Interpolation

Introduction and basic concepts

Computer User Training Course 2014

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Development Section

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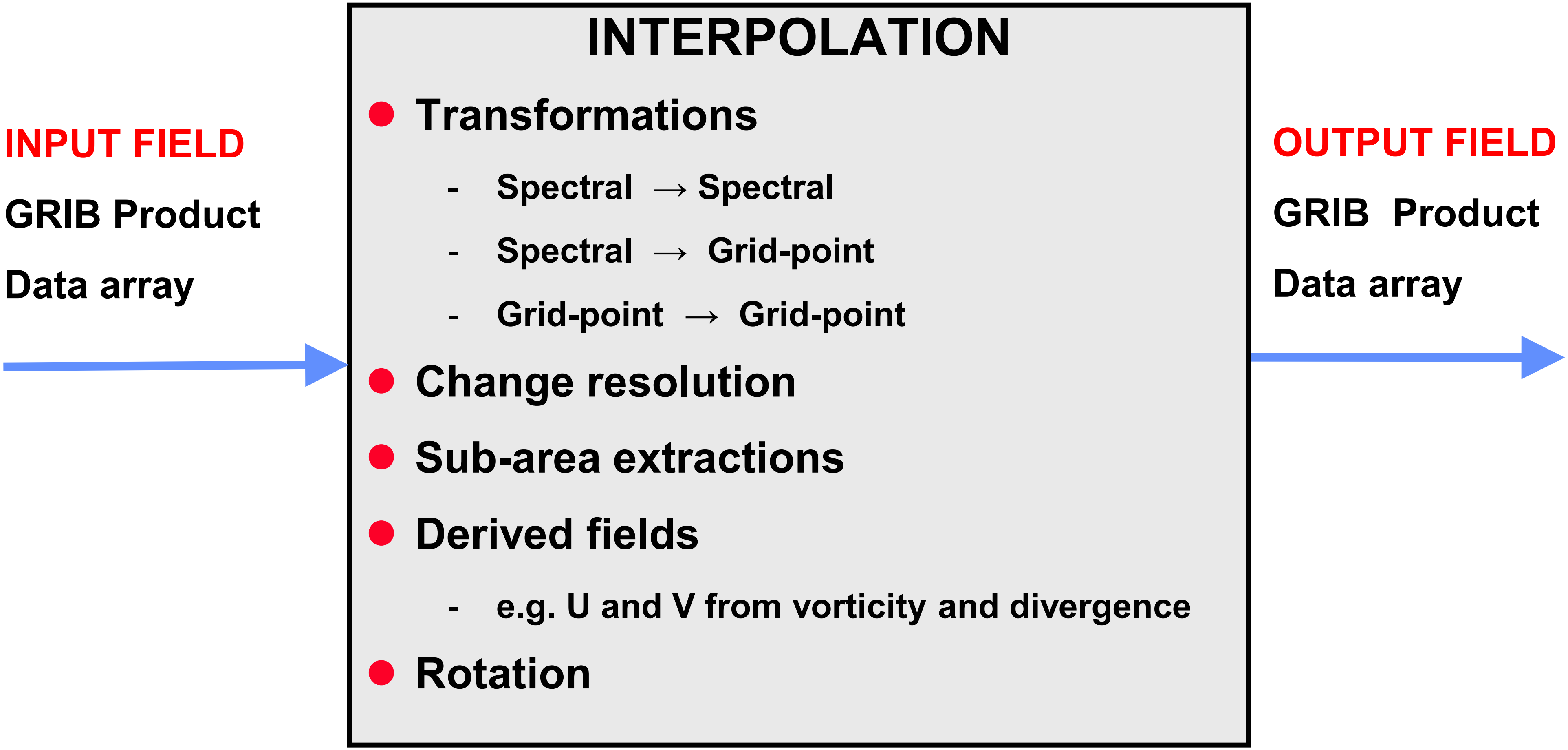
Introduction

- Weather data can have different representations
- Interpolation is how we recalculate data in a different representation
- Interpolation is available in
  - MARS
  - Operational dissemination
  - Metview graphics package

Documentation:

https://software.ecmwf.int/emoslib

Introduction - Interpolation “black box”



INPUT FIELD

GRIB Product

Data array

INTERPOLATION

- Transformations
  - Spectral → Spectral
  - Spectral → Grid-point
  - Grid-point → Grid-point
- Change resolution
- Sub-area extractions
- Derived fields
  - e.g. U and V from vorticity and divergence
- Rotation

OUTPUT FIELD

GRIB Product

Data array

Introduction – Interpolation black box (2)

- Input can be a GRIB product or value array
- Output can be a GRIB product or value array
- For GRIB products, characteristics / info read from the GRIB header

- A number of Fortran routines (part of EMOSLIB) perform the interpolation
- MARS calls these for you

- Possible to make calls to these functions yourself
- Example programs on internet pages for EMOSLIB

Spectral Transformations

- Some data (e.g. PL and ML) is stored in Spectral format
- These fields cannot be plotted directly
  - Need to be transformed to grid points

Spectral to grid-point

- Latitude/Longitude
- Regular and Reduced Gaussian
- Automatic truncation based on output grid resolution
- Interpolation coefficient files created (in `$PPDIR`)

Spectral to Spectral

- With truncation
- With rotation (very expensive in resources)

Spectral to grid-point: truncation

- *Automatic* truncation before interpolation reduces resources needed and avoids spurious “aliased” values

Grid increment	Truncation
2.5 ≤ Δ	T63
1.5 ≤ Δ < 2.5	T106
0.6 ≤ Δ < 1.5	T213
0.4 ≤ Δ < 0.6	T319
0.3 ≤ Δ < 0.4	T511
0.15 ≤ Δ < 0.3	T799
0.09 ≤ Δ < 0.15	T1279
0.0 ≤ Δ < 0.09	T2047

- *Optionally* controlled using *truncation* option in call to INTOUT
- MARS retrievals can override using *resol* keyword, e.g. resol=106

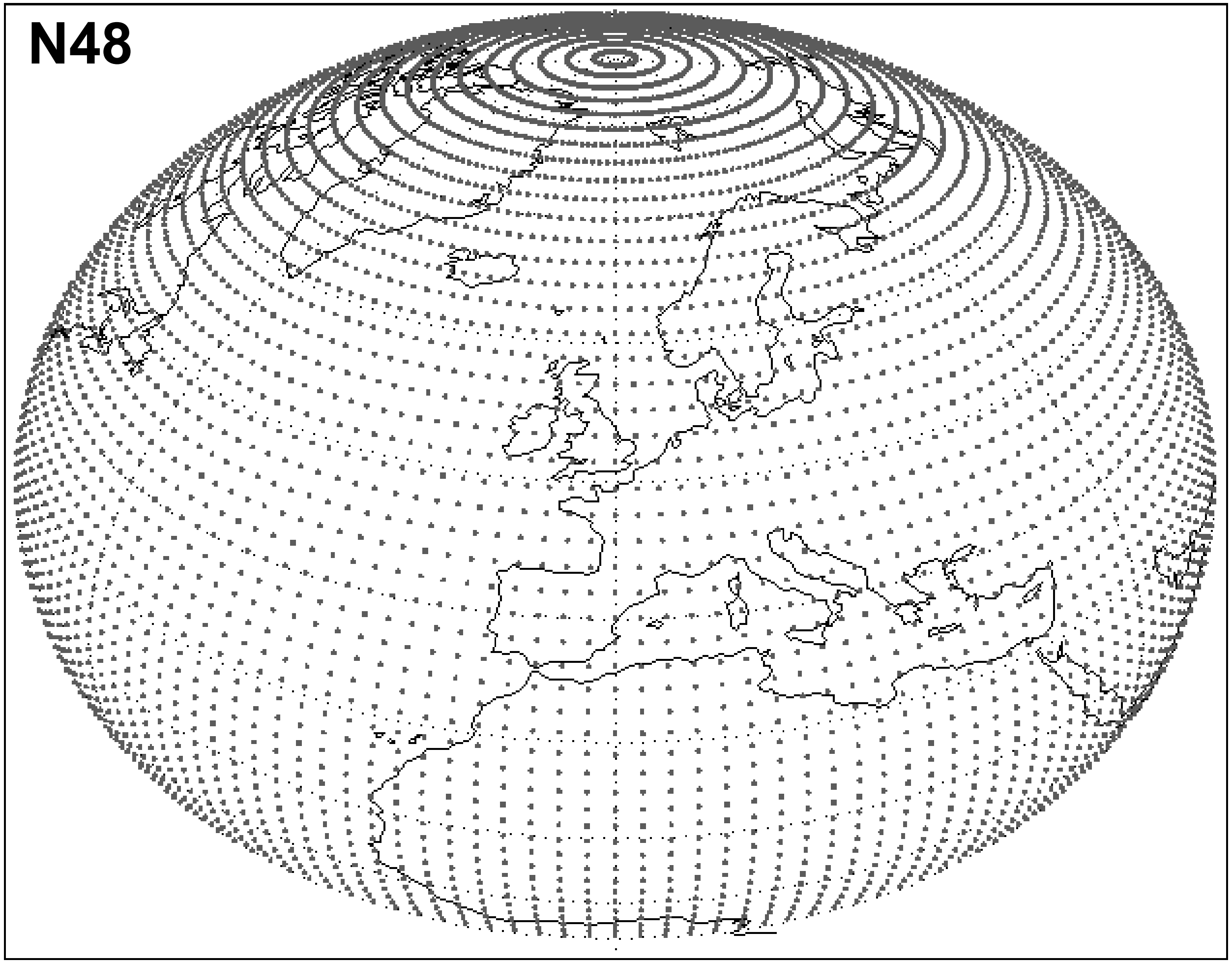
Grid-point Transformations

- Allowed combinations

TO →	Regular Lat /Lon	Regular Gaussian	Reduced Gaussian
Regular Lat /Lon	✓	✓	⊘
Regular Gaussian	✓	✓	⊘
Reduced Gaussian	✓	✓	✓

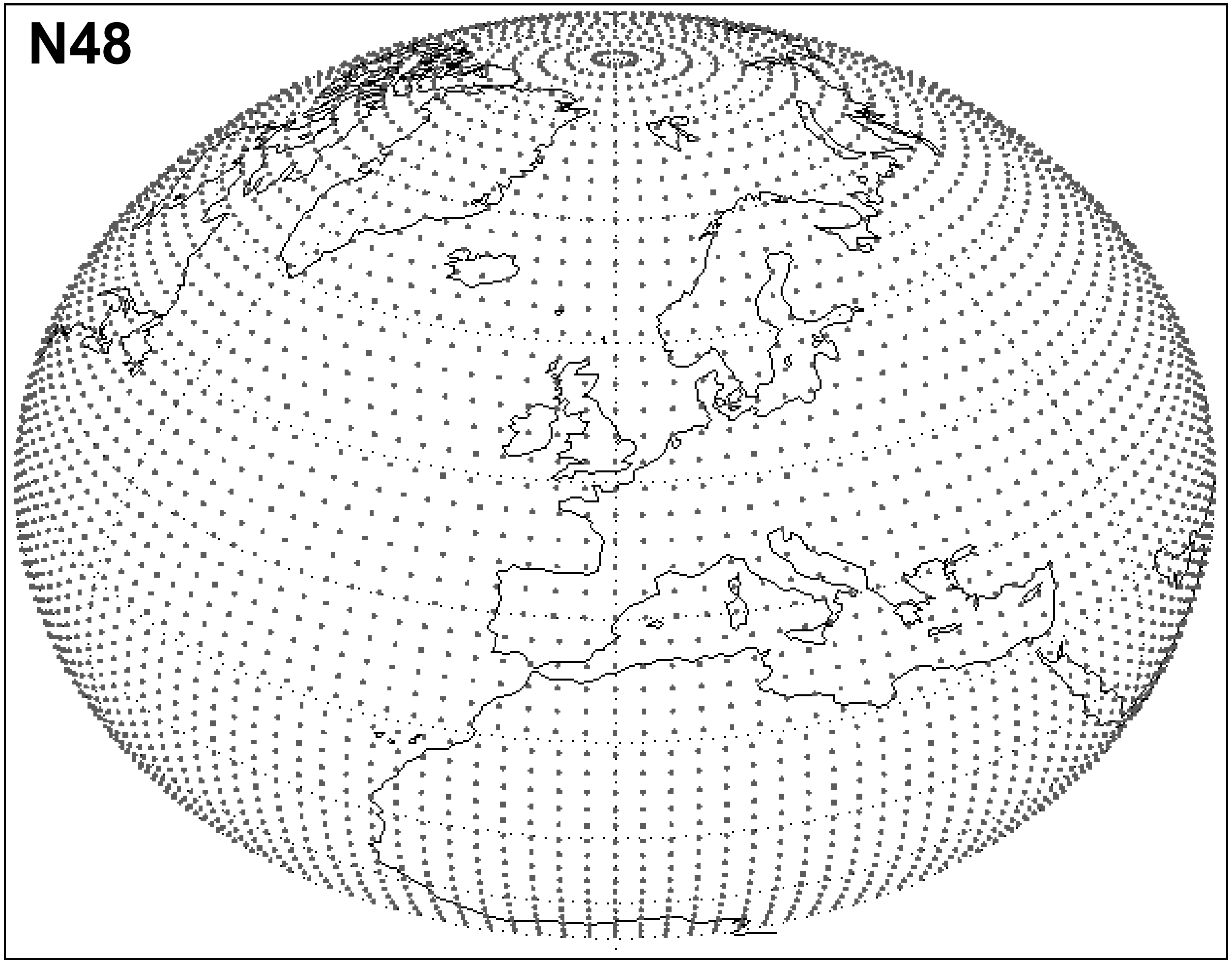
- NB cannot interpolate to reduced Gaussian from different repr

Regular Gaussian Grids



- N lines of latitude between pole and equator
- Latitude spacing not regular but is symmetric about equator
- 4 x N equally spaced points at each latitude
- No latitude points at poles or equator
- Special treatment at poles

Reduced Gaussian Grids



- **Lines of latitude same as a regular Gaussian grid**
- **Fewer longitude points at latitudes close to poles**
- **Local east-west grid length similar for all latitudes**

Interpolation Options

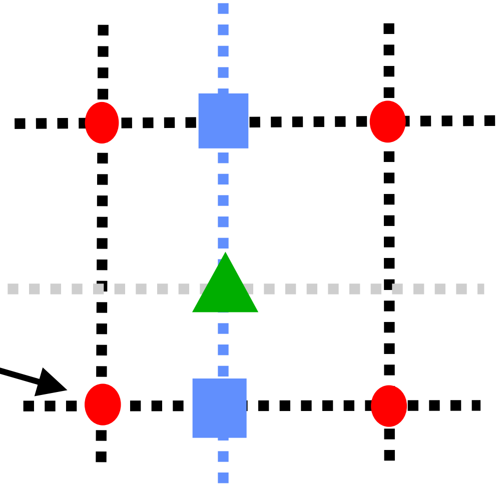
These apply only to Grid-point Interpolation

- Interpolation schemes
  - Bilinear
  - Nearest-neighbour
  - 12-point scheme for rotation
- Treatment of
  - land-sea masks
  - precipitation
- Geographical sub-areas

Bilinear Interpolation

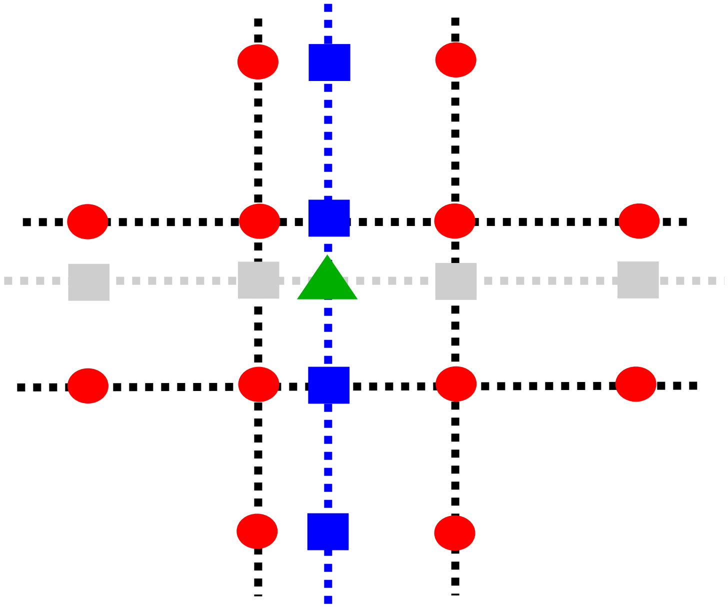
- Default for all parameters except vegetation and soil type fields and Wave 2D spectra
- Each point of output grid generated from 4 neighbouring points of input grid – approximated as Cartesian coordinates
- Weights applied to the 4 input grid points calculated:
  - by performing a linear fit along each line of latitude
  - normalising the two partial weights for each point
  - performing a linear fit in the north-south direction

Vegetation and soil type fields and Wave 2D spectra use nearest neighbour



Rotation from Gaussian Grids

- Uses a 12-point interpolation scheme



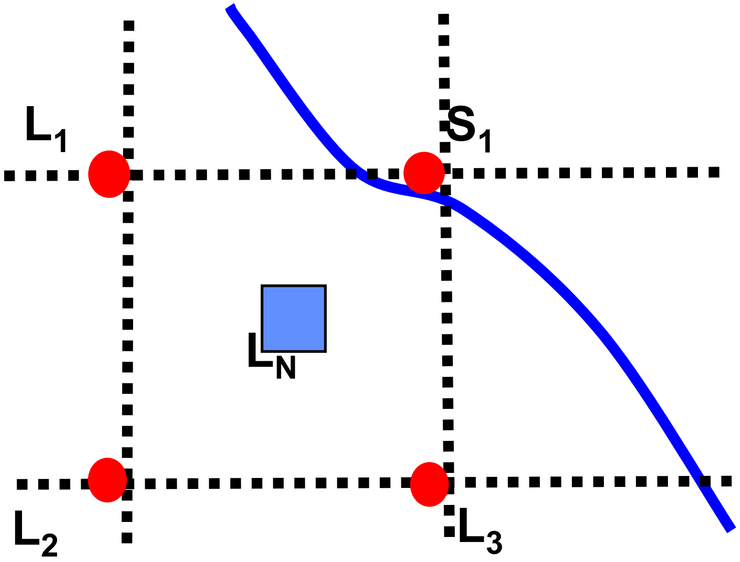
● Old grid point

▲ New grid point

- Spline fitting can produce non-physical values for some fields, e.g., cloud cover
  - Consider using bilinear interpolation for such fields
  - i.e. with MARS keyword interpolation = bilinear

Land-Sea Masks

- Land-sea masks represented as values 0 and 1 (or fractional)
- If land-sea mask of neighbouring point differs from grid-point being generated, weight of input point is modified to reduce effect



“Point S_1 has lower (0.2x) weight in calculation of L_N”

- Land-sea masks are applied by default to surface fields (except MSL and LSM and Reduced Gaussian)

Precipitation – an “accumulated field”

- Rules are applied to prevent spreading of ‘trace’ amounts:
- Interpolated value for precipitation at a point is set to zero if:
  - the calculated value is less than a defined threshold
  - its neighbour with the highest weight had no precipitation
- Polar values for precipitation are always the average of nearest Gaussian line with no threshold check applied
- For ensembles. accumulated fields can use “double” interpolation
  - E.g. Interpolate from N320 to N160 and then to lat-lon

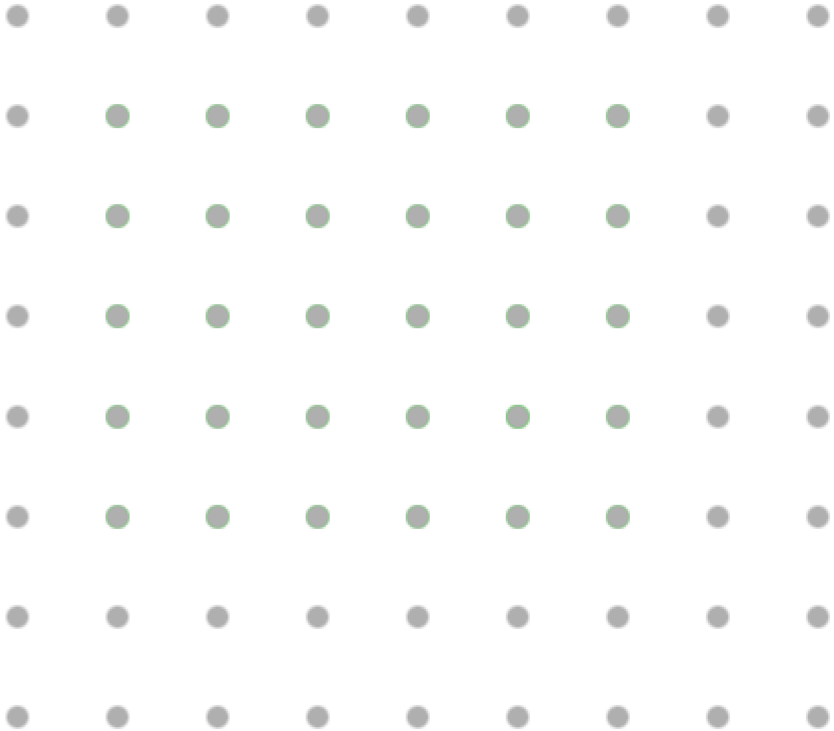
Geographical Sub-areas

- Sub-areas can be created for new fields by specifying lat / lon boundaries (north / west / south / east)
- Sub-areas are based on the full global grid
  - Global regular grids have dateline at 0° West
  - Lat/long grids have a line of latitude at the equator
  - Gaussian grids are symmetrical about the equator
- Boundaries of sub-areas are expanded outwards towards global grid (for rotations, boundaries are preserved)
  - Can change behaviour in MARS by setting the environment variable

    $MARS_INTERPOLATION_INWARDS
- Sub-areas not currently supported for reduced Gaussian grids – full global grid is produced for these

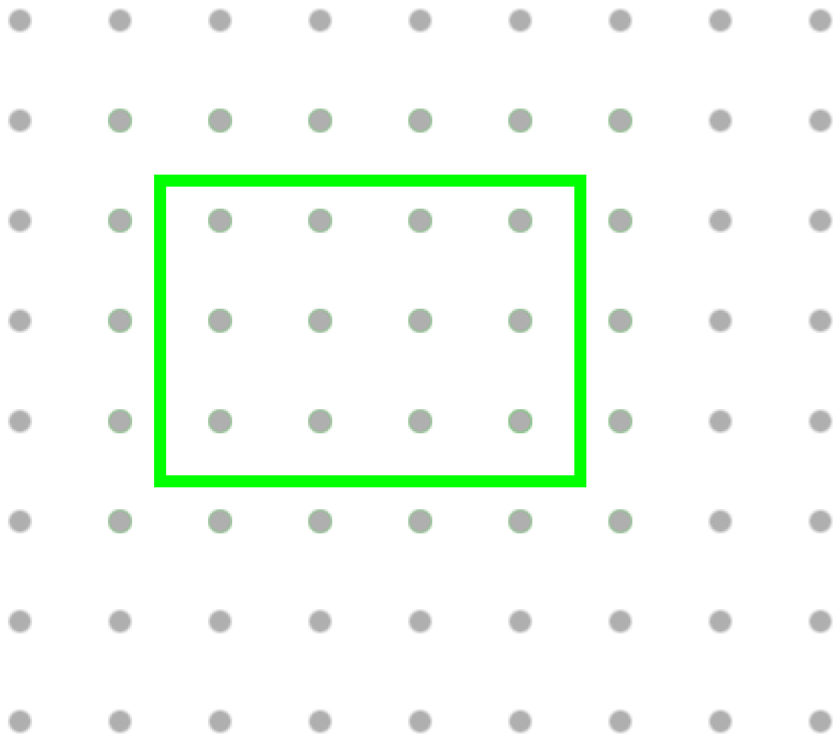
Geographical sub-areas – an example

- Adjustment of Sub areas
- Original (regular Lat / Lon) grid



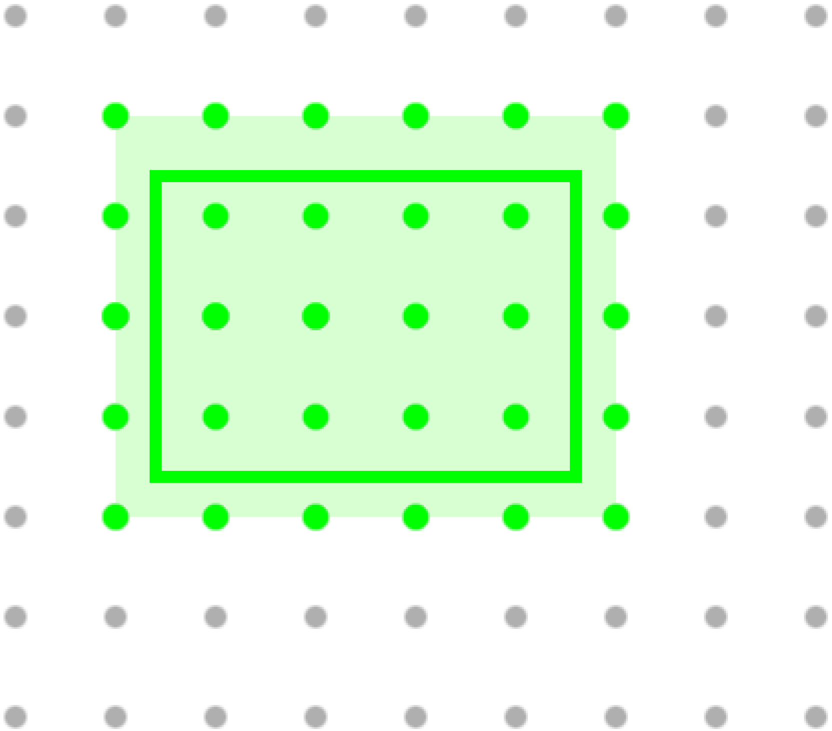
Geographical sub-areas – an example

- User requests a subarea
- In this case, their subarea falls between grid points



Geographical sub-areas – an example

- The subarea is widened
  - to encompass all points within and around the specified subarea
  - e.g. for 1x1 grid, NWSE (10.5, 2.5, -20.3, 84.2) becomes (11, 2, -21, 85)



Interfaces to the interpolation

- Fortran interface
  - Low level interface
  - Code needs to be complied and linked with Emoslib library
  - Special functions for GRIB2 (*intf2* & *intuvp2*)

  https://software.ecmwf.int/emoslib/Field+interpolation+software

- MARS/Metview interface
  - Recommended high level interface
  - Interpolation during data retrieval from archive
  - Options are described in MARS user guide
  - Same interface even if underlying interpolation package will change
  - This is what we use for the practical exercises…

```
retrieve,
   type      = forecast,
   param   = t,
   levelist = 1000/500,
   grid     = 1.5/1.5,
   area     = 75/-20/10/60,
   target   = "t_ll_eu.grb"
```

http://www.ecmwf.int/publications/manuals/mars/guide/Post_processing_keywords.html

Future plans

- EMOSLIB is not easy to maintain
- A new interpolation package is being written in C++
  - Improve code, efficiency, maintainability and portability
- The new package will provide a Library and API
  - It will be callable from C, C++, Fortran 90, Python
  - It will include some Unix-style command line tools
- All current EMOSLIB features will be supported
- Some new features will be added
  - Include routines for ‘single-point’ interpolation
  - Handle different grid types
  - Parallelisation / multiple-threaded
- Will undergo extensive testing at ECMWF before release

Practical: Interpolation with MARS

- Work in your $SCRATCH
- Copy the scripts from ~trx/maf/scripts

```
cd $SCRATCH
cp /home/ectrain/trx/maf/scripts/interp*.ksh ./
```

- First, run interp1.ksh:

```
./interp1.ksh
```

  This will retrieve some data from MARS to a file out1.grib

- Next run the other scripts in turn. Each will create a new file called out2.grib, … , out7.grib
- Inspect each output file with grib_ls and grib_dump
  - Note how the grid description in Section 2 of the header differs
  - Look at the MARS requests that create each of the files