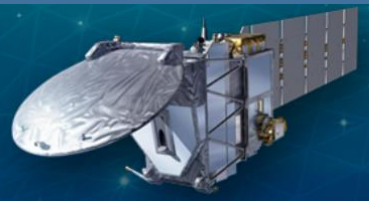


ESA-JAXA Pre-Launch EarthCARE
Science and Validation Workshop
13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

# Validation for the EarthCARE observations with use of spaceborne lidar ACDL and ground-based lidar-net over China

Guangyao Dai[1], Songhua Wu[1], Kangwen Sun[1], Wenrui Long[1], lidar group[1] ,

Jiqiao Liu[2], Weibiao Chen[2], Shengguang Qin[3], Xitao Wang[3], Rongzhong Li[3]

*1 Faculty of Information Science and Engineering, Ocean University of China, Qingdao, China*

*2 Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Shanghai, China*

*3 Qingdao Leice Transient Technology Co., Ltd., Qingdao, 266100, China*

2023/11/16 @ ESA-ESRIN

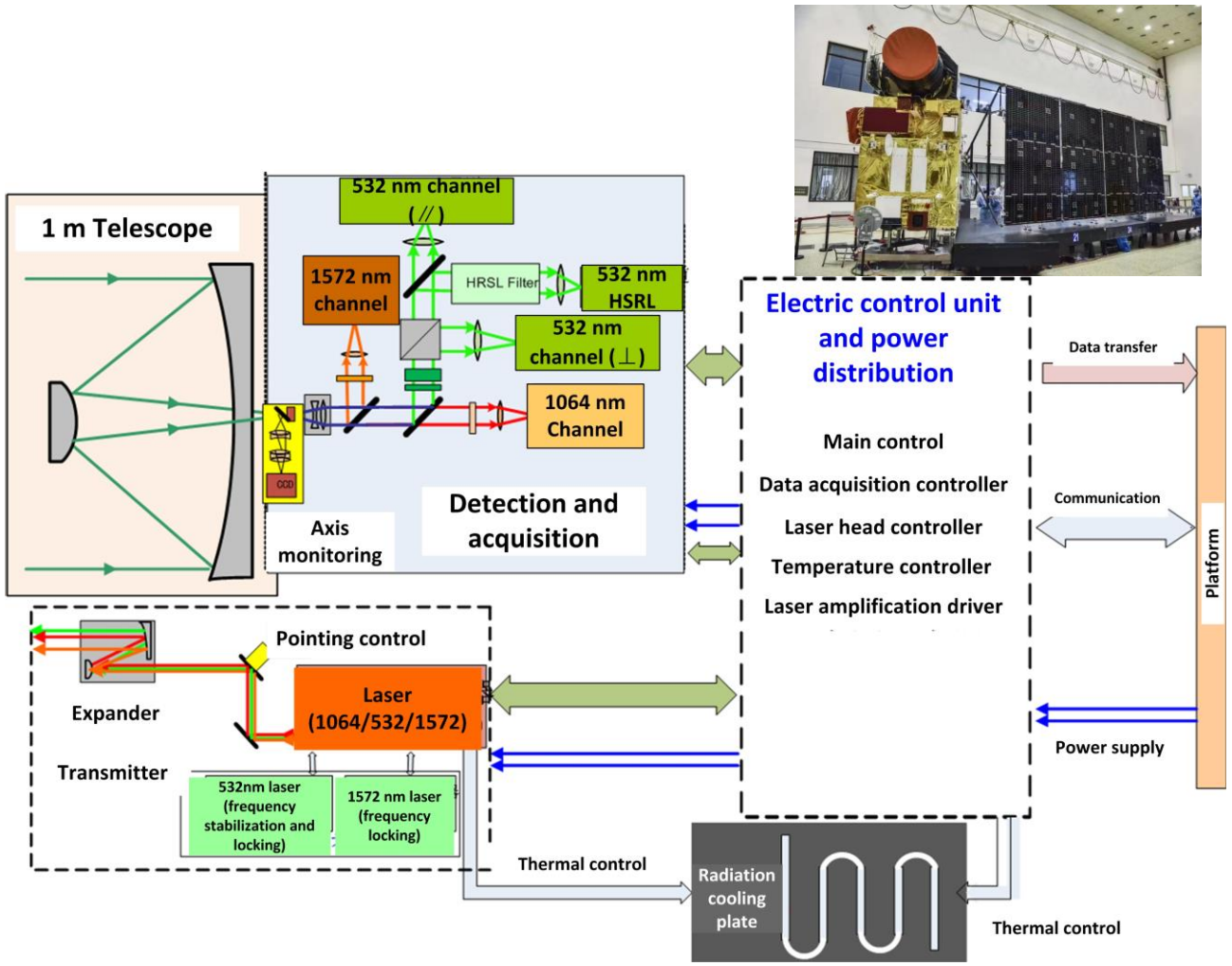
# Content

1. ACDL/DQ-1 introduction and comparison with EarthCARE

2. Recent lidar instruments at OUC

3. Summary

# 2. ACDL/DQ-1 introduction





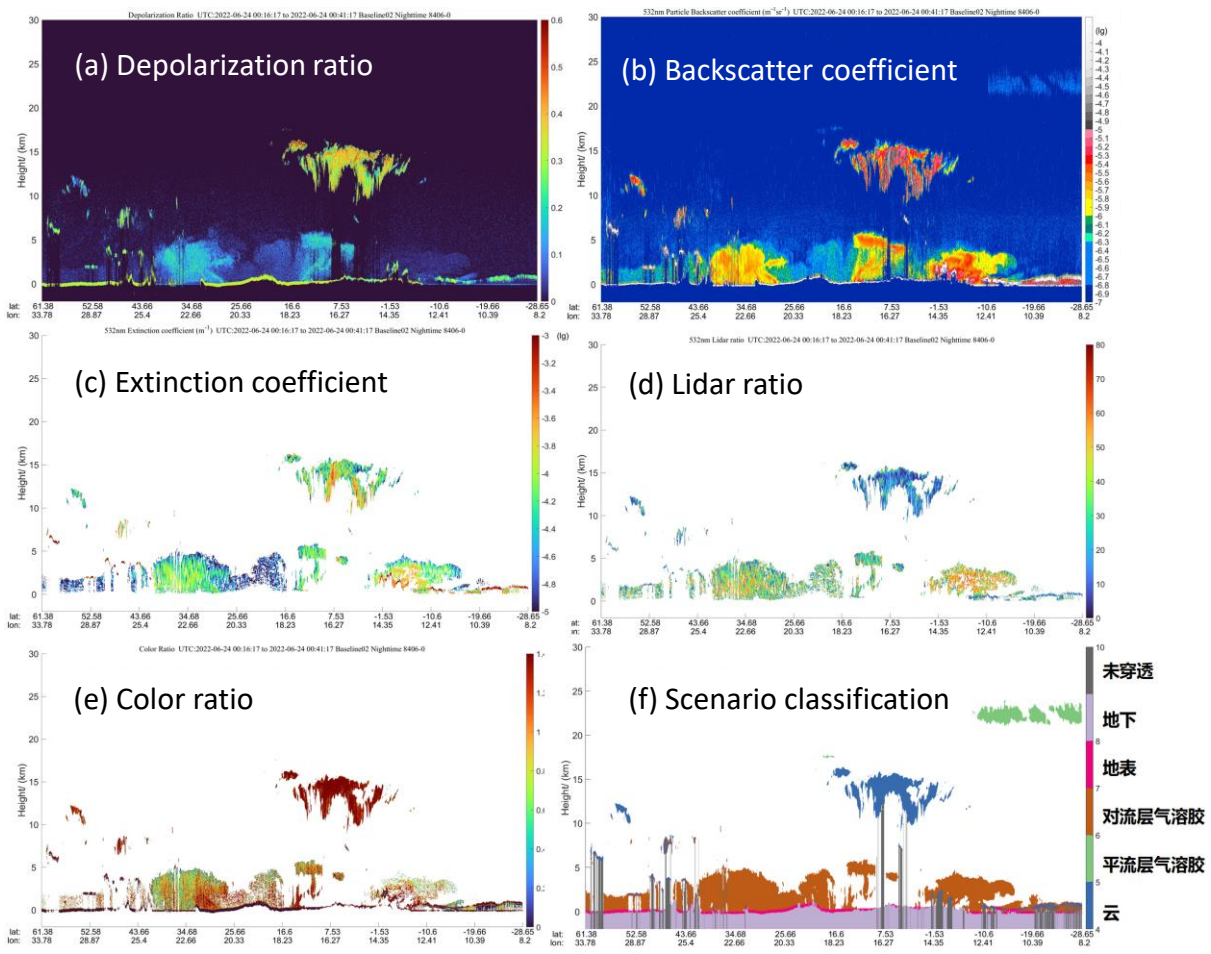

- **The first spaceborne lidar (IPDA) for CO2 detection in the world**
- **The first spaceborne Iodine-based HSRL working at 532nm in the world**

| Specifications | Parameters |
|---|---|
| Wavelengths | 532nm, 1064nm and 1572nm; |
| Laser energy | ≥130mJ@532nm<br>≥190mJ@1064nm<br>≥40mJ@1572nm |
| Divergence | 50μrad |
| Stability of the laser linewidths | 1572nm: 0.6MHZ@10000s<br>1064nm: 5MHz@10000s |
| PRF | 20Hz@1572nm (On/Off dual-pulse)<br>20Hz@532nm and 1064nm (dual-pulse) |
| Telescope aperture | 1000mm |
| FOV | 190μrad |
| HSRL | Iodine cell: OD > 25dB |
| Receiver channels | 532nm HSRL |
| | 532nm parallel-polarized |
| | 532nm cross-polarized |
| | 1064nm aerosol |
| | 1572nm CO2 |

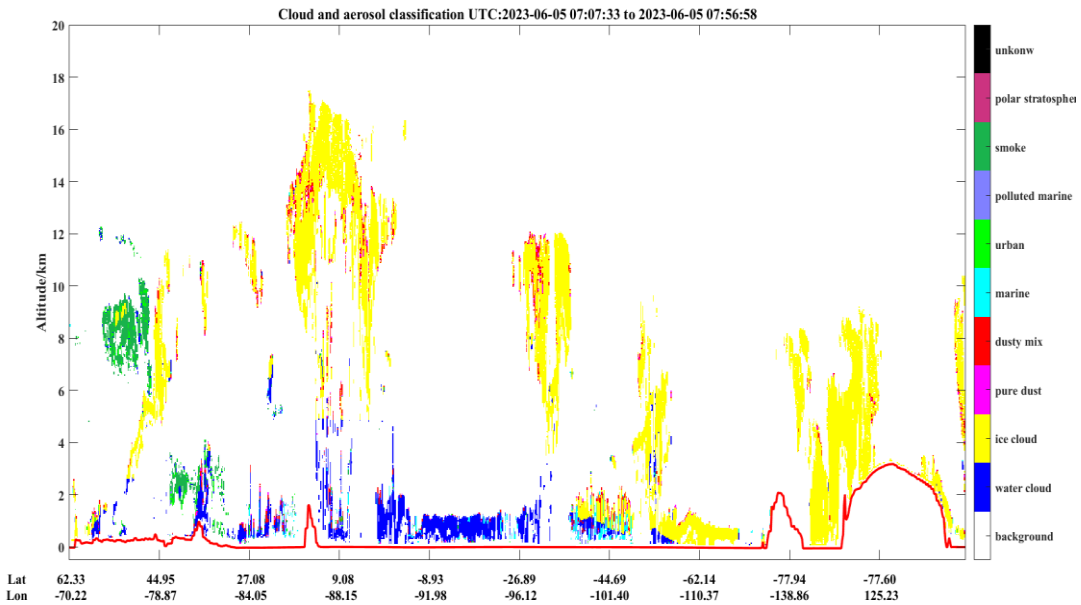
# 1. ACDL/DQ-1 introduction: Data products

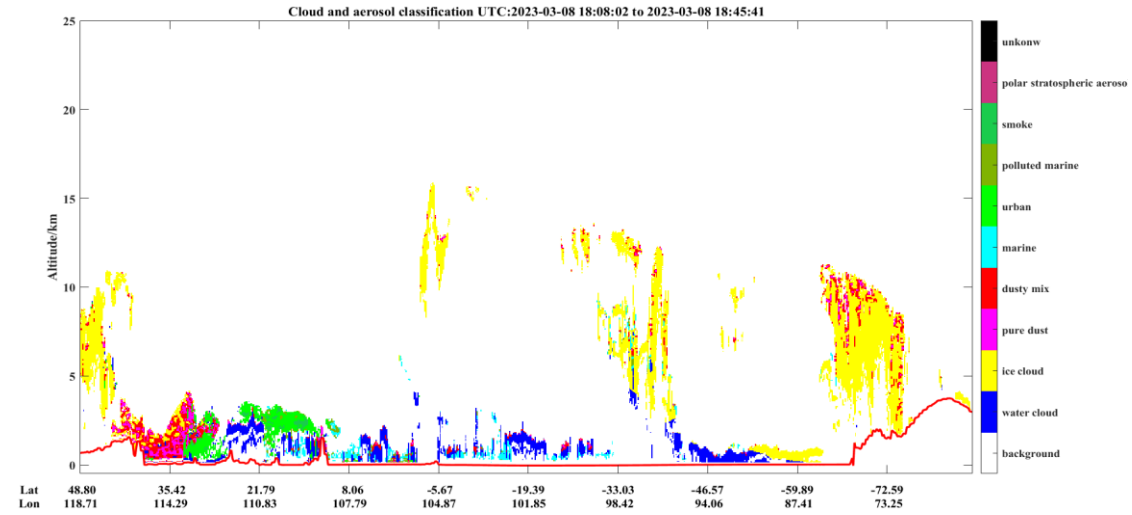
| level | Data processing | Data products | Format |
|---|---|---|---|
| Level 0 | The observation data obtained by downlinking multi-packet data integrity inspection and data splicing through the two channels of the satellite. | Raw data | RAW |
| Level 1A | Process the level 0 aerosol data, obtain the profiles of 532 nm and 1064 nm channels, with the geographic location and height corrected. | Profiles data of 532 nm and 1064 nm channels | HDF5 |
| Level 1B | Process the level 0 CO2 data, obtain the profiles of 1572 nm channel, with the geographic location and height corrected. | Profiles data of 1572 nm channel | HDF5 |
| Level 2A | Attenuated backscatter coefficient with systematic constant correction | Attenuated backscatter coefficient | HDF5 |
| Level 2B | Differential Absorption Optical Depth (DAOD) products | DAOD | HDF5 |
| Level 2C | Cloud and aerosol products including extinction coefficient, backscatter coefficient, depolarization ratio, AOD, lidar ratio and color ratio (vertical resolution: 50 m); (Horizontal resolution: 10km/3.3km adjustable at this moment); | Cloud and aerosol optical properties | HDF5 |
| Level 2D | XCO2 | XCO2 | HDF5 |

# 1. ACDL/DQ-1 introduction: Aerosol and cloud optical properties




**Nighttime** measurement over Europe and Africa



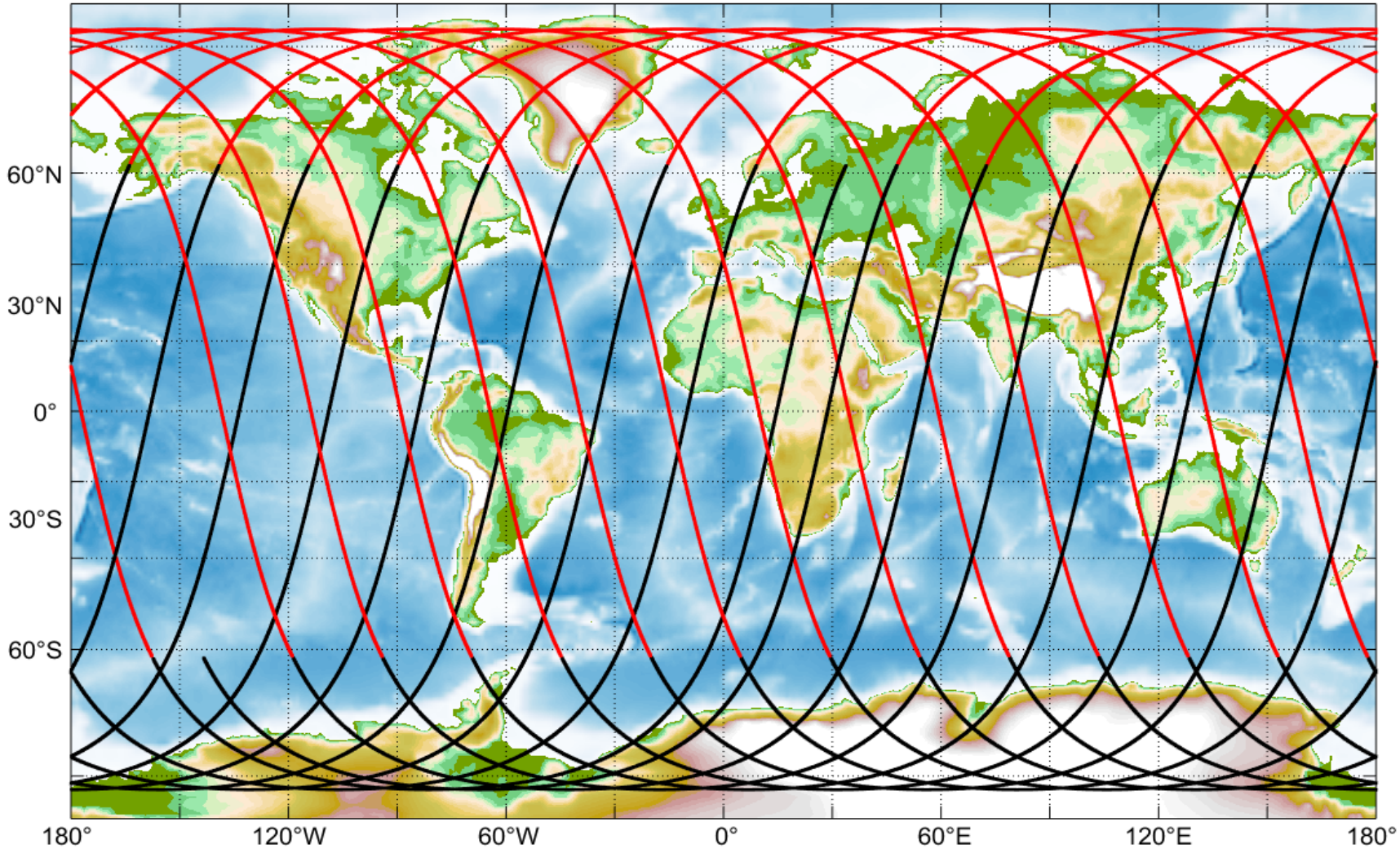




**Aerosol classification**

# 1. ACDL/DQ-1 introduction: orbits

**Satellite trajectory during 24th June, 2022 as an example**

**Red denotes the daytime/ascending orbit, Black represents the nighttime/descending orbits.**



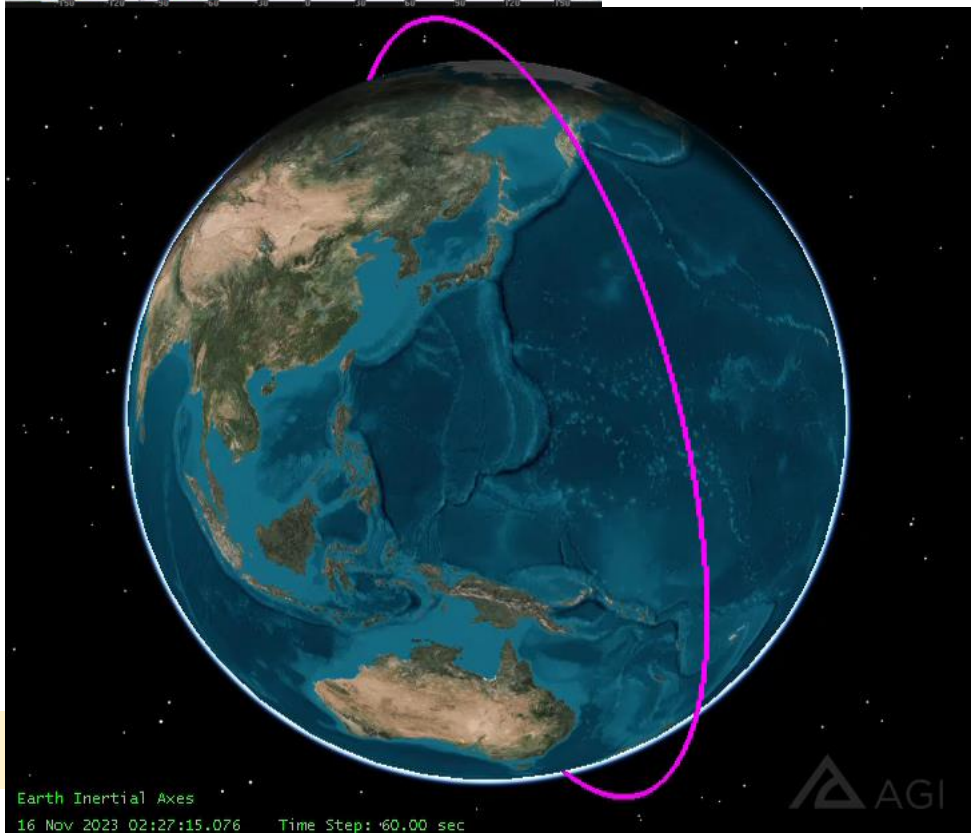

The ACDL/DQ-1 orbits in a sun-synchronous orbit at 705-km altitude with an ascending node equator crossing time of **13:20 LST.**

The orbit inclination of **98° provides coverage between 82° N and 82 ° S,** with orbit tracks that repeat around 51 days.

# 1. ACDL/DQ-1 introduction: orbit quick look and prediction

| Official name | Space Surveillance Catalog Number | Owner | Operational Status | Data Source |
|---|---|---|---|---|
| DAQI 1 | **52257** | People's Republic of China | Operational | AGI's Standard Object Data Service |

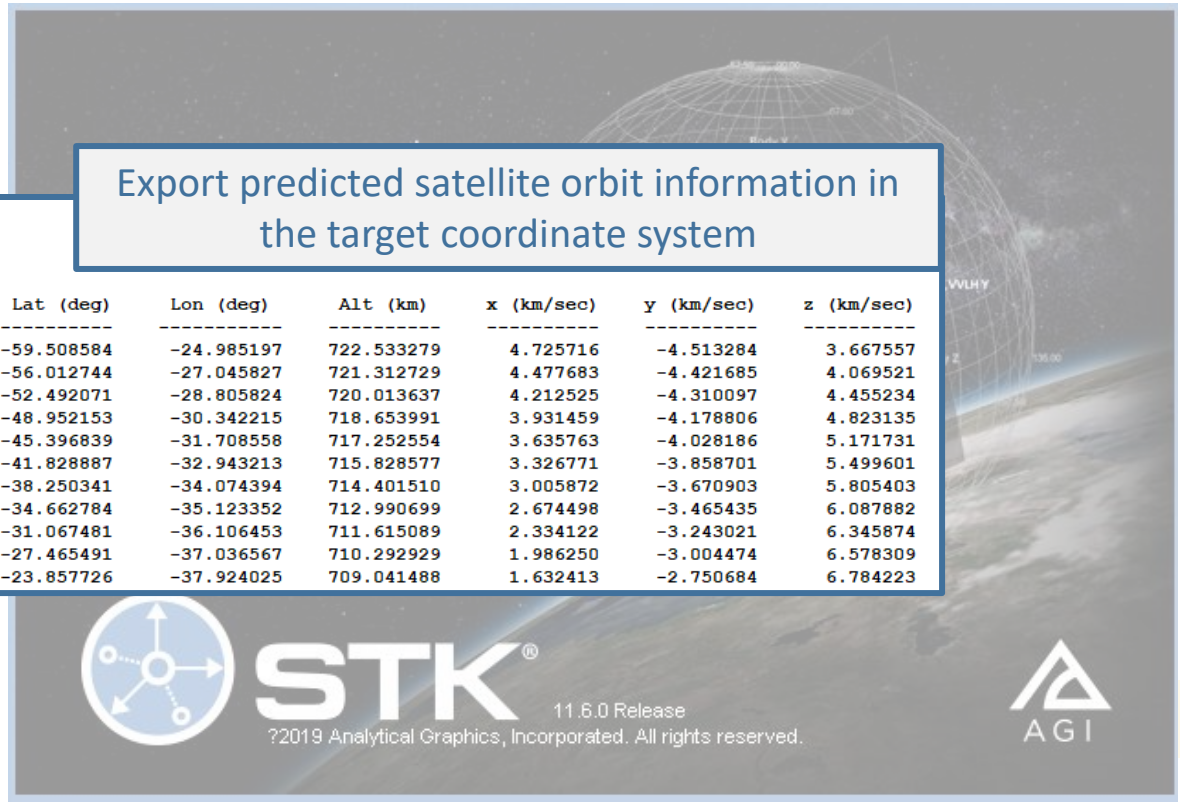
Satellite Tool Kit (STK): an analysis engine for calculating the position and attitude of the satellite at any given moment, and DQ1 has been uploaded to the SSC coded satellite database, which can be easily used for satellite orbit display and orbit prediction.



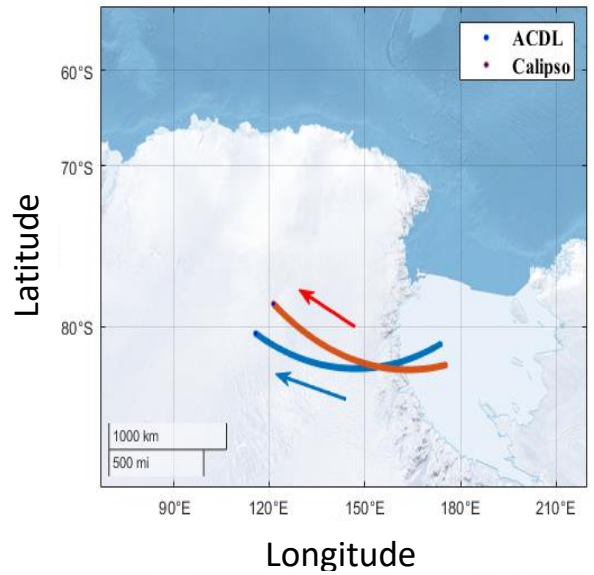

Export predicted satellite orbit information in the target coordinate system

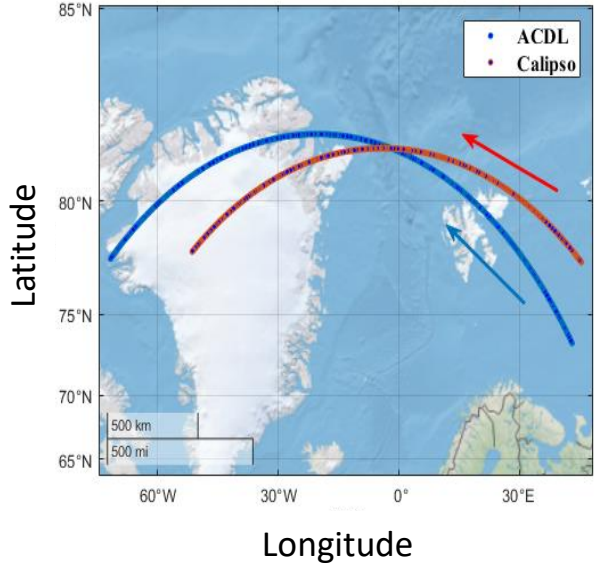
Civil Air Patrol Use Only
Satellite-DAQI_1_52257

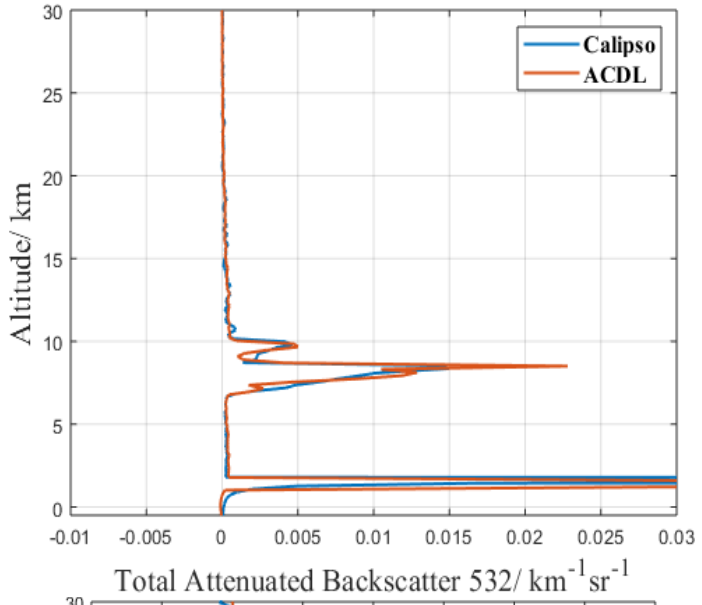
| Time (UTCG) | Lat (deg) | Lon (deg) | Alt (km) | x (km/sec) | y (km/sec) | z (km/sec) |
|---|---|---|---|---|---|---|
| 14 Nov 2023 16:00:00.000 | -59.508584 | -24.985197 | 722.533279 | 4.725716 | -4.513284 | 3.667557 |
| 14 Nov 2023 16:01:00.000 | -56.012744 | -27.045827 | 721.312729 | 4.477683 | -4.421685 | 4.069521 |
| 14 Nov 2023 16:02:00.000 | -52.492071 | -28.805824 | 720.013637 | 4.212525 | -4.310097 | 4.455234 |
| 14 Nov 2023 16:03:00.000 | -48.952153 | -30.342215 | 718.653991 | 3.931459 | -4.178806 | 4.823135 |
| 14 Nov 2023 16:04:00.000 | -45.396839 | -31.708558 | 717.252554 | 3.635763 | -4.028186 | 5.171731 |
| 14 Nov 2023 16:05:00.000 | -41.828887 | -32.943213 | 715.828577 | 3.326771 | -3.858701 | 5.499601 |
| 14 Nov 2023 16:06:00.000 | -38.250341 | -34.074394 | 714.401510 | 3.005872 | -3.670903 | 5.805403 |
| 14 Nov 2023 16:07:00.000 | -34.662784 | -35.123352 | 712.990699 | 2.674498 | -3.465435 | 6.087882 |
| 14 Nov 2023 16:08:00.000 | -31.067481 | -36.106453 | 711.615089 | 2.334122 | -3.243021 | 6.345874 |
| 14 Nov 2023 16:09:00.000 | -27.465491 | -37.036567 | 710.292929 | 1.986250 | -3.004474 | 6.578309 |
| 14 Nov 2023 16:10:00.000 | -23.857726 | -37.924025 | 709.041488 | 1.632413 | -2.750684 | 6.784223 |

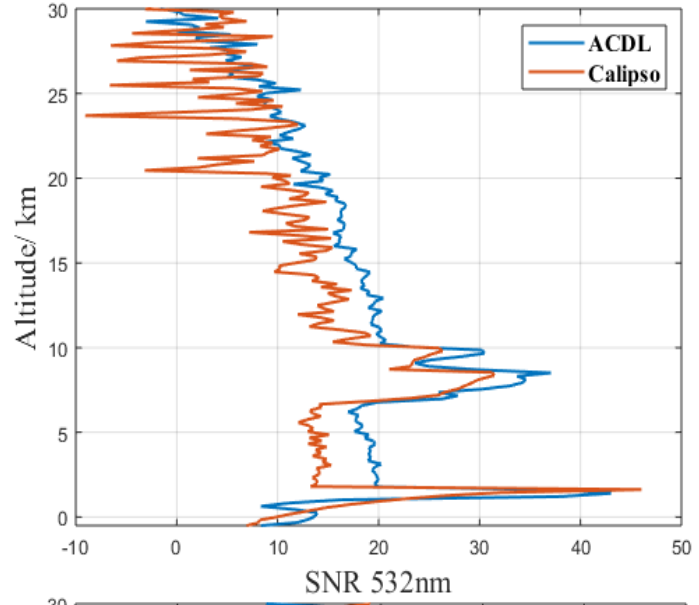


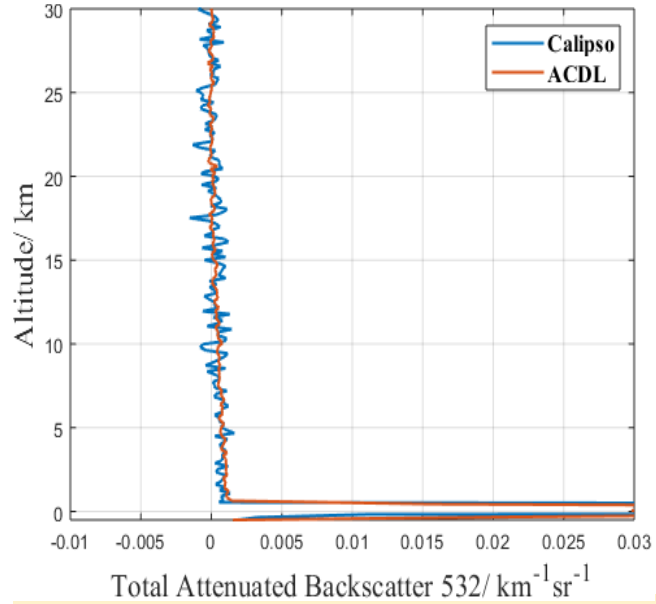
# 1. ACDL/DQ-1 introduction: validation with CALIOP

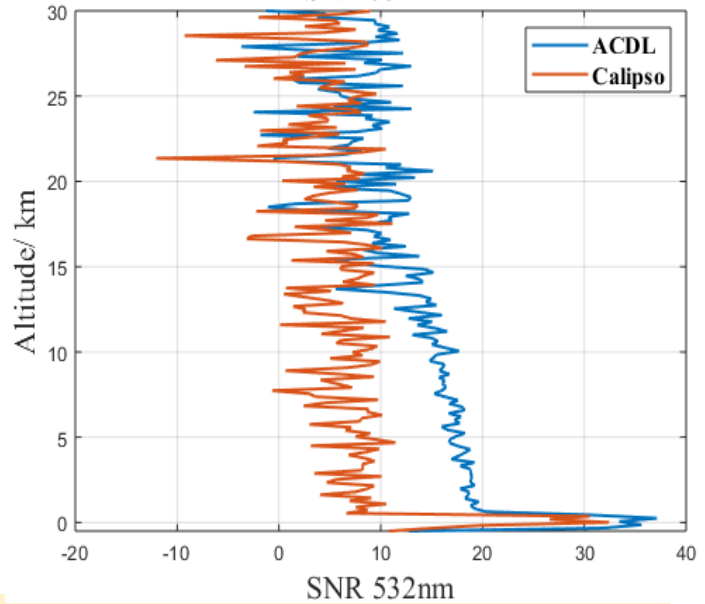


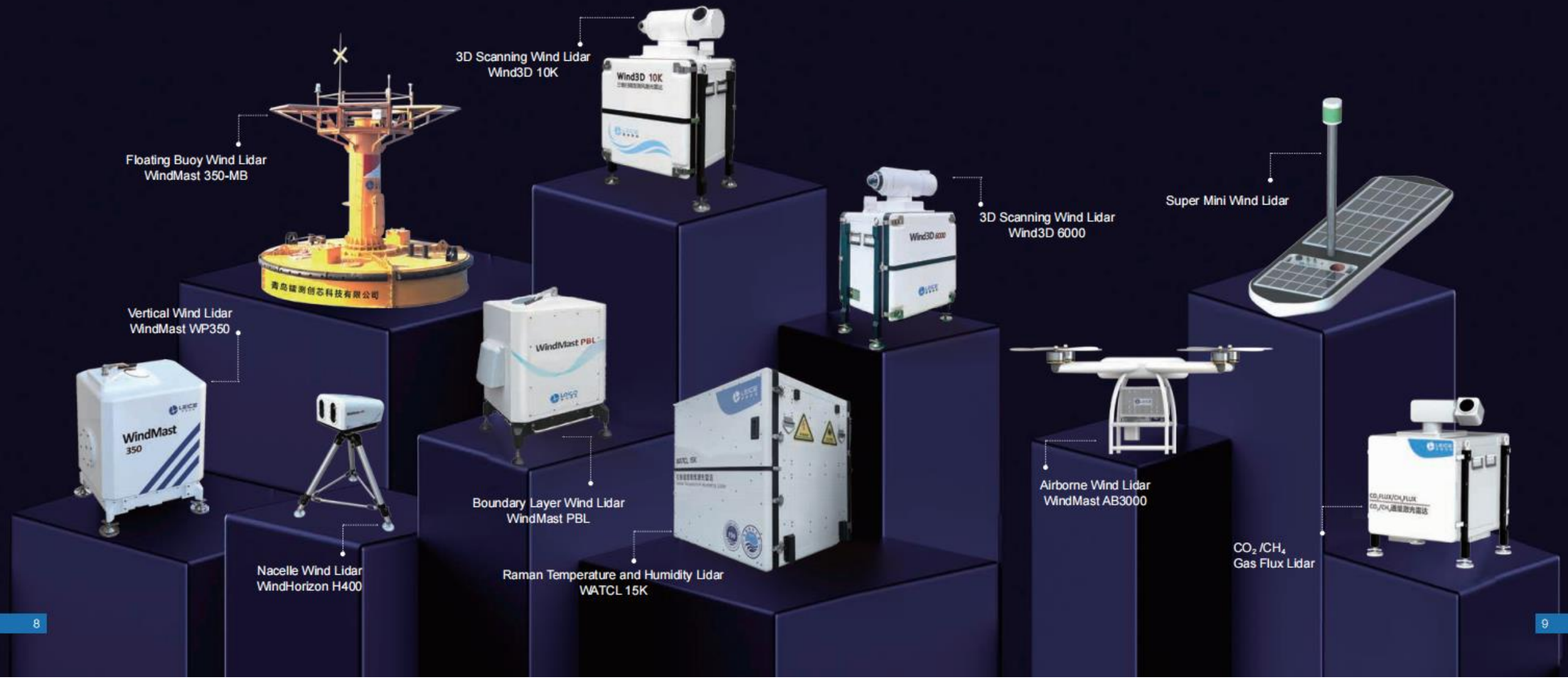

ACDL and CALIOP simultaneous measurement: 2-3 times higher

# 2. Recent lidar instruments at OUC

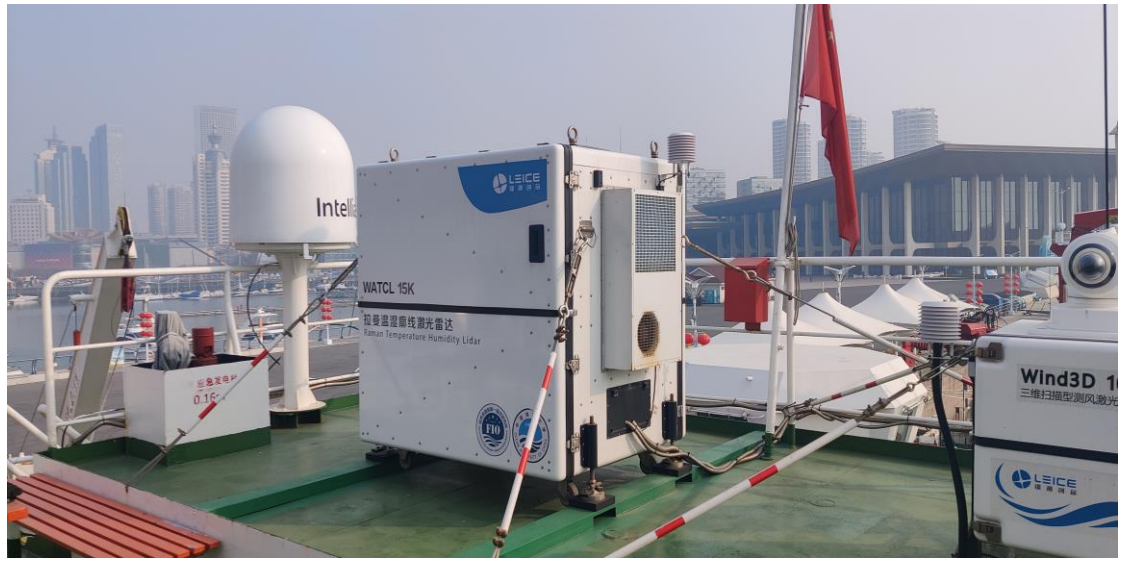
- **Raman lidar - WATCL**
- **Atmospheric and ocean HSRL**
- **Coherent Doppler wind lidars**

# Coherent Doppler wind lidars and Raman lidar

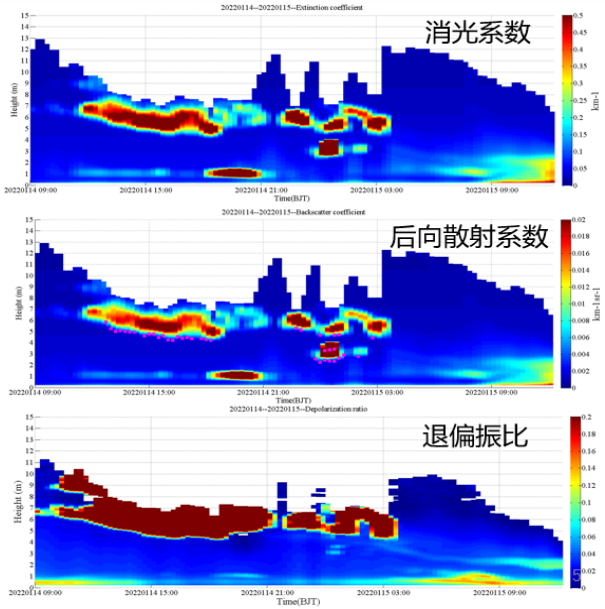
## Our Products

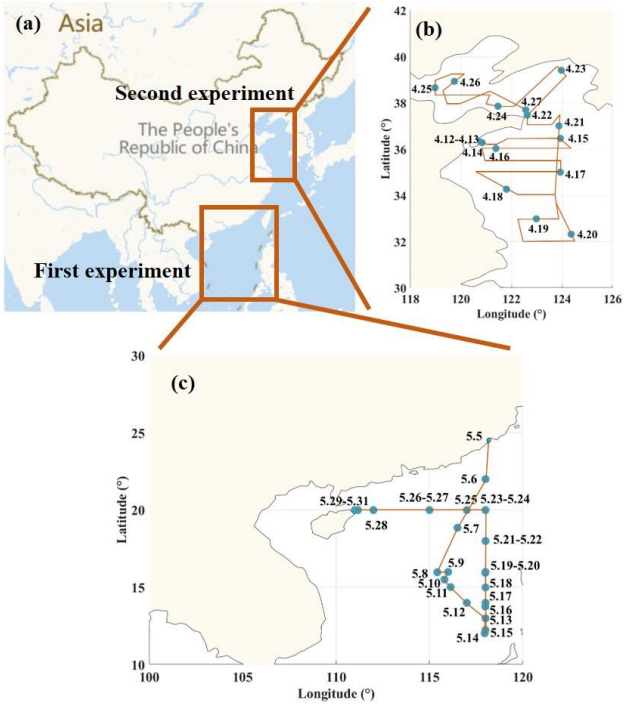


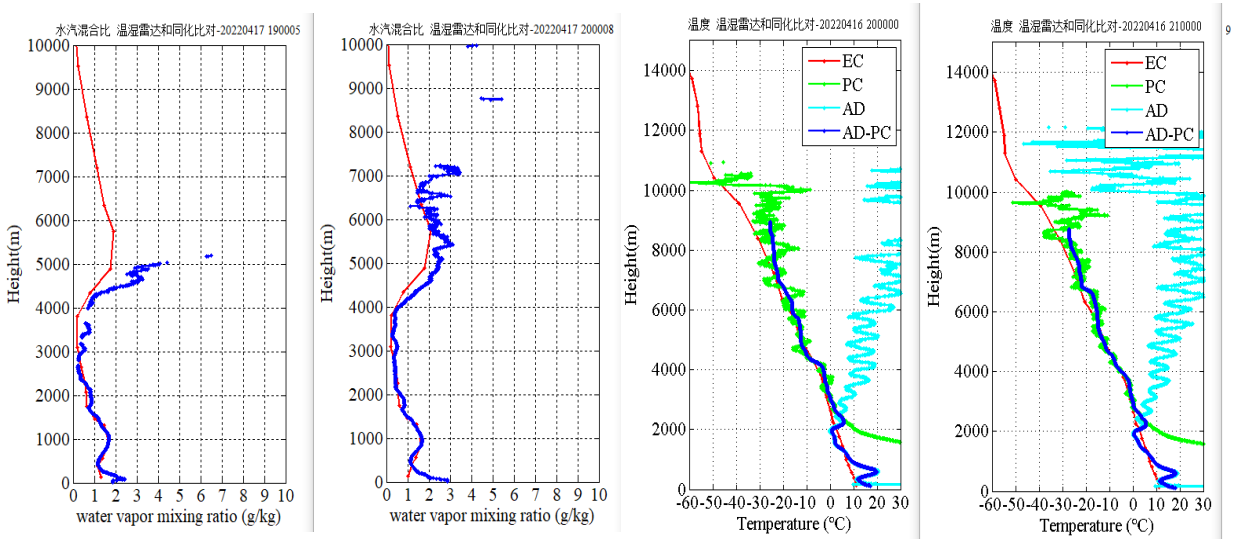
# WATCL Raman Lidar



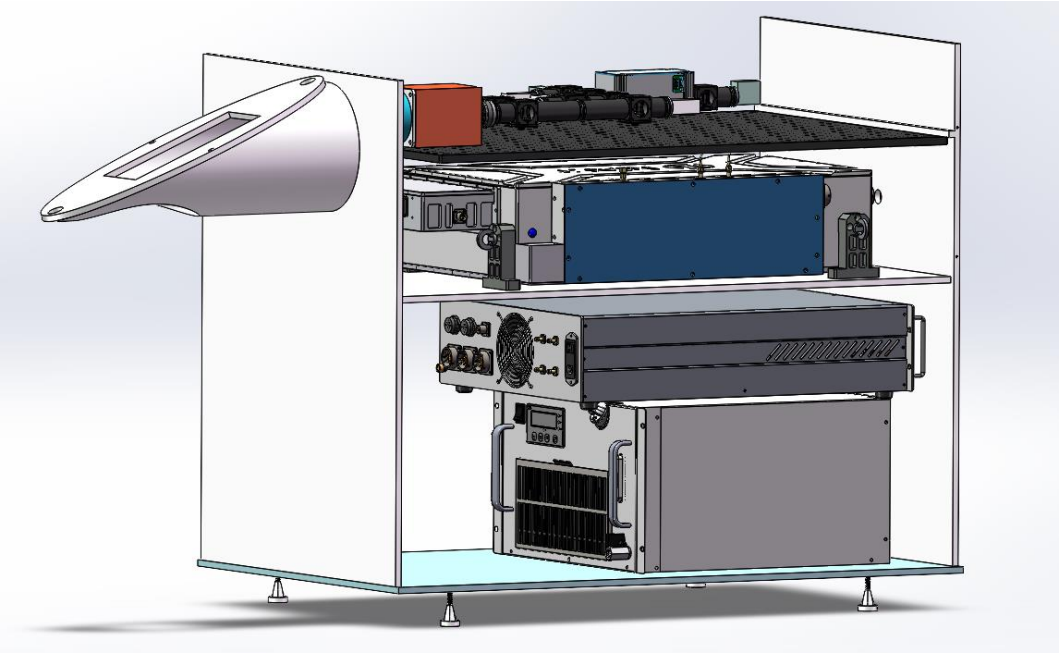

| Specifications | Parameters |
|---|---|
| Wavelengths | 355nm; |
| Laser energy | ≥100mJ@532nm |
| PRF | 20Hz@355nm |
| Telescope aperture | 300mm/Cassegrain |
| Temporal resolution | 1 s (adjustable) |
| Vertical resolution | 7.5 m (adjustable) |
| Data products | α, β, δ, LR, WV, T, RH (6+ channels) |

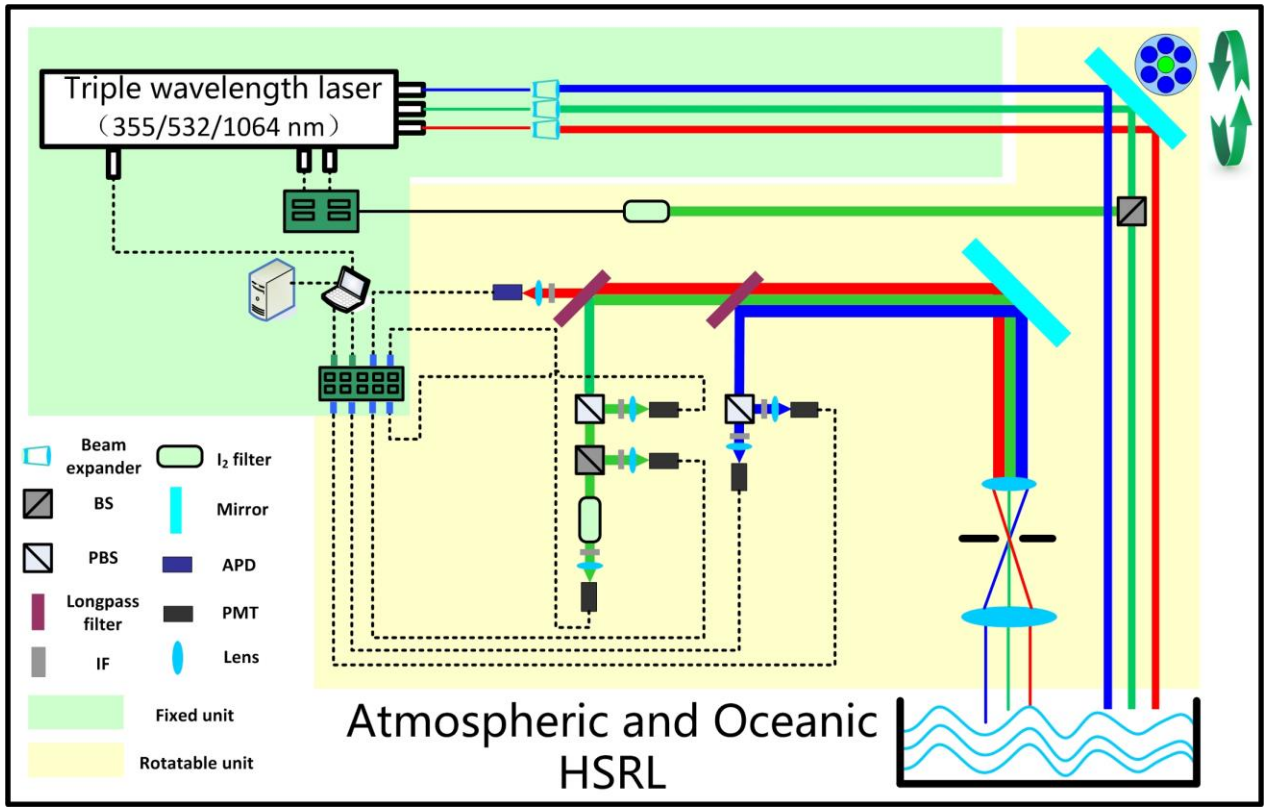


# Atmospheric and Oceanic HSRL





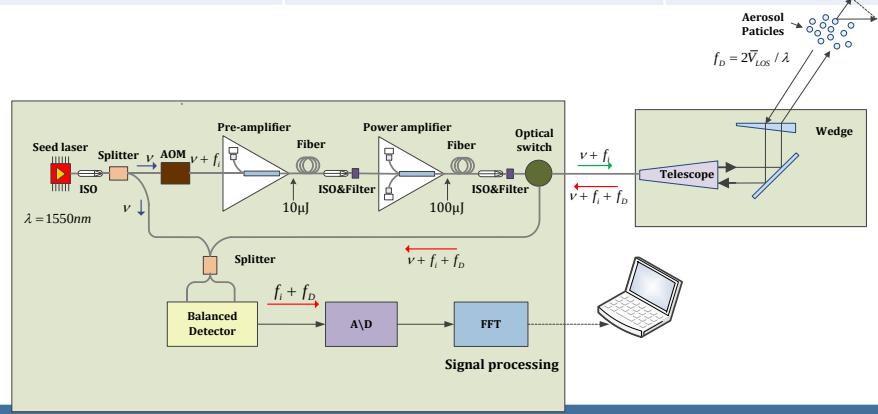

| Specifications | Parameters |
|---|---|
| Wavelengths | **532nm/355nm；** |
| Laser energy | **≥10mJ@532nm; ≥10mJ@355nm;** |
| PRF | **1kHz@532nm&355nm** |
| Linewidth | **100MHz@532nm** |
| Temporal resolution | 1 s (adjustable) |
| Vertical resolution | 7.5 m (adjustable) |
| Data products | α, β, δ, LR |

- The **Atmospheric and Oceanic High-spectral-resolution** lidar based on Iodine absorption cell technique is under developing.
- The scheduled accomplishment time: **April 2024**
- One scheduled cruiser expedition: **September 2024**

# Coherent Doppler Lidar

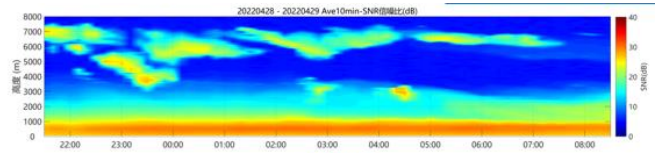


| Qualification | Specifications | |
|---|---|---|
| | Wind3D 6000 | WindMast PBL |
| **Wavelength** | 1550 nm | 1550 nm |
| **Repetition rate** | 10 kHz | 10 kHz |
| **Pulse energy** | 160 μJ | 100 μJ |
| **Pulse width** | 100 ns to 400 ns | 100 ns to 400 ns |
| **Detection range** | **80 m to 6000 m** | **30 m to 4000 m** |
| **Data update rate** | 4 Hz | 4 Hz |
| **Range resolution** | 15 m to 60 m | 15 m to 30 m |

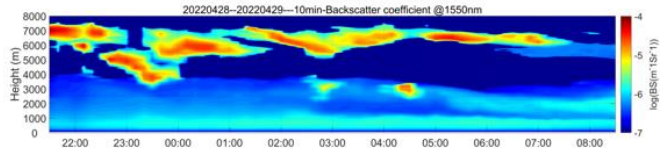



**mainly measure wind/aerosol profiles in atmospheric/planet boundary layer (PBL) and lower troposphere**

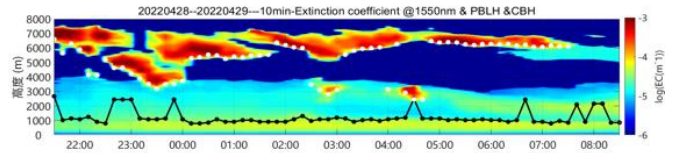
**Be noted: Only parallel-polarization components!**



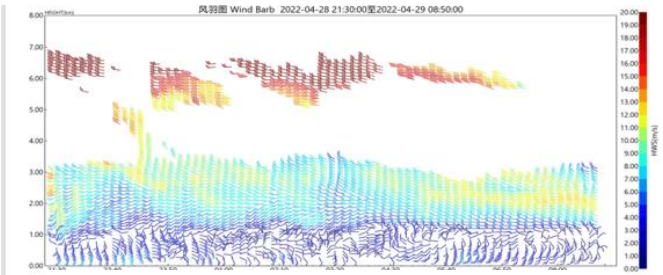
Signal-to-Noise ratio



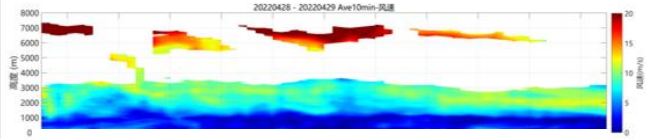

Backscatter coefficient



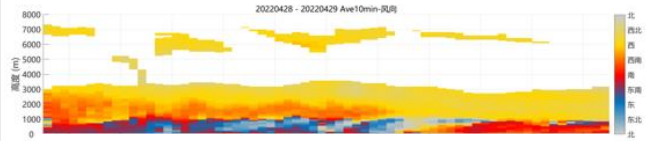

Extinction coefficient/CBH/BLH



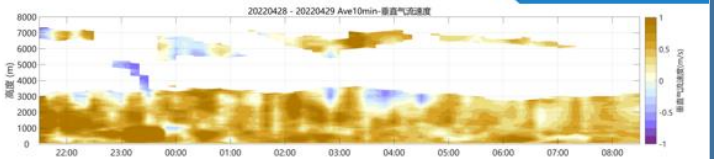

Wind profiles



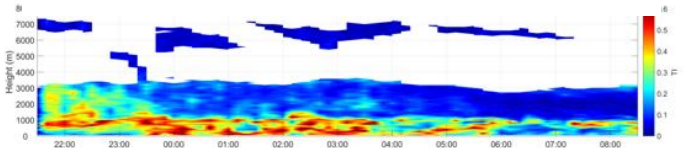
Wind fields (10 mins averaged)



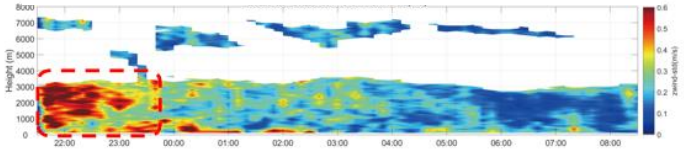
Wind directions (10 mins averaged)



Vertical velocities

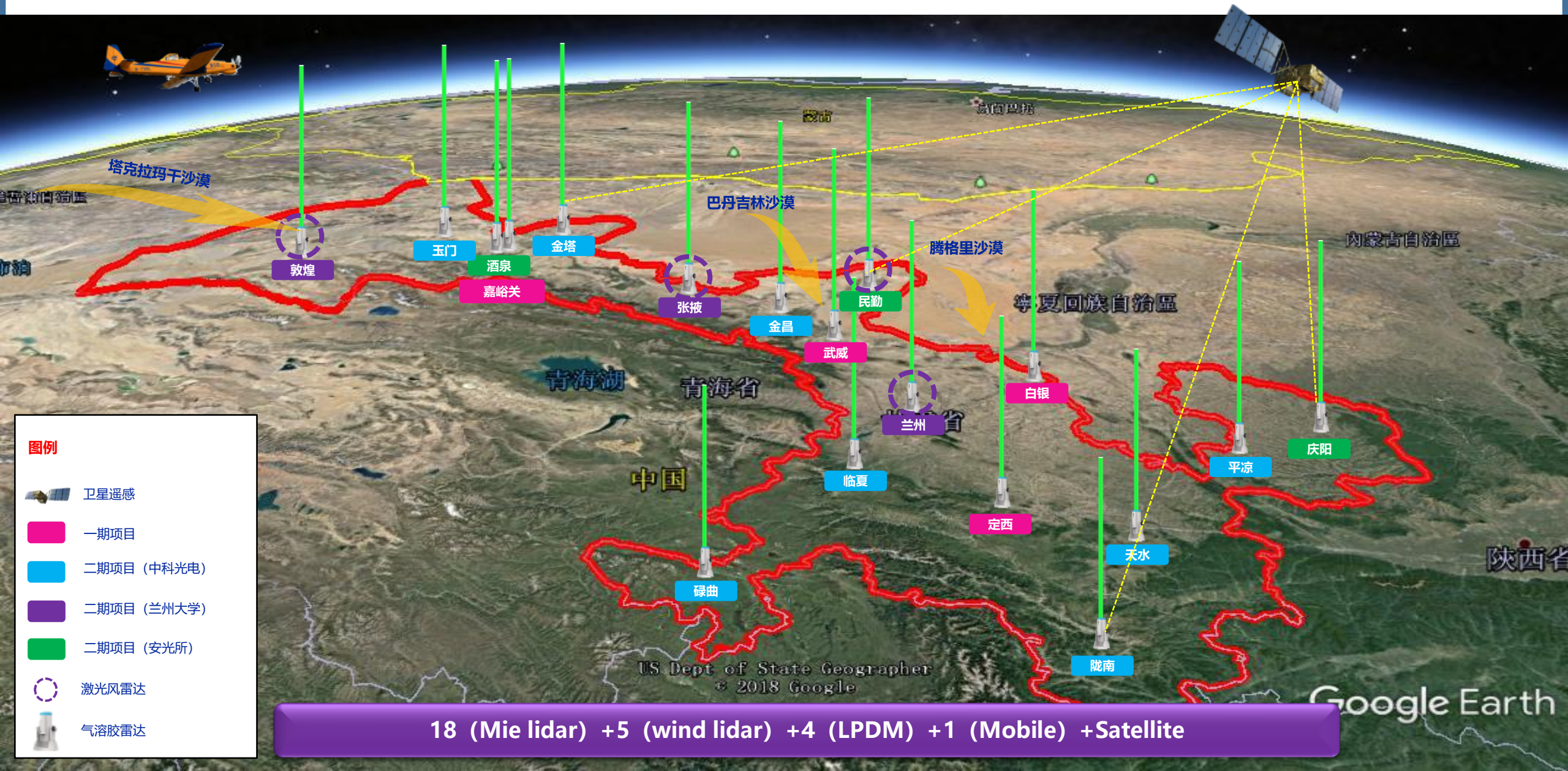



Turbulence




SD of the vertical velocities

# "The Belt and Road" Lidar Network for Dust Monitoring



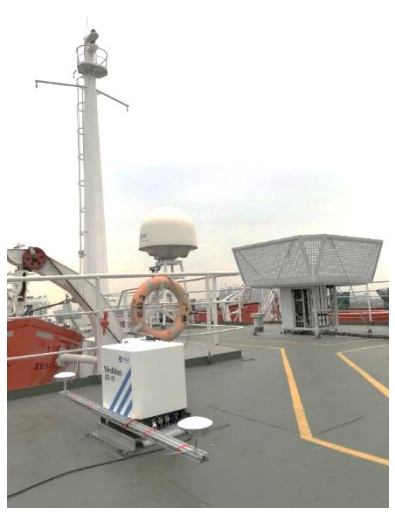
# Onshore & Offshore Doppler LiDAR Network

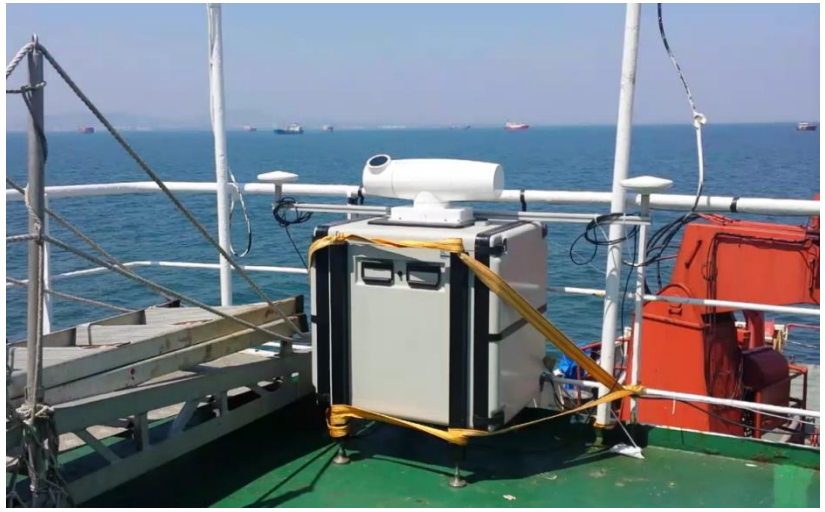

**LiDAR networking information data platform**

- A multi source, multi type, and multi-dimensional information data platform helps improve the level of comprehensive air quality control services and refined meteorological monitoring and forecasting, pollution emergency prevention and control.
- **In this project, all of the data are the potential reference data sources for EarthCARE CAL/VAL.**

# Shipborne Lidars in Navigation Observation of Oceanic and Atmospheric Profile





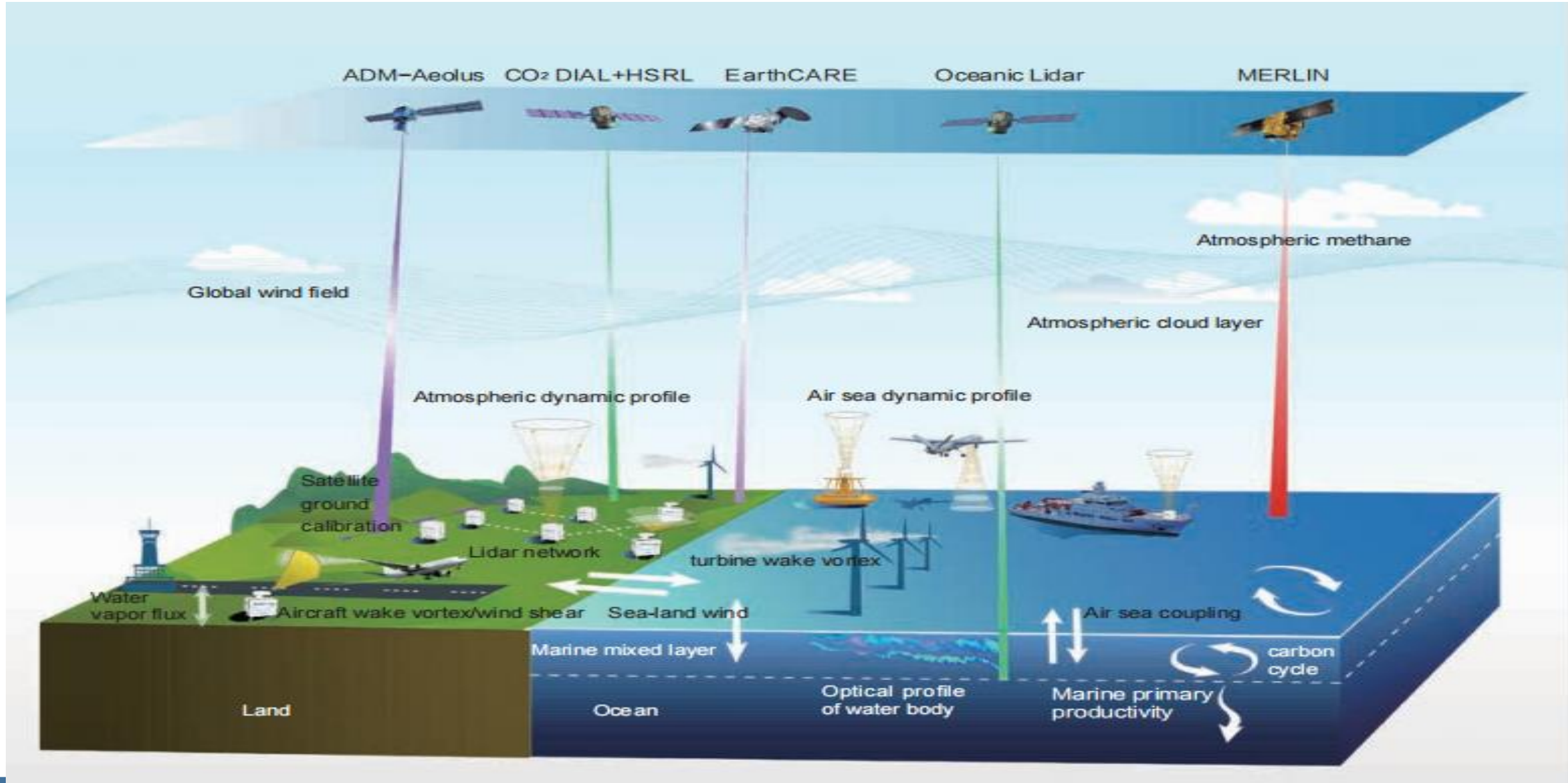


# 3. Summary

1. **The first spaceborne lidar for simultaneously observation of CO2 and aerosol based on IPDA and HSRL techniques are introduced, including the data processing, orbit display and prediction.**
2. **The data products (including backscatter, extinction, depolarization ratio and lidar ratio) from ACDL/DQ-1 can be utilized for the cross-checking of data products from EarthCARE after the wavelength convert.**
3. **The lidar-net over China including HSRL, Raman Lidar, Doppler lidar is capable of providing simultaneous observation of aerosol profiles with EarthCARE. Actually the lidars are also be able to be applied for shipborne measurements.**
4. **We have already learnt some lessons during the CAL/VAL for Aeolus, which may benefit for the CAL/VAL for the EarthCARE.**

Email:
wush@ouc.edu.cn
daiguangyao@ouc.edu.cn

# Construction of "Ground-Sea-Air-Space" Stereoscopic Remote Sensing Monitoring System by Integrated Lidars




Nirringrazzjak
Salamat Спасибо
Kiitos Welalin
Chokrane ありがとう Juspaxar
Obrigado
Kiitos Thank 고맙습니다
Raibh Maith Agat
Dankon You ありがとう
Mochchakkeram
Spasibo 谢谢 Kiitos
Merci Matondo
Obrigado
Kiitos Thank You Asante
Dank Je Raibh Maith Agat
고맙습니다 Kia Ora
Grazie Multumesc
Raibh Maith Agat

# Thanks

# 1. ACDL/DQ-1 introduction: Data processing and Retrieval algorithms

A data processing and optical properties retrieval method adapted to the specific characteristics of ACDL-A global observation dataset