

Community Multi-purpose Formatting Toolkit (CMFT)

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1. Introduction

The purpose of the toolkit is to centralize the BUFRization of all satellite data into a single tool, to make it available to a wider range of scientific community and to facilitate its extension in the future. It includes 3 major components: **BUFR**, **GRIB** and **TANK**. BUFR is to convert various raw/intermediate data into BUFR format; GRIB is to convert data into GRIB2 format; TANK is to save BUFR files into database files.

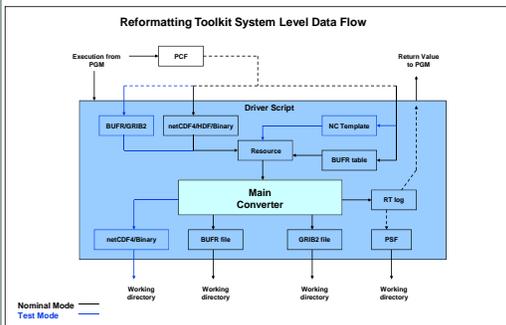
2. Abstract

A tailoring software system that will convert the satellite products into Binary Universal Form for the Representation of meteorological data (BUFR) and GRIdded Binary Edition 2 (GRIB2) formatted files is under development at NOAA/NESDIS/STAR. This Reformatting Toolkit extends the Operational NPP BUFR and GRIB Tailoring System that converts the NPP Cross-track Infrared Sounder (CrIS) Radiances, Advanced Technology Microwave Sounder (ATMS) Radiances, Visible/Infrared Imager Radiometer Suite (VIIRS) Radiances, VIIRS Aerosol Optical Thickness (AOT), Ozone Mapping and Profiler Suite (OMPS) Nadir Profile, OMPS Total Column data, VIIRS Sea Surface Temperature (SST), VIIRS Polar Winds and Ozone Limb Profile files into BUFR files, and converts the NPP Vegetation Index and Green Vegetation Fraction files into GRIB2 files. The extension includes more functions to reformat MODIS Aerosol Optical Depth (AOD), 1B raw data into BUFR files. Currently, the NPP operational part of this toolkit is running in NPOESS Data Exploitation (NDE), and the produced BUFR files of ATMS radiances, CrIS radiances, VIIRS radiances and VIIRS SST are distributed to NOAA EMC and EUMETSAT. The MODIS AOD component of this software is running in NOAA/NESDIS, NCAR and other research communities, and has been test in Amazon cloud using Condo as a scheduling system. The future functions to convert the GCOM-W1 Advanced Microwave Scanning Radiometer 2 (AMSR2) Total Precipitable Water (TPW), Cloud Liquid Water (CLW), Sea Surface Temperature (SST) and Sea Surface Winds (SSW) into BUFR files, and convert Soil Moisture (SM) into GRIB2 file are being planned. The details of this toolkit and its products will be discussed.

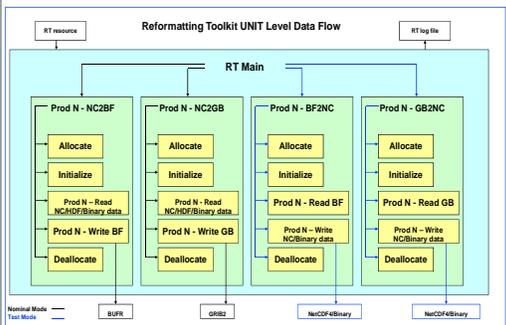
3. Components of the System

- **NC2BF**: Converts NetCDF4/HDF5 file to BUFR file.
- **NC2GB**: Converts NetCDF4/HDF5 file to GRIB2 file.
- **BF2NC**: Converts BUFR file to NetCDF4 file.
- **GB2NC**: Converts GRIB2 file to NetCDF4 file.
- **1B2BF**: Converts raw 1B / derived data into BUFR file.
- **TANK**: Save WMO/NCEP BUFR file into database files.

4. System Level Data Flow



5. Unit Level Data Flow

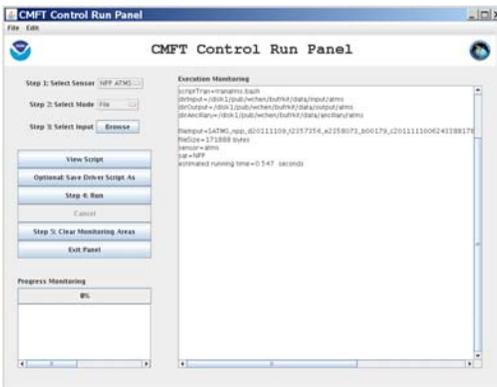


6. Development History

- July 08: IPT Branch Lead was informed to begin product development
- July 08: Work with NDE to verify product requirements
- Aug 08: Design the operational BUFR and GRIB Tailoring toolkit
- Nov 08: CrIS BUFR table was finalized.
- Apr 09: Preliminary Design Review
- Aug 09: ATMS BUFR table was finalized
- Sep 09: Critical Design Review
- June 10: VIIRS BUFR table was finalized
- Apr 11: Test the system with NDE P72 data
- May 11: Decision to include only bands 12, 13, 15 and 16 in the VIIRS M-Band BUFR file
- June 11: Decision to include only band 5 in the VIIRS I-Band BUFR file
- July 11: Subset of 399 CrIS channels was selected and included into BUFR file.
- Aug 11: Test utility h5augjps and use this utility to convert HDF5 file to NetCDF4 file
- Oct 11: SST, AOT and OMPS Nadir Profile BUFR tables were approved as pre-operational
- Oct 11: Test Readiness Review for CrIS, ATMS and VIIRS SDR Products
- Nov 11: The Linux version Toolkit was sent to Sid Boukabara's team for testing
- Feb 12: Walter Wolf and Sid Boukabara decided to enlarge this operational toolkit for an offline version including more functions for other products.
- May 12: Delivered the operational BUFR/GRIB2 Toolkit DAP for NPP CrIS, ATMS, VIIRS radiances and VIIRS SST products to NDE

7. Source Code Description

- **Code standard**: STAR software standards and GNU convention
- **Programming languages**: Fortran, C/C++, Perl, Bash, Java
- **Development platform and compilers**: IBM AIX xlf/xlc/xLC
- **Other platform and compilers**: Linux ifort/icc/gfortran/gcc/g++
- **Ancillary libraries source included**: zlib, szlib, jpeg, hdf4, hdf5, netcdf3, netcdf4, w3, bacio, grib2, NCEP bufrlib.
- **Build**: just type a **make** in top level source directory will build all libraries and all executables
- **Run**: stand-alone unit either from a central GUI or from driver script in command line



8. Sensors / Data Types Included

Sensors / Data Types Included		
AMSU-A	AMSU-B	MHS
AVHRR (GAC)	MSU	HIRS3
HIRS4	SSMIS TDR	Aura OMI
Aura MLS	TRMM TMI_2A12	NPP ATMS
NPP CrIS	Windsat (EDR068)	ASCAT
NPP VIIRS AOT	NPP VIIRS SST	NPP VIIRS M-band Radiances
NPP VIIRS I-band Radiances	AMSRE Swath	SSMIS EDR & SDR

9. Test and Operational Status

The 6 NPP sensor data is operationally running in NDE and the rest are operationally running in NCEP/EMC; the tool was tested successfully in NOAA/STAR Linux x86_64, S4 Badger and JIBB.

10. BUFR Table Examples

Main Entries in CrIS Radiance BUFR Table		
Latitude	Longitude	Satellite Zenith Angle
Satellite Azimuth	Solar Zenith	Solar Azimuth
Satellite Height	Geolocation Quality	Height of Land Surface
Land Fraction	Land/Sea Indicator	Cloud Cover
Height of Cloud Top	Radiance Type	Scan-Level Quality Flags
Type of Band	Starting Wave number	Ending Wave number
Start Channel	End Channel	Calibration Quality Flags
NUCAPS Quality	Channel Number	Channel Radiance

Main Entries in VIIRS Radiance BUFR Table		
Latitude	Longitude	Satellite Zenith Angle
Satellite Azimuth	Solar Zenith	Solar Azimuth
Satellite Height	Geolocation Quality	Surface Type
Cloud Mask	Type of Band	Channel Number
Channel Wavelength	Radiance Quality	Channel Radiance
Channel Reflectance		

Main Entries in ATMS Radiance BUFR Table		
Latitude	Longitude	Satellite Zenith Angle
Satellite Azimuth	Solar Zenith	Solar Azimuth
Satellite Height	Geolocation Quality	Scan-Level Quality Flags
Channel Number	Chan. Central Frequency	Channel Bandwidth
Antenna Polarization	Antenna Temperature	Brightness Temperature
Cold Target NEDT	Warm Target NEDT	Channel-Level Quality Flags

Main Entries in VIIRS Polar Winds BUFR Table		
Latitude	Longitude	Satellite Zenith Angle
Surface Type	Pressure	Temperature
Channel Wavelength	Satellite Derived Wind Computation Method	Wind Direction
Wind Speed	Forecast Wind Direction	Forecast Wind Speed
Wind Quality Flags		

Message Types in NCEP BUFR Table 021		
AMSUA 1B TB	AMSUB 1B TB	MHS 1B TB
MSU 1B TB	HIRS2/3/4 1B TB	AVHRR(GAC) 1B TB
RARS(EARS,AP,SA) AMSU-A 1C TB (N15-19)	RARS(EARS,AP,SA) AMSU-B 1C TB (N15-17)	RARS(EARS,AP,SA) HIRS 1C TB (N15-19)
AMSUA 1B TA	RARS(EARS,AP,SA) MHS 1C TB	PROCESSED GOES IMAGER TB
ATOVS AMSUA/ AMSUB AIRRADIANCE	AIRS PRINCIPAL COMPONENTS	AMSR-E CHANNEL DATA

Message Types in NCEP BUFR Table 012		
SSMIS EDR & SDR	SSMIS TDR	AVHRR TB/Albedo
POES SST	GOES SST	ERS/SAR
Metop ASCAT 25/50 km Scatterometer Data	AMSRE Level 2 Ocean Surface Products	Windsat Scatterometer Data (FNMOOC & NESDIS)
QuickSCAT Scatterometer Data	GPS - Integrated Precipitable Water	ERS/Scatterometer Winds
ERS/Radar Altimeter Data	NASA Langley Pixel-Level Cloud Data	SSMIS Neural Net 3 Products

Message Types in NCEP BUFR Table 008		
ATOVS SBUV-1 Ozone	MODIS AEROSOL OPTICAL DEPTH (AOD)	NOAA-09/14 OZONE DATA
OZONE(AIRNOW) 1&8-HR BKWRD AVG-DELAYED	OZONE(AIRNOW) 1 & 8-HR FWD AVG-DELAYED	PARTICULATE(AIRNOW) 1H BKWRD AVG-HOURLY & DAILY INGSST
Meop-2 Global Ozone Monitoring Exp-2 (GOME-2)	Ozone Monitoring Instruments (OMI)	Microwave Limb Sounder Ozone (MLS)

11. Future Work

- Migrate more sensors from NCEP operational environment to Linux environment;
- Extend toolkit to OMPS Nadir Profile, OMPS Total Column, VIIRS Polar Winds and Ozone Limb Profile;
- Extend toolkit to GCOM-W1 AMSR2;
- Add Tank capability;
- Test toolkit on more platforms with compilers to make the toolkit as generic as possible.

12. Conclusion

This toolkit has shown that it's useful and beneficial to science community to have a centralized BUFR tool, and to migrate those systems on supercomputers to other platforms is not as daunting and hard as some we thought.

Acknowledgements

The authors would like to thank Greg Krasowski for providing the test data.