APPENDIX C. MAPPING EVAPOTRANSPIRATION AT HIGH RESOLUTION WITH INTERNALIZED CALIBRATION (UCD-METRIC)

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SUMMARY

METRIC method utilized by UC Davis approach basis its algorithms on a surface energy balance to provide estimations of actual evapotranspiration (ET). Inputs into the model are elevation and land use maps, remote sensed imagery data provided by the Landsat 8 satellite, and local CIMIS station weather data. The METRIC methodology integrates instantaneous remotely-sensed reflectance, thermal, and weather data in order to estimate the partitioning of energy into net incoming radiation (Rn), heat flux into the ground (G), sensible heat flux to the air (H), and latent heat flux (LE). The latent heat flux, which is computed as a residual in the energy balance, represents the energy consumed by ET (Garcia et al., 2009). Table C-1 presents a sequence of sub-models required to estimate ET using METRIC.

The advantage of estimating ET by energy balance is that actual ET is obtained rather than the potential ET that is typically represented by crop coefficients. Actual ET is generally less than potential due to effects of under-irrigation, low irrigation uniformity, salinity of soil and water, sparse vegetation, waterlogging and disease (Allen et al., 2014). Internal calibration of the energy balance in METRIC utilizes ground-based alfalfa reference ET (ETr) to "tie-down" the derived energy balance to local field conditions (Allen et al., 2014).

For the 2015 water year, hourly and daily data from the Twitchell Island CIMIS station was used (elev. -0.3 m. ; 38.116125, 121.65921). Where there were gaps in reported CIMIS station values, spatial CIMIS values were substituted. The solar radiation values from spatial CIMIS were also used. The reference ET (ETr) was calculated using the ASCE Penmann-Monteith equation.

Table C-1. Sequence of sub-models computed by METRIC UCD and respective outputs.

METRIC – UCD Models - Outputs		
MODEL 1	**MODEL 2**	**MODEL 3**
Spectral radiance Surface reflectance Albedo Vegetation indexes (NDVI, NDWI, LAI) Broadband emissivity	Tall Crop Albedo Snow/Water indicators Aerodynamic water Evaporation Sensible Heat Flux (H)	Net Radiation (Rn) Ground Heat Flux (G) Instantaneous ETrF 24 hours ET

Surface Temperature		

PRODUCTS

METRIC generates and integrates several intermediate products such as vegetation indexes (NDVI, LAI, and NDWI), surface reflectance (albedo) and surface temperature maps. NDVI (normalized difference vegetation index) and LAI (leaf area index) maps are used in METRIC as indicators of biomass and aerodynamic roughness, and as predictors of ratios of soil heat flux to net radiation (Garcia et al., 2009). The final products are instantaneous Kc rasters and daily ETc rasters, at 30 by 30 meter resolution, for the Landsat overpass dates.

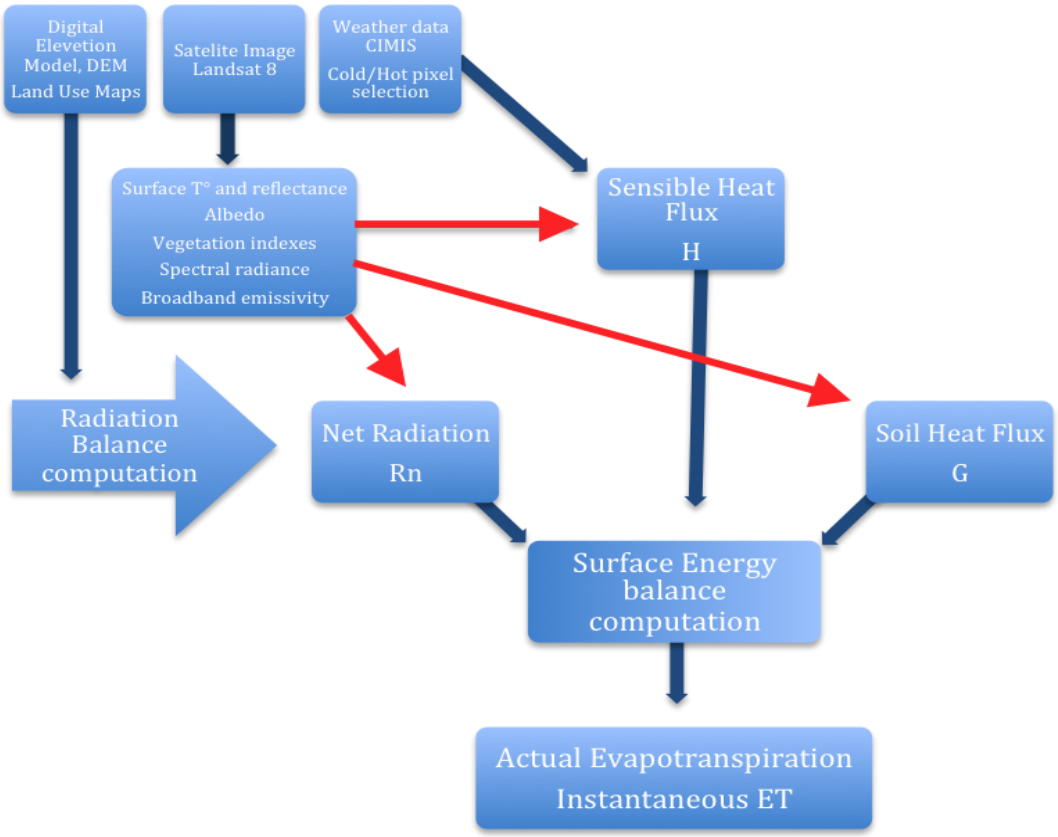

Figure C-1. Flowchart of the general computational process for estimating actual evapotranspiration in METRIC-UCD approach. Red arrows connect the inputs used in the model to the output variables obtained to calculate evapotranspiration through Energy balance model.

INTERPOLATION

Between Landsat image dates, Kc was linearly interpolated and multiplied by daily ETr in order to calculate the monthly ETc.

FUTURE DEVELOPMENT

In order to improve the accuracy of the METRIC processing, future model runs will have more iterations around the hot and cold pixel selection. In addition, cloud masking must be developed and the new models that handle thermal sharpening and reference evapotranspiration will undergo QAQC testing and sensitivity analysis.

REFERENCES

Allen, R., Trezza, R., Tasumi, M., & Kjaersgaard, J. (2014). Mapping Evapotranspiration at High Resolution using Internalized Calibration Applications. *Manual for Landsat Satellite Imagery, Version 3.0*.

Garcia, M., Allen, R. G., & Robison, C. (2009). Application of METRIC to determine Evapotranspiration for Southeastern and South central portions of Idaho including the Eastern Snake River Plain for 2006. University of Idaho.