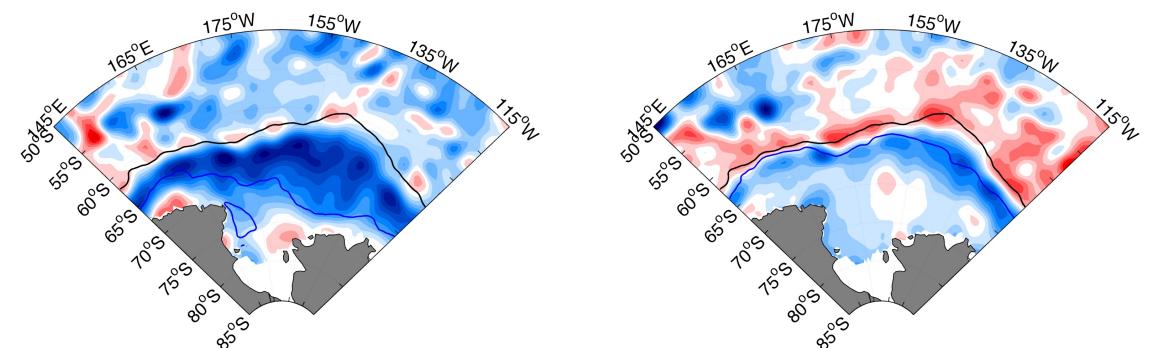
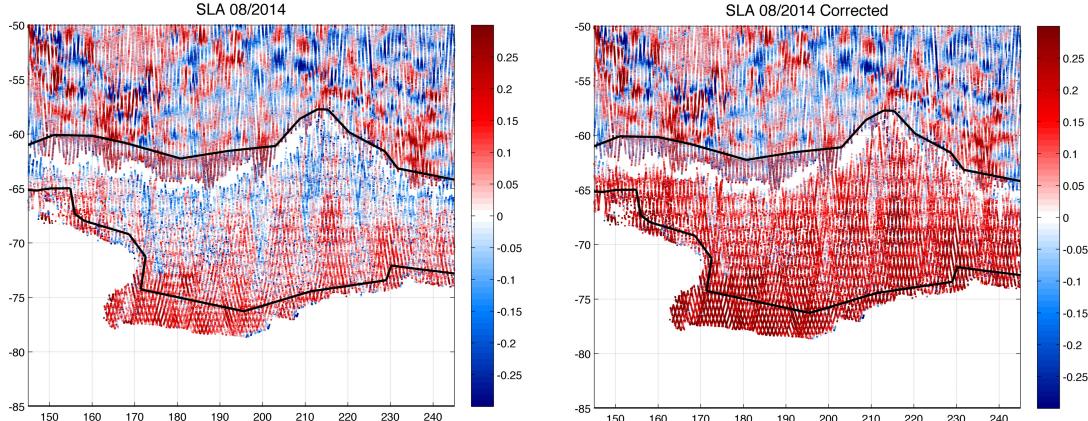


CryoSat-2 processing, creating DOT

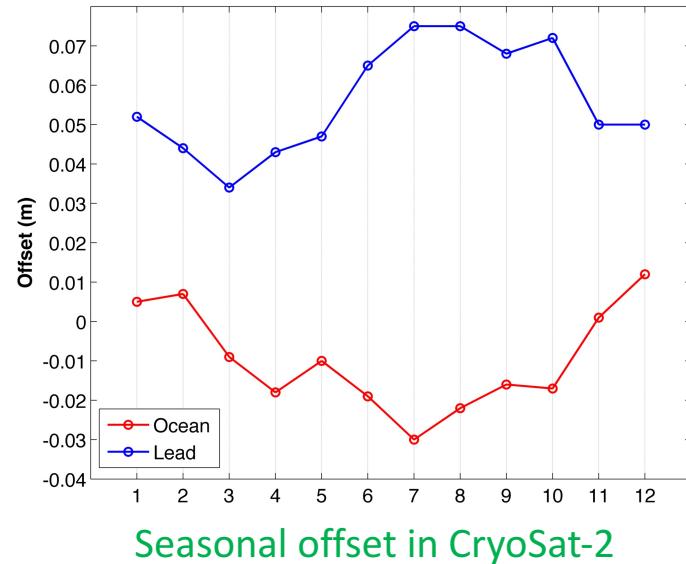
- a) Correction of modes
- b) Choosing the Geoid
- c) DOT calculation
- d) Gridding the maps

Correction of the modes

- CrySat-2 uses 3 modes → each mode is processed with one retracker
- This, creates steps when crossing from one mode to the other → it must be corrected



Example of final product SLA without offset correction



- LRM uses a proper retracker → it was my “true”
- Differences between the regions where retracker changes
- *Seasonal offset* → in theory, the offset should be a constant value everywhere
- Caution to not include noise in the data
- The difference is added back for correction
- Probably you'll need to apply different offsets for different satellites and an offset between the satellites, after the correction (see Armitage et al. 2016)

Choosing the geoid

- The best geoids have resolution of $O(10)$ km. However, in ice-covered regions, relies on GRACE and GOCE (footprint of 100-200 km) → actual resolution in the Southern Ocean is >10 km, mainly on the continental shelves [Equation for maximum resolution of the geoid = 20000/degree]. See the papers below:
 - Hughes & Bingham (2008), *An Oceanographer's Guide to GOCE and the Geoid*
 - Bingham et al (2008), *Calculating the Ocean's Mean Dynamic Topography from a Mean Sea Surface and a Geoid*
- The choice of the geoid depends on what you want to show → main changes are at the coast
- New geoids include GOCE data, which improves the resolution at the coast
- EGM2008 → high resolution at open ocean, but errors increase toward the Southern Ocean
- Website for geoid calculation → <http://icgem.gfz-potsdam.de/home>

ICGEM
International Centre for Global Earth Models (ICGEM)

ICGEM Home

Gravity Field Models

- Static Models
- Temporal Models

Topographic Gravity Field Models

Calculation Service

3D Visualisation

- Static Models
- Temporal Models
- Trend & Amplitude
- Spherical Harmonics

Evaluation

Spectral domain

GNSS Leveling

Appointment of the new director:
The longtime director of the ICGEM service, Franz Barthelmes retired on December 31st 2017. We would like to acknowledge the invaluable contributions he provided to ICGEM service and GFZ family.
As of January 1st 2018, E. Sinem Ince has been appointed as the new director of the ICGEM service.

ICGEM is one of five services coordinated by the International Gravity Field Service (IGFS) of the International Association of Geodesy (IAG). The other services are:

- BGI (Bureau Gravimétrique International), Toulouse, France
- ISG (International Service for the Geoid), Politecnico di Milano, Milano, Italy
- IGETS (International Geodynamics and Earth Tide Service), EOST, Strasbourg, France
- IDEMS (International Digital Elevation Model Service), ESRI, Redlands, CA, USA

Services of ICGEM

- collecting and archiving of all existing global gravity field models
- web interface for getting access to global gravity field models

icgem@gfz-potsdam.de

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 links **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". If you click on the reference, the complete list of references can be seen.

Nr	Model	Year	Degree	Data	References	Download	Calculate	Show	DOI
168	Tongji-Grace02k	2018	180	S(GRACE)	Chen, Q. et al., 2018	gfc zip	Calculate	Show ✓	
167	SGG-UGM-I	2018	2159	S(GOCE)	Liang, W. et al., 2018 & Xu, X. et al. (2017)	gfc zip	Calculate	Show ✓	
166	GOSGO1S	2018	220	S(GOCE)	Xu, X. et al., 2018	gfc zip	Calculate	Show ✓	
165	IGGT_R1	2017	240	S(GOCE)	Lu, B. et al., 2017	gfc zip	Calculate	Show ✓	
164	IIE_GOCE05s	2017	250	S(GOCE)	Wu, H. et al., 2017	gfc zip	Calculate	Show ✓	
163	GO_CONS_GCF_2_SPW_RS	2017	330	S(GOCE)	Gatti, A. et al., 2016	gfc zip	Calculate	Show ✓	
162	GAO2012	2012	360	A, G, S(GOCE), S(GRACE)	Demianov, G. et al., 2012	gfc zip	Calculate	Show ✓	
161	XGM2016	2017	719	A, G, S(GOCO05s)	Pail, R. et al., 2017	gfc zip	Calculate	Show ✓	
160	Tongji-Grace02s	2017	180	S(Grace)	Chen, Q. et al., 2016	gfc zip	Calculate	Show ✓	
159	NULP-02s	2017	250	S(Goce)	A.N. Marchenko et al., 2016	gfc zip	Calculate	Show ✓	
158	HUST-Grace2016s	2016	160	S(Grace)	Zhou, H. et al., 2016	gfc zip	Calculate	Show ✓	
157	ITU_GRAE16	2016	180	S(Grace)	Akyilmaz, O. et al., 2016	gfc zip	Calculate	Show ✓	
156	ITU_GGC16	2016	280	S(Goce), S(Grace)	Akyilmaz, O. et al., 2016	gfc zip	Calculate	Show ✓	
155	EIGEN-6S4 (v2)	2016	300	S(Goce), S(Grace), S(Lageos)	Förste, C. and Bruijnsma, S.L., 2016	gfc zip	Calculate	Show ✓	

Choosing the geoid

ICGEM Home

Gravity Field Models

- Static Models
- Temporal Models
- Topography related Models

Calculation Service

- 3D Visualisation
- Static Models
- Temporal Models
- Trend & Amplitude
- Spherical Harmonics

Evaluation

Spectral domain

**EIGEN-5C
EIGEN-5S
EIGEN-6C
EIGEN-6C2
EIGEN-6C3stat
EIGEN-6C4**

Choose geoid model

Functional selection

- height_anomaly
- height_anomaly_ell
- geoid
- gravity_disturbance
- gravity_disturbance_geoid
- gravity_disturbance_sa
- gravity_anomaly
- gravity_anomaly_cl
- gravity_anomaly_sa
- gravity_anomaly_bg

The Geoid is one particular equipotential surface of the gravity potential of the Earth. Among all equipotential surfaces, the geoid is those which is equal to the undisturbed sea surface and its continuation below the continents.
Here it will be approximated by the height anomaly plus a topography dependent correction term (eqs. 71 and 117 of STR09/02).

Truncation

Maximum Resolution (representation) of the geoid

Start Gentle Cut: 2190 Maximal Degree : 2190

Choose region and resolution of the grid

File size restriction

Grid Step [°]: 0.025

Height over Ellipsoid [m]: 0

Reference System: WGS84

Radius: 6378137.0

Gm: 3.986004418e+14

Flat: 298.257223563

Omega: 7.292115e-5

Tide System: tide free

Zero Degree Term

Definitions of the Filterlength Φ

Definitions of the Filterlength Φ

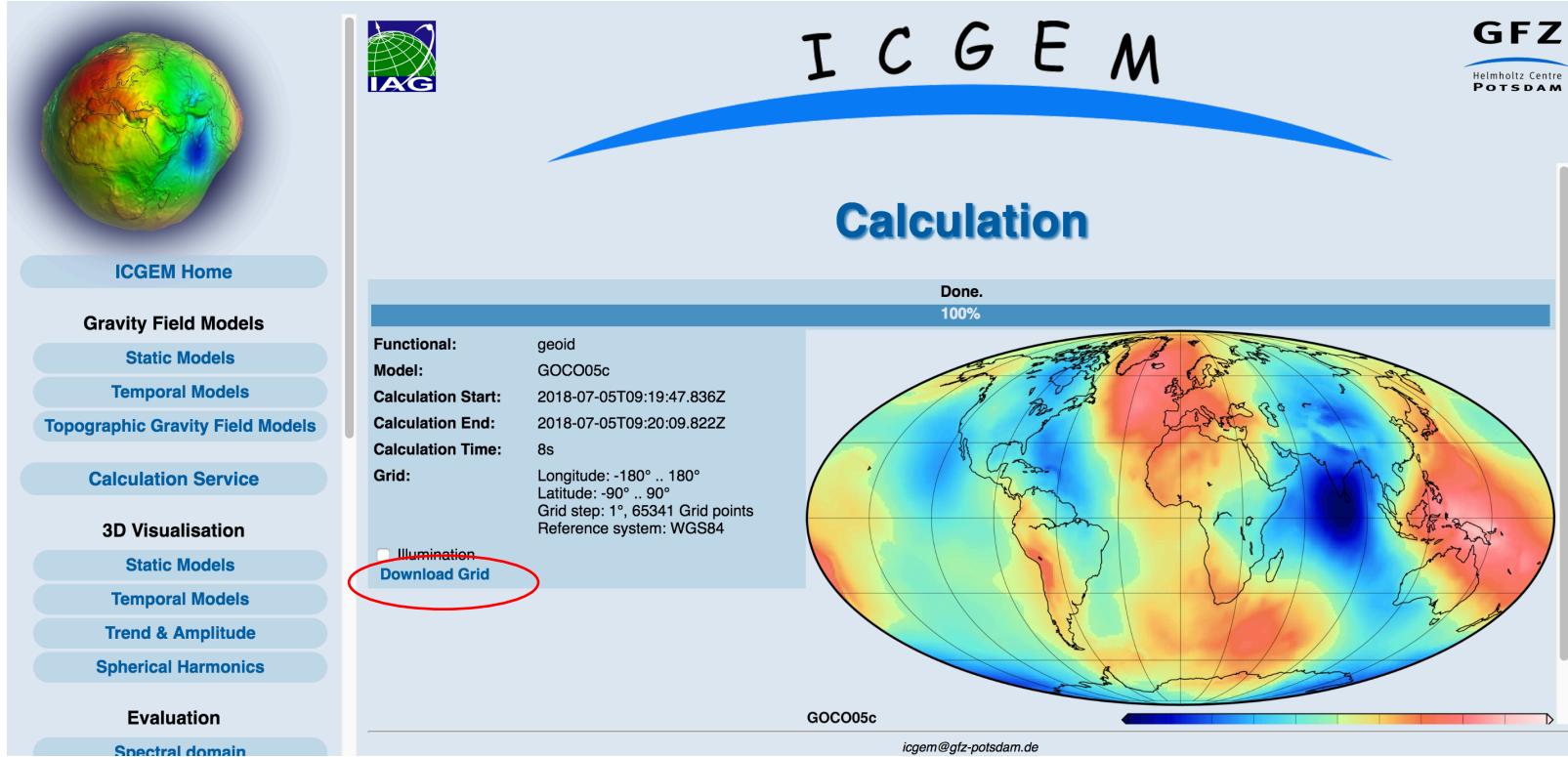
- None
- Half response
- Half transfer
- 6 Sigma

Filter Length: 1.0 ° [Degree]

Calculation → **start computation**

icgem@gfz-potsdam.de

Choosing the geoid



- It will download a gdf file with the information of the geoid and the options you chose previously
- You can open this file in a txt reader
- Lon/Lat/Height → it is a grid
- GMT software to open it and create the along-track

generating_institute	gfz-potsdam
generating_date	2018/07/05
product_type	gravity_field
body	earth
modelname	GOCO05c
max_used_degree	720
tide_system	functional
functional	
zero_degree_term	
unit	
crust_density	
refsysname	
gmrefpot	
radiusrefpot	
flatrefpot	
omegarerefpot	
normal_potential	
long_lat_unit	
latlimit_north	
latlimit_south	
longlimit_west	
longlimit_east	
gridstep	
latitude_parallel	181
longitude_parallel	361
number_of_gridpoints	65341
gapvalue	999.0000
weighted_mean	-3.1993218E-02 meter
maxvalue	8.4729459E+01 meter
minvalue	-1.0611245E+02 meter
signal_wrms	3.0586831E+01 meter
grid_format	long_lat_value
longitude [deg.]	latitude [deg.]
latitude [deg.]	geoid [meter]
end_of_head	=====
-180.0000	90.0000
-179.0000	90.0000
-178.0000	90.0000
-177.0000	90.0000
-176.0000	90.0000
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-1.0000	90.0000
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Geoid processing

- To create a netCDF with the grid in the GMT (remove the header from the files and save it in .txt). Ex:

```
xyz2grd GOCO05s_140180E.txt(table x y z) -GGRID.nc(new netCDF to be saved) -R145/180/-85/-60(geographical limits) -I0.1[d]/0.1[d] (resolution that you want)
```

- If you have more than one file, you'll need to merge them in one single netCDF file (e.g. matlab or GMT or python)
- Now you have a single file with the geoid grid. You'll need to interpolate this grid into the along-track coordinates of the satellite (in GMT, it is fast):

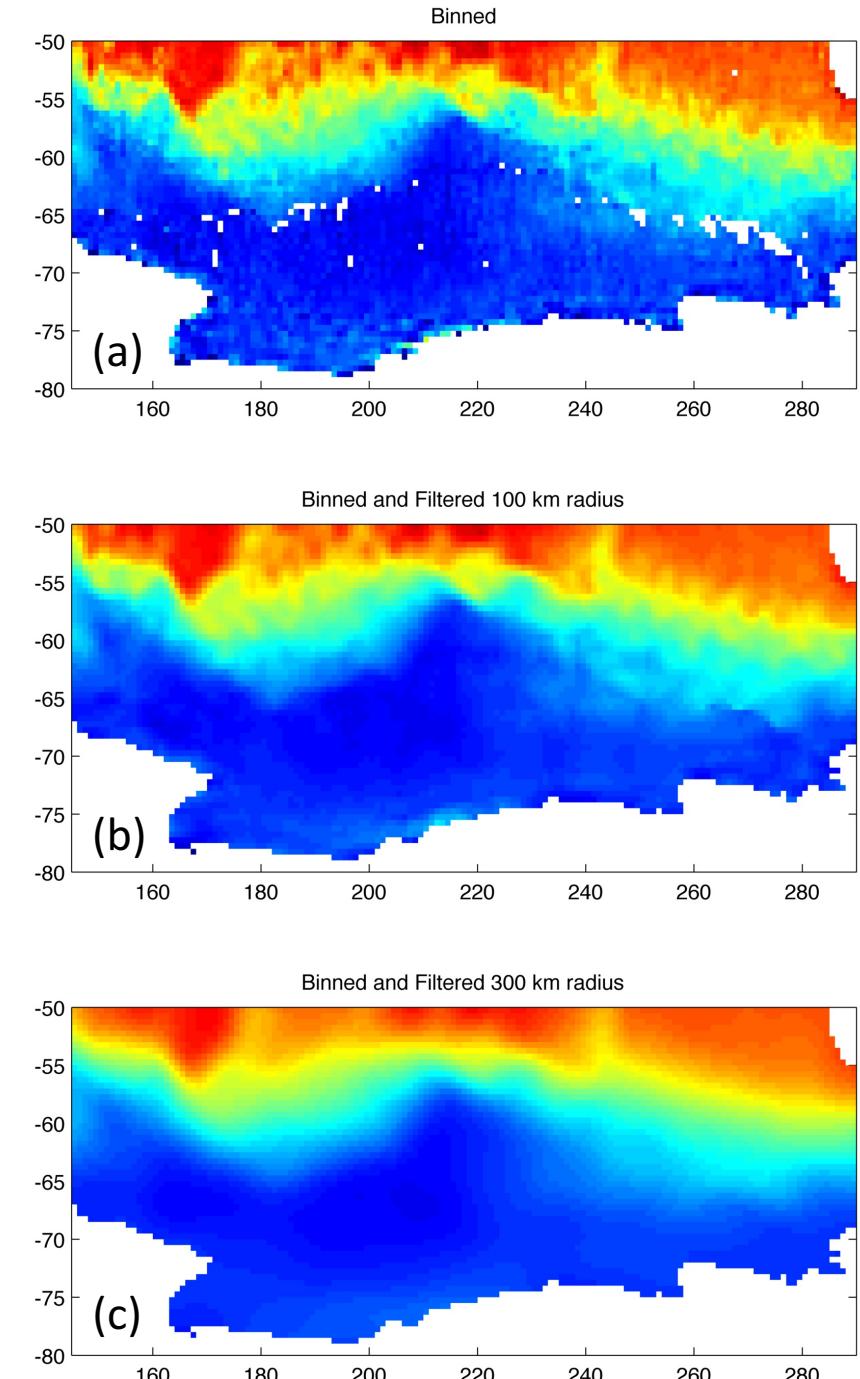
```
grdtrack INPUT.txt(satellite along-track lon/lat) -GGRID.nc(netCDF file you created above) > output_test.txt(file with the geoid height interpolated onto the along-track lon/lat/geoid)
```

INPUT.txt is the monthly location of the along-track (lon/lat) and *GRID.nc* should contain files named x y z (see grdtrack for information in the GMT docs)

- Finally, open the along-track and subtract the geoid [DOT = SSH – H_{geoid}]

Gridding processing

- Open the DOT along-track and bin into the grid you want → filtering is needed, mainly if you want to work with geostrophic velocity
 - In this case, the data were binned into a grid of 1° lon x 0.5° lat. The higher the resolution, more white cells with no data
 - With more satellite tracks, the resolution can be enhanced
 - Or, new interpolation technique
- Filtering is a balance between oceanographic features that are important and removing artificial features (e.g. big gradients and jets)
 - Caution to avoid filtering too little or too much



At the end...

