Geophysical Research Abstracts
Vol. 21, EGU2019-2831, 2019
EGU General Assembly 2019

Monitoring agricultural drought in Australia using brightness temperature observed by geostationary satellite

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Amongst various remote sensing-based agricultural drought indices that have been developed, indices based on thermal remote sensing have merit for effective early warning of agricultural droughts. These approaches, however, are relatively complex or sensitive to uncertainties in land surface temperature (LST) estimation. Here, we propose the temperature rise index (TRI), a drought index that is easy to calculate directly from brightness temperatures in the split-window channels, as the anomaly of the intrinsic morning rise of LST. The underlying principle is that the rate of LST rise between 1.5 and 3.5 h after the sunrise is approximately linear and over vegetated surfaces occurs more rapidly under dry conditions as a consequence of stomatal control. TRI during the growing seasons of 2015−2018 was calculated over the Australian wheatbelt from LST retrievals from the newly launched geostationary Himawari-8 instrument. The calculated TRI was compared with indices based on precipitation over different time scales, on soil moisture derived from passive microwave remote sensing, and on vegetation condition derived from optical remote sensing. The various indices were also compared to annual wheat yield over large areas. The correlation coefficient between TRI and precipitation anomaly that serves as an operational drought index in Australia was above 0.6 in general with a 3-month integrative timescale for precipitation. TRI produced spatiotemporal dryness patterns that were very similar to those in soil moisture, but with more detail due to its finer resolution. A time lag was found between TRI and observed vegetation condition, supporting the use of TRI in early warning. Among the compared drought indices, TRI explained the largest fraction of wheat yield variations. TRI correlations with wheat yields peaked higher and earlier by almost one month in comparison to other indices. We conclude that the thermal drought index proposed here shows considerable potential as an effective complement for early warning.