NORTH ATLANTIC TREATY ORGANISATION
(NATO)

ADDITIONAL MILITARY LAYERS
ATMOSPHERIC AND METEOROLOGICAL CLIMATOLOGY
PRODUCT SPECIFICATION

Version No. 1.0, 3 November 2004

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CONTENTS

1 INTRODUCTION

1.1 SCOPE

The main body of this Product Specification describes the content and defines the data dictionary of the Additional Military Layers: Atmospheric and Meteorological Climatology (AML AMC) product, independent of any exchange standard data format. The schema and data format imposed by the chosen exchange standard implementation are defined in separate annexes (where provided).

It has been prepared in accordance with the draft NATO STANAG 4564, Performance Standards for Warship Electronic Chart Display and Information System (WECDIS) Data Products, and is based on the proposed Common Product Specification Framework which is contained as Annex B to the draft STANAG.

The AML AMC Product Specification is designed to facilitate the encoding of the following components:

- Surface (meteorological) climatology at sea level and above the sea, also over land surfaces, at one or more fixed grid points
- Upper air (atmospheric) climatology above sea and land at one or more fixed grid points

The AML AMC Product is intended to be used in the planning stages of military or civil operations, either at sea, in the air or over land. It does not contain any information about the actual sea or land surface.

1.2 GENERAL INFORMATION ON THE PRODUCT SPECIFICATION

1.2.1 Version Number

The Version Number is 1.0.

1.2.2 Date of Issue

The Date of Issue is 03 November 2004.

1.2.3 Custodian of the Product Specification

The Custodian of this specification is United Kingdom Hydrographic Office.

United Kingdom Hydrographic Office
Admiralty Way
Taunton
Somerset
TA1 2DN
United Kingdom

Telephone: +44 (0)1823 337900
Fax: +44 (0)1823 284077
E-mail: brian.parish@ukho.gov.uk

1.2.4 Relevant STANAG Number

STANAG 7170 Additional Military Layers (AML)

1.3 STATUS OF THE PRODUCT SPECIFICATION

This product specification has been endorsed by the Ad Hoc Hydrographic Working Group of the NATO Geographic Conference and is subject to the change control procedures implemented by that group.

1.4 SECURITY

1.4.1 Security Classification of the Specification

The Product Specification is UNCLASSIFIED

1.4.2 Security Classification of the Product

AML AMC can be issued at various security classification levels according to content. However, most basic products will be UNCLASSIFIED. AML AMC products of differing security levels (specified at the dataset level by the 'Protective Marking' and 'National Caveat(s)' details) are physically partitioned.

The table below, common to all AML products, defines how AML AMC security classification information must be described at a dataset level (see section 5.3.1).

Dataset Security Classification Information	Values
International Defence Organisation (IDO) status (see note)	- North Atlantic Treaty Organisation (NATO) - North Atlantic Co-operation Council (NACC) - Partnership for Peace (PfP) - Western European Union (WEU)
Protective Marking	- COSMIC TOP SECRET - FOCAL TOP SECRET

	- TOP SECRET - SECRET - CONFIDENTIAL - RESTRICTED - UNCLASSIFIED
Owner Authority	e.g. UK, US
Caveat (see note)	e.g. UK/US Eyes only

Note:
International Defence Organisation (IDO) markings and caveats are mutually exclusive. If the data has an IDO status, then the caveat is not applicable. Additionally, caveats only apply to data that has an IDO/Protective Marking of CONFIDENTIAL or above.

AML AMC security information may also be encoded at the following levels in a dataset:

- meta information (see section 5.5.1)

1.4.3 Copyright Statement

Producers of AML datasets must ensure that:

- the Intellectual Property Rights of those owning the information that has been used for production of the AML product is not compromised.
- sufficient mechanisms are put in place to ensure that material is not copied either in whole or part, except as specifically required within the host system, without prior agreement of the data producer and any other copyright holders

Copyright statements should be shown at the following locations:

- on the product label
- on the product packaging
- within the product

1.5 CONTENTS OF THE DOCUMENT

The AML AMC Product Specification conforms to the Common Product Specification Framework (CPSF) specified in NATO STANAG No. 4564, Performance Standards for Warship Electronic Chart Display and Information System (WECDIS), Edition 1, Annex B, Data Products.

In accordance with the CPSF, the AML AMC Product Specification defines the real-world entities and metadata required for the production and use of the product.

This Product Specification is divided into the following sections:

- Introduction (section 1)
- General Product Description (section 2)
- General Data Description (section 3)
- Data Structure (section 4)
- Data Dictionary (section 5)
- Data Capture Guide-lines (section 6)
- Data Presentation (section 7)
- Provision of Data (section 8)
- Testing Method (section 9)

Also included, as annexes to the product specification, are details of the implementation using the relevant exchange standard(s).

Each annex (if included) is identified as follows:

- AML AMC Grib Implementation (ANNEX A)

A cross-reference box (an example of which is shown below) will be included for instances when there are relevant details in one or more of the implementation annexes. The box should contain the reference to the annex section number.

ANNEX A	A. EXAMPLE

1.6 REFERENCES

The following standards and specifications affect the content of this Product Specification.

1.6.1 Standards

NATO STANAG 1059

(Edition 6)	Distinguishing Letters for Geographical Entities for use in NATO.
NATO STANAG 2211	Geodetic Datums, Ellipsoids, Grids & Grid References.
NATO STANAG 4564	Standard for Warship Electronic Chart Display and Information System (WECDIS), Edition 1, Annex B, Data Products.
NATO STANAG 7170	Additional Military Layers (AML) – Digital Geospatial Data Products.
WMO FM92-VIII	Standard for general purpose, bit-oriented data exchange format GRIB (GRIdded Binary) from publication 306, Manual on Codes Vol 1, Part B plus supplements 1-3.
ISO 8859	Information processing - 8-bit single-byte coded graphic character sets Part 1: Latin alphabet No.1
ISO 9660	Information Processing - Volume and File Structure of CD-ROM for Information Interchange.
ANSI/IEEE 802.3	IEEE Standards for Local Area Networks, Carrier Sense Multiple Access with Collision Detection (CSMA/CD)Access Method and Physical Layer Specifications
ISO/IEC 10646	Information technology - Universal Multiple-Octet Coded Character Set (UCS) Part 1: Architecture and Basic Multilingual Plane

1.6.2 Specifications

N/A

1.6.3 Other References

AML	Object and Attribute Catalogue

1.7 DEFINITIONS

AML	**AML is a unified range of digital geospatial data products designed to satisfy the totality of NATO non-navigational maritime defence requirements.**
ERA	**European Centre for Medium Range Weather Forecasting (ECMWF) Re-Analysis Project**
WMO	**World Meteorological Organisation**
GRIB	**GRIdded Binary**
NCEP	**National Centre for Environmental Prediction**

1.8 KEY WORDS

AML

AMC

PRODUCT SPECIFICATION

1.9 MAINTENANCE AND SUPPORT OF THE PRODUCT SPECIFICATION

Specific processes and mechanisms that are established for the maintenance of AML Product Specifications are described in the sections 1.9.1 to 1.9.6 below.

1.9.1 Frequency of Review

The AML AMC Product specification (version 1.0) will be frozen for a period of 2 years following endorsement.

1.9.2 Method of Maintenance

Corrections, clarifications and requests for change will be administered by the custodian. Discussion regarding proposed changes will be carried out by correspondence with national Points of Contact. Consolidated maintenance documents will be issued periodically containing published corrections and clarifications together with details of agreed extensions (these will be formally incorporated into the Product Specification and become live at its next revision).

Changes to the Product Specification beyond extensions will be reviewed by committee[1] during preparatory work for production of the next edition of the specification.

1.9.3 Method of Promulgation

Maintenance documents, new editions of specifications, and related documentation will be sent to nations through their appointed AML point of contact.

1.9.4 Authority Responsible for Maintenance

AML Product Specifications will be maintained by the Custodian specified in section 1.2.3.

1.9.5 Error Reporting/Change Request Procedure

Comments concerning the content of the AML Product Specifications and requests for change should be addressed to the Custodian.

1.9.6 Available Support

Contact the Custodian for guidance and advice relating to this product specification.

[1] Will be a specific group reporting to the GMWG or its successor.

2 GENERAL PRODUCT DESCRIPTION

PRODUCT TITLE

Additional Military Layers – Atmospheric and Meteorological Climatology.

SHORT TITLE

AML AMC

REFERENCE

NATO STANAG No. 4564 (Performance Standards for Warship Electronic Chart Display and Information System (WECDIS), Edition 1, Annex B, Data Products.

2.1 MAINTENANCE OF THE DATA PRODUCT

The frequency and method of provision of replacement data will be defined by each AML producing agency.

2.2 SUPPORT FOR MULTIPLE MODES OF OPERATION

AML AMC data is compiled for a variety of purposes such as the depiction of monthly climatological values over an area for the planning of operations. At larger scales, values at the nearest grid point or interpolated from surrounding grid points can be processed from the data. The data itself is at a grid resolution of 1.125°.

SCALE BAND	DATA COMPILATION SCALE	DATA COMPUTATION GRID SIZE
1	<1:100,000,000	20° or coarser
2	1:25,000,000	5°
3	1:5,000,000	1°

SCALE BAND	DATA DISPLAY SCALE RANGE	DATA USAGE GRID SIZE
1	<1:40,000,000	8° or coarser
2	1:10,000,000 to 1:62,500,000	2° to 12.5°
3	1:2,000,000 to 1:12,500,000	24' to 2°

ANNEX A	A.1.2.7.1

2.3 Geographic Organisation

2.3.1 Regional Scheme

AML AMC products will be partitioned by geographic region

ANNEX A	A.1.1.1

2.3.2 Tiling Scheme

ANNEX A	A.1.1.1

2.4 LAYER ORGANISATION

The content of the product is not layered. However, specific exchange standards may impose their own internal layering requirements.

2.5 EXCHANGE STANDARD IMPLEMENTATION

This product specification has been written to be independent of the exchange standard used. Details of exchange standard implementations are given in the relevant annex.

2.5.1 Spatial Data Type

AML AMC does not contains spatial objects as vector data. For each parameter and area, it consists of a four-dimensional grid of parameter values, where the three spatial dimensions are z (vertical), x (eastwards) and y (northwards), and the time dimension for climatology is normally 'weekly' (1-52) and 'annual'(53).

2.5.3 Relationship with Layering

N/A

2.5.4 Textual Information

N/A

2.5.5 Reference to External Files

N/A

2.6 SIZING REQUIREMENTS

N/A

2.7 GENERAL SOURCE DESCRIPTION

2.7.1 Minimum Source Requirements

2.7.1.1 Parameters

Parameters should not be used if their values at a large fraction (say 20%) of grid points worldwide are thought to be incorrect or grossly misleading. Consideration should be given to omitting certain areas if the number of data points used to form the mean value is small. Averages of worldwide numerical analyses will usually overcome this problem so that all values can be used; however, errors may then be less obvious, and their detection reliant on later investigations.

2.7.1.2 Time Period

The time period of the analysis should normally be at least several years, perhaps up to several decades. Single years or months do not give a climatology which can be relied upon, so should be avoided. Periods should end as recently as possible, because of changes caused by global warming.

2.7.1.3 Grid-point Spacing

Horizontal grid-point spacing should be small enough so that linear interpolation does not give a misleading value. For worldwide analyses the minimum spacing may be fixed.

2.7.2 Applicable Sources

Well-established worldwide sources such as the ERA atmospheric re-analyses are preferred. However NCEP atmospheric re-analyses made provide an additional data source if required. Grid-point values from a data set are preferred to digitising from graphical representations.

3 GENERAL DATA DESCRIPTION

3.1 DATUMS

Please refer to NATO STANAG 2211 - Geodetic Datums, Ellipsoids, Grids & Grid References, which establishes the NATO guidelines to the use of horizontal and vertical datums.

3.1.1 Horizontal Datum

The horizontal datum for the AML AMC is the World Geodetic System 1984 (WGS 84).

ANNEX A	A.1.2.7.1.3

3.1.2 Vertical Datums

3.1.2.1 *Height Datum*

Nominal altitudes are used, for example 0 metres for "surface" parameters over the sea, and ground elevations over the land. In this case, the parameter name should indicate the difference from these values, for example '2-metre air temperature'. Otherwise, differences should be added to altitudes and not included in the parameter names. For "non-surface" based atmospheric data, constant pressure levels are be used rather than fixed altitudes. The default height datum for the AML AMC is specified in the metadata of the dataset.

ANNEX A	A.1.2.7.1.3

3.1.2.2 *Sounding Datum*

N/A

3.2 UNITS

The default units to be used in AML AMC are SI and scaled where necessary, for example:

- Position: latitude and longitude in decimal degrees
- Height: metres (geopotential metres for Atmospheric data at constant pressure levels)
- Pressure: pascals (hectopascals for constant pressure levels)
- Temperature: kelvins
- Speed: m/s
- Relative humidity: %
- Cloud cover: fraction 0-1
- Precipitation: kg/m^2 (equivalent to mm depth of water)
- Direction: degrees clockwise from true north
- Ice cover: 0 or 1
- Soil moisture: metres depth of water
- Probabilities & frequencies: %

ANNEX A	A.2.2.1.6

3.3 CO-ORDINATE SYSTEM

The co-ordinate system used by AML AMC is Latitude and Longitude. These will be recorded as:

Positive values: Used for latitudes **north** of the equator and longitudes **east** of the Greenwich Meridian.

Negative values: are used for latitudes **south** of the equator and longitudes **west** of the Greenwich Meridian.

3.4 PROJECTION

AML AMC is based upon geographical co-ordinates and is not projected.

3.5 LANGUAGE AND CHARACTER SETS

3.5.1 Language

The exchange language used by AML AMC is English.

ANNEX A	A.1.1.4

3.5.2 Character Sets

ISO 8859-1 supports English and most European languages. For those languages that it does not support ISO/IEC 10646 shall be used.

3.6 DATA QUALITY

AML AMC data quality information should be encoded at an appropriate level, as specified by the exchange standard implementation.

AML data quality information encompasses the following categories:

- Accuracy
- Up-to-dateness/currency
- Source(s) of the data
- Conformance to the Product Specification

Data quality information defined for AML AMC can be encoded in the dataset as:

- dataset metadata (see section 5.3.1)

ANNEX A	A.1.2.7.1.2

3.6.1 Accuracy

3.6.1.1 Standard Deviation

The grid-point climatological values in AML AMC are normally the result of extensive quality control and processing, so the likely errors are often not available. The standard deviation of individual values used in the climatology, or of weekly means, presented as a parameter, can help in deciding how likely a particular value will be, but does not give the accuracy.

3.6.1.2 Number of Observations

The number of independent observations used to produce the grid-point mean would be a more useful parameter for representing accuracy or representivity of the mean, especially if the means are calculated from raw data, or are for a short period. This number varies with each meteorological parameter, so should be used sparingly, if at all.

3.6.2 Up-to-Dateness/Currency

Where applicable, currency information shall specify the up-to-dateness of the AML dataset(s). This information shall include:

- issue date

3.6.3 Source(s) of the data

Where available, AML source information shall include the following details:

- authority (e.g. data provider)
- source data set
- source period

3.6.4 Conformance to the Product Specification

AML products may be produced to fulfil operational requirements, and therefore, may not conform fully to this Product Specification.

All AML datasets must specify instances when:

- all available data/information has been encoded. Missing data means that the information is not available
- only specified/required data/information is encoded

4 DATA STRUCTURE

Refer to the appropriate implementation annex for details of specific implementation, format, and structure.

ANNEX A	A.1.2.7

5 DATA DICTIONARY

5.1 GENERAL GUIDELINES

This section provides real-world descriptions for the metadata and features contained within the AML AMC dataset. Details of how this information is to be encoded (e.g. using the chosen Exchange Standard) can be found in the tables contained in the implementation annexes.

5.2 UNKNOWN/MISSING ATTRIBUTE VALUES

The way in which an unknown or missing attribute value is handled is dependent upon the exchange standard implemented.

5.3 USE OF META INFORMATION

AML datasets contain the following meta-information:

5.3.1 Dataset Metadata

The following table provides the descriptions of dataset meta information required by AML AMC to conform to this Product Specification.

For details of how to represent the dataset metadata described, refer to the appropriate exchange standard implementation annex.

ANNEX A	A.2.1.1

General/Production Information	Description
Production Agency	The agency responsible for the production of the data
Dataset Name	The name of the dataset
Edition Number	The edition number of the dataset
Date of Release	The date of the dataset was made available by the data producer (e.g. edition or revision date)
Product Specification Description	The name of the AML Product Specification to which the dataset conforms (see section 2)
Product Specification Edition Number	The edition number of the AML Product Specification to which the dataset conforms (section 1.2.1)
Product Application	The usage application grid spacing of the dataset (see section 2.2)

Security Classification Information	Description
International Defence Organisation (IDO) status (see note)	The International Defence Organisation (IDO) status (if applicable) that must precede, and be applied to, the Protective Marking thus making it an IDO Marking. - North Atlantic Treaty Organisation (NATO) - North Atlantic Co-operation Council (NACC) - Partnership for Peace (PfP) - Western European Union (WEU)

Protective marking	A marking indicating the minimum standards of protection required of the data. - COSMIC TOP SECRET - FOCAL TOP SECRET - TOP SECRET - SECRET - CONFIDENTIAL - RESTRICTED - UNCLASSIFIED
Owner Authority	The NATO country code (NATO STANAG 1059) denoting the 'owner' that is responsible for establishing and setting the protective marking level
Caveat (see note)	A component of a security clearance and/or security class used for computing access rights and controlling information flow by authorising a specific group of subjects to have access to the information

NOTE:

International Defence Organisation (IDO) markings and caveats are mutually exclusive. If the data has an IDO status, then the caveat is not applicable. Additionally, caveats only apply to data that has an IDO/Protective Marking of CONFIDENTIAL or above.

5.4 MANDATORY META INFORMATION

All dataset meta information stated in section 5.3.1 is mandatory.

5.5 SCHEMA

The following tables (5.5.1, 5.5.2, and 5.5.3) provide the descriptions of meta information, real-world features, and associated attributes required by AML AMC to conform to this Product Specification. Regular grid points or centres of latitude/longitude cells can be considered as zero-dimensional features, and climatological parameters at these points as associated attributes.

For details of how to represent the real-world features and associated attributes described, refer to the appropriate exchange standard implementation annex.

ANNEX A	A.2.2.1, A.2.2.2 and A.2.2.3

5.5.1 Meta Information

N/A

5.5.2 Feature Classes.

The object 'primitive point' is only allowable for any object/feature in AML AMC It can be a grid point where a climatological field is sampled, or the centre of a latitude/longitude cell over which the field is averaged. The following table contains the information described below:

- Feature Class – gives the name of the feature class
- Description – describes the feature class
- Associated Attributes – indicates allowable attributes relevant to each feature class. (see section 5.5.3 for attribute descriptions and values.)
- M – denotes that export of the attribute field is mandatory
- Form – indicates the geometric form that the feature class can take (i.e. **P**oint, **L**ine, or **A**rea)

ANNEX A	A.1.2.7.1

Feature Class	Description	Associated Attributes		Form		
		Description	M	P	L	A
Grid Point	A geographical point & vertical column and month or other time period	• Climatological parameter	√	√		

For details of how to encode the feature classes listed in this section, refer to the appropriate exchange standard implementation annex.

5.5.2.1 **Mandatory Features**

Real-world objects that are mandatory for this product are:

- Grid Point – the only feature type

5.5.3 Attributes (mainly climatological parameters in AML AMC)

The climatological parameters can be considered as attributes of the point features. The table below displays the following information:

- Attribute – gives the name of attribute (climatological parameter).
- Definition – gives a more detailed description of the attribute if required.
- Domain – atmospheric depth (UA), surface (SF), land only (L), sea only (S)
- Values – specifies the approximate range of values the attribute may take

Attribute	Definition	Domain	Values
Mean scalar speed of wind	Scalar magnitude	UA	0-80 m/s
Mean u-speed of wind	West to east positive	UA	-50 to +80 m/s
Mean v-speed of wind	South to north positive	UA	-50 to +50 m/s
Standard vector deviation	2-D population standard deviation	UA	0-50 m/s
Mean temperature	Dry-bulb air temperature.	UA	183-318 K
Standard Deviation of	Population standard	UA	0-40 K degrees

temperature	deviation.		
Mean relative humidity	Relative to water above 273K & ice below 273K.	UA	5-98 %
Mean dew point	Relative to water above 273K & ice below 273K.	UA	173-303 K
Mean lowest 0degC isotherm	Vertical altitude of freezing point.	UA	0-6000 gpm
Mean height of pressure surface	Altitude equivalent to standard pressure surface.	UA	-200 to 25000 gpm
Mean 10-m scalar speed of wind	Scalar magnitude at 10m above local surface.	SF	0-20 m/s
Mean 10-m u-wind	West to east positive vector component at 10m above local surface.	SF	-20 to +20 m/s
Mean 10-m v-wind	South to north positive vector component at 10m above local surface.	SF	-20 to +20 m/s
Mean total cloud cover	Mean numbers of oktas/8.	SF	0-1
Mean 2-m temperature	Dry-bulb air temperature at 2m above local surface.	SF	193-318 K
Mean 2-m dew point	At 2m above local surface.	SF	183-303 K
Mean MSL pressure	Mean pressure at sea level.	SF	97000-104000 Pa
Standard Deviation of MSL pressure	Population standard deviation.	SF	50-2000 Pa
Mean low cloud cover	Cloud amount below Xm.	SF	0-1
Mean medium cloud cover	Cloud amount between Xm & Ym.	SF	0-1
Mean high cloud cover	Cloud amount between Ym & Zm.	SF	0-1

For details of how to encode the attributes listed in this section, refer to the appropriate exchange standard implementation annex.

ANNEX A	A.2.2.1 and A.2.2.2

6 DATA CAPTURE GUIDELINES

The ‘AML AMC Guidance on Feature Coding and Attribution’ provides guidance on the conventions that are to be used to encode features (grid points), and associated attribution

(parameters), using a relevant implementation standard. The content of the AML AMC is at the discretion of the producing authority.

6.1 CONTINUITY

Datasets consisting of multiple digital source files should aim to be contiguous for consistency of display. To avoid duplication, grid points on the eastern and northern boundaries of a selected area should not be included, in case an adjacent area is added later.

7 DATA PRESENTATION

7.1 SCOPE

The way in which AML AMC is displayed is dependent upon an individual customer's requirement. How their systems are developed to display AML AMC data will largely be governed by the:

- environment in which the data is to be viewed
- types of products that are to be displayed with the AML product

This Product Specification is designed to support the production and supply of Atmospheric and Meteorological Climatology. It does not address data presentation.

8 PROVISION OF DATA

8.1 GENERAL

8.1.1 File Format (Encapsulation)

The file format or encapsulation is exchange standard specific.

ANNEX A	A.1.1.5

8.1.2 Auxiliary Information

All media containing AML products will contain cataloguing information regarding the coverage of the products contained within it. A complete AML catalogue is planned for future development.

The data will neither be encrypted nor compressed.

8.2 DISTRIBUTION MEDIA

AML is available in the following format(s):

- **CD-ROM**

Other approved means of distribution will be promulgated in due course. While data must be available to users on standard media, other media/transmission means may be agreed directly between producers and recipients.

8.3 VOLUME NAMING

AML volumes (defined as packages) may contain several datasets, each from a different product specification. The volume naming convention for AML 'Packages' is not defined by AML Product Specifications.

8.4 FILE NAMING

CD-ROM AML file naming conforms to ISO 9660, International Standards Organisation, Information Processing - Volume and File Structure of CD-ROM for Information Interchange.

8.5 DIRECTORY STRUCTURE

CD-ROM The directory structure conforms to ISO 9660, International Standards Organisation, Information Processing - Volume and File Structure of CD-ROM for Information Interchange.

8.6 ERROR DETECTION

N/A.

8.7 COMPRESSION

N/A.

8.8 ENCRYPTION

N/A.

8.9 HARDWARE AND SOFTWARE REQUIREMENTS

N/A.

9 TESTING METHOD

This product specification has been designed to achieve interoperability of AML data products and other digital data products. This is achieved by the separation of the data dictionary from the standard used to encode the data and by the use of internationally recognised standards for the transfer of the data.

It is the responsibility of the data producer to ensure that AML data products fully conform to this Product Specification and to the chosen transfer standard.

ANNEX A GRIB IMPLEMENTATION OF AML AMC PRODUCT SPECIFICATION

A.1 AML GRIB FORMAT TABLE AND FILE STRUCTURE

A.1.1 GENERAL INFORMATION

The World Meteorological Organization (WMO) Commission for Basic Systems (CBS) Extraordinary Meeting Number VIII (1985) approved a general purpose, bit-oriented data exchange format, designated FM 92- VIII Ext. GRIB (GRIdded Binary). It is an efficient vehicle for transmitting large volumes of gridded data to automated centers over high speed telecommunication lines using modern protocols. By packing information into the GRIB code, messages (or records - the terms are synonymous in this context) can be made more compact than character oriented bulletins, which will produce faster computer-to-computer transmissions. GRIB can equally well serve as a data storage format, generating the same efficiencies relative to information storage and retrieval devices.

Changes and extensions to GRIB were approved at the regular meeting of the WMO/CBS in February, 1988; additional changes were introduced at the CBS/WGDM/Sub-Group on Data Representation (SGDR) meetings in May 1989 and in October 1990. The 1990 changes were of such structural magnitude as to require a new Edition of GRIB, Edition 1, which this document describes. Further augmentations and interpretations were made by the SGDR in September 1993, with approval by the WGDM in February 1994. These changes did not result in a new Edition to GRIB, but did change some of the Tables, resulting a new Version number for them. This brings us now to Table Version 2. The changes from Version 1 were mainly additions of new parameters or more precise definition of existing ones.

It is not anticipated that there will be any large-scale structural changes to GRIB for at least four to five years, or more. The SGDR is undertaking a thorough review of the present and future requirements that GRIB is supposed to satisfy. The plan is to design a major revision of GRIB capable of accommodating these requirements and more, without "straining" the structure of the data representation form

Each GRIB record intended for either transmission or storage contains a single parameter with values located at an array of grid points, or represented as a set of spectral coefficients, for a single level (or layer), encoded as a continuous bit stream. Logical divisions of the record are designated as "sections", each of which provides control information and/or data. A GRIB record consists of six sections, two of which are optional:

(0) Indicator Section
(1) Product Definition Section (PDS)
(2) Grid Description Section (GDS) - optional
(3) Bit Map Section (BMS) - optional
(4) Binary Data Section (BDS)
(5) '7777' (ASCII Characters)

Although the Grid Description Section is indicated as optional, it is highly desirable that it be included in all messages. That way there will be no question about just what is the "correct" geographical grid for a particular field.

In this product specification, certain symbols are used to clarify the contents of octets (groups of eight consecutive binary bits). If unadorned letters are used, they are symbolic and their meanings are described in the text; a decimal number is simply printed as is; a character or string of characters is represented inside single quote marks. International Alphabet No. 5, which is identical in its essential elements to the U.S. National Standard 7-bit ASCII, is used for character representation in the GRIB code.

Octets are numbered consecutively from the start of each section; bits within an octet are also numbered from left (the most significant bit) to right (the least significant bit). Thus an octet with bit 8 set to the value 1 would have the integer value 1; bit 7 set to one would have a value of 2, etc.

The numbering of Tables in the following text corresponds to the description of GRIB in the WMO Manual on Codes. Some additional tables not found in the WMO Manual are indicated by letters. These, generally, contain information unique to a particular processing center.

The application profiles define the structure and content of the catalogue file and data set files.

A.1.1.1 Cells

In order to facilitate the efficient processing of AML data the geographic coverage of a given usage may be split into cells. Each cell of data must be contained in a physically separate, uniquely identified file on the transfer medium, known as a data set file (see sections A.1.1.6 and A.1.1.7.3 of this Product Specification).

Cells must be rectangular (i.e. defined by 2 meridians and 2 parallels). It is recommended that the geographic extent of the cell be chosen by the AML producer to ensure that the resulting data set file contains no more than 100 Megabytes of data. Subject to this consideration, the cell size must not be too small in order to avoid the creation of an excessive number of cells. The coordinates of the borders of the cell are encoded in decimal degrees in the catalogue file.

A.1.1.4 Language and Alphabet

A.1.1.4.1 Language

The exchange language must be English. Other languages may be used as a supplementary option.

A.1.1.5 Exchange Set (Folder)

The AML AMC will consist of data set folders, each containing a number of files.

A.1.1.5.1 Content of the Folder

A folder is composed of one and only one catalogue file and at least one data set file. Additional files can also be included in the AML exchange set. These files may be included to provide additional information within an AML product.

A folder may also contain an optional README file.

|--<3>-- Data set folder (named as in A.1.1.5.2)
|
|--<1>-- README file (see A.1.1.7.1) (optional)
|
|--<1>-- Catalogue file (see A.1.2.6) (ISO compliant)
|
|--<R>-- GRIB data set file (see A.1.1.6)
|
|--<R>-- Metadata file (named as in A.1.1.7) (optional, and undefined at present)

In tables A.1.1.5.1.1 and A.1.1.5.1.2, all files (shown in the File Type columns) must be in the formats given in column two of the tables (File Format/Extension).

A.1.1.5.1.1 Mandatory File Types

The table below provides details of the file types and formats that are mandatory in an AML Exchange Set.

File Type	Implementation
Catalogue	ASCII
Data Set	Binary

A.1.1.5.1.2 Additional File Types

The table below provides examples of the file contents and formats that may be included within an AML AMC folder.

File Type	File Format/Extension
Metadata	Undefined
Text	TXT

A.1.1.5.2 Folder Naming

All AML products will follow the naming convention specified in this section.

Format

XXABcDDD

Where

XX = the two-letter NATO country code of the producer (NATO STANAG 1059)

A = the first character of the three-letter AML product identifier AMC. . As defined, the overall basic AML service would be made up of eight products:

a – AMC (Atmospheric and Meteorological Climatology)
m – MFF (Maritime Foundation and Facilities)
e – ESB (Environment, Seabed and Beach)
r – RAL (Routes Areas and Limits)
l – LBO (Large Bottom Objects)
s – SBO (Small Bottom Objects)
c – CLB (Contour Line Bathymetry)
i – IWC (Integrated Water Column)

B = identifies that the exchange set is a base, not an update exchange set.

B – Base. A base exchange set may contain original base cells, new editions and re-issues. All three are base cell files as defined in section A.1.2.7.

U – Update. Not used in AML AMC

c = the security classification code:

N – COSMIC TOP SECRET
W – FOCAL TOP SECRET
T – TOP SECRET
S - SECRET
C - CONFIDENTIAL
R - RESTRICTED
U - UNCLASSIFIED

DDD =is the mandatory alphanumeric geographic area identification code. Codes for use in AML are product specific and have yet to be defined.

A.1.1.5.3 Directory Structure

The following is an example directory structure for an AML AMC exchange set (folder) in MS-DOS format.Directory of D:\UKABuDDD

<DIR>			09-15-96	12:40p
<DIR>			09-15-96	12:40p
CATALOG[4]	031	1,584	09-15-96	12:46p CATALOG.031
UKA0c123[1]000		45,584	09-15-96	12:50p UKA0c123.000[3]
UKA0c123[1]001		1,095	09-15-96	12:54p UKA0c123.001
UKA0c123[1]002		1,722	09-15-96	12:54p UKA0c123.002
README[2]TXT		504	09-15-96	12:44p README.TXT
		5 file(s)	49,489 bytes	
		2 dir(s)	1,405,952 bytes free	

Notes:

1. UKA0c123 follows the file naming convention specified in section A.1.1.7 of this Product Specification.

2. The directory may also contain a general README file containing ASCII text.

3. For each file in the exchange set the catalogue file must contain the name of the volume on which it is held and the full path name relative to the exchange set directory in that volume. The full path name relative to the exchange set directory must be encoded in the FILE subfield of the “Catalogue Directory” [CATD] field. The LFIL subfield of the CATD field may be used for other purposes. The full path name of the UKA0c123 file shown in the example is UKA0c123.000.

4. The catalogue file must be in the root directory of the exchange set

A.1.1.6 Data Sets

For each individual AML grid-point product, two kinds of data sets may be produced:

- new data set: no AML data has previously been produced for this area for the same purpose, or, at the same security classification
- new edition of a data set: including new or revised information

Each new data set or new edition is called a base file.

A.1.1.7 File Naming

AML AMC will follow the file naming convention specified below.

Format

XXAnc123.eee

Where

XX = the two-letter NATO country code of the producer (NATO STANAG 1059)

A = the first character of the three-letter AML product identifier.

a – AMC (Atmospheric and Meteorological Climatology)
m – MFF (Maritime Foundation and Facilities)
e – ESB (Environment, Seabed and Beach)
r – RAL (Routes Areas and Limits)
l – LBO (Large Bottom Objects)
s – SBO (Small Bottom Objects)
c – CLB (Contour Line Bathymetry)
i – IWC (Integrated Water Column)

n = 'Usage Band' values of grid-point spacing for climatological AML products. Potential values are given below.

0 – Unscaled data

c = the security classification code:

N – COSMIC TOP SECRET
W – FOCAL TOP SECRET
T – TOP SECRET
S - SECRET
C - CONFIDENTIAL
R - RESTRICTED
U - UNCLASSIFIED

123 = product specific alphanumeric identification. This is dependent upon the geographical partitioning of the product and has yet to be fully defined.

eee = extension where 000 is base cell and 001, 002 etc are successive revised editions.

A.1.1.7.1 README File

The README file is an optional ASCII file of general information. References to descriptions and papers on limitations of the data source will be useful here but restricted to items that cannot be recorded in the mandatory, structed, quality meta data.

README.TXT is the mandatory name for this file.

A.1.1.7.2 Catalogue File

The catalogue file acts as the table of contents for the exchange set (see section A.1.1.5.3).

The catalogue file of the exchange set must be named CATALOG.EEE
where EEE is the edition number of GRIB used for this exchange set, i.e. 002 for the current edition (1). No other file may be named CATALOG.

A.1.1.7.3 Data Set Files

Each data set file contains data for one cell (see section A.1.1.1) that represents the whole globe or a regular array of cells that represent geographical regions. This includes:

- data set descriptive information that is specific to the data set
- the description and location of the real-world features (grid points and their climatological parameters)

A.1.1.8 Data Processing

The code form represents numeric data as a series of binary digits (bits). Such data representation is independent of any particular machine representation; by convention data lengths are measured in octets (groups of eight consecutive binary bits). Data are coded as binary integers using the minimum number of bits required for the desired precision. Numeric values, with units as shown in A.2.2.1.6 (Table 2), may first be scaled by a power of ten to achieve an appropriate decimal precision, a reference value is subtracted from them to reduce redundancy and eliminate negative values, and they may then be further scaled by a power of two to pack them into a pre-selected word length. The two scaling operations are independent; which, or both, are used in any given case depends upon choices made as to the method of packing. See below.

The representation of a single value is such that:

$$\mathbf{Y} * 10^{\mathbf{D}} = \mathbf{R} + (\mathbf{X} * 2^{\mathbf{E}})$$

where

Y = original or unpacked value; units as in A.2.2.1.6 (Table 2);
D = decimal scale factor, to achieve desired precision (sign bit, followed by a 15-bit integer);
R = reference value (32 bits);
X = internal value (No. of bits varies for each record);
E = binary scale factor for variable bit word length packing (sign bit, followed by a 15-bit integer).

The reference value (R) is the minimum value of the (possibly) decimally scaled data that is being encoded.

R is placed in the Binary Data Section in four octets as a single precision floating-point number:

sAAAAAAA BBBBBBBB BBBBBBBB BBBBBBBB

where

s = sign bit, encoded as 0 => positive; 1 => negative
A = 7-bit binary integer, the characteristic

B = 24-bit binary integer, the mantissa.

The appropriate formula to recover the value of R is:

$$\mathbf{R} = (-1)^{\mathbf{S}} * 2^{-24} * \mathbf{B} * 16^{(\mathbf{A}-64)}$$

This formula is the standard IBM representation for a single precision (real) floating point number. (Consideration is being given to using the IEEE floating point representation in the future, in a later Edition of GRIB.)

If second order (or "complex") packing is used (see the description of that later on) the internal value, X, will be made up of two values, a "local minimum value", X_i, and a "second order packed value", X_j. There will be one X_j for each grid point and a variable number of X_i values. This will all come clear later on when we get to the description of second-order packing.

A.1.2 USE OF GRIB SECTIONS

A.1.2.1 General

The Official International Documentation for GRIB is the just referenced Manual on Codes (World Meteorological Organization publication No. 306, Manual on Codes, **Vol. 1**, **Part B**, *Secretariat of the WMO*, Geneva, Switzerland, 1988, plus Supplements No. 1, 2, & 3). This document is a summary of all of the features currently found in the Manual and is used for producing AML AMC.

The “Implementation” [IMPL] subfield of the “Catalogue Directory” [CATD] field must be set to “BIN” for the data set files (see section A.1.2.6.1.1).

A.1.2.2 Catalogue and Data Set Files

These files are composed of the files and groups defined sections (A.1.2.6.1) and (A.1.2.7). The order of data in each base file is described below:

Dataset file

- Indicator Section (Group 0)
- Product Definition Section (PDS) (Group1)
- Grid Description Section (GDS) - optional (Group 2)
- Bit Map Section (BMS) - optional (Group 3)
- Binary Data Section (BDS) (Group 4)
- '7777' (ASCII Characters) (Group 5)

A.1.2.3 Files

Files and groups that do not appear in the following tree structure diagrams are prohibited. The order must be the same as that described in the tree structure diagrams. The file name must provide a unique world-wide identifier of the record.

A.1.2.4 Groups

For base files, although the Grid Description Section is indicated as optional, it is highly desirable that it be included in all messages. That way there will be no question about just what is the "correct" geographical grid for a particular field.

A.1.2.5 Fields

Mandatory fields must be filled by the non-null value 9999.

Prohibited fields must be encoded as missing fields values. Any missing attribute value is encoded by 9999.

In the tables following the tree structure diagrams, mandatory fields are shown by “M” in the “use” column and prohibited fields by “P” in the same column. If there is nothing in this column, it means that the use of this field is optional. When a field value is prescribed, it is indicated in the “value” column. The “comment” column contains general comments and an indication of whether the field is ASCII or binary coded.

A.1.2.6 Catalogue File

A.1.2.6.1 Catalogue File Structure

Catalogue file

|

|--<R>--**Catalogue Directory record**

|

A.1.2.6.1.1 Catalogue Directory Record

NB: All field values are encoded as ASCII.

ID	Field	Use	Value	Comment
FILE	File name	M		full path name
IMPL	Implementation	M	ASC BIN TXT	Examples for the catalogue file for the data set files for ASCII text files (including the README.TXT file)
SLAT	Southernmost latitude			mandatory for data set files
WLON	Westernmost longitude			mandatory for data set files
NLAT	Northernmost latitude			mandatory for data set files
ELON	Easternmost longitude			mandatory for data set files

A.1.2.7 AML File Structure

A.1.2.7.1 Data Set Descriptive Field Content

With the exception of the first four octets of the Indicator Section, and the End Section, all octets contain binary values. All sections contain an even number of octets; the variable length sections are padded with zero values as necessary. These extra bits must be accounted for in finding one's way through the sections; their content should be ignored.

A.1.2.7.1.1 GRIB Indicator Section – IS (Group 0)

The indicator section serves to: identify the start of the record in a human readable form, indicate the total length of the message, and indicate the Edition number of GRIB used to construct or encode the message. The section is always eight octets long.

Octet no	Content
1-4	'GRIB' (Coded CCITT-ITA No. 5) (ASCII)
5-7	Total length, in octets, of GRIB message (including Sections 0 & 5)
8	Edition number - currently 1

A.1.2.7.1.2 GRIB Product Definition Section – PDS (Group 1)

The PDS contains indicators for the Parameter table Version, the originating center, the numerical model (or "generating process") that created the data, the geographical area covered by the data, the parameter itself, the values for the appropriate vertical level or layer where the data reside, the decimal scale factor, and date/time information. The PDS is normally 28 octets long but it may be longer if an originating center chooses to make it so. Users of GRIB messages are strongly urged to use the length-of-section portion of the PDS to determine where the next section begins. Never assume a fixed octet length in this, or any other, section.

Octet no	PDS Content
1-3	Length in octets of the Product Definition Section
4	Parameter Table Version number. Currently Version 2 for international exchange. Parameter table version numbers 128-254 are reserved for local use
5	Identification of center in A.2.2.1.3 (Table 0 - Part 1)
6	Generating process ID number (allocated by the originating center; A.2.2.1.1 – Table A)
7	Grid Identification (geographical location and area; A.2.2.1.2 – Table B)
8	Flag specifying the presence or absence of a GDS or a BMS in A.2.2.1.5 (Table 1)
9	Indicator of parameter and units in A.2.2.1.6 (Table 2)
10	Indicator of type of level or layer in A.2.2.1.7 & A.2.2.1.8 (Tables 3 & 3a)
11-12	Height, pressure, etc. of the level or layer in A.2.2.1.7 (Table 3)

13	Year of century Initial (or Reference) time of forecast – UTC or Start of time period for averaging or accumulation of analyses
14	Month of year
15	Day of month
16	Hour of day
17	Minute of hour
18	Forecast time unit in A.2.2.1.9 (Table 4)
19	P1 - Period of time (Number of time units) (0 for analysis or initialized analysis.) Units of time given by content of octet 18
20	P2 - Period of time (Number of time units) or Time interval between successive analyses, successive initialized analyses, or forecasts, undergoing averaging or accumulation. Units given by octet 18.
21	Time range indicator in A.2.2.1.10 (Table 5)
22-23	Number included in average, when octet 21 in A.2.2.1.10 (Table 5) indicates an average or accumulation; otherwise set to zero.
24	Number Missing from averages or accumulations.
25	Century of Initial (Reference) time (=20 until Jan. 1, 2001)
26	Identification of sub-center in A.2.2.1.4 (Table 0 - Part 2)
27-28	The decimal scale factor D. A negative value is indicated by setting the high order bit (bit No. 1) in octet 27 to 1 (on).
29-40	Reserved (need not be present)
41	Reserved for originating center use.

Note (1): Octet 8 may indicate the presence of the Grid Description Section (GDS) even though octet 7 specifies a predefined grid. In this case the GDS must describe that grid - this device serves as a mechanism for transmitting new "predefined" grids to users prior to their formal publication in this or the official WMO documentation. It is, however, the desired practice to always include the GDS in GRIB bulletins.

Note (2): The use of octet 26 to indicate a "sub-center" is not (yet) an officially sanctioned WMO practice. The Manual indicates the octet is to be "reserved", and set to 0. The use arises out of an upcoming change in the Manual in which the "originating centers" for both GRIB and BUFR (FM 94) will reference a single common table. The difficulty is that BUFR has two octets available for an originating center number while GRIB has only one. The compromise solution is to allow the use of octet 26 as the "second" octet for GRIB, but only in a national context. The WMO will coordinate the assignment of the numbers for octet 5 for national and international centers (for both GRIB and BUFR), while each national center will then be free to assign sub-center numbers at will to be placed in the octet 26. A zero value in octet 26 will serve as the default indicating that there is no sub- center associated with a particular center. Table 0, in this document, shows, in Part 1, a selection of the WMO recognized originating centers (those that are currently active) as would be found in octet 5.

A.1.2.7.1.3 GRIB Grid Description Section – GDS (Group2)

The purpose of the (optional) GDS is to provide a grid description for grids not defined by number in A.2.2.1.2 (Table B).

Octet no	PDS Content
1-3	Length in octets of the Grid Description Section
4	NV, the number of vertical coordinate parameters
5	PV, the location (octet number) of the list of vertical coordinateparameters, if present or PL, the location (octet number) of the list of numbers of points in each row (when no vertical parameters are present), if present or 255 (all bits set to 1) if neither are present
6	Data representation type on A.2.2.2.2 (Table 6)
7-32	Grid description, according to data representation type, except Lambert, Mercator or Space View or,
7-42	Grid description for Lambert or Mercator grid or,
7-44	Grid description for Space View perspective grid
PV	List of vertical coordinate parameters (length = NV x 4 octets); if present, then PL = 4 x NV + PV
PL	List of numbers of points in each row, used for quasi-regular grids (length = NROWS x 2 octets, where NROWS is the total number of rows defined within the grid description)

Note: NV and PV relate to features of GRIB not, at present, in use in international exchange. See the WMO Manual on Codes<1> for the descriptions of those features.

PL is used for "quasi-regular" or "thinned" grids; e.g., a lat/lon grid where the number of points in each row is reduced as one moves poleward from the equator. The reduction usually follows some mathematical formula involving the cosine of the latitude, to generate an (approximately) equally spaced grid array. The association of the numbers in octet PL (and following) with the particular row follows the scanning mode specification in Table 8.

A.1.2.7.1.4 GRIB Bit Map Section – BMS (Group 3)

The purpose of the (optional) BMS is to provide either a bit map or a reference to a bit map pre-defined by the center. The bit map consists of contiguous bits with a bit-to-data-point correspondence as defined in the grid description. A bit set equal to 1 implies the presence of a datum for that grid point in the BDS; a value of zero implies the absence of such. This is useful in shrinking fields where fair portions of the field are not defined. An example would be global grids of sea surface temperature; the bit map would be used to suppress the "data" at grid points over land. One would not want to use the BMS if the data were un-defined at only a small number of grid points as the overhead of adding the bit map array (one bit for each grid point) might add more bits to the overall message that were subtracted by the removal of a few data values.

Octet no	Meaning
1-3	Length in octets of Bit Map Section
4	Number of unused bits at end of Section 3.
5-6	Numeric: = 0: a bit map follows; otherwise: the numeric refers to a predefined bit map provided by the center
7-nnn	Bit map, zero filled to an even number of octets

A.1.2.7.1.5 GRIB Binary Data Section – BDS (Group 4)

The BDS contains the packed data and the binary scaling information needed to reconstruct the original data from the packed data. The required decimal scale factor is found in the PDS, above. The data stream is zero filled to an even number of octets.

Octet no	Meaning
1-3	Length in octets of binary data section
4	Bits 1 through 4: Flag – A.2.2.3.1 (Table 11), Bits 5 through 8: Number of unused bits at end of Section 4.
5-6	The binary scale factor (E). A negative value is indicated by setting the high order bit (bit No. 1) in octet 5 to 1 (on).
7-10	Reference value (minimum value); floating point representation of the number
11	Number of bits into which a datum point is packed
12-nnn	Variable, depending on octet 4; zero filled to an even number of octets.
14	Optionally, may contain an extension of the flags in octet 4. A.2.2.3.1 (Table 11)

Here are some of the various forms the binary data can take; the flag table in BDS octet 4, possibly extended into octet 14, identifies which variant is in use.

A.1.2.7.1.5.1 Grid-Point Data – simple packing

Here the data simply begin in octet 12 and continue, packed according to the simple packing algorithm described above, without any particular regard for computer "word" boundaries, until there is no more data. There may be some "zero-fill" bits at the end.

If all the data in a grid point field happen to have the same value, then all of the deviations from the reference value are set to zero. Since a zero value requires no bits for packing, octet 11 is set to zero, thus indicating a field of constant data, the value of which is given by the reference value. Under these circumstances, octet 12 is set to zero (the required "zero fill to an even number of octets") and bits 5-8 of octet 4 contain an 8. The number of data points in the field is implied by the grid identification given in the PDS and/or the GDS and BMS.

The layout of the information, with further explanatory notes, when second order packing has been employed:

Octet no	Content
1-3	Length in octets of binary data section
4	Bits 1 through 4: Flag – See A.2.2.3.1 (Table 11), Bits 5 through 8: Number of unused bits at end of Section 4.
5-6	The binary scale factor (E). A negative value is indicated by setting the high order bit (bit No. 1) in octet 5 to 1 (on).
7-10	Reference value (minimum value); floating point representation of the number. . This is the overall or "global" minimum that has been subtracted from all the values.
11	Number of bits into which a datum point is packed. . This width now refers to the collection of first order packed values that serve as the local minimum values, one for each sub-section. It is determined in the same manner as for the simple (first order) packing.
12-13	N1 - Octet number, relative to the start of the BDS, at which the collection of first order packed numbers begins, i.e. the collection of local minimum values.
14	The flags that are an extension of octet 4. See A.2.2.3.1 (Table 11)
15-16	N2 - Octet number, relative to the start of the BDS, at which the collection of second order packed numbers begins.
17-18	P1 - The number of first order packed values, the local minima. This number is the same as the number of sub-sections.
19-20	P2 - The number of second order packed values actually in the message. This is the number of actual data points as (possibly) modified by the bit map in the BMS, if any, and/or reduced by the number of identical points collapsed together by the run-length encoding (see below)
21	Reserved
22-(xx-1)	Width(s), in bits, of the second order packed values; each width value is contained in 1 octet. There are as many width values, or octets, as there are sub- sections, P1 of them. However, there may be but one such value under special circumstances; see below. Also, the width value for a particular sub-section may perfectly well be zero.
xx-(N1-1)	Secondary bit map, one bit for each data point. It will be P2 bits long, then padded to an even number of octets with binary 0
N1-(N2-1)	P1 first order packed values, the local minima, each held in a "word" of bit-length found in octet 11, then padded to a whole number of octets with 0s
N2-…	P2 second order packed values. There is no "marking" of the sub-sections here; all the sub-section second order values are placed in a continuous string of bits. The bit-length of the "words" holding the values will change from place to place but again this has to be determined by reference to the other information.

	As usual, there may be padding by binary 0 bits sufficient to bring the entire section to an even number of octets.

Notes::

(1). If the bit-width for a sub-section is zero, then no second order values for that sub-section are included in the part of the message starting at octet N2. The value of P2 will reflect the absence of those points. This will happen is all the first order values in the sub-section are identical. This is a form of "run-length encoding" and contributes greatly to packing efficiency if the original data contains strings of constant value (including zero).
(2). Under some circumstances, it may turn out that there is no need to use different bit-widths for each of the sub-sections. In that case, a flag is set in bit 8 of the extended flags found in octet 14 (section A.2.2.3.1 – Table 11) indicating that all the sub-sections are packed with the same bit- width, and that the single value will be found in octet 22.
(3). Row by row packing is defined as selecting entire rows (or columns) to serve as sub-sections, without regard to "variability" determinations. It can have some compression value. If row by row packing is employed, this is indicated by setting a flag in bit 7 of the extended flags found in octet 14 (see Table 11) and NOT including the secondary bit map in the message. It is unnecessary since the length of the rows (columns) is known from the grid specifications given elsewhere in the message.

A.1.2.7.1.5.2 Spherical Harmonic Coefficients - Simple Packing

Octets 12-15 contain the real part of the (0.0) coefficient in the same floating point format as the reference value in octets 7-10. The imaginary part of the (0.0) coefficient, mathematically, is always equal zero. Octets 16 to the end contain the remaining coefficients packed up as binary data with the same sort of scaling, reference value, and the like, as with grid-point numbers. Excluding the (0,0) coefficient, which is usually much larger than the others, from the packing operation means that the remaining coefficients can be packed to a given precision more efficiently (fewer bits per word) than would be the case otherwise.

Octet no	Meaning	
12-13	N, Pointer to the start of the packed data (i.e. gives the octet number)	
14-15	P, scaling factor by which is packed not the field itself, but the modulus of the laplacian^P. Thus the co-efficients Xnm will be multiplied by $(n(n+1))^P$ before packing, and divided by this factor after unpacking.	
16	J^1	For spherical harmonics-complex packing, the J^1, K^1, M^1 are the pentagonal resolution parameters specifying the truncation of a subset of data, which shall be represented unpacked (as the reference value) and shall precede the packed data.
17	K^1	
18	M^1	
19-…	Unpacked binary data represented in 4 octets in the same way as the reference value (pairs of co-efficients)	
N-…	Packed binary data	

Notes:

(1). Removal of the real (0,0) coefficient considerably reduces the variability of the coefficients and results in better packing
(2). For some spherical harmonic representations, the (0,0) coefficient represents the mean value of the parameter represented.
(3). The representation code (Code figure=2 in section A.2.2.2.6 – Table 10) in Section 2 shall indicate this type of packing, but as Section 2 is optional, the flag field in Section 4 may also be used to indicate the more complex method.
(4). ECMWF provides this error report regarding its archive including a suitable workaround

A.1.2.7.1.5 GRIB End Section – BDS (Group 5)

The end section serves a human readable indication of the end of a GRIB record. It can also be used for computer verification that a complete GRIB record is available for data extraction. It should not be used as a search target since a '7777' bit combination could exist anywhere in the binary data stream.

Octet no	Meaning
1-4	'7777' (Coded CCITT-ITA No. 5)

A.2 AML GRIB DATA DICTIONARY

A.2.1 USE OF META INFORMATION

A.2.1.1 AML Data Set Metadata

For all AML Products, the Data Set Descriptive records (defined in the application profile structures - sections A.1.2.7.1) are used to contain the metadata of the dataset. The mandatory meta information specified in section 5.3.1 is encoded in GRIB Group 1.

A.2.2 SCHEMA

A.2.2.1 Product Definition Section (PDS)

A.2.2.1.1 Table A – Generating Process or Model

These values and model ("generating process") numbers would be supplied by the individual centers. There is no standard generation method.

A.2.2.1.2 Table B – Grid Identification

Various National Grids would be identified here by the Center. International exchange grids are included here.

Value	Grid
21-26	International Exchange grids - see below
37-44	Eight lat-long 1.25x1.25 "thinned" grids, covering the globe by octants of 3447 points. Full GRIB specifications below. For WAFC, ICAO, and International exchange.
61-64	International Exchange grids - see below.
255	(non-defined grid - specified in the GDS)

International Exchange Grids						
Value	Resolution (degrees) lon x lat	Area Coverage (degrees)		Grid Shape		Grid Points
				cols	rows	
21	5.0 x 2.5	0-180E	0-90N	37	36 + pole	1333
22	5.0 x 2.5	180W-0	0-90N	37	36 + pole	1333
23	5.0 x 2.5	0-180E	90S-0	pole + 37	36	1333
24	5.0 x 2.5	180W-0	90S-0	pole + 37	36	1333
25	5.0 x 5.0	0-355E	0-90N	72	18 + pole	1297
26	5.0 x 5.0	0-355E	90S-0	pole + 72	18	1297
61	2.0 x 2.0	0-180E	0-90N	91	0-90N	4096
62	2.0 x 2.0	180W-0	0-90N	91	45 + pole	4096

63	2.0 x 2.0	0-180E	90S-0	pole + 91	45	4096
64	2.0 x 2.0	180W-0	90S-0	pole + 91	45	4096
255	(non-standard grid - defined in the GDS)					

Notes on International Exchange FOS Grids:

(1). The grid points are laid out in a linear array such that the longitude index (the columns) is the most rapidly varying. For the northern hemisphere grids the first point in the record is at the intersection of the western-most meridian and southern-most circle of latitude; the last point is the single polar value (see note iii, below). For the southern hemisphere grids the first point in the record is the single polar value (see note iii, below); the last point is at the intersection of the eastern-most meridian and northern-most circle of latitude. For those familiar with FORTRAN subscripting conventions, longitude is the first subscript, latitude the second.
(2). In grids 21 through 26, and 61 through 64, the values on the shared boundaries are included in each area.
(3). The datum for the pole point is given only once in each grid. The user must expand, if desired, the single pole point value to all the pole "points" at the pole row of a latitude-longitude grid. Scalar quantity values are the same for all pole points on a the grid. Wind components at the poles are given by the formulae:

$$\mathbf{u} = -\mathbf{speed} * \sin(\mathbf{dd}) \qquad \mathbf{v} = -\mathbf{speed} * \cos(\mathbf{dd})$$

where dd is the direction of the wind as reported according to the specification of wind direction at the poles (refer to WMO Manual on Codes, code table 878).

The WMO convention can be given this operational definition: At the North Pole, face into the wind and report the value of the west longitude meridian along which the wind is coming at you; at the South Pole do likewise but report the east longitude meridian value. This is equivalent to placing the origin of a right-handed Cartesian coordinate system on the North Pole with the y-axis pointing to the prime (0 degree) meridian and the x-axis pointing to the 90 degrees west meridian, and then resolving any vector wind at the pole point into components along those axes. At the South Pole the coordinate axes are oriented such that the y-axis points toward 180 degrees west. Those components are the u- and v-values given as the single pair of pole point winds in the GRIB format.

In terms of a longitude/latitude grid these are the wind components for the pole point at the 180 degree meridian. For example, on a 2.5x2.5 degree northern hemisphere grid (145x37 points), with the abscissa along the equator and the ordinate along the prime meridian, the transmitted north pole wind components are those that belong at the gridpoint (73,37). The wind components at the other grid points along the pole row may be obtained through suitable rotation of the coordinate system. All the components at the pole row are, of course, simply representations of the same vector wind viewed from differing (rotated) coordinate systems. In the southern hemisphere the analogous situation holds; the single set of transmitted pole point wind components belong at the gridpoint (73,1).

A.2.2.1.2.1 Wafs/Icao/International Exchange/Fos Grids

In Figure 1 the boxes indicate the location of the octants of the globe, the numbers are the corresponding

(Grids 37 - 44)

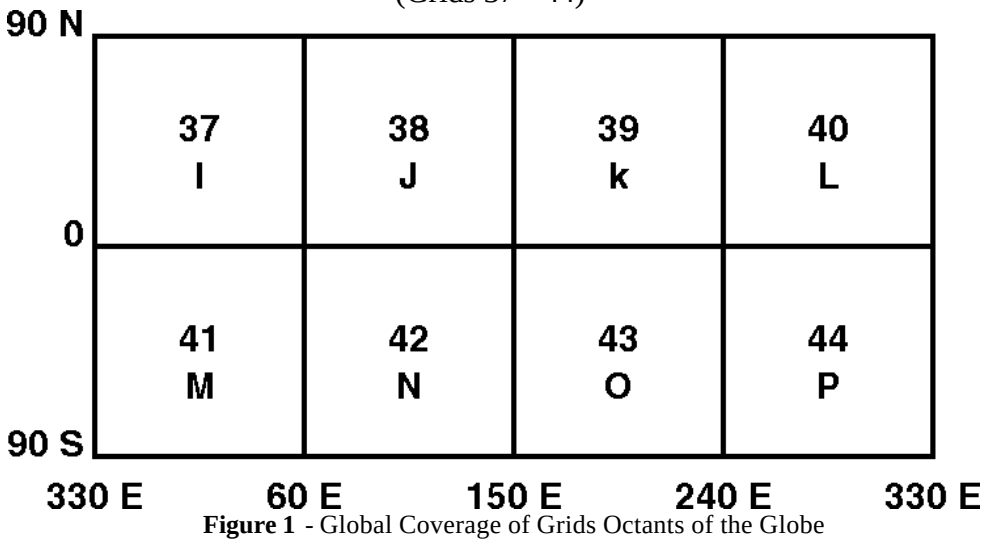


Figure 1 - Global Coverage of Grids Octants of the Globe

grid identification numbers (PDS Octet 7), and the letters are the grid identification used in the WMO Abbreviated Heading. The left and right meridional columns of each octant/grid are shared with the neighbours. The basic grid point separation is 1.25x1.25 deg. on a latitude/longitude array, but the grid is "thinned" by reducing the number of points in each row as one goes northward (or southward) away from the equator. In GRIB terms, this is referred to as a "quasi- regular" grid. The latitudinal increment is always 1.25 deg.; this results in 73 rows where the pole is included as a "row", not a single gridpoint. The longitudinal spacing at the equator is also 1.25 deg.; thus there will be 73 gridpoints at the equator in each octant.

The number of points on each latitudinal row, other than the equator, is given by (using FORTRAN notation):

NPOINTS = IFIX(2.0 + (90.0/1.25) * COS(LATITUDE))

Thus at the pole there will be two gridpoints, one each at the meridians that delineate the edges of the octant. The formula was worked out so that there is (approximately) equal geographic separation between the grid points uniformly across the globe.

Because of variations in precision and roundoff error in different computers, the value of NPOINTS may vary by 1 at "critical" latitudes when calculated on various hardware platforms. Here is a table of the exact values of NPOINTS as a function of latitude as used in the internationally exchanged grids. These numbers will, of course, be found in the Grid Description Section of each GRIB bulletin.

Latitude Range inclusive (north or south)	NPOINTS	Latitude Range inclusive (north or south)	NPOINTS
0.00 - 8.75	73	55.00	43
10.00 - 12.50	72	56.25	42
13.75 - 16.25	71	57.50	40
17.50 - 18.75	70	58.75	39
20.00 - 21.25	69	60.00	38
22.50	68	61.25	36
23.75 - 25.00	67	62.50	35
26.25	66	63.75	33
27.50 - 28.75	65	65.00	32
30.00	64	66.25	30
31.25	63	67.50	29
32.50	62	68.75	28
33.75	61	70.00	26
35.00 - 36.25	60	71.25	25
37.50	59	72.50	23
38.75	58	73.75	22
40.00	57	75.00	20
41.25	56	76.25	19
42.50	55	77.50	17
43.75	54	78.75	16
45.00	52	80.00	14
46.25	51	81.25	12
47.50	50	82.50	11
48.75	49	83.75	9
50.00	48	85.00	8
51.25	47	86.25	6
52.50	45	87.50	5
53.75	44	88.75	3
		90.00	2

When all this is put together the result is that there are 3447 points of data actually transmitted in any individual GRIB bulletin containing one octant of the globe.

In the GRIB bulletins all of this information will be included in the Grid Description Section (GDS); the GDS must be included in order to describe the thinned or "quasi-regular" grid structure. See Section 2 and section A2.2.2.1 (Table C) for the general description of the GDS; what follows are the specific values of the variables in the GDS that describe these eight grids.

GDS Contents	
Octets	Value or variable
1-3	178 (length of GDS)
4	0 (or 255, either indicating no PV)
5	33 (pointer to start of PL list)

6	0
7-32	Grid description - see below
33-178	number of points in each of 73 rows (2 octets per point)

Details Of Octets 7-32 - Grid Description									
Octets	Variable & Value								
7-8	Ni = all bits set to 1 (missing)								
9-10	Nj = 73								
	GRID	37	38	39	40	41	41	43	44
11-13	La1=	0	0	0	0	90S	90S	90S	90S
14-16	Lo1=	330	60	150	240	330	60	150	240
17	Resolution & Component Flag = [10000000] (binary)								
	GRID	37	38	39	40	41	41	43	44
18-20	La2=	90N	90N	90N	90N	0	0	0	0
21-23	Lo2=	60	150	240	330	60	150	240	330
24-25	Di = all bits set to 1 (missing)								
26-27	Dj = 1.25 deg								
28	Scan Mode = [01000000] (binary)								
29-32	Set to 0 (unused)								

Note that the scanning direction is from the bottom (south edge) to the top of the octant grids, regardless of the hemisphere. Thus in the northern hemisphere the first 73 data points (in the BDS) will be the equatorial values and the last two will be the polar values. The PL counts in the GDS octets 33-178 will, of course, indicate contain these numbers.

In the southern hemisphere, the first two data points will be the south pole values, and the last 73 points will be the equatorial values. Octets 33-34 in the GDS will contain "2", octets 35-36 will contain a "3", and so on to octets 177-178 which will contain "73".

A.2.2.1.3 Table 0 - Part 1: National/International Originating Centers

Assigned by The WMO

Value	Centre
07	US Weather Service - National Met. Center
08	US Weather Service - NWS Telecomms Gateway
09	US Weather Service - Field Stations
34	Japanese Meteorological Agency - Tokyo
52	National Hurricane Center, Miami
54	Canadian Meteorological Service - Montreal
57	U.S. Air Force - Global Weather Center
58	US Navy - Fleet Numerical Meteorology & Oceanography Center
59	NOAA Forecast Systems Lab, Boulder CO
74	U.K. Met Office - Exeter

85	French Weather Service - Toulouse
97	European Space Agency (ESA)
98	European Center for Medium-Range Weather Forecasts - Reading
99	DeBilt, Netherlands

A.2.2.1.4 Table 0 - Part 2: National Sub-Centers

Assigned By The Nation – National sub-centers, if any, would be found here.

A.2.2.1.5 Table 1: Flag for GDS or BMS

Bit	Value	Meaning
1	0	GDS Omitted
	1	GDS Included
2	0	BMS Omitted
	1	BMS Included
3-8	0	reserved

A.2.2.1.6 Table 2: Parameters & Units, Version 2

Value	Parameter	Units
000	Reserved	
001	Pressure	Pa
002	Pressure reduced to MSL	Pa
003	Pressure tendency	Pa/s
004		
005		
006	Geopotential	m^2/s^2
007	Geopotential height	gpm
008	Geometric height	m
009	Standard deviation of height	m
010		
011	Temperature	deg. K
012	Virtual temperature	deg. K
013	Potential temperature	deg. K
014	Pseudo-adiabatic potential temperature	deg. K
015	Maximum temperature	deg. K
016	Minimum temperature	deg. K
017	Dew point temperature	deg. K
018	Dew point depression (or deficit)	deg. K
019	Lapse rate	deg. K/m
020	Visibility	m
021	Radar Spectra (1)	-
022	Radar Spectra (2)	-

023	Radar Spectra (3)	-
024		
025	Temperature anomaly	deg. K
026	Pressure anomaly	Pa
027	Geopotential height anomaly	gpm
028	Wave Spectra (1)	-
029	Wave Spectra (2)	-
030	Wave Spectra (3)	-
031	Wind direction	deg. true
032	Wind speed	m/s
033	u-component of wind	m/s
034	v-component of wind	m/s
035	Stream function	m2/s
036	Velocity potential	m2/s
037	Montgomery stream function	m2/s2
038	Sigma coord. vertical velocity	/s
039	Pressure Vertical velocity	Pa/s
040	Geometric Vertical velocity	m/s
041	Absolute vorticity	/s
042	Absolute divergence	/s
043	Relative vorticity	/s
044	Relative divergence	/s
045	Vertical u-component shear	/s
046	Vertical v-component shear	/s
047	Direction of current	deg. true
048	Speed of current	m/s
049	u-component of current	m/s
050	v-component of current	m/s
051	Specific humidity	kg/kg
052	Relative humidity	%
053	Humidity mixing ratio	kg/kg
054	Precipitable water	kg/m^2
055	Vapor pressure	Pa
056	Saturation deficit	Pa
057	Evaporation	kg/m^2
058	Cloud Ice	kg/m^2
059	Precipitation rate	$kg/m^2/s$
060	Thunderstorm probability	%
061	Total precipitation	kg/m^2
062	Large scale precipitation	kg/m^2
063	Convective precipitation	kg/m^2
064	Snowfall rate water equivalent	kg/m^2s
065	Water equiv. of accum. snow depth	kg/m^2
066	Snow depth	m
067	Mixed layer depth	m
068	Transient thermocline depth	m
069	Main thermocline depth	m
070	Main thermocline anomaly	m

071	Total cloud cover	%
072	Convective cloud cover	%
073	Low cloud cover	%
074	Medium cloud cover	%
075	High cloud cover	%
076	Cloud water	kg/m^2
077		
078	Convective snow	kg/m^2
079	Large scale snow	kg/m^2
080	Water Temperature	deg K
081	Land-sea mask (1=land;0=sea) (see note)	fraction
082	Deviation of sea level from mean	m
083	Surface roughness	m
084	Albedo	%
085	Soil temperature	deg. K
086	Soil moisture content	kg/m^2
087	Vegetation	%
088	Salinity	kg/kg
089	Density	kg/m^3
090	Water runoff	kg/m^2
091	Ice concentration (ice=1;no ice=0)(see note)	fraction
092	Ice thickness	m
093	Direction of ice drift	deg. true
094	Speed of ice drift	m/s
095	u-component of ice drift	m/s
096	v-component of ice drift	m/s
097	Ice growth rate	m/s
098	Ice divergence	/s
099	Snow melt	kg/m^2
100	Significant height of combined wind waves and swell	m
101	Direction of wind waves	deg. true
102	Significant height of wind waves	m
103	Mean period of wind waves	s
104	Direction of swell waves	deg. true
105	Significant height of swell waves	m
106	Mean period of swell waves	s
107	Primary wave direction	deg. true
108	Primary wave mean period	s
109	Secondary wave direction	deg. true
110	Secondary wave mean period	s
111	Net short-wave radiation (surface)	W/m^2
112	Net long wave radiation (surface)	W/m^2
113	Net short-wave radiation (top of atmos.)	W/m^2
114	Net long wave radiation (top of atmos.)	W/m^2
115	Long wave radiation	W/m^2
116	Short wave radiation	W/m^2
117	Global radiation	W/m^2

118		
119		
120		
121	Latent heat net flux	W/m^2
122	Sensible heat net flux	W/m^2
123	Boundary layer dissipation	W/m^2
124	Momentum flux, u component	N/m^2
125	Momentum flux, v component	N/m^2
126	Wind mixing energy	J
127	Image data	
128-254	Reserved for use by originating center	
255	Missing	

Notes:

(1). ECMWF Version of Table 2 for FM92-VIII Ext. GRIB uses values 128-254 for its own purposes, i.e. centre dependent.
(2). By convention, downward net fluxes of radiation or other quantities are assigned negative values; upward net fluxes of radiation or other quantities are assigned positive values.
(3). Unidirectional flux values, where the direction of flow is indicated in the name of the parameter shall all have positive values irrespective of the direction of flow. Net (vertical) fluxes shall be calculated by subtracting the downward flux values from the upward flux values.
(4). The u and v components of vector quantities are defined with reference to GDS Octet 17 and section A.2.2.2.3 (Table 7). However, if the GDS is not included in a message, then any wind components are assumed to be resolved relative to the grid specified in the PDS with u and v defined as positive in the direction of increasing x and y (or i and j) coordinates respectively.
(5). Provision is made for three types of spectra:
a) Direction and Frequency
b) Direction and radial number
c) Radial number and radial number
(6). Parameters 81 and 91 show the units as "fraction", thus allowing for a range of coverage. It is up to the user to employ the D (power of ten) scaling to assure that the necessary precision is retained in the numeric values.

A.2.2.1.7 Table 3: Type and Value of Level

Octet Number 10		Number 11	Number 12
Value	Meaning	Contents	
0-99	special codes, see section A.2.2.1.8.(Table 3a)	0	0
100	isobaric level	pressure in hectoPascals (hPa) (2 octets)	
101	layer between two isobaric levels	pressure of top (kPa)	pressure of bottom (kPa)

102	mean sea level	0	0
103	fixed height level	height above mean sea level (MSL) in meters	
104	layer between two height levels above msl	height of top (hm) above mean sea level	height of bottom (hm) above mean sea level
105	fixed height above ground	height in meters (2 octets)	
106	layer between two height levels above ground	height of top (hm) above ground	height of bottom (hm) above ground
107	sigma level	sigma value in 1/10000 (2 octets)	
108	layer between two sigma levels	sigma value at top in 1/100	sigma value at bottom in 1/100
109	Hybrid level	level number (2 octets)	
110	layer between two hybrid levels	level number of top	level number of bottom
111	depth below land surface	centimetres (2 octets)	
112	layer between two depths below land surface	depth of upper surface (cm)	depth of lower surface (cm)
113	isentropic (theta) level	Potential Temp. degrees K (2 octets)	
114	layer between two isentropic levels	475K minus theta of top in Deg. K	475K minus theta of bottom in Deg. K
115	level at specified pressure difference from ground to level	hPa (2 octets)	
116	layer between two levels at specified pressure differences from ground to levels	pressure difference from ground to top level hPa	pressure difference from ground to bottom level hPa
121	layer between two isobaric surfaces (high precision)	1100 hPa minus pressure of top, in hPa	1100 hPa minus pressure of bottom, in hPa
125	Height level above ground (high precision)	centimeters (2 octets)	
128	layer between two sigma levels (high precision)	1.1 minus sigma of top, in 1/1000 of sigma	1.1 minus sigma of bottom, in 1/1000 of sigma
141	layer between two isobaric surfaces (mixed precision)	pressure of top, in kPa	1100hPa minus pressure of bottom, in hPa
160	depth below sea level	meters (2 octets)	
200	entire atmosphere considered as a single layer	0 (2 octets)	
201	entire ocean considered as a single layer	0 (2 octets)	

Note:

(1) The numbering allows for additions within this framework:

- 100-119 normal precision
- 120-139 high precision
- 140-159 mixed precision

A.2.2.1.8 Table 3a: Special Levels

Value	Level
00	reserved
01	surface (of the Earth, which includes sea surface)
02	cloud base level
03	cloud top level
04	0 deg (C) isotherm level
05	adiabatic condensation level (parcel lifted from surface)
06	maximum wind speed level
07	tropopause level
08	Nominal top of atmosphere
09	Sea bottom
10-99	reserved

A.2.2.1.9 Table 4: Forecast Time Unit

Value	Time Unit
0	minute
1	hour
2	day
3	month
4	year
5	decade
6	normal (30 years)
7	century
8-253	reserved
254	second

A.2.2.1.10 Table 5: Time Range Indicator

Value	Meaning
0	Forecast product valid at reference time + P1 (P1>0), or Uninitialized analysis product for reference time (P1=0). or Image product for reference time (P1=0)
1	Initialized analysis product for reference time (P1=0).
2	Product with a valid time ranging between reference time + P1 and reference time + P2
3	Average (reference time + P1 to reference time + P2)

4	Accumulation (reference time + P1 to reference time + P2) product considered valid at reference time + P2
5	Difference (reference time + P2 minus reference time + P1) product considered valid at reference time + P2
6-9	reserved
10	P1 occupies octets 19 and 20; product valid at reference time + P1
11-50	reserved
51	Climatological Mean Value: multiple year averages of quantities which are themselves means over some period of time (P2) less than a year. The reference time (R) indicates the date and time of the start of a period of time, given by R to R + P2, over which a mean is formed; N indicates the number of such period-means that are averaged together to form the climatological value, assuming that the N period-mean fields are separated by one year. The reference time indicates the start of the N-year climatology. N is given in octets 22-23 of the PDS. If P1 =0 then the data averaged in the basic interval P2 are assumed to be continuous, i.e., all available data are simply averaged together. If P1 = 1 (the units of time - octet 18, code table 4 - are not relevant here) then the data averaged together in the basic interval P2 are valid only at the time (hour, minute) given in the reference time, for all the days included in the P2 period. The units of P2 are given by the contents of octet 18 and Table 4.
52-112	reserved
113	Average of N forecasts (or initialized analyses); each product has forecast period of P1 (P1=0 for initialized analyses); products have reference times at intervals of P2, beginning at the given reference time.
114	Accumulation of N forecasts (or initialized analyses); each product has forecast period of P1 (P1=0 for initialized analyses); products have reference times at intervals of P2, beginning at the given reference time.
115	Average of N forecasts, all with the same reference time; the first has a forecast period of P1, the remaining forecasts follow at intervals of P2.
116	Accumulation of N forecasts, all with the same reference time; the first has a forecast period of P1, the remaining follow at intervals of P2.
117	Average of N forecasts, the first has a period of P1, the subsequent ones have forecast periods reduced from the previous one by an interval of P2; the reference time for the first is given in octets 13- 17, the subsequent ones have reference times increased from the previous one by an interval of P2. Thus all the forecasts have the same valid time, given by the initial reference time + P1.
118	Temporal variance, or covariance, of N initialized analyses; each product has forecast period P1=0; products have reference times at intervals of P2, beginning at the given reference time.

119 -122	reserved
123	Average of N uninitialized analyses, starting at the reference time, at intervals of P2.
124	Accumulation of N uninitialized analyses, starting at the reference time, at intervals of P2.
125-254	reserved

Notes:

(1). For analysis products, or the first of a series of analysis products, the reference time (octets 13 to 17) indicates the valid time.
(2). For forecast products, or the first of a series of forecast products, the reference time indicates the valid time of the analysis upon which the (first) forecast is based.
(3). Initialized analysis products are allocated numbers distinct from those allocated to uninitialized analysis products.
(4). A value of 10 allows the period of a forecast to be extended over two octets; this accommodates extended range forecasts.
(5). Where products or a series of products are averaged or accumulated, the number involved is to be represented in octets 22- 23 of Section 1, while any number missing is to be represented in octet 24.
(6). Forecasts of the accumulation or difference of some quantity (e.g. quantitative precipitation forecasts), indicated by values of 4 or 5 in octet 21, have a product valid time given by the reference time + P2; the period of accumulation, or difference, can be calculated as P2 - P1.

A.2.2.2 Grid Description Section (GDS)

A.2.2.2.1 Table C – Sundry Grid Definitions

A.2.2.2.1.1 Latitude-Longitude Grids Including Gaussian

Octet No.	Content and Meaning
7 -8	Ni - No. of points along a latitude circle
9 - 10	Nj - No. of points along a longitude meridian
11 - 13	La1 - latitude of first grid point units: millidegrees (degrees x 1000) values limited to range 0 - 90,000 bit 1 (leftmost) set to 1 for south latitude
14 - 16	Lo1 - longitude of first grid point units: millidegrees (degrees x 1000) values limited to range 0 - 360,000 bit 1 (leftmost) set to 1 for west longitude
17	Resolution and component flags in section A.2.2.2.3 (Table 7)
18 - 20	La2 - Latitude of last grid point (same units, value range, and bit 1 as La1)
21 - 23	Lo2 - Longitude of last grid point (same units, value range, and bit 1 as Lo1)
24 - 25	Di - Longitudinal Direction Increment (same units as Lo1) (if not given, all bits set = 1)

26 - 27	*Regular Lat/Lon Grid*: Dj - Latitudinal Direction Increment (same units as La1) (if not given, all bits set = 1) *Gaussian Grid*: N - number of latitude circles between a pole and the equator Mandatory if Gaussian Grid specified
28	Scanning mode flags in section A.2.2.2.4 (See Table 8)
29 - 32	Reserved (set to zero)

Notes:

(1). The latitude and longitude of the first and last grid points should always be given, for regular grids.
(2). If a quasi-regular grid is to be described, in which all the rows or columns do not necessarily have the same number of grid points, either Ni (octets 7-8) or Nj (octets 9-10) and the corresponding Di (octets 24-25) or Dj (octets 26-27) shall be coded with all bits set to 1 (missing).
(3). A quasi-regular grid can be defined only for rows or columns, but not both simultaneously. The first point in each row (column) shall be positioned at the meridian (parallel) indicated in octets 11-16. The grid points shall be evenly spaced in latitude (longitude).
(4). For Gaussian grids only the rows can be rendered quasi-regular; the first point shall be located at the meridian given in octets 14-16 and the last point at the meridian given in octets 21-23.

A.2.2.2.1.2 Polar Stereographic Grids

Octet No.	Content and Meaning
7 - 8	Nx - Number of points along x-axis
9 - 10	Ny - Number of points along y-axis
11 - 13	La1 - Latitude of first grid point
14 - 16	Lo1 - Longitude of first grid point
17	Resolution and component flags in section A.2.2.2.3 (Table 7)
18 - 20	Lov - The orientation of the grid; i.e., the east longitude value of the meridian which is parallel to the y-axis (or columns of the grid) along which latitude increases as the y-coordinate increases. (Note: The orientation longitude may, or may not, appear within a particular grid.)
21 - 23	Dx - the X-direction grid length (see Note 2)
24 - 26	Dy - the Y-direction grid length (see note 2)
27	Projection center flag (see note 5)
28	Scanning mode in section A.2.2.2.4 (Table 8)
29 - 32	Set to 0 (reserved)

Notes:

(1). Latitude and longitude are in millidegrees (thousandths)
(2). Grid lengths are in units of meters, at the 60 degree latitude circle nearest to the pole in the projection plane.

(3). Latitude values are limited to the range 0 - 90,000. Bit 1 is set to 1 to indicate south latitude.
(4). Longitude values are limited to the range 0 - 360,000. Bit one is set to 1 to indicate west longitude.
(5). Octet 27:

Bit 1 set to 0 if the North pole is on the projection plane.
Bit 1 set to 1 if the South pole is on the projection plane.

(6). The first and last grid points may not necessarily be the same as the first and last data points if the bit map section (BMS) is used.
(7). The resolution flag (bit 1 of section A.2.2.2.3 – Table 7) is not applicable.

A.2.2.2.1.3 Lambert Conformal Secant Or Tangent Cone Grids

Octet No.	Content and Meaning
7 - 8	Nx - Number of points along x-axis
9 - 10	Ny - Number of points along y-axis
11 - 13	La1 - Latitude of first grid point
14 - 16	Lo1 - Longitude of first grid point
17	Resolution and component flags in section A.2.2.2.3 (Table 7)
18 - 20	Lov - The orientation of the grid; i.e., the east longitude value of the meridian which is parallel to the y-axis (or columns of the grid) along which latitude increases as the y-coordinate increases. (Note: The orientation longitude may, or may not, appear within a particular grid.)
21 - 23	Dx - the X-direction grid length (see note 2)
24 - 26	Dy - the Y-direction grid length (see Note 2)
27	Projection center flag (see note 5)
28	Scanning mode in section A.2.2.2.4 (Table 8)
29 - 31	Latin 1 - The first latitude from the pole at which the secant cone cuts the spherical earth. (See Note 8)
32 - 34	Latin 2 - The second latitude from the pole at which the secant cone cuts the spherical earth. (See Note 8)
35 - 37	Latitude of southern pole (millidegrees)
38 - 40	Longitude of southern pole (millidegrees)
41 - 42	Reserved (set to 0)

Notes:

(1). Latitude and longitude are in millidegrees (thousandths)
(2). Grid lengths are in units of meters, at the intersection latitude circle nearest to the pole in the projection plane.
(3). Latitude values are limited to the range 0 - 90,000. Bit 1 is set to 1 to indicate south latitude.
(4). Longitude values are limited to the range 0 - 360,000. Bit one is set to 1 to indicate west longitude.
(5). Octet 27:

Bit 1 set to 0 if the North pole is on the projection plane.

Bit 1 set to 1 if the South pole is on the projection plane.
Bit 2 set to 0 if only one projection center used
Bit 2 set to 1 if projection is bipolar and symmetric

(6). The first and last grid points may not necessarily be the same as the first and last data points if the bit map section (BMS) is used.
(7). The resolution flag (bit 1 of section A.2.2.2.3 – Table 7) is not applicable.
(8). If Latin 1 = Latin 2 then the projection is on a tangent cone.

A.2.2.2.1.4 Mercator Grids

Octet No.	Content and Meaning
7 - 8	Ni - Number of points along a latitude circle
9 - 10	Nj - Number of points along a longitude meridian
11 - 13	La1 - Latitude of first grid point
14 - 16	Lo1 - Longitude of first grid point
17	Resolution and component flags in section A.2.2.2.3 (Table 7)
18 - 20	La2 - latitude of last grid point
21 - 23	Lo2 - longitude of last grid point
24 - 26	Latin - The latitude(s) at which the Mercator projection cylinder intersects the earth.
27	Reserved (set to 0)
28	Scanning mode in section A.2.2.2.4 (Table 8)
29 - 31	Di - the longitudinal direction increment (see Note 2)
32 - 34	Dj - the latitudinal direction increment (see note 2)
35 - 42	Reserved (set to 0)

Notes:

(1). Latitude and longitude are in millidegrees (thousandths)
(2). Grid lengths are in units of meters, at the circle of latitude specified by Latin.
(3). Latitude values are limited to the range 0 - 90,000. Bit 1 is set to 1 to indicate south latitude.
(4). Longitude values are limited to the range 0 - 360,000. Bit one is set to 1 to indicate west longitude.
(5). The latitude and longitude of the last grid point should always be given.
(6). The first and last grid points may not necessarily be the same as the first and last data points if the bit map section (BMS) is used.

A.2.2.2.1.5 Space View Or Perspective Or Orthographic

Octet No.	Content and Meaning
7-8	Nx - number of points along x axis (columns)
9-10	Ny - number of points along y axis (rows or lines)
11-13	Lap - latitude of sub-satellite point
14-16	Lop - longitude of sub-satellite point
17	Resolution and component flags in section A.2.2.2.3 (Table 7)

18-20	dx - apparent diameter of earth in grid lengths, in x direction
21-23	dy - apparent diameter of earth in grid lengths, in y direction
24-25	Xp - X-coordinate of sub satellite point
26-27	Yp - Y-coordinate of sub-satellite point
28	Scanning Mode in section A.2.2.2.4 (Table 8)
29-31	the orientation of the grid; i.e., the angle in millidegrees between the increasing y axis and the meridian of the sub-satellite point in the direction of increasing latitude (see Note 3).
32-34	Nr - the altitude of the camera from the earth's center, measured in units of the earth's (equatorial) radius (See Note 4).
35-44	reserved

Notes:

(1). It is assumed that the satellite is at its nominal position, i.e., it is looking directly at its sub-satellite point.
(2). Octet 32-34 shall be set to all ones (missing) to indicate the orthographic view (from infinite distance).
(3). It is the angle between increasing y axis and the meridian 180 degrees east if the sub-satellite point is the North pole; or the meridian 0 degrees, if the sub-satellite point is the south pole.
(4). The apparent angular size of the earth will be given by 2 * asin(1/Nr).
(5). The horizontal and vertical angular resolutions of the sensor (Rx and Ry), needed for navigation equations, can be calculated from the following:

$$Rx = 2 * \text{asin}(1/Nr) / dx$$
$$Ry = 2 * \text{asin}(1/Nr) / dy$$

A.2.2.2.1.6 Spherical Harmonic Coefficients

Octet No.	Content and Meaning
7 - 8	J - Pentagonal Resolution Parameter
9 - 10	K - Pentagonal Resolution Parameter
11 - 12	M - Pentagonal Resolution Parameter
13	Representation Type in section A.2.2.2.5 (Table 9)
14	Coefficient Storage Mode in section A.2.2.2.6 (Table 10)
15 - 32	Set to zero (reserved)

A.2.2.2.2 Table 6: Data Representation Type

Value	Meaning
0	Latitude/Longitude Grid also called Equidistant Cylindrical or Plate Carree projection grid
1	Mercator Projection Grid
2	Gnomonic Projection Grid

3	Lambert Conformal, secant or tangent, conical or bipolar (normal or oblique) Projection Grid
4	Gaussian Latitude/Longitude Grid
5	Polar Stereographic Projection Grid
6 - 12	(reserved - see Manual on Codes)
13	Oblique Lambert conformal, secant or tangent, conical or bipolar, projection
14 - 49	(reserved - see Manual on Codes)
50	Spherical Harmonic Coefficients
51 - 89	(reserved - see Manual on Codes)
90	Space view perspective or orthographic grid
91 - 191	(reserved - see Manual on Codes)
192 - 254	reserved for local use

A.2.2.2.3 Table 7: Resolution And Component Flags

Bit	Value	Meaning
1	0	Direction increments not given
	1	Direction increments given
2	0	Earth assumed spherical with radius = 6367.47 km
	1	Earth assumed oblate spheroid with size as determined by IAU in 1965: 6378.160 km, 6356.775 km, f = 1/297.0
3-4		reserved (set to 0)
5	0	u- and v-components of vector quantities resolved relative to easterly and northerly directions
	1	u and v components of vector quantities resolved relative to the defined grid in the direction of increasing x and y (or i and j) coordinates respectively
6-8		reserved (set to 0)

Note:

(1) If the GDS is not included in a message then any wind components are assumed to be resolved relative to the grid specified in the PDS with u and v defined as positive in the direction of increasing x and y (or i and j) coordinates respectively.

A.2.2.2.4 Table 8: Scanning Mode Flag

Bit	Value	Meaning
1	0	Points scan in +i direction
	1	Points scan in -i direction
2	0	Points scan in -j direction
	1	Points scan in +j direction
3	0	Adjacent points in i direction are consecutive (FORTRAN: (I,J))

	1	Adjacent points in j direction are consecutive (FORTRAN: (J,I))

Notes:

(1). i direction is defined as west to east along a parallel of latitude, or left to right along an x axis.
(2). j direction is defined as south to north along a meridian of longitude, or bottom to top along a y axis.

A.2.2.2.5 Table 9: Spectral Representation Type

Value	Meaning
1	Associated Legendre Polynomials of the First Kind with normalization such that the integral equals 1

A.2.2.2.6 Table 10: Coefficient Storage Mode

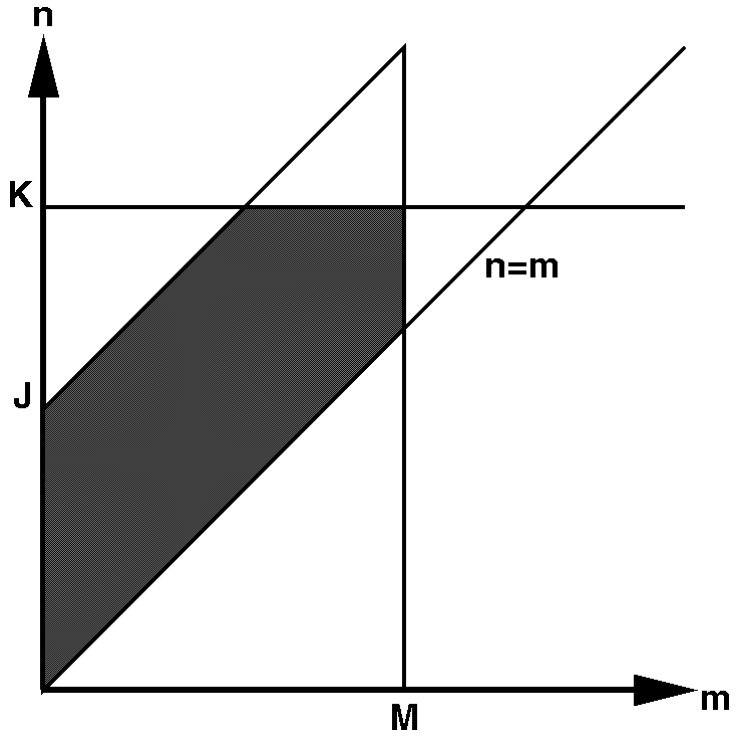
Value	Meaning
1	The complex coefficients Xnm are stored for m>0 as pairs of real numbers Re(Xnm), Im(Xnm) ordered with n increasing from m to N(m), first for m = 0 and then for m = 1, 2, 3,...M. The real part of the (0,0) coefficient is stored in octets 12-15 of the BDS, as a floating point number in the same manner as the packing reference value, with units as in Table 2. The remaining coefficients, starting with the imaginary part of the (0,0) coefficient, are packed according to the GRIB packing algorithm, with units as given in Table 5, in octets 16 and onward in the BDS.
2	Refer to Section 4, Spherical harmonics-complex packing for discussion

Notes on Spectral Truncation:

(1). Using the associated Legendre Polynomials of the First Kind, Pnm, as typical expansion functions, any variable x(?,μ), which is a function of longitude, lambda, and sin(latitude), mu, can be represented by,

$$x(\lambda,\mu) = \sum_{m=-M}^{M} \sum_{n=|m|}^{N(m)} X_n^M P_n^M(\mu) e^{im\lambda}$$

(2). In the summations, M is the maximum zonal wave number that is to be included, and K & J together define the maximum meridional total wave number N(m), which, it should be noted, is a function of m. A sketch shows the relationships:



In this figure, the ordinate is n the zonal wave number, the abscissa, m, is the total meridional wave number, the vertical line at m = M is the zonal truncation, and the diagonal passing through (0,0) is the line n = m. The Legendre Polynomials are defined only on or above this line, that is for n > m. On the n-axis, the horizontal line at n = K indicates the upper limit to n values, and the diagonal that intersects the n-axis at n = J indicates the upper limit of the area in which the Polynomials are defined. The shaded irregular pentagon defined by the n-axis, the diagonal from n = J, the horizontal n = K, the vertical m = M, and the other diagonal n = m surrounds the region of the (n x m) plane containing the Legendre Polynomials used in the expansion.

(3). This general pentagonal truncation reduces to some familiar common truncations as special cases:

- Triangular: K = J = M and N(m) = J
- Rhomboidal: K = J + M and N(m) = J + m
- Trapezoidal: K = J, K > M and N(m) = J

In all of the above m can take on negative values to represent the imaginary part of the spectral coefficients.

A.2.2.3 Binary Data Section (BDS)

A.2.2.3.1 Table 11 – Flag

Bit	Value	Meaning
1	0	Grid point data
	1	Spherical Harmonic Coefficients

2	0	Simple packing
	1	Second order ("Complex") Packing
3	0	Original data were floating point values
	1	Original data were integer values
4	0	No additional flags at octet 14
	1	Octet 14 contains flag bits 5 - 12
The following gives the meaning of the bits in octet 14 ONLY if bit 4 is set to 1. Otherwise octet 14 contains regular binary data.		
5		Reserved (set to 0)
6	0	Single datum at each grid point
	1	Matrix of values at each grid point
7	0	No secondary bit maps
	1	Secondary bit maps present
8	0	Second order values have constant width
	1	Second order values have different widths
9-12		Reserved (set to 0)

Notes:

(1). Bit 3 is set to 1 to indicate that the original data were integers; when this is the case any non-zero reference values should be rounded to an integer value prior to placing in the GRIB BDS.
(2). Bit 4 is set to 1 to indicate that bits 5 to 12 are contained in octet 14 of the data section.
(3). Although GRIB is not capable of representing a matrix of data values at each grid point, the meaning of bit 6 is retained in anticipation of a future capability.
(4). When secondary bit maps are present in the data (used in association with second order packing) this is indicated by setting bit 7 to 1.
(5). When octet 14 contains the extended flag information octets 12 and 13 will also contain "special" information; the actual data will begin in a subsequent octet. See above.

A.2.2.4 AML AMC Version of Table 2 for FM92-VIII Ext. GRIB

The table below defines the AML-AMC parameter table originating from the Met Office that forms part of the specific AML-AMC Product Definition section of the GRIB encode (see section A.2.2.1.6). Parameter acronym for each of the weekly & annual parameters, parameter domain and units are also presented.

Value	Parameter Name	Parameter Acronym	Parameter Domain	Parameter Units
121	Mean scalar speed of wind	SCALS	UA	m/s
122	Mean dew point	TD	UA	K
123	Mean height of pressure surface	GP	UA	gpm
124	Mean 10-m scalar speed of wind	10SS	SF	m/s

126	Mean accum'd total ppn	TPPN	SF	kg/m^2 (equiv. to mm of rain)
130	Mean temperature	T	UA	K
131	Mean u-speed of wind	U	UA	m/s
132	Mean v-speed of wind	V	UA	m/s
	Standard vector deviation	SVD	UA	m/s
151	Mean MSL pressure	MSLP	SF	Pa
	S.D. of temperature	SDT	UA	K
157	Mean relative humidity	R	UA	% RH
	Mean lowest 0degC isotherm	HT0C	UA	geopotential metres (gpm)
165	Mean 10-m u-wind	10U	SF	m/s
166	Mean 10-m v-wind	10V	SF	m/s
164	Mean total cloud cover	TCC	SF	Fraction (0-1)
167	Mean 2-m temperature	2T	SF	K
168	Mean 2-m dew point	2D	SF	K
	S.D. of MSL pressure	SDMSLP	SF	Pa
186	Mean low cloud cover	LCC	SF	Fraction (0-1)
187	Mean medium cloud cover	MCC	SF	Fraction (0-1)
188	Mean high cloud cover	HCC	SF	Fraction (0-1)

Notes:

(1). Some AML AMC parameters cannot use the identifiers specified so far in GRIB as they are unique to the requirements of AML-AMC. Care should be taken that any which are used have SI units. Coverage of cloud or ice should be represented as a decimal fraction between 0 and 1, not as oktas. Probabilities of occurrence are better represented as a percentage rather than a fraction. Heights of pressure levels will be expressed in geopotential metres (gpm) as for this application the difference from geometric metres is insignificant.