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Generation of 1-km all-weather land surface temperature from satellite thermal infrared and passive microwave observations

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Land surface temperature (LST) is a key variable at the land-atmosphere boundary. For many research projects and applications an "all-weather" LST product at moderate spatial resolution (e.g. 1 km) would be highly useful, especially in frequently cloudy areas. However, current single-source remote sensing in the thermal infrared (TIR) or passive microwave (MW) part of spectrum is unable to derive such an all-weather LST, while the current empirical/statistical algorithms for downscaling MW LST are not readily generalized to merge TIR LST and MW LST into an all-weather LST. In this context, this study proposes a practical method to generate 1-km LST from TIR and MW observations that utilizes component decomposition of LST time series into two temporal components: (1) a steady-state component (i.e. the annual temperature cycle and diurnal temperature cycle as prescribed by solar geometry) obtained from daily TIR LST and (2) a weather temperature component obtained from daily MW LST. The method was applied to MODIS and AMSR-E/AMSR2 data to generate an 11-year record of 1-km all-weather LST over northeast China: the resulting merged LST have a standard deviation of error (STD) of 1.21-2.82 K compared to the 1-km MODIS LST (MYD11A1) and successfully fill missing pixels due to clouds. Validated against in-situ LST from three ground sites with diverse land cover types, the merged LST have a root mean square of error (RMSE) of 1.20-2.75 K, which is comparable to MODIS LST; furthermore, no obvious differences in the performance of the method were found between daytime and nighttime, or under clear sky and cloudy conditions. The proposed method has an improved capability to generate 1-km all-weather LST data suitable for continuous monitoring of Earth's surface temperature.