# Statewide evaluation of "no overdraft policy" with a hydroeconomic model, CALVIN

## Mustafa S. Dogan, Ian Buck,  Jay Lund

Center for Watershed Sciences, UC Davis

msdogan@ucdavis.edu

CWEMF
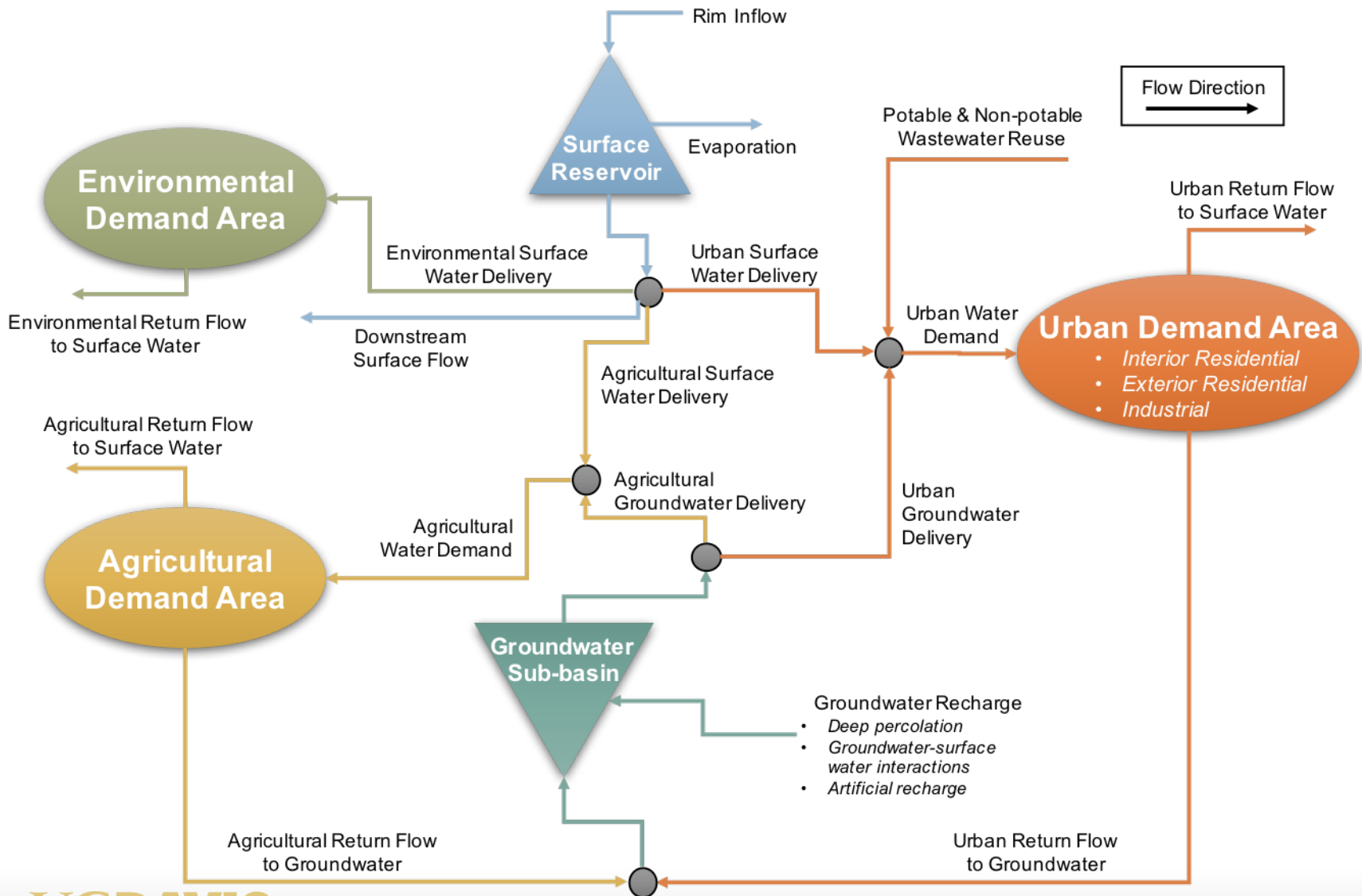California Water & Environmental Modeling Forum

# No overdraft policy

- Sustainable Groundwater Management Act (SGMA) 2014

- Local agencies managing groundwater

- SGMA aims to sustainable manage groundwater, including eliminating overdraft

- This study focuses only on eliminating overdraft

UC DAVIS
UNIVERSITY OF CALIFORNIA

# CALVIN

- Hydroeconomic optimization model for water planning and allocation

- ~90 % of urban and agricultural activities

- Environmental requirements

- Groundwater and surface water used conjunctively

- Minimize statewide operating and scarcity costs



Legend

**Regions**

- Not Included in CALVIN
- Upper Sacramento Valley
- Lower Sacramento Valley & Bay Delta
- San Joaquin Valley & South Bay
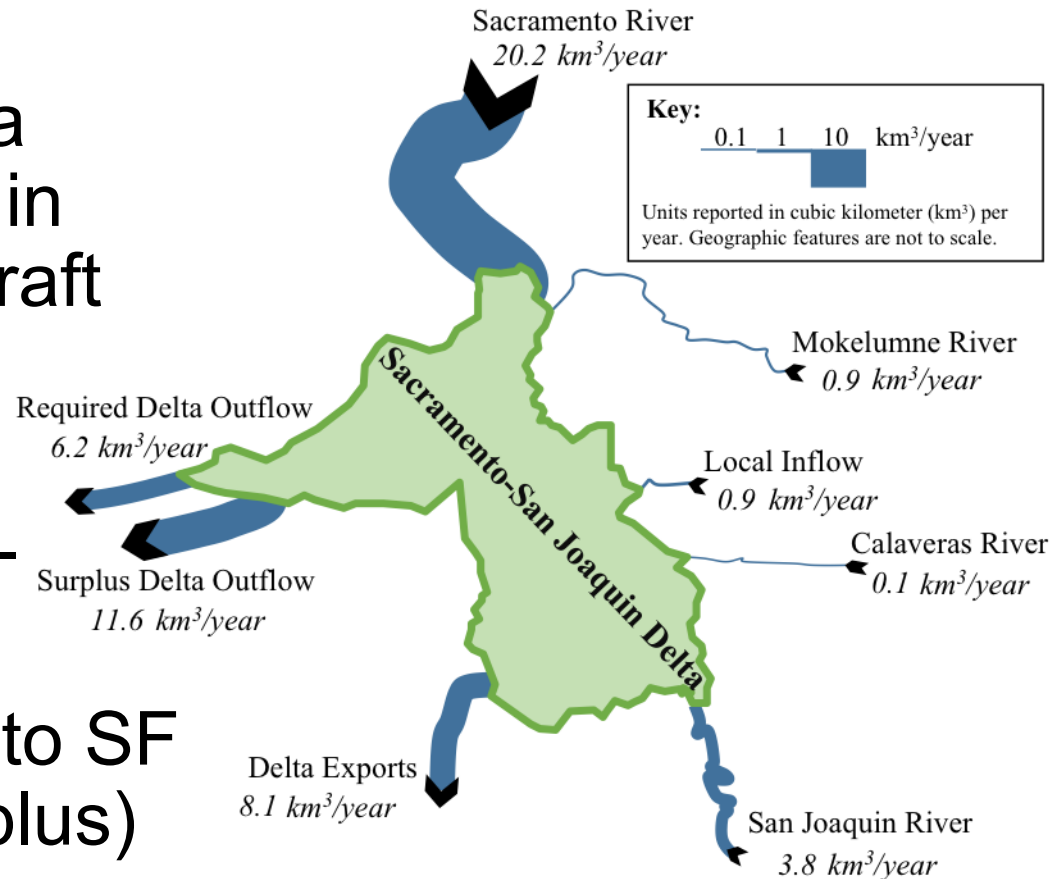- Tulare Basin
- Southern California

# Demand representation

# Limitations of CALVIN

- Not a hydrologic model to represent all properties of groundwater (fixed recharges from C2VSim)

- Fixed groundwater heads for pumping

- Knows all hydrologic events in its period, providing optimistic values for scarcity and cost

- Perfect water market conditions, where users can buy and sell water (subject to constraints)

# Delta water balance

- Restrictions on Delta outflow and exports in addition to no overdraft policy

- Exports: California Aqueduct and Delta-Mendota Canal

- Outflow: drainage into SF Bay (required + surplus)

Sacramento River
20.2 $km^3/year$

Key:
0.1   1   10   $km^3/year$

Units reported in cubic kilometer ($km^3$) per year. Geographic features are not to scale.

Mokelumne River
0.9 $km^3/year$

Required Delta Outflow
6.2 $km^3/year$

Local Inflow
0.9 $km^3/year$

Sacramento-San Joaquin Delta

Calaveras River
0.1 $km^3/year$

Surplus Delta Outflow
11.6 $km^3/year$

Delta Exports
8.1 $km^3/year$

San Joaquin River
3.8 $km^3/year$

# Management cases

- Under historical and warm-dry climates

| # | Scenario | Description | Importance |
|---|----------|-------------|------------|
| *Scenario 1* | Base historical | Historical overdraft (1921-2003) | Base case operations |
| *Scenario 2* | No overdraft | Ending groundwater storage cannot be less than initial storage | Operations without overdraft and any restrictions on Delta |
| *Scenario 3* | No overdraft & no reduction in Delta outflow | No reduction in Delta outflow is allowed | Water use re-allocation across basins |
| *Scenario 4* | No overdraft & no additional Delta exports | No additional Delta exports are allowed | Operations and use changes within basins |
| *Scenario 5* | No overdraft & no Delta exports | Delta exports are limited to 5% of export capacity | Effects of only minimal Delta exports |

# Warm-dry conditions

- Derived from GFDL CM2.1 A2 climate scenario

- Snowmelt recession

- Peaking in January
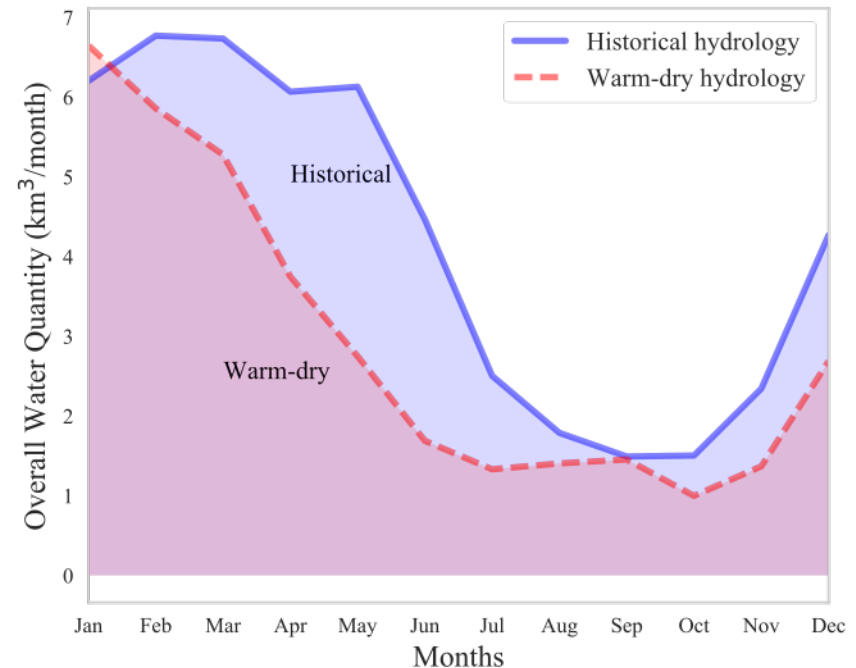


| Component | Historical (km³/year) | Warm-dry (km³/year) | Change (%) |
|---|---|---|---|
| Rim inflow | 38.1 | 27.5 | -28% |
| Gw recharge | 7.5 | 7.1 | -6% |
| Local runoff | 2.1 | 0.7 | -68% |
| Total | 47.7 | 35.2 | -26% |

# Results

- Effects of no overdraft policy and warm-dry hydrology on water deliveries

- Groundwater storage effects

- Value of additional Delta exports and reduced outflow

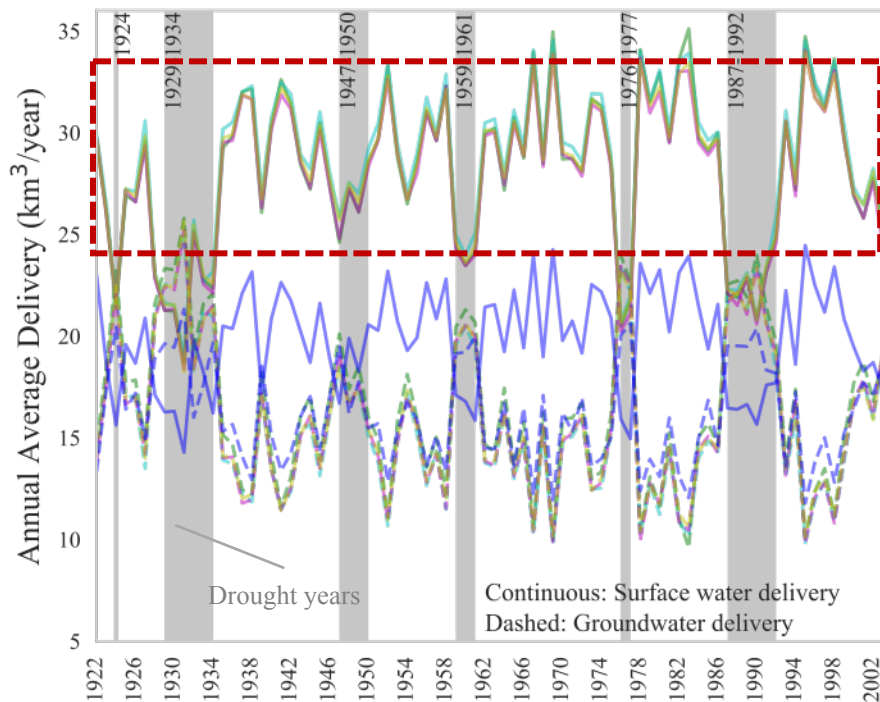- Surface storage expansion

# Water deliveries

- Groundwater and surface water deliveries
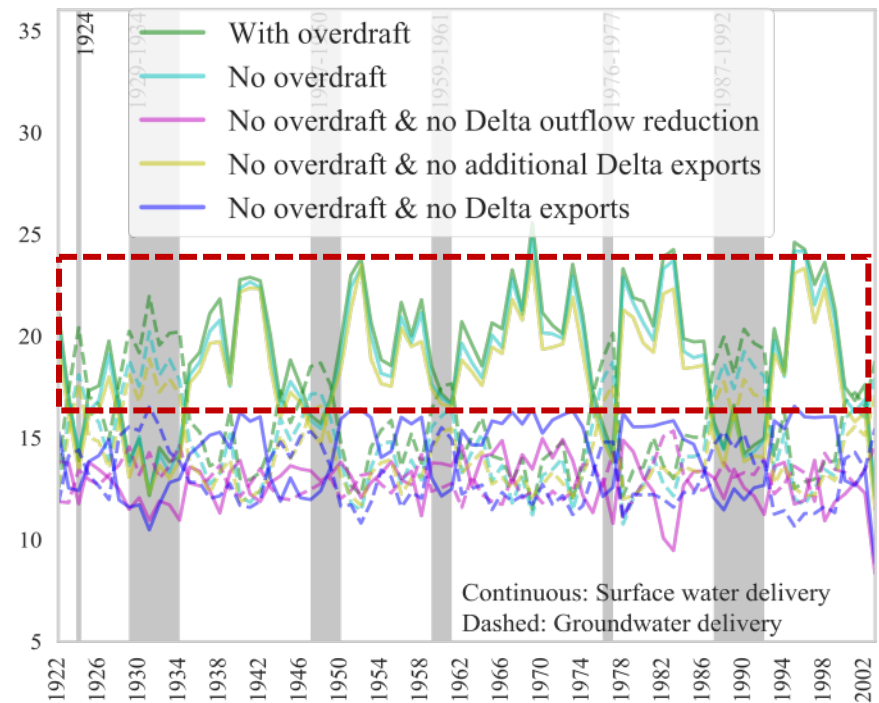- No big change in portfolio under no overdraft
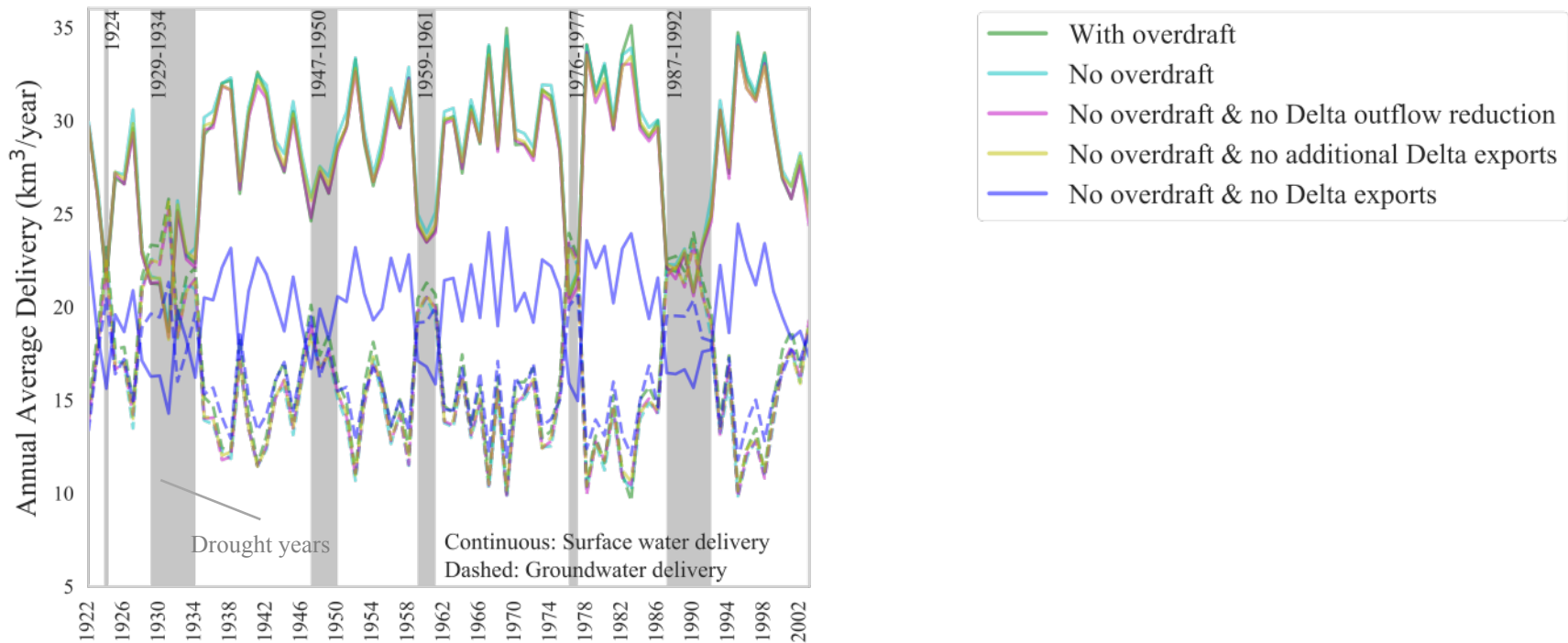


a) Historical hydrology

# Water deliveries

- Groundwater and surface water deliveries
- No big change in portfolio under no overdraft
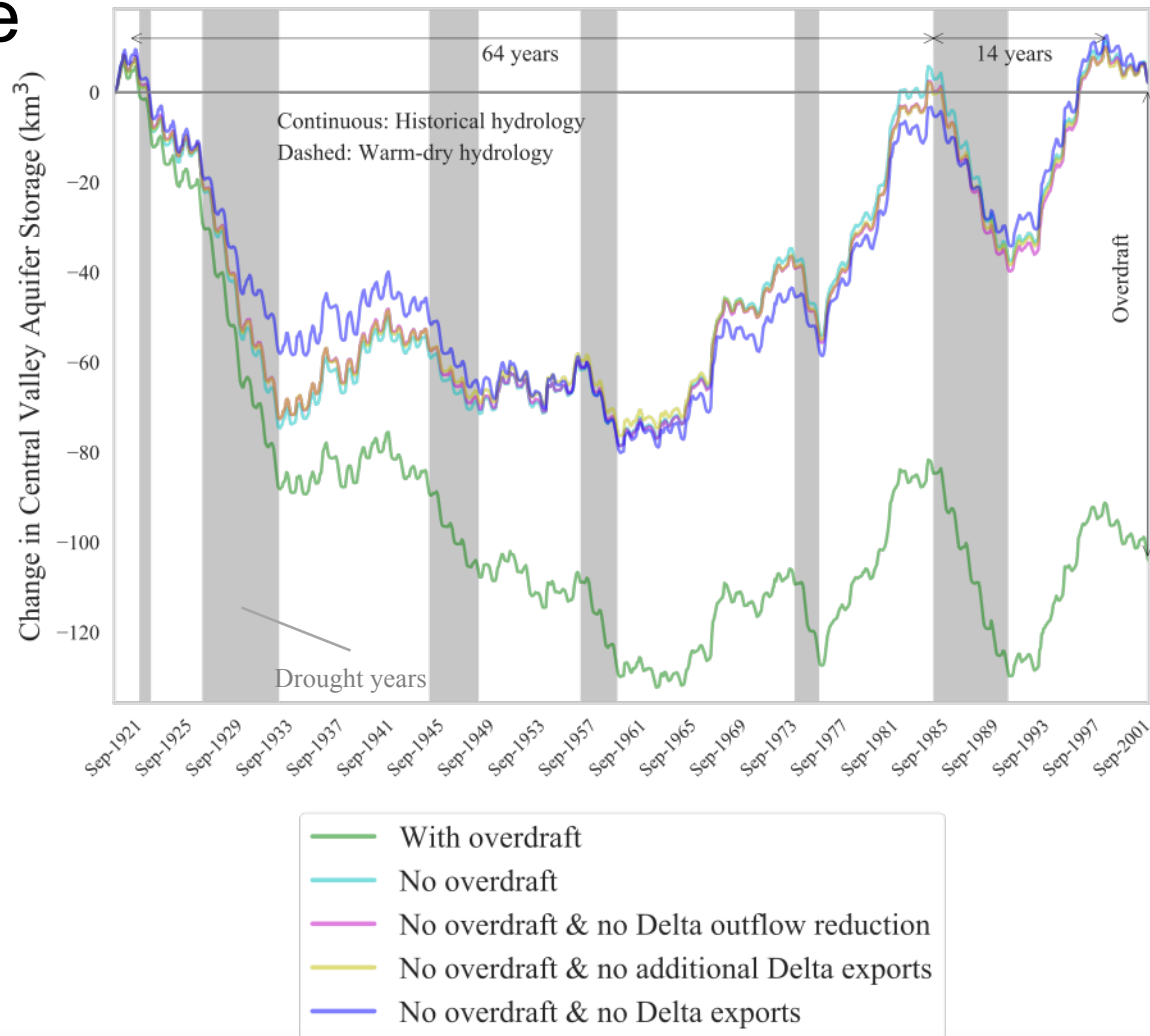- Warm-dry hydrology reduce surface deliveries



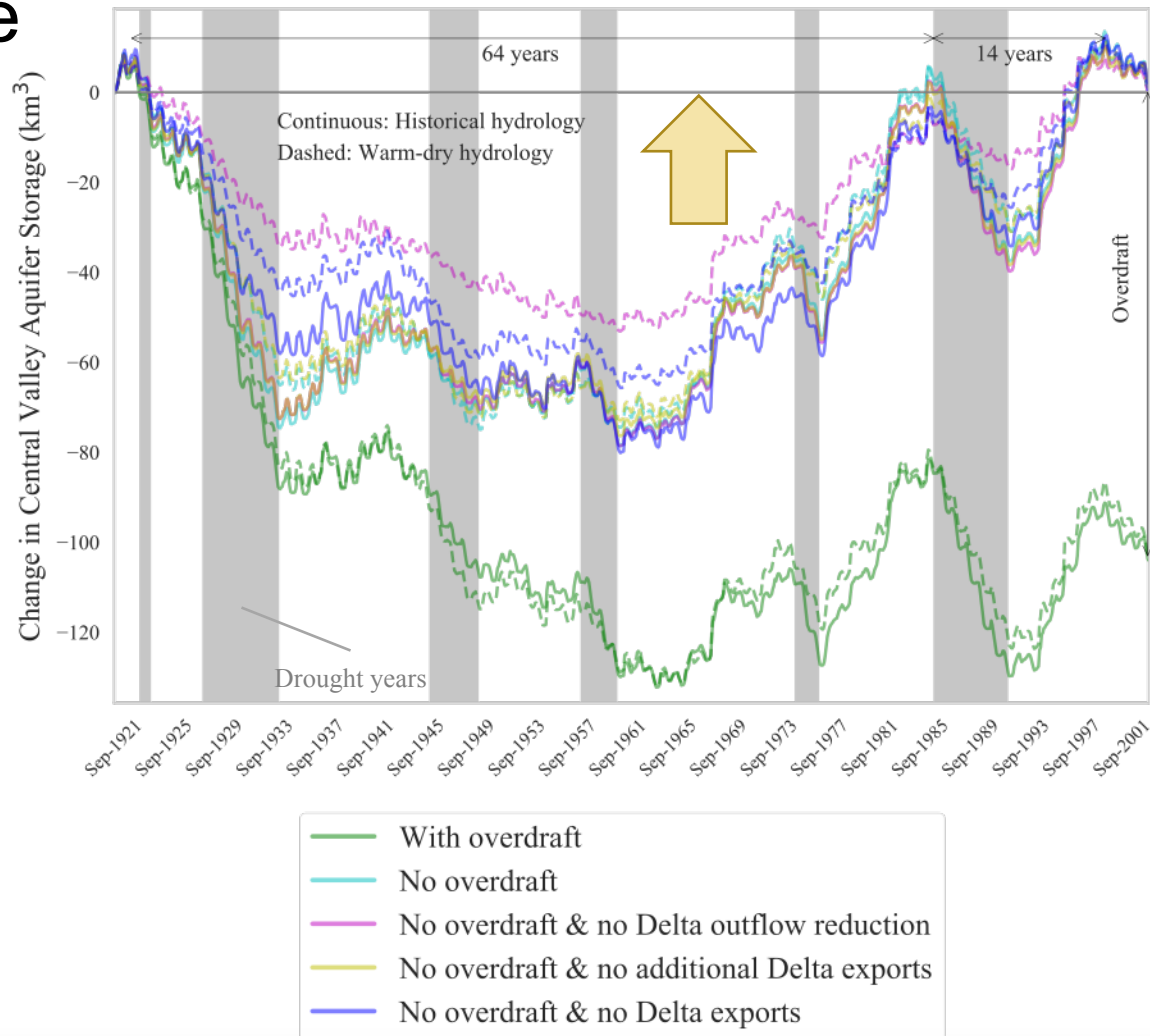a) Historical hydrology

b) Warm-dry hydrology

# Groundwater storage

- Modeled storage
  (between 1921 - 2003)

- Drawdown-refill cycles

- No long-term overdraft

- Short term overdraft useful

- Large recovery periods (64 & 14 years)

# Groundwater storage

- Modeled storage
  (between 1921 - 2003)

- Drawdown-refill cycles

- No long-term overdraft

- Short term overdraft useful

- Large recovery periods (64 & 14 years)
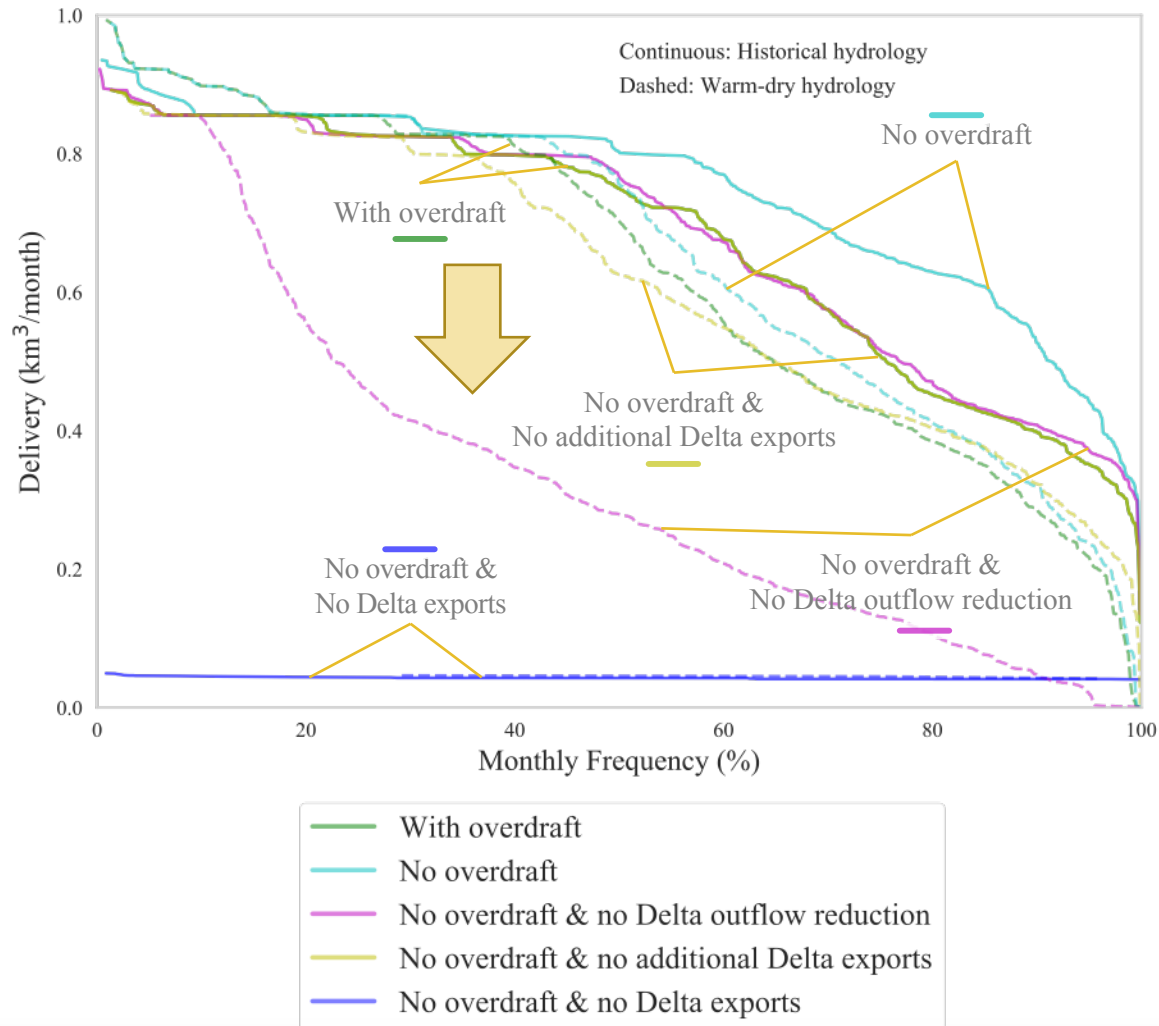
- Warm-dry



Change in Central Valley Aquifer Storage (km$^3$)

64 years | 14 years

Continuous: Historical hydrology
Dashed: Warm-dry hydrology

Overdraft

Drought years

Legend:
- With overdraft
- No overdraft
- No overdraft & no Delta outflow reduction
- No overdraft & no additional Delta exports
- No overdraft & no Delta exports

# Delta exports

- Exports from DMC & CAA
- Delivery-reliabilities
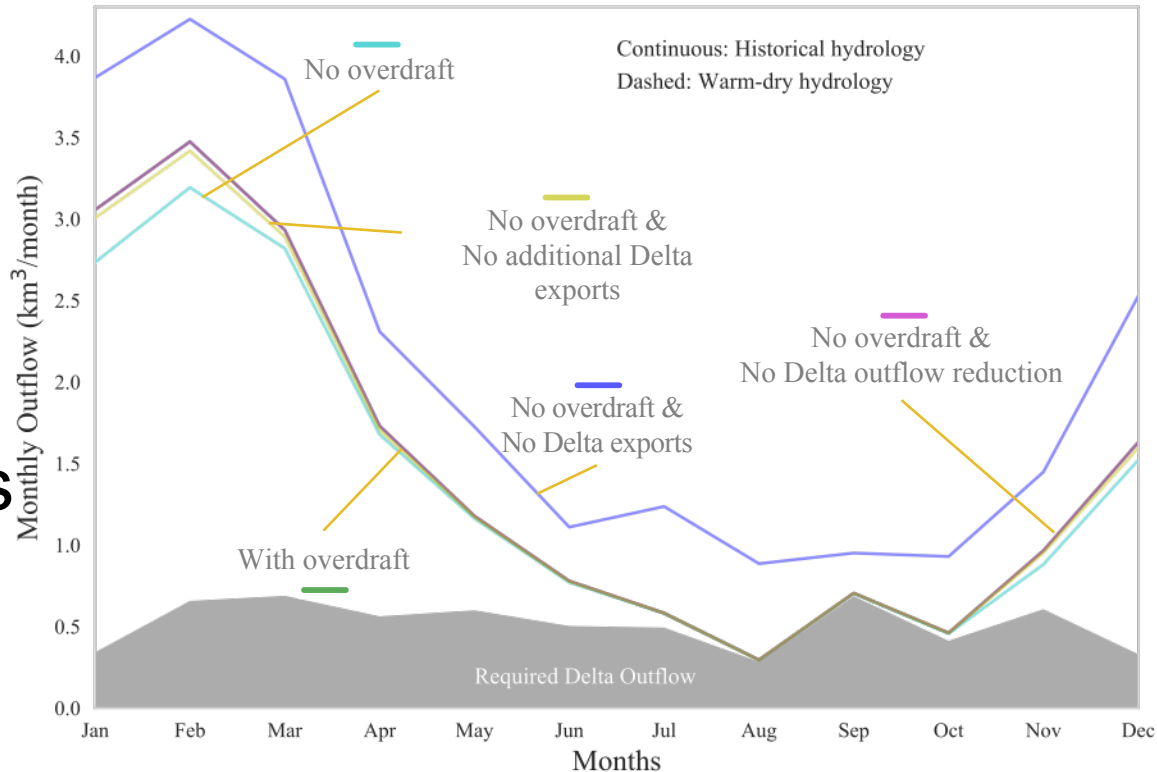- Increase with no overdraft
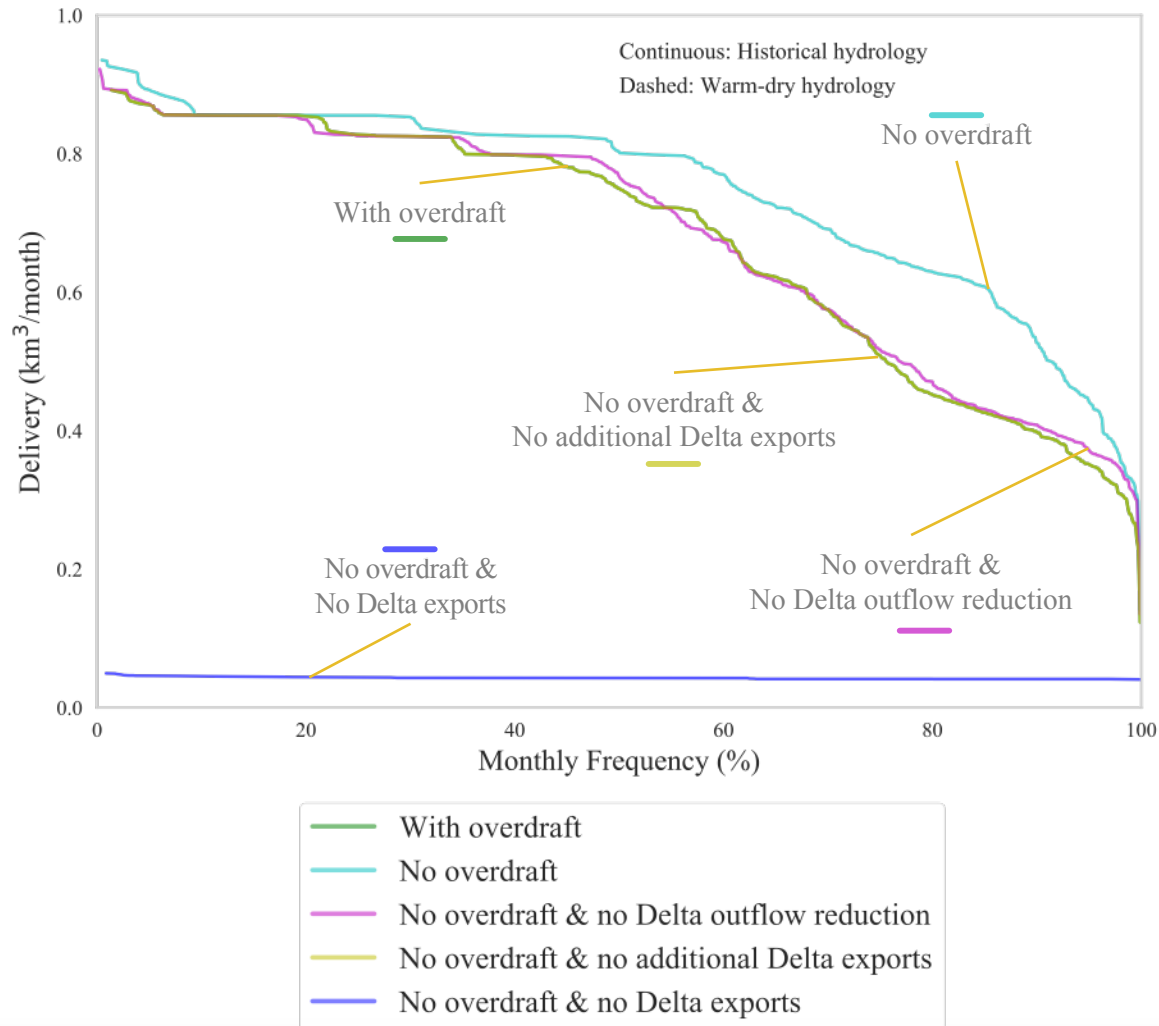
# Delta exports

- Exports from DMC & CAA

- Delivery-reliabilities

- Increase with no overdraft

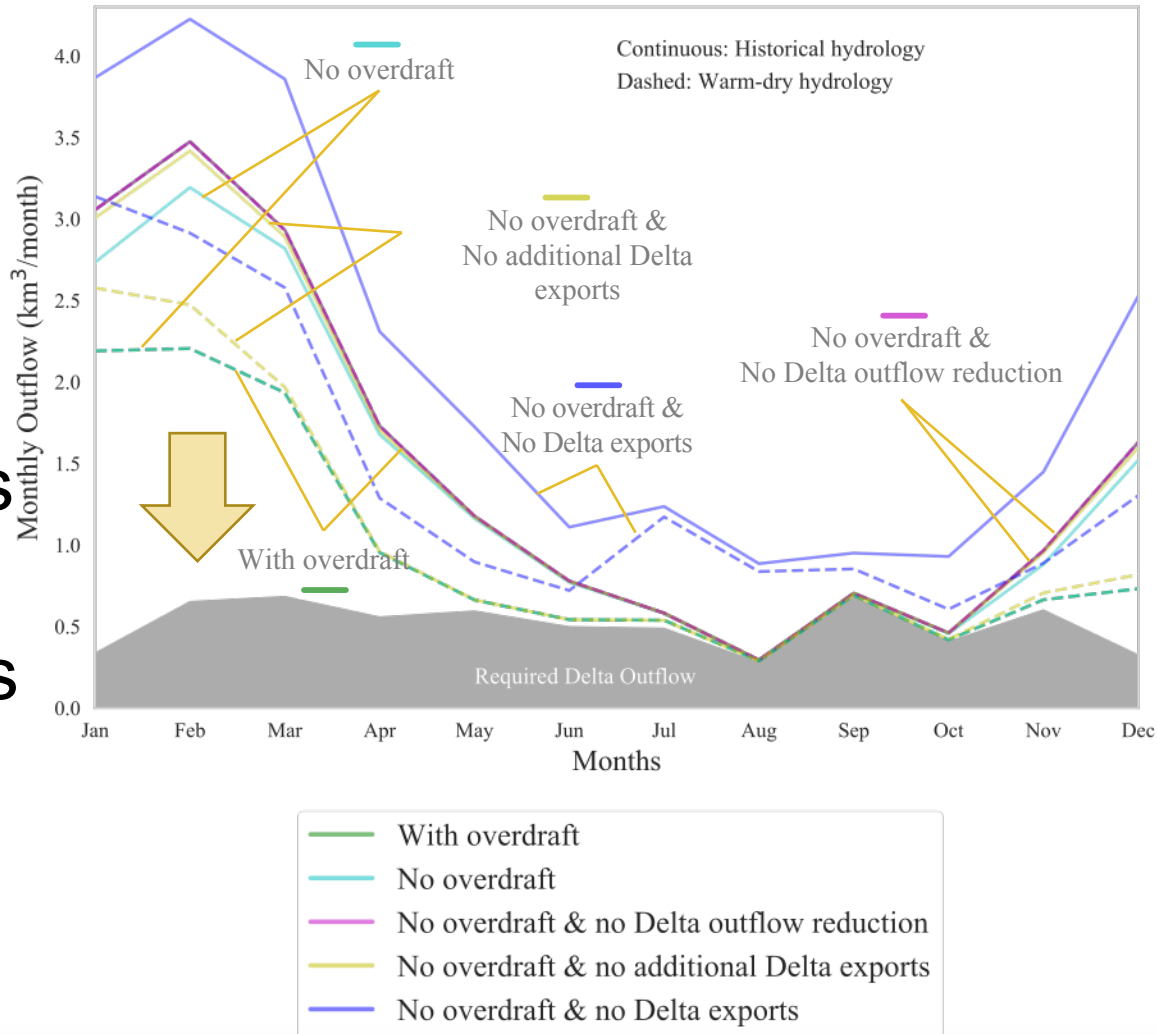- Large reduction in deliveries with warm-dry hydrology

# Delta outflow

- Required + surplus outflow

- Drainage from Central Valley into SF Bay

- Small reductions in Jan-Feb-Mar

# Delta outflow

- Required + surplus outflow

- Drainage from Central Valley into SF Bay

- Small reductions in Jan-Feb-Mar

- Large reductions with warm-dry hydrology

# Surface storage expansion

- Solution for temporal disconnection between supply and demand

Average marginal value of expanding storage capacity ($ / 1000 m³ / year)

| Scenario | Historical hydrology | |
| --- | --- | --- |
| | NOD | SOD |
| With Overdraft | 7 | 7 |
| No overdraft (OD) | 8 | 7 |
| No OD + no Delta outflow reduction | 6 | 6 |
| No OD + no additional Delta export | 8 | 6 |
| No OD + no Delta export | 5 | 1 |

NOD: North of Delta
SOD: South of Delta
1000 m³ = 0.81 Acre-foot

# Surface storage expansion

- Solution for temporal disconnection between supply and demand

- Value of expanding capacity increases with warm-dry hydrology NOD

- Cost of expansion ~$300-$800 per 1000 m³ per year

Average marginal value of expanding storage capacity ($ / 1000 m³ / year)

| Scenario | Historical hydrology | | Warm-dry hydrology | |
|---|---|---|---|---|
| | NOD | SOD | NOD | SOD |
| With Overdraft | 7 | 7 | 141 | 1 |
| No overdraft (OD) | 8 | 7 | 149 | 1 |
| No OD + no Delta outflow reduction | 6 | 6 | 41 | 1 |
| No OD + no additional Delta export | 8 | 6 | 159 | 1 |
| No OD + no Delta export | 5 | 1 | 78 | 1 |

NOD: North of Delta
SOD: South of Delta
1000 m³ = 0.81 Acre-foot

UCDAVIS
UNIVERSITY OF CALIFORNIA

# Conclusions

- No overdraft policy and warm-dry hydrology change operations

- Large filling and drawdown periods require long-term planning for managing groundwater

- Demand for Delta's water increases

- Warm-dry hydrology has more impacts than no overdraft policy

- Surface storage expansion benefits are probably lower than its costs

# Questions?

*Mustafa S. Dogan*

*Center for Watershed Sciences, UC Davis*

msdogan@ucdavis.edu