Field observation of rainfall distributed in vertical cross section with Xband radar under severe windy conditions in 2018

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Between atmosphere and ocean there exists a thick layer of ‘a third fluid’: sea spray and rain droplets, consisting of many droplets under severe conditions. However serious gaps in knowledge about the air-sea interaction at wind speeds over 40 m/s remain difficult to fill by observation or experiment.

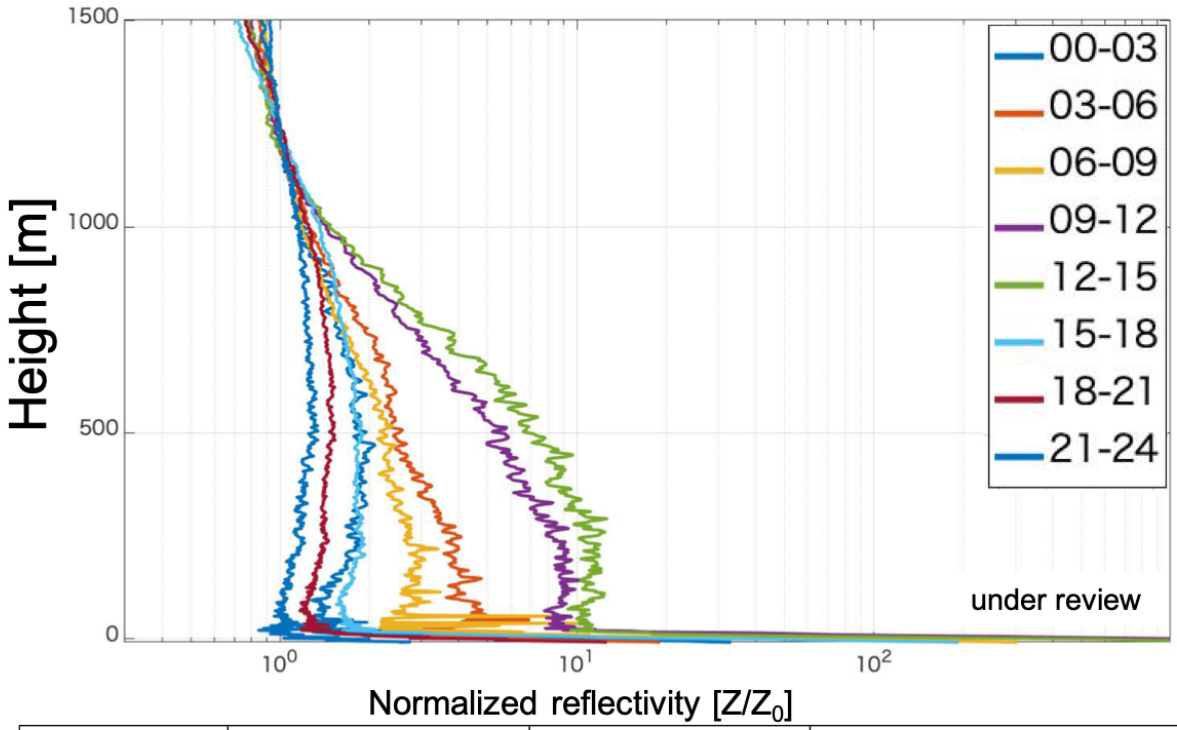
To reveal the air-sea interaction under severe windy conditions with sea spray, rainfall and wave, marine observations with disdrometer and X-band radar are performed in a coastal area in Wakayama prefecture, Japan, where typhoons often hit. Characteristics of rainfall and turbulent flow under high windy conditions are captured. In this observation, the signal received by radar contains reflections from various objects besides the intended targets clutter, sea clutter. From the X-band radar, vertical cross-sectional observation of rainfall is received in summer 2018. During this period, typhoons No. 20th, 21st, and 24th pass the observation site. We succeed in the obtainment of valuable data.

From this observation, the behavior of the vertical distribution of radar echo r including sea clutter is compared with wind speeds, rainfall intensity and significant wave height. As a result, the reflection intensity tends to remain strong even if the wind speed or rainfall intensity decreases. The signals from 0 m to 1500 m height are uniformly distributed during heavy rainfall. Figure shows the result.

In another observation with two optical disdrometers at 10 and 15 m height on the observational tower, it is intended to obtain rain drop size distributions. Total number of particles with diameter at less than 1mm detects at 10m-height is larger than another disdrometer at 15m-height. The drop size distribution with a diameter at 1 mm obtains a feature that increases with the wind speed. This is considered to be sea spray generated from the sea surface. In this case, it is suggested in the observation of rainfall on the sea that the variation of drop size distribution fluctuates according to the wind speed. Furthermore, it is necessary to consider the mixture of droplets.

Furthermore, in theoretical analysis for the momentum exchange, a drag coefficient is proposed; that is an indicator of momentum exchange that additionally includes the effect of raindrop on an indicator that takes into account of sea spray proposed by Andreas (2004). Under wind speed at 23~38 m/s, the drag coefficient decreases with heavy rainfall intensity. At stronger wind greater than 38 m/s, the CDN10 decreases due to the effect of sea spray than the effect of raindrop. This new indicator can evaluate effects of sea spray and raindrop on momentum exchange. Concerning of the sensible and latent heat exchange, we derived their exchange coefficients which indicate how much heats are conveyed between the air and the sea including two effects, wave age and the heat exchange between droplets and the atmosphere. Additionally, further analysis to evaluate a cooling effect of rainfall on the air temperature at the lower boundary layer is taken. In poster presentation, I will show these results.

Keywords: X band radar, typhoon, rainfall



Time	Wind speed [m/s]	Wave height[m]	Rina intensity[mm/h]
00:00-02:50	7.87	1.52	0.33
03:00-05:50	7.11	1.92	0.43
06:00-08:50	7.53	2.68	0.95
09:00-11:50	10.19	3.17	1.83
12:00-14:50	12.41	3.56	4.67
15:00-17:50	14.22	3.37	13.50
18:00-20:50	16.93	3.63	35.33
21:00-23:50	25.35	2.73	9.50

The upper figure is cerical distribution of normalized reflectivity
The legend shows the time for these distributions. The table shows wind speed, significant wave height and precipitation at each time.