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Satellite Data Processing for NCMRWF Unified Model (NCUM)

V.S. Prasad

January 2014

REPORT

National Centre for Medium Range Weather Forecasting

Earth System Science Organisation

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Ministry of Earth Sciences
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1. **Introduction :**

National Center for Medium Range Weather Forecasting (NCMRWF) is in the process of establishing a seamless numerical modeling system based on Unified Model of UK met. office. As a part of it weather model modules that consist of three parts, viz.

a. Observation Processing System (OPS),
b. four dimensional variational data assimilation system (4D-VAR)
c. Unified Model (UM)

are implemented by Rajagopal et al 2012 and called it as NCMRWF's Unified Modeling (NCUM) system. This system is designed to take input observations from the "OBSTORE " files which are prepared at UK Met. Office. To make the system independent of UKMO, Prasad (2012) proposed and developed a pre-processing system to prepare obstore files using the data dump files that are created in the T574L64 Global Data Assimilation and Forecasting (GDAF) system. This system is adopted to conventional observations (Sonde, Synoptic, Aircraft, GPSRO, Satwind, Scatwind observations etc) and started making use it since 1 January 2013.

OPS has also provision to read data in from files in UKMO bufr format for certain bulk observation types as tabulated in Table 1. The use of this provision is not explored so far on operational mode in UKMO user user community. NCMRWF started putting efforts to explore this application for reading bulk in observations files, such as satellite radiance, in OPS. Presently this method is adopted to handle NOAA-ATOVS, Metop-ISAI and Aqua-AIRS radiance data sets and efforts are on to extend this method to MeghaTropique- Saphir Radiance also. This report gives full account of usage of BUFR in OPS at NCMRWF. In future most of bulk data sets as tabulated (Table 1) will be handled in BUFR format only.

Table 1: Depicting Meteorological Observations that can be Processed by OPS in UKMO BUFR fomat

S.No	Type of observation	Coverage/source	BUFR file
1	NOAA / Metop ATOVS Radiance	Global	ATOVSG
		Regional	ATOVSL
2	Metop IASI Radiance	Global	IASIG
		Regional	IASIL
3	AQUA/TERA AIRS Radiance	GLOBAL	AIRS
		Regional	AIRSL
			AIRSSMS
			AIRSWF
4	Scatterometer winds	OSCAT/WINDSAT	SEAWINDS
		Metop-A/Metop-B	ASCAT
		ERS	ESAURA
		ERS	ESAUWI
5	MeteoSat AMV winds	Satob type Water vapour winds	ESACSWVW,
		Satob type CMV	ESACMW
		High Resolution CMV	ESAHRVW
		High Resolution Water vapour	ESAHRWVW
		Second Generation	MSGWINDS
6	MeteoSat Radiance	Metop Cloud cleared	ESACSR
		SEVIRI cloud cleared	MSGCSR
		SEVIRI Radiance	MSGRAD
			MSGRADFD
7	GOES Radiance	Cloud Cleared GOES Imager	GOESCSR
8	GEOS AMV winds	GOES AMV winds	GOESBUFR
9	JMA AMV wind	MTSAT AMV winds	JMAWINDS
10	Polar AMV	MODIS, AVHRR	MODIS
11	Surface based GPS IPWV	Integrated Precipitable Water vapour	GPSIWV
12	DMSP Radiances	Imager	SSMI
		sounder	SSMIS
13	AMSRE Radiance		AMSRE
14	SST	UKMO	UKMOSST

2. Processing for NOAA -ATOVS

NCMRWF is receiving NOAA and METOP Global Area Coverage (GAC) ATOVS radiance data (level 1b) sets from NOAA NESDIS on near real time basis. To make this data at more quicker phase NCMRWF is making efforts to get Regional ATOVS Retransmission Service(RARS) data sets. This service promise to deliver the data within 30 minutes of data acquisition, where as GAC data takes about 1 to 3 hours depending on satellite pass. The RARS data over Europe (EARS) is available through EUMETCAST broadcast- which NCMRWF is receiving through Space Application Center (SAC), Ahmedabad. Efforts are on get RARS data over Asia-Pacific region through India Meteorological Department (IMD). In India, IMD is maintaining 3 HRPT stations at New Delhi, Chennai and Gowhati. It is observed that IMD- Chennai HRPT data is very crucial, with the that station coverage and becoming member in Asia-Pacific RARS-total coverage (Figure 1) over this region is possible and the whole data will be available in 30 minutes for its usage at NWP centers. This RARS data is available in level 1C in BUFR format.

The ATOVS and AVHRR Pre-processing Package (AAPP) is supplied and maintained by the EUMETSAT through its satellite Application Facilty for Numerical Weather Prediction (NWPSAF). This package processes data from instruments on board the NOAA POES polar orbiting satellites - namely HIRS, AVHRR, AMSU and MHS - and from HIRS, AVHRR, AMSU, MHS and IASI on the European METOP satellites. For these satellites AAPP can ingest and process raw direct readout data. It also processes Sensor Data Record data from the new-generation Suomi NPP satellite, and from the sounders on the Chinese FY-3 satellites. The AAPP is freely available by licence, and distributed by the Met Office. The current version of AAPP is V7, first released in March 2012 and acquired by NCMRWF. In the unified Modeling system all three Channels (HIRS, AMSU-A, MHS/AMSU-B) are interpolated to HIRS resolution and used all together, i.e in level 1 D form Thus AAPP code is used to process both level 1b and level 1c data to the leve1d and then encode it in BUFR format. As mentioned in the table 1 the data then can be read directly by OPS. The total processing steps are depicted in the flow chart as shown in the figure 2 and scripts used are given in the annexure.

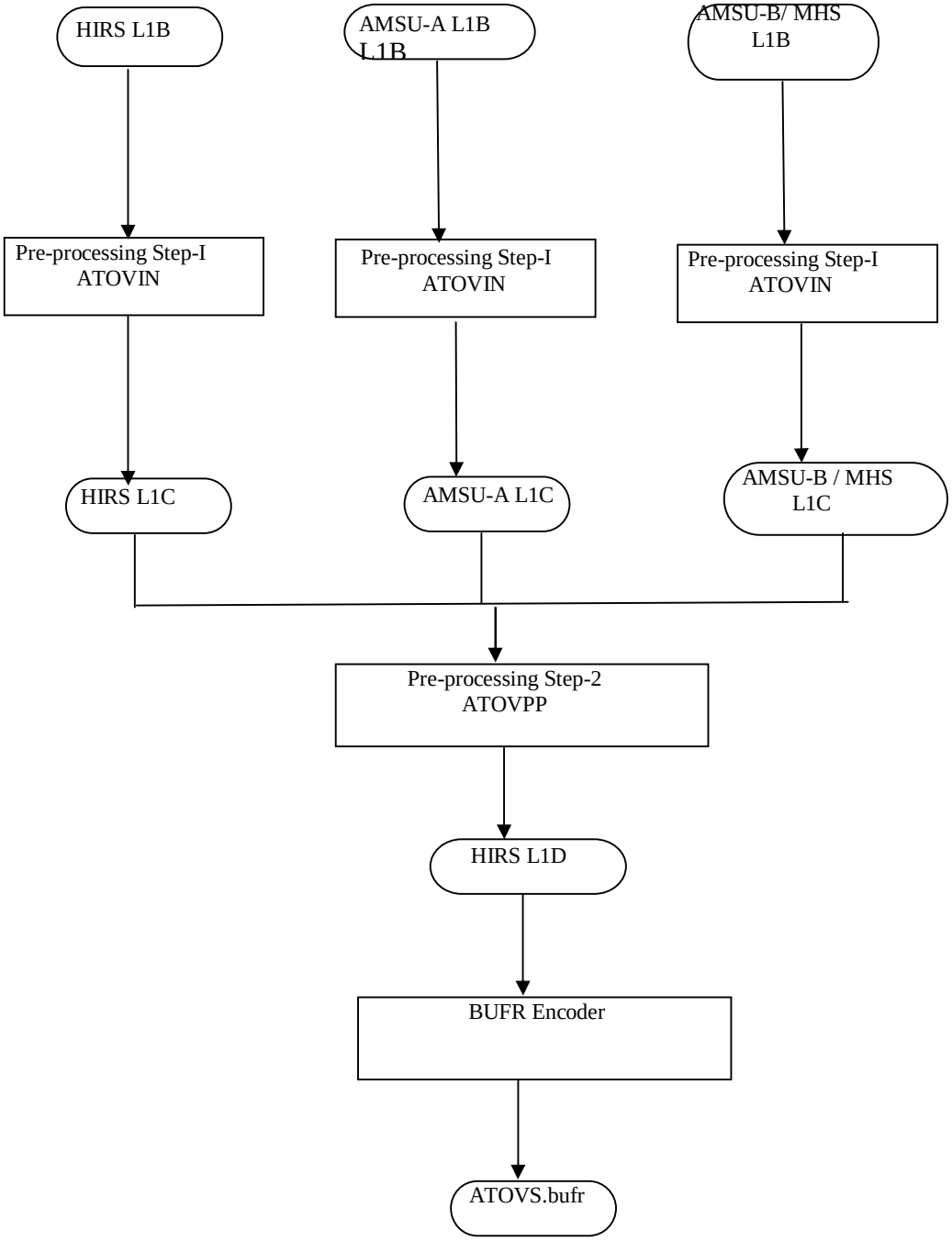

Figure 2 : Depicting Processing of ATOVS data using AAPP code.

The level 1D BUFR files contains all the data that as per the coverage but not organised as per analysis time window. The OPS has the capability to extract it as per requirement of analysis time To process the BUFR files OPS requires the observation element listing for the type of observation it process. The list for this ATOVS observations is tabulated in the Table 2.

Table 2: List of Observational elements for ATOVS observations :

SN	Element Name	Element Description	Unit/code
1	STLT_IDNY	Satellite Identifier	code tbl 001007
2	YEAR	Year	year
3	MNTH	Month	month
4	DAY	Day	day
5	HOUR	Hour	hour
6	MINT	Minute	minute
7	SCND	Second	second
8	LTTD	Latitude	degrees
9	LNGD	Longitude	degrees
10	SCAN_LINE_NMBR	Scan line number	numeric
11	FOV_NMBR	Field of view number	numeric
12	SRFC_TYPE	Surface type	code tbl 008012
13	SRFC_HGHT	Surface height	m
14	STLT_ZNTH_ANGL	Satellite zenith angle	degrees
15	STLT_AZMH	Satellite azimuth	degrees
16	SOLR_ZNTH_ANGL	Solar zenith angle	degrees
17	SOLR_AZMH	Solar azimuth	degrees
18	AMSU_BRGTS_TMPR	) 20 AMSU-A 1-15	AMSU-A 1-15 b.temps
19	AVHRR_CLER_PIXL_FRCN	fraction clear pixels in HIRS FOV	%
20	IASI_FOV_QLTY_FLGS	FOV quality flags	flag tbl 025215
21	PRE_PRCSG_QLTY_FLAGS	Pre-processing quality flags	flag tbl 025214
22	GQIS_FLAG_QUAL	General quality flag	flag tbl xxxxxx
23	AMSU_SRFC_TYPE	Nearest AMSU surface type	code tbl 008205
24	SRFC_COST_FNCN	Surface cost function	numeric
25	SCTRG_INDX	Scattering index	numeric
26	EMSY_PMTR	) 10 Emissivity coefficient	numeric
27	STRT_CHNL	Start channel for scale factor	numeric
28	END_CHNL	End channel for scale factor	numeric
29	CHNL_SCAL_FCTR	Scale factor for radiances	numeric
30	SCLD_RDNC	Scaled IASI radiance	numeric
31	CHNL_SLCTN_VRSN_NMBR	Channel selection version	numeric

32	EGNR_VRSN_NMBR	Principal Component version	numeric
33	LOG10_NRMZD_PRNL_CMPT	Quality flag for rad reconstruction	numeric
34	MET_OFC_CLOD_TSTS	AAPP Cloud tests applied	flag tbl xxxxxx
35	MET_OFC_CLOD_FLGS	Results of AAPP Cloud tests	flag tbl xxxxxxSTLT_IDNY
36	YEAR	Year	year
37	MNTH	Month	month
38	DAY	Day	day
39	HOUR	Hour	hour
40	MINT	Minute	minute
41	SCND	Second	second
42	LTTD	Latitude	degrees
43	LNGD	Longitude	degrees
44	SCAN_LINE_NMBR	Scan line number	numeric
45	FOV_NMBR	Field of view number	numeric
46	SRFC_TYPE	Surface type	code tbl 008012
47	SRFC_HGHT	Surface height	m
48	STLT_ZNTH_ANGL	Satellite zenith angle	degrees
49	STLT_AZMH	Satellite azimuth	degrees
50	SOLR_ZNTH_ANGL	Solar zenith angle	degrees
51	SOLR_AZMH	Solar azimuth	degrees
52	AMSU_BRGTS_TMPR	) 20 AMSU-A 1-15	AMSU-B 1-5 b.temps
53	AVHRR_CLER_PIXL_FRCN	fraction clear pixels in HIRS FOV	%
54	IASI_FOV_QLTY_FLGS	FOV quality flags	flag tbl 025215
55	PRE_PRCSG_QLTY_FLAGS	Pre-processing quality flags	flag tbl 025214
56	GQIS_FLAG_QUAL	General quality flag	flag tbl xxxxxx
57	AMSU_SRFC_TYPE	Nearest AMSU surface type	code tbl 008205
58	SRFC_COST_FNCN	Surface cost function	numeric
59	SCTRG_INDX	Scattering index	numeric
60	EMSY_PMTR	) 10 Emissivity coefficient	numeric
61	STRT_CHNL	Start channel for scale factor	numeric
62	END_CHNL	End channel for scale factor	numeric
63	CHNL_SCAL_FCTR	Scale factor for radiances	numeric
64	SCLD_RDNC	Scaled IASI radiance	numeric
65	CHNL_SLCTN_VRSN_NMBR	Channel selection version	numeric
66	EGNR_VRSN_NMBR	Principal Component version	numeric
67	LOG10_NRMZD_PRNL_CMPT	Quality flag for rad reconstruction	numeric
68	MET_OFC_CLOD_TSTS	AAPP Cloud tests applied	flag tbl xxxxxx
69	MET_OFC_CLOD_FLGS	Results of AAPP Cloud tests	flag tbl xxxxxx

3. Processing for Aqua -AIRS :

Low spectral resolution sounders like ATOVS, with relatively few spectral bands, are being phased out by advanced high spectral resolution infrared sounders with thousands of narrow spectral bands (channels) for example IASI, CrIS etc. The Atmospheric Infrared Sounder (AIRS) is the first high spectral resolution infrared sounder data to be routinely distributed to Numerical Weather Prediction (NWP) Centers in near real-time – generally within 3 hours from observation. NOAA. NOAA receives raw AQUA data from EOS Data and Operations System (EDOS). Process AIRS, AMSU, and HSB data to Level 1B (calibrated and navigated), 35 GB of data per day. The data is then subjected to various types of thinning to get various Subset Level 1B (U1,U3,U6 etc) data and convert it to BUFR format to enable distribution on a timely basis. Send BUFR files to the NOAA/NESDIS Central Environmental Satellite Computer System (DDS) for distribution to the NWP centers. For NCUM U3 type BUFR files are used and this product contains an AIRS field of view (FOV) centered at every AMSU-A fov. These BUFR files received contain 324 AIRS channels with the warmest field in 2 X 2 pixels retained and 15 AMSU-A channels.

The following scripts are developed using AAPP to process the AIRS U3 type BUFR data and to encode it into UK Met. Office BUFR format. OPS can read this BUFR data directly and will process to create required VAR-OBS and VAR-cx type files by using elements list as given in Table 3.

Data processing script:

```
ProcessData()
{set -x
DATAIN=/gpfs1/home/prod/idata/DATA/${PDY}/radiance/HypSpec
ls -1 $DATAIN/*.S${Hour}*U3 >> $ListFile
DATAOUT=$HOME/GFS_UMPROD/data/bufr_app/ukmo.${PDY}/${CYC}
mkdir -p $DATAOUT
while read fl
do
  tot_numobs=`expr $tot_numobs + 1`
  /gpfs1/home/exp/gfs/nwprod/util/ush/cwordsh unblk $fl  BUFRFILE$tot_numobs
done < $ListFile
echo $tot_numobs >./BufrEncodeAIRS_1c.in
cp $FIXDIR/* .
cp TableD_NESDIS  LOCALSEQ
$EXECDIR/BufrEncodeAIRS_1c
```

```
mv AIRS_BUFR_OUT $DATAOUT/AIRS_${PDY}${CYC}_${Hour}.bufr
return
}

######################
set -x
date
STAMP=$1
CYC=$2
. $HOME/AAPP/AAPP_7_runtime/ATOVS_ENV7
. $HOME/AAPP/AAPP_7_runtime/ATOVS_CONF
export PATH=$PATH:$HOME/util
alias advday="$HOME/util/advday"
EXECDIR=/gpfs1/home/umprod/AAPP/airs/AIRS_Common_PreProc/src
FIXDIR=/gpfs1/home/umprod/AAPP/airs/AIRS_Common_PreProc/fix
WORKDIR=/gpfs1/home/temp/umprod/airswork
PDY=`advday /${STAMP} 0 yyyymmdd`
DATAOUT=$HOME/GFS_UMPROD/data/bufr_app/ukmo.${PDY}/${CYC}
rm -rf $WORKDIR
mkdir -p $WORKDIR
cd $WORKDIR
tot_numobs=-1

ListFile=AirsList.tmp
rm $ListFile
case $CYC in
  00)
     PDY=`advday /${STAMP} -1 yyyymmdd`
#    Hour=2[1-3]
     for Hour in 21 22 23; do
       tot_numobs=-1
       rm $ListFile
       ProcessData
     done
     PDY=`advday /${STAMP} 0 yyyymmdd`
#    Hour=0[0-2]
     for Hour in 00 01 02; do
       tot_numobs=-1
       rm $ListFile
       ProcessData
     done
    ;;
    ::
    ;;
  06)
     PDY=`advday /${STAMP} 0 yyyymmdd`
#    Hour=0[3-8]
     for Hour in 03 04 05 06 07 08; do
       tot_numobs=-1
       rm $ListFile
       ProcessData
     done
    ;;
  12)
     PDY=`advday /${STAMP} 0 yyyymmdd`
#    Hour=09
     for Hour in 09 10 11 12 13 14; do
```

```
        tot_numobs=-1
        rm $ListFile
        ProcessData
#      Hour=1[0-4]
     done
   ;;
  18)
     PDY=`advday /${STAMP} 0 yyyymmdd`
#      Hour=1[5-9]
     for Hour in 15 16 17 18 19 20; do
        tot_numobs=-1
        rm $ListFile
        ProcessData
#      Hour=20
     done
   ;;
esac
### Delete Blank Files. NK, 02aug2013.
cd $DATAOUT
find . -size 0c -exec rm {} \;

#ProcessData
exit
##########
##DATAOUT=$HOME/AAPP/bufr/ukmo.${PDY}
DATAOUT=$HOME/GFS_UMPROD/data/bufr_app/ukmo.${PDY}/${CYC}
mkdir -p $DATAOUT
##for fl in `ls -1 $1/*U3`
while read fl
do
  tot_numobs=`expr $tot_numobs + 1`
###ln -fs $fl   BUFRFILE$tot_numobs
  /gpfs1/home/exp/gfs/nwprod/util/ush/cwordsh unblk $fl  BUFRFILE$tot_numobs
done < $ListFile
echo $tot_numobs >./BufrEncodeAIRS_1c.in
cp $FIXDIR/* .
cp TableD_NESDIS  LOCALSEQ
$EXECDIR/BufrEncodeAIRS_1c
mv AIRS_BUFR_OUT $DATAOUT/AIRS_${PDY}${CYC}.bufr
exit
```

Job submitting Scripts

```
dstamp=$1   ########## <ddmmmyyyy>
cyc=$2     ########## <hh>
stamp=`$HOME/GFS_UMPROD/exec/advday /$dstamp 0 ddmmyyyy`
export PATH=$PATH:$HOME/util
cd $HOME/AAPP/jobs
AIRS_Decode.sh $stamp $cyc >$HOME/AAPP/log/AIRS_Decode_${dstamp}_${cyc}.log 2>&1
echo AIRS job over
exit
```

Table-3. The script files to process in given in appendix-B.

Element name	Element Description	Units
STLT_IDNY	Satellite Identifier	code tbl 001007
SOLR_ZNTH_ANGL	Solar zenith angle	degrees
SOLR_AZMH	Solar azimuth angle	degrees
YEAR	Year	years
MNTH	Month of year	months
DAY	Day of month	days
HOUR	Hour of day	hours
MINT	Minute of hour	minutes
SCND	Seconds of minute	seconds
LTTD	Latitude	degrees
LNGD	Longitude	degrees
STLT_ZNTH_ANGL	Satellite zenith angle	degrees
STLT_AZMH	Satelite azimuth angle	degrees
FOV_NMBR	Field of view number	numeric
CHNL_RPLTN_CONT	Number of AIRS Channels	numeric
START OF GROUP OF 3 ELEMENTS REPEATED 339 TIMES		
CHNL_NMBR	AIRS Channel number	numeric
BRGTS_TMPR	AIRS channel brightness temperature	kelvins
EMSY_PMTR	AIRS channel emissivity parameter	numeric
WATR_FRCN	AIRS field of view water fraction	numeric
MAIN_LAND_TYPE	AIRS field of view main land type	code tbl 008194
MAIN_LAND_TYPE_FRCN	AIRS fov main land type fraction	numeric
SRFC_HGHT	Surface Height	metres
AMSU_ZNTH_ANGL	AMSU satellite zenith angle	degrees
START OF GROUP OF 2 ELEMENTS REPEATED 15 TIMES		
AMSU_BRGTS_TMPR	AMSU channel brightness temperature	kelvins
AMSU_EMSY_PMTR	AMSU channel emissivity parameter	numeric

4. Processing of METOP-IASI :

The European Meteorological Satellite Agency (EUMETSAT) is distributing its global EPS products at different levels in near real-time via it's Data Distribution System (EUMETCast). It utilises the services of a satellite operator and telecommunications provider to distribute data files using Digital Video Broadcast (DVB) to a wide audience located within the geographical coverage zone which includes most of Europe and certain areas in Africa. A typical EUMETCast reception station comprises a standard PC with DVB card inserted and a satellite off-set antenna fitted with a digital universal V/H LNB. In addition, users require the multicast client software, which can be obtained via the EUMETSAT User Services. Products distributed on EUMETCast can be formatted in a variety of formats, including EPS native format and the WMO formats (BUFR and GRIB). West coast of India lies at the extreme edge of this broadcast. Space Application Center (SAC), Ahmedabad is maintaining one such reception station for receiving station and making it available to NCMRWF through its MOSDAC server (via NKN). Various radiance products of METOP sensors are available in this distribution. IASI full-spectrum BUFR files are available in the EUMETCast channel EPS-11 and have names such as ;-

W_XX-EUMETSATDarmstadt,SOUNDING+SATELLITE,METOPA+IASI_C_EUMP_*_eps_o_l1.bin

It is contains the IASI Principal Component stream, with the name in the form;.

W_XX-EUMETSATDarmstadt,SOUNDING+SATELLITE,METOPA+IASI_C_EUMP*eps_o_pcs_l1.bin

The AMSU and MHS files are available in the EUMETCast channels EPS-2 and EPS-8 respectively. These data sets (IASI, AMSU and MHS) are downloaded in real time and processed using AAPP. It involves decoding all three sensors data and thinning the IASI data spatially and spectrally and mapping AMSU and MHS to the IASI grid and finally re-code it as BUFR. As NCMRWF receiving data via MOSDAC, it faced difficulties in handling full spectrum data and started using Principal Component Stream. This is achieved by employing a reconstructed radiance generation step using AAPP tool iasi_reconstruct" before mapping. The use of the Principal component stream is unique to NCUM. The out put re-coded BUFR is compatible to NCUM OPS and it can process this BUFR using the element list as depicted in Table 4.

Table 4: Depicting IASI radiance data element file:

Element name	Element Description	Units
STLT_IDNY	Satellite Identifier	code tbl 001007
YEAR	Year	year
MNTH	Month	month
DAY	Day	day
HOUR	Hour	hour
MINT	Minute	minute
SCND	Second	second
LTTD	Latitude	degrees
LNGD	Longitude	degrees
SCAN_LINE_NMBR	Scan line number	numeric
FOV_NMBR	Field of view number	numeric
SRFC_TYPE	Surface type	code tbl 008012
SRFC_HGHT	Surface height	m
STLT_ZNTH_ANGL	Satellite zenith angle	degrees
STLT_AZMH	Satellite azimuth	degrees
SOLR_ZNTH_ANGL	Solar zenith angle	degrees
SOLR_AZMH	Solar azimuth	degrees
START OF GROUP OF 1 ELEMENTS REPEATED 20 TIMES(AMSU)		
AMSU_BRGTS_TMPR	20	b.temps
AVHRR_CLER_PIXL_FRCN	fraction clear pixels in HIRS FOV	%
IASI_FOV_QLTY_FLGS	FOV quality flags	flag tbl 025215
PRE_PRCSG_QLTY_FLAGS	Pre-processing quality flags	flag tbl 025214
GQIS_FLAG_QUAL	General quality flag	flag tbl xxxxxx
AMSU_SRFC_TYPE	Nearest AMSU surface type	code tbl 008205
SRFC_COST_FNCN	Surface cost function	numeric
SCTRG_INDX	Scattering index	numeric
START OF GROUP OF 1 ELEMENTS REPEATED 10 TIMES		
EMSY_PMTR	Emissivity coefficient	numeric
START OF GROUP OF 3 ELEMENTS REPEATED 10 TIMES		
STRT_CHNL	Start channel for scale factor	numeric
END_CHNL	End channel for scale factor	numeric
CHNL_SCAL_FCTR	Scale factor for radiances	numeric
START OF GROUP OF 1 ELEMENTS REPEATED 314 TIMES		
SCLD_RDNC	Scaled IASI radiance	numeric

Script for IASI Process :

```
export BUFR_TABLES=$AAPP_PREFIX/AAPP/data/bufrtables/
WORKDIR=/gpfs1/home/temp/vsprasad/IASIwork2
rm -rf $WORKDIR
mkdir $WORKDIR
cd $WORKDIR
#--------------------------------------
PDY=$1
#DATADIR=/gpfs1/home/prod/idata/MOSDAC/${PDY}
DATADIR=/scratch/ncmrtmp/john/BUFR/DATA
DATAOUT=${HOME}/AAPP/bufr
#orbitnum=$2
ls ${DATADIR}/IASI_L1/*eps_o_pcs_l1.bin | cut -d"_" -f7 | sort | uniq > Orbits
while read orbitnum; do
time1=`ls  ${DATADIR}/IASI_L1/*${orbitnum}* | cut -d"_" -f6 |head  -1`
time2=`ls  ${DATADIR}/IASI_L1/*${orbitnum}* | cut -d"_" -f6 |tail  -1`
echo $orbitnum $time1 $time2
cat                                                    $DATADIR/IASI_L1/W_XX-
EUMETSAT*${PDY}*${orbitnum}*eps_o_pcs_l1.bin >IASI.bufr
cat $DATADIR/AMSUA_L1/W_XX-EUMETSAT*${PDY}*${orbitnum}*eps_o_l1.bin
>AMSU.bufr
cat      $DATADIR/MHS_L1/W_XX-EUMETSAT*${PDY}*${orbitnum}*eps_o_l1.bin
>MHS.bufr
aapp_decodebufr_1c -i IASI.bufr   PCIASI  >./aapp_decodebufr_1c.iasi.out 2>&1
aapp_decodebufr_1c -i MHS.bufr   MHS  >./aapp_decodebufr_1c.mhs.out 2>&1
aapp_decodebufr_1c -i AMSU.bufr AMSU-A >./aapp_decodebufr_1c.amsu.out 2>&1
cp IASI.lpc iasi.lpc
mv AMSU.l1c aman.l1c
mv MHS.l1c  ambn.l1c
export ATOVPP_USE_RR=T
iasi_reconstruct iasi.lpc >iasi_reconstruct.out 2<&1
atovpp -i "AMSU-A MHS PCIASI" -g "IASI"
####BUFR encode the l1d file using Met Office sequence
rm *.bufr
#export BUFR_TABLES=/gpfs1/home/vsprasad/AAPP/metopa_20100128/bufrtables/
#export MASTER_TABLE=10
#export ORIGINATING_CENTRE=254
#export LOCAL_TABLE=1
#export ENHANCED_IASI=Y
#aapp_encodebufr_1c -i "iasi.l1d" IASI  >>aapp_encodebufr_1c.out 2>&1 || \
#   { echo "aapp_encodebufr_1c failed for iasi.l1d"; exit 1; }
###cp iasi.bufr $DATAOUT/iasil1d_${PDY}_${orbitnum}.bufr
export BUFR_LIBRARY=/gpfs1/home/vsprasad/AAPP/iasi/MetDB_BUFR18.0
#export MASTER_TABLE=10
#export ORIGINATING_CENTRE=254
#export LOCAL_TABLE=1
```

```
#export ENHANCED_IASI=Y
#aapp_encodebufr_1c -i "iasi.l1d" IASI  >>aapp_encodebufr_1c.out 2>&1 || \
#   { echo "aapp_encodebufr_1c failed for iasi.l1d"; exit 1; }
###cp iasi.bufr $DATAOUT/iasil1d_${PDY}_${orbitnum}.bufr
export BUFR_LIBRARY=/gpfs1/home/vsprasad/AAPP/iasi/MetDB_BUFR18.0
export ATOVS_ORIGIN=HRG
ln -sf iasi.l1d fort.11
ln -sf ${DATAOUT}/iasi.l1d_${orbitnum}_${time1}_${time2}.bufr fort.20
ln -sf $BUFR_LIBRARY/TABLED $WORKDIR/TABLED
ln -sf $BUFR_LIBRARY/TABLEB $WORKDIR/TABLEB
$HOME/AAPP/EncodeIASI_1d.exe >EncodeIASI_1d.out 2>EncodeIASI_1d.err
done < Orbits
```

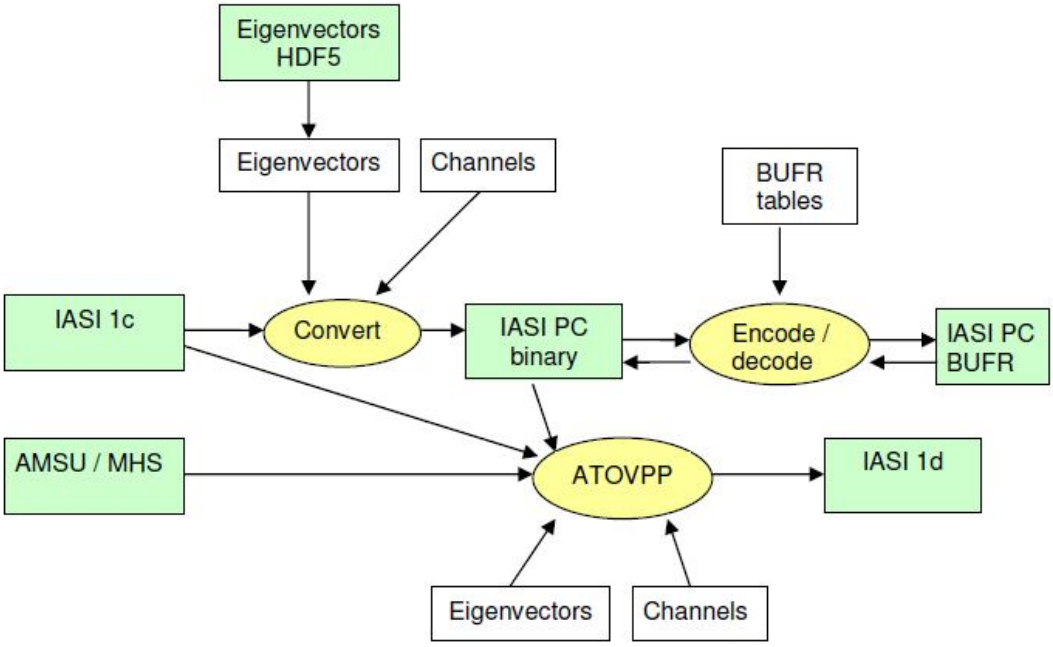

Figure 2: Processing steps for IASI radiance using AAPP.

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