GRIB API
A database driven decoding library

Enrico Fucile, Cristian Codorean

Data & Services

ECMWF

Overview

- **Introduction**
- **GRIB code**
- **GRIB API keys database**
- **Parameters database**

GRIB API

- **Developed at ECMWF**
- **Provides an easy and reliable way of encoding and decoding data in GRIB format**
- **Written entirely in C**
- **C and Fortran 90 interfaces available**
- **Provides many command line tools to quickly manipulate data without writing one line of code**

Introduction

- **Provides an interface which is independent of the type of data accessed**
- **Open to change and extensible through definition files**
- **To replace GRIBEX**
- **Available on many unix / linux flavours and easy to install**
- **Available for download from ECMWF's website:**

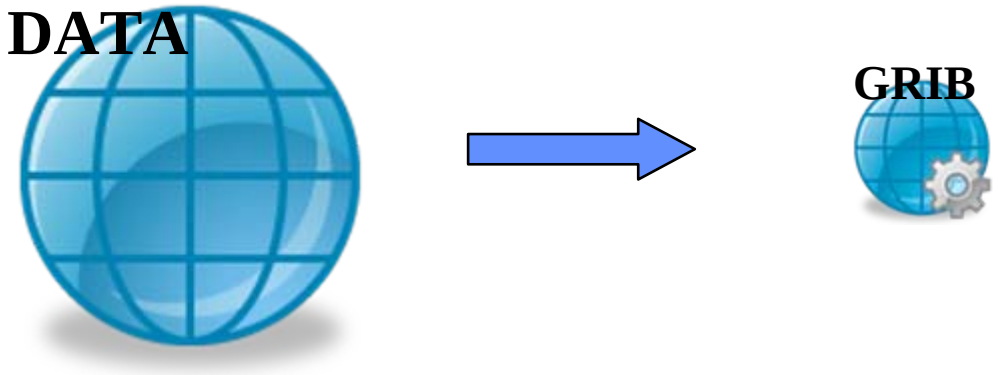
http://www.ecmwf.int/products/data/software/download/grib_api.html

GRIB code

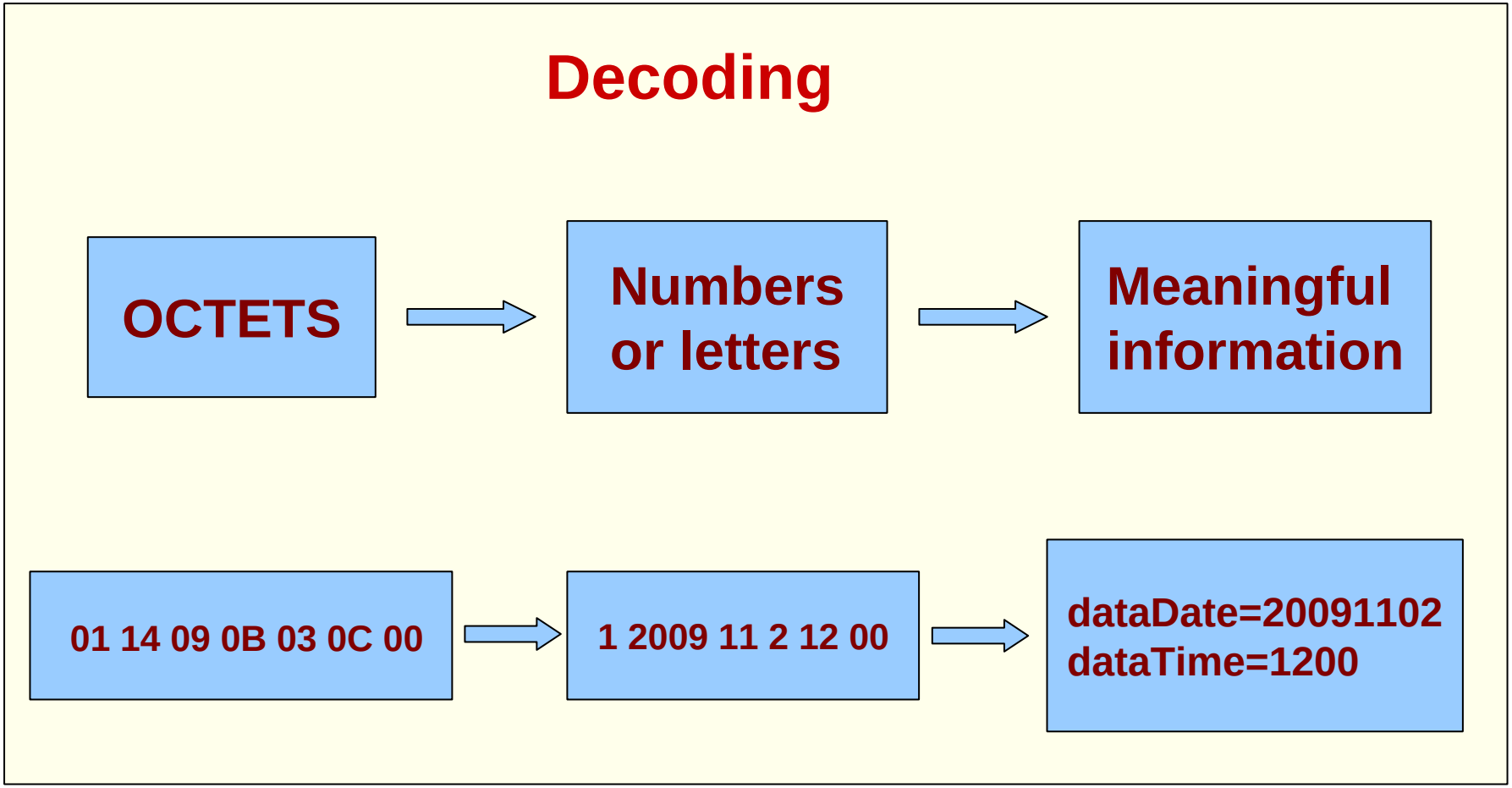
- Binary coded message
- Sequence of octets (= 8 bits)
- It isn't human readable
- Edition 1: GRIdded Binary
- Edition 2: General Regularly distributed Information in Binary form
- Cambridge dictionary: CODE is “a system of words, letters or signs which is used to represent a message in SECRET form”

GRIB code

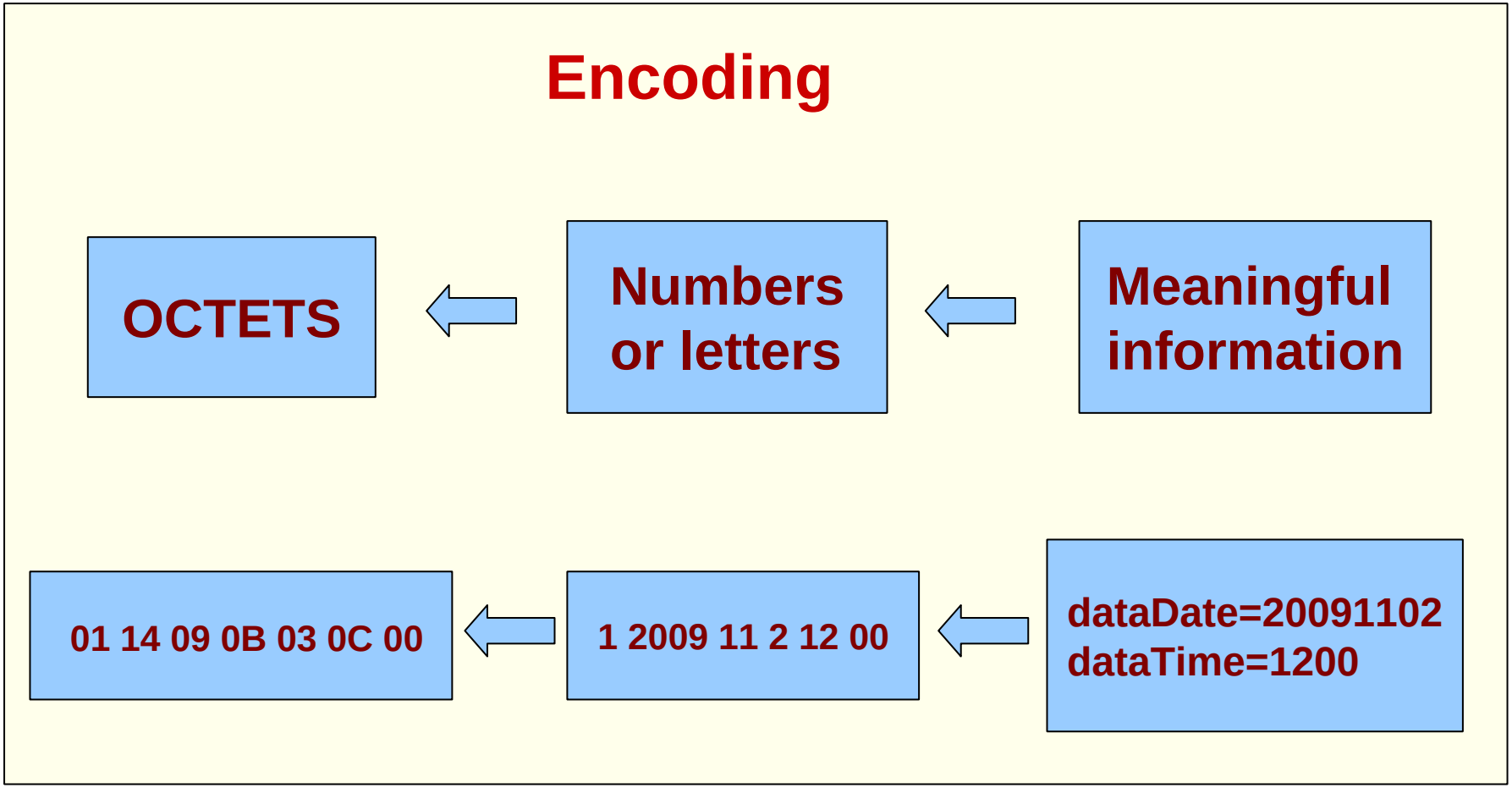
GRIB (GRIdded Binary) is a BINARY CODED format to exchange and store "general regularly-distributed information".



GRIB code


Decoding
OCTETS
Numbers or letters
Meaningful information
01 14 09 0B 03 0C 00
1 2009 11 2 12 00
dataDate=20091102
dataTime=1200

GRIB code


Encoding
OCTETS
Numbers or letters
Meaningful information
01 14 09 0B 03 0C 00
1 2009 11 2 12 00
dataDate=20091102
dataTime=1200

GRIB code Edition 2

Octet	Meaning
12	Significance of reference time
13-14	Year (4 digits)
15	Month
16	Day
17	Hour
18	Minute
19	Second

GRIB code Edition 2

Significance of reference time

Code	Meaning
0	Analysis
1	Start of forecast
2	Verifying time of forecast
3	Observation time
4-191	Reserved
192-254	Reserved for local use
255	Missing

GRIB code Edition 2

Octet	Meaning
56-59	La2 – latitude of last grid point
60-63	Lo2 – longitude of last grid point
64-67	Di – i direction increment
68-71	Dj – j direction increment
72	Scanning mode

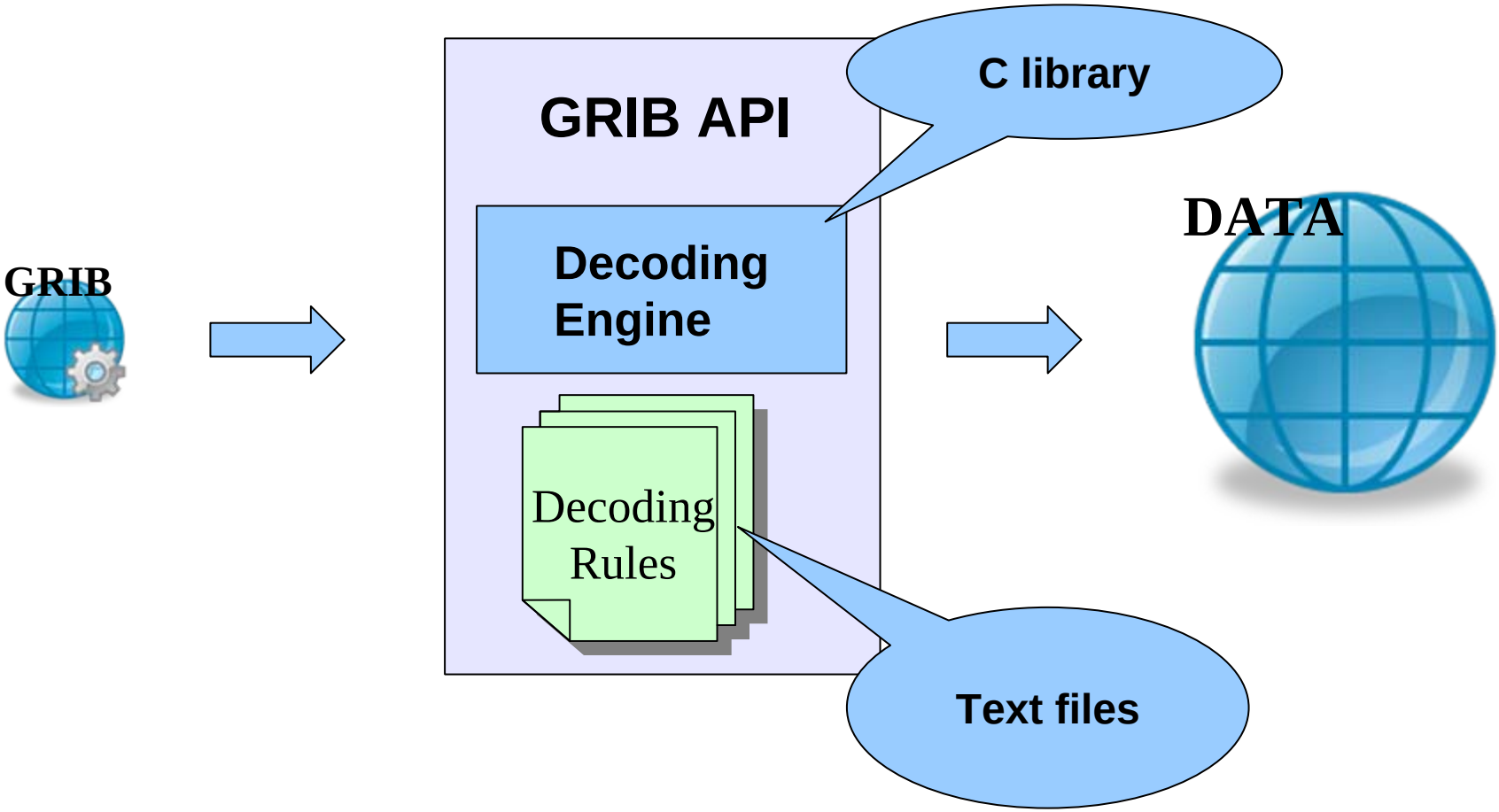
GRIB code Edition 2

Scanning mode

Bit Number	Value	Meaning
1	0	Points of first row or column scan in the +i (+x) direction
	1	Points of first row or column scan in the -i (-x) direction
2	0	Points of first row or column scan in the -j (-y) direction
	1	Points of first row or column scan in the +j (+y) direction
3	0	Adjacent points in i (x) direction are consecutive
	1	Adjacent points in j (y) direction is consecutive
4	0	All rows scan in the same direction
	1	Adjacent rows scans in the opposite direction

GRIB API keys database

```
grib_get(ig,"dataDate",dataDateValue)
```



SPECIFICATION OF OCTET CONTENTS

SECTION 0 - INDICATOR SECTION

Octet No.	Contents
1-4	"GRIB" (coded according to the International Alphabet No. 5.)
5-6	Reserved
7	Discipline - GRIB Master Table Number (see Code Table 0.0)
8	GRIB Edition Number (currently 2)
9-16	Total length of GRIB message in octets (including Section 0)

SECTION 1 - IDENTIFICATION SECTION

Octet No.	Contents	
1-4	Length of section in octets (21 or nn)	
5	Number of section (1)	
6-7	Identification of originating/generating centre (see Common Code Table C-11)	
8-9	Identification of originating/generating sub-centre (allocated by originating/generating Centre)	
10	GRIB Master Tables Version Number (see Code Table 1.0 and Note 1)	
11	Version number of GRIB Local Tables used to augment Master Tables (see Code Table 1.1 and Note 2)	
12	Significance of Reference Time (see Code Table 1.2)	
13-14	Year (4 digits)	|
15	Month	|
16	Day	| Reference time of data
17	Hour	|
18	Minute	|
19	Second	|
20	Production status of processed data in this GRIB message (see Code Table 1.3)	
21	Type of processed data in this GRIB message (see Code Table 1.4)	
22 - nn	Reserved: need not be present	

Notes:

(1) Local tables shall define those parts of the master tables which are reserved for local use except for the case described below. In any cases, the use of local tables in messages intended for non-local or international exchange is strongly discouraged.

(2) If octet 10 contains 255 then only local tables are in use, the local tables version number (Octet 11) must not be zero nor missing, and local tables may include entries from the entire range of the tables.

(3) If Octet 11 is zero, Octet 10 must contain a valid master tables version number and only those parts of the tables not reserved for local use may be used.

SECTION 2 - LOCAL SECTION USE

Octet No.	Contents
1-4	Length of section in octets (nn)
5	Number of section (2)
6-nn	Local use

SECTION 3 - GRID DEFINITION SECTION

Octet No.	Contents
1-4	Length of section in octets (nn)
5	Number of section (3)
6	Source of grid definition (see Code Table 3.0 and Note 1)
7-10	Number of data points
11	Number of octets for optional list of numbers (see Note 2)
12	Interpretation of list of numbers (see Code Table 3.11)
13-14	Grid Definition Template Number (= N) (see Code Table 3.1)
15-xx	Grid Definition Template (see Template 3.N, where N is the Grid Definition Template Number given in octets 13-14)

[xx+1]-nn Optional list of numbers defining number of points (see Notes 2, 3 and 4)

Notes:

(1) If octet 6 is not zero, octets 15-xx (15-nn if octet 11 is zero) may not be supplied. This should be documented with all bits set to 1 (missing value) in Grid Definition Template Number.

(2) An optional list of numbers may be used to document a quasi-regular grid In such a case, octet 11 is non zero, and gives the number of octets used per item in the list. For all other cases, such as regular grids, octets 11 and 12 are zero and no list is appended to the Grid Definition Template.

(3) If a list of numbers defining number of points is present, it is appended at the end of Grid Definition Template (or directly after Grid Definition Template Number if template is missing), the length of the list is given by the grid definition. When the Grid Definition Template is present, the length is given according to bit 3 of scanning mode flag octet (length is Nj or Ny for flag value 0). List ordering is implied by data scanning.

(4) Depending on code value given in octet 12, the list of numbers either:
- corresponds to the coordinate lines as given in the grid definition, or
- corresponds to a full circle, or
- does not apply

SECTION 4 - PRODUCT DEFINITION SECTION

Octet Number(s)	Contents
1-4	Length of section in octets (nn)
5	Number of section (4)
6-7	Number of coordinates values after Template (see Note 1)
8-9	Product Definition Template Number (see Code Table 4.0)
10-xx	Product Definition Template (see Template 4.X, where X is the Product Definition Template Number given in octets 8-9)
[xx+1]-nn	Optional list of coordinates values (see Notes 2 and 3)

Notes:

(1) Coordinates values are intended to document the vertical discretisation associated with model data on hybrid coordinate vertical levels. A number of zero in octets 6-7 indicates that no such values are present. Otherwise the number corresponds to the whole set of values.

(2) Hybrid systems, in the context, employ a means of representing vertical coordinates in terms of a mathematical combination of pressure and sigma coordinates. When used in conjunction with a surface pressure field and an appropriate mathematical expression, the vertical coordinate parameters may be used to interpret the hybrid vertical coordinate.

(3) Hybrid coordinate values, if present, should be encoded in IEEE 32-bit floating point format. They are intended to be encoded as pairs.

SECTION 5 - DATA REPRESENTATION SECTION

Octet No.	Contents
1-4	Length of section in octets (nn)
5	Number of section (5)
6-9	Number of data points where one or more values are specified in Section 7 when a bit map is present, total number of data points when a bit map is absent.
10-11	Data Representation Template Number (see Code Table 5.0)
12-nn	Data Representation Template (see Template 5.x, where x is the Data Representation Template Number given in octets 10-11)

TEMPLATE DEFINITIONS

TEMPLATE DEFINITIONS USED IN SECTION 3

Grid Definition Template 3.0: Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Octet Number(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Ni - number of points along a parallel
35-38	Nj - number of points along a meridian
39-42	Basic angle of the initial production domain (see Note 1)
43-46	Subdivisions of basic angle used to define extreme longitudes and latitudes, and direction increments (see Note 1)
47-50	La1 - latitude of first grid point (see Note 1)
51-54	Lo1 - longitude of first grid point (see Note 1)
55	Resolution and component flags (see Flag Table 3.3)
56-59	La2 - latitude of last grid point (see Note 1)
60-63	Lo2 - longitude of last grid point (see Note 1)
64-67	Di - i direction increment (see Note 1)
68-71	Dj - j direction increment (see Note 1)
72	Scanning mode (flags - see Flag Table 3.4)
73-nn	List of number of points along each meridian or parallel (These octets are only present for quasi-regular grids as described in notes 2 and 3)

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) For data on a quasi-regular grid, where all the rows or columns do not necessarily have the same number of grid points, either Ni (Octets 31-34) or Nj (Octets 35-38) and the corresponding Di (Octets 64-67) or Dj (Octets 68-71) shall be coded with all bits set to 1 (missing). The actual number of points along each parallel or meridian shall be coded in the octets immediately following the Grid Definition Template (Octets [xx+1] – nn), as described in the description of the Grid Definition Section.

(3) A quasi-regular grid is only defined for appropriate grid scanning modes. Either rows or columns, but not both simultaneously, may have variable numbers of points or variable spacing. The first point in each row (column) shall be positioned at the meridian (parallel) indicated by Octets 47-54. The grid points shall be evenly spaced in latitude (longitude).

(4) A scaled value of radius of spherical Earth, or major or minor axis of oblate spheroid Earth is derived from applying appropriate scale factor to the value expressed in metres.

Grid Definition Template 3.1: Rotated Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Octet Number(s)	Contents
15-72	Same as Grid Definition Template 3.0 (see Note 1)
73-76	Latitude of the southern pole of projection
77-80	Longitude of the southern pole of projection
81-84	Angle of rotation of projection
85-nn	List of number of points along each meridian or parallel (These octets are only present for quasi-regular grids as described in note 3)

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the

Key based GRIB decoder

level, step, latitudeOfFirstGridPoint, centre, ...

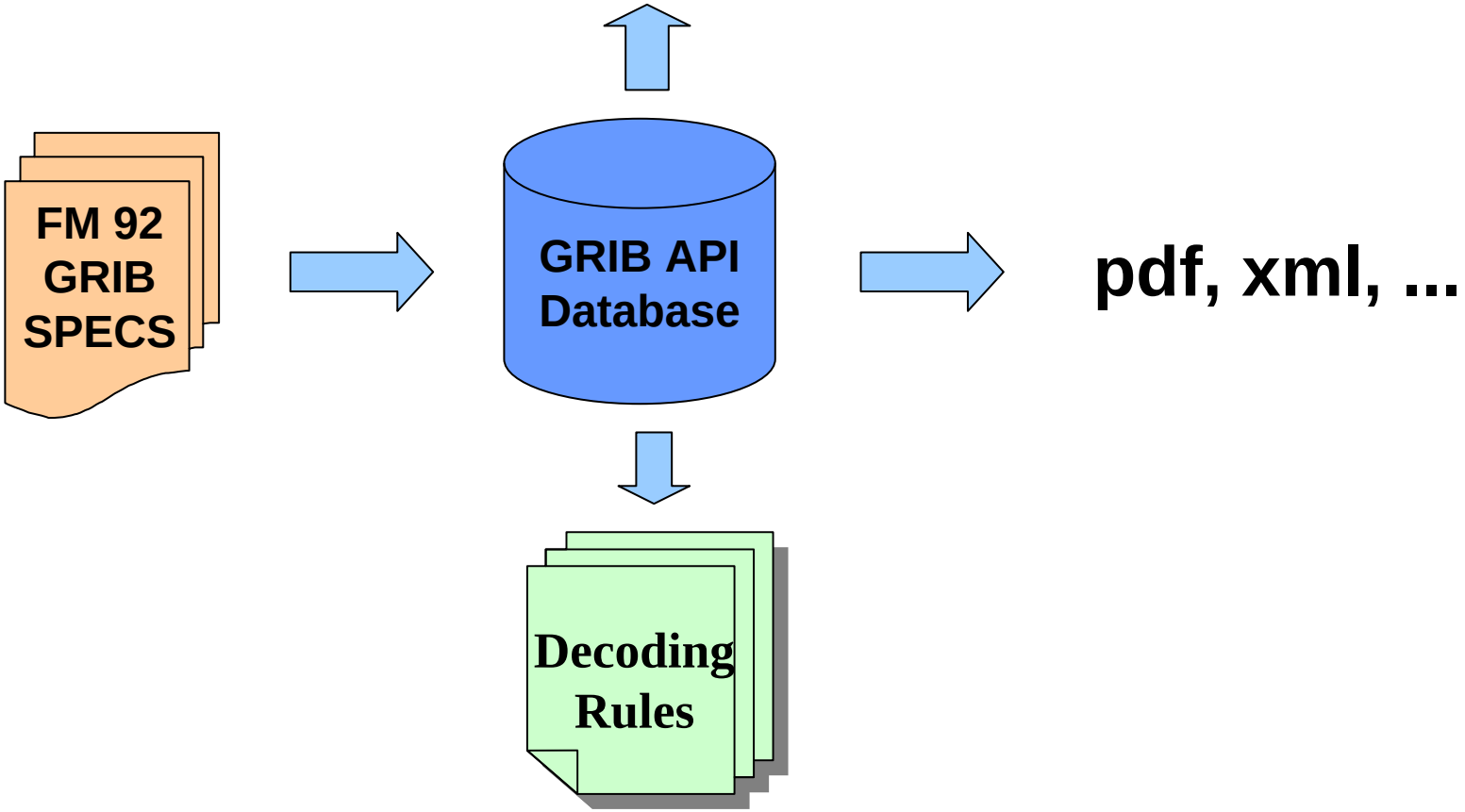
Hundreds of keys available

Requirements

- **Dictionary of the keys**
- **Synchronisation: decoder ←→ GRIB specs**

GRIB API keys database

http://www.ecmwf.int/publications/manuals/grib_api/index.html



GRIB API keys

Two types of keys

- **CODED: coming directly from the message after applying only the decoding rules**
- **VIRTUAL: elaboration of the information contained in the message to provide higher level access independent from the specific coding (GRIB 1, GRIB 2, …)**

Parameters in GRIB API

- **paramId** — **unique numeric identifier**
- **name** — **descriptive name**
- **shortName** — **abbreviation**
- **units** — **units**

name = 2 metre temperature

indicatorOfParmeter = 11 [Temperature (K)]
table2Version = 3
levelType = 103 [Specified height level above ground (m)]
level = 2

name = 2 metre temperature

discipline = 0 [Meteorological products]

parameterCategory = 0 [Temperature]

parameterNumber = 0 [Temperature (K)]

typeOfFirstFixedSurface = 103 [Specified height level above ground (m)]

scaleFactorOfFirstFixedSurface = 0

scaledValueOfFirstFixedSurface = 2

typeOfSecondFixedSurface = 255 [Missing]

scaleFactorOfSecondFixedSurface = MISSING

scaledValueOfSecondFixedSurface = MISSING

ECMWF coding with local table

name = 2 metre temperature

indicatorOfParameter = 130 [Temperature (K)]
table2Version = 128

Parameters in GRIB API

- **Why local coding?**
- **Because in the user code we need a single number or string to identify the parameter**
- **GRIB 2 is more complex than GRIB 1**
- **Local coding still necessary?**

GRIB API solution

- **use a virtual key to decouple user level from coding level**
- **allow local configuration to deal with local codes**

Parameters in GRIB API

http://www.ecmwf.int/publications/manuals/d/gribapi/param

Questions ?