Supplementary materials

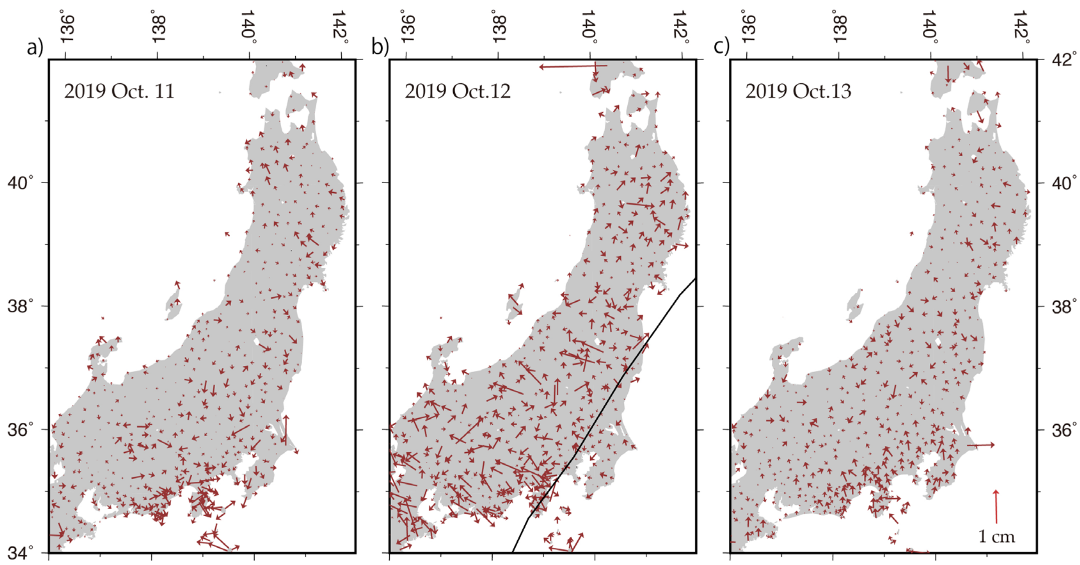

Figure S1. Horizontal displacement on 2019 Oct. 11, 12, and 13 of GNSS stations relative to their one-month median positions (F5c). They show lengths of a few mm, and the signals are larger on the typhoon landfall day. However, it is difficult to find systematic behaviours useful for estimating the surface load distribution.

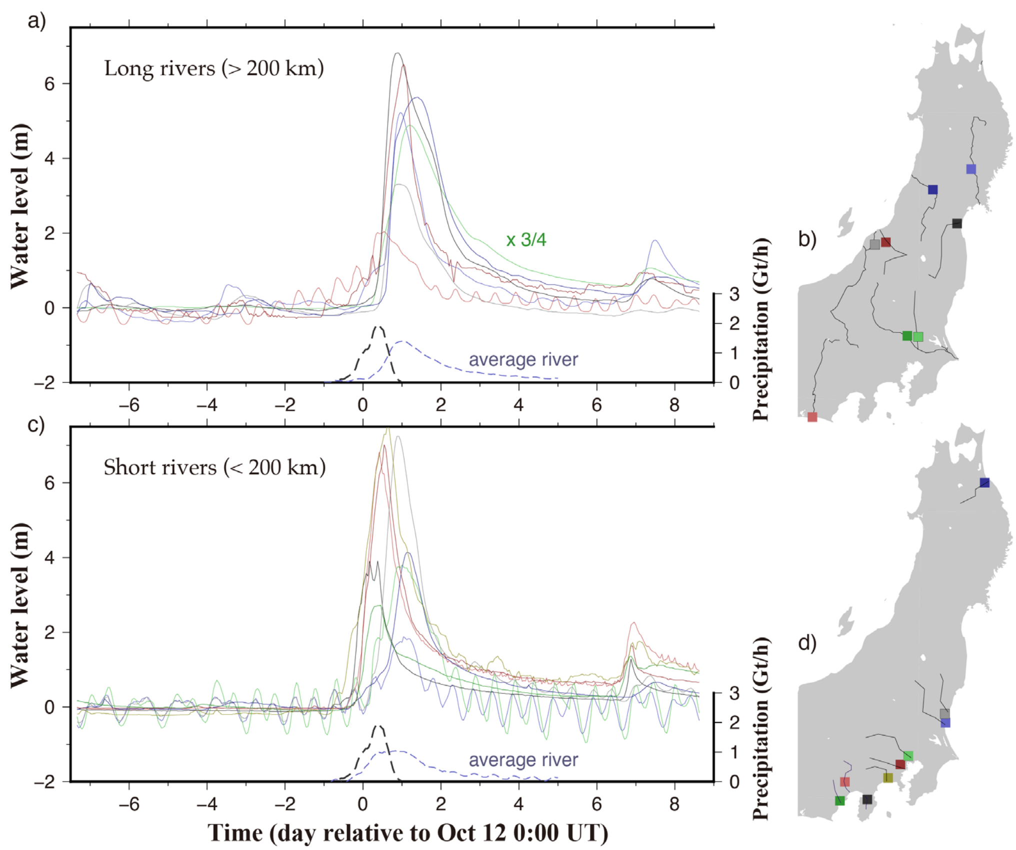

Figure S2. Hourly water level records at 8 stations of rivers longer than 200 km (a) and 7 stations of shorter rivers (c). The rivers are, Kitakami, Mogami, Abukuma, Agano, Shinano, Tone, Kokai, and Tenryu, in (a), and

Mabechi, Kuji, Naka, Ara, Tama, Sagami, Fuji, Kano, and Abe, in (c), in the order from north to south of the stations (squares in the maps in b and d) from Water Information System (www1.river.go.jp). We used the Oct. 5-11 average level as the reference (zero level). Because of the large amplitude at the Tone-river station (dark green in a and c), we multiplied it by 0.75. Semi-diurnal changes seen at stations close to the coast come from the ocean tide. For relatively short rivers (c), increased water level lasts for only a day. On the other hand, some rivers in (a) show longer time constants in its decay. Thick dashed curves in (a,b) indicate precipitation integrated over eastern Honshu land area from RRAP. Thin dashed curves in (a) and (b) show average waveforms of water levels of the long and short rivers (unitless), respectively, obtained by averaging curves of the individual rivers after normalizing their amplitudes.

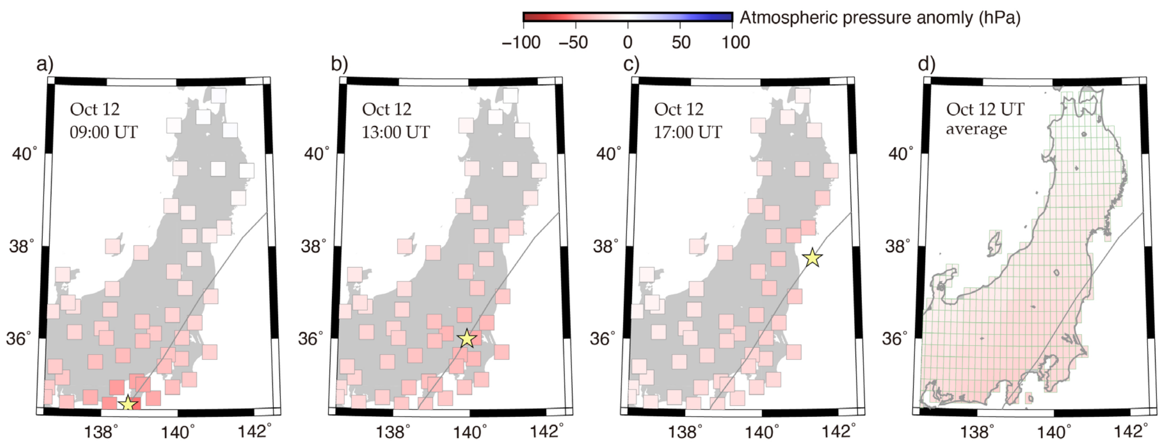

Figure S3. Sea level atmospheric pressure anomaly (difference in hPa from 1 atm) at AMeDAS stations of JMA. (a-c) shows snapshots at three different epochs on the typhoon landfall day (2019 Oct. 12) together with the eye of the typhoon Hagibis (yellow stars). To correct for the estimated load, we calculated average pressure anomalies over the whole Oct. 12 and interpolated them for 437 blocks used to estimate surface load distribution (Fig.10) (d).

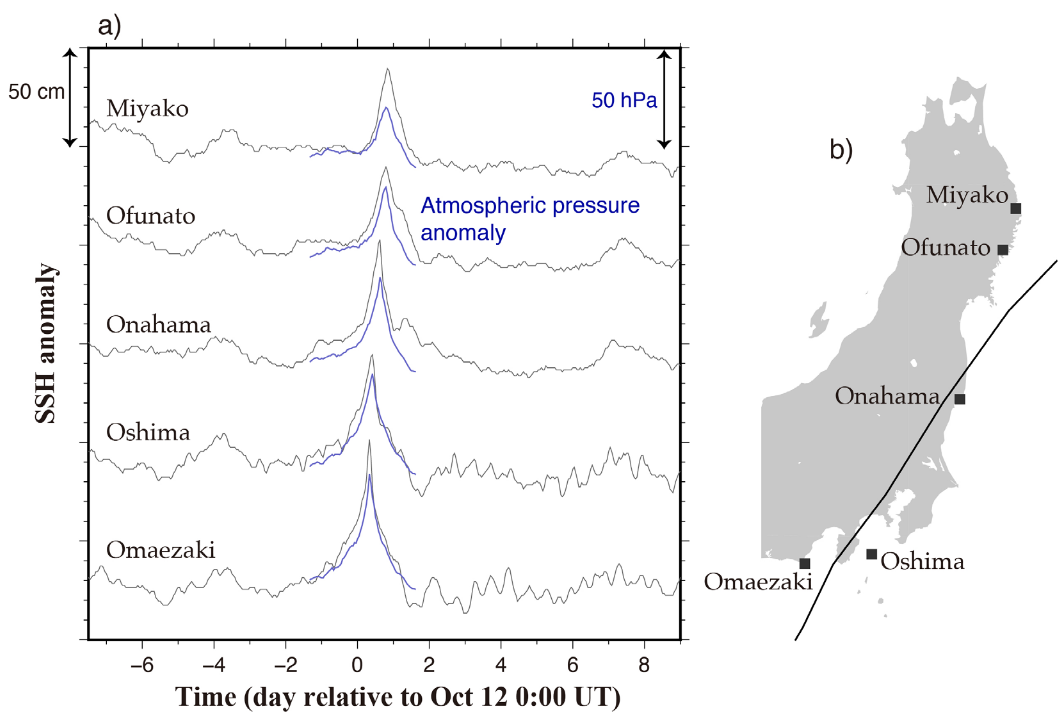

Figure S4. Sea surface height anomalies (deviation of the sea level measured by tide gauges from height calculated using an ocean tidal model) and sea level atmospheric pressure anomalies (difference from 1 atm) from JMA (www.data.jma.go.jp/gmd/kaiyou/db/tide/genbo/index.php) (a) at five stations where both tide gauges and AMeDAS sensors are available (b). Pressure anomalies are drawn taking negative deviation in up direction. Negative pressure anomaly of 1 hPa is compensated by sea level rise of ~1 cm.

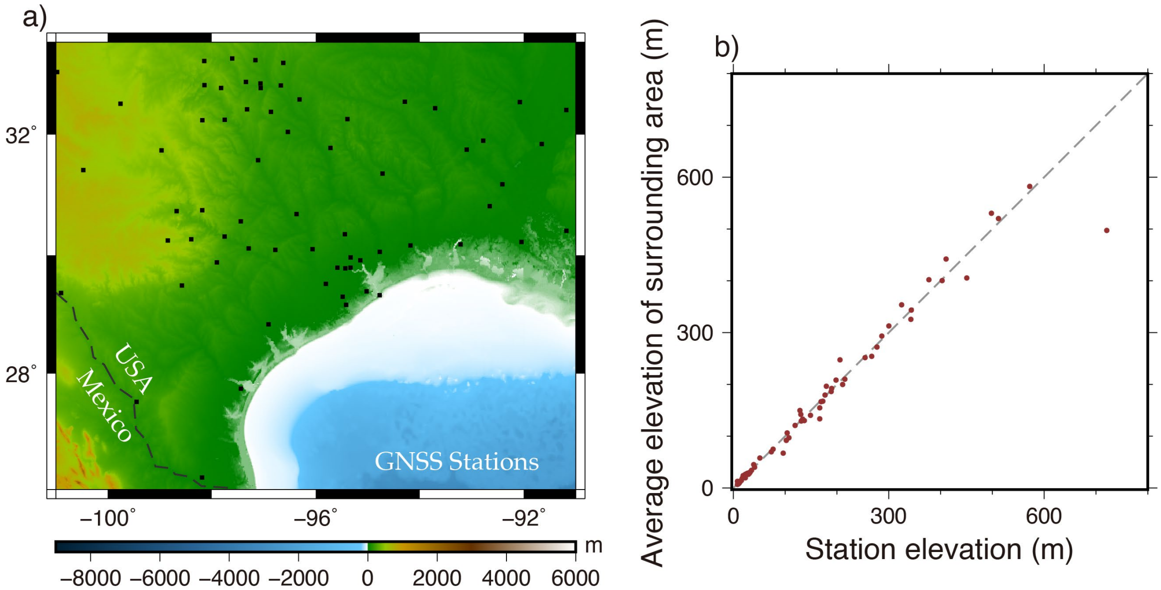

Figure S5 Same as Fig.12 but we compare GNSS station elevation with the average elevation of a ±10 km rectangle surrounding the GNSS station in the region studied by Milliner et al. (2018). Elevation data are from the ETOPO1 model. We do not see significant topographic concavity like in Japan (Fig. 12).