Real-Time Remote Sensing ET Estimation for Vineyard Irrigation Management: Current Limitations and Practical Challenges

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Operational irrigation management in vineyards depends on accurate and timely evapotranspiration (ET) estimation. Remote sensing–based ET models show strong potential, but several key limitations restrict their use for real-time irrigation scheduling. First, daily field-scale ET estimates are required for irrigation scheduling; however, thermal-based remote sensing ET models generally provide only instantaneous ET derived from land surface temperature (LST) snapshots, typically available from Landsat 8 and 9 about once per week under clear-sky conditions. While current approaches perform reasonably well when scaling instantaneous ET to daily ET on Landsat overpass dates, uncertainties increase substantially on days without LST observations. Irrigation practices and heatwave events can further amplify discrepancies between actual and estimated ET during the intervals between consecutive Landsat overpasses. Second, irrigation managers require both past water-use assessments and short-term ET forecasts, but remote sensing–based ET models are inherently retrospective and provide no forward-looking predictions. Beyond temporal constraints, Leaf Area Index (LAI) is a critical structural parameter in remote sensing–based ET models; however, accurately estimating LAI in vineyards using universal remote sensing approaches remains challenging due to the diversity of trellis and spacing configurations. The challenge is further amplified by mixed-pixel effects, as coarse satellite pixels capture spectral contributions from both vines and interrow cover crops, especially early in the season when cover crops are at peak greenness. In addition, canopy geometry (width and height) affects aerodynamic resistance in ET models, yet these parameters cannot be retrieved from multispectral imagery. This study examines these limitations and explores practical approaches to mitigate them when deploying remote sensing ET models for operational, real-time vineyard irrigation scheduling.