Transport pathways in the Asian Monsoon Anticyclone diagnosed from Spaceborne Measurements and Model Simulations

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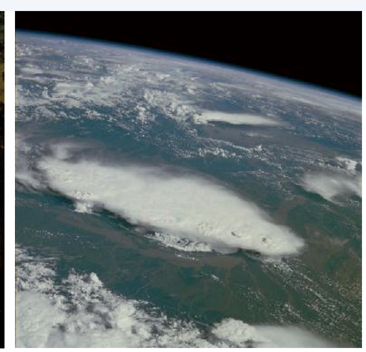

4th SPARC General Assembly, 2008, Bologna

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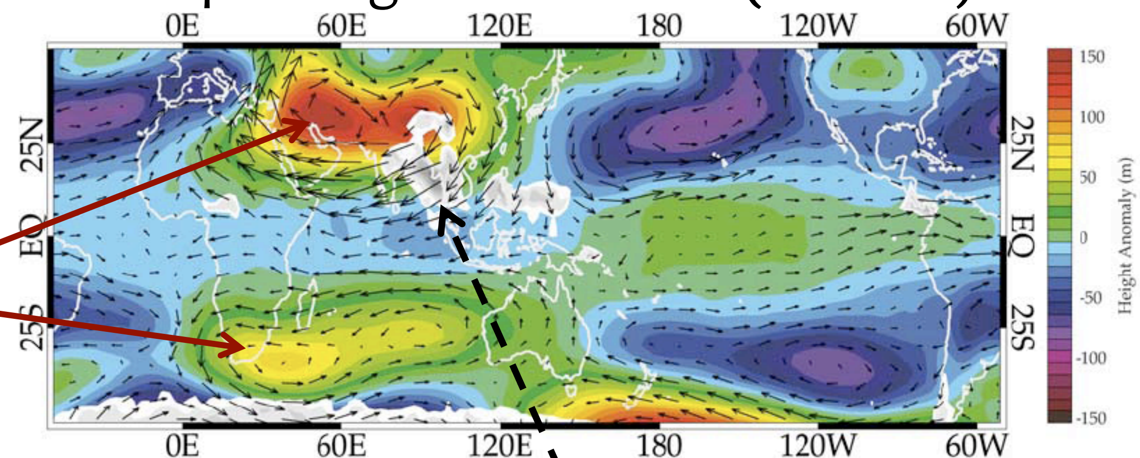
Asian Monsoon Anticyclone

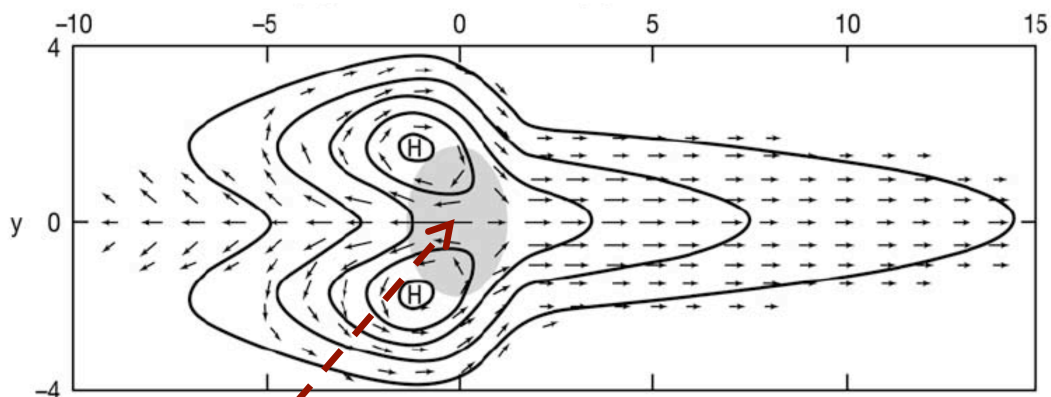
anticyclones

anticyclone does not lie on top of the deep convection!

Geopo. height and winds (100 hPa)



convection

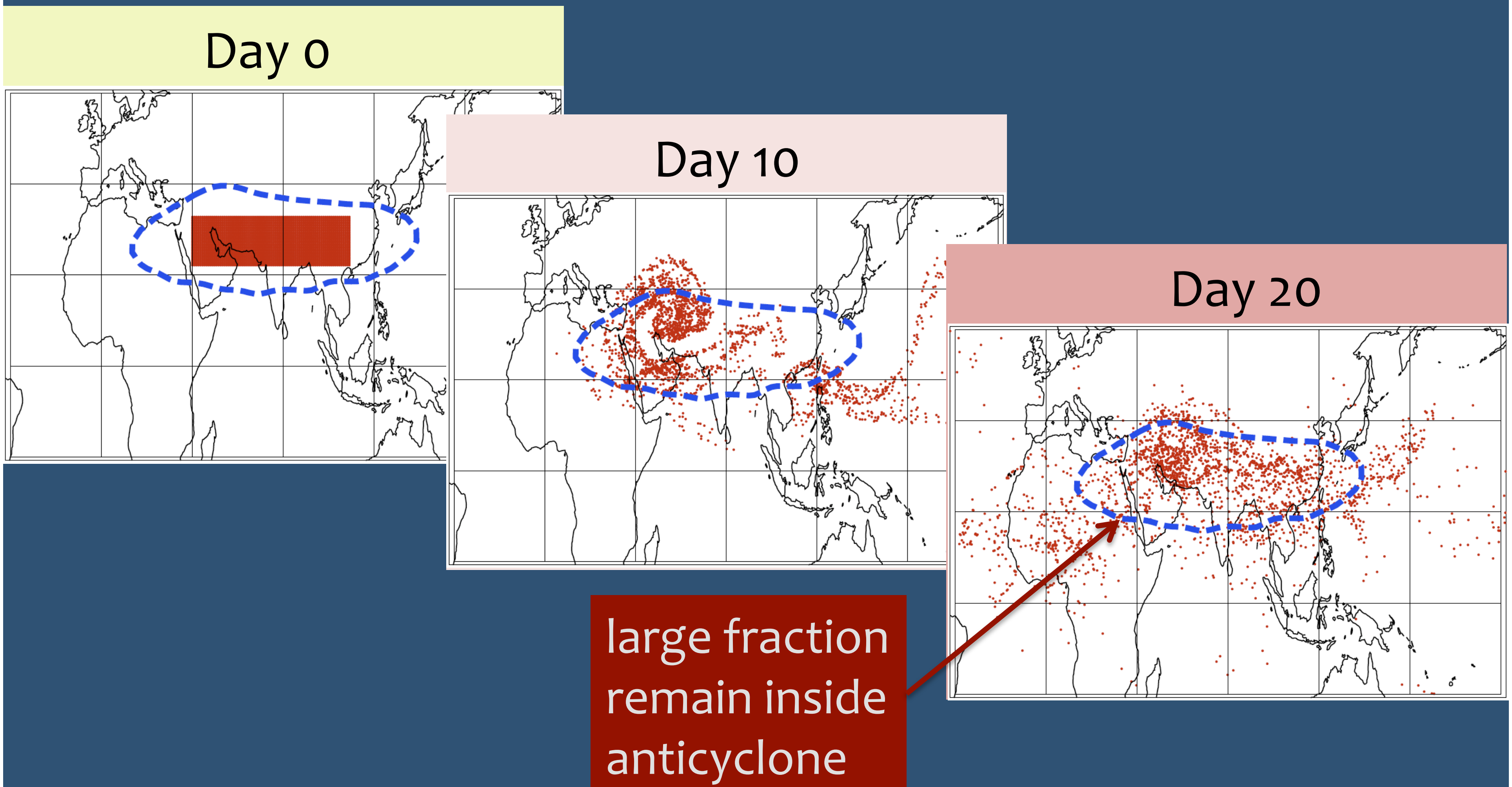


Imposed heating

Adapted from Gill (1980)

Strong confinement

(trajectory simulation at 150 hPa)



Enhanced upper tropospheric CO in Asian monsoon anticyclone

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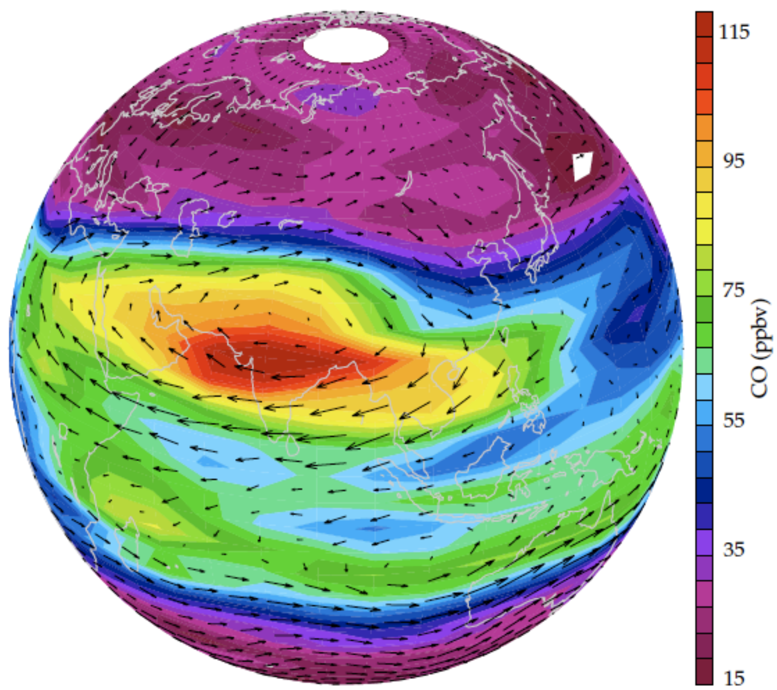
2 day average of MLS CO

(Jun 20-21, 2005)

MLS CO 100 hPa



MLS CO and O_3 (Jul-Aug)

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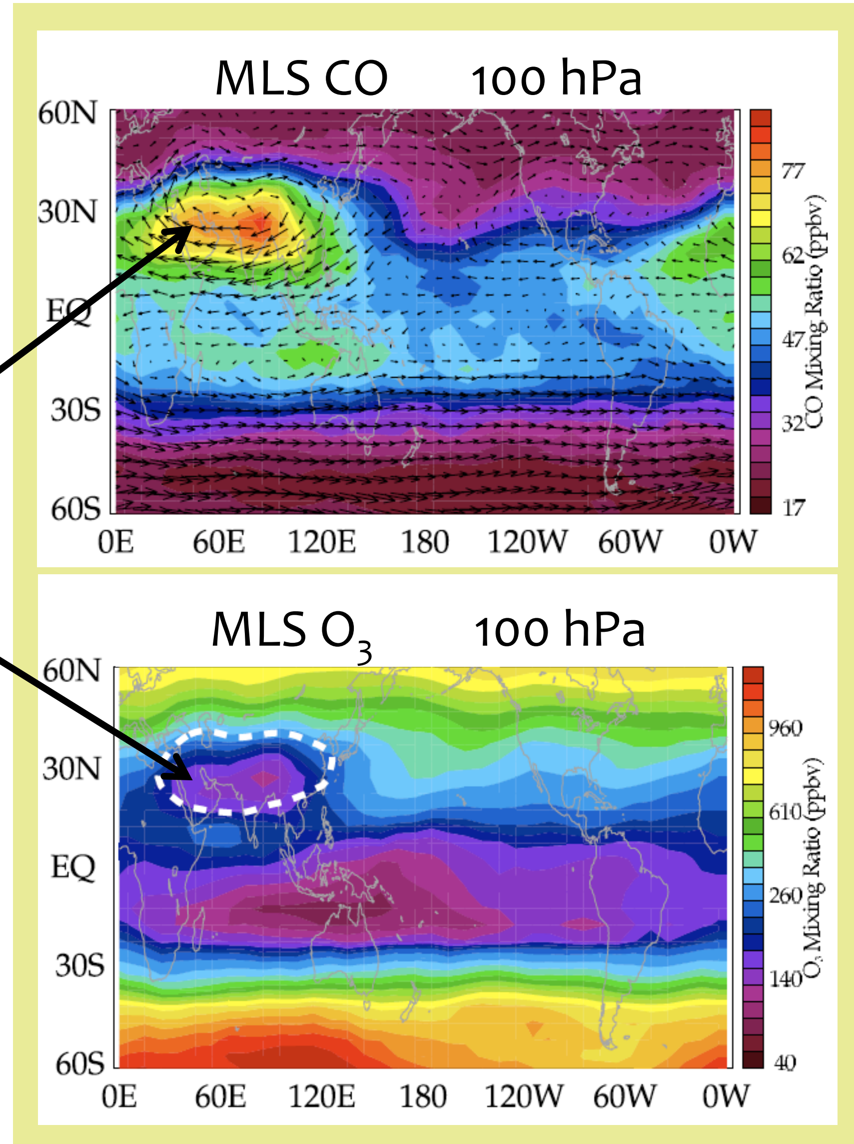
MLS CO max (O_3 min) within the anticyclone in the UTLS



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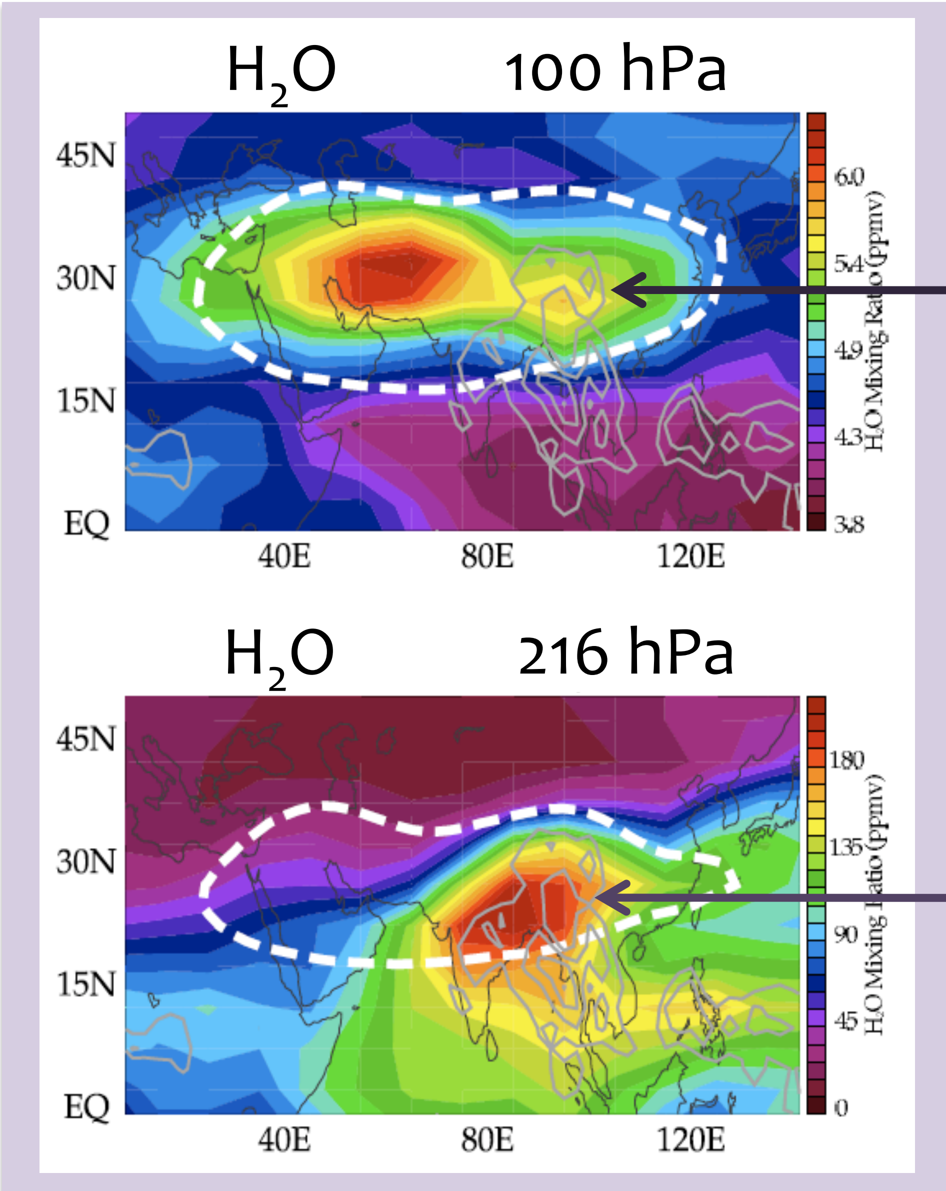
MLS H_2O (Jul-Aug)



Asian monsoon anticyclone

over deep convection

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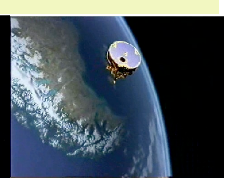
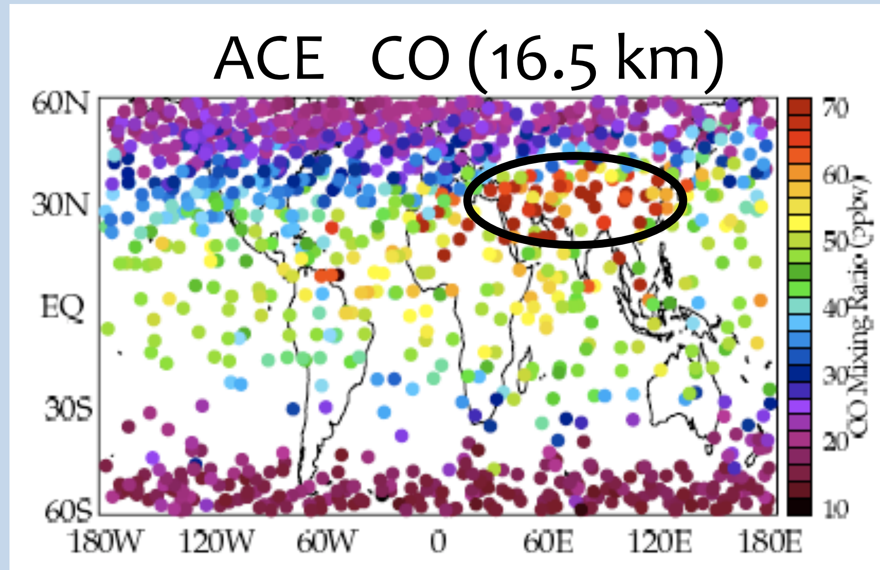
ACE-FTS

- Atmospheric Chemistry Experiment Fourier Transform Spectrometer (**ACE-FTS**) is a high spectral resolution infrared Fourier Transform Spectrometer on SCISAT-1
- ACE-FTS measures atmospheric absorption spectra (750-4400cm^{-1}) using solar occultation technique
- CO, HCN, C_2H_6, C_2H_2, OCS, CH_3Cl, O_3, HNO_3, HCl, etc…

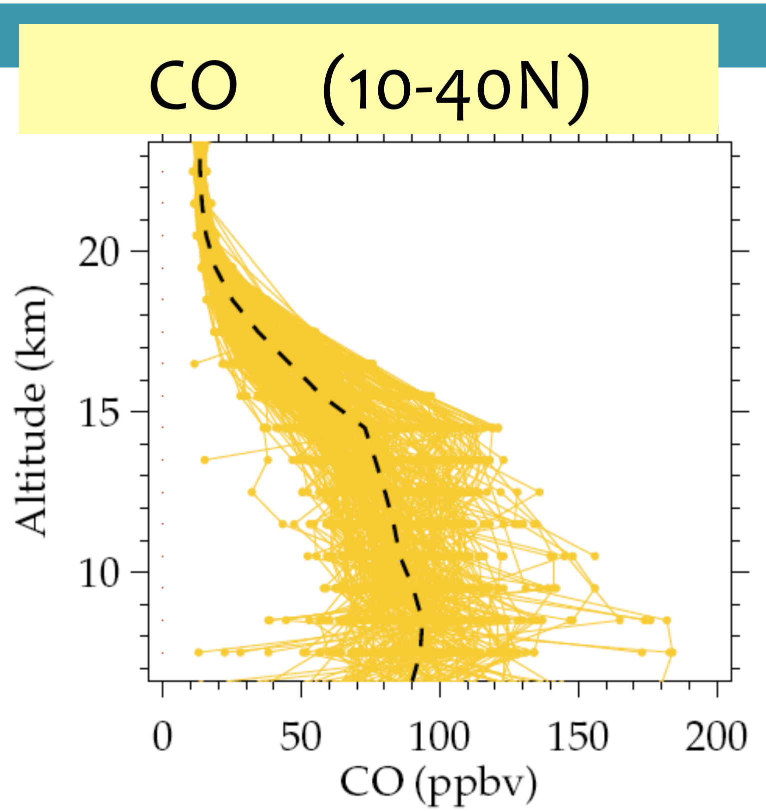


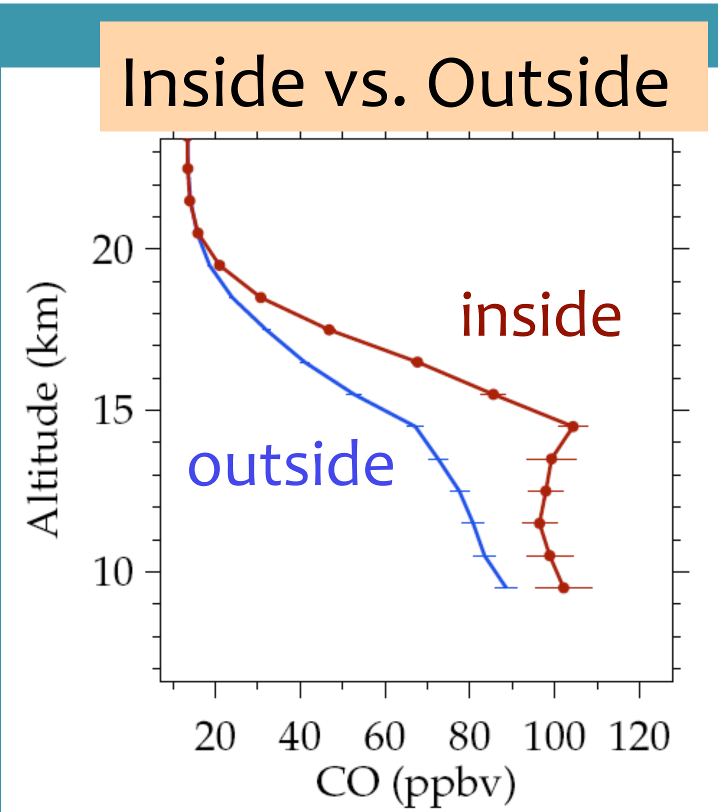


Inside: CO ≥ 60 ppbv
(10-40N/0-120E)

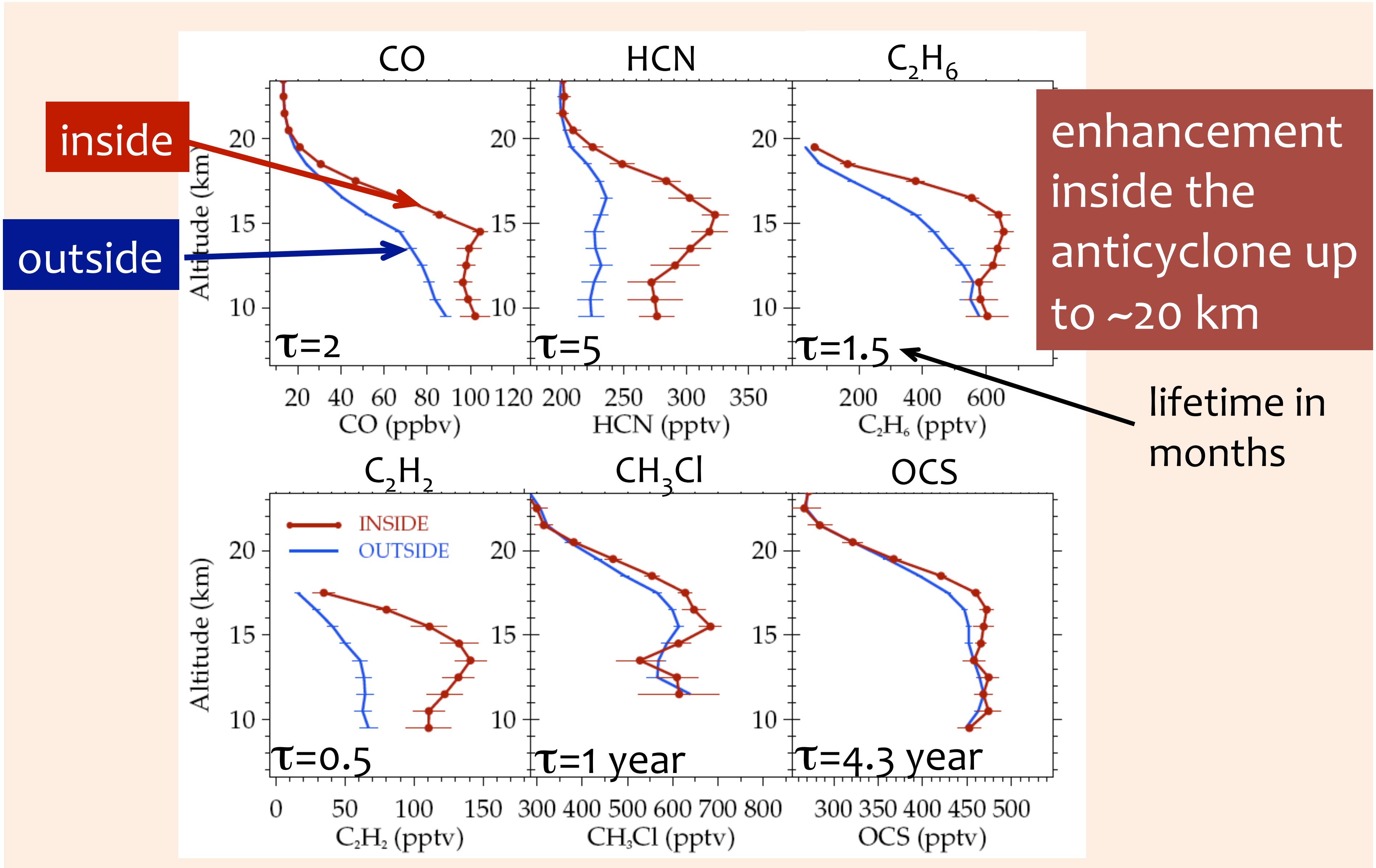
Outside: CO < 60 ppbv
(10-40N/0-360)

CO Profiles


CO (10-40N)
Altitude (km)
10
15
20
0
50
100
150
200
CO (ppbv)


Inside vs. Outside
inside
outside
Altitude (km)
10
15
20
20
40
60
80
100
120
CO (ppbv)

Tropospheric Tracers



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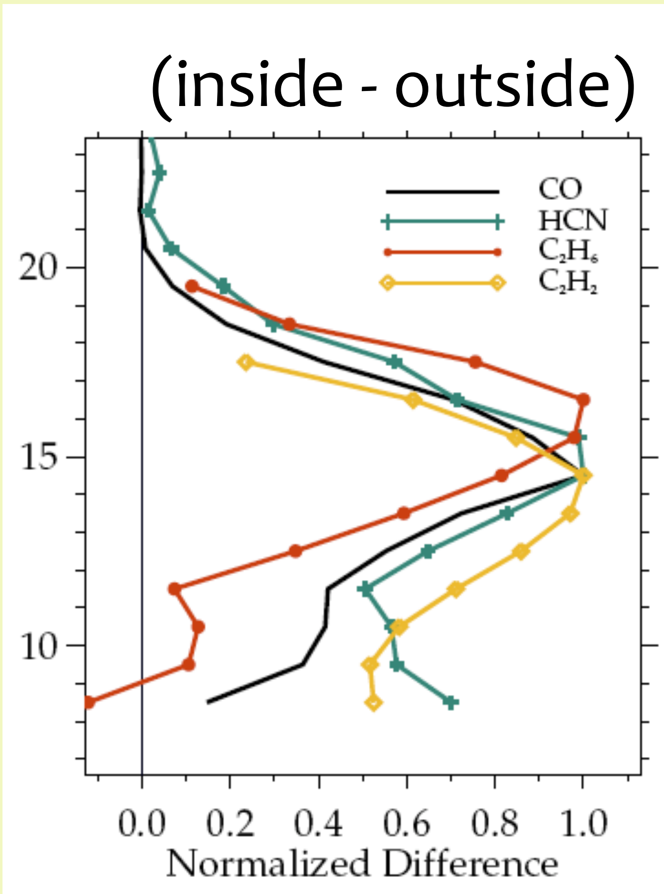
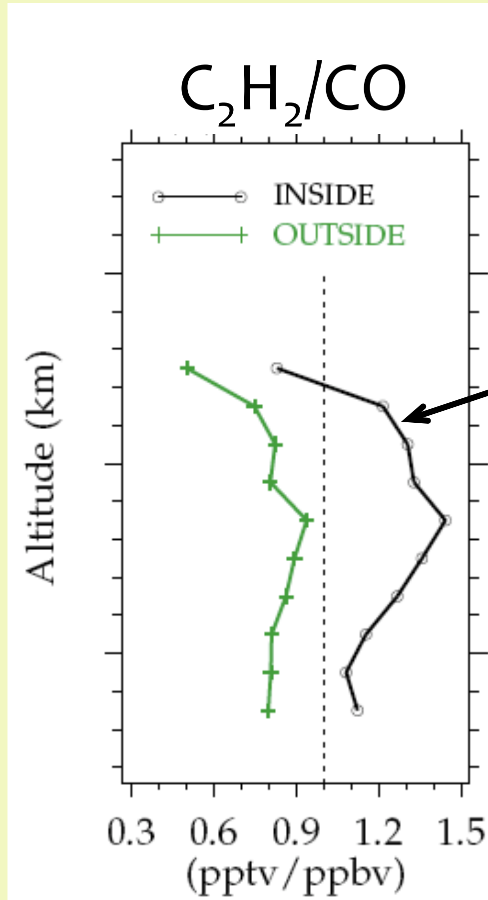
Normalized Differences

max





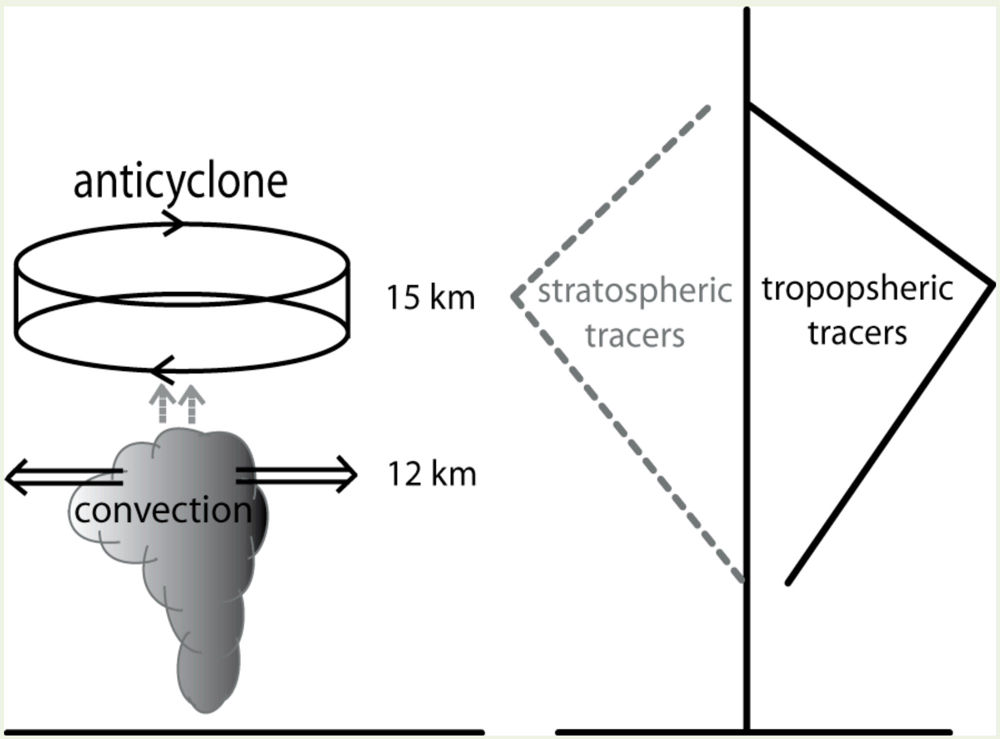
relatively young air inside the anticyclone

C_2H_2/CO ~ relative age of air

How do tracers reach the tropopause?

convection

tracers

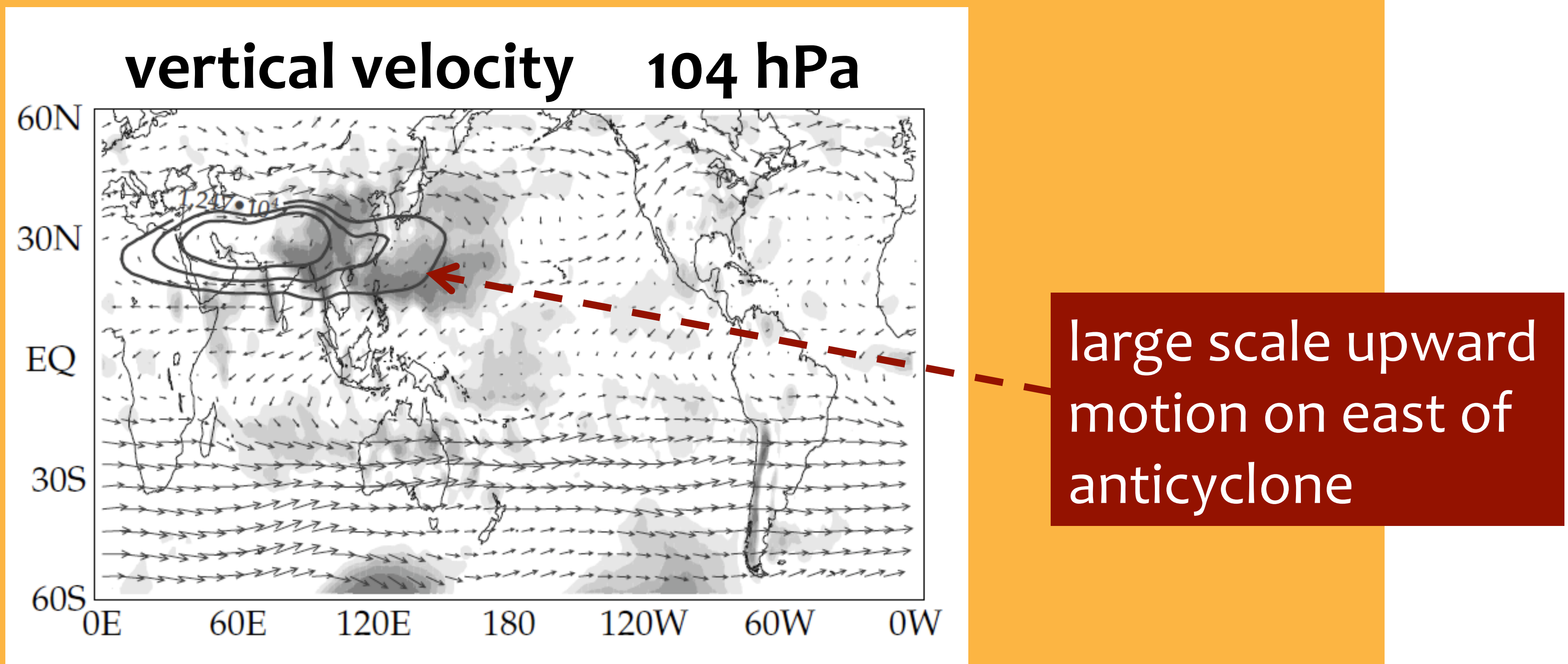


tracer max (min)

convective outflow (near ~12 km)

- large scale circulation ? - Park et al. (2007)
- convective overshooting ?

Vertical velocity from ERA40 Reanalysis



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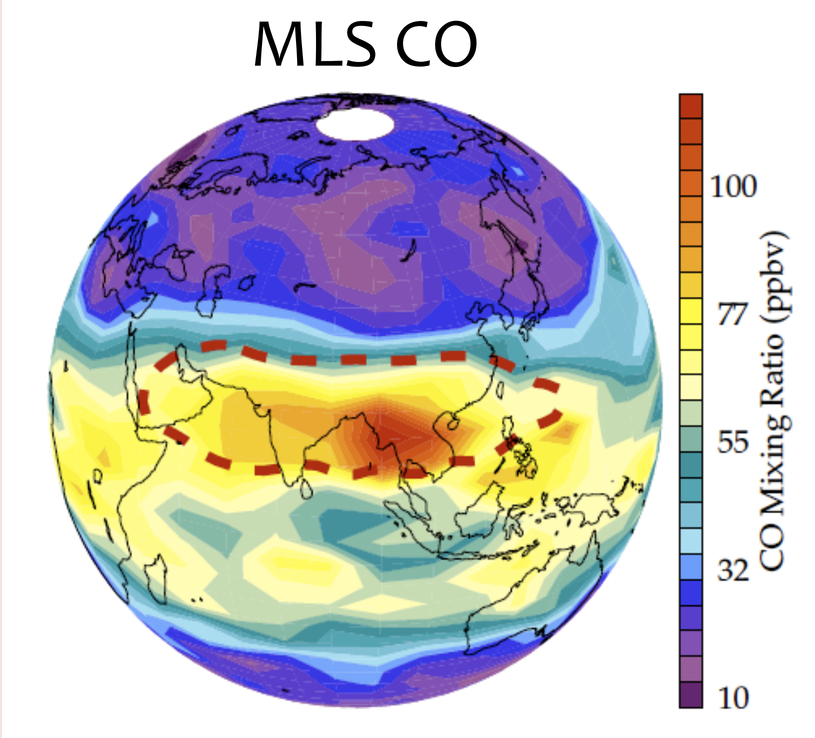
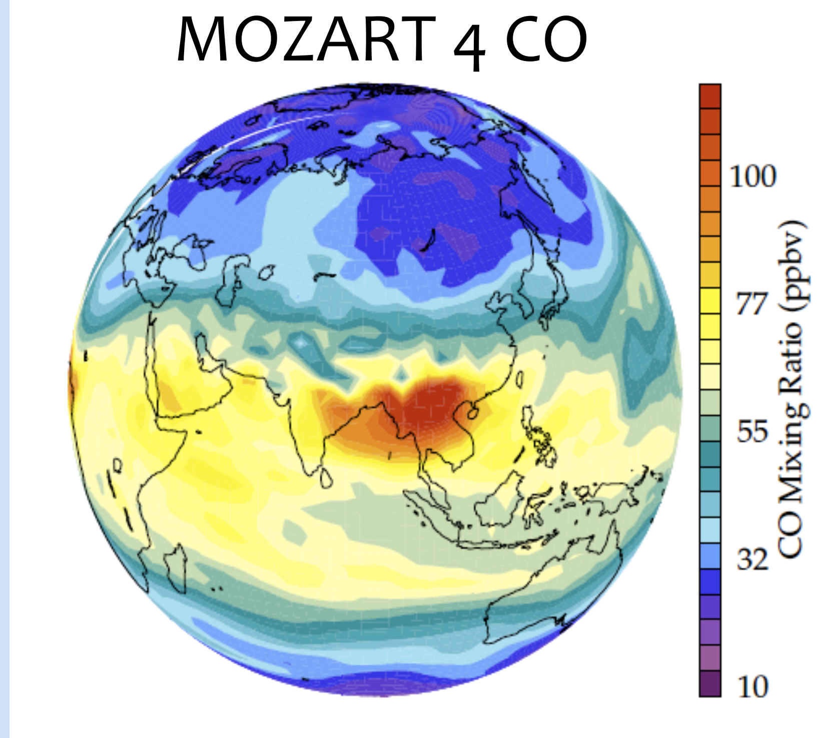
Chemistry Transport Model (**CTM**)

1. Model for OZone And Related chemical Tracers, version 4 (**MOZART 4**)
2. Driven by the NCEP/GFS analysis meteorology
3. Biomass burning + anthropogenic sources of CO (Granier et al., 2004; van der Werf et al., 2006)
4. Horizontal resolution - 2.8° × 2.8° (lat × lon)
5. Vertical grid - 42 sigma-levels (surface ~ 2 hPa)
6. June - September 2005

TWO DAY AVG. (Jun 6-7, 2005)





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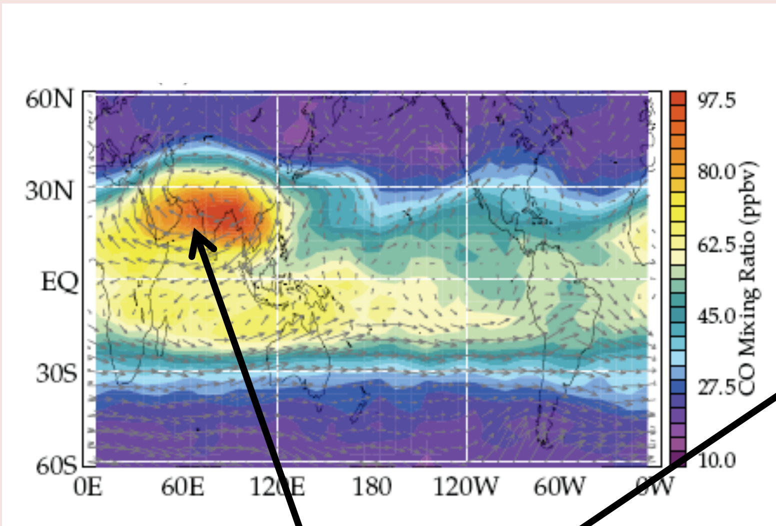
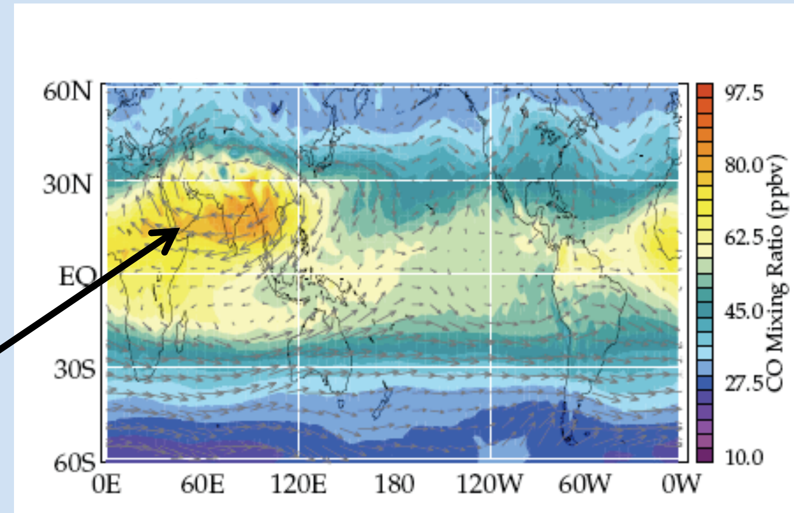
CO Climatology (Jun, 2005)

MLS (100 hPa)



MOZART 4 (100 hPa)



monsoon anticyclone

CO max – West vs. East

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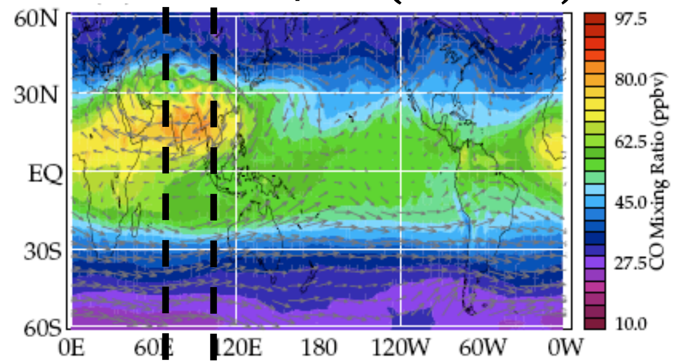
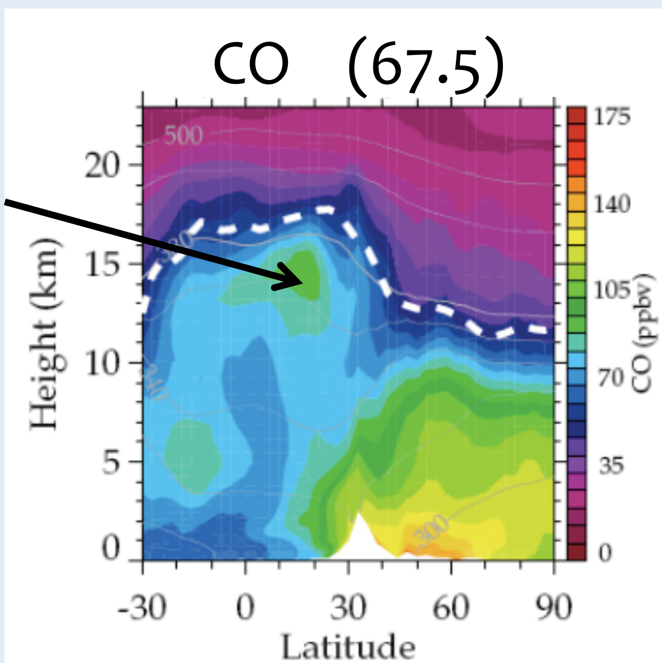
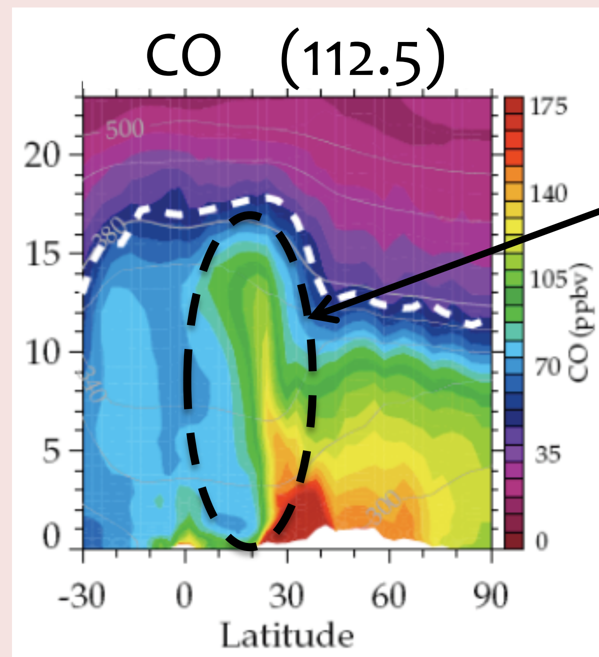
MOZART 4 CO (100 hPa)



far from CO max – **West** | **East** – on top of CO max

high CO



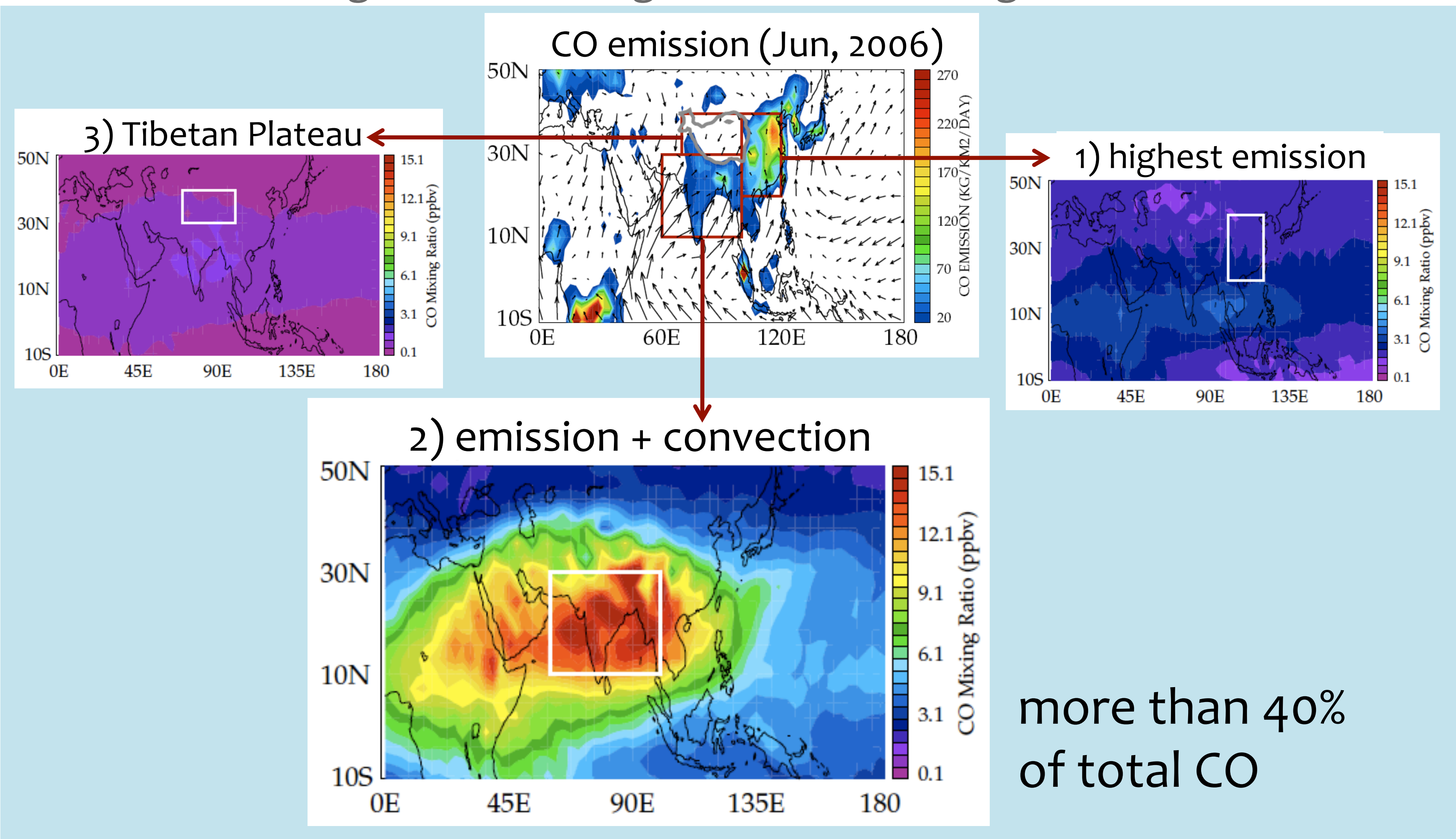


high CO

Tagged CO run

Where is the high CO originated from?

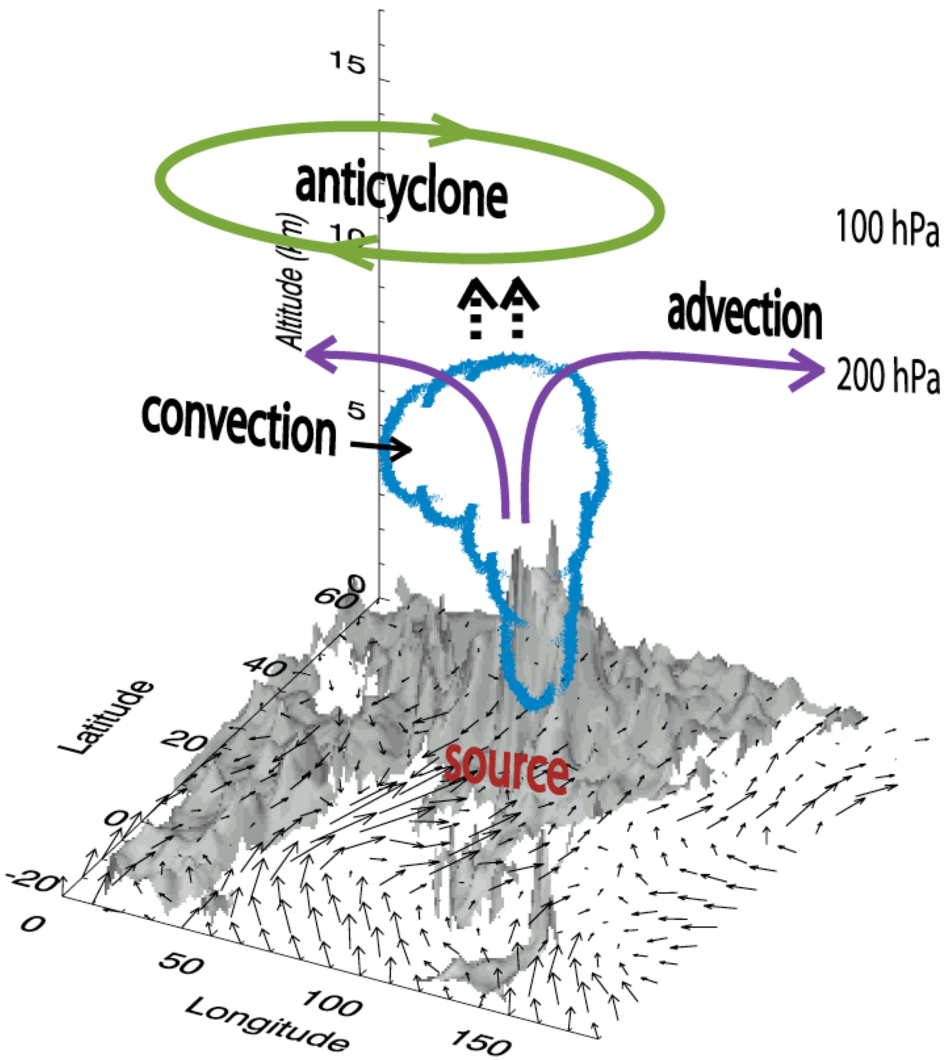
- Tag CO according to the source regions



more than 40% of total CO

Transport Pathways

(over Asian monsoon)



anticyclonic circulation

(vertical +horizontal advection)

convective outflow

(200 hPa)

convective transport

(mid-troposphere)

CO surface emission

(India and Southeast Asia)

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Summary

1. Satellites measurements of tracers show an enhancement inside the anticyclone.
2. MOZART 4 simulates large-scale CO variability reasonably well in the UTLS during NH summer.
3. Most of the high CO inside the monsoon anticyclone comes from India and Southeast Asia.
4. Convective transport contributes to CO budget over Southeast Asia up to about ~ 200 hPa.
5. Vertical advection by large-scale circulation accounts for transport up to ~15 km within anticyclone.