Additional constraints on black carbon aerosol distribution from MOPITT CO observations

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in collaboration with NCAR/IMAGe/DAReS
• demonstrate added capability of ensemble-based chemical DA
• explore synergies between chemical species in providing additional constraints
Data assimilation solves for $p( x | Y )$, e.g. $p( \text{CO} | \text{MOPITT CO})$, $p( \text{Black Carbon} | \text{MOPITT CO} )$

$\Delta BC_x = \frac{\sigma(BC_x, CO_y)}{\sigma(CO_y)} \Delta CO_y$

$\Delta BC_x = \beta \Delta CO_y$

adapted from Jeffrey Anderson
observed sensitivities (ΔBC/ΔCO)

Empirical correlations between black carbon aerosol and carbon monoxide in the lower and middle troposphere

Temporal variations of elemental carbon in Tokyo

INDOEX 1999
~12-27 mg/g

TexAQS 2006
~5.8

Tokyo 2004
~5.8

Mexico ~1.1

Germany ~2.2

Analysis of black carbon and carbon monoxide observed over the Indian Ocean: Implications for emissions and photochemistry

Diagnosing black carbon trends in large urban areas using carbon monoxide measurements
GCTM (CAM-Chem)

Community Atmosphere Model (CAM3.4) with simplified CO chemistry and bulk aerosol model scheme with fixed oxidants (FV 1.9°x2.5°x26L)

- ensembles of CO and Aerosol emissions (based on MOZART/CAM-Chem emission)
- ensembles injection heights (based on AEROCOM suggestions Dentener, et al. 2006)
- ensembles of CAM initial conditions (based on previous CAM climatological runs)

EnKF Package (DART) see http://www.image.ucar.edu/DARes for details

Data Assimilation Research Testbed (DART-J) with adaptive inflation and localization (using 40-member ensemble)

- state variables include temperature (T), horizontal winds (U,V), specific humidity (Q), cloud ice (CLDICE), cloud water (CLDLIQ), CO, Black Carbon (BC1, BC2), Organic Carbon (OC1, OC2), Sulfates (SO2, SO4), Dust (4 size bins), Sea-Salt (4 size bins), and DMS
### DART/CAM-Chem Experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Assimilation</th>
<th>Impact to BC</th>
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</thead>
<tbody>
<tr>
<td>Control</td>
<td>NCEP Bufr, MOPITT CO (700 hPa)</td>
<td>None</td>
</tr>
<tr>
<td>Constrained</td>
<td>NCEP Bufr, MOPITT CO (700 hPa)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

#### Radiosonde U Wind

![Radiosonde U Wind Map](image1)

04/28/06

#### MOPITT CO (700 hPa)

![MOPITT CO Map](image2)

04/28/06
modeled sensitivities (ΔBC/ΔCO)

Mean Sensitivities (April 16- May 15, 2006)
verification with INTEX-B SP2 data (over land)

Median Black Carbon Concentrations during INTEX-B Field Campaign
SP2 BC Obs from R. Subramanian (G. Kok / D. Baumgardner PIs)

flight tracks
Median Black Carbon Concentrations during INTEX-B Field Campaign

SP2 BC Obs from R. Subramanian (G. Kok / D. Baumgardner PIs)

Verification with INTEX-B SP2 data (over ocean)

Flight tracks
implications to CAM-Chem BC representation

Mean Difference (Constrained – Control) for April 16 to May 15, 2006 period

![Map of global distribution showing implications to CAM-Chem BC representation. The maps at 600 hPa and 990 hPa show the mean difference in ng m⁻³ across the globe.]
implications with new observing systems

figures from C. Clerbaux