The ISG-format

(version 2.0)

International Service for the Geoid,
c/o Politecnico di Milano, DICA, Geodesy and Geomatics Division
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The ISG-format accommodates local/regional geoid/quasi-geoid models given as undulations with respect to a reference ellipsoid on a grid or sparse points.

Each individual data file consists of three sections:

1. The **comment-section,** which starts at the beginning of the file and ends with the keyword "begin_of_head" (as a separator between the comment section and the header).
   This section is optional.
2. The **header-section,** which contains textual and numerical parameters. The beginning of the header is marked by the keyword "begin_of_head", while the end of the header is marked by the keyword "end_of_head". This section is mandatory.
3. The **data-section** with the undulation values.

Comment section

Three paragraphs are strongly recommended, the first one with the licence under which the data are distributed, the second one with the reference to cite when using the data, the third one indicating the data provider and recalling that the model is distributed by ISG.

Header section

The records in the header have the following keywords with the following meaning:

Keywords	Type	Text or value
model name	textual	name of the model; if it does not exist, indicate the name of the country or the geographical region covered by the data
model year	textual	year of the model computation
model type	textual	type of the model depending on the input data, i.e. "gravimetric", "geometric" or "hybrid"; the model is classified as "gravimetric" if based on gravity data, "geometric" if based on GNSS/levelling data or "hybrid" if based on both gravity and GNSS/levelling data
data type	textual	type of undulation data, i.e. "geoid" or "quasi-geoid"
data units	textual	units of the undulation data, i.e. "meters" or "feet"
data format	textual	spatial distribution of undulation data, i.e. "grid" or "sparse"
data ordering	textual	convention on the data ordering, i.e. "N-to-S, W-to-E" for row and column ordering of grid data, "lat, lon, N" or "east, north, N" for column ordering of sparse data with geodetic or projected coordinates, respectively; write "N" for the geoid undulation and "zeta" for the height anomalies
ref ellipsoid	textual	reference ellipsoid of the geoid/quasi-geoid undulations, e.g. "GRS80"
ref frame	textual	reference frame of the geoid/quasi-geoid undulations, e.g. "ITRF2014", "ETRF2000"
height datum	textual	height datum of the geoid/quasi-geoid undulations, i.e. the levelling reference system; applicable only for geometric or hybrid models
tide system	textual	"tide-free", "mean-tide" or "zero-tide"

coord type	textual	coordinate type, i.e. “geodetic” (latitude and longitude) or “projected” (east and north coordinates)
coord units	textual	units of the data coordinates, i.e. “dms” or “deg” for geodetic coordinates, “meters” or “feet” for projected coordinates; according to the units, data coordinates are given in the following formats: - “dms”: `%4d°%02d′%02d″` - “deg”: `%11.6f` - “meters”: `%11.3f` - “feet”: `%11.3f`
map projection	textual	adopted map projection, e.g. “UTM 32N”; applicable only for projected coordinates
EPSG code	textual	EPSG code of the datum, e.g. “7912” for “ITRF2014”
lat min / north min	numeric	values depending on the “data format” and the “coord type” keywords, see table below; values given according to the format specified in the “coord units” keywords
lat max / north max	numeric	
lon min / east min	numeric	
lon max / east max	numeric	
delta lat / delta north	numeric	
delta lon / delta east	numeric	
nrows	numeric	number of rows of the grid or number of sparse points, for consistency check, (format %10d)
ncols	numeric	number of columns of the grid, for consistency check, (format %10d); it is equal to 3 in case of sparse data
nodata	numeric	fictitious value to be used for grid knots with no data available, e.g. “-9999.0000”, (format %10f.4)
creation date	numeric	creation date of the file (dd/mm/yyyy)
ISG format	numeric	version of the ISG format, use “2.0” to refer to this document

data type = “grid” and coord type = “geodetic”		
lat min	numeric	grid minimum latitude
lat max	numeric	grid maximum latitude
lon min	numeric	grid minimum longitude
lon max	numeric	grid maximum longitude
delta lat	numeric	grid step in latitude
delta lon	numeric	grid step in longitude
data type = “grid” and coord type = “projected”		
north min	numeric	grid minimum north coordinate
north max	numeric	grid maximum north coordinate
east min	numeric	grid minimum east coordinate
east max	numeric	grid maximum east coordinate
delta north	numeric	grid step in north direction
delta east	numeric	grid step in east direction
data type = “sparse” and coord type = “geodetic”		
lat min	numeric	minimum latitude value among the sparse points
lat max	numeric	maximum latitude value among the sparse points
lon min	numeric	minimum longitude value among the sparse points
lon max	numeric	maximum longitude value among the sparse points
delta lat	numeric	not applicable
delta lon	numeric	not applicable

data type = “sparse” and coord type = “projected”		
north min	numeric	minimum north coordinate value among the sparse points
north max	numeric	maximum north coordinate value among the sparse points
east min	numeric	minimum east coordinate value among the sparse points
east max	numeric	maximum east coordinate value among the sparse points
delta north	numeric	not applicable
delta east	numeric	not applicable

Recommendations:

- keywords are left-aligned and occupy 14 characters;
- the separator between the keyword and the corresponding value is “:” for textual records or “=” for numeric records;
- a blank is typed before and after the separator;
- textual records have no limits of characters and are left-aligned;
- numeric records occupy at most 11 characters and are right-aligned;
- not applicable and unknown values are filled in as “---” and are left-aligned;
- the given keyword ordering is strongly recommended but not mandatory;
- the given data ordering is strongly recommended but not mandatory.

Data section

Undulation values are stored in a different way depending on the data format, i.e. grid or sparse data. The value format is %10f.4.

In case of grid data, undulation values are always stored row by row. The default ordering is from north to south, each row going from west to east; other orderings are possible but not recommended and have to be specified by the field “data ordering” in the header section. Undulation values are separated by at least one blank (no tabs) and the carriage return is typed at the end of the row only.
The grid resolution is defined by the fields “delta lat” and “delta lon” for geodetic coordinates or “delta north” and “delta east” for projected coordinates in the header section. The grid extension is defined by the fields “lat max”, “lat min”, “lon min” and “lon max” for geodetic coordinates or “north max”, “north min”, “east min” and “east max” for projected coordinates in the header section. The grid number of rows and columns are reported in the header section for check and are given by the following relations:

for geodetic coordinates

“nrows” = (“lat max” - “lat min”) / “delta lat” + 1
“ncols” = (“lon max” - “lon min”) / “delta lon” + 1

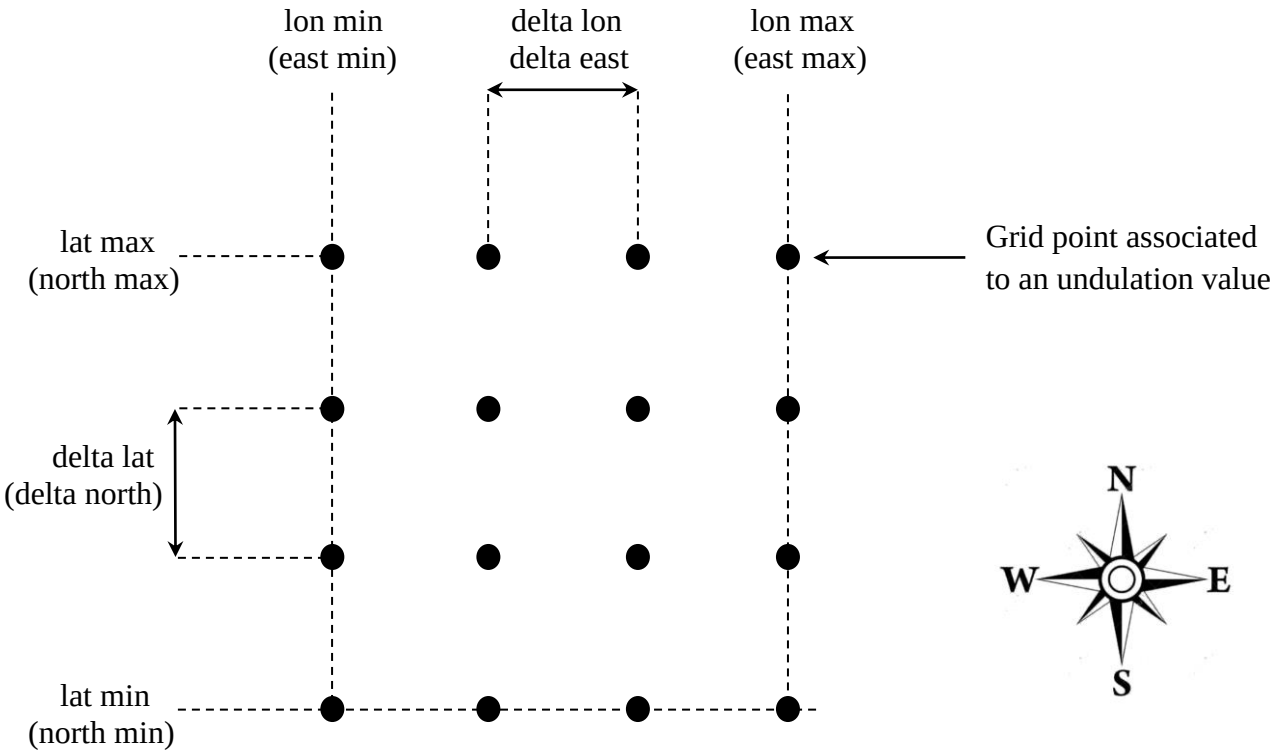
for projected coordinates

“nrows” = (“north max” - “north min”) / “delta north” + 1
“ncols” = (“east max” - “east min”) / “delta east” + 1

Note that latitude values range from -90 to +90 and are positive in the northern hemisphere and negative in the southern hemisphere. Longitude values generally range from -180 to 180 and are positive on the east side of the Greenwich meridian and negative on its west side. Alternatively, longitude values can range from 0 to 360, starting from the Greenwich meridian and rotating in the east direction. In any case, the condition “lon max” > “lon min” in the header section must be satisfied; this means that:
- if the model includes the Greenwich meridian, the convention -180 < lon < 180 must be used;
- if the model includes the Greenwich antimeridian, the convention 0 < lon < 360 must be used.

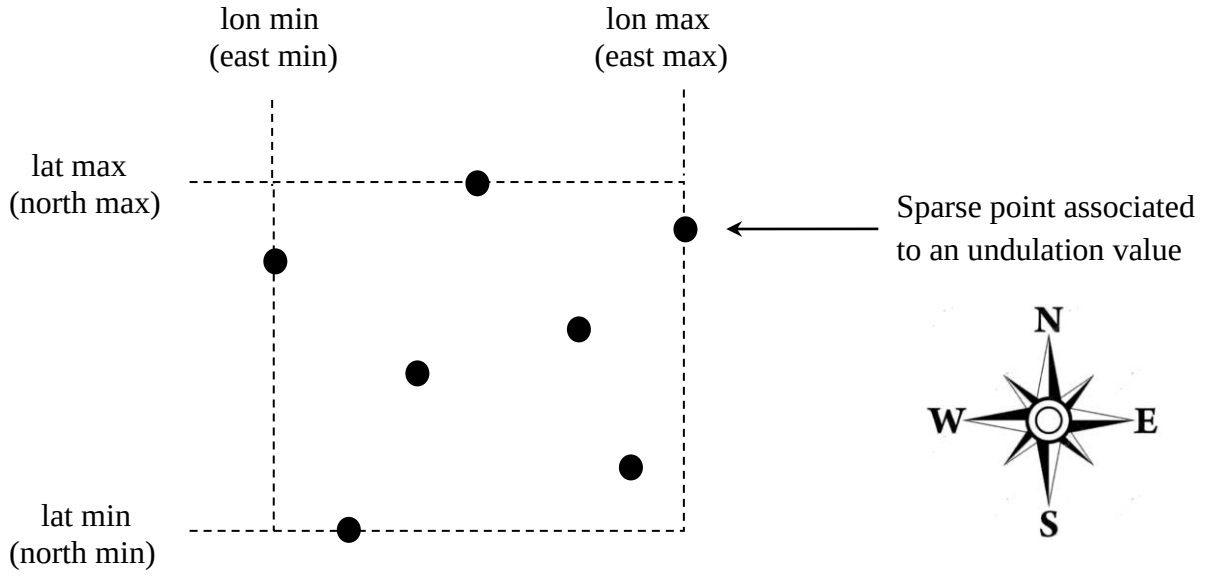
Note that, with the default data ordering, the same values have to be stored in the first row if "lat max" = 90 and in the last row if "lat min" = -90. Furthermore, the first column has to be equal to the last column if "lon min" = -180 or 0, and "lon max" = 180 or 360, respectively.

The meaning of the grid parameters is displayed in the figure below:



In case of sparse data, each point is stored on a different row, providing its latitude, longitude and undulation for the geodetic coordinates, and east, north and undulation for the projected coordinates. This is the default column ordering; other choices are possible but not recommended and have to be specified by the field "data ordering" in the header section. The coordinates and the undulation of each point are separated by at least one blank (no tabs). There is no predefined sorting of the points.

The meaning of the parameters for sparse points is displayed in the figure below:



Example 1

```
These data are freely available under a Creative Commons Attribution 4.0
International Licence (CC BY 4.0)

When using the data, please cite:
A. Name1, B. Name2 (year). Title. Version 1.0. GFZ Data Services.
http://doi.org/10.5880/isg.2020.001

The original data were provided by C. Name3 (email of dd/mm/yyyy to ISG).
The present file is distributed by ISG.

This is an example.
Here some information about model computation can be provided.

Bibliographic reference:
D. Name4, E. Name5 (year). Title. Journal, Volume(Number), pp. xxx-yyy.

begin_of_head ================================================
model name     : EXAMPLE
model year     : 2020
model type     : gravimetric
data type      : geoid
data units     : meters
data format    : grid
data ordering  : N-to-S, W-to-E
ref ellipsoid  : GRS80
ref frame      : ITRF2014
height datum   : ---
tide system    : mean-tide
coord type     : geodetic
coord units    : dms
map projection : ---
EPSG code      : 7912
lat min        =   39°50'00"
lat max        =   41°10'00"
lon min        =  119°50'00"
lon max        =  121°50'00"
delta lat      =    0°20'00"
delta lon      =    0°20'00"
nrows          =          4
ncols          =          6
nodata         =  -9999.0000
creation date  =  31/05/2020
ISG format     =         2.0
end_of_head ==================================================
   30.1234    31.2222    32.3456    33.4444    34.5678    36.6666
   41.1111    42.2345    43.3333    44.4567    45.5555    46.6789
   51.4321    52.9753    53.6543    54.8642 -9999.0000 -9999.0000
   61.9999    62.8888    63.7777    64.6666 -9999.0000 -9999.0000
```

Example 2 (the same of Example 1, but with “deg” coordinate units)

```
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International Licence (CC BY 4.0)

When using the data, please cite:
A. Name1, B. Name2 (year). Title. Version 1.0. GFZ Data Services.
http://doi.org/10.5880/isg.2020.001

The original data were provided by C. Name3 (email of dd/mm/yyyy to ISG).
The present file is distributed by ISG.

This is an example.
Here some information about model computation can be provided.

Bibliographic reference:
D. Name4, E. Name5 (year). Title. Journal, Volume(Number), pp. xxx-yyy.

begin_of_head ================================================
model name     : EXAMPLE
model year     : 2020
model type     : gravimetric
data type      : geoid
data units     : meters
data format    : grid
data ordering  : N-S, W-E
ref ellipsoid  : GRS80
ref frame      : ITRF2014
height datum   : ---
tide system    : mean-tide
coord type     : geodetic
coord units    : deg
map projection : ---
EPSG code      : 7912
lat min        =   40.000000
lat max        =   41.000000
lon min        =  120.000000
lon max        =  121.666667
delta lat      =    0.333333
delta lon      =    0.333333
nrows          =           4
ncols          =           6
nodata         =  -9999.0000
creation date  =  31/05/2020
ISG format     =         2.0
end_of_head ==================================================
   30.1234    31.2222    32.3456    33.4444    34.5678    36.6666
   41.1111    42.2345    43.3333    44.4567    45.5555    46.6789
   51.4321    52.9753    53.6543    54.8642 -9999.0000 -9999.0000
   61.9999    62.8888    63.7777    64.6666 -9999.0000 -9999.0000
```

Example 3 (the same of Examples 1 and 2, but listing data as sparse points)

```
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International Licence (CC BY 4.0)

When using the data, please cite:
A. Name1, B. Name2 (year). Title. Version 1.0. GFZ Data Services.
http://doi.org/10.5880/isg.2020.001

The original data were provided by C. Name3 (email of dd/mm/yyyy to ISG).
The present file is distributed by ISG.

This is an example.
Here some information about model computation can be provided.

Bibliographic reference:
D. Name4, E. Name5 (year). Title. Journal, Volume(Number), pp. xxx-yyy.

begin_of_head ================================================
model name     : EXAMPLE
model year     : 2020
model type     : gravimetric
data type      : geoid
data units     : meters
data format    : grid
data ordering  : lat, lon, N
ref ellipsoid  : GRS80
ref frame      : ITRF2014
height datum   : ---
tide system    : mean-tide
coord type     : geodetic
coord units    : deg
map projection : ---
EPSG code      : 7912
lat min        =   40.000000
lat max        =   41.000000
lon min        =  120.000000
lon max        =  121.666667
delta lat      = ---
delta lon      = ---
nrows          =          20
ncols          =           3
nodata         =  -9999.0000
creation date  =  31/05/2020
ISG format     =         2.0
end_of_head ==================================================
  40.000000  120.000000    30.1234
  40.000000  120.333333    31.2222
  40.000000  120.666667    32.3456
  40.000000  121.000000    33.4444
  40.000000  121.333333    34.5678
  40.000000  121.666667    36.6666
  40.333333  120.000000    41.1111
  40.333333  120.333333    42.2345
  40.333333  120.666667    43.3333
  40.333333  121.000000    44.4567
  40.333333  121.333333    45.5555
```

```
40.333333  121.666667    46.6789
40.666667  120.000000    51.4321
40.666667  120.333333    52.9753
40.666667  120.666667    53.6543
40.666667  121.000000    54.8642
41.000000  120.000000    61.9999
41.000000  120.333333    62.8888
41.000000  120.666667    63.7777
41.000000  121.000000    64.6666
```