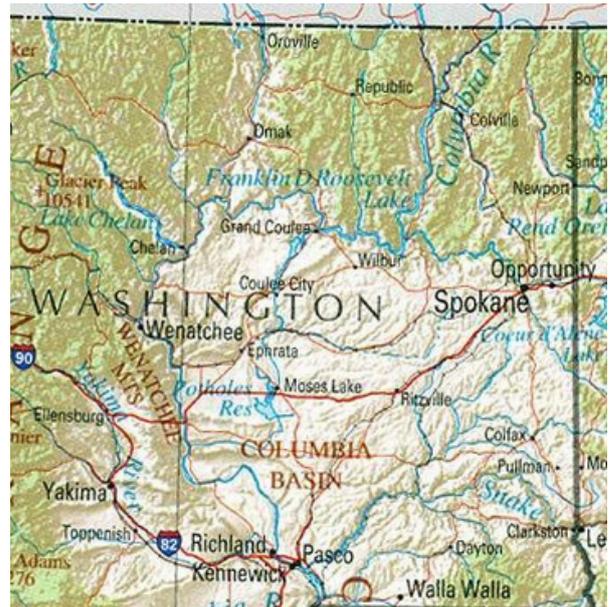


Integrating Satellite Images with Agriculture Modeling for Estimating Field Scale Crop Evapotranspiration and Irrigation Water Demand

Canopy cover and crop growth stages derived from high-spatial resolution satellite images were used with modeling to estimate crop evapotranspiration, biomass gain, and irrigation demand at field- and pixel-scales over the Columbia River Basin project area. This was an effort to provide reliable and real-time information to support farm level water management.

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This research highlight is based on work in progress.

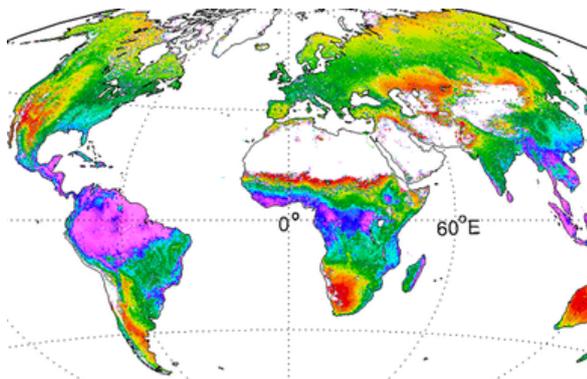


Crop evapotranspiration (ET) is one of the most important metrics for guiding agricultural management on both irrigated and dry farming land, particularly under the context of global climate change. Satellite based ET estimation, such as METRIC and MODIS-ET, has been

developed and applied widely in recent years. However, many challenges exist to meet the high-spatial and -temporal resolution requirements for field-scale precision farming practices. Similarly, process-based agricultural models have been

used for many decades in assisting regional and point scale agricultural decision-making, thereby increasing our understanding of interactions between biophysical conditions and biogeochemical cycles within managed agricultural systems. However, process-based agricultural models require intensive work and data input, which limits field application. In this research, we integrated satellite imagery and a process-based agriculture model to estimate consumptive water use at field- and pixel-scale to provide reliable and real-time information to support farm level water management.

Evapo-transpiration (ET) describes water loss occurring by the processes of evaporation and transpiration. It can be estimated using satellite imagery. Source: NASA



To facilitate remote sensing information and high spatial resolution simulation, we used a simplified version of the well-established crop growth and water use simulation model CropSyst (Stöckle et al, 1994). The simplified model (hereafter CropSyst-W) functions similarly to CropSyst, but does not consider nutrient limitation and field preparation processes. The phenology development and the maximum canopy cover within CropSyst-W are estimated from *Landsat* Normalized Difference Vegetation Index (NDVI) observations with fitted growth curves. For

“Normalized Difference Vegetation Index (NDVI) is used to quantify vegetation greenness and is useful in understanding vegetation density and assessing changes in plant health.” -USGS

comparison, EEFlux (Earth Engine Evapotranspiration Flux), a version of METRIC that operates on the Google Earth Engine system (<https://eeflux-level1.appspot.com/>) data products have been interpolated to daily values (Kadam et al., 2021).

We selected the Columbia Basin Project (CBP) (which served about

671,000 acres in east central Washington, USA), as a case study (Figure 1). Irrigators use about 2.5 million acre-feet of Columbia River water each year. Based on the agricultural land use geodatabase from the Washington State Department of Agriculture, four crops (alfalfa hay, corn grain, potato, and wheat) were selected for analysis due to their abundance (Figure 1). Daily gridMET data (Abatzoglou, J. T. (2013)), were used for climate data, gSSURGO (USDA) for soil property and profile, and WSDA agriculture land use data for crop type, field boundary, and irrigation method.

Figure 1. Study domain and selected crops for model simulation and comparisons

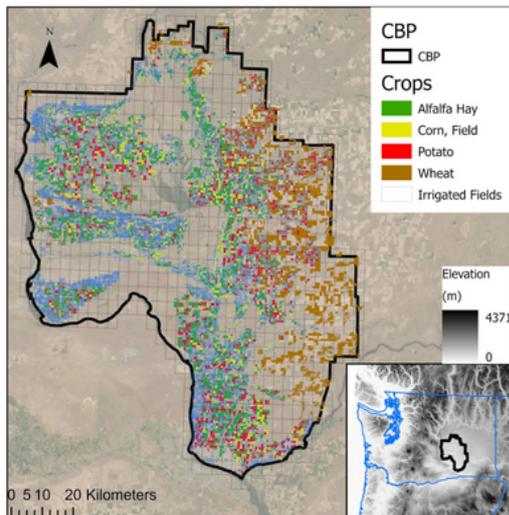


Figure 3. Comparison of ET estimated from EEFlux and CropSyst-W for each crop (averaged over CBP)

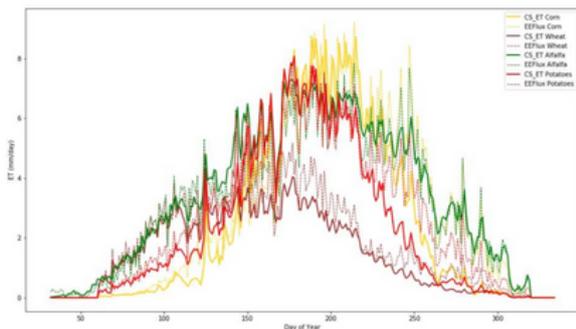


Figure 2. Total growing season ET estimated from CropSyst-W

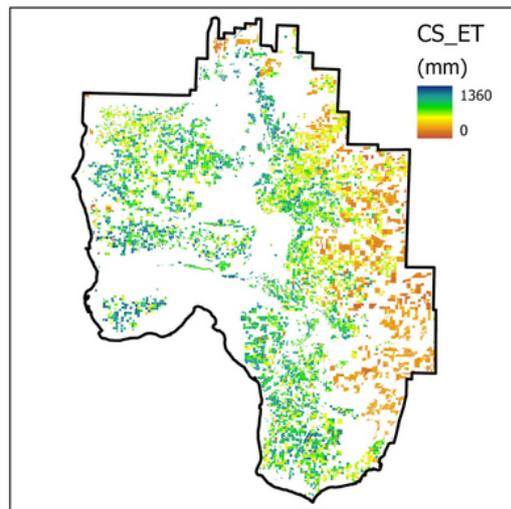
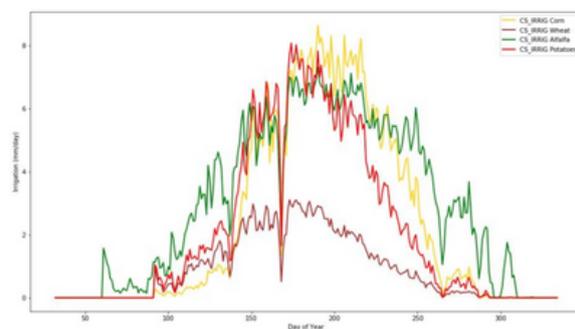


Figure 4. Estimated daily transpiration and soil evaporation (left) and irrigation (right) for each crop during growing season (averaged over CBP)



CropSyst-W successfully retrieved the spatial variation and temporal fluctuations of field-scale ET (Figure 2); while the comparison data set EEFlux normally overestimated ET near the end of growing season (Figure 3). Simulation results indicate that the integrated CropSyst-W model with remotely sensed data can provide more detailed information such as separated transpiration and soil evaporation and irrigation demand

(Figure 4) than products based only on remote sensing data such as EEFlux. In particular, the application of real-time canopy cover for hay crops significantly improved the capability of CropSyst for assisting with real-time irrigation water requirement and hay yields. In field-scale simulations, agricultural management (planting and harvest dates and irrigation scheduling) is conducted at whole field scale, but

each pixel (30 meter by 30 meter) has its own specific growing curve and water requirements so that it can represent the spatial variability of ET (Figure 2) within each field as needed for precision farming practices. These results suggest that CropSyst-W provides valuable and detailed information beyond what has been previously available that could support farm scale irrigation management practices.

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