GSI Radar Data Interface

for DTC community GSI release version 3.2

1. Introduction

This note is to help users to generate their own radar radial velocity and reflectivity BUFR files that can be used by the GSI to do radial velocity and reflectivity analysis. The content and structure of the radial velocity and reflectivity BUFR files are explained in this memo. Also, we created couple of sample BUFR code to help users decode and encode Level II radar velocity BUFR and reflectivity.

Please note the radar data process for quality control is not included here because of the complexity of the problem. Also Level 3 and 2.5 radar wind BUFR files are not discussed here.

Users should already be familiar with the basic BUFR process skills and the sample BUFR code DTC released with the GSI package in directory *./util*. The new samples for radar data process is also included in directory *./util* as a sub directory *./radar_process*. If radar process sample code is downloaded as a separate tar file, please untar it in your GSI *./util* directory.

2. GSI interface to Level II radar velocity

In GSI code and run script, the Level II radial velocity BUFR file is named as "l2rwbufr" and reads in through a subroutine *radar_bufr_read_all*, which is site in file *read_l2bufr_mod.f90*. The main functions of this subroutine are:

- decodes the BUFR file to read in the radial wind observations
- does "super-obbing" to get radar velocity super obs
- write out the new super obs to a binary file called "*radar_supobs_from_level2*"

To add your own radar level II radial velocity data into GSI analysis, the first is to understand how GSI decodes the radar Level II radar velocity BUFR files. Under directory *./util/radar_process/radialwind*, we provide two sample files: *bufr_decode_l2rwbufr.f90* and *bufr_encode_l2rwbufr.f90* to illustrate the structure of these data in the BUFR file and how to read and write out the data from and to BUFR file "l2rwbufr". A makefile in the same directory is provided for user to compile the code into executables.

The sample code *bufr_decode_l2rwbufr.f90* only has 87 lines. But we will not show the whole file here because it has the same structure as other BUFR decoding code. The key to understand the radar decode process is to know what mnemonics are needed in the code and the meanings of these mnemonics. Users can get all those information from radar BUFR table. During decoding, the sample code will read the radar BUFR table from file "l2rwbufr" and write out the BUFR table as a text file named "*bufr_radar.table*". In this document, we provide the following table to explain the meanings of the mnemonics used in GSI code. Please refer to the BUFR table itself for more details.

The mnemonics and their meanings for radar Level II radial velocity

mnemonic	meaning	dimension
SSTN	RADAR STATION IDENTIFIER (SHORT)	1
CLAT	RADAR STATION LATITUDE (COARSE ACCURACY)	1
CLON	RADAR STATION LONGITUDE (COARSE ACCURACY)	1
HSMSL	HEIGHT OF RADAR STATION GROUND ABOVE MSL	1
HSALG	HEIGHT OF ANTENNA ABOVE GROUND	1
ANEL	ANTENNA ELEVATION ANGLE	1
ANAZ	ANTENNA AZIMUTH ANGLE	1
QCRW	QUALITY MARK FOR WINDS ALONG RADIAL LINE	1
YEAR	YEAR OF OBSERVATION BEAM	1
MNTH	MONTH OF OBSERVATION BEAM	1
DAYS	DAY OF OBSERVATION BEAM	1
HOUR	HOUR OF OBSERVATION BEAM	1
MINU	MINUTE OF OBSERVATION BEAM	1
SECO	SECOND OF OBSERVATION BEAM	1
DIST125M	DISTANCE FROM ANTENNA TO GATE CENTER IN UNITS OF 125M	Beam
DMVR	DOPPLER MEAN RADIAL VELOCITY	Beam
DVSW	DOPPLER VELOCITY SPECTRAL WIDTH	Beam
SCID	RADAR SCAN ID (RANGE 1-21)	1
HNQV	HIGH NYQUIST VELOCITY	1
VOCP	VOLUME COVERAGE PATTERN	1
VOID	RADAR VOLUME ID (IN THE FORM DDHHMM)	1

In NCEP Level II radar radial velocity BUFR file, radar observations are organized and saved by each radial observation beams. For each radial beam, the following head information is available to describe the beam features:

```
SSTN CLAT CLON HSMSL HSALG ANEL ANAZ QCRW
YEAR MNTH DAYS HOUR MINU SECO
SCID HNQV VOCP VOID
```

Then, the observation location (DIST125M), mean radial wind (DMVR), and velocity spectral width (DVSW) along the whole beam are saved.

In our sample decoding file *bufr_decode_l2rwbufr.f90*, the above information for each beam is read in one subset (beam) by one subset (beam). Then, if this beam includes valid radial wind or velocity width observations, it is saved to a binary file: *l2rwbufr.bin*. We comment out most of the standard output information, but leave the final count on the total subsets that have valid observations.

After familiar with the NCEP radar Level II radial wind BUFR file, users can easily understand the sample code for encoding is *bufr_encode_l2rwbufr.f90*, siting in the same directory as decoding sample. Starting from this file, users can encode their own observations into a BUFR file for GSI to do radial wind analysis.

The encoding shares the same mnemonics as decoding. So, after run decode sample, users can run encode sample, which reads in the radar observations from *l2rwbufr.bin* and encode them into BUFR file called: l2rwbufr_new. Users may notice that the file size of *l2rwbufr_new* is much smaller than the size of *l2rwbufr*. This is because the *l2rwbufr_new* only includes radial beam with valid observations while the *l2rwbufr* includes beams with missing observations.

If users have trouble to understand the sample files or need to append the new radial wind observations to the exiting NCEP radial wind BUFR files, please refer to the BUFR user's guide from DTC BUFR website:

http://www.dtcenter.org/com-GSI/BUFR/index.php

In generating these sample files, we also referenced the BUFR output interface code for the NCEP radar Level II radial wind process. Based on the NCEP radar data interface, 4 variables, SCID HNQV VOCP VOID, are added in our sample code. These 4 variables are not read in by GSI.

3. GSI interface to radar reflectivity

The GSI interface to radar reflectivity is different from the radar radial wind. Now, the radar reflectivity is used by the GSD cloud analysis package in GSI to improve the precipitation analysis and storm forecast. The GSI reads in the reflectivity from a BUFR file called "*refInGSI*", in which the reflectivity observations have been horizontally interpolated into columns over the analysis grid.

Because the GSD have been using NSSL radar reflectivity mosaic as resources to generate the reflectivity BUFR for RAP GSI. The GSD radar reflectivity preprocess package will be used here as a sample to explain how to feed radar reflectivity into GSI for precipitation hydrometeor analysis. The package is under *"./util/radar_process/reflectivity".* It can be compiled with the makefile under the

same directory. After compile, an executable named as "*process_NSSL_mosaic.exe*" should be in the same directory.

There are three steps to set up running environment for this executable:

1. The sample code assumes that the radar reflectivity data are NSSL new 4 tiles mosaics in MRMS binary format. The 4 tiles should be renamed as:

   mosaic_t1 mosaic_t2 mosaic_t3 mosaic_t4

2. Configure mosaic.namelist:

   ```
   &setup
     tversion=4,
     analysis_time = 2013111518,
     dataPath = '../data/',
     bkfile = '../data/wrfinput_d01',
    /
   ```

   where tversion is always set to 4. The sample code we provided can only process 4 tiles binary files available from NSSL since summer 2013. The old 8 tiles netcdf files are not included in this code. The `analysis_time` have format YYYYMMDDHH; the `dataPath` is the directory that includes 4 mosaic tiles (mosaic_t1-4); the `bkfile` is path and wrf background file used for GSI analysis.

3. Run *process_NSSL_mosaic.exe* with 4 cores. Please note the code has to be run by over 4 cores because each tile needs one core to process. After run, one BUFR file called "NSSLRefInGSI.bufr" should show up in run directory.

Please note the namelist "*mosaic.namelist*" and BUFR table file "*prepobs_prep.bufrtable*", which provided with the package, have to be in the same run directory.

In this package, the file "*write_bufr_ref.f90*" is to write column reflectivity into the BUFR file. There are only 6 mnemonics used in this file:

The mnemonics and their meanings for radar reflectivity

mnemonic	meaning	dimension
SID	RADAR STATION IDENTIFIER (not used in GSI)	1
XOB	X-index for grid coordinate of reflectivity column	1
YOB	Y-index for grid coordinate of reflectivity column	1
DHR	OBSERVATION TIME MINUS CYCLE TIME (not used in GSI)	1
TYP	PREPBUFR REPORT TYPE (not used in GSI)	1
HREF	Horizontal reflectivity	31

Only XOB, YOB, and HREF are used by GSI, if user can wire their only reflectivity observations over analysis grid with columns that has vertical level list below (in km):

0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 10, 11, 12, 13, 14, 15, 16, 18

Then, users can use ""*write_bufr_ref.f90*" directory to encode BUFR for GSI. If user's radar reflectivity column has different vertical levels, please contact DTC GSI help desk for how to change the cloud analysis code for the new vertical levels.