GRACE-FO and ECOSTRESS synergies quantify the human impact on the water cycle

Madeleine Pascolini-Campbell (NASA JPL)
Joshua B. Fisher (UCLA)
John T. Reager (NASA JPL)

2021 ECOSTRESS Team Meeting

Jet Propulsion Laboratory
California Institute of Technology

How does human activity influence the water cycle?

- Increasing demands on freshwater
- Irrigation uses 80% of freshwater globally

Evapotranspiration = Evaporation + Transpiration

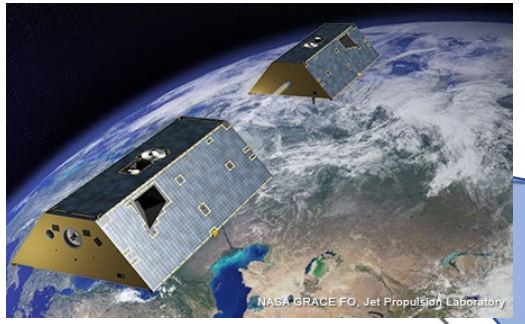
Linking water, carbon and energy cycles

- Irrigation locally *increases* ET
- Recent increases in global ET attributed to croplands [*Javadian et al. 2020*]
- Implications for the energy balance and temperature

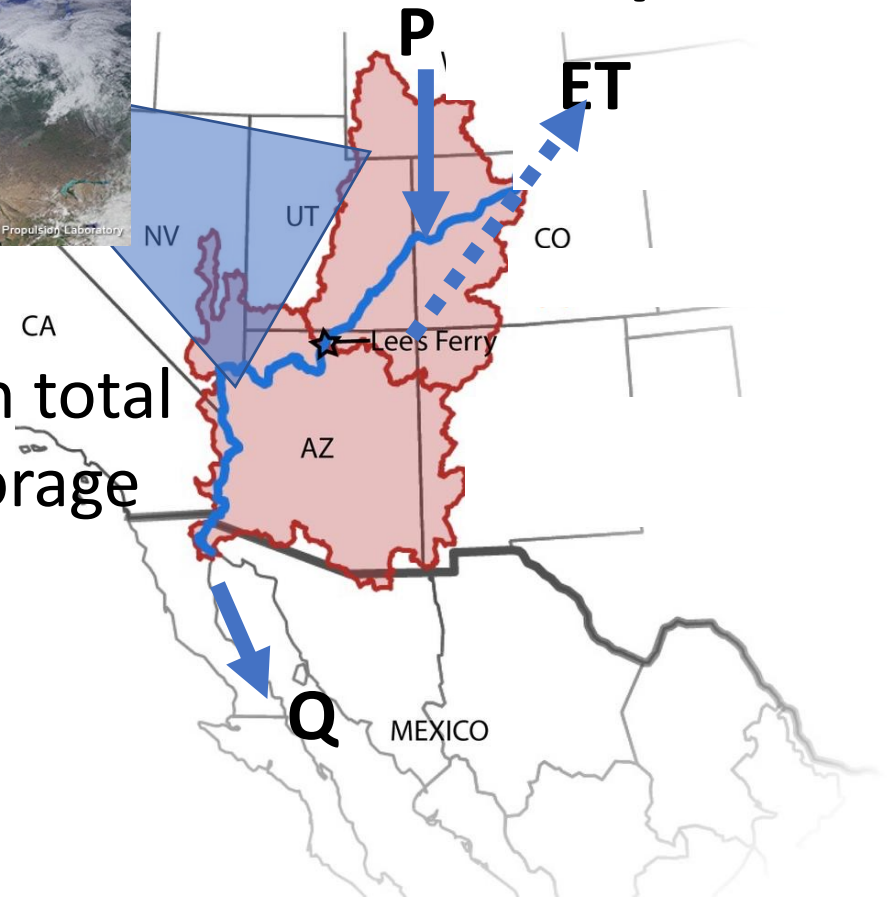
Regional Scale ET: water-balance ET using GRACE/GRACE-FO

Gravity **R**ecovery **A**nd **C**limate **E**xperiment (**GRACE**) and **GRACE**-**F**ollow **O**n (**GRACE-FO**)

- Gravity-based total water storage anomaly
- GRACE/GRACE-FO detect both natural and human changes in the water cycle
- Basin-scale ET



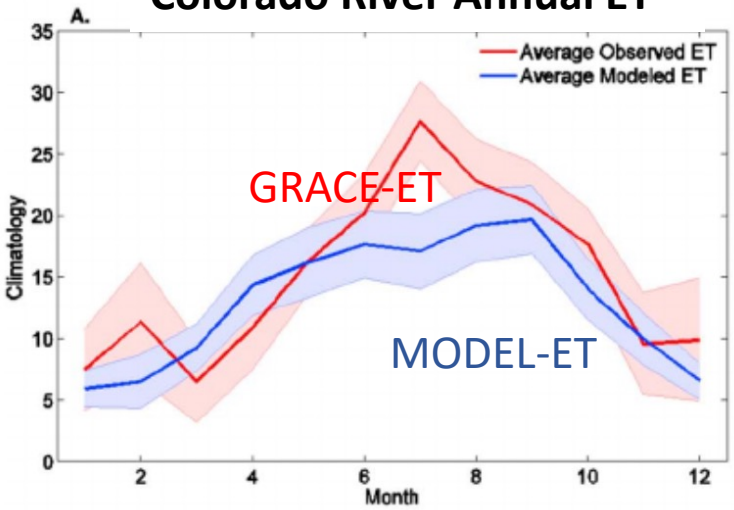
ET = P - Q -dS/dt



dS/dt ~ change in total water storage GRACE

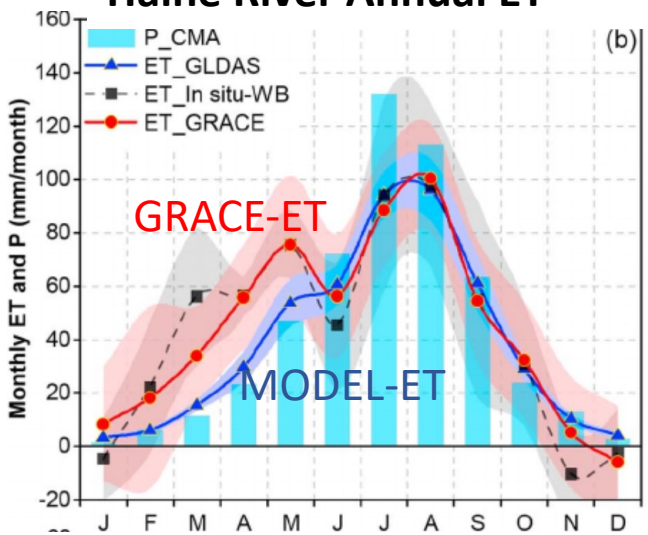
Human impacts have been estimated by contrasting GRACE-based ET and state-of-the-art land hydrology models in managed basins

Colorado River Annual ET



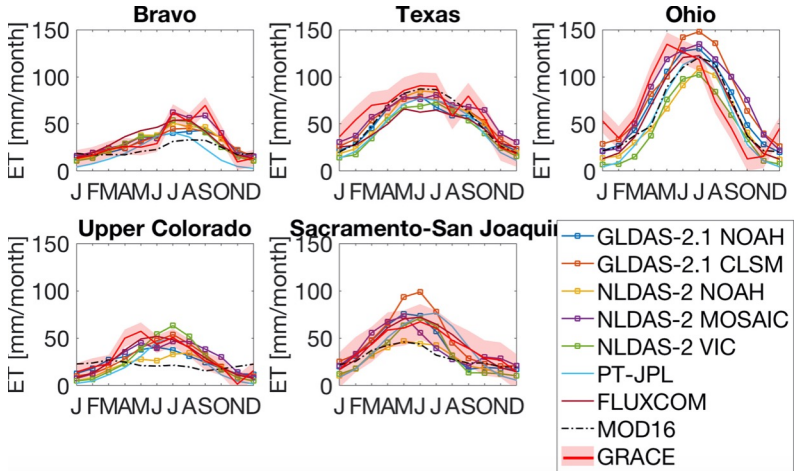
[Castle et al., 2016, *Geophysical Research Letters*]

Haihe River Annual ET



[Pan et al., 2017, *Geophysical Research Letters*]

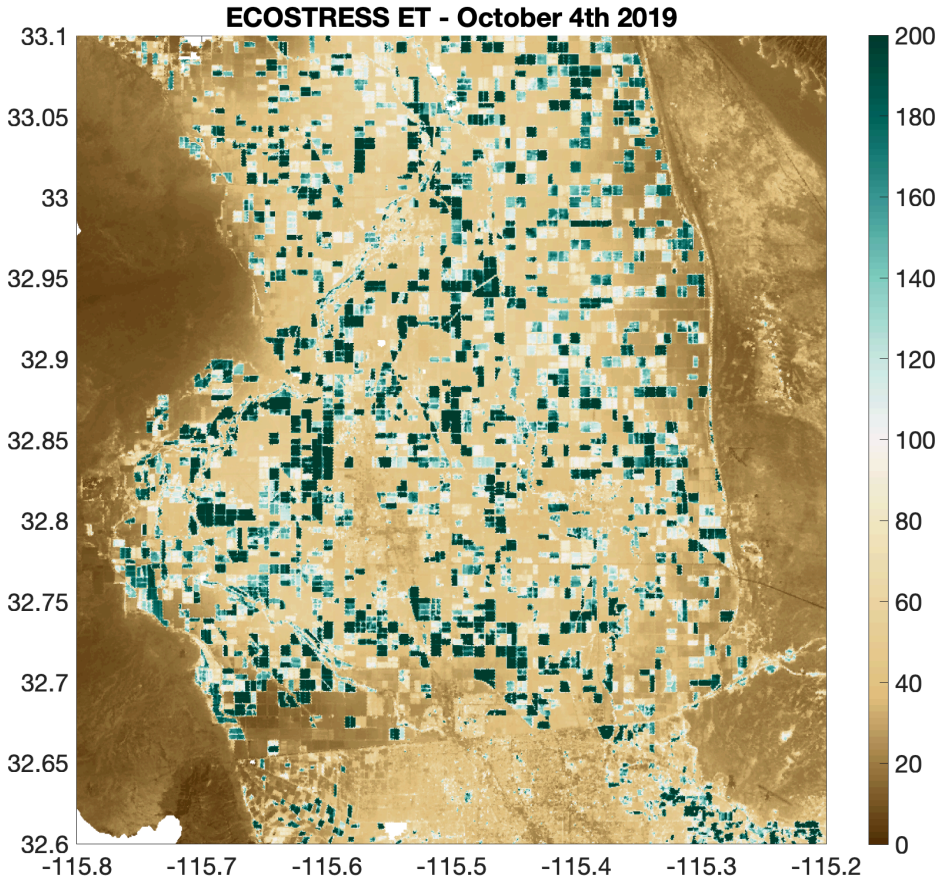
Major River Basins US



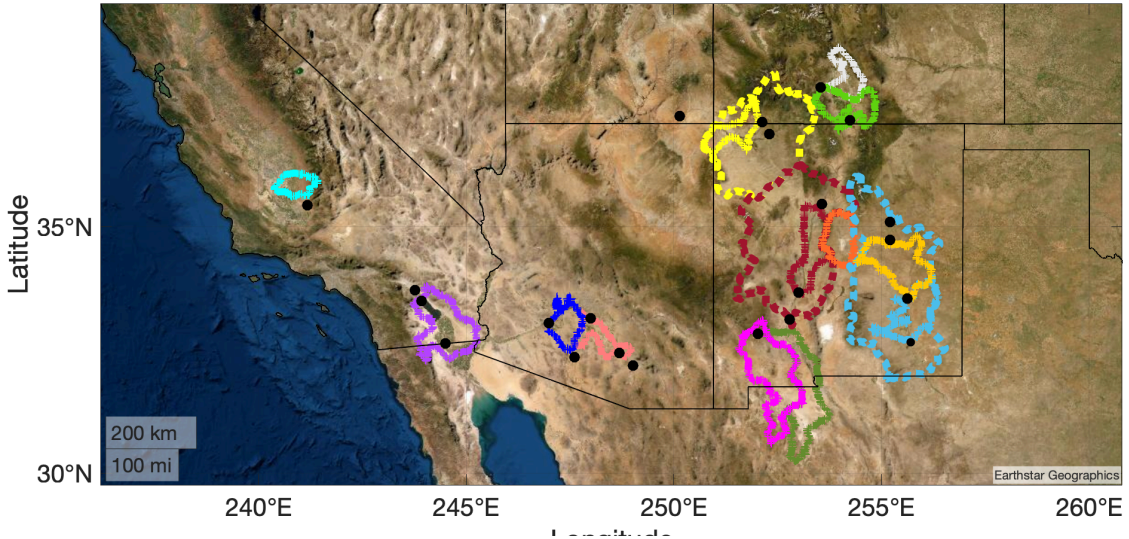
[Pascolini-Campbell et al., 2020, *Water Resources Research*]

ECOSTRESS 70m ET resolves farm-scale irrigation

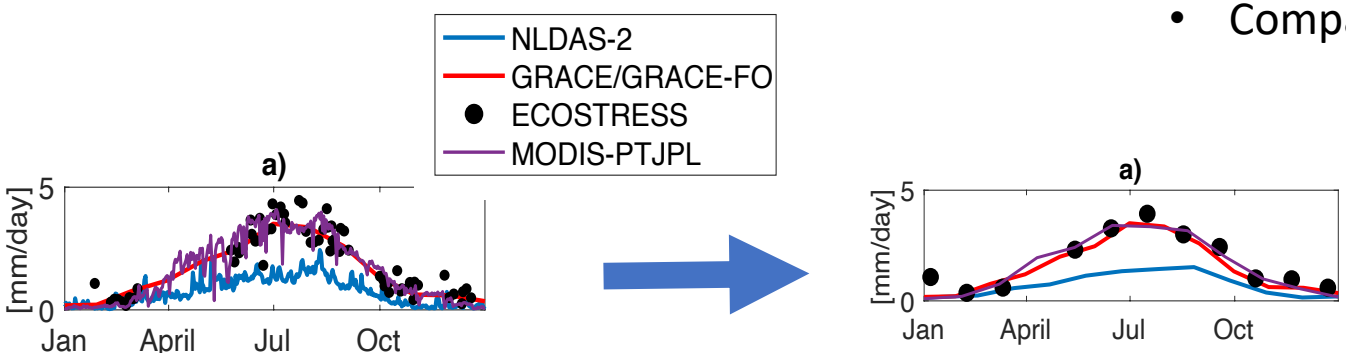
Imperial, California



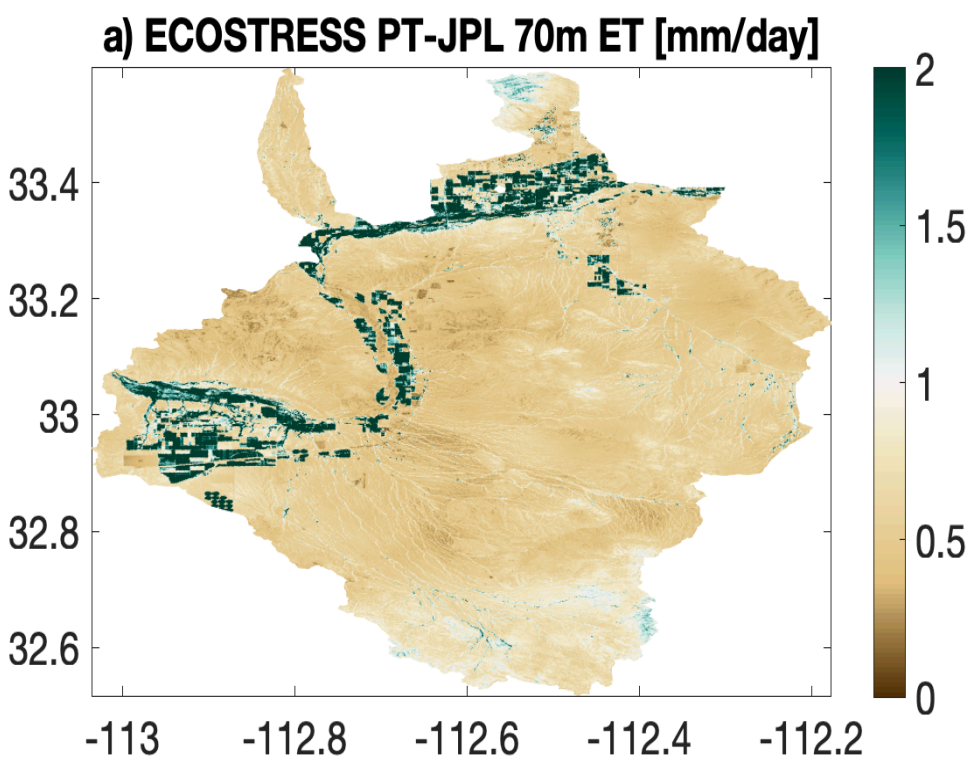
Methodology

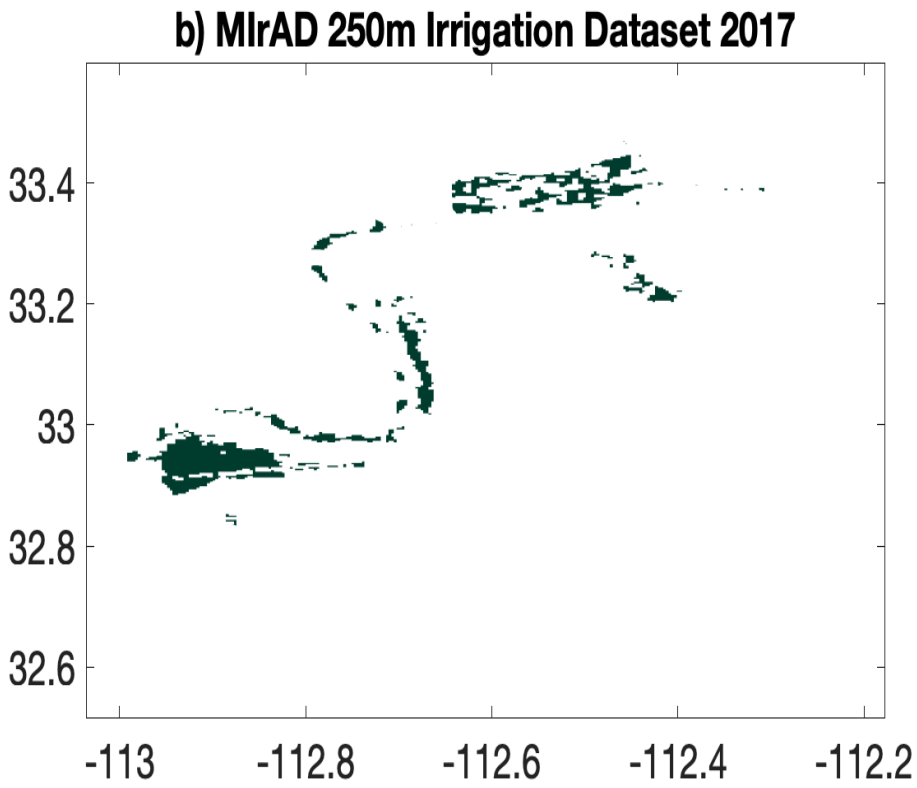


- Arid basins with agriculture
- Calculate basin-scale ET from water balance [GRACE/GRACE-FO]
- ECOSTRESS PT-JPL ET daily
- 1km MODIS PTJPL ET
- Compare with NLDAS-2 model ET



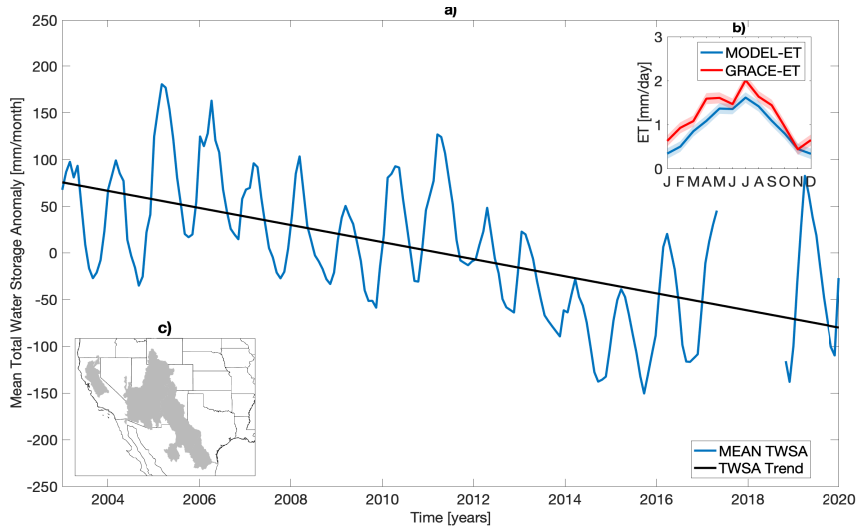
Determine pixels with irrigated agriculture for each basin





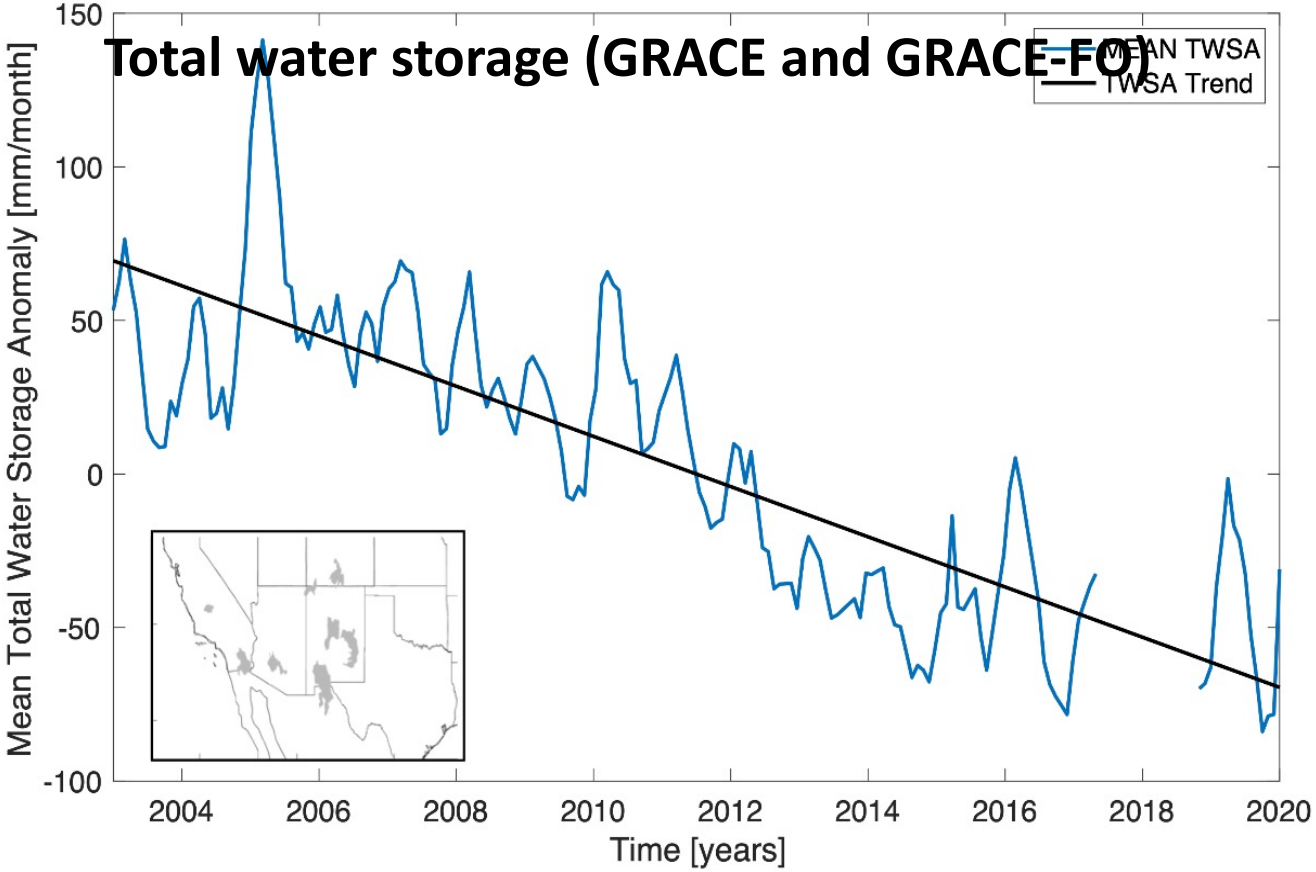
Overall decline in total water storage

Southwest Region



Total water storage (GRACE and GRACE-FO)

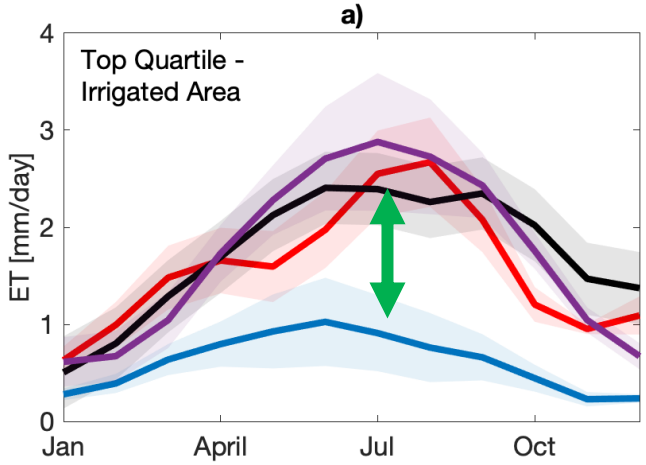
13 HUC8 Basins



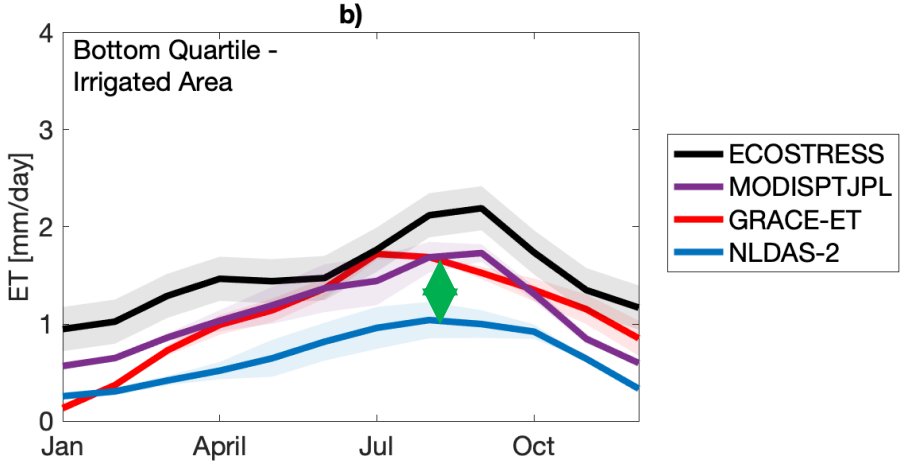
Model bias increases in more irrigated basins

Annual cycle of evapotranspiration

Top %-Irrigated

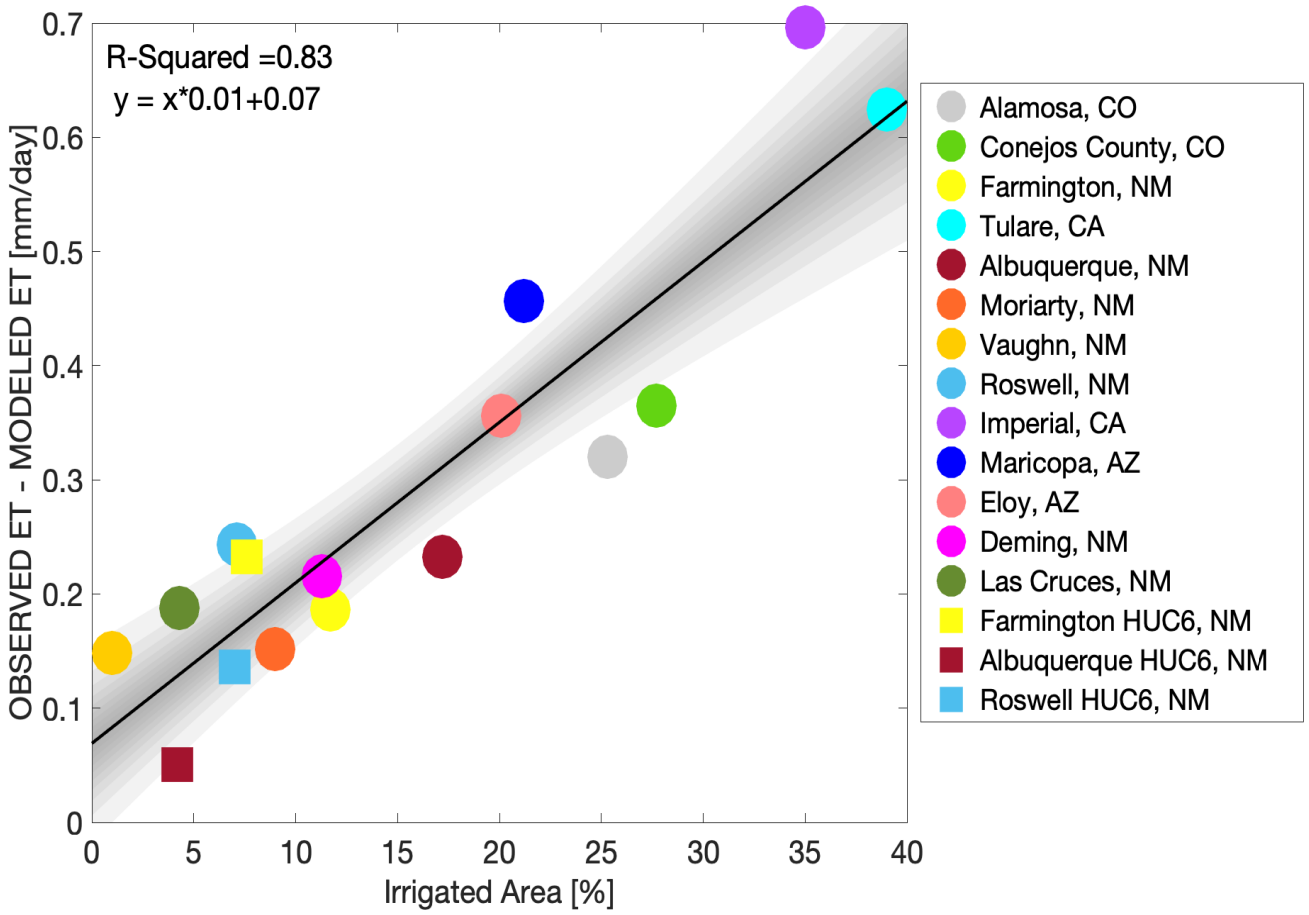


Bottom %-Irrigated



- Models are biased-low in top irrigated basins compared with observations
- Difference is greatest during growing season months (JJAS)
- Good agreement among observed-ET

%-Area irrigated explains bias between OBSERVED and MODELED ET

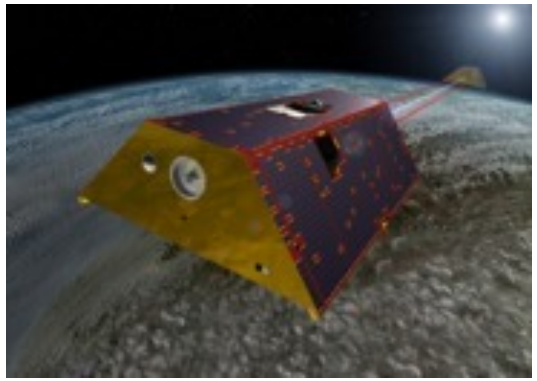


- Irrigation accounts for 35% of evapotranspirated water in growing season months

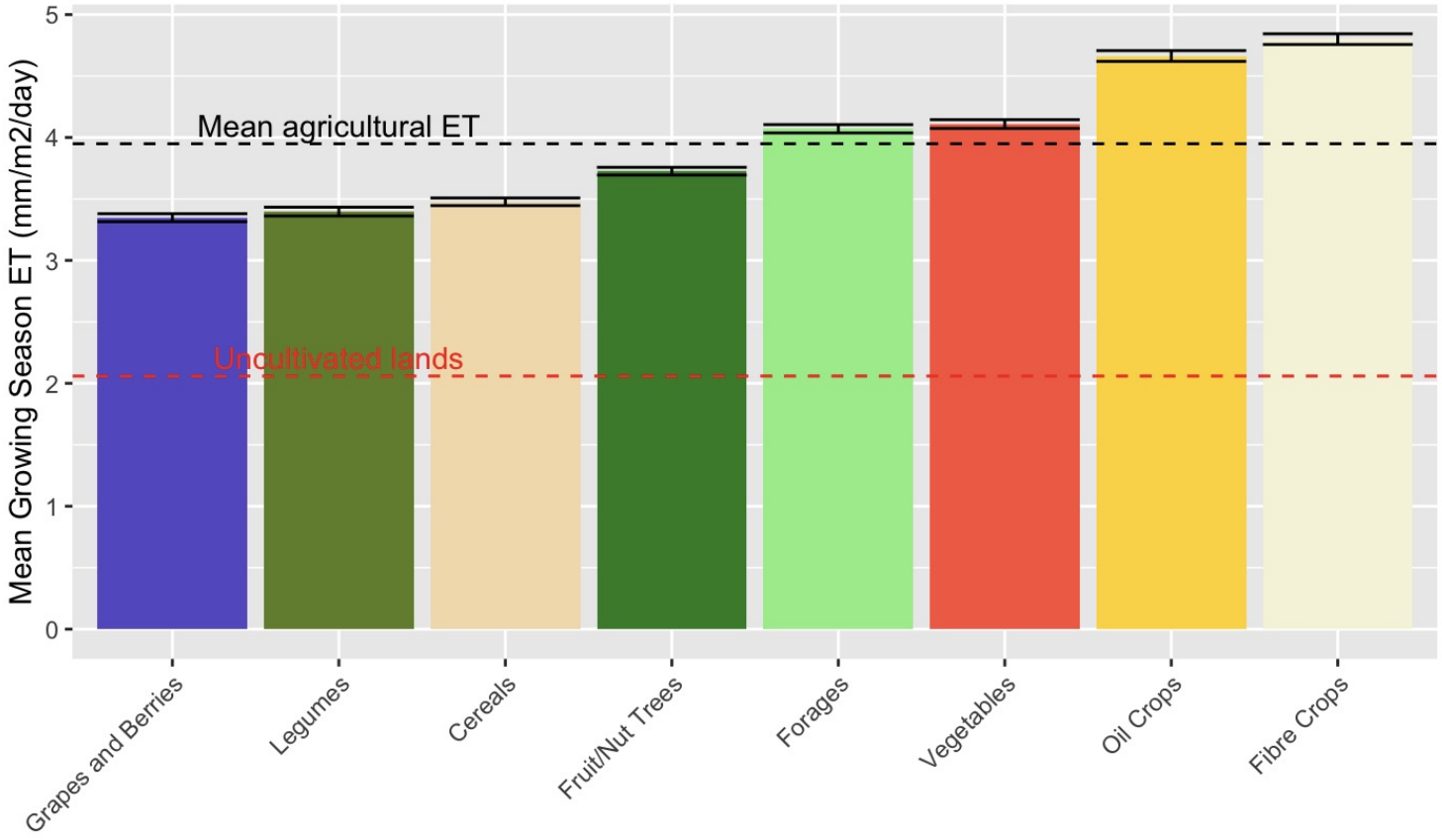
Summary & Future directions

- Framework to use GRACE-based ET and ECOSTRESS to characterize human impacts on water cycle

- Extend these results to other climates and regions
- Estimate impact of agriculture on recent observed increased in global land ET
- Look at impact of individual crops



ECOSTRESS resolves crop ET variability in California Central Valley



[Anna Boser, UCSB]

Thank you!

madeleine.a.pascolini-campbell@jpl.nasa.gov

Geophysical Research Letters

Research Letter

GRACE-FO and ECOSTRESS synergies constrain fine-scale impacts on the water balance

Madeleine Pascolini-Campbell, Joshua B. Fisher, John T. Reager

First published: 15 July 2021 | https://doi.org/10.1029/2021GL093984