

→ 10th COASTAL ALTIMETRY WORKSHOP

SAR Altimetry Training Course



The background of the slide features a satellite in the upper left corner, emitting a beam towards a coastal region. Below the satellite is a map showing SAR altimetry data with contour lines and shaded areas representing elevation. The map includes a large landmass and several smaller islands, with a river system visible on the right side.

GUT Demo

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Gravity field and steady-state Ocean Circulation Explorer (GOCE)

- Launched in March 2009, end of mission in November 2013
- Dedicated to measure **Earth's static gravity field**, and by so allowing us to model the geoid
- Achieved a mean global accuracy of **2.4 cm** in terms of geoid heights and **0.7 mGal** for gravity anomalies at a spatial resolution of **100 km**.



goce

GOCE User Toolbox (GUT)

GUT is a toolkit to facilitate the use, viewing and post-processing of GOCE's Level 2 gravity field data products, applicable in the fields of **geodesy, solid Earth physics and oceanography**.

- Collection of command-line tools (C++) and graphical user interface (Python)
- Runs under Windows, Linux and Mac OS
- NetCDF (CF 1.6) used for final and intermediate products
- Fully open source software under GNU GPL license
- Extensible by means of three APIs in C, C++ and Fortran
- Current version **3.1**



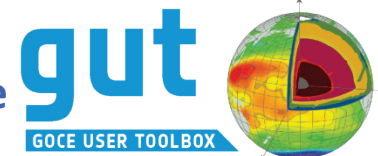
GOCE User Toolbox (GUT)

- First public release (1.0) of GUT was in April 2009 (right after GOCE launch)
- The last one (3.1) was in December 2015
- There is an average of 2 to 3 downloads per week
- In the coming months, new work will be started around studying the error covariances structure associated with the MDT and also providing further user support



GUT v3.1

- Read **GOCE** Level 2 products and ancillary datasets, including a priori surfaces, calibrated gravity gradients and geoid height errors.
- Calculate the **error variance-covariance** matrix of GOCE's gravity models.
- Read **GRACE** Level 2 products.
- Read global and local gravity models in **ICGEM** format.
- Compute **geoid heights** at a chosen maximum degree and order over a grid or transect.
- Compute **gravity and height anomalies**, and **vertical deflections** on the surface of the terrain for a range of maximum degree and order expansions over a grid or transect.
- Compute the **spherical harmonic synthesis** and calculate the **potential gradients**.
- Compute the ocean's **mean dynamic topography** and associated **geostrophic velocities, kinetic energy** and the vertical component of **relative vorticity**.
- Smooth gridded fields with a wide range of **spatial and spectral filters**, including diffusive filtering.
- Transform data between **different reference ellipsoid and tide-systems**.
- Compute **gravity disturbances, Bouguer and free-air anomalies** at different heights
- Produce final output products in **netCDF** format (CF 1.6).
- **Graphical User Interface**



Main concepts

GUT performs a series of processing steps as described in XML files called **workflows**.

```
<?xml version="1.0"?>
<workflow>
  <units>
    <CmdLineArgInputFileName name="InFile"></CmdLineArgInputFileName>
    <CmdLineArgReferenceEllipsoid name="RE" />
    <CmdLineArgGrid name="Grid">0.50 359.50 -89.50 89.50 1.0
1.0</CmdLineArgGrid>
    <CmdLineArgDegreeAndOrder name="DegreeAndOrder" />
    <CmdLineArgTideSystem name="TideSystem"></CmdLineArgTideSystem>
    <CreateReferenceEllipsoid name="DefaultRE" />
    <SphericalHarmonicPotentialImport name="DataShp" />
    <ChangePotentialDegreeAndOrder name="DegOrdSetShp" />
    <ChangePotentialTideSystem name="TideSetShp" />
    <GridFunctionGeoidHeight name="GeoidHeight" />
    <CmdLineArgOutputFileName
name="OutFile">geoid_height.nc</CmdLineArgOutputFileName>
    <GridFunctionExport name="Export" />
  </units>
  <connection>
    <socket unit="InFile" port="OutFileName" />
    <plug unit="DataShp" port="InFileName" />
  </connection>
  <connection>
    <socket unit="DefaultRE" port="OutReferenceEllipsoid" />
    <plug unit="RE" port="InReferenceEllipsoid" />
  </connection>
</workflow>
```

Main concepts

The **workflows** are defined by means of the **processing units** and the **connections** between them

```
<?xml version="1.0"?>
<workflow>
  <units>
    <CmdLineArgInputFileName
name="InFile"></CmdLineArgInputFileName>
    <CmdLineArgReferenceEllipsoid name="RE" />
    <CmdLineArgGrid name="Grid">0.50 359.50 -89.50 89.50 1.0
1.0</CmdLineArgGrid>
    <CmdLineArgDegreeAndOrder name="DegreeAndOrder" />
    <CmdLineArgTideSystem name="TideSystem"></CmdLineArgTideSystem>
    <CreateReferenceEllipsoid name="DefaultRE" />
    <SphericalHarmonicPotentialImport name="DataShp" />
    <ChangePotentialDegreeAndOrder name="DegOrdSetShp" />
    <ChangePotentialTideSystem name="TideSetShp" />
    <GridFunctionGeoidHeight name="GeoidHeight" />
    <CmdLineArgOutputFileName
name="OutFile">geoid_height.nc</CmdLineArgOutputFileName>
    <GridFunctionExport name="Export" />
  </units>
  <connection>
    <socket unit="InFile" port="OutFileName" />
    <plug unit="DataShp" port="InFileName" />
  </connection>
  <connection>
    <socket unit="DefaultRE" port="OutReferenceEllipsoid" />
    <plug unit="RE" port="InReferenceEllipsoid" />
  </connection>
</workflow>
```

Main concepts

GUT's basic algorithms are encapsulated within the processing units (C, C++, Fortran)

```
<?xml version="1.0"?>
<workflow>
  <units>
    <CommandLineArgInputFileName name="InFile"></CommandLineArgInputFileName>
    <CommandLineArgReferenceEllipsoid name="RE" />
    <CommandLineArgGrid name="Grid">0.50 359.50 -89.50 89.50 1.0
1.0</CommandLineArgGrid>
    <CommandLineArgDegreeAndOrder name="DegreeAndOrder" />
    <CommandLineArgTideSystem name="TideSystem"></CommandLineArgTideSystem>
    <CreateReferenceEllipsoid name="DefaultRE" />
    <SphericalHarmonicPotentialImport name="DataShp" />
    <ChangePotentialDegreeAndOrder name="DegOrdSetShp" />
    <ChangePotentialTideSystem name="TideSetShp" />
    <GridFunctionGeoidHeight name="GeoidHeight" />
    <CommandLineArgOutputFileName
name="OutFile">geoid_height.nc</CommandLineArgOutputFileName>
    <GridFunctionExport name="Export" />
  </units>
  <connection>
    <socket unit="InFile" port="OutFileName" />
    <plug unit="DataShp" port="InFileName" />
  </connection>
  <connection>
    <socket unit="DefaultRE" port="OutReferenceEllipsoid" />
    <plug unit="RE" port="InReferenceEllipsoid" />
  </connection>
</workflow>
```

```
#include "config.h"
#include "SphericalHarmonicPotentialImport.h"
#include "SphericalHarmonicPotentialExtraction.h"
#include "GutDebug.h"

//-----
// SphericalHarmonicPotentialImport
//-----

SphericalHarmonicPotentialImport::SphericalHarmonicPotentialImport(
Workflow &workflow, const std::string &name, const std::string
&parsableDefault) :
  ProcUnit(workflow, name),
  m_inFileName(*this, "InFileName"),
  m_outShp(*this, "OutSphericalHarmonicPotential")
{}

void SphericalHarmonicPotentialImport::calculate(LogSystem &log) {
  TRACE4("SphericalHarmonicPotentialImport::calculate");

  SphericalHarmonicPotential shp =
GUT::sphericalHarmonicPotentialImport(log, m_inFileName.data().c_str());
  if (shp.isValid())
    m_outShp.setData(shp);
}
```


Workflows and Processing Units Portfolio

- GUT offers to users a portfolio of more than **70 prebuilt workflows** and about **140 processing units** for the more general tasks in the fields of Geodesy and Oceanography
- These can be **extended** by user-made workflows and processing units

The screenshot displays a page from the GUT User Guide and Algorithm Descriptions. It includes a header with the GUT logo and document information: Reference: ESA-GUT-AD-001, Version: 3.5, Date: 10 Mar 2016, page 43/130. The main content features a mathematical equation (7.4.2) for the radial component of gravity, W_r , and a section titled '7.4 Gravity' which defines the local coordinate system and the gravity vector g_p . The vector is defined as $g_p = \sqrt{W_x^2 + W_y^2 + W_z^2}$ (7.4.3). The text explains that W_x is positive northward, W_y is positive eastward, and W_z is positive inward. It also describes the iterative process for determining the point Q where $W_p = U_0$. The document further details the 'Free Air Gravity Anomaly' algorithm, which extracts spherical harmonic potential coefficients and calculates the gravity anomaly on a chosen track or grid.

Graphical User Interface

A user is no longer limited to editing XML files and executing command line tools.

```
<?xml version="1.0"?>
<workflow>
  <units>
    <CmdLineArgInputFileName name="InFile"></CmdLineArgInputFileName>
    <CmdLineArgReferenceEllipsoid name="RE" />
    <CmdLineArgGrid name="Grid">0.50 359.50 -89.50 89.50 1.0
1.0</CmdLineArgGrid>
    <CmdLineArgDegreeAndOrder name="DegreeAndOrder" />
    <CmdLineArgTideSystem name="TideSystem"></CmdLineArgTideSystem>
    <CreateReferenceEllipsoid name="DefaultRE" />
    <SphericalHarmonicPotentialImport name="DataShp" />
    <ChangePotentialDegreeAndOrder name="DegOrdSetShp" />
    <ChangePotentialTideSystem name="TideSetShp" />
    <GridFunctionGeoidHeight name="GeoidHeight" />
    <CmdLineArgOutputFileName
name="OutFile">geoid_height.nc</CmdLineArgOutputFileName>
    <GridFunctionExport name="Export" />
  </units>
  <connection>
    <socket unit="InFile" port="OutFileName" />
    <plug unit="DataShp" port="InFileName" />
  </connection>
  <connection>
    <socket unit="DefaultRE" port="OutReferenceEllipsoid" />
    <plug unit="RE" port="InReferenceEllipsoid" />
  </connection>
</workflow>
```

```
ex Command Prompt
effect. GUT specific options may be specified anywhere in the command-line
except between a workflow flag and its argument.

C:\Documents and Settings\salvatore di nardo\Desktop\GUT 1.0\gut-1.0b\bin>gut
help

The GUT Command-Line Processor has several basic run-modes and precisely one
of these is active for each invocation of GUT. Some run-modes do not require
any additional input, but most require a workflow file and most workflows
will require additional command-line flags and arguments. Command-line flags
that start with -- are treated as GUT specific options. Flags with a single
- are treated as workflow specific options. In general a workflow flag will
be followed by an argument. The first command-line argument that is NOT a
flag is interpreted as the workflow.
The workflow name is used to locate a workflow definition file. The file
search process is...

* Treat the workflow name as a filename, as-is.
* If not already present, append .xml to the name and treat as a filename.
* Prepend the Standard Workflow Definition directory to the name and append
.xml if it is not already present.

The minimal command-line required for each run-mode is shown below.

--help           : Shows this help information.
--version        : Shows the version and installation information.
--workflows      : Shows the list of installed workflows. Note that a
file in the current directory may obscure these
workflows. The --man option can be used to determine
precisely which file is located.
--man <workflow> : Extracts the internal documentation from a workflow
definition and gives the full path of the workflow
file.
--dot <workflow> : Constructs the workflow and produces the file
<workflow>.dot in the current directory. This file
describes the structure of the workflow graph in the
DOT language, and can be visualized with OpenSource
tools (ie. Graphviz). Additional arguments, specific
to the workflow may be required for error-free
construction of the workflow.
--test <workflow> : Constructs the workflow to check that it is valid
and can be executed with the specified flags and
arguments.

<workflow>      : Construct and execute a workflow. Additional command-
line arguments are usually required. The precise
nature of these arguments is defined by the content
of the workflow definition file.

For the workflow execution run-mode additional GUI options may be supplied.
These are...
--quiet         : Suppresses all error, warning, information and
progress messages.
```

Graphical User Interface

- Built with Python over the C++ command lines tools.
- Interaction by **dragging and dropping** workflow nodes, user-friendly **dialogs**, and **colour coded feedback**.
- Run and visualise results without leaving the GUI.

The screenshot displays the GOCE User Toolbox GUI. On the left, a 'Workflow Library' lists various system workflow functions such as 'adapt_of', 'addscalar_of', and 'filter_of'. The main workspace shows a workflow diagram with nodes like 'E-ellipse', 'adapt_of', and 'filter_of' connected by arrows. A 'BRAT World Plot - #0' window is open, showing a global map with a color-coded geoid height. The plot includes a 'Properties' panel with settings for 'Vector Scale', 'Projection', 'Center Lat', 'Center Lon', 'Data Layers', and 'View'. A 'Workflow Description - geoidheight_of.xml' window is also visible, providing a detailed synopsis and arguments for the workflow, including file names and grid specifications.

Graphical User Interface

GOCE User Toolbox GUI

File Edit View Execute Visualize Help

Workflow Library

- geoidheightcorrection_gf
- geoidheight_gf
- gravityanomaly_gf
- gravitydisturbance_gf
- gravitypotentialgradient_gf
- gskineticeenergy_gf
- gsvdirectionspeed_gf
- gsveast_gf
- gsvnorth_gf
- heightanomaly_gf
- import2_gf
- import_gf
- landmask_gf
- multiply_gf
- relativevorticity_gf
- scale_gf
- simplebouguer_gf
- spatialmdt_gf
- sqr_gf
- stats_gf
- subtract_gf
- surfacegravitationalpot_gf
- surfacegravitation_gf
- surfacegravitypot_gf
- surfacegravity_gf
- verticaldeflectioneast_gf
- verticaldeflectionnorth_gf

Track Function

project1.gut

Wrong or Missing

Optional

OK

Project Parameters

Name	Value
geoidheight_gf	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	
-Dkm	
-Ddeg	
-T	
geoidheight_gf1	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	
-Dkm	
-Ddeg	
-T	
subtract_gf	
-PQ1	
-PQ2	
Global Parameters	

Output

Graphical User Interface

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram with nodes for 'geoidheight_gf', 'geoidheight_gf1', and 'subtract_gf'. A red arrow points from the 'Parameters' text to the 'Project Parameters' panel on the right. Another red arrow points from the 'Parameters' text to the 'Set empty parameters' dialog box, which is open over the workflow diagram. The dialog box shows the workflow description for 'geoidheight_gf.xml' and a field for 'Parameter name: -InFile' with a corresponding 'Parameter value' input field.

Parameters

Name	Value
▲ geoidheight_gf	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	160
-Dkm	
-Ddeg	
-T	
▲ geoidheight_gf1	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	160
-Dkm	

Workflow Description - geoidheight_gf.xml

extracts the ellipsoid from the meta-data in this file

- DO degree_and_order (option 1 of 3)
Specifies the degree and order of the geopotential expansion. degree_and_order must be a positive integer.

OR

- Dkm scale_length (option 2 of 3)
Specifies the degree and order of the geopotential expansion by specifying a scale length, in km, at the Earth surface.

OR

- Ddeg scale_angle (option 3 of 3)

Set empty parameters

Workflow description

geoidheight_gf.xml

Synopsis : Extract a set of spherical harmonic potential coefficients (and GM, R, tide system) from file and calculate the height of the geoid on a chosen Grid with a specified expansion of the geopotential. The Grid can be specified in one of several ways. The default is a global 1x1 degree grid on the GRS80 ellipsoid with the potential expanded to the degree and order defined by the input file.

Arguments :

- InFile input_file_name
Input file containing the geopotential.
- Gf input_grid_file (option 1 of 3)
Specify the file that defines the output Grid. This can

Parameter name: -InFile

Parameter value:

Buttons: Set, Skip, Skip All

Graphical User Interface

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram with three nodes: 'geoidheight_gf', 'geoidheight_gf1', and 'subtract_gf'. The 'geoidheight_gf' node is selected, and its parameters are listed in the 'Project Parameters' panel on the right. A red arrow points from the 'Parameters' text to the 'Project Parameters' panel. Another red arrow points from the 'Parameters' text to the 'Set empty parameters' dialog box, which is open in the foreground. The dialog box shows a list of parameters, with '-T' selected and a dropdown menu showing options: 'tide-free', 'tide-free', 'mean-tide', and 'zero-tide'. The 'Workflow description' panel on the right provides details for the selected workflow, including parameters like '-DO degree_and_order', '-R', '-I', '-DO', '-Dkm', '-Ddeg', and '-T'.

Parameters

Name	Value
geoidheight_gf	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	160
-Dkm	
-Ddeg	
-T	
geoidheight_gf1	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	160
-Dkm	

Workflow description - geoidheight_gf.xml

extracts the ellipsoid from the meta-data in this file

- DO degree_and_order (option 1 of 3)
Specifies the degree and order of the geopotential expansion. degree_and_order must be a positive integer.
- OR
- Dkm scale_length (option 2 of 3)
Specifies the degree and order of the geopotential expansion by specifying a scale length, in km, at the Earth surface.
- OR
- Ddeg scale_angle (option 3 of 3)

Set empty parameters

Please set the Tide System. This could be optional, please consult the workflow description for more information.

Parameter name: -T

Parameter value: tide-free

Key Processing Units: (See the GUT User Guide for more information)

- * SphericalHarmonicPotentialImport
- * ChangePotentialDegreeAndOrder
- * ChangePotentialTideSystem
- * GridFunctionGeoidHeight

Graphical User Interface

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram with nodes: 'geoidheight_gf', 'geoidheight_gf1', and 'subtract_gf'. The 'geoidheight_gf' node is highlighted with a red dashed box. A red arrow points from the text 'Constant Feedback' to the 'geoidheight_gf' node. Another red arrow points from the same text to the 'Workflow Description' panel on the right, which contains the following text:

extracts the ellipsoid from the meta-data in this file

- DO degree_and_order (option 1 of 3)
Specifies the degree and order of the geopotential expansion. degree_and_order must be a positive integer.
- OR
- Dkm scale_length (option 2 of 3)
Specifies the degree and order of the geopotential expansion by specifying a scale length, in km, at the Earth surface.
- OR
- Ddeg scale_angle (option 3 of 3)

The 'Project Parameters' panel on the right shows a table of parameters for 'geoidheight_gf' and 'geoidheight_gf1':

Name	Value
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	160
-Dkm	
-Ddeg	
-T	mean-tide
-R	TOPEX
-I	0.50:359.50,-89.50:89.50
-DO	160
-Dkm	

The 'Output' panel at the bottom shows the workflow processing finished and the following command was executed:

```
Executing workflow: 'C:\Program Files (x86)\gut-3.1\workflow\geoidheight_gf.xml'
With the following parameters: '-InFile C:\Program Files (x86)\gut-3.1\apriori\GO_CONS_EGM_GOC_2_20091031T000000_20100705T235959_0001.DBL -T mean-tide -OutFile C:\Program Files (x86)\gut-3.1\output\4737inter1.nc -R 0.50:359.50,-89.50:89.50 -I 1.0:1.0 -DO 160 -Ellipse TOPEX'
```

Graphical User Interface

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram for 'example_1.gut'. The workflow starts with 'import_shp' (green oval) which outputs '1705inter1.nc'. This file is used as an input for 'spatialmdt_gf' (red oval). 'spatialmdt_gf' also receives inputs from '-Gf', '-Af', '-InShpFile', '-InSshFile', 'GUT_LSM.nc', and '-InLsmFile'. Its output is 'mdt.nc'. 'mdt.nc' is then used as an input for 'add_gf' (red oval). 'add_gf' also receives inputs from 'MDT_DTU_10_10M.nc', 'C:\Users\Americo Tiago\Documents\ESA_1\outreach\2017_CAW\GUT\fr24_demo\exer\go_cons_gcf_2_tim_r5.gfc', and 'C:\Users\Americo Tiago\Documents\ESA_1\outreach\2017_CAW\'. Its output is '1705inter2.nc'. A red arrow points to the 'add_gf' node with the text 'Constant Feedback'.

The 'Project Parameters' panel on the right shows a table of parameters:

Name	Value
-Fbox	0,0,0,0
-IntAlg	spline
import_shp	
-T	mean-tide
-DO	
-Dkm	
-Ddeg	
add_gf	
-PO1	mdt

The 'Workflow Description - adapt_gf.xml' panel shows the following text:

Synopsis : Adaptation of a Grid Function to a specific Grid. The Grid can be specified in one of several ways. The default is a global 1x1 degree grid on same ellipsoid. The output data are the result of interpolation, which includes a height correction if the ellipsoid changes and the data are heights with respect to the ellipsoid.

Arguments :

- InFile input_file_name
Input file containing the grid function(s).
- PQ physical_quantity (optional)
Specifies the required data set. If the input file lacks the meta-data to allow this to be used for selection of the data set, it is used to explicitly set the physical quantity of the data. The physical quantity can effect

The 'Output' panel at the bottom shows the following error message:

```
Processing done.
Workflow processing finished

Executing workflow: 'C:\Program Files (x86)\gut-3.1\workflow\spatialmdt_gf.xml'
With the following parameters: '-InShpFile C:\Program Files (x86)\gut-3.1\output\1705inter1.nc -InSshFile C:\Program Files (x86)\gut-3.1\output\1705inter2.nc -InLsmFile C:\Program Files (x86)\gut-3.1\apriori\GUT_LSM.nc -Op gt -Thr 0.5 -Substitute NaN -IntAlg spline -OutFile C:\Program Files (x86)\gut-3.1\output\mdt.nc -R 0.5:359.5,-89.5:89.5 -I 1:1 -Fhan 2,3 -Ellipse wgs84rev1'
INFO: Processing started.
ERROR: Filename given as argument to command line flag -InSshFile does not exist.
ERROR: Workflow cannot be processed because error(s) have been reported.
Workflow processing finished
Project execution finished.
Unlock: C:/Users/Americo Tiago/Documents/ESA_1/outreach/2017_CAW/GUT/fr24_demo/exer/example_1.gut
```


Graphical User Interface

GOCE User Toolbox GUI

File Edit View Execute Visualize Help

Workflow Library

System Workflows

- Grid Function
- adapt_gf
- addscalar_gf
- add_gf
- airyanomaly_gf
- bougueranomaly_gf
- changeellipse_gf
- changetide_gf
- changetime_gf
- diffusion_gf
- divide_gf
- exportgravsoft_gf
- exportkml_gf
- exporttiff_gf
- extract_gf
- filter_gf
- freeairgravityanomaly_gf
- geoidheightcorrection_gf
- geoidheight_gf
- gravityanomaly_gf
- gravitydisturbance_gf
- gravitypotentialgradient_gf
- gskincticenergy_gf
- gsdirectionspeed_gf
- gsveast_gf
- gsnorth_gf
- heightanomaly_gf

BRAT World Plot - #0

File View

Results visualisation

Properties

Vector Scale: 3D
Projection: 3D

Latitude/Longitude
Center Lat: 0 Center Lon: 0
 Show Grid Labels

Data Layers

Layer: geoid_height
 Show Solid Color Show Contour
Number of Labels (Color Bar): 5

Vector Scale: 10
Range
Min: -0.5 Max: 0.5

View

State:

geoid_height (geoid_height) - Unit: m
-0.5 -0.25 0 0.25 0.5

Output

INFO: ... Done
Processing done.
Workflow processing finished

Executing workflow: 'C:\Program Files
With the following parameters: '-InFile
INFO: Processing started.
INFO: Specified Maximum Degree and
INFO: Calculating Geoid Height ...
PROGRESS: 180/180
INFO: ... Done
Processing done.

Value
TOPEX
0.50:359.50,-89.50:89.50
1.0:1.0
160
mean-tide
TOPEX
0.50:359.50,-89.50:89.50
1.0:1.0
160

geoidheight_gf.xml

the ellipsoid from the meta-data in this file

Order (option 1 of 3)
degree and order of the geopotential
egree_and_order must be a positive integer.

th (option 2 of 3)
degree and order of the geopotential
specifying a scale length, in km, at the Earth

le (option 3 of 3)

00 160 -Ellipse TOPEX'

Graphical User Interface

GOCE User Toolbox GUI

File Edit View Execute Visualize Help

Processing Unit Library

- ChangeFunctionDegreeAndOrder
- ChangeGridFunctionTideSystem
- ChangePotentialDegreeAndOrder
- ChangePotentialTideSystem
- ChangeSphericalHarmonicFunction
- ChangeTrackFunctionReferenceEllipsoid
- ChangeTrackFunctionTideSystem
- CmdLineArgDegreeAndOrder
- CmdLineArgDouble
- CmdLineArgFilter
- CmdLineArgGrid
- CmdLineArgInputFileName
- CmdLineArgInt
- CmdLineArgLogicCmpOperator
- CmdLineArgOptionalOutputFileName
- CmdLineArgOutputFileName
- CmdLineArgPhysicalQuantity
- CmdLineArgReferenceEllipsoid
- CmdLineArgString
- CmdLineArgStringAndDouble
- CmdLineArgTideSystem
- CmdLineArgTime
- CreateReferenceEllipsoid
- CreateSpatialFilterKernel
- CreateSpectralFilterKernel
- CreateTimeSystem
- FixedValueDouble
- FixedValueInt
- FixedValueLogicCmpOperator
- FixedValuePhysicalQuantity
- FixedValueArgString
- FixedValueTideSystem
- GridExport
- GridFromGridFunction
- GridFunctionAdapt
- GridFunctionAdd
- GridFunctionAddScalar
- GridFunctionExport

Workflow Description - geoidheight_gf.xml

(and GM, R, tide system) from file and calculate the height of the geoid on a chosen Grid with a specified expansion of the geopotential. The Grid can be specified in one of several ways. The default is a global 1x1 degree grid on the GRS80 ellipsoid with the potential expanded to the degree and order defined by the input file.

Arguments :

- Infile input_file_name
Input file containing the geopotential.
- Gf input_grid_file (option 1 of 3)
Specifies the file that defines the output Grid. This can be any file from which GUT can extract a grid. Note, this includes the ellipsoid.
- OR
- Af input_grid_file (option 2 of 3)
Specifies the file that defines the latitude and longitude axes of the output Grid. This can be any file from which GUT can extract a grid. The -Ellipse flag can be used to specify the ellipsoid, otherwise the GUT default of GRS80 is assumed.
- OR
- R w:e,s:n (option 3 of 3)
Specifies the latitude and longitude bounds of the geopotential output grid. The latitude limits (w,e) must be

Workflow Parameters

Processing Unit	Default Value	Processing Unit Type
geoidheight_gf.xml		
InFile		CmdLineArgInputFileName
RE		CmdLineArgReferenceEllipsoid
Grid	0.50 359.50 -89...	CmdLineArgGrid
DegreeAndOrder		CmdLineArgDegreeAndOrder
TideSystem		CmdLineArgTideSystem
DefaultRE		CreateReferenceEllipsoid
DataShp		SphericalHarmonicPotentialImport
DegOrdSetShp		ChangePotentialDegreeAndOrder
TideSetShp		ChangePotentialTideSystem
GeoidHeight		GridFunctionGeoidHeight
OutFile	geoid_height.nc	CmdLineArgOutputFileName
Export		GridFunctionExport

Build your own workflow

Graphical User Interface

The screenshot displays the GOCE User Toolbox GUI. On the left is a 'Processing Unit Library' with a scrollable list of units. The main workspace shows a workflow diagram for 'api_example_f.xml'. The diagram includes nodes for 'InFile', 'PhysQuantity', 'RawData', 'Example', and 'Export', connected by arrows representing data flow. The 'Example' node is circled in red. On the right, there are two panels: 'Workflow Description - api_example_f.xml' containing a synopsis and arguments, and 'Workflow Parameters' containing a table of parameters.

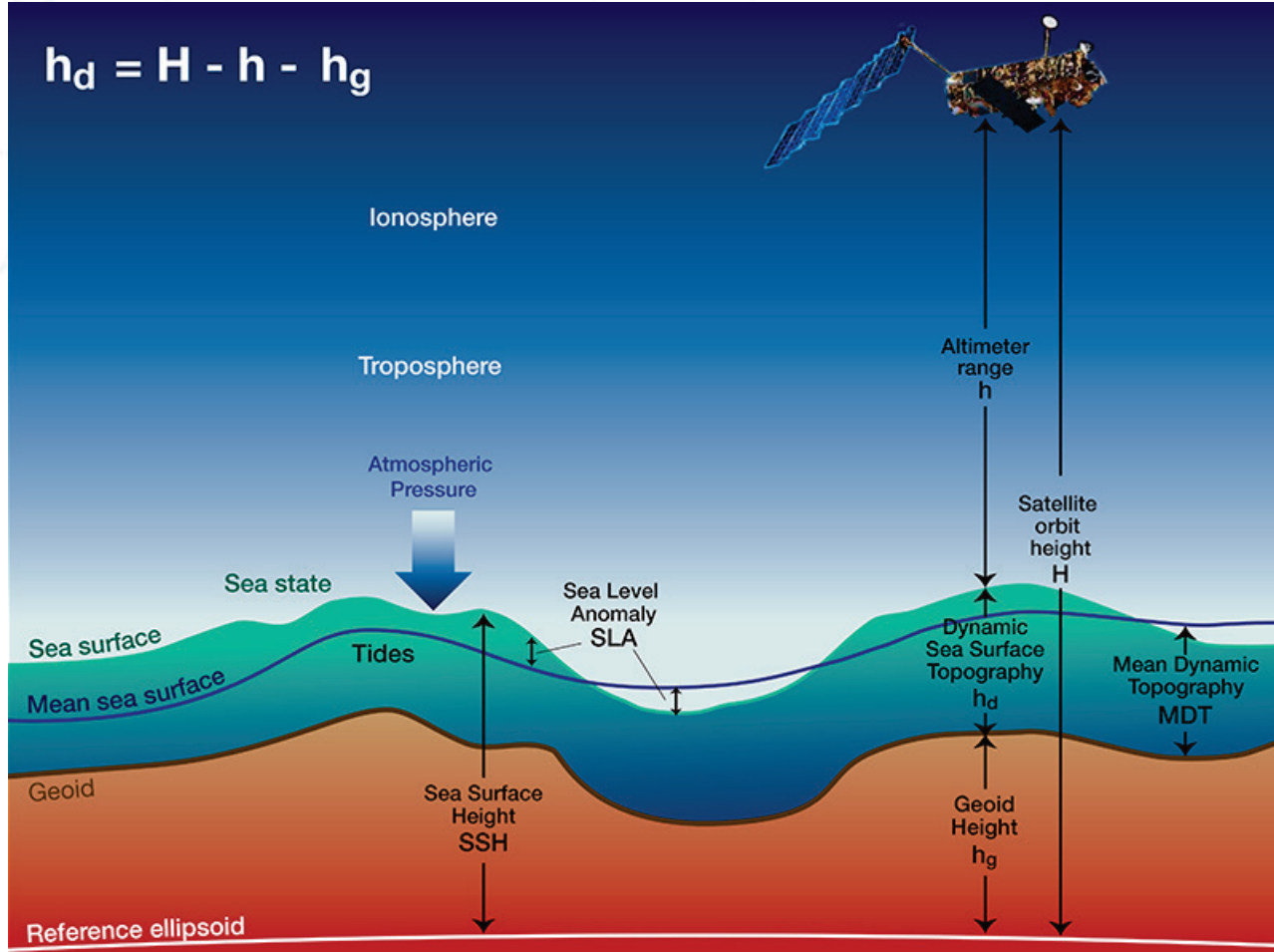
Build your own workflow

... with your own processing units

Processing Unit	Default Value	Processing Unit Type
api_example_f.xml		
InFile	GUT_GOCE2_Exampl...	CmdLineArgInputFileName
PhysQuantity		CmdLineArgPhysicalQuantity
RawData		GridFunctionImportSelected
Example		Example_Extension_F
Export		GridFunctionExport
OutFile	exampleF.nc	CmdLineArgOutputFileName

Demo

How to calculate a Mean Dynamic Topography only from GOCE?



Demo

How to calculate a Mean Dynamic Topography only from GOCE?

Global Gravity Field Models

We kindly ask the authors of the models to check the links to the original websites of the models from time to time. Please let us know if something has changed.

The table can be interactively re-sorted by clicking on the column header fields (Nr, Model, Year, Degree, Data, Reference).

The buttons `calculate` and `show` in the last columns of the table directly invoke the [Calculation Service](#) and [Visualization page](#) for the selected model.

For models with a registered doi ("digital object identifier") the last column contains the symbol ✓, which directly opens the page on "http://dx.doi.org/".

The full reference of each model is displayed as 'tooltip' if you move the mouse over the table cell. The complete list of references can be found in the [references section](#).

Nr ▲	Model ⇅	Year ⇅	Degree ⇅	Data ⇅	Reference ⇅	download	calculate	show	doi
158	HUST-Grace2016s	2016	160	S(Grace)	Zhou Hao et al, 2016	gfc zip	<code>calculate</code>	<code>show</code>	✓
157	ITU_GRACE16	2016	180	S(Grace)	Akyilmaz et al, 2016b	gfc zip	<code>calculate</code>	<code>show</code>	✓
156	ITU_GGC16	2016	280	S(Grace,Goce)	Akyilmaz et al, 2016a	gfc zip	<code>calculate</code>	<code>show</code>	✓
155	EIGEN-6S4v2	2016	300	S(Goce,Grace,Lageos)	Förste et al, 2016	gfc zip	<code>calculate</code>	<code>show</code>	✓
154	GOCO05c	2016	720	S,G,A (see model)	Pail, et al. 2016	gfc zip	<code>calculate</code>	<code>show</code>	✓
153	GGM05C	2016	360	S(Grace,Goce),G,A	Ries et al, 2016	gfc zip	<code>calculate</code>	<code>show</code>	✓
152	GECO	2015	2190	S(Goce),EGM2008	Gilardoni et al, 2015	gfc zip	<code>calculate</code>	<code>show</code>	
151	GGM05G	2015	240	S(Grace,Goce)	Bettadpur et al, 2015	gfc zip	<code>calculate</code>	<code>show</code>	
150	GOCO05s	2015	280	S(see model)	Mayer-Gürr, et al. 2015	gfc zip	<code>calculate</code>	<code>show</code>	
149	GO_CONS_GCF_2_SPW_R4	2014	280	S(Goce)	Gatti et al, 2014	gfc zip	<code>calculate</code>	<code>show</code>	
148	EIGEN-6C4	2014	2190	S(Goce,Grace,Lageos),G,A	Förste et al, 2015	gfc zip	<code>calculate</code>	<code>show</code>	✓
147	ITSG-Grace2014s	2014	200	S(Grace)	Mayer-Gürr et al, 2014	gfc zip	<code>calculate</code>	<code>show</code>	
146	ITSG-Grace2014k	2014	200	S(Grace)	Mayer-Gürr et al, 2014	gfc zip	<code>calculate</code>	<code>show</code>	
145	GO_CONS_GCF_2_TIM_R5	2014	280	S(Goce)	Brockmann et al, 2014	gfc zip	<code>calculate</code>	<code>show</code>	
144	GO_CONS_GCF_2_DIR_R5	2014	300	S(Goce,Grace,Lageos)	Bruinsma et al, 2013	gfc zip	<code>calculate</code>	<code>show</code>	
143	JYY_GOCE04S	2014	230	S(Goce)	Yi et al, 2013	gfc zip	<code>calculate</code>	<code>show</code>	

Go to <http://icgem.gfz-potsdam.de/ICGEM/> and download a geoid model built using only GOCE data!



Demo: MDT from GOCE

Technical University of Denmark

DTU Space
National Space Institute

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Global Mean Sea Surface

The mean sea surface is the displacement of the sea surface relative to a mathematical model of the earth and it closely follows the geoid. Amplitudes ranges between +/- 100 meters.

DTU10 Ocean wide Mean Sea Surface height (relative to the Ellipsoid) has been mapped with a resolution of 1 minute by 1 minute corresponding to a 2 minute resolution at Equator.

Contact

Ole Baltazar Andersen
Senior Scientist
DTU Space

Arctic Sea Level Data
Sea Level Change
Global Bathymetry Model
Global Gravity Field Model
Global Ocean Tide Model
Global Mean Dynamic topography
Global Mean Sea Surface
Integral Data
Interpolation Error File
Galaxy Cluster Survey
EMISAR data samples
Magnetic Field Models
Magnetic Ground Stations

2 minute resolution grid

Global Gravity Field:

GRAVSOFTE ASCII gzip (200Mb)

NetCDF gzip(100Mb)

Mean Sea Surface

GRAVSOFTE ASCII gzip (200 Mb)

→ NetCDF gzip (100Mb)

Go to
http://www.space.dtu.dk/english/research/scientific_data_and_models/global_mean_sea_surface and
download a **Mean Sea Surface** grid

Demo: MDT from GOCE

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram for 'example_4.gut'. The workflow starts with an 'import_shp' node (yellow oval) which is an 'InFile' node. It connects to a 'geoidheight_gf' node (green oval), which is an 'InFile' node. The 'geoidheight_gf' node has three input nodes: '-Ellipse' (yellow circle), '-Gf' (yellow circle), and '-Af' (yellow circle). The 'geoidheight_gf' node also has an 'OutFile' connection to 'geoid_height.nc'. The 'import_shp' node has an 'OutFile' connection to '3839inter1.nc'. The 'Workflow Library' on the left lists various geoid processing tools. The 'Project Parameters' panel on the right shows parameters for 'geoidheight_gf' and 'import_shp'. The 'Output' panel at the bottom shows the workflow description for 'geoidheight_gf.xml'.

Project Parameters

Name	Value
geoidheight_gf	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	
-Dkm	
-Ddeg	
-T	mean-tide
import_shp	
-T	mean-tide
-DO	
-Dkm	
-Ddeg	
Global Parameters	

Workflow Description - geoidheight_gf.xml

geoidheight_gf.xml

Synopsis : Extract a set of spherical harmonic potential coefficients (and GM, R, tide system) from file and calculate the height of the geoid on a chosen Grid with a specified expansion of the geopotential. The Grid can be specified in one of several ways. The default is a global 1x1 degree grid on the GRS80 ellipsoid with the potential expanded to the degree and order defined by the input file.

Arguments :

Demo: MDT from GOCE

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram for 'example_4.gut'. The workflow starts with an 'import_shp' node (yellow oval) which reads an input file. Its output is an 'InFile' node (green circle) that feeds into a 'geoidheight_gf' node (green oval). The 'geoidheight_gf' node has several inputs: '-Ellipse' (yellow circle), '-Gf' (yellow circle), '-InFile' (green circle), and '-Af' (yellow circle). It produces an 'OutFile' (green circle) named 'geoid_height.nc'. This 'OutFile' then feeds into a 'subtract_gf' node (green oval). The 'subtract_gf' node has two inputs: '-InFileLhs' (red circle) and '-InFileRhs' (red circle). It produces an 'OutFile' (green circle) named 'diff.nc'. A red arrow points from the 'subtract_gf' node to the 'Workflow Description - subtract_gf.xml' window at the bottom.

The 'Project Parameters' window on the right shows the following table:

Name	Value
geoidheight_gf	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	
-Dkm	
-Ddeg	
-T	mean-tide
import_shp	
-T	mean-tide
-DO	
-Dkm	
-Ddeg	
subtract_gf	
-PQ1	
-PQ2	
Global Parameters	

The 'Workflow Description - subtract_gf.xml' window at the bottom contains the following text:

subtract_gf.xml

: Point-wise subtraction of two Grid Functions. The Grids of the two inputs must be equivalent (ie. the same coordinates and reference ellipsoids) and the units of the two physical quantities involved must be identical. If both physical quantities are tidal then both operands must be in the same tide-system. The resultant grid function will be assigned the physical quantity of the Left-Hand-Side argument unless GUT can deduce this from the two operands.

Demo: MDT from GOCE

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram with nodes: 'import_shp' (yellow oval), 'geoidheight_gf' (green oval), 'adapt_gf' (green oval), and 'subtract_gf' (green oval). Data flows are indicated by arrows and labels like '-InFile', '-OutFile', and file names. A 'Project Parameters' panel on the right lists parameters for 'geoidheight_gf', 'import_shp', 'subtract_gf', and 'adapt_gf'. An 'Output' panel at the bottom shows the workflow description for 'adapt_gf.xml'.

Name	Value
geoidheight_gf	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	
-Dkm	
-Ddeg	
-T	mean-tide
import_shp	
-T	mean-tide
-DO	
-Dkm	
-Ddeg	
subtract_gf	
-PQ1	
-PQ2	
adapt_gf	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-PQ	
-IntAlg	spline
Global Parameters	

Workflow Description - adapt_gf.xml

Synopsis : Adaptation of a Grid Function to a specific Grid. The Grid can be specified in one of several ways. The default is a global 1x1 degree grid on same ellipsoid. The output data are the result of interpolation, which includes a height correction if the ellipsoid changes and the data are heights with respect to the ellipsoid.

Arguments :
-InFile input file name

Demo: MDT from GOCE

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram for 'example_4.gut'. The workflow starts with an 'import_shp' node (yellow) which outputs '3839inter1.nc'. This file is used as input for a 'geoidheight_gf' node (green), which also takes parameters like '-Gf', '-Af', and '-Ellipse'. The 'geoidheight_gf' node outputs '3839inter2.nc'. This file is then used as input for an 'adapt_gf' node (green), which also takes parameters like '-Gf', '-Af', and '-Ellipse'. The 'adapt_gf' node outputs 'adapted.nc'. This file is used as input for a 'subtract_gf' node (green), which also takes parameters like '-InFileLhs' and '-InFileRhs'. The 'subtract_gf' node outputs 'masked.nc'. Finally, the 'masked.nc' file is used as input for a 'landmask_gf' node (green), which also takes parameters like 'GUT_LSM.nc' and '-InLsmFile'. The 'landmask_gf' node outputs 'masked.nc'.

The 'Project Parameters' panel on the right shows the following parameters:

Name	Value
-DO	
-Dkm	
-Ddeg	
-T	mean-tide
import_shp	
-T	mean-tide
-DO	
-Dkm	
-Ddeg	
subtract_gf	
-PQ1	
-PQ2	
adapt_gf	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-PQ	
-IntAlg	spline
landmask_gf	
-PQ	
-Op	gt
-Thr	0.5
-Substitute	NaN
-IntAlg	spline
Global Parameters	

The 'Output' panel at the bottom shows the following workflow description for 'landmask_gf.xml':

```

landmask_gf.xml

Synopsis : Mask the (Land) Regions in a Grid Function by substituting a
values based on a (Land-Sea) Mask. The default behaviour
will mask Land Regions by substitution of NaN.

Arguments :
-InFile input_file_name
Input file containing the grid function(s).

-PQ physical quantity (optional)
    
```

Demo: MDT from GOCE

The screenshot displays the GOCE User Toolbox GUI. A red arrow points to the 'GOCE User Toolbox GUI' title bar. The main window shows a workflow diagram for 'example_4.gut'. The workflow starts with an 'import_shp' node, followed by 'geoidheight_gf', 'adapt_gf', 'subtract_gf', 'landmask_gf', and 'filter_gf'. The 'filter_gf' node is selected, and its parameters are shown in the 'Project Parameters' panel on the right.

Name	Value
-Ddeg	
subtract_gf	
-PQ1	
-PQ2	
adapt_gf	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-PQ	
-IntAlg	spline
landmask_gf	
-PQ	
-Op	gt
-Thr	0.5
-Substitute	NaN
-IntAlg	spline
filter_gf	
-Fg	
-Ftg	
-Fsc	
-Fhan	2,3
-Fham	
-Fbox	
-PQ	
Global Parameters	

The 'Output' panel at the bottom left shows a list of files opened during the workflow execution:

```

Opening: C:\Program Files (x86)\gut-3.1\workflow\geoidheight_gf.xml
Opening: C:\Program Files (x86)\gut-3.1\workflow\subtract_gf.xml
Opening: C:\Program Files (x86)\gut-3.1\workflow\adapt_gf.xml
Opening: C:\Program Files (x86)\gut-3.1\workflow\landmask_gf.xml
Opening: C:\Program Files (x86)\gut-3.1\workflow\landmask_gf.xml
Opening: C:\Program Files (x86)\gut-3.1\workflow\landmask_gf.xml
Opening: C:\Program Files (x86)\gut-3.1\workflow\filter_gf.xml
    
```

The 'Workflow Description - filter_gf.xml' panel at the bottom right provides a synopsis and arguments for the filter_gf node:

```

filter_gf.xml

Synopsis : Filter a Grid Function by convolution with a filter kernel.
The result is the filtered grid function, and optionally,
the residual. The set of invalid data (NaN) maps from input
to output unaltered. The filter also kernels ignore any
invalid (NaN) data in their footprint when the filtered
values are being computed.

Arguments :
-InFile input file name
    
```

Demo: MDT from GOCE

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram for 'example_4.gut'. The workflow starts with an 'import_shp' node, followed by 'geoidheight_gf', 'adapt_gf', 'subtract_gf', 'landmask_gf', and 'filter_gf'. Each node is connected to its inputs and outputs, with file paths and file names specified. The 'Project Parameters' panel on the right lists various parameters for the 'filter_gf' node, such as '-Ddeg', '-PQ1', '-PQ2', '-R', '-I', '-PQ', '-IntAlg', '-Op', '-Thr', '-Substitute', '-IntAlg', '-Fg', '-Ftg', '-Fsc', '-Fhan', '-Fham', '-Fbox', and '-PQ'. The 'Output' panel at the bottom shows the execution log for the 'filter_gf' node, including the command line and the workflow description.

Project Parameters

Name	Value
-Ddeg	
subtract_gf	
-PQ1	
-PQ2	
adapt_gf	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-PQ	
-IntAlg	spline
landmask_gf	
-PQ	
-Op	gt
-Thr	0.5
-Substitute	NaN
-IntAlg	spline
filter_gf	
-Fg	
-Ftg	
-Fsc	
-Fhan	2,3
-Fham	
-Fbox	
-PQ	
Global Parameters	

Workflow Description - filter_gf.xml

```

filter_gf.xml

Synopsis : Filter a Grid Function by convolution with a filter kernel.
The result is the filtered grid function, and optionally,
the residual. The set of invalid data (NaN) maps from input
to output unaltered. The filter also kernels ignore any
invalid (NaN) data in their footprint when the filtered
values are being computed.

Arguments :
-InFile input file name
    
```

Demo: MDT from GOCE

The screenshot displays the GOCE User Toolbox GUI. The main window shows a workflow diagram for 'example_4.gut'. The workflow starts with 'import_shp' (green node) which outputs '3839inter1.nc'. This feeds into 'geoidheight_gf' (green node), which also receives parameters '-Ellipse' and '-Af'. The output of 'geoidheight_gf' is '3839inter2.nc', which then feeds into 'adapt_gf' (green node). 'adapt_gf' also receives '-Ellipse' and '-Af' parameters and outputs 'adapted.nc'. This output feeds into 'subtract_gf' (red node), which also receives '-InFileRhs' and outputs '3839inter4.nc'. This output feeds into 'landmask_gf' (red node), which also receives 'GUT_LSM.nc' and '-InLsmFile' parameters and outputs '3839inter5.nc'. Finally, '3839inter5.nc' feeds into 'filter_gf' (red node), which outputs 'filtered.nc' and a residual file '-ResFile'.

On the left, the 'System Workflows' list includes various grid function modules such as 'adapt_gf', 'addscalar_gf', 'add_gf', 'airyanomaly_gf', 'bouguer anomaly_gf', 'changeellipse_gf', 'changetide_gf', 'changetime_gf', 'diffusion_gf', 'divide_gf', 'exportgravsoft_gf', 'exportkml_gf', 'exporttiff_gf', 'extract_gf', 'filter_gf', 'freeairgravityanomaly_gf', 'geoidheightcorrection_gf', 'geoidheight_gf', 'gravityanomaly_gf', 'gravitydisturbance_gf', 'gravitypotentialgradient_gf', 'gskineticeenergy_gf', 'gsdirectionspeed_gf', 'gsveast_gf', 'gsnorth_gf', and 'heightanomaly_gf'.

On the right, the 'Project Parameters' table lists parameters for several modules:

Name	Value
geoidheight_gf	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	
-Dkm	
-Ddeg	
-T	mean-tide
import_shp	
-T	mean-tide
-DO	
-Dkm	
-Ddeg	
subtract_gf	
-PQ1	
-PQ2	
adapt_gf	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-PQ	
-IntAlg	spline
landmask_gf	
-PQ	
-Op	gt

The 'Output' window at the bottom shows the execution log for the 'filter_gf.xml' workflow. A red arrow points to an error message: 'ERROR: GUT:gridFunctionSubtract Mismatch in the grids associated with the GridFunctions. ERROR: Data is not accessible via : Export:InGridFunction. Check input data.' The log also shows 'INFO: Processing started.' and 'Workflow processing finished.'

Demo: MDT from GOCE

GOCE User Toolbox GUI

File Edit View Execute Visualize Help

Workflow Library

System Workflows

- Grid Function
- adapt_gf
- addscalar_gf
- add_gf
- airyanomaly_gf
- bougueranomaly_gf
- changeellipse_gf
- changetide_gf
- changetime_gf
- diffusion_gf
- divide_gf
- exportgravsoft_gf
- exportkml_gf
- exporttiff_gf
- extract_gf
- filter_gf
- freeairgravityanomaly_gf
- geoidheightcorrection_gf
- geoidheight_gf
- gravityanomaly_gf
- gravitydisturbance_gf
- gravitypotentialgradient_gf
- gskineticeenergy_gf
- gsdirectionspeed_gf
- gsveast_gf
- gsnorth_gf
- heightanomaly_gf

example_4.gut

```

    graph TD
      InFile1[C:\Users\Americo Tiago\Documents\ESA_1\outreach\2017_CAW\GUT\fr24_demo\exer\go_cons_gcf_2_tim_r5.gfc] -- InFile --> import_shp
      import_shp -- OutFile --> OutFile1[3839inter1.nc]
      OutFile1 -- InFile --> geoidheight_gf
      Ellipse1[-Ellipse] --> geoidheight_gf
      Gf1[-Gf] --> geoidheight_gf
      Af1[-Af] --> geoidheight_gf
      geoidheight_gf -- OutFile --> OutFile2[3839inter2.nc]
      OutFile2 -- InFile --> adapt_gf
      Ellipse2[-Ellipse] --> adapt_gf
      Gf2[-Gf] --> adapt_gf
      Af2[-Af] --> adapt_gf
      adapt_gf -- OutFile --> OutFile3[3839inter6.nc]
      OutFile3 -- InFileLhs --> subtract_gf
      InFileLhs2[C:\Users\Americo Tiago\Documents\ESA_1\outreach\2017_CAW\GUT\fr24_demo\exer\MSS_DTU_10_2M.nc] -- InFileLhs --> subtract_gf
      InFileRhs2[C:\Users\Americo Tiago\Documents\ESA_1\outreach\2017_CAW\GUT\fr24_demo\exer\go_cons_gcf_2_tim_r5.gfc] -- InFileRhs --> subtract_gf
      subtract_gf -- OutFile --> OutFile4[3839inter4.nc]
      OutFile4 -- InFile --> landmask_gf
      GUT_LSM_nc[GUT_LSM.nc] -- InLsmFile --> landmask_gf
      landmask_gf -- OutFile --> OutFile5[3839inter5.nc]
      OutFile5 -- InFile --> filter_gf
      filter_gf -- OutFile --> OutFile6[filtered.nc]
      ResFile[-ResFile] --> filter_gf
  
```

Project Parameters

Name	Value
geoidheight_gf	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	
-Dkm	
-Ddeg	
-T	mean-tide
import_shp	
-T	mean-tide
-DO	
-Dkm	
-Ddeg	
subtract_gf	
-PQ1	
-PQ2	
adapt_gf	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-PQ	
-IntAlg	spline
landmask_gf	
-PQ	
-Op	gt

Output

Workflow Description - filter_gf.xml

filter_gf.xml

Synopsis : Filter a Grid Function by convolution with a filter kernel. The result is the filtered grid function, and optionally, the residual. The set of invalid data (NaN) maps from input to output unaltered. The filter also kernels ignore any invalid (NaN) data in their footprint when the filtered values are being computed.

Arguments :

- InFile input file name

Demo: MDT from GOCE

The screenshot displays the GOCE User Toolbox GUI. A red arrow points to the 'Execute' button in the top toolbar. The main window shows a workflow diagram for 'example_4.gut'. The workflow starts with 'import_shp' (InFile) leading to 'geoidheight_gf' (OutFile). 'geoidheight_gf' leads to 'adapt_gf' (OutFile), which then leads to 'subtract_gf' (OutFile). 'subtract_gf' leads to 'landmask_gf' (InFile), which leads to 'filter_gf' (OutFile). The 'filter_gf' node has an 'InFile' and an 'OutFile' (filtered.nc) and a 'ResFile'.

The 'Project Parameters' panel on the right shows the following table:

Name	Value
geoidheight_gf	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	
-Dkm	
-Ddeg	
-T	mean-tide
import_shp	
-T	mean-tide
-DO	
-Dkm	
-Ddeg	
subtract_gf	
-PQ1	
-PQ2	
adapt_gf	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-PQ	
-IntAlg	spline
landmask_gf	
-PQ	
-Op	gt

The 'Output' panel at the bottom left shows the following log:

```

INFO: Processing started.
INFO: Extracted 'mdt'
INFO: Filtering...
PROGRESS: 180/180
INFO: ... Done
INFO: Grid Function Subtraction ...
PROGRESS: 180/180
INFO: ... Done
Processing done.
Workflow processing finished
Project execution finished.
Unlock: C:/Users/Americo Tiago/Documents/ESA_1/outreach/2017_CAW/GUT/fr124_demo/exer/example_4.gut
    
```

The 'Workflow Description - filter_gf.xml' panel at the bottom right shows the following text:

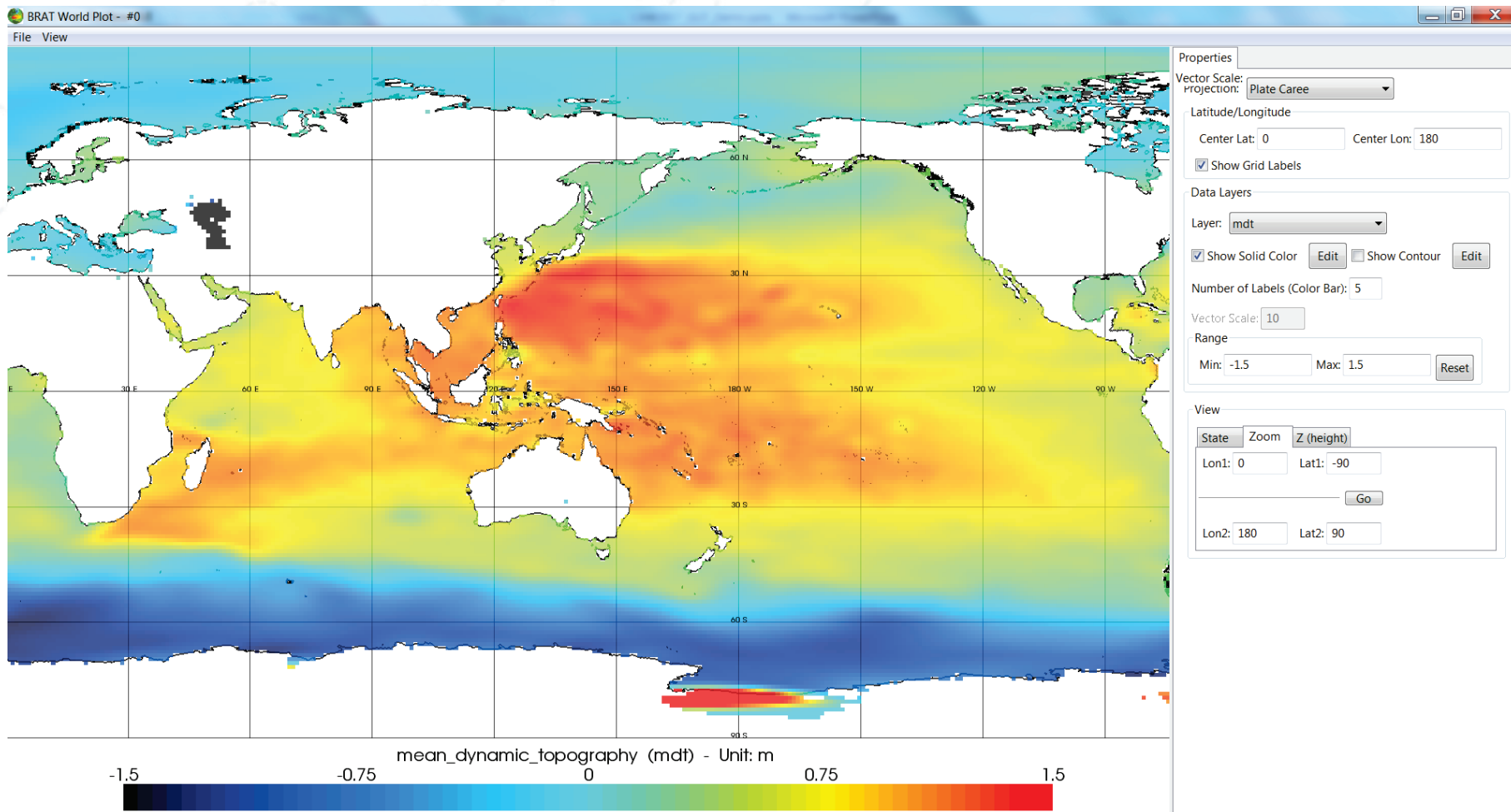
```

filter_gf.xml

Synopsis : Filter a Grid Function by convolution with a filter kernel.
The result is the filtered grid function, and optionally,
the residual. The set of invalid data (NaN) maps from input
to output unaltered. The filter also kernels ignore any
invalid (NaN) data in their footprint when the filtered
values are being computed.

Arguments :
-InFile input file name
    
```

Demo: MDT from GOCE



ANY QUESTIONS?

ANY QUESTIONS?

YES

Questions

GOCE User Toolbox GUI

File Edit View Execute Visualize Help

Workflow Library

System Workflows

- Grid Function
- adapt_gf
- addscalar_gf
- add_gf
- airyanomaly_gf
- bougueranomaly_gf
- changeellipse_gf
- changetide_gf
- changetime_gf
- diffusion_gf
- divide_gf
- exportgravsoft_gf
- exportkml_gf
- exporttiff_gf
- extract_gf
- filter_gf
- freeairgravityanomaly_gf
- geoidheightcorrection_gf
- geoidheight_gf
- gravityanomaly_gf
- gravitydisturbance_gf
- gravitypotentialgradient_gf
- gskineticeenergy_gf
- gsdirectionspeed_gf
- gsveast_gf
- gsnorth_gf
- heightanomaly_gf

example_4.gut

Choose a file name

Enter filename: 3839inter5.nc

landmask_gf

filter_gf

Project Parameters

Name	Value
geoidheight_gf	
-Ellipse	TOPEX
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-DO	
-Dkm	
-Ddeg	
-T	mean-tide
import_shp	
-T	mean-tide
-DO	
-Dkm	
-Ddeg	
subtract_gf	
-PQ1	
-PQ2	
adapt_gf	
-Ellipse	
-R	0.50:359.50,-89.50:89.50
-I	1.0:1.0
-PQ	
-IntAlg	spline
landmask_gf	
-PQ	
-Op	gt

Output

```

INFO: Processing started.
INFO: Extracted 'mdt'
INFO: Filtering...
PROGRESS: 180/180
INFO: ... Done
INFO: Grid Function Subtraction ...
PROGRESS: 180/180
INFO: ... Done
Processing done.
Workflow processing finished
Project execution finished.
Unlock: C:/Users/Americo Tiago/Documents/ESA_1/outreach/2017_CAW/GUT/fr124_demo/exer/example_4.gut
    
```

Workflow Description - filter_gf.xml

filter_gf.xml

Synopsis : Filter a Grid Function by convolution with a filter kernel. The result is the filtered grid function, and optionally, the residual. The set of invalid data (NaN) maps from input to output unaltered. The filter also kernels ignore any invalid (NaN) data in their footprint when the filtered values are being computed.

Arguments :

- InFile input file name



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Tutorial

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GUT TUTORIAL

10 March 2016

Document change record

Version	Date	Prepared by	Change description
1.0	31 March 2008	MH Rio	Initial version
1.1	30 September 2008	MH Rio	Beta version
2	24 March 2009	MH Rio	Final version
3	9 April 2009	MH Rio	Final version after ESA review
4	14 March 2011	MH Rio	Initial version of GUT v2.0 tutorial
5	22 March 2011	MH Rio	Final version of GUT v2.0 after ESA review
6	16 May 2011	MH Rio	GUT v2.1
6.1	23 June 2011	MH Rio	GUT v2.1
7.0	19 December	S. Mulet	GUT v2.2 (add information about simple Bouguer)
7.1	19 December	C. Braitenberg	GUT v2.2 (more detail about simple Bouguer)
7.2	22 January	S.Mulet	Take into account

1



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GUT

User Guide and Algorithm Descriptions

https://earth.esa.int/gut

Overview

The GOCE User Toolbox GUT is a compilation of tools for the utilisation and analysis of GOCE Level 2 products. GUT supports applications in Geodesy, Oceanography and Solid Earth Physics.

The GUT Tutorial provides information and guidance on how to use the toolbox for a variety of applications. GUT consists of a series of advanced computer routines that carry out the required computations. It may be used on Windows PCs, UNIX/Linux Workstations, and Mac.

The toolbox is supported by the [GUT Algorithm Description and User Guide](#) and the [GUT Install Guide](#). A set of a-priori data and models are made available as well.

Software Tools

- Software Tools Home
- GUT
- About GUT
 - Motivation
 - Main Features
 - Project Structure
 - Future Work
 - References
 - Project Management
 - Project Members
 - Releases
 - User Support
- GUT Applications
- GUT Resources
- Download GUT here
- BEST - Basic Envisat SAR Toolbox

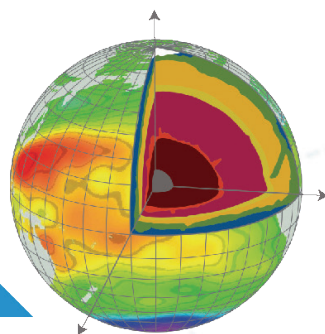
- [December 2015] [Version 3.1](#) has arrived with many improvements! Chief among them the new Graphical User Interface (GUI), that enables users to unleash the full potential of the tool with ease.
- [November 2015] GOCE User Toolbox brochure is available to download [here](#).
- [April 2015] Updated Tutorial and a priori Data Package are available to download [here](#).
- [April 2014] Version 2.2 released! A new version of [GUT Package](#), with updated a priori Data Set and [Variance/Covariance Tool](#) is now available [here](#). The new version now allows for the computation of

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Thank you!

gut

GOCE USER TOOLBOX



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For any questions
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