

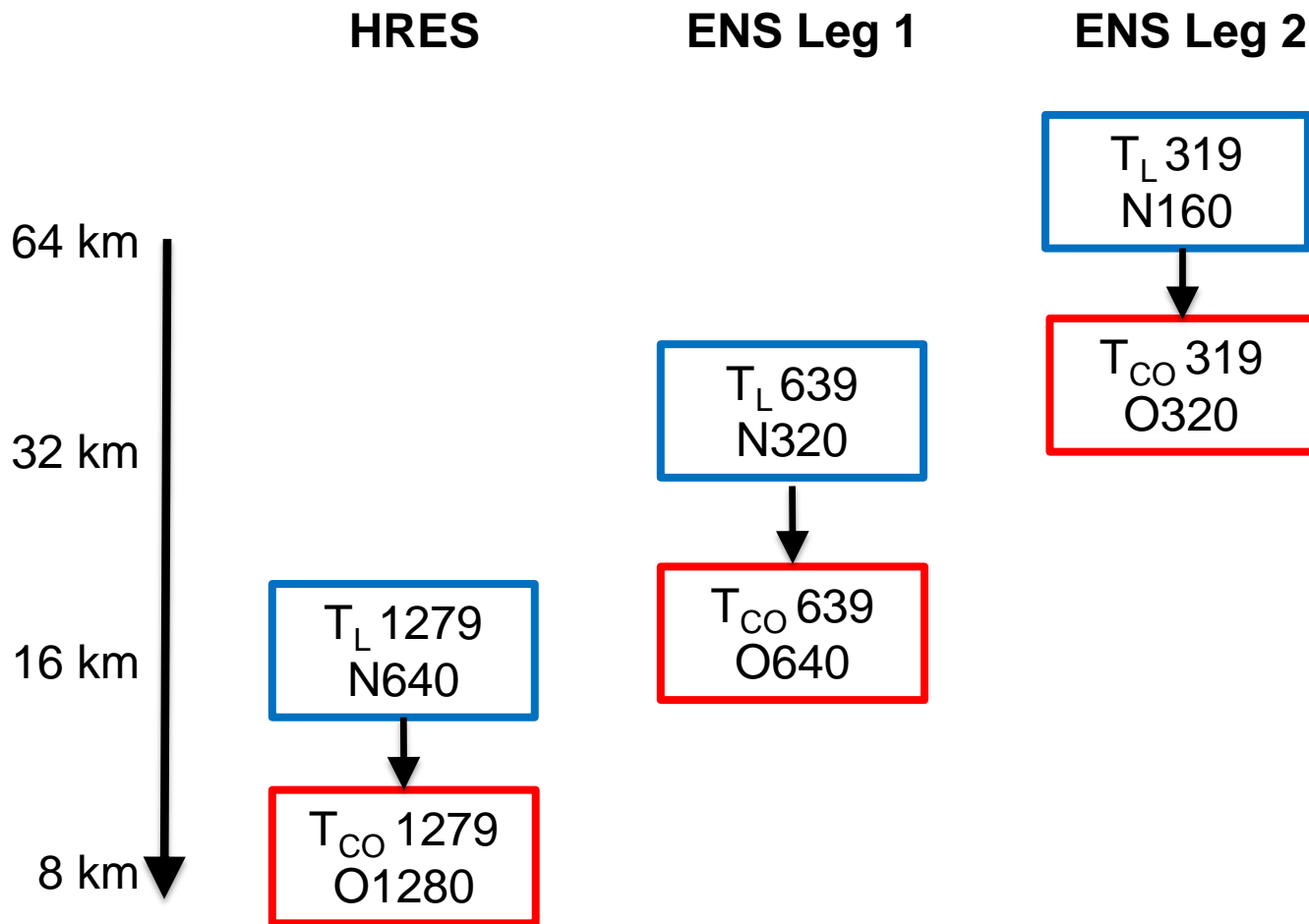
# Changes to ECMWF's grids in 2016

26<sup>th</sup> EGOWS – ECMWF Reading: 29 Sep - 1 Oct 2015

Paul Dando

ECMWF User Support Section

# Horizontal resolution increase planned for early 2016



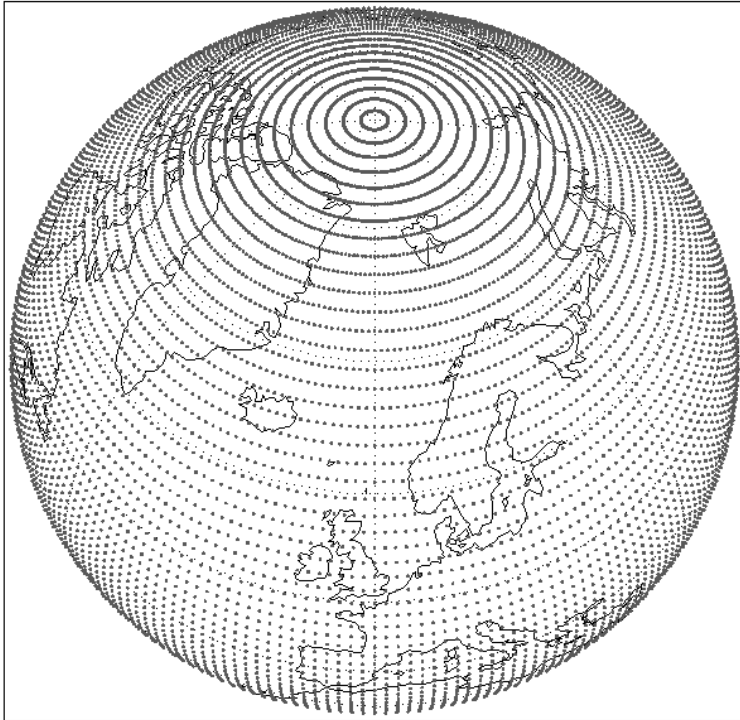
Resolution increase achieved by:

- 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



$4N$  longitude points at each latitude

No point at pole

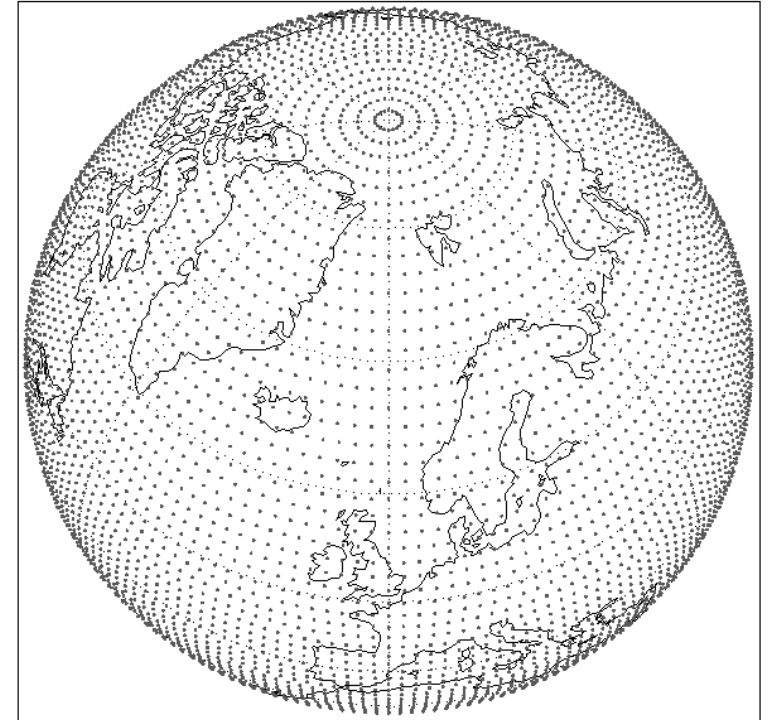
$N$  latitude lines between pole and equator

Latitude lines not evenly spaced

No latitude line at equator

Symmetric about equator

Original reduced grid

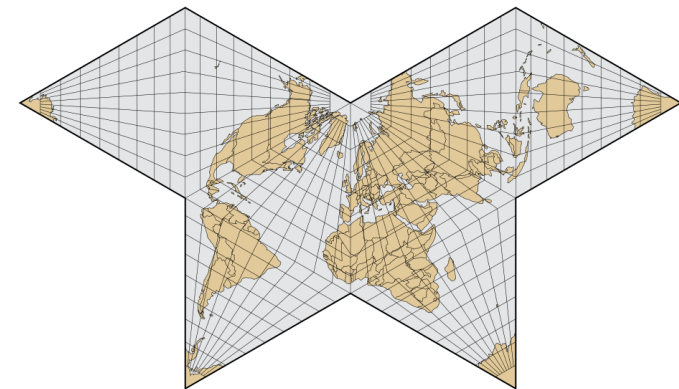
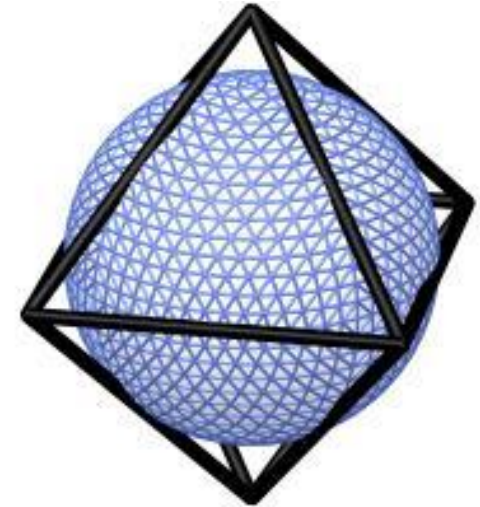


$4N$  longitude points close to equator

Fewer longitude points towards poles

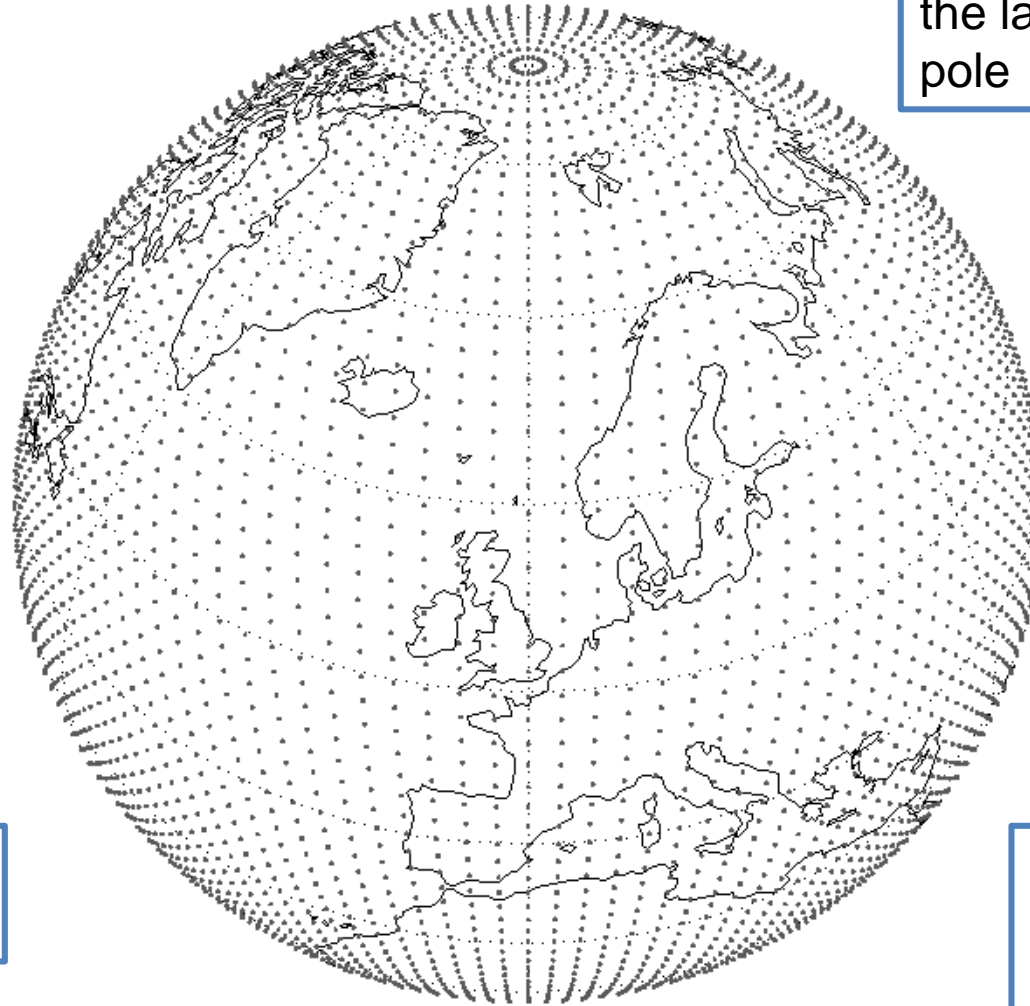
## What is the octahedral grid ?

- 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



20 longitude points at the latitude nearest the pole

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

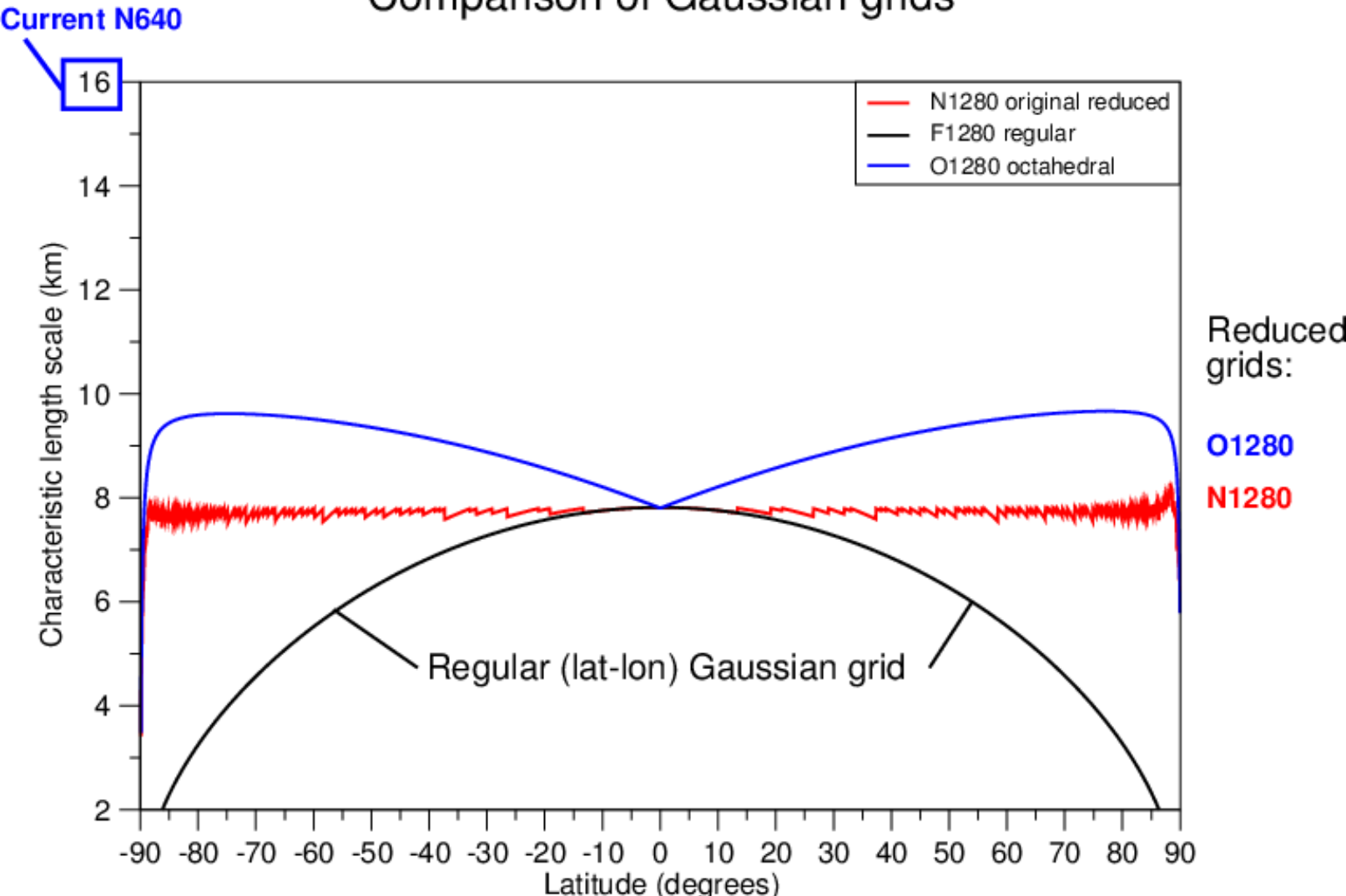
Increases by 4 points at each latitude line from pole towards the equator

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

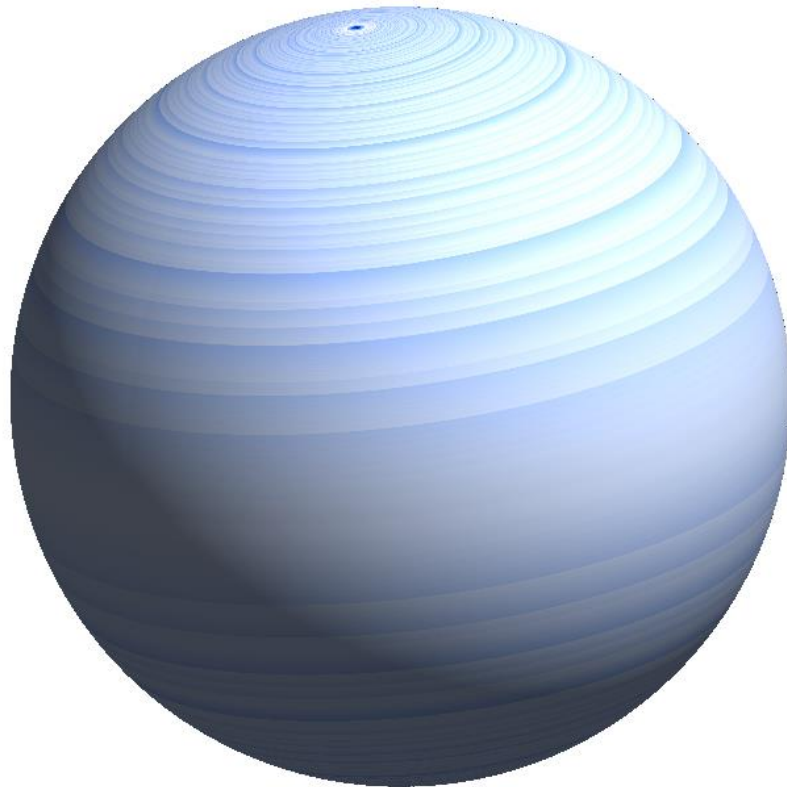
**$4N + 16$**  longitude points at latitude lines closest to equator

# Comparison of zonal variation

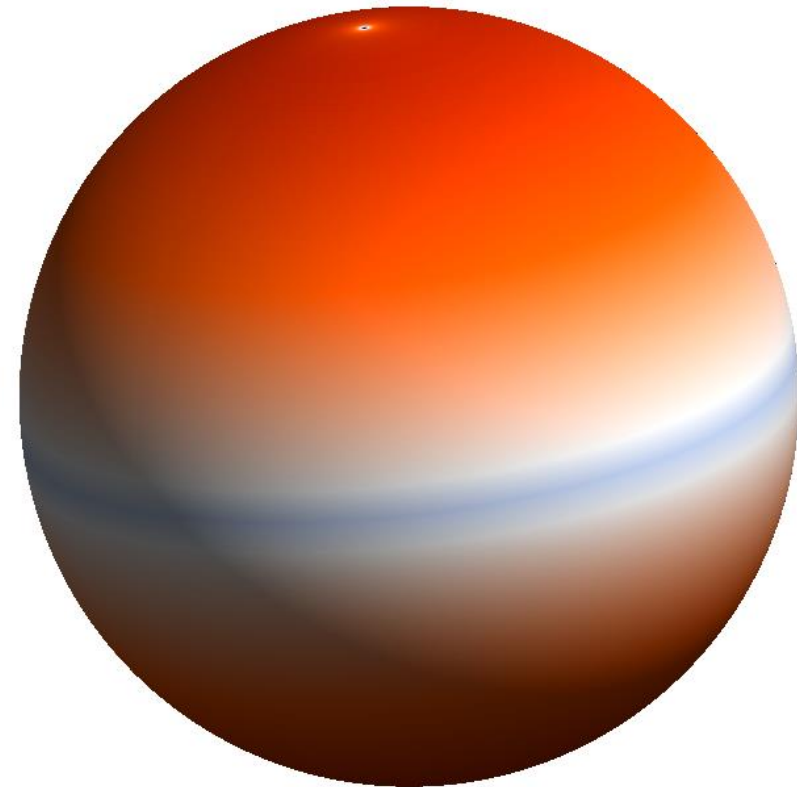
## Comparison of Gaussian grids



# Comparison of zonal variation



resolution [km]



resolution [km]

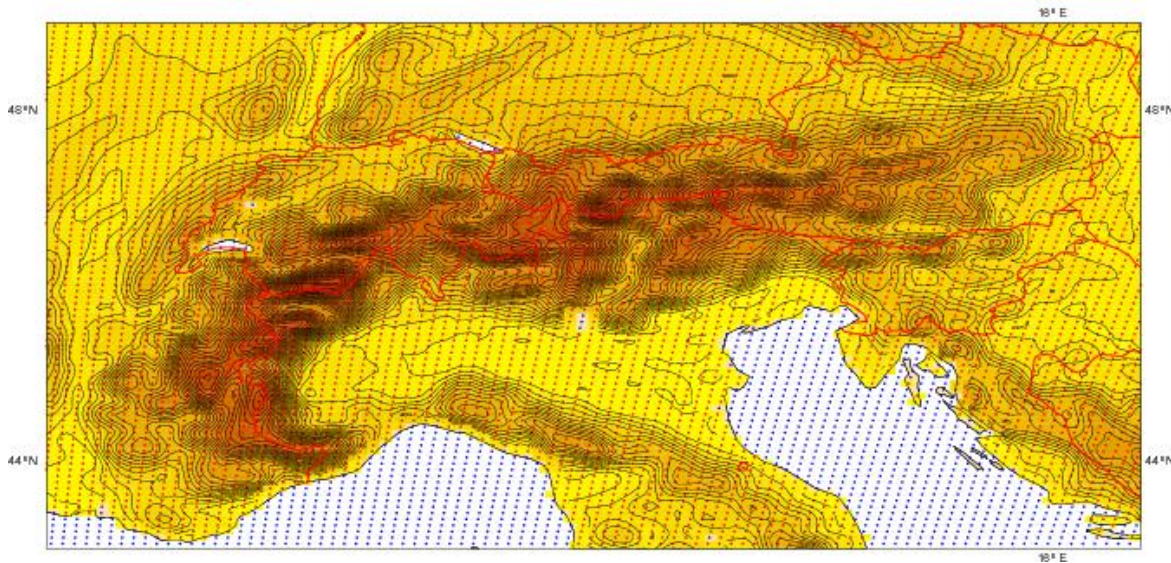


Original reduced Gaussian N1280

Octahedral reduced Gaussian O1280

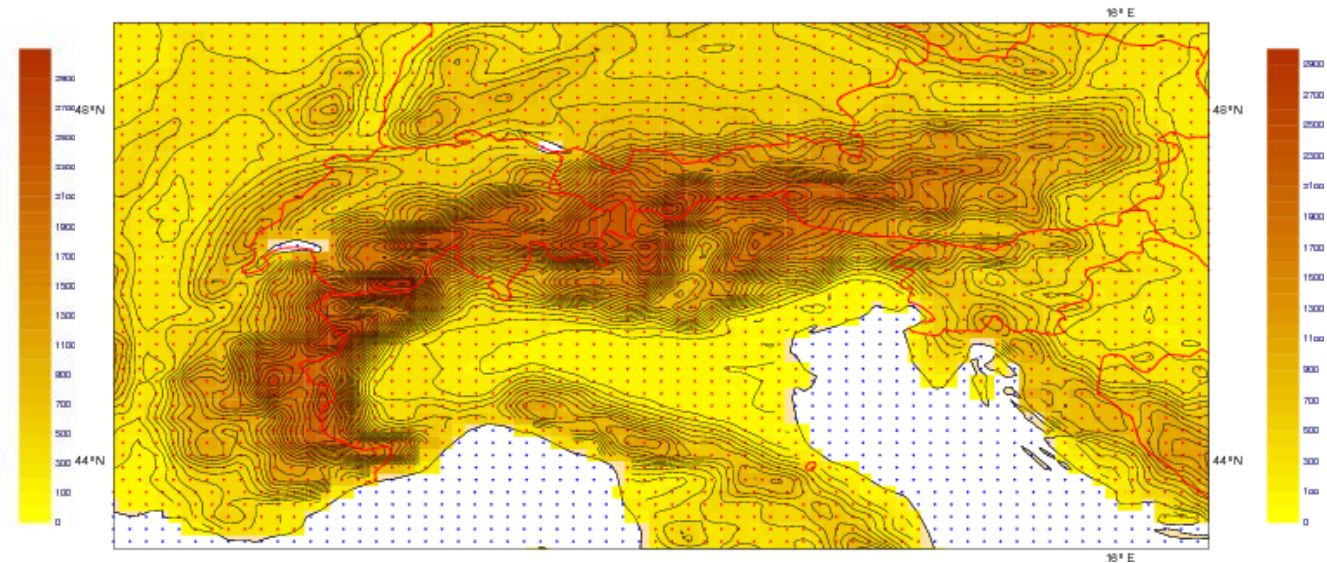
# Land-sea mask and orography: HRES

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



New: O1280 (~9km)

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

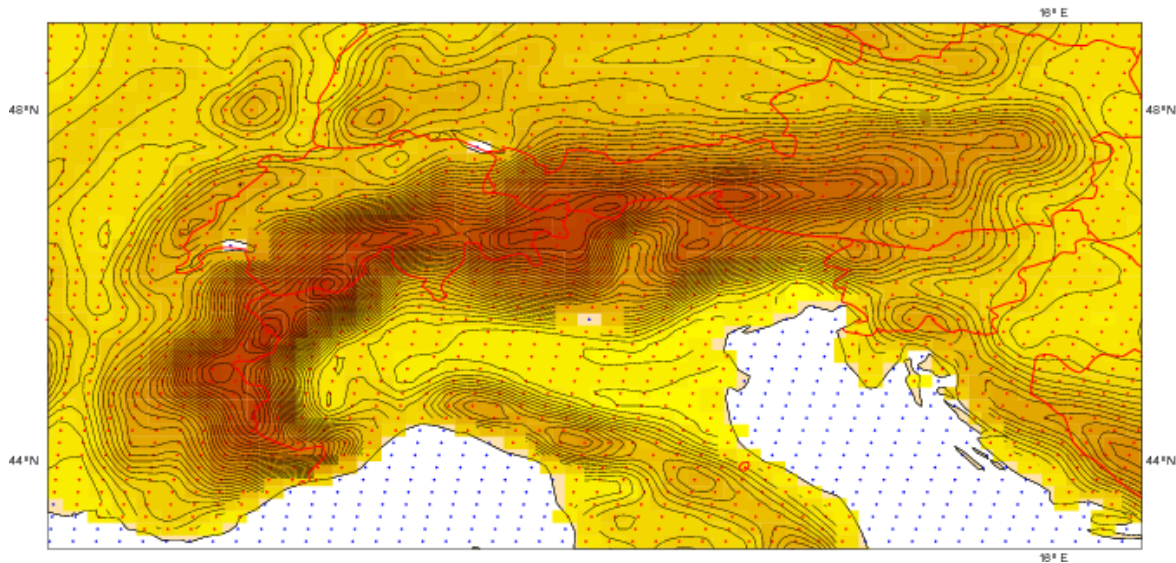


Current: N640 (~16km)



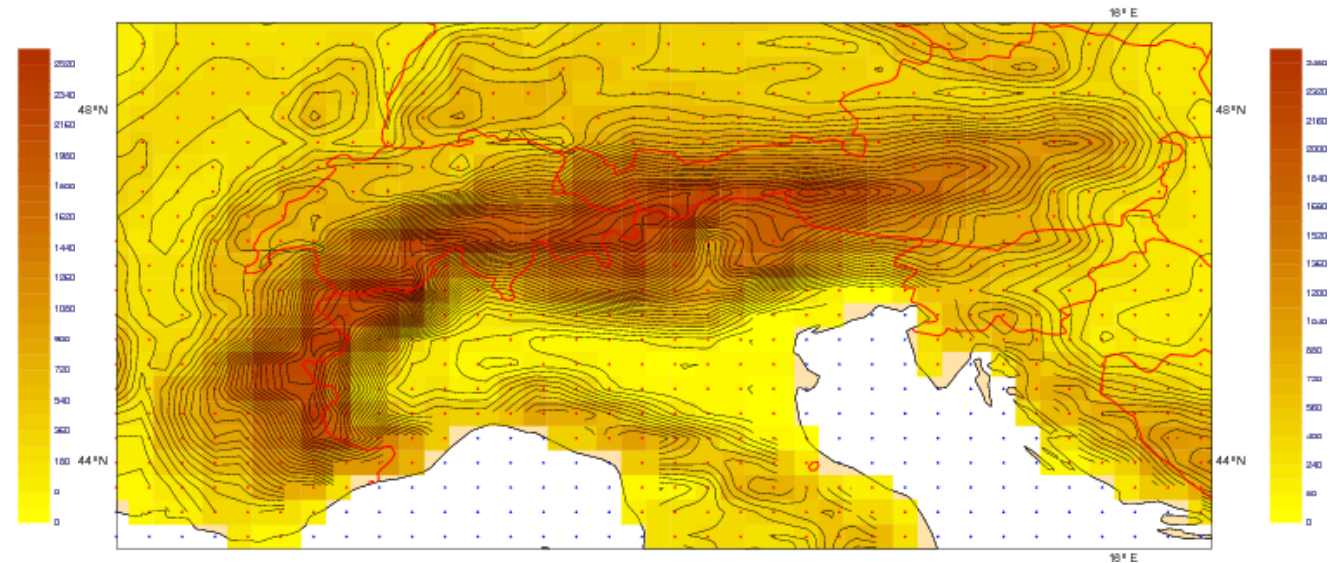
# Land-sea mask and orography: ENS Leg 1

OROGRAPHY, GRID POINTS AND LAND\_SEA MASK FOR O640 OCTAHEDRAL GRID  
orography shaded (height in m), land grid points (red), sea grid points (blue)



New: O640 (~18km)

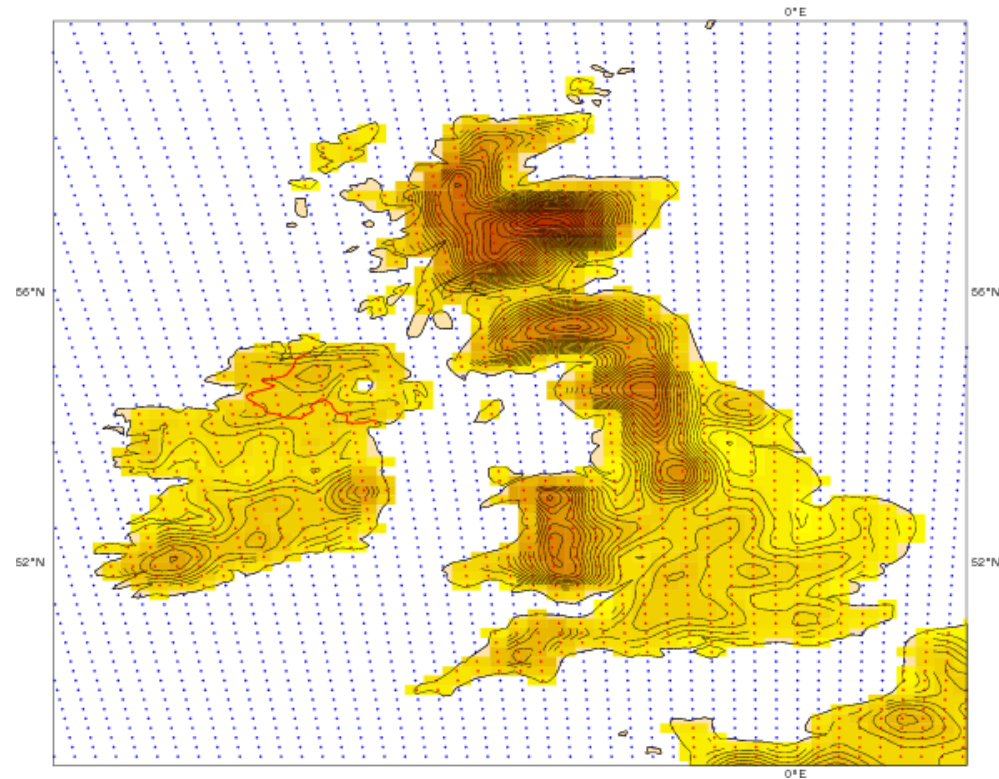
OROGRAPHY, GRID POINTS AND LAND\_SEA MASK FOR N320 ORIGINAL GRID  
orography shaded (height in m), land grid points (red), sea grid points (blue)



Current: N320 (~32km)

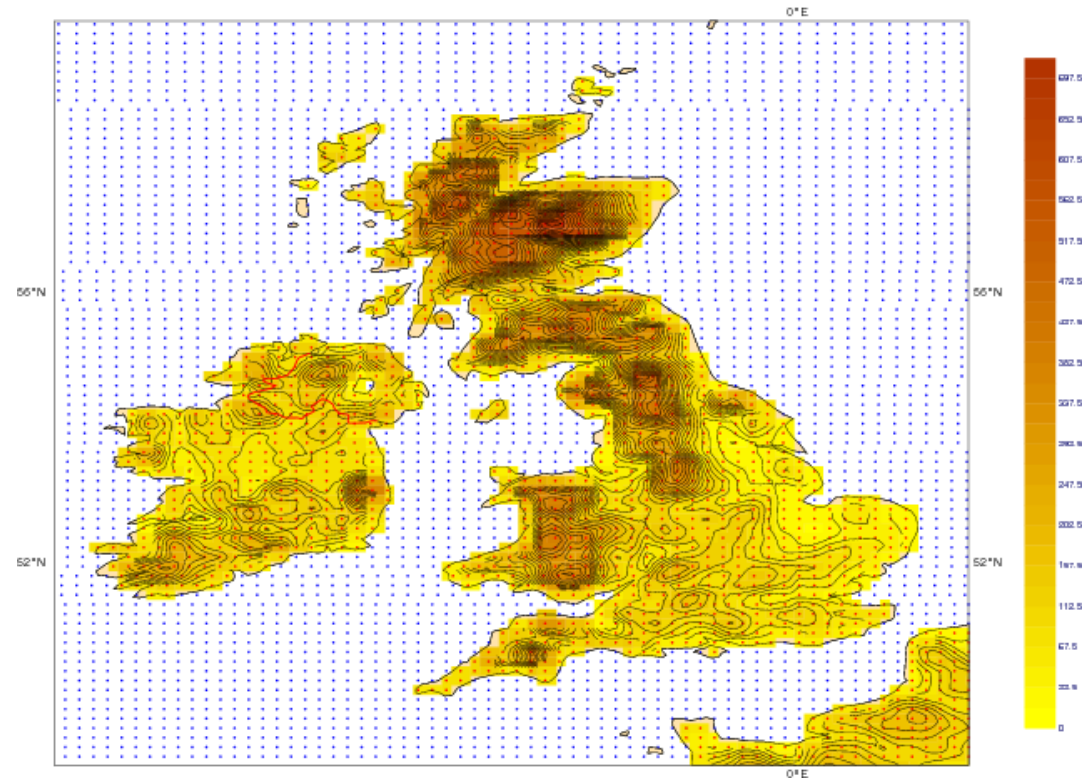
# Land-sea mask and orography: O640 versus N640

OROGRAPHY, GRID POINTS AND LAND\_SEA MASK FOR O640 OCTAHEDRAL GRID  
orography shaded (height in m), land grid points (red), sea grid points (blue)



Octahedral: O640 (~18km)

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



Original: N640 (~16km)


# What about regular latitude-longitude grids ?

- ECMWF plans to disseminate
  - HRES data at multiples of  $0.0625^\circ \times 0.0625^\circ$
  - ENS Leg1 / Leg 2 data at multiples of  $0.125^\circ \times 0.125^\circ / 0.25^\circ \times 0.25^\circ$
- **Grid increments of  $0.0625^\circ$  cannot be encoded precisely in GRIB edition 1 (milli-degree limitation)**
- ECMWF proposes **not** to encode the grid increments of  $0.0625^\circ$  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 ( $D_i$ ,  $D_j$ ) 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

```
===== SECTION_3 ( length=72, padding=0 ) =====
1-4      section3Length = 72
5        numberOfSection = 3
6        sourceOfGridDefinition = 0 [Specified in Code table 3.1
      (grib2/tables/5/3.0.table) ]

...

31-34    Ni = 5760
35-38    Nj = 2881
39-42    basicAngleOfTheInitialProductionDomain = 0
43-46    subdivisionsOfBasicAngle = MISSING
47-50    latitudeOfFirstGridPoint = 90000000
51-54    longitudeOfFirstGridPoint = 0
55       resolutionAndComponentFlags = 0 [00000000]
56-59    latitudeOfLastGridPoint = -90000000
60-63    longitudeOfLastGridPoint = 359938000
64-67    iDirectionIncrement = MISSING
68-71    jDirectionIncrement = MISSING
72       scanningMode = 0 [00000000]
```

Bits 3 & 4 set to 0

**grib\_api key:**  
**ijDirectionIncrementGiven=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  $0.0625^\circ \times 0.0625^\circ$  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:       | $N640 \rightarrow O1280$   | x3 |
| Regular latitude-longitude: | $0.0125^\circ \times 0.125^\circ \rightarrow 0.0625^\circ \times 0.0625^\circ$ | x4 |
| Spherical harmonics:        | $T_L1280 \rightarrow T_{CO}1280$   | x1 |

- Consider requesting compressed data in dissemination – gives ~30% saving on average !

## Where can I get test data ?

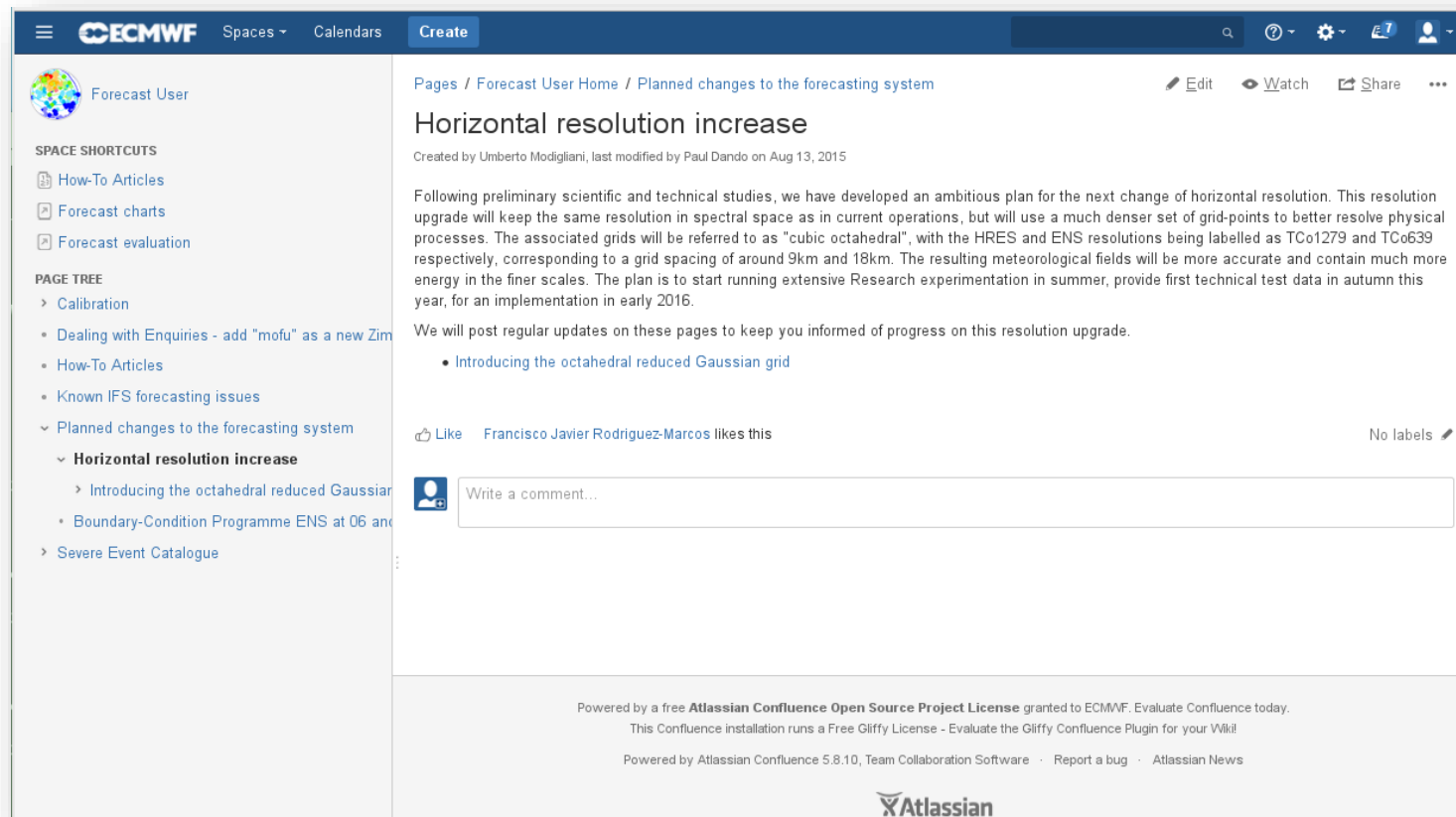
- Examples of the new land-sea masks and orography fields are available from the ECMWF anonymous ftp server:
  - HRES (O1280): [ftp://ftp.ecmwf.int/pub/landseamask/lsmoro\\_cy41r2\\_O1280.grib](ftp://ftp.ecmwf.int/pub/landseamask/lsmoro_cy41r2_O1280.grib)
  - ENS Leg 1 (O640): [ftp://ftp.ecmwf.int/pub/landseamask/lsmoro\\_cy41r2\\_O640.grib](ftp://ftp.ecmwf.int/pub/landseamask/lsmoro_cy41r2_O640.grib)
  - ENS Leg 2 (O320): [ftp://ftp.ecmwf.int/pub/landseamask/lsmoro\\_cy41r2\\_O320.grib](ftp://ftp.ecmwf.int/pub/landseamask/lsmoro_cy41r2_O320.grib)
- 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

<https://software.ecmwf.int/wiki/display/FCST/Horizontal+resolution+increase>



The screenshot shows a Confluence page within the ECMWF Forecast User space. The page title is "Horizontal resolution increase", created by Umberto Modigliani and last modified by Paul Dando on August 13, 2015. The main content discusses a plan to increase horizontal resolution from 18km to 9km, involving a denser grid of points (TCo1279 and TCo639) and a "cubic octahedral" grid. It mentions that the upgrade will be implemented in early 2016 and that regular updates will be provided. A bullet point lists "Introducing the octahedral reduced Gaussian grid". The page also features a "Like" button (Francisco Javier Rodriguez-Marcos likes this) and a "Write a comment..." input field. The left sidebar shows a navigation menu with categories like "SPACE SHORTCUTS", "PAGE TREE", and "Horizontal resolution increase". The footer includes the Atlassian logo and text: "Powered by a free Atlassian Confluence Open Source Project License granted to ECMWF. Evaluate Confluence today. This Confluence installation runs a Free Giffy License - Evaluate the Giffy Confluence Plugin for your Wiki! Powered by Atlassian Confluence 5.8.10, Team Collaboration Software · Report a bug · Atlassian News".