ALES dataset in OpenADB

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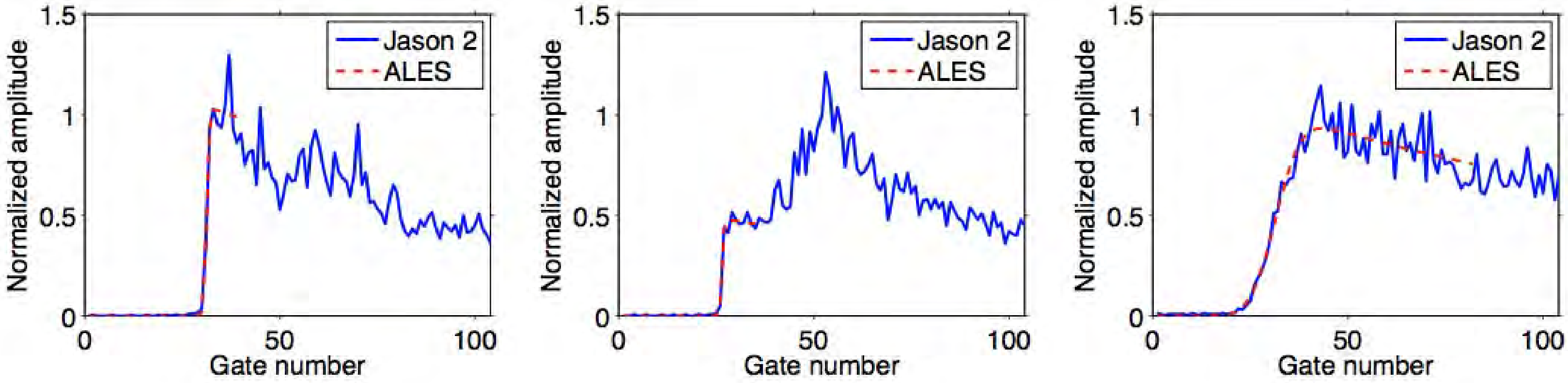
25 years of progress in radar altimetry - OSTST
24-29 September 2018
Ponta Delgada, Azores

What is ALES



The ALES product is, generally speaking, the name of a processing scheme for altimetry data, consisting in:

1) A dedicated re-fitting of the radar signal (retracking algorithm), since 2014
2) A dedicated „sea state bias“ correction, since 2017
3) The application over a multi-mission dataset, the post-processing to derive sea level and the cross-calibration (using MMXO method from Bosch et al., 2014)

Today, a global dataset for Jason-1 and Jason-2 is available at 1-Hz via direct download and at 20-Hz under request (also for Envisat and ERS-2) as easy-to-use already-corrected sea level estimations

Statistics

Jason-1

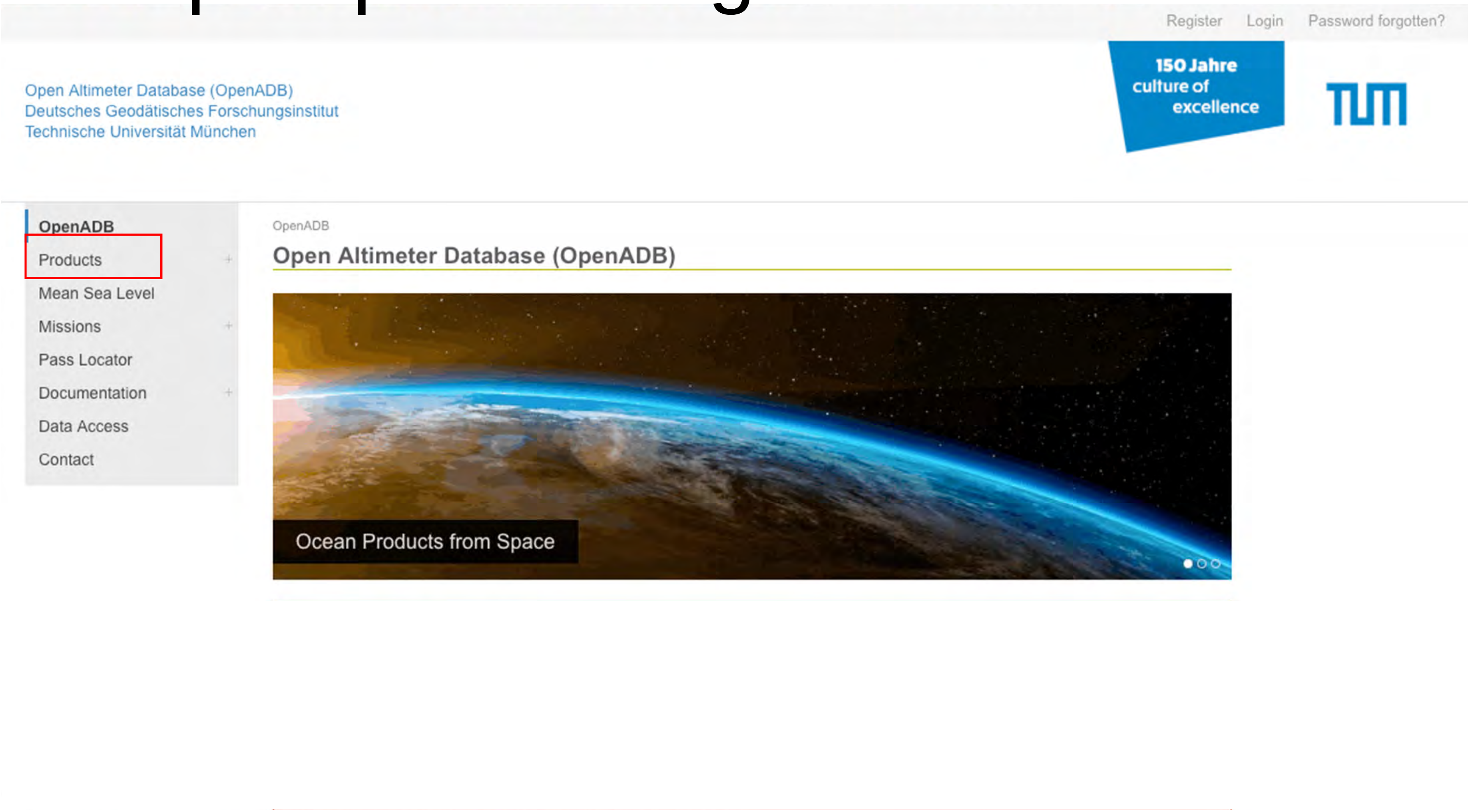
	Between 20 and 3 km from the coast	In the global ocean
Std ALES	22.09 cm	7.99 cm
Std SGDR	25.41 cm	9.27 cm
Outliers XOs ALES	6060	14679
Outliers XOs SGDR	7248	20132

	Between 20 and 3 km from the coast	In the global ocean
Std ALES	28.66 cm	8.17 cm
Std SGDR	29.92 cm	9.86 cm
Outliers XOs ALES	6104	12773
Outliers XOs SGDR	8589	20245

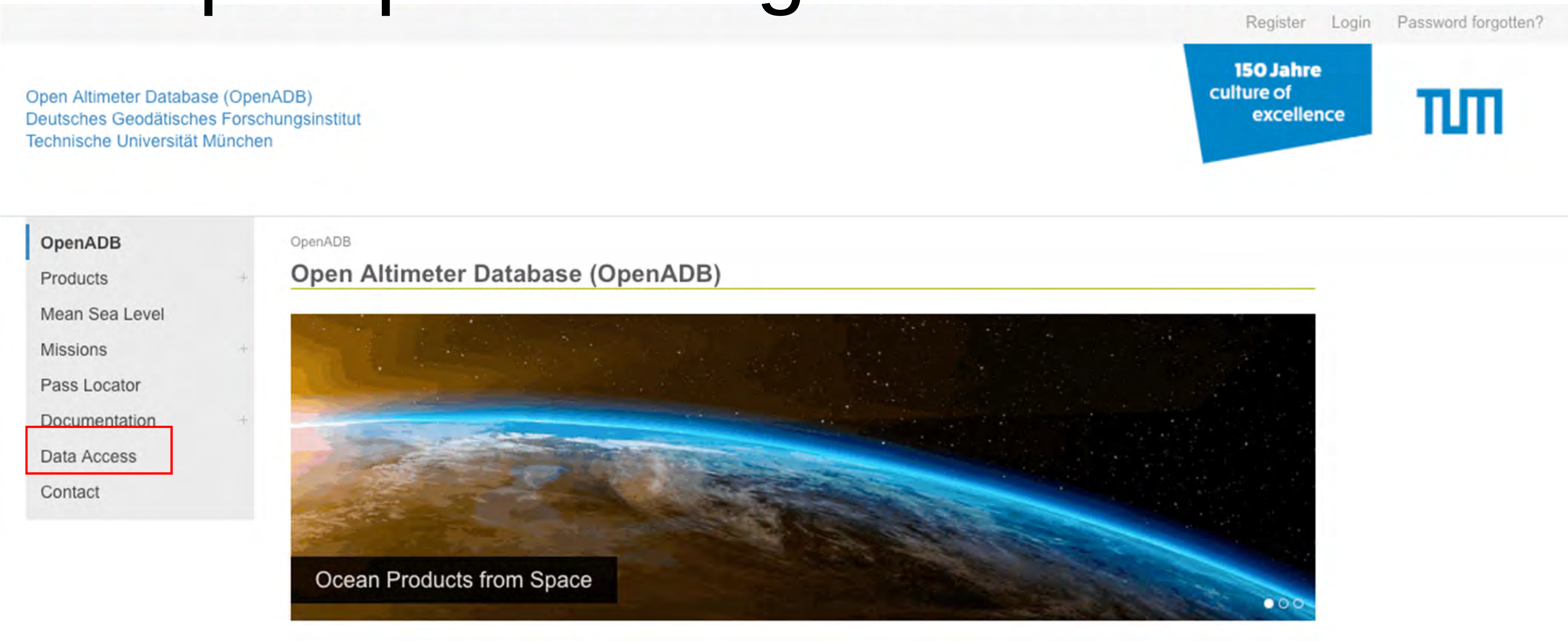
Jason-2

ALES brings improvements in data quality and quantity compared to current standards (see global validation in references)

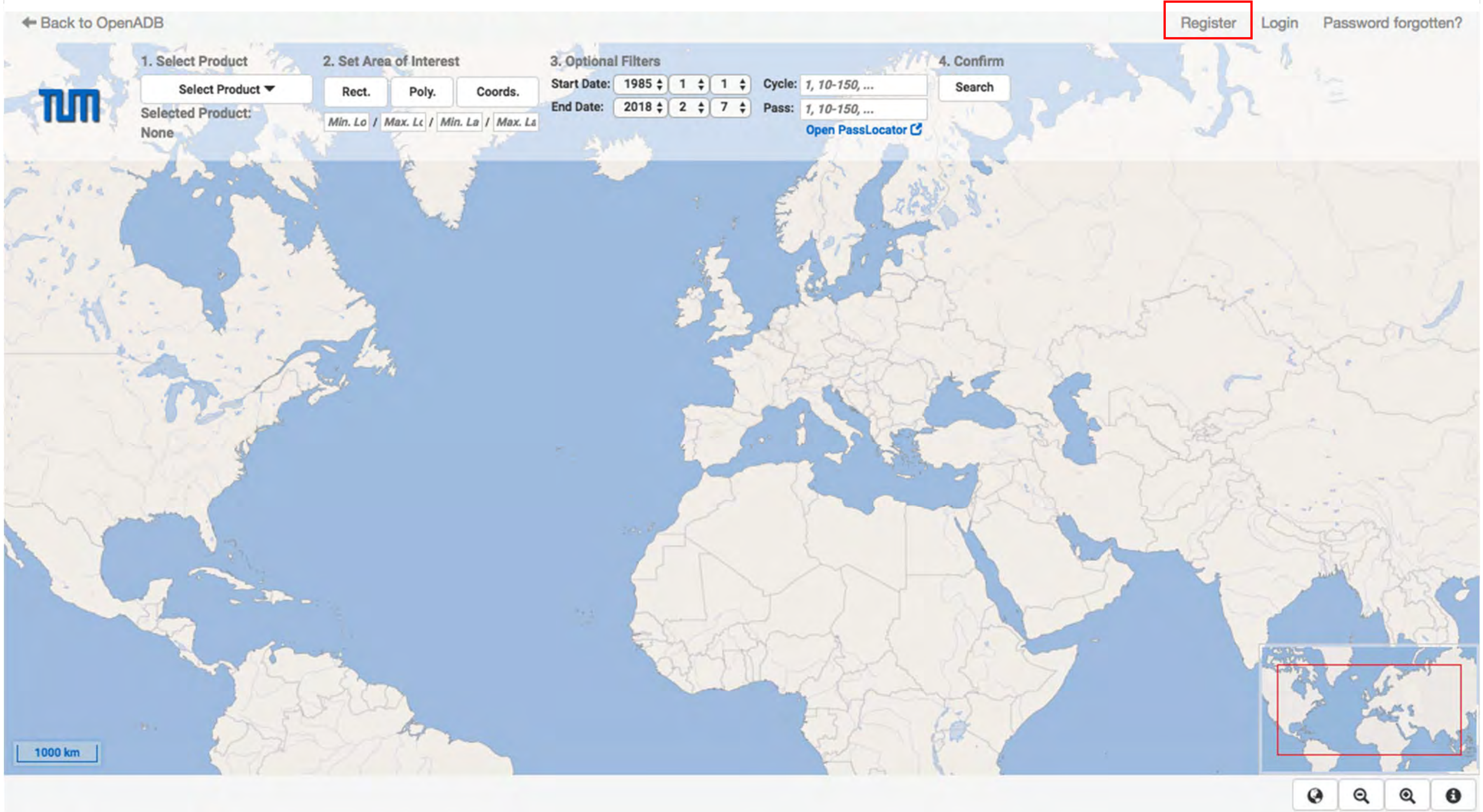
OpenADB – Product Information http://openadb.dgfi.tum.de/



OpenADB – Data Access
http://openadb.dgfi.tum.de/

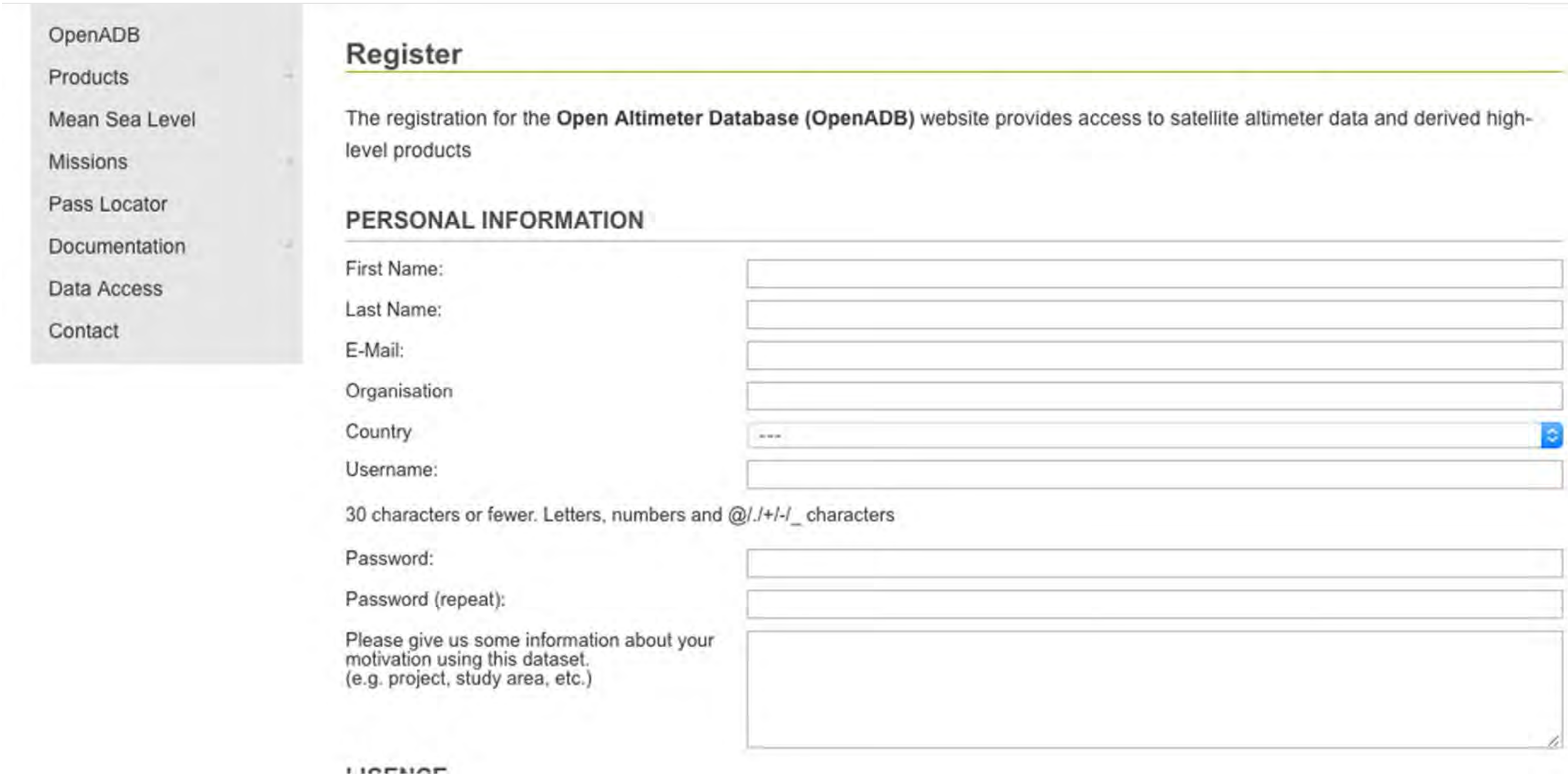


Data Access



Back to OpenADB
Register
Login
Password forgotten?
1. Select Product
Select Product
Selected Product:
None
2. Set Area of Interest
Rect.
Poly.
Coords.
3. Optional Filters
Start Date: 1985 1 1
End Date: 2018 2 7
Cycle: 1, 10-150, ...
Pass: 1, 10-150, ...
Open PassLocator
4. Confirm
Search
1000 km

Data Access - Register


OpenADB
Products
Mean Sea Level
Missions
Pass Locator
Documentation
Data Access
Contact

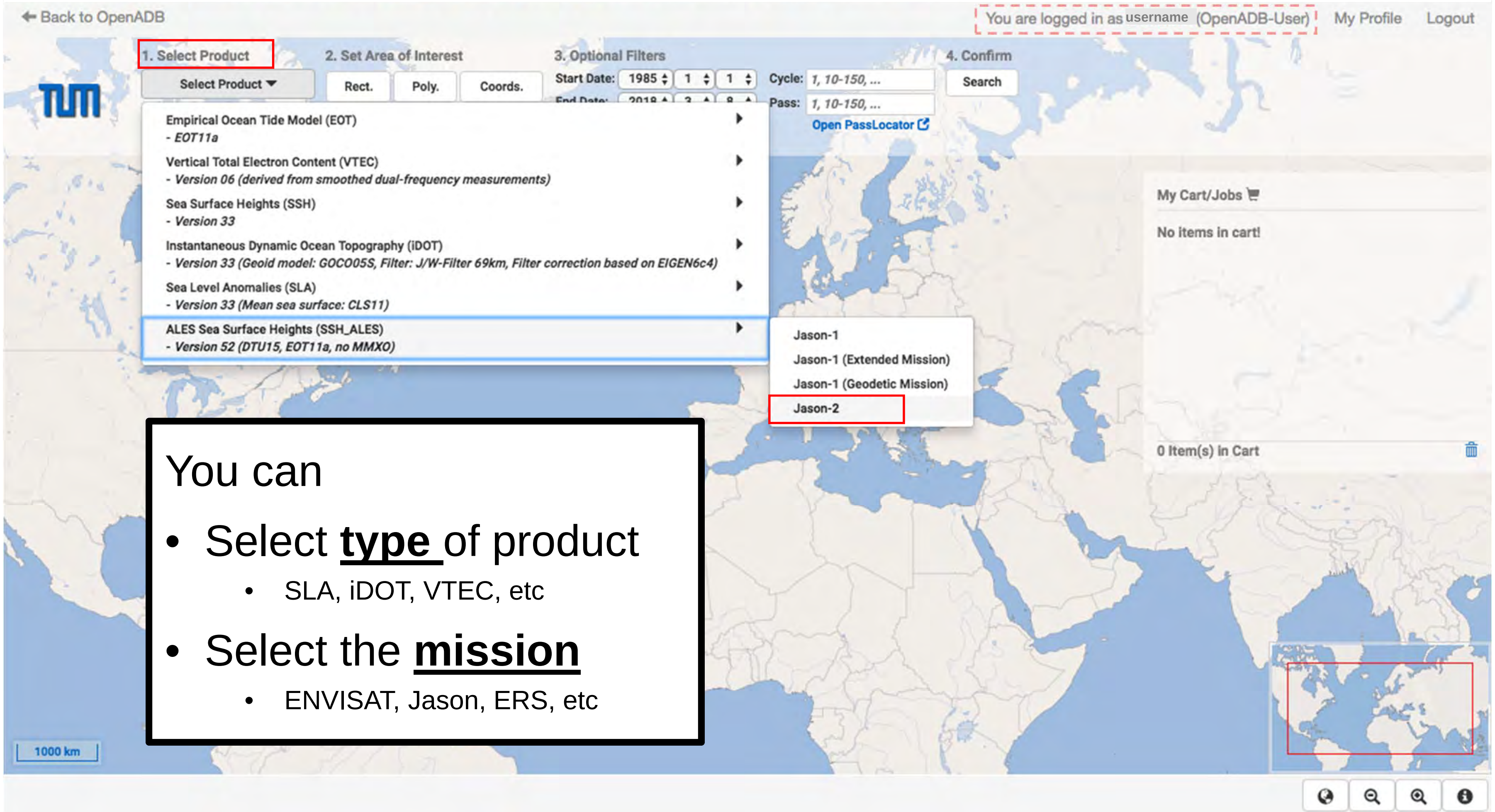
Register

The registration for the **Open Altimeter Database (OpenADB)** website provides access to satellite altimeter data and derived high-level products

PERSONAL INFORMATION

First Name:
Last Name:
E-Mail:
Organisation
Country ---
Username:
30 characters or fewer. Letters, numbers and @/./+/-/_ characters
Password:
Password (repeat):
Please give us some information about your motivation using this dataset.
(e.g. project, study area, etc.)

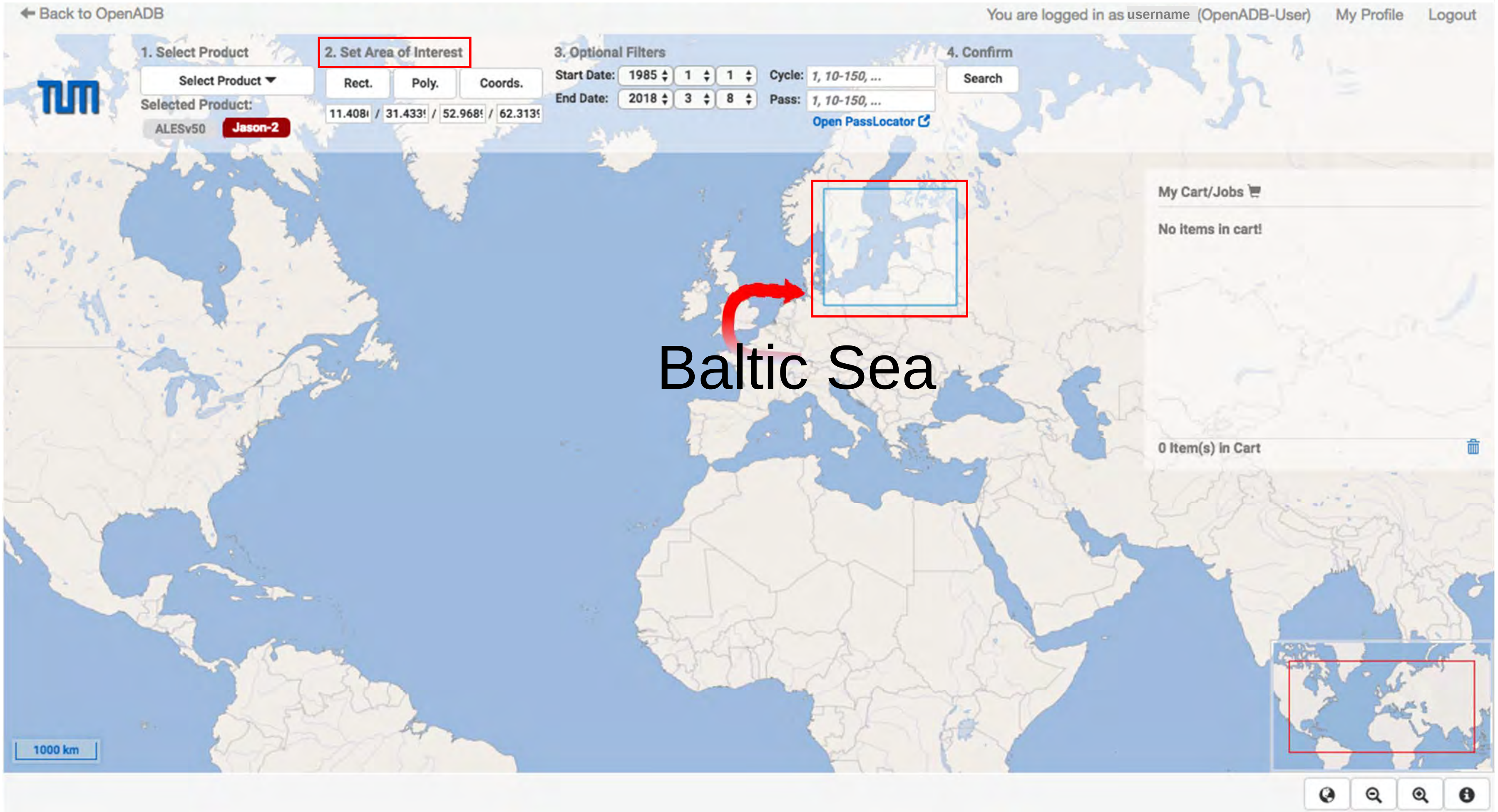
1. Select Product



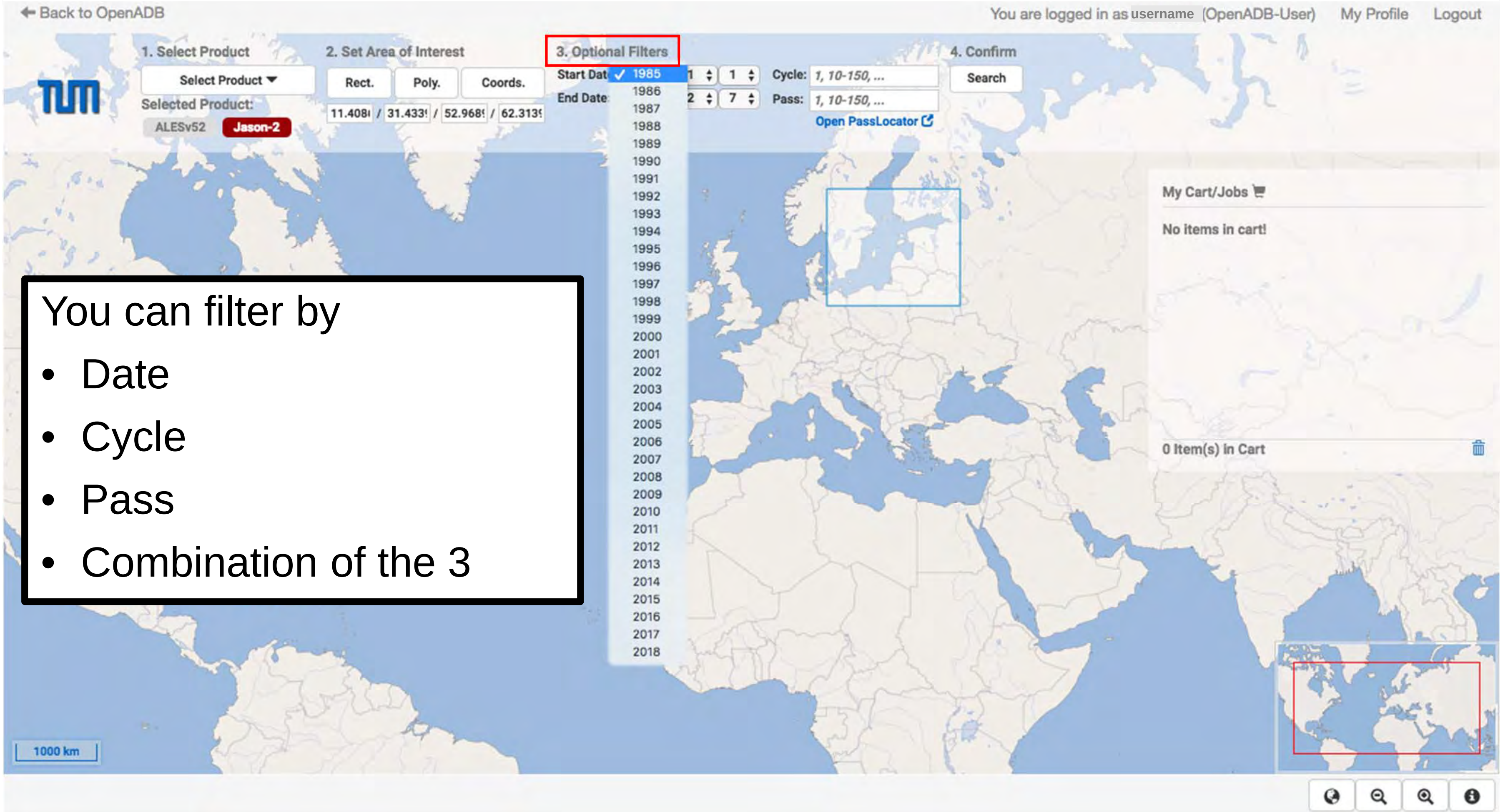
You can

- Select **type** of product
  - SLA, iDOT, VTEC, etc
- Select the **mission**
  - ENVISAT, Jason, ERS, etc

2. Area of Interest



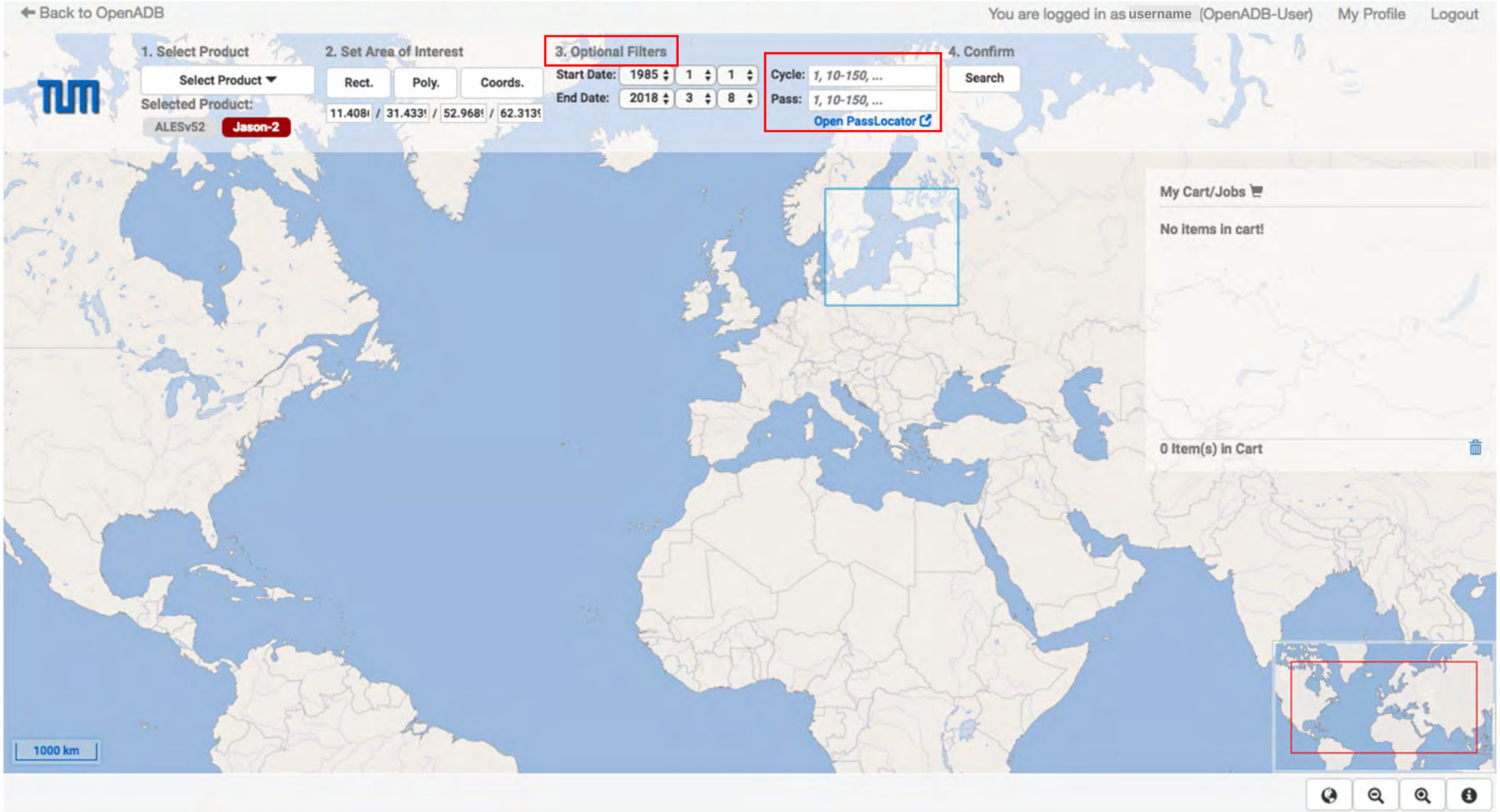
3. Optional Filters



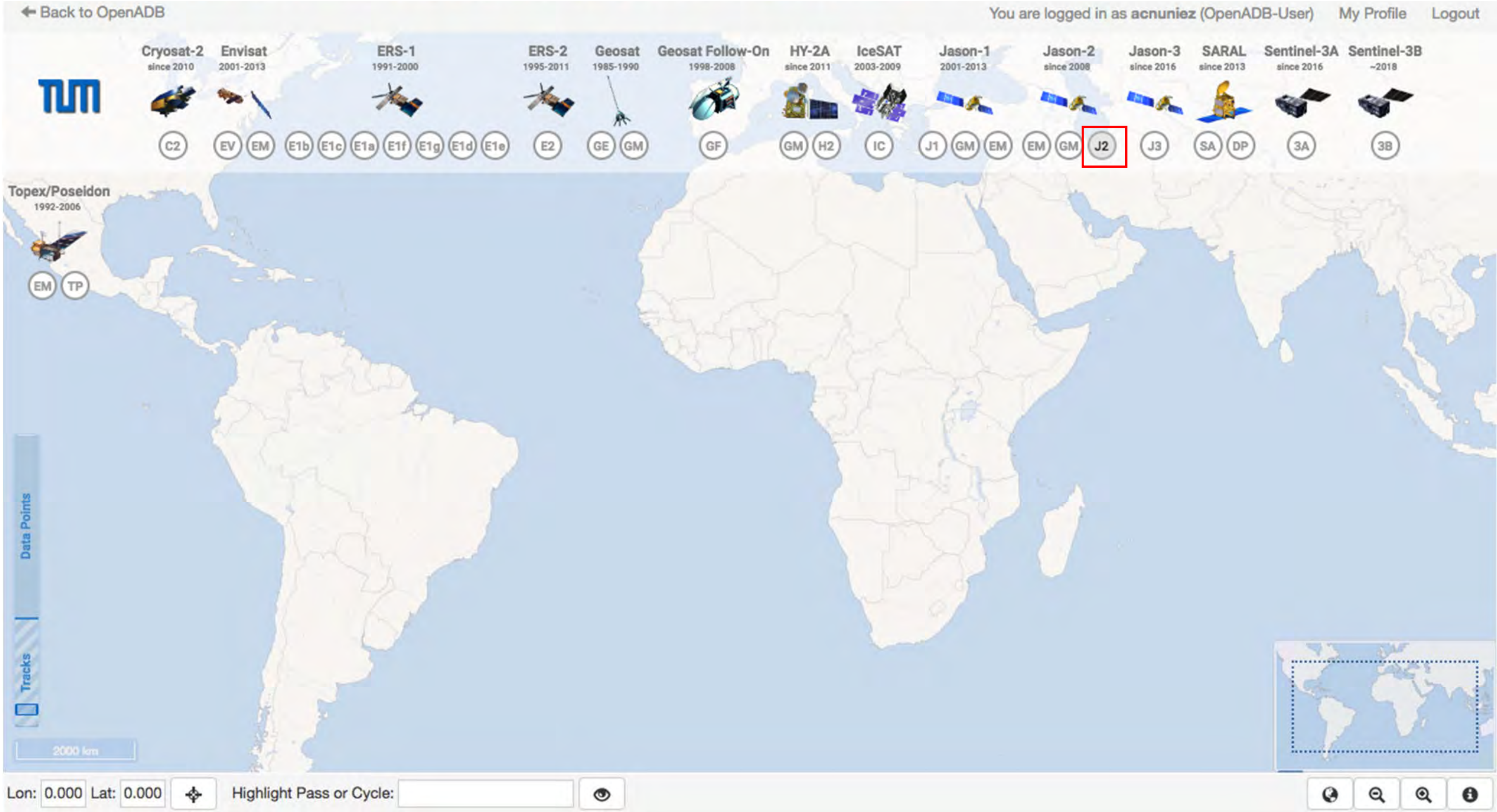
You can filter by

- Date
- Cycle
- Pass
- Combination of the 3

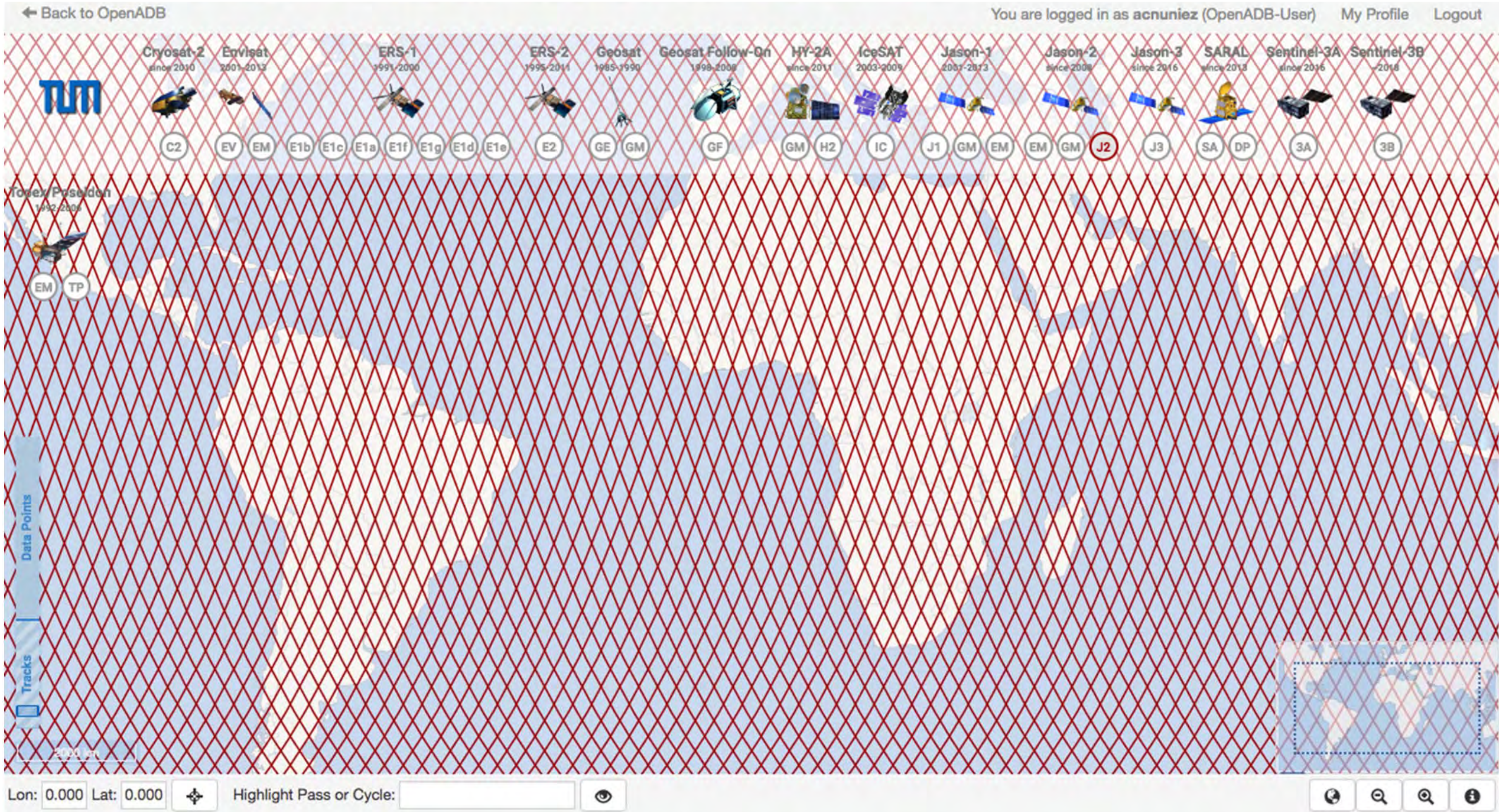
3. Optional Filters



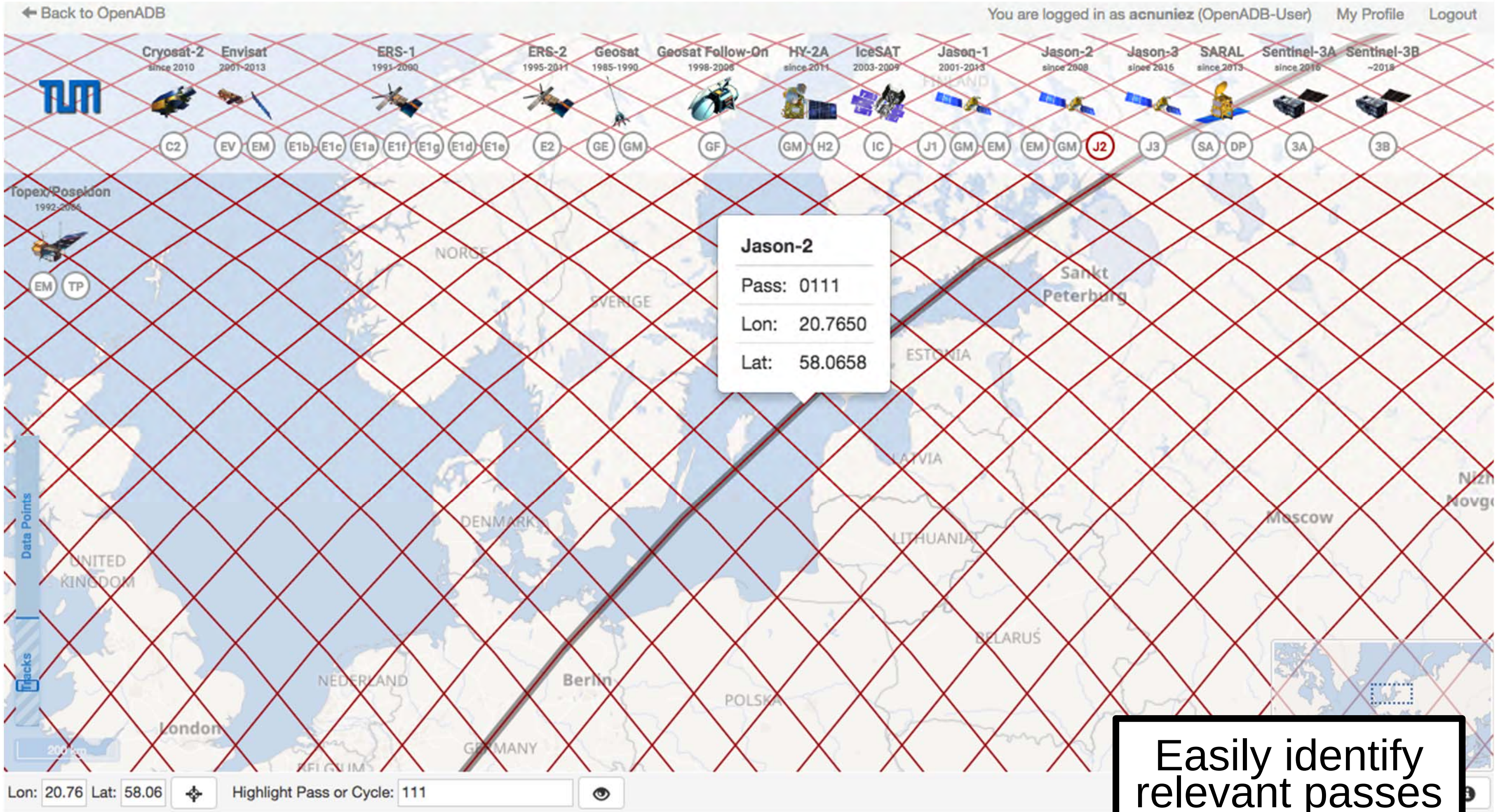
3. Optional Filters – Pass Locator



3. Optional Filters – Pass Locator

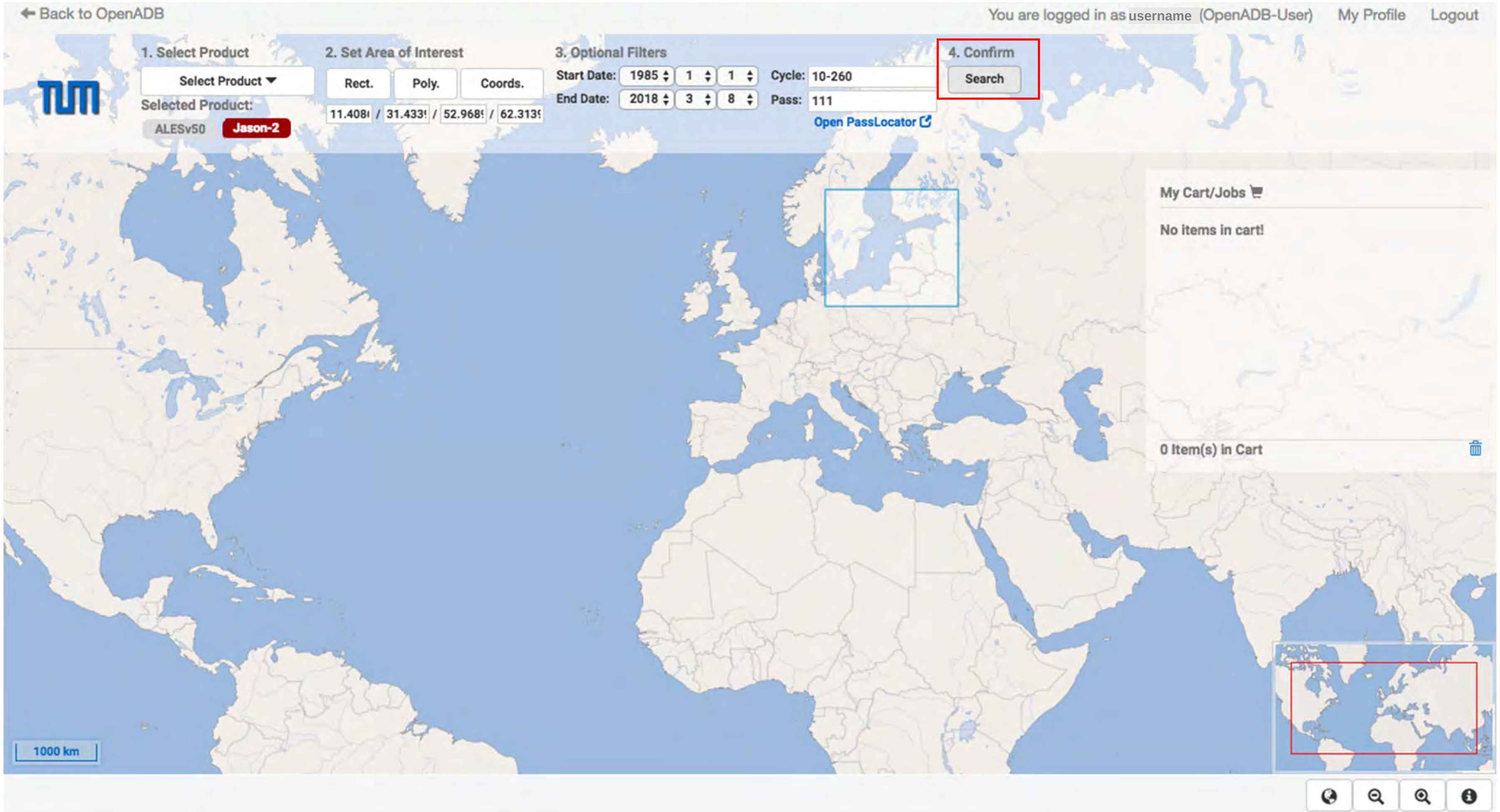


3. Optional Filters – Pass Locator

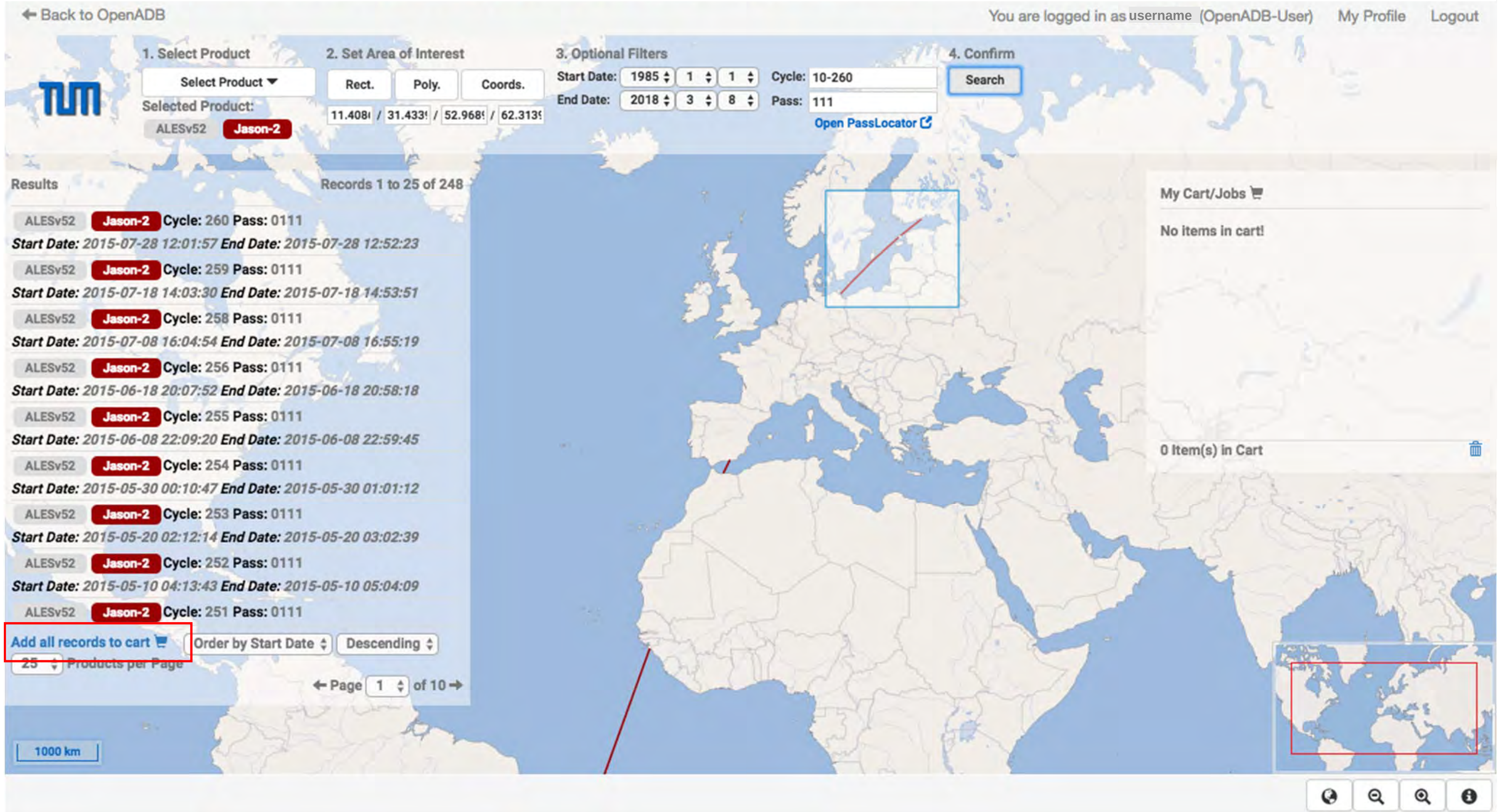


Easily identify relevant passes

4. Confirm Search

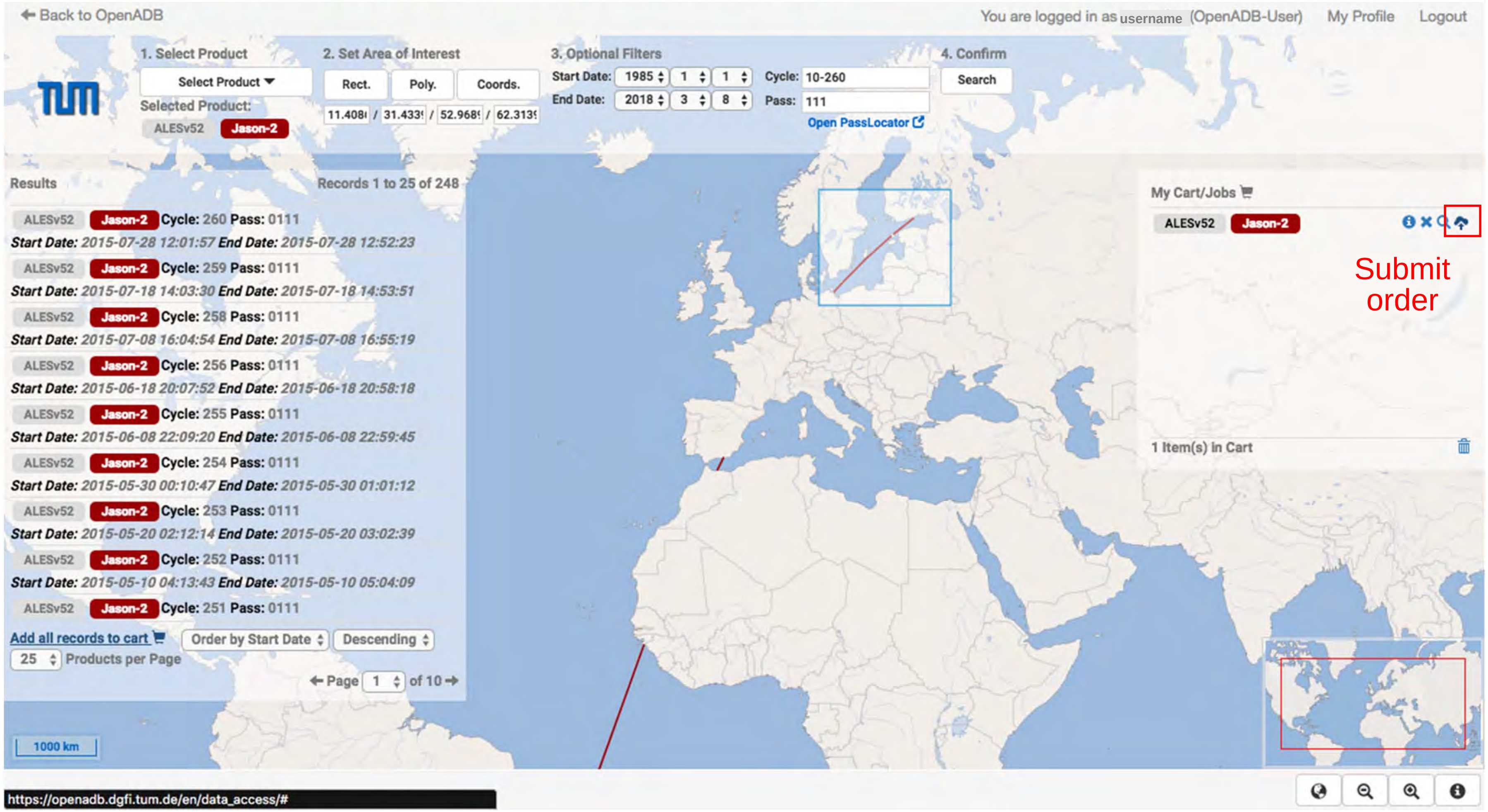


5. Add to Cart



Back to OpenADB
You are logged in as username (OpenADB-User)
My Profile
Logout
1. Select Product
Select Product
Selected Product:
ALESv52
Jason-2
2. Set Area of Interest
Rect.
Poly.
Coords.
3. Optional Filters
Start Date: 1985 1 1
End Date: 2018 3 8
Cycle: 10-260
Pass: 111
Open PassLocator
4. Confirm
Search
Results
Records 1 to 25 of 248
ALESv52 Jason-2 Cycle: 260 Pass: 0111
Start Date: 2015-07-28 12:01:57 End Date: 2015-07-28 12:52:23
ALESv52 Jason-2 Cycle: 259 Pass: 0111
Start Date: 2015-07-18 14:03:30 End Date: 2015-07-18 14:53:51
ALESv52 Jason-2 Cycle: 258 Pass: 0111
Start Date: 2015-07-08 16:04:54 End Date: 2015-07-08 16:55:19
ALESv52 Jason-2 Cycle: 256 Pass: 0111
Start Date: 2015-06-18 20:07:52 End Date: 2015-06-18 20:58:18
ALESv52 Jason-2 Cycle: 255 Pass: 0111
Start Date: 2015-06-08 22:09:20 End Date: 2015-06-08 22:59:45
ALESv52 Jason-2 Cycle: 254 Pass: 0111
Start Date: 2015-05-30 00:10:47 End Date: 2015-05-30 01:01:12
ALESv52 Jason-2 Cycle: 253 Pass: 0111
Start Date: 2015-05-20 02:12:14 End Date: 2015-05-20 03:02:39
ALESv52 Jason-2 Cycle: 252 Pass: 0111
Start Date: 2015-05-10 04:13:43 End Date: 2015-05-10 05:04:09
ALESv52 Jason-2 Cycle: 251 Pass: 0111
Add all records to cart
Order by Start Date
Descending
25 Products per Page
Page 1 of 10
My Cart/Jobs
No items in cart!
0 Item(s) in Cart
1000 km

6. Submit Order



OpenADB – Jobs (Orders)

OpenADB › My Jobs

My Jobs

Notice: All existing Jobs from the former OpenADB version will be convert to the new version soon.

Every job will be deleted automatically 30 days after submission!
All submitted jobs will be processed in a row.

3004	**ALES Sea Surface Heights (SSH_ALES)** *Version 52 (DTU15, EOT11a, no MMXO)* *Mission: Jason-2 (1 Hz) - Cycle(s): 10-260 - Pass(es): 111*	*2018-03-02 15:24:28* Download (1.6 MB) - Details	finished

It only takes ~ 10 minutes for your order to be ready

OpenADB - Data

- Provided along-track
- Sequential structure following hierarchy mission-cycle-pass
- Measurements already corrected
- Possible to merge and combine the products of different missions
- Data Format: NetCDF

```
Range Bias:
mean Jason-2 = -0.060350 +- 0.004090 (# = 20) [m] (wrt. Jason-1)
```

Application Example

MATLAB: Mean Sea Surface Difference

- ncinfo

  - Filename
  - Name
  - Dimensions
  - Variables
  - Attributes
  - Groups
  - Format

- ncread

info.Variables

Fields	Name	Dimensions
1	'jday.00'	*1x1 struct*
2	'glon.00'	*1x1 struct*
3	'glat.00'	*1x1 struct*
4	'ssh.50'	*1x1 struct*
5	'stdalt.05'	*1x1 struct*
6	'swh.05'	*1x1 struct*
7	'mssh.05'	*1x1 struct*
8	'otide.15'	*1x1 struct*
9	'ltide.15'	*1x1 struct*
10	'distance....	*1x1 struct*
11	'sflag.50'	*1x1 struct*
12	'oflags.00'	*1x1 struct*
13	'iflags.05'	*1x1 struct*

ALES product Variables

Application Example

MATLAB: Suggested data editing

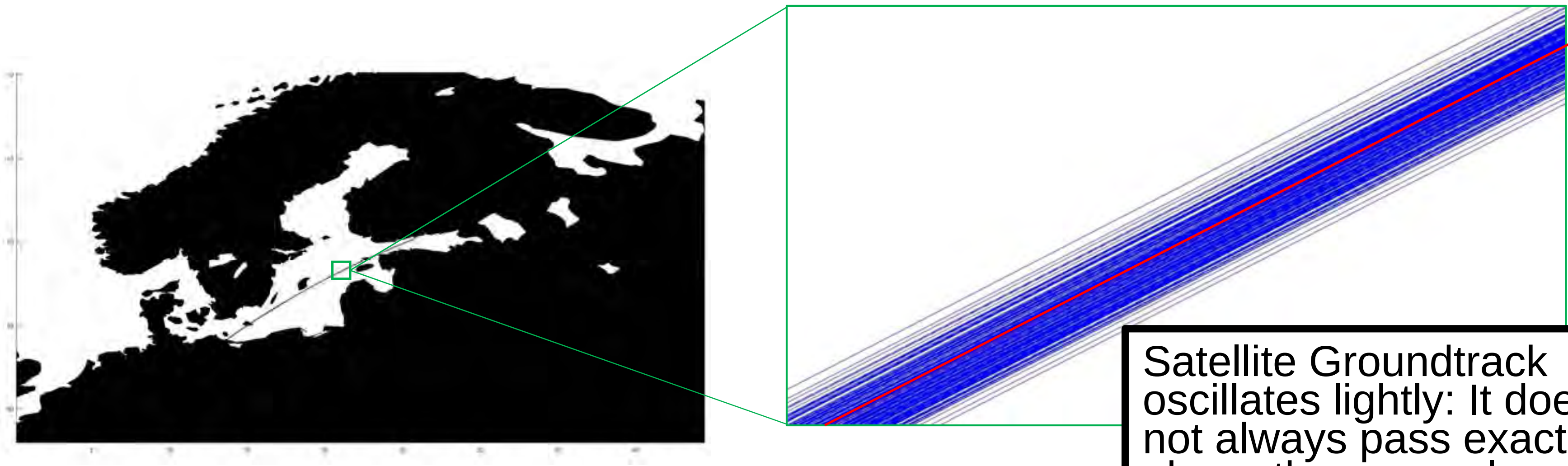
```matlab
% Read nc files
ncfile = fullFileName ;
info=ncinfo(ncfile);

% Create matrix with the nc file variables
for i=1:length(info.Variables)
    VAR=info.Variables(i).Name;
    myvar(:,i) = ncread(ncfile,VAR) ;
end

% Cycles= Rows, Passes = Columns
MAT{k,1}=myvar;
myvar=[];
```

```matlab
%% Filter Data
for i=1:length(MAT)
    %Filter SWH < 0, SWH > 11
    [s,~]=find(MAT{i}(:,6)>11 | MAT{i}(:,6)<0);
    MAT{i}(s,:)=[];
    %Filter Distance < 3
    [d,~]=find(MAT{i}(:,10)<3);
    MAT{i}(d,:)=[];
    %Filter Std. Range > .2
    [t,~]=find(MAT{i}(:,5)>.2);
    MAT{i}(t,:)=[];
end
```

Application Example
MATLAB: Mean Sea Surface Difference

- Compare MSS from a Model vs MSS from ALES Product from OpenADB
    - We can compute our own Along-Track Mean Sea Surface taking into account data close to the coast with ALES Product data

1. First: Choose ”Central” Pass



Satellite Groundtrack oscillates lightly: It does not always pass exactly above the same place

Application Example

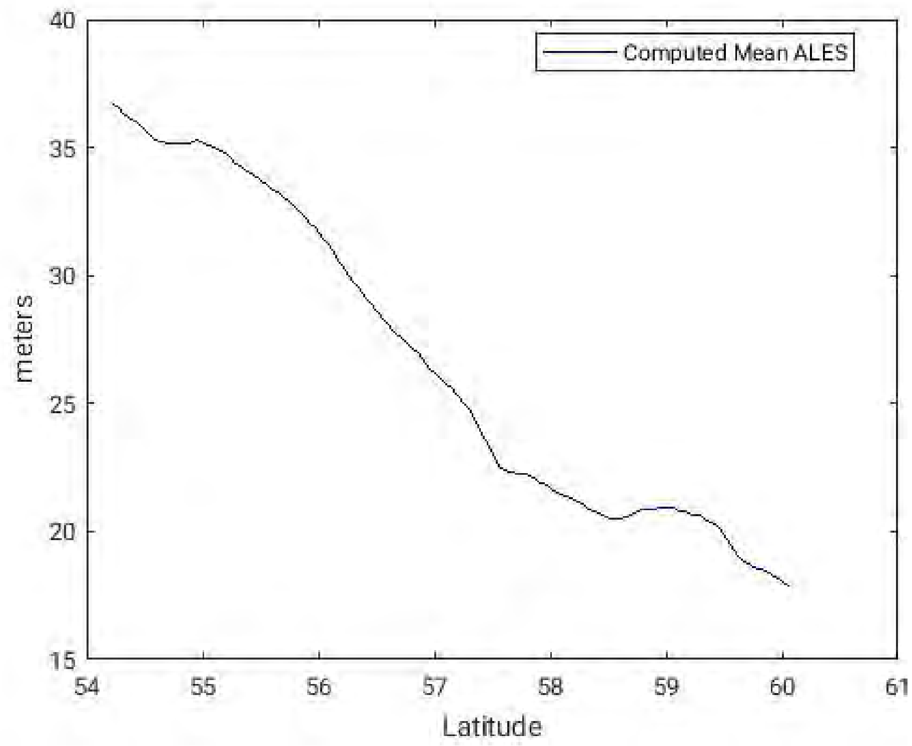
MATLAB: Mean Sea Surface Difference

2. Interpolate the data onto chosen Pass

3. Average to obtain the Mean Sea Surface

The Mean Sea Surface represents the sea level due to constant phenomena.

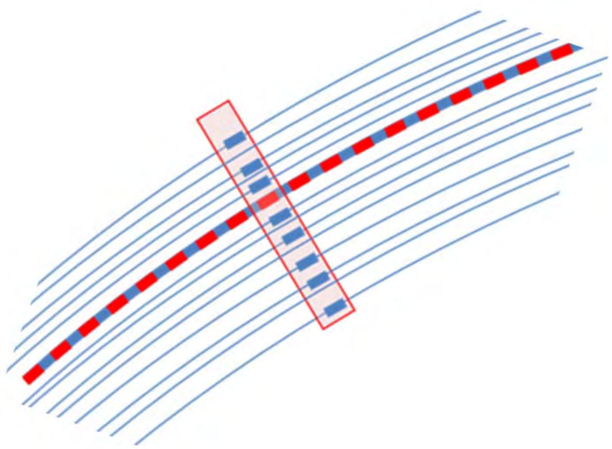
Geoid and Mean Sea Surface are similar, since the sea surface conforms to the earth‘s gravitational potential.
But the geoid is ‚the ocean at rest‘, the shape that the ocean would have if the waters were redistributing only due to gravity and rotation.
The mean sea surface corresponds to the sum of geoid + mean ocean circulation.



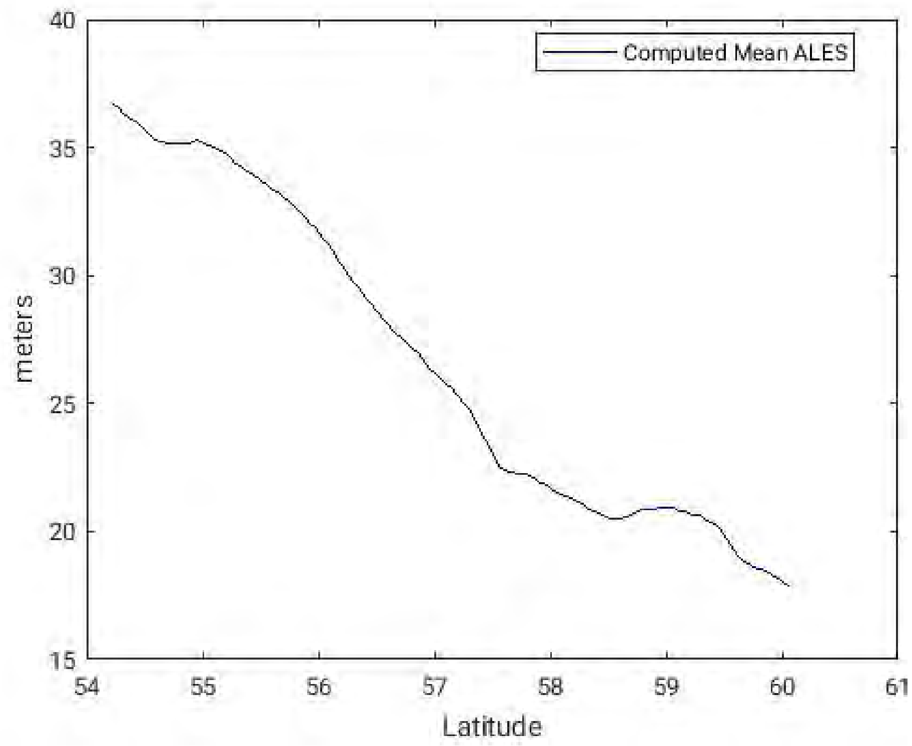
Application Example

MATLAB: Mean Sea Surface Difference

2. Interpolate the data onto chosen Pass



3. Average to obtain the Mean Sea Surface

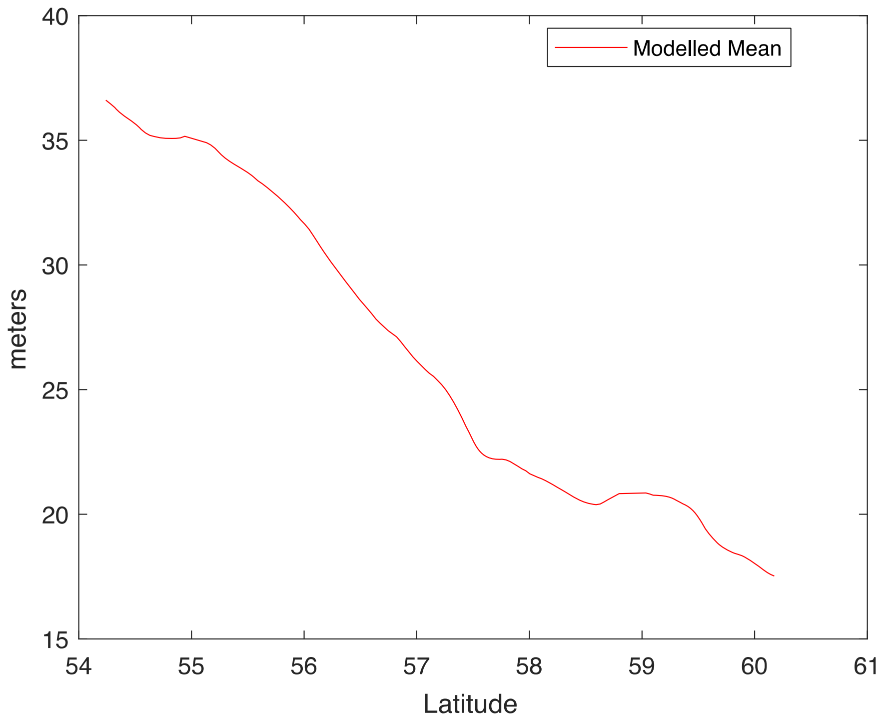


Application Example
MATLAB: Mean Sea Surface Difference

- Variable 7 contained in ALES data = Modelled Mean Sea Surface

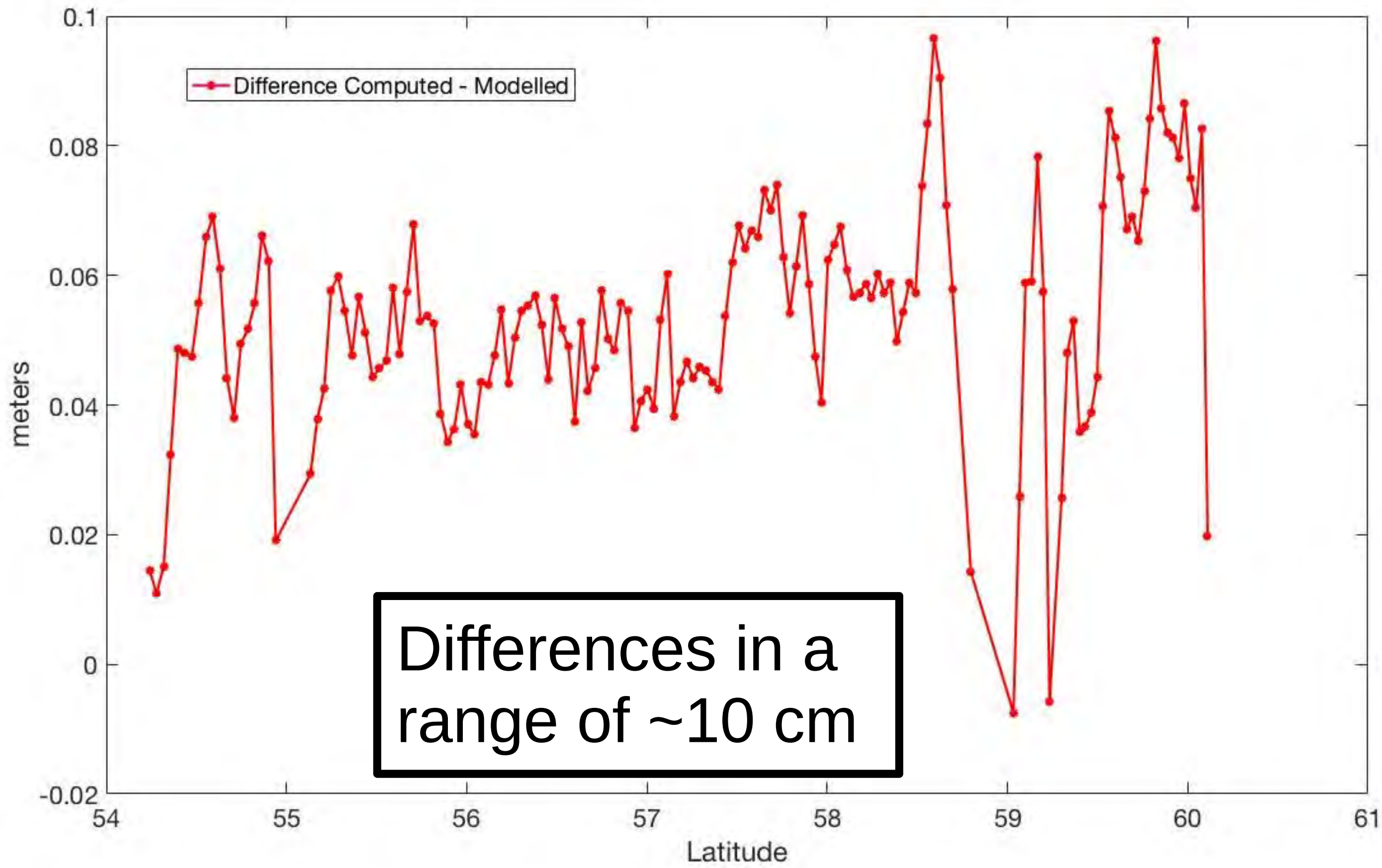
info.Variables

Fields	Name	Dimensions
1	'jday.00'	1x1 struct
2	'glon.00'	1x1 struct
3	'glat.00'	1x1 struct
4	'ssh.50'	1x1 struct
5	'stdalt.05'	1x1 struct
6	'swh.05'	1x1 struct
7	'mssh.05'	1x1 struct
8	'otide.15'	1x1 struct
9	'ltide.15'	1x1 struct
10	'distance....	1x1 struct
11	'sflag.50'	1x1 struct
12	'oflags.00'	1x1 struct
13	'iflags.05'	1x1 struct

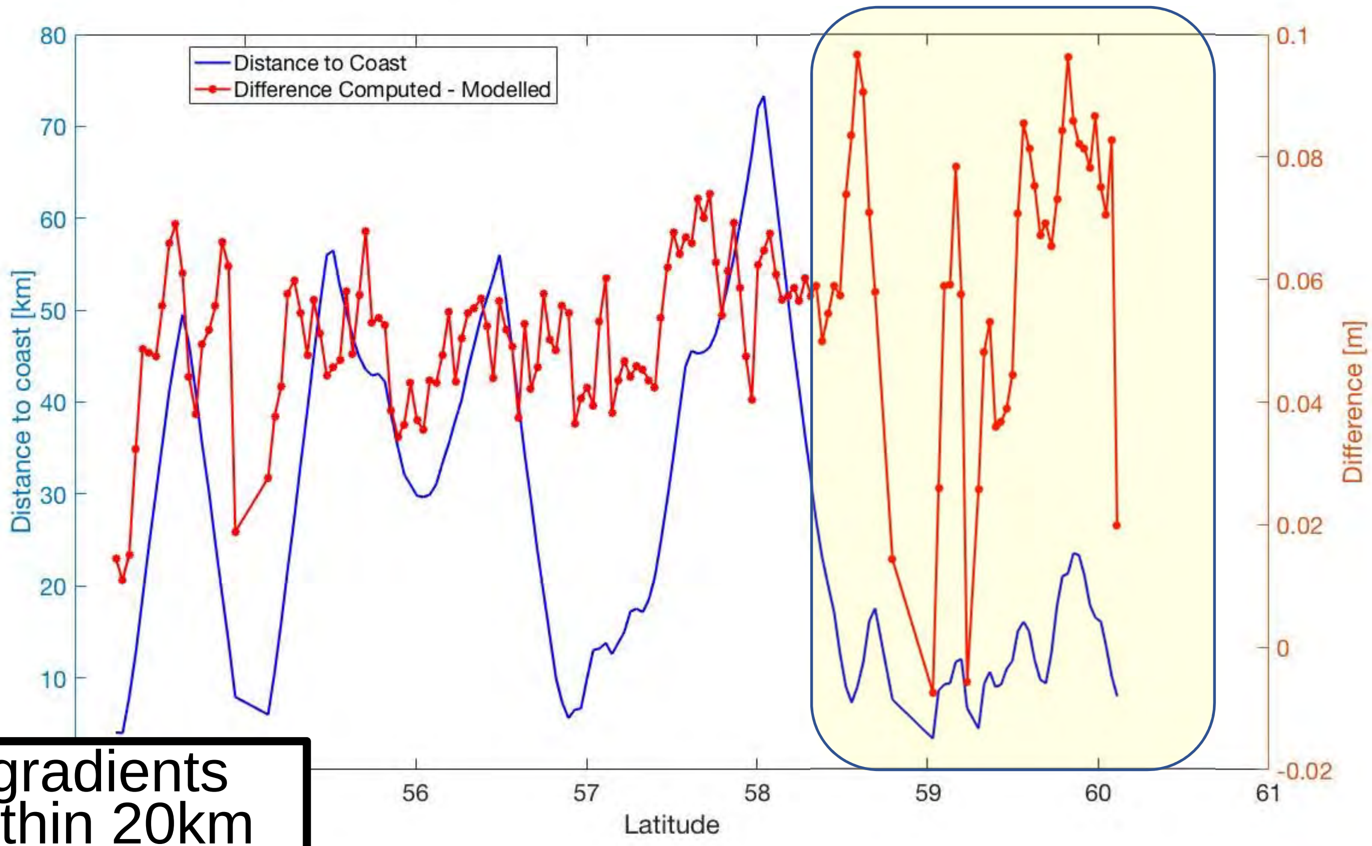


Application Example

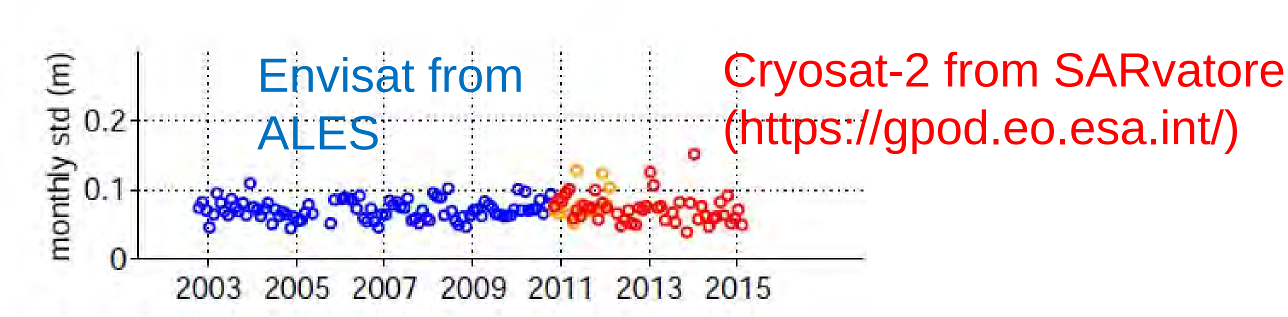
MATLAB: Mean Sea Surface Difference



Application Example
MATLAB: Mean Sea Surface Difference



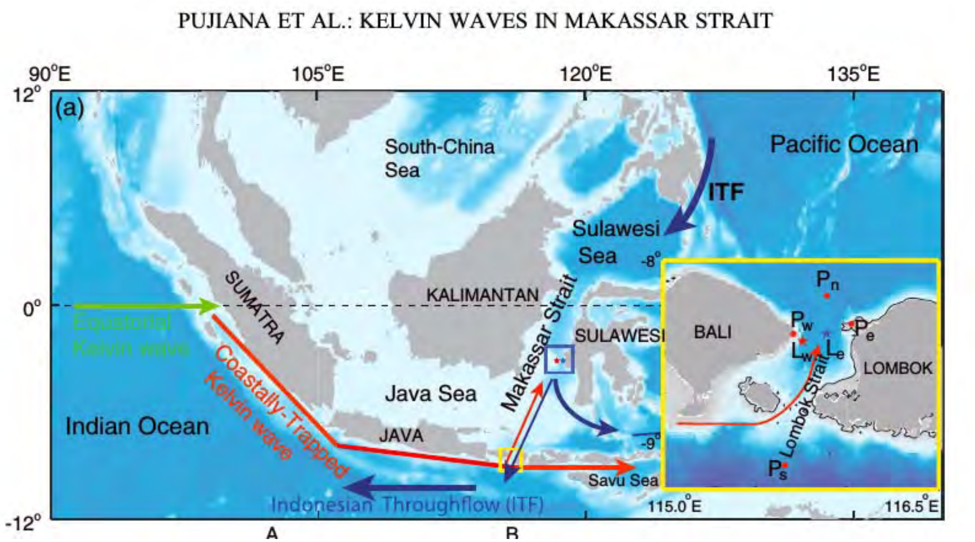
Larger gradients seen within 20km of the coast!



Example of application from Passaro et al. 2016

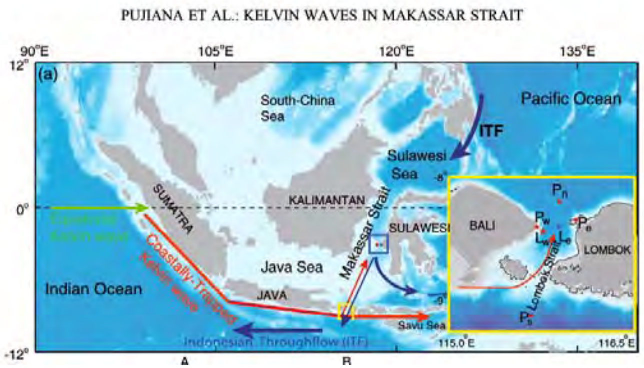
Study focus: seasonalities of the internal seas of the Indonesian Archipelago

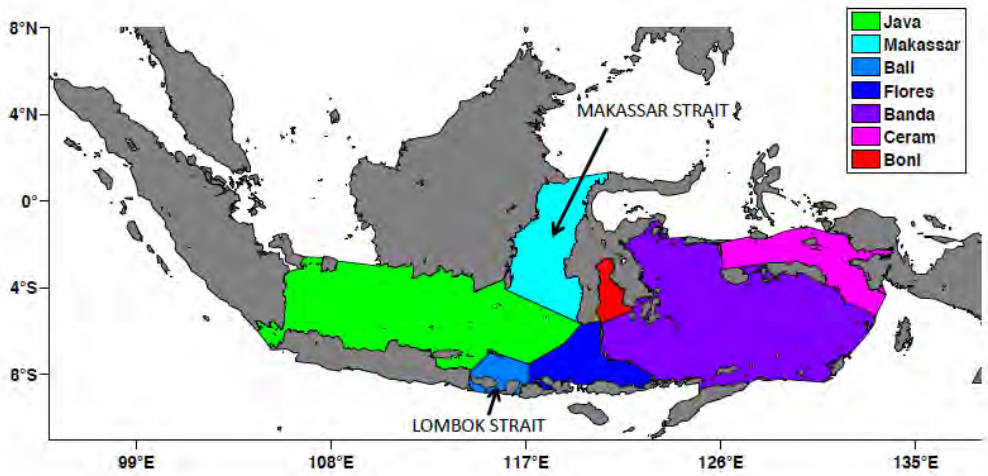
Pujiana, K., Gordon, A. L., and Sprintall, J. (2013). Intraseasonal Kelvin wave in Makassar Strait. J. Geophys. Res.-Oceans, 118(4), 2023–2034.



	Java	Flores	Banda	Ceram
Trend (mm/y)	2.9±2.0	2.9±2.4	1.7±4.2	3.3±3.2
Ann Ampl (mm)	52.3±10.6	59.1±10.1	79.1±10.1	78.4±11.8
Semi Ampl (mm)	26.7±6.8	4.2±6.3	2.8±5.9	6.3±7.4

Table 9: Trend, annual amplitude and semiannual amplitude of the multimission EnvB+CS2 time series for Java, Flores, Banda and Ceram seas.





Area of influence of the Kelvin Wave detected! (Moorings detected Kelvin wave path from Lombok to Makassar Strait [Pujiana et al. 2013]

Conclusions

Remember: how do I obtain the latest version of ALES data?

- you can directly download 1-Hz sea level data from ALES via http://openadb.dgfi.tum.de/
- you can contact us through the same website and request 20-Hz data of Jason-1, Jason-2, ERS-2, Envisat, Altika

Thanks for your attention!
Any questions?

Global validation of this dataset:

Passaro M., Smith W., Schwatke C., Piccioni G., Dettmering D.: **Validation of a global dataset based on subwaveform retracking: improving the precision of pulse-limited satellite altimetry**. 11th Coastal Altimetry Workshop, Frascati (ESA-ESRIN), Italy, 2018-06-15 (available from https://www.dgfi.tum.de/staff/passaro-marcello/)

Other Sources used in this presentation
[1] Unidata, (2012): Integrated Data Viewer (IDV) version 3.1 [software]. Boulder, CO: UCAR/Unidata. (http://doi.org/10.5065/D6RN35XM)
[2] https://visibleearth.nasa.gov/view.php?id=57752

THANKS FOR YOUR ATTENTION

"The naturalness of a superior human being consists in the harmony between what is man made and what is made by Nature.„

Freely translated from Fernando Pessoa, *Livro do Desassossego*

Opportunities for Talents

The Deutsches Geodätisches Forschungsinstitut (German Geodetic Research Institute) of the Technical University of Munich (DGFI-TUM) is accepting applications for a

PhD student (m/f) in the research area Satellite Altimetry

DGFI-TUM is hiring
Contact us and/or get a flyer: marcello.passaro@tum.de
Poster Zone: CVL_009, TID_005, TID_004, IPM_005

SPARE SLIDES

What is ALES

ALES:

1) Improves the quality and the quantity of sea level retrieval at the coast w.r.t. the current official products

2) Has been validated in a large number of papers and presentations

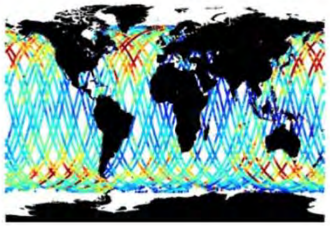
3) Algorithm description is published and has been re-coded and adapted to other scopes by other authors

4) Has been applied to observe sea level variability, improve the tidal models at the coast, …see also list of talks at the end of this presentation

Background

- A version of ALES data at 20-Hz within 50 km of the coast is available from PODAAC for Jason-2 and Envisat (currently no Sea State Bias correction): ftp://podaac.jpl.nasa.gov/allData/coastal_alt/L2/ALES/

- Jason-2 https://podaac.jpl.nasa.gov/dataset/ALES_L2_OST_JASON2_V1
- Envisat https://podaac.jpl.nasa.gov/dataset/ALES_L2_OST_ENVISAT_V1



ALES Jason-2 Coastal Altimetry Version 1

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https://podaac.jpl.nasa.gov/dataset/ALES_L2_OST_JASON2_V1

Please contact us if there are any discrepancies or inaccuracies found below.

Information | Data Access | Citation | Granule (File) Listing

DOI	Not Registered
Short Name	ALES_L2_OST_JASON2_V1
Description	Adaptive Leading Edge Subwaveform (ALES) provides coastal and open ocean altimetric measurements by applying a specialized retracker to Jason-2 data. This is an along-track dataset that takes takes the high frequency SGDR data and retracks it to remove the waveforms that show land contamination. Therefore these data are provided at 20 Hz. It is similar to the Jason-2 SGDR data except that it also includes ALES variables for the range, significant wave height and sigma0 so that the user can calculate the retracked SSHA.

Background

- A version of ALES data at 20-Hz within 50 km of the coast is available from PODAAC for Jason-2 and Envisat (currently no Sea State Bias correction): ftp://podaac.jpl.nasa.gov/allData/coastal_alt/L2/ALES/
- Regional post-processed sea level time series in North Sea and Med at 20-Hz and 1-Hz are available from COSTA: https://doi.pangaea.de/10.1594/PANGAEA.871920
- Today, a global dataset for Jason-1 and Jason-2 is available at 1-Hz via direct download and at 20-Hz under request (also for Envisat and ERS-2) as easy-to-use already-corrected sea level estimations

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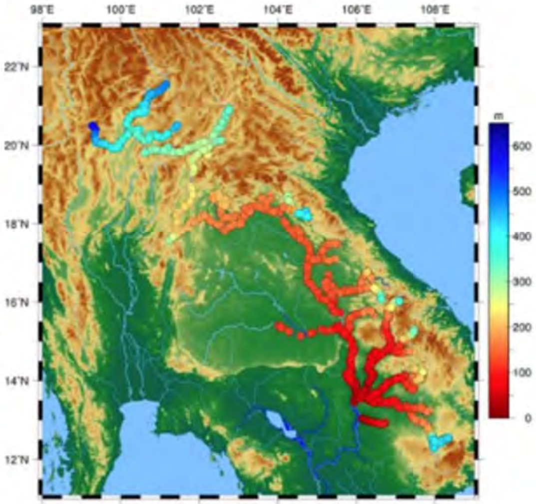
Recent news:

New approach to resolve water level changes of small rivers with CryoSat-2 SAR altimetry

CryoSat-2, launched in 2010, is the first altimetry satellite partly operating in synthetic-aperture radar (SAR) mode. Compared to conventional radar altimeters, the SAR mode enables altimetry measurements at increased along-track resolution and with smaller footprint. This opens new possibilities for the determination of water levels also of smaller inland water bodies that could not reliably be observed by the classical altimetry satellites. With its repeat time of 369 days CryoSat-2 does not provide a good temporal resolution, but on the other hand this long repeat orbit configuration results in a very dense spatial sampling of the water level, e.g. along a river.

The first step in the calculation of the water levels from CryoSat-2 data is the classification of the recorded radar returns into signals from water and land surfaces.



Water levels in the Mekong river basin from CryoSat-2 SAR data

Deutsches Geodätisches Forschungsinstitut

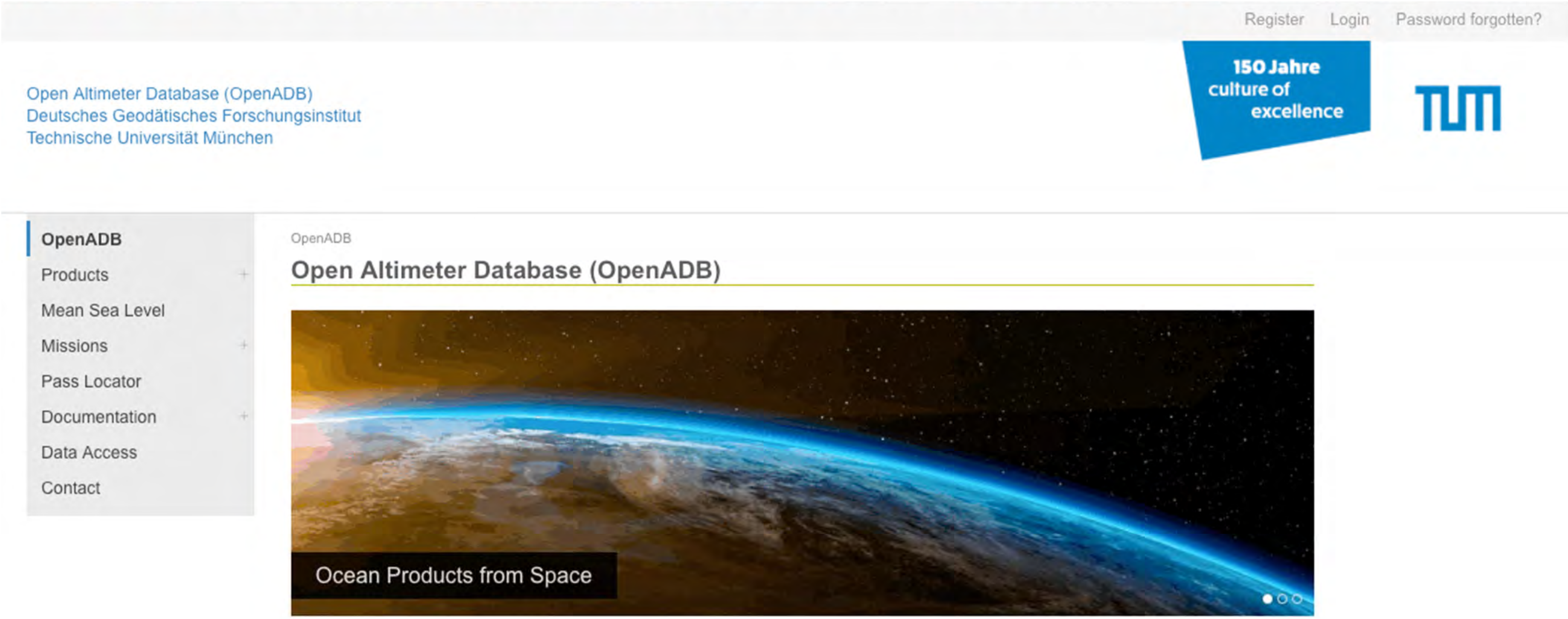
Prof. Dr.-Ing. habil. Florian Seitz

Technische Universität München
Arcisstraße 21
80333 München

See also:

- DGFI Open Altimeter Database (OpenADB) →
- Database for Hydrological Time Series of Inland Waters (DAHITI) →
- DGFI Science Data Products →
- ITRS Combination Center at DGFI →
- GGOS Bureau for Products and Standards →

Open Altimetry DataBase: http://openadb.dgfi.tum.de/



openabd.dgfi.tum.de

Open Altrimetry DataBase

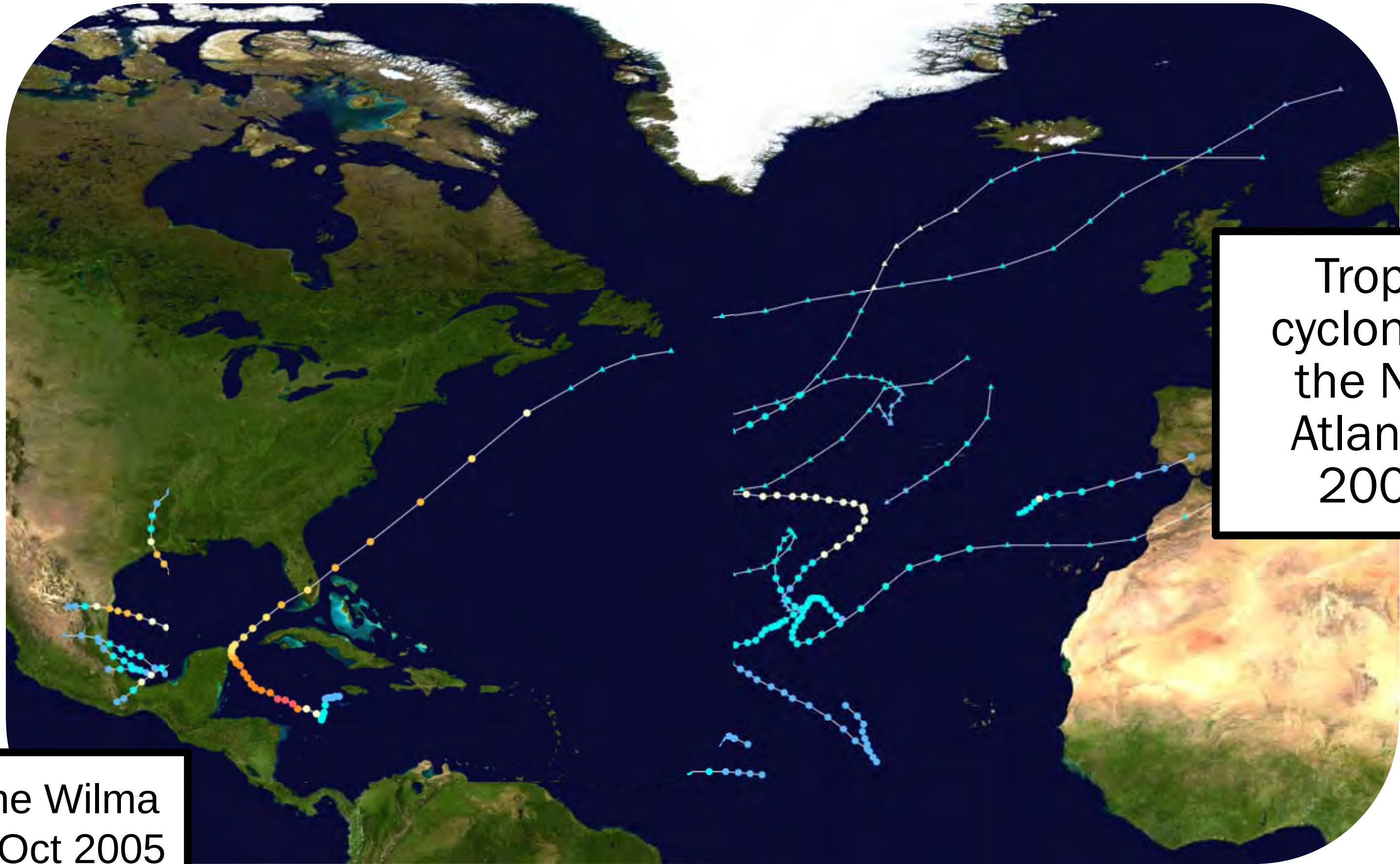
- Database for satellite altimeter data and derived high-level products
- For users with little experience and scientific users
    - Evaluate data
    - Generate new products, models and algorithms
- Products available
    - Sea Surface Heights (SSH)
    - Sea Level Anomalies (SLA)
    - Instantaneous Dynamic Ocean Topography Profiles (iDOT)
    - Empirical Ocean Tide Model (EOT)
    - Vertical Total Electron Content (VTEC)
    - Adaptive Leading Edge Subwaveform (ALES) Retracker

NetCDF: Network Common Data Format

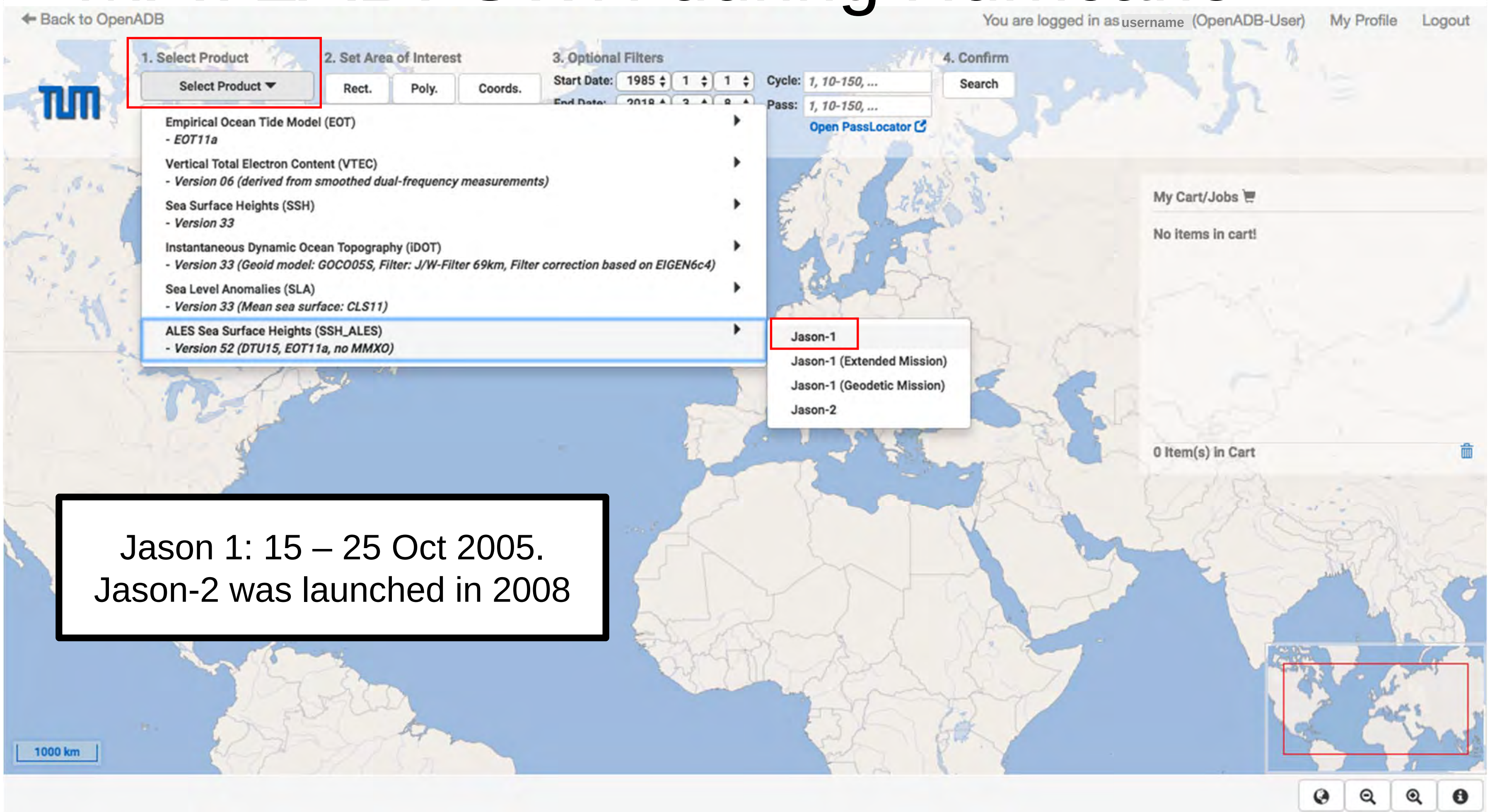
- Free software: ESA's toolboxes (BRAT, SNAP), Panoply, Python, etc.
- Licensed software: MATLAB, ArcGIS, etc.

- Set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data. [1]
- The structure of each NetCDF is the same. They differ only in the number and types of the parameters which are product depending.

Application Example 2
MATLAB: SWH during Hurricane

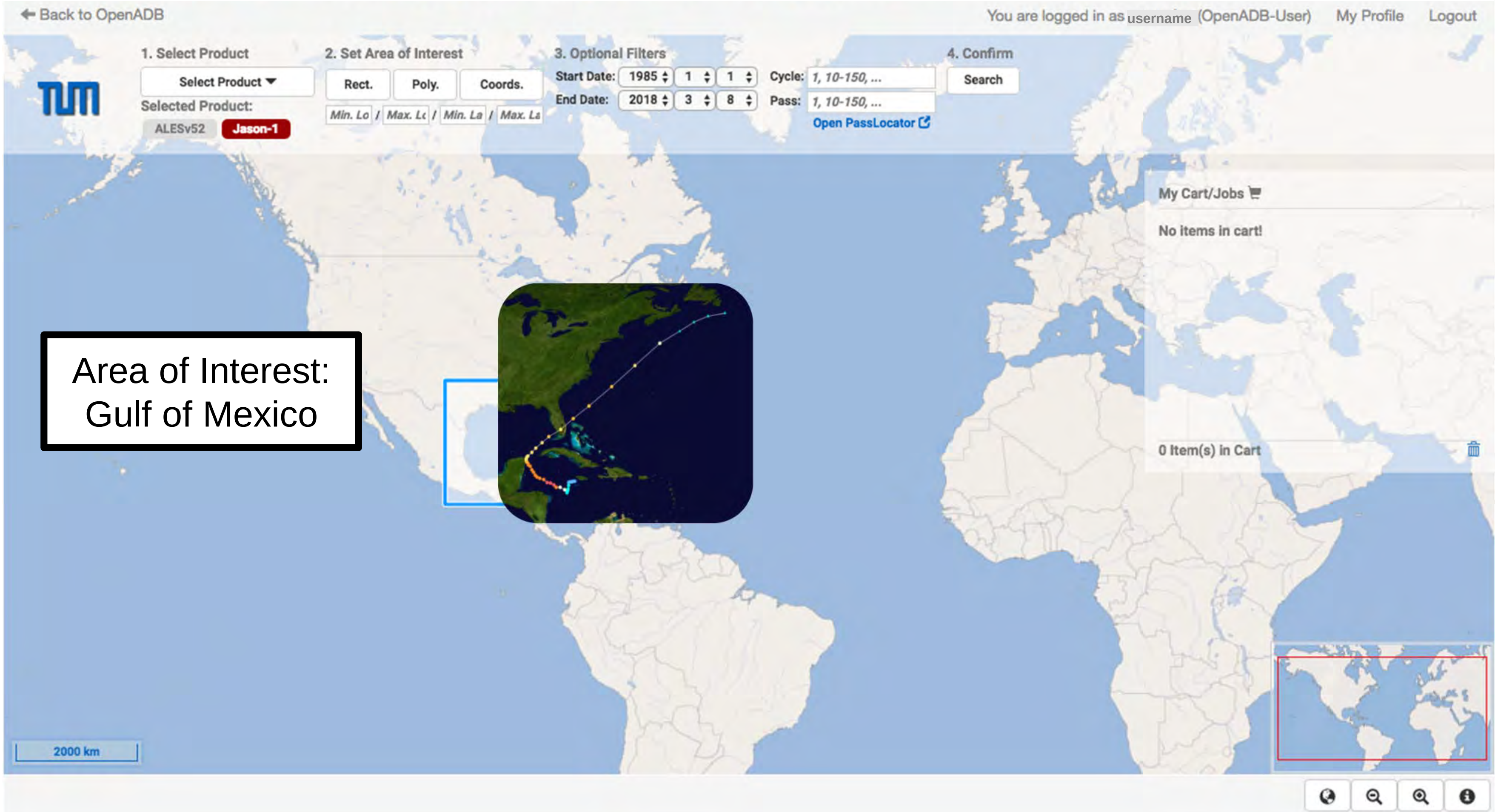


Application Example 2
MATLAB: SWH during Hurricane

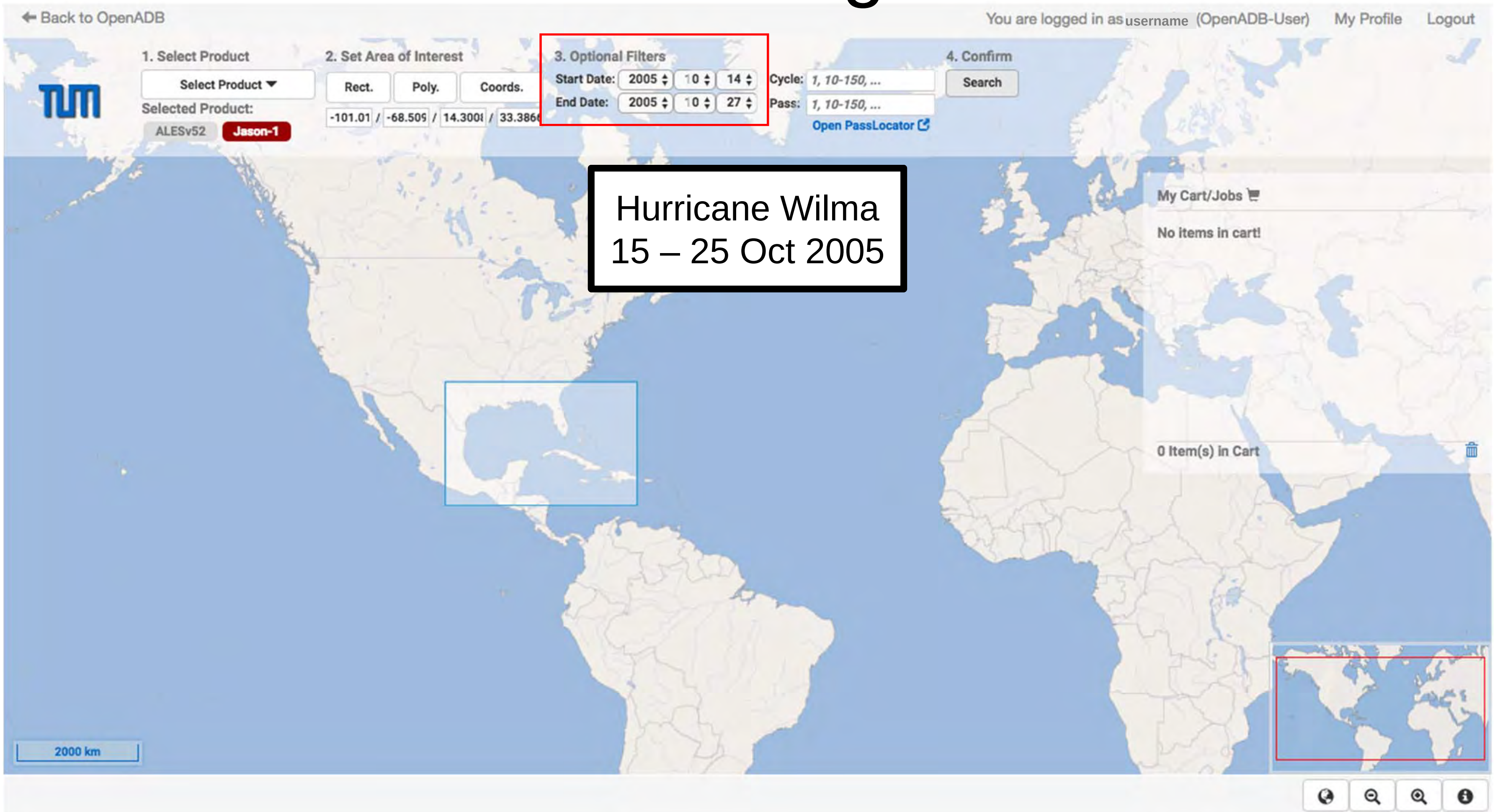


Jason 1: 15 – 25 Oct 2005.
Jason-2 was launched in 2008

Application Example 2
MATLAB: SWH during Hurricane



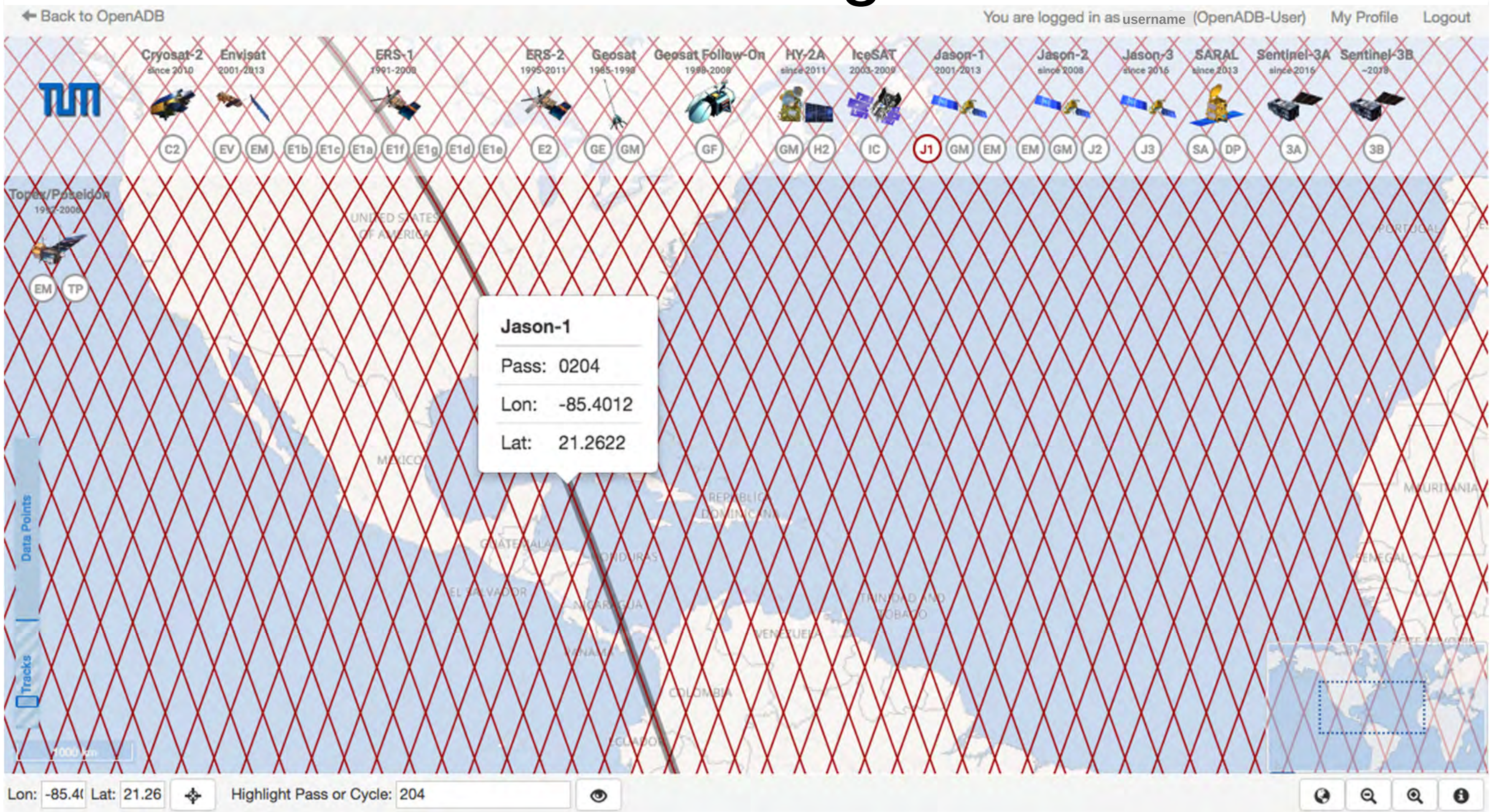
Application Example 2
MATLAB: SWH during Hurricane



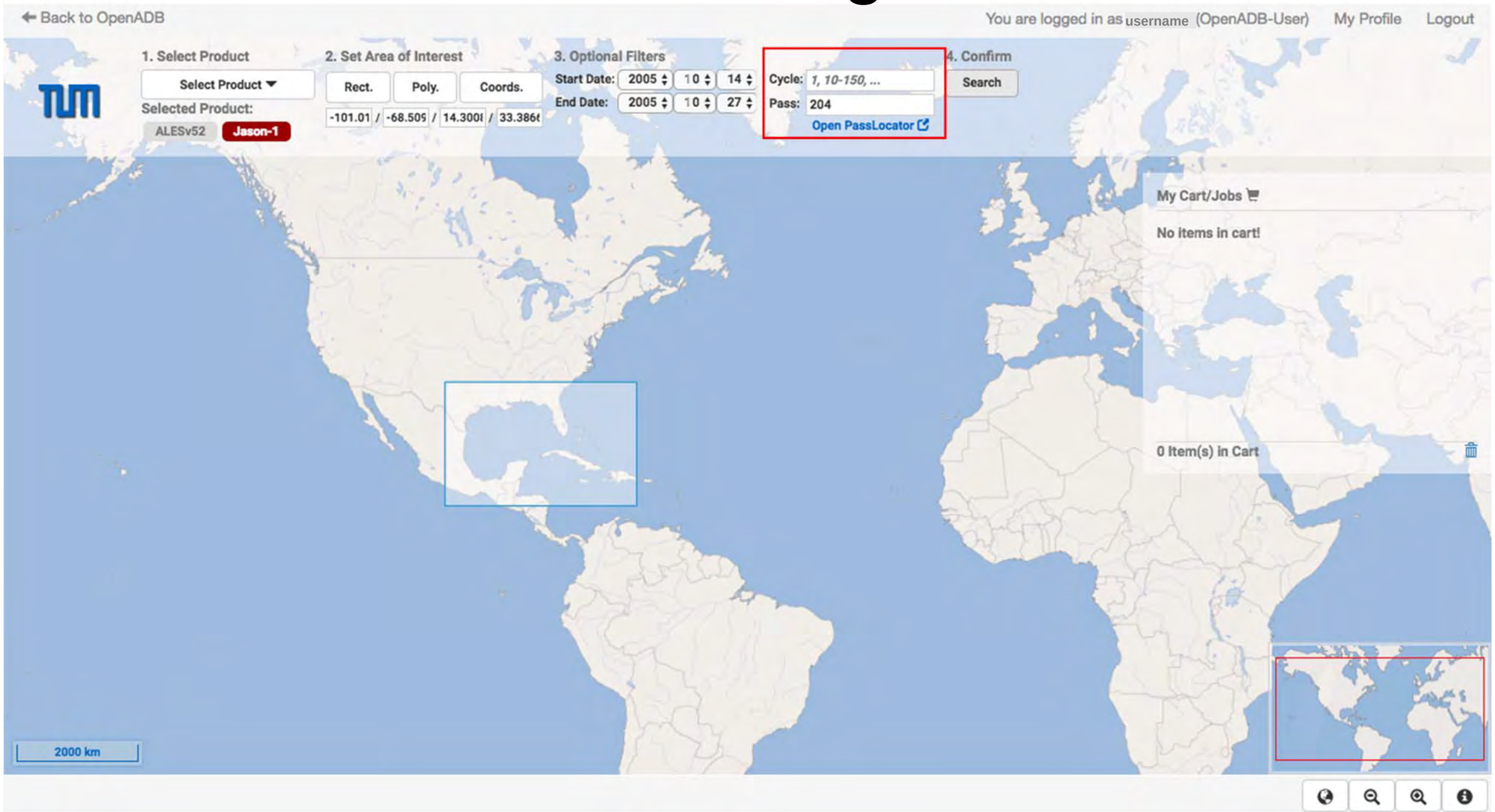
Hurricane Wilma
15 – 25 Oct 2005

Application Example 2

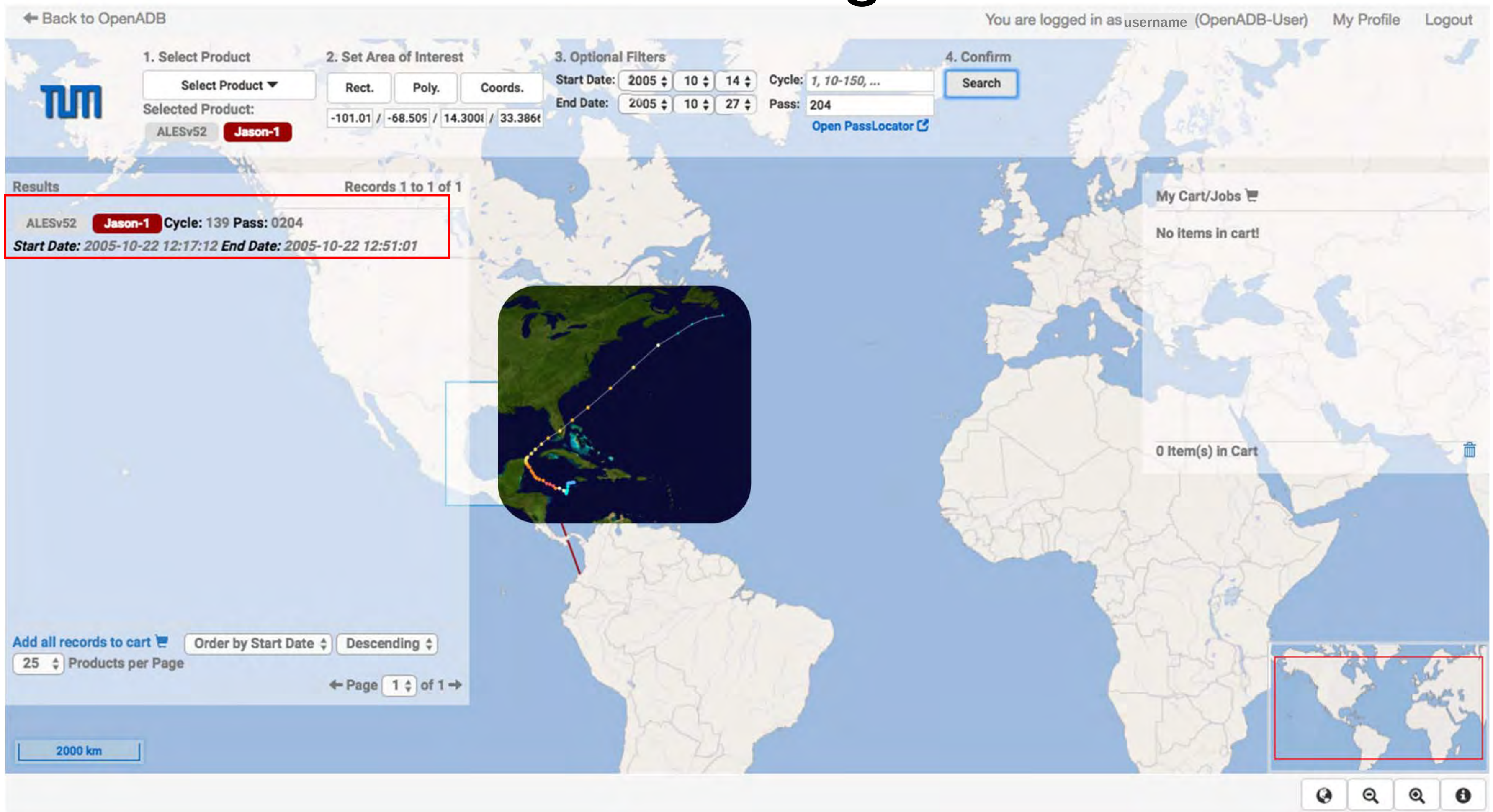
MATLAB: SWH during Hurricane



Application Example 2
MATLAB: SWH during Hurricane



Application Example 2
MATLAB: SWH during Hurricane



Application Example 2

MATLAB: SWH during Hurricane

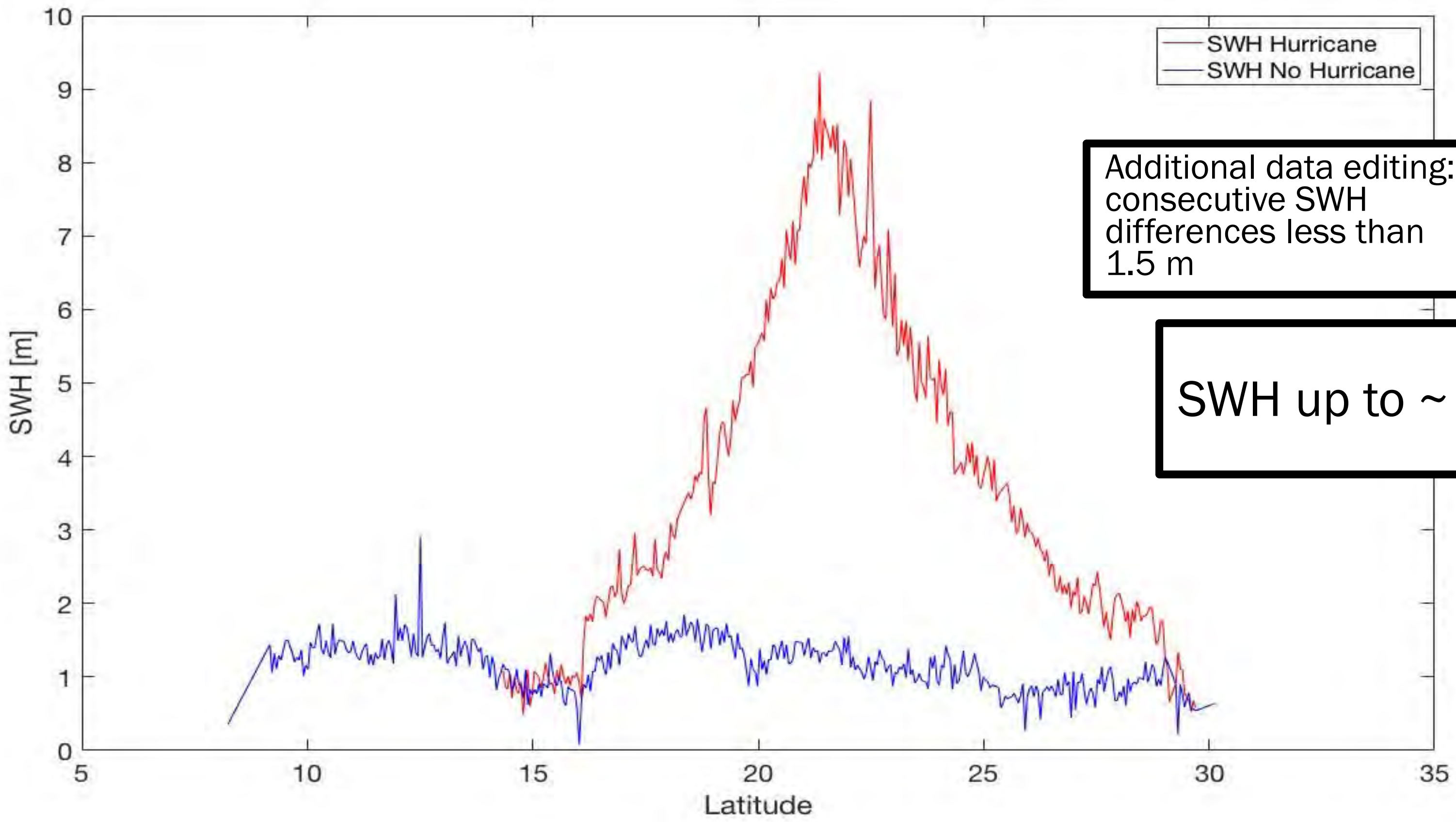
```
%% Open NETCDF

ncfile = '139_0204ales.52.nc';
ncfile2= '141_0204ales.52.nc';
info=ncinfo(ncfile);
info2=ncinfo(ncfile2);
C139=zeros(info.Variables(1).Size,14);
C141=zeros(info2.Variables(1).Size,14);

for i=1:length(info.Variables)

    VAR=info.Variables(i).Name;
    C139(:,i) = ncread(ncfile,VAR) ;

    VAR2=info2.Variables(i).Name;
    C141(:,i) = ncread(ncfile2,VAR2) ;
end

plot(C139(:,3),C139(:,6),'r')
hold on
plot(C141(:,3),C141(:,6),'b')
ylabel('SWH [m]')
xlabel('Latitude')
legend('SWH Hurricane','SWH No Hurricane')
```

info.Variables

Fields	Name	Dimensions
1	'jday.00'	1x1 struct
2	'glon.00'	1x1 struct
3	'glat.00'	1x1 struct
4	'ssh.50'	1x1 struct
5	'stdalt.05'	1x1 struct
6	'swh.05'	1x1 struct
7	'mssh.05'	1x1 struct
8	'otide.15'	1x1 struct
9	'ltide.15'	1x1 struct
10	'distance....	1x1 struct
11	'sflag.50'	1x1 struct
12	'oflags.00'	1x1 struct
13	'iflags.05'	1x1 struct

Application Example 2

MATLAB: SWH during Hurricane



Additional data editing: consecutive SWH differences less than 1.5 m

SWH up to ~ 9m

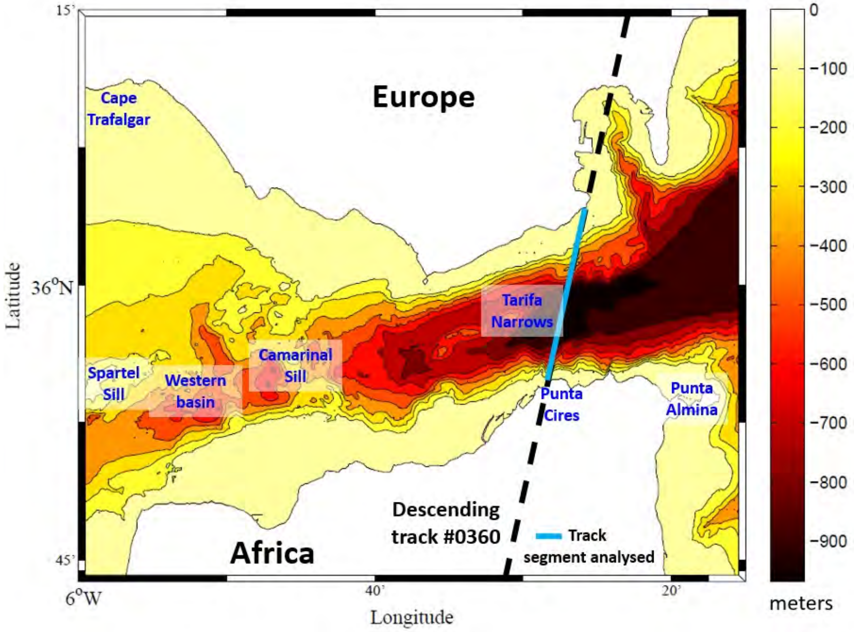
Studies about coastal sea level based on ALES

- Gomez-Enri et al., 2018

Mission: Envisat

ALES Envisat data are available on request through OpenADB. They are not yet directly downloadable, because we are waiting for the NetCDF version of the SGDR from ESA.

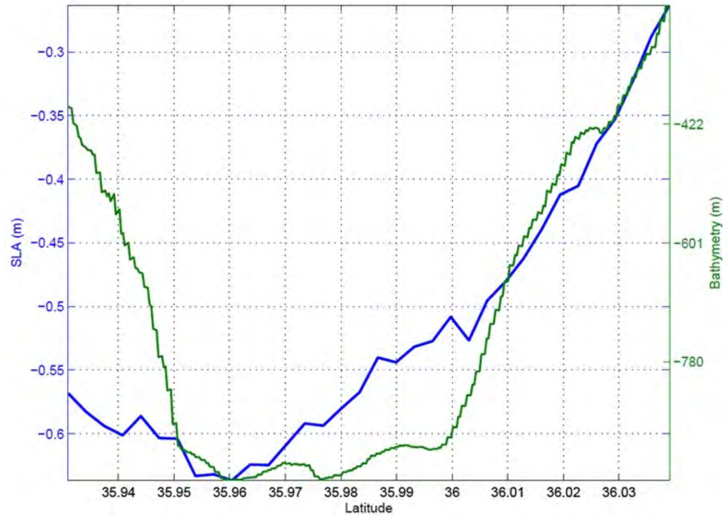
AT_SLA = Orbit – Range – Range Corrections – Geophysical Corrections – DTU15MSS



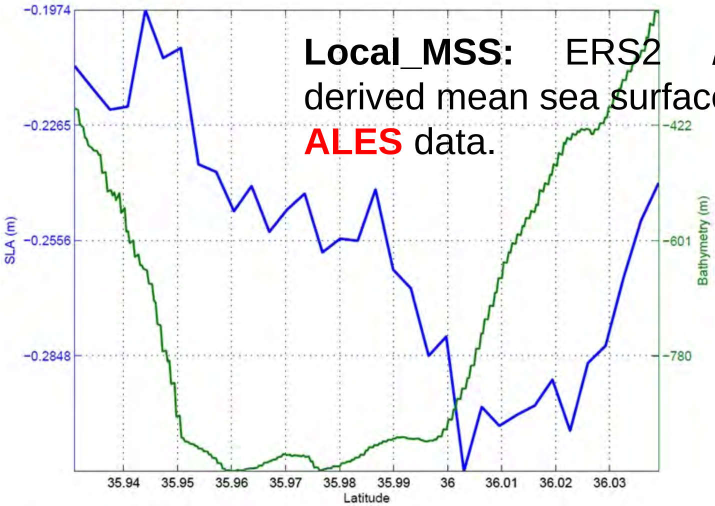
Bormans and Garret (1989), Ross et al. (2000) and Stanichny et al. (2005) reported that in normal conditions there is a higher / lower sea level on the southern / northern side of the Strait, respectively.

(Envisat cycle 14)

AT_SLA (DTU15MSS)

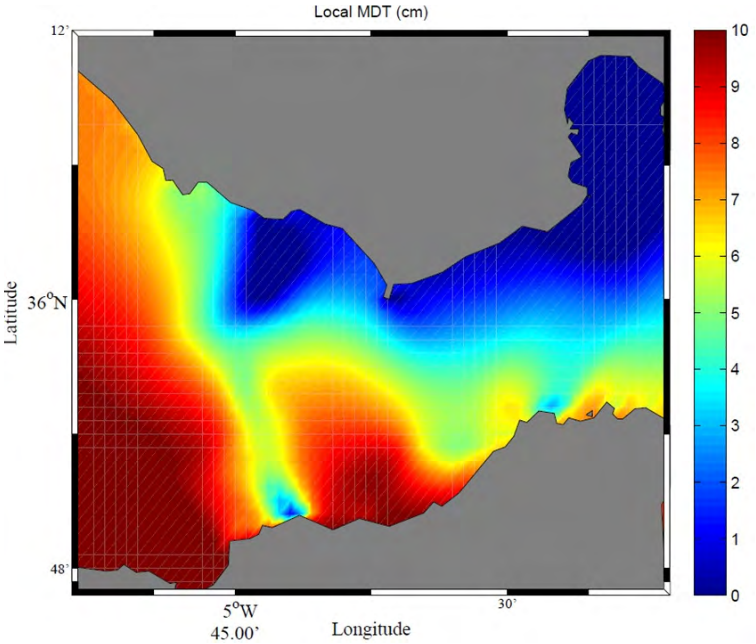


AT_SLA (Local_MSS)



Local_MSS: ERS2 / Envisat derived mean sea surface based on **ALES** data.

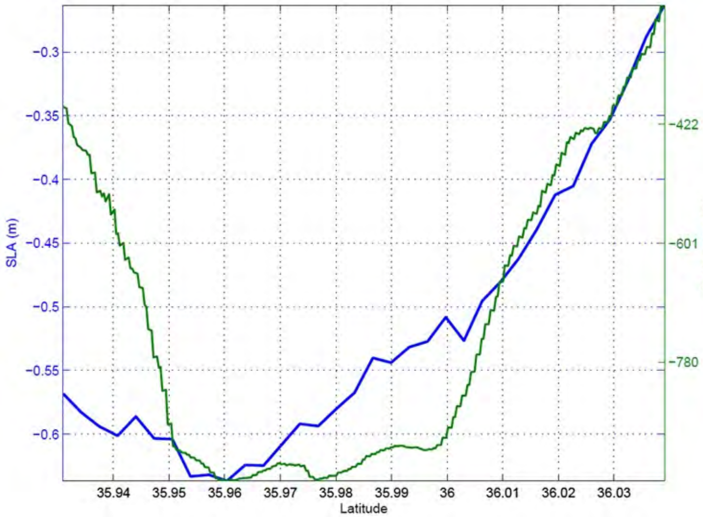
AT_SLA = Orbit – Range – Range Corrections – Geophysical Corrections – DTU15MSS



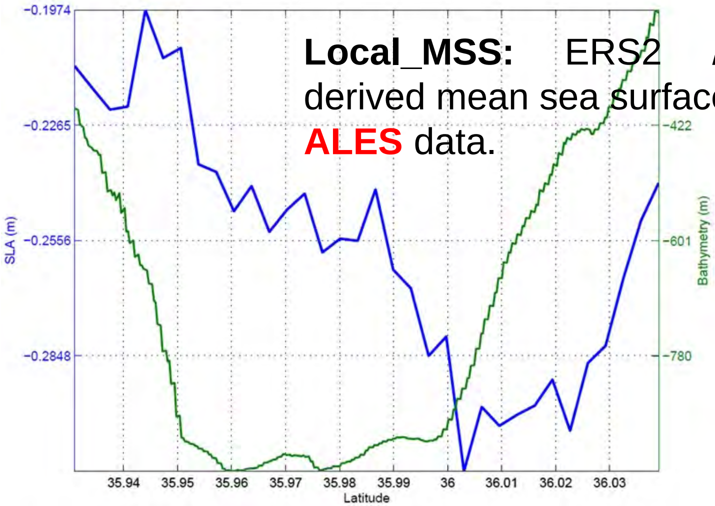
Bormans and Garret (1989), Ross et al. (2000) and Stanichny et al. (2005) reported that in normal conditions there is a higher / lower sea level on the southern / northern side of the Strait, respectively.

(example Envisat cycle 14)

AT_SLA (DTU15MSS)



AT_SLA (Local_MSS)



Local_MSS: ERS2 / Envisat derived mean sea surface based on **ALES** data.

Main findings:

The use of a global MSS in the Strait of Gibraltar to obtain the anomalies might hide some of the sea level variability, and hence complicate their oceanographic interpretation.

An ad-hoc local along-track MSS (based on ERS2/Envisat using the ALES retracker) gives a more realistic cross-strait variability in the Strait. This improves the analysis of the oceanographic processes in the area.

More details in:

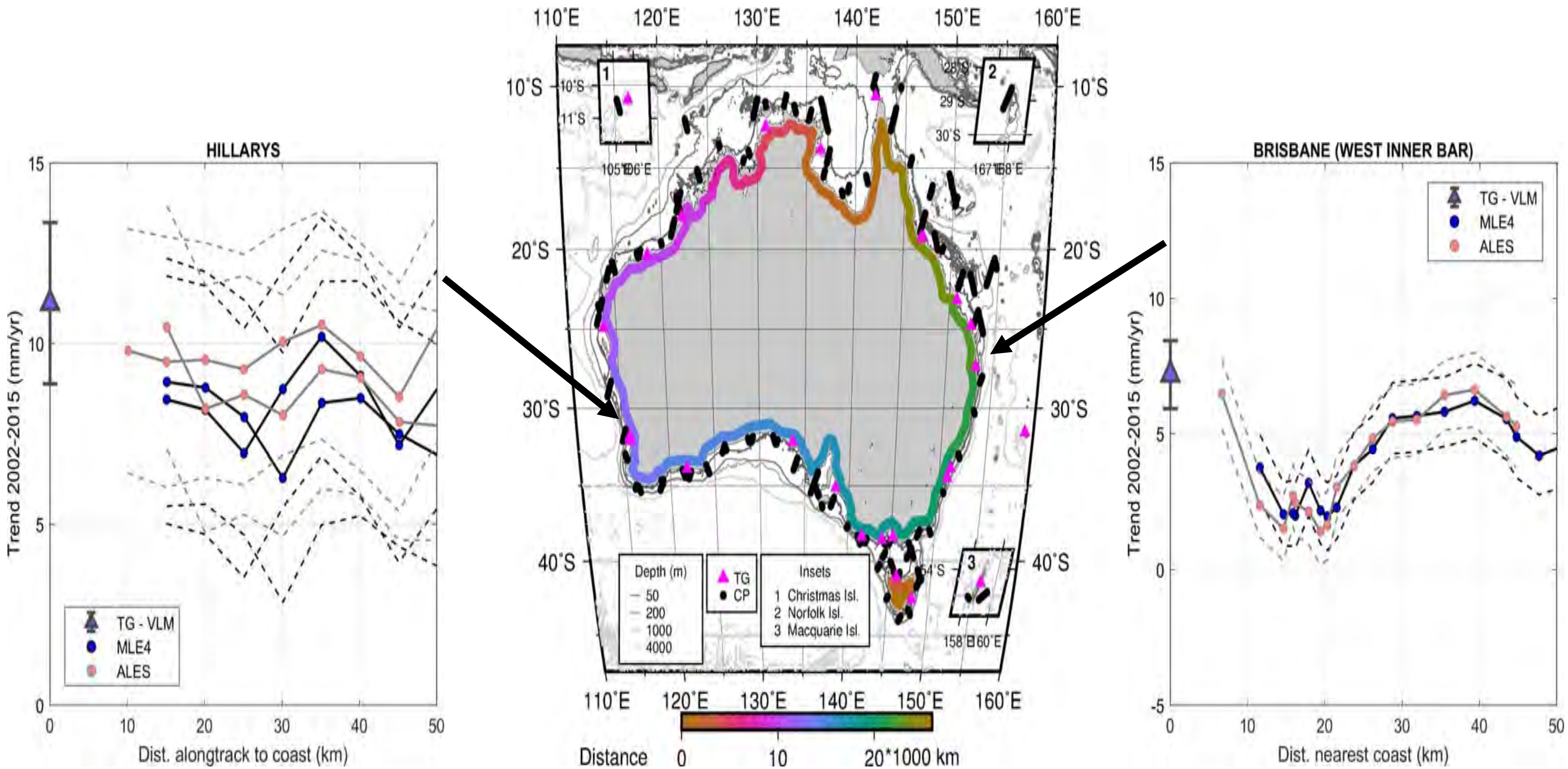
Coastal Altimetry for Ocean applications in the Strait of Gibraltar
(by: Gómez-Enri et al. **Thursday @09:40 in Session 2A: Application of Coastal Altimetry Data)**

Studies about coastal sea level based on ALES

- Royston et al. (ongoing)

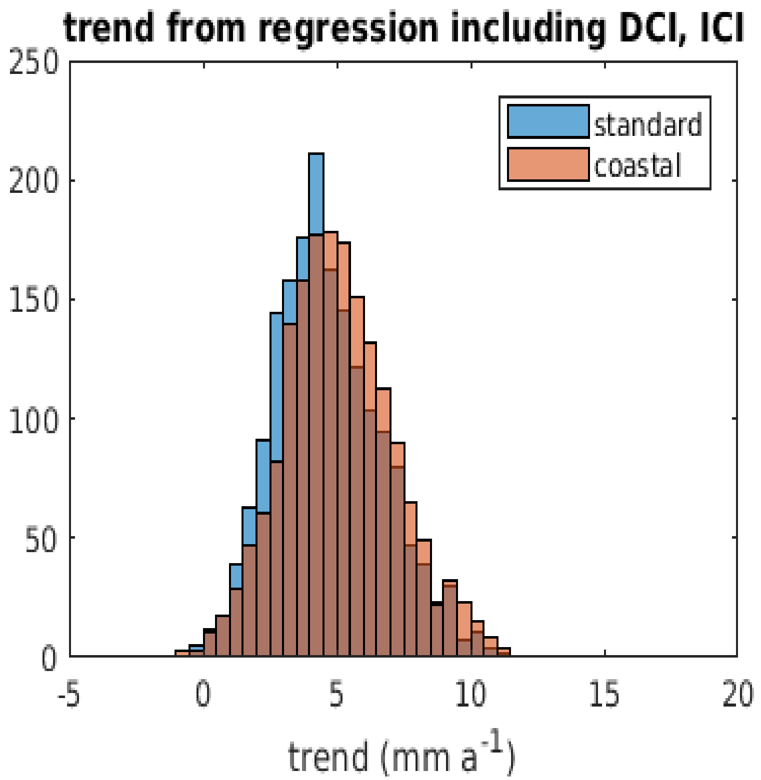
Mission: Jason-1 and Jason-2

Trends around Australia (2002 – 2015, J1/J2)



ALES: Some sites get valid time series closer to coast, enabling trend analysis closer to tide gauge (TG)

Trends around Australia (2002 – 2015, J1/J2)



Histograms of the trend (mm a^{-1}) in the coastal region, comparing the standard corrections (MLE4 waveform re-tracker) to the coastal correction (ALES re-tracker), both using FES tides

Trend (mm a^{-1})	**Mean**	**Median**
Coastal region, default retrack with GOT tides	4.67 ± 2.07	4.43
Coastal region, default with FES tides	4.68 ± 1.51	4.45
Coastal region, coastal retrack	5.05 ± 1.47	4.94
Tide gauge mean	6.25 ± 1.91	6.10

Differences within observational error, but best estimates of ALES and TG are close

PhD at DGFI-TUM

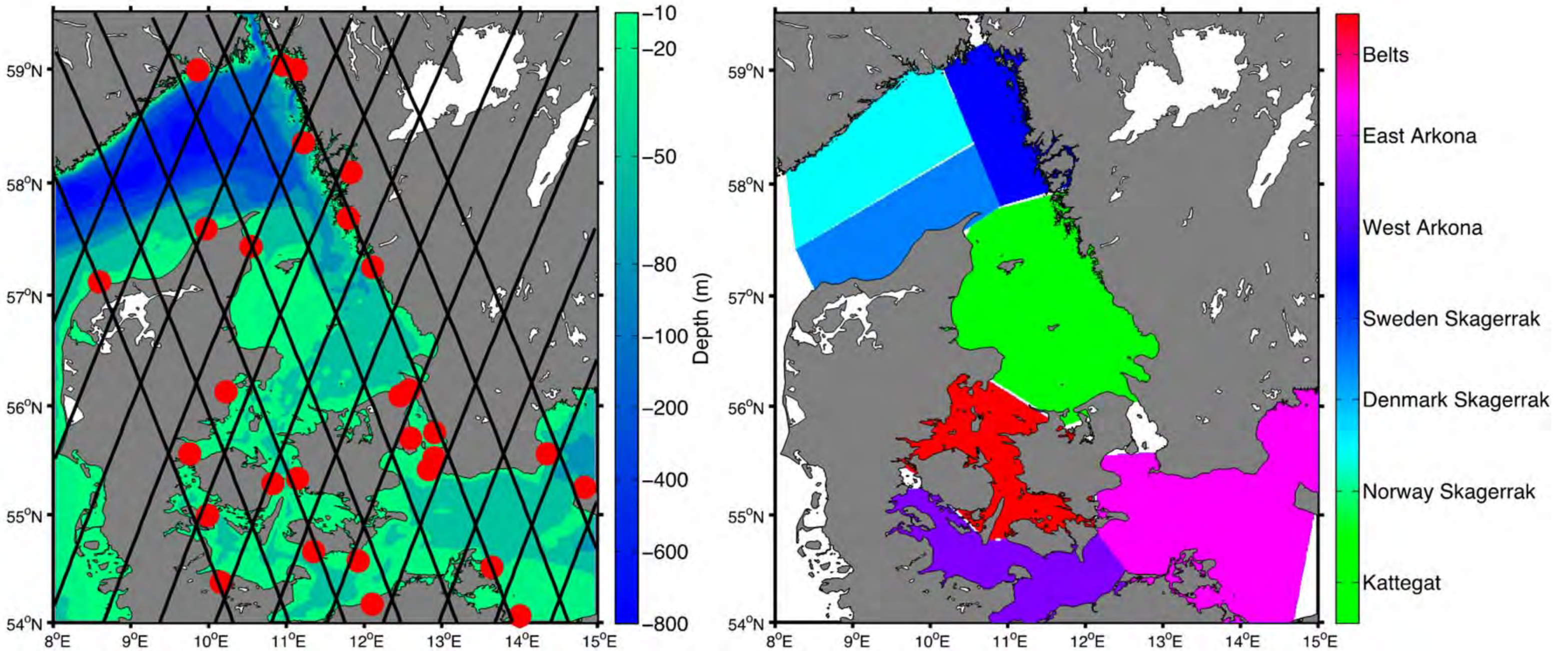
We are looking for a skilled student with strong skills in programming and/or signal processing and/or mathematics and statistics to work on retracking of altimetry data for sea state retrieval (context ESA Sea State Climate Change Initiative).

Contact me directly or via marcello.passaro@tum.de

Studies about coastal sea level based on ALES

- Passaro et al. 2015

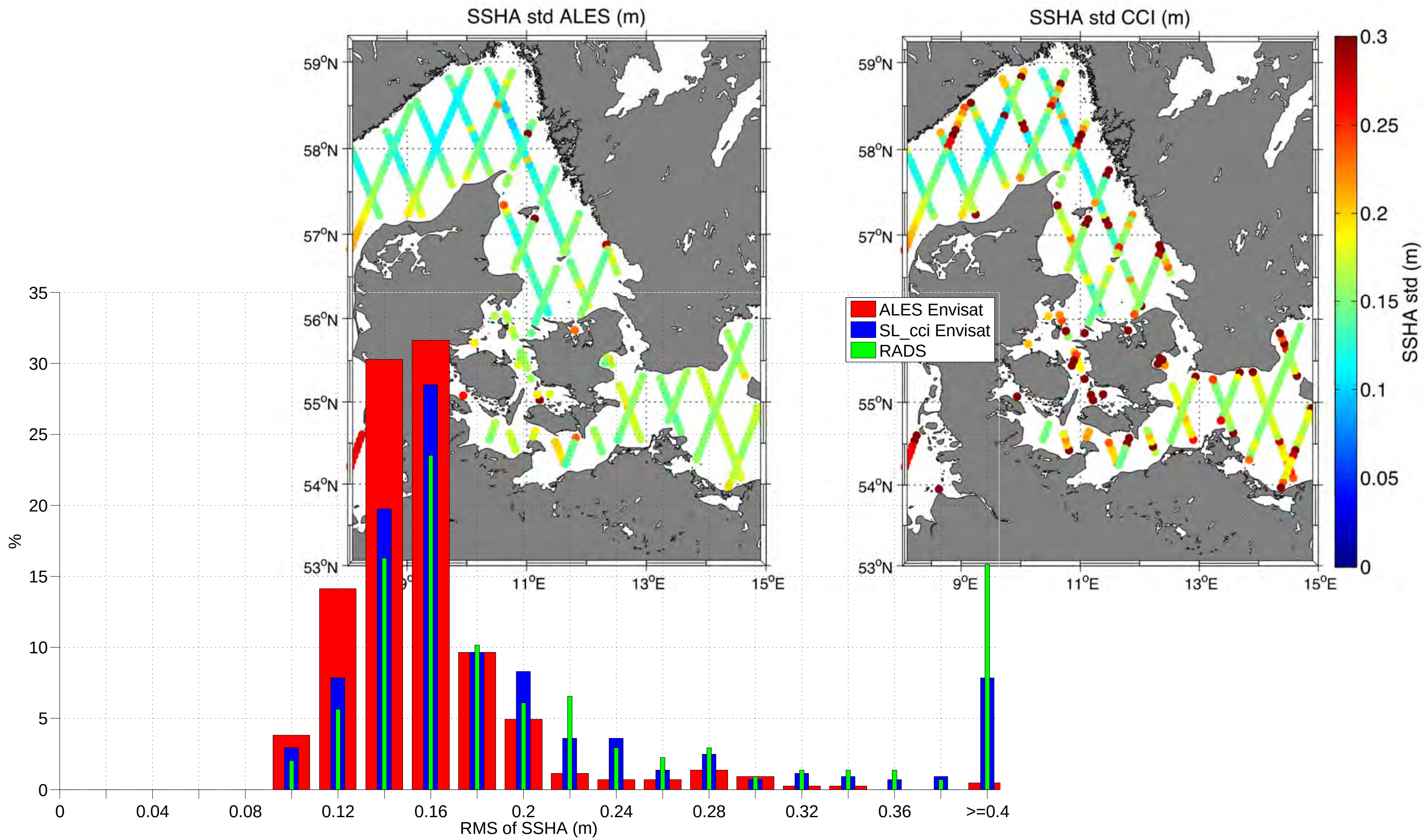
Showcase: an example with Envisat



AREA OF STUDY: North Sea/Baltic Sea Transition (2002-2010)
- challenging for altimetry (small scales, shallow water, jagged coastline)
- several tide-gauges (TGs) for coastal validation

CIRCULATION CHARACTERISTICS:
- Atlantic waters enter through the Jutland Current (D Skagerrak) and exit through the Norwegian Current (N. Skagerrak)

Showcase



SSHA std ALES (m)
SSHA std CCI (m)
59°N
58°N
57°N
56°N
55°N
54°N
53°N
9°E
11°E
13°E
15°E
SSHA std (m)
0
0.05
0.1
0.15
0.2
0.25
0.3
ALES Envisat
SL_cci Envisat
RADS
%
RMS of SSHA (m)
0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
0.32
0.36
>=0.4
0
5
10
15
20
25
30
35

APPLICATION: Modelling the annual cycle

y -> Sampled sea level time series

$$\hat{y} = A + Bx + C\sin 2\pi f x + D\cos 2\pi f x$$

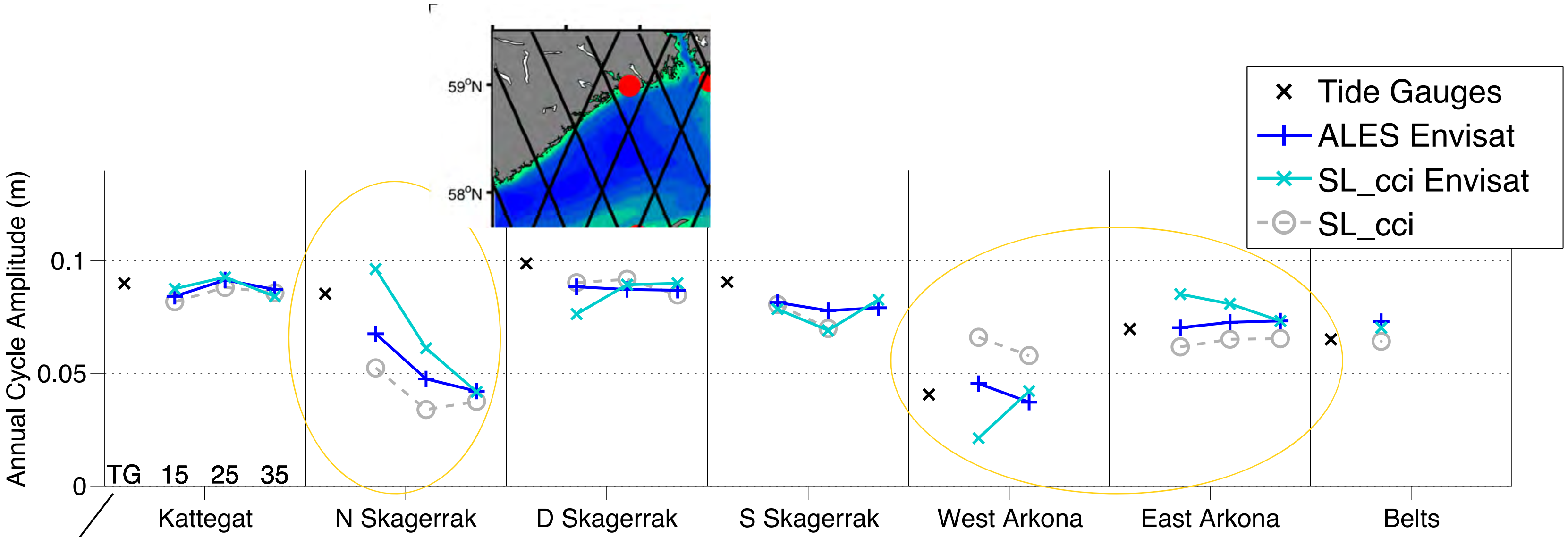
Problem: estimate the four parameters

Method: Least squares estimation (actually not really, Feasible Generalised Least Square Method)

Objective: find the minima of $\sum(y-\hat{y})^2$

f -> annual frequency

$$Am = \sqrt{C^2 + D^2}$$
$$Ph = \tan^{-1}\left({}^{D}/_{C}\right)$$



Km from
the coast

1) ALES Envisat coastal estimates agree within 1 cm with Tide Gauges FOR EACH SUB-BASIN

2) Slope in N Skagerrak -> Norwegian Current circulation & Bathymetry