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Technical Memorandum | Final

To:	**Blaine Dwyer, Matt Brown (AECOM)**
Distribution:	**Distribution List**
From:	**Ben Harding (AMEC Earth & Environmental)**
Subject:	**CRWAS Phase I | Task 7.1 | Coordination with Front Range Vulnerability Study**
Date:	**~~December 15, 2009 Updated December 23, 2009~~ January 2012 updates in red**

CRWAS Phase I included a public comment period on the draft CRWAS Phase I Report and public outreach workshops to solicit feedback from stakeholders on the Study. CWCB and the CRWAS technical team used these forms of feedback to refine Study deliverables, such as this technical memorandum, which may include content that has been updated.

Introduction

This Technical Memorandum summarizes the coordination activities between the Colorado River Water Availability Study (CRWAS or Study) and the Front Range Climate Change Vulnerability Study (FRCCVS) as part of Task 7 of the Study.

The objective of Task 7 is to:

Provide agency coordination, literature review, diagnostic analysis, data preparation, and model testing to generate projections for temperature, precipitation, weighted and scaled alternate hydrology, and water use relative to potential changes in forest and climate scenarios.

This memo is associated with subtask 7.1 (Coordination with Front Range Vulnerability Study) and documents the coordination activities and the primary conclusions of the coordination meetings. Subsequent sections of this technical memorandum discuss: 1) the requirements of CRWAS, 2) a description of coordination activities, and 3) the primary conclusions resulting from the coordination activities.

Requirements of CRWAS

The principal objective of Task 7 of CRWAS is to develop an alternate hydrology of climate change. In meeting this objective, the CWCB directed that coordination take place between the Study and the FRCCVS "…to help assure that the two studies are as cost effective as possible, to maximize consistency and comparability of results (within constraints arising from the respective objectives of the two studies) and to maximize the technical value of the two studies to their respective stakeholders."

Coordination Activities

Coordination activities between CRWAS and FRCCVS are shown in the following table.

Date	Description	Type
11-Jun-08	Initial Description of CRWAS Approach. The AECOM team presented the technical approach to be used for CRWAS. The presentation was made to the FRCCVS Technical Team, some FRCCVS stakeholders, and members of the Colorado Climate Change Technical Advisory Group. This presentation is included in the Appendix A.	Meeting
7-Nov-08	Discussion Regarding Selection of Projections. The AECOM team met with the FRCCVS technical team to discuss the study time frames for analysis, the number of projections to be used to represent each study time frame, and how to select representative projections for each study time frame.	Meeting
9-Nov-08	Memo Regarding Selection of Projections. The AECOM team provided a memorandum to the FRCCVS technical team documenting the method for selecting representative projections for each study time frame. This memorandum is included in the Appendix B.	Memorandum
20-Mar-09	Presentation of CRWAS Approach. The AECOM team presented the technical approach that AECOM recommended to the CWCB for the CRWAS project. This presentation is included in the Appendix C.	Meeting
27-Apr-09	Discussion Regarding Projections. The AECOM team coordinated with FRCCVS technical team members on the process of obtaining the necessary projections of future climate.	Conference Call
24-Jul-09	Description of FRCCVS SAC Model Approach. The AECOM team attended a meeting where the FRCCVS team described the methods by which the Sacramento Model was applied to the FRCCVS study.	Meeting
28-Aug-09	Description of FRCCVS WEAP Model Approach. The AECOM team attended a meeting where the FRCCVS team described the methods by which the WEAP model was applied to the FRCCVS study.	Meeting
31-Aug-09	Discussion Regarding Temperature Adjustment. The AECOM team coordinated with FRCCVS on the means by which temperatures would be adjusted to reflect projected climate.	E-mail
14-Oct-09	Discussion Regarding Presentation of Results. The AECOM team conducted e-mail discussions with FRCCVS technical team members regarding approaches to displaying study results for good comprehension.	E-mail

Conclusions Resulting from Coordination Activities

Listed below are conclusions resulting from CRWAS / FRCCVS coordination activities.

- *Conceptual CRWAS Approach.* The conceptual technical approach suggested by the AECOM team to develop alternate hydrology of climate change was determined to be well-suited to the CRWAS objectives and compatible with the work of FRCCVS.

- CRWAS Hydrology Modeling Approach. The CRWAS hydrology modeling approach (use of the VIC hydrology model) was determined to be well-suited to the CRWAS objectives and compatible with the work of FRCCVS.

- *Selection of Study Time Frames.* The study time frames were established at 2040 and 2070, with each time frame characterized by a 30-year window (2025-2054 and 2055-2084, respectively).

- *Selection of Projections*. A method for selecting projections to characterize climate at the study time frames was developed, and five climate projections were selected to characterize each study time frame (i.e., to represent the variability of projected climate across climate scenarios and climate models). The selected projections and their characteristics were documented in a PowerPoint presentation that is included in the Appendix D. Please refer to the July 25, 2011 Technical Memorandum, "CRWAS Phase I – Projection Selection (refinement to CRWAS Phase I Tasks 7.1, 7.2 and 7.5)" and the revised CRWAS Phase I Report (both posted at http://cwcb.state.co.us) for updated information associated with this technical memorandum.

- *Adjustment of Temperature*. It was agreed that temperatures would be adjusted by adding the mean temperature change to both the daily maximum temperature and the daily minimum temperature. This will change the daily mean temperature by the amount of the projected change while leaving the daily temperature swing unchanged.

Where to find more detailed information:

Details on the conclusions listed above are provided in the CRWAS Technical Memoranda *Task 7.2 Climate Change Literature Review and Methods Evaluation* and *Task 7.5 Climate Change Approach, Hydrology Model Selection*.

Appendix A: Initial CRWAS Approach (Presentation)

Colorado Water Availability Study

Climate Change Analyses

Boyle Engineering
AMEC Earth & Environmental
Leonard Rice Engineers
Stratus Consulting

Ben Harding, P.E
Subhrendu Gangopadhyay, Ph.D., P.E.

June 11, 2008

Team Organization

Climate Change Tasks

- TASK 6 Implement Alternate Historical Hydrology
- TASK 7 Implement Alternate Hydrology for Climate Change and Forest Change
- TASK 8 Colorado River Compact Analyses and Preliminary Administration Considerations.

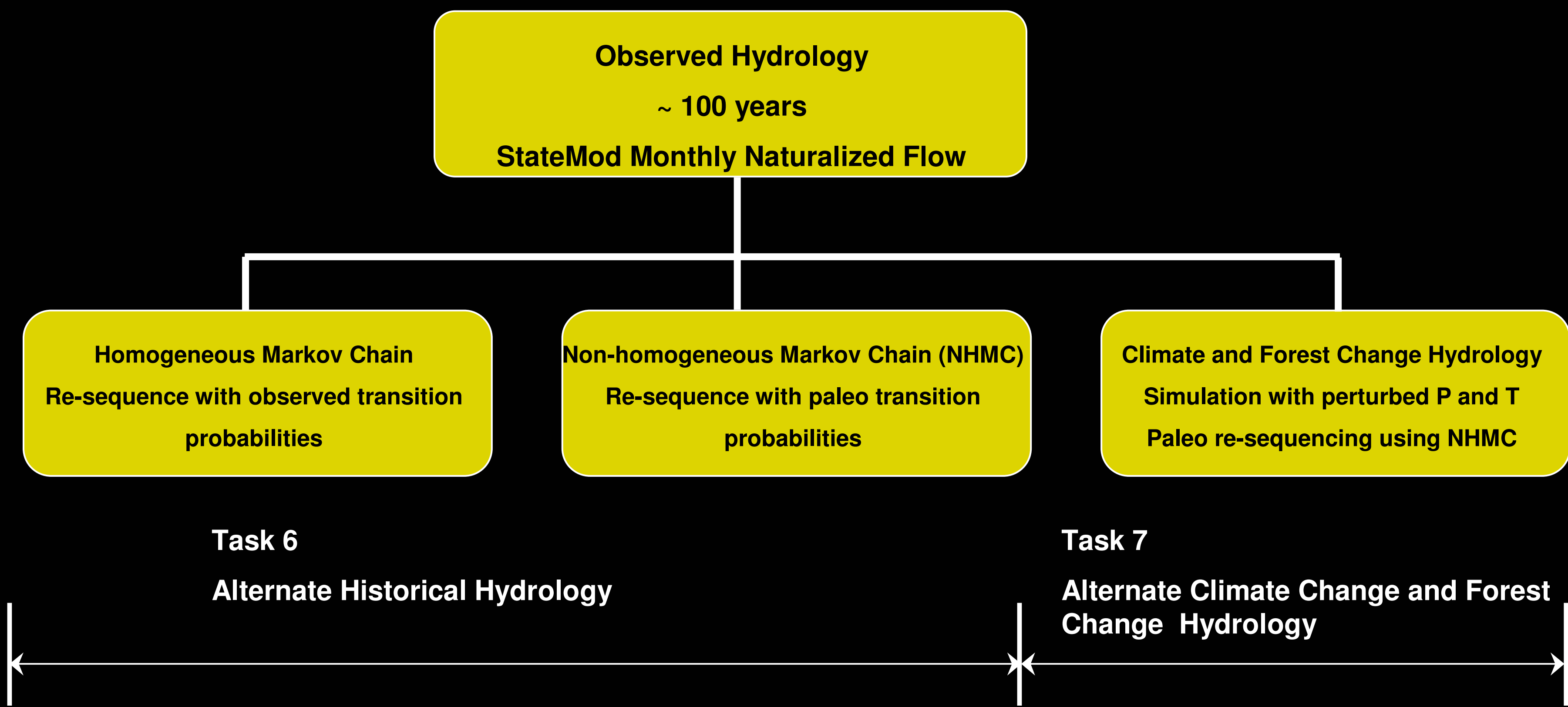
Coordination with Front Range Vulnerability Study

- Geographical overlap
  – Colorado River Main Stem in Colorado
- Methodological overlap
  – Observed climatology
  – Climate projections
  – Time frames
  – Selection of projections
- CRWAS differences
  – Hydrology
  – Re-sequencing
  – Details of climate adjustments
  – Water rights analysis
  – "Big River" analysis

Technical Approach

- Early tasks will review potential methods
- CWCB will approve approach
- This presentation is a *suggested* approach
  - Builds on:
    - Forecasting
    - Paleo
    - Boulder study
    - FRVS

Generation of Hydrology Scenarios



Task 6 – Implement Alternate Historical Hydrology

- Re-sequence observed hydrology with observed transition probabilities – Homogeneous Markov Chain Approach.

- Re-sequence observed hydrology with paleo transition probabilities – Non-homogeneous Markov Chain (NHMC) Approach.

Task 6 – Homogeneous Markov Chain

- Assign states – dry/wet to the years of the annual flow time series, ~100 years of StateMod naturalized flow.

- Calculate transition probability matrix (dd, dw, wd, ww) using the ~100 year state sequence.

Task 6 – Homogeneous Markov Chain

- Climatological period, 56-years, 1950-2005 – consistent with downscaled climate archive and hydrology model setup (more in Task 7).

- Generate 100 ensemble members each of length 50-100 years via resampling using the homogeneous transition probability matrix and the observed flows from the 1950-2005 climatological period.

Task 6 – Non-homogeneous Markov Chain (NHMC)

- Use *Woodhouse et* al. [2006] Lees Ferry reconstructions to assign basin state – dry/wet.

- Alternatively, reconstruct flow at an index gage using for example, the non-parametric paleo reconstruction algorithm, and assign states – dry/wet to the suite of years in the paleo and overlap period.

- Calculate transient transition probability matrix following *Prairie et al.* [2008] – time varying (dd, dw, wd, ww) transition probabilities.

Task 6 – Non-homogeneous Markov Chain (NHMC)

- Transient transition probability matrix following *Prairie et al.* [2008] – time varying (dd, dw, wd, ww) transition probabilities.
- Climatological period, 56-years, 1950-2005 – consistent with downscaled climate archive and hydrology model setup (more in Task 7).
- Generate 100 ensemble members each of length 50-100 years via resampling using the non-homogeneous transition probability matrix and the observed flows from the 1950-2006 climatological period following *Prairie et al.* [2008].

Task 7 – Implement Alternate Hydrology for Climate Change and Forest Change

- Re-calibrate VIC (Variable Infiltration Capacity) model using forcings from the 56-year, 1950-2005, climatological period for CO gages/locations of interest – modeled runoff for the climatological period.

- Timeframes, 2040 and 2070 – Front Range Vulnerability Study.

- Climate models, ~ 112 downscaled climate projection traces (1/8th degree grid), *Maurer –Brekke* archive.

Task 7 – Implement Alternate Hydrology for Climate Change and Forest Change

- For each model grid cell - obtain average precipitation (P) and temperature (T) estimates for each climate trace for each month, over say, a 11-year window centered around the years of interest, 2040 (2035-2045) and 2070 (2065-2075).
- For each model grid cell - calculate the change in precipitation (ΔP, multiplicative) and temperature (ΔT, additive) for each month between the climatological mean (1950-2005) and the mean P and T for each climate change trace.

Task 7 – Implement Alternate Hydrology for Climate Change and Forest Change

- Perturb P and T for each month of the 56-year climatological period, 1950-2005 using the precipitation and temperature changes, ΔP (multiplicative) and temperature ΔT (additive).

- Same ΔP and ΔT from a given trace will be applied to each month of the climatological period – superimpose change on observed interannual variability of P and T.

Task 7 – Implement Alternate Hydrology for Climate Change and Forest Change

- Perturbed monthly P and T values – 56-year climatological period, 1950-2005.
- Run the calibrated VIC model using the above perturbed P and T fields to obtain the perturbed model runoff.
- Calculate change in runoff (runoff adjustment factor) ΔQ , ratio of perturbed model runoff and modeled runoff from the climatological period – each model grid, each trace, each month.

Task 7 – Implement Alternate Hydrology for Climate Change and Forest Change

- Runoff adjustment factor, *ΔQ* - each model grid, each trace, each month, derived from the climatological period, 56 years, 1950-2005.

- Adjust observed runoff for each CO gage/locations of interest using the monthly *ΔQ* above (area weighted) for the 56 years naturalized streamflow data to obtain the *"As-If"* Hydrology for a given trace.

- "*As-If"* Hydrology – basin hydrology that would have occurred had the projected changes in mean climate conditions been fully developed at the beginning of and throughout the observed period.

Task 7 – Implement Alternate Hydrology for Climate Change and Forest Change

- "*As-If*" Hydrology – basin hydrology that would have occurred had the projected changes in mean climate conditions been fully developed at the beginning of and throughout the observed period.

- Re-sequence the *"as-if"* hydrology (56 years, 1950-2005) for each climate trace using the Non-homogeneous Markov Chain (NHMC) transient transition probabilities [*Prairie et al.,* 2008] derived from the paleo data (Task 6 NHMC) – 100 ensemble members each 50-100 year long.

Alternate Water Use

- StateCU input data constitute observed *field-level* climatology
- Re-sequence observed field-level climatology
  - Observed transition probabilities
  - Paleo-derived transition probabilities
- Adjust observed field-level climatology
  - Apply mean pattern of *Δ* P & *Δ* T
  - Obtain *As-If field-level climatology*
- Run StateCU to obtain *As-If water use*
- Re-sequence *As-If water use*

Task 8 – Colorado River Compact Analyses and Preliminary Administration Considerations

- Use CRSS
- Adjusted upper basin depletions
  - CO: as estimated by StateMod
  - Other UB states: proportional change
- Lower basin depletions un-changed
  - Limited by contracts
  - Assume no return flows
- Same scenarios as for intrastate analyses
  - CRSS natural flows are foundation
  - Same adjustment method
  - Same yearly sequences
- Simplified compact representation

Next Steps

Discussions!

Colorado Water Availability Study
Climate Change Analyses

Boyle Engineering
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Leonard Rice Engineers
Stratus Consulting

Ben Harding, P.E
Subhrendu Gangopadhyay, Ph.D., P.E.

June 11, 2008

Appendix B: Selection of Projections (Memo)

DRAFT

MEMORANDUM

To: Laurna Kaatz, Denver Water
From: Ben Harding, AMEC
Subject: Selection of Projections
Date: November 9, 2008
cc:

As we discussed Friday, here is what I understood to be the approach to selecting projections.

Five qualitative scenarios have been identified as follows:

- Hot and Dry
- Hot and Wet
- Warm and Dry
- Warm and Wet
- Median

Two projection time frames will be used, 2025-2054 and 2055-2084. For each time frame a projection will be selected, so up to ten projections may be used in the analysis (it is possible that the same projection will be selected for both time frames for a given qualitative scenario).

For each scenario a characteristic value will be determined for the projected change in temperature and precipitation. Change in temperature will be expressed as an absolute projected increase or decrease while change in precipitation will be expressed as a percent projected increase or decrease. The characteristic values will be determined as follows.

Scenario	Characteristic T	Characteristic P
Hot and Dry	90th Percentile	10th Percentile
Hot and Wet	70th Percentile	70th Percentile
Warm and Dry	30th Percentile	30th Percentile
Warm and Wet	10th Percentile	90th Percentile
Median	50th Percentile	50th Percentile

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Projections will be selected based on their proximity (in terms of Euclidean distance in the T and P dimension space) to the characteristic values for the five scenario points. Five neighbors will be selected as candidate projections at each scenario point. One of these candidate projections will be selected based on the following criteria:

- Proximity to the characteristic point
- Having a representative monthly pattern

For the five scenarios selected on the basis of proximity, the average monthly pattern of normalized precipitation (normalized against the annual mean value) will be averaged to obtain a mean normalized pattern for precipitation. The individual pattern with the lowest root mean square error to the mean pattern will be selected to represent that qualitative scenario.

References

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Appendix C: Recommended CRWAS Approach (Presentation)

Colorado Water Availability Study

Climate Change Analyses

Boyle Engineering
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Leonard Rice Engineers
Stratus Consulting

Ben Harding, P.E
March 20, 2009

Study Team – Management

CWCB Board of Directors

Ray Alvarado
Ross Bethel
Eric Hecox
Veva Deheza
CWCB & DWR Staff

Department of Natural Resources

Attorney General's Office

IBCC - Basin Roundtables

Boyle Management

Blaine Dwyer, P.E.
Project Manager

Matt Brown, P.E.
Assistant P.M.

Boyle Team Organization

Climate Change Tasks

- TASK 6 Implement Alternate Historical Hydrology
- TASK 7 Implement Alternate Hydrology for Climate Change and Forest Change
- TASK 8 Colorado River Compact Analyses

Climate Change & Down - Scaling

Earth
- Emissions Scenarios
- Global Climate Models

Result: *Altered Temperature and Precipitation*

Colorado River Basin
- "Down-Scaled" Projections
- Revised Basin-Wide Hydrology

Result: *Altered Stream Flows*

State of Colorado
- CDSS Modeling

Result: *Water Availability*

Methodological Decisions

- Representation of uncertainty
  - Selection of projections
- Representation of Changing Climate
  - Transient or static
- Time Frames
- Hydrology
- Inter-annual sequences
- Operational modeling

Coordination with Front Range Vulnerability Study

- Geographical overlap
  - Colorado River Main Stem in Colorado
- Methodological overlap
  - Observed climatology (for climate impacts)
  - Climate projections
  - Time frames
  - Selection of projections
- CRWAS differences
  - Hydrology
  - Re-sequencing
  - Details of climate adjustments
  - Water rights analysis
  - “Big River” analysis

Technical Approach

- Early tasks will review potential methods
- CWCB will approve approach
- Approved:
  - Use of VIC model
  - Paleo methodology
- Approval Expected for:
  - Alternate Hydrology of Climate Change
  - Proposed method will be discussed today

Interim Work Products

Completed deliverables:

- Public Information - Newsletter - Volume 1 (Task 1.3)
- 6 CDSS Model Briefs - CDSS Overview, Yampa, White, Upper Colorado, Gunnison, San Juan/Dolores (Task 4.1)
- BRT Workshops - Yampa/White, Colorado, Gunnison, Southwest (Task 4.2)
- Alternate Historical Hydrology - Literature Review, Method Evaluation, Analysis of Tree-Ring Data, and Recommendations (Task 6.1-6.3)
- Climate and Forest Change - Hydrologic Approach and Model Selection (Task 7.5)

Draft CRWAS deliverables:

- Coordination with Front Range Vulnerability Study (Task 7.1)
- Climate Change - Literature Review and Methods Evaluation (Task 7.2)
- Forest Change Literature Review and Suggested Methods (Task 7.3)
- Colorado River Compact Overview Summary of Key Issues (Task 8.1)

Three Step Hydrologic Analysis

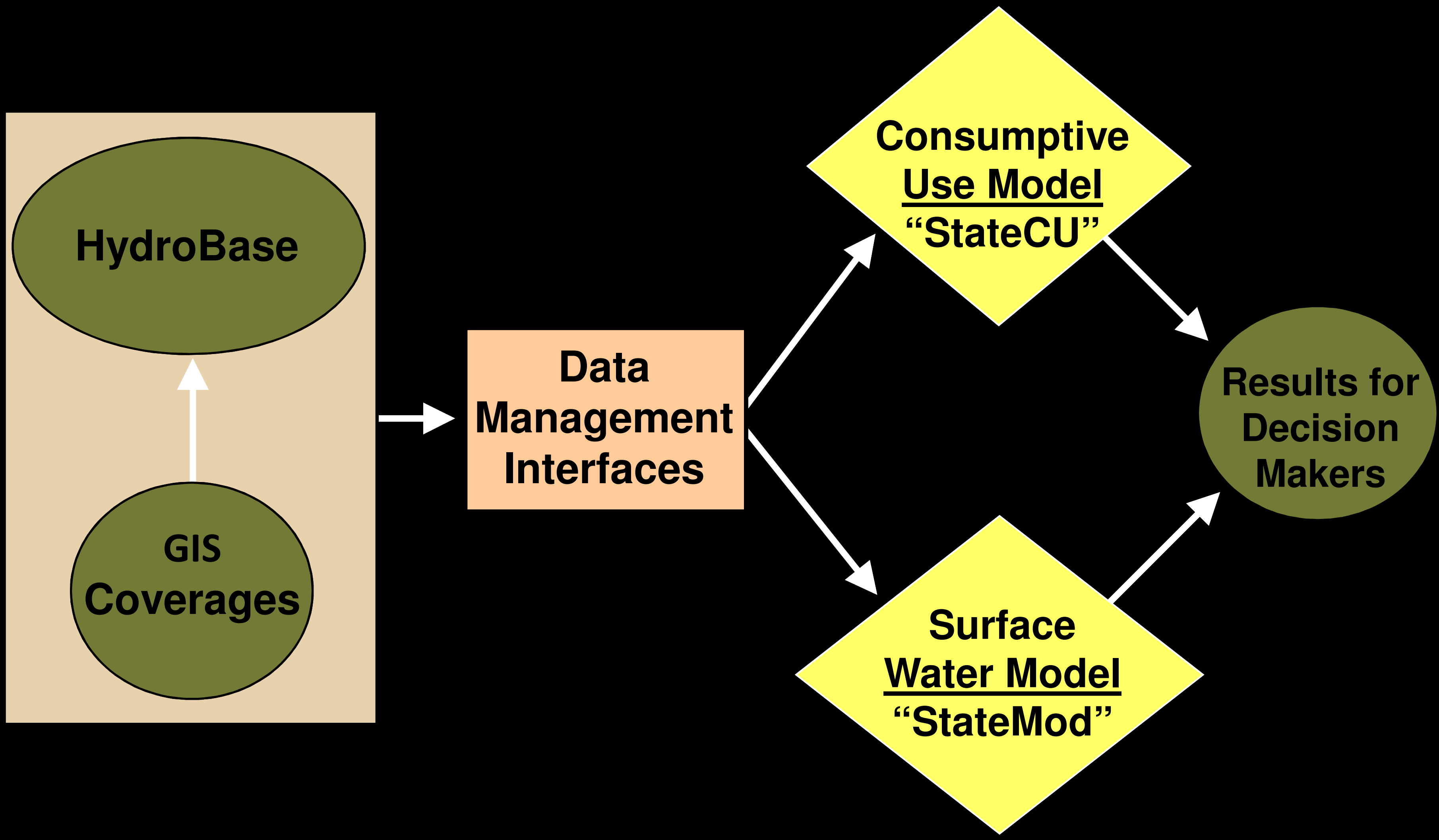
1) Historical Hydrology

- To be used for comparative analysis
- 1950's forward (most reliable data)

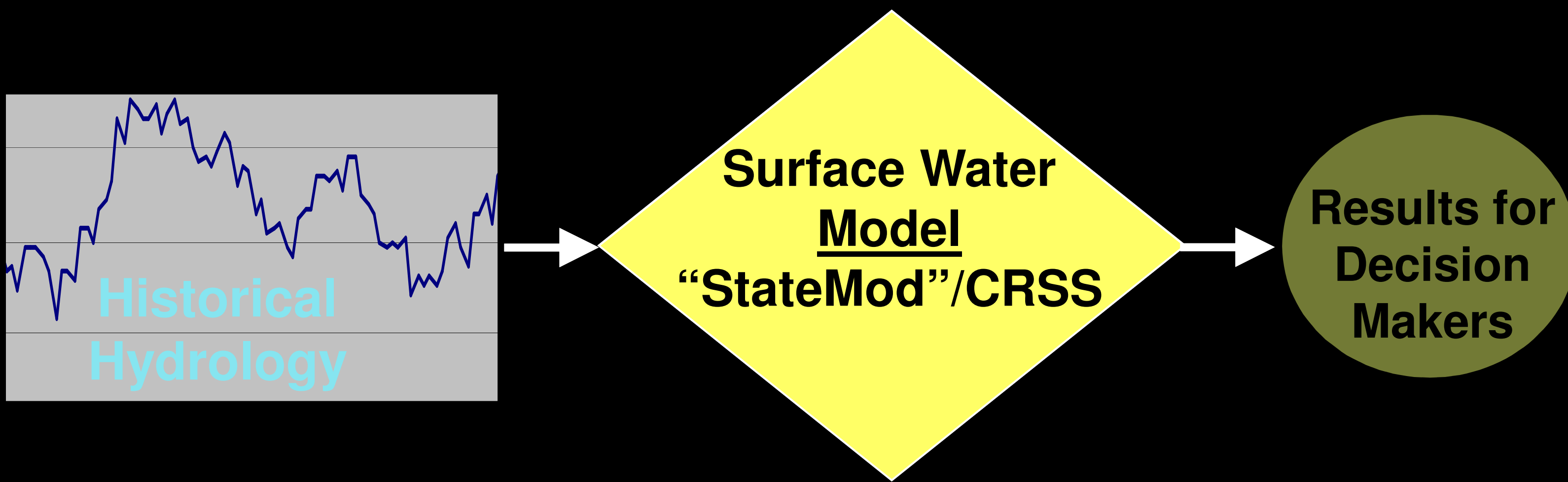
2) Alternate Historical: Paleo -Hydrology | Extend Records with Tree-Rings & Stochastic Methods

3) Climate Change and Forest Change

Historical Hydrology – Data-Centered CDSS

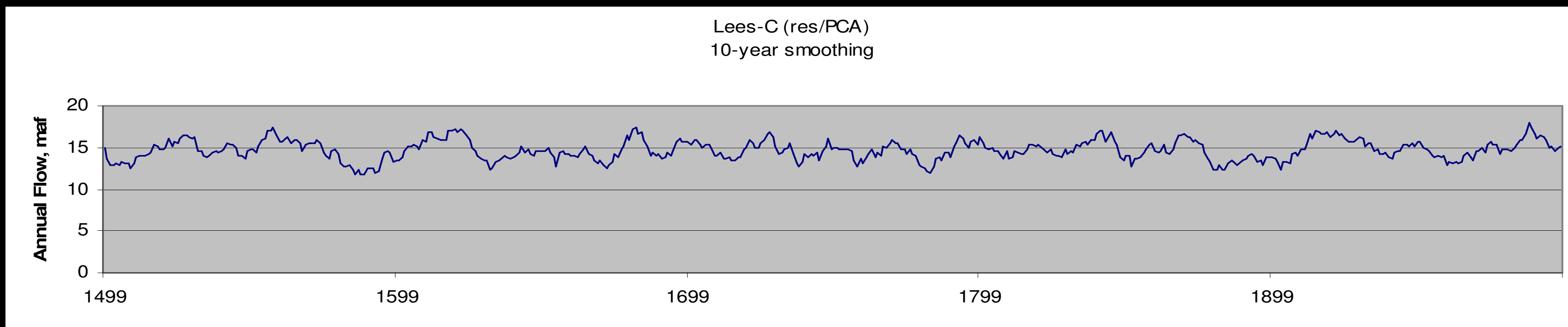


Historical Hydrology → Water Availability

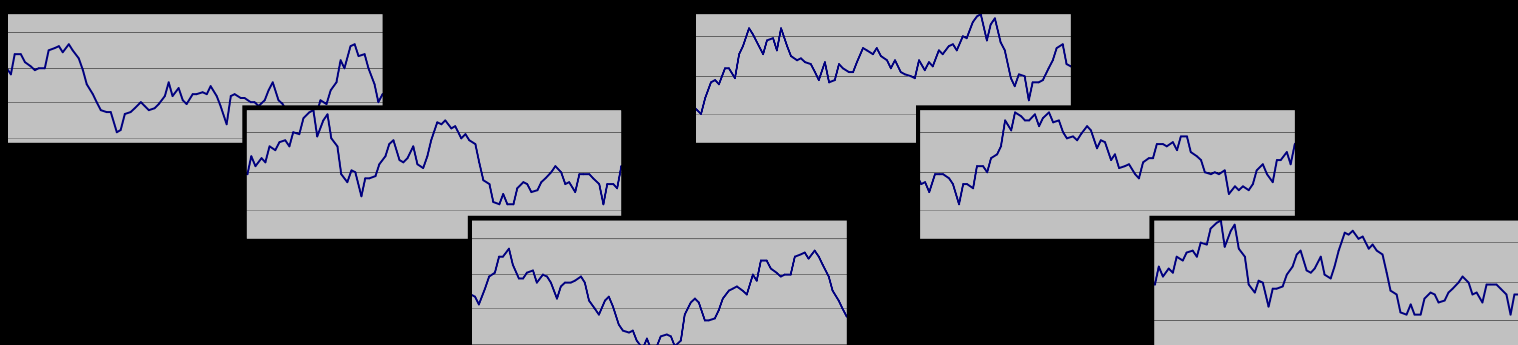


Alternate Historical Hydrology (Paleo-hydrology)

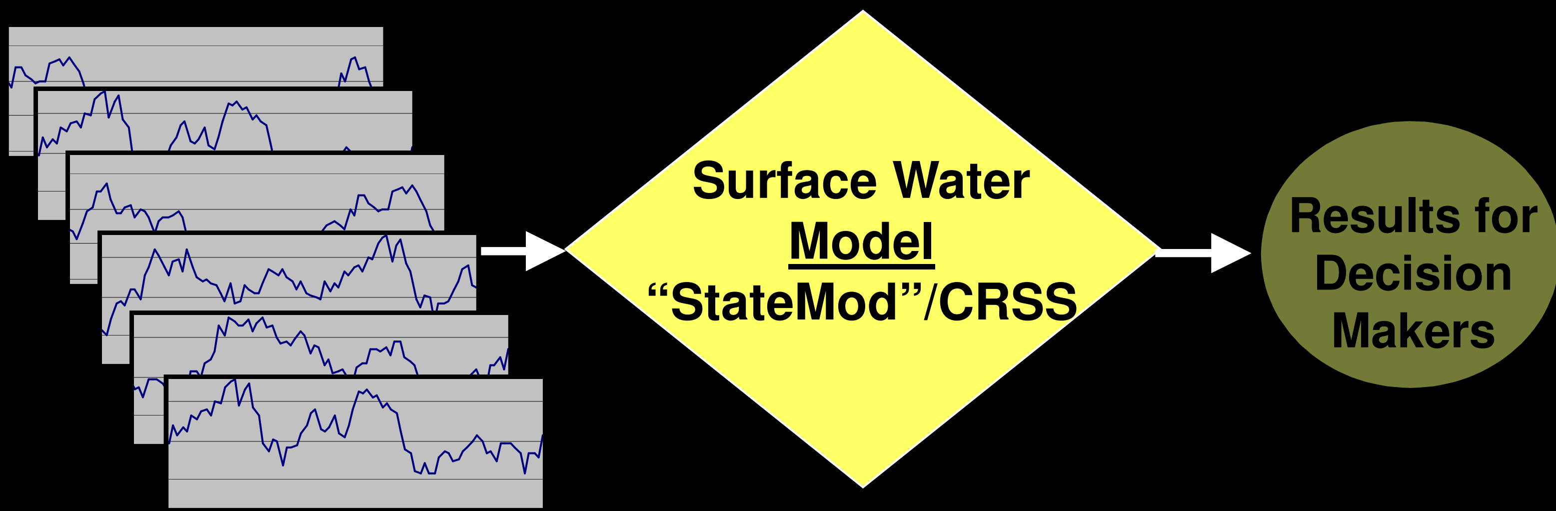
Reconstructed Flows



"Ensemble" of "Traces"



Alternate Historical Hydrology → Water Availability



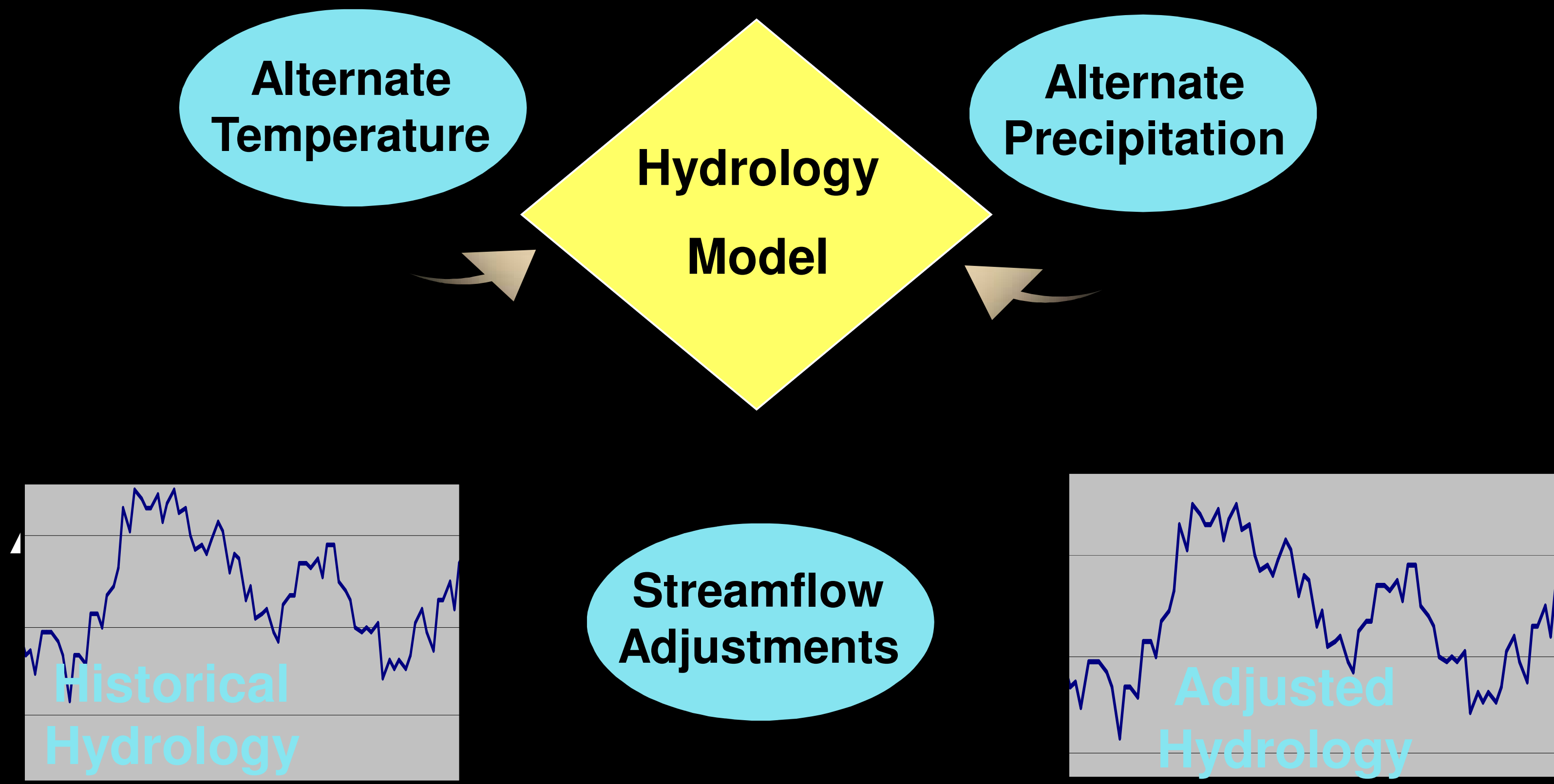
Alternate Historical Hydrology

- Considered 3 methods involving regression- and re-sequencing techniques
- Two have been previously applied to Colorado River basin
- Selected the re-sequencing approach:
  – Efficiency/ automated validation processes
  – Can be applied to both “Big River” (CRSS) and CDSS models
  – Spatial correlations and seasonal patterns maintained

Non-homogeneous Markov Chain (NHMC)

- Use *Woodhouse et* al. [2006] Lees Ferry reconstructions to assign basin state – dry/wet.
- Follow *Prairie et al.* [2008] to create a non-parametric stochastic model of *sequences* of flows
- Stochastic technique generates sequences of *years*, e.g. 1955, 1972, 1963…
- Sequence generated based on transition probabilities and flow magnitude.
- The sequences are used to construct model input files.
- Generate 100 ensemble members each of length 50-100 years

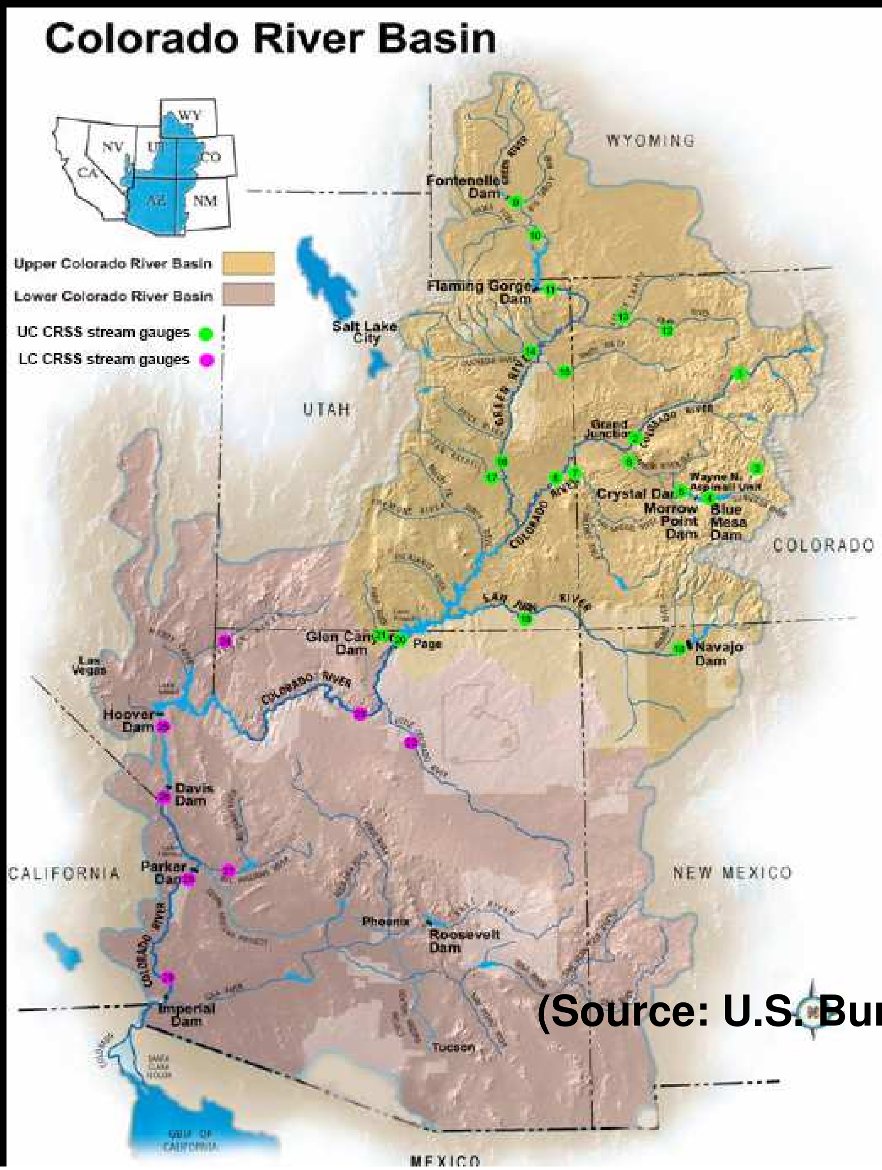
3) Alternate Hydrology of Climate Change



CRDSS Natural Flows
CRSS Natural Flows

CRDSS Adjusted Flows
CRSS Adjusted Flows

CRSS Inflow Points



(Source: U.S. Bur

29 Natural Inflow Stations in CRSS

1	Colorado River at Glenwood Springs, CO
2	Colorado River near Cameo, CO
3	Taylor River below Taylor Park Reservoir, CO
4	Gunnison River below Blue Mesa Reservoir, CO
5	Gunnison River at Crystal Reservoir, CO
6	Gunnison River near Grand Junction, CO
7	Dolores River near Cisco, UT
8	Colorado River near Cisco, UT
9	Green River below Fontenelle Reservoir, WY
10	Green River near Green River, WY
11	Green River near Greendale, UT
12	Yampa River near Maybell, CO
13	Little Snake River near Lily, CO
14	Duchesne River near Randlett, UT
15	White River near Watson, UT
16	Green River at Green River, UT
17	San Rafael River near Green River, UT
18	San Juan River near Archuleta, NM
19	San Juan River near Bluff, UT
20	Colorado River at Lees Ferry, AZ
21	Paria River at Lees Ferry, AZ
22	Little Colorado River near Cameron, AZ
23	Colorado River near Grand Canyon, AZ
24	Virgin River at Littlefield, AZ
25	Colorado River below Hoover Dam, AZ-NV
26	Colorado River below Davis Dam, AZ-NV
27	Bill Williams River below Alamo Dam, AZ
28	Colorado River below Parker Dam, AZ-CA
29	Colorado River above Imperial Dam, AZ

Basin-wide Hydrology Models

- Use changes in temperature and precipitation to generate new streamflows and evaporative conditions
- Evaluated 5 existing models: a) VIC; b) MMS-PRMS; c) NWSRFS/SAC-SMA; d) TWB; and e) WEAP
- Selected "VIC" *(for the Colorado River):*
  - Practicality and previous wide-ranging & CC applications
  - Compatible spatial resolution (vs downscaled GCM's)
  - Soil moisture dynamics, snow dynamics, & evapotranspiration

Implement Alternate Hydrology for Climate Change

- Re-calibrate VIC (Variable Infiltration Capacity) model using forcings from the 56-year, 1950-2005, climatological period for CO gages/locations of interest – modeled runoff for the climatological period.

- Timeframes, 2040 and 2070 – Front Range Vulnerability Study.

- Climate models, ~ 112 downscaled climate projection traces (1/8th degree grid), *Maurer –Brekke* archive.

Implement Alternate Hydrology for Climate Change

- For each model grid cell - obtain average precipitation (P) and temperature (T) estimates for each climate trace for each month, over a 30-year window surrounding the years of interest, 2040 (2025-2054) and 2070 (2055-2084).
- For each model grid cell - calculate the change in precipitation *(ΔP*, multiplicative*)* and temperature (*ΔT,* additive) for each month between the climatological mean (1950-1999) and the mean P and T for each climate change trace.

Implement Alternate Hydrology for Climate Change

- For each grid cell, perturb P and T for each month of the 56-year climatological period, 1950-2005 using the precipitation and temperature changes, ΔP (multiplicative) and temperature ΔT (additive) for that grid cell.

- Same ΔP and ΔT from a given trace will be applied to each month of the climatological period – superimpose change on observed interannual variability of P and T.

Implement Alternate Hydrology for Climate Change

- Perturbed monthly P and T values – 56-year climatological period, 1950-2005.
- Run the calibrated VIC model using the above perturbed P and T fields to obtain the perturbed model runoff.
- Calculate change in runoff (runoff adjustment factor) *ΔQ* , ratio of perturbed model runoff and modeled runoff from the climatological period – each model grid, each trace, each month.

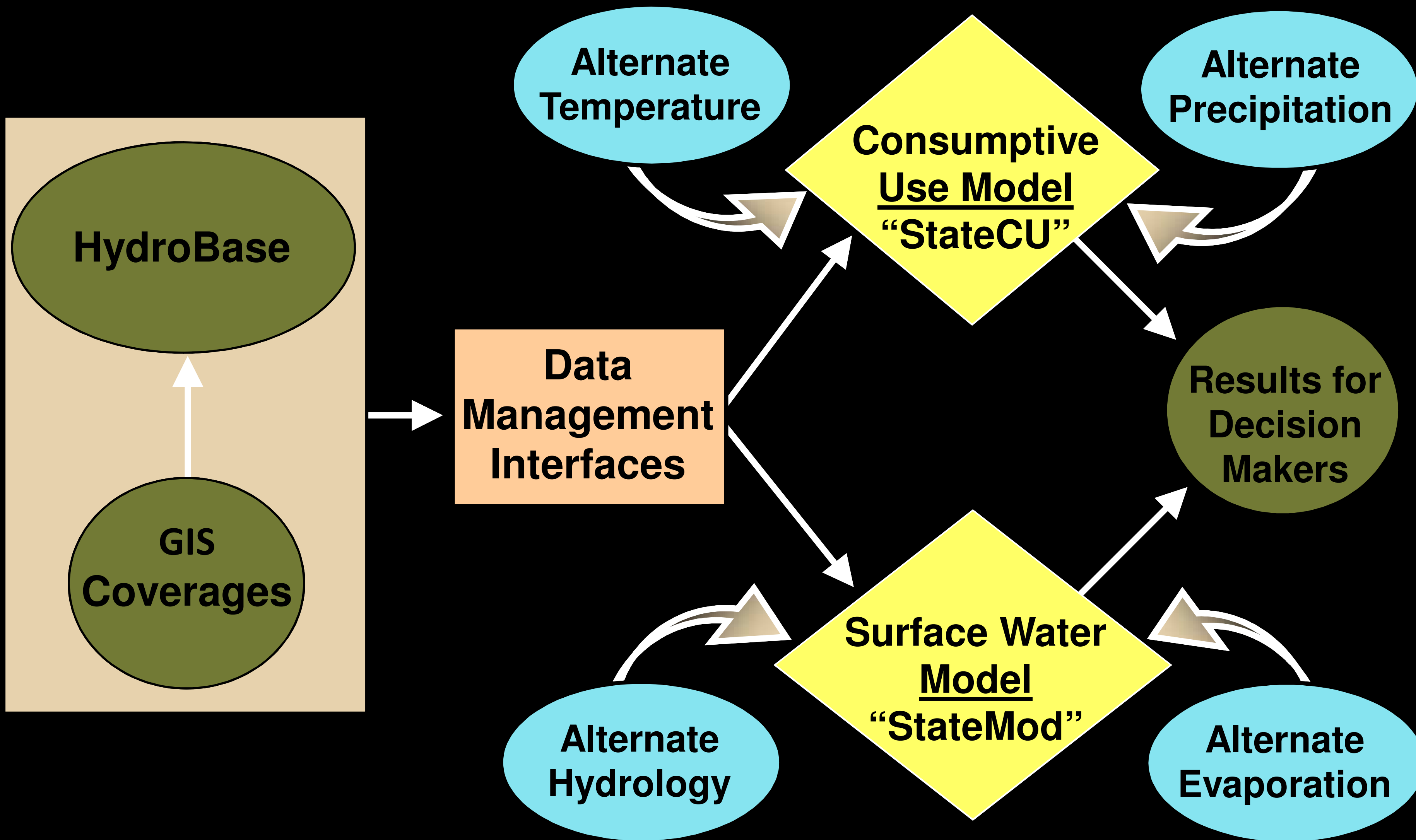
Implement Alternate Hydrology for Climate Change

- Runoff adjustment factor, *ΔQ* - each model grid, each trace, each month, derived from the climatological period, 56 years, 1950-2005.

- Adjust observed natural flows for each CO gage/locations of interest using the monthly *ΔQ* above (area weighted) for the 56 years naturalized streamflow data to obtain the *"As-If"* Hydrology for a given trace.

- "*As-If"* Hydrology – basin hydrology that would have occurred had the projected changes in mean climate conditions been fully developed at the beginning of and throughout the observed period.

Alternate Historical Hydrology



Implement Alternate Hydrology for Climate Change

- "*As-If*" Hydrology – basin hydrology that would have occurred had the projected changes in mean climate conditions been fully developed at the beginning of and throughout the observed period.

- Re-sequence the *"as-if"* hydrology (56 years, 1950-2005) for each climate trace using the Non-homogeneous Markov Chain (NHMC) transient transition probabilities [*Prairie et al.,* 2008] derived from the paleo data (Task 6 NHMC) – 100 ensemble members each 50-100 year long.

Alternate Water Use

- StateCU input data constitute observed *field-level* climatology
- Adjust observed field-level climatology
  - Apply mean pattern of *Δ* P & *Δ* T
  - Obtain *As-If field-level climatology*
- Run StateCU to obtain *As-If water use*
- Re-sequence *As-If water use*
  - Same sequences as used for streamflow
  - Water use remains associated with the same calendar year

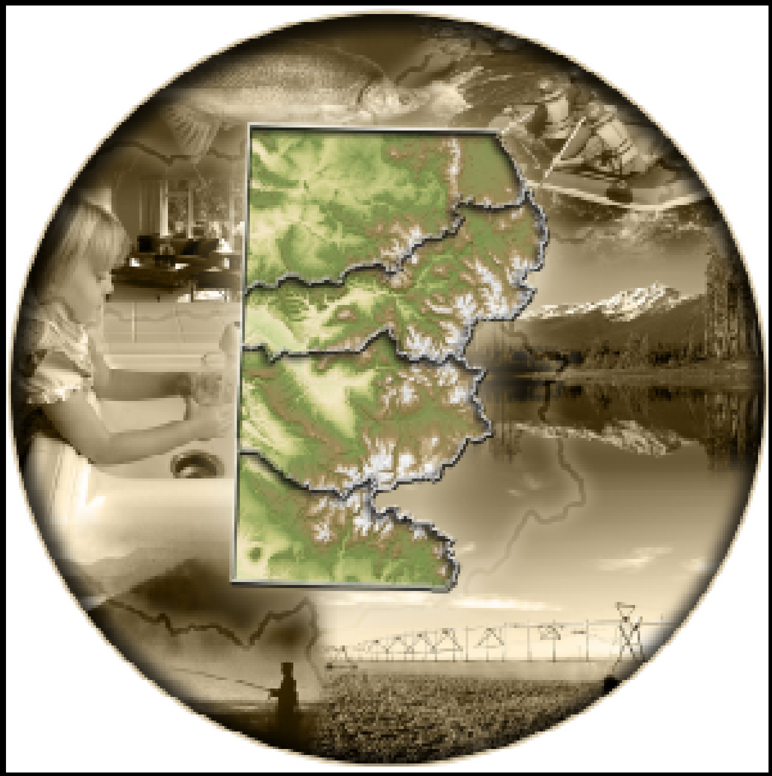
Colorado River Compact Analyses and Preliminary Administration Considerations

- Use CRSS
- Same approach as for intrastate analyses
  - CRSS natural flows are foundation (29 inflow points)
  - Same climate projections
  - Same adjustment method
- Use Reclamation Depletion Schedule
  - No adjustment of depletions

Discussions!

Colorado Water Availability Study

Climate Change Analyses



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Ben Harding, P.E

March 20, 2009

Appendix D: Documentation of Selected Projections

GCM Selection and Monthly T/P Patterns

Please review:

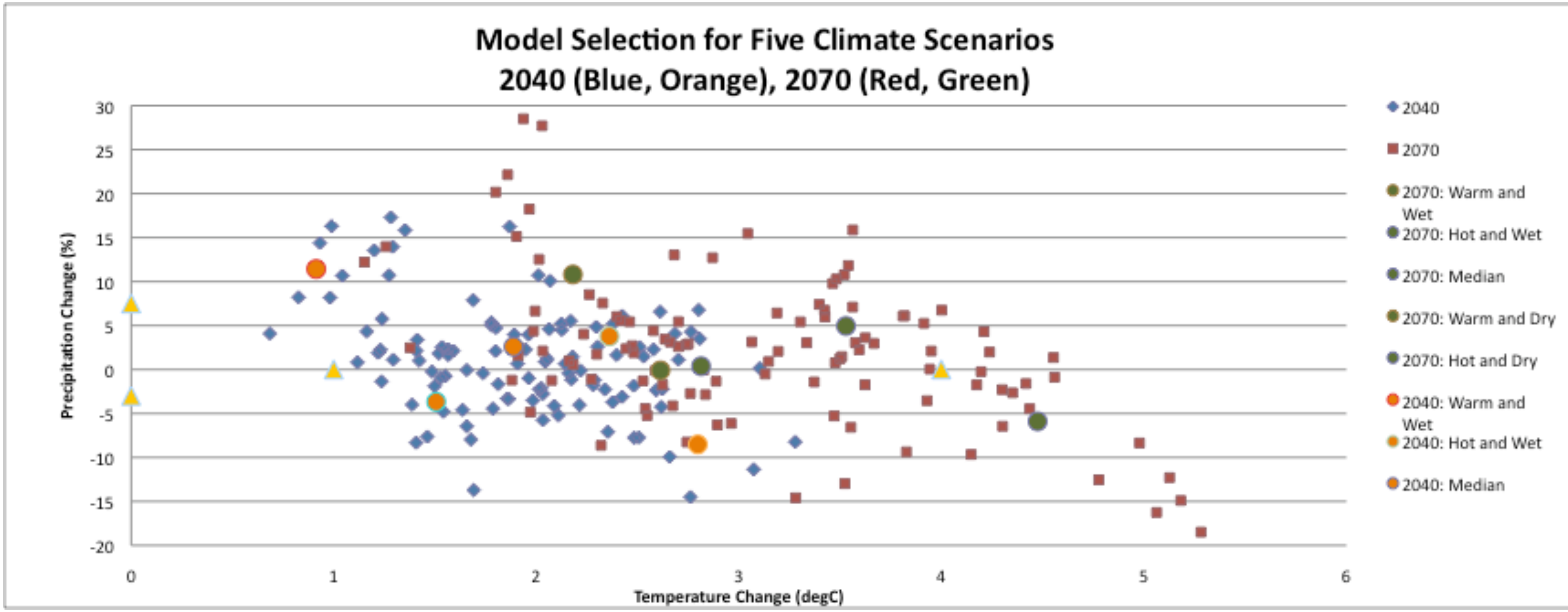
Spread of Models Chosen

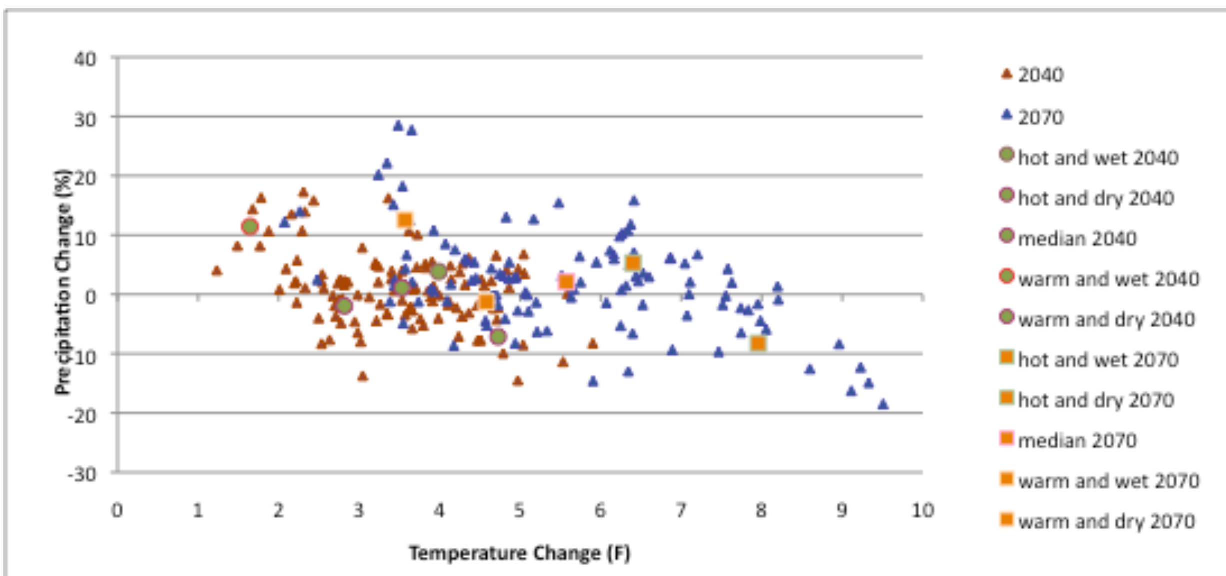
Correlating Pattern for Each Model

Scenario Description

Scenarios	**Dry**	**Wet**
Hot	Hot and Dry	Hot and Wet
Warm	Warm and Dry	Warm and Wet

2040 & 2070 Model Spread

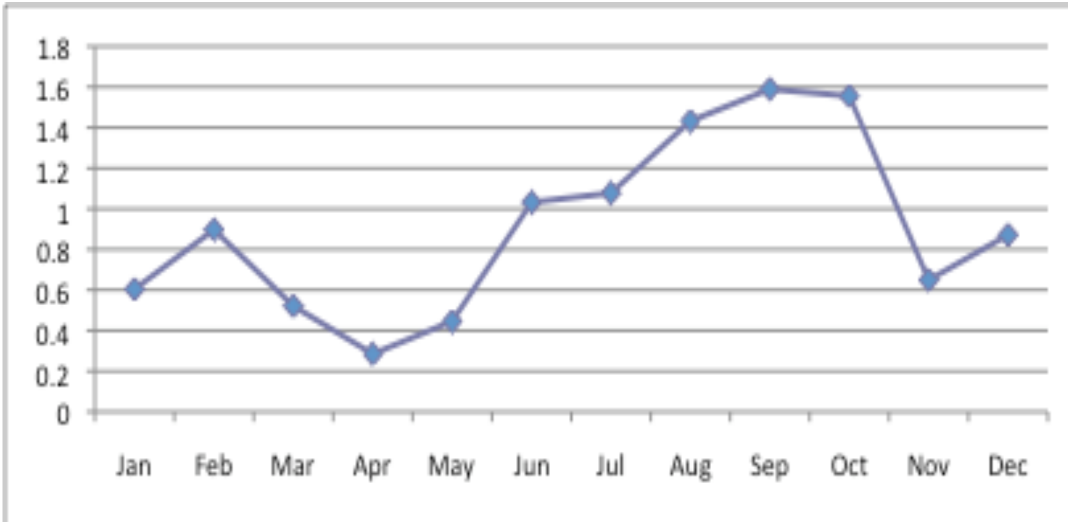




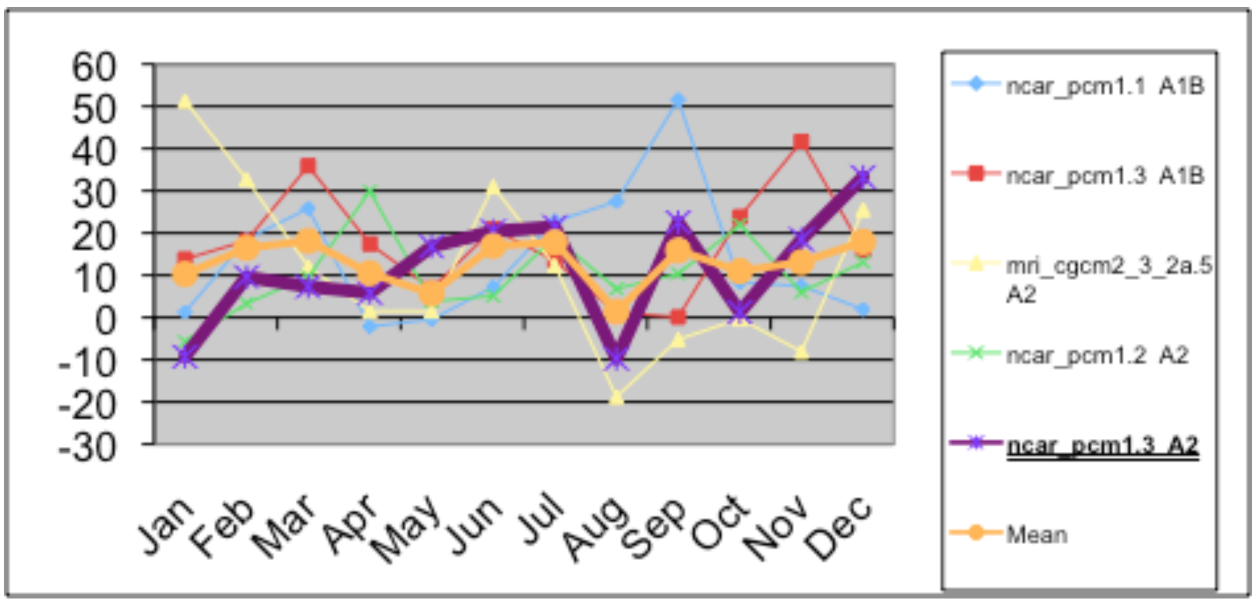
2040 Model Selection

Scenario	GCM	SRES	Annual T degC Change	Annual P % Change
Warm & Wet	ncar_pcm1.3	A2	0.91	11.43
Hot & Wet	ncar_ccsm3_0.2	A1B	2.36	3.77
Median	cccma_cgcm3_1.2	B1	1.46	2.60
Warm & Dry	mri_cgcm2_3_2a.1	A2	1.51	-3.67
Hot & Dry	miroc3_2_medres.1	A2	2.80	-8.51

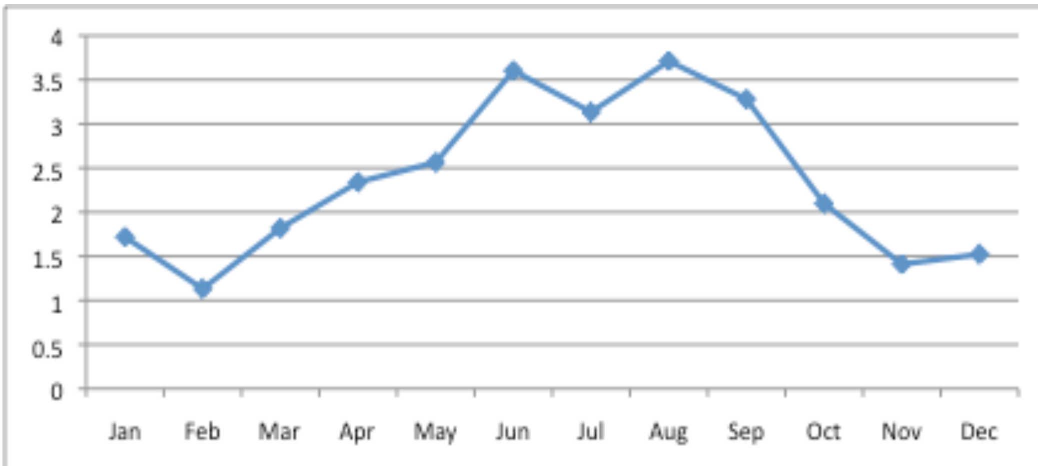
2040 Warm and Wet
ncar_pcm1.3_sresA2



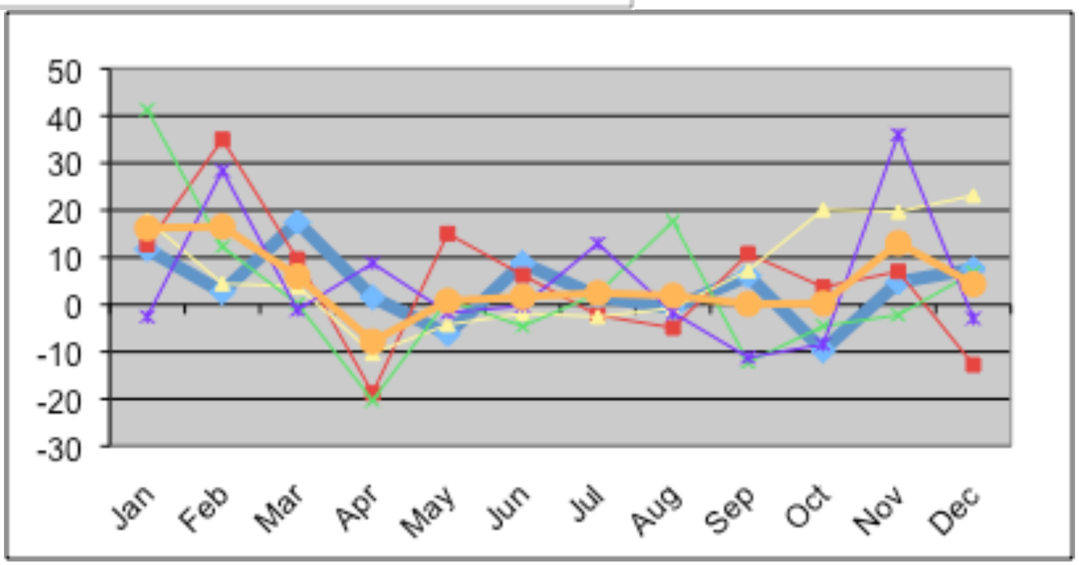
Temperature Pattern (degC) is on the top (left), Precipitation Pattern (%change) on the bottom (below). The thick orange line is the mean of the 5-nearest-neighbors. The best Fit is the PURPLE thick line. All 5 nearest point patterns are shown for comparison.



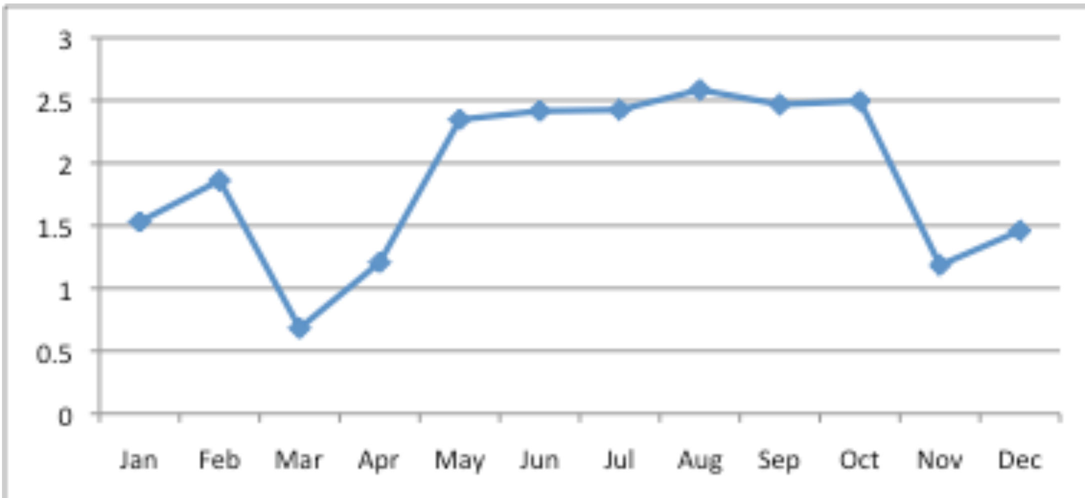
2040 Hot and Wet
ncar_ccsm3_0.2_sresA1B



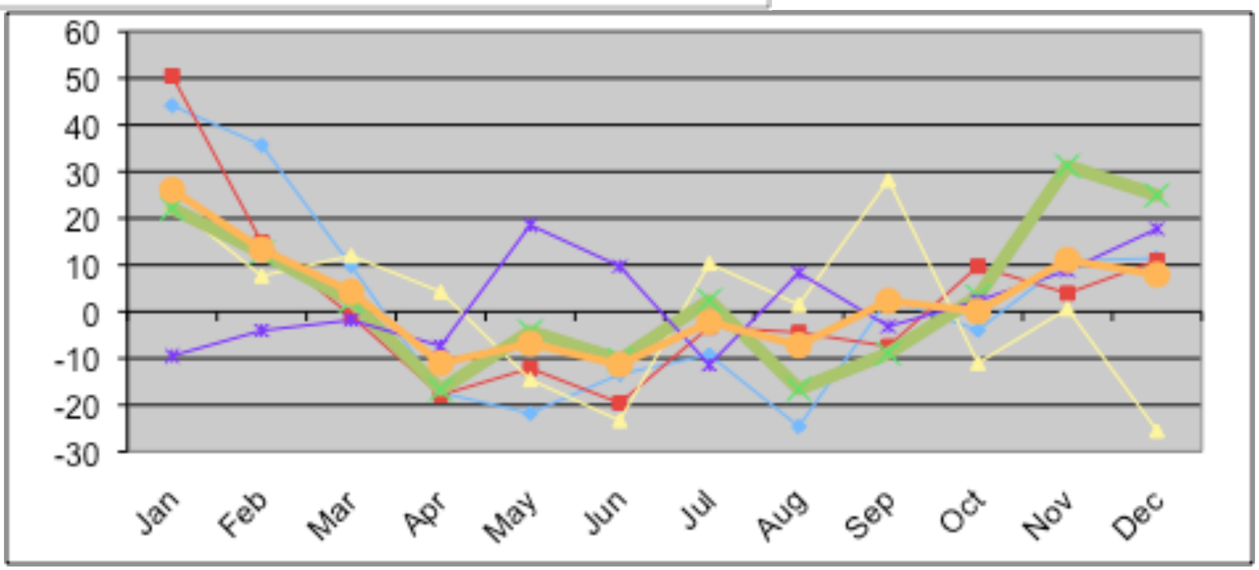
The Precipitation Pattern to consider is the thick BLUE line. The mean is in orange.



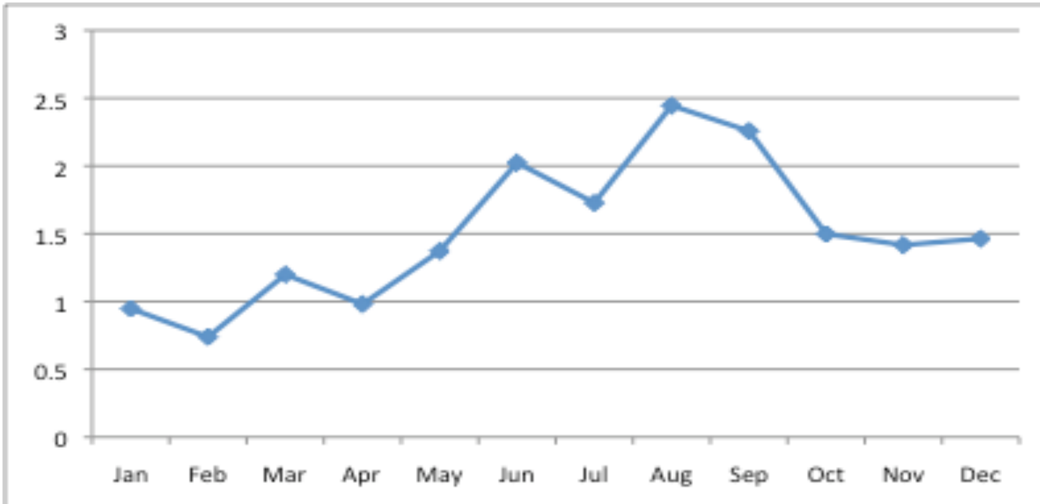
2040 Median
cccma_cgcm3_1.2_sresB1



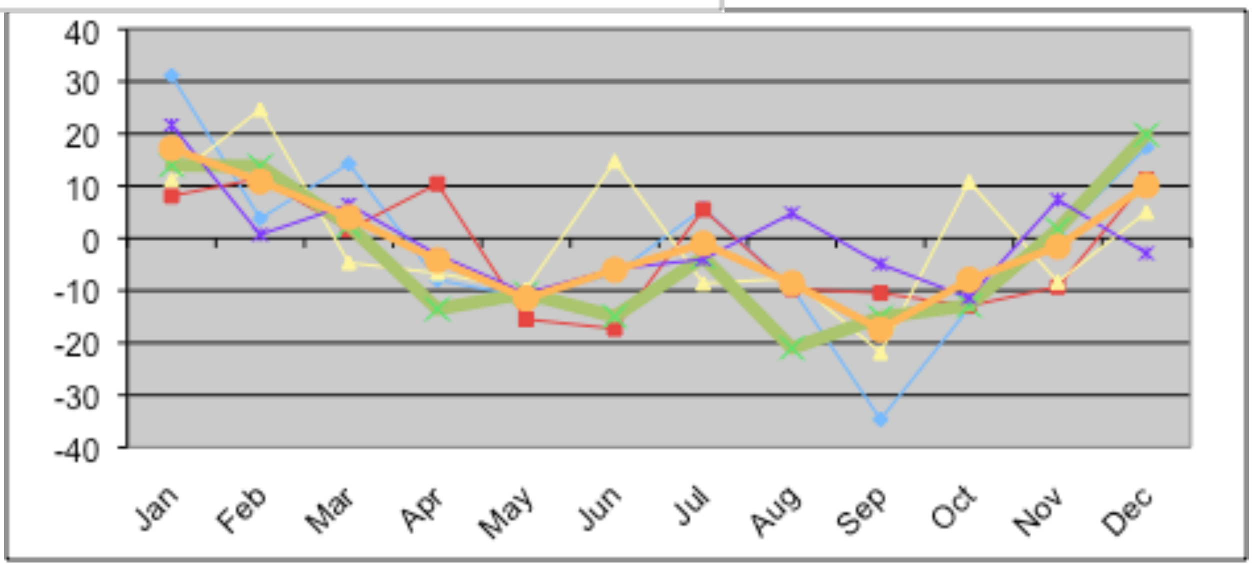
The Precipitation Pattern to consider is the thick GREEN line. The mean is in orange.



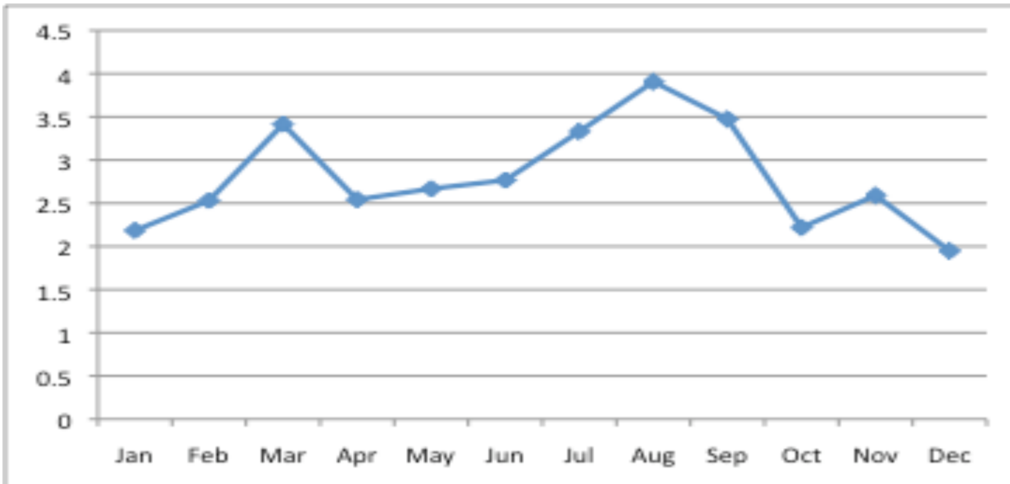
2040 Warm and Dry
mri_cgcm2_3_2a.1_sresA2



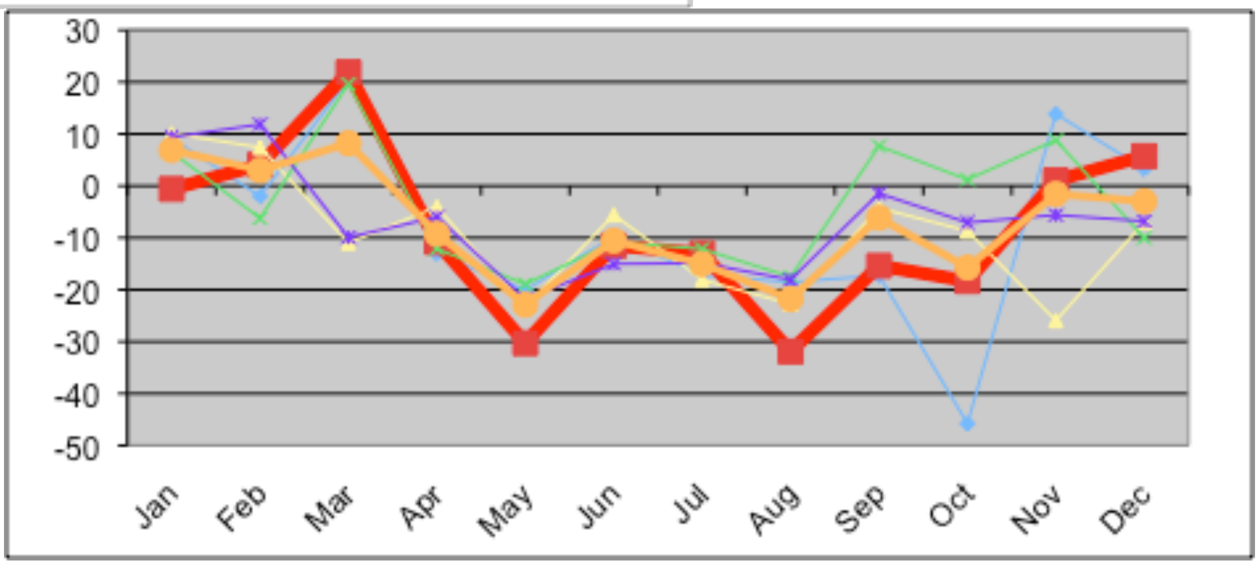
The Precipitation Pattern to consider is the thick GREEN line. The mean is in orange.



2040 Hot and Dry
miroc3_2_medres.1_sresA2



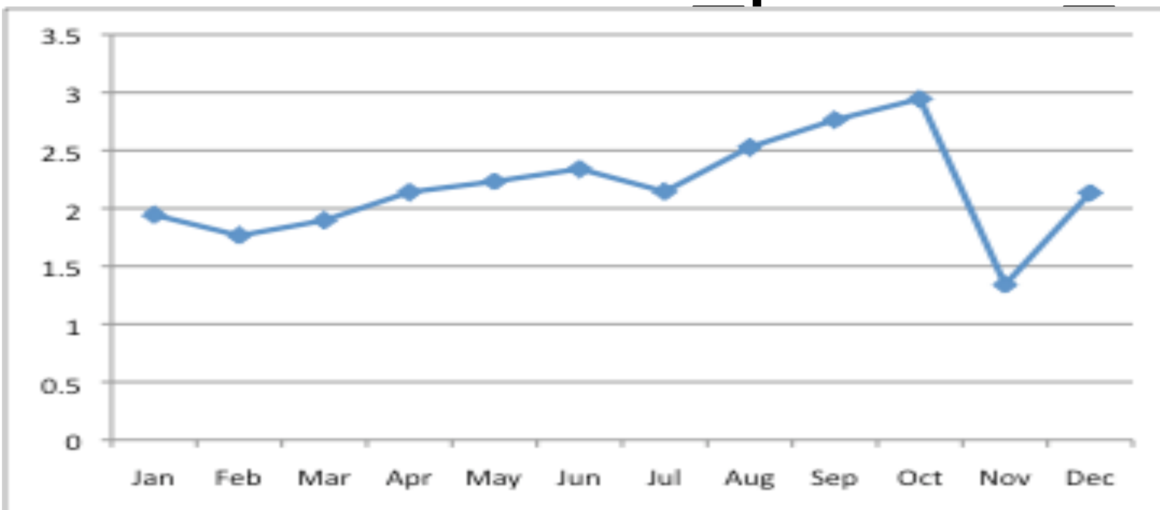
The Precipitation Pattern to consider is the thick RED line. The mean is in orange.

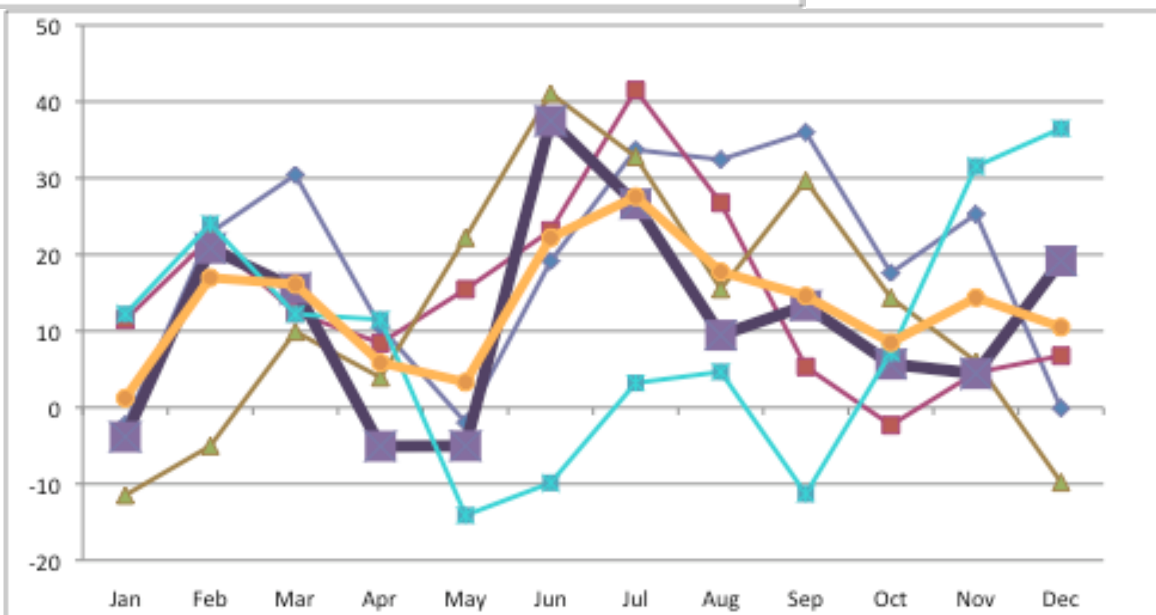


2070 Model Selection

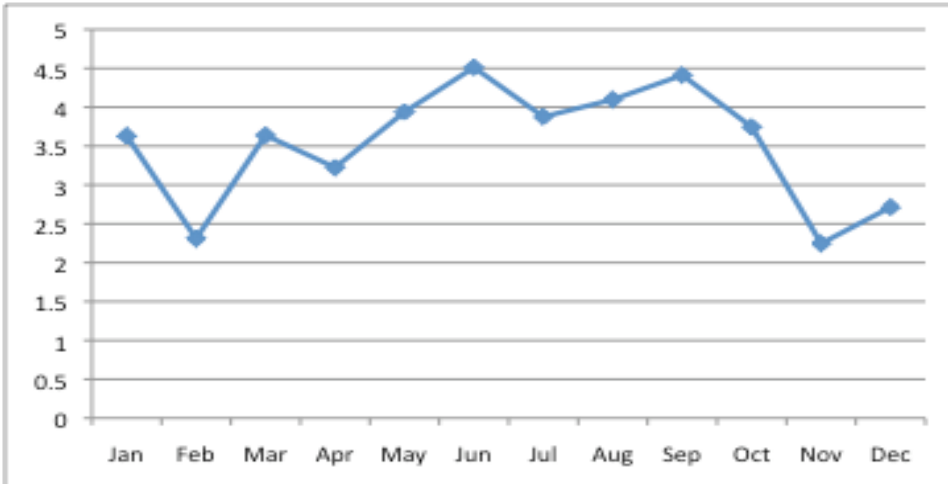
Scenario	GCM	SRES	Annual T degC Change	Annual P % Change
Warm & Wet	ncar_pcm1.3	A2	2.18	10.81
Hot & Wet	ncar_ccsm3_0.2	A1B	3.53	4.95
Median	mpi_echam5.1	B1	2.81	0.38
Warm & Dry	mri_cgcm2_3_2a.4	A1B	2.61	-.097
Hot & Dry	gfdl_cm2_0.1	A1B	4.48	-5.90

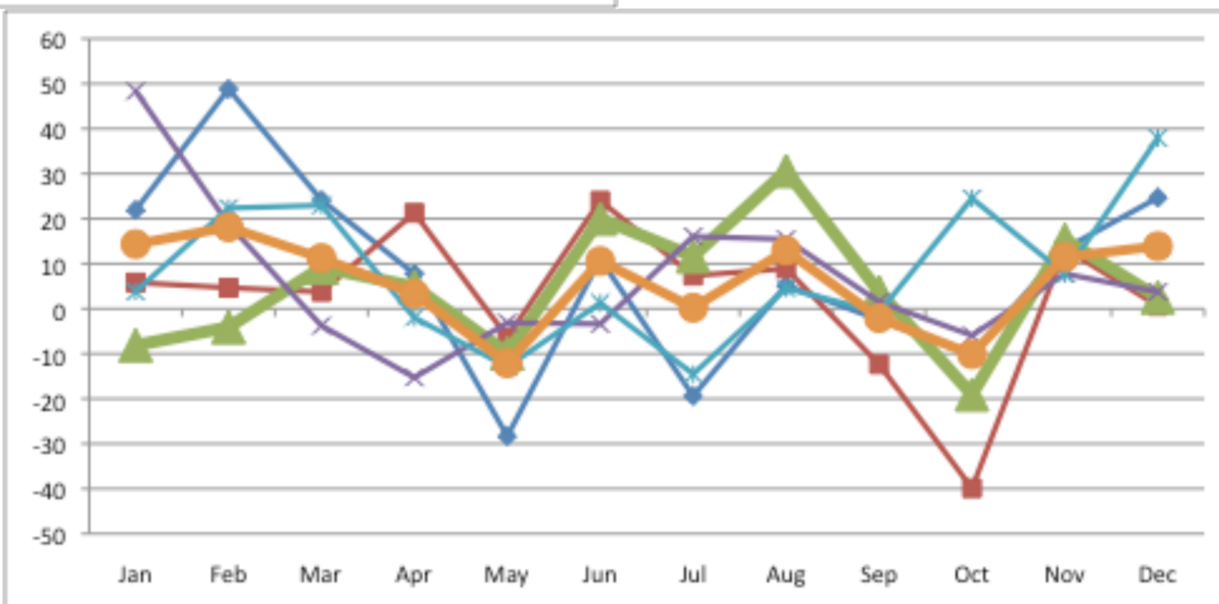
2070 Warm and Wet
ncar_pcm1.3_sresA2



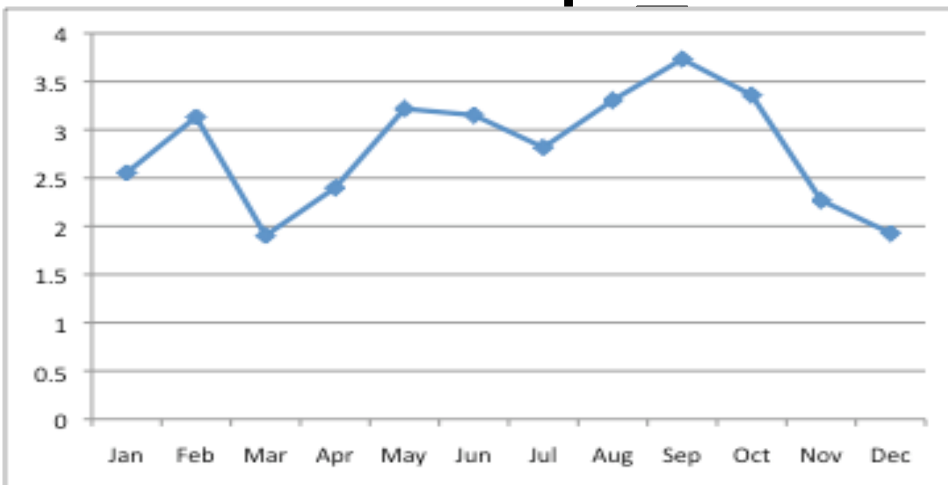


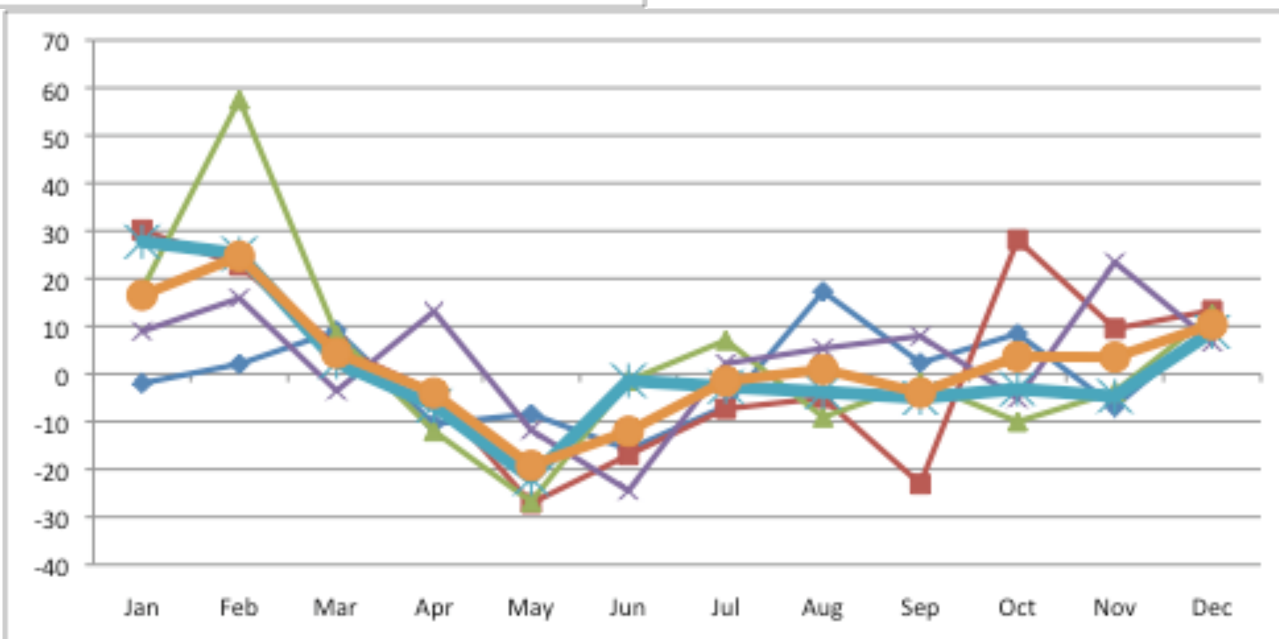
2070 Hot and Wet
ncar_ccsm3_0.2_sresA1B



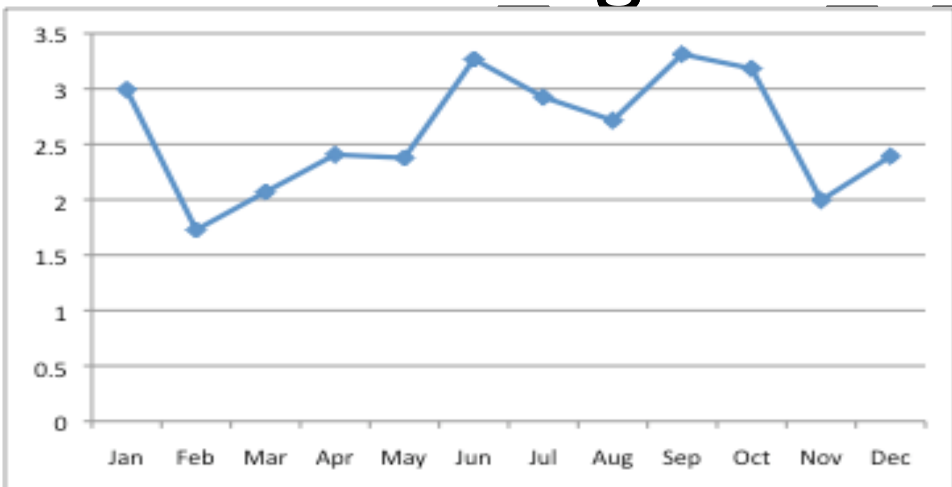


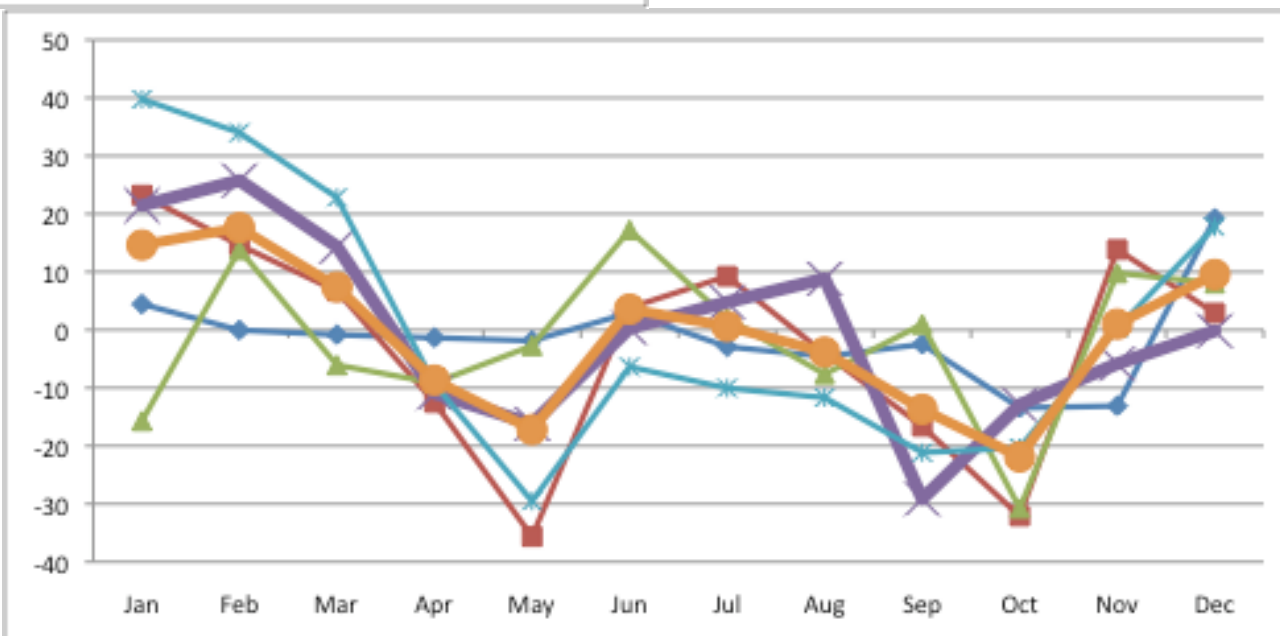
2070 Median mpi_echam5.1_sresB1





2070 Warm and Dry
mri_cgcm2_3_2a.4_sresA1B





2070 Hot and Dry
gfdl_cm2_0.1_sresA1B