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IMPACT OF NORTH AMERICAN FOREST FIRE EMISSIONS ON THE ARCTIC ATMOSPHERIC COMPOSITION IN SUMMER TIME

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INTRODUCTION

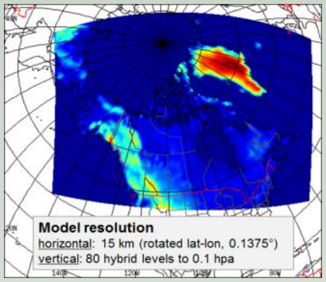
Arctic atmospheric composition is strongly influenced by long-range transport from mid-latitudes as well as processes occurring in the Arctic locally. In this study, model simulations, using the ECCC on-line air quality forecast model (GEM-MACH), were carried out for a field campaign conducted over the Canadian High Arctic during the summer of 2014. The model results were compared with detailed observational data from various platforms. The study shows that the Canadian High Arctic was impacted by North American regional biomass burning (BB) emissions particularly during the late July and early August time period. Tests were carried out to investigate the impact of fire plume injection algorithms on model predictions.

THE FIELD CAMPAIGN

Measurements of aerosol physical and chemical properties and trace gas were made during the NETCARE (NETwork on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments, http://www.netcare-project.ca) 2014 Arctic summer campaign on multiple platforms:

- AWI-Polar 6 (based from Resolute Bay, NU
- Amundsen icebreaker (sailed through the eastern Canadian Archipelago)
- Ground-based sites (Resolute and Cape Dorset, NU)

SIMULATION SETUP



Model: GEM-MACH v2 (svn #1929+), 12-bin configuration

Domain: Arctic 15-km

Anthropogenic emissions: 2010 Canadian, 2008/2010 US, 2010 HTAP inventories; 2010 Canadian marine/shipping emission inventory

Fire emissions: 2014 FireWork (starting on June 18, 2014)

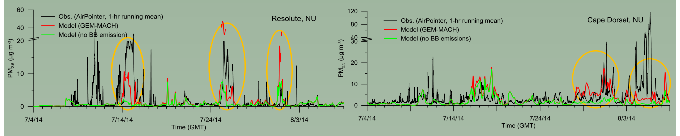
Meteorological piloting: GEM v4.6.2, 15-km GV

Chemical boundary conditions: MOZART-4 2014 (daily)

Simulation period: June 1 – August 30, 2014 (initialized with MOZART-4)

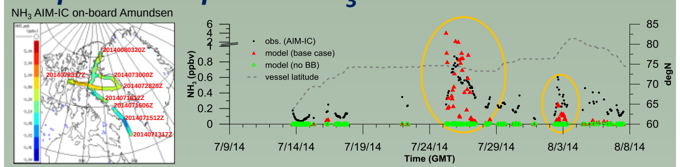
IMPACT OF NA WILDFIRE EMISSIONS IN THE ARCTIC

Impact at ground sites:



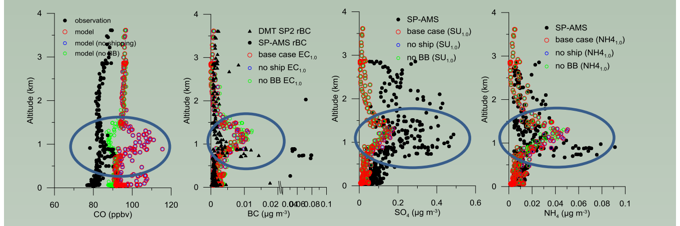
Impact on shipborne NH_3 measurement:

NH_3 AIM-IC on-board Amundsen

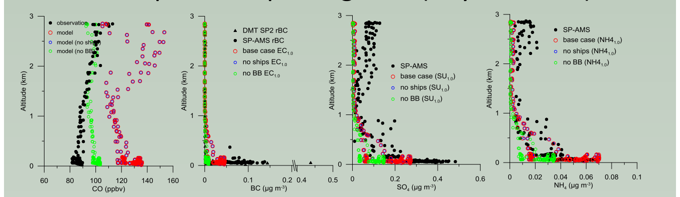


Impact seen in aircraft profiles:

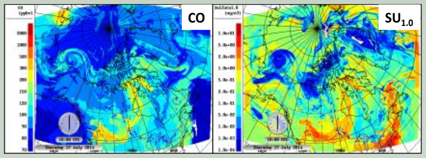
Case 1: BB and anthropogenic plume (July 17, 2014)



Case 2: BB plume impacting MBL (July 20, 2014)

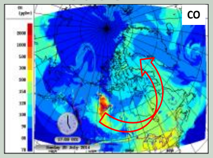


Case 1



CO in the plume were of BB origin – due to lack of wet and dry removal CO can be transported over longer distance; the aerosols in the plume were of anthropogenic origin from sources along the transport route in western and central Canada. The aerosols from BB in the plume may have been scavenged during the long-range transport.

Case 2



BB plume transported along a route via Hudson Bay, Labrador sea, through Davis Strait and Baffin Bay: descending over cold water, less removal…

How does plume injection affect its transport

- ***Base case ("R0")***: Briggs plume-rise (3 m stack-height, 773 K exit T, 1 m/s exit velocity);
- ***Sensitivity run 1 ("R1")***: using vegetation type based plume statics derived from 5-year satellite observation over NA;
- ***Sensitivity run 2 ("R2")***: same as "R1" but setting smoldering fraction (F-smolder) to zero.

Plume statistics based on 5-year satellite observation over NA (Val Martin et al. 2010)

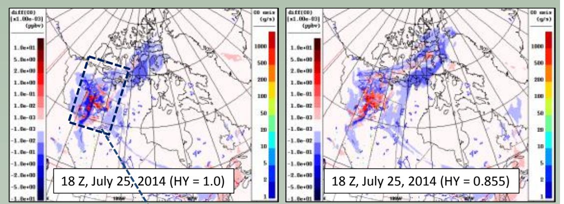
LU	Plume-med-hgt (mean)	Plume-med-hgt (std)	Plume-depth (mean)	Plume-depth (std)	F-smolder
Boreal forest (evergreen needleleaf forest)	1040	646	1100	703	.55
Temperate forest (deciduous broadleaf forest, mixed forest)	781	544	828	653	.55
Shrubs (tundra, dwarf trees, shrubs with ground cover)	935	604	967	695	.25
Grass and cropland (grassland, crops, mixed farming)	691	408	625	468	.03

R1:

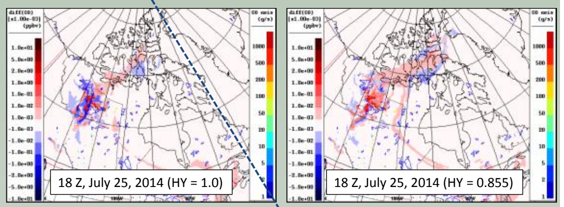
- Smoldering portion is distributed evenly within PBL
- Flaming portion is distributed using a Gaussian distribution: plume centre is determined using the mean and STD of plume-median-height, i.e., mean (neutral), mean + STD (unstable), and mean - STD (stable); σ is determined using mean and STD of plume-depth, i.e., ½ mean (neutral), ½ mean + ½ STD (unstable), and ½ mean – ½ STD (stable)
- Under unstable condition, the portion of the flaming plume (below PBL) is distributed evenly within PBL
- Additional consideration for plume centre located above PBL

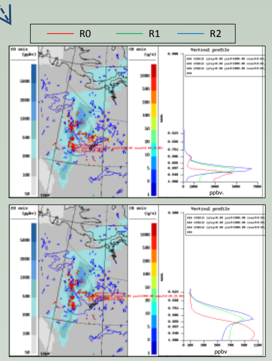
Example: NWT fire event (July 24 – 25, 2014)

R1 – R0 *difference at the surface (HY = 1) and at ~ 1.5 km (HY = 0.855)*



R2 – R1 *difference at the surface (HY = 1) and at ~ 1.5 km (HY = 0.855)*





- Comparing R1 and R0 (basecase): R1 generally puts more fire emission aloft than R0 – initial plume is allowed to penetrate above PBL;
- As intended, R2 distributes more emissions to elevated levels;
- Impact of different injection scheme is most pronounced in source region, less farther downwind due to dynamics and dispersion;
- Plume statistics reflects average plume characteristics; dependency on modelled PBL.

CONCLUSIONS

- The Canadian high Arctic can be impacted by long-range transported pollutants from both anthropogenic and biomass burning sources. Biomass burning plumes can impact the Arctic close to surface through either transport at low altitudes via a more direct route or transport over cold Arctic water channels.
- Fire injection algorithm has a profound impact over the source region but the impact is much reduced at longer range.

ACKNOWLEDGEMENT

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