Community Comment #1

Response: The authors are very grateful for your interest and quick comment to our work. Please find out our point-by-point responses below. Revised portion are marked in **red** in the revised paper.

First of all, we should explain the main target of this work here to avoid misunderstanding—to evaluate the performance of aerosol microphysical, optical and radiative properties measured from a multiwavelength photometer, rather than a commercial statements or competition for a monitoring instrument. In this campaign, we serve as the observation and data processing platform to conduct this intercomparison work with the reference of AERONET's result at "Beijing-CAMS". With that in mind, we intend to change the title of this paper from "A new multispectral photometer for monitoring aerosol microphysical, optical, and radiative properties" to "Evaluation of aerosol microphysical, optical and radiative properties measured from a multiwavelength photometer", to emphasize the principal target of this intercomparsion work. Also, aiming at this topic, some statements of little relevance will be revised in our paper, such as cost and weight. Therefore, this assessment work will contribute to the scientific research such as aerosol measurement, but **not for the commercial purpose nor for the instrument competition**.

Secondly, the scientific meaning of this work should be restated here to make it more clearly. As reported by WMO-GAW's report No. 207, 227 and 228 (2012; 2016; 2017), the multiwavelength aerosol optical depth (AOD) is still recommended as the long-term measurement variables at the GAW's implementation plan from 2016 to 2023. Particularly via ground based AOD attenuation observation, it is regarded as the highly accurate monitoring method to provide indispensable data for satellites validation and global modelling. Additionally, according to WMO's guideline, an absolute limit to the estimated uncertainty of 0.02 optical depths for acceptable data and <0.01 as a goal to be achieved in the near future. This guideline highlighted that data assessment is as important as the data observation. For this sake, we suggested that the work in this paper has practical significance. On the one hand, we tested the accuracy of multiwavelength AOD under various environmental conditions, including low and high aerosol loading (different PM concentration levels), clear and cloudy days (cloud contaminated). On the other hand, the retrievals evaluation is also provided such as single scattering albedo (SSA), volume size distribution (VSD) and radiative forcing, which are the importing parameters for the climate modelling. Thus, **this work could contribute to obtaining accurate AOD data and reduce its uncertainty in response to GAW's target**.

The last but not the least, the relevant statement of AERONET and its CE318 photometer in this paper is regarded as the criterion reference to test the observation results of CW193, but by no means as the competitor network or instrument. As recommended by Working Group II at WMO-GAW's report No. 162 (2004), the international coordination of AOD networks is inadequate and could be improved by a

federated network under the WMO/GAW umbrella, and networks should become traceable and maintainable via intercomparisons and calibrations. We all know that the AERONET is the most widely network around the world, which is mainly is composed of CE318 photometer, to provide quality assured aerosol optical products. Up to now, there are many photometers except CE318 and CW193 have realized the function of AOD measurement in China, such as DTF-5 and PSR-2 (Li et al., 2012; Huang et al., 2019). However, we suggest here also in our paper, all the instrument and its products should meet the WMO/GAW's criterion and keep consistency with AERONET, providing comprehensive, comparable aerosol optical products. Owing to the above factors, we selected the results of "Beijing-CAMS" in AERONET as the reference to assess the data of CW193. On the one hand, the CE318s, five master instruments, are periodically calibrated at Izaña observatory in every six months, indicating the instruments and their calibration coefficients are reliable enough for field calibration via intercomparison. On the other hand, the similar retrieval algorithm (Dubovik et al, 2002; 2006) with AERONET had been tested by previous studies based on CARSNET and can reduce the inversion bias as much as possible, though these biases may be affected by various factors such as sphere calibrations uncertainty. For these reasons above, we conduct this campaign **to present an overall assessment of AOD accuracy and inversion comparability with the reference of AEROENT, aiming at keeping consistency with AERONET rather than to replace it**.

In summary, we are much obliged to your community comments for pointing out the non-standard statements in this evaluation work. We will substantially revise this manuscript by following your insightful comments and constructive suggestions. As an observation and evaluation platform, we hope more instruments will appear to meet the WMO/GAW's criterion or AERONET' accuracy, which will be a great assistance to combat climate change.

References

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World Meteorological Organization. WMO Global Atmosphere Watch (GAW) Implementation Plan: 2016‐2023[J]. World Meteorological Organization, 2017. (GAW Report No. 228)

A. General comments

The manuscript presents a system for the monitoring of atmospheric aerosols, based on a new instrument. It is mainly based on a comparison with the AERONET system (based on the CE318 photometer), considered as the reference.

The main claims of the authors are

- novelty,
- additional functions,
- validity of metrology,
- validity of data processing chain,
- validity for network operations,
- simplified maintenance,
- low cost.

Having red this paper, I concluded that these claims are not substantiated by scientific and technical evidences:

1. No conceptual novelty is shown hence the work appears rather like an approximate duplication of the whole AERONET instrument and system.

Response: Thanks for your comments. The principal goal of this paper is to evaluate the performance of aerosol microphysical, optical and radiative properties measured from a multiwavelength photometer with the reference of AERONET, rather than a commercial statements or competition for a monitoring instrument. We have restated this point at the above discussion and will revise the corresponding sentences in our paper.

2. The comparison of CW193 specifications to the reference CE318 system is not complete and not fair:

a) First, this comparison should be done with the current AERONET reference instrument CE318T and not with the old version of CE318 as done in the paper

Response: Thanks. This paper is aiming at presenting data evaluation rather than the instruments competition. We chose main aerosol optical products of CW193 to conduct this assessment, and all the reference data were downloaded from the AERONET website. Since the CE318 is the main instruments that AEROENT used and the present version of CW193 could obtain data from direct Sun measurement and almucantar scan, we revised the corresponding tables with the reference of CE318-T mode. Anyway, no matter what kind of instrument it is, we suggested that data accuracy should meet the WMO/GAW's guideline and be comparable.

b) Second, and linked to point a), several important functions present in AERONET are lacking (Lunar measurements, polarized sky radiance option, multiple scenario configurations). Hence, this comparison looks unfair.

Response: Thanks. This comparison focused on data accuracy and comparability, rather than the monitoring network. We will revise some statement with small-relevance under this topic. Actually, for the present version of CW193, the Lunar measurements and polarized sky radiance is not available.

c) Third, the claimed benefits of some new features brought by CW193 are not explained nor proven.

1. CW193 performances are not characterized nor validated
2. Long term performance including robustness, sensitivity to weather conditions is not evaluated, therefore not validated.
3. In the paper, the data quality analysis is limited to a few selected measurement days. The evaluation of the system's quality requires a much more comprehensive experimental plan.
4. The additional benefits claimed for the improvement of operational observations (robustness, simple maintenance, low cost) are not evidenced.

Response: Thanks. We mainly compared the data accuracy and comparability with the reference of AEROENT. As a scientific paper, we considered that the introduction of basic design and parameters for an instrument is acceptable, because the target is data evaluation rather that instrument comparison. As for the system's quality, we agree that the long-terms observation is need. So far, the CW193 have been running at city Changchun (at the Northeast China, 125.35°E, 43.88°N) from 2020 to 2021 for the low temperature test at winter (~ -30°C of minimum temperature) as below shows. However, to evaluate its AOD and inversions' accuracy and comparability, the criteria is important since the AOD bias <0.02 is acceptable according to WMO/GAW's suggestion. So we conducted this synchronous observation at "Beijing-CAMS", considering the AEROENT results could be a standard, aiming at keeping consistency with AERONET. Additionally, after the discussion, we think this paper should be more focused on data evaluation and some statements that may cause misunderstanding will be modified, such as simple maintenance, low cost.

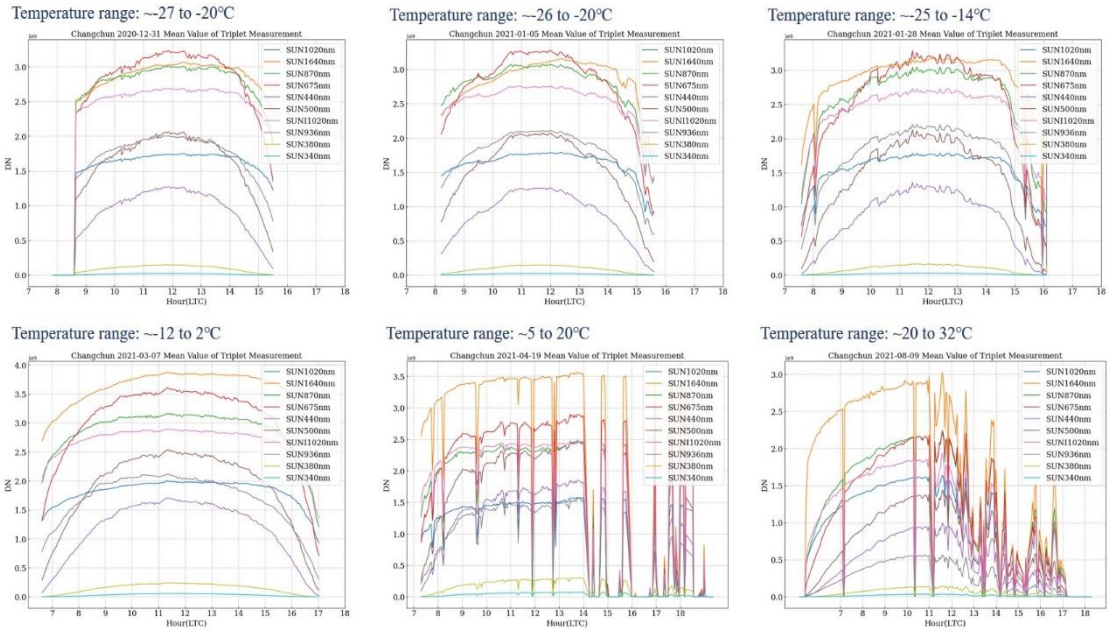

Figure 1. Examples of Raw digital signals at Changchun under the temperature range from ~ -30 to 35 ℃.

As conclusion,

- The work presented in the paper does not bring new knowledge to the scientific community, as it would expect.
- It mainly rather makes a series of technical and commercial statements on claimed advantages of CW193 instrument without providing corresponding evidences.
- In summary, these weaknesses and lacks are in opposition/contradiction with the claimed advantages of CW193: *novelty, additional functions, validity of metrology, validity for network operations, simplified maintenance, low cost.*

Response: Thanks for your constructive comments. Actually, we suggested that data assessment is as important as the data observation to meet the WMO/GAW's criterion or AERONET' accuracy, which will be a great assistance to combat climate change. Second, the introduction of the instrument is only used as an auxiliary description in this paper, rather than main topic. Also, we will modify some statements that may cause misunderstanding such as simplified maintenance, low cost as the response to specific comments below.

B. Detailed and specific comments

1. Line 83: "wired communication (for example, serial communication via RS-232) between the instruments and a personal computer is still necessary for most CE318-N photometers".

Comment: This statement is NOT correct. AERONET operates a large number of sites at remote locations without wired communication with a PC.
Response: Thanks. We are not aiming at the network or instruments comparison. This part has been deleted in our revised paper.

2. Line 85: "the non-integrated instrument components, such as the control unit, external battery, protection box, and stents platform, not only cause most of the operational problems but also make the deployment and maintenance difficult for staff with inadequate training"

Comment: This opinion is not justified and does not seem fair. In AERONET, the protection box and simple tripod platform are options that may be very useful for some types of installations, especially in remote places, where trained staff and technical means are not available. The modular design of CE318 is often an advantage in terms of easy replacement of parts.
Response: Thanks. We are not aiming at the network or instruments comparison. This part has been deleted in our revised paper.

3. Lines 92-93: "which makes the whole system efficient, secure, low cost and highly integrated."

Comment: this list of assertions is not justified by the information provided in the paper. The presented integrated design does not allow local control of the instrument without a PC, which may be a major issue in remote locations. The low cost should be quantified, including initial and expected maintenance costs, and spread over the proven expected lifetime of the instrument. Efficiency and security should be quantified over the long term, in terms of uptime of the instrument and proportion of data brought to some defined quality level. AERONET has proven an unmatched efficiency and service level in producing quality assured atmospheric aerosol products over the long term
Response: Thanks. We are not aiming at the network or instruments comparison. This sentence has been revised as below.

Lines 109-110 in the revised paper:
"…which makes the whole system efficient and highly integrated."

4. Lines 97-99: these assertions are not justified.

Response: Thanks. We are not aiming at the network or instruments comparison. This sentence has been revised as below.

Lines 97-99 in the revised paper:
"These features make the CW193 a particularly suitable multiwavelength photometer for monitoring aerosol microphysical, optical, and radiative properties, which is contribute to verifying the satellite and modelling products"

5. Line 125: "largest" should be qualified: probably refers to China

Response: Thanks. It has been qualified according to your suggestion as below.

Lines 97-99 in the revised paper:
"These features make the CW193 a particularly suitable multiwavelength photometer for monitoring aerosol microphysical, optical, and radiative properties, which is contribute to verifying the satellite and modelling products"

6. Line 126: "Same algorithm" *should be qualified. How has it been validated?*

Response: Thanks. It has been revised according to your suggestion as below.

Lines 128 in the revised paper:
"CARSNET uses the similar algorithm as AERONET…"

7. Line 143: *Again, comparison with CE318-N is not relevant as this is an old version of CE318. Most of AERONET sites are equipped with the more recent version CE318-**T**. The table should be corrected to present a fair comparison.*

Response: Thanks. We are not aiming at the network or instruments comparison. Because the AERONET use CE318s as the master and field instruments, we modified the table 1 with the reference of CE318-T mode. As a result, in this table, some of the parameters that of small-relevant with the main topic have been deleted such as weight, dimensions. Please find the revised one below.

Lines 150 in the revised paper:
"Table 1. Technical specifications for CE318-T and CW193*

	CE318-T	*CW193*
Main components	*Optical head, Control unit, Robot,*	*Optical head, Robotic drive platform, Stents system*

Spectral range	*340, 380, 440, 500, 675, 870, 937,1020, 1640 nm*	*340, 380, 440, 500, 675, 870, 937,1020, 1640 nm*
Field of view	*1.26°*	*1.30°*
Detection's azimuth range	*0° to 360°*	*0° to 360°*
Detection's zenith range	*0° to 180°*	*0° to 180°*
Sun tracking accuracy	*0.01°*	*0.02°*
Communication outputs	*RS232, USB, UMTS/3G/W-CDMA, GPRS*	*RS232, 4G*
Storage	*Flash memory (4 MB), SD card (32 G)*	*SD card (32 GB)*
Power supply	*Power adapter (110 to 240 V), Solar panel (5 W), External batteries (12 V, 16Ah)*	*Power adapter (110 to 240 V), Solar panel (30 W)*
Software	*PhotoGetData*	*DataMonitor*

*Photometer for CE318-T mode in standard version"

8. Table 1 - *The whole table 1 should be corrected with CE318-T technical specifications*

Response: Thanks. We have revised the table 1 and please see the response above.

9. Table 1: *what is the type of detector used?*

Response: Thanks. This item had been deleted according to the discussion above.

10. Table 1 - Drift of single band filter's transmission rate < 1% for CW193 :
    - Sun tracking accuracy: 0.02 °
    - Temperature range: -30° to 60°

    The characterization of these performances should be described.

Response: Thanks. In the revised table 1 above, we deleted the temperature, humidity range and drifts.

11. Table 1: - Power supply for CW193

The type and capacity of the battery system should be described. The autonomy of the system, in case of operation on the solar generator and absence of direct sun, should be stated.

Response: Thanks for the constructive comments. In table 1, we just listed the standard configurations of power supply.

12. Table 1: - Gross weight and flycase dimensions are not really relevant, or should be completed with net weight and dimensions, and with all components (solar panel)

Response: Thanks. Please find the revised table 1 above. We have deleted this item.

13. Lines 174-175: "the design of CW193 is very robust, ensuring long-term steady operation in a wide range of temperature and humidity, between about −30°C and 60°C and between about 0 and 100%, respectively"

Comment: This assertion is not supported by any evidence.

Response: Thanks for pointing out. The CW193 have been running at city Changchun (at the Northeast China, 125.35°E, 43.88°N) from 2020 to 2021 for the low temperature test at winter (~ -30°C of minimum temperature). Also, we conduct several field observations campaigns at remote stie. Here we present some of details at these campaigns below.

Figure 2. Field observation campaign at Wuhai, Alashan and Dunhuang.

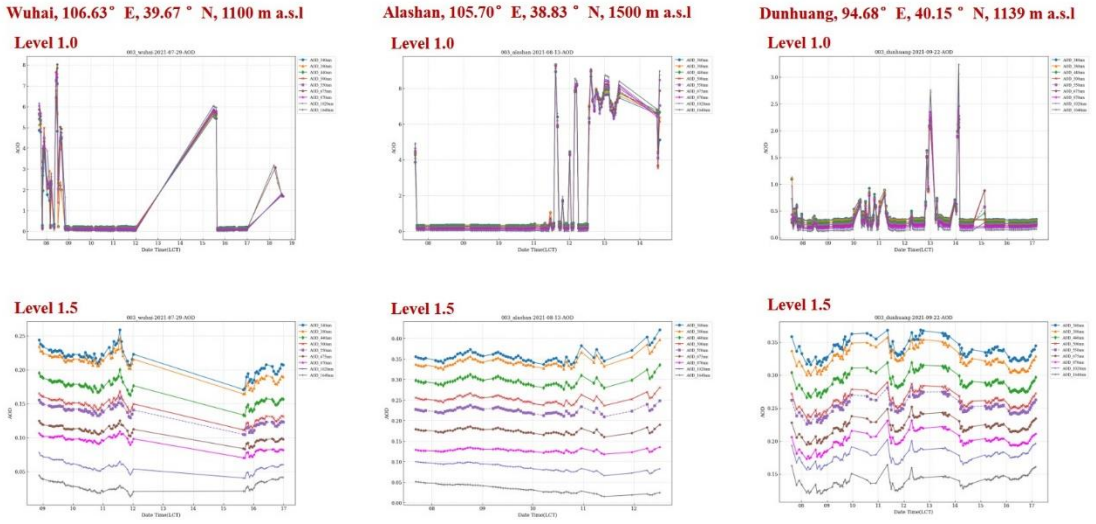

Figure 3. AOD in level 1.0 and level 1.5 during field observation campaigns at Wuhai, Alashan and Dunhuang.

14. Lines 189-192: "It is very convenient to receiving data via 4G network when the serial communication is unavailable in some remote regions, and also in this mode, multiple device control is achievable (device 003, 005 and 006 are on-line and controllable in Figure 3). In the data download part, the history data can be easy downloaded by selecting the start and end time via drop-down menu".

Comment: This is presented as a new function and an advantage, but the AERONET network already operates a large number of remote sites with direct telecommunication link. In AERONET, full data collection is ensured fully automatically in real time, or even after interruption of communications. This is more convenient than manual control through a software.

Response: Thanks. We just show the basic introduction of the data monitoring software in here rather than the comparison with AERONET's system. We all agree that the AERONET and its system is highly efficient and provides useful data for the global climate.

15. Table 2 - *The whole table 2 should be corrected with CE318-T functional specifications*

Response: Thanks. We modified the table 2 according to your constructive suggestion.

Lines 222 in the revised paper:
"Table 2. Functional specifications for CE318-T and CW193*

	CE318-T	*CW193*
Observation frequency for sun measurement	*15 mins (in default), up to 2 mins*	*3 mins (in default), up to 2 mins*
Mode of sun tracking	*At the beginning of every measurement*	*Keep tracking*
Observation frequency for ALM scan	*According to air mass, when air mass =1.7, 2.0, 2.2, 2.4, 2.6...*	*Every integral local time at 7, 8, 9,10, 11…19 O'clock (primary)* *According to air mass, when air mass =1.7, 2.0, 2.2, 2.4, 2.6... (subsidiary)*
*Observation schedule***	*Sun, Moon, Black, Principal plane, Almucantar, Hybrid, Cross Sun, Cross Moon. Curvature Cross.*	*- Sun, Black, Almucantar, Principal plane (in default)* *- only Sun (optional)* *- only Almucantar (optional, consecutive)* *- only Principal plane (optional, consecutive)*
Monitoring Software	*- instruments setup* *- wavelengths selection* *- scan modes & scenarios*	*- scan modes & scenarios configuration* *- measurement scheduling*

	configuration *- measurement scheduling* *- data analysis* *- data visualization* *- data storage (raw data, k8, ASCII files)*	*- wavelengths selection* *- data visualization* *- data retrieval* *- data storage (TXT files)* *- commands inputs* *- multidevice control (4G mode only)*

**Photometer for CE318-T mode in standard version*
***Photometer in auto mode"*

16. Line 211: "five instruments"

Comment: The method and specifics of the calibration of the studied CW193 should be described. For the whole intercomparison study, Sun calibration should be made on a different set of data. Is it the case?

Response: Thank you so much for your constructive comments. In this campaign, the CW193 (could be regarded as field instrument) was calibrated via coefficient transfer method (inter-comparison) with the reference of AERONET master instruments according to the Eq. 1 as below,

$$C(\lambda) = C(\lambda)_0 \times \left(\frac{V(\lambda)}{V(\lambda)_0}\right) \dots\dots Eq.1$$

where the $C(\lambda)$ and $C(\lambda)_0$ is the calibration coefficient for field instrument and master instrument at λ wavelength, respectively. $V(\lambda)$ and $V(\lambda)_0$ is the digital count for field instrument and master instrument at λ wavelength, respectively. We have rewritten this sentence in paper and added one corresponding reference of coefficient transfer method to make it more accurate.

Lines 204-205 in revised paper:
"…using the method of coefficient transfer (inter-comparison) with the reference master instruments of AERONET (Che et al., 2009, 2019c; Zheng et al., 2021)."

Che, H., Zhang, X., Chen, H., Damiri, B., Goloub, P., Li, Z., Zhang, X., Wei, Y., Zhou, H., Dong, F., Li, D. and Zhou, T.: Instrument calibration and aerosol optical depth validation of the China Aerosol Remote Sensing Network, J. Geophys. Res. Atmos., 114(D3), doi:10.1029/2008JD011030, 2009.

17. Line 313-314: "Therefore, in summary, the CW193 shows high stability under both high and low aerosol loadings; hence, the excellent detection ability makes it a reliable instrument for aerosol monitoring."

Comment: This conclusion regarding the reliability of the instrument is not justified in the paper.

Response: Thank you so much for your constructive comments. In this part, we intended to show the wavelength dependence of AOD measured from CW193 both at

clear and polluted days. We have revised these sentences according to your suggestion as below.

Lines 204-205 in revised paper:
"…the CW193 showed good ability of AOD's wavelength dependence under both high and low aerosol loadings…"

18. Figure 6:

Comment: This figure does not show interruption at nighttime. The observation time per day should be explained.

Response: Thanks for your constructive comments. At present version of CW193, the Lunar observation is not available as the revised table 2 and discussions show above. We have revised this sentence according to your suggestion as below.

Lines 319 in revised paper:
"Figure 6 shows the diurnal variation of cloud-screened AOD (only from daytime observation) for each band from CW193 during this campaign"

19. Line 352: "We set the envelopes as ±(0.05 + 10%)."

Comment: The choice of this criterium should be explained. It is quite large compared to the AERONET uncertainty.

Response: Thanks for your constructive suggestion. Actually, this envelope is widely used in many previous studies aiming at AOD validation from satellite, to show the error range versus reference. We used this figure here to highlight the AOD precision with statistical parameters, as well as the accuracy of ground-based observation against satellite monitoring. We all agree that the AERONET provide the high accuracy AOD data with uncertainty smaller than 0.02. And the specific analysis of AOD bias can be found in Figure 8 in our revised paper.

20. Line 412: "uncertainty of <10% is acceptable for the discussion"

Comment: This level of uncertainty is much higher than AERONET's.

Response: Thanks for your suggestions. This statement is inaccurate and we have deleted it in our revised paper.

21. Lines 568-570

Comment: This conclusion should be expressed as a preliminary only. It must be checked on long-term and various weather and aerosol conditions.

Response: Thanks for your constructive suggestion. Yes, we all agree that the stability of CW193 must be checked on long-term and various weather and aerosol conditions. So we just present the preliminary evaluation of these data with the reference of

AERONET in this study, showing its consistency with AERONET. We have revised this sentence according to your suggestion as below.

Lines 591 in revised paper:
"The results of this preliminary evaluation indicate that…"

22. Lines 582-585: "the highly integrated design and smart control performance make CW193 more convenient and suitable for the aerosol monitoring, providing similar aerosol optical properties to AERONET. In addition, owing to the built-in 4G communication module, CW193 could be used to create networks in an inexpensive and simple way."

Comment: as such, this is a commercial statement, not evidenced by the paper. It should be removed or rephrased.

Response: Thanks. We have rephrased this part according to your constructive suggestion as below.

Lines 604 in revised paper:
"Above all, the highly integrated design and smart control performance make CW193 suitable for the monitoring microphysical, optical, and radiative properties of aerosol. Due to its smart control performance and optional observation schedule, such as ALM mode, the CW193 could meet the different requirement of the aerosol microphysical, optical, and radiative properties. When the VSD and SSA is in great demand for the modification of numerical model and the verification of satellite inversion products, these inversions could be obtained about 2 to 3 times in an hour, while for once in default observation schedule. As a result, this instrument could be regarded as a contributor in regional and climate model data assimilation, satellite modification, and improving knowledge of the temporal and spatial variations of aerosols."