Adaptation Planning for Climate Change Impacts using Advanced Decision Support and Remote Sensing: Irrigated Agriculture in California's Central Valley

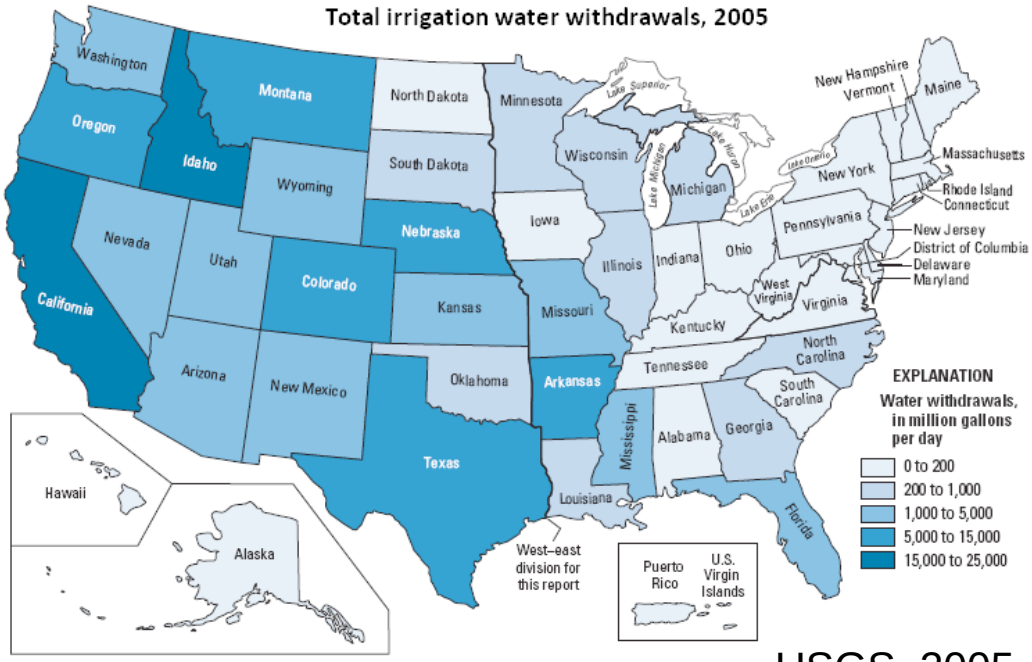
Jonathan Winter[1], Cynthia Rosenzweig[2], Alexander Ruane[2], David Purkey[3], Charles Young[3], David Yates[3], Vishal Mehta[3] Charles Vörösmarty[4], Kyle McDonald[4], Marzieh Azarderakhsh[4]

[1]Dartmouth College/Columbia University, [2]NASA Goddard Institute for Space Studies, [3]Stockholm Environment Institute, [4]The City College of New York

March 3, 2015

US Irrigated Agriculture Generates $118.5B/year

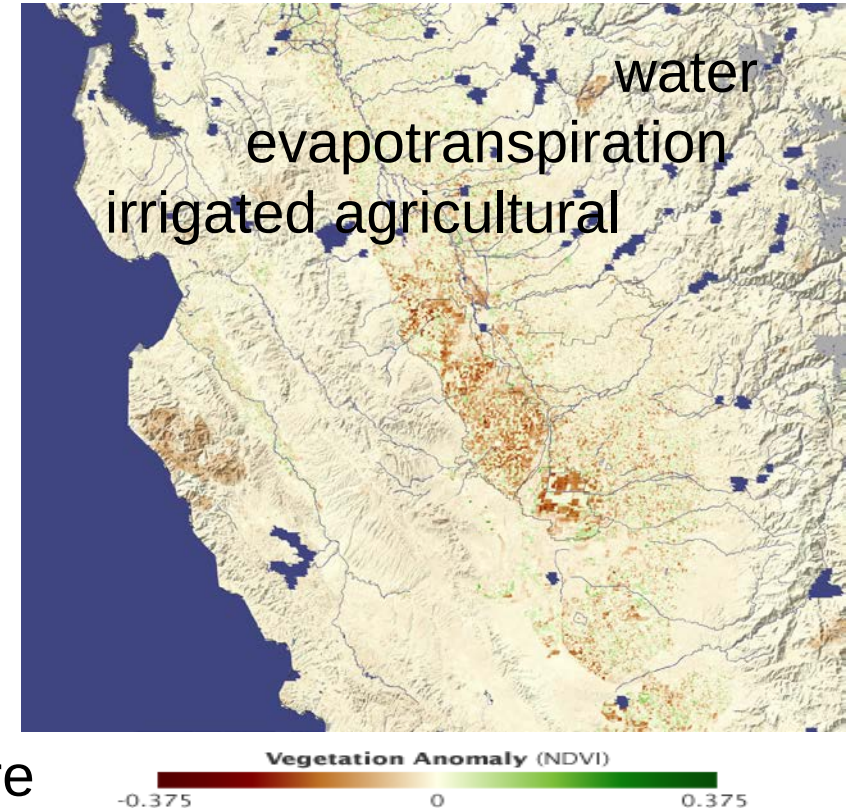
- Irrigated farms account for 80%-90% of consumptive water use in the United States (USDA ERS, 2007)
- Agriculture especially sensitive to future changes in water supply and demand, as irrigated croplands require large quantities of water at low prices
- Climate change will shift patterns of precipitation, altering the quantity of runoff
- California is of particular interest because of its $35-billion agricultural sector, limited water resources, and complexity



USGS, 2005

Explore Future Water Availability for Irrigation across the Central Valley

- Improve the representation of crops in a hydrologic model
- Simulate current and future available water throughout the Central Valley and distributions of that water among competing uses
- Assess the impacts of future availability on crop and yields in areas
- Evaluate water resources across the western US
- Link DWR's IWFM to WEAP, use to explore long-term planning of Yolo County Flood Control and Water Conservation District (YCFCWCD) infrastructure



NASA Earth Observatory, 2009

Project Team and Partners

Project Team

- PI: Cynthia Rosenzweig (NASA GISS), Jonathan Winter (Dartmouth College/Columbia University)
- Co-I: Alex Ruane (NASA GISS), David Purkey (Stockholm Environment Institute), Charles Vörösmarty (City College of New York)

Project Partners

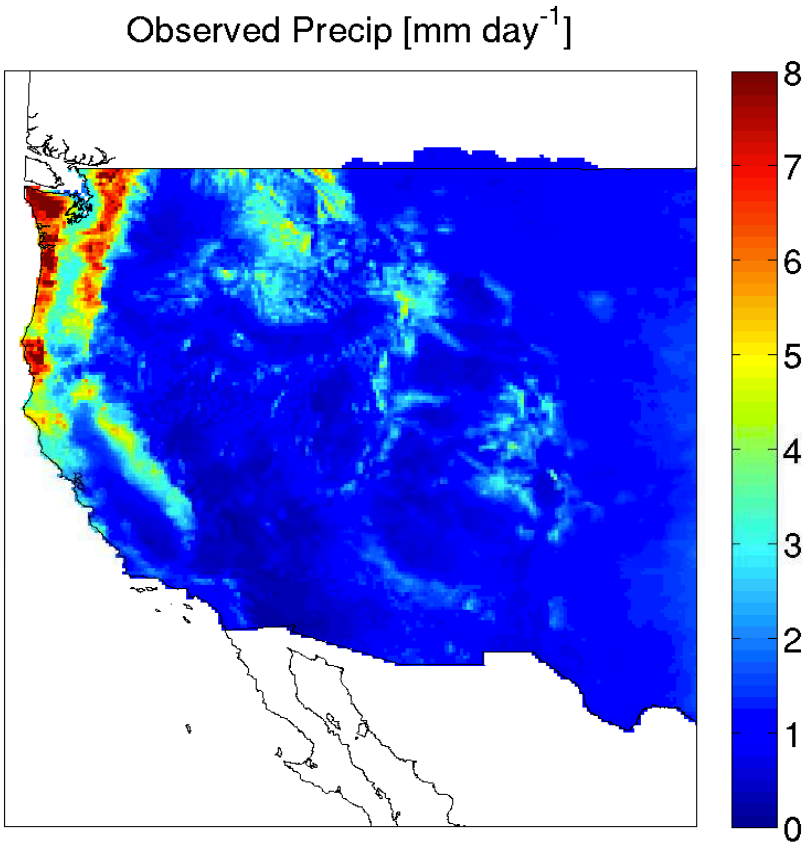
- Yolo County Flood Control and Water Conservation District (YCFCWCD), Agricultural Model Intercomparison and Improvement Project (AgMIP)

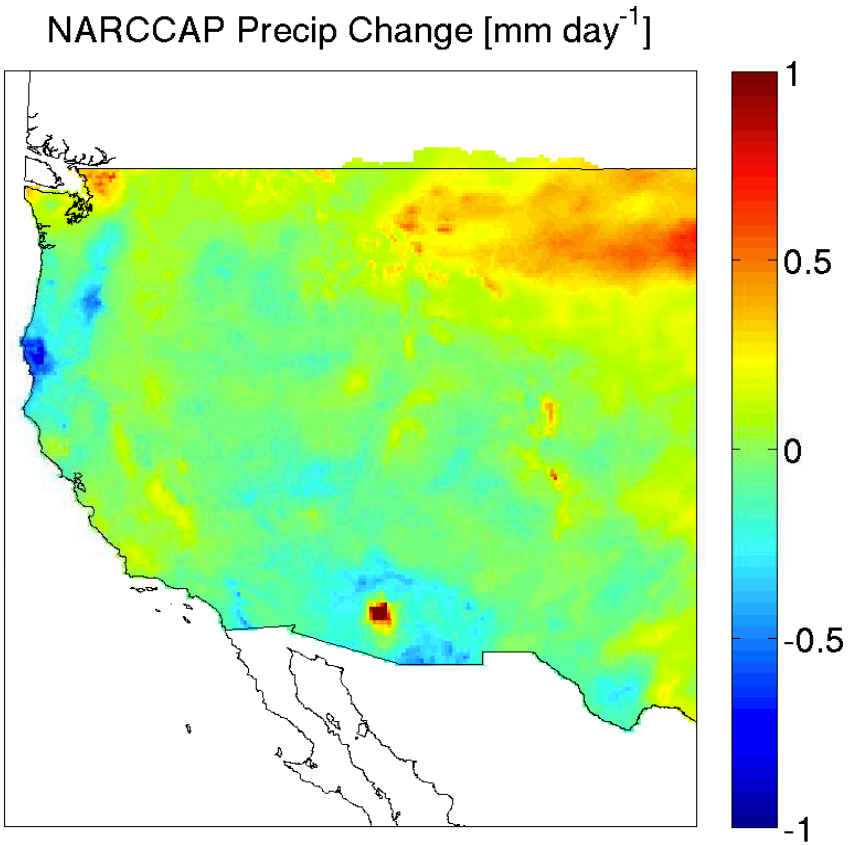
Project Collaborators

- California Department of Water Resources (DWR), US Bureau of Reclamation (USBR), University of California Davis

Approach: Climate and Climate Change

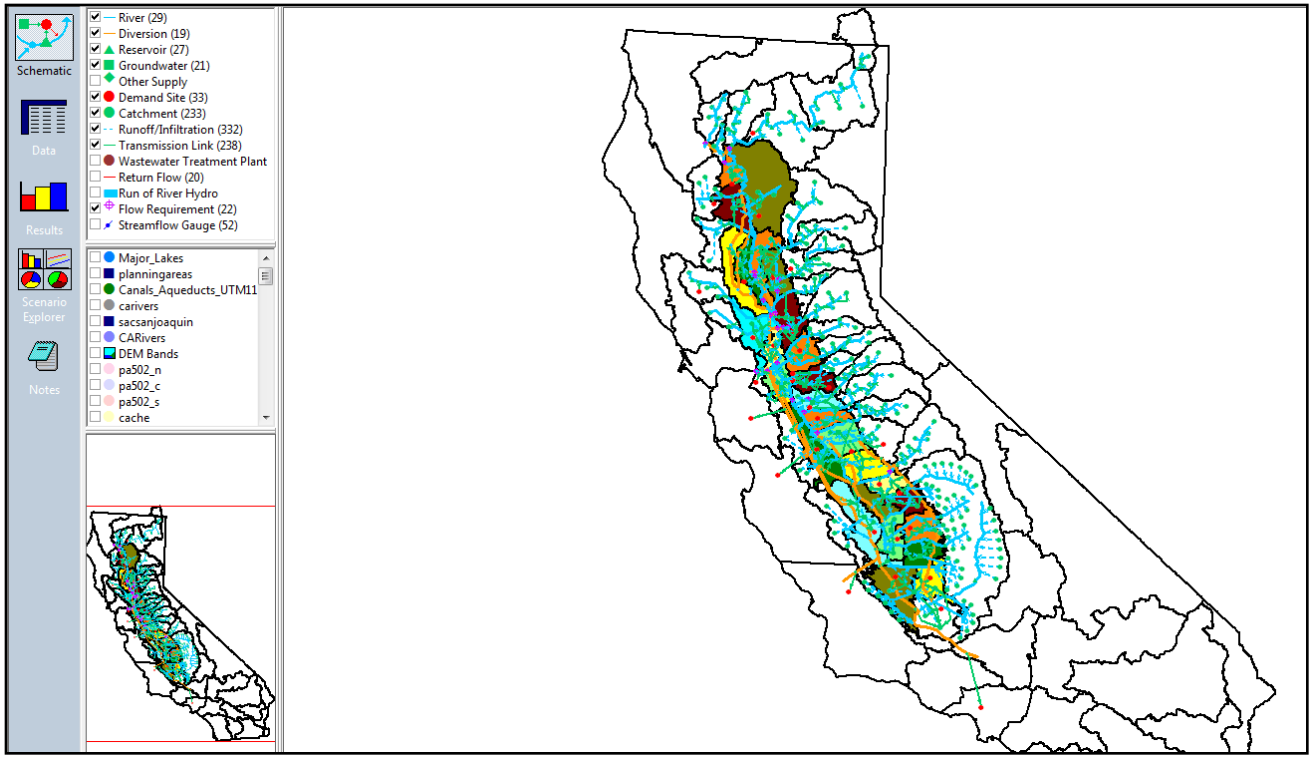
- Surface temperature and precipitation observations for 1980-2009, and 1998-2009 TRMM observations
- Difference between NARCCAP 2050-2069 and NARCCAP 1980-1999 temperature and precipitation





Approach: Water Resources and Crops

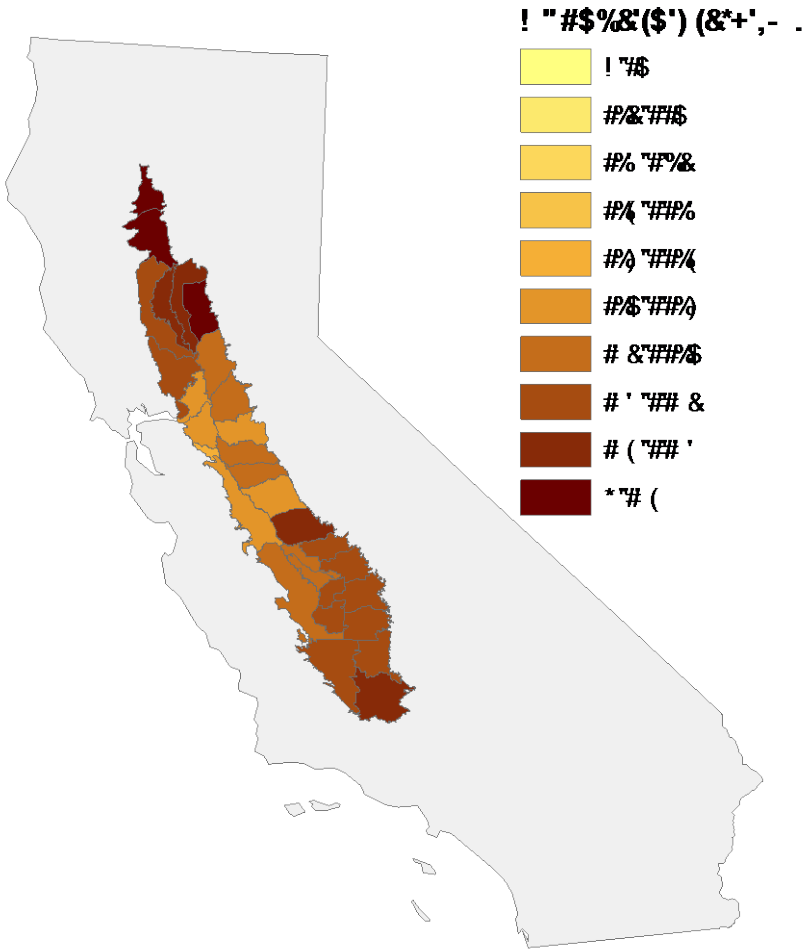
- Coupled Decision Support System for Agrotechnology Transfer Model (DSSAT) to Water Evaluation and Planning System (WEAP)
- Deployed over Central Valley (Stage 1) and Yolo County Flood Control and Water Conservation District (Stage 2)



Impacts: Yield Projections that Explicitly Account for Limited Water

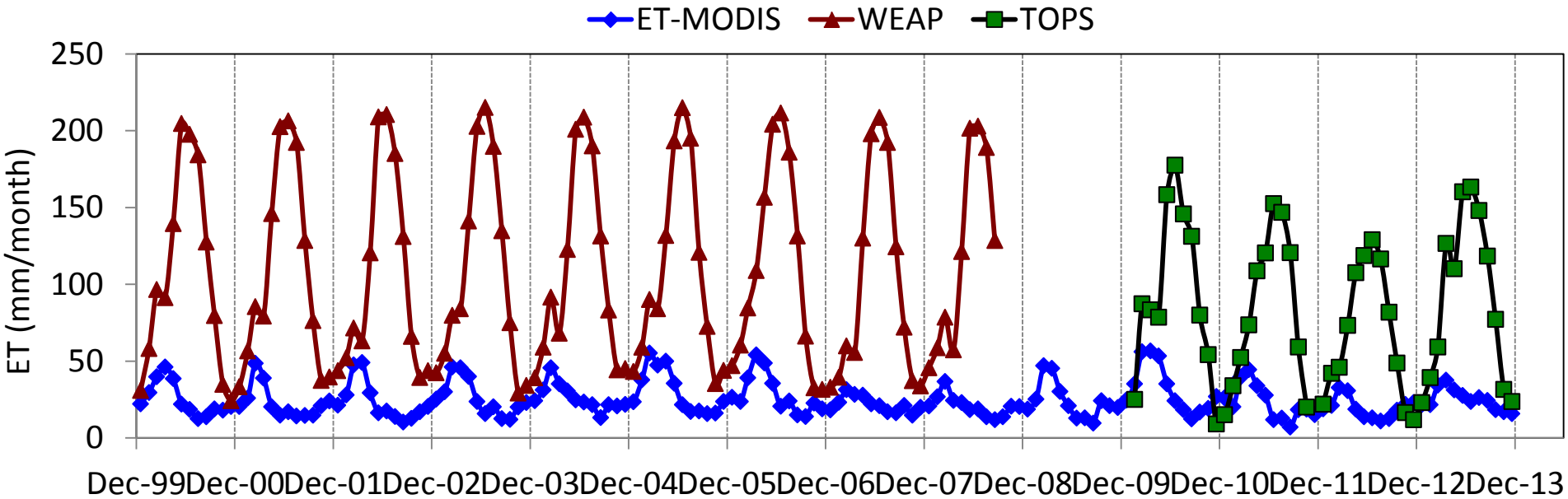
- Iterative WEAP-DSSAT simulations that irrigate fully, and then scale to make water applied meet water supply
- Pilot for future water-agriculture research, continued collaboration with the Agricultural Model Intercomparison and Improvement Project (AgMIP)
- Current plans to code limited irrigation into the broader DSSAT distribution

Corn



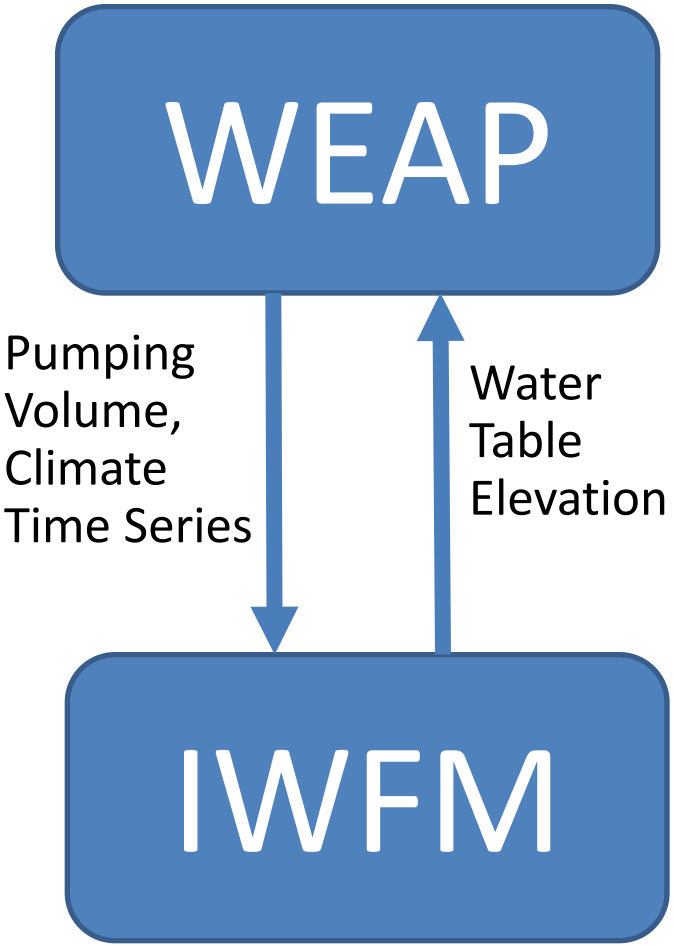
Impacts: Evaluation of WEAP and DSSAT Simulated Evapotranspiration

- Central Valley: Compare to MOD16 ET and MOD16 PET, catchment averaged
- YCFCWCD: Compare to MOD16 ET, MOD16 PET, CIMIS, TOPS, both catchment-averaged and field-scale
- Difficult comparisons given varying ET measures, spatial scales, time periods covered, assumptions, etc., but can inform crop model calibration



Impacts: YCFCWCD Future Planning

- XLRM Scenario Analysis: Exogenous Drivers, Management Levers, Relationships/Models, Performance Metrics
- Six Exogenous Drivers: 3 Climate x 2 Landuse
- Two Management Levers: Current and YCFCWCD groundwater pumping
- Relationships: WEAP soft linked to IWFM
- Performance: Economic sustainability, Water supply reliability, Ecological sustainability



Project Transition

- YCFCWCD involved in all aspects of the project through in-kind contribution of technical staff and XLRM scenario generation
- Instruct staff of the District on how to deploy, evaluate, and use WEAP-DSSAT and WEAP-DSSAT-IWFM
- Transfer all models and datasets to YCFCWCD with free WEAP licenses
- Collaborate with YCFCWCD to publish paper on water management under future climate using WEAP-DSSAT

Lee,

Lessons Learned

- Demand and interest for models that can capture the dynamics of water resources and agricultural production at a range of spatial and temporal scales: seasonal timescales for operational water and agricultural management, decadal timescales for infrastructure investment, and centennial timescales for policy development
- Many small, tailored, opportunities for applying a linked water resources and crop model
- Coupling relatively simple compared to deploying the model over the Central Valley and YCFCWCD

The Atlantic, 2012