

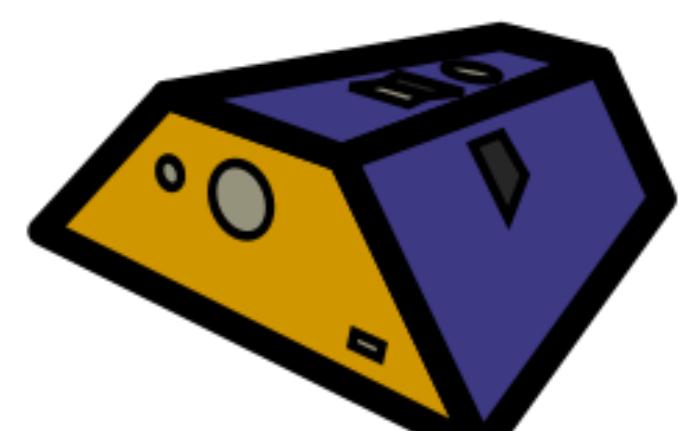
GROOPS: The Open-source Software from TU Graz

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Introduction

GROOPS: The Gravity Recovery Object Oriented Programming System

- Source code is available on GitHub under open-source license GPL-3.0: <https://github.com/groops-devs/groops>

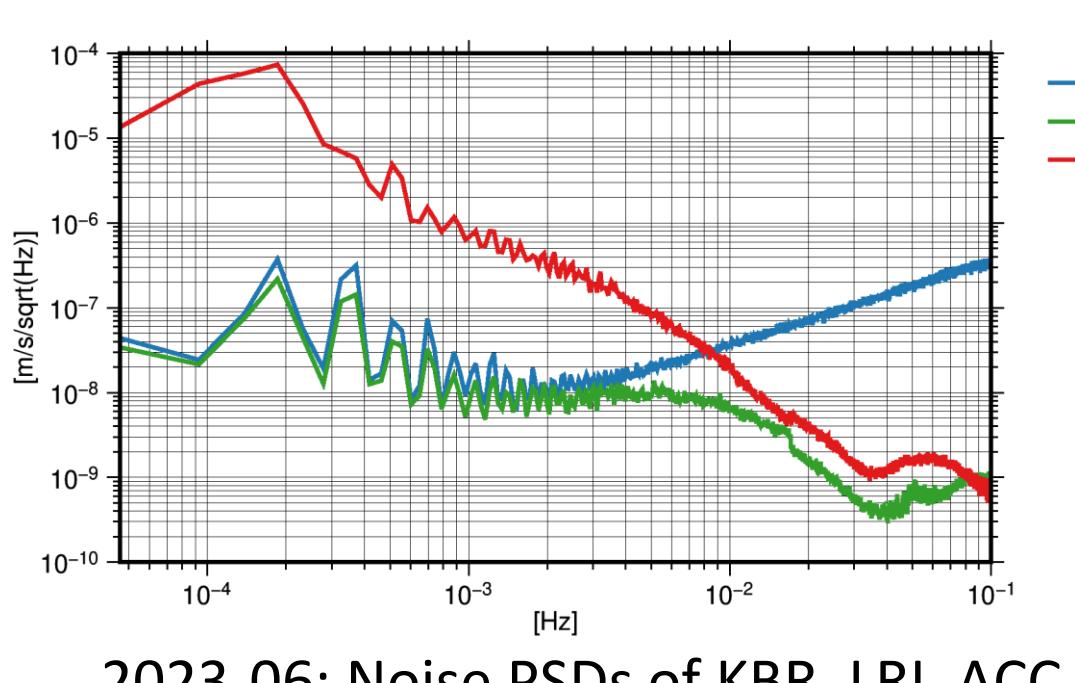


GROOPS

- > 300 programs
- ~200,000 lines of C++ code
- Parallelization using Message Passing Interface (MPI)
- Using fast BLAS/LAPACK for matrix algebra
- Linux, Windows, (Mac)

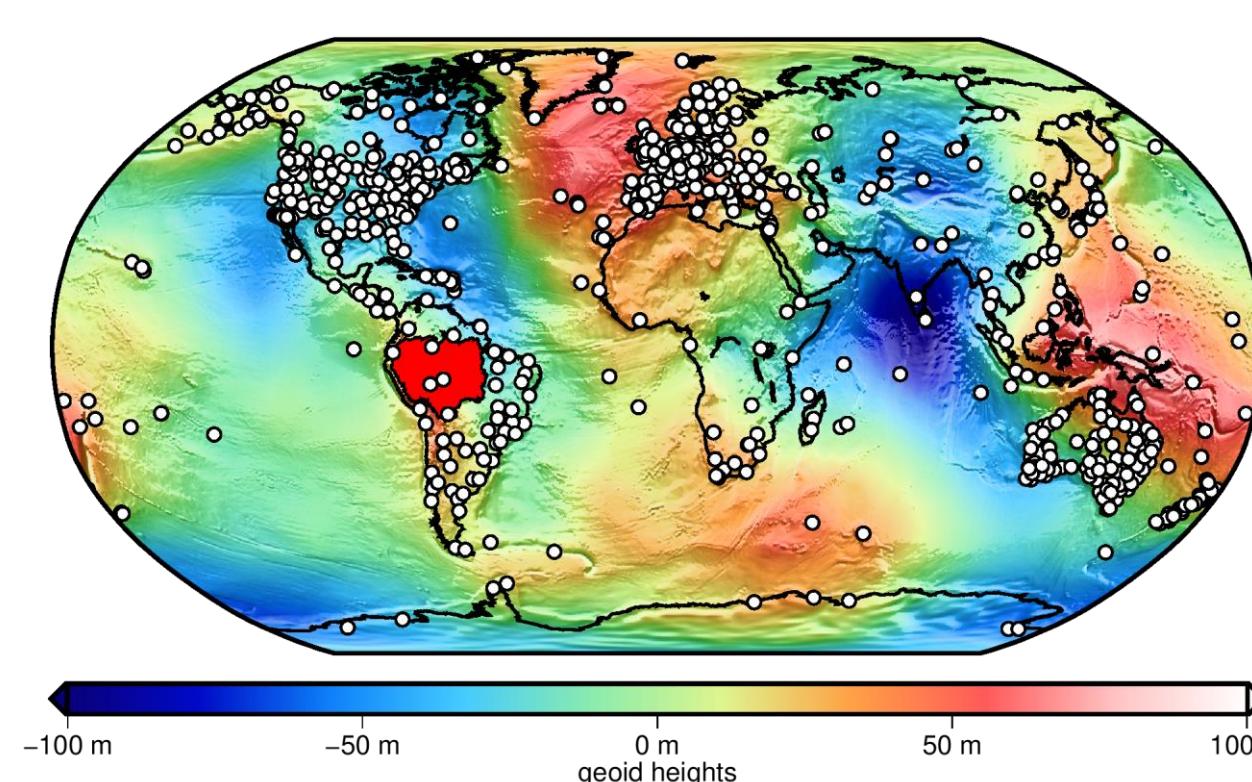
GRACE processing: ITSG-Grace2018

- Complete Level-1b to Level-2 processing
- Alternative accelerometer transplant product
- Kinematic orbits from GPS
- Integration of satellite orbits, variational equations
- Observation equations for orbits, KBR, LRI
- Sophisticated noise modelling:
 - Estimation of Power Spectral Densities (PSD) via Variance Component Estimation (VCE)
 - Subdaily errors in background models
 - Daily Kalman filtered solutions



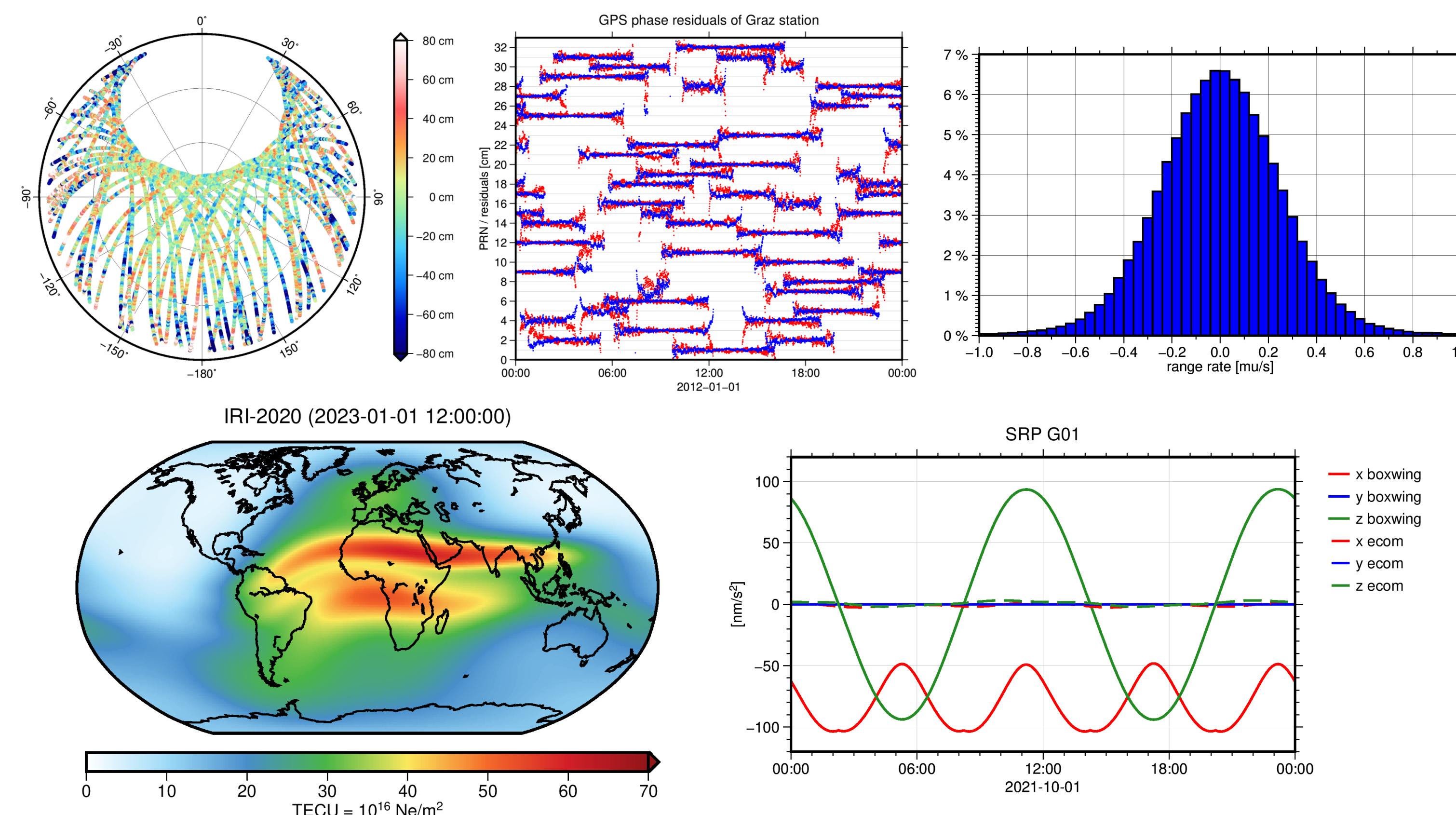
Terrestrial water storage

- Analysis/synthesis of spherical harmonics
- Gridding: Geographical, Reuter,
- Filtering: Gaussian, DDK, ...
- Conversion to TWS, Loading deformation, Geoid heights, Gravity anomalies, ...
- GIA correction
- Area mean of river basins
- Temporal analysis:
 - Trend, seasonal, polynomial, splines, wavlets, ...

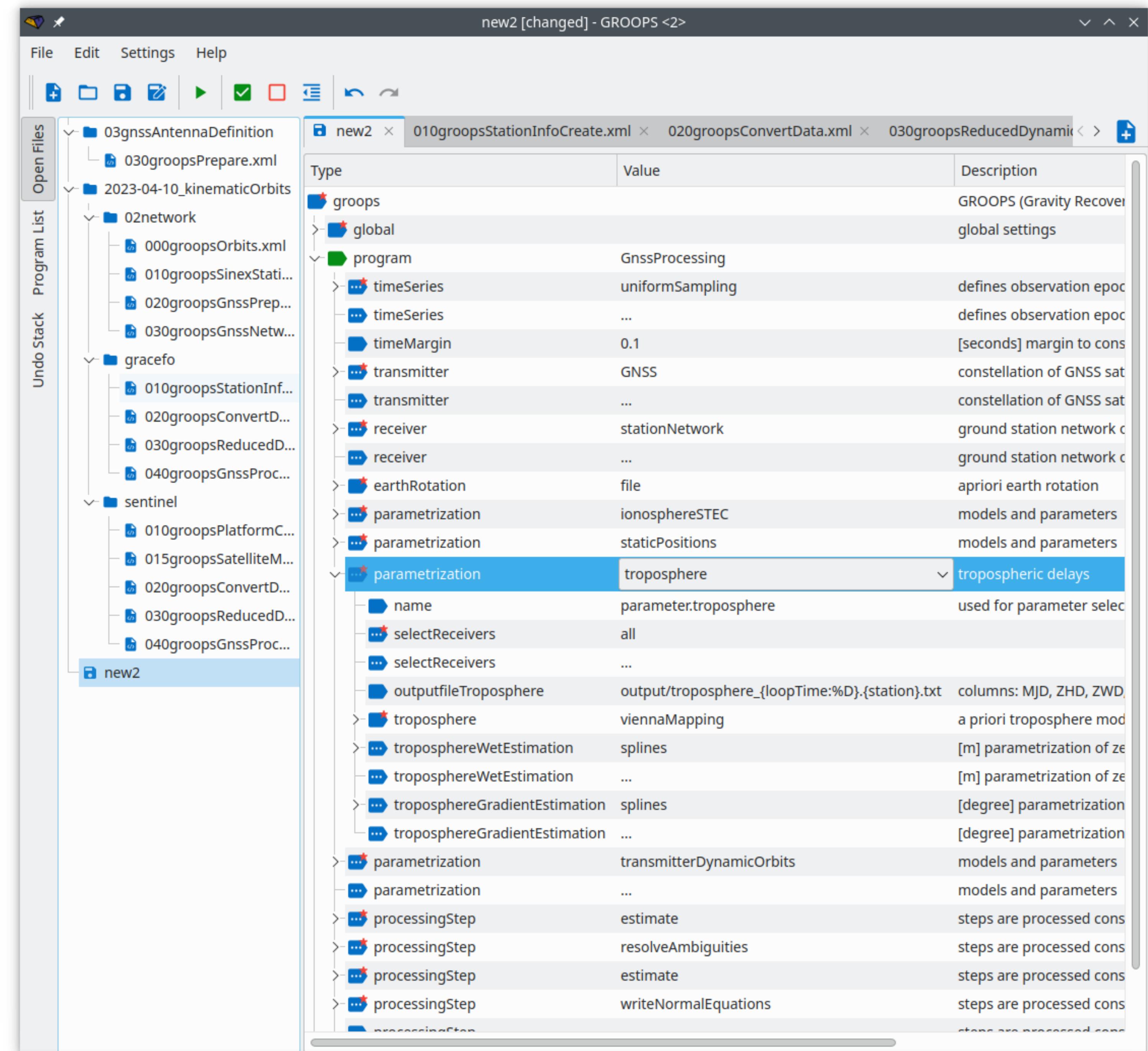


Data analysis and visualization

- Large number of data modification and analysis tools:
 - synchronization, outlier removal, filtering, sorting, ...
 - RMS, median, correlation, power spectral density, wavelets, ...
- Handling of normal equations:
 - parameter elimination, combination, Variance Component Estimation (VCE), ...
- Plotting using GMT: maps, sky views, graphs, ...



Graphical User Interface (GUI)



The screenshot shows the GROOPS configuration editor. On the left, there's a tree view of XML files under 'Open Files'. On the right, a table lists configuration parameters with their values and descriptions. Some parameters have dropdown menus or checkboxes.

Type	Value	Description
groops	GROOPS (Gravity Recovery)	global settings
global	GnssProcessing	
program	uniformSampling	defines observation epoch
timeSeries	...	defines observation epoch
timeMargin	0.1	[seconds] margin to consider
transmitter	GNSS	constellation of GNSS satellites
receiver	stationNetwork	ground station network configuration
receiver	...	ground station network configuration
earthRotation	file	a priori earth rotation
parametrization	ionosphereSTEC	models and parameters
parametrization	staticPositions	models and parameters
parametrization	troposphere	tropospheric delays
parametrization	name	parameter:troposphere
parametrization	selectReceivers	used for parameter selection
parametrization	...	
parametrization	outputfileTroposphere	columns: MJD, ZHD, ZWD, a priori troposphere model
troposphere	viennaMapping	[m] parametrization of zenith distance
troposphereWetEstimation	splines	[m] parametrization of zenith distance
troposphereWetEstimation	...	
troposphereGradientEstimation	splines	[degree] parametrization
troposphereGradientEstimation	...	
parametrization	transmitterDynamicOrbits	models and parameters
parametrization	...	models and parameters
processingStep	estimate	steps are processed consistently
processingStep	resolveAmbiguities	steps are processed consistently
processingStep	estimate	steps are processed consistently
processingStep	writeNormalEquations	steps are processed consistently

Scripting

Smooth transition of first „clicking“ the configuration towards automated jobs

- Frequently used settings can be defined as variables
- Mathematical expressions in all numeric input fields

removalCriteria $\text{abs}(\text{data0}-\text{data0median}) > 3 * 1.4826 * \text{data0mad}$

- Loops/conditions for programs and config elements

inputfile [loop] [condition] $\text{gnssReceiver}_{\{\text{loopTime}: \%D\}.(\text{station}).dat.gz}$

- loop timeSeries
- condition fileExist

- Date/time formating, regular expressions

station $\{\{\text{rinexFile}\}/(\#\{4\}.\#\{1\})\}$ first 4 characters in lower case

- Passing variables in a console command

`> groops -g timeStart=date2mjd(2024, 7, 2) --log logfile config.xml`

Further applications

- Gravity field recovery: ITSG-Grace2018, GOCO06s
- Global GNSS network processing
 - Contribution to ITRF2020
- Kinematic/reduced dynamic LEO orbits
 - CHAMP, GRACE, GOCE, Jason, MetOp, Sentinel, TerraSAR-X, ...
- Satellite Laser Ranging (SLR)
- Regional geoid determination: DACH, AlpGeoid
- Ocean tides for orbit determination
- Space weather: thermospheric densities

Products available: <https://ifg.tugraz.at/downloads>

Documentation

- Documentation and cookbooks <https://groops-devs.github.io/groops/html/index.html>
- YouTube tutorials <https://www.youtube.com/@groopsdevelopers8754>
- Discussion board <https://github.com/groops-devs/groops/discussions>

Acknowledgments

Financial support by the Austrian Research Promotion Agency (FFG) in the framework of the Austrian Space Application Program (ASAP 2022, Project CASPER, 47675856).



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