



A MULTI-MODEL ASSESSMENT OF BLACK CARBON EFFECTS ON HIGH-LATITUDE WARMING IN THE ARCTIC

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OUTLINE

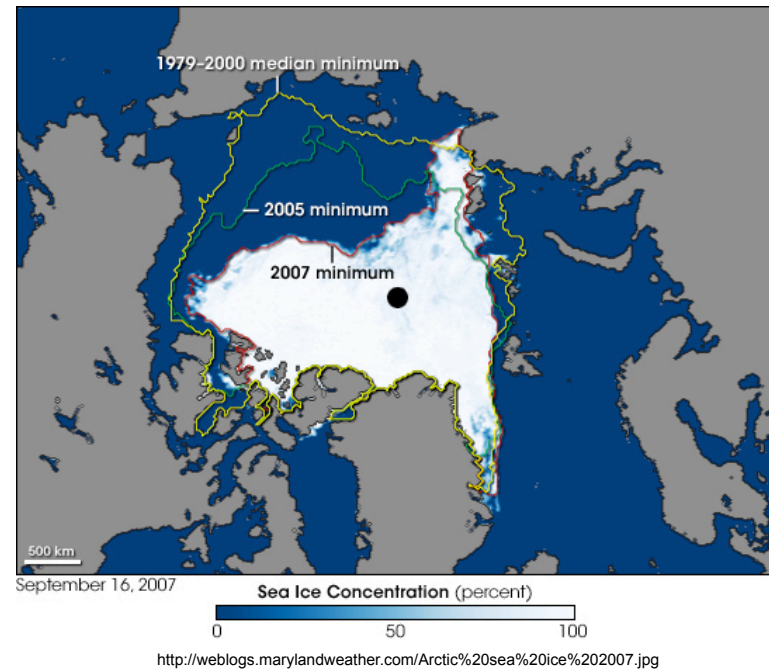
- Black Carbon (BC) Introduction
 - Sources and physical characteristics
 - Effects on climate
- Global aerosol modeling
- Goals
- Methods
- Example of work to date
- Future plans

BLACK CARBON: A PRIMER

- Carbon-based aerosol that affects the climate through...
 - Direct absorption of radiation
 - Decrease in the Earth's "reflectivity"
- Produced from the incomplete combustion of fossil fuels, biofuel, and biomass
 - Occurs naturally and anthropogenically (human-induced)
- BC's impact is not limited to only atmosphere
 - Particles are primarily removed from the atmosphere by deposition
 - Deposition onto snow and ice can exacerbate melting -> positive feedback

BLACK CARBON IN THE ARCTIC

- Therefore, black carbon's effects are most significant when it is above (or deposited) onto “white” surfaces
 - Clouds
 - Snow and ice
- Expect very pronounced effects over Arctic during summer
 - Long days -> Lots of sun -> Plentiful radiation
 - BC is either atmospherically distributed above snow and ice or gets deposited on the surface



WHAT IS THE IMPORTANCE?

- The lifetime of black carbon (days to weeks) very short compared to that of other major GHGs
 - Carbon dioxide (~ 100 years)
- Mitigation might result in a fairly significant reduction in climate effects

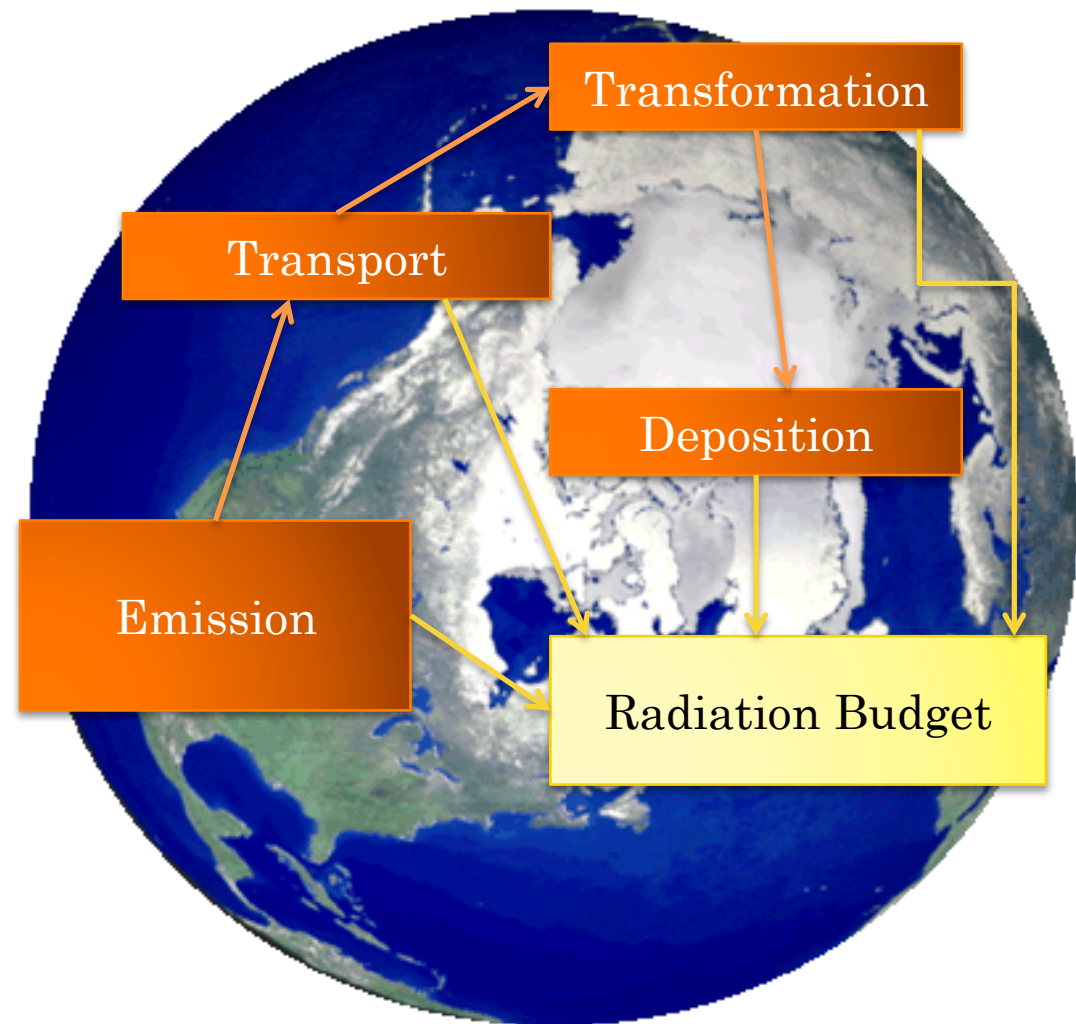
April 6th, 2009

“... we know that short-lived carbon forcers like methane, *black carbon*, and tropospheric ozone contributes significantly to the warming of the Arctic. And because they are short lived, they also give us an opportunity to make rapid progress if we work to limit them.”

– Sec. of State, Hillary Clinton

AEROSOL MODELS

- One way to estimate these effects -> transport models!
- Global aerosol models simulate physical processes to estimate concentration fields and calculate radiative forcing



SOURCES OF UNCERTAINTY



Emission, transportation,
transformation, deposition ->
all these parameters vary in
space...



JANUARY

day	Tuesday	Wednesday	Thursday	Friday
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... and **time...**

GOAL

- Quantify...
 - Uncertainties within global models
 - Variances across different aerosol models
 - Uncertainties/variance of interest lie in:
 - Regional emissions
 - Transport efficiency
 - Deposition flux
- What do we aim to achieve?
 - Better understanding of the physical processes driving Arctic snow/ice anomalies
 - Potential effects of black carbon mitigation on high-latitude warming

METHODS

- AEROCOM initiative
 - Multi-model global aerosol assessment consisting of sixteen participants
 - Data is available in space and time with respect to...
 - Emissions
 - Transport
 - Atmospheric burden
 - Deposition rates
 - Etc.
- Statistical analysis -> quantify variance among model processes that contribute significantly to radiative forcing due to black carbon in the Arctic

AN EXAMPLE: NDRF

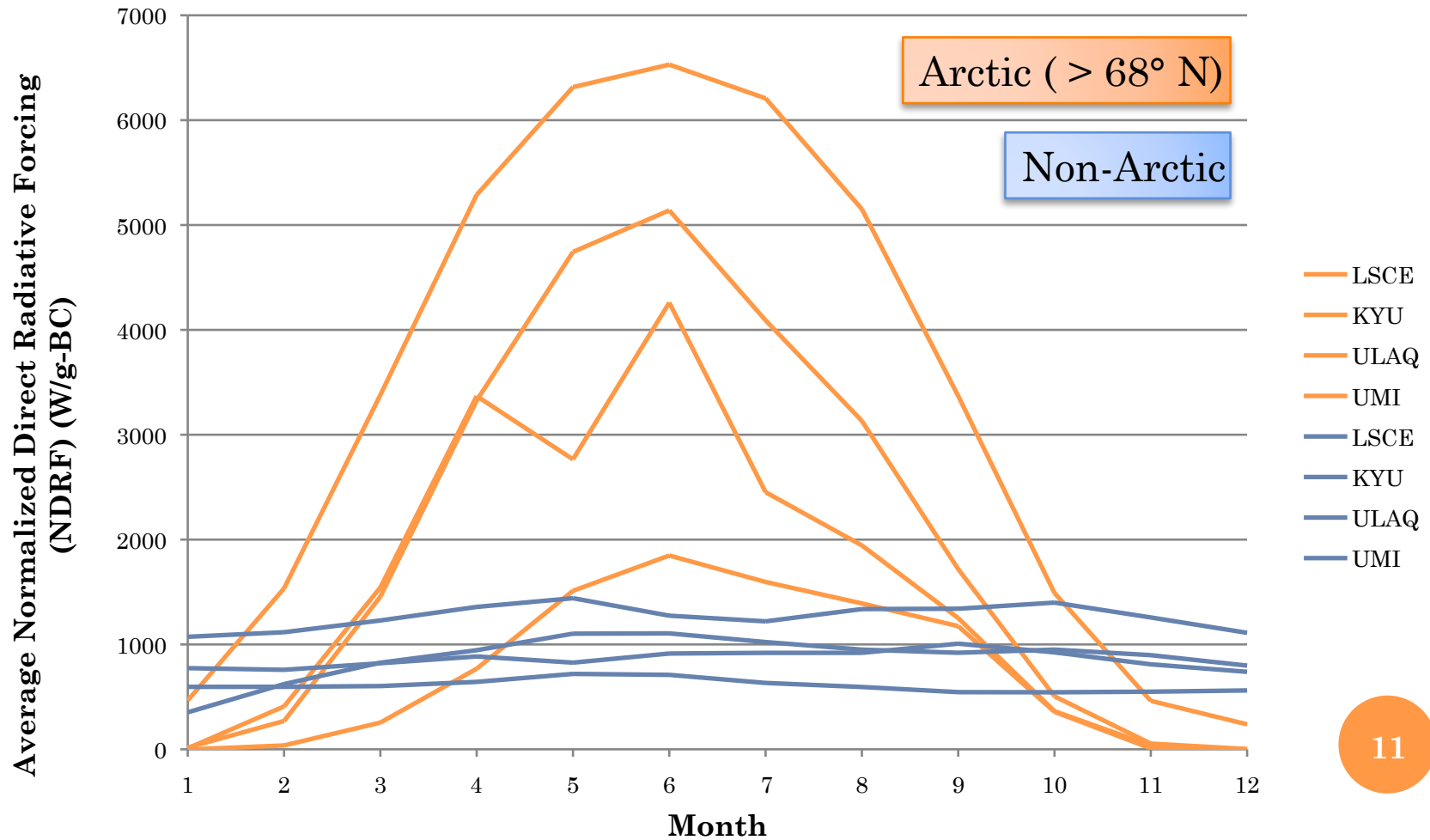
- One metric of interest in normalized direct radiative forcing (NDRF)

$$NDRF = \frac{\text{Column Forcing}}{\text{Column Burden}} = \frac{\frac{\text{Forcing}}{\text{Area}}}{\frac{\text{Mass}}{\text{Area}}} = \frac{\text{Forcing}}{\text{Mass}}$$

- Indication of overall effect a unit mass of black carbon has in varying regions
- Understanding this parameter -> understanding different regional responses to a unit mass of emissions

FOUR AEROSOL MODELS: APRIL NDRF

Monthly averaged NDRF for four AEROCOM models



WHAT ELSE?

- Just scratching the surface with regards to analysis
 - Regional transport
 - Example: Emission of a unit mass of BC in India -> where does it go?
 - Prescribe aerosol distribution vertically and horizontally
 - Given an individual model, what is the sensitivity of forcing values given varying concentration locations?
 - Above clouds?
 - Above snow and ice?

THANKS...

- Advisor, Dr. Tami Bond
- Fellow members of the Bond Research Group

Questions?