Intra-seasonal variability of oceanic low-level cloud in summertime North Pacific and its interaction with sea surface temperature

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Oceanic low-level cloud (i.e. fog, stratus, and stratocumulus) properties are important to determine radiative cooling at the sea surface via reflecting incident solar radiation, and they strongly interact with sea surface temperature (SST) with positive feedback process (Norris et al. 1998). Despite the importance of the role of low-level cloud in climate change or air-sea interaction, the mechanism of cloud evolution on short time-scale is not well investigated. Thus, the objective of this study is to reveal the evolution of low-level cloud cover (LCC) associated with cloud controlling parameters (e.g. SST, horizontal temperature advection, relative humidity in atmospheric boundary layer, and so on) on short time scale which cannot be revealed by monthly-mean dataset.

For cloud data, we used the level-3 daily gridded data product from MODIS imager (MYD08_D3) with 1 degree of horizontal resolution. OISST and ERA-Interim are used for SST and meteorological parameters, respectively. Spatial and temporal resolutions of these dataset are interpolated into that of MODIS. Target region is western North Pacific (150E-180E, 30N-40N) where standard deviation of LCC in summertime (JJASO) is large. Target period is each summertime from 2003 to 2016. To extract the shorter time-scale variability, we applied Lanczos band-pass filter for each variable. The extracted time scale by the band-pass filter is discussed in the next paragraph.

To investigate dominant time scales of LCC and SST, Fast Fourie Transform (FFT) analysis is applied. The results of FFT analysis for each variable show that 3-7-day and 20-100-day are dominant time-scale for LCC. The dominant time scale of temperature advection (Tadv) is similar to shorter one of LCC, which implies that Tadv is a key factor to control LCC on synoptic time scale rather than SST. On the other hand, for more longer time scale (20-100-day; intra-seasonal time scale), the correlation between SST and LCC is consistent with the previous studies (Norris 2000). To investigate the evolution process of LCC and SST on both time-scale, we applied the band-pass filter to them with two time-scale; (1) 3-7 day and (2) 20-100 day.

We further conducted phase composite analysis for each time scale. The result shows that (1) variation of SST (Tadv) lags (leads) to that of LCC on both time scales but (2) propagating direction of LCC anomaly and associated specific and relative humidity is eastward (westward) on synoptic (intra-seasonal) time scale. The difference in amplitude and propagation direction of LCC on each time-scale depend on different atmospheric dynamics and variation of associated moisture field. The above results also suggest that anomalous dry-cold Tadv is a trigger to increasing in LCC and SST decreasing is followed by them. This lead-lag relationship among each variable is clear on the intra-seasonal time scale. Temperature budget analysis for ocean mixed-layer shows that the SST decreasing is caused by shortwave cooling due to low-level cloud radiative effect and enhanced latent heat release. It emphasizes an importance of anomalous Tadv for the intra-seasonal variations of not only LCC but also SST.

Keywords: Summertime North Pacific, Oceanic low-level cloud, Synoptic and intra-seasonal variabilities, Air-sea interaction, Satellite observations

