Overview of Satellite Based Evapotranspiration Technology and Agricultural Water Demand Comparison in the Los Osos Groundwater Basin

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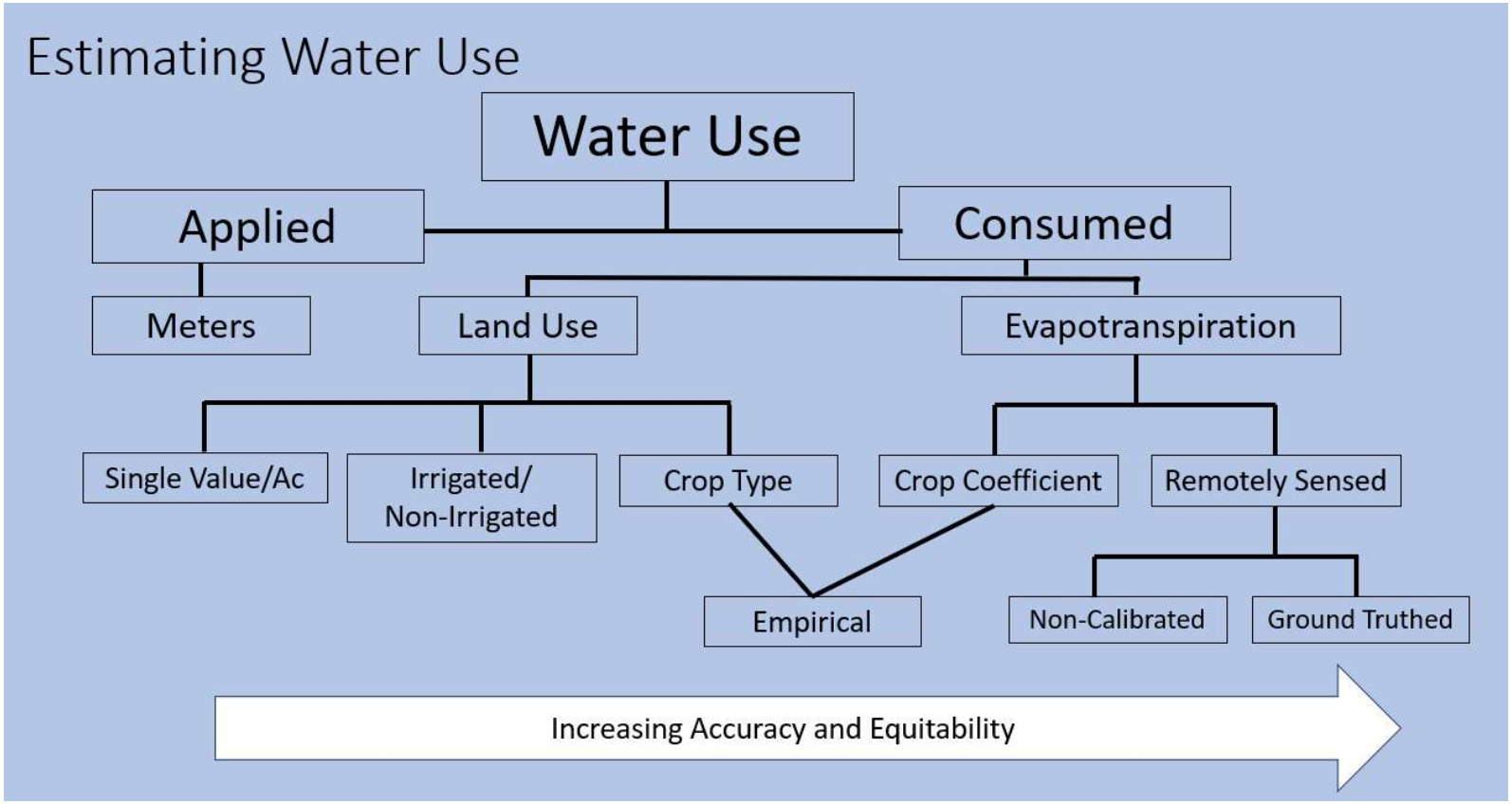
March 20, 2024

Estimating Agricultural Water Use

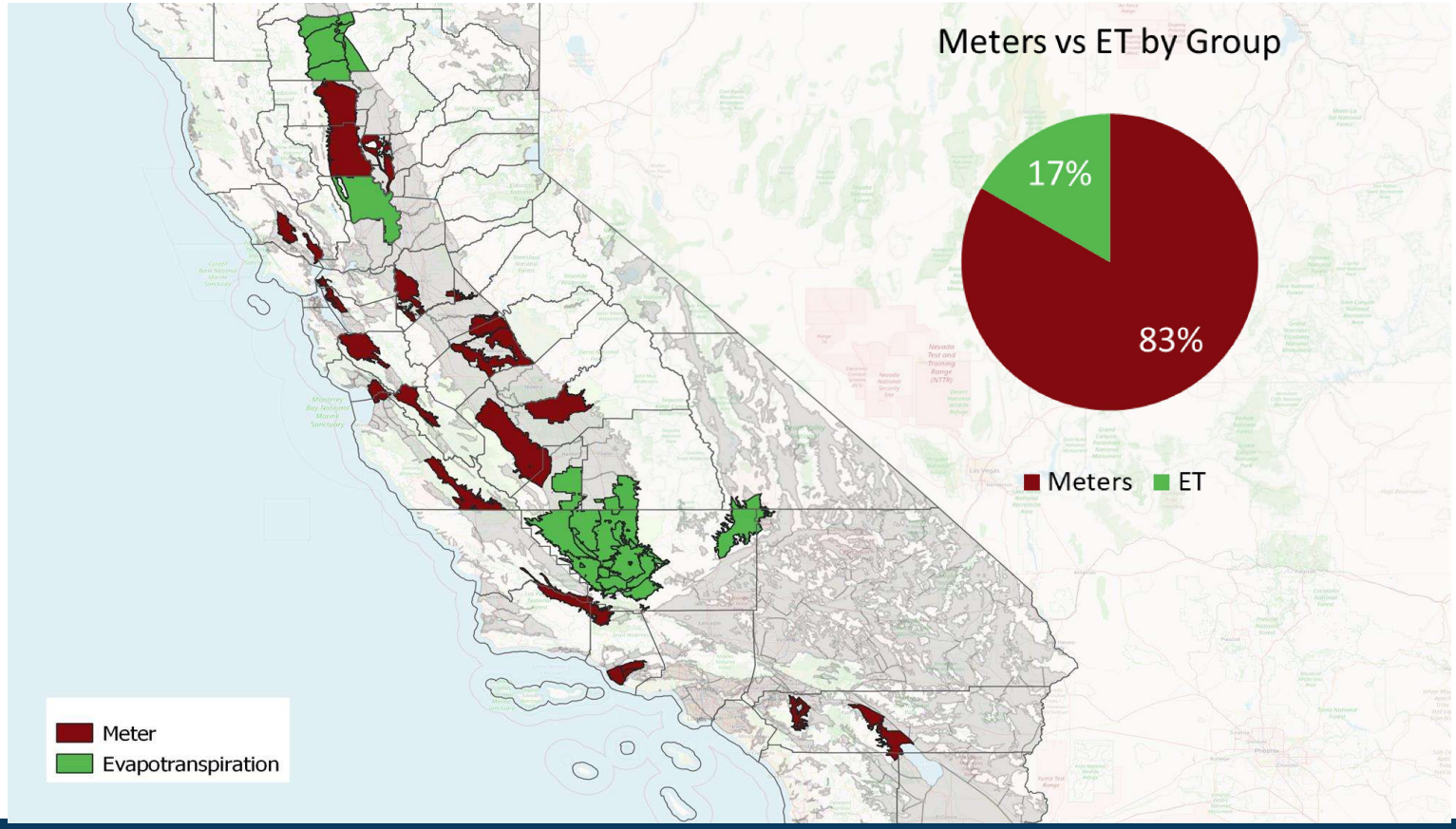


HOW IS WATER "USE" MEASURED AT THE FIELD LEVEL?

Two Ways:

- Meters
  - Water flow usually measured with an in-line propellor or magnetic type meter
  - This is also called applied water
  - Meter = Applied
- Evapotranspiration (ET)
  - Water that evaporates from the soil, plant or other surfaces AND water that transpires through and out of the plant
  - This is also called consumed water
  - ET = Consumed

Estimating Agricultural Water Use



HOW IS WATER "USE" MEASURED AT THE FIELD LEVEL?

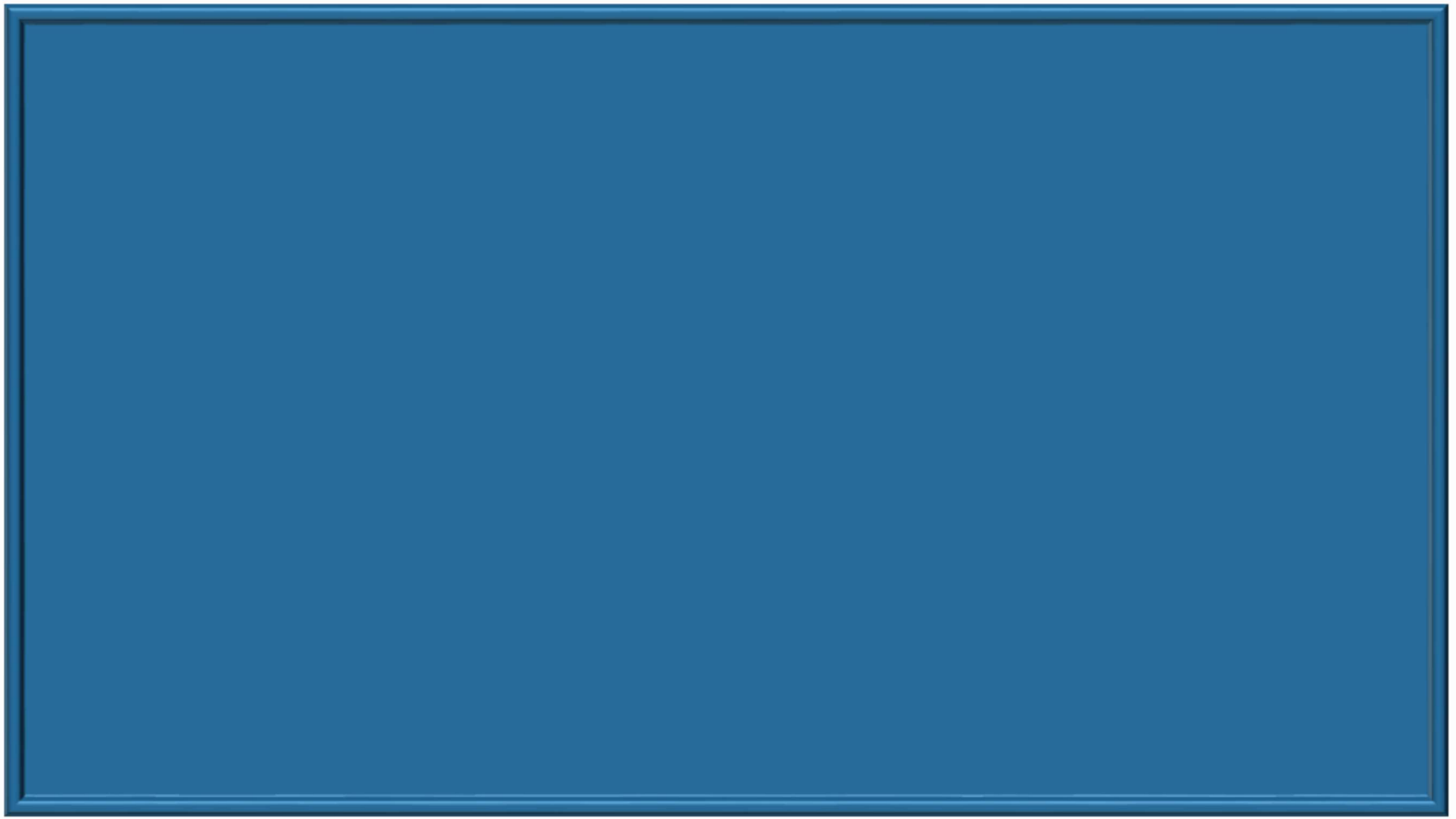
Meter (Applied Water) Attributes

- A "gross" measurement of water use
- Direct measurement of groundwater pumping
- Does not account for the portion of applied water that stays within the system
- Measured with in-line/in-pipe meters
- Wide range and quality of meters available on the market
- Requires repeated calibration of meters to result in accurate measurements of pumped water over time
- Data collection and management can be a significant effort
- Most beneficial if correlated to area irrigated

HOW IS WATER "USE" MEASURED AT THE FIELD LEVEL?

Evapotranspiration (Consumed Water) Attributes

- A "net" measurement of water use
- Best estimated via ground truthed/calibrated and validated remotely sensed models
- Results in differences between fields of the same crop
- Measures the water that leaves the system
- Any excess water not consumed stays within the system (e.g. percolates back to groundwater or is stored)
- Can be estimated with reference crop ET (ETo) and crop coefficients (Kc), however all crop types will have the same ET
- Accuracy matters



Potential Benefits of Satellite-Based ET in SLO County Groundwater Management

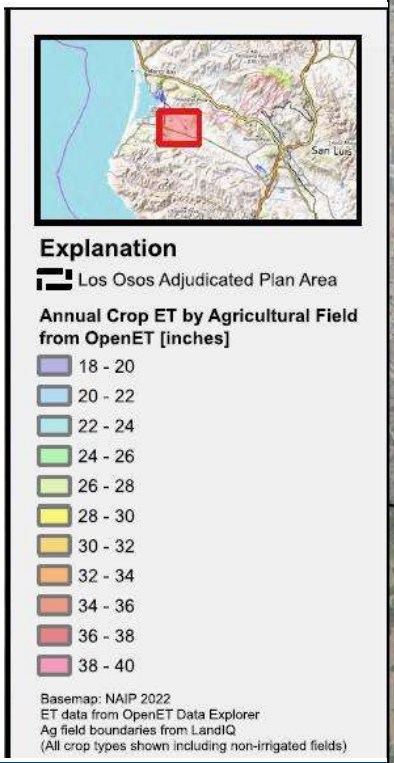
- Developing more effective management plans and incentive programs.
- Evaluate agricultural water demand and use patterns and inform basin planning to meet future groundwater basin sustainability goals.
- Understanding how much water crops are consuming to optimize irrigation, sustain groundwater basin conditions, and reduce groundwater pumping.
- Provide agencies with a transparent and neutral data source based on the best available science that can be used to co-develop solutions with local communities and reduce debate about the numbers used to justify decisions.
- Provides consistent, high-quality data for use by all decision-makers working to manage water supplies across multiple boundaries and jurisdictions.

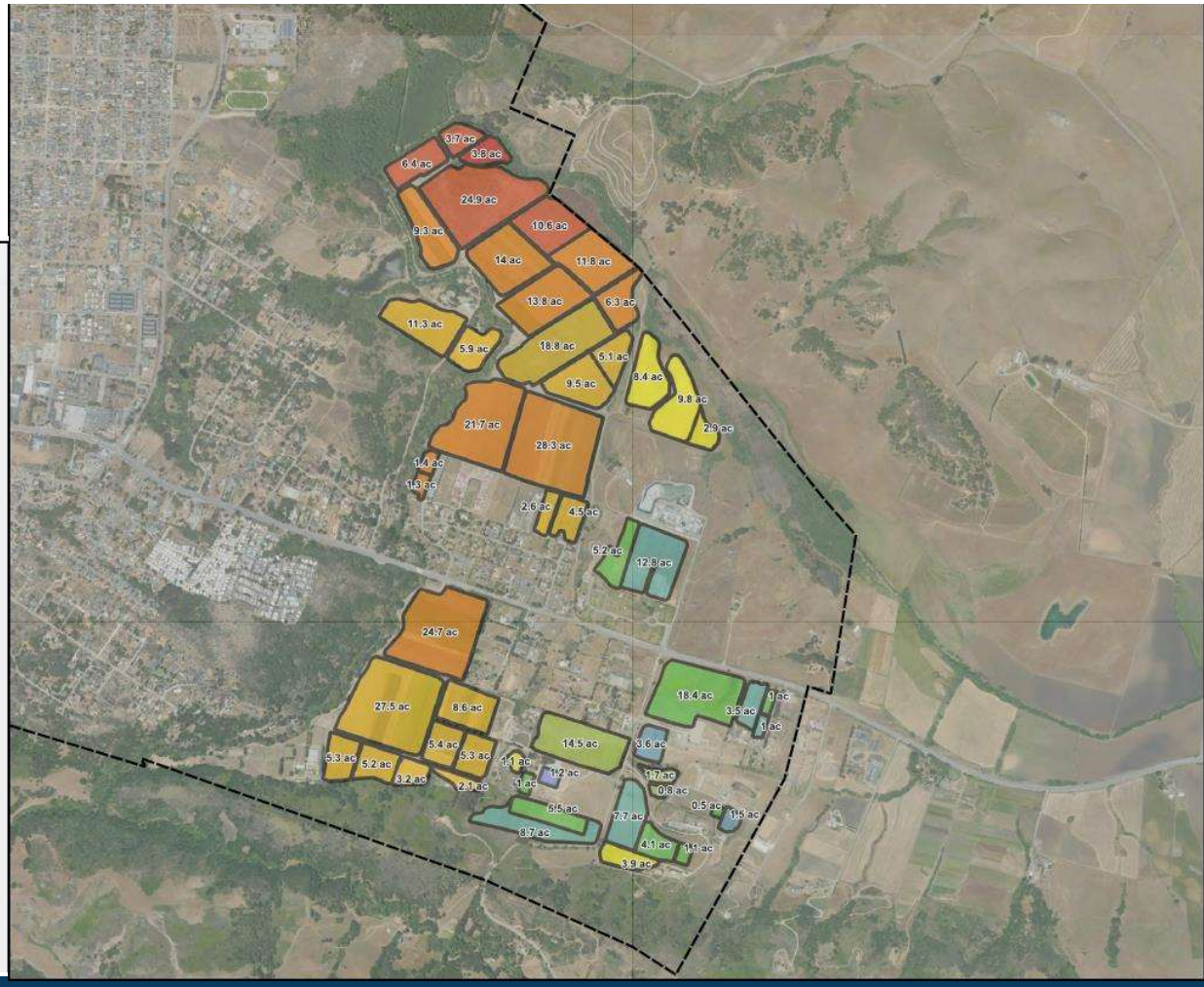
AGRICULTURAL WATER USE IN LOS OSOS GROUNDWATER BASIN

Agricultural water use is a major component of Basin groundwater use:

- Currently estimated at 34 percent of 2022 Basin production (680 acre-feet out of a total of 2,010 acre-feet).
- No water meter data are available from agricultural wells, so the production is estimated.
- The current methodology for agricultural irrigation water use estimates used for Los Osos Basin management involves a daily soil-moisture budget (SMB).
- An alternative methodology, used by OpenET, is based on open-source remote sensing (satellite) data and a surface energy balance.
- Agricultural water demand estimates using two methodologies are compared over three years (2020, 2021, and 2022) (CHG TM July 17, 2023)

Use of ET For Estimating Agricultural Groundwater Use Los Osos Basin





COMPARISON OF WATER USAGE ESTIMATING METHODOLOGIES

A comparison between OpenET and SMB reported monthly Crop Evapotranspiration (Etc) values for calendar years 2020, 2021, and 2022 is summarized in Table below.

Month	2020 ETc (in)		2021 ETc (in)		2022 ETc (in)		Average ETc (in)	
	OpenET	SMB	OpenET	SMB	OpenET	SMB	OpenET	SMB
Jan	1.22	0.96	1.16	1.13	1.27	1.09	1.22	1.06
Feb	1.51	1.39	1.60	1.32	1.35	1.46	1.49	1.39
Mar	2.08	1.80	2.24	2.24	2.63	2.37	2.32	2.13
Apr	3.06	2.38	3.05	2.40	3.73	2.79	3.28	2.52
May	3.64	4.73	3.83	4.24	4.08	4.96	3.85	4.65
Jun	3.94	5.54	4.21	5.64	4.39	6.16	4.18	5.78
Jul	3.90	5.24	4.26	5.30	4.36	5.45	4.17	5.33
Aug	4.21	4.18	3.71	4.31	3.90	4.84	3.94	4.44
Sep	3.03	3.10	2.59	3.28	3.12	3.66	2.91	3.35
Oct	1.75	2.40	1.79	2.32	1.89	2.00	1.81	2.24
Nov	1.02	1.43	1.44	1.44	1.30	1.30	1.26	1.39
Dec	0.87	0.89	0.76	0.57	0.77	0.53	0.80	0.66
Total	30.23	34.03	30.65	34.18	32.81	36.62	31.23	34.94
Difference (inches)		-3.80		-3.53		-3.81		-3.71
AFY (vegetables)	710	800	650	730	700	780	670	750
Difference (AFY)	-90		-80		-80		-80	

Notes: ETc = Crop evapotranspiration; in = inches; AFY = acre-feet per year; vegetable AFY based on acreages from DWR Land IQ.

COMPARISON OF WATER USAGE ESTIMATING METHODOLOGIES

- OpenET only provides Crop Evapotranspiration (Etc), therefore, any further comparison with SMB methodology requires some assumptions for effective rainfall and irrigation system efficiencies.
- Effective rainfall was estimated (for the purposes of processing OpenET data) based on a fixed percentage of total rainfall that offsets ETc on a monthly basis. The OpenET developer suggested 90 percent as a default rate, while the annual reports reviewed used total rainfall as effective rainfall (100 percent ETc offset on a monthly basis).
- For this comparison, effective rainfall was assigned as 50 percent and 100 percent of total rainfall to gauge the sensitivity.
- A comparison between OpenET and SMB applied water use assuming 50 percent and 100 percent effective rainfall (with 80 percent system efficiency) is summarized below in the following tables.

COMPARISON OF WATER USAGE ESTIMATING METHODOLOGIES

A comparison between OpenET and SMB reported monthly ETc values for calendar years 2020, 2021, and 2022, assuming 50% effective rainfall and 80% irrigation efficiency is summarized in Table below.

Month	2020 Water Use (in)		2021 Water Use (in)		2022 Water Use (in)		Average	
	OpenET	SMB	OpenET	SMB	OpenET	SMB	OpenET	SMB
Jan	1.40	0	0	0	1.47	0	0.95	0
Feb	1.87	0	1.76	0	1.59	0	1.74	0
Mar	0.00	0	1.89	0	2.02	0.53	1.30	0.18
Apr	2.62	0	3.59	0.59	4.18	1.11	3.46	0.57
May	4.48	2.64	4.49	4.6	4.80	5.40	4.59	4.20
Jun	4.90	5.98	4.96	6.1	5.17	6.69	5.01	6.27
Jul	4.88	5.69	5.01	5.8	5.13	5.93	5.01	5.79
Aug	5.23	4.50	4.36	4.7	4.59	5.26	4.73	4.82
Sep	3.78	3.37	3.04	3.6	3.13	2.98	3.32	3.31
Oct	2.19	2.61	0.53	2.0	2.20	2.13	1.64	2.25
Nov	0.98	1.03	1.51	0	0.76	0.17	1.08	0.40
Dec	0.00	0.48	0	0	0.00	0	0	0.16
Total	32.32	26.30	31.14	27.32	35.04	30.20	32.83	27.94
Difference		6.02		3.82		4.84		4.89
AFY (vegetables)	760	620	660	580	750	650	700	600
Difference (AF)	140		80		100		100	

Notes: ER = effective rainfall; EFF = irrigation system efficiency; in = inches; AFY = acre-feet per year; vegetable AFY based on acreages from DWR Land IO

COMPARISON OF WATER USAGE ESTIMATING METHODOLOGIES

A comparison between OpenET and SMB reported monthly ETc values for calendar years 2020, 2021, and 2022, assuming 100% effective rainfall and 80% irrigation efficiency is summarized in Table below.

Month	2020 Water Use (in)		2021 Water Use (in)		2022 Water Use (in)		Average	
	OpenET	SMB	OpenET	SMB	OpenET	SMB	OpenET	SMB
Jan	1.27	0	0	0	1.53	0	0.93	0
Feb	1.84	0	1.74	0	1.69	0	1.76	0
Mar	0.00	0	1.21	0	0.99	0.53	0.73	0.18
Apr	1.42	0	3.82	0.59	4.21	1.11	3.15	0.57
May	4.41	2.64	4.74	4.57	5.10	5.40	4.75	4.20
Jun	4.87	5.98	5.27	6.13	5.49	6.69	5.21	6.27
Jul	4.88	5.69	5.32	5.76	5.45	5.93	5.22	5.79
Aug	5.21	4.50	4.63	4.68	4.87	5.26	4.90	4.82
Sep	3.78	3.37	3.23	3.57	2.75	2.98	3.26	3.31
Oct	2.19	2.61	0	2.03	2.32	2.13	1.50	2.25
Nov	0.68	1.03	1.40	0	0	0.17	0.69	0.40
Dec	0.00	0.48	0	0	0	0	0	0.16
Total	30.54	26.30	31.37	27.32	34.41	30.20	32.11	27.94
Difference		4.24		4.05		4.21		4.17
AFY (vegetables)	720	620	670	580	740	650	690	600
Difference (AF)	100		90		90		90	

Notes: ER = effective rainfall; EFF = irrigation system efficiency; in = inches; AFY = acre-feet per year; vegetable AFY based on acreages from DWR Land IQ

DISCUSSION

- The strength of the OpenET methodology is that the estimates of ETc are based on processing local remote sensing data that account for the actual field-level climatic conditions, basically measuring ETc directly.
- The SMB methodology derives ETc from ETo calculated at a nearby climate station and various estimates for Kc.
- OpenET methodology appears to be more accurate than the SMB methodology for reporting ETc. The weakness of the OpenET methodology is the current practice of applying effective rainfall as a fixed percentage of total rainfall on a monthly basis.
- By comparison, the strength of the daily SMB methodology is a robust process for estimating effective rainfall. By allowing rainfall to be stored in the soil and balancing incremental ETc and rainfall on a daily basis, the full range of actual rainfall distributions can be more accurately modeled to estimate effective rainfall. The weakness of the SMB methodology is the ETc estimate, which is dependent on several assumptions and data that is not locally field-based.
- The ETc data from OpenET is available on a monthly basis, while effective rainfall is estimated on a daily basis by the SMB. In order to combined the methods, the daily effective rainfall from the SMB is summed for each month and applied to offset the monthly ETc from OpenET. The following Table provides the results of this combined methodology.

COMPARISON OF WATER USAGE ESTIMATING METHODOLOGIES

Month	2020 Water Use (in)		2021 Water Use (in)		2022 Water Use (in)		Average	
	SEB+SMB	SMB	SEB+SMB	SMB	SEB+SMB	SMB	SEB+SMB	SMB
Jan	0.32	0	0.05	0	0.22	0	0.20	0.00
Feb	0.15	0	0.34	0	0.00	0	0.16	0.00
Mar	0.36	0	0.01	0	0.94	0.53	0.44	0.18
Apr	0.85	0	1.50	0.59	2.45	1.11	1.60	0.57
May	1.67	2.64	4.74	4.57	5.10	5.40	3.84	4.20
Jun	4.87	5.98	5.27	6.13	5.49	6.69	5.21	6.27
Jul	4.88	5.69	5.32	5.76	5.45	5.93	5.22	5.79
Aug	5.21	4.50	4.63	4.68	4.87	5.26	4.90	4.82
Sep	3.78	3.37	3.23	3.57	2.75	2.98	3.26	3.31
Oct	2.19	2.61	1.67	2.03	2.32	2.13	2.06	2.25
Nov	0.68	1.03	0.00	0	0.20	0.17	0.29	0.40
Dec	0.53	0.48	0.23	0	0.30	0	0.36	0.16
Total	25.49	26.30	27.00	27.32	30.09	30.20	27.53	27.94
Difference		-0.81		-0.32		-0.10		-0.41
AFY (vegetables)	600	620	570	580	640	650	590	600
Difference (AF)	-20		-10		-10		-10	

Notes: SEB = surface energy balance; SMB = soil moisture budget; EFF = irrigation system efficiency; in = inches; AFY = acre-feet per year; vegetable AFY based on acreages from DWR Land IQ

Table 4 shows that the combined SEB+SMB methodology, which combines OpenET and SMB, is a close match for the stand-alone SMB methodology, and supports current estimates of applied water use in Los Osos annual reports.

CONCLUSIONS AND RECOMMENDATIONS

- Based on comparison and analysis of the results of two methodologies, OpenET and SMB, the OpenET data appears to be a better method for obtaining ETc values, while SMB provides the best estimates for effective rainfall.
- A proposed composite method, SEB+SMB, has the potential to combine the best of the two methodologies for estimating agricultural water use, and would allow replacement of the calibration factor with an actual efficiency factor.
- Field-based verification of the results of water use estimates is recommended. CHG can work with the County to find grower(s) who would be willing to share any irrigation well production data over the last three years, and/or would allow meter installation for future data collection on groundwater production.

Questions?

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