Flow Forecasting manual for WATFLOOD®/CHARM®

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WATFLOOD is open source

LGPL 3 Free Software

Free as in Freedom

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Original forecasting methodology developed in 2014 for the
Ontario Ministry of Natural Resources and Forestry

Revised from CWRA Pre-Conference Workshop handout
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Rev. 1 - April 7, 2017
Rev. 2 – May, 2019 (revised for lat-long)
Rev. 3 – January 2021 (revised for automatic forecasting)
Rev. 4 – January 2021 (revised for ensemble & HRDPS forecasting)

Subject to additions and more revisions.
User feedback appreciated.

Celebrating 150 years of Canada

Author's notes

This manual and the software described is made available free of charge.

It is intended to allow flow forecasters to use the most up-to-date numerical weather forecasts for flow and/or flood forecasting with up to 10 days of lead time

This manual describes a set of programs to automatically download and save daily numerical weather forecasts

It then goes on to give detailed instructions on how to process the data to make a flow forecast using:

NRC's Green Kenue™ graphical pre & post processor http://www.nrc-cnrc.gc.ca/eng/solutions/advisory/green_kenue/download_green_kenue.html

The hydrological modelling system WATFLOOD®/CHARM® (Canadian Hydrological And Routing Model) http://www.watflood.ca

The forecast is done automatically at night using the Windows Task Scheduler

Downloading & processing the files can take up to 1 hour depending on the size of the watershed and the computer's speed.

The system can be set up in-house

On-line support is available

Also available:

A fully automatic web-based system HydrologiX II incorporating the same process is available from 4DM http://www.4dm-inc.com/?s=watflood

A Python script based system is available from NRC
http://www.nrc-cnrc.gc.ca/eng/solutions/advisory/green_kenue_index.html

Flood forecasting system (Delft-FEWS)
https://www.deltares.nl/en/software/flood-forecasting-system-delft-fews-2/

DISCLAIMER

Contents

1. Introduction

Over the past few years, high resolution numerical weather forecasts with up to two weeks' lead time have become readily available. The distributed (gridded) hydrological model WATFLOOD and the pre & post processor GreenKenue™ have been coupled and configured for use in real-time streamflow forecasting applications. WATFLOOD due to its gridded approach to hydrological modelling and routing can take full advantage of the equally detailed numerical forecast thus highlighting locations of concern in a watershed.
This flood forecasting manual provides a detailed methodology for importing a GRIB2-formatted numerical weather forecast and applying it to any size watershed. It is expected that the user is familiar with the WATFLOOD/CHARM hydrological modelling system and the GreenKenue™ pre & post processor.

Abbreviations:
WF WATFLOOD **GK** GreenKenue
CMC Canadian Meteorological Centre **WSC** Water Survey of Canada
CaPA Canadian Precipitation Analysis
RDPA The Regional Deterministic Precipitation Analysis
bsnm basin name - bsnm is replaced by the actual watershed names in various applications
yyyy replace with appropriate year

Definition: WATFLOOD: a set of DOS based executables: various programs for pre & post processing and the model itself: CHARM (Canadian **H**ydrological **A**nd **R**outing **M**odel). The executable = CHARM*nnn*.exe where *nnn* denoted various versions: 32 or 64 bit, debug or release version.
The next few chapters describe the data sources and how each is processed beginning with the historical data and then the forecast numerical weather data

2. Flow Forecast Overview: Steps

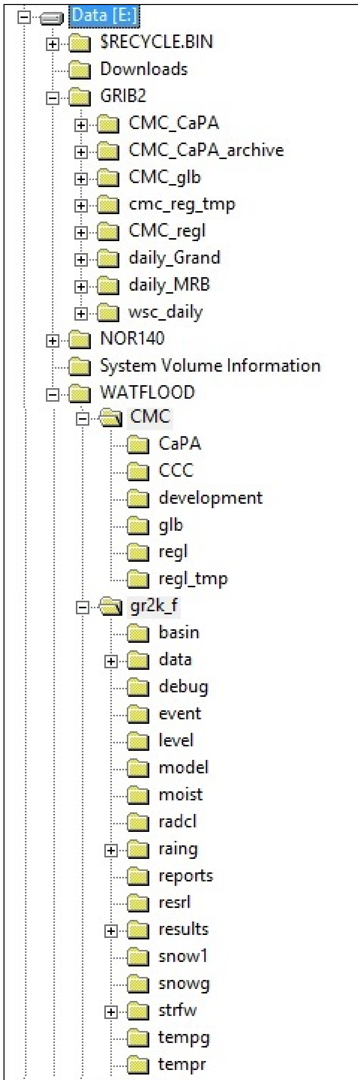
Download: provisional WSC flow; CaPA precipitation; CMC_Regional forecast; CMC_Global forecast for the CMC domains.

Convert the Grib2 format CMC model data to GK r2c files for the CMC domain(s)
Extract the CMC model data for the WF domain from the CMC model domain r2c
Execute the hydrological model: spin up & forecast
Evaluate flow forecast

3. Directory Structure

There are many gigabytes of data in play. To keep things manageable, the data is mostly divided by type and month. The CMC data is kept in monthly chunks but later combined in to annual events for WF. A number of data processing programs have been written to process the CMC and WSC files. These programs expect this structure on a particular drive. The examples to follow are based on this setup as shown in Table 1. All examples to follow are the **e:** drive. Two directories e:\GRIB2 and e:\WATFLOOD contain all files for the CMC meteorological and WATFLOOD data respectively. Users may substitute e: for a path of their choice.

This structure is set up so executables to download data are run in the Grib2 directory and the rest are run from the watershed directory as the working directory (eg. Watflood\gr2k_f). The GRIB2 dir has all the raw downloaded Grib2 & WSC files. The WATFLOOD\CMC dir contains the converted data i.e. Grib2 → *.r2c



In GRIB2:	201701
CMC_CaPA	201702
	Monthly Etc.
CMC_Glb	CMC_glb_20170101
CMC_reg_tmp	CMC_glb_20170102
CMC_regl	Daily etc.
	201701
	201702
Daily_Grand	Monthly Etc
	CMC_regl_20170101
	CMC_regl_20170102
	Daily Etc.
	20170101
In WF/CMC:	20170102
CaPA	Daily Etc.
Glb	
Regl	20170101_capa.r2c
Regl_tmp	20170201_capa.r2c
	Monthly Etc.
Directories and	20170101_tmp.r2c
files in gr2k as	20170201_tmp.r2c
described in the	Monthly Etc.
WF manual	

Table 1 – Directory Structure for Flow Forecasting

Note: watershed names are set for the Grand River in this figure.

4. CMC Regional Model Overview

CMC Regional Forecast:
Regional Deterministic Prediction System (RDPS), in GRIB2 format: 10 km

Source: http://weather.gc.ca/grib/grib2_reg_10km_e.html

Under the RDPS, the numerical weather prediction model is run on a variable-step grid with a 10 km central core resolution. The fields in the 10km resolution regional GRIB2 dataset are made available on a 935 [cols] x 824 [rows] polar-stereographic grid covering North America and adjacent waters with a 10 km resolution at 60°N.
[The zero meridian of the grid is at 60ºN and 249º as measured to the east from 0º at Greenwich (249-360)º = -111º = 111ºW]

Technical Grid Specification CMC Regional Model and CaPA

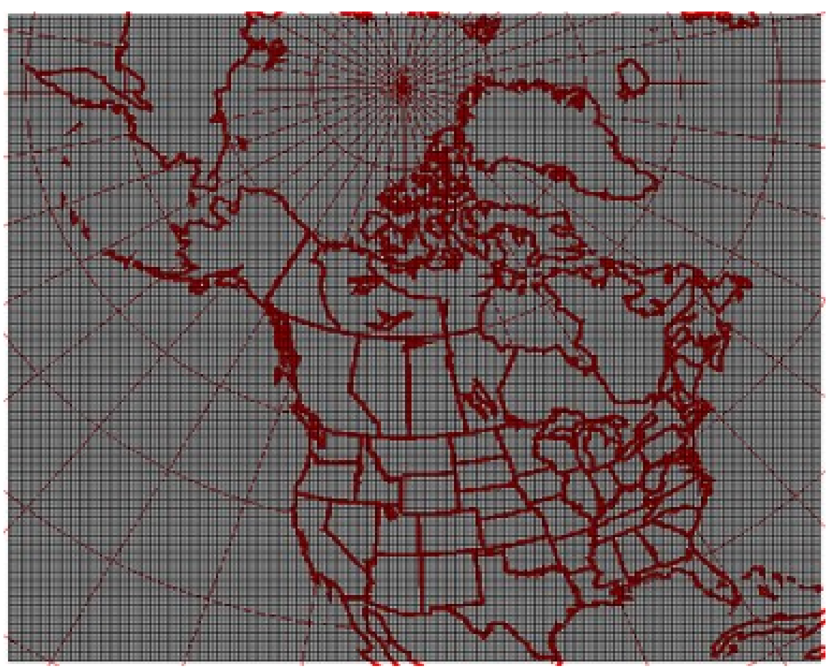


Figure 1 – CMC Regional model grid layout.

Grid specifications
Table lists the values of various parameters of the high resolution polar-stereographic grid.

Parameter	Value
ni [cols]	935
nj [rows]	824
resolution at 60° N	10 km
coordinate of first grid point	18.1429° N 142.8968° W
(i,j) coordinate of North Pole	(456.2, 732.4)
grid orientation (with respect to j axis)	-111.0°

4.1 File name nomenclature Regl model

4.1.1 Download

The data is available using the HTTP protocol and resides in a directory that is plainly accessible to a web browser. Visiting that directory with an interactive browser will yield a raw listing of links, each link being a downloadable GRIB2 file. In practice, we recommend writing your own script to automate the downloading of the desired data (using wget or equivalent). If you are unsure of how to proceed, you might like to take a look at our brief wget usage guide.

The data can be accessed at the following URLs:
http://dd.weather.gc.ca/model_gem_regional/10km/grib2/HH/hhh/

where:

HH: model run start, in UTC [00,12]
hhh: forecast hour [000,003,006,...,048]

4.1.2 File name nomenclature

The files have the following nomenclature:

CMC_reg_Variable_LevelType_level_ps10km_YYYYMMDDHH_Phhh.grib2

where:

CMC: constant string indicating that the data is from the Canadian Meteorological Centre
reg: constant string indicating that the data is from the RDPS
Variable: Variable type included in this file. To consult a complete list, refer to the variables section.
LevelType: Level type. To consult a complete list, refer to the variables section.
Level: Level value. To consult a complete list, refer to the variables section.

ps10km: constant string indicating that the projection used is polar-stereographic at 10km resolution.
YYYYMMDD: Year, month and day of the beginning of the forecast.
HH: UTC run time [00,12]
Phhh: *P* is a constant character. *hhh* is the forecast hour [000,003,006,...,048]
grib2: constant string indicating the GRIB2 format is used

4.2 Creating a list of Regl. Grid nodes

Creating WF compatible input files is a 2-step process:
First, the GRIB2 file is converted to an r2s file in Gk and then this r2s file is saved as a multiframe r2c file.
A program **Regl_conv.exe** will read the entire r2c **apcp** or **tmp** file for the Regional domain and create r2c files for just the watershed based on the WATFLOOD domain in the **shd.r2c** file.
These steps will be described in detail in Section 9.1.1

But before the GRIB2 files can be used for the forecast, the data on grid points falling on the watershed domain need to be extracted and written to a tb0 file.

There is a formatted ASCII file (compressed http://weather.gc.ca/grib/10km_res.bz2) containing the coordinates for each gridin long-lat. It looks like this once uncompressed (10km_res.txt):

```
1 1 217.107456,18.145030            Node 1,1 = top left corner
2 1 217.163959,18.178401
3 1 217.220531,18.211734
.
.
934 824 349.847696,45.486515
935 824 349.825579,45.405452        Node 935,824 = bottom right corner of the
grid
```

This file needs a bit of work before it can be used. The columns are col, row, long(W) & lat.

The file is modified (in Excel) to an XYZ format file for GK – long, lat, node# and called **rdps.xyz** It should be located in the CMC directory. The longitude is given in degrees measured to the east so needs to be converted to -ve degrees measured to the west: 360 is subtracted from the long given above – see example (below

```
     long        lat      station        row        col
  -142.89255    18.14503        1          1          1
  -142.83604    18.17840        2          1          2
  -142.77946    18.21173        3          1          3
  -142.72282    18.24503        4          1          4
  -142.66612    18.27828        5          1          5
  -142.60933    18.31150        6          1          6
```
.etc.

This file must be loaded into GK and assigned the Spatial Attributes: LatLong, NAD83 and saved with the same name. This puts a proper meta data header on the xyz file

rdps.xyz file for long-lat based watershed models

```
#
:FileType xyz  ASCII  EnSim 1.0
# National Research Council Canada (c) 1998-2017
# DataType                XYZ Point Set
#
:WrittenBy                Nick
:CreationDate             Tue, Feb 27, 2018 03:25 PM
#
#--------------------------------------------------------------------------
#
:DoublePrecision   False
:Mean   385220.500000
:StdDev   222406.870698
#
:Projection    LatLong
:Ellipsoid NAD83
#
:AttributeCount 1
:EndHeader
     -142.89255        18.14503              1
     -142.83604         18.1784              2
     -142.77946        18.21173              3
     -142.72282        18.24503              4
     -142.66612        18.27828              5
     -142.60933         18.3115              6
.etc.
```

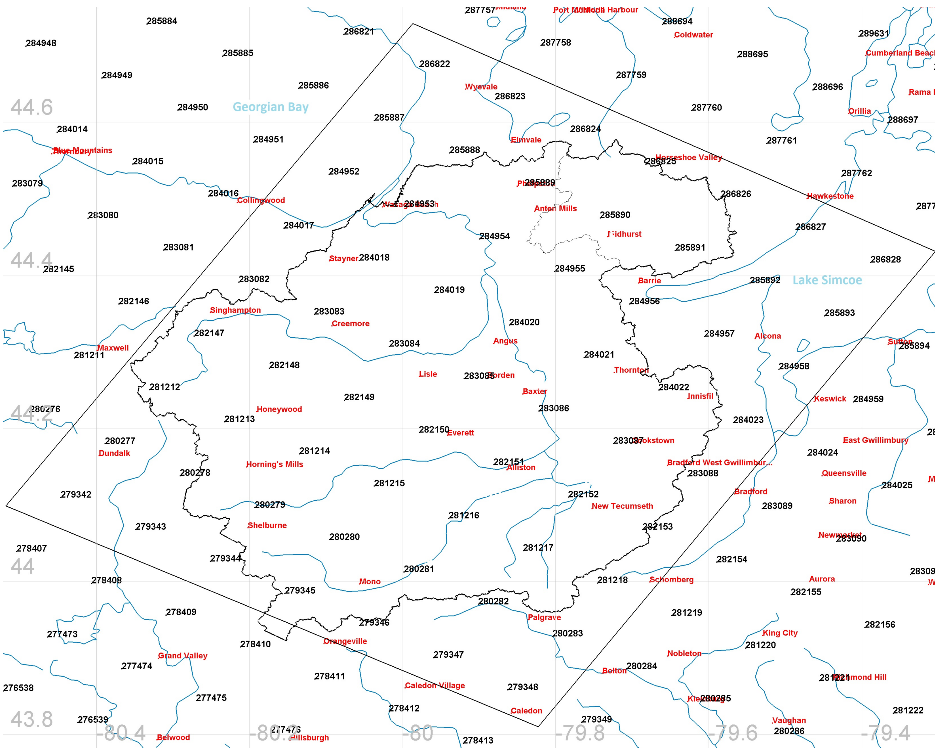


Figure 2 – CMC Regional model and CaPA nodes on the Nottawasaga Watershed
(The node range needed later can be obtained from this figure.)

Figure 2 shows the Nottawa saga watershed outlined in black and the water courses in blue. Georgian Bay is at the top left of the diagram.

4.3 For other coordinate systems e.g. UTM, PS, LC

Change the spatial characteristics in GK LatLong to a UTM Zone, a LambertConformal conic projection (LCC) or a PolarSteriographic projection. The converted data is then saved as a GK format files eg. **rdps_UTM.xyz, rdps_PS.xyz or rdsp_LC.xyz**

The WATFLOOD program **REGL_CONV.exe** will read these coordinates in the yyyy_capa.cfg file

Example rdps file for UTM coordinates (gr2k):

Note: this file is obtained by loading the **rdps.xyz** file shown above into GK, assigning lat-long coordsys and then converting and saving to a UTM coordsys for the proper zone. The last 2 columns are lost and not needed. A similar transformation can be made for other UTM zones or PS coordinate systems.

This xyz file is plotted in Fig. 2 for the Grand River Watershed in S. Ontario.

```
########################################################################
:FileType xyz  ASCII  EnSim 1.0
# National Research Council Canada (c) 1998-2014
# DataType                 XYZ Point Set
#
:Application              GreenKenue
:Version                  3.4.27
:WrittenBy                Nick
:CreationDate             Sun, Feb 12, 2017 10:01 AM
#
#-----------------------------------------------------------------------
:Mean   385220.500000
:StdDev   222406.870698
#
#
:Projection UTM
:Zone 17
:Ellipsoid WGS84
#
:EndHeader
-7269320.81696281 3776730.65497933               1
-7256690.86932646 3777968.33562176               2
-7244070.9148171  3779188.82045844               3
.
.
5683734.4607075   8095604.09128302          770439
5694528.13407998  8088401.46870663          770440


Easting          northing                  node #
```

5. CMC Global Model overview

https://weather.gc.ca/grib/grib2_glb_25km_e.html

As quoted from the CMC website:

"The fields of the Global Deterministic Forecast System (GDPS) GRIB2 dataset are made available on a 1500 x 751 latitude-longitude grid at a resolution of .24 x .24 degrees, which corresponds to about 25 km resolution.

"GDPS on a 25 km full-resolution Lat-Lon grid (grid step = 20)

"Download:

"The data is available using the HTTP protocol and resides in a directory that is plainly accessible to a web browser. Visiting that directory with an interactive browser will yield a raw listing of links, each link being a downloadable GRIB2 file. In practice, we recommend writing your own script to automate the downloading of the desired data (using wget or equivalent). If you are unsure of how to proceed, you might like to take a look at our brief wget usage guide.

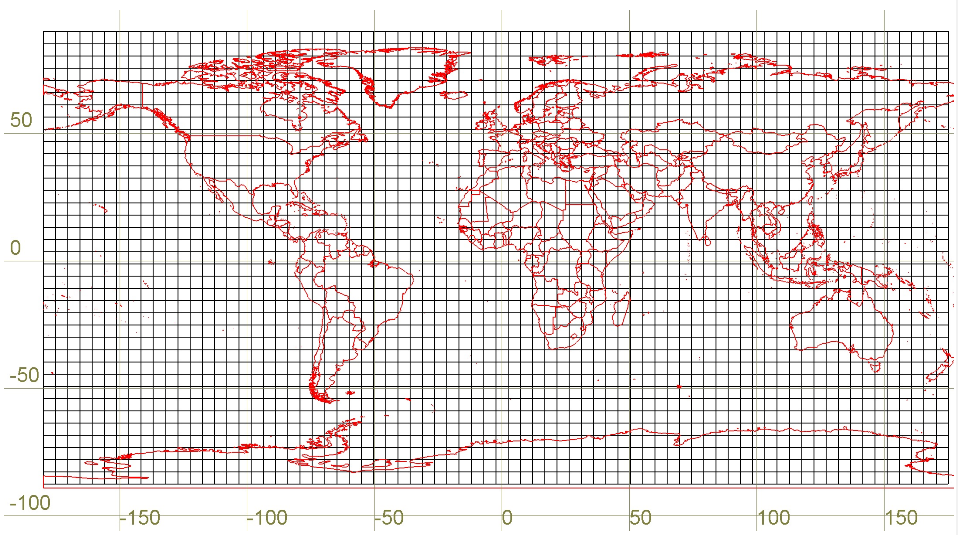


Figure 3 - GDPS on a 25 km full-resolution Lat-Lon grid (grid step = 20)

Grid specifications Table lists the values of various parameters of the high-resolution lat-lon grid.	
Parameter	Value
Ni (cols)	1500
Nj (rows)	751
resolution	0.24°
coordinate of first grid point	90° S 180° W

5.1 File name nomenclature Glb model

5.1.1 Download

"The data can be accessed at the following URLs:
http://dd.weather.gc.ca/model_gem_global/25km/grib2/lat_lon/HH/hhh/

"where:
HH: model run start, in UTC [00, 12]
hhh: forecast hour [000, 003, 006, ..., 240]

5.1.2 File name nomenclature

"The files have the following nomenclature:
CMC_glb_Variable_LevelType_Level_projection_YYYYMMDDHH_Phhh.grib2

where:
CMC: constant string indicating that the data is from the Canadian Meteorological Centre
glb: constant string indicating that the data is from the GDPS
Variable: Variable type included in this file. To consult a complete list, refer to the Data in GRIB2 format section.
LevelType: Level type. To consult a complete list, refer to the Data in GRIB2 format section.
Level: Level value. To consult a complete list, refer to the Data in GRIB2 format section.
Projection: projection used for the data. Can take the values [latlon, ps]
YYYYMMDD: Year, month and day of the beginning of the forecast.
HH: UTC run time [00, 12]
Phhh: *P* is a constant character. *hhh* is the forecast hour [000, 003, 006, ..., 240]
grib2: constant string indicating the GRIB2 format is used

"Example of file name:
CMC_glb_TMP_ISBL_925_latlon.24x.24_2010090800_P042.grib2
"This file originates from the Canadian Meteorological Center (CMC) and contains the data of the GDPS. The data in the file start on September 8th 2010 at 00Z (2010090800). It contains the temperature component (TMP) at the isobaric level 925 mb (ISBL_0925) for the forecast hour 42 (P042) in GRIB2 format (.grib2).

5.2 Creating a list of node long-lat attributes

Creating a WF compatible input file is a 2-step process:

1. First, the GRIB2 file is converted to an r2s file in Gk and then this r2s file is saved as a multiframe r2c file.

2. A program **Glb_conv.exe** will read the entire r2c **apcp** or **tmp** file for the Global domain and create r2c files for just the watershed based on the WATFLOOD domain in the **shd.r2c** file.

These steps will be described in detail in Sections 9.2.1 and 9.2.2

As for the Regl. Model, before the GRIB2 files can be used for the forecast, the data on grid points falling on the watershed domain need to be extracted and written to an r2c. In this case, the Gbl grid is already in lat – long coordinates as given in the Grid Specification table above but we still need a table for use in the model or to convert the points to UTM coordinates or other conformal systems if the watershed is not in lat-long coordinates.

The global grid has 1500 columns and 751 rows i.e. 1126500 grids which are numbered starting at the top left and ending as the bottom right. They are numbered from left to right, row by row. If the watershed is in lat-long, no conversion of the coordinates need to be made.

With each use of the global forecast, the program **glb_conv.exe** will calculate the lat-long coordinates for each Gbl model grid point and create the **glb_nodes.xyz** file in the GRIB2 directory with the long & lat for all nodes in the CMC Glb model domain.

Example of a xyz file for a UTM zone 17 based model - glb_UTM17.xyz

```
#########################################################################
:FileType xyz  ASCII  EnSim 1.0
# National Research Council Canada (c) 1998-2014
# DataType                 XYZ Point Set
#
:Application              GreenKenue
:Version                  3.4.27
:WrittenBy                Nick
:CreationDate             Sun, Oct 15, 2017 05:41 PM
#
#------------------------------------------------------------------------
:Mean   563250.500000
```

```
:StdDev   325192.539122
#
#
:Projection LatLong
:Ellipsoid GRS80
#
:EndHeader
        -179.88              90              1
        -179.64              90              2
         -179.4              90              3
        -179.16              90              4
        -178.92              90              5
        -178.68              90              6
```

5.2.1 Creating a list of node attributes for UTM, PS or LC

If needed for a UTM or other coordinate based watershed model, this file can then be loaded into GK and the coordinates converted into the proper watershed coordinate system (e.g. UTM) by manipulating the spatial characteristics feature in GK for subsequent use. The file is just a by-product of the Glb_conv.exe program if the watershed is modelled in long-lat and is not needed. But if present, in must have a GK header.

Example of a xyz file for a UTM zone 17 based model - glb_UTM17.xyz

```
#########################################################################
:FileType xyz  ASCII  EnSim 1.0
# National Research Council Canada (c) 1998-2014
# DataType                 XYZ Point Set
#
:Application              GreenKenue
:Version                  3.4.27
:WrittenBy                kouwen
:CreationDate             Tue, Mar 03, 2015 01:22 PM
#
#------------------------------------------------------------------------
:Mean   290665.500000
:StdDev   3436.932196
#
#
:Projection UTM
:Zone 17
:Ellipsoid WGS84
#
:EndHeader
499999.202038976 4902972.58936375          285413
519151.066072864 4903000.59279157          285414
538302.141180614 4903084.60410273          285415
.
.
559064.568792635 4716648.23542178          295916
578753.169825714 4716843.62771628          295917
598442.709396082 4717094.87201075          295918
```

```
Easting          Northing                   Grid #
```

Figure 4 shows the numbered CMC Glb model nodes on the Nottawasaga River watershed in S. Ontario. Note the spacing of the nodes is greater that for the Regl. Model shown in Fig. 2.

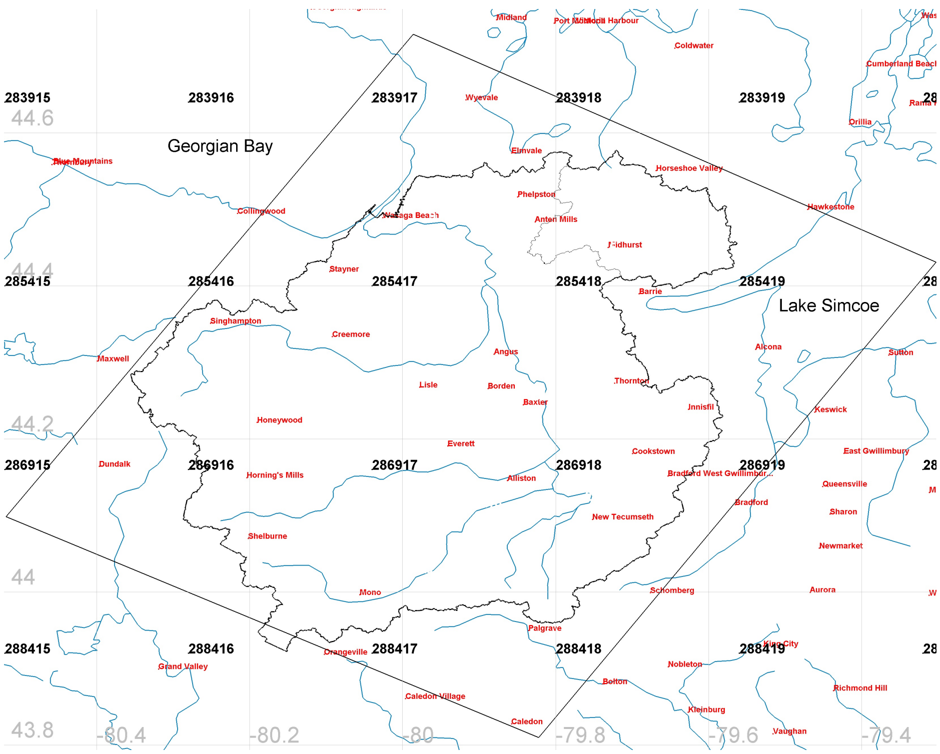


Figure 4 – CMC Global model nodes on the Nottawasaga River Watershed

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6. High Resolution Deterministic Prediction System – HRDPS

High Resolution Deterministic Prediction System - HRDPS

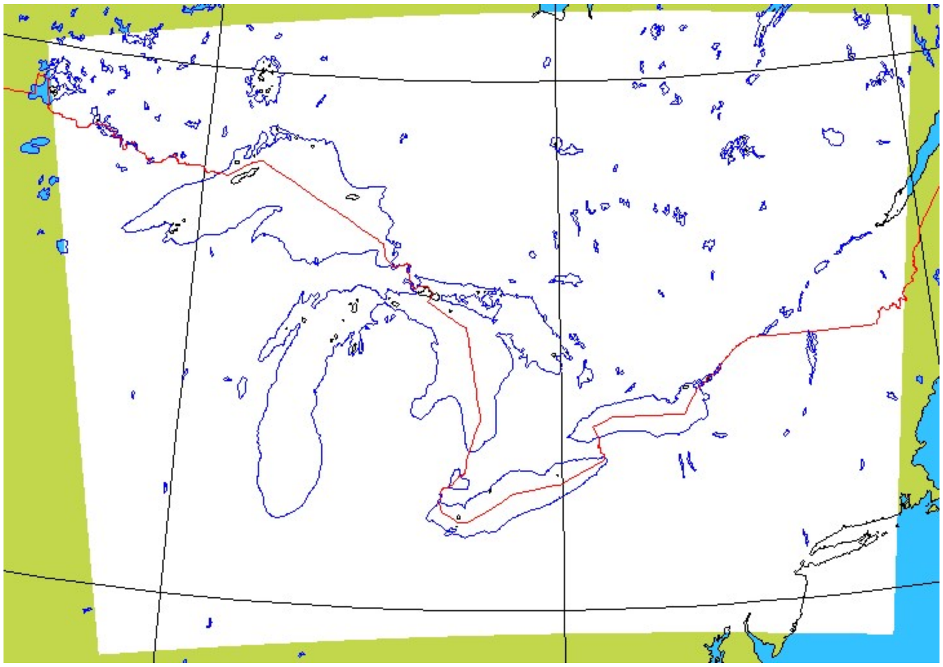
As quoted from the CMC website:

6.1 HRDPS data in GRIB2 format

The High Resolution Deterministic Prediction System or HRDPS is a set of nested limited-area model (LAM) forecast grids from the non hydrostatic version of the Global Environmental Multiscale (GEM) model with a 2.5 km horizontal grid spacing for the inner domain over one main Pan-Canadian region and a northern region over the Arctic archipelago and Greenland. The pilot model of the HRDPS is the Regional Deterministic Prediction System or RDPS (GEM Regional model). The HRDPS is operational except the northern domain which remains experimental. The fields in the HRDPS high resolution GRIB2 dataset are made available four times a day for the Pan-Canadian domain for a 48 hour forecast period (except the northern domain).

Users who will benefit most from using these new data are those for whom a detailed forecast of surface temperatures and winds is important. Especially during the change of seasons and in wintertime when rapid changes in temperature and winds cause phase transitions of precipitation (freezing rain to snow to rain for example), 2.5 km forecasts could add much value. Also in the case of short-term forecasts in the presence of complex terrain or along shores, the influence of changes in altitude, topography and nature of the terrain will be better described for phenomena at this scale (lake or sea breezes, local valley flows, phase changes, etc.). Even over less rugged terrain, or over water away from shore, these more precise forecasts could be useful, repeatedly over a long period. As well, for hydrological forecasts on smaller basins, the HRDPS should be considered.

The HRDPS not yet being equipped with its own data assimilation system, so its quality depends largely on the RDPS, which provides initial and boundary conditions, and on the global data assimilation system acting upstream. So if the forecast of the RDPS is questionable over the region of interest, it is likely that the higher resolution forecast will magnify the problems of the regional forecast. However, initial cloud and surface data are now provided by a coupled HRDPS-Caldas (Canadian Land Data Assimilation System) cycle, improving clouds, precipitation and surface fields. For forecast lead times of more than 24 hours the use of the regional or global forecasts might be required.



HRDPS East Domain

Grid specifications
Table lists the values of various parameters of the LAMEAST polar-stereographic grid

Parameter	Value
ni	765
nj	570
resolution at 60° N	2.5 km
coordinate of first grid point	38.6985° N 91.3395° W
(i,j) coordinate of North Pole	(450.0, 2240.0)
grid orientation (with respect to j axis)	-80.0°

There is also a formatted gzipped ASCII file containing geographical coordinates for each grid point:. https://weather.gc.ca/grib/HRDPS_HR/lameastpoints.gz

In WATFLOOD in the Grib2 dir HRDPS.xyz

7. Downloading & Processing Data Files

Aside from having an accurate forecast of precipitation and temperature, the most important aspect of flow forecasting is an accurate representation of the watershed condition at the time of the forecast. This entails a proper accounting of the soil moisture, the swe and the condition of the snow pack if present, the state of all rivers, lakes and reservoirs, the state of the ground water reservoir and wetlands. To accomplish this, the hydrological model usually requires a “spinup”. The length of the spinup depends on the time of year of the forecast, the size of the watershed and time constant for the storage in the watershed. Much depends on how well the watershed state can be observed, as with the Great Lakes for instance, where the water levels are known. For the GW reservoir, it is much more difficult to observe its state and spinup modelling provides a better indicator of its state at the time of the forecast. Generally, at least a year is required. Ideally the model is started on Oct. 1 when generally, storages are at a minimum and streamflow tends to be a good indicator of the lower zone storage.

For hindcasting, historical streamflow, precipitation and temperature records are required with an emphasis on the recent past. However, for the recent past, and especially for most of Canada, quality checked data is generally not available and we need to rely on provisional data as is the case for streamflow, reanalysis data for precipitation and past day-ahead forecasts of temperature as a substitute for actual temperatures. The advantage of using reanalysis data for precipitation and past forecasts of temperatures is that this information is gridded and hopefully circumvents the usual problems with distributing sparsely spaced meteorological observations, especially in remote areas. This WATFLOOD forecasting system is based on this approach. No meteorological gauge data is required but can be used if available as well as being of a high enough resolution.

7.1 Executables for downloading & processing Env. Can. data

run_daily.exe	create 4 .bat files to run wget
get_glb.bat	download the CMC global forecast
get_regl.bat	download the CMC regional forecast
get_geps1.bat	download the CMC day 1-16 20 member ens forecast
get_geps2.bat	download the CMC day 17-32 20 member ens forecast
get_capa.bat	downloads capa data (done before end of previous day)
make_r2c.exe	convert the grib2 formats to r2c
get_flow.bat	download wsc daily data (“flow” used generically here)

IMPORTANT: These command files are run automatically (task manager) with **grib2** as the working directory

Optional: **fc.bat** can be automatically run in the watershed working directory – see Section 13.1

Using these *.bat files and the Task Scheduler, the whole forecast is done automatically.

7.2 Step 1: RUN_DAILY.exe

The first step it to download CMC and WSC data on a daily basis. To facilitate automatic downloading of recorded streamflow, reanalysis precipitation data and both the CMC Regional and Global numerical weather forecasts in GRIB2 formats, a program called **RUN-DAILY.exe** has been written to generate the batch (.bat) files that will be used by a public domain program **WGET.exe** to download all the required files from Env. Canada.

RUN_DAILY.exe will read the clock on the PC and creates Windows (DOS) batch files (.bat) to allow wget.exe to download all the data files for the hindcast & forecast. Example .bat files will follow with each data type. The program RUN_DAILY.exe should execute at 1:00 every day and writes 5 bat files:

get_regl.bat	runs at 1:15 am every day	CMC 10km resolution 48 hr forecast
get_glb.bat	runs at 1:30 am every day	CMC 25km resolution extended forecast
get_geps1.bat	runs at 2:00 am every day	CMC 25km resolution extended forecast
get_geps2.bat	runs at 3:00 am every day	CMC 25km resolution extended forecast
get_capa.bat	runs at 10:00 **pm** every day	CMC re-analysis precipitation CaPA
make_r2c	runs at 3:30 am – converts separate groups of Grib2 files into r2c files	
make_geps1_r2c	4:00 am every day	CMC 20 member ensemble -> r3c files
make_geps2_r2c	5:00 am Thursdays	CMC 20 member ensemble -> r3c files
get_flow.bat	runs at 5:00** am every day	CWS provisional streamflow

** get_flow.bat is a generic file that can be configured any where in Canada. For some WATFLOOD users there are specially configured bat files.

Note: wget can be
- downloaded from http://gnuwin32.sourceforge.net/packages/wget.htm

By adding **RUN_DAILY.exe**, **get_glb.bat**, **get_regl.bat, get_geps1.bat, get_geps2.bat , get_capa.bat, get_flow.bat &** to **make_r2c.bat** the Task Scheduler (Fig. 5) in Window's Computer Management they will be executed automatically and be ready for use first thing in the morning. Figure 5 shows the entries in the Task Scheduler Library:

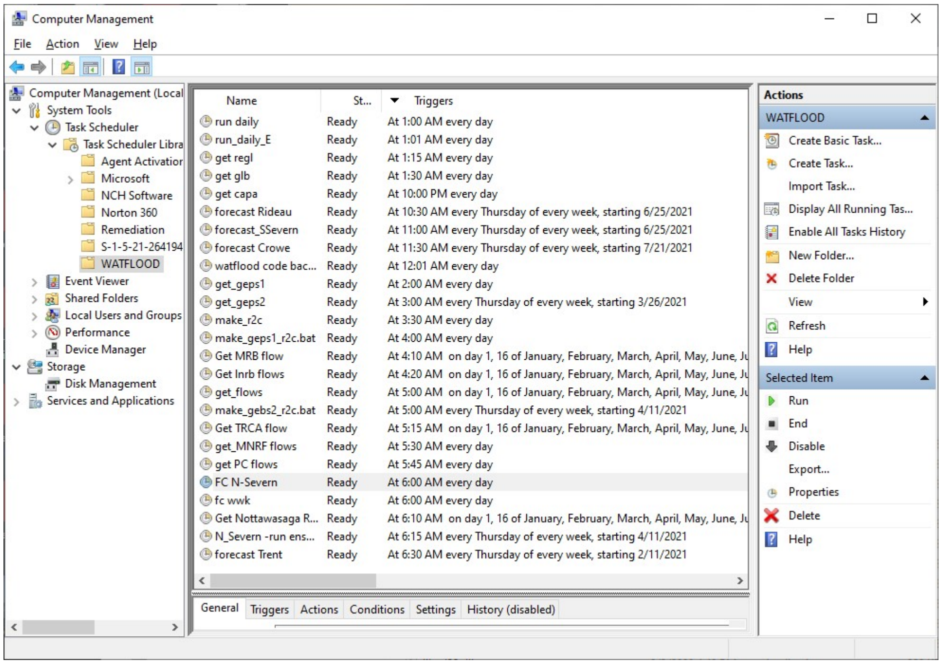


Figure 5 – Windows task scheduler showing the WATFLOOD tasks

8. Hindcasting (spinup)

For hindcasting, 3 sets of data are needed: precipitation, temperature and flow. For precipitation, gauge or model data are available. The use of gauge data is described in the WATFLOOD user's manual and is not considered in this manual. For a spinup to forecasting, CMC CaPA data are most appropriate as it is a combination of gauge, radar and model data, each used where most advantageous. For temperature, CMC Regional model data for previous day-ahead forecasts are adequate. Forecast temperatures are generally quite accurate – often good enough for hydrological use but the user should spot check that these day-ahead forecast temperatures are appropriate. If temperatures are generally too high or too low, an adjustment factor can be set in the event file. For flow data, WSC provisional flow can be downloaded on a daily basis and with some inspection of the results, wildly erroneous data (often due to ice) can usually be spotted and ignored.

8.1 Data Processing programs - overview

Regl_conv.exe will convert CaPA and regl tmp's to GK format r2c and wsc_rt.exe will tabulate WSC provisional flow data into tb0 files for WATFLOOD/CHARM. These programs can be run manually but optional bat files **Sect. 13.1** will speed things up and prevent errors.

```
Executable  Argument
regl_conv   yyyy_capa.cfg
regl_conv   yyyy_regl_tmp.cfg
wsc_rt      yyyy_wsc.cfg
```

regl_conv.exe	• This program is executed in the watershed directory • Arguments: **yyyy_capa.cfg** OR **yyyy_regl_tmp.cfg** • Extracts precip. and temp. data from the CMC Regional domain for the watershed domain – i.e the same domain as the .shd file in WF. • Reads CaPA and Regl_TMP r2c files & writes r2c files for CHARM
wsc_rt.exe	• This program is run in the watershed directory • Argument: **yyyy_wsc.cfg** • Reads the downloaded WSC provisional hourly flows & writes str.tb0 files for CHARM • The downloaded WSC provisional flow files contain one month of data so to do a whole year or a portion longer than one month, wsc_rt.exe will read up to 12 files but create only one. • For hind casting, the file will generally start on Jan. 1 and lengthen 1 day at a time if a forecast is made every day.

Example cfg files will be shown with the detailed instructions.

Commented [NK1]: This should come later

8.2 Historic precipitation

8.2.1 Regional Deterministic Precipitation Analysis (RDPA - CaPA)

The Regional Deterministic Precipitation Analysis (RDPA) based on the Canadian Precipitation Analysis (CaPA) system is on a domain that corresponds to that of the CMC operational regional model, i.e. the Regional Deterministic Prediction System (RDPS-LAM3D) (Section 4) except for areas over the Pacific ocean where the western limit of the RDPA domain is slightly shifted eastward with respect to the regional model domain. The resolution of the RDPA analysis is identical to the resolution of the operational regional system RDPS LAM3D. The fields in the RDPA GRIB2 dataset are on a polar-stereographic (PS) grid covering North America and adjacent waters with a 10 km resolution at 60 degrees north.

As quoted from:
http://collaboration.cmc.ec.gc.ca/cmc/cmoi/product_guide/docs/lib/capa_information_leaflet_20141118_en.pdf

“The aim of the CaPA system is to combine in near real time **different** sources of precipitation information along with a short term forecast provided by the Regional Deterministic Prediction System (RDPS) in order to produce a gridded analysis that covers all of North America. The statistical interpolation technique behind the system allows for a continuous coverage of the domain at a resolution of 10 km. The analysis is generated 4 times a day for 6 hour precipitation amounts and once a day for 24 hour amounts and it is available all year round.”

“The latest version (3.0) of the CaPA system not only ingests precipitation amounts from gauges but also Quantitative Precipitation Estimates (QPE) from the Canadian Weather Radar Network.”

In other words, at any point in North America, it blends together all the best sources of data for hindcast precipitation: gauge and radar data where available with the Regional Prediction System 1-day ahead forecast in areas not covered by gauges or radar.

8.2.2 CaPA Download

“The data is available using the HTTP protocol and resides in a directory that is plainly accessible to a web browser. Visiting that directory with an interactive browser will yield a raw listing of links, each link being a downloadable GRIB2 file. In practice, we recommend writing your own script to automate the downloading of the desired data (using wget or equivalent). If you are unsure of how to proceed, you might like to take a look at our brief wget usage guide.”

The data can be accessed at the following URLs:
http://dd.weatheroffice.gc.ca/analysis/precip/rdpa/grib2/polar_stereographic/hh

where: **hh**:time interval of 06 or 24 hours in which precipitation accumulations are analyzed

8.2.3 File name nomenclature for 6 hour CaPA increments

The file names have the following nomenclature:
CMC_RDPA_APCP-006-0100cutoff_SFC_0_ps10km_AAAAMMJJHH_000.grib2
or
CMC_RDPA_APCP-006-0700cutoff_SFC_0_ps10km_AAAAMMJJHH_000.grib2
CMC_RDPA_APCP-024-0100cutoff_SFC_0_ps10km_YYYYMMDDHH_000.grib2
or
CMC_RDPA_APCP-024-0700cutoff_SFC_0_ps10km_YYYYMMDDHH_000.grib2
where:

CMC: constant string indicating the data is from the Canadian Meteorological Centre

RDPA: constant string indicating the data is from the regional deterministic precipitation analysis (RDPA)

APCP: constant string indicating the variable included in this file is in this case the accumulated precipitation which has been analyzed.

006: Precipitation accumulation interval is 006 hours

024: Precipitation accumulation interval is 024 hours

0100cutoff: Observation cut-off time is one hour after the time YYYYMMDDHH indicating that possibly not all observations have been collected

0700cutoff: Observation cut-off time is about 007 hours after the time YYYYMMDDHH indicating that a maximum of observations has likely been collected

SFC: constant string indicating the type of level is at the surface.

0: elevation of the above level type where here 0 indicates the surface. For RDPA grib2 data this is the only level available.

ps10km: constant string indicating the projection used is polar-stereographic at 10km resolution.

YYYYMMDD: Year, month and day of the beginning time of the analysis.

HH: UTC run time [00,06, 12, 18]

000: represents the number of hours after the YYYYMMDDHH time at which the analysis is valid.

grib2: constant string indicating the GRIB2 format is used

8.2.4 Example of file name:

CMC_RDPA_APCP-006-0100cutoff_SFC_0_ps10km_2015011212_000.grib2

It contains the preliminary analysis of the accumulated precipitation represented here by APCP over a 6 (006) hour time interval starting at 2015011206 and ending at 2015011212. It is considered preliminary because the analysis has been produced using observations collected in a short 0100 hour period i.e. before all observations have been collected.

The data is on the same polar-stereographic grid as the CMC Regional model at 10km resolution (ps10km). The file name contains the valid time of the analysis which in this case is

2015011212_000. The data encoded in GRIB2 format (.grib2). More on the grid layout in the next section dealing with the Regional Forecast.

To download the data with **wget** for instance – 4 files at 6 hour intervals for May 12, 2015 use the bat file **get_capa.bat** which is generated by **RUN_DAILY.exe** (See Sect. 7.2) The Windows batch file **get_capa.bat** The **get_capa.bat** file can be run automatically by the Task Manager at a given time each day automatically.

Example of a get_capa.bat file:

```
wget
http://dd.weatheroffice.gc.ca/analysis/precip/rdpa/grib2/polar_stereographic/
06/CMC_RDPA_APCP-006_SFC_0_ps10km_2015051200_000.grib2
wget
http://dd.weatheroffice.gc.ca/analysis/precip/rdpa/grib2/polar_stereographic/
06/CMC_RDPA_APCP-006_SFC_0_ps10km_2015051206_000.grib2
wget
http://dd.weatheroffice.gc.ca/analysis/precip/rdpa/grib2/polar_stereographic/
06/CMC_RDPA_APCP-006_SFC_0_ps10km_2015051212_000.grib2
wget
http://dd.weatheroffice.gc.ca/analysis/precip/rdpa/grib2/polar_stereographic/
06/CMC_RDPA_APCP-006_SFC_0_ps10km_2015051218_000.grib2
move CMC_RDPA*.grib2  q:\grib2\cmc_capa
rem
mkdir                 e:\grib2\CMC_CaPA\201505
copy CMC_RDPA*.grib2  e:\grib2\CMC_CaPA\201505
mkdir                 g:\grib2\CMC_CaPA\201505
move CMC_RDPA*.grib2  g:\grib2\CMC_CaPA\201505
```

These files originate at the Canadian Meteorological Center (CMC) and contain data of the regional deterministic precipitation analysis (RDPA). The name of the file is highlighted.

Note also that the batch file **get_capa.bat** with the WGET command results in the downloaded files being added to the working directory of WGET. When the download is completed, the files are moved to another location eg.: `e:\grib2\CMC_CaPA\201505` to keep the various types of data segregated. In this case, the files are moved to a directory that will have all the files for the month of May, 2015. Every month a new directory is automatically created and the files moved there for further processing.

8.2.5 STEP 2: CaPA grib2 → WF yyyymmdd_CaPA.r2c

Once a day, download the CaPA re-analysis data set as above. Done automatically with a task in the Windows Task Manager.

Assemble sets of Grib2 files into r2c format files

Automatically with **make_r2c.exe** - **See Section 12.1**

Manually through using Green Kenue (= old way)

In GK **Import** the CaPA WMO GRIB/From Multiple GRIB Files for up to one calendar month at a time and save as **GRIB2\CMC_CaPA\yyyymmdd_CaPA.r2s** Note: dd = first day of the month

Please note: The imported GRIB2 data can only assigned an extension name = r2s in GK. The file is then converted (3. below) to an r2c ASCII (text) file for the purpose of extracting the portion of the CaPA file that is needed for the watershed.

For instance, during the month with the forecast, create and r2s and r2c files for just the days from the 1st day of the month to today. For previous months, use a full month for all files. As time goes on, the length of the event for the spinup increases by one day each day – i.e. the current month file must be re-done (= replaced) each day.

This can take 1-5 min. for a whole month (depending on your PC's performance specs and the spinup length)

Then save (in GK - **Save Copy As**) the files as a **multiframe ASCII** file **WATFLOOD\CMC\CaPA\yyyymm01_CaPA.r2c** Note: named as the first day of the month.

Run **regl_conv.exe** with **WATFLOOD\bsnm** as the working directory. This program requires an argument with the name of the **cfg** file – eg. **regl_conv yyyy_capa.cfg** This step will read montly CaPA r2c files for the whole Regl. domain and produce one file for Jan. 1 to yesterday for the WF = watershed domain.

To view the data in GK, you can overlay with the global map (File → base maps → 1:20,000,000 → world) and the watflood domain (watflood\basin\bsnm_shd.r2c\) and assign the Polar Steriographic (PS) coordinates (60,249) to the world map & WF bsnm; and make the grid step 1 (instead of 2)

8.2.6 REGL_CONV.exe - input/output files

- input files:
  yyyy_capa.cfg (has the files names -as below)
  basin\bsnm_shd.r2c
  WATFLOOD\CMC\rdps.xyz - has the lat-long coordinates and node number for each data point in the CMC Regional Model files (CaPA, APCP & TMP). (or e.g., rdps_UTM17.xyz for a UTM application)
  The CaPA grib2 file(s) converted to a GK ascii multiframe
  WATFLOOD\cmc\capa\yyyy0101_capa.r2c
  WATFLOOD\cmc\capa\yyyy0201_capa.r2c
  WATFLOOD\cmc\capa\yyyy0301_capa.r2c
  WATFLOOD\cmc\capa\yyyy0401_capa.r2c
  WATFLOOD\etc.
- output file:
  model\yyyy0101_CaPA.r2c – gridded time series CaPA for **diff64.exe**
  Note: **REGL_CONV.exe** is executed in the **WATFLOOD\bsnm** directory so the output file name needs only the sub-directory path defined to get the tb0 file in the **model** directory.

Note:
REGL_CONV.exe needs the argument yyyy_CaPA.cfg
Eg. the DOS command is: **Regl_conv 2016_CaPA.cfg**

8.2.7 Example yyyy_capa.cfg file for Notttawasaga domain

This example is for the first 2 months of 2017. The CaPA files are in monthly chunks and assembled into one r2c file for **CHARM.** Up to 12 files in one calendar year can be assembled in this way. **CHARM** events can also be in monthly increments in which case there would only be one file name for the regional or CaPA input file. The name of this file is entered as the argument for the **REGL_CONV.exe** program eg. **REGL_CONV 2019_capa.cfg**

```
# Config file for converting Regl model and CaPA reanalysis r2c files
# to the WATFLOOD watershed grid
#
# Enter the full path names for all files
# watershed file *_shd.r2c
basin\notta_shd.r2c
#
# name of the rdps file with the regl model grid locations
..\cmc\rdps.xyz
#
# Number of Regl or CaPA files to process
5
# file names for the regional files
..\cmc\capa\20190101_capa.r2c
..\cmc\capa\20190201_capa.r2c
..\cmc\capa\20190301_capa.r2c
..\cmc\capa\20190401_capa.r2c
..\cmc\capa\20190501_capa.r2c**
#
# Name of the output file
# The start date of this file must be the same
# as the first CaPA file name (above)
model\20190101_capa.r2c
# Number of gap filling passes:
# (from an inspection of the output file)
11
```

Notes:

The last line – 11 in this case – is the number of iterations required to fill all grids in the watershed model with CaPA data. The regional data is on a 10 km grid while the watershed is on a ~1 km grid. It takes 11 passes to add data to those watershed grids that do not coincide with a CaPA grid point.

All paths are relative as long as the GRIB2 & waflood are in the same directory

** on the second day of each month, another month is added. On the first day, the CaPA is for the last day of the previous month.

Regl_conv.exe is executed in the working directory for the watershed: ***\watflood\bsnm**

IMPORTANT: The CaPA file is for the precipitation for the preceding 6 hours. The first CaPA file in the new year for 00:00Z must be moved to be the last file of the previous year in the CMC_CaPA directory.

8.3 Historic temperatures

CMC regional forecast temperatures can be used as a substitute for recorded temperatures. The CaPA, CMC_regl_apcp and CMC_regl_tmp data are all on the same domain and grid so the same program can be used to extract the data for a watershed. Each data type on each watershed needs its own cfg file.

Alternatively, historic temperatures may be downloaded from Environment and Climate change Canada ECCC. Please see Chapter 2 in the WATFLOOD Supplementary Utilities Manual http://www.civil.uwaterloo.ca/watflood/downloads/Utilities_Manual.pdf

The forecast temperatures are archived separately so they can be used as a continuous temperature record. For this purpose, **CMC_reg_TMP_TGL_2_ps10km** files are downloaded and archived as
GRIB2\cmc_regl_temp\yyyymm \CMC_reg_TMP_2_ps10km_yyyymmdd00Pnnn.grib2
to form a historical record where nnn = 003, 006, 009, 012, 015, 018, 021, 024 I.e. only the first 24 hours of data is saved out of each 48 hour CMC Regional forecast.

After downloading, the **CMC_reg_TMP_TGL_2_ps10km** files are archived in 2 directories: one for forecasting and the other for hindcasting.

All 48 forecast files are saved as **GRIB2\CMC_regl\CMC_regl_yyyymmdd*.*** **-** i.e one directory for each day. (This directory will also have the apcp files.)

Only the first 24 hours of the regl. Apcp forecasts are copied to the **CMC_regl_tmp\yyyymm** directory.

The reason for having duplicates is so the proper sets of data can be easily combined in to the spinup and forecast periods.

As with the CaPA record, the files for hindcasting are saved in a monthly chunks in the **GRIB2\cmc_regl_tmp\yyyymm** directory. From this point on, the processing of the temperature files is the same as the CaPA process:

8.3.1 STEP 3: CMC Regl. TMP grib2 → WF yyyymmdd_tmp.r2c

Once a day, download the CMC_regl apcp and tmp data – automatically by the Windows Task Manager (note: precip & tmp files are downloaded together with one wget bat file)

1. In GK import the **CMC_reg_TMP GRIB2** files from Multiple GRIB Files for up to one calendar month at a time and save as ***\GRIB2\cmc_regl_temp\yyyymm\yyyymmdd_tmp.r2s**** Note: dd = first day of the month. Please note 2a in Sect. 8.2.5

2 Then save (Save Copy As) this same file as a multiframe ASCII file **WATFLOOD\CMC\regl_tmp\yyyymm01.r2c** Note: dd = first day of the month!!! Note also, earlier files for the month are replaced each day.

Run **regl_conv.exe** with **WATFLOOD\bsnm** as the working directory. This program requires an argument with the name of the **cfg** file – eg. **regl_conv 2019_regl_tmp.cfg**

To view the data in GK, you can overlay with the global map (File → base maps → 1:20,000,000 → world) and the watflood domain (watflood\basin\bsnm_shd.r2c\) and assign the Polar Steriographic (PS) coordinates (60,249) to the world map & WF bsnm; and make the grid step 1 (instead of 2)

For instance, during the month of the forecast, create and r2s and r2c files for just the days from the 1st day of the month until today. For previous month, use a full month for all files. As time goes on, the length of the event for the current month for the spinup increases by one day each day – i.e. the file has to be re-done (= replaced) each day.

This can take 2 – 10 min. for a whole month (depending on your PC's performance specs)

Please note (again): The imported of grib2 data can only assigned an extension name = r2s in GK. This is a binary file which NK has not been able to code for processing. As a temporary step, the file is converted to an r2c ASCII file which can read for the purpose of extracting the portion of the regional (or global) file that is needed for the watershed.

8.3.2 REGL_CONV.exe - input/output files

- input files:

.1 **yyyy_regl_tmp.cfg (has the files names -as below)**
.2 **basin\bsnm_shd.r2c**
.3 **WATFLOOD\CMC\rdps.xyz** - has the coordinates and node number for each data point in the CMC Regional Model files (CaPA, APCP & TMP) (or e.g., rdps_UTM17.xyz for a UTM application).
.4 **WATFLOOD\CMC\cmc_regl_tmp\yyyymmdd_tmp.r2c** – the CMC Regional model grib2 file converted to a GK ascii multiframe
.4.1 **WATFLOOD\CMC\cmc_regl_tmp\yyyy0101_tmp.r2c**
.4.2 **WATFLOOD\CMC\cmc_regl_tmp\yyyy0201_tmp.r2c**
.4.3 **WATFLOOD\CMC\cmc_regl_tmp\yyyy0301_tmp.r2c**
.4.4 **WATFLOOD\etc**

- output file:

.1 **tempr\20160101_tmp.r2c – gridded** time series temperature r2c file for **CHARM.exe**
.2 Note: REGL_CONV.exe is executed in the WATFLOOD\gr2k_f directory so the output file name name needs only the sub-directory path defined to get the tb0 file in the **tempr** directory.

Note:
REGL_CONV.exe needs the argument yyyy_regl_tmp.cfg
Eg. the DOS command is: **Regl_conv 2019_regl_tmp.cfg**

Once all temperature files have been created as well as the event files (yyyymmdd.evt etc.) the temperature difference r2c needs to be created for the Hargreaves & Samani ET formulation by **DIFF64.exe**

8.3.3 Example yyyy_regl_tmp.cfg file (for hindcasting)

This example is for the first 2 months of 2017. The CaPA files are in monthly chunks and assempled into one r2c file for **CHARM.** Up to 12 files in one calendar year can be assembled in this way. **CHARM** events can also be in monthly increments in which case there would only be one file name for the regional or CaPA input file. The name of this file is entered as the argument for the **REGL_CONV.exe** program eg. **REGL_CONV 2017_regl_tmp_.cfg**

```
# Config file for converting Regl model and CaPA reanalysis r2c files
# to the WATFLOOD watershed grid
#
# Enter the full path names for all files
# watershed file *_shd.r2c
basin\notta_shd.r2c
#
# name of the rdps file with the regl model grid locations
..\cmc\rdps.xyz
#
# Number of Regl or CaPA files to process
5
# file names for the regional files
..\cmc\regl_tmp\20190101_tmp.r2c
..\cmc\regl_tmp\20190201_tmp.r2c
..\cmc\regl_tmp\20190301_tmp.r2c
..\cmc\regl_tmp\20190401_tmp.r2c
..\cmc\regl_tmp\201905401_tmp.r2c
#
# Name of the output file
# The start date of this file must be the same
# as the first CaPA file name (above)
tempr\20190101_regl_tmp.r2c
# Number of gap filling passes:
# (from an inspection of the output file)
12
```

Notes:

The last line – 12 in this case – is the number of iterations required to fill all grids in the watershed model with Regl. data. The regional data is on a 10 km grid while the watershed is on a ~1 km grid. It takes 12 passes to add data to those watershed grids that do not coincide with a Regl. grid point.

All paths are relative as long as the GRIB2 & waflood are in the same directory

** on the second day of each month, another month is added. **Regl_conv.exe** is executed in the working directory for the watershed: ***\watflood\bsnm**

9. Forecasting with Numerical Weather Data

Processing programs

These executables are run manually but could be set up with optional bat files see Sect. 13.1:

regl_conv.exe reads CaPA and Regl Forecast r2c file & writes r2c files for WF/CHARM
glb_conv.exe reads CMC Glb forecast r2c file & writes r2c files for WF/CHARM

9.1 STEP 4: Regional Forecast:

9.1.1 Creating regl_apcp.r2c files for WATFLOOD

1. Download (daily) CMC_regional model forecast for precip (Automatic Ch. □)
2. **PRECIP: Import** the 48 hour precip (APCP) forecast (16 files P003-P049) into GK and save as **GRIB2\CMC \CMC_regl_yyyymmdd\ regl_apcp.r2s** Please see notes in Sect. 8.2.5
3. Save the file as a *multiframe (!!!!!)* ASCII **watflood\CMC\regl_apcp\regl_apcp.r2c**
4. In the working directory **bsnm** run **regl_conv regl_apcp.cfg**

9.1.2 Example regl_apcp.cfg file (for forecasting precip)

```
# Config file for converting Regl model precip r2c files
# to the WATFLOOD watershed grid
#
# Enter the relative path names for all files
# watershed file *_shd.r2c
basin\notta_shd.r2c
#
# name of the rdps file with the regl model grid locations
..\cmc\rdps.xyz
#
# Number of Regl or CaPA files to process
1
# file names for the regional files  (CMC regional model domain)
..\cmc\regl\regl_apcp.r2c
#
# Name of the output file   (watershed domain only)
model\regl_apcp.r2c
# Number of gap filling passes:
# (from an inspection of the output file)
11
```

Notes:

The last line – 11 in this case – is the number of iterations required to fill all grids in the watershed model with Regl. data. The regional data is on a 10 km grid while the watershed is on a ~1 km grid. It takes 11 passes to add data to watershed grids that do not coincide with a Regl. grid point.

To find how many passes are needed, plot the Regl grid on the WF grid as in Fig. 2 and count how many blank WF grids are between the Regl grids on the diagonal, divide by 2 and add 1.

When done, open the **regl_apcp.r2c** file in GK and check that all WF grids have data.

9.1.3 REGL_CONV.exe – input/output files – tmp

1. Download (daily) CMC_regional model forecast for temperature (Automatic Ch. □)
2. **Temperature: Import** the 48 hour temperature (TMP) forecast (17 files P000-P048) into GK and save as **GRIB2\CMC_CMC_regl_yyyymmdd\ regl_tmp.r2s** Please see notes in Sect. 8.2.5
3. Save the files as a *multiframe (!!!!!)* ASCII **watflood\CMC\regl_tmp\regl_tmp.r2c**
4. In the working directory **bsnm** run **regl_conv** **regl_tmp.cfg**

9.1.4 Example regl_tmp.cfg file (for forecasting temperatures)

```
# Config file for converting Regl model temperature r2c files
# to the WATFLOOD watershed grid
#
# Enter the relative path names for all files
# watershed file *_shd.r2c
basin\notta_shd.r2c
#
# name of the rdps file with the regl model grid locations
..\cmc\rdps.xyz
#
# Number of Regl files to process
1
# file names for the regional files
..\cmc\regl\regl_tmp.r2c
#
# Name of the output file
tempr\regl_tmp.r2c
# Number of gap filling passes:
# (from an inspection of the output file)
12
#
0 0
0 0
```

Notes:

The line – 11 in this case – is the number of iterations required to fill all grids in the watershed model with Regl. data. The regional data is on a 10 km grid while the watershed is on a ~1 km grid. It takes 11 passes to add data to watershed grids that do not coincide with a Regl. grid point.

To find how many passes are needed, plot the Regl grid on the WF grid as in Fig. 2 and count how many blank WF grids are between the Regl grids on the diagonal, divide by 2 and add 1.

When done, open the **regl_tmp.r2c** file in GK and check that all WF grids have data.

Last 2 lines are optional node limits – not needed for lat-long coordinates

9.2 STEP 5: Global Forecast

The procedure is the same as for the regional forecast

9.2.1 Creating glb_apcp.r2c files for WATFLOOD

Note: Use only the last 8 days of the glb forecast – first 2 are the regl forecast!!

Download (daily) CMC_regional model forecast for precip. (Automatic Ch. □)

Import ***00:00h of day 2 (p048)*** and the remaining ***last 8 days*** of the glb forecast into GK and save as **GRIB2\CMC\glb_apcp\glb_apcp.r2s**

The precip is cumulative so the last hour of day 2 of the glb forecast is needed as an initial base value. **I.e. import only P048 – P240**

Then save the files as a *multiframe (!!!!!)* ASCII **watflood\CMC\regl_apcp\yyyymmdd_glb_apcp.r2c**

Run **glb_conv glb_apcp.cfg**

Example glb_apcp.cfg file (for forecasting)

```
# Config file for converting glb model r2c files
# to the WATFLOOD watershed grid
#
# Enter the full relative names for all files
# watershed file *_shd.r2c
basin\bsnm_shd.r2c
#
# name of the file with the glb model grid locations
..\CMC\glb.xyz
#
# Number of files to process
1
# file names for the glb model precip files
..\cmc\glb\glb_apcp.r2c
```

```
#
# Name of the output file
model\glb_apcp.r2c
# Number of gap filling passes:
# (from an inspection of the output file)
18
```

Notes:

The last line – 18 in this case – is the number of iterations required to fill all grids in the watershed model with Glb data. The global data is on a 25 km grid while the watershed is on a ~1 km grid. It takes 18 passes to add data to watershed grids that do not coincide with a Glb. grid point.

To find how many passes are needed, plot the Glb grid on the WF grid as in Fig. 2 and count how many blank WF grids are between the Glb grids on the diagonal, divide by 2 and add 1.

When done, open the **model\glb_apcp.r2c** file in GK and check that all WF grids have data.

9.2.2 Creating glb_tmp.r2c temperature files for WATFLOOD

Note: Use only the last 8 days of the glb forecast – first 2 are the regl forecast!!

1. Download (daily) CMC_regional model forecast for temperature (Automatic Ch. □)
2. Import the ***last 8 days*** of the glb forecast into GK and save as **GRIB2\CMC_glb_glb_tmp.r2s** I.e. import **P054 – P240**
3. Then save the files as a *multiframe (!!!!!)* ASCII (text) file **watflood\CMC\glb_tmp\glb_tmp.r2c**
4. Run glb_conv glb_tmp.cfg

Example glb_tmp.cfg file (for forecasting)

```
# Config file for converting Regl model and CaPA reanalysis r2c files
# to the WATFLOOD watershed grid
#
# Enter the relative path names for all files
# watershed file *_shd.r2c
basin\bsnm_shd.r2c
#
# name of the file with the glb model grid locations
..\CMC\glb.xyz
#
# Number of glb  files to process
1
# file names for the glb files
..\cmc\glb\glb_tmp.r2c
#
# Name of the output file
tempr\glb_tmp.r2c
# Number of gap filling passes:
# (from an inspection of the output file)
23
```

Please see notes in previous section

10. Downloading and Processing Hydrometric Data for the Spinup period

For flow forecasting, it is important to use all data available at the time the forecast is made. To this end, recorded river flow and possibly lake levels can be downloaded and used to update certain state variables in the hydrological model. Computed flows at upstream stations can be replaced by observed flows where available and used to "nudge" the flow at that location. In this way, the recorded flows are routed downstream instead of the computed flows and so will greatly improve the predictions at downstream locations. In this way, flows from ungauged areas will be blended with the observed in a proper manner, taking into account automatically the non-linearity of flow summing process.

The RUN_DAILY.exe file will create a bat file called **get_flow.bat** and by executing this bat file the flows for the past month are downloaded and saved to a directory with today's date:
`e:\grib2\wsc_daily\20150513`

RUN_daily.exe will look for a default file name called flow_stations.txt with a list of stations to be downloaded e.g.:

```
ON_02GA003
ON_02GA005
ON_02GA006
ON_02GA010
Etc.
```

Notes:
- The drive choice is made by the user.
- RUN_DAILY.exe is hard coded to produce bat files for downloading WSC provisional data for various rivers in Canada. Please contact kouwen@uwaterloo.ca to modify this for other locations if so desired. The program can be easily modified to accommodate other locations.
- Of course you can create your own bat file like the example below by substituting your own station list. It's just that the last 2 lines need to be modified with each use.

An example of the bat file generated by **RUN_DAILY.exe** follows:

```
wget  http://dd.weather.gc.ca/hydrometric/csv/ON/daily/ON_02GA003_daily_hydrometric.csv
wget  http://dd.weather.gc.ca/hydrometric/csv/ON/daily/ON_02GA005_daily_hydrometric.csv
wget  http://dd.weather.gc.ca/hydrometric/csv/ON/daily/ON_02GB006_daily_hydrometric.csv
wget  http://dd.weather.gc.ca/hydrometric/csv/ON/daily/ON_02GB010_daily_hydrometric.csv
mkdir q:\grib2\wsc_daily\20150513
move *hydrometric.csv  q:\grib2\wsc_daily\20150513
```

Once these files are downloaded, they need to be converted into WF & GK readable tb0 files. This is accomplished by yet another program called **wsc_rt.exe.** This program also reads the file **flow_station_list.xyz** with the flow station coordinates for the flow stations which end up in the header for the **yyyymmdd_str.tb0** file

Examples of **flow_station_list.xyz:**

For UTM:

```
555447   4800254   02GA003   GRAND_RIVER_AT_GALT   3520
544798   4840280   02GA005   IRVINE_RIVER_NEAR_SALEM   174
536088   4821002   02GA006   CONESTOGO_RIVER_AT_ST._JACOBS   790
544285   4782025   02GA010   NITH_RIVER_NEAR_CANNING   1030
```

Or:

For lat-long

```
     -79.821      44.250     02ED003  "NOTTAWASAGA RIVER NEAR BAXTER        "      1231.
     -79.762      44.119     02ED004  "BAILEY CREEK NEAR BEETON             "       207.
     -80.002      44.304     02ED005  "MAD RIVER NEAR GLENCAIRN             "       295.
     -79.644      44.425     02ED009  "WILLOW CREEK ABOVE LITTLE LAKE       "        95.
     -79.730      44.444     02ED010  "WILLOW CREEK AT MIDHURST             "       127.
     -79.960      44.200     02ED014  "PINE RIVER NEAR EVERETT              "       190.
     -80.072      44.307     02ED015  "MAD RIVER AT AVENING                 "       244.
    Etc.
```

This file needs to be created once using the data in the CWS HYDAT. The long-lat coordinates can be converted to coordinate systems by GK if needed.

10.1 Creating current yyyymmdd_str.tb0 and yyyymmdd_rel.tb0 files

- Download hourly provisional WSC hydrometric CSV files from http://dd.weather.gc.ca/hydrometric/csv/ON/daily/ - eg.
- wget http://dd.weather.gc.ca/hydrometric/csv/ON/daily/ON_02GA003_daily_hydrometric.csv
- files are saved on **c:\grib2\daily_bsnm\yyyymmdd**
- Update the tb0 files – in DOS:

  make **watflood\bsnm** the working directory

  run **wsc_rt wsc_2019.cfg**

  - Reads the file wsc_2019.cfg
  - Reads the file with station particulars `c:\spl\bsnm\flow_station_list.xyz`
  - Opens files with the provisional streamflow data – eg: ON_02GA003_daily_hydrometric.csv
  - Writes the tb0 file for the (hard coded for some Cndn rivers) **c:\spl\bsnm\strfw\yyyymmdd_str.tb0**

- In ***\watflood\bsnm\strfw**, edit the current **str** file **yyyymmdd_str.tb0** & IF NEEDED delete future flows and keep up to but not including the forecast day. e.g. if there are 9 days from the 1st of the month to the day before the forecast, keep only 9 * 24 = 216 lines of data.**

*****This is very important as the length of the model run is based on the length of the yyyy,,dd_str.tb0 file.***
I.e. if there are 96 entries in the str file, even if they are –ve, the model will do a 4 day run

Example cfg file:

```
:Projection         LatLong
:Ellipsoid          WGS84
:deltaT             1
:outputFile         strfw\20190101_str.tb0
..\..\GRIB2\daily_notta\20190201\ON_
..\..\GRIB2\daily_notta\20190301\ON_
..\..\GRIB2\daily_notta\20190401\ON_
..\..\GRIB2\daily_notta\20190501\ON_
..\..\GRIB2\daily_notta\20190501\ON_
```

This file needs to be edited the first day of each month. NEW: The last line will be changed by the program to today's date automatically. I.e. this file is good for all of May. This process repeats until the end of the year is reached and a new file created.

11. File maintenance guide

11.1 Annual maintenance e.g. Jan. 2022

From time to time new directories need to be created to archive the downloaded data.

The batch files created by **run_daily.exe** will automatically create new directories for the CaPA, Regl_tmp, Regl and Glb data sets.

The programs are set up to only run from Jan. 1 of the current year to today's data, then the 2 day regional forecast and followed by the last 8 days of the global forecast.

The CaPA and regl_tmp files need to be updated to ensure they cover the whole previous year.

In the Check that all the CaPA and regl_tmp files are updated for the whole month of 20201201 by importing and saving them as usual.

11.2 In the GRIB2\CaPA directories:

11.2.1 Step 1 – Move 1st CaPA file to previous year

Note (important): CaPA data is for the 6 hours preceeding the timestamp. So each Jan. 2 (or later) move the first CaPA file for the year to the Dec. directory of the previous year.

E.g. move the first CaPA GRIB2 file for 00:00Z of 2021

`CMC_RDPA_APCP-006-0700cutoff_SFC_0_ps10km_2022010100_000.grib2`
from the GRIB@\CMC_capa\202201 folder to the 202112 folder. This is to prevent and error in CHARM. This file covers the last 6 hours of 2021. For subsequent years, use the same approach.

11.3 In each watersged directory:

11.3.1 Step 2: make new .evt files

Next - in a DOS window run: (copy this to a bat file – e.g. 2022.bat in the watflood dir.))

```
rem Warning: do not over write after having edited the new
files!
pause Hit enter to continue  -  ctrl C to quit

rem
**************************************************************
rem
```

```
rem Warning: do not over write after having edited the new
files!
pause Hit enter to continue  -  ctrl C to quit

Copy /-y  event\2021.evt                event\2022.evt
copy /-y  event\2021_flownudged.evt    event\2022_flownudged.evt
copy /-y  event\2021_flowreset.evt     event\2022_flowreset.evt
copy /-y  event\2021_2015.evt          event\2022_2015.evt
copy /-y  event\2021_2016.evt          event\2022_2016.evt
copy /-y  event\2021_2017.evt          event\2022_2017.evt
copy /-y  event\2021_2018.evt          event\2022_2018.evt
copy /-y  event\2021_2019.evt          event\2022_2019.evt
copy /-y  event\2021_2020.evt          event\2022_2020.evt
copy /-y  event\2021_ens_??.evt        event\2022_ens_??.evt
copy /-y  event\2021_ens_long_??.evt   event\2022_ens_long_??.evt
Copy /-y  level\20210101_ill.pt2       level\20220101_ill.pt2
Copy /-y  diver\20210101_div.tb0       diver\20220101_div.tb0
Copy /-y  level\20210101_lvl.tb0       level\20220101_lvl.tb0
copy /-y  resrl\20210101_rel.tb0       resrl\20220101_rel.tb0
Copy /-y  moist\20210101_gsm.r2c       moist\20220101_gsm.r2c
Copy /-y  snow1\20210101_swe.r2c       snow1\20220101_swe.r2c
Copy /-y  snowg\20210101_swe.ts5       snowg\20220101_swe.ts5
Copy /-y  2021_capa.cfg                2022_capa.cfg
Copy /-y  2021_regl_tmp.cfg            2022_regl_tmp.cfg
Copy /-y  2021_wsc.cfg                 2022_wsc.cfg
Copy /-y  2021_lvl.cfg                 2022_lvl.cfg
Rem  Parks Canada Ony:
Copy /-y  2021_PCdly.cfg               2022_PCdly.cfg
Copy /-y  event\2021_nbs.evt           event\2022_nbs.evt
Copy /-y  event\2021_no_nbs.evt        event\2022_no_nbs.evt
```

- **Edit all 2022*.evt files in the event dir and replace 2021 with 2022**
- **Edit all 2022*.cfg and replace 2021 with 2022**
- **Then run 2022 in the watershed working dir. ?????**

11.3.2 Step 3: Create the FINAL precip, temperature & streamflow files for 2021.

These files will be permanent for future simulation of the past year.

BTW – this is how historical files for annual events are created – one year at a time.

Create strfw\20210101_str.tb0:

```
:Projection         LatLong
:Ellipsoid          NAD83
:deltaT             1
:outputFile         strfw\20210101_str.tb0
..\..\GRIB2\wsc_daily\20210101\ON_
..\..\GRIB2\wsc_daily\20210201\ON_
..\..\GRIB2\wsc_daily\20210301\ON_
..\..\GRIB2\wsc_daily\20210401\ON_
..\..\GRIB2\wsc_daily\20210501\ON_
..\..\GRIB2\wsc_daily\20210515\ON_
..\..\GRIB2\wsc_daily\20210601\ON_
..\..\GRIB2\wsc_daily\20210701\ON_
..\..\GRIB2\wsc_daily\20210801\ON_
..\..\GRIB2\wsc_daily\20210901\ON_
..\..\GRIB2\wsc_daily\20211001\ON_
..\..\GRIB2\wsc_daily\20211101\ON_
..\..\GRIB2\wsc_daily\20211201\ON_
..\..\GRIB2\wsc_daily\20220101\ON_
```

Create 2021_capa.cfg

```
# Config file for converting Regl model and CaPA reanalysis r2c files
# to the WATFLOOD watershed grid
#
# Enter the full path names for all files
# watershed file *_shd.r2c
basin\*******_shd.r2c           <- use watershed name from the basin dir.
#
# name of the rdps file with the regl model grid locations
..\cmc\rdps.xyz
#
# Number of Regl or CaPA files to process
12
# file names for the regional files
..\cmc\capa\20210101_capa.r2c
..\cmc\capa\20210201_capa.r2c
..\cmc\capa\20210301_capa.r2c
..\cmc\capa\20210401_capa.r2c
..\cmc\capa\20210501_capa.r2c
..\cmc\capa\20210601_capa.r2c
..\cmc\capa\20210701_capa.r2c
..\cmc\capa\20210801_capa.r2c
..\cmc\capa\20210901_capa.r2c
..\cmc\capa\20211001_capa.r2c
..\cmc\capa\20211101_capa.r2c
..\cmc\capa\20211201_capa.r2c
```

```
#
# Name of the output file
# The start date of this file must be the same
# as the first CaPA file name (above)
model\20210101_capa.r2c
# Number of gap filling passes:
# (from an inspection of the output file)
**                                      <- use appropriate number from your files
```

Create 2021_lvl.cfg

```
:Projection         LatLong
:Ellipsoid          NAD83
:deltaT             1
:outputFile         level\20210101_lvl.tb0
..\..\GRIB2\daily_MNRF\20210101\ON_
..\..\GRIB2\daily_MNRF\20210201\ON_
..\..\GRIB2\daily_MNRF\20210301\ON_
..\..\GRIB2\daily_MNRF\20210401\ON_
..\..\GRIB2\daily_MNRF\20210501\ON_
..\..\GRIB2\daily_MNRF\20210601\ON_
..\..\GRIB2\daily_MNRF\20210701\ON_
..\..\GRIB2\daily_MNRF\20210801\ON_
..\..\GRIB2\daily_MNRF\20210901\ON_
..\..\GRIB2\daily_MNRF\20211001\ON_
..\..\GRIB2\daily_MNRF\20211101\ON_
..\..\GRIB2\daily_MNRF\20211201\ON_
..\..\GRIB2\daily_MNRF\20220101\ON_
..\..\GRIB2\daily_MNRF\20220101\ON_
```

Create 2021_regl_tmp.cfg:

```
# Config file for converting Regl model and CaPA reanalysis r2c files
# to the WATFLOOD watershed grid
#
# Enter the full path names for all files
# watershed file *_shd.r2c
basin\*******_shd.r2c          <- use watershed name from the basin dir.
#
# name of the rdps file with the regl model grid locations
..\cmc\rdps.xyz
#
#
# Number of Regl or CaPA files to process
12
# file names for the regional files
..\cmc\regl_tmp\20210101_tmp.r2c
..\cmc\regl_tmp\20210201_tmp.r2c
..\cmc\regl_tmp\20210301_tmp.r2c
..\cmc\regl_tmp\20210401_tmp.r2c
..\cmc\regl_tmp\20210501_tmp.r2c
..\cmc\regl_tmp\20210601_tmp.r2c
..\cmc\regl_tmp\20210701_tmp.r2c
..\cmc\regl_tmp\20210801_tmp.r2c
..\cmc\regl_tmp\20210901_tmp.r2c
```

```
..\cmc\regl_tmp\20211001_tmp.r2c
..\cmc\regl_tmp\20211101_tmp.r2c
..\cmc\regl_tmp\20211201_tmp.r2c
#
# Name of the output file
# The start date of this file must be the same
# as the first CaPA file name (above)
tempr\20210101_regl_tmp.r2c
# Number of gap filling passes:
# (from an inspection of the output file)
**
```
<- use appropriate number from your files

Edit the event\2021.evt file:

- set noeventstofollow = 0.
- cAlso, change the **tbcflg to y** (this will create the "resume" files) and
- In the working dir: copy event\2021.evt event\event.evt (copy this cmd)
- Then run:

```
wsc_rt       2021_wsc.cfg
wsc_lvl      2021_lvl.cfg
regl_conv    2021_capa.cfg
regl_conv    2021_regl_tmp.cfg
diff64
charm64x
```

You can copy these 6 commands into a bat file

11.3.3 Step 4 - Creating new « resume » files

Copy the 4 files in the resume directory to the working directory :

```
Copy resume\*.*
```

11.3.4 Step 5 – Edit the .cfg files for the new year

Create the 2022_wsc.cfg for just the first month of this year (the rest will be automatically inserted):

Edit 2021_wsc.cfg and change the year to 2022 and save this as **2022_wsc.cfg** in the working dir: (your source in the GRIB2 dir may be different)

```
:Projection         LatLong
:Ellipsoid          NAD83
:deltaT             1
:outputFile         strfw\20220101_str.tb0
..\..\GRIB2\daily_MNRF\20220101\ON_
```

11.3.5 Step 6 - Edit the fc***.bat files to have 2022 (or current year instead of last year)

1.1.1.1 For a simple forecast fc.bat

```
del runReport.txt
wsc_rt      2022_wsc.cfg
regl_conv   2022_capa.cfg
regl_conv   2022_regl_tmp.cfg
regl_conv   regl_apcp.cfg
regl_conv   regl_tmp.cfg
glb_conv    glb_apcp.cfg
glb_conv    glb_tmp.cfg
da 0
diff64
charm64x
type runReport.txt
```

1.1.1.1 For a forecast with past years data for next 90 days after regl & glb forecast fc.bat

```
del runReport.txt
wsc_rt      2022_wsc.cfg
regl_conv   2022_capa.cfg
regl_conv   2022_regl_tmp.cfg
regl_conv   regl_apcp.cfg
regl_conv   regl_tmp.cfg
glb_conv    glb_apcp.cfg
glb_conv    glb_tmp.cfg
rem ***********************************
copy event\2022_2015.evt event\event.evt
da
diff64
charm64x
copy results\spl.csv results\spl_c2015.csv
type runReport.txt
rem ***********************************
copy event\2022_2016.evt event\event.evt
charm64x
copy results\spl.csv results\spl_c2016.csv
.
.
Etc.
```

1.1.1.1 For a 16 day ensemble forecast fc_ens16.bat

```
del runReport.txt
rem get the stuff for the regular forecasts
wsc_rt      2022_wsc.cfg
regl_conv   2022_capa.cfg
regl_conv   2022_regl_tmp.cfg
regl_conv   regl_apcp.cfg
regl_conv   regl_tmp.cfg
```

```
glb_conv    glb_apcp.cfg
glb_conv    glb_tmp.cfg
Rem extract the data from the global domain to the watershed
rem for 20 members of the ensemble
geps_conv geps_apcp1.cfg
geps_conv geps_tmp1.cfg
rem Run each WF sequence for 20 enseamble members
rem ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
copy event\ens_01.evt event\event.evt
da
diff64
copy event\2022_ens_01.evt event\event.evt
charm64x
copy results\spl.csv   results\spl_01.csv
copy results\charm_dly.csv results\charm_dly_01.csv
copy results\watflood.wfo   results\watflood_01.wfo
rem ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
copy event\ens_02.evt event\event.evt
da
diff64
copy event\2022_ens_02.evt event\event.evt
charm64x
copy results\spl.csv   results\spl_02.csv
copy results\charm_dly.csv results\charm_dly_02.csv
rem ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
.
.
etc.
```

1.1.1.1 For a 32 day ensemble forecast   fc_ens32.bat

```
del runReport.txt
rem get the stuff for the regular forecasts
wsc_rt      2022_wsc.cfg
regl_conv   2022_capa.cfg
regl_conv   2022_regl_tmp.cfg
regl_conv   regl_apcp.cfg
regl_conv   regl_tmp.cfg
glb_conv    glb_apcp.cfg
glb_conv    glb_tmp.cfg
Rem extract the data from the global domain to the watershed
rem for 20 members of the ensemble
geps_conv geps_apcp1.cfg
geps_conv geps_tmp1.cfg
geps_conv geps_apcp2.cfg
geps_conv geps_tmp2.cfg
rem Run each WF sequence for 20 enseamble members
rem ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
copy event\2022_ens_long_01.evt event\event.evt
da
diff64
charm64x
copy results\spl.csv   results\spl_01.csv
copy results\charm_dly.csv results\charm_dly_01.csv
copy results\watflood.wfo   results\watflood_01.wfo
```

```
rem ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
copy event\2022_ens_long_02.evt event\event.evt
da
diff64
charm64x
copy results\spl.csv   results\spl_02.csv
copy results\charm_dly.csv results\charm_dly_02.csv
rem ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
copy event\2022_ens_long_03.evt event\event.evt
da
diff64
charm64x
copy results\spl.csv   results\spl_03.csv
copy results\charm_dly.csv results\charm_dly_03.csv
rem ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
.
.
etc.
```

12. Forecast quick reference guide

Notes:
All required must have been downloaded as described in the previous chapters. This can be done by automatically running run_daily.exe and the bat files it creates every day – see Chapter 6. Sections 9.1 and 9.2 should be executed in the order shown to avoid mixups!!

12.1 Converting Grib2 files to R2C formats NEW Dec. 2020

Follow Section 12.1.1 OR 12.1.2 – not both!

12.1.1 Automatic conversion with Read_grib2.exe

Read_grib.exe replaces the conversion of Grib2 files to Green Kenue format r2c fils as described in Sect. 12.1.2. This allows complete automation of a flow forecast with WATFLOOD. This step follows the automatic file downloads from CMC.

Run_daily.exe creates the file make_r2c.bat in the Grib2 directory :

```
cd \grib2\cmc_capa\202101
read_grib2 capa
cd \grib2\cmc_reg_tmp\202101
read_grib2 rglT
cd \grib2\cmc_regl\cmc_regl_20210114
read_grib2 regPread_grib2 regT
cd \grib2\cmc_glb\cmc_glb_20210114
read_grib2 glbP
read_grib2 glbT
```

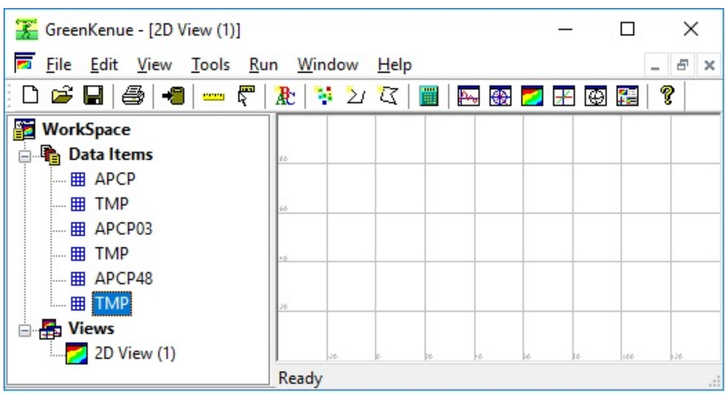
- The cd * commands put the user in the proper directory with each type of Grib2 data
- Capa, reglP, reglT, glbP & glb are arguments for the program read_grib.exe to indicate what type of data is being converted
- The r2c files created will be written in the WATFLOOD\CMC** directories as follows
  - Capa : watflood\CMC\capa\yyyymmdd_capa.r2c
  - reglT : watflood\ CMC\regl_tmp\yyyymmdd_tmp.r2c
  - regP : watflood\ CMC\regl\regl_apcp.r2c
  - regT : watflood\ CMC\regl_tmp.r2c
  - glbP : watflood\ CMC\glb_apcp.r2c
  - glbT : watflood\ CMC\glb_tmp.r2c

Notes
the directory structure is shown in Chapter 3, Table 1
These files are for the whole regl & glb model domains
Next step is to extract the data for the watershed domain & convert from the regl & glb grids to the WATFLOOD grid – please see Section 12.2

12.1.2 In Green Kenue, import & convert all 6 sets of grib2 files to r2s

Import the CaPA WMO GRIB/From Multiple GRIB Files for up to one calendar month at a time and save as **GRIB2\CMC_CaPA\yyyymmdd_CaPA.r2s** Note: dd = first day of the month – but remember, it may not be a month long file. Note: In same month, previous file is overwritten.
Import the **CMC_regl_TMP GRIB2** files from Multiple GRIB Files for up to one calendar month at a time and save as **GRIB2\cmc_regl_temp\yyyymm\yyyymmdd_tmp.r2s**** Note: dd = first day of the month – but remember, it may not be a month long file. Note: In same month, previous file is overwritten.
Import the 48 hour precip (APCP) forecast (16 files P003-P049) into GK and save as **GRIB2\CMC \CMC_regl\yyyymmdd\regl_apcp.r2s**
Import the 48 hour temperature (TMP) forecast (17 files P000-P048) into GK and save as **GRIB2\CMC_regl\yyyymmdd\ regl_tmp.r2s**
Import the ***last 8 days*** of the glb apcp forecast into GK and save as **GRIB2\CMC_glb\yyyymmdd\glb_apcp.r2s** I.e. import **P048 – P240**
Import the ***last 8 days*** of the glb TMP forecast into GK and save as **GRIB2\CMC_glb\yyyymmdd\glb_tmp.r2s** I.e. import **P054 – P240**

If all went well, you will see this:



Convert all 6 to r2c and save – for the order of imports shown above. Note: CaPA & regl_tmp files are replaced in same month; regl & glb forecast files are replaced each day – old files not kept.

Save the files as a *multiframe* **ASCII watflood\CMC\CaPA\yyyymm01_CaPA.r2c**

Save this file as a *multiframe* ASCII **watflood\CMC\regl_tmp\yyyymm01_tmp.r2c**

Save the file as a *multiframe* ASCII **watflood\CMC\regl\regl_apcp.r2c**

Save the files as a *multiframe* ASCII **watflood\CMC\regl\regl_tmp.r2c**

Save the files as a *multiframe* ASCIIw**atflood\CMC\glb\glb_apcp.r2c**

Save the files as a *multiframe* ASCII **watflood\CMC\glb\ glb_tmp.r2c**

12.2 Create the WATFLOOD files – in the watershed working directory :

Note:

Update the **2019_capa.cfg** file to have the correct # of monthly entries if starting a new month. Update needs to be done on the 2nd day of each month. On or after Jan. 2, start a new cfg file with last year +1.

Next set of instructions can be done automatically using the fc.bat cmd file shown in Sect. 11.5

Run **regl_conv yyyy_capa.cfg** (Ignore mismatch msg)

Update the **2019_regl_tmp.cfg** file to have the correct # of monthly entries if starting a new month. Update needs to be done on the 2nd day of each month. On or after Jan. 2, start a new cfg file with last year +1

Run **regl_conv yyyy_regl_tmp.cfg** (Ignore mismatch msg)

Run **regl_conv regl_apcp.cfg**

Run **regl_conv regl_tmp.cfg**

Run **glb_conv glb_apcp.cfg**

Run **glb_conv glb_tmp.cfg**

12.3 Update WSC provisional flow – Sect. 10.1

Download WCS provisional flows and save in **c:\grib2\wsc_daily\yyyymmdd**

Edit WSC_yyyy.cfg - see Sect. 10.1

Update the WSC_yyyy.cfg file: This file needs to be edited each day. Eventually, `yyy0228` will become `yyyy0301` and then `yyyy0401`. This process repeats until the end of the year is reached and a new file created.

In **watflood\fc_notta** run **wsc_rt yyyy_wsc.cfg**

Check the the strfw\yyyymmdd_str.tb0 file is the proper length. E.g. if there are 99 days from the 1st of the year to the day before the forecast, keep only 99 * 24 = 2376 lines of data.

13. Create the forecast with CHARM

Next set of executables – da, diff & charm can be done as part of the fc.bat cmd file shown in Sect. 11.5

Edit the **event\event**.evt file to have the proper set of files included

With fc_**basinname** as the working directory, run

da.exe ← to disaggregate r2c

diff*nnn*.exe ← to create daily temp differences

charm*nnn*.exe ← run the model

(*nnn= version designation)*

DONE! Look at forecast in **results\spl.csv –** open this file in Excel. (spl.csv has pairs of observed/computed flows; column locations are in the file flow_stations_location.xyz)

13.1 Automatic execution for updating after Grib2 conversion

The instructions in 11.1 – 11.6 are to execute the 6 programs to convert the CMC domains to the WATFLOOD domain. The last three are to convert the WSC provisional data and run the model. This is most easily done with a batch file, for example, f**c.bat**

```
del runReport.txt
wsc_rt      2019_wsc.cfg
regl_conv   2019_capa.cfg
regl_conv   2019_regl_tmp.cfg
regl_conv   regl_apcp.cfg
regl_conv   regl_tmp.cfg
glb_conv    glb_apcp.cfg
glb_conv    glb_tmp.cfg
da 0
diff64
charm64x
type runReport.txt
```

Results in **results\spl.csv**

Note: the file runReport.txt shows whether each program has executed properly.