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Land Surface Process Updates to C2VSimFG

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  - Kern Groundwater Authority and Todd Groundwater
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  - Tracy Subbasin GSAs
  - Turlock and Modesto Subbasins GSAs
  - White Wolf Subbasin GSAs

Outline

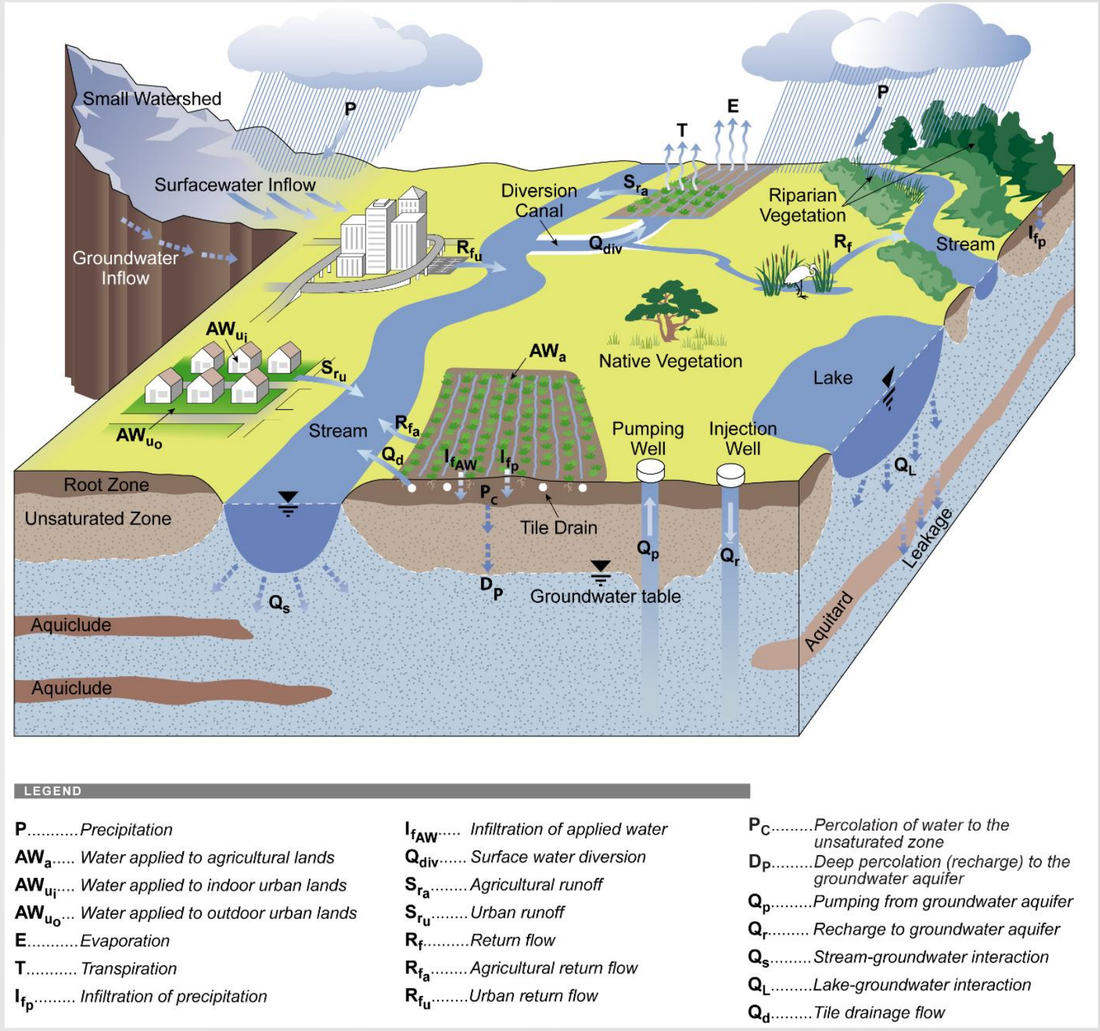
- C2VSimFG v1.5 model updates in land surface process
  1. Historical simulation extended from WY1974-2015 to WY1974-2021.
  2. Reconstructing precipitation, land use, ET, and urban water use for WY1922-2021.
  3. Manual calibration of root zone with measured groundwater levels. No full calibration.
  4. Understand the correlations among integrated surface water-groundwater processes at subregional scale.

- V1.5 resolved some major issues of root zone process in v1.01
  1. Land Use: data discontinuity and inconsistency.
  2. Evapotranspiration(ET): unreasonable ET for native, water surface, urban; spatial distribution.
  3. Precipitation: data processing bug
  4. Soil parameters: unreasonably high supply requirement, percolation, and …
  5. Delta: tile drain and pumping
  6. Groundwater elevations: Groundwater levels above ground surface

Major land surface water budget

- Major reason of groundwater change in Central Valley: pumping
- Major components of land surface water budget to determine pumping

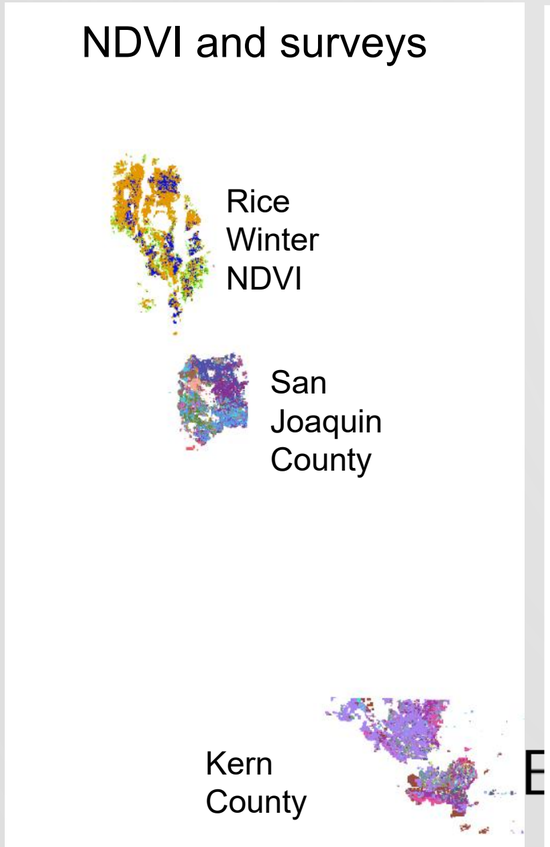
major supplies ~ **major supply requirements**

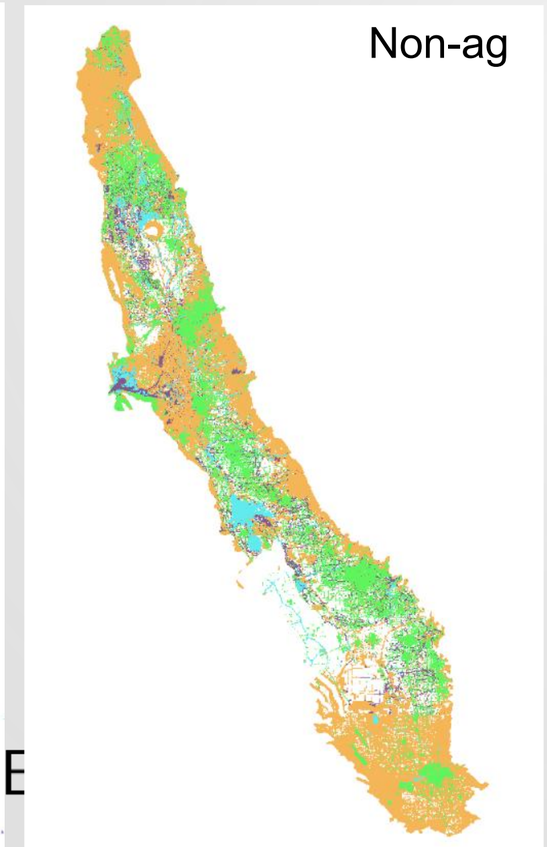


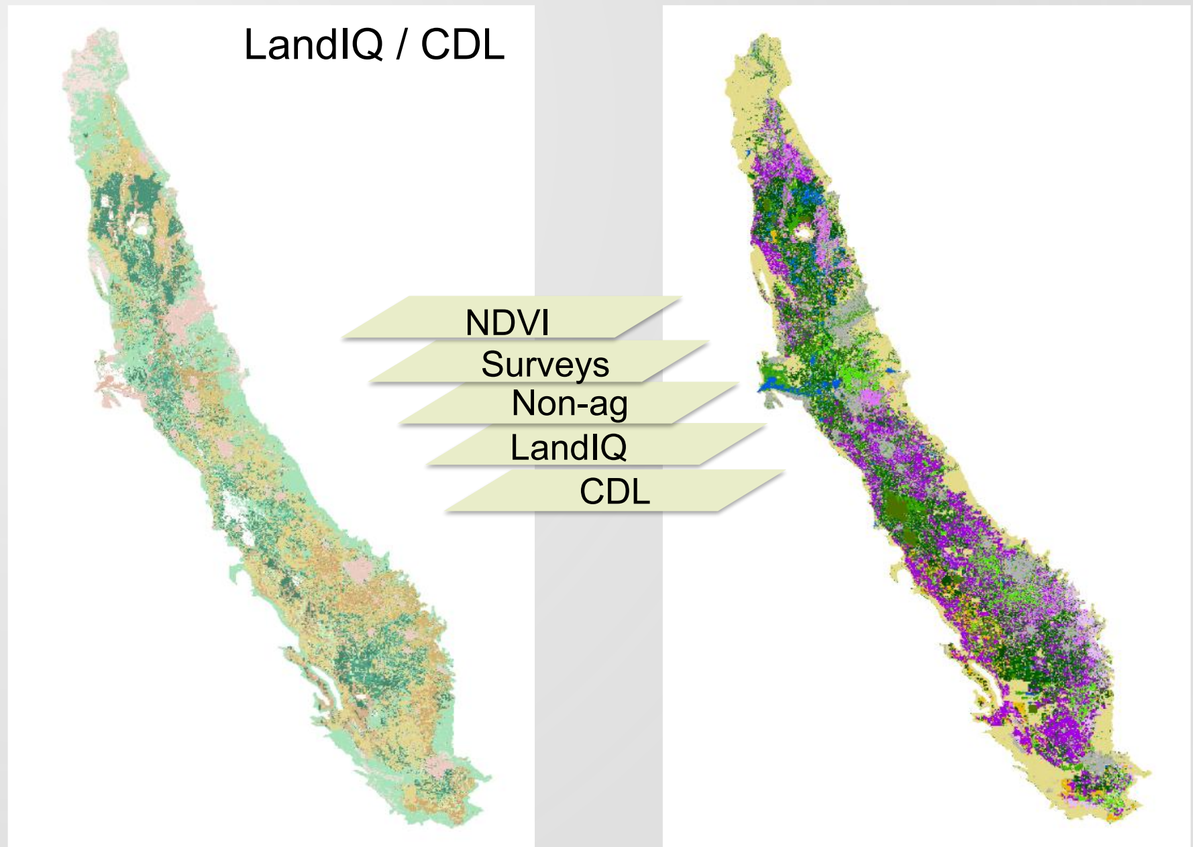
From IWFM

Historical land use (1974-2021)

- Vectors
  - DWR or county surveys for the years 1976, 1986, 1988-1991, 1993-current
  - LandIQ agriculture crop mapping (2014, 2016, 2018-2021)
  - LandIQ 2018 fill-in map of Central Valley
- Rasters
  - USDA Cropland Data Layer(CDL) for the years 2008-2021
  - Landsat images since 1984
  - Sentinel 2 images since 2016
- Tables, DWR Water Plan before 2008
- **Annual land use sources priorities, crosswalk tables**



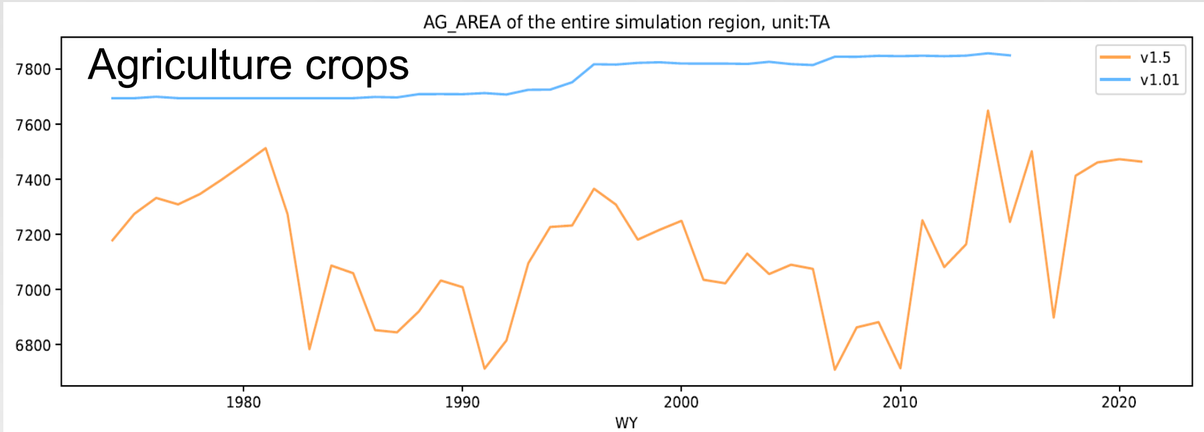


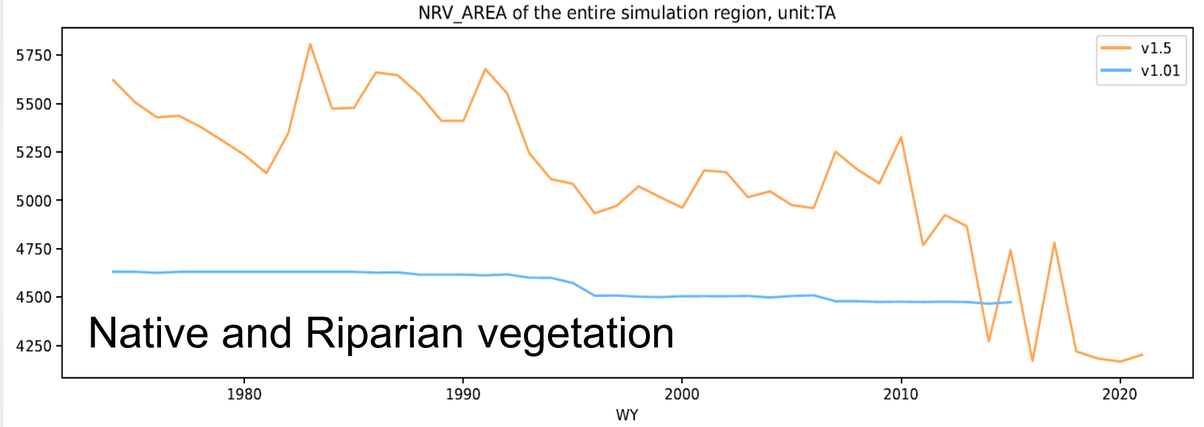


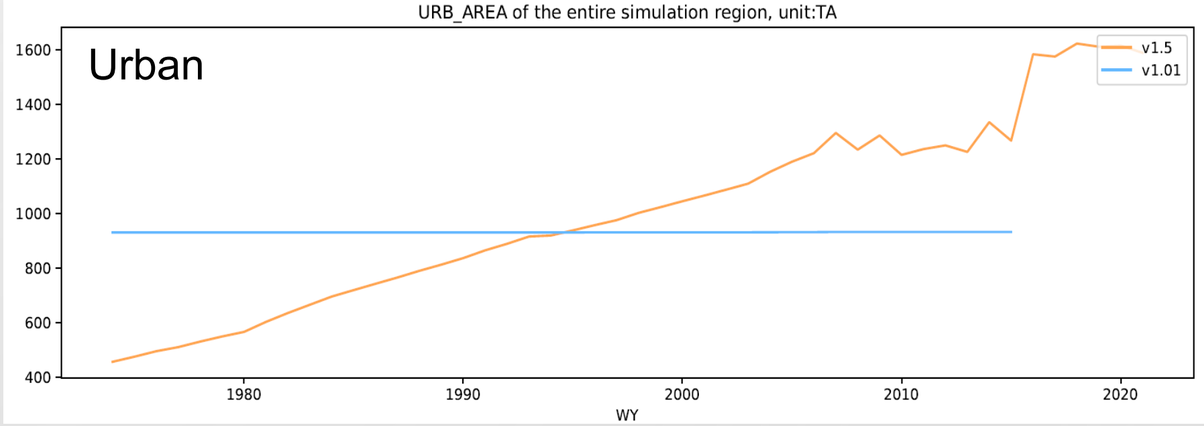
Land use comparison

- Compare historical land use inputs of v1.5 and v1.01 for the whole Central Valley
  - Agriculture crops
  - Native and riparian vegetation
  - Urban

- V1.5 reflects more historical variations of land use.







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ET improvement

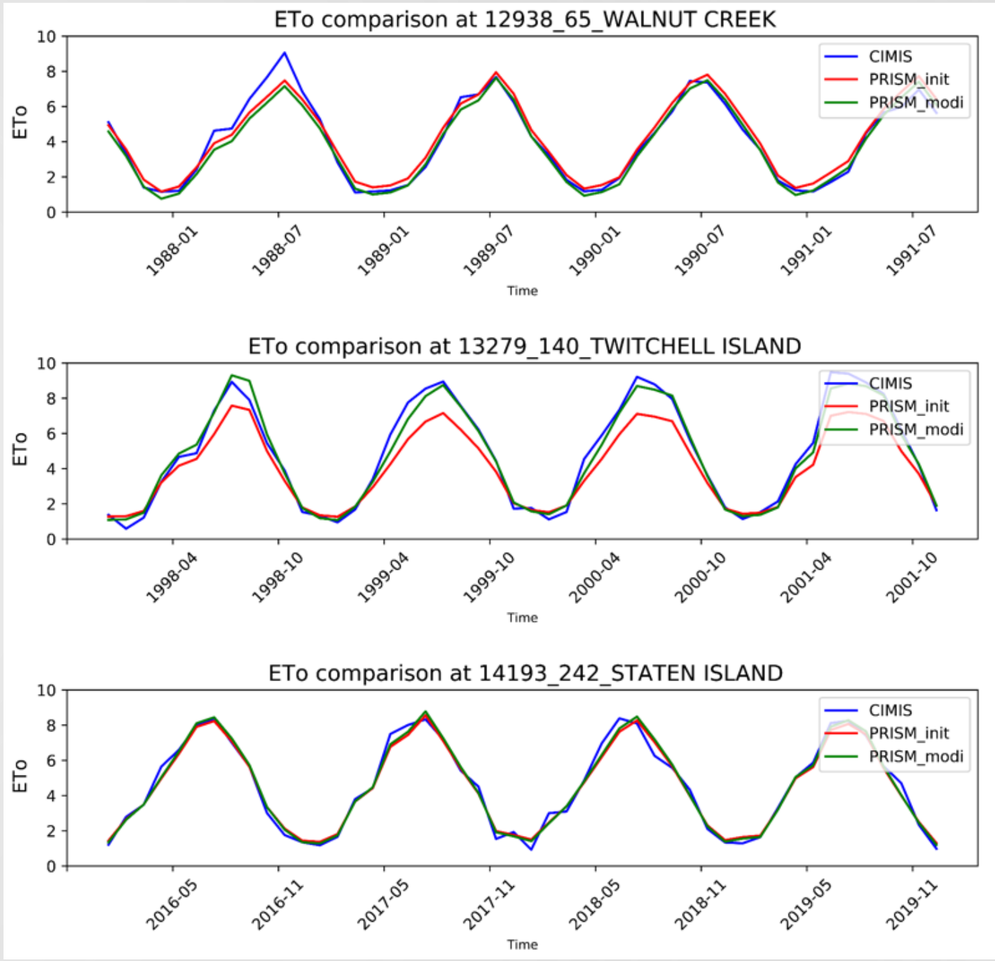
- The methodology to estimate historical ET input in the Central Valley:

$$ET = K_{gw} * K_t * (K_{0a} * ET_0 + K_{0b})$$

- Reference ET(ETo)
  - Calculate historical ETo with PRISM temperature
  - K_{0a} and K_{0b}, calibrated from the ETo of CIMIS weather stations

- ET target (ETt)
  - ETt, spatial averaged of ET estimated by ITRC for 25 land use categories and 21 subregions
  - $K_t = ETt / (K_{0a} * ET_0 + K_{0b})$

- Calibrate C2VSimFG ET input
  - Apply spatial averages of OpenET ensemble as the ET input for small watersheds
  - Calibrate ET input and make model output AET close to ETt
  - K_{gw} determined by calibrating soil parameters, tile drains, and other model inputs to match local ET and observed groundwater levels



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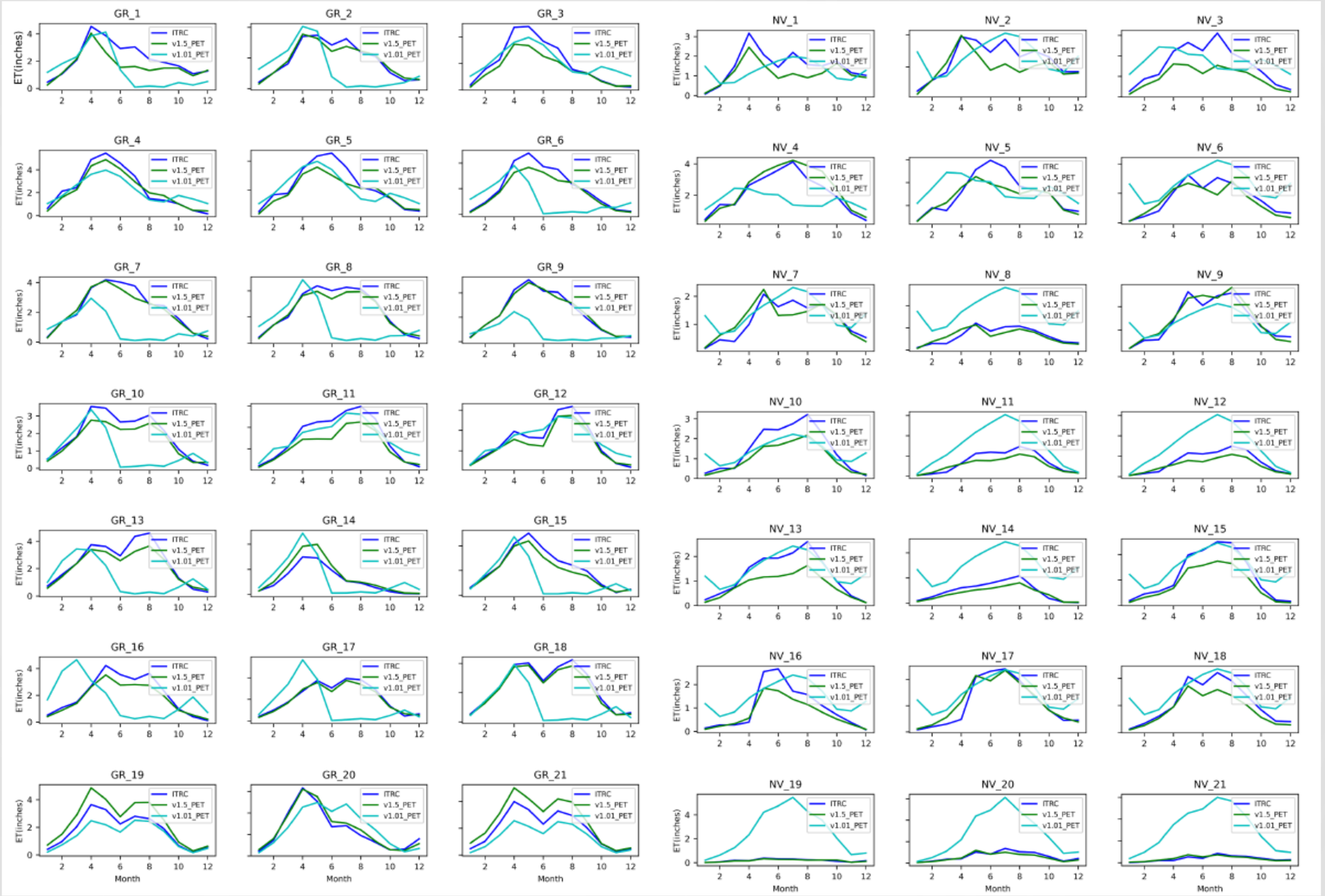
Regional scale comparison

- Examples to show ET improvement:
  - grain(GR) and native(NV)
  - the spatial difference in 2011
  ITRC-based ETt
  v1.5 ET input (PET)
  v1.01 PET
- Adjust ET input of v1.5 according to ITRC ETt



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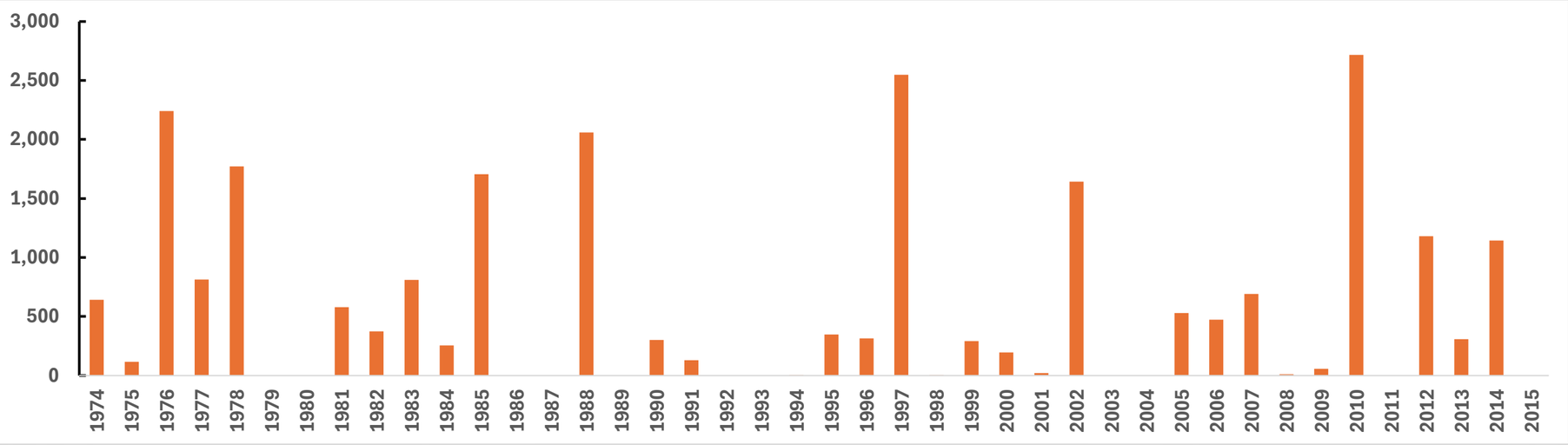
Precipitation

- ArcGIS parallel processing will be interrupted randomly when running too long.
- C2VSimFG v1.5 corrected the missed precipitation in south Central Valley.
- V1.5 has higher precipitation for a few months than v1.01.

Annual precipitation difference (v1.5-v1.01) in the Central Valley (unit: TAF)

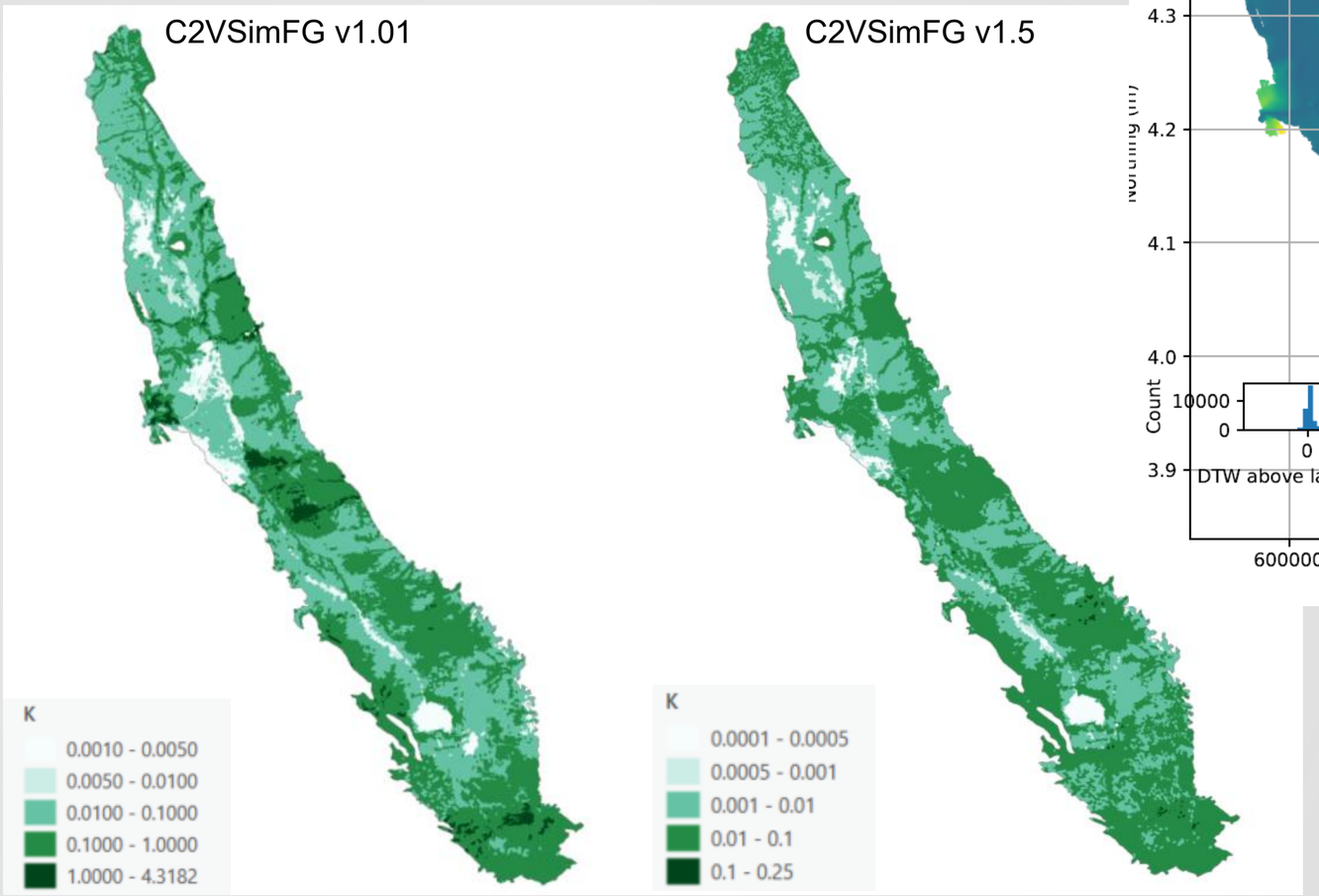


Soil parameters for root zone

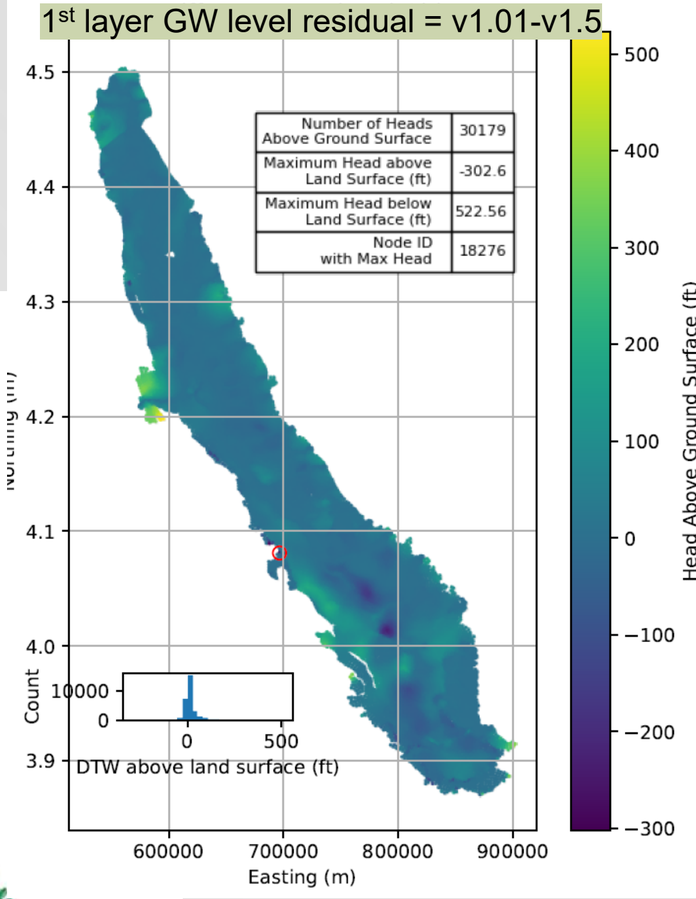
- Goals
  - Remove abnormal values
  - Balance between water demand and supplies
  - Better match of observed groundwater elevations

- Adjusted parameters
  - <u>hydraulic conductivity [0, 0.2008]</u>
  - capillary rise [0, 5]
  - field capacity [0.001, 0.5236]
  - wilting point [0, 0.4398]
  - total porosity [0.01, 0.6068]
  - <u>ponded-K [0, 0.7465]</u>

- Example:
  - hydraulic conductivity (K)



Unit: ft/day



Brings significant reduction of groundwater head residuals between v1.5 and v1.01 in Subregions 6,7,9,14

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The impacts of model updates

- Impact on water budget
  - ET
  - Pumping
  - other water budget terms

- Impact on groundwater
  - groundwater level
  - groundwater storage
  - groundwater-surface water interaction

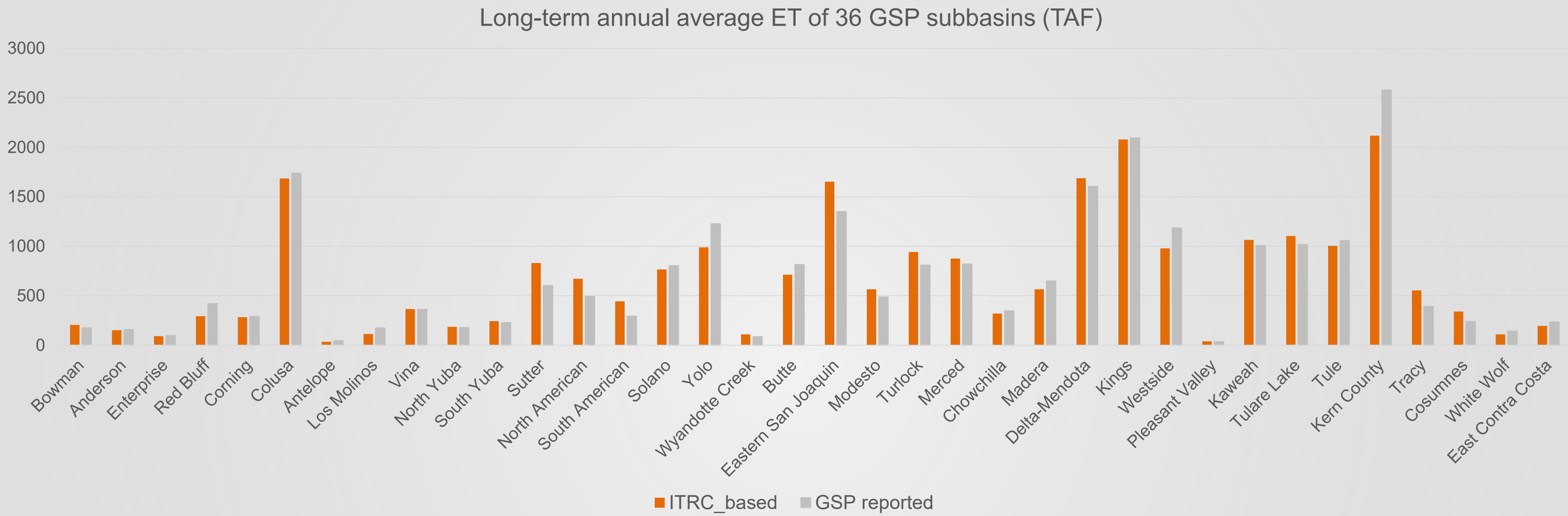
1985-2015 C2VSimFG v1.5 actual ET

- Model estimated Agriculture AET could meet ETt.
- Due to limits of C2VSimFG, non-ag AET could not meet ETt well currently.

Actual ET averages

Unit: TAF	1985-2015 ITRC ETt	1985-2015 V1.5 AET	1974-2015 V1.01 AET
Agriculture	17705	18023	19074
Urban	1156	950	907
Native & Riparian	6226	4935	3910
Total	25087	23908	23891

C2VSimFG v1.5 historical ET



- ITRC based ETt: long term averages for WY1985-2015
- GSP reported ET: long term averages of available years from GSP reports, except Delta-Mendota and Kern County. The total water use of these two GSPs without managed recharge in the 2019-2021 annual reports were used to substitute ET.
- Total ET of 36 GSPs: ITRC based ETt 24366 TAF; GSP reported 24262 TAF

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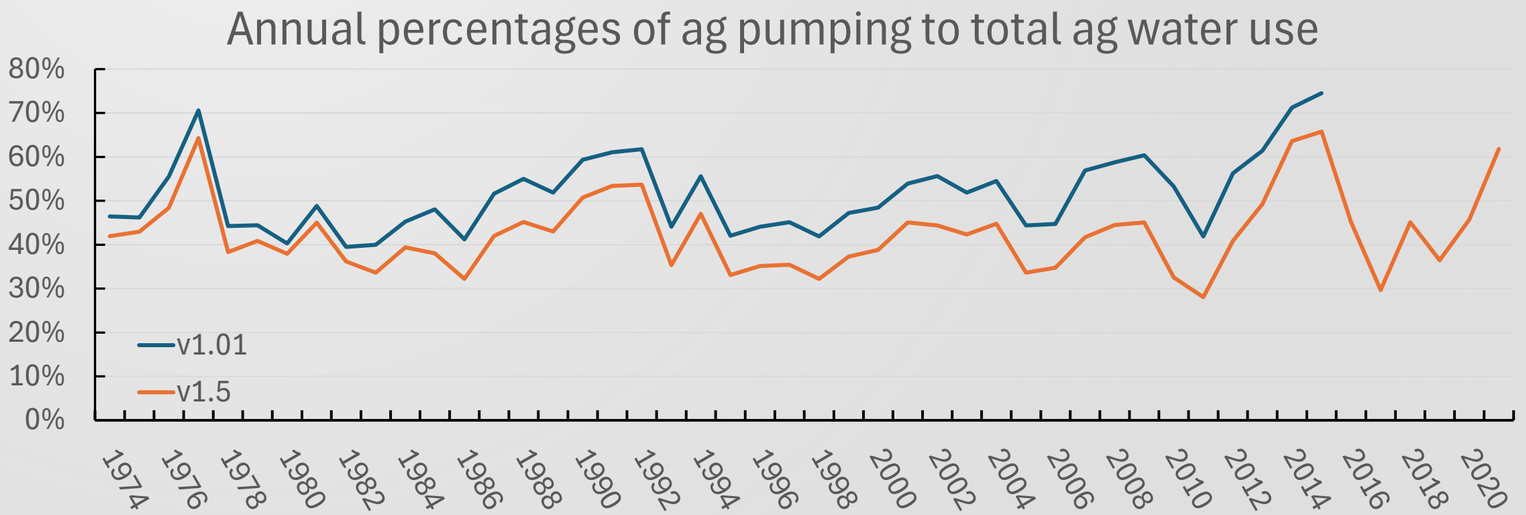
1985-2015 average major demands and supplies

C2VSimFG v1.01	Area	PET	AET	ETaw	Supply Requirement	Deliveries (Div)	Pumping (P)	Div+P	Ag Return	Percolation	Eff. P
Agriculture	7791	21641	19075	14962	23495	10997	12383	23380	1862	8121	4114
Urban	931	3140	966		1710	376	1334	1710		1511	
Native & Riparian	4534	10315	3904		0	0	0	0		266	
Total	13256	35096	23945	14962	25205	11373	13717	25090		9898	

C2VSimFG v1.5	Area	PET	AET	ETaw	Supply Requirement	Deliveries (Div)	Pumping (P)	Div+P	Ag Return	Percolation	Eff. P	GW uptake
Agriculture	7068	19683	18023	12856	17190	11253	8177	19430	2787	4184	4454	713
Urban	1044	2170	950		1808	405	1395	1800		340		
Native & Riparian	5144	6124	4935		0	0	0	0		1382		201
Total	13256	27977	23908		18998	11658	9572	21230		5906		914

Unit:
area – TA
volume - TAF

- Supply Req ~ ETaw + Percolation
- Major issue in v1.01: percolation
- Percolation impacts on pumping



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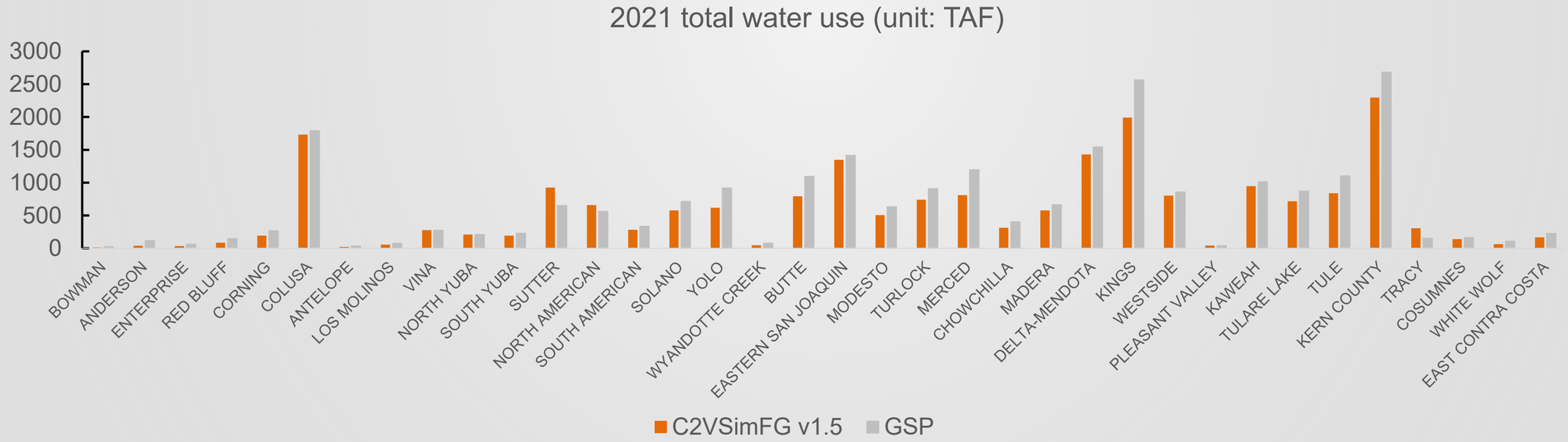
Compare to GSP water supplies

- GSP listed WY2021 water supplies for 36 GSP GW basins are higher than v1.5 simulated.
- The 2021 total GW pumping is much higher than surface deliveries.

	Total Water Use	Pumping	Deliveries
Listed in 36 GSPs	24131	15469	8662
C2VSimFG v1.5	21287	13452	7835
Percent = v1.5/GSP	88%	87%	90%



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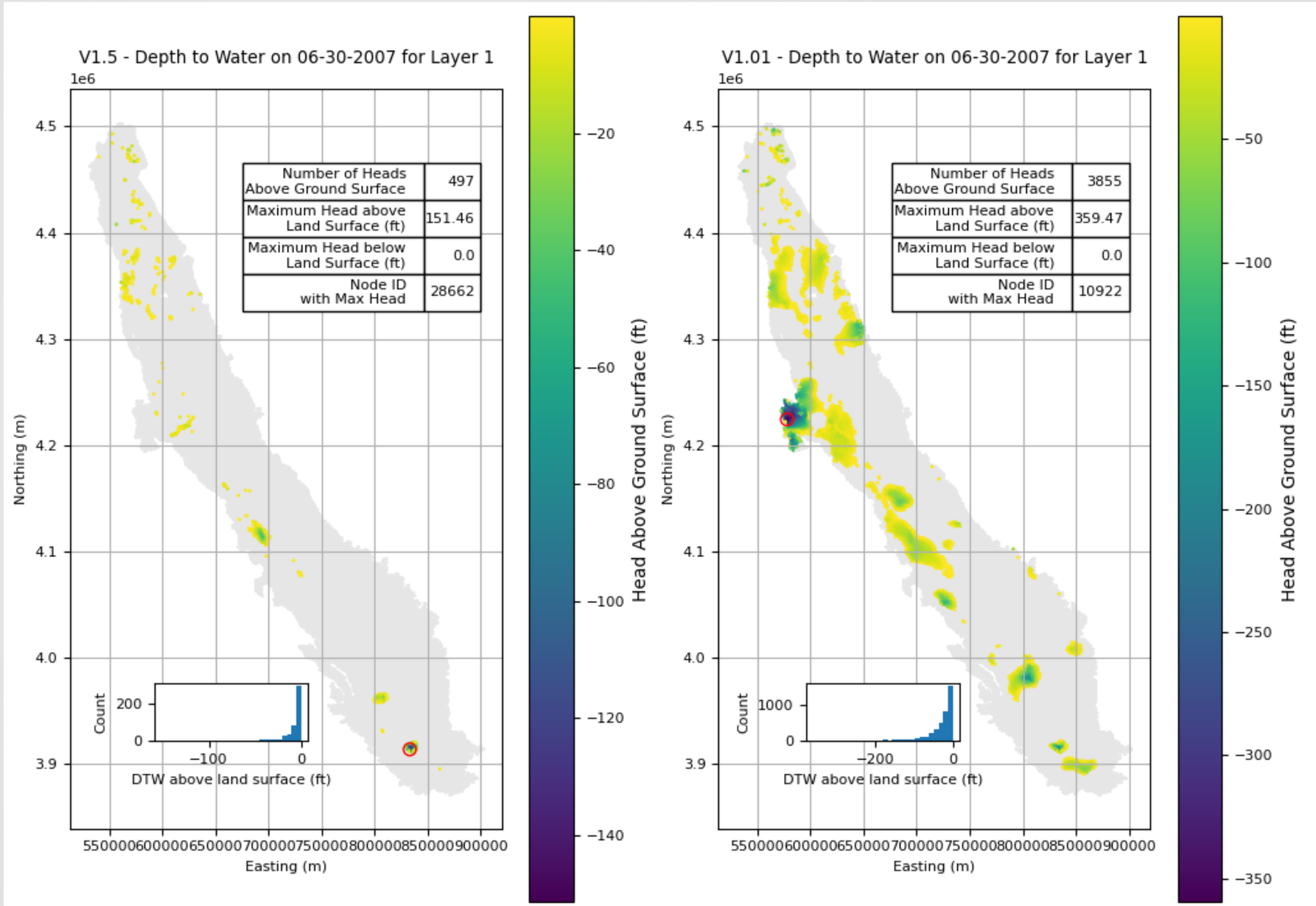
Root zone adjustment on groundwater levels

- Groundwater levels above ground in C2VSimFG v1.01

- Major reasons:
  - Supply requirement
  - Low ET in NV and RV
  - No tile drain in Delta
  - Channel bathymetry
  - Managed recharge

- Adjustments in v1.5:
  - Root-zone hydraulic conductivities and other soil parameters
  - Land use and ET
  - Groundwater uptake
  - Tile drain in Delta

- GW levels spatial difference:
  - One example



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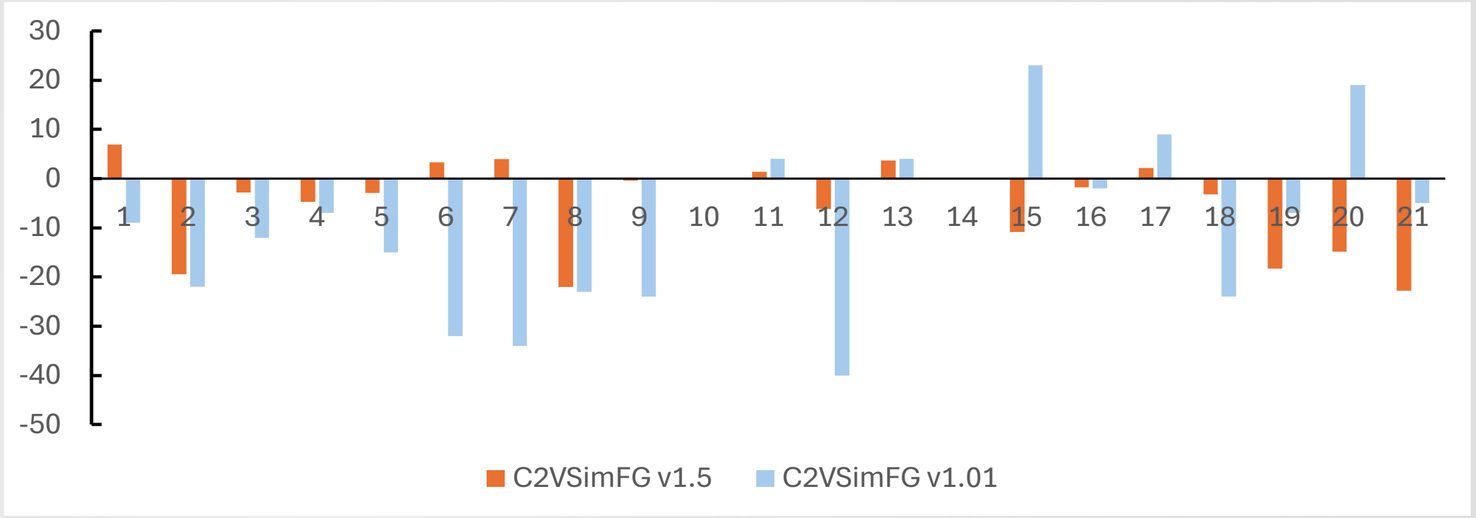
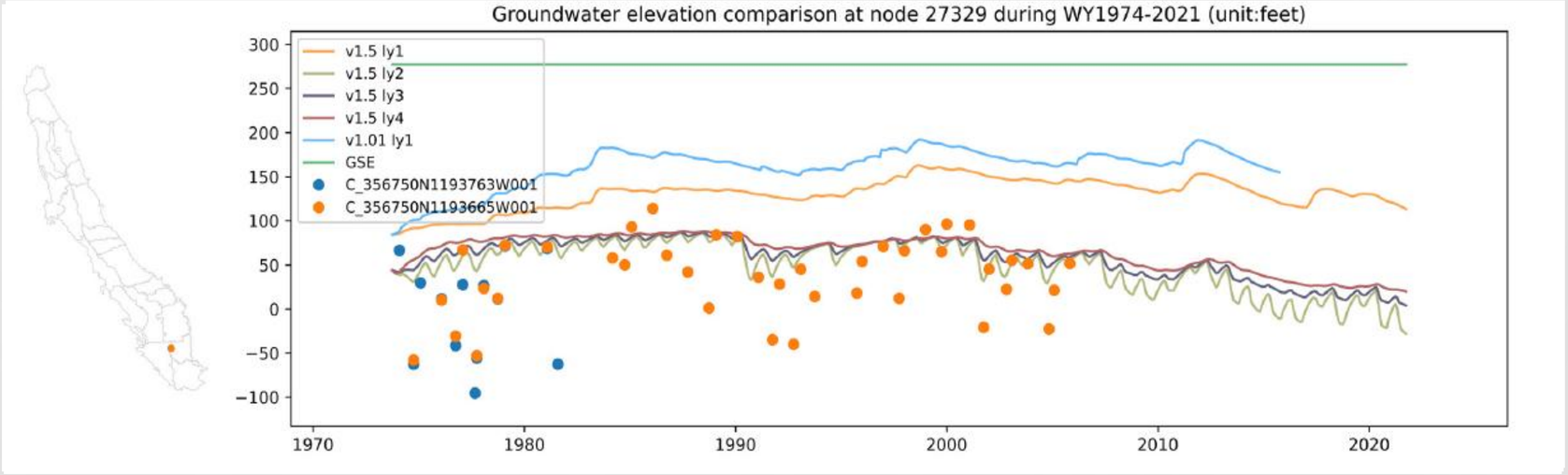
Groundwater level estimates for subregions

- 12,204 well data from DWR Periodic Groundwater Level Measurements dataset
- Improved GWL in most subregions in middle of the Central Valley, such as subregions 3, 5, 6, 7, 9,10,12,14,15, and 18
- Improvement in subregion 18 after removing Kaweah and Tule Rivers end of reaches recharge as flood bypass
- C2VSimFG v1.5 groundwater level in north and south ends of the Central Valley needs more investigation, such as subregions 19-21.

Comparison of averaged groundwater residuals by subregions (unit:feet)





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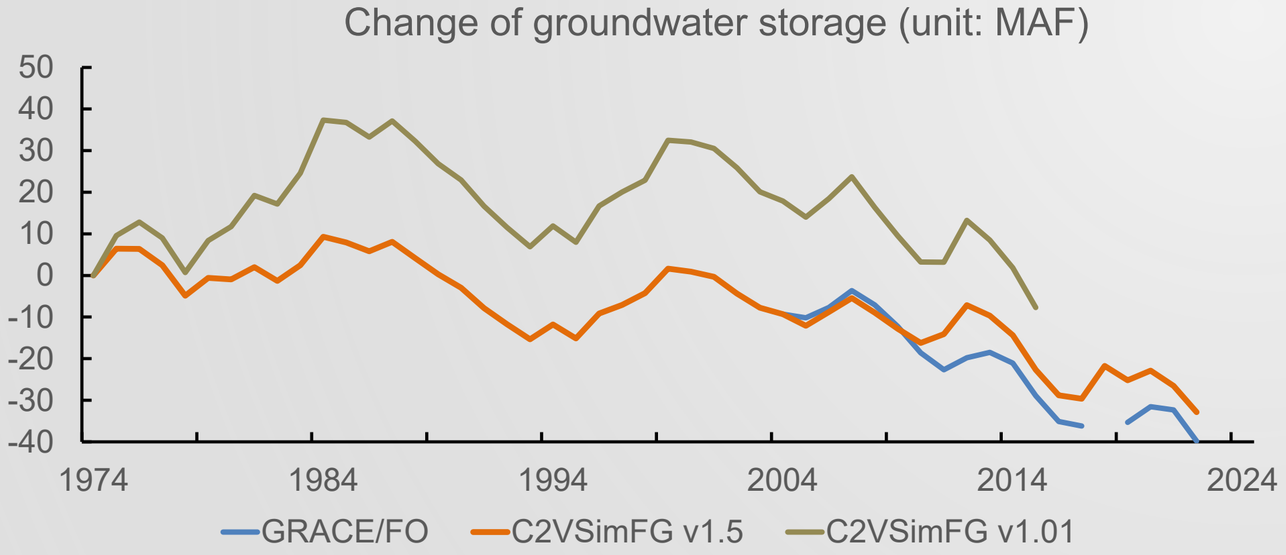
Groundwater storage change

- About 33MAF groundwater storage reduction from 1974 through 2021
- Similar temporal trend and magnitude as GRACE/FO data for the Central Valley
- The pumping has serious impact on groundwater storage and groundwater level.



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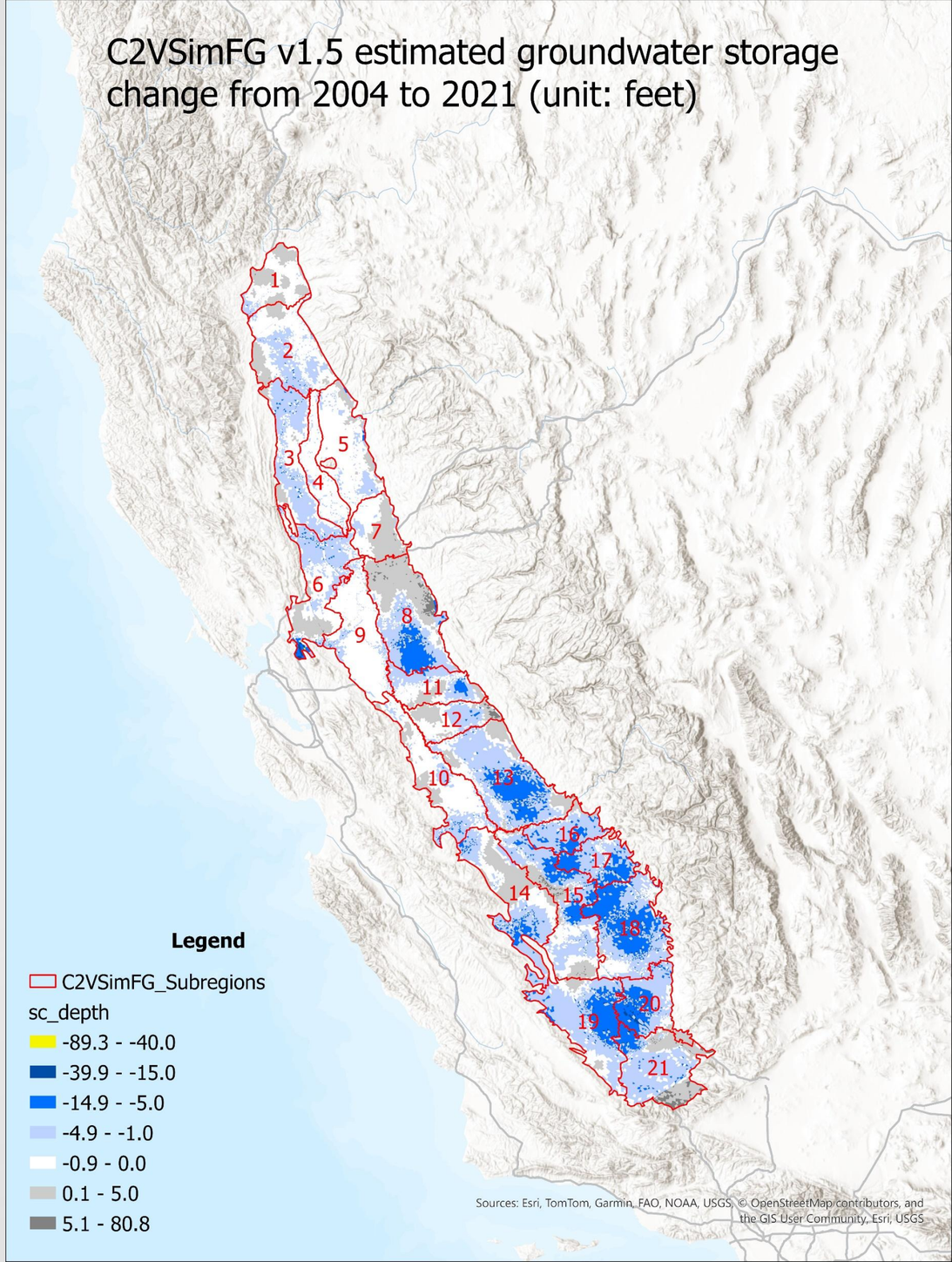
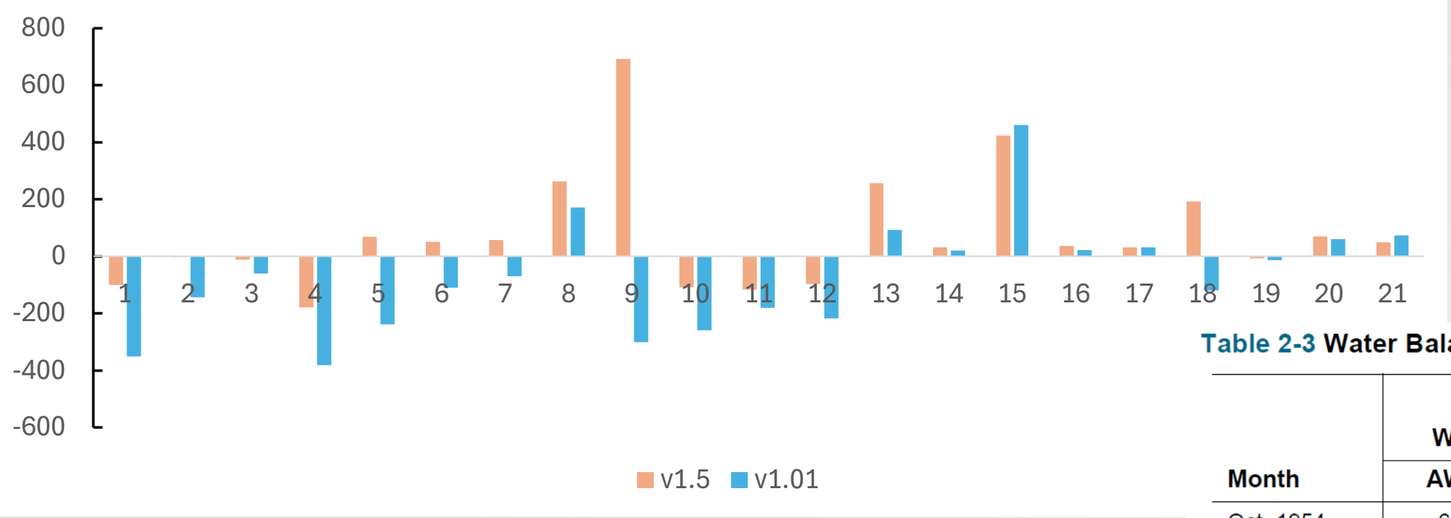


Groundwater-surface water interaction

Comparison of annual averaged groundwater gain from stream (unit: TAF)



From DCD document

Table 2-3 Water Balance in Delta Lowlands, Water Year 1955 (in acre-feet)

	Water Supply		Water Disposal		Subsurface Water (Drn+CU) – (AW+P)		
Month	AW	P	Drn	CU	SSW	AW+SSW	SSW/(AW+SSW)
Oct. 1954	6,560	350	46,817	91,164	131,071	13,7631	
Nov. 1954	0	81,441	46,537	42,573	7,669	7,669	
Dec. 1954	0	127,579	85,731	32,915	-8,933	-8,933	
Jan. 1955	0	104,161	95,668	22,371	13,878	13,878	
Feb. 1955	0	40,895	41,960	26,108	27,173	27,173	
March 1955	6,560	23,768	32,419	35,001	37,092	43,652	
Apr. 1955	26,240	75,499	37,628	84,015	19,904	46,144	
May 1955	45,910	24,467	49,813	129,609	109,045	154,955	
June 1955	118,060	0	71,084	136,679	89,703	207,763	
July 1955	216,450	0	80,606	191,744	55,900	272,350	
Aug. 1955	170,540	0	72,170	211,339	110,969	281,509	
Sept. 1955	65,590	17,127	43,116	156,805	117,204	182,794	
Total	655,910	495,287	703,549	1,160,323	710,675	1,366,585	52%

Source: Based on Table 12 in *Investigation of the Sacramento-San Joaquin Delta, Report No. 4, quantity and quality of waters applied to and drained from the Delta lowlands*, Kabakov S, et al. 1956.

Notes: AW = applied water, CU =consumptive use, Drn = drainage, P =precipitation, SSW = subsurface water

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Conclusion

- The new methodologies were developed to build up the historical land use and ET for C2VSimFG. They have been updated with more reliable information and could extend time series systematically.
- With the historical land use, ET, precipitation, and root zone calibration and validation, the major issues in v1.01 have been removed or mitigated.
- The current version improves groundwater levels for the middle regions in Central Valley but still needs more investigation, especially near the south and north boundaries.