Border Region Climate Change Summary

Water and Energy Sustainability with Rapid Growth in the Arizona-Sonora Border Region

June 1, 2009 – Arizona Water Institute

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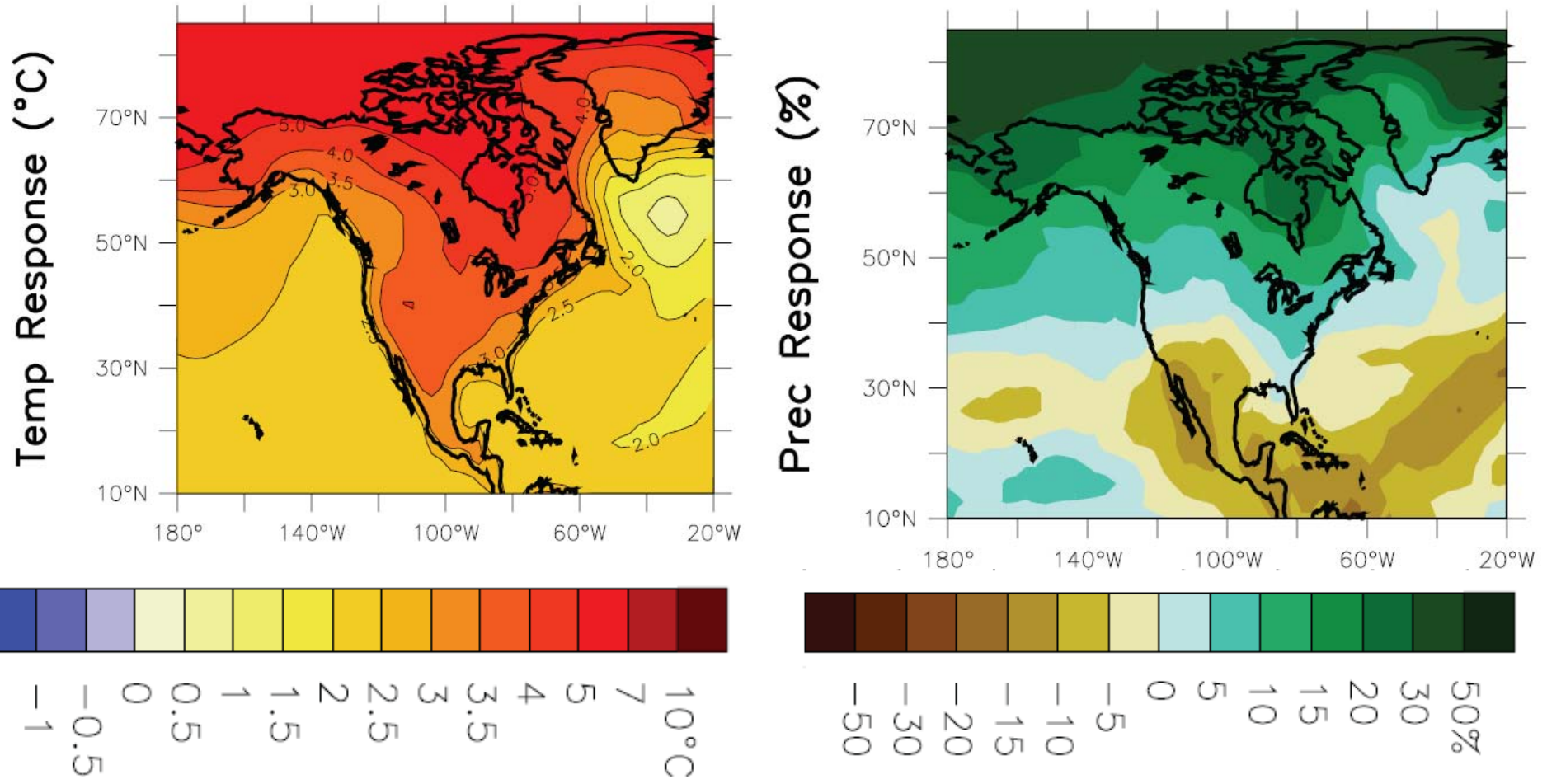
INSTITUTE FOR THE STUDY OF PLANET EARTH

CLIMAS
Climate Assessment Project for the Southwest

RISA
Regional Integrated Sciences and Assessments
Building Bridges Between Climate Sciences and Society

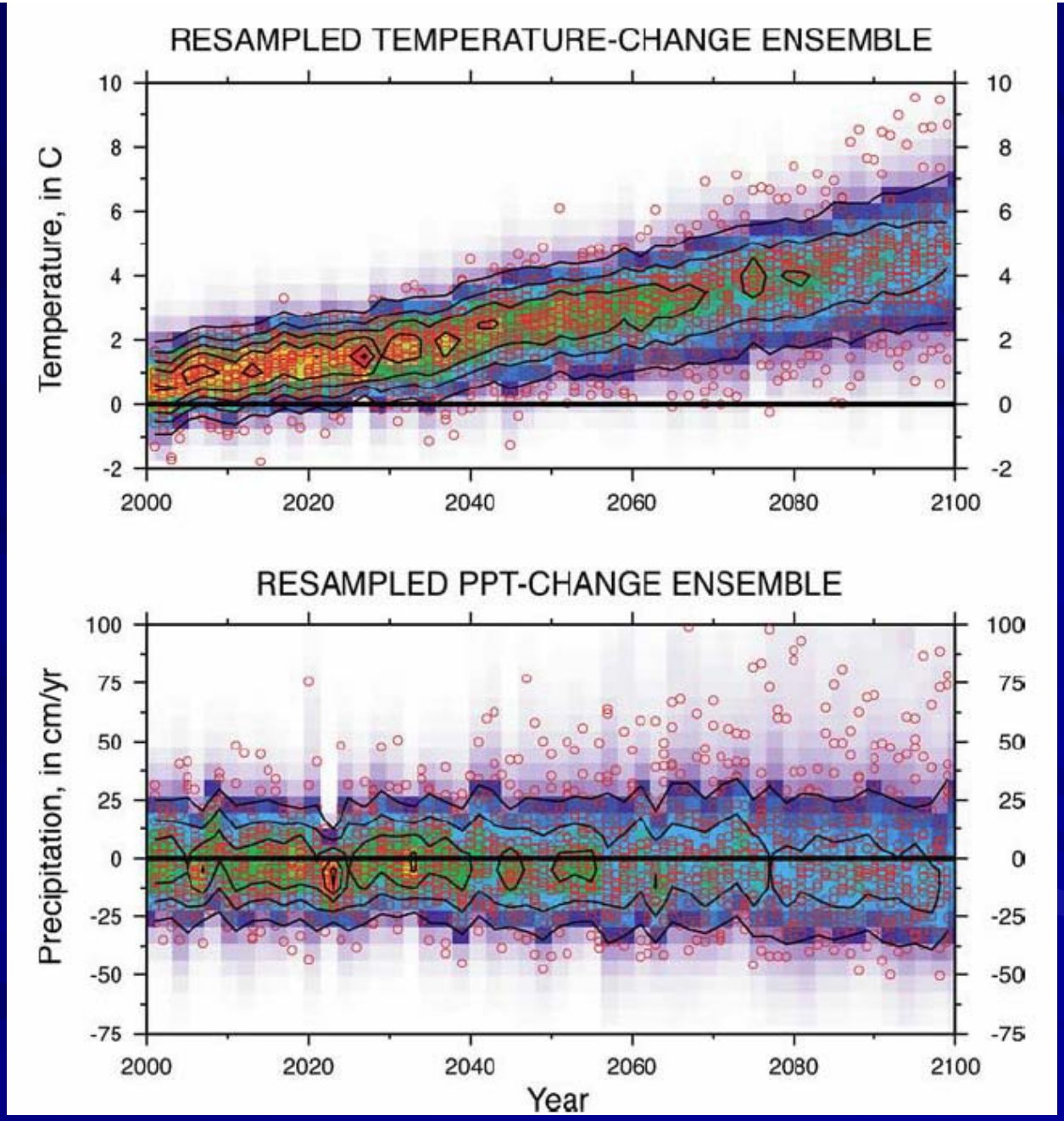
Basic message: HOT (confident), DRY (less confident; no confidence in summer)



Annual Temperature and Precipitation Change
End of 21st Century — Scenario: A1b

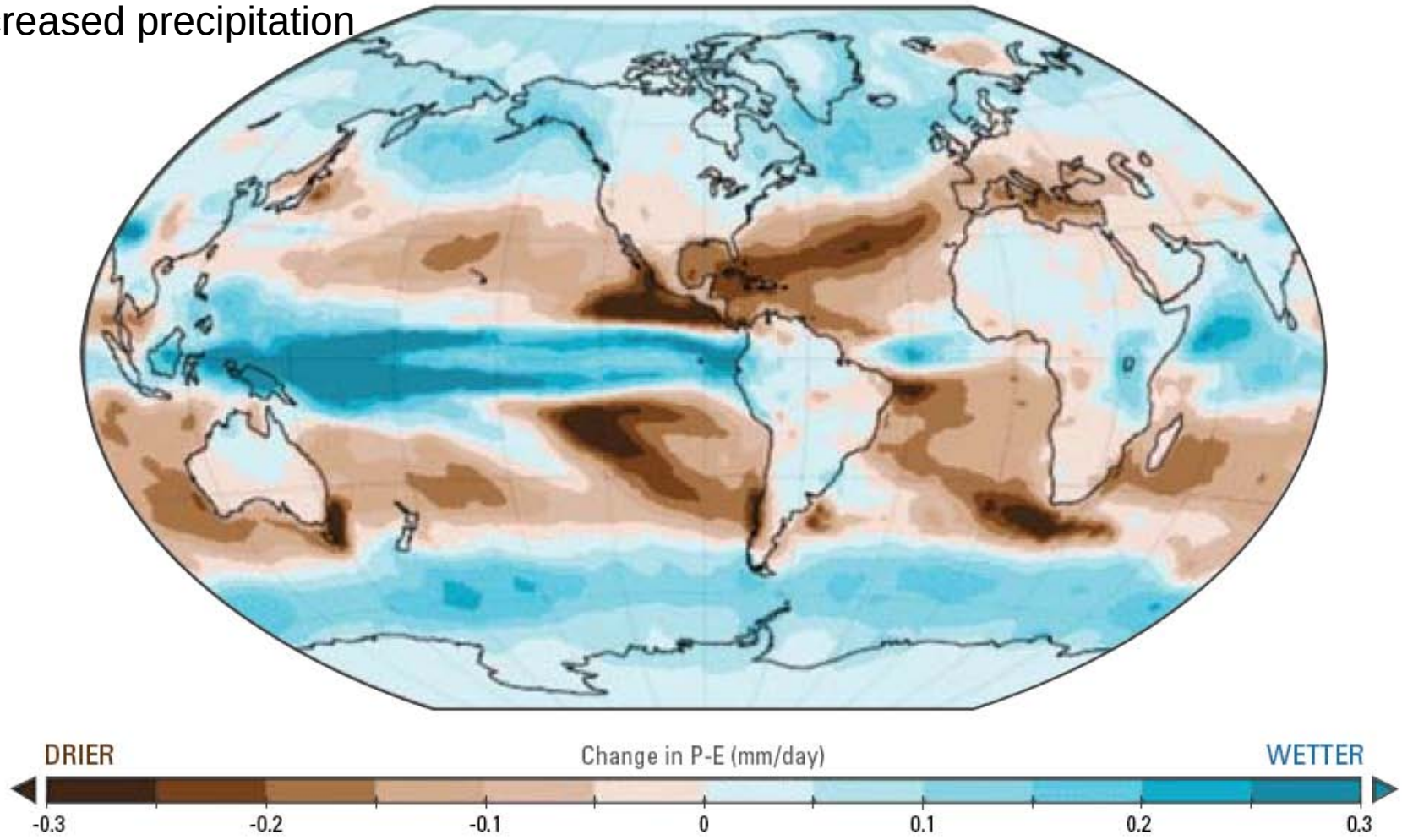
IPCC 4th Assessment: Working Group I, Chapter 11, Regional Projections

These graphs express the confidence statement mentioned in the previous slide. (example for Northern California)

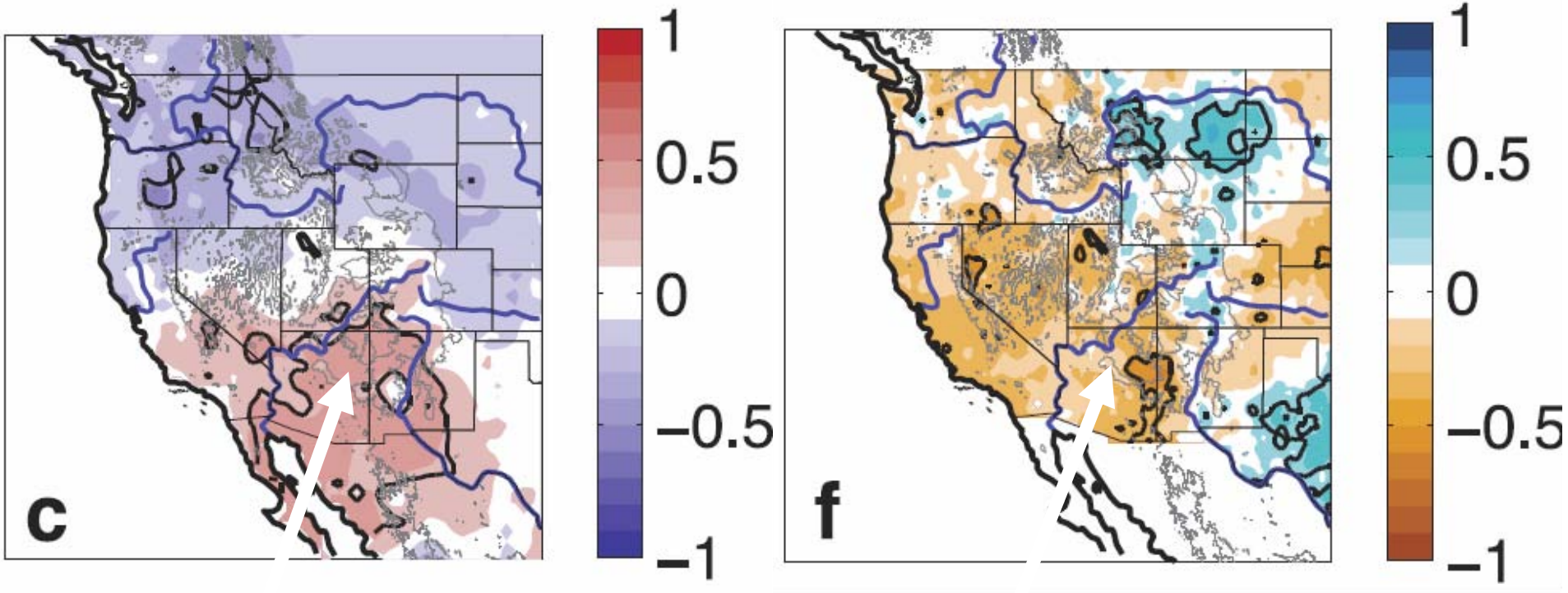


M. Dettinger, *Climatic Change*, 2006

Basic message: by mid-century, water balance gets drier, due to increased ET, and decreased precipitation



Seager et al. 2007, *Science*

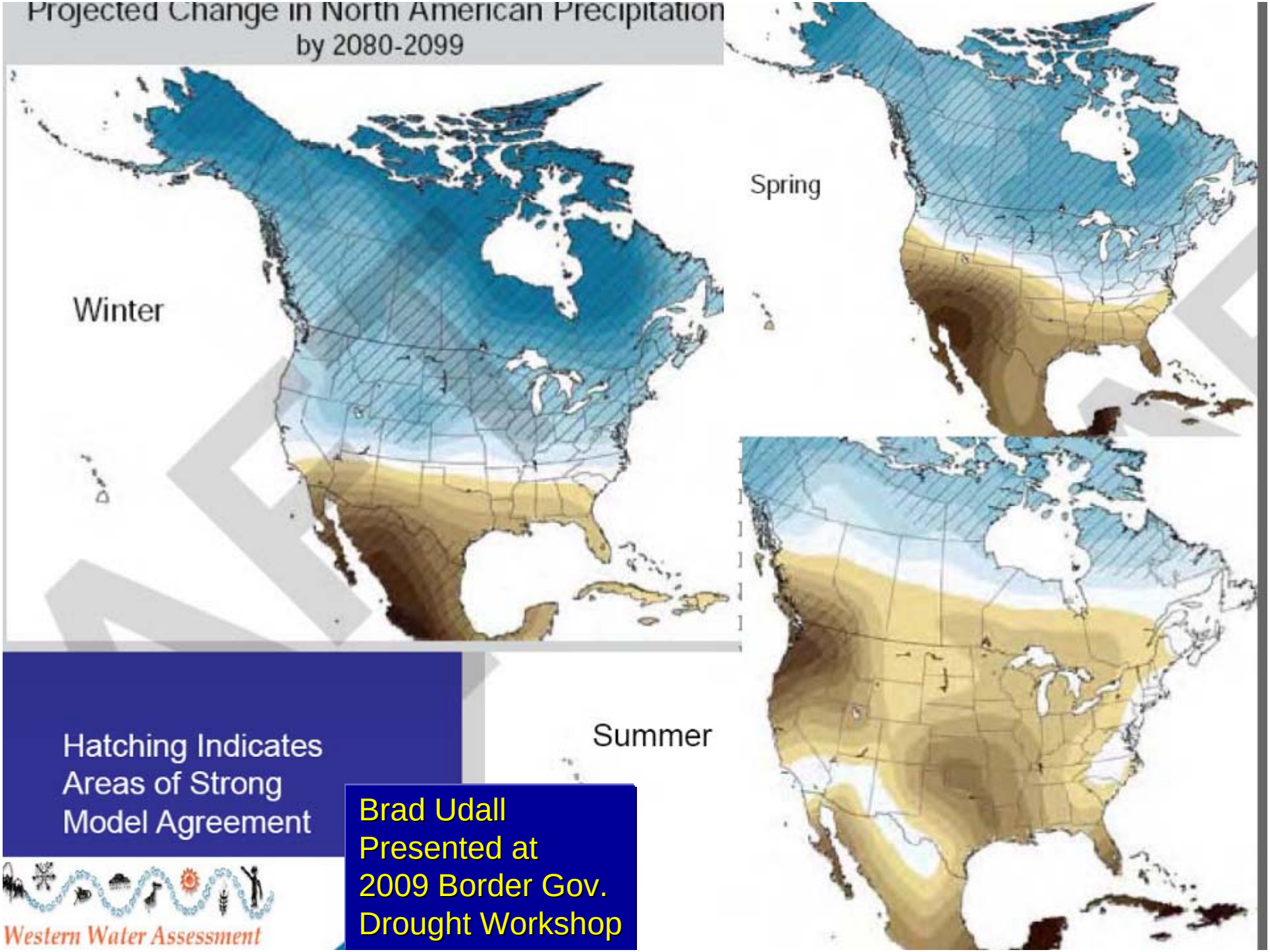


Higher TEM in the Southwest

Lower PRECIP in the Southwest

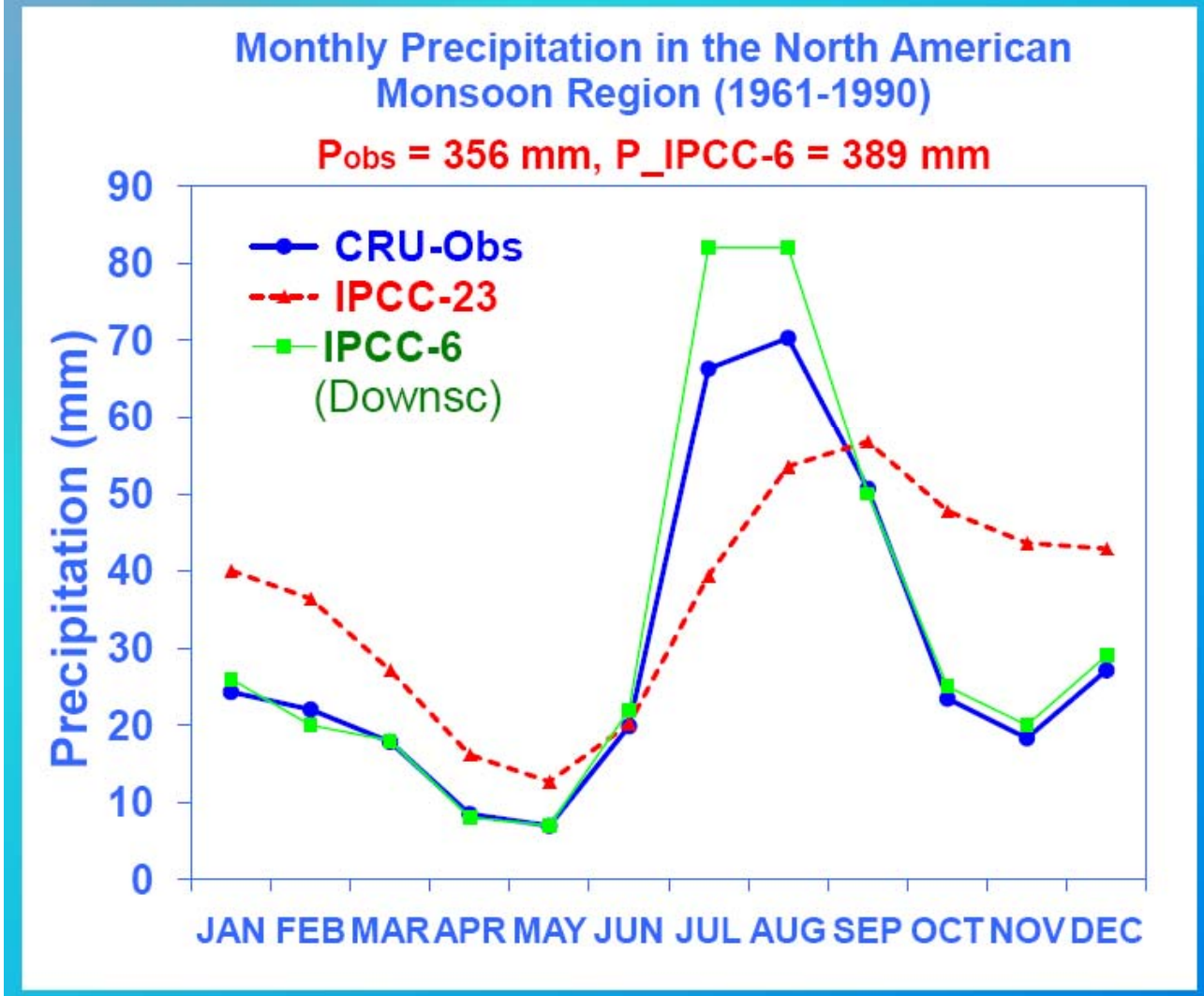
Basic message: Storm track is migrating northward; effects greatest in spring time, which contributes to early snow melt.

Northern Annular Mode Impact on **Spring** Climate
in the Western United States
McAfee and Russell, 2008 Geophysical Research Letters


Projected Change in North American Precipitation
by 2080-2099
Winter
Spring
Summer
Hatching Indicates
Areas of Strong
Model Agreement
Western Water Assessment
Brad Udall
Presented at
2009 Border Gov.
Drought Workshop

NAM: Annual cycle of precipitation

Basic message: well selected models over-predict summer precip, but IPCC average is not realistic for summer

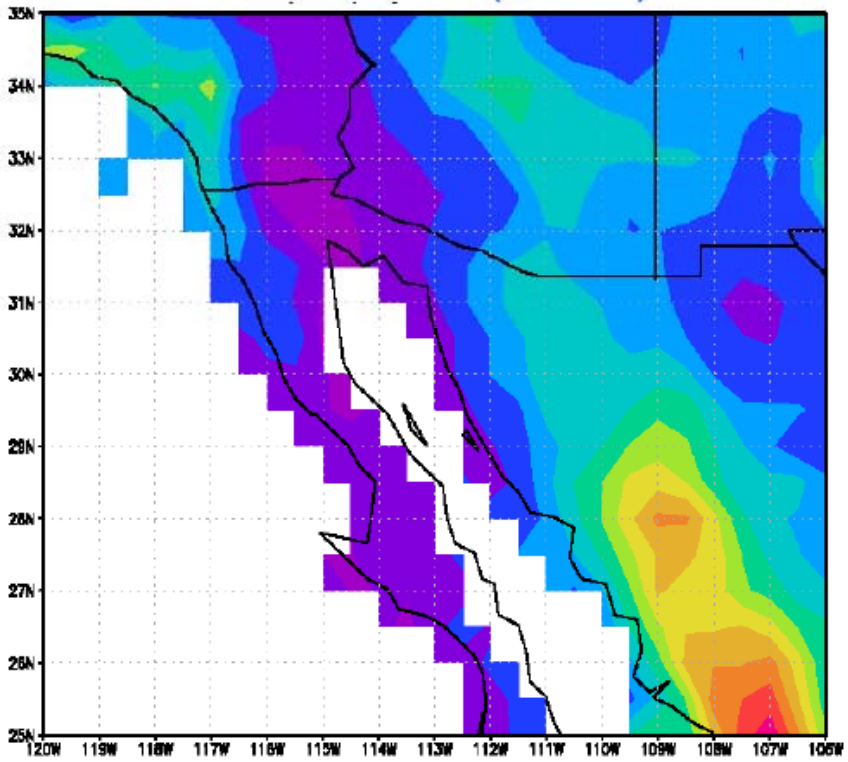


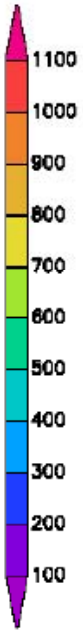
T. Cavazos, CICESE
Presented at 2009 Border Gov. Drought Workshop

Basic message: 6 models selected for monsoon get basic spatial features right

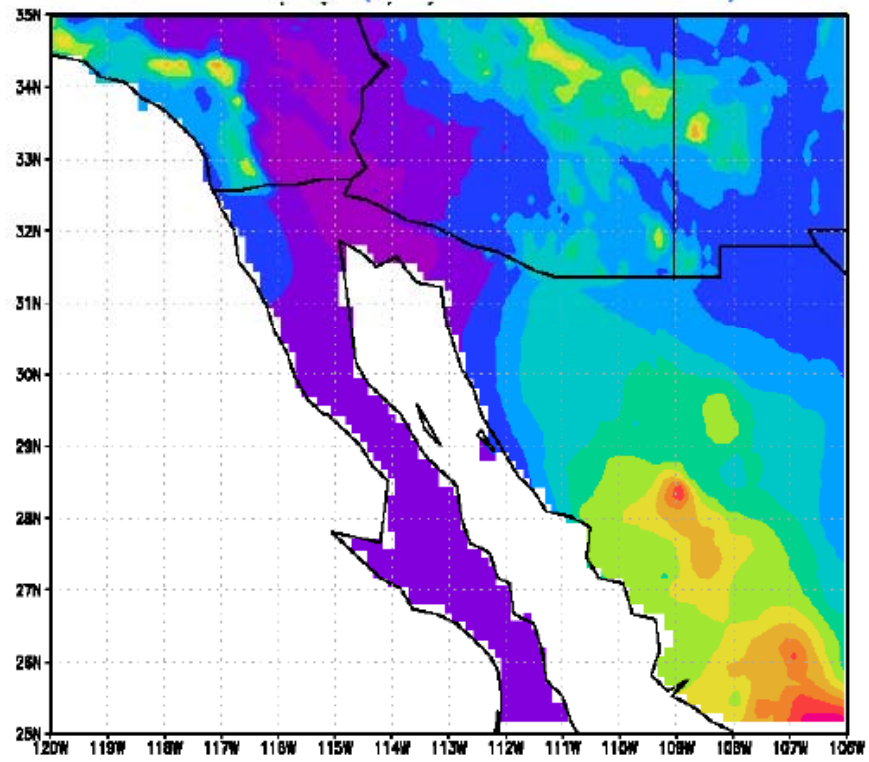
Annual Precipitation (mm): 1961-1990

CRU-OBS (50km)





IPCC-6 (Downsc 12 km)



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Statistically downscaled model data from (Ed Maurer):
http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/

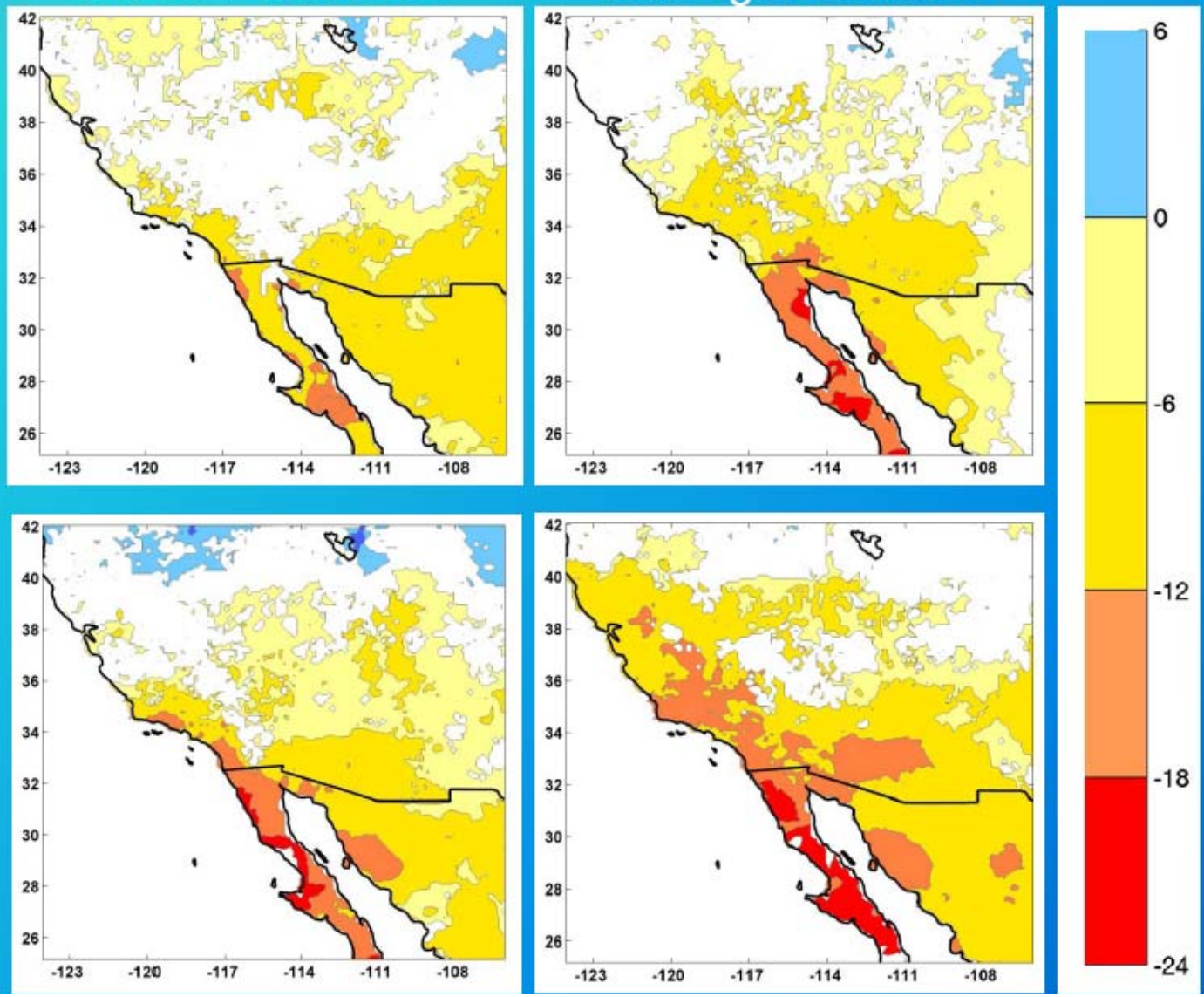
Decadal change of precipitation (%) under B1 and A2 scenarios

Plotted when 2/3 of the models agree on the sign of change, relative to 1961-1990

Basic message: using the 6 good monsoon models, the region still dries out

B1: Low emissions

A2: High emissions



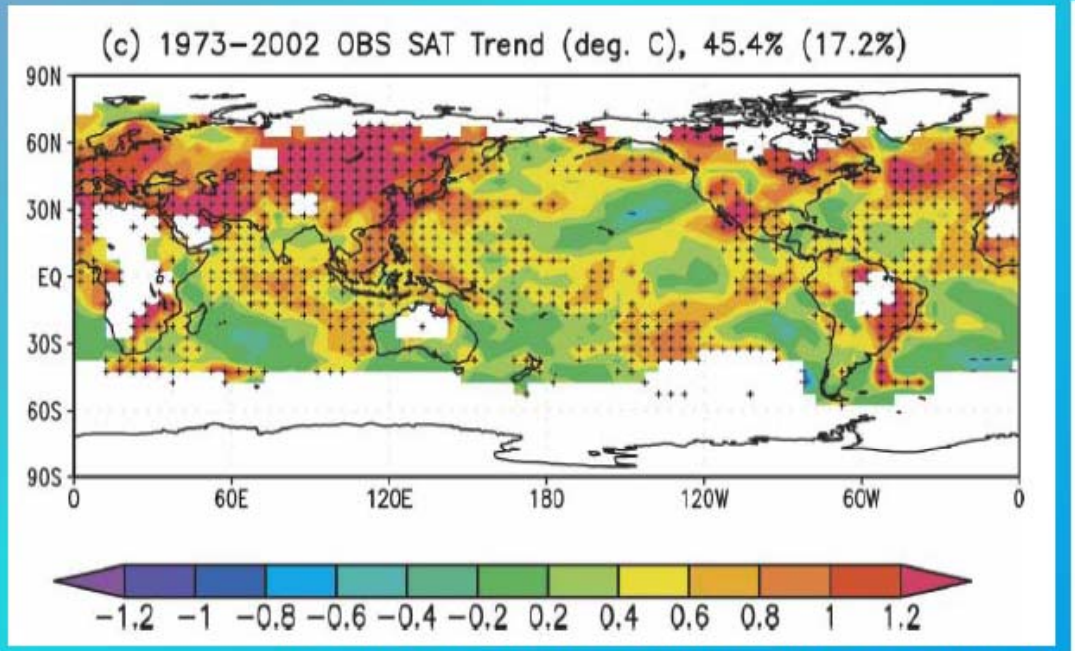
2010-2029

Cavazos and Arriaga, 2009 (in prep.) CICESE Presented at 2009 Border Gov. Drought Wkshp.

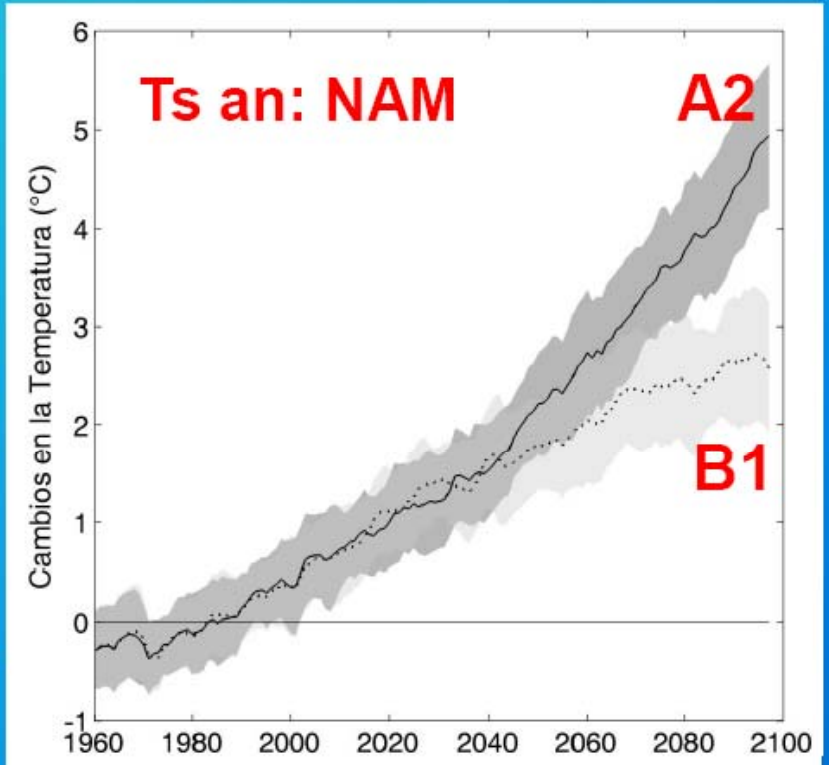
2030-2049

Surface air temperature trends

Basic message: Regardless of precip, temperatures are increasing



(Fig. 2c from Karoly and Wu, 2005, J. Climate)



Changes in median temperature ± 1 std in the NAM region for A2 and B1 climate change scenarios from 6 downscaled IPCC models (12 realizations) at 12 km resolution. Based period 1961-1990.

(Cavazos and Arriaga, 2009, in preparation)

T. Cavazos, CICESE
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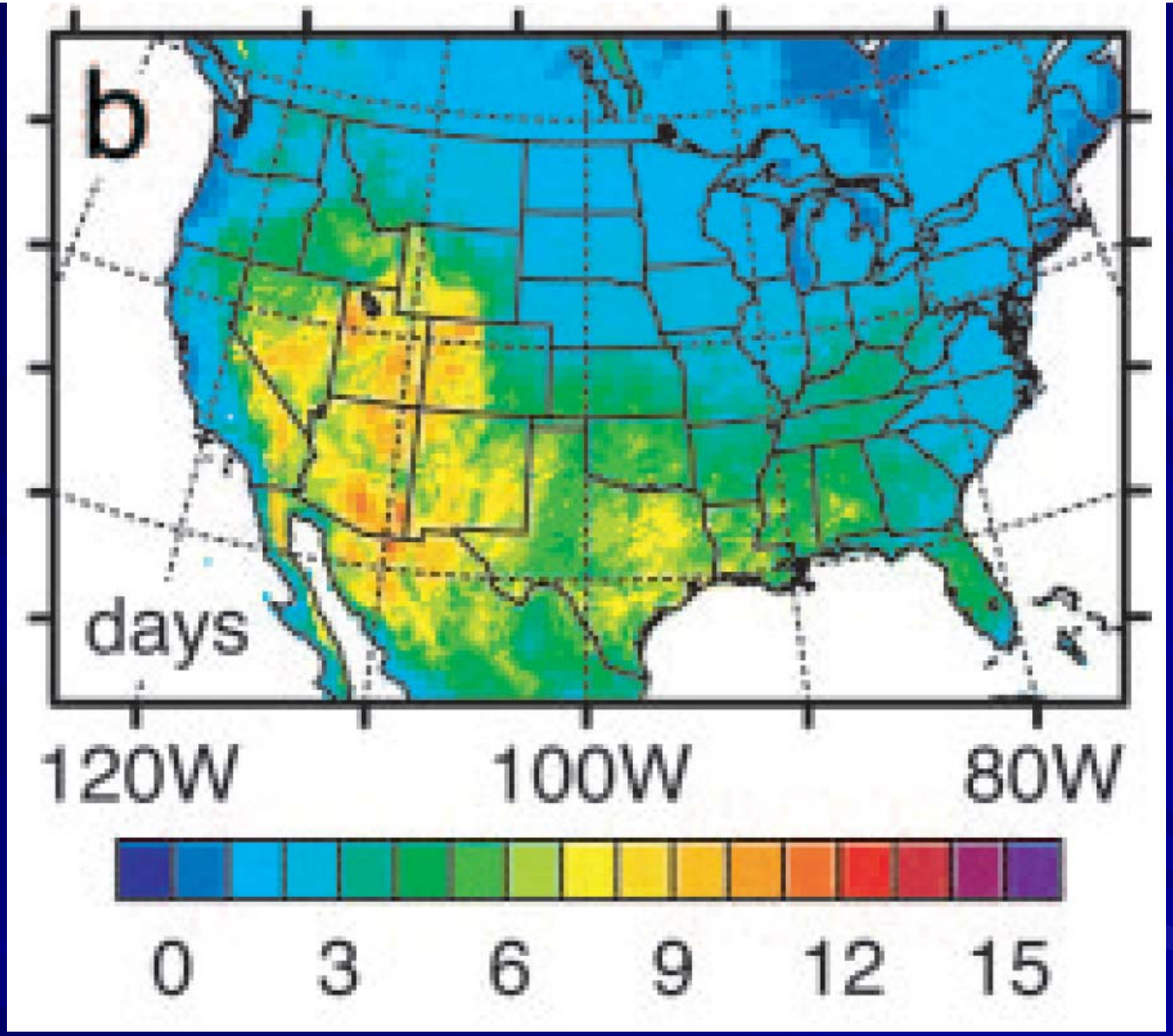
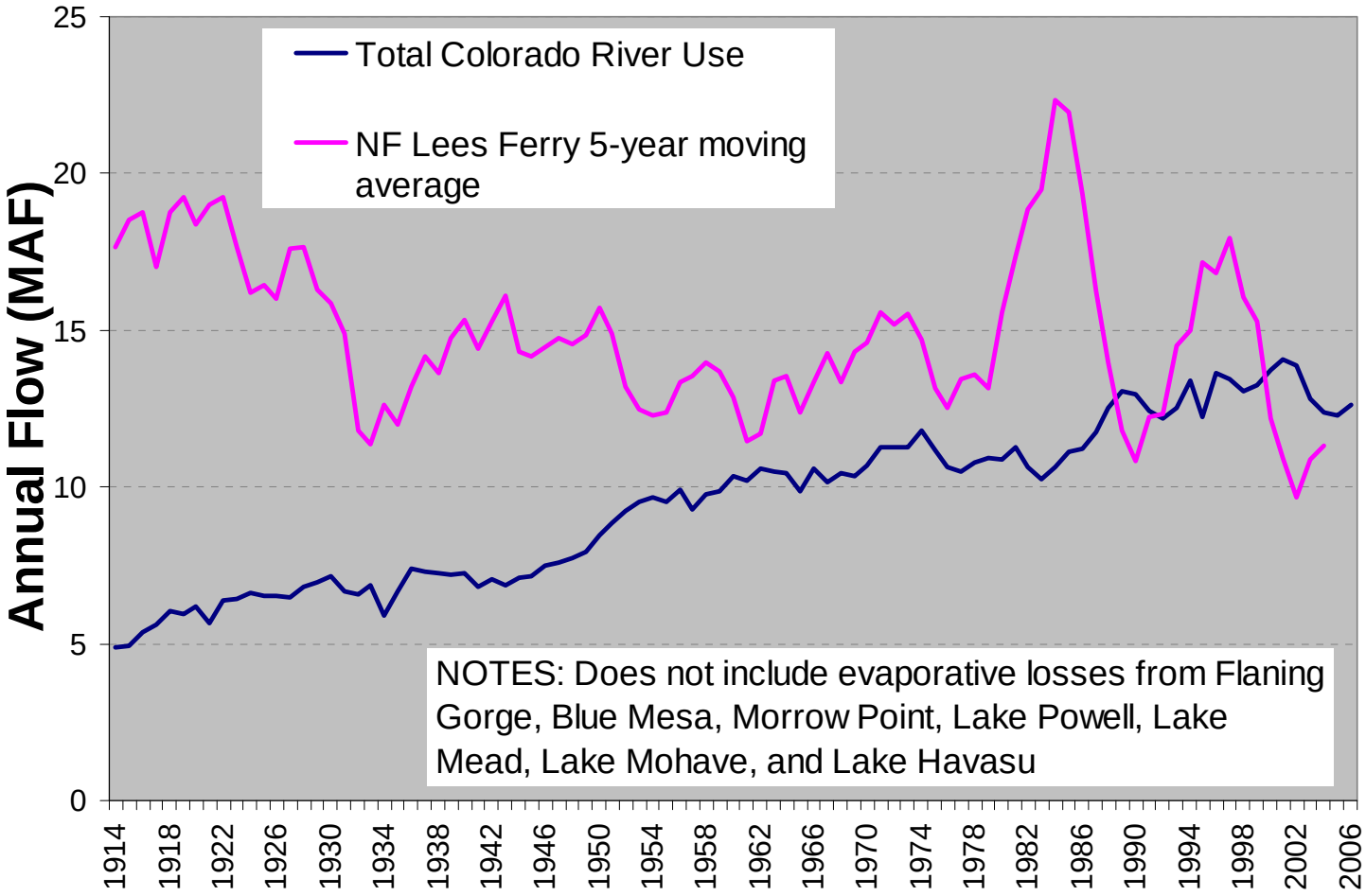


Longer Heat Waves

Basic message: enhanced snow melt in Upper Basin; enhanced demand in lower basin

Diffenbaugh et al., 2005; Proceedings of the National Academy of Science

Colorado Water System Demand – Supply (*stressed in recent decades*)



Basic message: not rocket science: Colorado River is stressed

Balaji Rajagopalan et al. (CU, Reclamation, NOAA)

Brad Udall, WWA, Presented at 2009 Border Governors Drought Workshop

Recent Colorado River Studies Table

Source: Climate Change in Colorado, 2008

Basic message: hydrologic projections say Colorado River flow will decrease

TABLE 5-1. Projected Changes in Colorado River Basin Runoff or Streamflow in the Mid-21st Century from Recent Studies

Study	*GCMs (runs)*	*Spatial Scale*	*Temperature*	*Precipitation*	*Year*	*Runoff (Flow)*	*Risk Estimate*
Christensen et al. 2004	1 (3)	VIC model grid (~8 mi)	+3.1°F	-6%	2040–69	-18%	Yes
Milly 2005, replotted by P.C.D. Milly	12 (24) (~100–300 mi)	GCM grids —	—		2041–60	-10 to -20% 96% model agreement	No
Hoerling and Eischeid 2006	18 (42)	NCDC Climate Division	+5.0°F	~0%	2035–60	-45%	No
Christensen and Lettenmaier 2007	11 (22)	VIC model grid (~8 mi)	+4.5°F (+1.8 to +5.0)	-1% (-21% to +13%)	2040–69	-6% (-40% to +18%)	Yes
Seager et al. 2007*	19 (49)	GCM grids (~100–300 mi)	—	—	2050	-16% (-8% to -25%)	No
McCabe and Wolock 2008	—	USGS HUC8 units (~25–65 mi)	Assumed +3.6°F	0%	—	-17 %	Yes
Barnett and Pierce 2008*	—	—	—	—	2057	Assumed -10% to -30%	Yes

Values and ranges (where available) were extracted from the text and figures of the references shown. Columns provide the number of climate models and individual model runs used to drive the hydrology models, the spatial scale of the hydrology, the temperature and precipitation changes that drive the runoff projections, and whether or not the study quantified the risk these changes pose to water supply (e.g., the risk of a compact call or of significantly depleting reservoir storage).

Reconciling Year 1- Runoff "Elasticity"

- How Do Hydrology Models Perform During Historical Period?
  - If you only modify Temperature by 1° C?
    - +1C = -2% to -9% runoff
    - Results very model dependent
  - If you only modify Precipitation by -10% / + 10%
    - -10% precipitation = -20% runoff
    - +10% precipitation = +20% runoff
    - Results Independent of the hydrology model
  - +1C Warming Equivalent to -1% to -5% Precipitation
  - At 2050 with 2C Warming, -4% to -18% Runoff w/ No Changes in Precipitation

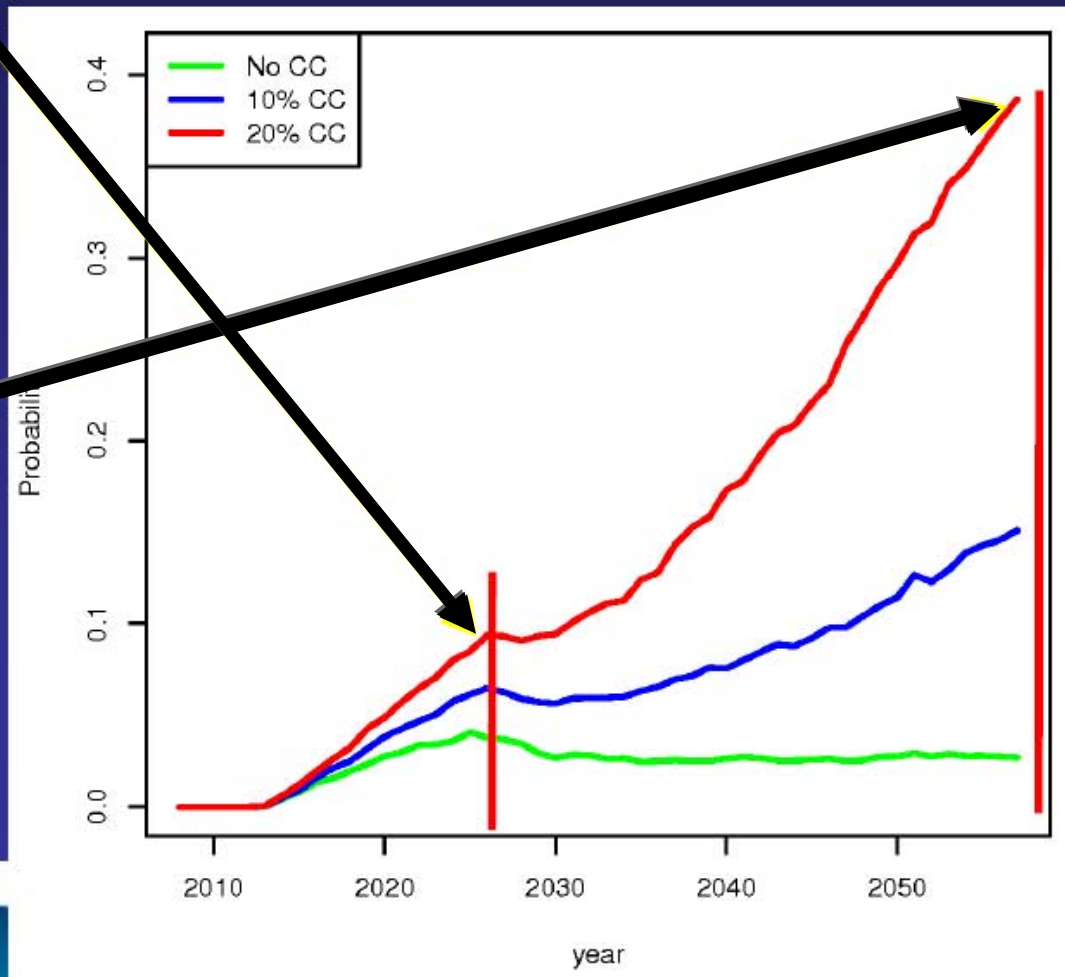
Risk of Reservoir Drying at 2026 and 2050

Rajagopalan, et al., 2009 Water Resources Research

Risk of Empty Reservoirs in at 2026…
Low = 5-10% For All Flows

at 2058….
No Flow Change = 3%
-10% Flows = 10%
-20% Flows = 40%

Key Lesson: Large Non-linear increase in risk with 20% CC – Understanding -10% vs -20% is Important!



Western Water Assessment

Aquifer storage/baseflow change ratios

Republican River Basin:

3% depletion of groundwater storage led to
50% decline in baseflow

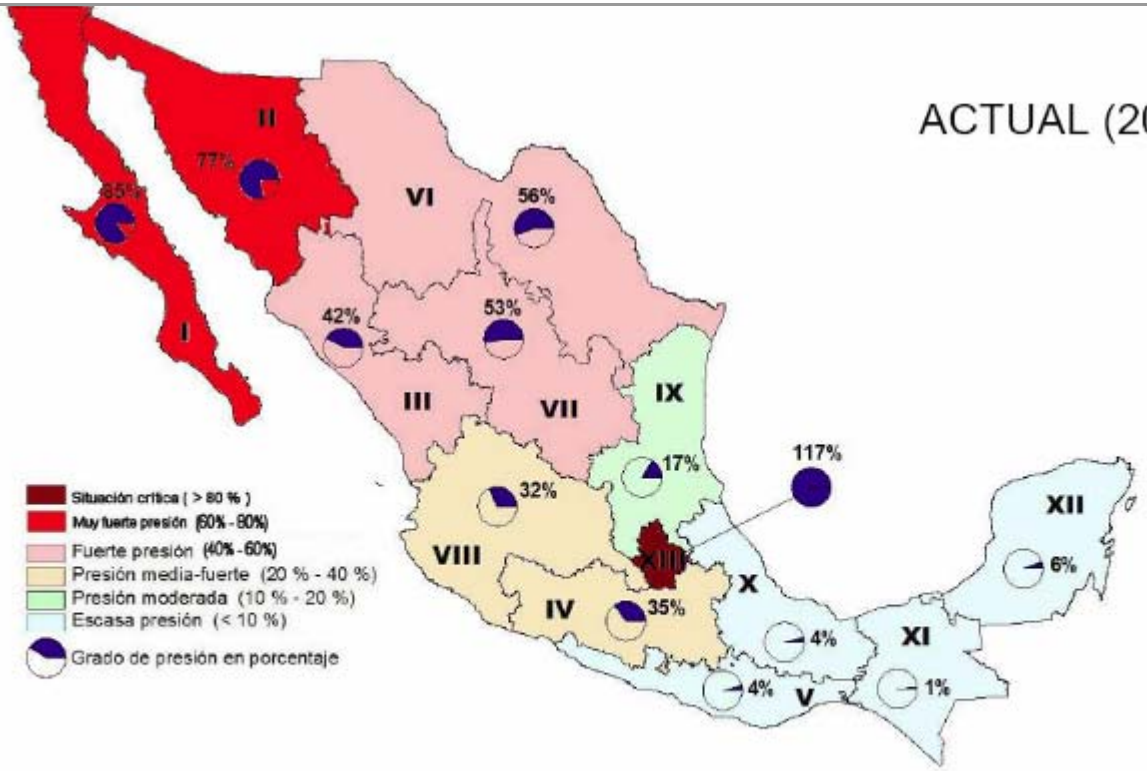
Basic message: projected decreases in snowpack and effective recharge can result in declining groundwater recharge rates

(Data from Alley, 2005)

S. Earman, Scripps

consumptive use / total availability

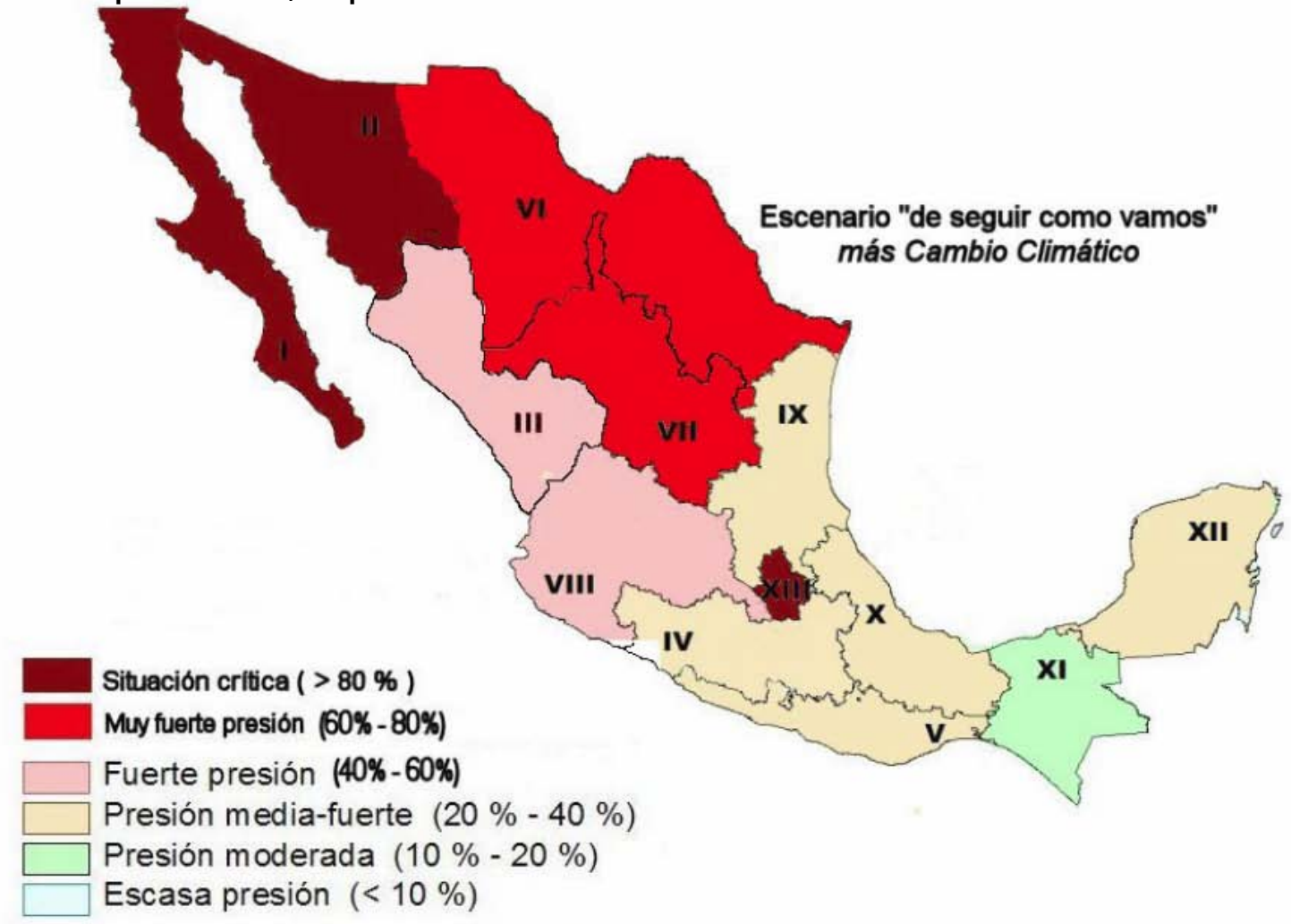
Basic message: currently Mexican aquifers are stressed



Victor Magaña, UNAM, 2006 NADM Workshop

PROYECCIÓN AL 2030 SI SE CONSIDERA TAMBIÉN CAMBIO CLIMÁTICO

Basic message: with climate change and no changes to demands or practices, aquifers will be even more stressed



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