Overview of 10-year Sounding Water vapor, Ozone, and Particle campaign (SWOP) during the Asian summer monsoon (2009~2018)

Jianchun Bian , Z.-X. Bai, D. Li, Q. Li , J.-Q. Zhang, Y.-J. Xuan (LAGEO/IAP/CAS, China);

Y.-J. Duan (Kunming Meteorological Bureau); W.-G. Wang (Yunnan U.); Bianba (Lhasa Meteorological Bureau);

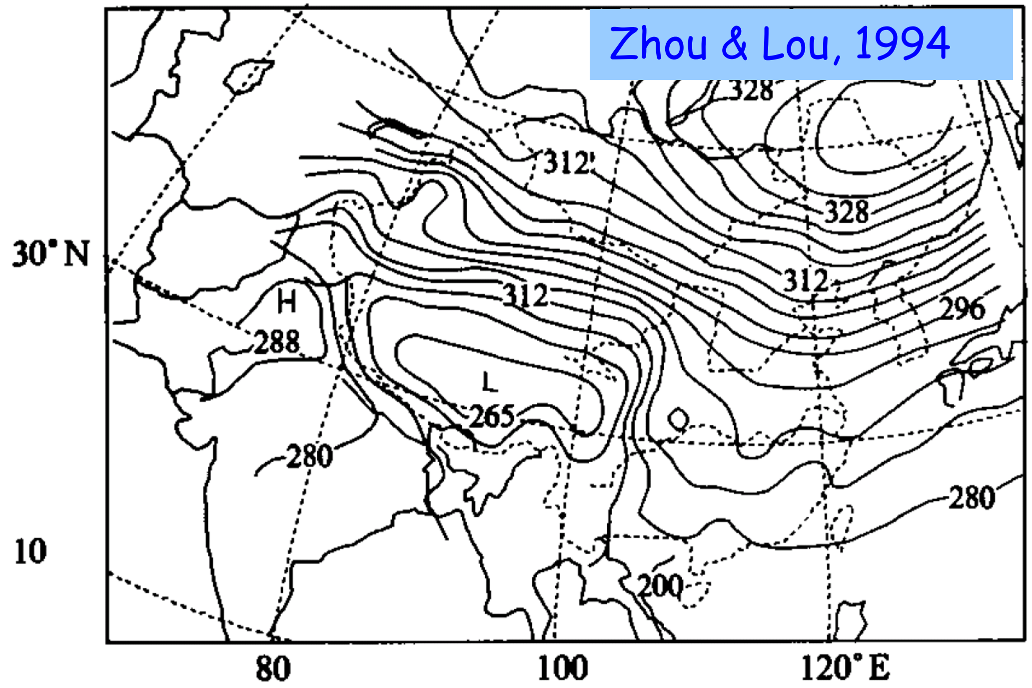
S. Liu (U. Science & Technology of China);

H. Vömel, L. Pan (NCAR, USA); F. Weinhold, T. Peter (ETH zürich) ;

R.-S. Gao, P.-F. Yu, D. Hurst, E. Hall, A. Jordan, S. J. Oltmans (ESRL/NOAA, USA)

From Tibetan Plateau - Early history

- TP ~ a long-lasting topic for atmospheric research (Yeh, 1949, 1950; Yin, 1949; Bolin, 1950). -dynamics
- TOMS data show a summertime total ozone valley (Zhou & Luo, 1994) -chemistry

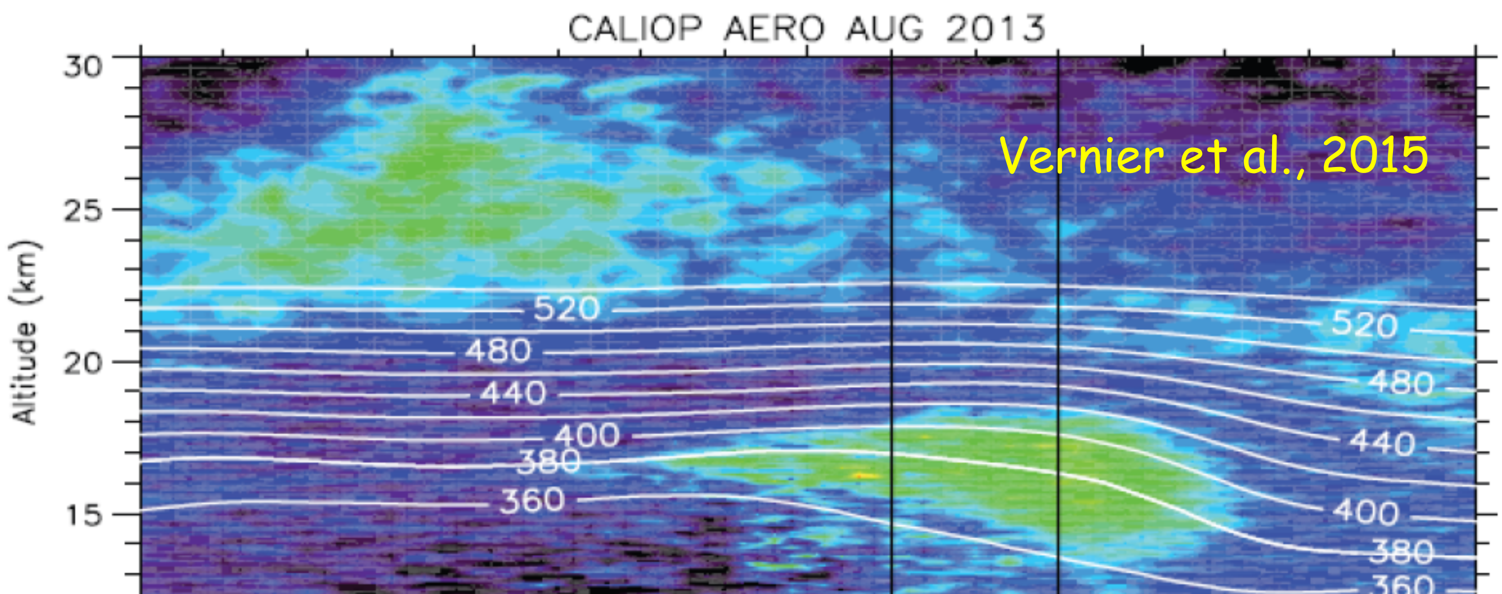


- Hypothesis: BL pollutants converge to TP, then transport to UTLS by ASM updraft, which is induced by the huge elevated heat source (Zhou et al., 1995).
- Mechanisms: dynamics, chemistry

Zhou X., and C. Luo, 1994: Ozone valley over Tibetan plateau, J. Meteorological Research, 8(4): 505-506

Recent progresses

- **ASM anticyclone – its significance**
  - — Enhanced center of tropospheric tracers (CO, H_2O, HCN) (e.g. Rosenlof et al., 1997; Filipiak et al., 2005; Li et al., 2005; Fu et al., 2006; Park et al., 2007,Randel et al., 2010)
  - — Low center of stratospheric tracers (O_3, HCl) (Gettelman et al., 2004)
  - — Largest center of cirrus fraction (Pan & Munchak, 2011)
  - — Enhanced center of aerosol (Vernier et al., 2011)



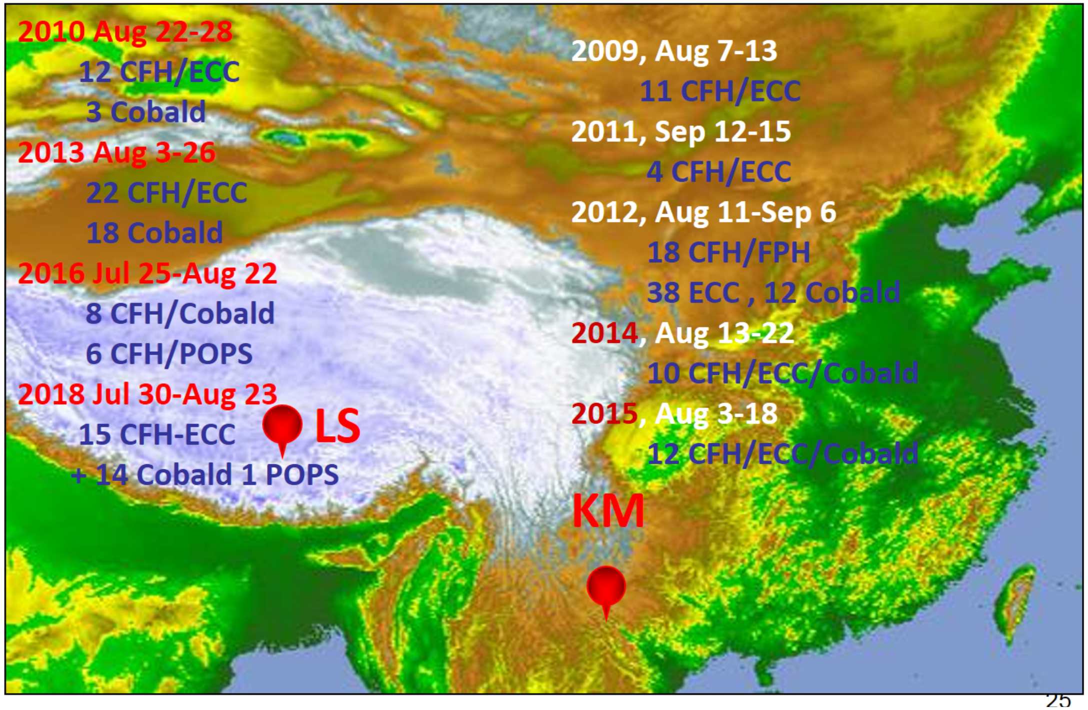
[redacted]

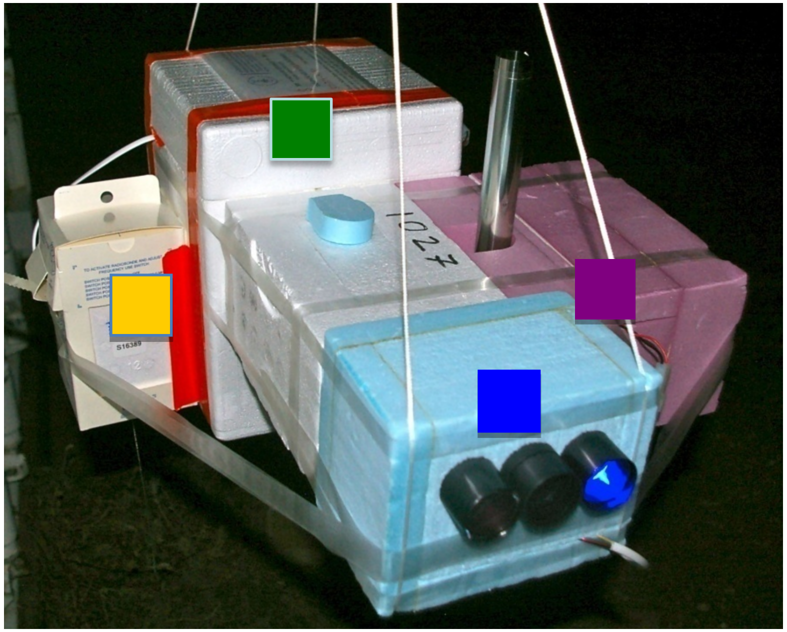
Importance of in situ observations

- ✓ Previous observation is largely based on satellite retrievals. Satellite data and models often do not provide sufficiently resolved details for describing the transport process. Satellite product lacks of validation over the ASM region.
- ✓ In situ measurements inside the anticyclone are scarce. We report the first in situ measurements of water vapor, ozone, and particles within the ASM anticyclone. Balloon-borne instruments were launched from Kunming and Lhasa over the Tibetan plateau during 2009-2018 summers.
- ✓ These observations will be significant for quantifying the moisture and pollutant transport associated with the ASM, for identifying the transport pathway, and for understanding microphysical and chemical process in the UTLS.

Balloon-borne sondes

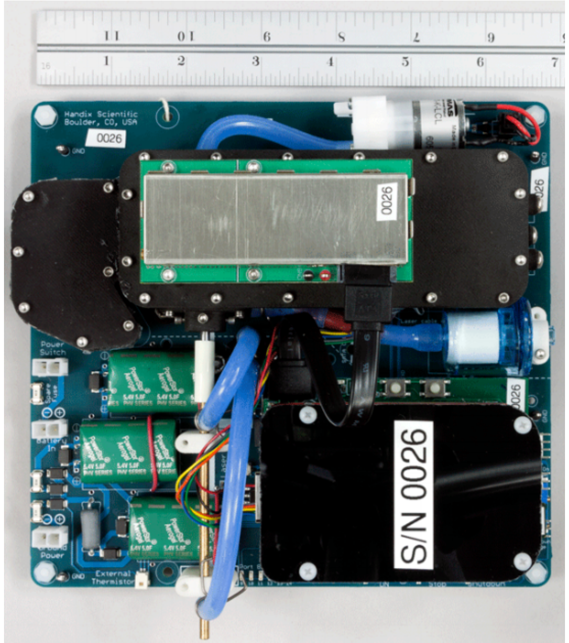
- Compact Optical Backscatter Aerosol Detector (COBALD - ETH)
- Cryogenic Frost-point Hygrometer (CFH - Vömel)
- Electrochemical Concentration Cell (ECC) Ozonesonde
- Radiosonde: P, T, U, winds (u,v) (iMet)





Bian et al. GRL, 2012

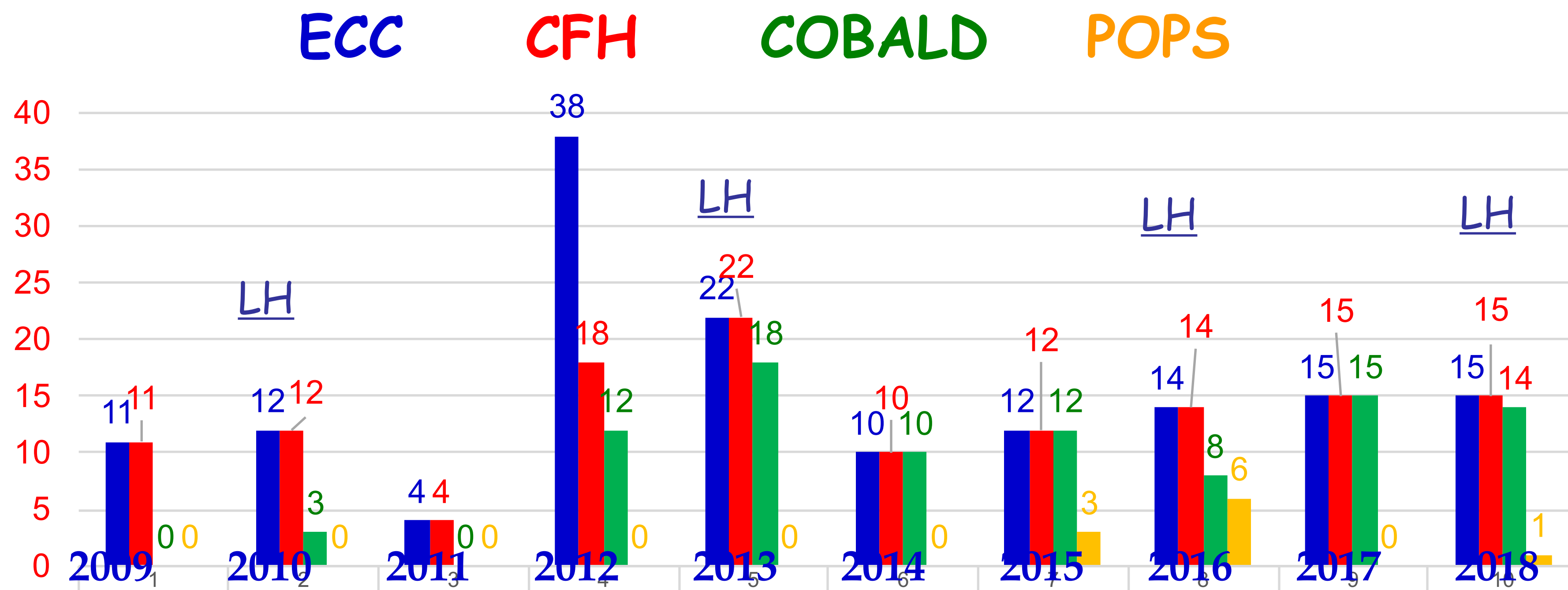
POPS since 2015



Measure profiles of aerosol size spectrum: 140~3000nm

Ru-shan Gao (ESRL/NOAA, Handix)

Sounding numbers



	1	2	3	4	5	6	7	8	9	10
Series1	11	12	4	38	22	10	12	14	15	15
Series2	11	12	4	18	22	10	12	14	15	15
Series3	0	3	0	12	18	10	12	8	15	14
Series4	0	0	0	0	0	0	3	6	0	1

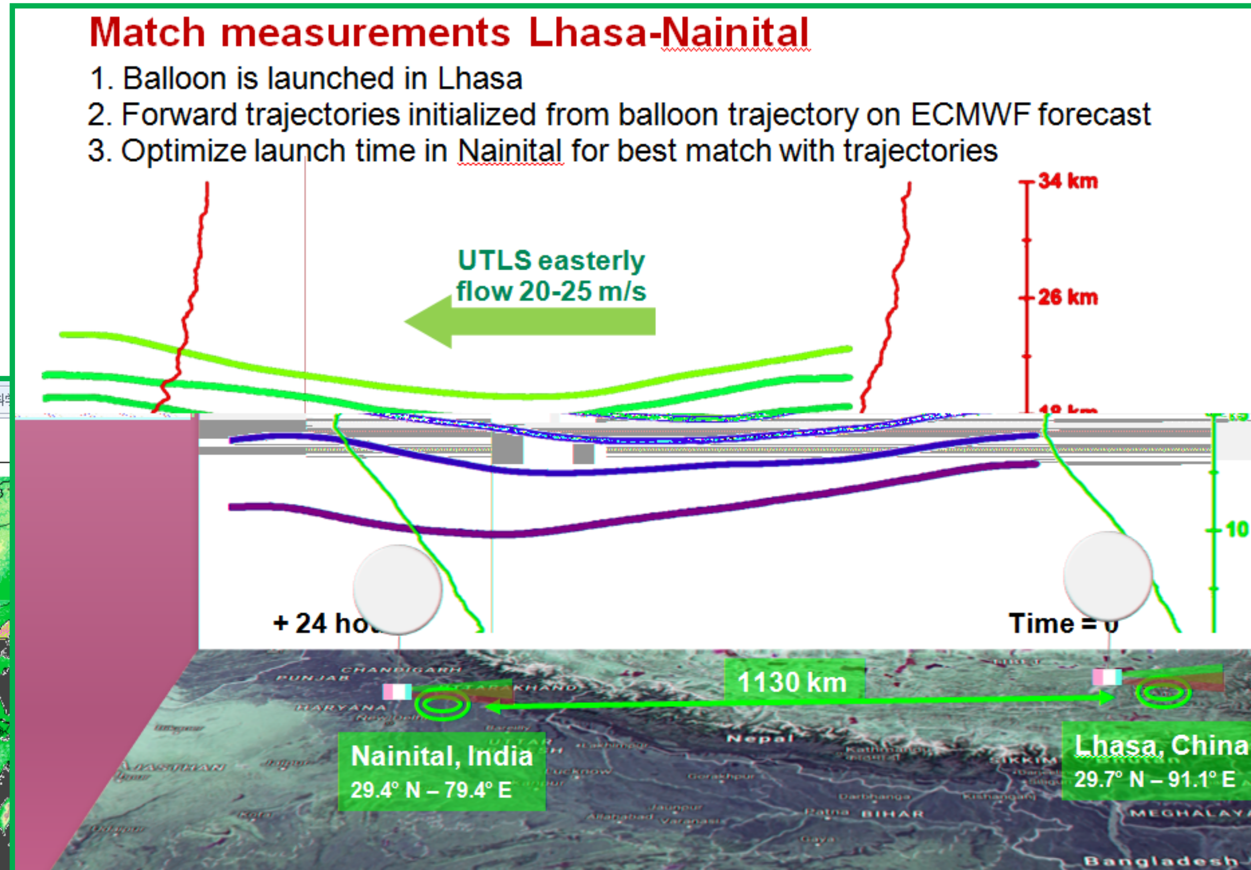
Series1 Series2 Series3 Series4

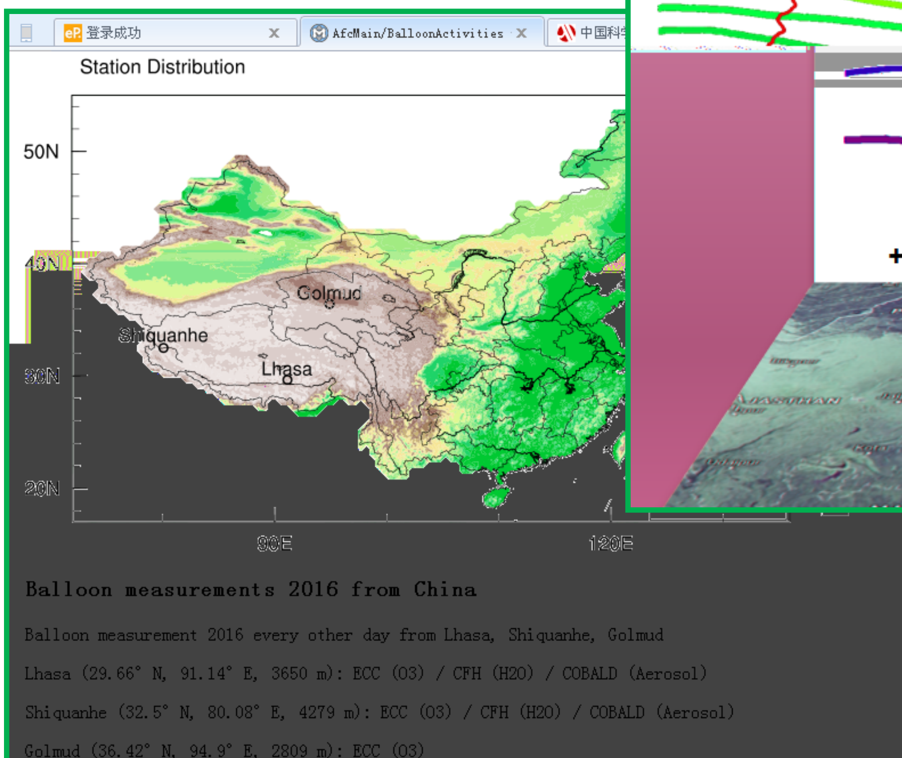
Kunming total: 90 ECC, 70 CFH, 49 COBALD, 3 POPS

Lhasa total: **63** ECC, **63** CFH, **43** COBALD, **7** POPS

Collaboration with StratoClim

Match sounding in 2016-2017 summers

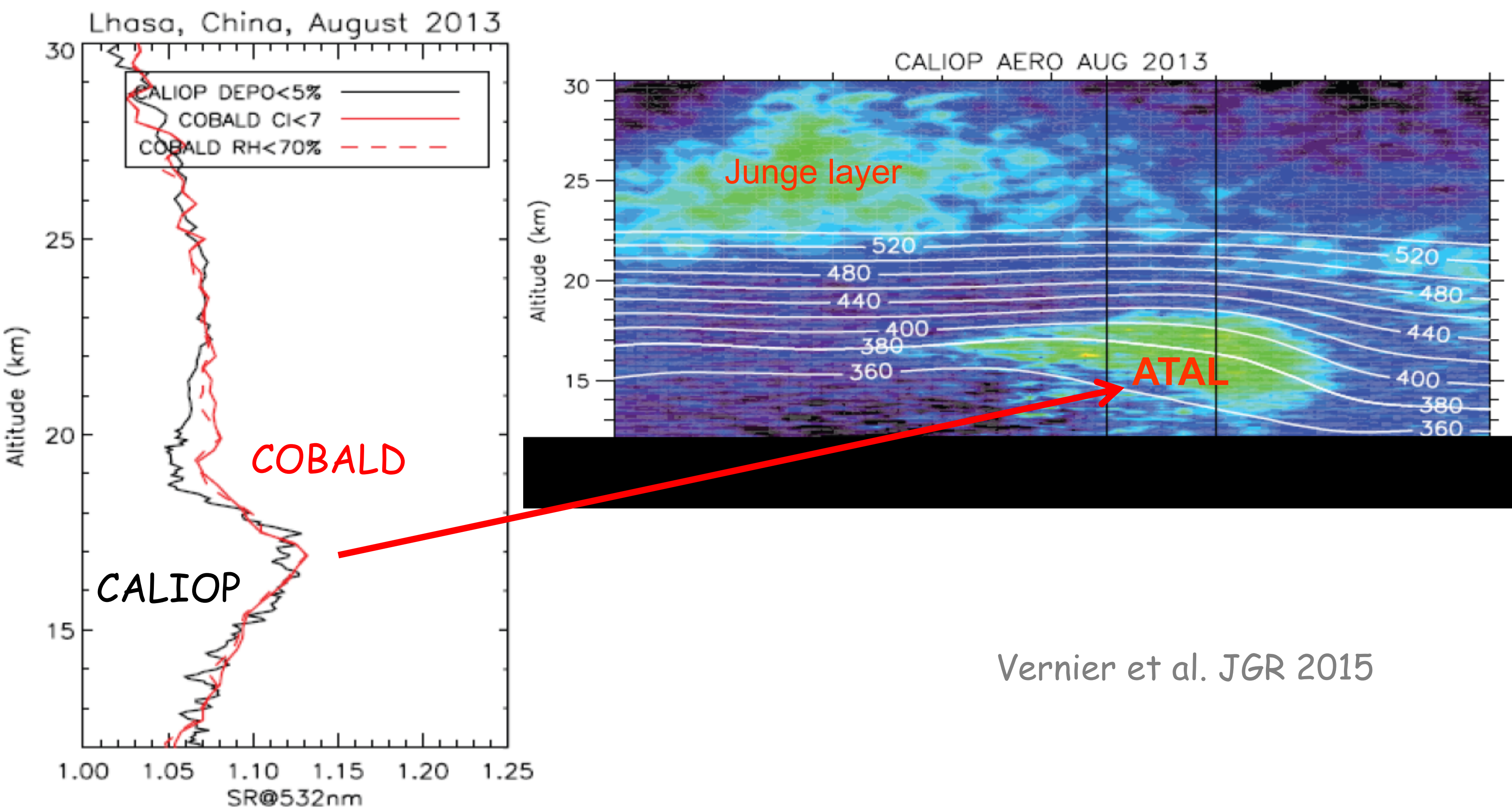




From Peter et al., 2017

Obs. highlights

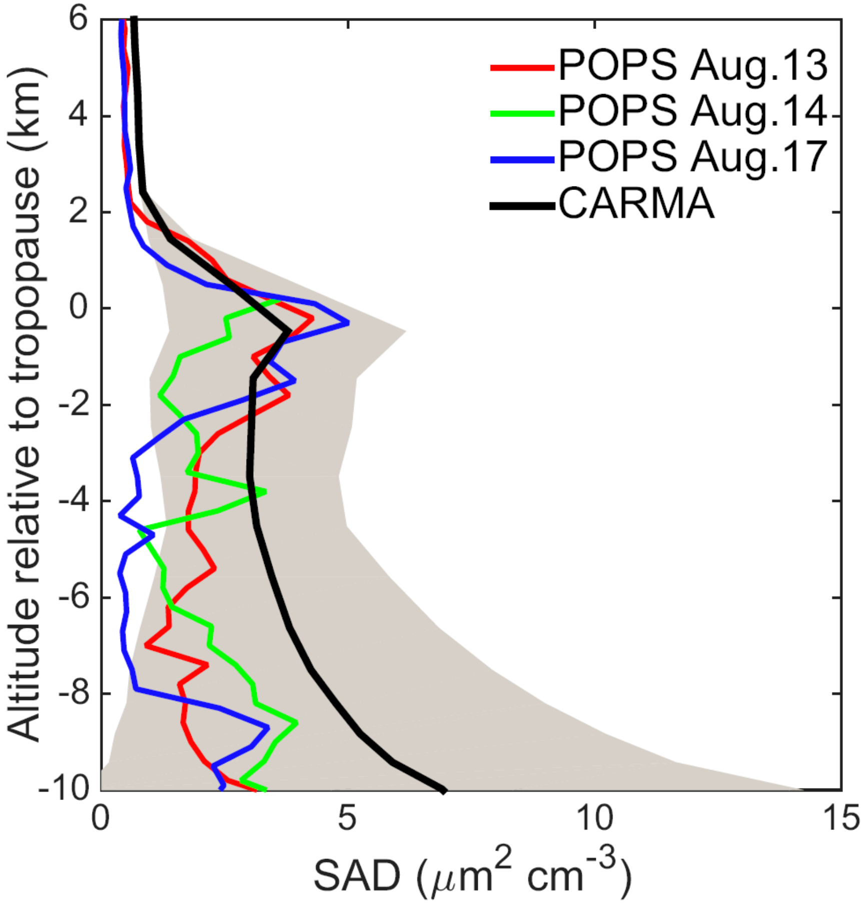
1. COBALD data confirmed the ATAL finding from CALIOP



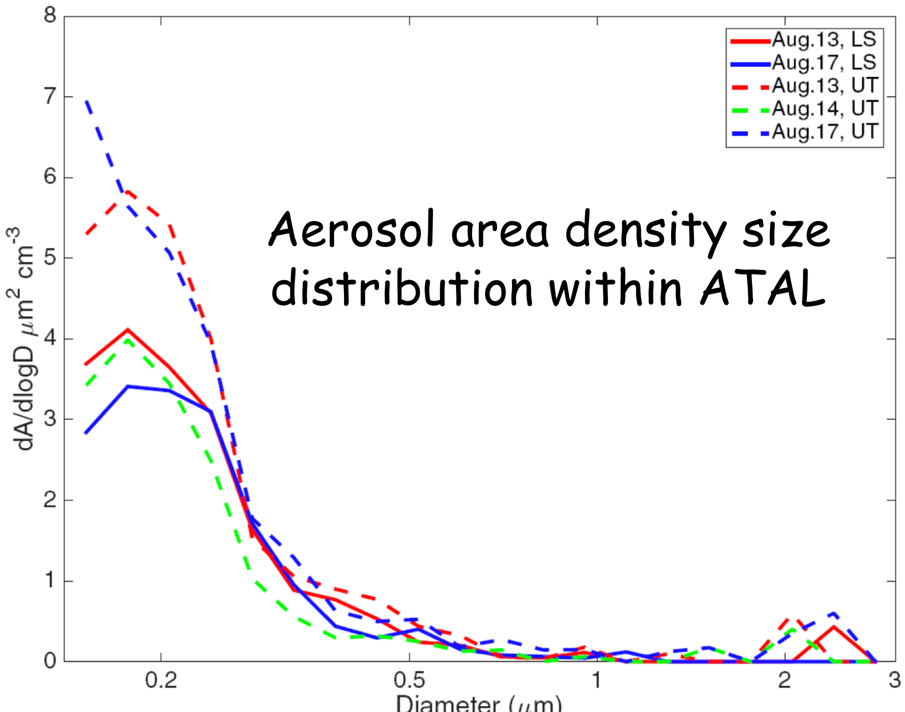
Vernier et al. JGR 2015

Obs. highlights

2. POPSs measured aerosol size distribution profile in the ATAL



1. Enhanced @ 14-19km
2. Extend 2km above CPT
3. Interstitial aerosol (in cirrus)



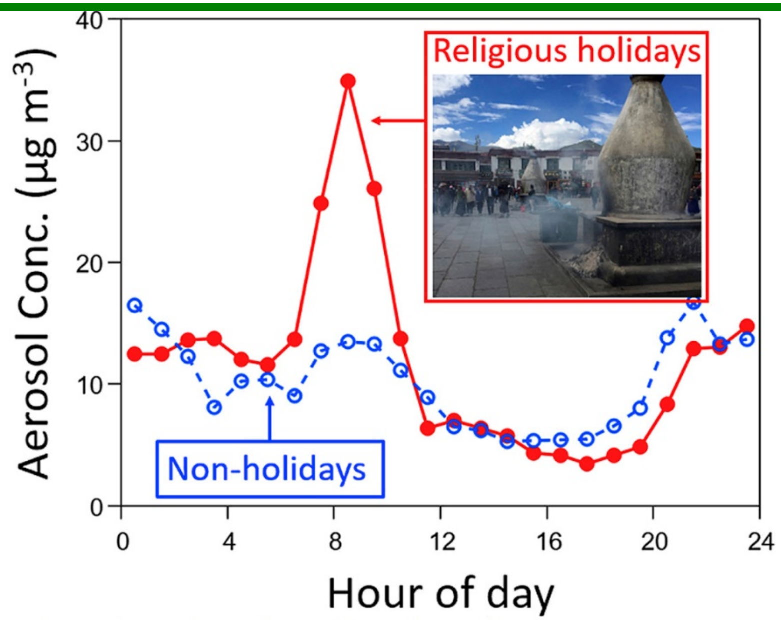
Yu et al. PNAS, 2017

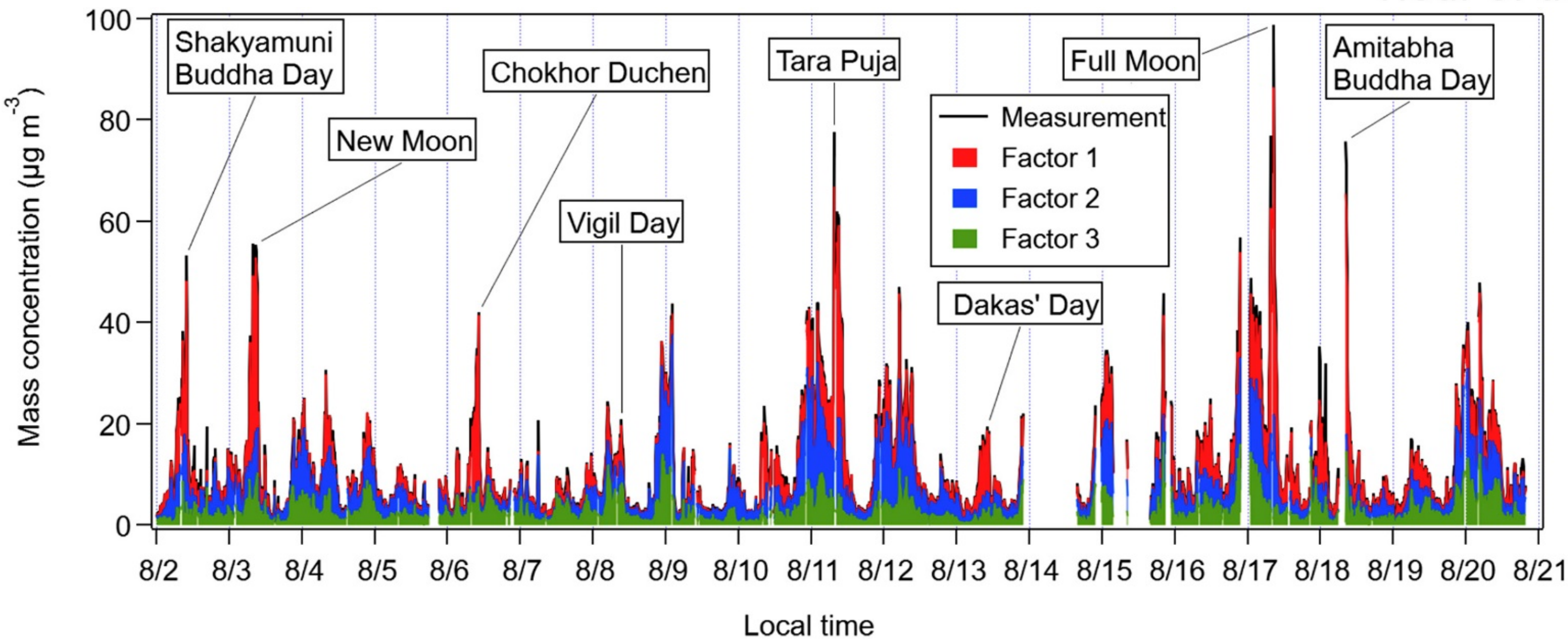
Obs. highlights

3. Boundary layer aerosols in summertime Lhasa

Religious burnings may significantly contribute to aerosol mass

Cui et al. AE, 2018

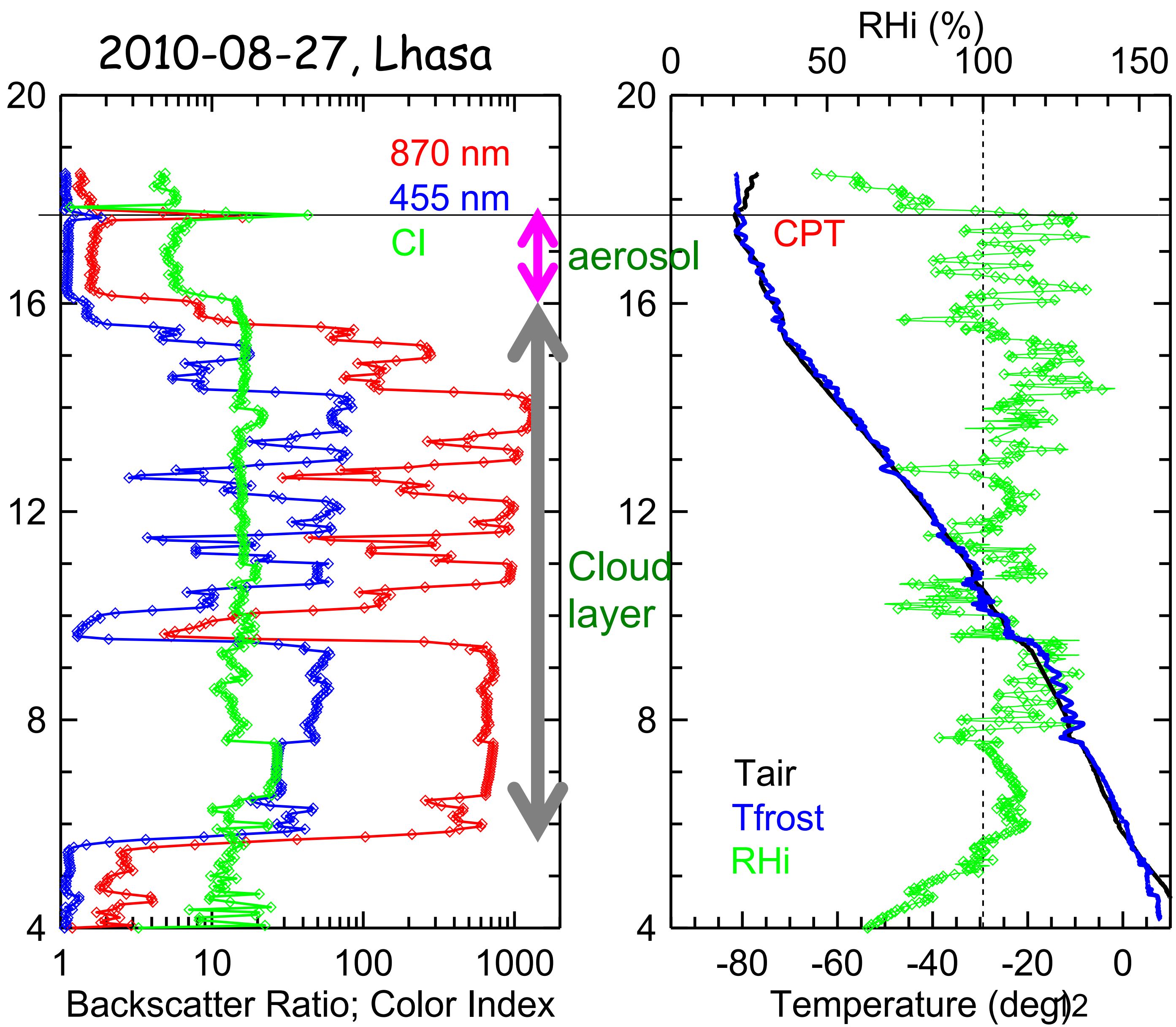




Individual cases

Case 1:

A deep layer of supersaturated air & cloud – thickness 10km

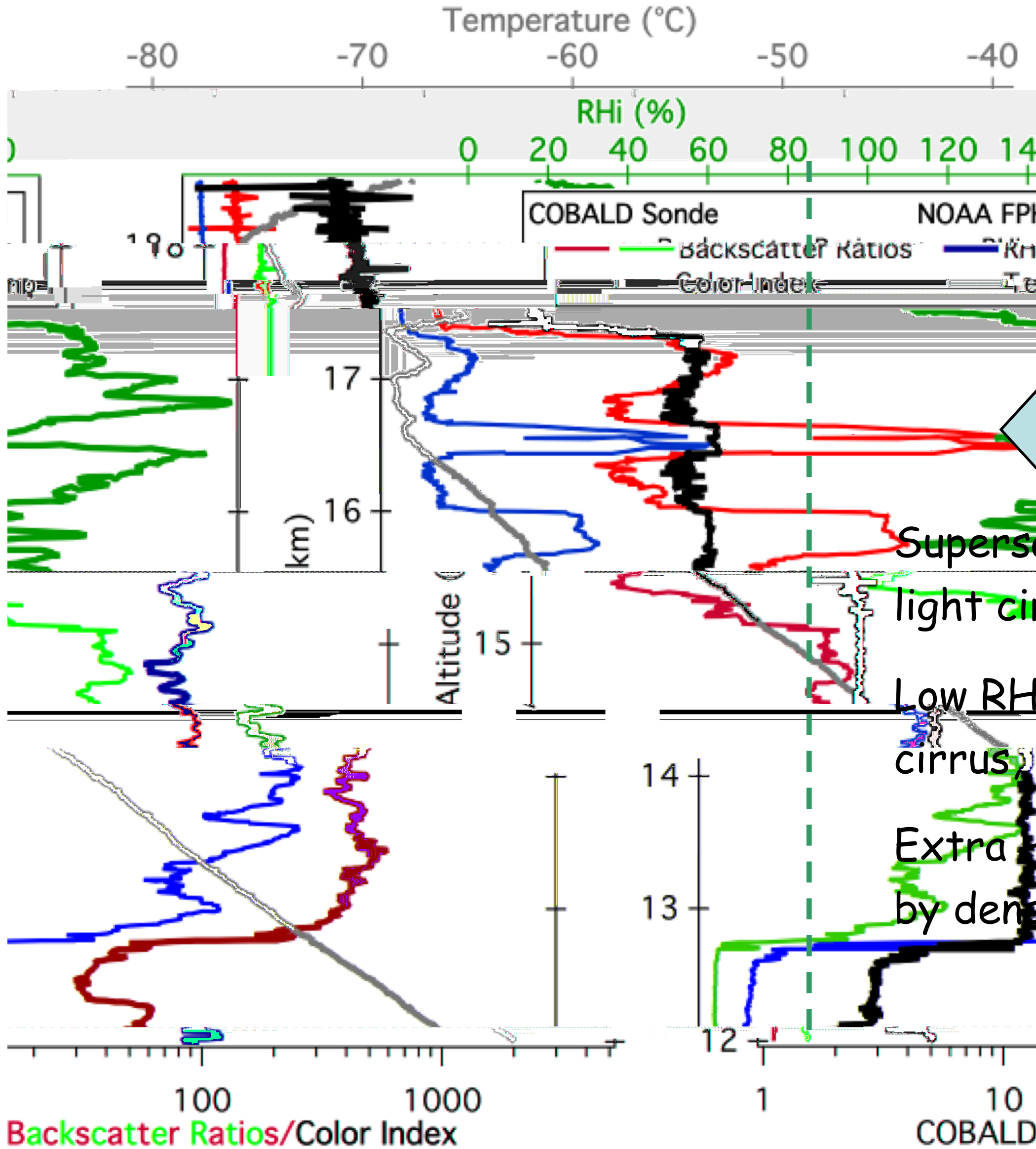


Individual cases

Kunming, 20 Aug'12

Case 2:

Anti-correlation between cirrus layer and supersaturation



Supersaturation @ light cirrus;

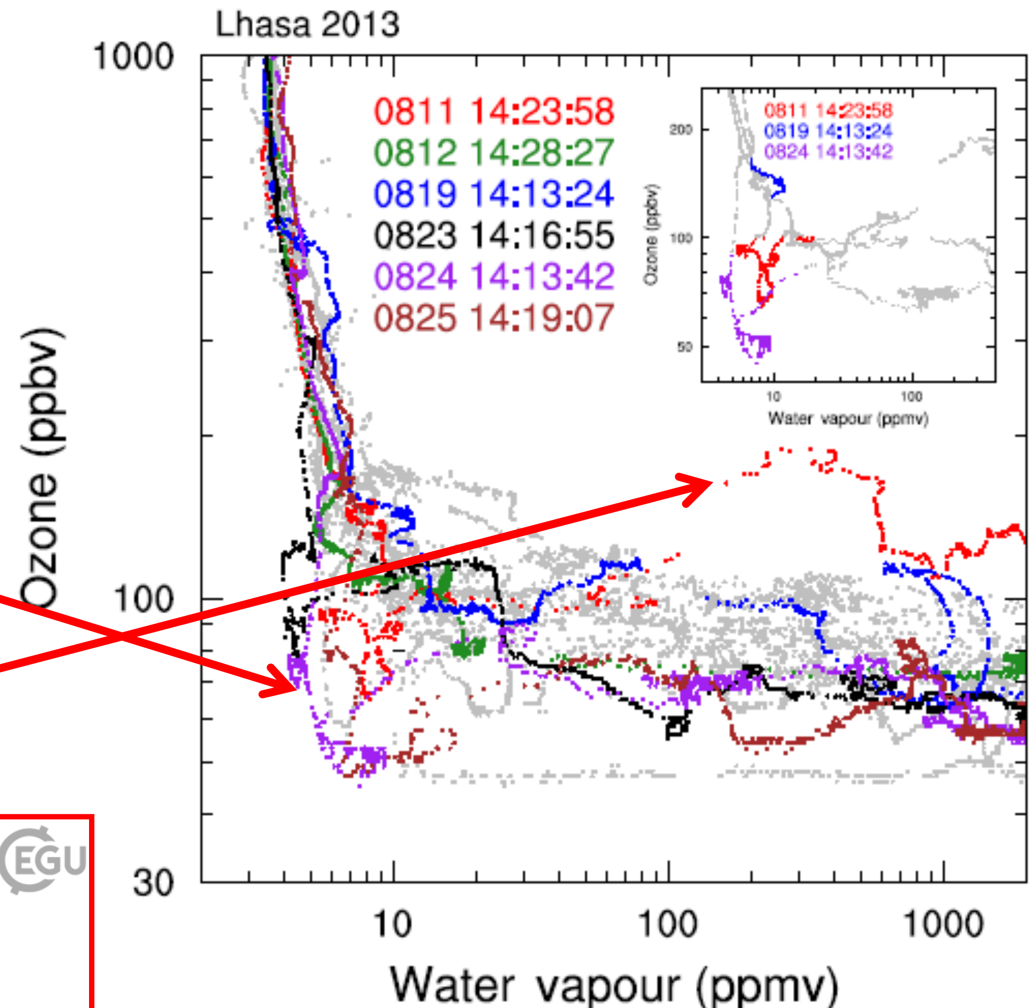
Low RHi @ dense cirrus;

Extra H_2O taken by dense cirrus.

Individual cases

Case 3:

- Typhoon transport
- Stratospheric intrusion



Atmos. Chem. Phys., 17, 4657–4672, 2017
www.atmos-chem-phys.net/17/4657/2017/
doi:10.5194/acp-17-4657-2017

Atmospheric Chemistry and Physics
Open Access
EGU

Impact of typhoons on the composition of the upper troposphere within the Asian summer monsoon anticyclone: the SWOP campaign in Lhasa 2013

Dan Li[1,2], Bärbel Vogel[2], Jianchun Bian[1,3], Rolf Müller[2], Laura L. Pan[4], Gebhard Günther[2], Zhixuan Bai[1,3], Qian Li[1], Jinqiang Zhang[1], Qiujun Fan[1,3], and Holger Vömel[5]

Papers from SWOP data

1. Bian, J., et al., 2011: **Intercomparison** of humidity and temperature sensors: GTS1, Vaisala RS80, and CFH. Adv. Atmos. Sci., 28.
2. Bian, J., et al., 2012: **In situ water vapor and ozone measurements** in Lhasa and Kunming during the Asian summer monsoon. Geophys. Res. Lett., 39.
3. Zhang, J., et al., 2012: Development of **cloud detection methods** using CFH, GTS1, and RS80 radiosondes, Adv. Atmos. Sci., 29.
4. Pan, L. L., et al., 2014: Identification of the **tropical tropopause transition layer** using the ozone-water vapor relationship, J. Geophys. Res. Atmos., 119.
5. Vernier, J.-P., et al., 2015, **Increase** in upper tropospheric and lower stratospheric aerosol levels and its potential connection with Asian pollution, J. Geophys. Res. Atmos., 120.
6. Gu, Y., et al., 2016: Summertime **nitrate aerosol** in the upper troposphere and lower stratosphere over the Tibetan Plateau and the South Asian summer monsoon region, ACP.
7. Yu, P., et al., 2017: **Efficient transport** of tropospheric aerosol into the stratosphere via the Asian summer monsoon anticyclone, PNAS, 114.
8. Li, D., et al., 2017: **Impact of typhoons** on the composition of the upper troposphere within the Asian summer monsoon anticyclone: the SWOP campaign in Lhasa 2013. ACP.
9. Li, D., et al., 2018: **High tropospheric ozone** in Lhasa within the Asian summer monsoon anticyclone in 2013: influence of convective transport and stratospheric intrusions, ACP.
10. Cui, Y., et al., 2018: **Religious burning** as a potential major source of atmospheric fine aerosols in summertime Lhasa on the Tibetan Plateau, Atmospheric Environ., 181.

SWOP plan for 2020 collaborated with ACCLIP

- late May to early September
- 15 soundings each station
- 6~8 POPS each station

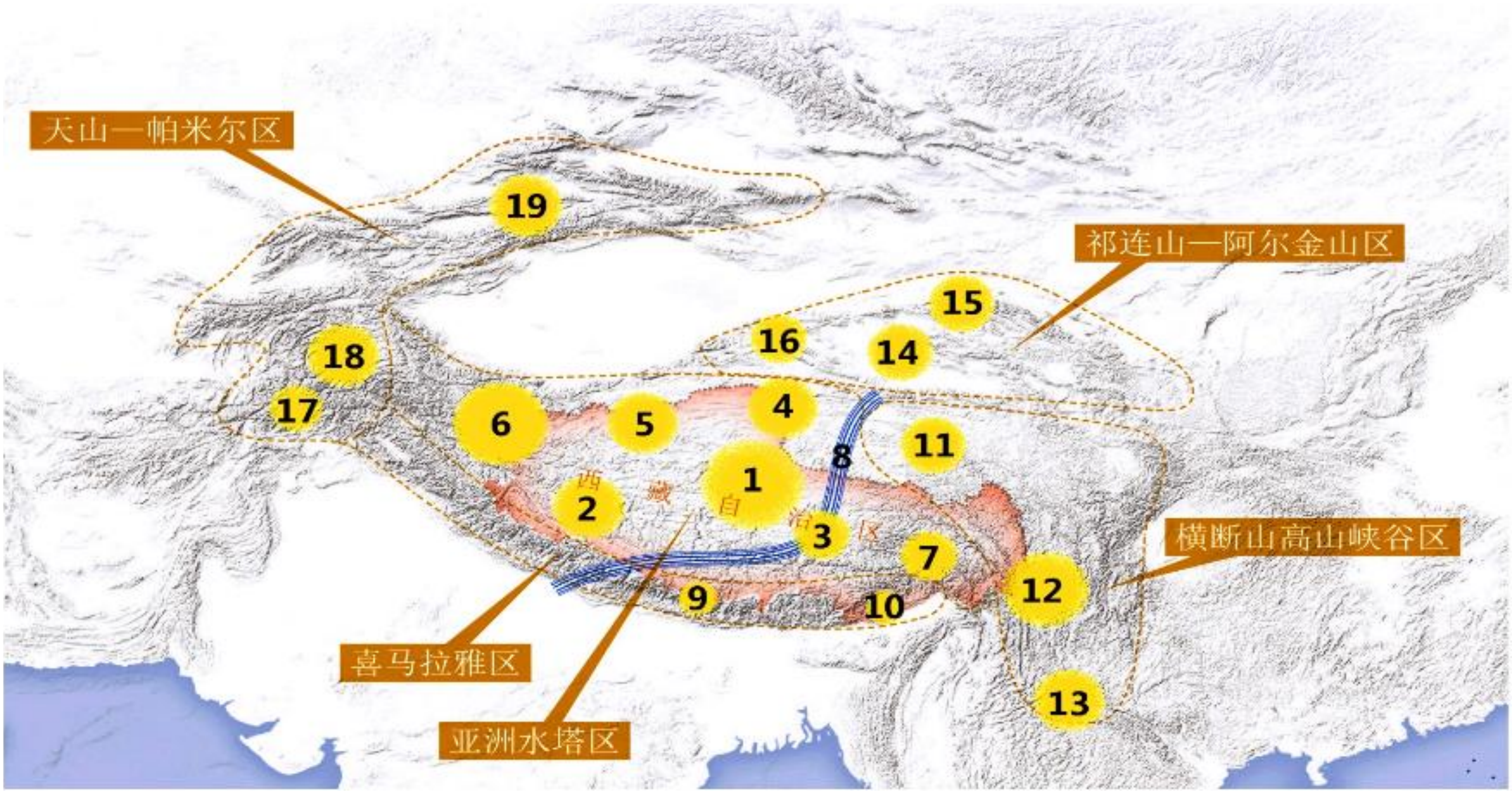
ECC, CFH, Cobald, POPS

SWOP plan for 2019-2023

- Lhasa (2019, 2022), Golmud (2020), Kunming (2021, 2023)
- 16 soundings each year, once monthly + 4 times in summer

第二次青藏科考范围

5个综合区和19个关键区的科考方案



Ⅰ 亚洲水塔区（1.江湖源区 2.河湖源区 3.一江两河区 4.可可西里 5.羌塘高原 6.喀喇昆仑-西昆仑区 7.藏东南区 8.南亚通道）**Ⅱ 喜马拉雅区**（9.喜马拉雅山 10.边境区）**Ⅲ 横断山高山峡谷区**（11.三江源 12.三江流域及横断山区 13.东南亚跨境区）**Ⅳ 祁连山-阿尔金区**（14.祁连山南坡与柴达木盆地 15.祁连山北坡与河西走廊 16.阿尔金山）**Ⅴ 天山-帕米尔区**（17.中巴经济走廊 18.帕米尔区 19.西天山区）