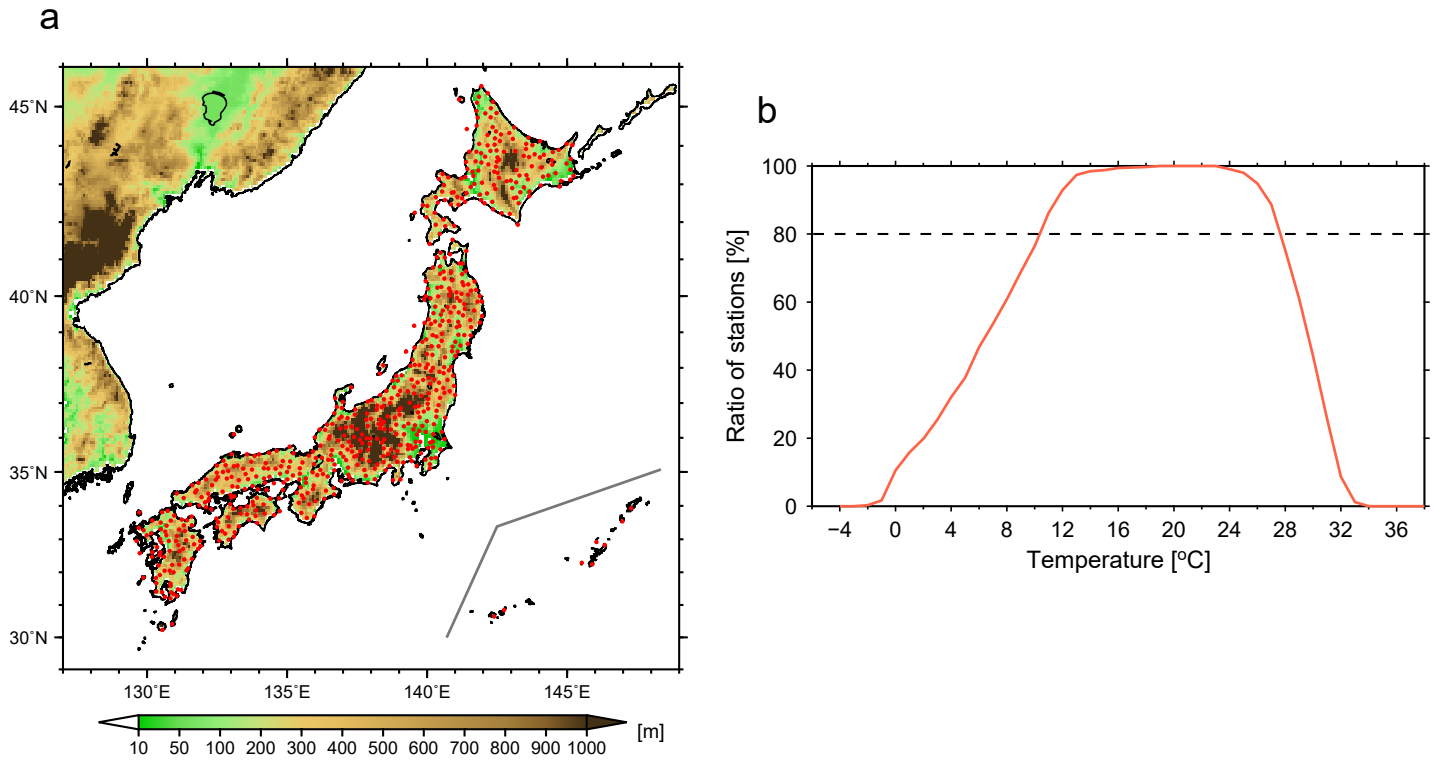
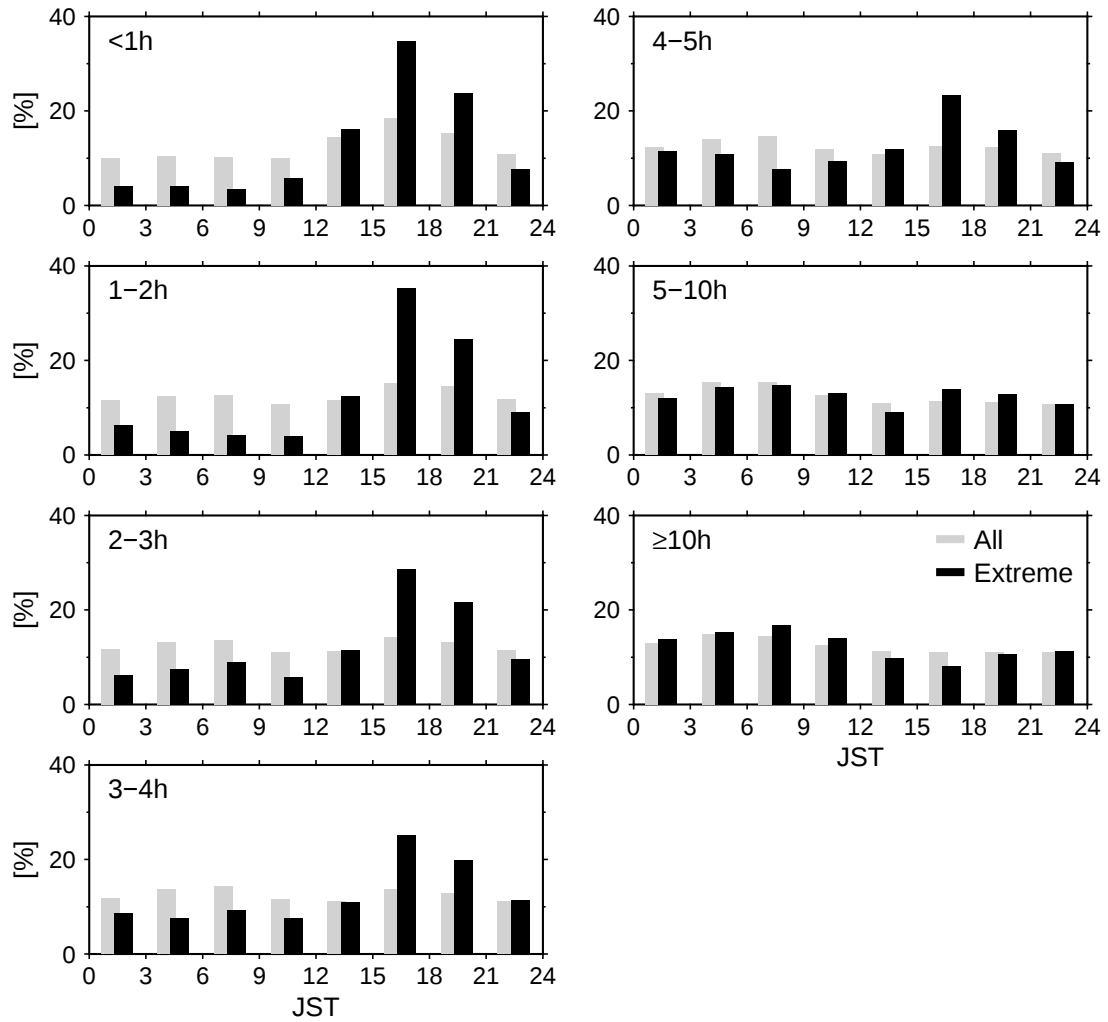
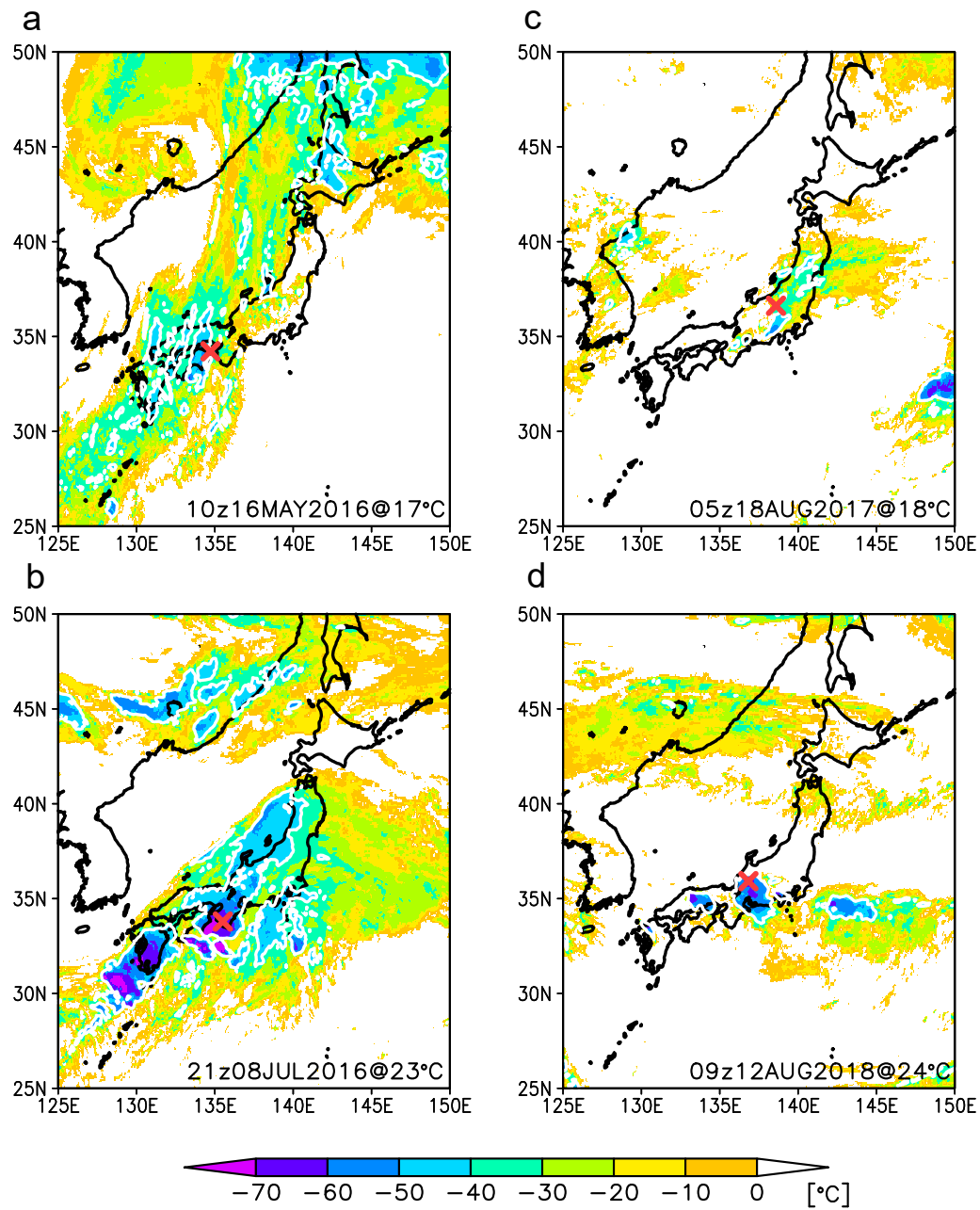




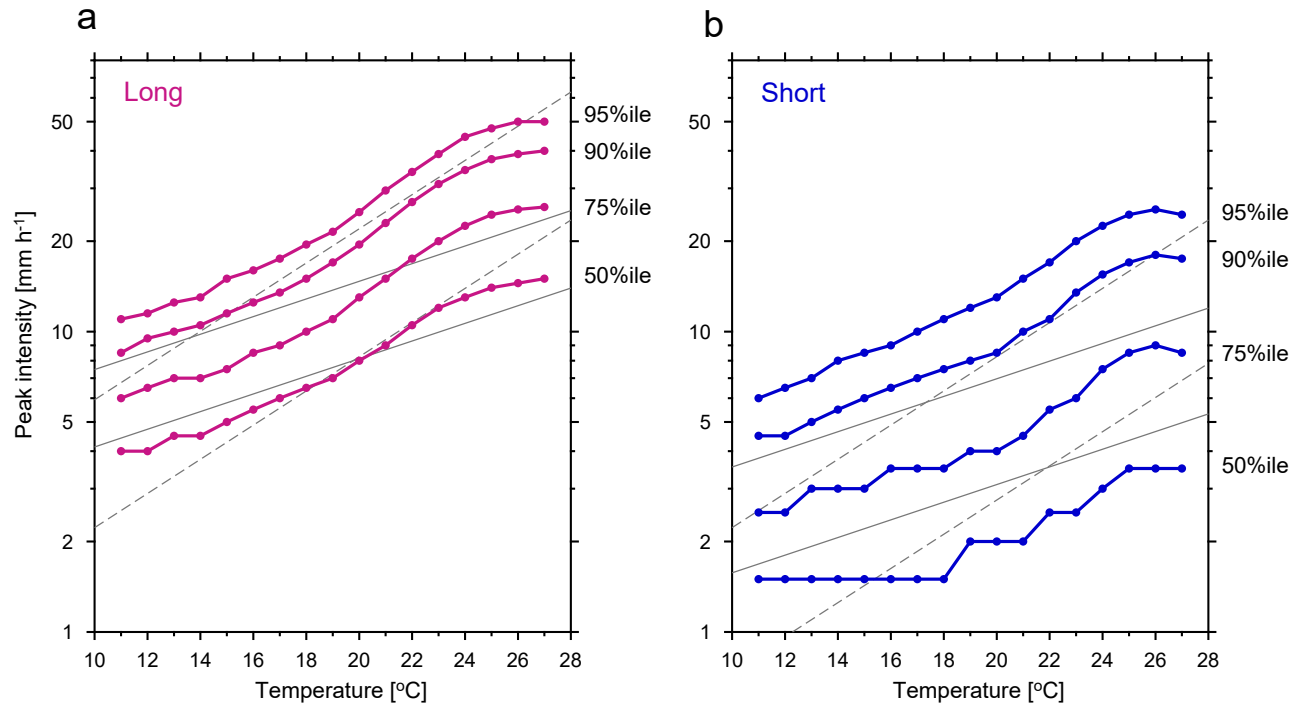
Supplementary Figure 1 | Observation stations analysed in this study. **a**, Locations of the stations (red circles). The background map displays the elevation. **b**, The percentage ratio of stations having data in each temperature bin. Note that the number of stations for each bin is counted according to temperature ranges of each station from minimum to maximum irrespective of precipitation events. The dashed line corresponds to 80% of the total stations (approximately 517 out of 646 stations).



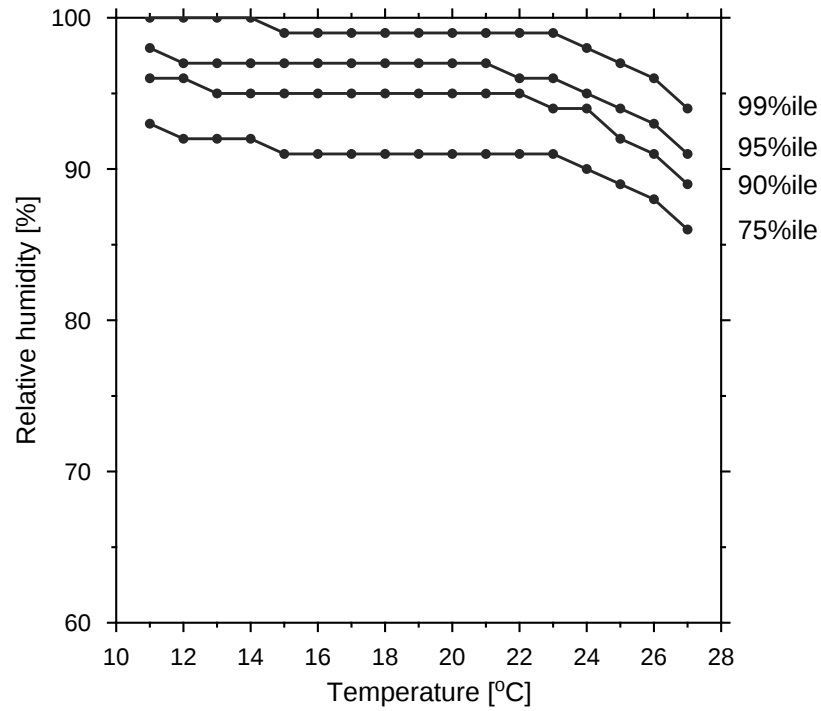
Supplementary Figure 2 | The diurnal variations of precipitation event frequency for different event durations. The diurnal variation of relative frequency of total (grey bars) and extreme (black bars) precipitation events for different length of event durations. The frequency is counted based on the occurrence timing of event peak hourly precipitation. Extreme events are defined as events having strong hourly peak intensity that exceeds the 99th percentile for each duration class.



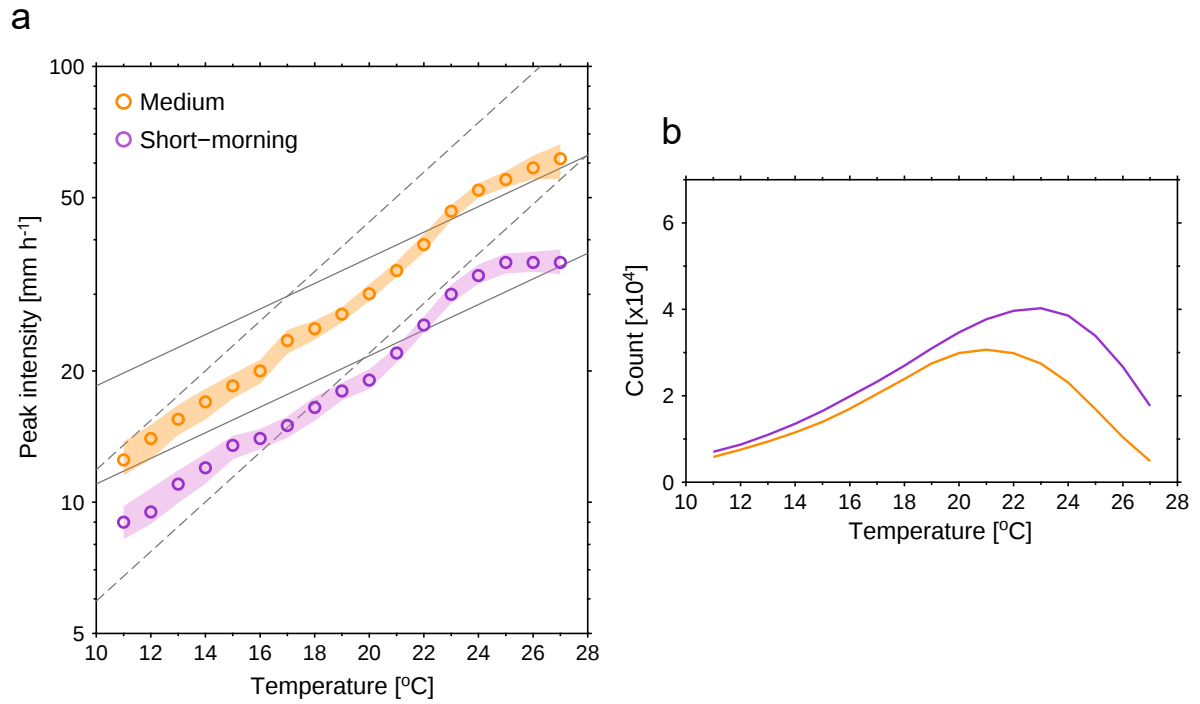
Supplementary Figure 3 | Comparison of cloud patterns in typical extreme events between different durations and between different temperature classes. a,b, Spatial distributions of equivalent black-body temperature for typical long-duration events at lower (a) and higher (b) temperatures. **c,d,** Same as **a,b** but for typical short-duration events. Red crosses represent the event locations. The date and time of the events and the corresponding daily mean temperature are indicated at the lower right of each panel. The white contour is the -40°C isothermal line. The data are derived from hourly infrared images from the Himawari-8 geostationary satellite provided by Kochi University.



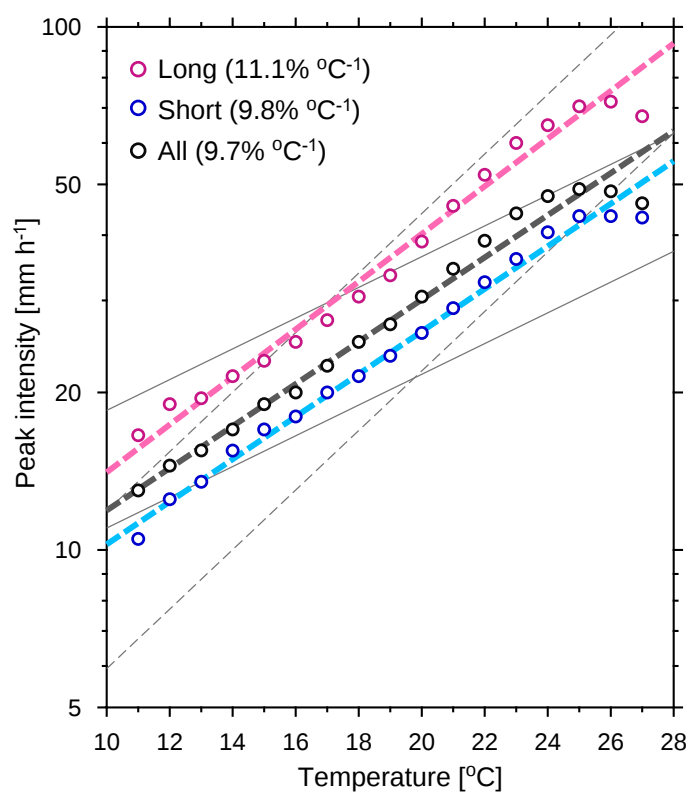
Supplementary Figure 4 | Dependency of different percentiles of event peak intensity on surface air temperature. The 50th, 75th, 90th, and 95th percentiles (from bottom to top) of event peak hourly precipitation as a function of daily mean surface air temperature. **a**, long-duration event. **b**, short-duration event. Solid and dashed lines indicate 7% °C⁻¹ and 14% °C⁻¹ rates, respectively. A logarithmic vertical axis is used. The estimated scaling rates are 11.9, 11.8, 11.3, and 10.2% °C⁻¹ for long-duration events and 10.4, 10.1, 8.9, and 6.6% °C⁻¹ for short-duration events, for the 95th, 90th, 75th, and 50th percentiles, respectively.



Supplementary Figure 5 | The relationship between temperature and relative humidity at the surface. The 99th, 95th, 90th, 75th percentiles (from bottom to top) of daily mean relative humidity as a function of daily mean surface air temperature. Surface observations from 147 stations (where relative humidity data is available) with the same analysed period (1994-2018) are used. Only rainy days (defined as days observing at least 1.0 mm) were analysed.



Supplementary Figure 6 | The relationship between surface air temperature and extreme hourly precipitation. Same as Fig. 3a and b, but for mid-duration (5-10 hours) events (orange) and short-duration events with morning peak intensity (purple).



Supplementary Figure 7 | The relationship between surface air temperature and extreme hourly precipitation. Same as Fig. 3a, but with exponential regression lines for each event.