# Characteristics of cloud fraction from whole-sky camera and ceilometer observations onboard R/V *Shirase* during JARE 60

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Cloud has opposite effects on the earth climate system: warming and cooling. Their magnitudes depend on cloud fraction, height, and so on. They influence the radiation balance on the earth and they are one of the greatest error sources for the climate prediction [IPCC, 2013]. Nevertheless, it is not easy to make a detailed observation due to their spatial and temporal variability. Furthermore, we do not have enough observation sites over ocean which covers approximately 70% of the earth surface. It is, therefore, important to elucidate their behavior. Thus, we make a periodical shipboard observation to investigate maritime cloud using whole-sky camera, ceilometer and visual observations onboard R/V *Shirase* between Japan and Antarctica.
Shipboard observations were carried out onboard R/V *Shirase* (AGB-5003) [Kuji et al., 2016]. The whole-sky camera system mainly consists of a digital camera (Nikon D7000, Nikon Corporation) and a circular fisheye lens (4.5 mm F2.8 EX DC Circular Fisheye HSM, SIGMA Corporation) to take a photo of a whole sky. The observation interval is 5 min. We have 66,529 images from 21 August 2018 to 11 April 2019 (JARE 60). We investigated the distribution of clouds over ocean by estimating cloud fraction from whole-sky camera images based on a cloud detection method [Yoshimura and Yamashita, 2013]. However, we analyzed the whole-sky images over sea ice region as a function of solar height because sea surface albedo over sea ice regions is very different from that over open ocean [Kuji et al., 2018]. The ceilometer is an instrument to determine cloud base heights by measuring the return time of laser beam (Vaisala CL51). The observation interval is 36 s. We have 558,969 profiles from 21 August 2018 to 11 April 2019 (JARE 60). We can obtain up to three cloud base height with the software built in the system. The cloud fraction with the ceilometer as defined as a frequency of cloud appearance, that is, the ratio of cloudy to total effective profiles. In addition, we can use the cloud fraction by visual observation as one of the meteorological datasets. The observation interval is 1 h. We have 3,267 cloud fractions from 10 November 2018 to 9 April 2019 (JARE 60).
Figure 1 illustrates the temporal variation of the cloud fractions resulted from the ceilometer and visual observations during JARE 60 from 2 December 2018 to 13 March 2019. It is found that the variation of cloud fractions is generally consistent. As a result of the initial analysis, the correlation coefficient is very high of 0.84.

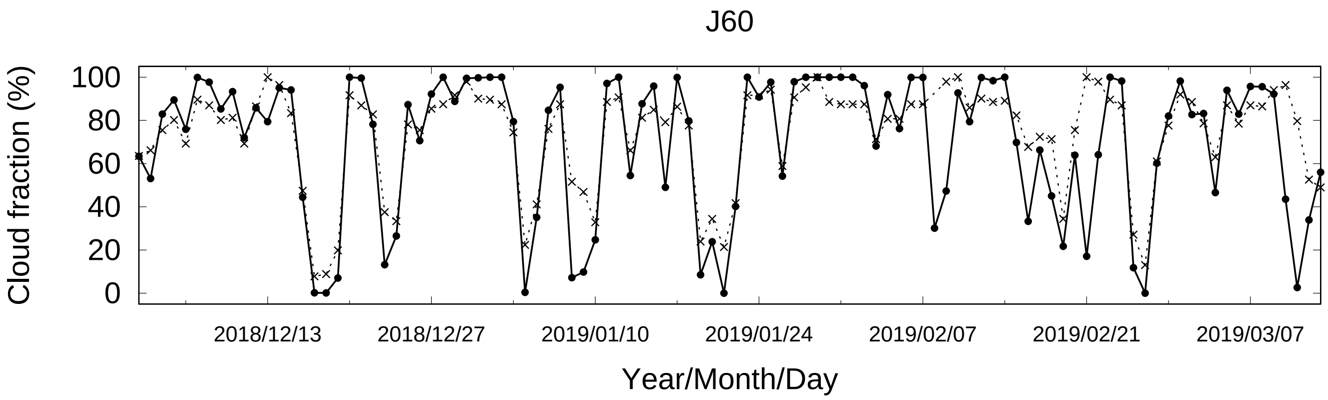


Figure 1: Temporal variation of daily-averaged cloud fractions during JARE 60 from 1 December 2018 to 13 March 2019. Solid and dashed lines correspond to the ceilometer and the visual observations, respectively.

We are going to examine the characteristics of the cloud fraction estimated from the whole-sky camera on the ship tracks. Furthermore, we will make a validation study comparing the cloud fractions from R/V *Shirase* as well as satellite observations.

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