Balloon- borne measurement of Asian tropopause aerosol layer at Lhasa and Kunming during Asian summer monsoon

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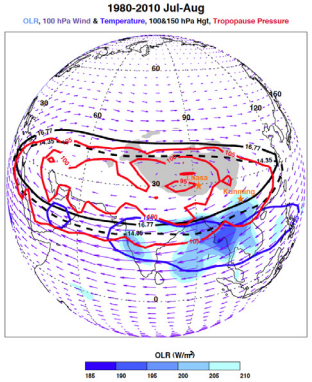
Abstract

Satellite observations show that the Asian summer monsoon (ASM) anticyclone has higher concentration of tropospheric tracers (such as CO, H_2O, HCN, cirrus, and aerosol) and lower stratospheric tracers (such as O_3) in the upper troposphere and lower stratosphere (UTLS), which seems to imply that the ASM circulation system is be a significant transport pathway for water vapor and pollutants to enter the stratosphere. These satellite retrievals, however, have coarse vertical resolution and lack of validation in this region, so in situ measurements is critical for better understanding the truth and related atmospheric dynamical and physical processes. During the last few summers, we have conducted tens of balloon-borne water vapor, ozone, and particle measurements at Kunming and Lhasa during the ASM. We are giving a brief introduction of the field campaign, and presenting some key results from these measurements about the distribution of water vapor, ozone, relative humidity over ice, cirrus and aerosol in the UTLS, and related features of tropopause transient layer within the ASM anticyclone. Some interesting cases are also shown for attracting your attention.

ASM Anticyclone and the Sounding Locations



Lhasa is located slightly east of the anticyclone center over the Tibetan Plateau, and is consistently within the anticyclone limit.

Kunming was inside the anticyclone limit most times during the campaign but influenced by the air-mass from outside.

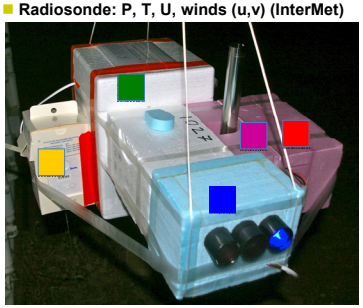
The tropopause is higher over the ASM anticyclone.

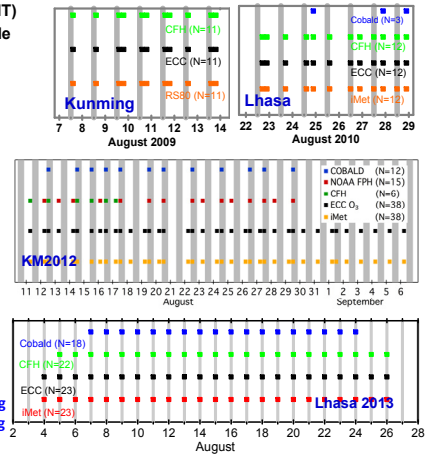
The lowest OLR, showing strong deep convection, is located over the southeast of the anticyclone. The region is also associated with coldest temperatures.

Climatology (July-August, 1980-2010) of the ASM anticyclone and the campaign locations. The anticyclone is shown using GPH at 100 hPa (solid black contour, 16.77 km) and 150 hPa (dashed black, 14.35 km), and the 100 hPa wind vectors (purple). Also shown are selected contours for tropopause pressure (red, hPa), outgoing longwave radiation (OLR) (filled blue,Wm^{-2}), and temperature at 100 hPa (blue, 195° K). Grey shading identifies terrain with altitude over 3 km. NCEP/NCAR reanalyses fields are used.

Balloon-borne sondes and launch schedule

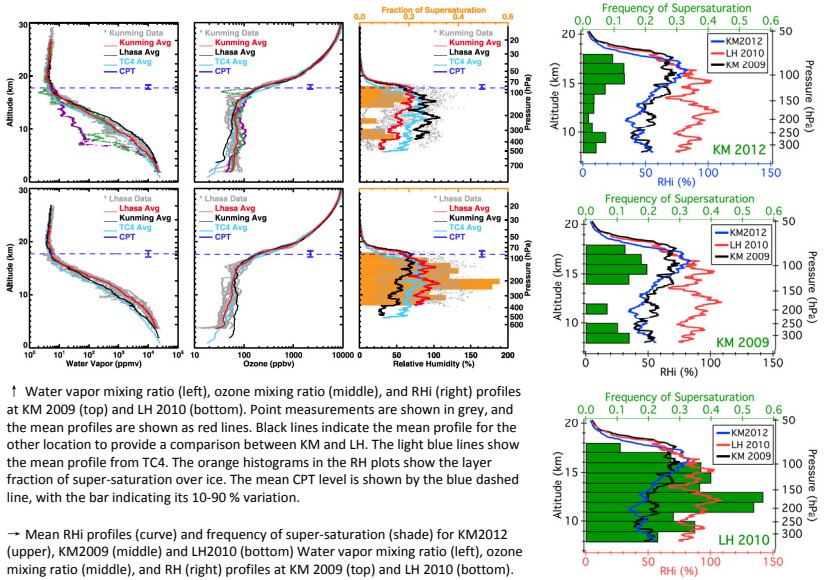
- Compact Optical Backscatter Aerosol Detector (ETH)
- NOAA Frost Point Hygrometer (NOAA GMD)
- Cryogenic Frost Point Hygrometer (Vömel - DMT)
- Electrochemical Concentration Cell ozonesonde
- Radiosonde: P, T, U, winds (u,v) (InterMet)





- CFH & FPH measure the water vapor concentration and RHi by detecting the frost point of the air-mass.
- COBALD detects cloud particle and aerosol by emitting light at two wavelengths (455nm, 870nm), and receiving the back-scattered signal.

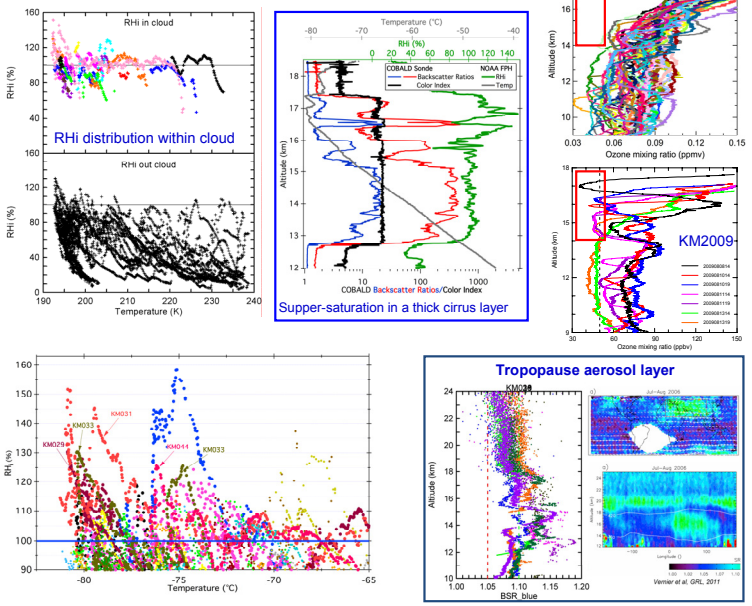
Water Vapor, Ozone, and Relative Humidity



↑ Water vapor mixing ratio (left), ozone mixing ratio (middle), and RHi (right) profiles at KM 2009 (top) and LH 2010 (bottom). Point measurements are shown in grey, and the mean profiles are shown as red lines. Black lines indicate the mean profile for the other location to provide a comparison between KM and LH. The light blue lines show the mean profile from TC4. The orange histograms in the RH plots show the layer fraction of super-saturation over ice. The mean CPT level is shown by the blue dashed line, with the bar indicating its 10-90 % variation.

→ Mean RHi profiles (curve) and frequency of super-saturation (shade) for KM2012 (upper), KM2009 (middle) and LH2010 (bottom) Water vapor mixing ratio (left), ozone mixing ratio (middle), and RH (right) profiles at KM 2009 (top) and LH 2010 (bottom).

Some Cases and Features



Cold Point Tropopause (CPT)

CPT	Kunming	Lhasa	Alajuela
Lat., Lon.	25.0 N, 102.7 E	29.7 N, 91.1 E	10 N, 84.2 W
Altitude (km)	17.8 / 17.3	17.7	16.7
Pressure (hPa)	85.1 / 91.0	87.2	98.9
Temperature (K)	193.4 / 193.9	194.2	194.3
Pot. Temp (K)	390.1 / 385.0	389.2	375.8
Year	2009 / 2012	2010	2007

Citation: (some of the work shown here are published in a GRL paper)

Bian, J., L. L. Pan, L. Paulik, H. Vömel, H. Chen, and D. Lu (2012), In situ water vapor and ozone measurements in Lhasa and Kunming during the Asian summer monsoon, *Geophys. Res. Lett.*, **39**, L19808, doi:10.1029/2012GL052996

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