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

(2009~2015)

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Frank Weinhold (ETH)

Outline

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

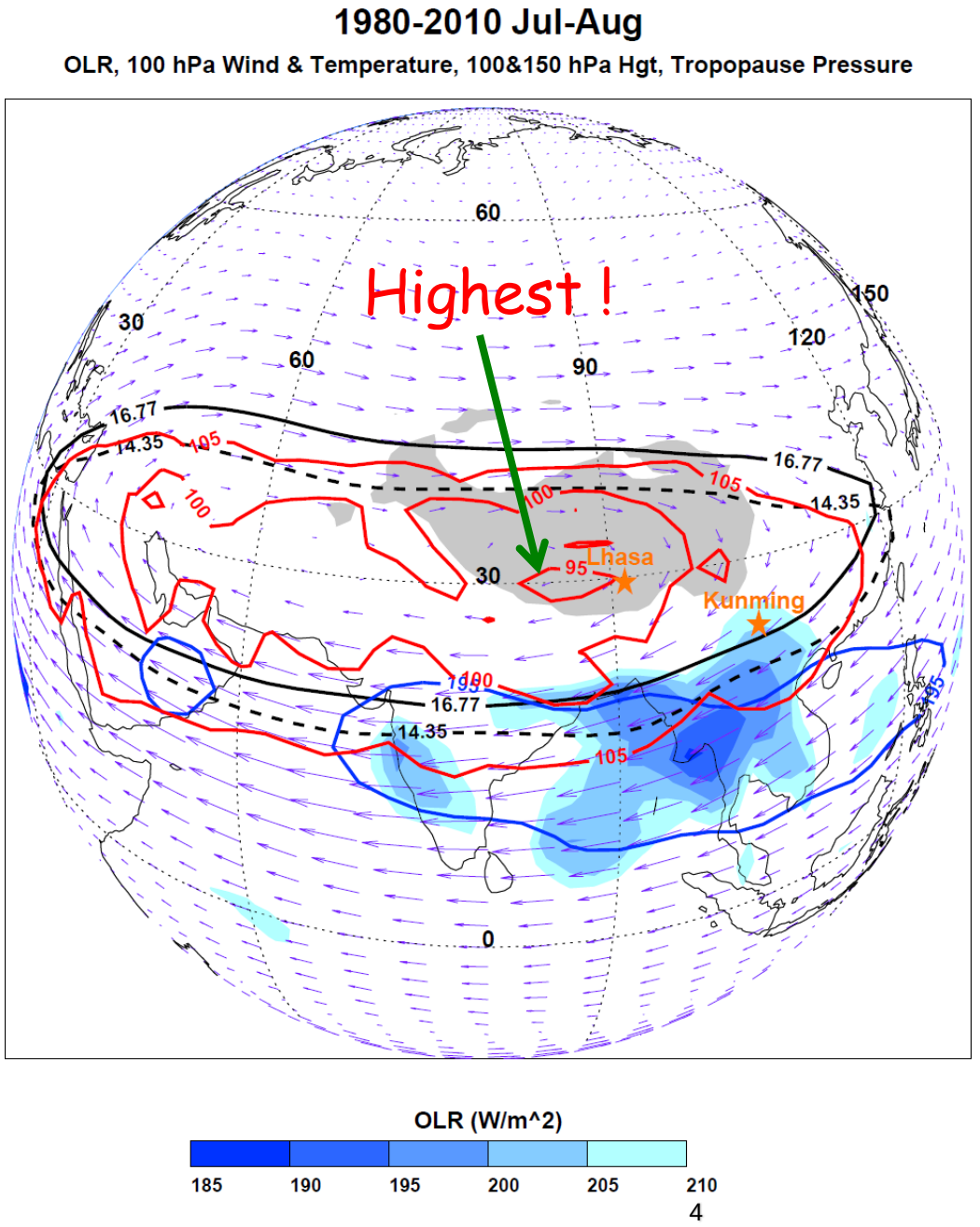
Motivations

Importance of in situ observations:

- ✓ Satellite validation over this region
- ✓ For understanding transport and microphysical process in the UTLS

Campaign Locations

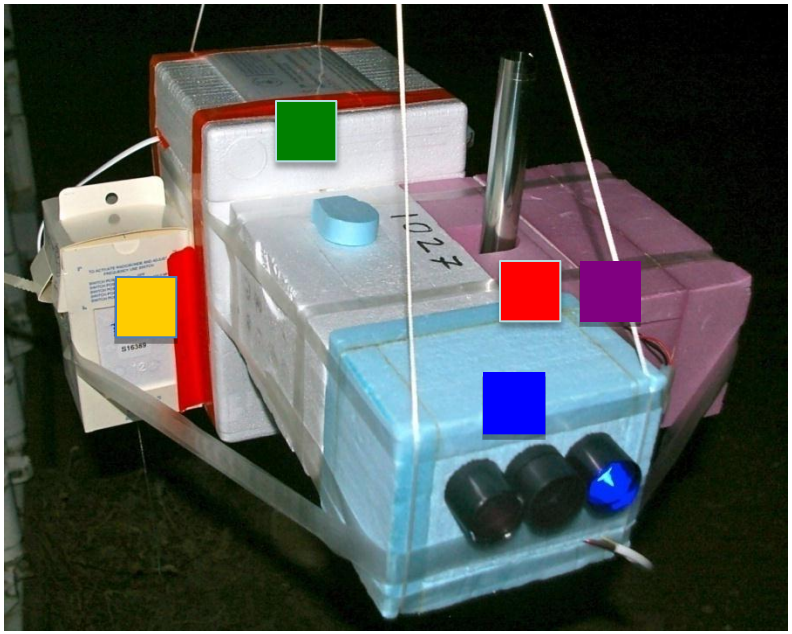
- ASM anticyclone spans subtropical Asian continent between 20°–40°N, higher tropopause
- KM (25°N, 103°E) within southeast edge of anticyclone, influenced by the air mass from outside
- LH (30°N, 91°E) @ anticyclone center and almost consistently within anticyclone limit



Bian et al. GRL, 2012

Balloon-borne sondes

- Compact Optical Backscatter Aerosol Detector (COBALD - ETH) ci. & aerosol
- Frost Point Hygrometer (FPH - NOAA GMD) H_2O & RHi
- Cryogenic Frost-point Hygrometer (CFH - Vömel) H_2O & RHi
- Electrochemical Concentration Cell (ECC) Ozonesonde O_3
- Radiosonde: P, T, U, winds (u,v) (iMet)

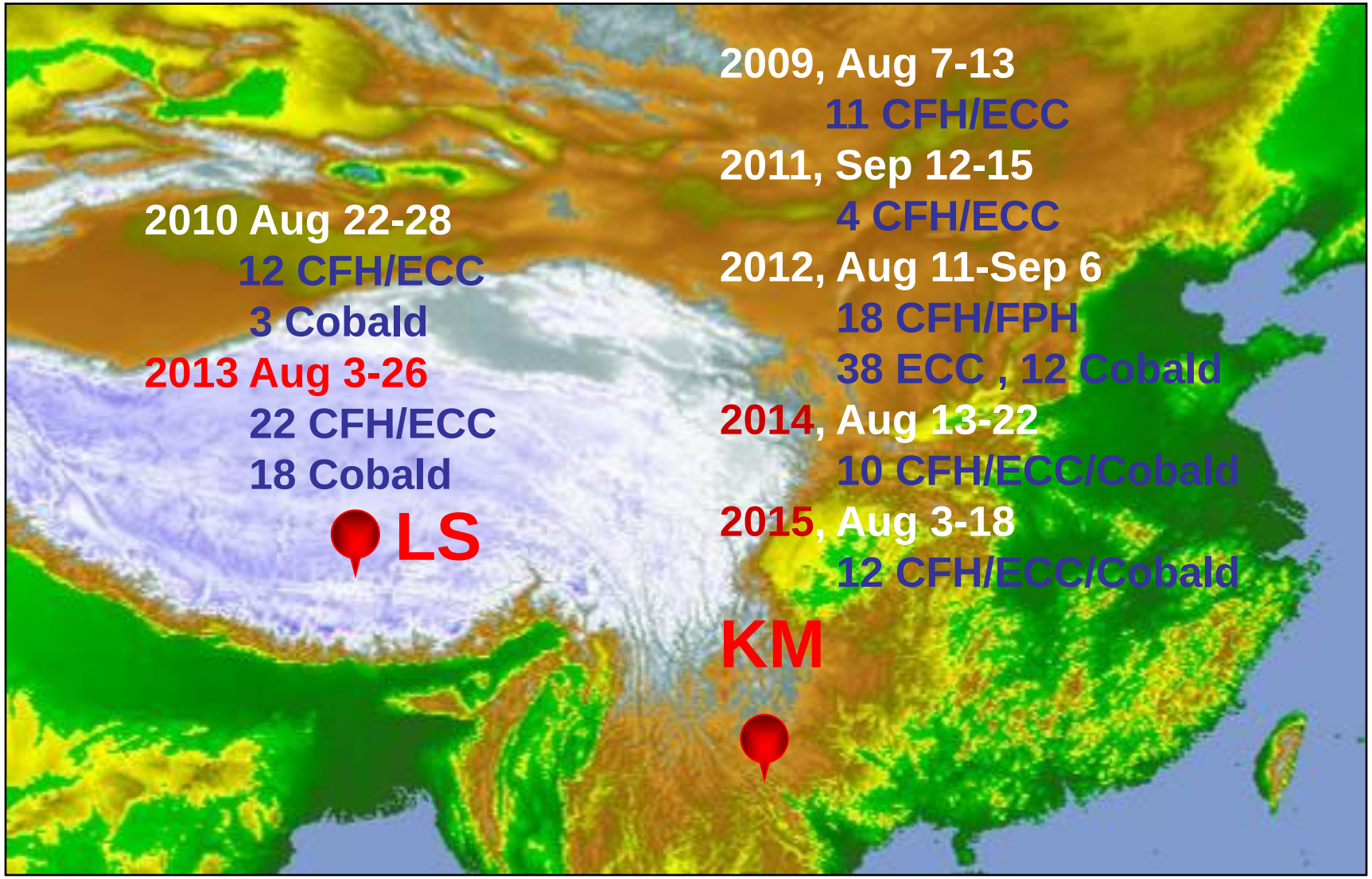


See talk of Frank Weinhold (tomorrow)

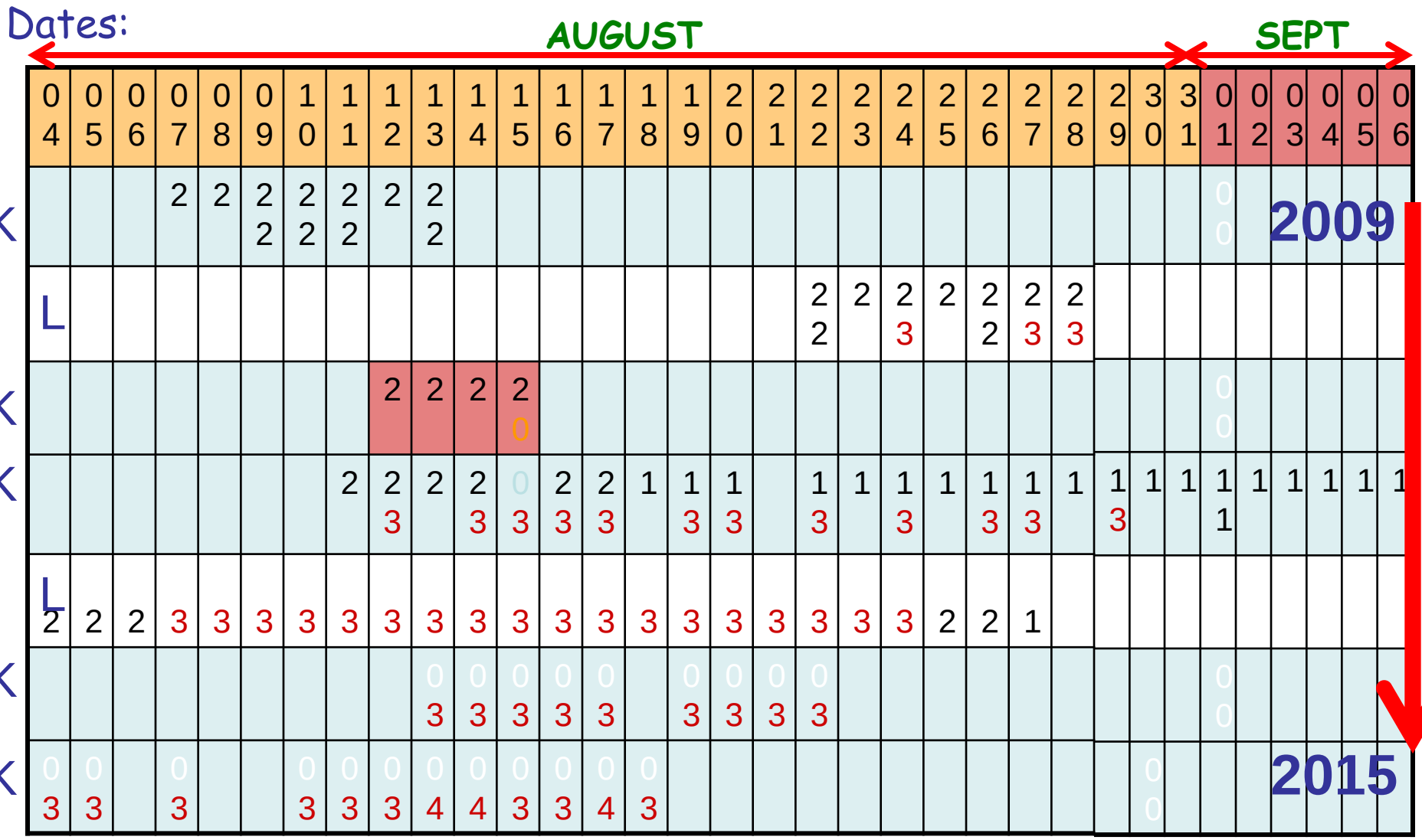
POPS – a newcomer in 2015

- ✓ Measure aerosol profiles of size spectrum
  - Talk of Ru-shan Gao (tomorrow)

Seven IOPs during 2009-2015



Sounding & Instruments

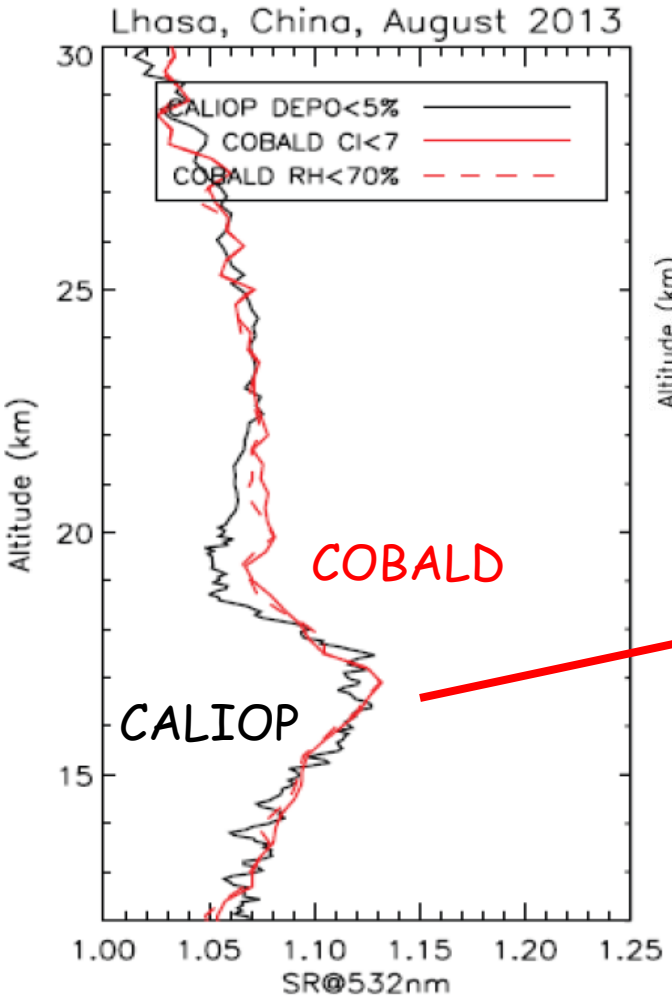


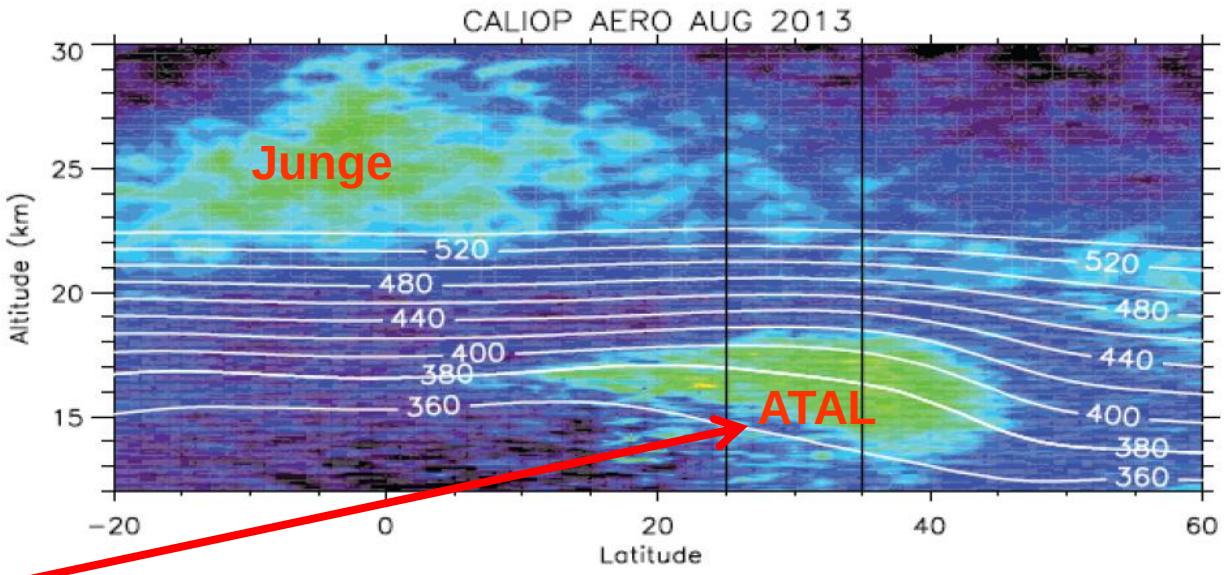
1=ECC; 2=1+CFH; 3=2+CBD; 4=3+POP

O_3 → H_2O → cirrus +aerosol → aerosol

Obs. highlights – ATAL issues

1. COBALD data confirms the ATAL finding from CALIOP





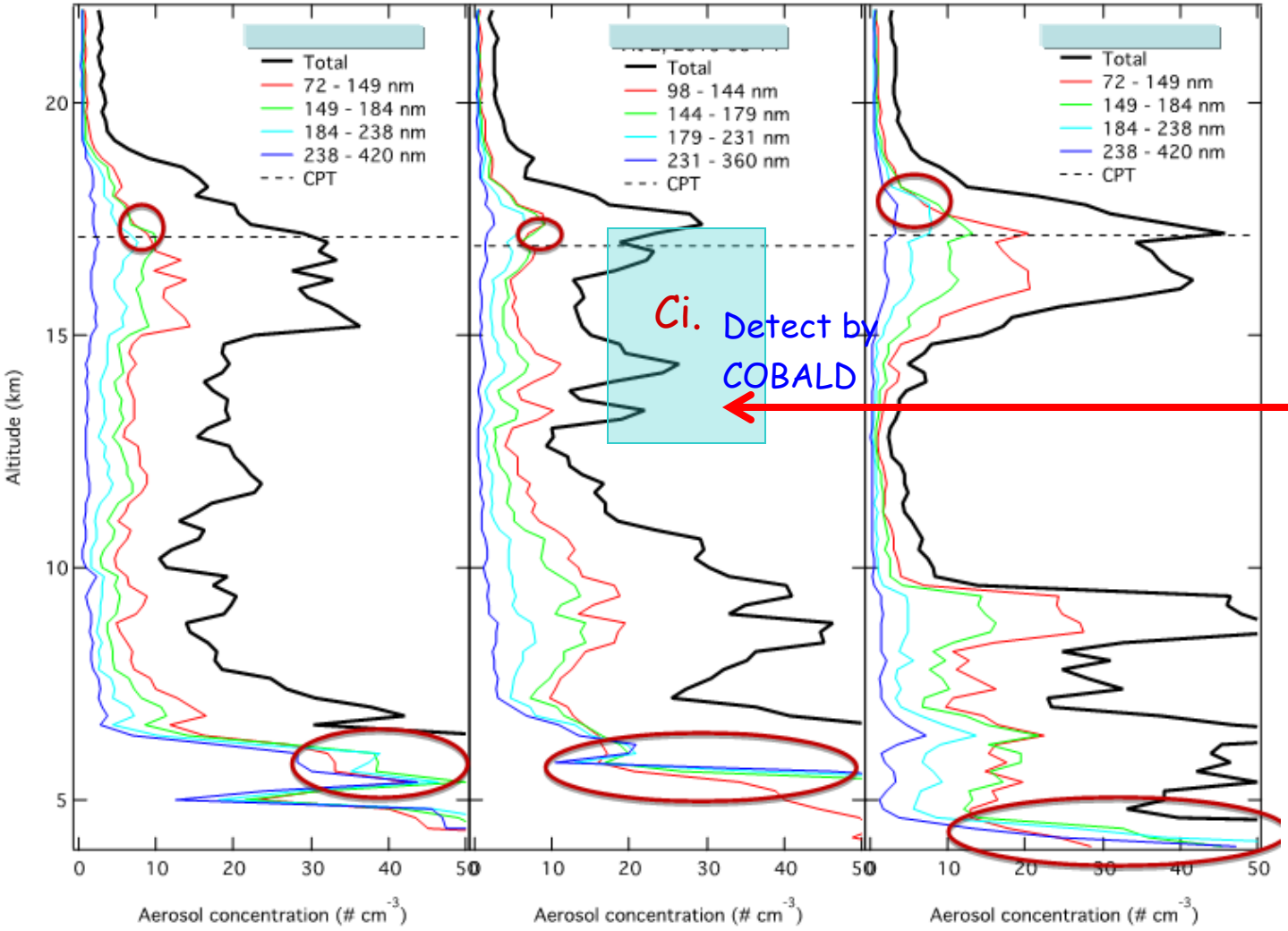
Vernier et al. JGR 2015

Details to be seen in talk of J-P Vernier

(tomorrow)

Obs. highlights – ATAL issues

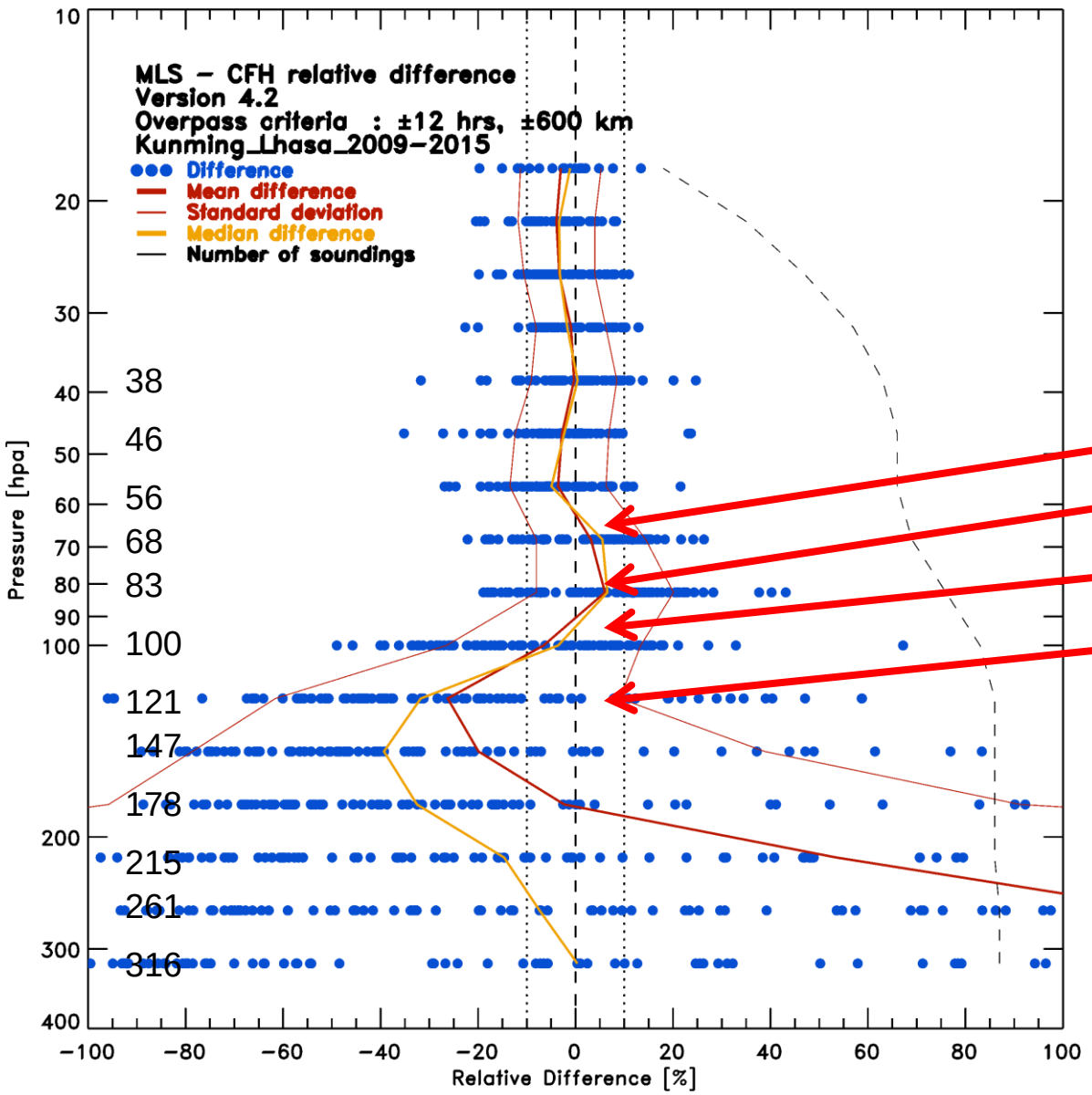
2. POPSs see size distribution profile in the ATAL



1. Enhance 14-19km
2. Extend 2km above CPT
3. Interstitial aerosol

Details to be seen in talk of Ru-Shan Gao

Obs. highlights – MLS Validation



H_2O rel. diff.
(MLS – CFH)

<5% above 68mb

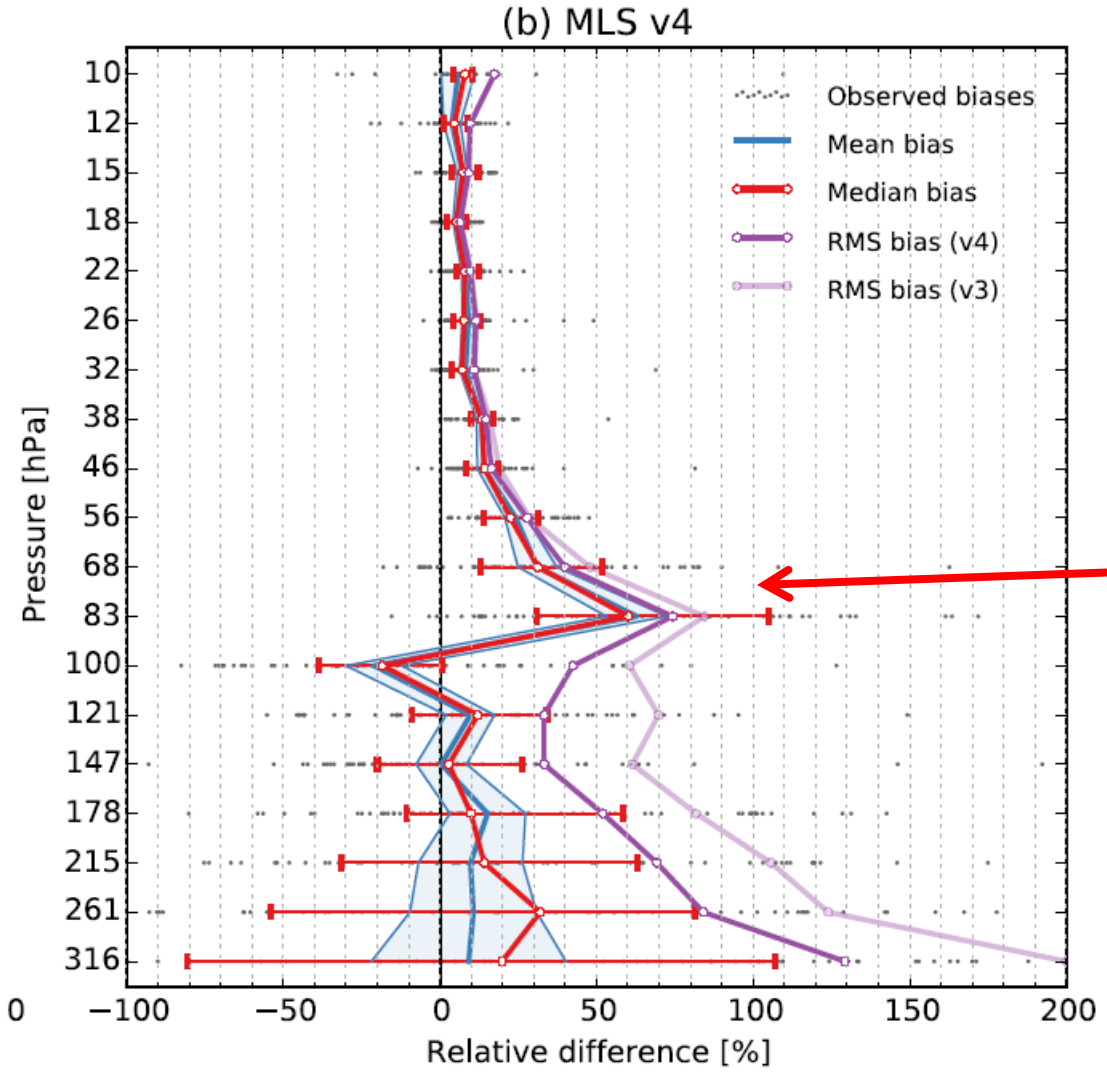
+7% @83mb

–7% @100mb

larger bias & dev.

Similar plot Can be found in
Yan et al. AMTD, 2016

Obs. highlights – MLS Validation



O_3 rel. diff.
(MLS – ECC)

bias abrupt jump

Yan et al. AMTD, 2016

RESULTS -- Statistics

1. CPT variables

KM

H: 17.30±0.43

T: 193.7±1.7

Θ: 384.2 ±8.4

LH

H: 17.54±0.53 +0.24km

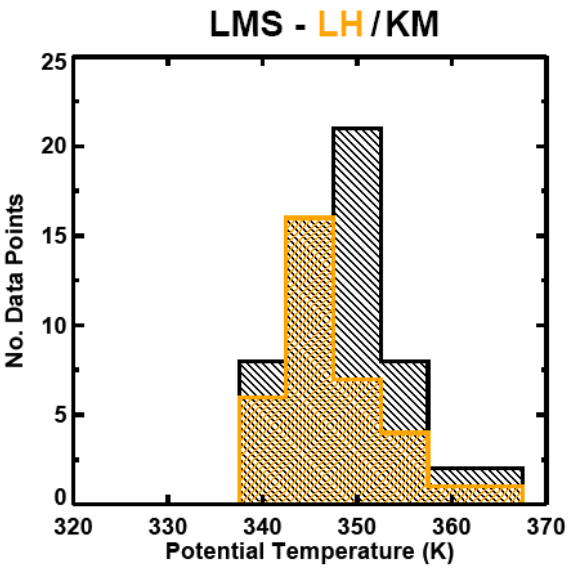
T: 195.2 ±1.7 +1.5K

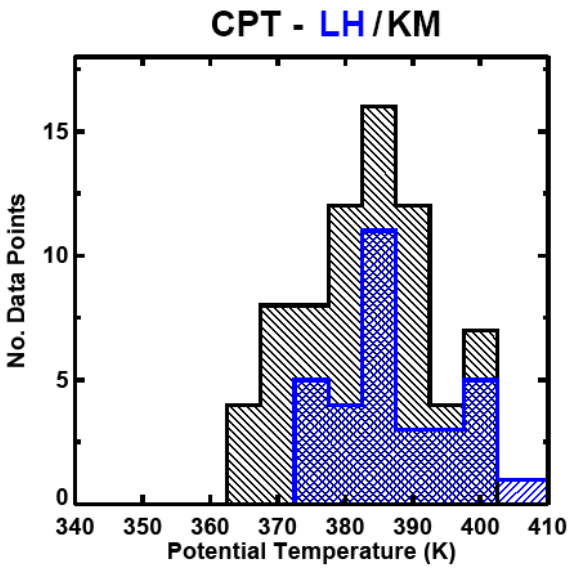
Θ: 390.4 ±10.3 + 6K

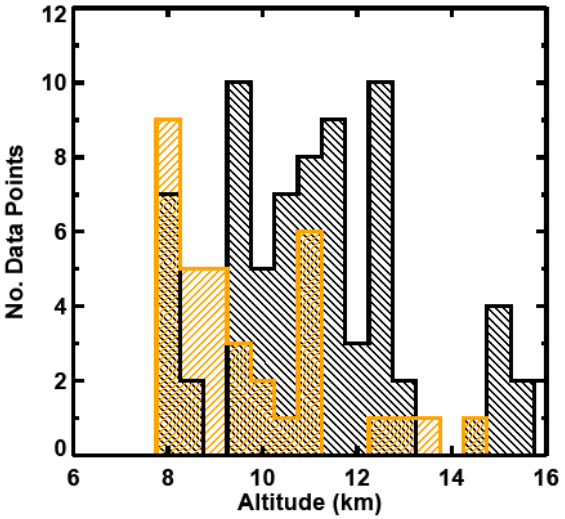
TC^4

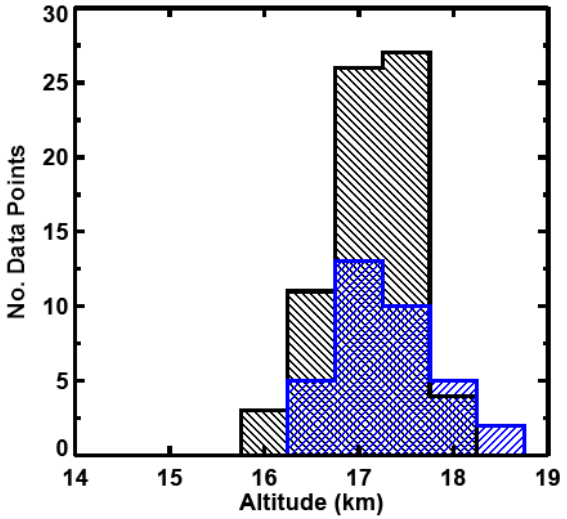
H: 16.6 ± 0.7 km

Θ: 375.1 ±13 K







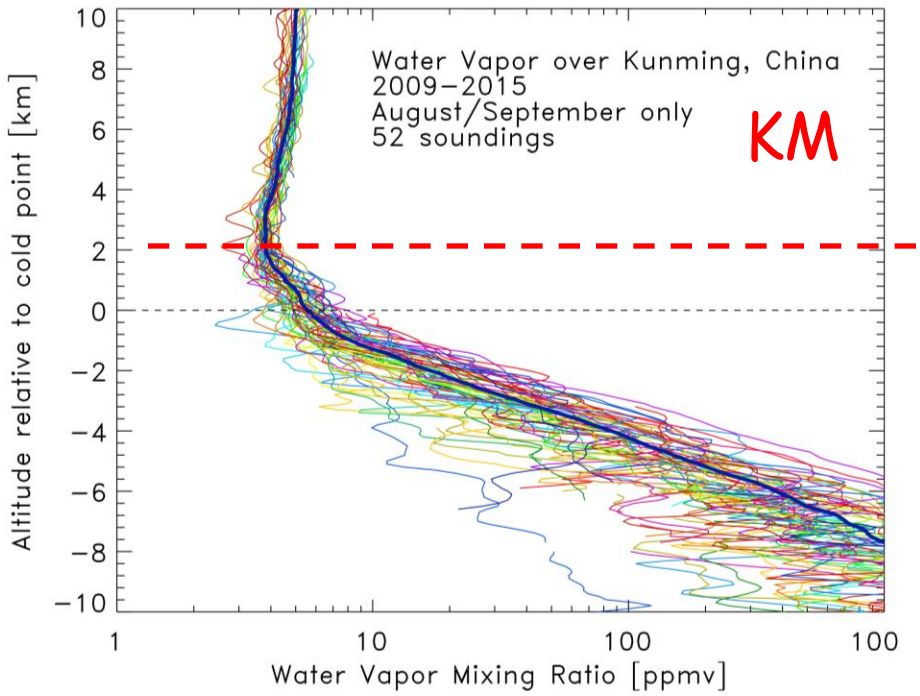


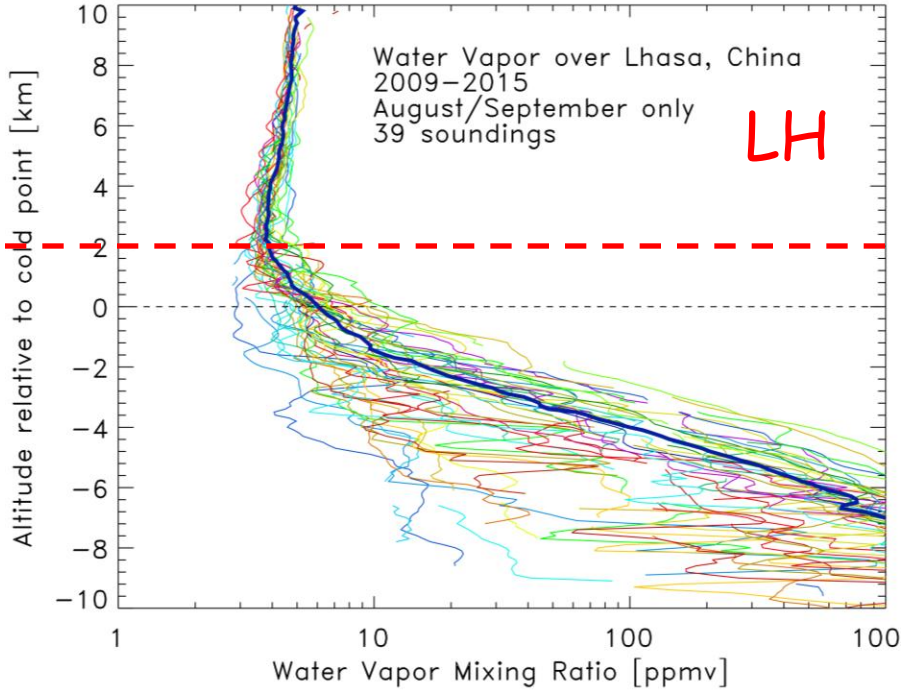
Pan et al. JGR, 2014

RESULTS -- Statistics

1. CPT variables

min H_2O locates @ 2 km above CPT - "tape recorder"



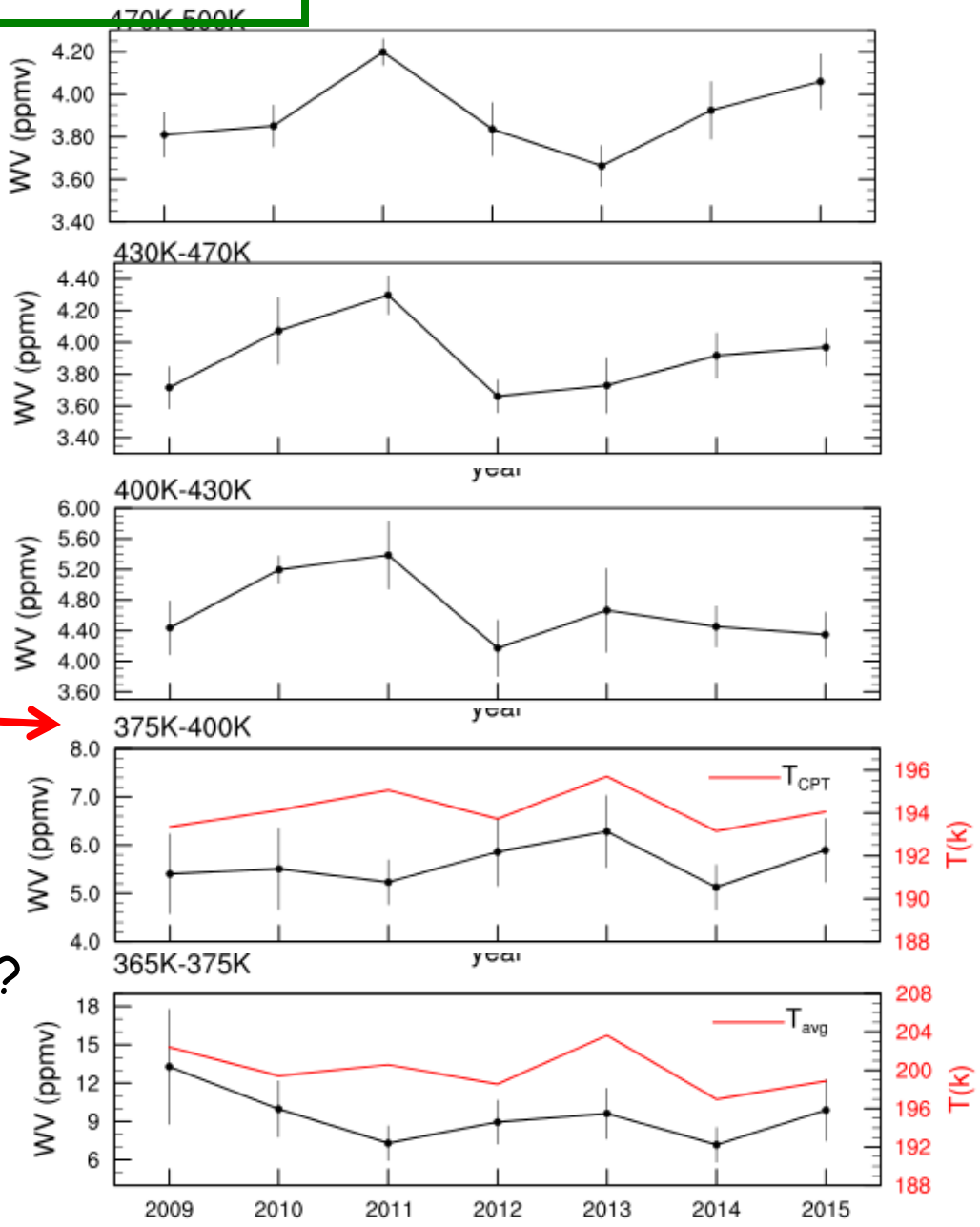


RESULTS -- Statistics

2. Interannual variation of H_2O in UTLS

Decoupled with lower levels

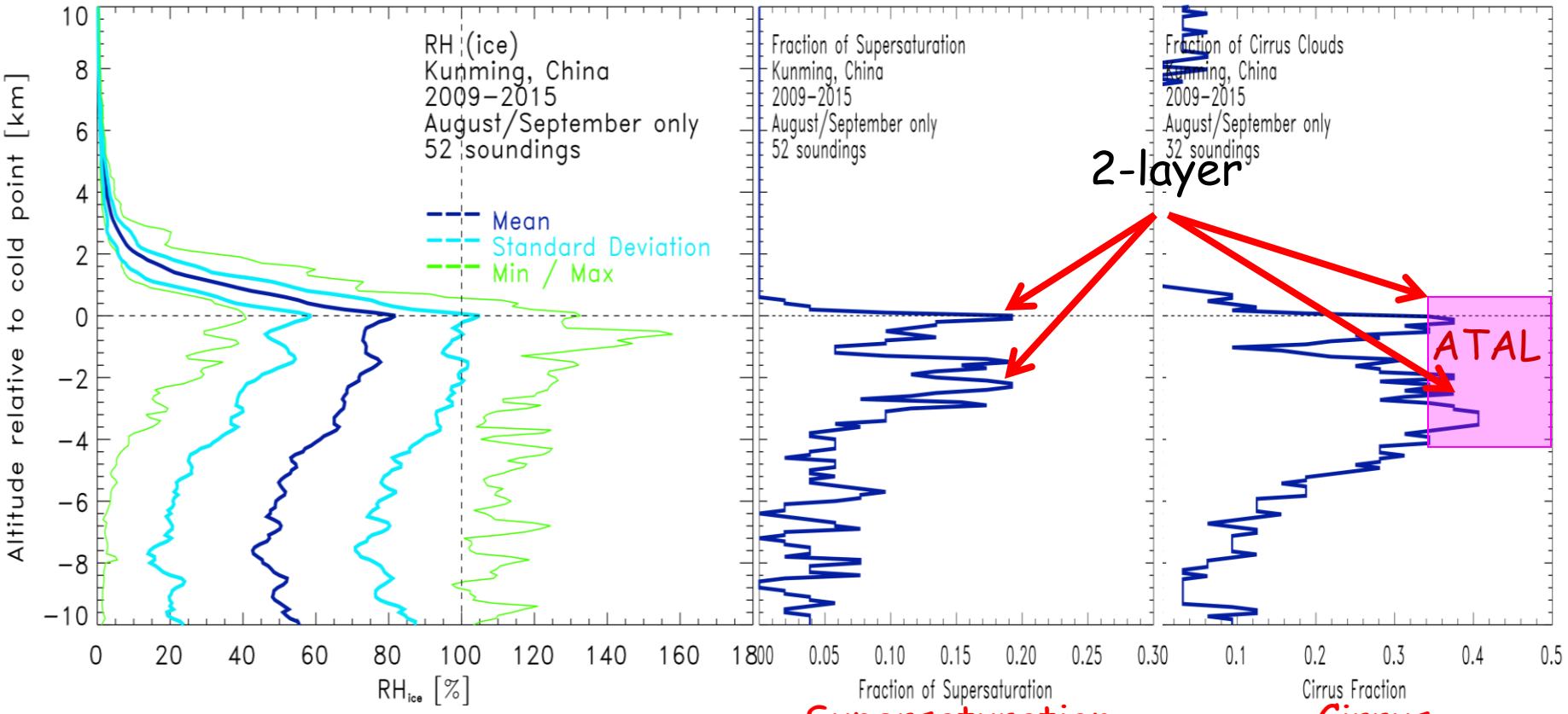
Interannual variation tuned by T?

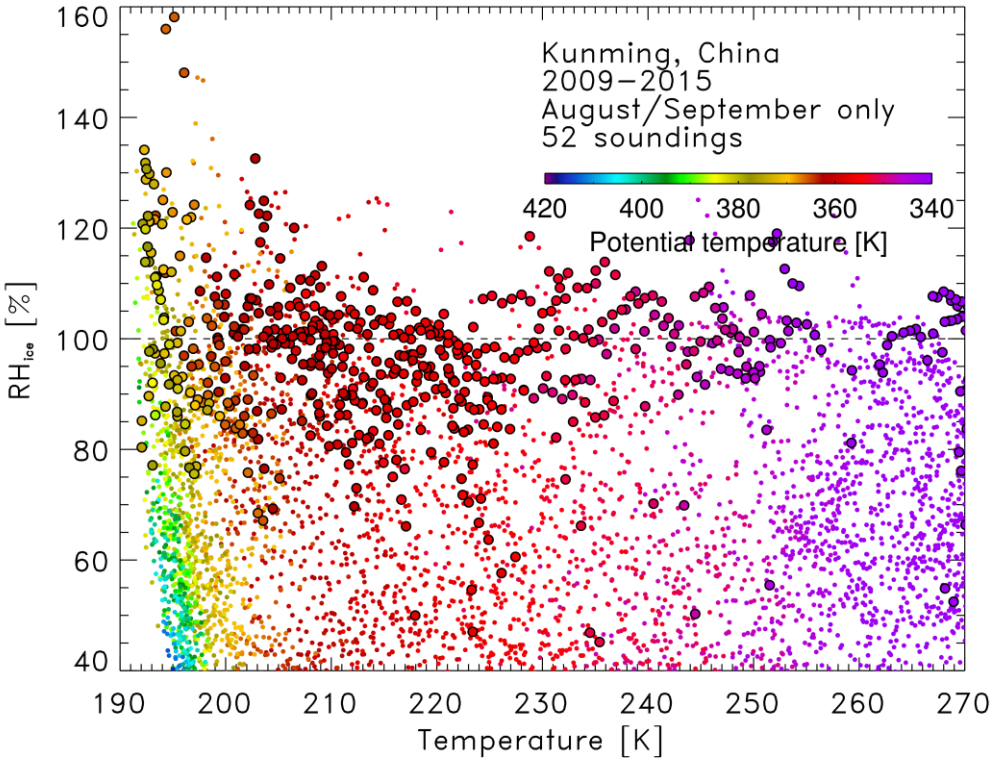


RESULTS -- Statistics

3. RHi, super-saturation, cirrus

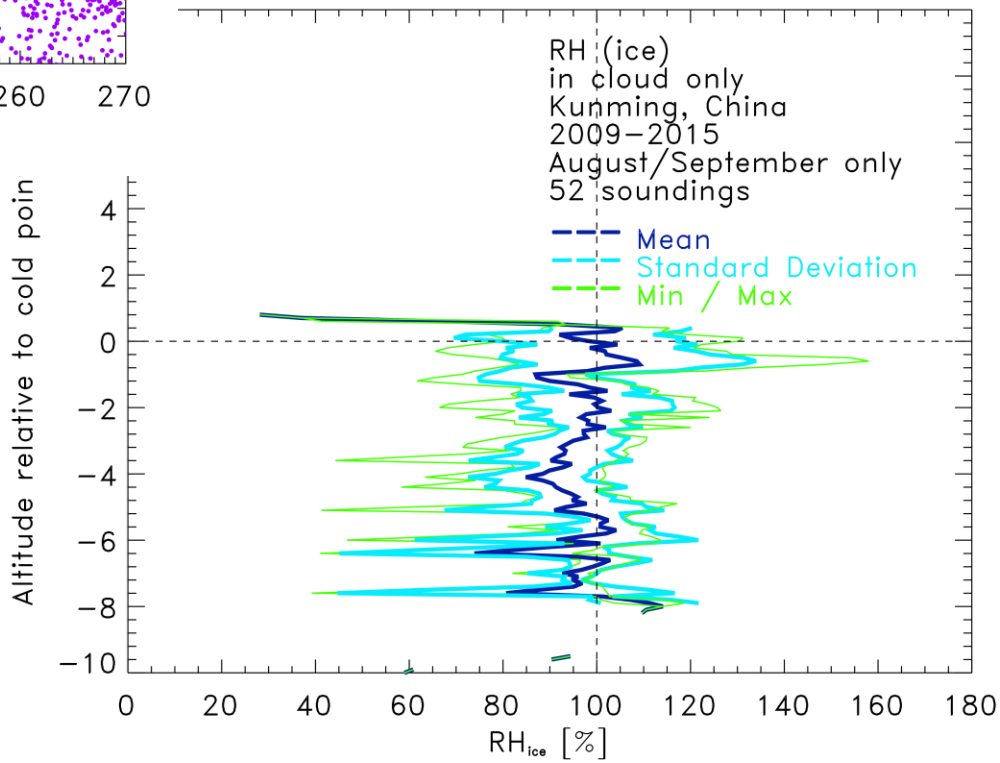
KM



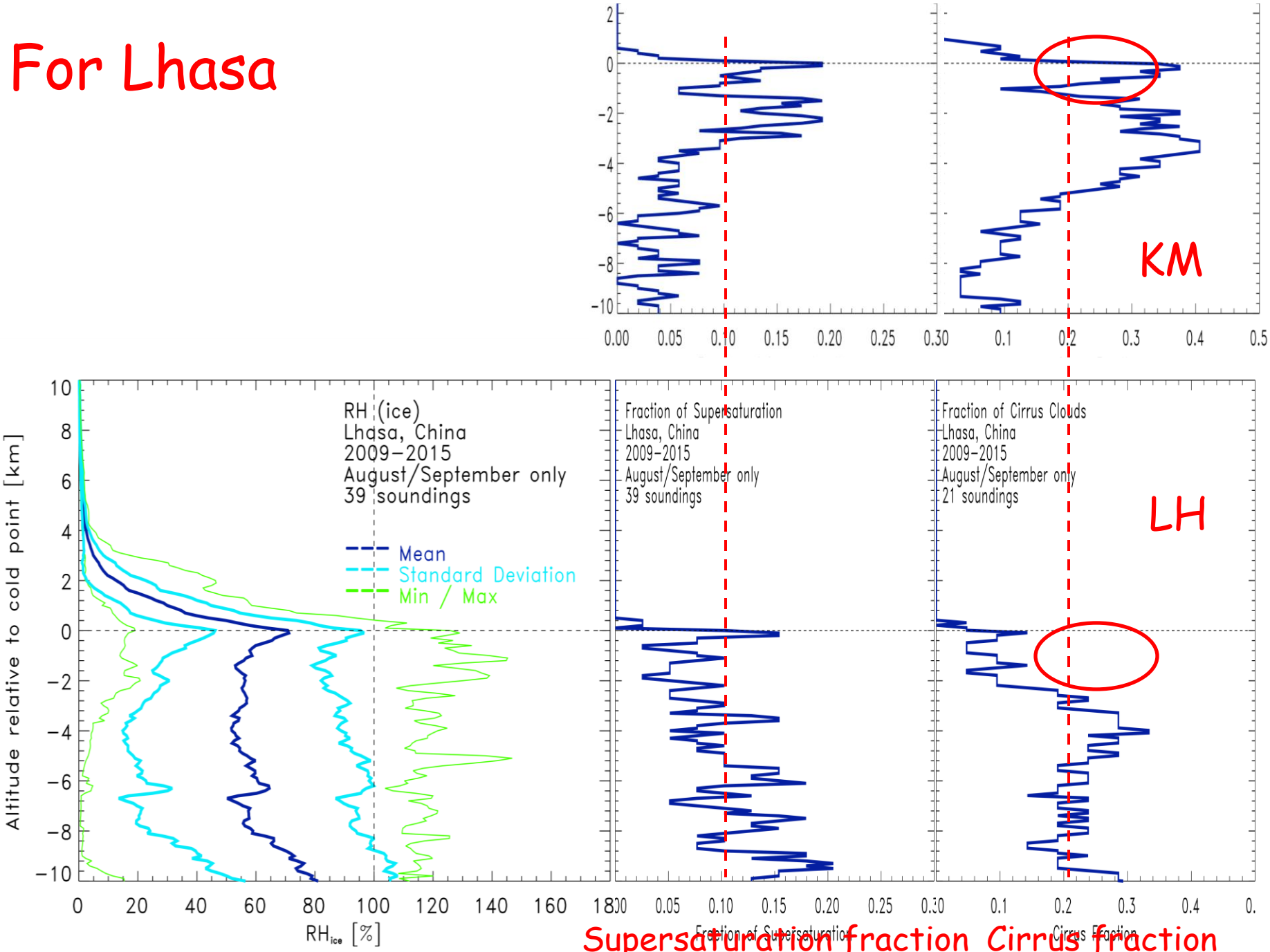


KM

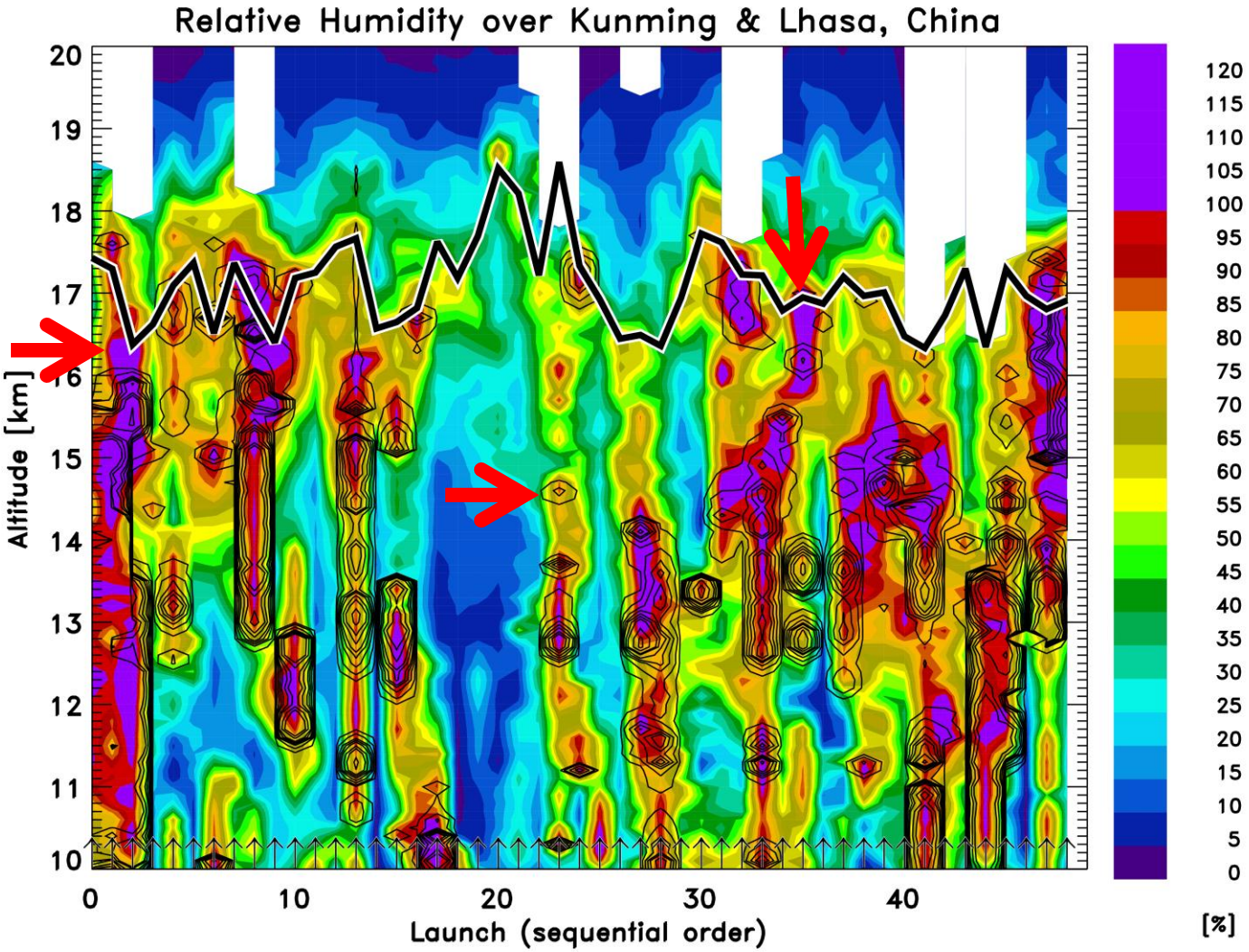
Inside cloud



For Lhasa


RH (ice)
Lhasa, China
2009–2015
August/September only
39 soundings
Mean
Standard Deviation
Min / Max
Altitude relative to cold point [km]
RH$_{ice}$ [%]
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
KM
LH
Supersaturation fraction
Cirrus fraction

RHi & Cirrus - detected by COBALD BSR_blue

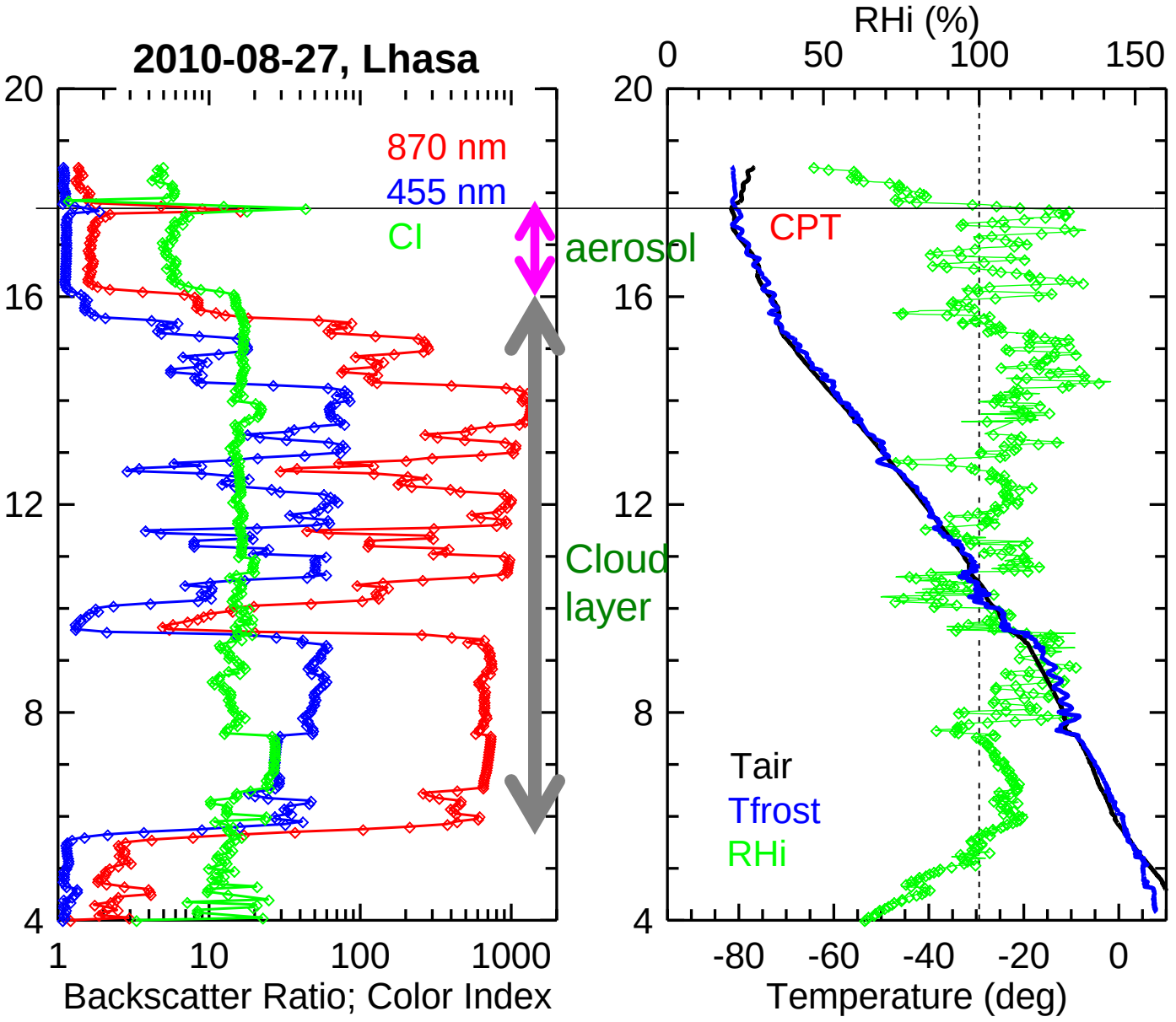


1. Generally, high RHi ↔ cirrus, but sometimes no.
2. In situ obs has finer RHi & cirrus structure

Some cases

Case 1:

A deep layer of supersaturated air & cloud

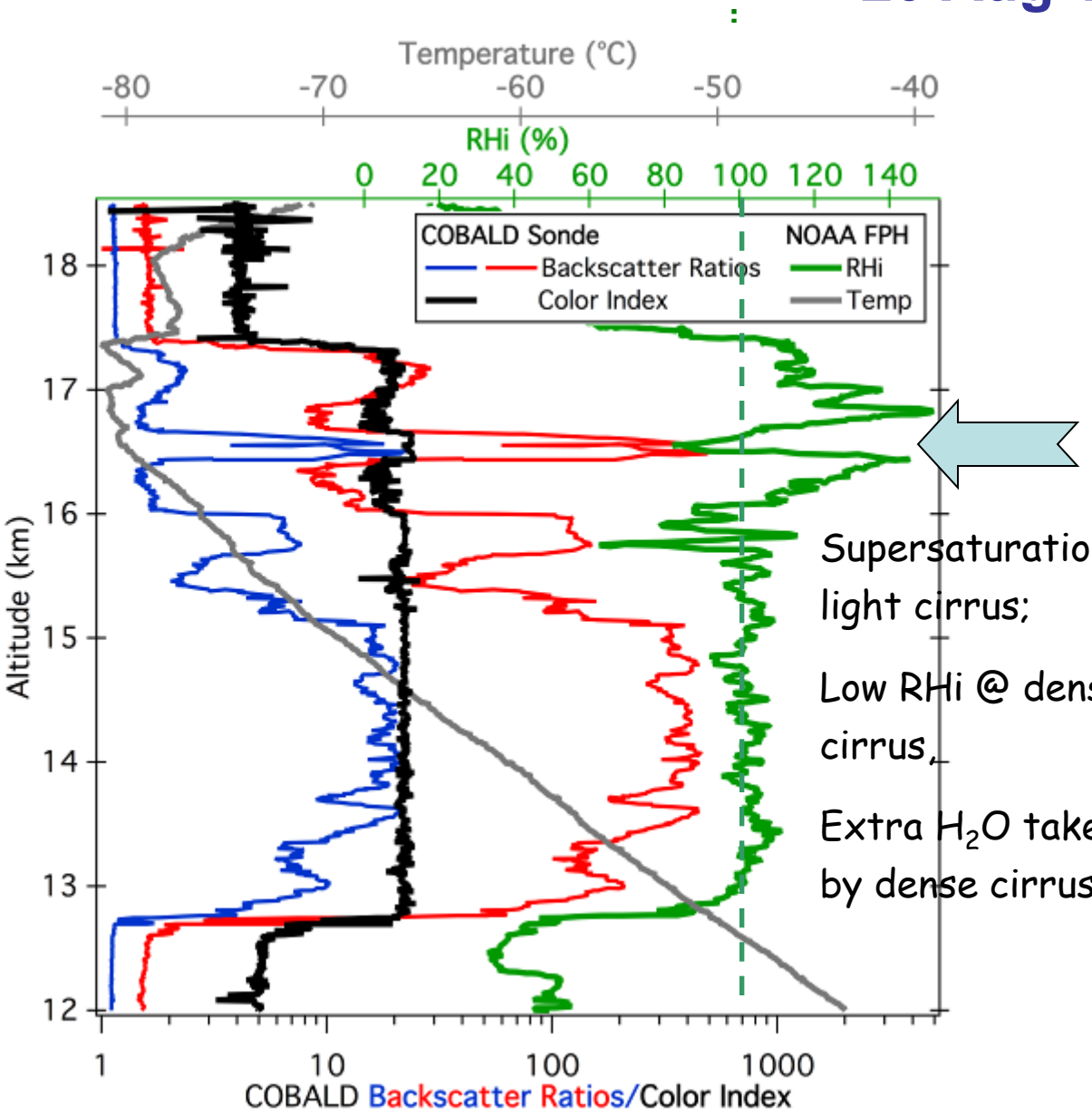


Some cases

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.

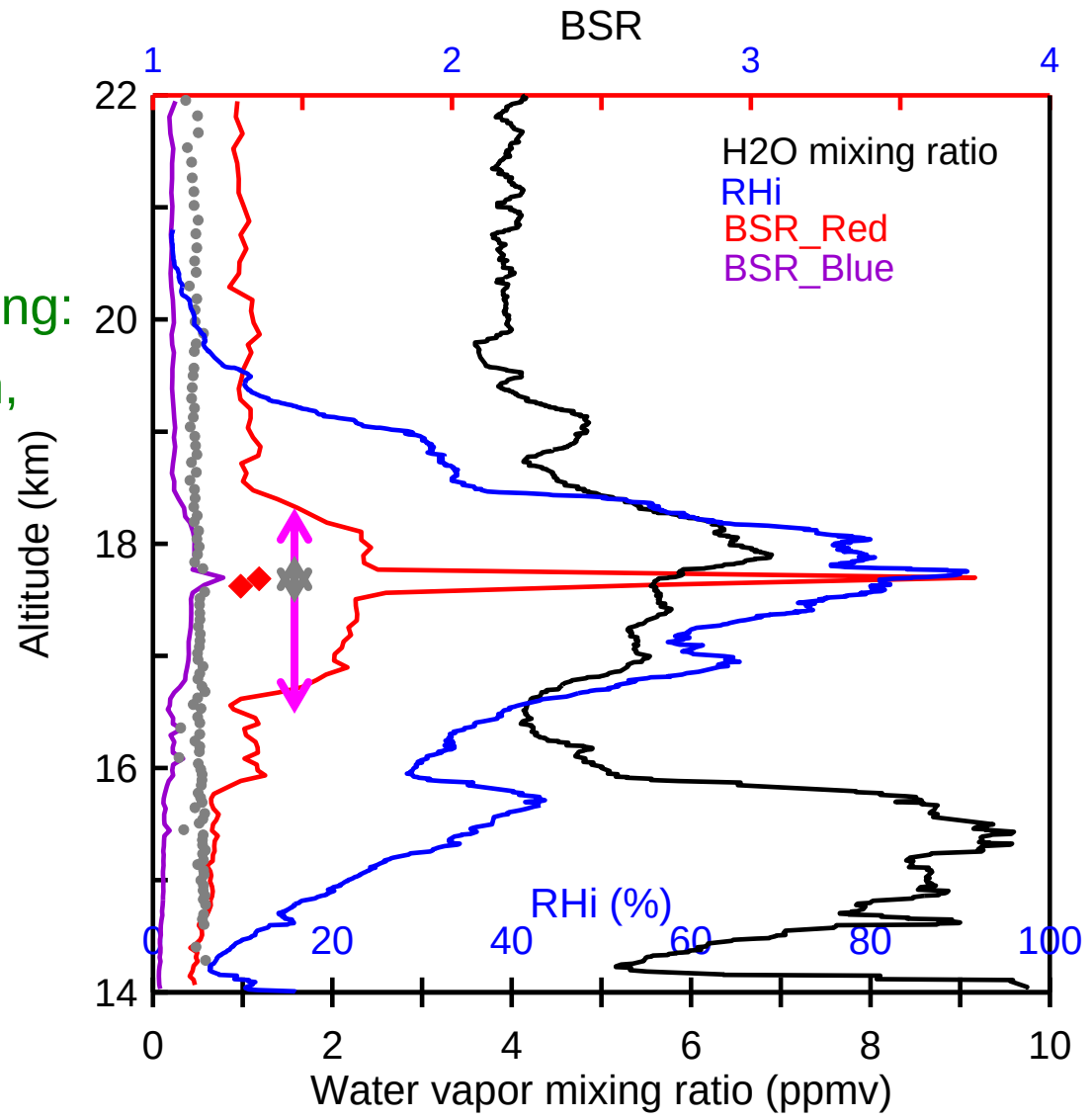
Also reported using Global Hawk data.

Jensen et al., PNAS, 2013

Some cases

Case 3:

Aerosol-cirrus coupling:
Hygroscopic swollen,
or evaporation?



Some cases

Case 4:

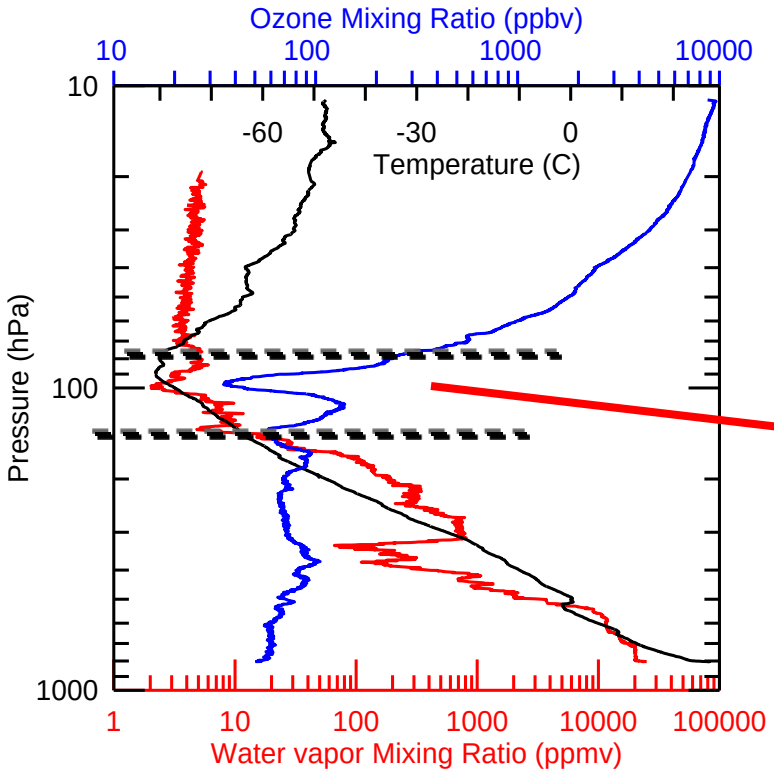
Typhoon transport followed by fast advection

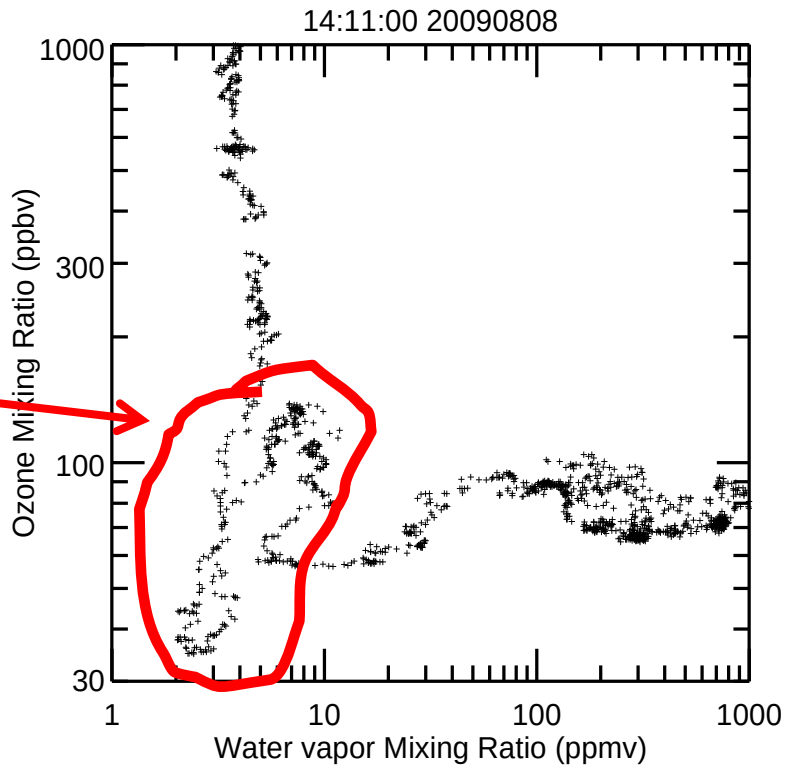
O_3: 35 ppb

H_2O: 2.0 ppm → -84ºC

CPT: -80.89ºC

@100mb

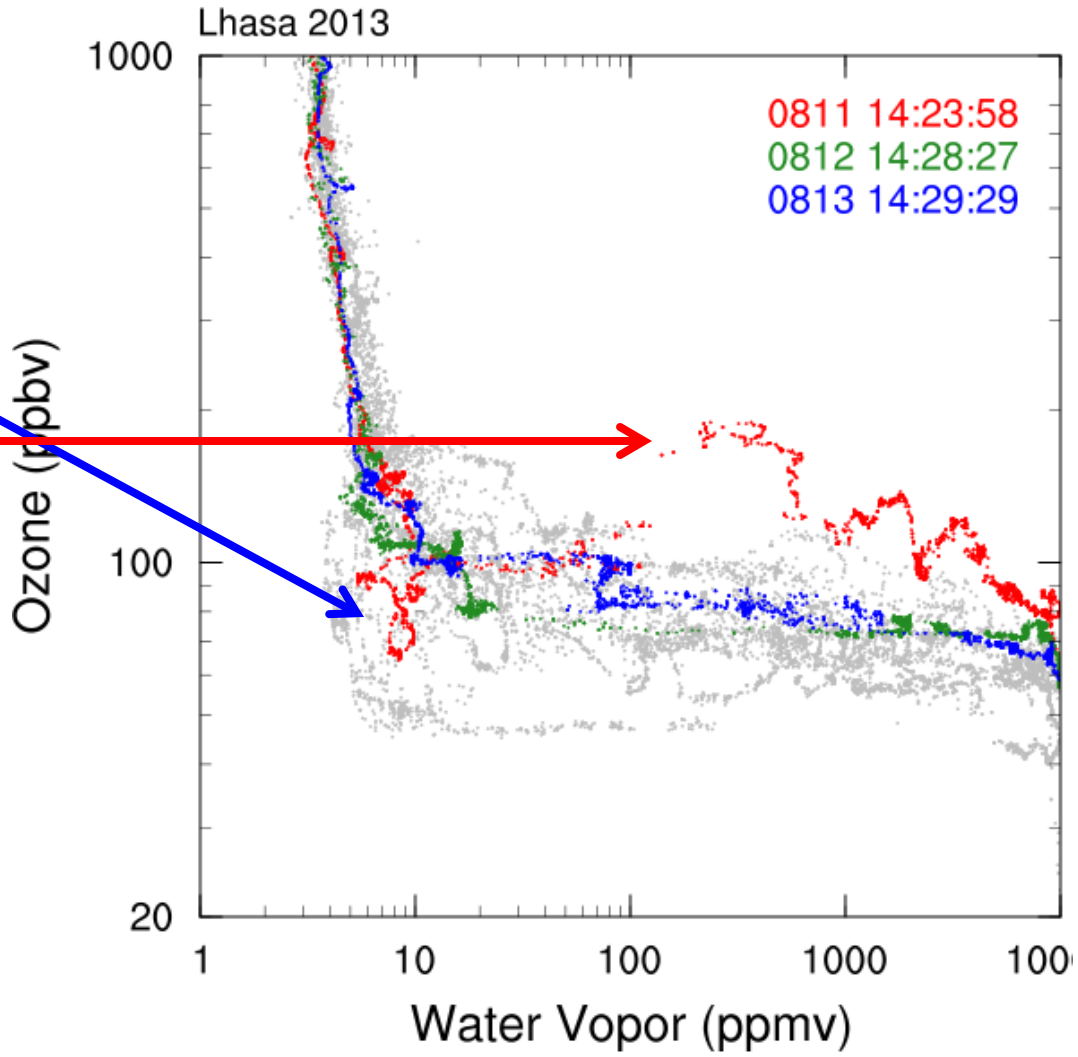




Some cases

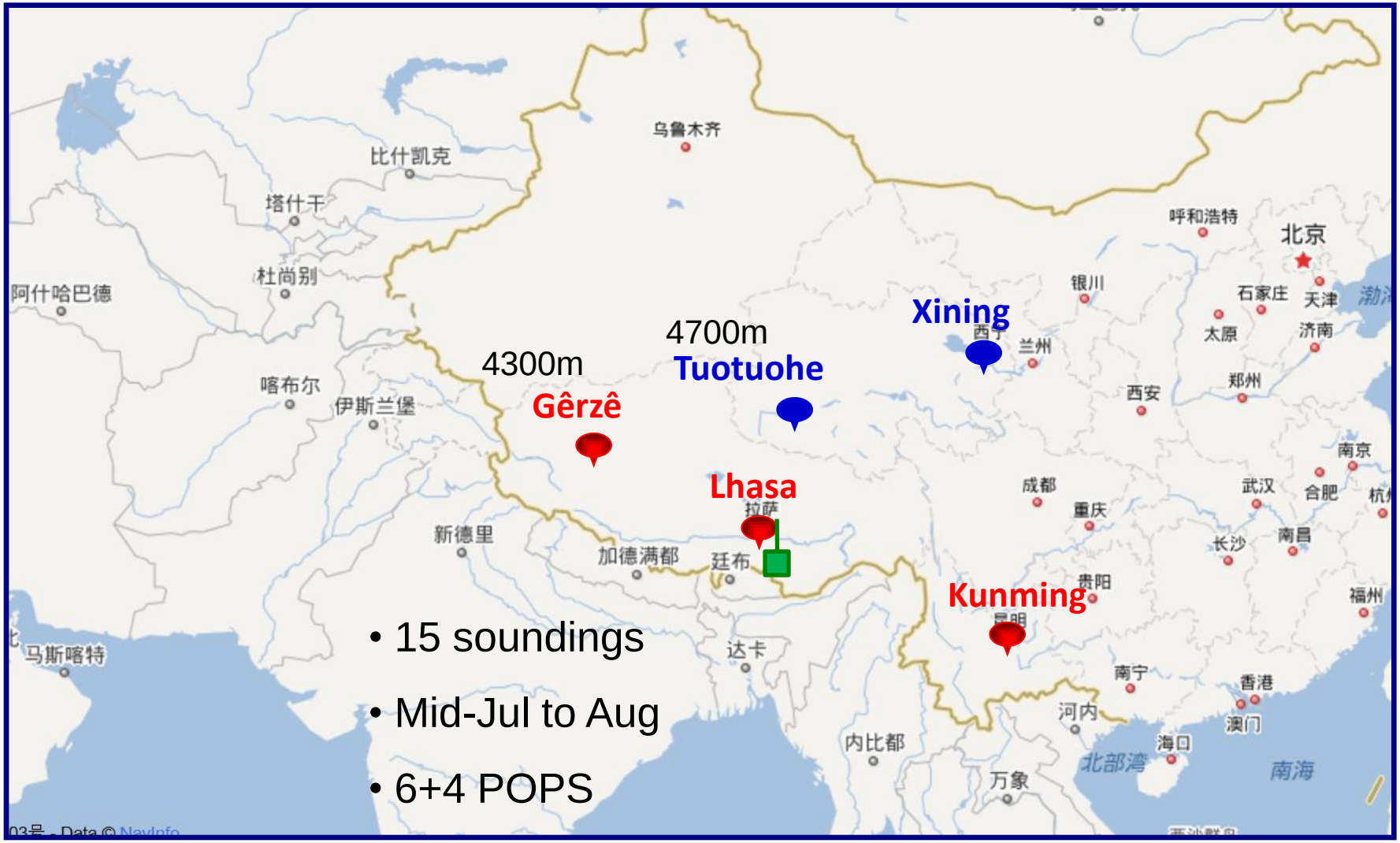
Case 5:

Typhoon convection & extra-tropical isentropic advection.



Details to be seen in talk of Baerbel Vogel

Field Campaign in 2016 Summer



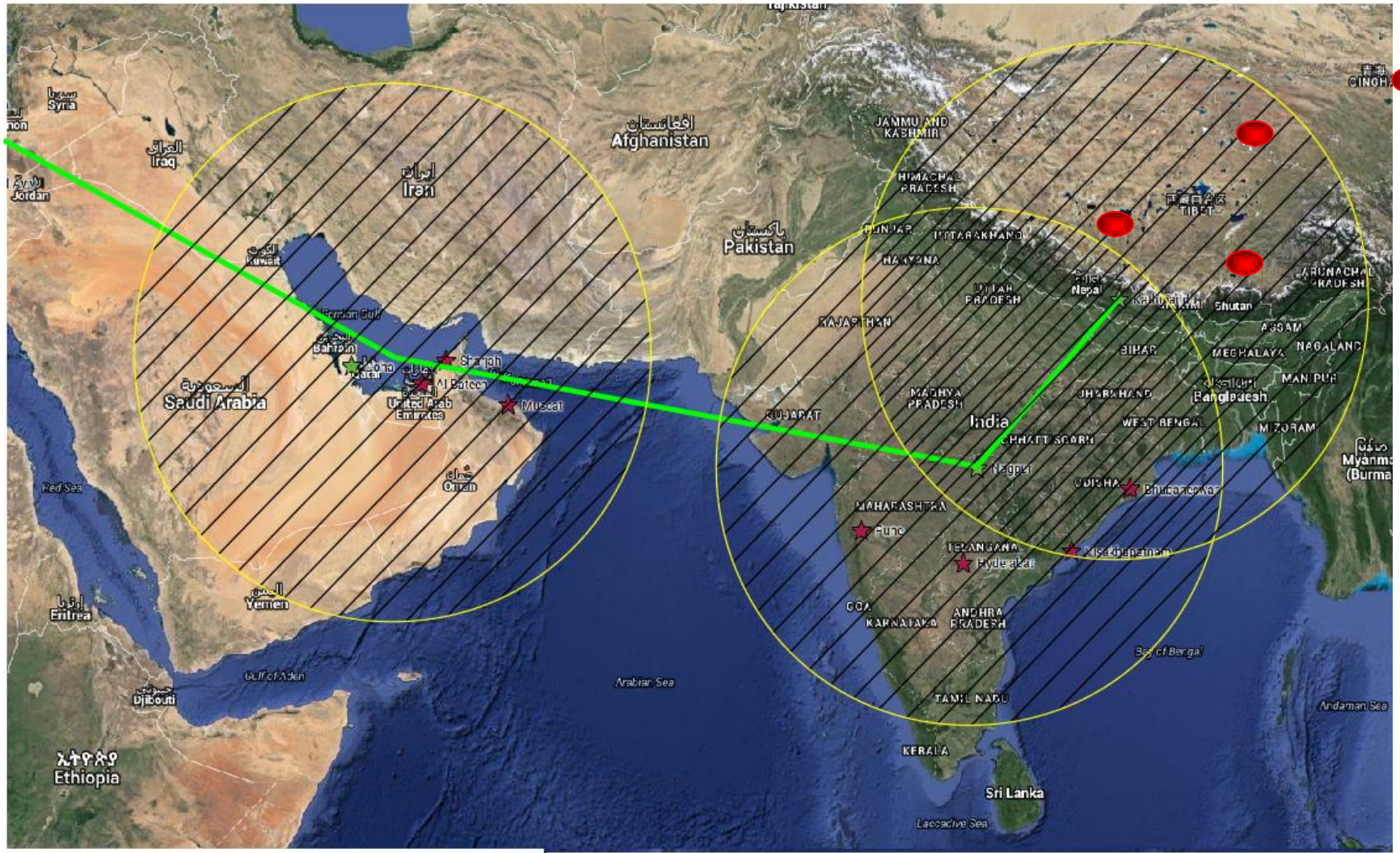
O_3, H_2O, particle

O_3

Lidar

To coordinate with

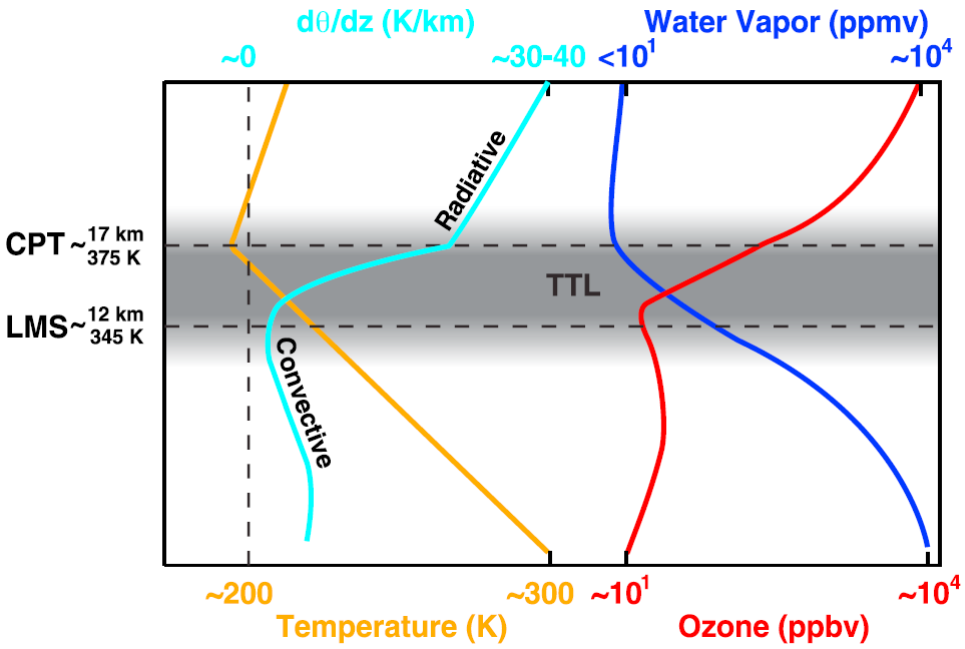
StratoClim Field Campaign



Single flight operational ranges for selected campaign bases (1200km) of M55-Geophysica during StratoClim

Summary

Pan et al. JGR, 2014



- 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:

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Thanks for your attention!