Water vapor, ozone and cirrus in the Asian monsoon

New results from Kunming, China

Dale Hurst, Emrys Hall, Allen Jordan
NOAA ESRL Global Monitoring Division & CIRES, University of Colorado Boulder, Colorado

Jianchun Bian, Qian Li
Institute of Atmospheric Physics Beijing, China

Holger Vömel
GRUAN Lead Center Lindenberg, Germany

Frank Wienhold, Thomas Peter
ETH, Zürich, Switzerland

Karen Rosenlof
NOAA ESRL Chemical Sciences Division

Laura Pan
NCAR, Boulder, Colorado
The Revised Plan – August 2012

Kunming & Lhasa: 60+ balloon launches
SEAC$^4$RS: Bay of Bengal – 3 aircraft from LT to UTLS

Jun-Jul-Aug @ 100 hPa from Wright et al. (2011)
Instrumentation and Launch Schedule

- Compact Optical Backscatter Aerosol Detector (ETH)
- NOAA Frost Point Hygrometer (NOAA GMD)
- Cryogenic Frost Point Hygrometer (Vömel - DMT)
- Electrochemical Concentration Cell Ozonesonde (DMT)
- Radiosonde: P, T, U, winds (u,v) (InterMet)
Balloon-based Vertical Profile Measurements

Kunming 2012

N: 38 Flights
CPT: $17.3 \pm 0.5$ km
T: $-79.3 \pm 1.5$ °C
$\theta$: $385 \pm 10$ K
P: $91 \pm 7$ hPa

10°S - 10°N, August

$\theta$: 
- LRT: 370 K
- CPT: 375 K

25°N

Tropics

385K 17.3 km
16.2 km
15.7 km

375K

LRT

370K

25°N
Kunming 2012: Supersaturation

![Graph showing supersaturation data with altitude on the y-axis and RHi (%) on the x-axis.](image-url)
Kunming 2012: Supersaturation

Flights with COBALD
COBALD Data

**COBALD Specifics**

2-channels:

- 870 nm
- 455 nm

Color Index = 

\[
\frac{(BSR-1)}{(BSR-1)}
\]

>15 indicative of cirrus (>3 μm)
Flight KM031 – a case study

COBALD Color Index

KM031
20120820
RHi (%)  Color Index

Altitude (km)

RHi (%)  Color Index

13.0-17.3 km
Supersaturation: Frequency of Occurrence

**Ssat Freq 16-18 km**

KM2012: 10 – 13%

KM2009: 13 – 18%

LH2010: 11 – 27%
Summary

- KM2012 (August) Balloon-borne measurements of: P, T, O\textsubscript{3} (N=38), FP H\textsubscript{2}O (N=21), COBALD Cirrus (N=12)

- Influences of convective uplift to CPT, but not above i.e. no evidence of ice lofting into LS

- COBALD detection of cirrus layers (Color Index)
  - RH\textsubscript{i} up to 160\% in clear air
  - Relaxation of supersaturation within cirrus
  - Anticorrelation between RH\textsubscript{i} and Color Index

- KM2012: 10-13\% of UT air masses were supersaturated similar frequency as KM2009 but smaller than LH2010
  - KM2012 freq increases by 3\% if UT cirrus are included

- August 2013: Lhasa campaign planned but access to non-Chinese nationals is very difficult at this time