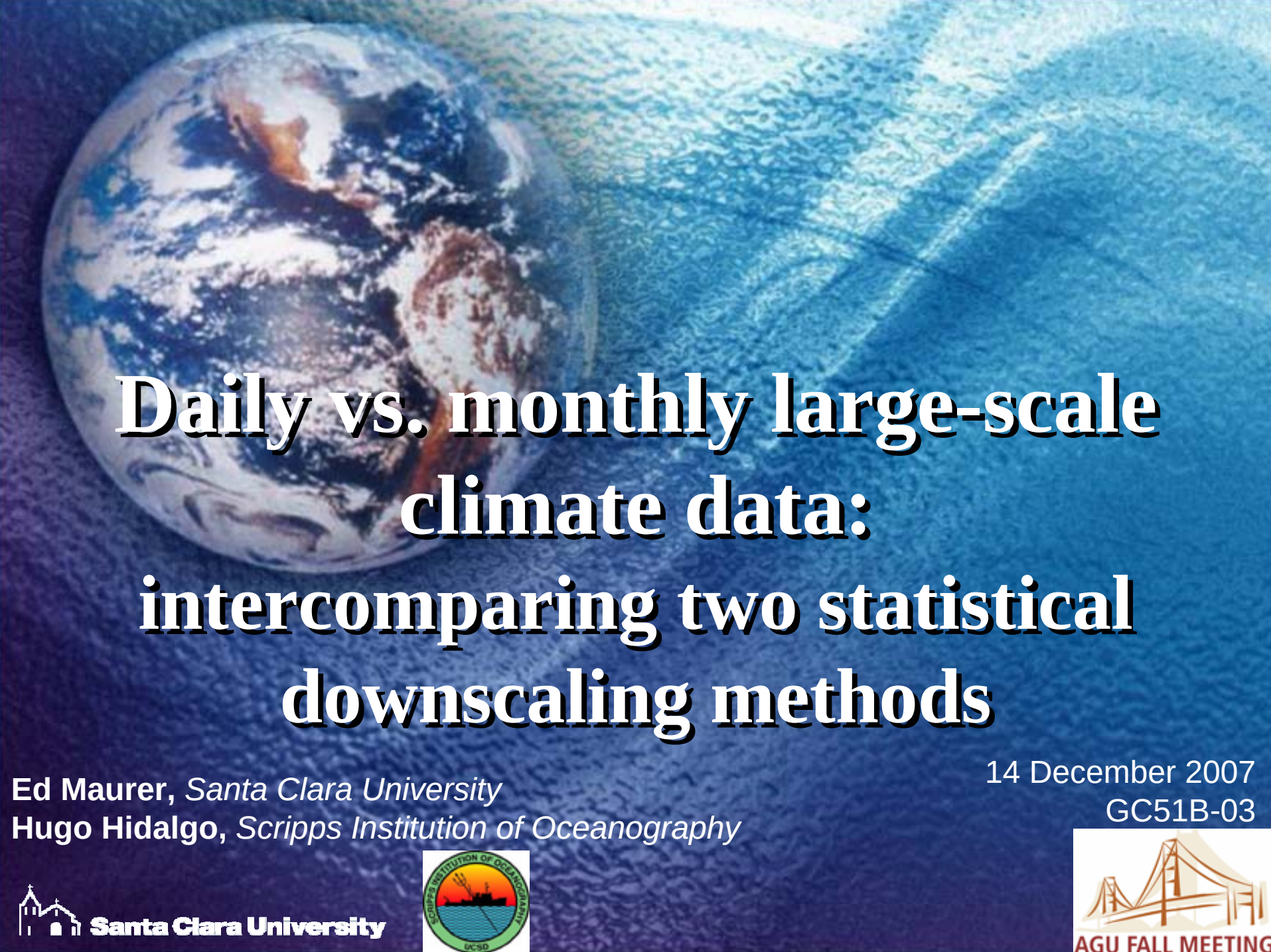

Daily vs. monthly large-scale climate data: intercomparing two statistical downscaling methods

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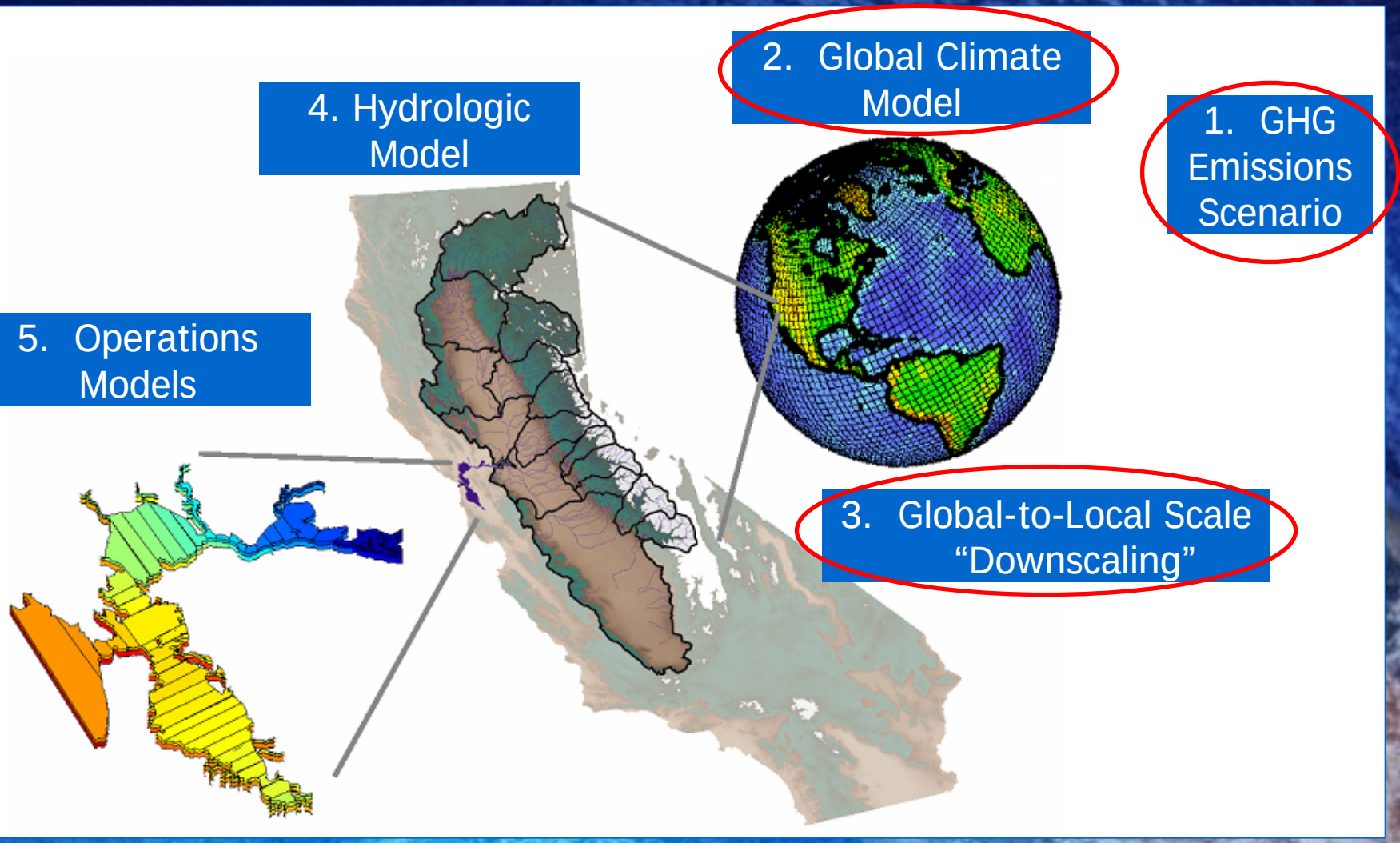
Hugo Hidalgo, *Scripps Institution of Oceanography*

14 December 2007
GC51B-03

Santa Clara University

AGU FALL MEETING

Estimating Regional Climate Impacts



Adapted from Cayan and Knowles, SCRIPPS/USGS, 2003 by Levi Brekke

GCM Simulations

- 20th century through 2100 and beyond
- >20 GCMs
- Multiple Future Emissions Scenarios

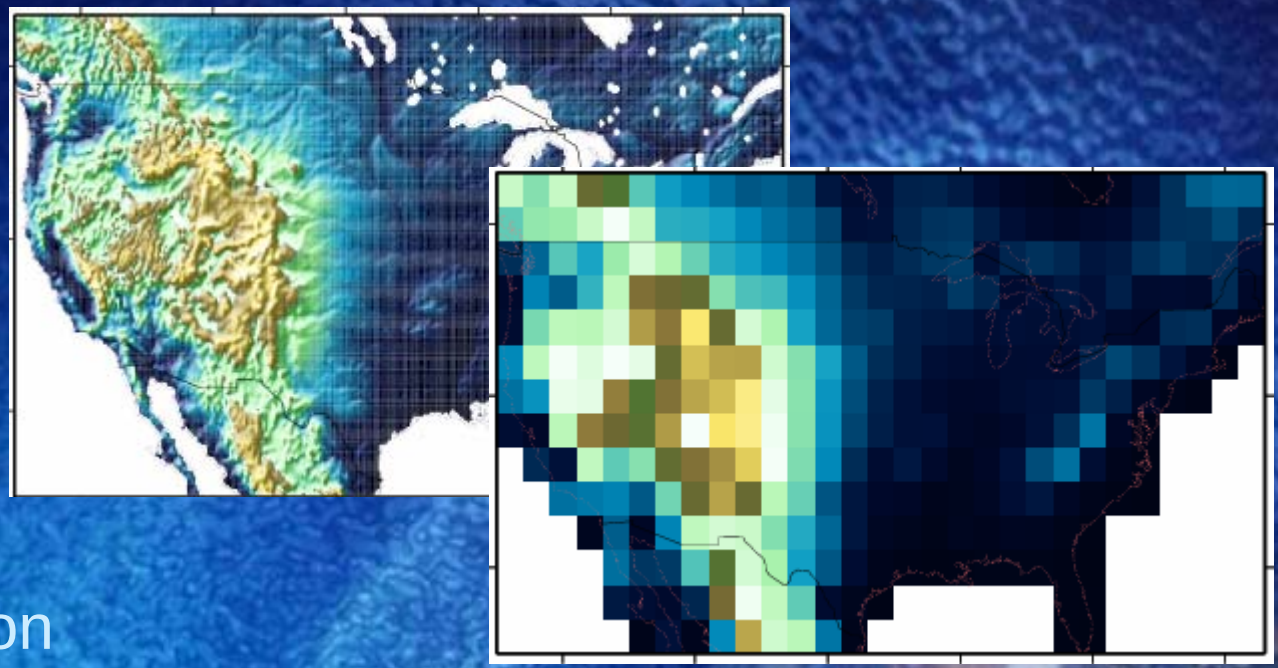
WCRP CMIP3 Multi-Model Data

1 realization multiple realizations

	PIcntrl	PDcntrl	20C3M	Commit	SRESA2	SRESA1B	SRESB1	1%to2x	1%to4x	Slabcntl	2xCO2	AMIP
BCC-CM1, China		2	4				2	1	1			4
BCCR-BCM2.0, Norway	1		1	1	1	1	1	1				
CCSM3, USA	2	1	9	5	5	7	8	1	1	1	1	1
CGCM3.1(T47), Canada	1		5	5	5	5	4	1	1	1	1	
CGCM3.1(T63), Canada	1		1			1	1	1		1	1	
CNRM-CM3, France	1		1	1	1	1	1	1	1			1
CSIRO-Mk3.0, Australia	2		3	1	1	1	1	1		1	1	
CSIRO-Mk3.5, Australia	1		1	1	1	1	1	1				
ECHAM5/MPI-OM, Germany	1		4	3	3	4	3	3	1	1	1	3
ECHO-G, Germany/Korea	1	1	5	4	3	3	3	1	1			
FGOALS-g1.0, China	3		3	3		3	3	3				3
GFDL-CM2.0, USA	1		3	1	1	1	1	1	1	1	1	
GFDL-CM2.1, USA	1		3	1	1	1	1	1	1			
GISS-AOM, USA	2		2			2	2					
GISS-EH, USA	1		5			4		1				
GISS-ER, USA	1		9	1	1	5	1	1	1	1	1	4
INGV-SXG, Italy	1		1		1	1		1	1			
INM-CM3.0, Russia	1		1	1	1	1	1	1	1	1	1	1
IPSL-CM4, France	1	1	2	1	1	1	1	1	1			6
MIROC3.2(hires), Japan	1		1			1	1	1		1	1	1
MIROC3.2(medres), Japan	1		3	1	3	3	3	3	3	1	1	3
MRI-CGCM2.3.2, Japan	1	1	5	1	5	5	5	1	1	1	1	1
PCM, USA	1	1	4	3	4	4	4	5	1			1
UKMO-HadCM3, UK	2		2	1	1	1	1	1				
UKMO-HadGEM1, UK	1		1		1	1		2	1	1	1	1

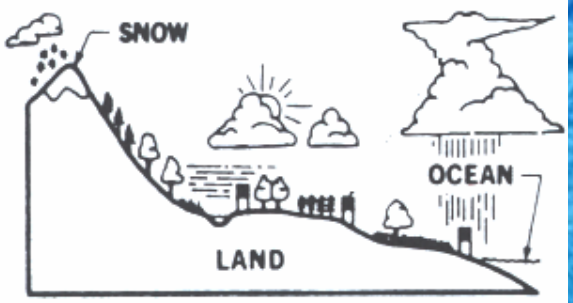
GCMs and Regional Impacts

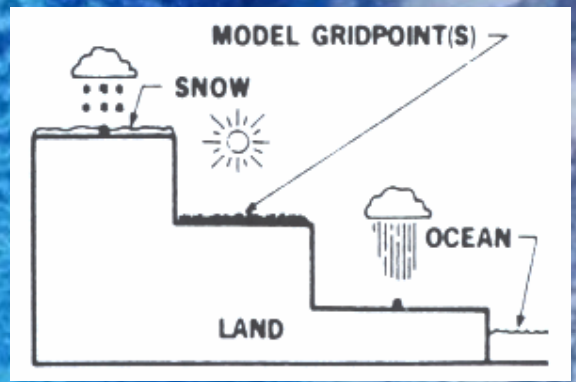
- GCM problems:
  - Scale incompatibility between GCM and impacts
  - Regional Processes not well represented



- Resolved by:
  - Bias Correction
  - Spatial Downscaling

Figure: Wilks, 1995

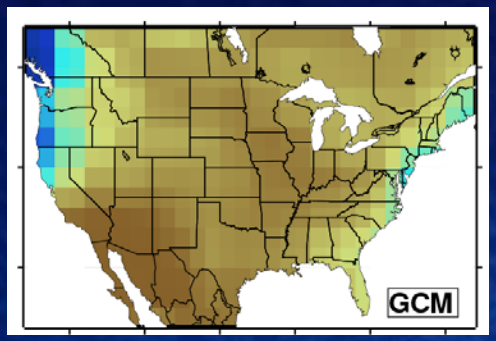




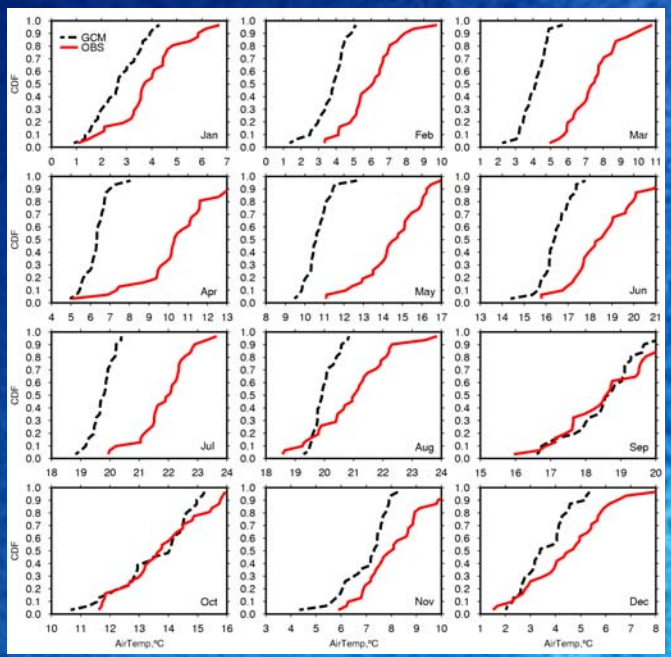
Desired Downscaling Characteristics

- Provide spatially continuous (gridded) downscaled fields
- Observed spatial and temporal climate structure maintained
- Automated and Efficient for Ensembles
- Capable of downscaling long transient GCM runs
- Capable of producing daily output
- Selections:
  - Bias Correction/Spatial Downscaling (BCSD) [Wood et al, 2004]
  - Constructed Analogues (CA) [Hidalgo et al., 2007]

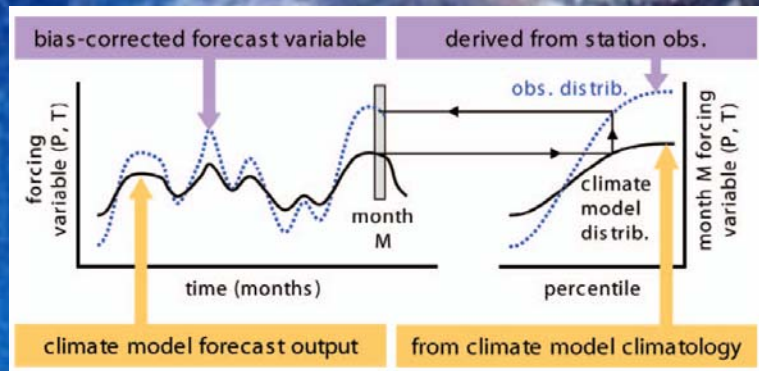
BCSD Method – "BC"



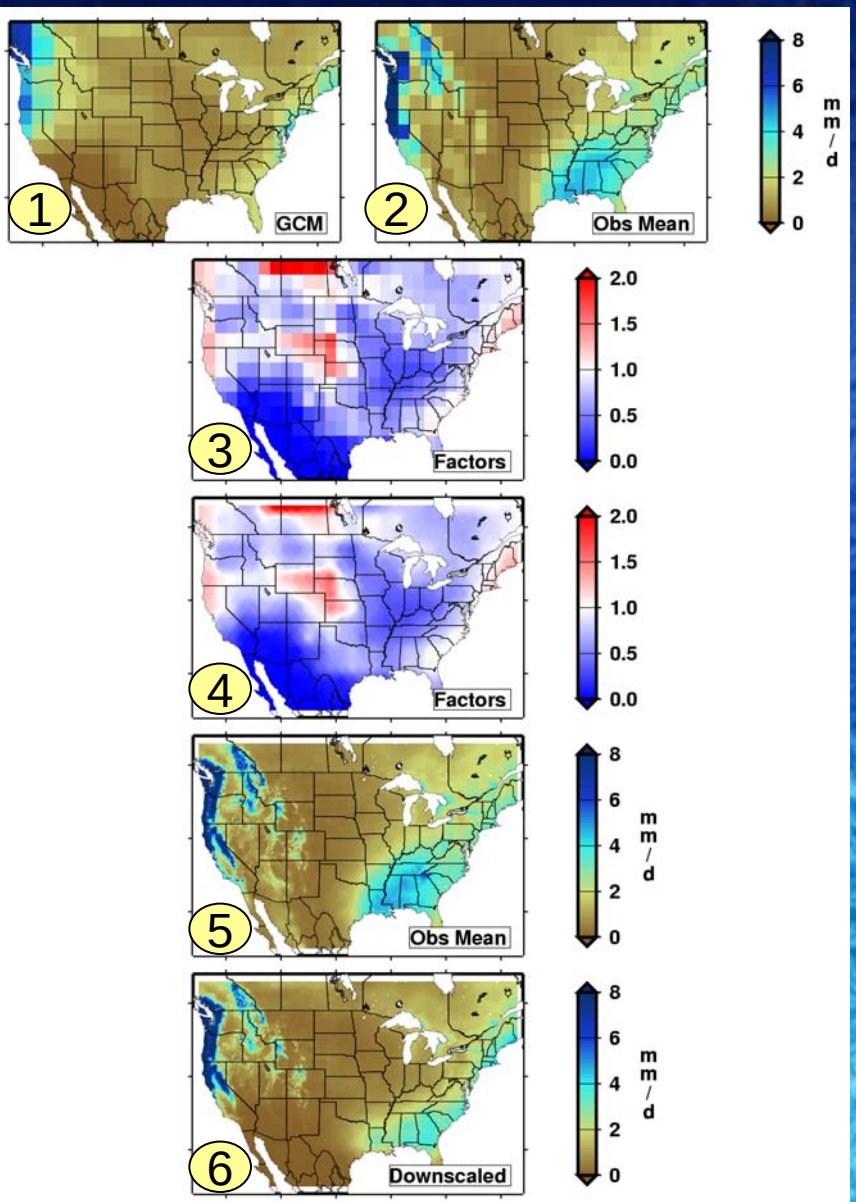
- At each grid cell for "training" period, develop monthly CDFs of P, T for
  - GCM
  - Observations (aggregated to GCM scale)
  - *Obs are from Maurer et al. [2002]*
- Use quantile mapping to ensure monthly statistics (at GCM scale) match
- Apply same quantile mapping to "projected" period



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

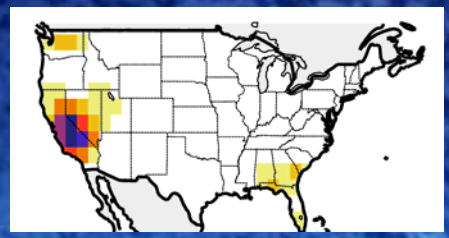
  (3) = (1) / (2) (P) (3) = (1) - (2) (T)
- Interpolate factors to 1/8° grid (4)
- Apply to fine-scale climatology

  (6) = (4) * (5) (P) (6) = (4) + (5) (T)

Daily Values from rescaled historical values

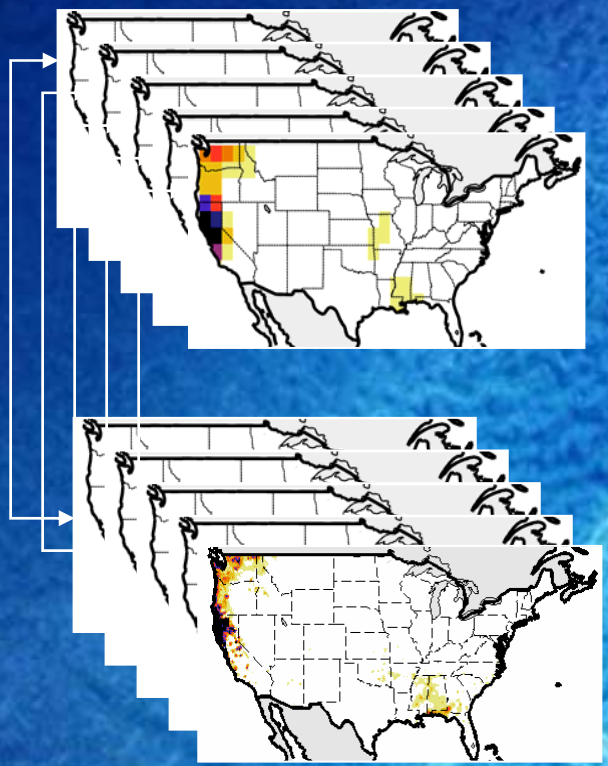
Constructed Analogues - CA

Given daily GCM anomaly:

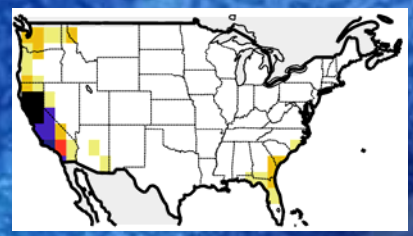


Bias in mean accommodated by using anomalies

Library of previously observed anomaly patterns:

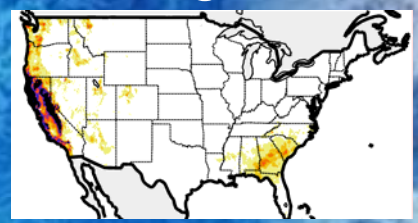


Coarse resolution analogue:



Analogue is linear combination of best 30 observed

Fine resolution analogue:



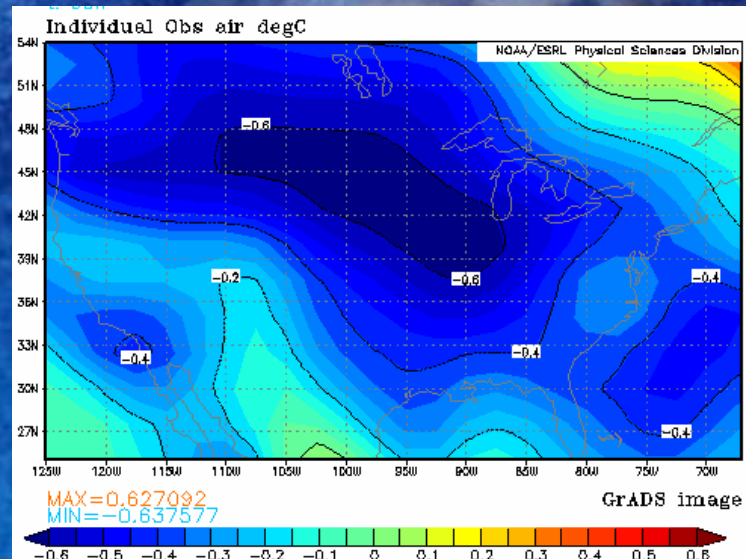
Apply analogue to fine-resolution climatology

Contrasting CA and BCSD

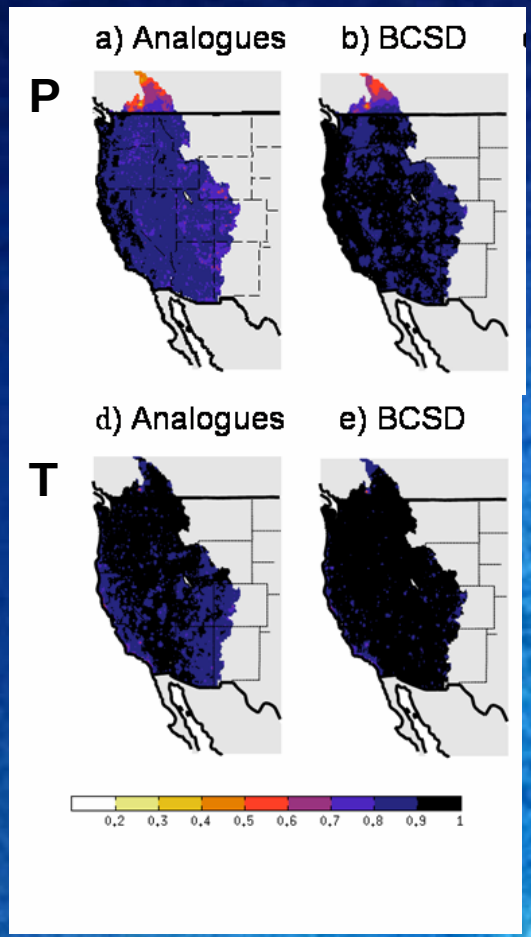
- CA uses daily data; BCSD monthly w/random resampling
- perfect prog vs MOS
- BCSD (MOS-type) relates GCM to obs, explicitly correcting for biases
- CA corrects mean bias (using anomalies) but not
  - spatial GCM biases
  - variability biases
- Two sources of error considered:
  - large-scale simulation error (GCM)
  - downscaling error (inadequate or non-stationary coarse-scale to fine-scale relationships)

NCEP/NCAR Reanalysis as Surrogate GCM

- Best possible GCM since obs assimilated
  - Should show max differentiation in methods
  - T62 (~1.9°) resolution, comparable to GCMs
- Full period daily and monthly data available
- 1950-1976 used to “train” downscaling
    - CA: coarse obs to fine (1/8°) obs
    - BCSD: coarse reanalysis to fine (1/8°) obs
- 1977-1999 used to assess
- Shift in PDO in 1976-77, late 20th century warming
- Warmer, wetter in later period over Western U.S.



Monthly skill

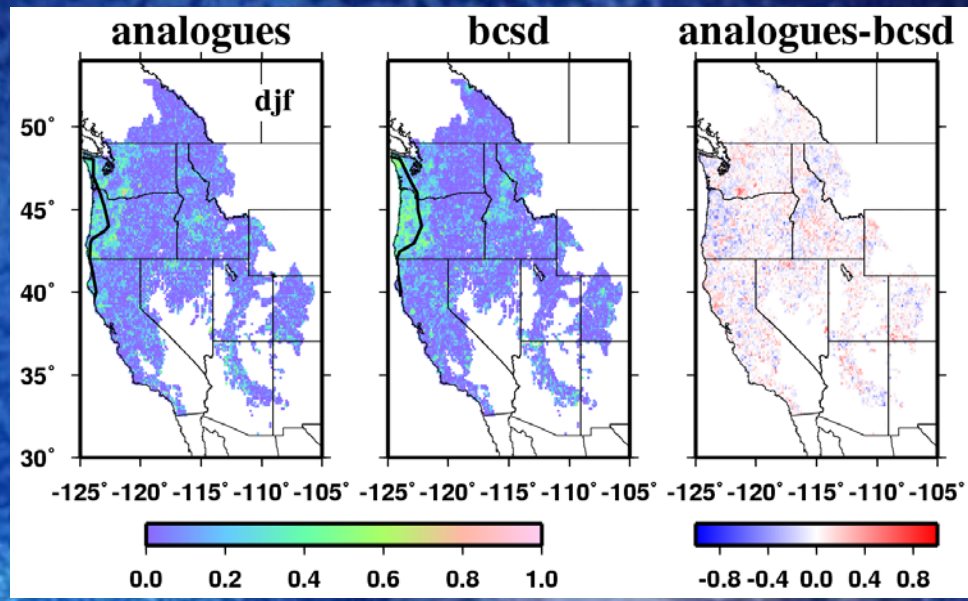


Correlation of monthly projected values with obs.

BCSD shows higher monthly skill than CA

RMSE comparable

Daily Skill: Dry Extremes

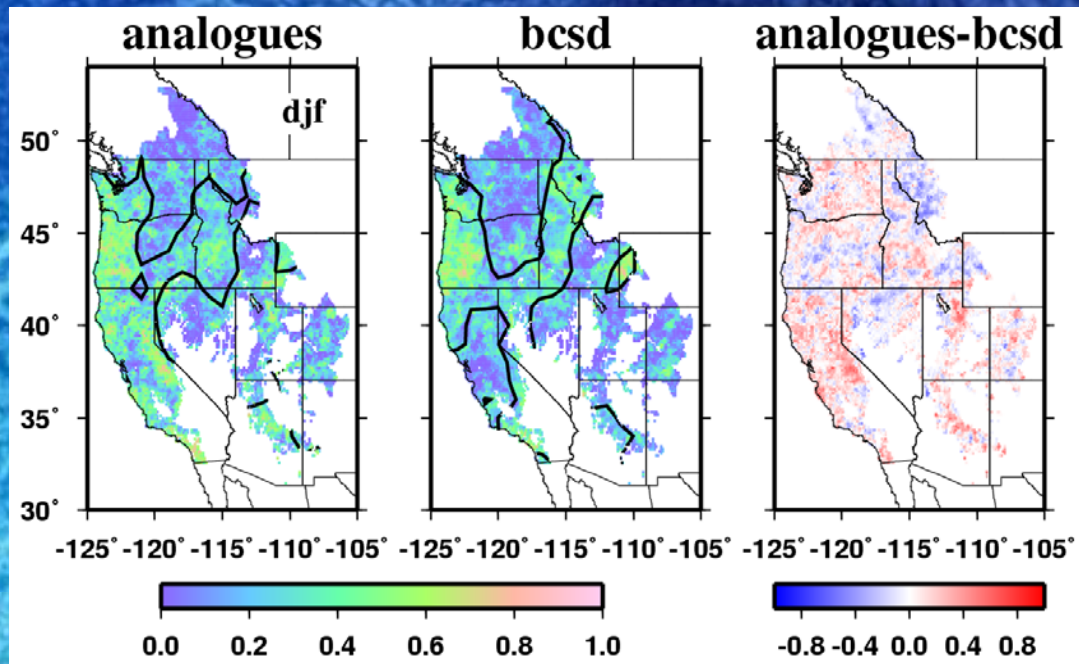


- 20th percentile winter P
- r^2 values shown
- 90% confidence line
- White areas have insufficient data
- Low skill for both methods
  - Daily large-scale data cannot counter lack of skill, poor relationship between scales
- No statistical difference for CA, BCSD
- Difficulty downscaling dry extremes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

Daily Skill: Wet Extremes

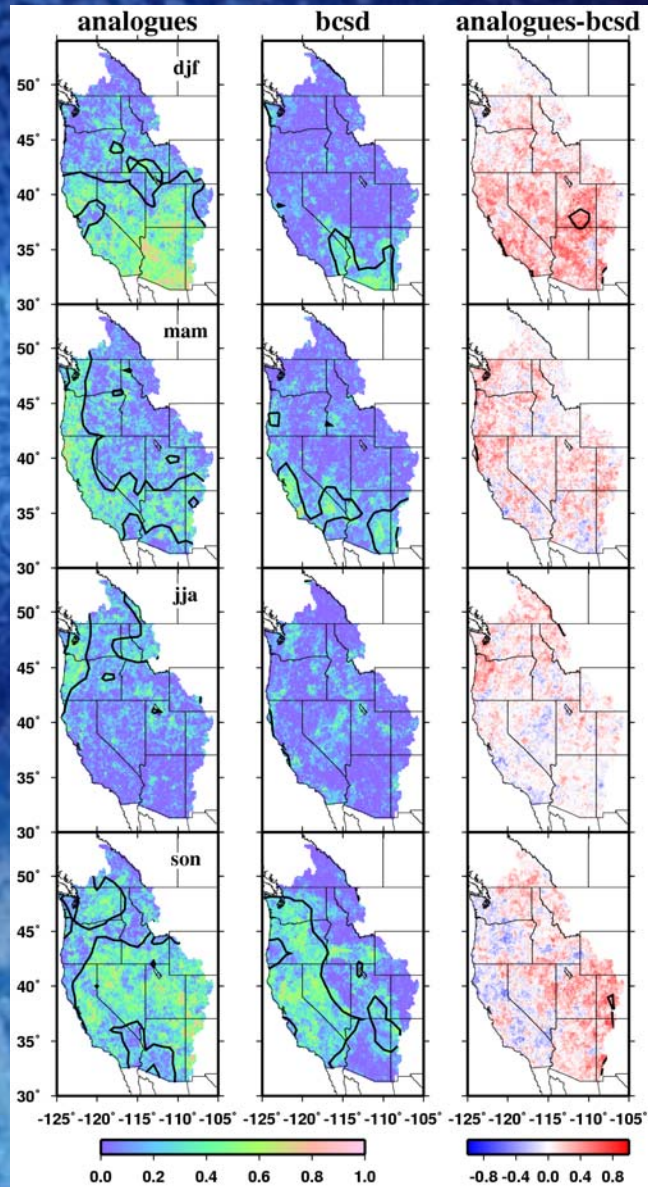
- 90th percentile daily winter P
- Higher r^2, some significant areas
- Methods comparable for wet extremes
- Differences not significant

- Large-scale daily P information not useful
- Climatological daily sequences equivalent to simulated
- Domain-wide patterns important?



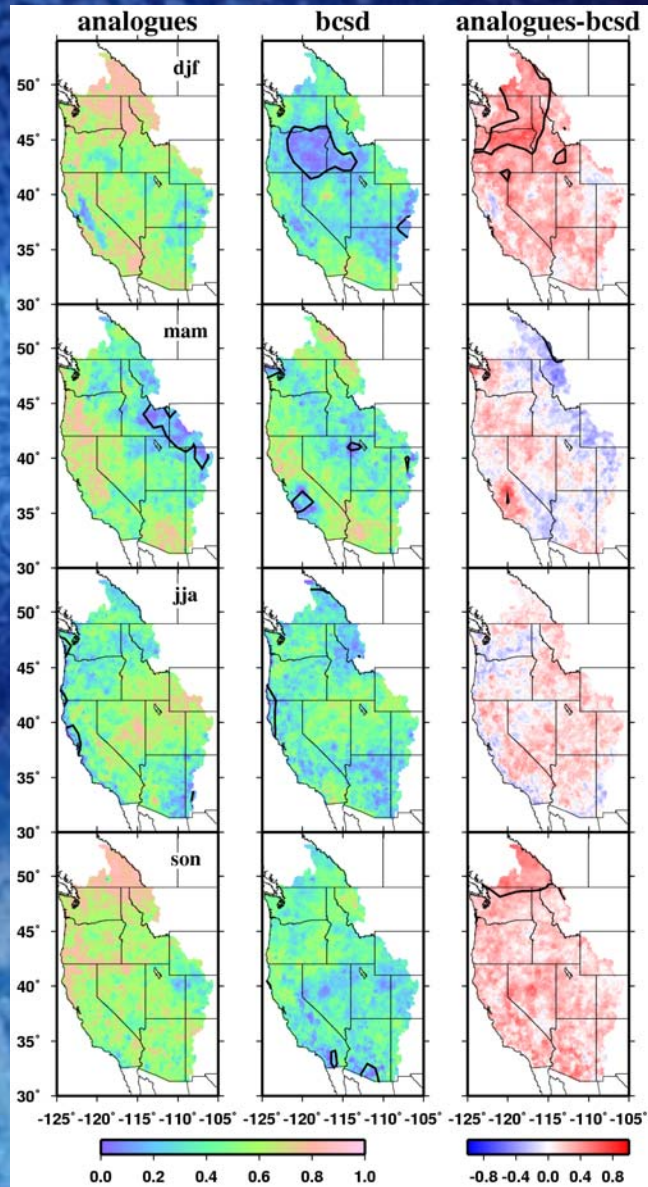
Daily Skill: Consecutive Dry Days

- Seasonal max consecutive dry days
- Winter: CA has higher skill
  - some differences are statistically significant
- Difference in other seasons minor & insignificant
- Max consecutive wet days has similar results
- At annual level differences are also negligible



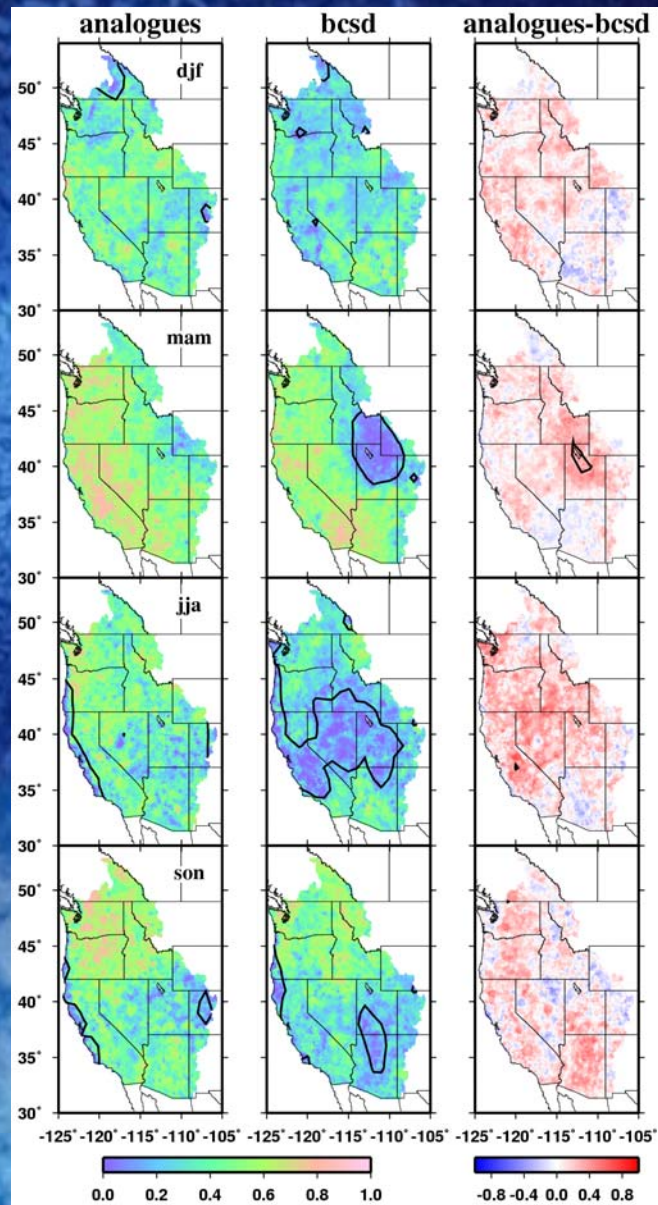
Daily Skill: Cool Extremes

- 10 percentile daily T by season
- Almost all of domain has significant r^2 for CA & BCSD
- Winter:
  - CA higher skill than BCSD
  - ~30% of domain shows significant differences
  - Most significant difference in Columbia R basin
- Spring: differences are split
- Regional/seasonal importance in technique assessment



Daily Skill: Warm Extremes

- 90 percentile daily T by season
- Higher skill with CA
  - esp Central California & Great Basin
  - seasons other than summer no significant difference
  - high spatial variation
- Reanalysis daily T skill successfully transferred to fine scale by CA
- Lower skill with BCSD & CA near coast



Conclusions

- Monthly skill comparable between CA and BCSD
  - higher T skill, lower P skill in reanalysis
- Daily large-scale P not useful for extreme *amounts*
  - BCSD and CA indistinguishable
- Skill in reanalysis daily P *sequencing* has value
  - CA shows better winter consecutive wet/dry days
  - large-scale circulation better than precipitation processes?
- Daily reanalysis T adds skill to CA
  - summer warm extremes
  - winter cool extremes
- Value of using daily large-scale data depends on large-scale skill
- Next Steps:
  - compare with GCM output
  - add bias-correction to CA?