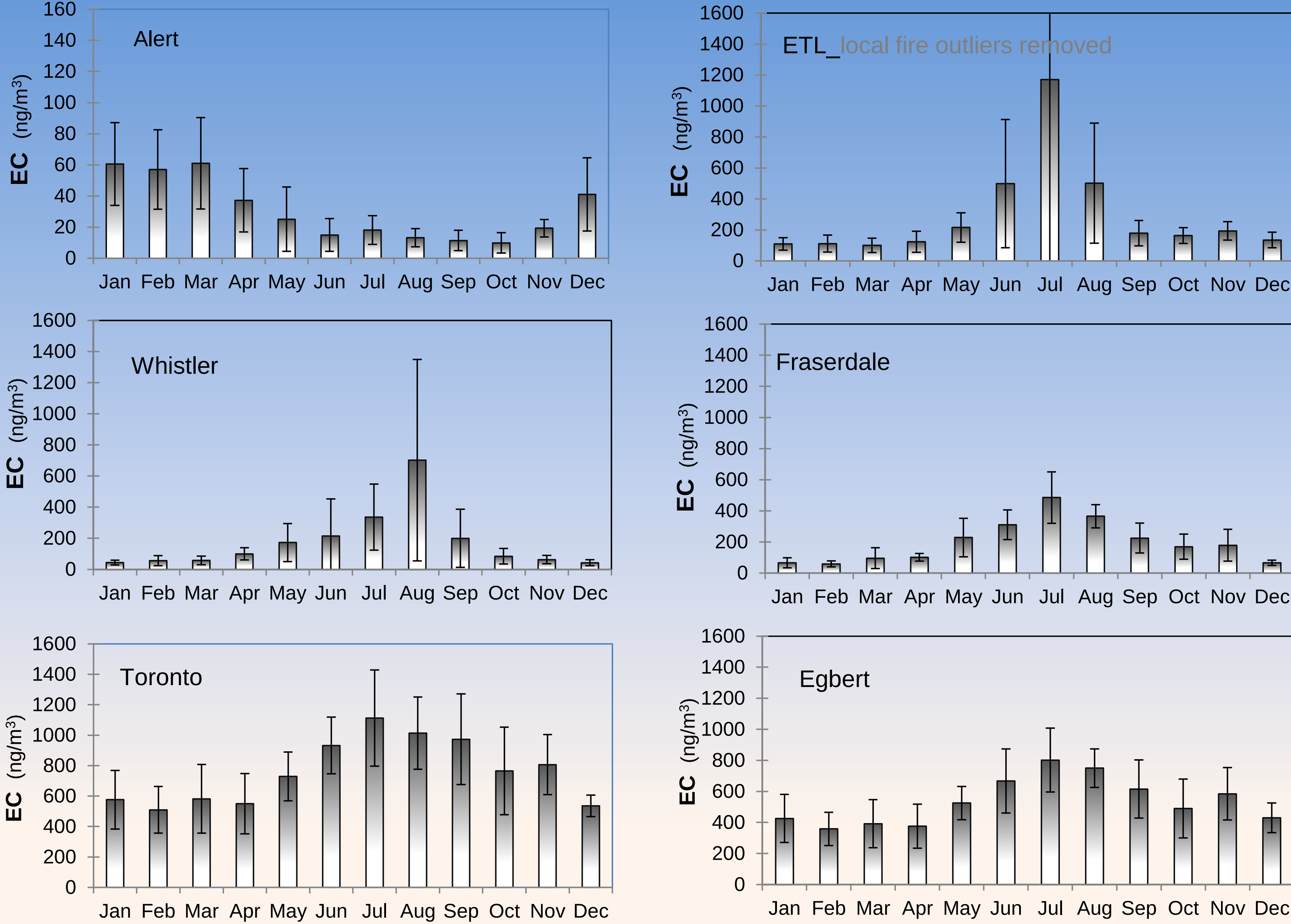
BC mass Trends Observed Across Canada

(annual means: 2006 -2015)

Lin Huang, IPCC_EM-SLCF, Geneva, May 21-31, 2018

BC mass Seasonal Profiles across Canada

(monthly means: 2006 -2015)

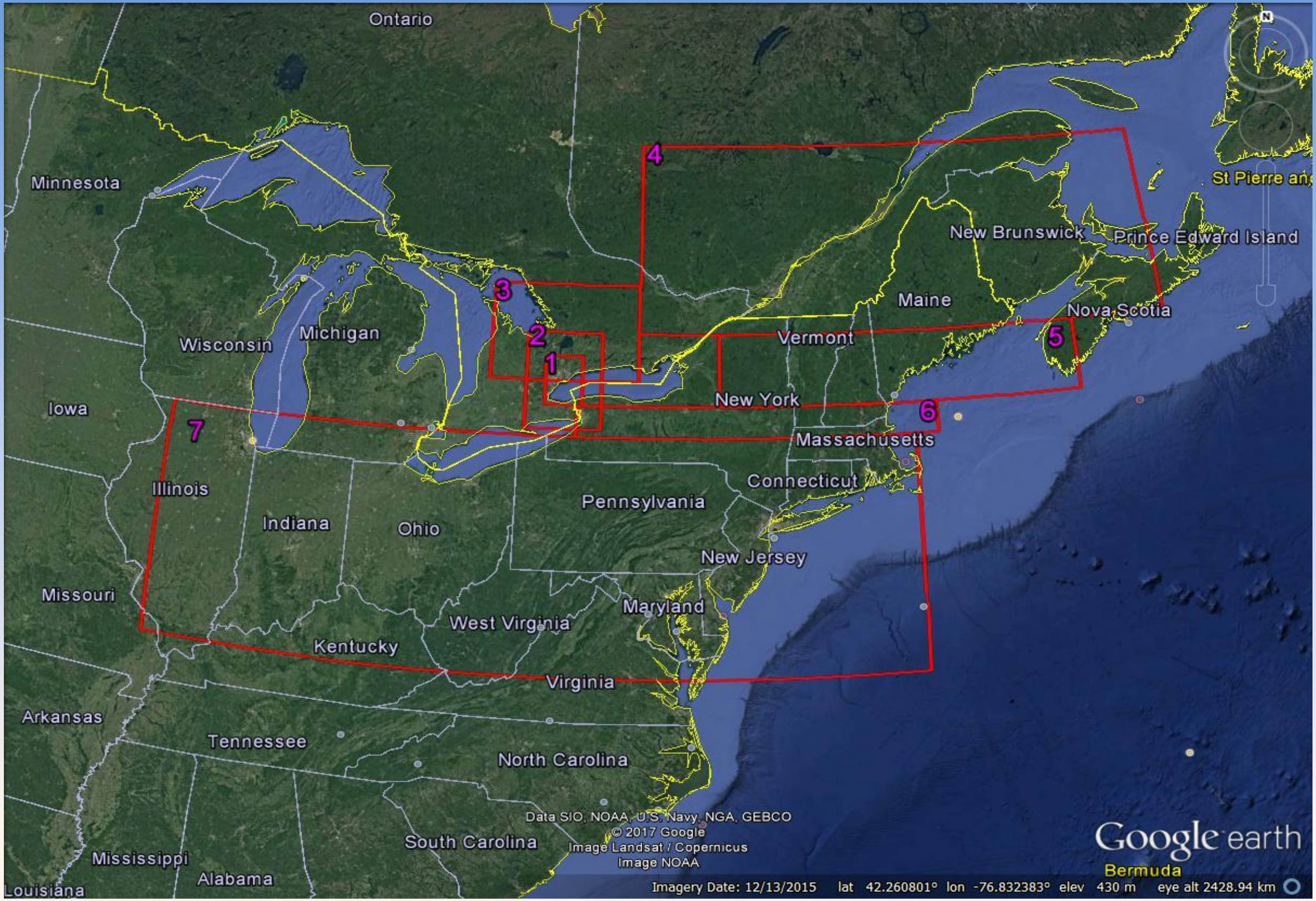


Lin Huang, IPCC_EM-SLCF, Geneva, May 21-31, 2018

Environment Canada Environnement Canada

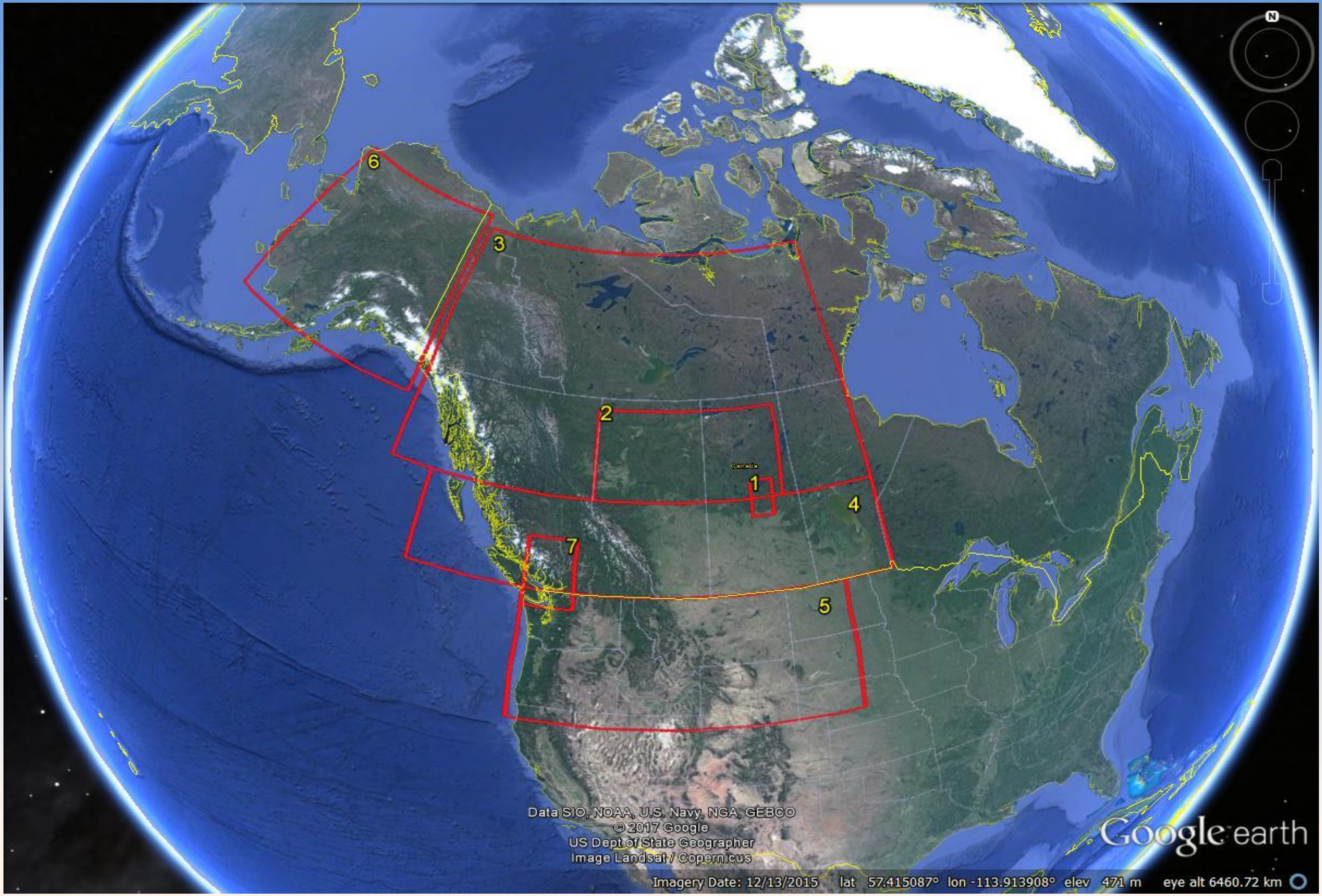
Possible areas influencing our measurements in the Eastern North America

(based on footprints by Flexpart lagrangian particle dispersion model)



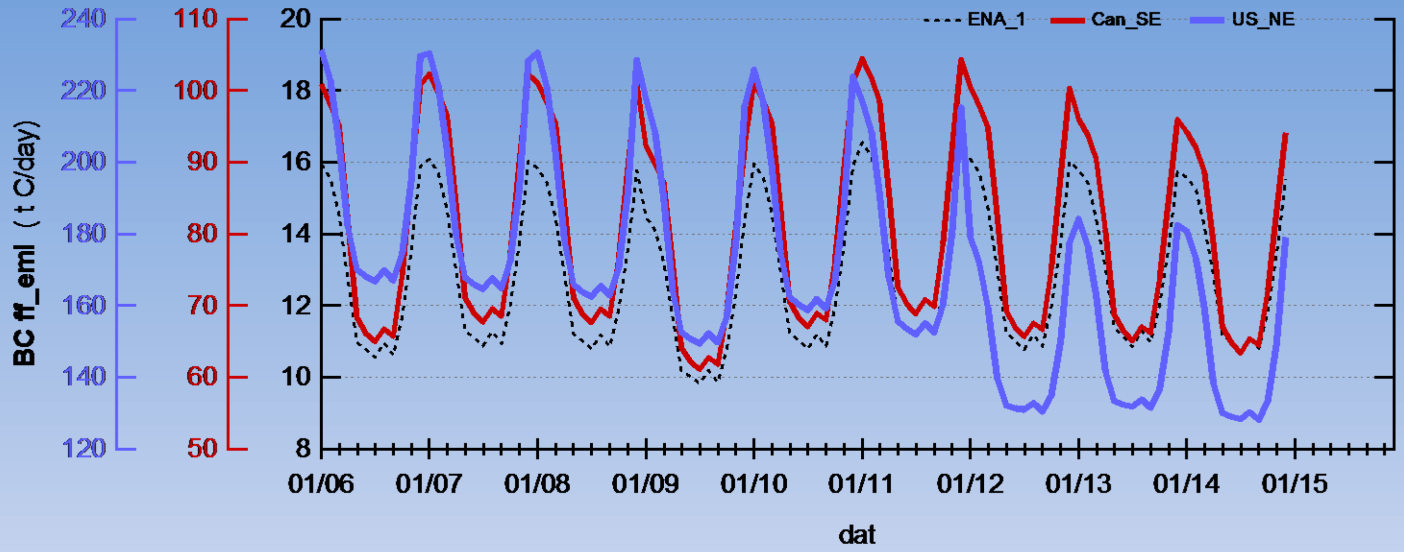
Possible areas influencing our measurements in the Western North America

(based on footprints by Flexpart lagrangian particle dispersion model)

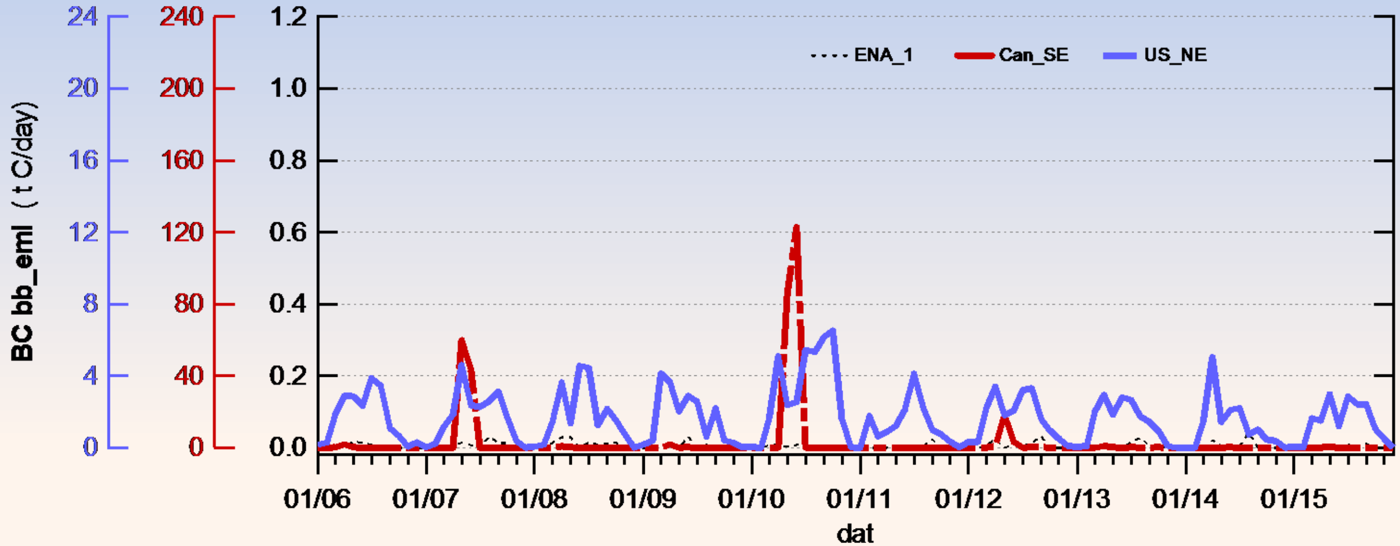


Assembled **Historical BC Emissions** for CMIP6 in Eastern North America (2006-2015)

van Marle et al., Geosci. Model Dev., 10, 3329–3357, 2017, https://doi.org/10.5194/gmd-10-3329-2017
Hoesly et al., Geosci. Model Dev., 11, 369–408, 2018, https://doi.org/10.5194/gmd-11-369-2018



Anthropogenic emissions



Fire Emissions

Lin Huang, IPCC_EM-SLCF, Geneva, May 21-31, 2018

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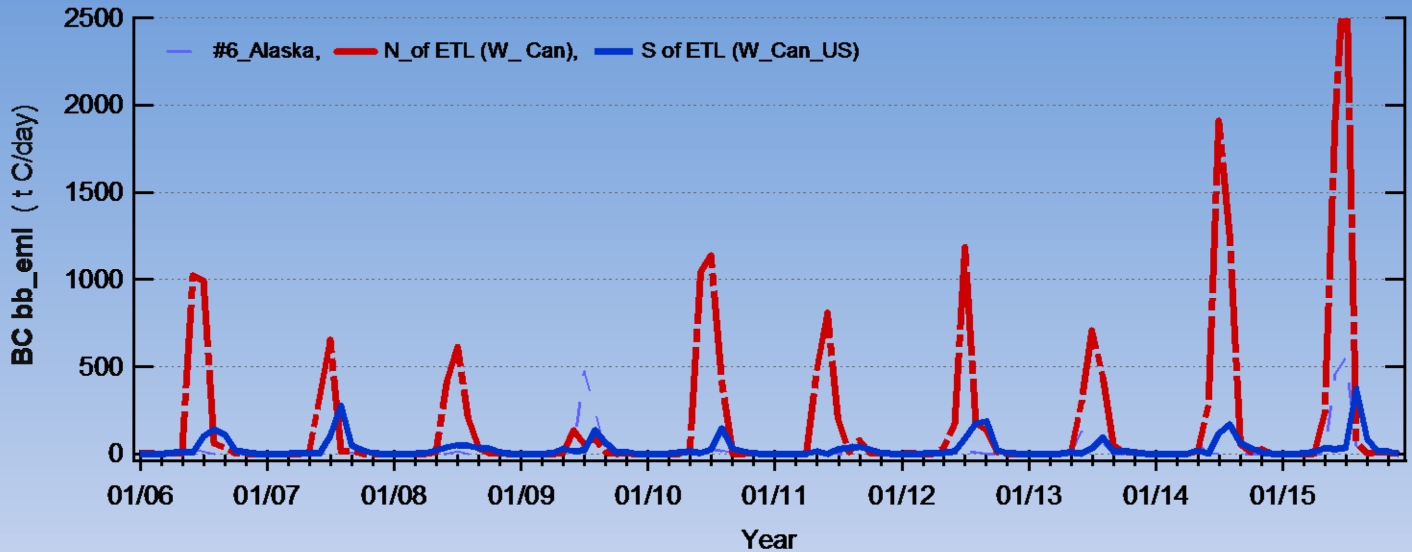
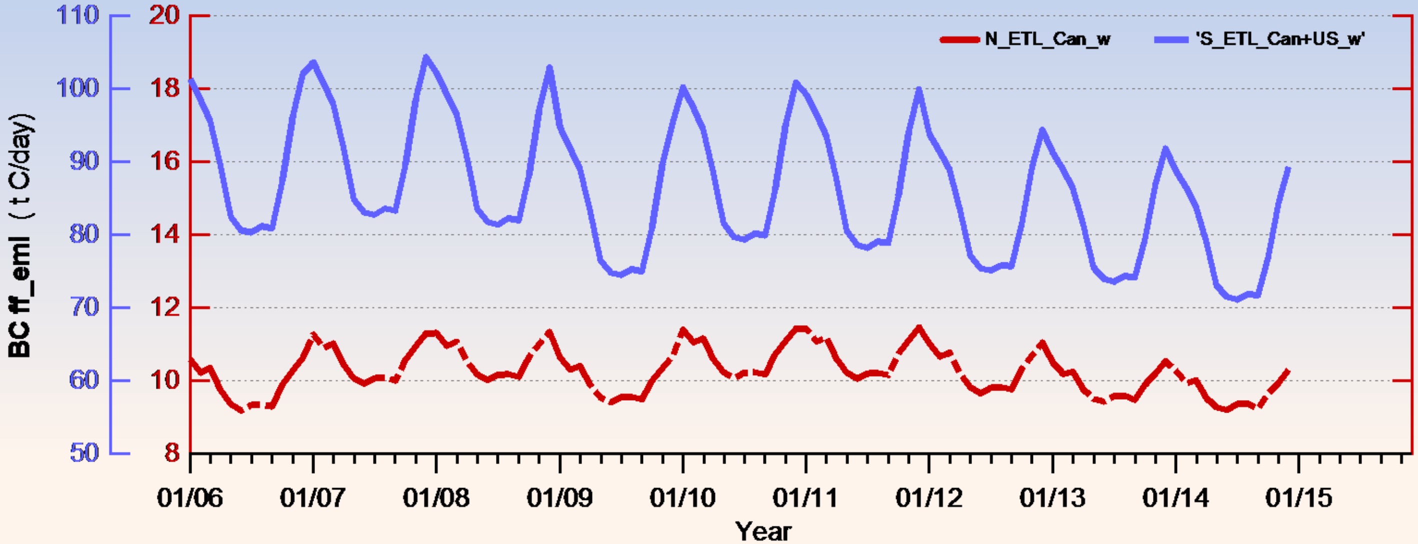


Fire Emissions



Anthropogenic emissions

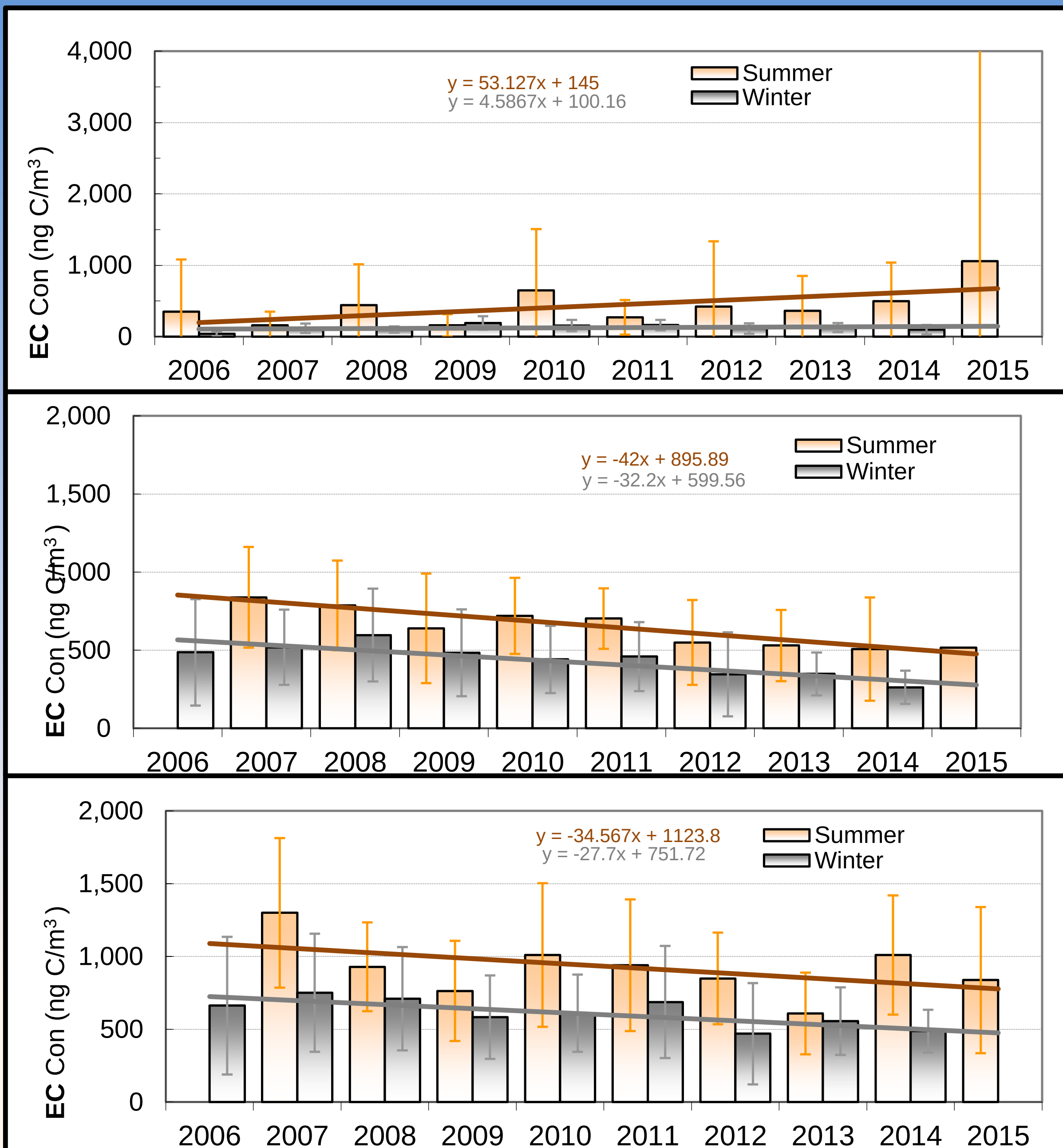
BC Mass Observations in East & West Canada

(Annual seasonal means: 2006 -2015)

a).

b).

c).



West NA

ETL: dominated by

Fire influences

East NA

Egbert: dominated by

Anthropogenic influences

East NA

Toronto: dominated by

Anthropogenic influences

Take Home

- It is possible to use Top-down method to constrain BC emissions or emission trends for **harmonizing** the methodologies for emission inventories of GHGs with those of SLCFs

- Long-term robust and traceable atmosphere measurements are required for top-down approach

- A universal reference is strongly recommended to ensure robust and traceable BC measurements.

Thank you !

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For IPCC-Expert Meeting on SLCF, Geneva, May 28-31, 2018

Environment Canada Environnement Canada