Remote sensing of Asian pollution from space: tracking the long range transport from China using ACE measurements Preliminary analysis

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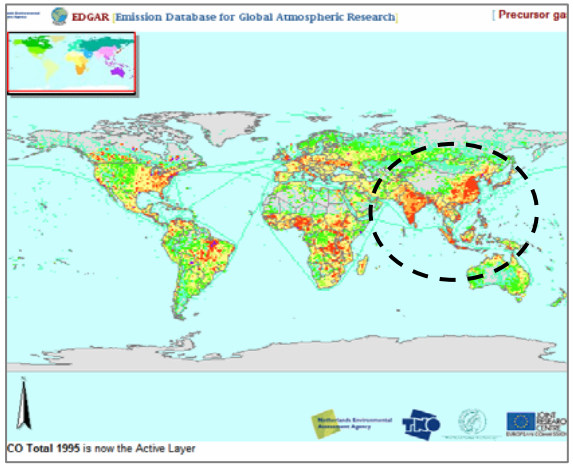
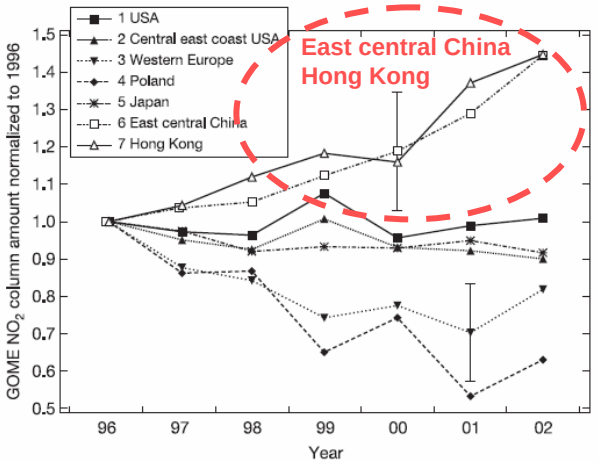
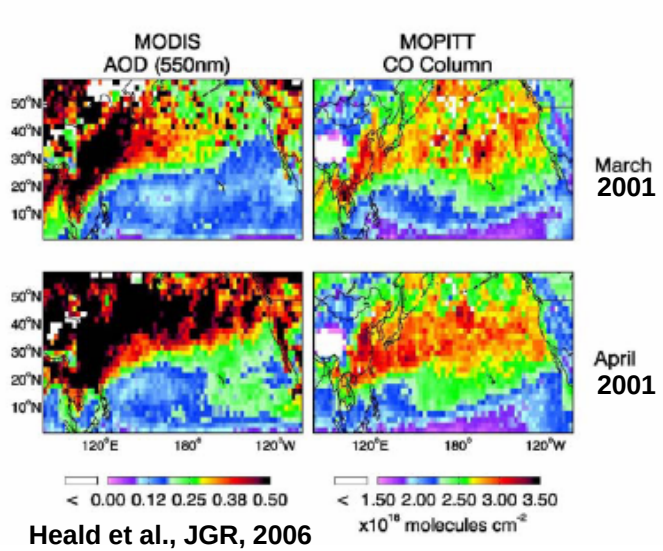




Richter et al., Nature, 2005



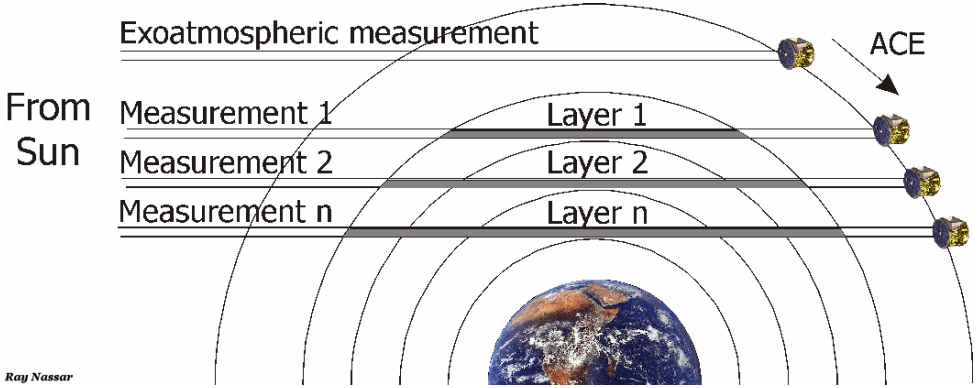
Heald et al., JGR, 2006

IPCC : CO emissions × 3 for East Asia and India between 2000 and 2100 (scenario A2p)
NOx emissions × 4

Is there information on Asian pollution in the ACE measurements in the middle and upper troposphere?

ACE – Atmospheric chemistry Experiment

- ACE-SCISAT-1 is a Canadian mission launched on August 13th, 2003
- High inclination (74°), circular low earth orbit
- Primary instrument : ACE-FTS, high resolution IR spectrometer
- Solar occultation : measurement of atmospheric profiles of temperature, pressure and a series of trace gases during sunrise and sunset in the stratosphere and upper troposphere
- Vertical resolution ~4km



http://www.ace.uwaterloo.ca/mission.htm

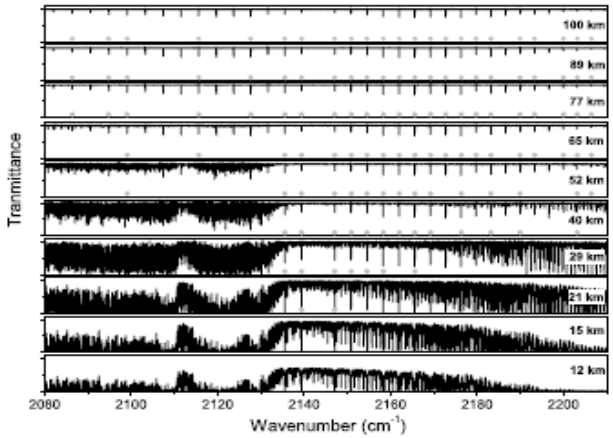


Figure 1. ACE-FTS occultation spectra for selected tangent altitudes, in the fundamental 1-0 absorption band. The transmittance scale is between 0 and 1. The microwindows used in the retrieval, varying with altitude, are identified by grey dots. Below 25 km, most of the information is retrieved from the 2-0 overtone band (not shown) as saturation and interferences due to other trace gases absorption increase when the instrument is sounding deeper in the atmosphere.

[Clerbaux et al., GRL, 2005]

ACE – Atmospheric chemistry Experiment

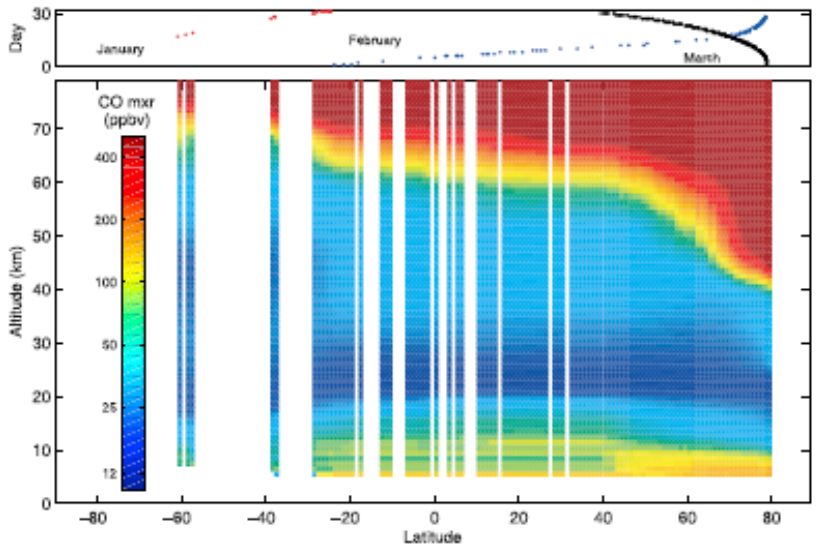
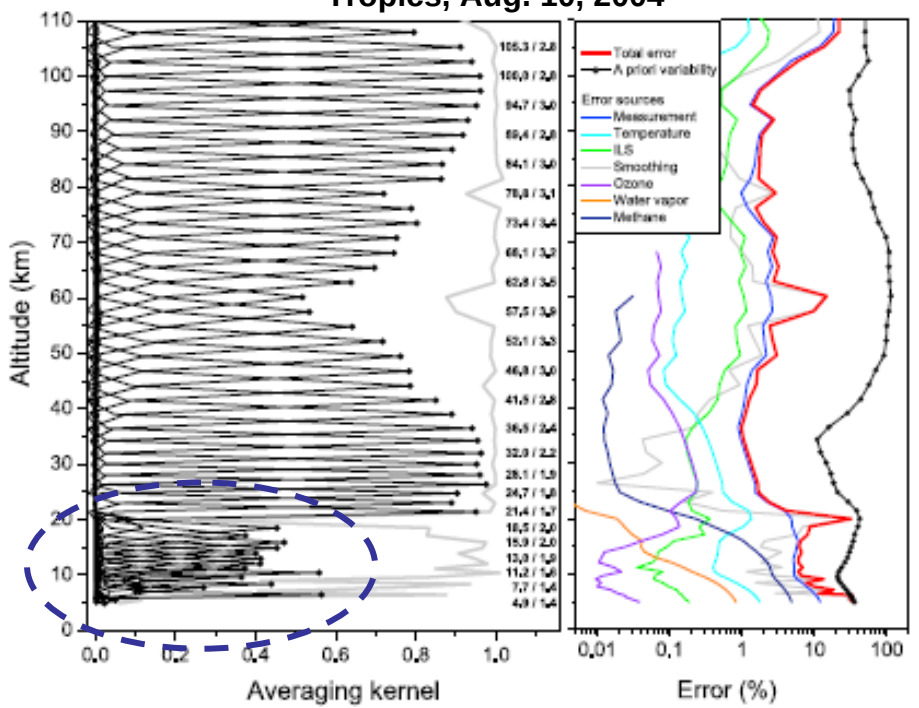


Figure 4. Latitudinal averages of CO mixing ratio profiles observed by ACE-FTS for the January to March 2004 period (corresponding to 508 occultations), plotted with a logarithmic colorscale.

Tropics, Aug. 10, 2004



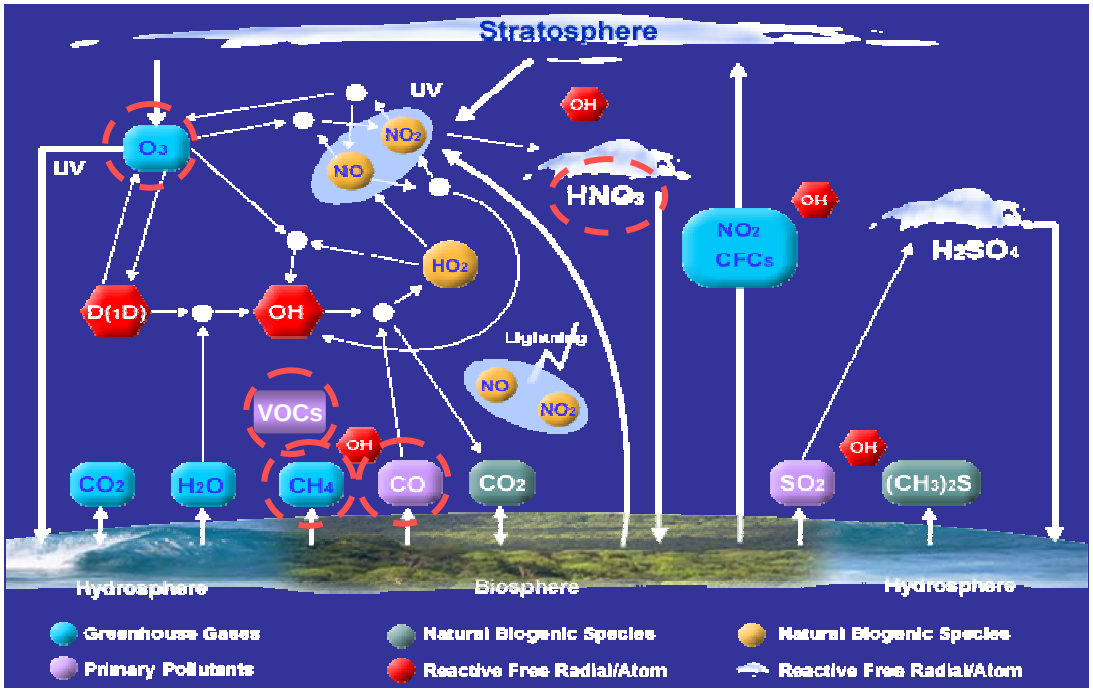
[Clerbaux et al., GRL, 2005]

ACE operational retrievals:Modified global fit approach

- All parameters determined simultaneously using a Levenberg-Marquardt nonlinear least-squares method.
- Optimized for stratosphere – mesosphere

[C. Boone et al., 2005]

Simplified tropospheric chemistry



Can ACE measurements be used to improve understanding of trospospheric chemistry and long range transport?

Species detected with interest for tropospheric chemistry:

- **O3** ☺?
- **H2O** ☺
- **H2O2**
- **CO** ☺
- **CH4** ☺
- **C2H6** ☺
- **C2H2** ☺
- **HCN** ☺
- **CH3Cl** ☺
- **HCHO** ☹
- **NO, NO2** ☹
- **PAN** ☺?
- **HNO3** ☺?

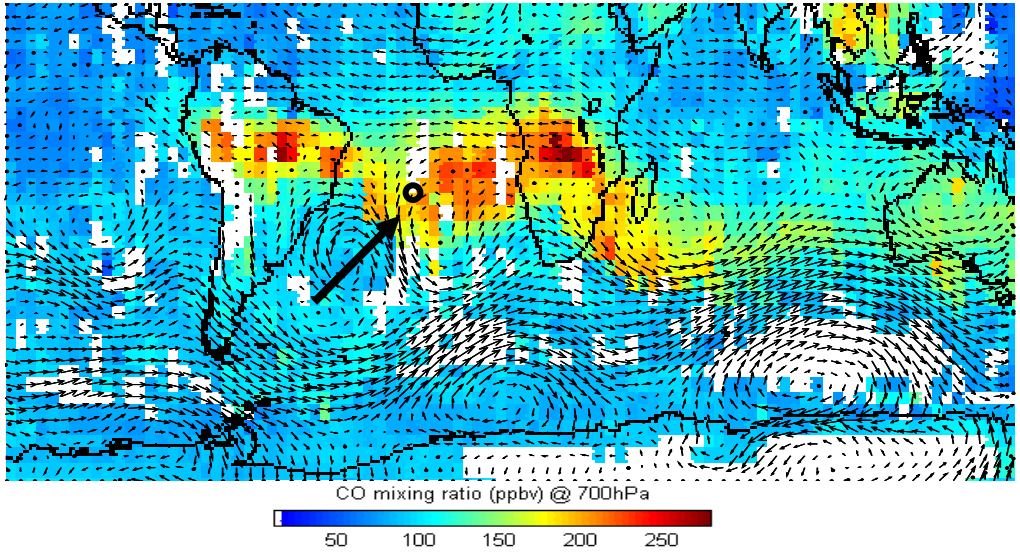
☹ No data in the troposphere
☺ Data available in the troposphere

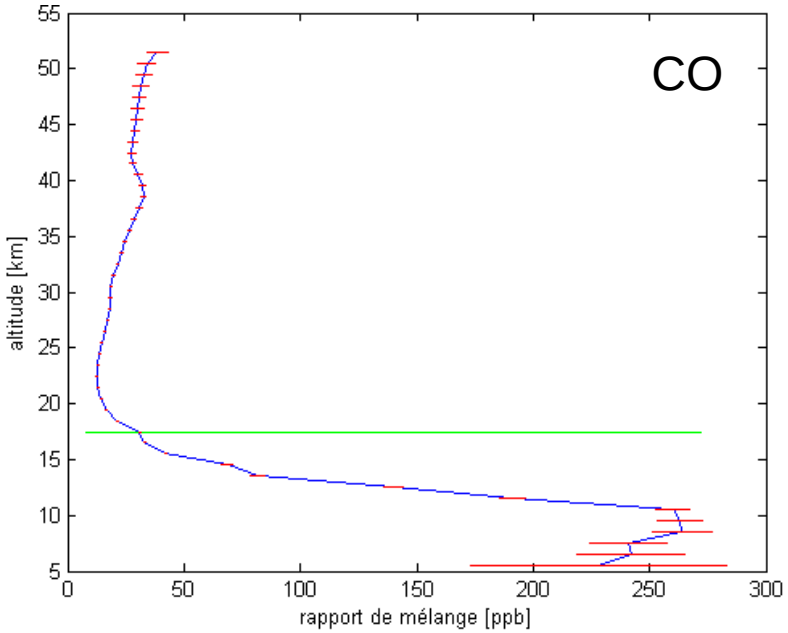
Note: operational algorithm optimized for stratospheric studies
More evaluation and studies required for the troposphere

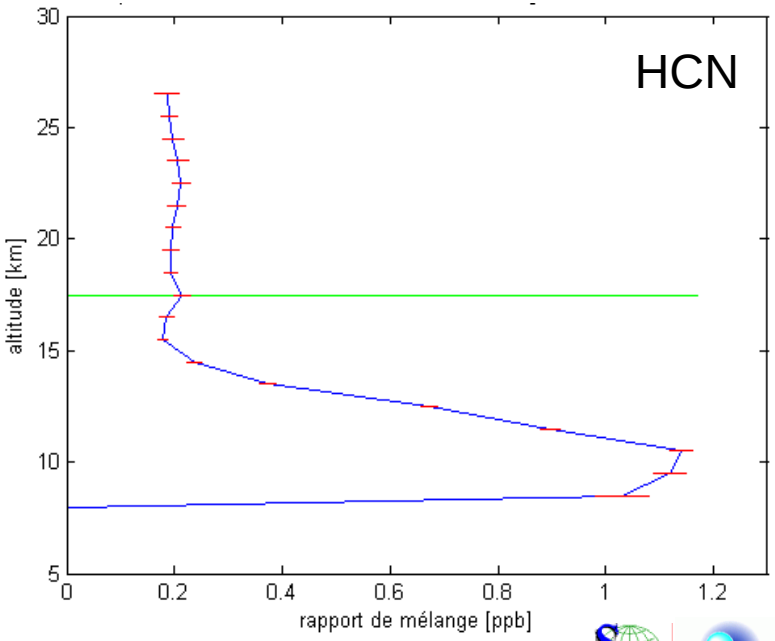
Signature from biomass burning

MOPITT CO
ECMWF zonal winds
October 5-8, 2004

A. Razavi, ULB

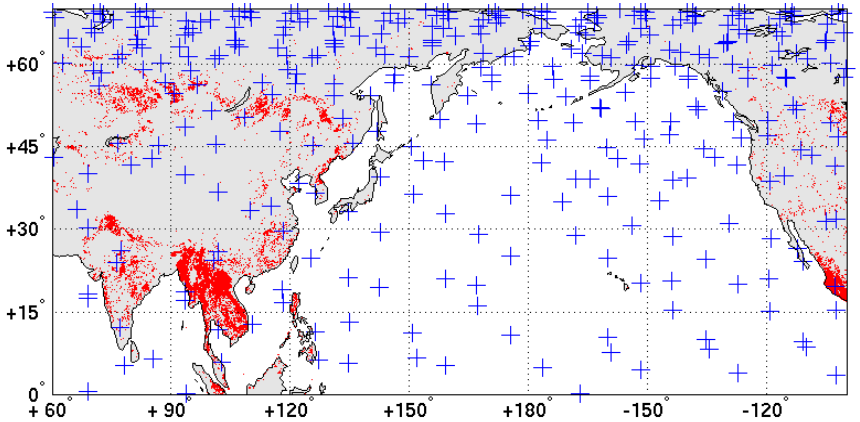




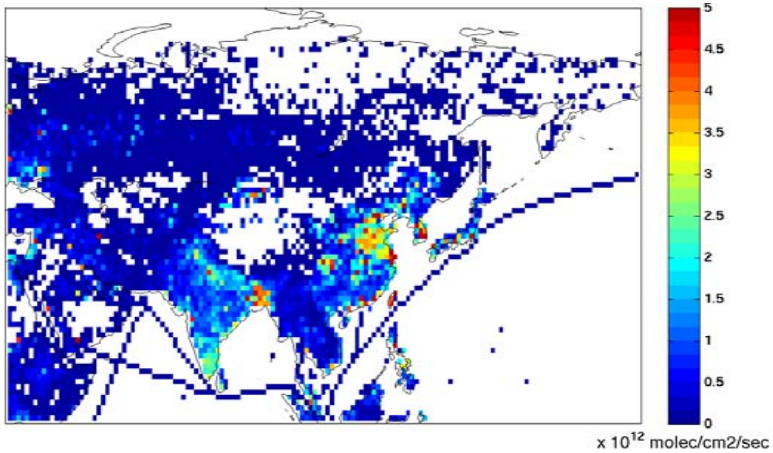


Tracking the long range transport from China using ACE measurements

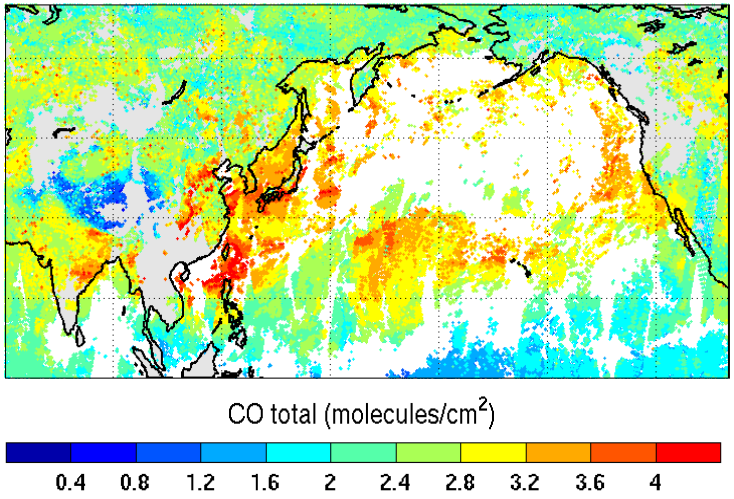
ACE occultations for March – April – May 2005
w/ MODIS hotspots



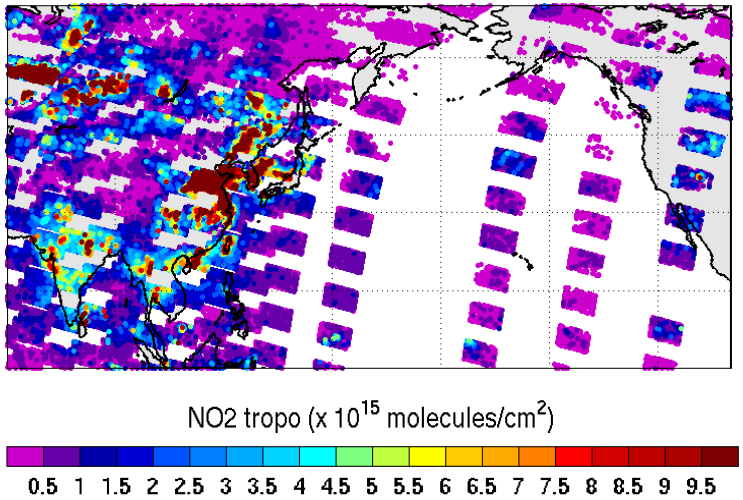
POET – CO FF emissions - April



MOPITT/Terra : April 1-4, 2005



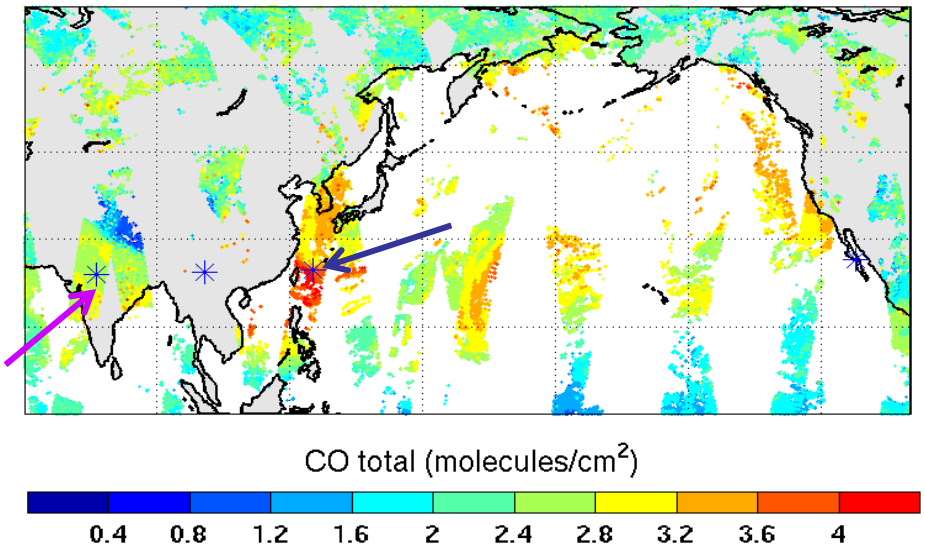
SCIAMACHY/Envisat : April 1-4, 2005



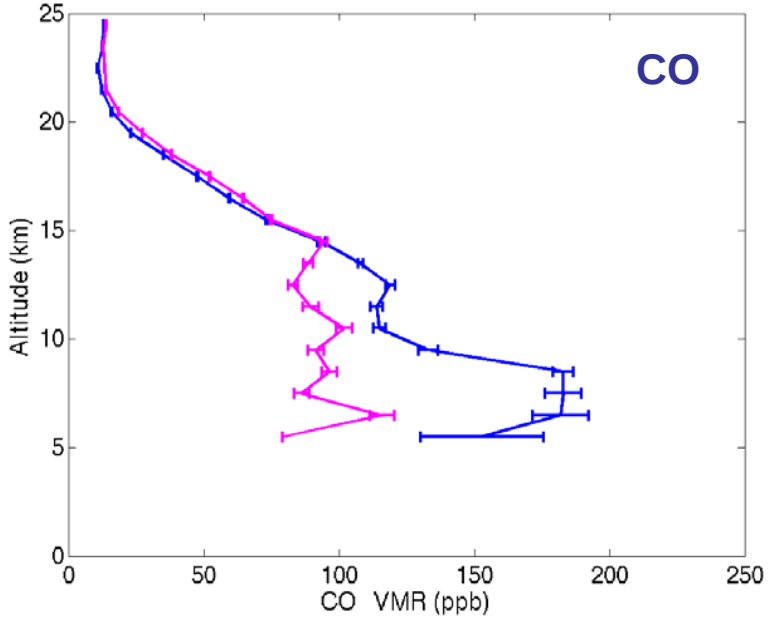
Influence from both urban/industrial pollution and biomass burning
Can we differentiate these signatures in the ACE data?

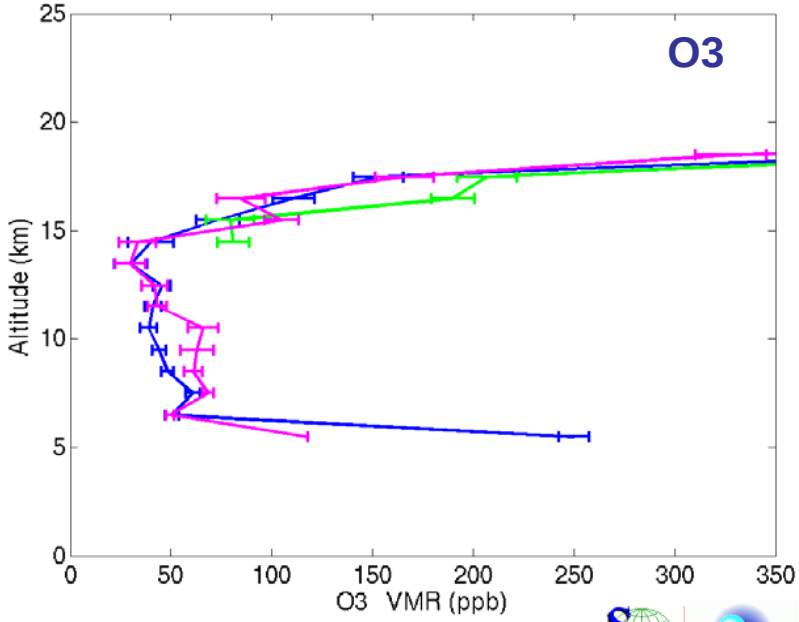
High CO mixing ratio on April 4, 2005

MOPITT – April 4, 2005



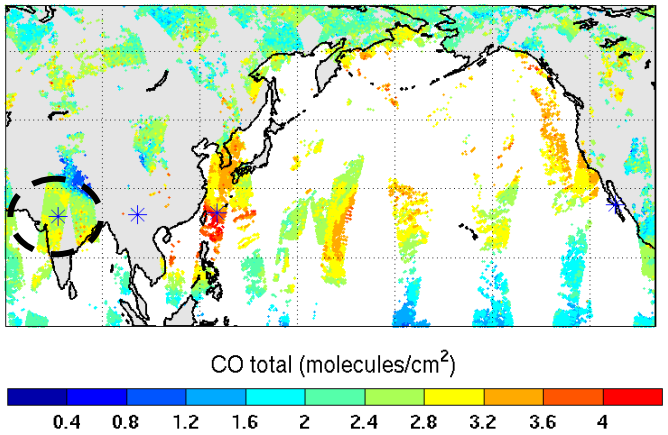
* ACE occultation





First step: comparison of CO measured by ACE and MOPITT

MOPITT – April 4, 2005



* ACE occultations

- - ss8850.asc

(Rodgers and Connor, 2003)

$$\mathbf{x}_{s,ACE} = \mathbf{x}_{a,MOPITT} + \mathbf{A}_{MOPITT}\left(\mathbf{x}_{h,ACE} - \mathbf{x}_{a,MOPITT}\right)$$

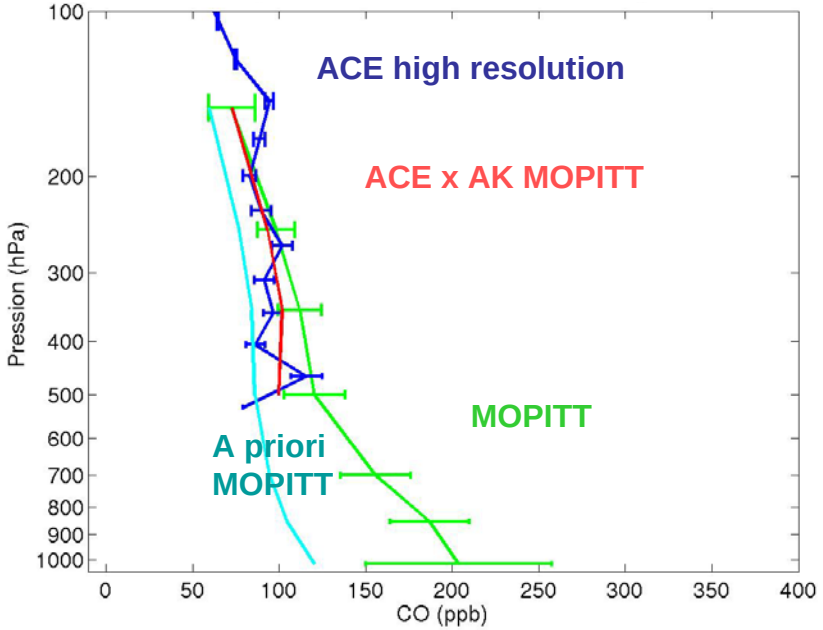
ACE smoothed using MOPITT characteristics

MOPITT a priori profile

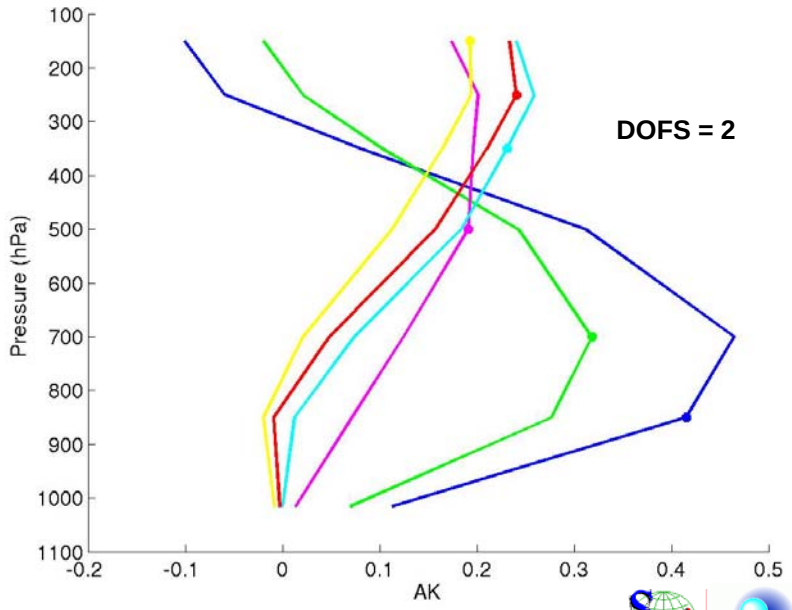
MOPITT Averaging kernels

ACE high resolution (original retrieval)

Intercomparison ACE - MOPITT



MOPITT Averaging kernels



First step: comparison of CO measured by ACE and MOPITT

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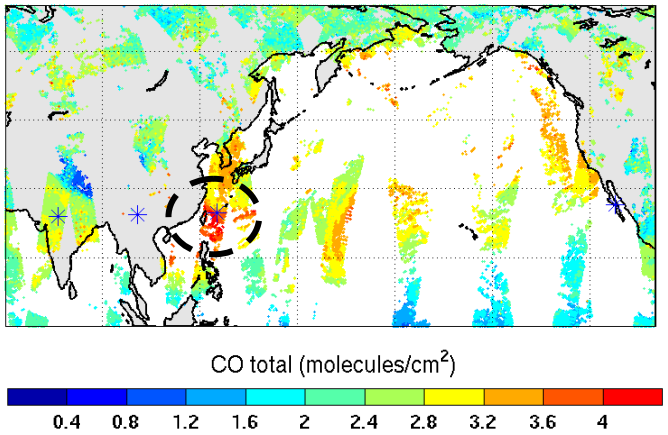


* ACE occultations

- - ss8848.asc

(Rodgers and Connor, 2003)

$$\mathbf{x}_{s,ACE} = \mathbf{x}_{a,MOPITT} + \mathbf{A}_{MOPITT}\left(\mathbf{x}_{h,ACE} - \mathbf{x}_{a,MOPITT}\right)$$

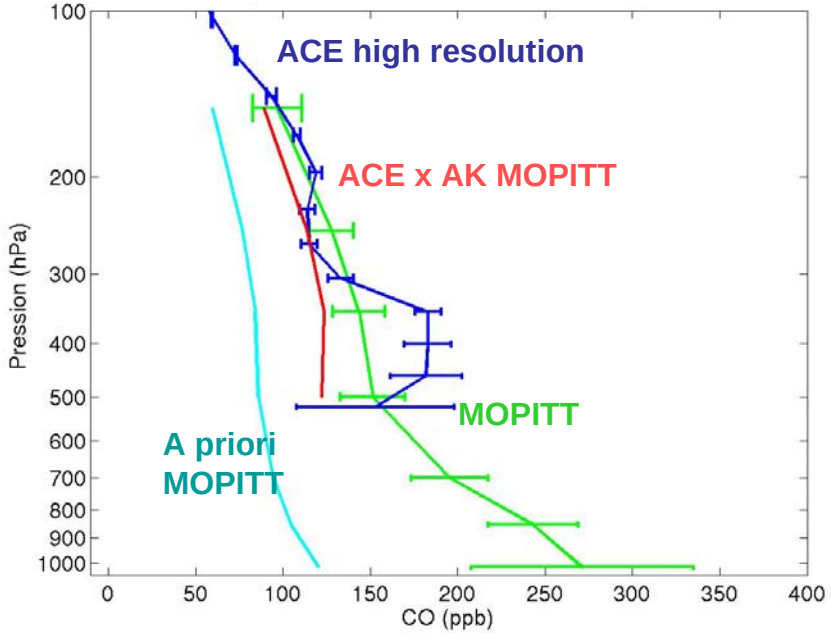
ACE smoothed using MOPITT characteristics

MOPITT a priori profile

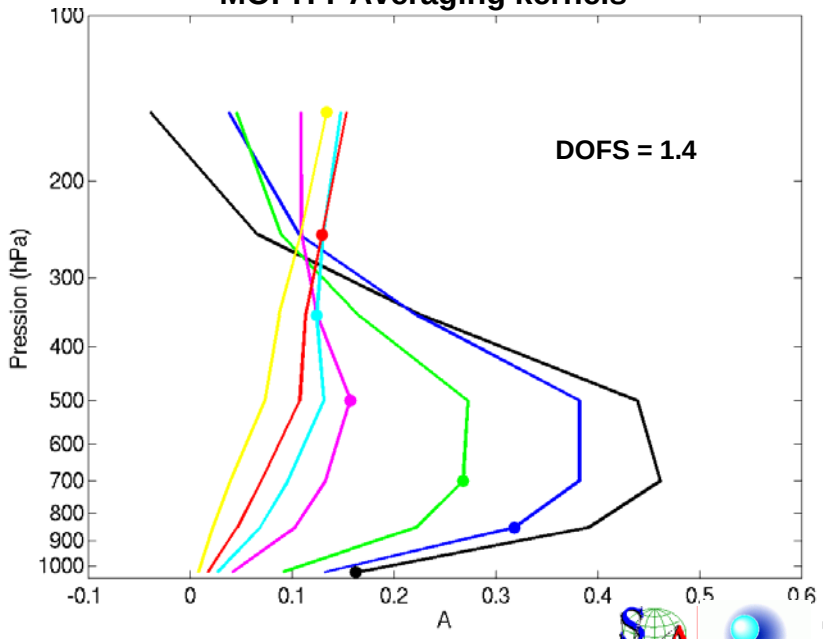
MOPITT Averaging kernel

ACE high resolution (original retrieval)

Intercomparison ACE - MOPITT

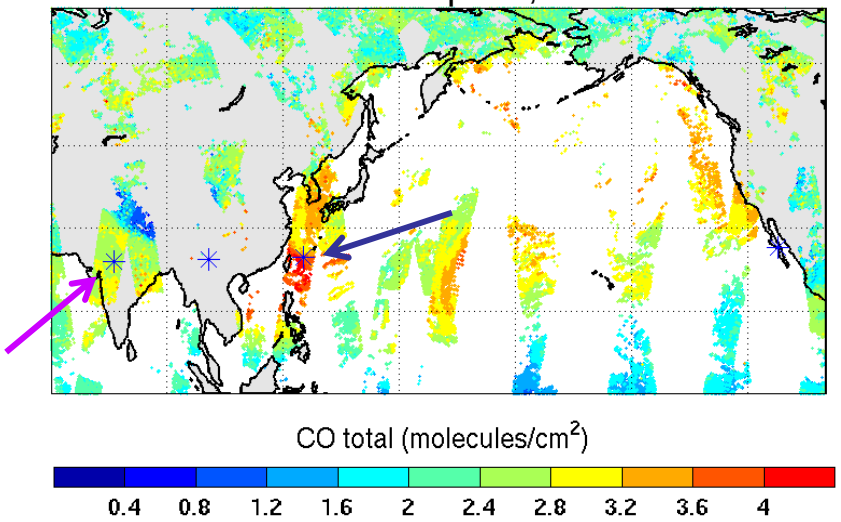


MOPITT Averaging kernels

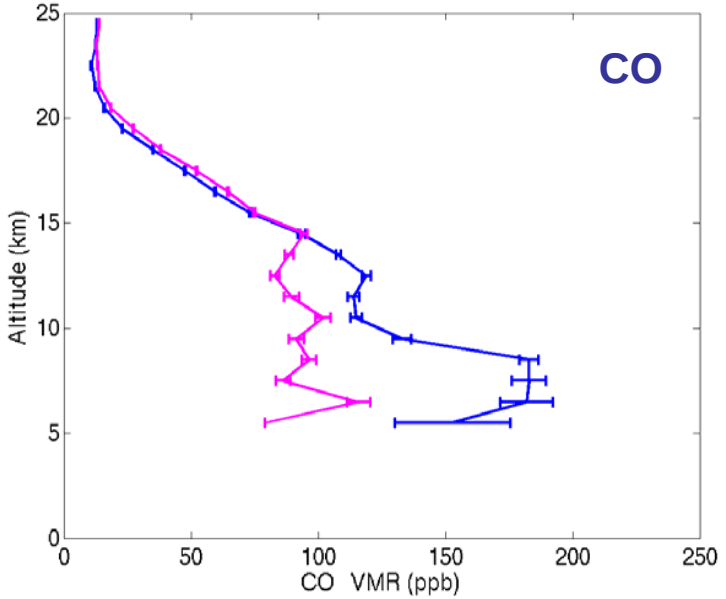


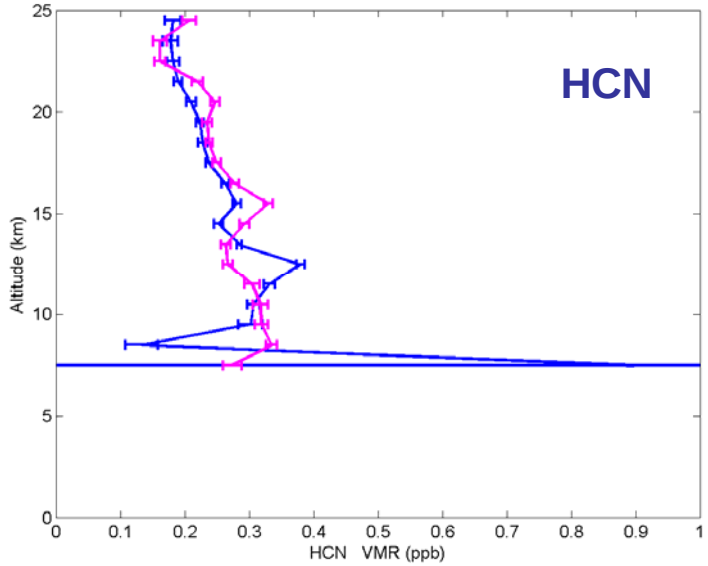
Fossil fuel / biofuel combustion or biomass burning?

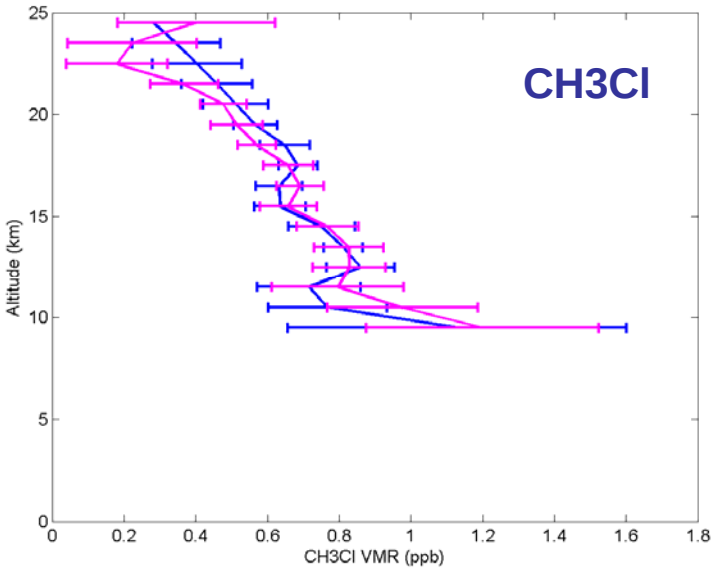
MOPITT – April 4, 2005



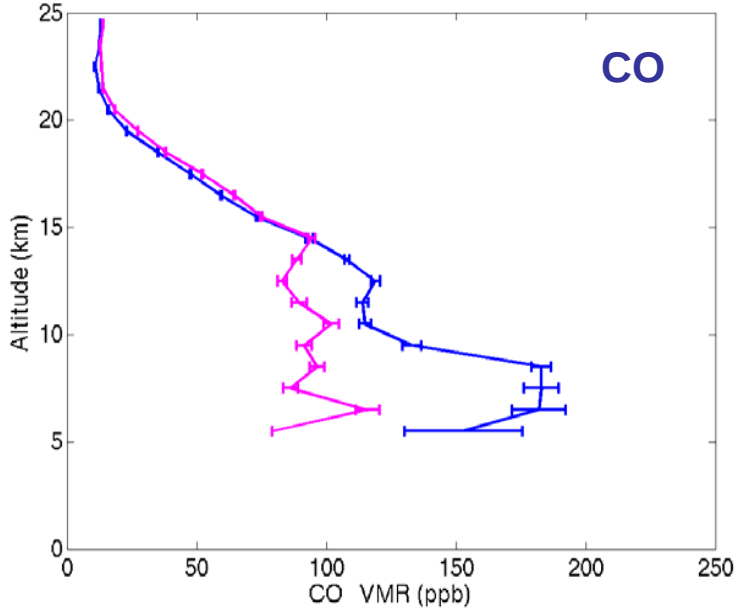
* ACE occultation

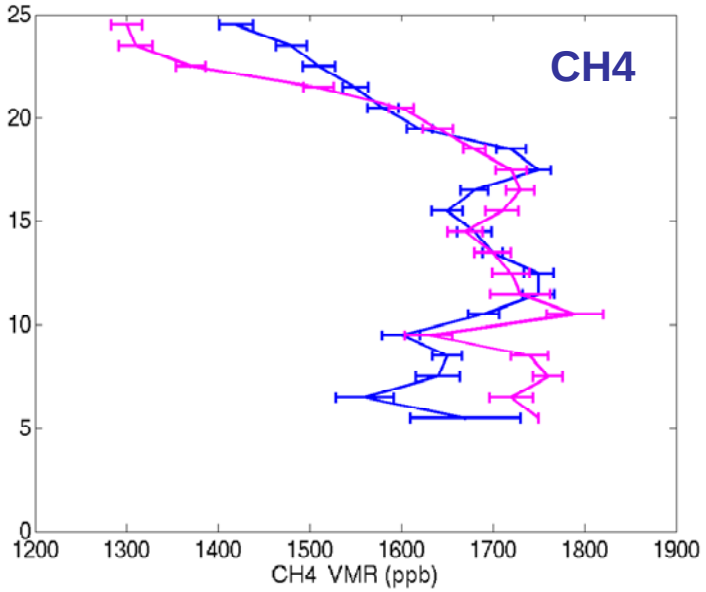


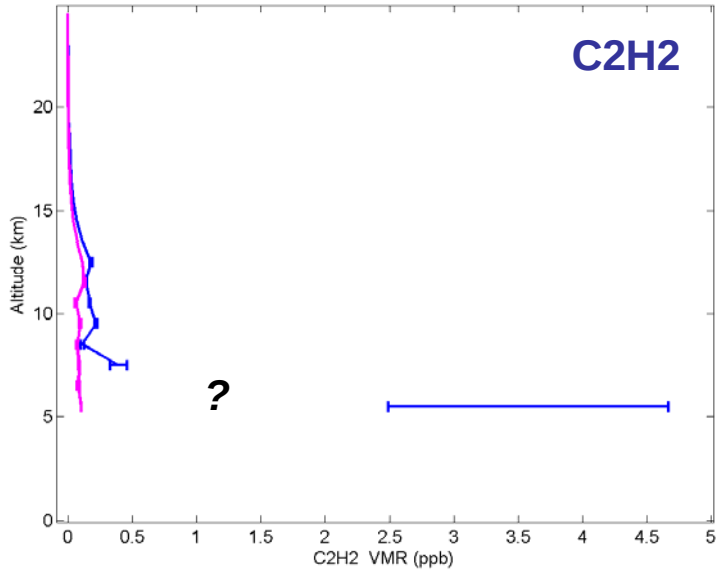


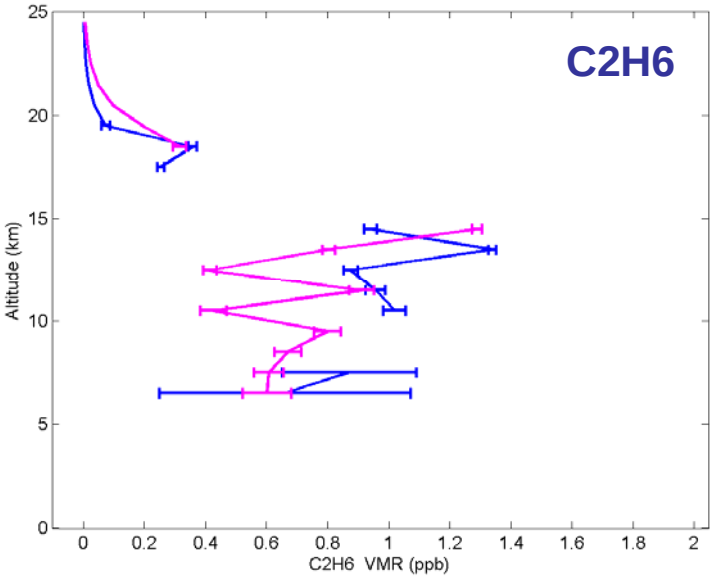


Fossil fuel / biofuel combustion or biomass burning?









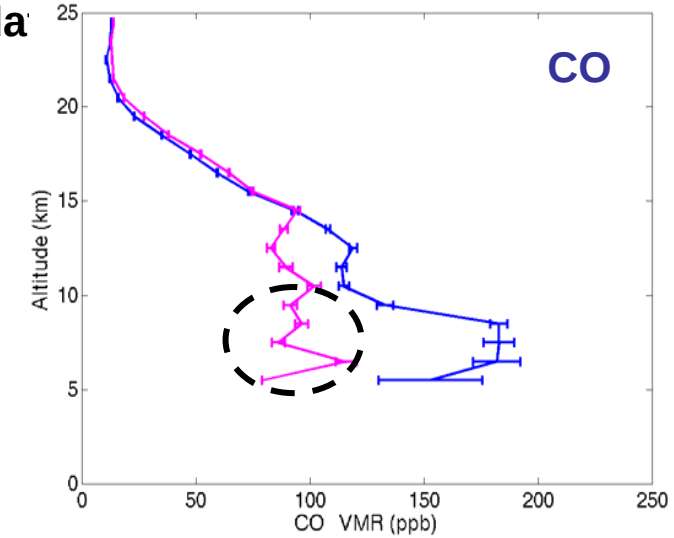
High C2H2/CO (?): transport of freshly emitted air masses (less photochemically processed)

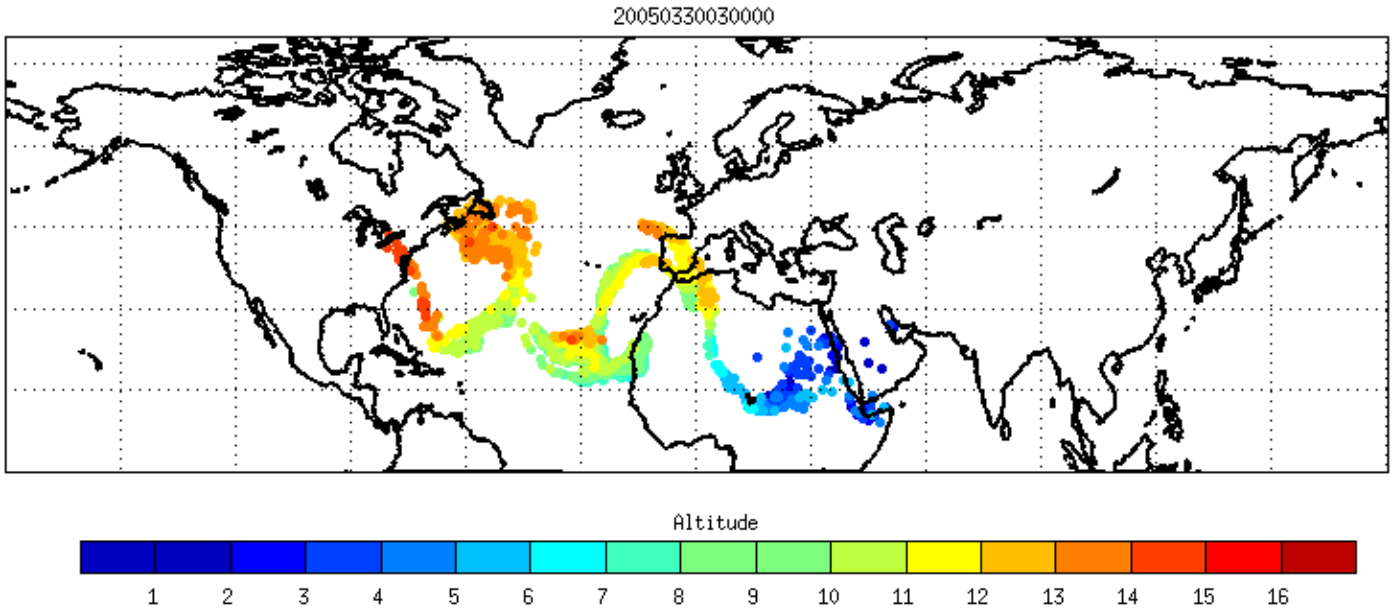
Back-trajectories from the CO maximum : origin of the plume

Use Flexpart model (A. Stohl, NILU) with ECMWF met da

Release of 10000 particles from : ss8850.asc
- 2005/04/04 13:08 GMT ; [24N,76E]
- Layer 5 – 7 km

(http://zardoz.nilu.no/~andreas/flextra+flexpart.html)



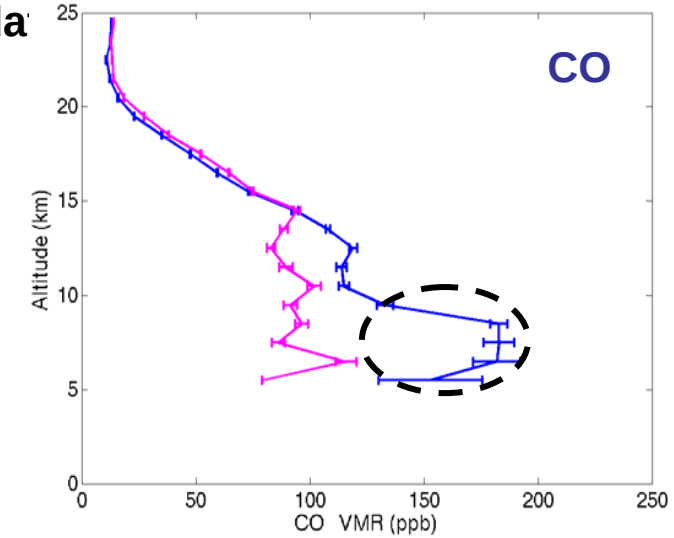


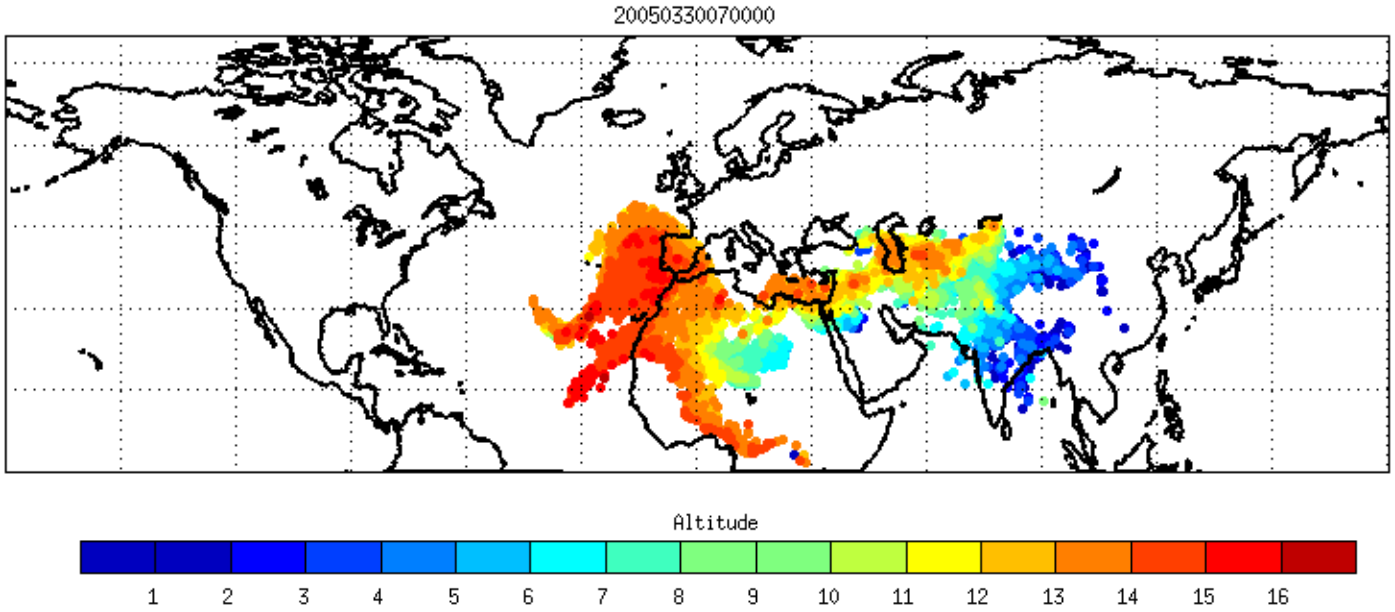
Back-trajectories from the CO maximum : origin of the plume

Use Flexpart model (A. Stohl, NILU) with ECMWF met da

Release of 10000 particles from : ss8848.asc
- 2005/04/04 9:53 GMT ; [25N,125E]
- Layer 5 – 7 km

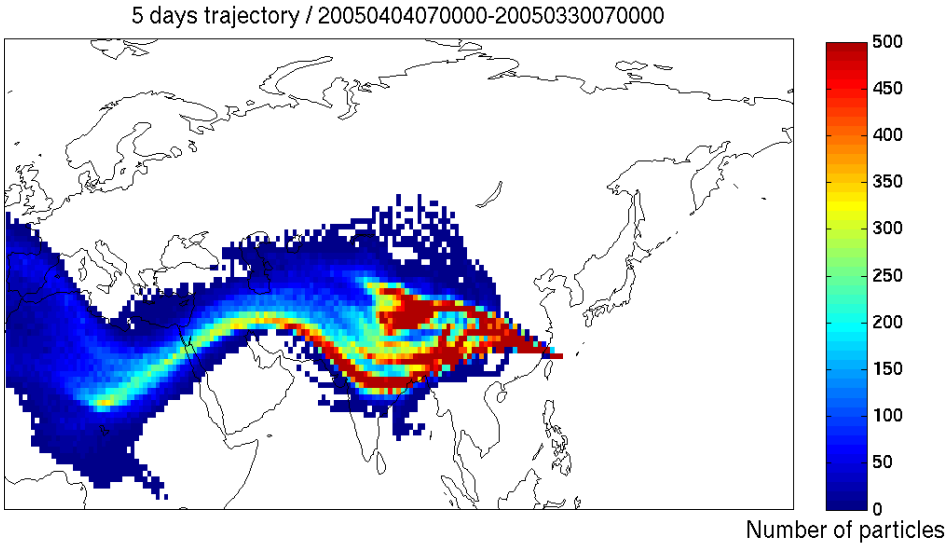
(http://zardoz.nilu.no/~andreas/flextra+flexpart.html)

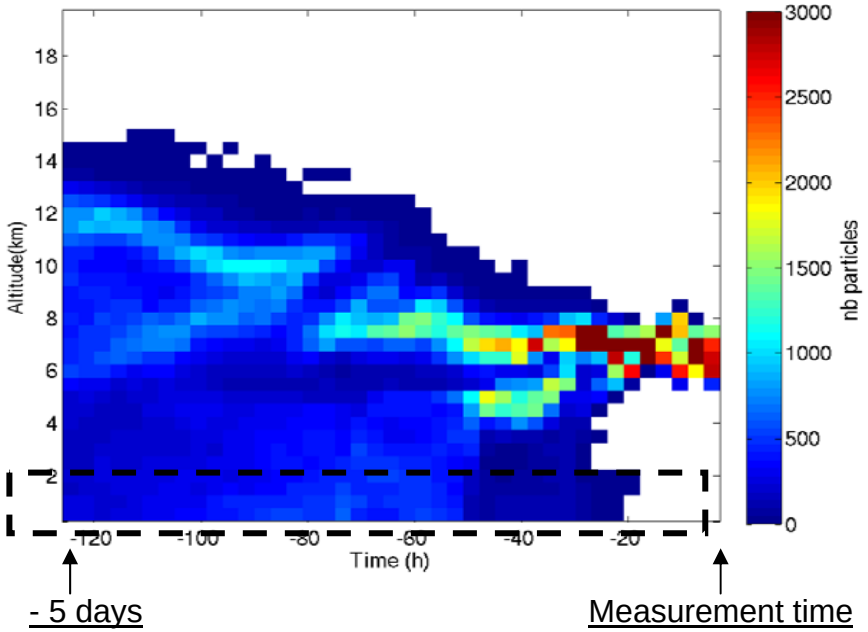




Back-trajectories from the CO maximum : origin of the plume

Accumulative number of particles on a 1°x1° grid from 5 days back-trajectories





2 branches:

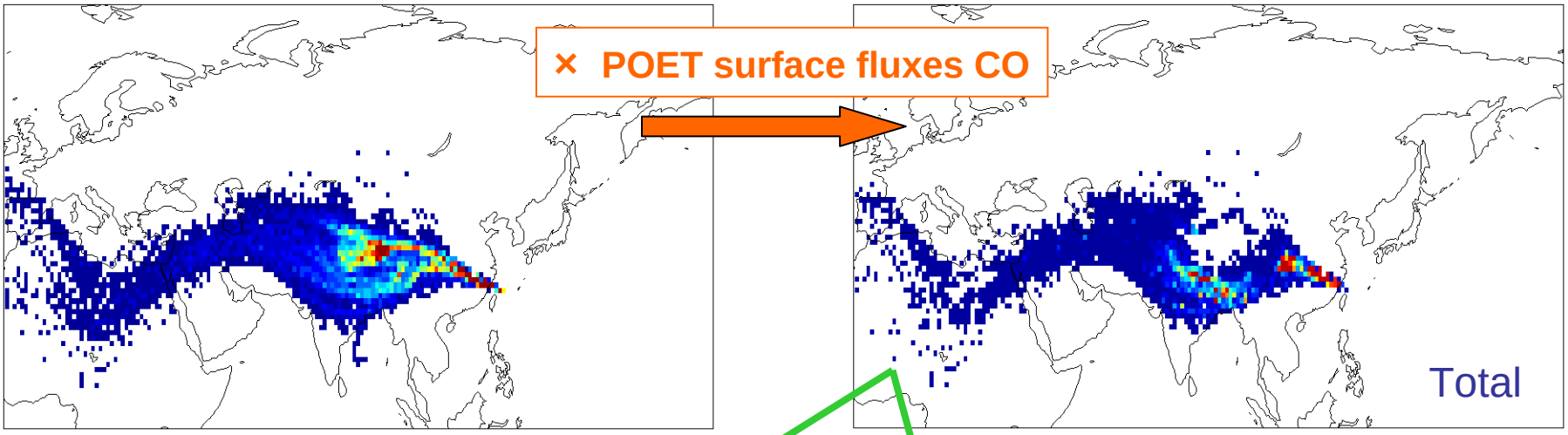
- High altitude long range transport
- Contribution from surface emissions in Asia

Contribution from surface emissions in China and India

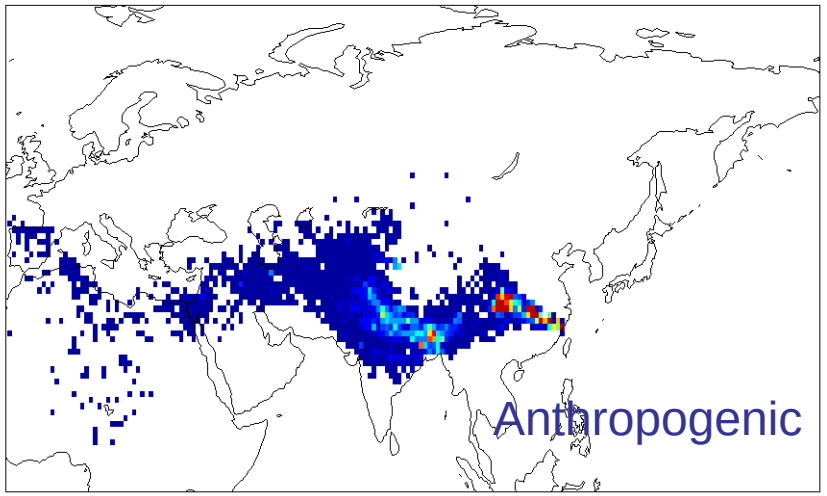
Accumulative number of particles @ altitudes < 1km

× POET surface fluxes CO

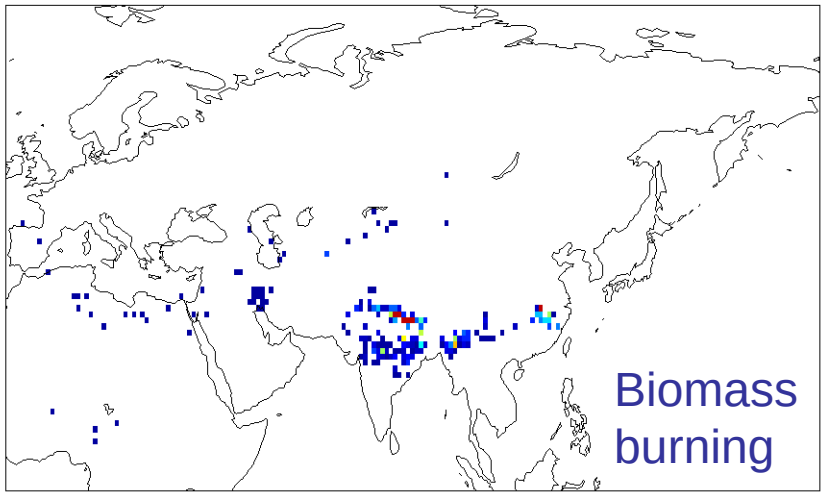
Nb × Total emissions



Nb × FF/BF emissions



Nb × BB emissions



Conclusions and Future work

- ACE data have potential for tropospheric studies:
  - Transport in the upper troposphere
  - Good vertical resolution
  - Large variety of species measured

- Complementarities with nadir measurements in the upper troposphere

- More work needed on the evaluation of ACE tropospheric data
  - comparisons with MOPITT, SCIAMACHY, TES
  - comparisons with in situ data from MOZAIC

- Need for improvement of the retrievals in the troposphere;
Intercomparison between two different retrievals: Optimal estimation (e.g. Atmosphit: poster Daniel Hurtmans, ULB) and operational retrieval

- Analysis with the global model LMDz-INCA: origin and chemical processes

Posters:

❖ ACE retrievals using Atmosphit, a user friendly fitting software based on the optimal estimation method, Daniel Hurtmans (Université Libre de Bruxelles)

❖ Distributions of nitric acid in the troposphere and the stratosphere, Catherine Wespes (Université Libre de Bruxelles)