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David Woolhiser

20-1402-861 Watershed Modeling

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CLIMATE MODELING - CONTENTS

D. A. Woolhiser

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CLIMATE MODELING (CON'T)
DAW 10/18/99

This notebook is a continuation of studies documented in pages 1 - 172 of the supplemental volume "CLIMATE MODELING - YUCCA MOUNTAIN, NEVADA - PART A" with work performed from Aug 1998 to Date.

On 10-1-99 I received an e-mail from S. Stothoff documenting regressions he had obtained for mean summer, winter and annual precipitation as functions of:
Z = elevation (km)
Nt = normalized Latitude
Ng = normalized longitude
S_w = normalized clear-sky solar radiation
He used a log 10 transformation of:
P_s = mean summer precipitation (mm/yr)
P_w = " winter " "
P = " annual " "
He used data from 171 coop. weather stations
The regressions he obtained are:

$$\log P_s = 1.355 + 0.3522 Z S_W + 0.4346 S_w S_w + 0.3673 Z N_t N_t \quad (1)$$
$$R^2 = 0.450$$
$$\text{max err} = (-.336, 0.379)$$

$$\log P_w = 1.89 + 0.28 Z - 1.682 N_t N_g S_w + 0.3295 N_g^3 \quad (2)$$
$$R^2 = 0.622$$
$$\text{max err} = (-.325, 0.28)$$

$$\log P = 2.005 + 0.2755 Z - 1.517 N_g S_w + 1.197 N_g^2 S_w + 0.4715 S_w^3 \quad (3)$$
$$R^2 = 0.742 \quad \text{max err} = (-.285, .264)$$

In order to interpret this information properly, I need the following additional information:

okay RWF 3/23/04

S. Stothoff regressions (con't) DAW 10/18/99

1.) Stothoff states that N_t, N_g and S_w are "normalized" variables that range between 0 and 1. In statistical terminology "normalized" usually means that the variables have been transformed so that they have a normal distribution. It appears that he has used the form (for example)

$$N_t = \frac{n_t - n_{t\,min}}{n_{t\,max} - n_{t\,min}}$$

This is correct. Latitude range (34 to 42 degrees) longitude (113-120) radiation 2750 to 3050 J/cm²/d. DAW 10/19/99

2.) He hasn't indicated the software package used or the significance level of the coefficients. He coded Matlab routines for least squares fit. No significance testing. DAW 10/19/99

3) What months were used for winter and summer?
Julian days 171 to 280 June 20 - Oct. 7 DAW 10/19/99

It is of interest to compare his results with those of French (1983). For example if we use French's Eq (3) for excess and deficit stations and assume that $N_g = S_w = 0.5$ we get

$\log \bar{P} = 0.446 + (7.86 \times 10^{-5})(5000) = 0.8390$

$\bar{P} = 6.90$ inches $= 175.32$ mm

With Stothoff's eq. (3) we get $\bar{p} = 179.5$ mm

okay RWF 3/23/04
RWF = Randall Fedors

DAW 10/19/99

Received an e-mail from Stothoff with answers to the questions. Answers are noted after questions above.

DAW 10/19/99

$\therefore\ N_{g\,max} - N_{g\,min} = 120 - 113 = 7$

$S_{w\,max} - S_{w\,min} = 3050 - 2750 = 300$ J/cm²/d

$N_{t\,max} - N_{t\,min} = 42 - 34 = 8$

S. Stothoff Regressions (con't) DAW 10/19/99

First: Compare with French's (1983) equation, given the latitude and longitude ~~elev~~ elev DAW 10/19/99 :

Beatty 8N: Lat ~~38°07'~~ 36°54' Long ~~115°35'~~ 116°45' DAW 10/19/99 El = 3,550 ft = 1082 m

Adaven: Lat 38°07' Long 115°35' El = 6,250 ft = 1905 m

For Beatty 8N:

$$N_g = \frac{116.75 - 113}{7} = 0.536$$

Since I do not have the mean annual clear sky radiation for these stations, I will scale with latitude

$N_t = \frac{36.9 - 34}{8} = 0.3625$ assume $S_w = 1 - N_t = 0.6475$

Stothoff eq. (3)

$\log P = 2.005 + 0.2755(1.082) - 1.517(.536)(.6475) + 1.197(0.536^2)(.6475)$
$+ 0.4175(.6475)^3 = 2.005 + 0.2981 - 0.5265 + 0.2227 + 0.1132$
$= 2.116$

$P = 129.61$ mm (~ 17% underestimate)

French:

$\log P = 0.446 + (7.86 \times 10^{-5}) 3550 = 0.725$ (all stations)

$P = 5.31$ inches $= 134.86$ mm (deficit $P = 4.31'' = 109$ mm)

From coop data I have mean annual $P = 156.5$ mm

From French $P = 6.27$ in $= 159.26$

For Adaven:

$N_g = (115.58 - 113)/7 = 0.369$

$N_t = (38.12 - 34)/8 = 0.515$ $S_w = 1 - 0.515 = 0.485$

Stothoff: $\log P = 2.005 + 0.2755(1.905) - 1.517(0.369)(0.485) + 1.197(0.369)^2(0.485)$
$+ 0.4175(.485)^3 = 2.005 + 0.525 - 0.2715 + 0.079 + 0.0476$
$= 2.385$

$P = 242.72$ mm (~ 25% underestimate)

French: $\log P = 0.9373$ $P = 8.65$ in $= 219.8$ m (excess eq $P = 11.7'' = 297.8$ mm)

From Coop data $P = 324.9$ mm

From French Table $P = 12.75$ in $= 323.8$ mm

Stothoff Regressions (Cont) DAW 10/19/99

Conclusion: Neither the Stothoff or French equations give very good estimates for these two stations.

DAW 12/14/99 Revision of Markov Chain and Mixed Exponential Programs. C:\CONSULT\SWRI\CLIMATE

The Markov Chain program MCF01R.EXE seems to be working O.K. The output files are of the form ADAVEN.OUT.

Output files can be edited to create a file for input to the mixed exponential program MIXEX.FOR. We wish to have the optimum parameters for the Markov chain so we can calculate the theoretical accumulated precipitation.

This file will be of form ADAVEN.MCP and will have have 5 lines

1. Title ie Markov Chain Parameters for (Adaven)
2. Mean plus amplitudes of P_{00} logits
3. 0 + Phase angles of P_{00} logits
4. Mean plus amplitudes of P_{10} logits
5. 0 plus phase angles of P_{10} logits

Note: ADAVEN4.OUT has 4 harmonics

Form of new input file for MIXEX

(3X,
ADAVEN MARKOV CHAIN AMPLITUDES & PHASE ANGLES (ADAVEN4.MCP)

2.3819	0.36420	0.37052	0.33419	0.22590
0.0000	-1.6064	-.77698	2.5482	-.47310
0.55822	0.17989	0.16553	0.23534	0.29469
0.0000	-1.2667	-.50407	2.3300	-.61901

3X, 5(2X, G11.5)

DAW 12-16-99 Revision of programs con't.

After the Mixed exponential Fourier series parameters I wish to create an out put file of the form:

							Accumulated Precipitation		No of wet day
Day	P_{00}	P_{10}	α	β	θ	μ	Obs. Ave	Theor. Ave.	obs theor.
1-366									

This provision (with a plot) was in the original MCMELOGW but was removed when the program was ~~dvd~~ ?? divided into two programs for the P.C.

Define 2 new arrays,
ACCUMP(I) accumulated precipitation on day I for NCOUNS
ACCUMN(I) " number of wet days " "

DAW 12-17-99

New temporary control file ADATEST.CON

Has α fixed at 0.298
Has input of MC parameters ADAVEN4.MCP
error read unit 20 line 88 of Main

DAW 12-18-99

DAW 1-12-2000 Revum climate analysis Programs.

Procedure:
1. Identifiability test.
<u>Objective:</u> to see how well MCF01R and MIXEX can identify known Fourier series parameters:
Tasks:
1) generate 30, 40, and 50 year records for 2 stations, say Las Vegas and Adaven.
2) Run both programs to identify parameters
3) Compare known parameter values with those identified for each n years

DAW 1-19-2000 Comparison of Likelihood Functions with various numbers of harmonics for Mixed Exponential Distribution.

Objective: Use Akaike Information Criterion (AIC) to determine optimum number of harmonics for α, β and μ.

Procedures

1. Create .MCP files (see p 5) for all stations
   - ADAVEN4.MCP ✓
   - BEAT4.MCP ✓
   - CAL4.MCP ✓
   - GOL4.MCP ✓
   - TON4.MCP ✓
   - VEG4.MCP ✓

   } 4 harmonics for P_{00} & P_{10}

2. Create .CON files for all stations. These files will have α variable, β - 2 harmonics, μ - 3 harmonics
   - ~~ADA3ME~~ ADAC21.CON ✓ DAW 1-19-00 output form ADAC21.01, 02, 03
   - BEAC19.CON ✓ BEAC19.01, .02, .03 etc
   - CALC20.CON ✓
   - GOLC16.CON ✓
   - TONC17.CON ✓
   - 57 1937 VEGC18.CON ✓
3. Make computer runs with MIXEX2000. ✓
4. Make plots for each station with PSIPLOT

File: ADAC21.03 → import → ADAC21.PDW DAW 1-19-00

Plots: parameter. 5" x 4" ~~ADAC21~~ ADC21PAR.PGW ✓

Accum wet days and precipitation ADC21WP.PGW ✓

Comparism with empirical values ADC21EMP.PGW ✓

Note that there is a lot of "noise" in the values of ALPHA, BETA and the mean are more stable.

1-21-00 DAW

The Akaike Information Criterion (AIC) is given by the equation:

$$AIC = -2 \log(\text{maximum likelihood}) + 2m$$

where m is the number of fitted parameters
The model with minimum AIC is to be selected
Thus for Adaven, run C21 we have

No. of Parameters	MLik	AIC
78	483.79	~~327.79~~ -811.58 DAW 1-21-00
13	436.10	-846.20 *

* Minimum AIC
Therefore the 13 parameter model should be selected

The summary parameter values for the 6 stations were combined into a WORDPERFECT FILE: CLIMATE\SUMMARY1-wpd

1-25-00 DAW

Station	Likelihood Func.		AIC	
	78 parameter	13	78	13
Beatty 8N	665.039	620.781	-1174.08	-1189.56 *
Caliente	1662.78	1641.54	-3169.56	-3257.08 *
Goldfield	648.09	613.81	-1140.18	-1201.62 *
Las Vegas	1114.87	1117.51	-2073.74	-2209.02 *
Tonopah	1753.33	1712.73	-3,350.66	-3399.46 *

Thus, according to the AIC the Fourier series representation is superior for all stations.

1-25-00 DAW

Linear regression analyses were performed to relate the mean annual values of α, β and μ to mean annual precipitation. Results are as follows:

$$\overline{\alpha} = 0.4129 - 0.0008676\, \overline{P}_A \;; \quad r^2 = 0.657 \; (\overline{P}_A \text{ in mm}) \quad (1)$$

$$\log\left(\frac{\alpha}{1-\alpha}\right) = -0.1958 - 0.005077\, \overline{P}_A \;; \quad r^2 = 0.672 \quad (2)$$

The logit form is superior because it will not allow incorrect values of the weighting parameter, α.

$$\overline{\beta} = 0.0471 + 0.00423\, \overline{P}_A \;; \quad r^2 = 0.290 \quad (3)$$

0.01405 DAW 1-25-00

$$\overline{\mu} = 2.2152 + \cancel{0.1405}\, \overline{P}_A \;; \quad r^2 = 0.662 \quad (4)$$

1-27-00 DAW

Compare above results with findings of Hanson et al (1989)

They found: $\Theta_3 = -0.0449 - 0.00115\,X \quad R^2 = 0.74 \quad (5)$
where $\Theta_3 = \log\left(\frac{\alpha}{1-\alpha}\right)$ and X = mean annual precip. in mm

The equation show some similarities with eq. (2) above the gradients are similar -0.00115 vs -0.00507 (in sign)
They didn't find any relation between $\overline{\beta}$ and $\overline{P}_A$.
For $\overline{\mu}$ they found

$$\overline{\mu} = 1.644 + 0.00531\,X \qquad R^2 = 0.99 \quad (6)$$

This shows an increase of $\overline{\mu}$ with $\overline{P}_A$ but it is much smaller for their Idaho stations. They used 16 sites within the Reynolds Gulch experimental watershed with a range of mean annual precipitation of ~~534~~ 241 DAW 1-25-00 mm to 1144 mm. Only 3 of their stations had $\overline{P}_A$ within the range of this study. This may suggest that the relation between $\overline{\mu}$ and $\overline{P}_A$ is nonlinear with a steeper slope for small $\overline{P}_A$.

1-28-00 DAW

A regression analysis was also run between the amplitude of the 1st harmonics of β and μ and $\overline{P}_A$. Results were:

$$C_{1\beta} = -0.1515 + 0.001845\,\overline{P}_A \; ; \; R^2 = 0.519 \qquad (7)$$

$$C_{1\mu} = 0.2105 + 0.004146\,\overline{P}_A \; ; \; R^2 = 0.55 \qquad (8)$$

Hanson et. al could not detect a relationship between $\overline{\beta}$ or $C_{1\beta}$ and $\overline{P}_A$. They found that $C_{1\mu}$ was approximately a constant of 0.445 mm for stations with $\overline{P}_A < 500$ mm, but increased with $\overline{P}_A$ for $\overline{P}_A > 500$ mm. From Fig. 2 in Hanson et al (1989) the slope is 0.0042 which is very close to that in eq. 8.

A weak relationship was found between the phase angles of the first harmonics of β and μ and $\overline{P}_A$, ie.

$$\phi_{1\beta} = 1.798 - 0.01115\,\overline{P}_A \; ; \; R^2 = 0.456 \qquad (9)$$

$$\phi_{1\mu} = -1.5683 - 0.003316\,\overline{P}_A \; ; \; R^2 = 0.165 \qquad (10)$$

Hanson et. al found a non-linear decrease of $\phi_{1\mu}$ with $\overline{P}_A$ and no relation between $\phi_{1\beta}$ and $\overline{P}_A$.

PSI PLOT was used to create some Figures

station
Adaven ADAC21
Beatty 8N BEAC19ACCUM.PGW BEAC19PAR.PGW, .PDW
Las Vegas VEGC18PAR.PGW VEGC18.pdw

1-28-00 DAW

Tentative Conclusions:

1. May be overfitting by using 4 harmonics for G_{10}
2. There are significant relationships between the following MCME parameters and average annual precipitation, $\overline{P}_A$: $\overline{G}_{00}$, $\overline{G}_{10}$, $\overline{\alpha}$, $\overline{\beta}$, $\overline{\mu}$, $\log\left(\frac{\overline{\alpha}}{1-\overline{\alpha}}\right)$, $C_{1\beta}$, $C_{1\mu}$, $\phi_{1\beta}$, $\phi_{1\mu}$.
3. Should check C_{1G00}, C_{1G10}, ϕ_{1G00}, ϕ_{1G10} etc.

DAW 2-16-00
From PSIPLOT sheet G00.PDW

For G00: regression of C_{1G00} on $\overline{P}_A$ (mm) ← No relationship

$\phi_{1G00} = -1.108 - 0.00224\overline{P}_A$ " " ϕ_{1G00} " " $R^2 = 0.166$ * ?

" of C_{2G00} " " " $R^2 = 0.0002$ no relationship

" ϕ_{2G00} " " ~~$R^2 = 0.645$~~ DAW 1-28-00 *

$$\overline{G}_{00} = 3.049 - 0.00234\,\overline{P}_A \quad R^2 = 0.645 \quad *$$

$$\phi_{2G00} = \cancel{3.049 - 0.00234\,\overline{P}_A} \; \cancel{(R^2 = 0.645)} \text{ DAW 1-28-00}$$

$$" = -1.2102 + 0.00140\,\overline{P}_A \quad (R^2 = 0.386) \quad *$$

For G_{10} (From Psi Plot file G10.PDW

$$\overline{G}_{10} = 0.889 - 0.001374\,\overline{P}_A \quad R^2 = 0.3455 \quad *$$

$C_{1G10} =$ No relation

$\phi_{1G10} =$ " "

$C_{2G10} = 0.263 - 0.000357\,\overline{P}_A$ $R^2 = 0.214$ * ?

$\phi_{2G10} =$ no relation

Conclusion: ϕ_{2G00}, $\overline{G}_{00}$, $\overline{G}_{10}$ and possibly ϕ_{1G00} and C_{2G10} are related to mean annual precipitation

This suggests that the seasonality of rainfall occurrence is only slightly related to $\overline{P}_A$

DAW 2-16-00

Adjustment of parameters for an increase in mean annual precipitation.

Example: Suppose that we wish to adjust the parameters of Beatty8n for an increase of 150 mm.

Current $\bar{P}_A$ for Beatty 8n = 156.5 mm

$\Delta\bar{P}_A$ = 150 mm

306.5 mm

Markov chain:

$\hat{G}_{00} = 2.75 - 0.00234(150) = 2.39$ using the slope of the regression line

$= 3.049 - 0.00234(306.5) = 2.33$ using the regression

$\hat{G}_{10} = 0.6733 - 0.001374(150) = 0.467$ (slope)

$= 0.889 - 0.001374(306.5) = 0.468$ (regression)

$\phi_{1G00} = -1.2549 - 0.00224(150) = -1.591$ (slope)

$\phi_{1G00} = -1.008 - 0.00224(306.5) = -1.695$ (regression)

$\phi_{2G00} = -1.249 + 0.00140(150) = -1.039$ (slope)

$\phi_{2G00} = -1.2102 + 0.00140(306.5) = -0.781$ (regression)

$C_{2G10} = 0.1982 - 0.000357(150) = 0.1447$ (slope)

$C_{2G10} = 0.263 - 0.000357(306.5) = 0.1536$ (regression)

All other amplitudes + phase angles – ~~two~~ three options DAW 2/16/00

1) use values for nearest station
2) use regional average
3) use values for station with nearest $\bar{P}_A$

DAW 2-16-00

For mixed exponential:

$\bar{\alpha} = 0.3274 - 0.000868(150) = 0.1972$ slope

$\bar{\alpha} = 0.4129 - 0.000868(306.5) = 0.1469$ regression

$\log\left(\frac{\alpha}{1-\alpha}\right) = -0.72 - 0.00508(150) = -1.482$ slope $\alpha = 0.22$

$= -0.1958 - 0.00508(306.5) = -1.753$ regression $\alpha = 0.173$

$\bar{\beta} = \cancel{.040}$ 1.019 DAW 2-14-00 $+ .00423(150) = 1.654$ mm (slope)

$\bar{\beta} = 0.0471 + .00423(306.5) = 1.344$ (regression)

$\bar{\mu} = \cancel{0.176}$ 4.47 DAW 2-14-00 $+ 0.01405(150) = 6.58$ mm (slope)

$\bar{\mu} = 2.215 + 0.01405(306.5) = 6.57$ mm (regression)

$C_{1\beta} = 0.0594 + 0.001845(150) = 0.336$ mm (slope)

$C_{1\beta} = -0.1515 + 0.001845)(306.5) = 0.414$ mm (regression)

$C_{1\mu} = 0.500 + 0.00415(150) = 1.123$ mm (slope)

$C_{1\mu} = 0.2105 + 0.00415(306.5) = 1.48$ mm (regression)

$\phi_{1\beta} = 1.126 - 0.0112(150) = -0.554$ (slope)

$\phi_{1\beta} = 1.798 - 0.0112(\cancel{150}$ 306.5 DAW 2-14-00$) = -1.63$ (regression)

$\phi_{1\mu} = -3.144 - 0.00332(150) = -3.64$ (slope)

$\phi_{1\mu} = -1.568 - 0.00332(306.5) = -2.58$ (regression)

DAW 2-16-00

Objective: Examine differences in accumulated average precipitation function $E\{S(m)\}$ using each of the three techniques shown at the bottom of p 14.

Parameter set 1 - use Beatty 8n as base case.
Use the slope method to estimate parameters
use values for Beatty for all parameters not significantly related to $\bar{P}_A$

Parameter set 2 - use regression estimates
use regional average for other parameters

Parameter set 3 - use Adaven as base case
use slope method to adjust parameters $\Delta \bar{P}_A = 17.35$ mm
use Adaven parameters for others not sig. related to $\bar{P}_A$.

Use program PDISPLAY.BAS to calculate daily values for each parameter set. and for $E\{S(m)\}$

This approach will result in 3 somewhat different sets of parameters.
Could run 50 yr. simulations with each set and compare expected number of wet days, mean and std. dev. of annual precipitation and CDF's of total rainfall for selected periods.

DAW 2-21-00 Precipitation model adjustment

1. Get regional averages for all parameters
CLIMATE\MCMEPAR2.PDW + MEPAR2.PDW
Markov Chain G00.PDW

$\bar{G}_{00}$	$\bar{C}_{1G00}$	ϕ_{1G00}	C_{2G00}	ϕ_{2G00}	C_{3G00}	ϕ_{3G00}	C_{4G00}	ϕ_{4G00}
~~2.610~~ 2.617 DAW 2-21-00	~~0.630~~ 0.332 DAW 2-21-00	-1.422	~~0.364~~ 0.349 DAW 2-21-00	-0.952	0.283	2.445	0.342	-0.596

G_{10}	C_{1G10}	ϕ_{1G10}	C_{2G10}	ϕ_{2G10}	C_{3G10}	ϕ_{3G10}	C_{4G10}	ϕ_{4G10}
~~0.638~~ 0.635 DAW	0.137	-0.515	0.197	-0.913	0.159	0.969	0.162	1.021

Mixed exponential from ME

$\bar{\alpha} = 0.252$ $\overline{\log\left(\frac{\alpha}{1-\alpha}\right)} = -1.137$

$\bar{\beta}$	$C_{1\beta}$	$\phi_{1\beta}$	$C_{2\beta}$	$\phi_{2\beta}$
0.0327"	0.191	-0.893	0.195	2.765?
0.831 mm				

$\bar{\mu}$	$C_{1\mu}$	$\phi_{1\mu}$	$C_{2\mu}$	$\phi_{2\mu}$	$C_{3\mu}$	$\phi_{3\mu}$
0.190"	0.979	-2.183	0.868	1.876	0.452	
4.82 mm						

2. Create ~~excel~~ Quattro Pro DAW 2-21-00 spreadsheets to calculate parameters by slope or by regression
G_{00} — CLIMATE\G00PRED.QPW ✓
G_{10} " G10PRED.QPW ✓

DAW 2-22-00
Mixed exp: CLIMATE\MEPRED.QPW ✓

DAW 2-23-00

The spreadsheets: G00PRED.QPW, G10PRED.QPW and MEPRED.QPW were set up to utilize the regional regressions or the slopes of the regression lines and the parameter value at the nearest station (geographically or mean annual precip) to estimate MEME parameters for a hypothesized P_A. An example using Beatty 8N and Adaven is included for a future P_A of 306.5 mm.
Where there is no relation between parameter values and P_A, the current spreadsheets show regional averages. Alternatives would be the parameters for the nearest station.

Temperature and Radiation

From pp 116–118 Attachment to this notebook
For a future climate, the mean annual temperature will be specified. The most significant parameters in the climate model are:

TXMD – mean of TMAX for dry days
TXMW – " " wet days
TN – mean of Tmin for wet or dry days

The mean annual temperature = T_A

$$T_A = \frac{1}{N}\sum_{1}^{N}\sum_{i=1}^{365}\left(T_{max_i} + T_{min_i}\right)/2$$

If the number of wet days are increased, T_A will also decrease, but probably not as much as desired. In the previous analysis, significant regression relationships were found between TXMD, TXMW, TD and elevation, for example

$$TXMD = 87.46 - 0.00374E \qquad R^2 = 0.98$$

This could be adjusted simply by subtracting ΔT from the constant. E would be the elevation of Yucca Mtn in ft.

DAW 2-23-00

Similarly the constants could be corrected for

$$TXMW = 77.756 - 0.003408E \qquad R^2 = 0.965$$

$$TN = 59.62 - 0.004084E \qquad R^2 = 0.82$$

All temperatures are in °F

Somewhat poorer relations were found for 1) CVTX, the adjusted coefficient of variation of Tmax for wet + dry days

$$CVTX = 0.10645 - 8.84\times10^{-6}E \qquad R^2 = 0.474$$

2) ACVTX, amplitude of the adjusted coef. of variation of Tmax for wet and dry days

$$ACVTX = -0.01933 - 1.906\times10^{-6}E \qquad R^2 = 0.22$$

3) ATN, amplitude of Tmin for wet or dry days

$$ATN = 20.083 - 0.0004374E \qquad R^2 = 0.202$$

These parameter values could be adjusted to Yucca Mtn. elevation.

DAW 2-23-00

The other temperature parameters, ATX, ~~TXMW~~, CVTN, ACVTN can be obtained from the maps in Hanson, et al. (1994)
ATX = amplitude of Tmax for dry days
CVTN = adjusted coef. of var. of Tmin for wet or dry days
ACVTN = amplitude of the coef. of Var. of Tmin for wet or dry days.

The 8 parameters describing solar radiation for wet and dry days can be estimated from the maps Figs A-10 to A-17 in Hanson, et. al (1994)

DAW 2-23-00
Adjustments in radiation parameters could also be made to account for changes in earth orbital parameters in a future climate scenario.

Change in seasonality of precipitation

If we wish to have a change in the seasonal pattern of precipitation, it would be necessary to devise an optimization scheme.

One approach would be to hypothesise the Expected sum of precipitation for each day of the year, $E_H(t)$ $t = 1, 365$

The expectation function for the MCME model is:

$$E\{S(t)\} = \sum_{n=1}^{t} E\{Y(t)\}E\{X(t)\}$$

and is a function of MCME parameters

If we devise an objective function:

$$F(\Omega) = \sum_{t=1}^{365} \left[E_H S(t) - E\{S(t)\}\right]^2 \qquad 20-1$$

where Ω is the MCME parameter set.
Changes in seasonality would generally require changes in the phase angles of G_{00}, G_{10} and μ (possibly β as well)

2-25-00 DAW

The simplex algorithm could be used to adjust amplitudes, C_{ij} and phase angles Φ_{ij} to minimize the objective function, subject to the constraint that the annual precipitation $E\{S(365)\} = E_H S(365)$

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6-9-00 DAW How might the seasonalities change under a future climate?

1. Suppose the shift is to a seasonality similar to southern Arizona — monsoonal pattern, or to a Pacific N.W. pattern (E. Washington state).

Approach:
a) Fit MCME to stations in these locations and obtain $E_{SW}S(t)$ and $E_{NW}S(t)$ $t = 1, 2 \cdots 365$ from the model fit or merely use the empirical fits $\bar{E}S(t)$ for each station.

b) Write a FORTRAN PROGRAM with the following inputs:
i) Adjusted MC and ME parameters for the hypothesized total annual precipitation as described in pages 14 – 18.
ii) The accumulated (expected) precipitation either $\bar{E}\{S(t)\}$ or $E_{SW}\{S(t)\}$ or $E_{NW}\{S(t)\}$

Note: The expected accumulated precip should be ~~no stat~~ DAW 2-25-00 normalized on the total annual precipitation.

Optimization should be done in two stages:
1) adjust phase angles
2) adjust amplitudes

DAW 6-9-00 Seasonality optimization

This sequence of optimization was quite effective in the program UNIOP used by Woolhiser and Pegram (1979) (See Below) *

However there could be a strong dependency between the MC and ME parameters if optimization is done simultaneously. Therefore it would be preferable to work with the expected number of wet days function before optimizing the expected accumulated precipitation. In the MCME model these processes are assumed to be independent so this would be the proper approach.

DAW 6-14-00 Seasonality optimization (con't)

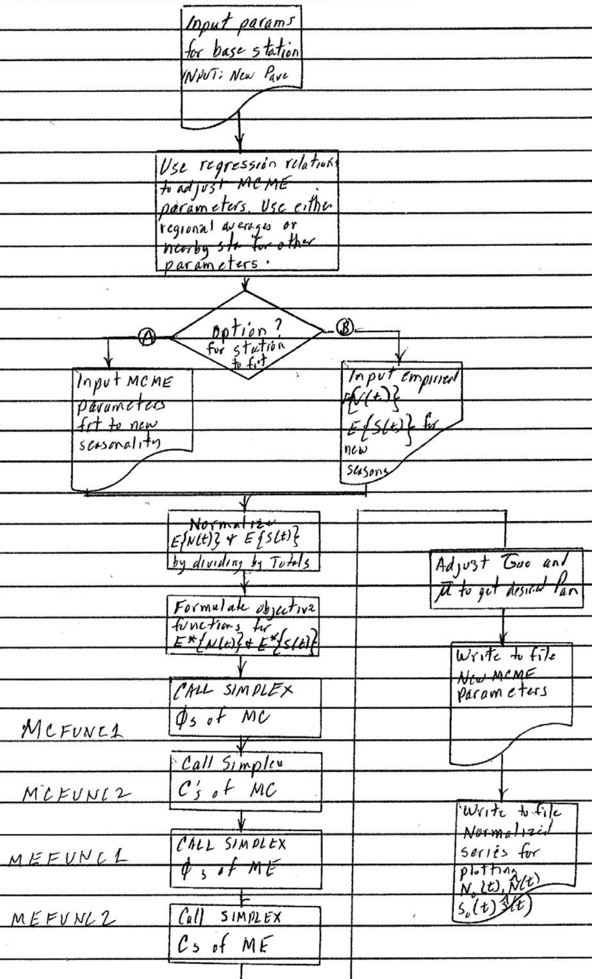
A generalized flow chart of the FORTRAN program SEASON.FOR is shown on p 23.

The expected accumulated number of wet days should also be normalized 0-1 on the E{N(365)}. Normalization is required because the E{S(365)} and E{N(365)} may not be the same for Yucca Mtn future climate and for the analog station

* Woolhiser, D.A. and G.G.S. Pegram. 1979. "Maximum likelihood estimation of Fourier coefficients to describe seasonal variations of parameters in stochastic daily precipitation models." J. Applied Meteorology 18(1):34-42.

DAW 6-14-00 Seasonality optimization (con't).

Preliminary FLOWCHART: PROGRAM SEASON.FOR



DAW 6-21-00 Seasonality (con't)

The objective function for the normalized number of wet days is:

$$FNT = \sum_{t=1}^{365}\left[\frac{E\{N(t)\}}{E\{N(365)\}} - \frac{E\{N_A(t)\}}{E\{N_A(365)\}}\right]^2$$

$\downarrow$ ENT1( ) $\downarrow$ ENT2( )

This will be written as SUBROUTINE MCFUNC1(N, Y, F)
N = number of parameters
Y = array of parameter values
F = returned function value

DAW 6-22-00
ENT2NORM( ) is the normalized $E\{N_A(t)\}$
in common/SIX/

use CODE=1 to optimize phase angles of G00
CODE=2 " " " " of G10

Now to optimize amplitudes of G00 and G10, write
SUBROUTINE MCFUNC2(N, Y, F)

Better still use CODE=3 for Amplitudes of G00
and CODE = 4 for Amplitudes of G10

DAW 6-23-00 Seasonality (Con't)

Input files:
CONTROL FILE
file names: MCFILE } amps + phase/S - YM
MEFILE
all (A) MC2FILE } analog station
ME2FILE
OUTFILE main output
PLOTFILE information to plot
* Max harmonics for G00, G10, Beta, mu, PAREPS + FNEPS ← optimization criteria

MCFILE:
(A) Name of station
* $\bar{G}_{00}$, $\bar{G}_{10}$
* $C_{G_{00}}$ Amplitudes of G00 logits
* $\Phi_{G_{00}}$ Phase/S
* $C_{G_{10}}$
* $\Phi_{G_{10}}$

For program testing, use Beatty as base station and adjust parameters to 306.5 mm.
Use the adjusted parameters for analog station but change C_1 and Φ_1 for G_{00}, G_{10}, and Mu.
This will provide an identifiability test.

DAW 7-5-00 Set up control file: file name ~~CON~~ TEST1.CON (DAW 7-5-00)

BEATTYMC.PAR
BEATTYME.PAR
ANALOGMC.PAR
ANALOGME.PAR
TEST1.OUT
TEST1.FIG
2, 1, 1, 3, 320.

7-24-00 DAW Continued editing of Climate analysis program.

In setting up the optimization for each parameter, there will be a maximum number of harmonic parameters to be optimized. However there will be an equal or larger number of harmonics used to calculate the daily time series of the parameter.

7-29-00 DAW Set up test files

CONTROL FILE: FILENAME = TEST1.CON ✓

IN THE CONTROL FILE

MCFILE: MCTEST1.MCP ✓
MEFILE: METEST1.MEP ✓
MC2FILE: MC2TEST1.MCP ✓
ME2FILE: ME2TEST1.MEP ✓
OUTFILE: TEST1.SEA
PLOTFILE TEST1. ~~PLT~~ DAT DAW 7-29-00
~~2~~ 4 DAW 7-29-00 ~~2~~ 3 DAW 7-29-00 / ~~2~~ DAW 7-29-00 ~~2~~ 3 DAW 7-29-00 300
MAXHG00 MAXHG10 MAXHB MAXHMU ANNUALP

MCTEST1.MCP DAW 7-29-00
BEATTY8N
2.7511 ~~2.7447~~ DAW 7-29-00 0.67661 N from p 82 of attachment DAW 7-29-00
α: ~~0.47567~~ 0.48574 0.29087 0.17489 0.39786
−1.2549 −1.2489 2.1432 −0.76458
0.25750 0.19439 0.11715 } from p 44
−1.6441 −0.87659 −0.0959 } of attachment

Note: This material was inadvertantly entered on p 124 of scientific notebook 362
DAW 7-29-00

DAW 8-1-00 Input files for test continued

METEST1.MEP from p 140 of attachment
BEATTY8N

0.32741	1.019	4.47	$\bar{\alpha}$	$\bar{\beta}$	μ	
0.0594	0.457		C_β	$C_{2\beta}$		
1.126	3.0356		θ_β	$\theta_{2\beta}$		
0.500	0.692	0.318	$C_{1\mu}$	$C_{2\mu}$	$C_{3\mu}$	
−3.144	1.8101	0.45835	$\theta_{1\mu}$	$\theta_{2\mu}$	$\theta_{3\mu}$	

MC2TEST1.MCP

For this test, ~~the~~ ~~p~~ DAW 8-1-00 I will use BEATTY8N parameters, except the first phase angle of G00 will be changed from −1.2549 to +1.00. The amplitude will be unchanged.

ME2TEST1.MEP

For this test, I will use BEATTY8N parameters as in METEST1.MEP (above), except the first phase angle of μ will be changed from ~~0.5 to 1.~~ −3.144 to −2.0 rad DAW 8-1-00

DAW 8-2-00

Ran program SEASON2.EXE with above input files. Output files were created O.K. but results don't look good. Check calls to ASIMPLX.

8-5-00 DAW Revised ASIMPLEX subroutine to conform to FORTRAN 90/95. Program ran successfully on 8-4.

The normalized E{N(t)} of base and analog stations are nearly identical. The normalized E{S(t)} of base and analog stations are different
Difference seems to be described by a sin curve and must be due to mixed exponential adjustment

DAW 8-5-00

In reviewing the output from ASIMPLEX, the scheme appears to work O.K. for phase angles of μ, but goes astray in optimizing the amplitudes. (Although the iteration limited, 300, is exceeded for phase ∠s of mu.

DAW 8-7-00

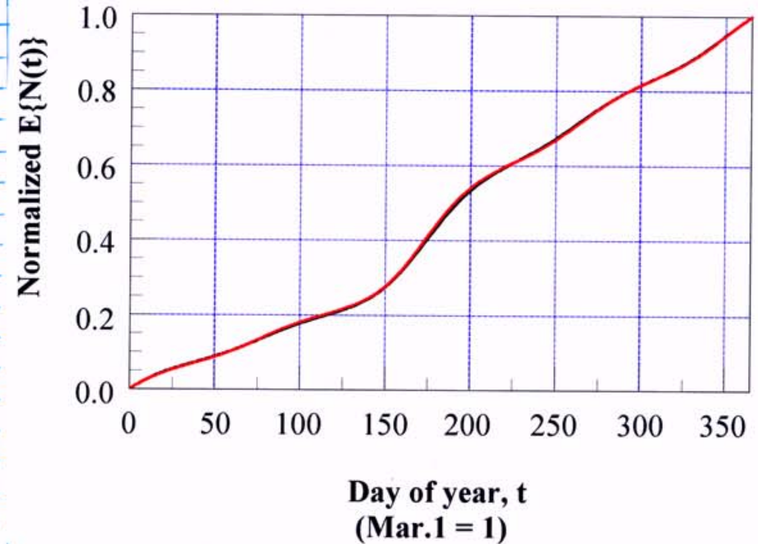
Made correction in subroutine MEFUNC1. Now the normalized $E\{N(t)\}$ and $E\{S(t)\}$ both look good. The optimized MCME parameters (amplitudes and phase angles) are shown below

```
New Markov chain parameters
G00bar= 2.34700012*
  0.5160✓ 0.3400✓ 0.1746   0.3979   0.0000   0.0000
  1.0299✓-1.1698✓ 2.1432  -0.7646   0.0000   0.0000
G10BAR= 0.476799995*
  0.1988✓ 0.1575✓ 0.1172   0.0000   0.0000   0.0000
 -1.2808✓-1.5133✓-0.0959   0.0000   0.0000   0.0000
New mixed exponential parameters
ALPHA= 0.218178079*
BEBAR= 1.31610000*
  0.4020* 0.4570   0.0000   0.0000   0.0000   0.0000
 -1.5620* 3.0356   0.0000   0.0000   0.0000   0.0000
MUBAR= 6.42999983*
  0.7388✓ 0.8044✓ 0.3180   0.0000   0.0000   0.0000
 -1.8584✓ 2.3810✓ 0.4584   0.0000   0.0000   0.0000
  48.266      331.962
 E{N(365)}    E{S(365)}
```

The parameters with a √ mark were optimized with ASIMPLEX subroutine to minimize the objective function on page 24 or the alternative with S(t) replacing N(t). The parameters with an * were changed by the regression relations with an estimated mean annual precipitation of 300 mm.

DAW 8-7-00 Con't. testing of SEASON2

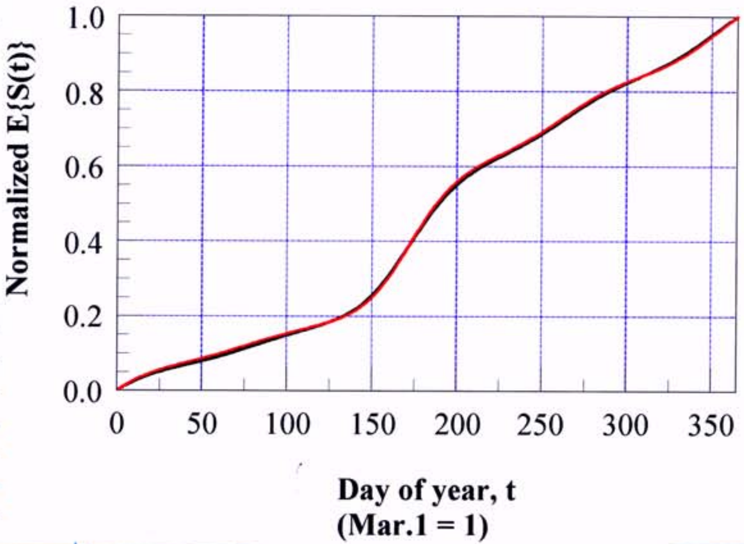
The goodness of fit of the normalized functions $E\{N(t)\}$ and $E\{S(t)\}$ to those of the analog station is demonstrated by the graph below and the graph on p 30.



On the above graph the normalized $E\{N(t)\}$ for the base station (black) and the analog station (red) are plotted versus day of year. The curves are virtually indistinguishable! On p 30 the normalized $E\{S(t)\}$ for the base station (black) and the analog station (red) are plotted versus day of the year. Again the curves are virtually indistinguishable!

Note that the expected annual precipitation $E\{S(365)\}$ is 331.9 mm while the target was 300 mm. This is not surprizing since the target annual precipitation is not a constraint. However, a scheme to adjust the mean for and possibly mean μ should be added

DAW 8-7-00 Con't Testing of SEASON2



DAW 8-8-00 Con't Testing of SEASON2

For the second test, I will use Tonopah as the base station and Las Vegas as the analog station. There are considerable differences between the phase angles for both the MC and ME, so this should provide a good test. Again, the regression results will be used to adjust Tonopah parameters for a target annual precipitation of 300 mm.

DAW 8-8-00

DAW 8-~~7~~8-00 Con't Testing of SEASON2

CONTROL FILE: TEST2.CON
MCTEST2.MCP
METEST2.MEP
MC2TEST2.MCP
ME2TEST2.MEP
TEST2.SEA
TEST2.DAT

4	2	2	3	300	Harmonics in station parameter file
2	2	1	2		← optimized harmonics
G_{c-}	G_{c}		μ		

MCTEST2.MCP ✓ DAW 8-8-00

TONOPAH	0.56979			
2.5885	~~0.5702~~			
0.71903	0.73607	0.73945	0.37065	} p76 attachment
-1.7080	-0.94035	2.4147	-.72411	
0.03077	0.15309	0.77068		} from p 56 attachment
-1.0481	-0.75559	-0.47891		

MC2TEST2.MCP ✓

16 params

LAS VEGAS				
2.913	0.91045			
0.339	0.510	0.355	0.335	} p 86 attachment
-0.650	-0.990	2.716	-0.490	
0.31115	0.93388	0.0956		} pg. 53 attachment
-0.715	-0.818	2.43		

METEST2.MEP ✓

TONOPAH			
0.260	0.361	3.56	
0.0014	0.0787		} p 142 attachment
1.044	-0.719		
0.831	0.424	0.312	} p 142 "
-1.33	0.439	-3.88	

DAW 8-8-00 TESTING SEASON 2 (Con't)

MEZTEST2.MEP ✓

LAS VEGAS

13 params

0.294	0.301	3.835
0.164	-0.0012	
0.485	2.193	
0.703	0.546	0.141
-1.786	2.046	-0.355

p 142 attachment

Stage	OBJ. FUNC	No. of evaluations
$\phi\ G_{00}$	0.25446	102
$\phi\ G_{10}$	0.25049	94
$C\ G_{00}$	0.09409	96
$C\ G_{10}$	0.09343	102
$\phi\ \mu$	0.1234	113
$C\ \mu$	0.0510	126

The optimized MCME parameters are shown below

```
New Markov chain parameters *      Test 2
G00bar= 2.34700012
  0.2959  0.3958  0.2394  0.3706  0.0000  0.0000
 -0.5234 -0.4423  2.4147 -0.7241  0.0000  0.0000
G10BAR= 0.476799995
  0.0279  0.2005  0.2207  0.0000  0.0000  0.0000
 -0.6419 -0.5706 -0.4789  0.0000  0.0000  0.0000
New mixed exponential parameters
ALPHA= 0.218178079
BEBAR= 1.31610000
  0.4020  0.0287  0.0000  0.0000  0.0000  0.0000
 -1.5620 -0.2190  0.0000  0.0000  0.0000  0.0000
MUBAR= 6.42999983
  1.0915  1.6615  0.3120  0.0000  0.0000  0.0000
 -1.7018  1.6431 -3.8800  0.0000  0.0000  0.0000
   48.114   324.234
```

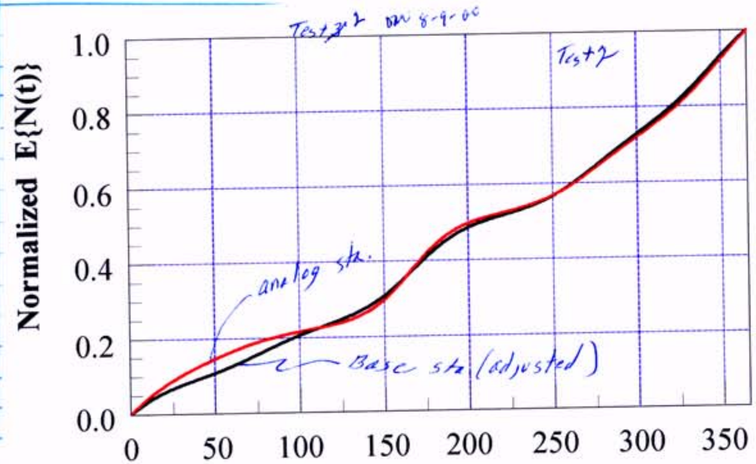
$E\{N(t)\}$ $E\{S(365)\}$ $E\{N(\cdot)\}$

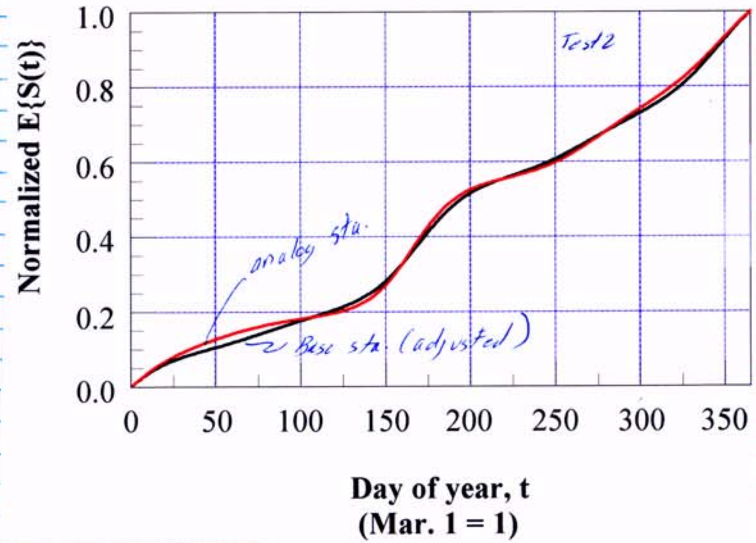
From TEST2.SEA

This was a more difficult test than test 1 because all 24 parameters were different for the base and analog site. 17 ~~16~~ (DAW 8/9/00) parameters were adjusted to fit normalized $E\{N(t)\}$ and $E\{S(t)\}$.

DAW 8-9-00 TESTING SEASON 2 (Con't)

The fit was not as good as for TEST 1 as shown by the following figures



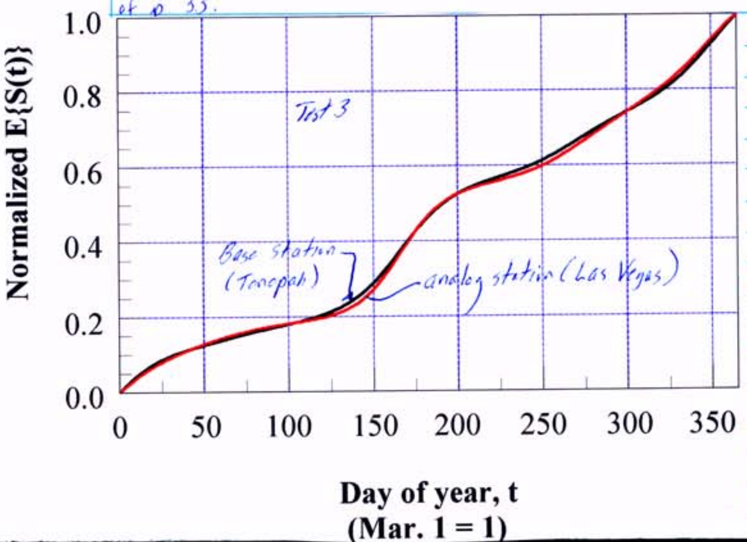


DAW 8-9-00 Testing SEASON2 (Con't)

It appears that the degree of goodness of fit is restricted by optimizing only 12 parameters (2 harmonics for G_{00}, G_{10} and μ). A third test was devised where the number of parameters to be optimized were increased – 3 harmonics for G_{00}, 2 harmonics for G_{10} and 3 harmonics for μ.

stage	Objective Func.	No. of evaluations
ϕ_{G00}	0.199	196
ϕ_{G10}	0.1979	98
C_{G00}	0.0923	164
C_{G10}	0.09229	86
ϕ_{μ}	0.11186	172
C_{μ}	0.02808	192

This led to an improvement in the fit as indicated by comparing the table above with that on p 32, and the Figure below with the same figure for Test ~~3~~ 2 (DAW 8-9-00) on the bottom of p 33.

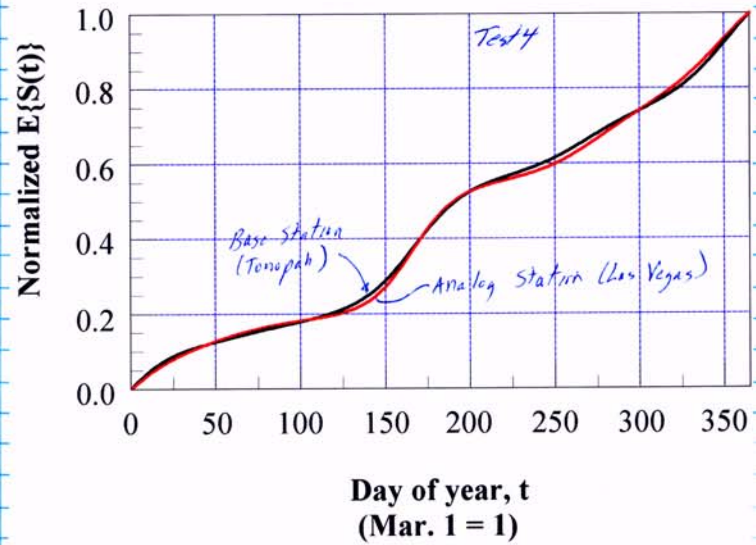


DAW 8-9-00 Testing SEASON2 (Con't)

Now, try a change in strategy by optimizing the amplitudes for G_{00} before the phase angles for G_{10}. Control file is TEST4.CON. Output files TEST4.SEA and TEST4.DAT.

stage	Objective Func.	No. of evaluations	Test 5	
ϕ_{G00}	0.19902	196	0.04769	155
C_{G00}	0.092127	177	0.051927	145
ϕ_{G10}	0.086358	109	0.004132	111
C_{G10}	0.081160	107	0.002087	118
ϕ_{μ}	0.090467	276	0.01309	174
C_{μ}	0.033737	179	0.01015	163

Interestingly, this change in optimization order resulted in an improvement of fit for $E\{N(t)\}$ $F=0.08116$ vs $F=0.09229$ but a slight decrease in the fit of $E\{S(t)\}$ $F=0.033737$ vs $F=0.02808$.



DAW 8-10-00 Testing Season 2 (Con't)

Adjusting Model Parameters to achieve the target mean annual precipitation

When the regression relationships between MCME model parameters and mean annual precipitation are used to adjust the parameters for a new target annual precipitation, and amplitudes and phase angles of $\mathcal{G}_{00}$, $\mathcal{G}_{10}$ and μ are adjusted to reflect changes in seasonality as defined by an analog station, the target annual precipitation is not maintained. For example the printout for Test 2 on p 32 shows an overestimate of 24.7 mm/yr. This is undesirable because sensitivity studies require that we obtain the target annual precipitation. To correct parameter values to obtain the target annual precipitation, P_A, Adjustments could be made in the two most sensitive parameters, $\bar{\mathcal{G}}_{00}$ and $\bar{\mu}$. There is no objective way to determine how much of the correction should be made by the counting process and how much by adjusting the mean of the mixed exponential, because the relationship between mean annual number of wet days and annual precipitation would not be preserved under a future climate. For a first approach to the correction, use the scheme on pages 5 and 6 of the attachment to this notebook. The excess mean annual precipitation can occur because of too many wet days and/or an excess in the mean daily precipitation. As an approximation, let

$$P+\Delta P = (N+\Delta N)(\mu+\Delta\mu) = N\mu + \mu\Delta N + N\Delta\mu + \Delta\mu\,\Delta N$$

where:

P = Target annual precipitation = 300 mm

ΔP = Error = 24.7 mm

N = Target number of wet days

μ = Target mean depth of rainfall per wet day

$\Delta\mu$ and ΔN = errors

DAW 8-10-00 Adjusting Model Parameters to get Target Annual Precipitation

It appears that an iterative approach similar to that used by Hanson, et al. (1994) Microcomputer Program for Daily Weather Simulation in the ~~UNIT~~ contiguous United States, ARS-114 would be superior to that approach on p 36. DAW 8-10-00

The error between the target precipitation and the model precipitation, E, is apportioned equally between the counting process and the mixed exponential μ

$$0.5E + \frac{\partial E}{\partial \bar{\mathcal{G}}_{00}}\Delta\bar{\mathcal{G}}_{00} = 0$$

$$0.5E + \frac{\partial E}{\partial \bar{\mu}}\Delta\bar{\mu} = 0$$

Now the expected annual precipitation is

$$E\{S(365)\} = \sum_{n=1}^{365}\left[P\{X_{n-1}=0\}\,p_{01}(n) + P\{X_{n-1}=1\}\,p_{11}(n)\right]\left[\mu(n)+T\right]$$

To approximate the derivatives we can take the values of p_{00} and μ in the above equation as constants leading to:

$$E\{S(365)\} \approx \left\{\left[1-P\{X(n)=1\}\right]\left[P_{01}\right] + \left[1-P_{00}\right]\Big/\left[1+P_{10}-P_{00}\right]\right\}\mu\cdot 365$$

$$E\{S(365)\} \approx \left[\frac{1-\bar{P}_{00}}{1+\bar{P}_{10}-\bar{P}_{00}}\right]\bar{\mu}\cdot 365$$

$$\frac{\partial E}{\partial \bar{\mu}} = \left[\frac{1-\bar{P}_{00}}{1+\bar{P}_{10}-\bar{P}_{00}}\right]365 = \frac{1-\dfrac{e^{\bar{\mathcal{G}}_{00}}}{(1+e^{\mathcal{G}_{00}})}}{\left[1+\dfrac{e^{\mathcal{G}_{10}}}{(1+\mathcal{G}^{10})}-\dfrac{e^{\mathcal{G}_{00}}}{(1+e^{\mathcal{G}_{00}})}\right]}\cdot 365$$

$$\frac{\partial E}{\partial \mathcal{G}_{00}} = \frac{\partial E}{\partial P_{00}}\frac{dP_{00}}{d\mathcal{G}_{00}}\mu \cancel{\times} 365 = \frac{-e^{\mathcal{G}_{10}}}{(1+e^{\bar{\mathcal{G}}_{10}})}\frac{e^{\mathcal{G}_{00}}}{[1+e^{\mathcal{G}_{00}}]^2}\cdot\mu\cdot 365$$

DAW 8-10-00 Correction of parameters to match target annual precipitation

Procedure:

This will be an iterative procedure

1. Calculate error - $E\{S(365)\}$ - AnnualP = ERR
2. Calculate $\Delta \bar{G}_{00}$ and $\Delta \mu$

$$\Delta \bar{G}_{00} = -0.5\, ERR \big/ \left(\partial E / \bar{G}_{00}\right)$$

$$\Delta \bar{\mu} = -0.5\, ERR \big/ \left(\partial E / G_{\mu}\right)$$

3. Calculate new $E\{S(365)\}$

Repeat until $\left| E\{S(365)\} - ANNUALP \right| \leq 0.001 * ANNUALP$

Now, it is quite likely that these changes will affect the goodness of fit of the normalized functions $E\{N(t)\}$ and $E\{S(t)\}$ so it will be necessary to iterate the fitting procedure as well.

DAW 8-11-00 Correction of Parameters - Test

Revised Program is SEASON3.F90

Create New Control file TEST5.CON
output files will be: TEST5.SEA
TEST5.DAT

DAW 8-17-00

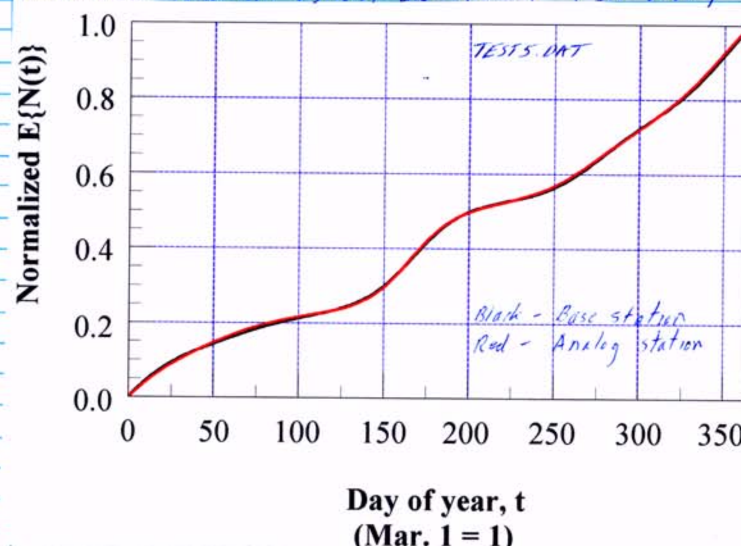
Program SEASON3 was created from SEASON2.

Changes were:

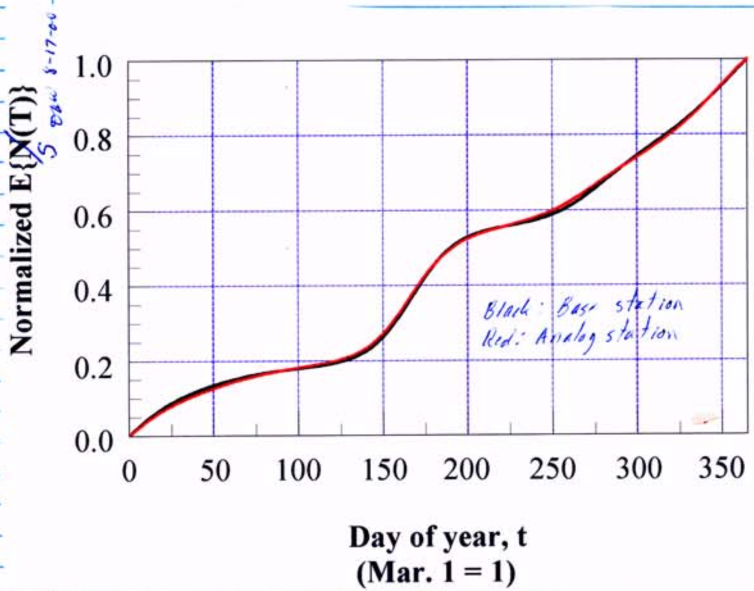
1. Adjust $\bar{G}_{00}$ and $\bar{\mu}$ to make the theoretical mean annual precipitation $E\{S(365)\}$ agree with the target (within 0.001*AnnualP)

2. Add a second round of optimization, i.e. after adjusting $E\{S(365)\}$

These modifications led to very good fits for the normalized functions $E\{N(t)\}$ and $E\{S(t)\}$ (see below)



DAW 8-17-00 Correction of Parameters (Con't)



The counting process fit is excellent. The accumulative precipitation process shows a minor deviation during $230 < t$ 275, although the base and analog stations would have the same relative accumulation between line crossings,

Conclusion:

The program is working properly. Now the following should be done:

1) Identify MCME parameters for NTS precipitation gages (See p 41)
2) Check to see that the programs I am using give results consistent with those by ARS-Tucson
9) Repeat regression analysis

DAW 8-17-00 Analysis of NTS Precipitation Data.

The data were obtained from R Fedors, who obtained them from a web site as shown below.

Nevada Test Site Meteorological Stations - Cleaned Up Daily Data

Data obtained June 6, 2000 from web page http://wwwsord.nv.doe.gov/SORD_Rain.html

Data was collated into one spreadsheet by Deb Waiting (one "raw" and one "clean"ed up file).

readme.txt

Files: CUM_PRECIP_raw.xls
CUM_PRECIP_clean.xls

	ID	lat	long	elev ft	start yr	end yr
Rainier Mesa	A12	37 11 28 N	116 12 55 W	7490	1959	2000
Buster Jangle	BJY	37 03 46 N	116 03 09 W	4070	1960	2000
Cane Springs	CS	36 48 44 N	116 06 29 W	4000	1964	2000
Device Assembly Facility	DAF	36 53 58 N	116 02 04 W	3710	1997	2000
Desert Rock	DRA	36 37 16 N	116 01 33 W	3250	1963	2000
E Tunnel	Etu	37 11 30 N	116 12 04 W	6250	1996	2000
Jackass Flats	4JA	36 47 05 N	116 17 20 W	3422	1957	2000
40 Mile Canyon North	40Mi	37 02 57 N	116 17 15 W	4820	1960	2000
Little Feller 2	LF2	37 07 05 N	116 18 14 W	5120	1976	2000
Mercury	MER	36 39 59 N	116 00 66 W	3770	1962	2000
Mid Valley	MV	36 58 21 N	116 10 19 W	4660	1964	2000
Pahute Mesa 1	PM1	37 14 56 N	116 26 15 W	6550	1964	2000
PHS Farm	PHS	37 12 32 N	116 02 19 W	4565	1964	2000
Rock Valley	RV	36 41 07 N	116 11 32 W	3400	1963	2000
Tippipah Springs	TS2	37 03 11 N	116 11 29 W	4980	1960	2000
Well 5 B	W5B	36 48 07 N	115 57 55 W	3080	1962	2000
Yucca Dry Lake	UCC	36 57 23 N	116 02 51 W	3924	1958	2000

1.) Create an input file for Markov chain analysis for Ranier Mesa, ID = A12
   a) Copy first 5 cols. from spreadsheet to new spreadsheet RANIER.WRK Col. 5 F is daily precipitation in inches.
   b.) Remove leap year rows ✓
   c.) Remove up to Mar 1 of first year (Mar 1, 1959)
   d.) " after Mar 1 of last year (Mar 1 '99 - Feb 28, 2000)
   e) Copy col. 5 to new sheet and save as RANIER.PTT in Text format. (Formatted text, space delimited) Prior to copy replace (blanks) with 0.0

DAW 8-17-00 Analysis of NTS precipitation

Now will need to revise programs:
MCF01R.FOR and MIXEX2~1.FOR to
change the format for reading daily
precipitation. Format is

should also change output so means and
amplitudes can be in mm for mixed exponential
Provide an option in the control file

Note: MIXEX2~1.FOR is MIXEX2000.FOR

Work with Lahey Fujitsu Fortran 95 compiler

e) Save MCF01R.FOR as MCF02R.FOR
Make revisions in MCF02R.FOR

DAW 8-18-00 Test Programs
Received data file rg004.3-2 from T. Keefer,
ARS, Tucson, AZ. This contains daily precipitation
data in the Mar-~~Apr~~ DAW 8-18-00 Feb ACUA format (16F5.2)
for rain gage 4 (Walnut Gulch Experimental Watershed)
for Mar 1, 1955 → Feb. 28, 1996. Also received
parameter values identified by the ARS program
for the period Mar 1, 1955 → Feb 28, 1990. (35 yrs)

To run these data, I need to change the read
format.
Copy MCF02R.FOR → MCF03R.FOR ✓

Control file WG_4MC.CON

DAW 1-19-01 Notes on USGS Climate Change Report
Report on ZIP disk, obtained from R. Fedors.

Objective is to forecast climate at Yucca Mtn for the
next 10,000 yrs.

6.1 Past climate was analyzed to select meteorological
stations that can be used to estimate climate at YM
for the next 10,000 yrs.
Assume no tectonic scale changes

Sierra Nevada and Transverse Range exert significant control
over YM climate.

Present: Late spring - early fall - northward movement & intensification
of subtropical highs; but not a strong monsoonal pattern.
But produces convective thunderstorms. Local importance
Late fall - easy spring - influence of westerlies; but Polar
Low and Arctic High pressure may intrude resulting in more
precipitation and less evaporation.
Wettest winters associated with El Nino years ← could check
this with SOI.

6.3 Assume that climate is cyclical.

Present day is interglacial
The delta oxygen-18 ($\delta^{18}O$) isotope record from a calcite
core at Devils Hole, NV. provides information about climate
change in the region - Records character of regional
groundwater flow.

The Devil's Hole $\delta^{18}O$ sequence was compared with
precession to establish an orbital clock & provides a
rationale for timing future climate change.
6.5

DAW 1-26-01 Climate report Examination of NTS station 4JA (Jackass Flats). In climate report, daily precipitation for this station was increased to the Yucca Mtn. total for present day climate. I hypothesize that this procedure is incorrect because number of wet days should also increase. To test this, I will create a file Jackass.PTT for input to MCME00_4.f95.
for procedures see p. 41.

a) Copied columns from spreadsheet CUM_PRECIP_clean.XLS to new file –
b) Remove leap year rows ✓
c) Remove up to Mar 1 of first year 1959 ✓
Last year is 2000
d) Remove Mar 1 – Apr 30, 2000 ✓
e) Copy col. 5 to new sheet and save as Jackass.PTT formatted text, space delimited
(first replace space with zeros ✓

RAN PROGRAM with 40 yrs' beginning in 1959
control file: JACKASS.FIL in CLIMATE
Av. No. of wet days = 32.10; Av. precip = 140.80 mm
Created File CUM_PRECIP_REV.XLS with leap-day rows removed. This is an intermediate procedure. Final files for input to MCME00-4 have extension .PTT

DAW 2-8-01
Examine intermediate elevation station
Try 40 mi. Canyon North (40Mi) el = 4820 ft.
First Yr. is 1959 starts Jan. 1
Precip file is FORTY~1.PTT
Control file: FORTY.FIL in CLIMATE
Av. No. wet days = 43.03
Av. Ann Precip = 8.02 inches = 203.71 mm
40 yrs. beginning in 1959

DAW 2/23/01 Complete MCME analysis of NTS stations

Buster Jangle BJY 1960-2000

Work from spreadsheet (XL) CUM_PRECIP_REV.XLS
1) delete col. AI2 ✓
2) Copy Cols A – E ✓
3) Del A – E through Feb 28, 1959 ✓
4) Remove Mar 1 – end 2000
5) Create BUSTER.PTT
USE MCME00_4.F95
Ave No. of wet days = 30.2
Ave Annual precip = 6.44 in = 163.5 mm
6) Control file BUSTER.FIL ✓
Run MCME 39 yrs beginning 1960

Cane Springs CS 1964-2000
Note 1964 is probably not complete so start in '65

start Mar 1, 1965 35 yrs ✓
CANE.FIL
CANESPRINGS.PTT → renamed to CANE.PTT
Ave annual number of wet days = 37.97
" " precipitation = 203.8 mm

DAW 2/23/01 NTS Stations (Cont)

Desert Rock, DRA, 1963 – 2000
1963 not complete, start Mar. 1, 1964
DESERT.PTT
CONTROL FILE: DESERT.FIL ✓ 36 yrs.
Av. ann. number of wet days (NWET) = 33.306
" " precip = 5.85 in = 148.70 mm

MERCURY 1962 – 2000 Start Mar. 1, 1963
MERCURY.PTT ; MERCURY.FIL 37 yrs
Average annual number of wet days = 28.43
Average annual precipitation = 4.76 in = 120.99 mm

Tippipah Springs TS2 1960 – 2000

1960 not complete. Start in 1961

TIPPIPAH.PTT, TIPPIPAH.FIL
39 years

Ave. No. of wet days = 43.90
Ave. An. Precip. = 224.28 mm

DAW 2/23/01 NTS Stations (Cont)

Well 5B W5B 1962 – 2000

WELL5B.PTT, WELL5B.FIL 38 yrs. beginning in 1962.

Ave. No. of wet days = 32.66
Ave An. precip = 123.3 mm.

Yucca Dry Lake UCC 1958 – 2000

Mar 1, 1959 – ~~M~~ Feb 28, 2000 40 yrs.
Yucca.PTT, YUCCA.FIL

NWET = 35.97
$\overline{P}$ = 6.82 in = 173.25 mm

DAW 3/1/01 Regional Regressions

From PROSTAT File: CLIMATE/MCMETSTPAR.PDW

G_{00} vs MAP: $\overline{G_{00}} = 3.095 - 0.00236\,MAP$; $R^2 = 0.702$
G_{10} vs MAP: $\overline{G_{10}} = 0.8548 - 0.00205\,MAP$; $R^2 = 0.3456$
$\overline{G_{10}} = 1.430\exp(-0.006369\,MAP)$; $R^2 = 0.430$
$\overline{\mu}$ vs MAP: $\overline{\mu} = 2.2773 + 0.01227\,MAP$; $R^2 = 0.752$

$\log\left(\frac{\alpha}{1-\alpha}\right)$ vs MAP $G_\alpha = -0.4568 - 0.00169\,MAP$; $R^2 = 0.117$

$\overline{\beta}$ vs MAP $\overline{\beta} = -0.0782 + 0.00428\,MAP$; $R^2 = 0.355$
$\overline{\alpha}$ vs MAP $\overline{\alpha} = 0.3802 - 0.000323\,MAP$; $R^2 = 0.107$

DAW 3/1/01 Regional Regressions (Con't)

C_{100} vs MAP N.S. $R^2 = 0.0069$; $\bar{C}_{100} = 0.3462$ Std dev = 0.0757
C_{200} vs MAP N.S $R^2 = 0.0050$; $\bar{C}_{200} = 0.2217$ Std. dev = 0.0635

C_{110} vs MAP N.S $R^2 = 0.0288$; $\bar{C}_{110} = 0.1715$ S.D. = 0.0888
C_{210} vs MAP N.S. $R^2 = 0.00113$; $\bar{C}_{210} = 0.17373$ S.D. = 0.0677

Mean of $\bar{\alpha} = 0.3194$, S.D. = 0.0660

mean MAP = 188.42, S.D. = 66.96, Range: 105.918 → 324.866 mm

To check phase angles, save file MCMETSTPAR.PDW in /CLIMATE as MCPHASE.PDW

Phase ∠s for Ranier Mesa appear to be incorrect
Create new precip. file. Note: It appears that records were not complete for 1959 so start Mar 1, 1960.

DAW 3/2/01 Continue with Ranier Mesa
Mar 1, 1960 – Feb 28, 2000 = 39 yrs

RANIER2.PTT ; RANIER3.FIL

Results look good

Now correct CLISTAT spread sheets ✓

Correlations shown above and on p. 47 are not reliable for phase angles because data for Ranier Mesa started on Jan. 1. The regressions above include NTS stations and the six stations previously analyzed. Adaven, Beatty 8N, Caliente, Tonopah, Las Vegas and Goldfield.

DAW 3/13/01

DAW 3/13/01 Regressions with NTS stations + Las Vegas

Set up new PSIPLOT Spreadsheets using only NTS stations and Las Vegas. First is for Markov Chain only
CLIMATE\NTSMCPHASE.PDW Markov Chain parameters
\NTSMEPHASE.PDW Mixed exponential parameters

1) Regression: Ave No. of wet days, NWET versus Mean annual precipitation, MAP

NWET = 15.109 + 0.1246 MAP $r^2 = 0.942$ N=10
NWET = 15.037 + 0.1249 MAP $r^2 = 0.943$ N=11 includes Desert Rock

DAW 3/14/01

2) $\bar{G}_{00}$ vs. MAP Done with PROSTAT

$G_{00} = 3.158 - 0.00253 * MAP$ $R^2 = 0.897$ N=10
$G_{00} = 3.144 - 0.00249 * MAP$ $R^2 = 0.884$ N=11 includes Desert Rock

3) $\bar{G}_{10}$ vs MAP

$\bar{G}_{10} = 2.507 \exp(-0.01099 * MAP)$ $R^2 = 0.828$ N=10
$\bar{G}_{10} = 2.438 \exp(-0.01054 * MAP)$ $R^2 = 0.799$ N=11

4) $\bar{\mu}$ vs MAP

$\bar{\mu} = 2.782 + 0.00899 * MAP$ $R^2 = 0.870$ N=11

5) $\ln(\alpha/(1-\alpha))$ vs MAP Not significant
A plot shows a generally upward trend except for Ranier Mesa. Ranier Mesa has a significant first harmonic for α. However α values have a rather small range 0.307 – 0.397 with $\alpha_{mean} = 0.350$ std. dev. = 0.032

6) $\bar{\beta}$ vs MAP
$\bar{\beta} = 0.297 + 0.001497 * MAP$ $R^2 = 0.519$

DAW 3/15/01

7) $C_{1\mu}$ vs MAP
$C_{1\mu} = 0.2513 + 0.002876 * MAP$ $R^2 = 0.6208$

DAW 3/15/01 Regressions (Con't)

8) $\phi_{1\mu}$ vs MAP

For Cane Springs, $\phi_1 = 3.2368$ while for all others ϕ_1 are negative.

3.2368 rad is equivalent to $-[3.1416-(3.2368-3.1416)]$

$= -3.0464$ Changed to this value in CLIMATE\NTSMEPhase.PDW

~~$\phi_{1\mu} = -3.5847 + 0.0119 * MAP$ $R^2 = 0.108$~~

incorrect see below

~~$\phi_{1\mu} =$~~ DAW 3/15/01

Note: There is also a positive ϕ for Jackass Flats

$\phi_1 = 2.9948$

change to negative:

$\phi_1 = -[3.1416 + (3.1416 - 2.9948)] = -3.288$ rad

Changed to above value in NTSMEPhase.PDW

~~$\phi_{1\mu} = -5.1972 + 0.01789 * MAP$~~ $R^2 = 0.432$

DAW 3/15/01

Note: Ranier Mesa also has + $\phi = 2.5994$

$\phi_1 = -(2\pi - 2.5994) = -3.6837$ rad

$\phi_{1\mu} = -1.4946 - 0.00656 * MAP$ $R^2 = 0.414$

In viewing a plot, much of the regression significance is probably due to Ranier Mesa, the wettest station.

$\bar{\Phi}_{1\mu} = -2.6414$ Std dev $= 0.6105$ CV $= 0.23$

min $= -3.6837$ max $= -1.693$

So there is quite a bit of noise

However in checking confidence bands, go with regression

DAW 3/15/01 Regressions (Con't)

Therefore, there is an effect of MAP on the phase of the first harmonic of μ (as well as the amplitude)

9) $C_{2\mu}$ vs MAP

$C_{2\mu} = 0.0489 + 0.004267 * MAP$ $R^2 = 0.8544$

This appears to be highly significant. A curvilinear relationship might be better.

$C_{2\mu} = 0.0028 * MAP^{1.0923}$ $R^2 = 0.860$

10) $\phi_{2\mu}$ vs MAP

~~From inspection all phase ∠s are positive~~

~~Regression not significant $R^2 = 0.0037$~~ Not correct DAW 3/15/01

~~$\Phi_{2\mu} =$~~

Actually, Buster Jangle has $\phi_{2\mu} = -3.19$

Correct to positive angle $\phi_{2\mu} = 3.0938$

Regression not significant

$\bar{\Phi}_{2\mu} = 2.357$ std. dev. $= 0.3548$ CV $= 0.189$

min $= 1.877$ max $= 3.093$

No obvious trends or errors so use mean value

3/16/01 Regional Regressions (Cont) DW

11) C_{1600} vs MAP

Linear Regression with PROSTAT – Not significant

$\overline{C}_{1600} = 0.36112$ std. dev = 0.0549 CV = 0.152

Min = 0.2865 Max = 0.456

Buster Jangle Mercury

12) ϕ_{1600} vs MAP

$\phi_{1600} = -0.8843 - 0.001245$ MAP $R^2 = 0.143$

Try exponential

$\phi_{1600} = 0.8467 \exp(0.001403 * MAP)$ $R^2 = 0.130$

$\overline{\phi}_{1600} = -1.102$ std. dev = 0.197

min = −1.356 Forty Mile max = −0.6091 Las Vegas

Most of neg. trend due to Las Vegas

13) C_{2600} vs MAP

$C_{2600} = 0.2871 - 0.000469$ MAP $R^2 = 0.184$

$\overline{C}_{2600} = 0.2051$ std. dev = 0.0654 CV = 0.319

min = 0.1537 Jackass Flats Max = 0.3902 Las Vegas

Plot saved as NTSMCPARS.PGW

C_{1600}, ϕ_{1600}, C_{2600}, vs MAP

14) ϕ_{200} vs MAP

$\phi_{200} = -0.9153 - 0.001516$ MAP $R^2 = 0.1347$

$\overline{\phi}_{200}$ −1.1805 std. dev = 0.2473 CV = 0.209

min −1.6409 Forty Mile max = −0.764 Buster Jangle

DW 3/16/01 Regressions (Cont)

15) C_{1G10} vs MAP

$C_{1G10} = 0.2685 - 0.000342$ MAP $R^2 = 0.1957$

$\overline{C}_{1G10} = 0.20864$ std. dev = 0.04631 CV = 0.222

min = 0.14928 Ranier Mesa max = 0.2998 Buster Jangle

16) ϕ_{1G10} vs MAP

$\phi_{1G10} = -0.60242 - 0.003028$ MAP $R^2 = 0.282$

Averages for remaining amplitudes and phase angles of Markov Chain Parameters

DW 3/16/01

	C_{3600}	ϕ_{3600}	C_{4600}	ϕ_{4600}	~~ϕ~~ C_{5600}	ϕ_{5600}
Av.	0.1891	3.0485	0.1748	0.1603	0.14649	−1.8199
std. dev.	0.0360	0.2323	0.006977	0.3734	0.0309	0.6162
CV	0.19	~~0.0770~~ DW 3/20/01 0.0762	0.0399	2.329	0.211	0.339

	C_{2G10}	ϕ_{2G10}	C_{3G10}	ϕ_{3G10}
Av.	0.2030	−0.5657	.07986	No coherence so don't
S.D.	0.0702	0.3496	.05006	use 3rd harmonic
CV	0.346	0.6180	0.6268	

	$C_{3\mu}$	$\phi_{3\mu}$	$C_{4\mu}$	$\phi_{4\mu}$	$C_{5\mu}$	$\phi_{5\mu}$
Av	only 1 sta		0.495	−3.955	only 1 sta with	
SD	with sig ϕ_3		0.1764	0.7246	sig. ϕ_5	

6 sig.

	$C_{1\beta}$ of 4	$\phi_{1\beta}$	$C_{2\beta}$	$\phi_{2\beta}$
Av	0.1965	3.516	0.036	2.88
	only 4 sig		2 sig	

Av 0.0715 of 11

DAW 3/17/01 Daily Climate MCME
Create Figures

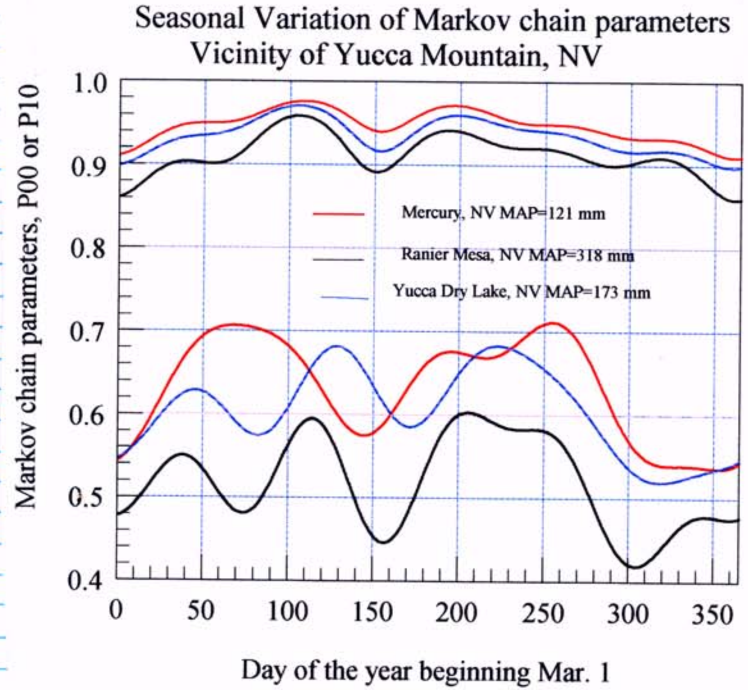
1) $G_{00}(t)$ $t=1, 365$ transform to $P_{00}(t)$
Use PSIPLOT to create figures on p 55
Show 3 stations
Ranier Mesa MAP = 318 mm
Yucca Dry Lake MAP = 173 mm
Mercury, NV MAP = 121 mm
Precipitation at Yucca Mtn is within this range.
For both Mercury and Yucca Dry Lake P_{00} is greater than 0.90, while for Ranier Mesa it drops below 0.90 in winter and early spring and again around day 140-160 (August)

2) $P_{10}(t)$ wet-dry transition probabilities.

Persistence is much greater for Ranier mesa than for the other two stations. There is not as much coherence between Mercury and the other two stations, probably because of the rather small sample size for the dry climate of Mercury

3. Mean of the mixed exponential
The fitted means for the 3 stations are shown in the figure on p. 56. While there are similarities in the seasonal variations, there is probably a greater sampling error because of the small sample size.

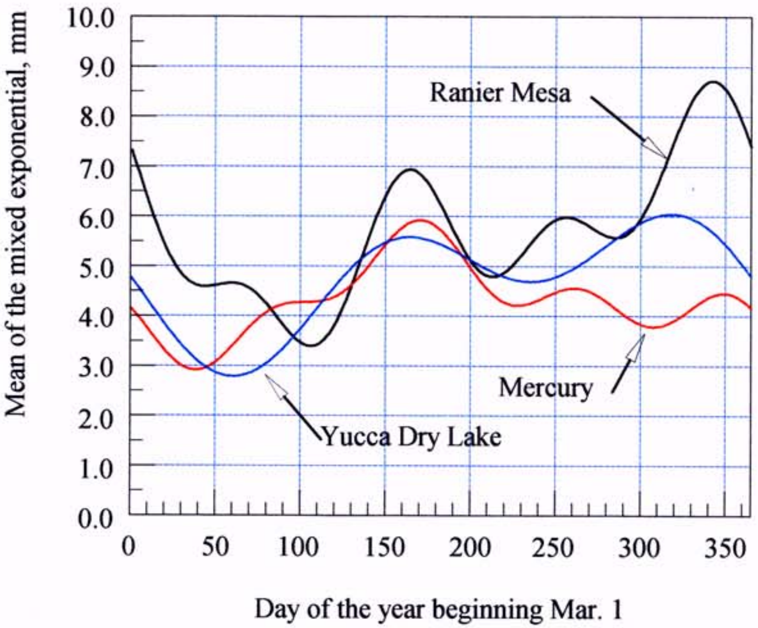
DAW 3/17/01



File: CLIMATE/ P00_P10.PGW
daw 3/17/01

Daw 3/17/01

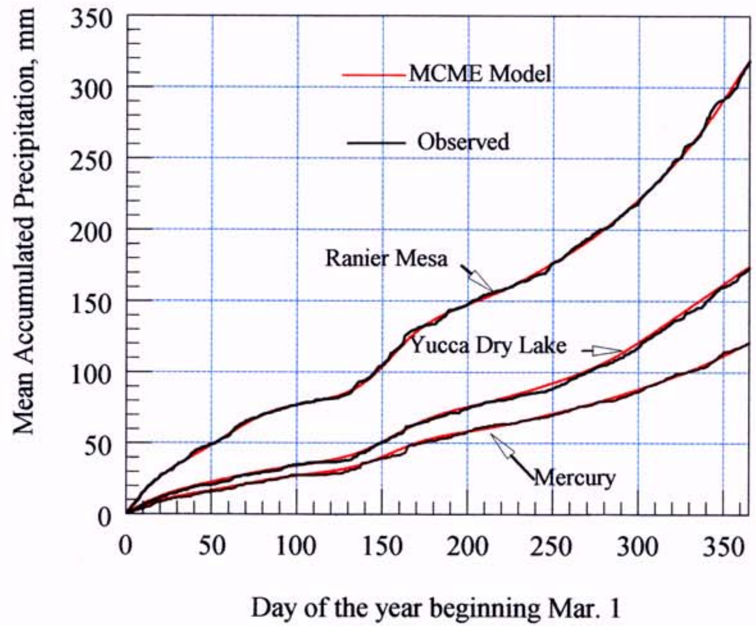
Seasonal Variation of the mean of the mixed exponential distribution. Vicinity of Yucca Mountain, Nevada



File: CLIMATE/ME_Means.pgw
daw 3/17/01

Daw 3/17/01

Observed and Modeled Mean Accumulated Precipitation Vicinity of Yucca Mountain, Nevada



File: CLIMATE/ACCUMPRE.PGW
daw 3/17/01

DAW 3/19/01 Present Climate Model

Use regression relationships to create a parameter file for an annual mean precipitation of 181 mm which was cited by USGS for Yucca Mtn.

— From p49

$G_{00} = 3.144 - 0.00249(181) = 2.6933$

$\bar{G}_{10} = 2.438 \exp(-0.01054(181)) = 0.36184$

$\bar{\mu} = 2.782 + 0.00899(181) = 4.409$ mm

$\bar{\alpha} = 0.350$

$\bar{\beta} = 0.297 + 0.001497(181) = 0.5680$ mm

$C_{1\mu} = 0.2513 + 0.002876(181) = 0.7719$ mm

From p 50

$\phi_{1\mu} = -1.4946 - 0.00656(181) = -2.6820$ rad.

Note: $\phi_{1\mu}$ was shown as + and had same value in YUCCTEST.PA DAW 8/30/01

From p 51

$C_{2\mu} = 0.0028(181)^{1.0933} = 0.8189$ mm (power) ← use

$C_{2\mu} = 0.0489 + 0.004267(181) = 0.8212$ mm (linear)

$\phi_{2\mu} = 2.357$ rad

From p. 52

$C_{1G00} = 0.36112$

$\phi_{1G00} = -0.8843 - 0.001245(181) = -1.1097$

DAW 3/19/01 Present Climate Model (Con't)

From p 52

$C_{2G00} = 0.2871 - 0.000469(181) = \cancel{2.7861}$ 0.2022 DAW 3/19/01

$\phi_{2G00} = -0.9153 - 0.001516(181) = 1.190$ (should be -1.190) DAW 8/30/01

From p 53

$C_{1G10} = 0.2685 - 0.000342(181) = 0.2066$

$\phi_{1G10} = -0.60242 - 0.003028(181) = -1.1505$

Use averages shown on p 53 for remaining parameters

DAW 3/20/01

Correct phase angles when both positive and negative angles around 2π have been identified. Make them either + or −.

DAW 3/20/01

Parameter	mean	C_1	ϕ_1	C_2	ϕ_2	C_3	ϕ_3	C_4	ϕ_4	C_5	ϕ_5
G_{00}	2.6933	0.36112	-1.1097	~~0.2022~~	~~1.190~~	~~0.0799~~		.1748	0.1603	.14649	-1.82
				~~0.1891~~	~~3.0485~~	.1891	3.0485				
				0.2051	1.190						
G_{10}	0.36184	0.2066 ~~-1.1505~~ DAW 3/20/01	-1.1505	0.203	-.6657	Don't use higher harmonics					
α	0.350										
β	0.568	0.1965	-3.516	Note: − sign left off on 3/19/01 Corrected 8/30/01 DAW							
μ	4.409	0.7719	2.682	0.8189	2.357	0	0	0.495	-3.955	0	0

DAW 3/22/01 Simulate 100 years of daily precipitation for current Yucca Mtn climate based upon regional regression parameters shown on p. 59.

Current U.S. Climat.BAS uses Fourier input for P_{00} and P_{10} instead of logits G_{00} and G_{10}

The quickest method is to modify USCLIMAT to accept the logits.
1) Rename USCLIMAT.BAS → CLIMAT2.BAS

DAW 3/26/01 Documentation of files sent to R. Fedors on a ZIP disk.

Directory: CLIMATESEPT-MAR01
Contains files between the dates 1/3/01 – 3/21/01
File name CLIMDOC.wpd
File extensions

.DAT	output from MCMEOO_X for input to PSIPLOT
.DET	Detailed output from MCMEOO_X
.F95	FORTRAN programs written on my own time. Different versions accomodate different input formats
.FIL	Control files for MCMEOO_X runs
.MAP	F95 file
.MOD	Module files for F95
.OBJ	F95 object file
.OUT	Condensed output files for MCMEOO_X
.PDW	PROSTAT or PSIPLOT data file
.PGW	" " graph file
.PTT	Daily precipitation file - input to MCMEOO_X

/

DAW 3/26/01 Documentation of files sent to R. Fedors on a ZIP disk

Directory: QUALCLIMSEPT-MAR01
QUALCLIMDOC.wpd
Files included from 1/16/01 to 1/26/01

$\left.\begin{array}{l}\text{.DAT}\\ \text{.DET}\\ \text{.OUT}\end{array}\right\}$ output files from MCMEOO_* All for raingage 4 - Walnut Gulch Experimental watershed.

DAW 3/27/01

Completed porting USCLIMAT.BAS to CLIMSIM.BAS
No changes were made in the computational algorithms.
CLIMSIM.BAS will simulate M years of daily precipitation or daily precipitation, maximum temperature, Minimum temperature and solar radiation. Units are: mm, °F and Langleys

<u>Changes in input:</u>

- Format changed see p 62
- Fourier series amplitudes and phase angles for the 1st order Markov chain are for logits (ie $G_{00} = \ln\left(P_{00}/1-P_{00}\right)$ rather than raw transition probabilities
- Included the inverse transform to obtain transition probabilities.
- Changed the iteration routine to match a specified mean annual precipitation, so that the annual constants of G_{00} and mean of mixed exponential are modified rather than the ~~mes~~ DAW 3/27/01 constants for P_{10} and α as in USCLIMATE.BAS
- Eliminated the portion of the program that searches for stations based upon latitude and longitude.

DAW 3/28/01 CLIMSIM.BAS (Con't)

The parameter values for the Markov Chain-mixed exponential precipitation were obtained as described on pgs 58 and 59. Parameters for the temperature and radiation simulation were obtained as described on p 18 and 19 adjusted for an elevation of 4,594 ft. where there wasn't a significant relation with elevation, parameters were obtained from the maps in Hanson, et. al. 1994 "Microcomputer Program for Daily Weather Simulation in the Contiguous United States" USDA, ARS, ARS-114.

A printout of the input file for Yucca Mtn with mean annual precipitation of 181 mm is shown on p. 63. With these values for the MCME model theoretical expected MAP was 176.1. After the iterative adjustment MAP was 181.2 and AWET = 38.1 $\bar{G}_{00} = 2.673$ and the constant for the mean was 4.440 mm. So $\bar{G}_{00}$ changed by -0.7% and $\bar{\mu}$ by +0.7%, well within the parameter std. dev due to sample size.

Mean # of wet days was 37.34

Note: See pages 116-127 of Attachment to this notebook

DAW 3/28/01

BASICP~1\YUCCTEST.PAR

	G00,	G10,	BETA,	MEAN
CONSTANT,	2.6933,	.36184,	0.568,	4.409
AMP1,	.36112,	.206,	.1965,	.7719
PHI_1,	-1.1097,	-1.1505,	3.516,	2.682
AMP2,	? .2051,	.203,	0,	.8189
PHI_2,	1.19,	-.5657,	0,	2.357
AMP3,	.1891,	0,	0,	0
PHI_3,	3.0485,	0,	0,	0
AMP4,	.1748,	0,	0,	.495
PHI_4,	.1603,	0,	0,	-.3955
AMP5,	.1465,	0,	0,	0
PHI_5,	-1.82,	0,	0,	0
AMP6,	0,	0,	0,	0
PHI_6,	0,	0,	0,	0
ALPHA,	0.350			
TXMD,	✓70.28			
ATX,	22.0			
CVTX,	✓.06585			
ACVTX,	✓-0.028			
TXMW,	✓62.10			
TN,	✓40.9			
ATN,	17.99 17.2			
CVTN,	✓0.05			
ACVTN,	✓-0.02			
RMD,	✓500.			
ARD,	✓235.			
RMW,	✓320.			
ARW,	✓180.			
CVRD,	✓0.17			
ACVRD,	✓-0.04			
CVRW,	✓0.40			
ACVRW,	✓-0.14			
LATLONG,	37., 116.			

3.516 DAW 2-7-03

-1.19 DAW 8/30/01

-2.682 DAW 8/30/01

Note: should be -3.955 DAW 8/30/01

DAW 8/30/01 17.99

Note: Phase ∠s in rad.

Constants and amplitudes of β and μ in mm.

Parameters for Temperature and radiation simulation.

USCLIMAT USES AVERAGE VALUES FOR THESE PARAMETERS. THESE ARE TAKEN FROM THE MAPS IN USCLIMAT, Hanson etal

Changed above parameter file & saved as YUCTEST2.PAR

$\bar{G}_{00} = 2.673$ $\bar{\mu} = 4.44$

Simulate 100 yrs. YUCCSIM2

DAW 3/28/01

Used USCLIMAT with lat. and long. of Las Vegas, then printed out the following parameter file.

BASICP~1\VEGASIM.PAR

	$\bar{P}_{00}$ 0.9441E+00	C_1 0.1078E-01	ϕ_1 -.3883E+00	C_2 0.1764E-01	ϕ_2 -.1248E+01
	0.1043E-01 C_3	-.3414E+01 ϕ_3	0.1320E-01 C_4	-.2678E+00 ϕ_4	0.8763E-02 C_5
	-.2348E+01 ϕ_5	0.5021E-02 C_6	0.1652E+01 ϕ_6		
$\bar{P}_{10}$ -	0.7073E+00	0.0000E+00 C_1	0.0000E+00 ϕ_1	0.0000E+00 C_2	0.0000E+00 ϕ_2
	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
	0.0000E+00	0.0000E+00	0.0000E+00		
$\bar{B}$	0.1145E-01	0.4804E-02 C_1	0.1765E-01 ϕ_1	0.0000E+00	0.0000E+00
	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
	0.0000E+00	0.0000E+00	0.0000E+00		
$\bar{T}_a$	0.1475E+00	0.2004E-01 C_1	-.2126E+01 ϕ_1	0.0000E+00	0.0000E+00
	0.0000E+00	0.0000E+00	0.2820E-01 C_4	0.2814E+01 ϕ_4	0.0000E+00
	0.0000E+00	0.0000E+00	0.0000E+00		
	0.3107E+00 - $\bar{\alpha}$				
	0.8000E+02 - TXMD				
	0.2200E+02 - ATX				
	0.4500E-01 - CVTX				
	-.1300E-01 ACVTX				
	0.7200E+02 TXMW				
	0.5100E+02 TN				
	0.2100E+02 ATN				
	0.4400E-01 CVTN				
	-.1000E-01 ~~RATO~~ ACVTN				
	0.5150E+03 ~~ARD~~ RMD				
	0.2300E+03 ARD				
	0.3400E+03 RMW				
	0.1850E+03 ARW				
	0.3500E+02 LAT	0.1418E+03 LONG			

DAW 3/28/01

DAW 3/28/01

Used USCLIMAT to simulate precipitation, maximum and minimum temperature and radiation to demonstrate output format. see below.

VEGASIM.PTR

MON	DAY	YR	PRECIP.	TMAX	TMIN	SOLAR
MAR	1	1	0.00	68.3	36.9	314.4
MAR	2	1	0.00	75.0	41.9	459.3
MAR	3	1	0.00	79.6	34.4	471.4
MAR	4	1	0.00	70.7	43.4	378.4
MAR	5	1	0.00	65.8	46.0	282.3
MAR	6	1	0.05	56.5	34.8	67.0
MAR	7	1	0.00	66.1	40.8	342.9
MAR	8	1	0.00	74.1	45.3	310.2
MAR	9	1	0.00	66.7	47.4	256.4
MAR	10	1	0.00	78.1	49.7	352.2
MAR	11	1	0.28	68.6	48.1	533.0
MAR	12	1	0.00	76.0	45.1	482.6
MAR	13	1	0.00	71.2	41.9	611.1
MAR	14	1	0.00	67.8	36.0	603.1
MAR	15	1	0.00	60.9	29.2	621.2

Note: On p. 7 I outlined an approach for a test of parameter identifiability. This could be tested for various climates by using USCLIMAT to create a precipitation file. Propose Portland, OR, Waterloo, IA and Tucson, AZ. or Las Vegas.

Procedure:

1) Use CLIMAT to simulate 50 yrs of precipitation for each station

Las Vegas - CLIMAT parameter file is: Vegasim.par

Simulated record is ~~Vegasim.ptr~~ DAW 3/28/01 Vegasim.Pre

Run USCLIMAT to get 57 years. (Same as from real data)

Store results in QUALCLIM C:CONSULT/QUALCLIM

File VEGASIM.PRE

Continue on p. 70

DAW 4/5/01 Simulate 100 yrs of daily precipitation to provide input to Upper Split Wash model.

1. Used CLIMSIM.BAS to generate 100 yrs
Random number seed = 577
Input file YUCTEST2.PAR
Input 181 mm as mean annual precipitation
Output file: YUCCSIM1.PRE

2. Revised condense.bas to take input in mm
New program is CONDEN2.BAS

Extension of output file will be .CON

3. Revise program DAYDIS.BAS to accept input in mm. This is done internally by converting mm in input to inches

New PROGRAM is DAYDISMM.BAS

Output extension .DUR

Sent e-mail to S. Stothoff with copy to R. Fedors
Attached CLIMSIM.BAS and YUCTEST2.PAR.
Try to coordinate activities so that I can get an estimate of soil water content at the beginning of major events.

DAW 4/5/01 Test Seasonal Adjustment.

Objective: Use SEASON3.F90 to adjust parameters of YUCTEST2.PAR (Precipitation only) to match seasonality of Precipitation at Walnut Gulch, AZ (Monsoon climate) and Spokane, WA (Interglacial)

1) Revise SEASON3.F90 to include most recent regional regression results. ✓

2) Set up parameter files for base station

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DAW 4/6/01 Parameter identifiability (Con't)

Another factor of interest is the effect of record length, especially in arid zones.
I have simulated 100 yrs of precipitation for Yucca Mtn using the parameters shown on p 63.
File name: YUCCSIM2.PRE
copy to QUALCLIM
Set up 3 control files with length of record = 20, 40 and 60 years

DAW 4/6/01
~~YUCCID~~ YUCID20.FIL
YUCID40.FIL
YUCID60.FIL

Output files have the same names but extensions are:
.OUT Condensed output
.DET Detailed output
.DAT For graphics

DAW 4/7/01

Parameter values identified for each length or record are compared with the simulation model values in tables

For G_{00}, the Model had 5 harmonics with the 20 yr. record, 3 of these were declared nonsignificant according to the Akaike Information Criterion (AIC). All harmonics were correctly identified as significant for the 40 and 60 year records. The absolute values of the amplitudes and phase angles were identified remarkably well for the 40 and 60 year records

DAW 4/7/01

Parameter G_{00}

	Model	20 yr.	40 yr	60 yr
$\overline{G}_{00}$	2.673	2.6088	2.6159	2.6315
C_1	0.36112	0.3386	0.2918	0.3293
ϕ_1	-1.1097	-1.1036	-1.1617	-1.0921
C_2	0.2051	0.29765	0.2750	0.2259
ϕ_2	1.19	1.5818	1.354	1.2639
C_3	0.1891	0.08639 NS	0.1429	0.1726
ϕ_3	3.0485	3.1367	3.0729	3.1038
C_4	0.1748	0.07145 NS	0.1640	0.1773
ϕ_4	0.1603	0.8360	0.08125	0.2172
C_5	0.1465	0.1328 NS	0.1745	0.1639
ϕ_5	-1.82	-1.5082	-1.877	-1.795

Parameter G_{10}

	Model	20 yr	40 yr	60 yr
$\overline{G}_{10}$	0.36184	0.4439	0.3834	0.37462
C_1	0.206	0.3021	0.2811	0.1688
ϕ_1	-1.1505	-1.320	-1.4169	-1.4282
C_2	0.203	0.1571 NS	0.1701 NS	0.20556
ϕ_2	-0.5657	0.01772	0.03719	-0.04742
C_3		0.20195 NS	0.07819 NS	0.11352 NS
ϕ_3		1.1561	1.746	0.6910
C_4		0.1832 NS	0.05308 NS	0.05603 NS
ϕ_4		-2.0178	-1.1563	-0.7428
C_5		0.1394 NS	0.1288 NS	0.08661 NS
ϕ_5		1.211	1.448	1.0156

For G_{10} the model had 2 harmonics. With the 20 yr and 40 yr records MCMEDO-* ~~was~~ DAW 4/7/01 declared the 2nd harmonic to be insignificant, while with the 60 year record, it was identified. The amplitudes and phase angles were not reproduced as closely as for G_{00}, reflecting the much smaller sample size of transitions from wet to dry.

DAW 4/7/01

Mixed exponential distribution

Parameter α

	Model	20yr	40yr	60yr
$\bar{\alpha}$	0.350	0.33758	0.33476	0.34405
C_1				
ϕ_1				

Parameter β

	Model	20yr	40yr	60yr
$\bar{\beta}$	0.568	0.6160	0.59365	0.59174
C_1	0.1965	0.3256	0.22805	0.19627
ϕ_1	3.516	-3.2246	-2.8198	-2.8008

Same as -2.767

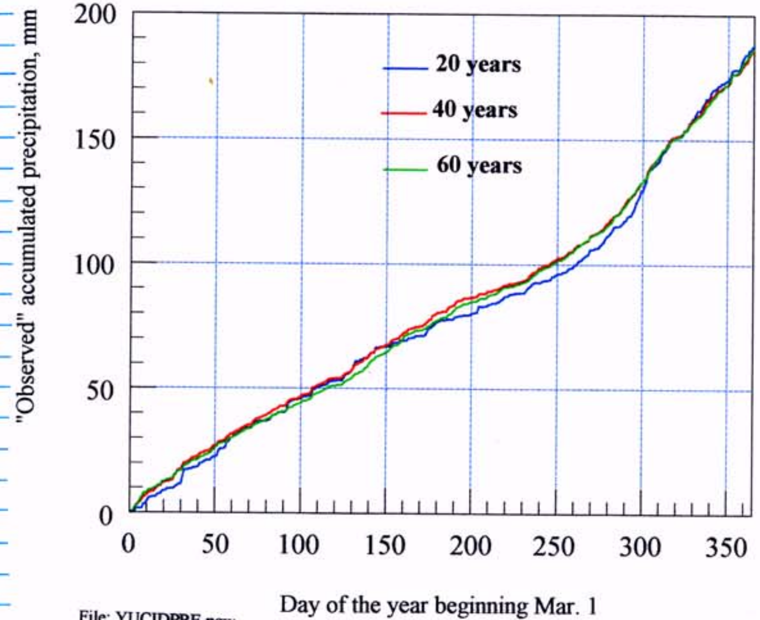
Parameter μ

	Model DAW 4/7/01	20yr	40yr	60yr
$\bar{\mu}$	~~4.409~~ 4.44	4.5339	4.5941	4.6143
C_1	0.7719	0.67106	0	0.41825
ϕ_1	2.682	1.9536		2.7502
C_2	0.8189	1.1635	1.132	1.0455
ϕ_2	2.357	2.4952	2.137	2.0475
C_3	0	0	0	0
ϕ_3				
C_4	0.495	0	0.5386	0.6625
ϕ_4	-0.3955		-0.21185	0.06612

The parameter $\bar{\alpha}$ is identified quite well and no harmonics were identified. For β, the mean and C_1 were matched closely, but the phase angle showed large variation for 20yr record. However it was closely identified for the 40 and 60 yr records

DAW 4/7/01

Yucca Mtn. Model. Effect of length of record on mean accumulated precipitation

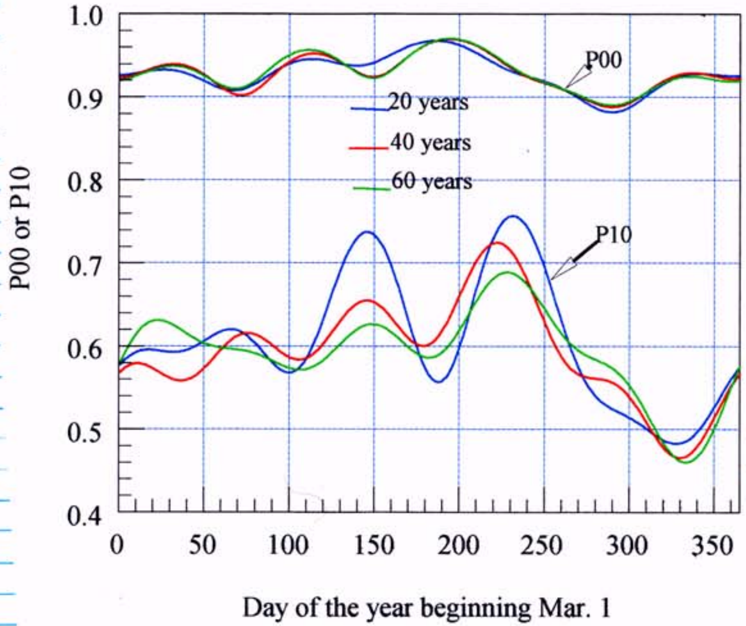


File: YUCIDPRE.pgw
daw 4/6/01

-The above figure shows the sample mean accumulated precipitation. These are not independent samples because the 20 yr period is part of the 40 and both are part of the 60. The 40 yr and 60 yr sample functions are quite close except for the dry period for days 150-200. The 20 year function shows a 10-15 mm deviation during the 200-300 day period.

daw 4/7/01

Yucca Mtn. Model: Effect of length of record on Markov chain transition probabilities



File: YUCIDMC.pgw
daw 4/6/01

The Figure shows that the logits, $G_{00}(t)$ and the transform, $P_{00}(t)$ is identified quite closely, even for the 20 yr record because of the large number of dry-dry transitions in this climate. $G_{10}(t)$ has more variability, with the 60 record providing less interseasonal variabity. This figure shows $G_{10}(t)$ calculated for 5 harmonics, although the "true" model has only 2. Thus some "noise" is being fitted.

daw 8/30/01 Check Input Parameter Values in YUCTEST2.PAR

I compared the MCME parameters shown on p 63 with the values for the NTS stations shown in files NTSMEPHASE.PDW and NTSMCPHASE.PDW and discovered some transcription mistakes. Mistakes were

$\phi_{1\mu}$ shown as 2.682 rather than −2.682

$\phi_{4\mu}$ shown as −0.3955 rather than −3.955

$\phi_{1\beta}$ shown as 3.516 rather than −3.516

ϕ_{2G00} shown as 1.19 rather than −1.19

These mistakes probably account for the seasonal discrepancies discussed on p 55 of Scientific Notebook 444.

Need to create a corrected parameter file.

Copy YUCTEST2.PAR to YUCPRES.PAR ✓

Make above corrections ✓

Now generate 2 new 50yr files of precip, max + min temp and solar radiation
use program CLIMSIM
From corrected parameter file YUCPRES.PAR MAP = 177.58 mm
NWET = 37.57

Input 181 mm get MAP = 181.17 NWET = 38.11
$\overline{G_{00}}$ = 2.679
$\overline{\lambda}$ = 4.4308 mm

YUCSIMC.PTR random seed = 527 50 yrs.

YUCSIMD.PTR random seed = −527 50 yrs

DAW 9/4/01 50 yr. simulations with corrected parameters.

Now have 2 files with 50 yrs of precipitation, temperature + radiation:

YUCSIMC.PTR MAP = 170.76 MNW =
YUCSIMD.PTR MAP = 191.1 mm

After running PSTAT02B.BAS have 2 files with statistical summaries

YUCSIMC.STA
YUCSIMD.STA

Using MSDOS Editor, extract monthly statistics from each file and create files of monthly values.

YUCSIMC.MON
YUCSIMD.MON

Note: Above files are in zip disk sent to Fedors in 9/26/01 or 3/26/01 DAW 7-15-03

DAW 4/25/01 Simulation of 100 yrs of precipitation, maximum and minimum temperature and solar radiation for present day Yucca Mtn.

Use CLIMSIM.BAS with input parameter file Yuctest2.PAR to generate 2 - 50yr. records. Adjust to MAP = 181. mm. ✓

Output files YucsimA.PTR random no. seed 527
YucsimB.PTR random no. seed -527

No leap years generated.

Simulated files are of the form

Line 1	MON	DAY	YR	PRECIP.	TMAX	TMIN	SOLAR
Line 2.	MAR	1	1	0.00	60.8	30.0	340.2
Line 3	MAR	2	1	0.00	70.6	35.8	435.4
etc							
	MAR	1	2				
			⋮				
	Feb	28	50				

Because there is a finite depth of soil for Split Wash, it is possible to generate saturation overland flow. For this reason, during the winter period, storms of more than one day should be considered.

One approach is to keep two running totals - one 3 day and a 7 day. The 7-day would be in the form of an antecedent precipitation index and the 3-day would allow a 3-day storm in the winter. For winter storms, should also show the maximum and minimum temperature to evaluate the possibility of snow.

DAW 4-26-01 100 year Rainfall simulation
- Selection of storms to be run with KINEROS. The daily amounts will be disaggregated into storm amounts and the storm amounts will be assigned durations and further disaggregated into 20 increments. For the summer storms, we can follow the procedures used for the Solitario Canyon study, but for winter storms, procedures must be revised to account for the possibility of saturation-induced overland flow. The winter threshold should be based upon the amount of precipitation that can cause saturation of the shallowest soil in Upper Split Wash. Because of seasonal variations in the initial water content, the threshold for saturated flow could vary seasonally.

Assumptions:

1) Saturation overland flow can only occur during the months of Dec, Jan., Feb and Mar
2) Rainstorms in the remainder of the year can cause Hortonian runoff. Since intensity will be the major factor, use a threshold of 12.7 mm, as used in the Solitario Canyon study
3) During the winter period, storms of up to 3 days can occur. For any 3-day sequence
if $n_t = 0$ it is a dry day,
if $n_t = 1$ it is a wet day, but the amount is smaller than the threshold
if $n_t = 2$ it is a wet day and the amount is greater than the threshold.
4) An event cannot have a dry day in the middle

Shallowest soil depth = 170 mm Porosity = 0.34
In Jan-Apr SAT = 0.325
Deficit = (0.95 - 0.325) 0.34 (120) = 25.5 mm

DAW 4-26-01

Case	n_{t-2}	n_{t-1}	n_t	n_{t+1}	Comment
1	0	0	2	0	Isolated wet day P > T
2	0	2	2	0	two wet days both P > T
3	2	2	2	0	three wet days all P > T
4	1	1	1	0	" " " " P < T
5	0	1	2	0	
6	0	2	1	0	
7	1	1	2	0	
8	1	2	1	0	
9	1	2	2	0	
10	2	1	1	0	
11	0	1	1	0	

Scanned the file YuccsimA.PTR, found one sequence of 7 wet days and two of 5 wet days in only part of the file

DAW 4-27-01

As examples

1) Summer Sequence

Yr 1	Jul	23	2.15 mm
		24	8.55 mm
		25	10.75 mm
		26	10.28
		27	5.34
		Total	37.07 mm

Max. 3 day = 29.58

2) Winter Sequence

				Σ
Yr 21	Dec.	9	1.03	1.03
		10	12.66	13.69
		11	0.54	14.23
		12	14.07	28.30 *
		13	5.92	34.22
		14	0.52	34.74
		15	6.79	41.53
		Total	41.53 mm	

Max. 3-day = 27.27 mm

DAW 4-27-01 Selection of storms for 100 yr simulation - Upper Split Wash (Con't.)

The minimum bedrock infiltration rate is 0.355 mm/h and the maximum rate is 0.682 mm/h. Once the soil saturates infiltration into bedrock can occur at the rate of 8.52 mm/d to 16.37 mm/day.

It appears that a conservative approach would be to take the maximum 3-day total in a sequence of wet days and consider it as one storm. Assign a duration based on the winter relation for depth and duration (do not truncate at 8 hrs as was done for Solitario Canyon) and disaggregate into 20 increments. This procedure may require modification if the durations are too short.

DAW 4-30-01

The program COND7SUM.BAS which selects significant rainfall events and calculates a 7-day running sum of precipition must be modified to:

1) Read in Tmax, Tmin and Radiation in addition to precipitation
2) Precipitation is in mm rather than inches

3) Sequences of wet days in the winter period must be considered as described above.

The revised program is COND7-3.BAS reflecting 7 day API (antecedant precipitation index) and 3-day sums

DAW 5-10-01

The program COND7-3.BAS has been completed and run with Yucsima.PTR and Yucsimb.PTR. The summer rainfall is handled in the same manner as it was for the Solitario Canyon simulations

DAW 5/10/01

Examine output of COND7-3.BAS

Yucsima.CON

Max. 3 day winter 71.95 mm out of 4 day seq.
Max 1 day summer 38.56
Max 3 day winter 56.75 - does not include 4 day out of longer sequence

Yucsimb.CON

Max 3 day winter 75.62 mm
Max 1 day summer 33.55 mm
Max 3 day out of 5 - 7+ day sequence 46.61

DAW 9/24/01 Document Precipitation and Climate files sent to R. Fedors

1) Set up directories on zip disks

CLIMATEMAR_SEP
40 Files dated 3/26/01 to 4/6/2001 ✓

CLIMATE2
4 files dated 4/06/2001 ✓

YUCPRES (Present Climate at Yucca Mtn.)
35 Files dated 7/13/2001 to 9/04/2001 ✓

QUALCLIMMAR_SEP
19 files dated 4/05/2001 to 4/07/2001 ✓
See pages 70–74 Scientific Notebook 363 (This book)

BasicMar-Sep01
18 Files dated 4/05/2001 to 9/19/2001

Basic programs dealing with both climate and Upper Split Wash Runoff Analysis

DAW 11/5/01 Analyses of USGS simulated Rainfall

3 files were sent to me by R. Fedors Note: file 001.txt on 10/22/01.

File 1: Newspl2\ rainstat\ 4ja-501.txt
5 cols

Month	day	yr	day of yr	Daily precip. mm
col 1, 2	9, 10	17-19	25, 26, 27	33–37

File 2: Area12.501
5 cols , No headings but same information as 4ja-501.txt for different station.

Objective: Compare the 2-100yr sequences generated by USGS with the 100yr sequences I have generated with the MCMF model. and with the statistics for 40 Mile Canyon and Yucca Dry Lake (See Notebook 444 p 58–61)

Procedure:
To use the programs I have used, use the editor to eliminate the extra day in leap year and remove Jan → Feb 28 for the first year and Mar 1 – Dec 31 for the last year. This will reduce the sample number to 99 yrs.

For 4ja-501.txt save as 4ja-501.PTT

DAW 11/5/01

For monthly statistics, use ~~CLISTAT2.BAS~~ PSTAT01B.BAS. This version has input in mm and writes output to a file.

DAW 11/9/01 Analysis of USGS Simulated
Rainfall (Con't)
In subdirectory RAINSTAT
4JA-S01.TXT was imported into a PROSTAT file
Leap days were deleted and the period Jan1-Feb 28
of the first year and Mar 1 - Dec 31 of the last
year were deleted. Cols 1-4 were deleted, leaving
1 col of daily precipitation amounts in mm for
99 years. This was saved as a text file 4ja.TXT

4Ja.TXT was used as input to PSTAT01B.BAS and
output file is 4JA.STA.

Second file AREA12.S01 100 yrs

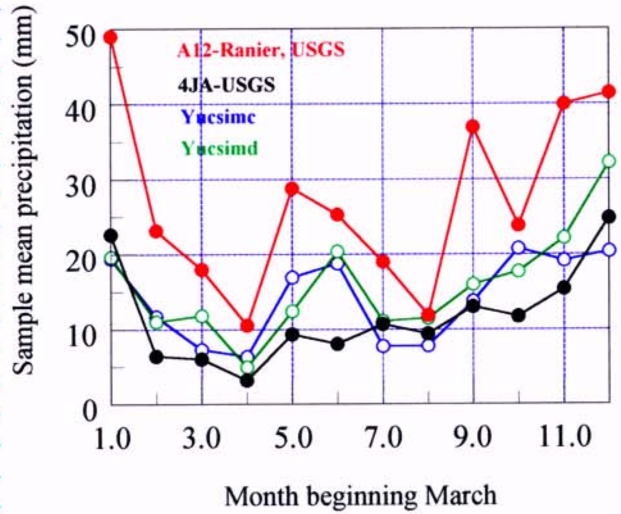
Import into PROSTAT and perform the same
edits as described above
Save as AREA12.TXT also AREA12.PDW

Use AREA12.TXT as input to PSTAT01B.BAS
and output file is AREA12.STA. Select monthly
portion of output file and save as AREA12.MON

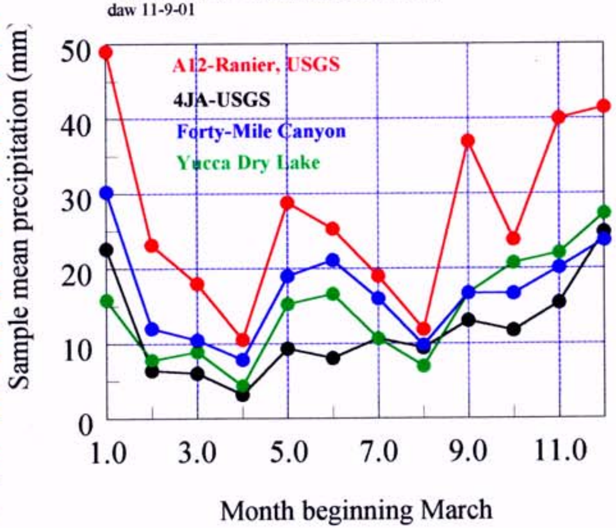
Note: 4JA is Jackass Flats (see p 41)
AREA12 is Ranier Mesa "

Plots of monthly average precipitation for the USGS
simulations for 4JA and A12 are compared with
2 50-yr simulations of present day Yucca Mtn
precipitation (Yucsimc and Yucsimd) and with
records from 40 mile Canyon and Yucca Dry Lake
on p 84. There are some inconsistensies. A12 USGS shows
an average Nov. precipitation 20 mm greater than
40 mile Canyon. 4JA-USGS shows a summer peak in July
(as does A12-USGS) rather than August as both the data
and simulations for Yucca Mtn. show.

Simulated and Measured Monthly Mean Precipitation



File: CLIMATE|YUCPRES|MO_PCOMP.PGW
daw 11-9-01

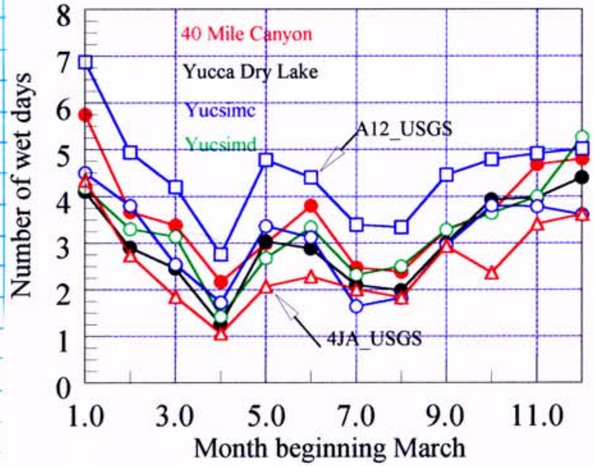


File: CLIMATE|YUCPRES|MO_PUSGS.PGW
daw 11-9-01

DAW 11-12-01 Analysis of USGS simulated 100yr precipitation (Con't)

A plot showing simulated and measured sample mean numbers of wet days per month is shown below. The USGS simulated values appear consistent.

Simulated and Measured
Sample mean number of wet days per month

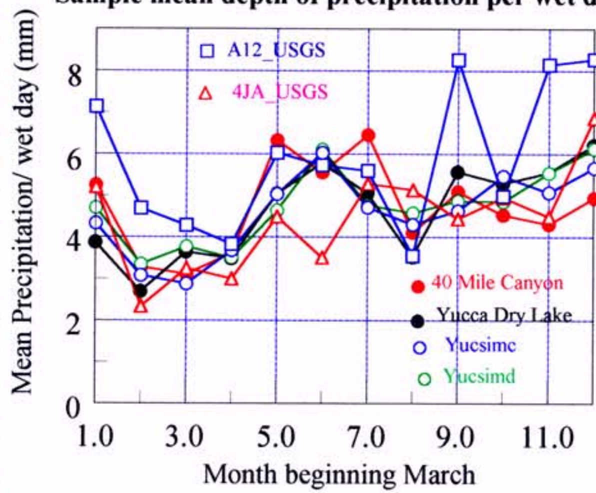


File: CLIMATE|YUCPRES|USGS_N.PGW
daw 9-12-01 11 DAW 11-13-01

A plot showing sample mean depths of precipitation for wet days is shown on p.87. The mean daily precipitation for period 9 (November) for A12-USGS appears to be too large while Dec may be too low. This indicates a structural problem because 100 yr simulations should result in low std dev of means.

DAW 11-13-01 Analysis of USGS simulated 100 yr precip (Con't)

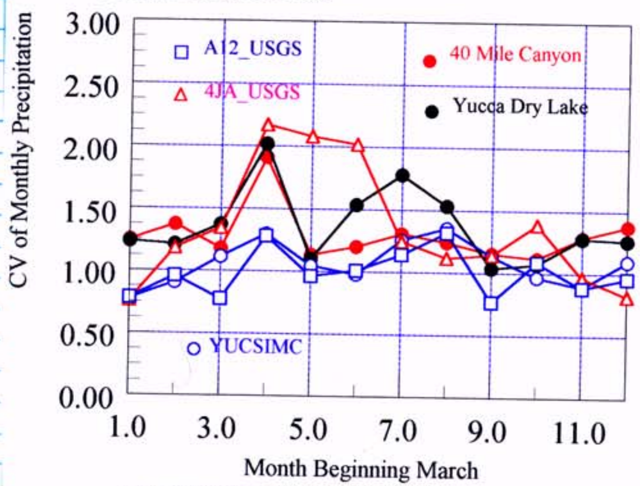
Simulated and Measured
Sample mean depth of precipitation per wet day



File: CLIMATE|YUCPRES|USGSPday.PGW
daw 9-12-01 11 DAW 11-13-01

It is usually difficult to maintain the variability of functionals of precipitation stochastic processes. To examine one aspect, the coefficient of variation of monthly precipitation is plotted for each month on p 88. The CV for A12-USGS looks fairly consistent. However the low value for period 9 reflects the unusually large mean for the month. The CVs for 4JA-USGS are less consistent, with extremely large values for periods 5 and 6 and rather low values for periods 7 and 8.

CV of Monthly Precipitation for USGS 100-yr Simulations & Data

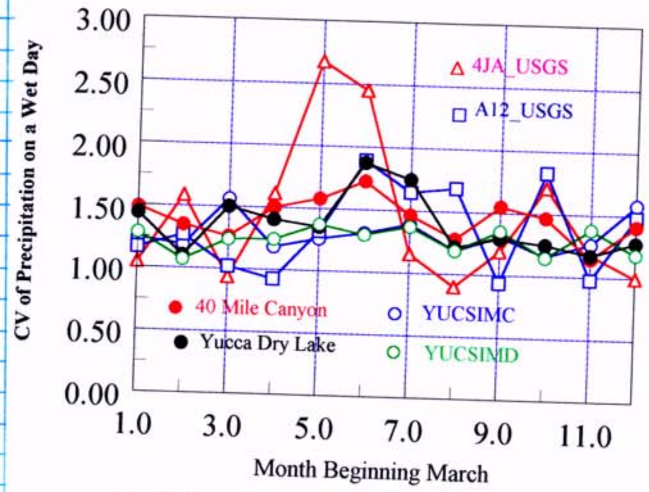


File: CLIMATE|YUCPRES|CV_MONP.PGW
daw 10-12-01
" DAW 11-13-01

It is expected that the coefficient of variation (CV) of monthly precipitation would decrease with increasing monthly precipitation. On this basis 4JA-USGS should have the largest CV's and A12-USGS should have the lowest. The figure above shows that this is generally true. However, rainfall simulations usually result in reduced CV's. The 4JA simulation has a high CV (≈ 2.0) for June - Aug, but appears low for Mar and Feb. The CVs for Yucca Mtn simulation (YUCSIMC, 50 yrs) are greater than A12_USGS for most months, but probably are biased low because the annual precipitation is lower.

The CV's of precipitation given a wet day are shown on p 89. The CV's for 4JA-USGS seem too high for July and August. CV's for YUCSIMC are consistent with those for measured data at Yucca Dry Lake and 40 Mile Canyon except for August.

Monthly Variation of CV of Precipitation on a Wet Day



File: CLIMATE|YUCPRES|CV_WETP_PGW
daw 10-12-01
" DAW 11-13-01

Relation of CV of Yucca Mtn simulations to those of 40 Mile Canyon and Yucca Dry Lake

Month	
Mar	−
Apr	ok
May	ok
June	−
July	−
Aug	−
Sept	−
Oct	ok
Nov	ok
Dec	−
Jan	+
Feb	ok

− = low
+ = high

DAW 1-16-02 Investigate the Effect of the Southern Oscillation Index (SOI) on the parameters of the Markov Chain - Mixed Exponential (MCME) model.

As discussed on p 87 of Scientific notebook 444 the simulated daily rainfall for present-day Yucca Mtn underestimates the variance of monthly and annual precipitation. One method of increasing the variance is to allow the Markov chain parameters to be perturbed by the SOI as demonstrated by:
Woolhiser, D.A., T.O. Keefer and K.T. Redmond (1993) "Southern Oscillation effects on daily precipitation in the Southwestern United States" Water Resour Res 29(4) 1287–1295.

Two FORTRAN 70 programs were used in the analyses for this paper:

1) SOIMC.FOR . This program calculates the log likelihood function for the daily rainfall occurrence function modeled as a first order Markov chain with the logits of the transition probabilities perturbed by a linear function of the SOI

$$\hat{G}_{00}(t) = G_{00}(t) + a_{00}\, SOI(t-T)$$
$$\hat{G}_{10}(t) = G_{10}(t) + a_{10}\, SOI(t-T)$$

where $\hat{G}_{00}$ and $\hat{G}_{10}$ are perturbed parameters and
where $G_{00}(t) = \log\left[\frac{P_{00}(t)}{1-P_{00}(t)}\right]; \; G_{10} = \log\left[\frac{P_{10}(t)}{1-P_{10}(t)}\right]$

and T is a lag in days. Both coefficients and T are varied to maximize the log likelihood function

2) SOIME.FOR This program calculates the log likelihood function for the mixed exponential distribution

$$f_t(u) = \frac{\alpha(t)}{\beta(t)} \exp(-u/\beta(t)) + \frac{(1-\alpha(t))}{\delta(t)} \exp(-u/\delta(t))$$

with mean $\mu(t) = \alpha(t)\beta(t) + [1-\alpha(t)]\delta(t)$.

DAW 1-16-02 SOI effects (Cont)

The SOI perturbation is of the form

DAW 1-16-02

$$\cancel{\hat{\delta}(t) = \delta(t) + b_\mu [SOI(t) - T)]}$$

$$\hat{\mu}(t) = \mu(t) + b_\mu\, SOI(t-T)$$

$G_{00}(t)$, $G_{10}(t)$, $\beta(t)$ and $\mu(t)$ have been fitted by Fourier series by the program MCME00-4.f95

Objective 1.

Post programs SOIMC.FOR and SOIME.FOR to FORTRAN 95

f95: program SOIMC.FOR becomes SOIMC_02.f95

program SOIME.FOR becomes SOIME_02.f95

Programs are in SWRI\CLIMATE

Objective 2.

Run SOIMC_02.f95 with precipitation data for NTS stations Yucca Dry Lake (YCC) and Forty Mile Canyon North (40mi), to see if SOI has effect.

Procedure:

SOIMC_02.f95 has been created from SOIMC.FOR and assembled with Lahey-Fujitsu FORTRAN 95.

Input files for Yucca Dry Lake:

1.) INFILE: YUCCDMC.FIL
2) PREFILE: YUCCA.PTT
3) SOIFILE: SOIDATA.PFC
4) FOURFILE: YUCCD.FOU

Daw 1-16-02 SOI Effects (con't)

	Line	YUCCDMC.FIL in C:\CONSULT\SWRI\CLIMATE
	1	YUCCDMC.OUT in C:\CONSULT\SWRI\CLIMATE\SOI
PRE	2	C:\CONSULT\SWRI\CLIMATE\YUCCA.PTT
	3	C:\CONSULT\SWRI\CLIMATE\SOIDATA.PFC
Fourier	4	" " " " \YUCCDMC.FOU
	5	Daw 1-16-02 ~~IRSY~~ FIRST_YR LAST_YR NSKIP UNITCODE YRT_SOI
inches	6	1958 1998 0 1 1933
	7	MAXLAG = 5
	8	0 30 60 90 120
	9	0
	10	0 0.20 0.05

Daw 1-17-02

Created file C:\CONSULT\SWRI\CLIMATE\YUCCDMC.FIL

Create file: YUCCDMC.FOU

These are the Fourier parameters for the Markov Chain for Yucca Dry Lake.

~~0.3465 0.20671~~ Daw 1-17-02

~~0.21816 -0.98639 0.14216 -1.313~~ Daw 1-17-02

~~0.19963 -1.0336~~ Daw 1-17-02

2.7105	0.42178		
0.3465	-0.98639	0.20671	-1.313
0.21816	-1.0336	0.14216	-0.24399
0.19963	3.0531	0	0
0.14763	0.38925	0	0
0.12945	-1.7146	0	0

Note: There will be a smaller number of years for this analysis compared with output for MCME so the log likelihoods for no perturbation will not be identical

Daw 1-28-02 SOI Effects (con't)

The program SOIMC_02.F95 was run with the control file YUCCDMC.FIL. The output file is reproduced below.

```
OUTPUT FROM PROGRAM SOIMC_02.F95. SOI PERTURBATION OF G00 AND G10
DATE OF RUN =20020128
CONTROL FILE NAME:yuccdmc.fil
PRECIPITATION FILE NAME:C:\CONSULT\SWRI\CLIMATE\YUCCA.PTT
OUTPUT FILE NAME:C:\CONSULT\SWRI\CLIMATE\SOI\YUCCDMC.OUT
SOI FILE NAME            :C:\CONSULT\SWRI\CLIMATE\SOIDATA.PFC
SOI Data begin in 1933
Analysis begins in 1959  and ends in 1998
FOURIER COEFFICIENT FILE NAME:C:\CONSULT\SWRI\CLIMATE\YUCCDMC.FOU
NULL_START= 366 NULL_END= 0

NSTA=UCC   STATION NAME =YUCCA
YEARS OF PRECIPITATION DATA:(1958-99)  Data in Inches
Annual average precipitation= 6.82100058 Inches
Annual average number of wet days 35.9749985
Maximum Annual precipitation= 13.3100014 in  1977
Minimum Annual precipitation= 2.00999999  in  1989
SOI: STAND TAHITI MINUS STAND DARWIN SLP, FROM CAC,
SOIM(0,1)= -0.300000012   SOIM(0,2)= 0.100000001
SOIM(1,1)= 0.800000012   SOIM(1,2)= 0.200000003
SOID(0,1)= -0.300000012   SOID(0,32)= 0.100000001
SOID(1,1)= 0.800000012   SOID(1,32)= 0.200000003
MEAN G00= 2.71050000  MEAN G10= 0.421779990
```

Amp G00	Phase G00	Amp G10	Phase G10
0.346500	-0.986390	0.206710	-1.313000
0.218200	-1.033600	0.142160	-0.243990
0.199600	3.053100	0.000000	0.000000
0.147600	0.389300	0.000000	0.000000
0.129500	-1.714600	0.000000	0.000000

G00 IS PERTURBED

Lag	G00Coef	G10coef	LogL 0/0	LogL 1/0	Total LogL
0.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
0.	0.05	0.00	-3106.4709	-967.3844	-4073.8555
0.	0.10	0.00	-3105.2288	-967.3844	-4072.6133
0.	0.15	0.00	-3106.5439	-967.3844	-4073.9282
0.	0.20	0.00	-3110.5393	-967.3844	-4077.9238
30.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
30.	0.05	0.00	-3107.7366	-967.3844	-4075.1211
30.	0.10	0.00	-3107.6992	-967.3844	-4075.0835
30.	0.15	0.00	-3110.2073	-967.3844	-4077.5918
30.	0.20	0.00	-3115.3323	-967.3844	-4082.7168
60.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
60.	0.05	0.00	-3106.1147	-967.3844	-4073.4990
60.	0.10	0.00	-3104.3882	-967.3844	-4071.7725
60.	0.15	0.00	-3105.1194	-967.3844	-4072.5039
60.	0.20	0.00	-3108.3899	-967.3844	-4075.7744
90.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
90.	0.05	0.00	-3105.0562	-967.3844	-4072.4404
90.	0.10	0.00	-3102.2571	-967.3844	-4069.6416
90.	0.15	0.00	-3101.9004	-967.3844	-4069.2847
90.	0.20	0.00	-3104.0344	-967.3844	-4071.4189
120.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
120.	0.05	0.00	-3104.0759	-967.3844	-4071.4604
120.	0.10	0.00	-3100.4036	-967.3844	-4067.7881
120.	0.15	0.00	-3099.2620 *	-967.3844	-4066.6465
120.	0.20	0.00	-3100.7844	-967.3844	-4068.1689

G10 IS PERTURBED

Lag	G00Coef	G10coef	LogL 0/0	LogL 1/0	Total LogL
0.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
0.	0.00	0.05	-3110.2104	-966.4913	-4076.7017
0.	0.00	0.10	-3110.2104	-966.7669	-4076.9773
0.	0.00	0.15	-3110.2104	-968.2136	-4078.4241
0.	0.00	0.20	-3110.2104	-970.8295	-4081.0400
30.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
30.	0.00	0.05	-3110.2104	-965.6455	-4075.8560
30.	0.00	0.10	-3110.2104	-965.1861 *	-4075.3965
30.	0.00	0.15	-3110.2104	-966.0051	-4076.2156
30.	0.00	0.20	-3110.2104	-968.1015	-4078.3120
60.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
60.	0.00	0.05	-3110.2104	-965.8964	-4076.1069
60.	0.00	0.10	-3110.2104	-965.6700	-4075.8804
60.	0.00	0.15	-3110.2104	-966.7056	-4076.9160
60.	0.00	0.20	-3110.2104	-968.9978	-4079.2083
90.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
90.	0.00	0.05	-3110.2104	-966.2090	-4076.4194
90.	0.00	0.10	-3110.2104	-966.1794	-4076.3899
90.	0.00	0.15	-3110.2104	-967.2949	-4077.5054
90.	0.00	0.20	-3110.2104	-969.5543	-4079.7646
120.	0.00	0.00	-3110.2104	-967.3844	-4077.5947
120.	0.00	0.05	-3110.2104	-965.8256	-4076.0361
120.	0.00	0.10	-3110.2104	-965.3961	-4075.6064
120.	0.00	0.15	-3110.2104	-966.0996	-4076.3101
120.	0.00	0.20	-3110.2104	-967.9338	-4078.1443

The columns G00Coef and G10coef show the values of a_{00} and a_{10} respectively in the equations shown on p 90.

The maximum likelihood values are indicated by asterisks. In this exploratory study, lags were limited to 30 day increments and the perturbation coefficients to increments of 0.05 so the combinations shown would not coincide with a true optimum. However, it is of interest to note that the increase in the likelihood is statistically significant for both $G_{00}(t)$ and $G_{10}(t)$ according to the Akaike Information Criterion (AIC).

The coefficient a_{00} (+0.15) and lag, 120 days are the same as the values reported by Woolhiser et al (1993) for Palm Springs, CA. Woolhiser, et al (1993) also found a seasonal effect with SOI affecting winter precipitation more than summer precipitation.

DAW 1-28-02 SOI Effects (Con't)

To examine the effect of seasonality the input file was changed so that NULL_START = 62 and NULL_END = 154. This means the neither G_{00} or G_{10} are perturbed during the months May - July.

File → New control file: YUCCDMC2.FIL in Dir \CLIMATE

New output file: YUCCDMC2.OUT in Dir \CLIMATE\SOI

The Likelihood function increased for G_{00} to -3092.1492 at a lag of 120 days and with a_{00} = 0.20.

For G_{10}, Log L = -964.9319 at a lag of 30 days with a_{10} = 0.10.

YUCCA DRY LAKE

→ CONCLUSION

Conclusion: For YUCCA DRY LAKE, SOI effects both G_{00} and G_{10} with negative SOI leading to increased probability of a wet day following both a dry day or a wet day. This impact of SOI is most pronounced during the winter. However, this is an exploratory analysis only, so the seasonal effect (i.e.) specific seasonal variation could be different

Forty Mile Canyon North

Similar procedures were followed for Forty Mile Canyon North Precipitation data.

Files Control: FORTYMC.FIL Dir: \CLIMATE\

Output: FORTYMC.OUT Dir: \CLIMATE\SOI

A reduced copy of the output file is shown on p95. The likelihood is also increased significantly for this station. For G_{00} the lag and a_{00} are the same as for Yucca Dry Lake.

The seasonal effect was also examined with the same Null period i.e. $a_{10} = a_{00} = 0$ $62 < t < 154$

DAW 1-28-02 SOI Effects (Con't)

OUTPUT FROM PROGRAM SOIMC_02.F95. SOI PERTURBATION OF G00 AND G10
DATE OF RUN =20020128
CONTROL FILE NAME:FORTYMC.FIL
PRECIPITATION FILE NAME:C:\CONSULT\SWRI\CLIMATE\FORTYM~1.PTT
OUTPUT FILE NAME:C:\CONSULT\SWRI\CLIMATE\SOI\FORTYMC.OUT
SOI FILE NAME :C:\CONSULT\SWRI\CLIMATE\SOIDATA.PFC
SOI Data begin in 1933
Analysis begins in 1959 and ends in 1998
FOURIER COEFFICIENT FILE NAME:C:\CONSULT\SWRI\CLIMATE\FORTY.FOU
NULL_START= 366 NULL_END= 0

NSTA=40Mi STATION NAME =FORTYMILE_CANYON
YEARS OF PRECIPITATION DATA:(1959-99) Data in Inches
Annual average precipitation= 8.02275085 Inches
Annual average number of wet days 43.0499992
Maximum Annual precipitation= 15.7000027 in 1992
Minimum Annual precipitation= 5.00000007E-02 in 1959
SOI: STAND TAHITI MINUS STAND DARWIN SLP, FROM CAC,
SOIM(0,1)= -0.300000012 SOIM(0,2)= 0.100000001
SOIM(1,1)= 0.800000012 SOIM(1,2)= 0.200000003
SOID(0,1)= -0.300000012 SOID(0,32)= 0.100000001
SOID(1,1)= 0.800000012 SOID(1,32)= 0.200000003
MEAN G00= 2.64000010 MEAN G10= 0.104450002

Amp G00	Phase G00	Amp G10	Phase G10
0.332660	-1.356200	0.154780	-1.350000
0.156060	-1.640900	0.266860	-0.682350
0.197440	2.690500	0.000000	0.000000
0.187820	-0.154270	0.000000	0.000000
0.120300	-2.567400	0.000000	0.000000

G00 IS PERTURBED

Lag	G00Coef	G10coef	LogL 0/0	LogL 1/0	Total LogL
0.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
0.	0.05	0.00	-3177.5964	-1182.2200	-4359.8164
0.	0.10	0.00	-3177.1697	-1182.2200	-4359.3896
0.	0.15	0.00	-3179.4082	-1182.2200	-4361.6279
0.	0.20	0.00	-3184.3760	-1182.2200	-4366.5957
30.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
30.	0.05	0.00	-3178.1514	-1182.2200	-4360.3711
30.	0.10	0.00	-3178.2598	-1182.2200	-4360.4795
30.	0.15	0.00	-3181.0107	-1182.2200	-4363.2305
30.	0.20	0.00	-3186.4978	-1182.2200	-4368.7178
60.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
60.	0.05	0.00	-3176.5767	-1182.2200	-4358.7969
60.	0.10	0.00	-3175.0854	-1182.2200	-4357.3057
60.	0.15	0.00	-3176.2395	-1182.2200	-4358.4595
60.	0.20	0.00	-3180.0969	-1182.2200	-4362.3169
90.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
90.	0.05	0.00	-3175.8657	-1182.2200	-4358.0859
90.	0.10	0.00	-3173.6003	-1182.2200	-4355.8203
90.	0.15	0.00	-3173.8293	-1182.2200	-4356.0493
90.	0.20	0.00	-3176.6489	-1182.2200	-4358.8691
120.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
120.	0.05	0.00	-3175.2288	-1182.2200	-4357.4487
120.	0.10	0.00	-3172.3899	-1182.2200	-4354.6099
120.	0.15	0.00	-3172.1492*	-1182.2200	-4354.3691
120.	0.20	0.00	-3174.5559	-1182.2200	-4356.7759

G10 IS PERTURBED

Lag	G00Coef	G10coef	LogL 0/0	LogL 1/0	Total LogL
0.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
0.	0.00	0.05	-3180.5837	-1181.4949	-4362.0786
0.	0.00	0.10	-3180.5837	-1182.2345	-4362.8184
0.	0.00	0.15	-3180.5837	-1184.4371	-4365.0210
0.	0.00	0.20	-3180.5837	-1188.0800	-4368.6636
30.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
30.	0.00	0.05	-3180.5837	-1180.8265	-4361.4102
30.	0.00	0.10	-3180.5837	-1180.9541	-4361.5381
30.	0.00	0.15	-3180.5837	-1182.5997	-4363.1836
30.	0.00	0.20	-3180.5837	-1185.7473	-4366.3311
60.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
60.	0.00	0.05	-3180.5837	-1180.9904	-4361.5742
60.	0.00	0.10	-3180.5837	-1181.1998	-4361.7837
60.	0.00	0.15	-3180.5837	-1182.8456	-4363.4292
60.	0.00	0.20	-3180.5837	-1185.9084	-4366.4922
90.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
90.	0.00	0.05	-3180.5837	-1179.9644	-4360.5479
90.	0.00	0.10	-3180.5837	-1179.0977*	-4359.6816
90.	0.00	0.15	-3180.5837	-1179.6085	-4360.1924
90.	0.00	0.20	-3180.5837	-1181.4846	-4362.0684
120.	0.00	0.00	-3180.5837	-1182.2200	-4362.8037
120.	0.00	0.05	-3180.5837	-1180.6315	-4361.2153
120.	0.00	0.10	-3180.5837	-1180.4410	-4361.0249
120.	0.00	0.15	-3180.5837	-1181.6371	-4362.2207
120.	0.00	0.20	-3180.5837	-1184.2094	-4364.7930

The files are
FORTYMC2.FIL
FORTYMC2.OUT

For G_{00}, Log L = -3170.3269
Lag = 120 days, a_{00} = 0.15

For G_{10}, Log L = -1180.5917
Lag = 120, a_{10} = 0.10

However, Log L G_{10} for null a_{10} in the summer is less than if a_{10} is perturbed for the entire year.

Ranier Mesa

Similar analyses were performed for Ranier Mesa. Files are
RANIERMC.FIL
RANIERMC.OUT

The maximum Log L was for a lag of 120 days and a_{00} = 0.10. The increase in Log L was significant. The increase for G_{10} was not significant.

Files for seasonal effect are RAN_MC2.FIL and RANMC2.OUT
Log L was increased for G_{00}; Lag = 120 days a_{00} = 0.15
Log L increase was not significant for G_{10}.

Daw 1-28-02 SOI Effects (Con't)

Conclusions for SOI Effects on Markov Chain:

1) Perturbing the logits G_{00} and G_{10} with a linear function of the SOI results in a significant increase in the log likelihood function for the dry-dry transitions for 3 NTS stations
2) The effect is strongest in the winter season.

3) All lags were 120 days and the coefficients a_{00} were 0.15 for Yucca Dry Lake and Forty Mile Canyon North and 0.10 for Ranier Mesa.

4) SOI effects on G_{10} were significant for Yucca Dry Lake and Forty Mile Canyon but didn't show a strong seasonal effect. Woolhiser et al (1993) did not detect significant effects on G_{10}.

5) Given the above conclusions, it is appropriate to examine effects of the Pacific Decadal Oscillation (PDO) on the precipitation process.

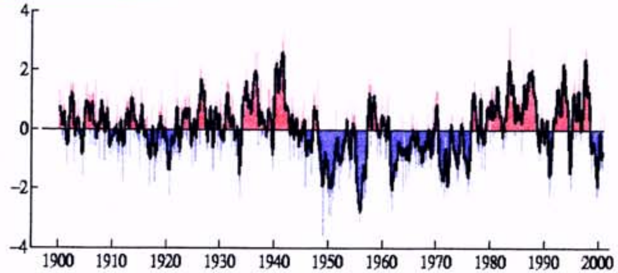
Daw 1-29-02 Effects of PDO on Daily Precipitation

Information and references on the PDO were downloaded from the website shown on p 96. A time series of monthly values is also shown.

Dettinger and Cayen (2000) reported that 20 yr floods in rivers in the southwestern U.S. are 34% smaller ~~than~~ Daw 1-29-02 when the PDO is in the positive phase than when it is in the negative phase.

Dettinger, M. and Cayan, D. (2000) Abstract of paper "The Pacific Decadal Oscillation and Flood Frequencies in the United States" Geological Soc. of Am. Annual Meeting Reno, NV. http://meteora.ucsd.edu/~meyer/pdo-flood.html

Daw 1-29-02 Effects of PDO (Con't)



The "Pacific Decadal Oscillation" (PDO) is a long-lived El Niño-like pattern of Pacific climate variability. While the two climate oscillations have similar spatial climate fingerprints, they have very different behavior in time. Fisheries scientist Steven Hare coined the term "Pacific Decadal Oscillation" (PDO) in 1996 while researching connections between Alaska salmon production cycles and Pacific climate (his dissertation topic with advisor Robert Francis). Two main characteristics distinguish PDO from El Niño/Southern Oscillation (ENSO): first, 20th century PDO "events" persisted for 20-to-30 years, while typical ENSO events persisted for 6 to 18 months; second, the climatic fingerprints of the PDO are most visible in the North Pacific/North American sector, while secondary signatures exist in the tropics - the opposite is true for ENSO. Several independent studies find evidence for just two full PDO cycles in the past century: "cool" PDO regimes prevailed from 1890-1924 and again from 1947-1976, while "warm" PDO regimes dominated from 1925-1946 and from 1977 through (at least) the mid-1990's. Shoshiro Minobe has shown that 20th century PDO fluctuations were most energetic in two general periodicities, one from 15-to-25 years, and the other from 50-to-70 years. http://ingrid.ldeo.columbia.edu/%28/home/alexeyk/mydata/TSsvd.in%29readfile/.SST/.PDO/

Major changes in northeast Pacific marine ecosystems have been correlated with phase changes in the PDO; warm eras have seen enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the contiguous United States, while cold PDO eras have seen the opposite north-south pattern of marine ecosystem productivity.

Causes for the PDO are not currently known. Likewise, the potential predictability for this climate oscillation are not known. Some climate simulation models produce PDO-like oscillations, although often for different reasons. The mechanisms giving rise to PDO will determine whether skillful decades-long PDO climate predictions are possible. For example, if PDO arises from air-sea interactions that require 10 year ocean adjustment times, then aspects of the phenomenon will (in theory) be predictable at lead times of up to 10 years. Even in the absence of a theoretical understanding, PDO climate information improves season-to-season and year-to-year climate forecasts for North America because of its strong tendency for multi-season and multi-year persistence. From a societal impacts perspective, recognition of PDO is important because it shows that "normal" climate conditions can vary over time periods comparable to the length of a human's lifetime.

http://tao.atmos.washington.edu/pdo/ 12/06/2001

Note that in the above fig. PDO is in a negative phase from 1960-1978 and in a positive phase until about 1998. Because floods are the product of extreme events, it is hypothesized that the PDO will cause the precipitation process to be non-stationary, possibly with more frequent precipitation and/or larger daily amounts during the negative phase.

DAW 1-29-02 PDO effect (con't)

There are also likely to be interactions with the higher frequency SOI which, in it's negative phase results in more frequent rainfall and greater mean rainfall amounts per wet day (Woolhiser et al 1993). The SOI has a lagged effect, but it is likely that the PDO does not because it is a function of sea-surface temperature. It may be possible to construct an index that is a function of current PDO and SOI lagged 120 days. One possible candidate would be:

$$SPF(t) = PDO(t) + SOI(t-\tau) \quad \text{or}$$

$$* \quad SPF2(t) = C[PDO(t)] + [1-C][SOI(t-\tau)]$$

A better form is to perturb as shown at the bottom of this page.
Using this formulation, negative PDO and SOI or positive SOI and PDO, would reinforce each other, while different signs would bring the index closer to zero.

A time series of monthly PDO was downloaded from the site:
ftp://ftp.atmos.washington.edu/mantua/pnw_impacts/INDICES/PDO.latest on 1/23/2002.

DAW 2-6-02 PDO Effects (Con't)

The program SOIMC_02.f95 was modified to create a new program PDOMC_02.f95. This program uses the same structure as SOIMC_02.f95 but uses the PDO for a perturbing factor ie

$$\hat{G}_{00}(t) = G_{00}(t) + b_{00}\, PDO(t-\tau)$$
$$\hat{G}_{10}(t) = G_{10}(t) + b_{10}\, PDO(t-\tau)$$

* This form is not appropriate

DAW 2-6-02 PDO effect (Con't)

Program PDOMC-02.f95 was run first with data from Forty mile canyon.
Files: Compaq Computer :: My Documents\SWRI\SOI
CONTROL: FORTYPDOMC.FIL
Precip.: FORTYM~1.PTT FORTY.FOU (Fourier coeffs)
OUTPUT: FORTYPDOMC.OUT PDO_LATEST.TXT
The control file set up the program to consider lags of 0, 30, 60, 90 and 120 days and coefficients b_{00} + b_{10} of -0.25 to +0.15 at increments of 0.05
For G_{00} Log likelihood was maximized with $b_{00} = 0.10$, $\tau = 90$ days the Log L was -3149.52 compared with unperturbed Log L = -3152.11 so there is a significant increase of 2.59
For G_{10} Log L (max) = -1169.80 at $b_{10} = -0.25$, $\tau = 0$
Unperturbed Log L = -1181.39 an increase in Log L due to perturbation of 11.59.

DAW 2-7-02

Now run for Yucca Dry Lake:
Files: YUCPDOMC.FIL YUCCOMC.FOU (Fourier Coeffs)
YUCPDOMC.OUT YUCCA.PTT
PDO-LATEST.TXT
G_{00}: Log L (max) = -3,106.81 $b_{00} = 0.10$; $\tau = 0$
Unperturbed Log L = -3,110.21 an increase for perturbation of 3.40 (sig)
G_{10}: Log L (max) = -966.86 $b_{10} = -0.05$; $\tau = 0$
Unperturbed Log L = -967.38 an increase of 0.52 (N.S.)

Now run for Ranier Mesa.
Files: RANPDOMC.FIL RANIERMC.FOU
RANPDOMC.OUT RANIER2.PTT
G_{00}: Log L (Max) = -3252.11 $b_{00} = -0.05$; $\tau = 30$ (NS)

G_{10}: Log L (max) = -1321.74 $b_{10} = 0.05$; $\tau = 60$
unperturbed Log L = -1323.31 increase = 1.57 (NS)

Daw 2-7-02 PDO Effects (Con't)

Now try restricting the season of perturbation to winter. In the following let NULL_START = 62
NULL_END = 154

Forty Mile Canyon:
FORPDOMC2.FIL } in Compaq SWRI\SOI
OUTPUT FORPDOMC2.OUT

G_{00}: Log L (max) = −3150.35 b_{00} = 0.05 τ = 90
Δ Log L = 1.76 (NS)

G_{10}: Log L (max) = −1173.87 b_{10} = −0.20 τ = 0
Δ Log L = +7.57 Significant

Daw 2-8-02 Combination of SOI and PDO

For Forty Mile Canyon, it appears that the PDO may have a significant effect throughout the year. Therefore it may be necessary to have both SOI and PDO for part of the year with only PDO for the remainder. However this is only tentative.

An e-mail from Fedors suggests using a null period for SOI of Apr – Sept.

Control file: FORTYMC4.FIL
NULL_BEGIN = 32 NULL_END = 183

G_{00}: Log L (max) = −3137.96 a_{00} = 0.20 τ = 120
Δ Log L = 14.15 (SIG)

G_{10}: Log L (max) = −1178.89 a_{10} = 0.10 τ = 90
Δ Log L = 2.50 (SIG)

Note: It appears that the year 1959 was not complete for Forty Mile Canyon. I reran FORTYMC.FIL with analysis starting in 1960

G_{00}: Log L (max) = −3143.13 a_{00} = 0.15 τ = 120
Δ Log L = 8.98

G_{10}: Log L (max) = −1178.31 a_{10} = 0.10 τ = 90
Δ Log L = 3.08 (SIG)

Daw 2-8-02 Combination of SOI and PDO (Con't)

Combine features of SOIMC_02.F95 and PDOMC_02.F95 so that both SOI and PDO are read. $G_{00}(t)$ and $G_{10}(t)$ then can be perturbed by a combination of SOI and PDO

Modified Program: SOIPDOMC.F95

Outline of exploratory procedure:
1. Input monthly time series of both PDO + SOI
2. Convert both to daily series
3. Perturbations of the form

$$\hat{G}_{i0} = G_{i0} + a_{i0}\, SOI(t-\tau) + b_{i0}\, PDO(t-\tau)$$

$i = 0, 1$

Calculate and write Log Likelihood functions for lags 0, 30, 60, 90, 120
a_{i0}, b_{i0} from −0.20 to +0.25 by increments of 0.05

Input file: FORTYSP1.FIL

OUTFILE: FORTYSP1.OUT
PREFILE: FORTYM~1.PTT
SOIFILE: SOIDATA.PFC
PDOFILE: PDO_LATEST.TXT
FOURFILE: FORTY.FOU

FIRST_YR	LAST_YR	NSKIP	UNITCODE	YR1_SOI	YR1_PDO
1960	1998	1	1	1933	1900

NULL_START	NULL_END	
366	0	(No Null season)

MAXLAG = 5
LAGT 0, 30, 60, 90, 120
LSTART = 0

ABEGIN =	AEND =	DELTA
−.25	0.20	0.05

DAW 2-8-02 Combination of SOI and PDO (Con't)

For this version of SOIPDOMC.F95 a_{i0} and b_{i0} are the same

Using this strategy, the maximum log L for G_{00} is -3147.5996 with $a_{00} = b_{01} = 0.10$; $\tau = 90$ days

$\Delta \log L = 4.51$

G_{10} LogL(max) = -1177.662 $a_{10} = b_{10} = 0.10$; $\tau = 60$ days

an increase of LogL of 3.718

Now examine effects of a null period from day 32 to 183

Input file: FORTYSP2.FIL

output FORTYSP2.OUT

G_{00}: LogL(max) = -3145.17 $a_{00} = b_{00} = 0.10$; $\tau = 90$

G_{10}: LogL(max) = -1178.5096 $a_{10} = b_{10} = 0.10$; $\tau = 120$

For this comparison we see that the incorporation of the null period did not increase LogL for G_{10}, but did for G_{00}.

Conclusions Regarding Effects of SOI and PDO on Markov Chain for Forty Mile Canyon.

DAW 2-19-02

The maximum Likelihoods, coefficients and Lags are shown for the Markov Chain Dry-Dry and Wet-dry processes on p 103.

DAW 2-19-02

Forty Mile Canyon 1960-1998

Effects of SOI and PDO on Markov Chain

		G_{00}			G_{10}		
.OUT FILE	Perturbation	LogL(max)	a_{00}	τ_{00}	LogL(max)	a_{10}	τ_{10}
	None	-3152.11	–	–	-1181.38	–	–
FORTYMC3	SOI ONLY	-3143.13 ✓	0.15	120	-1178.31 ✓	0.10	90
FORTYMC4	SOI SEASON *	-3137.96 †✓	0.20	120	-1178.89 ✓	0.10	90
FORTYPDOMC	PDO ONLY DAW 2-22-02	$-3149.$~~72~~ 53 ✓	0.10	90	-1169.803 ~~-1174.11~~ †✓	~~.10~~ $-.225$	~~30~~ 0 DAW 2-22-02
FORPDOMC2	PDO, Season **	-3150.35	0.05	90	-1174.82 ✓	$-.20$	60
FORTYSP1	PDO + SOI	-3147.60 ✓	0.10	90	-1177.67 ✓	0.10	60
FORTYSP2	PDO/SOI/SEASON	-3145.17 ✓	0.10	90	-1178.50 ✓	0.10	120
FORPDOMC3	PDO, Season *	-3150.96	-0.05	0	-1175.51	-0.15	0

* Perturbation coeff (a_{00} or a_{10}) = 0 for Day 32-183

† Maximum Likelihoods

✓ Significant improvement according to AIC

** Perturbation coeff (b_{00} or b_{10}) = 0 for 62-154

In reviewing the above table we see that for SOI perturbations LogL for G_{00} is improved with the seasonal variation while it is not for G_{10}.

For PDO perturbation seasonal variation does not improve Log Likelihoods.

Furthermore, SOI affects G_{00} more than PDO, while G_{10} is strongly affected by PDO.

The combination of SOI and PDO is inconclusive because all interactions are not considered.

To examine such interactions program SOIPDOMC.F95 was revised so that combinations of a_{i0} and b_{i0} $i = 0, 1$ could be examined for various lags.

DAW 2-26-02 Combination of SOI and PDO (Cont)

In developing the program SOIPDOMC.F95 it was found that the PDO input for the data shown on p104 was incorrect and that the conversion of both SOI and PDO formats was incorrect. Corrections were made and Fortymile canyon data were analyzed with the combinations of a_{i0} and b_{i0}

With these corrections, FORTYSP3 and FORTYSP4 were rerun with interactions between SOI + PDO but with the same lag. Results were:

FORTYSP3 : G_{00} Max loglik = −3136.892

$a_{00} = 0.1599$ } $\tau_{SOI} = 30$ days
$b_{00} = 0.05$

G_{10} Maxloglik = −1172.114

$a_{10} = 0.0$ } $\tau = 0$
$b_{10} = -0.20$

FORTYSP4 : Removing affects for days 32-183 did not increase likelihoods

Because both likelihoods are greater than those on p104, it appears that interactions are significant. However the lags for PDO appear to be smaller than those

DAW 2/28/02

for SOI, so the program was modified so that the lag for PDO was zero. Files are:

FORTSP3A: G_{00} Max LogL = −3136.713

$a_{00} = 0.16$; $b_{00} = 0.05$; $\tau_{SOI} = 30$ days

G_{10}: Max LogL = −1171.950

$a_{10} = 0.02$; $b_{10} = -0.20$; $\tau_{SOI} = 60$ days

FORTSP4A: G_{00} Max LogL = −3140.193

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$a_{00} = 0.16$; $b_{00} = -0.05$ $\tau_{SOI} = 30$

G_{10} $a_{10} = 0.08$; $b_{10} = -0.20$ $\tau_{SOI} = 90$

Max LogL = −1171.63

DAW 2-27-02 SOI + PDO (Cont)

Examine effects of SOI on mixed Exponential distribution

Program SOIPDOME.F95 was modified from program SOIME.FOR used by ARS-USDA, Woolhiser et al. (1993) see ref. p 90. Results for Forty Mile Canyon are shown below

$$\hat{\mu}(t) = \mu(t) + C_1 SOI(t-\tau_1) + C_2 PDO(t-\tau_2)$$

.OUT File	Perturbation	Log Likelihood	C_1	τ_1	C_2	τ_2
FORTYME1	NONE	−4009.656				
FORTYME1	SOI only	−4005.962	−0.30	90	—	—
FORTYME1	PDO only	−4005.321	—	—	0.30	0
FORTYME2	SOI (season)*	−4007.836	−0.30	90	—	—
"	PDO (season)*	−4008.868	—	—	0.20	0
FORTYME3	SOI (season)**	−4007.656	−0.25	90	—	—
"	PDO (season)**	−4007.881	—	—	0.25	0

Since $\mu(t)$ is perturbed by PDO and SOI independently, there are 2 free parameters, C_1 and τ_1 or C_2 and τ_2. Therefore if the log likelihood function is increased by 2 the AIC considers this to be a statistical improvement. For the seasonal impact, * indicates that SOI or PDO was inactive (i.e. C_1 or $C_2 = 0$) from day 32–183. ** indicates a null season from day 62–154. It is interesting to note that the maximum likelihoods occurred when $\mu(t)$ was perturbed all year for both SOI and PDO. A negative C_1 means that the daily mean precipitation is increased for negative SOI (El Niño) and decreased for positive SOI. A positive C_2 shows that daily means are increased for positive PDO.

Program SOIPDOME.F95 was revised so that combinations of C_1 and C_2 can be examined. The revised program name is S_PDOME2.F95

DAW 2-28-02 Effects of SOI and PDO on Mixed Exponential (Con't.)

Run program S_PDOME2.F95 with Forty Mile Canyon

DAW 2-28-02   4 DAW 2-28-02

Control File: ~~FORTYSP5.FIL~~ FORTYME~~3~~4.FIL

.OUT File: FORTYME4.OUT

From the table on p 105 we see that the optimum lag for PDO is always zero so only the SOI was lagged.

The Likelihood was maximized at -4004.23 with $C_1 = -0.20$; $C_2 = 0.25$ and $\tau_1 = 90$ days. This demonstrates that there is an interaction between SOI and PDO as reflected in the mean daily precipitation given a wet day. The relation is significant because the increase in log likelihood is 5.426.

Program was modified so that the lag for PDO is always zero.

Now run for YUCCA DRY LAKE and RANIER MESA

First Run for Markov Chain: Program SOIPDOMC.F95

	File Name	Perturb	Log L G_{00}	Log L G_{10}	a_{00}	b_{00}	τ_{00}	a_{10}	b_{10}	τ_{10}
	YUC_SP1	None	-3110.210	-967.384	—	—		—	—	
	YUC_SP1	All Yr.	-3088.674 *	-964.652*	0.16	0	0	0.08	-0.05	0
	YUC_SP2	Null 32-183	-3087.277*	-964.954*	0.20	0	0	0.01	-0.08	90
				DAW 3/1/02						
	RAN_SP1	None	-3252.611	-1323.31 ~~-3239.009~~	—	—	—	—	—	
	RAN_SP1	All Yr.	-3242.006*	-1319.59*	0.14	0.05	0	0.08	-0.05	0
p104	RAN_SP2	Null 32-183	-3239.009*	-1321.13	0.20	0.05	120	0.06	-0.05	0
see DAW 8-17-02	FORTSP3A	All yr.	-3136.71*	-1171.95*	0.16	-0.20	30	0.02	-0.20	60
see p 109	VEGASMC2	"	-29~~33.47~~35.42*	-682.210	0.20	0	30	0.10	0.08	120
See p 110+108	JACKASS	"	-2963.11 *	-832.14*	0.20	0.06	90	0.14	-0.08	120
See p 126	RG4	"	-3450.71 *	-1450.58	0.12	-0.06	90	0.08	0.06	60

DAW 2-28-02 Effects of PDO and SOI (Con't)

DAW 2/28/02 ~~Markov Chain~~ Mixed Exponential Perturbed by SOI + PDO

	.OUT FILE	PERTURBATION	Log Likelihood	C_1	C_2	τ_{SOI}
DAW 2/28/02	~~YUC_SP3~~	~~None~~	~~-3413.353~~	~~-0.20~~	~~0.05~~	~~10~~
	YUC_SP3	None	-3413.353	0	0	0
	YUC_SP3	All year	-3411.398	-0.2	0.05	120
	YUC_SP4	Null 32-183	-3412.399	-0.15	0.10	30
	RAN_SP3	None	-4989.348	0	0	0
	RAN_SP3	All year	-4893.784*	-0.2	0.3	120
	RAN_SP4	Null 32-183	-4982.688*	-0.4	0.3	30
	FORTYME4	None	-4009.656	0	0	0
	FORTYME4	All year	-4004.231*	-0.2	0.25	90
	FOR_SP5	Null 32_183	-4004.759*	-0.15	0.3	90

DAW 8-17-02 entered later results for comparative purposes

See p109	VEGAS	All YEAR	-2386.12	-0.20	-0.05	90
See p108	JACKASS	All YEAR	-2886.58 *	-0.20	0.46	30
See p127	RG4	All Year	-5652.17*	-0.47	-0.20	90

* Significant improvement in Log likelihood

DAW 3-4-02 SOI + PDO Effects (Cont)

As a continuation of the exploratory phase, I will examine SOI and PDO Effects on 2 more stations

1) 4JA - Jackass Flats. In an e-mail 2/08/02 Fedors indicated that SOI had a strong effect on this station.

2) Las Vegas - One of the longest records of high quality. Note: the format for Vegas. PTT has 3 columns precip Tmax Tmin

Jackass Flats:

Markov Chain: JACKASS1.FIL
JACKASS.FOU MC coefficients

G_{00}: Unperturbed Log Lik = -2983.729 } increase 20.62
LogLik(Max) = -2963.108
$a_{00} = 0.20$; $b_{00} = 0.04$ $\tau_{00} = 0$

G_{10}: Unperturbed Log Lik = -839.517 } increase = 7.32
Log lik (max) = -832.142
$a_{10} = 0.14$; $b_{10} = -0.08$ $\tau_{10} = 120$

ME: Unperturbed LogL = -2898.05
LogL(max) = -2886.577 *
$C_1 = -0.20$; $C_2 = 0.46$; $\tau_{soi} = 30$

DAW 3-5-02 SOI + PDO Effects (cont)

Las Vegas

Markov Chain: VEGASMC1.FIL
" .OUT

Note: In "Attachment to Notebook 363" p35, it is shown that the years 1938, '48 and '52 were eliminated because of incomplete data. Therefore the entire record cannot be used for the SOI-PDO analysis which is dependent on concurrence of records. For the MCME analysis it is assumed that the parameters have an annual periodicity, so it was permissable to use the total of 57 years. However for the SOI-PDO analysis a shorter record must be used or the programs must be modified so that they skip over missed years. First, just use data from the period Mar 1, 1957-Feb 28, 1998. This record was taken from the file VEGAS.PTT and the file is VEGASSOI.PTT. The program MCME_.F95 was run with this length of record to estimate MCME parameters. The parameter files are: VEGASMC2.FOU and VEGASME2.FOU. The new control file is:
VEGASMC2.FIL
" .OUT

G_{00}: Unperturbed Log L = -2933.420
$a_{00} = 0.20$; $b_{00} = 0$; $\tau = 30$ LogL = -2915.420 (S)

G_{10}: Unperturbed Log L = -682.210
$a_{10} = 0.10$; $b_{10} = 0.08$ $\tau = 120$ day LogL = -680.306 (NS)

ME: Unperturbed Log L = -2387.284
$C_1 = -0.20$; $C_2 = -0.05$; $\tau = 90$ LogL = -2386.195 (NS)

DAW 3-6-02 SOI and PDO Effects (Cont)

Seasonal Effects of SOI

Objective: To determine if there are months in which setting a_{20}, b_{20} for the Markov Chain and C_1 or C_2 for the Mixed exponential to zero will result in an increased log likelihood

Procedure: Both SOI and PDO have a significant effect for Jackass Flats. Set up a control file TEST-FIL with output file TEST.OUT. Change the null period to each month, starting with March. i.e. NULL_BEGIN=1; NULL_END=31 etc.

Results: For interactive program SOIPDOMC.F95

G_{00}: Unperturbed log L = -2983.862
Perturbed all year: -2963.108 (Sig)
Log L was improved by elminating perturbations for the months of Apr., Aug and Oct.

G_{10}: Unperturbed log L = -839.538
perturbed all year -832.142 (Sig)
Log L was improved by eliminating perturbations for the months of Apr, May, July, Dec, Jan, Feb.

DAW 3-7-01

Check impact of PDO alone:
Run program PDOMC_02.F95 with null period for each month
G_{00}: Unperturbed Log L = -2983.862
perturbed all year -2983.862 (No effect)
Slight increases by setting $b_{00}=0$ for May, June, Aug, Nov, Dec, Jan, Feb, but coefficients varied from -0.05 to +0.05 and τ from 0 to 120

G_{10}: Unperturbed LogL = -839.538
Perturbed all year ~~-832.142~~ (Sig) -835.731 DAW 3/7/02
Slight increase by setting $b_{10}=0$ for May, June, July and Jan.

DAW 3-7-02 SOI and PDO Effects (Cont)

Conclusions:
1) PDO has much greater effect on persistence (G_{10}) than on G_{00}.
2) There is a significant interaction between SOI and PDO
3) The only consistent seasonal effect was for Apr., but that month has rather low precipitation anyway.

Mixed Exponential Distribution - Seasonal Effects
Check Impact of SOI ~~alone~~ and PDO on Jackass Flats
DAW 3/7/02 program: S_PDOME2.F95

Perturbation	Log L	C_1	C_2	τ_{soi}	
None	-2898.05	—	—	—	
All year	-2886.577	-0.20	0.46	30	
Not Mar	-2887.364	-0.20	0.48	30	
Not Apr	-2886.044*	-0.20	0.46	30	
" "	-2886.009*	-0.22	0.46	30	Finer search
Not May	-2885.630*	-0.34	0.48	30	
Not June	-2886.553*	-0.20	0.46	30	
Not July	-2887.520	-0.14	0.48	30	
Not Aug	-2886.783	-0.18	0.48	30	
Not Sep	-2886.145*	-0.26	0.44	120	
Not Oct	-2886.958	-0.18	0.48	30	
Not Nov	-2886.154*	-0.22	0.46	30	
Not Dec	-2886.838	-0.18	0.48	30	
Not Jan	-2886.382*	-0.22	0.46	30	
Not Feb	-2886.010	-0.22	0.48	120	

* Indicates an increase in LogLik

Note that no likelihood increase is as great as 1 unit.

Conclusion: For this station no strong evidence for seasonal effects.

Daw 3-7-02 SOI and PDO Effects (Con't)

Now examine some of the effects of either extremes of SOI or PDO on MCME parameters for Jackass flats

PDO Extremes

PDO	Date	SOI	ΔG_{00}	ΔG_{10}	$\Delta \mu$
-2.28	Sept 1933	-0.10	-0.156	0.1468	-1.029
-2.01	Jan '49	+0.50			
-3.60	Feb '49	+0.20			
-3.08	Nov '55	+1.40	0.095	0.44	-1.69
+3.01	June '41	-1.3			
+3.31	Aug '41	-0.7			
+3.57	July '83	-2.1	-0.209	-0.575	+2.03

SOI Extremes

PDO	Date	SOI	ΔG_{00}	ΔG_{10}	$\Delta \mu$ (mm)
-1.77	Jun '50	3.0	0.49	0.56	-1.41
0.84	Nov '82	-3.2			
0.56	Jan '83	-3.4			
1.14	Feb '83	-3.5	-0.63	-0.58	+1.22

$\Delta G_{00} = 0.20\,(SOI) + 0.06\,(PDO)$

$\Delta G_{10} = 0.14\,(SOI) + (-0.08)(P_{00})$

$\Delta \mu = -0.20\,(SOI) + 0.46\,(PDO)$

For Jackass flats $\bar{G}_{00} = 2.793$

$\bar{G}_{10} = 0.590$

$\bar{\mu} = 4.00$ mm

Thus, with the extreme combinations shown above the perturbations of the means could be:

$2.58 < G_{00} < 3.283$; $0.929 < P_{00} <$ ~~0.929~~ 0.964 Daw 3/8/02

$0.01 < G_{10} < 1.15$ $0.50 < P_{10} < 0.759$

$2.31 < \mu < 6.03$

Daw 3-7-02 SOI and PDO Effects (Con't)

These ranges are conservative because they are based on the means rather than values given by the Fourier Series

Now run simulations with perturbed parameters to see if precipitation variance is preserved

Procedure:

1) Port CLIMSIM.BAS to Fortran95

New Name: CLIMSIM_02.F95 in \SIMULATIONS_02

Daw 3-8-02

Program logic Daw 3-8-02

Read ~~MCME~~ Log parameters, File Names + Perturbation parameters

Daw 3/8/02 Read PDO ~~SOI~~ Data - subroutines PDODAY( ), PDODAILY

Read SOI ~~PDO~~ Data - subroutines SOIDAY( ), SOIDAILY

Read Fourier Coefs for Markov Chain: Subroutine MCFOURIER

" " " " Mixed Exponential: " MEFOURIER

" Temperature + Radiation parameters: " TEMP_RAD

Call subroutine CLOGIT to calculate daily G_{00} + G_{10}

Call subroutine PLOGIT to perturb G_{00} and G_{10} by SOI + PDO

Call Daw " 3/8/02 PERPROB to calculate P_{00} and P_{10}

Call subroutine ME_MU_BE to calculate daily β and μ

Call " ME_PERTURB to perturb β and μ

Call " PERDELT to calculate perturbed delta

Call Subroutine SIMULATE to simulate daily precipitation, Tmax, Tmin and Radiation

SIMULATE CALLS SUB TRADSIM

Output: Input parameters are printed out for checking purposes, along with first months of SOI and PDO

DAW 3-20-02 SOI and PDO effects (Cont)

Objective: To see if incorporating SOI and PDO effects in precipitation simulation will increase annual and monthly variance

Procedure:

1. First try Jackass Flats.
   Control File: JACKASS.SIM shown below. Parameters are from p 108

File: JACKASS.SIM

```
JACK_SIM1.TPR   ← OUTPUT FILE
SOIDATA.PFC   ← SOI Data
PDO_LATEST.TXT ← PDO Data
JACKASS.FOU  ← MC parameters } for Jackass Flats
JACKME.FOU   ← ME     "      }
JACKCLIM.DAT ← Tmax, Tmin + Rad parameters *
FIRST_YR  LAST_YR  UNITCODE  YR1_SOI  YR1_PDO
1946      1995        1        1933     1900
MCNULL_START    MCNULL_END  } perturbations in effect
 366              1         }
MENULL_START    MENULL_END  } all year
 366              1
A00   B00   A10    B10    C1    C2   } Perturbation
0.20  0.06  0.14  -0.08  -0.2  0.46  } parameters
LAG_G00   LAG_G10   LAG_MU           }
  0         120       30
  0 — day before 1st day assumed to be dry
```

* From Hanson, et al. 1994

2. Run CLIMSIM_02.F95

control file SOI\JACKASS.SIM

DAW 3-25-02 Check precipitation statistics for simulated data.

Run Program PSTAT01C.BAS with SOI\JACKSIM1.DAT input

JACKSIM1.DAT created from JACKSIM1.TPR by removing text information

DAW 3-25-02 Statistics of Simulated Data for Jackass Flats

Output file is JACKSIM1.STA (statistics)

40 years were simulated
Mean annual = 146.5 mm; StdDev = 55.8; CV = 0.38
Range = 64.4 — ~~227.5~~ mm 254.8 DAW 3-25-02

Run program PSTAT01C.BAS with JACKASSB.PTT as input
This is the measured data for Jackass Flats
Output file is JACKASSB.STA
Mean annual = 143.7 mm, Std Dev = 68.7; CV = 0.48
Range 54.4 — 315.2 mm

The CV and range for the simulated data are both smaller than for the measured data. However, it appears that SOI and PDO effects increase the variance as compared with the basic unperturbed model.

Copies to FedBTS 3/29/02

DAW 4-1-02

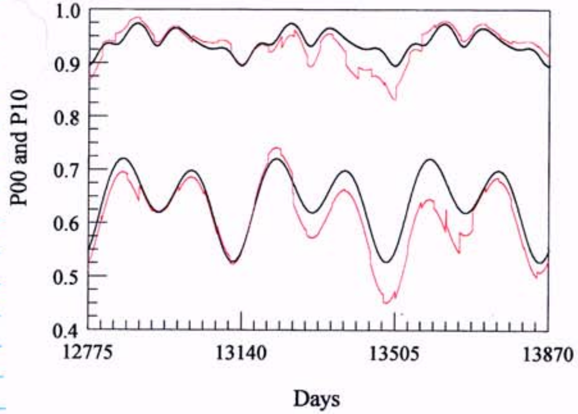
Prepare figure showing perturbations of P_{00}, P_{10} and μ

\SOI\ P00_P10.PGW. - Three years of perturbed + unperturbed P_{00} and P_{10}

\SOI\ Muperturb.PGW - Three years of perturbed + unperturbed Mu.

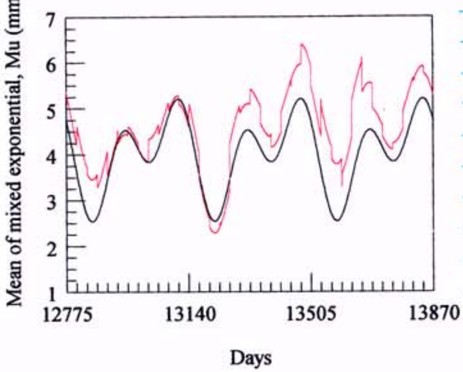
The figures are shown on the next page (116). Note that the winter of the second year has lower P_{00} and P_{10} (wetter - more frequent wet days) and higher μ (more precipitation per wet day)

Unperturbed and Perturbed P00 and P10
4JA Jackass Flats



File: SOI00_P10.PGW
daw 4-1-02

Unperturbed and perturbed Mu
Three-year period. 4JA Jackass Flats



File: SOI |Muperturb.PGW
daw 4-1-02

DAW 6-21-02 Statistics of simulated data for Jackass flats without SOI and PDO perturbation

Create control file SOI\Jackass2.SIM ✓ with perturbations nullified for entire year
output file SWRI\SOI\JACK_SIM2.TPR
Run CLIMSIM_02.F95 ✓

Run program PSTAT02C.BAS with JACKSIM2.DAT input

Output is SOI\JACKSIM2.STA

Use 40 yrs of simulated data

Mean = 138.2 mm   STD DEV = 49.2 mm ; CV = 0.356
Range: 53.29 – 303.1 mm

Conclusion: The perturbations of G_{00}, G_{10} and μ by the PDO and SOI do increase the variance of the simulated data

	Perturbed	Unperturbed	Data
Std Dev.	55.8	49.2	68.7
Low range DAW 6/27/02	~~54.4~~ 64.4	53.29	54.4
High range	~~315.2~~ 354.8	303.1	315.2
Mean Ann			~~140.8~~ 143.7 DAW 6-21-02

Above values are for annual amounts

DAW 6-24-02 Now examine CDFs of monthly total precipitation for JACKSIM1.STA, JACKSIM2.STA and JACKASS3.STA. Consider months of Jan and Feb. (11 and 12)

Files:
Jan. SOI\JACK11.PDW and .PGW
Feb. SOI\JACK12.PDW and .PGW
Monthly Mean JACKMO.PGW   Mean No: JACKMC.PGW
Data files were created in PSIPLOT by importing data from above .STA files.
Mean depth / wet day JACKME.PGW

Daw 6-24-02

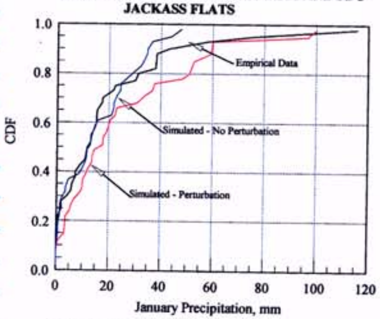
In reviewing the files for the figures for the CDFs of total precipitation for the months of Jan. and Feb. (below), it is clear that the perturbation creates heavier tailes that more closely approximate the empirical CDFs. However the probability of zero rainfall is reduced. For January

$P\{S=0\} = 0.20$, $= 0.12$ and $= 0.10$ for data, MCME and perturbed MCME respectively

For February

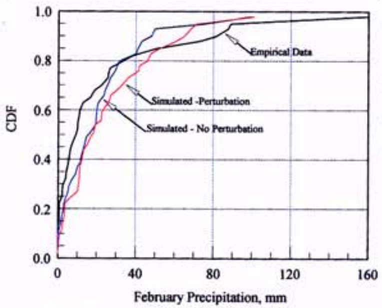
$P\{S=0\} = 0.15$, 0.05 and 0.12 for data, MCME and Perturbed MCME

EFFECT OF PERTURBATION BY SOI AND PDO
JACKASS FLATS



File: c:|SOI|JACK11.PDW and JACK11.PGW
daw 6-24-02

EFFECT OF PERTURBATION BY SOI AND PDO
JACKASS FLATS



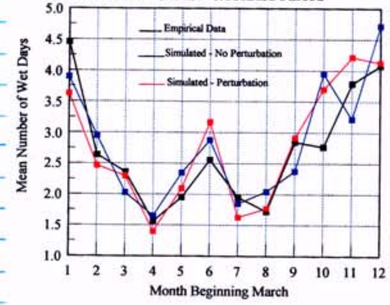
File: C:|SOI|JACK12.PDW and JACK12.PGW
daw 6-24-02

Daw 6-25-02

Figures for monthly means of number of wet days, precipitation per wet day and mean monthly precipitation are shown on p 119. Although there will be differences due to sampling between the simulations, the statistics for the perturbed sequence appear to be closer to those for the data than those for the unperturbed sequence

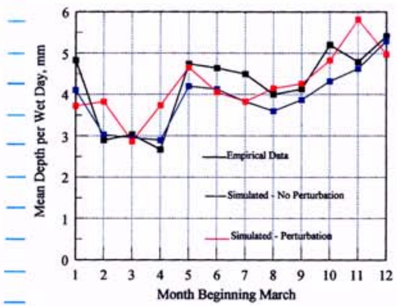
Daw 6-25-02

EFFECT OF PERTURBATIONS BY SOI AND PDO
ON MARKOV CHAIN - JACKASS FLATS



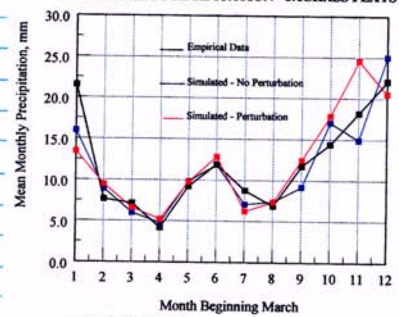
File: C:|SOI|JACKMC.PGW
daw 6-25-02

EFFECT OF PERTURBATIONS BY SOI AND PDO
ON MEAN OF MIXED EXPONENTIAL - JACKASS FLATS



File: C:|SOI|JACKME.PGW
daw 6-25-02

EFFECT OF PERTURBATIONS BY SOI AND PDO
ON MONTHLY PRECIPITATION - JACKASS FLATS



File: C:|SOI|JACKMO.PGW
daw 6-25-02

Daw 6-26-02

Given the trends in the PDO data for the period of record for Jackass Flats (See p97), improvements in model identification may be achieved by repeating the identification of the Fourier series coefficients with SOI and PDO perturbations. This will require adding an option to programs MCMEOC_3.F95 and MCMEOO_4.F95

DAW 6-26-02

Set up new folder: C:\CLIMAT02
Copy MCME00_4.f95 to " for NTS input
MCME00_3.f95 to " 3 col input

save MCME00_4.f95 as MCMEPERT.f95

DAW 6-27-02

For the Markov Chain there will be a change in strategy. In MCME00_4.f95 the data are the counts of transitions, dry-dry, wet-dry for each day of the year over all years. This is correct if year-to-year stationarity is assumed. However with G_{01} and G_{10} perturbed by SOI and PDO there no longer is year-to-year stationarity. The logical procedure is to:

1) Calculate G_{01} and G_{10} from parameters estimated based on stationarity

DAW 6-28-02

2) Add perturbations due to SOI and PDO

3) New optimization of MC parameters

4) Note that time coincidence must be maintained between precipitation, SOI and PDO.

DAW 6-29-02

DAW 7-30-02 Set up control file to examine effect of second optimization of Markov Chain Parameters, given SOI and PDO perturbations

Control File Name: C:\CLIMAT02\JACKTEST.FIL

Line
1. NSTA STATION TEST OF MCMEPERT
2. 4JA JACKASS
3. \JACKTEST.OUT in dir C:\CLIMAT02
4 C:\SOI\ JACKASS.PTT (Precip. file)
5 C:\CLIMAT02\JACKTEST.DET (Detailed output)
6. C:\CLIMAT02\JACKTEST.CDF (CDF file)
7. C:\CLIMAT02\JACKTEST.DAT (daily parameters)
8. C:\SOI\SOIDATA.PFC
9. C:\SOI\PDO-LATEST.TXT
10. 1933 1900 (YR1 SOI, YR1_PDO)
11. 0.20 0 0.06 0.14 120 -0.08
12 MaxHarMC NRE YR1_PRECIP, FIRST_YR, LAST_YR
13. 0 1301 1959 1959 1998
14 MAXA1 MAXA MAXB MAXMU
15 5 1 2 5
16. PAREPS FNEPS ZMIS
17 0.0001 0.0001 -9.90
18 CALPA NPER KALFA NUMSAV UNITCODE
19 0 26 0 0 1

Add heading: DAW 7-30-02
~~A00 B00 A10~~
A00 TLAG00 B00COEF, A1COEF, TLAG_10, B10COEFF

DAW 7-31-02
Check output of MCMEPERT.F95

DAW 8-1-02
Check output of MCMEPERT.F95

DAW 8-2-02
In checking the output of MCMEPERT.F95 with control file JACKTEST.FIL, I found that the optimization subroutine, ASIMPLX was converging properly when G_{00} or G_{10} were fitteded with only one harmonic. However when 2 harmonics were to be fitted (a total of 5 parameters for each series) the simplex algorithm didn't converge. One possible explanation was that the input parameters to be optimized in the presence of SOI and PDO perturbations were the Fourier coefficients a_0, a_1, b_1, a_2, b_2 while in the previous usage of ASIMPLX the amplitude-phase angle form was used.
Accordingly a change in the order of subroutine calls was made such that mean, amplitudes and phase angles were optimized.

DAW 8-12-02 The following summary was obtained from the output file: C:\ CLIMATOZ\ JACKTEST.
Logits of Dry-Dry transitions, G_{00} (One harmonic)

	Log L	a_0	a_1	ϕ_1
26 day period	-3000.2	2.7662	0.449	-1.15
Daily	-3000.6	2.7747	0.407	-1.233
Perturbed	-2978.9	2.8279	0.3953	-1.269

Logits of Dry-Dry transitions, G_{00} (two harmonics)

	Log L	a_0	a_1	ϕ_1	a_2	ϕ_2
26-day	-2996.25	2.7778	0.407	-1.130	0.17726	-1.2056
Daily	-2991.85	2.7759	0.3899	-1.203	0.1433	-1.454
Perturbed	-2976.6 ← initial value with above parameters					

but ASIMPLX does not converge.

DAW 8-12-02

An examination of the tables on p 122 reveals that adding SOI and PDO perturbations increased the log likelihood function by 21.70 for one harmonic and 19.65 for two harmonics. In comparing these differences with those for 5 harmonics on p 108 (20.62 for G_{00}) we see that the SOI and PDO perturbations affect the low-frequency (annual) variation of the periodic portion of G_{00}. Given the frequency characteristics of the PDO and SOI, this is not surprising.

Now examine Logits of wet-dry transitions G_{10}

	Log L	a_0	a_1	ϕ_1	(one harmonic
26 day	-845.85	0.56005	0.2557	-1.0158	
daily	-845.62	0.56107	0.23552	-1.0778	
Perturbed	-836.95	0.63495	0.21353	-1.0031	

					a_2	ϕ_2
26 day	-839.18	0.59045	0.19744	-.98559	0.28921	-0.96082
daily	-839.51	↓	↓	↓	↓	↓
Perturbed	-831.62	0.61998	0.19744	-.98559	0.28921	0.59045

* but ASIMPLX does not converge.

Again the increase in the Log likelihood function attributed to the SOI and PDO perturbations is similar (7.89 as compared to 7.32 for 5 harmonics) so again the SOI and PDO effects are in the low frequency portion.
However, the changes in the terms a_0, a_1 and ϕ are rather small, for both G_{00} and G_{10}, and the increase in log L due to optimization by ASIMPLX 1.2 for G_{00} and 0.97 for G_{10} suggests that little is gained by a reoptimization of the Fourier coefficients in the presence of PDO + SOI perturbations

DAW 8-12-02

Conclusion:

A reoptimization of the means, amplitudes and phase angles of G_{00} and G_{10} ~~test~~ DAW 8-12-02 in the presence of PDO and SOI perturbations with previously identified perturbation coefficients, does not lead to significant changes in the parameters for one harmonic. The optimization subroutine ASIMPLX does not converge for 2 harmonics.

There fore the two stage optimization sequence is appropriate:

1) Identify periodic coefficients of Markov Chain
2) Identify SOI and PDO perturbation parameters, given the periodic coefficients.

By inference assume that the above is valid for the mixed exponential

DAW 8-13-02

For future climate simulations, we wish to create a Yucca Mtn. climate with a seasonal pattern similar to Southern Arizona. Therefore it would be useful to examine the Effects of SOI and PDO on the Walnut Gulch station WG4. (See p 42)

The precipitation file for this station is rg004.3-1 and was recovered from archives and copied to c:\CLIMATO2\ARIZONA. The record is from Mar. 1, 1955 to Feb 28, 1990 (35 yrs.)

First run MCME00_4.F95 to get Fourier coefs

rg004.3-1 is in a Format 16F5.2

Note: Found file RG4TST4.OUT which is an output file for MCME analysis of RG4. This run had a constant value of 0.4166 input for ALPHA

DAW 8-14-02

Another file RG4TST5.OUT and RG4TST5.DET are from MCME002.F95.

These files have the correct MCME parameters

The control file RG4TST5.FIL is attached below:

```
STATION NO   STATION NAME                          RG4TST5
  RG4        'WALNUT GULCH'
C:\CONSULT\SWRI\QUALCLIM\RG4TST5.OUT
C:\CONSULT\SWRI\QUALCLIM\RG004.3_2
C:\CONSULT\SWRI\QUALCLIM\RG4TST5.DET
C:\CONSULT\SWRI\QUALCLIM\RG4TST5.CDF
C:\CONSULT\SWRI\QUALCLIM\RG4TST5.DAT
THRES    LMAXH    NRE    NCOUNT    SKIPYEARS
 0.008    11      1301    40          0
MAXH1    MAXA     MAXB   MAXMU     INIC
 5        1        3      5        1955
PAREPS    FNEPS          ZMIS
 0.0001   0.0001         -.99
CALFA    NPER    KALFA   NUMSAV
 0        26       0       0
```

All files listed were sent to CNWRA in Mar 2001.

Parameters are: For 40 yrs 1955 – 95

a_0 G_{00}	a_1	a_2 ✓	ϕ_1 ✓	a_3	ϕ_2 ✓	a_4 ✓	ϕ_3 ✓
2.3206	0.67646	0.82920	1.5083	0.37614	-.72322	0.14065	~~0.88479~~ 3.0678

DAW 8/14/02 DAW 8-14-02 DAW 8/14

ϕ_4	a_5	ϕ_5
0.88479	0.09444	-1.2867

DAW 8/14/02

$\text{Log } L = -3657.55$

G_{10}: DAW 8/14/02 DAW 8/14 DAW 8/14/02 DAW 8/14/02 DAW 8/14/02

a_0	a_1	a_2	ϕ_1	a_3	ϕ_2	a_4	ϕ_3 ✓	a_5	ϕ_4	ϕ_5
0.50639	0.21489	0.31656	0.85233	0.16691	-0.54487	0.12381	3.1176	0.14817	1.8505	-.99961

$\text{Log } L = -1452.41$

Ave No of wet days = 54.22

Ave An. Precip = 12.10 In. = 307.38 mm

ME: (in mm)

$\alpha = 0.9953$

β: $a_0 = 1.0795$ $a_1 = 0.3536$ $\phi_1 = 2.6397$

μ: $a_0 = 5.038$ $a_1 = 1.6678$ $\phi_1 = -2.1764$ $a_5 = 0.58672$ $\phi_5 = 1.0011$

$\text{Log } L = 1352.28$

DAW 8-14-02 DAW 8-14-02

Set up control file ~~RG4.FIL~~ RG4MC.FIL

This will be control file for SOIPDOMC.F95

Fourier Coefs for MC RG4MC.FOU

in CLIMATO2\ARIZONA

Modify Program SOIPDOMC.F95 so that several precipitation input formats can be used.

DAW 8-16-02

A code variable (integer) is read on 3rd line of input file: IF READFORMAT=1 one column

=3 three cols

=16 16 cols. (AZ data)

Control file for Walnut Gulch RG4: C:\SOI\RG4.FIL

Output file is C:\CLIMATO2\ARIZONA\RG4SOI.OUT

For G_{00}:

Unperturbed Log L = -3664.32

Perturbed Log L = -3650.71

$a_{00} = 0.12$ $b_{00} = -0.06$

at Lag = 90 days (for SOI)

For G_{10}:

Unperturbed Log L = -1452.44

Perturbed Log L = -1450.58

$a_{10} = 0.08$ $b_{10} = 0.06$

at Lag = 60 days

For comparative purposes the above parameters were entered into the table on p 106.

DAW 8-17-02 RG4 Walnut Gulch SOI + PDO

Revise input format for S_PDOME2.F95 so that precipitation data in the format 16F5.2 can be input.

Control file: C:\SOI\RG4ME.FIL

FOURIER COEF FILE: C:\CLIMATO2\ARIZONA\RG4ME.FOU

OUTPUT FILE " " " \RG4SOIME.~~FOU~~ OUT

DAW 3-10-03

Unperturbed Log L = -5658.89

Max Log Lik = -5652.17

see p 96 DAW 3-10-03

$C_1 = -0.47$ $C_2 = -0.20$ Lag = 90 days

Note: This is consistent with the analysis of Dettinger + Cayan (2000)

For comparative purposes the above parameter values were entered into the table on p 107.

DAW 8-19-02

Discussion: See Tables p 106 and 107

1) Effects of SOI and PDO on Markov Chain

Recall that the Markov Chain Logits are perturbed in the following way:

$$\hat{G}_{i0} = G_{i0} + a_{i0}\, SOI(t-\tau) + b_{i0}\, PDO(t)$$

For $\hat{G}_{00}$ we see that a_{00} for all stations is positive with a range from 0.12 to 0.20. This implies a greater probability of rain if the SOI is negative - consistent with other studies. The sign of b_{00} is not consistent. Lags of SOI range from 0 to 120 days

DAW 8-19-02

For $\hat{G}_{10}$ the coefficient a_{10} ranges from ~~0.05~~ 0.03 to 0.14 (for all year perturbation) Lags range from 0 to 120 days. The b_{10} coefficients are negative except for Las Vegas and RG4, both monsoonal climates.

Daw 9/9/02 Impact of SOI + PDO

Effect for Mixed Exponential mean μ:
Recall that the perturbation is of the form:
see p 105:

$$\hat{\mu}(t) = \mu(t) + C_1\, SOI(t-\tau_1) + C_2\, PDO(t-\tau_2)$$

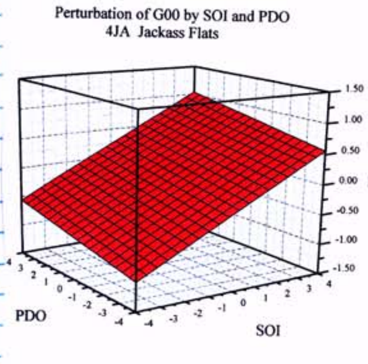
In this analysis τ_2 was set to zero because of the low frequency of PDO. From table on p107 we see

For $\hat{\mu}(t)$ the SOI coefficient, C_1 is always ~~negative~~ Daw 9/9/02 negative and ranges from -0.15 (for null effect for days 32-183) to -0.47 for RG4. This means that a negative SOI (El Nino) will increase the mean depth of daily precipitation.

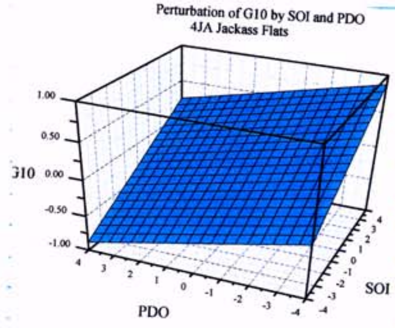
The PDO coefficient, C_2, ranges from -0.20 for RG4 to $+0.46$ for Jackass Flats. All coefficients in the Yucca Mtn region are positive, while C_2 for Las Vegas is negative, but small (-0.05). This suggests that for stations more strongly influenced by monsoonal activity that positive PDO tends to decrease $\hat{\mu}$. However the sample size is too small for strong conclusions. If this relationship is true it suggests that in the Yucca Mtn region, the combination of a positive SOI and a negative PDO would lead to lower precipitation depths, while for RG4 the combination of positive SOI and a positive PDO would lead to smaller mean depths, given rainfall. Because of the differences in size of the coefficients it is difficult to say what the effect of other combinations will be. An analysis of the deviations of $\hat{\mu}$ from μ as a time series might be useful.

Daw 12-31-02 Graphical Presentation of combined effects of SOI and PDO.

Prepared 12-31-02

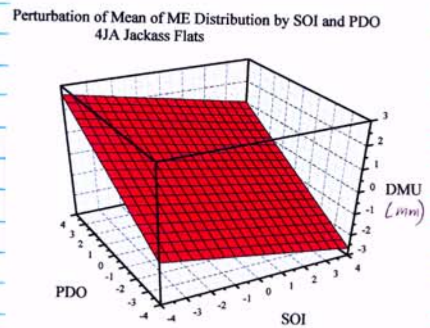


File: C:|CLIMAT02|DELG00.PGW
daw 12-31-02



File: C:|CLIMAT02|DELG104JA.PGW
daw 12-31-02

Note that in the above figures positive DG00 and DG10 lead to dryer than normal conditions. In general, negative SOI and positive PDO lead to increased frequency of rainfall and greater mean depths



File: C:|CLIMAT02|DELMU4JA.PGW
daw 12-31-02

DAW 1-13-03 Prepare Files and run example of creating monsoon climate at YM. For analog station use Walnut Gulch RG4. RG4 data were for period 1955 to 1994, MAP = 307.4 mm, MNWD = 54.2 days
Base station: Yucca Mtn. modern climate

New annual precip, MAP =
Program: C:\CLIMATOZ\SEASON3.F90
Files required for input
DAW 1-14-03
CONTROL FILE: C:\CLIMATOZ\MONSOON.CON

✓ MCFILE \YM181.MCP 5 har G_{00} 2 har G_{10}
MEFILE \YM181.MEP 1 har. β 4 har μ
✓ MC2FILE: C:\ \RG4MC.MCP 5 harmonics
✓ ME2FILE RG4ME.MEP 1 har, β " μ

Parameter values for YM181.MCP + ~.MEP were taken from table on p 63 with adjusted values for $\bar{G}_{00}$ and $\bar{\mu}$ shown on the bottom of page.
Parameters for RG4MC.MCP + RG4ME.MEP taken from files RG4MC.FOU and RG4ME.FOU

DAW 1-15-03
Create Control file

C:\CLIMATOZ\YM181.MCP
" YM181.MEP
" RG4MC.MCP
" RG4ME.MEP
" MONSOON.SEA output
" MONSOON.DAT plot file
5 5 1 5 331
3 2 1 3

DAW 1-15-03
Run SEASON3.F90 with control + parameter files shown on p 130.
Create PSIPLOT Figures

C:\CLIMATOZ\YUCMON_N.PGW Normalized $E\{N(t)\}$
\YUCMON_P.PGW Normalized $E\{S(t)\}$
YUCMONMC.PGW MC parameters P_{00} + P_{10}
YUCMONME.PGW ME parameters μ, β, α

Note: This version of SEASON3 used an old regression result to adjust α as a function of MAP. Change code so that α does not change.

Set up new control file: MONSOON2.CON

Output files: MONSOON2.SEA
MONSOON2.DAT
DAW 1-16-03
Now see if using phase angles and amplitudes for analog station as starting values for the control station harmonics that were insignificant will improve fit and allow more harmonics to be optimized.

Control file Monsoon3.CON
New parameter files for YM181: YM181A.MCP
YM181A.MEP
For YM181A.MCP added amps + phase angles for G_{10} harmonics 3, 4, 5
For YM181A.MEP added amp and ϕ for μ harmonic 5.

Increase harmonics to be optimized
4 3 1 5
Save as SEASON.CON
Output files MONSOON3.SEA
MONSOON3.DAT
Normalized $E\{N(t)\}$ and $E\{S(t)\}$ are nearly identical

DAW 1-22-03 Run SEASON3.F90 with YM181.* as base station, WG RG4 as analog station but with a projected MAP of 281 mm. This corresponds to approximately the 90% level for precipitation increase for the consensus predictions by the expert panel - DeWispelare et al. (1993).

4 DAW 1-22-03

Create Control file: MONSOON~~3~~4.CON

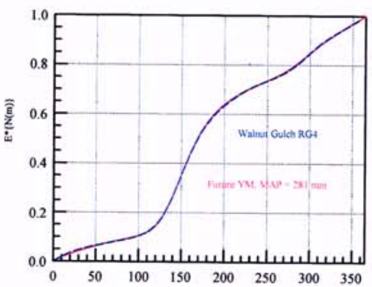
All files in: Save as SEASON.CON - Temporary DAW 1-22-03

C:\CLIMAT02\

This control file will be the same as MONSOON~~2~~3.CON except the MAP will be 281 mm instead of 331 mm and the output files will be: 4 DAW 1-22-03 4 DAW 1-22-03

MONSOON~~3~~4.DAT & MONSOON~~3~~4.SEA

With the files MONSOON4.DAT and MONSOON3.DAT as input, the normalized annual expected number of wet days and the normalized expected total precipitation functions for the base and analog stations were virtually indistinguishable when plotted. The plot for $E^*\{N(m)\}$ is shown below.



File: C:|CLIMAT02|NSTAR_4.PGW
daw 1-23-03

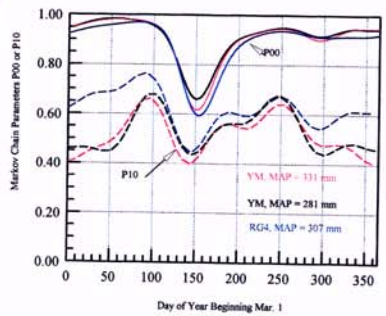
Comparison of Normalized Expected Number of Wet Day Functions Walnut Gulch RG4 and Future YM with MAP = 281 mm

DAW 1-23-03

This demonstrates that the program SEASON 3 does an excellent job of fitting the normalized expected value functions and that the seasonal distribution of precipitation for the YM future is nearly identical to the analog station.

DAW 1-23-03

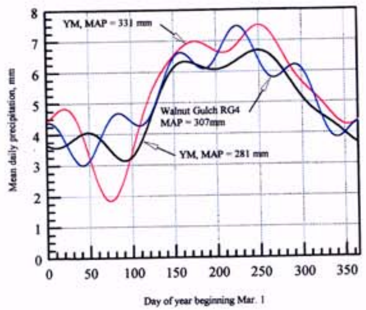
The Markov chain parameters P_{00} and P_{10} are shown for two future YM models and for Walnut Gulch RG4 in the following figure. The major difference between the functions is during the intervals 0-100 days and 290-365 days, with YM showing much higher persistence but lower P_{00}. This can be attributed to the local relationship between $\bar{G}_{10}$ and MAP which results in $\bar{G}_{10} = 0.12559$ for MAP = 281 mm and $\bar{G}_{10} = 0.0741$ for MAP = 331 mm. This results from the regression $\bar{G}_{10} = 2.428 \exp(-0.01054\ \mathrm{MAP})$. The YM functions are quite consistent with the 331 mm functions generally having smaller values of P_{00} and P_{10}.



File: C:|CLIMAT02|MC3_4.PGW
daw 1-22-03

Comparison of Markov Chain Parameters for Analog Station and Two Future YM Models

The daily variations of the ME $\bar{\mu}$ are shown in the following figure. The differences are the result of the relationships between $\bar{\mu}$ and MAP, with the YM model with MAP = 331 mm generally have greater values than YM (281 mm) or WG4. The RG4 model has more significant amplitudes in the higher frequencies. Because the fit for $E^*\{S(m)\}$ is dependent on $E^*\{N(m)\}$, the differences in P_{10} shown above will have an effect on μ.



File C:|CLIMAT02|MU3_4.PGW
daw 1-22-03

Comparison of the Mean of Mixed Exponential for Analog Station and Two Future YM Models daw 1-24-03 Set up control files to simulate 50yr records of precipitation, maximum and minimum daily temperatures and radiation for MONSOON3 and MONSOON4.

Objective:

1) To develop simulated sequences and to analyze the results to determine the effect of changes in seasonality on the monthly averages of precipitation, temperatures and radiation

Procedure   daw 1-27-03

1) ~~Create files similar to YUCTEST7.PAR (see p 63)~~

Note: Rather than use the BASIC program for simulation, use the program CLIMSIM_02.F95 and create a control file similar to JACKASS.SIM on p 114. All files will be in:

C:\SIMULATIONS_02 ✓

Control file names: MONSOON3.SIM ✓ and MONSOON4.SIM ✓

Fourier coef. files: MON4MC.FOU ✓ and MON4ME.FOU ✓

MON3MC.FOU ✓ and MON3ME.FOU ✓

T_{max}, T_{min} and RAD Parameter file: MON3-4.DAT ✓

Output files: MONSOON3.TPR ✓ and MONSOON4.TPR ✓

SOI and PDO will be nullified for entire year.

The T_{max}, T_{min} and Rad parameters in MON3_4.DAT are the same as those on p 63 and were obtained for an elevation of 4,594 ft.

The simulation for each will be for 50 yrs

daw 1-27-03

Completed 2 50yr simulations

MONSOON3.TPR + MONSOON4.TPR

2-4-03 Statistical Analysis of simulation output.

Run program STATCLIM.F95 with input files

C:\CLIMAT02\MONSTAT3.CON daw 2-7-03

" " \MONSTAT4.CON daw 2-7-03

Output files: " \MON3STAT.OUT

" \MON4STAT.OUT

The differences in the monthly statistics for these 2 runs will reflect the differences in expected MAP

To see how the change in seasonal characteristics as well as MAP affects T_{max}, T_{min} and Rad statistics do an analysis of the present-day YM climate with MAP = 181 mm

Files YUCSIMC.PTR and YUCSIMD.PTR were copied from ZIP disk storage to C:\SIMULATIONS_02

These are two 50yr simulations are discussed on p 76.

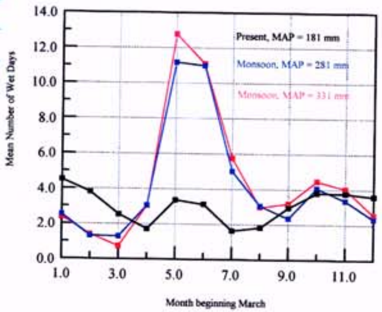
Control Files:

C:\CLIMAT02\YUCSTATC.CON

Output File " \YUCSTATC.OUT

Prepare Graphics

1) Monthly precipitation - mean number of wet day and mean monthly precipitation.



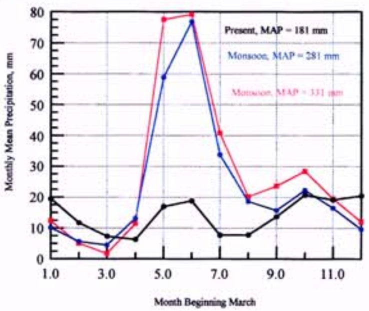
Sample Mean Number of Wet Days for 50-Yr. Simulations
Present Yucca Mountain and Monsoonal Seasonal Patterns

File C: | CLIMAT02 | N_PRE_MON.PGW
daw 2-4-03

The adjacent Fig. shows the dramatic effect of the monsoonal pattern where the expected number of wet days in July and August increases from around 3 to (11 to 13)

The present climate has more frequent precipitation in the period Feb - May. The monsoon climate with MAP=331 mm generally has a greater sample mean number of wet days than Monsoon with MAP=281 mm.

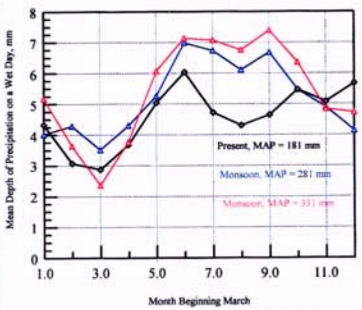
DAW 2-6-03 Comparison of statistics for present YM climate and future YM climate with increased precipitation and monsoonal seasonality.



Sample Mean Monthly Precipitation for 50-Yr. Simulations
Present Yucca Mountain and Monsoonal Seasonal Patterns

File: C: | CLIMAT02 | P_PRE_MON.PGW
daw 2-4-03

The mean monthly precipitation patterns compare more closely with the number of wet days (Fig on p136) than the pattern of mean precipitation per wet day as shown below. The general pattern is the same for present and monsoonal climates, but the monsoonal precipitation regime is dominated by the months of July and August while the present regime has more winter precipitation.

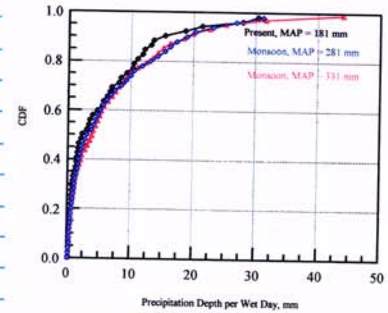


Mean Precipitation on a Wet Day for 50 - Yr Simulations
Present Yucca Mountain and Monsoonal Seasonal Patterns

File: C: | CLIMAT02 | MEANP_MON.PGW
daw 2-5-03

DAW 2-7-03

The empirical CDFs of daily wet day precipitation for the month of August is shown below. There is very little difference between the monsoon climates, but the present seasonality with MAP = 181 has a smaller probability of daily precipitation > 15 mm.

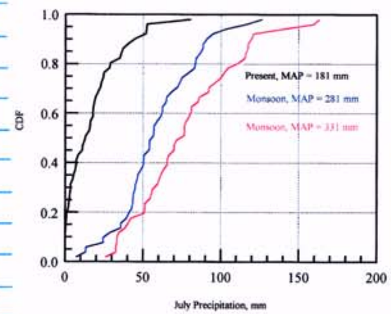


Cumulative Distribution Functions of August Wet-Day Precipitation
Present Yucca Mountain and Monsoonal Precipitation Patterns

File: C: | CLIMAT02 | CDF_AUG_MON.PGW
daw 2 - 5 - 03

This is consistent with the daily variation of the means of the ME distribution for the two future YM models. It is also consistent with the observation on p136 that the number of wet days is most important for total monthly mean precipitation.

The CDFs of the monthly totals of precipitation for July are shown below. The differences are substantial as would be expected by the differences in the means shown in the Fig. on top of p 36.



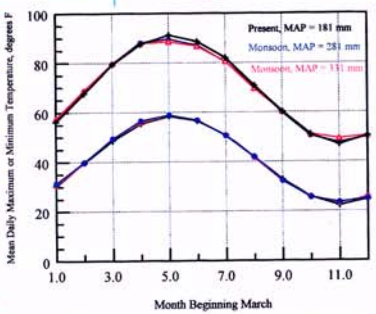
Cumulative Distribution Functions of July Precipitation
Present Yucca Mountain and Monsoonal Precipitation Patterns

File: C: | CLIMAT02 | CDFMONTH_JUL.PGW
daw 2 - 5 - 03

It is clear that with a monsoon type seasonality that there would be more summer rainfall and there would be more Hortonian runoff. The mean monthly precipitation in Feb is smaller with the monsoon pattern so there could be less saturation-induced runoff.

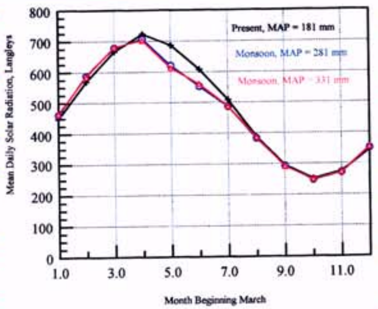
DAW 2-7-03

The monthly mean maximum daily temperatures (TMAX), minimum daily temperatures (TMIN) and solar radiation (RAD) are shown in the following two figures.



Monthly Mean Daily Maximum and Minimum Temperatures
Present Yucca Mountain and Monsoonal Seasonal Patterns

File: C: | CLIMAT02 | TMAXMINMON.PGW
daw 2-5-03



Monthly Mean Daily Solar Radiation for 50-Yr Simulations
Present Yucca Mountain and Monsoonal Seasonal Patterns

File: C: | CLIMAT02 | RAD_MON.PGW
daw 2-5-03

For this location the mean TMAX on a dry day is 75°F while on a wet day it is 62°. (See pgs 18, 19 & 62).
For July the mean number of wet days for these 3 climates is: (Present MAP=181; ~3 days); (Monsoon MAP=281 mm; ~11 days) and (Monsoon, MAP=331 mm; ~13 days). This would result in a decrease of TMAX of about 2°F for MAP=281 and about 3°F for MAP=331 mm. This is consistent with the above figure.

The mean TMIN is not conditioned on the state of the day (wet or dry) so TMIN should only be affected by the lag and cross-correlation structure of USCLIMATE. Apparently this structure does not have a significant effect on the monthly mean TMIN.

The mean of RAD on a ~~wet~~ dry day is 540 Langleys while on a wet day is 380 Langleys. DAW 5-15-03 DAW 2-7-03

DAW 2-7-03

This results in substantial decreases in monthly mean radiation during the summer monsoon season

Conclusions

1) The techniques utilized in the program SEASON3.F90 are effective in changing the seasonal distributions of wet days and precipitation at a base station so that they conform to those of an analog station.
2) The resulting functions $P_{00}(t)$ and $P_{10}(t)$ are consistent with the differences in mean annual number of wet days.
3) The resulting function $\mu(t)$ is generally consistent with the differences in MAP but some high frequency noise is introduced by the optimization scheme with 5 harmonics.
4) Statistical analysis of 50-yr simulations for 3 climate scenarios show that the approach is feasible and the monthly statistics of Nwet, P, Tmax, Tmin and Rad are consistent with the model.
5) With a Monsoon type climate at YM, there would be more Hortonian surface runoff, which would result in higher peak runoff rates and greater channel infiltration. These higher runoff rates could also cause increased erosion and possible channel alterations (scour or aggredation)

Daws 3-21-03 Analysis of the Rosalia, WA daily precipitation record. This is one of the analog stations for the interglacial climate at Yucca Mtn. Data were obtained from R.E. Fedors on this date. File name is ROSALIA.DAY which was created from ROSALIA.DAT which, in turn, was from EARTHINFO NOAA daily climate records WEST2 database
Downloaded to C:\PRE_DATA

Copy ROSALIA.DAY to ROSALIA.PRE for editing

Data format:

Record Day number	Year	Mo	Day of Mo	Day of Yr	Precip mm	Code	Tmax °C	Tmin °C	Snow fall mm

when -999.9

When -999.9 Code may be M
Code may also be T for trace

Record from 6-1-48 to 12-31-1997
There is a lot of missing data. Doesn't appear to be feasible.

Daws 3-24-03 Prepare figures for SOI-PDO effects report.

Data from Jackass Flats 50 yr simulation
Data file: C:\SOI\JACK_SIM1.PDW (P's Plotsheet)

1) Create a graph of time series of SOI-PDO perturbations of dry-dry transition probabilities
Mean perturbation = -0.004608 n = 18,250
std. dev = 0.01404
Max = +0.031
Min = -0.067
$\{ \bar{p}_{00} = 0.939$ S.D. = 0.0201
pert $\bar{p}_{00} = 0.9344$ S.D. = 0.0212
Figure JACK_P00PERT.PGW in C:\SOI\

2) Create a graph of the time series of SOI-PDO perturbations of wet-dry transition probabilities
mean perturbation = 0.000525 n = 18,250
std. dev. = 0.02855
max = 0.081 min = -0.093
$\{ \bar{p}_{10} = 0.6416$; SD = 0.0523
per $p_{10} = 0.6421$; SD = 0.0627
Figure C:\SOI\JACK_P10PERT.PGW

3) Create a graph of the time series of SOI-PDO perturbations of mean wet-day precipitation
mean perturbation = -0.045685 mm; Mean μ = 4.002 mm
std dev = 0.768
std. deviation = 0.6082 Max = 5.81 mm; min = 2.54
max = 1.79 min = -1.95 mm $\underbrace{}_{\text{unperturbed}}$
Figure C:\SOI\JACK_MUPERT.PGW
Perturbed μ: mean = 3.957 mm; Max = 6.4 mm; Min = 1.17 mm
std. dev = 0.942

DAW 4-9-03 Examine effects of SOI and PDO on analog future climates cited in:
Hevesi, J.A. (Draft 1999) "Simulation of Net Infiltration for Modern an Potential Future Climates"
ANL-NBS-HS-000032 Report to U.S. Dept. of Energy
The monsoon climate stations were:

	NCDC Code		
NOGALES, AZ	AZ 5921 ✓	Upper Bound	48-68 + 68-83
HOBBS, NM	NM 4026 ✓		46-86 + 86-99

The Glacial Transition

Rosalia, WA	WA7180 ✓	Upper Bound	48-63; 63-99
Spokane, WA	WA7938 (WSO Airport)		65-87 + 87-99

Call Western Regional Climate Center (775) 674-7010 to order data.

32 + 5 in

4-10-03 DAW Connected to FTP site and downloaded data files: Hobbs, Nogales, Rosalia, Spokane

Located BASIC programs used in 1999 to convert NCDC files to proper input format for MCME analysis. See p 31 of Attachment to Scientific Notebook 363.
Programs are DAYREAD.BAS and DAYREADT.BAS
Note: Data file format has changed since 1999.
An example partial file is shown on p 143

The current monthly time series I have for SOI is for the period ~~Jan 1900 Dec~~ DAW 4-10-03 Jan 1933 - Dec 1999
Data for PDO is for Jan 1900 - Dec 2001.

Station	Data Start	Stop	
Nogales	1892 -	1983	
Hobbs	~~1880~~ 1912 -	2002	DAW 4-11-03
Rosalia	1893 -	2002	~~No accumulated amount codes~~ DAW 4-11-03
Spokane	~~1880~~ 1889 -	2002	DAW 4-11-04

DAW 4-10-03

Example

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<!-- saved from url=(0040)ftp://ftp.wrcc.dri.edu/woolhiser/spokane -->
<HTML><HEAD>
<META http-equiv=Content-Type content="text/html; charset=windows-1252">
<META content="MSHTML 6.00.2716.2200" name=GENERATOR></HEAD>
<BODY><PRE>: BACKGROUND INFORMATION ON :
: SUMMARY OF THE DAY LISTING FOR NOAA COOPERATIVE STATIONS.
:
: S:      STATE NUMBER
: STN:    NCDC STATION NUMBER
: YER:    YEAR
: MM:     MONTH
: DD:     DAY OF MONTH
: HH:     HOUR OF OBSERVATION
: PCPN:  24-HOUR PRECIPITATION        [HUNDREDTHS OF INCHES]
: SNFL:  24-HOUR SNOWFALL             [TENTHS OF INCHES]
: SNDP:  SNOW DEPTH AT OBSERVATION    [WHOLE INCHES]
: TMAX:  24-HOUR MAXIMUM TEMPERATURE  [WHOLE DEGREES F]
: TMIN:  24-HOUR MINIMUM TEMPERATURE  [WHOLE DEGREES F]
:
:
: IMMEDIATELY AFTER EACH OBSERVATION ARE TWO FLAGS;
: THE FIRST IS A MEASUREMENT FLAG AND THE SECOND IS A QUALITY FLAG
: THE FOLLOWING FLAGS ARE USED BY NCDC---&gt;
: POSSIBLE VALUES OF MEASUREMENT FLAG:
: A:  ACCUMULATED AMOUNT
: B:  ACCUMULATED AMOUNT INCLUDES ESTIMATED VALUES
: E:  ESTIMATED (SEE SECOND FLAG FOR METHOD OF ESTIMATION
: J:  VALUE HAS BEEN MANUALLY VALIDATED
: M:  DATA IS MISSING
: S:  INCLUDED IN A SUBSEQUENT VALUE
: T:  TRACE (DATA = 00000 IN THIS CASE)
: (:  EXPERT SYSTEM EDITED VALUE, NOT VALIDATED
: ):  EXPERT SYSTEM APPROVED EDITED VALUE
: &gt;:  OSC FLAG; ORIGINAL DATA DATA VALUE TOO HIGH TO STORE
: &lt;:  OSC FLAG; ORIGINAL NCDC DATA VALUE TOO  LOW TO STORE
:  :  (BLANK) NO FLAG NEEDED
:
: POSSIBLE VALUES OF QUALITY FLAG:
: 0:  VALID DATA ELEMENT (FOR ORIGINAL DATA ONLY)
: 1:  VALID DATA ELEMENT (FOR "UNKNOWN" SOURCE)
: 2:  INVALID DATA ELEMENT, REPLACED BY SUBSEQUENT VALUE
: 3:  INVALID DATA ELEMENT, NOT REPLACED
: 4:  VALIDITY UNKNOWN (NOT CHECKED)
: 5:  ORIGINAL NON-NUMERIC REPLACED BY DECIPHERED NUMERIC
: A:  SUBSTITUTED TOBS FOR TMAX OR TMIN
: B:  TIME SHIFTED VALUE
: C:  ESTIMATED BY 10:1 RATIO, PRECIP FROM SNOWFALL
: D:  TRANSPOSED DIGITS
: F:  ADJUSTED TMAX OR TMIN BY +- A MULTIPLE OF 10 DEGREES
: G:  CHANGED SIGN
: H:  MOVED DECIMAL POINT
: I:  OTHER RESCALING THAN F,G,H
:
: J:  EDUCATED GUESS (SUBJECTIVELY DERIVED VALUE)
: K:  EXTRACTED FROM AN ACCUMULATED VALUE
: L:  SWITCHED TMAX AND TMIN
: M:  SWITCHED TOBS FOR TMAX OR TMIN
: N:  SUBSTITUTION OF "3 NEAREST STATION MEAN"
: O:  SWITCHED SNOW AND PRECIPITATION AMOUNT
: P:  ADDED SNOWFALL TO SNOWDEPTH
: Q   SWITCHED SNOWFALL AND SNOW ON GROUND
: R:  PRECIPITATION NOT REPORTED - ZERO ESTIMATED
:
: S:  MANUALLY EDITED VALUE
: T:  FAILED INTERNAL CONSISTENCY CHECK
: U:  FAILED AREAL CONSISTENCY CHECK (BEGINNING OCT 1992)
: ):  EXPERT SYSTEM APPROVED EDITED VALUE
:
: STATION NUMBER 457938   SPOKANE WSO AIRPORT
: OVERALL PERIOD CONSIDERED: 18800101-20021231
: WINDOW (START AND END)    : 0101-1231
: Note: Corrected and later-entered data may follow, out of time order
:
:S STNYEARMMDDHH   PCPN    SNFL    SNDP    TMAX    TMIN
:-------------   ------  ------  ------  ------  ------
:
457938188908011 8   0 1     0M      0M     84 1    56 1
4579381889080218    0 1     0M      0M     83 1    56 1
4579381889080318    0 1     0M      0M     90 1    54 1
4579381889080418    0 1     0M      0M     85 1    57 1
4579381889080518    0 1     0M      0M     78 1    52 1
4579381889080618    0 1     0M      0M     80 1    46 1
4579381889080718    0 1     0M      0M     84 1    46 1
4579381889080818    0 1     0M      0M     82 1    52 1
4579381889080918    0 1     0M      0M     83 1    53 1
4579381889081018    0 1     0M      0M     82 1    63 1
4579381889081118    0 1     0M      0M     90 1    55 1
4579381889081218    0 1     0M      0M     87 1    58 1
4579381889081318    0 1     0M      0M     88 1    55 1
4579381889081418    0 1     0M      0M     88 1    54 1
4579381889081518    0 1     0M      0M     84 1    62 1
```

YR hr cl/12 46 54

DAW 4-15-03 Calculate MCMF and SOI-PDO perturbation parameters for Spokane, WA

1. Save c:\Analog-precip\Spokane.htm to Spokane.dat for editing. Delete to 3-01-1890 DAW 4-15-03
2. Revise BASIC program DAYREADT.BAS to DAYREAD2.BAS to accomodate revised format.

with this program create SPOKANE.PTT ✓
edit + eliminate leap days ✓

DAW 4-15-03 MCME analysis of Spokane

Create control file for MCME analysis SPOKANE.FIL

Try run beginning 1890 for ~~120~~ 110 yrs ~DAW 4-15-03

DAW 4-16-03

Restricted α in mixed exponential to zero harmonics

Max of ~~6~~ 5 harmonics for MC DAW 4-16-03

" " 4 " for Beta

" " 6 harmonics for μ

Try a second run allowing 2 harmonics for α

Control file spokane2.FIL Program

First harmonic for α was significant

output files are: c:\analog-precip\spokane2.OUT

" .DET

" .DAT

Run MCME analysis of ROSALIA, WA

3/1/1893 to 2-28-2002 =

In checking the file, I found several years where data lines were missing. For this analysis those years were omitted, leaving 96 years of data. This is a poor station for SOI-PDO analysis.

DAW 4-17-03

Checked the data file SPOKANE.PTT. Found 8 days missing (actual lines missing)

2-20-1922 - entered 0 precip ave of Tmax + Tmin

3-23 through 3-29, 1945 entered -9.99 precip + T_{max}, T_{min} of 3-22

Need to rerun MCME analysis. Control file SPOKANE2.FIL

Run completed. File names SPOKANE2.* (Wrote over files)

4-17-03 DAW

Checked data file for Nogales. Several gaps in the data.

File NOGALES.PTT starts 3-1-1922 with 61 yrs of data.

Missing periods: Jan 1 - July 1, 1948 entered -9.99 for precip Temps for '47

4/27-5/3, 1949 " " -99.9 for temp

7/25/50 " "

7/16/57 + 8/30/57 " "

July 1966 " "

Run with MCME00_3.F95 completed ✓

File Names C:\ANALOG-PRECIP\NOGALES.*

Check file for Hobbs, NM

Start in 1938 - previous period had major gaps

Missing periods: July, 1947 entered -9.99 for precip Temp for 1946

10-1-1953 entered missing codes

3-11-1956 " " "

60 yrs.

Run with MCME00_3.F95 completed ✓

File names C:\ANALOG-PRECIP\HOBBS.*

Effects of SOI and PDO

Use programs SOIPDOMC.F95 and SOIPDOME.F95

in directory C:\SOI

For Spokane, Markov Chain

Control file: C:\ANALOG-PRECIP\SPOK_MC.FIL

112 full years in file ✓, but yr 1 of SOI is 1933 so start in 1934

Last full yr. begins in 2001, skip 44 yrs. SPOKANE.PTT begins Mar. 1, 1890

Output file: C:\ANALOG-PRECIP\SPOKA_MC.OUT

G_{00}: Log Lik (no perturb) = -8258.7842

perturbed -8257.31934 at a_{00} = -0.02; b_{00} = 0.02, SOI lag = 120 days

G_{10}: Log Lik (no perturb) = -4932.9521

perturbed: -4930.75049 at a_{10} = -0.06; b_{10} = -0.02; SOI lag = 90

DAW 4-23-04 Continue SOI-PDO Analysis of analog station.

There is a slight improvement in both log likelihoods but the unperturbed model has the minimum AIC. This is consistent with the results of SOI perturbations obtained by Woolhiser (1992) for three Oregon stations: Corvallis, Crater Lake and Bonneville Dam.

Now check SOI and PDO effects on mixed exponential.
Control file: C:\ANALOG-PRECIP\SPOK-ME.FIL
Output file: C: " " \SPOK_ME.OUT
Unperturbed log likelihood = -15959.2793
Perturbed " = -15958.5098
$C_1 = 0.05$, Lag = 60 days; $C_2 = 0$
Therefore SOI and PDO perturbations do not lead to a minimum AIC.

DAW 4-24-04
Checked output file and verified that precipitation, SOI and PDO are concurrent for the period analyzed.

One factor that should be checked - The Fourier coefficients for both the Markov chain and the mixed exponential were obtained using 110 years of precipitation data, while the SOI-PDO analyses was done for the period 1934-1998. Thus the coefficients are not optimal for the shorter period.

DAW 4-25-04
Rerun MCME analysis for period 1934-1998
Use program MCMEDO_3.F95 (revised with 6 col. input option)
Control file: C:\ANALOG_PRECIP\SPOKANE8.FIL
In a quick examination of the output data, the Markov chain parameters are little affected by the difference in the period of record, however, there is a difference in the ME parameters

DAW 4-25-03
New run of SOI-PDO effects
Control file: C:\ANALOG-PRECIP\SPOK_ME3.FIL
Fourier coefs taken from " \SPOKANE3.OUT
Run program S_PDOME2.F95 (Modified to allow harmonics for α)
Results:
Unperturbed log likelihood = -15943.105
perturbed " = -15941.87
$C_1 = 0.10$, lag = 60 days, $C_2 = 0.05$
However perturbed model does not lead to minimum AIC

Now perform SOI-PDO analysis for ROSALIA, WA
Record starts in 1893, analysis for 1934-1998; 65 yrs.
Last record ys is 2001, skip 41 yrs.
For Mixed exponential
Control file: C:\ANALOG-PRECIP\ROSA_ME.FIL
Fourier parameters " " \ROSA_ME.FOU

In examining ROSALIA.PTT there is too much data missing to perform analysis!!
It is O.K. for the MCME analysis because we assume year to year stationarity.

Now perform SOI-PDO analysis for Nogales, AZ

DAW 4-28-03
Now perform SOI-PDO analysis for Nogales, AZ
Record starts in 1922 last year is 1982 ∴ 61 years
Start analysis in 1934 - skip 12 years
Control file: C:\ANALOG-PRECIP\NOGAL-MC.FIL (for Markov Chain)
MC Fourier Coef. C:\ " NOGAL-MC.FOU
Unperturbed Log L for G_{00} = -4355.0713 ✓
Perturbed Log L " G_{00} = -4346.2441
at $a_{00} = 0.12$, Lag = 90; $b_{00} = 0.02$
However Max Log Lik with $b_{00} = 0$ is -4346.827
Therefore SOI effect is significant, PDO is not.
$a_{00} = 0.12$ $\tau = 90$

DAW 4-28-03

For G_{10} unperturbed Log L = −1900.8523
perturbed Log L = −1898.29639
at a_{00} = 0.08 b_{01} = 0.06 Lag = 0
Therefore effect of PDO and SOI not significant

Now run ME analysis
control file C:\ ANALOG—PRECIP \ NOGAL—ME.FIL
Fourier Coefs " " \ NOGAL—ME.FOU
Output file " " \ NOGAL—ME.OUT
unperturbed Log L = − 8148.8789
Perturbed Log L = − 8147.4229
at C_1 = 0.0, Lag = 0; C_2 = 0.2
However this value of C_2 was at the upper limit specified in the control file.
Try raising the upper limit.
Now maximum perturbed Log L = −8142.8667
at C_1 = − 0.44, Lag = 60 days, C_2 = 0.10

with C_1 = −0.44 @ 60 days and C_2 = 0 Log L = −8143.1455
Therefore SOI is highly significant but PDO is not.
One explanation for lack of sensitivity to PDO is that Nogales record ends in 1982 so don't have as many years with + PDO as RG4 which goes to 1994.
However, a reexamination of C:\ CLIMAT02\ARIZONA\RG4SOIME.OUT
reveals that C_2 = 0 was not included in the search grid so it is not clear if C_2 is significant

DAW 5-2-03 with C_1 = −0.46 @ 60 days and C_2 = 0
Log L = − 8143.1118

DAW 4-28-03

Now perform SOI-PDO Analysis for Hobbs, NM
Data from 1938 − 1997, 60 yrs
CONTROL File: C:\ ANALOG—PRECIP \ HOBBS—MC.FIL
MC Fourier coefs " " \ HOBBS—MC.FOU
output file " " \ Hobbs—MC.OUT

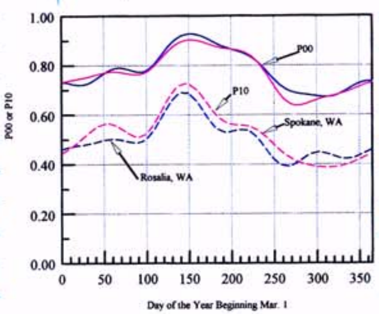
G_{00}: Unperturbed Log L = −5855.1943
perturbed " = −5842.8613
at a_{00} = 0.10, Lag = 0; b_{00} = −0.04
Both SOI + PDO are significant
G_{110}: Unperturbed Log L = −1673.1736
perturbed Log L = −1672.580
SOI + PDO are not significant

New run ME analysis:
Control file: C:\ ANALOG—PRECIP \ HOBBS—ME.FIL
ME Fourier Coefs " " \ HOBBS—ME.FOU
Output file " " \ HOBBS—ME.OUT

Unperturbed Log L = −8189.9487
Perturbed Log L = −8181.9565
at C_1 = −0.32; Lag = 30 days C_2 = 0.2
However C_2 was at upper bound of search grid so raise search grid.
Perturbed Log L = − 8181.58838
at C_1 = −0.32; Lag = 30 days; C_2 = 0.48

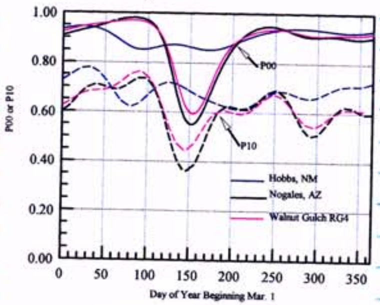
Revised bounds again
Perturbed Log L = −8181.39014
at C_1 = −0.26; Lag = 30 days; C_2 = 0.58
Checked Log Likelihoods when C_1 = 0 and C_2 = 0
when C_1 = 0, C_2 = 0.58 Log L = −8182.5913
when C_1 = − 0.26, Lag = 30 + C_2 = 0 Log L = −8187.2892

DAW 4-30-03
Prepared figures of MCME parameters and observed precipitation characteristics for analog stations



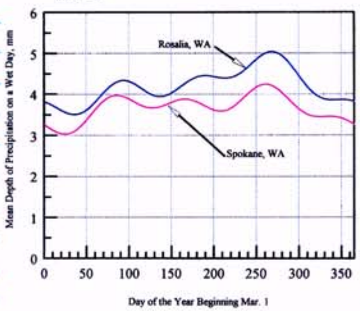
Markov Chain Transition Probabilities P00 and P10
Washington Stations

File: C: | ANALOG_PRECIP | MC_WA.PGW
daw 4-30-03



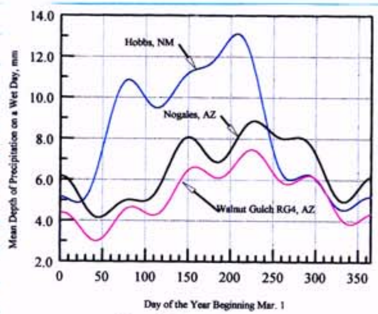
Markov Chain Transition Probabilities, P_{00} and P_{10}
for Arizona and New Mexico Stations

File: C: | ANALOG_PRECIP | MC_AZNM.PGW
daw 4-30-03



Mean of Wet Day Precipitation, Washington Stations

File: C: | ANALOG_PRECIP | ME_WA.PGW
daw 5-1-03



Mean of Wet Day Daily Precipitation
Arizona and New Mexico Stations

File: C: | ANALOG_PRECIP | ME_AZNM.PGW
daw 4-30-03

The dramatic differences in the seasonal frequency of wet days and daily precipitation amounts are demonstrated in the above figures. The seasonality of P_{00} & P_{10} for the Washington stations is the opposite of the monsoon stations. The mean depth, μ for the Washington stations is smaller than for the monsoon stations and doesn't vary as much during the year. The expected accumulated precipitation functions (empirical) are shown on p152.

DAW 5-5-03 Adjust parameters of Yucca Mtn climate model to get seasonality of Spokane, WA.

Program: C:\ \ SEASON3.F95

For MAP = 331 mm

Control file: C:\CLIMATC2\YM-SPOK3.CON
MC File YM: C:\ " \YM181A.MCP ✓
ME " " : " " \YM181A.MEP ✓
MC File SPOKANE: C:\CLIMATC2\SPOK.MCP ✓ } From
ME File SPOKANE " " \SPOK.MEP ✓ } SPOKANE 3.OUT
output file " " \YM-SPOK3.SEA
Graphics file \YM-SPOK3.DAT

Note: Spokane had one harmonic significant for ME parameter α
Adjust SEASON3.F95 → SEASON4.F95 to account for this
Also performed a 50yr simulation for Monsoon Climate with perturbations: YM_MONB.MO
DAW 5-12-03 It is of interest to examine the variance of the distribution function of daily precipitation given rainfall when the seasonal distribution and mean annual precipitation (MAP) are adjusted by the program SEASON4.F95

The variance of the mixed exponential is given by the expression.

$$\sigma^2(t) = 2\alpha(t)\beta(t)^2 + 2[1-\alpha(t)]\delta(t)^2 - \{\alpha(t)\beta(t) + [1-\alpha(t)]\delta(t)\}^2$$

(Woolhiser et al 1993 "Southern Oscillation Effects ..." WRR 29(4) 1287-1295
Because the mean values will change as MAP changes, the coefficient of variation as a function of time, CV(t) may be the most interesting statistic

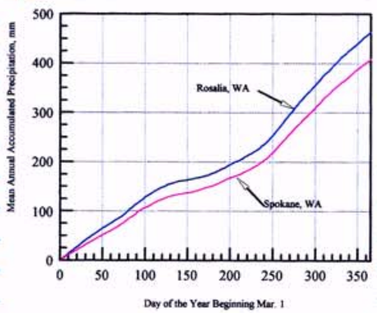
$$CV(t) = \sqrt{\sigma^2(t)} / \mu(t)$$

In examining the file YM-SPOK3.DAT we find the the CV for the adjusted YM station is greater than it is for Spokane. This appears to be a result of the higher regional value of α in the YM vicinity. It would be possible to adjust the CV with a fixed μ by adjusting α and β

Daw 5-12-03 CV of adjusted dist of precip depth
Thus it would be possible to closely match the CV of the analog station, if that seemed desirable
Run YM_SPOK4.CON for MAP = 424 mm

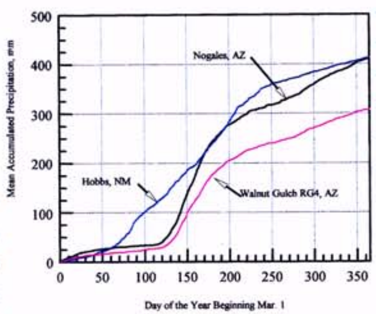
Daw 5-13-03 4 Daw 5-13-03
In examining file C:\CLIMATE02\YM_SPOK3.SEA we find that for a target MAP of 424 mm the adjusted base station has a mean number of wet days (MNW) = 64.05 while the analog station has MNW = 112 days. This results from the regional regressions used to estimate $\bar{G}_{oo}$, $\bar{\mu}$, etc. It could be argued that with a change in seasonality and climate, the local regressions would no longer hold and the counting process and $\bar{\mu}$ would more closely resemble those of the analog stations. The figures on p153 show the accumulated expected number of wet days functions for the two regions.

Daw 5-23-03 The two figures on the bottom of p153 demonstrate that the normalized E{S(M)} functions may match rather closely, but the Markov Chain counting process as controlled strongly by $P_{00}(t)$ may not be appropriate when the analog station has many more wet days than the base station.



Mean Accumulated Precipitation, Inter-glacial Stations

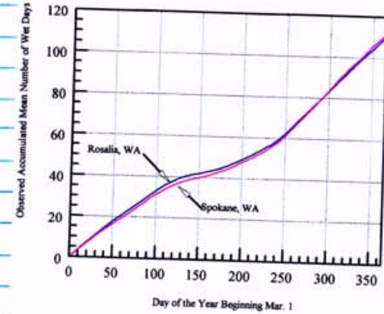
File: C: | ANALOG_PRECIP | PREOBS_WA.PGW
daw 5-1-03



Mean Accumulated Precipitation
Arizona and New Mexico Stations

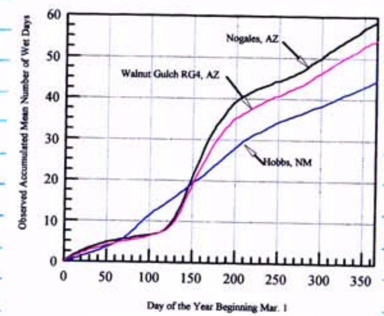
File: C: | ANALOG_PRECIP | PREOBS_AZNM.PGW
daw 4-30-03

Daw 5-13-03



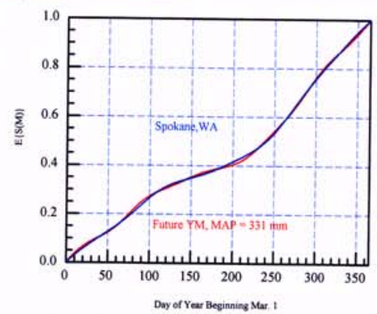
Observed Accumulated Mean Number of Wet Days, Washington

File: C: | ANALOG_PRECIP | WETOBS_WA.PGW
daw 5-1-03



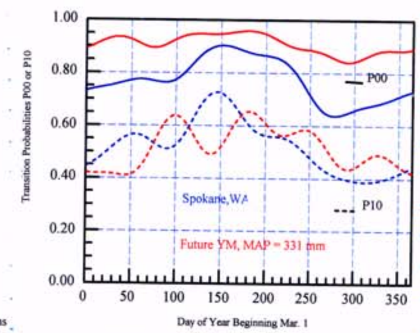
Observed Accumulated Mean Number of Wet Days
Arizona and New Mexico Stations

File: C: | ANALOG_PRECIP | WETOBS_AZNM.PGW
daw 4-30-03



Comparison of Normalized Expected Accumulated Precipitation Functions
Spokane, WA and Future YM with MAP = 331 mm.

File: C: | CLIMATE02 | SSTAR_YM_SPOK3.PGW
DAW 5-20-03



Comparison of Markov Chain Transition Probabilities
Spokane, WA and Adjusted Yucca Mountain Model

File: C: | CLIMAT02 | MC_YM_SPOK3.PGW
daw 5-20-03

DAW 5-14-03 Simulate 50 years of daily precipitation, Tmax, Tmin + Rad for Yucca Mt with Spokane climate. No SOI-PDO perturbation

1) Create control file c:\SIMULATIONS_02\YM_SPOK1.SIM ✓
2) " Fourier Coef file " \SPOKMC.FOU ✓
3) " " " " " \SPOKME.FOU ✓
Fourier coefs from file: c:\ " \SPOKANE3.OUT
Output file: " " \YM_SPOK1.PTR

DAW 5-15-03
Run program C:\SIMULATIONS_02\CLIMSIM_03.F95 ✓
output file has 50 yr. record.
Temp and radiation file was " \MON3-4.DAT
which has parameters for the YM location.
Although the greater frequency of precipitation will affect temperature and radiation, the effect of increased humidity is not accounted for.
With the MCME parameters above, the theoretical mean annual number of wet days is 111.9 and the MAP = 423.2 mm
→ File YM_SPOK1.PTR given to R.E. Smith for input to OPUS.
Perform a statistical analyses of 50 yr record (See p 135)
Use program c:\CLIMATO2\STATCLIM.F95 ✓
CONTROL FILE: " " \Y_S1STAT.CON
Output File: c: " " \Y_S1STAT.OUT
Note: Because simulated data now has leap days will need to modify the program to account for this.
Revised program STATCLIM.F95 → STATCLIM2.F95 ✓
Check Col. statistics with PSIPLOT — For YM181PER.OUT
Mean annual simulated precip = 183.3 mm
" Tmax = 69.12 °F max = 118.8 min = 1.4
" Tmin = 40.64 °F max = 73.5 min = -9.6

DAW 5-19-03 Simulate 50 yrs of daily precipitation, Tmax, Tmin + Radiation for Yucca Mtn, current climate, with SOI PDO perturbations
1) Control file c:\SIMULATIONS_02\YM181PER.SIM
2) Fourier Coeff, Markov Chain " \YM_MC.FOU
3) " " ME \YM_ME.FOU
(Fourier coefficients from YUCPRES.PAR) see p 03 and p 75
4) output file c:\ " \YM181PER.~~SIM~~ PTR DAW 5-19-03

Perturbation parameters for Jackass Flats see pp 106-107
Temp + Radiation parameter file c:\ " \MON3-4.DAT
Note: Adjustments shown on p 63 of $\bar{\sigma}_{w}$ and $\bar{\mu}$ were entered in the *.FOU files to create a theoretical MAP of 181 mm
Expected MAP = 181.73 mm Wet Days = 38.2
Run program C:\SIMULATIONS_02\CLIMSIM_03.F95 ✓
DAW 5-20-03
Perform statistical analyses with C:\CLIMATE02\STATCLIM2.F95
1) Control file C:\ " \Y181PSTA.CON → ~~SEASON~~ STAT.CON for input
2) Output file " " \Y181PSTA.OUT ✓ DAW 5-20-03
CDFs for Months of July, Aug, Sep, Dec, Jan, Feb
MAP SOI-PDO perturbation
→ Sent file YM181PER.PTR to R.E. Smith

Create file for report FUTClimate0-2Rev.WPD
E{S(m)}* for Spokane and adjusted YM with MAP = 331 mm
Data from file C:\CLIMATO2\YM_SPOK3.DAT
PSI PLOT File C:\CLIMATO2\SSTAR-YM_SPOK3.PGW

Markov chain parameters C:\CLIMATO2\MC_YM_SPOK3.PGW
Data from C:\CLIMATO2\YM_SPOK3.DAT
and C:\ANALOG-PRECIP\SPOKANE3.DAT

Daw 5-21-03 Prepare Figures comparing YM with interglacial climate with present day YM

1) Create figures for Spokane climate at YM MAP = 423 mm
Data in file C:\CLIMATO2\Y_S1STAT.OUT
Create separate files for specific data to be plotted
a) C:\CLIMATO2\Y_S1MON.DAT – monthly means

Plotted monthly mean precipitation from Y_S1MON.DAT onto C:\CLIMATO2\P_PRE_MON.PGW – see p136. New file name P_PRE_M&I.PGW
See Fig p157

Plotted monthly mean number of wet days on N-PRE_MON.PGW
New file is N_PRE-M+I.PGW (See p135) See Fig p157

Plotted monthly mean depth of precipitation per wet day on MEANP_MON.PGW (see p136). New file is MEANP_M+I.PGW

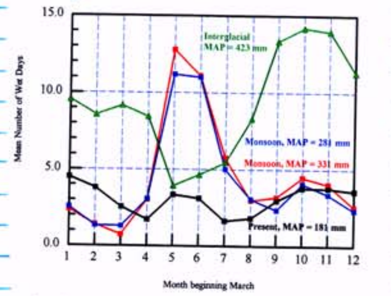
Temperature Plots
Create Y_S1TMAX.DAT and Y_S1TMIN.DAT p138
Plotted on C:\CLIMATO2\TMAXMINMON.PGW → TMAXMIN2.PGW ✓
Radiation Y_S1RAD.DAT
Plotted on C:\ " \RAD_MON.PGW p138 → RAD_MON2.PGW ✓

Monthly precipitation CDFs Daw 5/21/03
Create file C:\CLIMATO2\~~YMS1DEC~~ Y-P DECCDF YPDECCDF.DAT from
" " \YUCSTATC.OUT
Create file C:\ " \YIDECCDF.DAT from Y_S1STAT.OUT
" "

These files have CDFs for December precipitation

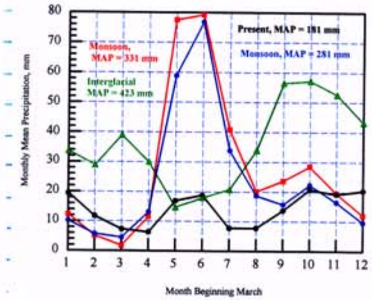
Plot file: C:\CLIMATO2\DECCDFM+I.PGW ✓
For YM Monsoon climate MAP = 281 mm data from MON4STAT.OUT
to C:\ " \MON4DECCDF.DAT

Daw 5-22-03



Sample Mean Number of Wet Days for 50-Yr. Simulations
Present Yucca Mountain, Monsoonal and Interglacial Seasonal Patterns

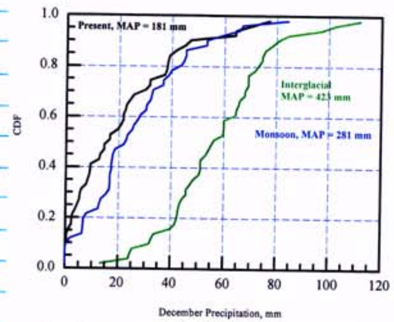
File:C:|CLIMAT02|N_PRE_M&I.PGW
daw 5-21-03



Sample Mean Monthly Precipitation for 50-Yr. Simulations
Present Yucca Mountain, Monsoonal and Interglacial Seasonal Patterns

File: C:|CLIMAT02|P_PRE_M&I.PGW
daw 5-21-03

The dramatic difference in the seasonal occurrence and amounts of precipitation between the monsoon climate and the interglacial climate as represented by Spokane WA is demonstrated by the above figures.

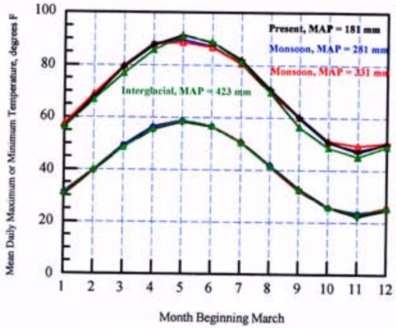


Cumulative Distribution Functions of December Precipitation
Present Yucca Mountain, Monsoonal and Interglacial Seasonal Patterns

File: C:|CLIMAT02|DECCDFM&I.PGW
daw 5-21-03

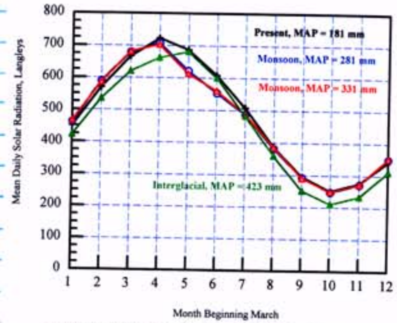
The CDFs of December precipitation show the differences to be expected given the differences in the monthly mean precipitation. The much greater amounts of precipitation with many more events would lead to increased saturation-induced overland flow and increased deep percolation at Yucca Mountain.
From the temperature statistics on p158 it appears that a significant amount of precipitation in December January and February may occur as snow. With reduced maximum temperatures and solar radiation, the snow would persist longer than with the current or monsoonal climates.

Daw 5-23-03 Monthly mean temperature and radiation statistics for Yucca Mt. with present climate and 3 additional climate scenarios



Monthly Mean Daily Maximum and Minimum Temperatures
Present Yucca Mountain and Monsoonal Seasonal Patterns

File: C: | CLIMAT02 | TMAXMIN2.PGW
daw ~~2-5-03~~ 5-21-03 Daw 5-23-03



Monthly Mean Daily Solar Radiation for 50-Yr Simulations
Present Yucca Mountain, Monsoonal and Interglacial Seasonal Patterns

File: C: | CLIMAT02 | RAD_MON2.PGW
daw 5-21-03

The interglacial climate results in lower maximum temperatures during spring and winter months. The minimum temperatures generated by the USCLIMATE model show slight increases for January but differences are probably insignificant. It is quite likely that the minimum temperatures for the interglacial climate should be higher than for the other climates because of increased cloud cover and less radiative cooling.

The mean daily radiation is decreased significantly for the interglacial climate during the winter and spring. This is realistic given the increased cloud cover with more frequent precipitation.

DAW 6-6-03 Literature Review
Objective: Locate any scientific literature examining concurrent effects of SOI and PDO on precipitation
Performed computer search of Water Resources Research Abstracts
Found:

McCabe, G. J. and Dettinger, M. D. 1999. "Decadal variations in the strength of ENSO Teleconnections with precipitation in the Western United States" International Journal of Climatology 19: 1399-1410.

Using 30 yr. overlapping Oct-Mar precipitation records for 84 climate divisions in the Western US they they found decadal time scale variations in the strength of the correlation of precipitation with the previous June - Nov. SOI. ENSO teleconnections are strong when PDO is negative but are weak when PDO is positive.
I have prepared figures of the SOI-PDO perturbations in P_{ww}, P_{wd} and μ for Jackass Flats. It would be useful to have the same information for a monsoon station. (For Jackass Flats see p 141)

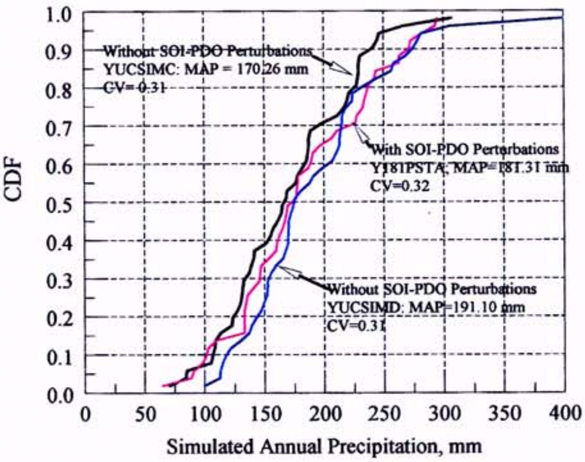
DAW 6-16-03

DAW 7-15-03 Consider the effects of SOI-PDO perturbation on CDFs of monthly precipitation for Yucca Mt.
For files w/o perturbations see p 76
For files with perturbations see p 155

First look at CDFs of annual precipitation
Edit annual simulated precip from YUCSIMC.STA; YUCSIMD.STA and Y181PSTA.OUT and copy to files with same names but extention .ANN in C:\CLIMAT02
Use PSI PLOT to create a figure - See page 160

It appears that adding SOI and PDO perturbations does not significantly increase the coefficient of variation of annual precipitation.

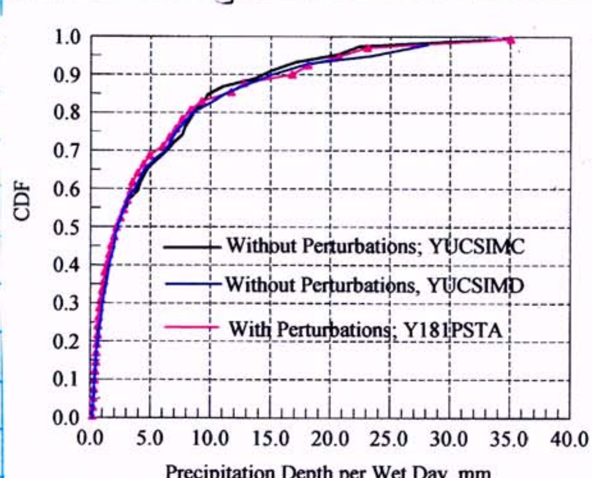
DAW 7-15-03



File: C:CLIMAT02\Y181_ANCDF.PGW
Data: C: CLIMAT02\Y181PSTA.ANN, YUCSIMD.ANN & YUCSIMC.ANN
daw 7-15-03

Cumulative Distribution Functions of Simulated Annual Precipitation
Yucca Mountain, Present Climate, With and Without SOI-PDO Effects

DAW 7-16-03 Examine CDF's of monthly values of wet-day precipitation. Copy CDF tables from files shown on previous page to dummy files. Import dummy files to PSIPLOT. Create file C:\CLIMATO2\JANDAYCDF.PGW for January.



CDFs of Wet Day Precipitation in January
Present Day Yucca Mountain

File: C: | CLIMAT02 | JANDAYCDF.PGW
Data: C: | CLIMAT02 | YUCSIMC.STA, YUCSIMD.STA & Y181PSTA.OUT
daw 7-16-03

The differences between the CDFs' for the perturbed and unperturbed Jan. wet-day precipitation were smaller than expected. A review of the control file for simulation file C:\SIMULATIONS_02\YM181PER.PTR reveals that the null boundaries for SOI perturbation were incorrect so the SOI perturbation was not effective.

Continued in Scientific Notebook # 597