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Model Documentation Report

Short-Term Hydroelectric Generation Model

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Model Documentation Report: Short-Term Hydroelectric Generation Model

Introduction

Purpose of the Report

The purpose of this report is to define the objectives of the Energy Information Administration's (EIA) Short-Term Hydroelectric Generation Model (STHGM), describe its basic approach, and to provide details on the model structure. This report is intended as a reference document for model analysts, users, and the general public. Documentation of the model is in accordance with the EIA's legal obligation to provide adequate documentation in support of its models (Public Law 94-385, Section 57.b.2).

Model Summary

The STHGM performs a short-term (18 to 27-month) forecast of regional (Census Division) hydroelectric generation in the United States using an autoregressive integrated moving average (ARIMA) time series model with precipitation as an explanatory variable. The model results are used as input for the *Short-Term Energy Outlook*.

Model Archival Citation

The STHGM is archived on the Energy Information Administration mainframe system and is available through the sponsoring office. The model contact is:

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Report Organization

The remainder of this report is organized in the following manner: (1) model purpose, (2) model rationale, (3) model structure, (4) properties of the mathematical solution, (5) calibration and sensitivity analysis, (6) documentation of technical detail on the model data and equations, and (7) appendices.

Model Purpose

Model Objectives

The STHGM is used to provide quarterly projections of national hydroelectric generation for the *Short-Term Energy Outlook*. The model uses an ARIMA time series model with explanatory variables, otherwise known as a transfer function model,[1] as the basis for its forecasting. The model is based on monthly historic data from 1970 to the present. The model also incorporates variations in precipitation as an explanatory variable.

Model Input\Output

The STHGM uses both DOE and non-DOE data input sources. The DOE data are national totals of the plant-level net hydroelectric generation data reported monthly on the Form EIA-759, "Monthly Power Plant Report," and its predecessors. The historical dataset is updated prior the quarterly run of the model.

The non-DOE data are monthly precipitation data from the National Climatic Data Center.[2] These data generally are released 6 months later than the generation data for a particular month. Also, precipitation data are not collected for Alaska and Hawaii. The hydroelectric generation for these two States is incorporated into the Pacific Region with the States of California, Oregon, and Washington. Generation in Alaska and Hawaii was less than 1 percent of total U.S. generation in 1994.[3]

Forecasts of precipitation data are also required for the model. Monthly averages of data from 1970 to the present are used as "normal" precipitation. The monthly averages are calculated in a SAS program using data from the National Climatic Data Center.

The output data is an 18 to 27-month forecast of net hydroelectric generation.

Relationship to Other Models

The STHGM does not directly interface with other EIA models; however, its forecast is utilized as input in the Short-Term Integrated Forecasting System (STIFS). The hydroelectric forecast is independent of other renewable and nuclear generation forecasts, but it does have an impact as an input to STIFS fossil fuel generation forecasts.

Model Rationale

The Time Series Approach

Time series models, which are used here, predict future generation (by region) as a function of past generation and account for trends and seasonality. No use is made of engineering knowledge or economic concepts in these models. Since a seasonal pattern is observed in historical monthly net hydroelectric generation data and the level of generation is affected by the availability of water, the STHGM is designed as an ARIMA time series model with the addition of two explanatory variables, precipitation and deterministic monthly seasonal dummies.

Assumptions

The STHGM uses an ARIMA time series model with precipitation as an explanatory variable. The model is based on normal ARIMA modelling assumptions. That is, the data are assumed to follow a model which is linear and time invariant with constant coefficients. Fixed monthly values are used to describe seasonality. Precipitation is assumed to be "normal" from the last month of available data forward. A monthly average for precipitation is calculated using data from 1970 to the latest available data, and this average is the assumed "normal" precipitation for that month.

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[1]George E. Box and Gwilym Jenkins, *Time Series Analysis, Forecasting and Control* (1976).

[2]**1970-1992:** National Climatic Data Center (NCDC), Disc. Resident Historical Divisional DataBase (DRD964X). These data are weighted by population using State and regional weights from the NCDC's *State, Regional, and National Monthly and Annual Precipitation Weighted by Area for the Contiguous United States January 1931 - December 1987* (Asheville, NC, August 1988). The calculated data differ slightly from the published data due to updates of the State and regional weights. **1993-present:** National Climatic Data Center, *Monthly State, Regional and National Heating Degree Days Weighted by Population* (Asheville, NC, March, 1989 through present), Table 3.3, "Regional and National Average Precipitation." These data are updated each time the model is run. Data are published weighted by population.

[3]Energy Information Administration, *Electric Power Annual 1994 Volume I*, DOE/EIA-0348(94)/1 (Washington, DC, July 1995), p. 25.

Alternative Approaches

The previous approach for forecasting hydroelectric generation used by the Energy Information Administration was to use a purposive sample. For each month during the current water year, which ends September 30, or a nine-month period from presently available data if longer, hydroelectric generation projections were based upon information obtained by phone from 10 utilities/organizations representing eight U.S. geographic regions (Table 1). Generation in each region was projected to change by the same percentage as generation for the sample. That is, estimations for each of the forecast months was determined by calculating a monthly ratio of each utility's projected generation to its actual generation in the past year. This ratio was applied to the region's generation for the previous year to arrive at a projected value for the corresponding month of the current year. The regional projections were aggregated to obtain a national projection for generation.

Table 1. Hydroelectric Generating Regions

Region	State
1	Connecticut, Delaware, District of Columbia, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont.
2	Alabama, Florida, Georgia, Kentucky, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia, Alaska, Hawaii.
3	California.
4	Arizona, Colorado, Nevada, New Mexico, Utah.
5	Idaho, Oregon, Washington.
6	Arkansas, Illinois, Indiana, Iowa, Kansas, Louisiana, Michigan, Minnesota, Missouri, Ohio, Oklahoma, Texas, Wisconsin.
7	Montana, Wyoming.
8	Nebraska, North Dakota, South Dakota.

Hydroelectric generation in the succeeding years was assumed to be normal. Normal generation was calculated for conventional and pumped storage units by using capacity information from the Form EIA-860, "Annual Electric Generator Report," and historical monthly capacity factors averaged over 10 years.

This methodology included a considerable amount of analyst judgement: the assessment of patterns and other factors, such as precipitation, weather, demand, or market conditions. Another shortcoming of this method was that different methodologies were used by the different sampled organizations.

In the development of the STHGM, the specific form of the model used for forecasting was selected from among reasonable alternatives of the same form including the use of regular and seasonal differencing. Another alternative to the use of monthly dummies to explain seasonality was also considered. First the periodogram of the generation data was examined and the seasonal frequencies having the greatest impact were selected. The seasonal mean was defined to be the sum of estimated coefficients multiplying the sine and cosine functions having these selected periodicities. The monthly dummy variable approach was adopted because it gave smaller root mean square error forecasts in the out of sample forecast evaluations (described in Calibration and Sensitivity Analysis, p. 7). These tests were run using a national level model only. Regional models were developed after the general form of the model had been chosen.

Another approach that was examined included the effects of trading day variations. The historic hydroelectric generation data were tested for trading day variation using the procedure X11 in SAS. The purpose of this test was to determine if the data needed to be adjusted for trading days, i.e., do hydroelectric facilities generate more on a Monday than on a Sunday. Any month can be looked at as having 28 days plus 0 to 3 extra different days of the week. Depending upon which days are extra, i.e. Monday and Tuesday or Saturday and Sunday, the net hydroelectric generation in a month could be affected. Tests at the 5 percent level indicated some trading day effect with the lowest generation on Sundays and the largest on Mondays and Tuesdays (Table 2). Tests of regional trading day variation using hydroelectric generation data for the 10 Census Divisions (Appendix C) indicated that while some trading day effect was noticeable, it was negligible. Therefore, the national data were not adjusted for trading day variation.

Further consideration might examine knowledge of current precipitation conditions instead of assuming normal precipitation throughout the forecast period. That is, the model could be modified to use average precipitation for low years or high years for sensitivity analysis.

Table 2. National Trading Day Variation Output

Final Trading Day Regression

	Combined Weight	Prior Weight	Reg. Coeff.	St. Err. Comb. Wt.	T (1)	T Pr. Wt.
Monday	99.478	******	99.478	113.47	0.877	******
Tuesday	104.71	******	104.710	111.63	0.938	******
Wednesday	79.931	******	79.931	113.42	0.705	******
Thursday	-44.29	******	-44.290	115.28	-0.384	******
Friday	-38.61	******	-38.610	113.89	-0.339	******
Saturday	76.899	******	76.899	112.77	0.682	******
Sunday	-278.1	******	-278.100	113.94	-2.441	******

* Comb. wt. differs from 1 at 1 percent level
** Comb. wt. differs from prior weight at 1 percent level

Source of Variance	Sum of Squares	Dgrs. of Freedom	Mean Square	F
Regression	5792155	6	965359.145	2.146
Error	116067925	258	449875.677	
Total	121860080	264		

Probability of a larger F is .0487498

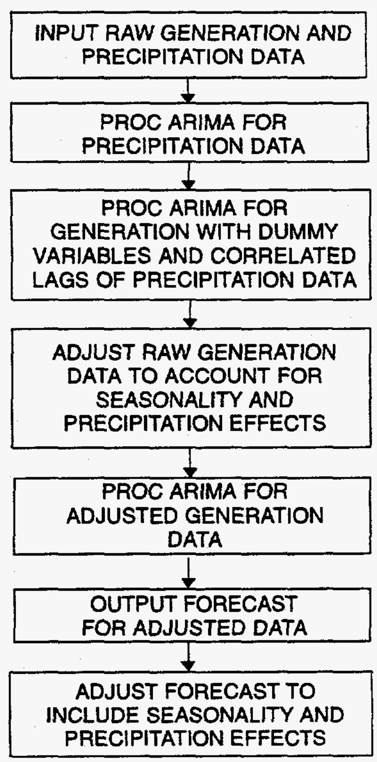
Std. Errors of Trading Day Adjustment Factors	
31-day-month	337.877
30-day-month	357.280
29-day-month	391.275
28-day-month	0.000

Model Structure

Flow Diagram

The initial step of the STHGM is reading in the historical net hydroelectric generation and the precipitation data with a 3-year forecast of normal precipitation levels. The data are divided by the number of days in each month in order to account for the different lengths of the months. Next, the first ARIMA procedure is run to estimate the prewhitening model for precipitation. The second ARIMA model is run to estimate coefficients for the monthly dummy variables and the correlated lags of the precipitation data. The generation data are then adjusted using these coefficients to account for seasonality and the effects of precipitation. The ARIMA procedure is then run with the adjusted data which outputs the forecast. The forecast is multiplied by the number of days in each month and readjusted for seasonality and the effects of precipitation (Figure 1).

Figure 1. Flow Diagram of the STHGM



List of Computations and Equations

The time series models considered for this project come from the ARIMA family of models with explanatory variables. Model identification and estimation were done using PROC ARIMA in SAS version 6.08. In particular the model structure for the national model is of the form

$$\Phi(B)(NATIONAL_t - \sum_{k=1}^{12} NUM_{k+1} DUM_{t,k} - v(B)RAINNAT_t) = \Theta(B)a_t \qquad (1)$$

where,

NATIONAL$_t$ is the national daily average hydro generation in month t;
DUM$_{t,k}$ is a seasonal dummy variable which is zero unless observation t is in month k, in which case it is one;
RAINNAT$_t$ is the national daily average precipitation in month t;
$\phi(B)$ is the autoregressive part of the model (Equation 6);
$\theta(B)$ is the moving average part of the model (Equation 7);
$\nu(B)$ is the transfer function part of the model (Equation 3); and
NUM$_{k+1}$ are the coefficients of the seasonal mean, where k=1 is the coefficient for January.

Specific model structure was selected from this family of models based on standard diagnostics: the autocorrelation function, partial autocorrelation function, and inverse autocorrelation function of both the generation data and the model residuals, significant t-statistics for estimated parameters, the Portmanteau goodness of fit Chi square test for departures from model assumptions, the Akaike Information Criterion (AIC) to select the best from competing models, and comparisons of the model forecasts to actual data otherwise known as out-of-sample testing.[4]

The specific estimated parameters are shown in Table 3.

This model includes two functions which explain the time varying mean of the generation data: the first is the mean due to seasonal variation, the second is the mean due to the impact of precipitation. In particular, the average seasonal effect in month t is given by

$$MEANS_t = \sum_{k=1}^{12} NUM_{k+1}\ DUM_{t,k}. \tag{2}$$

Where NUM$_{k+1}$ is the estimated parameter (Table 3) and DUM$_{t,k}$ is unchanged. The variance of the estimated seasonal mean in a month, VARS$_t$, is the square of the approximate standard error of the appropriate estimated coefficient (Table 3).

The transfer function part of the model describes the impact of precipitation on hydroelectric generation. This relationship is given formally by

$$MEANR_t = \nu(B) RAINNAT_t. \tag{3}$$

Using the estimated coefficients (Table 3) it is written specifically

$$\begin{aligned} MEANR_t = {} & 896.22\ RAINNAT_t - 834.26\ RAINNAT_{t-1} - 526.13\ RAINNAT_{t-2} \\ & - 262.03\ RAINNAT_{t-8} - 171.29\ RAINNAT_{t-9}. \end{aligned} \tag{4}$$

The variance of the estimated mean of the changes in precipitation is given by

$$VARR_t = (140.39\ RAINNAT_t)^2 + (145.49\ RAINNAT_{t-1})^2 + (139.87\ RAINNAT_{t-2})^2$$

[4]For more information, see: Sas Institute Inc., *SAS/ETS User's Guide*, Version 6 (Cary, NC, January 1989).

$$+ (130.23\ RAINNAT_{t-8})^2 + (131.45\ RAINNAT_{t-9})^2.$$

where the approximate standard errors of the estimated coefficients come from Table 3.

Table 3. ARIMA Output Containing Estimated Dummy Variable and Precipitation Lag Parameters

Parameter	Estimate	Approximate Std. Error	T Ratio	Lag	Variable	Shift
MA1,1	-0.29039	0.07168	-4.05	13	NATIONAL	0
MA2,1	-0.13117	0.07594	-1.73	12	NATIONAL	0
AR1,1	0.85116	0.03234	26.32	1	NATIONAL	0
AR1,2	-0.09212	0.04206	-2.19	11	NATIONAL	0
NUM1	896.22200	140.38903	6.38	0	RAINNAT	0
NUM1,1 ...	-634.25619	145.49253	-5.73	1	RAINNAT	0
NUM1,2 ...	-S26.13090	139.86515	-3.76	2	RAINNAT	0
NUM1,3 ...	-262.02553	130.23461	-2.01	8	RAINNAT	0
NUM1,6 ...	-171.28614	131.44949	-1.30	9	RAINNAT	0
NUM2	595.29831	35.24633	16.89	0	DUM1	0
NUM3	600.13781	35.31950	16.99	0	DUM2	0
NUM4	605.04081	35.52695	17.03	0	DUM3	0
NUM5	600.80657	36.09334	16.65	0	DUM4	0
NUM6	610.64743	38.26016	15.96	0	DUM5	0
NUM7	589.90960	38.65004	15.26	0	DUM6	0
NUM8	511.49184	39.02628	13.11	0	DUM7	0
NUM9	453.11518	38.12019	11.89	0	DUM8	0
NUM10	404.01621	37.03964	10.91	0	DUM9	0
NUM11	404.01113	35.34626	11.43	0	DUM10	0
NUM12	476.45024	35.54321	13.46	0	DUM11	0
NUM13	560.71792	35.08532	15.98	0	DUM12	0

Variance Estimate	=	1688.87656
Std. Error Estimate	=	41.0959434
AIC	=	2764.43375
SBC	=	2839.76597
Number of Residuals	=	267

Lag	Chi Square	DF	Prob	Autocorrelations					
6	4.31	2	0.116	0.029	-0.002	-0.058	0.029	0.060	0.084
12	7.77	8	0.456	0.030	0.001	-0.066	0.025	-0.078	0.018
18	14.07	14	0.444	0.018	0.080	-0.099	-0.054	0.010	0.049
24	20.55	20	0.424	0.043	0.024	0.074	-0.005	-0.011	0.118
30	22.18	26	0.679	-0.032	0.041	-0.004	-0.030	-0.037	0.022
36	27.30	32	0.703	-0.004	0.065	-0.017	-0.023	-0.085	-0.065
42	36.22	38	0.552	0.010	-0.093	-0.011	-0.136	-0.009	-0.028

For purposes of forecasting generation, these two mean functions are subtracted from the past generation data, the autoregressive and moving average parts of the model (Table 3) are reestimated, and used to forecast 18 to 27 months ahead. MEANS, the seasonal effects on the generation, is calculated for the forecasts using the known dummy variables each representing a month. MEANR, the impact of precipitation on the generation, is calculated for the forecasts using the actual precipitation for past months which are still affecting generation in the forecast period and an estimated "normal" monthly precipitation as the monthly forecasts.[5] These impacts are then added to the forecasts from ARIMA. The estimated forecast variance from ARIMA is added to $VARS_t$ and $VARR_t$, the variances of the estimated seasonal and precipitation effects, and is used to calculate 95 percent confidence intervals for the forecasts.

The autoregressive part of the model using coefficients given by AR (Table 3) is

$$\Phi(B) = (1 - 0.85B + 0.09B^{11})$$

The moving average part of the model using coefficients given by MA (Table 3) is

$$\theta(B) = (1 + 0.29B^{13})(1 + 0.13B^{12})$$

After specifying the model for the ARIMA procedure, the procedure automatically makes use of these formulas in calculating the forecasts.

Detailed output from the model is available upon request.

Regional Models

The national model described above was used for several years as input for the STEO. However, regional models were needed for the STEO. Therefore, models were developed by region using the same methodology used in determining the national model as described above. The regional models replace the national model, with the sum of all regional models becoming the forecast for the Nation as a whole. Table 4 contains a summary of the parameters chosen for each regional model. Appendix E contains the estimated dummy variable and precipitation lag parameters for all the regional models.

Table 4. Regional Model Parameters

	Moving Average Parameters	Autoregressive Parameters	Rain Lags
Region 1	None	(1,9)	(1,2,3,4,5,7)
Region 2	(1)	(1,8)	(1,2,3,4,5,8,9)
Region 3	None	(1,5)	(1,2,3,4,6)
Region 4	(11)(12)	(1,8)	(9,10,13,14)
Region 5	None	(1,3,7)	(1,2,3,4,5,6,7)
Region 6	None	(1,2)	(1,2,3,4,5,7)
Region 7	(11)	(1,7,17)	(1,2,3,4,5,7)
Region 8	(2)	(1)	(1,2,3,4,10,11)
Region 9	(1,4,8,15,17)(12,13)	(1,9)	(1,2,3,5,9)

[5]Monthly averages of precipitation data from 1970 to the present are used as "normal" precipitation.

Properties of the Mathematical Solution

Theoretical Considerations

See Assumptions, Alternative Approaches, and List of Computations and Equations.

Subject-Matter Considerations

Because the hydroelectric generation data exhibit seasonality, the STHGM uses dummy variables each representing a month to account for seasonality. Seasonality needs to be accounted for in the raw data in order for the time series model to reflect it in the forecasts.

Precipitation is an explanatory variable to the time series model because of the dependency of hydroelectric generation on precipitation historically. Precipitation levels determine the availability of water in reservoirs for electricity generation, as well as the effects of recent rain or snow on run-of-river hydroelectric facilities. Average precipitation is used during the forecast period for hydroelectric generation which is consistent with the assumption of normal weather for the *STEO* forecasts.

Calibration and Sensitivity Analysis

Results of Calibration

Evaluation of the model was performed using out-of-sample tests. That is, several different periods of actual data were deleted from the input data, the parameters in the model were reestimated, and forecasts made as described above for a 24-month period. These forecasts were compared to actual data and past forecasts for the *Short-Term Energy Outlook* based on the same historical data.

National Model

The first comparison was to graph the out-of-sample results (Figures 2, 3, and 4). From the graphs, the following conclusions are illustrated: (1) the STHGM forecast is in general closer to the actual generation than the previous *STEO* forecasts; (2) the 1990 and 1991 actual data are close to the long run average hydroelectric generation and the STHGM forecasts for these years is generally within 1 to 2 billion kilowatthours of the actual generation; (3) for 1992, an unusually low year for hydroelectric generation, both forecasts are not as good as for 1990 and 1991, which can be explained by the forecast assumption of normal precipitation and the fact that precipitation was below normal in 1992; (4) in 1992, with the below normal hydroelectric generation, the STHGM still provides a closer forecast than used in the *STEO*; and (5) as the input data gets closer to 1992, the STHGM forecasts improved for 1992.

The second comparison was with the Root Mean Square Errors (RMSE) of the model runs (Table 4), where n is the number of months of the forecast included in the calculation and

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(FORECAST_i - ACTUAL_i)^2}{n}}.$$

In all cases the RMSE of the STHGM is smaller than the RMSE of the *STEO* forecasts. The RMSEs show the improvement of both forecasts for a particular year as the input data gets closer to that year.

Regional Models

As for the national STHGM, out-of-sample tests were performed for the regional STHGM (Figures 5, 6, 7, and 8). Precipitation data for the out-of-sample tests was lagged 6 months behind the generation data as this is the normal occurrence. From the graphs, the following conclusions are illustrated: (1) the regional STHGM forecast based on actual data through 1992 provides a closer national forecast than the methodology used in the STEO at the time, that is, the pre-model methodology described earlier in this documentation; (2) the regional STHGM forecast and the STEO forecast (national STHGM model) based on actual data through 1993 provide very similar forecasts; (3) looking individually at two of the regional forecasts, the regional STHGM provides closer regional forecasts than the methodology previously used to determine regional forecasts.[6]

The second comparison was again the RMSE of the model runs and previous STEO forecasts (Table 5). In only one instance is the RMSE greater for the STHGM; however, that is only the case for the national total—both regional forecasts have a lower RMSE in that sample.

Correlation Concerns

One further concern involves the correlation of the dummy variables and the precipitation variables. Correlation is not taken into account when the two mean functions are subtracted from the past generation data, nor is it taken into account in the forecast. However, correlation among the dummy variables is always 0, because only one of the variables is non-zero for any one observation. The precipitation variables do have correlation, but it is not large enough to be of concern. Therefore, the model remains acceptable with no correction for correlation among the explanatory variables.

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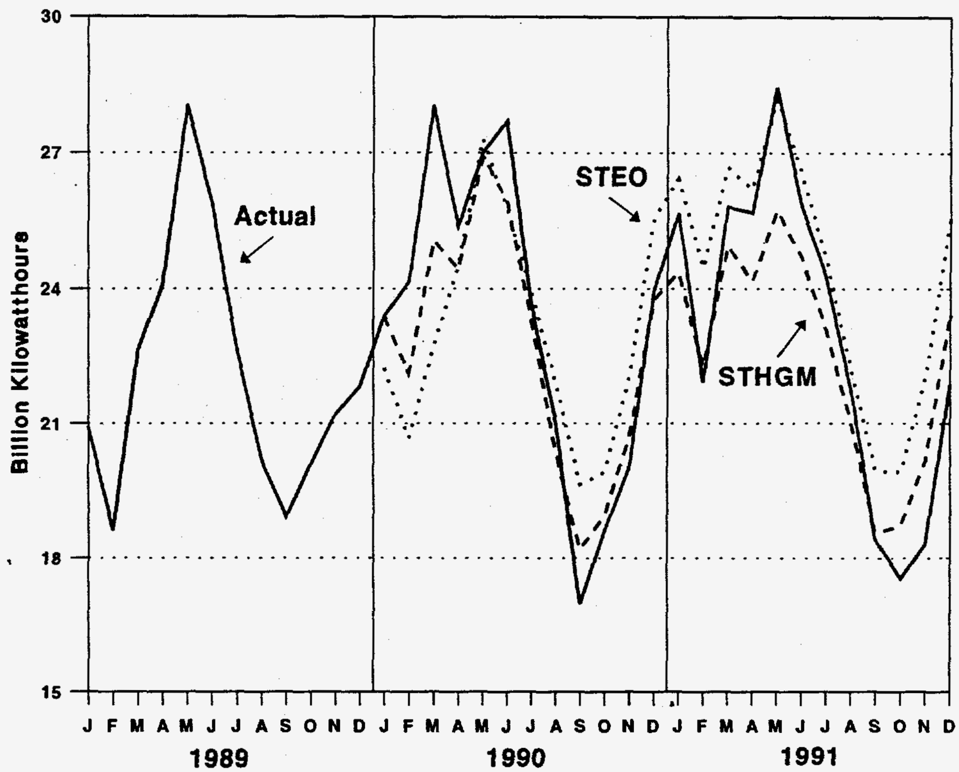
[6]The previous methodology used to determine regional forecasts of hydroelectric generation was based on the output from the national STHGM. Regional splits of the national yearly forecasted generation were determined based on previous years' splits and knowledge of the current year's increase or decrease from normal levels of generation in each region. These regional totals were used along with the monthly national level generation forecast from the STHGM to proportionally determine monthly regional levels of generation.

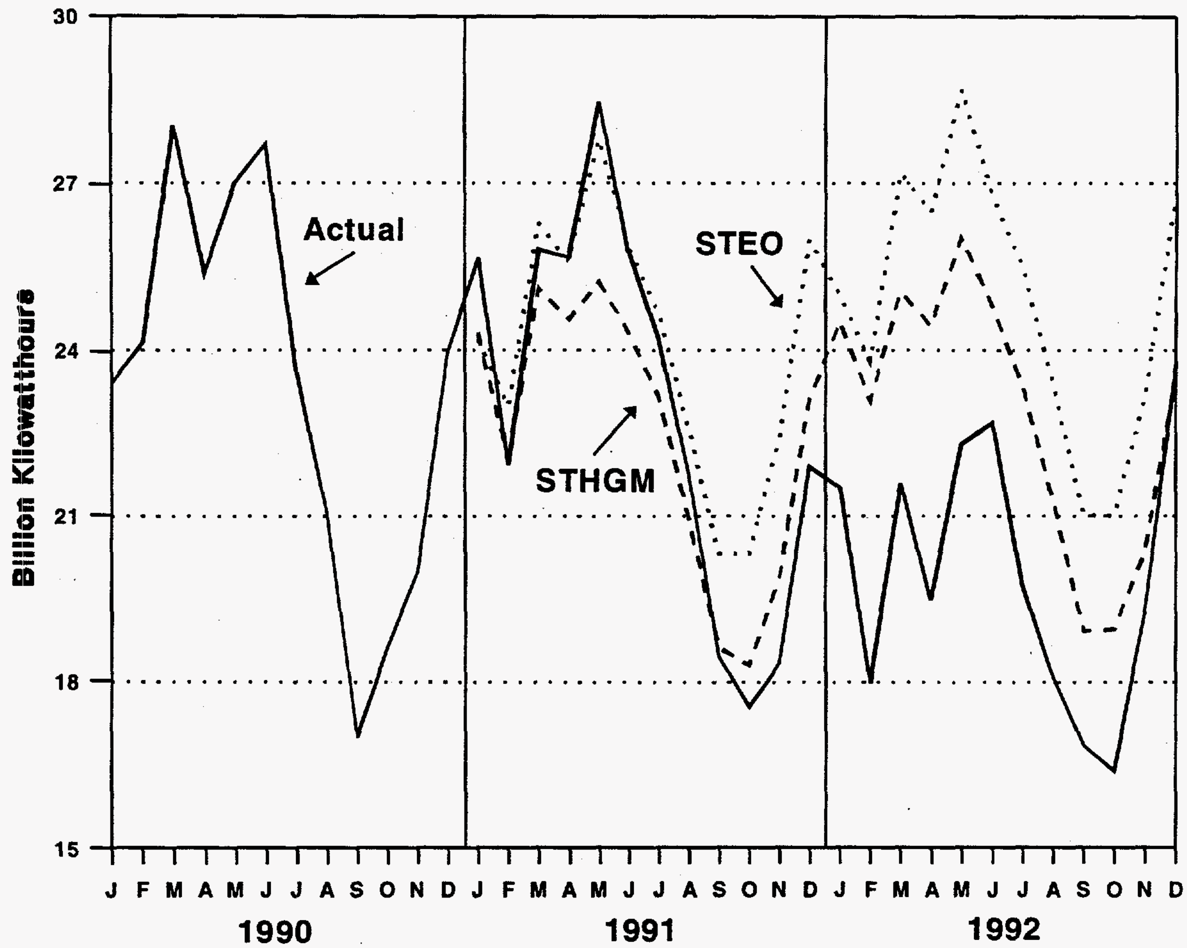
Figure 2. Out of Sample and *STEO* Forecasts Using Actual Data through 1989 Compared to Actual Data, 1990 and 1991



Notes: •All forecasts are based on actual generation and precipitation data through the indicated year. •All forecasts assume normal precipitation during the forecast period. •Data shown in Table C1.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 13, 1990. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.TIME.SERIES.FINAL.D060193. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

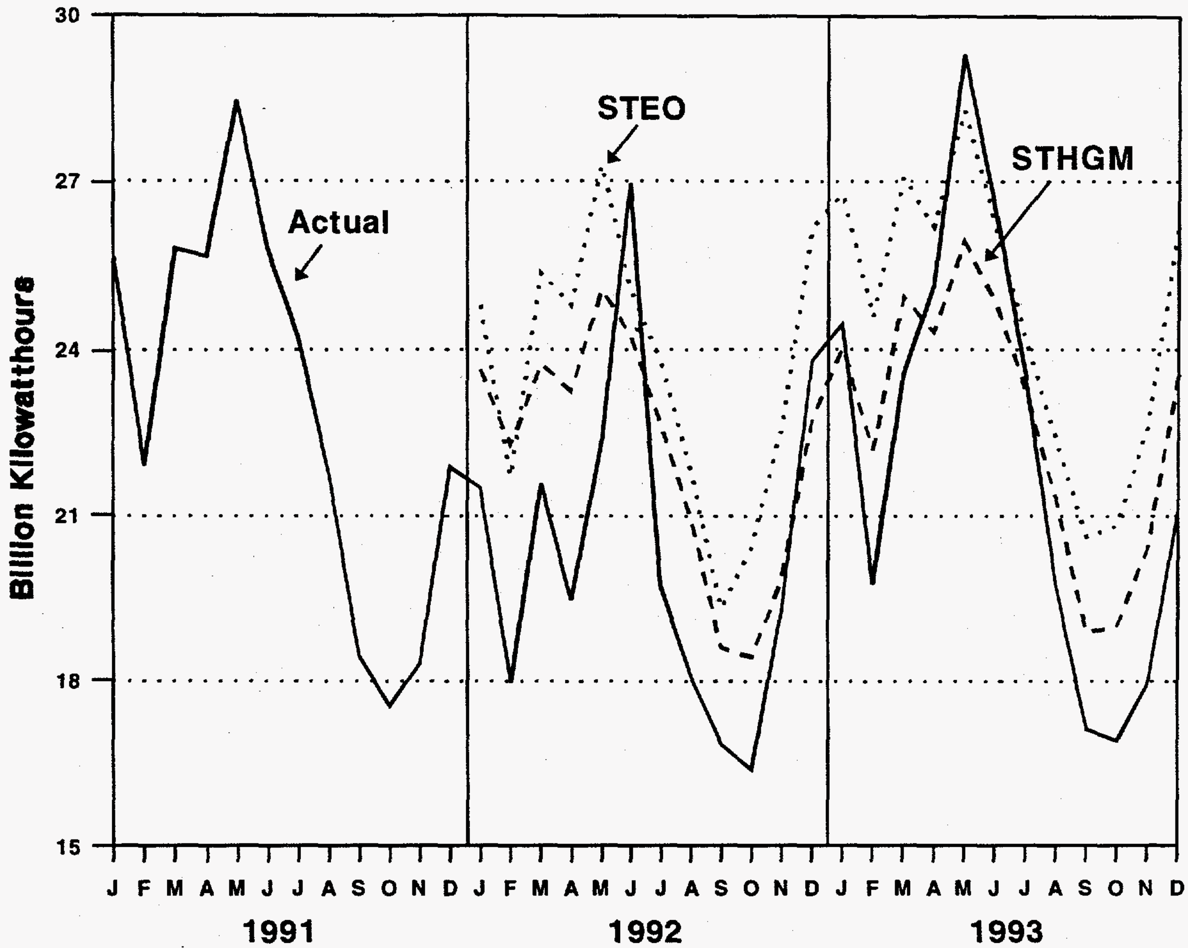
Figure 3. Out of Sample and *STEO* Forecasts Using Actual Data through 1990 Compared to Actual Data, 1991 and 1992



Notes: ●All forecasts are based on actual generation and precipitation data through the indicated year. ●All forecasts assume normal precipitation during the forecast period. ●Data shown in Table C2.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 19, 1991. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.TIME.SERIES.FINAL.D060193 **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

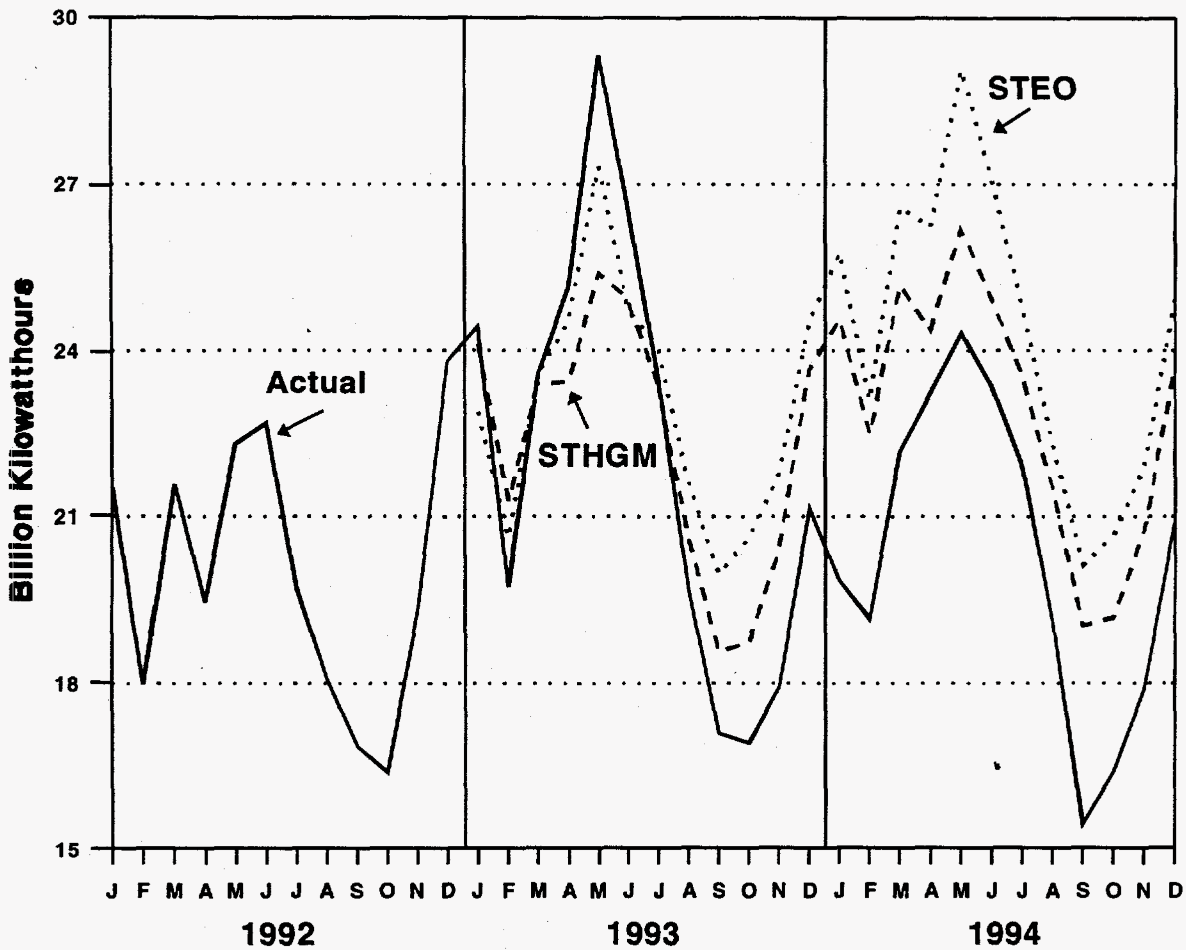
Figure 4. Out of Sample and *STEO* Forecasts Using Actual Data through 1991 Compared to Actual Data, 1992 and 1993



Notes: •All forecasts are based on actual generation and precipitation data through the indicated year. •All forecasts assume normal precipitation during the forecast period. •Data shown in Table C3.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 6, 1992. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.TIME.SERIES.FINAL.D060193. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

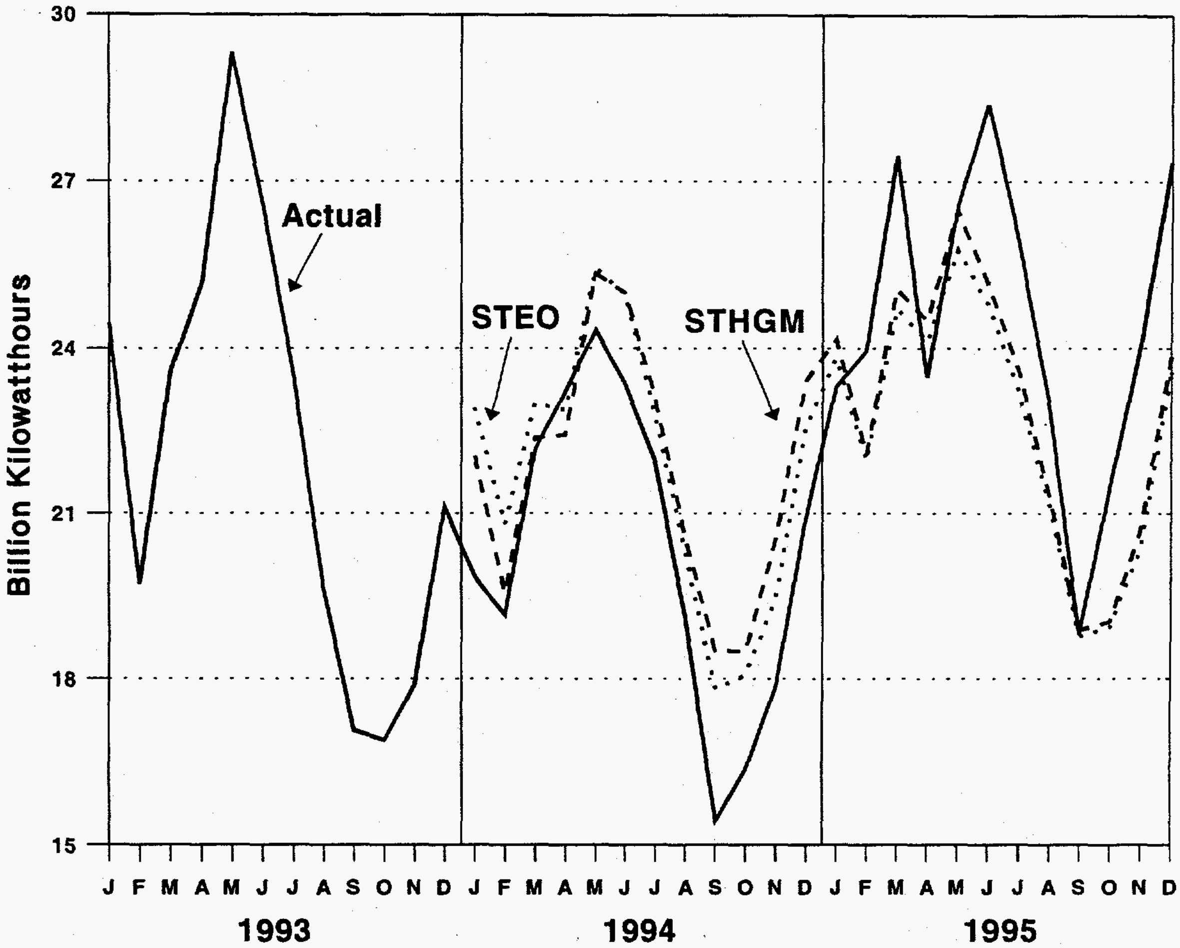
Figure 5. Out of Sample (Regional STHGM) and *STEO* Forecasts Using Actual Generation Data through 1992 Compared to Actual Data, 1993 and 1994



Notes: •All forecasts are based on actual generation data through 1992 and precipitation data through June of 1992. •All forecasts assume normal precipitation after the last month of available actual data. •Data shown in Table C4.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 8, 1993. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.MODEL. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

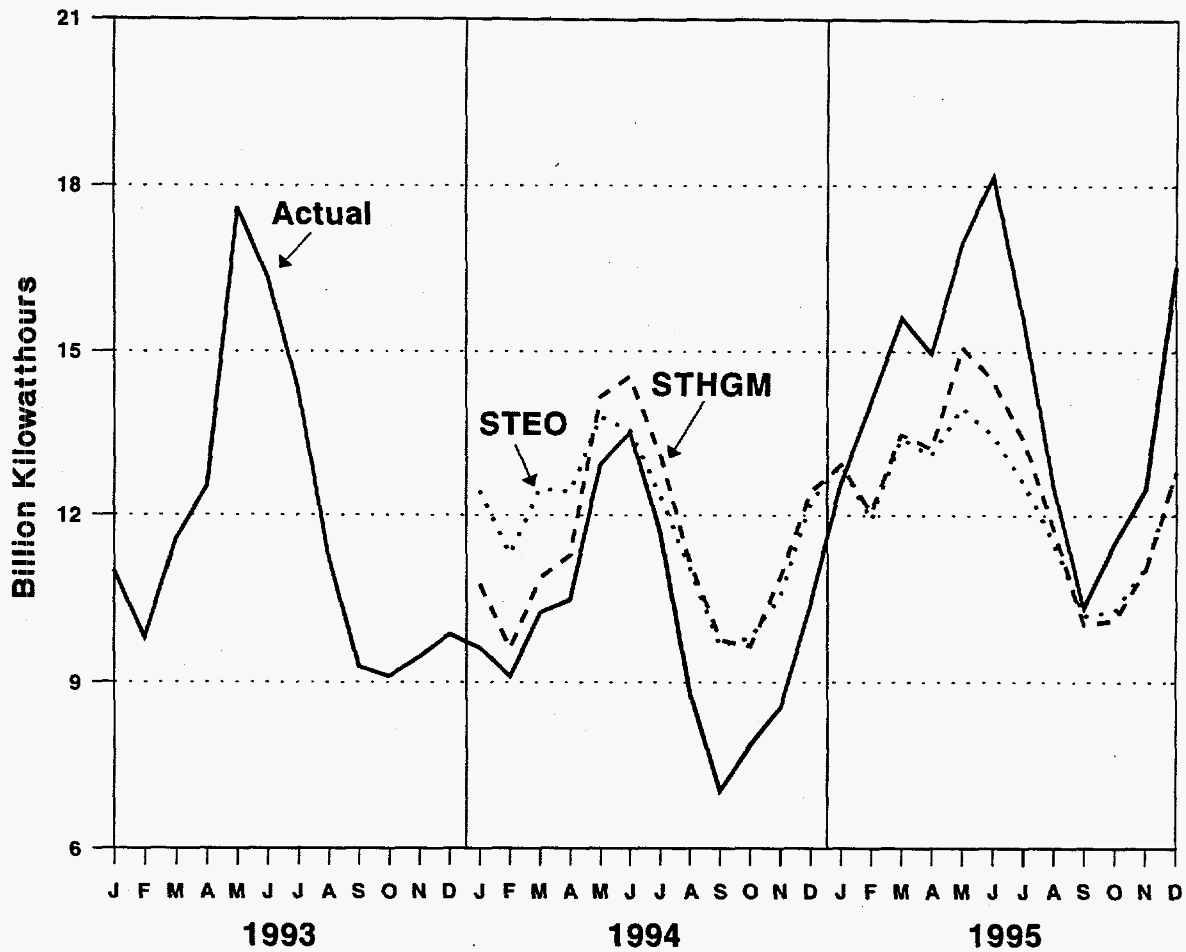
Figure 6. Out of Sample (Regional STHGM) and *STEO* Forecasts Using Actual Generation Data through 1993 Compared to Actual Data, 1994 and 1995



Notes: •All forecasts are based on actual generation data through 1993 and precipitation data through June of 1993. •All forecasts assume normal precipitation after the last month of available actual data. •Data shown in Table C5.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 7, 1994. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.MODEL. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

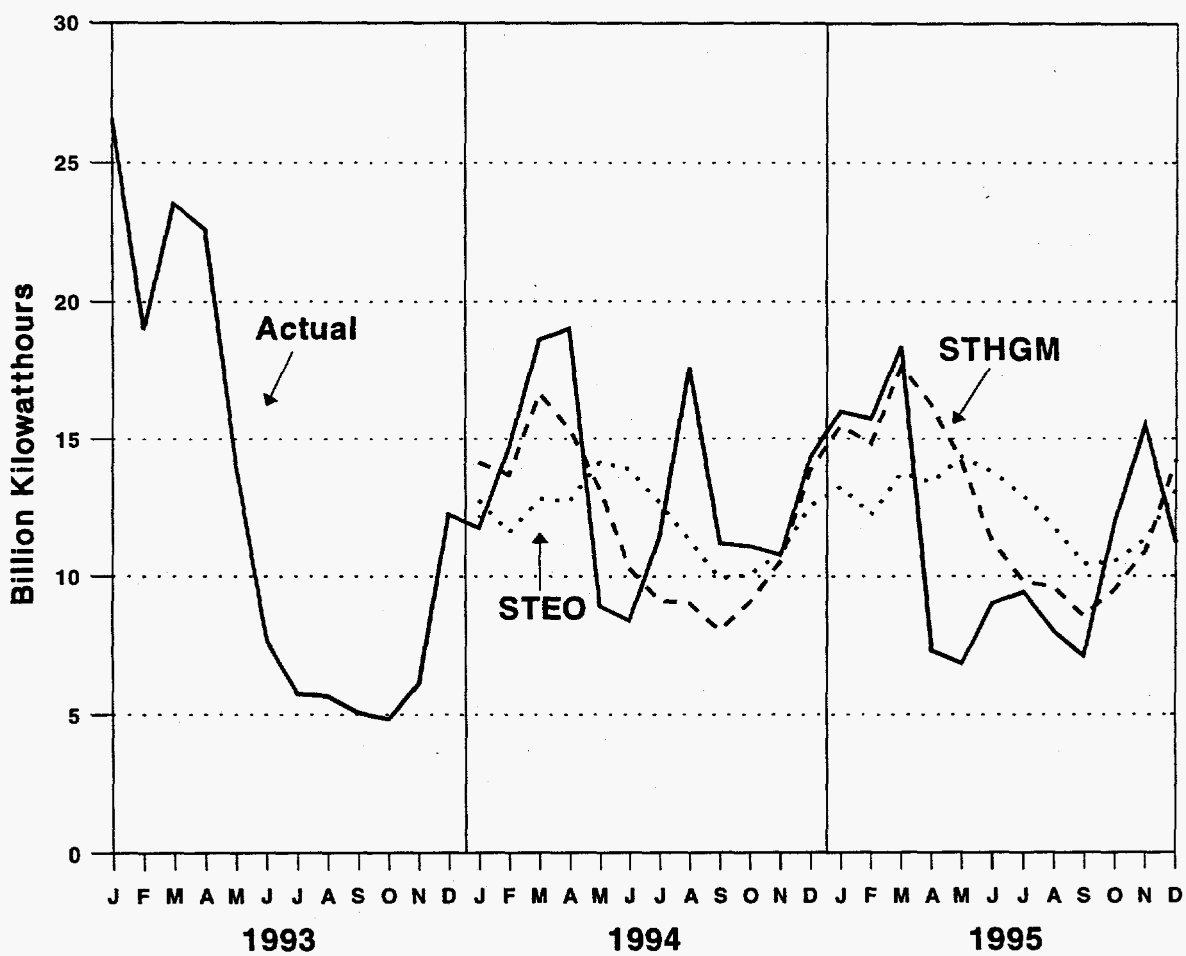
Figure 7. Out of Sample (Regional STHGM) and *STEO* Forecasts for Region 9 (Using Actual Generation Data through 1993 Compared to Actual Data, 1994 and 1995



Notes: •All forecasts are based on actual generation data through 1993 and precipitation data through June of 1993. •All forecasts assume normal precipitation after the last month of available actual data. •Data shown in Table C6.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 7, 1994. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.MODEL. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Figure 8. Out of Sample (Regional STHGM) and *STEO* Forecasts for Region 5 (Using Actual Generation Data through 1993 Compared to Actual Data, 1994 and 1995



Notes: •All forecasts are based on actual generation data through 1993 and precipitation data through June of 1993. •All forecasts assume normal precipitation after the last month of available actual data. •Data shown in Table C6.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 7, 1994. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.MODEL. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Table 5. Comparison of Root Mean Square Errors for Regional STHGM

Using Historical Data through:	Year(s) of Forecast Included in the RMSE	RMSE: National		RMSE: Region 9		RMSE: Region 5	
		STHGM	STEO	STHGM	STEO	STHGM	STEO
1992:	1993	1,887	2,293	1,632	1,925	538	770
	1994	2,881	4,160	2,784	3,183	354	403
	1993 and 1994	2,400	3,358	2,282	2,630	455	615
1993:	1994	1,830	1,654	1,650	1,950	340	396
	1995	2,218	2,426	2,097	2,445	388	428
	1994 and 1995	2,033	2,077	1,887	2,212	365	412

Notes: •All forecasts are based on actual generation data through the indicated year and actual precipitation data through 6 months prior to the indicated years. All forecasts assume normal precipitation after the last month of available actual data.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memos to Office of Energy Markets and End Use dated March 8, 1993, March 7, 1994, and March 6, 1992. **STHGM Forecasts:** Energy Information Administration, STHGM runs using HYDRO.MODEL.

Documentation of Technical Detail on the Model Data and Equations

Description of Input Data

Input hydroelectric generation data for the STHGM is from archived databases of the Form EIA-759, "Monthly Power Plant Report," from 1970 through 1992. Data prior to 1978 may differ from published data due to unreturned forms that were estimated in the published data. The differences in the published data and the database is generally less than 0.1 percent; and, therefore, the database was used.

Once the model has read in the generation data, the data are divided by the number of days in each month in order to account for the different lengths of the months. Once the time series procedure is completed, the forecast of average daily generation is multiplied by the number of days in each month to produce estimates of monthly generation.

The monthly input precipitation data from 1970 to 1992 and the 57-year average precipitation data are from the National Climatic Data Center. These numbers were hand typed into the needed format. Forecasted precipitation data are the monthly averages for the 57-year period from 1931 to 1987 from the National Climatic Data Center.[7] The precipitation data, like the generation data, was adjusted to account for the number of days in the month.

Non-DOE Input Sources

- **1970-1992:** National Climatic Data Center (NCDC), Disc. Resident Historical Divisional DataBase (DRD964X). These data are weighted by population using State and regional weights from the NCDC's *State, Regional, and National Monthly and Annual Precipitation Weighted by Area for the Contiguous United States January 1931 - December 1987* (Asheville, NC, August 1988). The calculated data differ slightly from the published data due to updates of the State and regional weights. **1993-present:** National Climatic Data Center, *Monthly State, Regional and National Heating Degree Days Weighted by Population* (Asheville, NC, March, 1989 through present), Table 3.3, "Regional and National Average Precipitation." These data are updated each time the model is run. Data are published weighted by population.

  - Regional precipitation data.

DOE Data Input Sources

- Energy Information Administration, Databases for Form EIA-759, "Monthly Power Plant Report," and predecessors.

  - Hydroelectric generation data.

ARIMA Output Providing Coefficient Estimates

The coefficient estimates and a number of statistics related to the goodness-of-fit of the equations estimated by the STHGM are listed in Appendix E.

[7]National Climatic Data Center, *State, Regional, and National Monthly and Annual Precipitation Weighted by Area for the Contiguous United States January 1931 - December 1987* (Asheville, NC, August 1988), p. 66.

Appendix A. Model Abstract

Model Name: Short-Term Hydroelectric Generation Model

Model Acronym: STHGM

Model Description: The STHGM performs a short-term (18 to 27-month) forecast of hydroelectric generation in the United States by Census Division using an autoregressive integrated moving average (ARIMA) time series model with precipitation as an explanatory variable. The model results are used as input for the *Short-Term Energy Outlook.*

Last Model Update: March 1995

Part of Another Model: None.

Model Interfaces: None. Results used as independent input into the Short-Term Integrated Forecasting System (STIFS).

Sponsor:

- Office: Office of Coal, Nuclear, Electric and Alternate Fuels.
- Division: Analysis and Systems Division.
- Branch: Supply Analysis Branch, EI-532.
- Model Contact: William Liggett.
- Telephone: 202-426-1139.

Documentation: Energy Information Administration, "Model Documentation Report: Short-Term Hydroelectric Generation Model."

Archive Media and Installation Guides: Archived on Energy Information Administration mainframe system under the name "HYDRO.FINAL" on account RMF6434. The model is written in SAS version 6.08.

Purpose: The STHGM is to be used for general forecasting purposes to provide quarterly projections of monthly national and regional hydroelectric generation for the *Short-Term Energy Outlook.*

Energy Systems Described by Model: National and regional (Census Division) hydroelectric generation.

Coverage:

- Geographic: National and Census Division.
- Time Unit/Frequency: Monthly.
- Products: Hydroelectric Generation.

Modelling Features:

- Model Structure: Autoregressive integrated moving average (ARIMA) time series model with an explanatory variable.
- Modelling Technique: Time series analysis.
- Special Features: None.

Non-DOE Input Sources

- **1970-1992:** National Climatic Data Center (NCDC), Disc. Resident Historical Divisional DataBase (DRD964X). These data are weighted by population using State and regional weights from the NCDC's *State, Regional, and National Monthly and Annual Precipitation Weighted by Area for the Contiguous United States January 1931 - December 1987* (Asheville, NC, August 1988). The calculated data differ slightly from the published data due to updates of the State and regional weights. **1993-present:** National Climatic Data Center, *Monthly State, Regional and National Heating Degree Days Weighted by Population* (Asheville, NC, March, 1989 through present), Table 3.3, "Regional and National Average Precipitation." These data are updated each time the model is run. Data are published weighted by population.

  - Regional (Census Division) precipitation data.

DOE Data Input Sources

- Energy Information Administration, Databases for Form EIA-759, "Monthly Power Plant Report," and predecessors.

  - Hydroelectric generation data.

General Output Descriptions: STHGM is used to generate short-term (18 to 27-month), monthly forecasts of U.S. hydroelectric generation by Census Division.

Computing Environment:

- Hardware Used: Energy Information Administration Mainframe System (Model Number IBM 3090).
- Operating System: MVS.
- Software Used: SAS version 6.08.
- Estimated Run Time: Approximately 1 minute computer time on EIA Mainframe System.
- Special Features: None.

Independent Expert Reviews: None.

Status of Evaluations by Sponsor: On-going.

Bibliography:

- George E. Box and Gwilym Jenkins, *Time Series Analysis, Forecasting and Control* (1976).
- Sas Institute Inc., *SAS/ETS User's Guide*, Version 6 (Cary, NC, January 1989).

Appendix B. Source Code

Following is the complete source code for the STHGM. The model was written in SAS 6.08 and is run in a mainframe environment using SuperWylbur and JCL. A list of variable definitions follows the code.

```
//RR5UTIMD JOB (6434,HST,,80),'HYDRO.TIME',TIME=(1,30)
//STEP1 EXEC SAS,OPTIONS='MACRO',REGION=4024K,TIME=(1,30)
//FORM1 DD DSN=CN6434.RR5.HYDRO.HISTORY.DATA.USE,
//        DISP=SHR,LABEL=(,,,IN)
//PREC DD DSN=CN6434.RR5.PRECIP.USE,
//        DISP=SHR,LABEL=(,,,IN)
//*
*OPTIONS MPRINT NONOTES NOSOURCE NOCENTER;
OPTIONS MPRINT NOCENTER;

*-----------------------------------------*
| THIS JOB PERFORMS A TIME SERIES FOR HYDRO    |
*-----------------------------------------*;


***** MACROS *****;


*--- CALCULATE THE NUMBER OF DAYS IN EACH MONTH ---*;

%MACRO NUMDAYS;
 IF MONTH < 12 THEN NEXTMON=MONTH+1; ELSE NEXTMON=1;
 IF MONTH < 12 THEN NEXTYR=YR; ELSE NEXTYR=YR+1;
 DAYS=MDY(NEXTMON,1,NEXTYR)-MDY(MONTH,1,YR);
 DROP NEXTYR NEXTMON;
%MEND;

*---- MULTIPLY THE FORECAST BY THE NUMBER OF DAYS IN EACH MONTH -*;

%MACRO FOREDAYS;
  DO I=1 TO 9;
    F(I)= (FORE(I) + MEANS(I) + MEANR(I))*DAYS;
    STDF(I)=SQRT(STDEV(I)**2 + VARS(I) + VARR(I))*DAYS;
    U95CI(I)=F(I)+1.96*STDF(I);
    L95CI(I)=F(I)-1.96*STDF(I);
  END;

%MEND;

*---- DROP UNNEEDED VARIABLES ----*;

%MACRO DROP1;
 DROP I1_1 I1_2 I1_3 I1_4 I1_5 I1_6 I1_7 I1_8 I2_1 I3_1 I4_1 I5_1
      I6_1 I7_1 I8_1 I9_1 I10_1 I11_1 I12_1 I13_1;
 DROP S1_1 S1_2 S1_3 S1_4 S1_5 S1_6 S1_7 S1_8 S2_1 S3_1 S4_1 S5_1
      S6_1 S7_1 S8_1 S9_1 S10_1 S11_1 S12_1 S13_1;
%MEND;
```

```
*---- CALCULATE YEAR & MONTH OF FORECAST ----*;

%MACRO YRCAL;
C=_N_;
YR=1900+(70+INT((C-.5)/12));
MONTH=C-(YR-1970)*12;
%MEND;

 *---- GET OUTPUT FROM ARIMA RUN IN USEABLE DATA FILE ----*;

%MACRO PARAMETR;

DATA EST1; SET ESTS;
 IF _TYPE_='EST';
 MERGEVAR=1;

DATA ONE; SET ONE;
 MERGEVAR=1;

DATA ONE2;
 MERGE ONE (IN=A) EST1;
 BY MERGEVAR;
 IF A;

DATA EST2; SET ESTS;
 IF _TYPE_='STD';
 MERGEVAR=1;
 S1_1=I1_1;
 S1_2=I1_2;
 S1_3=I1_3;
 S1_4=I1_4;
 S1_5=I1_5;
 S1_6=I1_6;
 S1_7=I1_7;
 S1_8=I1_8;
 S2_1=I2_1;
 S3_1=I3_1;
 S4_1=I4_1;
 S5_1=I5_1;
 S6_1=I6_1;
 S7_1=I7_1;
 S8_1=I8_1;
 S9_1=I9_1;
 S10_1=I10_1;
 S11_1=I11_1;
 S12_1=I12_1;
 S13_1=I13_1;
 DROP I1_1 I1_2 I1_3 I1_4 I1_5 I1_6 I1_7 I1_8 I2_1 I3_1 I4_1 I5_1
     I6_1 I7_1 I8_1 I9_1 I10_1 I11_1 I12_1 I13_1;
 DROP _TYPE_ ERRORVAR MA1_1 MA1_2 MA1_3 MA1_4 MA1_5 MA2_1 MA2_2
                AR1_1 AR1_2 AR1_3 AR1_4;
```

```
DATA ONE3;
 MERGE ONE2 (IN=A) EST2;
 BY MERGEVAR;
 DROP MERGEVAR;
 IF A;

%MEND;


*******************************************************
****************** MAIN PROGRAM ********************
*******************************************************;


**** READ IN GENERATION DATA ****;

DATA AA (DROP=REGION10);
   INFILE FORM1;
   ARRAY REGION(*) REGION1-REGION10;
   INPUT YR 1-4 MONTH 9-10
     @22 (REGION1-REGION10) (9.1);
   DATE = MDY(MONTH,1,YR); FORMAT DATE MONYY.;
   REGION9=REGION9+REGION10;
   IF YR >= 70 THEN YR=1900+YR;
     ELSE YR = 2000+YR;

DATA AA;
   SET AA NOBS=NUM;
   NUMAA=NUM;

**** READ IN PRECIPITATION DATA ****;

DATA RR;
   INFILE PREC;
   ARRAY RAIN(*) RAIN1-RAIN9;
   INPUT YR 1-4 MONTH 9-10
     @22 (RAIN1-RAIN9) (6.2);
   DATE = MDY(MONTH,1,YR); FORMAT DATE MONYY.;

DATA RR;
   SET RR NOBS=NUM;
   NUMRR=NUM - 36;

**** MERGE DATASETS ****;

PROC SORT DATA=AA;
 BY YR MONTH;

PROC SORT DATA=RR;
 BY YR MONTH;
```

```
DATA ONE;

  MERGE AA (IN=A) RR (IN=B);
  BY YR MONTH;

  IF (A OR B) THEN OUTPUT;

**** ADJUST FOR # OF DAYS PER MONTH ****;

DATA ONE (DROP=I DAYS);
  SET ONE;

  %NUMDAYS
  ARRAY REGION(*) REGION1-REGION9;
  ARRAY RAIN(*) RAIN1-RAIN9;

  DO I=1 TO 9;
    REGION(I)=REGION(I)/DAYS;
    RAIN(I)=RAIN(I)/DAYS;
  END;

**** ESTABLISH DUMMY VARIABLES ****;

DATA ONE (DROP=I); SET ONE;
ARRAY DUM(*) DUM1-DUM12;

DO I=1 TO 12;
  DUM(I)=0;
  IF MONTH=I THEN DUM(I)=1;
END;


**** USE PORTION OF MERGED DATASET THAT INCLUDES ****
**** ACTUAL VALUES OF GENERATION AND PRECIPITATION ****;

DATA ONES; SET ONE;
   IF _N_ LE NUMRR;

**** FIRST ARIMA PROCUDURE ****;
**** COEFFECIENTS OF PARAMTERS USED FROM OUTPUT ****;

*??? REGION 9 ;

PROC ARIMA DATA=ONES;

   IDENTIFY VAR=RAIN9 NLAG=24;
   ESTIMATE P=(1,7)(12) Q=(11,12) ML PLOT;
   TITLE1 'REGION 9: FIRST ARIMA';

   IDENTIFY VAR=REGION9 CROSSCORR=(RAIN9 DUM1 DUM2 DUM3
    DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12) NLAG=22;
   ESTIMATE P=(1,9) Q=(1,4,8,15,17)(12,13) ML PLOT NOINT
    INPUT=((1,2,3,5,9) RAIN9 DUM1 DUM2
    DUM3 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12)
    OUTEST=ESTS;
```

```
%PARAMETR

**** ADJUST DATA FOR SEASONALITY AND PRECIPITATION CORRELATION **;

DATA NAT9; SET ONE3;
  MEANS9=I2_1*DUM1+ I3_1*DUM2 + I4_1*DUM3 + I5_1* DUM4 +
  I6_1*DUM5+ I7_1*DUM6 +I8_1*DUM7+I9_1* DUM8+
  I10_1*DUM9+I11_1*DUM10+I12_1*DUM11+I13_1*DUM12;

  MEANR9=I1_1*RAIN9-I1_2*LAG(RAIN9)-I1_3*LAG2(RAIN9)-
    I1_4*LAG3(RAIN9)-I1_5*LAG5(RAIN9)-I1_6*LAG9(RAIN9);

  VARS9= (S2_1**2)*DUM1 + (S3_1**2)*DUM2 + (S4_1**2)*DUM3 +
       (S5_1**2)*DUM4 + (S6_1**2)*DUM5 + (S7_1**2)*DUM6 +
       (S8_1**2)*DUM7 + (S9_1**2)*DUM8 + (S10_1**2)*DUM9 +
       (S11_1**2)*DUM10 + (S12_1**2)*DUM11 + (S13_1**2)*DUM12;

  VARR9= (S1_1**2)*(RAIN9**2) +
       (S1_2**2)*LAG(RAIN9)**2 +
       (S1_3**2)*LAG2(RAIN9)**2 +
       (S1_4**2)*LAG3(RAIN9)**2 +
       (S1_5**2)*LAG5(RAIN9)**2 +
       (S1_6**2)*LAG9(RAIN9)**2;

  %DROP1

  NEWNAT9=REGION9-MEANS9-MEANR9;

*??? REGION 8 ;

PROC ARIMA DATA=ONES;

    IDENTIFY VAR=RAIN8 NLAG=24;
    ESTIMATE P=(1,2,5,17,19)(12) ML PLOT;
    TITLE1 'REGION 8: FIRST ARIMA';

    IDENTIFY VAR=REGION8 CROSSCORR=(RAIN8 DUM1 DUM2 DUM3
     DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12) NLAG=22;
    ESTIMATE P=(1) Q=(2) ML PLOT NOINT
     INPUT=((1,2,3,4,10,11) RAIN8 DUM1 DUM2
     DUM3 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12)
     OUTEST=ESTS;

%PARAMETR

**** ADJUST DATA FOR SEASONALITY AND PRECIPITATION CORRELATION **;

DATA NAT8; SET ONE3;
  MEANS8=I2_1*DUM1+ I3_1*DUM2 + I4_1*DUM3 + I5_1* DUM4 +
  I6_1*DUM5+ I7_1*DUM6 +I8_1*DUM7+I9_1* DUM8+
  I10_1*DUM9+I11_1*DUM10+I12_1*DUM11+I13_1*DUM12;

  MEANR8=I1_1*RAIN8-I1_2*LAG(RAIN8)-I1_3*LAG2(RAIN8)-
    I1_4*LAG3(RAIN8)-I1_5*LAG4(RAIN8)-I1_6*LAG10(RAIN8)-
    I1_7*LAG11(RAIN8);
```

```
VARS8= (S2_1**2)*DUM1 + (S3_1**2)*DUM2 + (S4_1**2)*DUM3 +
      (S5_1**2)*DUM4 + (S6_1**2)*DUM5 + (S7_1**2)*DUM6 +
      (S8_1**2)*DUM7 + (S9_1**2)*DUM8 + (S10_1**2)*DUM9 +
      (S11_1**2)*DUM10 + (S12_1**2)*DUM11 + (S13_1**2)*DUM12;

VARR8= (S1_1**2)*(RAIN8**2) +
      (S1_2**2)*LAG(RAIN8)**2 +
      (S1_3**2)*LAG2(RAIN8)**2 +
      (S1_4**2)*LAG3(RAIN8)**2 +
      (S1_5**2)*LAG4(RAIN8)**2 +
      (S1_6**2)*LAG10(RAIN8)**2 +
      (S1_7**2)*LAG11(RAIN8)**2;

%DROP1

NEWNAT8=REGION8-MEANS8-MEANR8;

*??? REGION 7 ;

PROC ARIMA DATA=ONES;

   IDENTIFY VAR=RAIN7 NLAG=24;
   ESTIMATE P=(1,15)(12) Q=(2) ML PLOT;
   TITLE1 'REGION 7: FIRST ARIMA';

   IDENTIFY VAR=REGION7 CROSSCORR=(RAIN7 DUM1 DUM2 DUM3
    DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12) NLAG=22;
   ESTIMATE P=(1,7,17) Q=(11) ML PLOT NOINT
    INPUT=((1,2,3,4,5,7) RAIN7 DUM1 DUM2
    DUM3 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12)
    OUTEST=ESTS;

%PARAMETR

**** ADJUST DATA FOR SEASONALITY AND PRECIPITATION CORRELATION **;

DATA NAT7; SET ONE3;
 MEANS7=I2_1*DUM1+ I3_1*DUM2 + I4_1*DUM3 + I5_1* DUM4 +
 I6_1*DUM5+ I7_1*DUM6 +I8_1*DUM7+I9_1* DUM8+
 I10_1*DUM9+I11_1*DUM10+I12_1*DUM11+I13_1*DUM12;

 MEANR7=I1_1*RAIN7-I1_2*LAG(RAIN7)-I1_3*LAG2(RAIN7)-
  I1_4*LAG3(RAIN7)-I1_5*LAG4(RAIN7)-I1_6*LAG5(RAIN7)-
  I1_7*LAG7(RAIN7);

 VARS7= (S2_1**2)*DUM1 + (S3_1**2)*DUM2 + (S4_1**2)*DUM3 +
      (S5_1**2)*DUM4 + (S6_1**2)*DUM5 + (S7_1**2)*DUM6 +
      (S8_1**2)*DUM7 + (S9_1**2)*DUM8 + (S10_1**2)*DUM9 +
      (S11_1**2)*DUM10 + (S12_1**2)*DUM11 + (S13_1**2)*DUM12;
```

```
VARR7= (S1_1**2)*(RAIN7**2) +
     (S1_2**2)*LAG(RAIN7)**2 +
     (S1_3**2)*LAG2(RAIN7)**2 +
     (S1_4**2)*LAG3(RAIN7)**2 +
     (S1_5**2)*LAG4(RAIN7)**2 +
     (S1_6**2)*LAG5(RAIN7)**2 +
     (S1_7**2)*LAG6(RAIN7)**2;

 %DROP1

 NEWNAT7=REGION7-MEANS7-MEANR7;

*??? REGION 6 ;

PROC ARIMA DATA=ONES;

   IDENTIFY VAR=RAIN6 NLAG=24;
   ESTIMATE P=(1,19,22) Q=(4)(12) ML PLOT;
   TITLE1 'REGION 6: FIRST ARIMA';

   IDENTIFY VAR=REGION6 CROSSCORR=(RAIN6 DUM1 DUM2 DUM3
    DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12) NLAG=22;
   ESTIMATE P=(1,2) ML PLOT NOINT
    INPUT=((1,2,3,4,5,7) RAIN6 DUM1 DUM2
    DUM3 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12)
    OUTEST=ESTS;


%PARAMETR

**** ADJUST DATA FOR SEASONALITY AND PRECIPITATION CORRELATION **;

DATA NAT6; SET ONE3;
  MEANS6=I2_1*DUM1+ I3_1*DUM2 + I4_1*DUM3 + I5_1* DUM4 +
  I6_1*DUM5+ I7_1*DUM6 +I8_1*DUM7+I9_1* DUM8+
  I10_1*DUM9+I11_1*DUM10+I12_1*DUM11+I13_1*DUM12;

  MEANR6=I1_1*RAIN6-I1_2*LAG(RAIN6)-I1_3*LAG2(RAIN6)-
    I1_4*LAG3(RAIN6)-I1_5*LAG4(RAIN6)-I1_6*LAG5(RAIN6)-
    I1_7*LAG7(RAIN6);

  VARS6= (S2_1**2)*DUM1 + (S3_1**2)*DUM2 + (S4_1**2)*DUM3 +
      (S5_1**2)*DUM4 + (S6_1**2)*DUM5 + (S7_1**2)*DUM6 +
      (S8_1**2)*DUM7 + (S9_1**2)*DUM8 + (S10_1**2)*DUM9 +
      (S11_1**2)*DUM10 + (S12_1**2)*DUM11 + (S13_1**2)*DUM12;

  VARR6= (S1_1**2)*(RAIN6**2) +
      (S1_2**2)*LAG(RAIN6)**2 +
      (S1_3**2)*LAG2(RAIN6)**2 +
      (S1_4**2)*LAG3(RAIN6)**2 +
      (S1_5**2)*LAG4(RAIN6)**2 +
      (S1_6**2)*LAG5(RAIN6)**2 +
      (S1_7**2)*LAG7(RAIN6)**2;
```

```
%DROP1

NEWNAT6=REGION6-MEANS6-MEANR6;

*??? REGION 5 ;

PROC ARIMA DATA=ONES;

   IDENTIFY VAR=RAIN5 NLAG=24;
   ESTIMATE P=(1,7,9) Q=(12) ML PLOT;
   TITLE1 'REGION 5: FIRST ARIMA';

   IDENTIFY VAR=REGION5 CROSSCORR=(RAIN5 DUM1 DUM2 DUM3
    DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12) NLAG=22;
   ESTIMATE P=(1,3,7) ML PLOT NOINT
    INPUT=((1,2,3,4,5,6,7) RAIN5 DUM1 DUM2
    DUM3 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12)
    OUTEST=ESTS;

%PARAMETR

**** ADJUST DATA FOR SEASONALITY AND PRECIPITATION CORRELATION **;

DATA NAT5; SET ONE3;
 MEANS5=I2_1*DUM1+ I3_1*DUM2 + I4_1*DUM3 + I5_1* DUM4 +
 I6_1*DUM5+ I7_1*DUM6 +I8_1*DUM7+I9_1* DUM8+
 I10_1*DUM9+I11_1*DUM10+I12_1*DUM11+I13_1*DUM12;

 MEANR5=I1_1*RAIN5-I1_2*LAG(RAIN5)-I1_3*LAG2(RAIN5)-
   I1_4*LAG3(RAIN5)-I1_5*LAG4(RAIN5)-I1_6*LAG5(RAIN5)-
   I1_7*LAG6(RAIN5)-I1_8*LAG7(RAIN5);

 VARS5= (S2_1**2)*DUM1 + (S3_1**2)*DUM2 + (S4_1**2)*DUM3 +
      (S5_1**2)*DUM4 + (S6_1**2)*DUM5 + (S7_1**2)*DUM6 +
      (S8_1**2)*DUM7 + (S9_1**2)*DUM8 + (S10_1**2)*DUM9 +
      (S11_1**2)*DUM10 + (S12_1**2)*DUM11 + (S13_1**2)*DUM12;

 VARR5= (S1_1**2)*(RAIN5**2) +
      (S1_2**2)*LAG(RAIN5)**2 +
      (S1_3**2)*LAG2(RAIN5)**2 +
      (S1_4**2)*LAG3(RAIN5)**2 +
      (S1_5**2)*LAG4(RAIN5)**2 +
      (S1_6**2)*LAG5(RAIN5)**2 +
      (S1_7**2)*LAG6(RAIN5)**2 +
      (S1_8**2)*LAG7(RAIN5)**2;

 %DROP1

 NEWNAT5=REGION5-MEANS5-MEANR5;
```

```
*??? REGION 4 ;

PROC ARIMA DATA=ONES;

    IDENTIFY VAR=RAIN4 NLAG=24;
    ESTIMATE P=(1,3,7,10,19) Q=(1) ML PLOT;
    TITLE1 'REGION 4: FIRST ARIMA';

    IDENTIFY VAR=REGION4 CROSSCORR=(RAIN4 DUM1 DUM2 DUM3
     DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12) NLAG=22;
    ESTIMATE P=(1,8) Q=(11)(12) ML PLOT NOINT
     INPUT=((9,10,13,14) RAIN4 DUM1 DUM2
     DUM3 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12)
     OUTEST=ESTS;

%PARAMETR

**** ADJUST DATA FOR SEASONALITY AND PRECIPITATION CORRELATION **;

DATA NAT4; SET ONE3;
 MEANS4=I2_1*DUM1+ I3_1*DUM2 + I4_1*DUM3 + I5_1* DUM4 +
 I6_1*DUM5+ I7_1*DUM6 +I8_1*DUM7+I9_1* DUM8+
 I10_1*DUM9+I11_1*DUM10+I12_1*DUM11+I13_1*DUM12;

 MEANR4=I1_1*RAIN4-I1_2*LAG9(RAIN4)-I1_3*LAG10(RAIN4)-
  I1_4*LAG13(RAIN4)-I1_5*LAG14(RAIN4);

 VARS4= (S2_1**2)*DUM1 + (S3_1**2)*DUM2 + (S4_1**2)*DUM3 +
      (S5_1**2)*DUM4 + (S6_1**2)*DUM5 + (S7_1**2)*DUM6 +
      (S8_1**2)*DUM7 + (S9_1**2)*DUM8 + (S10_1**2)*DUM9 +
      (S11_1**2)*DUM10 + (S12_1**2)*DUM11 + (S13_1**2)*DUM12;

 VARR4= (S1_1**2)*(RAIN4**2) +
      (S1_2**2)*LAG9(RAIN4)**2 +
      (S1_3**2)*LAG10(RAIN4)**2 +
      (S1_4**2)*LAG13(RAIN4)**2 +
      (S1_5**2)*LAG14(RAIN4)**2;

 %DROP1

 NEWNAT4=REGION4-MEANS4-MEANR4;

*??? REGION 3 ;

PROC ARIMA DATA=ONES;

    IDENTIFY VAR=RAIN3 NLAG=24;
    ESTIMATE P=(1,8,10,11,17,20) Q=(6)(12) ML PLOT;
    TITLE1 'REGION 3: FIRST ARIMA';
```

```
IDENTIFY VAR=REGION3 CROSSCORR=(RAIN3 DUM1 DUM2 DUM3
 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12) NLAG=22;
ESTIMATE P=(1,5) ML PLOT NOINT
 INPUT=((1,2,3,4,6) RAIN3 DUM1 DUM2
 DUM3 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12)
 OUTEST=ESTS;

%PARAMETR

**** ADJUST DATA FOR SEASONALITY AND PRECIPITATION CORRELATION **;

DATA NAT3; SET ONE3;
 MEANS3=I2_1*DUM1+ I3_1*DUM2 + I4_1*DUM3 + I5_1* DUM4 +
 I6_1*DUM5+ I7_1*DUM6 +I8_1*DUM7+I9_1* DUM8+
 I10_1*DUM9+I11_1*DUM10+I12_1*DUM11+I13_1*DUM12;

 MEANR3=I1_1*RAIN3-I1_2*LAG(RAIN3)-I1_3*LAG2(RAIN3)-
  I1_4*LAG3(RAIN3)-I1_5*LAG4(RAIN3)-I1_6*LAG6(RAIN3);

 VARS3= (S2_1**2)*DUM1 + (S3_1**2)*DUM2 + (S4_1**2)*DUM3 +
      (S5_1**2)*DUM4 + (S6_1**2)*DUM5 + (S7_1**2)*DUM6 +
      (S8_1**2)*DUM7 + (S9_1**2)*DUM8 + (S10_1**2)*DUM9 +
      (S11_1**2)*DUM10 + (S12_1**2)*DUM11 + (S13_1**2)*DUM12;

 VARR3= (S1_1**2)*(RAIN3**2) +
      (S1_2**2)*LAG(RAIN3)**2 +
      (S1_3**2)*LAG2(RAIN3)**2 +
      (S1_4**2)*LAG3(RAIN3)**2 +
      (S1_5**2)*LAG4(RAIN3)**2 +
      (S1_6**2)*LAG6(RAIN3)**2;

 %DROP1

 NEWNAT3=REGION3-MEANS3-MEANR3;

*??? REGION 2 ;

PROC ARIMA DATA=ONES;

  IDENTIFY VAR=RAIN2 NLAG=24;
  ESTIMATE P=(1,17) ML PLOT;
  TITLE1 'REGION 2: FIRST ARIMA';

  IDENTIFY VAR=REGION2 CROSSCORR=(RAIN2 DUM1 DUM2 DUM3
   DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12) NLAG=22;
  ESTIMATE P=(1,8) Q=(1) ML PLOT NOINT
   INPUT=((1,2,3,4,5,8,9) RAIN2 DUM1 DUM2
   DUM3 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12)
   OUTEST=ESTS;

%PARAMETR
```

```
**** ADJUST DATA FOR SEASONALITY AND PRECIPITATION CORRELATION **;

DATA NAT2; SET ONE3;
 MEANS2=I2_1*DUM1+ I3_1*DUM2 + I4_1*DUM3 + I5_1* DUM4 +
 I6_1*DUM5+ I7_1*DUM6 +I8_1*DUM7+I9_1* DUM8+
 I10_1*DUM9+I11_1*DUM10+I12_1*DUM11+I13_1*DUM12;

 MEANR2=I1_1*RAIN2-I1_2*LAG(RAIN2)-I1_3*LAG2(RAIN2)-
  I1_4*LAG3(RAIN2)-I1_5*LAG4(RAIN2)-I1_6*LAG5(RAIN2)-
  I1_7*LAG8(RAIN2)-I1_8*LAG9(RAIN2);

 VARS2= (S2_1**2)*DUM1 + (S3_1**2)*DUM2 + (S4_1**2)*DUM3 +
      (S5_1**2)*DUM4 + (S6_1**2)*DUM5 + (S7_1**2)*DUM6 +
      (S8_1**2)*DUM7 + (S9_1**2)*DUM8 + (S10_1**2)*DUM9 +
      (S11_1**2)*DUM10 + (S12_1**2)*DUM11 + (S13_1**2)*DUM12;

 VARR2= (S1_1**2)*(RAIN2**2) +
      (S1_2**2)*LAG(RAIN2)**2 +
      (S1_3**2)*LAG2(RAIN2)**2 +
      (S1_4**2)*LAG3(RAIN2)**2 +
      (S1_5**2)*LAG4(RAIN2)**2 +
      (S1_6**2)*LAG5(RAIN2)**2 +
      (S1_7**2)*LAG8(RAIN2)**2 +
      (S1_8**2)*LAG9(RAIN2)**2 ;

 %DROP1

 NEWNAT2=REGION2-MEANS2-MEANR2;


*??? REGION 1 ;

PROC ARIMA DATA=ONES;

   IDENTIFY VAR=RAIN1 NLAG=24;
   ESTIMATE P=(3) ML PLOT;
   TITLE1 'REGION 1: FIRST ARIMA';

   IDENTIFY VAR=REGION1 CROSSCORR=(RAIN1 DUM1 DUM2 DUM3
    DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12) NLAG=22;
   ESTIMATE P=(1,9) ML PLOT NOINT
    INPUT=((1,2,3,4,5,7) RAIN1 DUM1 DUM2
    DUM3 DUM4 DUM5 DUM6 DUM7 DUM8 DUM9 DUM10 DUM11 DUM12)
    OUTEST=ESTS;


%PARAMETR

**** ADJUST DATA FOR SEASONALITY AND PRECIPITATION CORRELATION **;

DATA NAT1; SET ONE3;
 MEANS1=I2_1*DUM1+ I3_1*DUM2 + I4_1*DUM3 + I5_1* DUM4 +
 I6_1*DUM5+ I7_1*DUM6 +I8_1*DUM7+I9_1* DUM8+
 I10_1*DUM9+I11_1*DUM10+I12_1*DUM11+I13_1*DUM12;
```

```
MEANR1=I1_1*RAIN1-I1_2*LAG(RAIN1)-I1_3*LAG2(RAIN1)-
  I1_4*LAG3(RAIN1)-I1_5*LAG4(RAIN1)-I1_6*LAG5(RAIN1)-
  I1_7*LAG7(RAIN1);

VARS1= (S2_1**2)*DUM1 + (S3_1**2)*DUM2 + (S4_1**2)*DUM3 +
     (S5_1**2)*DUM4 + (S6_1**2)*DUM5 + (S7_1**2)*DUM6 +
     (S8_1**2)*DUM7 + (S9_1**2)*DUM8 + (S10_1**2)*DUM9 +
     (S11_1**2)*DUM10 + (S12_1**2)*DUM11 + (S13_1**2)*DUM12;

VARR1= (S1_1**2)*(RAIN1**2) +
     (S1_2**2)*LAG(RAIN1)**2 +
     (S1_3**2)*LAG2(RAIN1)**2 +
     (S1_4**2)*LAG3(RAIN1)**2 +
     (S1_5**2)*LAG4(RAIN1)**2 +
     (S1_6**2)*LAG5(RAIN1)**2 +
     (S1_7**2)*LAG7(RAIN1)**2;

%DROP1

NEWNAT1=REGION1-MEANS1-MEANR1;


**** MERGE ALL DATA SETS WITH ALTERED DATA ****;

DATA NAT;

 MERGE NAT1 (IN=A) NAT2 (IN=B) NAT3 (IN=C) NAT4 (IN=D) NAT5 (IN=E)
      NAT6 (IN=F) NAT7 (IN=G) NAT8 (IN=H) NAT9 (IN=I);
 BY YR MONTH;

 IF (A OR B OR C OR D OR E OR F OR G OR H OR I) THEN OUTPUT;

**** BEGIN ALL REGIONS TOGETHER ****;

DATA NATS; SET NAT;
   IF _N_ LE NUMAA;

**** RUN ARIMA WITH ADJUSTED DATA ****;

*??? REGION 9 ****;
PROC ARIMA DATA=NATS;

  IDENTIFY VAR=NEWNAT9 NLAG=24;
  ESTIMATE P=(1,9) Q=(1,4,8,15,17)(12,13) ML PLOT NOINT;
  TITLE 'REGION 9: SECOND ARIMA';

  FORECAST LEAD=36 OUT=OUTNAT;

DATA OUTNAT9; SET OUTNAT;
  %YRCAL
  FORE9=FORECAST;
  STDEV9=STD;
```

```
*??? REGION 8 ****;
PROC ARIMA DATA=NATS;

  IDENTIFY VAR=NEWNAT8 NLAG=24;
  ESTIMATE P=(1) Q=(2) ML PLOT NOINT;
  TITLE 'REGION 8: SECOND ARIMA';

  FORECAST LEAD=36 OUT=OUTNAT;

DATA OUTNAT8; SET OUTNAT;
  %YRCAL
  FORE8=FORECAST;
  STDEV8=STD;

*??? REGION 7 ****;
PROC ARIMA DATA=NATS;

  IDENTIFY VAR=NEWNAT7 NLAG=24;
  ESTIMATE P=(1,7,17) Q=(11) ML PLOT NOINT;
  TITLE 'REGION 7: SECOND ARIMA';

  FORECAST LEAD=36 OUT=OUTNAT;

DATA OUTNAT7; SET OUTNAT;
  %YRCAL
  FORE7=FORECAST;
  STDEV7=STD;

*??? REGION 6 ****;
PROC ARIMA DATA=NATS;

  IDENTIFY VAR=NEWNAT6 NLAG=24;
  ESTIMATE P=(1,2) ML PLOT NOINT;
  TITLE 'REGION 6: SECOND ARIMA';

  FORECAST LEAD=36 OUT=OUTNAT;

DATA OUTNAT6; SET OUTNAT;
  %YRCAL
  FORE6=FORECAST;
  STDEV6=STD;

*??? REGION 5 ****;
PROC ARIMA DATA=NATS;

  IDENTIFY VAR=NEWNAT5 NLAG=24;
  ESTIMATE P=(1,3,7) ML PLOT NOINT;
  TITLE 'REGION 5: SECOND ARIMA';

  FORECAST LEAD=36 OUT=OUTNAT;

DATA OUTNAT5; SET OUTNAT;
  %YRCAL
  FORE5=FORECAST;
  STDEV5=STD;
```

```
*??? REGION 4 ****;
PROC ARIMA DATA=NATS;

  IDENTIFY VAR=NEWNAT4 NLAG=24;
  ESTIMATE P=(1,8) Q=(11)(12) ML PLOT NOINT;
  TITLE 'REGION 4: SECOND ARIMA';

  FORECAST LEAD=36 OUT=OUTNAT;

DATA OUTNAT4; SET OUTNAT;
  %YRCAL
  FORE4=FORECAST;
  STDEV4=STD;

*??? REGION 3 ****;
PROC ARIMA DATA=NATS;

  IDENTIFY VAR=NEWNAT3 NLAG=24;
  ESTIMATE P=(1,5) ML PLOT NOINT;
  TITLE 'REGION 3: SECOND ARIMA';

  FORECAST LEAD=36 OUT=OUTNAT;

DATA OUTNAT3; SET OUTNAT;
  %YRCAL
  FORE3=FORECAST;
  STDEV3=STD;

*??? REGION 2 ****;
PROC ARIMA DATA=NATS;

  IDENTIFY VAR=NEWNAT2 NLAG=24;
  ESTIMATE P=(1,8) Q=(1) ML PLOT NOINT;
  TITLE 'REGION 2: SECOND ARIMA';

  FORECAST LEAD=36 OUT=OUTNAT;

DATA OUTNAT2; SET OUTNAT;
  %YRCAL
  FORE2=FORECAST;
  STDEV2=STD;

*??? REGION 1 ****;
PROC ARIMA DATA=NATS;

  IDENTIFY VAR=NEWNAT1 NLAG=24;
  ESTIMATE P=(1,9) ML PLOT NOINT;
  TITLE 'REGION 1: SECOND ARIMA';

  FORECAST LEAD=36 OUT=OUTNAT;

DATA OUTNAT1; SET OUTNAT;
  %YRCAL
  FORE1=FORECAST;
  STDEV1=STD;
```

```
**** MERGE ALL OUTPUT DATASETS ****;

DATA ONE4;

 MERGE OUTNAT9 (IN=A) OUTNAT8 (IN=B)
       OUTNAT7 (IN=C) OUTNAT6 (IN=D)
       OUTNAT5 (IN=E) OUTNAT4 (IN=F)
       OUTNAT3 (IN=G) OUTNAT2 (IN=H)
       OUTNAT1 (IN=I) NAT (IN=J);
 BY YR MONTH;

 IF (A OR B OR C OR D OR E OR F OR G OR H OR I OR J) THEN OUTPUT;

**** ADJUST FORECAST FOR # OF DAYS PER MONTH AND OUTPUT ****;

DATA OUTALL (KEEP= YR MONTH F1-F9 STDEV1-STDEV9
             U95CI1-U95CI9 L95CI1-L95CI9);
  SET ONE4;
  ARRAY F(*) F1-F9;
  ARRAY FORE(*) FORE1-FORE9;
  ARRAY VARS(*) VARS1-VARS9;
  ARRAY VARR(*) VARR1-VARR9;
  ARRAY STDEV(*) STDEV1-STDEV9;
  ARRAY STDF(*) STDF1-STDF9;
  ARRAY MEANR(*) MEANR1-MEANR9;
  ARRAY MEANS(*) MEANS1-MEANS9;
  ARRAY U95CI(*) U95CI1-U95CI9;
  ARRAY L95CI(*) L95CI1-L95CI9;
%NUMDAYS
%FOREDAYS

DATA PP;
  SET OUTALL NOBS=NUM;
  EXTRA=NUM-35;
  IF _N_ GE EXTRA;
  DROP NUM EXTRA;
  NATIONAL=F1+F2+F3+F4+F5+F6+F7+F8+F9;


 PROC PRINT DATA=PP;
 VAR YR MONTH F1-F9 NATIONAL;
 TITLE 'FORECAST OF HYDROELECTRIC GENERATION BY REGION';


 PROC PRINT DATA=PP;
 VAR YR MONTH U95CI1-U95CI9;
 TITLE 'UPPER 95 % CONFIDENCE INTERVAL';


 PROC PRINT DATA=PP;
 VAR YR MONTH L95CI1-L95CI9;
 TITLE 'LOWER 95 % CONFIDENCE INTERVAL';
```

Variable Definitions

YR	year
MONTH	month
REGION(*)	array of regional hydroelectric generation data
NUMAA	number of observations of national hydroelectric generation data
RAIN(*)	array of regional precipitation data
NUMRR	number of observations of national precipitation data
$DAYS_k$	number of days in month k
$DUM_{t,k}$	monthly dummy variables where $DUM_{t,k} = 1$ if t observed in month k and $DUM_{t,k} = 0$ otherwise
MEANS(*)	array of average seasonal effect of the hydroelectric generation data for each region; calculated using coefficients of the dummy variables from the procedure ARIMA runs
MEANR(*)	array of average impact of past and present changes in precipitation for each region; calculated using coefficients of the lags of the correlated precipitation data from the procedure ARIMA runs
VARS(*)	array of variance of the estimated seasonal mean of the hydroelectric generation data for each region
VARR(*)	array of variance of the estimated mean of the changes in precipitation for each region; calculated using the approximate standard error of the estimated coefficients from the procedure ARIMA runs
NEWNAT(*)	array of regional hydroelectric generation data which has been adjusted for the effects of seasonality and assumed normal forecasted precipitation
F(*)	array of readjusted regional forecasts for hydroelectric generation
FORE(*)	array of regional forecasts of hydroelectric generation from the procedure ARIMA run on the adjusted hydroelectric generation data
STDF(*)	array of estimations of the standard deviation of the readjusted regional hydroelectric generation forecast
STDEV(*)	array of standard deviations for the regional hydroelectric generation from the procedure ARIMA run on the adjusted regional hydroelectric generation data
U95CI(*)	array of estimated upper 95 percent confidence intervals for the readjusted regional hydroelectric generation forecasts
L95CI(*)	array of estimated lower 95 percent confidence intervals for the readjusted regional hydroelectric generation forecasts
NATIONAL	national hydroelectric generation data

Appendix C. Data

Table C1. Out of Sample and *STEO* Forecasts Using Actual Data through 1989 Compared with Actual Hydroelectric Generation, 1990-1991

Year	Month	Net Hydroelectric Generation	Forecasts	
			STHGM	STEO
1989	January	20.9	NA	NA
	February	18.6	NA	NA
	March	22.6	NA	NA
	April	24.1	NA	NA
	May	28.0	NA	NA
	June	25.9	NA	NA
	July	22.7	NA	NA
	August	20.2	NA	NA
	September	18.9	NA	NA
	October	20.1	NA	NA
	November	21.2	NA	NA
	December	21.8	NA	NA
1990	January	23.4	23.4	22.2
	February	24.2	22.1	20.7
	March	28.0	25.1	22.7
	April	25.4	24.4	24.5
	May	27.0	26.9	27.3
	June	27.7	25.9	25.8
	July	23.7	23.3	23.9
	August	21.0	20.4	21.9
	September	17.0	18.2	19.6
	October	18.6	18.9	19.9
	November	20.0	20.7	22.0
	December	24.0	23.8	25.6
1991	January	25.7	24.4	26.5
	February	21.9	22.3	24.5
	March	25.8	24.9	26.7
	April	25.7	24.2	26.2
	May	28.5	25.7	28.2
	June	25.8	24.7	26.6
	July	24.3	23.1	24.7
	August	21.7	21.0	22.2
	September	18.4	18.6	19.9
	October	17.5	18.7	19.9
	November	18.3	20.2	22.0
	December	21.9	23.4	25.6

Notes: •All forecasts are based on actual generation and precipitation data through the indicated year. •All forecasts assume normal precipitation during the forecast period.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 13, 1990. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.TIME.SERIES.FINAL.D060193. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Table C2. Out of Sample and *STEO* Forecasts Using Actual Data through 1990 Compared with Actual Hydroelectric Generation, 1991-1992

Year	Month	Net Hydroelectric Generation	Forecast	
			STHGM	STEO
1990	January	23.4	NA	NA
	February	24.2	NA	NA
	March	28.0	NA	NA
	April	25.4	NA	NA
	May	27.0	NA	NA
	June	27.7	NA	NA
	July	23.7	NA	NA
	August	21.0	NA	NA
	September	17.0	NA	NA
	October	18.6	NA	NA
	November	20.0	NA	NA
	December	24.0	NA	NA
1991	January	25.7	24.4	24.2
	February	21.9	22.0	23.0
	March	25.8	25.1	26.3
	April	25.7	24.5	25.6
	May	28.5	25.2	27.8
	June	25.8	24.3	25.9
	July	24.3	23.3	24.7
	August	21.7	21.1	22.6
	September	18.4	18.7	20.3
	October	17.5	18.3	20.3
	November	18.3	19.8	22.4
	December	21.9	23.1	26.0
1992	January	21.5	24.5	25.0
	February	18.0	23.1	23.8
	March	21.6	25.1	27.2
	April	19.5	24.4	26.5
	May	22.3	26.0	28.7
	June	22.7	24.8	26.8
	July	19.7	23.5	25.5
	August	18.1	21.4	23.4
	September	16.8	19.0	21.0
	October	16.4	19.0	21.0
	November	19.3	20.4	23.2
	December	23.8	23.5	26.9

Notes: •All forecasts are based on actual generation and precipitation data through the indicated year. •All forecasts assume normal precipitation during the forecast period.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 19, 1991. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.TIME.SERIES.FINAL.D060193. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Table C3. Out of Sample and *STEO* Forecasts Using Actual Data through 1991 Compared with Actual Hydroelectric Generation, 1992-1993

Year	Month	Net Hydroelectric Generation	Forecasts	
			STHGM	STEO
1991	January	25.7	NA	NA
	February	21.9	NA	NA
	March	25.8	NA	NA
	April	25.7	NA	NA
	May	28.5	NA	NA
	June	25.8	NA	NA
	July	24.3	NA	NA
	August	21.7	NA	NA
	September	18.4	NA	NA
	October	17.5	NA	NA
	November	18.3	NA	NA
	December	21.9	NA	NA
1992	January	21.5	23.6	24.8
	February	18.0	22.3	21.7
	March	21.6	23.8	25.4
	April	19.5	23.3	24.8
	May	22.3	25.1	27.3
	June	22.7	24.3	25.1
	July	19.7	22.7	23.8
	August	18.1	20.9	21.8
	September	16.8	18.6	19.3
	October	16.4	18.4	20.4
	November	19.3	19.8	22.6
	December	23.8	22.8	26.2
1993	January	24.5	24.1	26.8
	February	19.7	22.2	24.6
	March	23.6	25.0	27.1
	April	25.2	24.3	26.2
	May	29.3	25.9	28.3
	June	26.6	24.9	26.3
	July	23.6	23.3	24.2
	August	19.7	21.3	22.4
	September	17.1	18.9	20.6
	October	16.9	19.0	20.8
	November	17.9	20.4	22.6
	December	21.1	23.6	26.2

Notes: •All forecasts are based on actual generation and precipitation data through the indicated year. •All forecasts assume normal precipitation during the forecast period.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 6, 1992. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.TIME.SERIES.FINAL.D060193. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Table C4. Out of Sample (Regional STHGM) and *STEO* Forecasts Using Actual Generation Data through 1992 with Actual Hydroelectric Generation, 1993-1994

Year	Month	Net Hydroelectric Generation	Forecasts	
			STHGM	STEO
1992	January	21.5	NA	NA
	February	18.0	NA	NA
	March	21.6	NA	NA
	April	19.5	NA	NA
	May	22.3	NA	NA
	June	22.7	NA	NA
	July	19.7	NA	NA
	August	18.1	NA	NA
	September	16.8	NA	NA
	October	16.4	NA	NA
	November	19.3	NA	NA
	December	23.8	NA	NA
1993	January	24.5	24.1	22.9
	February	19.7	21.3	20.6
	March	23.6	23.4	23.6
	April	25.2	23.4	24.5
	May	29.3	25.4	27.3
	June	26.6	24.9	24.8
	July	23.6	23.4	24.1
	August	19.7	20.6	21.6
	September	17.1	18.6	19.9
	October	16.9	18.7	20.6
	November	17.9	20.4	21.7
	December	21.1	23.7	24.5
1994	January	19.8	24.6	25.8
	February	19.1	22.5	23.1
	March	22.2	25.2	26.6
	April	23.2	24.4	26.2
	May	24.3	26.2	29.1
	June	23.4	25.0	27.1
	July	21.9	23.6	24.8
	August	19.1	21.5	22.3
	September	15.4	19.0	20.1
	October	16.4	19.2	20.6
	November	17.9	20.7	21.9
	December	20.9	23.8	25.0

Notes: •*All forecasts are based on actual generation data through 1992 and* precipitation data through June of 1992. •All forecasts assume normal precipitation after the last month of available actual data.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 8, 1993. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.MODEL. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Table C5. Out of Sample (Regional STHGM) and *STEO* Forecasts Using Actual Generation Data through 1993 Compared with Actual Hydroelectric Generation, 1994-1995

Year	Month	Net Hydroelectric Generation	Forecasts	
			STHGM	STEO
1993	January	24.5	NA	NA
	February	19.7	NA	NA
	March	23.6	NA	NA
	April	25.2	NA	NA
	May	29.3	NA	NA
	June	26.6	NA	NA
	July	23.6	NA	NA
	August	19.7	NA	NA
	September	17.1	NA	NA
	October	16.9	NA	NA
	November	17.9	NA	NA
	December	21.1	NA	NA
1994	January	19.8	22.0	22.9
	February	19.1	19.6	20.8
	March	22.2	22.4	23.0
	April	23.2	22.4	22.9
	May	24.3	25.3	25.4
	June	23.4	25.0	25.0
	July	21.9	23.1	22.8
	August	19.1	20.6	20.3
	September	15.4	18.5	17.8
	October	16.4	18.5	18.1
	November	17.9	20.5	19.5
	December	20.9	23.4	22.6
1995	January	23.3	24.2	23.8
	February	24.0	22.1	22.0
	March	27.5	25.1	24.7
	April	23.5	24.5	24.1
	May	26.6	26.5	25.8
	June	28.4	25.2	24.8
	July	25.9	23.6	23.2
	August	23.0	21.3	21.2
	September	18.8	18.9	18.8
	October	21.4	19.0	18.9
	November	24.0	20.7	20.4
	December	27.3	23.9	23.6

Notes: •All forecasts are based on actual generation data through 1993 and precipitation data through June of 1993. •All forecasts assume normal precipitation after the last month of available actual data.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 7, 1994. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.MODEL. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Table C6. Out of Sample (Regional STHGM) and *STEO* Forecasts for Region 9 Using Actual Generation Data through 1993 Compared with Actual Hydroelectric Generation, 1994-1995

Year	Month	Net Hydroelectric Generation	Forecasts	
			STHGM	STEO
1993	January	11.0	NA	NA
	February	9.8	NA	NA
	March	11.6	NA	NA
	April	12.5	NA	NA
	May	17.6	NA	NA
	June	16.3	NA	NA
	July	14.3	NA	NA
	August	11.2	NA	NA
	September	9.3	NA	NA
	October	9.1	NA	NA
	November	9.5	NA	NA
	December	9.9	NA	NA
1994	January	9.6	10.8	12.4
	February	9.1	9.6	11.3
	March	10.3	10.9	12.5
	April	10.5	11.3	12.4
	May	12.9	14.1	13.8
	June	13.5	14.5	13.6
	July	11.7	13.1	12.4
	August	8.8	11.1	11.0
	September	7.0	9.8	9.7
	October	7.9	9.7	9.8
	November	8.6	10.9	10.6
	December	10.4	12.4	12.2
1995	January	12.6	12.9	12.9
	February	14.1	12.0	11.9
	March	15.6	13.5	13.4
	April	15.0	13.2	13.1
	May	17.0	15.1	14.0
	June	18.2	14.5	13.5
	July	15.6	13.4	12.6
	August	12.5	11.7	11.5
	September	10.3	10.0	10.2
	October	11.5	10.1	10.3
	November	12.5	11.0	11.1
	December	16.5	12.7	12.8

Notes: •All forecasts are based on actual generation data through 1993 and precipitation data through June of 1993. •All forecasts assume normal precipitation after the last month of available actual data.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 7, 1994. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.MODEL. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

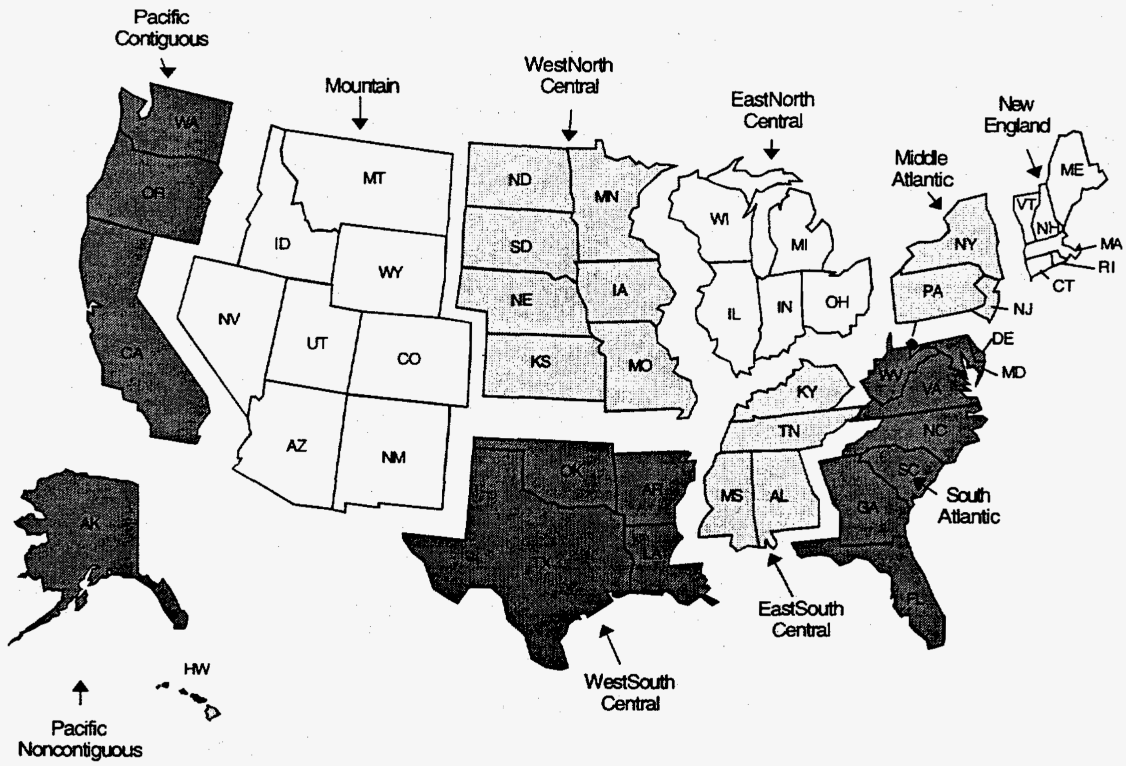
Table C7. Out of Sample (Regional STHGM) and *STEO* Forecasts for Region 5 Using Actual Generation Data through 1993 Compared with Actual Hydroelectric Generation, 1994-1995

Year	Month	Net Hydroelectric Generation	Forecasts	
			STHGM	STEO
1993	January	2.7	NA	NA
	February	1.9	NA	NA
	March	2.4	NA	NA
	April	2.3	NA	NA
	May	1.4	NA	NA
	June	0.8	NA	NA
	July	0.6	NA	NA
	August	0.6	NA	NA
	September	0.5	NA	NA
	October	0.5	NA	NA
	November	0.6	NA	NA
	December	1.2	NA	NA
1994	January	1.2	1.4	1.3
	February	1.5	1.3	1.2
	March	1.9	1.7	1.3
	April	1.9	1.5	1.3
	May	0.9	1.3	1.4
	June	.9	1.0	1.4
	July	1.1	0.9	1.3
	August	1.8	0.9	1.1
	September	1.1	0.8	1.0
	October	1.1	0.9	1.0
	November	1.1	1.1	1.1
	December	1.4	1.4	1.3
1995	January	1.6	1.5	1.3
	February	1.6	1.5	1.2
	March	1.8	1.8	1.4
	April	0.7	1.6	1.3
	May	0.7	1.4	1.4
	June	0.9	1.1	1.4
	July	0.9	1.0	1.3
	August	0.8	1.0	1.2
	September	0.7	0.9	1.0
	October	1.2	1.0	1.0
	November	1.6	1.1	1.1
	December	1.1	1.4	1.3

Notes: •All forecasts are based on actual generation data through 1993 and precipitation data through June of 1993. •All forecasts assume normal precipitation after the last month of available actual data.

Source: **STEO Forecasts:** Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels memo to Office of Energy Markets and End Use dated March 7, 1994. **STHGM Forecasts:** Energy Information Administration, STHGM run using HYDRO.MODEL. **Actual:** Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Appendix D. Census Divisions



Source: United States Bureau of the Census.

Appendix E. ARIMA Output Containing Estimated Dummy Variable and Precipitation Lag Parameters for Each Region

Table E1. REGION 1: FIRST ARIMA
ARIMA Procedure
Maximum Likelihood Estimation

			Approximate			
Parameter	Estimate	Std Error	T Ratio	Lag	Variable	Shift
AR1,1	0.32716	0.05697	5.74	1	REGION1	0
AR1,2	0.09857	0.06022	1.64	9	REGION1	0
NUM1	30.97437	2.60164	11.91	0	RAIN1	0
NUM1,1	-29.02922	2.67429	-10.85	1	RAIN1	0
NUM1,2	-21.81069	2.69897	-8.08	2	RAIN1	0
NUM1,3	-12.75138	2.70353	-4.72	3	RAIN1	0
NUM1,4	-6.03342	2.69117	-2.24	4	RAIN1	0
NUM1,5	-7.28596	2.56361	-2.84	5	RAIN1	0
NUM1,6	-2.86038	2.43221	-1.18	7	RAIN1	0
NUM2	-1.26783	1.14070	-1.11	0	DUM1	0
NUM3	0.23437	1.09256	0.21	0	DUM2	0
NUM4	3.29200	1.07962	3.05	0	DUM3	0
NUM5	6.24873	1.06476	5.87	0	DUM4	0
NUM6	4.41512	1.05036	4.20	0	DUM5	0
NUM7	-1.00352	1.07464	-0.93	0	DUM6	0
NUM8	-5.04584	1.09137	-4.62	0	DUM7	0
NUM9	-5.82971	1.11906	-5.21	0	DUM8	0
NUM10	-5.85377	1.13067	-5.18	0	DUM9	0
NUM11	-2.96688	1.13874	-2.61	0	DUM10	0
NUM12	-1.10625	1.15259	-0.96	0	DUM11	0
NUM13	-0.39156	1.14756	-0.34	0	DUM12	0

Variance Estimate = 3.87080013
Std. Error Estimate = 1.96743491
AIC = 1273.64937
SBC = 1351.35868
Number of Residuals = 299

Table E2. REGION 2: FIRST ARIMA
ARIMA Procedure
Maximum Likelihood Estimation

Parameter	Estimate	Approximate Std. Error	T Ratio	Lag	Variable	Shift
MA1,1	0.19711	0.08904	2.21	1	REGION2	0
AR1,1	0.76742	0.05760	13.32	1	REGION2	0
AR1,2	0.09998	0.04256	2.35	8	REGION2	0
NUM1	50.18500	5.40395	9.29	0	RAIN2	0
NUM1,1	-58.57675	6.06958	-9.65	1	RAIN2	0
NUM1,2	-35.41456	6.44717	-5.49	2	RAIN2	0
NUM1,3	-28.37758	6.46572	-4.39	3	RAIN2	0
NUM1,4	-17.37502	6.12167	-2.84	4	RAIN2	0
NUM1,5	-19.53508	5.43458	-3.59	5	RAIN2	0
NUM1,6	-11.13276	5.05552	-2.20	8	RAIN2	0
NUM1,7	-14.20975	5.06152	-2.81	9	RAIN2	0
NUM2	47.26268	3.32644	14.21	0	DUM1	0
NUM3	49.41137	3.20753	15.40	0	DUM2	0
NUM4	57.44716	3.10451	18.50	0	DUM3	0
NUM5	56.29613	3.08097	18.27	0	DUM4	0
NUM6	53.73374	3.10359	17.31	0	DUM5	0
NUM7	46.52378	3.21574	14.47	0	DUM6	0
NUM8	39.96163	3.37783	11.83	0	DUM7	0
NUM9	37.01887	3.51676	10.53	0	DUM8	0
NUM10	36.41020	3.58125	10.17	0	DUM9	0
NUM11	39.70007	3.54343	11.20	0	DUM10	0
NUM12	49.64310	3.51844	14.11	0	DUM11	0
NUM13	52.48807	3.43597	15.28	0	DUM12	0

Variance Estimate = 14.1522228
Std Error Estimate = 3.76194402
AIC = 1652.84107
SBC = 1737.79691
Number of Residuals = 297

Table E3. REGION 3: FIRST ARIMA
ARIMA Procedure
Maximum Likelihood Estimation

			Approximate			
Parameter	Estimate	Std Error	T Ratio	Lag	Variable	Shift
AR1,1	0.53989	0.04937	10.94	1	REGION3	0
AR1,2	0.17526	0.04989	3.51	5	REGION3	0
NUM1	18.58225	2.67945	6.94	0	RAIN3	0
NUM1,1	-20.76281	2.88729	-7.19	1	RAIN3	0
NUM1,2	-13.69547	2.92567	-4.68	2	RAIN3	0
NUM1,3	-11.46399	2.87685	-3.98	3	RAIN3	0
NUM1,4	-7.76854	2.65863	-2.92	4	RAIN3	0
NUM1,5	-4.17651	2.50633	-1.67	6	RAIN3	0
NUM2	1.86045	0.98655	1.89	0	DUM1	0
NUM3	2.57332	0.89401	2.88	0	DUM2	0
NUM4	4.53200	0.86925	5.21	0	DUM3	0
NUM5	6.79340	0.85450	7.95	0	DUM4	0
NUM6	4.64072	0.94919	4.89	0	DUM5	0
NUM7	1.84177	1.03064	1.79	0	DUM6	0
NUM8	-0.82603	1.10425	-0.75	0	DUM7	0
NUM9	-1.96818	1.15578	-1.70	0	DUM8	0
NUM10	-0.84953	1.19452	-0.71	0	DUM9	0
NUM11	0.19339	1.17724	0.16	0	DUM10	0
NUM12	1.81097	1.14305	1.58	0	DUM11	0
NUM13	1.68889	1.08163	1.56	0	DUM12	0

Variance Estimate = 2.22688366
Std Error Estimate = 1.49227466
AIC = 1111.46519
SBC = 1185.54084
Number of Residuals = 300

Table E4. REGION 4: FIRST ARIMA
ARIMA Procedure
Maximum Likelihood Estimation

			Approximate			
Parameter	Estimate	Std Error	T Ratio	Lag	Variable	Shift
MA1,1	-0.12023	0.06450	-1.86	11	REGION4	0
MA2,1	-0.09457	0.06356	-1.49	12	REGION4	0
AR1,1	0.72888	0.04101	17.77	1	REGION4	0
AR1,2	0.07313	0.04366	1.68	8	REGION4	0
NUM1	-9.16199	7.69044	-1.19	0	RAIN4	0
NUM1,1	-19.73652	8.84313	-2.23	9	RAIN4	0
NUM1,2	-17.07626	8.89245	-1.92	10	RAIN4	0
NUM1,3	-11.97527	8.84900	-1.35	13	RAIN4	0
NUM1,4	-9.74195	8.95804	-1.09	14	RAIN4	0
NUM2	26.41504	2.27566	11.61	0	DUM1	0
NUM3	25.45865	2.42980	10.48	0	DUM2	0
NUM4	26.18127	2.64931	9.88	0	DUM3	0
NUM5	29.73292	2.74400	10.84	0	DUM4	0
NUM6	30.99500	2.82142	10.99	0	DUM5	0
NUM7	32.66785	2.94100	11.11	0	DUM6	0
NUM8	33.59860	2.99140	11.23	0	DUM7	0
NUM9	33.90268	2.84048	11.94	0	DUM8	0
NUM10	31.86042	2.63381	12.10	0	DUM9	0
NUM11	29.40386	2.45551	11.97	0	DUM10	0
NUM12	29.83701	2.29628	12.99	0	DUM11	0
NUM13	27.95204	2.21046	12.65	0	DUM12	0

Variance Estimate = 18.697746
Std Error Estimate = 4.32408904
AIC = 1705.25195
SBC = 1782.46378
Number of Residuals = 292

Table E5. REGION 5: FIRST ARIMA
ARIMA Procedure
Maximum Likelihood Estimation

			Approximate			
Parameter	Estimate	Std Error	T Ratio	Lag	Variable	Shift
AR1,1	0.46802	0.05354	8.74	1	REGION5	0
AR1,	0.13450	0.05549	2.42	3	REGION5	0
AR1,3	0.12530	0.05350	2.34	7	REGION5	0
NUM1	132.28522	10.77061	12.28	0	RAIN5	0
NUM1,1	-145.30453	11.41047	-12.73	1	RAIN5	0
NUM1,2	-70.55626	11.37731	-6.20	2	RAIN5	0
NUM1,3	-31.27813	11.44142	-2.73	3	RAIN5	0
NUM1,4	-37.77321	11.48769	-3.29	4	RAIN5	0
NUM1,5	-27.76961	11.44659	-2.43	5	RAIN5	0
NUM1,6	-22.05329	11.42586	-1.93	6	RAIN5	0
NUM1,7	-19.57495	10.78865	-1.81	7	RAIN5	0
NUM2	-11.21812	6.56380	-1.71	0	DUM1	0
NUM3	-8.81714	6.37095	-1.38	0	DUM2	0
NUM4	-6.79212	6.18395	-1.10	0	DUM3	0
NUM5	-7.45635	5.90769	-1.26	0	DUM4	0
NUM6	-15.90721	5.88121	-2.70	0	DUM5	0
NUM7	-29.03854	6.15195	-4.72	0	DUM6	0
NUM8	-41.79964	6.49370	-6.44	0	DUM7	0
NUM9	-45.22885	6.76757	-6.68	0	DUM8	0
NUM10	-46.11361	6.87316	-6.71	0	DUM9	0
NUM11	-37.11977	6.80680	-5.45	0	DUM10	0
NUM12	-26.14523	6.65821	-3.93	0	DUM11	0
NUM13	-14.59699	6.63753	-2.20	0	DUM12	0

Variance Estimate = 63.3734597
Std Error Estimate = 7.96074492
AIC = 2111.73838
SBC = 2196.84859
Number of Residuals = 299

Table E6. REGION 6: FIRST ARIMA
ARIMA Procedure
Maximum Likelihood Estimation

		Approximate				
Parameters	Estimate	St. Error	T Ratio	Lag	Variable	Shift
AR1,1	0.39999	0.05959	6.71	1	REGION6	0
AR1,2	0.13812	0.05983	2.31	2	REGION6	0
NUM1	127.60369	10.72076	11.90	0	RAIN6	0
NUM1,1	-131.22813	11.06416	-11.86	1	RAIN6	0
NUM1,2	-70.62778	11.34183	-6.23	2	RAIN6	0
NUM1,3	-58.54659	11.30710	-5.18	3	RAIN6	0
NUM1,4	-59.71659	11.08111	-5.39	4	RAIN6	0
NUM1,5	-27.36970	10.73523	-2.55	5	RAIN6	0
NUM1,6	-10.19426	10.25001	-0.99	7	RAIN6	0
NUM2	8.87288	6.16474	1.44	0	DUM1	0
NUM3	3.93678	6.47986	0.61	0	DUM2	0
NUM4	-5.68812	6.73989	-0.84	0	DUM3	0
NUM5	-20.64724	7.00780	-2.95	0	DUM4	0
NUM6	-25.46061	7.05445	-3.61	0	DUM5	0
NUM7	-24.93368	7.03086	-3.55	0	DUM6	0
NUM8	-25.22582	7.05546	-3.58	0	DUM7	0
NUM9	-20.66863	6.75302	-3.06	0	DUM8	0
NUM10	-21.93916	6.46586	-3.39	0	DUM9	0
NUM11	-18.82081	6.26673	-3.00	0	DUM10	0
NUM12	-11.71735	6.05148	-1.94	0	DUM11	0
NUM13	-0.07367	6.16153	-0.01	0	DUM12	0

Variance Estimate = 100.811818
Std Error Estimate = 10.0405088
AIC = 2248.39582
SBC = 2326.10514
Number of Residuals = 299

Table E7. REGION 7: FIRST ARIMA
ARIMA Procedure
Maximum Likelihood Estimation

			Approximate			
Parameter	Estimate	Std. Error	T Ratio	Lag	Variable	Shift
MA1,1	-0.13908	0.06228	-2.23	11	REGION7	0
AR1,1	0.62490	0.04673	13.37	1	REGION7	0
AR1,2	0.08829	0.04755	1.86	7	REGION7	0
AR1,3	-0.09010	0.04642	-1.94	17	REGION7	0
NUM1	57.51590	7.24461	7.94	0	RAIN7	0
NUM1,1	-83.21246	7.86509	-10.58	1	RAIN7	0
NUM1,2	-56.85843	8.16580	-6.96	2	RAIN7	0
NUM1,3	-38.33788	8.16511	-4.70	3	RAIN7	0
NUM1,4	-31.96039	7.84372	-4.07	4	RAIN7	0
NUM1,5	-18.55984	7.24935	-2.56	5	RAIN7	0
NUM1,6	0.22318	6.66795	0.03	7	RAIN7	0
NUM2	-6.61343	3.27410	-2.02	0	DUM1	0
NUM3	-4.31522	3.11555	-1.39	0	DUM2	0
NUM4	-0.28479	2.94580	-0.10	0	DUM3	0
NUM5	0.18115	2.95732	0.06	0	DUM4	0
NUM6	-4.43114	3.14464	-1.41	0	DUM5	0
NUM7	-8.03146	3.33700	-2.41	0	DUM6	0
NUM8	-13.37111	3.46792	-3.86	0	DUM7	0
NUM9	-16.40648	3.50933	-4.68	0	DUM8	0
NUM10	-18.71805	3.59181	-5.21	0	DUM9	0
NUM11	-20.69295	3.59412	-5.76	0	DUM10	0
NUM12	-15.17221	3.43924	-4.41	0	DUM11	0
NUM13	-9.26818	3.39393	-2.73	0	DUM12	0

Variance Estimate = 20.4297487
Std Error Estimate = 4.51992795
AIC = 1773.76133
SBC = 1858.87154
Number of Residuals = 299

Table E8. REGION 8: FIRST ARIMA
ARIMA Procedure
Maximum Likelihood Estimation

			Approximate			
Parameter	Estimate	Std Error	T Ratio	Lag	Variable	Shift
MA1,1	0.19921	0.06561	3.04	2	REGION8	0
AR1,1	0.93694	0.02265	41.37	1	REGION8	0
NUM1	17.12660	38.01592	0.45	0	RAIN8	0
NUM1,1	-77.88977	46.84543	-1.66	1	RAIN8	0
NUM1,2	-80.15278	47.42176	-1.69	2	RAIN8	0
NUM1,3	-124.79380	47.20417	-2.64	3	RAIN8	0
NUM1,4	-135.58321	38.29286	-3.54	4	RAIN8	0
NUM1,5	-43.81052	37.74573	-1.16	10	RAIN8	0
NUM1,6	13.95544	37.45018	0.37	11	RAIN8	0
NUM2	73.81276	8.34365	8.85	0	DUM1	0
NUM3	69.57116	8.19003	8.49	0	DUM2	0
NUM4	69.15844	8.29106	8.34	0	DUM3	0
NUM5	76.01582	8.41343	9.04	0	DUM4	0
NUM6	86.45438	8.69972	9.94	0	DUM5	0
NUM7	94.08019	9.08916	10.35	0	DUM6	0
NUM8	87.97149	9.28358	9.48	0	DUM7	0
NUM9	76.25540	9.45321	8.07	0	DUM8	0
NUM10	69.60030	9.48332	7.34	0	DUM9	0
NUM11	61.14777	9.26755	6.60	0	DUM10	0
NUM12	64.15687	9.04369	7.09	0	DUM11	0
NUM13	70.59709	8.64654	8.16	0	DUM12	0

Variance Estimate = 67.1611543
Std Error Estimate = 8.19519092
AIC = 2100.28093
SBC = 2177.70741
Number of Residuals = 295

Table E9. REGION 9: FIRST ARIMA
ARIMA Procedure
Maximum Likelihood Estimation

			Approximate			
Parameter	Estimate	Std Error	T Ratio	Lag	Variable	Shift
MA1,1	-0.15148	0.06932	-2.19	1	REGION9	0
MA1,2	-0.19642	0.06136	-3.20	4	REGION9	0
MA1,	-0.10936	0.06331	-1.73	8	REGION9	0
MA1,4	0.11991	0.06099	1.97	15	REGION9	0
MA1,5	0.11147	0.06059	1.84	17	REGION9	0
MA2,1	-0.17778	0.06347	-2.80	12	REGION9	0
MA2,	-0.27488	0.06253	-4.40	13	REGION9	0
AR1,1	0.76305	0.04783	15.95	1	REGION9	0
AR1,2	-0.11173	0.04386	-2.55	9	REGION9	0
NUM1	242.86253	40.02920	6.07	0	RAIN9	0
NUM1,1	-345.00145	45.23678	-7.63	1	RAIN9	0
NUM1,2	-257.94334	45.78707	-5.63	2	RAIN9	0
NUM1,3	-180.91120	40.47501	-4.47	3	RAIN9	0
NUM1,4	-137.11588	37.49100	-3.66	5	RAIN9	0
NUM1,5	45.68164	37.85467	1.21	9	RAIN9	0
NUM2	306.01131	18.82996	16.25	0	DUM1	0
NUM3	299.16636	20.15721	14.84	0	DUM2	0
NUM4	299.76553	19.98029	15.00	0	DUM3	0
NUM5	310.56450	19.28665	16.10	0	DUM4	0
NUM6	377.66153	17.30740	21.82	0	DUM5	0
NUM7	402.11565	15.31178	26.26	0	DUM6	0
NUM8	373.50305	14.06109	26.56	0	DUM7	0
NUM9	338.77761	14.07950	24.06	0	DUM8	0
NUM10	305.19467	13.33634	22.88	0	DUM9	0
NUM11	291.72308	13.32575	21.89	0	DUM10	0
NUM12	303.40849	14.82985	20.46	0	DUM11	0
NUM13	311.66057	16.96499	18.37	0	DUM12	0

Variance Estimate = 816.414495
Std Error Estimate = 28.5729679
AIC = 2863.23154
SBC = 2962.96231
Number of Residuals = 297