ecCodes GRIB: Advanced Topics

Part I

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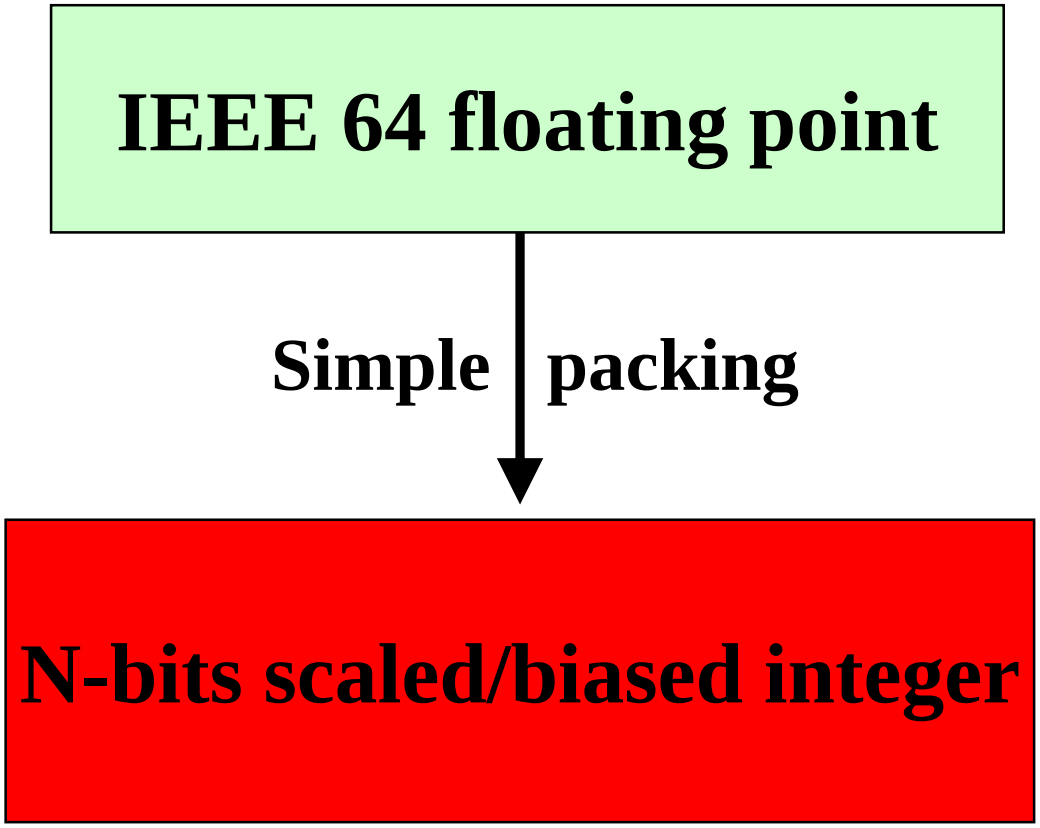
Overview

- **Simple Packing**
- **Constant fields**
- **Bitmap**
- **Multi-field messages**

Simple packing: Loss of information



Usually N = 8, 10, 16, 24

Simple packing: Keys

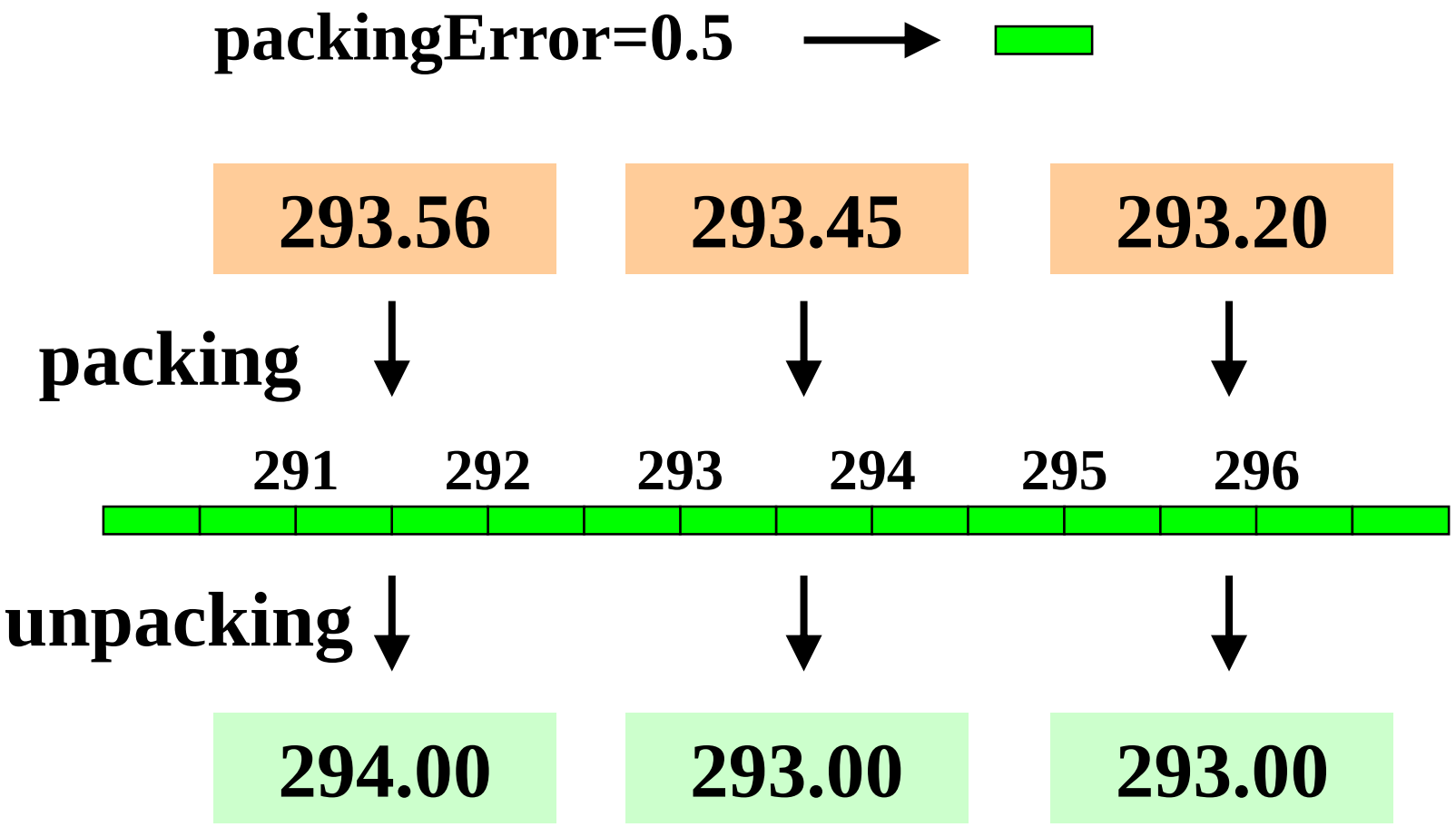
- values
- decimalPrecision
- changeDecimalPrecision
- packingError (read only)

- referenceValue (read only)
- bitsPerValue
- decimalScaleFactor
- binaryScaleFactor (read only)

Use these keys only if you know how packing works

Note: setting "decimalPrecision" does not repack data but setting "changeDecimalPrecision" does!

Simple packing = discretization



Simple packing

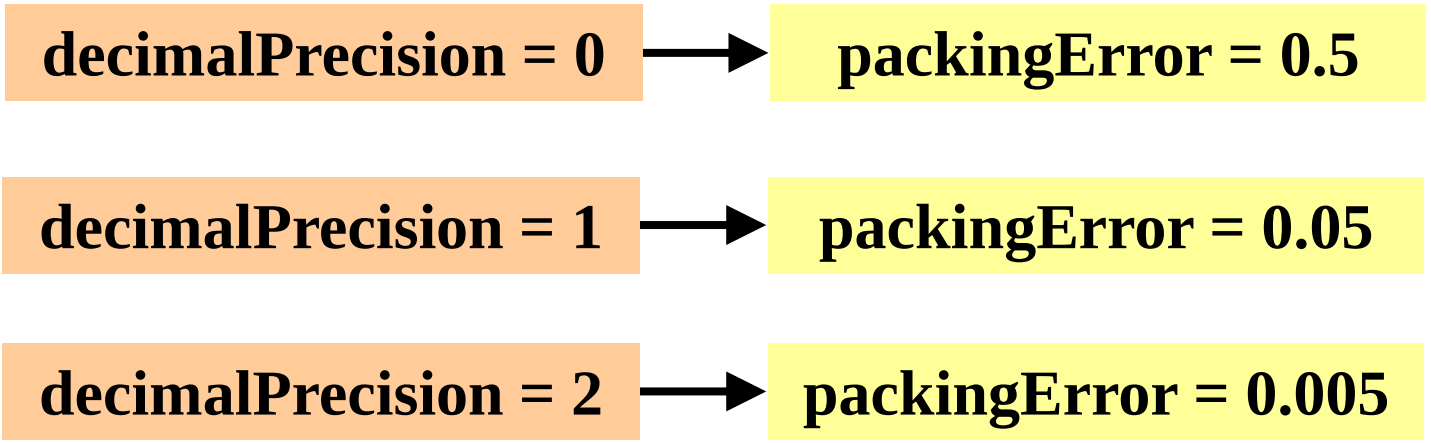
Original value = **Unpacked value** +/- **packingError**

Packing error depends on the packing parameters:

bitsPerValue, decimalScaleFactor, binaryScaleFactor, referenceValue

Decimal precision

Decimal precision = decimal digits to be preserved



Simple packing: Example

- **Imagine a hypothetical 12-hour 500 hPa geopotential height forecast with values ranging from 5340 to 5460 gpm**
- **For a decimal precision of 1 we scale all values by 10 so now they will range from 53400 to 54600**
- **The "decimalScaleFactor" D is chosen such that when the original data is multiplied by 10^D, the integer part of the result will have enough precision to contain all the information**
- **The "referenceValue" is the minimum (i.e. 53400) . Subtract this from all values to leave non-negative residuals ranging from 0 to 1200**
- **The calculated bit-length for this range is 11 bits**
- **All values are now packed into words 11 bits long**

Constant fields

- **In a constant field all the values are the same**
- **Repeating the same value N times is very inefficient**
- **The constant value is the only value stored and the data section is empty**
- **Constant fields are very small and they are very precisely encoded**
- **A constant field can be easily created with:**

```
grib_set -d 1 in.grib out.grib
```

- **In a constant field the packing parameters are not defined (bitsPerValue=0)**

Constant fields problem

WARNING

At this point the packing parameters are not known.

We load a constant field

```
codes_grib_new_from_file(infile,igrib)
```

We set some non-constant values

```
codes_set(igrib,'values',values)
```

We write the field

```
codes_write(igrib,outfile)
```

What packingError can we expect?

In the constant field the packing parameters are not set.
ecCodes doesn't know what precision we require.
A safe choice is made bitsPerValue=24.

Constant fields

It is better practice to set decimalPrecision or bitsPerValue before packing the values

```
codes_grib_new_from_file(infile,igrib)
codes_set(igrib,'decimalPrecision',4)
codes_set(igrib,'values',values)
codes_write(igrib,outfile)
```

```
codes_grib_new_from_file(infile,igrib)
codes_set(igrib,'bitsPerValue',16)
codes_set(igrib,'values',values)
codes_write(igrib,outfile)
```

Constants and precision: Practicals

```
cd $SCRATCH
tar -xf  ~trx/ecCodes/eccodes_grib_packing.tar
cd grib_packing/constant
```

1. **You have a GRIB file constant.grib**
2. **Set values = {23.26, 42.51, 61.22, 45.95} and print packingError and bitsPerValue**
3. **Set decimalPrecision=1 and set the same values. Print again packingError and bitsPerValue**
4. **Compare file sizes and packingErrors**

(Hint: you can use grib_filter)

Bitmap

- **The bitmap is an array of binary values. Its purpose is to indicate the presence or absence of data at each of the grid points. A value of '0' means data is missing and a '1' means data is present**
- **In order to conserve space, the bitmap is used to efficiently indicate those data points that actually appear in the Data Section**

0	0	0	0
0	1	1	0
0	0	1	0

Bitmap section

	2.45	4.67	
		9.11	

Data section

Bitmap

- **The bitmap size is the number of points in the grid (numberOfPoints)**
  - **0 -> value is missing**
  - **1 -> value is present**
- **When encoding, you can use the key missingValue to tell the library where data is missing**
- **By default this is 9999 but it can be changed by the user e.g. a value out of the range of normal data**
- **You must also set the key bitmapPresent to 1**
- **When the library encounters a value equal to the missing value in the data array, it will set the bitmap entry to 0 for that grid point**
- **When decoding, you can directly query the bitmap to discover missing data values**

Bitmap: Practicals

cd $SCRATCH
cd grib_packing/bitmap

1. You have a GRIB start.grib with 4 messages. Set

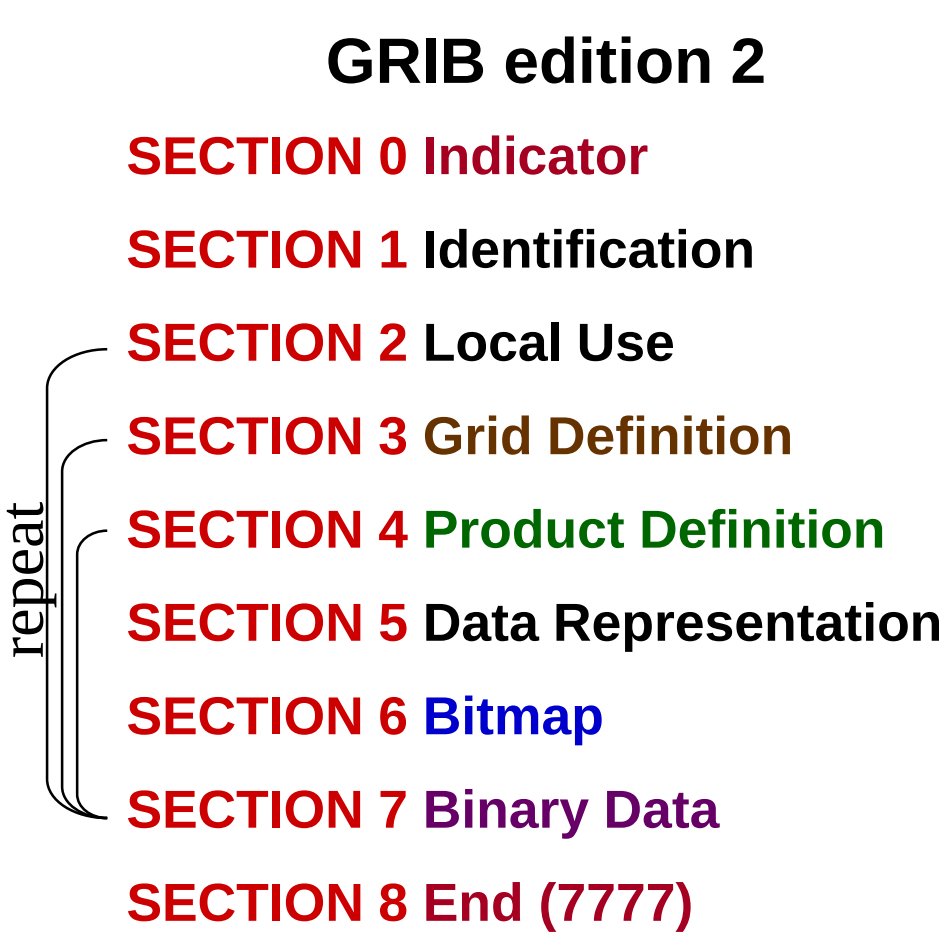
1. **bitsPerValue=8, bitmapPresent=0 in the first message**
2. **bitsPerValue=16, bitmapPresent=0 in the second message**
3. **bitsPerValue=24, bitmapPresent=0 in the third message**
4. **bitsPerValue=8, bitmapPresent=1 in the fourth message**

2. Set values = {0.2, 0.4, 0.6, 0.7, 9999}

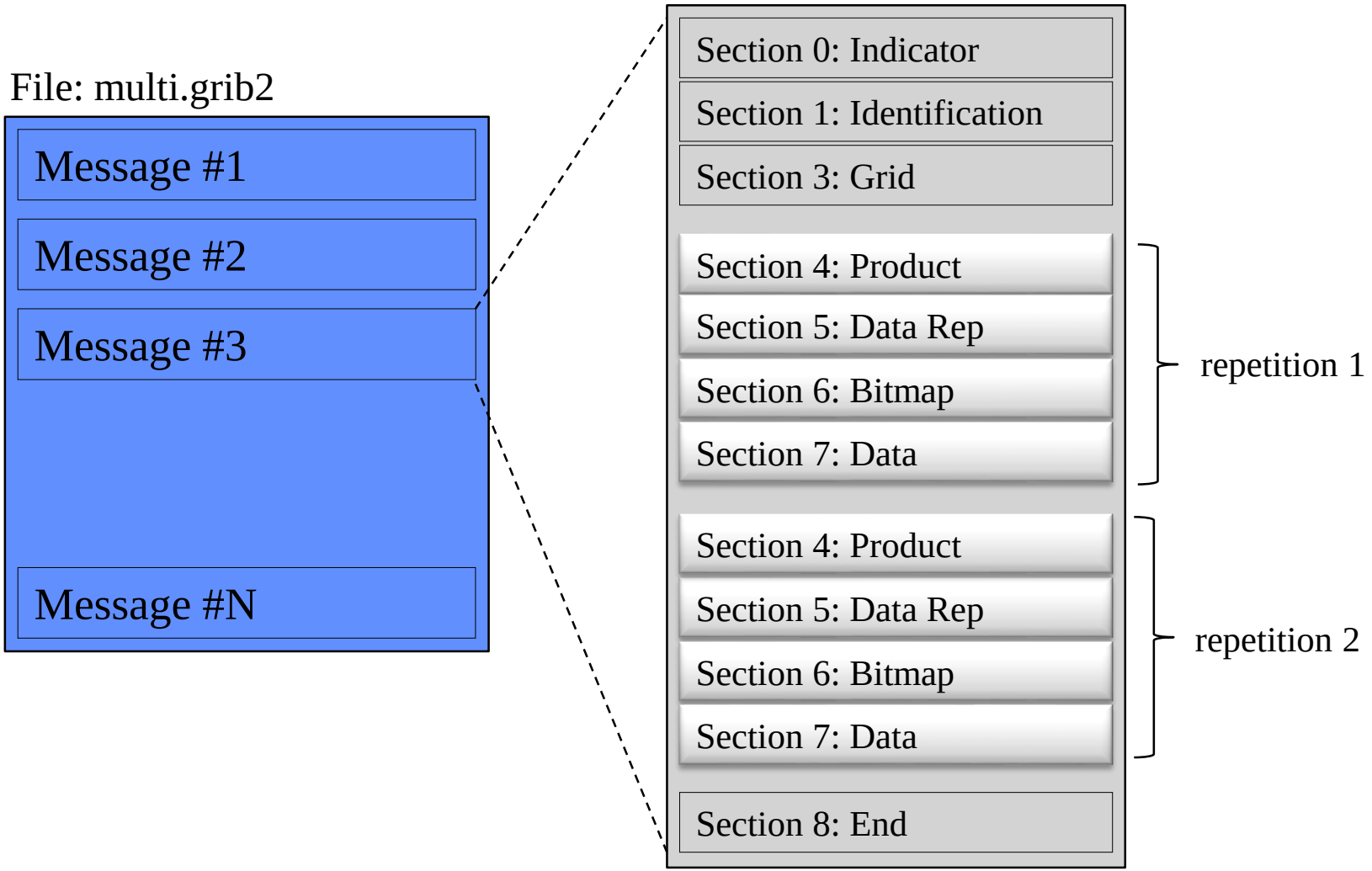
3. Print the values

(Hint: you can use grib_filter)

GRIB Multi-field messages



Multi-field message structure



Multi-field messages: example

- **Consider 500 hPa height field forecasts produced by a numerical model at forecast hours 12 and 24.**

```
Section 0: Indicator Section
Section 1: Identification Section
Section 2: Local Use Section (optional)
Section 3: Grid Definition Section

Section 4: Product Definition Section    (hour = 12)| repetition 1
Section 5: Data Representation Section              |
Section 6: Bit-Map Section                          |
Section 7: Data Section                             |

Section 4: Product Definition Section    (hour = 24)| repetition 2
Section 5: Data Representation Section              |
Section 6: Bit-Map Section                          |
Section 7: Data Section                             |

Section 8: End Section
```

- **Note that since the Grid Definition Section is not repeated, it remains in effect for all forecast hours**

Multi-field messages: Practicals

```
cd $SCRATCH
tar -xf  ~trx/ecCodes/eccodes_grib_multi.tar
cd grib_multi
```

1. Compile the Fortran program write_multi.f90 and run it. This will produce a multi-field message multi.grib
(make ; ./write_multi)

2. Using grib_copy, copy multi.grib to copied.grib

3. Do a grib_count on multi.grib and copied.grib

4. Now do a grib_ls on these files