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

Mijeong Park¹, William J. Randel¹, Louisa K. Emmons¹, and Nathaniel J. Livesey²

¹National Center for Atmospheric Research
²Jet Propulsion Laboratory

4th SPARC General Assembly, 2008, Bologna
Asian Monsoon Anticyclone

Anticyclones do not lie on top of the deep convection!

Adapted from Gill (1980)
Strong confinement
(trajectory simulation at 150 hPa)

Day 0

Day 10

Day 20

large fraction remain inside anticyclone
Enhanced upper tropospheric CO in Asian monsoon anticyclone

2 day average of MLS CO
(Jun 20-21, 2005)
MLS CO and $O_3$ (Jul-Aug)

MLS CO max ($O_3$ min) within the anticyclone in the UTLS
MLS $H_2O$ (Jul-Aug)

**100 hPa**

- Asian monsoon anticyclone

**216 hPa**

- Over deep convection
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 (750-4400 cm\(^{-1}\)) using solar occultation technique
- CO, HCN, C\(_2\)H\(_6\), C\(_2\)H\(_2\), OCS, CH\(_3\)Cl, O\(_3\), HNO\(_3\), HCl, etc...

\[ \text{Inside: CO} \geq 60 \text{ ppbv} \]
\[ (10-40N/0-120E) \]

\[ \text{Outside: CO} < 60 \text{ ppbv} \]
\[ (10-40N/0-360) \]
CO Profiles

CO (10-40N)

Inside vs. Outside

inside outside
Tropospheric Tracers

Enhancement inside the anticyclone up to ~20 km

Lifetime in months

Inside

Outside
Normalized Differences

\[
\text{(inside - outside)}
\]

\[
\text{max}
\]

\[
\begin{align*}
\text{C}_2\text{H}_2/\text{CO} & \sim \text{relative age of air} \\
\end{align*}
\]

relatively young air inside the anticyclone
How do tracers reach the tropopause?

- Large scale circulation? - Park et al. (2007)
- Convective overshooting?
Vertical velocity from ERA40 Reanalysis

large scale upward motion on east of anticyclone
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)
CO Climatology (Jun, 2005)

MLS (100 hPa)

MOZART 4 (100 hPa)

monsoon anticyclone
CO max – West vs. East

MOZART 4 CO (100 hPa)

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

high CO
Tagged CO run

Where is the high CO originated from?
- Tag CO according to the source regions

1) highest emission

2) emission + convection

3) Tibetan Plateau

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)
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.