# VI.5.3C-SYSTEM-MARO PROGRAM FCST FUNCTION WGRFC MEAN AREAL RUNOFF (MARO)

Purpose

Function MARO is the WGRFC precipitation preprocessor for the grid point system upon which the WGRFC precipitation station network is defined.

Like the Mean Areal Precipitation (MAP) Function the WGRFC MARO Function produces time series of mean areal precipitation. However there are two important differences between Function MARO and Function MAP.

First the data produced by Function MARO is derived from the grid point network where that produced by Function MAP is from a station network.

Second Function MARO computes time series of Mean Areal Runoff (MARO). These runoff time series are input to Function FCEXEC. Thus runoff computations take place in a Preprocessor Component Function and not in a Forecast Component Operation. Therefore when computing mean areal runoff with Function MARO no runoff computations need be performed in the Forecast Component.

Three types of data are used to form the areal estimates:

1. Precipitation data from stations that are part of the defined station network (the network is defined using the program PPINIT command DEFINE STATION - see Section VI.3.3 [Hyperlink]),

2. Manually Digitized Radar (MDR) data and

3. Precipitation data from points where there are no defined network stations but are within the WGRFC defined grid point network.

The form of these data used by Function MARO is:

1. Daily total or precipitation increment since the start of the hydrologic day for all stations,

2. 6 hour incremental precipitation for any station, SASM or otherwise, in the defined station network of in the WGRFC defined grid point network (only 6 hourly data is processed - other time intervals are ignored) and

3. 6 hour summations of hourly reported MDR values.

Function MARO generates 6 hour MAPG time series (4 values), 6 hour MARO time series (4 values) and a 24 hour Mean Areal API (MAPI) time series (1 value) for a single day run. The MAPG and MAPI time series are primarily used for display purposes while the MARO time series is used primarily for simulation and soil moisture accounting.

Computational Elements

Computations within Function MARO can be divided into four primary elements:

1. Observed point precipitation - Observed data for the entire RFC area for those stations defined in the station network are read from the Preprocessor Data Base (PPDB). Observed data for stations not defined in the station network (if any), are input into Function MARO by grid point address with a run-time modification (MOD). If desired, MDR can be read to fill in certain grid points where there is no observed precipitation amount available.

2. Grid point placement and estimation - The precipitation data is defined in terms of its grid point address. Estimations are made for each grid point with a missing value. Using 6 hour precipitation data and optional MDR data, percentage distribution factors are determined for those grid points where 6 hour time distributions are available.

3. Mean areal computations - Using the MARO areal definition by grid point, a value of MAPG for the 24 hour period is determined for the MARO area. Next, each grid point in the MARO area that has at least 0.01 inch of precipitation for the 24 hour period is subjected to runoff computation. Constants belonging to the rainfall-runoff relation assigned to the grid point are used to empirically determine a 24 hour runoff amount for the grid point. If the precipitation is less than 0.01 inch, a runoff depth of zero is assumed. 24 hour values of Mean Areal Runoff (MARO) are determined by the numerical average of the runoff at all the grid points assigned to the MARO area. 6 hour breakdowns of MAPG and MARO are developed from the percentage distribution factors for those grid points assigned to the MARO area. Mean Areal API (MAPI) is determined as the average of the API values at each grid point. The entire process is then repeated for the next MARO area.

4. Data Base update - 6 hour time series of MARO and MAPG and 24 hour time series of MAPI are written to the Processed Data Base (PDB). All grid point precipitation, including estimations (data type PG24) and grid point API (data type APIG) is written to the Preprocessor Data Base (PPDB). Grid point values of runoff are NOT stored in any data base.

Types of MARO runs

With respect to the areas to be processed, there is only one type of MARO run permitted. All MARO runs perform computations for all MARO areas. Partial area runs cannot be performed. With respect to the run period, MARO runs can be for only one 24 hour period at a time. This can be for any full day with observed precipitation on the PPDB (typically the most recent) or for the first day into the future (using partial day precipitation reports and/or QPF).

At the user's option, MDR may be used to compute percentage 6 hour distributions and estimate missing precipitation. The user may also predesignate grid boxes that will use MDR in this way regardless of the MDR usage level specified. The DEFINE GRIDBOX command will specify which grid boxes are to have this feature. In these grid boxes, MDR is always used to estimate precipitation for all MDR centroid grid points.

## Parametric Data Definition

Function MARO requires certain parametric data in order to run. The following parametric array information must first be defined using program PPINIT (see Section VI.3.3 [Hyperlink]). This includes:

1. Defining user parameters using the DEFINE USER command (includes MDR subset),

2. Defining the grid point network by specifying the grid box numbers, their location and their surrounding grid boxes with the DEFINE GRIDBOX command,

3. Defining the named station network using the DEFINE STATION command (NOTE: you must include the grid point address in the definition if the station reports precipitation and you wish to process the precipitation),

4. Completing the station parameters by running the NETWORK command to relate the grid point address of each station in the named station network to the data location for the station, to determine those named network stations that share the same grid point address and to determine an alphabetical order list of all stations with a grid point address,

5. Defining the rainfall-runoff relation constants with the DEFINE RFROCNST command,

6. Generating the grid point address of the grid point nearest to the centroid of each MDR box with the MDRGRID command and

7. Defining MARO area parameters with the DEFINE AREA MARO command.

In addition, a future release of Function MARO will require that the ORDER command be run to specify the computational order of the MARO areas. Currently the computational order is preset to Function MARO.

## Run-time Input

Input to Function MARO is through the Hydrologic Command Language (HCL).

The input consists of Techniques and their Arguments (see Section VI.5.3C-MARO-TECH [Hyperlink]).

There is also one run-time modification (MOD) that is used with Function MARO. The .GRIDPX MOD can be used to input precipitation data by grid point address for a location that is not defined in the named station network.

A summary of the run-time modification for Function MARO is given in Section VI.5.3C-MARO-MOD [Hyperlink].

The form of the input, valid values, global defaults and examples for all techniques used by all functions in the Forecast Program (FCST) are given in Section VI.5.3D-TECH [Hyperlink].

## Sample HCL Input

The following sample HCL input demonstrates a few typical runs that can be made using Function MARO. In these examples, it is assumed that no local defaults are defined (i.e., only global defaults exist). Normally, the amount of input will be reduced to only a few lines since local defaults will be used for many of the techniques and arguments.

Example 1. A typical MARO run

```
@SETOPTIONS
 STARTRUN *-1
 ENDRUN *
 FTWMDRDS
 MDREST24(2) 0.05
 PP24MAX 10.00
 PRTMDR
 PRTPP6
 PRTPP24
@COMP MARO
@STOP
```

Perform a MARO run for the latest hydrologic day. Use MDR to compute 6 hour distribution percentages. Use MDR to estimate any missing precipitation up to 0.05 inches. Do not allow any precipitation amount to exceed 10.00 inches. Print out the MDR calibration results. Print out both observed 6 hour and 24 hour precipitation, provided the totals are greater than zero.

Example 2. A typical MARO run made on a day with only a minimal amount of precipitation

```
@SETOPTIONS
 STARTRUN *-1
 ENDRUN *
 FTWMDRDS
 MDREST24(1)
 PP24MAX 5.00
```

```
 PRTPP24
 PRTPP6
@COMPUTE MARO
@STOP
```

Perform a MARO run for the latest hydrologic day. Use MDR to compute 6 hour distribution percentages. Use MDR to estimate only precipitation amounts of zero. Do not allow any precipitation amount to exceed 5.00 inches. Print out both observed 6 hour and 24 hour precipitation, provided the totals are greater than zero.

Example 3. MARO run when there is a relatively substantial amount of precipitation

```
@SETOPTIONS
 STARTRUN *-1
 ENDRUN *
 FTWMDRDS
 MDREST24(2) 0.05
 PP24MAX 15.00
 PRTMDR
 PRTPP6
 PRTPP24
 PRTMARO
@COMPUTE MARO
@STOP
```

Perform a MARO run for the latest hydrologic day. Use MDR to compute 6 hour distribution percentages. Use MDR to estimate any missing precipitation up to 0.05 inches. Do not allow any precipitation amount to exceed 15.00 inches. Print out the MDR calibration results. Print out both observed 6 hour and 24 hour precipitation, provided the totals are greater than zero. Print out a MARO/MAPG/MAPI tabular summary.

Example 4. Partial day run - not a complete hydrologic day's data available

```
@SETOPTIONS
 STARTRUN 051088
 ENDRUN 051188
 LSTCMPDY 05118800Z
 FTWMDRDS
 MDREST24(2) 1.00
 PP24MAX 15.00
 PRTMDR
 PRTPP6
 PRTPP24
 PRTMARO
@COMPUTE MARO
@STOP
```

Perform a MARO run for the hydrologic day beginning at 12Z on May 10, 1988 and ending at 12Z on May 11, 1988. The date and time of the last observed data is May 11, 1988 at 00Z. Use MDR to compute 6 hour distribution percentages. Use MDR to estimate any missing precipitation up to 1.00 inches. Do not allow any precipitation amount to exceed 15.00 inches. Print out the MDR calibration results. Print out both observed 6 hour and 24 hour precipitation, provided the totals are greater than zero. Print out a MARO/MAPG/MAPI tabular summary.

Example 5. MARO run with no significant precipitation

```
@SETOPTIONS
 STARTRUN *-1
 ENDRUN *
 PP24MAX 1.00
@COMPUTE MARO
@STOP
```

Perform a MARO run for the latest hydrologic day. Do not allow any precipitation amount to exceed 1.00 inches. Do not use MDR at all and do not produce any printouts.

Example 6. API adjustment run

```
@SETOPTIONS
 STARTRUN *-1
 ENDRUN *
 FTWMDRDS
 MDREST24(2) 0.05
 PP24MAX 10.00
 APIREC 0.80
 APIRCMIN 0.75
 APISCON 0.05
 APIMIN 0.50
 PRTMDR
 PRTPP6
 PRTPP24
 PRTMARO
@COMPUTE MARO
@STOP
```

Perform a MARO run for the latest hydrologic day. Use MDR to compute 6 hour distribution percentages. Use MDR to estimate any missing precipitation up to 0.05 inches. Do not allow any precipitation amount to exceed 10.00 inches. For the current day only, set the API recession factor to 0.80 and set the minimum API for using the recession factor to 0.75 inches. For the current day only, set the API subtraction constant for APIs less than 0.75 inch to 0.05 inches. However, do not allow any APIs to fall below 0.50 inches. Print out the MDR calibration results. Print out both observed 6 hour and 24 hour precipitation, provided the totals are greater than zero. Print out a MARO/MAPG/MAPI tabular summary.

Example 7. Debug output run

```
@SETOPTIONS
 STARTRUN *-1
```

```
 ENDRUN *
 FTWMDRDS
 MDREST24(2) 0.25
 PP24MAX 10.00
 BOXDEBUG 42 43
 PPDEBUG GADR GDRC GDTM GOPT RFRO GMRO GRNF
 PPTRACE(3)
 PRTMDR
 PRTPP6
 PRTMARO
@COMPUTE MARO
@STOP
```

Perform a MARO run for the latest hydrologic day. Use MDR to compute 6 hour distribution percentages. Use MDR to estimate any missing precipitation up to 0.25 inches. Do not allow any precipitation amount to exceed 10.00 inches. Display the grid-box-dependent debug output for grid boxes 42 and 43 only. Dump out on the debug output data set the output generated by the following debug codes: GADR, GDRC, GDTM, GOPT, RFRO, GMRO and GRNF. Set the trace level for trace output to 3. Print out the MDR calibration results. Print out both observed 6 hour and 24 hour precipitation, provided the totals are greater than zero. Print out a MARO/MAPG/MAPI tabular summary.

Example 8. MARO run with grid box output

```
@SETOPTIONS
 STARTRUN *-1
 ENDRUN *
 FTWMDRDS
 MDREST24(2) 0.05
 PP24MAX 10.00
 BOXDUMP(1) 28
 BOXDKEY PG24
@COMPUTE MARO
@STOP
```

Perform a MARO run for the latest hydrologic day. Use MDR to compute 6 hour distribution percentages. Use MDR to estimate any missing precipitation up to 0.05 inches. Do not allow any precipitation amount to exceed 10.00 inches. Print out on a grid box background the grid point 24 hour precipitation (data type PG24) for grid box 28 and surrounding boxes (See Note below).

NOTE: When a grid box is specified in a BOXDUMP technique, that grid box, as well as surrounding grid boxes have their grid point data displayed. The surrounding grid boxes are defined for each grid box with the DEFINE GRIDBOX command.

Example 9. MARO run with run time modification

```
@SETOPTIONS
 STARTRUN *-1
 ENDRUN *
 FTWMDRDS
```

```
    MDREST24(2) 0.20
    PP24MAX 7.00
    PRTMDR
    PRTPP6
    PRTPP24
    PRTMARO
    MOD
     .GRIDPX  0823
     1564   10
     4115  120
     2941  106  3*0  106
     5563   67    0   12   50   15
     7207  420
     7219  110
     ENDMOD
   @COMPUTE MARO
   @STOP
```

Perform a MARO run for the latest hydrologic day. Use MDR to compute 6 hour distribution percentages. Use MDR to estimate any missing precipitation up to 0.20 inches. Do not allow any precipitation amount to exceed 7.00 inches. Print out the MDR calibration results. Print out both observed 6 hour and 24 hour precipitation, provided the totals are greater than zero. Print out a MARO/MAPG/MAPI tabular summary. Input with a run time modification the following 24 hour grid point precipitation data for the 24 hour period ending at 12Z on August 23: grid address 1564, precipitation 0.10 inches; grid address 4115, precipitation 1.20 inches; grid address 2941, precipitation 1.06 inches, with all of it occurring in the 4th period (06Z-12Z); grid address 5563, precipitation 0.67 inches, distributed as follows: zero in the 1st period (12Z-18Z), 0.12 inches in the 2nd period (18Z-00Z), 0.50 inches in the 3rd period (00Z-06Z) and 0.15 inches in the 4th period (06Z-12Z); grid address 7207, precipitation 4.20 inches; and grid address 7219, precipitation 1.10 inches. This precipitation data will replace any existing data that occupies the same grid point address.

Example 10.
MARO run for a previous day

```
   @SETOPTIONS
    STARTRUN *-4
    ENDRUN *-3
    FTWMDRDS
    MDREST24(2) 0.15
    PP24MAX 10.00
    PRTMDR
    PRTPP6
    PRTMARO
   @COMPUTE MARO
   @STOP
```

Perform a MARO run for the hydrologic day beginning at 12Z four days ago and ending at 12Z three days ago. Use MDR to compute 6 hour distribution percentages. Use MDR to estimate any missing precipitation up to 0.15 inches. Do not allow any precipitation amount to exceed 10.00 inches. Print out the MDR calibration results. Print out both observed 6 hour and 24 hour precipitation, provided the totals are greater than zero. Print out a MARO/MAPG/MAPI tabular summary.

Example 11. QPF and partial day run of MARO

```
@SETOPTIONS
 STARTRUN *
 ENDRUN   *+1
 LSTCMPDY *
 FTWQPF  0  3  5  4
 MDREST24(2) 1.00
 MDRTABLE(70)
 PP24MAX 10.00
 PRTPP6
 PRTPP24
 PRTMARO
 MOD
  .GRIDPX   100388
  1555  100
  1650  100
  1655  100
  2655  100
  2650  100
  2555  100
  2550  100
  2455  100
  2450  100
  1450  100
  1455  100
  1550  100
  1525  200
  1500  200
  2575  200
  1400  200
  1502  300
  1508  300
  ENDMOD
@COMPUTE MARO
@STOP
```

Perform a MARO run for the hydrologic day beginning at 12Z today and ending at 12Z tomorrow. The last day with observed data is today at 12Z. This is a QPF run of MARO. Use the following factors to distribute the forecast precipitation: (1) for the first period (12Z today - 18Z today) the distribution factor is zero; (2) for the second period (18Z today - 00Z tomorrow) the distribution factor is 3/12 of 1/4; for the third period (00Z tomorrow - 06Z tomorrow) the distribution factor is 5/12; and (4) for the fourth period (06Z tomorrow - 12Z tomorrow) the distribution factor is 4/12 of 1/3. Use MDR to estimate missing precipitation up to 1.00 inches. Use the MDR 70 percent probability table to compute missing precipitation values at the centroid grid points. Do not allow any precipitation amount to exceed 10.00 inches. Print out both observed 6 hour and twenty four hour precipitation, provided the totals are greater than zero. Print out the MARO/MAPG/MAPI tabular summary. The forecast precipitation for the 24 period ending at 12Z on October 3, 1988 is input with a run time modification. Precipitation totals are 1.00 inches at grid points 1555, 1650, 1655, 2655, 2650, 2555, 2550, 2455, 2450, 1450, 1455 and 1550; 2.00 inches at grid points 1525, 1500, 2575 and 1400; and 3.00 inches at grid points 1502 and 1508.

## Output

There are four types of output from Function MARO. The first is standard printer output. This consists of a title page giving the run period and options used. Also, data displays controlled by techniques BOXDUMP, BOXDKEY, PRTMARO, PRTMDR, PRTMDR6, PRTPP6, PRTPP24 and PRTPPZRO may be included in this display. The second type of output is printer trace and debug output, which is controlled by techniques PPTRACE, PPDEBUG and BOXDEBUG. The third type of output is time series of MARO, MAPG and MAPI which are written to the Processed Data Base (PDB). The fourth type of output is the daily hydrologic data arrays of 24 hour grid point precipitation, including estimations, (data type PG24) and grid point API (data type APIG), which are written to the Preprocessor Data Base (PPDB). There is currently no punch stream output for any type of AFOS displays available with MARO. However, a future release of MARO is expected to have this output option available.

## Error Messages

Error and warning messages generated by Function MARO are described in Section VI.5.3C-MARO-ERROR [Hyperlink].