# RESPONSES OF REGIONAL CLIMATES TO CALIFORNIA'S AGRICULTURAL IRRIGATION

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with great helps from
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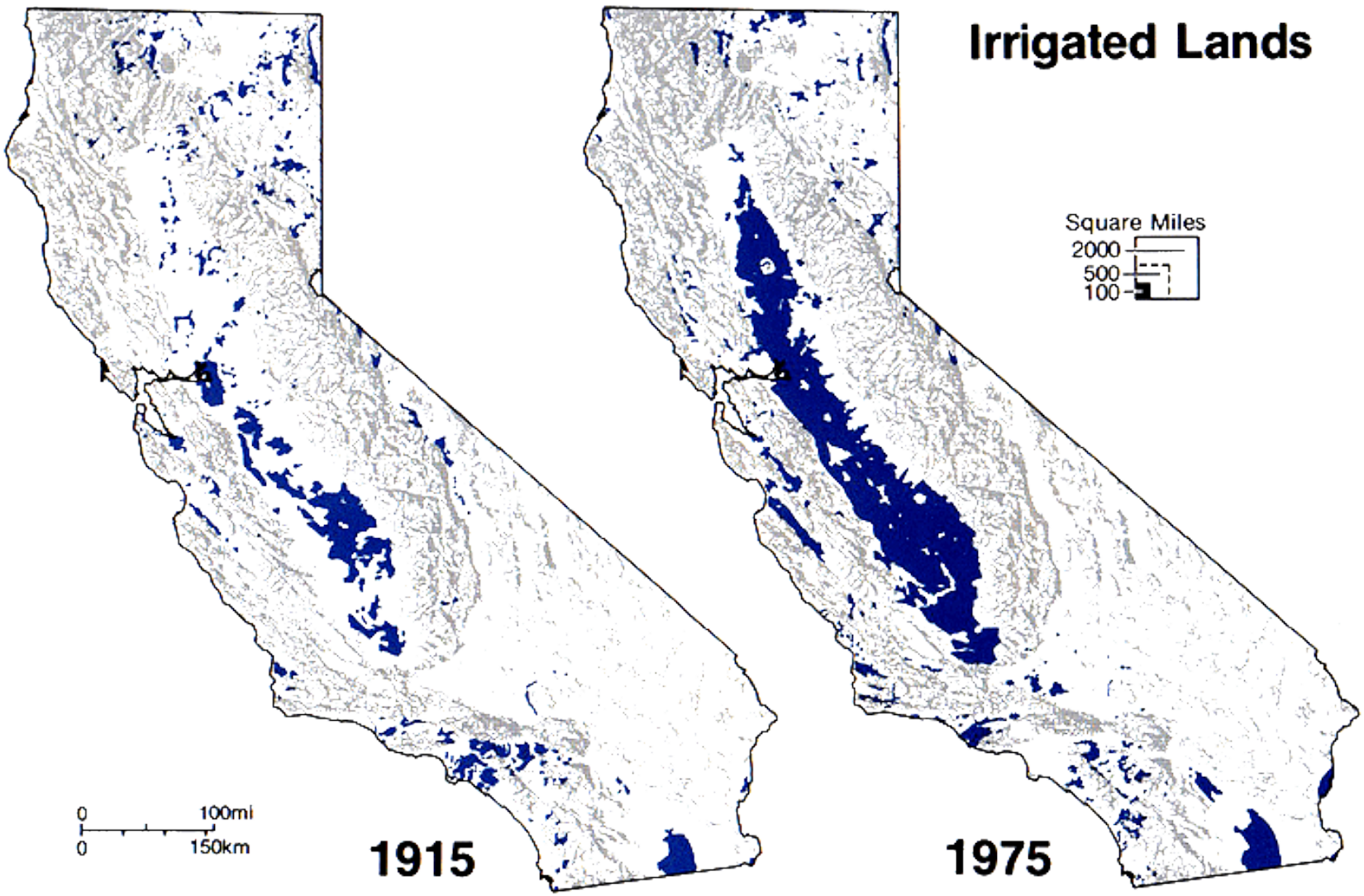
NCAR Land Working Group Meeting
2014/02/26

# Irrigation area changes in California

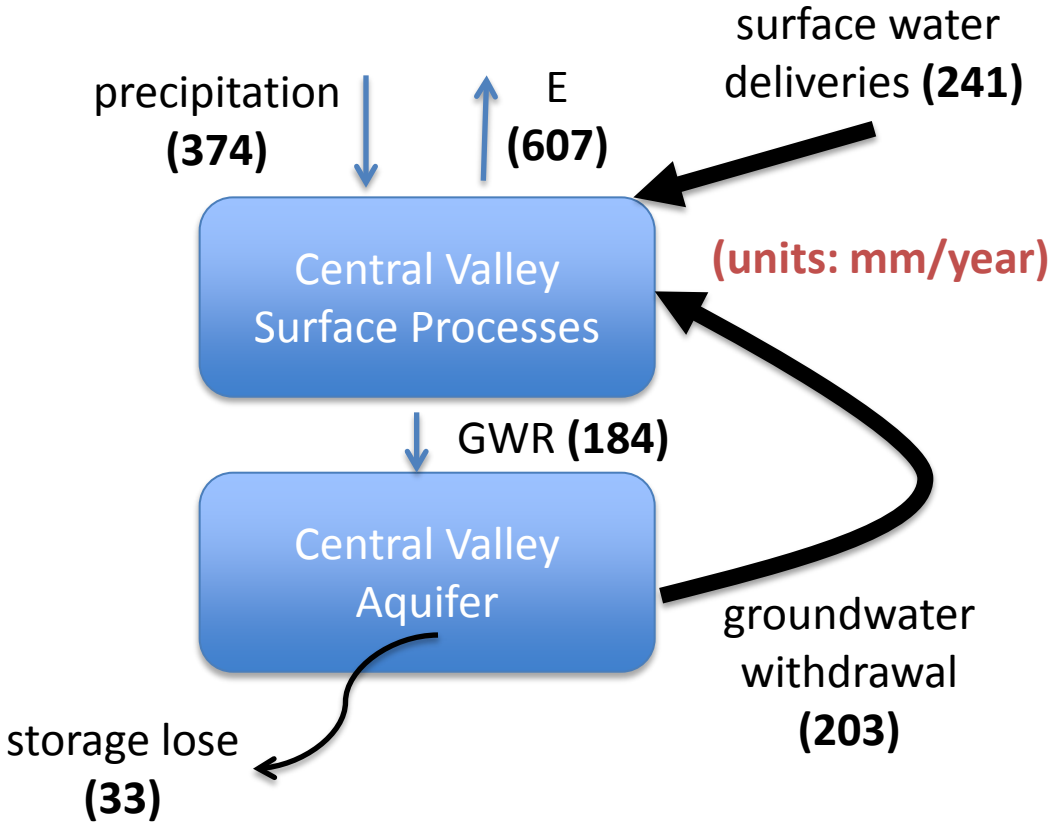



http://www.geog.ucsb.edu/~joel

# Water budget in heavily irrigated system

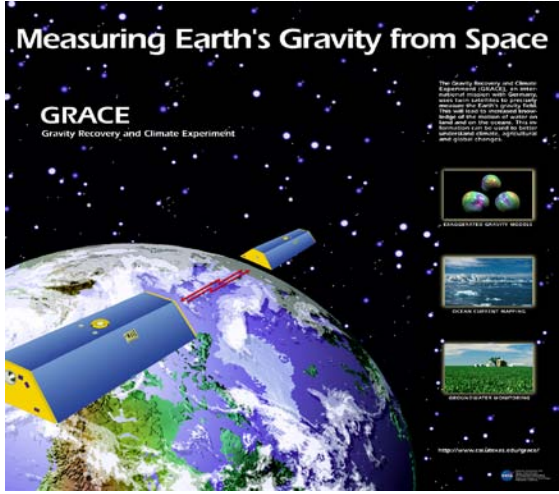
California's Central Valley
(52,000 km$^2$)

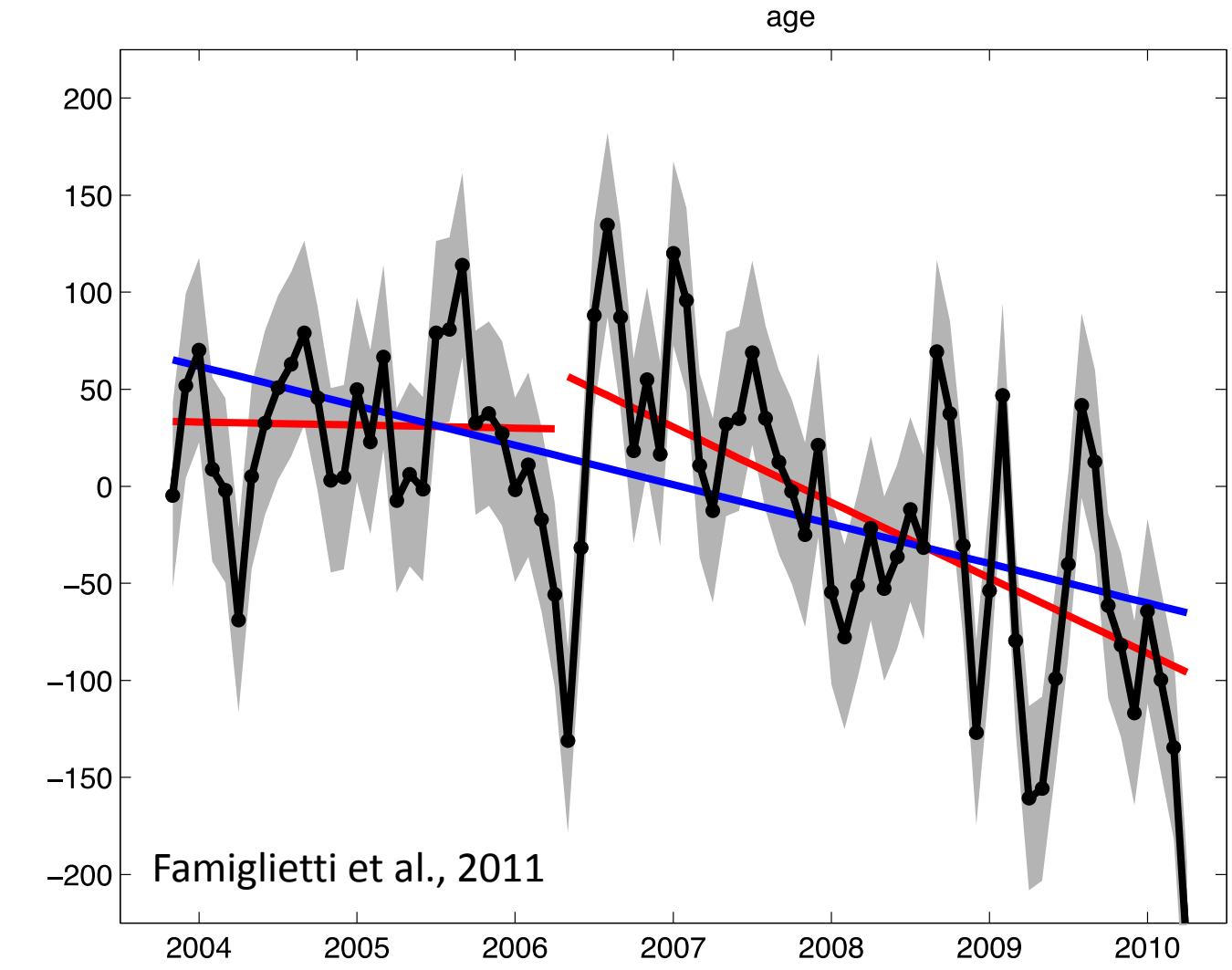
- one of the most productive agricultural regions in the world
- Produces 1/4 (in terms of value) of the food in the U.S.




modified from *Faunt et al.* [2009]

# GRACE estimated groundwater storage variations




# Impacts of irrigation on California climate

- *Kueppers et al.* [2007]; *Sorooshian et al.* [2011] have utilized RCMs to explore CV irrigation impacts on the local and regional climate (boundary conditions?)
- Imposed by lateral boundary conditions in regional models, as well as the uncertainty in the boundary forcing
- Global Model will be an important step forward in understanding the full role of irrigation in climate system feedbacks, especially for the remote effects from an individual irrigation sector

# NCAR GCM (CAM3.5 + CLM3.5) experiment setup

## 1) IRRI Experiment

Community Atmosphere Model
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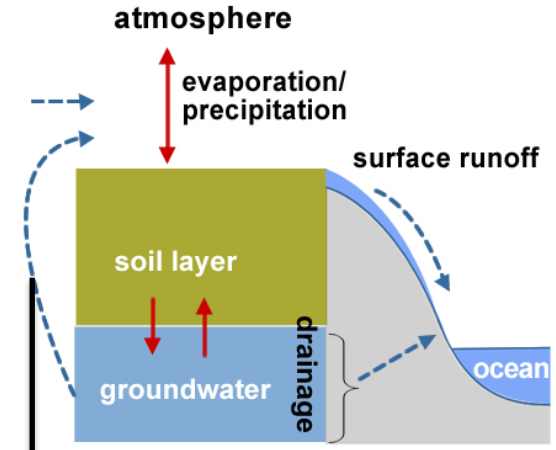


## 2) CTR Experiment

Community Atmosphere Model
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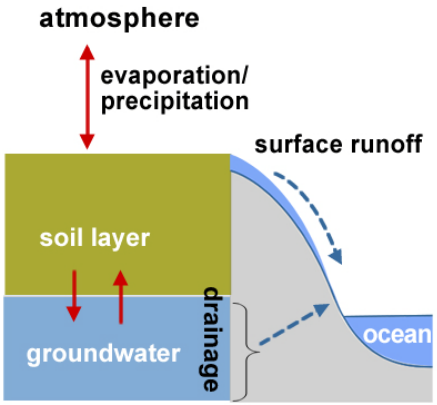
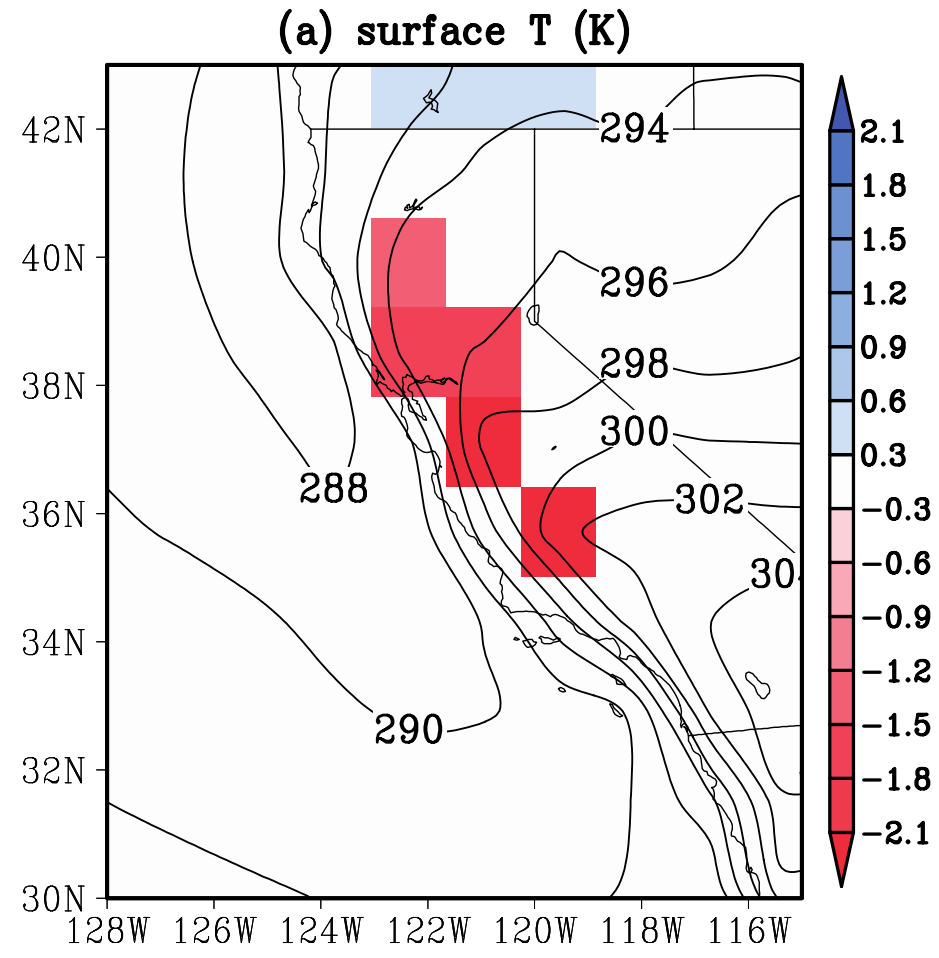
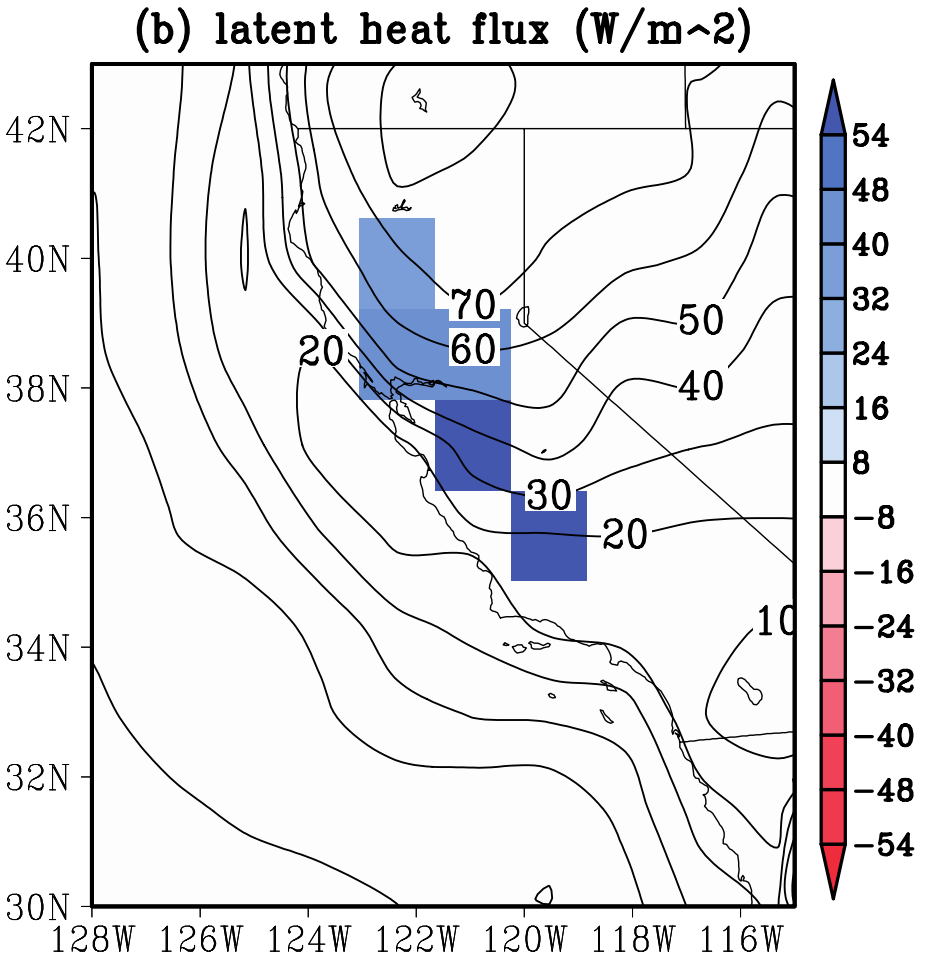


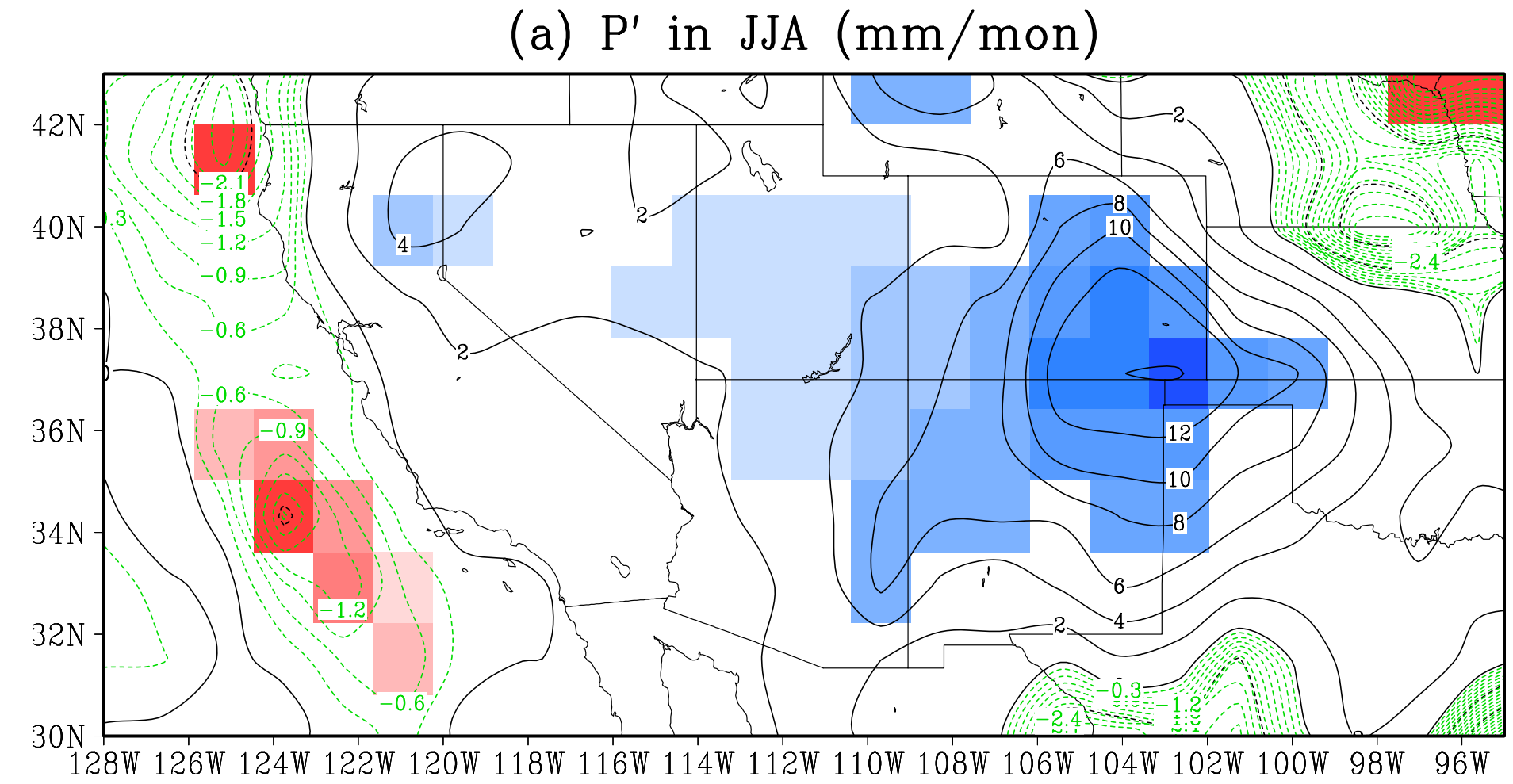

Prescribed Climatology SST/Sea Ice
at T85 resolution with 90-yr simulations

# Decreases in surface T



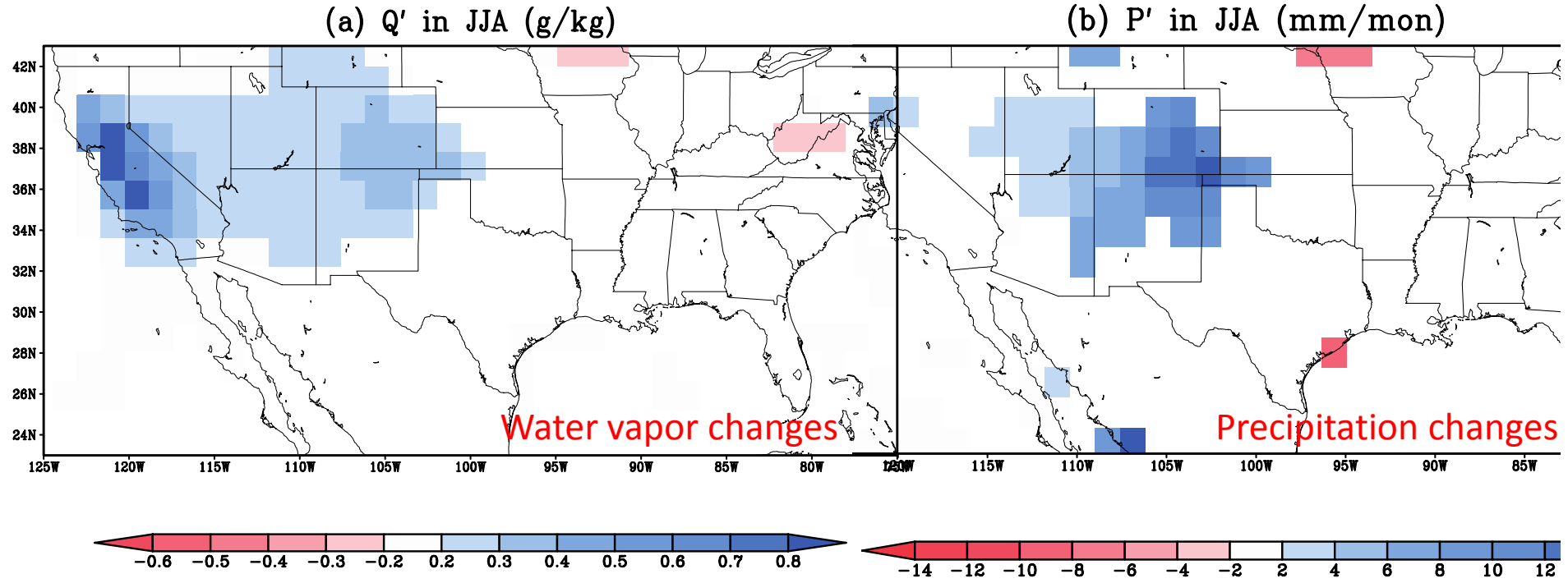
# Asymmetric responses of precipitation to CA irrigation




Lo et al., 2013 JGR

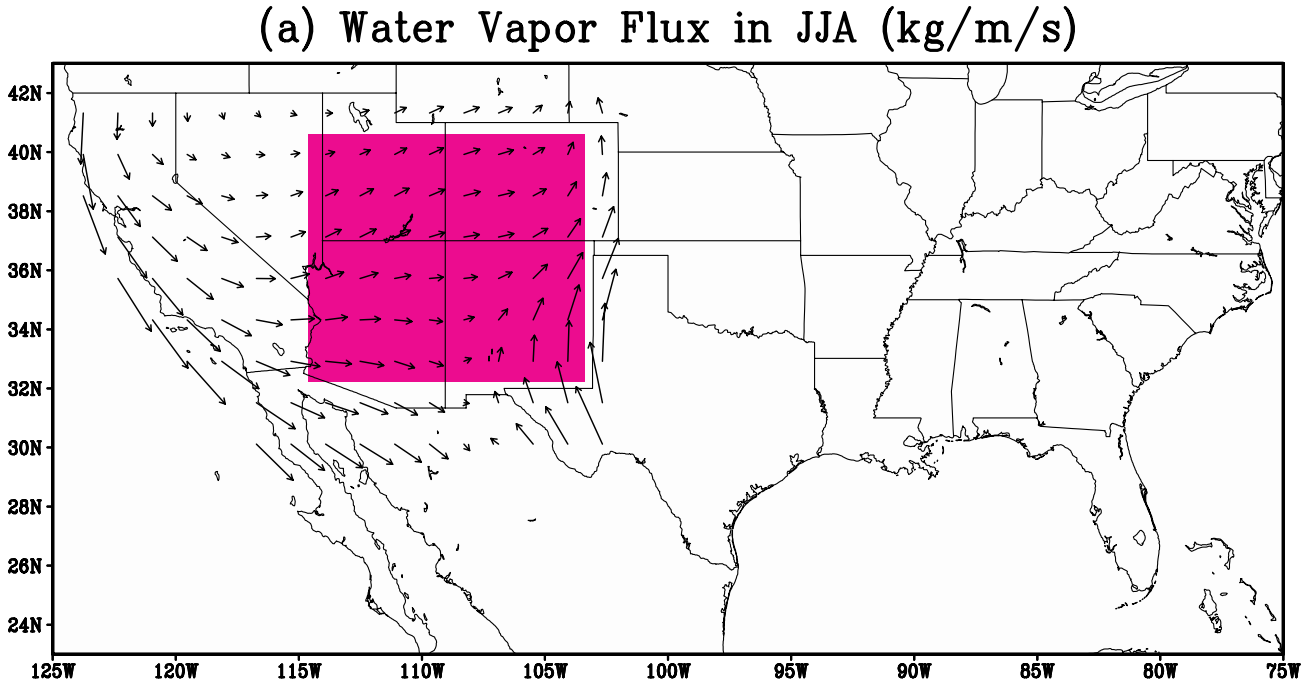
Lo and Famiglietti, 2013 GRL

# Increased water vapor and precipitation

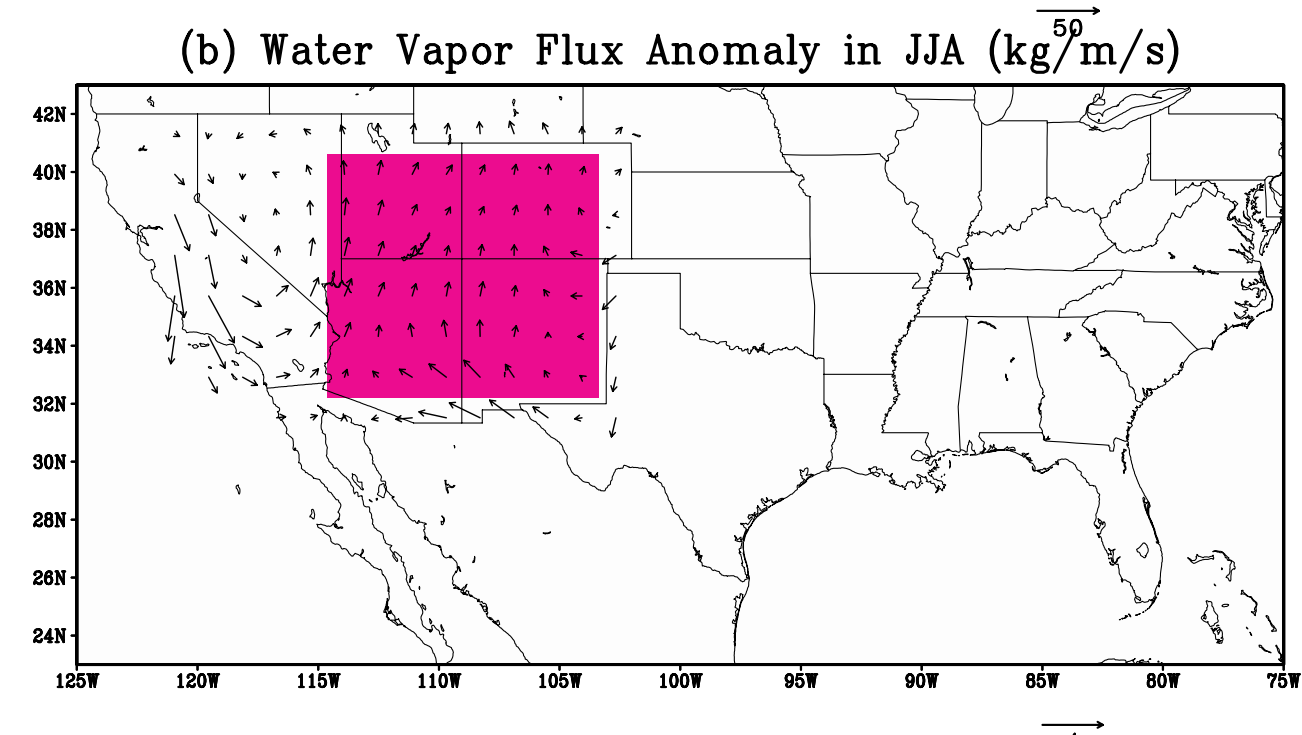



- Increase p in the downwind region (*DeAngelis et al.*, 2010 - Great Plains)
- Increase the precipitation in the existing convection area rather than generating new convections (*Sacks et al.*, 2009)

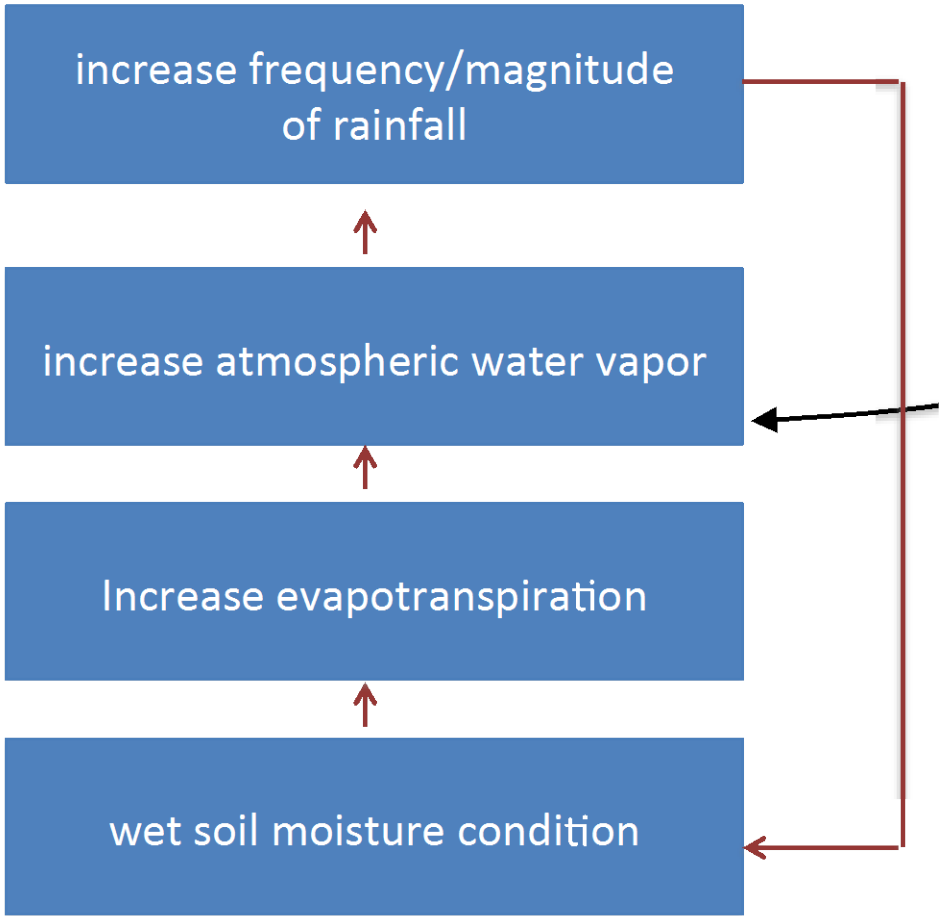
mean water vapor flux




vapor flux changes
due to irrigation in CA



# Impacts of irrigation in land-atmosphere coupling

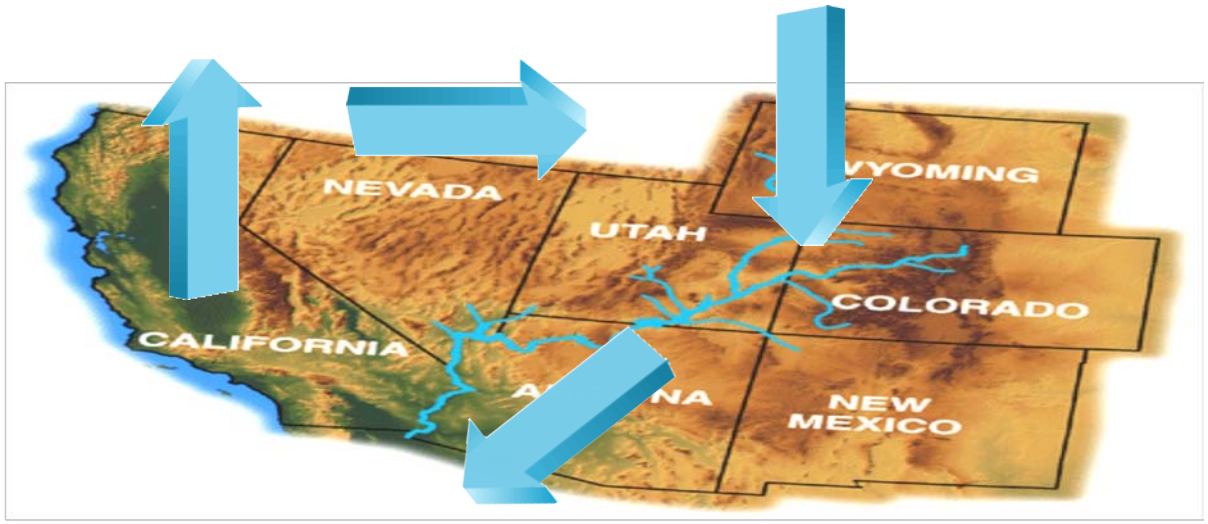


# Increase Precip and runoff over the Colorado River Basin



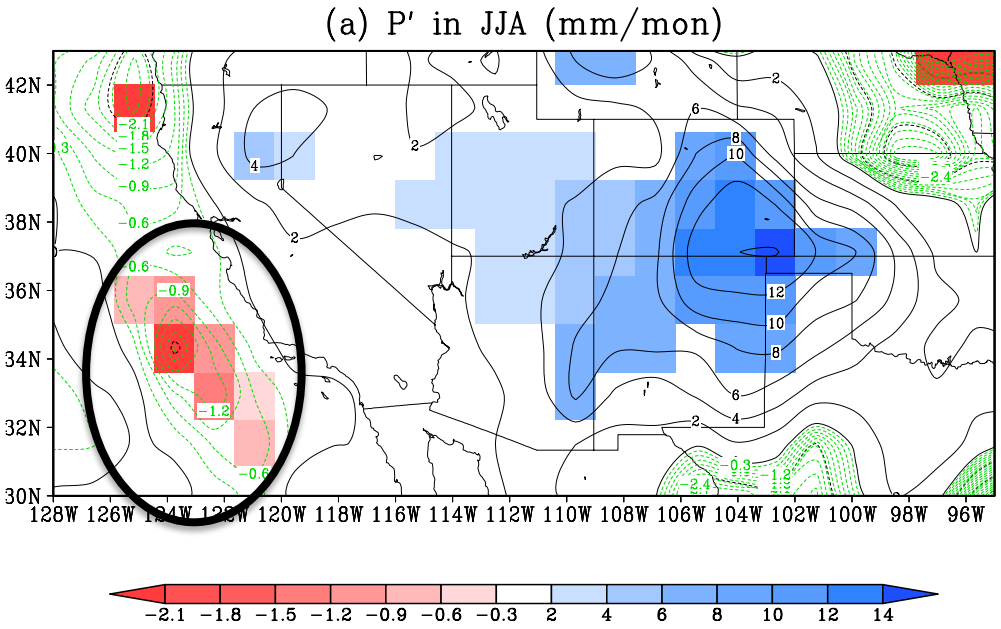
transport 5 $km^3$ of water from Colorado river to Southern CA

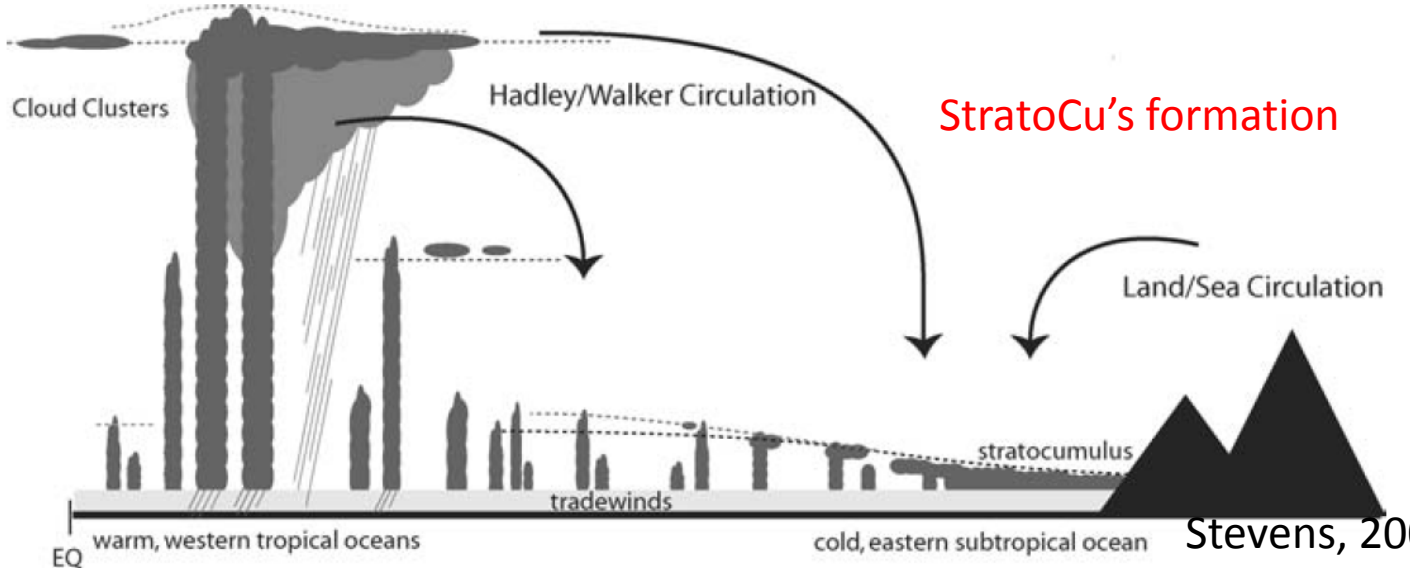
# human-induced changes in hydrological cycle




Anthropogenic cycling loop in formed due to irrigation and human water management

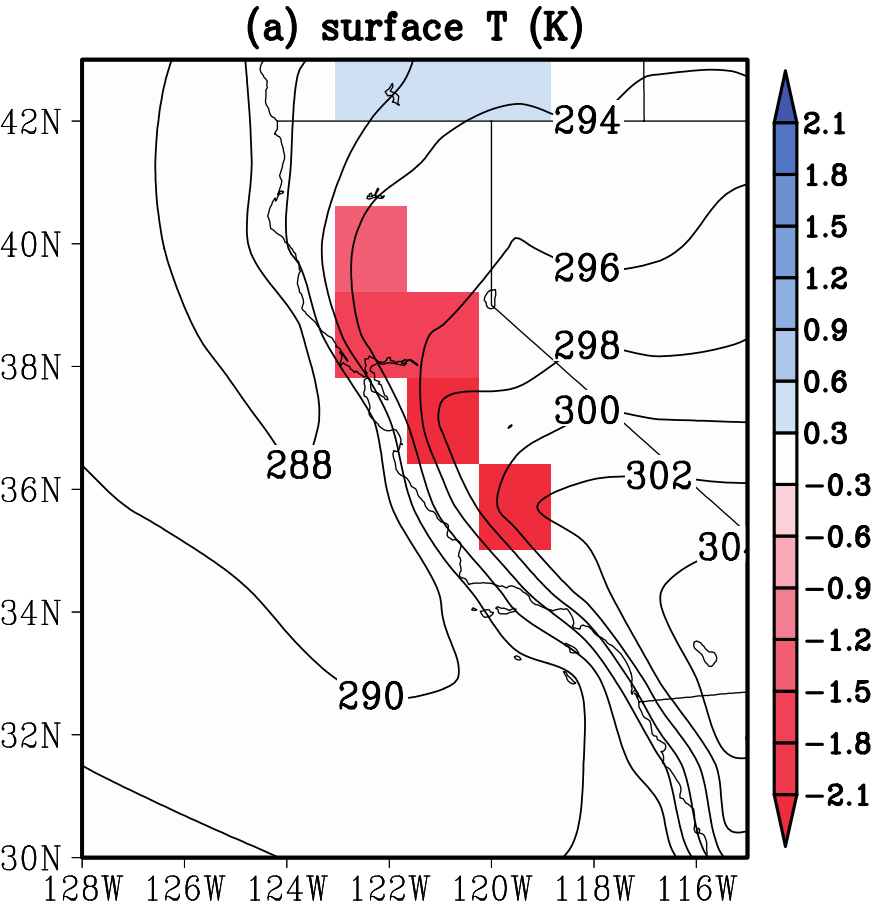
# declining in coastal stratocumulus

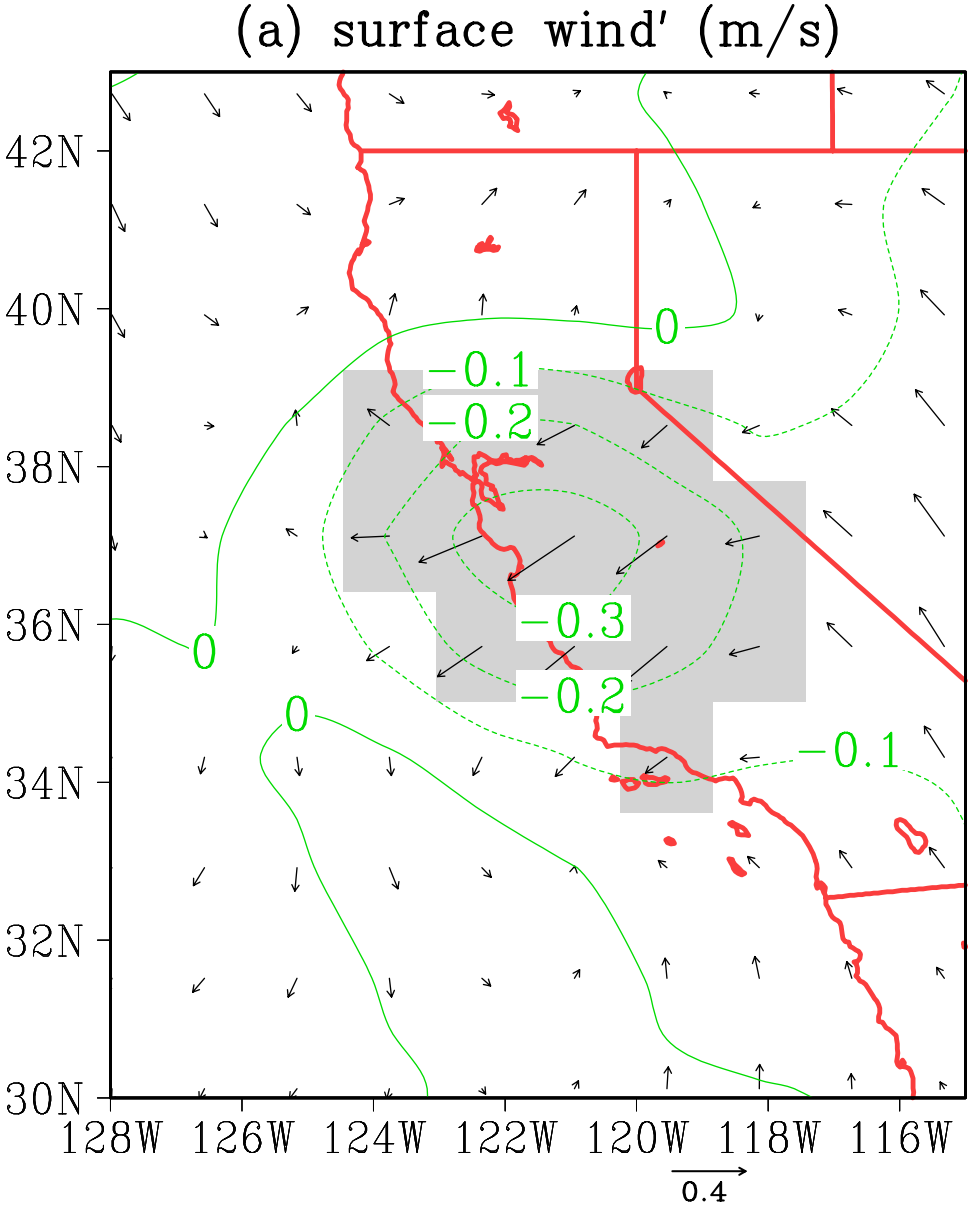


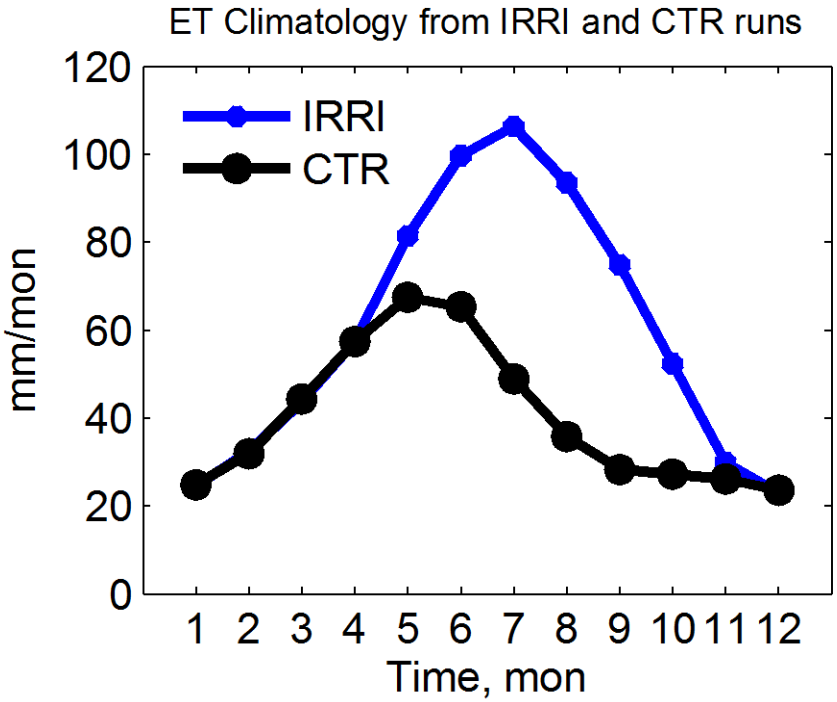



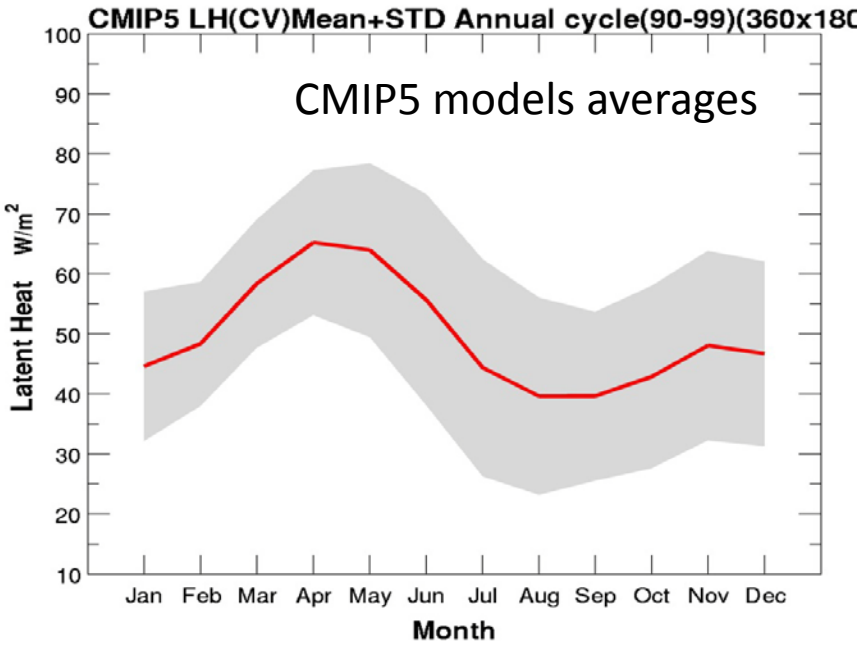

Stevens, 2005

# Reduced land-sea breeze



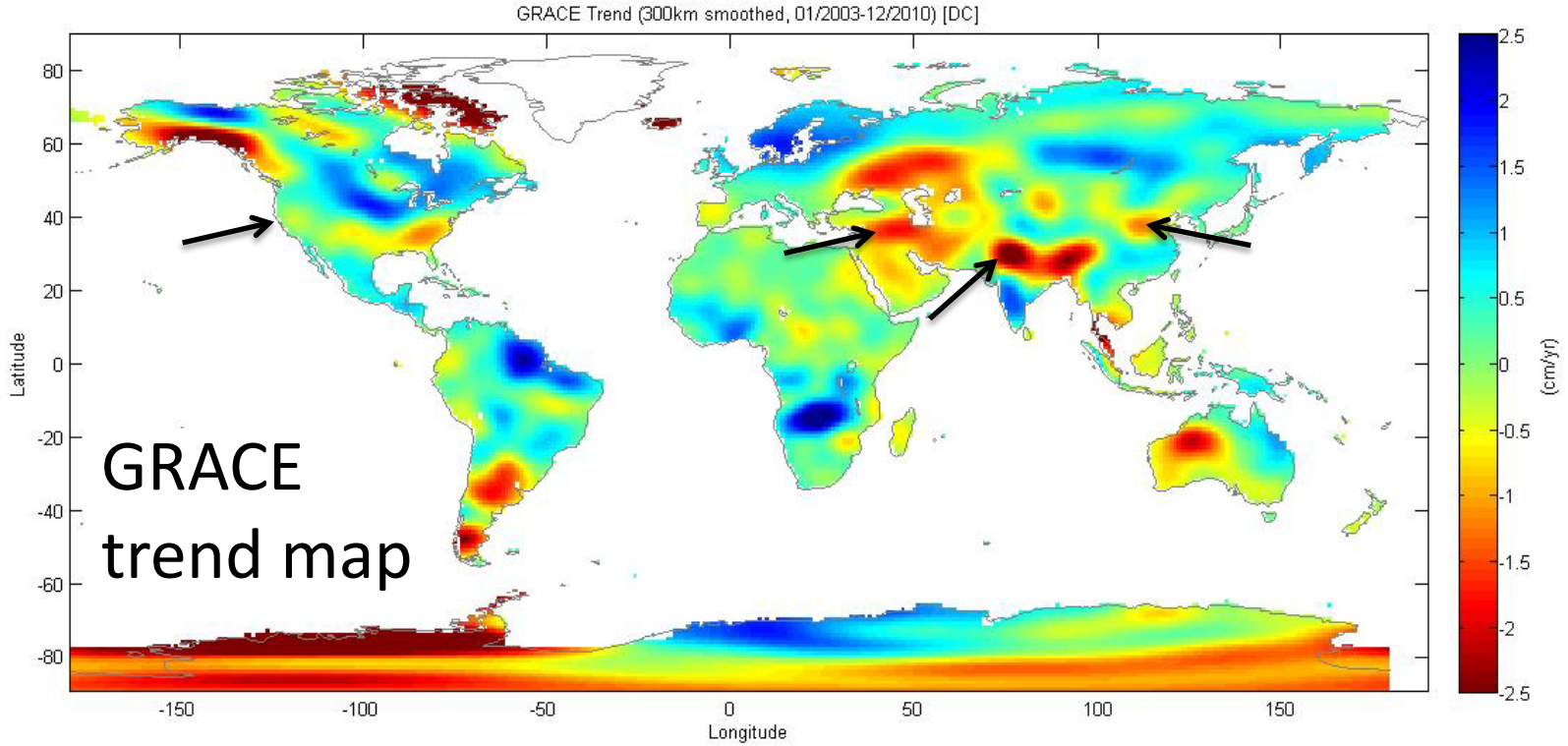


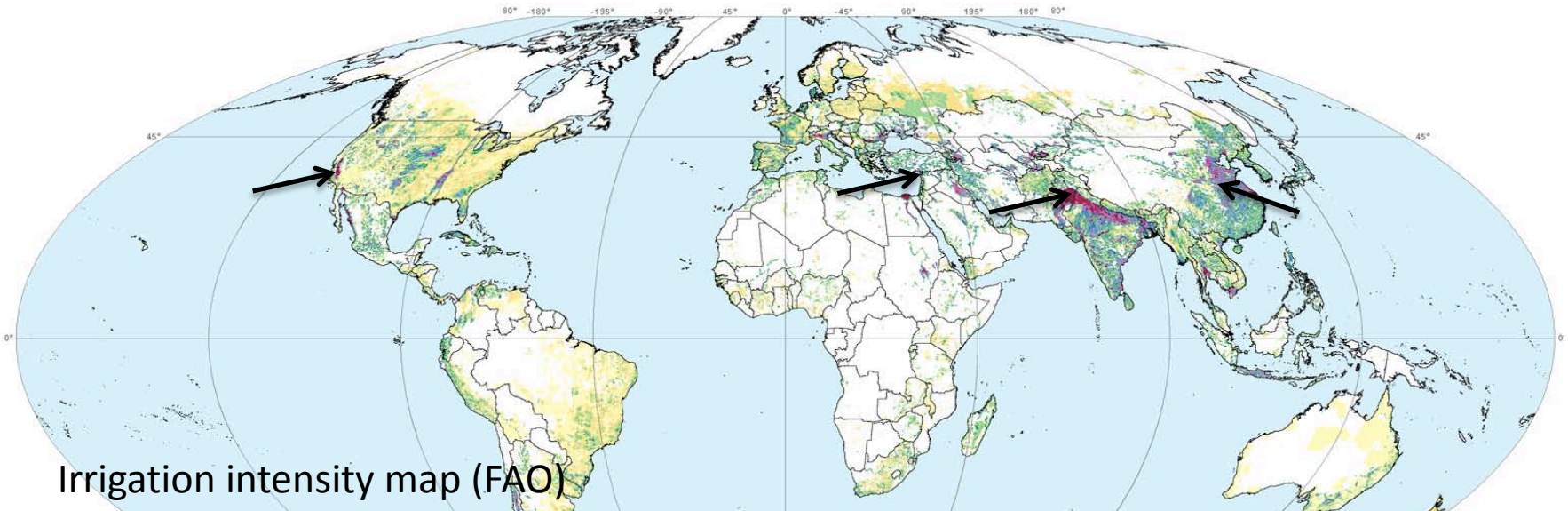




Latent heat fluxes in 21 CMIP5 models

Simulated near costal SC might overestimate?

Simulated Southwest P might underestimate?



Irrigation intensity map (FAO)

THANKS!

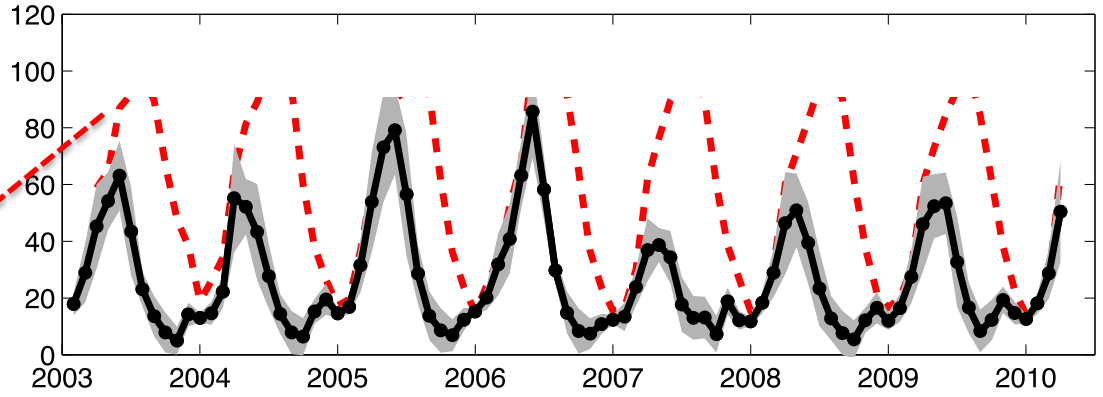
# summary

- The excessive water vapor from Central Valley irrigation acts as a trigger for enhancing the precipitation, soil moisture, and ET over the Southwestern U.S.
- The changes of ET can modify surface temperature and pressure system; hence, resulting in increases of low level water vapor transport.
- Form a regional, anthropogenic recycling loop in the water cycle.
- CA irrigation results in a decrease of land surface temperature, leading to a smaller land-sea heat contrast, and a corresponding reduction in sea breeze and subsidence.
- Simulated absorbed surface solar radiation over this region increases by 8W/m2 (3.7%) due to the reduction in stratocumulus cloud cover.

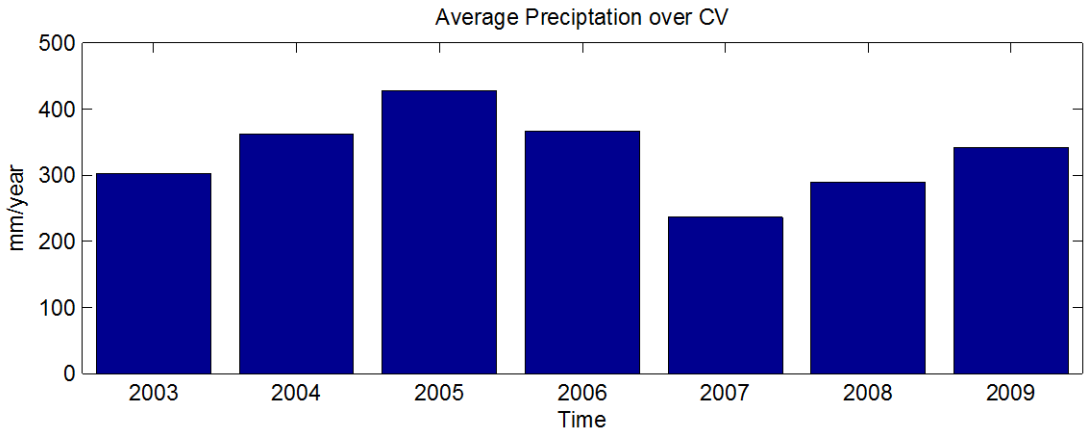
# How about the current Land Surface Models?

Compare the ET (evapotranspiration) of
4 different LSMs to observations

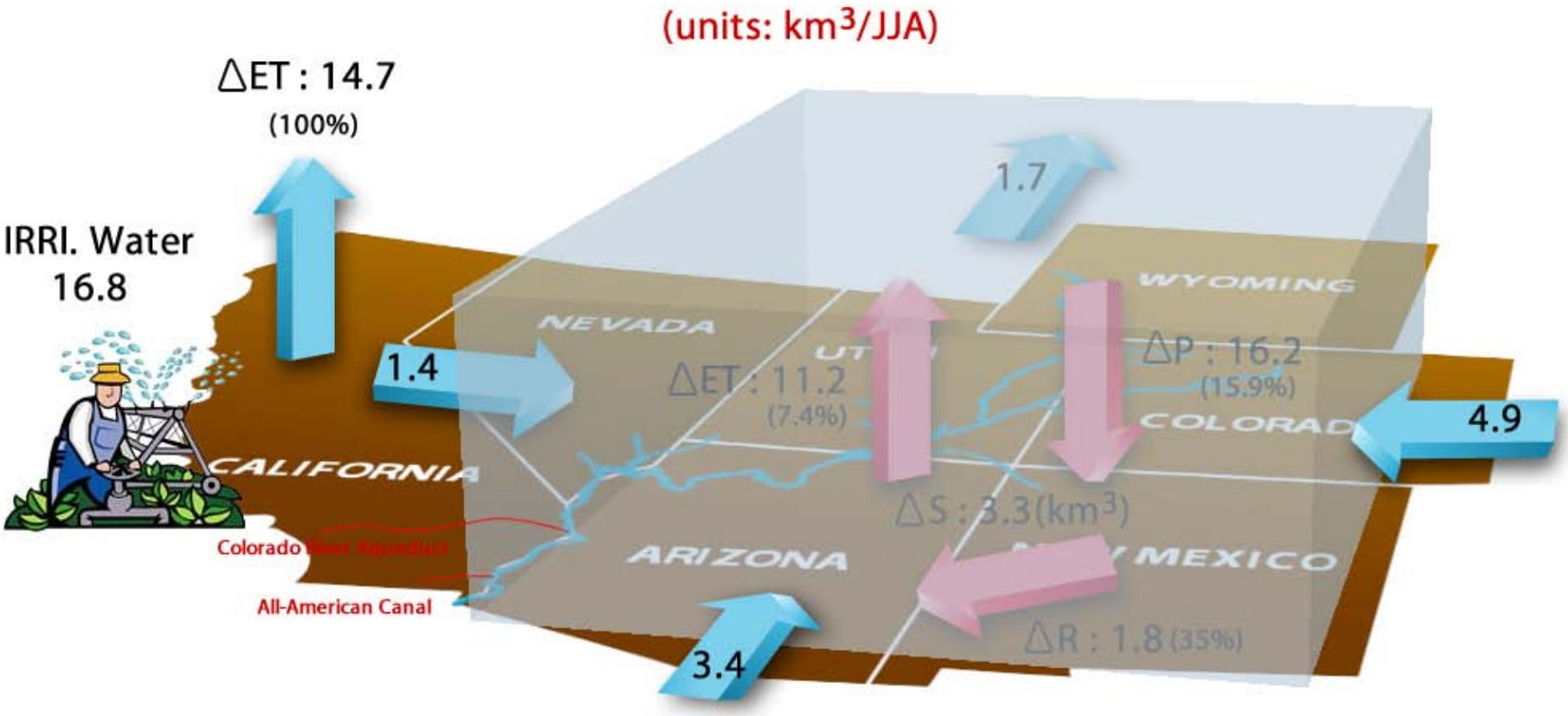
1) CLM
2) MOSAIC
3) NOAH
4) VIC




Observational ET from Anderson et al., 2012 -- MODIS (Moderate Resolution Imaging Spectroradiometer) based ET



# human-induced changes in the water cycle




anthropogenic recycling loop in formed due to irrigation and human water management

# NCAR GCM (CAM + CLM) experiment setup

## 1) IRRI Experiment

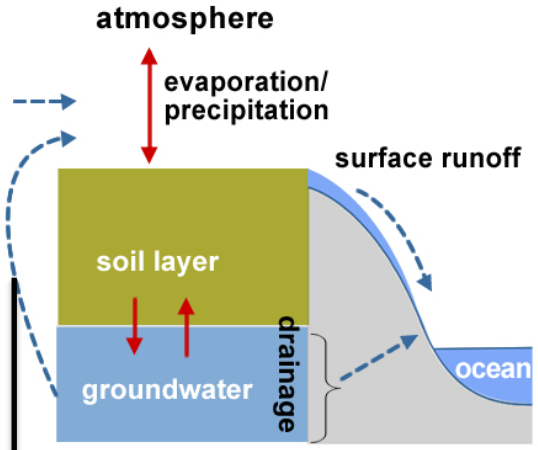
Community Atmosphere Model
+

210 mm/yr

140 mm/yr

*Wisser et al.* [2008]

*Siebert et al.* [2010]

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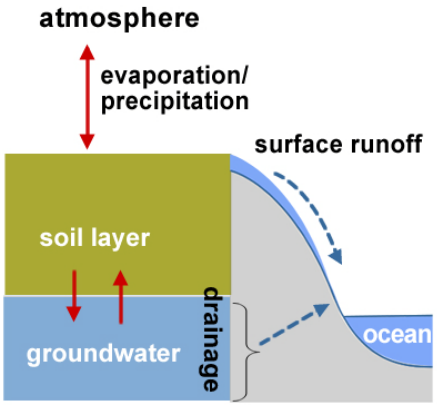


Prescribed Climatology SST/Sea Ice
at T85 resolution with 90-yr simulations

# CAM5 results