Development of UAV observation technology in NCU

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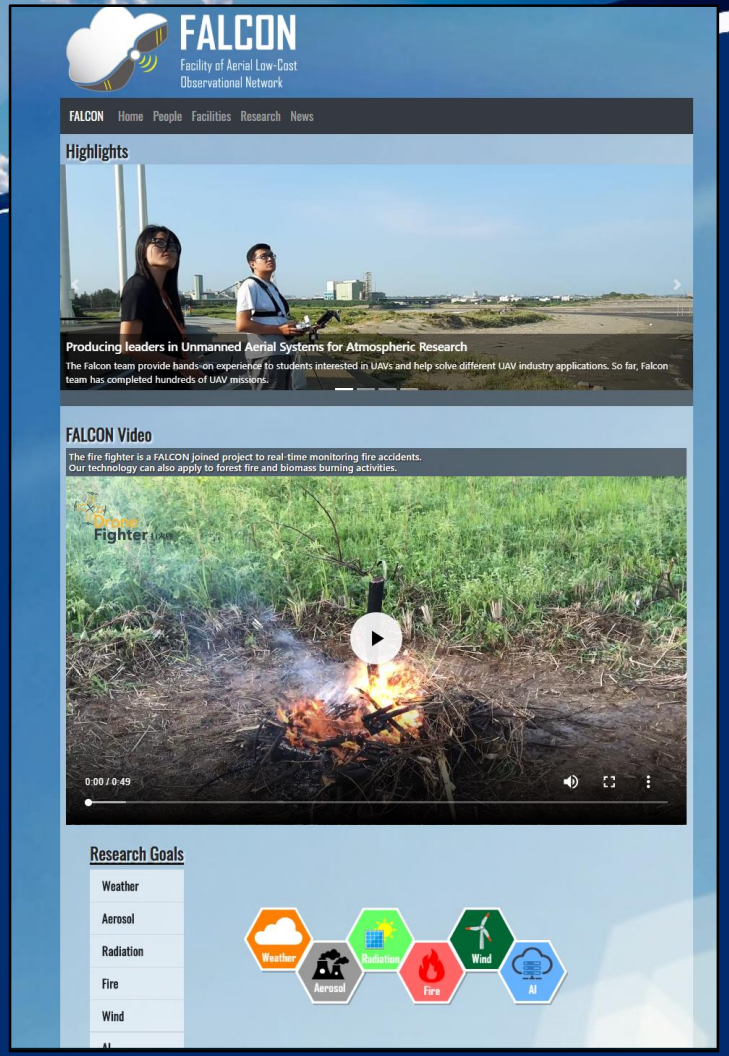
What is FALCON?

- **FALCON (Facility of Aerial Low-Cost Observational Network)** is an infrastructure to facilitate the atmospheric research community's need to fill the gap in hardware/firmware development related to unmanned aerial system (UAS) use.

For more information, please check out our poster and website
http://falcon.atm.ncu.edu.tw



What FALCON do?

- **Weather Measurement**

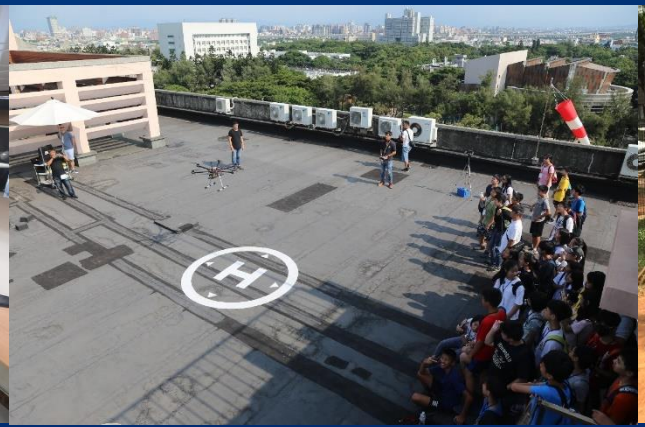
What FALCON do?

- **Commercial Application**

What FALCON do?

- **UAV education**

1. We provide UAV experiencing program for high school to under graduated students.
2. We also provide drone flight training, including, operational rules, understanding airspace, aircraft technology and how to become a certified remote pilot.

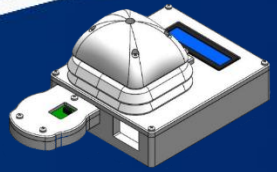



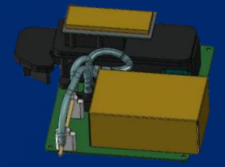

FALCON's UAS

	850V6	Sky-surfer X8	Skywalker X8	Red Falcon
Type	Hexacopter	Fixed-wing	Fixed-wing	Fixed-wing
Material	Aluminium alloy	EPO	EPO	Aircraft plywood
Power	Li-Po battery	Li-Po battery	Li-Po battery	Li-Po battery
Max. Payload	2 kg	0.1 kg	1 kg	2.5 kg
Endurance time	20-30 minute	40-60 minute	60-90 minute	60-90 min
Max. Flight level	1.5 km	5 km	5 km	5 km
Instrument	Aerobox / POPS / Windsond	Windsond	Aerobox / POPS / Windsond	Aerobox / POPS / Windsond and more
Cruising speed	3-4 ms^{-1}	20-30 ms^{-1}	30-40 ms^{-1}	50-60 ms^{-1}
Max. Takeoff Weight	6.5 kg	1.2 kg	2.4 kg	8 kg

FALCON sensor family

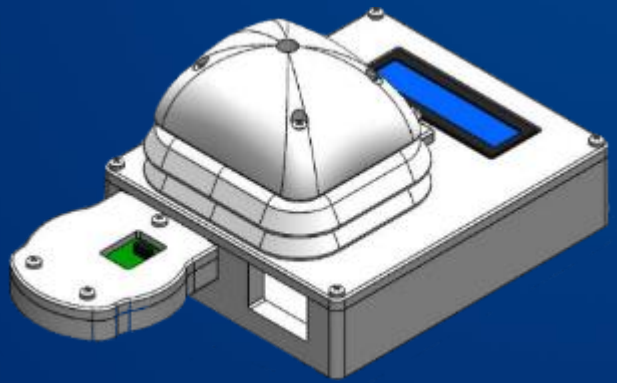
Type	Sensor/Module/Instrument	Parameter
Meteorology	temperature and humidity sensors	T, RH
	pressure sensors	P
	High-resolution wind field module	WD, WS
	2D Sonic wind sensor (FT technology)	WD, WS
	Radiation (EKO MS80s, MS01, SP Lite)	Radiation flux
Aerosol	POPS (NOAA)	Particle size distribution
	Low cost PM2.5 sensor (G3 and G5)	PM mass
	Black Carbon (AE51 and MA200)	BC conc.
Gases	trace gas and greenhouse gas sensors (CO, O_3, CO_2, CH_4)	Mixing ratio
Imagery	Real-time view and thermal imaging module	VIS Image
	FLIR thermal camera (fire one)	IR image





FALCON sensor family

Aerobox



- Aerobox is designed and developed by our laboratory.
- Aerobox can expand and add a variety of sensors such as PM2.5, CO, T, RH, GPS sensor.

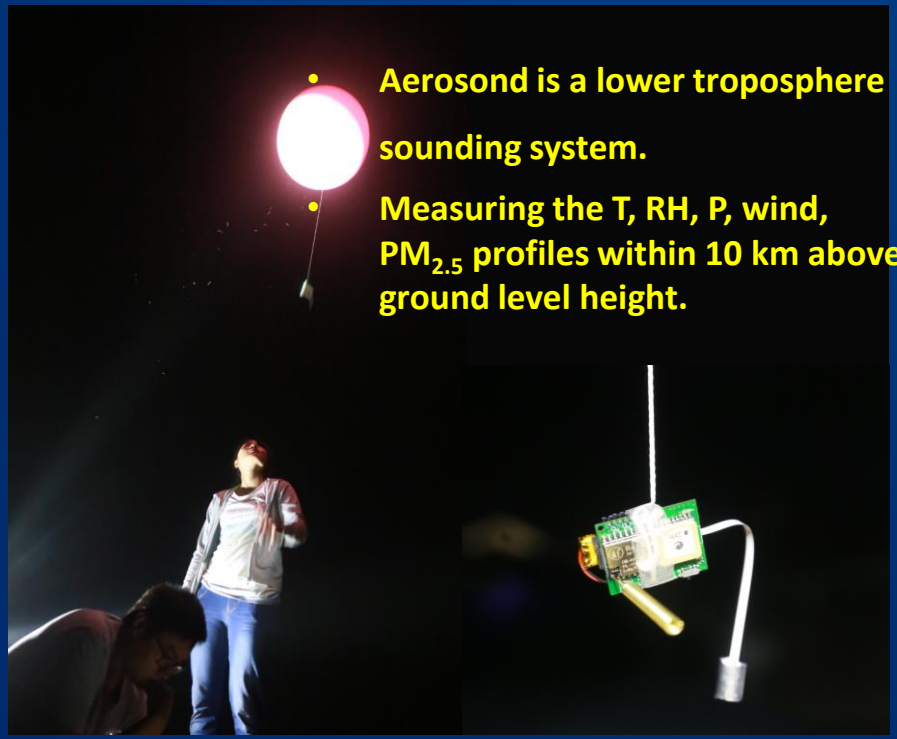
Control board

+

$PM_{2.5}$, CO, T, RH, GPS sensor

FALCON sensor family

Aerosond



- Aerosond is a lower troposphere sounding system.
- Measuring the T, RH, P, wind, $PM_{2.5}$ profiles within 10 km above ground level height.

Main circuit board	
model	Aerosond v0
Size	5 x 2.2 x 4 cm
Weight	57.2 g
MCU module	Atmel 328P AU
RF module	LoRa 433
GPS module	NMEA
Power supply	Typ:5.0VDC; Min:4.5VDC; Max: 5.5VDC
Operation Temperature	-40 ~ 85 ℃

$PM_{2.5}$ sensor	
model	Plantower PMS5003 G5
Size	5 X 2.2 X 4 cm
Effective Range	0~500 μg m^{-3}
Resolution	1 μg m^{-3}
Response Time	1 sec
Uncertainty	±10%@100~500μg m^{-3} ; ±10μg m^{-3}@0~100μg m^{-3}
Operation Temperature	-10~+60 ºC

Pressure sensor	
model	MPL3115A2
Size	0.3 x 0.5 cm
Effective Range	20-110 kPa
Resolution	0.25 Pa
Response Time	0.1 s
Uncertainty	± 0.4 kPa
Operation Temperature	-40~85 ℃

Temperature sensor	
model	SHT31
Size(cm)	0.24 x 0.24
Effective Range	Depend on RF module
Resolution	0.015
Response Time	0.25 s
Uncertainty	± 0.3 ºC
Operation Temperature	-40~90 ºC

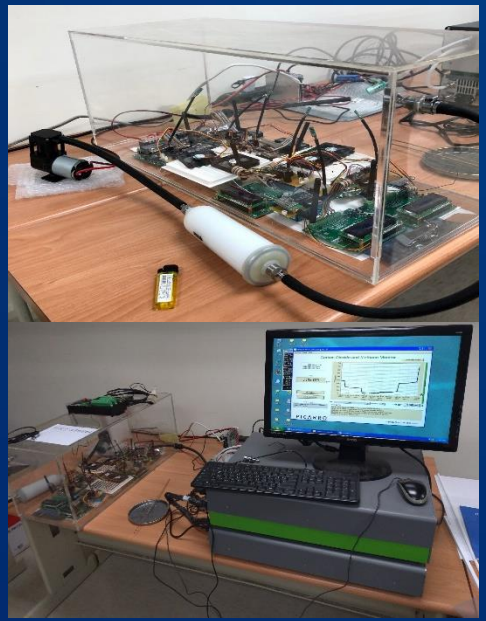
RH sensor	
model	SHT31
Size	0.24 X 0.24 cm
Effective Range	Depend on RF module
Resolution	0.01
Response Time	0.25 sec
Uncertainty	± 2 %
Operation Temperature	-40~90 ºC

FALCON sensor family

Buoyancy meter

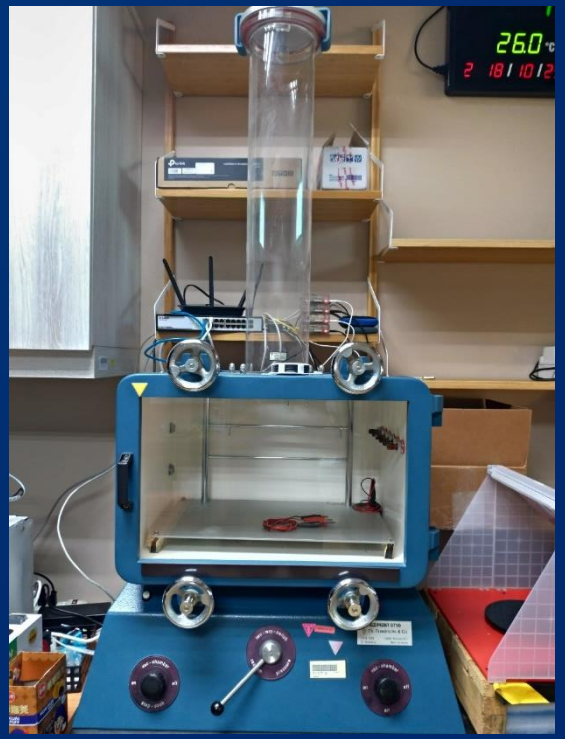
FALCON sensor calibration facility

CO_2, CH_4, and zero air chamber



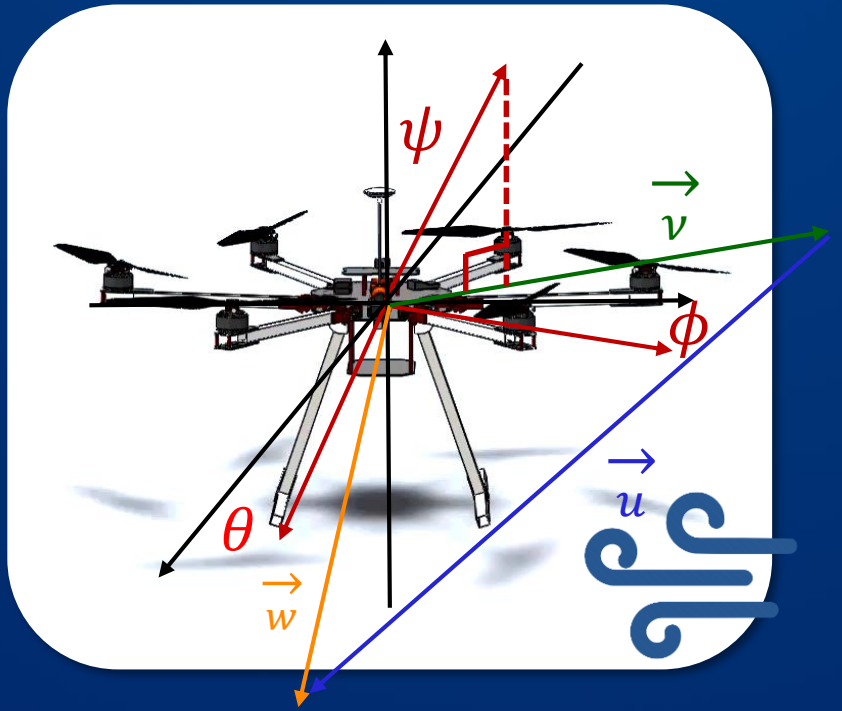
Humidity and Temperature chamber

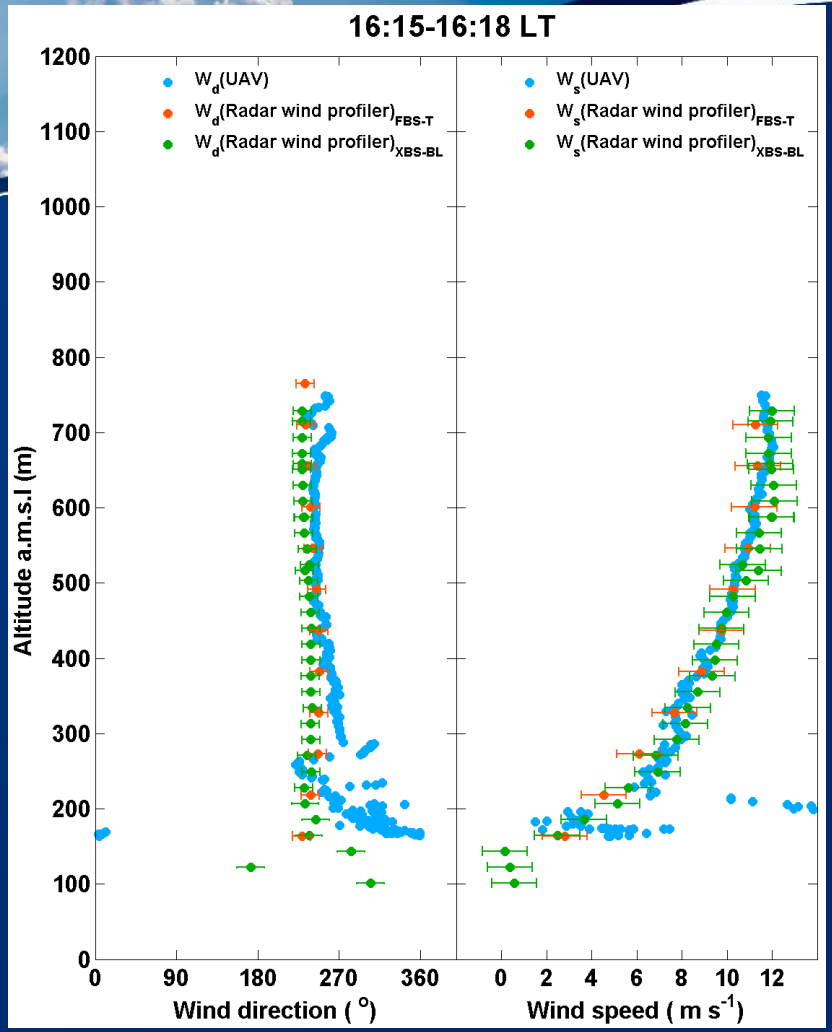
Pressure chamber



FALCON data inversion

Wind speed and direction inversion

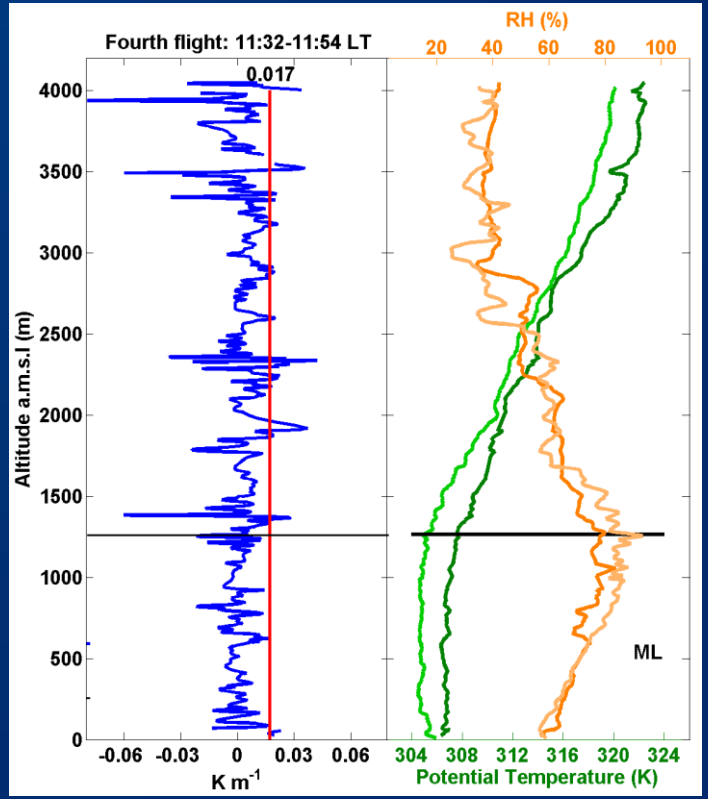




FALCON data inversion

PBL (or mixing layer) height detection

1. There is a temperature inversion layer between the mixed layer and the free atmosphere, so it can be assumed to be the height of the boundary layer.
2. The maximum gradient position of the vertical change of relative humidity.
3. The closest location of the dew point temperature and the temperature curve.
4. Select the gradient of the virtual potential temperature ($\frac{\partial \theta_v}{\partial z}$) is more than $+0.017$ K m^{-1} and then choose the nearest zero position.



FALCON Advantage

- Self-developed aircraft and sensors
- From 2014, the team began to develop atmospheric drone profile observations.
- Enriched atmospheric observation flight experience (more than 300 missions).
- Rich international cooperation and industry-university cooperation experience.

Facility of Aerial Low-Cost Observational Network

http://falcon.atm.ncu.edu.tw

Test field for the development of atmospheric UAV System

Special permission for flying airspace

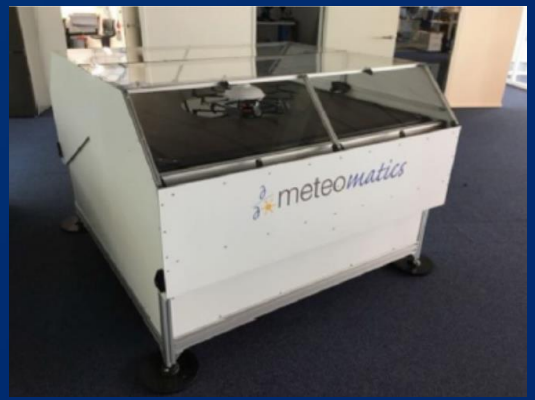
Ground-based remote sensing

Flight training and teaching

Industry and official cooperation

What is the challenge of FALCON ?

1. Airspace application
2. Aircraft registration
3. Automatic charging system and automatic flight (AI system can distinguish bad weather)
4. Integrate observational data with a combination of forecasting systems and data assimilation



2018-2019 7SEAS/Chiang Mai UAV exp.

Measurements:
T, RH, P, wind, solar flux, aerosol size distribution, $PM_{2.5}$ mass

(1195 m)
Doi Ang Khang
Myanmar
border
Thailand

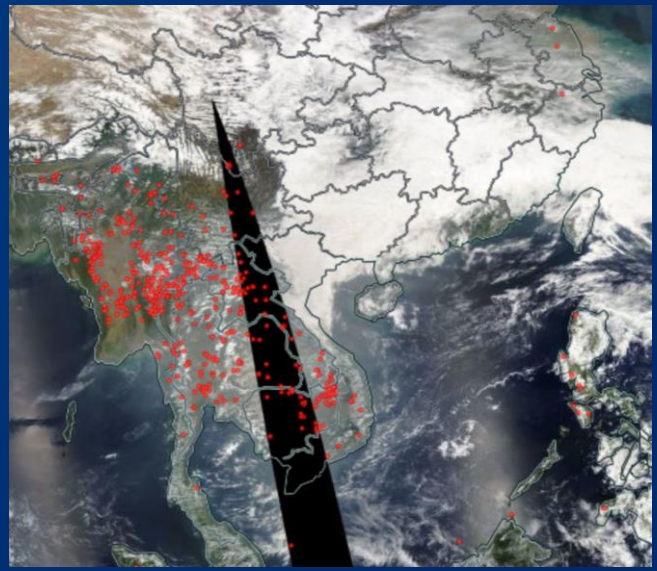
17 km

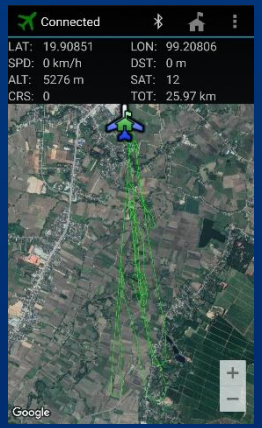
Measurements:
T, RH, P, wind, solar flux, $PM_{2.5}$ mass, $PM_{2.5}$ optical properties

Fang UAV site
(468 m)

Measurements:
T, RH, P, wind, solar flux, $PM_{2.5}$ mass, Ground-based remote sensing

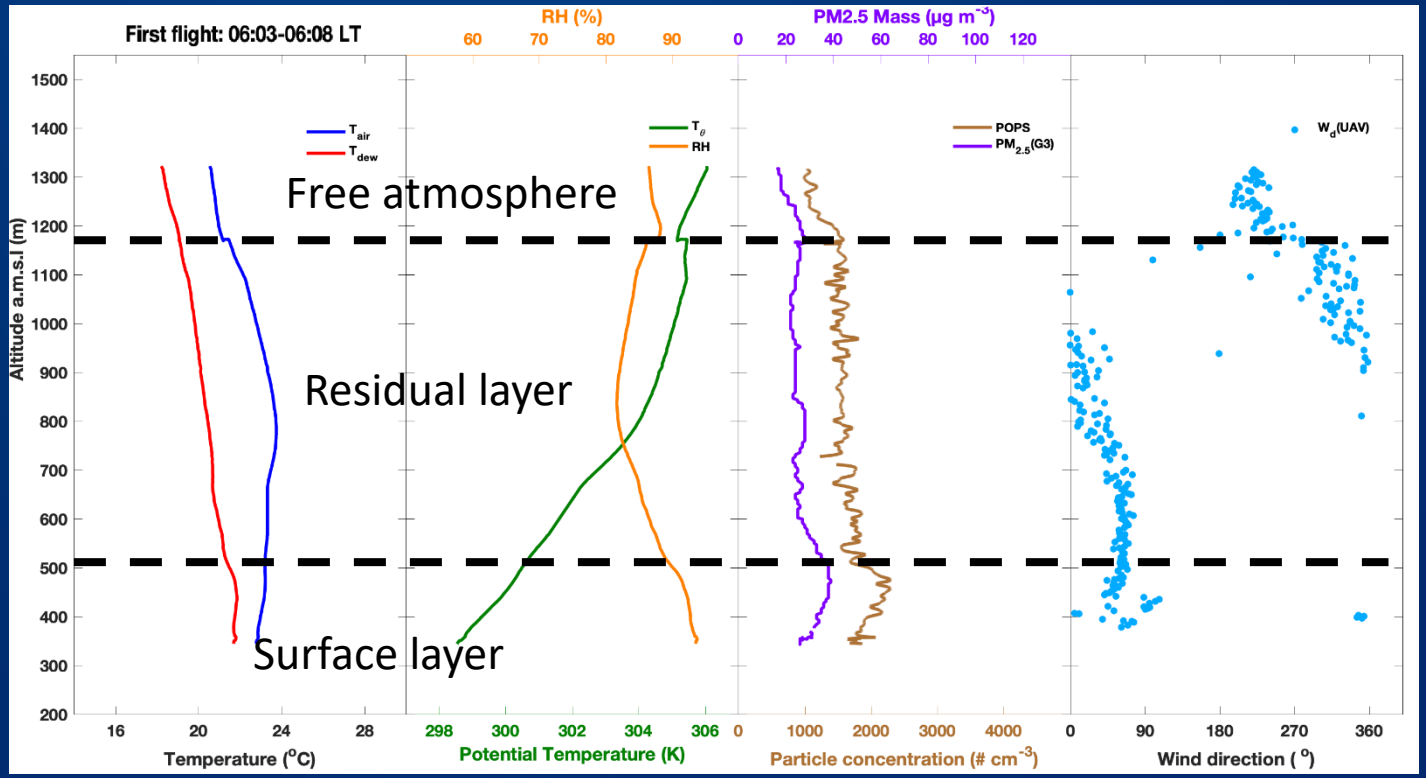
US Dept of State Geographer
Image Landsat / Copernicus
Image © 2018 CNES / Airbus
Image © 2018 DigitalGlobe



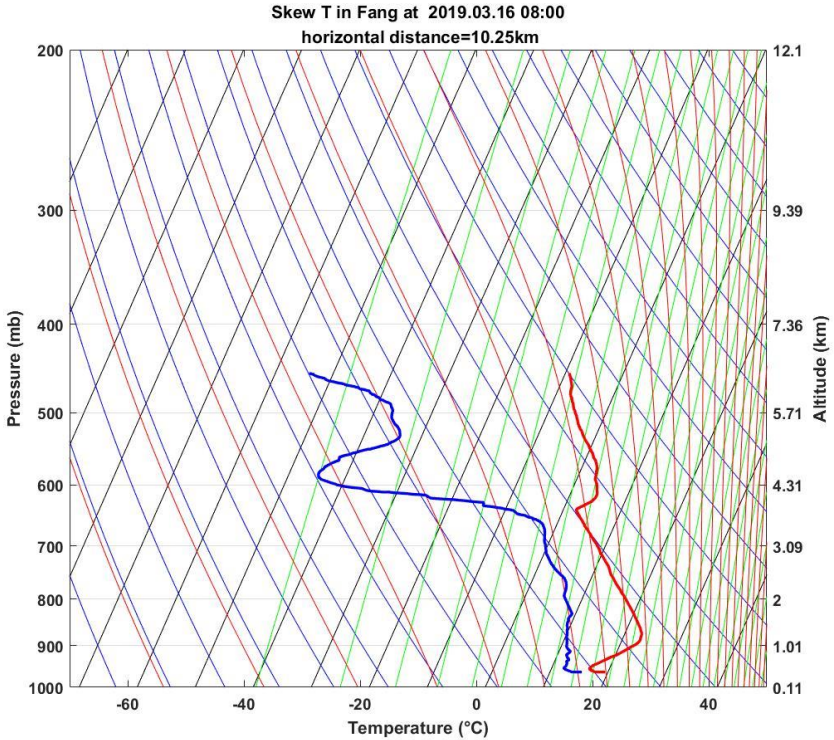

Connected
LAT: 19.90851
LON: 99.20806
SPD: 0 km/h
DST: 0 m
ALT: 5276 m
SAT: 12
CRS: 0
TOT: 25.97 km
Google

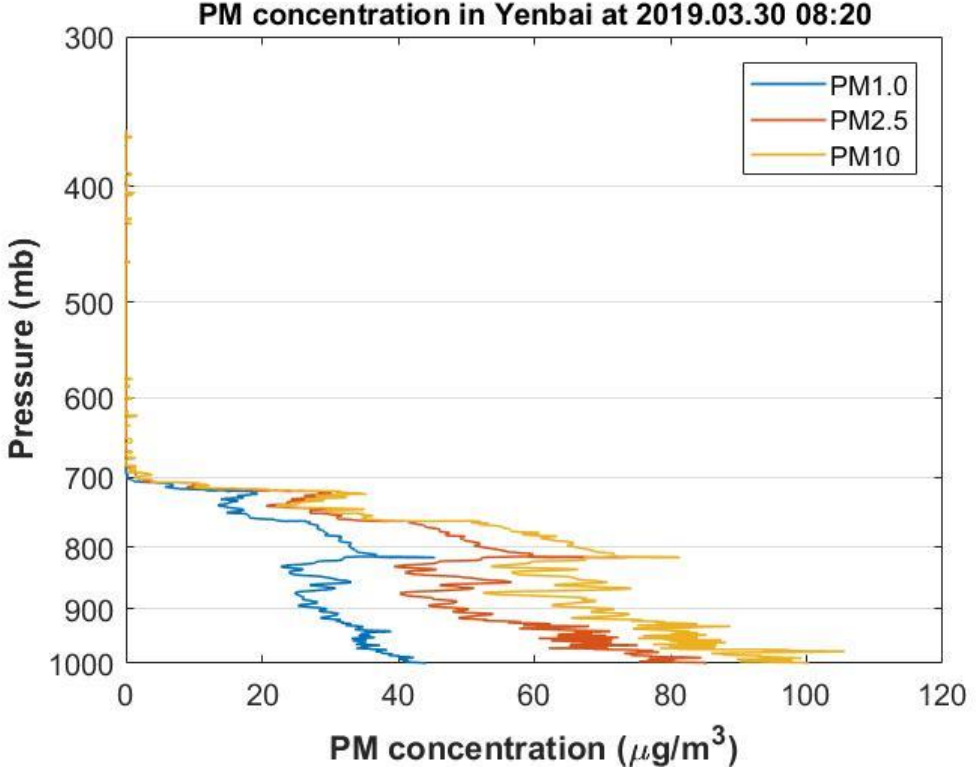
2018-2019 7SEAS/Chiang Mai UAV exp.

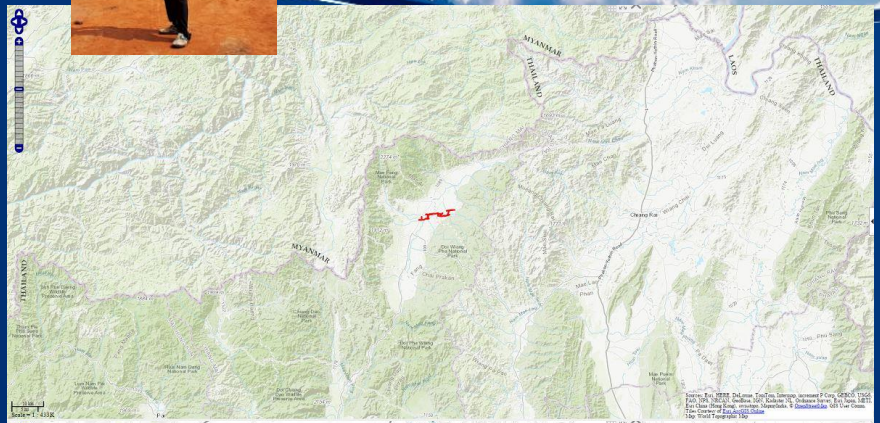
May 19, 2018 6:00

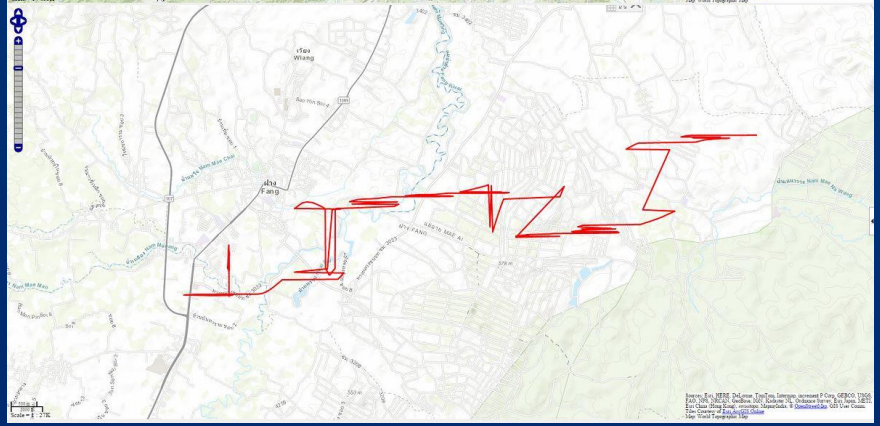


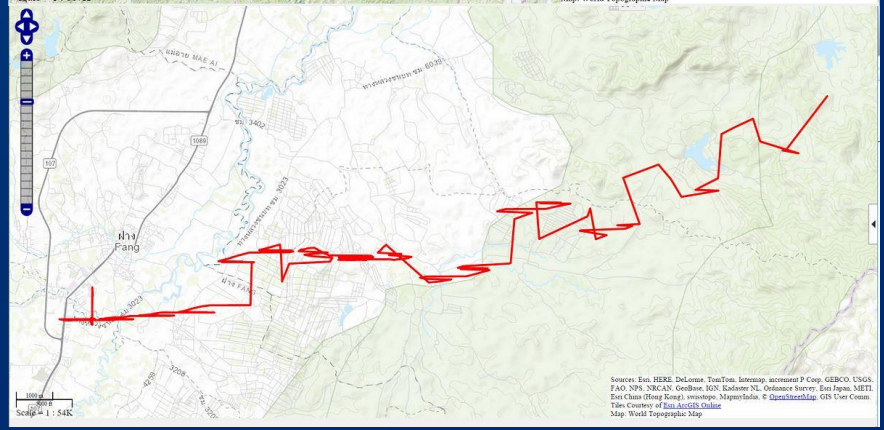
2019 7-SEAS泰國清邁觀測實驗


Skew T in Fang at 2019.03.16 08:00
horizontal distance=10.25km
Pressure (mb)
Altitude (km)
Temperature (°C)
200
300
400
500
600
700
800
900
1000
12.1
9.39
7.36
5.71
4.31
3.09
2
1.01
0.11
-60
-40
-20
0
20
40


PM concentration in Yenbai at 2019.03.30 08:20
PM1.0
PM2.5
PM10
Pressure (mb)
PM concentration (μg/m3)
300
400
500
600
700
800
900
1000
0
20
40
60
80
100
120

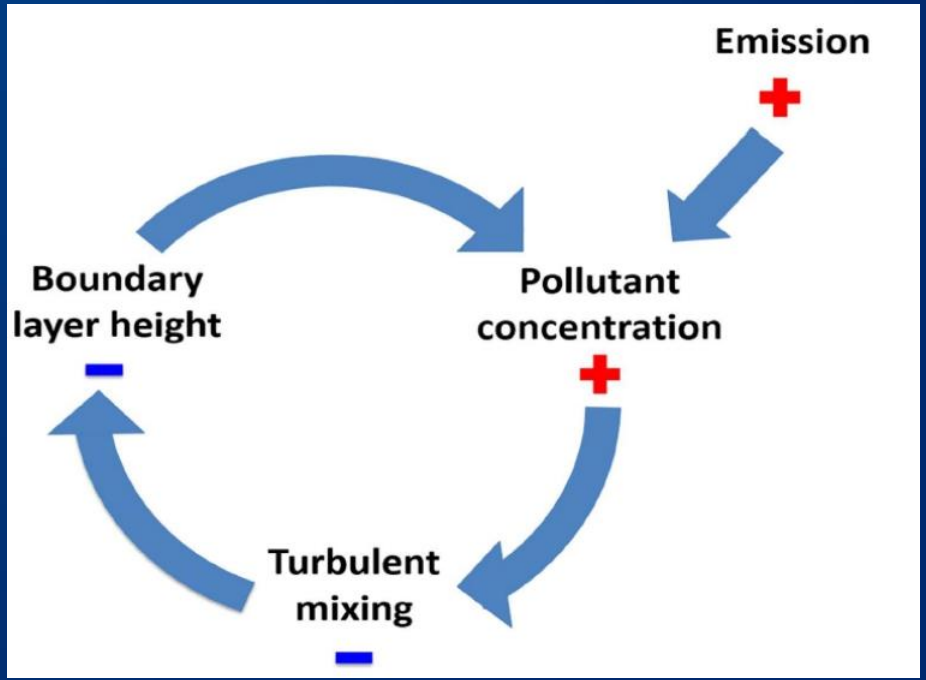

MYANMAR
THAILAND
LAOS
THAILAND
MYANMAR
Chiang Rai
Mae Sung National Park
Doi Wiang Pha National Park
Sun Pun Duong Wildlife Preserve Area
Tham Pla Namo Pha Sua National Park
Tham Pla Pha Sua National Park
Lum Nam Pa Wildlife Preserve Area
Chiang Dao National Park
Doi Chiang Dao Wildlife Preserve Area
Doi Pha Wiang National Park
Doi Luang National Park
Mae Puem National Park
Pai
Hua Nam Dang National Park
Hong Son
Scale = 1 : 867K


Wiang
Fang
Scale = 1 : 27K

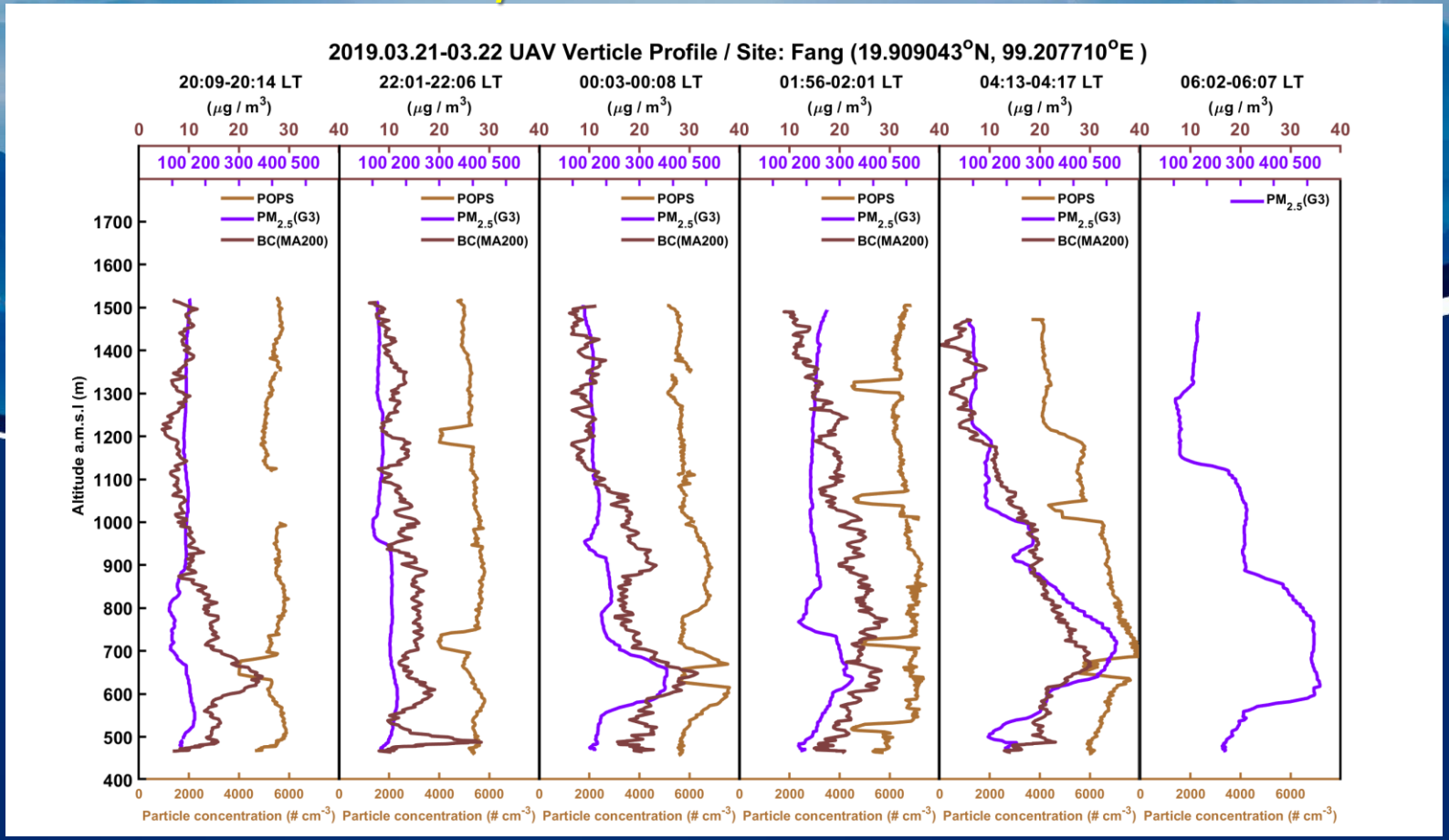

Fang
Scale = 1 : 54K

Compare UAV profile with Lidar data
March 21-25, 2019 Aerosol-PBL Interactions

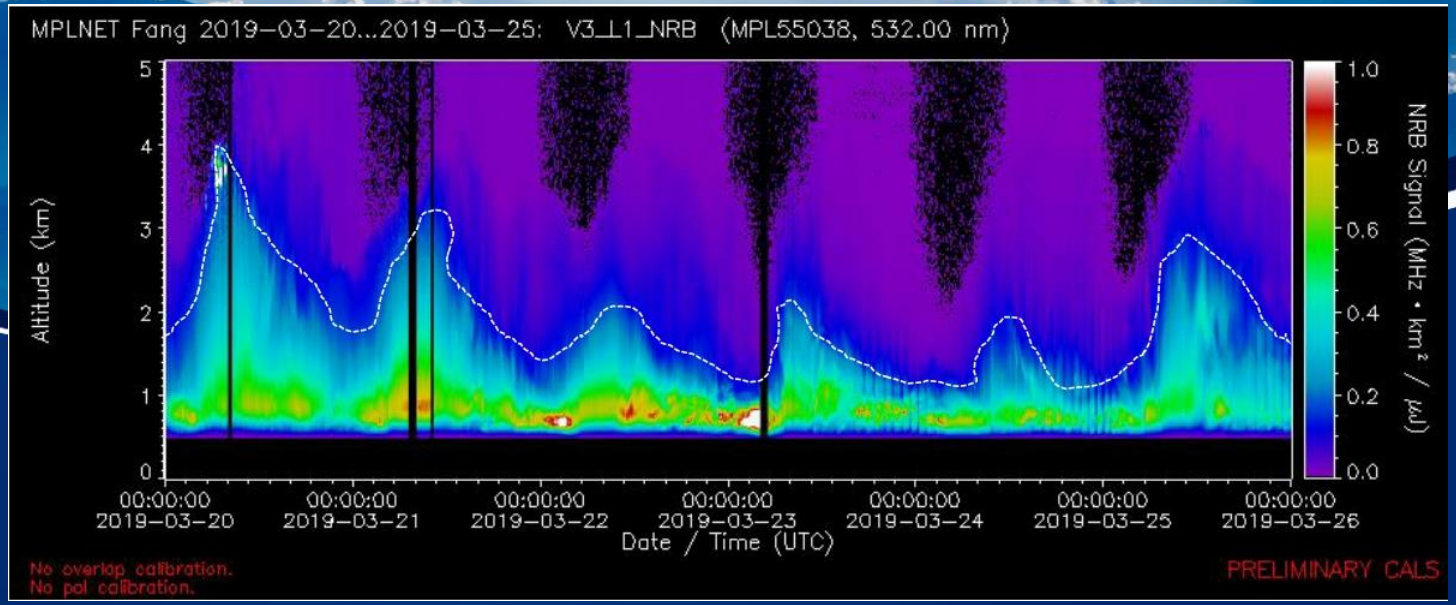
Feedback mechanism initiated by the increased aerosol concentration in the boundary layer leading to lower boundary layer height and hence elevated aerosol concentration.



Compare UAV profile with Lidar data
March 21-25, 2019 Aerosol-PBL Interactions



Compare UAV profile with Lidar data
May 21-25, 2019 Aerosol-PBL Interactions



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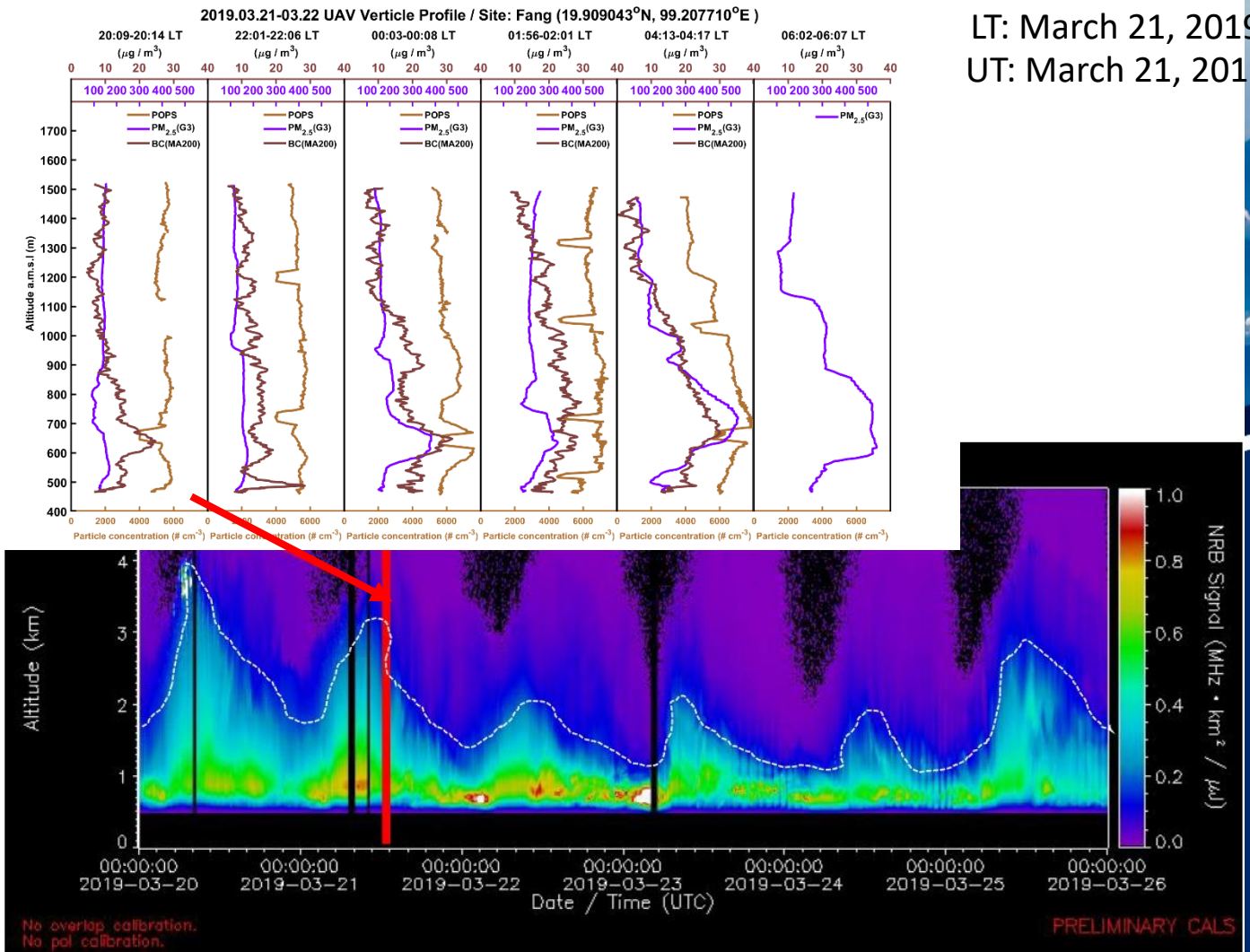
UT: March 21, 2019 (13:00)



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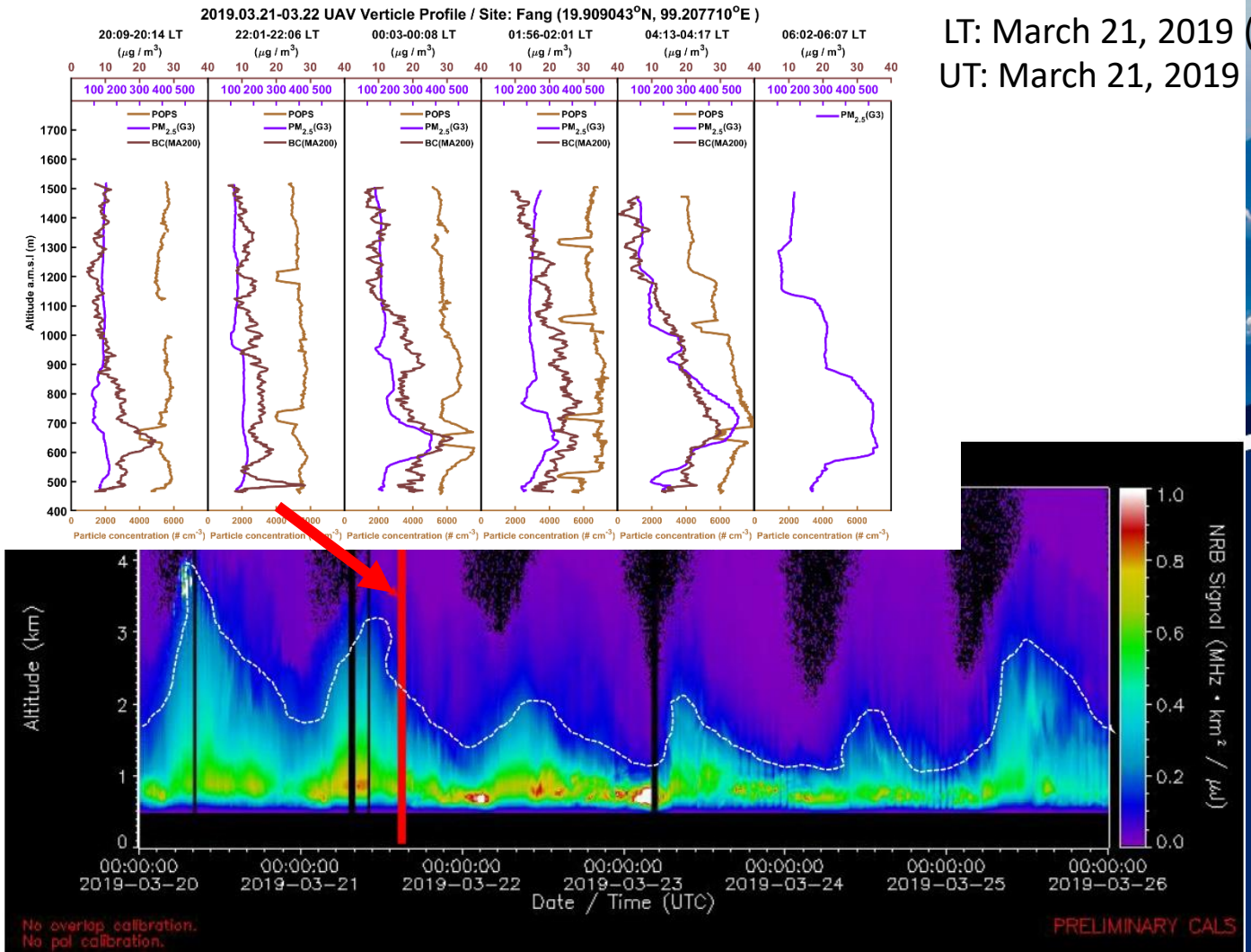

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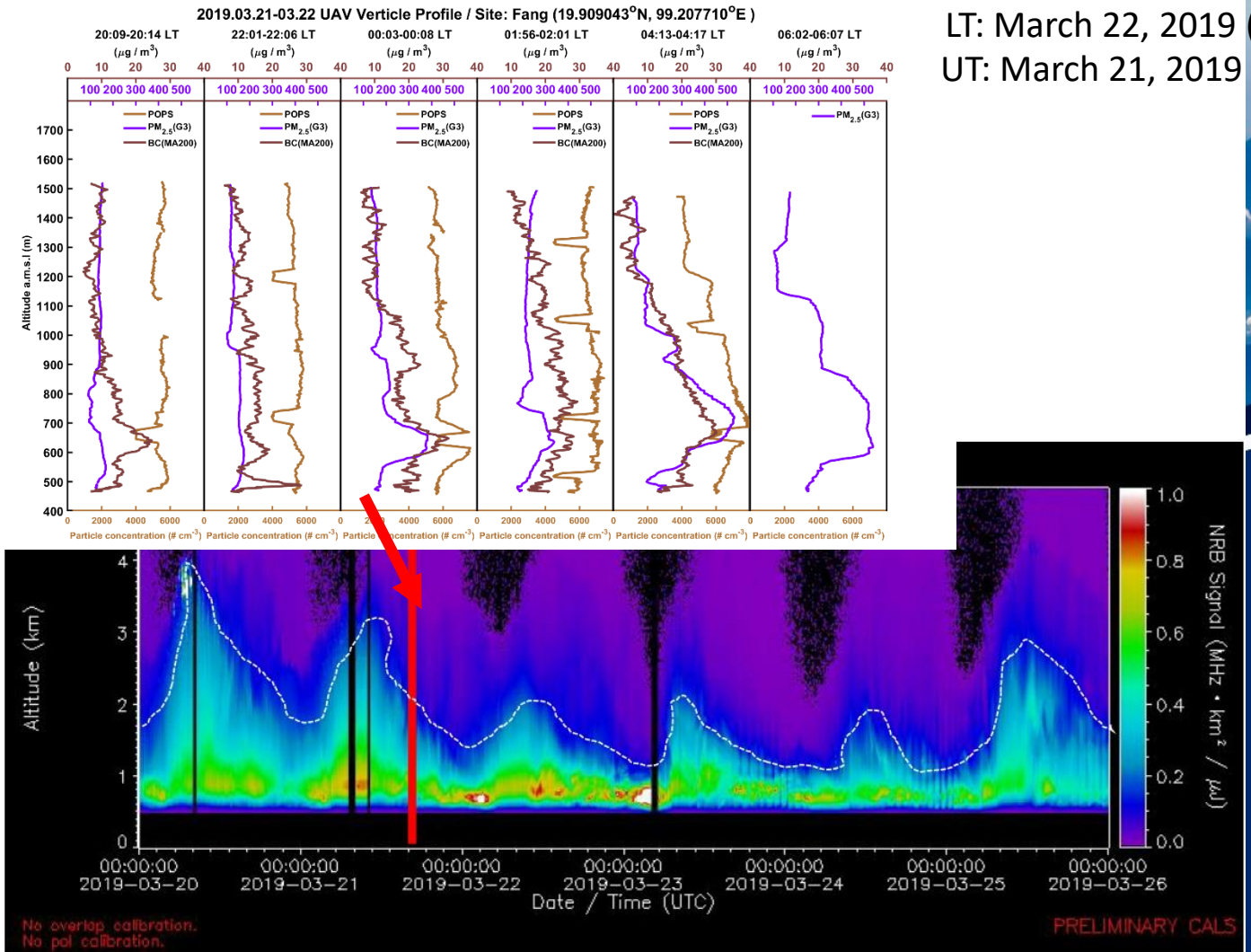

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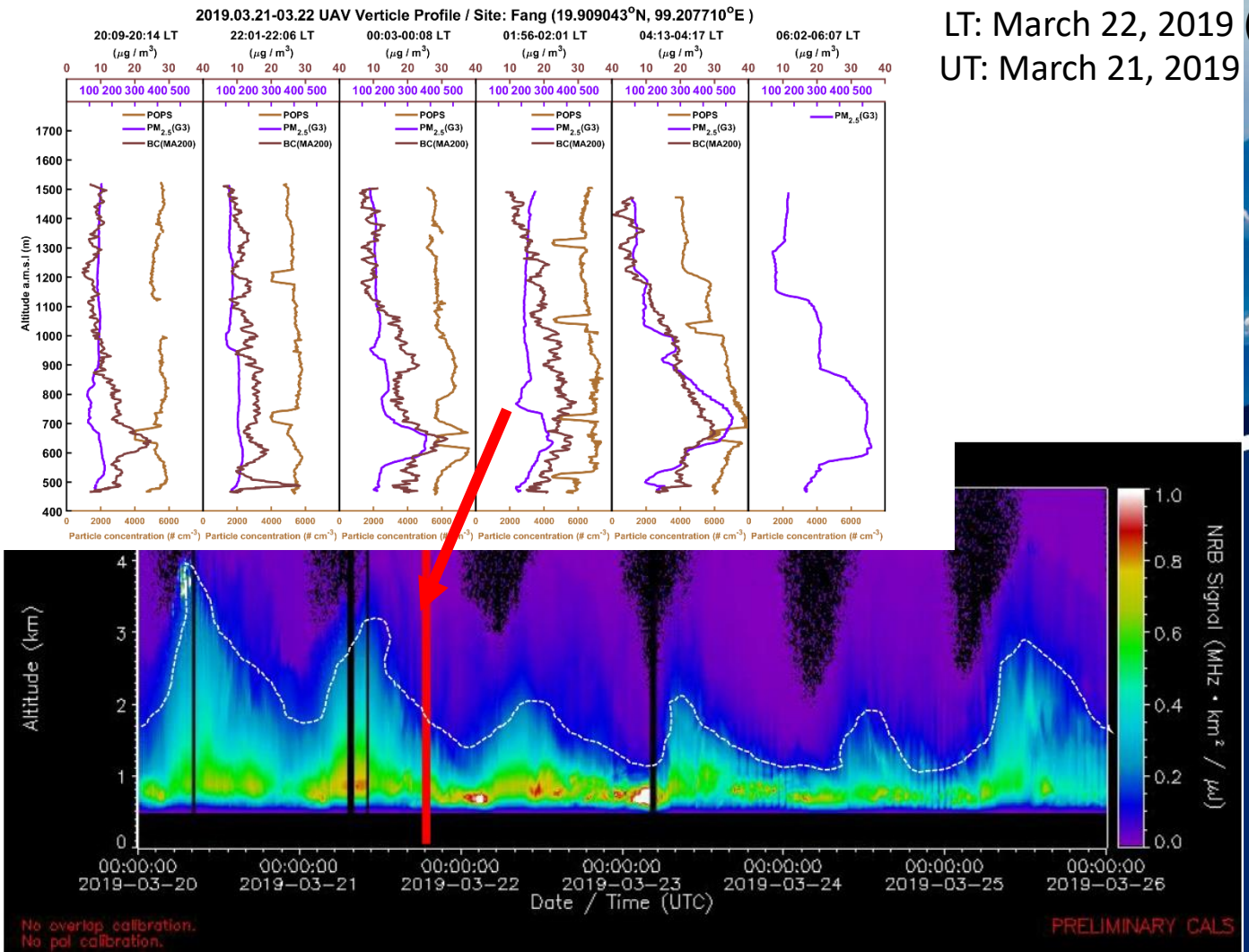

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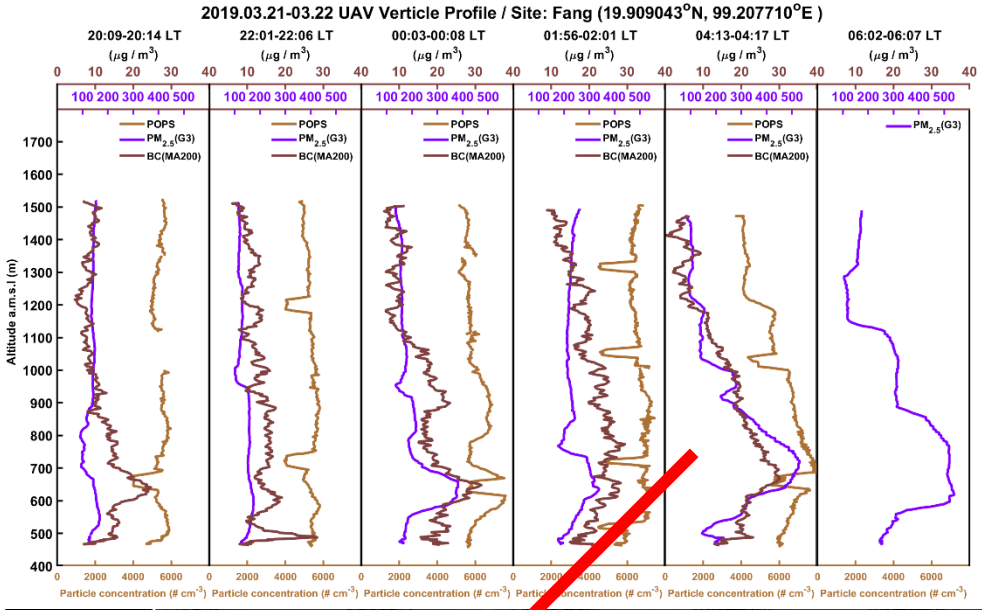

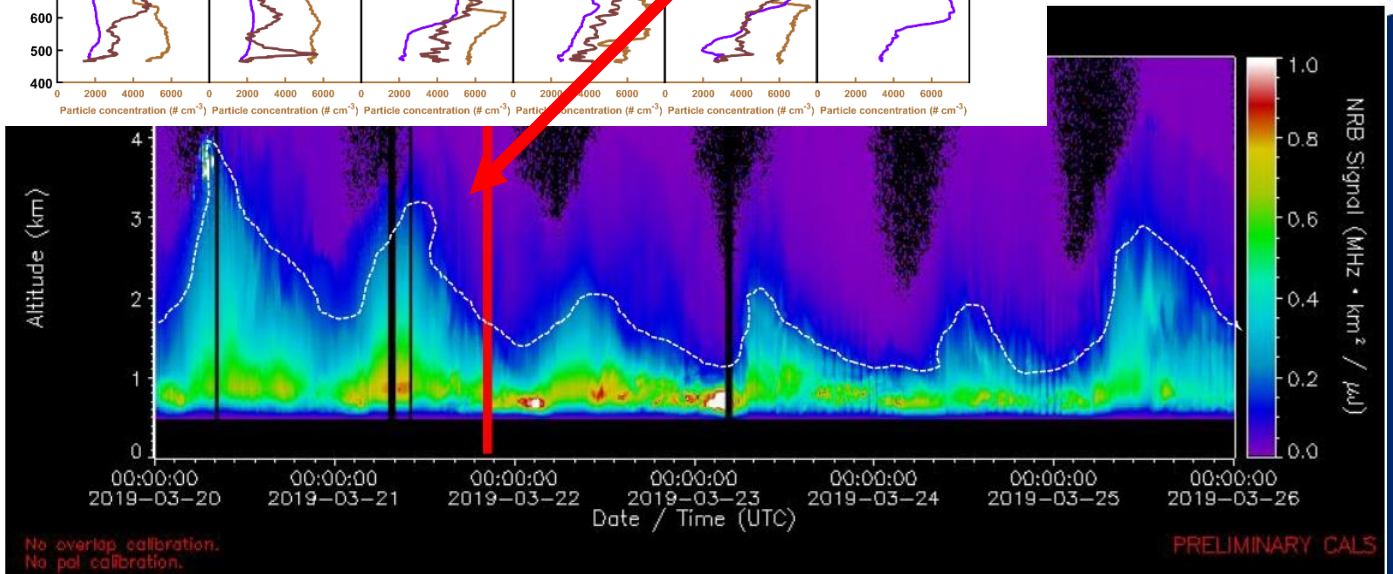

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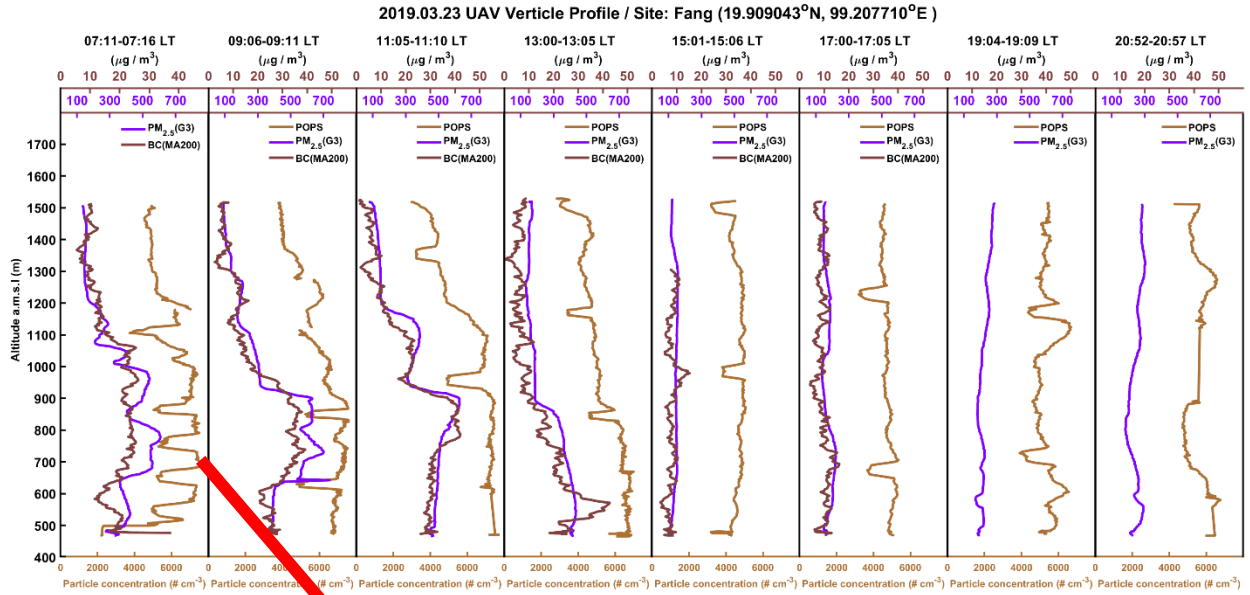

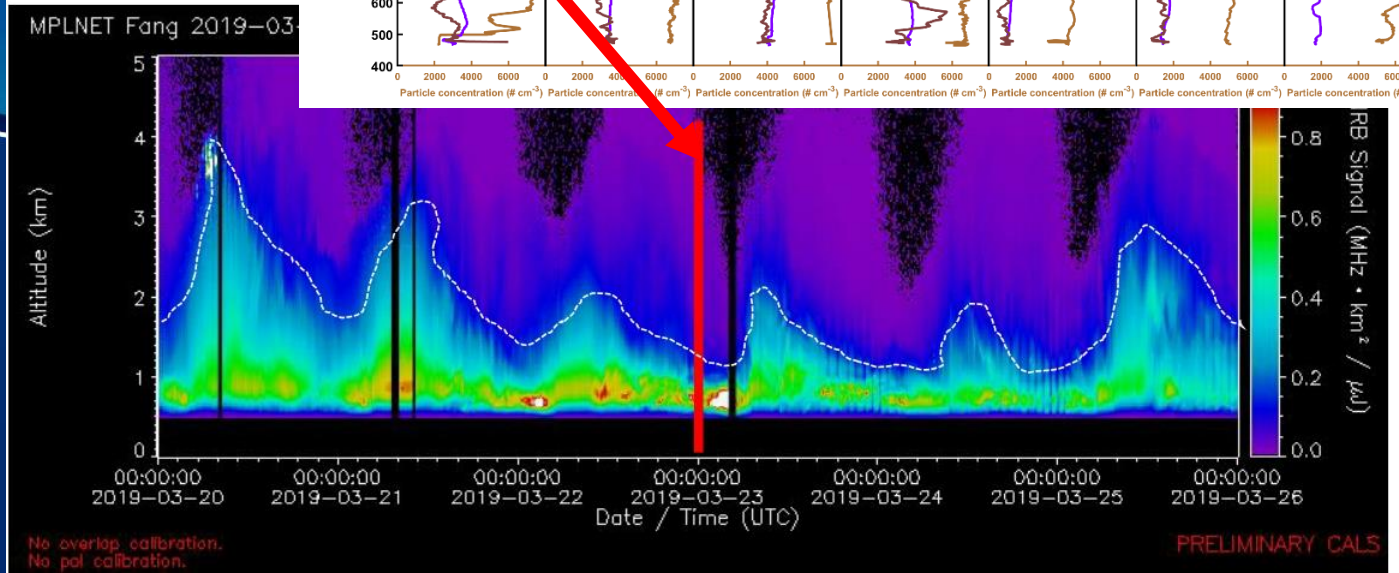

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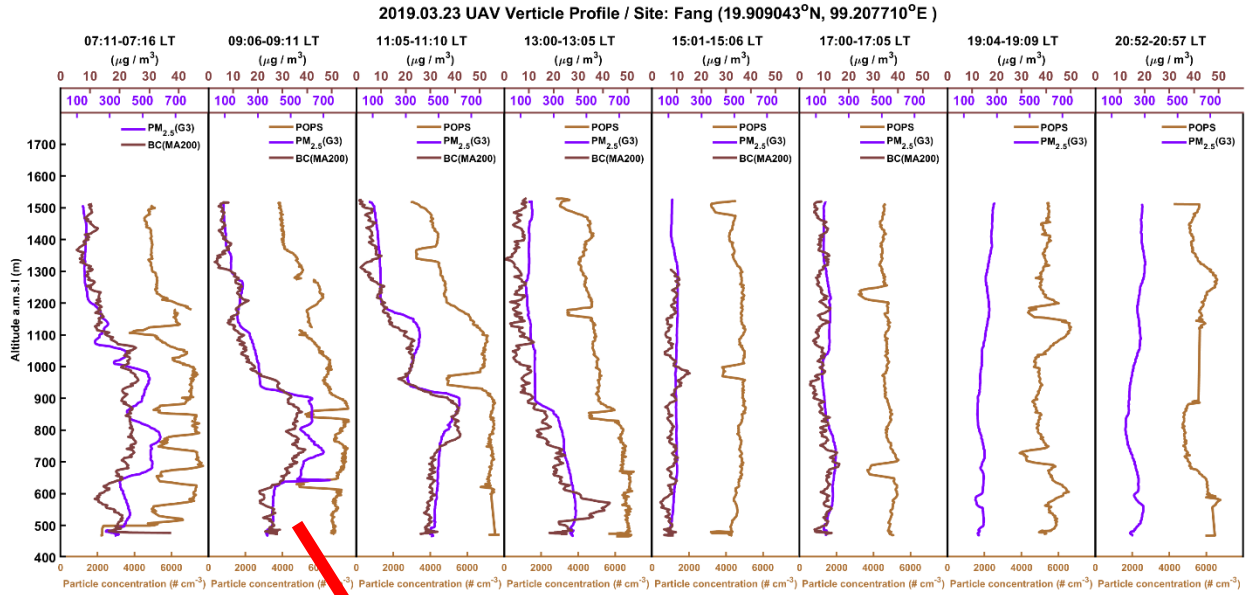

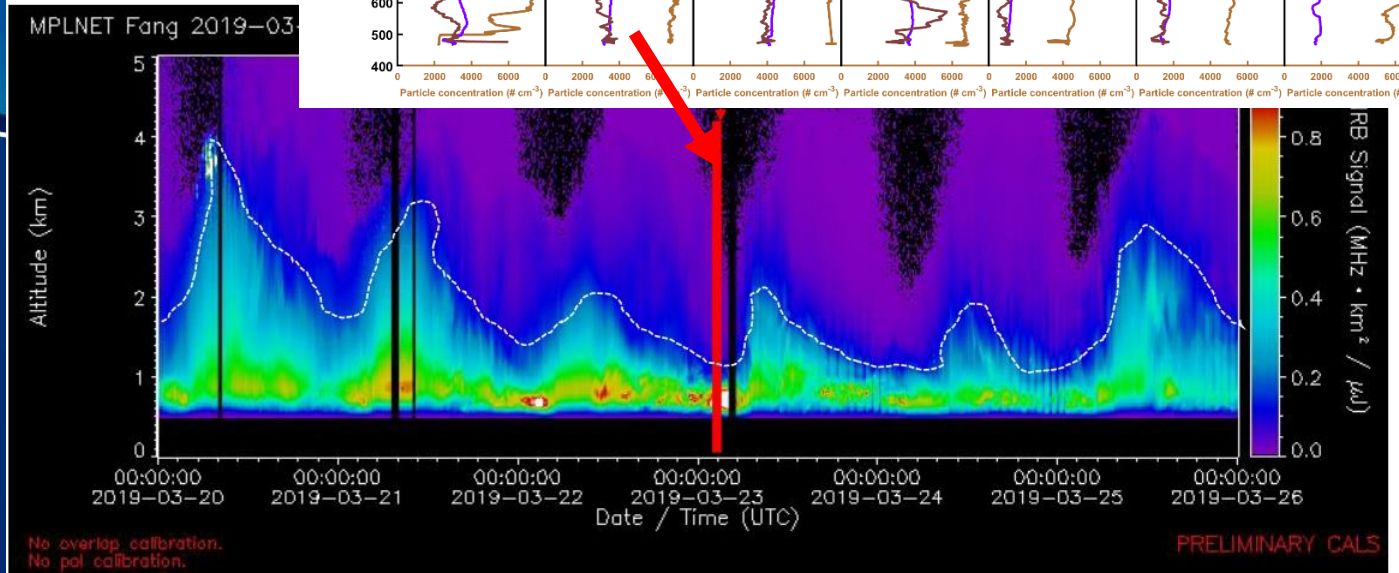

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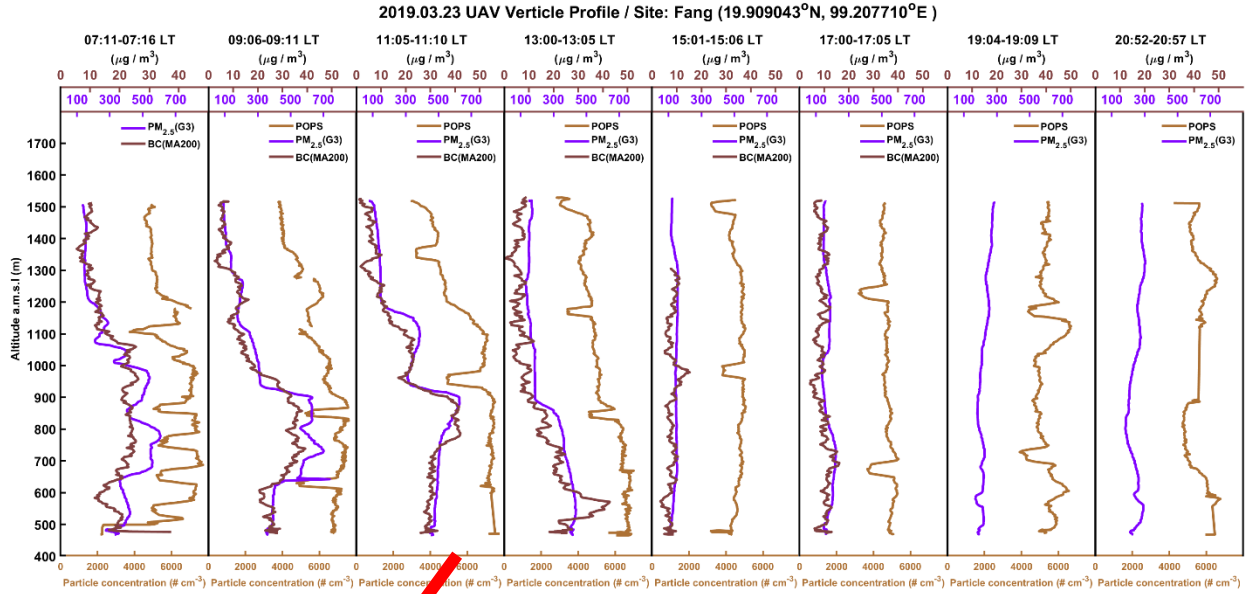

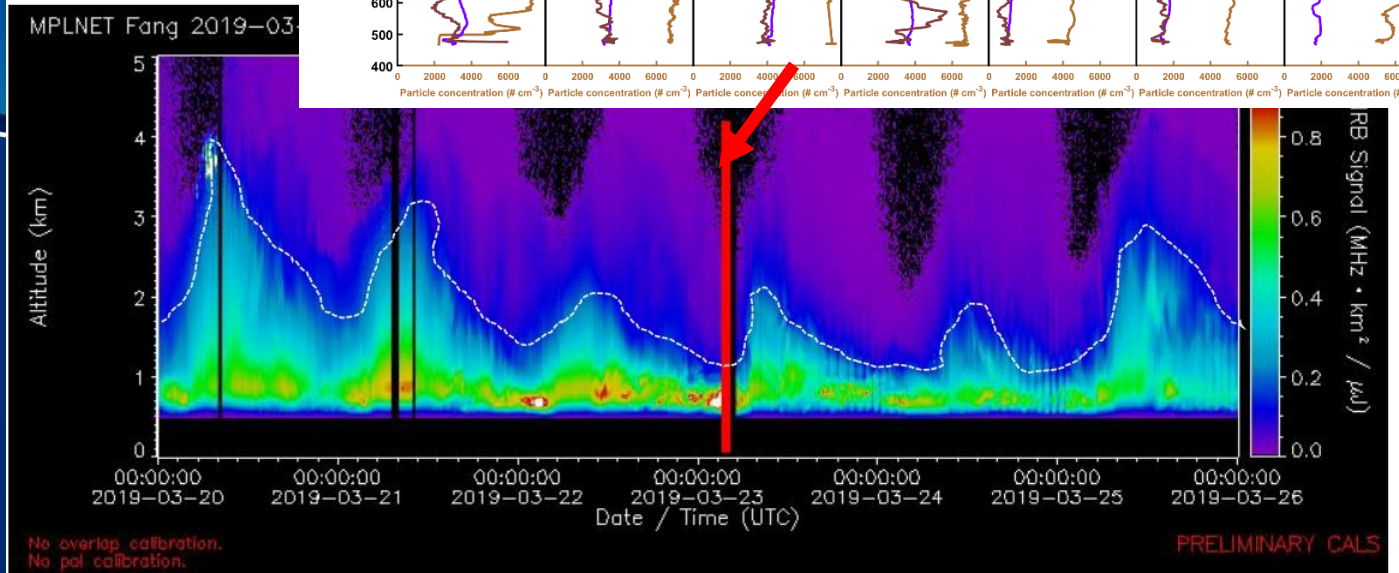

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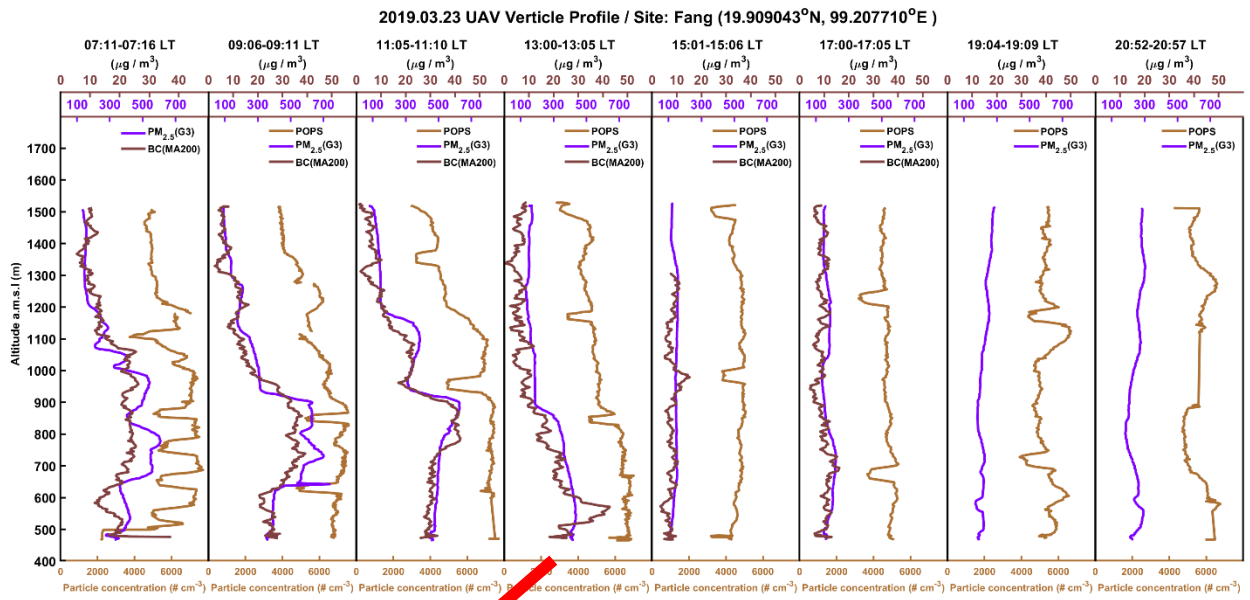

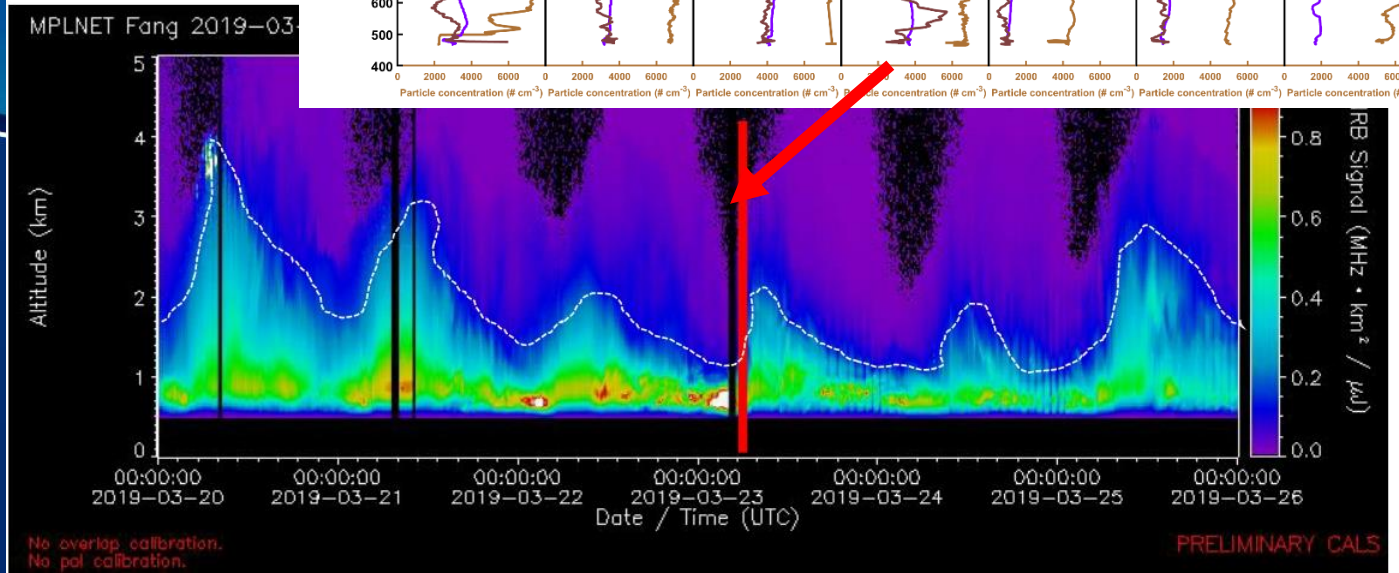

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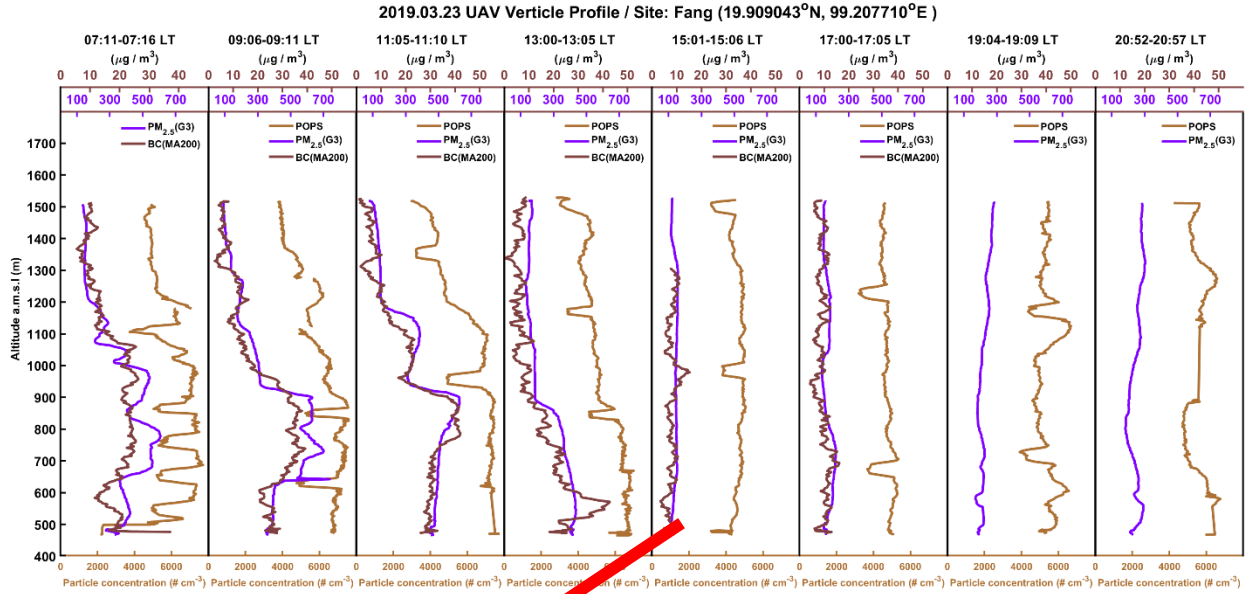

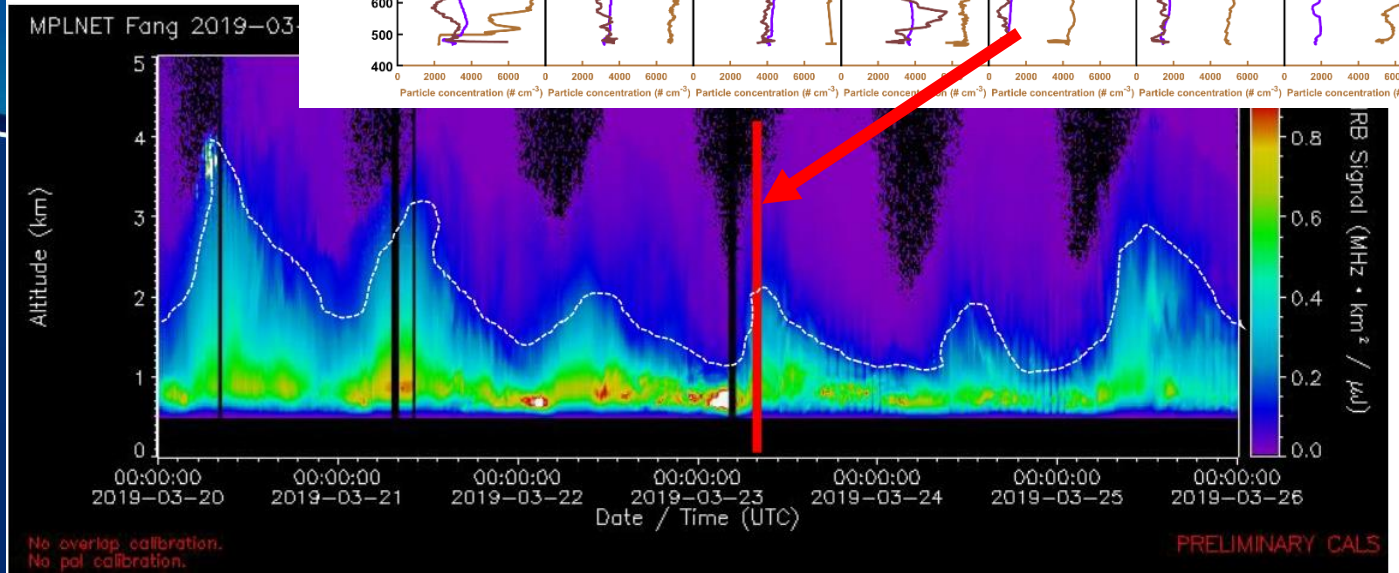

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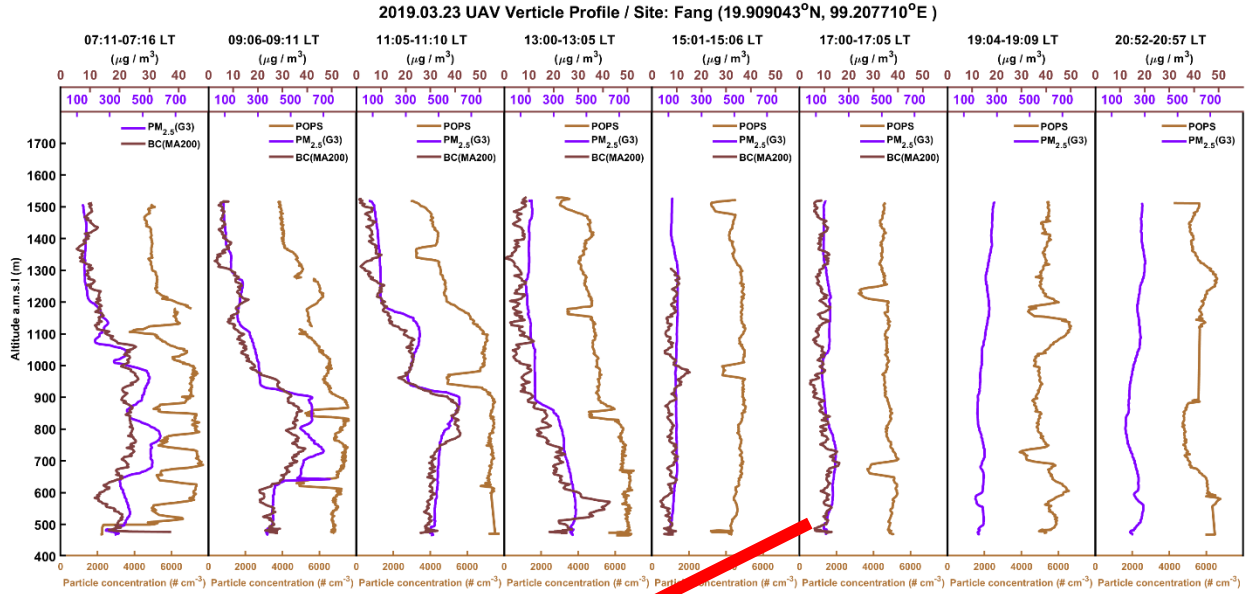
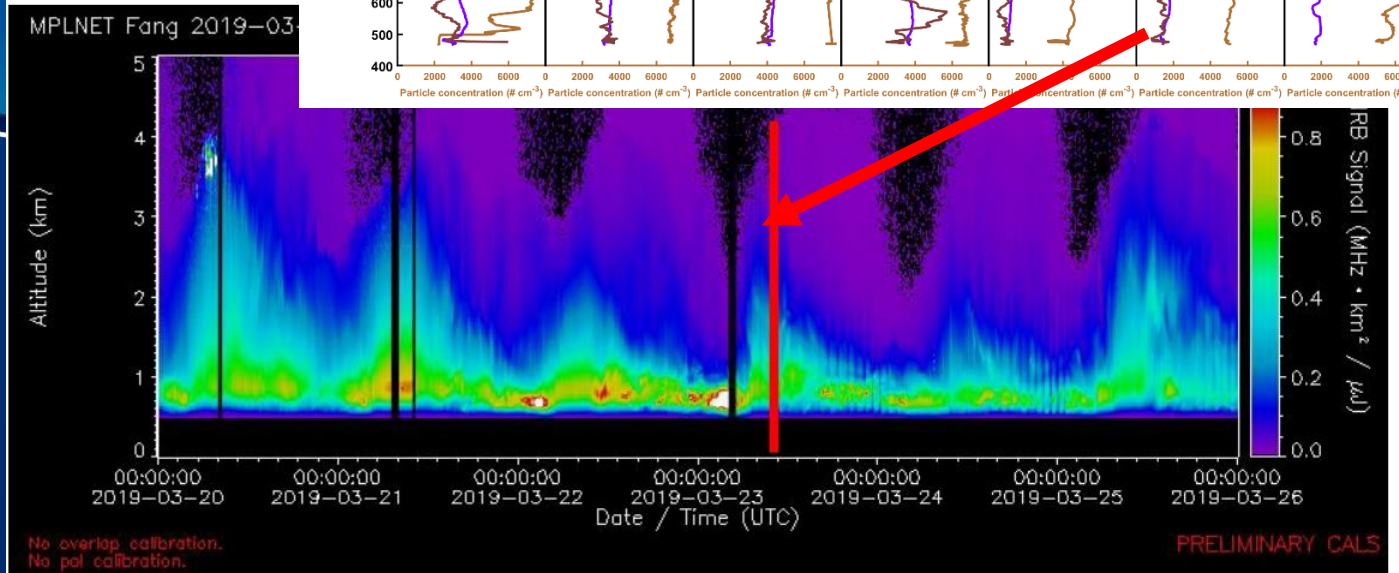
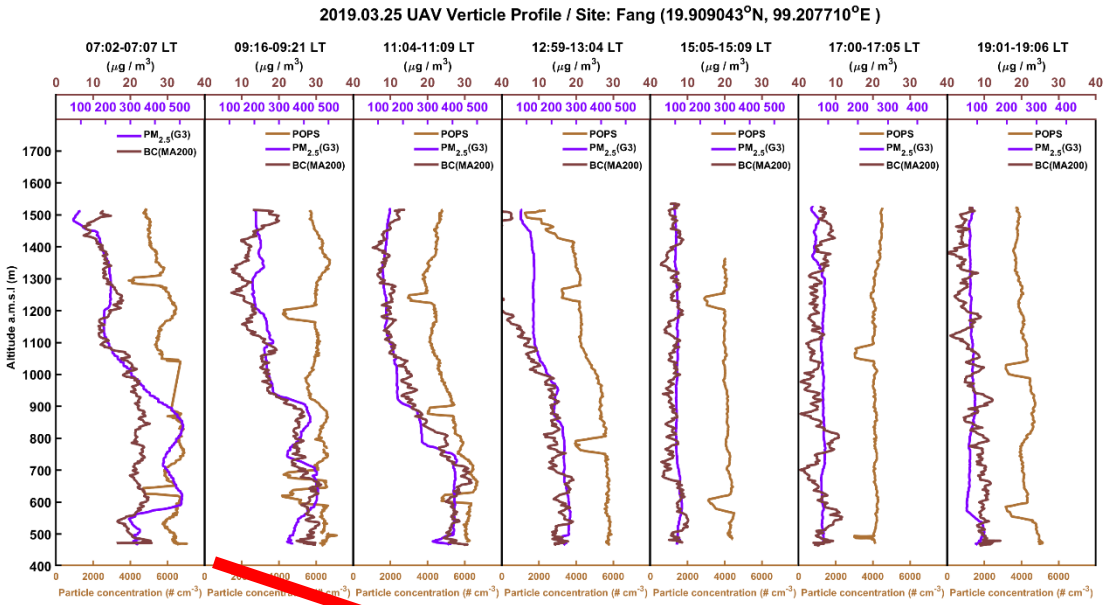
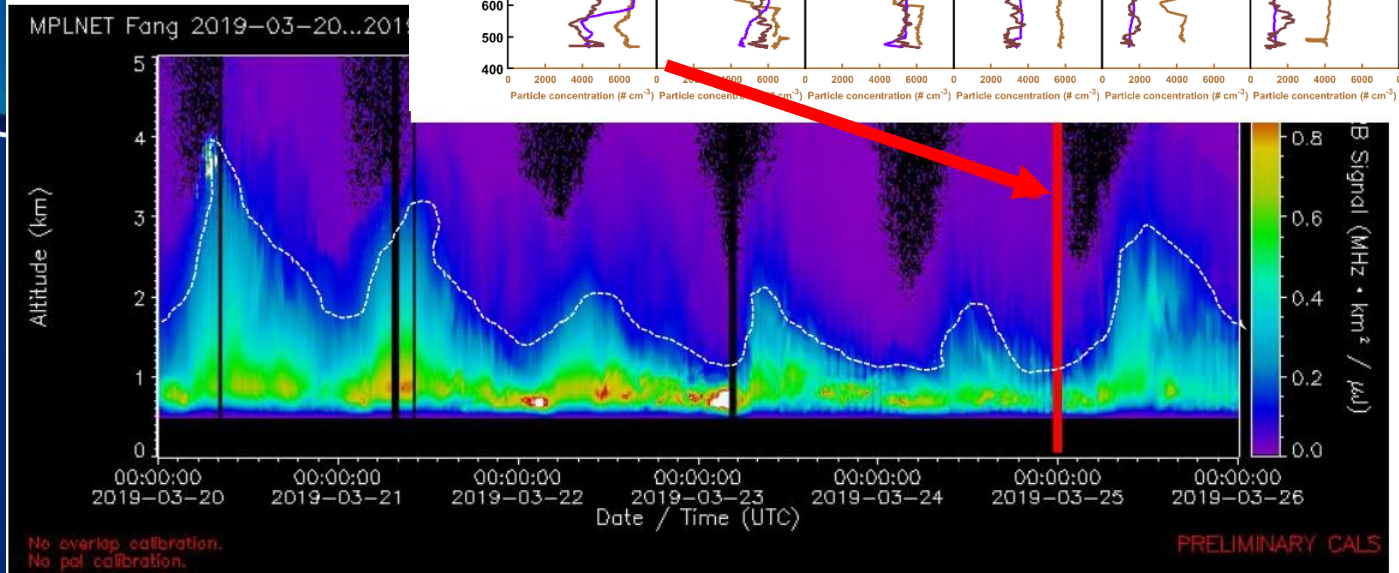


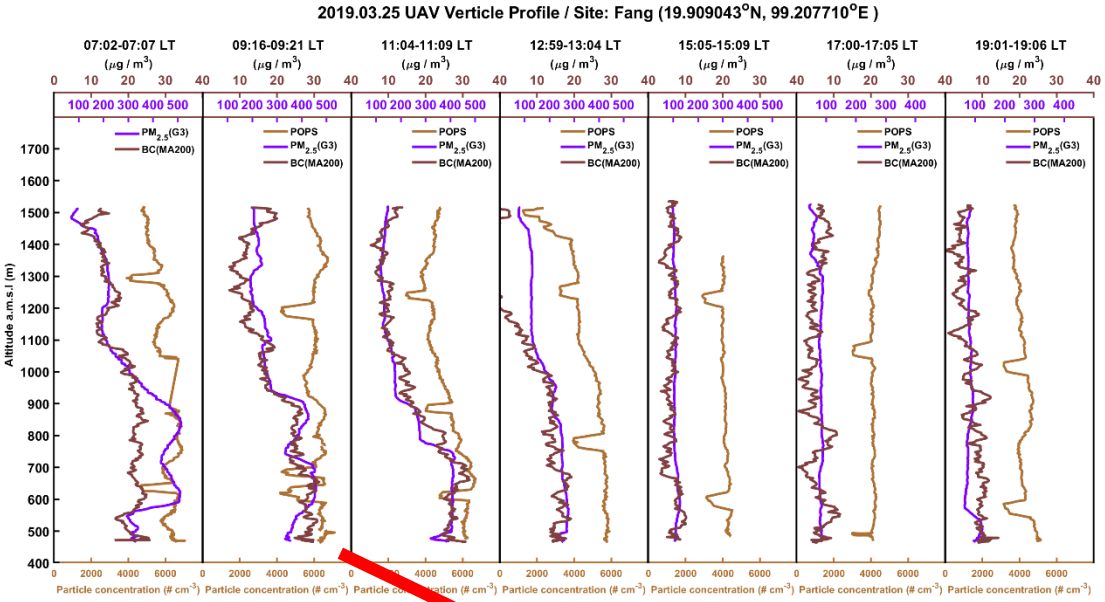


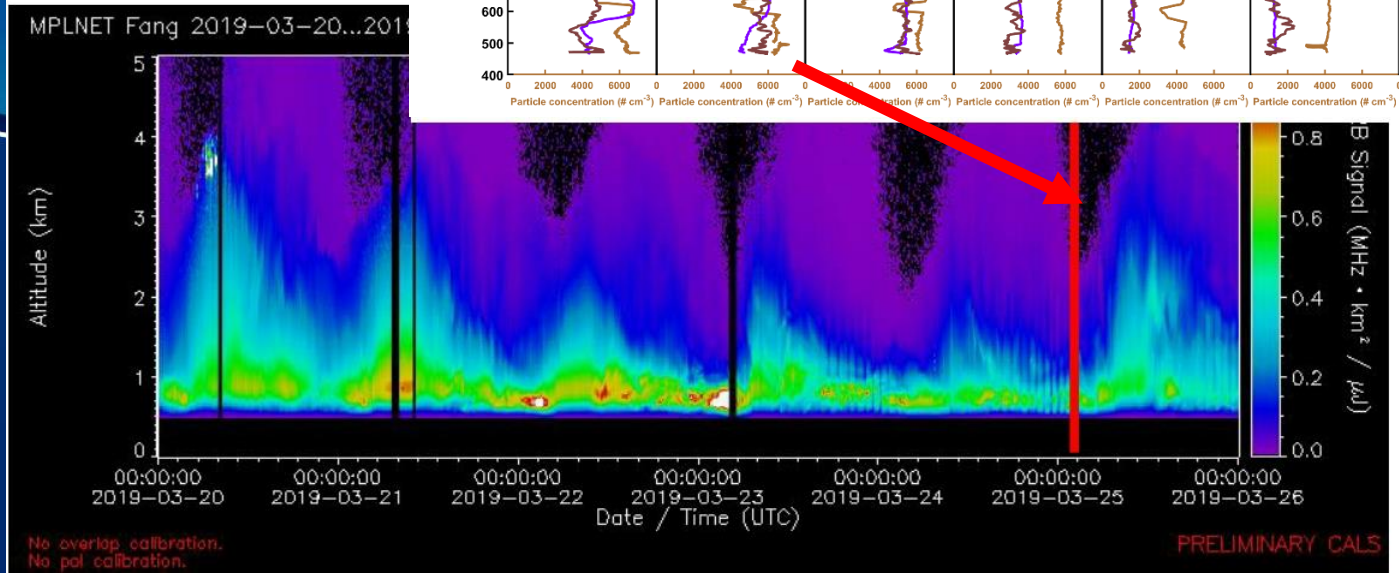
LT: March 25, 2019 (07:00)
UT: March 25, 2019 (00:00)



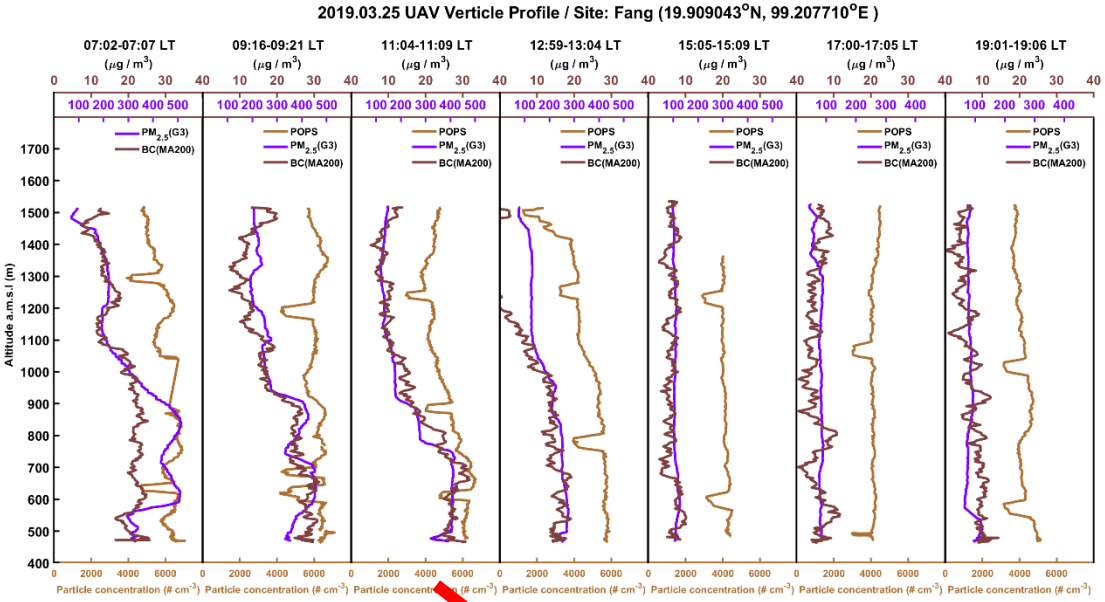


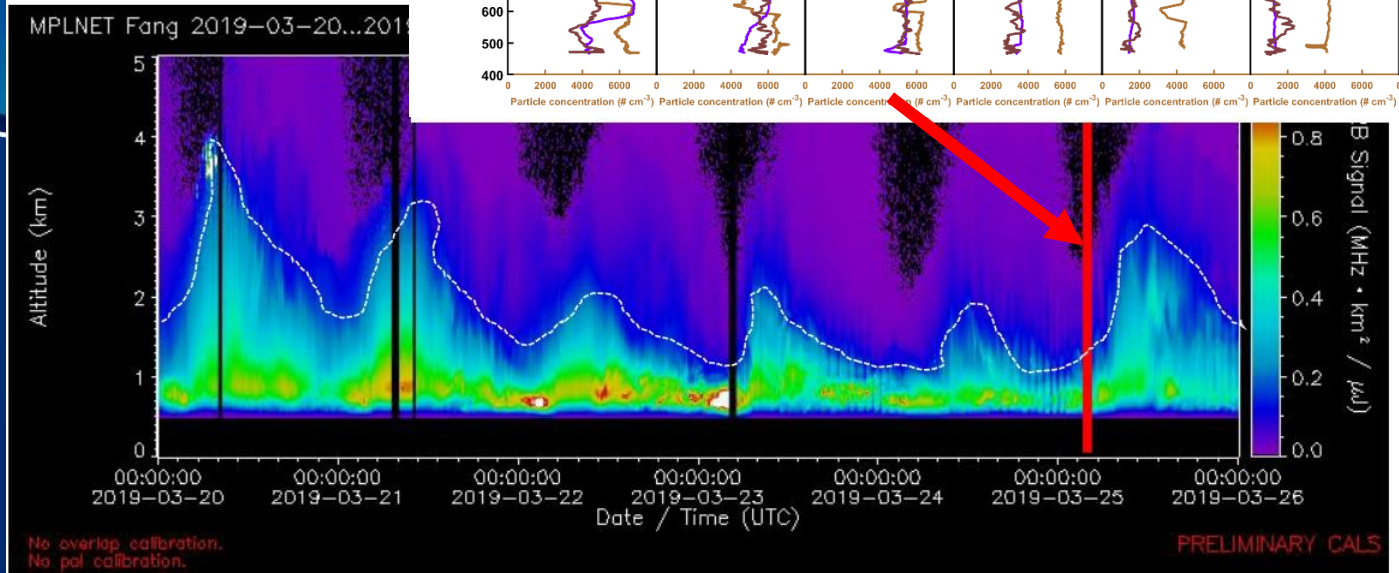
LT: March 25, 2019 (09:00)
UT: March 25, 2019 (02:00)



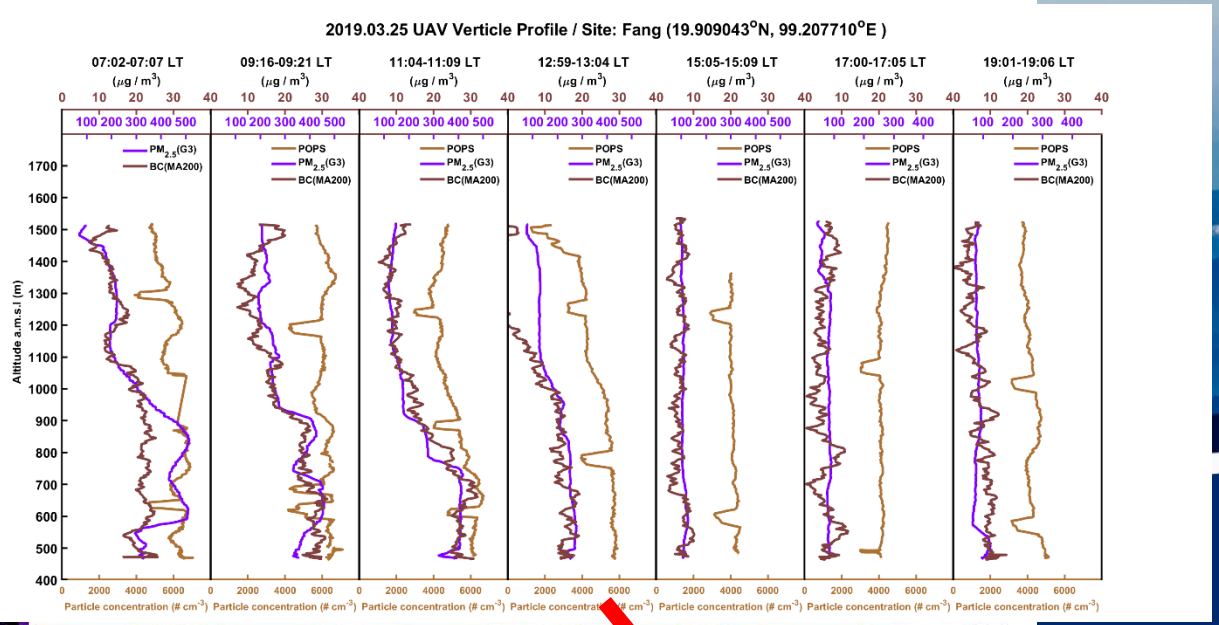


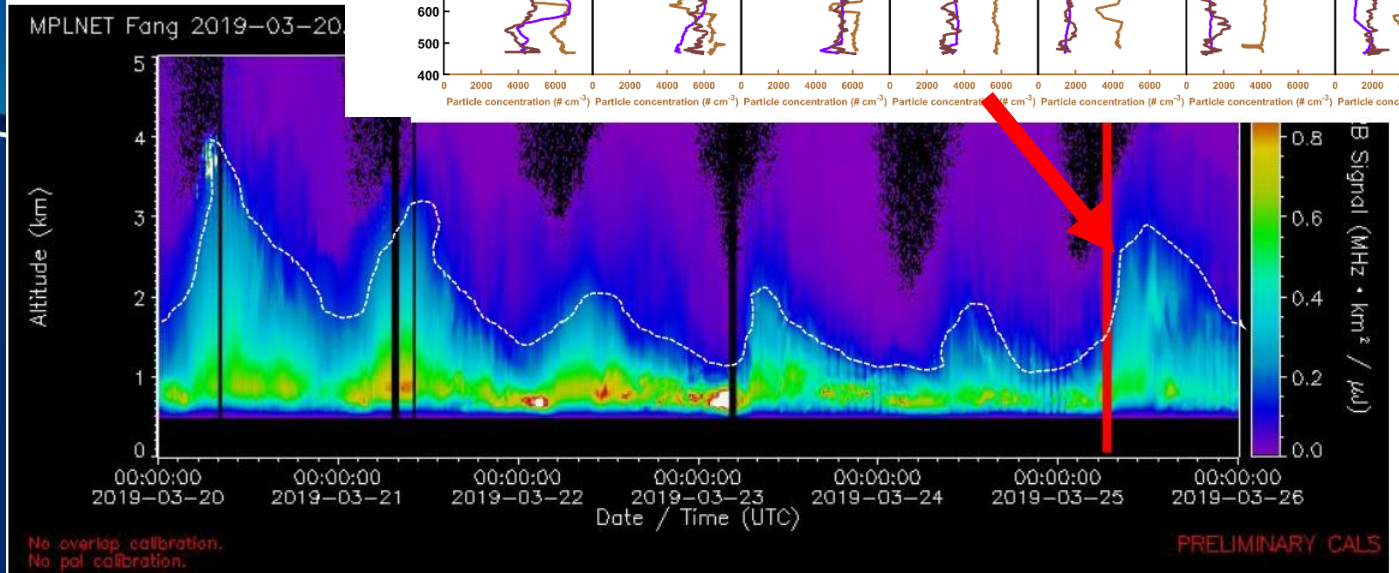
LT: March 25, 2019 (11:00)
UT: March 25, 2019 (04:00)



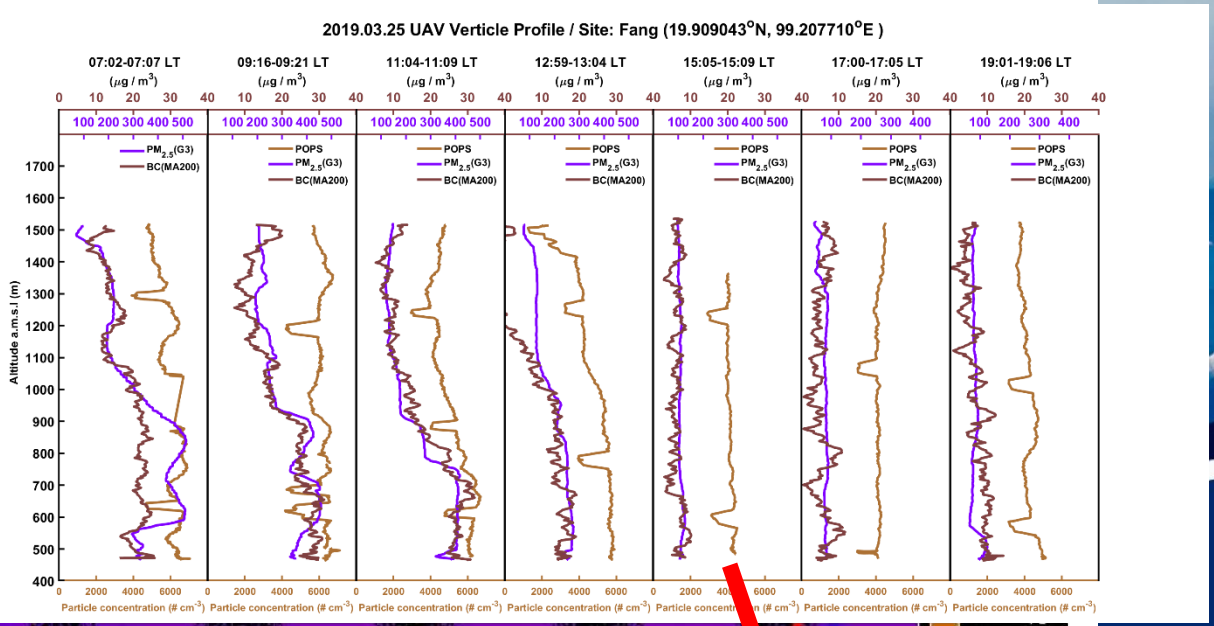


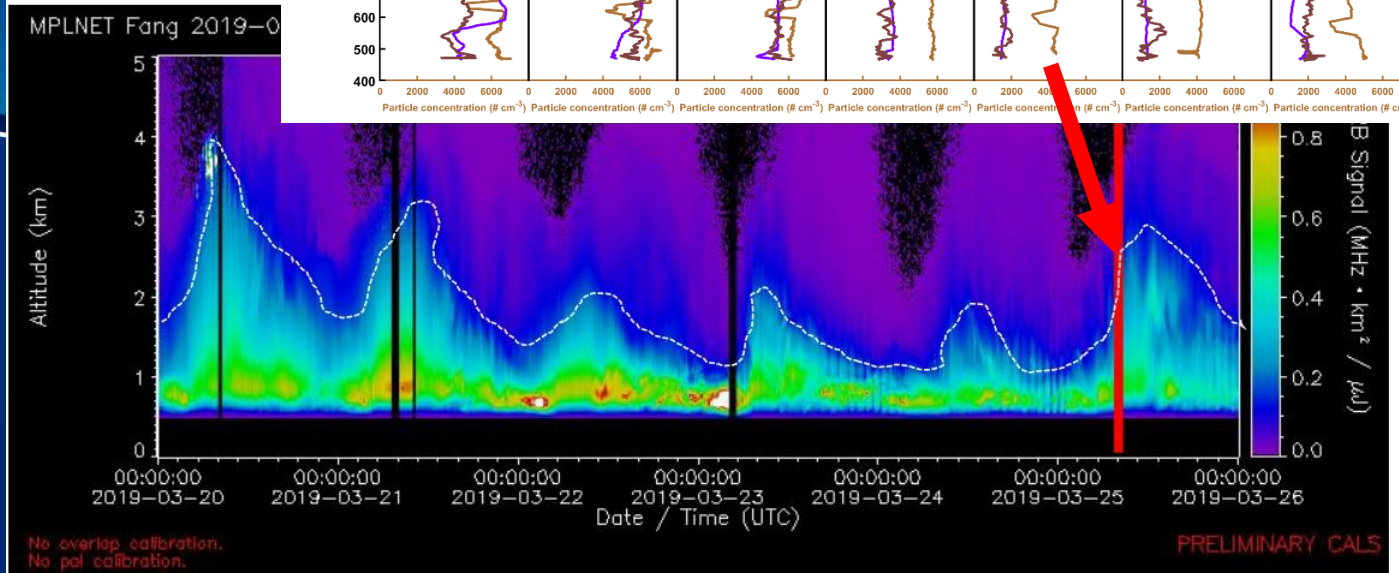
LT: March 25, 2019 (13:00)
UT: March 25, 2019 (06:00)



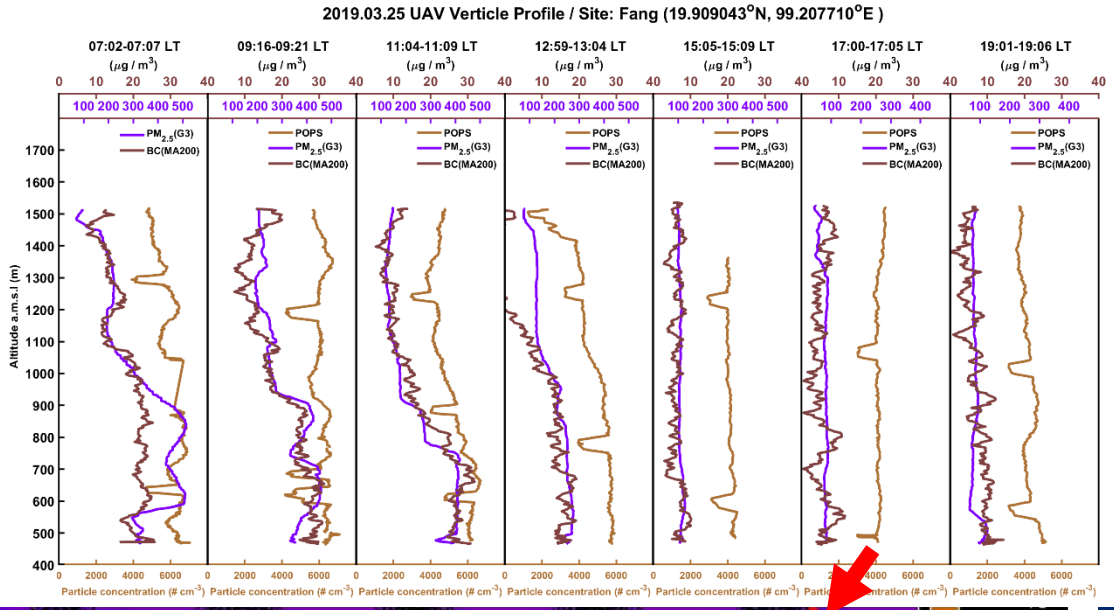


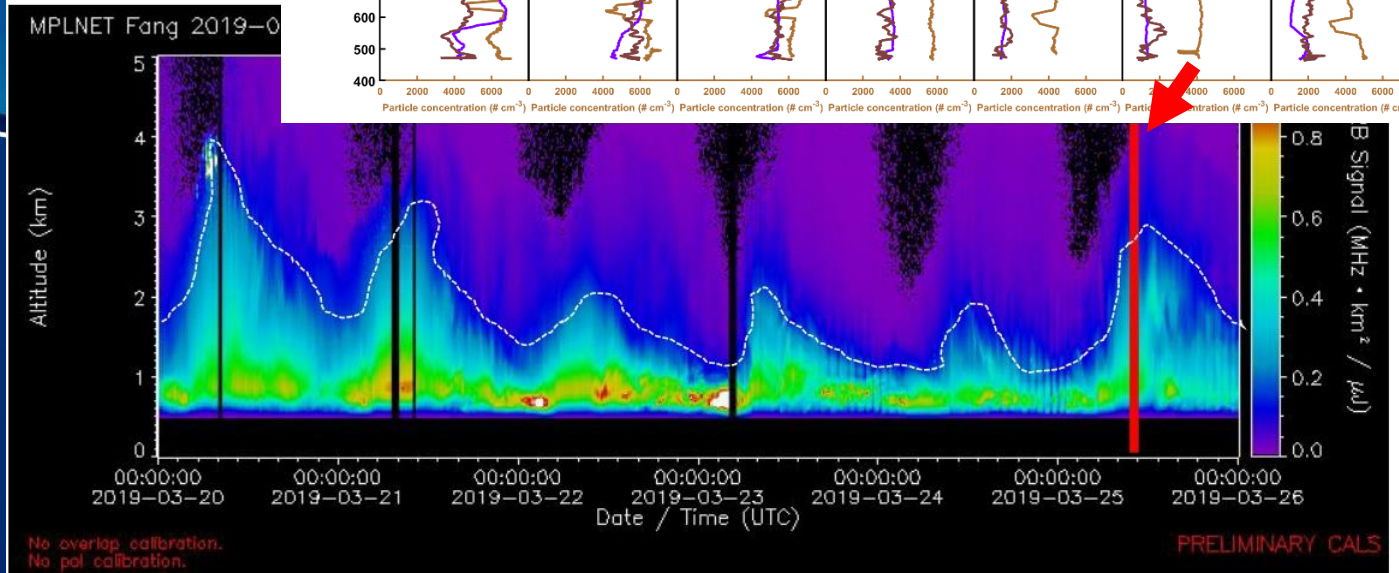
LT: March 25, 2019 (15:00)
UT: March 25, 2019 (08:00)



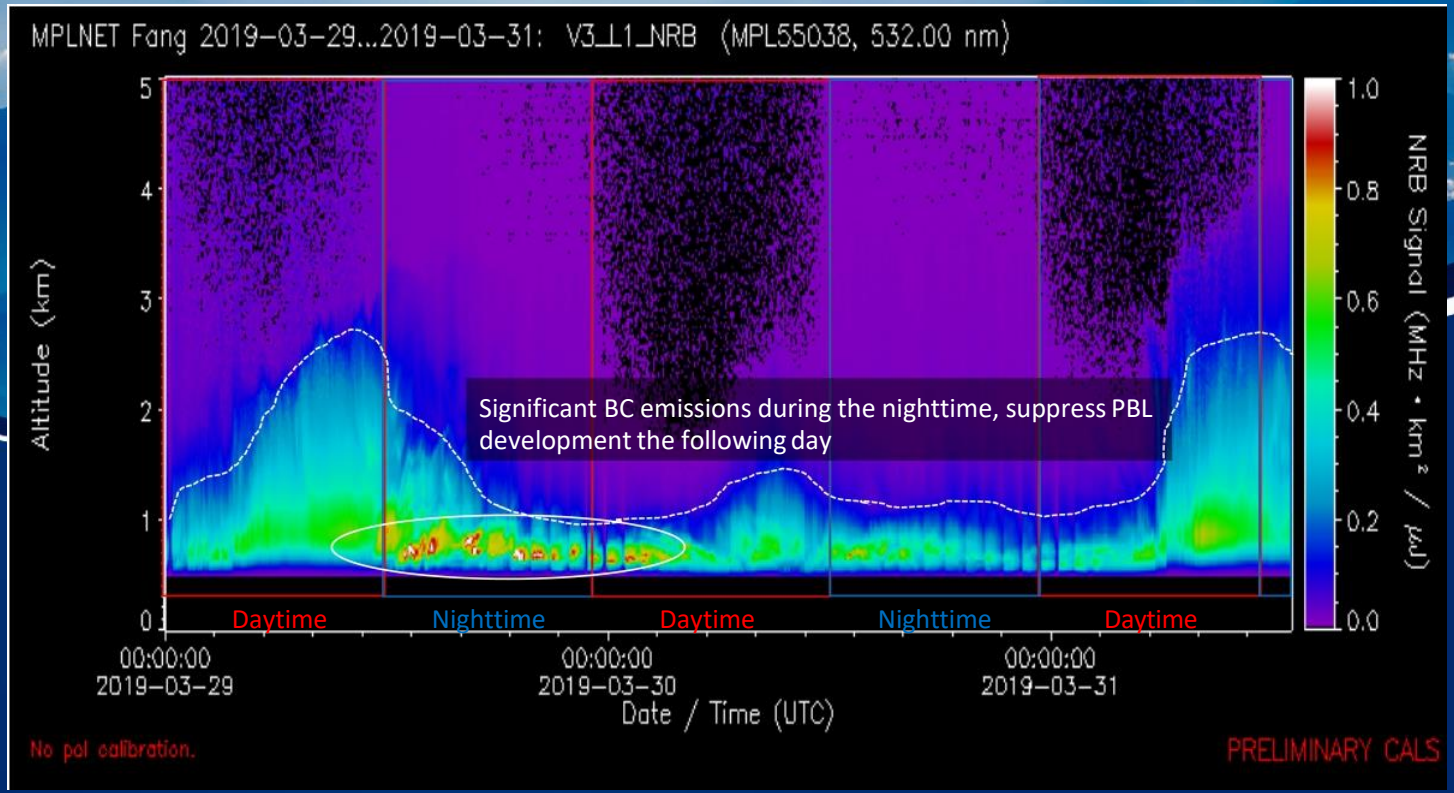


LT: March 25, 2019 (17:00)
UT: March 25, 2019 (10:00)





Compare UAV profile with Lidar data
May 21-25, 2019 Aerosol-PBL Interactions



Thank you!!