Does Dynamical Downscaling Matter for Climate Change Adaptation on the Colorado River?

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Thanks to: Carly Jerla, Andy Wood, Ben Harding

Colorado River Basin Water Supply and Demand Study

- Two-year, $2 million study cost shared by Reclamation and the Basin States
  - Assess future water supply and demand imbalances
  - Assess risks to all basin resources
  - Investigate options and strategies to mitigate impacts
- A transparent, collaborative study with input from all stakeholders
- Email:

ColoradoRiverBasinStudy@usbr.goV

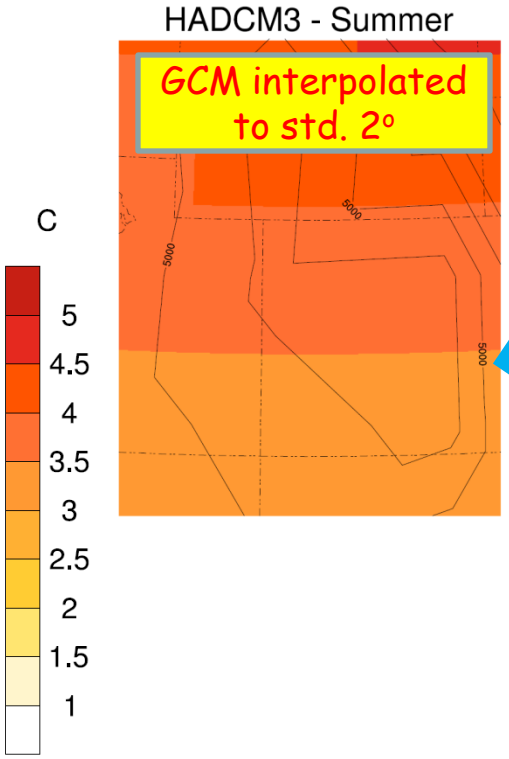
- Website:

http://www.usbr.gov/lc/region/programs/ crbstudy.html

Effects of downscaling method (Dynamical vs. Statistical) on hydrological projections in an adaptation framework

- This work is done as part of the Reclamation Colorado River Hydrology Working Group (NOT the Basin Study)
- Follows the Basin Study modeling methodology as closely as possible, substituting NARCCAP for BCSD GCMs
- Assesses how dynamically downscaled climate projections might change the “decision-relevant metrics” of system operation developed by basin study stakeholders
- Will support Reclamation modelers in assessing the potential influence of using different downscaled climate projections.

Effects of downscaling method (Dynamical vs. Statistical) on hydrological projections: Conceptual Framework



1. Bias Correction (of monthly T-avg and Precip) based on Maurer Climatology
2. Spatial downscaling to 1/8th degree
3. Temporal disaggregation to daily data

VIC → CRSS

CRSS Output from GCM derived Climate

CRSS Output from NARCCAP derived Climate

Comparison

- We are only working with the NARCCAP part. GCM derived values are already available for CRSS
- Comparison period: 2041-2070

Mean.

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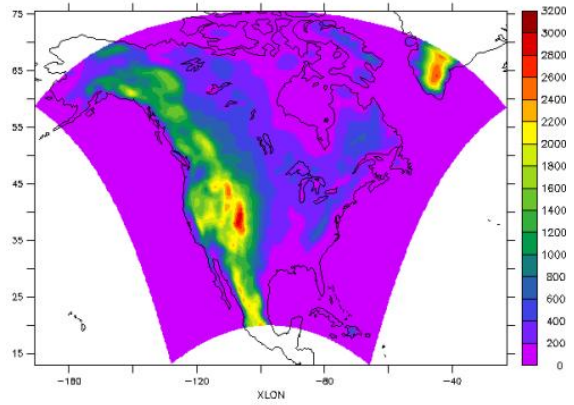
Effects of downscaling method (Dynamical vs. Statistical) on hydrological projections: Progress update (as of 10/11/2010)

NARCCAP – 0.5°



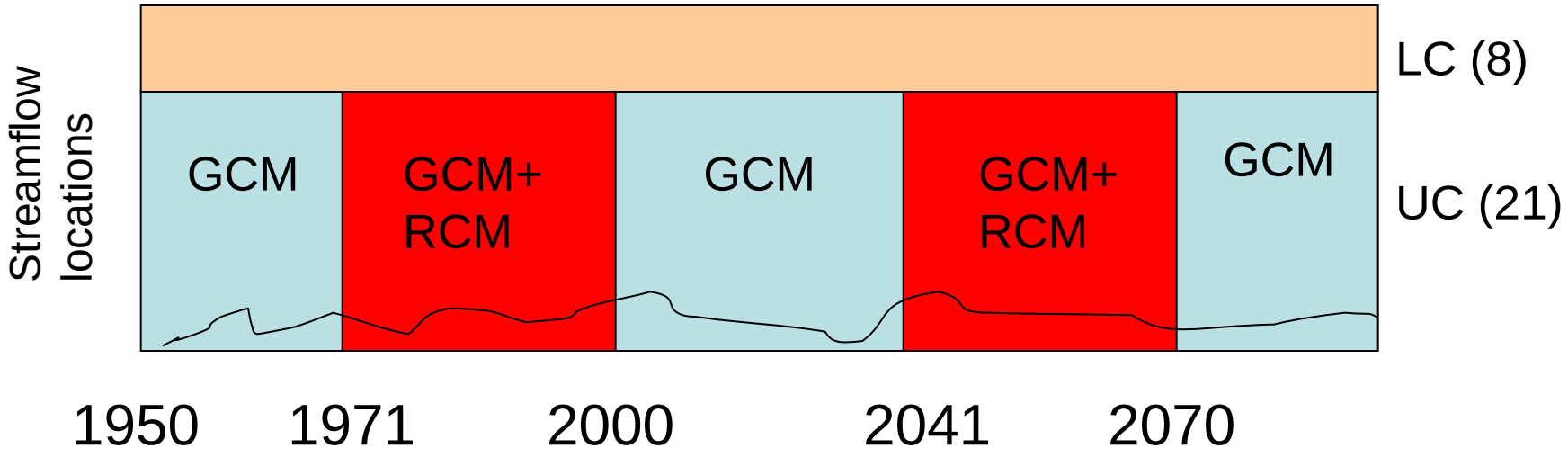
Regional Models	Climate Models				
	GFDL	CGCM3	HADCM3	CCSM	NCEP
CRCM	—	✓	—	✓	✓
ECP2	✓	—	✓	—	✓
HRM3	✓	—	✓	—	✓
MM5I	—	—	✓	✓	✓
RCM3	✓	✓	—	—	✓
WRFG	—	✓	—	✓	✓
Time Slices	✓	—	—	✓	—
ECPC	—	—	—	—	✓
WRFP	—	—	—	—	✓

- Only 5 model outputs on Tavg and Precip available
- Tavg and Precip data has been interpolated to std. 0.5 degree (Tension Spline)
- Bias correction of all Tavg and one Precip data
- Spatial downscaling (to 1/8th degree) of all bias corrected data
- Temporal disaggregation of one model data in progress
- VIC model version obtained from Ben Harding is available

Incorporating NARCCAP-forced streamflow into CRSS simulations

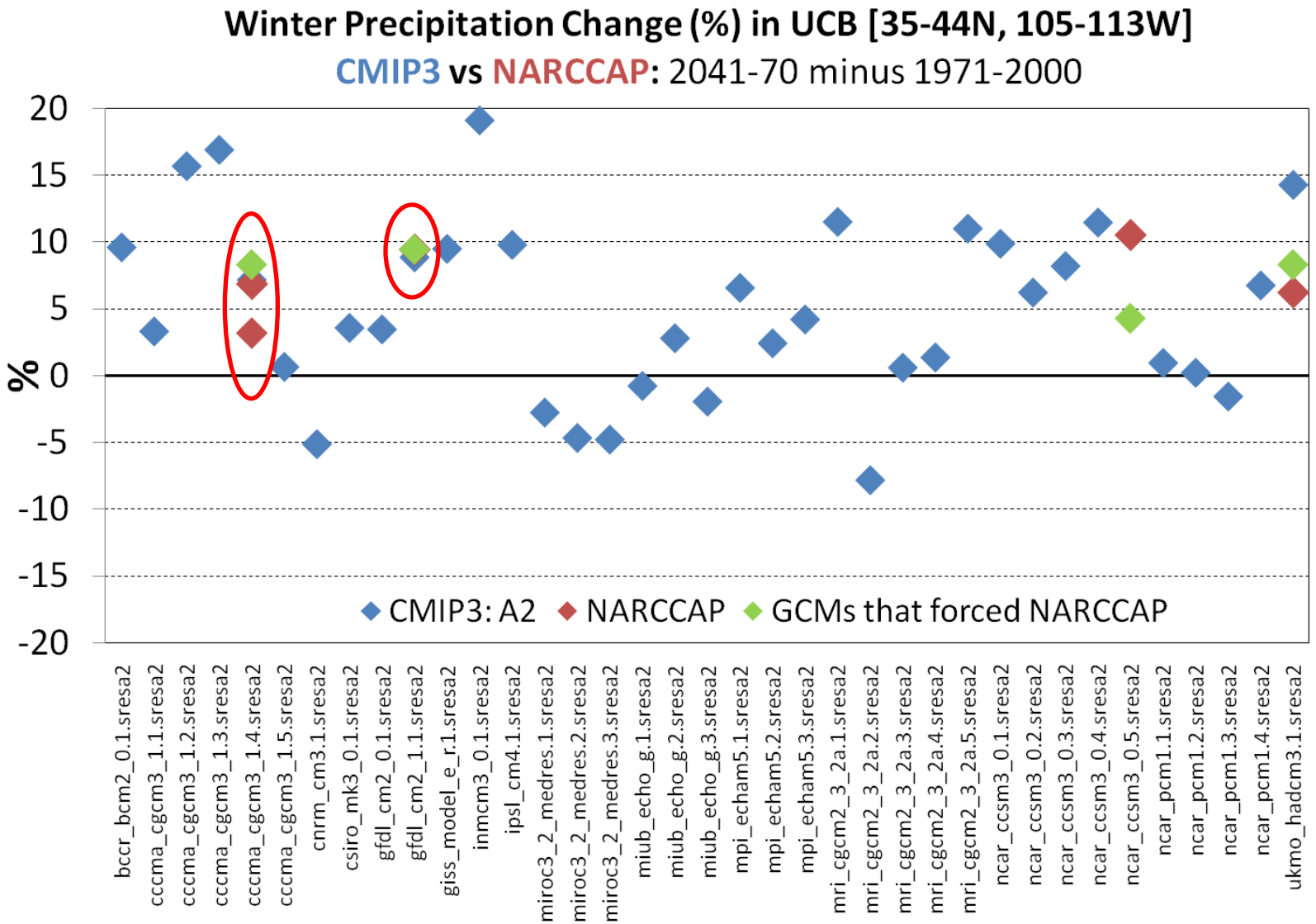
Colorado River Simulation System (CRSS)

- Simulates reservoir operations, deliveries
- Takes monthly streamflow amounts at 21 locations in the upper colorado (UC) basin and 8 in the lower (LC) basin
- Starts with current reservoir conditions (2010) and run forward in time to 2100
- Yields reservoir levels, actual (regulated) flows, (many) other metrics of system operation.

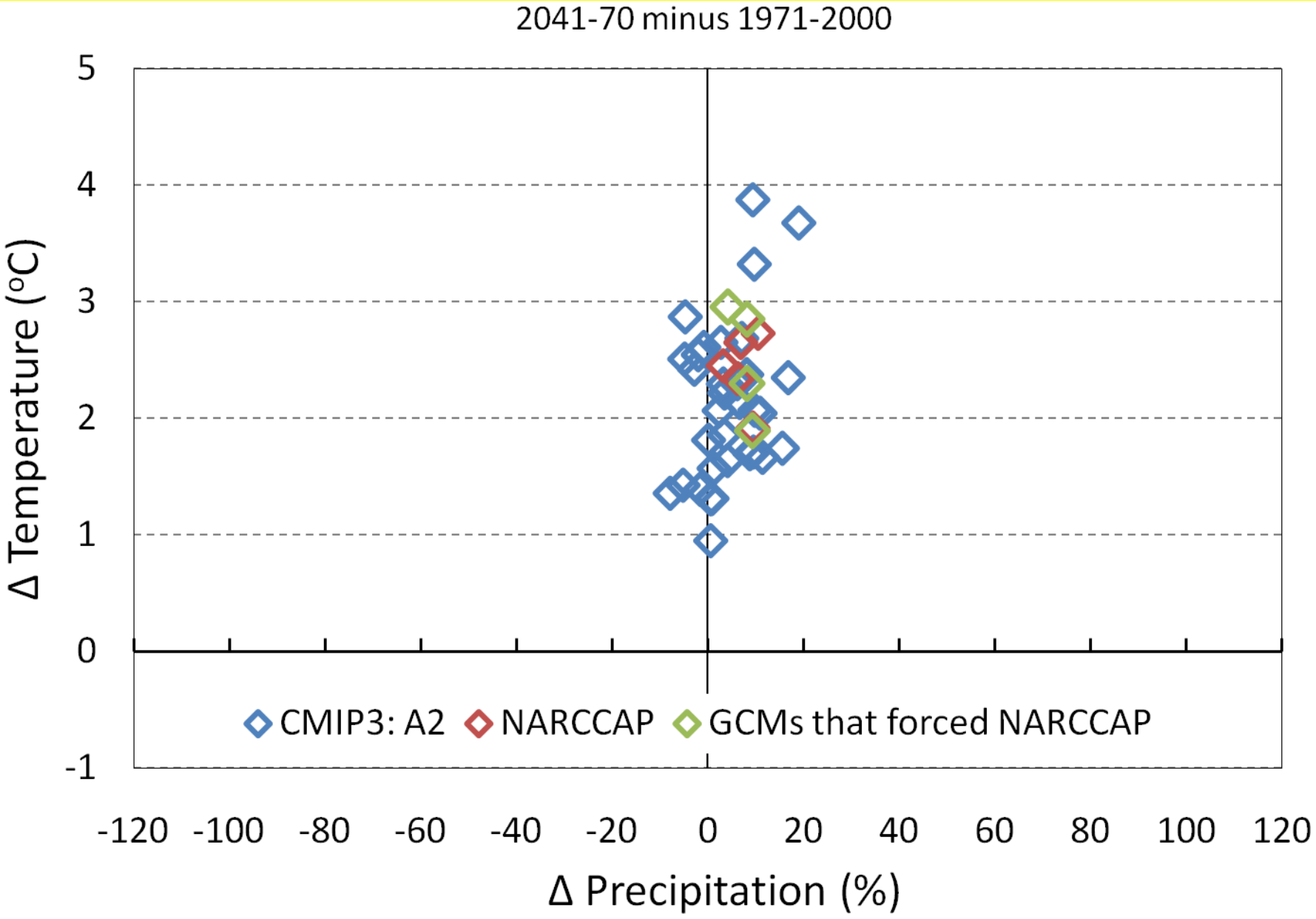


We use NARCCAP-derived flows in the upper Colorado during the two NARCCAP time windows, otherwise use GCM-derived flows.

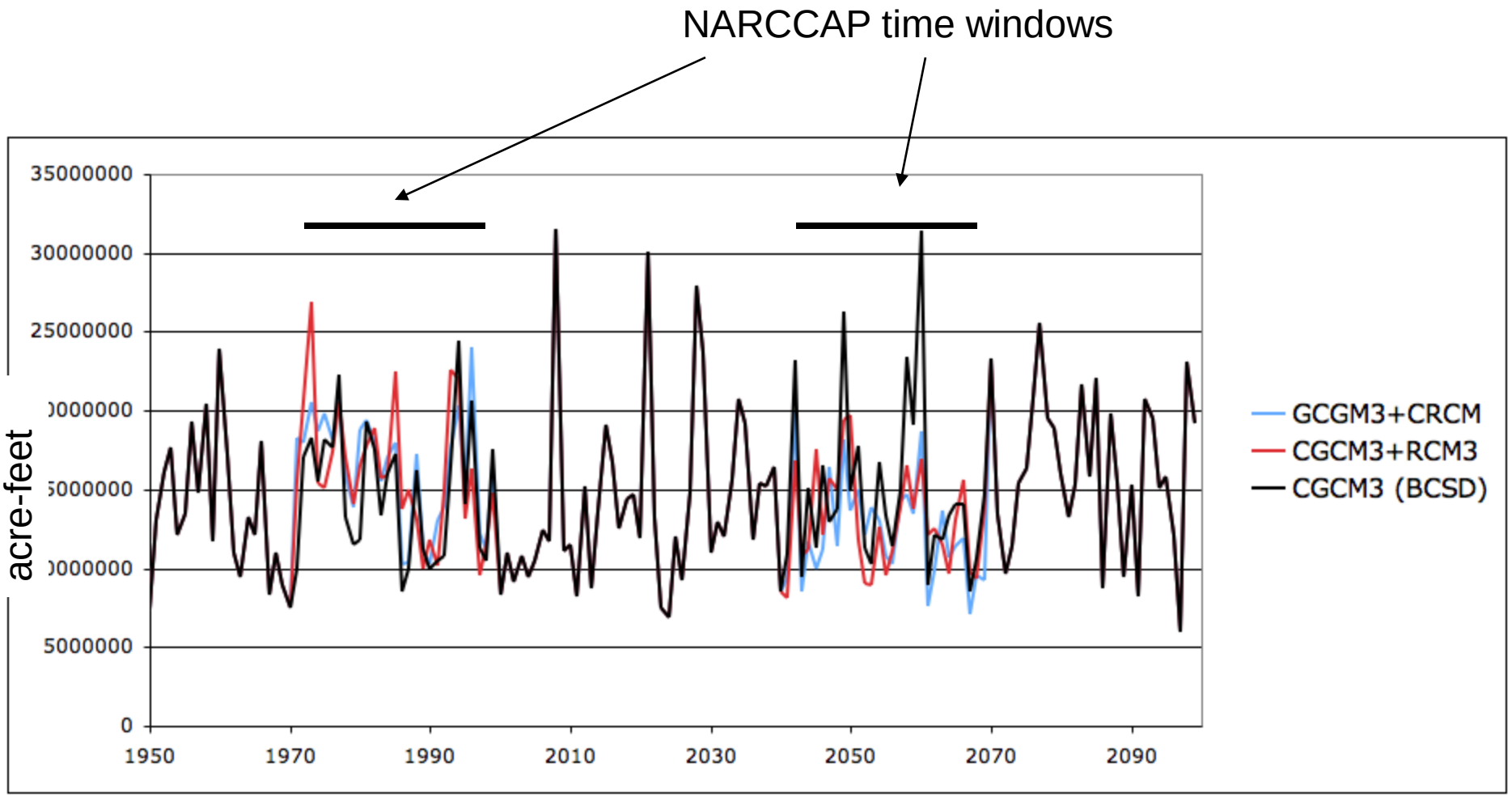
NARCCAP vs. GCM Precipitation Change (UC; Winter)



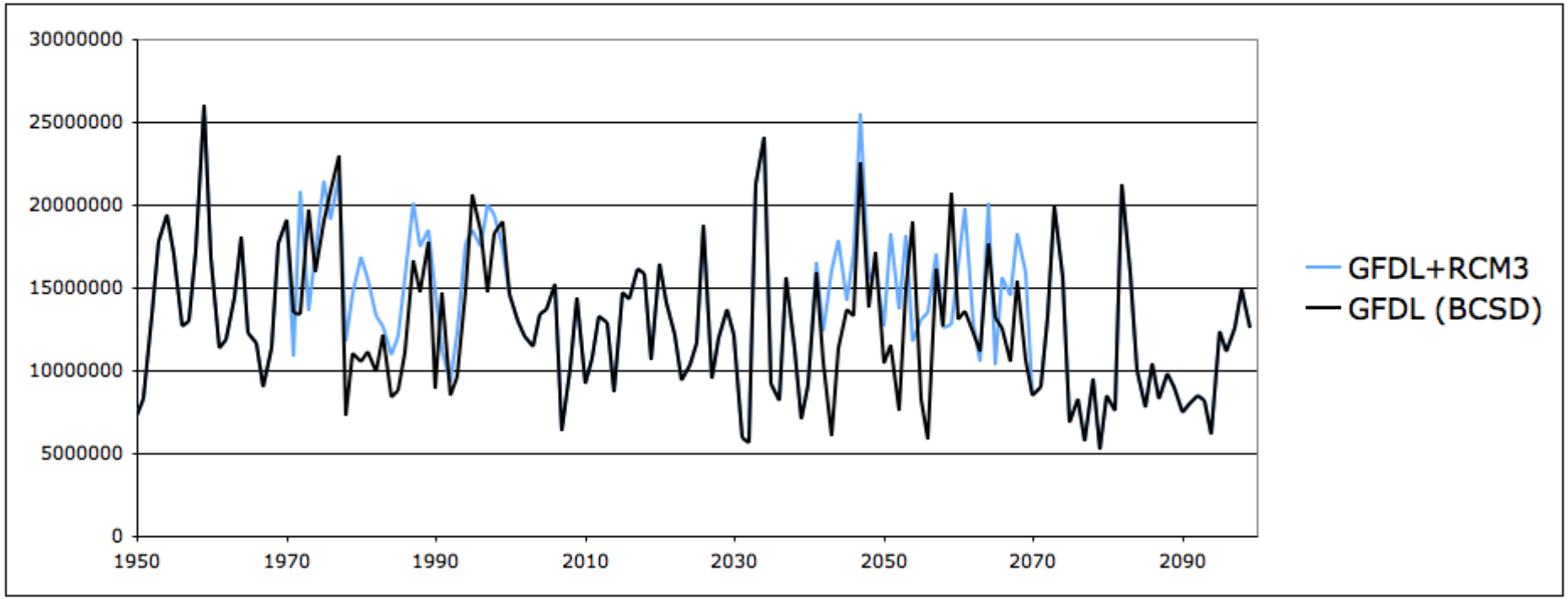
NARCCAP vs. GCM Precipitation and Temperature Change (UC; Winter)



Annual Streamflow at Lees Ferry for CGCM-forced runs

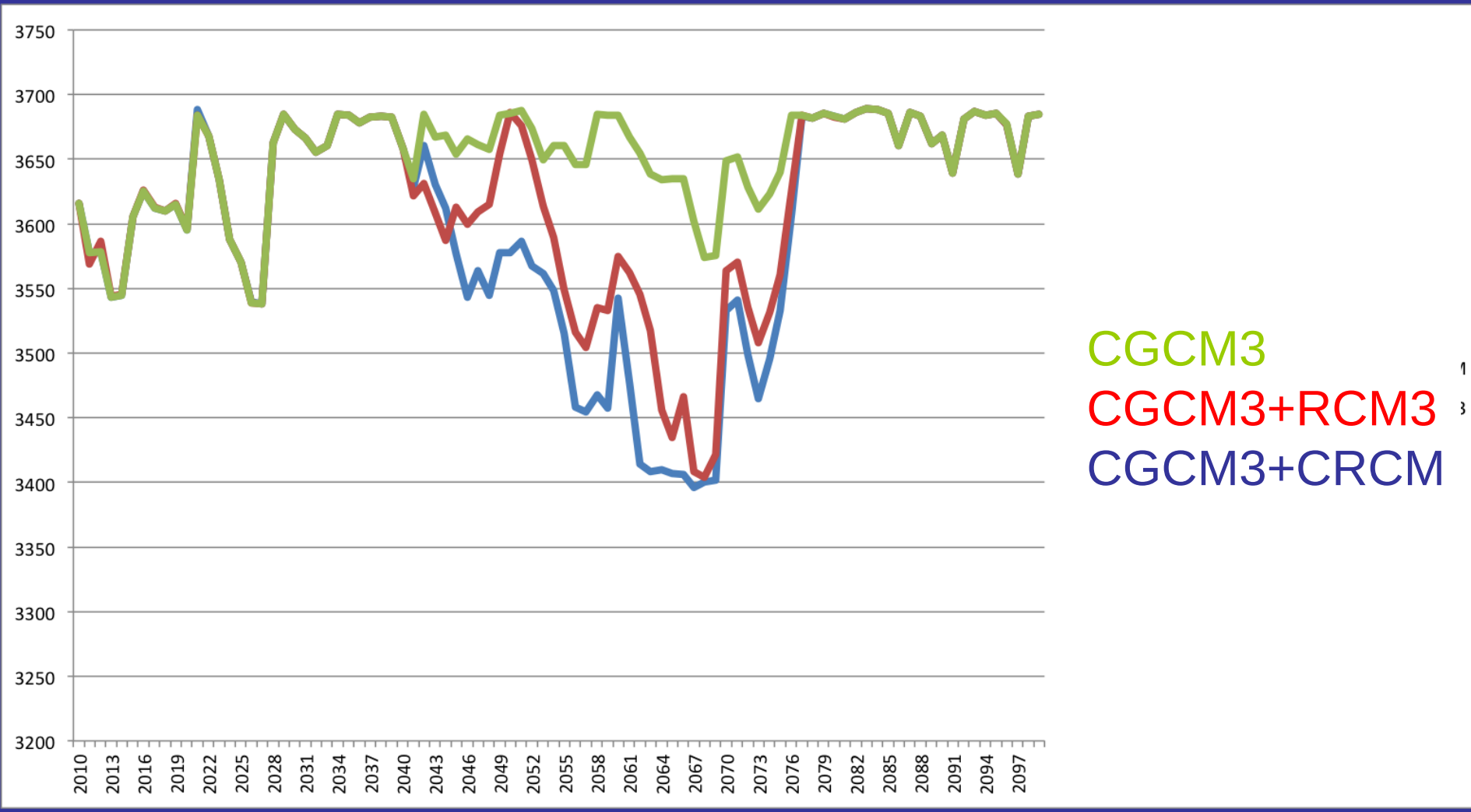


Annual Streamflow at Lees Ferry for GFDL-forced runs

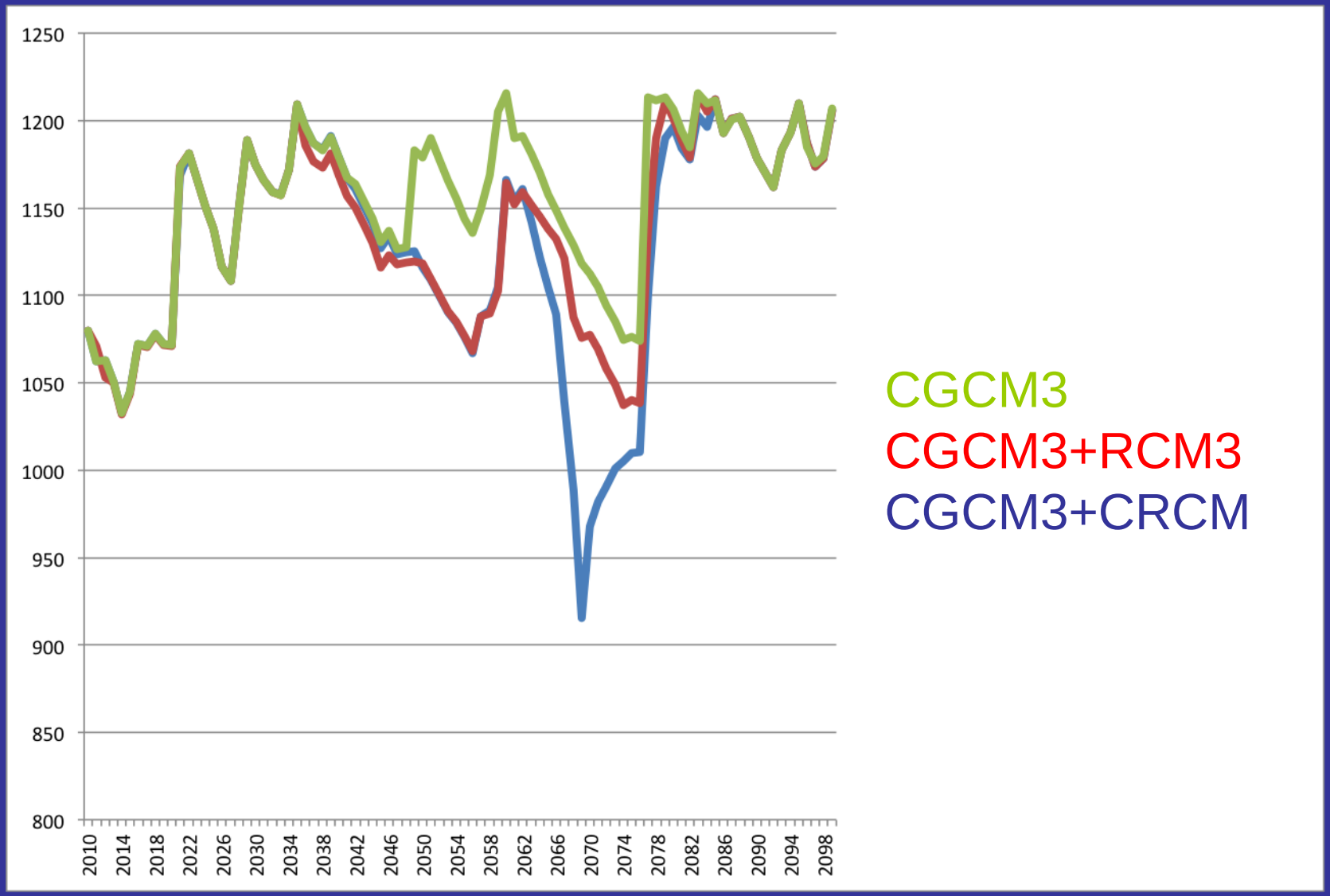


CRSS: Lake Powell and Mead Levels

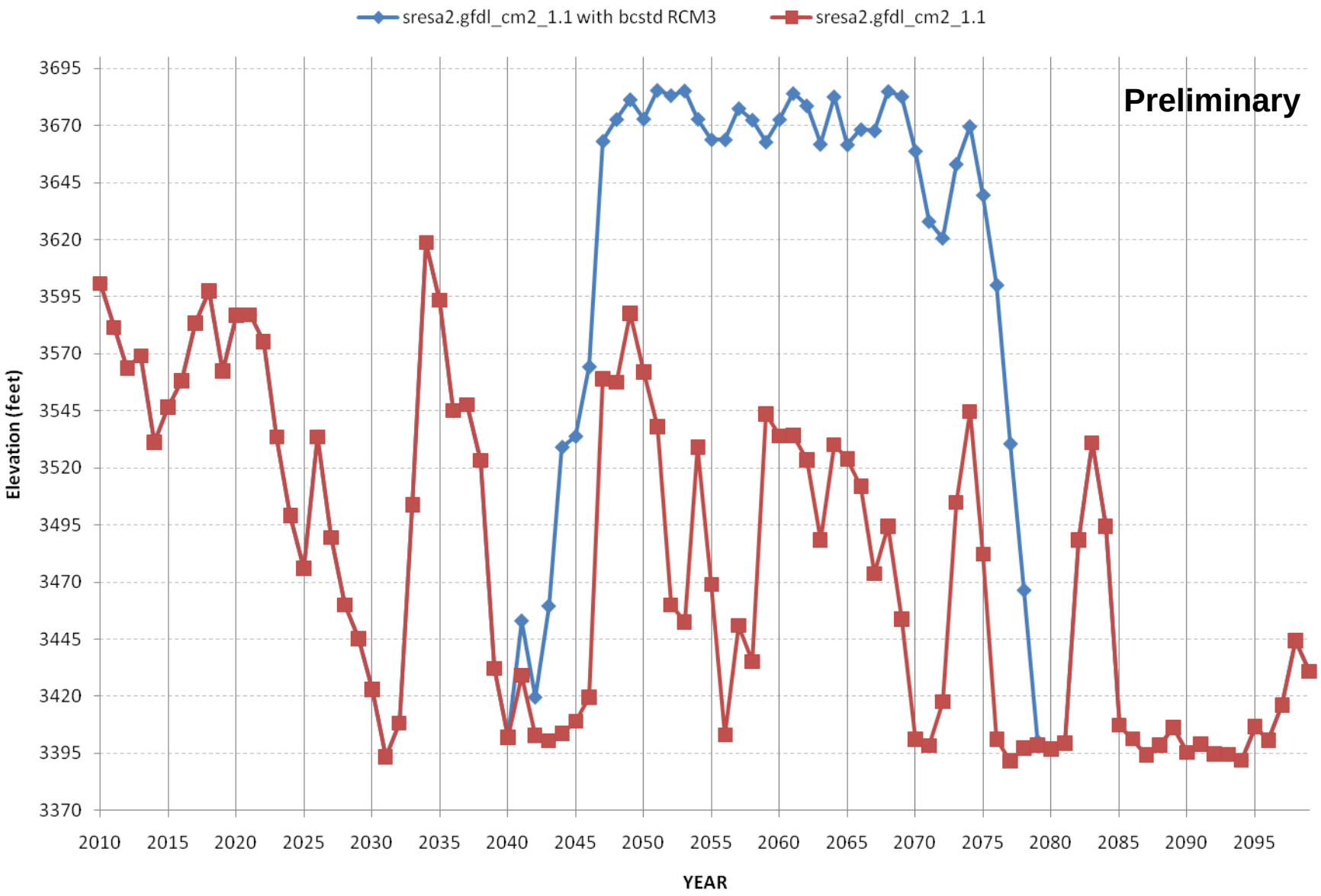
Lake Powell end-of-December Water Elevations



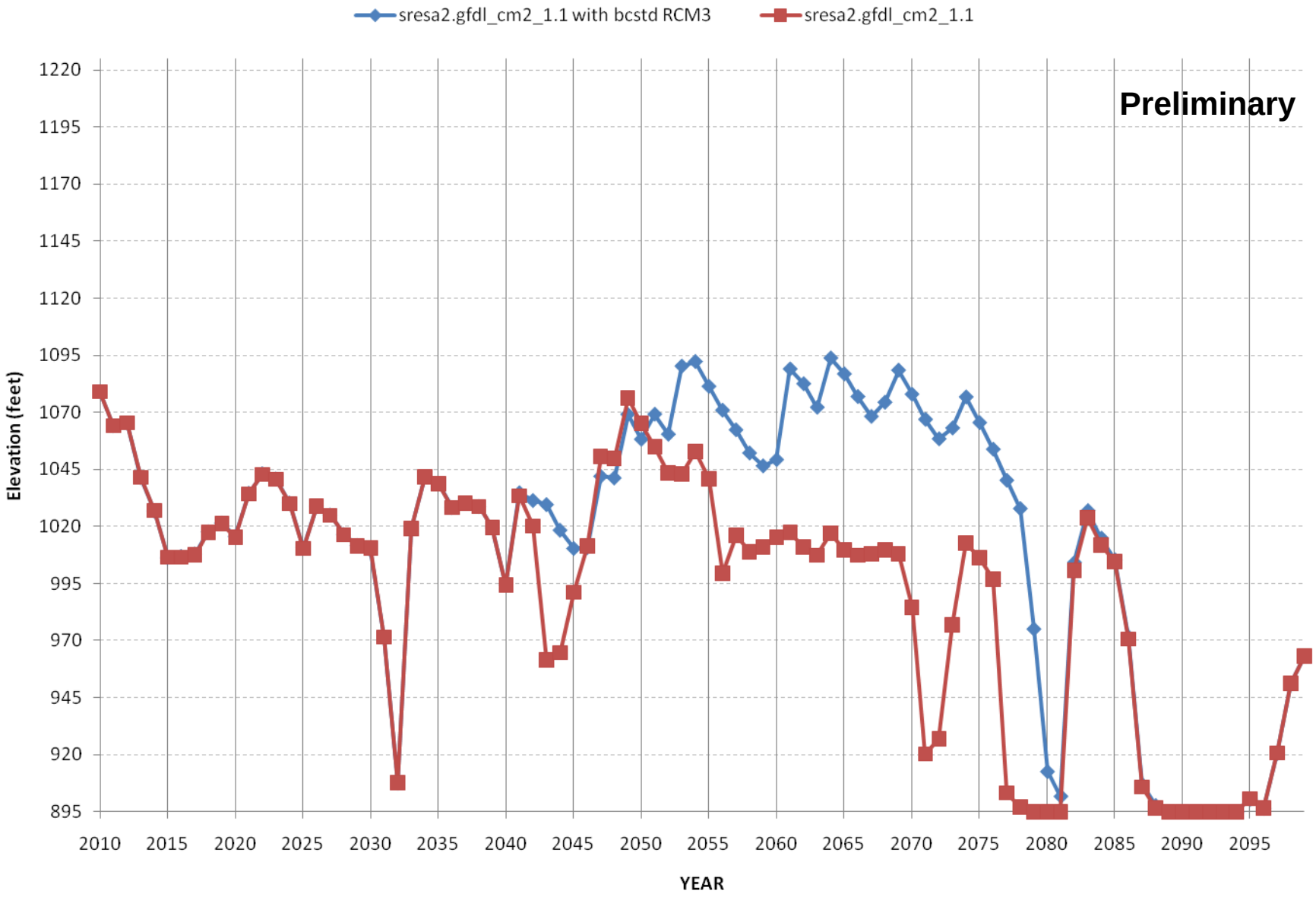
Lake Mead end-of-December Water Elevations



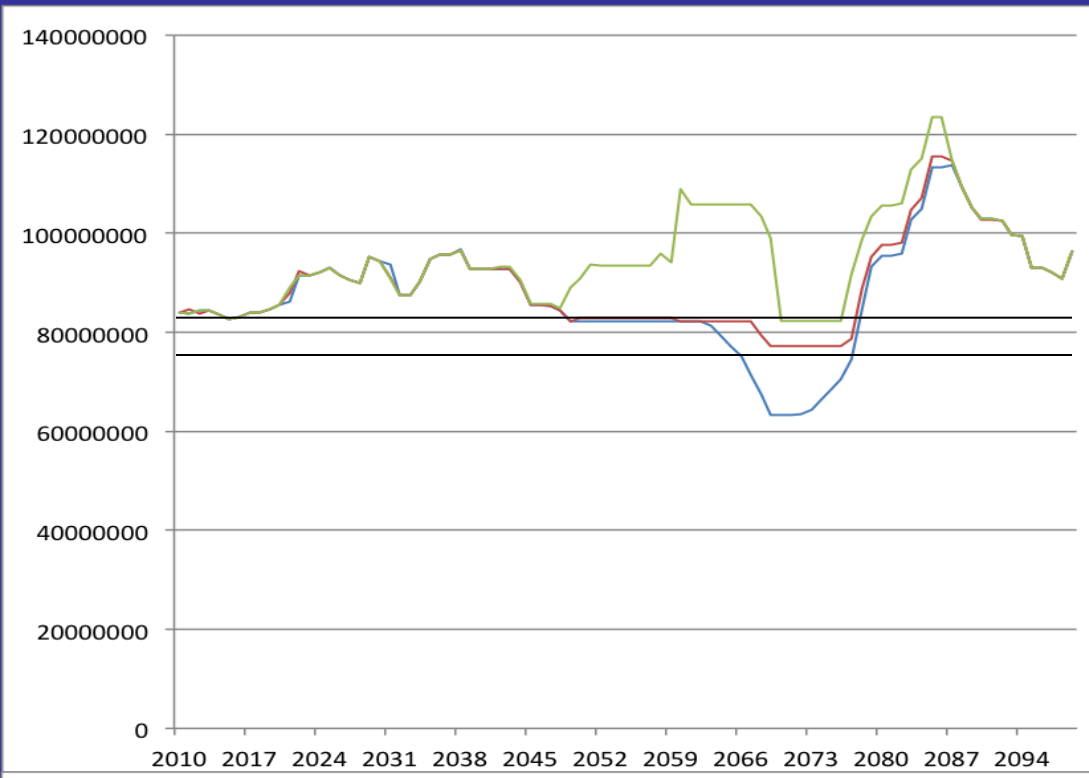
Lake Powell End-of-December Water Elevations



Lake Mead End-of-December Water Elevations



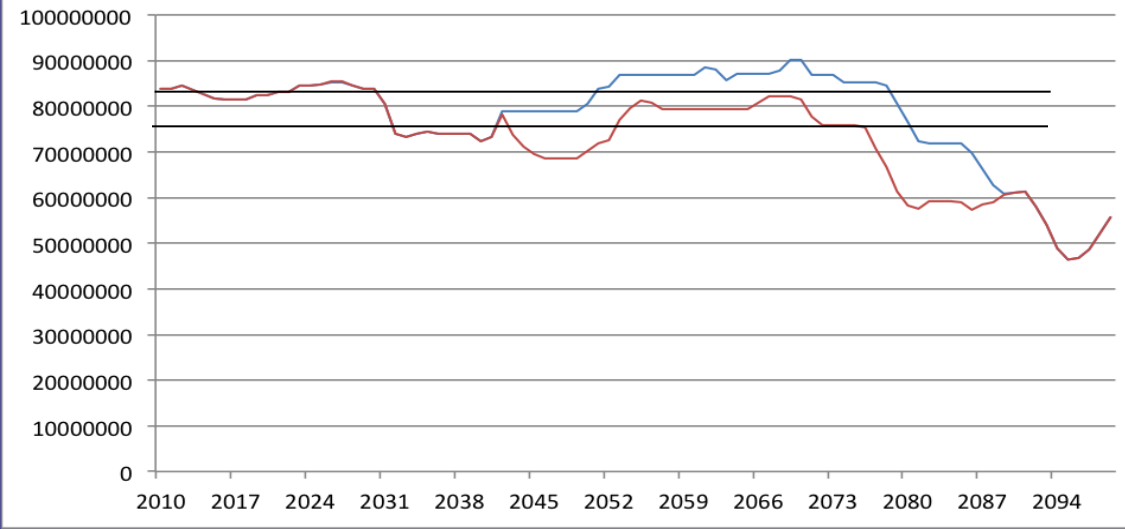
Lake Powell 10 year Water Deliveries



CGCM3

CGCM3+RCM3

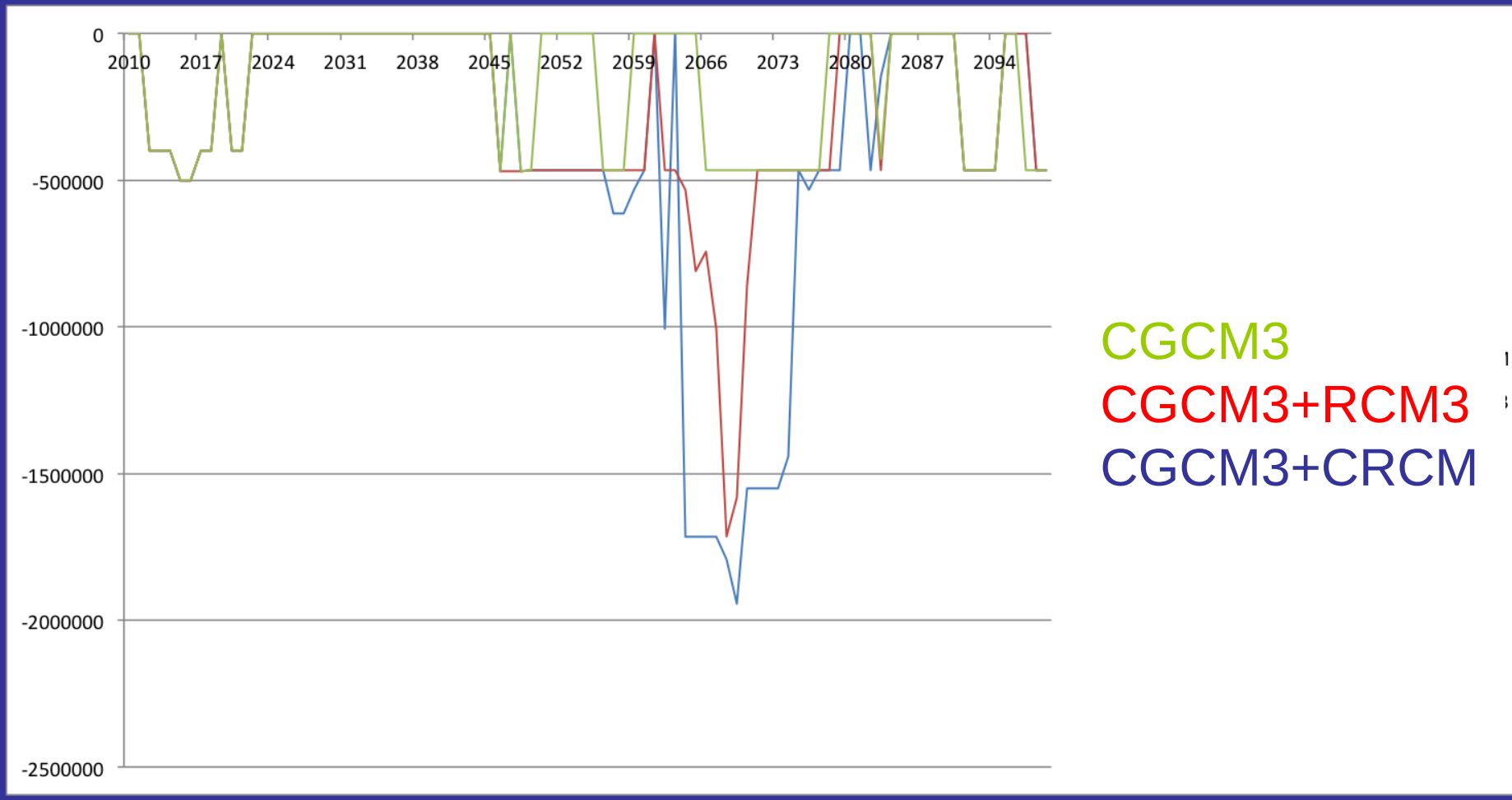
CGCM3+CRCM



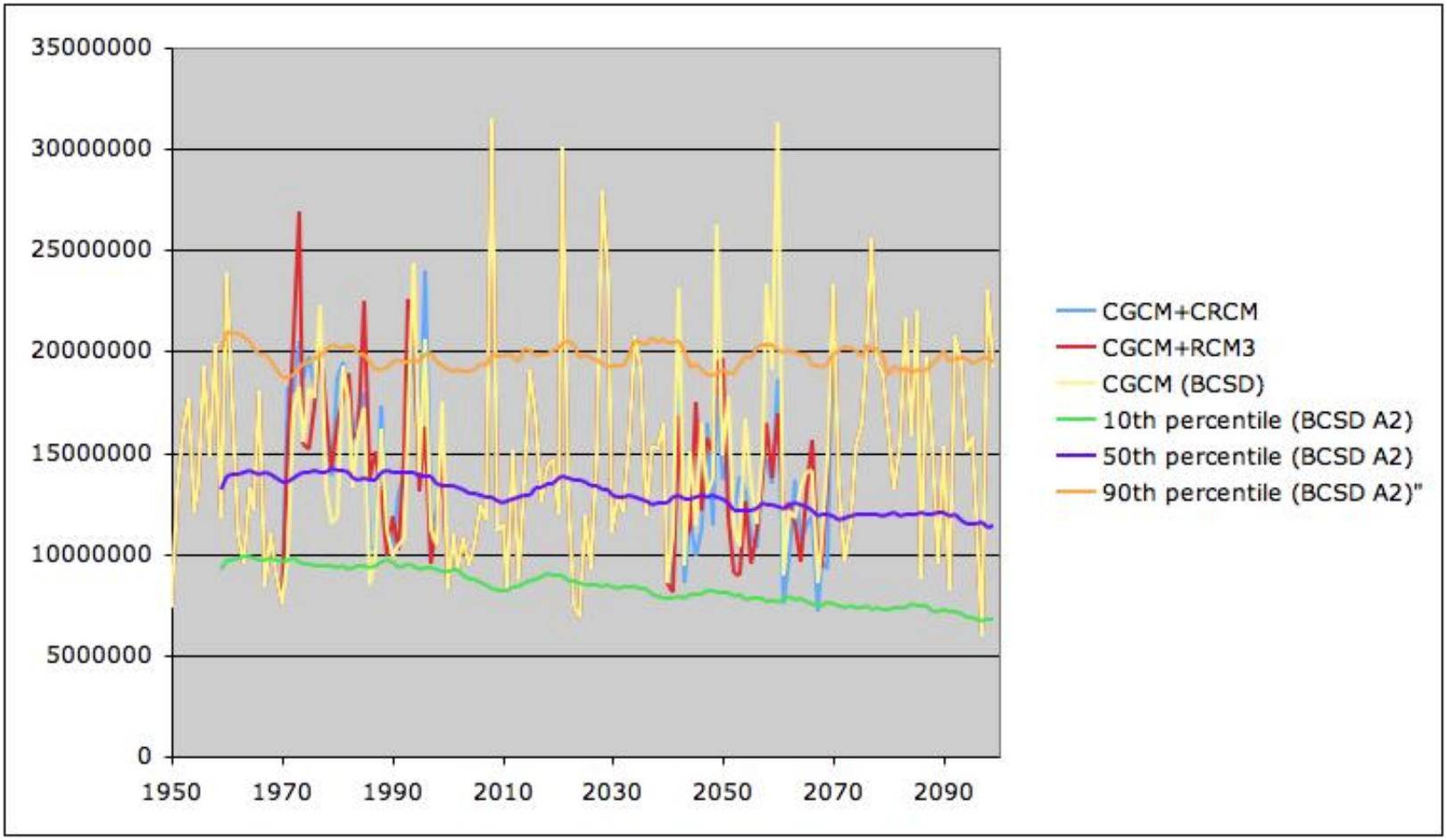
GFDL

GFDL+RCM3

Lower Basin Annual Shortage Amount



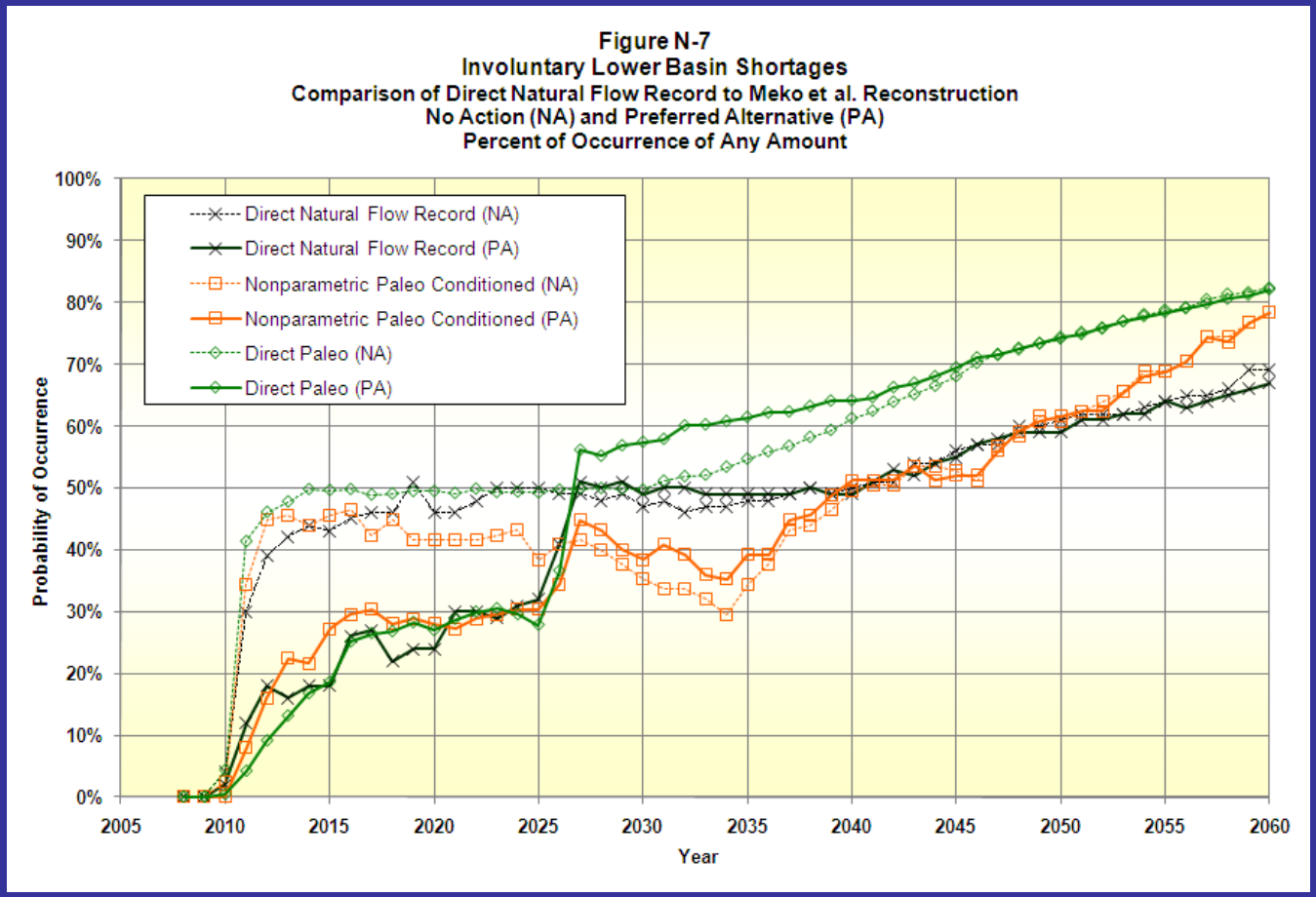
Annual Streamflow at Lees Ferry for CGCM-forced runs



Will the RCMs get lost in the crowd of GCMs?

Where we *might* want to go… Example from the "Interim Guidelines" EIS.

For example, how will inclusion of NARCCAP information change the probabilities of shortage



Bumps in the Road (NARCCAP and BCSD)

Problems with matching GCM runs in the “BCSD” archive with GCM runs used to force NARCCAP

- NARCCAP used CCSM “A2 run5” but only CCSM A2 runs 1-4 were downscaled in BCSD archive

- NARCCAP used “custom” runs from HADCM3 and -- the monthly values are available for the two narccap periods, but would need 1950-2100 to be fully compatible with “projection” methodology.

Bumps in the Road (Hydrologic and System Modeling)

Some methodological issues in bias correction of NARCCAP remain

Issues regarding bias correction of hydrologic model output remain

NARCCAP uses two time slices, but the Basin Study simulation (CRSS) methodology uses a continuous time period from 2010 - 2100.

- How to deal with periods where NARCCAP models not run?
- How to initialize reservoirs in “2040”
- How to incorporate 1971-2000 NARCCAP period?

Use of “T and P” forcing based on monthly averages throws out a lot of potential information from NARCCAP runs. Yet… some sort of strong bias correction is probably needed to run a calibrated hydrologic model.

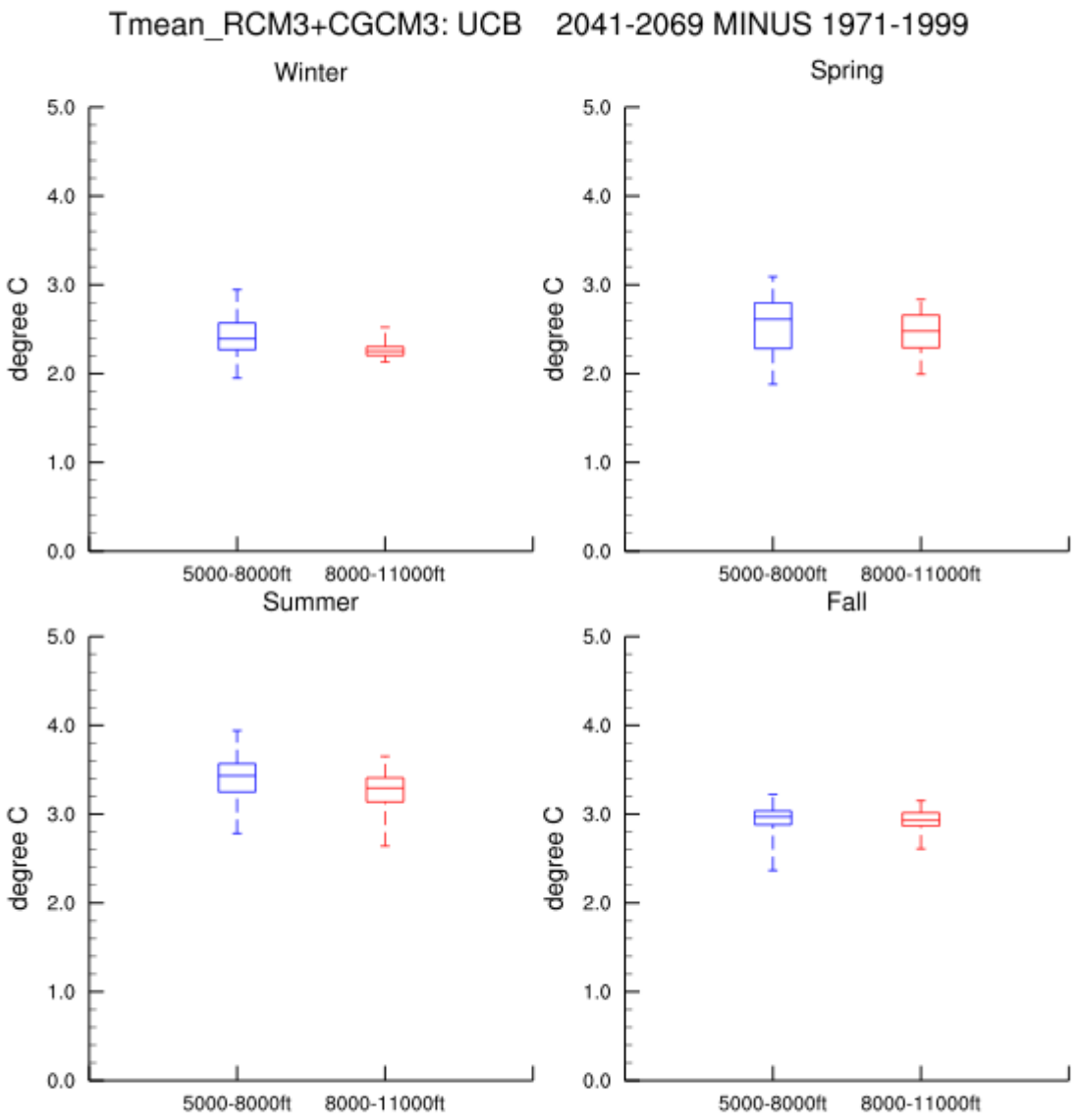
So far…

RCM effects not is not necessarily in the same direction (GFDL+RCM3 is wetter compared to the GFDL run, CGCM+RCM3 is drier)

Reservoir modeling/operations is very nonlinear, so changes in flows due to new information from RCMs -- particularly near certain thresholds -- may trigger large changes in reservoir levels.

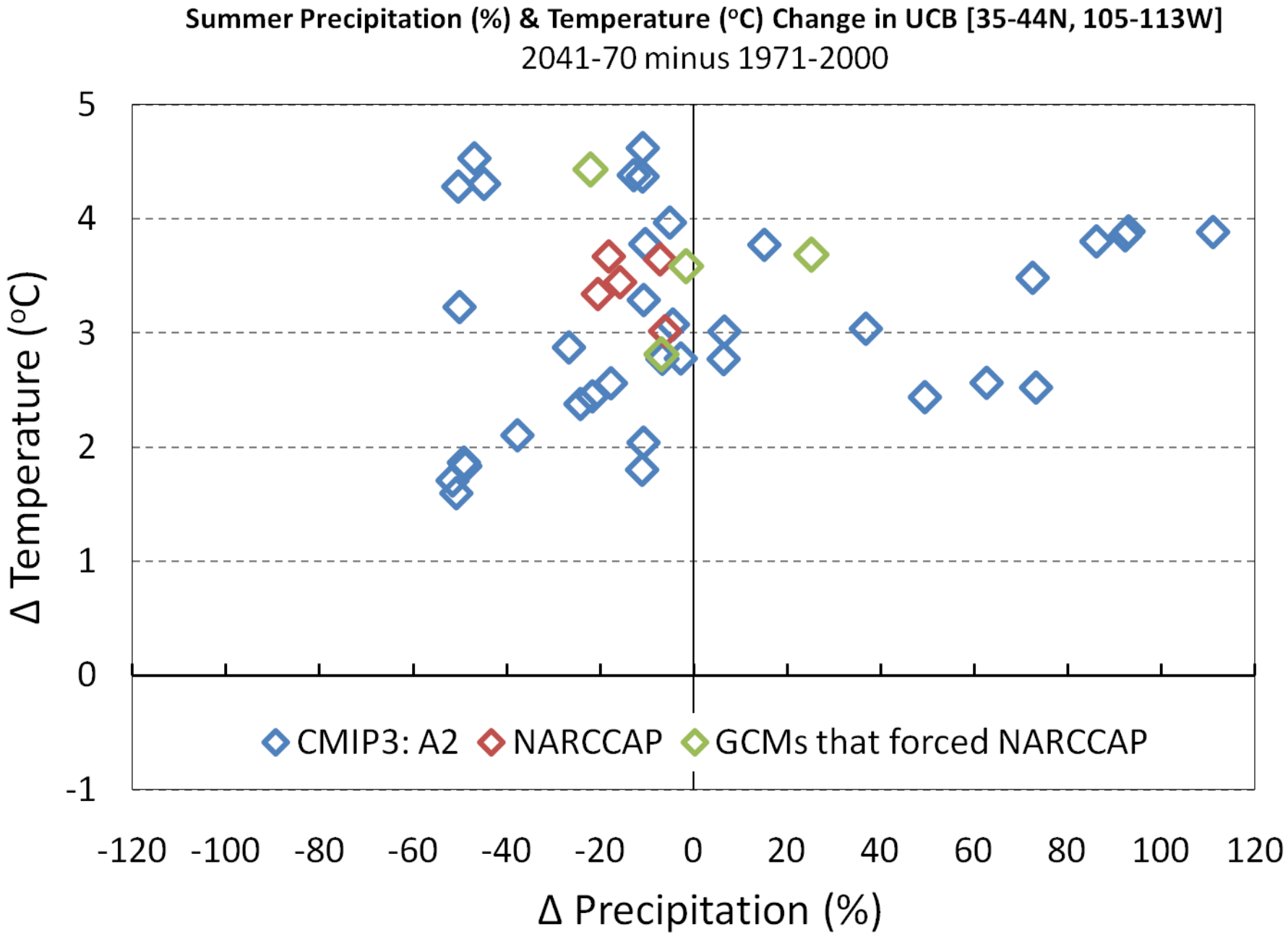
END

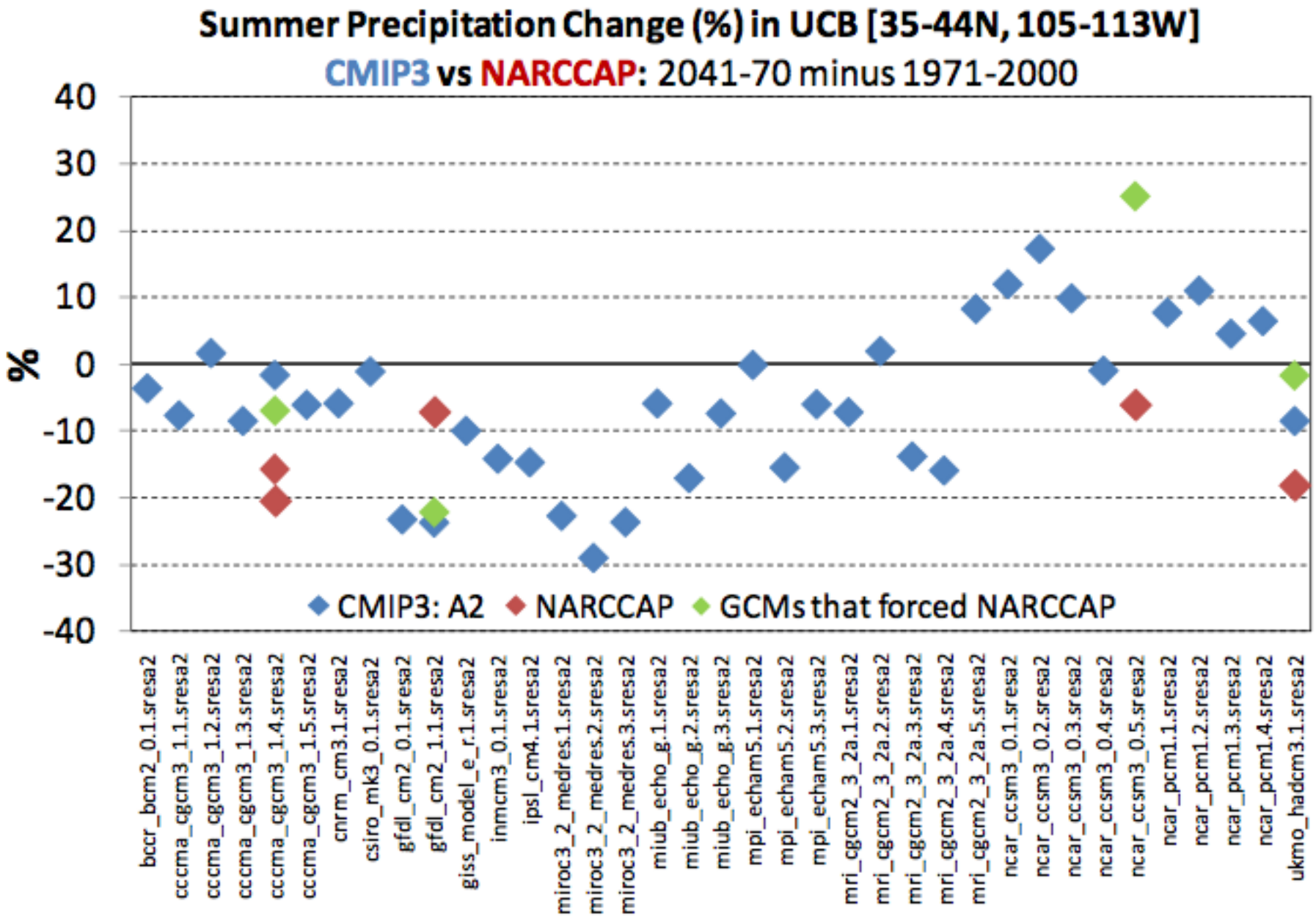
Temperature change vs. Elevation



Surprisingly little dependence on elevation in Tavg for most models, most seasons.

(though there is an elevation dependance for Tmin and Tmax in some seasons for some models)


Summer Precipitation (%) & Temperature (°C) Change in UCB [35-44N, 105-113W]
2041-70 minus 1971-2000
Δ Temperature (°C)
5
4
3
2
1
0
-1
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
Δ Precipitation (%)
CMIP3: A2
NARCCAP
GCMs that forced NARCCAP


Summer Precipitation Change (%) in UCB [35-44N, 105-113W]
CMIP3 vs NARCCAP: 2041-70 minus 1971-2000
40
30
20
10
0
-10
-20
-30
-40
%
CMIP3: A2
NARCCAP
GCMs that forced NARCCAP
bccr_bcm2_0.1.sresa2
cccma_cgcm3_1.1.sresa2
cccma_cgcm3_1.2.sresa2
cccma_cgcm3_1.3.sresa2
cccma_cgcm3_1.4.sresa2
cccma_cgcm3_1.5.sresa2
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csiro_mk3_0.1.sresa2
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miub_echo_g.1.sresa2
miub_echo_g.2.sresa2
miub_echo_g.3.sresa2
mpi_echam5.1.sresa2
mpi_echam5.2.sresa2
mpi_echam5.3.sresa2
mri_cgcm2_3_2a.1.sresa2
mri_cgcm2_3_2a.2.sresa2
mri_cgcm2_3_2a.3.sresa2
mri_cgcm2_3_2a.4.sresa2
mri_cgcm2_3_2a.5.sresa2
ncar_ccsm3_0.1.sresa2
ncar_ccsm3_0.2.sresa2
ncar_ccsm3_0.3.sresa2
ncar_ccsm3_0.4.sresa2
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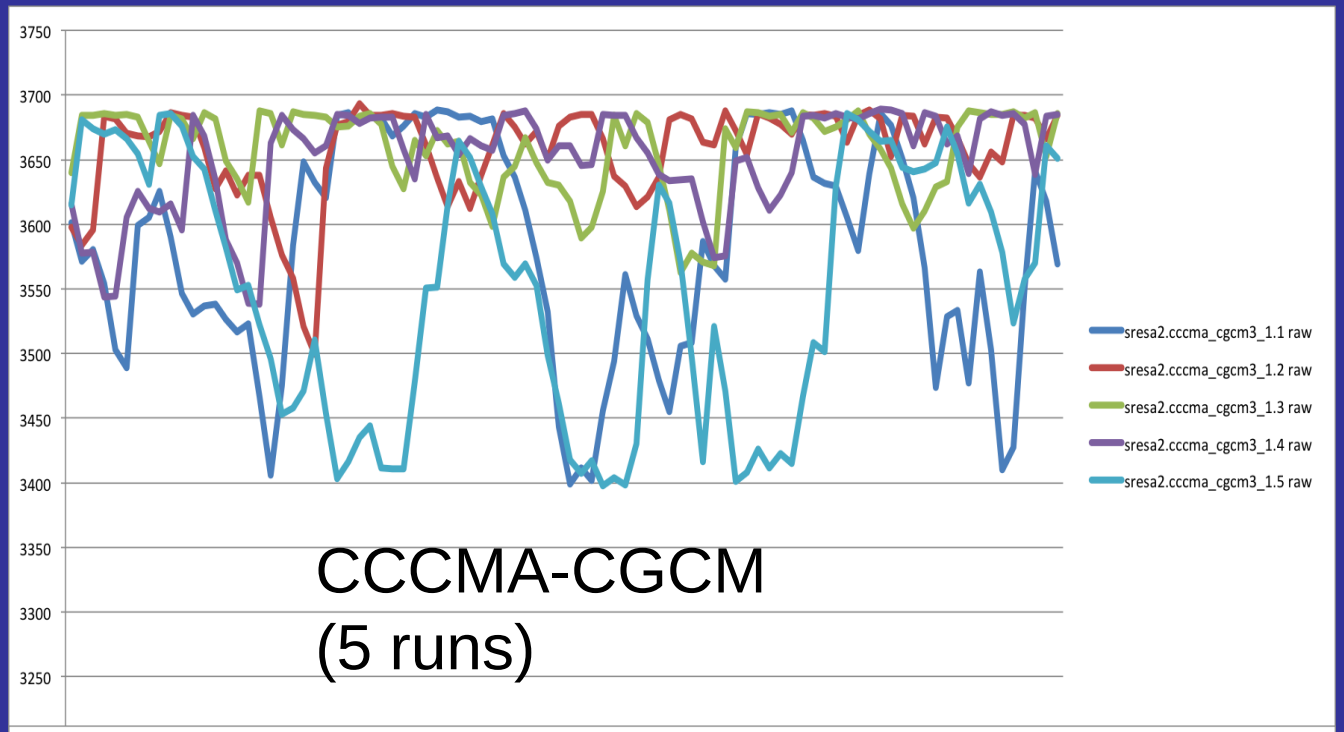
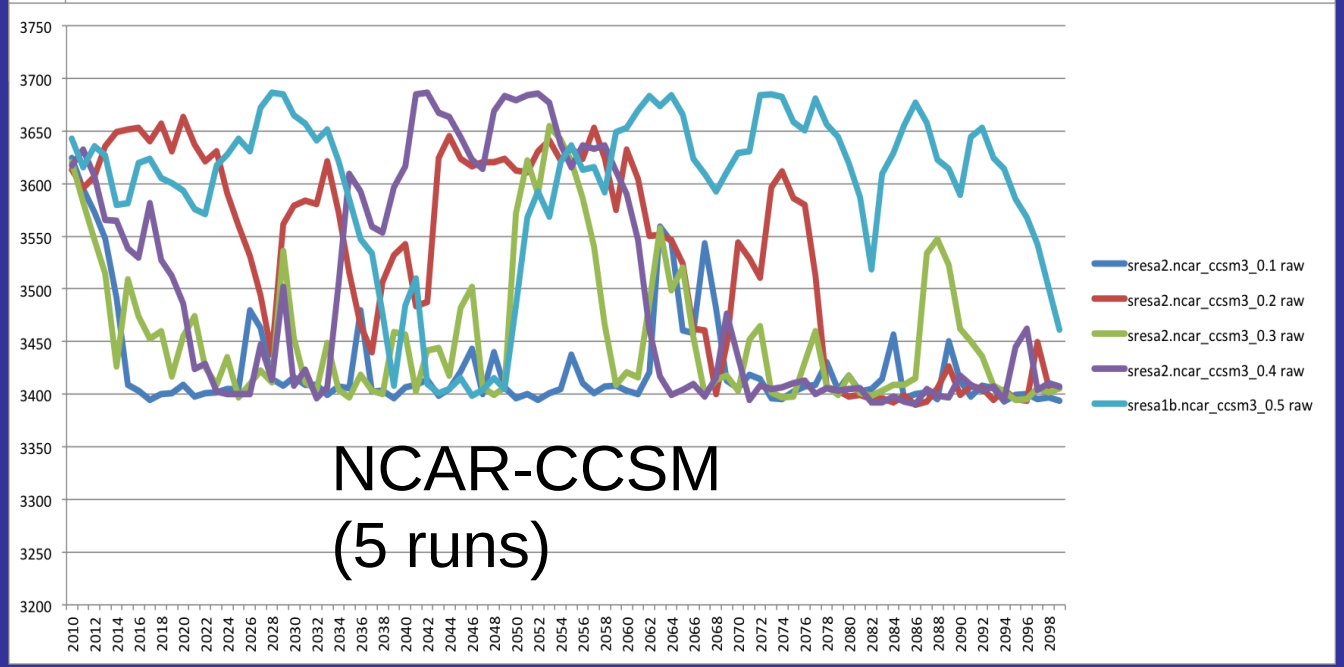
ncar_pcm1.4.sresa2
ukmo_hadcm3.1.sresa2


3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
3250
sresa2.cccma_cgcm3_1.1 raw
sresa2.cccma_cgcm3_1.2 raw
sresa2.cccma_cgcm3_1.3 raw
sresa2.cccma_cgcm3_1.4 raw
sresa2.cccma_cgcm3_1.5 raw
CCCMA-CGCM
(5 runs)


3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
3250
3200
2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040 2042 2044 2046 2048 2050 2052 2054 2056 2058 2060 2062 2064 2066 2068 2070 2072 2074 2076 2078 2080 2082 2084 2086 2088 2090 2092 2094 2096 2098
sresa2.ncar_ccsm3_0.1 raw
sresa2.ncar_ccsm3_0.2 raw
sresa2.ncar_ccsm3_0.3 raw
sresa2.ncar_ccsm3_0.4 raw
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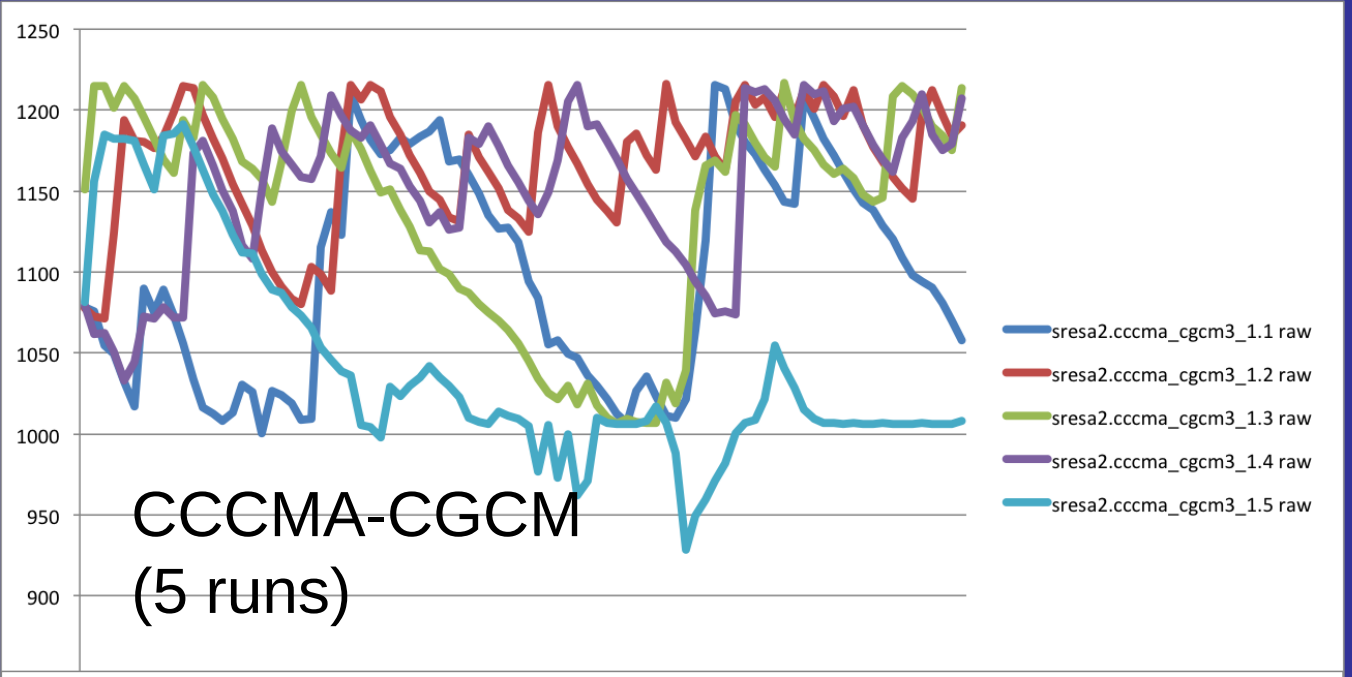
NCAR-CCSM
(5 runs)


1250
1200
1150
1100
1050
1000
950
900
CCCMA-CGCM
(5 runs)
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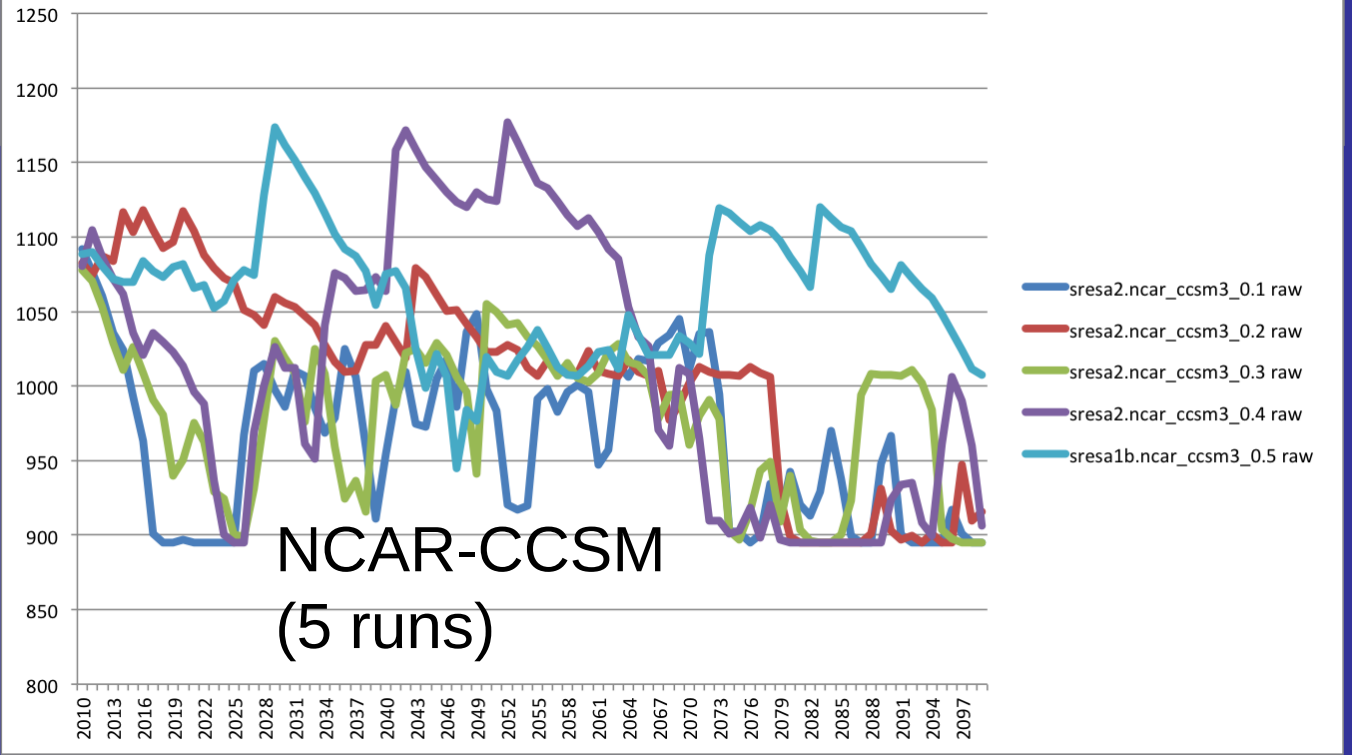
sresa2.cccma_cgcm3_1.3 raw
sresa2.cccma_cgcm3_1.4 raw
sresa2.cccma_cgcm3_1.5 raw


1250
1200
1150
1100
1050
1000
950
900
850
800
NCAR-CCSM
(5 runs)
2010
2013
2016
2019
2022
2025
2028
2031
2034
2037
2040
2043
2046
2049
2052
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2091
2094
2097
sresa2.ncar_ccsm3_0.1 raw
sresa2.ncar_ccsm3_0.2 raw
sresa2.ncar_ccsm3_0.3 raw
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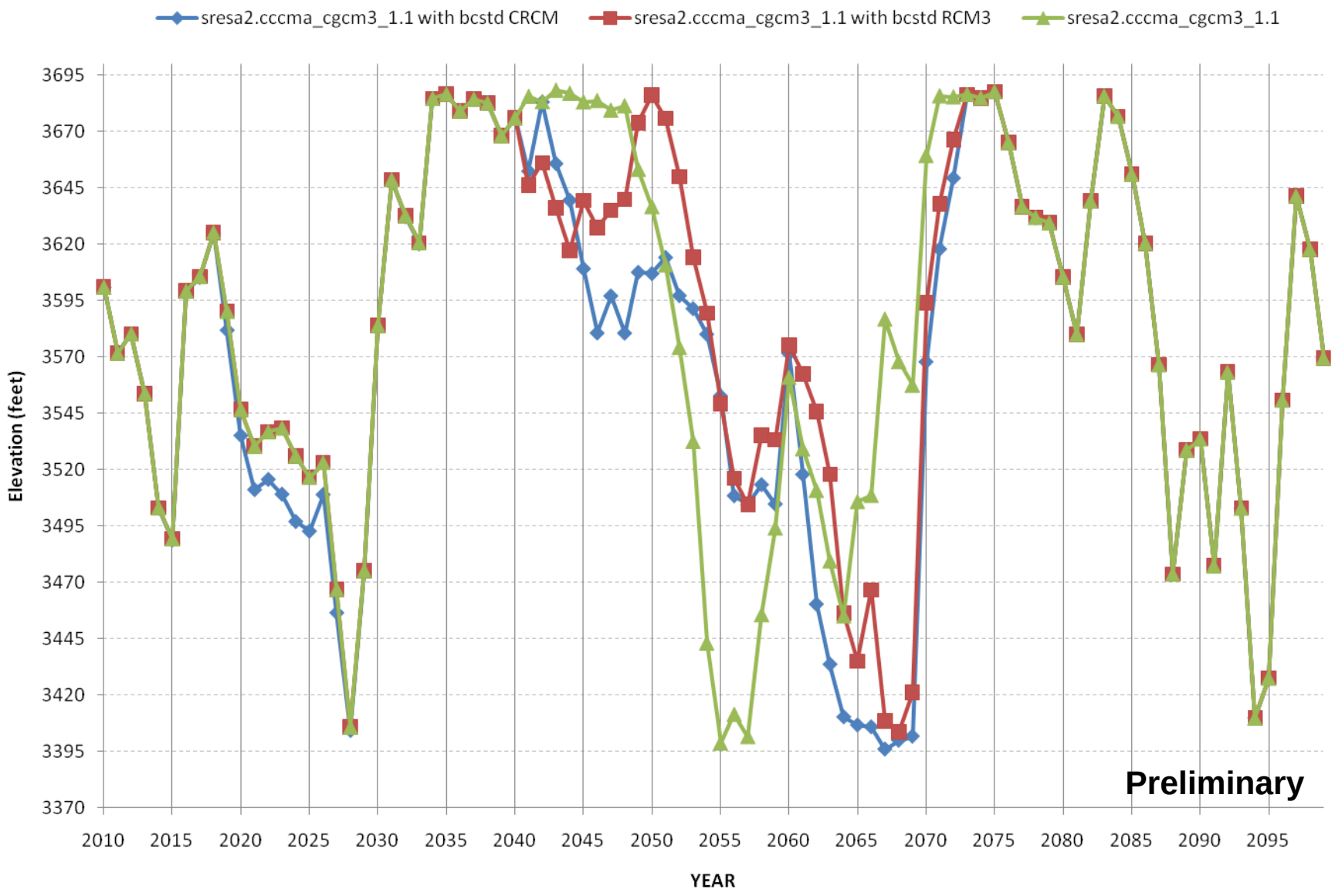
sresa1b.ncar_ccsm3_0.5 raw

Lake Powell End-of-December Water Elevations



Lake Mead End-of-December Water Elevations