2024 UC Statewide Pistachio Day

Initial evaluation of satellite remote-sensing estimates of pistachio evapotranspiration (ET)

P. Steduto; D. Zaccaria; L. Esteban Cigarra;
K. Shapiro; F. Gomez Diaz

University of California, Davis
Department of Land, Air and Water Resources (LAWR)

Wednesday, January 17, 2024
Visalia Convention Center, Visalia, California

Background and rationale

Several water-related assessments and decision processes are progressively relying on Satellite Remote Sensing (SRS) estimates of EvapoTranspiration (ET)

- Water Budgeting, Accounting and Monitoring
- Planning and allocation of water resources
- GSAs groundwater assessments
- Water supply allocation to different areas
- On-farm irrigation scheduling
- ……

This is because SRS represents the most convenient approach to evaluate ET over large areas at sufficiently high ground resolution (30 m pixel) and time scale (daily)

What is not yet sufficiently analyzed is the magnitude of errors occurring with SRS ET estimation on various agricultural landscapes, and specifically on orchards and vineyards

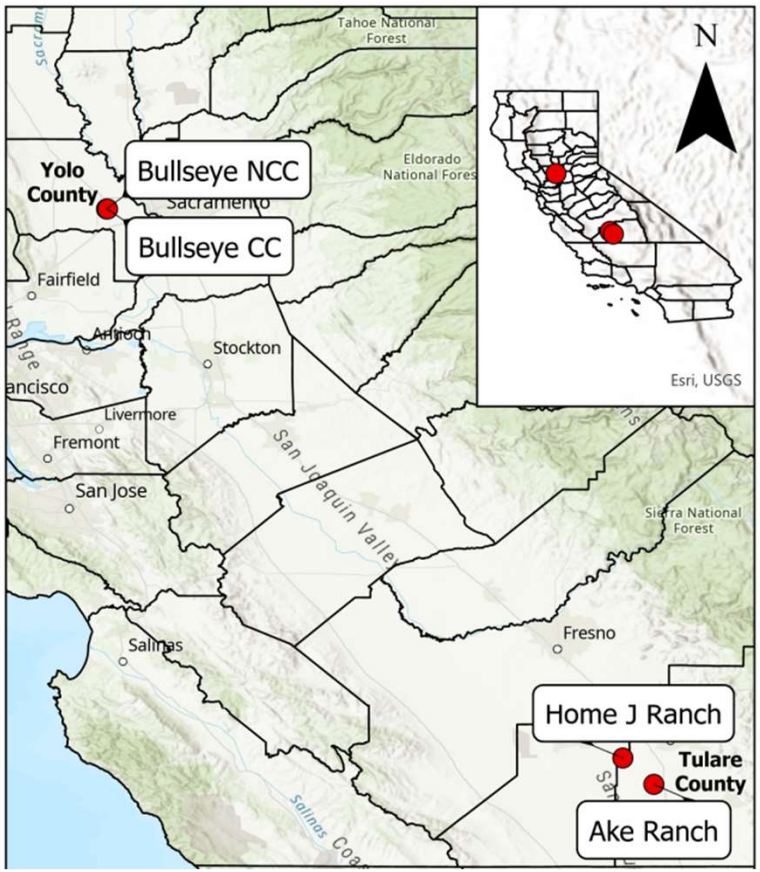
Orchards are characterized by a higher complexity of the canopy as compared to agronomic and field crops (e.g., plant density, 3D of the tree crown, row orientation, higher stomatal sensitivity to air humidity, etc.)

It is also not clear enough what is the error in ET considered acceptable for the various applications (planning, allocation, delivery, ground water sustainability, irrigation scheduling and management, etc.)

Objective

Evaluate the errors in SRS-based ET estimates by comparison with ground measurements over some mature and young micro-irrigated pistachio orchards located in Tulare and Yolo Counties

The Orchards



2 in Tulare (2022-2023)

- Home J Ranch
- Ake Ranch

Nichols Farms

2 in Yolo (2023)

- Bullseye Cover Crop (CC)
- Bullseye Non-Cover Crop (NCC)

Home J Ranch

- Sandy-clay loam soil (**non-saline and non-sodic**)
- Kerman cultivar grafted onto Pioneer Gold 1 (PG1) rootstock
- **Mature trees**, 38 years old (planted in 1985), 20 ft × 16 ft
- ~ 74 acre block
- Drip-irrigated with dual driplines
- Fractional canopy cover at full development: **~ 76%**

Ake Ranch

- Sandy-clay loam soil (**saline/sodic**)
- Kerman cultivar grafted onto Pioneer Gold 1 (PG1) rootstock
- **Mature trees**, 15 years old (planted in 2008), 20 ft x 18 ft
- ~ 86 acre block
- Drip-irrigated with dual driplines
- Fractional canopy cover at full development: **~ 55%**

Bullseye CC & NCC

- Sandy-clay loam soil (**non-saline and non-sodic**)
- Golden Hills cultivar grafted onto UCB1 rootstock
- **Young trees**, 5 years old (planted in 2018), 19 ft × 17 ft
- Planting pattern: 20 ft × 16 ft
- ~ 70 acre for each blocks
- Drip-irrigated with dual driplines
- Fractional canopy cover at full development: **~ 25%**

The SRS Platform

OPENET

Satellites:
Landsat 8, Sentinel-2; GOES; etc.

Spatial scale:
30m (0.22 acres per pixel)

Temporal scale:
day; month; year

Models:

- gegSEBAL
- egMETRIC
- DisALEXI

→ SEB (thermal & optical-MS)

- SSEBop
- PT-JPL

→ Simplifying assumptions

- SIMS

→ Kc (optical-MS)

Ensemble

The field measurements

ET (as λE) derived as residual of Surface Energy Balance (SEB)

$$\lambda E = Rn - G - H$$

Rn (net radiation) is measured through net radiometers

G (soil heat flux) is measured through soil heat units

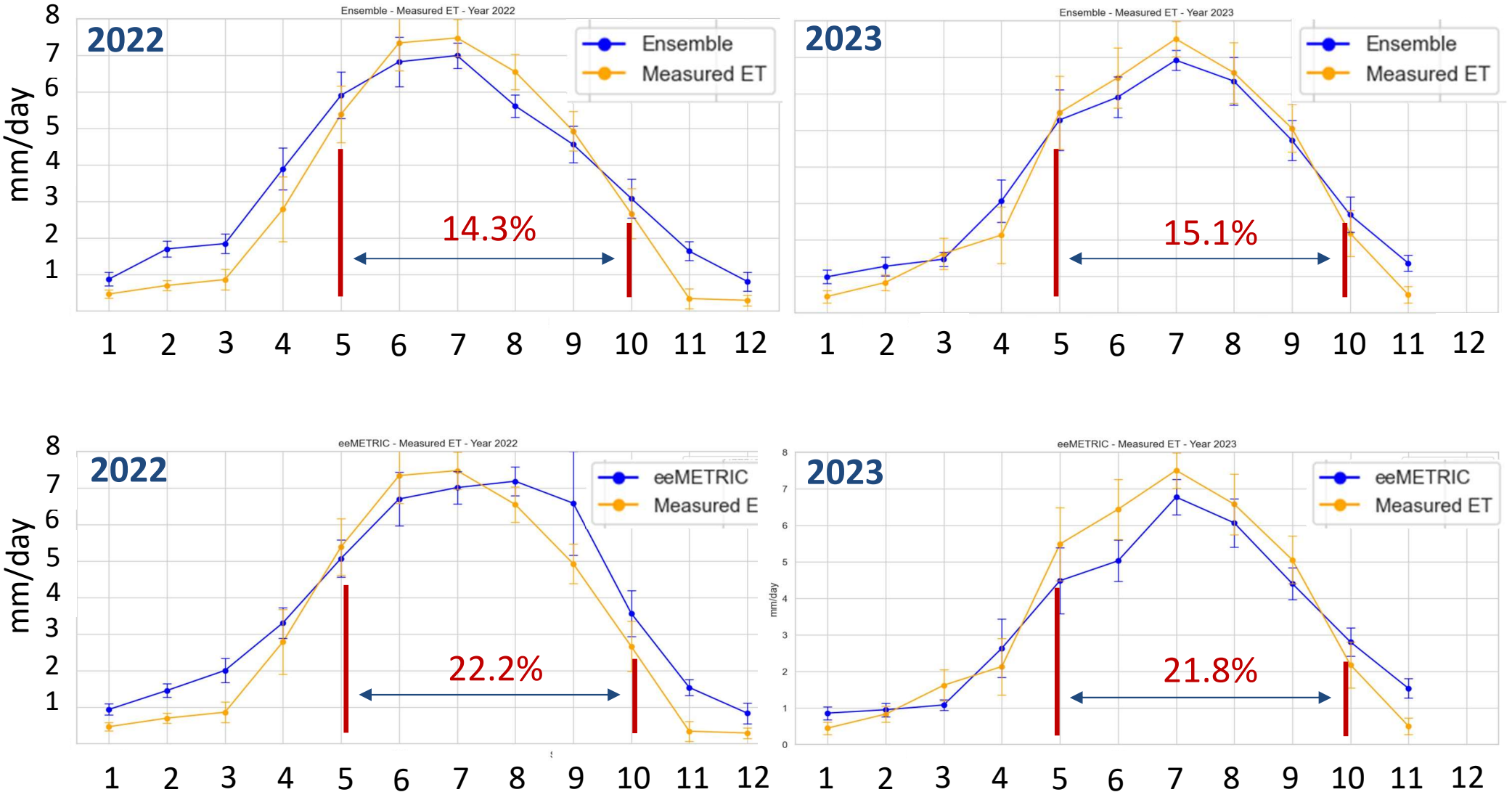
H (sensible heat flux) is measured through eddy covariance

Home J Ranch (Tulare)

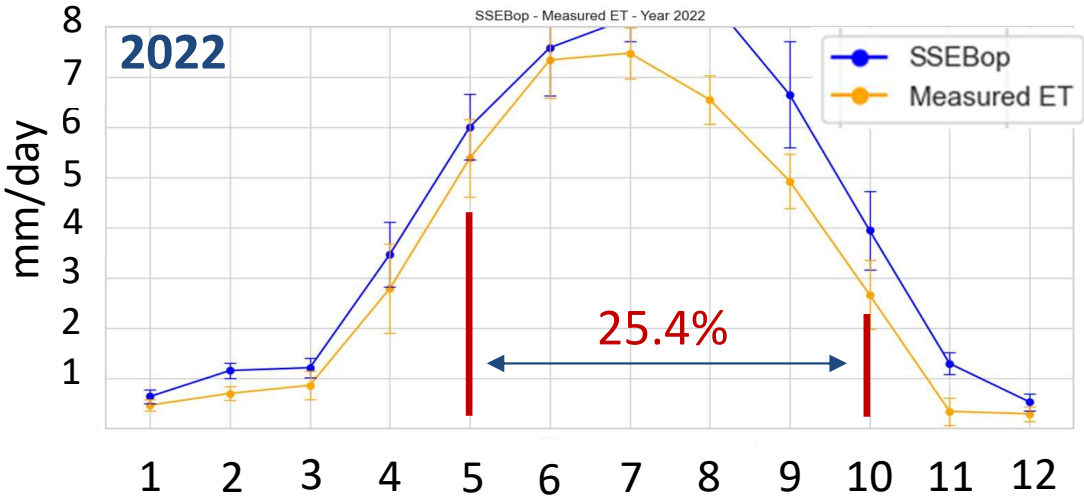
Non salt-affected
~ 76% F_{CC}

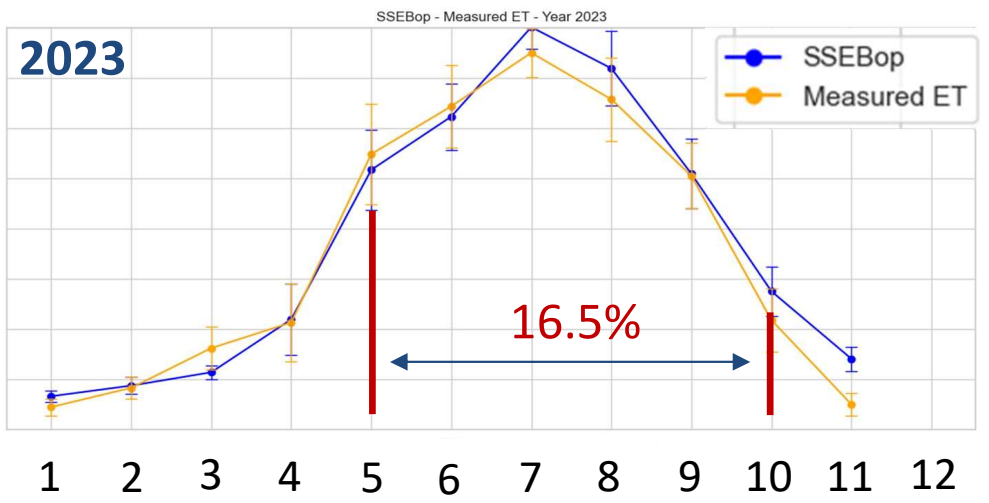
Monthly ET (NRMSE on May-Oct)

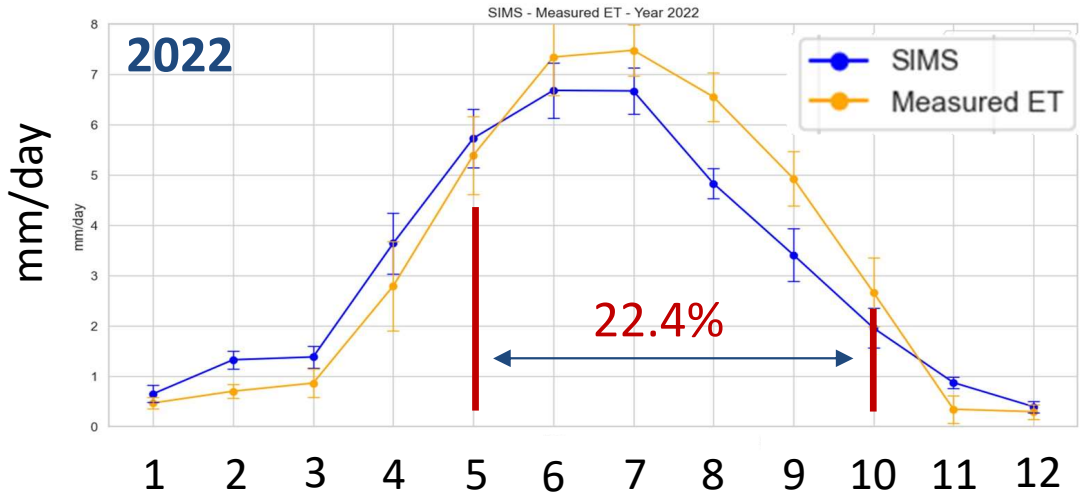
Initial Results

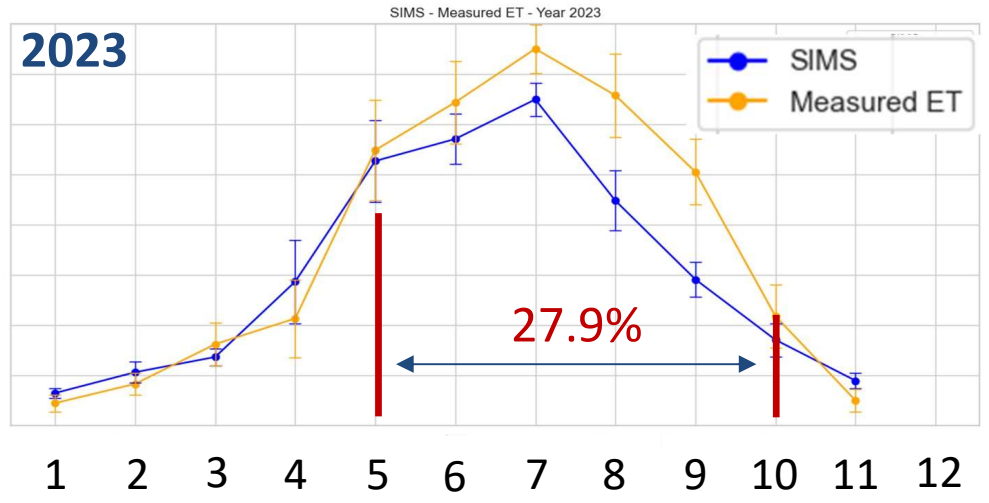


Monthly ET (NRMSE on May-Oct)

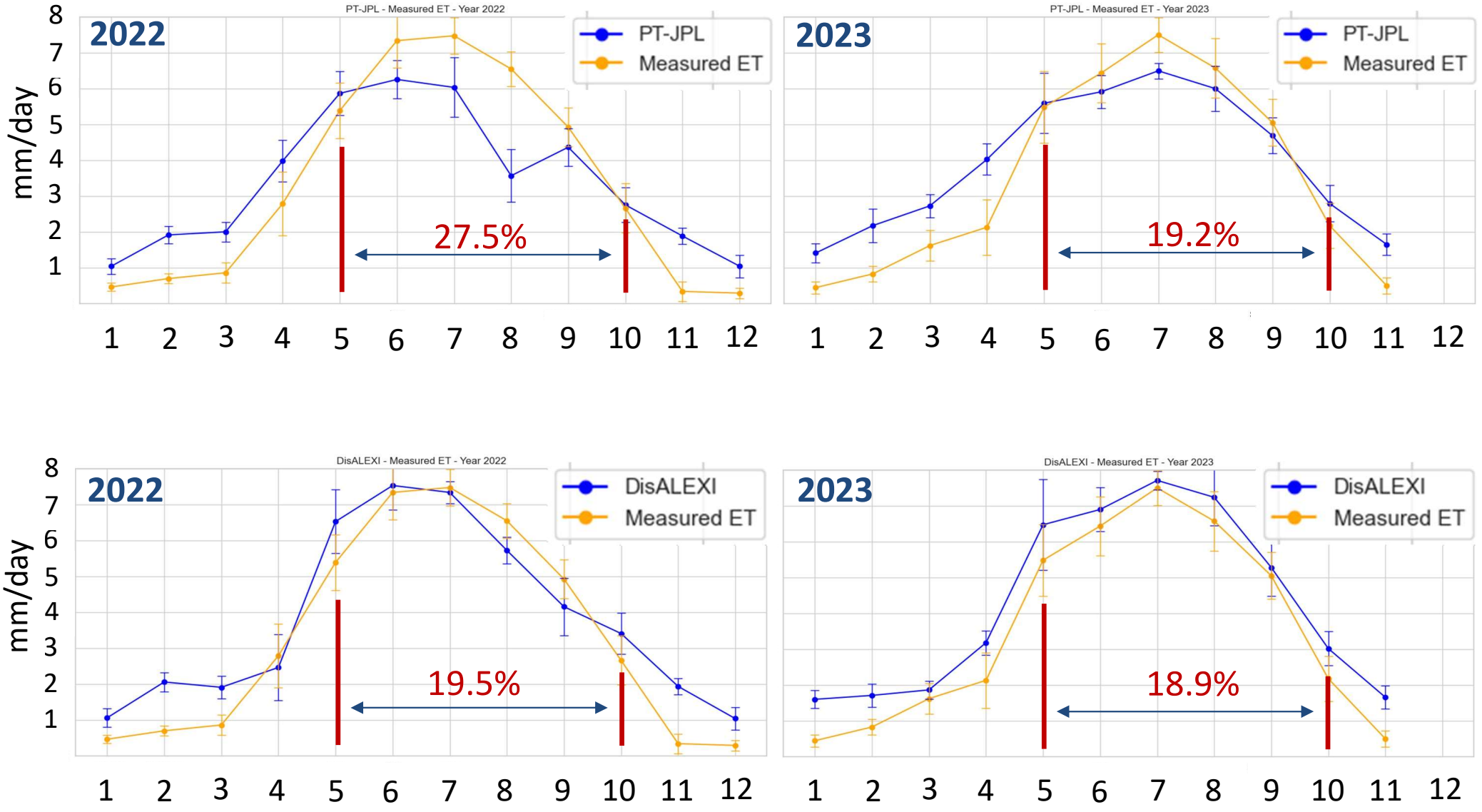




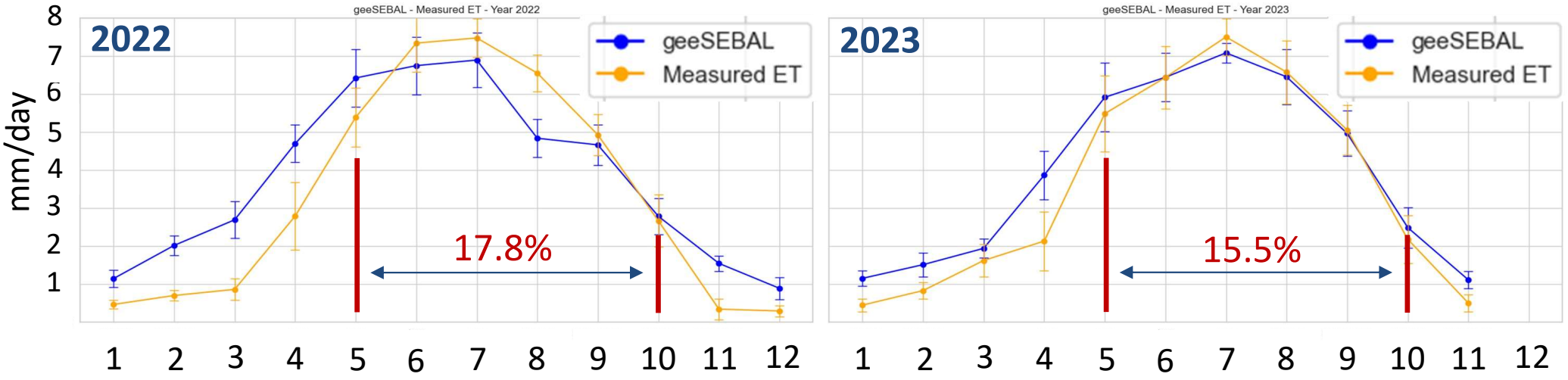




Monthly ET (NRMSE on May-Oct)



Monthly ET (NRMSE on May-Oct)

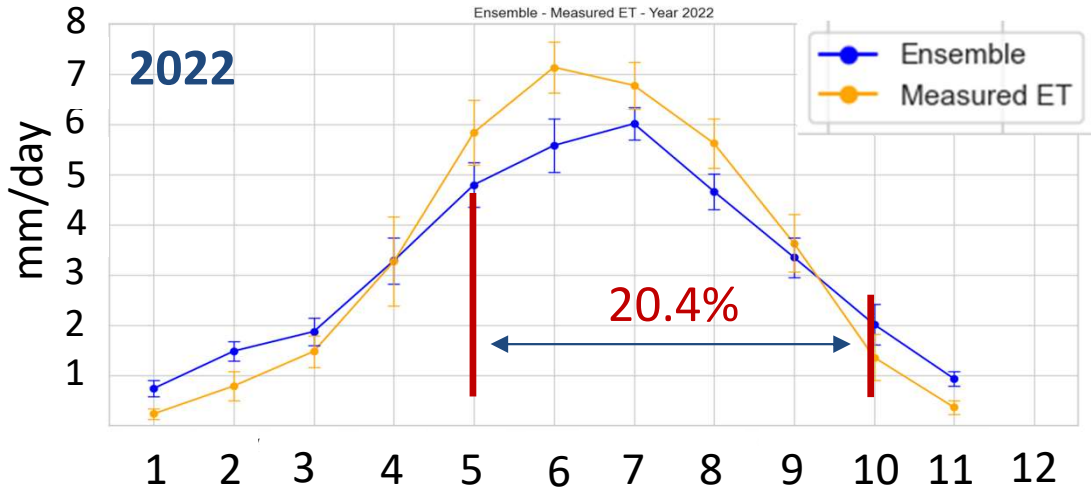


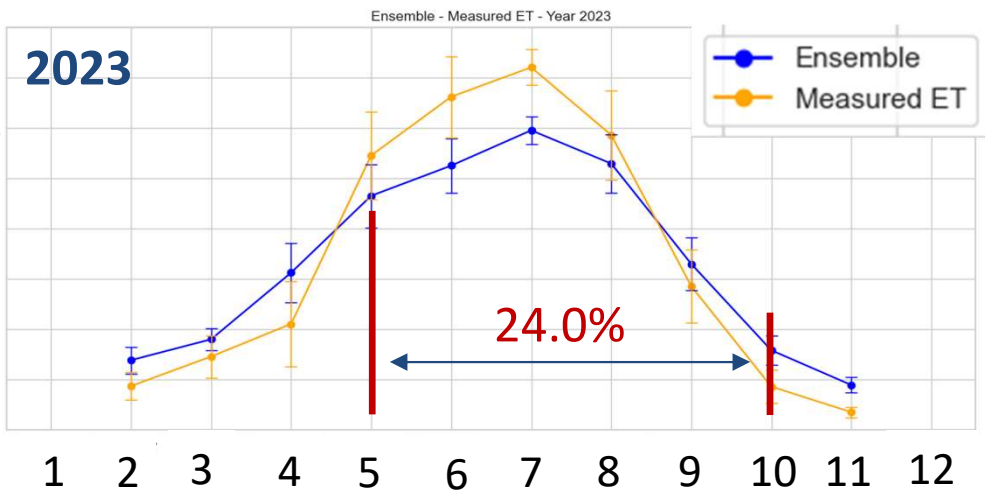
Ake Ranch (Tulare)

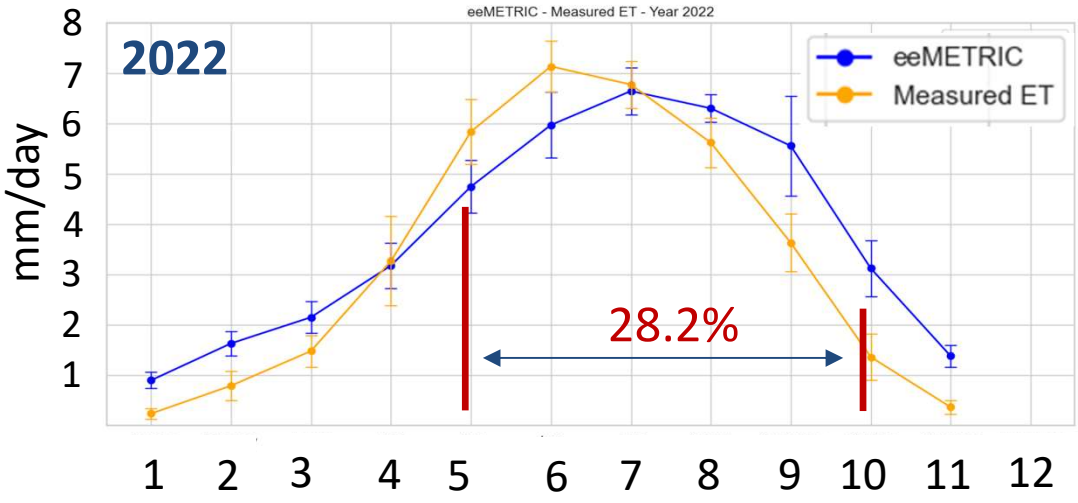
Salt-affected

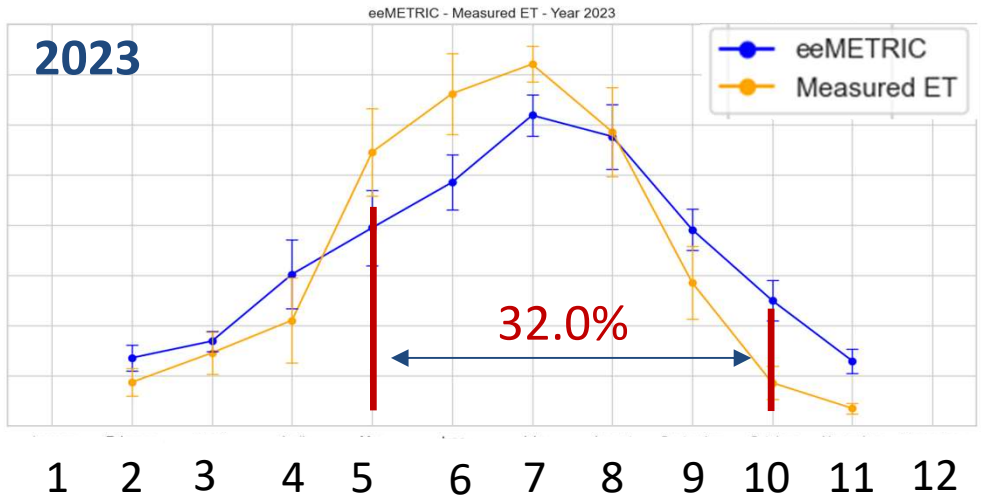
~ 55% F_{CC}

Monthly ET (NRMSE on May-Oct)

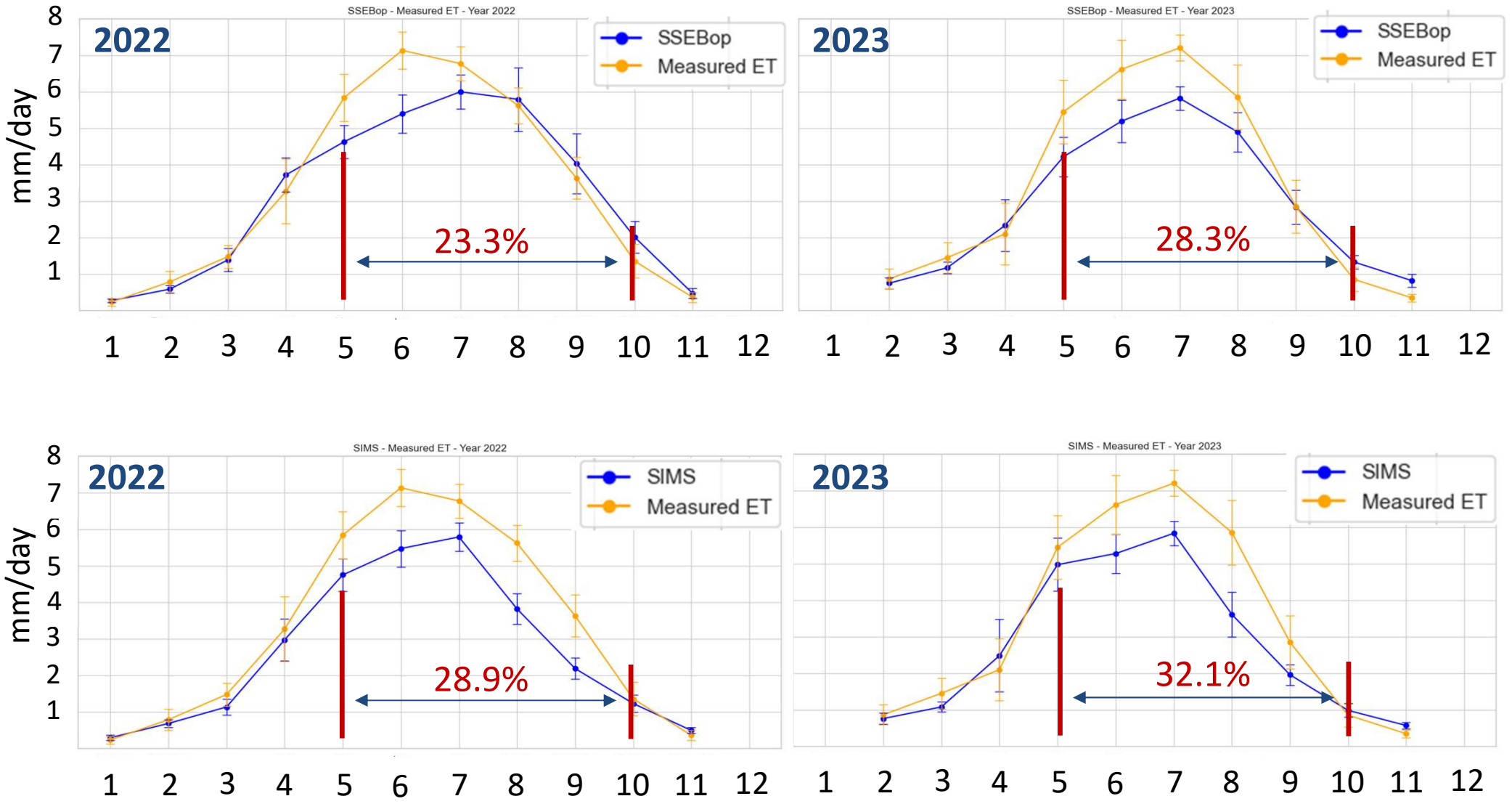




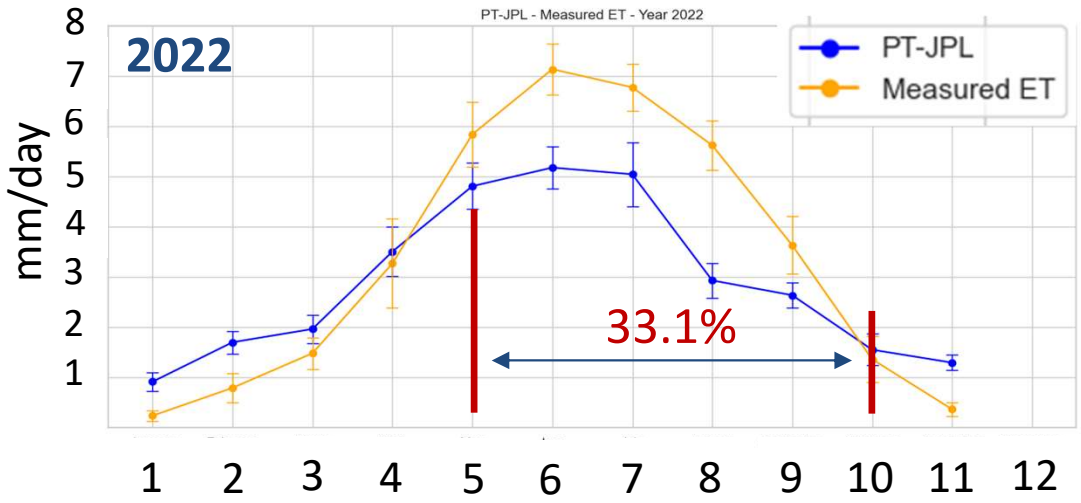


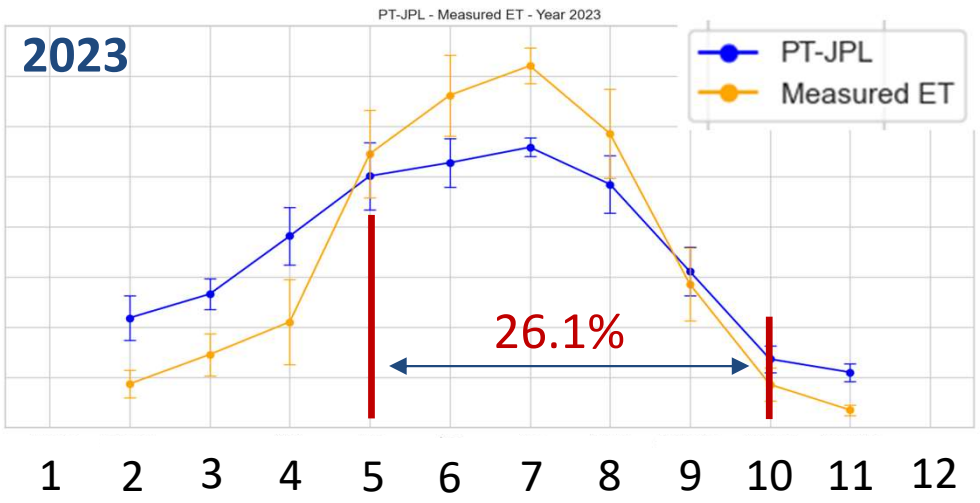


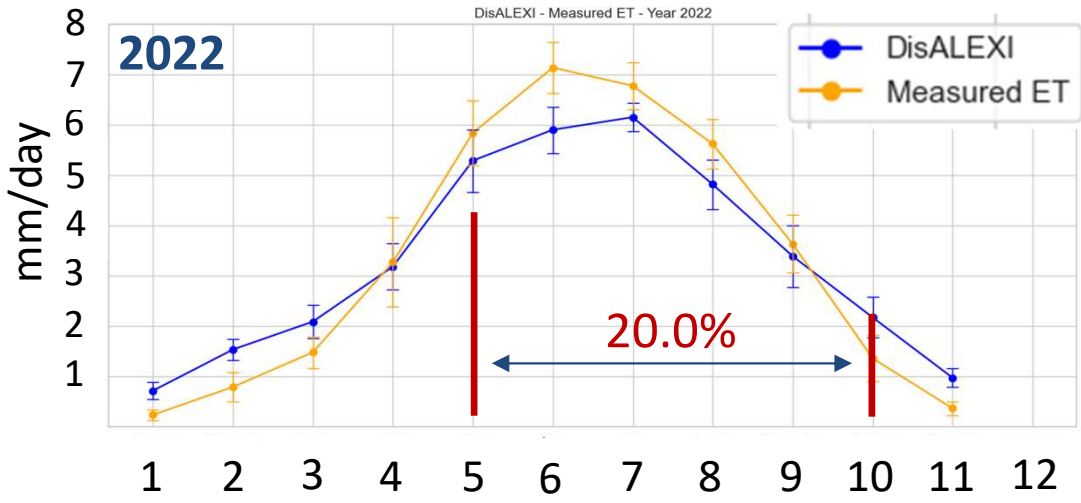
Monthly ET (NRMSE on May-Oct)

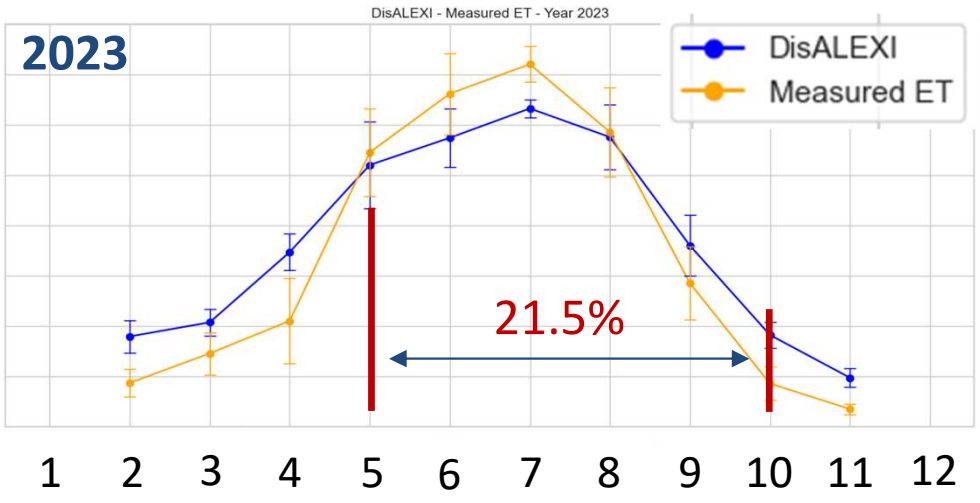


Monthly ET (NRMSE on May-Oct)

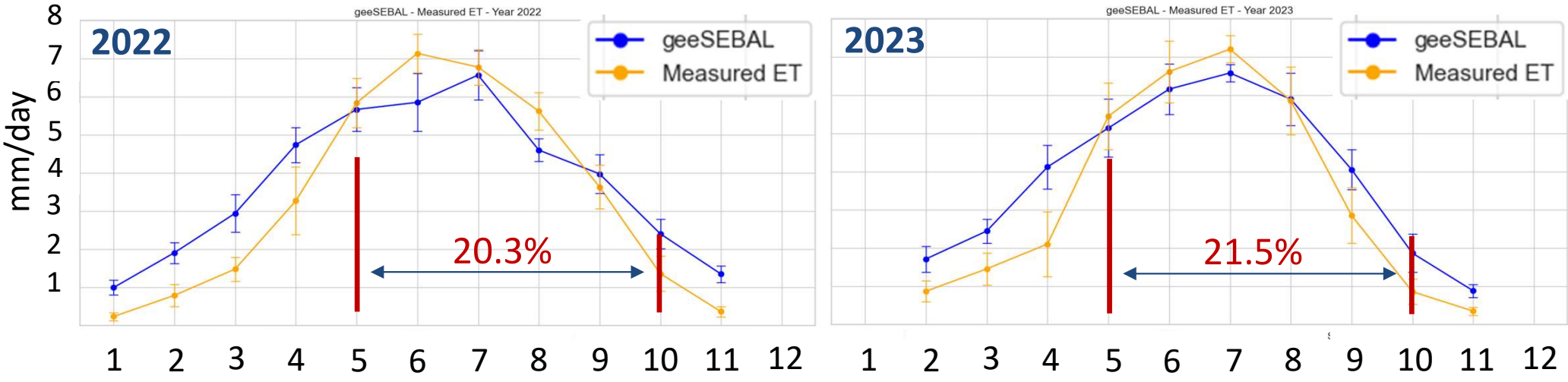








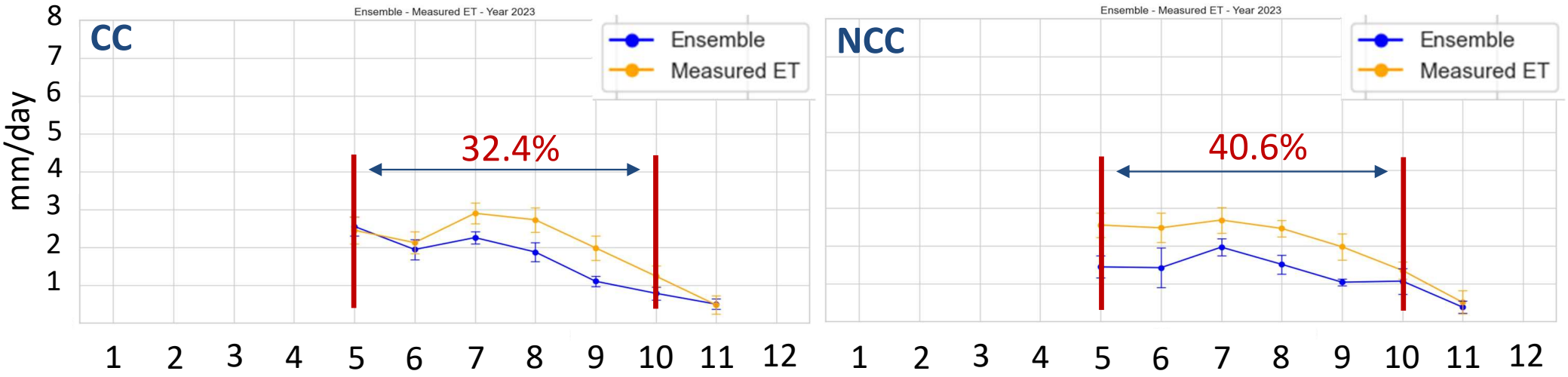
Monthly ET (NRMSE on May-Oct)

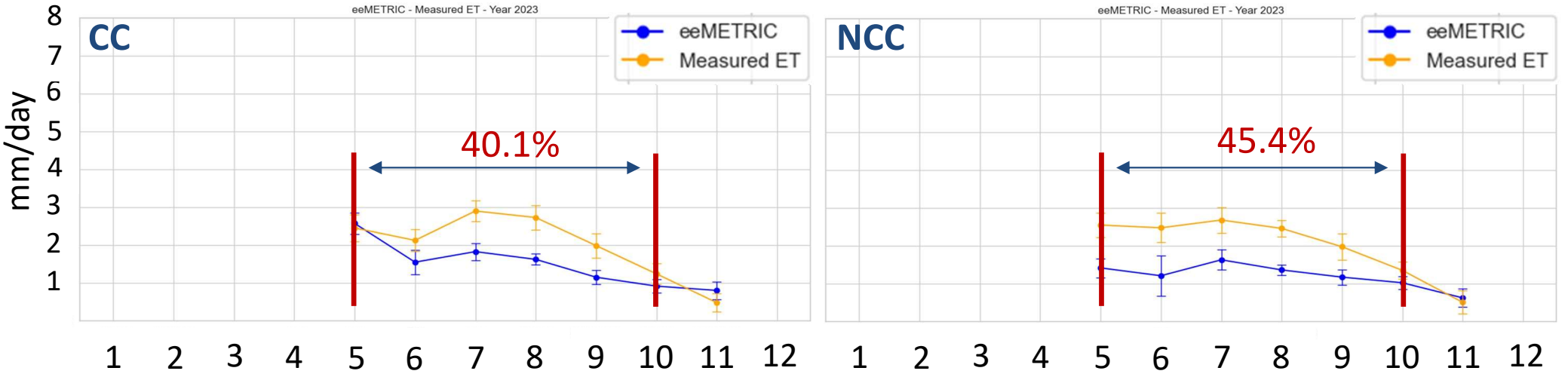


Bullseye (Yolo) 2023

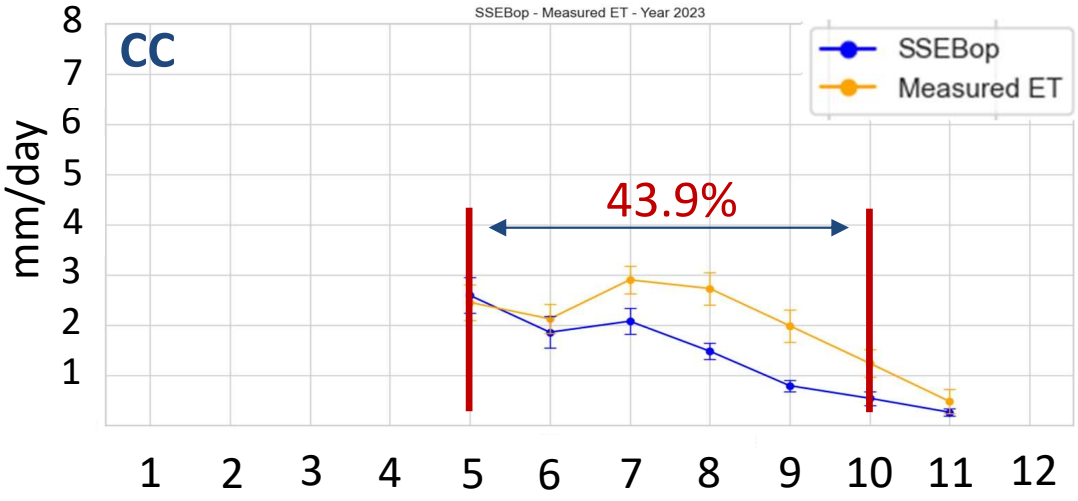
Non salt-affected
~ 25% F_{CC}

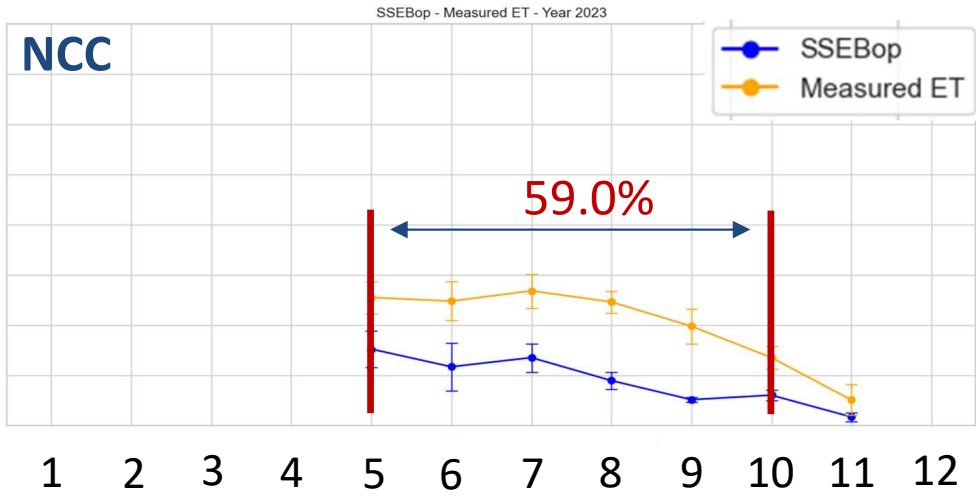
Monthly ET (NRMSE on May-Oct)

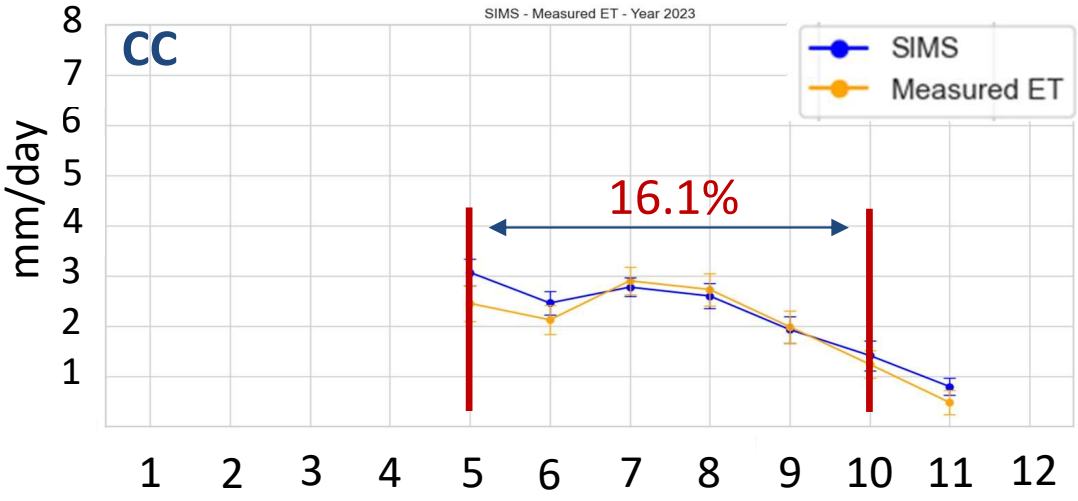


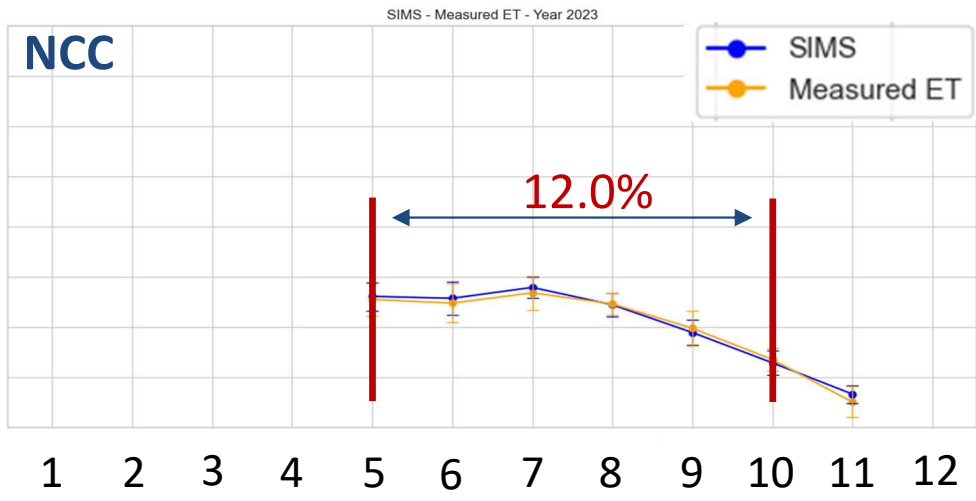


Monthly ET (NRMSE on May-Oct)

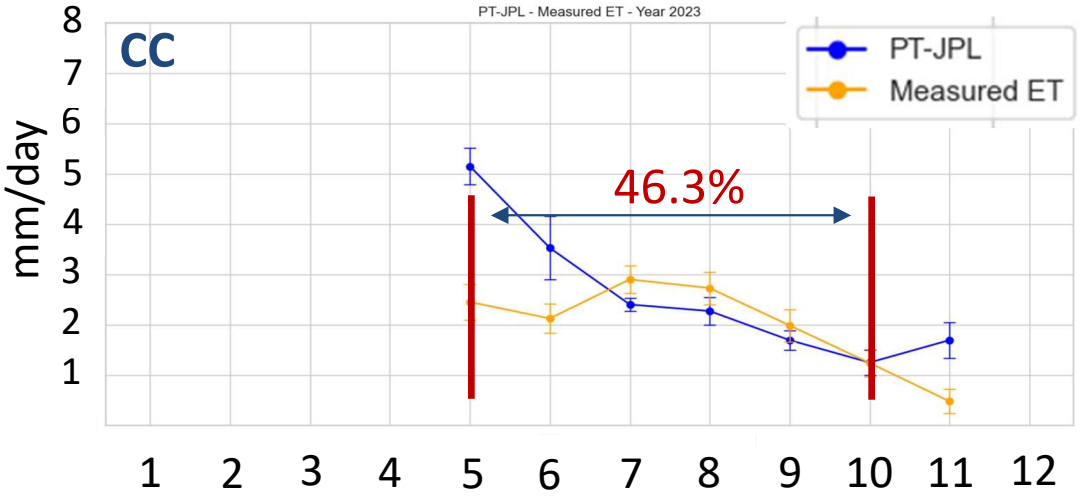


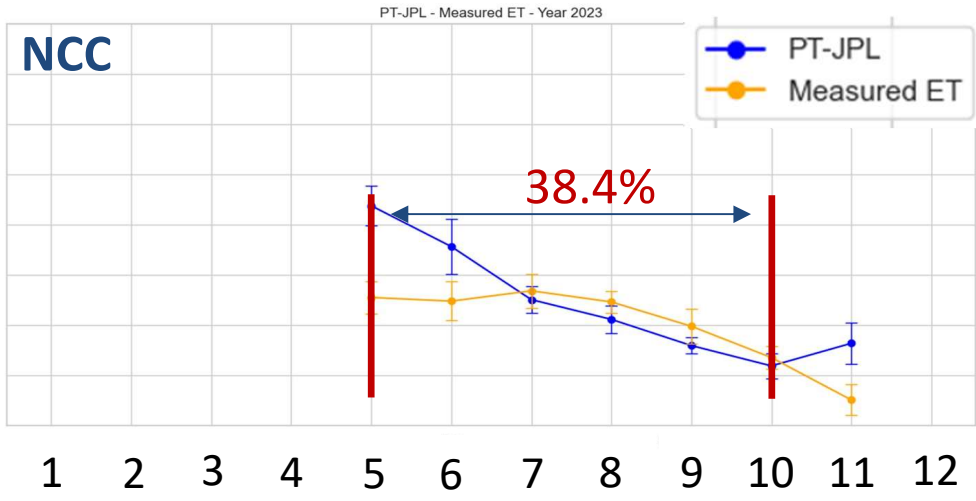


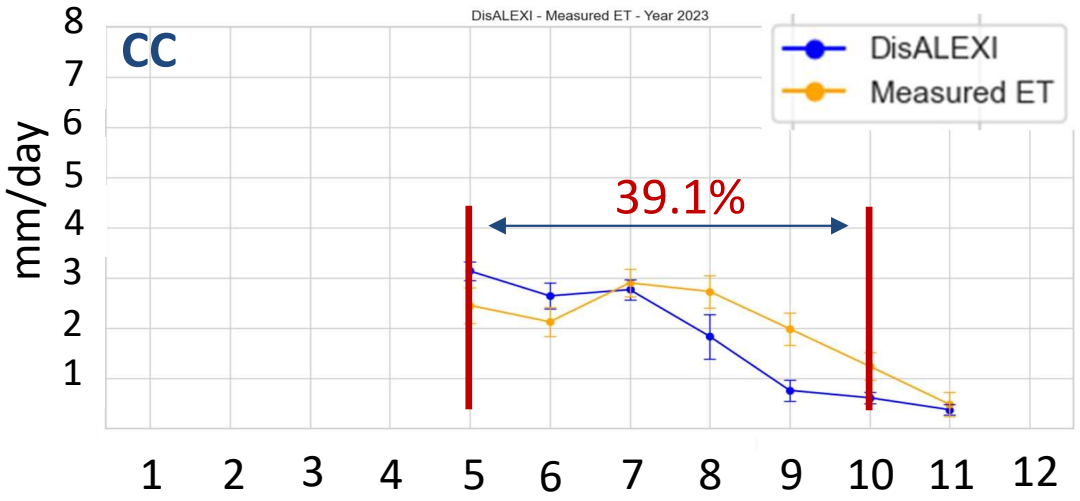


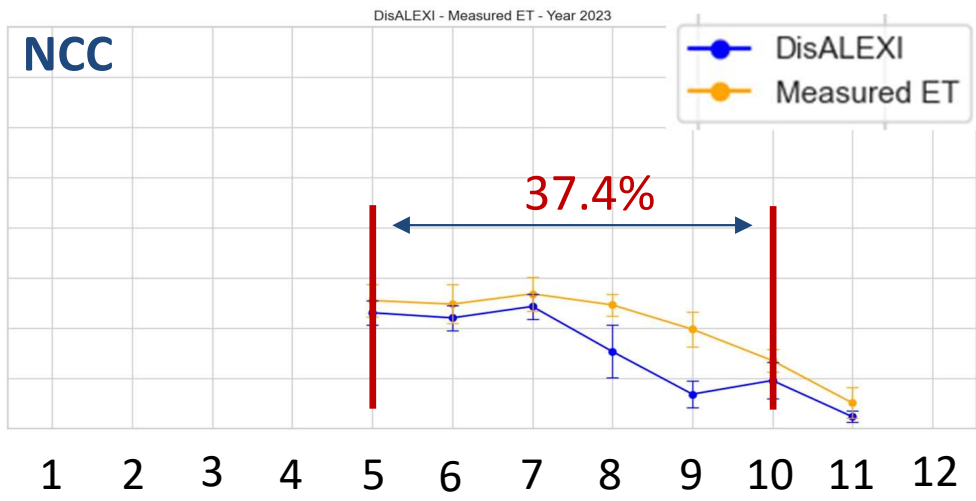


Monthly ET (NRMSE on May-Oct)

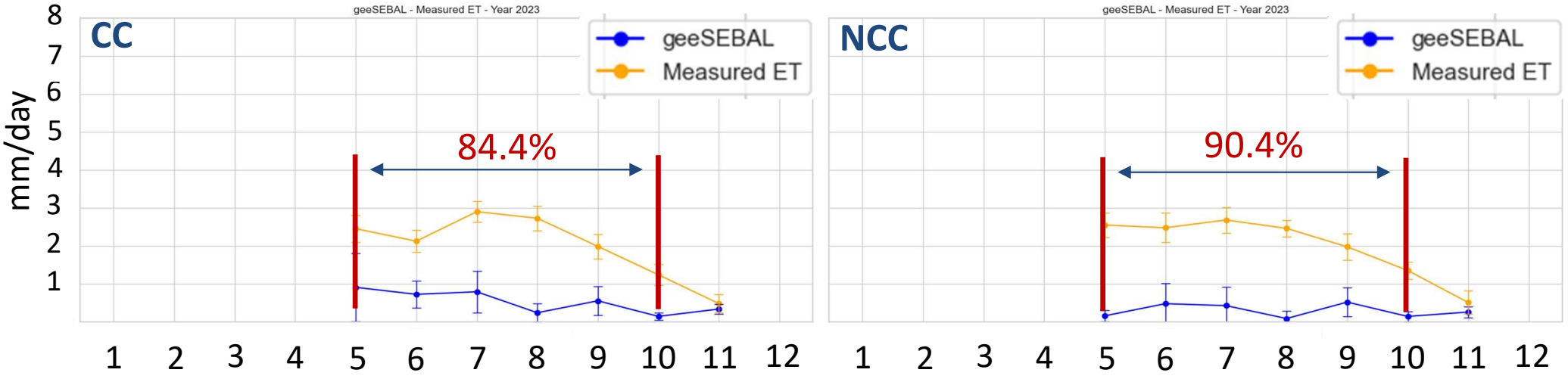








Monthly ET (NRMSE on May-Oct)



Concluding remarks

Observations

- overall, OpenET models tends to under-estimate pistachio ET
- under-estimate of ET tends to be higher in year 2022 (drought year) than in 2023 (wet year)
- NCC in Bullseye had slight higher ET under-estimation than CC
- Errors (NRMSE) ~ 14% up to 28% for all models in Home J Ranch (Tulare) – non salt affected/76% canopy cover
- Errors (NRMSE) ≥ 20% up to 33% for all models in Ake Ranch (Tulare) - salt affected/55% canopy cover
- Errors (NRMSE) > 32% up to 90% for all models in Bullseye (Yolo) except SIMS (NRMSE ~ 12% in NCC and 16% in CC) – 25% canopy cover (but SIMS did not performed as well in the other 2 sites)

Initial inferences

- the magnitude of pistachio ET error (under-estimation) increases with the decrease of fractional canopy cover & in salt-affected cases
- the largest magnitude of pistachio ET model under-estimation is for the youngest orchards (Bullseye in Yolo), except than with SIMS
- this means that under limited canopy cover, SEB-based models (measuring surface temperature) are more prone to errors than Kc-based models (measuring optical CC), as the exposed dry soil surface have a higher temperature inducing to over-estimate the sensible heat flux (H) and therefore under-estimate ET
- it appears that using selected models for specific cases would be better than using the Ensemble approach
- there is a need to get proper investigation on the accuracy before adopting the SRS-based ET (on more orchards with site specific conditions, - wet/dry year, young/mature trees, row orientations, salt affected and salt-affected/marginal soils, etc.)

Follow-up

- continue monitoring ET in the field and test the various OpenET models under different field conditions
- analyze the economic implications of inaccuracy by the RS-based ET estimates for the pistachio production industry, in view of the prospected limited water resources availability due either to drought (magnitude and frequency) and/or more stringent environmental regulations. Both, over-estimations and under-estimation of ET have an impact on the pistachio production industry (acreage and yield)
- the economic analysis will then guide on the acceptable limits of SRS-based ET errors
- elaborate practical recommendations to the users and to feedback OpenET for possible improvements

Thank you