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Evaluation of the novel Drought Potential Index (DPI) over Japan

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Despite receiving an annual rainfall of about 1718 mm (twice as the global average of 810 mm), Japan has erratically faced water shortages at various levels. Since most of these events last less than six months, their detailed assessment remains largely unexplored. Here, firstly we correct the GRACE- and GRACE-FO-derived terrestrial water storage anomaly (TWSA) for co- and post-seismic corrections corresponding to the Tohoku-Oki earthquake (Mw=9.1) that occurred on March 11th, 2011. Secondly, we fill the 34 missing values (23 due to battery management and 11 between the two missions) in the TWSA time series using the ANN and LSTM models. Lastly, we employ the Drought Potential Index (DPI) recently devised by Abhishek et al. (Journal of Hydrology, Volume 603, Part A, 2021, 126868) to quantity the drought potential of the region. The seismic correction using the least square fitting of the TWSA in the spectral domain results in a 76% increase (raw: -3.50 mm yr^{-1} vs. corrected: -0.83 mm yr^{-1}) in linear trends from May 2002 to April 2020. The seismic correction accounts for an increase of 54.45 mm of TWSA during March 2011, with continually decreasing post-seismic relaxations until 2017. Both ANN and LSTM performed reasonably well (r>0.85, NSE>0.70) during calibration and validation phases, and therefore, an average of the two modeled TWSA was used during the data gaps. The maximum water storage deficit (DPI = 1) was observed during July 2014, followed by September 2016 and October 2012 (DPI≈0.85 for both). Some other years of significant water-stressed conditions include 2005, 2007, 2008, and 2013. The crux of this effective water storage-based DPI is that, unlike traditional assessment of water deficit, it considers the monthly potential water deficit and is therefore capable of capturing the droughts that evolve during dry and wet seasons. DPI can also indicate the long-term tendency and transition of the study region to a drought-prone area.