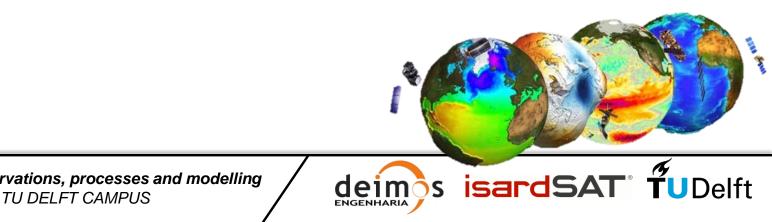






### **Broadview Radar Altimetry Toolbox** Albert Garcia-Mondéjar (isardSAT)







- 1. BRAT project
- 2. Along-track data
- 3. Gridded data
- 4. Wind and waves
- 5. Waveforms







- 2. Along-track data
- 3. Gridded data
- 4. Wind and waves
- 5. Waveforms







- Evolution of the Basic Radar Altimetry Toolbox (BRAT)
  - New datasets
  - New functionalities
  - New GUI
- Update and create new tutorial material
- Support both novice and expert users of the Altimetry Scientific Community.
- Collect feedback from the Altimetry Community on the new concept and gather suggestions for further improvements.







### 2. Along-track data

- 3. Gridded data
- 4. Wind and waves
- 5. Waveforms







- 2. Along-track data
  2.1 Basic functioning
  2.2 Advanced features
- 3. Gridded data
- 4. Wind and waves
- 5. Waveforms

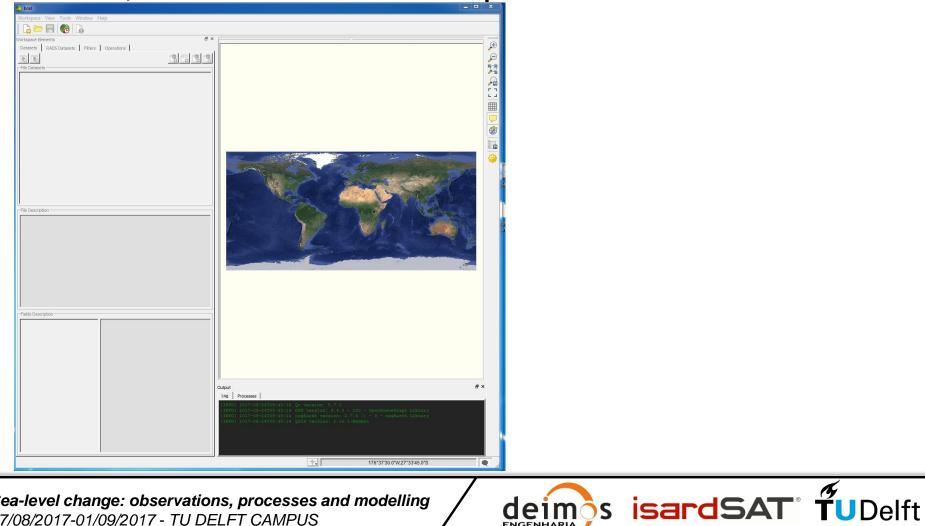




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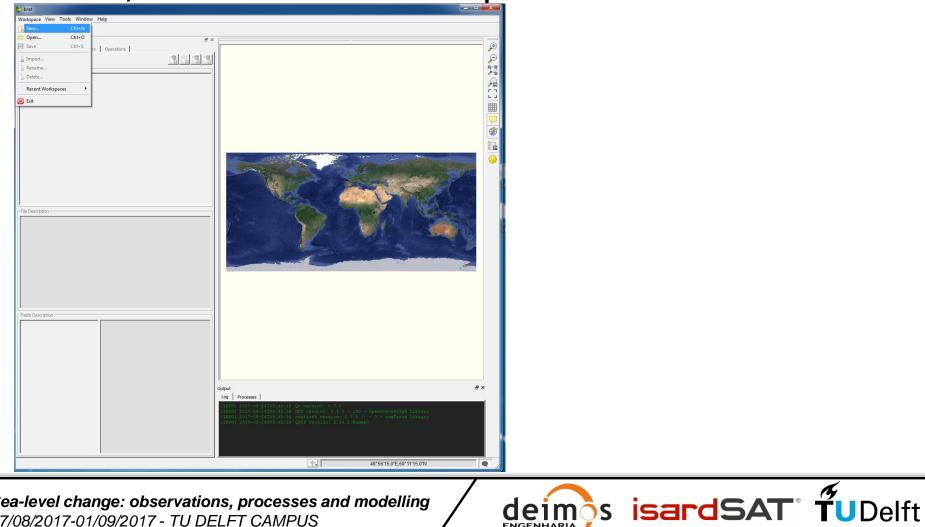
#### First, create a new workspace:







#### First, create a new workspace:



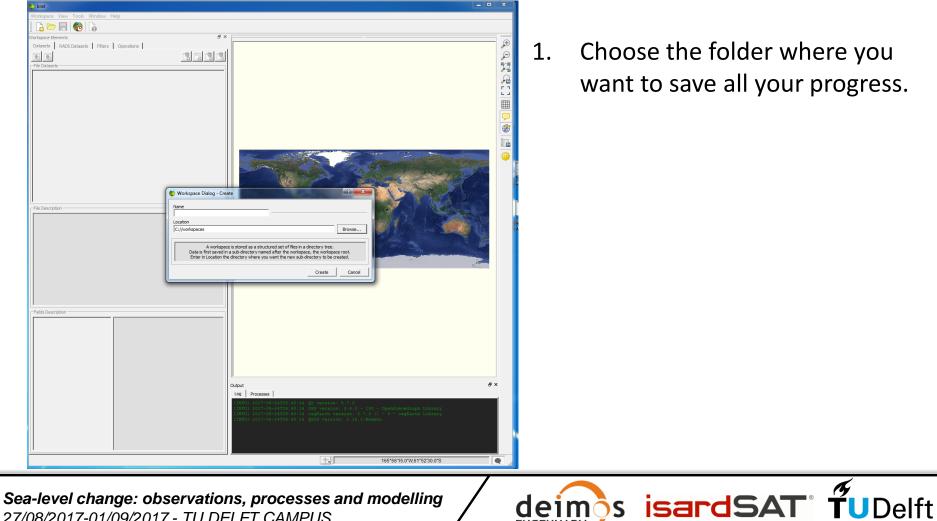
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First, create a new workspace:

27/08/2017-01/09/2017 - TU DELFT CAMPUS

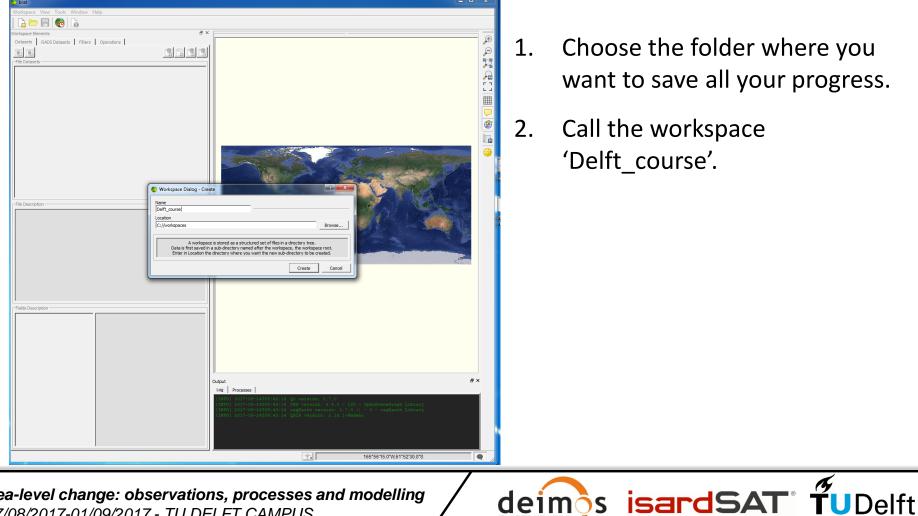


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First, create a new workspace:



- 1. Choose the folder where you want to save all your progress.
- Call the workspace 2. 'Delft\_course'.

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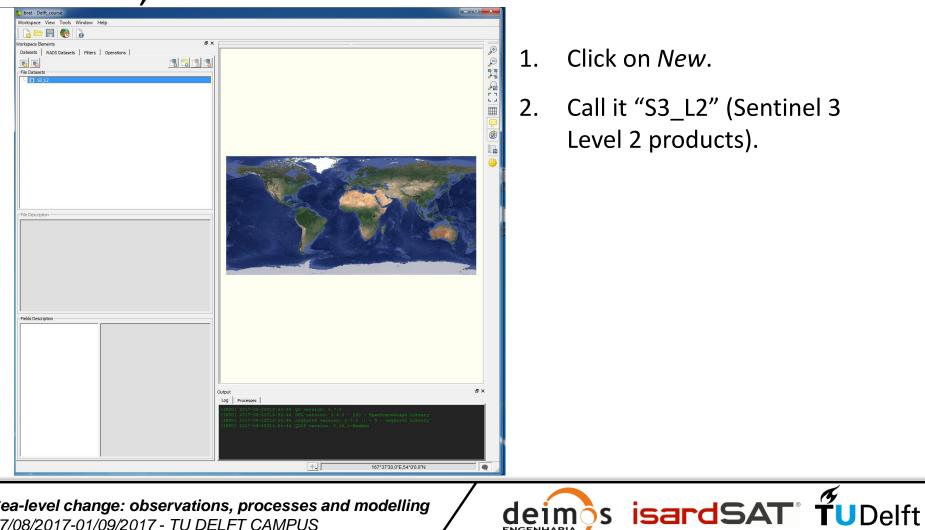
#### • Then, add a dataset:







#### Then, add a dataset:



Click on New. 1.

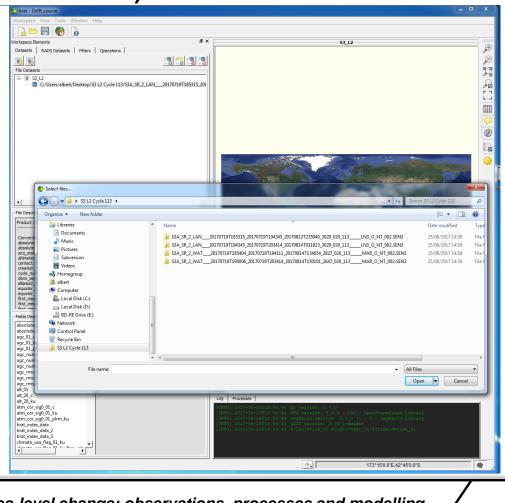
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Call it "S3\_L2" (Sentinel 3 2. Level 2 products).





#### • Then, add a dataset:



1. Click on New.

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- 2. Call it "S3\_L2" (Sentinel 3 Level 2 products).
- Click on Add File... and choose the files inside "S3 L2 Cycle 113" in the Datasets folder.

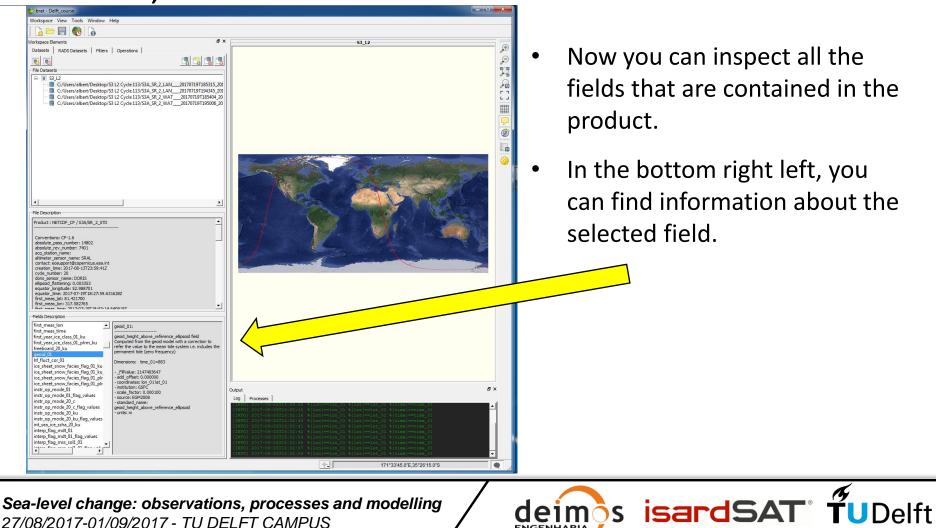
eimos isardSAT TUDelft





#### Then, add a dataset:

27/08/2017-01/09/2017 - TU DELFT CAMPUS



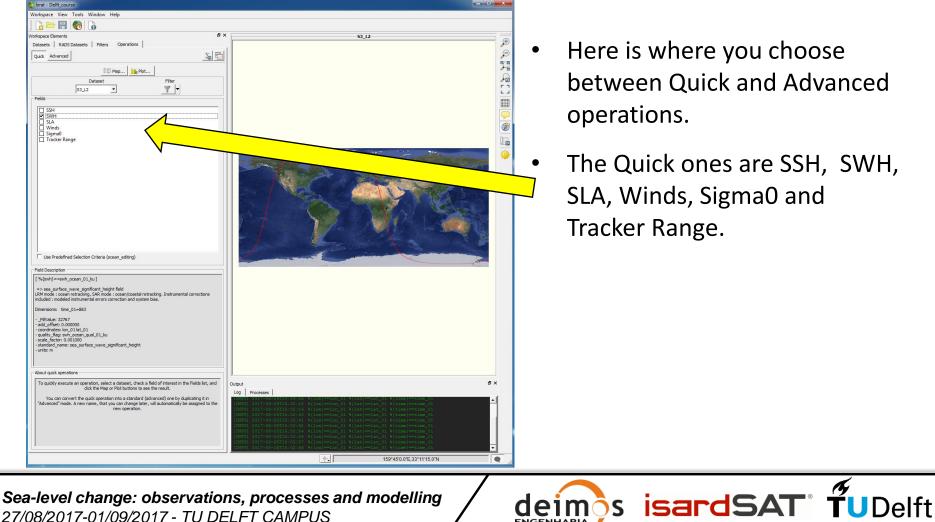
- Now you can inspect all the fields that are contained in the product.
- In the bottom right left, you can find information about the selected field.

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#### After that, go to Operations tab:

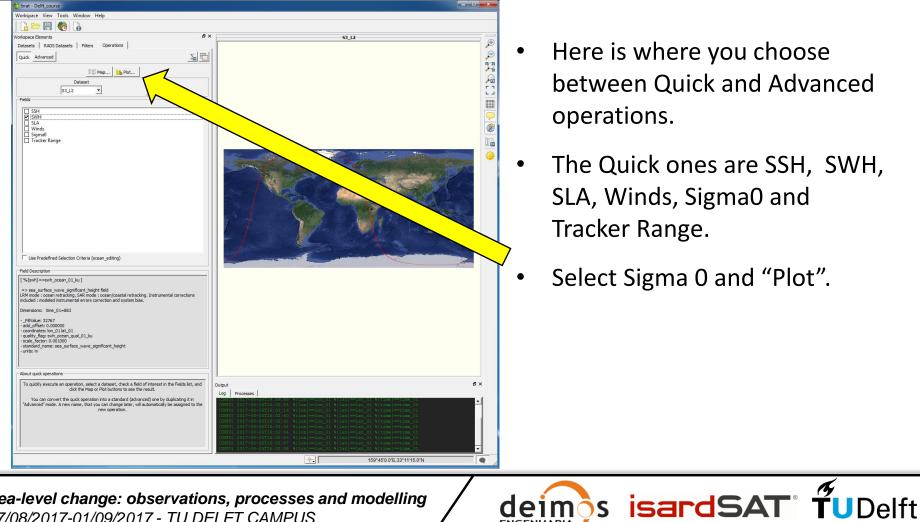


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#### After that, go to Operations tab:



- Here is where you choose between Quick and Advanced operations.
- The Quick ones are SSH, SWH, SLA, Winds, Sigma0 and Tracker Range.
- Select Sigma 0 and "Plot".

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#### • After that, go to Operations tab:

Dataset	Operations	<u>s3_12</u> کو او او او او او
elds SSH SVH SLA Unds Vinds Vinds Sigma0 Tracker Range	QuickOperation_Displays_2 [QuickOperation]	
Use Predefined Selection Oriteria ( add Description "(grant)==grant_ocean_01_ku]	Deperation California Displays 2 guickOperation_Displays_2 sigma0 -10 -15010*50 0 50100 <sup>150</sup> lon 00 [degrees_east]	$\begin{array}{c c} \mathbf{S}_{1} 1 2 \\ \mathbf{S}_{1} 1 1 1 \\ \mathbf{S}_{1} 1 1 1 1 \\ \mathbf{S}_{1} 1 1 \\ \mathbf{S}_{1} 1 1 \\ \mathbf{S}_{$
-> sea_priface_wave_sonfacent_he RM mode : coeen area konfacent chulded : modeled instrumental errors immensions: tmm_01=883 FilValue: 32767 add_offset: 0.00000 coordinates: ion_011st_011 coalty: figs: with coeen qual_01_bu scale_factor: 0.001000 standard_name: sea_purface_wave_ units: m	General Data Options Axis Options Animation	Lon_01 [degrees_east]  Reset  Pot Type  XY2  XY2  XY2  Hittogram
click the Map of You can convert the quick operation	in into a standard (advanced) one by duplicating it in our and hange latter, will automatically be assigned to the new operation.	A  Processa Processa  Proc

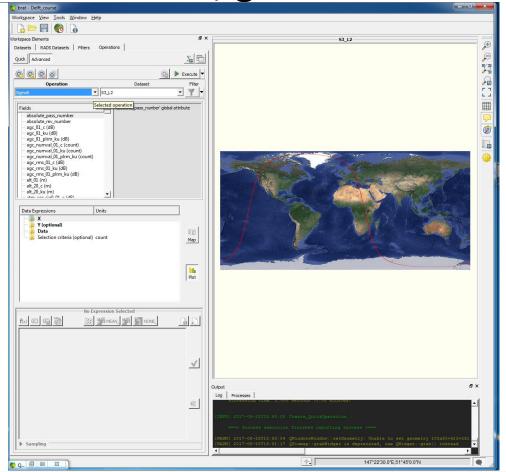
- Here is where you choose between Quick and Advanced operations.
- The Quick ones are SSH, SWH, SLA, Winds, Sigma0 and Tracker Range.
- Select Sigma 0 and "Plot".

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#### • After that, go to Advanced Operations tab:



- Click to create a new operation and name it Sigma0
- Notice there are 4 items in the *Data expressions* box:
  - X
  - Y
  - Data

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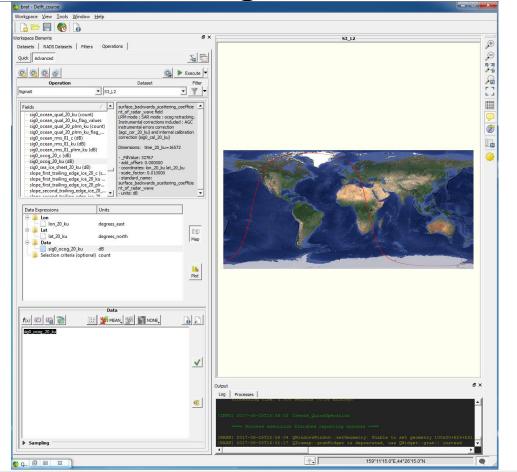
- Selection criteria (optional)
- These are the fields that have to be filled with meaningful information in order to execute a useful operation.

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#### After that, go to Advanced Operations tab:



- Selection "Map" type and the X and Y data expressions change to Lon and Lat.
- Add the "lon\_20\_ku" and "lat\_20\_ku" fields and the "sig0\_ocog\_20\_ku"
- Click "Execute" to see the plot for this variable.

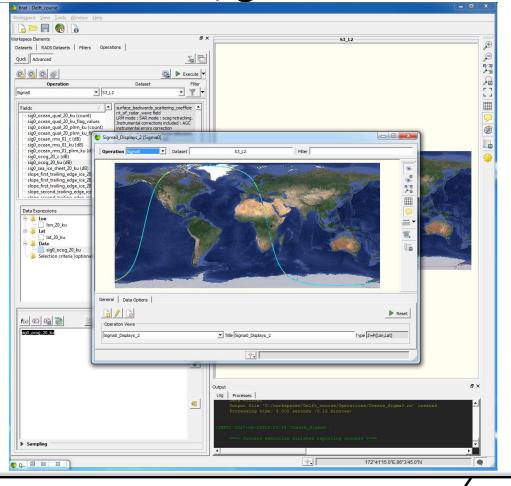
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#### • After that, go to Advanced Operations tab:



- Selection "Map" type and the X and Y data expressions change to Lon and Lat.
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- Click "Execute" to see the plot for this variable.

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#### • After that, go to Advanced Operations tab:

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sig0_ocean_rms_01_ku (dB sig0_ocean_rms_01_plrm_k		
sig0_ocog_20_c (dB) sig0_ocog_20_ku (dB)		
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	Reset	
	- Operation Views	
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	> Process execution finished reporting success <	
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	[WARN] Windows Error \$2000: WinS2WindowingSystem::OpenGLContext() - Unable to restore cur	cent-
Sampling		<b>•</b>
	92*48'45.0'E,60*11'15.0'N	
Q		

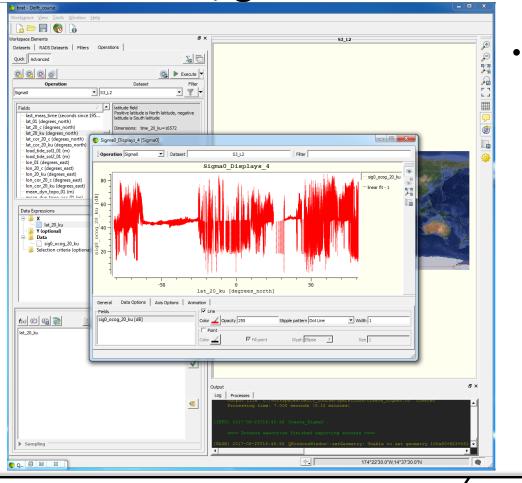
You can check that the backscatter is higher in the Antarctic ocean due to the presence of sea ice.

isar





#### • After that, go to Advanced Operations tab:



We can now see the same field only against latitude if we do a plot putting the "lat\_20\_ku" in the X Data Expression

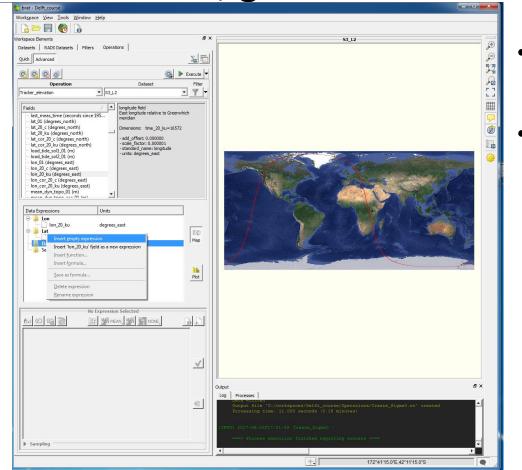
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#### • After that, go to Advanced Operations tab:



- Create a new operation and name it Ocog\_elevation.
- We are going to compute the elevation of the OCOG retracker using two fields combined.

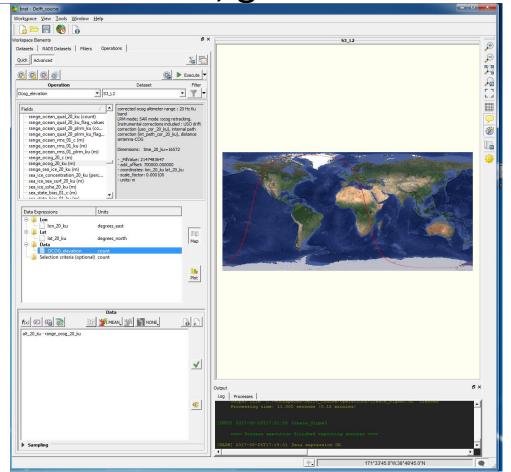
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#### After that, go to Advanced Operations tab:



- Create a new operation and name it Ocog\_elevation.
- We are going to compute the elevation of the OCOG retracker using two fields combined.
- Create a new empty expression
   and name it "OCOG\_elevation"
- Write in the bottom "alt\_20\_ku range\_ocog\_20\_ku". You can check the syntax and assign it to the expression

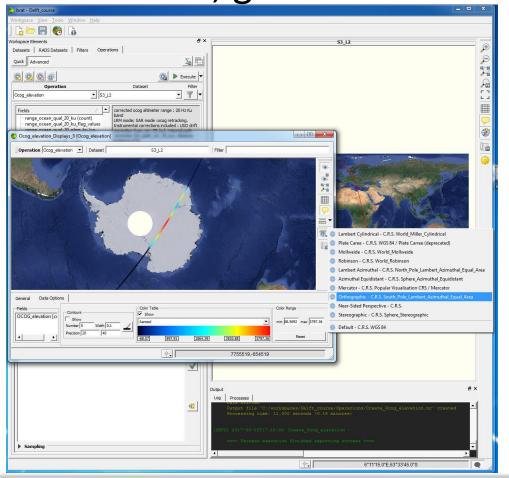
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#### After that, go to Advanced Operations tab:



- Press Execute to get the map plot.
- The projection can be changed if needed.

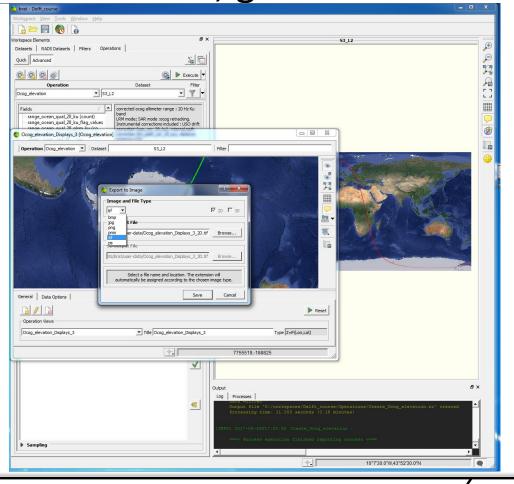
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#### • After that, go to Advanced Operations tab:



- Press Execute to get the map plot.
- The projection can be changed if needed.

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Save the plot as jpg.

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### 2. Along-track data

2.1 Basic functioning

#### 2.2 Advanced features

- 3. Gridded data
- 4. Wind and waves
- 5. Waveforms







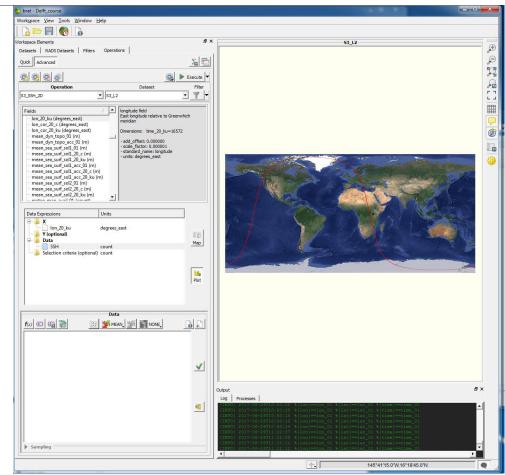
- Add formulas
- Export
- Filter
- Smooth







#### Add formulas



- Apart from dealing with fields included in the input product files, the toolbox allows you to include new expressions and formulas.
- Create a new operation
   ("S3\_SSH\_2D"). This time, only
   with longitude ('lon\_01') in the
   X expression.
- Click on Data, then Insert empty expression and call it "SSH".

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#### • Add formulas

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		lutput & ×
		Log Processes Output file 'C:/workspaces/Delft course/Operations/Create S3 SSH 2D.nc' created
	3	Processing time: 2.000 seconds (0.03 minutes)
		[INF0] 2017-08-29711:32:00 Create S3 S3H 2D :
		> Process execution finished reporting success <
Sampling		[WARN] 2017-08-29T11:32:00 QWindowsWindow::setGeometry: Unable to set geometry 100x30+623+531 ▼
		172*41'15.0'E.49*30'0.0'N
		T 112 41 15.0 E,49 30 0.0 14

- 3. Then, click on insert formula. A box pops up. Scroll down and select "SSH".
  - You can analise the expression that appears in the Log after pressing execute,

"Expression :"

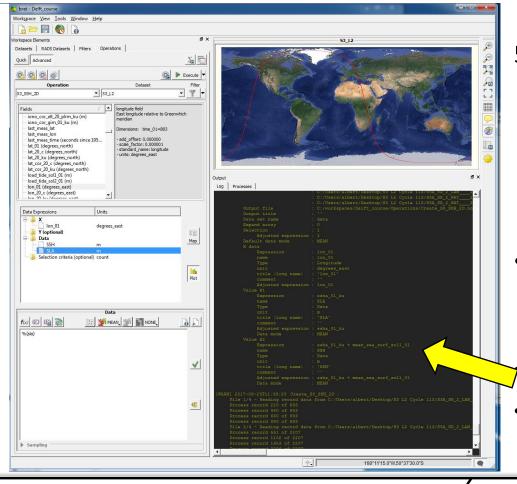
It will vary depending on the mission being inspected.

isardSA<sup>-</sup>





#### Add formulas



5. Before executing, create another empty expression called "SLA" and insert the "S3\_SLA\_2D" formula.

Now click on *Execute*.

You can find the expressions used for these formulas on the Log, or open the

**SSH** = "ssha\_01\_ku + mean\_sea\_surf\_sol1\_01"

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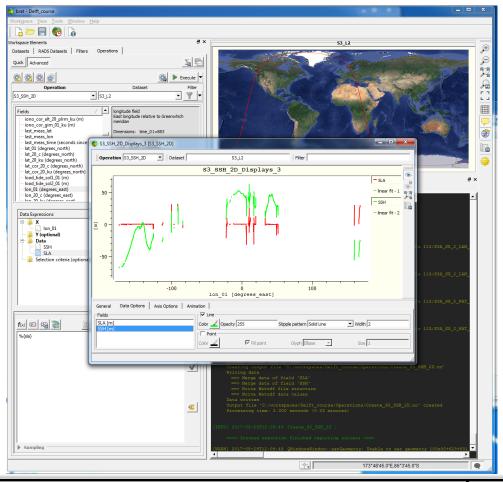
```
SLA = "ssha_01_ku".
```

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#### Add formulas



- 7. Take a look at the plot.
- 8. SSH is in green and SLA in red. Use the options on the right to thicken the curves, change colour, etc.
- 9. Observe the strange behaviour with the SLA?.
- What might have caused this?

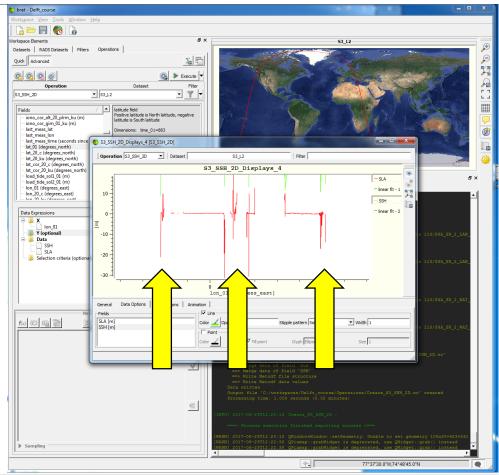
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#### Add formulas



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- SSH is in green and SLA in red.
   Use the options on the right to thicken the curves, change colour, etc.
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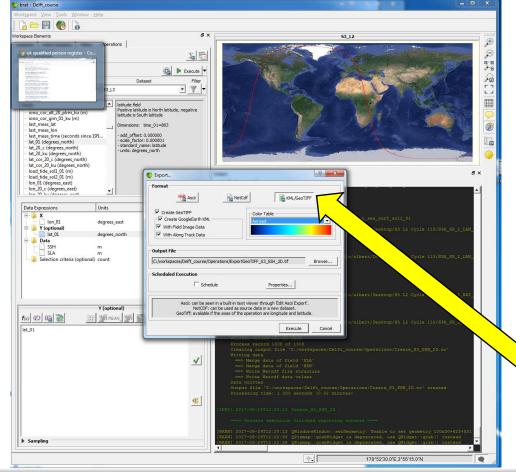
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• Export



- Usually, this is land
   contamination. But an ocean
   mask was already applied.
- You can do 2 things:

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- Plot S3 on Google Earth ("S3A\_ground\_track.kml")
- 2. Export data into a KML file and visualise it in Google Earth as well.

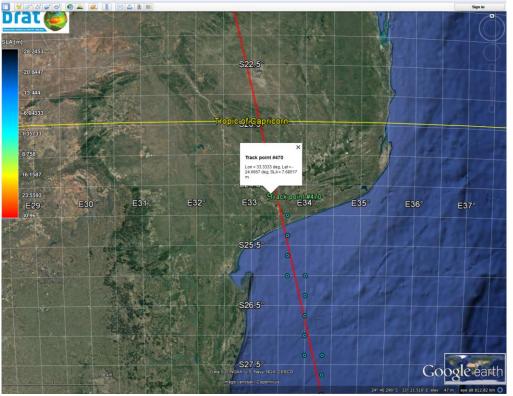
For this, go to Operations tab and go to the export button (the KML option will need to have lat and lon in the data expressions to be enabled).

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• Export



1. Go to your workspace folder and visualise in Google Earth the generated KML file:

> ../Operations/ExportGeoTIFF\_S3\_SSH \_2D

> > isardSAT **TU**Delft

 Observe that all the measurements over water bodies or ice sheets are related with the jumps in SLA.

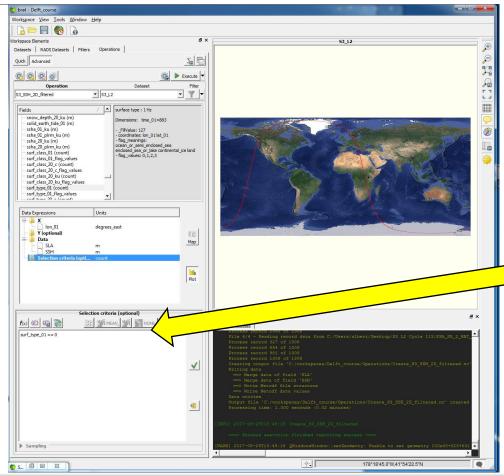
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#### • Filter



- However, this can be solved by editing the *Selection criteria*.
- Duplicate "S3\_SSH\_2D" and add "\_filtered" at the end.
- 2. Drag 'surface\_type' into the Selection criteria box. Find the information inside the variable to know the its value for ocean surfaces. Then type '==[the\_value])'.

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#### • Filter

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Quick Advanced	9 52
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FilValue: 127 FilValue: 127 coordinates: lon_01 lat_01	
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surf_class_20_c_flag_values	SH_2D_filtered_Displays_3
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<u></u>	Creating output file - C:/Workspaces/Delt5_course/Operations/Dreste_s5_SSH_2D_filtered.nc* Writing data
	==> Merge data of field 'SLA' ==> Merge data of field 'SSH'
	==> Write Netodf file structure ==> Write Netodf data values
	Data written Output file 'C:/workspaces/Delft course/Operations/Create S3 SSH 2D filtered.nc' created
<u>8</u>	Output file "C:/Workspaces/Deirt_course/Operations/Oreate_Ss_SaH_2D_filtered.hc" created Processing time: 1.000 seconds (0.02 minutes)
	(INFO) 2017-08-29T13:49:18 Create_S3_SSH_2D_filtered :
	===> Process execution finished reporting success <===
▶ Sampling	[WARN] 2017-08-29718:49:18 QWindowsWindow::setGeometry: Unable to set geometry 100x30+623+531 🗸
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	- 小- 107*26′15.0°E,77*54′22.5°S

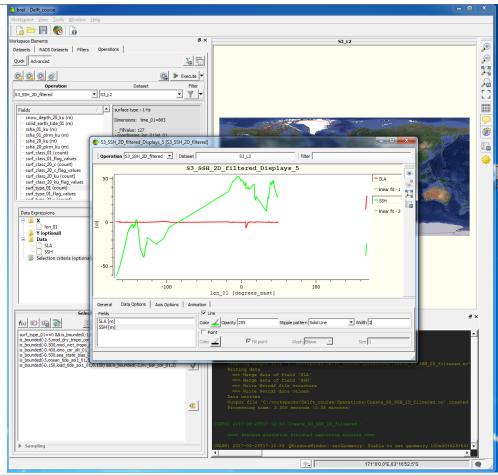
- Also, there is a predefined, more complete formula for this filtering that could be used as well.
- 3. Press *Execute* and generate a new view with both the original SLA values and the edited ones.

isar





#### • Filter



- Also, there is a predefined, more complete formula for this filtering that could be used as well ("Ocean data editing Sentinel3").
- 3. Press *Execute* and generate a new view with both the original SLA values and the edited ones.
- Results improve a lot, even though a marginal error remains.

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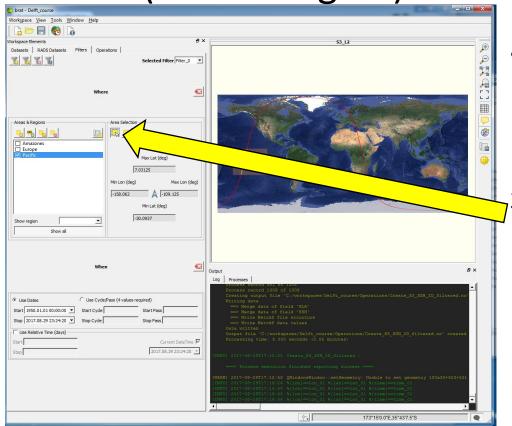
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## • Filter (draw a region)



- On the Filters tab, a geographical mask can be defined to select only regions from a region of interest
- 3. Create a new Filter and add it to the list.

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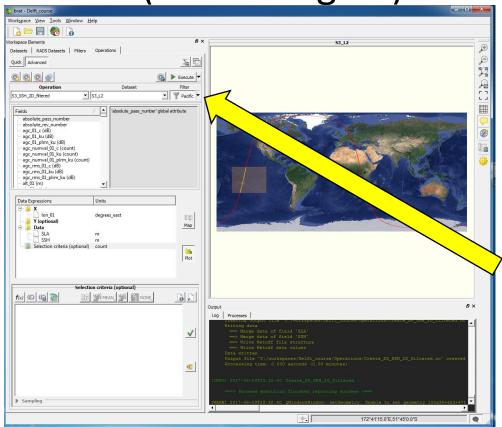
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## • Filter (draw a region)



- On the Filters tap, a geographical mask can be defined to select only regions from a region of interest
- Create a new Filter and add it to the list.
- 4. Activate the filters on the filter list and execute.

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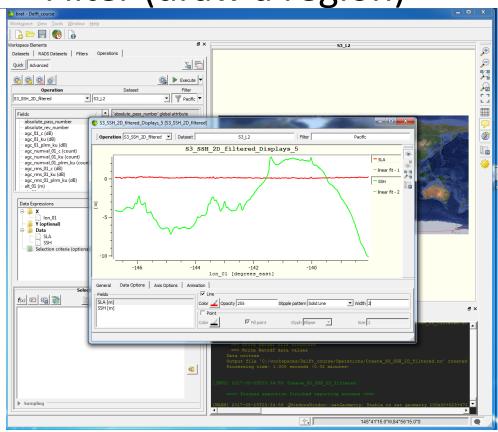
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## • Filter (draw a region)



- On the Filters tap, a geographical mask can be defined to select only regions from a region of interest
- 3. Create a new Filter and add it to the list.
- 4. Activate the filters on the filter list and execute.

s isardSAT TUDelft

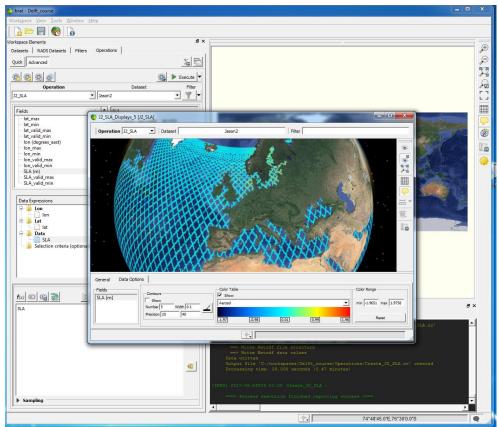
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#### Smooth



- Create a new dataset with a whole cycle

   ("J2\_240\_edit.nc")
- 2. Create a new operation with longitude / latitude and the SLA.
- 3. Play with the map zooming and change from 2D to 3D on the right in order to visualise smaller changes in SLA. Find the areas with lower/higher variability.

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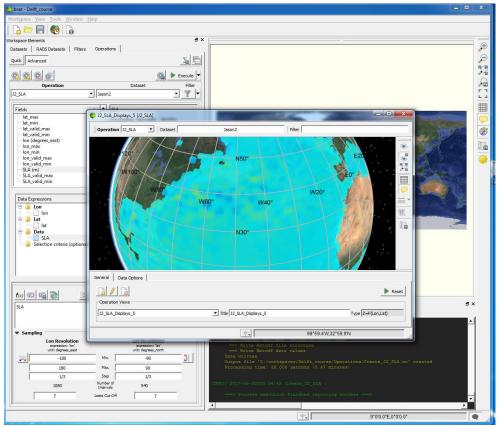
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#### • Smooth



- You can also obtain a fullcoloured map (not just tracks) applying the Loess filter before executing the operation.
- However, Jason-2 tracks are not close enough to get a good result and you will get a low resolution map with too much interpolated data.

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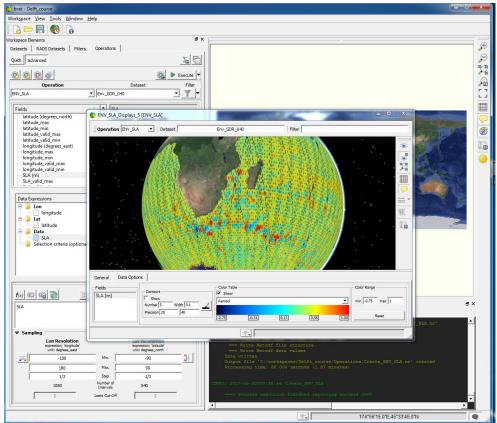
5. Try other filter options.

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#### Smooth



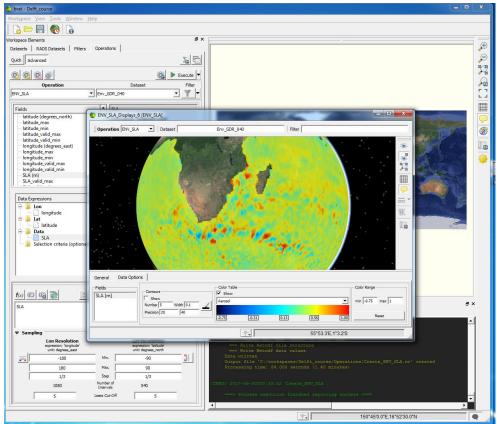
 Now create a new dataset and load the following file: "Env\_GDR\_040". This is an example available in the BRAT website. Visualise it.







#### Smooth



- Now create a new dataset and load the following file: "Env\_GDR\_040". This is an example available in the BRAT website. Visualise it.
- Now do the same and add the Loess cut-off filter with values set to 5. Reduce SLA range to [-0.75, 1] and you should get a map like the one shown here.

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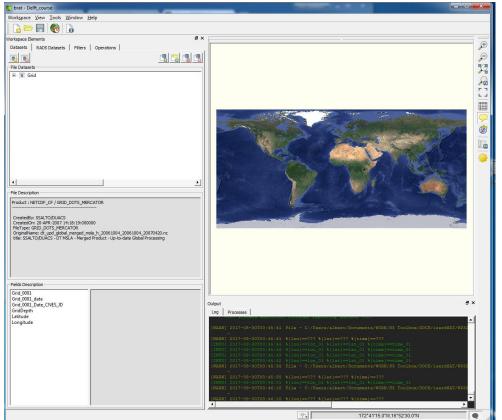
- 1. BRAT project
- 2. Along-track data
- 3. Gridded data
- 4. Wind and waves
- 5. Waveforms







#### Mean and standard deviation



- Gridded data are the result of converting altimeter measurements (individual tracks), that can come from different missions, into a regular grid of calculated, hypothetical values.
- Create a new dataset by clicking on Add Dir... and choose "/Grid/". These data is also available in the BRAT website.

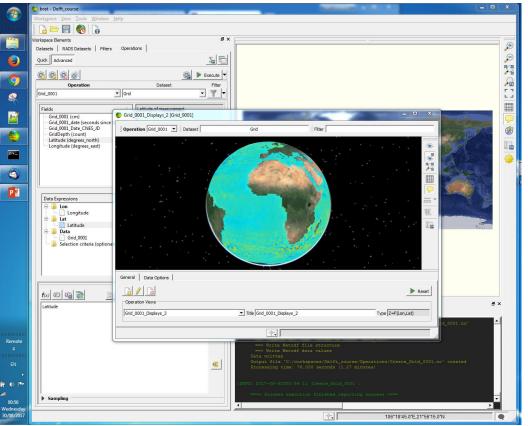
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#### Mean and standard deviation



- These 4 files that contain precomputed SLA over a year.
- Create a 3D operation with longitude, latitude and 'Grid\_0001(cm)' and visualise it.

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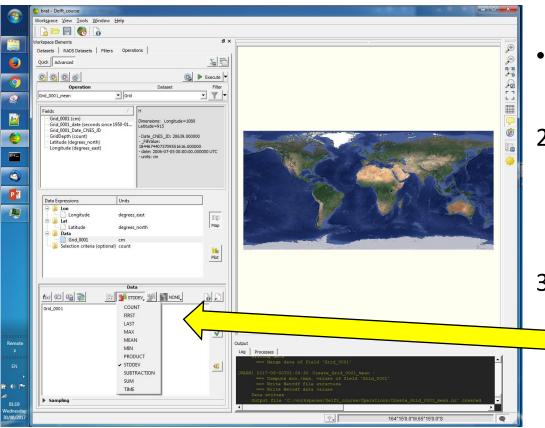
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#### Mean and standard deviation



- These 4 files that contain precomputed SLA over a year.
- Create a 3D operation with longitude, latitude and 'Grid\_0001(cm)' and visualise it.
- 3. After that, go back to the Operations tab and select
  STDDEV instead of MEAN. This will create the standard deviation of the input files. Visualise it too.

S

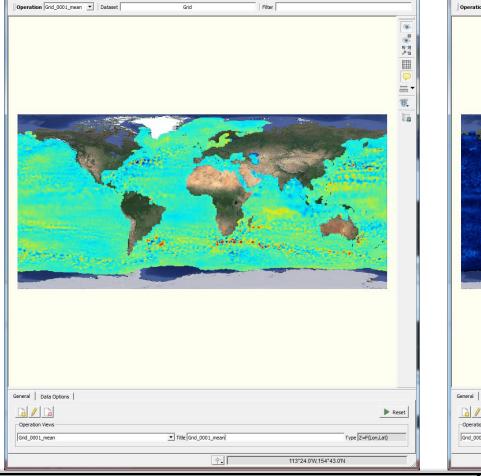
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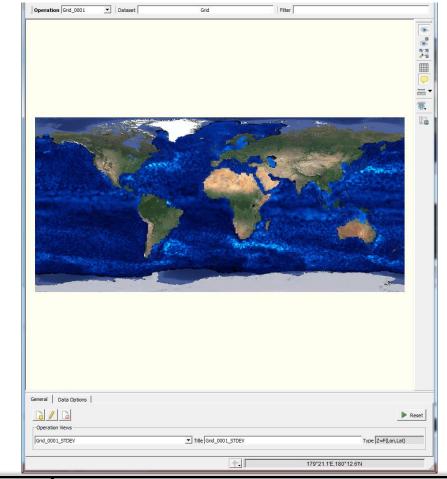




#### Mean



#### Standard deviation



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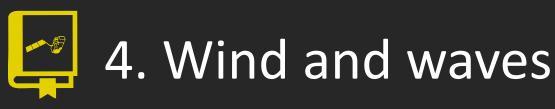
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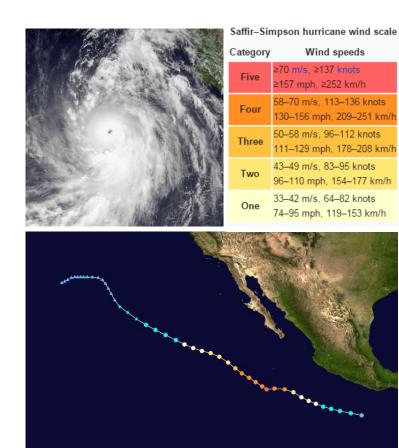
- 1. BRAT project
- 2. Along-track data
- 3. Gridded data
- 4. Wind and waves
- 5. Waveforms







Hurricane Marie

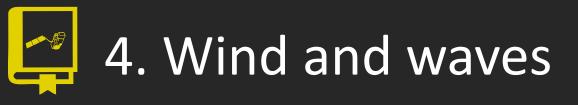


- In August 24-28 2014, Hurricane Marie hit the west coast of California and Mexico.
- It was classified as a Category 5 hurricane, since it reached peak sustained winds of 260 km/h.
- Bottom picture shows its track during this maximum-intensity 5 days.

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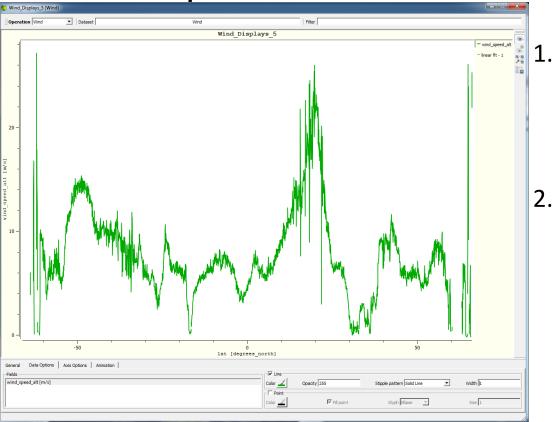
 This hurricane was also observed with altimetry.

Image Source: Wikipedia





Wind speed



Load the file "JA2\_GPR\_2PdP226\_130\_2014 0826\_024007\_20140826\_0336 20.nc".

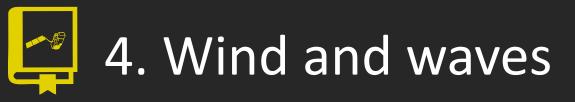
 Visualise the wind speed in a 2D plot. Up to almost 100 km/h were measured by Jason-2.

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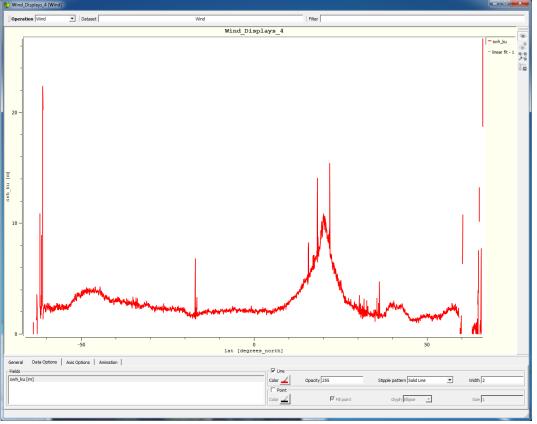
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• Significant Wave Height (SWH)



- 3. Now create another operation and visualise the SWH of the same file.
  - The highest peaks could be outliers, but the satellite measured waves of more than 10 m.







- 1. BRAT project
- 2. Along-track data
- 3. Gridded data
- 4. Wind and waves
- 5. Waveforms







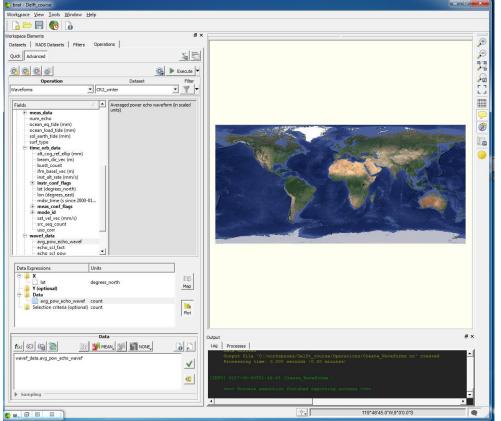
- Introduction
  - The toolbox also allows to go to almost the beginning of the processing of altimetry: waveforms.
  - Waveforms are the echoes that the altimeter receives back from the observed surface.
  - After L1B processing, retrackers are used to retrieve SSH, SWH, etc. from the resulting L1B waveforms.







#### Winter-Summer variations in Qinghai lake



- Create a new dataset with the CryoSat L1B file from February 2011 over the Qinghai lake, China.
- Set 'lat' as X and 'avg\_pow\_echo\_wavef' as Data from 'wavef\_data' tree.
- Execute. Change the "operation view" to Z=F(X,Y) on the bottom left.

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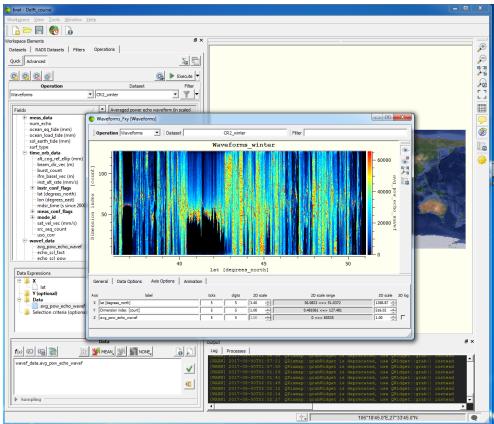
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Image Source: USGS-Landsat 8





#### • Winter



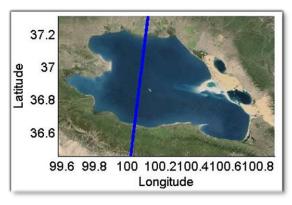
#### 1. Z=F(X,Y) view.

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- You will see a lot of noise. This is due to land contamination.
- 2. Instead of adding a filter, now narrow the latitude range (see figure below).

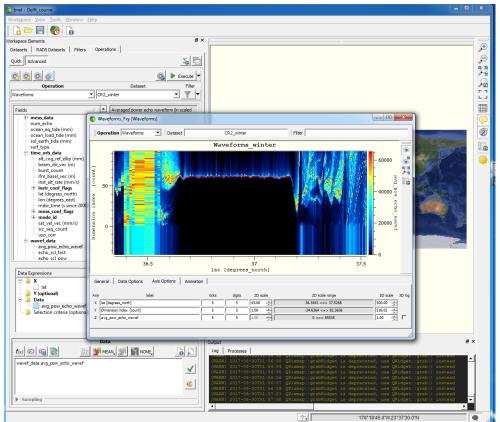


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#### Winter



- The plot looks completely different now. Note that the waveforms are only a few samples long.
- This is because it is winter season and the lake is frozen. And frozen water is very specular.

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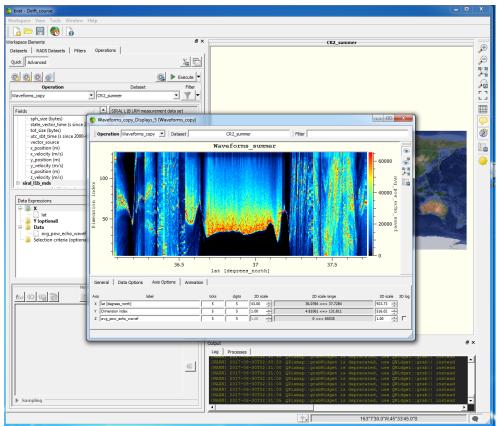
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#### • Summer



- Now load the other CryoSat file (July 2011) and compare them.
- Here, it is summer. The lake is not frozen and the waveforms are not so short and have a smooth transition to 0.
- Note that there are only 8 waveforms in this plot. If you try to do the 2D plot, you will see a shape like the following one.

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