TECHNICAL MEMORANDUM

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Software organisation of the variational analysis: Format of observations

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Abstract

In Technical Memorandum No. 150 (Pailleux, 1989), the scientific design of a variational analysis is documented, and especially the part dealing with the use of various observations. The present memorandum assumes that the reader is familiar with TM150. It documents some practical aspects of the software organization of a variational analysis on a super-computer. The main question which is addressed is the "observation structure" in both the central memory of the computer and the input observation file of the variational analysis. It covers aspects such as format, observation content and observation sorting.

This "observation structure" is presently used for the development of the variational analysis in the context of the "in-core system" at ECMWF and in the "ARPEGE" project in the French DMN. The same observation structure is used for the development of a new Optimum Interpolation scheme in France.

1. INTRODUCTION

The purpose of the variational analysis is to compute two cost functions, the distance of the model variable vector X to the observations (J_o) and the distance to a first guess vector X_g (J_g). In addition the variational analysis has to ensure some physical constraints on the analysed variables, such as the geostrophic assumption on the increments ($X-X_g$) like in the present OI analysis. The constraints are ensured either through a cost function Jc (weak constraint) or through some other technique. For more details see Pailleux (1989).

The cost functions J_o and J_g are generally two quadratic forms built on the observation and first-guess error covariance matrices O and P. They contain the departures of the model X from the observations (J_o) and from the first guess (J_g) respectively. We need to define the software specifications of the observations and their error covariance matrices, as well as the specifications of the forecast error statistics. The specifications of X and X_g are the ones of the in-core model.

In the in-core model, the computations of J_o, J_g (and perhaps J_c) will be performed in different parts of the analysis system and in completely independent ways.

For computing J_o we will process one or several sets of observations. The different sets of observations should be independent; "independent" meaning that the computation of J_o and its gradient for one set is independent of the other sets. Moreover, the multi-tasking should be done in such a way that the computations done in parallel should not touch the same components of the gradient with respect to the general model variable.

Observations are accessed by the variational analysis through a central memory array (CMA). Before the analysis an observation preprocessing program (PREOB) is run in order to create a file of observations in the CMA format.

2. STRUCTURE OF THE OBSERVATION FILES FOR THE VARIATIONAL ANALYSIS

The starting point for the observations in the variational analysis at ECMWF is a COF produced by the operational OI analysis. This has the advantage that all quality control and variable and level selection in the operational COF processing and OI analysis can be used. PREOB reads the COF and sorts the observations for each latitude band (model row) according to time slot and observation type. It then converts from COF format to the CMA format described in this document and selects the desired variables and the data which have been checked and used in the OI analysis. The observations with the selected data are then written to an output CMAFILE (see Fig. 1).

Two preliminary data description records (DDRs) contain the logistic information such as date, time as well as the lengths of the records corresponding to a row of observations (see Appendix A).

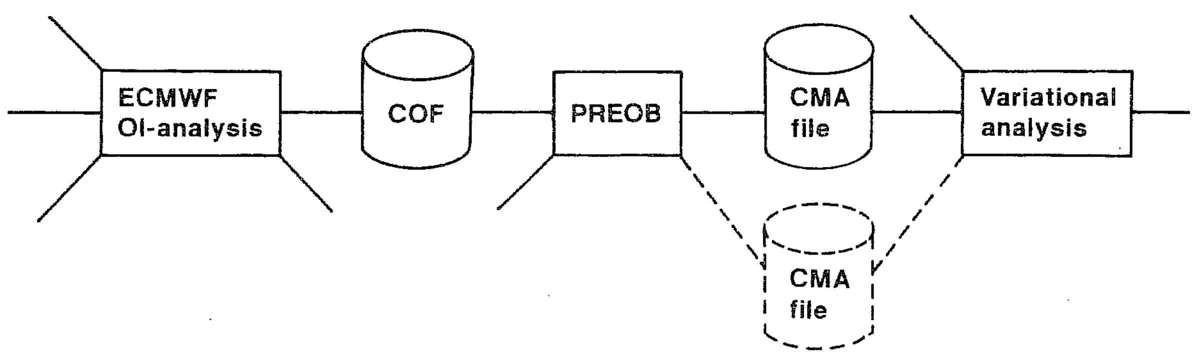

Fig. 1 Schematic organization of the preprocessing program PREOB and the variational analysis.

One main record of CMAFILE consists of the tables associated with N observations from the same time interval and for one latitude band (model row). A 4D-time slot is normally a one-hour period around each hour. It is meaningful only in the 4D runs; in the 3D-variational analysis there is only one.

If a switch in PREOB, LSPLOB, is set to TRUE the observations will be of one type only. Other observation types are read from different files CMAFILExx, where xx is a number depending on observation type and time slot. Otherwise, if LSPLOB=.FALSE. each record in CMAFILExx will contain all observation types in ascending observation type order for one latitude band.

The file CMAFILExx contains tables for each observation. The values are unpacked except for some time and type indicators which may be compressed in one integer. Only a few words contain site dependent flags set by decoding, OI analysis etc.. The format of CMAFILE is portable except that the meaning and packing of the site dependent words are specific to each site.

CMAFILExx is read by the variational analysis when the observations are transferred to a Central Memory Array (CMA). Different options are envisaged: CMA can be kept in memory throughout the assimilation or read time slot by time slot and optionally observation type by observation type at each iteration of the minimization scheme. For one given assimilation experiment the choice of the options will be driven by the memory size of the computer and by the observation volume.

3. FORMAT OF THE TABLE ASSOCIATED WITH EACH OBSERVATION

The basic structure of observations in the variational analysis is defined by a table associated with each observation. The format is derived from the COF structure of the present ECMWF analysis system (Haseler, 1988). The header associated with each observation is 15 words long, and the body (14 words long) is repeated N times (N = number of data used in the observation report). A full description with explanations of code and variable numbers can be found in Appendix B. Each parameter in the observation is accessed through a pointer variable giving the address relative to the beginning of the observation header or body. This makes the software flexible enough to allow further changes in the future. In the code the pointers in Appendix B are contained in COMMON blocks CMAHDR and CMABDY.

Compared to the COF structure the CMA format is somewhat simplified and information in COF needed only for the ECMWF OI analysis has been omitted. The main parts of the header and body have a portable format; the words are unpacked integers, reals or compressed integers (e.g. I1+100*I2). These parts are of a general nature and most words need to be used by any analysis system. The last words of the header and of the body contain site dependent information. Some originates from a Reports Data Base and other information is created during quality control and needs to be fed back into some data base. The information is usually in the form of flags and a large number of these are needed to describe properly the decisions and events for each datum and observation. These flags are usually packed. The packing can be binary or of the compressed integer type but the method of packing and the exact contents of these words are not deemed necessary to decide on in this document. The formats of the Reports Data Bases at the individual site determine the precise formats of the site dependent words.

One extra word (relative to COF) has been added in the body to store the representativeness error standard deviation as such in addition to the observation error standard deviation. (Currently no distinction is made and the representativeness error standard deviation can be put to zero, but in the future it will become more and more important to make the distinction).

4. CENTRAL MEMORY ARRAY (CMA)

Two main opertions are envisaged for keeping the observations in memory during the variational analysis. The first is to put all the observations in memory in the fully expanded form at the beginning of the assimilation and to keep them all the time. Alternatively (by switching LKEEPO from .TRUE. (default) to .FALSE.), the observations will be read from CMAFILE at each step of the minimization scheme, subset by subset. One subset corresponds to an ensemble of observations which can be used, independently of the rest, for the computation of the cost-function and its gradient.

4.1 OPTION 1: All the observations in memory

The observations are stored in an unpacked format in CMA, which is a 1-dimension array containing the sequence of the different observation tables. The sorting is the same as in CMAFILExx: first according to observation time slot, then according to latitude bands corresponding to the model rows, then according to observation type and finally according to the model boxes (longitude). (See Fig. 2).

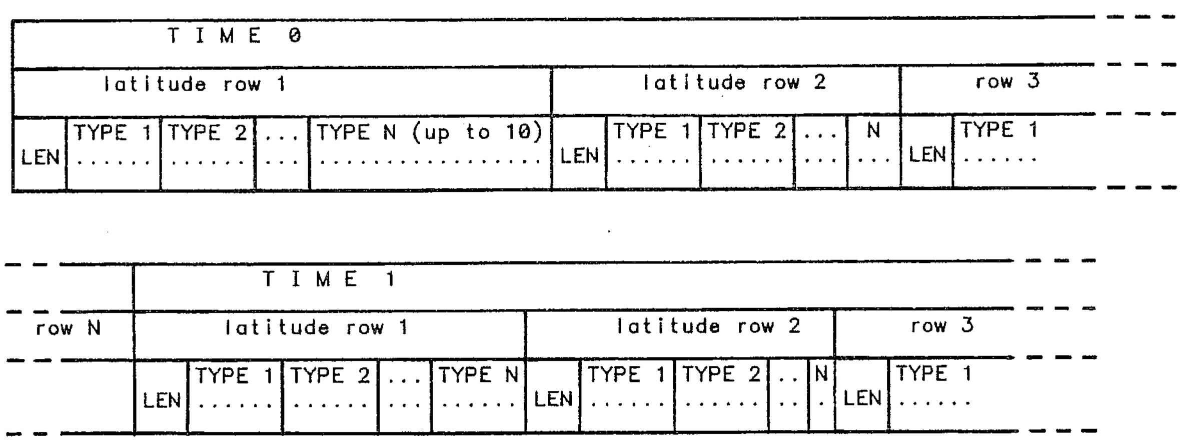

Fig. 2 Structure of CMA when all observations are in central memory.

4.2 OPTION 2: The observations are read at each iteration of the minimization scheme

The general structure of CMA is kept and all the management tables are initialized in the same way as option 1. But CMA will never contain more observations than from one 4D-time slot (and optionally only of one observation type at the time depending on LSPLOB). The CMA will not be kept after the end of the analysis and will be free for the minimization algorithm or for the forecast model and its adjoint in the 4D context. Fig. 3 shows the layout of the CMA for one time slot.

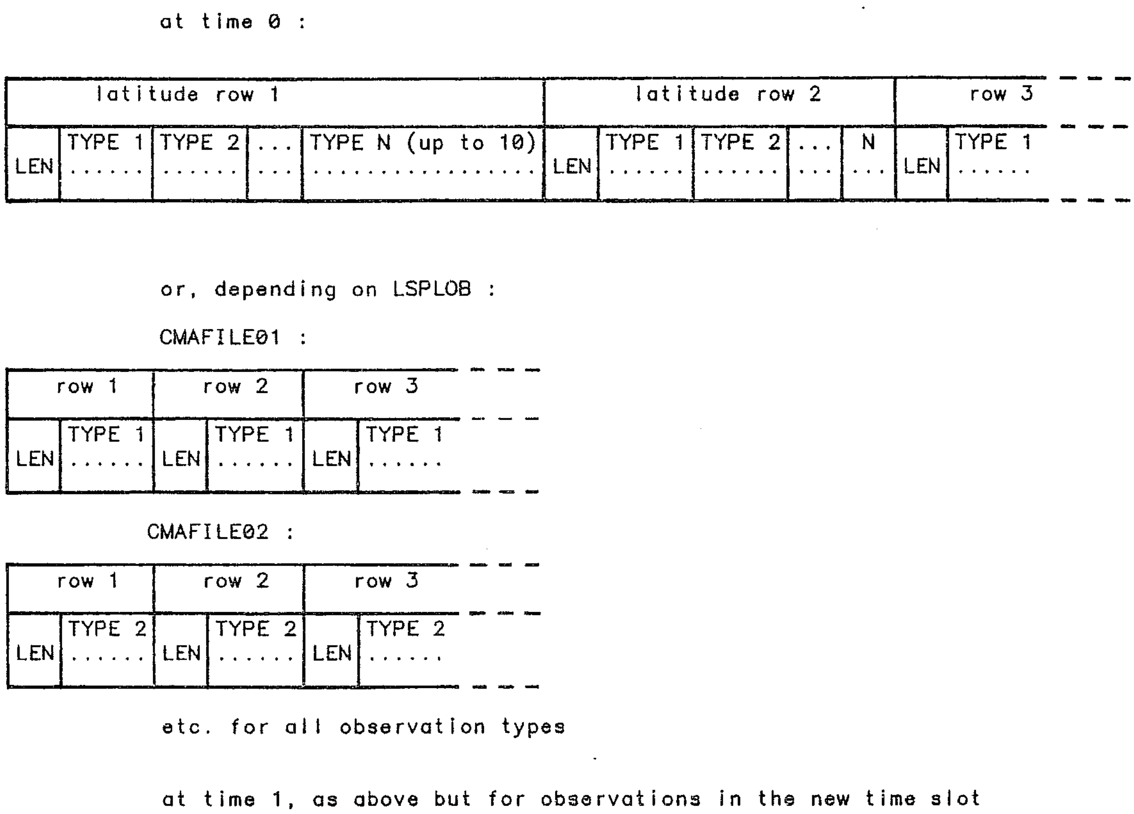

Fig. 3 Structure of CMA when only observations from one time slot and optionally of one observation type only are stored in central memory.

4.3 Which option to use

A rough estimation of the memory size needed for the CMA has been made. The first evaluation is based on the present operational system (OP89) with the maximum amount of observations typically available in a 6-hour period in 1989 (7000 SYNOP, 1000 AIREP, 400 DRIBU, 1500 SATOB, 200 PILOT, 700 TEMP and 6000 SATEM/TOVS). The second evaluation assumes a very large number of satellite data (HR SAT) (e.g. 80-120 km SATEM/TOVS or cleared radiances). These estimations are made both for a 3D-variational analysis with a 6 hour time window and for a 4D analysis with a 1 hour time slot.

	OPTION	OP89	HR SAT
3D 6hr	1 2	6	30
-"-	2 split by obs.type	2	13
4D 1hr	1	6	30
-"-	2	3	13
-"-	2 split by obs.type	2	2

Table 1. Estimated memory requirements in Mwords for the various options discussed in Section 4.2.

For the 3D 6hr application OPTION 2 is the same as OPTION 1 since there is no time stratification. The only memory saving is to stratify by observation type. In the 4D application OPTION 2 will save memory; the size is dependent on the time-slot with most observations. Splitting by observation type means a further saving, especially with high resolution satellite data.

4.4 Creation of Central memory Array

The observations are read into memory from one or more CMAFILEs (see Fig. 1). This is done only once in OPTION 1 or at each iteration in OPTION2 and for each observation type if the observations are split by type. Subroutines are provided which define the format of CMA and which read and optionally combine the CMAFILEs to one CMA. The subroutine REACMA in Appendix C serves this purpose and depending on its parameters performs the various functions depending on the options discussed previously.

When the observations are resident in memory subroutine SCANOB (see Appendix C) sets up some pointer arrays to facilitate the addressing of each observation and latitude band.

5. SUMMARY

The format of the observations for the variational analysis has been defined. A preprocessing software package, PREOB, has been written to extract and convert the format of the desired observations and variables from the Comprehensive Observation File (COF) originating from the ECMWF OI analysis. The result is written to one or more files which are read by the variational analysis program. The Central Memory Array (CMA) may contain all the observations or a subset if the central memory available proves to be too small.

REFERENCES

Haseler, J., 1988: ECMWF Data Assimilation Program Documentation. Research Manual 5. ECMWF Meteorological Bulletin M4.0/1, ECMWF, Shinfield Park, Reading, Berkshire RG2 9AX, England.

Pailleux, J., 1989: Design of a variational analysis: Organisation and main scientific points. Computation of the distance to the observations. Res.Dept. Tech.Memo. No. 150 23pp, ECMWF, Shinfield Park, Reading, Berkshire RG2 9AX, England.

APPENDIX A. Format of CMAFILE data description records.

FIRST CMA DDR FORMAT

WORD NO.	VARIABLE	TYPE	MEANING
1	NCD1LN	I	LENGTH OF FIRST COF DDR
2	NCD1IL	I	LENGTH OF INTEGER SECTION
3	NCD1NL	I	LENGTH OF NEXT COF DDR
4	NCD1NI	I	NO. OF NON-INTEGER SECTIONS
5	NCD1TY	I	TYPE OF NON-INTEGER SECTION
6	NCD1P1	I	WORD NUMBER OF FIRST WORD OF NEXT SECTION
7	NCD1CT	I	CREATION TIME OF DDR (HHMMSS)
8	NCD1CD	I	CREATION DATE OF DDR (YYMMDD)
9	NCD1OT	I	OBSERVATION TIME (TIME OF MIDDLE OF OBSERVATION PERIOD)
10	NCD1OD	I	OBSERVATION DATE (DATE OF MIDDLE OF OBSERVATION PERIOD)
11	NCD1NS	I	NO. OF SECONDS PER OBSERVATION TIME UNIT (MINUTE)
12	NCD1OP	I	LENGTH OF OBS. PERIOD IN TIME UNITS
13	NCD1FT	I	FIRST GUESS TIME (HHMMSS)
14	NCD1FD	I	FIRST GUESS DATE (YYMMDD)
15	NCD101	I	UNUSED WORD
16	NCD1ND	I	NO. OF DDRS
17	NCD1DR	I	NO. OF DATA RECORDS (= NO. OF RECORDS AFTER THE DDRS)
18	NCD1LD	I	MAX. LENGTH OF DDRS
19	NCD1MR	I	MAX. LENGTH OF DATA RECORD
20	NCD1RM	I	MAX. LENGTH CMA REPORT
21	NCD1NR	I	MAX. NO. OF DATA RECORDS
22	NCD1SL	I	NEXT FREE SLOT NUMBER FOR BACKGROUND FIELD DEPARTURE VALUE IN CMA REPORT BODY
23 -NMXDCL(512)	NOT YET DEFINED		

SECOND CMA DDR FORMAT

WORD NO. /	VARIABLE /	TYPE /	MEANING /
1	NCD2LN	I	LENGTH OF SECOND COF DDR
2	NCD2IL	I	LENGTH OF INTEGER SECTION
3	NCD2NL	I	LENGTH OF NEXT DDR
4	NCD2NI	I	NO. OF NON-INTEGER SECTIONS
5	NCD2T1	I	TYPE OF FIRST NON-INTEGER SECTION
6	NCD2T2	I	TYPE OF SECOND NON-INTEGER SECTION
7	NCD2P1	I	FIRST WORD OF FIRST NON INTEGER SEC.
8	NCD2P2	I	FIRST WORD OF SECOND NON INTEGER SEC.
9	NCD2TB	I	FIRST WORD OF TABLE GIVING THE DATA RECORD LENGTHS (SEE BELOW)
10	NCD2TL	I	NO. OF CLEAR SATEM THICKNESS LAYERS
11	NCD2TY	I	NO. OF CLOUDY SATEM THICKNESS LAYERS
12	NCD2TM	I	NO. OF MICROWAVE SATEM THICKNESS LAYERS
13 -30	NOT DEFINED		
NCD2TB -NCD2TB+NLATM		I	TABLE OF CMA RECORD LENGTHS WHERE NLATM IS THE NUMBER OF MODEL LATITUDES OR ROWS
NCD2P1 -NMXDCL(512)	NOT YET DEFINED		

APPENDIX B. Format of observations in CMA/CMAFILE

CMA REPORT HEADER FORMAT (OBSERVATION PART)

WORD NO./	VARIABLE /	TYPE /	MEANING /
1	NCMRLN	I	RECORD (REPORT) LEN.
2	NCMONM	I	OBSERVATION NUMBER (UNIVERSAL)
3	NCMBOX	I	MODEL GRID BOX
4	NCMOTP	I	OBSERVATION TYPE
5	NCMITY	IC	CODE, INSTRUMENT SPEC CODE AND RETRIEVAL TYPE (CODE TYPE + 1000*INSTRUMENT SPECIFICATION CODE + 1000000*RET TYPE)
6	NCMLAT	R	OBSERVATION LAT. IN RADIANS (NORTH POSITIVE)
7	NCMLON	R	OBSERVATION LON. IN RADIANS (EAST POSITIVE)
8	NCMDAT	IC	DATE AND SYNOPTIC TIME OF OBSERVATION (YYMMDDHHMM
9	NCMETM	IC	EXACT TIME OF OBSERVATION (YYHHMM)
10	NCMSID	I	STATION IDENTIFIER (HOLLERITH STRING)
11	NCMALT	R	STATION ALTITUDE
12	NCMNLV	I	NUMBER OF DATA (VARIABLES AND LEVELS)
13	NCMOEC	I	ERROR CORRELATION TYPE
14	NCMOFL	IP	REPORT FLAGS (RDB) (PACKED) (SITE DEPENDENT)
15	NCMST1	IP	REPORT STATUS (PACKED) (SITE DEPENDENT)

CMA REPORT BODY FORMAT

WORD NO. /	VARIABLE /	TYPE /	MEANING /
1	NCMVNM	I	VARIABLE NUMBER
2	NCMPPP	R	PRESSURE (OR OTHER VERTICAL COORDINATE)
3	NCMPRL	R	REFERENCE LEVEL PRESSURE
4	NCMPOB	IP	ORIGINAL REPORTED VERTICAL COORDINATE AND ITS FLAGS
5	NCMVAR	R	VALUE OF VARIABLE
6	NCMOMF	R	OBSERVED VALUE - FIRST GUESS VALUE
7	NCMOMA	R	OBSERVED VALUE - ANALYSED VALUE
8	NCMOMI	R	OBSERVED VALUE - INITIALISED VALUE
9	NCMOMN	R	OBSERVED VALUE - ITERATION N VALUE
10	NCMOER	R	OBSERVATION ERROR STANDARD DEVIATION
11	NCMRER	R	REPRESENTATIVENESS ERROR STANDARD DEVIATION
12	NCMFGE	R	FIRST GUESS ERROR STANDARD DEVIATION
13	NCMPER	R	PERSISTENCE ERROR STANDARD DEVIATION
14	NCMFLG	IP	FLAGS (PRESS., LEV. IND., VARIAB.)(SITE DEP)

*) TYPE I = Integer number in word
R = Real number in word
IC = Compressed integer in word (e.g. IA+100*IB+10000*IC)
IP = Integer with bit packed information

**) Units are SI-units unless otherwise stated.

OBSERVATION TYPE NUMBERS

VARIABLE /	VALUE /	MEANING /
NSYNOP	1	SYNOP
NAIREP	2	AIRCRAFT REPORTS
NSATOB	3	SATOB REPORTS
NDRIBU	4	DRIBU REPORTS
NTEMP	5	TEMP REPORTS
NPILOT	6	PILOT REPORTS
NSATEM	7	SATEM AND CLOUD CLEARED RADIANCES
NPAOB	8	PAOB REPORTS
NSCATT	9	SCATTEROMETER REPORTS
NRAWRA	10	RAW RADIANCES

CODE TYPE NUMBERS

VARIABLE /	VALUE /	MEANING /
NSRSCD	11	SYNOP SURFACE REPORT
NATSCD	14	AUTOMATIC SYNOP SURFACE REPORT
NSHSCD	21	SHIP SYNOP REPORT
NABSCD	22	SHIP SYNOP ABBREVIATED REPORT
NSHRED	23	SHRED REPORT
NATSHS	24	AUTOMATIC SHIP SYNOP REPORT
NAIRCD	141	AIRCRAFT REPORT
NCODAR	41	CODAR REPORT
NCOLBA	241	COLBA REPORT
NSTBCD	88	SATOB REPORT
NSST	188	SST REPORT
NDRBCD	165	DRIBU REPORT
NBATHY	63	BATHY REPORT
NTESAC	64	TESAC REPORT
NLDTCD	35	LAND TEMP REPORT
NSHTCD	36	TEMP SHIP REPORT
NTDROP	135	TEMP-DROP REPORT
NROCOB	39	ROCOB REPORT
NROCSH	40	ROCOB SHIP REPORT
NLDPCD	32	LAND PILOT REPORT
NSHPCD	33	SHIP PILOT REPORT
NSTMCD	86	GTS SATEM REPORT
NSTOVS	186	250 KM RESOLUTION SPECIAL FORMAT SATEM ("TOVS")
NPABCD	180	PAOB REPORT
NGTSTB	200	GTS BUFR SATEM REPORT (250 KM TEMP AND HUM PROFILES)
NGTST1	201	GTS BUFR SATEM CLEAR RADIANCE REPORT
NGTST2	202	GTS BUFR SATEM RETR PROFILES AND CLEAR RADIANCE REPORT
NGTHRB	210	HIGH RES 80 KM BUFR NON GTS SATEM RETR PROFILES
NGTHR1	211	HIGH RES 80 KM BUFR NON GTS SATEM CLEAR RADIANCE REPORT
NGTHR2	212	HIGH RES 80 KM BUFR NON GTS SATEM PROFILES AND CLEAR RADIANCE REPORT

INSTRUMENT SPECIFICATION CODE

See ECMWF DATA ASSIMILATION PROGRAM DOCUMENTATION,
ECMWF Research Manual 5, edited by J. Haseler.

RETRIEVAL TYPE

The retrieval type in word 5 of the CMA header of a SATEM report is an integer number which summarizes all the information coded in different parts of the SATEM code (such as the A and B parameters).

At present (1989) the values are:

1 = clear retrieval

2 = partly cloudy

3 = microwave.

The number of retrieval types may increase in the future and the table defined here will then be expanded.

FLAG BIT PATTERNS

WORD NO. /	VARIABLE /	TYPE /	MEANING /
NCMPOB	NPPOBP	I	BIT POSITIONS FOR RDB PRESS./GEOP.
"	NPPOOC	I	NO. OF BITS OCC. BY RDB PRESS./GEOP.
"	NPFOBP	I	BIT POSIT. FOR RDB PRESS./GEOP. FLAG
"	NPFOOC	I	NO. OF BITS OCC. BY RDB PRESS./GEOP. FLAG
NCMFLG	NFDBBP	I	BIT POSITIONS FOR RDB FLAGS
"	NFDBOC	I	NO. OF BITS OCC. BY RDB FLAGS RDB FLAGS ARE MADE OF: -PRESSURE FLAGS -VARIABLE FLAGS -LEVEL ID/PRESSURE CODE
"	NPDBBP	I	BIT POS. FOR PRESSURE FLAG
"	NPDBOC	I	NO. OF BITS OCC. BY PRESS. FLAG
"	NVDBBP	I	BIT POS. FOR VARIABLE RDB FLAG
"	NVDBOC	I	NO. OF BITS OCC. BY VARIABLE FLAG
"	NCFBPS(7)	I	BIT PATTERN FOR PRESSURE/VARIABLE FLAG: HUMAN SUBSTITUTION QUALITY CONTROL SUBSTITUTION OVERIDE FLAG FLAG RAISED BY QC/HUMAN MONITOR CONFIDENCE USED BY PREVIOUS ANALYSIS
"	NINLBP	I	BIT POS. FOR LEVEL ID
"	NINLOC	I	NO. OF BITS OCC. BY LEVEL ID
"	NLIDPT(9)	I	LEVEL ID BIT PATTERN
"	NLIDPO	I	NO. BITS OCC. BY EACH INDICATOR IN LE ID BIT PATTERN
"	NCDPBP	I	BIT POS. FOR PRESS. CODE, IF SYNOP
"	NCDPOC	I	NO. OF BITS OCC. BY PRESS. CODE -LEVEL ID (BIT PATTERN)/PRESSURE CODE LEVEL ID MAX. WIND LEVEL TROPOPAUSE D PART C PART B PART A PART SURFACE LEVEL SIGNIFICANT WIND LEVEL SIGNIFICANT TEMPERATURE LEVEL PRESSURE CODE 0 - SEA LEVEL 1 - STATION LEVEL PRESSURE

			2 - 850MB LEVEL GEOPOTENTIAL
			3 - 700MB LEVEL GEOPOTENTIAL
			4 - 500GPM LEVEL PRESSURE
			5 - 1000GPM LEVEL PRESSURE
			6 - 2000GPM LEVEL PRESSURE
			7 - 3000GPM LEVEL PRESSURE
			8 - 8000GPM LEVEL PRESSURE
			9 - 900MB LEVEL GEOPOTENTIAL
			10- 1000MB LEVEL GEOPOTENTIAL
			11- 500MB LEVEL GEOPOTENTIAL
"	NDACBP	I	BIT POS. OF "DATUM ACTIVE" INDIC.
"	NDACOC	I	NO. OF BITS OCC. BY "DATUM ACTIVE"
"	NDPSBP	I	BIT POS. OF "DATUM PASSIVE" INDIC.
"	NDPSOC	I	NO. OF BITS OCC. BY "DATUM PASSIVE"
"	NDRJBP	I	BIT POS. OF "DATUM REJECTED" INDIC.
"	NCDPOC	I	NO. OF BITS OCC. BY PRESS. CODE
"	NFGFBP	I	BIT POS. FOR "FIRST GUESS CHECK" FLAG
"	NFGFOC	I	NO.OF BITS OCC. BY" FIRST GUESS CHECK
"	NDPFBP	I	BIT POS. FOR BY "DEPATURE CHECK" FLAG
"	NDPFOC	I	NO. OF BITS OCC. BY "DEPARTURE CHECK"
"	NFNFBP	I	BIT POS. FOR "FINAL FLAG"
"	NFNFOC	I	NO. OF BITS OCC. BY "FINAL FLAG"
"	NCHKBP	I	BIT POS. FOR "CHECK DONE" INDIC.
"	NCHKOC	I	NO. OF BITS OCC. BY "CHECK DONE"
"	NSOBBP	I	BIT POS. FOR "SUP.OB" INDIC.
"	NSOBOC	I	NO. OF BITS OCC. BY "SUP.-OB"
"	NDEVBP	I	BIT POS. FOR DATUM EVENTS (25 OF THEM)
"	NDEVOC	I	NO. OF BITS OCC. BY EACH DATUM EVENT

VARIABLE NUMBERS

VARIABLE /	TYPE /	MEANING /
NVNUMB(53)	I	
		NVNUMB (1) = 3 (U COMPONENT)
		" (2) = 4 (V COMPONENT)
		" (3) = 1 (GEOPOTENTIAL IN J/KG)
		" (4) =57 (THICKNESS IN J/KG)
		" (5) =29 (RELATIVE HUMIDITY IN RANGE 0-1)
		" (6) = 9 (PRECITABLE WATER CONTENT IN KG/M**2)
		" (7) =58 (SYNOP BOGUS REL. HUM.)
		" (8) = 2 (TEMPERATURE)
		" (9) =59 (DEW-POINT)
		" (10) =39 (2M TEMPERATURE)
		" (11) =40 (2M DEW-POINT)
		" (12) =11 (SURFACE TEMPERATURE)
		" (13) =30 (PRESSURE TENDENCY PA/S)
		" (14) =60 (W) (FROM WMO OBSERVATION CODE)
		" (15) =61 (WW) -"-
		" (16) =62 (VV) -"-
		" (17) =63 (CH IN OCTAS) -"-
		" (18) =64 (CM IN OCTAS) -"-
		" (19) =65 (CL IN OCTAS) -"-
		" (20) =66 (NH) -"-
		" (21) =67 (NN) -"-
		" (22) =68 (HSHS) -"-
		" (23) =69 (C) -"-
		" (24) =70 (NS) -"-
		" (25) =71 (S) -"-
		" (26) =72 (E) -"-
		" (27) =73 (TGTG) -"-
		" (28) =74 (SPSP) -"-
		" (29) =75 (SPSP) -"-
		" (30) =76 (RS) -"-
		" (31) =77 (ESES) -"-
		" (32) =78 (IS) -"-
		" (33) =79 (TRTR) -"-
		" (34) =80 (RR) -"-
		" (35) =81 (JJ) -"-
		" (36) =82 (VS) -"-
		" (37) =83 (DS) -"-
		" (38) =84 (HWHW) -"-
		" (39) =85 (PWPW) -"-
		" (40) =86 (DWDW) -"-
		" (41) =87 (GENERAL CLOUD GROUP)
		" (42) =88 (RH FROM LOW CLOUDS)
		" (43) =89 (RH FROM MIDDLE CLOUDS)

"   (44) =90 (RH FROM HIGH CLOUDS)
"   (45) =91 (TOTAL AMOUNT OF CLOUDS)
"   (46) =92 (SNOW FROM RAIN INFORM))
"   (47) =110 (PRESSURE (VERT COORDINATE = Z))
"   (48) =111 (DD (WIND DIRECTION IN RADIANS))
"   (49) =112 (FF (WIND SPEED))
"   (50) =119 (CLEAR RADIANCE (BRIGHTNESS TEMPERATURE IN K))
"   (51) =120 (RAW RADIANCE)
"   (52) =121 (CLOUD AMOUNT (FROM SATELLITE, RANGE 0-1))
"   (53) =122 (SCATTEROMETER DATA (SIGMA0 or U*))

**) Units are SI-units unless otherwise stated for the physical variables. When the variable is a directly extracted from the WMO observation code (e.q. WW, VV, CLs etc.) the value of the WMO code is reproduced.

APPENDIX C. Subroutines for setting up CMA

1. SUBROUTINE REACMA

CALL REACMA(ICMNUM,IADDR)

where ICMNUM is the CMAFILE number (xx in CMAFILExx)
= IOBTYP + (ITIMSL-1)*NOBTYP
where
IOBTYP is observation type required and
ITIMSL is the 4D time slot required
if observations split by time AND observation type

or ITIMSL if split by time slot only.

and IADDR is the address of the first word of the CMA record read in (n.b. the first word in the CMA array always contains the current length of the CMA record)

The observation types considered are listed in Appendix B.

2. SUBROUTINE GETCMA

REACMA reads each record in CMAFILExx by calling subroutine GETCMA:

CALL GETCMA(KADDR,ICHECK,IOBROW,KCMNUM)

where KADDR is IADDR passed from REACMA above
ICHECK is an I/O check parameter and
IOBROW is the row/record number
KCMNUM is ICMNUM passed from REACMA above.

The output from REACMA is an array (CMA) filled with all observations contained in one CMAFILE.

3. SUBROUTINE SCANOB

Subroutine SCANOB scans the observations in CMA and sets up all pointers needed to access individual observations in a convenient way.

MOBPNT(NMXOBS) = pointer in CMA for each consecutive observation; CMA(1) is the length of the CMA record; CMA(MOBPNT(INOBS)+NCFRLN) is the first word of observation number INOBS. (NCFRLN = 1 and points to the word in the CMA header containing the length of the observation)

NMXOBS = maximum number of observations (dimensioning)

MFIOBN(NMXLAT+1,NMXTYP,NMXTIM) = first observation for each latitude, observation type and 4D-time slot

MLAOBN(NMXLAT,NMXTYP,NMXTIM) = last observation for each latitude, observation type and 4D-time slot (not strictly necessary but useful in the case that the originating COF has been created with a different model/model resolution) With the aid of these pointers the observations can be accessed one by one by just updating a pointer ICURPO=MOBPNT(INOBS) and then extract information from the observation table by using the pointers defined in COMMON blocks CMAHDR and CMABDY for the observation header and body respectively.