I2I Water

NEXT STEPS:

- A Breakdown of the top Priority

“MAJ. NEAR TERM RECOMMENDATIONS (TO CCST AT 2/14 MEETING)”

1. Develop and Implement an integrated water information management system
2. Expand the use of monitoring technology and management practices

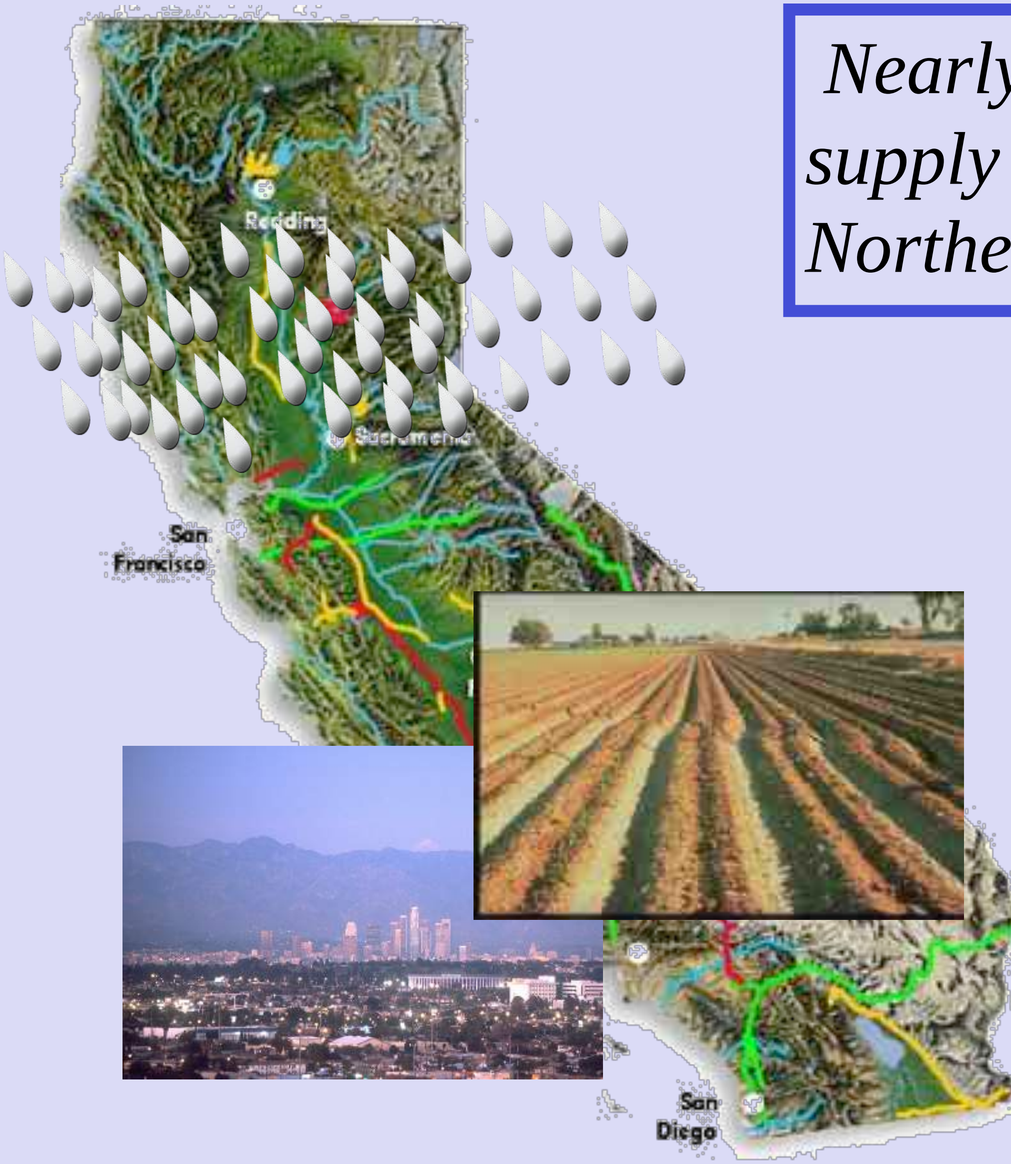
Jude’s “TOP FIVE” List:

1. NEED FOR AN INTEGRATED WATER INFORMATION MGMT SYSTEM INCL NEED TO METER ALL WATER USE

From the Report's Executive Summary

1. **Develop and implement an integrated water information management system** for water supplies, uses, and quality including precipitation, runoff, and storage; for surface water, groundwater, and water use. *In situ* and remote monitoring devices and networks should be expanded and linked to an integrated data management system, or implemented where not available but needed. A common portal, such as DWR's Water PIE and UC Davis' HOBBES, that forms the cyber core of a flexible data and information-management program and capable of supporting data analysis, trending and scenario forecasting, should be developed with a common set of standards to link data collection from all sources with an integrated data management system. **Near-Term Actions:** The Governor and key agencies should immediately take the lead to form a consortium of parties, including the State Water Resources Control Board and the Department of Water Resources as well as a broad coalition of water experts in academia, trade organizations and non-governmental organizations with the specific goals of (1) evaluating what is realistic and practical to do in the short term, (2) designing the data collection and management system to accomplish the near-term task while maintaining capability for future flexibility and then (3) fully implementing this recommendation.

Supply and Demand Variability of California

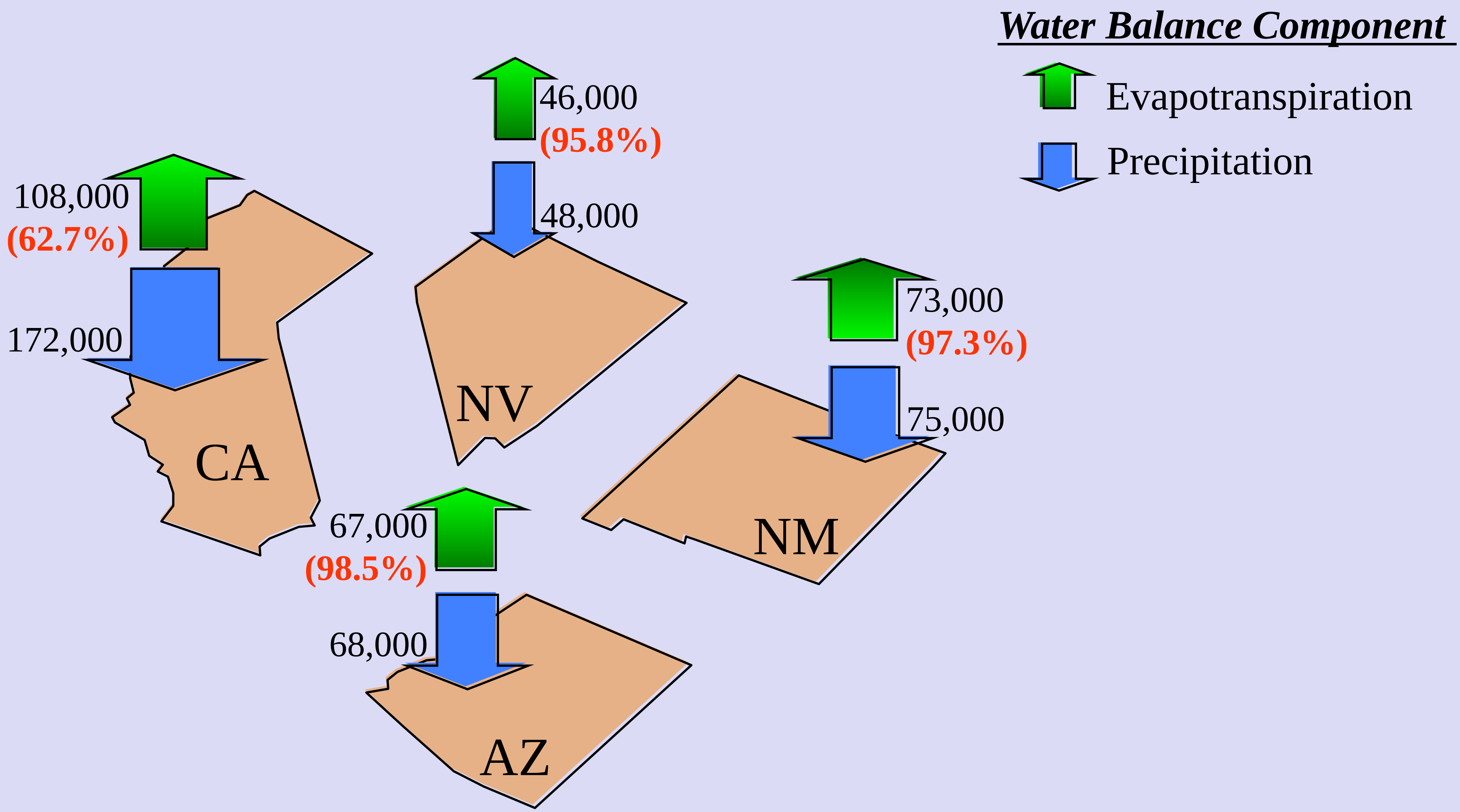


Nearly 75% of our supply is in Northern half

Almost 65% of our demand is in the Southern half and likely to grow with projected urban growth

Water Balance in the Semi-Arid Southwest

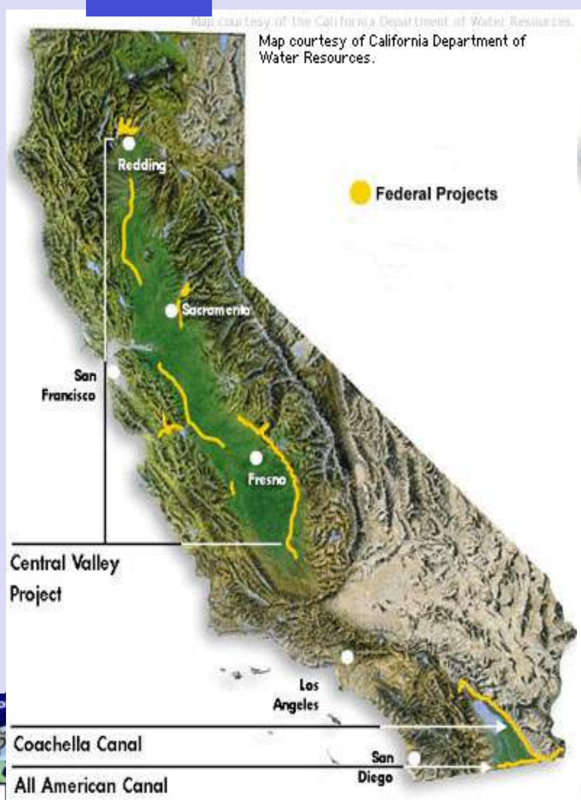
Data in Million Gallon/Day. Source: USGS Water Use Report 1990



California's Current Projects

*California has a vast water system: Central Valley Project (**CVP**), State Water Projects (**SWP**), and Local systems (**LOC**). **SWP** is the nation's largest state-built water and power development and conveyance system (Brown et al., 2012).*

CVP

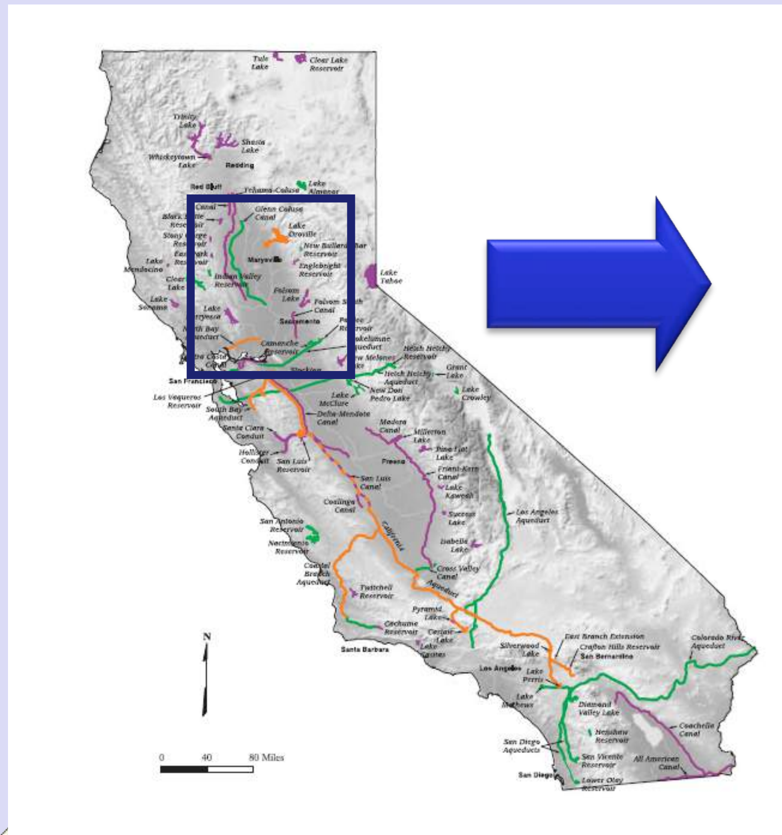


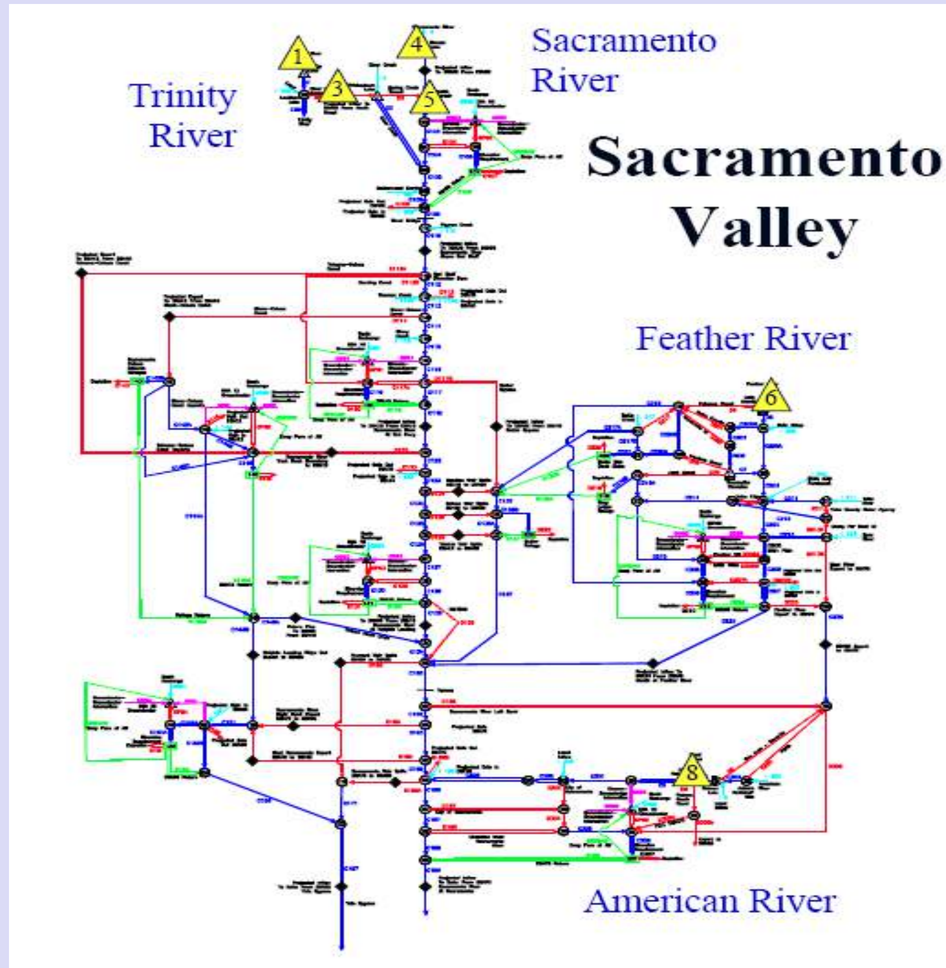
SWP

LOC

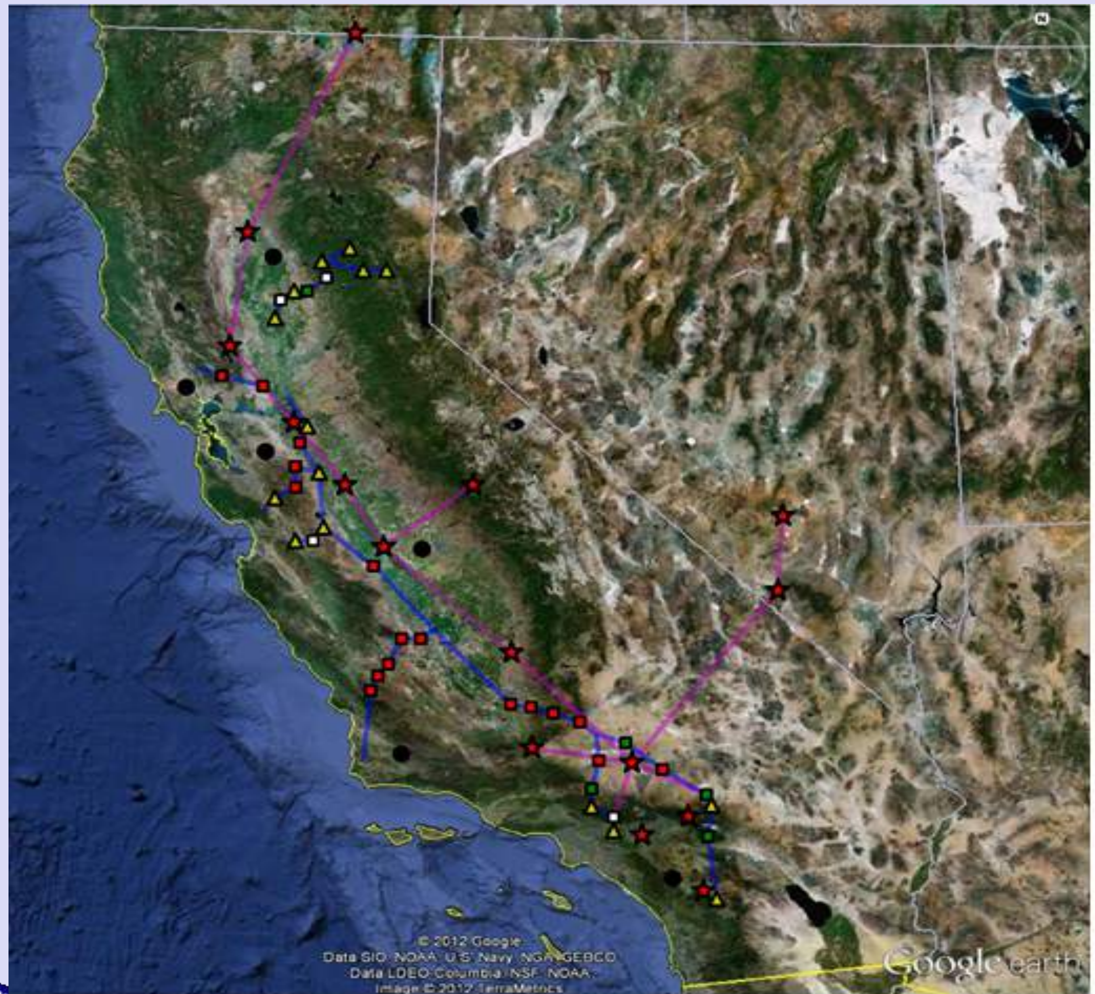
Complex Management

CalSim: California Water Resources Simulation Model:
A Decision Support System of California DWR.





Two-folded Network of Water and Energy for SWP



Reservoirs/Lakes

Pumping Station

Pumping & Generating Station

Hydro Power Plant

Substations in electricity grid (electricity facilities do not belong to SWP)

Regional Demand nodes

Water Links

Conceptual Electricity Transmission Lines

15 Reservoirs/Lake
27 Pumping/Pumping & Generation Plants
6 Major SWP demand Regions
15 Electricity substations

Joint Management Network of Water and Energy in SWP

Prediction Requirements for Water Resources

Short Range – · – · – · – · – · – · – · – · – · – · – · – · – · – · – · –>Long Range

hours - - - -> days - - - -> weeks - - -> months - -> seasons - -> years - - - - - -> decades

Flash Flood Warning

Flash Flood Guidance

Headwater Guidance

Flood Forecast Guidance

Reservoir Inflow Forecasts

Spring Snow Melt Forecasts

Water Supply Volume

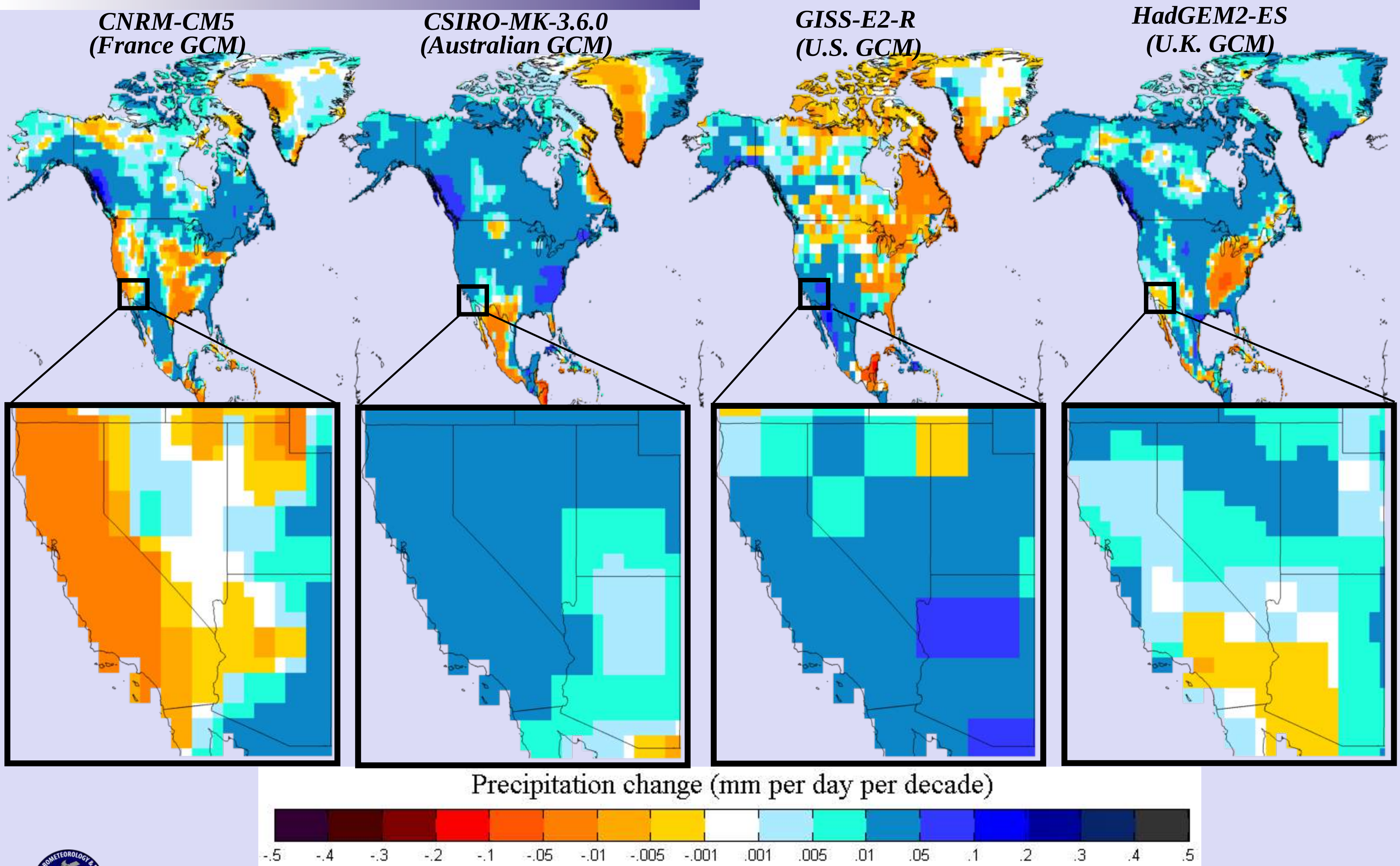
Short-range ***Mid-range*** ***Long-range***

Forecast Requirements

Western U.S. future model projections

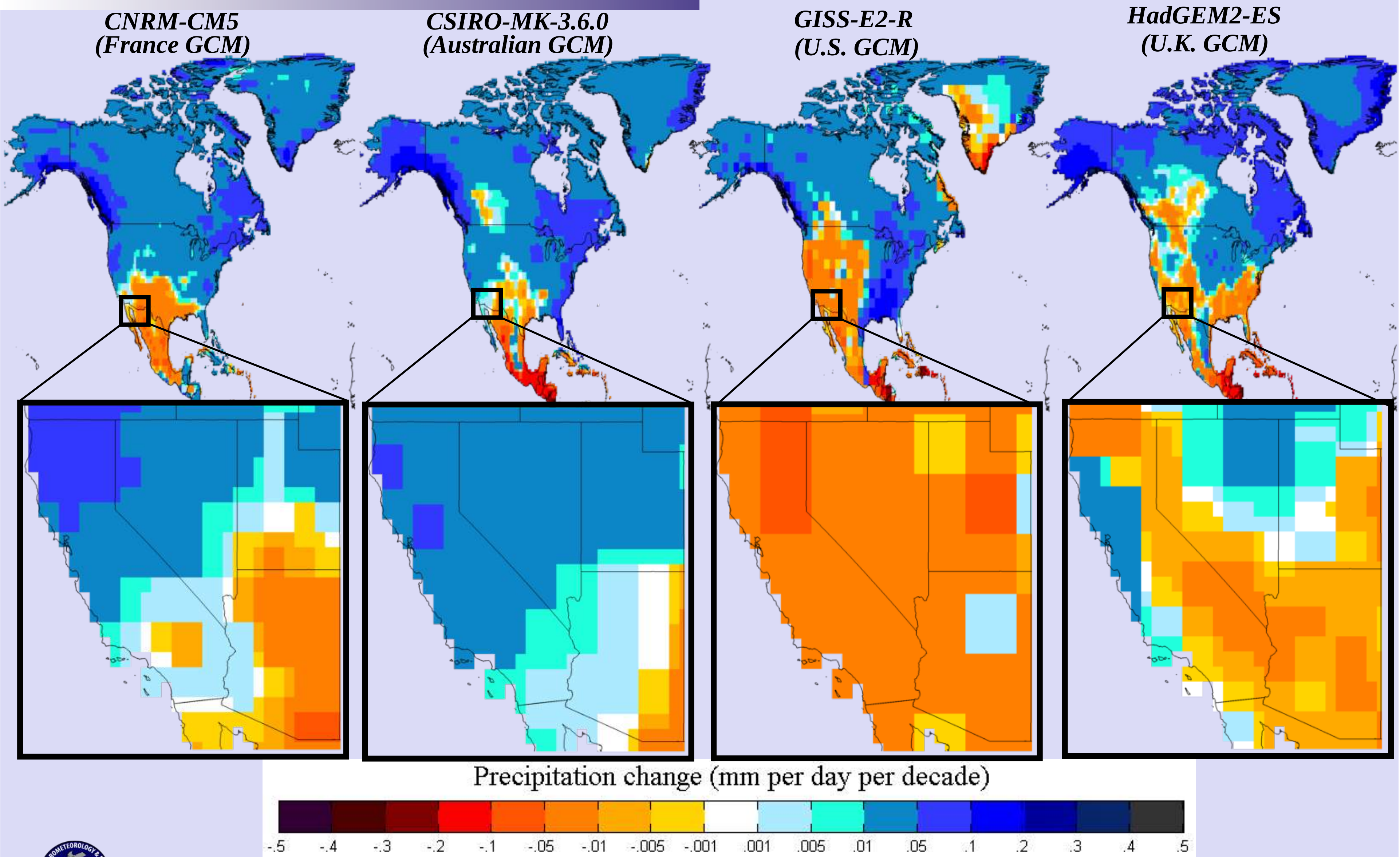
RCP2.6

Time period: 2006-2099



RCP8.5

Time period: 2006-2099



Recent Evaluation of RCM/GCM over Western U.S.

Wei Chu 2011

Regional Models	Climate Models			
	GFDL	CGCM3	HADCM3	CCSM
CRCM	——	📂	——	——
ECP2	📂	——	——	——
HRM3	——	——	📂	——
MM5I	——	——	——	📂
RCM3	——	📂	——	——
WRFG	——	——	——	📂

Current period:1971-2000

Future period: 2041-2070

Spatial Res.: 50 km

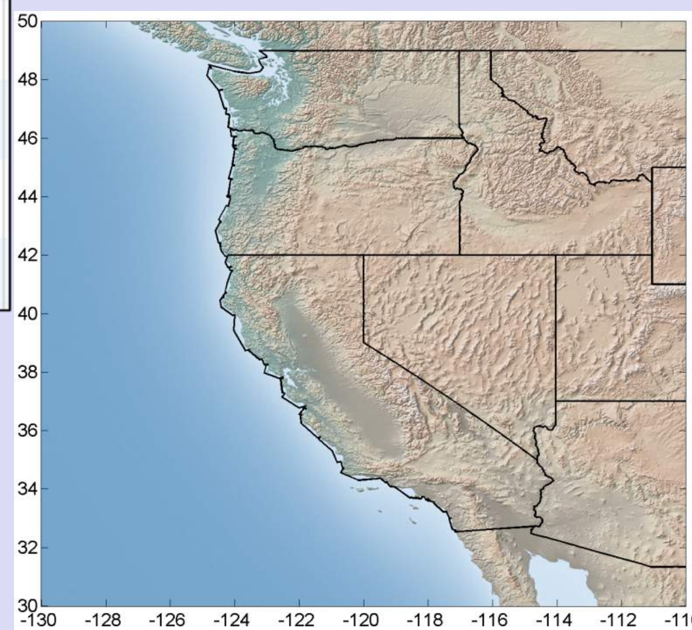
Temporal Res.: daily

<u>Outputs of six RCM/GCM sets:</u>

North American Regional Climate Change Assessment Program (NARCCAP)

Emissions Scenario:

A2: regionally oriented and fast economic growth

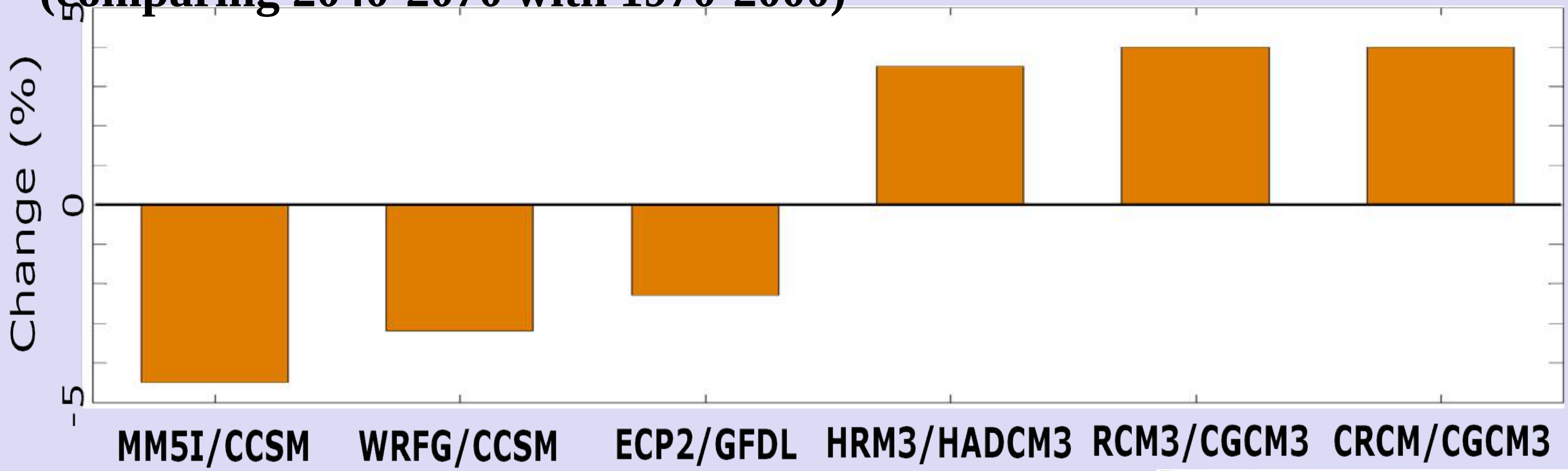


study region

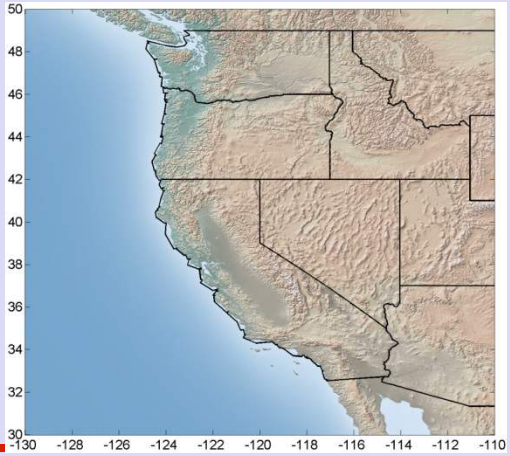
Recent Evaluation of RCM/GCM over Western U.S.

Getting wetter or dryer (50-50)

Trend of area-average precipitation
(comparing 2040-2070 with 1970-2000)

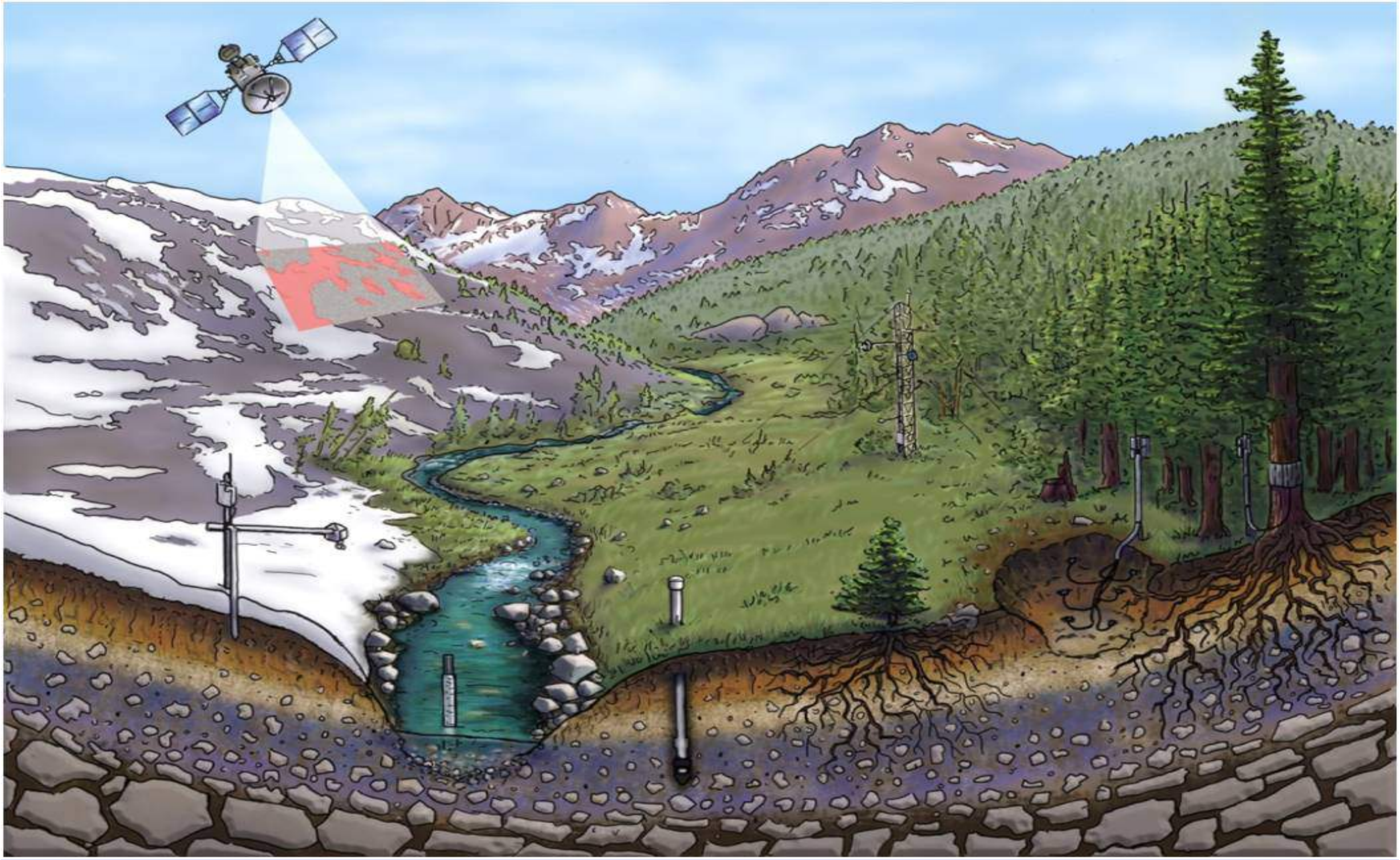


Wei Chu 2011



Observations and Model Generated Data

Observing System

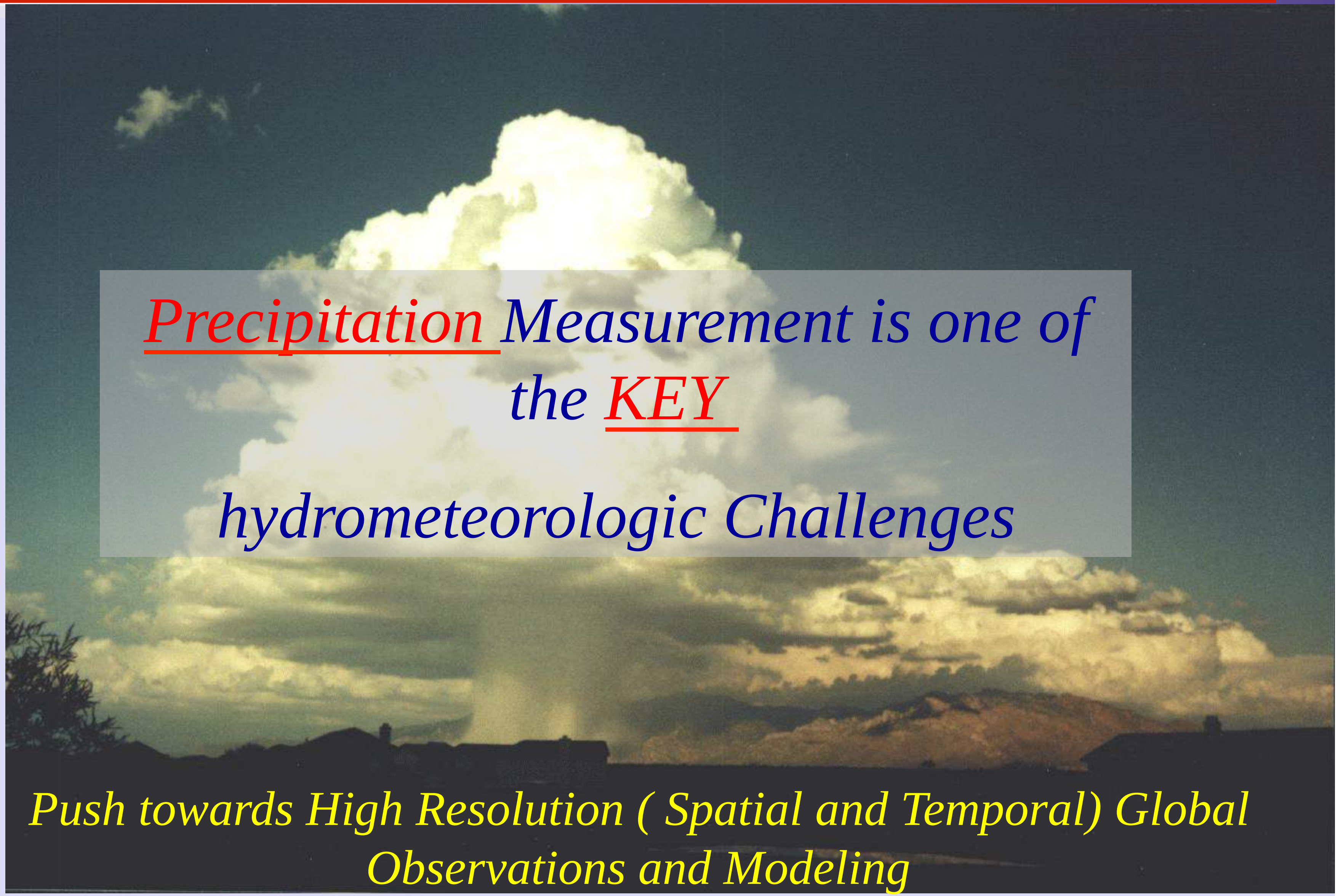


Courtesy of: Roger Bales UC Merced


embedded
sensor
networks


Soil moisture

A Key Requirement!



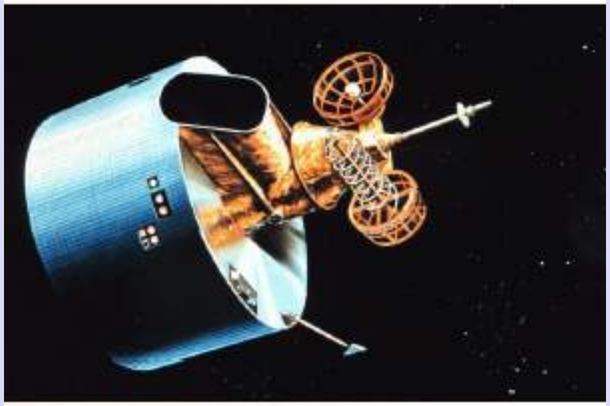
Precipitation Measurement is one of the KEY

hydrometeorologic Challenges

Push towards High Resolution (Spatial and Temporal) Global Observations and Modeling

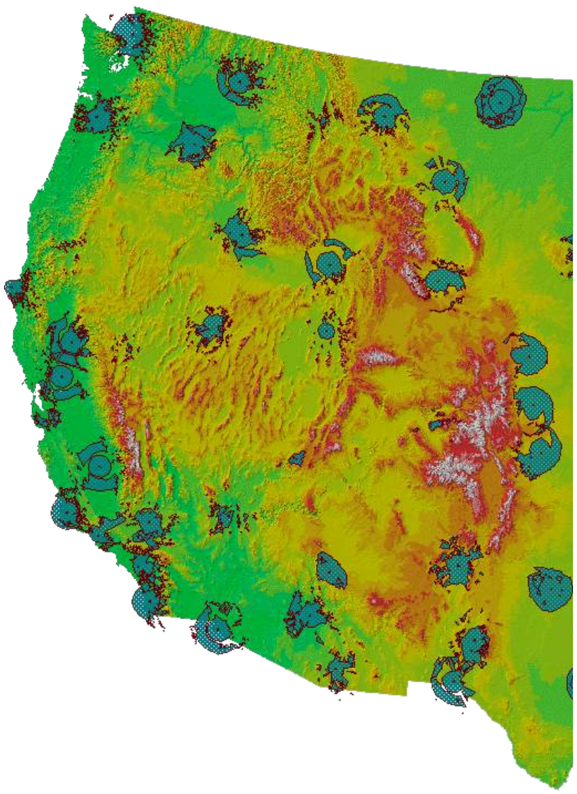
Precipitation Observations: Which to trust??

Rain Gauges



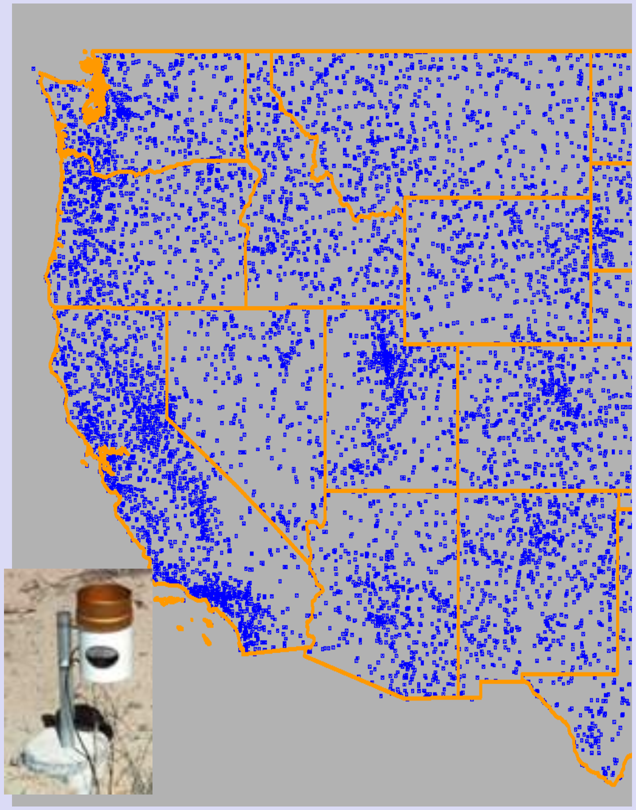
Satellite

Coverage of the WSR-88D and gauge networks



1 km AGL

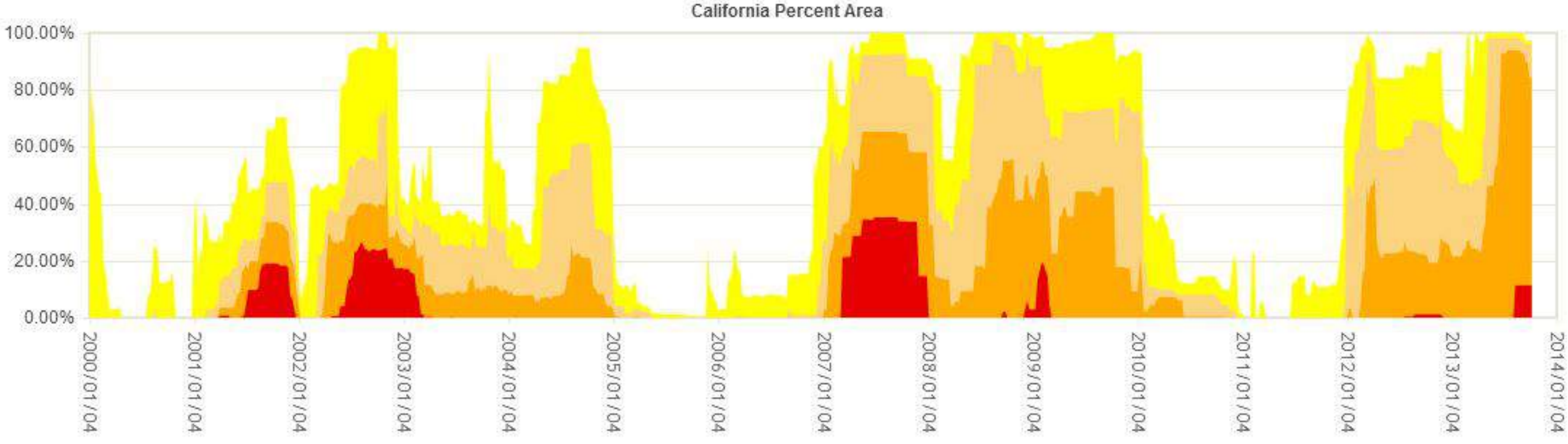
Maddox, et al., 2002

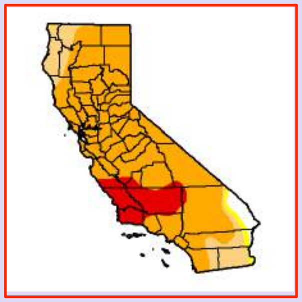


- ***Daily precipitation***
- ***Gages (1 station per 600 km^2)***
- ***Hourly coverage even more sparse***

California Drought Conditions (2000 ~ Present): high variability but no trend

The U.S. Drought Monitor, a composite index that includes many indicators, is the drought map that policymakers and media use in discussions of drought and in allocating drought relief.





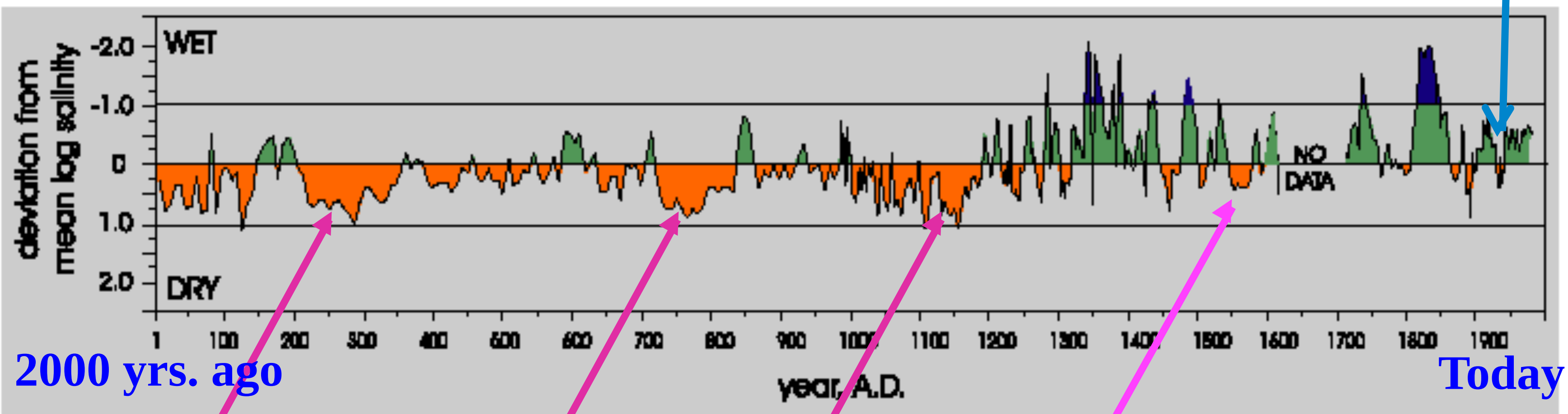
U.S. Drought Monitor for California – Oct.8 2013

Data Source: http://droughtmonitor.unl.edu/DataArchive.aspx

2000-year Climate history of central U.S.

The US Mid-West

1930's dustbowl



16th century "megadrought"

›100 year "megadroughts"

Source: Overpeck 2004

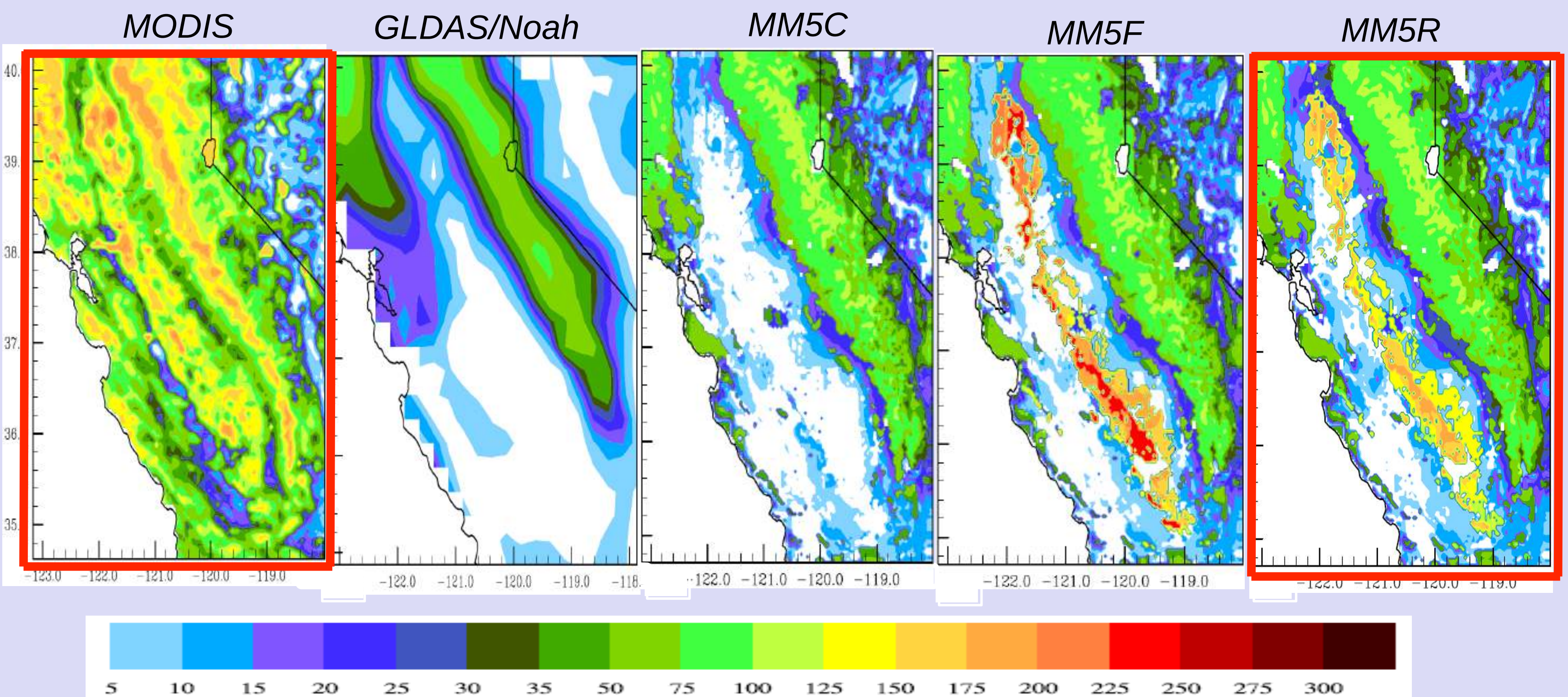
Somewhere in New Mexico, USA - Photo: J. Sorooshian

Backup information

Large-Scale Irrigation and Incorporation in Models

Impact of Irrigation

Actual ET comparison-spatial distribution – JJA 2007



Monthly ET (mm/month)

Results from MM5, with more realistic irrigation scheme, show significant improvement in capturing ET over irrigated Central Valley in California (compared to MODIS - ET estimates). MM5F overestimated.

In a nutshell!

- ***ET Underestimation by MM5 control run is roughly about 10 million Ac-Ft of water/yr***
- ***ET Overestimation by MM5 with "full-saturation" irrigation is about 6.5 Million Ac-Ft/yr***
- ***Use of the realistic irrigation scheme results in only 1.5 Million Ac-Ft/yr of overestimation.***

placed in Societal context :

Roughly speaking, the amount of ET underestimation equals supply requirement of 13 million households and the overestimation covers the needs of 9 million households per year.

Data and Information Needs: Agriculture

Agricultural water requirements and improvements in on-farm water use efficiency and water quality:

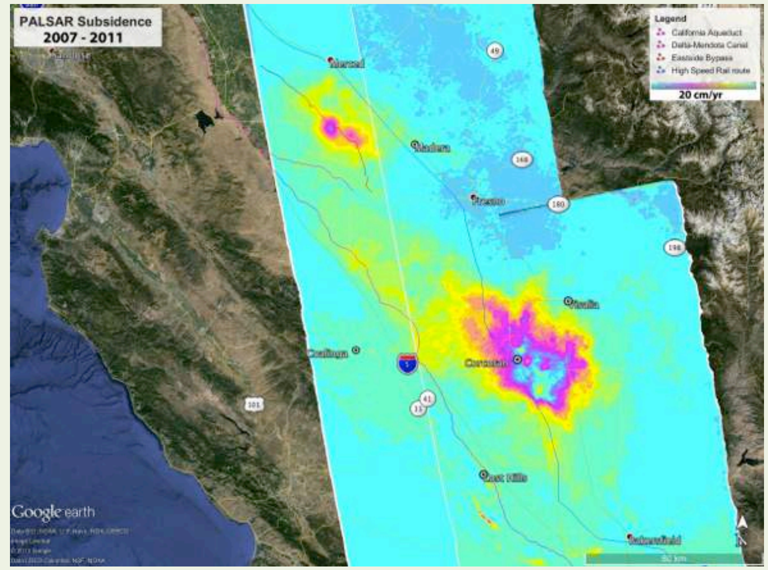
- Maintenance and expansion of California Irrigation Management and Information System (CIMIS) reference evapotranspiration (ET_o) network
- Development of network of evapotranspiration monitoring sites in agricultural areas
- Satellite mapping of crop water requirements and crop evapotranspiration
- Development of statewide monitoring network for soil moisture and deep percolation / nitrate loss at agricultural sites

Courtesy of: Forrest Melton - NASA Ames & CSU Monterey Bay

Data and Information Needs: Agriculture

Agricultural water supplies and drought impacts:

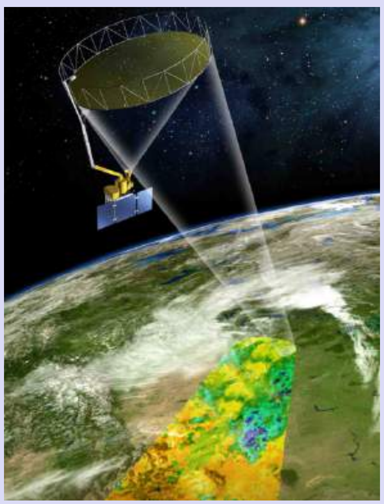
- Monitoring and forecasting of atmospheric river events and precipitation anomalies
- Groundwater withdrawals / expansion of CASGEM
- Surface deformation mapping using satellite and airborne data as indicator of groundwater overdraft
- Satellite mapping of crop condition and fallowing of agricultural lands
- Improved mapping of field boundaries and crop type in coordination with County Agricultural Commissioners and DWR for improved water planning



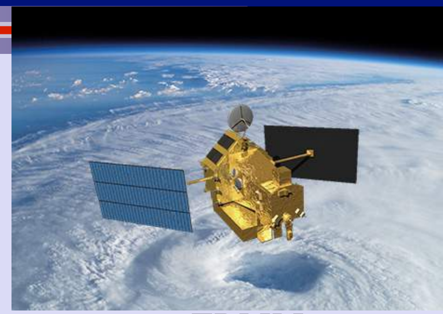
Courtesy of: Forrest Melton - NASA Ames & CSU Monterey Bay

Hydrologically - Relevant Remote Sensing Missions

SMOS
ESA's Soil Moisture and Ocean Salinity (2009)

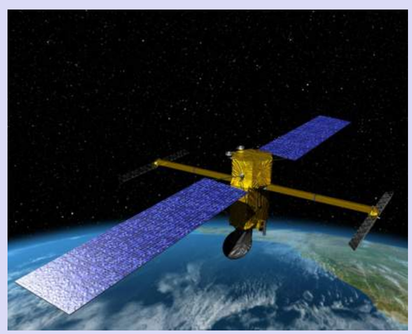


SMAP
Soil Moisture Active Passive Satellite(2014)

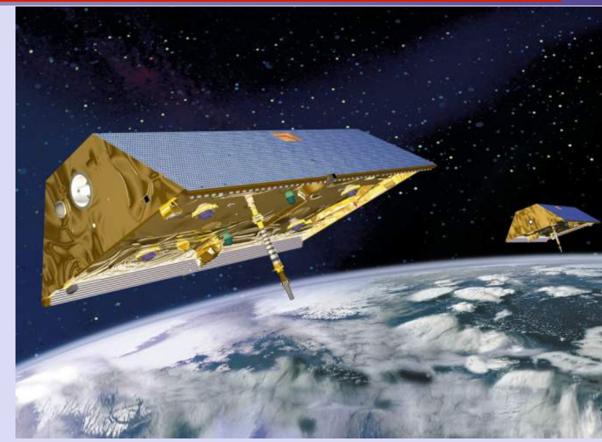


TRMM
The Tropical Rainfall Measuring Mission

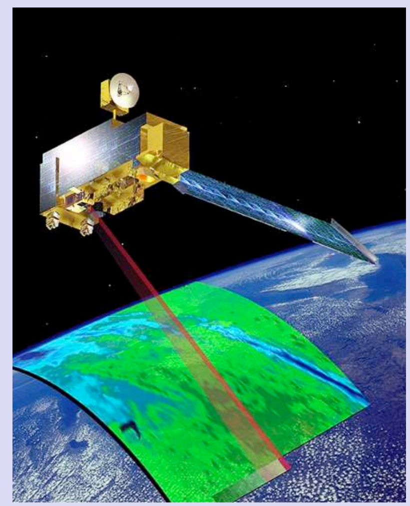
GPM
Global Precipitation Measurements (2014)



SWOT
Surface Water and Ocean Topography (2020)



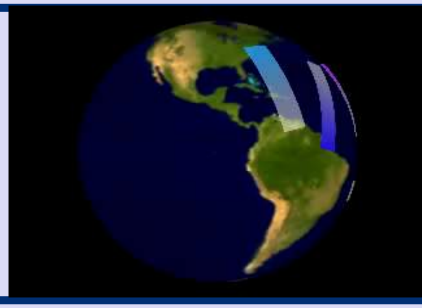
GRACE
Gravity Recovery and Climate Experiment (2002)



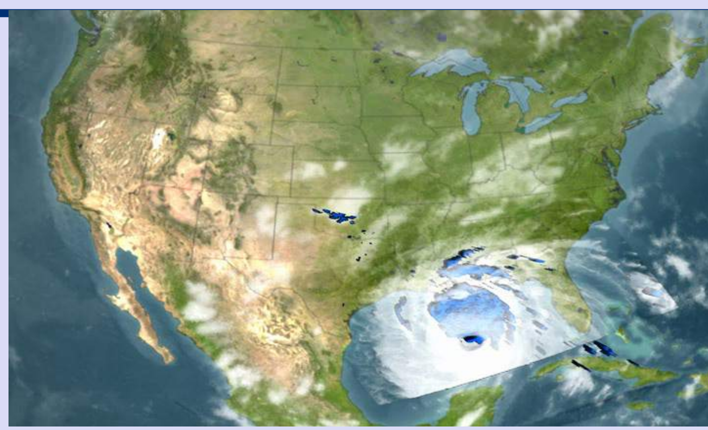
MODIS
Moderate Resolution Imaging Spectroradiometer (1999) , (2002)

Satellite Data for Precipitation estimation

Geostationary IR
Cloud top data
15-30 minute temporal resolution

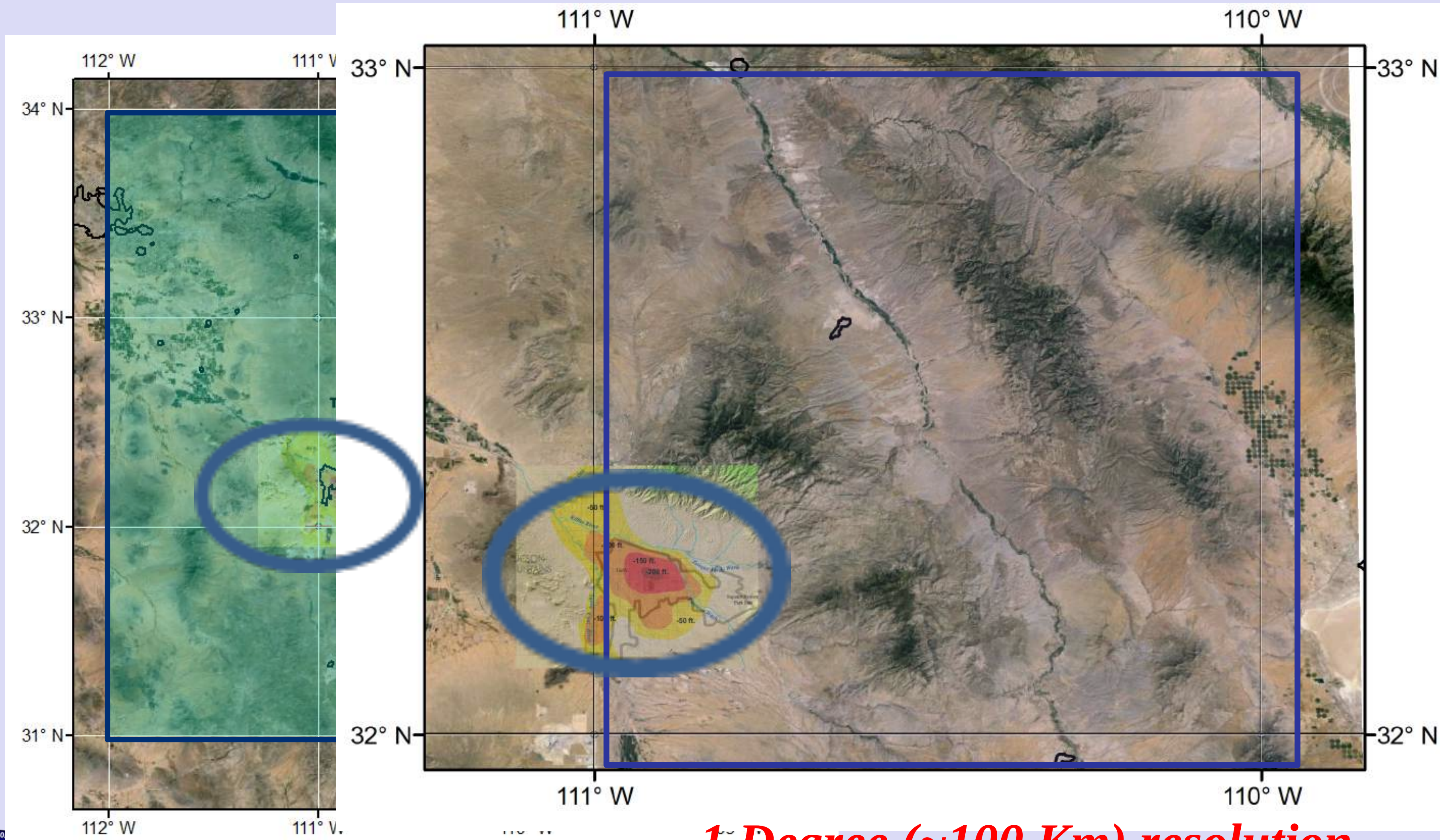


Passive Microwave (SSM/I)
Some characterisation of rainfall
~2 overpasses per day per spacecraft, moving to 3-hour return time (GPM)

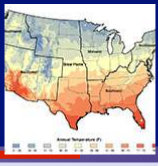


TRMM precipitation RADAR
3D imaging of rainfall
1-2 days between overpasses
(S-35°N-35 °)

GRACE Satellite Footprint



1 Degree (~100 Km) resolution



Precipitation

• Precipitation does not exhibit any obvious long-term trends for the Southwest U.S., except for fall, which shows a slight upward trend. Trends are not statistically significant for any season.

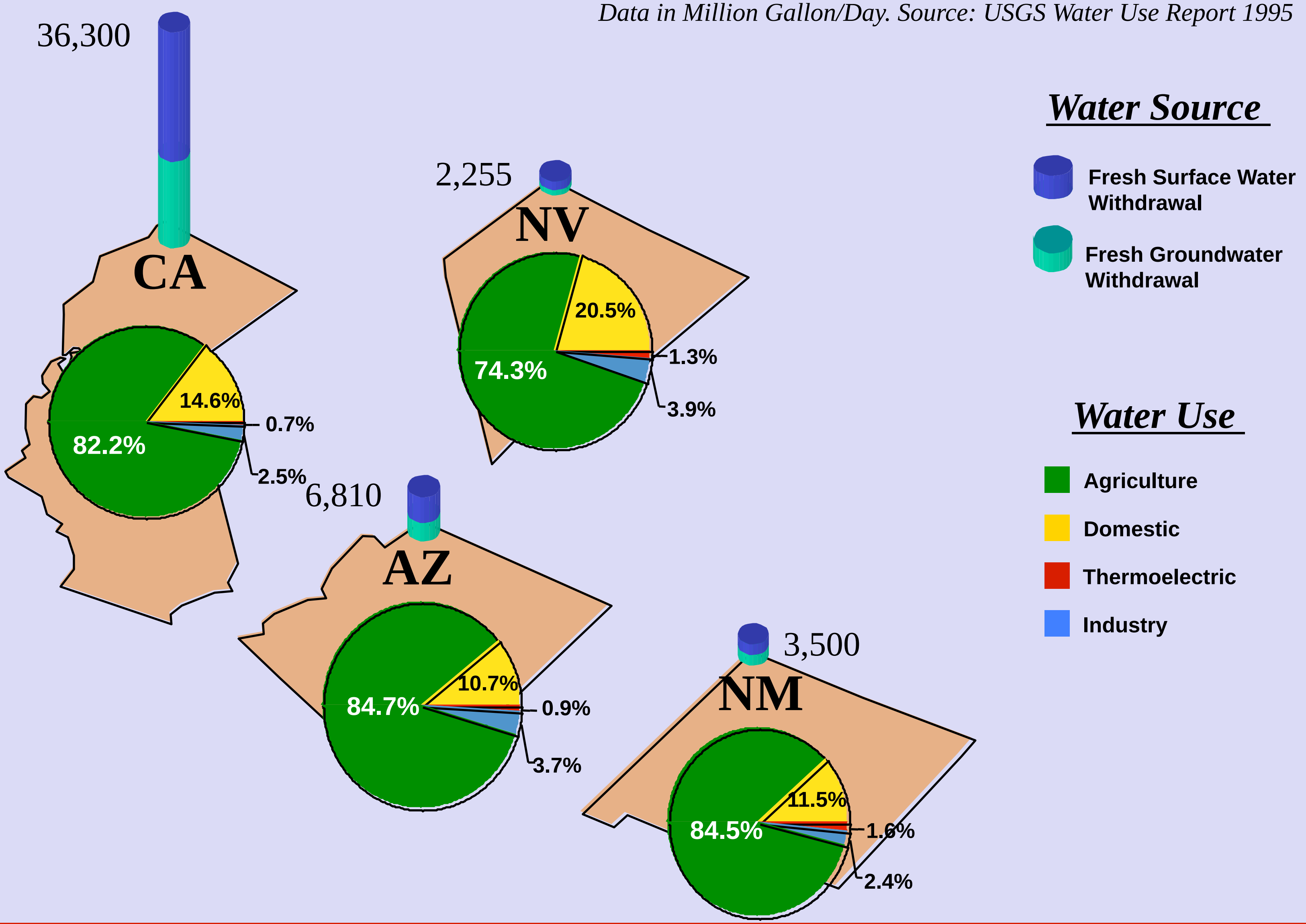
• The region experienced its wettest conditions in the 1980s and 1990s (coinciding with a shift in Pacific climate in 1976, after which El Niño became much more frequent), but has dried in the last decade.

Extremes

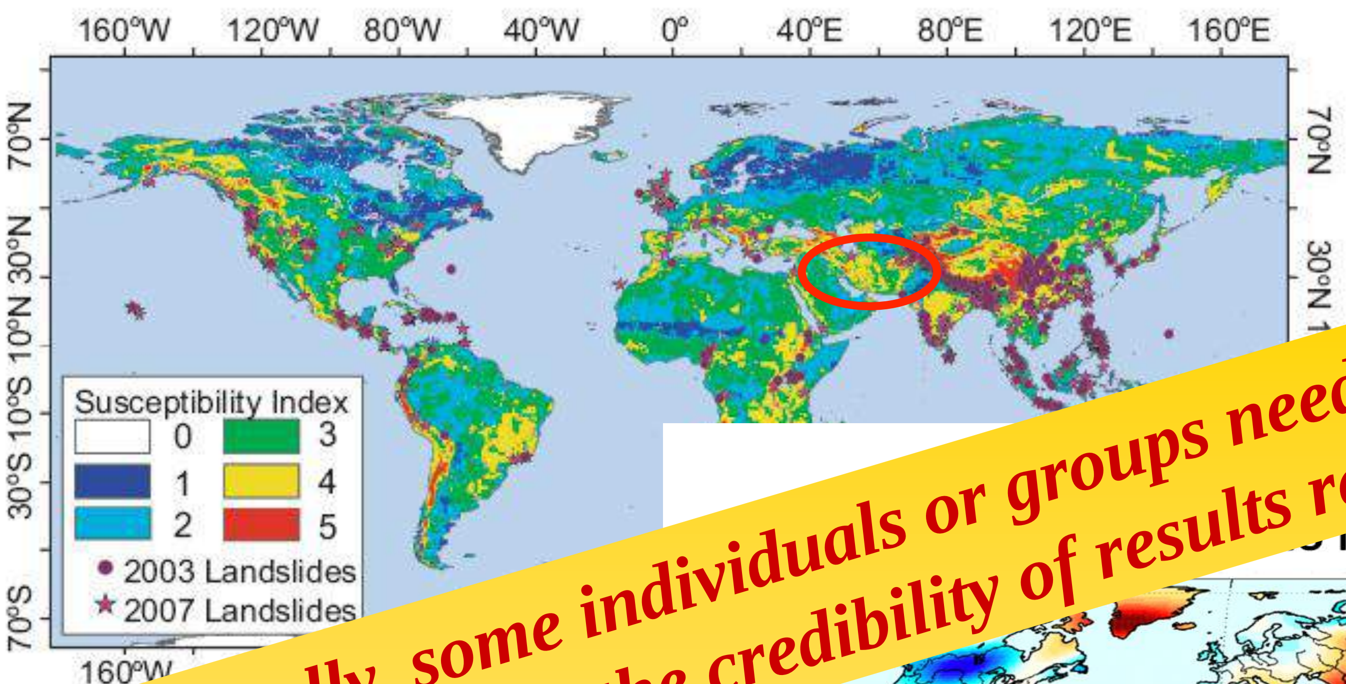
• There is not a statistically significant trend in the occurrence of extreme precipitation events in the Southwest.

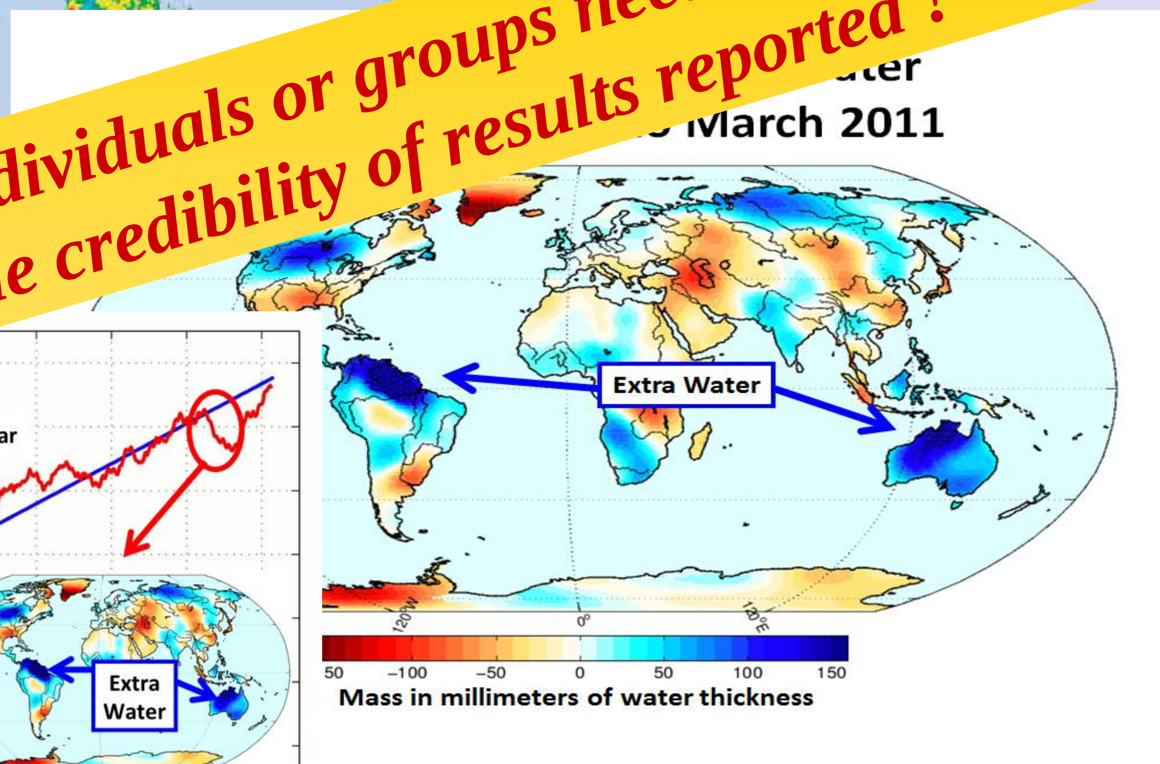
Large-Scale Irrigation and Hydroclimate Feedback

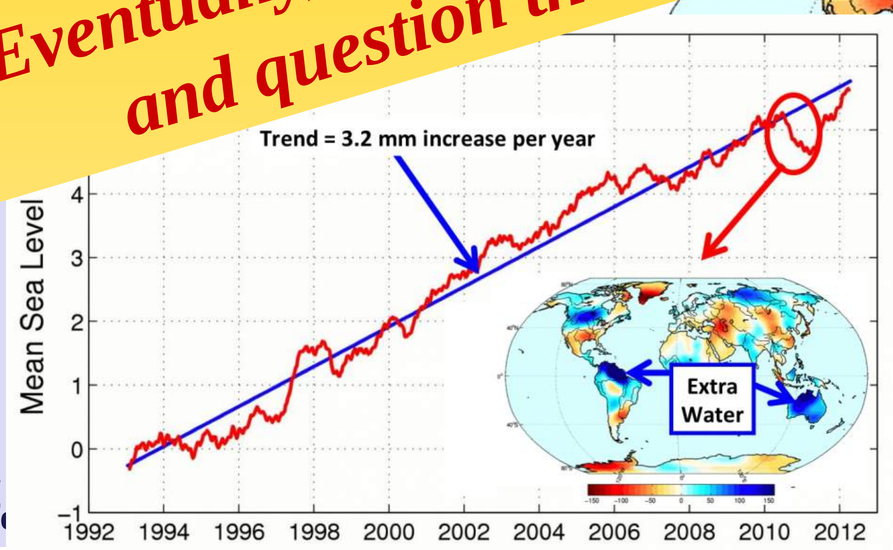
Data in Million Gallon/Day. Source: USGS Water Use Report 1995



Landslide Risk map:

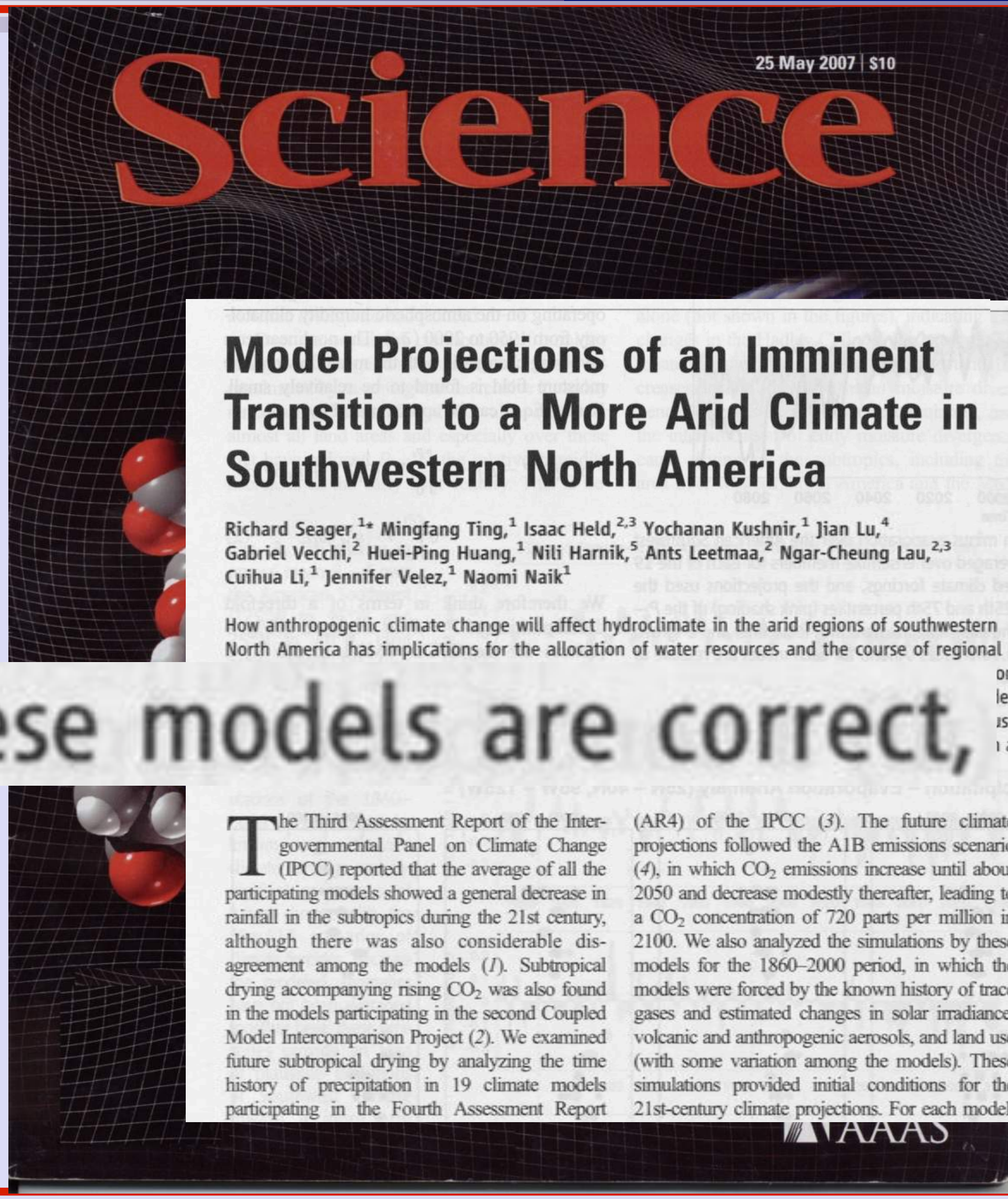






Eventually, some individuals or groups need to examine and question the credibility of results reported !

A Dryer Future for Southwest US?



Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America

Richard Seager,[1*] Mingfang Ting,[1] Isaac Held,[2,3] Yochanan Kushnir,[1] Jian Lu,[4] Gabriel Vecchi,[2] Huei-Ping Huang,[1] Nili Harnik,[5] Ants Leetmaa,[2] Ngar-Cheung Lau,[2,3] Cuihua Li,[1] Jennifer Velez,[1] Naomi Naik[1]

How anthropogenic climate change will affect hydroclimate in the arid regions of southwestern North America has implications for the allocation of water resources and the course of regional

If these models are correct,

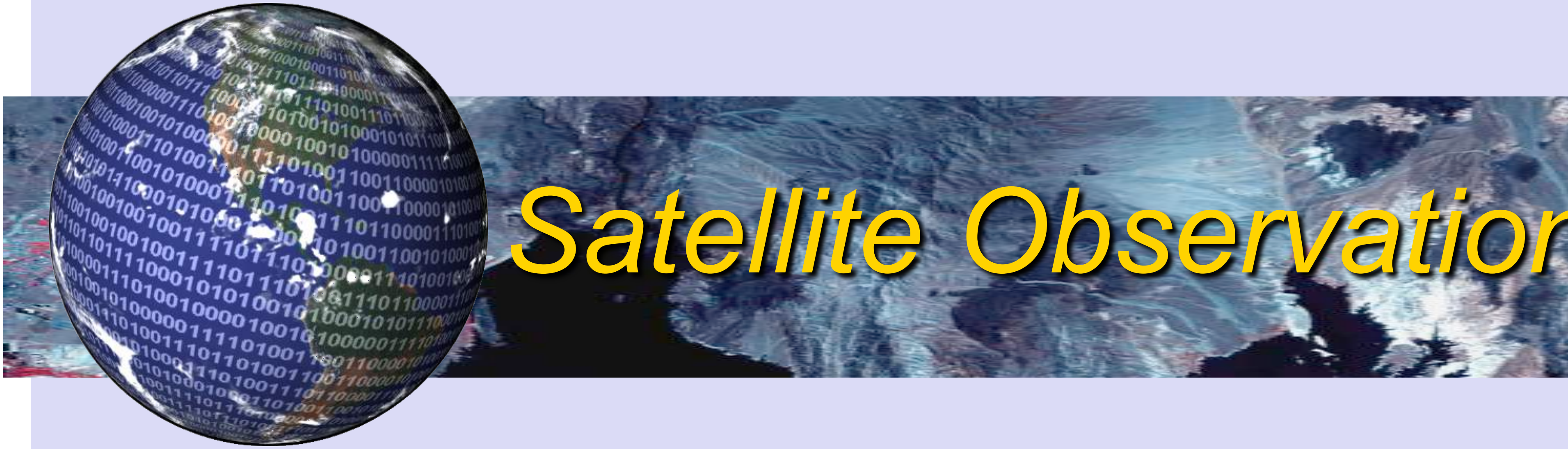
The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) reported that the average of all the participating models showed a general decrease in rainfall in the subtropics during the 21st century, although there was also considerable disagreement among the models (*1*). Subtropical drying accompanying rising CO_2 was also found in the models participating in the second Coupled Model Intercomparison Project (*2*). We examined future subtropical drying by analyzing the time history of precipitation in 19 climate models participating in the Fourth Assessment Report (AR4) of the IPCC (*3*). The future climate projections followed the A1B emissions scenario (*4*), in which CO_2 emissions increase until about 2050 and decrease modestly thereafter, leading to a CO_2 concentration of 720 parts per million in 2100. We also analyzed the simulations by these models for the 1860–2000 period, in which the models were forced by the known history of trace gases and estimated changes in solar irradiance, volcanic and anthropogenic aerosols, and land use (with some variation among the models). These simulations provided initial conditions for the 21st-century climate projections. For each model,

precipitation minus the evaporation ($P - E$), averaged over this region for the period common to all of the models (1900–2098). The median, 25th, and 75th percentiles of the model $P - E$ distribution and the median of P and E are shown. For cases in which there were multiple simulations with a single model, data from these simulations were averaged together before computing the distribution. $P - E$ equals the moisture convergence by the atmospheric flow and (over land) the amount of water that goes into runoff.

In the multimodel ensemble mean, there is a transition to a sustained drier climate that begins in the late 20th and early 21st centuries. In the ensemble mean, both P and E decrease, but the former decreases by a larger amount. $P - E$ is primarily reduced in winter, when P decreases and E is unchanged or modestly increased, whereas in summer, both P and E decrease. The annual mean reduction in P for this region, calculated from rain gauge data within the Global Historical Climatology Network, was 0.09 mm/day between 1932 and 1939 (the Dust Bowl drought) and 0.13 mm/day between 1948 and 1957 (the 1950s Southwest drought). The ensemble median reduction in P that drives the reduction in $P - E$ reaches 0.1 mm/day in midcentury, and one quarter of the models reach this amount in the early part of the current century.

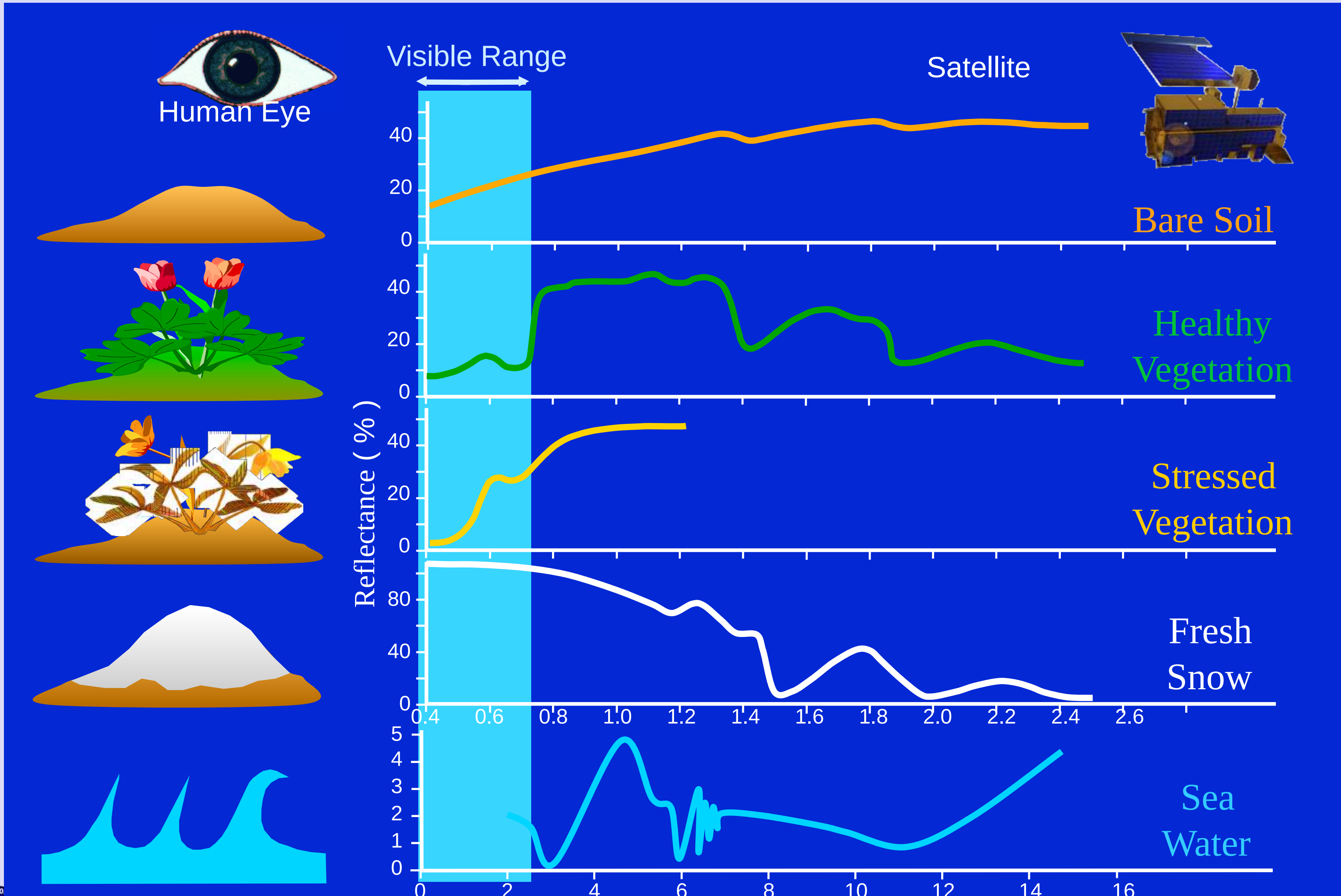
The annual mean $P - E$ difference between 20-year periods in the 21st century and the 1950–2000 climatology for the 19 models are shown in Fig. 2. Almost all models have a drying trend in the American Southwest and the con-

Space-Based Observations



Satellite Observations

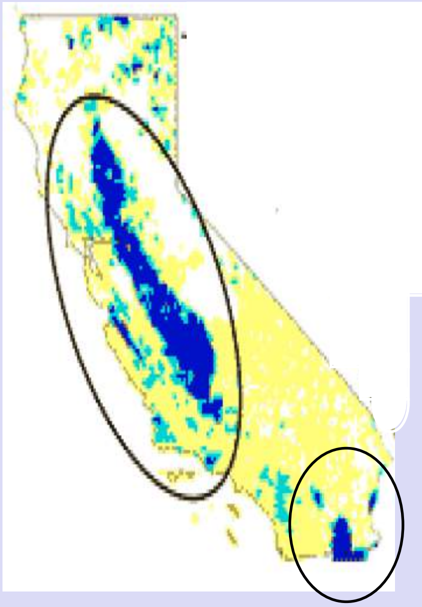
Remote Sensing Systems (Spectral Signal)

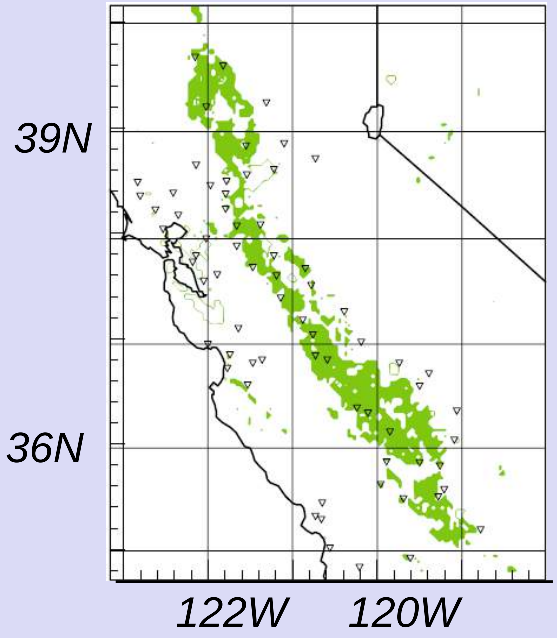


Satellite-Based Rainfall Estimation: Promising !

Observations from space: Near-continuous, global coverage,

"Observed" vs "Model-Generated" Data

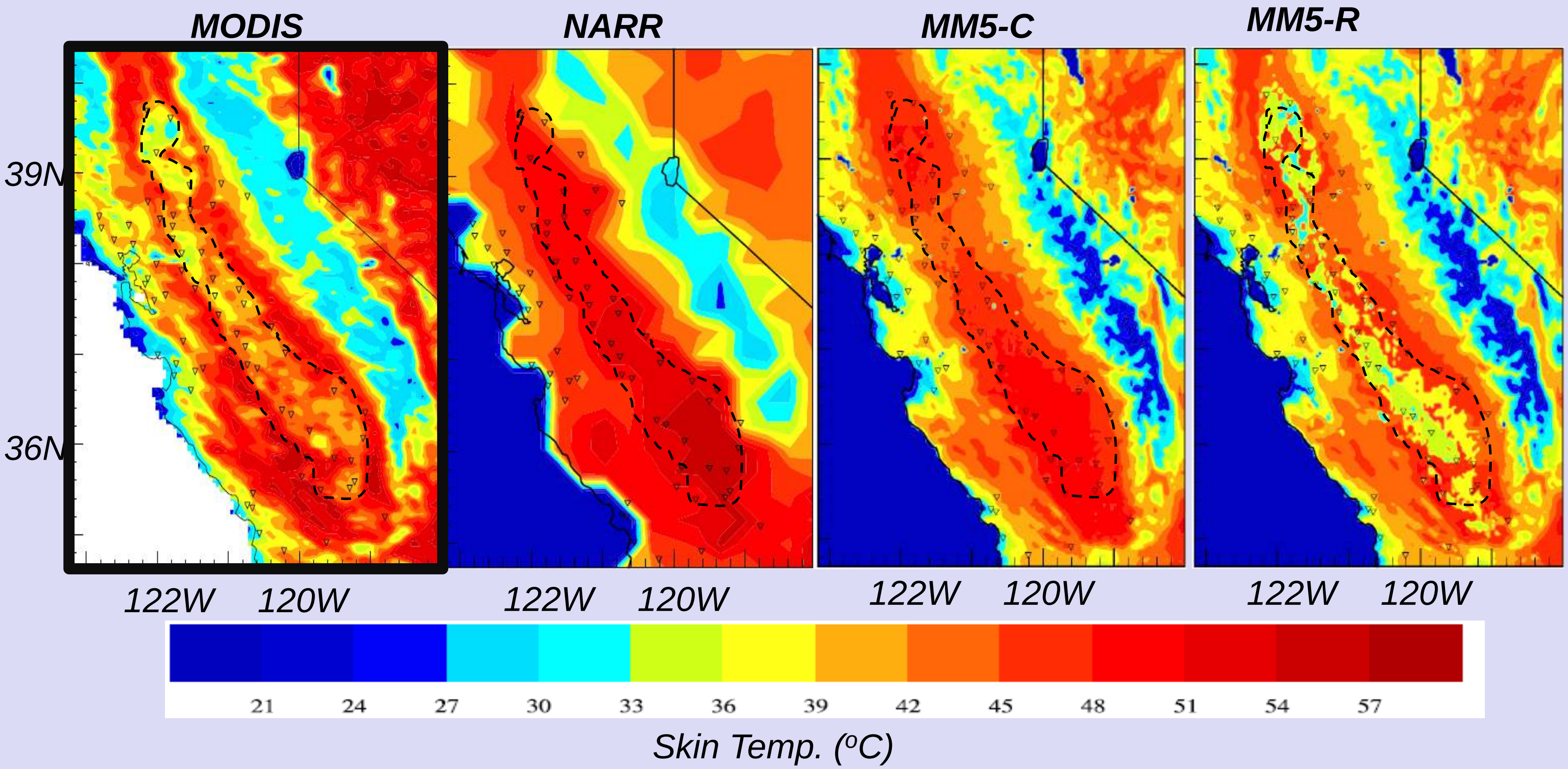




Studies over California's Central Valley Irrigation Region

Sorooshian et al. 2011 & 2012

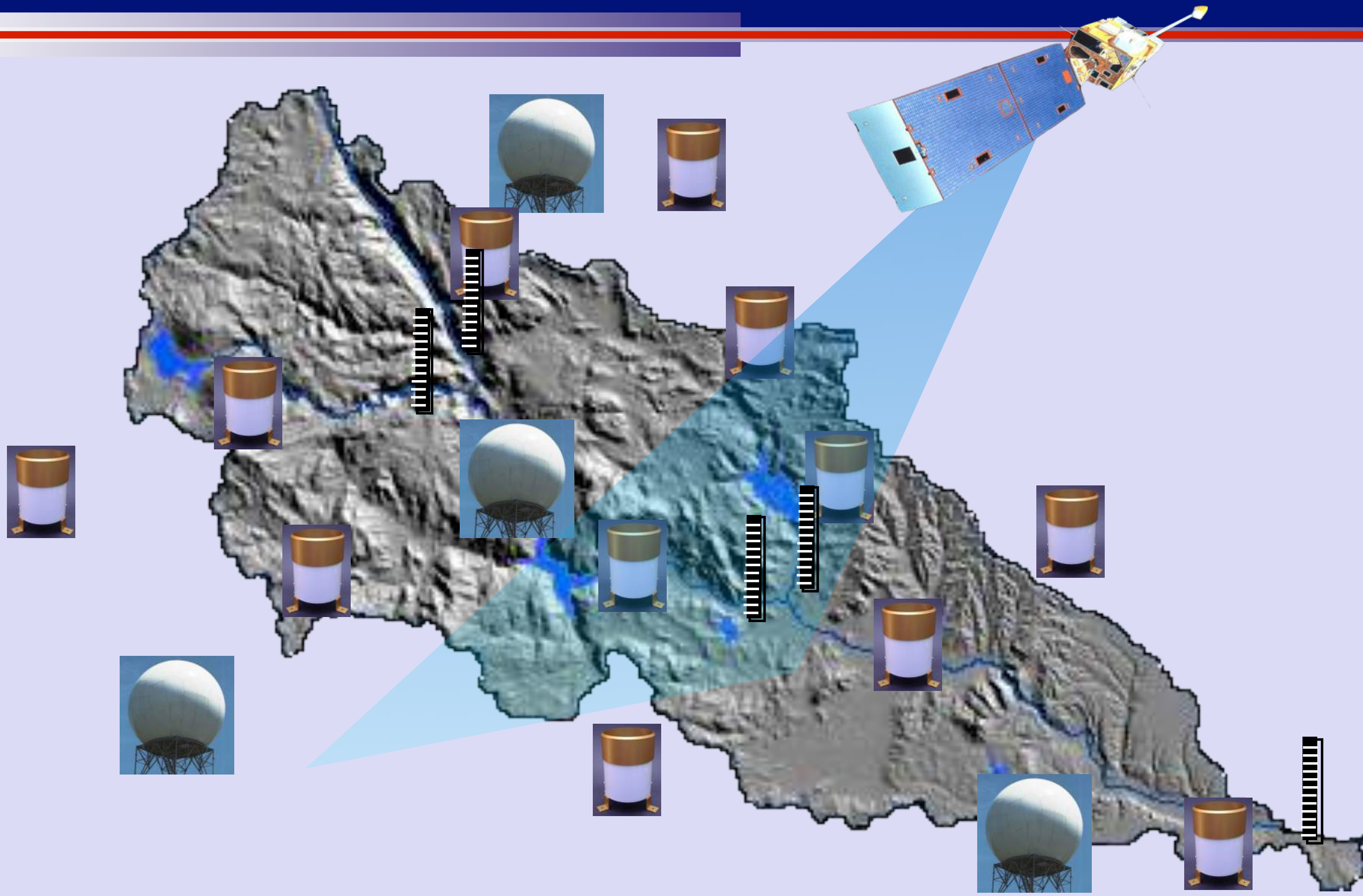
Mean skin surface temp. at daytime in June, July and August, 2007.



Adding irrigation into RCM (MM5), Improves the model's ability to simulate, more closely, the temperature patterns observed by MODIS

Sorooshian et al, (JGR 2011)

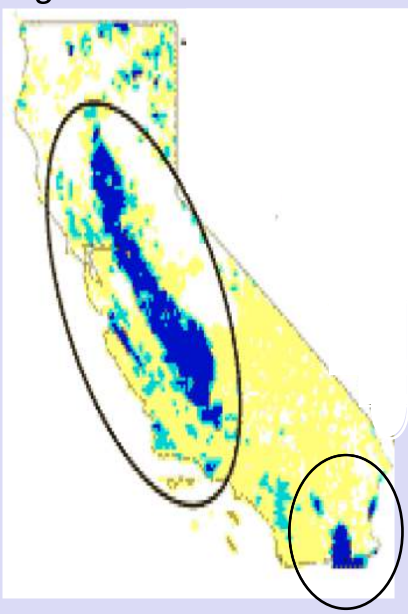
Data Requirements for Hydrologic Modeling

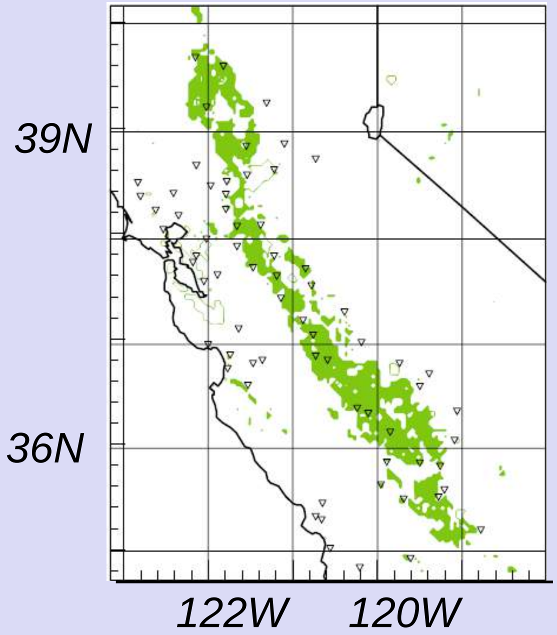


Data Limitation is an Important Factor in Success of Hydrologic Modeling

Irrigation over central California

Irrigation areas





- *Meteorological conditions are the key factors to decide when and how much water to apply,*

- *Californian Irrigation Management Information System (CIMIS) with more than 200 stations (nearly 150 active) provides the information to farmers.*

California Irrigation Management Information System (CIMIS)

- ***California Irrigation Management Information System (CIMIS)***
  - *Operating since 1982*
  - *More than 125 stations currently providing daily measurements of ETo (potential ET)*
  - ***Spatial CIMIS*** *data now available 2km statewide grid, daily*

Source: Forrest Melton

Provided By: Forrest Melton

http://wwwcimis.water.ca.gov/

Water Resources Situation in California

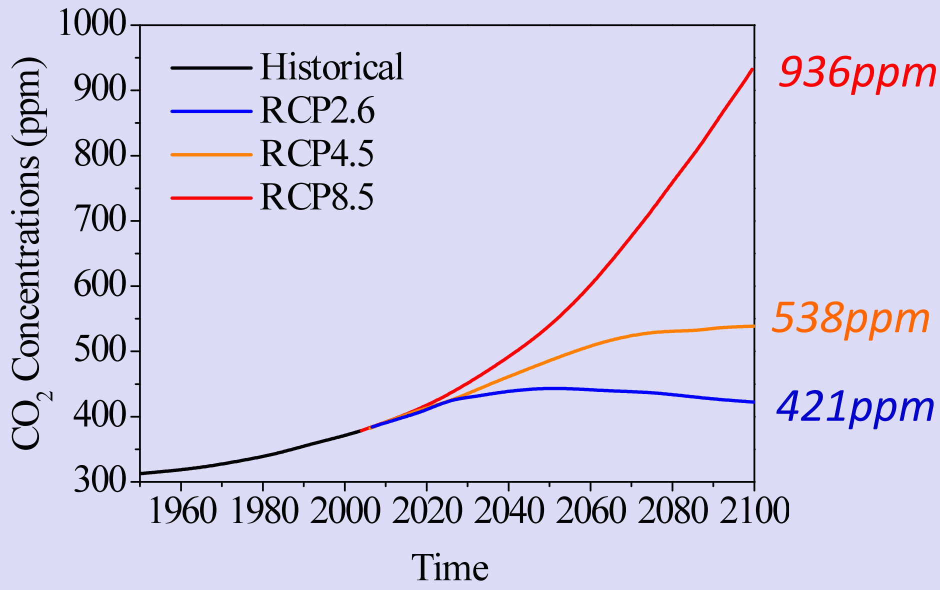
Future Modeling Scenarios

Representative Concentration Pathways (RCP) Scenarios:

RCP2.6: represent 'low' scenarios featured by the radiative forcing of 2.6 W/m^2 by 2100, the resulting CO_2-equivalent concentrations is 421 ppm in the year 2100 .

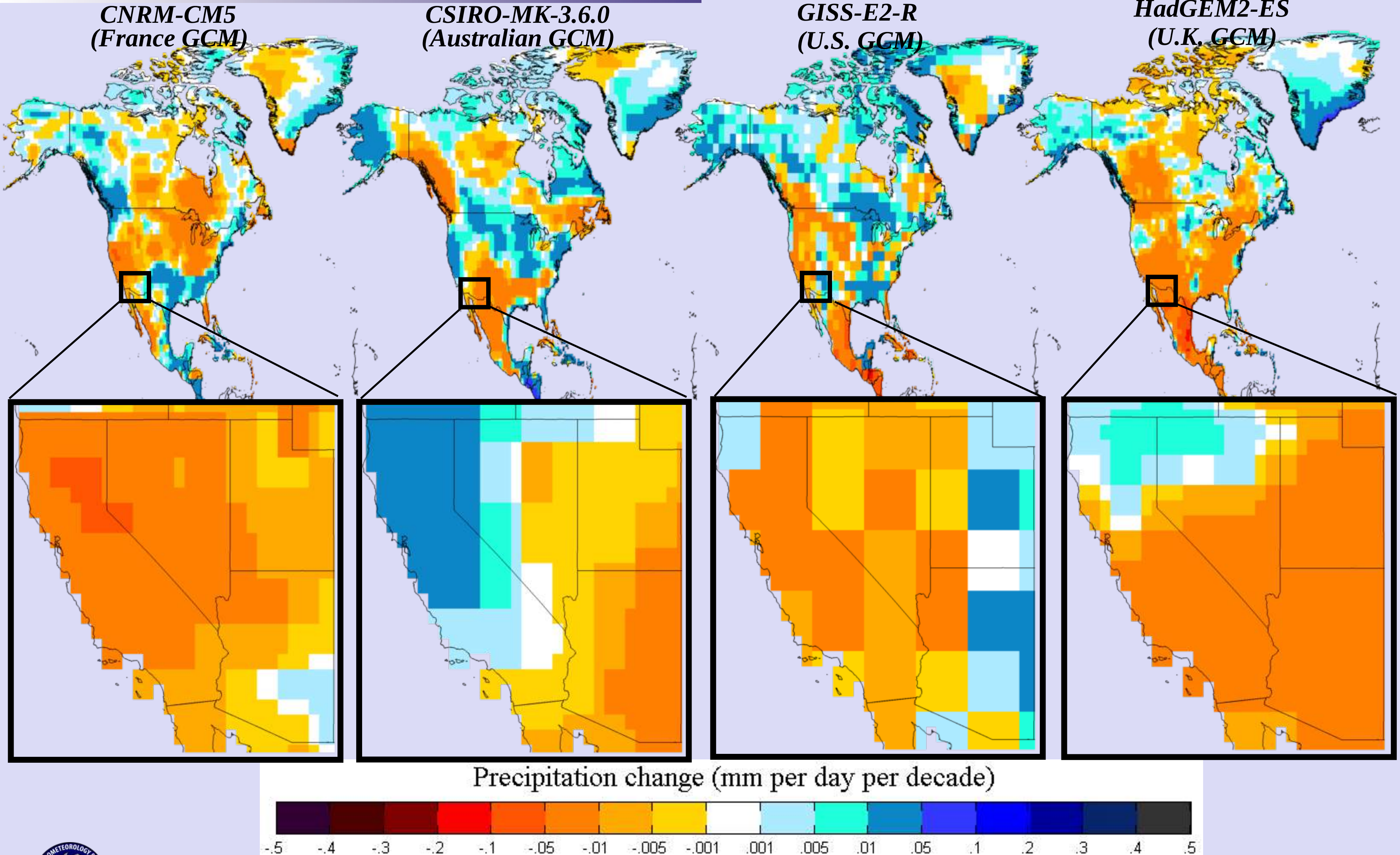
RCP4.5: represent 'medium' scenarios featured by the radiative forcing of 4.5 W/m^2 by 2100, the resulting CO_2-equivalent concentrations is 538 ppm in the year 2100 .

RCP8.5: represent 'high' scenarios featured by the radiative forcing of 8.5 W/m^2 by 2100, the resulting CO_2-equivalent concentrations is 936 ppm in the year 2100 .

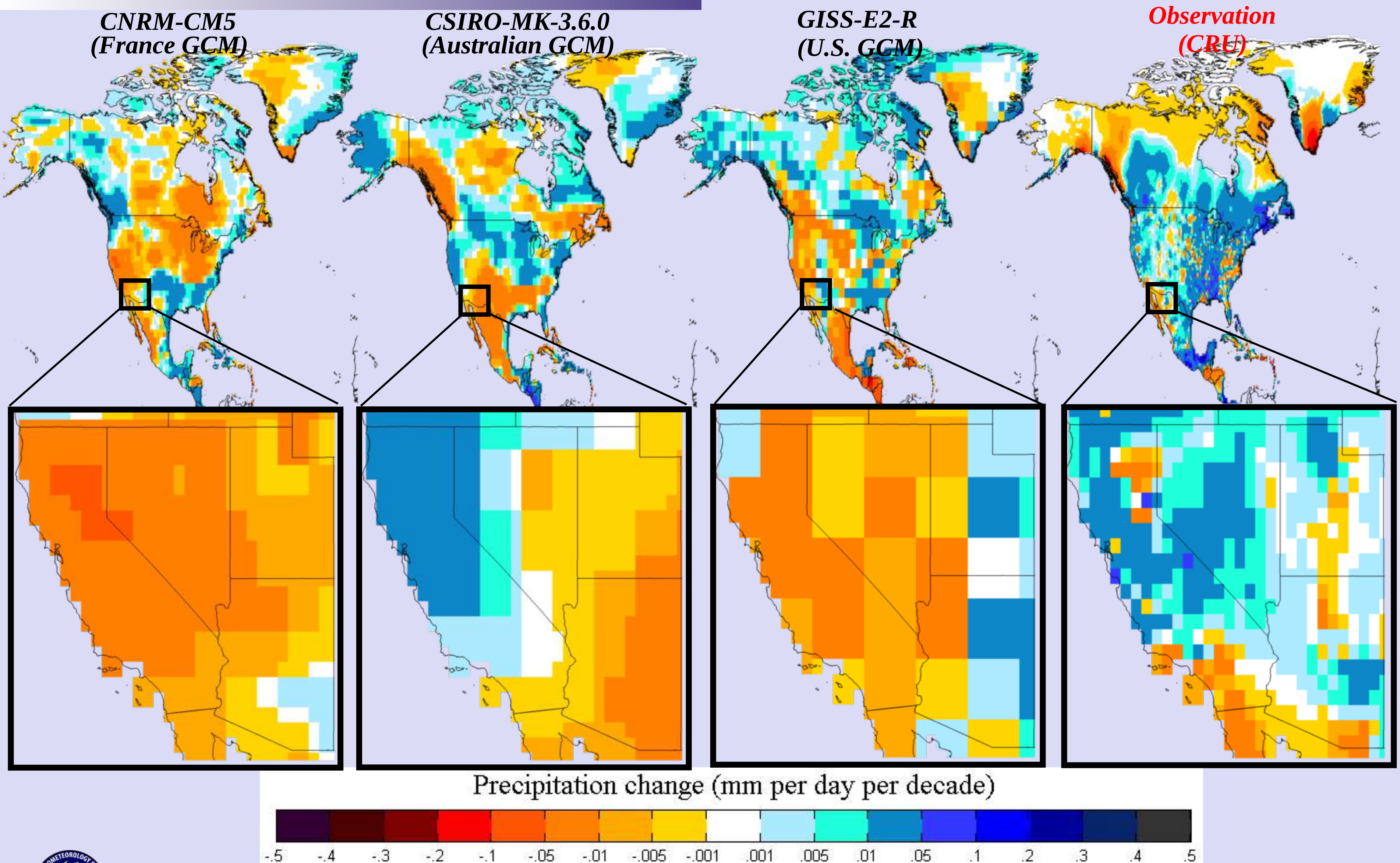


Western U.S. historical model simulations

Model historical simulation

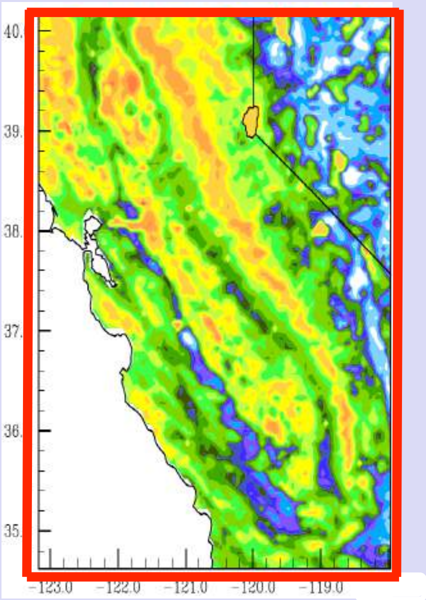


Model historical simulation vs observation

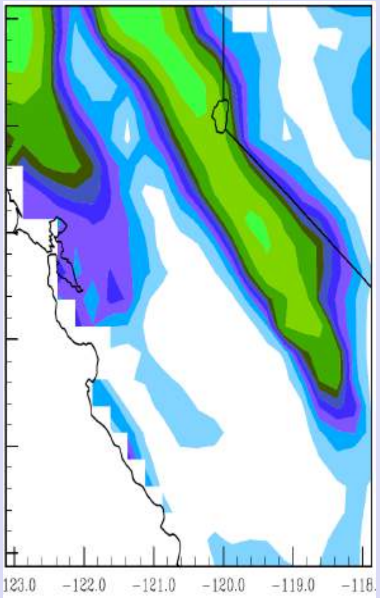


“Observed” vs “Model-Generated” Data

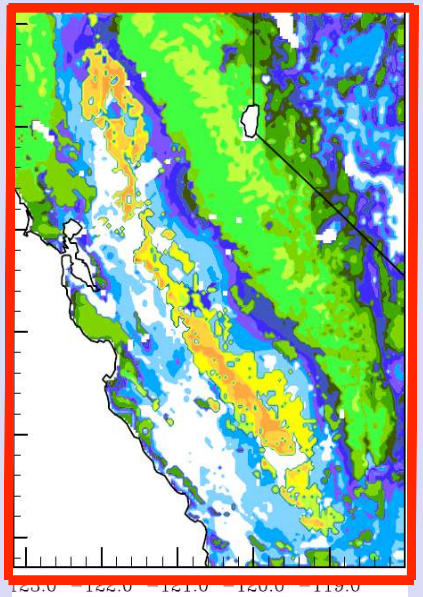
MODIS



GLDAS/Noah

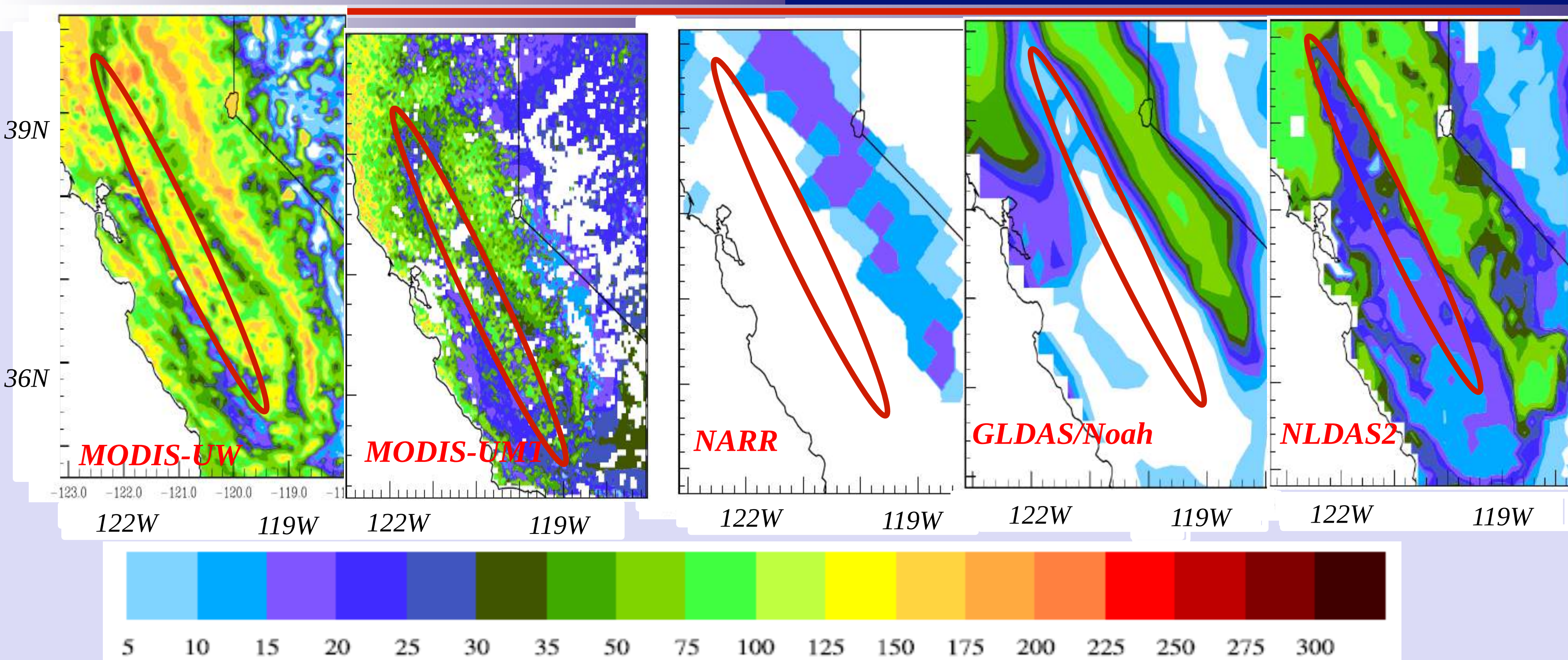


MM5R



Sorooshian et al. 2011 & 2012

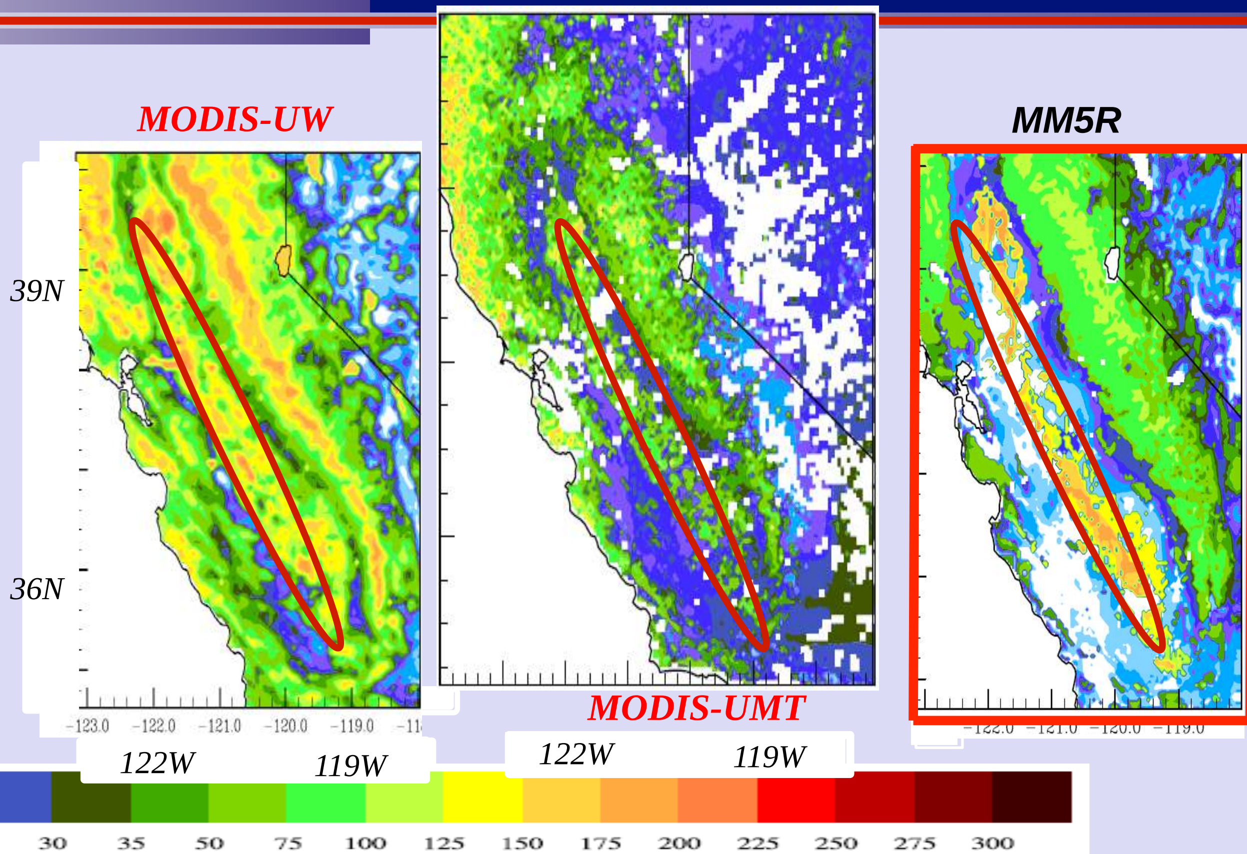
Actual ET Estimates From Different Data sets– JJA 2007



2007 JJA Monthly ET (mm)

Li et al, 2011

Actual ET comparison-spatial distribution – JJA 2007



Monthly ET (mm/month)

An Important Dilemma for the modeling application community will be:

Which Remotely Sensed ET Product should be used for model testing and validation??