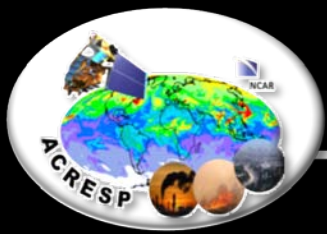


# Additional constraints on black carbon aerosol distribution from MOPITT CO observations

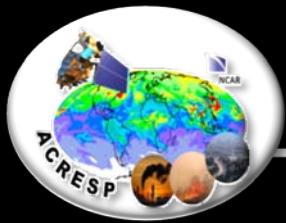
**Ave Arellano**

Atmospheric Chemistry Division  
National Center for Atmospheric Research

*in collaboration with NCAR/IMAGE/DAReS*

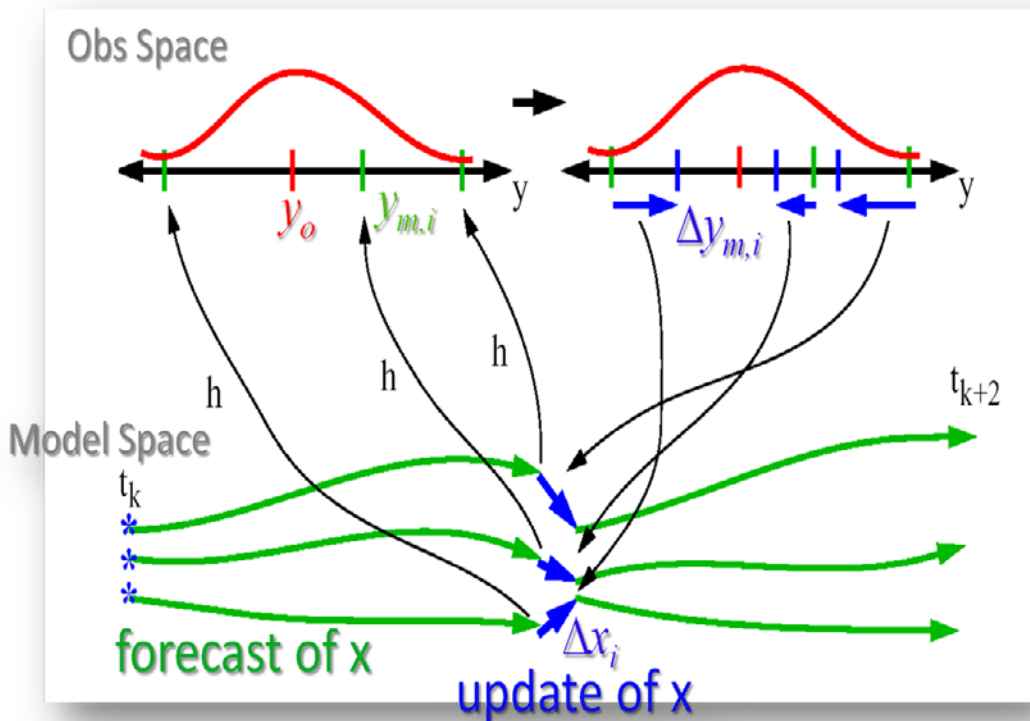


- demonstrate added capability of ensemble-based chemical DA
- explore synergies between chemical species in providing additional constraints



# motivation

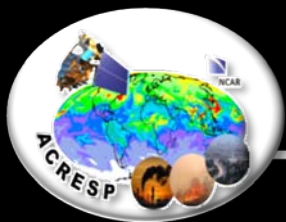
Data assimilation solves for  $p(\mathbf{x} | \mathbf{Y})$ ,  
 e.g.  $p(\text{CO} | \text{MOPITT CO})$ ,  $p(\text{Black Carbon} | \text{MOPITT CO})$



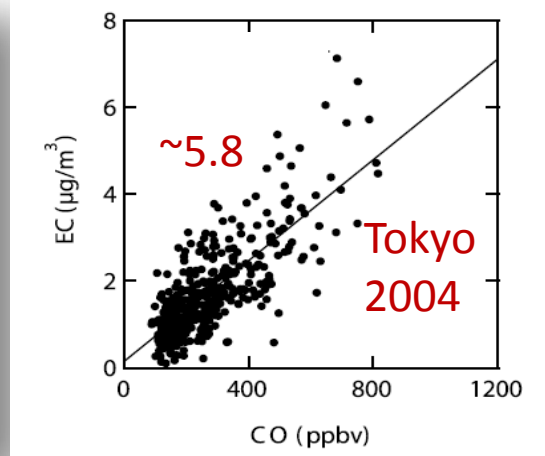
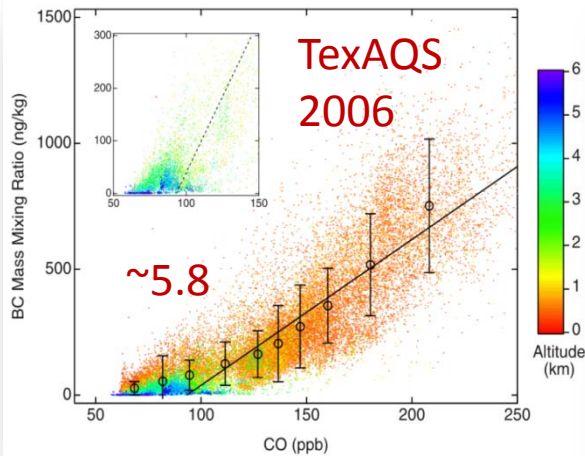
$$\Delta BC_x = \frac{\sigma(BC_x, CO_y)}{\sigma(CO_y)} \Delta CO_y$$

$$\Delta BC_x = \beta \Delta CO_y$$

adapted from Jeffrey Anderson



# observed sensitivities ( $\Delta BC/\Delta CO$ )



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

J. R. Spackman,<sup>1,2</sup> J. P. Schwarz,<sup>1,2</sup> R. S. Gao,<sup>1</sup> L. A. Watts,<sup>1,2</sup> D. S. Thomson,<sup>1,2,3</sup>  
D. W. Fahey,<sup>1,2</sup> J. S. Holloway,<sup>1,2</sup> J. A. de Gouw,<sup>1,2</sup> M. Trainer,<sup>1</sup> and T. B. Ryerson<sup>1</sup>

## Temporal variations of elemental carbon in Tokyo

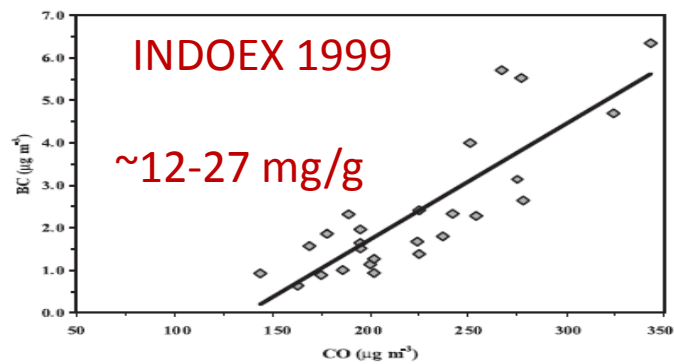
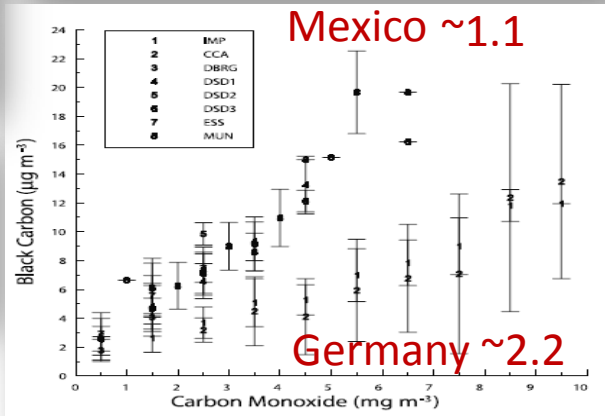
Y. Kondo,<sup>1</sup> Y. Komazaki,<sup>1</sup> Y. Miyazaki,<sup>1</sup> N. Moteki,<sup>1</sup> N. Takegawa,<sup>1</sup> D. Kodama,<sup>1</sup>  
S. Deguchi,<sup>1</sup> M. Nogami,<sup>1</sup> M. Fukuda,<sup>1</sup> T. Miyakawa,<sup>1</sup> Y. Morino,<sup>1</sup> M. Koike,<sup>2</sup>  
H. Sakurai,<sup>3</sup> and K. Ehara<sup>3</sup>

## Diagnosing black carbon trends in large urban areas using carbon monoxide measurements

Darrel Baumgardner, G. Raga, O. Peralta, I. Rosas, and T. Castro  
Centro de Ciencias de la Atmósfera, Universidad Nacional Autónoma de México, Mexico City, Mexico

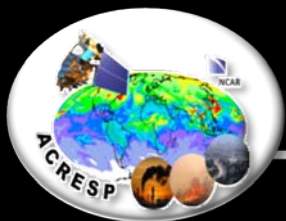
T. Kuhlbusch and A. John  
FB 9/AMT, University of Duisburg, Duisburg, Germany

A. Petzold  
Deutsches Zentrum für Luft und Raumfahrt, Oberpfaffenhofen, Germany



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

R. R. Dickerson,<sup>1,2</sup> M. O. Andreae,<sup>3</sup> T. Campos,<sup>4</sup> O. L. Mayol-Bracero,<sup>3</sup> C. Neusuess,<sup>5</sup>  
and D. G. Streets<sup>6</sup>



## GCTM (CAM-Chem)

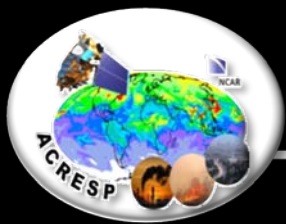
Community Atmosphere Model (CAM3.4) with simplified CO chemistry and bulk aerosol model scheme with fixed oxidants (FV 1.9°x2.5°x26L)

- 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)

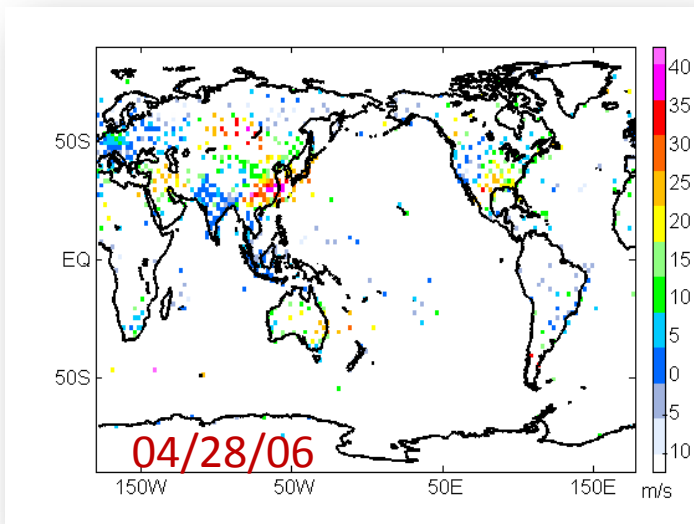
→ state variables include temperature (T), horizontal winds (U,V), specific humidity (Q), cloud ice (CLDICE), cloud water (CLDLIQ), CO, Black Carbon (BC1, BC2), Organic Carbon (OC1, OC2), Sulfates (SO<sub>2</sub>, SO<sub>4</sub>), Dust (4 size bins), Sea-Salt (4 size bins), and DMS



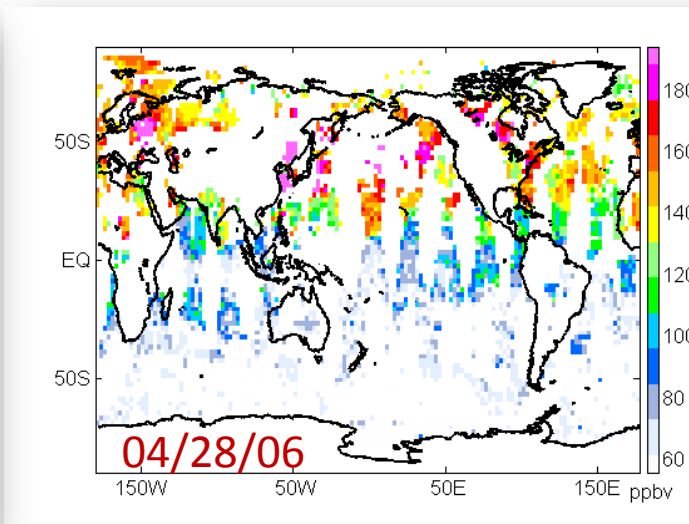
# DART/CAM-Chem Experiments

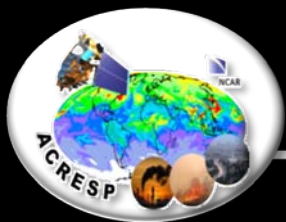
Experiment	Assimilation	Impact to BC
Control	NCEP Bufr, MOPITT CO (700 hPa)	None
Constrained	NCEP Bufr, MOPITT CO (700 hPa)	Yes

Radiosonde U Wind



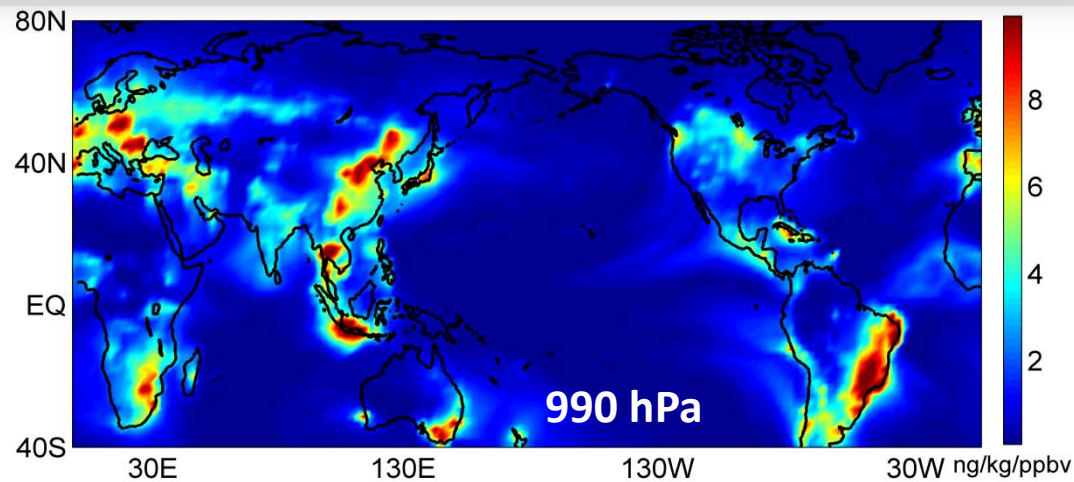
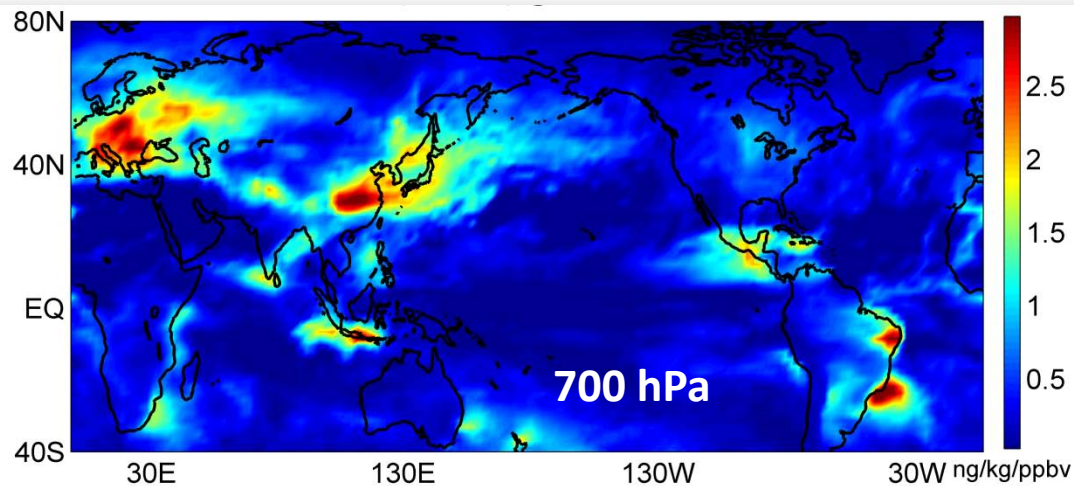
MOPITT CO (700 hPa)



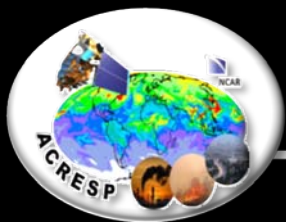


# modeled sensitivities ( $\Delta BC/\Delta CO$ )

## Mean Sensitivities (April 16- May 15, 2006)



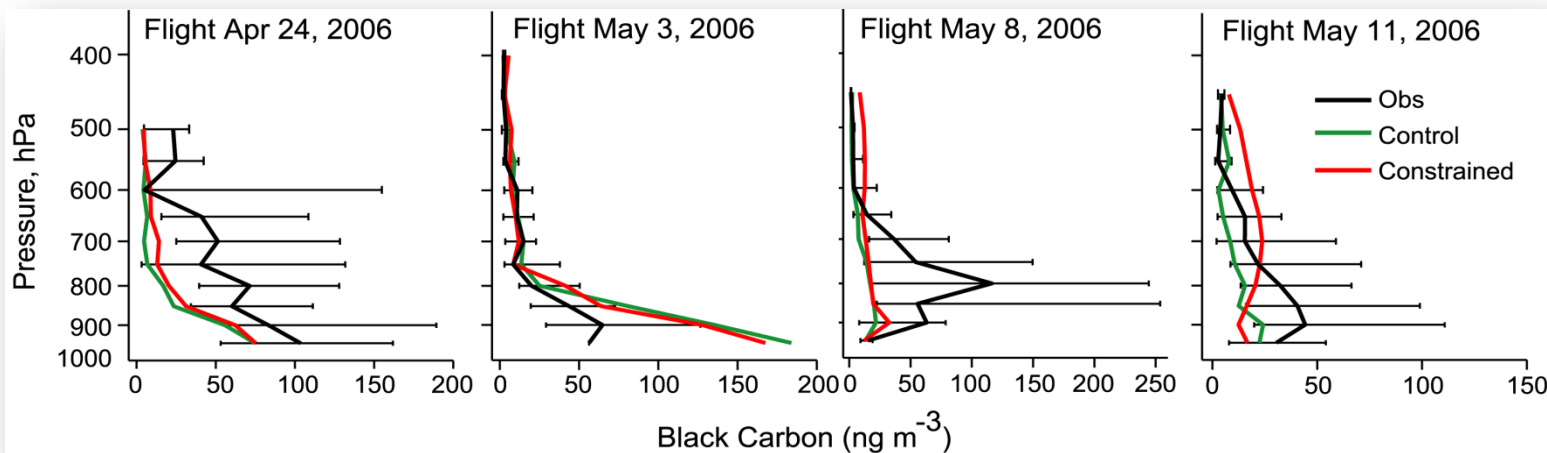




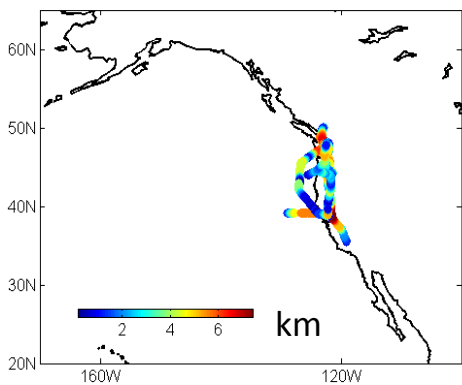
# verification with INTEX-B SP2 data (over land)

## Median Black Carbon Concentrations during INTEX-B Field Campaign

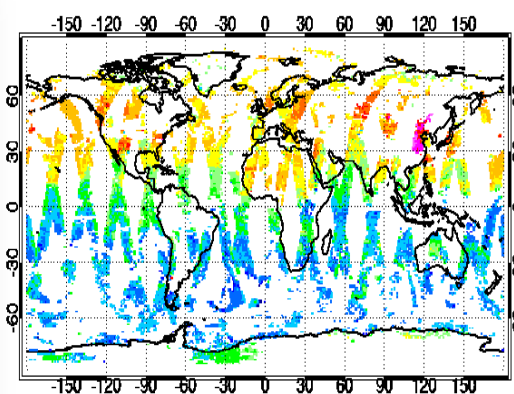
SP2 BC Obs from R. Subramanian (G. Kok /D. Baumgardner PIs)



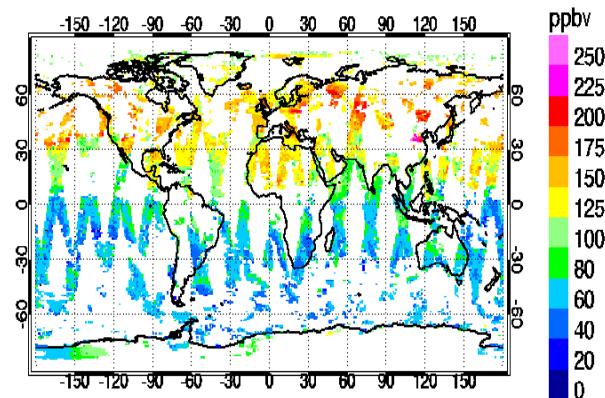
flight tracks



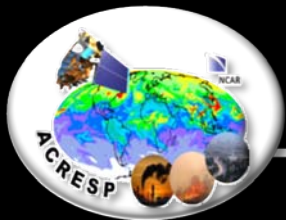
MOPITT CO (v3) 700hPa 2006-04-24



MOPITT CO (v3) 700hPa 2006-05-08



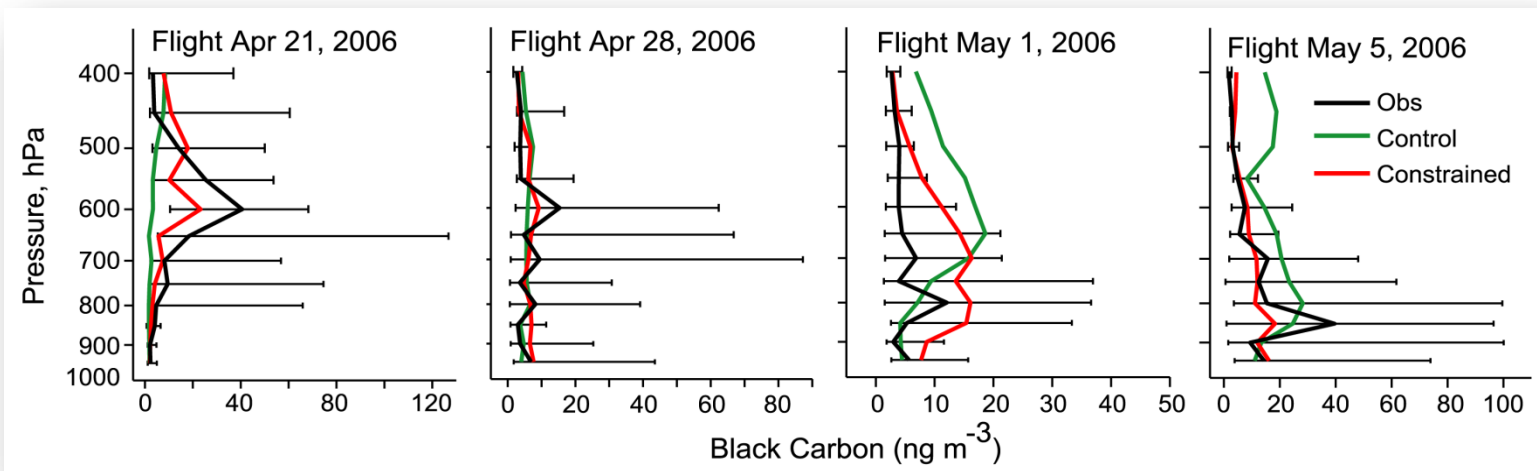




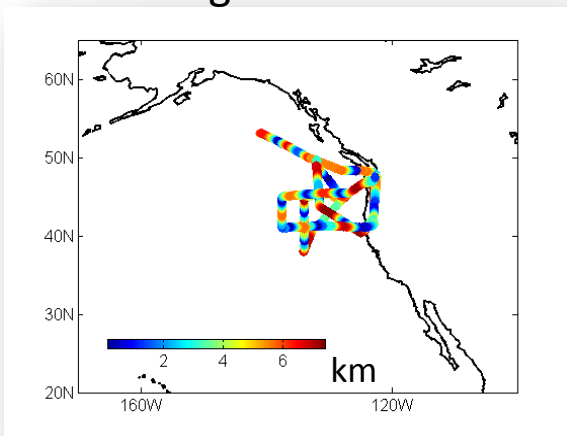
# verification with INTEX-B SP2 data (over ocean)

## Median Black Carbon Concentrations during INTEX-B Field Campaign

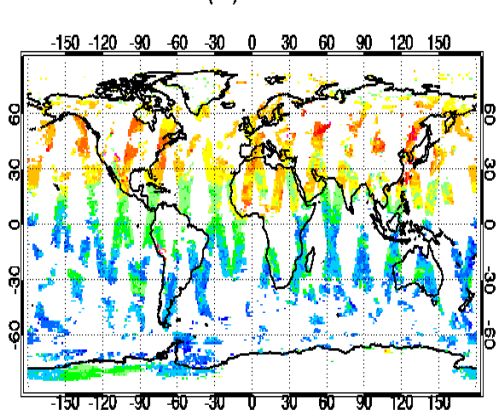
SP2 BC Obs from R. Subramanian (G. Kok /D. Baumgardner PIs)



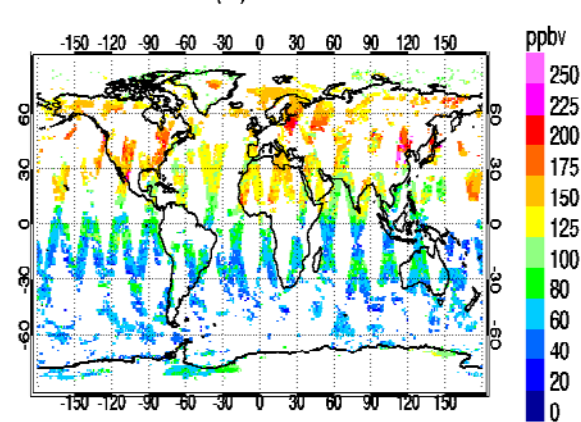
flight tracks

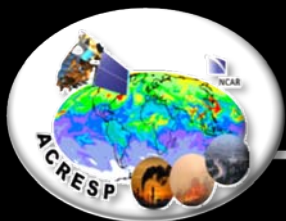


MOPITT CO (v3) 700hPa 2006-04-21



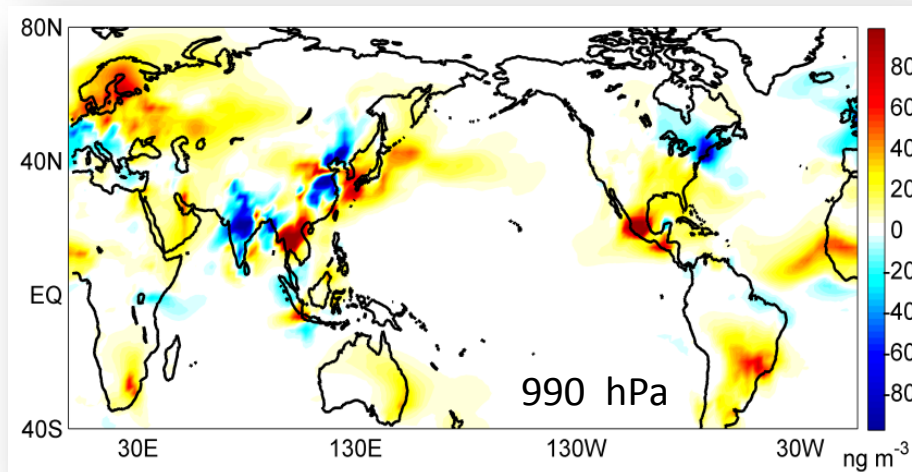
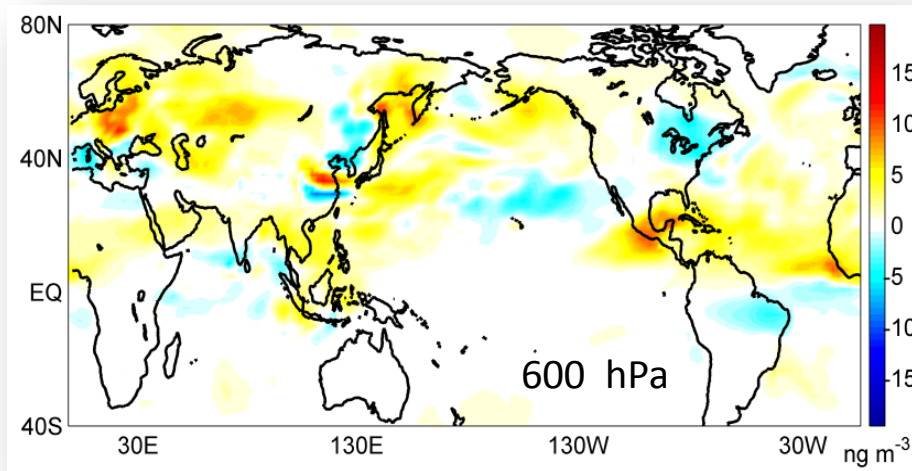
MOPITT CO (v3) 700hPa 2006-05-01

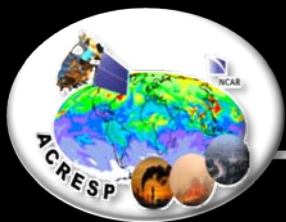




# implications to CAM-Chem BC representation

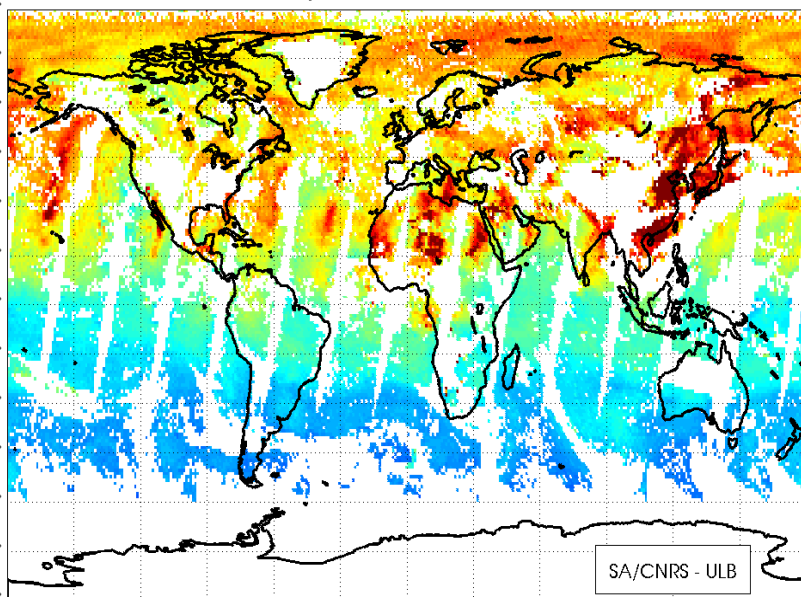
Mean Difference (Constrained – Control) for April 16 to May 15, 2006 period



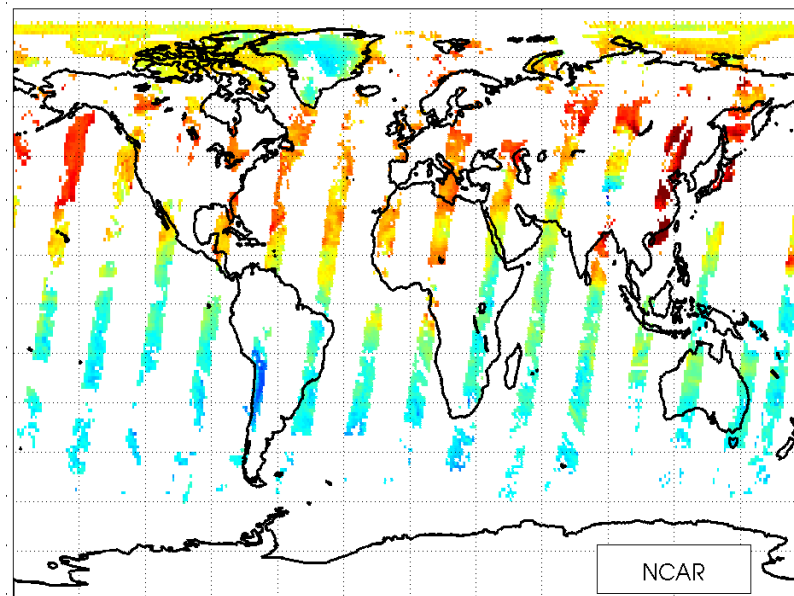


# implications with new observing systems

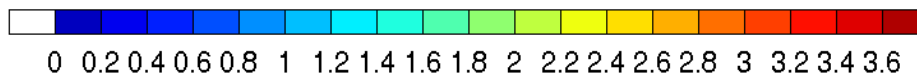
IASI May 15, 2008



MOPITT May 15, 2008



CO total (1.e18 molecules/cm<sup>2</sup>)



figures from C. Clerbaux

