

The GOCE User Toolbox – GUT

– An ESA effort to facilitate the use of GOCE Level-2 products

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Abstract

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

Background

The Gravity and Ocean Circulation Experiment - GOCE satellite mission is a new type of Earth observation satellite that will measure the Earth gravity and geoid with unprecedented accuracy. Combining GOCE geoid models with satellite altimetric observations of the sea surface height substantial improvements in the modelling of the ocean circulation and transport are foreseen. No ocean circulation products are planned to be delivered as level-2 products as part of the GOCE project so that a strong need exists, for oceanographers, to further process the GOCE level-2 geoid and merge it with Radar Altimetry. The primary requirement of oceanographers is to have access to a geoid and its error covariance at the highest spatial resolution and accuracy possible, although required resolution depends on application. For effective use of the geoid data, knowledge of the error covariance is mandatory.

Within the ESA supported GUT Specifications project, the user requirements for GUT associated with geodetic, oceanographic and solid earth applications were consolidated. For all applications the absolute minimal requirement of the toolbox includes the computation of geoid heights from the set of spherical harmonic coefficients at a given user-specified harmonic degree and order. For oceanographic applications the key quantity to be computed is the mean dynamic topography which basically is the height of the mean sea surface relative to the geoid. For this application GUT provide the tools for converting the mean sea surface and the geoid into the same geodetic system and for carrying out the needed filtering to compensate for the different resolution capabilities of the two surfaces. Furthermore, a-priori mean dynamic topography models derived from e.g. ocean circulation models, may be used.

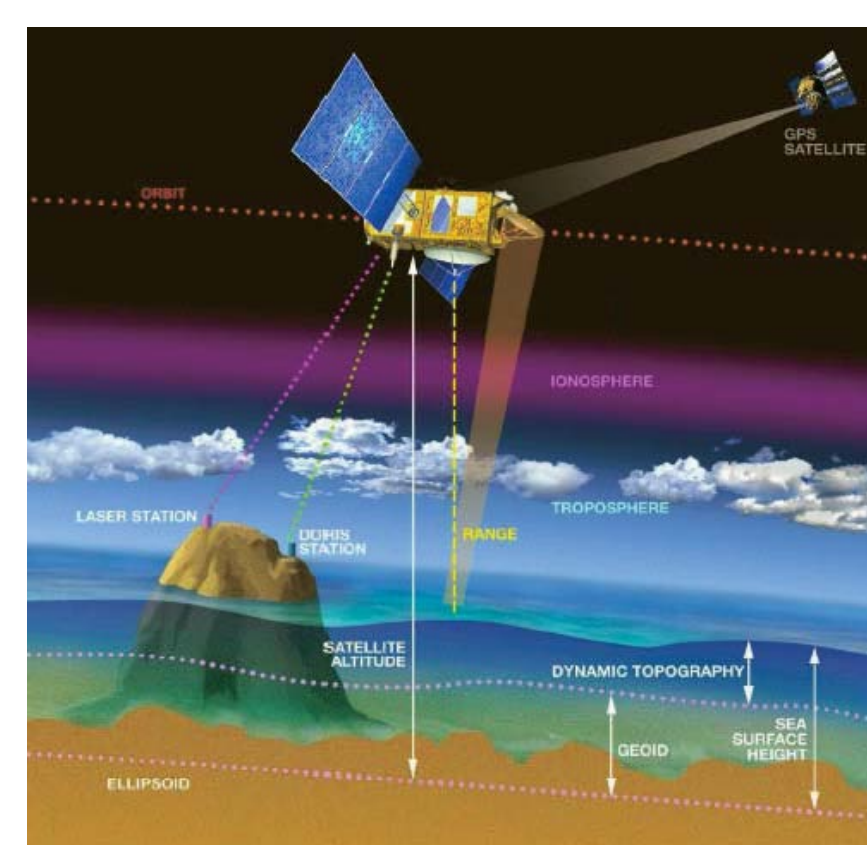
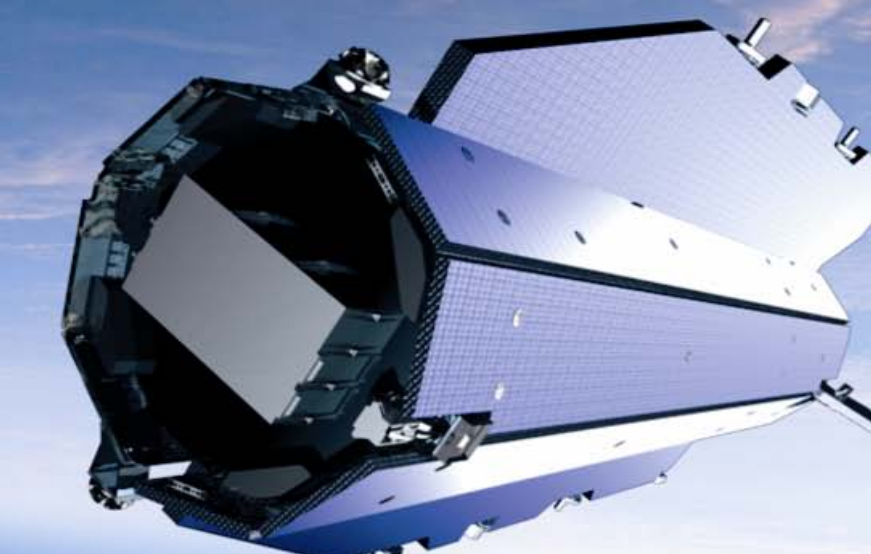


Figure 1: Sketch showing the relationship between the geoid, the Mean Dynamic Topography (MDT – the mean value of the Dynamic Topography) and the Mean Sea Surface (MSS – the mean value of the Sea Surface Height).

The basic definition of the ocean dynamic topography is simply the difference between the sea surface height and the geopotential reference surface called the geoid. Hence, the topography is a geometrical surface that describes the shape of the Earth. Simultaneously the dynamic topography may be considered as a reference surface for the ocean circulation at the ocean surface. The key application of oceanography will benefit because the sea level slopes relative to the geopotential surface allow calculation of surface ocean currents on a global scale.

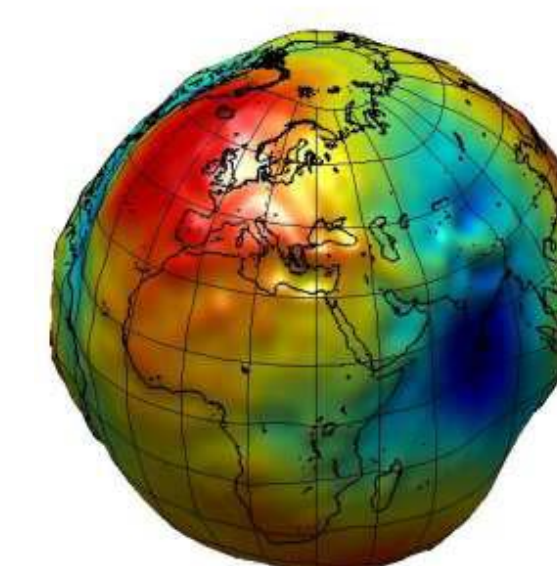
The Gravity field and steady-state Ocean Circulation Explorer (GOCE)



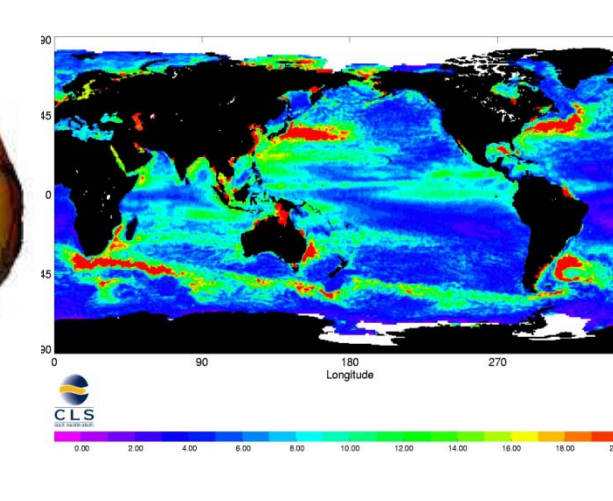
Its objectives are to improve understanding of:

- global ocean circulation and transfer of heat
- physics of the Earth's interior (lithosphere & mantle)
- topographic processes, ice sheets and sea level change

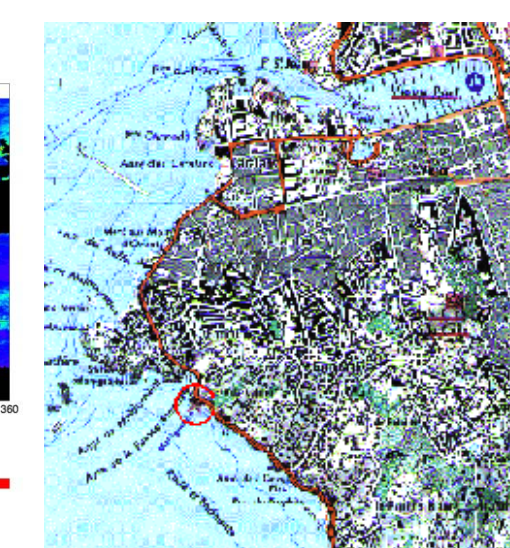
Examples of Scientific Applications



Gravity field map and improved global geoid models

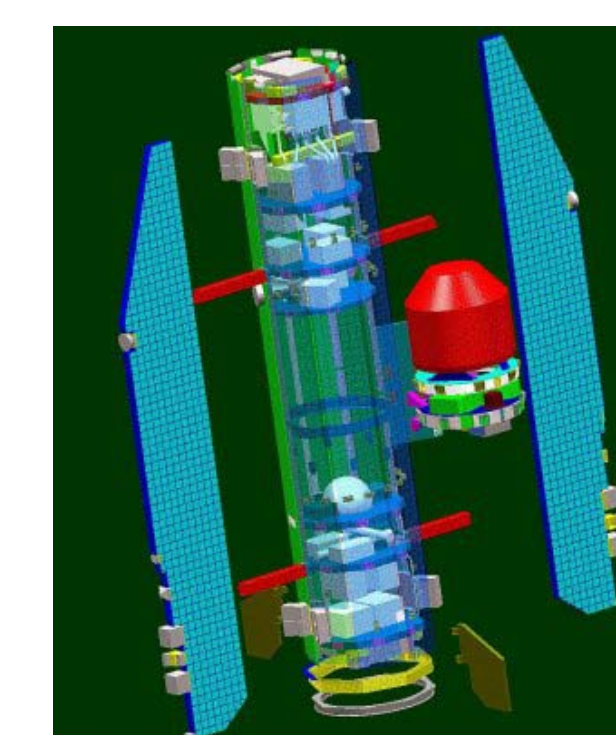
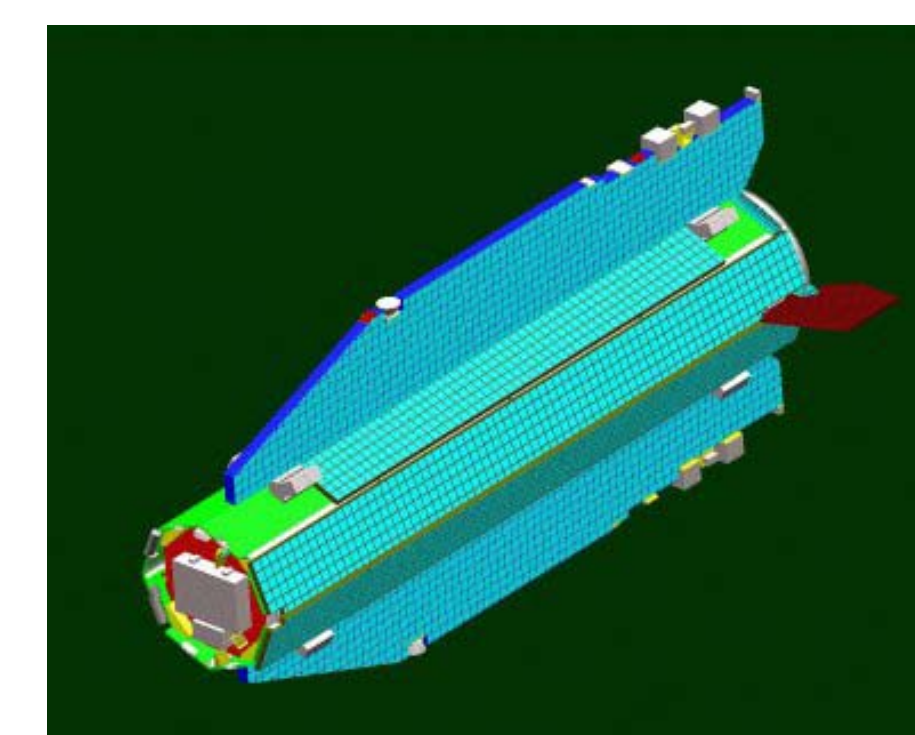


Improved understanding of ocean circulation and energy distribution



Global unification of height systems

The satellite and its instruments



Payload: Three-axis diagonal gravity gradiometer; sat-to-sat tracking (geodetic quality multi-channel GPS receiver with Helix antenna)

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GUT is available at <http://earth.esa.int/gut/> The GUT package includes

- * The source package for building on UNIX/Linux/Mac
- * Binary packages for Linux and Windows that include BratDisplay (v2.0.0b)
- * The GUT Algorithm Description and User Guide (v1.2)
- * The GUT Tutorial (Beta version)
- * The GUT Install Guide (applicable to ALL packages).

The a-priori data package gut-apriori.zip is available as well.

GUT use GOCE data associated with the following GOCE-L2 products:

- EGM_GCF_2: Spherical harmonic series in ICGEM format
- EGM_GEO_2: Grid with geoid heights in Grid format
- EGM_GAN_2: Grid with gravity anomalies in Grid format
- EGM_GVE_2: Grid with east-west vertical deflections in Grid format
- EGM_GVN_2: Grid with north-south vertical deflections in Grid format
- EGM_GVC_2: Variance-covariance matrix file of the spherical harmonics coefficients

These products will be stored in XML format, except for the Variance-Covariance Matrix (Internal HPF VCM format). In addition GUT uses auxiliary data such as MSS and errors, MDT, DEM in NetCDF format (COARDS/CF standard).

GUT is a command line processor. Its output may be exported and visualised using the ESA Basic Radar Altimetry Toolbox BRAT (<http://earth.esa.int/brat/>).

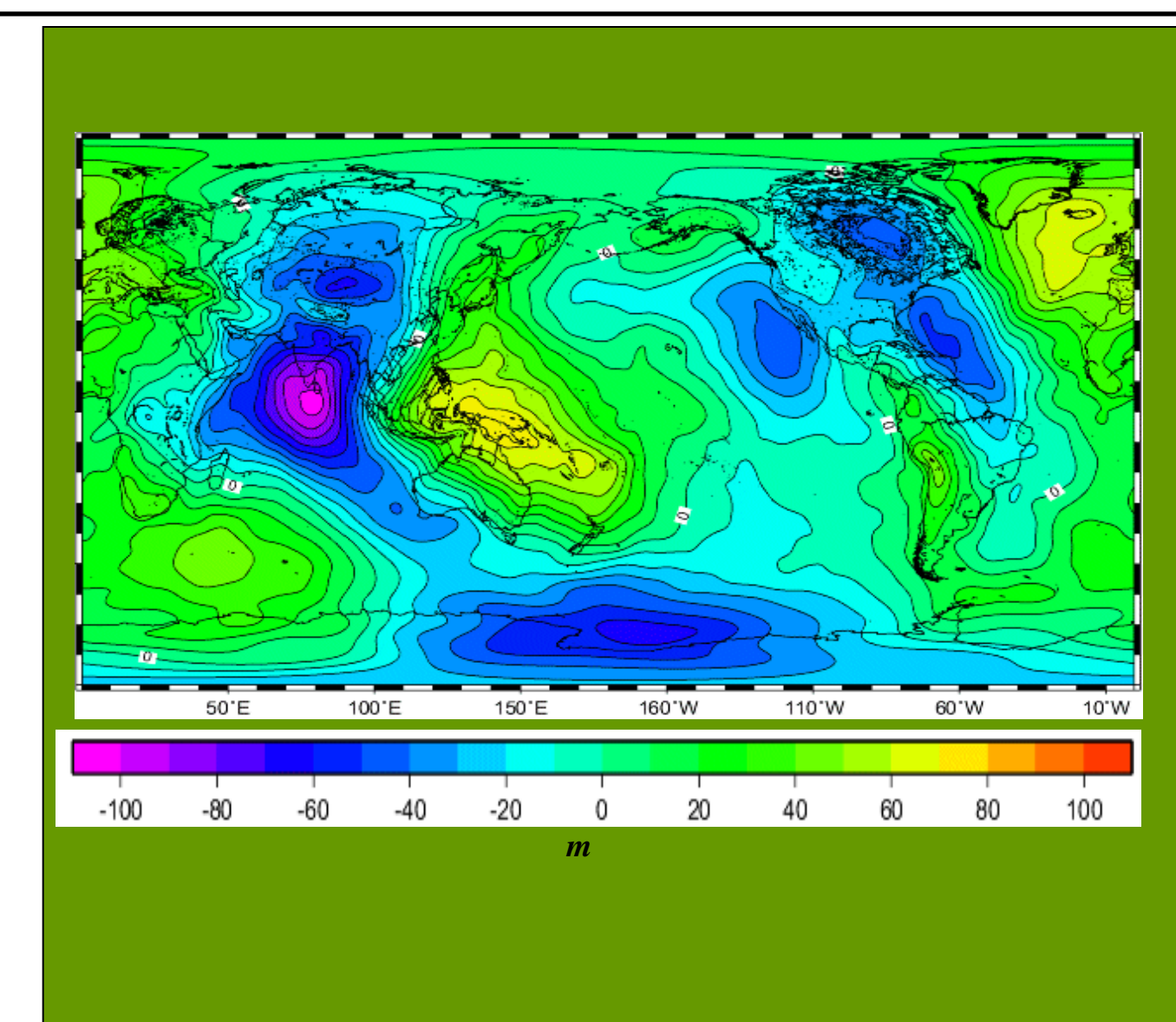


Example of GUT functionality:

Computation of Geoid

Input Data:
EIGEN-GRACEGL4S SH coefficients
(reference ellipsoid=GRIM
Tide system=FREE)
Output Reference ellipsoid: TP
Output tide system: Mean Tide
Degree/order of expansion: 40

Options:
Output Grid : regular, 1/2° resolution grid

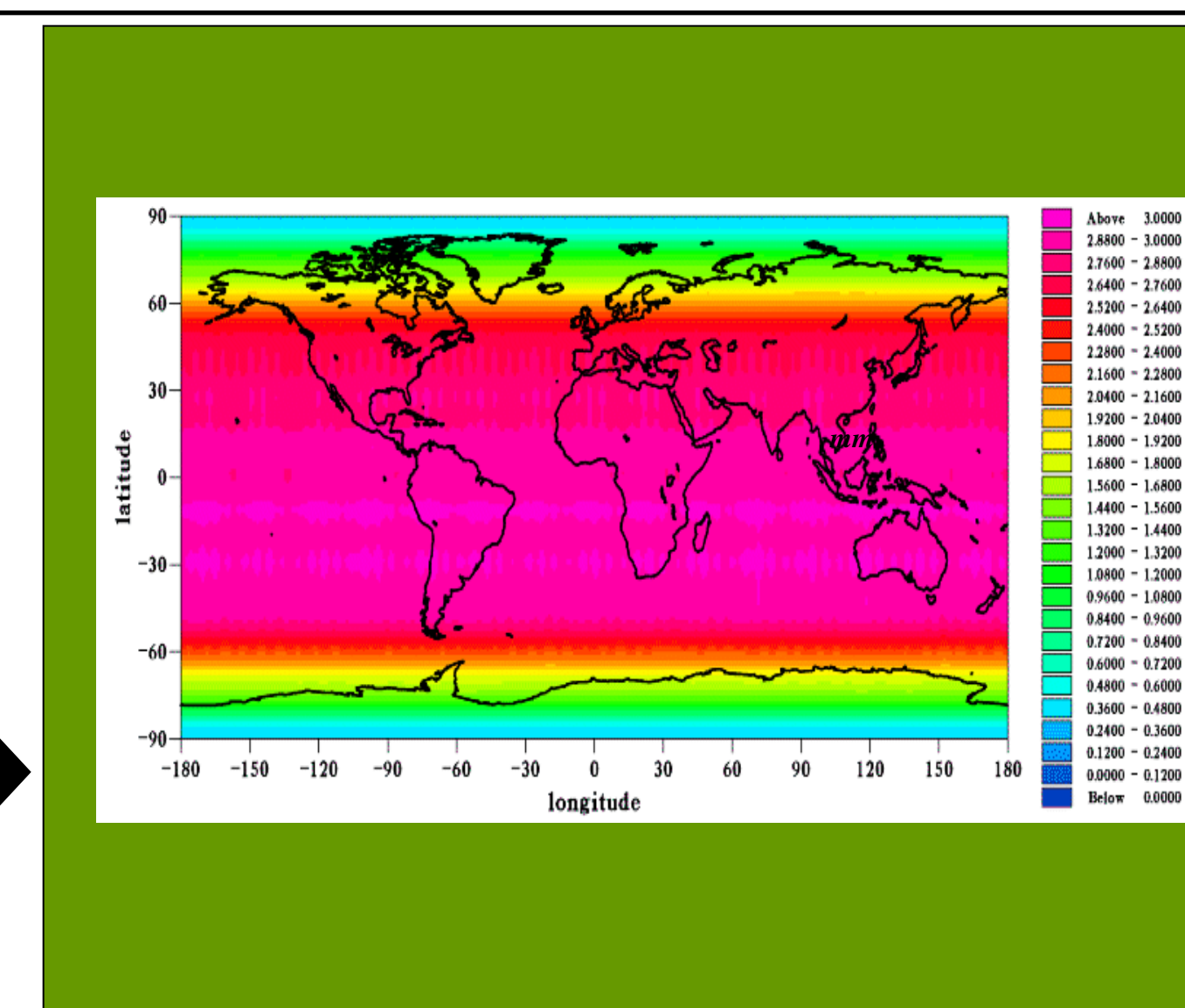


Example of GUT functionality:

Change reference ellipsoid

Input Data:
EIGEN-GRACEGL4S error covariance
matrix of SH coefficients
(reference ellipsoid=GRIM
Tide system=FREE)
Output Reference ellipsoid: TP
Output tide system: Mean Tide
Degree/order of expansion: 50

Options:
Output Grid : regular, 1/2° resolution grid

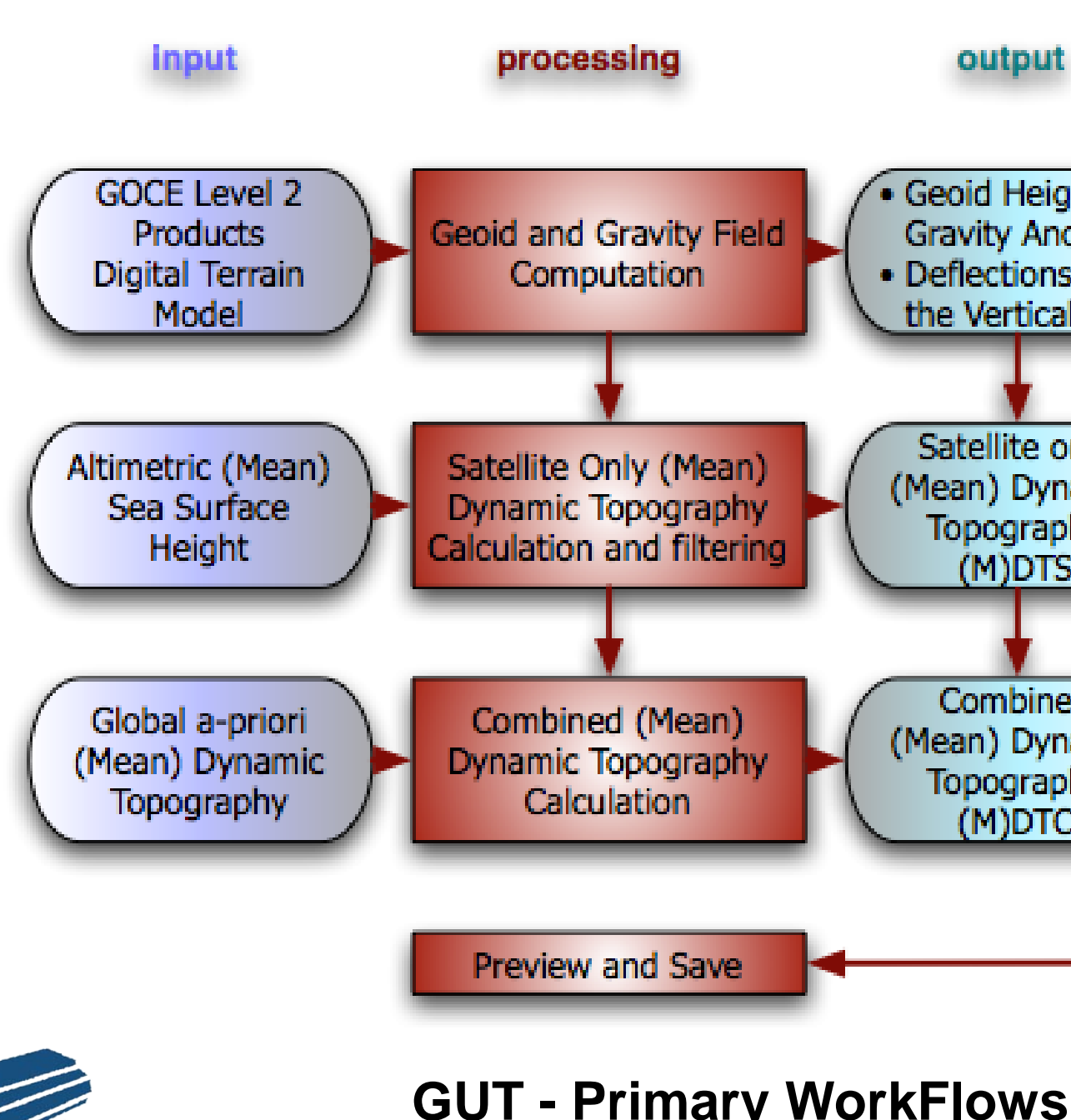
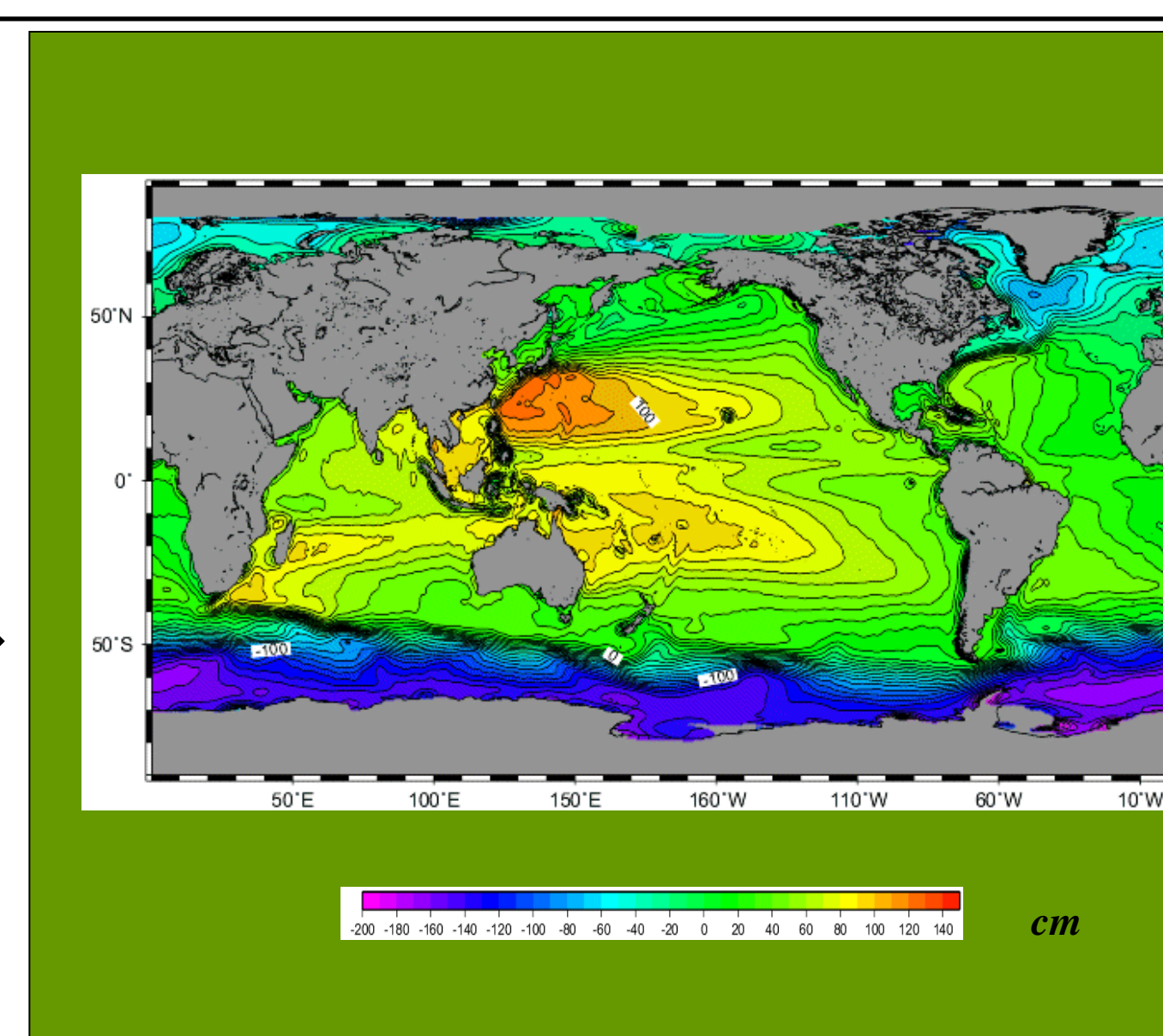


Example of GUT functionality:

Filter (MSS-geoid) to obtain the Mean Dyn Topography

Input Data:
MSSCLS01
EIGEN GL04S GRACE Geoid

Options:
Filter Type: Gaussian
Filter width=400 km



```

C:\Documents and Settings\Matija Herceg\gut --workflows
WorkFlows in the GUT installation directory.
* adapt_gf
* add_gf
* add_shf
* add_tf
* changeellipse_gf
* changeellipse_tf
* changetide_gf
* changetide_tf
* changetide_gf
* changetide_tf
* exportgravity_gf
* exportgravity_tf
* filter_gf
* filter_tf
* filter_shf
* geoidheight_gf
* geoidheight_tf
* gfc2shf
* gravityanomaly_gf
* gravityanomaly_tf
* gravityanomalyapprox_gf
* gsvest_gf
* gsvest_tf
* gsvnorth_gf
* gsvnorth_tf
* heightanomaly_gf
* heightanomaly_tf
* import_gf
* import_shf
* import_tf
* import_tf
* landmask_gf
* scale_gf
* scale_tf
* sh2gf
* spatialmdt_gf
* spectralmdt_gf
* state_gf
* subtract_gf
* subtract_tf
* subtract_gf
* subtract_tf
* surfacegravitationalpot_gf
* surfacegravity_gf
* surfacegravity_tf
* transect_gf
* transect_tf
* verticaldeflectioneast_gf
* verticaldeflectioneast_tf
* verticaldeflectioneastapprox_gf
* verticaldeflectioneastapprox_tf
* verticaldeflectionnorth_gf
* verticaldeflectionnorth_tf
* verticaldeflectionnorthapprox_gf
* verticaldeflectionnorthapprox_tf
    
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<http://earth.esa.int/gut/>