US Army Corps
of Engineers
Hydrologic Engineering Center

Stochastic Modeling of Extreme Floods on the American River at Folsom Dam

Appendix F - Analysis of Air Temperature Profiles and Air Temperature Lapse Rates During Storms for the American River Watershed

September 2005

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14. ABSTRACT

This report presents the results of the application of a stochastic flood model to develop flood-frequency relationships for the American River at Folsom Dam. Flood-frequency relationships are presented for flood characteristics of peak discharge, maximum 24-hour discharge, maximum 72-hour discharge, maximum reservoir release, runoff volume, and maximum reservoir level.

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ANALYSIS OF AIR TEMPERATURE PROFILES AND AIR TEMPERATURE LAPSE RATES DURING STORMS FOR THE AMERICAN RIVER WATERSHED

October 1, 2002

BACKGROUND

Information on air temperature profiles to be expected during extreme storms is needed for computation of snowmelt runoff for the stochastic modeling of extreme floods for the American River watershed. An initial analysis of air temperature lapse rates was conducted for the American River watershed and published in March 2000[6]. That study found temperature lapse rates during storms to range from a minimum of –4.3°F/1000 feet to a maximum of –2.0°F/1000 feet. A probability-plot of the historical data showed the lapse rates to be well described by a Normal distribution with a mean value of –3.3°F/1000 feet and a standard deviation of 0.55°F/1000 feet. Correlation analyses of temperature lapse rate with 72-hour basin-average precipitation indicated a very low-level of correlation with 72-hour storm magnitude.

Subsequent to the original study, questions have been raised whether lapse rates might be more highly correlated with precipitation at shorter durations, such as maximum 12-hour or 24-hour precipitation. At the time of the original study, GIS-based storm analyses had not yet been completed and estimates of maximum 12-hour and 24-hour precipitation for storms were not available. Those storm analyses[7,8] have since been completed and results are available for maximum 12-hour and 24-hour basin-average precipitation.

This follow-up study was conducted to further examine air temperature profiles during storms to determine if profile characteristics are correlated with 12-hour or 24-hour precipitation, or correlated with some other hydrometeorological parameter. Profile characteristics of interest include sea-level temperature, freezing level, and air temperature lapse rate. It is important to understand the behavior of air temperature profiles during extreme storms because air temperature characteristics directly affect the volume of snowmelt runoff. Snowmelt runoff can be a significant contributor to flooding during rain-on-snow events on the American River.

AIR TEMPERATURE LAPSE RATES

The air temperature lapse rate data utilized here were computed on a daily basis using the maximum daily temperature observed along a network of stations within and adjacent to the watershed. These stations (Table 1) spanned the range in elevation from near sea-level at Sacramento to 8,000-feet at the Twin Lakes station. As part of this analysis, it was necessary to identify the 24-hour period during which the maximum 24-hour basin-average precipitation occurred. This was accomplished using the results of GIS-based storm analyses[7,8]. Figures 1a,b,c depict representative air temperature profile characteristics and lapse rate computations using maximum daily temperature. This type of analysis was conducted for a set of 28 storms (Appendix A), representing storm events with the largest 72-hour basin-average precipitation.

Investigation of the relationship between temperature lapse rate and storm magnitude was accomplished by regression analysis using the maximum 24-hour precipitation during the storm as the explanatory variable. The scatterplot of temperature lapse rates with maximum 24-hour precipitation is depicted in Figure 2a. It is seen that that temperature lapse rates are correlated with maximum 24-hour precipitation, with the trend line indicating reduced lapse rates with increasing storm magnitude. Similar results were obtained for the relationship between temperature lapse rate and maximum 12-hour basin-average precipitation (Figure 2b).

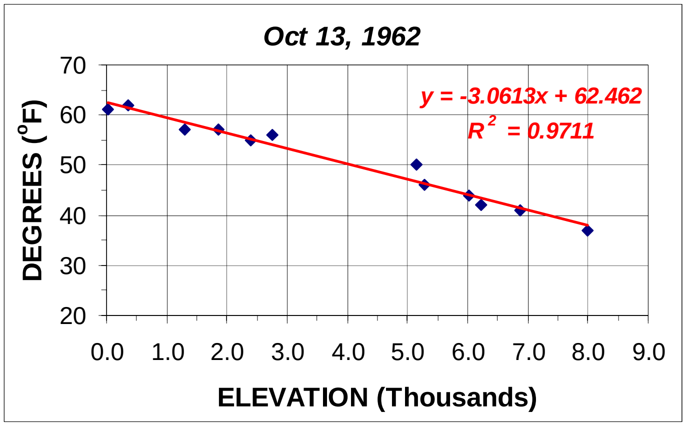


Figure 1a – Air Temperature Profile for October 13, 1962
with Estimated Sea-Level Temperature of 62.5°F,
Freezing Level of 9,940 feet, and Temperature Lapse Rate of –3.06°F /1000 feet

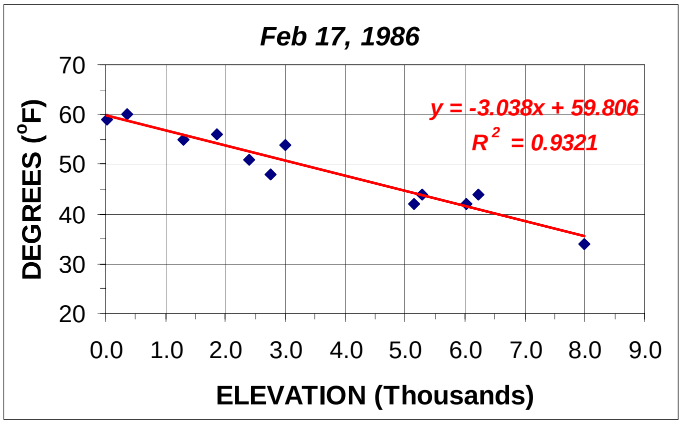


Figure 1b – Air Temperature Profile for February 17, 1986
with Estimated Sea-Level Temperature of 59.8°F
Freezing Level of 10,100 feet, and Temperature Lapse Rate of –3.04°F /1000 feet

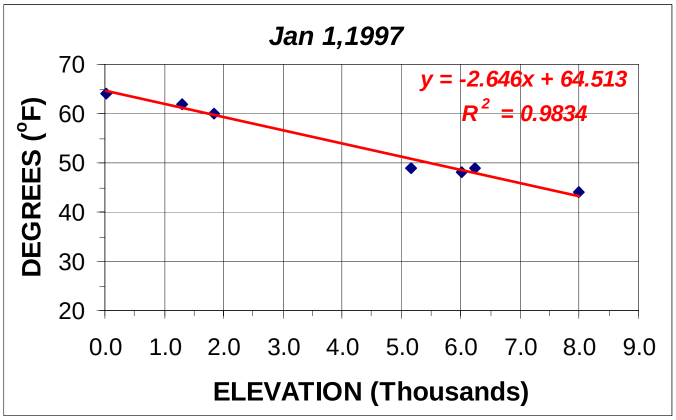


Figure 1c – Air Temperature Profile for January 1, 1997
with Estimated Sea-Level Temperature of 64.5°F
Freezing Level of 11,600 feet, and Temperature Lapse Rate of –2.65°F /1000 feet

Table 1 – Air Temperature Recording Stations Used in Analyses - Ordered by Elevation

STATION NAME	LATITUDE	LONGITUDE	ELEVATION (Feet)	PERIOD OF RECORD
SACRAMENTO DOWNTOWN	38.7000° N	121.1667° W	25	1877-2002
FOLSOM DAM	38.5667° N	121.4833° W	350	1955-2002
AUBURN	38.9000° N	121.0833° W	1290	1948-2002
PLACERVILLE	38.6333° N	120.8167° W	1850	1948-2002
COLFAX	39.1167° N	120.9500° W	2400	1948-2002
PLACERVILLE IFG	38.7333° N	120.7333° W	2755	1955-1991
GEORGETOWN RANGER STATION	38.9167° N	120.8000° W	3000	1948-2002
FORESTHILL RANGER STATION	39.0000° N	120.8333° W	3015	1948-2002
IOWA HILL	39.1167° N	120.8333° W	3100	1948-2002
GOLD RUN 2 SW	39.1500° N	120.8500° W	3320	1949-2002
MOUNT DANAHER	38.7500° N	120.6667° W	3410	1948-1973
PACIFIC HOUSE	38.7500° N	120.5000° W	3440	1948-2002
LAKE SPAULDING	39.3167° N	120.6333° W	5155	1948-2002
BLUE CANYON	39.2833° N	120.7000° W	5280	1945-2002
TRUCKEE RANGER STATION	39.3333° N	120.1833° W	6020	1948-2002
TAHOE CITY	39.1667° N	120.1333° W	6230	1931-2002
SODA SPRINGS 1 E	39.3167° N	120.3667° W	6885	1941-2002
TWIN LAKES	38.7000° N	120.0333° W	8000	1920-2002

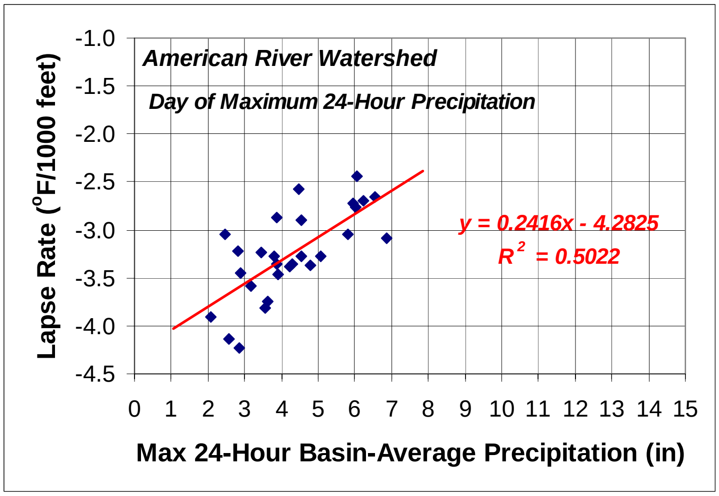


Figure 2a – Relationship Between Air Temperature Lapse Rate
and Maximum 24-Hour Precipitation on Day of Maximum 24-Hour Precipitation

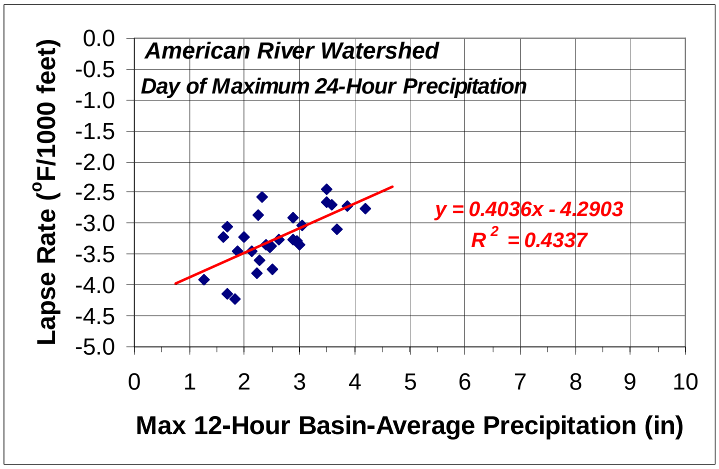


Figure 2b – Relationship Between Air Temperature Lapse Rate
and Maximum 12-Hour Precipitation on Day of Maximum 24-Hour Precipitation

In the stochastic modeling of extreme storms, maximum 24-hour precipitation for simulated storms will be in the range from 3-inches to about 12-inches. For comparison, basin-average Probable Maximum Precipitation (PMP)[4] for the 24-hour duration is about 14.5-inches. Extrapolation of the trend line in Figure 2a to a 24-hour precipitation magnitude of 12-inches or greater results in a lapse rate approaching –1.0°F /1000 feet. In contrast, lapse rates near the wet pseudo-adiabatic rate of about –2.70°F/1000 feet are considered consistent with the atmospheric conditions expected during a very extreme storm[5,11,12]. Thus, a temperature lapse rate approaching –1.0°F/1000 feet is not considered plausible.

It is not clear from the lapse rate data and the discussion above what lapse rate values are appropriate for use during very extreme storms. After further examination of air temperature profiles, it was decided to utilize data on freezing levels to provide an alterative perspective of air temperature profiles to be expected during extreme storms.

EXAMINATION OF FREEZING LEVELS DURING STORMS

Analysis of freezing level data from storms allows another approach to determining the character of air temperature profiles to be expected during very extreme storms. Computation of freezing level has the further advantage of allowing a more direct interpretation of the hydrologic implications with regard to the location of the snow line during the storm and relative magnitude of the air temperatures in the watershed.

For each of the 28 storms in the sample set, the freezing level for the day of maximum 24-hour precipitation was estimated utilizing the lapse rates computed previously (Figures 1a,b,c) and solving for the elevation corresponding to 32°F. A regression analysis was then conducted for freezing level using maximum 24-hour basin-average precipitation as the explanatory variable (Figure 3). A review of Figure 3 shows six storm events where freezing levels exceeded 10,000-feet, and it is clear that freezing levels vary with the magnitude of 24-hour basin-average precipitation. The physical interpretation is that air temperature profiles comprised of deep layers of warm, moisture-laden air are conducive to large precipitation events. Therefore, very high freezing levels would be expected during very extreme storms.

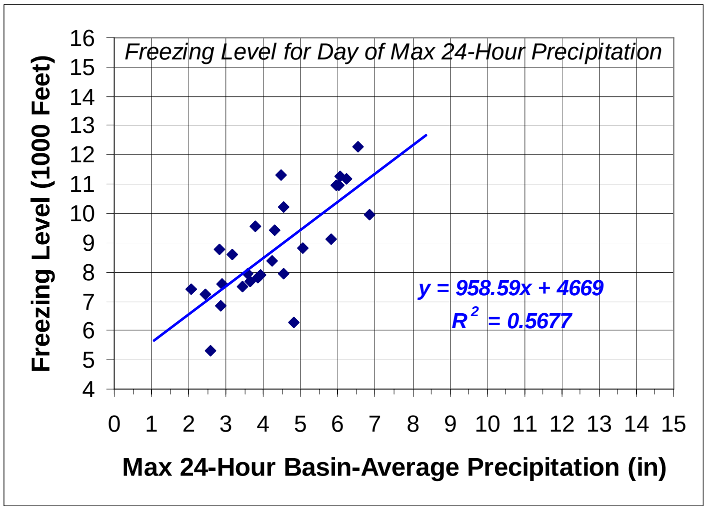


Figure 3 – Relationship Between Freezing Level and Maximum 24-Hour Precipitation for Day of Maximum 24-Hour Basin-Average Precipitation

However, there are questions about the behavior of the freezing level as 24-hour precipitation approaches extraordinary magnitudes. Extrapolation of the regression relationship shown in Figure 3 to 24-hour precipitation magnitudes of 12-inches or greater indicates freezing levels of 16,000-feet and higher, which seems to stretch the bounds of plausibility. This raises questions whether there is a practical limit to the freezing level? It was concluded that a more physically-based approach would be needed to provide guidance in the defining the shape of the upper portion of the trend seen in Figure 3. The remaining sections of this report describe the procedures used for defining the upper portion of the freezing level relationship with maximum 24-hour basin-average precipitation.

Radiosonde Data and Air Temperature Profiles

Computation of freezing levels from land-based air temperature measurements often involved extrapolation. In order to corroborate the computed land-based freezing levels, radiosonde data from the Oakland CA airport were examined. Figures 4a,b,c depict representative air temperature profiles and freezing levels obtained from the radiosonde measurements taken on the day of the maximum 24-hour precipitation. Figures 4a,b,c are for the same storm dates as the land-based results shown in Figure 1a,b,c.

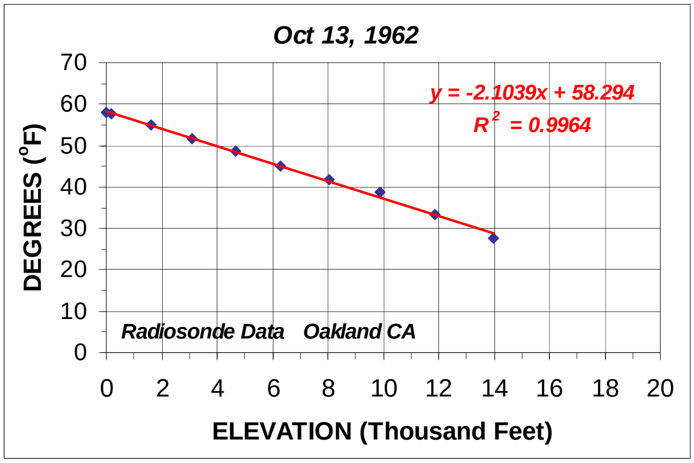
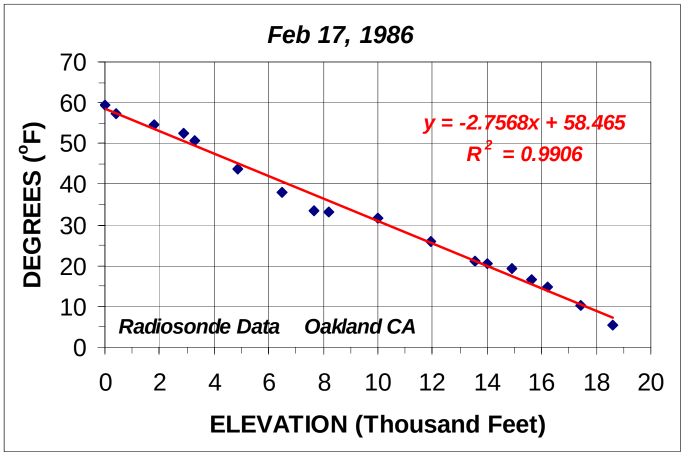


Figure 4a – Radiosonde Air Temperature Profile at Oakland CA for October 13, 1962 with Estimated Sea-Level Temperature of 58.3°F, Freezing Level of 12,500 feet, and Temperature Lapse Rate of –2.10°F /1000 feet



F igure 4b – Radiosonde Air Temperature Profile at Oakland CA for February 17, 1986 with Estimated Sea-Level Temperature of 58.5°F Freezing Level of 9,600 feet, and Temperature Lapse Rate of –2.76°F /1000 feet

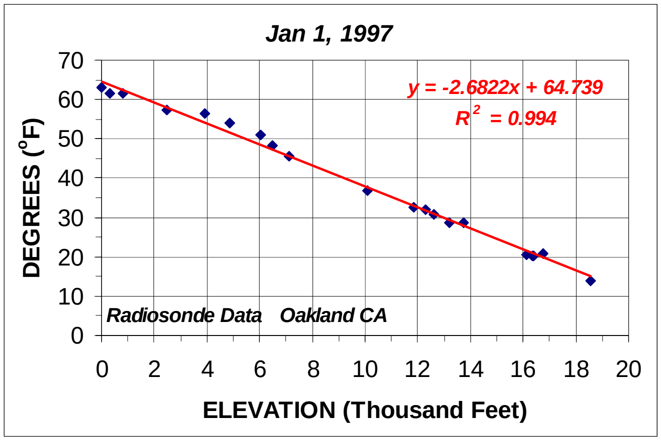


Figure 4c – Radiosonde Air Temperature Profile at Oakland CA for January 1, 1997
with Estimated Sea-Level Temperature of 64.7°F
Freezing Level of 12,200 feet, and Temperature Lapse Rate of –2.68°F /1000 feet

Freezing levels determined from the Oakland CA radiosonde data were compared with freezing levels computed using the land-based network of stations (Figure 5). These freezing level data are representative of days of heavy precipitation within the multi-day storm period for the 28 storms in the sample set. The solid blue line in Figure 5 represents equivalent measurements. Computation of sample statistics for the freezing level data showed the radiosonde findings to be on-average 750-feet above (dashed red line) those of the land-based freezing level measurements. This generally represents less than a 10% difference.

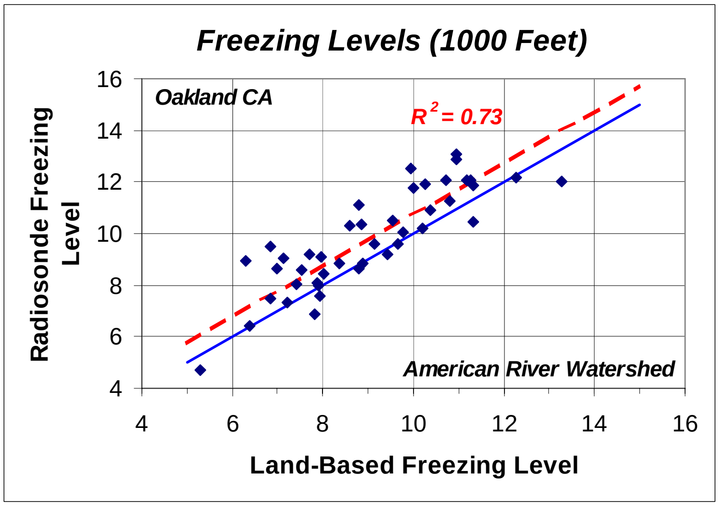


Figure 5 – Comparison of Freezing Levels Determined from Radiosonde Data at Oakland CA
and Land-Based Network of Air Temperature Measurement Stations

There are numerous reasons why the freezing levels from radiosonde data might differ from the land-based measurements. In particular, the radiosonde data are from a source some 90-miles upwind of the watershed and represent a single temperature profile both in time and space. The land-based measurements are computed from temperature maxima with unknown synchronicity of actual time of maxima. And, the uppermost stations may be influenced by the presence of snow-on-the-ground. Nonetheless, there is good agreement between the freezing levels computed from the land-based measurements and radiosonde data. It is reasonable to conclude that the land-based temperature measurements provide a practical estimation of the freezing level over the watershed.

Sea-Level Temperatures

Sea-level temperatures were obtained as regression intercept values from the land-based air temperature profiles (Figures 1a,b,c). Further regression analyses of freezing levels with sea-level air temperatures showed freezing levels to be correlated with sea-level temperatures (Figure 6). Therefore, freezing levels are correlated with both the maximum 24-hour basin-average precipitation during the storm (Figure 3) and the initial sea-level temperature of the moist air mass supporting precipitation (Figure 6).

The relative nearness of observed sea-level temperatures to maximum expected sea-level temperatures provides a method for estimation of the behavior of freezing levels for extreme storm events. Specifically, persisting 12-hour dewpoints used in PMP analyses (Table 2) can provide a measure of the upper limit of dewpoint temperature to be expected for a given month. The PMP 12-hour persisting dewpoints[4] can then be compared with estimated 12-hour persisting dewpoints for the observed dataset of maximum air temperatures.

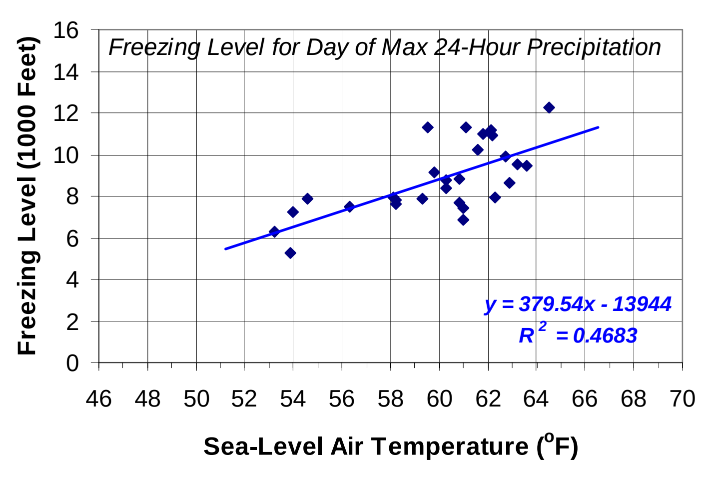


Figure 6 – Relationship Between Freezing Level and Sea-Level Air Temperature for Day of Maximum 24-Hour Basin-Average Precipitation for the American River Watershed

<u>Estimation of Freezing Level for Near-PMP Conditions</u> – Analysis of temporal air temperature patterns for the sample set of 28 storms revealed that 12-hour persisting air temperatures on the day of the maximum 24-hour precipitation are on-average about 4°F below that of the maximum air temperature. Relative humidity on the day of maximum 24-hour precipitation is typically near saturation. Using a value of 95% relative humidity equates to a difference of about 2°F between air temperature and dewpoint temperature for a total of 6°F difference between maximum daily air temperature and 12-hour persisting dewpoints. Accordingly, 12-hour persisting dewpoints at sea-level for the sample set of 28 storms were obtained by subtraction of 6°F from the maximum daily sea-level temperatures. These values were then compared to the 12-hour persisting dewpoints for PMP for the month of storm occurrence. The resultant differences between observed and maximum 12-hour persisting dewpoints are shown in Figure 7. The average difference in dewpoints is 7.5°F. An increase of 7.5°F in dewpoint temperature would equate to an increase of about 2,800-feet in the freezing level for PMP conditions based on a wet pseudo-adiabatic lapse rate of –2.7°F /1000 feet.

Table 2 – Mid-Month 12-Hour Persisting PMP Dewpoints for American River Watershed

OCT	NOV	DEC	JAN	FEB	MAR	APR
65.0°F	63.2°F	62.3°F	60.9°F	60.2°F	60.7°F	61.5°F

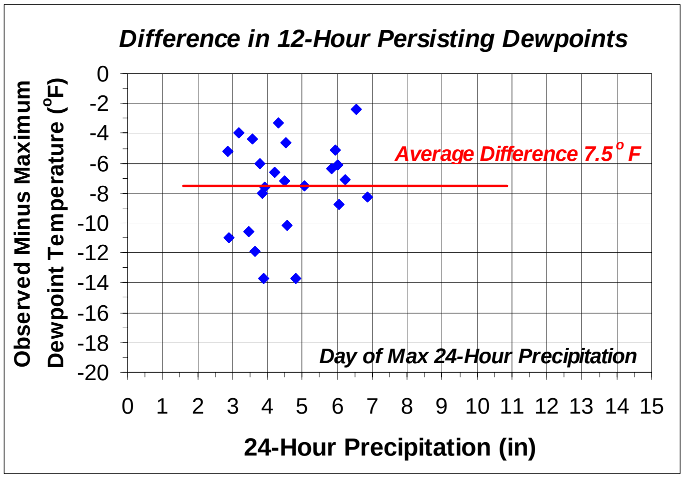


Figure 7 – Difference Between 12-Hour PMP Persisting Dewpoint and
Estimated 12-Hour Persisting Dewpoint in Observed Storms
at Sea-Level on Day of Maximum 24-Hour Precipitation

Inspection of Figure 3 for the set of storms with the largest 24-hour precipitation indicates that a 2,800-foot increase in the freezing level over that for the largest observed storms would yield a nominal freezing level of about 14,000-feet for near-PMP conditions.

Stochastic Simulation of Freezing Levels

A methodology was needed for simulation of freezing levels that incorporated the findings of the prior analyses. A piecewise multiple regression was conducted for estimation of freezing level that included sea-level air temperature and maximum 24-hour precipitation as explanatory variables. The regression was conducted in a manner to incorporate the 14,000-foot asymptote for freezing level for near-PMP conditions (Figure 8). The resultant equation for simulation of freezing level on the day of maximum 24-hour precipitation is:

$$FL = -10000 + 256T_a + 968P_{24} - 34.5(P_{24})^2 + Z_n(\sigma_r) \qquad (1)$$

where: FL is the freezing level in feet; T_a is the maximum sea-level air temperature in degrees Fahrenheit on the day of maximum 24-hour basin-average precipitation; P_{24} is the maximum 24-hour precipitation during the multi-day storm in inches; Z_n is a variate drawn from the standardized normal distribution N[0,1]; and σ_r is the standard deviation for the unexplained variance in the regression relationship, which equals 870 feet, (R^2 =0.744).

Figure 9 depicts an example of the variability to be expected in simulation of freezing levels as a function of maximum 24-hour basin-average precipitation. Inspection of Figure 9 shows the adopted relationship to be consistent with that depicted in Figure 3 for the range of observed data.

Simulated data for sea-level air temperature and freezing levels from the example in Figure 9 were used to compute temperature lapse rates. Figure 10 contains the results of those computations and depicts the relative variability in temperature lapse rates to be expected in the simulations for the American River watershed. Comparison of Figure 10 with Figure 2 shows the generated data to be consistent with measured lapse rates for the range of observed data. Review of Figure 10 also shows the temperature lapse rates plateau in the range of –2.2°F /1000 feet to –2.8°F /1000 feet for 24-hour basin-average precipitation that approaches the magnitude of PMP. These values are near the wet pseudo-adiabatic lapse rate.

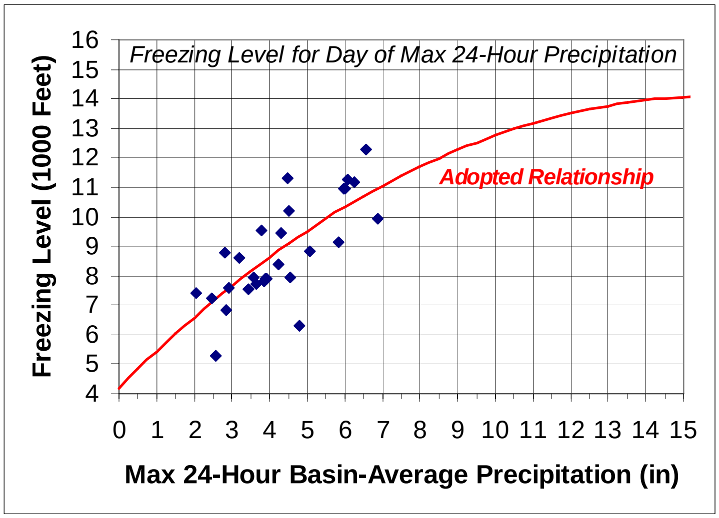


Figure 8 – Adopted Relationship of Freezing Level with Maximum 24-Hour Precipitation Using Expected Values of the Sea-Level Air Temperature

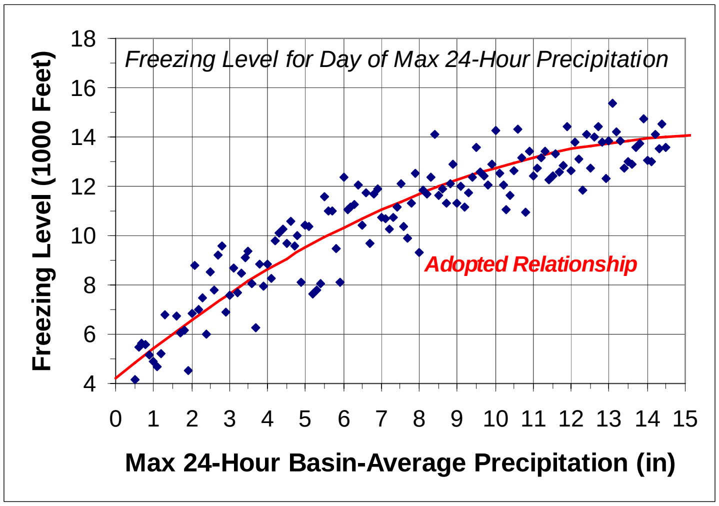


Figure 9 – Example of Variability in Simulation of Freezing Levels for American River Watershed Including Variability Due to Sea-Level Air Temperature

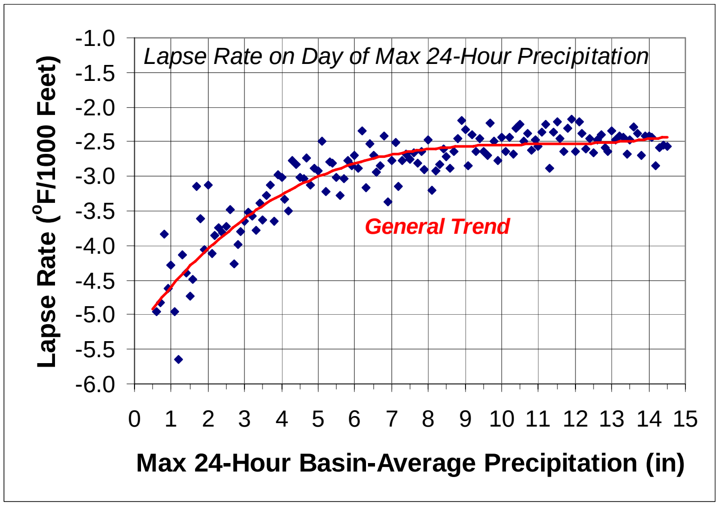


Figure 10 – Example of Variability in Simulation of Air Temperature Lapse Rates for American River Watershed

PROPOSED PROCEDURES FOR SIMULATION OF AIR TEMPERATURE PROFILES

The analyses described above provide a methodology for simulation of the air temperature profile for the period of time immediately surrounding the occurrence of the maximum sea-level and freezing level temperature on the day of maximum 24-hour basin-average precipitation. Air temperature profiles are also needed throughout the period of storm activity for each of the prototype storms. Air temperatures obtained from these profiles will be used for computation of snowmelt runoff.

Air Temperature Temporal Patterns for Describing Sea-Level Temperatures

The simulation of air temperature profiles for each simulated storm will be accomplished using air temperature temporal patterns for sea-level and freezing level conditions. An example of a sea-level air temperature temporal pattern is depicted in Figure 11a for the storm of Dec 28 - Jan 2, 1997. Daily maximum and minimum temperatures have been assigned to 2:00 PM and 6:00 AM, respectively, to coincide with the typical diurnal temperature variations in the winter season. In order for a given sea-level and freezing level temporal pattern to be used with other storm magnitudes, sea-level temperatures and freezing level temperatures, the pattern must be indexed so all temperatures are relative to the maximum temperature on the day of the maximum 24-hour precipitation. Figure 11b depicts the air temperature temporal pattern observed at Auburn CA indexed to the maximum air temperature observed on the day of maximum 24-hour basin-average precipitation.

During the simulation process, the chosen sea-level temperature for the day of maximum 24-hour precipitation will be used to adjust the temperature values (i.e. Figure 11b) to yield the air temperature temporal pattern at sea-level. This procedure will be discussed further in a later section. Figure 11c shows the temporal pattern of basin-average precipitation for comparison with the air temperature temporal patterns.

Temporal Patterns for Describing Freezing Levels

Temporal patterns for freezing level will be simulated in a manner similar to that for sea-level air temperature profiles. Freezing level temporal patterns were computed based on freezing levels computed using the air temperature temporal profiles observed at Auburn CA (1,290-feet) and Twin Lakes CA (8,000-feet). An example of an air temperature temporal freezing level temporal pattern is depicted in Figure 12a for the storm of Dec 28-Jan 2, 1997. Figure 12b depicts the freezing level temporal pattern indexed to the freezing level for the day of maximum 24-hour precipitation.

Components of Stochastic Storm Resampling Procedure

Twenty-four prototype storms have previously been selected for use with the stochastic storm resampling approach. Each of the prototype storms includes:

- Storm spatial template, comprised of the 72-hour precipitation for each of 33 sub-basins that aggregates to the 72-hour basin-average precipitation for the prototype storm
- Storm temporal template, comprised of a collection of dimensionless precipitation mass curves, one each for the 33 sub-basins, where each mass curve has been made dimensionless by division by the sub-basin 72-hour precipitation contained in the spatial template.
- Indexed temporal pattern for sea-level air temperature for the period of storm activity
- Indexed temporal pattern for freezing level for the period of storm activity

Simulation Procedure
The procedure for stochastic simulation of air temperature profiles can be described as follows:

1. At a prior point in the stochastic modeling of extreme storms, the 72-hour basin-average precipitation will have been selected. One storm temporal and spatial template will also have been selected from a sample set of 24 prototype storm templates. The storm temporal and spatial patterns will then be scaled by the 72-hour basin-average precipitation. This allows determination of the maximum 24-hour basin-average precipitation (P_{24}) for the simulation being conducted.
2. The 24-hour persisting sea-level dewpoint (T_d) will be stochastically generated based on the magnitude of the 24-hour basin-average precipitation. This will be accomplished based on a physically-based dewpoint temperature model described in SEFM[9]. A graphical depiction of the dewpoint temperature model is shown in Figure 13, where dewpoint temperatures are approximately log-normally distributed about the mean value between the minimum and maximum 24-hour persisting dewpoints.
3. The maximum sea-level air temperature (T_a) for the day of maximum 24-hour precipitation will be computed from the 24-hour persisting sea-level dewpoint temperature (T_d) by the addition of 7°F. This adjustment was determined from an analysis of the sample set of 28 storms. Numerically:

   $$T_a = T_d + 7°F \qquad (2)$$

4. The sea-level air-temperature temporal pattern will be determined by addition of the maximum air temperature (T_a) for the day of maximum 24-hour precipitation to the indexed temporal pattern to yield a scaled air temperature temporal pattern similar to that seen in Figure 11a.
5. The freezing level (FL) for the day of maximum 24-hour precipitation will be generated via Equation 1 using values of 24-hour basin-average precipitation (P_{24}) selected in Step 1 and maximum sea-level air temperature (T_a) generated in Step 3.
6. The freezing level temporal pattern will be determined by addition of the freezing level (FL) for the day of maximum 24-hour precipitation to the indexed freezing level temporal pattern to yield a scaled freezing level temporal pattern similar to that seen in Figure 12a.
7. Air temperatures applicable to each elevation zone in the watershed model will be computed based on the sea-level and freezing level temporal patterns developed in Steps 4 and 6.

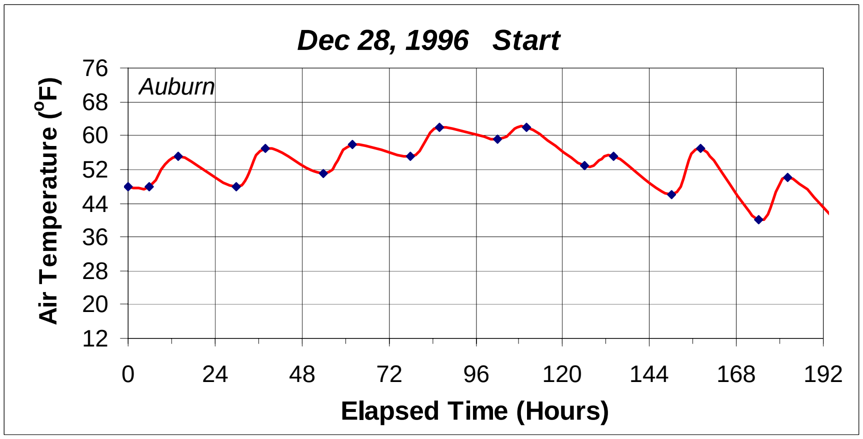


Figure 11a – Air Temperature Temporal Pattern for Storm of Dec 28, 1996-Jan 2, 1997
Observed at Auburn, CA (1,290-feet)

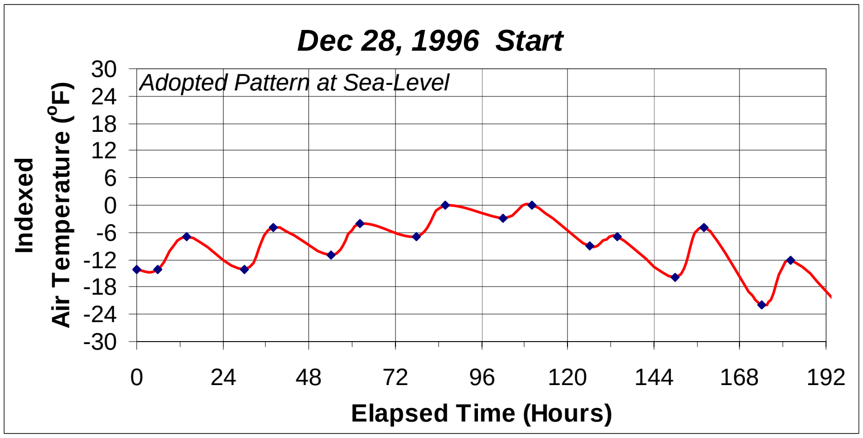


Figure 11b – Air Temperature Temporal Pattern for Storm of Dec 28, 1996-Jan 2, 1997
Indexed for Simulation of Sea-Level Temperatures

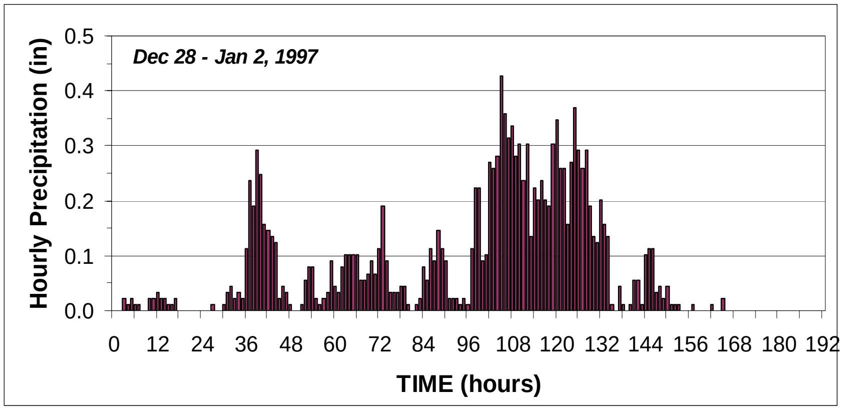


Figure 11c – Basin-Average Precipitation Temporal Pattern
for Storm of Dec 28, 1996-Jan 2, 1997 on the American River Watershed

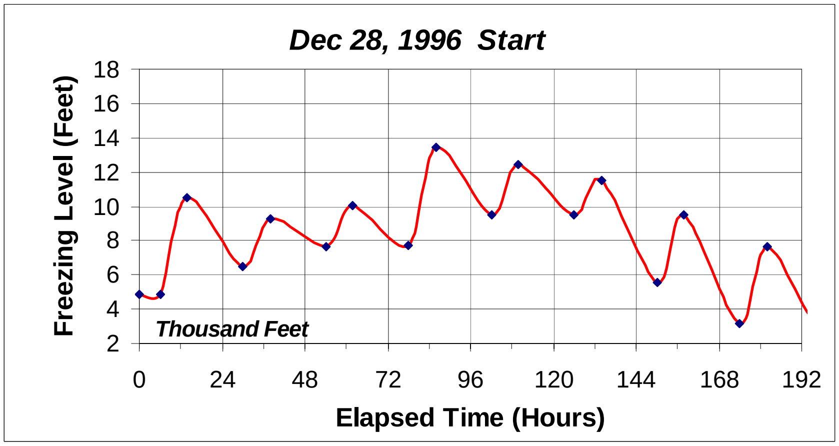


Figure 12a – Freezing Level Temporal Pattern for Storm of Dec 28, 1996-Jan 2, 1997

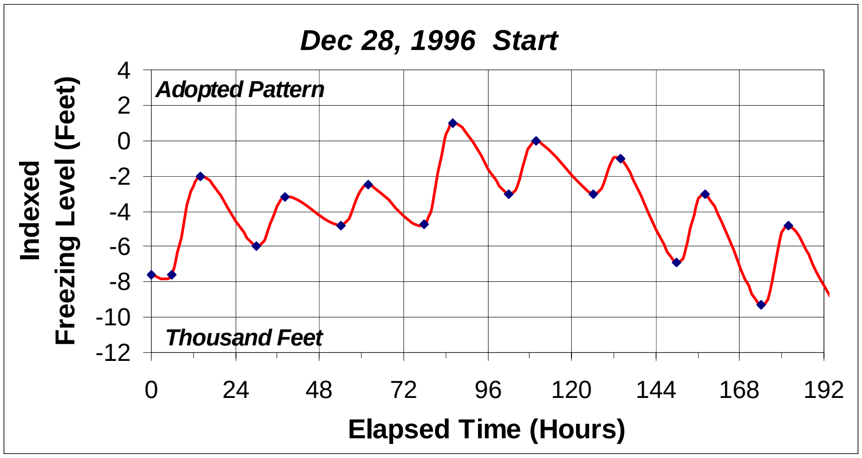


Figure 12b – Freezing Level Temporal Pattern for Storm of Dec 28, 1996-Jan 2, 1997
Indexed for Simulation of Freezing Levels

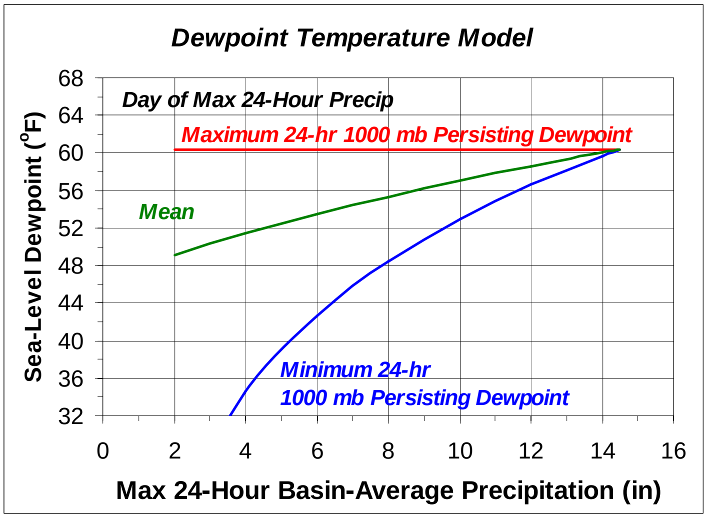


Figure 13 – Example Range of 24-Hour Persisting Dewpoint Temperatures
Utilized by Dewpoint Temperature Probability Model, Example for End-of-January

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APPENDIX A

STORM DATES AND LAND-BASED AIR TEMPERATURE PROFILE DATA

Table A1 – Storm Dates and Land-Based Air Temperature Profile Data

STORM DATES		BASIN-AVERAGE PRECIPITATION DATA			AIR TEMPERATURE PROFILE DATA		
STORM PERIOD	**DATE**	**MAX 72-HOUR PRECIP (in)**	**MAX 24-HOUR PRECIP (in)**	**MAX 12-HOUR PRECIP (in)**	**SEA-LEVEL TEMP (°F)**	**FREEZING LEVEL (Feet)**	**LAPSE RATE (°F/1000 Feet)**
Nov 16-22, 1950	Nov 18, 1950	12.47	6.24	3.58	62.1	11190	-2.69
	Nov 20, 1950	12.47			65.6	13281	-2.53
Dec 17-24, 1955	Dec 22, 1955	13.80	6.02	4.18	62.2	10942	-2.76
	Dec 23, 1955	13.80			63.4	8198	-3.83
Feb 7-13, 1962	Feb 09, 1962	7.36			60.8	7701	-3.74
	Feb 10, 1962	7.36	3.64	2.51	54.3	7125	-3.13
Oct 9-14, 1962	Oct 12, 1962	14.05			68.5	10253	-3.56
	Oct 13, 1962	14.05	6.86	3.68	62.7	9935	-3.09
Jan 29 - Feb 1, 1963	Jan 30, 1963	11.38			59.0	9643	-2.80
	Jan 31, 1963	11.38	5.96	3.86	61.8	10956	-2.72
Dec 19-24, 1964	Dec 21, 1964	12.46			57.2	9333	-2.70
	Dec 22, 1964	12.46	6.06	3.49	59.5	11270	-2.44
	Dec 23, 1964	12.46			64.2	10431	-3.09
Dec 3-8, 1966	Dec 05, 1966	4.99	2.45	1.68	54.0	7220	-3.05
	Dec 06, 1966	4.99			53.9	6833	-3.21
Jan 18-24, 1967	Jan 20, 1967	7.04			52.3	7329	-2.77
	Jan 21, 1967	7.04	4.80	2.49	53.2	6291	-3.37
Mar 10-17, 1967	Mar 12, 1967	5.03	2.58	1.69	53.9	5299	-4.13
Jan 17-22, 1969	Jan 19, 1969	10.34			59.2	8024	-3.39
	Jan 20, 1969	10.34	3.92	2.13	59.3	7890	-3.46
	Jan 21, 1969	10.34			59.5	6910	-3.98
Jan 23-30, 1969	Jan 24, 1969	5.08			54.9	7859	-2.91
	Jan 25, 1969	5.08	2.06	1.26	61.0	7419	-3.91
Jan 13-18, 1970	Jan 14, 1970	6.46			55.0	8984	-2.56
	Jan 16, 1970	6.46	3.18	2.26	62.9	8607	-3.59
Nov 9-16, 1973	Nov 11, 1973	6.20	2.90	1.87	63.1	11309	-2.75
	Nov 12, 1973	6.20			58.2	7594	-3.45
Jan 9-16, 1980	Jan 11, 1980	9.94			60.6	13364	-2.14
	Jan 12, 1980	9.94			65.4	10000	-3.34
	Jan 13, 1980	9.94	4.30	2.99	63.6	9433	-3.35
Feb 16-21, 1980	Feb 18, 1980	6.38			65.3	7929	-4.20
	Feb 19, 1980	6.38	2.85	1.84	61.0	6856	-4.23
Jan 26-30, 1981	Jan 27, 1981	6.37	3.45	1.99	56.3	7523	-3.23
	Jan 28, 1981	6.37			58.0	6388	-4.07
Nov 11-16, 1981	Nov 12, 1981	6.77			65.4	9766	-3.42
	Nov 13, 1981	6.77	3.80	2.62	63.2	9541	-3.27
Dec 17-21, 1981	Dec 18, 1981	8.17			61.7	10722	-2.77
	Dec 19, 1981	8.17	4.49	2.32	61.1	11323	-2.57
	Dec 20, 1981	8.17			62.3	8886	-3.41
Feb 13-16, 1982	Feb 14, 1982	8.13			61.6	9285	-3.19
	Feb 15, 1982	8.13	4.53	2.87	61.6	10207	-2.90
Dec 19-23, 1982	Dec 21, 1982	8.24	3.88	2.24	54.6	7875	-2.87
	Dec 22, 1982	8.24			59.3	6724	-4.06
Dec 21-29, 1983	Dec 25, 1983	6.04	2.82	1.62	60.3	8789	-3.22
Feb 12-20, 1986	Feb 16, 1986	13.98			56.3	9060	-2.68
	Feb 17, 1986	13.98	5.82	3.03	59.8	9145	-3.04
	Feb 18, 1986	13.98			67.1	7833	-4.48
	Feb 19, 1986	13.98			59.6	8263	-3.34
Dec 6-12, 1992	Dec 08, 1992	7.19			52.3	7178	-2.83
	Dec 09, 1992	7.19	4.55	2.94	58.1	7957	-3.28
Jan 6-12, 1995	Jan 09, 1995	7.35			63.3	8867	-3.53
	Jan 10, 1995	7.35	4.22	2.45	60.3	8373	-3.38
Mar 8-15, 1995	Mar 09, 1995	7.93			63.2	8715	-3.58
	Mar 10, 1995	7.93	3.57	2.24	62.3	7953	-3.81
Dec 10-13, 1995	Dec 11, 1995	7.88			64.5	10797	-3.01
	Dec 12, 1995	7.88	5.07	2.89	60.8	8807	-3.27
Dec 28 - Jan 3, 1997	Jan 01, 1997	11.22	6.55	3.50	64.5	12264	-2.65
	Jan 02, 1997	11.22			61.8	10383	-2.87
Feb 7-10, 1999	Feb 07, 1999	8.41	3.87	2.39	58.2	7821	-3.35
	Feb 08, 1999	8.41			56.7	7471	-3.31