

Seasonality of Arctic Black Carbon Processes in the AMAP Multi-Model Ensemble

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Model Simulations

- Models:
 - CanAM, CESM, NorESM, SMHI-MATCH
- All models use same:
 - anthropogenic emissions from ECLIPSE inventory, version 4a
 - monthly varying emissions for forest and grass fires from GFED, version 3.1
 - Simulation period (2006-2010), with specified sea surface temperatures, GHG concentrations, and volcanic forcings.
- For Vertical distribution of BC concentrations, the model data for year 2008 and 2009 is available on selected station locations.

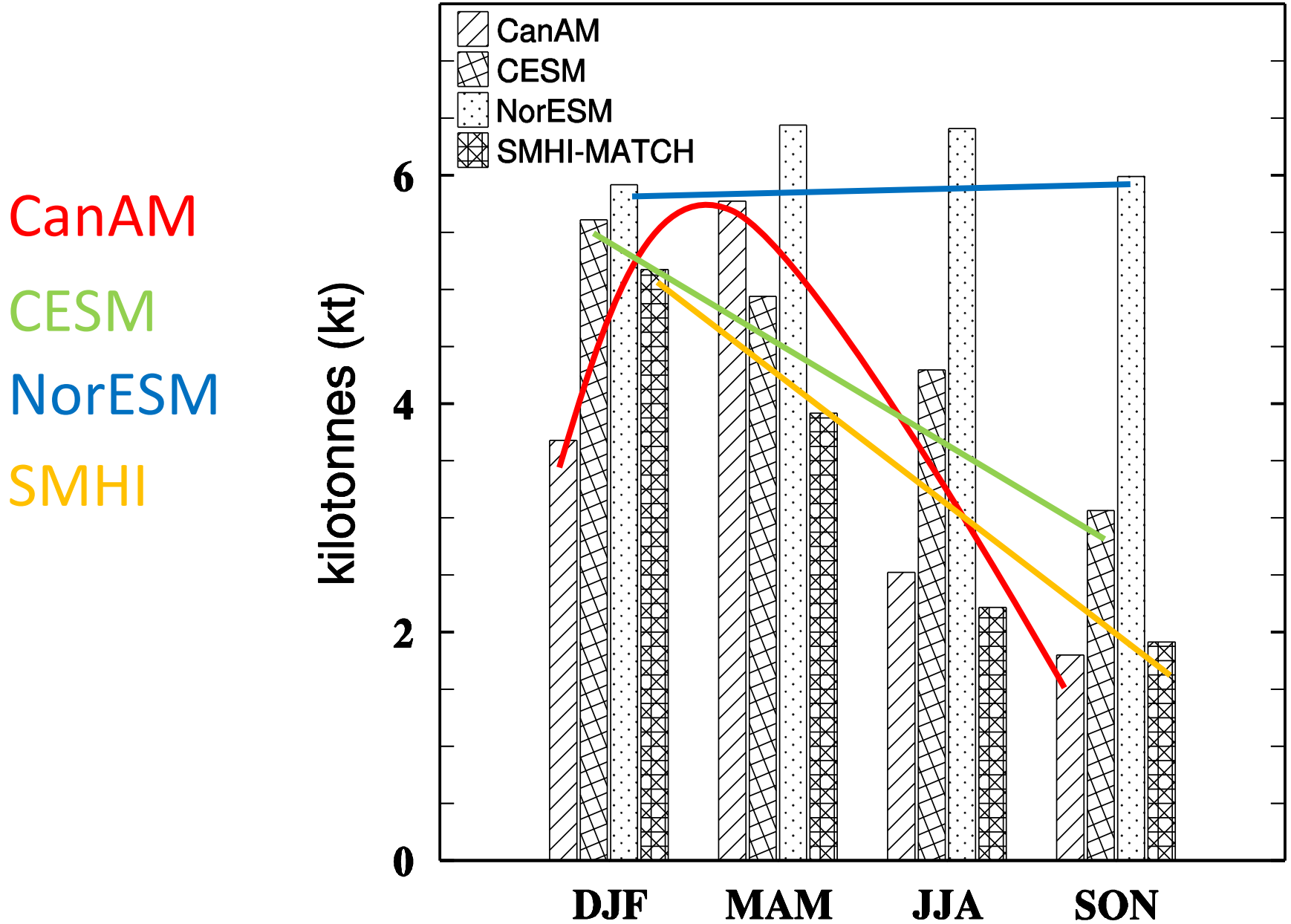
Some insights from Eckhardt et al. (2015)

- Models generally captured the measured BC and sulfate concentrations quite well, compared to previous comparisons.
- Concentrations of BC and sulfate averaged over three surface sights are **underestimated in winter/spring in all but one model (i.e. CanAM)**.
- Model mean BC (sulfate) **underestimated by 59% (37%) for Jan-Mar and overestimated by 88% (44%) for Jul-Sep.**
- BC and sulfate in Arctic probably have same origins.

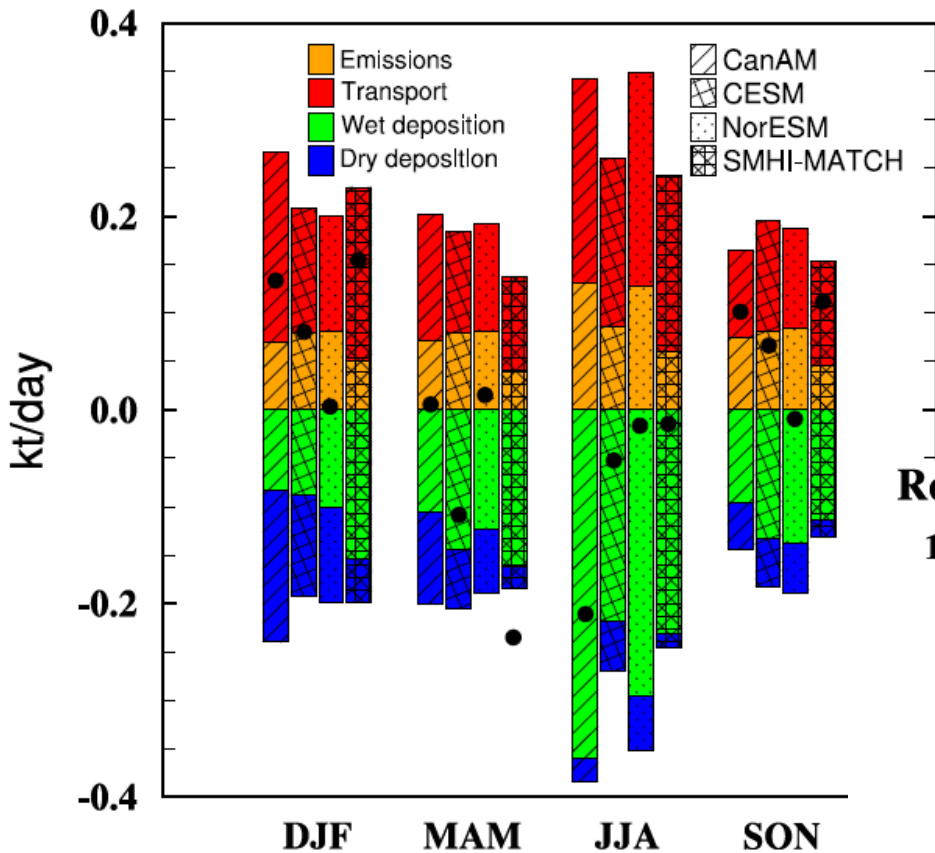
Objectives of Current Study

- Explore the seasonality of BC burdens in AMAP models since it is directly relevant to radiative forcings.
- Investigate different BC processes in the models.
- Perform sensitivity analysis to understand the role of different aerosol processes in contributing to overall burden differences among the models

BC Burden in Arctic

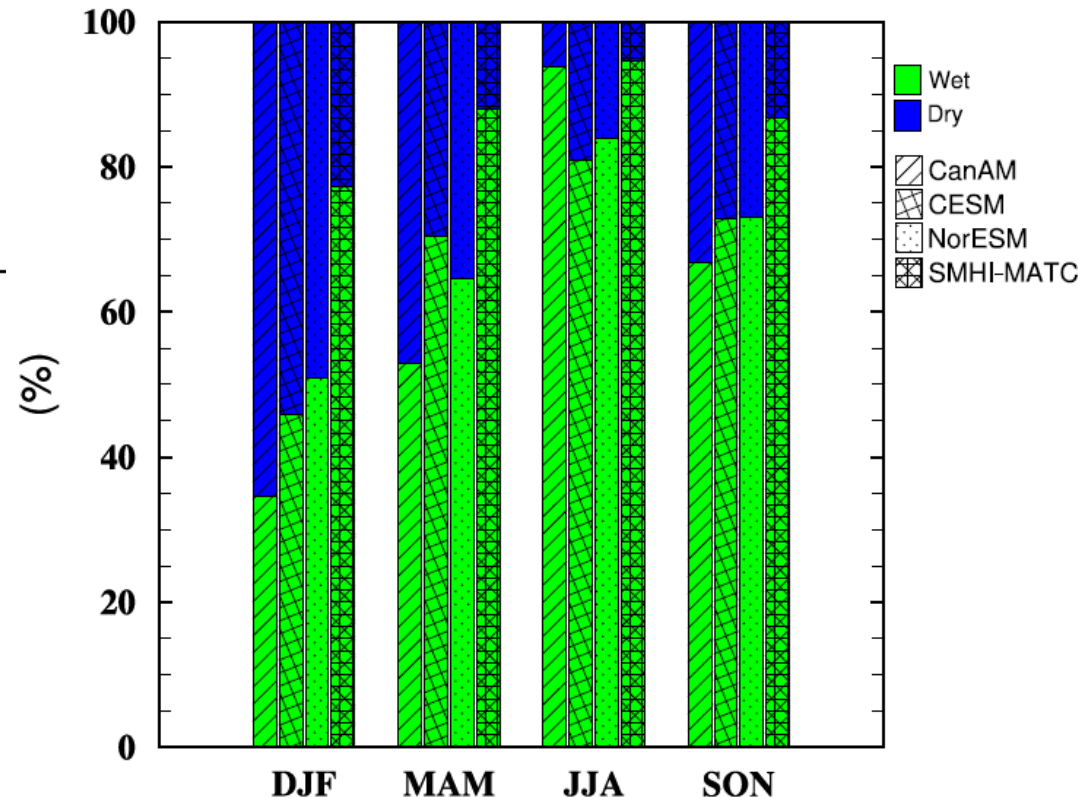


BC budgets in Arctic



- Transport plays major role in Arctic BC in models.
- In summer enhanced transport is caused by forest fires near ~60N
- Large differences in wet deposition rates.

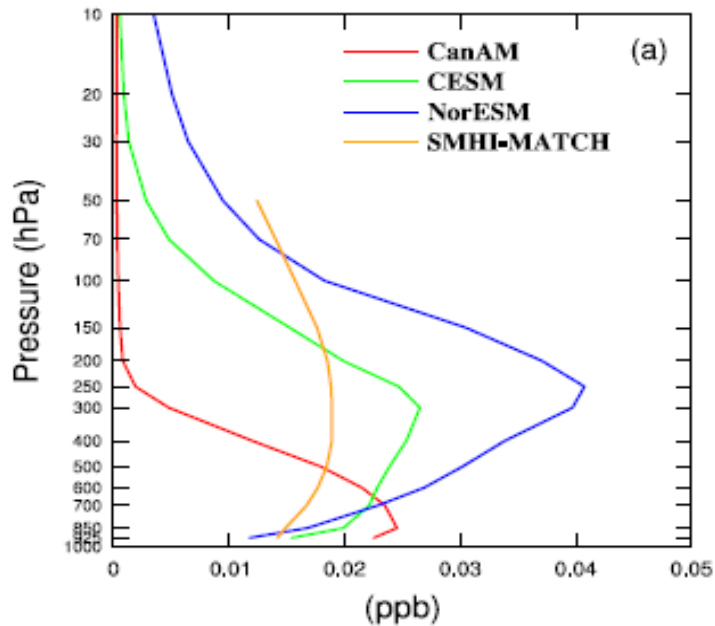
Relative Contribution of Wet and Dry Deposition



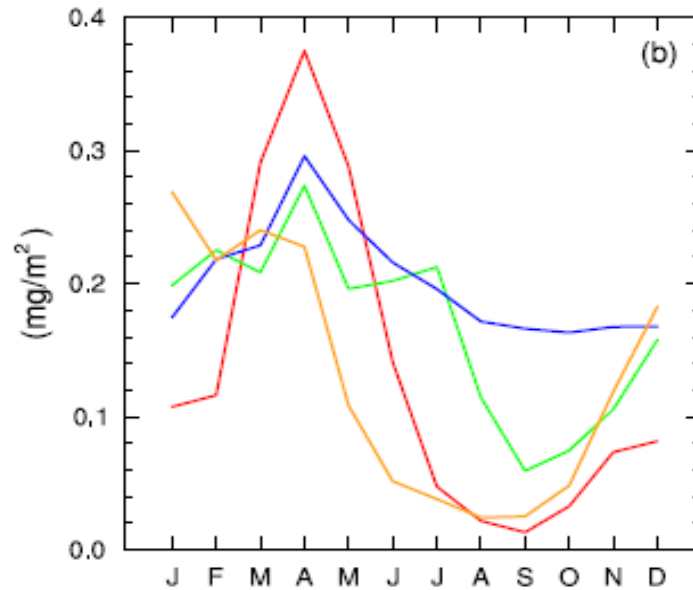
- The budgets does not fully explain the seasonal cycle of burdens especially in NorESM

Black dots represent net source*5

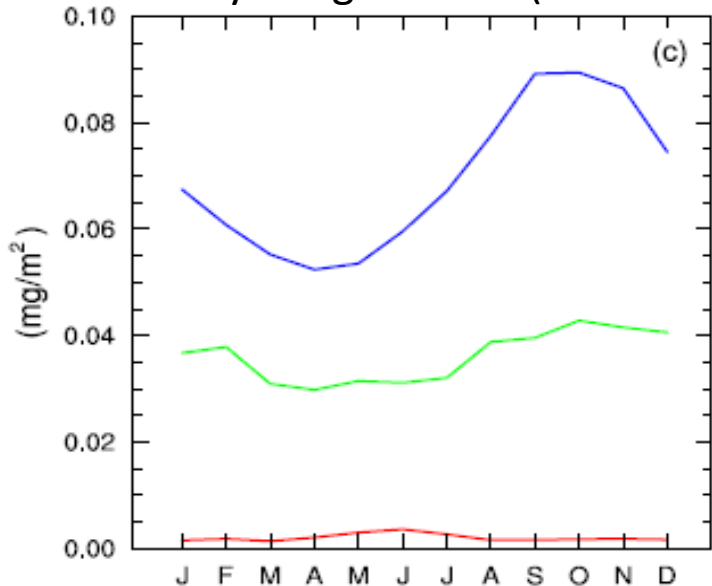
Annual mean BC



Vertically integrated BC (1000-250hPa)



Vertically integrated BC (250-10hPa)

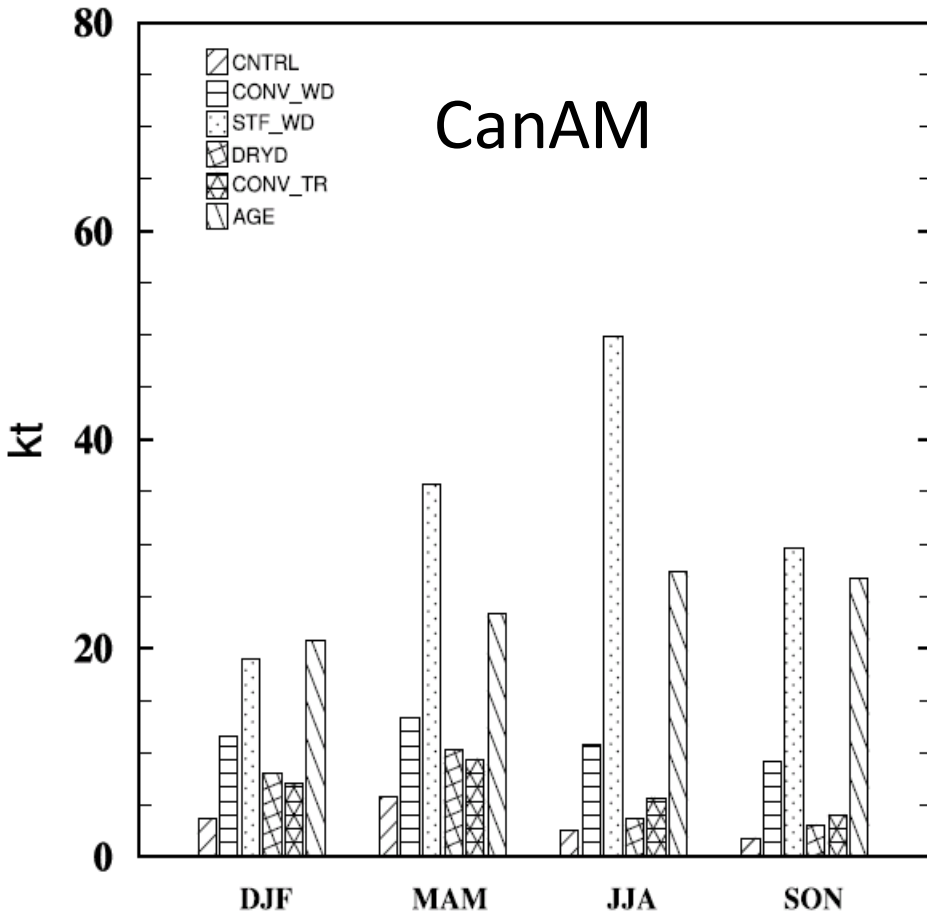


- Large differences in the middle and upper troposphere.
- The large differences in burdens are related to the differences in process timescales.

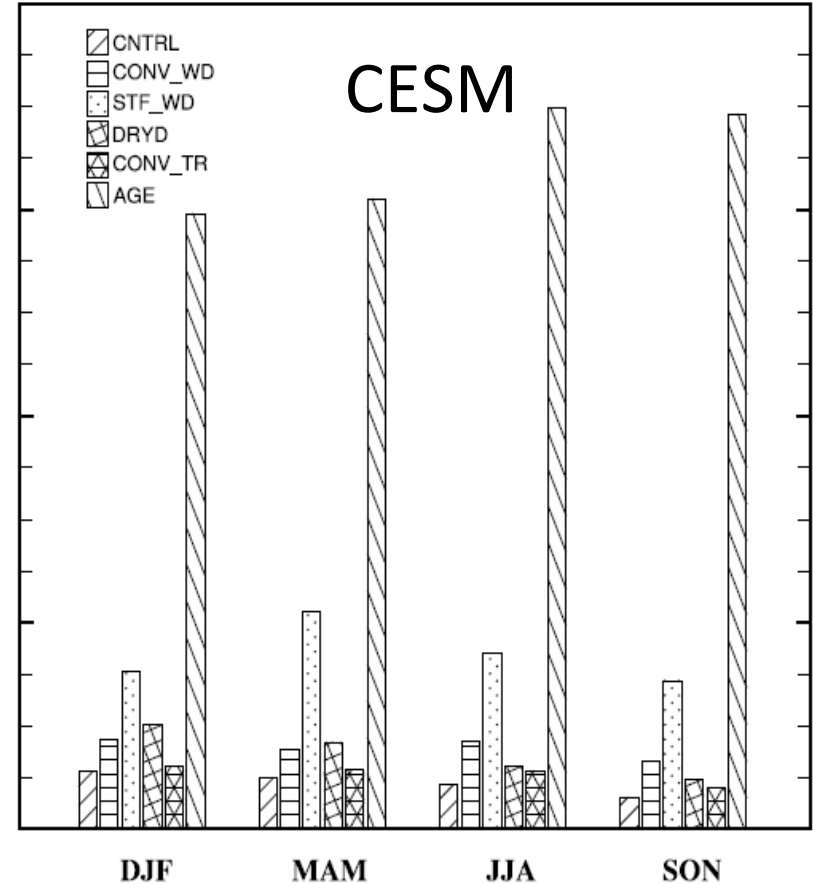
Sensitivity Tests

- To understand some of the differences among the models we designed the following tests using **CanAM** and **CESM**:
 - **CONV_WD**: No convective aerosol removal
 - **STF_WD**: No wet scavenging (in layered clouds)
 - **DRYD**: No dry deposition
 - **CONV_TR**: No convective transport and convective wet deposition
 - **AGE**: No aging

BC burden in Arctic



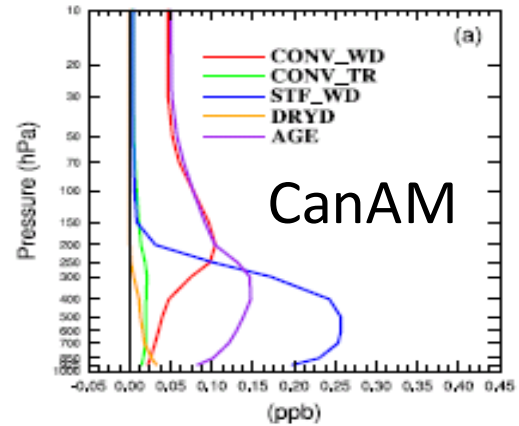
BC burden in Arctic



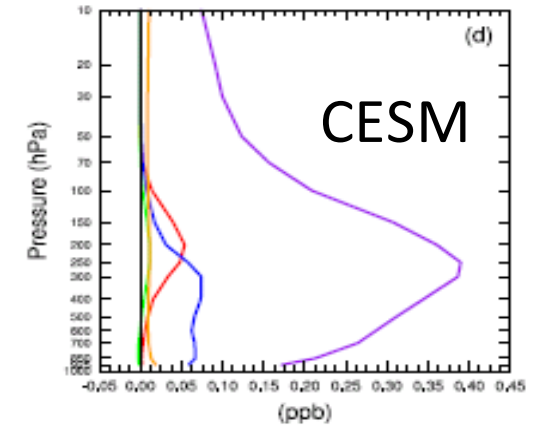
- Both models produce BC burdens larger than control run.
- Strongest responses are for STF_WD, AGE and CONV_WD.
- CONV_TR causes modest changes relative control run.

Experiment - Control

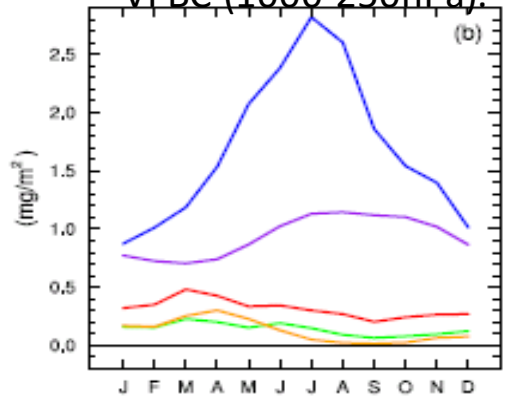
Annual mean BC.



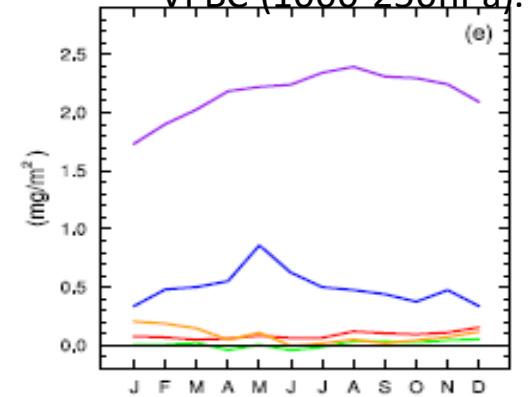
Annual mean BC.



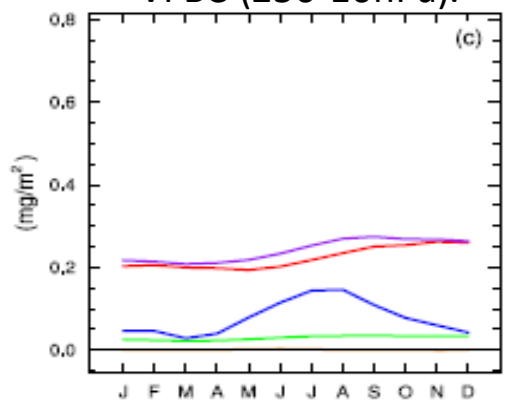
VI BC (1000-250hPa).



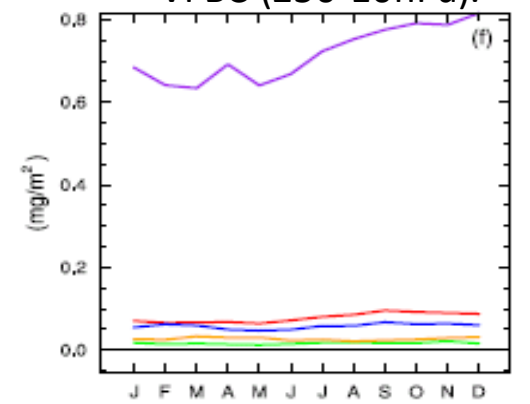
VI BC (1000-250hPa).



VI BC (250-10hPa).



VI BC (250-10hPa).

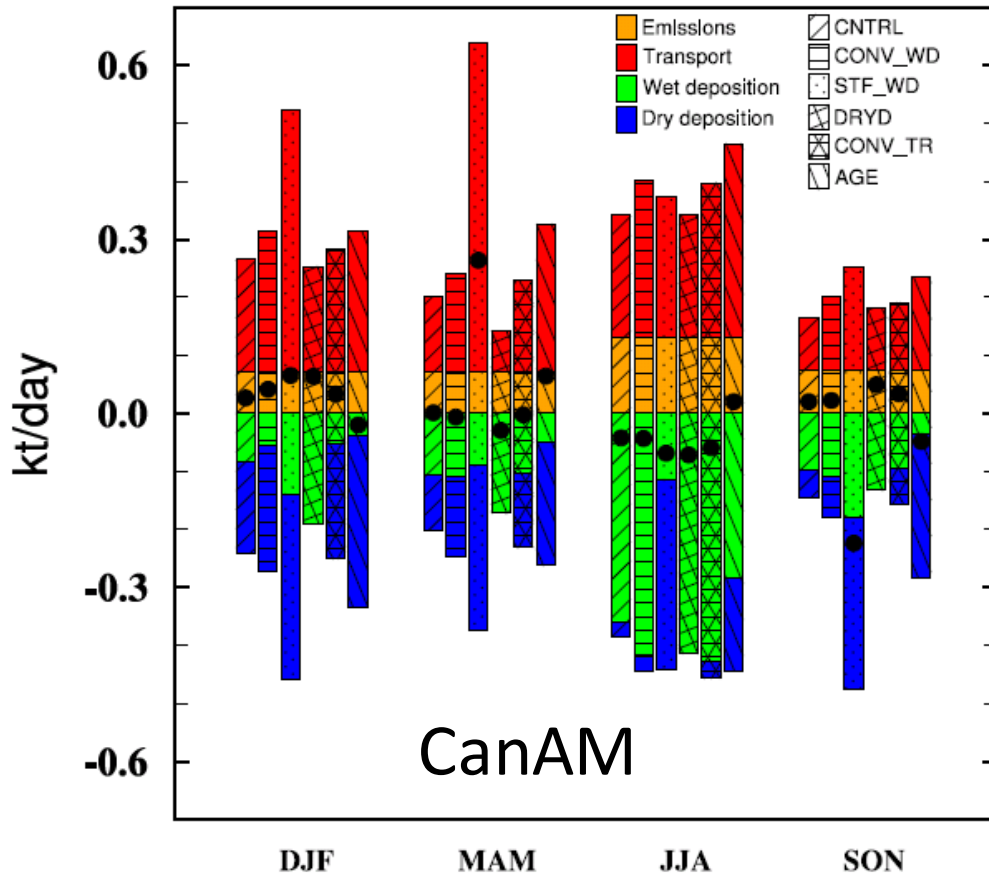


Current/Future Works

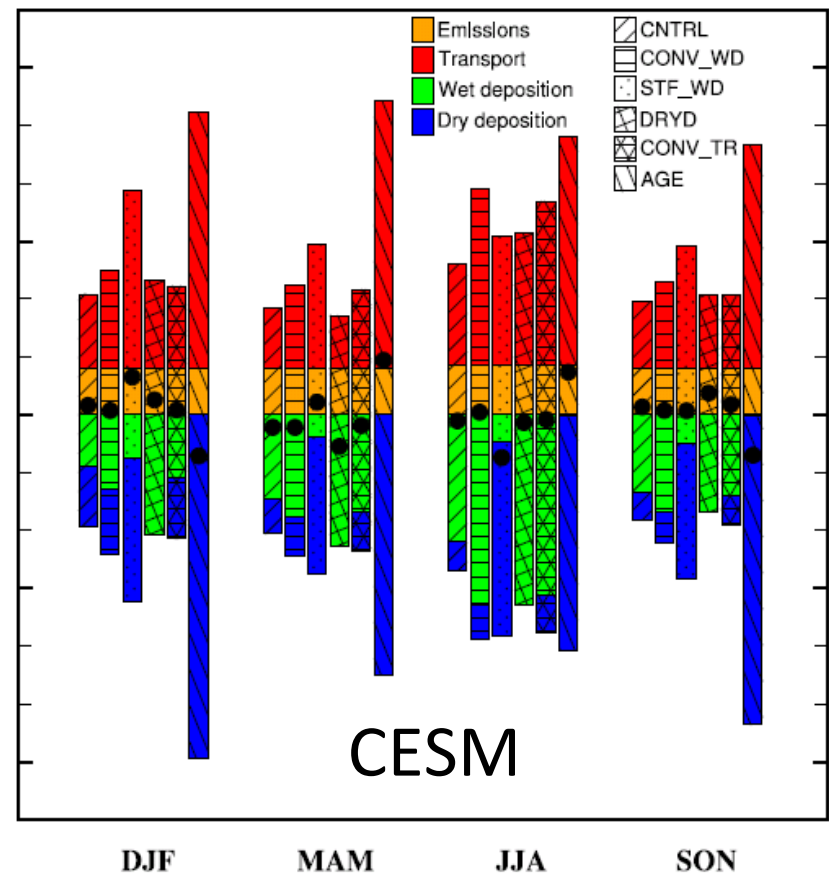
- Sensitivity tests to understand the role of local convection in the Arctic region in affecting vertical distribution of BC??
- Also working on expanding the current study on regional scales to understand aerosol processes and the radiative forcing when certain source regions are included/excluded in the CanAM model.

Thank You

BC budgets in Arctic



BC budgets in Arctic



1. Why wet deposition is stronger than control in sensitivity runs? Because of two types of wet deps.
2. 20% BC from fire emissions is hydrophobic upon emissions and subject wet deposition in CanAM not in CESM

Model Evaluation

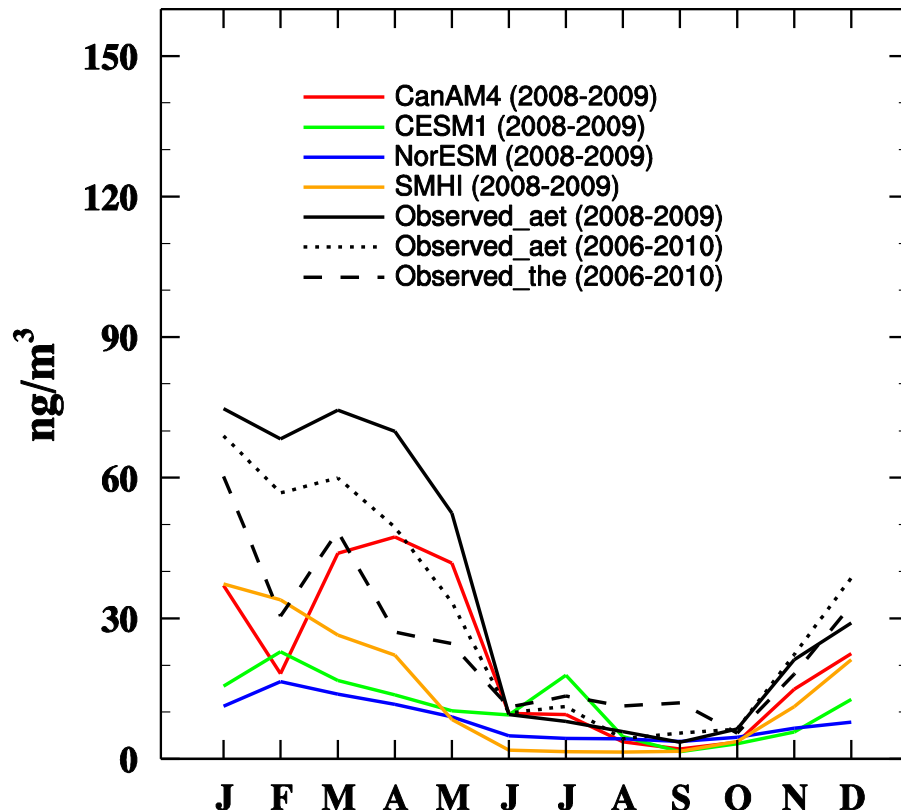
- In general, models reproduce seasonal cycle, i.e. largest concentrations in winter and spring seasons and lowest in summer season.

- However the magnitude is largely underestimated.

- CanAM4 has much better simulation.

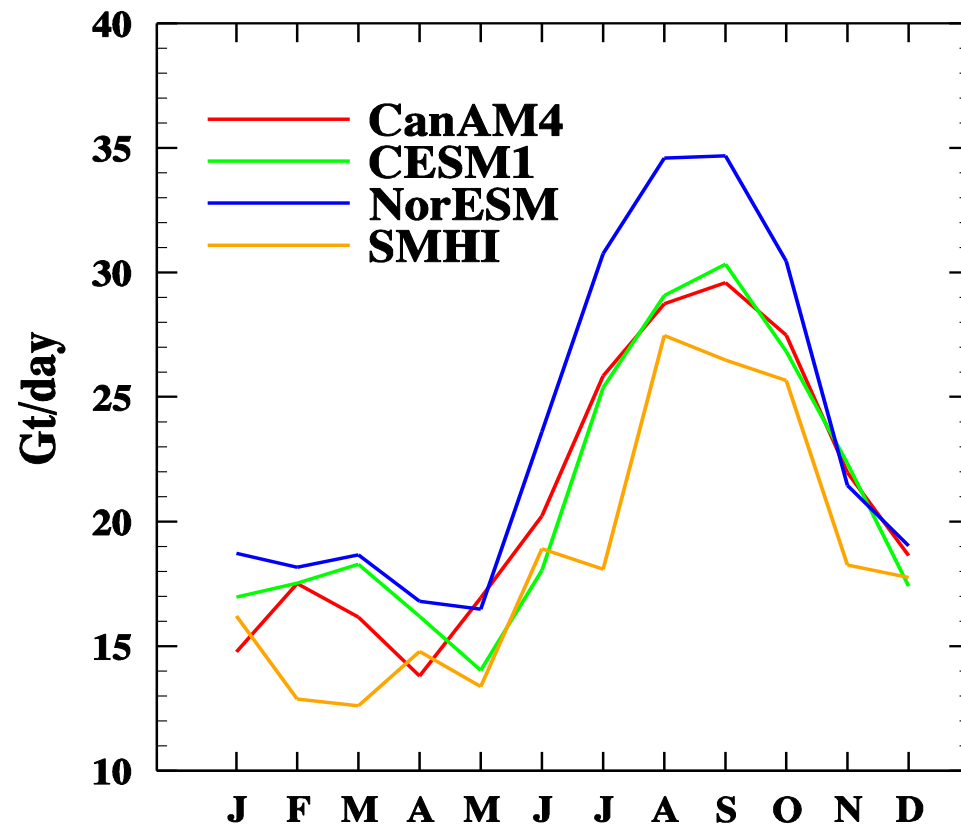
- SMHI also has relative better representation of magnitudes in most polluted months.

Alert, Canada

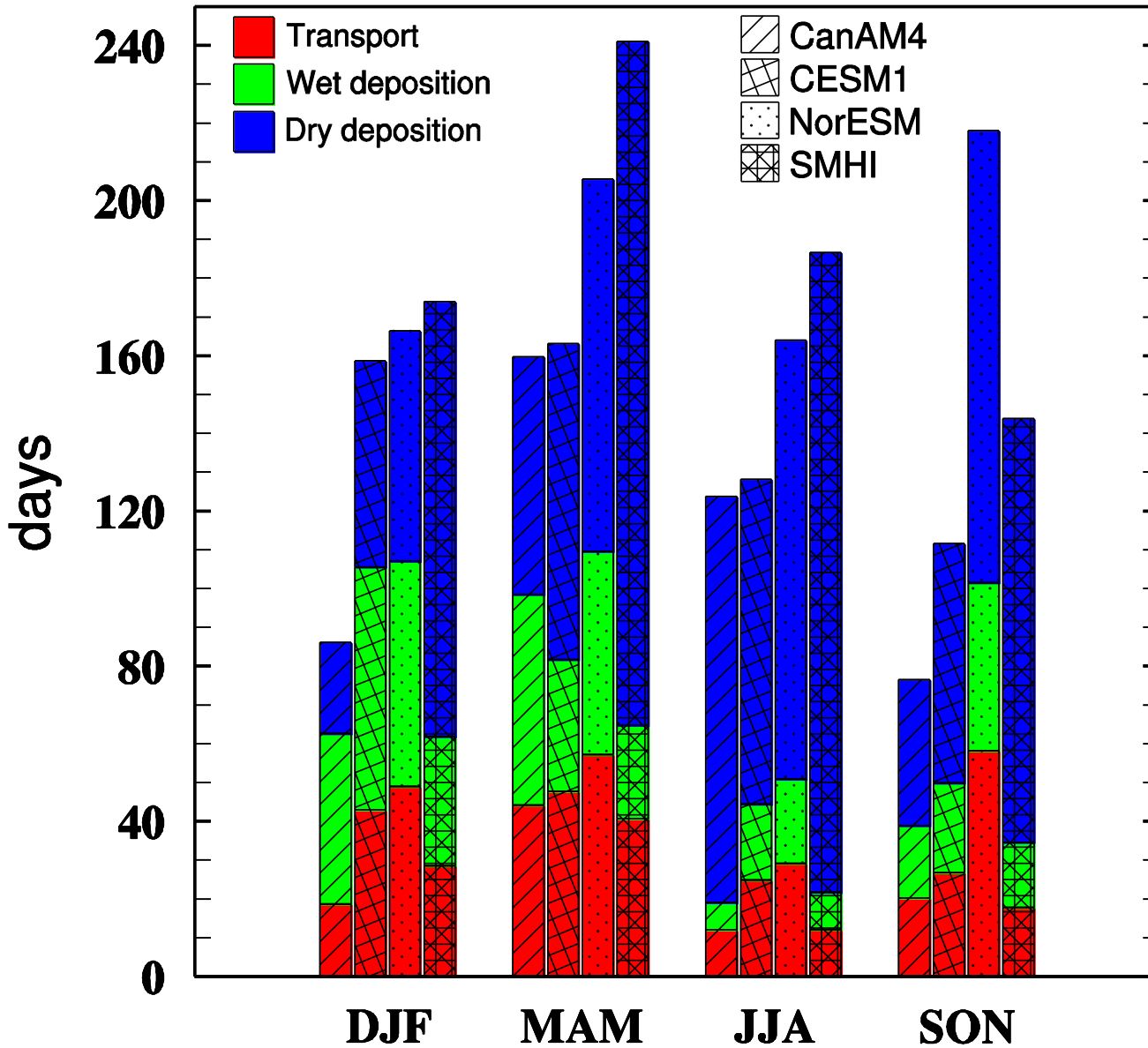


Comparison between observed and simulated monthly mean BC concentrations. Solid lines are mean of 2008 and 2009 while dotted and dashed lines represent mean for 2006 to 2010.

Precipitation



Burden Efficiencies in Arctic



CanAM

CESM

