Overview of the Sounding Water vapor, Ozone, and Particle (SWOP) project during the Asian summer monsoon (2009~2015)

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Outline

- Scientific motivations
- Location & Instruments
- Campaigns & Data information
- Some results
- Future plan
Motivations

Importance of in situ observations:

✓ Satellite validation over this region

✓ For understanding transport and microphysical process in the UTLS
Campaign Locations

- ASM anticyclone spans subtropical Asian continent between 20°-40°N, higher tropopause
- KM (25°N, 103°E) within southeast edge of anticyclone, influenced by the air mass from outside
- LH (30°N, 91°E) @ anticyclone center and almost consistently within anticyclone limit

Bian et al. GRL, 2012
Balloon-borne sondes

- Compact Optical Backscatter Aerosol Detector (COBALD - ETH)  ci. & aerosol
- Frost Point Hygrometer (FPH - NOAA GMD)  H₂O & RHi
- Cryogenic Frost-point Hygrometer (CFH - Vömel)  H₂O & RHi
- Electrochemical Concentration Cell (ECC) Ozonesonde  O₃
- Radiosonde: P, T, U, winds (u,v) (iMet)

See talk of Frank Weinhold (tomorrow)
POPS – a newcomer in 2015

- Measure aerosol profiles of size spectrum
- Talk of Ru-shan Gao (tomorrow)
Seven IOPs during 2009-2015

2010 Aug 22-28
12 CFH/ECC
3 Cobald

2013 Aug 3-26
22 CFH/ECC
18 Cobald

2009, Aug 7-13
11 CFH/ECC

2011, Sep 12-15
4 CFH/ECC

2012, Aug 11-Sep 6
18 CFH/FPH
38 ECC, 12 Cobald

2014, Aug 13-22
10 CFH/ECC/Cobald

2015, Aug 3-18
12 CFH/ECC/Cobald
### Sounding & Instruments

<table>
<thead>
<tr>
<th>Dates:</th>
<th>AUGUST</th>
<th>SEPT</th>
</tr>
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<tbody>
<tr>
<td>2009</td>
<td>0</td>
<td>2015</td>
</tr>
</tbody>
</table>

| K | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| L | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| K | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

1=ECC; 2=1+CFH; 3=2+CBD; 4=3+POP

\[ O_3 \rightarrow H_2O \rightarrow \text{cirrus + aerosol} \rightarrow \text{aerosol} \]
Obs. highlights - ATAL issues

1. COBALD data confirms the ATAL finding from CALIOP

Details to be seen in talk of J-P Vernier (tomorrow)
1. Enhance 14-19km
2. Extend 2km above CPT
3. Interstitial aerosol

Details to be seen in talk of Ru-Shan Gao
H$_2$O rel. diff.
(MLS – CFH)

<5% above 68mb
+7% @83mb
−7% @100mb
larger bias & dev.

Similar plot Can be found in Yan et al. AMTD, 2016
Obs. highlights - MLS Validation

(b) MLS v4

O$_3$ rel. diff.
(MLS – ECC)

bias abrupt jump

Yan et al. AMTD, 2016
RESULTS -- Statistics

1. CPT variables

**KM**

\[ \text{H: } 17.30 \pm 0.43 \]
\[ \text{T: } 193.7 \pm 1.7 \]
\[ \Theta: 384.2 \pm 8.4 \]

**LH**

\[ \text{H: } 17.54 \pm 0.53 \, +0.24\text{km} \]
\[ \text{T: } 195.2 \pm 1.7 \, +1.5\text{K} \]
\[ \Theta: 390.4 \pm 10.3 \, +6\text{K} \]

**TC^4**

\[ \text{H: } 16.6 \pm 0.7 \text{ km} \]
\[ \Theta: 375.1 \pm 13 \text{ K} \]

Pan et al. JGR, 2014
1. CPT variables

min H₂O locates @ 2 km above CPT - “tape recorder”
2. Interannual variation of H$_2$O in UTLS

Decoupled with lower levels

Interannual variation tuned by $T$?
RESULTS -- Statistics

3. RHi, super-saturation, cirrus
Inside cloud
For Lhasa

Cirrus fraction

Supersaturation fraction

RH_{ice} (Lhasa, China 2009–2015 August/September only 39 soundings)

Fraction of Supersaturation
Lhasa, China 2009–2015 August/September only 39 soundings

Fraction of Cirrus Clouds
Lhasa, China 2009–2015 August/September only 21 soundings
1. Generally, high RHi ↔ cirrus, but sometimes no.

2. In situ obs has finer RHi & cirrus structure
Some cases

Case 1:

A deep layer of supersaturated air & cloud
Some cases

Case 2:

Anti-correlation between cirrus layer and supersaturation

Also reported using Global Hawk data.
Jensen et al., PNAS, 2013

Kunming, 20 Aug’12

Supersaturation @ light cirrus;
Low RHi @ dense cirrus;
Extra H$_2$O taken by dense cirrus.
Some cases

Case 3:

Aerosol-cirrus coupling: Hygroscopic swollen, or evaporation?
Some cases

Case 4:

Typhoon transport followed by fast advection

O₃: 35 ppb
H₂O: 2.0 ppm ➔ -84°C
CPT: -80.89°C
@100mb
Some cases

Case 5:

Typhoon convection & extra-tropical isentropic advection.

Details to be seen in talk of Baerbel Vogel
Field Campaign in 2016 Summer

- 15 soundings
- Mid-Jul to Aug
- 6+4 POPS

O₃, H₂O, particle

O₃

Lidar
To coordinate with
StratoClim Field Campaign
Summary

- First in situ measurement within the ASM anticyclone.
- Highlights related to ATAL, MLS validation, TTL structure, RHi-supersaturation-cirrus, cirrus-aerosol coupling, dynamical transport, ...

Interested in SWOP data: bjc@mail.iap.ac.cn

Thanks for your attention!