

# SDI and a scientific approach

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## MSDI Open Forum, KMS/GST



DTU Space  
National Space Institute

# Summary

- ◆ Introduction
- ◆ Arctic Basemaps in Google Maps
- ◆ Three Dimensional Modelling of Ocean Temperature Data
- ◆ Homotopy based 3D/4D reconstruction of water columns from acoustic data

# Introduction

- ◆ All marine data acquisition techniques are very affected by noise.
- ◆ Noise removal **functions** need to be applied.
- ◆ All images can then be processed for feature detection / reconstruction by applying either implicit **functions** (e.g. marching cubes or soft cells) or homotopies (continuous deformation **functions**).
- ◆ Any marine SDI needs to handle both raster data, vector data, topological information and **functions** (filtering functions, implicit functions, homotopies, information extraction functions, information rendering functions, etc.).

# Arctic Basemaps in Google Maps

James Muggah, UNB, Department of Geodesy and Geomatics Engineering  
and Darka Mioc, DTU, National Space Institute

- The Ocean Mapping Group (OMG) and their role in ArcticNet.
- ArcticNet is a funded program that brings together scientists and managers from a number of different backgrounds to study the effects of global climate change in the Arctic.
- OMG's role is to map the sea floor topography and geological structure of the Canadian Arctic Archipelago. This is the first step towards the management of increased intercontinental ship traffic and resource exploration as ice conditions improve.
- The OMG will continue to build up coverage with each transit through the NW passage.



## Arctic Data

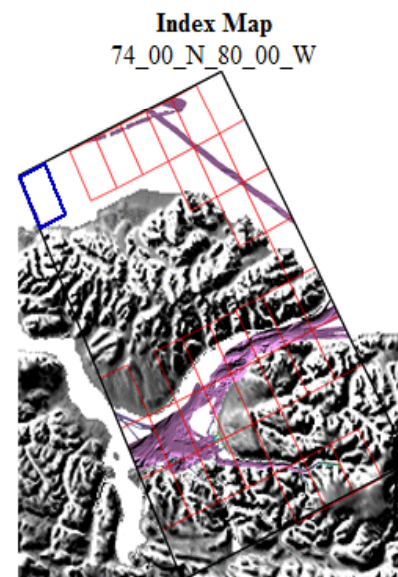
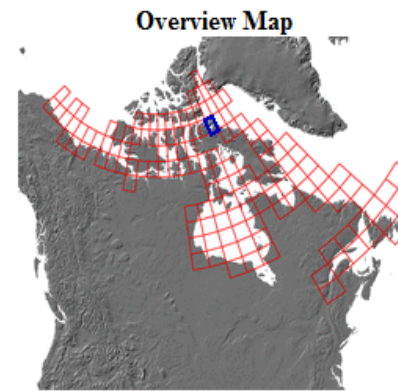
- OMG has been collecting data in the Arctic since 2003.
- Approximately 2,000 basemaps.
- In the current online storage format used by the OMG, it is difficult to view the data and users cannot easily pan and zoom.
- Demo - <http://www.omg.unb.ca/Projects/Arctic/basemaps/index.html>

# Objectives

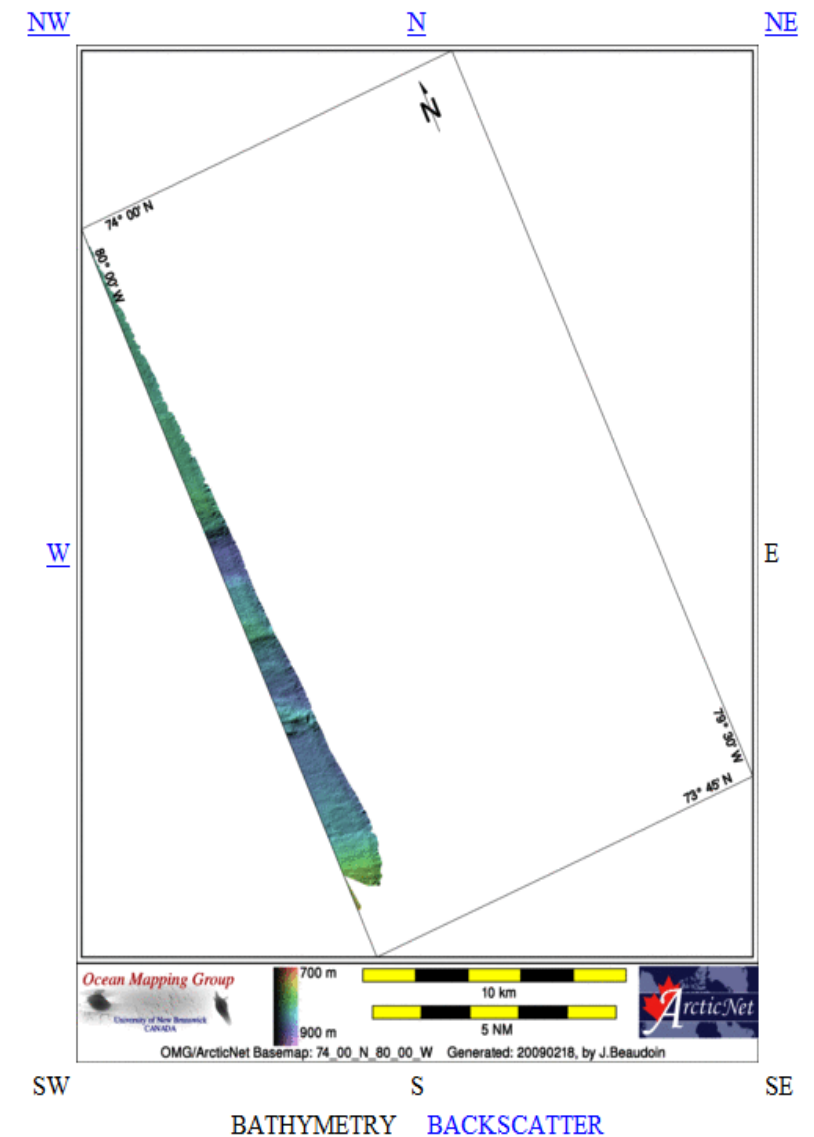
- The purpose of this project is to use a freely available program (Google Maps), to display the OMG's Arctic data.
- The maps will be available to all users on the web.
- Users will be able to pan and zoom as they choose.
- The map will load the large dataset in a reasonable time.
- Future work to add more functionality to the website.

## Google Maps Add-ons

- Google Maps application is created using Javascript which is embedded into html code. After the map is embeded into website, users can add some controls such as:
- Set the centre of the map, and zoom level
- Set the map type (satellite, streets or terrain)
- Add zoom, and pan controls as well as an overview map
- Many more controls, options and customization can be created using Javascript.



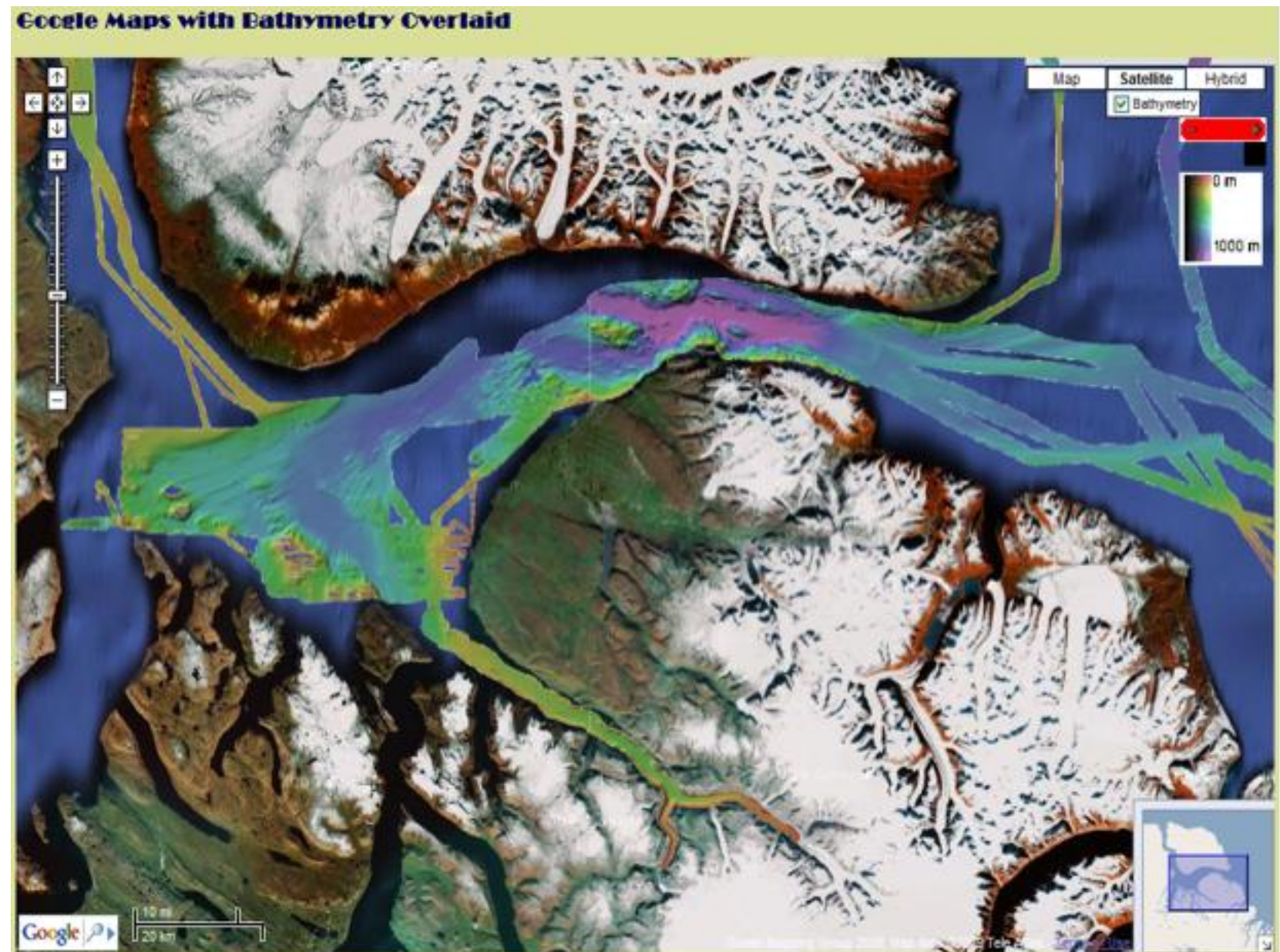
Downloads  
ESRI grid files for:  
[This basemap](#)  
[All basemaps in this index map](#)





# Data preparation

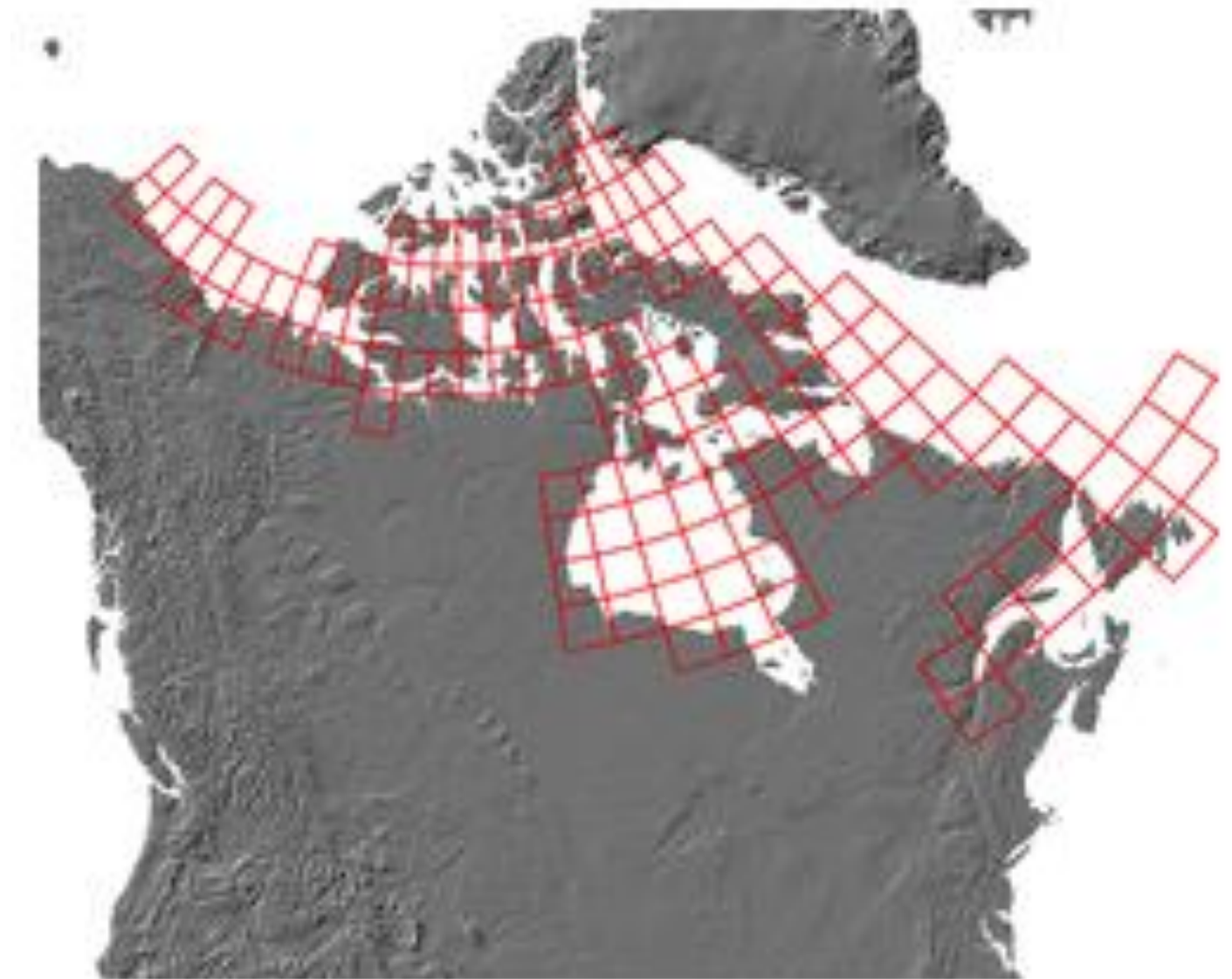
- The images were created using Linux software written by the OMG.
- With the help of Ian Church from the Ocean Mapping Group, a step-by-step process was used to create images from the multibeam data collected by the OMG in the Arctic.
- The website was also created using Linux software.
- The projection needed to be changed from Lambert Conformal Conic (useful at higher Latitudes) to Mercator (used by Google Maps).
- The data needed to have a common colour scheme.
- The data needed to be properly georeferenced.
- The background of the images needed to be transparent.
- The image bounds were determined (Lat/Long) for georeferencing.
- Code was written to add the images to Google Maps.





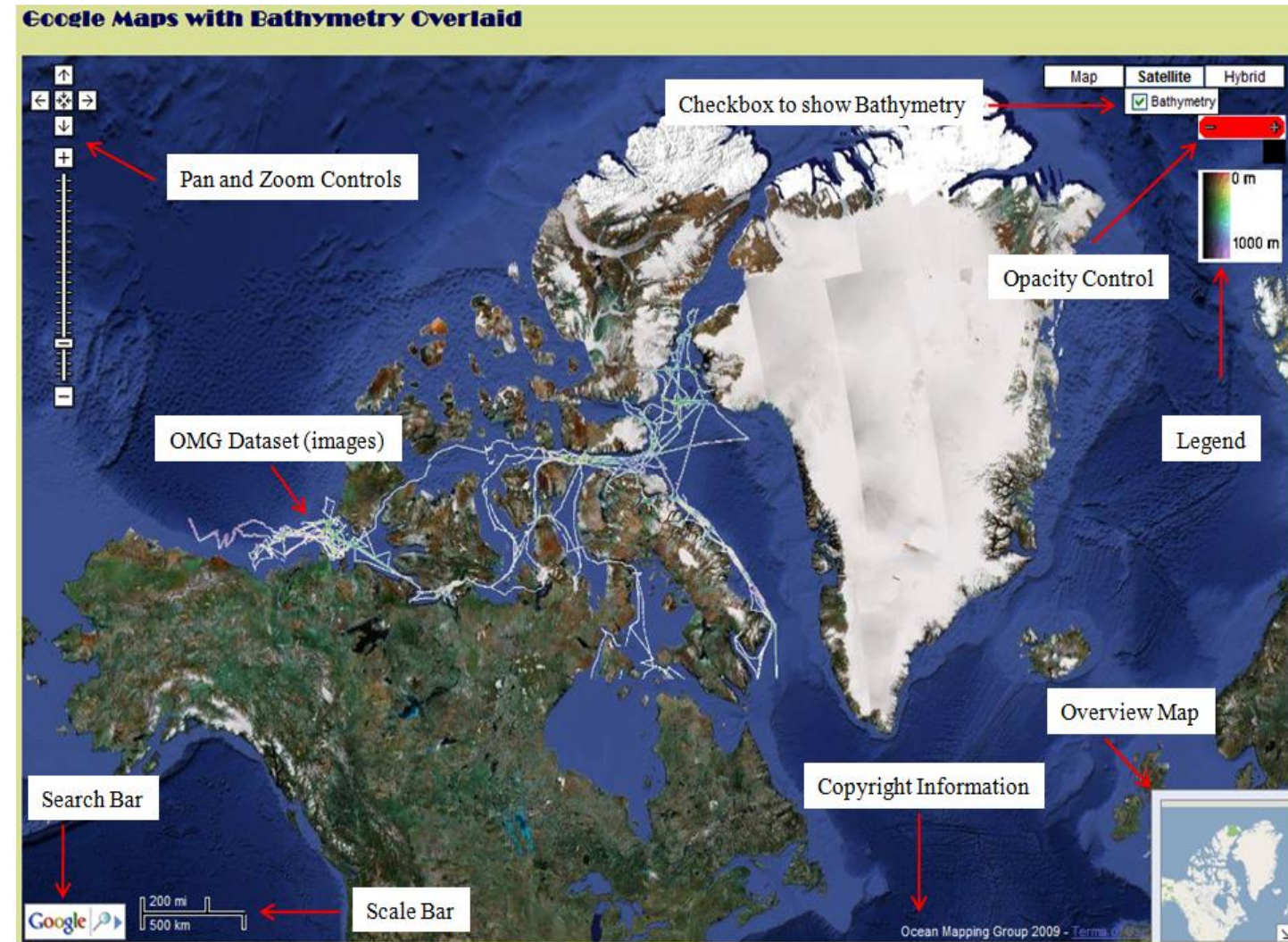
# Overlays

- For this project ground overlays were used to display the OMG's data in a test area around Pond Inlet.
- After creating and testing this website, it was determined that the high resolution images (10m) were loading too slow and the ground overlay method would not be useful for displaying the entire dataset.
- Tile overlays are useful for large datasets because they cut the image into many different tiles, and load only the part of the image (tile) within the map bounds.
- Tile overlays can be challenging to implement but are extremely efficient.



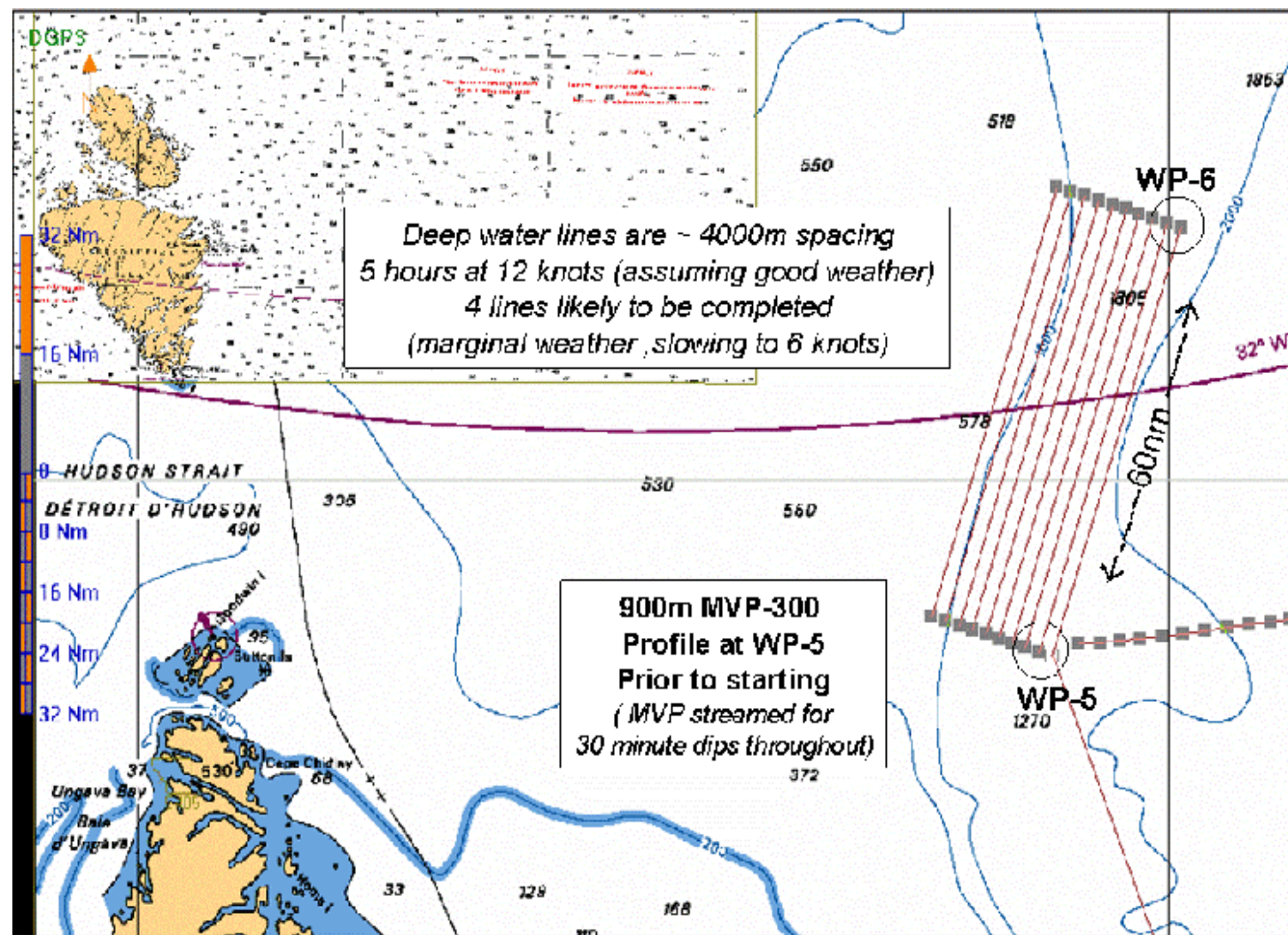
# Tile Overlays

- The next step was to create a tile overlay.
- Google requires tiles to be 256x256 pixels, and different images for every zoom level.
- A pyramid format is used when creating the tiles. At zoom level zero one tile represents the whole world at each subsequent zoom level, each tile is divided into 4.
- To create the tiles, one image of the test area was created, and a tile cutter (MapCruncher) was used to cut the image into 256x256 tiles for 14 zoom levels.
- The website was created with these tiles and after testing, it was determined that the tile overlay would be suitable for displaying the entire dataset.



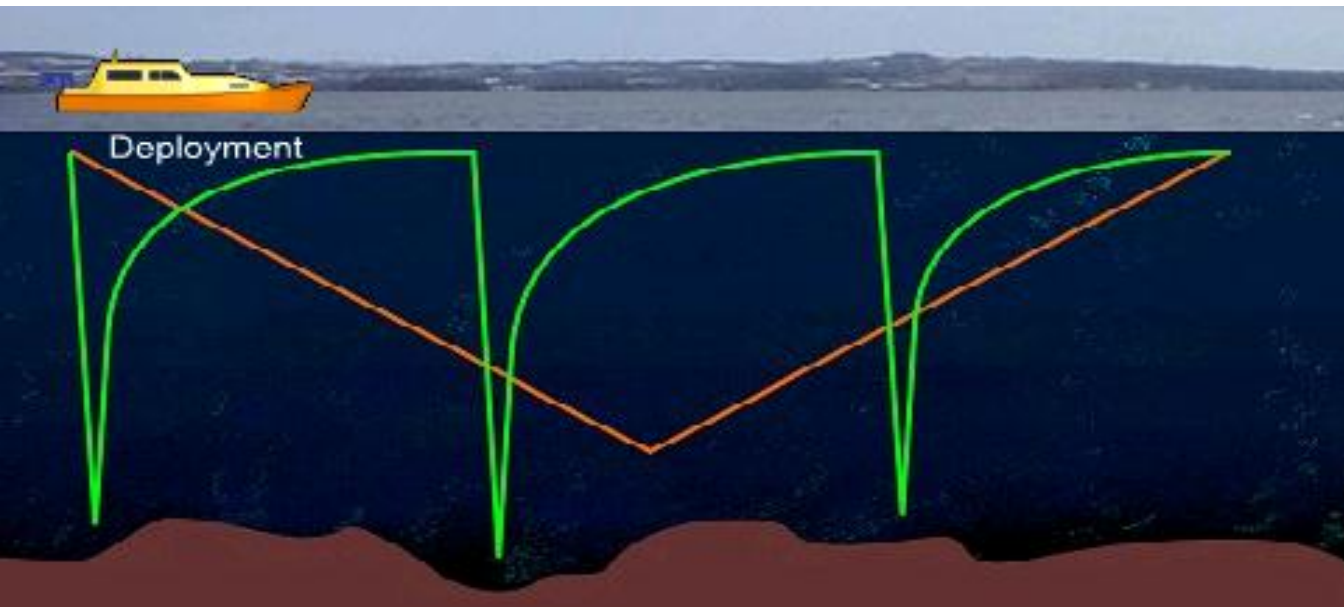


# Three Dimensional Modelling of Ocean Temperature Data

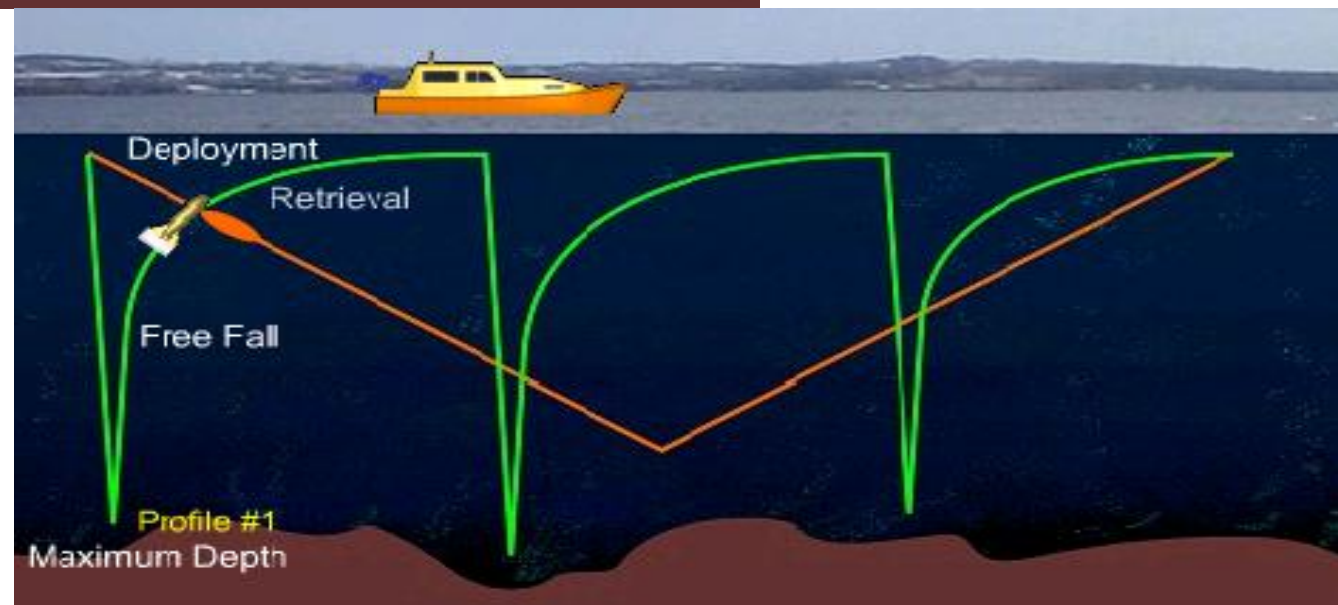


- The Moving Vessel Profiler (MVP) is a multi-purpose instrument for aiding in the collection of both shallow and deep-water data sets.
- The MVP primary function is to allow accurate data collection **without the need to stop the vessel.**

# Moving Vessel Profiler

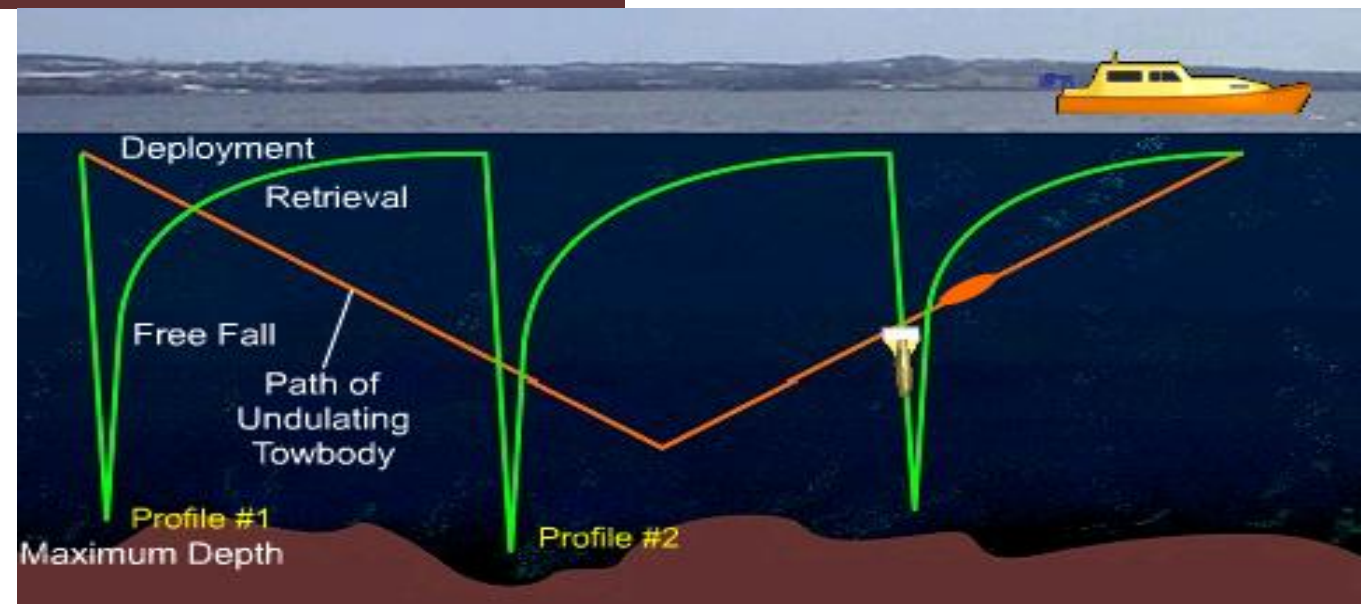


The figures above shows the **MVP™** deployed from a typical vessel



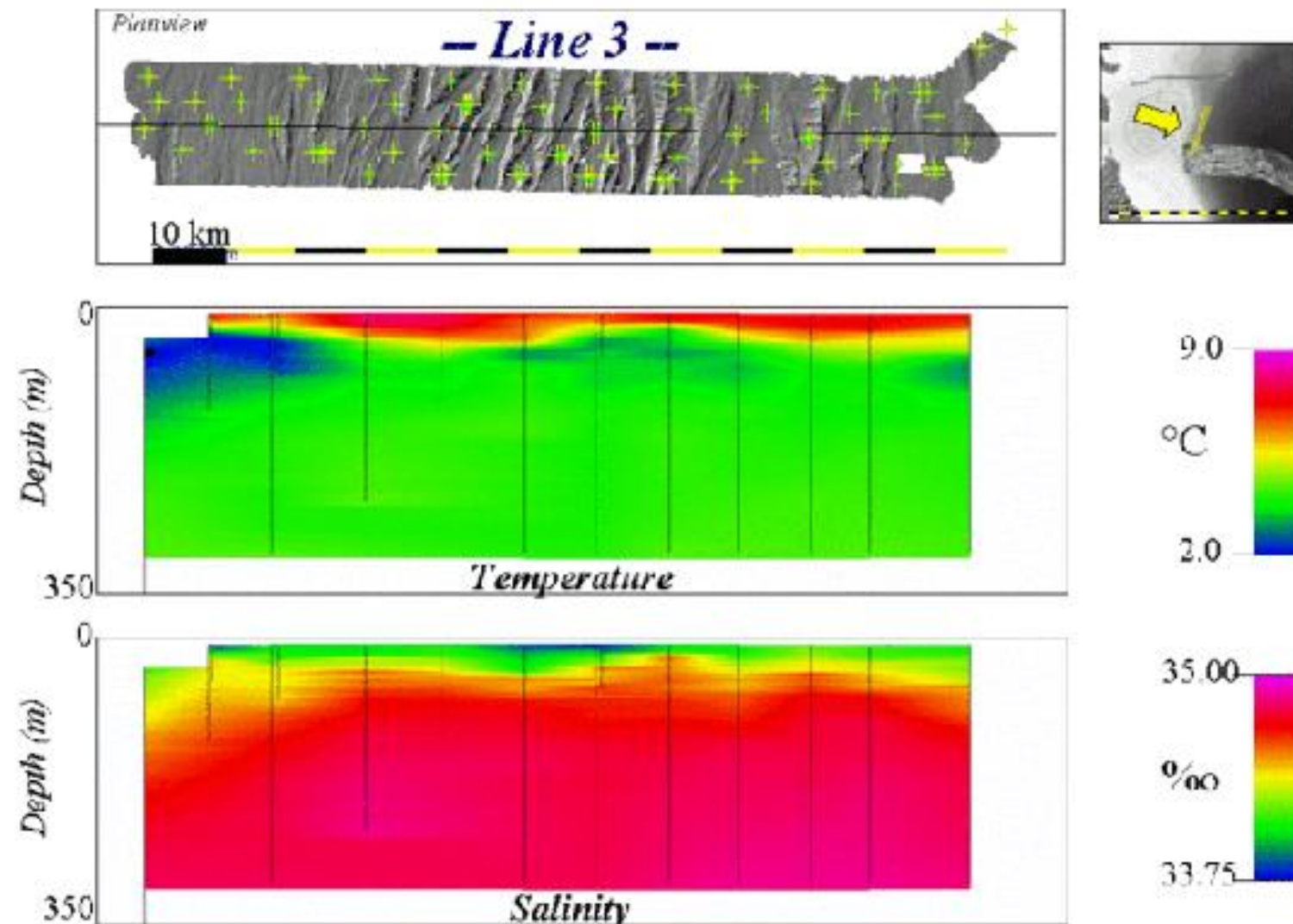
The sequence of events for a typical cast is:

1. Deployment
2. Freefall
3. Maximum depth
4. Retrieval





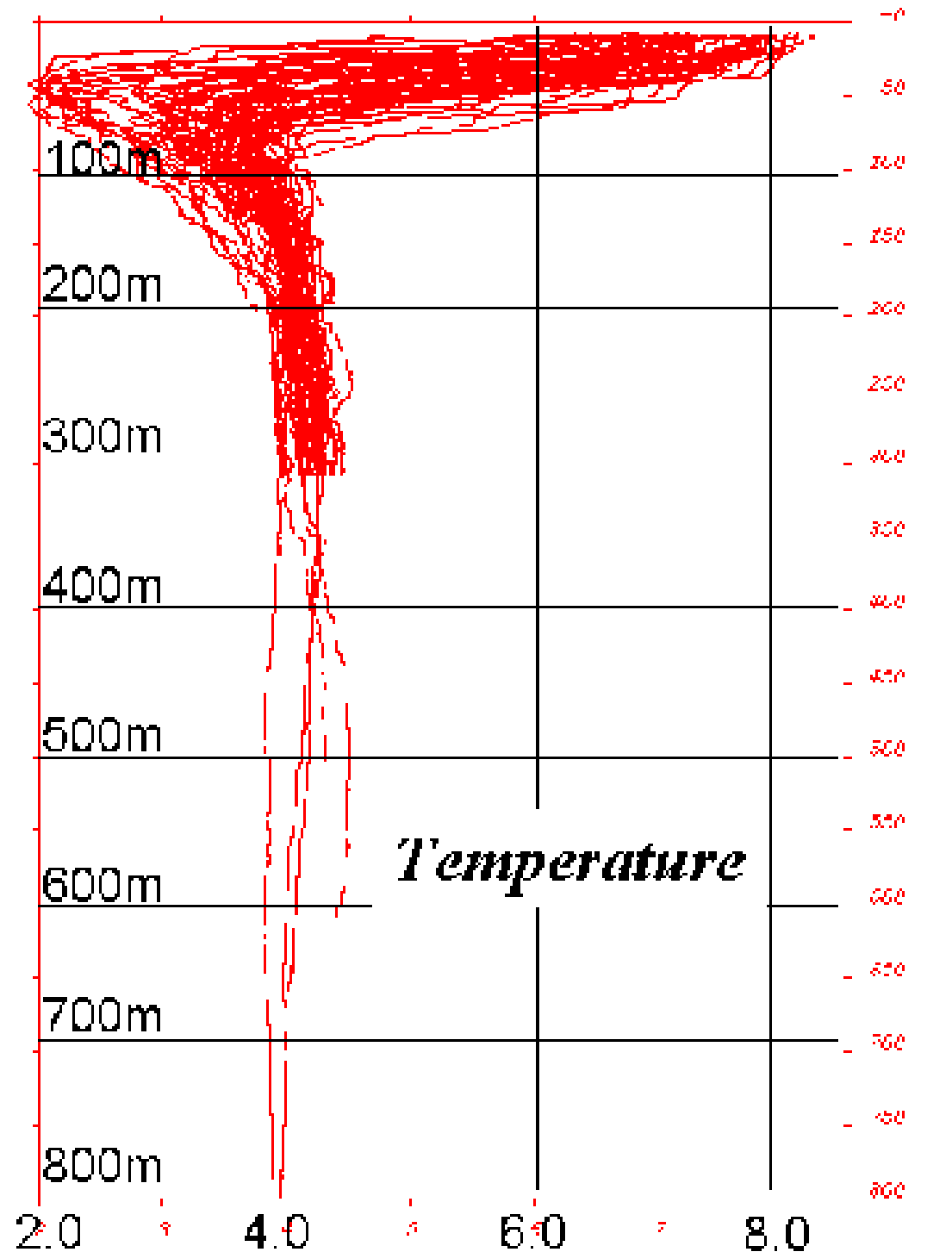
# Experiments with Moving Vessel Profiler



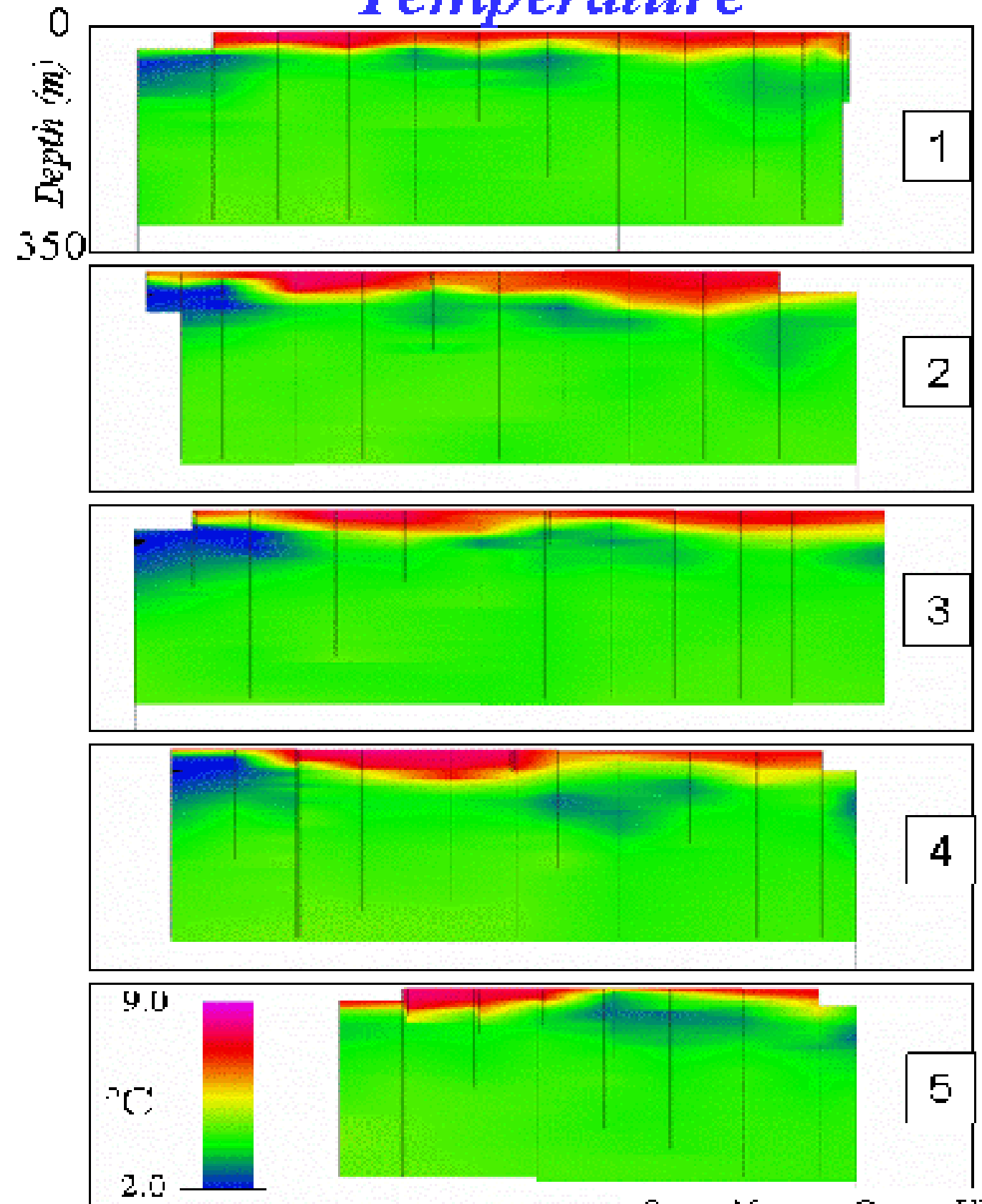


# Temperature and depth

*Temperature*



*Ocean Mapping Group, UNB*



*Ocean Mapping Group, UNB*

## The project implementation involves the following major stages:

1. **Data collection** (Data are obtained from Dr. John E. Hughes Clarke and Jonathan Beaudoin from the Ocean Mapping Group, University of New Brunswick).
2. Data extraction and manipulations.
3. Using **DOUGLAS PEUCKER** algorithm to refine the data.
4. Load the Data to **GRASS** system.
5. Interpolate the vector Data using **GRASS** to get G3D.
  1. Exports G3D grids to **V5D** format (**VIS5D**).
  2. View and Visualize G3D map using **Vis5D** application program.

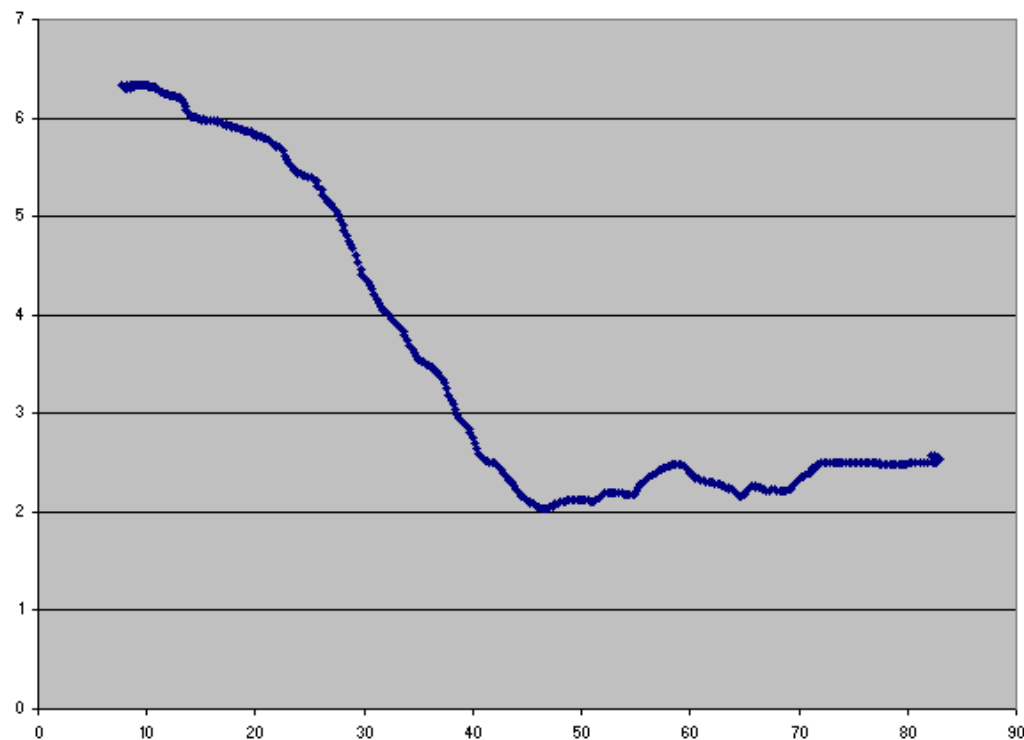
# Curve Simplification

Before applying  
Douglas Peucker Algorithm

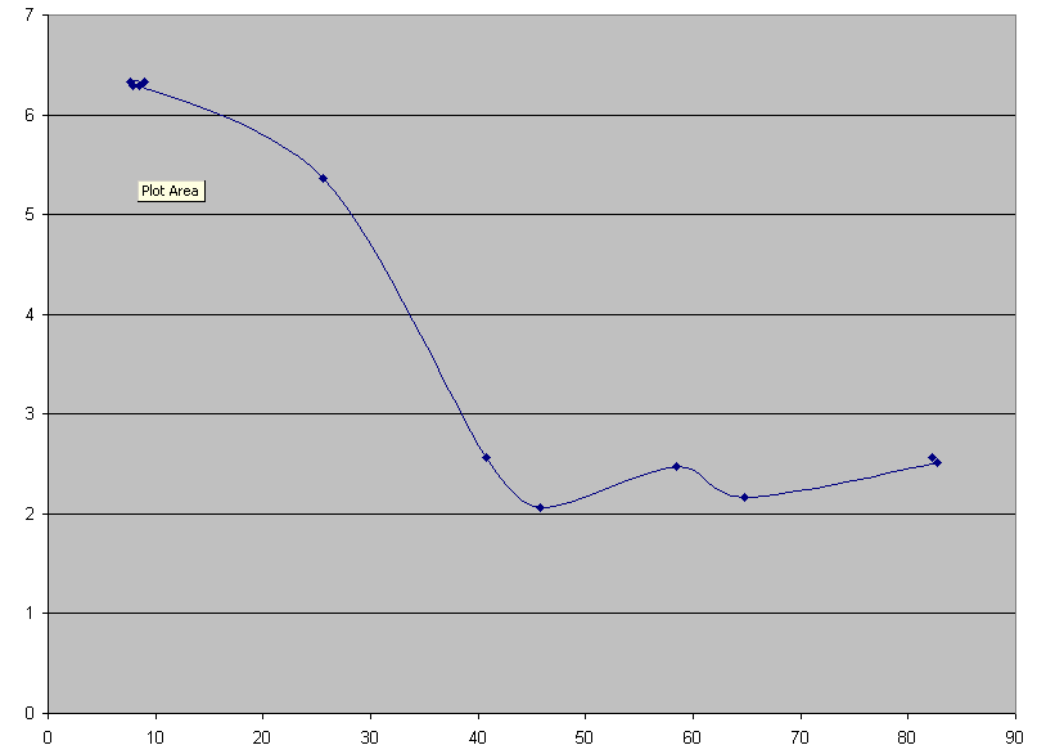
After applying  
Douglas Peucker  
Algorithm

The number of points (initially was 121745) has been reduced to 304  
Tolerance 0.2 degrees Celsius

Temp



Depth







# Interpolation Stage

1. Load the data after refining and extracting to **GRASS** system.
2. Interpolate the Data using GRASS to produce 3 Dimensional model of water column (Interpolates point data to a G3D grid volume using regularised spline with tension algorithm).
3. Interpolates values to a 3-dimensional grid from 3- dimensional point data.
4. **Exports** G3D grids to v5d format (VIS5D).

**VIS5D** is a system for interactive visualization of large 5-D gridded data sets weather models.

**With Vis5D** one can :

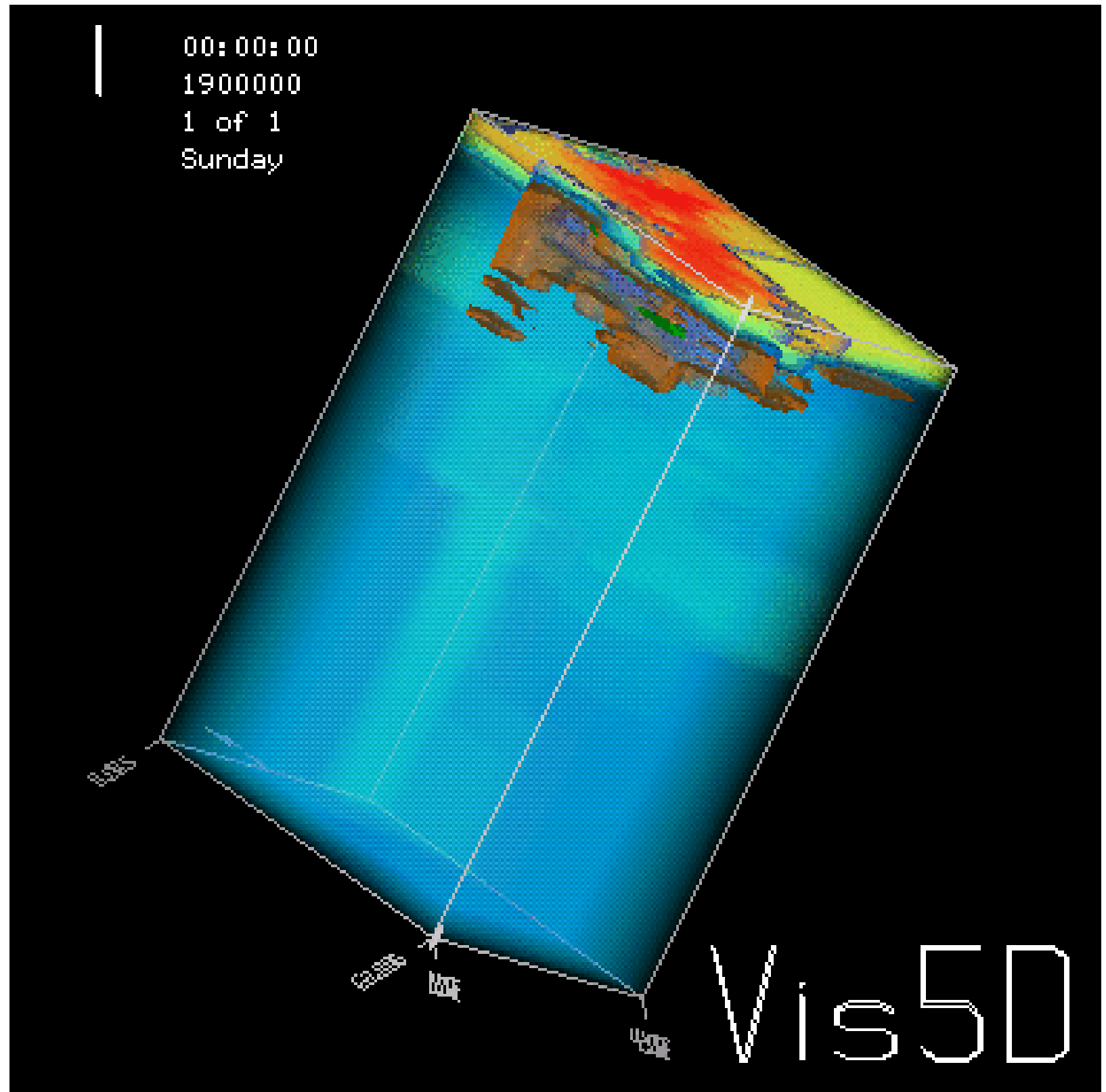
-  Make iso-surfaces, contour line slices, colored slices, volume renderings of data in a 3-D grid.
-  Rotate and animate the images in real time.

# 3D Modelling and visualisation

Viewing the 3D ocean data using Vis5D.

The example shows Latitudes, Longitudes, Depth and Temperature.

Volume is shown **before** filtering (using Douglas Peucker Algorithm).

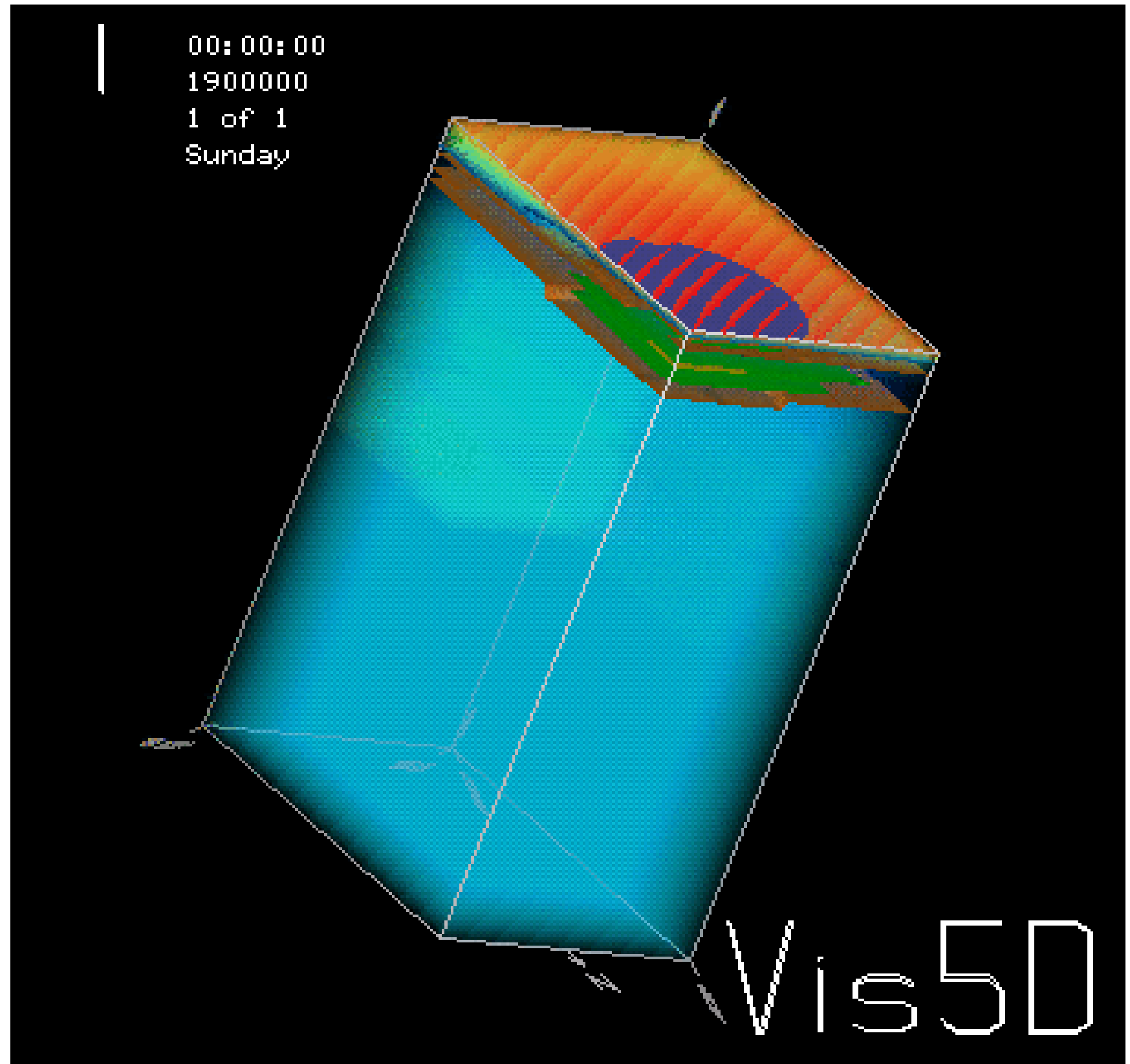


# 3D Modelling and visualisation

Viewing the 3D ocean data using Vis5D.

The example shows  
Latitudes,  
Longitudes,  
Depth and  
Temperature.

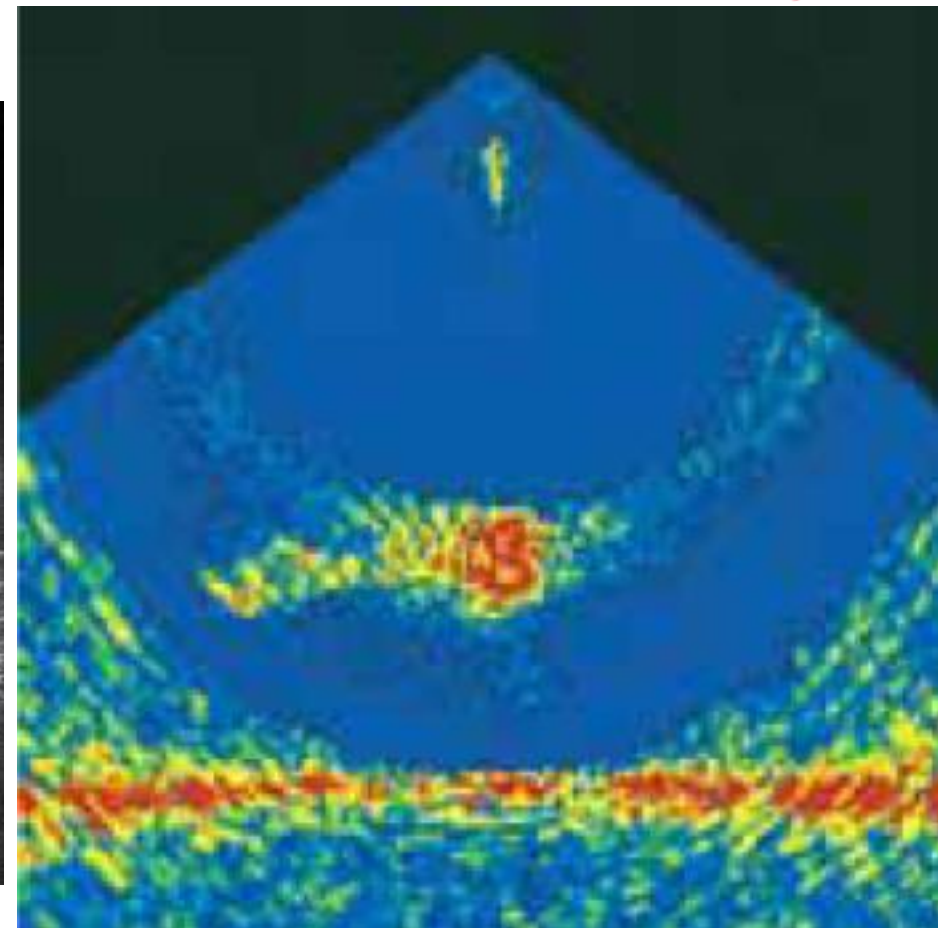
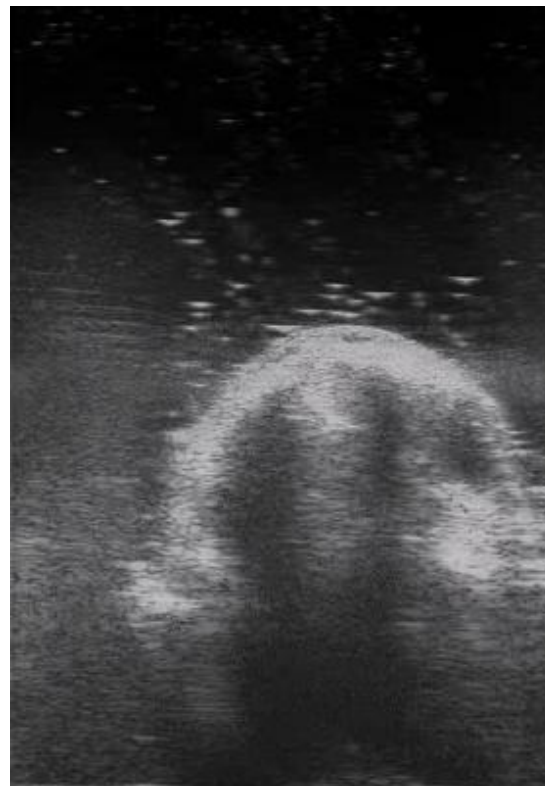
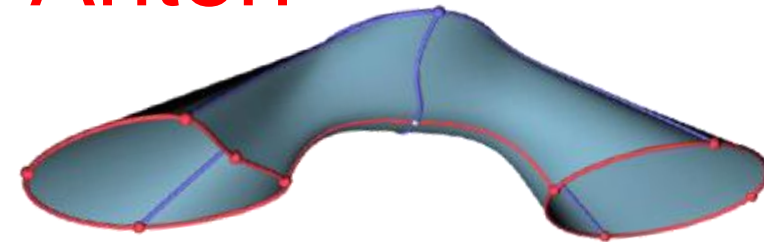
Volume is shown  
**after** filtering  
(using  
DouglasPeucker  
Algorithm).





# Homotopy based 3D/4D reconstruction of water columns from acoustic data

Ojaswa Sharma, François Anton



DTU



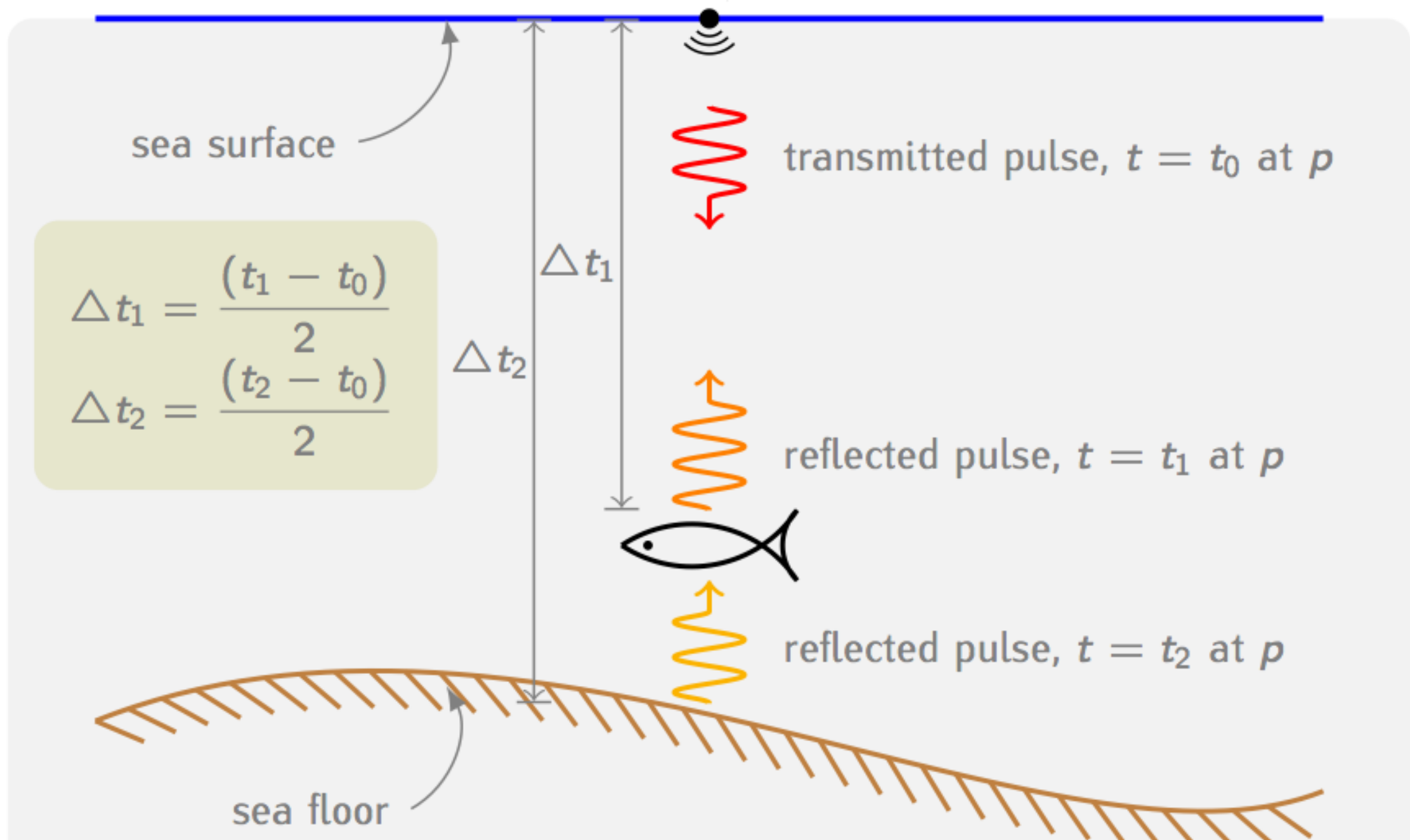
Informatics and Mathematical Modelling



Danish Institute for Fisheries Research

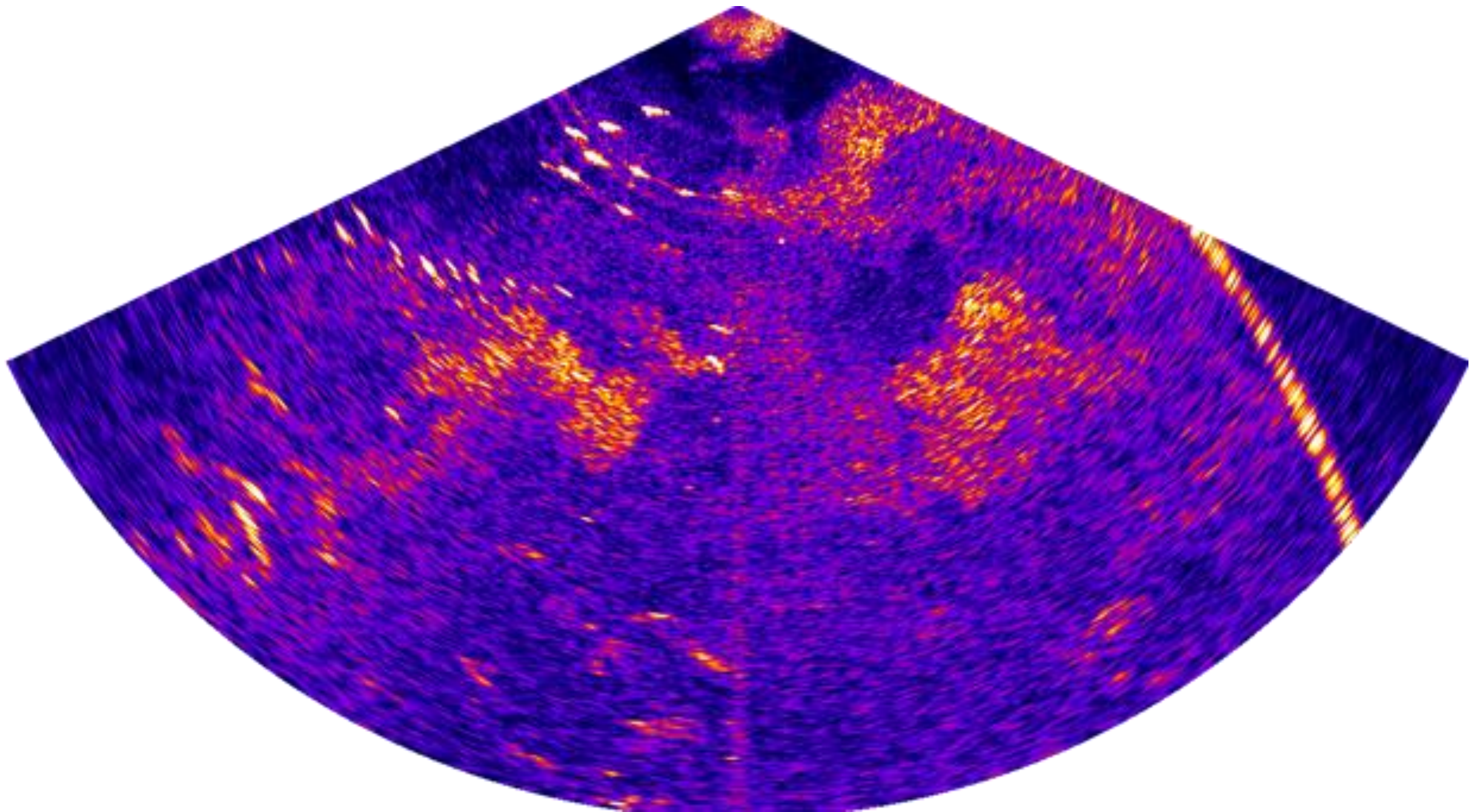
Useful fisheries research

# Acoustic waves reconstruction





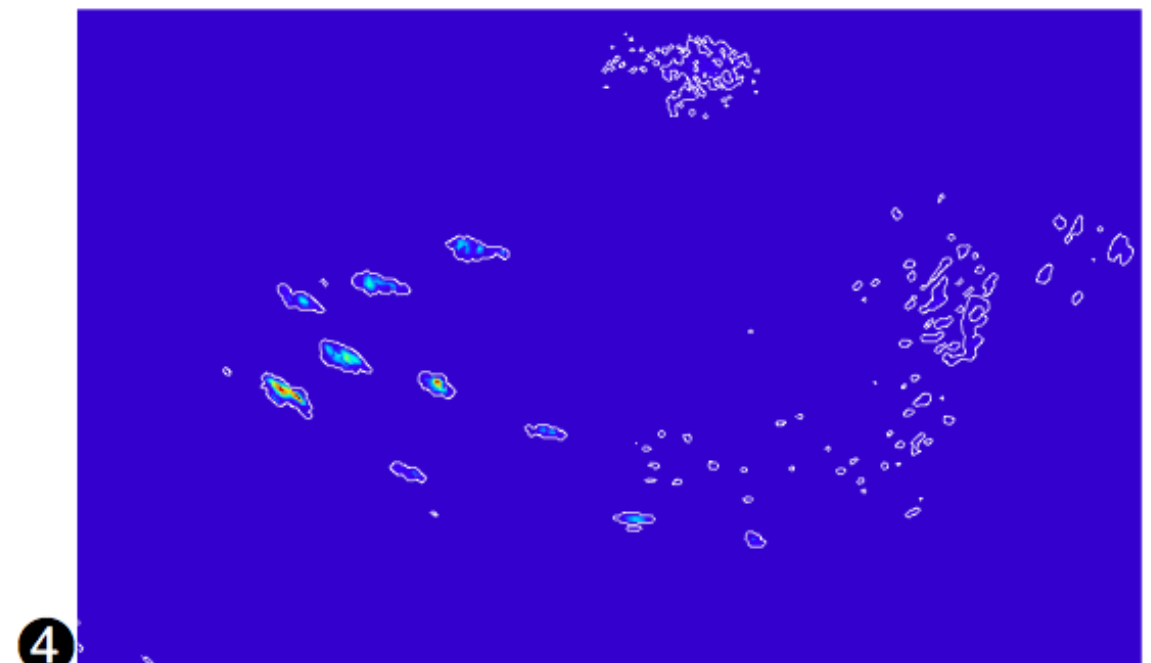
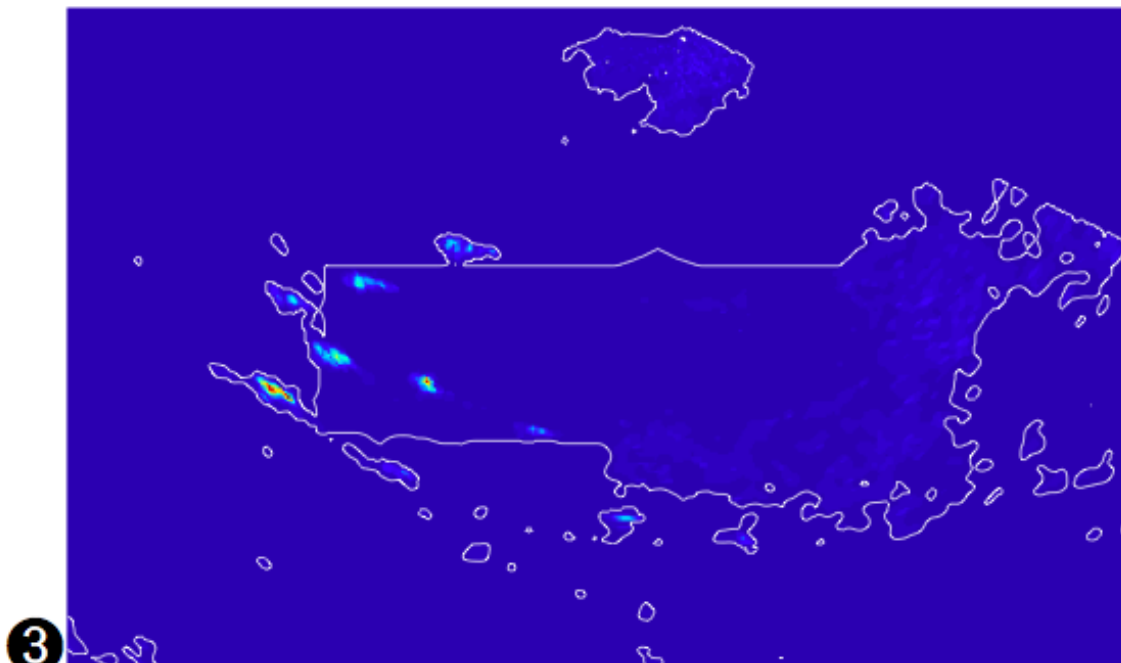
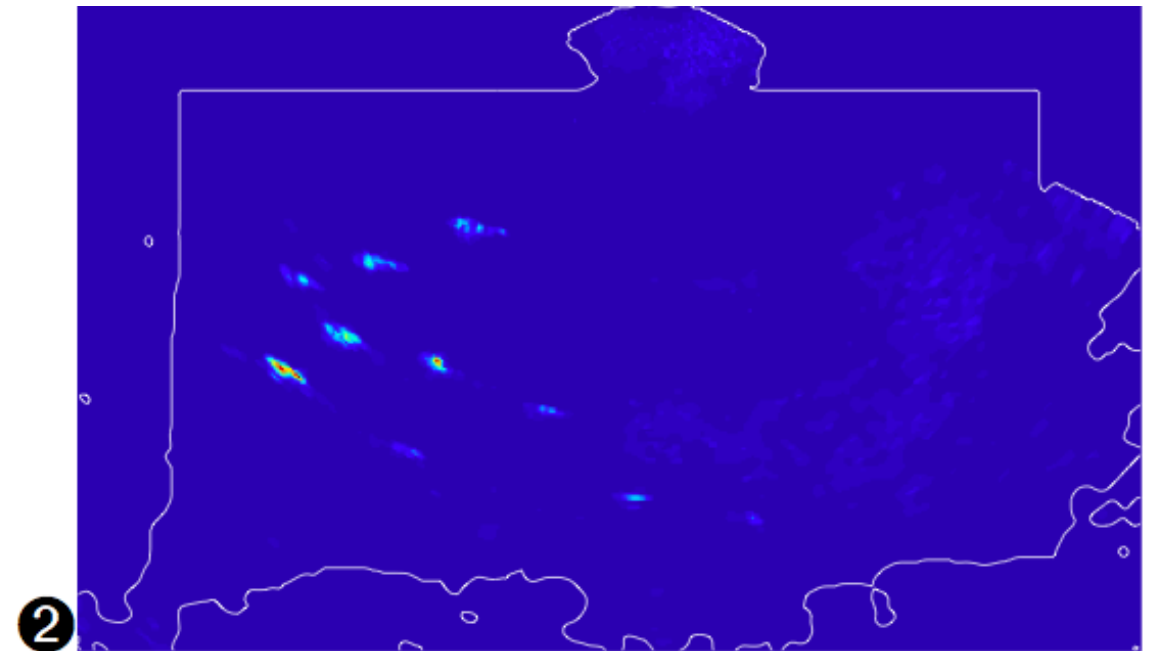
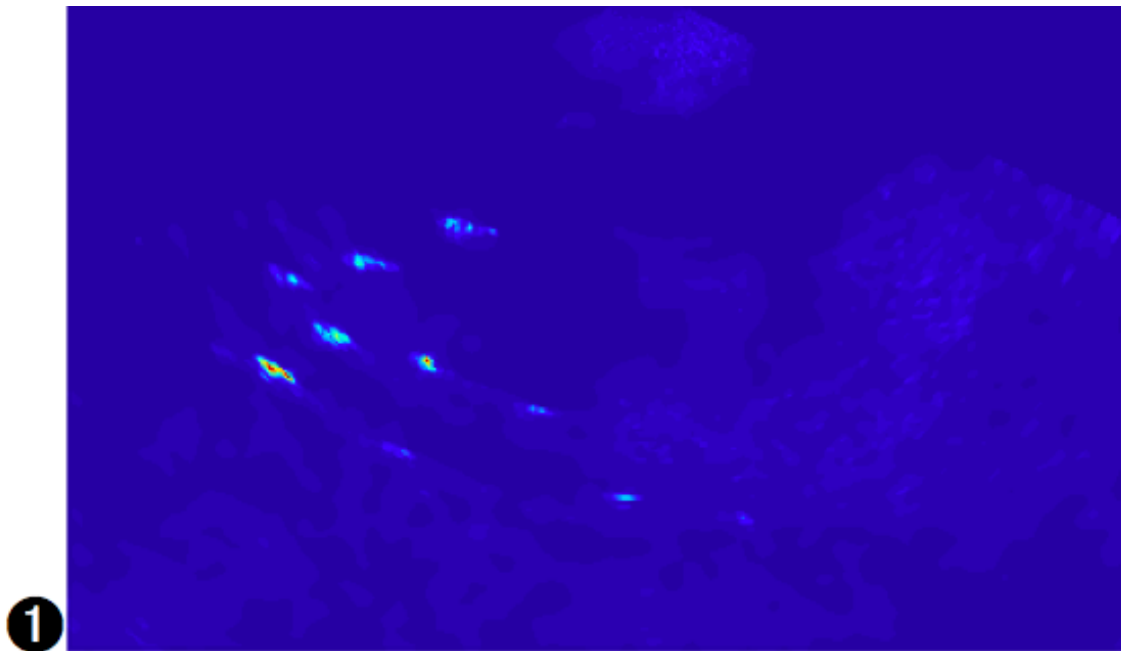
# Multibeam echo sounder image



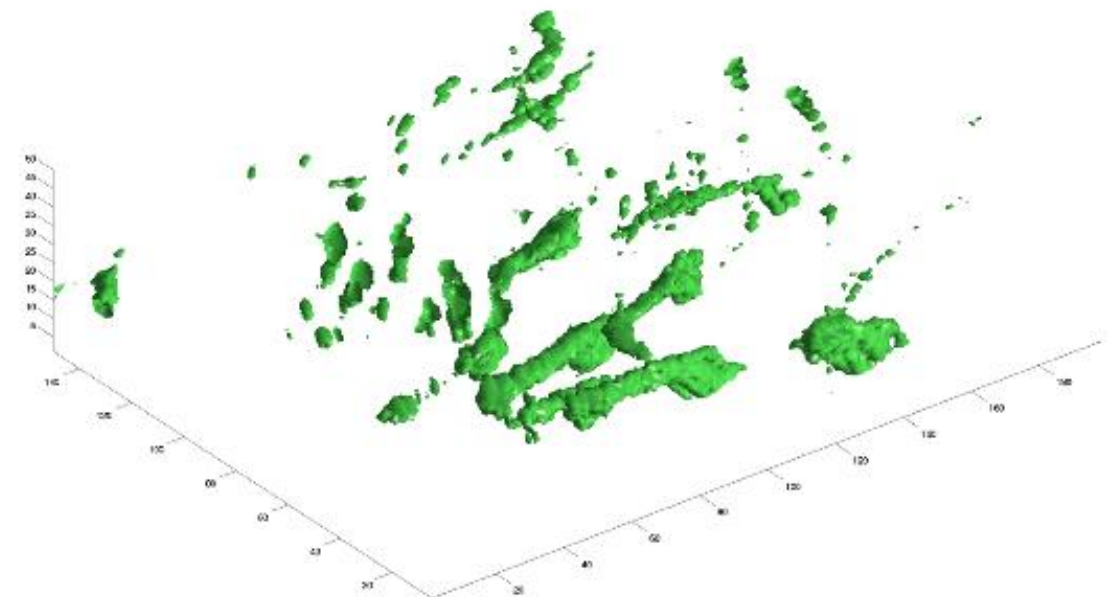
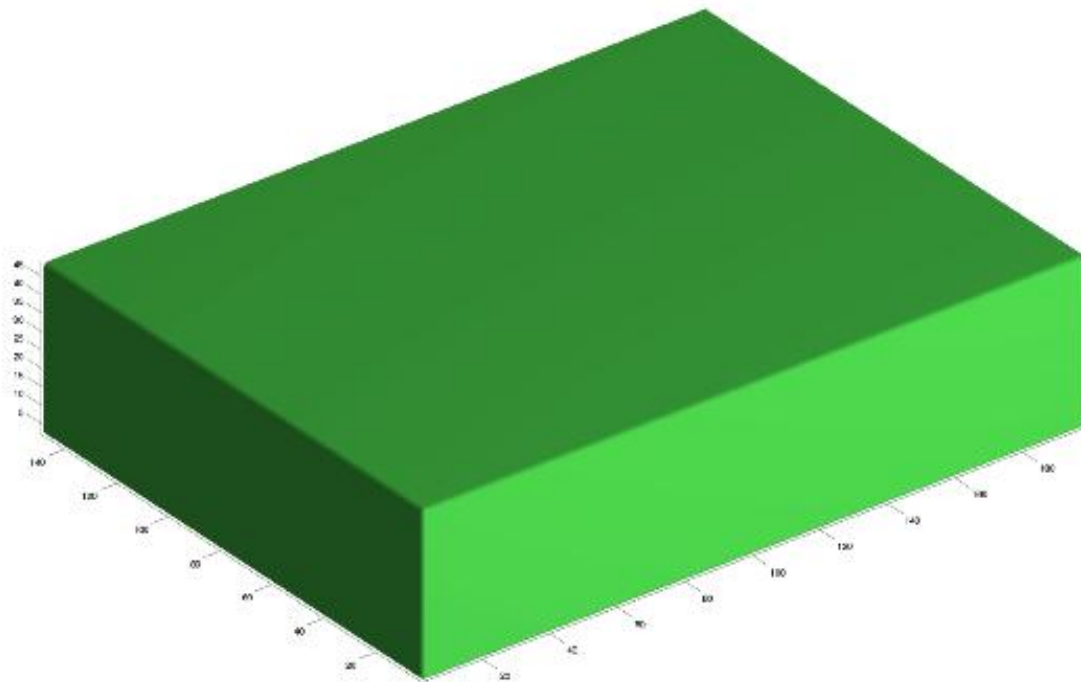
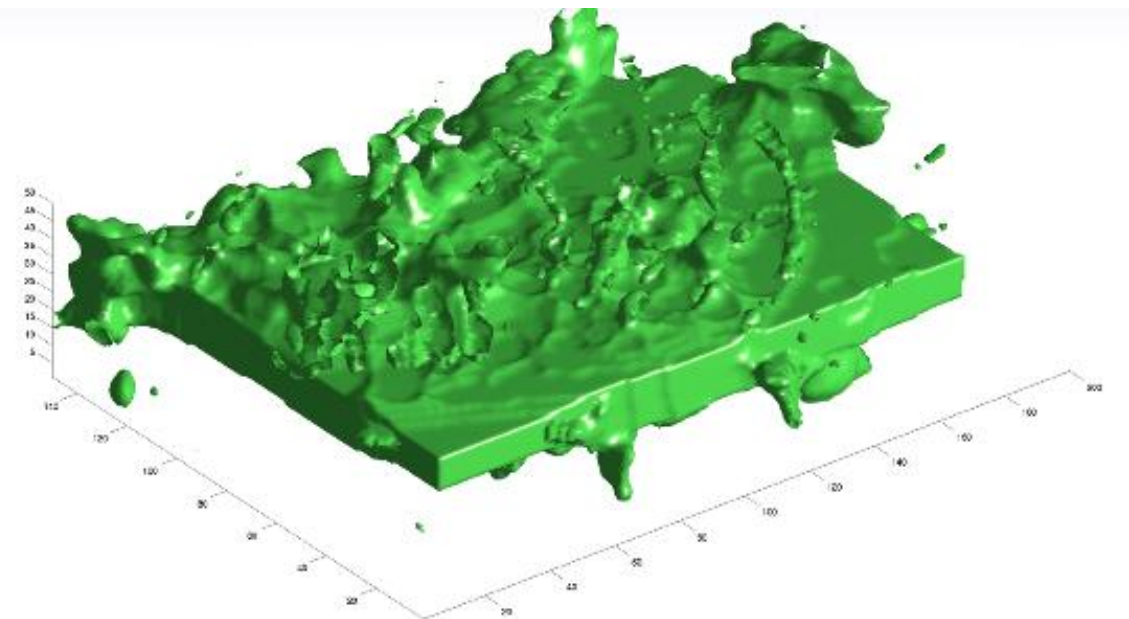
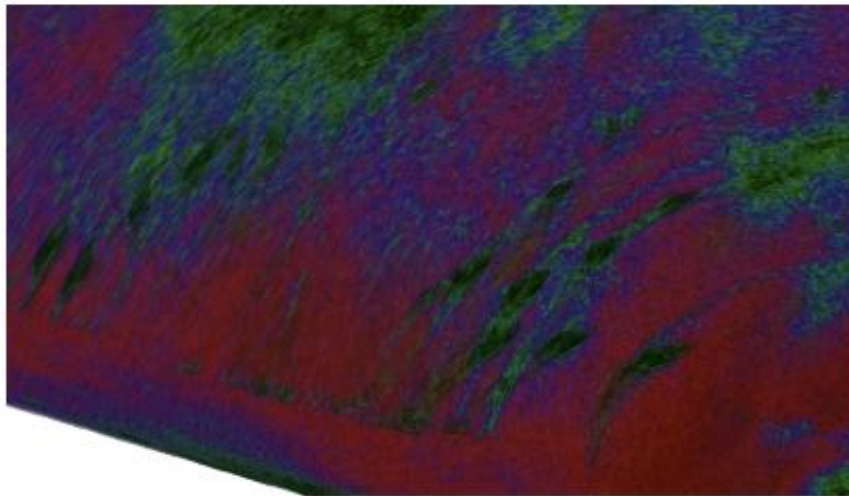


# Deforming Level Sets

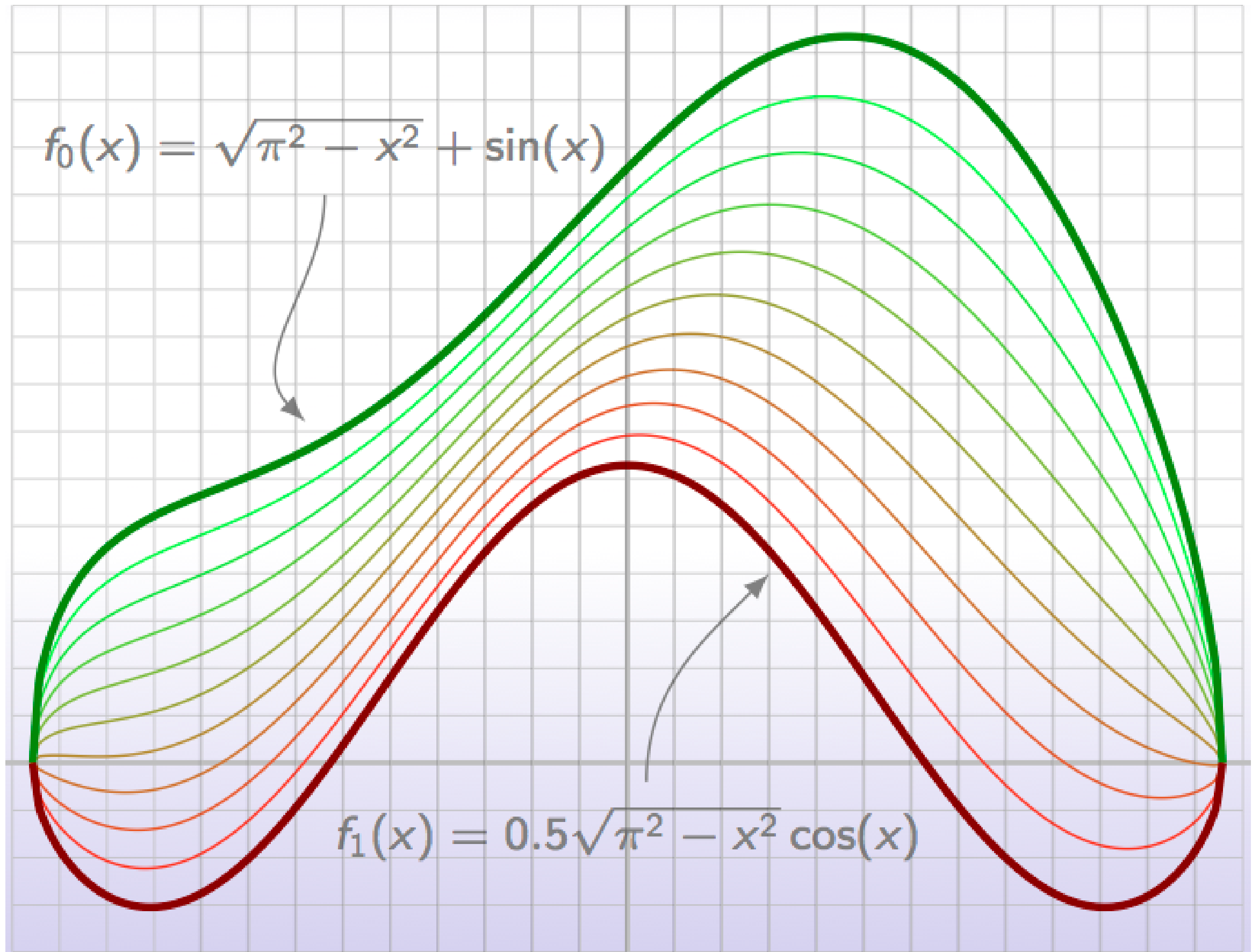
## Noise Reduction



# Deforming Level Sets Reconstruction



# Homotopies

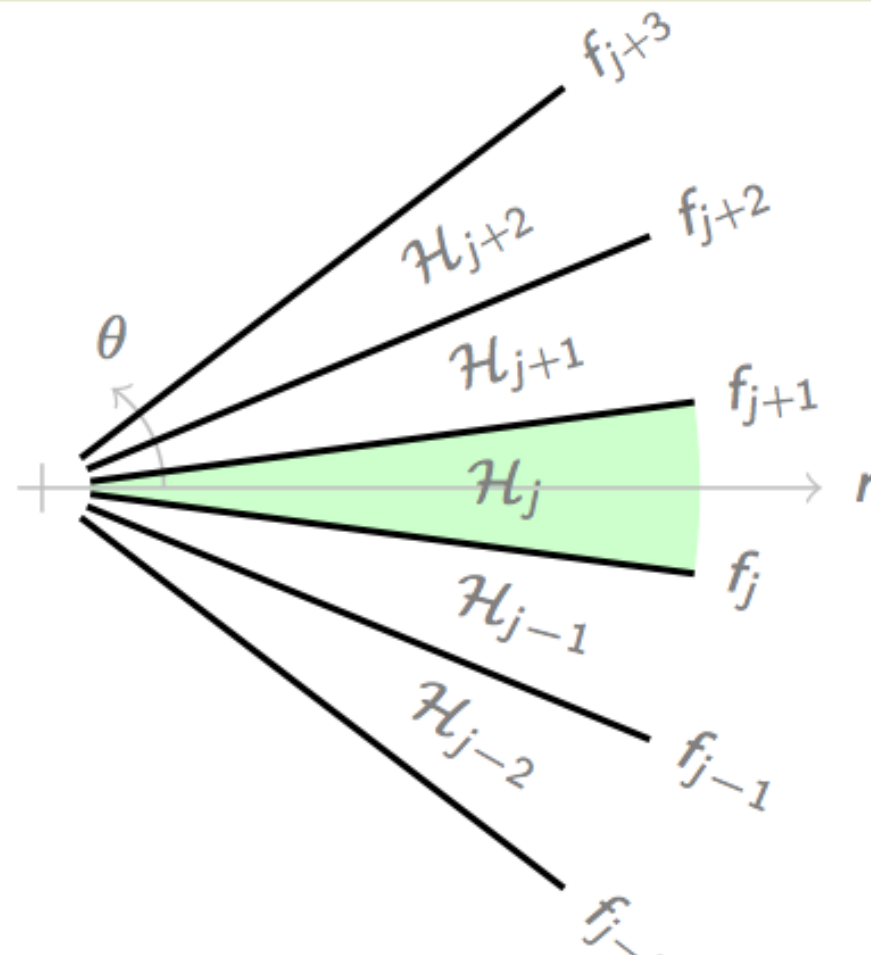


# Homotopies based Reconstruction

$$\mathcal{H}_j(r, \lambda) = (1 - \lambda)f_j(r) + \lambda f_{j+1}(r), \lambda \in [0, 1].$$

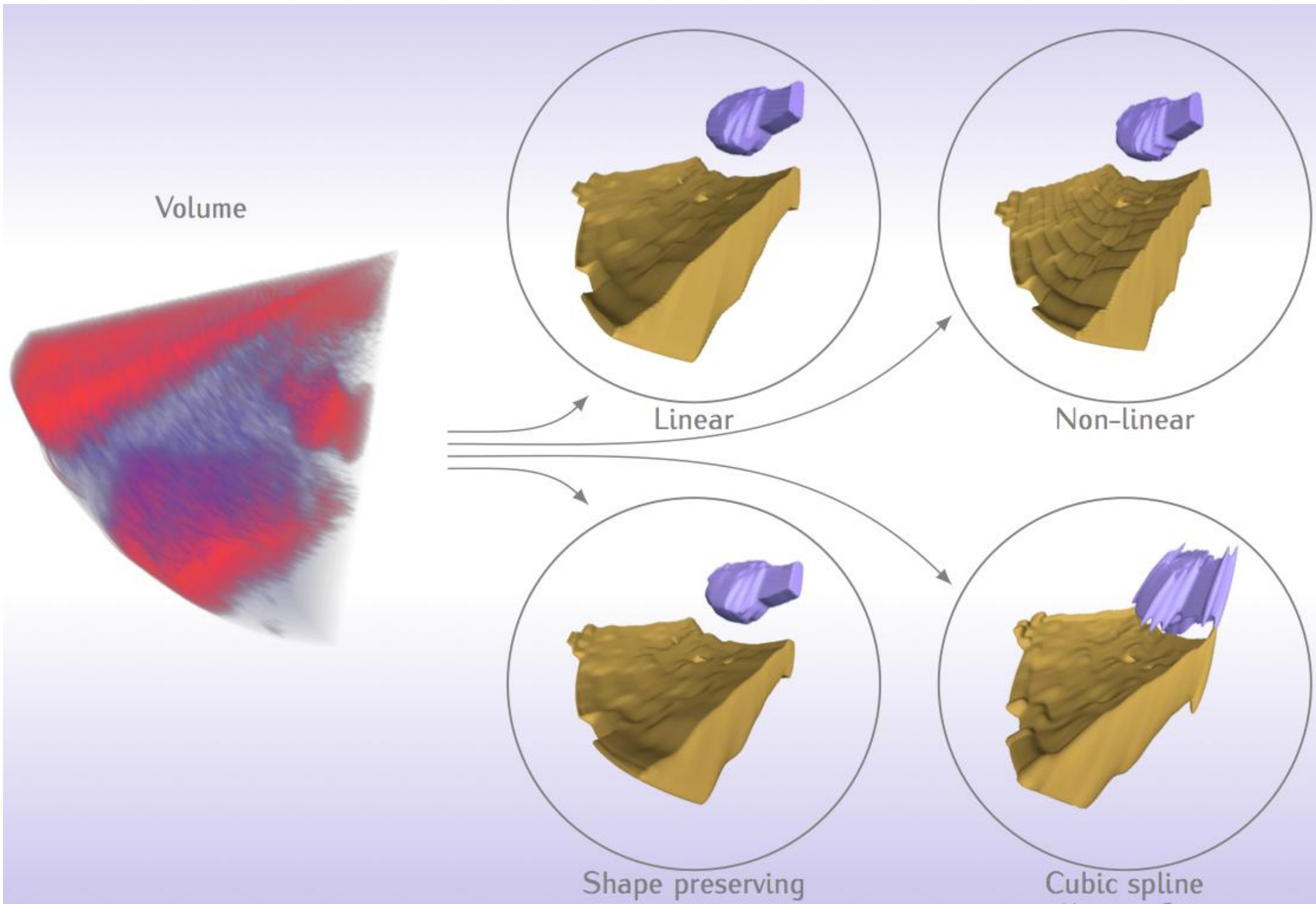
The homotopy parameter  $\lambda$  is linked to the radial angle  $\theta$  as

$$\lambda = \frac{\theta - \theta_j}{\theta_{j+1} - \theta_j}.$$





# Homotopies based Reconstruction



# Conclusions

- ◆ A marine SDI can be constructed using the parallelism in the CPU and the GPU and a functional database management system that unifies the storage of data and processing as functions.
- ◆ Processing techniques need to consider data locally.