Constraints on the sources of Arctic CO from AIRS, ARCTAS, and the GEOS-Chem model

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NASA Sounding Science Team Meeting

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GOAL: Assess pollution transport to the Arctic using AIRS combined with ARCTAS aircraft data and GEOS-Chem model

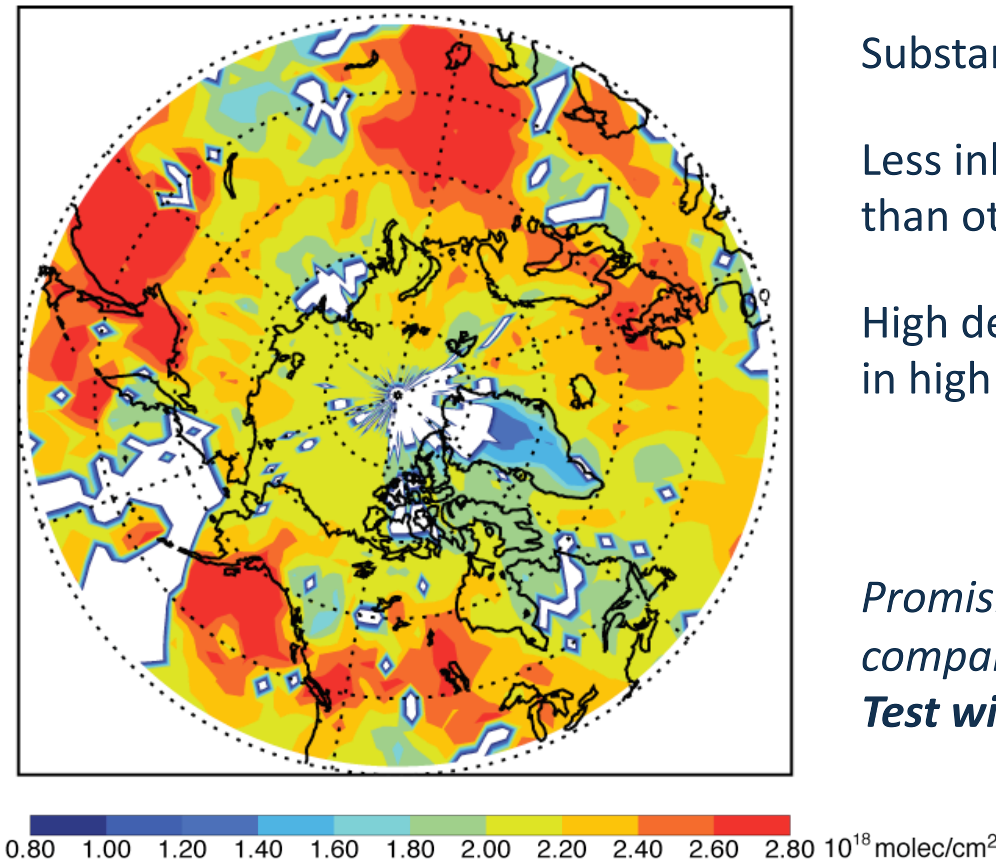
Motivation: Arctic is a known receptor of midlatitudes pollution, but sources and transport pathways are uncertain

Approach: Integrated analysis of carbon monoxide (CO) from:

1. **AIRS** – Version 5 Level 2 CO columns, daytime observations only, gridded to 2°x2.5° model resolution
2. **GEOS-Chem** – Chemical transport model (CTM), simulated CO is convolved with AIRS averaging kernels
3. **ARCTAS** – NASA aircraft campaign during April 2008, based in Fairbanks, AK

AIRS is a promising dataset for high-latitude analysis

Gridded AIRS CO column on 4/17/08



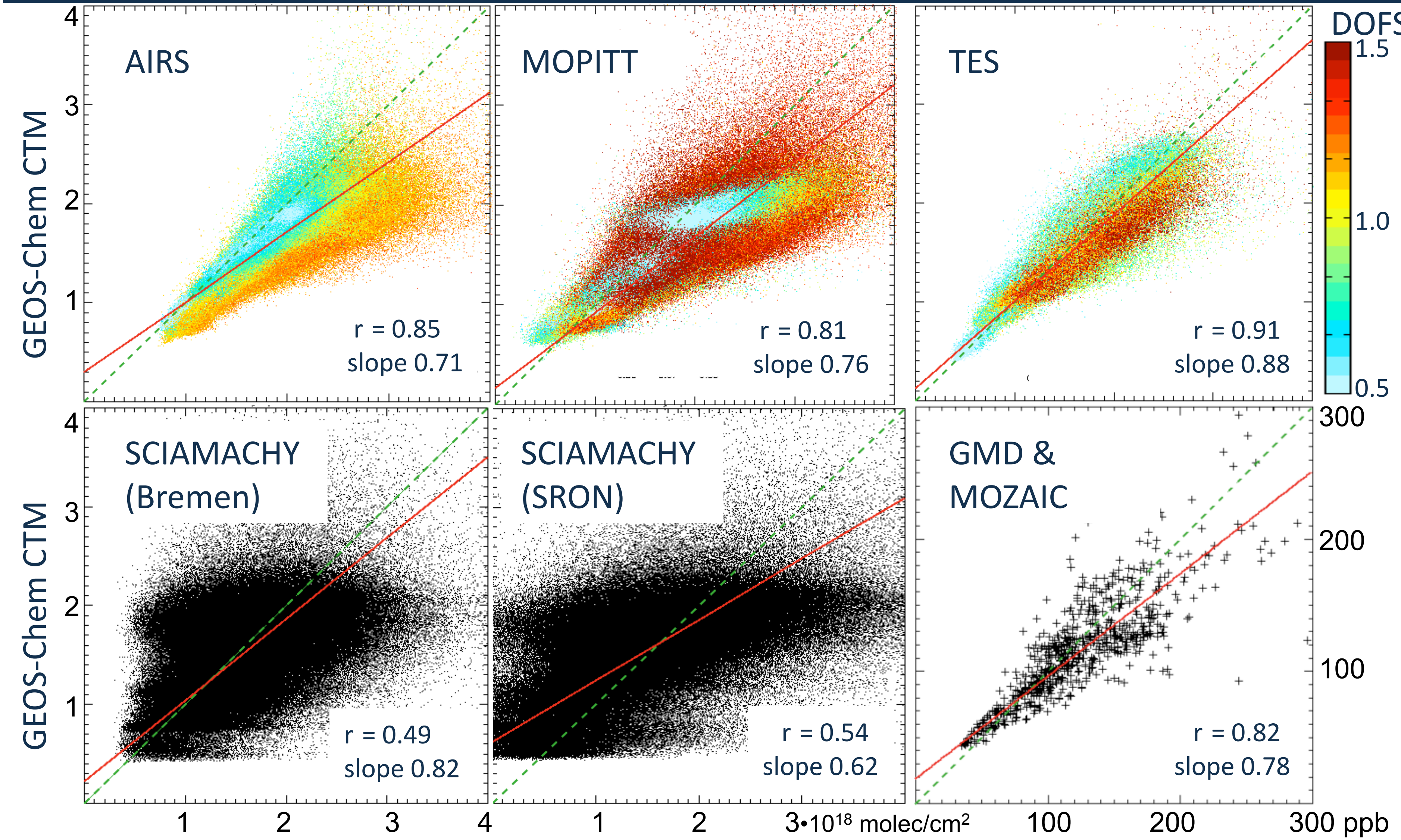
Substantial polar coverage on a daily basis

Less inhibited by pervasive Arctic cloudiness than other satellite instruments

High degrees of freedom for signal (DOFS), even in high latitudes (DOFS > 0.5 shown here)

Promising for the Arctic, but how does AIRS CO compare to other satellite observations?
Test with comparison via GEOS-Chem CTM

AIRS CO column is generally consistent globally with other satellite data sets



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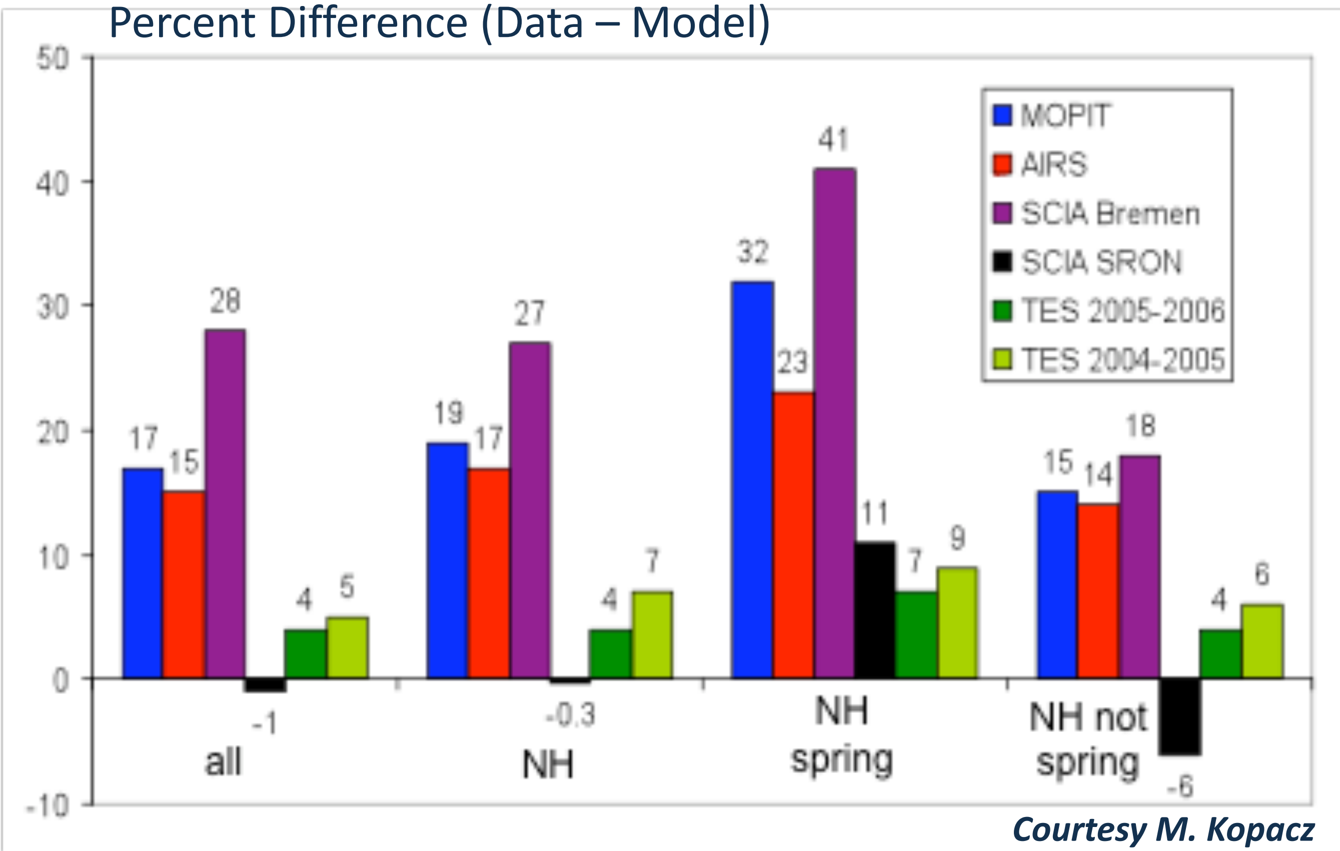
The datasets are less consistent and show higher biases in Northern Hemisphere spring



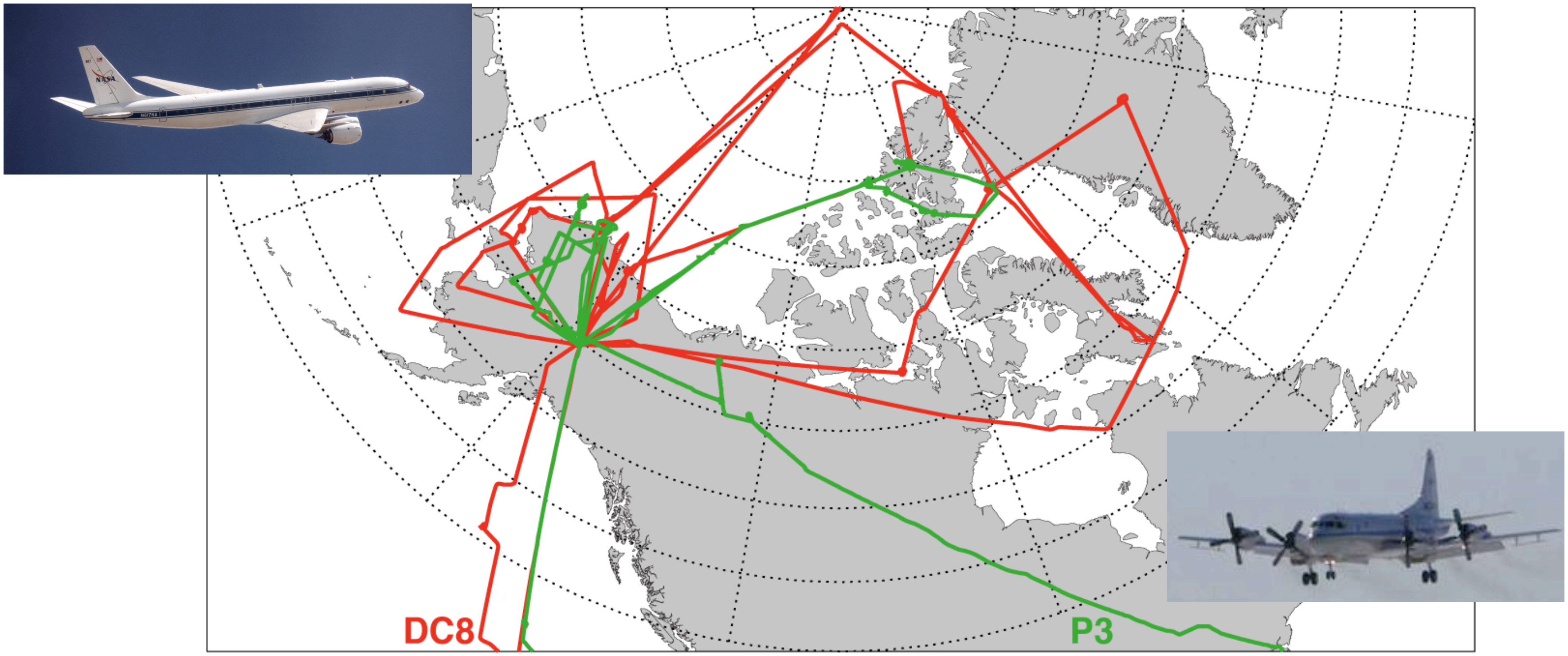
Highest AIRS vs. model difference in NH spring

Higher AIRS vs. MOPITT discrepancy in NH Spring

Most consistency of all instruments without spring data

In general, the different instruments (especially AIRS & MOPITT) are consistent and all show a low bias in GEOS-Chem, especially in spring.

ARCTAS (2008) provided a unique dataset for polar analysis



Arctic Research of the Composition of the Troposphere from Aircraft and Satellites

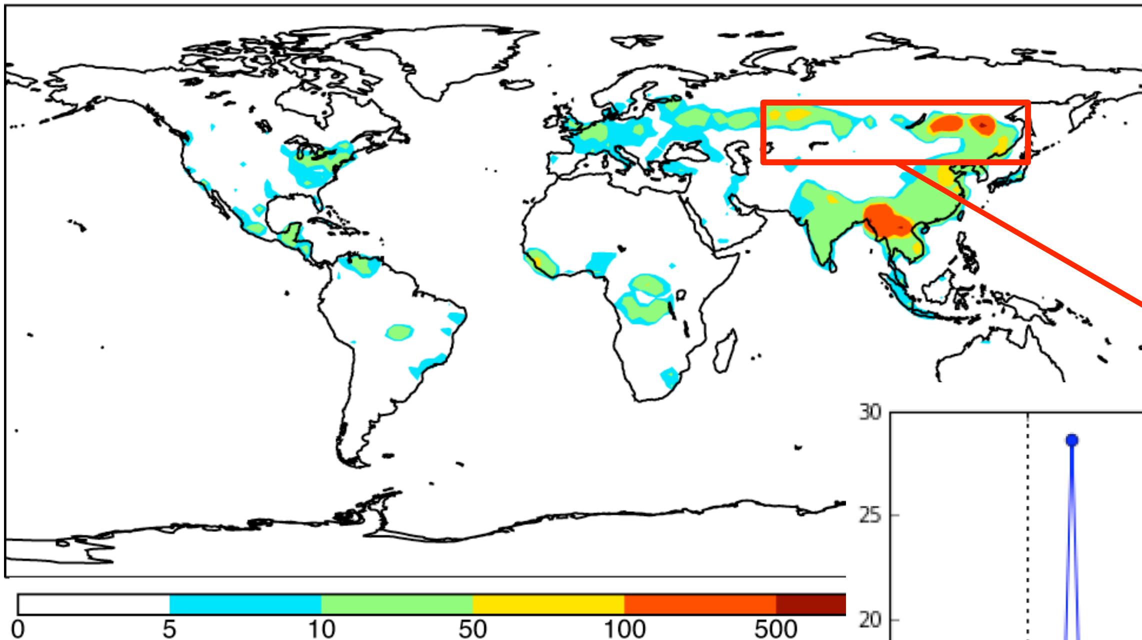
Coordinated aircraft campaign (NASA + NOAA + DOE + Europeans + …)

Simultaneous intensive surface sampling

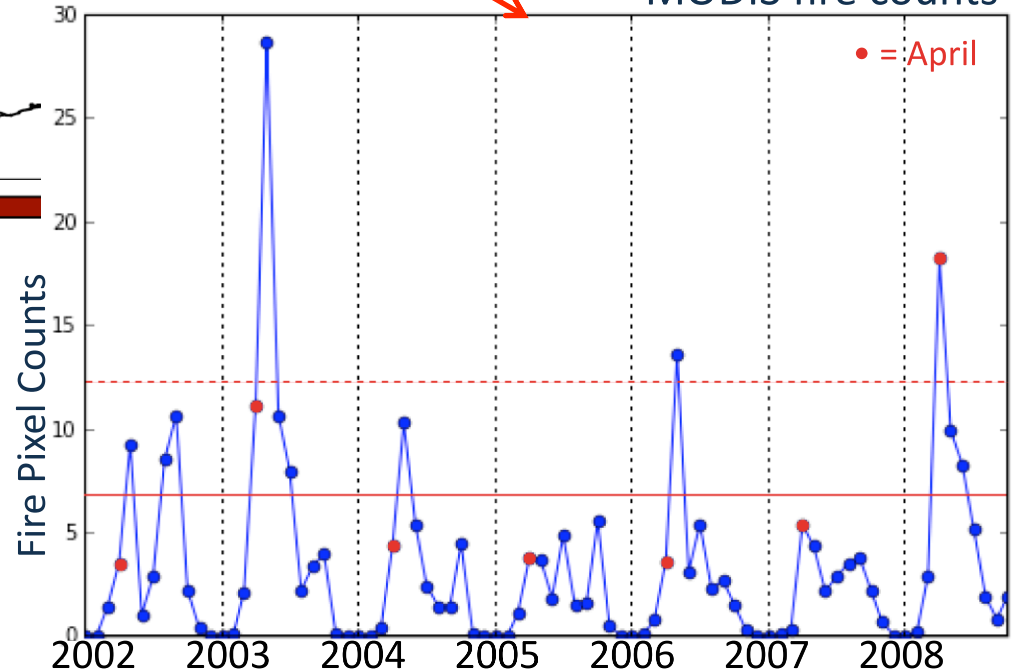
Focus on validation of polar-orbiting satellites, including AIRS

Intense, early fires in Russia led to high CO in April 2008

GEOS-Chem CO emissions



MODIS fire counts



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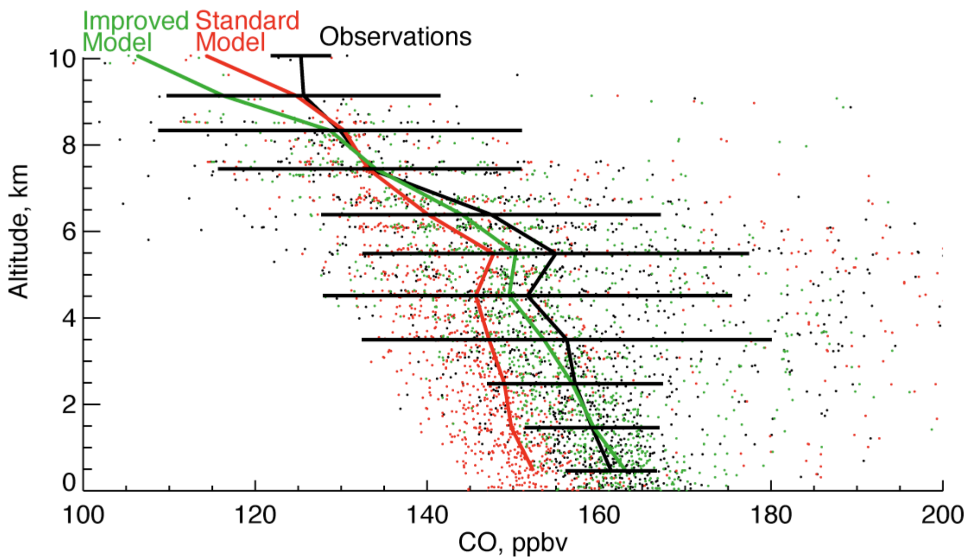
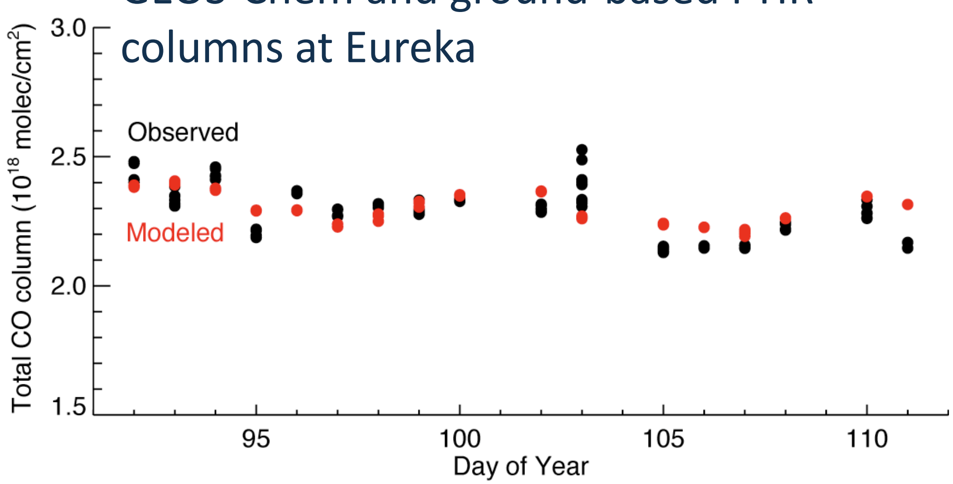
GEOS-Chem showed low bias relative to in-situ observations

GEOS-Chem and aircraft profiles



GEOS-Chem and ground-based FTIR columns at Eureka



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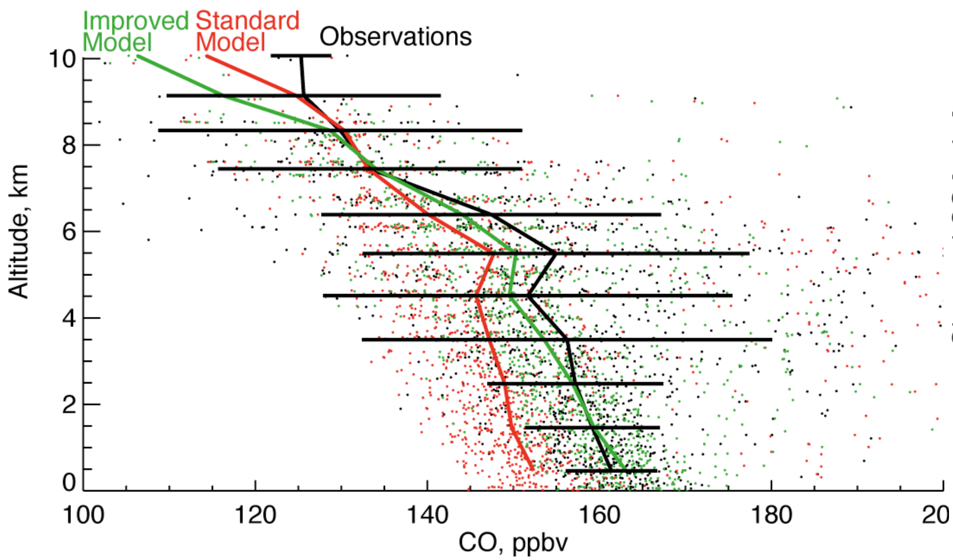

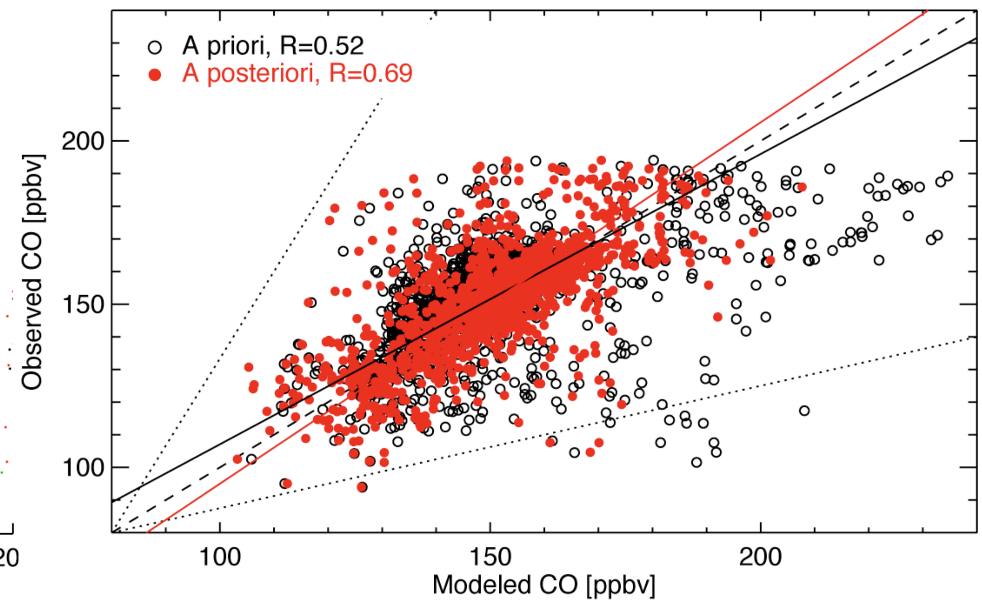

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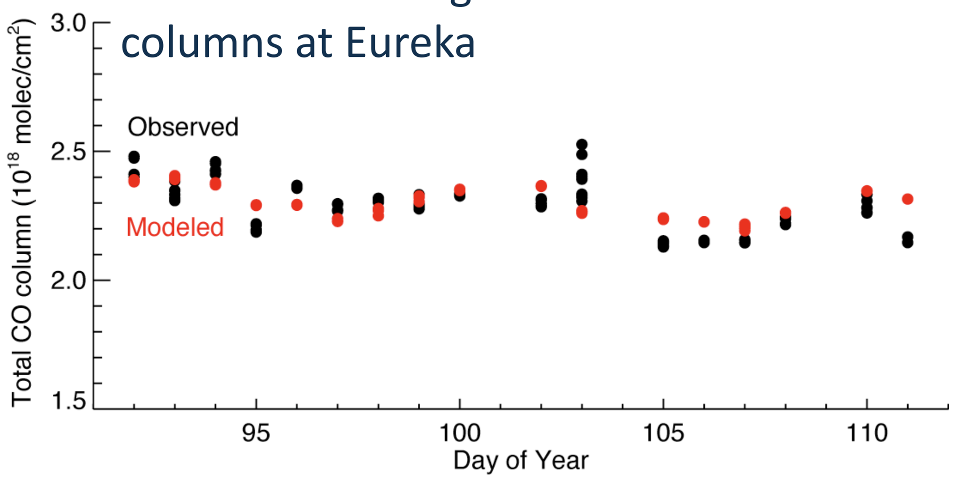
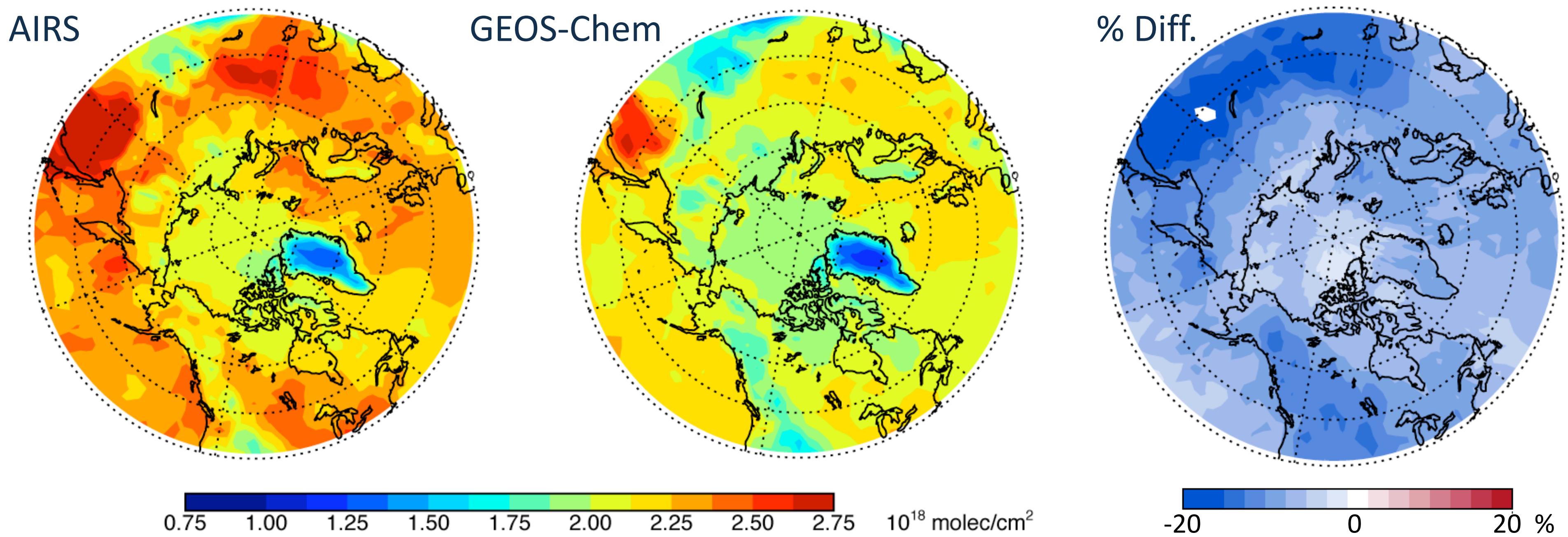


GEOS-Chem Source adjustments:

North American pollution	1.04
European pollution	1.39
Asian pollution	1.23
Russian biomass burning	0.21
Asian biomass burning	0.32

Even with source adjustment, GEOS-Chem is lower than AIRS throughout Arctic and midlatitudes

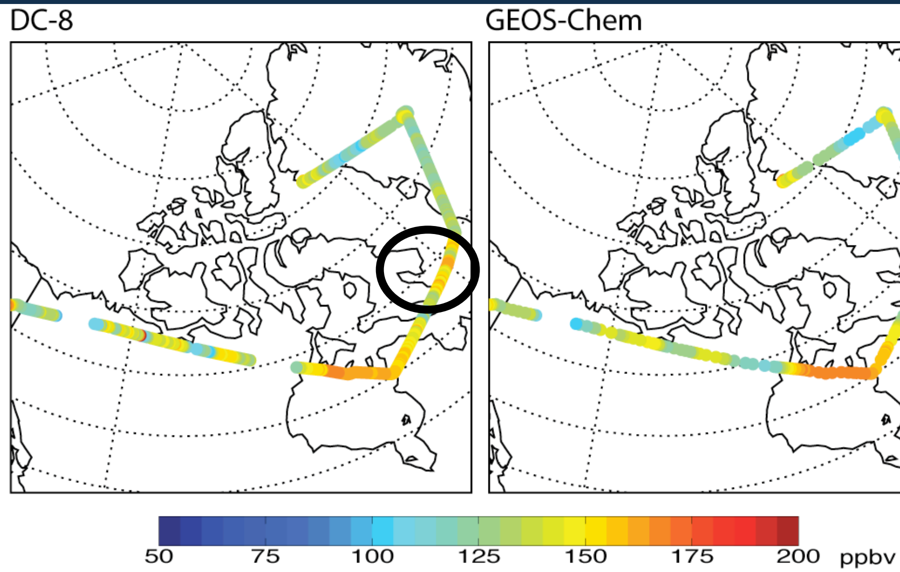


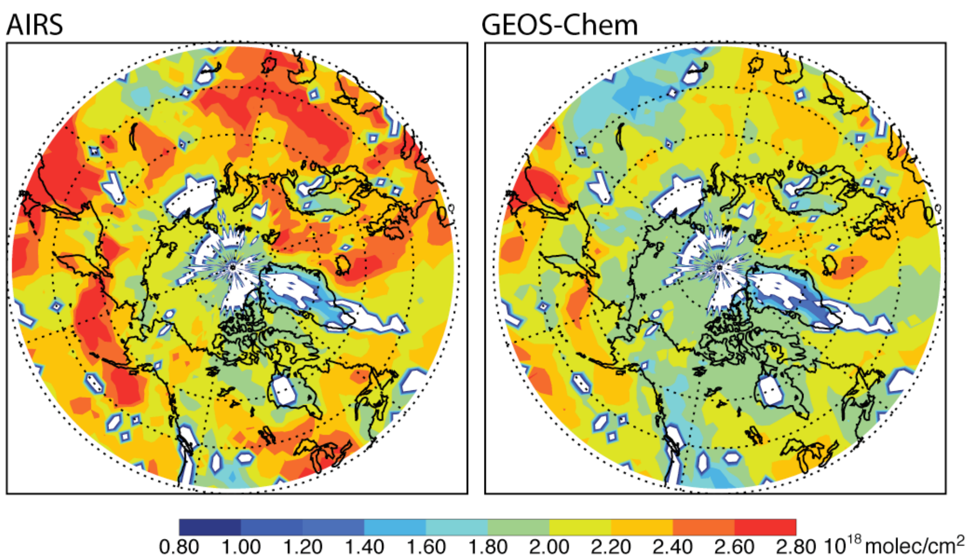
Difference likely reflects known high bias in AIRS CO

Largest bias over Russian fire region → source adjustment too severe?

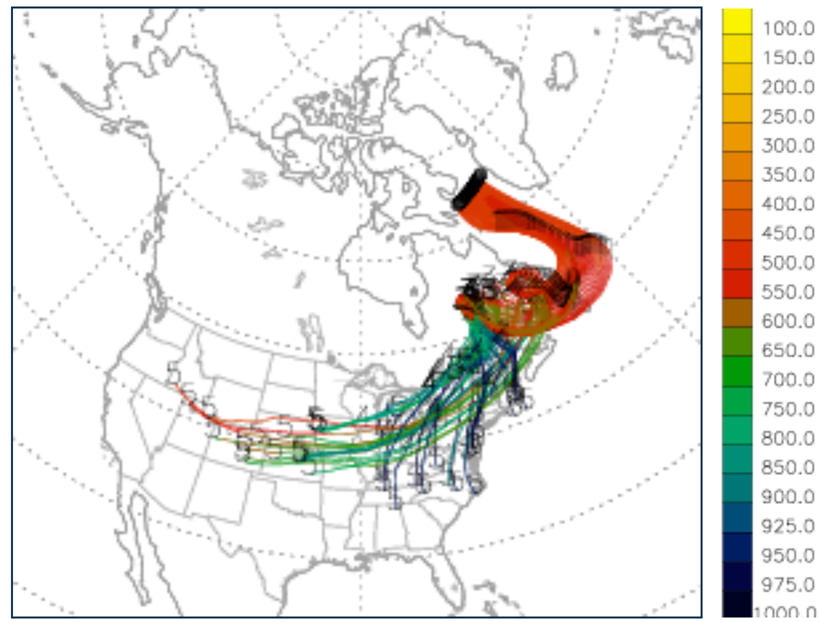
Lowest bias over North American Arctic (i.e. ARCTAS region)

Observed pollution from **North America** (April 5, 2008)





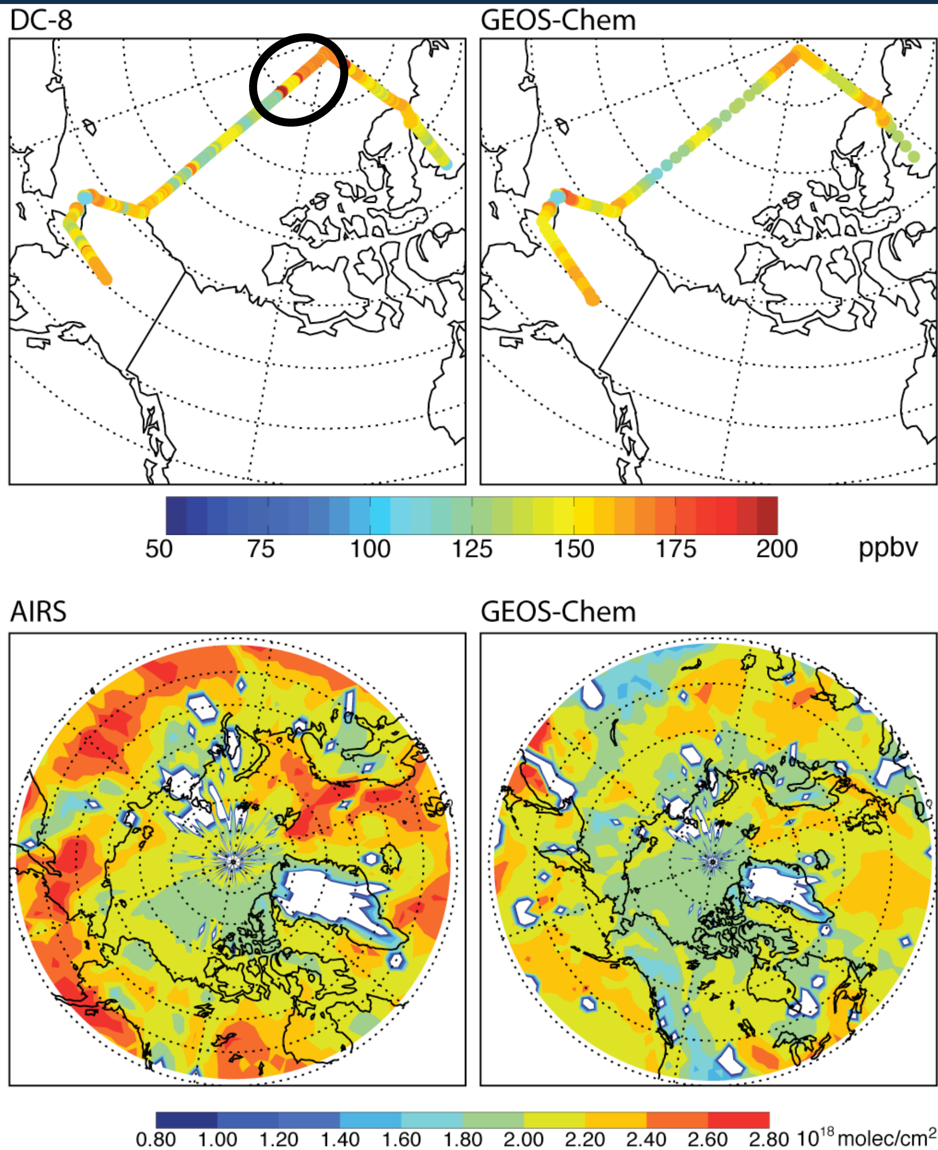
Back trajectories from FSU WRF/FLEXPART



Davis Strait enhancement seen in AIRS, aircraft, and GEOS-Chem

Good spatial agreement between AIRS and model throughout Arctic

Observed pollution from **Europe & Asia** (April 9, 2008)



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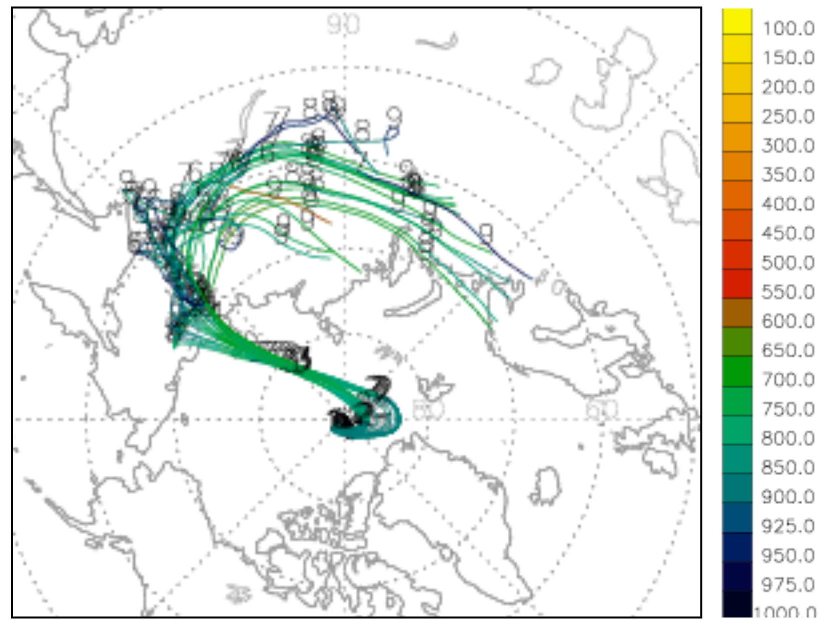
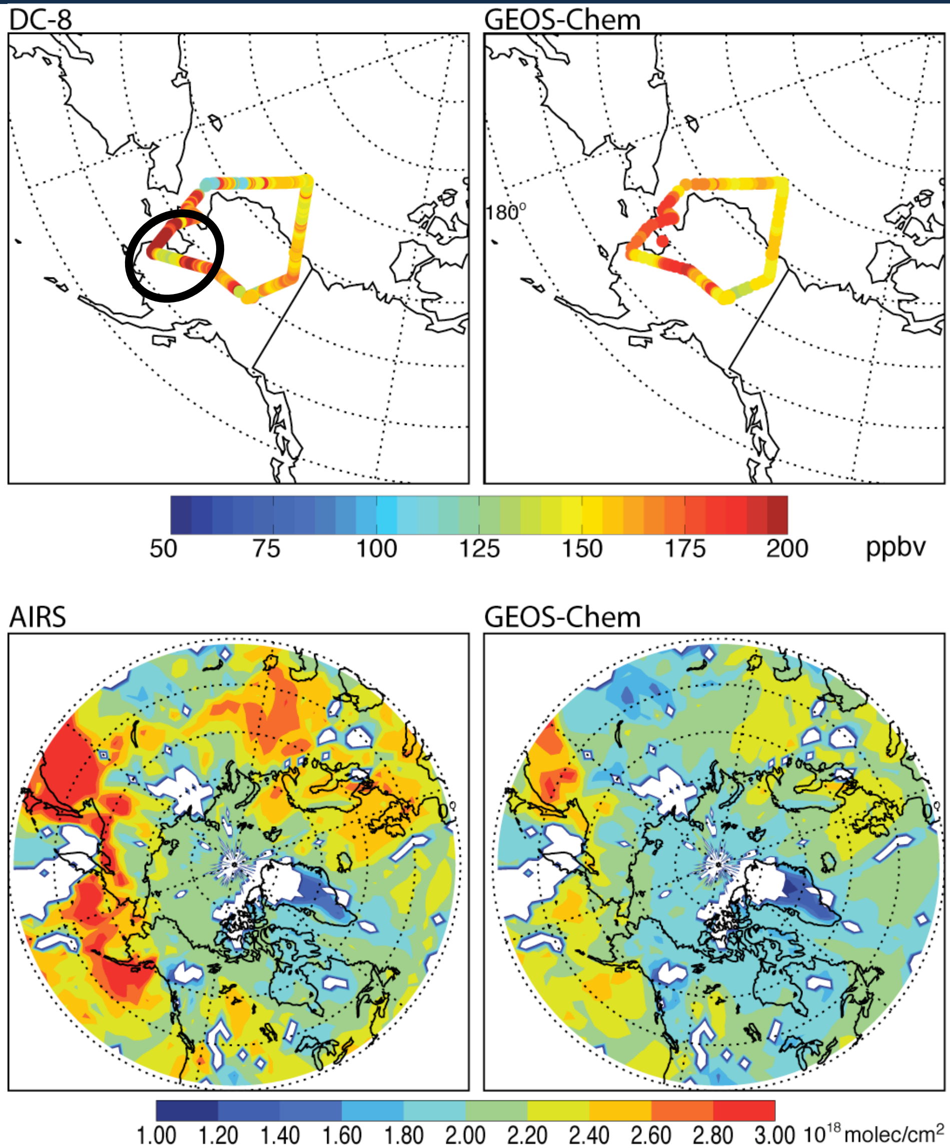


GEOS-Chem shows roughly equal contributions from Europe and Asia

No enhancement in AIRS, likely due to low altitude (>1000 hPa) of observation

Observed pollution from **Russian fires** (April 16, 2008)



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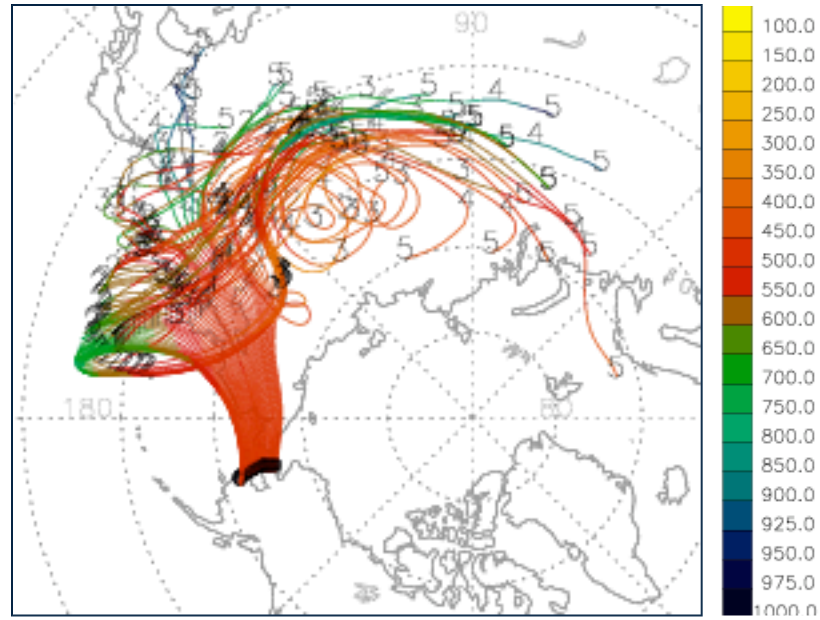
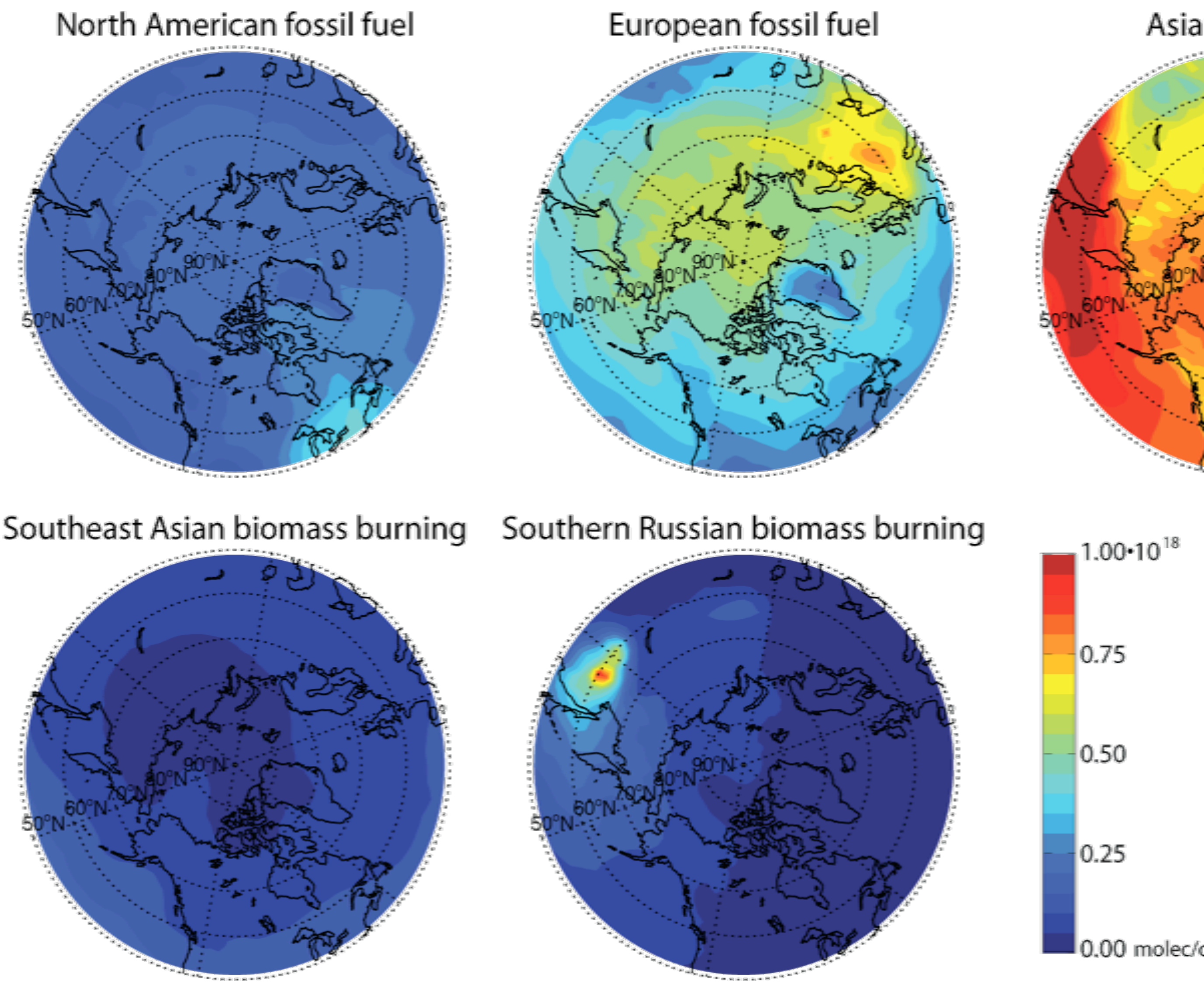


High consistency between AIRS, aircraft, and GEOS-Chem over Norton Sound and throughout Arctic

Observed enhancement was offshoot of main plume

GEOS-Chem shows the influence of different source regions on Arctic CO concentrations



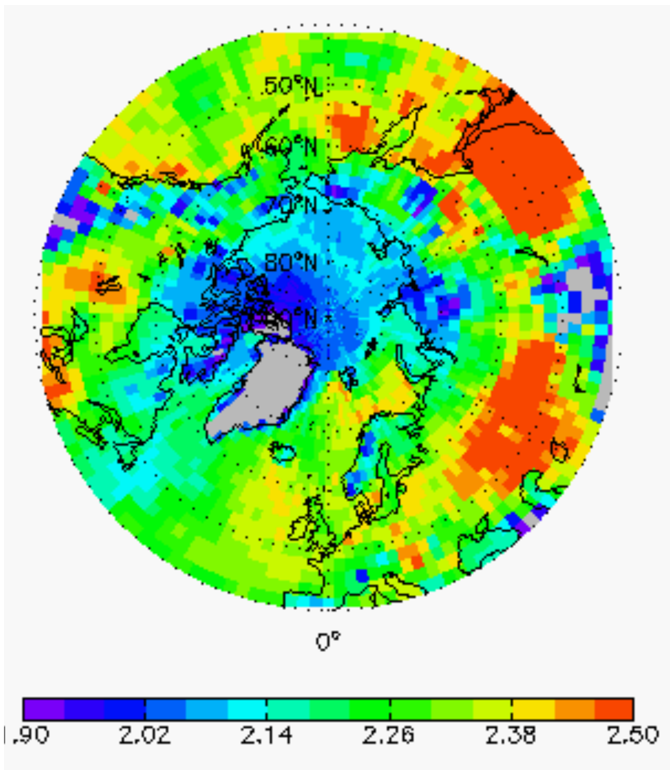
Asian FF important at all altitudes

European FF important near surface

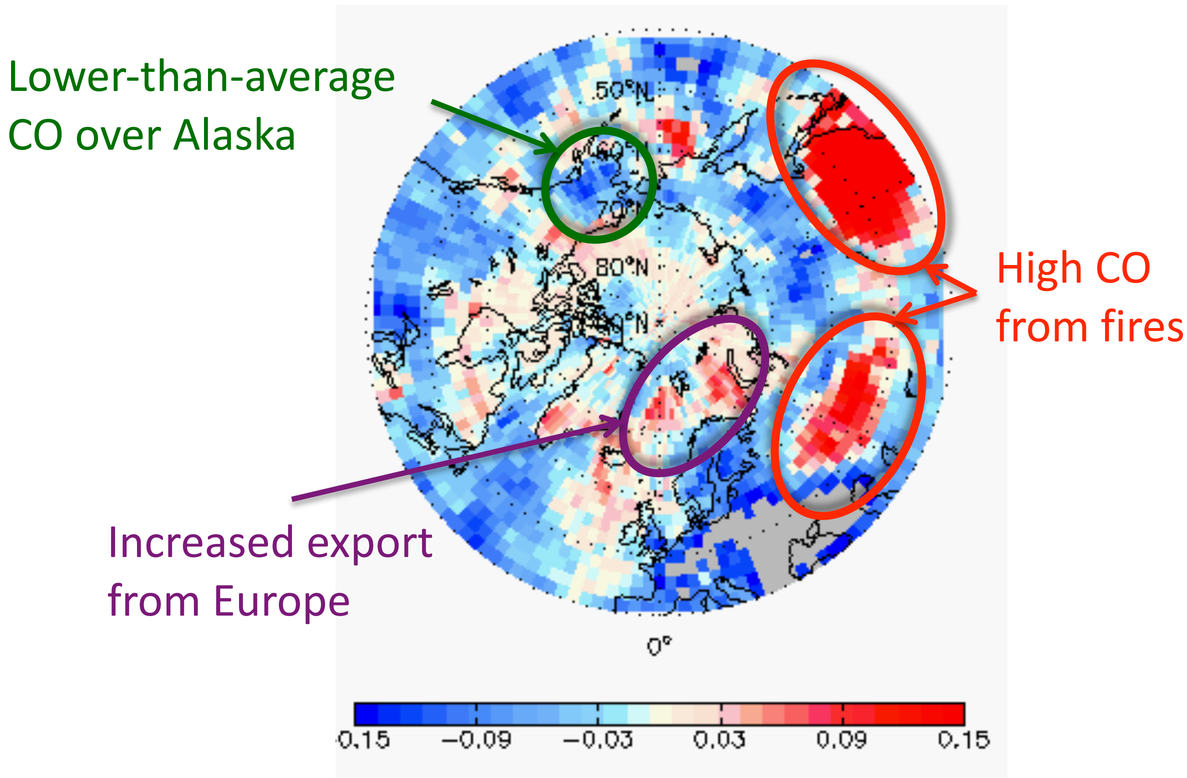
No major impact from North American FF or Russian/Asian BB

AIRS 6-year record provides context for 2008 results

Mean AIRS CO, April 2008



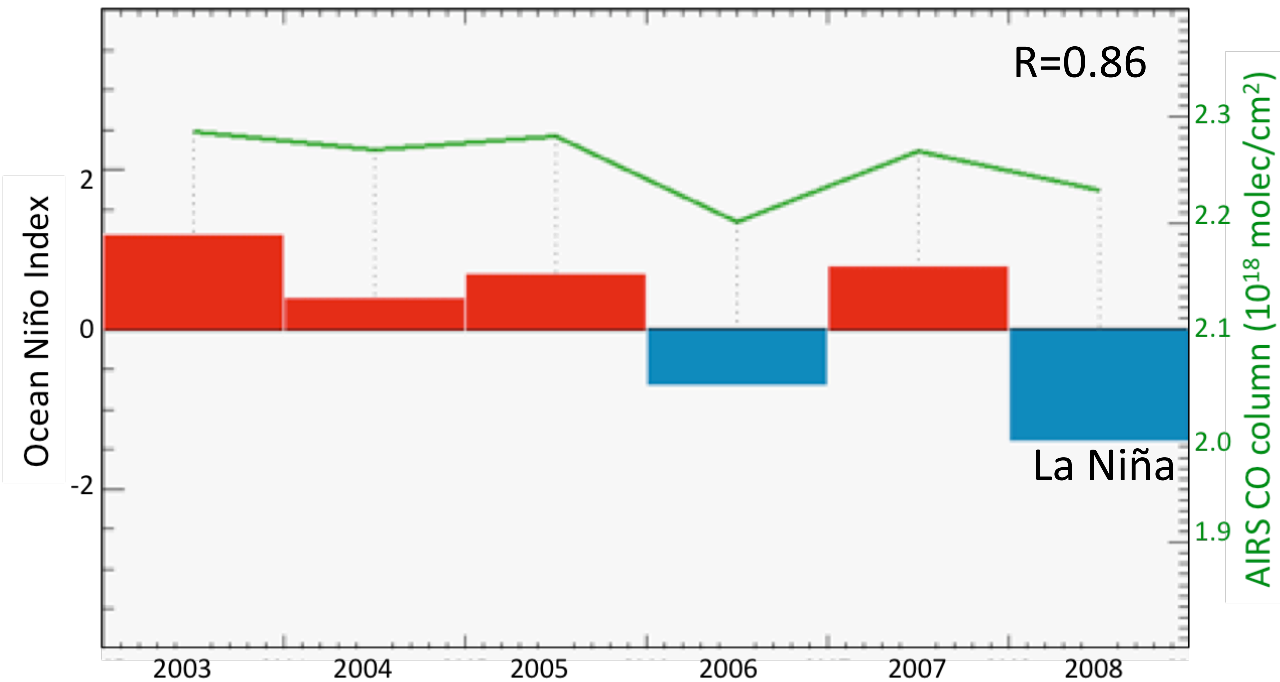
April 2008 AIRS CO anomaly



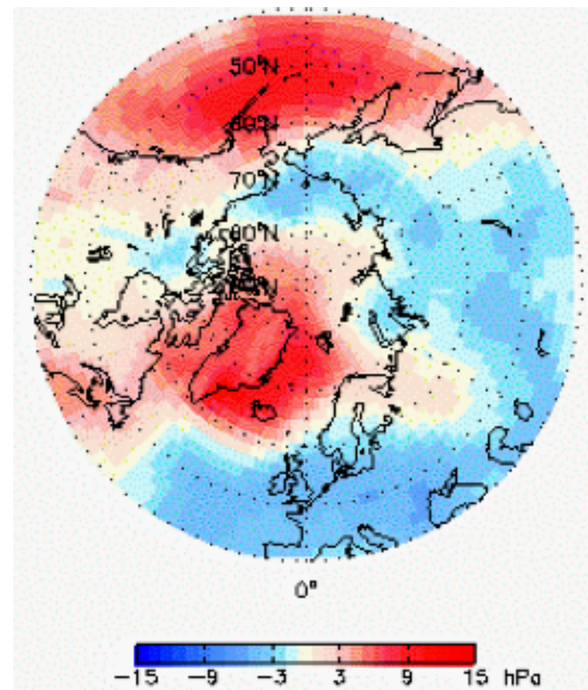
Courtesy M. Purdy

Climate impacted transport and CO accumulation in 2008

AIRS CO in Bering/Chukchi Seas and DJF Ocean Niño Index



2008 sea level pressure anomaly



Courtesy M. Purdy

2008 La Niña conditions led to weakened Aleutian low

Weakened low decreased transport to Alaska

Result was lower CO over N. American Arctic, despite increased source in Russia

Summary

1. AIRS CO column data is generally consistent with other satellite observations.

2. Mid-tropospheric pollution transport to the Arctic is evident in AIRS, GEOS-Chem, and ARCTAS in-situ data and is dominated by Asian fossil fuels.

3. Low-altitude pollution transport from Europe was observed by aircraft but not by AIRS.

4. Despite extremely large fires in Russia in April 2008, the impact of biomass burning on Arctic CO concentrations was minimal relative to European and Asian pollution

5. April 2008 showed above-average export of CO from Europe and lower-than-average CO over Alaska, which can be explained by transport changes associated with the La Niña-induced weakening of the Aleutian Low pressure system.

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