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# Development of the historical land use and evapotranspiration for C2VSimFG

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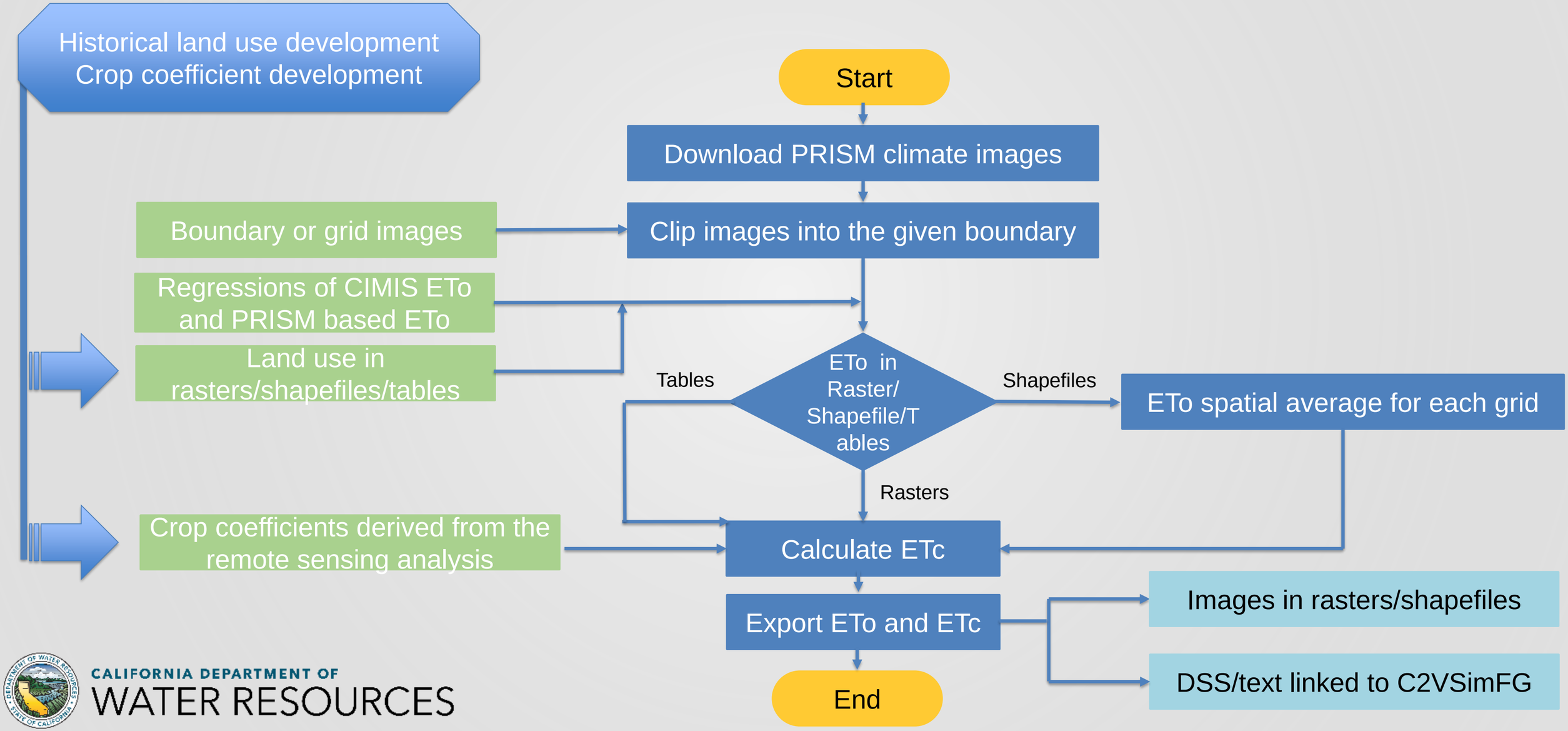
# Purposes

- To resolve the issues related to land use and ET in the current C2VSimFG.
  - Data gaps in the historical land use.
  - ET especially for native lands need calibration.
  - Water budgets and groundwater tables are related to land use and ET.

- Investigate and quantify the historical land use and ET in the Central Valley.
  - Historical land use by assembling and processing the remote sensing based land use and DWR surveys and water plan data.
  - Historical reference ET with PRISM and CIMIS data
  - Historical actual ET with latest developed land use and remote sensing based ET analysis.

# Annual land use input to actual ET calculation

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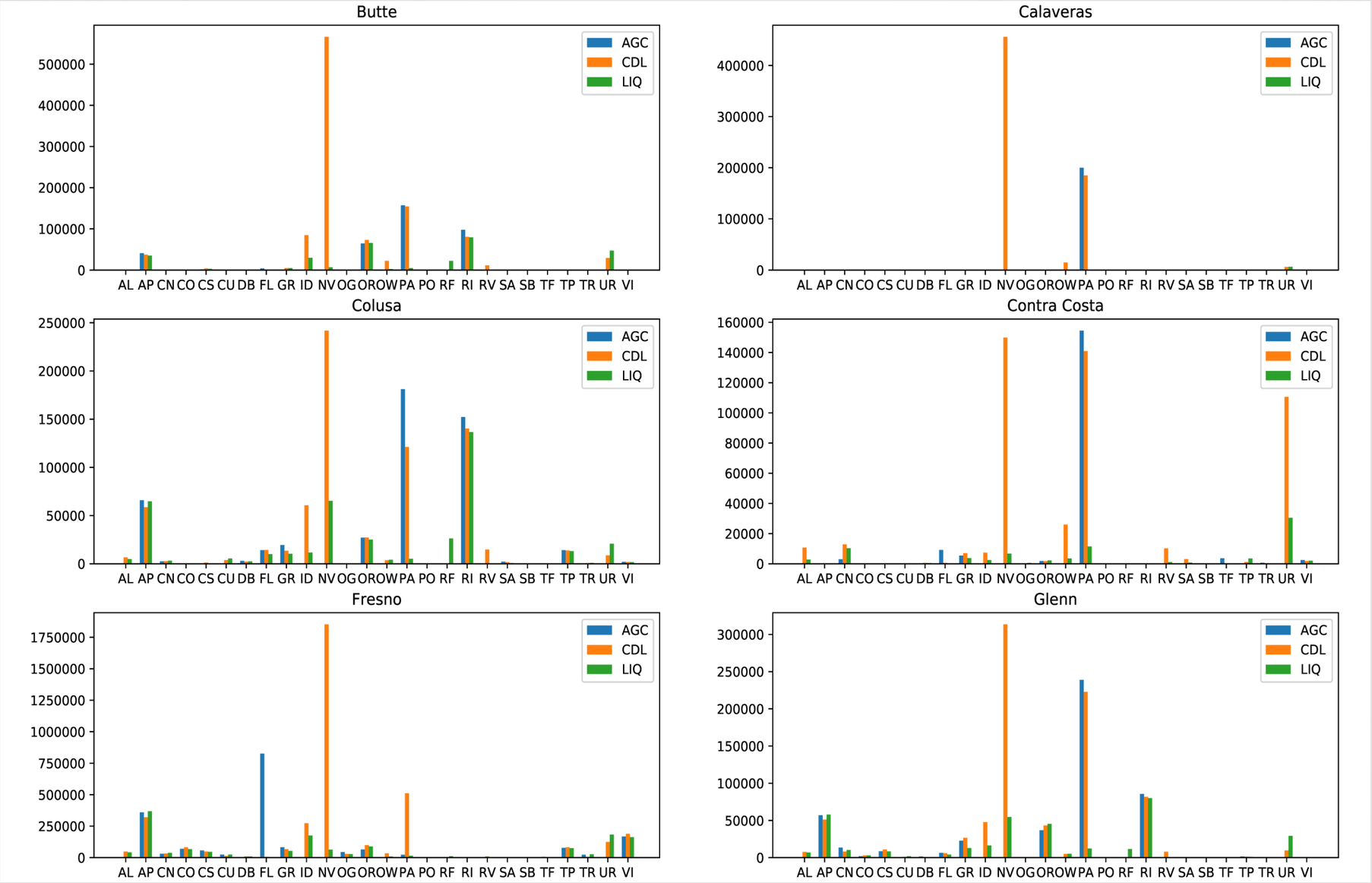
# Historical land use sources (1973-2021)

- Vectors based on surveys mostly
  - DWR and county surveys since 1986
  - LandIQ agriculture crop mapping (2014,2016,2018-2021)
  - LandIQ 2018 fill-in map of Central Valley
- Rasters from remote sensing data
  - USDA Cropland Data Layer(CDL, 2008-current)
  - Landsat images since 1984
  - Sentinel 2 images since 2016
- Tables
  - DWR Water Plan before 2008
  - USDA County Ag Commissioners' crop reports

# 2018 County land use difference by sources

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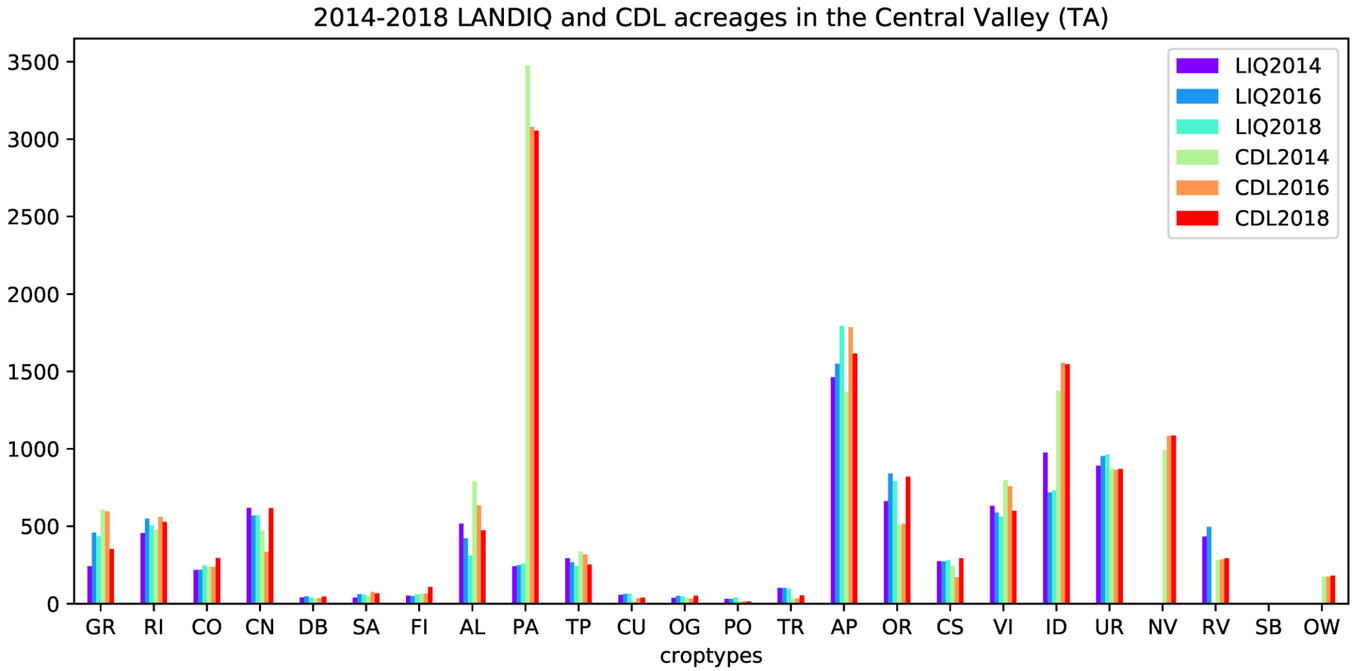
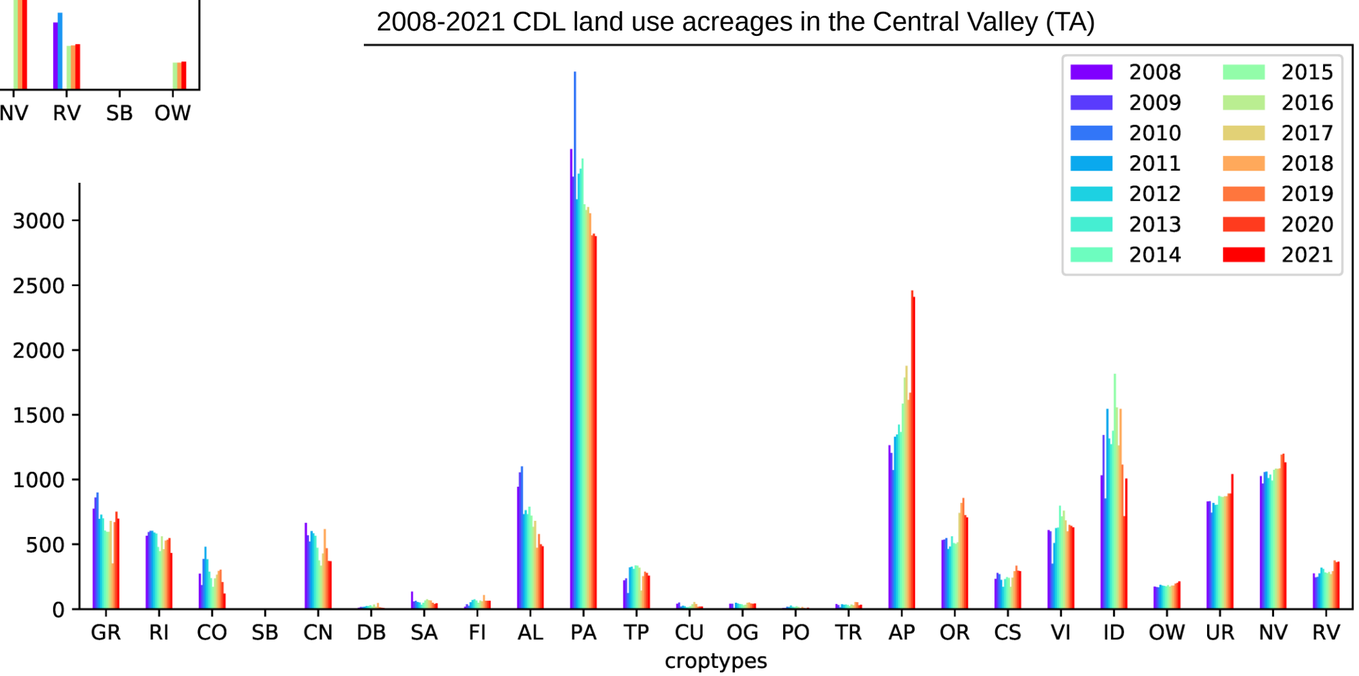
Unit: Acres

# Central Valley land use difference




- LandIQ vs CDL for three years
- Major difference from pasture and non-ag

- CDL 2008-2021
- Systematically misclassify pasture, native or idle

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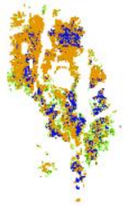
# Land use processing tool

- Assemble available rasters, vectors, and tables by years.
- Adjust land use tables and convert different land use codes to C2VSimFG code.
- Use the CDL or LandIQ fill-in map to fill data gaps.
- Calculate NDVI and NDWI from cloud-free remote sensing images for summer and winter.
- Analyzing NDVI/NDWI seasonal variation to differentiate habitats/ponds/flooding areas, rice flooded-decomposition, idled lands, and urban indoor and outdoor areas.
- Mosaic all layers into one map per year with priorities
- Convert annual maps to C2VSimFG land use inputs

# Annual land use sources priorities

Mosaic 2020 Land use

NDVI and surveys

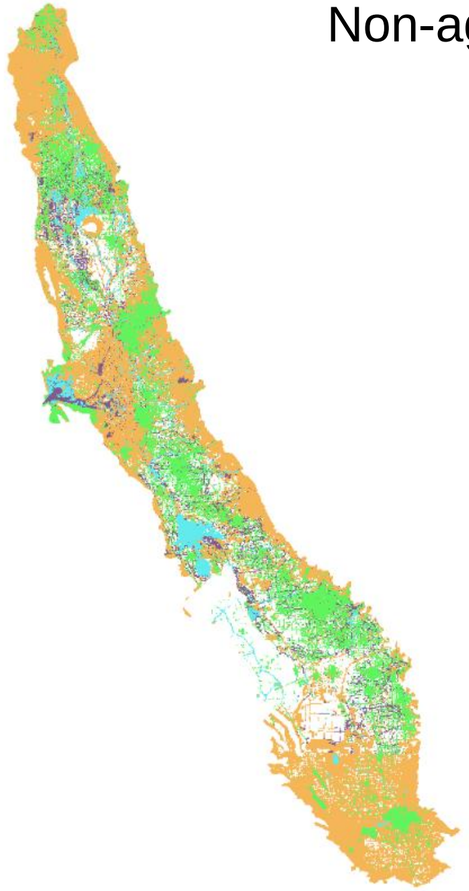


Rice Winter NDVI

San Joaquin County

Kern County

Non-ag



CDL

NDVI

Surveys

Non-ag

CDL

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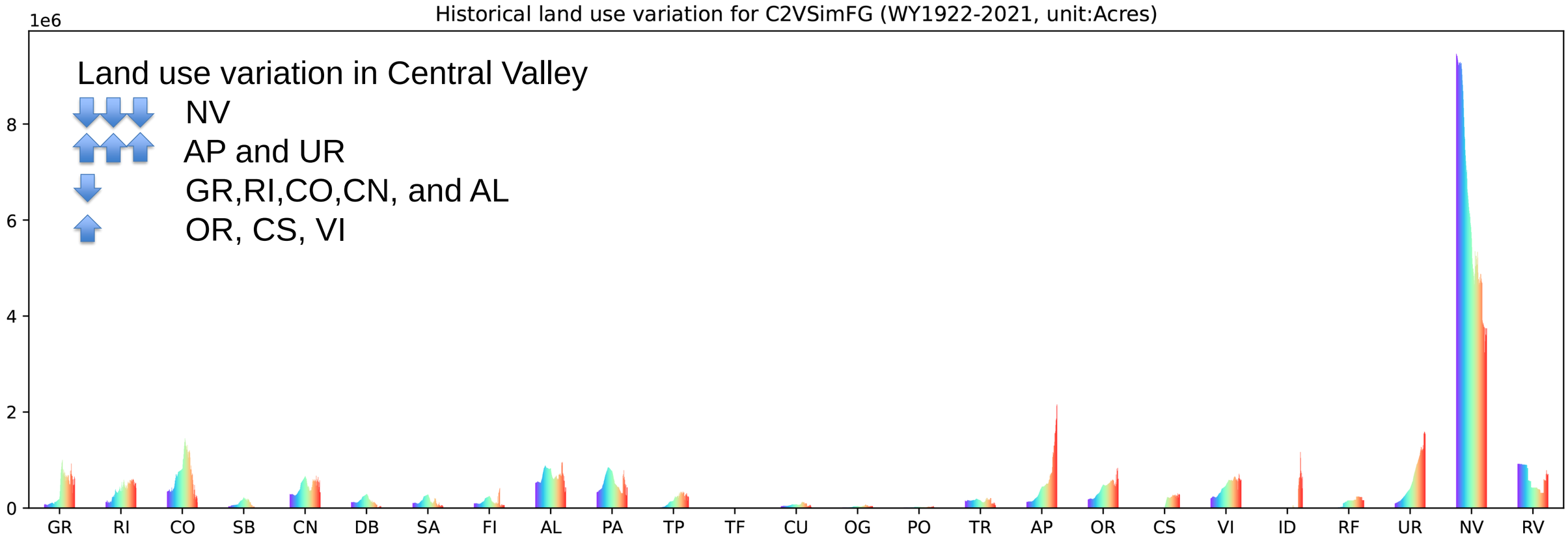
# 1922-2021 historical land use

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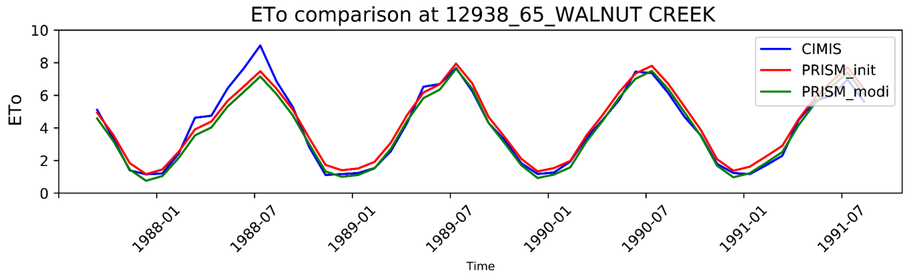
# Estimate 1922-2021 historical ET for C2VSimFG

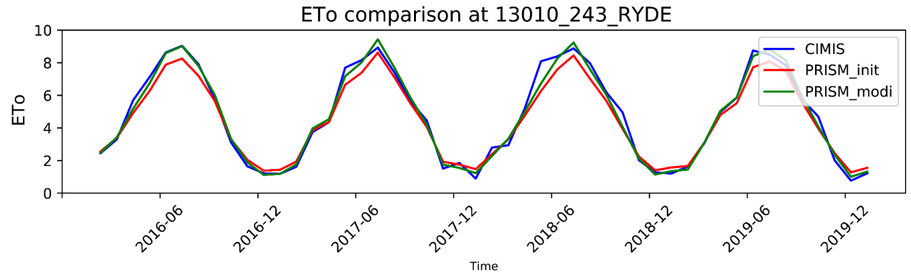
- Crop coefficient method: ETc_daily = Kc * ETo_HS

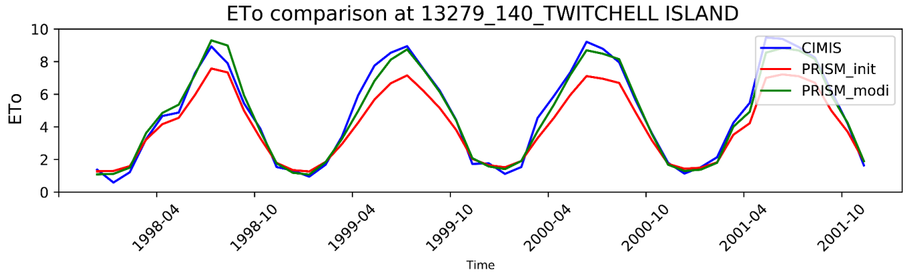
- ETo_daily of each C2VSimFG element:
  - ETo_HS: Hargreaves-Samani(HS) equation with daily temperature
  - 1921-1980 PRISM 800m monthly temperature
  - 1981-2021 PRISM 4k daily temperature
  - Linear regressions between ETo_HS and ETo_CIMIS at 70 station sites
  - Apply the regressions on each element using Thiessen polygons
  - Calculate daily ETo_HS by using the linear regressions

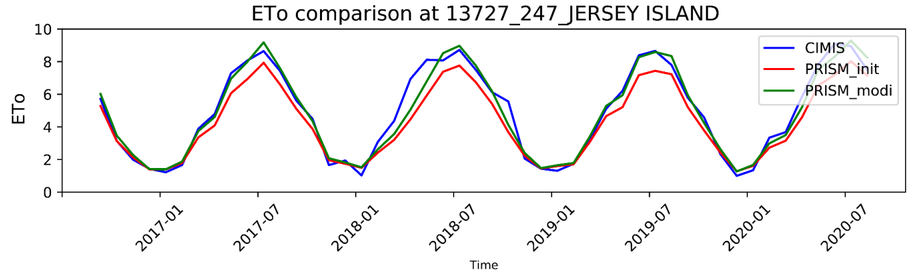
- Kc for each subregion and each land use type
  - the ratio between monthly remote sensing based ET and monthly average of daily ETo_HS

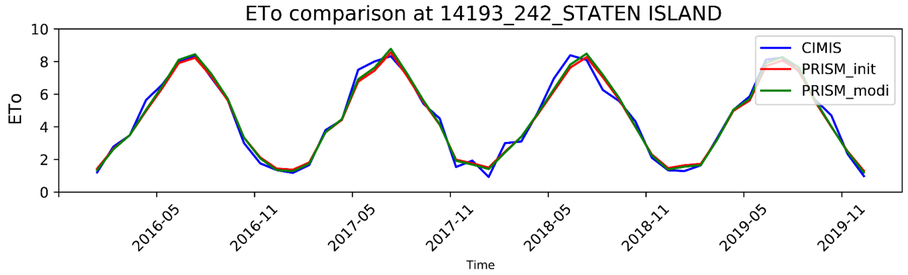
# Monthly averages of ETo_HS

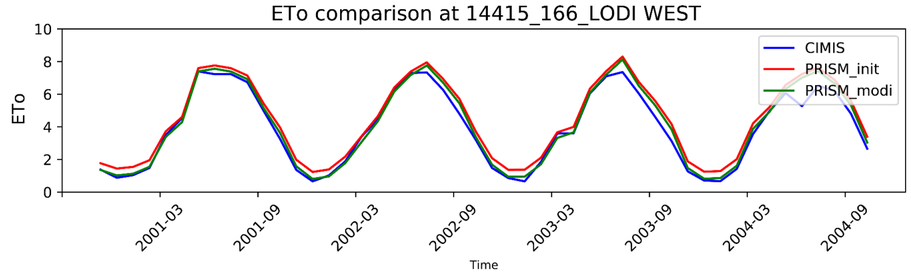


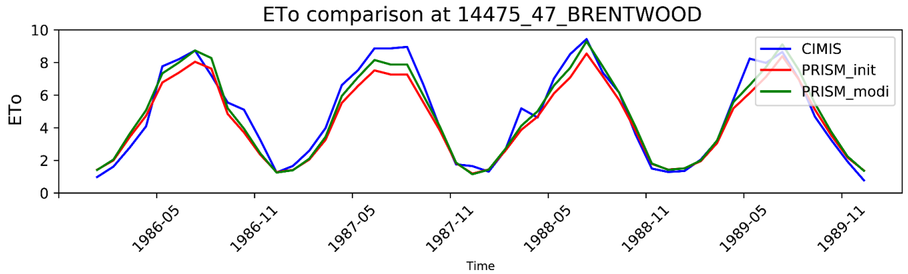



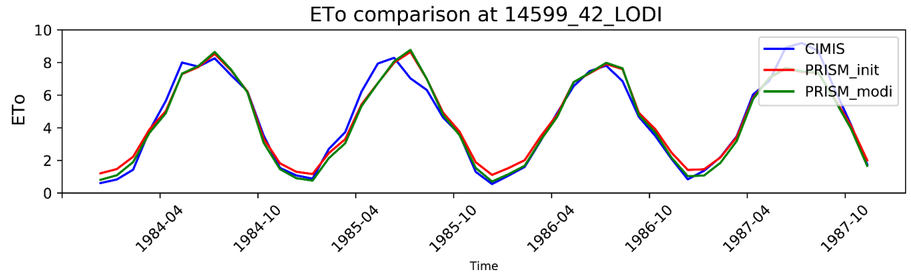

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# Available remote sensing based actual ET

- DWR sponsored remote sensing based ET studies in the Central Valley
  - 2011 and 2014 ITRC

  - 2010-2017 Formation Environmental (FE)

  - 2015-2016 Delta ET
    DisALEXI, ITRC-METRIC, SIMS, UCD-METRIC, and UCD-PT
    CalSIMETAW, DETAW (crop coefficient method)

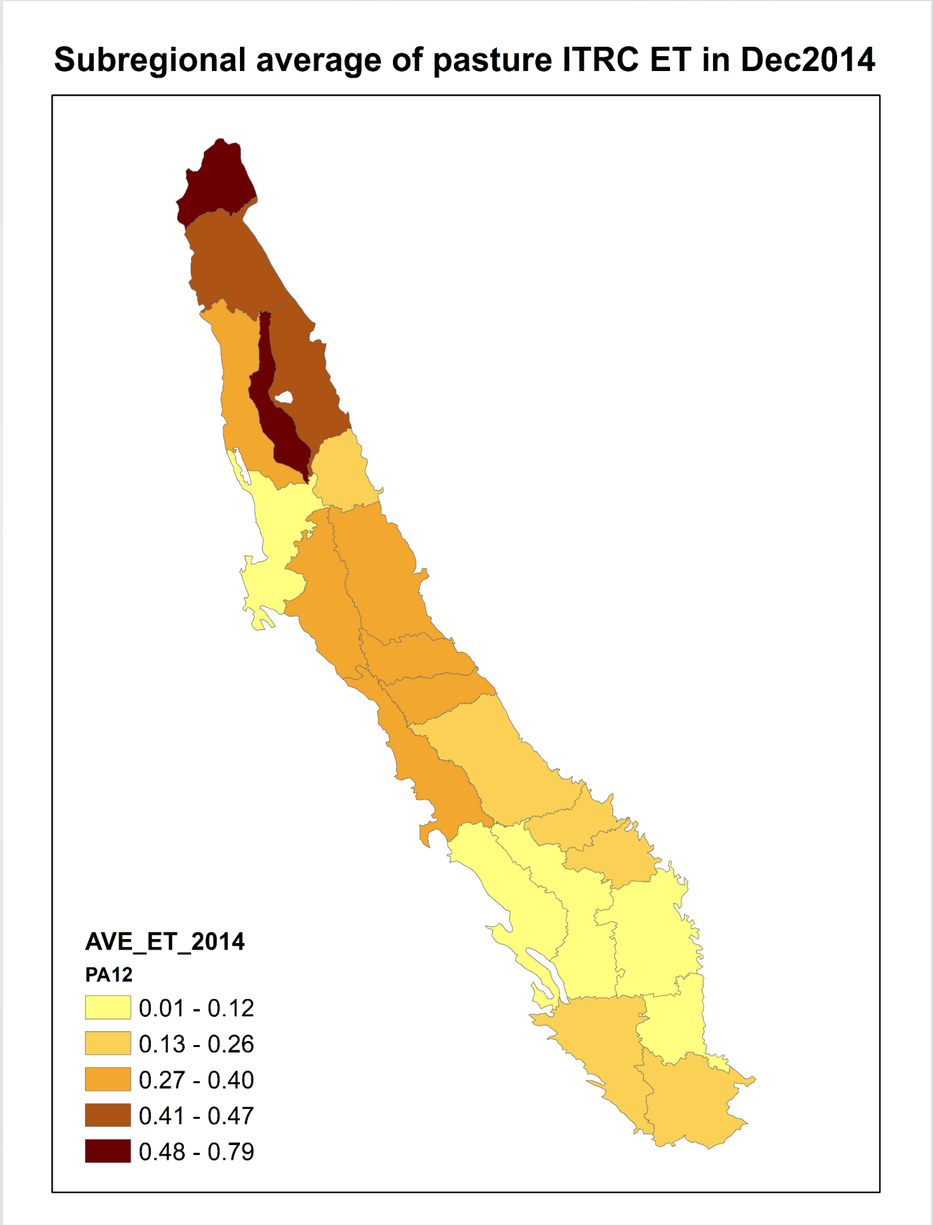
  - 2016-2022 OpenET (ongoing project)
    eeMETRIC, SSEBop, SIMS, PT-JPL, DixALEXI, and geeSEBAL
    ensemble average of six methods

# Spatial distribution of actual ET by land use

- Analyze the selected data
  - 2011 and 2014 ITRC
  - 2011, 2014, 2016, and 2017 FE
  - 2016 and 2017 OpenET ensemble

- Calculate the monthly subregional average for each C2VSimFG land use class

- The accuracy at the subregion scale for each land use category

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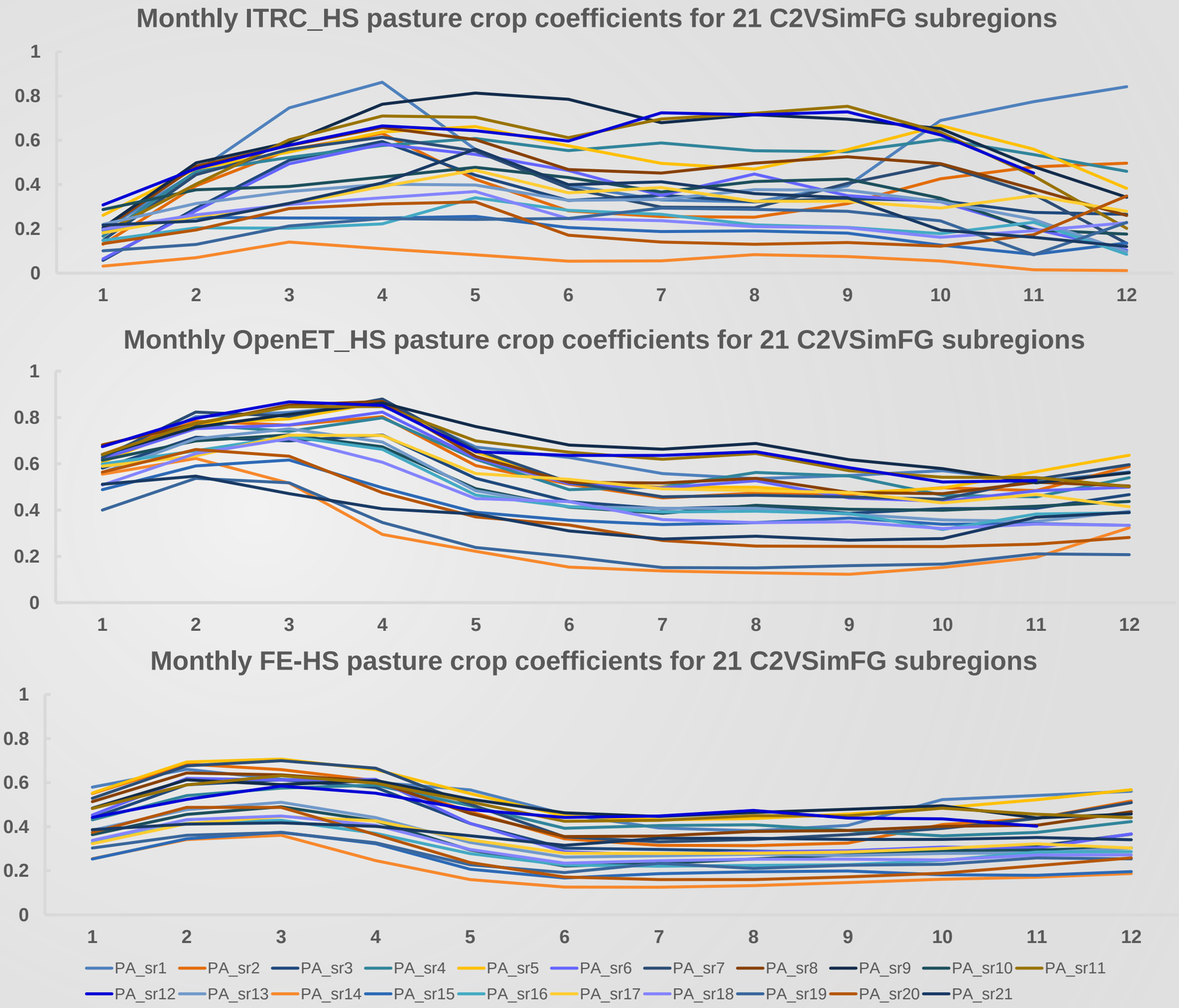
# Crop coefficients

- Three sets of crop coefficients derived from the ET analysis of ITRC, FE, and OpenET

- Calculate three sets of actual ET based on ETo_HS and three sets of Kc
  - ITRC_HS:
    ETc = Kc_ITRC * ETo_HS
  - OpenET_HS:
    ETc = Kc_OpenET *ETo_HS
  - FE_HS:
    ETc = Kc_FE *ETo_HS

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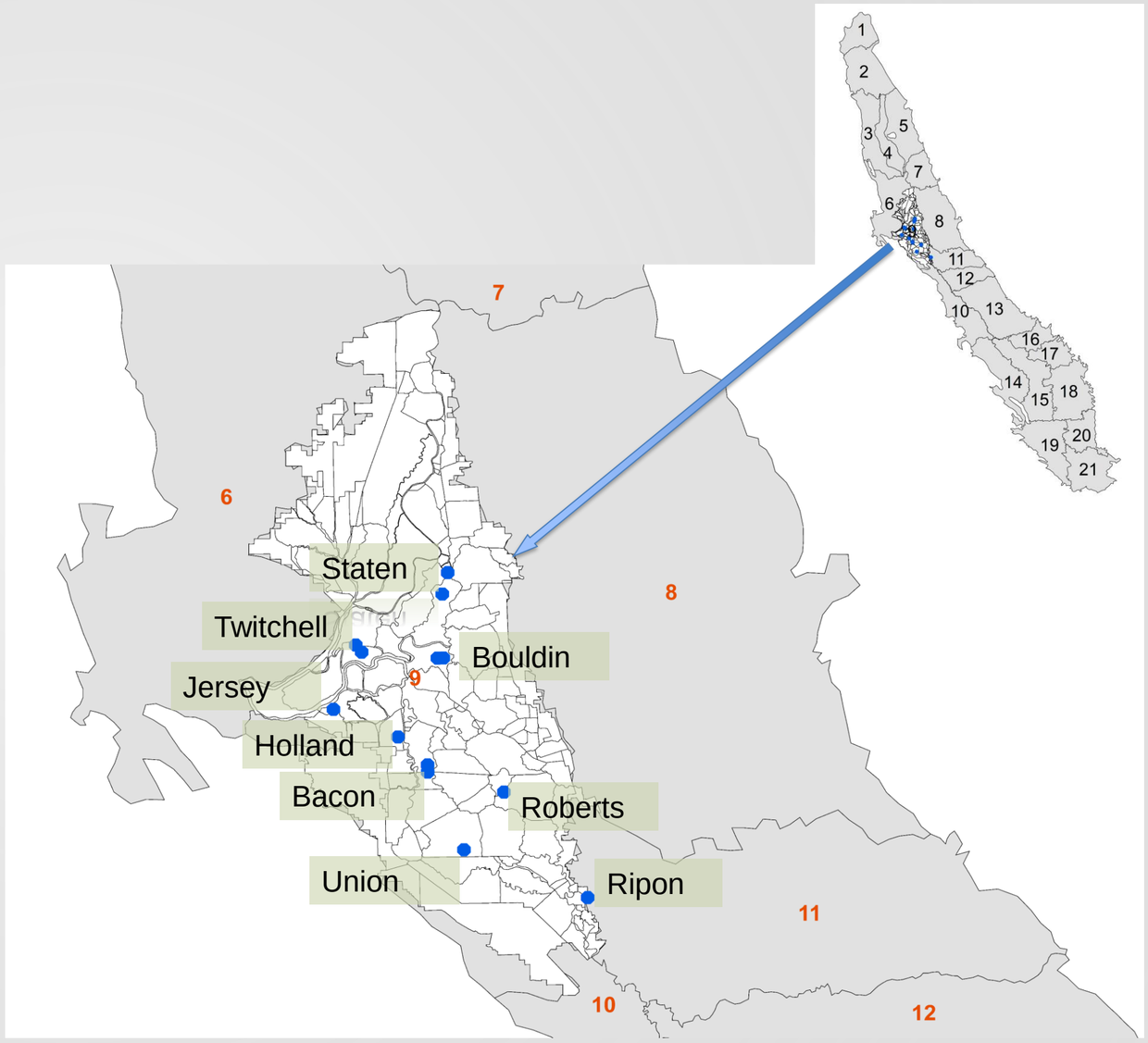
# ET comparison

- Point scale comparison (2016-2017)
  - observed vs ITRC_HS vs OpenET_HS

- Regional scale comparison
  - Subregions 1,5,9,14, and 21:
    RS-derived vs C2VSimFG v1.01
  - Subregion 9 Delta:
    RS-derived vs 2015-2016 estimates
  - Central Valley for long-term averages:
    RS-derived vs GSP estimates

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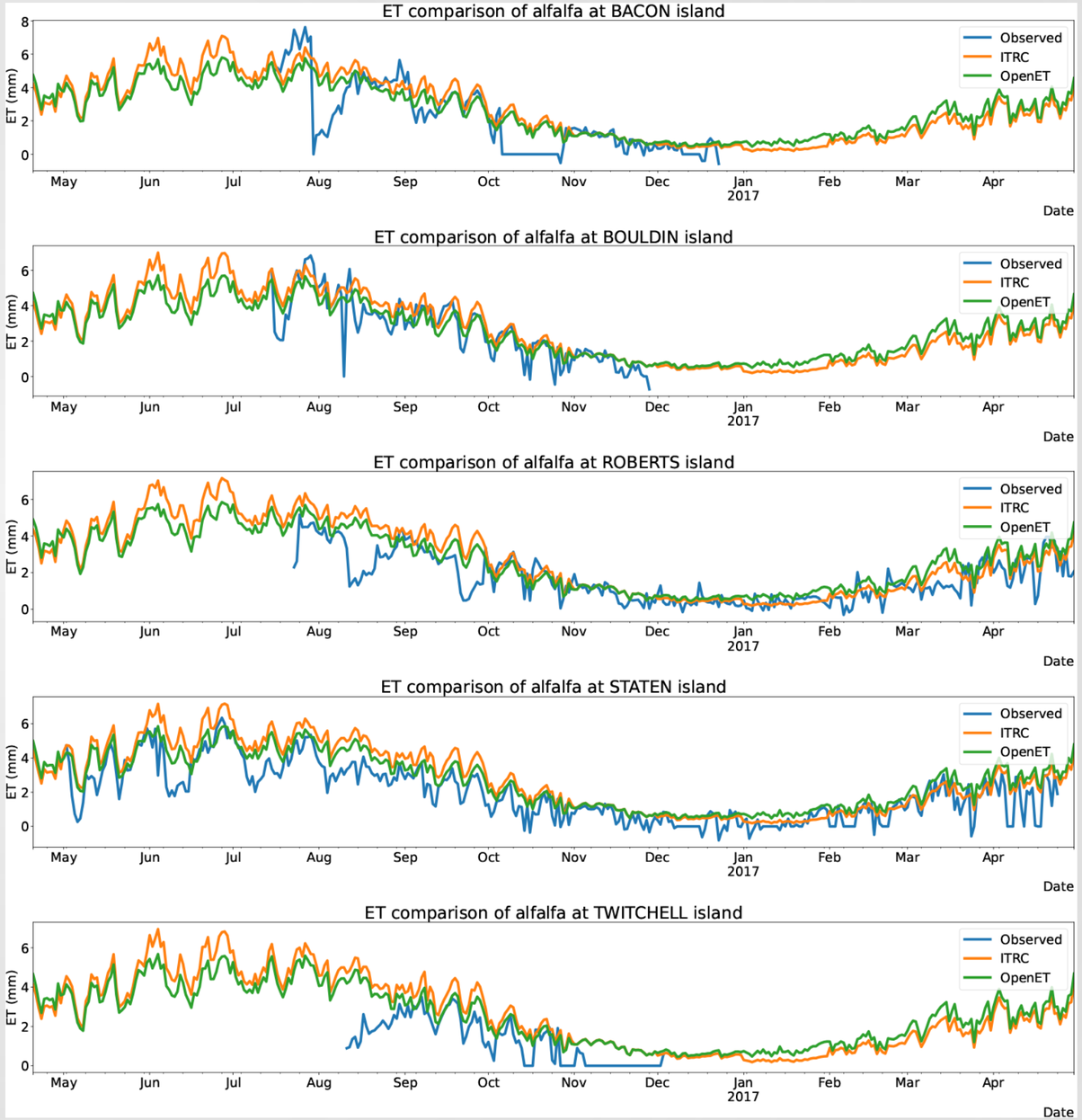
# Point scale comparison

- Time period: 2016-2017
- Sites in the Delta
- Crops: alfalfa, pasture, corn
- Catch most daily variation trends in time and space
- Missed harvest time for corn due to the subregional scale.

2016-2017 Alfalfa ET in Delta Islands

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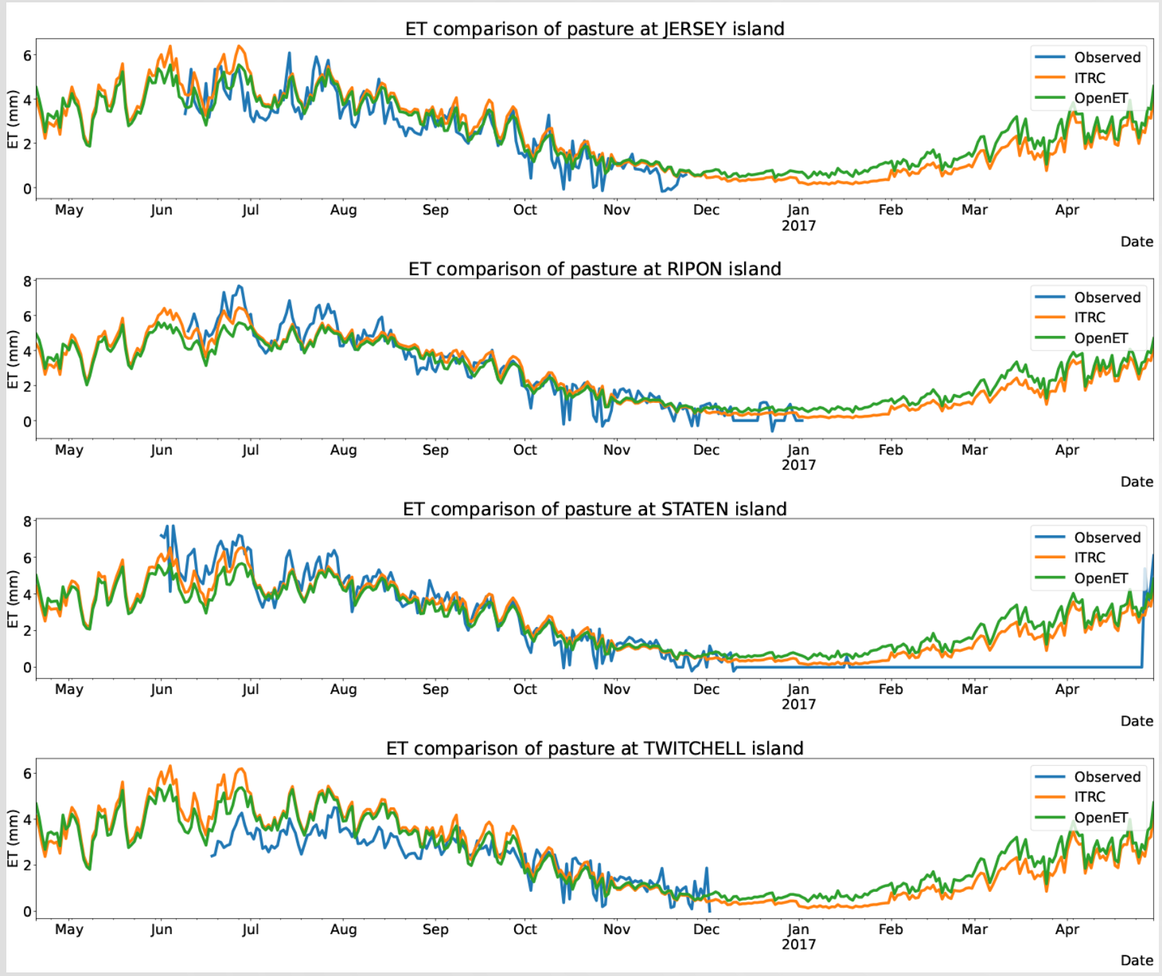
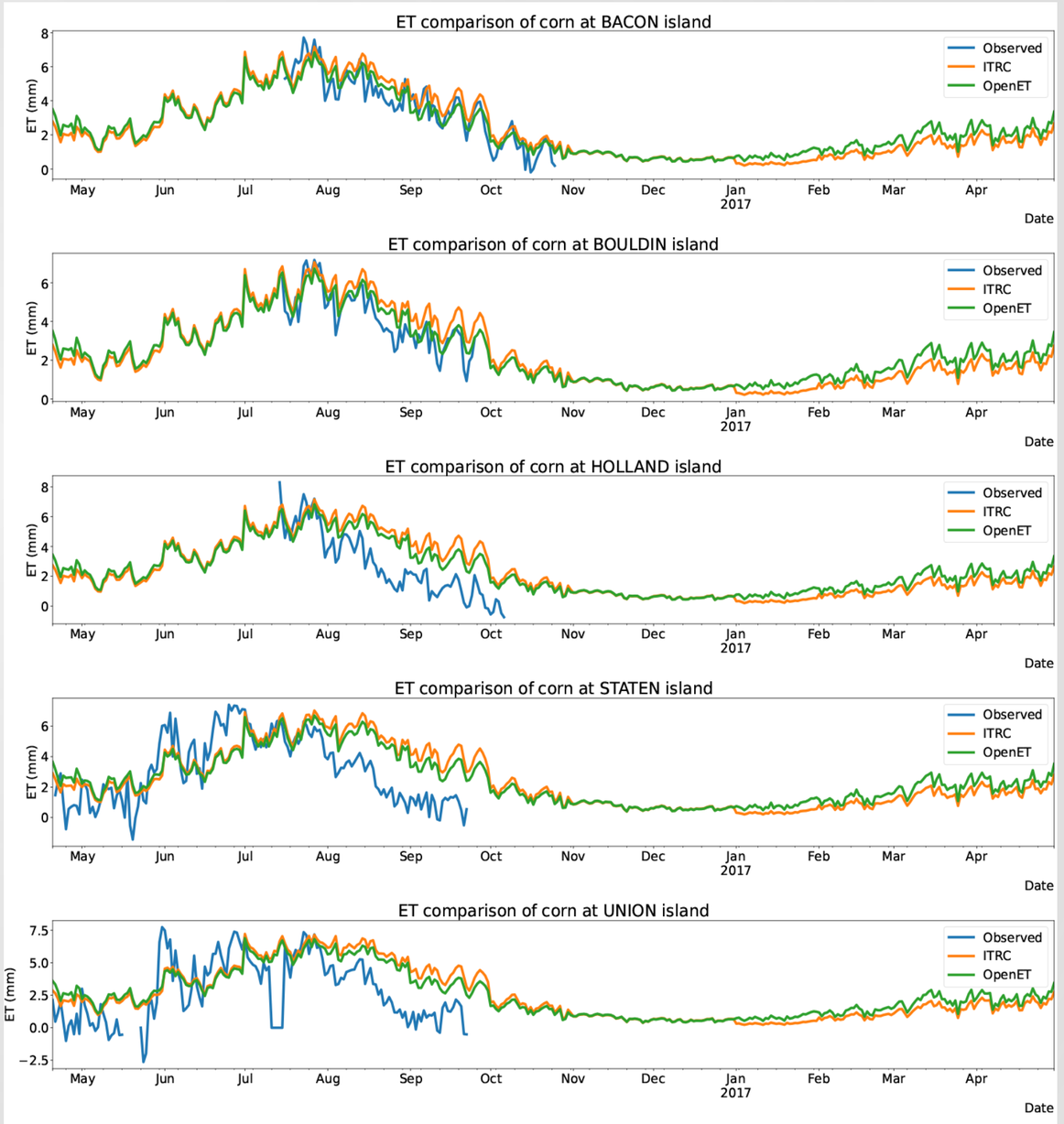
# 2016-2017 pasture ET in Delta Islands




# 2016-2017 corn ET in Delta Islands

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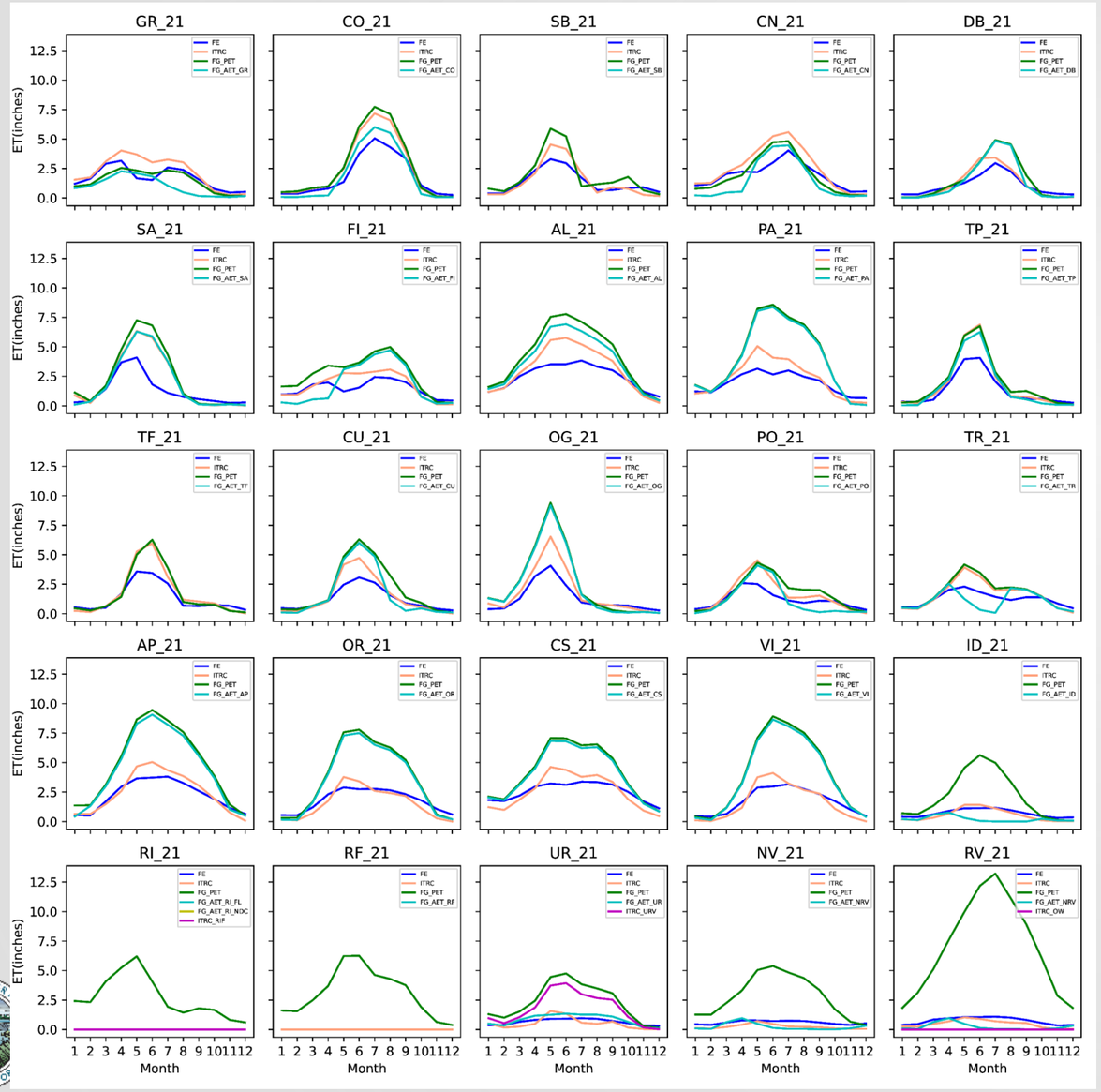
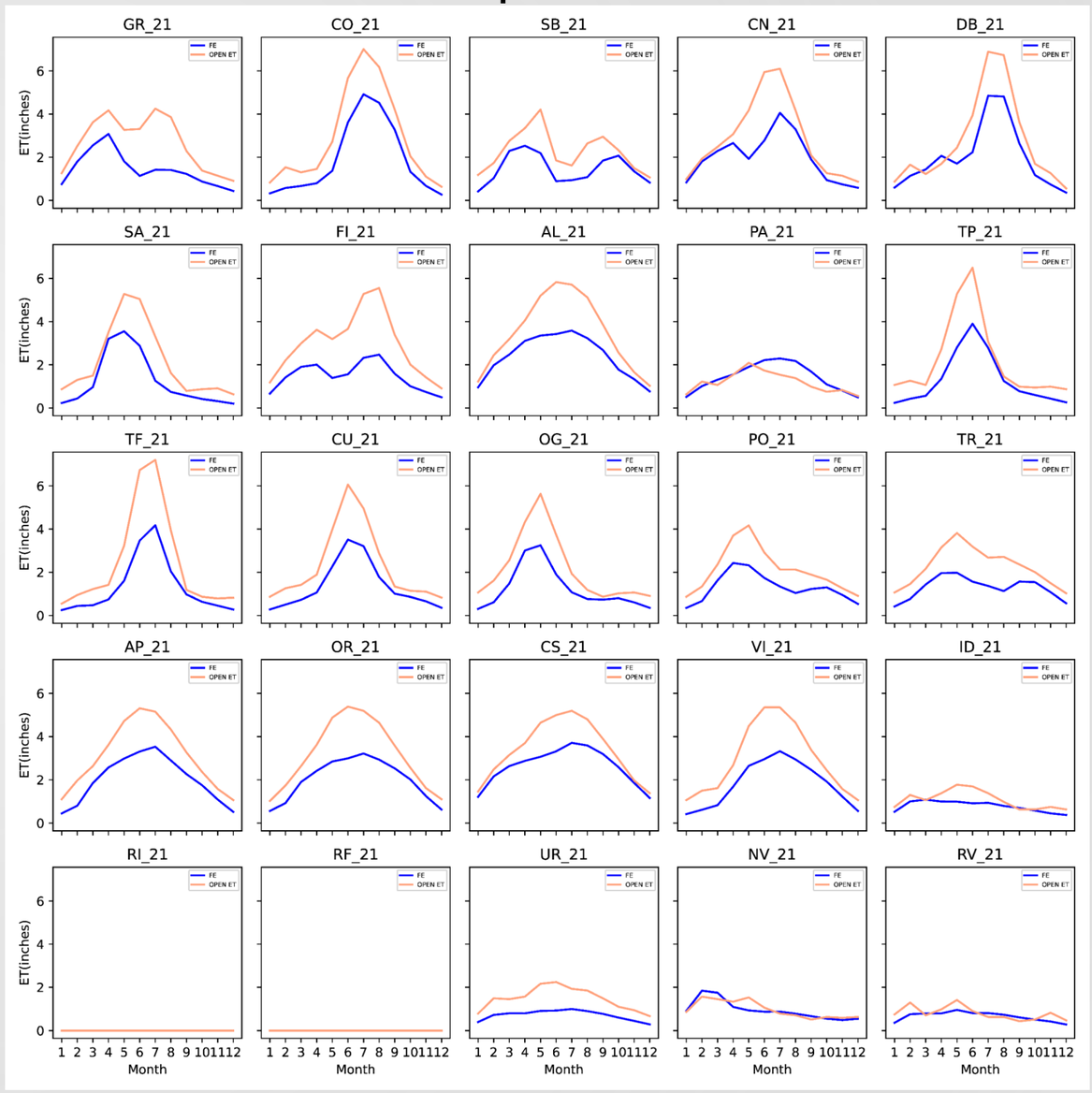
# Regional scale comparison – 5 subregions

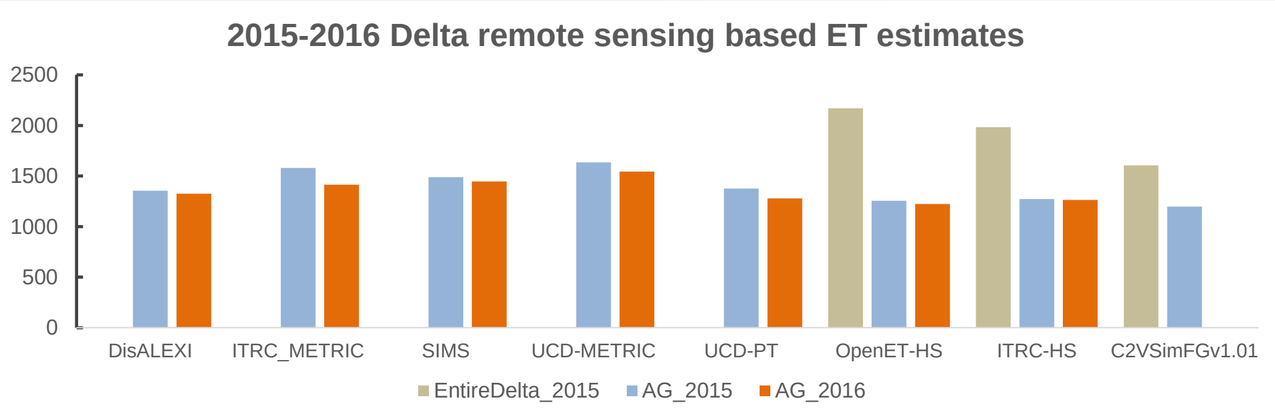
## 2014 – ITRC vs FE vs C2VSimFG

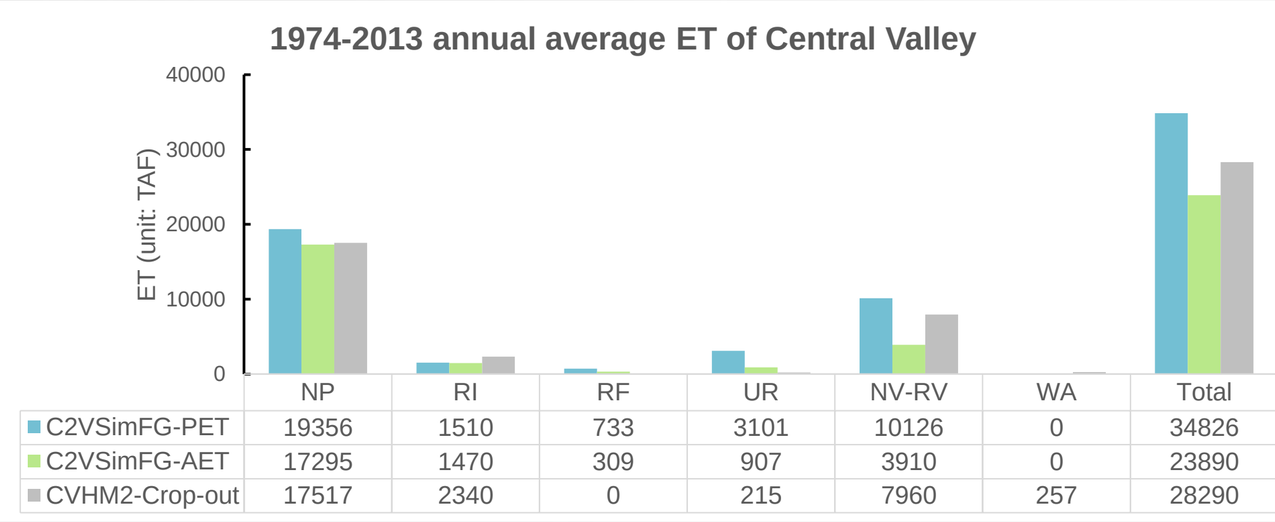



## 2016 – OpenET vs FE



# Regional scale comparison




| | NP | RI | RF | UR | NV-RV | WA | Total |
|---|---|---|---|---|---|---|---|
| C2VSimFG-PET | 19356 | 1510 | 733 | 3101 | 10126 | 0 | 34826 |
| C2VSimFG-AET | 17295 | 1470 | 309 | 907 | 3910 | 0 | 23890 |
| CVHM2-Crop-out | 17517 | 2340 | 0 | 215 | 7960 | 257 | 28290 |

- Agriculture land ET estimated by most models are similar.
- Ag ET in C2VSimFG v1.01 is relatively low compared to most remote sensing based ET.
- Native ET is one of the main issues in C2VSimFG, which remote sensing data will support to quantify reasonably.

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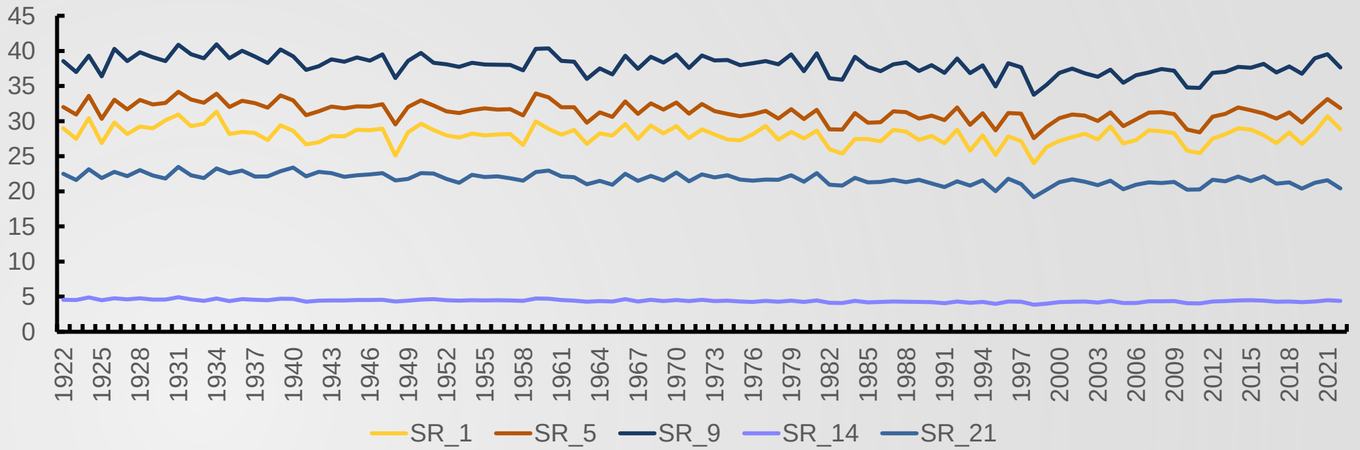
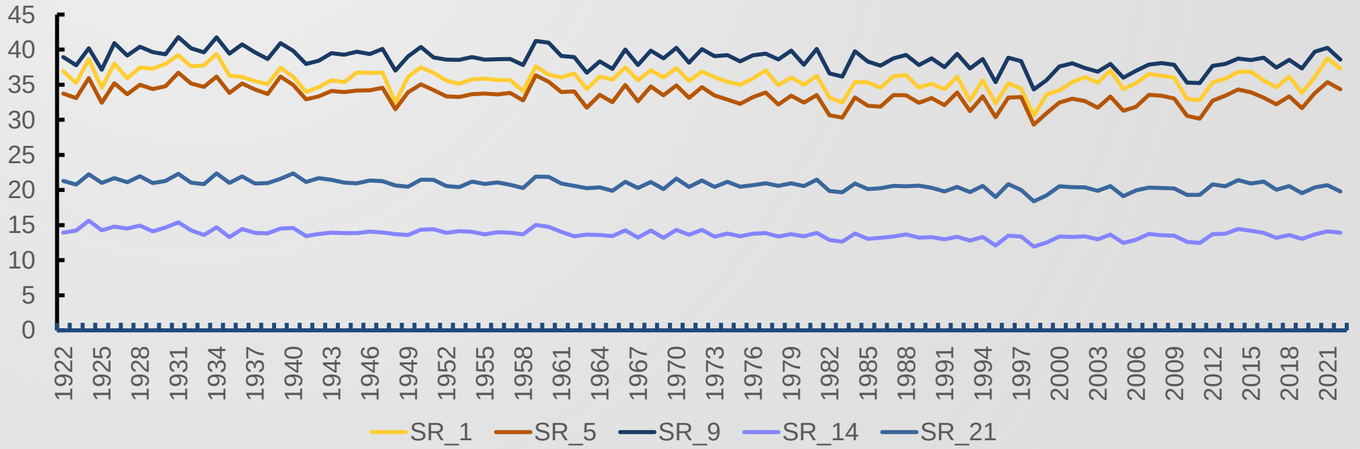
# Estimate actual ETc for 100 years

- The annual ETc in depth varies dramatically in different subregions.
- Some subregions have similar magnitudes for OpenET-HS and ITRC-HS, but some don’t. It needs more investigation.
- The crop coefficients and ET input for C2VSimFG will be improved by considering the remote sensing estimates, local observed data, GSP subbasin-level estimates, and related documents.

Annual ITRC-HS pasture ET for 5 C2VSimFG subregions (unit: inches)




Annual OpenET-HS pasture ET for 5 C2VSimFG subregions (unit: inches)

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# Summary

- The 1922-2021 Central Valley land use and ET have been estimated based on the current available data. Keep updating with new data.
- Remote sensing data analysis indicates the ET variation in time and space much more specifically.
- Calibrating C2VSimFG with latest ET/water demand analysis is on-going.
- Improving the data processing tools to apply more remote sensing information into hydrology modeling.