Assessment of black carbon emissions in the Arctic region from sources with various geography by backtrajectory modeling

U.S. Department of Energy Arctic Black Carbon Project

by

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Arctic Black Carbon Initiative: Copenhagen Summit, December 2009

• Arctic BC Initiative goals:

- 1) Fill information gaps
- 2) Identify implementation barriers and develop approaches to overcome them
- 3) Demonstrate and evaluate technological and non-technological mitigation options
- 4) Where possible, to lay the groundwork to quantify the climate and public health benefits of black carbon mitigation strategies

• Sources of Arctic BC

- 1) Typically, fossil fuel combustion sources above 40°N latitude
- 2) Russian sources may represent as much as half of all BC sources above 60°N
- **Basis for Research**: BC emissions in or near the Arctic have larger warming effect than other climate forcers
 - U.S. Environmental Protection Agency BC emissions from diesel & transportation
 - U.S. Department of Agriculture BC emissions from agriculture burning
 - U.S. Department of Energy Project: Focus on industrial and heat and power sources of BC

Funding for all three projects from the Department of State





The Atmospheric Research Component



Objectives of Potential Source Contribution Function (PSCF) Modeling

- To provide mitigation strategies by utilizing environmental observations
- To identify geographical location of sources of ABC emissions using reversed engineering approach
 - Based on environmental data (transport, physical and chemical characterization, etc.)
 - Reconstructing <u>source</u> distribution at multiple scales
- To resolve atmospheric transport pattern of ABC
 - Short- and long-term cycles (HF and LF components)
 - Effects connecting multiple time and space scales





Monitoring Stations for Back Trajectory Modeling



Environmental data observation sites

- Alert Station: Multiple PM species , aethalometer for BC, multiple years
- Tiksi Bay, relatively new at the time, uncharacterized local sources, no other species at time
- Barrow only PM, no BC



Pulsating Nature of Arctic Transport





The concentrations are very seasonally dependent due to changes in wind patterns and emissions



Potential Source Contribution Function (PSCF)

- A synthetic probability field describing the source strength of a geographical area (i.e., a grid cell)
- Combine pollutant chemistry data taken at ambient sites (receptors) with back trajectory data
 - First analyze receptor pollutant time series to determine source signal
 - Fuse "signals" with calculated back trajectory over the time domain
- A PSCF value > 0.6 indicates a likelihood of a grid cell being an emission source, < 0.2 indicates a low probability.







The autumn cluster

Trajectory Clusters



The winter cluster











Variation by season, and year observed



Alert Station maps, for 2000, 2001, and 2002





Geographical Locations of BC Emission Sources in Russia – at Alert Station, 2000-2006



PSCF Value







Comparing maps for BC and SO₄⁼





Location of Power Plants from CARMA







Summary

- Backward trajectory modeling has been used to identify Potential Source Contribution Functions (PSCF) for black carbon in the Russian Federation
 - Areas south of Moscow including Moscow consistently strong (higher population density)
 - Urals mountains (industry, oil/gas flaring, biomass burning in season)
 - Areas in Eastern Siberia (biomass burning, power plants)
- Geo-location results of sources consistent for both Canadian and Russian receptors, with growing number of sources over time

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Geolocating Russian sources for Arctic black carbon[☆] Meng-Dawn Cheng

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Extra slides





Tiksi Bay 2009-2012







Geographical Locations of BC Emission Sources in Russia – at Tiksi Bay 2009-2011







Tiksi Bay, 2009-2011 Composite









Variation by season, and year observed



Tiksi Bay Station maps, for 2009, 2010, and 2011



