Advancing Evapotranspiration Estimation through TSEB-Based Multi-Sensor Data Fusion on Google Earth Engine

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Abstract

Accurate field-scale evapotranspiration (ET) data with high spatiotemporal resolution are essential for water resource management. This study developed a Google Earth Engine (GEE)-based framework integrating ECOSTRESS and VIIRS thermal infrared observations with Harmonized Landsat-Sentinel (HLS) data to improve daily 30-m ET mapping. Landsat, ECOSTRESS, and VIIRS land surface temperature data were sharpened to 30 m using the Data Mining Sharpener (DMS) algorithm. Validation against flux tower observations at six sites showed that integrating ECOSTRESS and VIIRS improved ET accuracy relative to Landsat-only estimates, reducing average MAE by 8.64% (daily), 14.40% (weekly), and 16.37% (monthly).

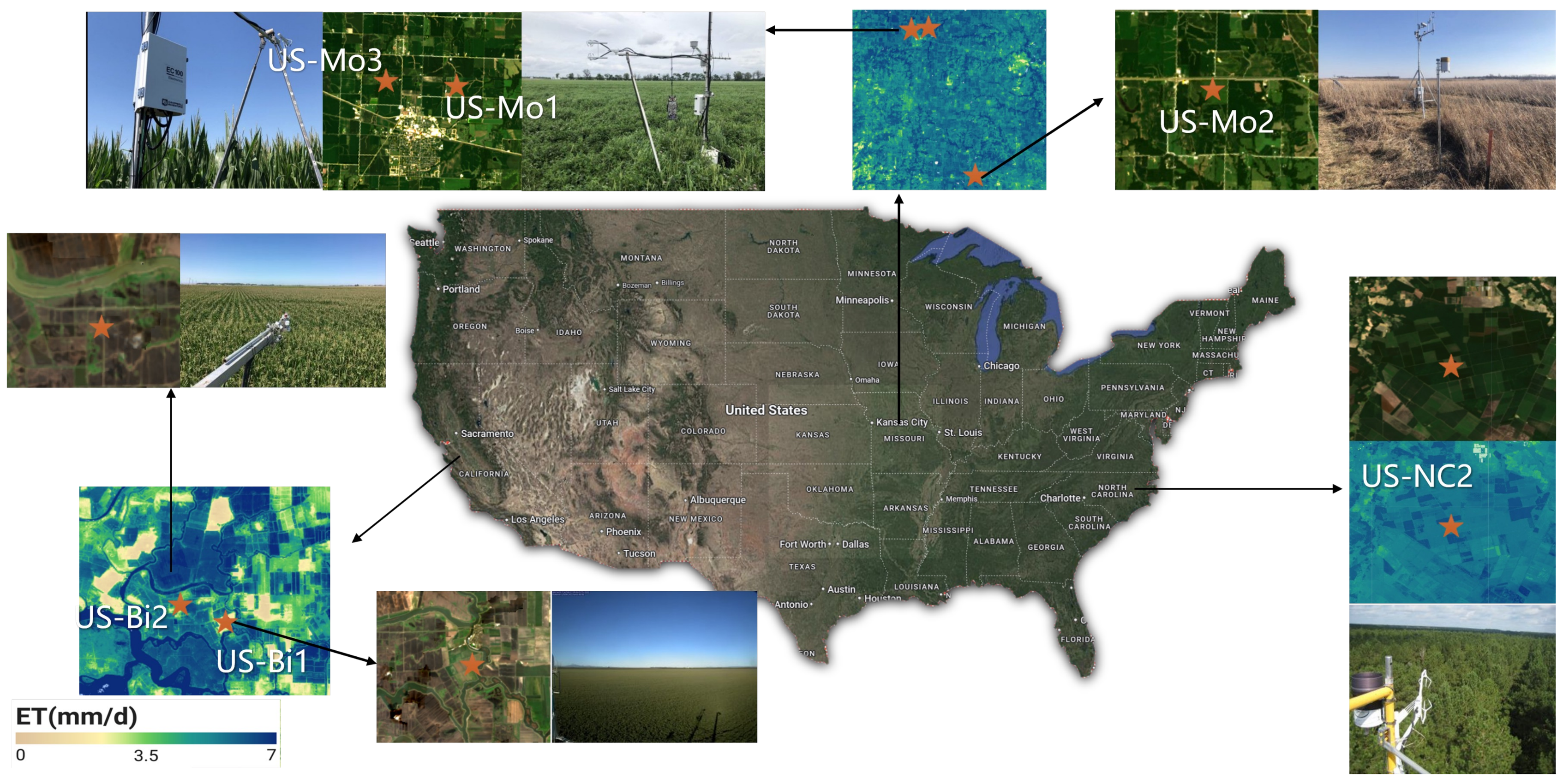

Fig. 1. Location of study sites. The image in the center is Google Earth true-color image for CONUS.

Study sites and Data

Table 1 Flux towers used in the analysis, listing surrounding landcover during study period

Site ID	State	Land cover	Study year	Ratio of energy balance closure
US-Bi1	CA	Alfalfa	2022,2023	0.83
US-Bi2	CA	Corn	2022,2023	0.74
US-NC2	NC	Evergreen Forests	2022,2023	0.88
US-Mo1	MO	Wheat-hay	2020	0.81
US-Mo2	MO	Grasslands	2020	0.75
US-Mo3	MO	Corn	2020	0.68

Methods

The general workflow is schematized in Fig. 2. First, the DMS method is used to sharpen coarse and multi-resolution LST data from ECOSTRESS and VIIRS to a consistent 30-m resolution using higher resolution VSWIR inputs from HLS. The DisALEXI ET model is applied to these Landsat-like inputs on the dates of satellite image acquisition. Finally, ET is interpolated between satellite overpass dates to generate a daily timeseries.

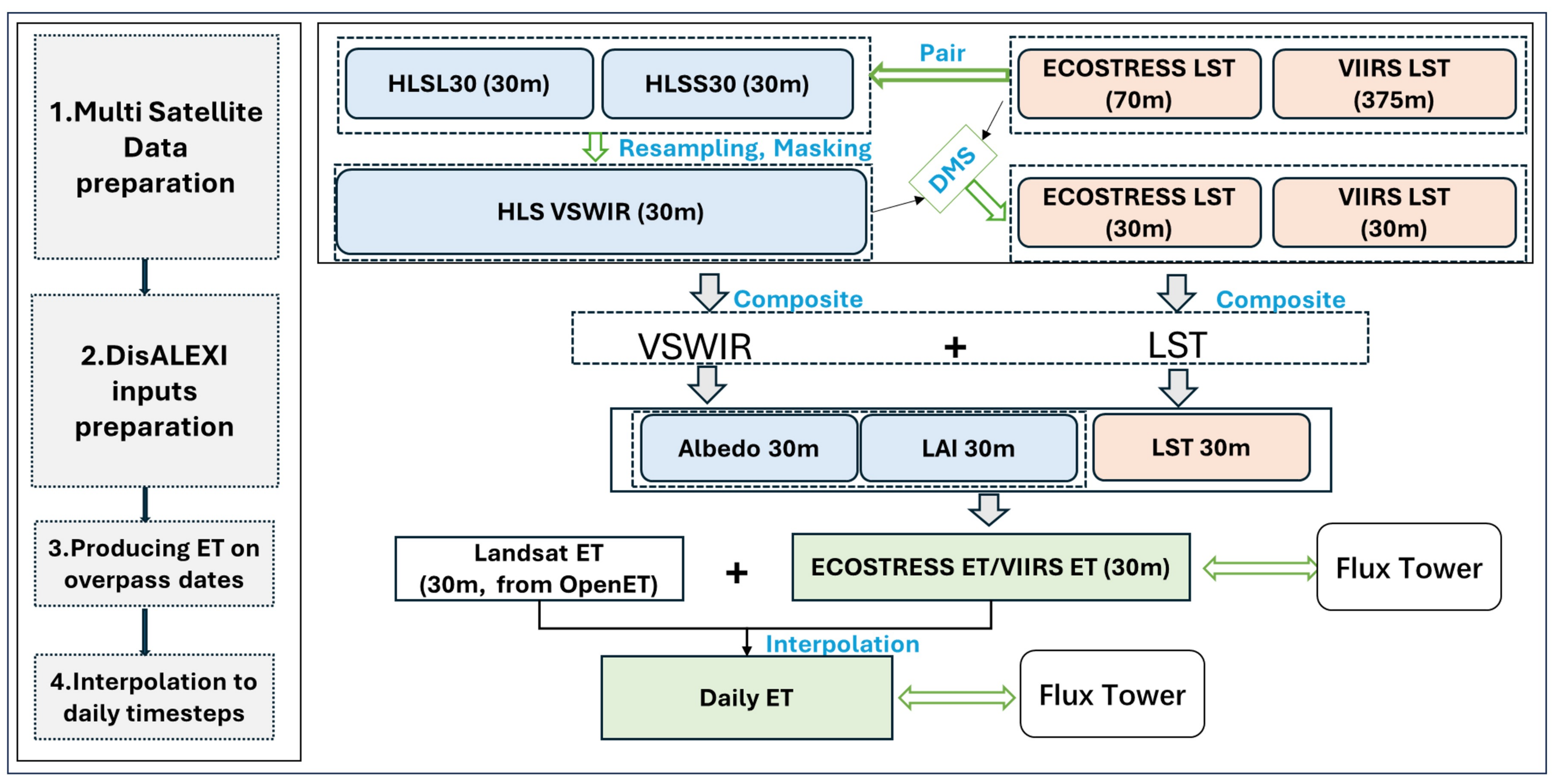

Fig. 2. The processing workflow for fusing multi-satellite data to generate daily 30-m ET estimates.

Results

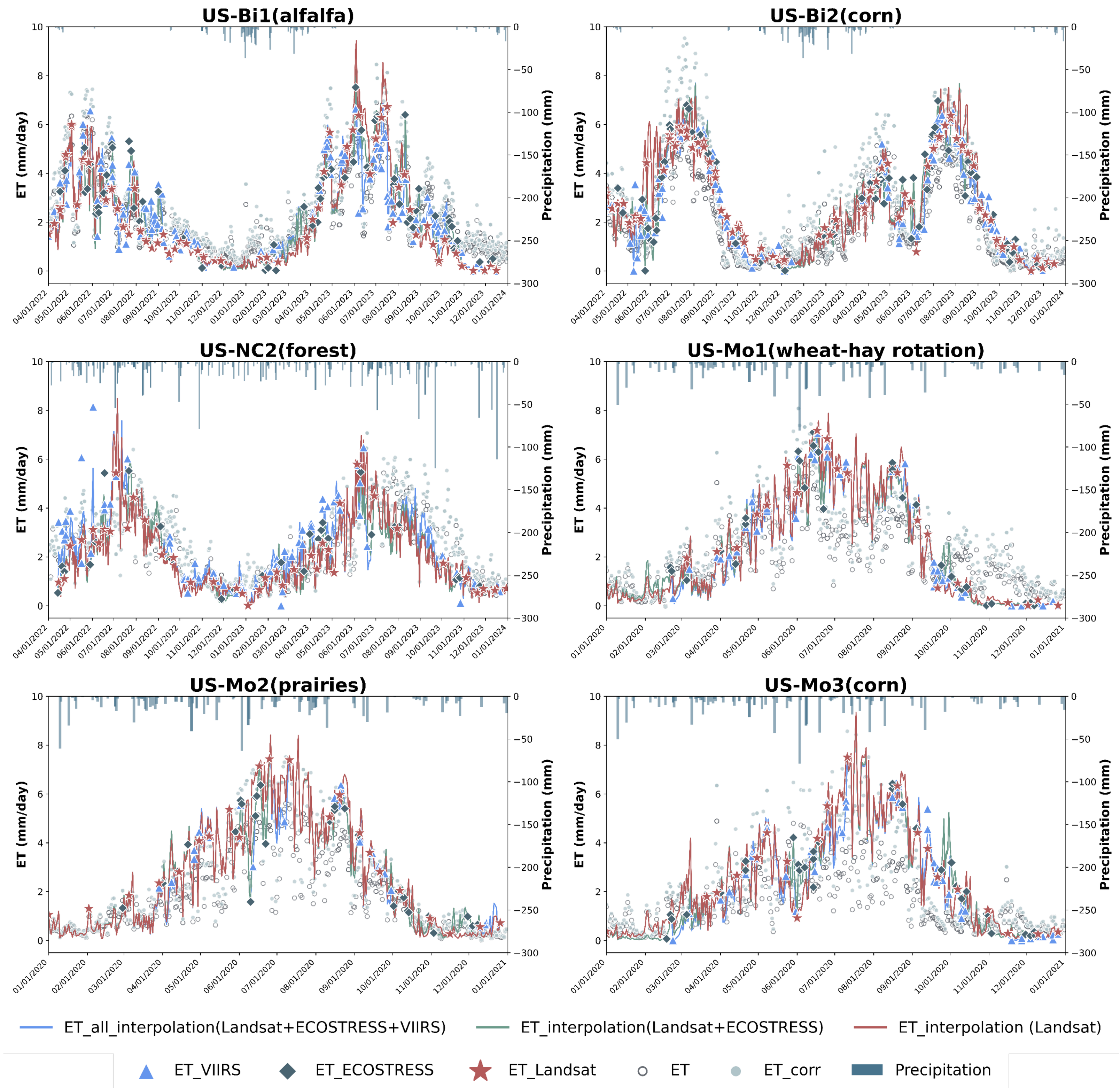

Fig. 3. Model – measurement time-series intercomparison at the US-Bi1, US-Bi2, and US-NC2 sites for the year of 2022 and 2023, and at the US-Mo1, US-Mo2, and US-Mo3 sites for the year of 2020.

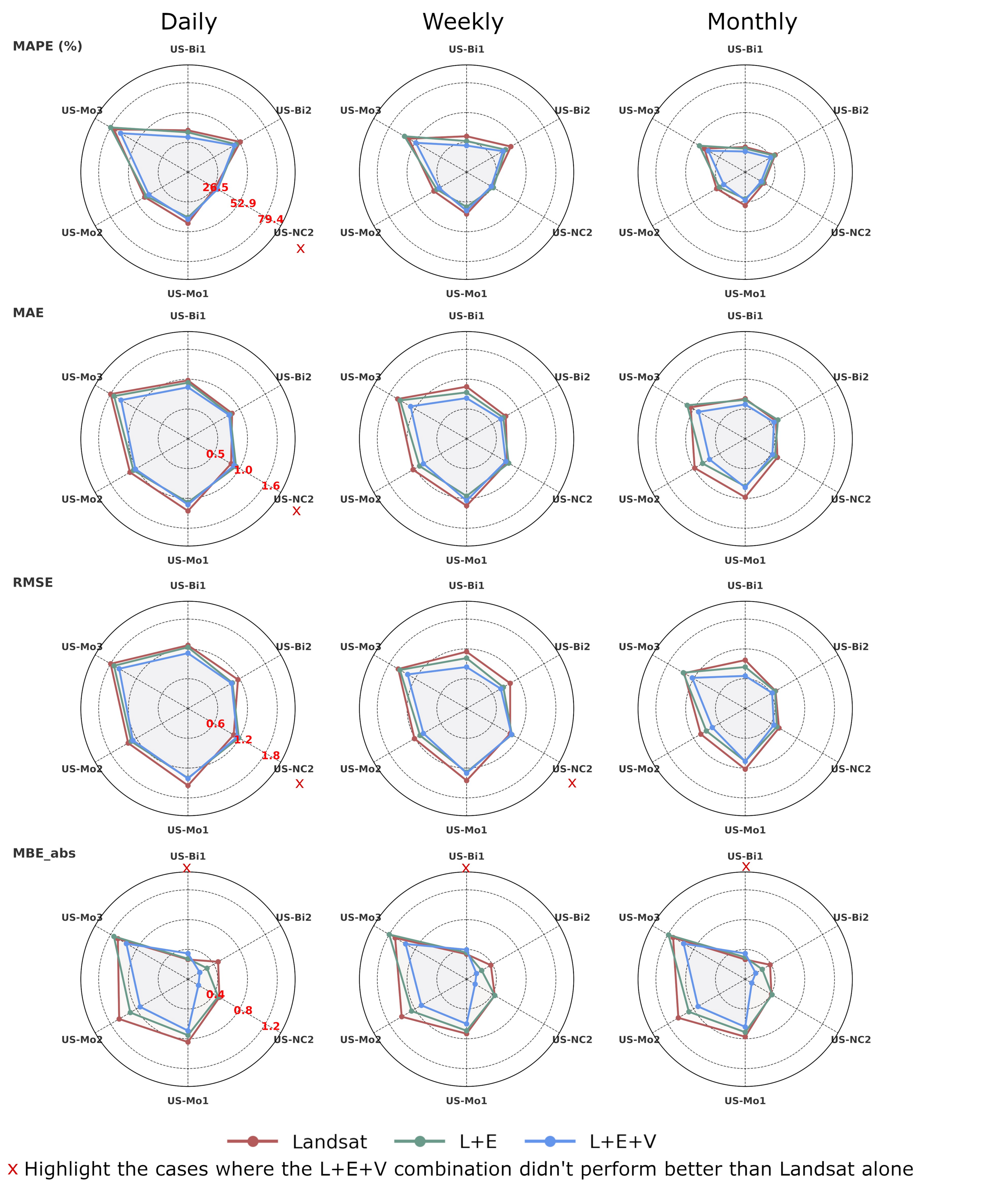

Fig. 4. Performance for interpolated daily ET and aggregated weekly, monthly statistics based on interpolated daily estimates, using different data combinations: Landsat only (Landsat), Landsat and ECOSTRESS (L + E), and Landsat, ECOSTRESS, and VIIRS (L + E + V), compared against ET_avg (calculated as the average of ET_unclosed and ET_closed) observed at tower sites during the green season (April to September).

Conclusions

- **Satellite ET vs. flux towers** → Good agreement overall, strongest at Bi1, Bi2, Mo2; larger errors at NC2, Mo1, Mo3 (Fig. 3).
- **Multidata fusion performance** → L+E+V generally outperforms Landsat-only, except at NC2 (daily) (Fig. 4).

More information about this study can be found: Liu et al., Multi-satellite data fusion for improved field-scale evapotranspiration mapping on Google Earth Engine, RSE, 2026