Changes to ECMWF's grids in 2016

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ECMWF User Support Section
Horizontal resolution increase planned for early 2016

Resolution increase achieved by:

- representing the shortest wave by four ("cubic") instead of two ("linear") grid points ($T_L \rightarrow T_C$)
- Using the octahedral grid ($T_C \rightarrow T_{CO}$, $N \rightarrow O$)

- $T_L$ xxx spectral linear
- $T_{CO}$ xxx spectral cubic octahedral
- Nxxx original reduced Gaussian
- Oxxx octahedral reduced Gaussian
Gaussian grids of order $N$

Regular (full) grid:
- No point at pole
- $N$ latitude lines between pole and equator
- Latitude lines not evenly spaced
- Symmetric about equator
- $4N$ longitude points at each latitude

Original reduced grid:
- No latitude line at equator
- Fewer longitude points towards poles
- $4N$ longitude points close to equator
What is the octahedral grid?

- The octahedral grid is a form of reduced Gaussian grid
- Inspired by the Collignon projection
- Latitude points:
  - same as the original reduced Gaussian grid
- Longitude points:
  - computed by a new formula
  - stored in the GRIB header PL array

- More continuous reduction in the number of longitude points
- More variation in zonal resolution
Octahedral reduced Gaussian grid

Same $N$ latitude lines between pole and equator as regular and original reduced Gaussian grids

Total number of points $= 4 \times N \times (N + 9)$

20 longitude points at the latitude nearest the pole

$4 \times i + 16$ longitude points at latitude line $i$

Increases by 4 points at each latitude line from pole towards the equator

$4 \times N + 16$ longitude points at latitude lines closest to equator
Comparison of zonal variation

Comparison of Gaussian grids

Current N640

Reduced grids:
- O1280
- N1280

Regular (lat-lon) Gaussian grid
Comparison of zonal variation

Original reduced Gaussian N1280

Octahedral reduced Gaussian O1280
Land-sea mask and orography: HRES

OROGRAPHY, GRID POINTS AND LAND_SEA MASK FOR O1280 OCTAHEDRAL GRID
orography shaded (height in m), land grid points (red), sea grid points (blue)

OROGRAPHY, GRID POINTS AND LAND_SEA MASK FOR N640 ORIGINAL GRID
orography shaded (height in m), land grid points (red), sea grid points (blue)

New: O1280 (~9km)  Current: N640 (~16km)
Land-sea mask and orography: ENS Leg 1

New: O640 (~18km)  
Current: N320 (~32km)
Land-sea mask and orography: O640 versus N640

Octahedral: O640 (~18km)  
Original: N640 (~16km)
What about regular latitude-longitude grids?

- ECMWF plans to disseminate
  - HRES data at multiples of 0.0625° x 0.0625°
  - ENS Leg1 / Leg 2 data at multiples of 0.125° x 0.125° / 0.25° x 0.25°

- Grid increments of 0.0625° cannot be encoded precisely in GRIB edition 1 (milli-degree limitation)

- ECMWF proposes **not** to encode the grid increments of 0.0625° in the GRIB header!
  - Appropriate bits of the Resolution and component flags will be set to 0 indicating increments not given
  - i and j direction increments (Di, Dj) will be set to MISSING

- Users will need to compute increments for themselves
  - grib_api will compute these for you:
    - Coded keys: iDirectionIncrement=MISSING   jDirectionIncrement=MISSING
    - Computed keys: iDirectionIncrementInDegrees=0.0625   jDirectionIncrementInDegrees=0.0625

- Same encoding will apply to BOTH GRIB edition 1 and GRIB edition 2 fields!
GRIB edition 1 Grid Description Section

```
============= SECTION_2 ( length=32, padding=0 ) =============
1-3      section2Length = 32
4      numberOfVerticalCoordinateValues = 0
5      pvlLocation = 255
6      dataRepresentationType = 0 [Latitude/Longitude Grid (grib1/6.table) ]
7-8      Ni = 5760
9-10     Nj = 2881
11-13    latitudeOfFirstGridPoint = 90000
14-16    longitudeOfFirstGridPoint = 0
17      resolutionAndComponentFlags = 0 [00000000]
18-20    latitudeOfLastGridPoint = -90000
21-23    longitudeOfLastGridPoint = 359938
24-25    iDirectionIncrement = MISSING
26-27    jDirectionIncrement = MISSING
28      scanningMode = 0 [00000000]
29-32    padding_grid0_1 = 4 {  
                   00, 00, 00, 00  
           } # pad padding_grid0_1

Bit 1 set to 0

Grib_api key:  
ijDirectionIncrementGiven=0
```
### GRIB edition 2 Grid Definition Section

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>section3Length</td>
<td>72</td>
</tr>
<tr>
<td>numberOfSection</td>
<td>3</td>
</tr>
<tr>
<td>sourceOfGridDefinition</td>
<td>0</td>
</tr>
<tr>
<td>Ni</td>
<td>5760</td>
</tr>
<tr>
<td>Nj</td>
<td>2881</td>
</tr>
<tr>
<td>basicAngleOfTheInitialProdDomain</td>
<td>0</td>
</tr>
<tr>
<td>subdivisionsOfBasicAngle</td>
<td>MISSING</td>
</tr>
<tr>
<td>latitudeOfFirstGridPoint</td>
<td>90000000</td>
</tr>
<tr>
<td>longitudeOfFirstGridPoint</td>
<td>0</td>
</tr>
<tr>
<td>resolutionAndComponentFlags</td>
<td>0 [00000000]</td>
</tr>
<tr>
<td>latitudeOfLastGridPoint</td>
<td>-90000000</td>
</tr>
<tr>
<td>longitudeOfLastGridPoint</td>
<td>359938000</td>
</tr>
<tr>
<td>iDirectionIncrement</td>
<td>MISSING</td>
</tr>
<tr>
<td>jDirectionIncrement</td>
<td>MISSING</td>
</tr>
<tr>
<td>scanningMode</td>
<td>0 [00000000]</td>
</tr>
</tbody>
</table>

**grib_api key:**

- `ijDirectionIncrementGiven = 0`

**Bits 3 & 4 set to 0**
ECMWF software stack

• **grib_api**
  – Full support of the octahedral grid is provided from grib_api 1.14.2
  – Older versions can decode the octahedral grid
  – Upgrade recommended for users of the grib_find_nearest routine

• **EMOSLIB**
  – EMOSLIB 420 provides preliminary support for the octahedral grids
  – Final testing before release to users and applications

• **Metview**
  – Current versions of Metview can plot fields on the octahedral grid
  – A new version will provide full support

• **MARS**
  – A MARS client is being prepared with full support for the octahedral grids

• All versions subject to change depending on testing
• Check the cycle upgrade page for up-to-date information!
What should I watch out for?

• Check array dimensions for any hard-coded ‘4N’
  – There are now 4N + 16 points at the latitude lines nearest the equator

• Check that the number of points at each latitude is read from the PL array

• If using HRES data at 0.0625° x 0.0625° resolution check how grid increments are obtained
  – No issue for ENS or HRES data at lower resolutions

• Increased resolution means increased data volumes

  Reduced (model) grid: N640 → O1280 x3
  Regular latitude-longitude: 0.0125° x 0.125° → 0.0625° x 0.0625° x4
  Spherical harmonics: $T_L^{1280} \rightarrow T_{CO}^{1280} \times 1$

• Consider requesting compressed data in dissemination – gives ~30% saving on average!
Where can I get test data?

• Examples of the new land-sea masks and orography fields are available from the ECMWF anonymous ftp server:
  

• Test data will soon be available in MARS

• Test data in dissemination will be made available at a later date
Watch this space!

- ECMWF Forecast User space
  => Planned changes to the forecasting system
  => Horizontal resolution increase
  [URL: https://software.ecmwf.int/wiki/display/FCST/Horizontal+resolution+increase]