The excitation location of external gravity waves traveling across the Pacific Ocean and its seasonal variation

*Takashi Tonegawa[1], Yoshio Fukao[1], Hajime Shiobara[2], Hiroko Sugioka[3], Aki Ito[1], Mikiya Yamashita[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Earthquake Research Institute, The University of Tokyo, 3. Department of Planetology, Graduate School of Science, Kobe University

At deep seafloor, large amplitude of external gravity wave, i.e., infragravity wave (IGW), is persistently observed at frequencies of 0.003–0.03 Hz (30–300 s) in noise spectrum of pressure records. Previous works reported that the generation of the IGW is possibly related to ocean swell and its location is near shoreline. In this study, we investigate the characteristics of the IGW propagating in the ocean, by examining a spectral analysis and an interferometric method. Comparing these observations with the spatio-temporal distribution of ocean swell, we try to find possible locations where the IGW observed off Aogashima is generated.
Off Aogashima in the Izu-Ogasawara region, south of Japan, 10 pressure gauges with a station spacing of 10 km were deployed during May 2014 and May 2015. The locations are 50–100 km east of Aogashima, and the water depth ranges from 1400 to 2300 m. The sampling rate is 4 Hz.
In the obtained results, we found the following three remarkable observations relevant to the IGW observed off Aogashima. Firstly, we calculated running spectrum, i.e., spectrogram, of ambient noise records for a time-period of four months (June–Sep. on 2014). As a result, we found temporal and frequency variations of the IGW amplitude. For example, there are several events that show large amplitude at lower frequencies (0.003–0.01 Hz), and also at higher frequencies, e.g., 0.03 Hz, but with a time-delay of 3 days relative to that at lower frequencies (one example is shown by an arrow in Fig. 1a). The amount of the delay is continuous as a function of frequency. Secondly, we investigated the propagation direction of the IGW. We extracted the IGW propagating between all pairs of two pressure gauges deployed off Aogashima by using an interferometric method, and performed an array analysis. As a result, the IGW is persistently coming from east in summer. If we calculate the ray path of the IGW eastward from the station, it reaches to the shoreline in South America. Moreover, the propagation times between South America and one station off Aogashima were approximately 360,000 s and 95,000 s at frequencies of 0.03 Hz and 0.007 Hz, respectively, resulting in 265,000 s (3.07 days) in differential time; the differential propagation speed as a function of frequency is caused by dispersion of the IGW. This is in good agreement with the observation of the time delay of 3 days. Thirdly, as mentioned above, several events with relatively large IGW amplitude can be seen in the running noise spectrum. It seems that the occurrences of these events correlate with the timings at which strong swell in the southern hemisphere approaches eastward to the shoreline in South America, rather than swell observed around Aogashima (Fig. 1b). Based on these observations, we interpret that the IGW observed off Aogashima in summer is excited near the shoreline in South America. On the other hand, in winter in the northern hemisphere, it seems that the excitation location of the IGW is changed to the shoreline in North America.

Keywords: external gravity wave, deep seafloor observation

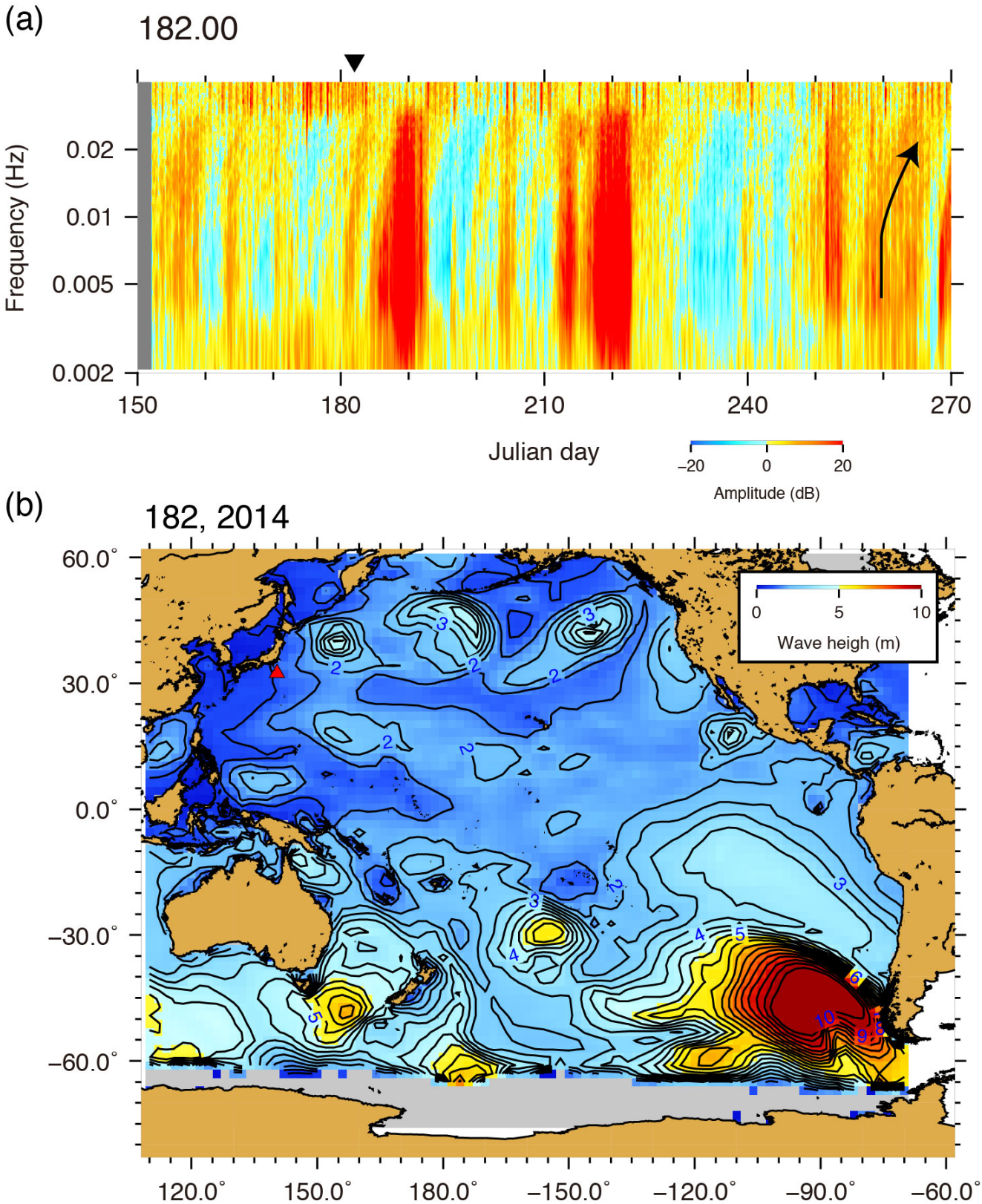

Figure 1. (a) Perturbations of the IGW amplitude as functions of time (day) and frequency, i.e., running spectrum. (b) Wave height distribution on 182 (julian day), 2014, from WAVE WATCH III (Tolman, 2005). A strong swell can be seen near South America, and a large IGW amplitude can also be seen on 182, indicated by inverted triangle in Fig. 1(a).