Arnold Schwarzenegger
Governor

INTEGRATED FORECAST AND RESERVOIR MANAGEMENT (INFORM) FOR NORTHERN CALIFORNIA: SYSTEM DEVELOPMENT AND INITIAL DEMONSTRATION

Appendices A through D

PIER FINAL PROJECT REPORT

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California Energy Commission
Public Interest Energy Research Program

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Appendix A

Summary of Proceedings for the INFORM Oversight and Implementation Committee Meetings

FIRST OVERSIGHT AND IMPLEMENTATION COMMITTEE MEETING
6 October 2003, Sacramento, California

PRESENT:

Agency Representatives

Paul Fujitani,	Central Valley Operations, U.S. Bureau of Reclamation
Robert Hartman,	California Nevada River Forecast Center, National Weather Service, NOAA
Gary Hester,	California Department of Water Resources
Mona Ismail,	GCAP Inc./CALFED (*through a conference call*)
Borden Johnson,	Sacramento District, U.S. Corps of Engineers
Claudia Nierenberg,	Office of Global Programs, NOAA (*through a conference call*)
Joe O'Hagan,	PIER, California Energy Commission
Eric Strem,	California Nevada River Forecast Center, National Weather Service, NOAA

INFORM Co-PIs and INFORM Core Office Staff

Theresa Carpenter,	Hydrologic Research Center
Aris Georgakakos,	Georgia Water Resources Institute
Kosta Georgakakos,	Hydrologic Research Center
Nick Graham,	Hydrologic Research Center
Jason Sperfslage,	Hydrologic Research Center

The meeting was held at the National Weather Service California Nevada River Forecast Center (CNRFC) Conference Room in the Joint Operations Center (3310 El Camino Ave.), started at 1:00PM and ended at 3:45PM. The meeting consisted of two parts. Part I gave a brief overview of the INFORM Progress, status, strategic planning issues and Oversight and Implementation Committee (OIC) mandate, while Part II focused on general INFORM implementation issues. The Meeting was held in a discussion format with the Co-PIs leading it with a set of discussion issues prepared in a power point

format. The presentation material is attached to become part of this Summary of Meeting Proceedings. Tables A-1 and A-2 present the issues discussed.

Important points made during the meeting by OIC Members in response to the issues identified by the Co-PIs are:

1. Current link of CNRFC models with climate information is through the Climate Prediction Center (CPC) probability outlooks; however, CNRFC would like to move toward the utilization of gridded climate information to generate ensemble streamflow.

2. Designing the INFORM system as a standalone system, at least initially, with a mirror image of the hydrologic modeling framework of CNRFC, and with data links to CNRFC and to management agencies is a reasonable approach.

3. Forecaster adjustments to NCEP synoptic-scale atmospheric forecasts will be treated approximately in the INFORM system, which will use NCEP ETA model products to drive the 0-5 days flow forecasts.

4. It is reasonable to assume that downstream concerns (some involving the Bay Delta) may be approximated in an aggregate way as downstream boundary objectives for the system of INFORM reservoirs.

5. The DSS component of the INFORM demonstration plan is envisioned as a "shared" resource by the management agencies.

6. CALSIM has a monthly resolution and it is not expected that within the time horizon of this project there will be a daily-resolution version available for Co-PI use. The code will be made available to the Co-PIs for INFORM.

7. Given the length of time it has taken the contracting process, and to align the tasks and time line of the three funding agencies, it is reasonable to modify the task and deliverables time line with a new critical review date of 1 March 2004.

OIC Members' comments and suggestions, which require Co-PI action are:

1. It is desirable to include an additional CALFED technical person in INFORM OIC

2. Keep fisheries agencies aware of our planning and OIC Meeting Proceedings (identify contacts through OIC Members)

3. The OIC should include an additional representative from the State Water Project (Gary Hester, member of OIC, will provide a contact person for the Co-Pis)

4. The INFORM implementation plan should be augmented to include the New Bullards Bar Dam on the Yuba River and the Black Butte Dam on Stony Creek, as they significantly contribute to the regulation of the tributary waters of the Sacramento River.

5. OIC should include an additional representative from the Yuba County
6. California Nevada River Forecast Center (CNRFC) Staff and INFORM Co-PI's should approach the National Centers for Environmental Prediction (e.g., Experimental Modeling Center) for the development of a link between CNRFC databases and climate and synoptic scale forecast products and retrospective run output.
7. INFORM Co-PI's and CNRFC Staff should contact Climate Diagnostics Center (CDC) to see if we can utilize their developing work on building a 14-day retrospective forecast database.
8. INFORM Co-PI's will work with CNRFC to finalize the historical hydrometeorological database to be used in INFORM for various calibration and validation tasks.
9. Maximum forecast lead-time for ensemble streamflow forecasts should be one year.
10. The Co-PIs will work with the California Department of Water Resources (DWR) and U.S. Bureau of Reclamation OIC contacts to define the link between the Bay Area management objectives with the objectives of the INFORM reservoirs.
11. After initial discussions with management agency the INFORM Co-PIs will generate a template decision support system design for review by OIC.
12. INFORM Co-PIs will work with DWR OIC member to determine the status and availability of CALSIM codes for use in INFORM.
13. Workshops have been identified as important components of the INFORM project and should be planned far in advance to allow wide participation by the forecast and management Agencies.
14. The INFORM Core Office will establish a secure web site for the exchange of data and information among OIC members and Co-PIs. Pre-approval of all publications by the OIC will be sought.
15. The INFORM Co-PIs will develop a new time line for tasks and deliverables for submission to the three funding agencies (NOAA, CEC, and CALFED).

Table A-1. Part I, INFORM Strategic Planning

Vision Statement

Increase efficiency of water use in Northern California using climate, hydrologic and decision science

Goal and Objectives

Demonstrate the utility of climate and hydrologic forecasts for water resources management in Northern California

Implement integrated forecast-management systems for the Northern California reservoirs

Perform tests with actual data and with management input

Application Area

Integrated System Design

Demonstration Concept

Work Accomplished

Feasibility studies for Folsom with historical data show benefits to management

Contracts in place (NOAA, CEC, CALFED)

Oversight and Implementation Committee in place

Initial technical phase of INFORM in progress

- Downscaling for precipitation

- Hydrologic/Uncertainty Modeling

- Decision Modeling

Folsom System

Time Line of Deliverables

Implementation Strategy

Link climate and weather forecasts of precipitation and temperature to hydrologic models

Link decision models with forecasts and downstream objectives to assess alternative policy options

Run integrated forecast-decision system for selected cases with management input to assess performance

Order of implementation: from individual reservoirs to the four-reservoir system (Folsom, Oroville, Shasta, Trinity)

Collaborative workshops

Oversight and Implementation Committee (OIC)

Provides strategic advice to INFORM Co-PIs on project direction

Provides assistance in the implementation of demonstration project

- Issues that cut across agency mandates

- Issues that influence implementation strategy, plans and timing

Develops collaboration protocol for specific technical issues

Assists Co-PIs in developing and executing the demonstration plan

Meets 2 times per project year and, as required, through an electronic forum

INFORM Core Office

Provides administrative assistance to INFORM Co-PIs and collaborating Agencies

Generates informational printed and web-site material, general interest meeting reports and announcements

Staff

- Kosta Georgakakos, HRC

- Theresa Carpenter, HRC

- Corinne Rice, HRC

Implementation Issues for First OIC Meeting

CNRFC Links to NCEP and climate/weather models

Reservoir management objectives for INFORM

Downstream simulation model (CALSIM-type)

Software/platform/database and links to operations

Collaboration and workshop plans

Follow-on to First OIC Meeting

Meeting Report

Development of any necessary modifications to INFORM Project tasks and timeline, and submission to Funding Agencies for approval

Table A-2. Part II, INFORM Implementation Issues

Implementation Issues for 1st Meeting

Software/platform/database and links to operations

- Hourly Precipitation Data

- Daily Precipitation Data

- Daily Temperature and Pan Data

- Snow Data

- Streamflow Discharge

CNRFC links to NCEP's climate and weather models

Forecast Model and Data

Forecast models and model-specific bias-adjustment algorithms available for quasi-operational use

Availability of retrospective simulation and forecast data

Reliable flow of consistent real-time forecast products

Links to NOAA NCEP (e.g., Experimental Modeling Center)

Climate Forecast Data

Fields: Prec, 10m T, (U, V, T, Q, H, at 700mb and 850mb)

Archive all received from NCEP CMB

Maximum lead time: at least 3 months

Retrieve and store these fields from any retrospective runs (forecast or AMIP) from current version of model

Synoptic Forecast Data

ETA 48 km (12 km?) and GFS

Fields: U, V, T, Q, H (necessary to run dynamic / statistical downscaling models) – Archive all

Request forecast data from NCEP (GFS, ETA 12 km)

Issues to resolve:

What is the relationship of INFORM system to CNRFC models and databases?

Can ensemble weather and climate forecasts be accommodated by CNRFC operational systems?

How do we acquire historical weather and climate (ensemble) forecasts? NCEP as a partner in this effort.

Should we represent Forecaster adjustments to weather and climate forecasts in INFORM?

Decision Support for Drought Forecasting, Assessment, and Management

Decision Support for Flood Forecasting, Assessment, and Management

Integrated Decision Support for Drought and Flood Management

Issues to resolve for reservoir management

Water uses impacted by reservoir management

- Water use type and geographic area

- Relevant Hydrologic Quantity (level, stage, discharge, volume)

- Applicable Time Scale (inter-annual, seasonal, monthly, weekly, daily, hourly)

- Reservoir(s) Involved (water use aggregation where applicable)

- Competing Water Uses (by reservoir and system-wide; information format)

Agencies/NGOs involved – DSS made operational

-Relevant Agencies/NGOs by Water Use and Reservoir

- Operational Process during Droughts, Floods, and Normal Periods

- DSS Demonstration Plan (Distributed? Centralized? Shared?)

Downstream simulation model

Which downstream objectives should we include in INFORM?

Temporal resolution of CALSIM

Links to CNRFC's Downstream Models

Computer code availability

Collaboration and workshop plans

Protocol for collaboration

- Agency contact persons for technical matters for each basin and reservoir

- INFORM Core Office web site for exchange of data, discussion, progress reports and graphics/results

Informational and Training Workshops in Technical Areas (1 per year)

SECOND OVERSIGHT AND IMPLEMENTATION COMMITTEE MEETING

14 April 2004, Sacramento, California

PRESENT:

Agency Representatives

Marchia Bond,	Sacramento District, U.S. Corps of Engineers
Robert Collins,	Sacramento District, U.S. Corps of Engineers
Rebecca Fris,	CALFED (*through a conference call*)
Paul Fujitani,	Central Valley Operations, U.S. Bureau of Reclamation
Robert Hartman,	California Nevada River Forecast Center, National Weather Service, NOAA
Gary Hester,	California Department of Water Resources
Mona Ismail,	GCAP Inc./CALFED (*through a conference call*)
Juniper Neill,	Office of Global Programs, NOAA
Joe O'Hagan,	PIER, California Energy Commission (*through a conference call)*
Eric Strem,	California Nevada River Forecast Center, National Weather Service, NOAA

INFORM Co-PIs and INFORM Project Scientists

Aris Georgakakos,	Georgia Water Resources Institute
Kosta Georgakakos,	Hydrologic Research Center
Nick Graham,	Hydrologic Research Center
Huaming Yao,	Georgia Water Resources Institute

The meeting was held at the National Weather Service California Nevada River Forecast Center (CNRFC) Conference Room in the Joint Operations Center (3310 El Camino Ave.), started at 11:30AM and ended at 1:30PM. The meeting served as the first critical review meeting for INFORM, mandated by the California Energy Commission and

CALFED funding agencies. Summary documents were submitted to the participants prior to the meeting by the INFORM Core Office Staff.

The meeting presentations were made in two parts. Part I consisted of a summary of the INFORM goals, and the work accomplished, as well as for highlighting strategic planning issues, while Part II focused on a demonstration by the Georgia Water Resources Institute (GWRI) Staff of the first version of the reservoir decision support software for Folsom and Oroville. Table A-3 presents the issues discussed in Part I, followed by a summary of the main comments made. This is followed by short summary of the capabilities of the software demonstrated in Part II and of the pertinent comments and suggestions made.

Important points made during Part I of the meeting by OIC Members in response to the issues identified by the Co-PIs are:

1. Stakeholder input significant for the final design of the decision component; Rebecca Fris provides input to the GWRI team for the upcoming stakeholder workshop of May 2004.

2. Upstream reservoirs (e.g., French Meadows and Union Valley within the Folsom watershed and Lake Almanor in the Oroville watershed) are being modeled as part of the CNRFC operations, and the USA Corps of Engineers has inflow and outflow historical data for such modeling efforts. INFORM PIs should consider incorporating this modeling effort even though it was not part of the original INFORM plan. Historical inflow and outflow data from these upstream reservoirs, when existing, can help define an "average management strategy" to be incorporated in the long-range hydrologic forecasts of the downstream larger reservoirs. Alternatively, full decision modeling of these upstream reservoirs may be done incorporating the uncertainty in the management strategy for long-range forecasts.

3. CNRFC Staff and the HRC modeling team should coordinate the request to NCEP for Global Forecast System (GFS) data.

4. DSS component should be released to agencies after the first version is finalized for gaining hands-on experience and for providing feedback to developers regarding the functions and graphical user interface.

The current version of the decision support system for Folsom and Oroville includes a suite of interlinked models that is capable for inflow forecasting and reservoir management at hourly, daily, and seasonal time scales. Hourly, daily, and seasonal reservoir management is addressed through three coupled models: turbine load dispatching, hourly release management within one day, and daily release management within a user specified time seasonal horizon (e.g., 3 months). The purpose of these models is to optimize the efficiency of energy generation while conserving water and meeting all relevant water resources requirements including flood protection, water

supply, drought management, and environmental protection. The DSS is embedded within a user-friendly, graphical interface that links models with data and helps visualize and manage results. A policy assessment model has also been developed and incorporated within the DSS to assess the value and implications of various forecasting schemes, reservoir management policies, and demand scenarios. The demonstration of the decision support system software developed by GWRI showed the following software capabilities:

1. User-data-model interface for data visualization and data management using Excel spreadsheets and MS Access and with user-friendly graphical menus based on visual basic
2. It is designed to run individual reservoirs or system wide.
3. Provides reservoir managers with a variety of quantitative measures that show the effect of various decision policies.
4. Incorporates a baseline ensemble forecasting component and provision for links to the INFORM climate-hydrology ensemble forecasts.
5. Allows the consideration of decisions on different time scales in an objective, consistent and quantitative manner.
6. Allows adaptive operation with decisions updated as frequently as desired.

The discussion that followed the presentation brought up the following comments made by participant agencies:

1. The current version of the decision support system shows promise as a very good tool for exploring the effects of decisions by several stakeholder groups and over different time scales (short term versus long term decisions).
2. A decision must be made to resolve the design trade-off issue of modeling a few large reservoirs in the region in great detail versus focusing on large scale interactions in decision making among all the INFORM reservoirs but with simplifying assumptions as to the decision parameters for each of these reservoirs. A solution to this trade-off issue that could be accommodated within the present funding and performance-time scope of the present INFORM project was considered: to proceed with the integration of all the INFORM reservoirs as originally planned with simplifying assumptions agreed upon by the forecast and management agencies (e.g., what downstream requirements to incorporate, etc.), and at the same time to focus in greater detail in one of these reservoirs for detailed modeling in collaboration with the management agencies of that reservoir. Further discussions will be held between the INFORM team and the participating staff of forecast and management agencies to find a mutually agreeable system configuration and level of modeling detail.

Table A-3. Part I, INFORM Strategic Planning

AGENDA FOR SECOND OIC MEETING

- Part I – Project Status Review

  (Climate – Hydrology – Decision)

- Part II – Demonstration of Reservoir Decision Support Software

  (Folsom and Oroville)

VISION STATEMENT

- Increase efficiency of water use in Northern California using climate, hydrologic and decision science

GOAL AND OBJECTIVES

- Demonstrate the utility of climate and hydrologic forecasts for water resources management in Northern California
- Implement integrated forecast-management systems for the Northern California reservoirs
- Perform tests with actual data and with management input

APPLICATION AREA

INTEGRATED SYSTEM DESIGN

DEMONSTRATION CONCEPT

WORK ACCOMPLISHED

- Coordination and Initial Design of the Weather and Climate Ingest Component
- Design, Implementation and Validation of Precipitation Downscaling Component
- Validation of Operational CNRFC Snow and Hydrology Models for American and Feather Rivers
- Design and Implementation of Stand Alone Ensemble Flow Forecast System for Folsom and (in progress) for Oroville
- Design and Implementation of Decision Support System for Folsom and Oroville Reservoirs

FOLSOM SYSTEM REFERENCE

TIME LINE OF DELIVERABLES

FOLLOW-ON TO 2ND OIC MEETING

- Meeting Report
- Development of any necessary modifications to INFORM Project tasks and timeline, and submission to Funding Agencies for approval
- Continued Agency and Co-PI collaboration by implementation task

CLIMATE COMPONENT

- Reliable probabilistic estimates of observed rainfall categories
- Snowmelt forecasts on the basis of NCEP forecast winds and temperature
- Collaborative activities between HRC, CNRFC and NCEP
- Initial plan of stand-alone climate-downscaling operations
- Validation of orographic downscaling precipitation component for Folsom

HYDROLOGY COMPONENT

- INFORM data inventory status
- Validation of NWS operational hydrologic simulations for Folsom drainage and sub-catchments (climatology, distributional characteristics, event simulations, snowpack)
- Validation of NWS operational hydrologic simulations for Oroville drainage and sub-catchments (climatology, distributional characteristics, event simulations, snowpack)
- On-going hydrologic activities for Folsom and Oroville

DECISION COMPONENT

- Outline of Tasks planned for the Decision Component of INFORM
- Reservoir data for decision support system models
- Description of short- and mid-range decision models
- Examples of short- and mid-range decision models for Folsom and Oroville
- Policy assessment model for Folsom and Oroville and examples
- Graphical user-model DSS interface overview
- Technical workshop for stakeholder agencies and users

THIRD OVERSIGHT AND IMPLEMENTATION COMMITTEE MEETING OF THE INFORM PROJECT

18 April 2005, Sacramento, California

PARTICIPANTS

Agency Representatives

Gary Bardini,	California Department of Water Resources
Robert Collins,	Sacramento District, U.S. Corps of Engineers
Pete Fickenscher,	California Nevada River Forecast Center, National Weather Service, NOAA
Josh Foster	NOAA Office of Global Programs (*through a conference call)*
Paul Fujitani,	Central Valley Operations, U.S. Bureau of Reclamation
Robert Hartman,	California Nevada River Forecast Center, National Weather Service, NOAA
Arthur Hinojosa,	California Department of Water Resources
John King,	California Department of Water Resources
Aaron Miller,	California Department of Water Resources
Claudia Nierenberg	NOAA Office of Global Programs (*through a conference call)*
Joe O'Hagan,	PIER, California Energy Commission
David Parker	California Department of Water Resources
Brendan Reed	California Bay-Delta Authority
Eric Strem,	California Nevada River Forecast Center, National Weather Service, NOAA

INFORM Co-PIs and INFORM Project Scientists

Theresa Carpenter	Hydrologic Research Center
Aris Georgakakos,	Georgia Water Resources Institute
Kosta Georgakakos,	Hydrologic Research Center
Nick Graham,	Hydrologic Research Center
Martin Kistenmacher,	Georgia Water Resources Institute
Huaming Yao,	Georgia Water Resources Institute

LOCATION AND TIME

The meeting was held at the National Weather Service (NWS) California Nevada River Forecast Center (CNRFC) Conference Room in the Joint Operations Center (3310 El Camino Ave.) on the 18th of April 2005. It started at 1:00PM and ended at 4:30PM.

PURPOSE AND INFORMATIONAL MATERIAL

The meeting served as a second critical review meeting for INFORM (Integrated Forecast and Reservoir Management), mandated by the California Energy Commission and CALFED funding agencies. Summary documents were submitted to the participants prior to the meeting by the INFORM Core Office Staff. A detailed INFORM Phase 2 Report was distributed to the meeting participants and was made available at the HRC web site: http://www.hrc-lab.org. The meeting consisted of the presentation of the INFORM project status by the Co-PIs, followed by an open discussion of the issues and strategies for the INFORM implementation completion and demonstration assessment design. The PDF forms of the meeting presentations are available at the aforementioned HRC web site.

INFORM STATUS PRESENTATION

The principle items discussed during the INFORM status presentation are listed in Table A-4. Pressing issues are: *(a)* the availability of climate forecast system high-resolution data from the NOAA/NWS National Centers of Environmental Prediction (NCEP); and *(b)* the availability of remaining reservoir information for the completion of the design of the reservoir management component for the entire INFORM region. A short summary of the first issue and suggested solutions are presented in Table A-5. It was agreed to pursue the high resolution climate data availability through May. If the high resolution data is not made available by that time to implement a statistical downscaling methodology that utilizes monthly climate forecast information that is currently available from NCEP. With respect to the second issue and as part of this OIC meeting, participating operational management agencies agreed to provide the remaining reservoir management information. Lastly, the INFORM PI reminded the OIC participants that INFORM is a five year project as proposed and it now enters the third year (last currently funded year of the project). The INFORM team within the next few months will provide funding agencies continuation/amendment proposals for the completion of the demonstration phase of the project (2 additional years).

DISCUSSION

After the INFORM status presentations, group discussion followed. An important issue discussed was the appropriate balance in depth versus breadth of the INFORM decision support system in view of the remaining project time—one year. With the incorporation of the Bay Delta in the long range planning model, the scope of the original project (demonstration of value of uncertain climate/hydrology forecasts for Trinity, Shasta, Oroville, and Folsom) has significantly expanded to encompass a more realistic

representation of the physical system in the INFORM region and associated management issues. While the project could proceed to incorporate more system and management details, it was felt that a strategy aiming to demonstrate the value of the integrated prediction-decision system using the existing models should take precedence. The following important points were made during the discussion.

1. Rob Hartman mentioned that (as agreed upon during the First INFORM OIC Meeting) the INFORM implementation plan should be augmented to include the New Bullards Bar Dam on the Yuba River and the Black Butte Dam on Stony Creek, as they significantly contribute to the regulation of the tributary waters of the Sacramento River. The GWRI team stated that this enhancement is planned in the next few months.

2. Bob Collins mentioned that it may also be important to model some of the more important smaller reservoirs (e.g., French Meadows and Union Valley within the Folsom watershed and Lake Almanor in the Oroville watershed) for the short term management operations in the region. The GWRI team will need additional information for this modeling effort and will consider the feasibility of modeling them within the remaining time frame of the project.

3. Paul Fujitani expressed concern for the ability of the INFORM project to fully capture the breadth and depth of required modeling of the water management operations in view of the project time frame, and he suggested focusing perhaps on regional long-term decisions rather than both short- and long-term decisions. Art Hinojosa offered that perhaps we can focus on years of a specific type for demonstration purposes. The INFORM development team acknowledged that the issue of breadth versus depth for INFORM is important and that the linkage of long and short range models and decisions under uncertain forecasts that has already been accomplished is a good basis for demonstrating the value of forecast information in the management of the INFORM system. It was agreed that a demonstration strategy should be developed to illustrate the value of the prediction-decision system for long range planning and mid/short range management.

4. Gary Bardini suggested that the INFORM remaining effort should address the following issues: *(a)* resolve the remaining links between climate and hydrology data and forecasts; *(b)* complete the decision model with all agreed upon components for the demonstration effort; *(c)* develop a demonstration strategy with OIC input; *(d)* identify the INFORM components that may directly add value to current operational tools for operational implementation, *(e)* perform a case-by-case assessment of benefits and risks. The group concurred with these suggestions and the INFORM development team recommended (and the OIC members concurred) that the development of the demonstration strategy must be carried out as soon as possible as it may dictate additional model modifications that would be required to address, for example, longer term regional benefits

from seasonal forecasts, or shorter term benefits during reservoir filling for specific sub-systems. It was suggested that another OIC meeting be convened at the end of May or early June to develop the demonstration strategy.

5. Along the lines of demonstration strategy, Rob Hartman suggested that along with average forecast benefits, benefits accrued during extreme events also be evaluated, and an assessment be made of the circumstances for which the INFORM prediction-decision approach would benefit system management. The INFORM development team concurred that this type of analysis should be an integral part of the demonstration strategy discussion.

6. The GWRI team also emphasized that the INFORM DSS is not intended to replace existing tools; rather, it is an additional tool that can screen a wide range of management strategies and identify a set to be evaluated by other more detailed models currently being used.

Table A-4: List of Items of INFORM Project Status Presentation

Meeting Agenda

- Project Status Review – Phase 2
  - Climate
  - Hydrology
  - Decision
- Tomorrow (4/19/05) – Workshop on Decision Support System

Vision Statement

- Increase efficiency of water use in Northern California using climate, hydrologic and decision science

Goal and Objectives

- Demonstrate the utility of climate and hydrologic forecasts for water resources management in Northern California
- Implement integrated forecast-management systems for the Northern California reservoirs using real-time data
- Perform tests with actual data and with management input

Application Area

Integrated System Diagram

Demonstration Concept

Work Accomplished in Phase 2

- Design and tests of GFS ingest component and links to downscaling components
- Regional Validation of Precipitation Downscaling Component
- Design, Implementation and Tests of Temperature Downscaling Component
- Validation of INFORM Forecast System Hydrologic Forecast Component for the Major Reservoir Drainage Areas
- Development and Testing of a Monthly Simulation and Planning Model for the Entire INFORM Region

Refereed Publications

Follow-on to 3rd OIC Meeting

- Meeting Report

- Development of any necessary modifications to INFORM Project tasks and timeline, and submission to Funding Agencies for approval
- Continued Agency and Co-PI collaboration by implementation task

Climate and Weather Components

Major Issues

- Availability of Climate Forecast Model (CFM) twice-daily forecasts and hindcasts – National Centers of Environmental Prediction (NCEP)
- Global Forecast System (GFS) downloads from NCEP servers

Status of Issue resolution - CFS

- NCEP Director indicated that NCEP will review the climate data status and will inform the Co-PIs of twice-daily climate data availability in the near future
- Co-PI's are considering the implementation of an alternative based on the use of monthly CFS ensemble forecasts.

Status of Issue Resolution - GFS

- Systems administrator for NCEP servers and HRC's system administrator are upgrading file transfer software to facilitate real-time downloads
- HRC is implementing complex download software to assure receipt of all available files

INFORM System Climate and Weather Data Components and Links

GFS Driven Mean Areal Precipitation: Software Tests

Precipitation and Temperature Downscaling - Domain

Precipitation Downscaling – Regional Validation

Precipitation Downscaling – Performance Measures

Temperature Downscaling - Model

Temperature Downscaling - Tests

Hydrology Component

INFORM Region and Major Basins

Distributed Tributary Basin System for Oroville – Example for INFORM Hydrology Modeling

Oroville Parameter Files – An Example

Overall Hydrology Model Performance Statistics

Examples of Hydrologic Performance Analysis – Time Series

Examples of Hydrology Performance Analysis – Exceedance Frequency

Examples of Hydrologic Performance Analysis – Daily Scatterplots

Examples of Hydrologic Performance Analysis – Monthly Climatology

Conclusion of Hydrologic Performance Analysis

INFORM Decision Support System

- Decision Support System Framework: Multi-scale, Multi-objective
- Long Range Simulation/Planning Model: Trinity, Shasta, Feather, American, San Joaquin, Bay Delta sub-systems
- Model Inputs: Reservoirs, River and Tributary Nodes, Hydro Power Plants, Water Supply Nodes, Ecosystem Nodes, Water Quality Nodes
- Model Outputs
- Long Range Assessment Model
- Assessments: Adaptive versus Static Management
- Outstanding Issues
- Way Forward

Table A-5: Availability of High Resolution Climate Forecast Data

A) The original design of the INFORM system envisioned the use of 6-hourly data from the NCEP Climate Forecast System (CFS). These data would be composed of

Retrospective forecasts going back to 1981

Operational (real time) forecasts

Ensembles of 5-15 members

Forecasts going out to (at least) 9 month lead times.

B) In discussions with NCEP Environmental Modeling Division management in December 2003 and January 2004 it was indicated that these CFS data would become available during summer, 2004. Subsequent correspondence in September 2004 indicated that the data would be delayed and become available by late winter to early spring, 2005. The actual retrospective forecast simulations were complete by approximately this time. Offers by HRC to purchase and install the necessary equipment to download the data directly at NCEP (inside their firewall and security systems) were not accepted by NCEP for security reasons.

C) Delivery of the Climate Forecast System (CFS) data from NCEP is now significantly behind schedule.

D) Monthly average ensemble retrospective (1981-2004) and operational forecast data is now available from CFS.

E) We are in continuing discussions with NCEP to obtain the 6-hourly data

F) The potential for continued delay in obtaining 6-hourly data requires the development of an alternative strategy using the monthly average data.

G) A candidate procedure is described in the Phase 2 Project Report (pp. 2-1 to 2.5). For a given basin (or set of basins) and a given month, this procedure identifies months in the observed record that are "similar" (in terms of precipitation and/or temperature) with the CFS ensemble output. Actual 6-hourly to daily series of precipitation and temperature from those identified similar months are then used to drive the hydrological component of the INFORM system (which feeds into the decision model). This alternative procedure retains the probabilistic character of the GFS ensemble forecasts and builds on elements of traditional ensemble streamflow prediction (ESP) methodology. This procedure (or variant) will be implemented if no 6-hourly data are available by (approximately) June, 2005.

FOURTH OVERSIGHT AND IMPLEMENTATION COMMITTEE MEETING OF THE INFORM PROJECT

21 SEPTEMBER 2005, Sacramento, California

PARTICIPANTS

Agency Representatives

M. Anderson,	California Department of Water Resources
Gary Bardini,	California Department of Water Resources
Pete Fickenscher,	California Nevada River Forecast Center, National Weather Service, NOAA
Josh Foster,	NOAA Office of Global Programs (*through a conference call)*
Paul Fujitani,	Central Valley Operations, U.S. Bureau of Reclamation
Robert Hartman,	California Nevada River Forecast Center, National Weather Service, NOAA
Arthur Hinojosa,	California Department of Water Resources
Aaron Miller,	California Department of Water Resources
Claudia Nierenberg,	NOAA Office of Global Programs (*through a conference call)*
Maury Roos,	California Department of Water Resources
Eric Strem,	California Nevada River Forecast Center, National Weather Service, NOAA

INFORM Co-PIs and INFORM Project Scientists

Aris Georgakakos,	Georgia Water Resources Institute
Kosta Georgakakos,	Hydrologic Research Center
Nick Graham,	Hydrologic Research Center
Martin Kistenmacher,	Georgia Water Resources Institute
Huaming Yao,	Georgia Water Resources Institute

LOCATION AND TIME

The meeting was held at the National Weather Service (NWS) California Nevada River Forecast Center (CNRFC) Conference Room in the Joint Operations Center (3310 El Camino Ave.) on the 21st of September 2005. It started at 1:00PM and ended at 3:00PM.

PURPOSE AND INFORMATIONAL MATERIAL

The meeting served as a second critical review meeting for INFORM (Integrated Forecast and Reservoir Management), mandated by the California Energy Commission and CALFED funding agencies. Documents with the presentations were submitted to the participants prior to the meeting by the INFORM Core Office Staff. The meeting consisted of the presentation of the INFORM project status by the Co-PIs, followed by an open discussion of the strategy for the INFORM "dry-run" demonstration design for winter 2005-2006. The PDF forms of the meeting presentations are available at the HRC web site: http://www.hrc-lab.org.

INFORM STATUS PRESENTATION

The Co-PIs summarized the status of system development and testing. Real time capability is being added to the forecast component to ingest ensemble forecasts from the Global Forecast System (GFS) of the National Centers of Environmental Predictions (NCEP). The Co-PIs discussed the design of the real time GFS data ingest, dynamic downscaling components to produce gridded and subsequently watershed areal-average surface precipitation and temperature, bias adjustment of the watershed precipitation and temperature and snow, soil and channel modeling with bias adjusted forcing to produce ensemble flow forecasts at various watershed locations including reservoir inflow for the four largest reservoirs in Northern California.

Progress on the decision component has been achieved along two parallel paths: First, the long range management model has been developed and is currently being tested. The model incorporates all major storage facilities along the Trinity, Sacramento, Feather, American, and San Joaquin Rivers, including the Bay Delta. In all, the model includes 10 reservoirs, 11 power plants, 14 river nodes, 15 inflow nodes, and 30 demand nodes. Second, the model is being compared for consistency with CALSIM. In this regard, CALSIM is currently operational at the GWRI facilities and is being used to *(1)* extend the INFORM hydrologic and demand data series, and *(2)* compare its consistency with the INFORM DSS. This effort was undertaken to test and ensure the compatibility of all existing simulation and management tools.

The Co-PIs presented their initial plan for the "dry run" of the winter 2005-2006, which will serve to finalize system components, establish links with operational agencies and define the objectives of the demonstration program of INFORM with real time and near real time runs. It is expected that during the following two years (2006-2008) INFORM will be funded (as originally proposed) to actually perform the

demonstration on the basis of the protocols defined during the "dry run" experiment of winter 2005-2006.

DISCUSSION

After the INFORM status presentations, group discussion followed. Important issues discussed were *(a)* the links anticipated between the operational forecast and management agencies of California and the INFORM system input and output components; and *(b)* the design of the "dry run" demonstration experiments of winter 2005-2006 with particular emphasis on the type of events to concentrate and the type of objective criteria to evaluate the INFORM forecast-decision system relative to the existing operational system.

1. Rob Hartman suggested and the Co-PIs concurred that it would be desirable for the California Nevada River Forecast Center (CNRFC) of the US National Weather Service (NWS) to receive bias adjusted mean areal precipitation and temperature ensemble forecasts and ensemble flow forecasts for various watershed flow points in real time, and to have the INFORM hydrology component use the state variables of the operational hydrologic model runs as initial conditions for the development of the GFS-driven ensemble flow forecasts.

2. Rob Hartman mentioned the existence of historical GFS output for use by INFORM to estimate the bias adjustment component for the mean areal precipitation and temperature on watershed scales.

3. Gary Bardini suggested that the demonstration plan of the winter 2005-2006 "dry run" should be designed to bring to fore the unique features of INFORM: *(a)* integration of uncertainty information in decisions, and *(b)* integration of decisions over different time scales seamlessly.

4. Paul Fujitani suggested questions that may be useful to examine with the demonstration: *How much can we deviate from the flood control diagram? What should the best release policy be in December and in May for Folsom and Shasta in order to maintain summer flows? After a significant inflow event how do we operate to evacuate storage? What is the required period of encroachment for Shasta to meet downstream objectives?*

5. Arthur Hinojosa suggested that INFORM Co-PIs participate in the weekly forum which starts in October pertaining to reservoir operations.

6. Gary Bardini stressed the value of retrospective studies in examining questions of the type: *What is the system impact of aggressive versus conservative reservoir management policies? What should the carry over reservoir storages be and how do these decisions affect water supply reliability and flood risk in the following season?*

7. Paul Fujitani mentioned that it is desirable to have ensemble flow forecasts of unregulated inflow points on the Sacramento River.

8. The Group agreed that a seasonal planning application of the integrated forecast-decision system could be scheduled for January 2006 to support planning decisions for the Spring 2006.

9. The Co-PIs informed the participants that the current submission date of draft final report for the first three funded years of INFORM is in February 2005 and if it remained thus it would not allow the "dry run" experiments to go into the last part of winter and the spring season (important for reservoir management decisions). The Co-PIs proposed and the participants agreed to the submission (to the funding agencies) of a no-cost extension to May for the delivery of the draft final report to allow inclusion of the late winter and spring forecast and management activities in Northern California.

FIFTH OVERSIGHT AND IMPLEMENTATION COMMITTEE MEETING OF THE INFORM PROJECT

29 JUNE 2006, Sacramento, California

PARTICIPANTS

Agency Representatives

John Andrew	California Department of Water Resources
Paul Fujitani,	Central Valley Operations, U.S. Bureau of Reclamation
Robert Hartman,	California Nevada River Forecast Center, National Weather Service, NOAA
Claudia Nierenberg,	NOAA Office of Global Programs (*through a conference call)*
Joe O'Hagan	California Energy Commission
Lloyd Peterson	U.S. Bureau of Reclamation
Eric Strem,	California Nevada River Forecast Center, National Weather Service, NOAA

INFORM Co-PIs and INFORM Project Scientists

Aris Georgakakos,	Georgia Water Resources Institute
Kosta Georgakakos,	Hydrologic Research Center
Nick Graham,	Hydrologic Research Center
Robert Jubach,	Hydrologic Research Center
Huaming Yao,	Georgia Water Resources Institute

LOCATION AND TIME

The meeting consisted of two sessions, a morning presentations session, and an afternoon OIC discussion session. Both sessions were held at the Joint Operations Center (3310 El Camino Ave.) in Sacramento on the 29th of June 2006. The morning session started at 10:00AM and ended at 12:15PM, and the afternoon session started at 1:30PM and ended at 3:30PM.

PURPOSE AND INFORMATIONAL MATERIAL

The meeting served as a second critical review meeting for INFORM (Integrated Forecast and Reservoir Management), mandated by the California Energy Commission

and CALFED funding agencies. Documents with a discussion of the INFORM system implementation was submitted to participants prior to the meeting by the INFORM Core Office Staff. The morning session meeting consisted of the presentation of the INFORM project final report and assessments by the Co-PIs, followed by open discussion, and the afternoon session consisted of a discussion of INFORM results and potential future collaborative directions. The PDF forms of the meeting presentations are available at the HRC web site:

http://www.hrc-lab.org/projects/dsp_projectSubPage.php?subpage=inform.

INFORM STATUS PRESENTATION

The Co-PIs summarized the technical activities of the three-year first phase of INFORM. The final report is being produced and will be submitted for review to funding agencies in July. The Co-PIs discussed the design and implementation of the real time GFS data ingest, dynamic downscaling components to produce gridded and subsequently watershed areal-average surface precipitation and temperature, bias adjustment of the watershed precipitation and temperature, and snow, soil, and channel modeling with bias adjusted forcing to produce ensemble flow forecasts at various watershed locations including reservoir inflow for the four largest reservoirs in Northern California, and the off-line climate forecast processing of INFORM for input to the decision component. Discussion of the INFORM decision component included *(a)* the design of the DSS model hierarchy comprising interlinked models for long range planning, mid range management, short range management, and near real time operations; *(b)* the management concerns incorporated as part of the decision modeling both at reservoir sites and downstream, and *(c)* the strategy for potential use of this component by management agencies to develop risk-based policies for water resources management. Assessments of the INFORM forecasts during the "dry run" of the wet season 2005-2006, and of the benefits of using uncertain forecasts for water management were also presented and discussed. The Co-PIs recommend that during the following two to three years (2006-2009) INFORM funding continues (as originally proposed) to support the system demonstration on the basis of the protocols defined during the "dry run" experiment of winter 2005-2006.

DISCUSSION

The afternoon INFORM session was devoted to group discussion. Important issues discussed were *(a)* the need for continuation of the INFORM assessments with real time data from 2 to 3 future wet and dry seasons for reliable results; *(b)* the links between the operational forecast and management agencies of California and the INFORM system input and output components; and *(c)* the necessary improvements in current INFORM system design to better fit operational forecast and management agency objectives in water resources prediction, planning, and management.

1. Rob Hartman said, and other agency representatives agreed, that the INFORM system is a useful tool for operational forecast and management.

2. Rob Hartman suggested, and the Co-PIs concurred, that for the next phase of INFORM a representative from NCEP should be included in the Oversight and Implementation Committee to provide input and to receive feedback as to the utility of climate forecast system (CFS) operational three-dimensional fields and to facilitate communication with NCEP on data issues and products.

3. Rob Hartman also suggested that for CNRFC it would be very useful to use the INFORM coastal range estimates of precipitation for real time streamflow prediction there (e.g., the Smith and Navarro Rivers). This region is within the precipitation and temperature downscaling grid of the INFORM forecast component, but no hydrologic model computations are effected at present for the coastal streams that drain into the Pacific Ocean.

4. The participants discussed the need for enhancing the ensemble size of the INFORM ensemble forecasts. Due to HRC machine limitations (8-processor computer platform), the current design of INFORM produces an 8-member ensemble of real time precipitation, temperature and flow forecasts, four times daily, out to 16 days with 6-hourly resolution. It was suggested that funds be included in the next phase funding to accommodate at least a 16-porocessor machine to accommodate the current 15-member ensemble size of the ingested global forecast system (GFS) forecasts from NCEP.

5. Paul Fujitani mentioned that at present the large reservoirs in Northern California are operated individually without significant co-ordination (except for the case of Oroville on the Feather River and New Bullards Bar on the Yuba River). A significant INFORM contribution is that it coordinates the operating policies of all these large reservoirs.

6. Lloyd Peterson suggested that a significant application of the INFORM system would be to support the management of reservoirs within the San Joaquin River drainage, especially the Friant Dam and New Melones reservoir (on the Stanislaus River tributary). He further asserted that, with respect to operational management difficulty, the Trinity and Friant reservoirs rank high due to their modest release capacity.

7. Lloyd Peterson and Paul Fujitani also emphasized that the INFORM DSS could be used to support the management of the San Luis reservoir, the Tracy pumping facility, and the water export to the south. The project co-PIs noted that, although some model modifications are needed to support this management objective, such INFORM DSS operational refinements could be carried out as part of the next INFORM phase.

8. There was consensus among the participants that the INFORM demonstration project should continue to provide information to forecast and management agencies through a next phase. Toward this end, it was decided that the Co-PIs develop a draft proposal as a discussion document and a meeting of the OIC be

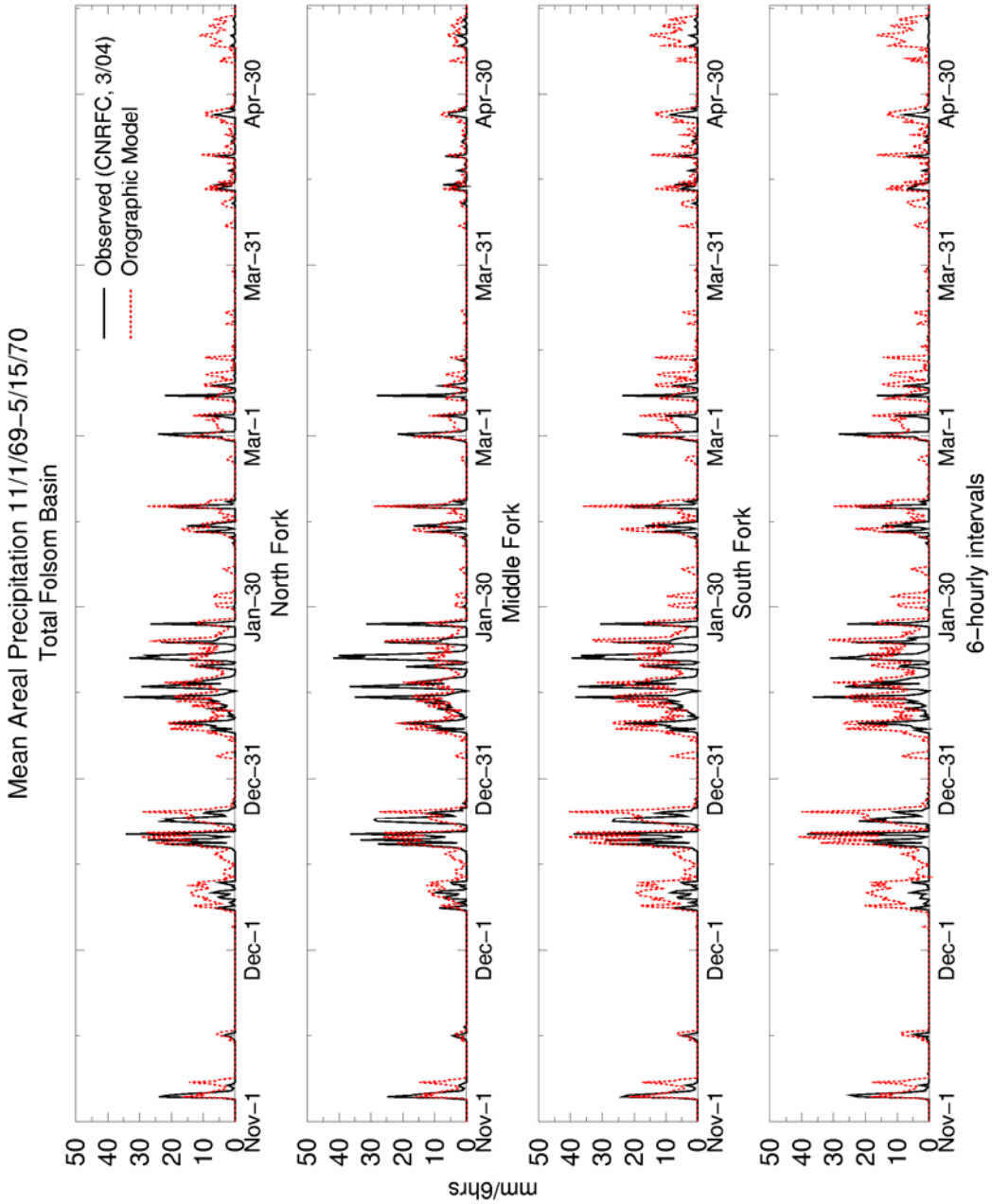
convened near the end of July 2006 to develop objectives and plans for the next phase of INFORM that reflect the interests of the participating agencies.

Appendix B

Validation Figures for the Application of the Downscaling Precipitation Model to the Folsom Lake Drainage

Figure Description

In this Appendix we show 6-hourly downscaled estimates of mean areal precipitation (red dotted line) for the North, Middle and South Fork and for the entire Folsom Lake drainage basin. Also shown in each case are the mean areal precipitation estimates produced by CNRFC (solid black line) using precipitation gauge data. The comparison is shown for the period 1 November through 15 May (wet season) for each water year and for the years 1969 through 1992. The units of mean areal precipitation are mm/6-hrs. Historical profiles of atmospheric state from NCEP Reanalysis runs ($2.5^{o} \times 2.5^{o}$) were used for boundary forcing of the orographic downscaling model (Chapter 3). The domain of analysis covered the northern California area with a 10-km resolution. Digital boundary data for the sub-catchments of the Folsom Lake drainage were used to map gridded model rainfall onto mean areal sub-catchment rainfall estimates.


Mean Areal Precipitation 11/1/69–5/15/70
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
Nov–1
Dec–1
Dec–31
Jan–30
Mar–1
Mar–31
Apr–30
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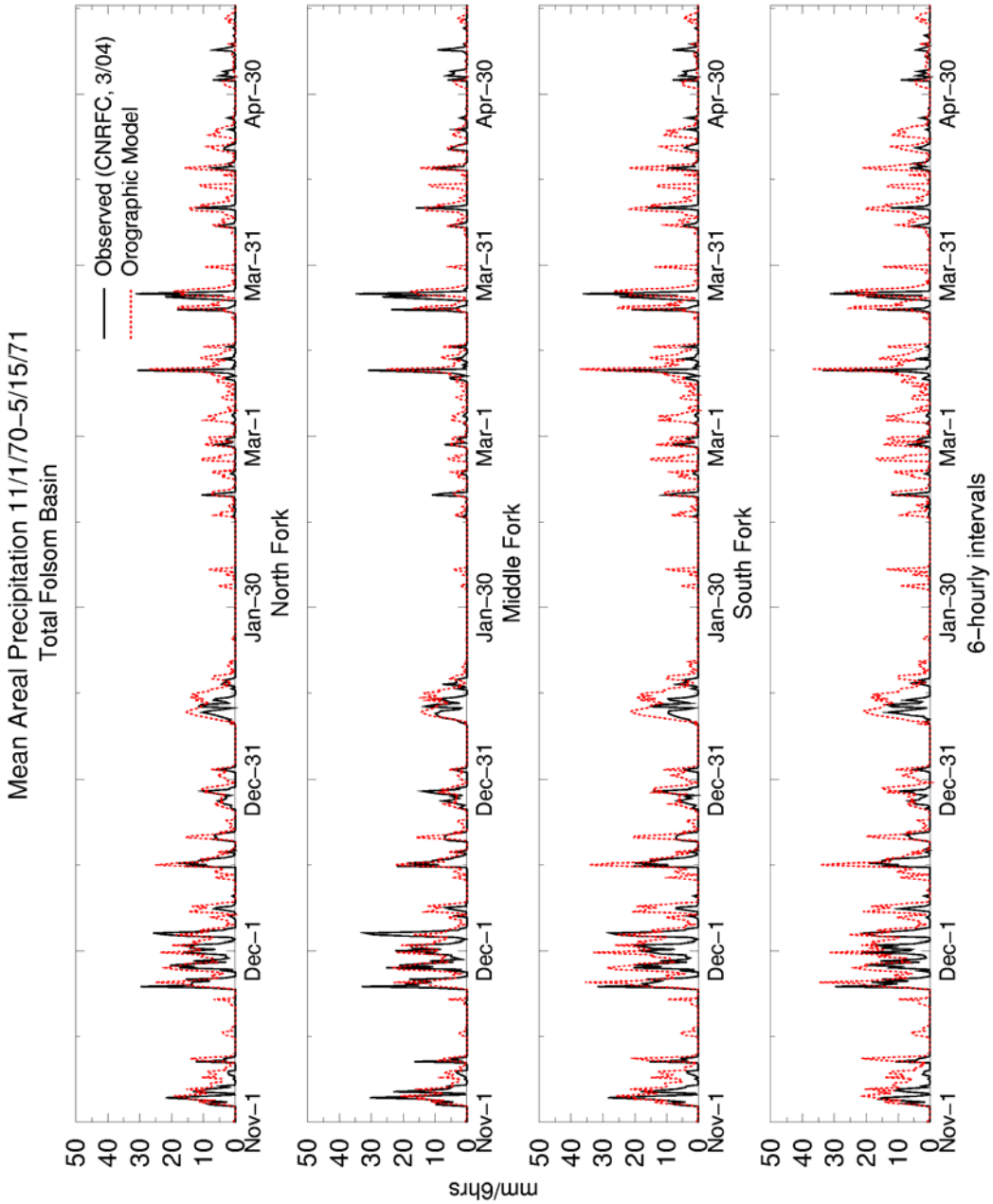
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Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
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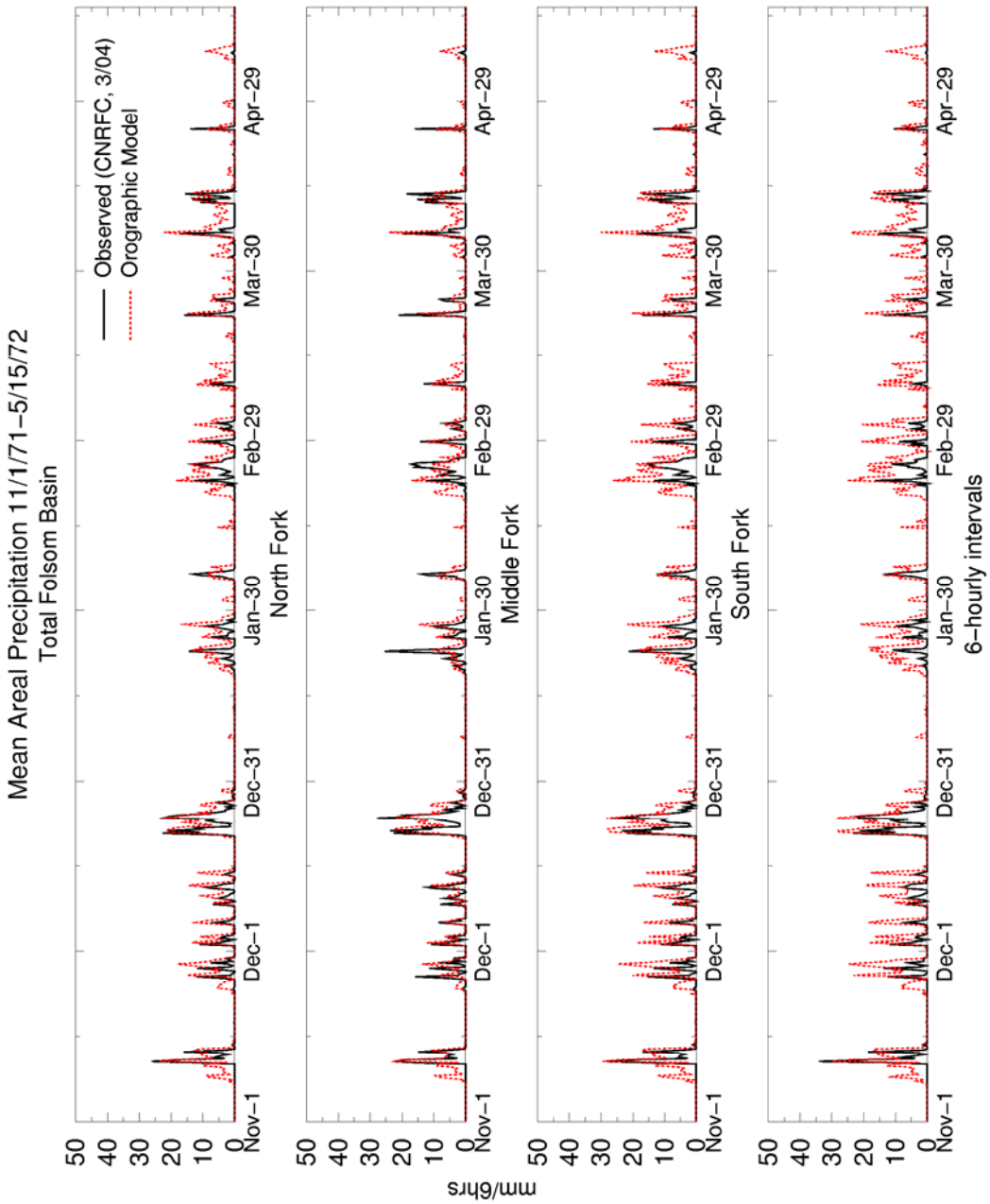
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Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
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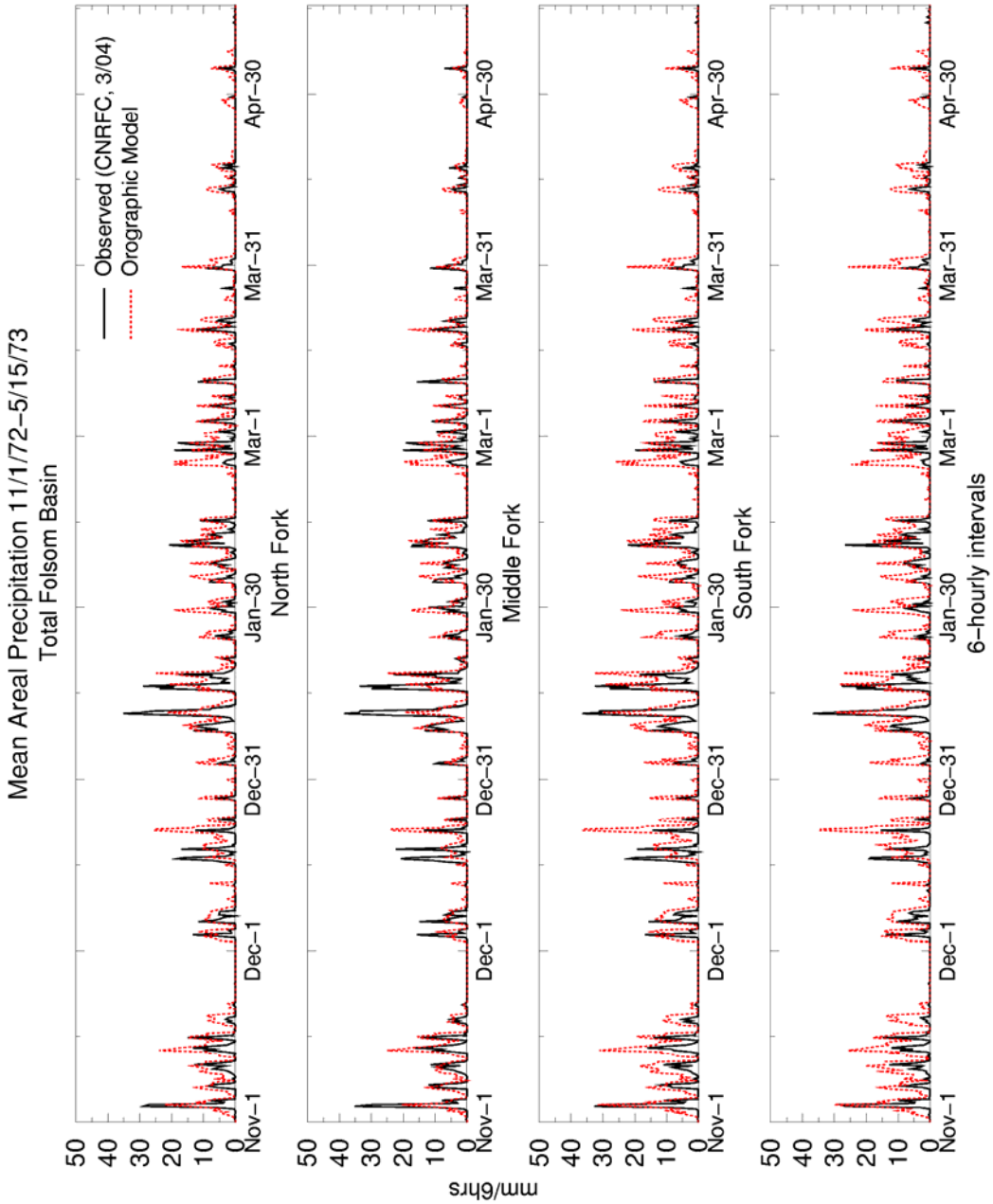
Mean Areal Precipitation 11/1/72–5/15/73
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
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0
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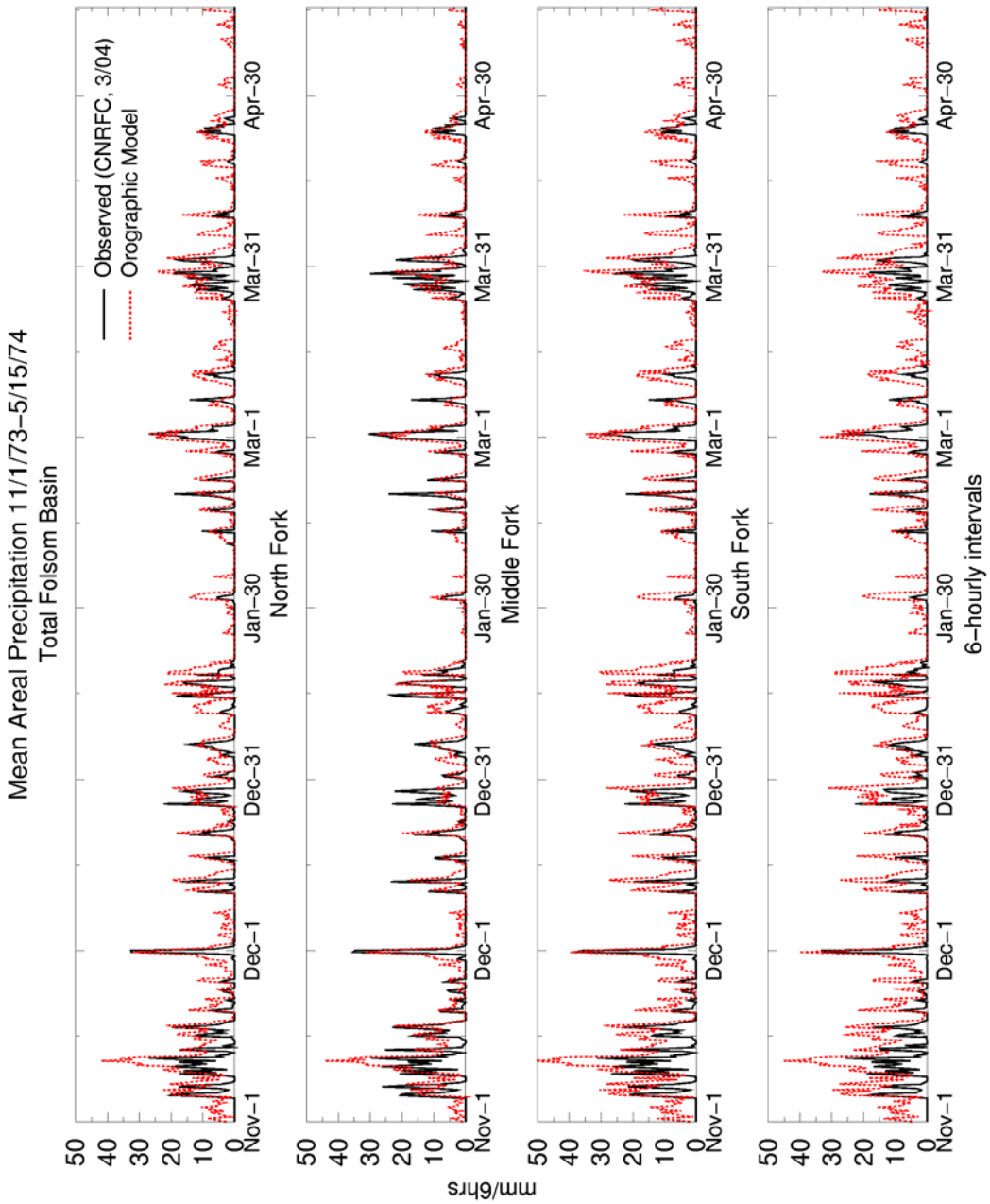
Mean Areal Precipitation 11/1/73–5/15/74
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
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Nov–1
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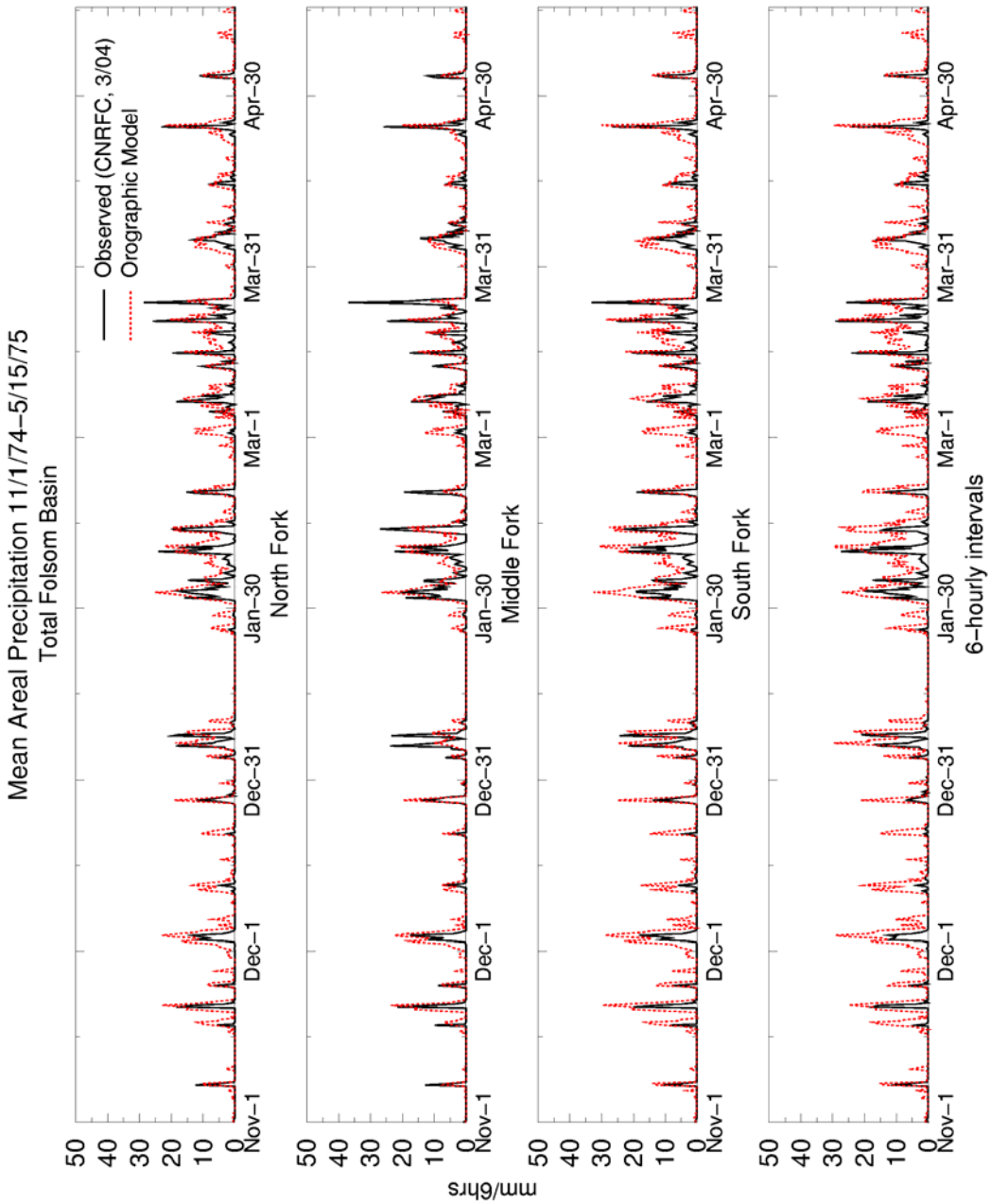
Mar–1
Mar–31
Apr–30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Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
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Nov–1
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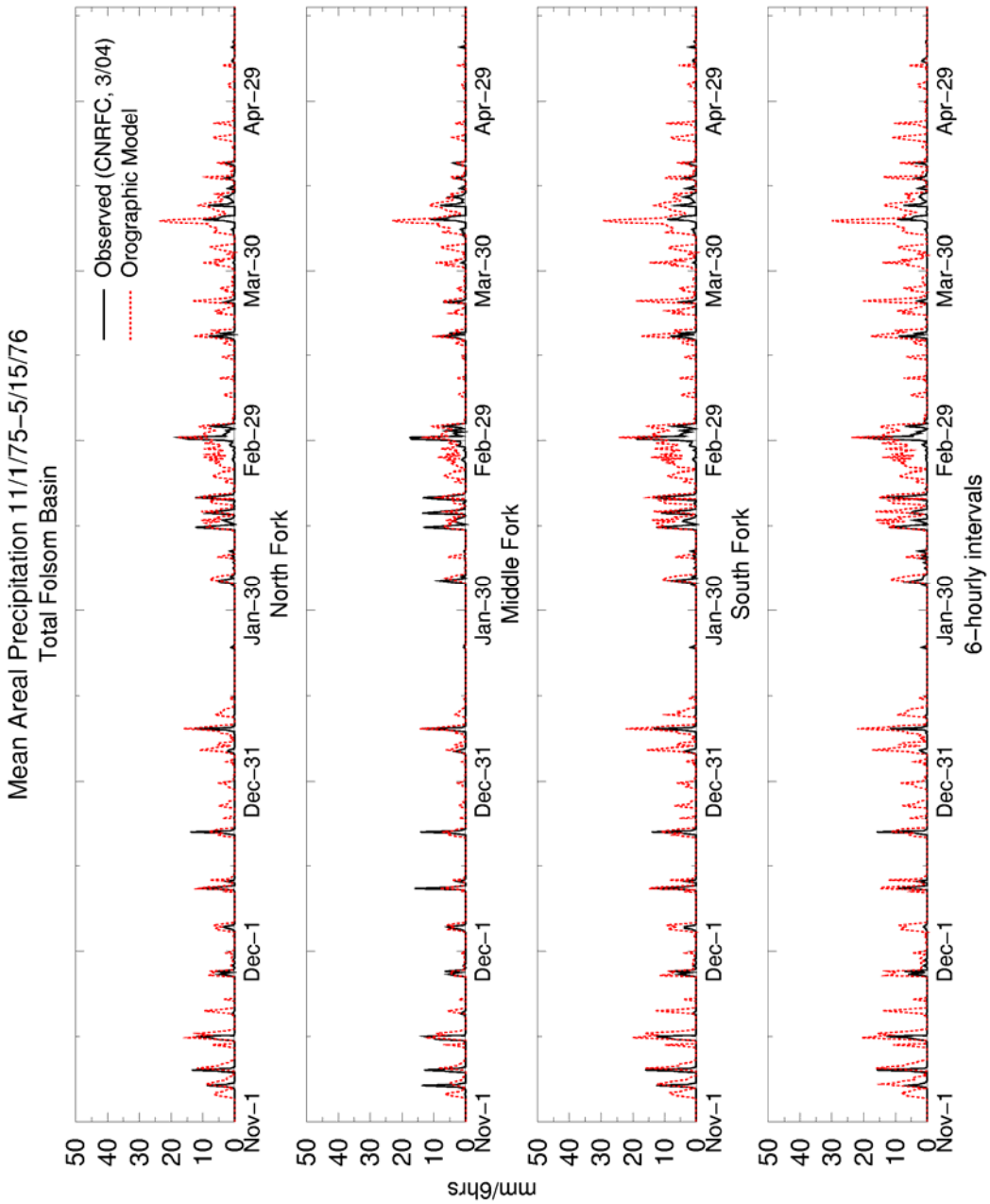
Mar–1
Mar–31
Apr–30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Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
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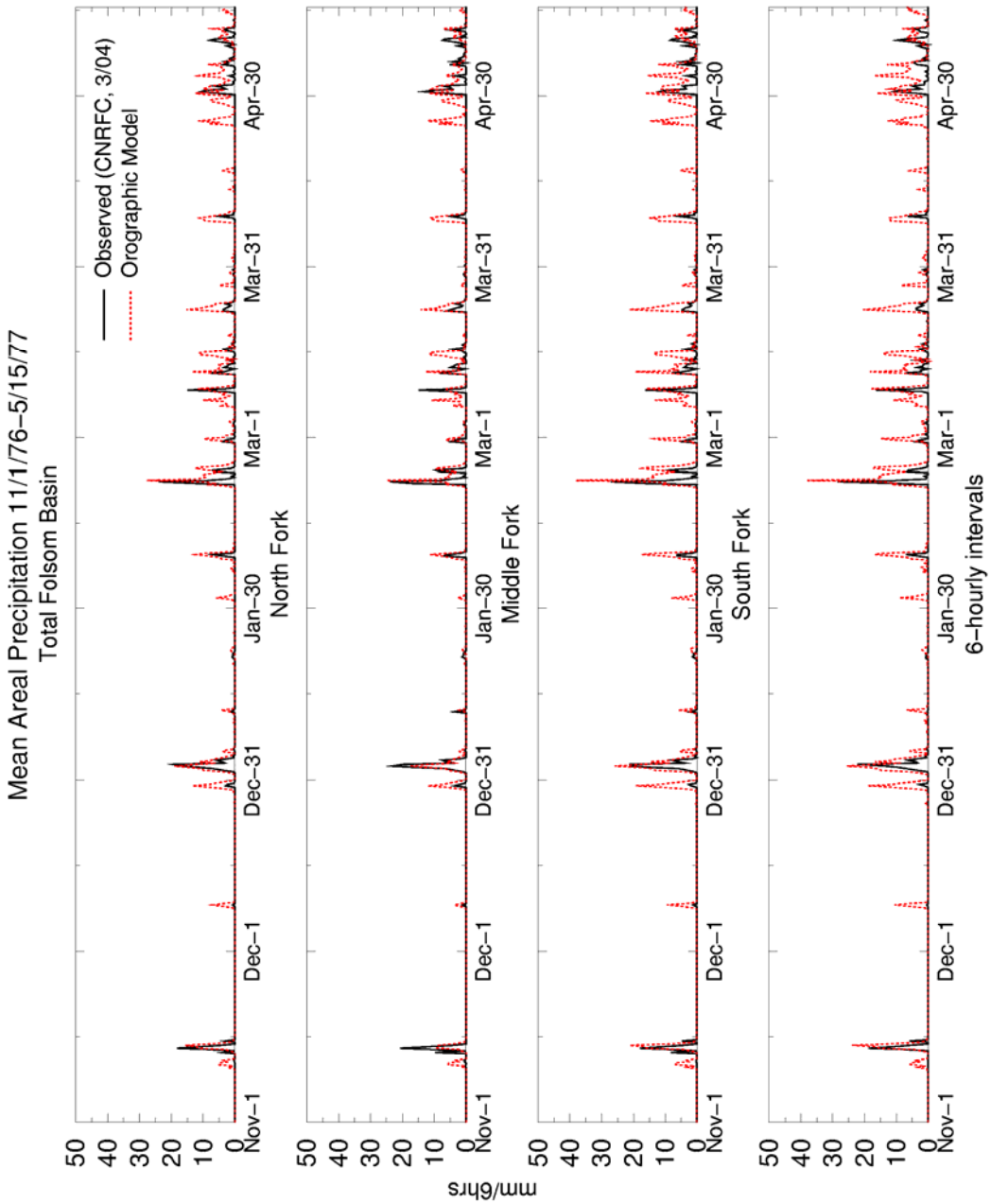
Mar–30
Apr–29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Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
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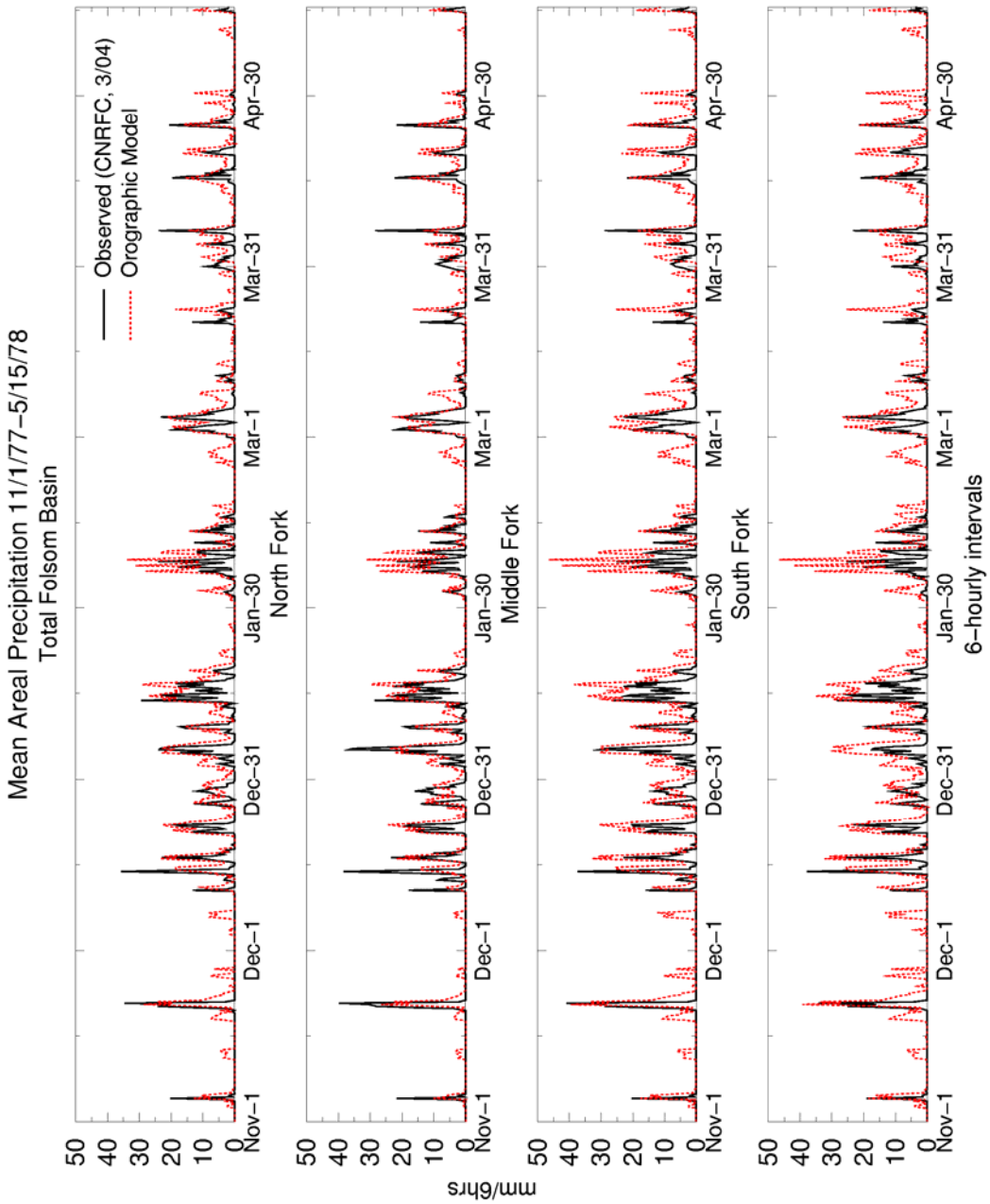
Mean Areal Precipitation 11/1/77–5/15/78
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
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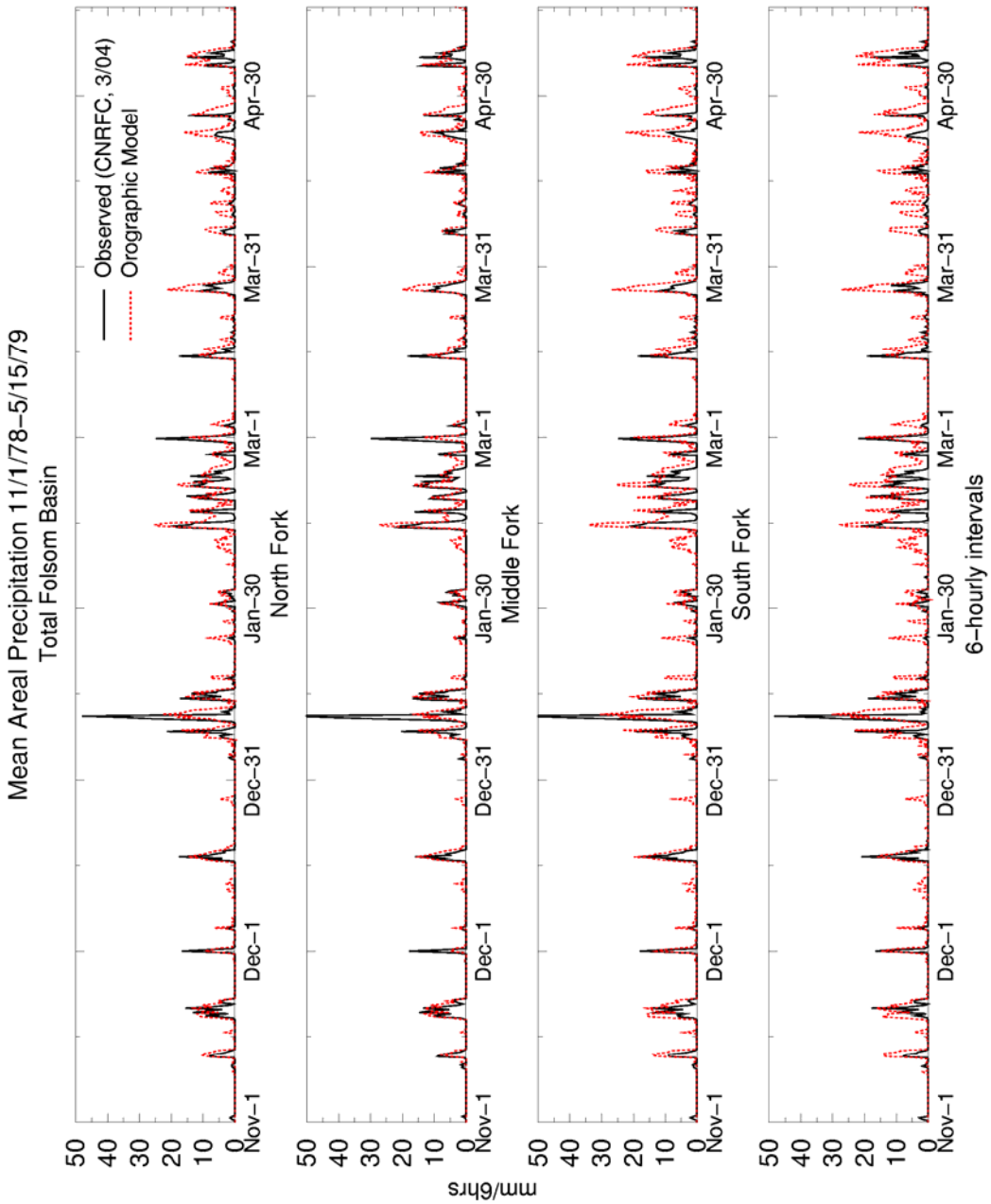
Apr–30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Orographic Model
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Middle Fork
South Fork
mm/6hrs
6–hourly intervals
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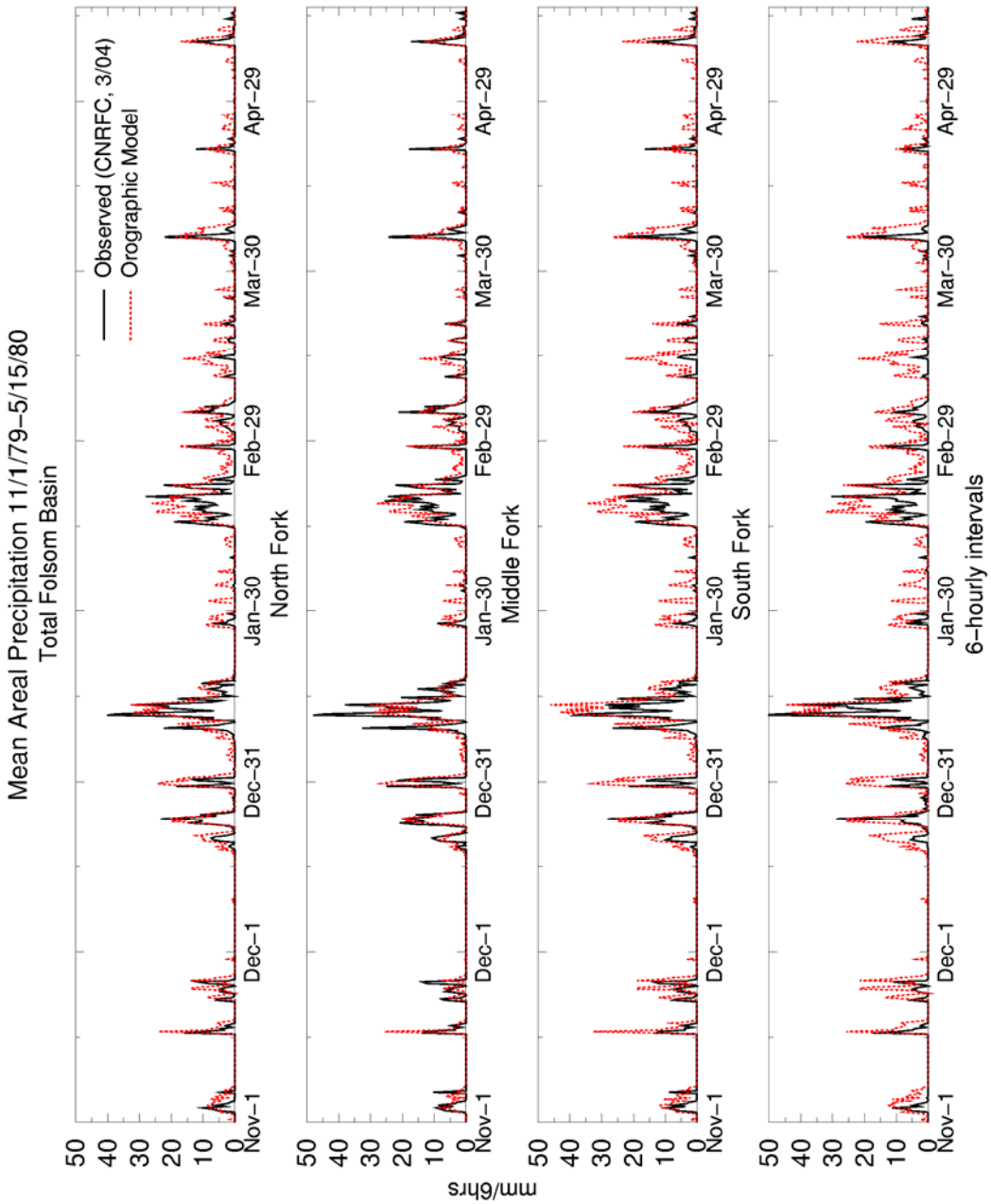
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Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
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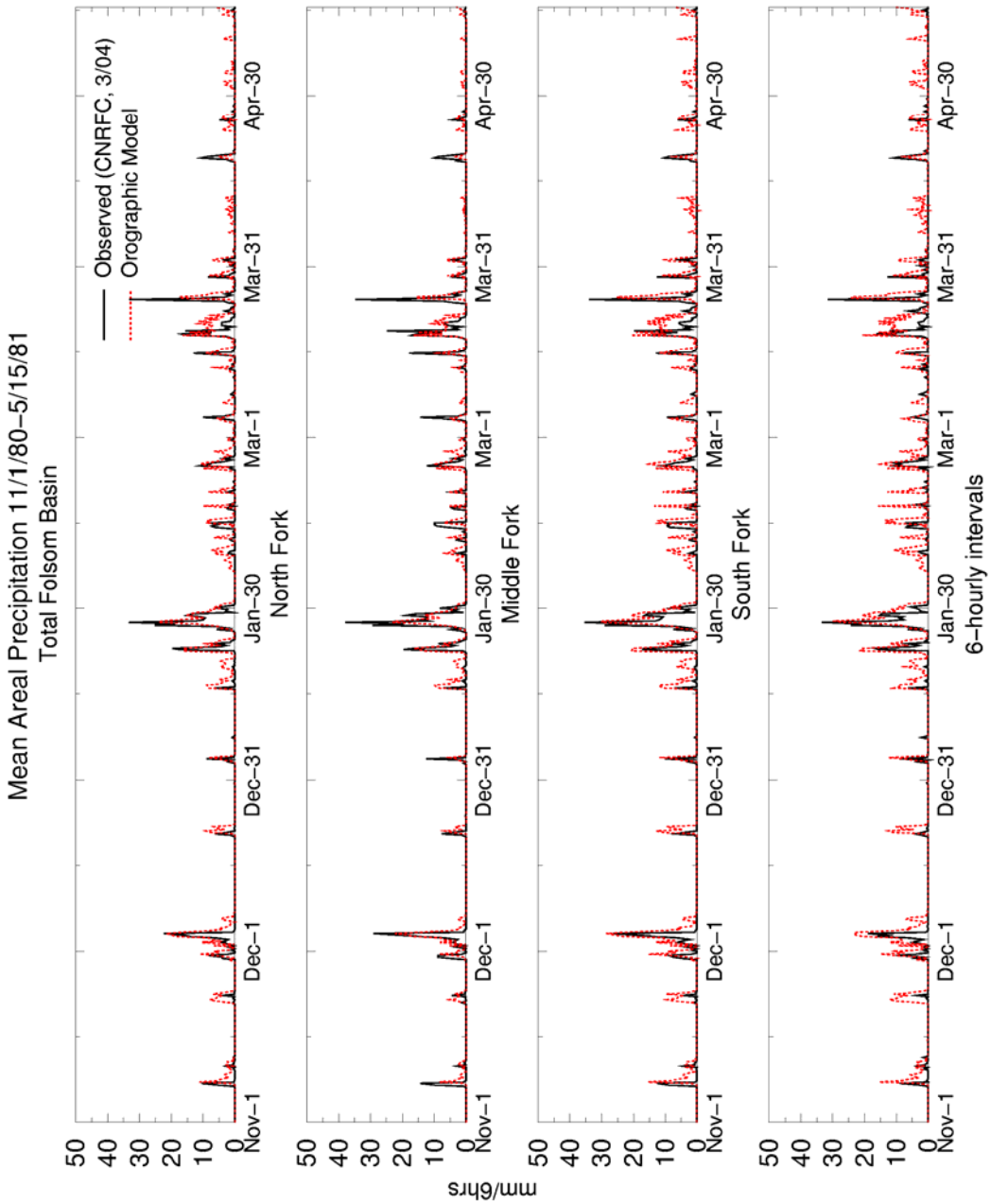
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Orographic Model
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Middle Fork
South Fork
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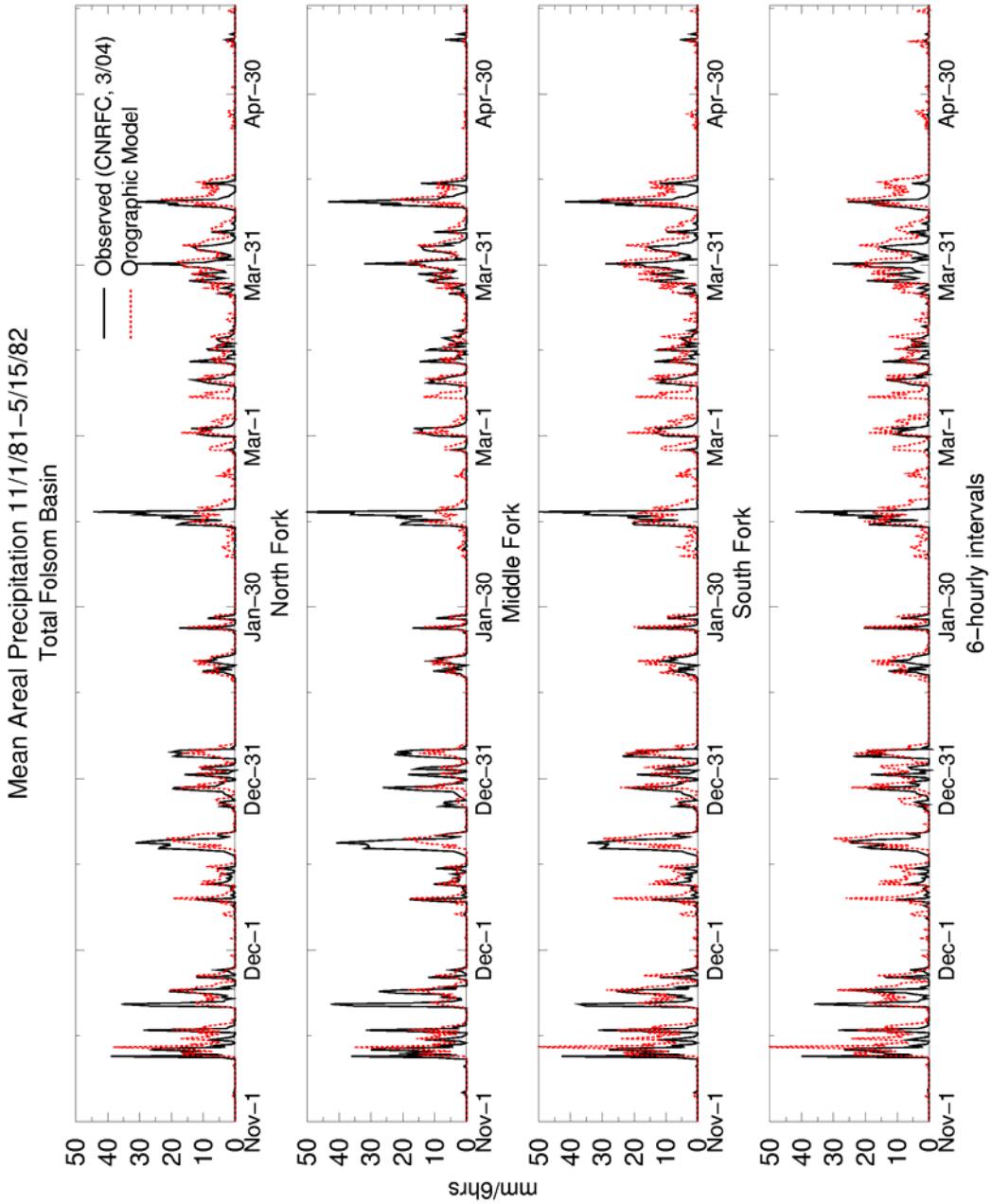
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Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
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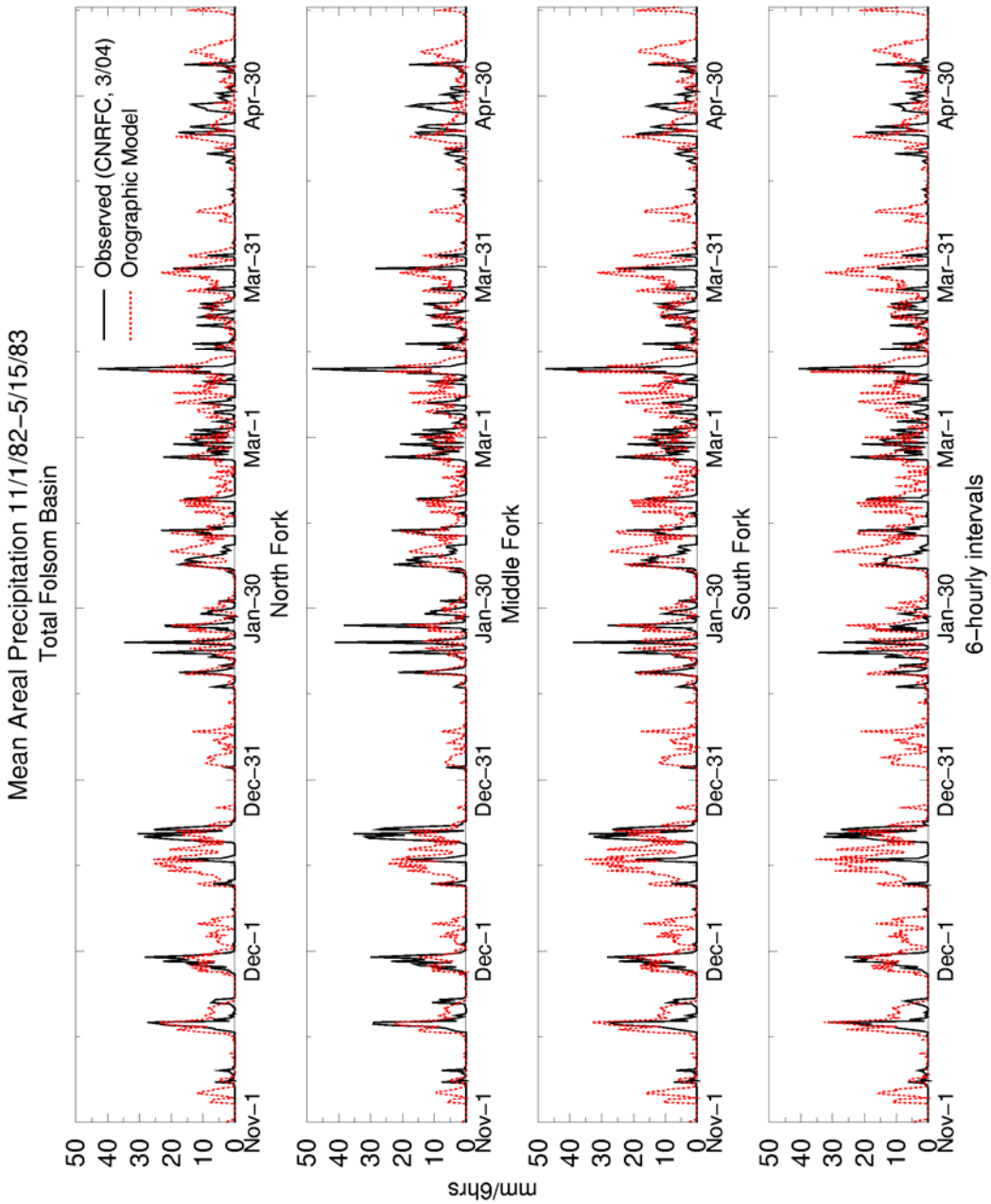
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South Fork
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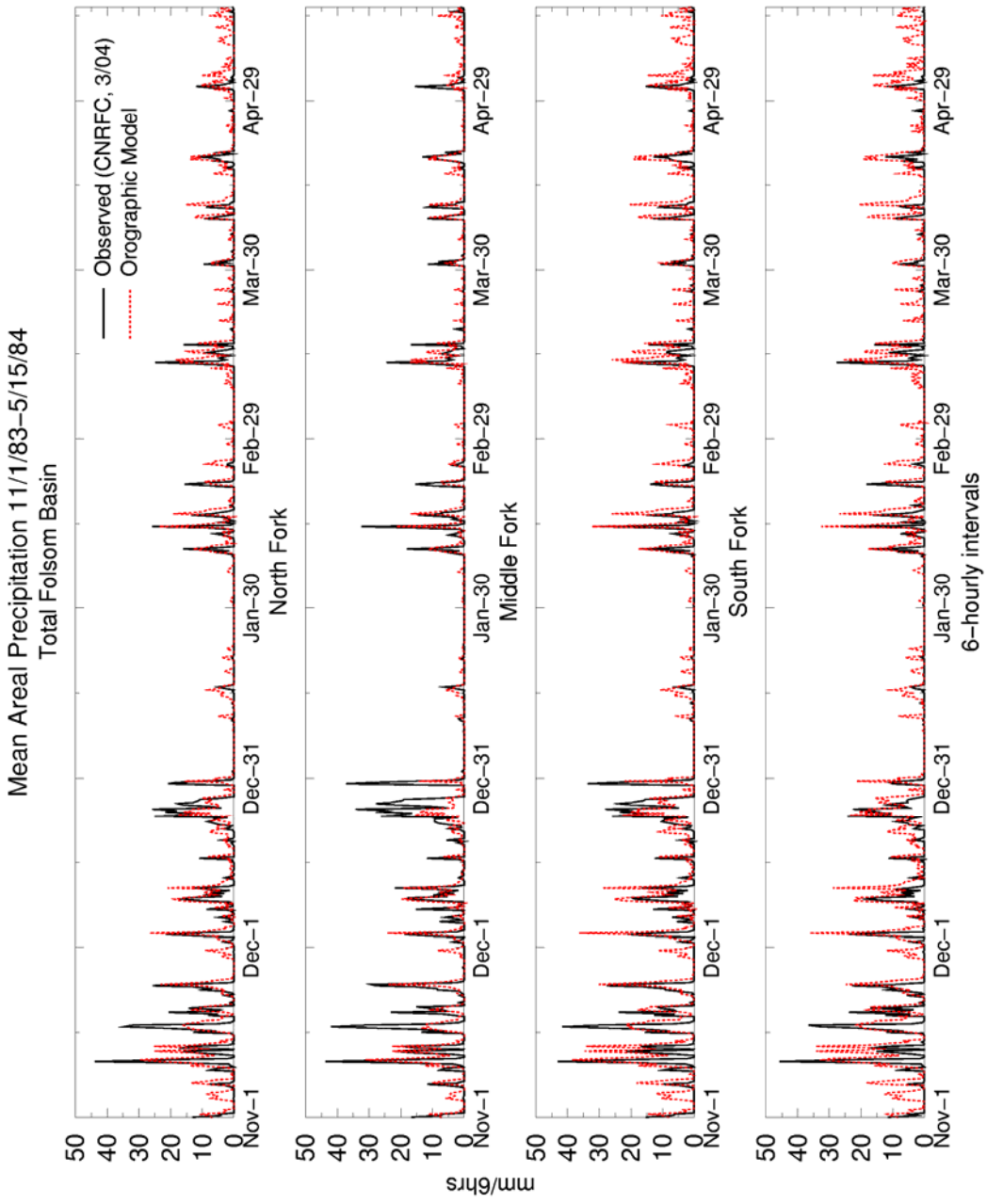
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Orographic Model
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Middle Fork
South Fork
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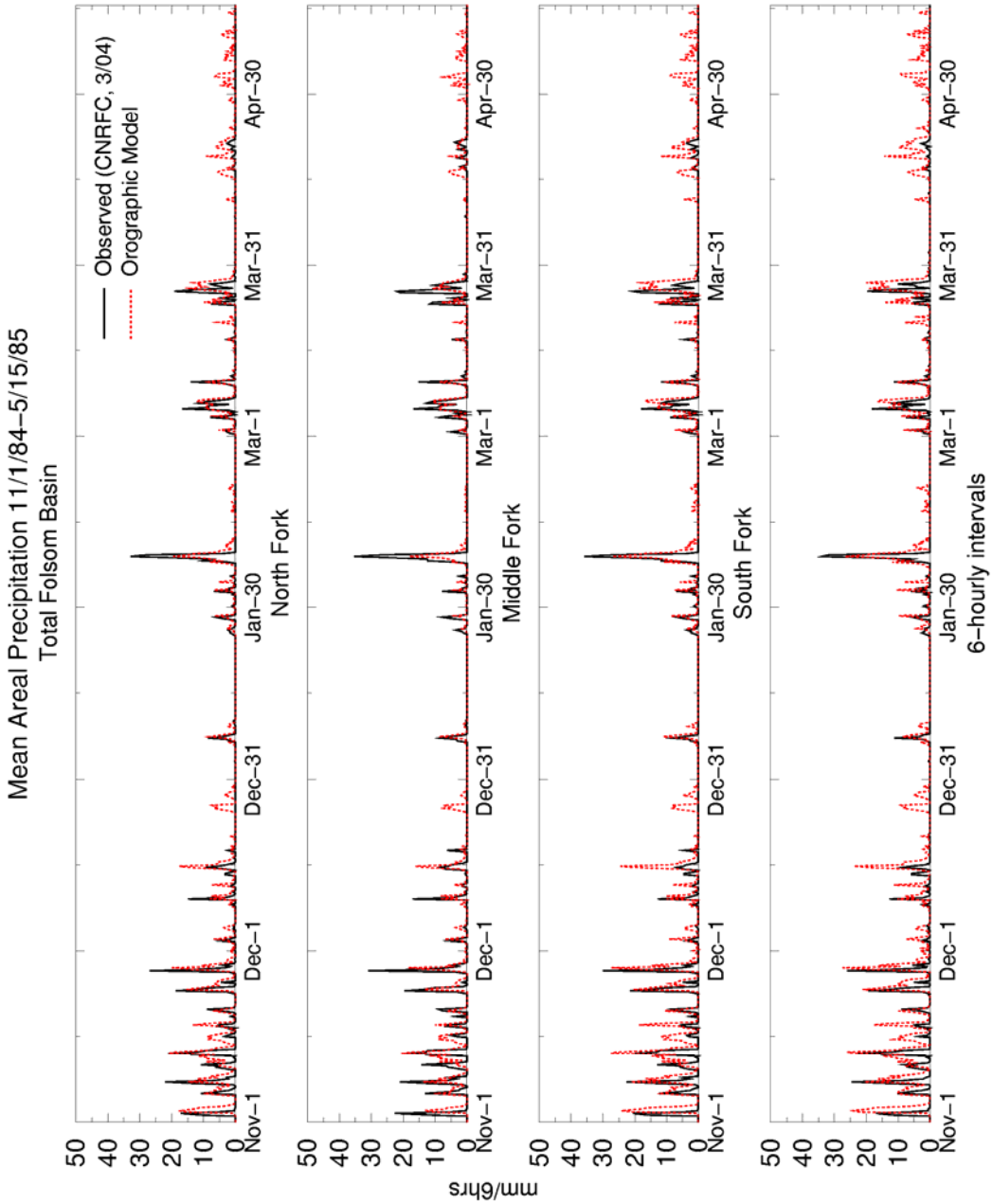
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South Fork
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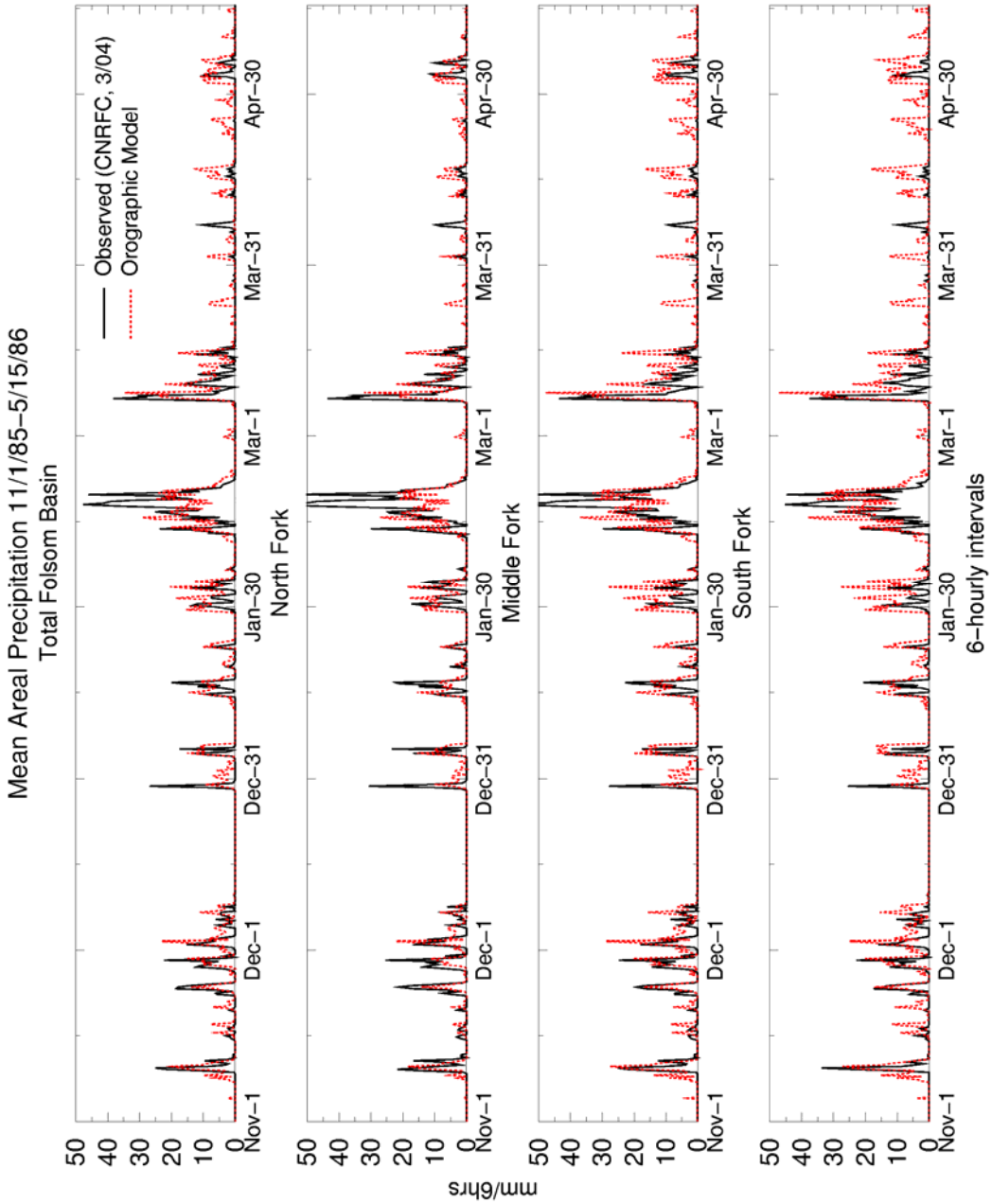
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Observed (CNRFC, 3/04)
Orographic Model
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Middle Fork
South Fork
mm/6hrs
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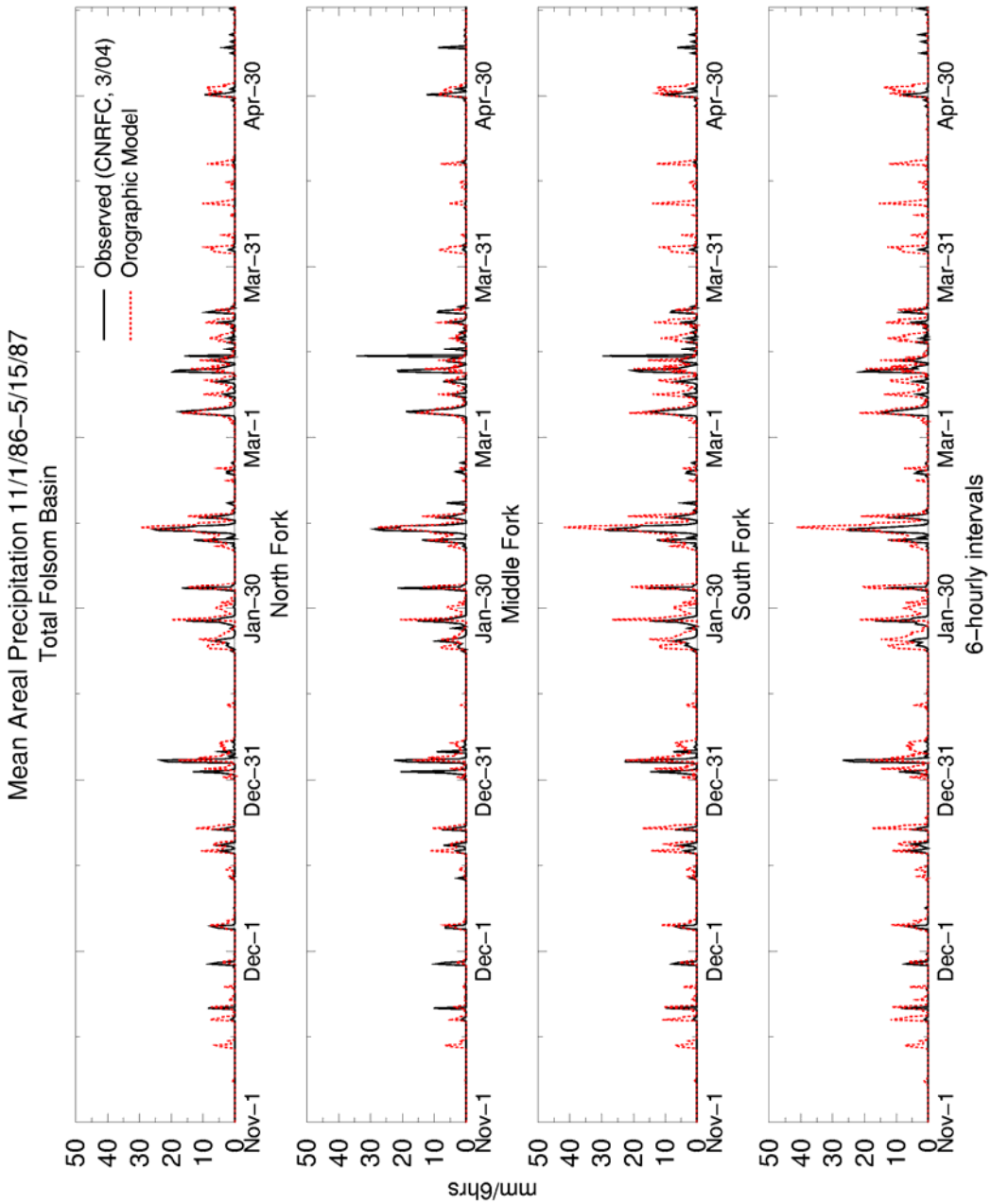
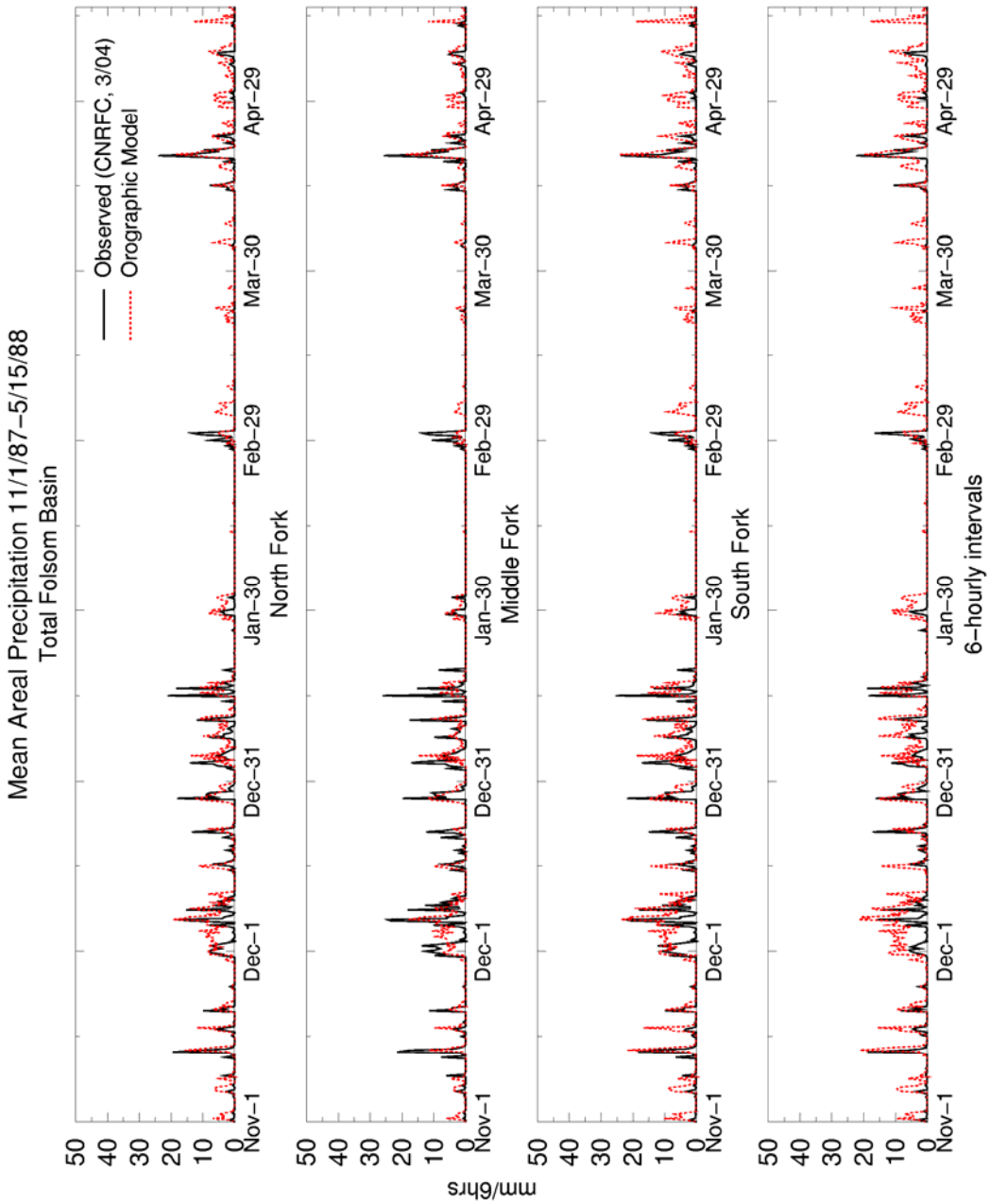
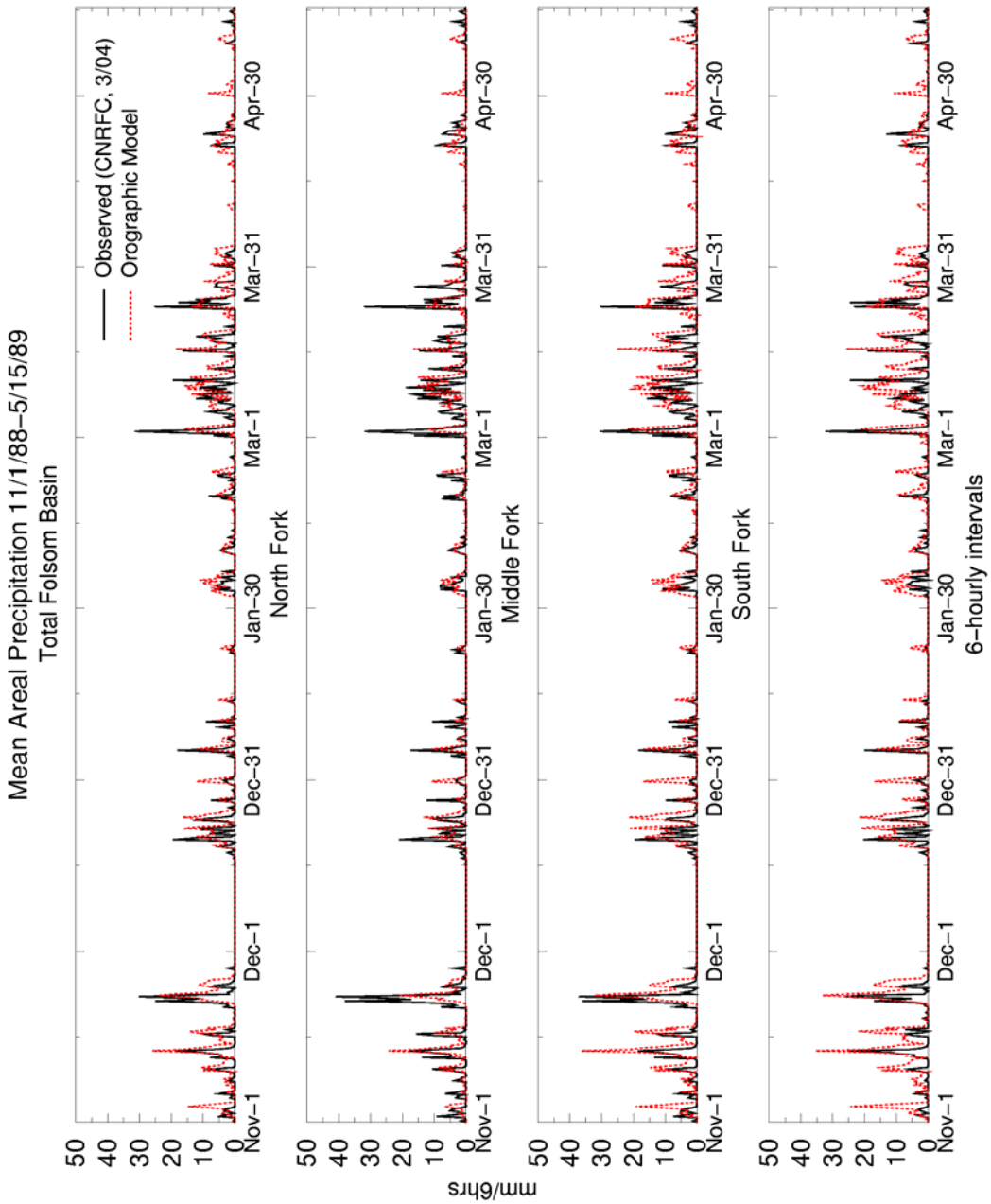
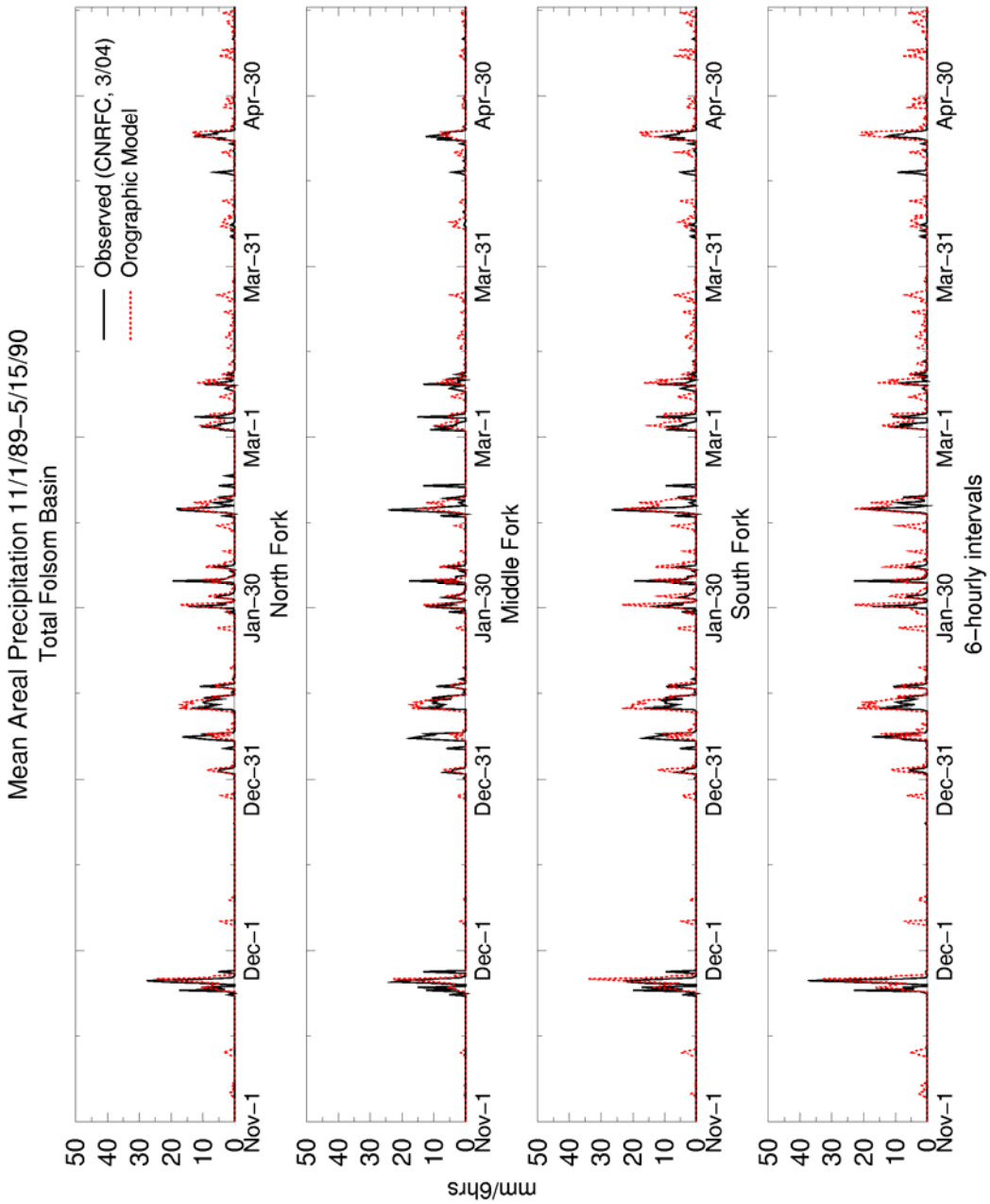
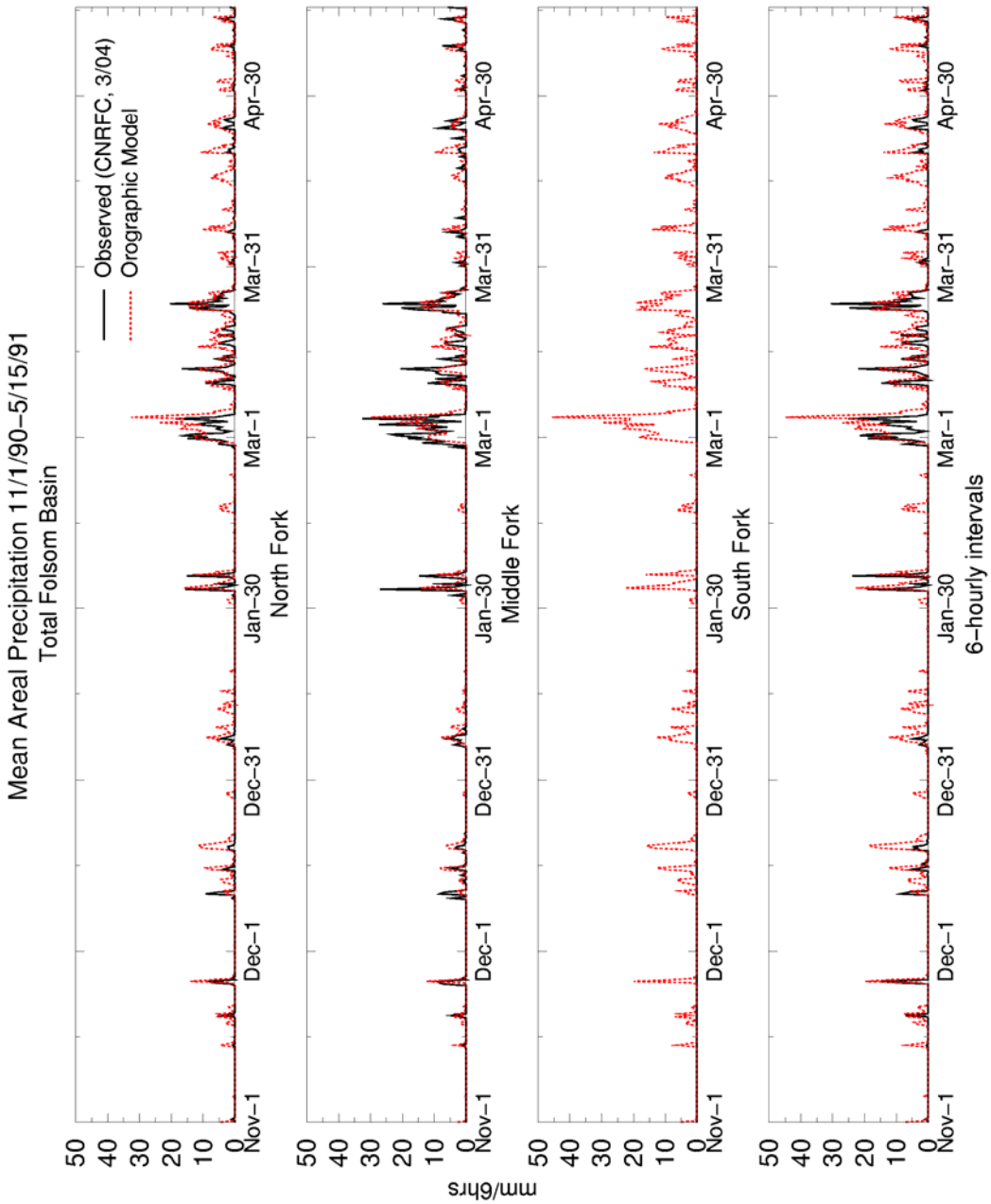
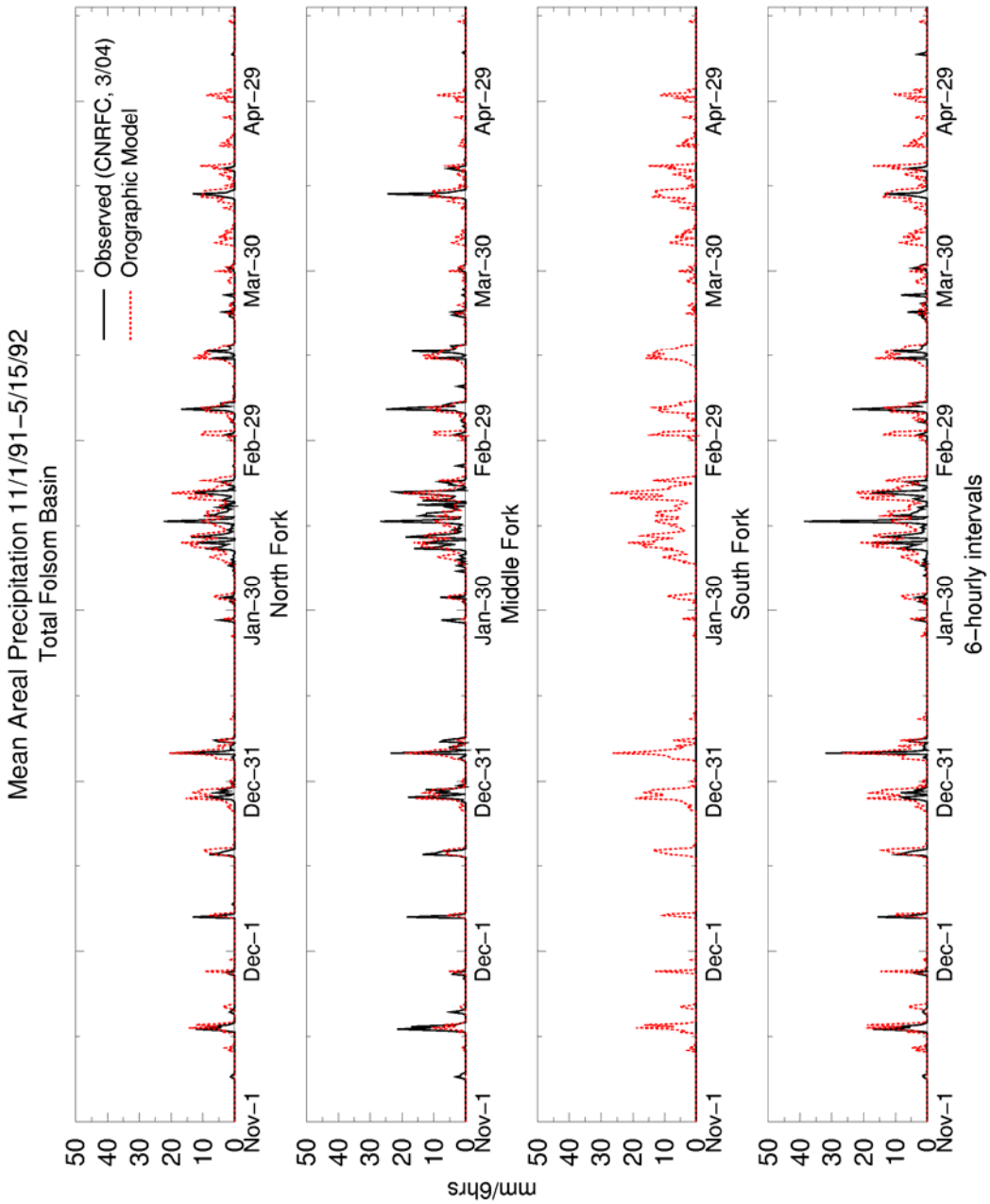

Mean Areal Precipitation 11/1/86–5/15/87
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
0
10
20
30
40
50
Nov–1
Dec–1
Dec–31
Jan–30
Mar–1
Mar–31
Apr–30


Mean Areal Precipitation 11/1/87–5/15/88
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
Nov–1
Dec–1
Dec–31
Jan–30
Feb–29
Mar–30
Apr–29
0
10
20
30
40
50


Mean Areal Precipitation 11/1/88–5/15/89
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
Nov–1
Dec–1
Dec–31
Jan–30
Mar–1
Mar–31
Apr–30
0
10
20
30
40
50


Mean Areal Precipitation 11/1/89–5/15/90
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
0
10
20
30
40
50
Nov–1
Dec–1
Dec–31
Jan–30
Mar–1
Mar–31
Apr–30


Mean Areal Precipitation 11/1/90–5/15/91
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
Nov–1
Dec–1
Dec–31
Jan–30
Mar–1
Mar–31
Apr–30
0
10
20
30
40
50


Mean Areal Precipitation 11/1/91–5/15/92
Total Folsom Basin
Observed (CNRFC, 3/04)
Orographic Model
North Fork
Middle Fork
South Fork
mm/6hrs
6–hourly intervals
0
10
20
30
40
50
Nov–1
Dec–1
Dec–31
Jan–30
Feb–29
Mar–30
Apr–29

Appendix C

Reliability-Diagram Tables for CFS-conditioned and Unconditioned ESP for INFORM Reservoir Inflows

Description of Tables

The following tables contain reliability diagram information for forecasts of N-day reservoir inflow volumes being in the upper and lower terciles of the observed distribution. Both CFS-conditioned and unconditioned ensemble streamflow prediction (ESP) forecasts are validated for the historical period 1981-1999, and for the wet season (October-April). The results are for all major INFORM reservoirs as indicated in the table headings.

FOLSOM RESERVOIR - CFS-CONDITIONED

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.16	0.05	76
0.125 - 0.250:	0.50	0.15	24
0.250 - 0.375:	0.62	0.31	8
0.375 - 0.500:	0.80	0.30	10
0.500 - 0.625:	0.50	0.33	8
0.625 - 0.750:	0.00	0.88	1
0.750 - 0.875:	1.00	0.74	1
0.875 - 1.000:	0.50	0.33	2

Brier Score: 0.0466

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.12	0.09	26
0.125 - 0.250:	0.11	0.14	28
0.250 - 0.375:	0.00	0.36	6
0.375 - 0.500:	0.28	0.19	25
0.500 - 0.625:	0.65	0.23	17
0.625 - 0.750:	0.17	0.36	6
0.750 - 0.875:	0.86	0.28	7
0.875 - 1.000:	0.87	0.12	15

Brier Score: 0.0254

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.16	0.05	73
0.125 - 0.250:	0.40	0.17	20
0.250 - 0.375:	0.44	0.29	9
0.375 - 0.500:	0.50	0.27	12
0.500 - 0.625:	0.80	0.30	10
0.625 - 0.750:	1.00	0.88	1
0.750 - 0.875:	0.75	0.37	4
0.875 - 1.000:	1.00	0.46	1

Brier Score: 0.0196

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.17	0.09	24
0.125 - 0.250:	0.23	0.13	35
0.250 - 0.375:	0.14	0.33	7
0.375 - 0.500:	0.28	0.17	32
0.500 - 0.625:	0.42	0.27	12
0.625 - 0.750:	0.33	0.51	3
0.750 - 0.875:	1.00	0.25	9
0.875 - 1.000:	0.88	0.16	8

Brier Score: 0.0175

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.19	0.05	73
0.125 - 0.250:	0.40	0.17	20
0.250 - 0.375:	0.50	0.36	6
0.375 - 0.500:	0.38	0.24	16
0.500 - 0.625:	0.78	0.31	9
0.625 - 0.750:	0.50	0.62	2
0.750 - 0.875:	1.00	0.43	3
0.875 - 1.000:	1.00	0.46	1

Brier Score: 0.0230

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.07	0.09	28
0.125 - 0.250:	0.35	0.13	34
0.250 - 0.375:	0.62	0.31	8
0.375 - 0.500:	0.20	0.17	30
0.500 - 0.625:	0.27	0.28	11
0.625 - 0.750:	0.75	0.44	4
0.750 - 0.875:	0.83	0.30	6
0.875 - 1.000:	0.89	0.15	9

Brier Score: 0.0336

NEW BULLARDS BAR RESERVOIR - CFS-CONDITIONED

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.11	0.06	55
0.125 - 0.250:	0.35	0.17	20
0.250 - 0.375:	0.38	0.31	8
0.375 - 0.500:	0.61	0.20	23
0.500 - 0.625:	0.18	0.28	11
0.625 - 0.750:	1.00	0.44	4
0.750 - 0.875:	0.80	0.33	5
0.875 - 1.000:	0.75	0.23	4

Brier Score: 0.0268

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.13	0.10	23
0.125 - 0.250:	0.17	0.13	35
0.250 - 0.375:	0.43	0.33	7
0.375 - 0.500:	0.36	0.18	28
0.500 - 0.625:	0.38	0.26	13
0.625 - 0.750:	0.20	0.39	5
0.750 - 0.875:	0.69	0.21	13
0.875 - 1.000:	1.00	0.19	6

Brier Score: 0.0169

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.15	0.06	59
0.125 - 0.250:	0.38	0.13	32
0.250 - 0.375:	0.57	0.33	7
0.375 - 0.500:	0.53	0.23	17
0.500 - 0.625:	0.58	0.27	12
0.625 - 0.750:	1.00	0.88	1
0.750 - 0.875:	0.00	0.74	1
0.875 - 1.000:	1.00	0.46	1

Brier Score: 0.0229

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.00	0.15	9
0.125 - 0.250:	0.26	0.11	42
0.250 - 0.375:	0.18	0.27	11
0.375 - 0.500:	0.40	0.17	30
0.500 - 0.625:	0.25	0.24	16
0.625 - 0.750:	0.60	0.39	5
0.750 - 0.875:	0.50	0.26	8
0.875 - 1.000:	0.89	0.15	9

Brier Score: 0.0223

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.24	0.06	62
0.125 - 0.250:	0.38	0.13	32
0.250 - 0.375:	0.17	0.36	6
0.375 - 0.500:	0.45	0.21	20
0.500 - 0.625:	0.62	0.33	8
0.625 - 0.750:	0.00	0.88	1
0.750 - 0.875:	****	****	0
0.875 - 1.000:	1.00	0.46	1

Brier Score: 0.0289

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.23	0.13	13
0.125 - 0.250:	0.24	0.12	41
0.250 - 0.375:	0.50	0.36	6
0.375 - 0.500:	0.27	0.15	37
0.500 - 0.625:	0.18	0.28	11
0.625 - 0.750:	0.86	0.33	7
0.750 - 0.875:	0.38	0.26	8
0.875 - 1.000:	1.00	0.17	7

Brier Score: 0.0392

OROVILLE RESERVOIR - CFS-CONDITIONED

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.07	0.06	58
0.125 - 0.250:	0.58	0.15	24
0.250 - 0.375:	0.50	0.36	6
0.375 - 0.500:	0.75	0.33	8
0.500 - 0.625:	0.38	0.33	8
0.625 - 0.750:	0.80	0.39	5
0.750 - 0.875:	0.80	0.33	5
0.875 - 1.000:	0.50	0.33	2

Brier Score: 0.0473

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.05	0.10	21
0.125 - 0.250:	0.11	0.14	27
0.250 - 0.375:	0.00	0.29	9
0.375 - 0.500:	0.48	0.21	21
0.500 - 0.625:	0.31	0.26	13
0.625 - 0.750:	0.80	0.39	5
0.750 - 0.875:	0.60	0.33	5
0.875 - 1.000:	0.93	0.12	15

Brier Score: 0.0190

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.17	0.06	64
0.125 - 0.250:	0.47	0.17	19
0.250 - 0.375:	0.43	0.33	7
0.375 - 0.500:	0.50	0.25	14
0.500 - 0.625:	0.88	0.33	8
0.625 - 0.750:	0.50	0.62	2
0.750 - 0.875:	****	****	0
0.875 - 1.000:	0.50	0.33	2

Brier Score: 0.0319

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.00	0.14	11
0.125 - 0.250:	0.19	0.14	27
0.250 - 0.375:	0.25	0.31	8
0.375 - 0.500:	0.36	0.18	28
0.500 - 0.625:	0.33	0.22	18
0.625 - 0.750:	0.33	0.36	6
0.750 - 0.875:	0.50	0.30	6
0.875 - 1.000:	0.92	0.13	12

Brier Score: 0.0219

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.19	0.06	67
0.125 - 0.250:	0.59	0.16	22
0.250 - 0.375:	0.56	0.29	9
0.375 - 0.500:	0.30	0.30	10
0.500 - 0.625:	0.60	0.42	5
0.625 - 0.750:	0.50	0.62	2
0.750 - 0.875:	****	****	0
0.875 - 1.000:	1.00	0.46	1

Brier Score: 0.0478

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.20	0.09	25
0.125 - 0.250:	0.31	0.12	36
0.250 - 0.375:	0.40	0.39	5
0.375 - 0.500:	0.27	0.18	26
0.500 - 0.625:	0.42	0.27	12
0.625 - 0.750:	0.75	0.44	4
0.750 - 0.875:	0.67	0.43	3
0.875 - 1.000:	1.00	0.21	5

Brier Score: 0.0181

SHASTA RESERVOIR - CFS-CONDITIONED

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.14	0.08	37
0.125 - 0.250:	0.18	0.22	11
0.250 - 0.375:	0.75	0.31	8
0.375 - 0.500:	0.67	0.31	9
0.500 - 0.625:	0.44	0.31	9
0.625 - 0.750:	0.50	0.44	4
0.750 - 0.875:	0.50	0.52	2
0.875 - 1.000:	1.00	0.46	1

Brier Score: 0.0329

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.10	0.15	10
0.125 - 0.250:	0.19	0.15	26
0.250 - 0.375:	0.33	0.51	3
0.375 - 0.500:	0.18	0.28	11
0.500 - 0.625:	0.50	0.27	12
0.625 - 0.750:	0.60	0.39	5
0.750 - 0.875:	0.60	0.33	5
0.875 - 1.000:	0.78	0.15	9

Brier Score: 0.0157

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.16	0.08	31
0.125 - 0.250:	0.45	0.17	20
0.250 - 0.375:	0.50	0.31	8
0.375 - 0.500:	0.40	0.30	10
0.500 - 0.625:	0.30	0.30	10
0.625 - 0.750:	****	****	0
0.750 - 0.875:	1.00	0.52	2
0.875 - 1.000:	****	****	0

Brier Score: 0.0338

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.00	0.23	4
0.125 - 0.250:	0.20	0.23	10
0.250 - 0.375:	0.12	0.31	8
0.375 - 0.500:	0.35	0.23	17
0.500 - 0.625:	0.33	0.22	18
0.625 - 0.750:	0.00	0.51	3
0.750 - 0.875:	0.58	0.21	12
0.875 - 1.000:	0.67	0.15	9

Brier Score: 0.0503

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.24	0.08	34
0.125 - 0.250:	0.48	0.16	21
0.250 - 0.375:	0.57	0.33	7
0.375 - 0.500:	0.23	0.26	13
0.500 - 0.625:	0.40	0.42	5
0.625 - 0.750:	0.00	0.88	1
0.750 - 0.875:	****	****	0
0.875 - 1.000:	****	****	0

Brier Score: 0.0543

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.00	0.23	4
0.125 - 0.250:	0.17	0.30	6
0.250 - 0.375:	0.00	0.51	3
0.375 - 0.500:	0.28	0.22	18
0.500 - 0.625:	0.30	0.20	23
0.625 - 0.750:	0.00	0.51	3
0.750 - 0.875:	0.58	0.21	12
0.875 - 1.000:	0.67	0.13	12

Brier Score: 0.0646

TRINITY RESERVOIR – CFS CONDITIONED

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.16	0.06	63
0.125 - 0.250:	0.50	0.19	16
0.250 - 0.375:	0.36	0.27	11
0.375 - 0.500:	0.60	0.24	15
0.500 - 0.625:	0.43	0.25	14
0.625 - 0.750:	0.60	0.39	5
0.750 - 0.875:	0.40	0.33	5
0.875 - 1.000:	1.00	0.46	1

Brier Score: 0.0286

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.23	0.13	13
0.125 - 0.250:	0.20	0.13	35
0.250 - 0.375:	0.41	0.21	17
0.375 - 0.500:	0.31	0.18	26
0.500 - 0.625:	0.44	0.31	9
0.625 - 0.750:	0.38	0.31	8
0.750 - 0.875:	0.45	0.22	11
0.875 - 1.000:	0.64	0.14	11

Brier Score: 0.0330

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.25	0.06	61
0.125 - 0.250:	0.23	0.16	22
0.250 - 0.375:	0.55	0.27	11
0.375 - 0.500:	0.43	0.21	21
0.500 - 0.625:	0.50	0.30	10
0.625 - 0.750:	0.50	0.62	2
0.750 - 0.875:	0.67	0.43	3
0.875 - 1.000:	****	****	0

Brier Score: 0.0220

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.05	0.11	19
0.125 - 0.250:	0.27	0.14	30
0.250 - 0.375:	0.33	0.51	3
0.375 - 0.500:	0.31	0.15	39
0.500 - 0.625:	0.47	0.23	17
0.625 - 0.750:	0.33	0.51	3
0.750 - 0.875:	0.60	0.23	10
0.875 - 1.000:	0.67	0.15	9

Brier Score: 0.0191

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.19	0.07	47
0.125 - 0.250:	0.39	0.14	28
0.250 - 0.375:	0.55	0.27	11
0.375 - 0.500:	0.38	0.19	24
0.500 - 0.625:	0.18	0.28	11
0.625 - 0.750:	0.80	0.39	5
0.750 - 0.875:	0.50	0.37	4
0.875 - 1.000:	****	****	0

Brier Score: 0.0362

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.17	0.11	18
0.125 - 0.250:	0.27	0.14	30
0.250 - 0.375:	0.22	0.29	9
0.375 - 0.500:	0.29	0.16	35
0.500 - 0.625:	0.57	0.21	21
0.625 - 0.750:	0.20	0.39	5
0.750 - 0.875:	0.67	0.43	3
0.875 - 1.000:	0.67	0.15	9

Brier Score: 0.0244

FOLSOM RESERVOIR – ESP (15 RANDOMLY SELECTED TRACES)

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.14	0.05	71
0.125 - 0.250:	0.45	0.16	22
0.250 - 0.375:	0.50	0.28	10
0.375 - 0.500:	0.71	0.36	7
0.500 - 0.625:	0.38	0.33	8
0.625 - 0.750:	1.00	0.62	2
0.750 - 0.875:	0.86	0.28	7
0.875 - 1.000:	0.67	0.27	3

Brier Score: 0.0277

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
UPPER			
0.000 - 0.125:	0.19	0.09	27
0.125 - 0.250:	0.20	0.13	35
0.250 - 0.375:	0.38	0.24	13
0.375 - 0.500:	0.25	0.21	20
0.500 - 0.625:	0.38	0.26	13
0.625 - 0.750:	0.67	0.51	3
0.750 - 0.875:	0.69	0.21	13
0.875 - 1.000:	1.00	0.19	6

Brier Score: 0.0139

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.14	0.06	64
0.125 - 0.250:	0.28	0.14	29
0.250 - 0.375:	0.71	0.33	7
0.375 - 0.500:	0.60	0.24	15
0.500 - 0.625:	0.86	0.36	7
0.625 - 0.750:	1.00	0.88	1
0.750 - 0.875:	0.80	0.33	5
0.875 - 1.000:	0.50	0.33	2

Brier Score: 0.0249

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.15	0.08	33
0.125 - 0.250:	0.19	0.12	36
0.250 - 0.375:	0.33	0.36	6
0.375 - 0.500:	0.45	0.17	31
0.500 - 0.625:	0.57	0.25	14
0.625 - 0.750:	0.60	0.39	5
0.750 - 0.875:	1.00	0.52	2
0.875 - 1.000:	1.00	0.27	3

Brier Score: 0.0030

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.11	0.06	56
0.125 - 0.250:	0.35	0.15	23
0.250 - 0.375:	0.46	0.24	13
0.375 - 0.500:	0.59	0.23	17
0.500 - 0.625:	0.29	0.36	7
0.625 - 0.750:	0.75	0.44	4
0.750 - 0.875:	0.71	0.28	7
0.875 - 1.000:	1.00	0.27	3

Brier Score: 0.0155

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.12	0.07	41
0.125 - 0.250:	0.30	0.12	37
0.250 - 0.375:	0.45	0.27	11
0.375 - 0.500:	0.45	0.20	22
0.500 - 0.625:	0.50	0.30	10
0.625 - 0.750:	1.00	0.51	3
0.750 - 0.875:	0.67	0.43	3
0.875 - 1.000:	1.00	0.27	3

Brier Score: 0.0094

NEW BULLARDS BAR RESERVOIR – ESP (15 RANDOMLY SELECTED TRACES)

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.12	0.07	50
0.125 - 0.250:	0.39	0.17	18
0.250 - 0.375:	0.44	0.29	9
0.375 - 0.500:	0.43	0.21	21
0.500 - 0.625:	0.56	0.22	18
0.625 - 0.750:	0.40	0.39	5
0.750 - 0.875:	0.57	0.28	7
0.875 - 1.000:	0.50	0.33	2

Brier Score: 0.0174

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.29	0.09	24
0.125 - 0.250:	0.18	0.12	39
0.250 - 0.375:	0.29	0.33	7
0.375 - 0.500:	0.26	0.17	31
0.500 - 0.625:	0.42	0.27	12
0.625 - 0.750:	0.80	0.39	5
0.750 - 0.875:	0.80	0.33	5
0.875 - 1.000:	0.86	0.17	7

Brier Score: 0.0202

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.09	0.06	58
0.125 - 0.250:	0.41	0.13	34
0.250 - 0.375:	0.70	0.28	10
0.375 - 0.500:	0.57	0.21	21
0.500 - 0.625:	0.80	0.42	5
0.625 - 0.750:	0.00	0.88	1
0.750 - 0.875:	1.00	0.74	1
0.875 - 1.000:	****	****	0

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.15	0.13	13
0.125 - 0.250:	0.18	0.13	33
0.250 - 0.375:	0.50	0.28	10
0.375 - 0.500:	0.34	0.15	38
0.500 - 0.625:	0.45	0.20	22
0.625 - 0.750:	0.50	0.44	4
0.750 - 0.875:	0.40	0.33	5
0.875 - 1.000:	0.80	0.21	5

Brier Score: 0.0165

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.20	0.06	55
0.125 - 0.250:	0.37	0.13	35
0.250 - 0.375:	0.43	0.24	14
0.375 - 0.500:	0.53	0.24	15
0.500 - 0.625:	0.33	0.31	9
0.625 - 0.750:	1.00	0.88	1
0.750 - 0.875:	1.00	0.74	1
0.875 - 1.000:	****	****	0

Brier Score: 0.0243

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.26	0.10	23
0.125 - 0.250:	0.27	0.12	37
0.250 - 0.375:	0.36	0.24	14
0.375 - 0.500:	0.31	0.18	29
0.500 - 0.625:	0.47	0.22	19
0.625 - 0.750:	0.00	0.62	2
0.750 - 0.875:	0.67	0.43	3
0.875 - 1.000:	1.00	0.27	3

Brier Score: 0.0217

OROVILLE RESERVOIR – ESP (15 RANDOMLY SELECTED TRACES)

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.06	0.06	54
0.125 - 0.250:	0.56	0.19	16
0.250 - 0.375:	0.62	0.24	13
0.375 - 0.500:	0.50	0.33	8
0.500 - 0.625:	0.50	0.30	10
0.625 - 0.750:	0.40	0.39	5
0.750 - 0.875:	0.83	0.30	6
0.875 - 1.000:	0.75	0.23	4

Brier Score: 0.0351

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.24	0.09	25
0.125 - 0.250:	0.07	0.14	28
0.250 - 0.375:	0.60	0.28	10
0.375 - 0.500:	0.14	0.20	22
0.500 - 0.625:	0.44	0.31	9
0.625 - 0.750:	0.75	0.44	4
0.750 - 0.875:	0.60	0.33	5
0.875 - 1.000:	0.92	0.13	13

Brier Score: 0.0376

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.12	0.06	60
0.125 - 0.250:	0.40	0.17	20
0.250 - 0.375:	0.70	0.28	10
0.375 - 0.500:	0.62	0.26	13
0.500 - 0.625:	0.88	0.33	8
0.625 - 0.750:	0.00	0.88	1
0.750 - 0.875:	0.67	0.43	3
0.875 - 1.000:	0.00	0.46	1

Brier Score: 0.0447

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.22	0.11	18
0.125 - 0.250:	0.00	0.15	23
0.250 - 0.375:	0.50	0.31	8
0.375 - 0.500:	0.34	0.18	29
0.500 - 0.625:	0.47	0.23	17
0.625 - 0.750:	0.67	0.36	6
0.750 - 0.875:	0.38	0.26	8
0.875 - 1.000:	0.86	0.17	7

Brier Score: 0.0304

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.17	0.06	63
0.125 - 0.250:	0.61	0.17	18
0.250 - 0.375:	0.50	0.28	10
0.375 - 0.500:	0.50	0.27	12
0.500 - 0.625:	0.42	0.27	12
0.625 - 0.750:	****	****	0
0.750 - 0.875:	1.00	0.74	1
0.875 - 1.000:	****	****	0

Brier Score: 0.0406

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.18	0.07	38
0.125 - 0.250:	0.32	0.12	38
0.250 - 0.375:	0.50	0.36	6
0.375 - 0.500:	0.40	0.21	20
0.500 - 0.625:	0.60	0.30	10
0.625 - 0.750:	****	****	0
0.750 - 0.875:	1.00	0.74	1
0.875 - 1.000:	1.00	0.27	3

Brier Score: 0.0128

SHASTA RESERVOIR – ESP (15 RANDOMLY SELECTED TRACES)

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.11	0.08	36
0.125 - 0.250:	0.36	0.22	11
0.250 - 0.375:	0.20	0.39	5
0.375 - 0.500:	0.45	0.28	11
0.500 - 0.625:	0.62	0.33	8
0.625 - 0.750:	0.60	0.39	5
0.750 - 0.875:	1.00	0.37	4
0.875 - 1.000:	1.00	0.46	1

Brier Score: 0.0087

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.20	0.12	15
0.125 - 0.250:	0.20	0.19	15
0.250 - 0.375:	0.29	0.33	7
0.375 - 0.500:	0.08	0.26	13
0.500 - 0.625:	0.50	0.27	12
0.625 - 0.750:	0.67	0.51	3
0.750 - 0.875:	0.50	0.26	8
0.875 - 1.000:	0.88	0.16	8

Brier Score: 0.0351

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.16	0.08	37
0.125 - 0.250:	0.33	0.17	18
0.250 - 0.375:	0.14	0.33	7
0.375 - 0.500:	0.67	0.31	9
0.500 - 0.625:	0.80	0.42	5
0.625 - 0.750:	1.00	0.51	3
0.750 - 0.875:	0.50	0.52	2
0.875 - 1.000:	****	****	0

Brier Score: 0.0271

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.17	0.19	6
0.125 - 0.250:	0.00	0.37	4
0.250 - 0.375:	0.00	0.36	6
0.375 - 0.500:	0.26	0.20	23
0.500 - 0.625:	0.44	0.19	25
0.625 - 0.750:	0.00	0.88	1
0.750 - 0.875:	0.57	0.28	7
0.875 - 1.000:	0.67	0.15	9

Brier Score: 0.0423

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.26	0.08	34
0.125 - 0.250:	0.43	0.16	21
0.250 - 0.375:	0.60	0.39	5
0.375 - 0.500:	0.29	0.25	14
0.500 - 0.625:	0.20	0.42	5
0.625 - 0.750:	****	****	0
0.750 - 0.875:	0.50	0.52	2
0.875 - 1.000:	****	****	0

Brier Score: 0.0518

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.00	0.27	3
0.125 - 0.250:	0.00	0.25	9
0.250 - 0.375:	0.00	0.44	4
0.375 - 0.500:	0.44	0.24	16
0.500 - 0.625:	0.25	0.21	20
0.625 - 0.750:	0.40	0.39	5
0.750 - 0.875:	0.53	0.19	15
0.875 - 1.000:	0.67	0.15	9

Brier Score: 0.0607

TRINITY RESERVOIR – ESP (15 RANDOMLY SELECTED TRACES)

30-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.18	0.06	57
0.125 - 0.250:	0.32	0.16	22
0.250 - 0.375:	0.33	0.36	6
0.375 - 0.500:	0.45	0.28	11
0.500 - 0.625:	0.41	0.23	17
0.625 - 0.750:	0.50	0.31	8
0.750 - 0.875:	0.75	0.37	4
0.875 - 1.000:	1.00	0.21	5

Brier Score: 0.0139

30-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.12	0.09	26
0.125 - 0.250:	0.29	0.13	34
0.250 - 0.375:	0.27	0.27	11
0.375 - 0.500:	0.39	0.18	28
0.500 - 0.625:	0.33	0.27	12
0.625 - 0.750:	0.75	0.44	4
0.750 - 0.875:	0.71	0.28	7
0.875 - 1.000:	0.62	0.16	8

Brier Score: 0.0156

60-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.15	0.06	62
0.125 - 0.250:	0.48	0.16	21
0.250 - 0.375:	0.33	0.29	9
0.375 - 0.500:	0.50	0.24	16
0.500 - 0.625:	0.67	0.31	9
0.625 - 0.750:	0.25	0.44	4
0.750 - 0.875:	0.71	0.28	7
0.875 - 1.000:	0.50	0.33	2

Brier Score: 0.0273

60-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.13	0.10	23
0.125 - 0.250:	0.24	0.11	42
0.250 - 0.375:	0.33	0.29	9
0.375 - 0.500:	0.47	0.17	30
0.500 - 0.625:	0.38	0.24	16
0.625 - 0.750:	0.33	0.51	3
0.750 - 0.875:	1.00	0.52	2
0.875 - 1.000:	0.80	0.21	5

Brier Score: 0.0104

90-day Volumes in Lower Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.19	0.08	36
0.125 - 0.250:	0.37	0.13	35
0.250 - 0.375:	0.23	0.24	13
0.375 - 0.500:	0.43	0.21	21
0.500 - 0.625:	0.47	0.24	15
0.625 - 0.750:	0.00	0.62	2
0.750 - 0.875:	0.50	0.26	8
0.875 - 1.000:	****	****	0

Brier Score: 0.0290

90-day Volumes in Upper Tercile

Ensemble Frequency Range	Observed Frequency	Error Bound	Count
0.000 - 0.125:	0.23	0.08	31
0.125 - 0.250:	0.29	0.11	49
0.250 - 0.375:	0.86	0.33	7
0.375 - 0.500:	0.23	0.20	22
0.500 - 0.625:	0.50	0.30	10
0.625 - 0.750:	0.00	0.88	1
0.750 - 0.875:	0.25	0.37	4
0.875 - 1.000:	1.00	0.19	6

Brier Score: 0.0473

Appendix D

INFORM Project Hydrometeorological Database

The types of data that form the INFORM project database are described in the following categorized by the source of the datasets. This is followed by several Tables with an exhaustive listing of the station data information.

APD.1: Data Collected From CNRFC

a. Historical 6-hour MAP and MAT (Table APD-1) for all the study subbasins
b. Daily resolution of Full Natural Flow in the regulated basins (Table APD-2)
c. Historical FMAP – Forecast MAP for same subbasins as historical MAP
   – 02/1997 – 10/2002
d. Operational Archive – SS-SAC output including MAP, FMAP, Q_{OBS}, and $Q_{FORECAST\ (SS\text{-}SAC)}$ for forecasts made during historical period covering:
   04/1998 – 12/10/1998
   01/1999 – 07/14/2000
   11/2000 – 08/31/2001
   01/2002 – 12/16/2002

APD.2: Data Collected From the BUREAU OF RECLAMATION

a. Folsom Inflows – hardcopy (paper) of generally bi-hourly reservoir inflows (computed based on change in storage & outflow) for selected events from 1955-1996.
   – currently digitizing significant events as previous identified

APD.3: Data Collected From the CORPS OF ENGINEERS

a. Folsom Water Control Manual
   – design and operational information on Folsom Dam
   – contains graphics of hourly operations during flood events of 1955, 1963, 1964, 1980, 1982, 1986 (no data)
   – contains historical *monthly* reservoir inflow data (1955-1986) and *monthly* unimpaired flow data for Fair Oaks (1905-1986)

APD.4: ADDITIONAL STREAMFLOW DATA

a. Hourly – North Fork (USGS #11427000) – digital data from USGS
   – 10/1987 – 11/2002
   – Middle Fork (USGS #11433300) – hardcopy hourly stage records + several rating tables (Placer County Water Agency)
   – 10/1986 – 09/1998
   – Digitized data for selected events

b. Daily (USGS) –

- NF American Dam, USGS #11427000 10/1941 – 9/2001
- MF American Foresthill, USGS #11433300 10/1958 – 9/2001
- SF American Placerville, USGS #11444500 10/1911 – 9/2001
- NF Feather nr. Pulga USGS #11404500 10/80 - 9/92
- MF Feather nr. Merrimac USGS #11394500 10/60 - 9/79
- NF Feather Indian Creek USGS #11401500 10/77 - 9/92
- MF Feather nr. Clio USGS #11392500 10/60 - 9/79
- NF Feather Lake Almenor USGS #11399000 10/81 - 9/97
- Oroville Local USGS #1140680010/69 - 9/87

APD.5: ADDITIONAL PRECIPITATION DATA

a. Snow Sensor Data

– California Data Exchange Center (CDEC), (Table APD-3)

b. NCDC Hourly Precipitation

– EarthInfo Inc. data CD's

– generally, period record is 7/1948 – 12/2000 (Table APD-4)

c. NCDC Daily Precipitation

– EarthInfo Inc. data CD's

– generally, period record is 7/1948 – 12/2000 (Table APD-5)

d. High Density Raingauge Study

– event data from Sierra Cooperative Pilot Project (see HRC Limited Distribution Report No. 9)

– period of record is 1/1980 – 3/1986

APD.6: ADDITIONAL TEMPERATURE DATA

a. NCDC Min Max daily surface temperature

– EarthInfo Inc. data CD's for gauges in the region

– generally period record is 07/1948 – 12/2000 (Table APD -6)

APD.7: ADDITIONAL EVAPORATION DATA

a. NCDC daily evaporation data

– EarthInfo Inc. data CD's for gauges in the region (Table APD-7)

Table APD-1. Six-hour Mean Areal Precipitation and Mean Areal Temperature (MAT) Data Obtained from CNRFC

Location	*MAP file name*	*Extent*	*MAT file name*	*Extent*
Folsom:				
North Fork up	nfdc1_upr.MAP06	10/58 –9/90	nfdc1_upr.MAT	10/58 –9/90
North Fork low	nfdc1_lwr.MAP06	10/58 –9/90	nfdc1_lwr.MAT	10/58 –9/90
Middle Fork up	mfac1_upr.MAP06	10/58 –9/90	mfdc1_upr.MAT	10/58 –9/90
Middle Fork low	mfac1_lwr.MAP06	10/58 –9/90	mfdc1_lwr.MAT	10/58 –9/90
South Fork up	cbdc1_upr.MAP06	10/58 –9/93	cnbc1_upr.MAT	10/58 –9/93
South Fork low	cbdc1_upr.MAP06	10/58 –9/93	cnbc1_upr.MAT	10/58 –9/93
Folsom Local	folsc1_lcl.MAP06	10/58 –9/99	folsc1_lcl.MAT	10/58 –9/99
Yuba:				
Nbbc1_upr	nbbc1_upr.MAP06	10/60 – 9/99	nbbc1_upr.MAT	10/60 – 9/99
Nbbc1_lwr	nbbc1_lwr.MAP06	10/60 – 9/99	nbbc1_lwr.MAT	10/60 – 9/99
hlec1_upr	hlec1_upr.MAP06	10/60 – 9/99	nbbc1_upr.MAT	10/60 – 9/99
hlec1_lwr	hlec1_lwr.MAP06	10/60 – 9/99	nbbc1_lwr.MAT	10/60 – 9/99
Feather:				
NF Indian Creek low	iifc1_lwr.MAP06	10/60 – 9/99	iifc1_lwrMAT	10/60 – 9/99
NF Indian Creek up	iifc1_uprMAP06	10/60 – 9/99	iifc1_uprMAT	10/60 – 9/99
MF Clio low	ftcc1_lwrMAP06	10/60 – 9/99	ftcc1_lwr.MAT	10/60 – 9/99
MF Clio up	ftcc1_uprMAP06	10/60 – 9/99	ftcc1_upr.MAT	10/60 – 9/99
NF Pulga low	plgc1_lwrMAP06	10/60 – 9/99	ordc1_lwr.MAT	10/60 – 9/99
NF Pulga up	plgc1_uprMAP06	10/60 – 9/99	ordc1_upr.MAT	10/60 – 9/99
MF Merimmac low	mrmc1_lwrMAP06	10/60 – 9/99	ordc1_lwr.MAT	10/60 – 9/99
MF Merimmac up	mrmc1_uprMAP06	10/60 – 9/99	ordc1_upr.MAT	10/60 – 9/99
Lake Almanor low	pllc1_lwr.MAP06	10/60 – 9/99	iifc1_lwr.MAT	10/60 – 9/99
Lake Almanor up	pllc1_uprMAP06	10/60 – 9/99	iifc1_upr.MAT	10/60 – 9/99
Oroville Lake Local low	ordc1_lwr.MAP06	10/60 – 9/99	ordc1_lwr.MAT	10/60 – 9/99
Oroville Lake Local up	ordc1_uprMAP06	10/60 – 9/99	ordc1_upr.MAT	10/60 – 9/99
Trinity:				
Cegc1_lwr	cegc1_lwr.MAP06	1/50-12/99	cegc1_lwr.MAT	1/50-12/99
Cegc1_upr	cegc1_upr.MAP06	1/50-12/99	cegc1_upr.MAT	1/50-12/99
Shasta:				
Pit River low	pitc1_lwr.MAP06	10/50-9/99	pitc1_lwr.MAT	10/50-9/99
Pit River up	pitc1_upr.MAP06	10/50-9/99	pitc1_upr.MAT	10/50-9/99
Delta low	dltc1_lwr.MAP06	10/60-9/99	dltc1_lwr.MAT	10/60-9/99
Delta up	dltc1_upr.MAP06	10/60-9/99	dltc1_upr.MAT	10/60-9/99
McCloud River low	mssc1_lwr.MAP06	1/60-12/99	mssc1_lwr.MAT	1/60-12/99
McCloud River up	mssc1_upr.MAP06	1/60-12/99	mssc1_upr.MAT	1/60-12/99
Cnbc1_lwr	cnbc1_lwr.MAP06	10/50-9/99	cnbc1_lwr.MAT	10/50-9/99

Table APD-2. Full Natural Flow at watersheds outlets obtained from CNRFC

Locations	*Filename*	*Extent*
Folsom Lake Inflow	Flsm_inflow_cfs.dat	8/64-9/96
MF American	Mfac1_fnf.qme	10/58-9/90
SF American	Cbdc1_fnf.qme	10/58-9/93
New Bullards Bar	nbbc1_fnf.qme	10/69-9/00
Engle Bright	Hlec1_fnf.qme	10/69-9/00
Oroville Lake inflow	Ordc1_comp_fnf_adj.qme	10/60-9/97
Almanor Lake inflow	Pllc1.qme	10/69- 9/97
Trinity Lake Inflow	Cegc1_fnf.qme	5/63-9/99
Shasta lake Inflow	Shdc1_fnf.qme	10/60- 9/00
Delta	Dltc1.qme	10/60 – 9/00
McCloud River	Mccloud_fnf.qme	10/58- 9/89
Pit River	Pit_fnf.qme	10/50-9/92

Table APD-3. Active Snow Sensors

	Elev(m)	*Latitude*	*Longitude*	*Basin*	*Name*
PET	2179.9	41.297	-122.522	TRINITY	PETERSON FLAT
RRM	2042.7	41.023	-122.885	TRINITY	RED ROCK
BNK	1966.5	41.083	-122.628	TRINITY	BONANZA KING
SHM	1951.2	41.008	-122.8	TRINITY	SHIMMY LAKE
HIG	1838.4	41.093	-122.483	TRINITY	HIGHLAND LAKES
MUM	1722.6	41.197	-122.523	TRINITY	MUMBO BASIN
BFL	1554.9	41.08	-122.942	TRINITY	BIG FLAT
SDF	2058.0	41.35	-122.246	Delta	SAND FLAT
SLT	1738.0	41.045	-122.478	Delta	SLATE CREEK
STM	1646.3	41.17	-121.938	McCloud	STOUTS
CDP	2164.6	41.583	-120.303	PIT	CEDAR PASS
BLA	2149.4	40.77	-121.198	PIT	BLACKS MOUNTAIN
MED	2042.7	41.592	-121.61	PIT	MEDICINE LAKE
ADM	1890.2	41.237	-120.792	PIT	ADIN MOUNTAIN
SNM	1814	40.778	-121.782	PIT	SNOW MOUNTAIN
KTL	2225.6	40.14	-120.715	FEATHER	KETTLE ROCK
GRZ	2103.7	39.917	-120.645	FEATHER	GRIZZLY RIDGE
PLP	2073.2	39.786	-120.875	FEATHER	PILOT PEAK
GOL	2057.9	39.675	-120.615	FEATHER	GOLD LAKE
HMB	1981.7	40.115	-121.368	FEATHER	HUMBUG
RTL	1859.8	40.125	-121.043	FEATHER	RATTLE SNAKE
BKL	1753	39.85	-121.242	FEATHER	BUCKS LAKE
FOR	1570.1	39.813	-121.321	FEATHER	FOUR TREES
MDW	2195.1	39.417	-120.508	YUBA	MEADOW LAKE
CSL	2103.7	39.325	-120.367	YUBA	CENT SIERRA
SCN	2667.7	38.747	-120.068	AMERICAN	SCHNEIDERS
LOS	2622	38.925	-120.197	AMERICAN	LAKE LOIS
CAP	2439	38.71	-120.042	AMERICAN	CAPLES LAKE
ALP	2317.1	38.805	-120.215	AMERICAN	ALPHA (SMUD)
FRN	2317.1	38.805	-120.213	AMERICAN	FORNI RIDGE
SIL	2164.6	38.678	-120.118	AMERICAN	SILVER LAKE
VVL	2042.7	38.945	-120.305	AMERICAN	VAN VLECK
HYS	2012.2	39.282	-120.527	AMERICAN	HUYSINK
RBB	1798.8	38.912	-120.378	AMERICAN	ROBBS SADDLE
GKS	1707.3	39.075	-120.558	AMERICAN	GREEK STORE
BLC	1609.8	39.276	-120.708	AMERICAN	BLUE CANYON
RBP	1570.1	38.903	-120.375	AMERICAN	ROBBS

Table APD-4. NCDC Hourly Precipitation Stations

Station Name	*Sta ID*	*Begin*	*End*	*Yr*	*% Cov*	*Dec Lat*	*Dec Lon*	*Elevation*
Alturas	161	7/1/1948	12/13/2000	53	97	41.4931	-120.5528	4400
Angwin Pac Union Col	212	11/1/1967	12/24/2000	34	88	38.5731	-122.4406	1715
Battle Creek Adr	546	7/1/1971	12/24/2000	30	86	40.3983	-122.1453	420
Bieber	731	7/1/1948	12/31/2000	53	87	41.1208	-121.1347	4125
Blodgett Exp Forest	883	10/1/1969	12/21/2000	32	88	38.9092	-120.6678	4414
Blue Canyon	897	7/1/1948	12/31/2000	52	93	39.2775	-120.7103	5280
Bowman Dam	1018	7/1/1948	12/22/2000	53	89	39.4539	-120.6556	5385
Brooks Farnham Ranch	1112	2/22/1949	3/18/1976	28	95	38.7667	-122.1500	294
Brush Creek R S	1130	7/1/1948	12/31/2000	53	77	39.6950	-121.3453	3560
Camptonville 1 Sw	1460	11/1/1994	12/31/2000	7	81	39.4397	-121.0711	2503
Camptonville R S	1462	7/1/1948	6/30/1994	47	82	39.4500	-121.0500	2755
Canyon Dam	1497	10/1/1975	12/21/2000	26	91	40.1706	-121.0886	4560
Capay 5 Wnw	1507	4/1/1976	4/30/1994	19	65	38.7333	-122.1333	360
Chico University Farm	1715	7/1/1948	12/13/2000	53	91	39.6911	-121.8211	185
Clearlake 4 Se	1806	10/1/1954	10/31/1985	32	88	38.9239	-122.5672	1349
Coffee Creek R S	1886	11/1/1960	12/22/2000	41	90	41.0906	-122.7094	2500
Davis 2 Wsw Exp Farm	2294	7/1/1948	12/11/2000	53	95	38.5350	-121.7761	60
Day	2306	7/1/1948	12/23/2000	53	93	41.2122	-121.3742	3650
Downieville	2500	7/1/1948	12/22/2000	53	95	39.5633	-120.8239	2915
Etna	2899	7/1/1948	12/23/2000	53	96	41.4556	-122.8983	2950
Ferguson Ranch	3020	7/1/1967	1/31/1987	21	74	40.3500	-122.4500	801
Fiddletown Dexter Ranch	3038	7/1/1948	12/24/2000	53	98	38.5236	-120.7061	2160
Georgetown	3381	7/1/1948	12/31/1967	20	99	38.9167	-120.8333	2723
Georgetown R S	3384	11/1/1967	12/21/2000	34	81	38.9331	-120.8008	3001
Grass Valley	3571	7/1/1962	9/30/1966	5	90	39.2167	-121.0667	2641
Grass Valley No 2	3573	9/1/1966	12/22/2000	35	94	39.2042	-121.0681	2400
Hamilton Branch Fire De	3725	4/1/1953	10/31/1985	33	83	40.2667	-121.0833	4560
Harrison Gulch R S	3791	11/1/1948	12/23/2000	53	89	40.3667	-122.9667	2749
Hat Creek Experiment St	3821	7/1/1948	10/31/1978	31	81	40.8000	-121.5000	3353
Hell Hole	3891	1/22/1954	12/23/2000	36	86	39.0583	-120.4150	4850
Hopland 8 Ne	4097	7/1/1948	9/30/1976	29	88	39.0167	-123.0000	2513
Hyampom	4191	7/1/1948	12/31/2000	53	96	40.6167	-123.4567	1275
Kyburz Strawberry	4616	7/1/1948	4/30/1980	33	91	38.8000	-120.1500	5705
Lake Mendocino Dam	4689	6/1/1972	12/31/2000	29	89	39.1981	-123.1856	670
La Porte	4773	11/1/1958	9/30/1977	20	84	39.6833	-120.9833	4984
Lake Solano	4712	10/1/1962	12/16/2000	39	92	38.4833	-122.0000	190
Mahnke	5258	1/1/1956	12/22/2000	45	94	38.8500	-122.7833	2390
Markleeville	5356	7/1/1948	12/14/2000	42	94	38.6919	-119.7803	5530
Mc Cloud	5449	7/1/1948	8/31/1975	28	84	41.2514	-122.1383	3280
Mc Cloud Ranger Stn	5452	8/1/1975	9/30/1980	6	70	41.2500	-122.1167	3281
Michigan Bluff	5586	7/1/1948	10/31/1985	38	90	39.0500	-120.7333	3481
Milford Laufman Rs	5623	7/1/1948	12/14/2000	53	96	40.1414	-120.3533	4860
Mineral	5679	7/1/1948	12/31/2000	53	84	40.3458	-121.6092	4874
Mount Danaher	5909	7/1/1948	4/30/1975	28	95	38.7500	-120.6667	3412
Mount Shasta	5983	8/1/1948	12/23/2000	52	95	41.3206	-122.3081	3590
North Bloomfield	6232	10/1/1969	12/22/2000	32	89	39.3675	-120.8992	3280

Oroville	6521	11/1/1982	12/14/2000	19	76	39.5178	-121.5531	171
Oroville Dam	6527	11/1/1979	2/28/1983	5	12	39.5333	-121.4833	845
Oroville Ranger Stn	6528	7/1/1948	4/30/1979	32	96	39.5333	-121.5667	302
Paskenta Ranger Stn	6726	12/1/1949	12/14/2000	52	85	39.8856	-122.5433	755
Placerville 2 W	6963	7/1/1948	6/30/1963	16	95	38.7333	-120.8167	1791
Placerville Disp Plant	6964	6/1/1963	12/15/2000	38	94	38.7311	-120.8461	1560
Plumas Eureka St Park	6998	5/1/1964	12/31/2000	37	93	39.7578	-120.6964	5165
Portola	7085	10/1/1954	12/31/2000	47	88	39.8053	-120.4719	4850
Red Bluff Ap	7292	7/1/1948	12/23/2000	46	94	40.1556	-122.2506	349
Red Bluff Treatment Pla	7293	2/1/1992	12/14/2000	9	79	40.1622	-122.2203	265
Redding 5 Sse	7295	1/1/1958	1/31/1992	35	86	40.5000	-122.3667	425
Redding Fire Stn 2	7296	7/1/1948	1/31/1958	11	96	40.5833	-122.4000	581
Redding Municipal Ap	7304	11/1/1986	12/24/2000	15	48	40.5150	-122.2967	497
Robbs Peak P H	7489	2/1/1967	12/21/2000	34	97	38.9028	-120.3767	5120
Round Mountain	7580	7/1/1961	6/30/1970	10	82	40.8167	-121.9333	2103
Round Mountain Pg & E	7581	6/1/1970	10/31/2000	31	80	40.8075	-121.9361	2100
Sacramento 5 Ese	7633	1/1/1936	12/14/2000	65	94	38.5556	-121.4169	38
Sacramento Ap	7630	7/1/1948	12/21/2000	53	91	38.5069	-121.4950	15
Sawyers Bar Rs	8025	6/1/1971	12/23/2000	30	71	41.3022	-123.1325	2169
Shasta Dam	8135	7/1/1948	12/21/2000	53	93	40.7142	-122.4161	1075
Sierraville R S	8218	7/1/1948	12/30/2000	53	87	39.5833	-120.3706	4975
Soda Springs	8331	7/1/1948	12/28/1958	11	93	39.3167	-120.3833	6755
Soda Springs 1 E	8332	7/1/1961	12/15/2000	40	77	39.3256	-120.3672	6885
Stirling City R S	8544	10/1/1957	6/30/2000	44	78	39.9047	-121.5283	3520
Stony Gorge Reservoir	8587	7/1/1948	12/22/2000	53	94	39.5861	-122.5342	800
Susanville 1 Wnw	8703	9/1/1952	12/31/2000	49	92	40.4239	-120.6747	4555
Termo 1 E	8873	7/1/1948	2/29/2000	53	94	40.8667	-120.4333	5300
The Geysers	8885	7/1/1948	12/31/2000	53	90	38.8011	-122.8283	1668
Trinity Center Ranger S	9023	7/1/1948	11/30/1960	13	97	41.0000	-122.6833	2303
Truckee Rs	9043	7/1/1948	12/21/2000	53	90	39.3311	-120.1892	6020
Tulelake	9053	7/1/1948	12/14/2000	53	95	41.9600	-121.4744	4035
Vollmers	9386	7/1/1948	10/31/1975	28	98	40.9500	-122.4500	1342
Volta Power House	9390	7/1/1948	12/24/2000	53	96	40.4569	-121.8656	2220
Weaverville	9490	7/1/1948	12/31/2000	53	91	40.7350	-122.9392	2040
Wheatland 2 Ne	9605	7/1/1948	12/26/2000	53	96	39.0278	-121.3908	105
Williams	9677	9/1/1952	10/1/1988	37	92	39.1500	-122.1500	85
Woodfords	9775	2/1/1979	8/19/1990	12	84	38.7833	-119.8000	5650

Table APD-5. NCDC Daily Precipitation Stations

Sta Name	*Sta ID*	*Begin*	*End*	*Yrs*	*% Cov*	*Dec Lat*	*Dec Lon*	*Elevation*
Adin RS	29	7/1/1948	12/31/2000	53	98	41.1939	-120.9447	4195
Alturas	161	5/11/1931	12/31/2000	70	99	41.4931	-120.5528	4400
Angwin Pac Union Col	212	7/1/1948	12/31/2000	53	97	38.5731	-122.4406	1715
Auburn	383	7/1/1948	12/31/2000	53	100	38.9072	-121.0839	1292
Big Bar 4 E	738	7/1/1948	12/31/2000	53	96	40.7403	-123.2075	1250
Blue Canyon	897	7/1/1948	12/31/2000	45	82	39.2775	-120.7103	5280
Bowman Dam	1018	7/1/1948	12/31/2000	53	97	39.4539	-120.6556	5385
Brooks Farnham Ranch	1112	7/1/1948	11/30/1985	38	97	38.7667	-122.1500	294
Brush Creek RS	1130	7/1/1948	5/31/1983	36	98	39.6950	-121.3453	3560
Buckhorn	1149	7/1/1948	12/31/2000	50	88	40.8669	-121.8464	3800
Bucks Creek PH	1159	7/2/1959	9/30/1999	41	99	39.9178	-121.3511	1850
Bullards Bar PH	1180	7/1/1948	7/31/1968	21	100	39.4167	-121.1500	1781
Burney	1214	7/1/1948	2/29/2000	49	89	40.8800	-121.6728	3198
Calistoga	1312	7/1/1948	11/30/2000	53	99	38.5772	-122.5722	370
Callahan	1316	7/1/1948	12/31/2000	53	99	41.3111	-122.8044	3185
Camptonville RS	1462	7/1/1948	3/31/1973	26	98	39.4500	-121.0500	2755
Canby 3 SW	1476	7/1/1948	12/31/2000	51	90	41.4219	-120.9017	4310
Canyon Dam	1497	7/1/1948	12/31/2000	53	99	40.1706	-121.0886	4560
Caribou PH	1522	6/1/1959	6/30/1977	19	99	40.0833	-121.1500	2992
Cecilville	1606	11/1/1954	12/31/2000	47	91	41.1403	-123.1292	2330
Cedarville	1614	7/1/1948	12/31/2000	53	98	41.5336	-120.1736	4670
Challenge RS	1653	7/2/1948	4/30/1994	47	97	39.4833	-121.2167	2570
Chester	1700	7/1/1948	12/31/2000	53	100	40.3000	-121.2356	4525
Chico University Farm	1715	1/8/1906	12/31/2000	95	99	39.6911	-121.8211	185
Clearlake 4 SE	1806	10/26/1954	12/31/2000	47	97	38.9239	-122.5672	1349
Cloverdale	1838	7/22/1950	12/31/2000	47	84	38.8067	-123.0169	333
Coffee Creek RS	1886	1/1/1998	12/31/2000	3	94	41.0906	-122.7094	2500
Coleman Fisheries	1907	7/1/1948	12/31/2000	53	99	40.4000	-122.1433	420
Colfax	1912	7/1/1948	12/31/2000	53	97	39.0997	-120.9544	2400
Colgate PH	1916	7/1/1948	12/31/2000	53	99	39.3308	-121.1922	595
Colusa 2 SSW	1948	10/1/1948	12/31/2000	53	98	39.1806	-122.0294	50
Corning Houghton Ranch	2027	7/1/1948	5/31/1984	37	95	39.9000	-122.3500	487
Dana 2 SE	2269	5/1/1959	5/31/1976	18	94	41.1000	-121.5167	3323
Davis 2 WSW Exp Farm	2294	1/4/1917	12/31/2000	84	100	38.5350	-121.7761	60
Deer Creek PH	2334	7/1/1948	4/30/1970	23	99	39.3000	-120.8500	3704
Deer Creek Forebay	2338	11/1/1969	4/30/1994	26	94	39.3000	-120.8333	4455
De Sabla	2402	7/1/1948	12/31/2000	53	98	39.8739	-121.6172	2710
Dobbins 1S	2456	6/1/1970	12/31/2000	31	82	39.3583	-121.2022	1640
Dobbins Colgate Forebay	2458	7/1/1948	5/31/1970	23	99	39.3333	-121.2000	1552
Donner Memorial Park	2467	10/1/1953	12/31/2000	48	99	39.3239	-120.2331	5937
Downieville	2500	7/1/1948	12/31/2000	52	95	39.5633	-120.8239	2915
Doyle	2504	7/2/1948	12/31/2000	51	94	40.0242	-120.1044	4240
Doyle 4 SSE	2506	7/1/1956	12/31/2000	45	100	39.9717	-120.0828	4390
Dunnigan	2568	7/1/1948	12/31/1978	31	93	38.8833	-121.9667	49
Dunsmuir	2572	7/1/1948	6/30/1978	31	99	41.2167	-122.2667	2421
Dunsmuir Treatment Plt	2574	7/1/1978	12/31/2000	23	100	41.1833	-122.2736	2170

East Park Reservoir	2640	7/1/1948	12/31/2000	53	100	39.3592	-122.5178	1205
Echo Sumt Sierra	2671	7/1/1948	3/31/1994	17	33	38.7833	-120.0333	7350
Fall River Mills CSD	2964	7/1/1948	12/31/2000	25	43	41.0161	-121.4425	3310
Fiddletown Dexter Ranch	3038	7/1/1948	12/31/2000	53	99	38.5236	-120.7061	2160
Folsom Dam	3113	10/26/1955	4/30/1993	39	99	38.7000	-121.1667	350
Foresthill R S	3134	7/1/1948	12/31/2000	53	98	39.0097	-120.8450	3015
French Gulch	3242	1/1/1952	11/30/1982	31	96	40.7000	-122.6333	1102
Carden Valley 2 S	3338	7/1/1948	7/31/1972	25	98	38.8333	-120.8500	1942
Georgetown RS	3384	7/1/1948	12/31/2000	53	96	38.9331	-120.8008	3001
Gold Run 2 SW	3491	10/29/1948	12/31/2000	53	96	39.1650	-120.8567	3320
Grass Valley	3571	7/1/1948	9/30/1966	19	100	39.2167	-121.0667	2641
Grass Valley No 2	3573	10/1/1966	12/31/2000	35	100	39.2042	-121.0681	2400
Greenville RS	3621	7/1/1948	12/31/2000	53	94	40.1406	-120.9428	3560
Harrison Gulch RS	3791	7/1/1948	12/31/2000	53	92	40.3667	-122.9667	2749
Harry Englebright Dam	3800	7/1/1955	12/31/2000	46	98	39.2372	-121.2667	800
Hat Creek	3824	7/1/1948	12/31/2000	52	96	40.9317	-121.5433	3015
Hidden Valley Ranch	3946	6/1/1961	5/31/1977	17	100	39.0333	-121.1000	1480
Hobergs	4010	7/1/1948	6/30/1974	27	94	38.8500	-122.7167	2963
Iowa Hill	4288	7/1/1948	12/31/2000	52	92	39.1181	-120.8350	3100
Jess Valley	4374	8/1/1948	12/31/2000	53	99	41.2683	-120.2947	5400
Kelsey 1 N	4484	8/1/1972	12/31/2000	22	69	38.8089	-120.8208	2000
Kilarc PH	4544	5/1/1959	6/30/1977	19	100	40.6833	-121.8667	2651
Lakeport	4701	1/11/1941	12/31/2000	60	94	39.0333	-122.9167	1315
Lakeshore 2	4709	7/1/1948	7/31/1972	25	99	40.8667	-122.3833	1079
Lake Solano	4712	8/1/1975	12/31/2000	26	99	38.4833	-122.0000	190
Lake Spaulding	4713	7/1/1948	12/31/2000	53	98	39.3183	-120.6392	5155
Lava Beds Nat. Monument	4838	10/7/1959	12/31/2000	42	94	41.7400	-121.5067	4770
Leesville Keegan Ranch	4880	5/1/1959	5/31/1977	19	91	39.1500	-122.4333	1332
Lehman Ranch	4886	6/1/1961	6/30/1977	17	100	38.6000	-121.0167	600
Little Valley	4988	10/1/1960	1/31/1974	15	91	40.8833	-121.1833	4173
Lookout 3 WSW	5093	5/1/1963	5/31/1977	15	96	41.2000	-121.2000	4183
Loyalton	5171	7/1/1948	11/30/1972	16	57	39.6833	-120.2500	4944
Manzanita Lake	5311	1/1/1949	12/31/2000	52	99	40.5419	-121.5764	5750
Markley Cove	5360	3/1/1970	12/31/2000	31	99	38.4939	-122.1261	480
Marsville	5385	7/1/1948	12/31/2000	53	98	39.1458	-121.5853	57
Mc Cloud	5449	7/1/1948	12/31/2000	53	99	41.2514	-122.1383	3280
Middletown	5598	7/1/1948	10/31/1999	52	93	38.7547	-122.6225	1130
Mineral	5679	7/1/1948	12/31/2000	53	99	40.3458	-121.6092	4874
Monticello Dam	5818	11/19/1957	1/31/1970	14	100	38.5000	-122.1167	512
Mount Danaher	5909	7/1/1948	5/31/1973	26	95	38.7500	-120.6667	3412
Mount Shasta	5983	7/1/1948	12/31/2000	52	96	41.3206	-122.3081	3590
Nevada City	6136	1/1/1931	12/31/2000	70	100	39.2467	-121.0006	2781
Nicolaus	6193	7/1/1948	11/30/1962	15	95	38.9000	-121.5833	49
Nicolaus 2	6194	12/1/1962	12/31/2000	39	98	38.9261	-121.5447	43
Ono	6455	1/3/1952	3/31/1984	33	88	40.4833	-122.6167	978
Orland	6506	7/1/1948	12/31/2000	53	99	39.7458	-122.1997	254
Oroville	6521	4/22/1953	12/31/2000	42	83	39.5178	-121.5531	171
Oroville Bridge	6525	7/1/1948	8/31/1975	28	99	39.5167	-121.5667	171
Oroville Dam	6527	11/1/1979	11/30/1982	4	92	39.5333	-121.4833	845
Oroville Ranger Stn	6528	7/1/1948	12/31/1978	8	20	39.5333	-121.5667	302

Pacific House	6597	7/1/1948	12/31/2000	53	98	38.7581	-120.5033	3440
Paradise	6685	5/1/1957	12/31/2000	44	99	39.7539	-121.6242	1750
Paskenta Ranger Stn	6726	7/3/1948	12/31/2000	53	97	39.8856	-122.5433	755
Paynes Creek	6761	1/1/1952	3/31/1984	32	75	40.3333	-121.9000	1841
Pit River PH 1	6944	9/1/1972	8/31/1996	25	94	41.0000	-121.5000	2880
Pit River PH 5	6946	7/1/1948	12/31/2000	53	99	40.9869	-121.9772	1458
Placerville	6960	7/1/1948	12/31/2000	53	97	38.6956	-120.8244	1850
Placerville IFG	6962	2/1/1955	12/31/1991	53	97	38.7333	-120.7333	2755
Portola	7085	7/1/1948	12/31/2000	53	95	39.8053	-120.4719	4850
Quincy	7195	7/1/1948	12/31/2000	52	89	39.9367	-120.9475	3420
Red Bluff AP	7292	11/1/1933	12/31/2000	65	93	40.1556	-122.2506	349
Redding Fire Stn 2	7296	1/11/1931	4/30/1979	49	99	40.5833	-122.4000	581
Redding Fire Stn 4	7300	5/1/1979	4/30/1987	9	96	40.5500	-122.3833	470
Redding Municipal AP	7304	11/1/1986	12/31/2000	15	100	40.5150	-122.2967	497
Represa	7370	7/1/1948	12/31/2000	53	99	38.6944	-121.1611	295
Round Mountain	7580	1/1/1952	6/30/1970	19	86	40.8167	-121.9333	2103
Round Mountain PG&E	7581	7/1/1970	8/31/2000	31	97	40.8075	-121.9361	2100
Sacramento AP	7630	11/10/1941	12/31/2000	60	93	38.5069	-121.4950	15
Sacramento 5 ESE	7633	07/11/1877	12/31/2000	124	99	38.5556	-121.4169	38
Sagehen Creek	7641	6/1/1953	10/31/2000	48	97	39.4317	-120.2406	6337
Salt Springs PH	7689	7/1/1948	11/30/1998	51	95	38.5006	-120.2189	3700
Shasta Dam	8135	7/1/1948	12/31/2000	53	99	40.7142	-122.4161	1075
Sierra City	8207	7/1/1948	5/31/2000	51	82	39.5678	-120.6228	4240
Sierraville RS	8218	7/1/1948	12/31/2000	53	96	39.5833	-120.3706	4975
Stonyford	8580	7/1/1948	12/31/2000	53	95	39.3753	-122.5461	1170
Stony Gorge Reservoir	8587	7/1/1948	12/31/2000	53	98	39.5861	-122.5342	800
Strawberry Valley	8606	11/1/1948	12/31/2000	53	100	39.5631	-121.1078	3808
Susanville 2 SW	8702	1/10/1931	12/31/2000	69	92	40.4167	-120.6631	4184
Tahoe City	8758	1/1/1931	12/31/2000	70	100	39.1678	-120.1428	6230
Termo 1 E	8873	8/1/1948	3/31/1999	42	78	40.8667	-120.4333	5300
Trinity Dam Vista Point	9024	7/1/1959	12/31/1973	15	99	40.8000	-122.7667	2503
Trinity River Hatchery	9026	8/1/1974	12/31/2000	27	99	40.7261	-122.7933	1860
Truckee RS	9043	7/1/1948	12/31/2000	53	98	39.3311	-120.1892	6020
Ukiah	9122	3/9/1906	12/31/2000	95	99	39.1478	-123.2103	633
Upper Lake 7 W	9167	7/1/1948	7/31/1988	40	93	39.1833	-123.0333	1564
Vacaville	9200	7/1/1948	12/31/2000	53	97	38.3956	-121.9608	110
Vinton	9351	3/1/1950	12/31/2000	51	100	39.8056	-120.1858	4950
Vollmer	9386	7/1/1948	10/31/1975	28	99	40.9500	-122.4500	1342
Volta Power House	9390	7/1/1948	12/31/2000	53	100	40.4569	-121.8656	2220
Weaverville	9490	7/1/1948	12/31/2000	53	93	40.7350	-122.9392	2040
Whiskeytown Reservoir	9621	4/16/1960	12/31/2000	41	99	40.6117	-122.5281	1295
Willows 6 W	9699	7/1/1948	12/31/2000	53	99	39.5231	-122.3058	233
Winters	9742	7/1/1948	12/31/2000	53	100	38.5228	-121.9683	135
Woodland 1 WNW	9781	7/1/1948	12/31/2000	53	95	38.6833	-121.8000	69

Table APD-6. NCDC Minimum and Maximum Daily Temperature Stations

Sta Name	*Sta ID*	*Begin*	*End*	*Yrs*	*% Cov*	*Dec Lat*	*Dec Lon*	*Elev*
Adin RS	29	2/19/1955	12/31/2000	46	89	41.1939	-120.9447	4195
Alturas	161	5/11/1931	12/31/2000	70	98	41.4931	-120.5528	4400
Angwin Pac Union Col	212	4/1/1952	12/31/2000	49	97	38.5731	-122.4406	1715
Auburn	383	7/1/1948	12/31/2000	53	100	38.9072	-121.0839	1292
Big Bar 4 E	738	3/1/1952	12/31/2000	49	86	40.7403	-123.2075	1250
Blue Canyon	897	7/1/1948	12/31/2000	45	82	39.2775	-120.7103	5280
Bowman Dam	1018	7/1/1948	12/31/2000	53	93	39.4539	-120.6556	5385
Brooks Farnham Ranch	1112	7/1/1948	11/30/1985	38	87	38.7667	-122.1500	294
Burney	1214	7/1/1948	2/29/2000	49	89	40.8800	-121.6728	3198
Calistoga	1312	9/19/1963	11/29/2000	24	51	38.5772	-122.5722	370
Callahan	1316	4/1/1953	12/31/2000	48	98	41.3111	-122.8044	3185
Canby 3 Sw	1476	10/1/1970	12/31/2000	28	72	41.4219	-120.9017	4310
Canyon Dam	1497	7/1/1948	12/31/2000	53	97	40.1706	-121.0886	4560
Cecilville	1606	11/1/1954	12/31/2000	47	89	41.1403	-123.1292	2330
Cedarville	1614	7/1/1948	12/31/2000	53	97	41.5336	-120.1736	4670
Challenge R S	1653	4/12/1970	9/30/1981	4	4	39.4833	-121.2167	2570
Chester	1700	8/22/1957	12/31/2000	44	98	40.3000	-121.2356	4525
Chico University Farm	1715	1/8/1906	12/31/2000	95	98	39.6911	-121.8211	185
Clearlake 4 Se	1806	10/26/1954	12/31/2000	47	96	38.9239	-122.5672	1349
Cloverdale	1838	7/22/1950	12/31/2000	47	84	38.8067	-123.0169	333
Colfax	1912	7/1/1948	12/31/2000	53	95	39.0997	-120.9544	2400
Colusa 2 Ssw	1948	10/1/1948	12/31/2000	53	98	39.1806	-122.0294	50
Davis 2 Wsw Exp Farm	2294	1/4/1917	12/31/2000	84	100	38.5350	-121.7761	60
Davis Creek	2296	11/19/1967	11/30/1967	1	100	41.7333	-120.3667	4754
Deer Creek Ph	2334	7/1/1948	4/30/1970	23	97	39.3000	-120.8500	3704
Deer Creek Forebay	2338	11/1/1969	5/31/1994	26	92	39.3000	-120.8333	4455
De Sabla	2402	7/1/1948	12/31/2000	53	95	39.8739	-121.6172	2710
Dobbins 1 S	2456	6/1/1970	12/31/2000	31	79	39.3583	-121.2022	1640
Dobbins Colgate Foreba	2458	7/1/1948	5/3/1970	23	78	39.3333	-121.2000	1552
Donner Memorial St Pk	2467	10/1/1953	12/31/2000	48	98	39.3239	-120.2331	5937
Downieville	2500	7/1/1948	12/31/2000	52	89	39.5633	-120.8239	2915
Doyle	2504	7/2/1948	2/28/1981	12	25	40.0242	-120.1044	4240
Doyle 4 Sse	2506	7/5/1956	12/31/2000	45	98	39.9717	-120.0828	4390
Dunsmuir Treatment Plan	2574	7/1/1978	12/31/2000	23	100	41.1833	-122.2736	2170
East Park Reservoir	2640	7/1/1948	12/31/2000	53	100	39.3592	-122.5178	1205
Echo Sumt Sierra At Tah	2671	7/1/1948	3/31/1994	17	33	38.7833	-120.0333	7350
Folsom Dam	3113	10/26/1955	4/30/1993	39	99	38.7000	-121.1667	350
Georgetown R S	3384	1/30/1954	12/29/2000	40	71	38.9331	-120.8008	3001
Grass Valley	3571	7/1/1948	9/30/1966	19	99	39.2167	-121.0667	2641
Grass Valley No 2	3573	10/1/1966	12/31/2000	35	100	39.2042	-121.0681	2400
Harrison Gulch R S	3791	11/1/1964	12/28/2000	30	56	40.3667	-122.9667	2749
Hat Creek	3824	7/1/1948	12/31/2000	52	93	40.9317	-121.5433	3015
Jess Valley	4374	8/1/1948	12/31/2000	53	96	41.2683	-120.2947	5400
Lakeport	4701	1/11/1941	12/28/2000	60	90	39.0333	-122.9167	1315
Lakeshore 2	4709	7/1/1948	7/10/1972	25	99	40.8667	-122.3833	1079
Lake Solano	4712	8/5/1975	12/31/2000	26	97	38.4833	-122.0000	190
Lake Spaulding	4713	7/1/1948	12/31/2000	53	97	39.3183	-120.6392	5155

Lava Beds Nat Monument	4838	10/7/1959	12/31/2000	42	93	41.7400	-121.5067	4770
Manzanita Lake	5311	1/1/1949	12/31/2000	52	100	40.5419	-121.5764	5750
Markley Cove	5360	3/1/1970	12/30/2000	31	99	38.4939	-122.1261	480
Marysville	5385	7/1/1948	12/31/2000	53	98	39.1458	-121.5853	57
Mc Cloud	5449	7/1/1948	12/31/2000	53	99	41.2514	-122.1383	3280
Mineral	5679	7/1/1948	12/31/2000	53	99	40.3458	-121.6092	4874
Monticello Dam	5818	11/20/1957	1/26/1970	14	100	38.5000	-122.1167	512
Mount Shasta	5983	7/1/1948	12/31/2000	52	96	41.3206	-122.3081	3590
Nevada City	6136	1/1/1931	12/31/2000	70	99	39.2467	-121.0006	2781
Orland	6506	7/1/1948	12/31/2000	53	99	39.7458	-122.1997	254
Oroville	6521	4/22/1953	12/31/2000	42	81	39.5178	-121.5531	171
Paradise	6685	5/2/1957	12/31/2000	44	99	39.7539	-121.6242	1750
Pit River P H 1	6944	10/1/1972	11/30/1981	4	5	41.0000	-121.5000	2880
Placerville	6960	7/1/1948	12/30/2000	53	96	38.6956	-120.8244	1850
Placerville Ifg	6962	2/1/1955	12/31/1991	37	98	38.7333	-120.7333	2755
Portola	7085	7/1/1948	12/31/2000	53	93	39.8053	-120.4719	4850
Quincy	7195	7/1/1948	12/31/2000	52	81	39.9367	-120.9475	3420
Red Bluff Ap	7292	11/1/1933	12/31/2000	65	93	40.1556	-122.2506	349
Redding Fire Stn 2	7296	1/11/1931	4/30/1979	49	98	40.5833	-122.4000	581
Redding Fire Stn 4	7300	5/1/1979	4/30/1987	9	96	40.5500	-122.3833	470
Redding Municipal Ap	7304	11/1/1986	12/31/2000	15	100	40.5150	-122.2967	497
Sacramento Ap	7630	11/10/1941	12/31/2000	60	93	38.5069	-121.4950	15
Sacramento 5 Ese	7633	07/11/1877	12/31/2000	124	99	38.5556	-121.4169	38
Sagehen Creek	7641	5/1/1966	12/31/2000	28	62	39.4317	-120.2406	6337
Salt Springs Pwr House	7689	7/1/1948	11/29/1998	51	93	38.5006	-120.2189	3700
Shasta Dam	8135	7/1/1948	12/31/2000	53	99	40.7142	-122.4161	1075
Sierra City	8207	7/1/1948	5/31/2000	51	81	39.5678	-120.6228	4240
Sierraville R S	8218	7/1/1948	12/29/2000	53	90	39.5833	-120.3706	4975
Stony Gorge Reservoir	8587	7/1/1948	12/31/2000	53	98	39.5861	-122.5342	800
Strawberry Valley	8606	11/1/1948	12/29/2000	53	99	39.5631	-121.1078	3808
Susanville 2 Sw	8702	1/10/1931	12/31/2000	69	91	40.4167	-120.6631	4184
Tahoe City	8758	1/1/1931	12/31/2000	70	99	39.1678	-120.1428	6230
Termo 1 E	8873	6/12/1962	3/31/1999	38	100	40.8667	-120.4333	5300
Trinity Dam Vista Point	9024	7/1/1959	12/31/1973	15	88	40.8000	-122.7667	2503
Trinity River Hatchery	9026	8/1/1974	12/31/2000	27	99	40.7261	-122.7933	1860
Truckee Rs	9043	7/1/1948	12/31/2000	53	96	39.3311	-120.1892	6020
Ukiah	9122	3/9/1906	12/31/2000	95	99	39.1478	-123.2103	633
Vacaville	9200	7/1/1948	12/31/2000	53	97	38.3956	-121.9608	110
Volta Power House	9390	7/1/1948	11/30/1974	27	99	40.4569	-121.8656	2220
Weaverville	9490	7/1/1948	12/31/2000	53	90	40.7350	-122.9392	2040
Whiskeytown Reservoir	9621	4/18/1960	12/31/2000	41	96	40.6117	-122.5281	1295
Willows 6 W	9699	7/1/1948	12/31/2000	53	99	39.5231	-122.3058	233
Winters	9742	7/1/1948	12/31/2000	53	100	38.5228	-121.9683	135
Woodland 1 Wnw	9781	7/2/1948	12/31/2000	53	95	38.6833	-121.8000	69

Table APD-7. NCDC Pan Evaporation Stations

Sta Name	*Sta ID*	*Begin*	*End*	*Yrs*	*% Cov*	*Dec Lat*	*Dec Lon*	*Elevation*
Auburn Dam Project	385	7/1/1972	9/30/1984	13	92	38.8833	-121.0667	1270
Berryessa Lake	705	11/18/1957	6/30/1970	14	99	38.5500	-122.2333	459
Chico University Farm	1715	5/2/1951	12/31/2000	50	87	39.6911	-121.8211	185
Davis 2 Wsw Exp Farm	2294	7/1/1948	12/31/2000	53	97	38.5350	-121.7761	60
Folsom Dam	3113	10/27/1955	4/30/1993	39	96	38.7000	-121.1667	350
Lake Pillsbury 2	4698	3/1/1964	4/30/1970	7	90	39.4167	-122.9833	1752
Lakeshore 2	4709	7/1/1948	7/10/1972	25	87	40.8667	-122.3833	1079
Lake Solano	4712	8/5/1975	12/31/2000	26	97	38.4833	-122.0000	190
Lake Spaulding	4713	5/6/1972	6/30/1978	7	41	39.3183	-120.6392	5155
Lake Spaulding Dam	4714	7/23/1955	9/28/1971	17	45	39.3333	-120.6333	5125
Markley Cove	5360	3/1/1970	12/30/2000	31	98	38.4939	-122.1261	480
Monticello Dam	5818	11/19/1957	1/26/1970	14	98	38.5000	-122.1167	512
Placerville Ifg	6962	2/1/1955	7/31/1978	24	92	38.7333	-120.7333	2755
Salt Springs Pwr House	7689	7/1/1948	7/31/1978	31	91	38.5006	-120.2189	3700
Shasta Dam	8135	7/1/1948	12/31/2000	53	93	40.7142	-122.4161	1075
Tahoe City	8758	7/1/1948	10/11/2000	53	40	39.1678	-120.1428	6230
Trinity Dam Vista Point	9024	7/1/1959	12/31/1973	15	67	40.8000	-122.7667	2503
Trinity River Hatchery	9026	8/1/1974	12/31/2000	27	90	40.7261	-122.7933	1860
Tulelake	9053	8/1/1955	10/6/1981	27	50	41.9600	-121.4744	4035
Whiskeytown Reservoir	9621	4/16/1960	12/29/2000	41	91	40.6117	-122.5281	1295