

A Comparative Analysis of the Environmental Conditions associated with the Occurrence and Non-Occurrence of Quasi-Stationary Linear Precipitation Systems over Shikoku Island

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More than half of landslide disasters in Japan are caused by quasi-stationary linear precipitation systems (QSLPSs); however, forecasting their occurrence remains challenging. This study aims to elucidate the environmental conditions related to the initiation and maintenance of QSLPSs by focusing on Shikoku Island, where QSLPSs frequently occur. We extracted "non-occurrence cases", defined as cases in which environmental conditions were favorable for QSLPS initiation, but no QSLPS actually occurred, and compared them with occurrence cases.

QSLPS cases were extracted using 1-km mesh composite radar data from JMA. Environmental-field analyses were conducted using the JMA mesoscale model, while synoptic-scale conditions were evaluated using surface weather charts. The analysis period was from May to October, 2006-2024.

QSLPS occurrence cases were identified using the following criteria: regions with 3-hour accumulated rainfall exceeding 80 mm, covering an area of 500 km² or more, an aspect ratio of ≥ 2.5 , and included areas with 3-hour accumulated rainfall greater than 150 mm. As a result, a total of 65 cases were extracted. Because the QSLPS orientations varied depending on the location, we classified them into nine groups according to the location and orientation.

For each group, we analyzed five conditions for the frequent occurrence of QSLPS proposed by Kato (2020), excluding the vertical motion condition (hereafter "Kato's five conditions") as well as the wind fields. The results confirmed that, in most occurrence cases, Kato's five conditions were satisfied in the vicinity of the initiation region. In addition, the orientation of the extracted QSLPSs showed the best agreement with the wind at 600 hPa. Therefore, in this study, the wind at this level was defined as the mid-level wind. In many cases, the orientation of the QSLPSs was consistent with the direction of the mid-level wind. Furthermore, the classified QSLPSs exhibited characteristic directions of low-level and mid-level winds depending on their initiation location. These findings suggest that the directions of low-level and mid-level winds may serve as useful indicators of the occurrence and initiation location of QSLPSs. On the other hand, in cases where the QSLPS orientation did not match the mid-level wind, a tropical cyclone was present nearby, implying the possible influence of orographic rainfall associated with local terrain.

Based on these results, we focused on two regions where QSLPSs frequently occur: the western coastal area of Kochi, and the coastal area from Muroto to the southern coast of Tokushima Prefecture (hereafter the Tokushima region). In these two regions, we extracted cases that satisfied Kato's five conditions and exhibited wind directions similar to those in the occurrence cases, namely southeasterly low-level winds and southwesterly mid-level winds, and defined them as "non-occurrence cases". As a result, the number of cases satisfying only Kato's five conditions was 2,280 in the western coastal area of Kochi and 2,184 in the Tokushima region. However, by adding the wind direction criteria, the number of cases was reduced to 334 and 330, respectively. To further refine the non-occurrence cases, we analyzed eight environmental indices, including CAPE, E CAPE, and the KT index, in addition to Kato's five conditions. In the occurrence cases, relative humidity at 700 hPa and the KT index were significantly higher than in the non-occurrence cases. We therefore added a threshold of KT index ≥ -7 K, corresponding to the minimum value in the occurrence cases. This reduced the non-occurrence cases to 241 in the western

coastal area of Kochi and 251 in the Tokushima region. These results indicate that combining wind-direction criteria and the KT index with Kato's five conditions improves discrimination of environments favorable for QSLPS occurrence.

Keywords: quasi-stationary linear precipitation systems, Shikoku Island, environmental parameters, occurrence conditions