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Description of Data Quality Control Flag Bits for Satellite Radiance Data BURP Files

Stephen Macpherson
Stephen.Macpherson@ec.gc.ca
Science and Technology Branch / MRD / ARMA

Version 1.2

October 2013

Revision history			
Version	Date	Author/modifications	Remarks
1.0	01/25/2011	S. Macpherson	First version
1.1	12/05/2012	S. Macpherson	Changes to AMSU data QC
1.2	10/23/2013	S. Macpherson	Made some updates/changes.

1. *Introduction*

This document describes how BURP file data quality control (QC) flag bits are used in the processing and QC of satellite radiance data for the CMC global data assimilation system. Bits in the QC flags contained in BURP file flag blocks are set by various programs at different stages of data preprocessing and in the "background check" prior to assimilation. The QC flag bits provide a way to identify data to be rejected for assimilation and also allow for identification of the reason(s) for the rejection.

Any proposed changes to the QC flag bit definitions given is section 2, or addition of new bits (bits 24-32 are currently not used), by research or development sections (ARMA, CMDA) must be approved by operations (CMOI).

2. *Data QC Flag Bit Definitions for Satellite Radiances*

Bit	Decimal	Meaning	Also Set	Programs that set bit
0	1	modified or generated by ADE		
1	2	exceeds climate extreme		
2	4	erroneous		
3	8	possibly erroneous		
4	16	doubtful		
5	32	interpolated		
6	64	bias corrected	**11** if OFF	bgck.satbcor
7	128	**AMSU,SSMIS**: data flagged for rejection by satellite QC for various reasons [1] **IA:** shortwave channel during day	**9** **IA: 11**	bgck.satqc_ssmis bgck.satqc_amsu(a/b) **IA:** 3DVAR (airsqc, iasiqc)
8	256	**IA**: unselected (blacklisted) channel		3DVAR (airsqc, iasiqc)
9	512	data rejected for assimilation due to failure of background check test [2]		bgck.ssmi_inovqc bgck.ssmis_inovqc bgck.satqc_amsu(a/b) **IA:** 3DVAR (airsqc, iasiqc)
10	1024	generated by analysis		
11	2048	**MW,GR**: unselected channel **MW**: thinned data; uncorrected data [3] **IA**: uncorrected data plus data flagged by satellite QC for rejection for other reasons [4]		bgck.ssmi_inovqc bgck.ssmis_inovqc bgck.satqc_amsu(a/b), bgck.tovsfilt **IA**: bgck.thinning1_{airs|iasi} **GR**: bgck.thinning1_csr
12	4096	data seen by analysis		3DVAR
13	8192	O-P rogue check failure level 1		
14	16384	O-P rogue check failure level 2		
15	32768	O-P rogue check failure level 3		
16	65536	O-P rogue check failure or any rejection based on O-P magnitude	**9**	bgck.ssmi_inovqc bgck.ssmis_inovqc bgck.satqc_amsu(a/b) **IA:** 3DVAR (airsqc, iasiqc)
17	131072	rejected by QC-Var		3DVAR
18	262144	**AMSU,SSMIS**: rejected over land due to higher topography (for sounding channels that "see" the surface in such cases) **GR**: rejected for topography	**9**	bgck.ssmis_inovqc bgck.satqc_amsu(a/b) **GR**: 3DVAR (sobscsbt)
19	524288	**IA**: rejected due to land/sea mask (surface)	**11**	3DVAR (airsqc, iasiqc)
20	1048576	aircraft TrackQC rejection		
21	2097152	**IA**: rejected due to transmittance (weighting function) above model top	**11**	3DVAR (airsqc, iasiqc)
22	4194304	QC Obs rejection		
23	8388608	**IA:** Cloud affected radiance	**11**	3DVAR (airsqc, iasiqc)

MW = **m**icro**w**ave = SSM/I, SSMIS, **AMSU** (AMSU-A, AMSU-B, MHS)
IA = **I**ASI, **A**IRS
GR = **G**eo**R**ad (CSR)

Data with QC flag bits in **bold** (8, 9 or 11) ON are currently rejected for assimilation by 3DVAR.

Light gray filled cells indicate data bits that could be set early on by ADE system in conversion of raw data files to derivate (or dbase) BURP files.

Yellow shaded cells indicate bits set by 3D-Var in analysis mode.

Data bits not applicable to satellite radiances are grayed out.

unselected = systematic rejection of data for a channel ("0" in UTIL column in satellite stats_* file)
uncorrected = data not corrected by *bgck.satbcor* program (bit 6 OFF)

[1] List of reasons for bit 7 ON for **AMSU** and **SSMIS**:
- **AMSU, SSMIS**: Tb gross error in any channel (all channels rejected)
- **AMSU, SSMIS**: cloud liquid water > threshold and/or precipitation detected (retrieved from Tb data), for imager channels and lower-peaking sounding channels with sensitivity in troposphere
- **AMSU, SSMIS**: land/sea-ice (surface sensitive channels)
- **SSMIS**: rain flag
- **AMSU-B/MHS, SSMIS**: dryness index (computed from Tb data)
- **AMSU, SSMIS**: scattering index (computed from Tb data), for imager channels and lower-peaking sounding channels with sensitivity in troposphere
- **AMSU**: bad orbit, invalid or inconsistent meta-data (terrain type, field of view, etc.)

[2] List of reasons for bit 9 ON (QC test failures):
- **AMSU, SSMIS, AIRS, IASI:** innovation (O-P) rogue check failure (bit 16 also set)
- **AMSU, SSMIS:** bit 7 ON [1]
- **AMSU, SSMIS,GeoRad:** topography (bit 18 also set)
- **AMSU, SSMIS:** rejected because O-P for another channel exceeds limit
- **AIRS, IASI**: Tb outside normal range (observed and simulated), data QC flags indicate bad or suspect Tb, bad Tb for another channel needed for profile cloud detection

[3] For **AMSU**, bit 11 is set in the QC program *bgck.satqc_amsu(a/b)* for
- unselected data (channel) or data from blacklisted satellite
- uncorrected data

Bit 11 is also set for data excluded by the thinning process in the program *bgck.tovsfilt* but the thinned data are removed from the output BGCKALT file.

[4] List of other reasons for bit 11 ON (besides uncorrected data) for **AIRS** and **IASI**:
- cloud affected radiance (also bit 23)
- surface affected radiance (also bit 19)
- transmittance above model top (also bit 21)
- shortwave channel during day (also bit 7)

It is important to note that:
- for **GeoRad** data, only QC flag bits 9, 11 and 18 are used. Bit 9 and 18 are set for data rejected for topography in 3D-Var (O-P mode). Bit 11 is set in *bgck.thinning1_csr* to flag data from unselected channels. Data that fail the various QC checks (uncorrected, cloud, topography, innovation rogue, etc.) in *bgck.thinning1_csr* are removed from the output thinned data BURP file (so no flag bits are set in these cases).
- for **SSM/I**, data rejected for "bit 7" reasons above[1] are removed early on by *bgck.process_ssmi*, the program that processes the raw dbase SSM/I data (in orbit format).

3. *Programs*

The following satellite radiance data processing programs and subroutines (s/r) set and/or check the data QC flag bits. These programs may need to be revised when modifications to the QC flag bit standard (given in the table in section 2) are mbgck. Only programs that are part of the conventional "dbase to bgckalt" processing stream for the global atmospheric upper air analysis system are considered. This list does not include programs used in other applications, such as monitoring or display of satellite radiance data, or in other systems (e.g., the sea-ice analysis system). Also not included are the programs used to create AMSU-(A/B), AIRS, IASI, and GeoRad derivate BURP files from raw/dbase data, where the ADE/dbase processing QC flag bits 0-3 could be set.

1. bgck.satqc_ssmis
2. bgck.satqc_amsua
3. bgck.satqc_amsub
4. bgck.ssmis_inovqc
5. bgck.ssmi_inovqc
6. 3D-Var: s/r airsqc (AIRS)
7. 3D-Var: s/r iasiqc (IASI)
8. 3D-Var: s/r sobscsbt (GeoRad)
9. bgck.thinning1_csr (GeoRad)
10. bgck.thinning1_airs (AIRS)
11. bgck.thinning1_iasi (IASI)
12. bgck.gen_table
13. bgck.satbcor
14. bgck.tovsfilt (AMSU-(A/B))
15. 3D-Var (analysis mode) – bits checked to reject data are specified with an array of reference numbers (parameter NLISTFLG) in the &NAMFILT section of the namelist file

All programs in this list set data bits in the radiance data QC flags (as indicated in the section 2 table) except for *bgck.gen_table* (12), a dynamic bias correction system program that checks bits in the data QC flags to select appropriate data for output to bias correction tables.

AIRS and IASI data processing is unique in that most of the data QC and background check for 3D-Var is done with special subroutines inside the 3D-Var program (6,7).

In the case of GeoRad, QC and thinning are combined in program *bgck.thinning1_csr* (9). The topography rejection is done by 3D-Var (8)

The SSMIS instrument contains channels that are similar to SSM/I, AMSU-A and AMSU-B. Thus, in the two SSMIS QC programs *bgck.satqc_ssmis* (1) and *bgck.ssmis_inovqc* (4)

- QC applied to SSM/I like channels is based on QC applied in SSM/I programs *bgck.process_ssmi* and *bgck.ssmi_inovqc* (5)
- QC applied to AMSU-like channels is based on QC applied in AMSU programs *bgck.satqc_amsua* (2) and *bgck.satqc_amsub* (3) (and *bgck.tovsfilt* (14))

There is an important difference between SSM/I and SSMIS data processing and QC. In the case of SSM/I, data rejected by the first SSM/I data processing program *bgck.process_ssmi* are removed by that program. For SSMIS, data that are rejected for similar reasons by *bgck.satqc_ssmis* (1) are retained in the data files but with the appropriate data QC flag bit set (bit 7).