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Evaluating crop water requirements and actual crop water use with center pivot irrigation system in Inner Mongolia of China

Peejush Pani[1,2],
Li Jia[1], *Massimo Menenti*[1,3], *Guangcheng Hu*[1], *Chaolei Zheng*[1], *Qiting Chen*[1], *Yelong Zeng*[1,2]

[1]State Key Laboratory of Remote Sensing Science, Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing 100101, China;
[2]University of Chinese Academy of Sciences, Beijing 100049, China;
[3]Faculty of Civil Engineering and Earth Sciences, Delft University of Technology, 2628, Delft, Netherlands

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Background

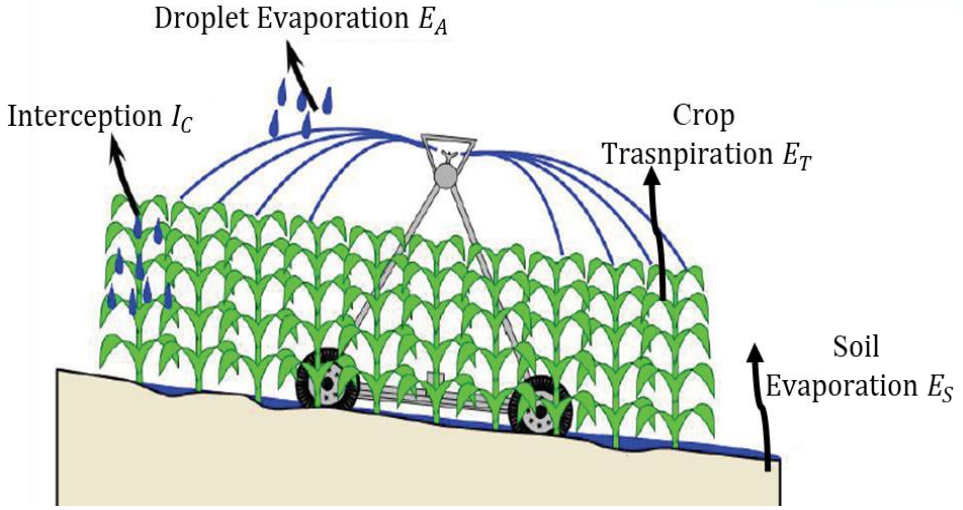
- **Objective:**

Assess Irrigation Performance Indicator (IPI) using high resolution satellite remote sensing

- **Definition:**
  - **Crop water requirement (CWR)**: water required for crops to grow under optimal situation with **un-restricted water supply**.
  - **Actual crop water use (CWU):** water used by crops growing under **actual scenario** of water supply including application losses.

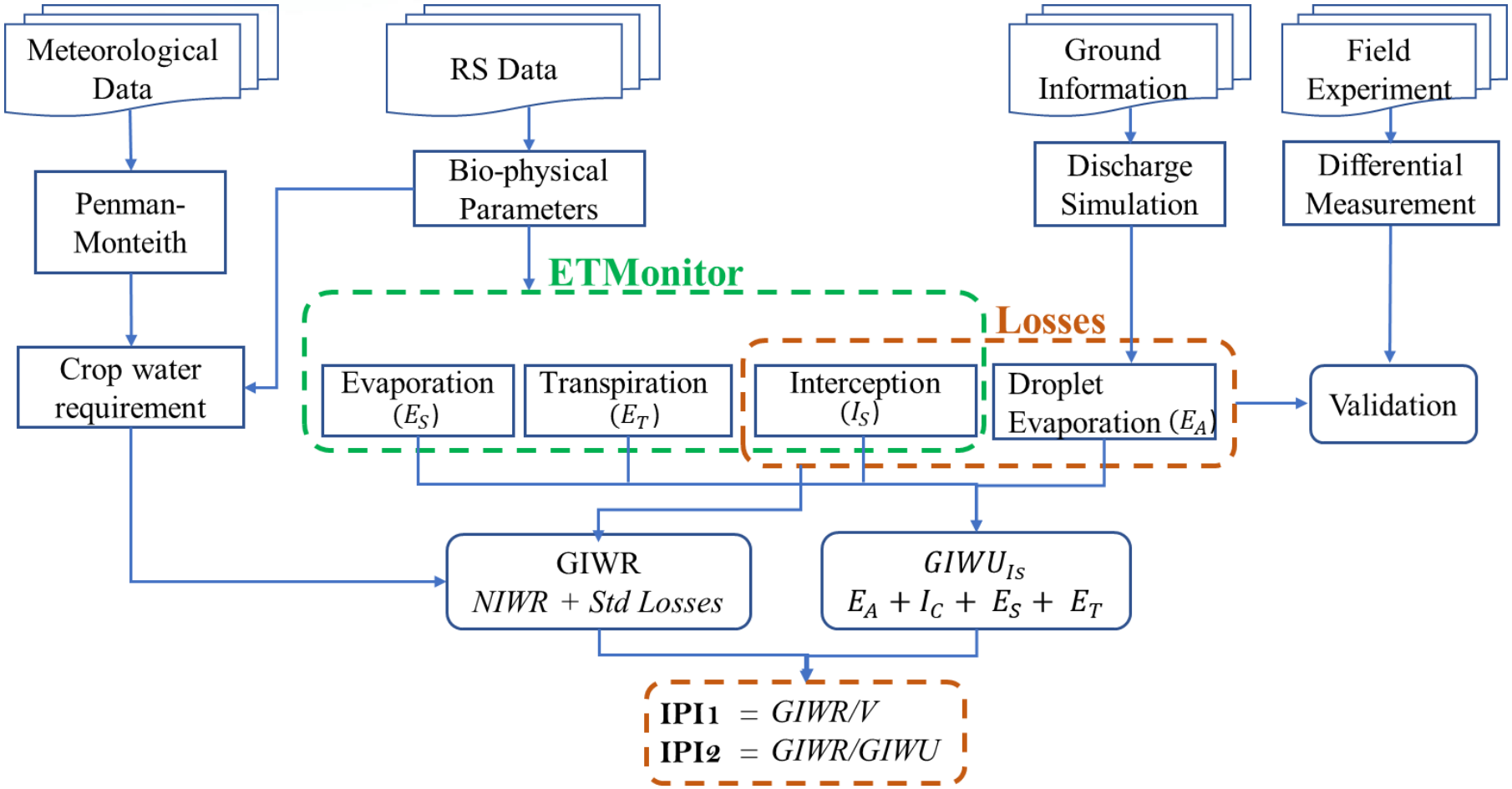
- **New approach:**
  - To estimate (gross = crop water requirements + loss) and actual crop water.
  - Integrate farmer's irrigation practice & application losses at farm-scale for center pivot irrigation systems (CPIS)
  - Sentinel-2 MSI and Landsat-8 OLI with meteorological forcing data and soil moisture retrievals.

Components of CWU in CPIS



... Martin et al., 2013

Methodology: Framework



GIWR = Gross irrigation water requirement (mm)

$GIWU_{Is}$ Gross irrigation water use by sprinkler irrigation (*IS)*

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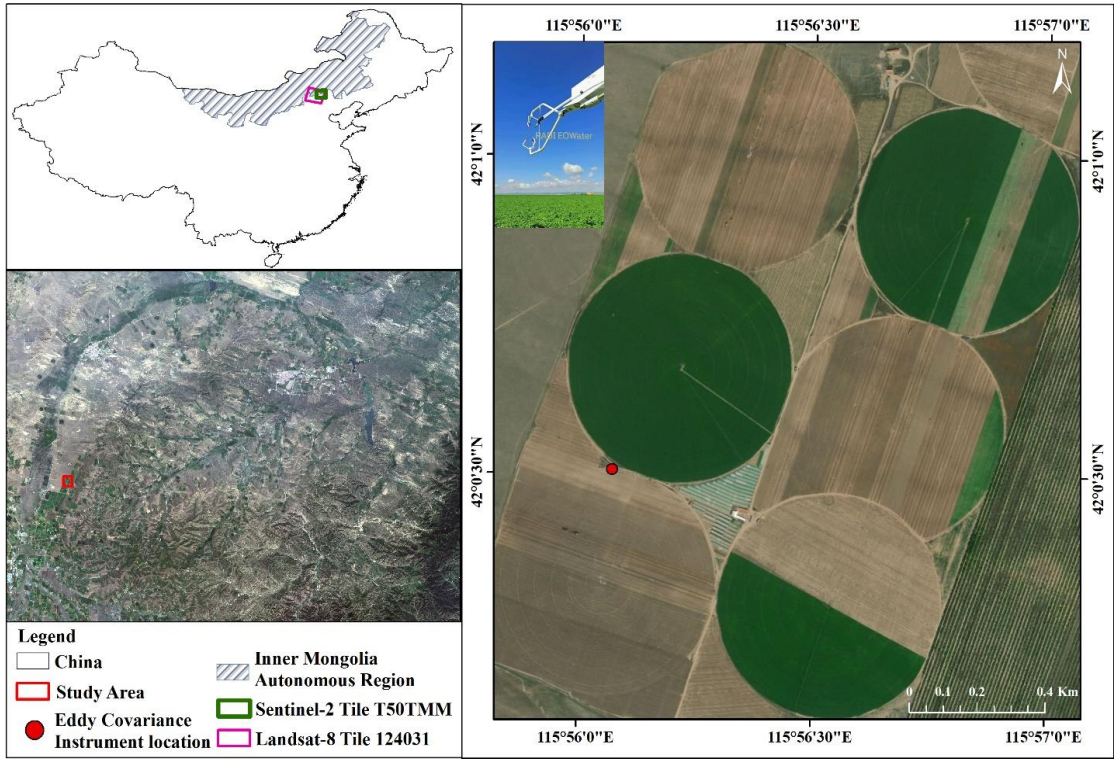
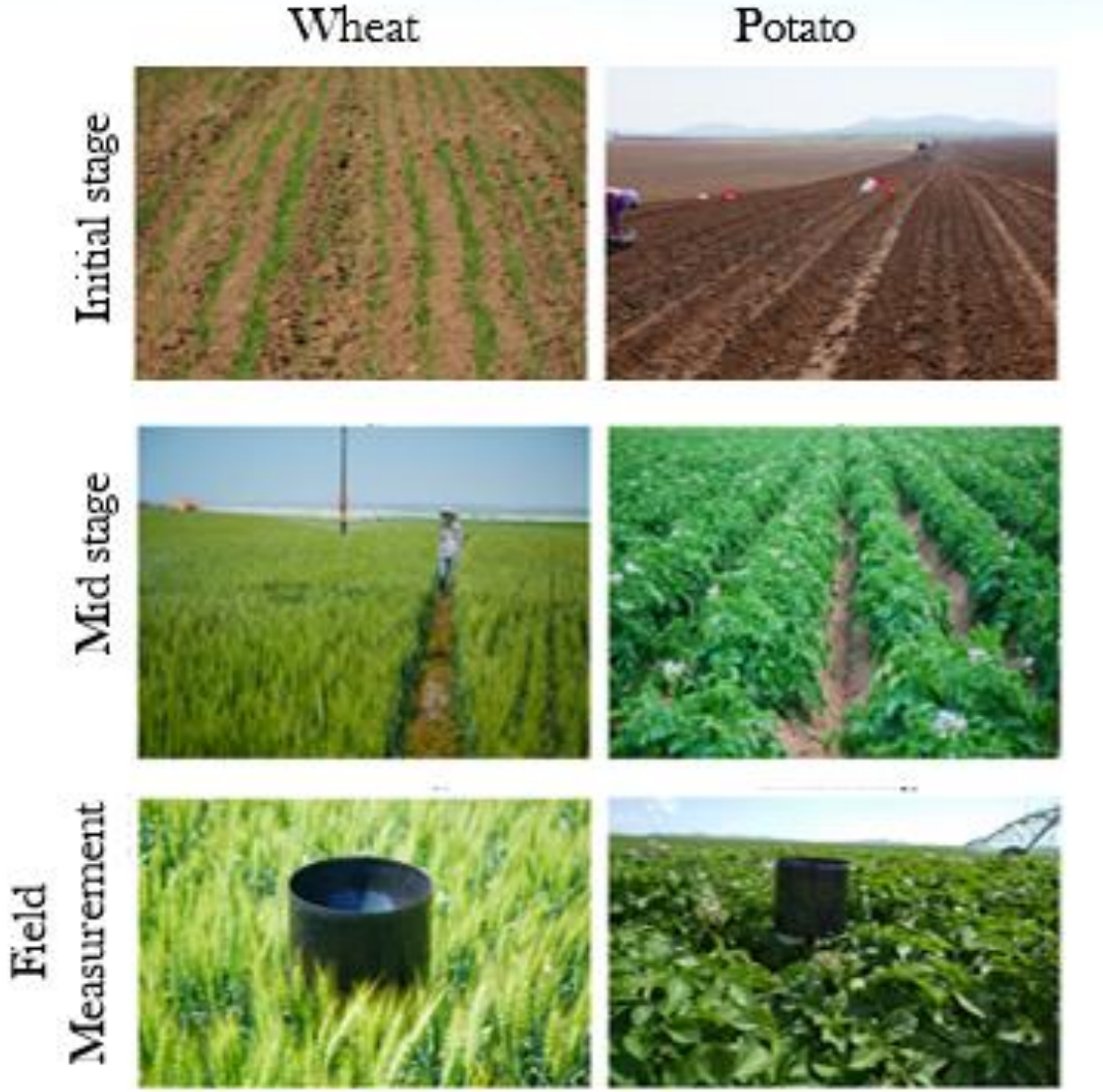
Study Area

CPIS irrigated area in Inner Mongolia, China



Located in north-central Inner Mongolia autonomous region of China, extending between 41°59' N to 42°01' N latitude and 115°55' E to 115°57' E longitude.



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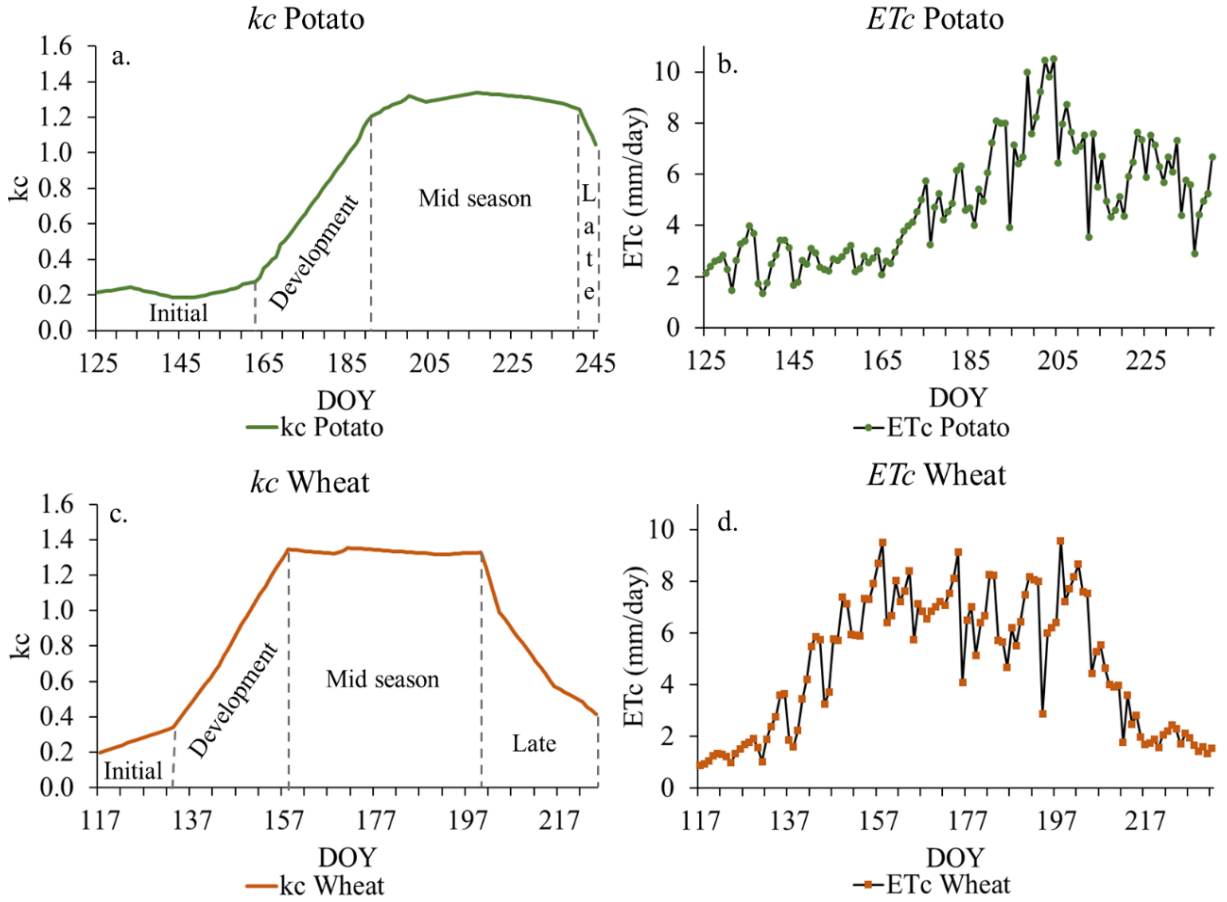
Results: Crop Water Requirement (CWR)

- Daily CWR using *kc* times reference ET shows distinct variation of CWR for potato and wheat.
- Clear and distinct stages of each crop is reflected in the *kc* graphs based on daily reconstructed NDVI from MSI and OLI data following kc-NDVI method.
- Daily fluctuation in the *ETc* is because of variation in meteorological condition



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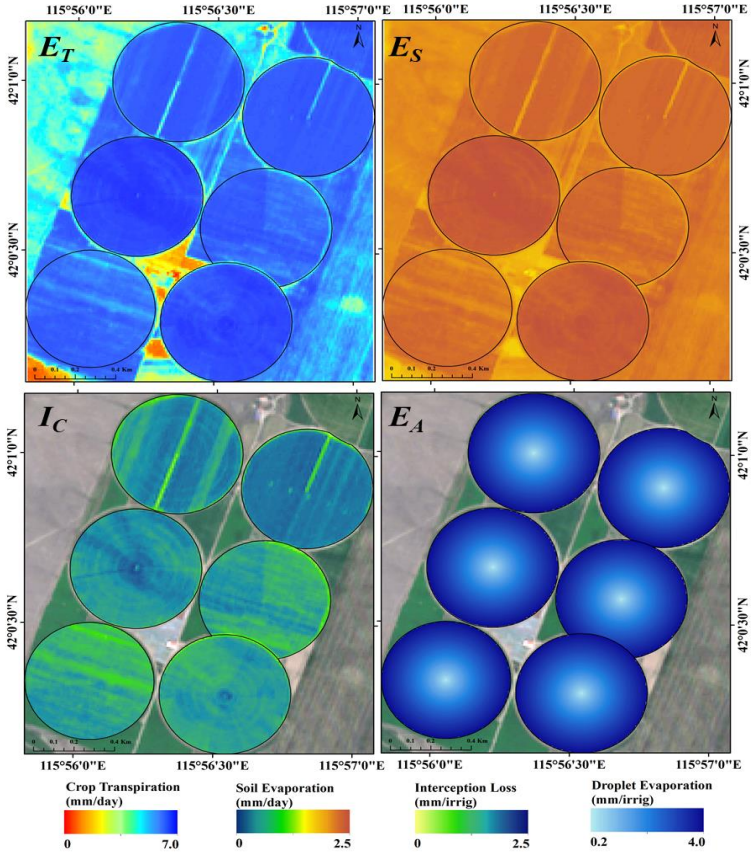
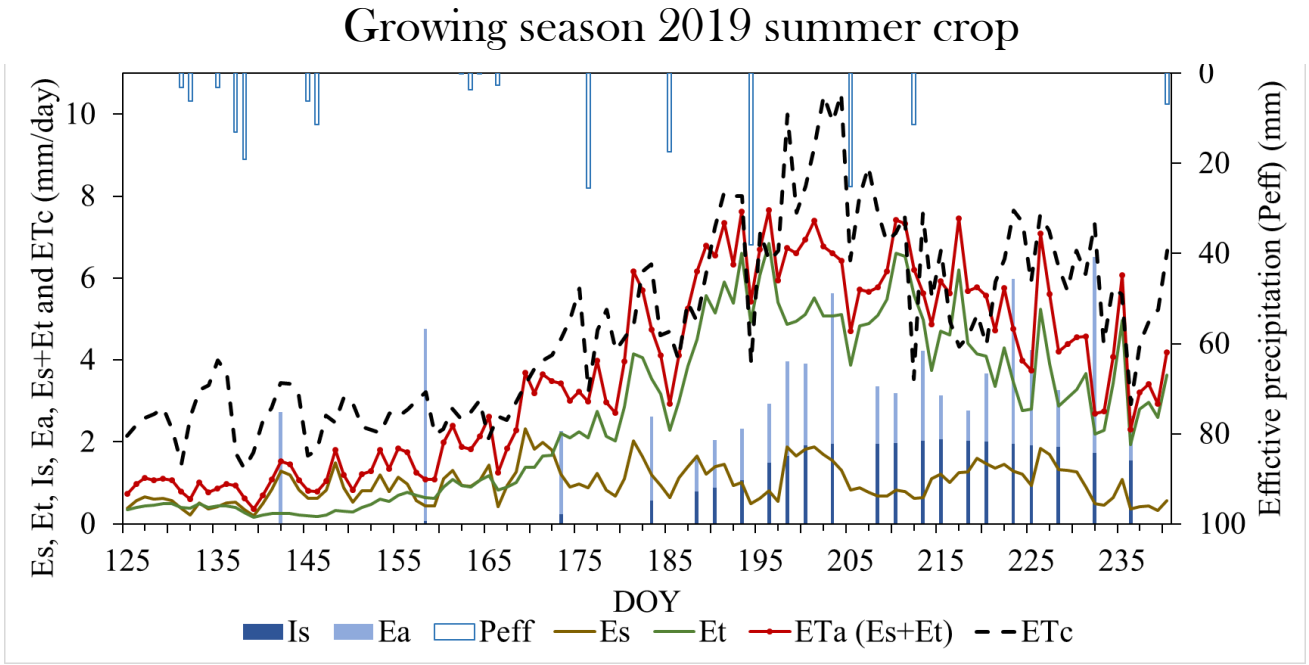
Results: Daily Estimates of GIWU components

- GIWU using fine resolution MSI & OLI multi-spectral remote sensing for each CPIS field.
- E_T ranges between 6-7mm/day; E_S between 1.5-2.5 mm/day; whereas, I_S 0.5-2.5 mm/irrigation; E_A simulation model between 0.2 - 4.0 mm/irrigation.



- Lines = daily estimates whereas, discrete Bars = Irrigation events.
- ET_C (black dash line) > ET_a (red line) [E_S+ E_T] estimates.



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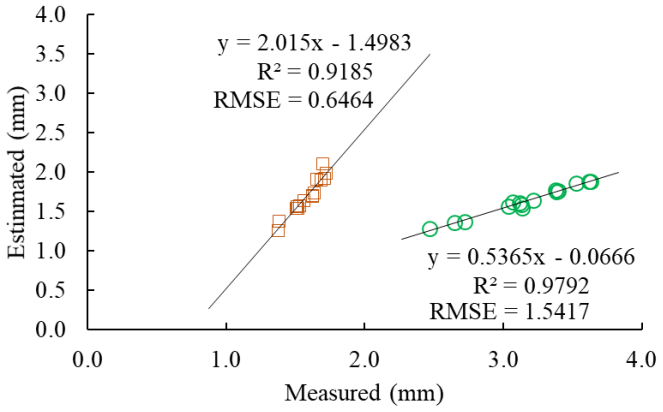
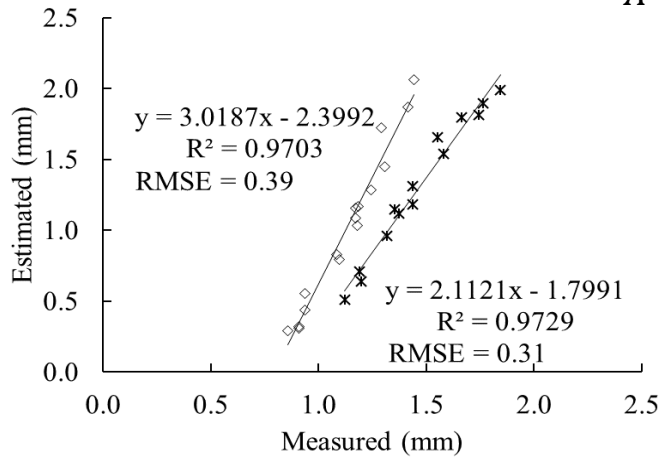
Results: Model Validation

- Estimated I_S shows a good correlation with measured values R^2 0.91 & 0.97 for wheat and potato respectively, with lesser RMSE over wheat (0.65) compared to potato (1.54)
- E_A estimated on (cross = 13th July; diamond=14th July) shows distinct trend because of varying daily meteorological condition and agrees highly with measured values (R^2 0.97).
- The ETMonitor estimates shows a good correlation with the Eddy covariance instrument measured ET.

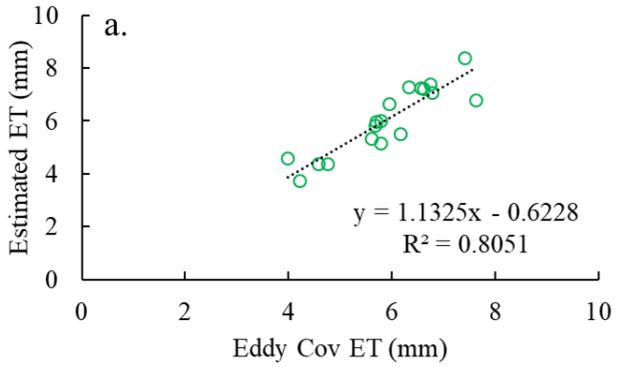
Estimated vs Measured I_S



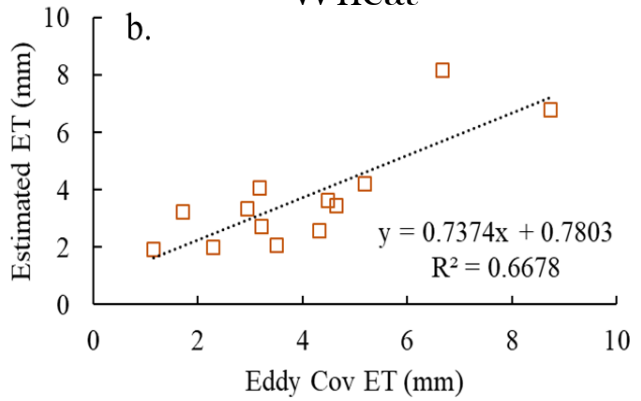
Estimated vs Measured E_A



Estimated E_T + E_S vs Eddy Cov. Potato



Estimated E_T + E_S vs Eddy Cov. Wheat



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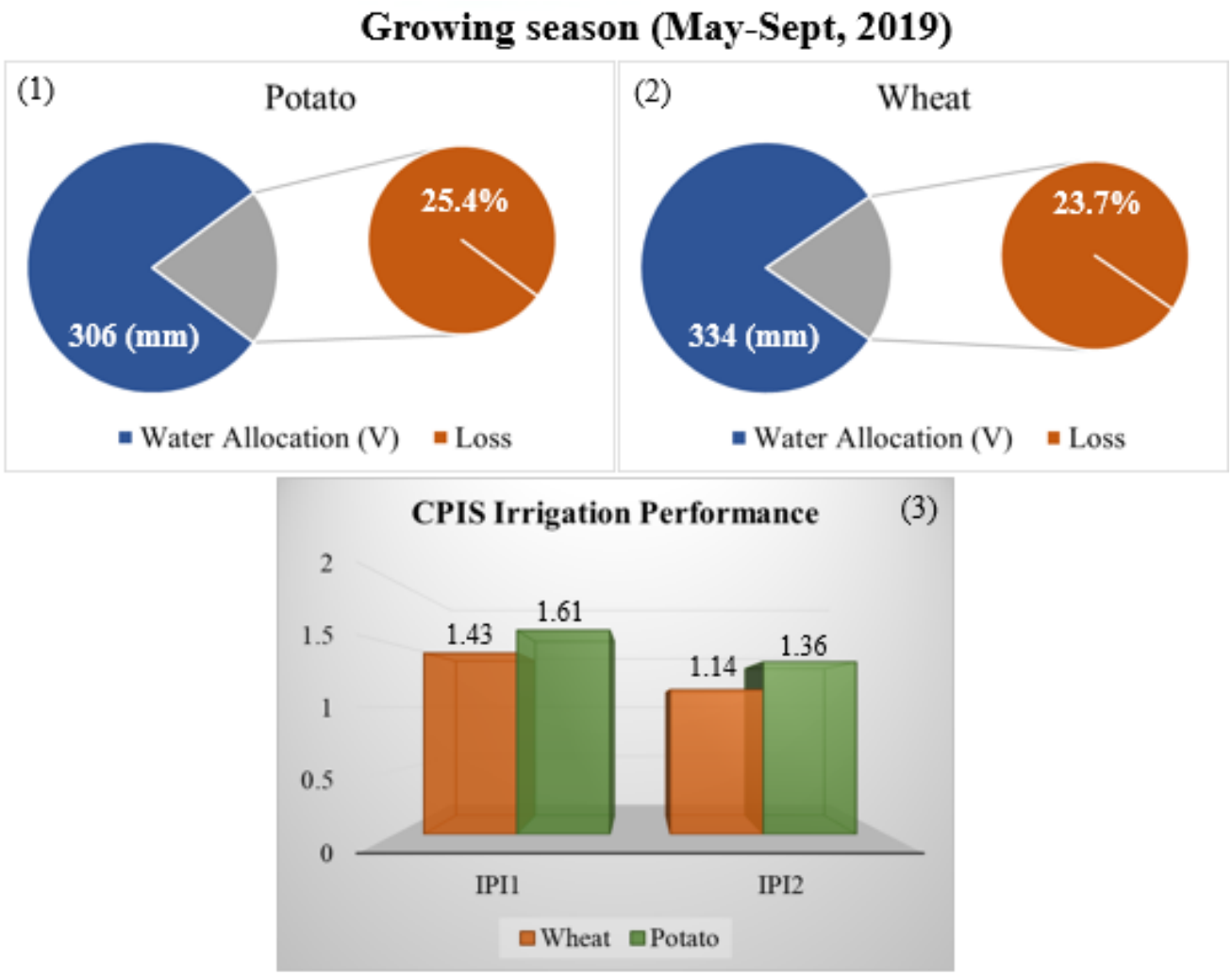
Results: Irrigation Performance Indicator



- Figure 1 (Potato) & 2 (wheat) shows V and percentage of estimated losses by CPIS.
- IPI1 shows that V is insufficient (1.61) to fulfill the requirement of CPIS.
- IPI2 shows CPIS has performed better with respect to the actual use over wheat (1.14) compared to potato (1.36) in fulfilling the requirement.
- Out of total water allocated, 23.7 & 25.4 % is lost over potato and wheat field, respectively.

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Conclusion & Discussion

- The current approach of evaluating separately the gross and net irrigation water requirement and actual water use considering the water losses, is very essential in evaluating the performance of any irrigation system.
- ETMonitor along with modified RS-Gash and modified Yasar's algorithm can play a vital role in estimating the actual water use of irrigated agriculture.
- Combined use of Sentinel-2 MSI level-2 and Landsat-8 OLI level-2 multi-spectral images provide data at higher temporal frequency to construct a continuous crop's growth stage for daily estimates at field-scale.
- Considering the method of irrigation application and farmer's practice is highly recommended for estimating CWR & CWU through remote sensing as well as evaluating the performance of an irrigation system.

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