



Sixth Annual — 2009
Climate Change Symposium

*The Future Is Now: Climate Change Mitigation,
Impacts, and Adaptation Research*



New Statistical Downscaling Techniques for California and the West

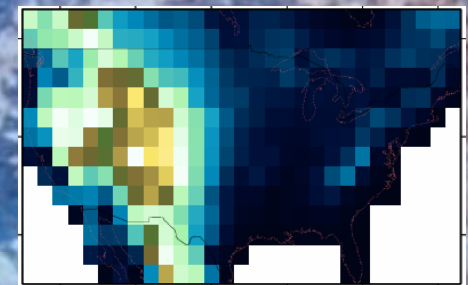
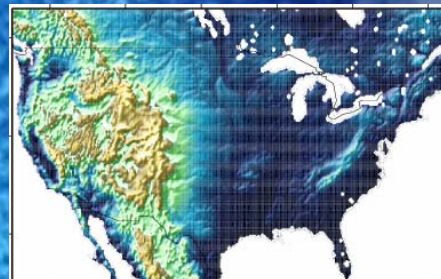
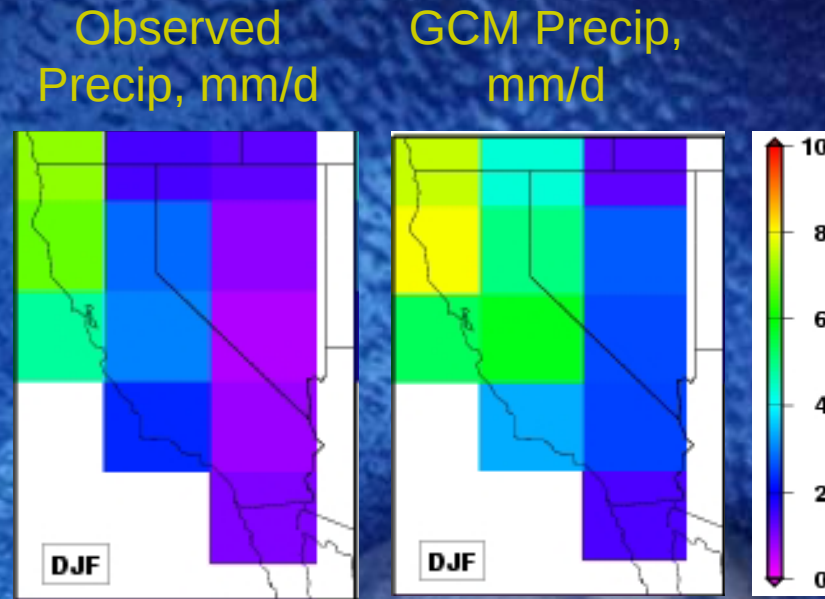
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Projecting Future Climate - GCMs

- Climate Models (GCMs) Necessary
- These have biases
 - Spatial resolution
 - Parameterization
 - etc.
- At inappropriate scale for most impact analysis



Need for Downscaling

- Dynamic
 - Better representation of terrain captures local processes and feedbacks
 - Computationally expensive
 - Still contain biases
- Statistical
 - Assumes stationary transfer function

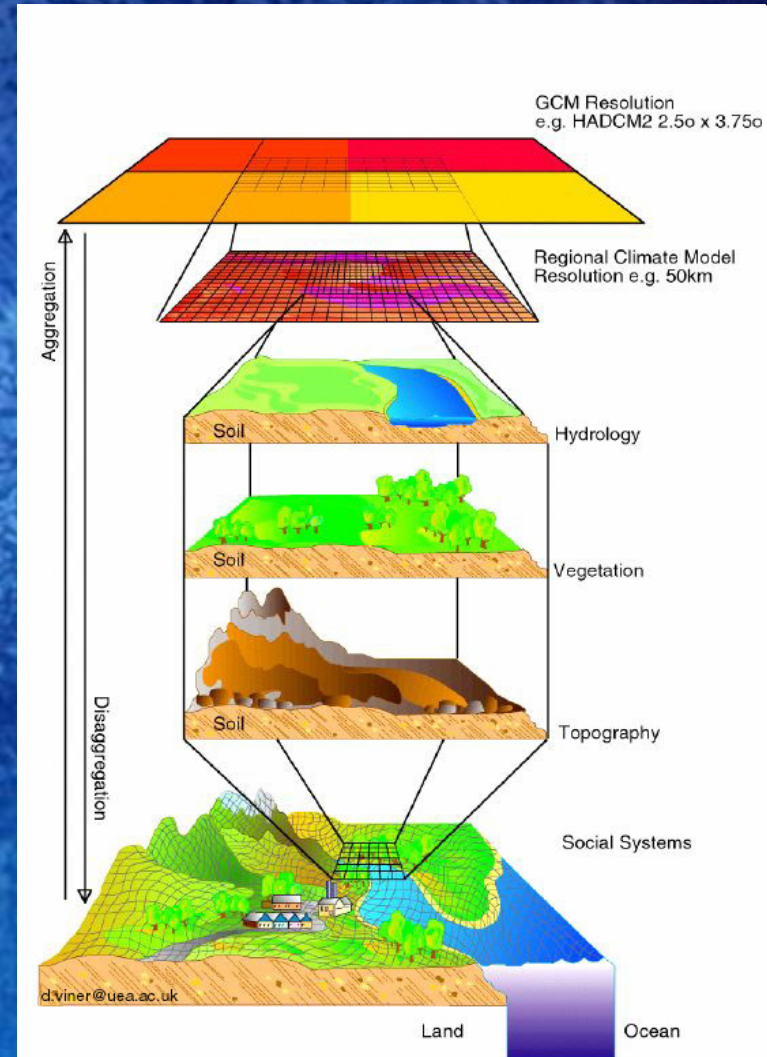
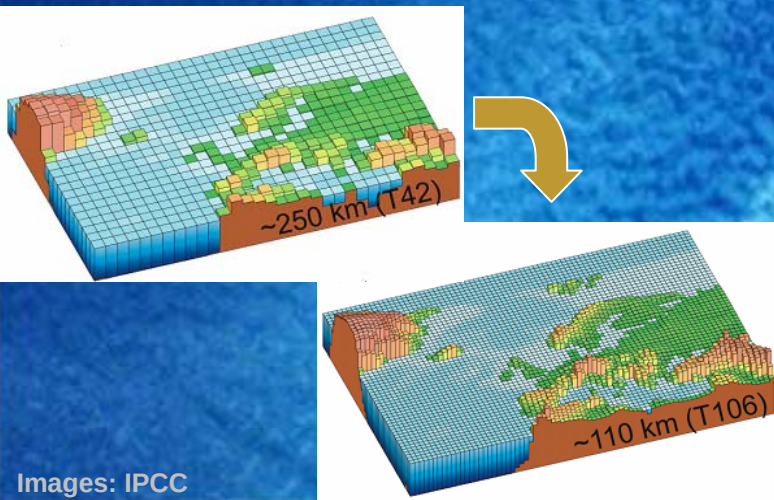
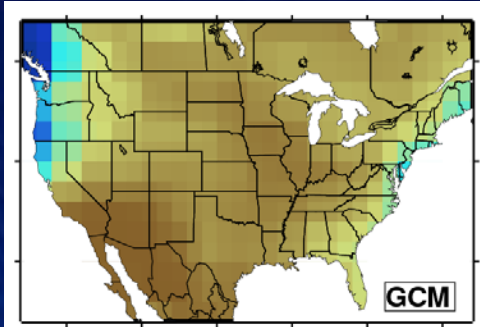
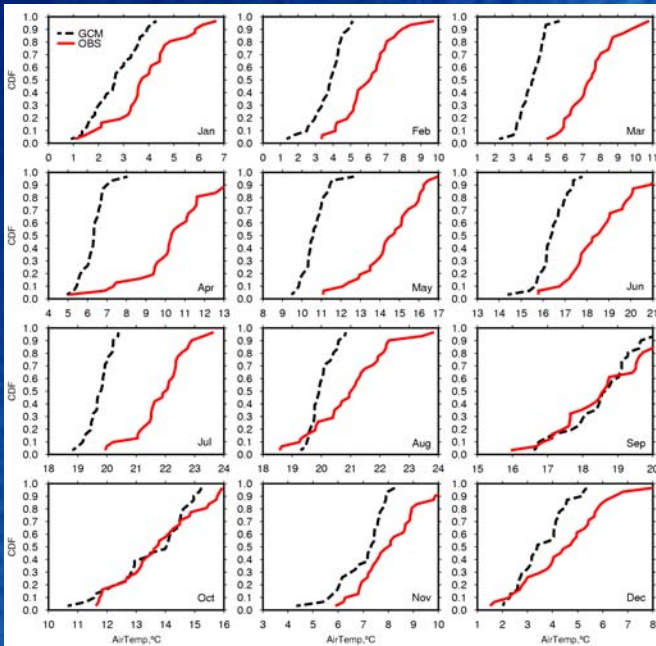


Image: Canadian Climate Change Scenarios Network

BCSD Method – “BC”

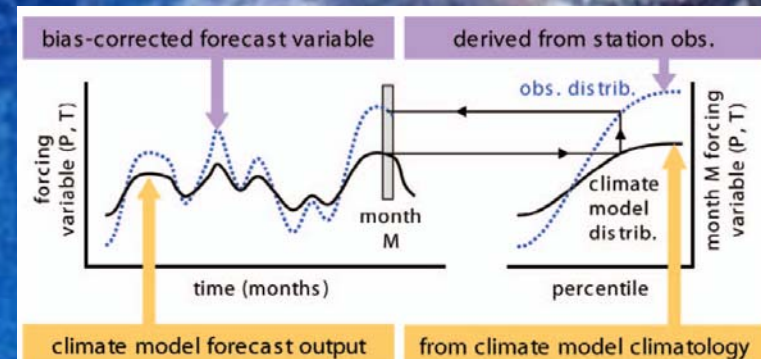


- At each grid cell for “training” period, develop monthly CDFs of P, T for
 - GCM
 - Observations (aggregated to GCM scale)
 - *Obs are from Maurer et al. [2002]*

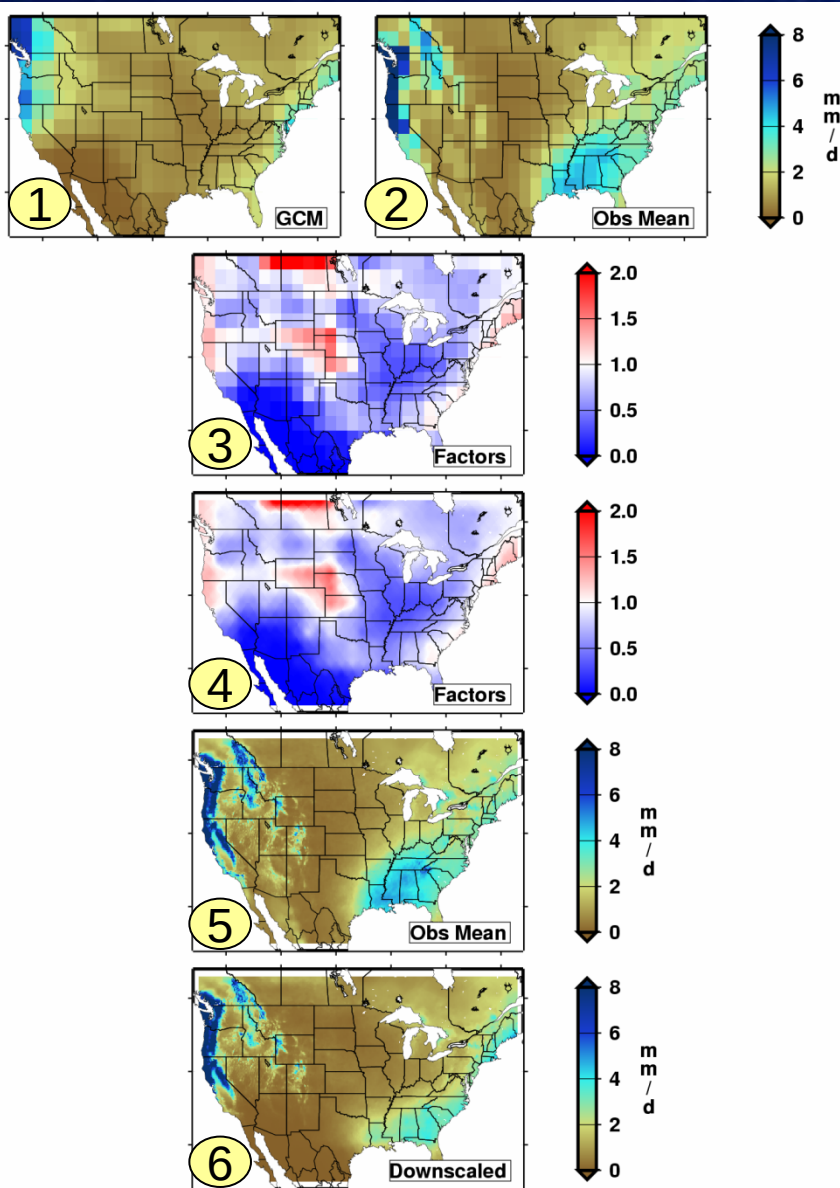


- Use quantile mapping to ensure monthly statistics (at GCM scale) match
- Apply same quantile mapping to “projected” period

Wood et al., BAMS 2006



BCSD Method – “SD”



- Use bias-corrected monthly GCM output **1**
 - Aggregate obs to GCM scale **2**
 - Calculate P,T factors relative to coarse-scale climatology
 - $\text{3} = \text{1} / \text{2} \text{ (P)}$ $\text{3} = \text{1} - \text{2} \text{ (T)}$
 - Interpolate factors to $1/8^\circ$ grid **4**
 - Apply to fine-scale climatology
 - $\text{6} = \text{4} * \text{5} \text{ (P)}$ $\text{6} = \text{4} + \text{5} \text{ (T)}$
- Daily Values from rescaled historical values**

BCSD is Computationally Parsimonious

- PCMDI CMIP3 archive of global projections
- New archive of 112 downscaled GCM runs
- gdo4.ucllnl.org/downscaled_cmip3_projections
- Allows quick analysis of multi-model ensembles

Downscaled Climate Projections Archive

Welcome About Data Retrieval: Standard Data Retrieval: Custom Data Retrieval: Tutorial Links

The form below permits retrieval of data subsets according to user selections for variables, models, emissions scenarios, time periods, geographical areas, series versus statistical output, and output format. Submissions are constrained so that retrieval requests do not exceed approximately 2 gigabytes per request (form responds to user selections to indicate whether the specified request is within this size constraint). Requests are queued at LLNL Green Data Oasis for processing. When request has been processed and made ready for download, user is notified via email submitted in the form below.

Submit Request

Request Size (Mb, limit of 2000)		
NetCDF ASCII Units		
No Analysis	0	0
Statistics	0	0

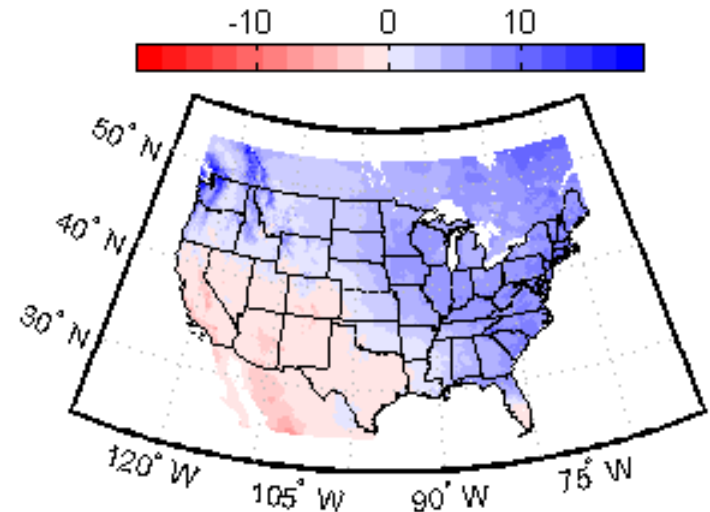
Variables & Projections Temporal & Spatial Extent Options & Info Tools

Variables

- ☐ Precipitation Rate (mm/day)
☐ Surface Air Temperature (deg C)

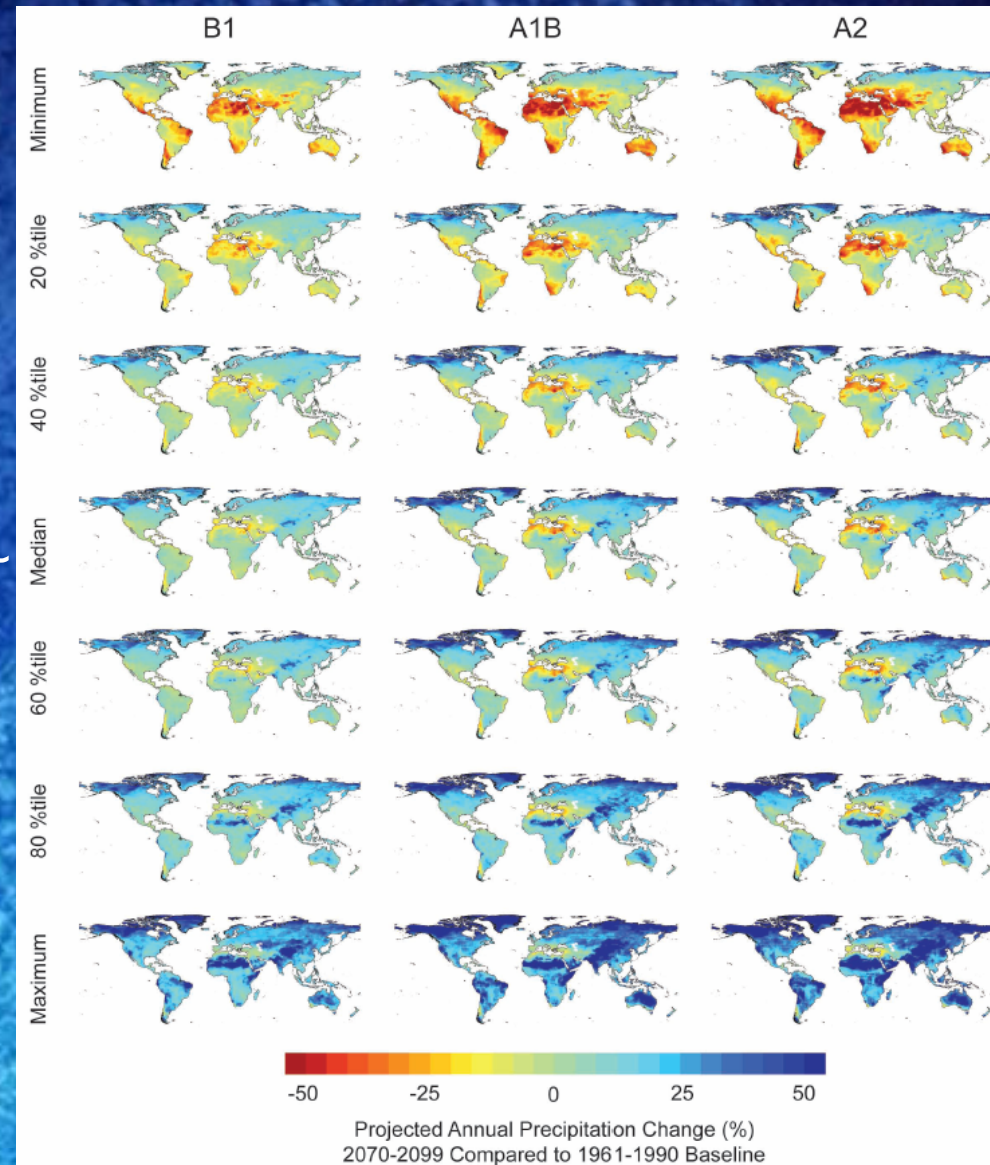
Emissions Scenarios, Climate Models and Runs

De-select all runs	None	None	None
Select all runs	All	All	All
	A1b	A2	B1
bccr_bcm2_0	☐	☐	☐
ccma_cgcm3_1	☐	☐	☐
cnrm_cm3	☐	☐	☐
csiro_mk3_0	☐	☐	☐
gfdl_cm2_0	☐	☐	☐
gfdl_cm2_1	☐	☐	☐
giss_model_e_r	☐	☐	☐
inmcm3_0	☐	☐	☐
ipsl_cm4	☐	☐	☐
miroc3_2_medres	☐	☐	☐
miub_echo_g	☐	☐	☐



Global BCSD

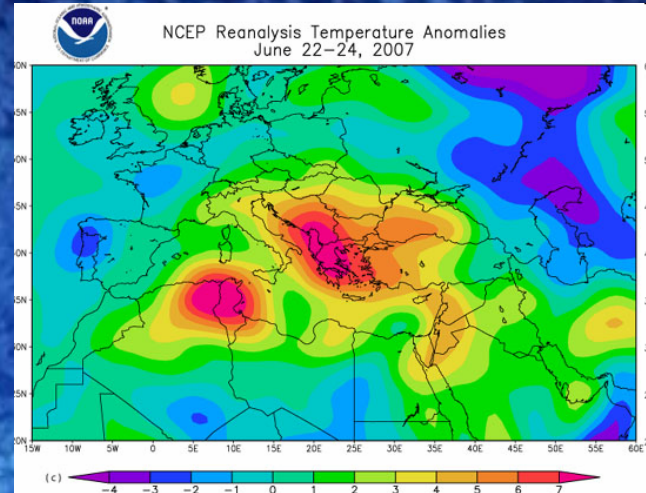
- Similar to US archive
- Allows probabilistic representation of projections
- Captures variability among GCMs
- http://www.engr.scu.edu/~emaurer/global_data/
- <http://climatewizard.org/>



Source: Girvetz et al, PloS, accepted

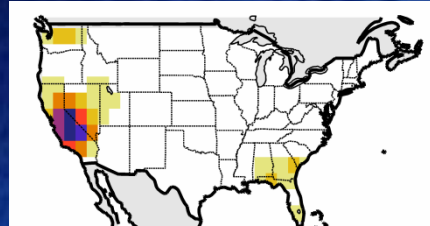
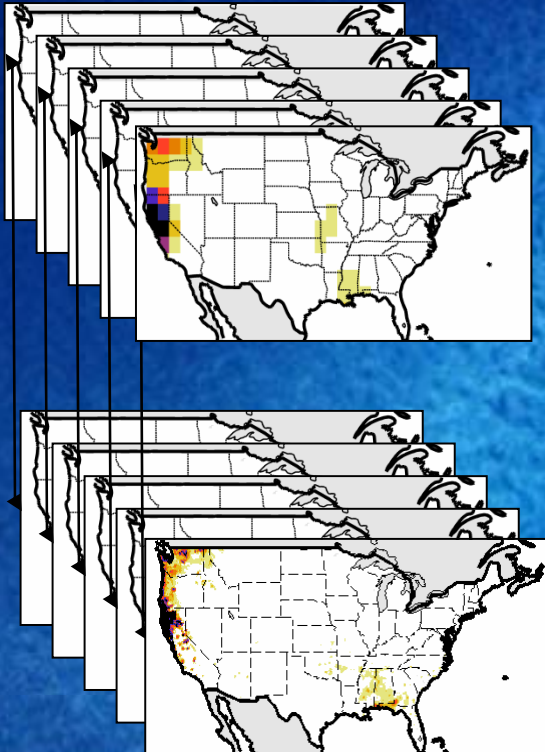
Need for enhanced downscaling

- Some impacts due to changes at short time scales
- Heat waves
- Flood events
- BCSD limited

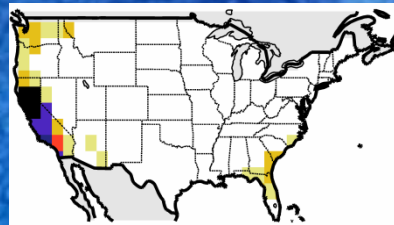


Constructed Analogues

Library of previously
observed anomaly
patterns:

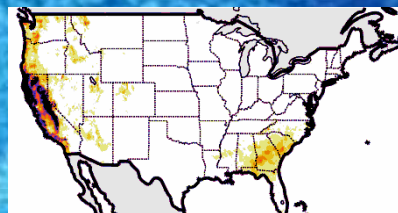


Coarse resolution
analogue:



Given daily
GCM anomaly

Analogue is
linear
combination of
best 30 observed



**Apply analogue
to fine-resolution
climatology**

Can CA improve daily downscaled projections?

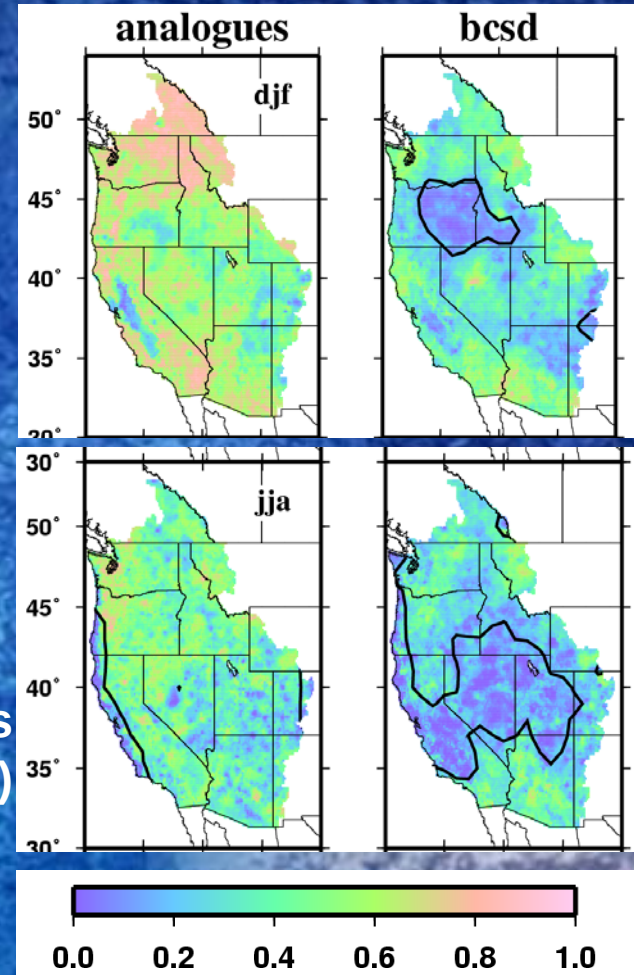
- Downscaled NCEP-NCAR Reanalysis for 1950-1999
- Use 1950-1976 as “observed”
- 1977-1999 as “projected”
- Monthly skill in reproducing Reanalysis P and T is high for both methods

Daily Temperature Extremes

- CA able to recover Reanalysis skill

Winter Cool Extremes
(10 %tile daily T)

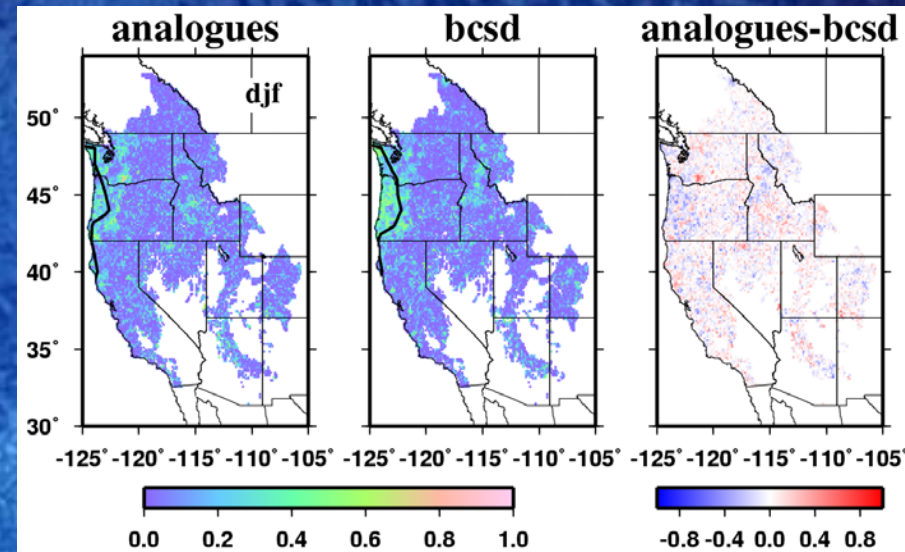
Summer Warm Extremes
(90 %tile daily T)



Daily Skill: Dry Extremes

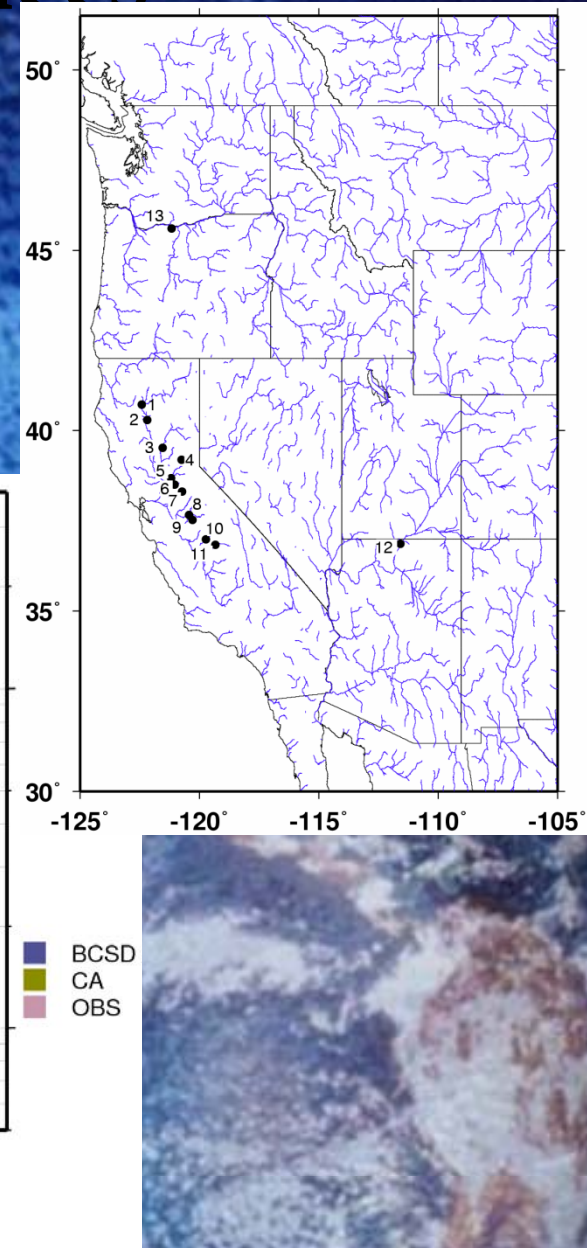
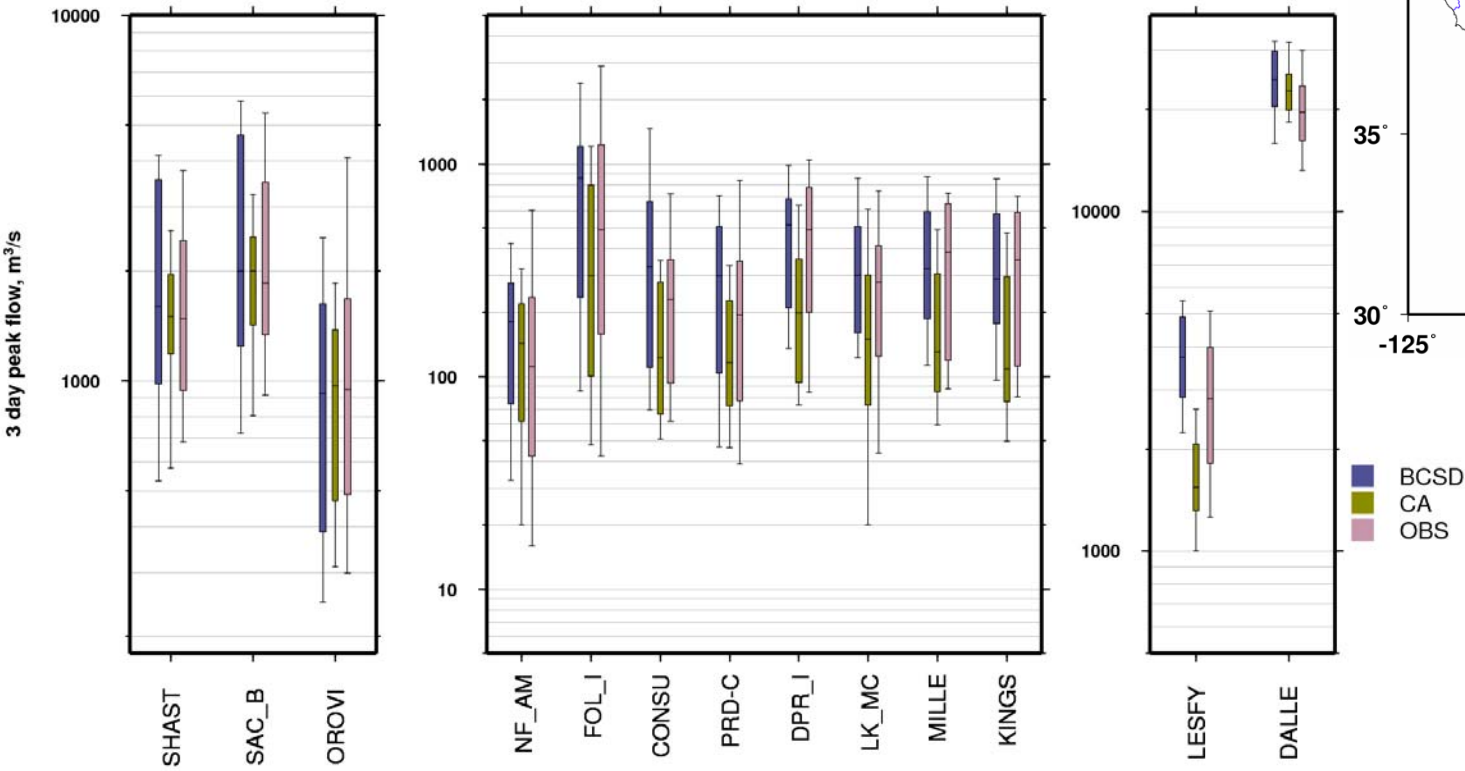
Dry Extremes (20 %tile daily P)

- 20th percentile winter P
- r^2 values shown
- 90% confidence line
- Low skill for both methods
 - Daily large-scale data cannot counter lack of skill, poor relationship between scales
- No statistical difference for CA, BCSD
- Similar results for wet extremes
- Difficulty downscaling dry extremes



Peak Flow Differences

- Most sites comparable for both methods and Obs.
- Tuolumne R and Colorado R worse with CA than BCSD
- Room for improvement?

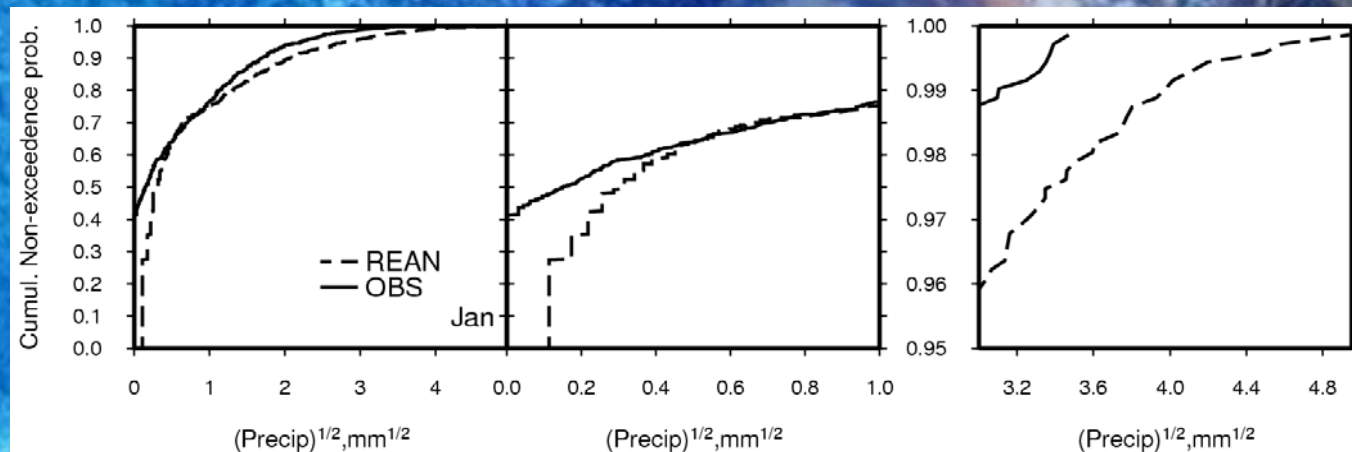


Differences between BCSD and CA

- CA uses daily GCM data; BCSD uses monthly w/random resampling to produce daily values
- BCSD explicitly corrects for systematic GCM biases based on historic GCM performance
- CA corrects mean bias (using anomalies) but not:
 - spatial GCM biases
 - variability biases

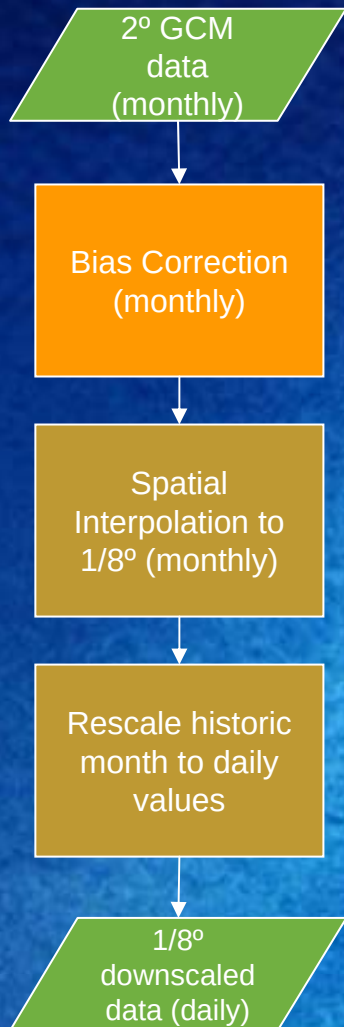
Looking in detail at one GCM cell

- At high and low extremes, reanalysis exhibits bias
- Accounting for bias in mean alone is insufficient
- Improvement: Bias correct daily GCM data prior to CA: BCCA
- Since BCCA is bias corrected, no need to anomalize

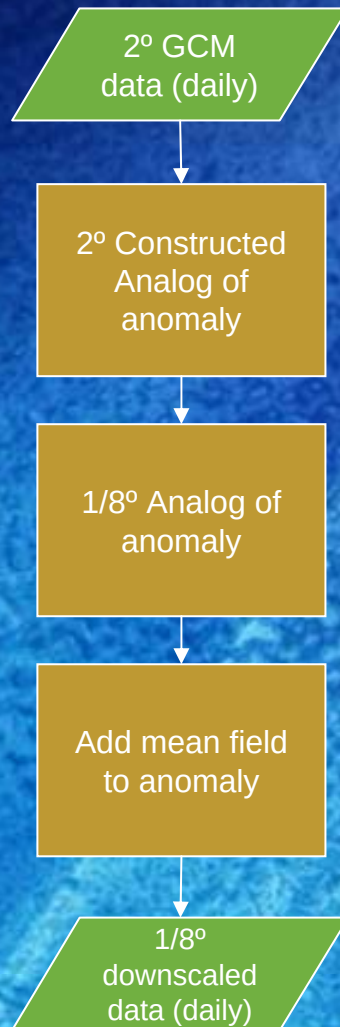


Schematic of Procedures

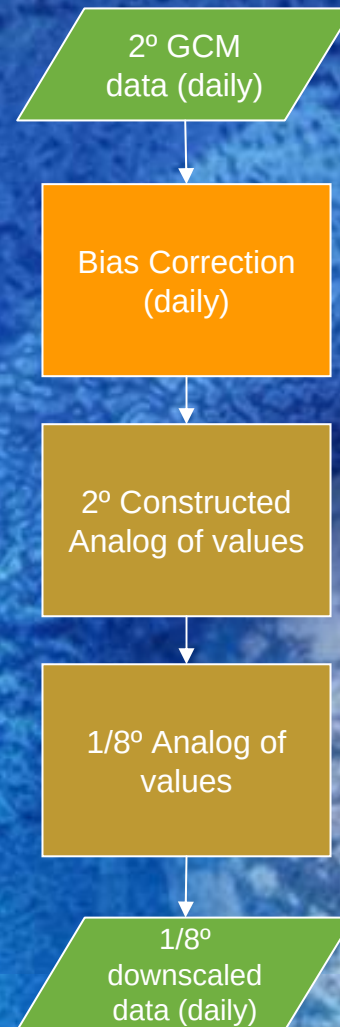
BCSD



CA

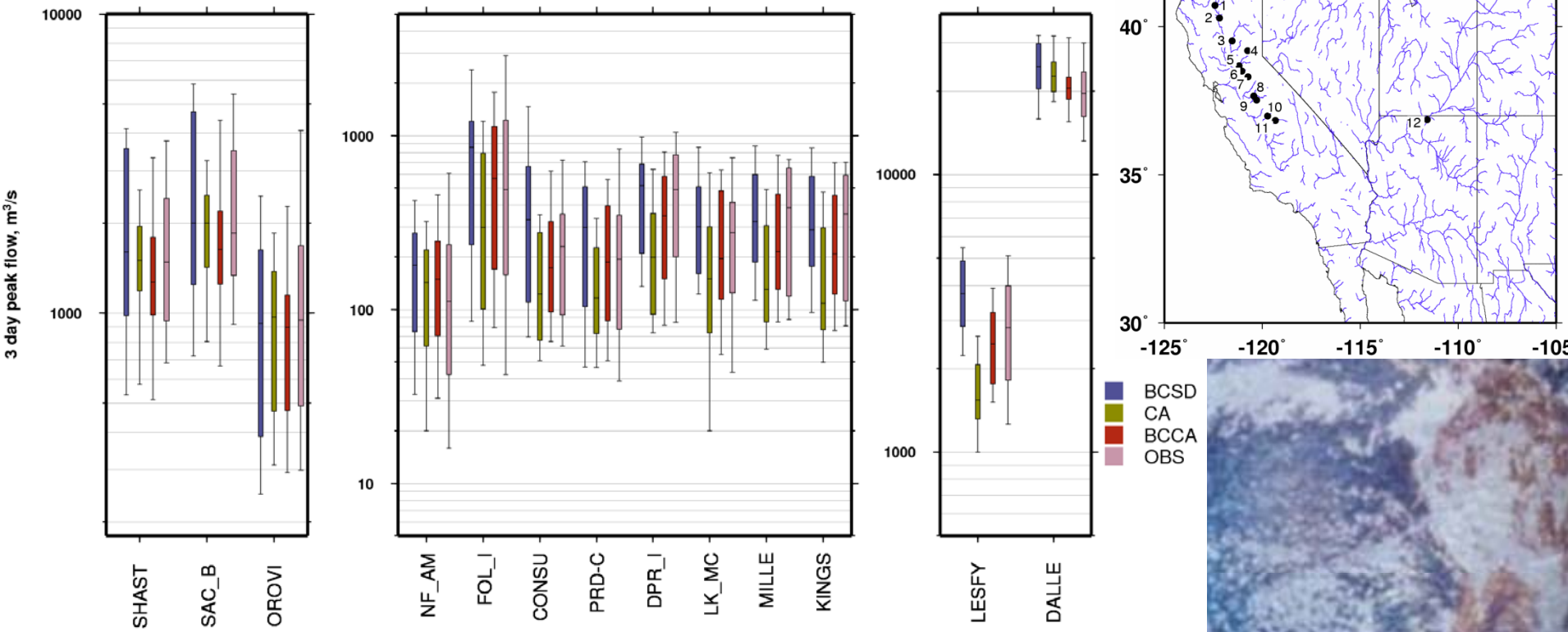


BCCA



Effect of BCCA on Peak Streamflow

- Improvement with BCCA at most sites



Effect of BCCA

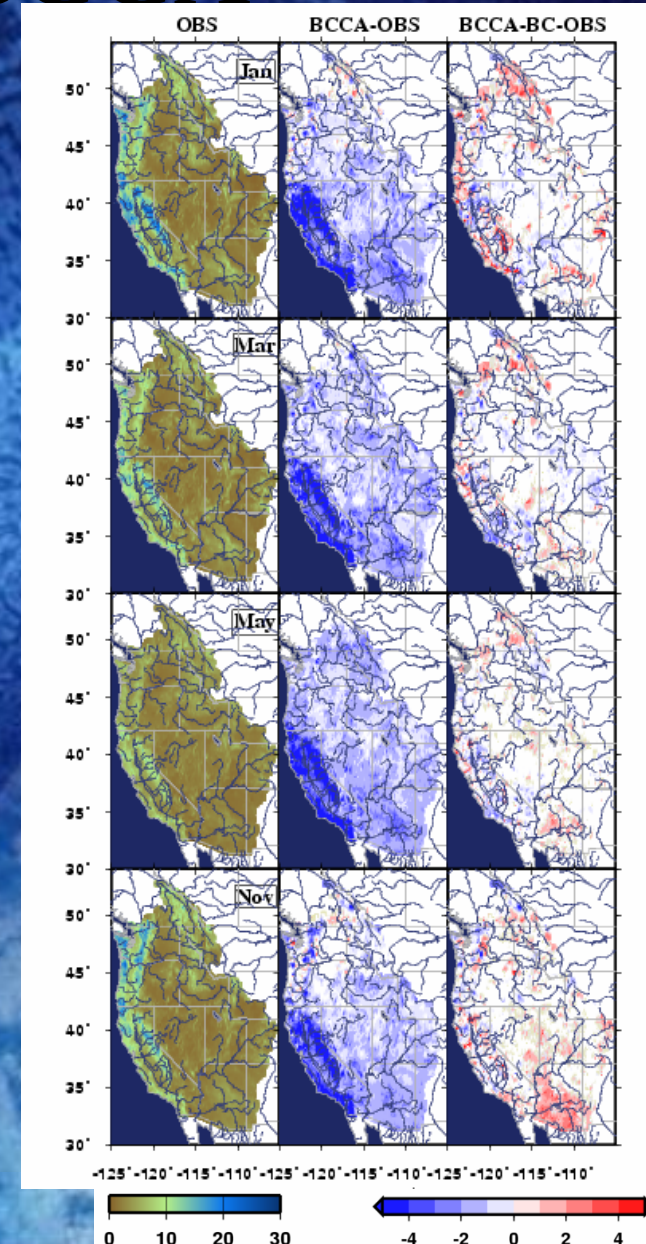
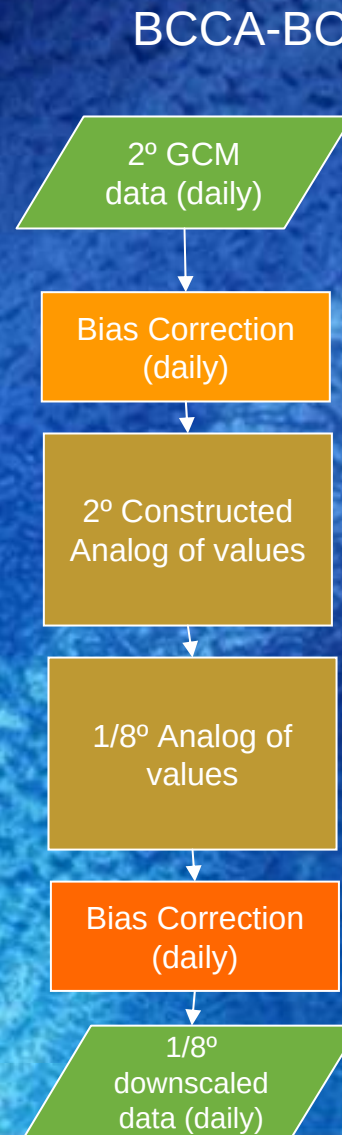
- Compared to CA, BCCA improves:
 - simulation of annual flow volumes
 - Simulation of flood peaks
- Problems remain for low flows, timing of snowmelt

Center Timing			3- Day Peak			7-Day Low Flow			Annual Flow Vol.		
BCSD	CA	BCCA	BCSD	CA	BCCA	BCSD	CA	BCCA	BCSD	CA	BCCA
SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST	SHAST
SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B	SAC_B
OROV	OROV	OROV	OROV	OROV	OROV	OROV	OROV	OROV	OROV	OROV	OROV
NF_AM	NF_AM	NF_AM	NF_AM	NF_AM	NF_AM	NF_AM	NF_AM	NF_AM	NF_AM	NF_AM	NF_AM
FOL_I	FOL_I	FOL_I	FOL_I	FOL_I	FOL_I	FOL_I	FOL_I	FOL_I	FOL_I	FOL_I	FOL_I
CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU	CONSU
PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C	PRD_C
DPR_I	DPR_I	DPR_I	DPR_I	DPR_I	DPR_I	DPR_I	DPR_I	DPR_I	DPR_I	DPR_I	DPR_I
LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC	LK_MC
MILLE	MILLE	MILLE	MILLE	MILLE	MILLE	MILLE	MILLE	MILLE	MILLE	MILLE	MILLE
KINGS	KINGS	KINGS	KINGS	KINGS	KINGS	KINGS	KINGS	KINGS	KINGS	KINGS	KINGS
LESFY	LESFY	LESFY	LESFY	LESFY	LESFY	LESFY	LESFY	LESFY	LESFY	LESFY	LESFY
DALLE	DALLE	DALLE	DALLE	DALLE	DALLE	DALLE	DALLE	DALLE	DALLE	DALLE	DALLE

Highlighted indicates downscaled different from observed

Improvement on BCCA

- Downscaling evidently introduces additional bias
- Precipitation intensity has low bias
- Potential solution: second bias correction after downscaling
- As before, use 1950-1976 for training, 1977-1999 as “projected”



Conclusions

- Statistical downscaling has skill, especially at monthly level
- Some daily skill from large (GCM) scale can be translated to regional/local scale
- Bias-correction of large-scale signal improves skill
- Further refinement may be possible



Thanks!