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Estimate the historical evapotranspiration of the Central Valley

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CWEMF, April 5th, 2022

Purposes

- Develop land use and ET tools to automatically prepare the C2VSimFG land use and ET input files.
- Convenient to calculate, analyze or modify land use and ET in different data formats.
- Estimate the actual historical ET using limited historical input data.
- It will be much easier to calibrate C2VSimFG.

Highlights of the ET tool

- Built on Python and ArcGIS
- Raster calculation to estimate the fine resolution ET
- Flexible spatial and temporal outputs
  - Export the reference ET(ETo) and crop ET(ETc) at the raster resolution or any given spatial level for hydrologic models.
  - Use Pyhecdss. Convert into daily, monthly, or annual time steps.
- Streamline the processes to apply the remote sensing and CIMIS data into the actual ET estimation and C2VSimFG.

Basic algorithms to calculate the actual ET

- ETo using Hargreaves-Samani(HS) equation
  - Input: PRISM daily max and min air temperature

- Regressions between CIMIS ETo and PRISM data based ETo
  - Reduce the systematic bias due to the HS equation and unknown local weather condition

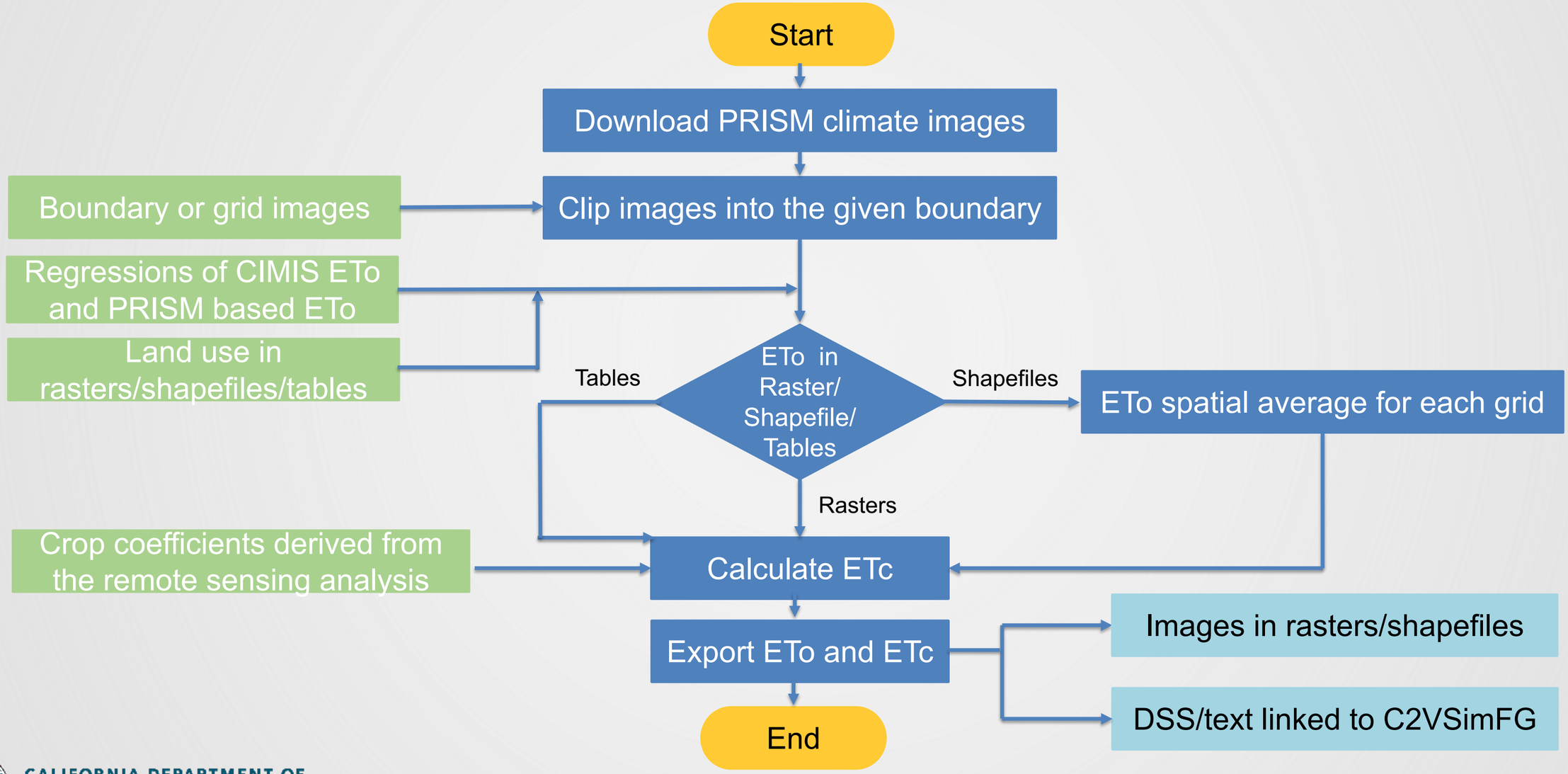
- Use the regressions to modify the HS ETo

- Use the land use tool to develop the historical land use
  - Remote-sensing multispectral data
  - Available land use surveys

- Develop the crop coefficients
  - Analyze the remote-sensing based actual ET and PRISM based ETo

- ETc: the products of crop coefficients and modified HS based ETo

ET tool flow chart



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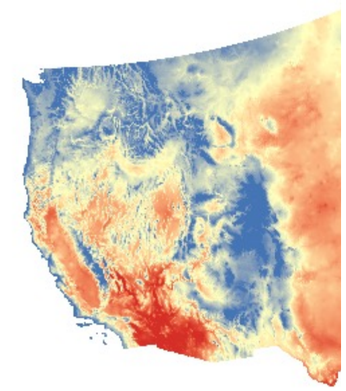
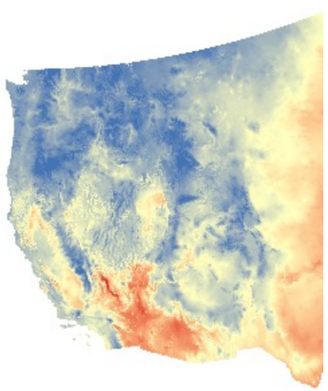
ET tool inputs

- PRISM daily max and min air temperature (1981-current)
- Regressions of CIMIS ETo and PRISM based ETo
- Historical land use
- Crop coefficients

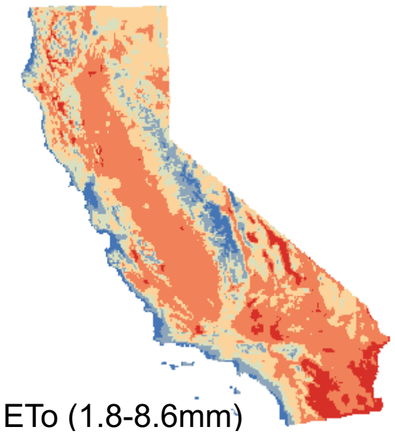
Apply to C2VSimFG



Tmax (8°-46°)

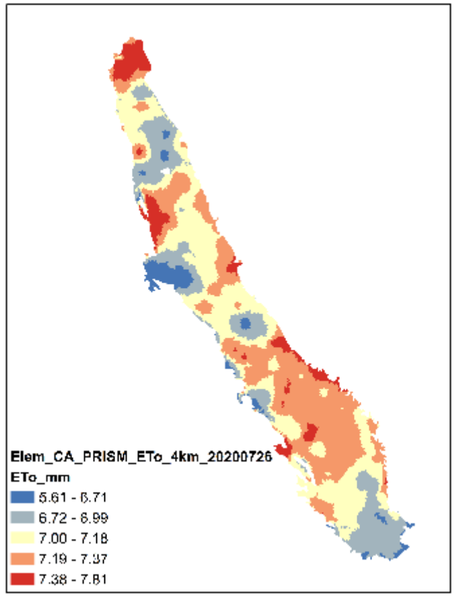


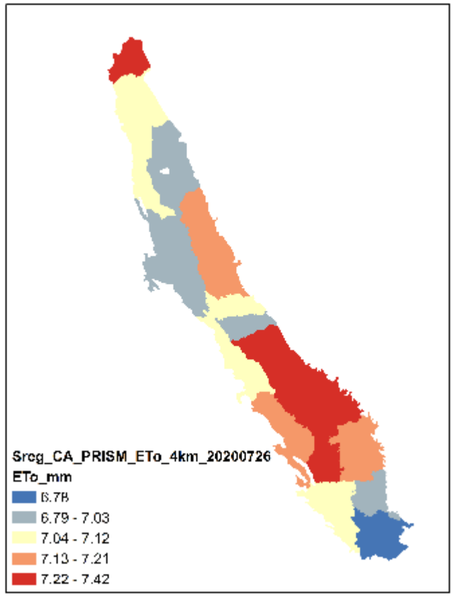
Tmin (-1.8°-31°)

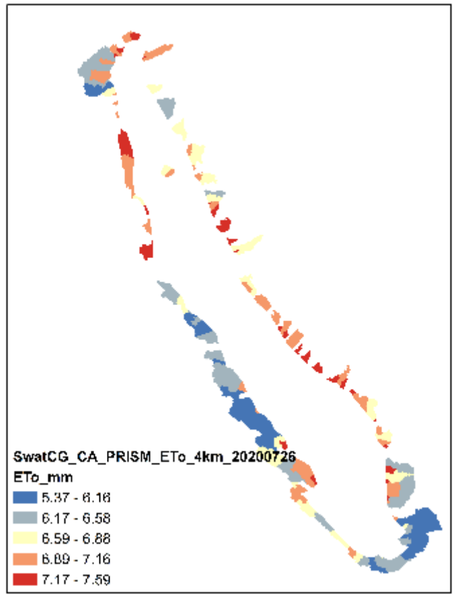


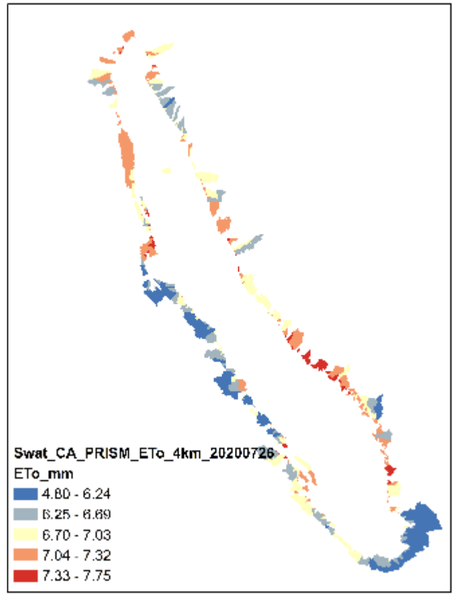
ETo (1.8-8.6mm)

- PRISM 4km daily and 800m monthly climate data (1900-current)
- ETo in the CA state boundary
- ETo spatial averages for C2VSimFG 32537 elements, 21 subregions, 210 small watersheds, and 1024 small watersheds
- An example of ETo on 07/26/2020









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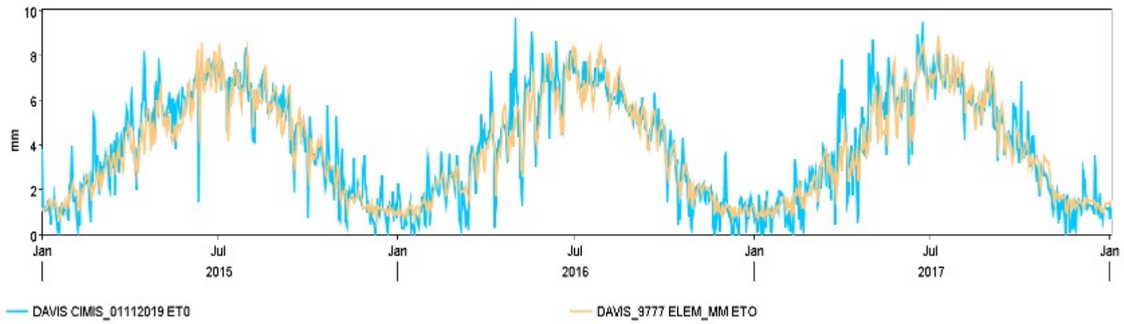
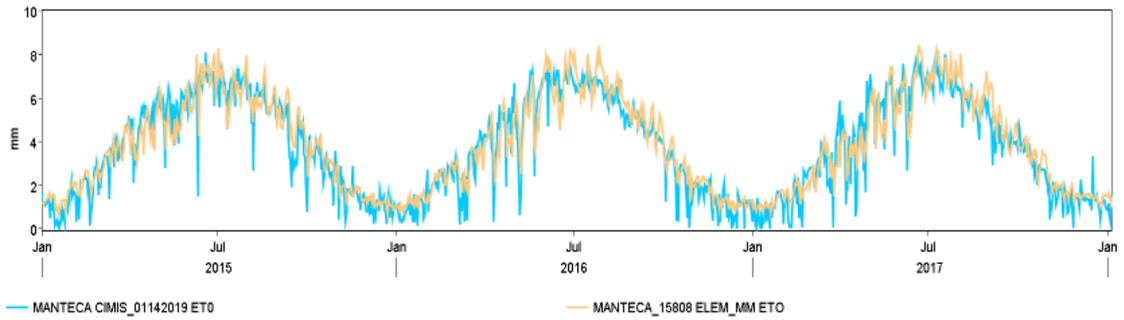
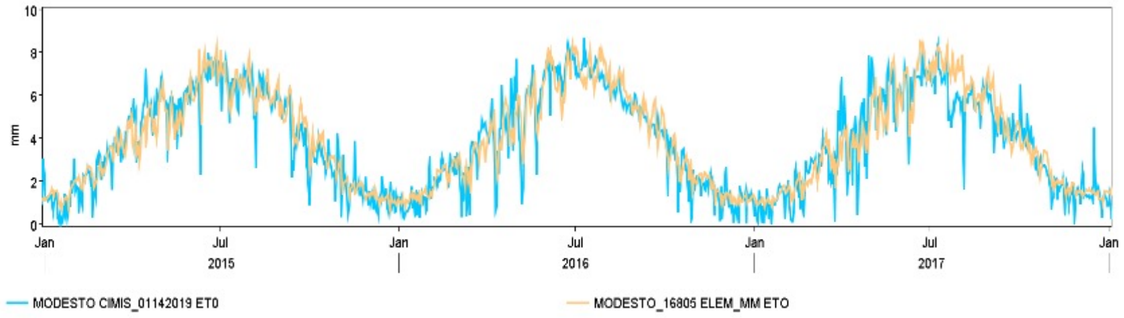
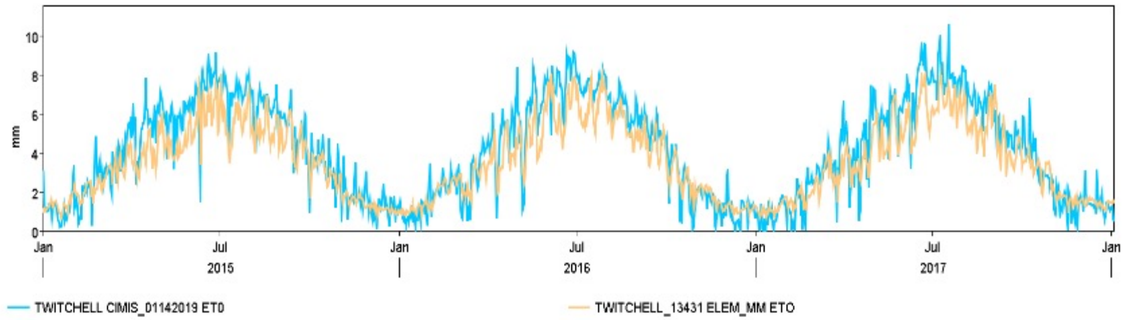
Daily ETo comparison

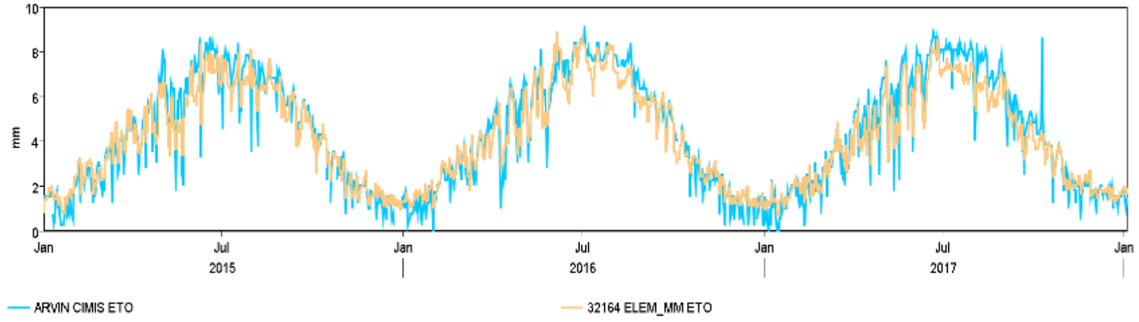






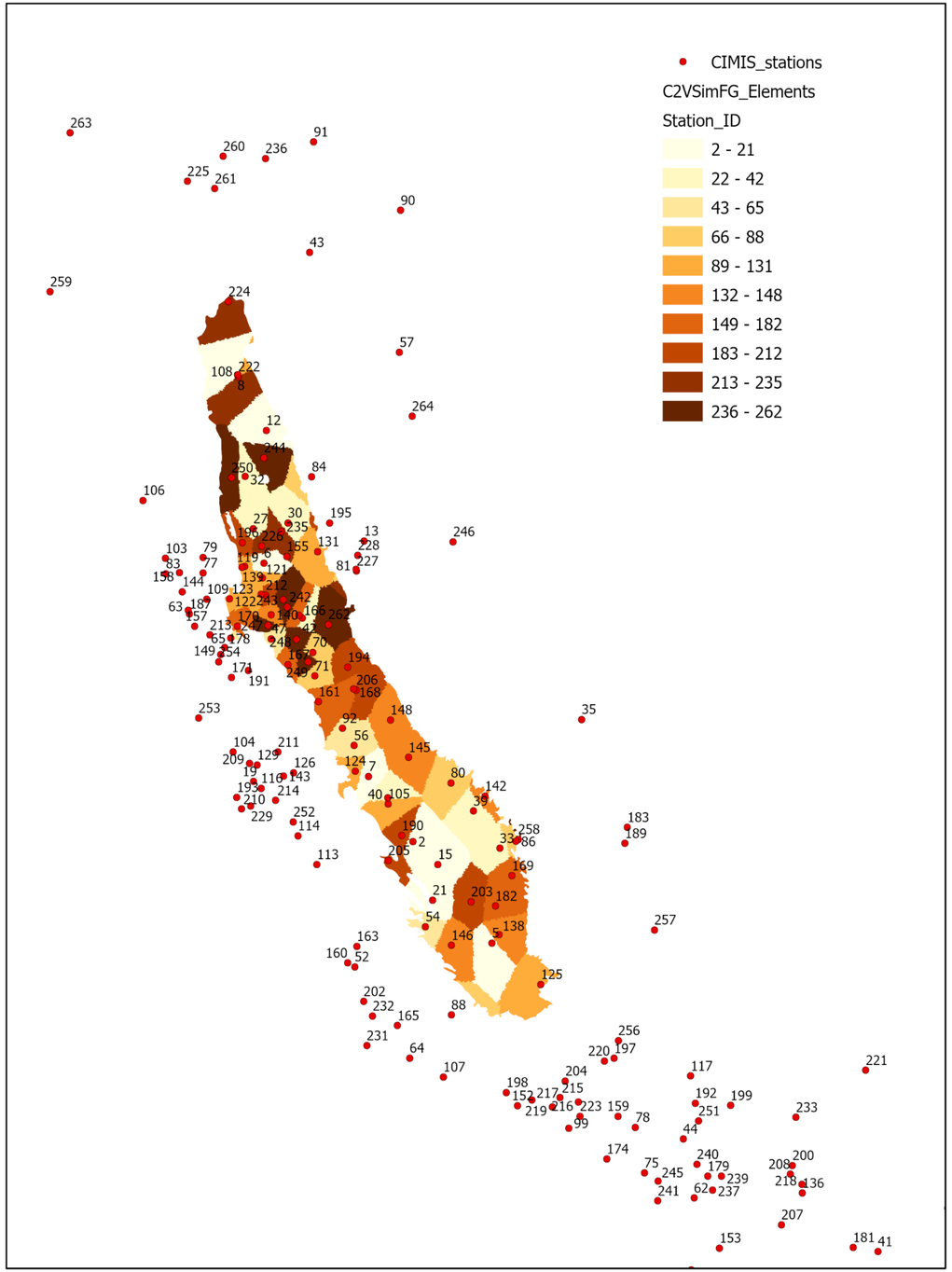
- Compare the PRISM data based ETo to the ETo at CIMIS stations:
  Davis, Manteca, Twitchell, Modesto, Arvin
- Most ETo of two methods match well, except Twitchell.





CIMIS ETo Data

- Using the modified Penman equation with the inputs: measured air temperature, vapor pressure, relative humidity, cloud cover, elevation, solar radiation and wind speed.
- 64 stations in the Central Valley
- Use Thiessen polygons to link CIMIS data to C2VSimFG elements
- Use 70 CIMIS active and inactive stations data to develop linear regressions
- Apply regressions to C2VSimFG elements



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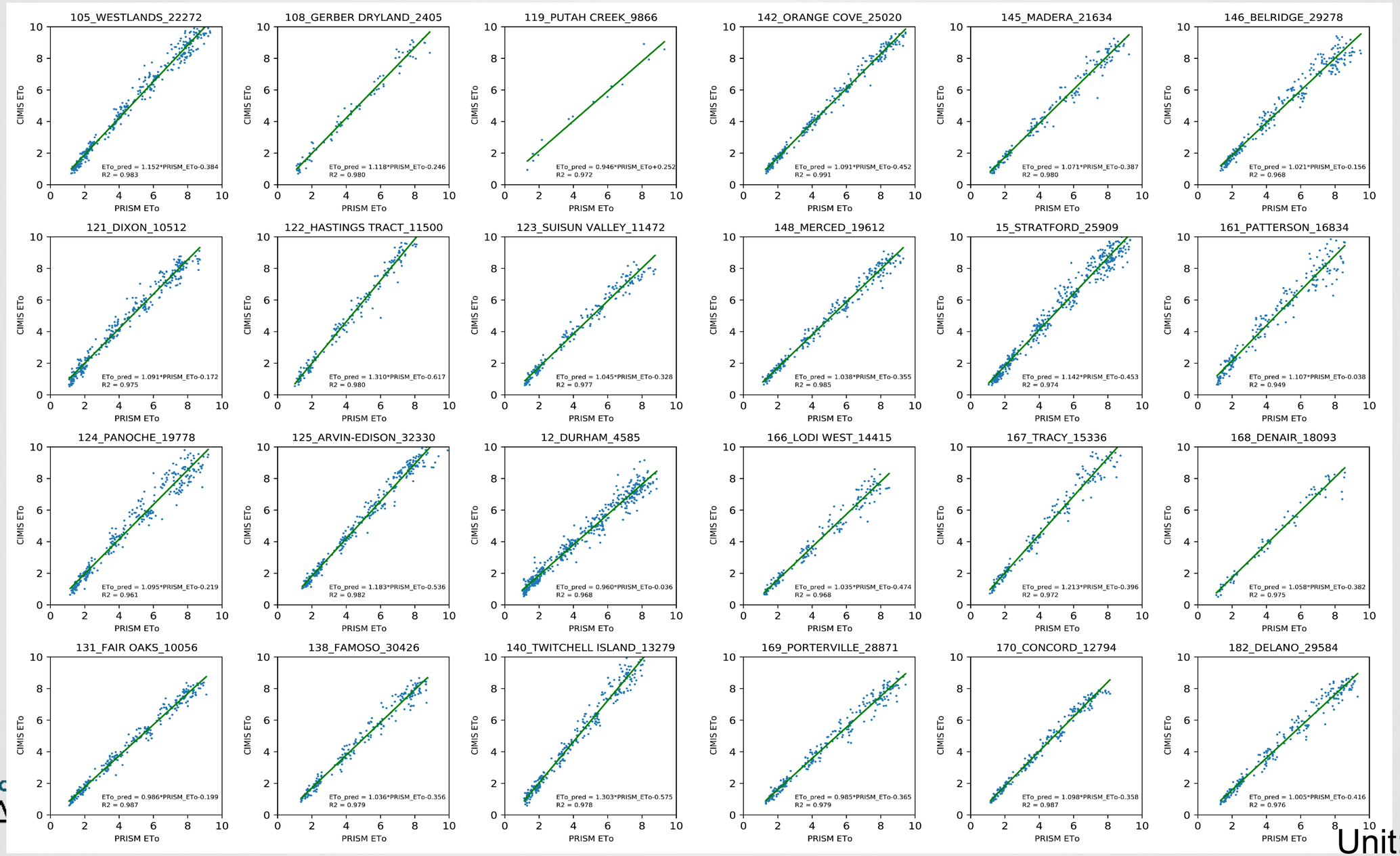
Regressions between CIMIS ETo and PRISM ETo



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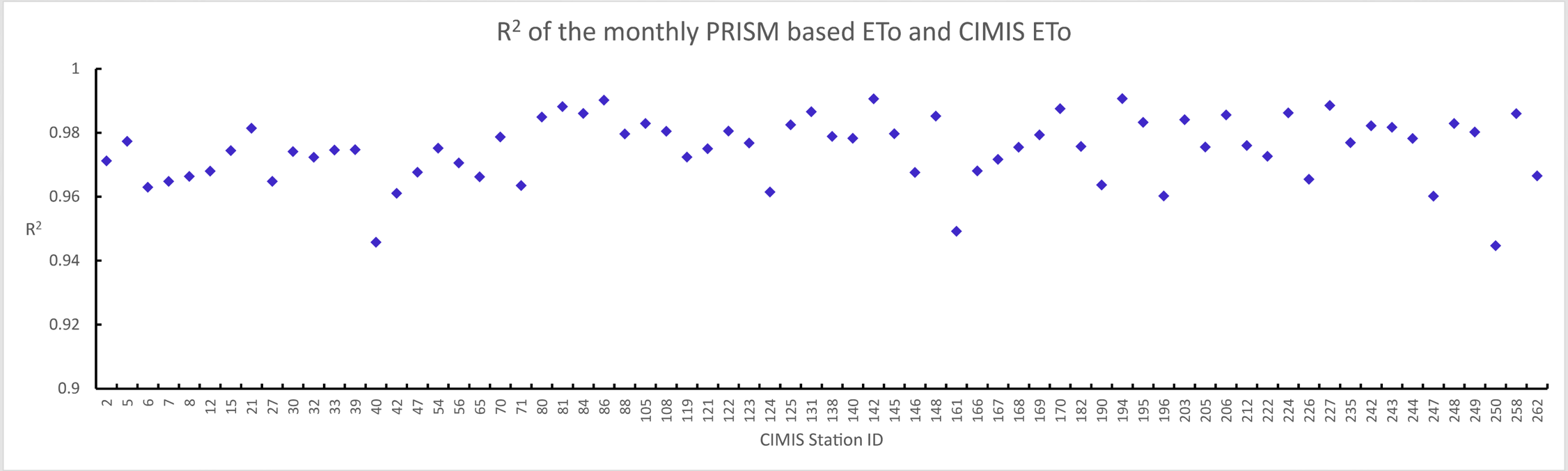
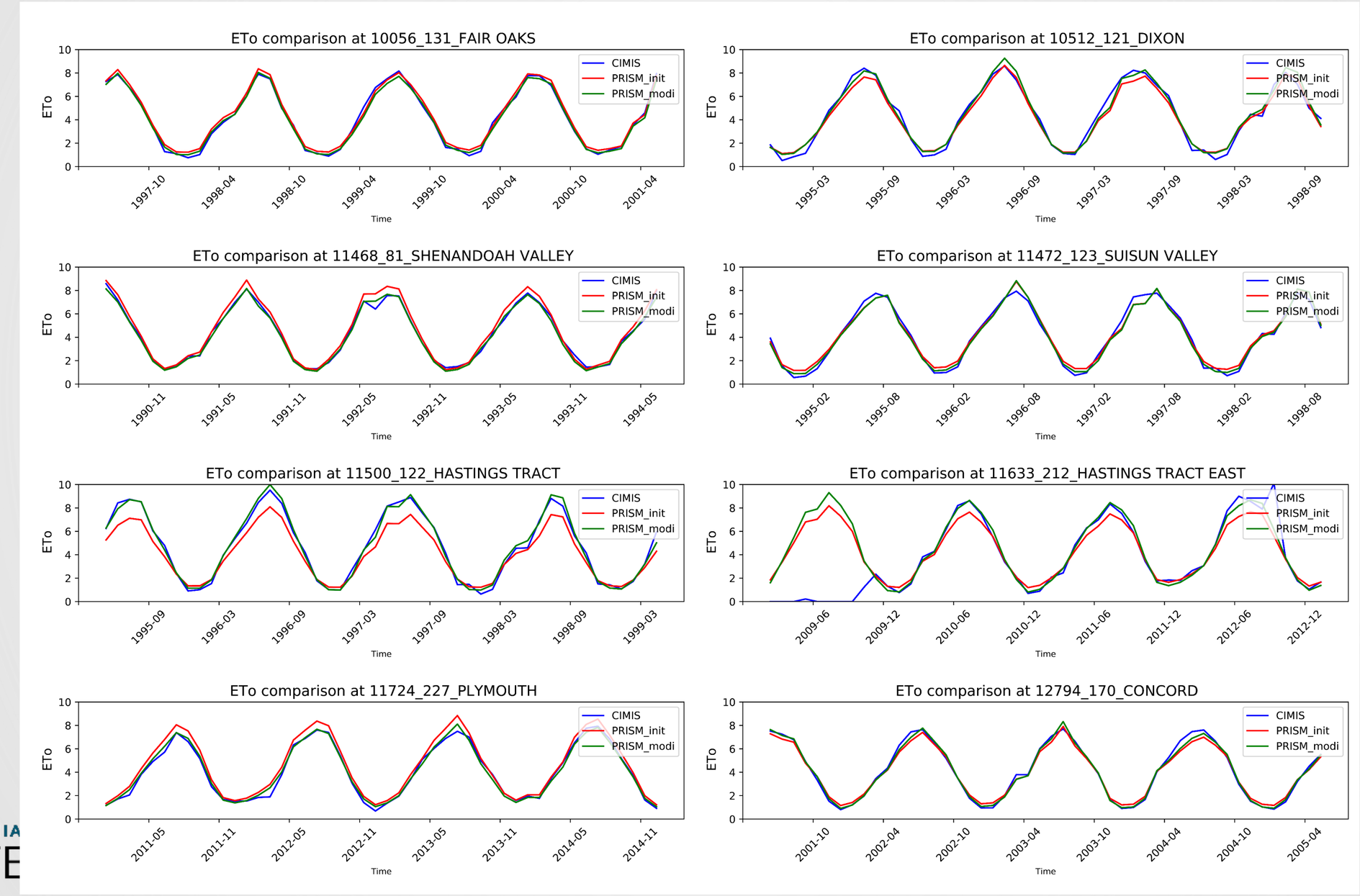
Unit: in/month

R^2 of all the 70 CIMIS stations



- Cleaned the daily CIMIS ETo
- Accumulated the cleaned daily CIMIS ETo to monthly ETo
- R^2 between 0.94~0.99 for all the 70 CIMIS stations inside or near the Central Valley

The modified PRISM-based ETo



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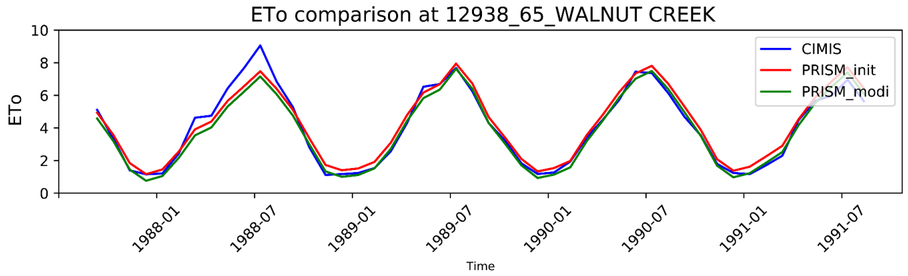
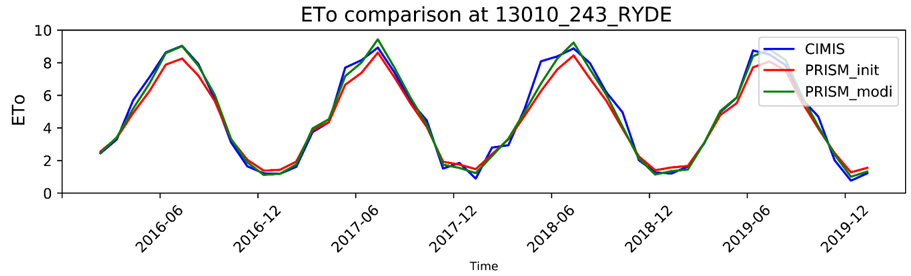
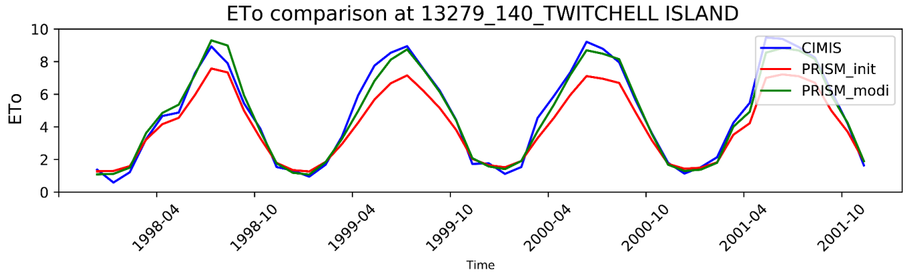
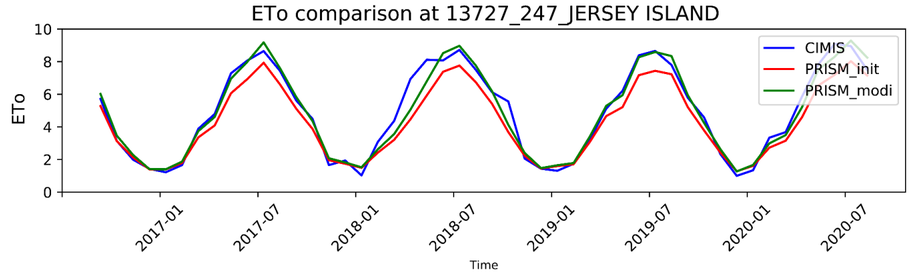
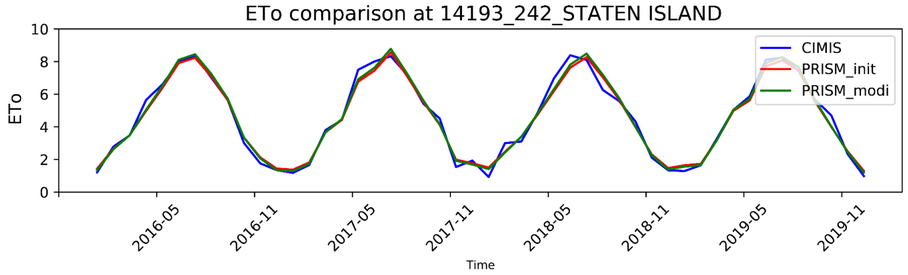
The modified PRISM-based ETo

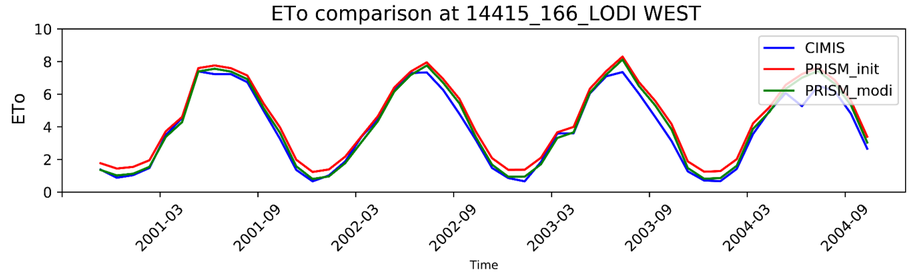


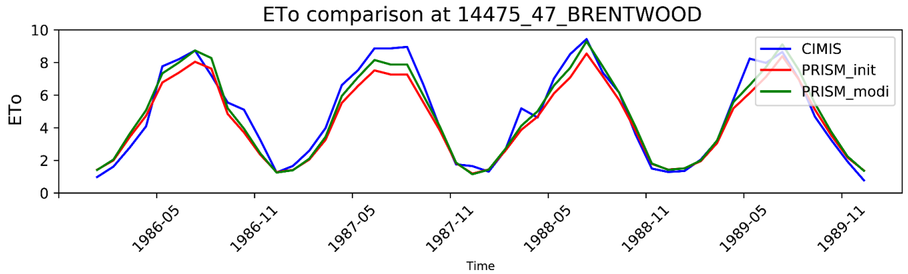


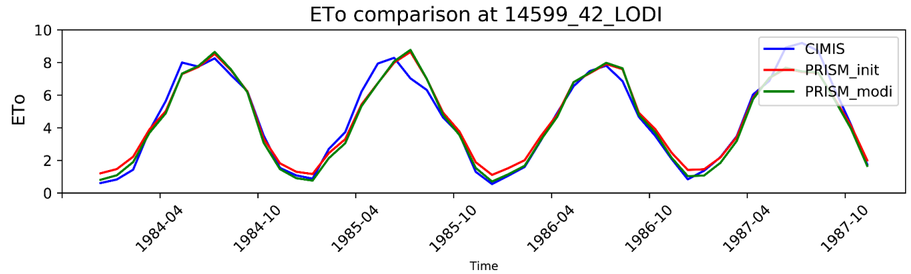












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Historical Land Use Data Collection

- Available land use maps:
  - DWR land use survey by counties from 1980's to 2015
  - 2014, 2016, and 2018 LandIQ agriculture land use
  - 2015 Delta land use developed by LandIQ

- Land use under development:
  - 2018 Central Valley fill-in land use developed by LandIQ
  - 2017 land use developed by USGS-DWR

- Remote sensing data:
  - From Google Earth Engine
  - Landsat NDVI (1980's-current)
  - Sentinel 2 surface reflectance (2016-current)

The functions of remote sensing data

- Fill in the land use data gaps

- Detect more specific land use spatially
  - multi-cropping
  - subcategories in native vegetation and urban

- Detect the land use variations in time
  - the rice flooded decomposition area in winter and idled land in summer
  - the flooding periods and areas of refuges, Delta leaching, Tulare lake

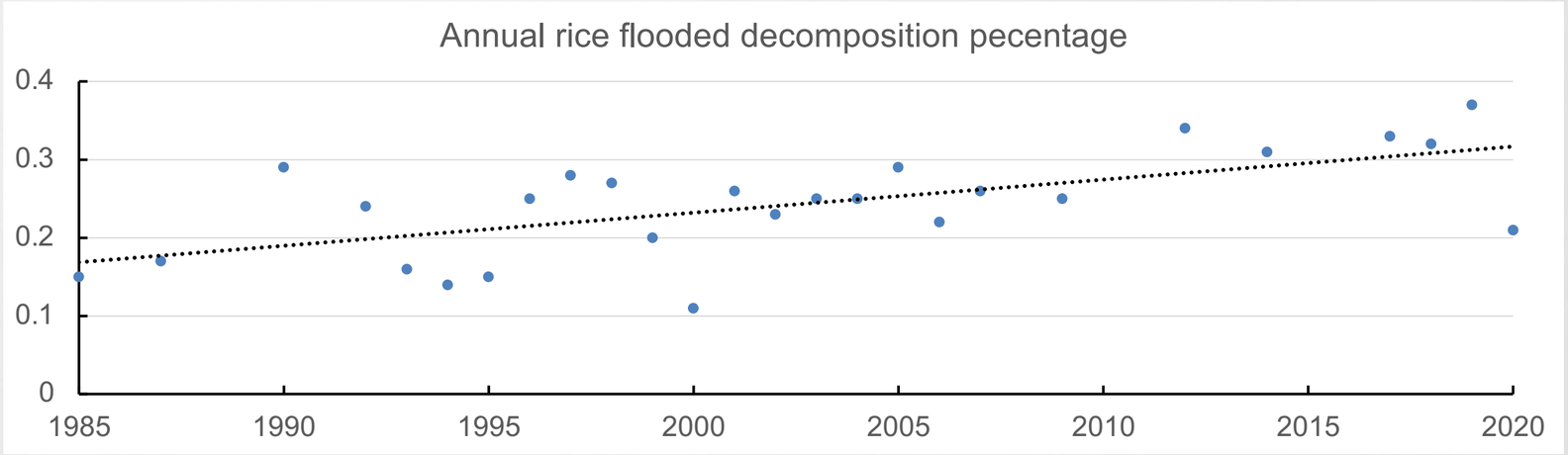
- Verify the estimates of land use, actual ET, and soil moisture later.

Rice flooded decomposition lands

2017/01 2018/12 2019/11

- Use Landsat NDVI to find the flooded areas in dark purple
- Examples of the Sacramento Valley rice flooded decomposition areas in WY 2017, 2019, and 2020

- The annual percentages of the winter flooded area to the entire rice area



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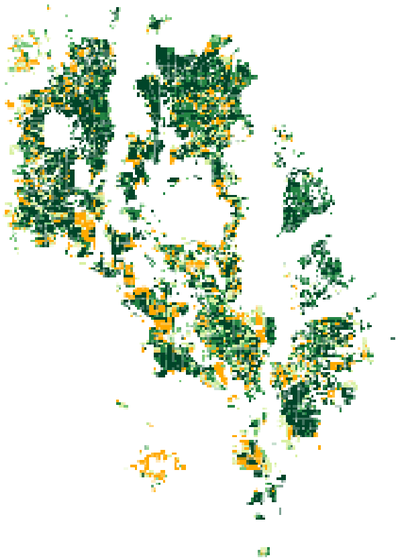
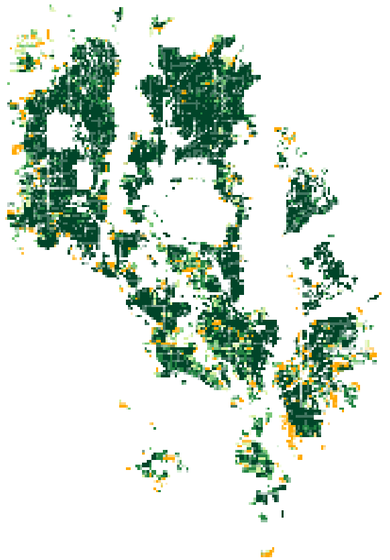
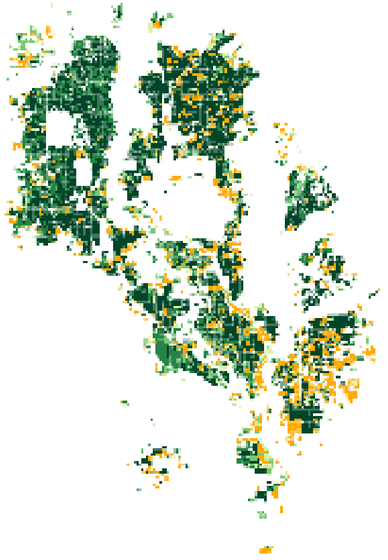
Annual idled rice fields in the Sacramento Valley detected by NDVI (2015 – 2021)



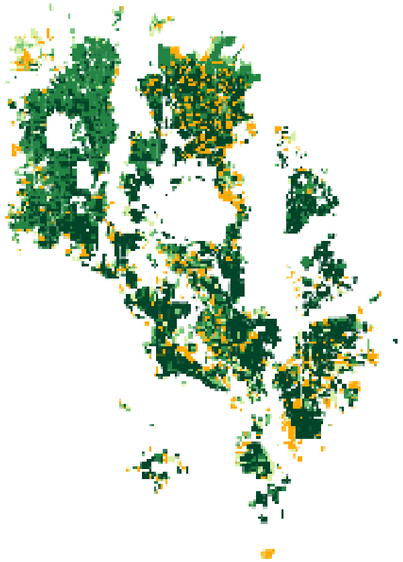
2015



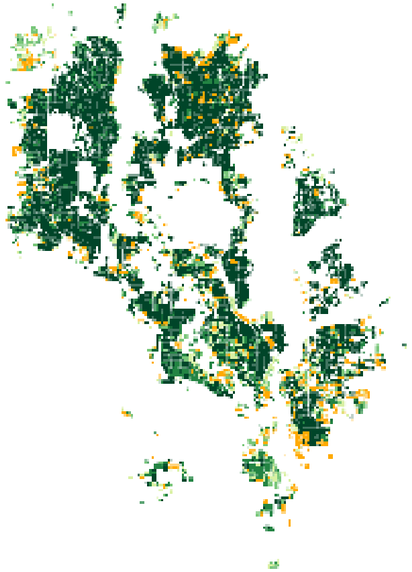
2016



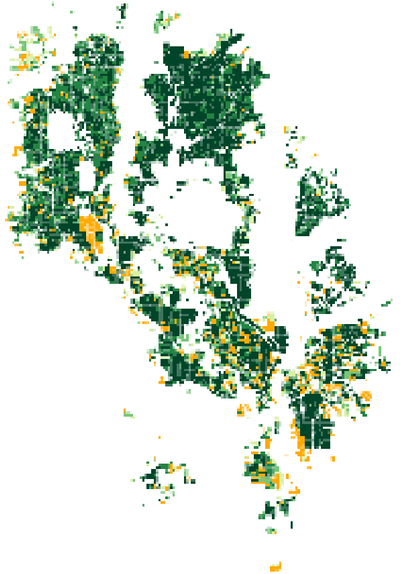
2017



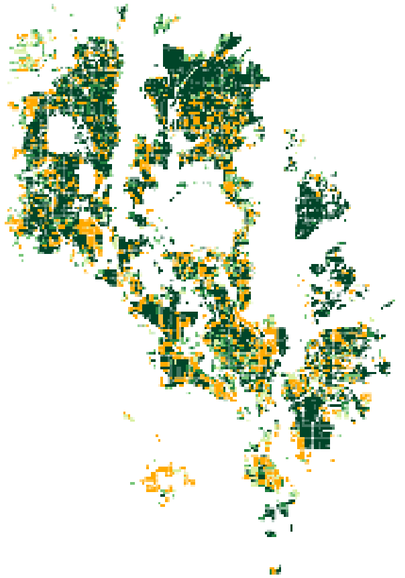
2018



2019



2020



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* Idled fields in orange

Historical Land Use for C2VSimFG

- Developed python scripts to mosaic the land use survey and remote sensing data for each year and create the historical land use input for C2VSimFG automatically
- 25 land use categories and 4 multi-cropping categories
- Generate the model input of the annual rice flooded decomposition area

Summary

- Developed python scripts to automatically generate the land use and ET inputs for C2VSimFG with weather, land use, and remote sensing data.

- Refining the historical land use and ET in order to simulate more reasonable ET and water balances using C2VSimFG.

Next steps

- Finalize the historical land use with more incoming data.
- Use the historical land use, modified PRISM-based ETo, and remote-sensing based actual ET to analyze the crop coefficients of all the land use categories in C2VSimFG.
- Calculate the actual ET based on the modified PRISM-based ETo and crop coefficients.
- Validate the estimated actual ET with Open-ET and others.
- Apply the estimated historical land use and actual ET into C2VSimFG and find the impact on the Central Valley water balances.