Water Resources Management in the Colorado River Basin: Challenges and Opportunities

Sajjad Ahmad

Associate Professor

Department of Civil and Environmental Engineering

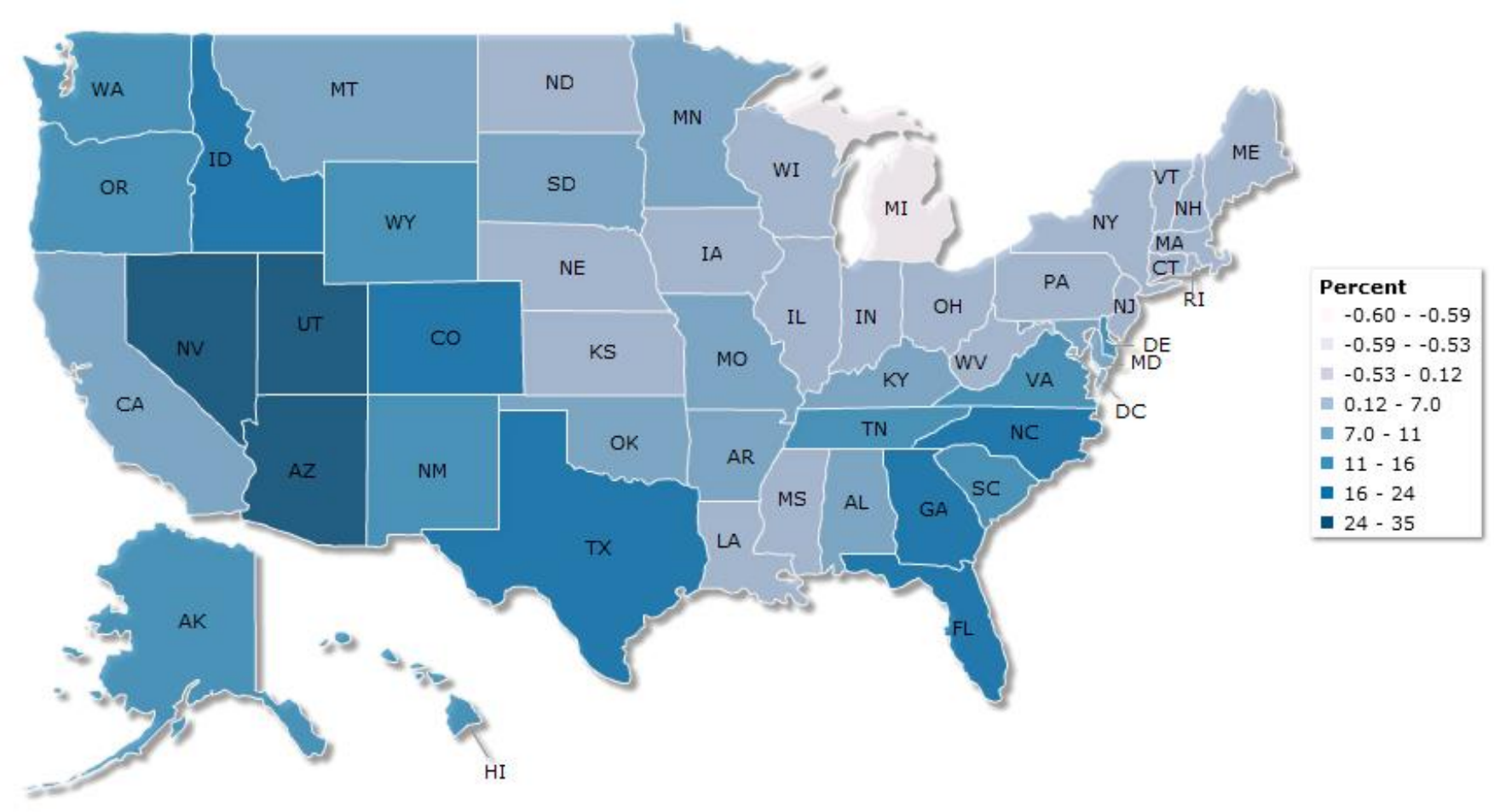
UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Research Themes

1. System dynamics modeling for water resources planning and management
2. Water-Energy nexus
3. Remote sensing for UHI and soil moisture
4. Stream flow analysis for change
5. Seasonal to inter-annual estimation of precipitation and streamflow

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

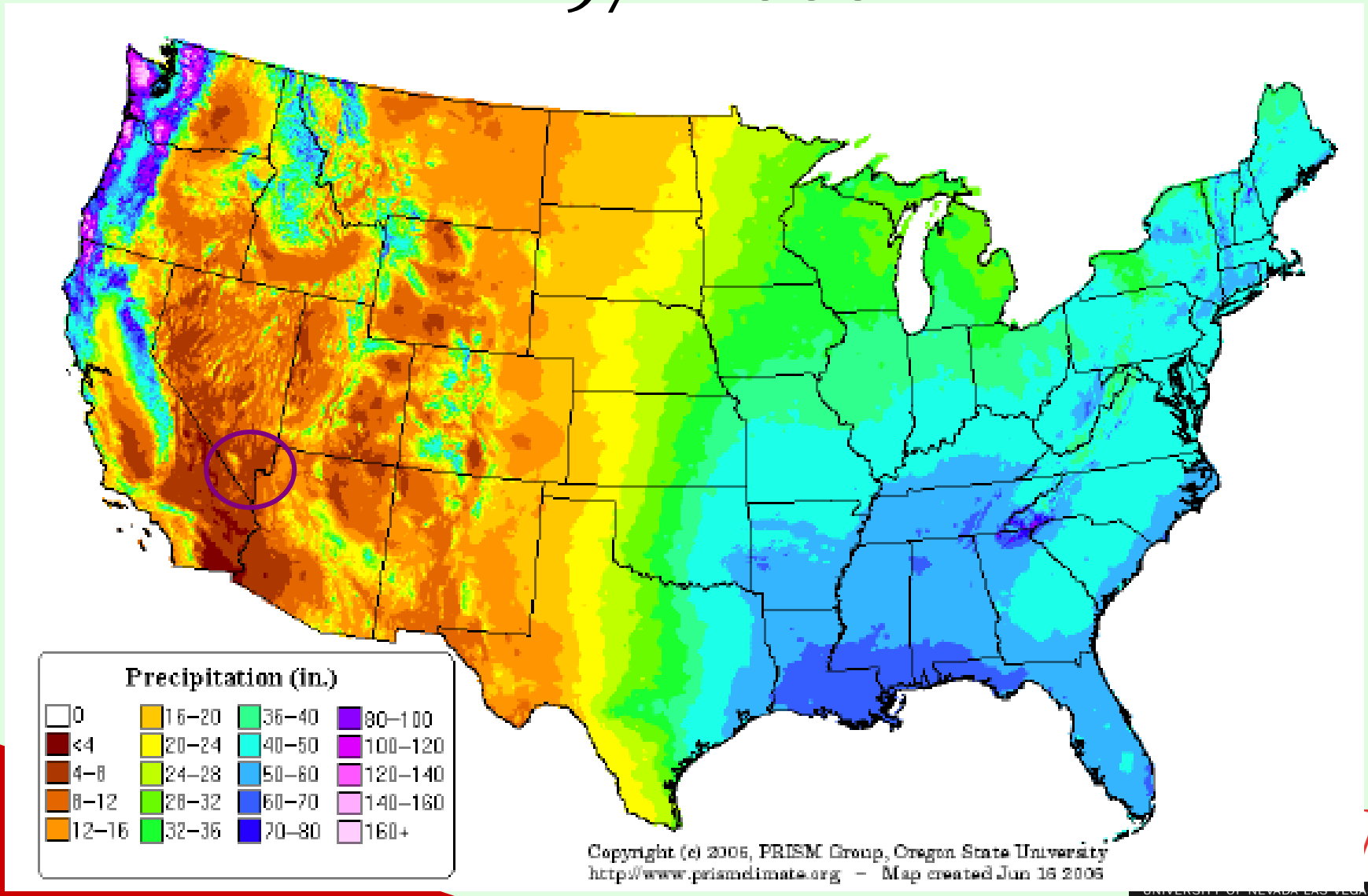
Percent Change in US Population 2000-2010



NV (35%), AZ (25%), UT (24%), CO (17%)

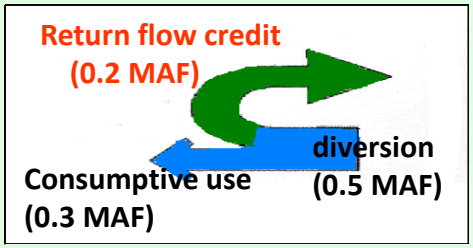
UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Average annual precipitation in the US 1971-2000



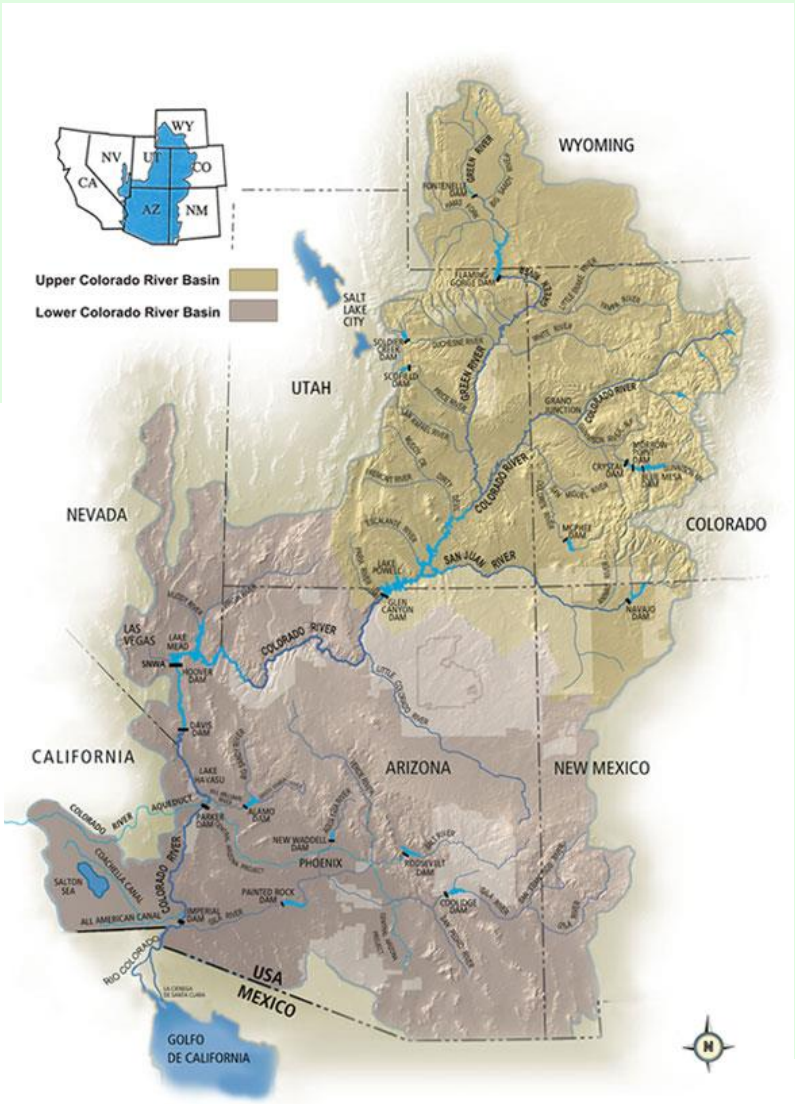
Colorado River Allocations

- Length 1450 miles
- Drainage Basin 246,000 sq mi
- Supplies water to 7 States in USA and to Mexico
-



Lake Mead and Powell have combined storage capacity of **56 MAF**)

User	Amount (MAF) [n 5]	Share
United States	15.0	90.9%
CA	4.4	26.7%
CO	3.88	23.5%
AZ	2.8	17.0%
UT	1.72	10.4%
WY	1.05	6.4%
NM	0.84	5.1%
NV	0.3	1.8%
Mexico	1.5	9.1%
Total	16.5	100%



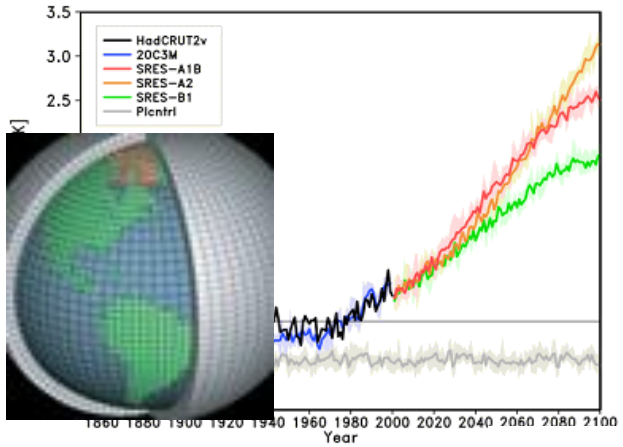
UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Reservoir Operation and Shortage Criteria

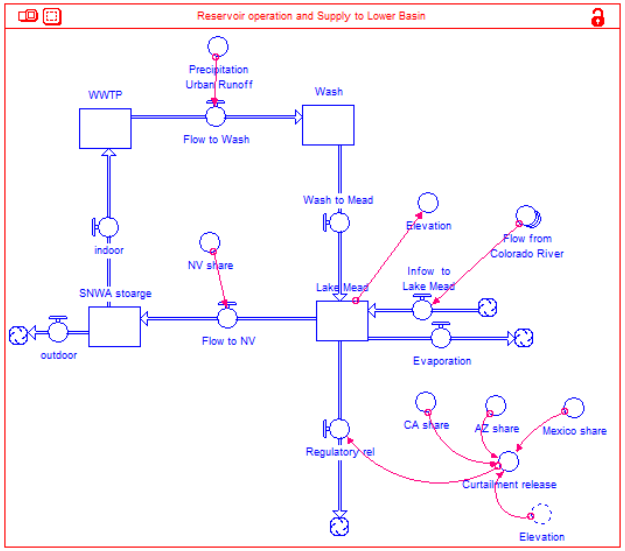
- Lake Mead level:
  - > 1075 ft -- LCRB 7.5 MAF (**NV: 300,000**)
  - 1050 ft -1075ft– LCRB 7.167 MAF (**NV: 287,000**)
    - Intake 1 goes out (1050 ft)
  - 1025 ft -1050ft– LCRB 7.083 MAF (**NV: 283,000**)
  - < 1025 ft– LCRB 7.0 MAF (**NV: 280,000**)
    - Intake 2 goes out (1000 ft)
- Prolonged drought (2000-2010) resulted in 40 m drop in Lake levels.
- City is building a new (lower) water intake from Lake Mead (Cost $800 M)

Decision Support

- System Dynamics Model (Stella)
- Modeling horizon : 1970-2035, monthly



1. Risk analysis of water supply to Lower Basin states and NV
2. Evaluation of water management policies

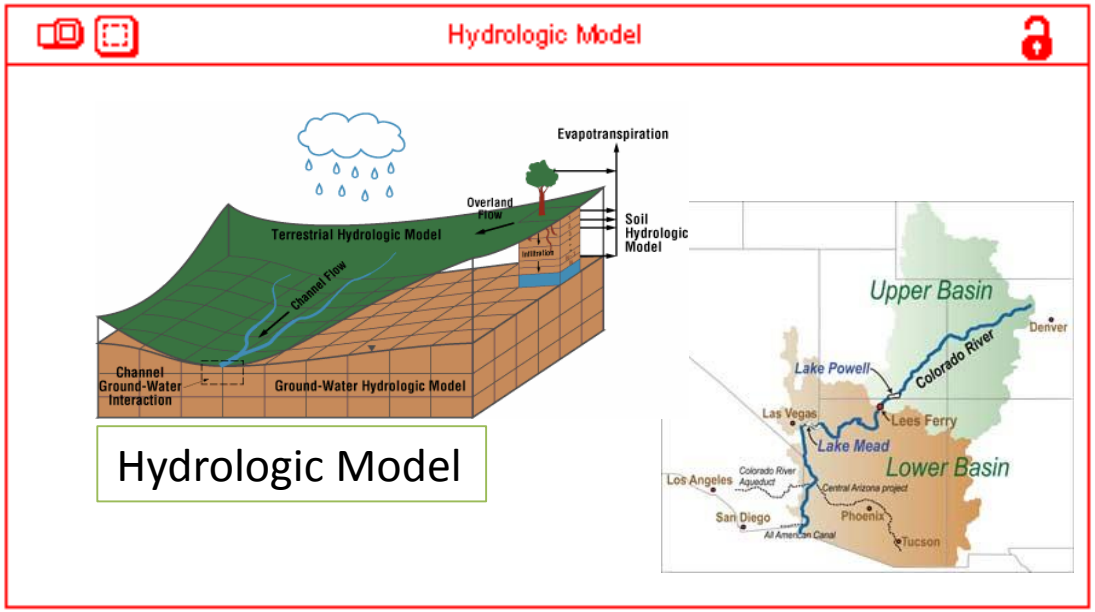


Reservoir Operation and Basin States Allocation Sector

Stream flow

16 GCMs, 3 Emission Scenarios (CMIP3)

Temp. & Precip.



Hydrologic Model

-Naturalized streamflow
-reservoir operation rules

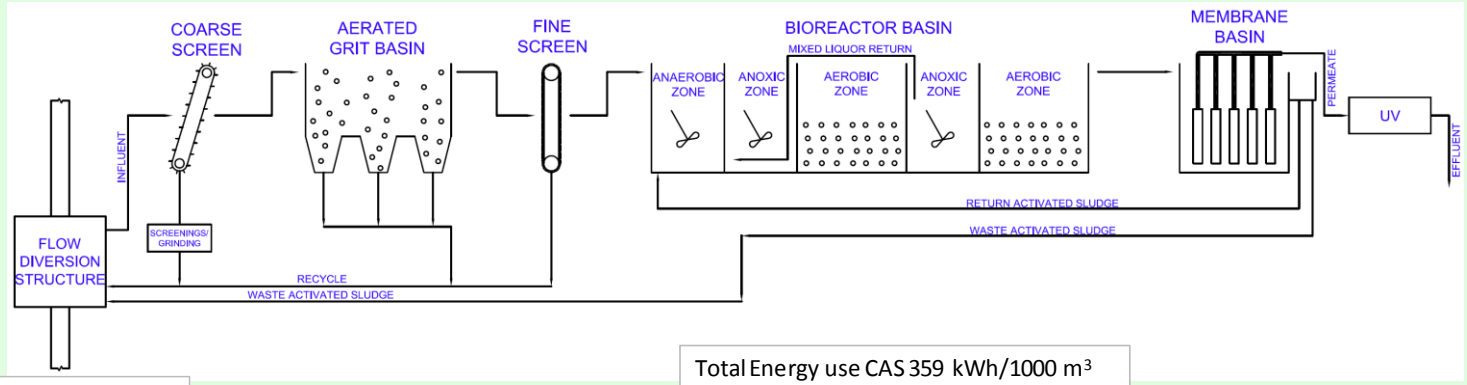
UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Water-Energy Nexus

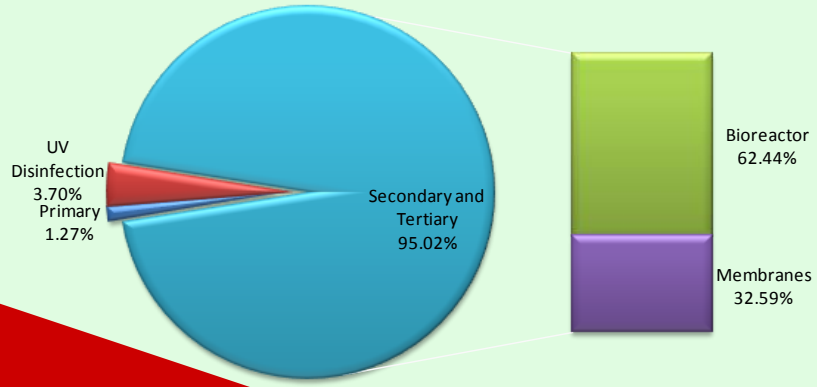
Energy use in wastewater treatment Plants and water distribution system

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

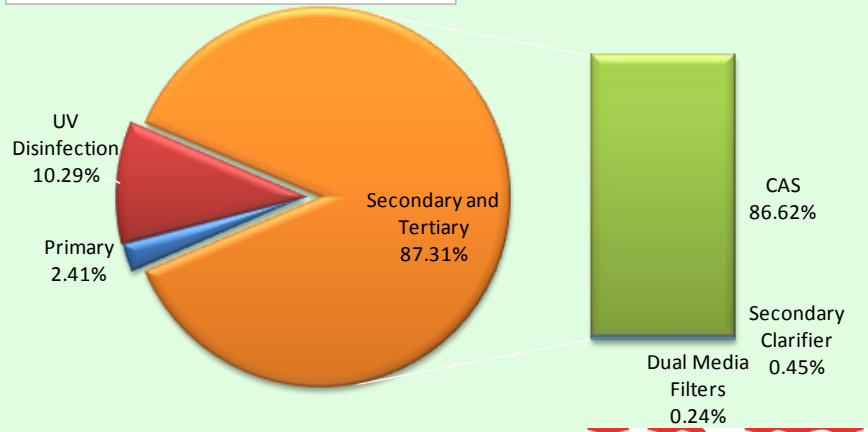
Energy Use in Waste Water Treatment and Reuse Plants



Total Energy use MBR 680 kWh/1000 m^3

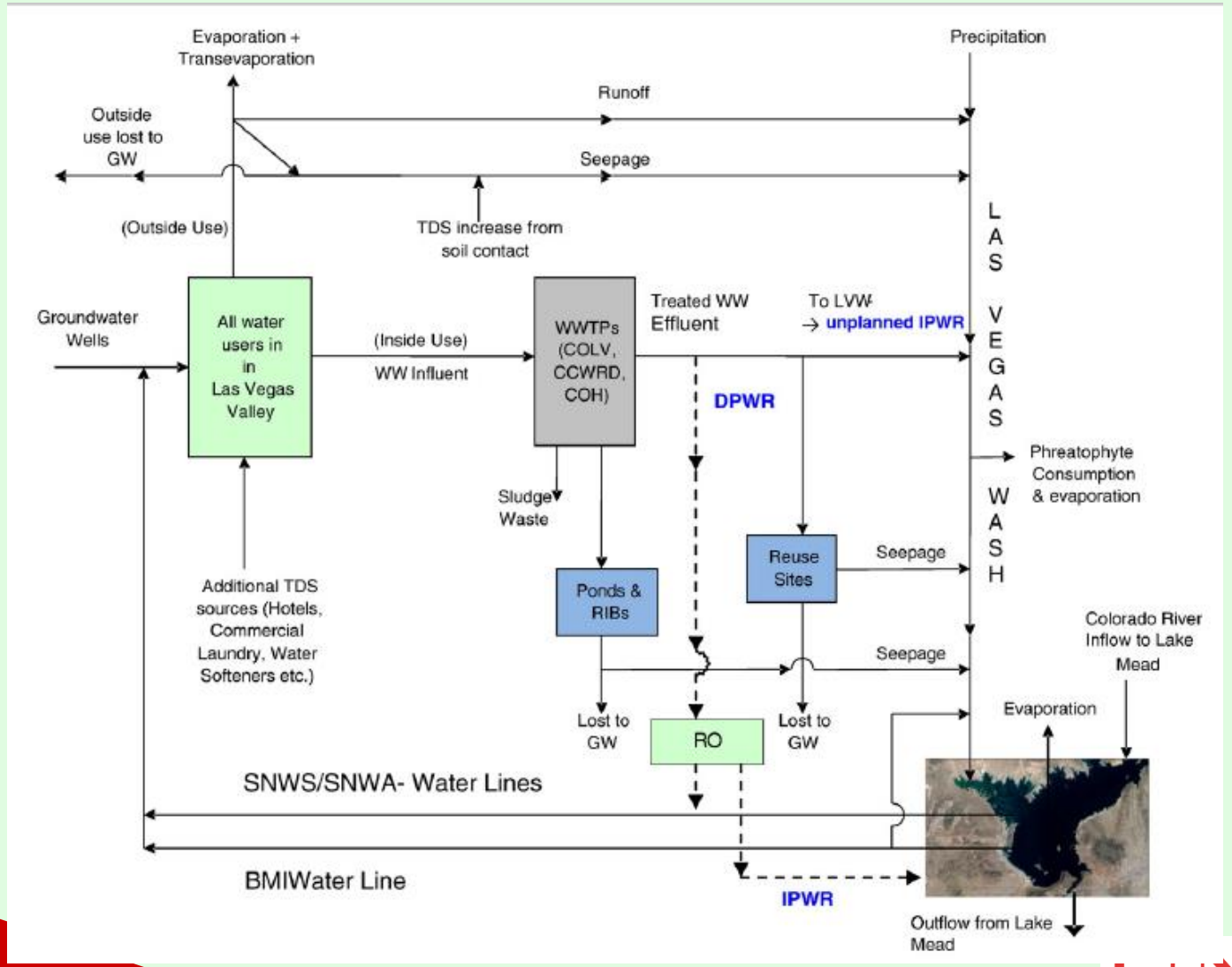


Total Energy use CAS 359 kWh/1000 m^3



UNLV
UNIVERSITY OF NEVADA LAS VEGAS

DPWR and IPWR



UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Energy Use in LVV Water System

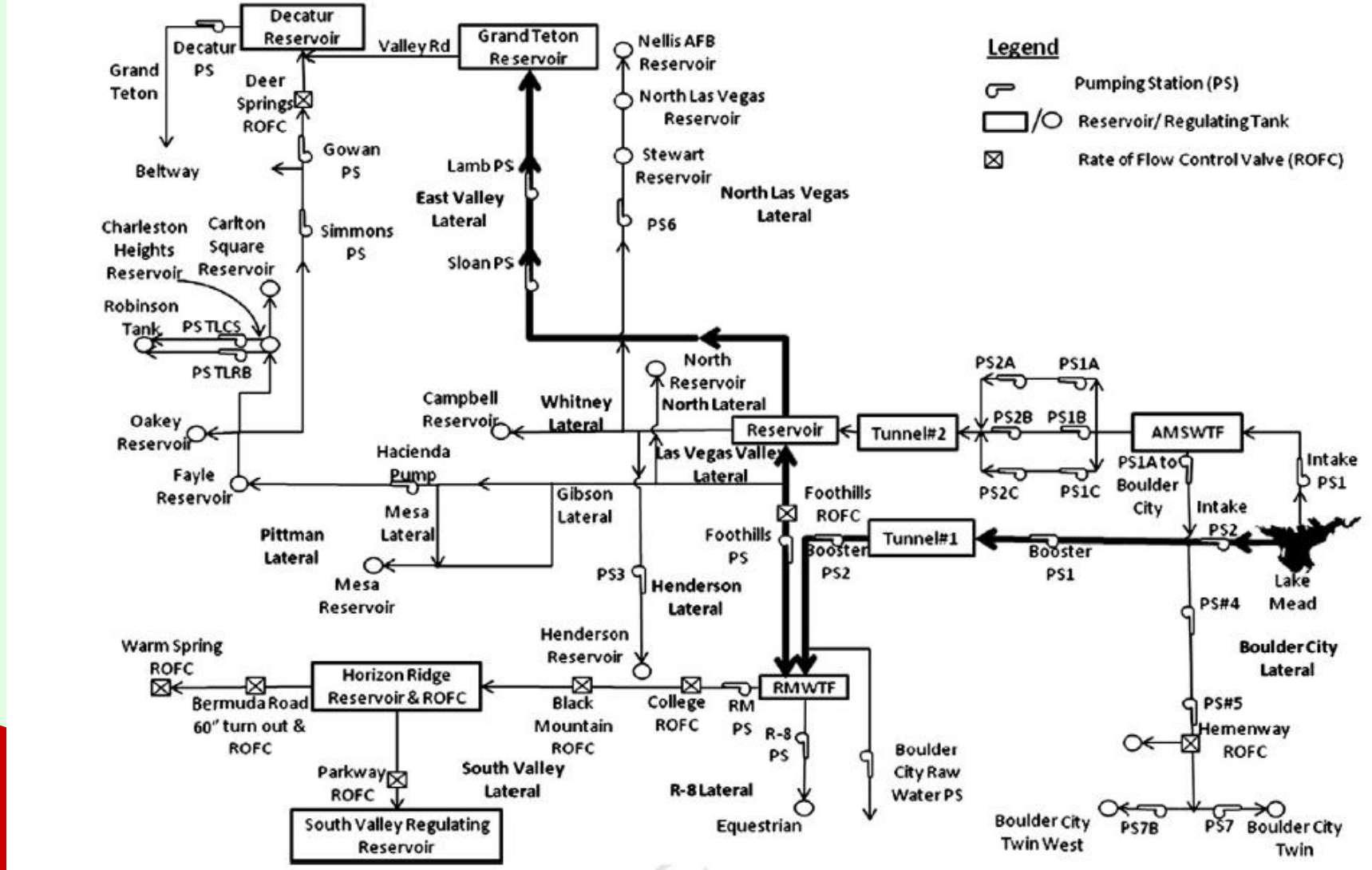


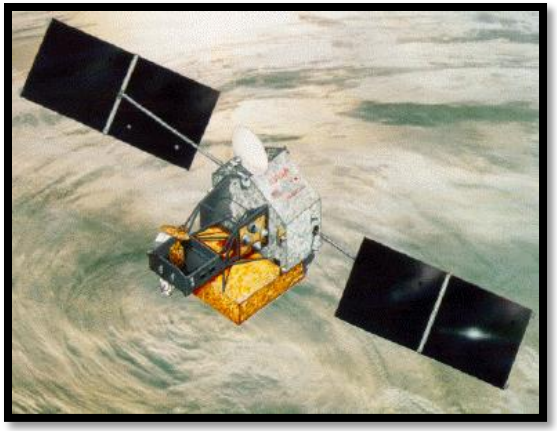
Fig. 1. Schematic of water conveyance system laterals in the Las Vegas Valley.

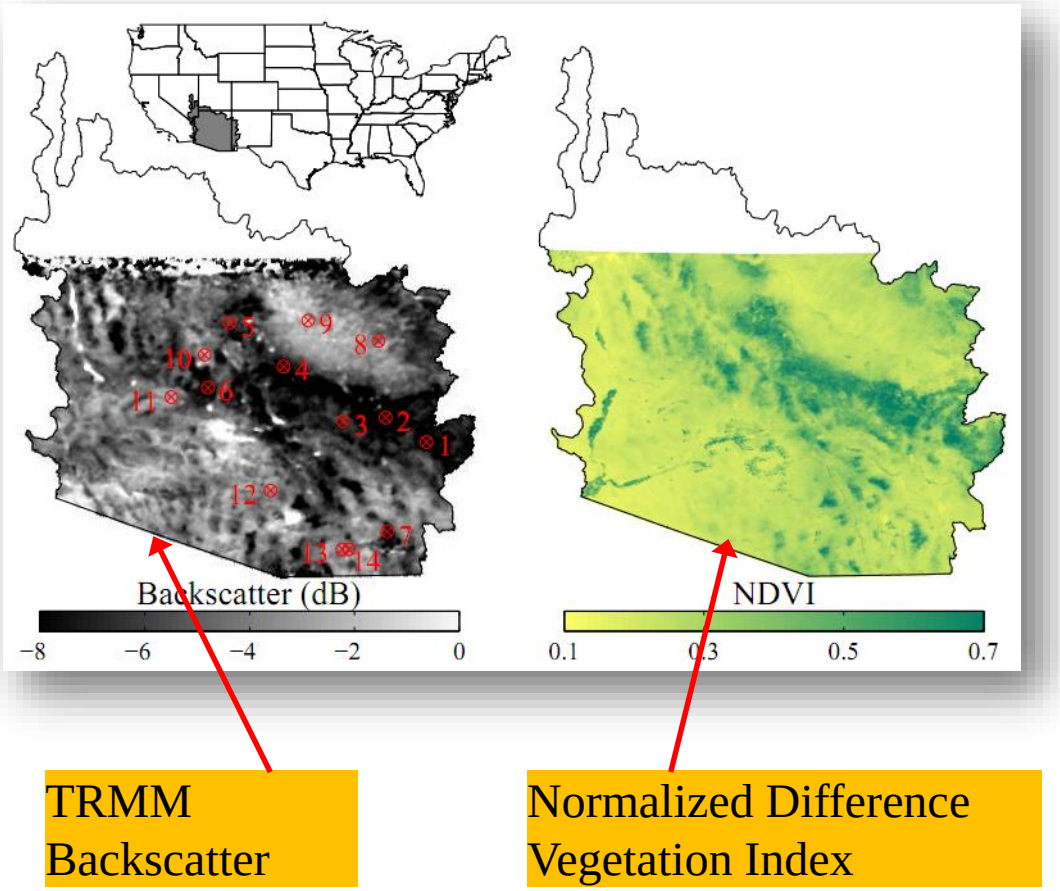
Remote Sensing for:
Soil Moisture Estimation;
Urban Heat Island Study

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

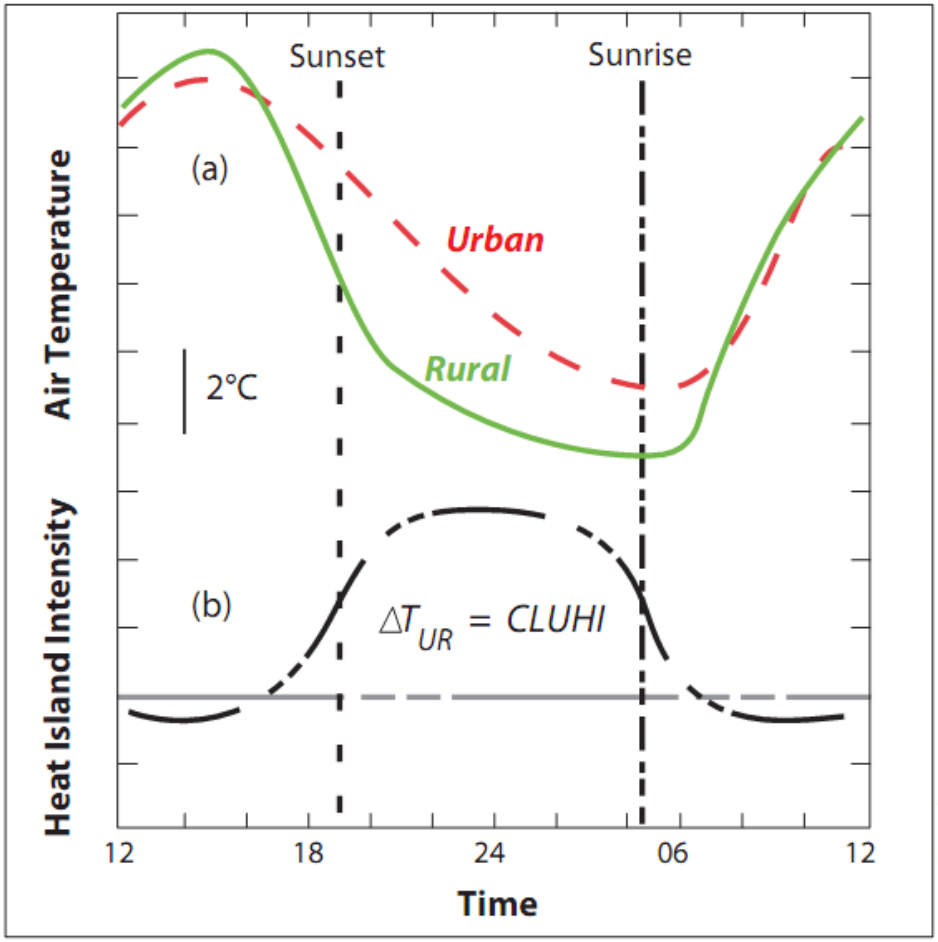
Soil Moisture Estimation (droughts)

- Lower Colorado River Basin :
  - semi-arid (shrublands).
- Sensor
  - Tropical Rainfall Measuring Mission Precipitation Radar



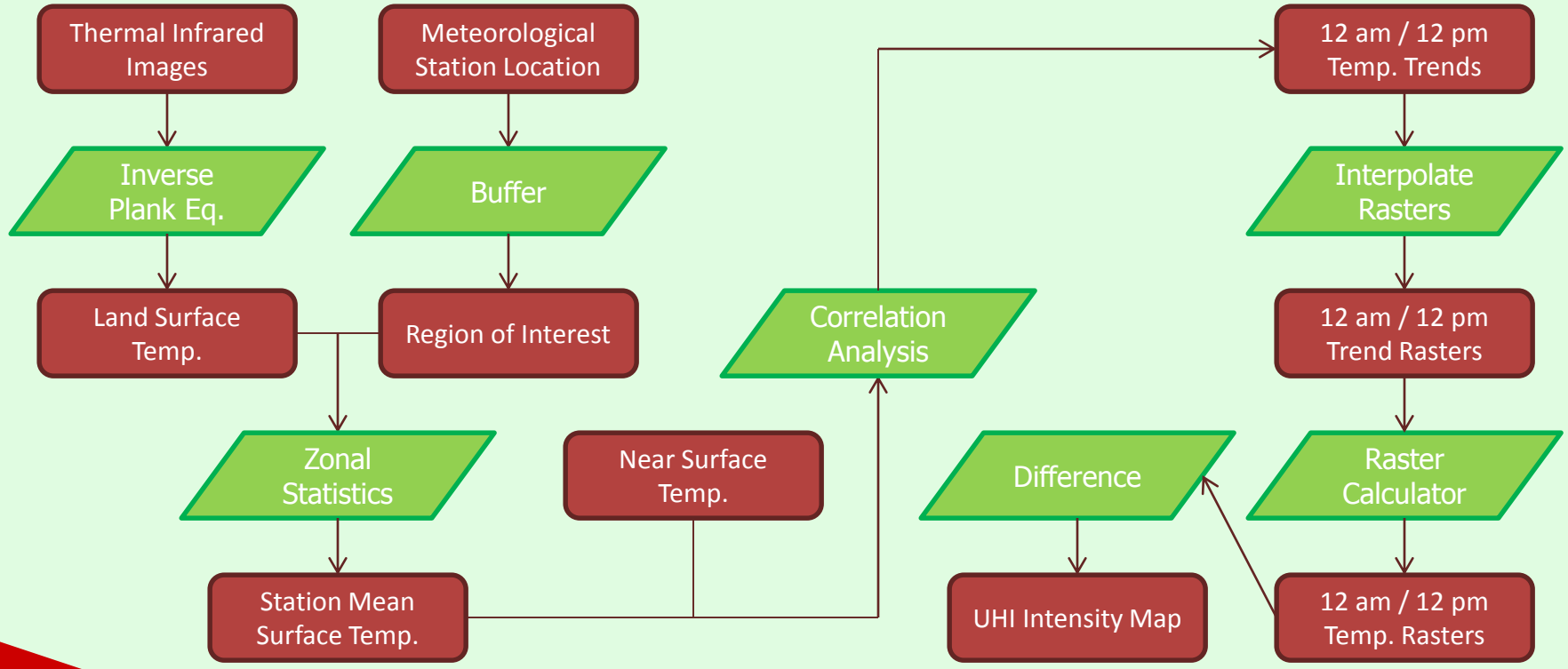


Urban Heat Island



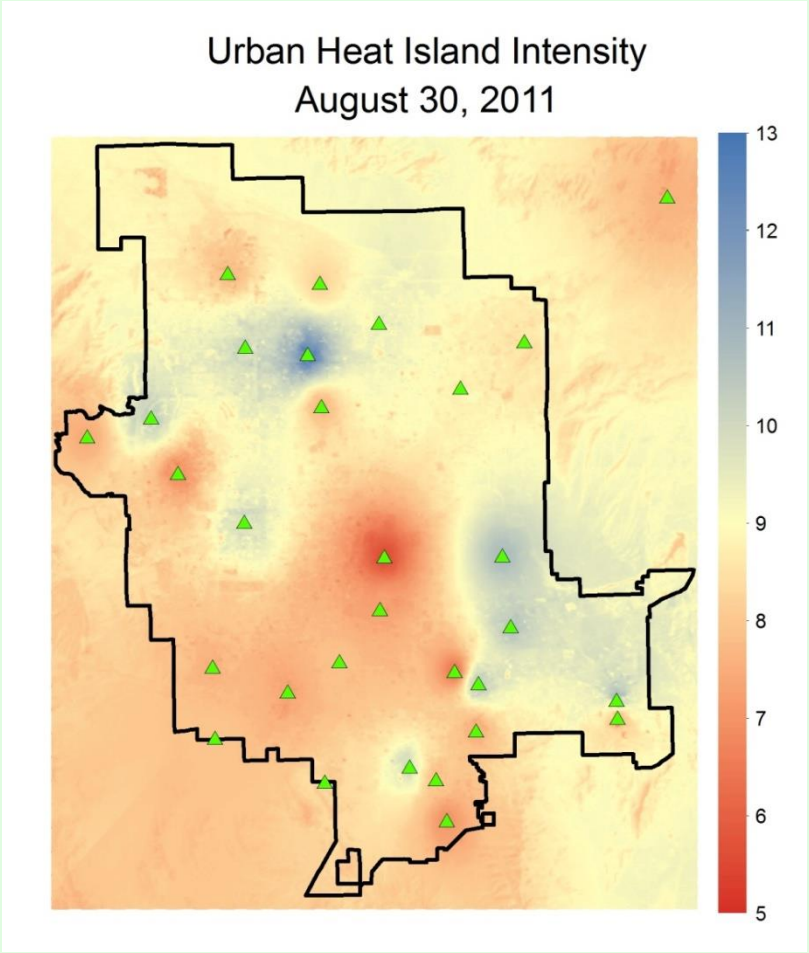
Modified from Oke, 1982, and Runnalls and Oke, 2000

Method: Urban Heat Island Intensity



UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Urban Heat Island Intensity Map



Landsat 5 Band 6: 360 raster images captured between 1984 and 2011

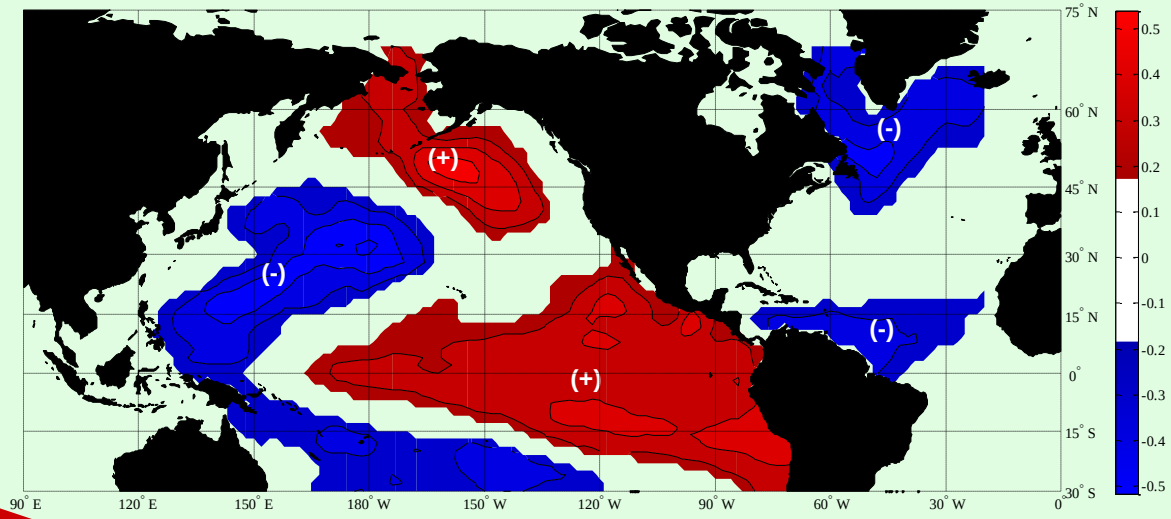
UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Seasonal to Inter-annual Estimation of Precipitation and Streamflow

Change Detection in Streamflow

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Seasonal to interannual estimation for precipitation and streamflow



Heterogeneous correlation Map for previous year Oct-Dec average SSTs and current year spring-summer streamflow

SVD first temporal expansion series explained 95% (93%) of the variance in the SST/Flow relationship for 3 (6) month lead time

The significant regions were spatially part of the Nino 3.4 (170°W-80°W and 20°S-15°N) and Hondo (150°E-160°W and 24°N-34°N) region

UNIV
UNIVERSITY OF NEVADA LAS VEGAS

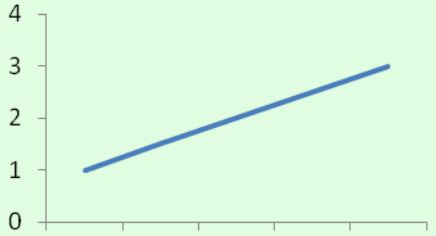
Change Detection in Streamflow

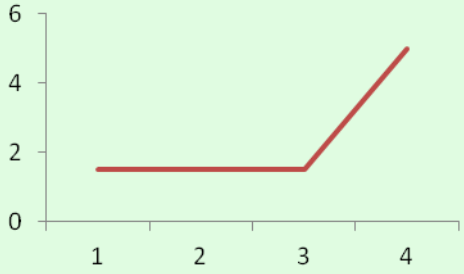
Monthly streamflow data - 1951-2010 (60 years)
- 240 unimpaired stations

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Method

- **Trend Test**
  - MK1- Independent Mann-Kendall test
- Persistence (Clustering behavior)
  - MK2- Mann Kendall test + lag-1 auto correlation and trend free pre whitening (TFPW)
  - MK3- Mann Kendall test + Hurst component
- **Abrupt Shifts**
  - Pettitt test
- **Walker Test** - global significance



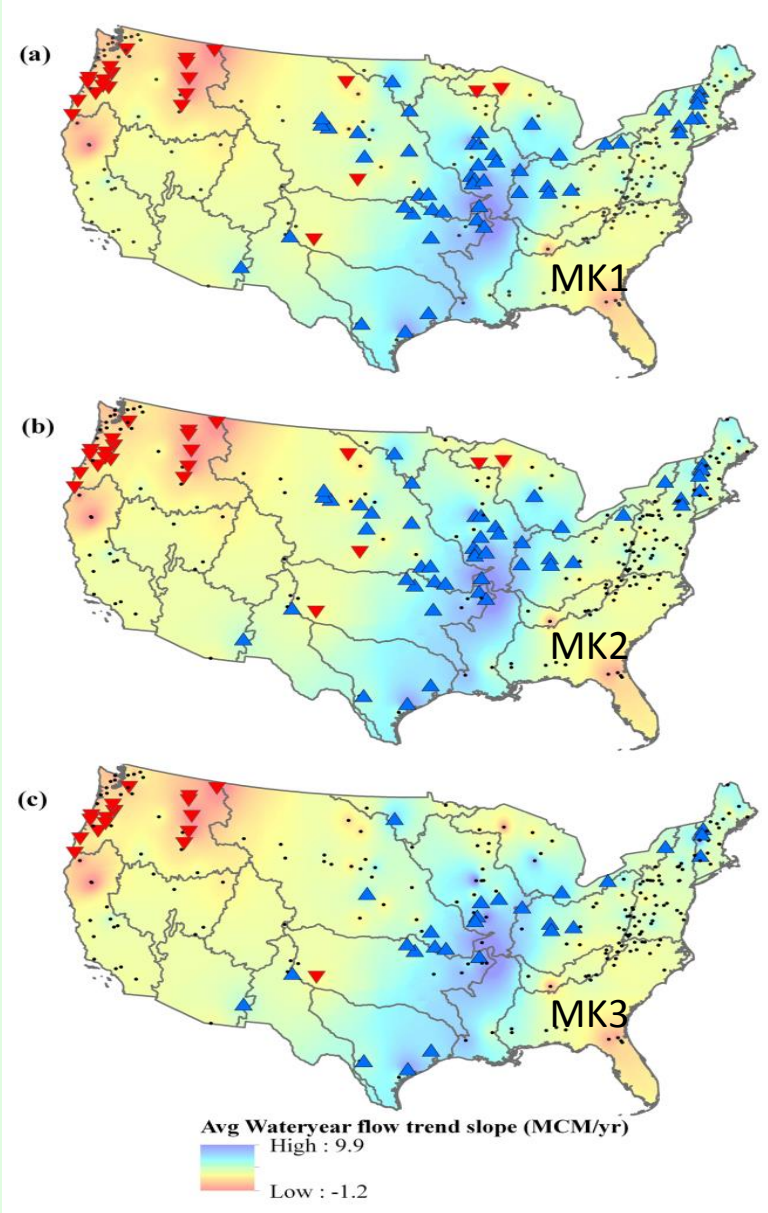


UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Trends

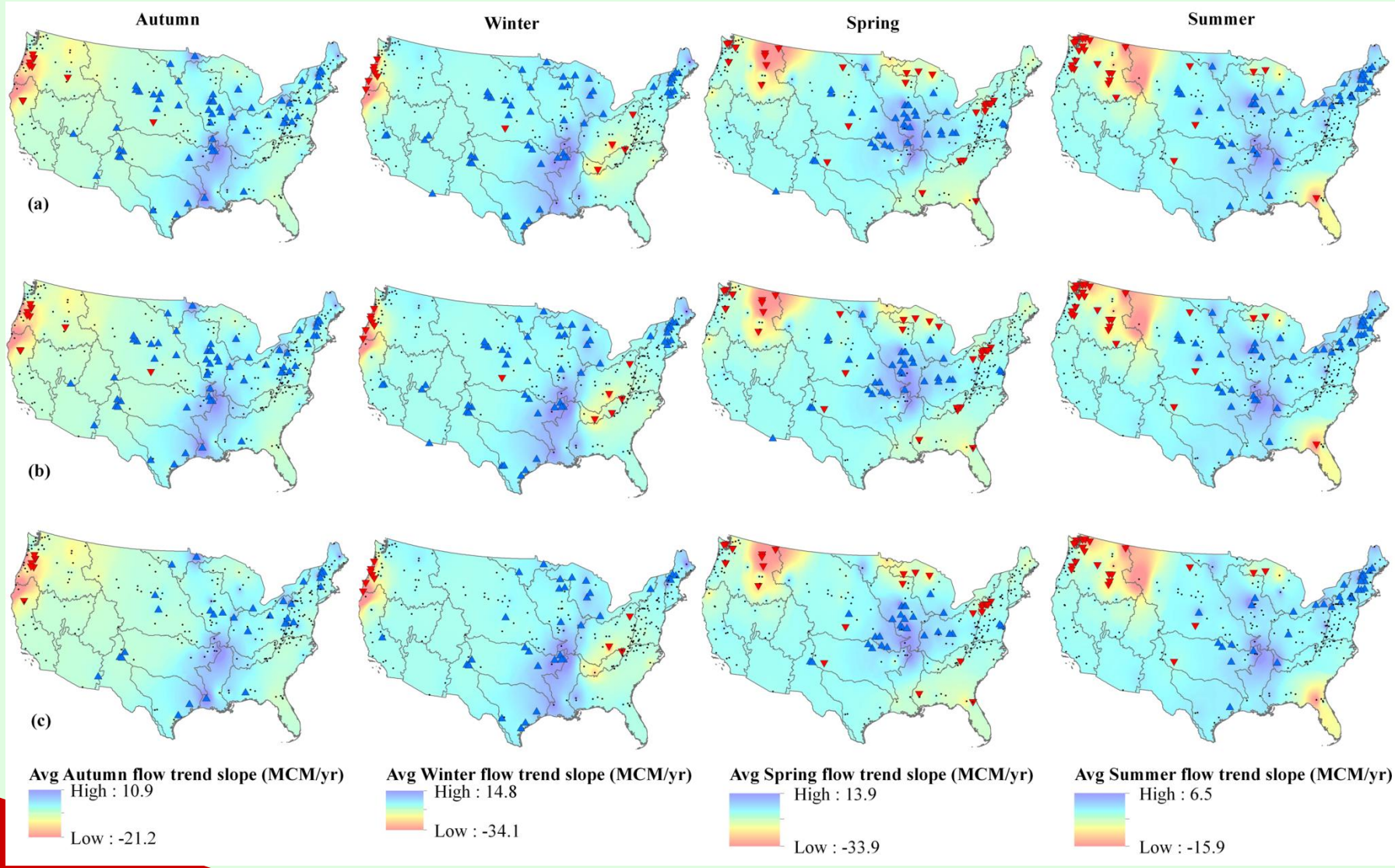
- Increases – central east and northeast (9.9 MCM/yr)
- Decreases - northwest and southeast (1.2 MCM/yr)
- 50 stations - Increasing
- 23 stations – Decreasing

- **MK3**
- 27 stns - Increasing
- 18 stns - Decreasing



UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Seasonal Trends



UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Thank You

UNLV
UNIVERSITY OF NEVADA LAS VEGAS