OAA Techniques Development Laboratory
omputer Program NWS TDL CP 83-5

GENERALIZED EXPONENTIAL MARKOV (GEM) UPDATING PROCEDURE FOR AFOS

Silver Spring, Md.
December 1983

U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / National Weather Service

PREFACE

The Techniques Development Laboratory's (TDL's) computer program (CP) series is a subset of the Lab's technical memorandum series. The CP series documents computer programs written at TDL primarily for the Automation of Field Operations and Services (AFOS) computers.

The format for the series follows that given in the AFOS Reference Handbook, Volume 6, Background Applications.

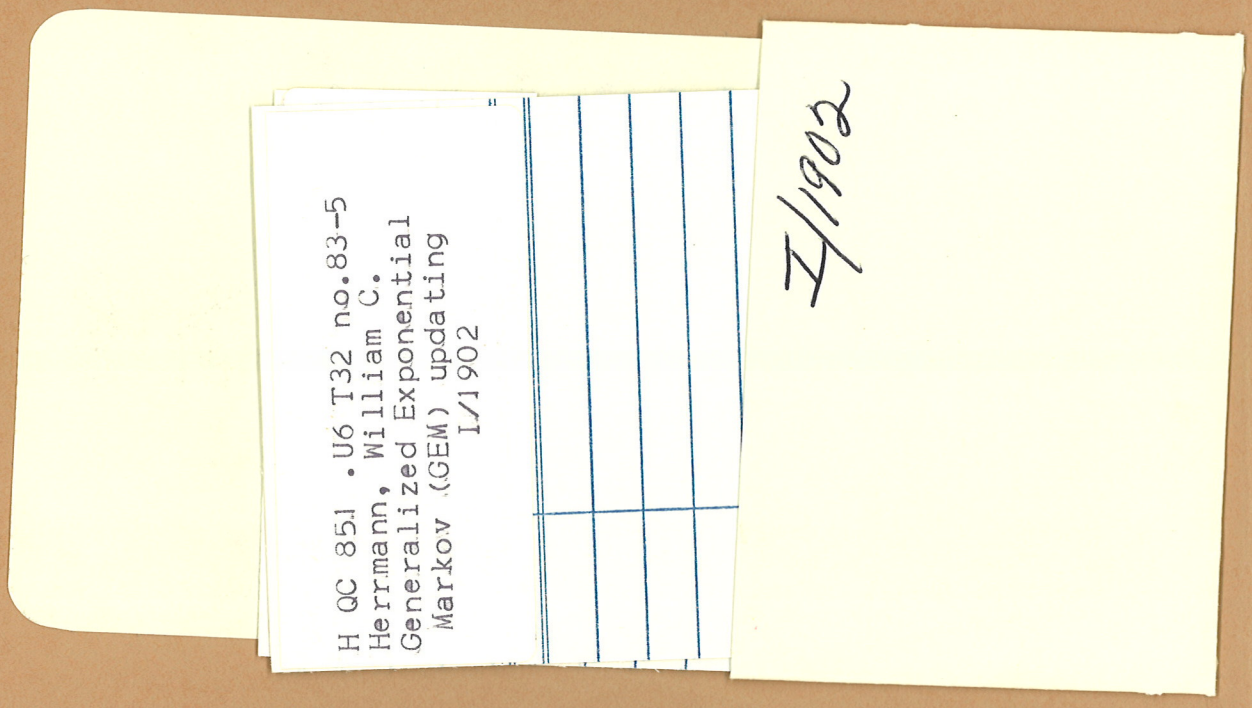
NOAA Techniques Development Laboratory
Computer Program NWS TDL

CP 83-1 Cross Sectional Analysis of Wind Speed and Richardson Number. Gilhousen, Kemper, and Vercelli, May 1983. (PB83 205062)

CP 83-2 Simulation of Spilled Oil Behavior in Bays and Coastal Waters. Hess, October 1983. (PB84 122597)

CP 83-3 AFOS-ERA Forecast Verification. Heffernan, Newton, and Miller, October 1983. (PB84 129303)

CP 83-4 AFOS Monitoring of Terminal Forecasts. Vercelli, December 1983.



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William C. Herrmann

Techniques Development Laboratory
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December 1983

UNITED STATES
DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Oceanic and
Atmospheric Administration
John V. Byrne, Administrator

National Weather Service
Richard E. Hallgren,
Assistant Administrator

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GENERALIZED EXPONENTIAL MARKOV (GEM) UPDATING PROCEDURE FOR AFOS

William C. Herrmann

1. INTRODUCTION

The Generalized Exponential Markov (GEM) updating program described here is an AFOS applications program which supplies short range guidance to the field forecaster. The guidance is in the form of categorical forecasts for all elements of a weather observation projected 1, 2, 4, and 6 hours into the future. GEM can be initiated in response to an alert generated by the monitoring program (Vercelli, 1983) or it can run as a stand-alone program for selected stations. GEM needs only the station's call letters to execute; no other input is required of the user. For detailed information on GEM see Miller (1981). Briefly, GEM is a statistical procedure consisting of a matrix of regression equations with the same weather elements as both predictors and predictands. The predictands are for 1 hour hence. Reentering the predictions made at 1 hour to be the observation for the next hour projects the forecast out to 2 hours. This iteration is repeated to achieve a forecast out to hour six. The same matrix of generalized coefficients is used at any location. The nature of the model is that the forecast system begins with just the knowledge of a single surface observation, the statistical history being represented by the regression coefficients modified by an exponential damping function.

2. METHODOLOGY AND SOFTWARE STRUCTURE

As shown in Fig. 1, the GEM programs are composed of a chain of four major modules in the basic input-process-output configuration. The input program, GEM, accepts a file of decoded station observations generated by the monitoring program (Vercelli, 1983) or retrieves and decodes up to five station observations selected by the forecaster. The process program, DRIVER, performs two major functions. Initially it converts, in turn, each decoded observation into a vector of pointers indicating which category of an observation element is to be considered. Secondly, it generates probability forecasts for every category of an observation element and categorical forecasts for every observation element. Before the categorical forecasts are displayed, they are checked in CONSIS for consistencies. These consistency checks are concerned with clouds, weather and obstructions to vision, and visibility.

The output module, OUTMTX, converts the checked categorical values to their appropriate ASCII alphanumeric equivalents for display on the AFOS ADM.

Fig. 2 shows the program structure and load lines for each of the four programs in the GEM series. Programs references are indicated by arrows.

A. Input Program: GEM

The input program for the GEM application, GEM, expects to (1) read station call letters from a file MONITR.D2 generated by the monitoring program or (2) read a maximum of five station call letters keyed in by the user on the AFOS

console. The latest observation is retrieved from the database and decoded (see Thomas, 1981). If it is a special observation, the temperature, dew point, and sea level pressure are retrieved from the appropriate previous hourly. In both cases, the WSFO's node call sign (ccc) and time zone information are obtained from AFOS SKEL and AFOSGEN files, respectively.

In either case, the decoded observation is then converted into the format required by the process module, DRIVER. Most observation elements are a one-to-one conversion, but weather, obstructions to vision, and clouds are special cases. The converted observations are written to a sequential file, GEM.D1. The total number of original stations read in and all the station call letters are also written to GEM.D1. Later, this list is compared with the final list to determine for which stations forecasts were unavailable. The GEM module chains to DRIVER.

B. Process Program: DRIVER

In DRIVER, channels are first opened to most files used by the module. Program control information is read and passed on to other routines to control processing. Station observations are then read from GEM.D1. Each station's observation is processed sequentially. One station's categorical forecasts are written to the sequential file DRIVER.D2 before doing the next.

The categorical forecast values are obtained in a two step process. The observation is first made into a pointer vector. That is, the observation element is compared to breakpoint values defining the boundaries of the categories of an element. When one is selected, a pointer is set and the next element is considered. One can imagine a resultant binary vector wherein the "zeros" of an observation element reflect ignored categories while the "ones" select the category whose predictors are used. In the second step, the pointers are incorporated into a mathematical algorithm to enable a vector of coefficients corresponding to the selected category to be read from a random file of exponentially weighted regression equations. The predictor vectors are added as they are obtained, producing a vector of predictand probabilities. Selecting the best category is done simply by comparing the probabilities to threshold values. The DRIVER module chains to the consistency check module, CONSIS.

C. Consistency Check Program: CONSIS

Consistency checks are performed on the categorical forecast values from DRIVER.D2 for several reasons. For example, precipitation type may be changed to be in agreement with the temperature. Rain is changed to snow at temperatures below freezing. Obstructions to vision are changed to agree with the dew point spread. Fog, is changed to haze when the dew point spread is greater than 4 degrees Farenheit. In general, the forecasts are altered to conform with reporting criteria for surface airways observations (U.S. Department of Commerce, et. al., 1982). The categorical forecasts are processed projection by projection and written in turn to file CONSIS.D1. CONSIS then chains to OUTMTX.

D. Output Program: OUTMTX

The output program, OUTMTX, reads the consistent categorical forecasts from CONSIS.D1 and converts them to their alphanumeric equivalents. Except for elements that employ the expected value method (i.e., temperature, dew point, and sea level pressure), these are actually the mid-point values of the categories the forecasts are designed to represent. For display on the AFOS ADM, all non-ASCII variables are converted to ASCII to store as an AFOS data base product.

OUTMTX first creates RDOS disk file entries with the name cccALGxxx, where ccc is the WSFO's call letters and xxx is the WSO's call letters for each station executed in GEM. Once a station's file is created, the program builds the communications header and stores it in the file. The formatted GEM output is then written line by line to cccALGxxx disk files. An example of the output display is shown in Fig. 3.

Once the output product has been built, it is stored in the AFOS database through a call to FSTOR. As these product files are built, their product names are written to disk file cccALGLIS. Also written here are the call letters of stations for which forecasts were unavailable. cccALGLIS is then stored into the AFOS database. The user can use this file as a redisplayable log of available station forecasts.

In the event of a program failure, a message will be displayed on the ADM with an error code listing typed out on the Dasher. Section 5-B details each of the error code messages.

3. CAUTIONS

At times the station observations are unavailable or are erroneous. In such cases, no forecasts will be produced for those stations and a list of stations without forecasts will be contained in cccALGLIS, a displayable database product.

Allow sufficient space on DPOF to insure all the programs and data files transfer completely from floppy disk. Insure that there is enough space on DPO to accommodate the cccALGxxx product files.

4. REFERENCES

Miller, R. G., 1981: GEM: A statistical weather forecasting procedure. NOAA Technical Report NWS-28, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, 103 pp.

Thomas, R. D., 1981: Surface airways observation decoder. Unpublished manuscript, National Meteorological Center, National Weather Service, NOAA, U.S. Department of Commerce, 22 pp.

U.S. Department of Commerce, U.S. Department of Defense, U.S. Department of Transportation, 1982: Federal Meteorological Handbook No. 1, Surface Observations, 3d Ed., Washington D.C., 321 pp.

Vercelli, D. J., 1983: AFOS monitoring of terminal forecasts. Techniques Development Laboratory Computer Program NWS TDL CP 83-4, National Weather Service, NOAA, U.S. Department of Commerce, 17 pp.

5. PROGRAM INFORMATION AND PROCEDURES FOR INSTALLATION AND EXECUTION

GENERALIZED EXPONENTIAL MARKOV (GEM) UPDATING PROCEDURE FOR AFOS

PART A: PROGRAM INFORMATION and INSTALLATION PROCEDURES

PROGRAM NAME: GEM

AAL ID: MOH008
Revision No.: 01.00

FUNCTION: Generates guidance forecasts for sky condition, visibility, weather, obstructions to vision, pressure, temperature, dewpoint, and wind direction and speed at projections of 1, 2, 4, and 6 hours, based on an input surface observation (SAO) and the statistical history given by regression coefficients. Can be run in conjunction with MONITR (DBC 009), responding to FT's that need updating.

PROGRAM INFORMATION:

Development Programmers:

William C. Herrmann
Newton A. Williams

Location: Techniques Development Laboratory
Phone: FTS 427-8067

Maintenance Programmer:

Thomas J. Perrone

Location: Techniques Development Laboratory
Phone: FTS 427-8067

Language: FORTRAN IV/ Rev 5.20

Type: Chain, Overlay

Save file creation dates: GEM.SV, DRIVER.[SV,OL], CONSIS.SV, OUTMTX.[SV,OL]
Original release/Rev 01.00 - April 1, 1983

Running times: 1/2 minute/station (Based on 5 stations)

Disk space: Program (SV,OL) - 205 RDOS blocks
Data files - 682 RDOS blocks

PROGRAM REQUIREMENTS

Program Files:

NAME	COMMENTS
GEM.SV	GEM chains to DRIVER
DRIVER.[SV,OL]	DRIVER chains to CONSIS
CONSIS.SV	CONSIS chains to OUTMTX
OUTMTX.[SV,OL]	

Data Files:

NAME	DP	READ/WRITE	COMMENTS
MONITR.D2	DPO	R	Used when run in conjunction with the MONITOR program.
GEM.D1	DPO	W/R	Created by GEM, input to DRIVER and OUTMTX.

NAME	DP	READ/WRITE	COMMENTS
DRIVER.D1	DPO	R	Supplied with program, contains category thresholds.
DRIVER.D2	DPO	W/R	Created by user, written by DRIVER, read in CONSIS, contains preliminary categorical forecasts. Remains after program execution.
DRIVER.D3	DPO	R	Supplied with program, contains program control parameters.
DRIVER.D5	DPO	R	Supplied with program, contains local climatology.
DRIVER.D6	DPO	R	Supplied with program, contains regression equations.
CONSIS.D1	DPO	W/R	Created by user, read in OUTMTX, contains final forecasts after consistency checks. Remains after program execution.
cccALGxxx	DPO	W	Station forecasts, created by program.
xxxALGLIS	DPO	W	Contains the list of stations processed and completion status, created by program.

AFOS Products:

ID	ACTION	COMMENTS
cccALGxxx	STORED	
cccALGLIS	STORED	

LOAD LINES

GEM: RLDR GEM OBSASG WEATHR SKY GETPRD AIRXX CKEY ANDEQ ANDGO ORGO NUMBR UTIL.LB FORT.LB BG.LB

DRIVER: RLDR DRIVER [OPNCHN, GETOBS, DUMYOB, GEMCAT] UTIL.LB FORT.LB

CONSIS: RLDR CONSIS WEAFIX CLOFIX AVRAGE CHECK UTIL.LB FORT.LB

OUTMTX: RLDR OUTMTX INITIT [OUTCAT, CONVERT, DISPLY] UTIL.LB BG.LB FORT.LB

PROGRAM INSTALLATION

1. Move program files GEM.SV, DRIVER.SV, DRIVER.OL, CONSIS.SV, OUTMTX.SV and OUTMTX.OL to either DPO or DPOF with links to them on DPO. The total disk space requirement for the GEM series of programs and data files is typically 910 RDOS blocks with a variation of 20 blocks, depending upon site options.

2. Create data file names DRIVER.D2 and CONSIS.D1 on DPO.

3. Insure that the following product keys exist:
   cccALGLIS
   cccALGxxx (for each station in node ccc).

GENERALIZED EXPONENTIAL MARKOV (GEM) UPDATING PROCEDURE FOR AFOS

PART B: PROGRAM EXECUTION and ERROR CONDITIONS

PROGRAM NAME: GEM

AAL ID: MOHOO8
Revision No.: 01.00

PROGRAM EXECUTION

1. GEM can be initiated in response to an alert generated by the monitoring program (MONITR) or it can be run as a stand alone program for selected stations. The program requires that DRIVER.D2 and CONSIS.D1 exist on DPO. If they do not, then execute an RDOS CREATE for each. In the first case enter: RUN:GEM

   In the second case enter: RUN:GEM XXX XXX XXX XXX XXX

   Here, XXX is a station's call letters (maximum of 5).

2. GEM runs in 11K and takes about 3 minutes to execute for 5 stations. Input consists of data base SAO's, parameters from WSFO SKEL and AFOSGEN files, data control elements, station climatologies, thresholds for categorical forecasting, and generalized operator equations. The output will be stored in individual cccALGxxx files (e.g. WBCALGDCA).

3. Program completion will be signified by activation of the alarm light. A list of products will be written to a text file called cccALGLIS. To display this file enter: cccALGLIS

   Then, to display individual product files enter: DSP:cccALGxxx

ERROR CONDITIONS

Error messages are printed at the Dasher.

NOTE: Error conditions other than those listed here, denote problems that occur while accessing files. The conditions are most likely caused by system/disk problems rather than program failures.

	MESSAGE	MEANING
1.	"GETPRD KSRCH ERROR"	Can't locate a current station SAO product for the site ccc in the product data base. Check station call letters in the RUN: line or, if run with MONITR, in the input file, MONITR.D2 (see section 2-A).
2.	"DRIVER OPNCHN OPENN DRIVER.D1 ERROR"	DRIVER.D1 was probably not successfully moved from DP3 to DPOF. Insure sufficient space on DPOF.

	MESSAGE	MEANING
3.	"DRIVER OPNCHN DRIVER.D3 ERROR"	DRIVER.D3 was probably not successfully moved from DP3 to DPOF. Insure sufficient space on DPOF.
4.	"DRIVER OPNCHN DRIVER.D5 ERROR"	DRIVER.D5 was probably not successfully moved form DP3 to DPOF. Insure sufficient space on DPOF.
5.	"DRIVER GEMCAT RDS EQUATIONS (DRIVER.D6) ERROR"	DRIVER.D6 was probably not successfully moved from DP3 to DPOF. Insure sufficient space on DPOF. Check link from DPO to DPOF.

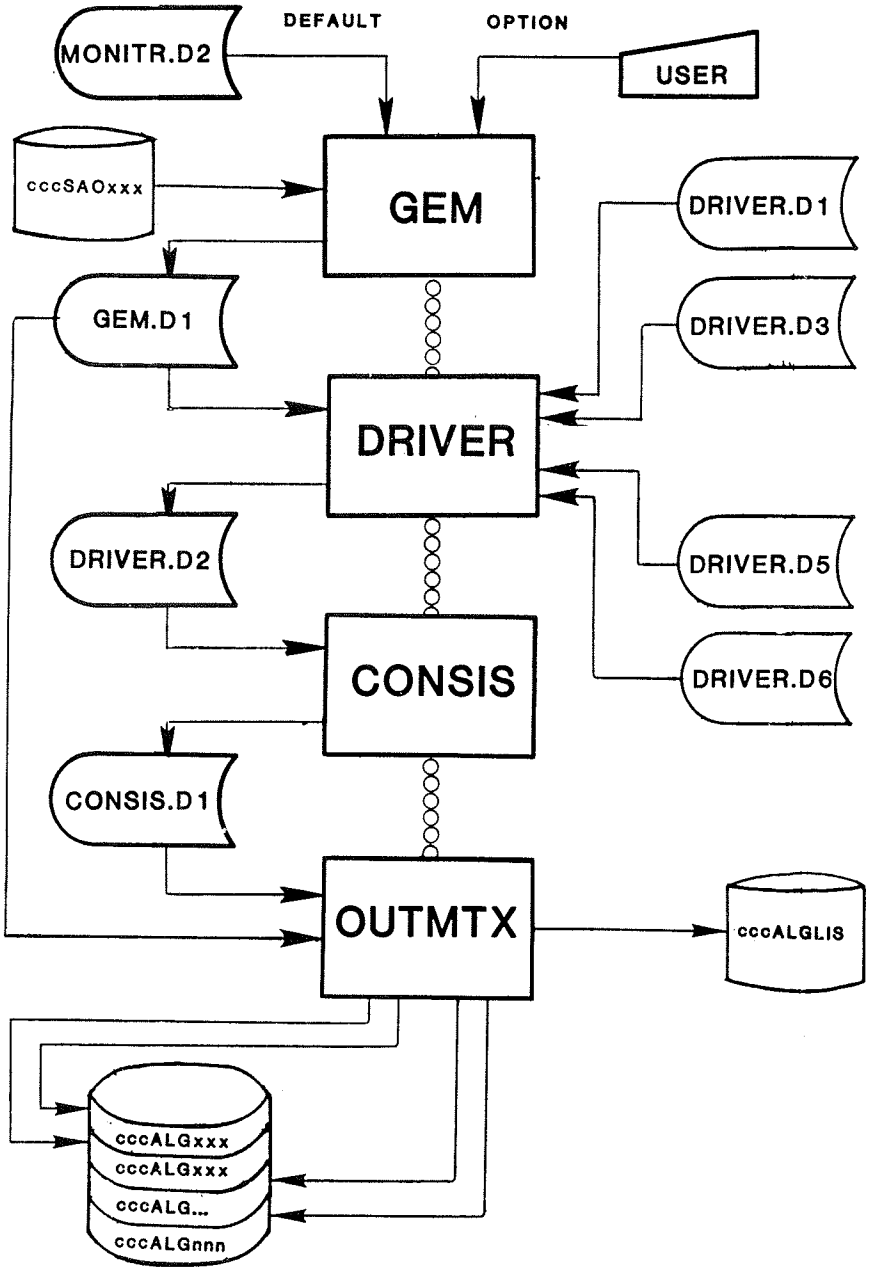


Figure 1. Flowchart for GEM software.

GEM

MAIN PROGRAM

GEM

Subroutines

GETPRD → CKEY

AIRXX → ANDEQ, ANDGO, ORGO, NUMBR

OBSASG
WEATHR
SKY

LOAD LINE

```
RLDR GEM OBSASG WEATHR SKY GETPRD CKEY AIRXX ORGO ANDEQ ANDGO NUMBR
  UTIL.LB FORT.LB BG.LB
```

DRIVER

MAIN PROGRAM

DRIVER

SUBROUTINES

OPNCHN
GETOBS
DUMYOB
GEMCAT

LOAD LINE

```
RLDR DRIVER [OPNCHN, GETOBS, DUMYOB, GEMCAT]  UTIL.LB FORT.LB
```

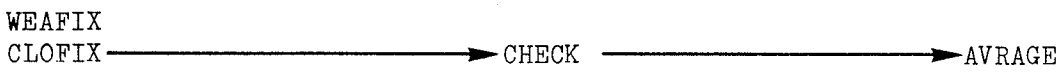
Figure 2. Chained program hierarchy and load line (continued on next page).

CONSIS

MAIN PROGRAM

CONSIS

SUBROUTINES



LOAD LINE

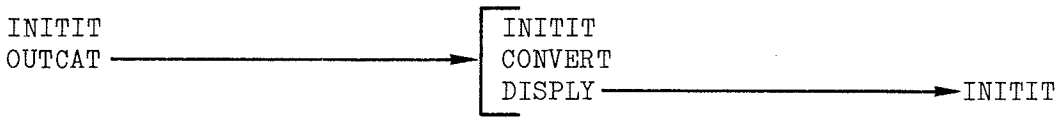
RLDR CONSIS WEAFIX CLOFIX CHECK AVRAGE UTIL.LB FORT.LB

OUTMTX

MAIN PROGRAM

OUTMTX

SUBROUTINES



LOAD LINE

RLDR OUTMTX INITIT [OUTCAT, CONVERT, DISPLY] UTIL.LB BG.LB FORT.LB

Figure 2. (Continued).

TDL / GEM FOR: PDX VALID FOR 6 HOURS AFTER OCT 12: 1300 GMT

HOUR	TT	DPT	VV	WEATHER	DDFF	PPP	H1	C1	H2	C2	CIG	TCA
13Z	46	44	1.00	F	3005	1022	10	OVC			10	OVC
14Z	49	48	1.00	F	3005	1022	10	OVC			10	OVC
15Z	52	51	1.00	F	3005	1023	10	OVC			10	OVC
17Z	55	53	2.00	F	3005	1022	10	OVC			10	OVC
19Z	58	55	3.00	F	3505	1021	10	OVC			10	OVC

Figure 3. Example of GEM output. Categorical forecasts are produced for Portland, Oregon using the 1300 GMT, October 12, 1983 SAO as input. Column headings are TT=temperature (°F), DPT=dewpoint (°F), VV=visibility (mi), DDFF=wind direction (tens of degrees) and speed (kt), PPP=pressure (mb), H1=height of first cloud layer (hundreds of feet), C1=cloud coverage of first cloud layer (clear, scattered, broken, overcast, totally obscured), H2=height of second layer if present (hundreds of feet), C2=cloud coverage of second cloud layer (clear, scattered, broken, overcast), CIG=ceiling height (hundreds of feet), and TCA=total cloud coverage (clear, scattered, broken, overcast).

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2.	"DRIVER OPNCHN OPENN DRIVER.D1 ERROR"	DRIVER.D1 was probably not successfully moved from DP3 to DPOF. Insure sufficient space on DPOF.

	MESSAGE	MEANING
3.	"DRIVER OPNCHN DRIVER.D3 ERROR"	DRIVER.D3 was probably not successfully moved from DP3 to DPOF. Insure sufficient space on DPOF.
4.	"DRIVER OPNCHN DRIVER.D5 ERROR"	DRIVER.D5 was probably not successfully moved form DP3 to DPOF. Insure sufficient space on DPOF.
5.	"DRIVER GEMCAT RDS EQUATIONS (DRIVER.D6) ERROR"	DRIVER.D6 was probably not successfully moved from DP3 to DPOF. Insure sufficient space on DPOF. Check link from DPO to DPOF.

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