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Assessing Moisture Adequacy over Semi-arid and Arid Indian Agricultural Farms using High-Resolution Thermography

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Abstract : Crop water stress (W) at a given growth stage starts to set in as moisture availability (M) to roots falls below 75% of maximum. It has been found that ratio of crop evapotranspiration (ET) and reference evapotranspiration (ET0) is an indicator of moisture adequacy and is strongly correlated with 'M' and 'W'. The spatial variability of ET0 is generally less over an agricultural farm of 1-5 ha than ET, which depends on both surface and atmospheric conditions, while the former depends only on atmospheric conditions. Solutions from surface energy balance (SEB) and thermal infrared (TIR) remote sensing are now known to estimate latent heat flux of ET. In the present study, ET and moisture adequacy index (MAI) (=ET/ET0) have been estimated over two contrasting western India agricultural farms having rice-wheat system in semi-arid climate and arid grassland system, limited by moisture availability. High-resolution multi-band TIR sensing observations at 65m from ECOSTRESS (ECOsystemSpaceborne Thermal Radiometer Experiment on Space Station) instrument on-board International Space Station (ISS) were used in an analytical SEB model, STIC (Surface Temperature Initiated Closure) to estimate ET and MAI. The ancillary variables used in the ET modeling and MAI estimation were land surface albedo, NDVI from close-by LANDSAT data at 30m spatial resolution, ET0 product at 4km spatial resolution from INSAT 3D, meteorological forcing variables from short-range weather forecast on air temperature and relative humidity from NWP model. Farm-scale ET estimates at 65m spatial resolution were found to show low RMSE of 16.6% to 17.5% with R2 >0.8 from 18 datasets as compared to reported errors (25 – 30%) from coarser-scale ET at 1 to 8 km spatial resolution when compared to in situ measurements from eddy covariance systems. The MAI was found to show lower (<0.25) and higher (>0.5) magnitudes in the contrasting agricultural farms. The study showed the potential need of high-resolution high-repeat spaceborne multi-band TIR payloads alongwith optical payload in estimating farm-scale ET and MAI for estimating consumptive water use and water stress. A set of future high-resolution multi-band TIR sensors are planned on-board Indo-French TRISHNA, ESA's LSTM, NASA's SBG space-borne missions to address sustainable irrigation water management at farm-scale to improve crop water productivity. These will provide precise and fundamental variables of surface energy balance such as LST (Land Surface Temperature), surface emissivity, albedo and NDVI. A synchronization among these missions is needed in terms of observations, algorithms, product definitions, calibration-validation experiments and downstream applications to maximize the potential benefits.

Keywords : thermal remote sensing, land surface temperature, crop water stress, evapotranspiration
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