How Much Water is Evaporated Across California?: An Assessment of State-Wide Evaporation using ECOSTRESS Data, Bench-Marked with a Meso-Network of Eddy Covariance Sites and a Hierarchy of a Biophysical Models



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Ecostress PI Meeting Feb, 2020 Ventura, CA



## Long-Time (~60 years) Interest in Evaporation of California



Circa 1960, Walnut Orchard near Brentwood, CA

#### Can We Circumvent the Myths and Politics of CA Water and Share It Better?











'Whisky is for Drinkin; Water is for Fighting Over'

# Big Questions to Ecostress and ET

- Basic Questions
  - How to Assess ET Every Where, All the Time?
  - How Does ET Vary Seasonally and Spatially with LAI, Plant Functional Group, Photosynthetic Capacity and Soil Moisture Deficits?
  - Are there Trends in ET due to Busts and Booms in Rain and Global Warming?
- Applied Questions
  - How much Water is Evaporated Across California?
  - Can Atmospheric Humidity Deficits Act as a Proxy to Soil Moisture Deficits?
    - Ecosystem-PBL Feedbacks Ultimate Soil Moisture Sensor
  - Can Reflected NIRv Be Used to Estimate GPP ->Gsfc ->E:PenmanMonteith?

## California Ideal Venue to Test ET Models

- Large Interannual Variation in Rainfall (+/- 30%)
- Huge Range and Gradients in Rainfall (>2000 mm -> < 200 mm), and ET
- Mediterranean Climate Yields Seasonality in Rainfall and ET and Repeated Wet/Dry Cycles
- Much of California is Cloud Free during the Growing Season
- Huge Range in Ecosystem Structure and Function, Actual/Potential ET

#### Eddy Covariance Flux Measurements Across California







BESS: Coupled Energy Balance, Photosynthesis, Stomatal Conductance MODIS inputs 1 Km Resolution Daily-weekly

Baldocchi, D., D. Dralle, C. Jiang, and Y. Ryu (2019), How Much Water Is Evaporated Across California? A Multiyear Assessment Using a Biophysical Model Forced With Satellite Remote Sensing Data, *Water Resour. Res.*, *55*(4), *2722-2741*, *doi:10.1029/2018wr023884*.

## What is the Truth?



#### Conventional Wisdom based on Irrigation Application:



Histogram

http://www.itrc.org/reports/pdf/californiacrop.pdf

**Central Valley** 



#### Near Fresno, August



#### Evaporation as a Function of Coupled PBL and Penman Monteith Models





Baldocchi, D. D., L. Xu, and N. Kiang (2004), How plant functional-type, weather, seasonal drought, and soil physical properties alter water and energy fluxes of an oak-grass savanna and an annual grassland, *Agricultural and Forest Meteorology*, *123(1-2)*, *13-39*.

#### Reflected Near Infrared Radiation from Vegetation is a Proxy for Ecosystem Photosynthesis



## Can Atmospheric Humidity Deficits Serve as a Proxy for Soil Moisture Deficits?





Annual Evaporation and Precipitation across CA, July-June Hydrological Year









## Early Influences on Measuring and Modeling Evaporation

#### **UC** Davis



**Bill Pruitt** 

#### Nebraska



Norm Rosenberg



Jerry Hatfield



Shashi Verma



John Norman

## Fruits of the CA's Water Projects, \$4T Economy, 5<sup>th</sup> Largest in the World





CA Evaporation