

# Optical properties of marine aerosols from shipboard skyradiometer observation between Japan and Australia

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## 1. Introduction

Aerosols play important roles in the Earth's radiation balance because of their direct and indirect effects. However the role of aerosols are not understood enough due to their considerable spatial and temporal variations. Therefore, it is important to investigate characteristics of aerosols not only over land but also over ocean. There are not so many observation sites over ocean, thus, shipborne observation is very precious.

The Research Vessel (R/V) *Shirase* travels between Japan and Syowa station, Antarctica from November to April of the next year. There are variety of instruments to measure optical, physical and chemical properties of aerosols onboard *Shirase* (Yabuki et al. 2003, Shiobara et al. 2007).

In this study, we analyzed the solar radiation data observed with a sky radiometer. In this paper, we discuss the optical properties of marine aerosols between Japan and Australia from 2000 to 2006.

## 2. Observation and data analyses

We have sky radiometry observation data for six years over ocean along with the ship tracks. We also made back trajectories to investigate the source of the air masses.

**Sky radiometer** (Fig. 1)

- Onboard Research Vessel (R/V) *Shirase* (5002)
- Measuring sunlight and skylight every 5 minutes in the day time
- Wavelength: 315, 400, 500, 675, 870, 940, 1020 nm

(The underlined were used in this study)

- Observation period: Japanese Antarctic Research Expedition from 42nd to 47th (JARE42-47): November 2000 to April 2006.

**Analyses**

The data were analyzed using SKYRAD.pack ver. 4.2 (Nakajima et al. 1996) to retrieve the optical properties of aerosols, such as aerosol optical thickness at 500 nm (AOT), Ångström Exponent  $\alpha$ , single scattering albedo at 500 nm (SSA). We chose the retrieval results only with the reconstructed irradiances less than ten percent compared to the observed irradiances.

To investigate air mass traveling paths at analyzed sites for 1000 m above ground level, 5-day backward trajectories were calculated using HYbrid Single Particle Lagrangian Integrated Trajectory (HYSPLOT; Draxler and Rolph 2015). We divided the retrieved data into six groups (a) to (f) according to the origins of air masses so as to investigate optical properties of aerosols (Fig. 2).

**Moderate Resolution Imaging Spectroradiometer (MODIS)**

- Platform: Terra and Aqua
- Product: the Level 2 data (MOD04\_3K and MYD04\_3K) of Collection6 (C006).
- Spatial resolution: 3 × 3 km
- AOT: 470, 550, 650, 860 and 1240 nm
- $\alpha$ : estimated with the least square fitting in Equation 1

$$\tau = \tau_{0.5} \lambda^{-\alpha} \quad (1)$$

where  $\tau$  is the AOT at 470, 550, 650, 860 and 1240 nm.



Fig. 1. A sky radiometer POM-01MKII (Prede) for shipboard observation.

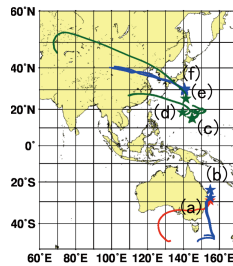


Fig. 2. The analyzed sites and air mass traveling paths: red, blue and green lines correspond to JARE42, 46 and 47, respectively.

## 3. Results

Figure 3 shows the optical properties of marine aerosols from (a) to (f) in Fig. 2.

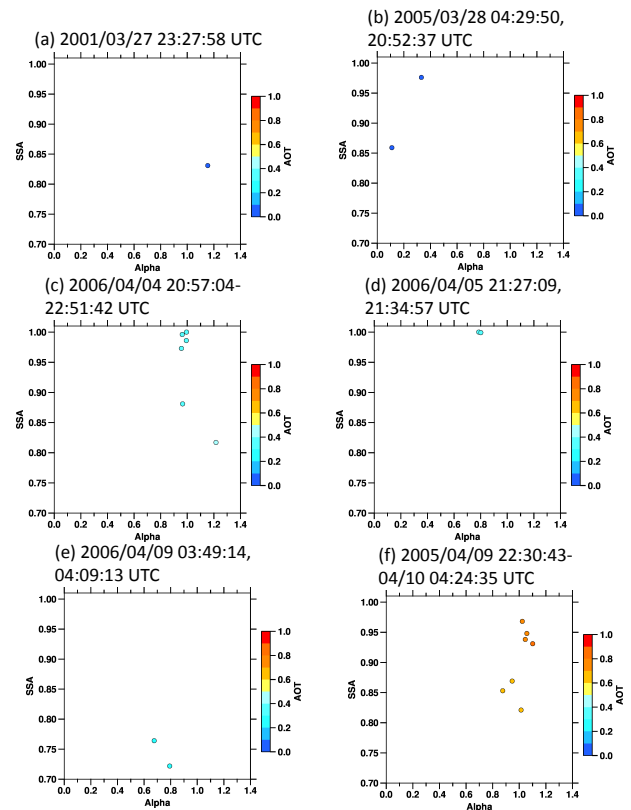


Fig. 3. The optical properties of aerosols. Single scattering albedo (SSA) vs. Ångström exponent  $\alpha$  with the color bar as aerosol optical thickness (AOT) at 500 nm. (a) to (f) correspond to the trajectories in Fig. 2.

The optical properties of aerosols were specific in the analyzed sites and year (Figs. 3a to f):

- AOT: The AOT over the western Pacific Ocean near Japan (Figs. 3c to f) was larger than around eastern Australia (Figs. 3a and b). The AOT were larger than the global mean value of 0.11 reported for marine aerosols by Smirnov et al. (2009). Thus, the aerosol loading was high even over the open ocean.
- $\alpha$ : The smaller particles were predominant at (a), (c) and (f) because  $\alpha$  was large (Figs. 3a, c and f). The coarse particles were predominant at (b) because  $\alpha$  was small (Fig. 3b).
- SSA: The non-light-absorbing aerosols existed over the western Pacific Ocean (Figs. 3c and d), while the light-absorbing aerosols prevailed near Japan (Figs. 3e and f).

Figure 4 shows comparison of sky radiometer and MODIS observation data. The AOT at 550 nm of Sky radiometer was estimated as Equation 1.

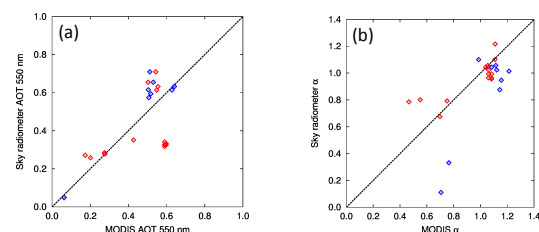


Fig. 4. Comparison of the aerosol optical properties from sky radiometer and MODIS observation: red and blue plots correspond to Terra and Aqua, respectively. The dashed line is 1:1 line.

- (a) aerosol optical thickness AOT at 550 nm
- (b) Ångström exponent  $\alpha$

The validations were shown in Figs. 4a and b. One of the possible explanations of the differences is that sky radiometer and MODIS observed different sky ranges.

## 4. Summary

The optical properties of marine aerosols were estimated from the solar radiation data observed with a sky radiometer onboard R/V *Shirase* from November 2000 to April 2006. As a result, we found that the optical properties of aerosols were specific in the analyzed sites and year. In particular, aerosol loading was high over the western Pacific Ocean.

Moreover, we compared the aerosol optical properties retrieved with sky radiometer and MODIS observation. As a result, the match-up analyses show that the retrieved aerosol properties are comparable. One of the possible explanations for some discrepancies is that range of observations was different.

We will make the similar analyses for the training cruises around Japan, and investigate characteristics of aerosols over ocean.

## References

- Yabuki et al., *J. Meteor. Soc. Japan*, **81**, 151-162, 2003.
- Shiobara et al., *Atmos. Environ.*, **42**, 4638-4652, 2007.
- Nakajima et al., *Appl. Opt.*, **35**, 2672-2686, 1996.
- Draxler, R.R. and Rolph, G.D., 2015: HYSPLOT Model access via NOAA ARL READY Website (<http://ready.arl.noaa.gov/HYSPLIT.php>). NOAA Air Resources Laboratory, Silver Spring, MD.
- Smirnov et al., *J. Geophys. Res.*, **114**, D06204, doi:10.1029/2008JD011257, 2009.

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