

Tempest Hydro-Met Analysis System



A suite of tools for retrieving, storing, validating, analyzing, & displaying hydro-meteorological data

The HydroMet Analysis System stores your decoded data in an SQL Time Series Database. The schema is simple and efficient, capable of storing several years worth of your decoded data on-line. A powerful computation module handles derived parameters such as USGS ratings, table-lookup, interpolation, averaging, and user-defined equations. We provide tools for limit and rate-of-change alarms,

import/export, spreadsheet-access, plotting, and custom applications.

Tempest Suite

Figure 1 shows how the members of the Tempest family fit together. 1) Use an LRGS System to retrieve raw DCP Data from several possible links: satellite, radio, internet or file. 2) Then use the DCS Toolkit Decoder to convert raw data to time-tagged engineering units. 3) Finally use the Tempest™ Hydro-Met Analysis System to perform all of the tasks shown:

- ▶ Efficiently store your decoded data in a standards-based SQL database,
- ▶ View & correct the data graphically using several automated tools,
- ▶ Perform automated computations, limit-checking, and alarm notification,
- ▶ Generate web-content for your analysts and for public release,
- ▶ Export data to your custom applications.

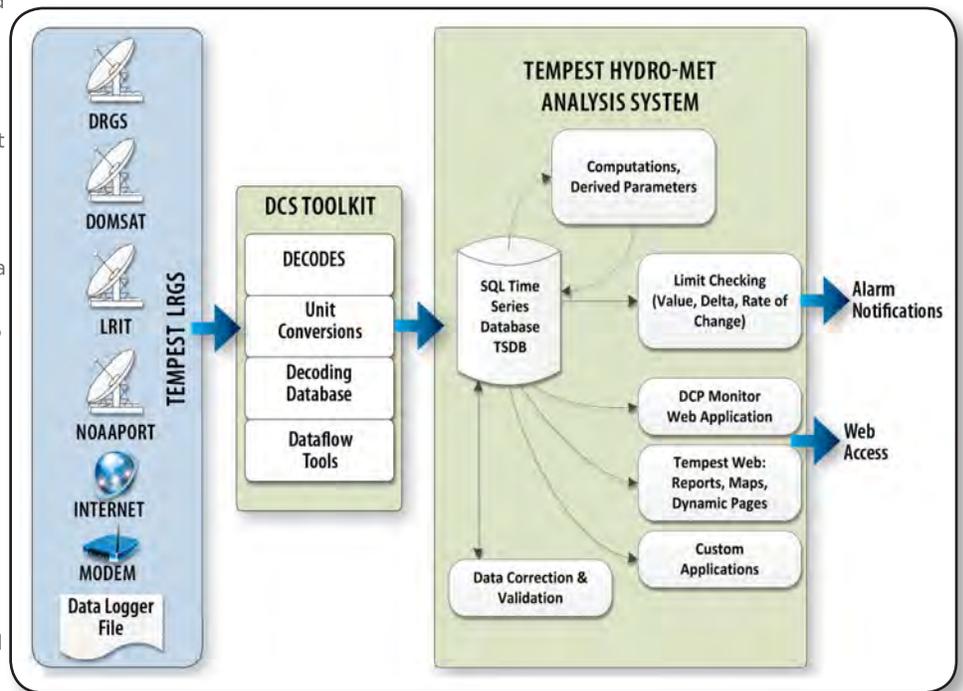


Figure 1

Time Series Database

The heart of the system is our time-series database. After reviewing the design of several large hydro-met databases in use by the U.S. Federal Government, we designed our system for maximum performance:

- ▶ Standard SQL DBMS: We currently use PostgreSQL (a full-featured open source database). We have plans to port the system to Oracle and Microsoft SQL Server in the near future.
- ▶ Accommodate Vast Amounts of Hydro-Met Data: The data-storage is limited only by the underlying DBMS (terabytes).

Data ID	Site	TS Name	Interval	Description
102	OKM14	HG	30m n	HG at OKM14 (DECODES)
103	OKM14	PC	four	PC at OKM14 (DECODES)
104	OKM14	V3	four	V3 at OKM14 (DECODES)
112	OKM14	QR-30min-Derived	30m n	QR at OKM14 (Comp_tec)
24	RAPM5	stage	15m n	stage at RAPM5
25	RAPM5	temp-air	15m n	temp-air at RAPM5
26	RAPM5	battery	irregular	battery at RAPM5 update
27	RAPM5	HP	15m n	HP at RAPM5
29	RAPM5	HG	day	HG at RAPM5
RR	RAPM5	QR-15min-Derived	15m n	QR at RAPM5
107	WJM12	HG	15m n	HG at WJM12 (DECODES)
108	WJM12	PC	four	PC at WJM12 (DECODES)
109	WJM12	V3	four	V3 at WJM12 (DECODES)
113	WJM12	QR-15min-Derived	15m n	QR at WJM12 (Computed)

Figure 2 GUI Time Series Database Editor

Time Series Database

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- ▶ Accommodate Vast Amounts of Hydro-Met Data: The data-storage is limited only by the underlying DBMS (terabytes).
- ▶ Efficient, Fast Storage & Retrieval: Our flexible schema allows the database to grow without adversely affecting the speed of storage & retrieval.
- ▶ Easy to Use Table Structures: Add your own custom applications by using our API or accessing the tables directly.

Figure 2, the GUI Time Series Database Editor, shows a list of time series groups defined in our database. Note that Figure 2 shows that we have opened the time series for HG (Height of a Gage or 'Stage') at the site named OKMI4.

Figure 3 demonstrates how to enter and maintain the 'meta-data' about each of the time-series in the database. This includes the parameter code, periodicity, engineering units, description, limits, alarms, etc.

Note the area at the bottom of the screen: Here you can easily define value and rate-of-change limits on each parameter. As well as flagging or rejecting values that are out-of-limits, you can cause various types of alarms to be executed, such as sending a text-message or email.

For value limits, we allow yellow (warning) and red (critical) bands above and below the normal range. You can also enter a reject high/low limit (values outside this range are rejected automatically as garbage-data).

You will also want to divide your time-series into meaningful groups. Groups are used for selecting parameters to display, alarm assignments, etc. Figure 4 shows a variety of groups that we have defined in our test database.

Some groups show related data-types, like 'River Stages', and 'Battery Voltages'. Some groups represent geographic regions, such as river systems. Other groups represent DCPs relevant to a certain power-plant. Finally, you can also define groups for your technicians who maintain DCPs.

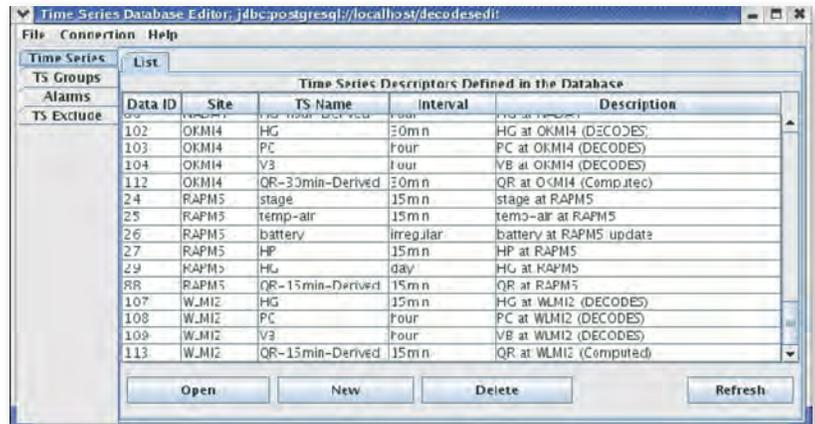


Figure 2 GUI Time Series Database Editor

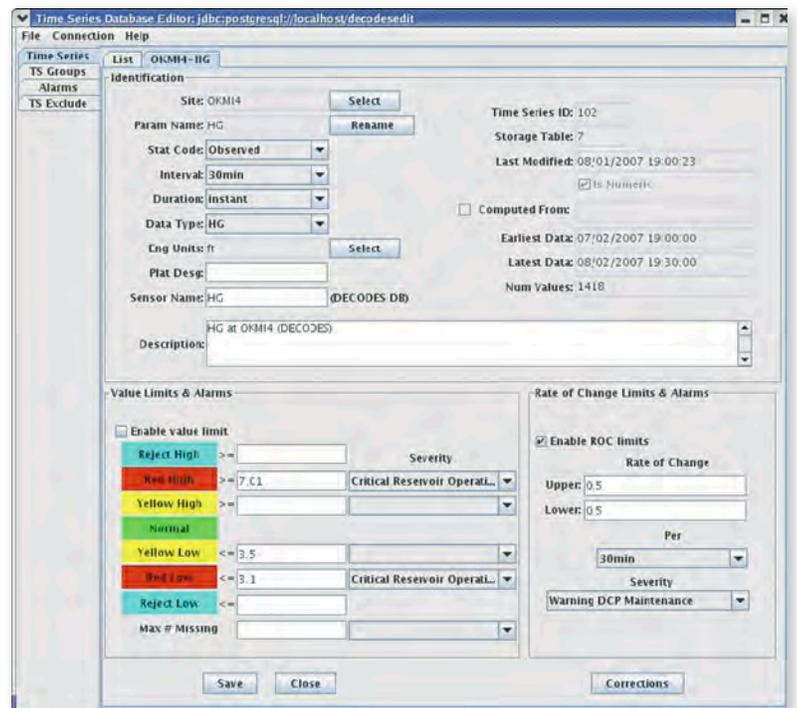


Figure 3 Time Series Database Editor - Edit Tab



Figure 4: Time Series Groups.

Real Time Data Ingest

The database is fully integrated with the decoding engine (a.k.a. 'DECODES') contained in the DCS Toolkit. You can run retrieval processes which ingest data directly into the database without the need for intermediate files. This ingest can be done periodically on a schedule, in real-time, or interactively in an ad-hoc manner.

If desired, you can have the ingest process automatically create new time-series as needed for incoming data. This saves a lot of work, especially if you are already using DECODES. Simply run DECODES for a representative period of time (say, a day's worth). It will create time-series as needed for each DECODES platform/sensor.

Later, after your database is set up the way you want, you may want to turn off this feature, or at least restrict it for specific platforms and/or data-types.

For example, suppose you do not want to store battery-voltage parameters in the database. Figure 5 shows how you could create a rule that excludes all parameters with data-type 'VB'. The rule will match any site.



Figure 5: Create Rules to Control how DECODES Auto-Create is Done.

Computations Derived from Parameters

In the past several years, we have worked with the U.S. Geological Survey, the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers to develop a powerful computation engine for hydro-met applications. We have incorporated this into our Hydro-Met Analysis System.

The Computation Engine allows you to specify 'Algorithms' and then apply the algorithms to specific 'Computations' on specific time-series. For example, Figure 6 shows the definition for computing Discharge at the site 'KEQ14' by using a table-lookup from a USGS RDB file.

Once this computation is defined and enabled, it will be automatically executed when new stage values are stored in the database. When an insert, update, or delete operation is performed, a trigger is fired which signals the computation engine to perform any dependent computations.

We provide a fairly complete set of initial 'algorithms' including rating-table lookup for discharge and volume, periodic statistics such as min/max/mean/median/std-dev, summing and scaling multiple input points, and others. It is easy to supplement this set with custom Java code. Thus any type of computation can be handled.

In addition to the automatic trigger-based approach, you can run your computation interactively in the screen shown in Figure 7. This can be used for testing new computations, or processing historical data that was entered before a computation was defined.

The Figure 7 shows the execution of a single computation, stage/discharge at site 'OKM14' over a one-month period. The

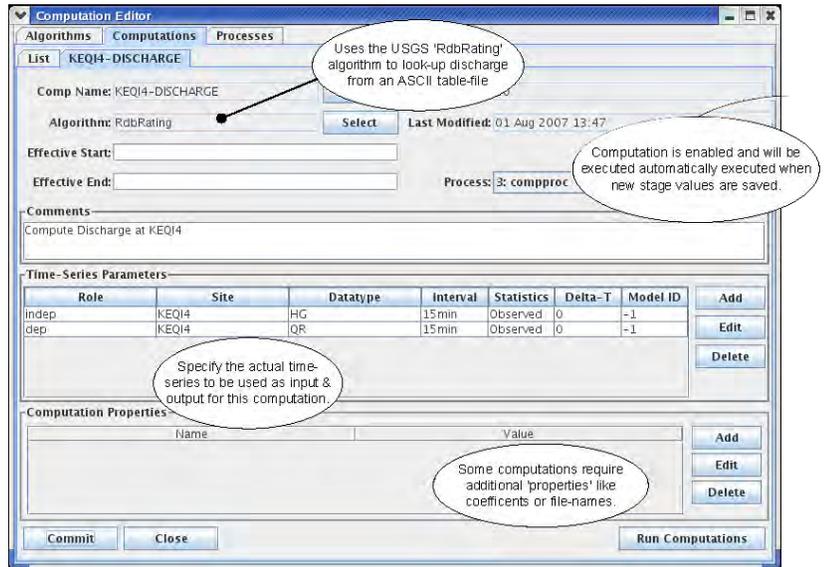


Figure 6: Computation Editor Showing a Stage/Discharge Computation.

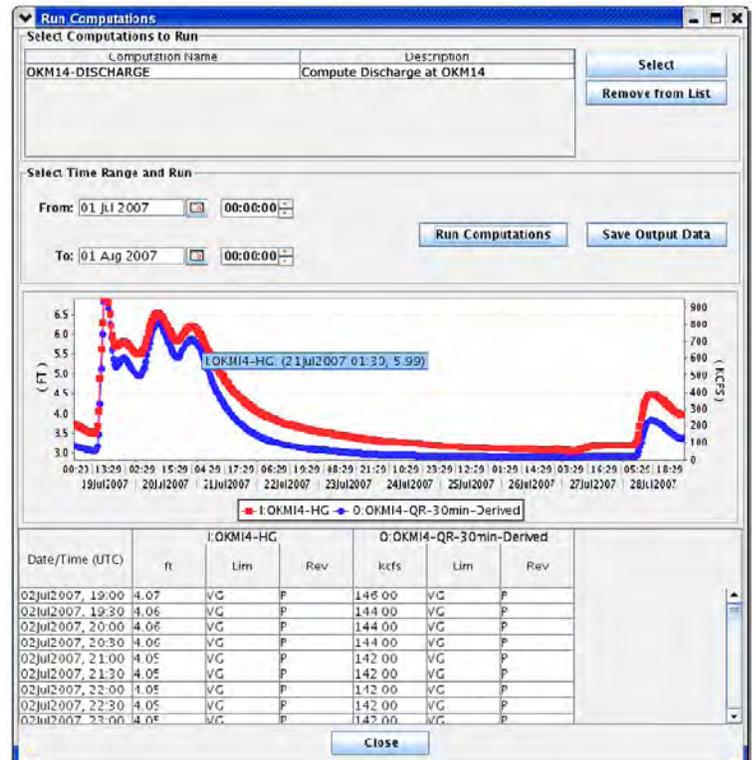


Figure 7: Run Computations Interactively in a GUI.

Limit Checking & Alarm Tracking

Refer back to Figure 3 where you set red/yellow limits on each parameter. Now you need a way to see at a glance whether your time-series values are in or out of limits. The screen shown in

Figure 8 answers that need. Here you specify a time-range and a group of time-series that you want to monitor.

The sample screen shows all of my Battery Voltage values for the previous day. The 'Quality Color Bar' shows good values in green, warning-level values in yellow, and critical values in red. Missing values are shown in white.

Now refer once again back to Figure 3 and notice the 'Severity' assigned to each of the defined limits at the bottom of the screen. Each Severity corresponds to one or more actions that can be taken. For example, the Severity 'Critical Reservoir Operations' might cause an audible alarm to sound and might Text-Messages to the cell-phones of critical personnel.

Conversely, the severity 'Warning DCP Maintenance' is less severe, indicating a possible problem on a DCP. This might just send email to maintenance personnel.

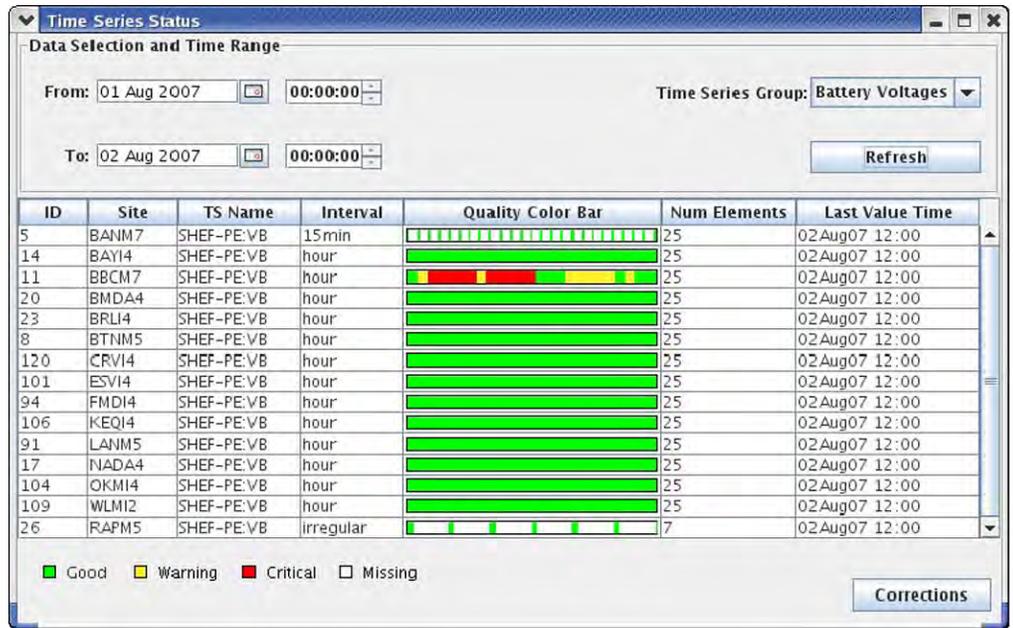


Figure 8: Time Series Status Screen.

Automated Data Correction Tools

Any data that arrives via sensors in the field must be quality-controlled. You need automated tools to view the data and correct it if necessary. The screen shown in Figure 9 provides these tools.

The screen below shows us correcting the stage value for site 'OKMI4'. You can display this point along with a set of 'reference points'. We are displaying our data against the stage value from 'BRLI4'.

The screen shows the data graphically and in table-form. The tools at the right allow you to correct data via interpolation, keyboard-entry, or adding a constant. You also set the review level here to one of Provisional, Reviewed, or Approved.

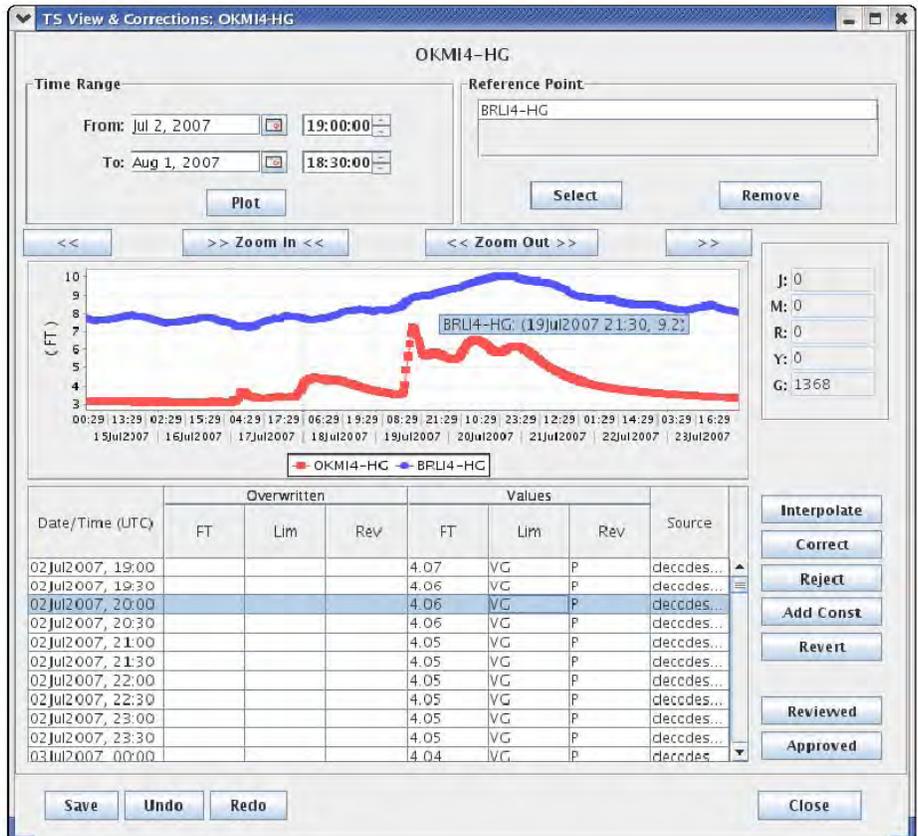


Figure 9: Time Series Corrections Screen.

DCP Monitor

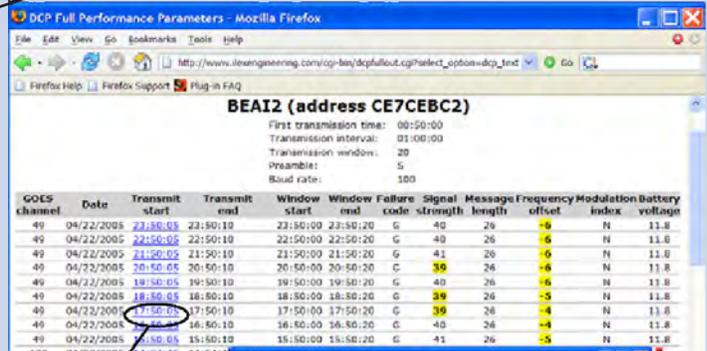
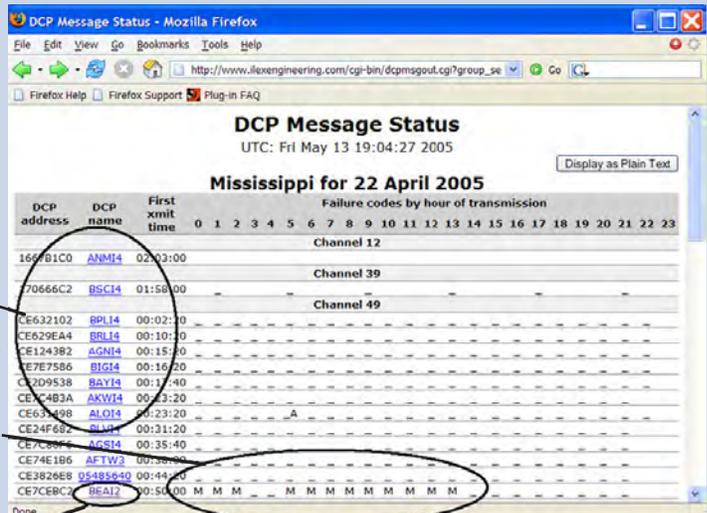
The Hydro-Met Analysis System contains a web-based tool to help you maintain your DCP network. This tool is called the 'DCP Monitor' and is currently in use by several Federal U.S. Agencies. The following two figures show the text-based and graphical screens.

Shows DCP transmissions by Channel, Transmit Time, Address & Name

Underscore = good transmissions. Character codes = transmission problems.

Click name for detailed information on a DCP.

Detailed info on each transmission. Red/Yellow colors indicate problems.



Click Transmit Time to show individual message (raw & decoded).

Figure 10: DCP Monitor Text-Based HTML Screens.

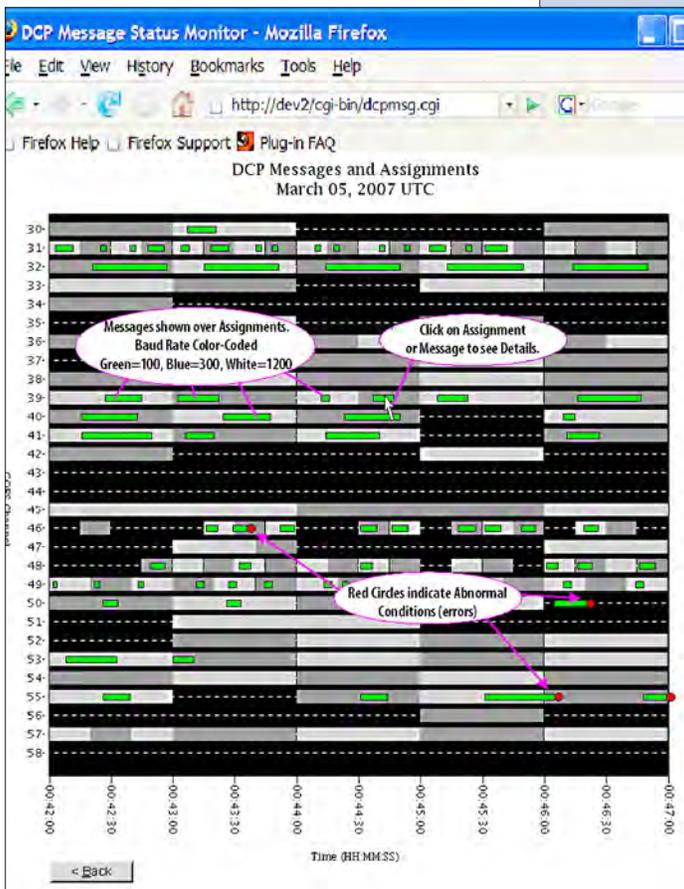


Figure 11: DCP Monitor - Graphic Time-Slot Viewer.

Web Content

The preceding sections describe how the user collects, QCs, corrects, maintains, and computes timeseries data. The final step is to generate web content for distribution to hydrologists, meteorologists, etc.. The 'Tempest Web' module performs this function.

Tempest Web can generate many types of web-displays:

- ▶ Time Series Plots: Multi-variable/Multi-Axis
- ▶ Tabular Displays
- ▶ Excel-compatible data downloads
- ▶ Wind speed/direction plots
- ▶ Bar charts: Multi-variable/Multi-Axis
- ▶ Graphical Gages (e.g. Dashboard-type displays) including integration with Google™ Maps for showing clickable locations of your gages on a map or satellite image overlay.

For each display, time series can be selected individually or by group. Commonly-viewed plots can be generated on a schedule and stored as HTML files for very fast display. Ad-hoc reports (e.g. where the user enters individual time-series and specific timeranges) are generated dynamically using JSP (Java Server Pages) technology.

You can customize the appearance of the web displays by adding your own organization's header, footer, logo, links, etc.

Summary

The Tempest™ product family provides a complete solution:

- ▶ Data collection from a wide variety of satellite, internet and other sources
- ▶ Decoding engine that can handle any DCP currently using the GOES DCS, as well as a wide variety of EDL (Electronic Data Logger) files
- ▶ Real-time Ingest into Time Series Database
- ▶ Automated rate-of-change and value limit checking
- ▶ Automated computations for rating curves, periodic statistics, multi-variable and other algorithms
- ▶ Graphical data editing and correction
- ▶ Automated alarms and notification system
- ▶ Web content generation, graphical or tabular, interactive and 'canned'
- ▶ Interfaces to other popular Hydro-Met products

Furthermore, the Tempest solution runs on a wide variety of platforms including Linux, Windows, and Solaris. The real-time software is 100% Java, making it easy to host on new platforms and architectures.

ORDERING	
9400-0012	Tempest Hydro-Met Analysis System Bundle
9400-0102	Annual Maintenance Contract Required for updates and phone support