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Aeolus wind products validation with ground-based CDLs net over China and Aeolus products application on aerosol transport

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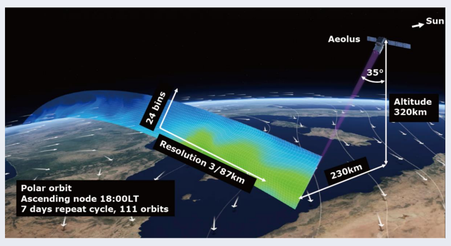
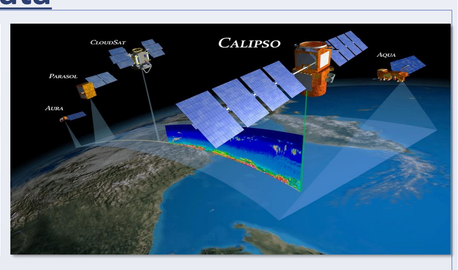
Abstract

- After the successful launch of Aeolus, which is the first spaceborne wind lidar developed by the European Space Agency (ESA), on 22 August 2018, 17 ground-based coherent Doppler wind lidars (CDLs) was deployed to verify the wind observations from Aeolus. By the simultaneous wind measurements with CDLs, the Rayleigh-clear and Mie-cloudy horizontal-line-of-sight (HLOS) wind velocities from Aeolus in the atmospheric boundary layer (ABL) and the lower troposphere are compared with those from CDLs. The profiles comparison results and the statistical results are acquired and analyzed.
- Aeolus has the capability to measurement wind profiles and aerosol optical properties profiles synchronously, which provide the possibility of the observation of aerosol transport and advection. Based on the observation of ALADIN (Atmospheric Laser Doppler Instrument), combined with the data of CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization), ECMWF (European Centre for Medium-Range Forecasts) and HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory model), a long-term large-scale Saharan dust transport event which occurred between 14 and 27 June 2020 is tracked and the possibility of calculating the dust mass advection is explored.

Instruments and data

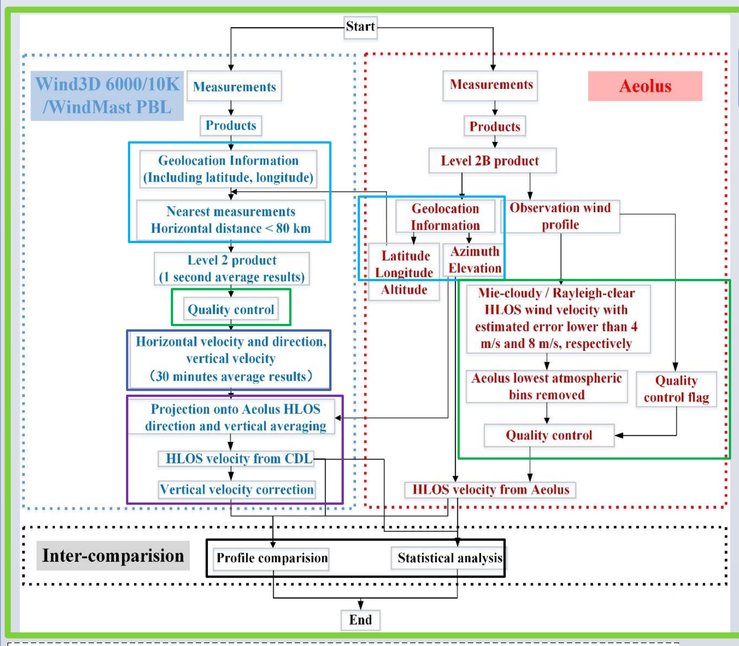




Instruments	ground-based CDL	ALADIN/Aeolus	CALIOP/CALIPSO
Data	• horizontal wind fields • vertical velocity	• L2A aerosol optical properties (α, β) @355nm • L2B Mie/Rayleigh channel HLOS wind • L2C reanalysis wind vectors	• L2 aerosol optical properties (α, β) @532nm/1064nm • L2 vertical feature mask
Horizontal resolution	/	10km@Mie channel 90km@Rayleigh channel	5km
Vertical resolution	15m to 60m	500m@0-2km 1km@2-16km 2km@>16km	30m@-0.5-8.2km 60m@8.2-20.2km 180m@20.2-30.1km

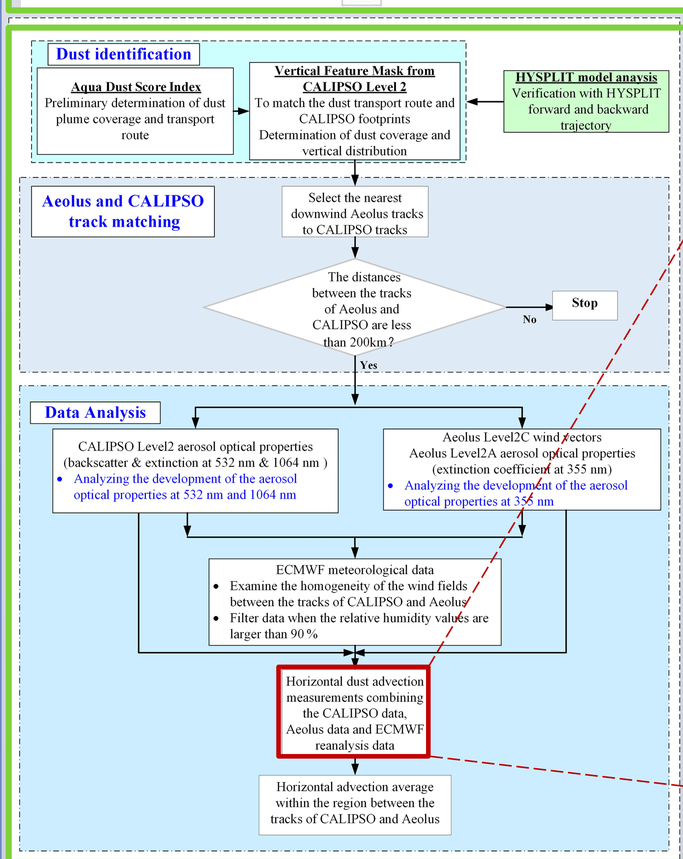
Aeolus wind products validation — **Aeolus products application on aerosol transport**

Methods

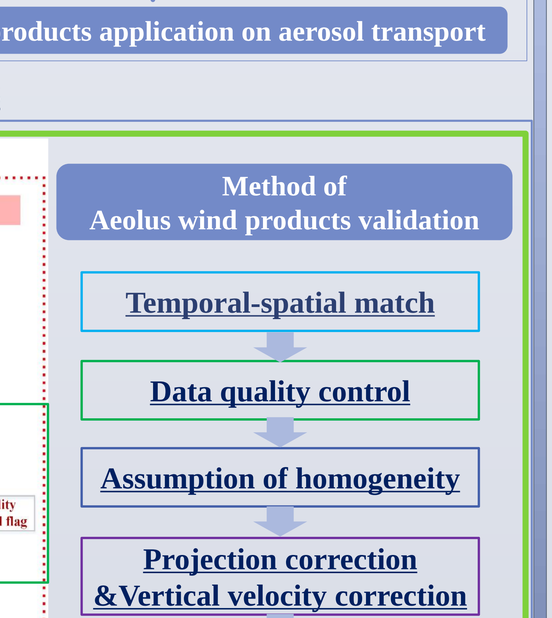


Method of Aeolus wind products validation

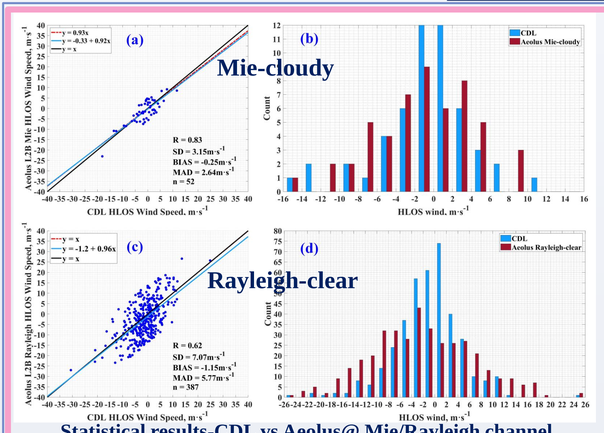
- Temporal-spatial match
- Data quality control
- Assumption of homogeneity
- Projection correction & Vertical velocity correction
- Profiles comparison & Statistical analysis



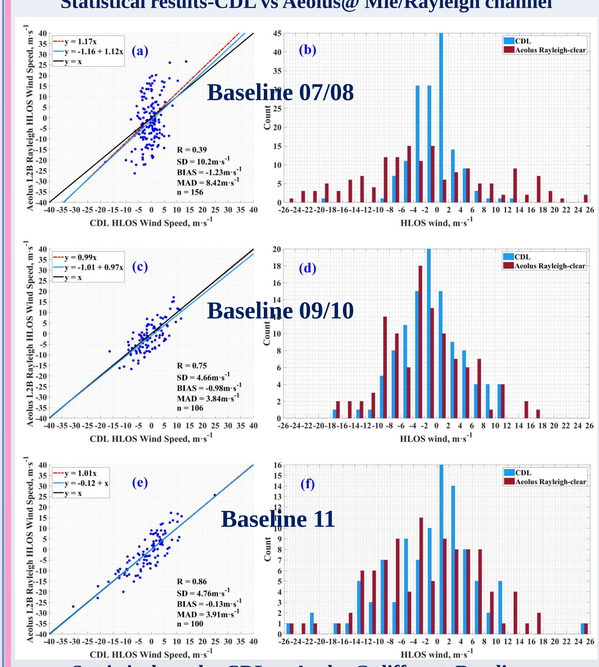
Method of Aeolus products application on aerosol transport



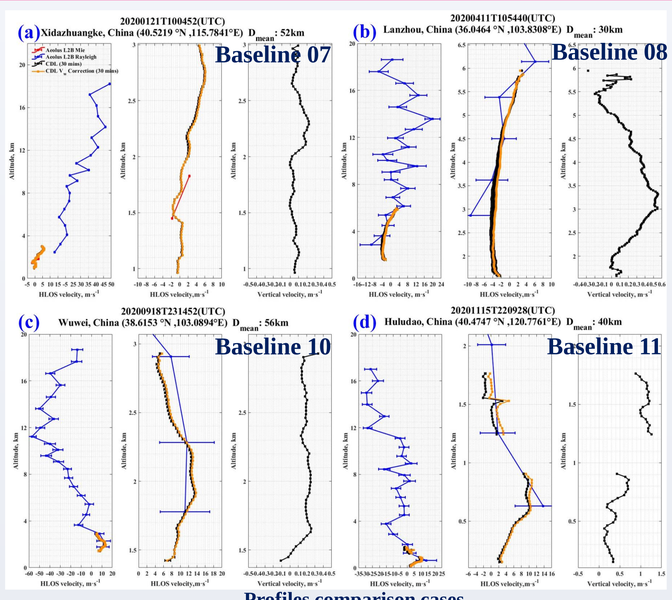
Results and discussion



Statistical results-CDL vs Aeolus@ Mie/Rayleigh channel



Statistical results-CDL vs Aeolus@ different Baselines



Profiles comparison cases

Aeolus L2B Rayleigh-clear HLOS profile:
- ☐ In the atmospheric boundary layer and the lower troposphere are almost trustable
- ☐ The lowest height bin of Aeolus Rayleigh-clear HLOS profile has a large bias

Aeolus L2B Mie-cloudy HLOS profile:
- ☐ In the range of Aeolus estimated error

30-minute averaged vertical velocity profile:
- ☐ vertical velocity: mainly in the range of ±0.30 m/s
- ☐ HLOS retrieved difference: around ±0.40 m/s

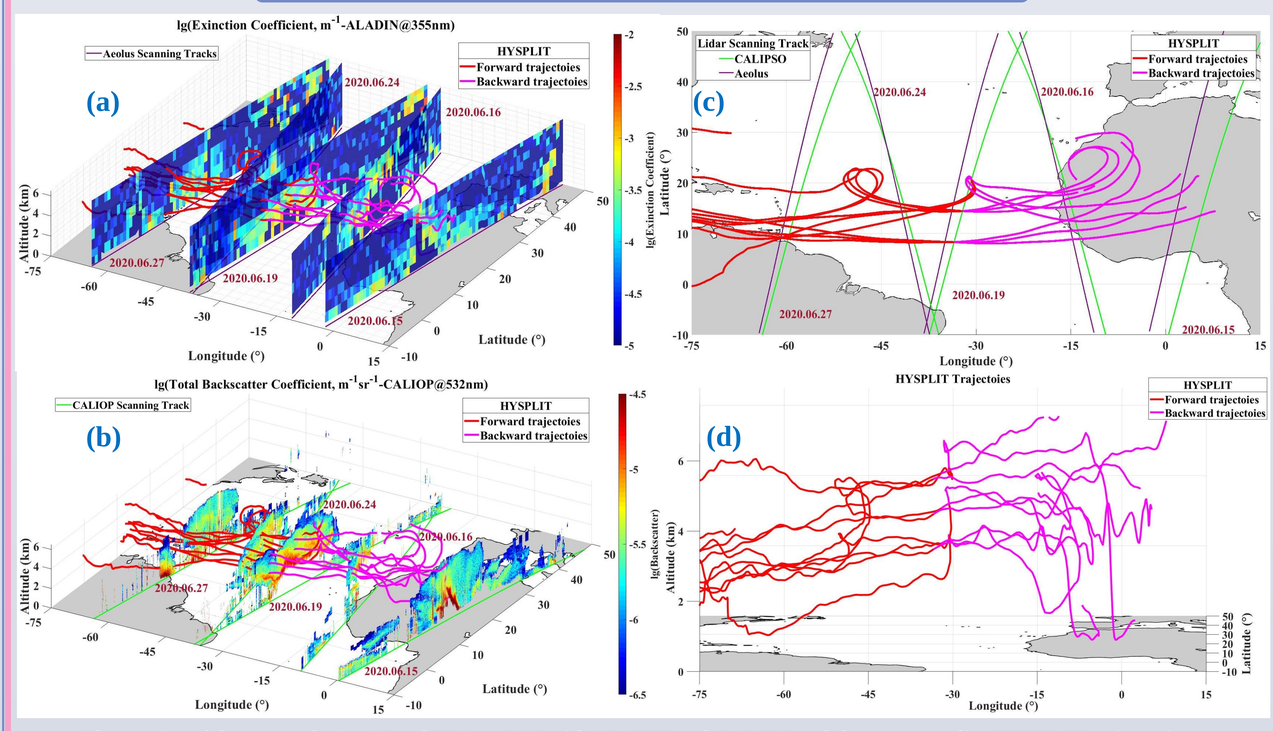
Results of Aeolus wind products validation

Statistical results-CDL vs Aeolus@ Mie/Rayleigh channel:
- ☐ The number of comparison pairs at Mie channel are less than at Rayleigh channel
- ☐ The SD, scaled MAD, BIAS of Mie channel are lower than of Rayleigh channel

Statistical results-CDL vs Aeolus@ different Baselines:

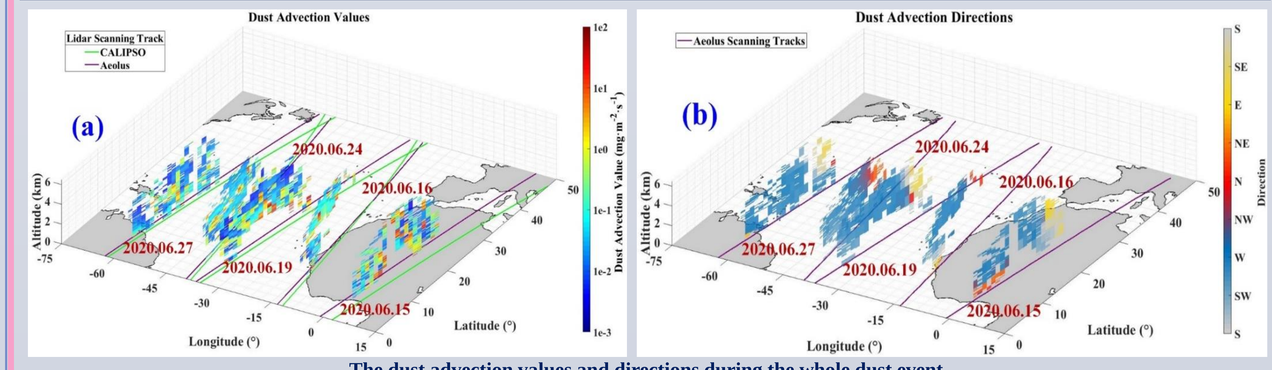
Thanks to the
- M1 mirror temperature correction
- different SNR thresholds for classification of Mie and Rayleigh
- Worldwide CAL/VAL team inputs
- ☐ Baseline 09/10/11 improved significantly than that from Baseline 07/08

Results of Aeolus products application on aerosol transport



Observation of dust event during 15 and 27 June 2020 with ALADIN and CALIOP and the corresponding HYSPLIT trajectories

The dust event generated on 14 and 15 June 2020 **from the Sahara Desert** in North Africa dispersed and moved westward **over the Atlantic Ocean**, finally being deposited **in the west part of Atlantic Ocean, the Americas and the Caribbean Sea**. During the transport and deposition processes, the dust plumes were trapped and transported **in the Northeasterly Trade-wind zone between the latitudes of 5°N and 30°N and altitudes of 0 km and 6 km**. Aeolus provided the observations of the **dynamics of this dust transport event** in the SAL (Saharan Air Layer).



The dust advection values and directions during the whole dust event

In the whole life-time of the dust event, the dust advection values and directions are calculated. During the dust development stage, the mean advection values gradually increase and reach the maximum value on 16 June with the enhancement of the dust event. Then, the mean advection values decrease since most of the dust was deposited in the Atlantic Ocean, the Americas and the Caribbean Sea.

Summary

- The validation campaign of Aeolus in the ABL was implemented with deploying ground-based CDLs over China. The comparison and statistical results were acquired to evaluate the performance of Aeolus L2B HLOS wind. It is found that Aeolus L2B HLOS wind in the ABL is acceptable and is improved with the Baseline updating.
- Based on the match and the analysis of ALADIN and CALIOP data, evaluate the performance of the ALADIN and CALIOP on the observations of dust optical properties and wind fields, and explore the capability of tracking the dust events and in calculating the dust mass advection.

Reference

- Wu, S., Sun, K., Dai, G., Wang, X., Liu, X., Liu, B., Song, X., Reitebuch, O., Li, R., Yin, J., and Wang, X.: Inter-comparison of wind measurements in the atmospheric boundary layer and the lower troposphere with Aeolus and a ground-based coherent Doppler lidar network over China, Atmos. Meas. Tech., 15, 131–148, https://doi.org/10.5194/amt-15-131-2022, 2022.
- Dai, G., Sun, K., Wang, X., Wu, S., E, X., Liu, Q., and Liu, B.: Dust transport and advection measurement with spaceborne lidars ALADIN and CALIOP and model reanalysis data, Atmos. Chem. Phys., 22, 7975–7993, https://doi.org/10.5194/acp-22-7975-2022, 2022.