Applied Visualization & Modeling For Environment and Geology

Overview of projects VIRCOLA, DECOFF, GeoIllustrator

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Visualization for
Cross-Discipline Collaboration

VIRCOLA

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CMR Computing

In this presentation you will see:

Part 1: CCS and activities in Longyearbyen CO2 lab (Svalbard)

Part 2: An overview of the activities in the VIRCOLA project

Part 1. CCS and activities in Longyearbyen CO2 lab (Svalbard)

Why is Carbon Capture and Storage (CCS) importnat?

Intergovernmental Panel on Climate Change (IPCC):

"global greenhouse gas (GHG) emissions must be reduced by 50- 80% by 2050 to avoid dramatic consequences of global warming"

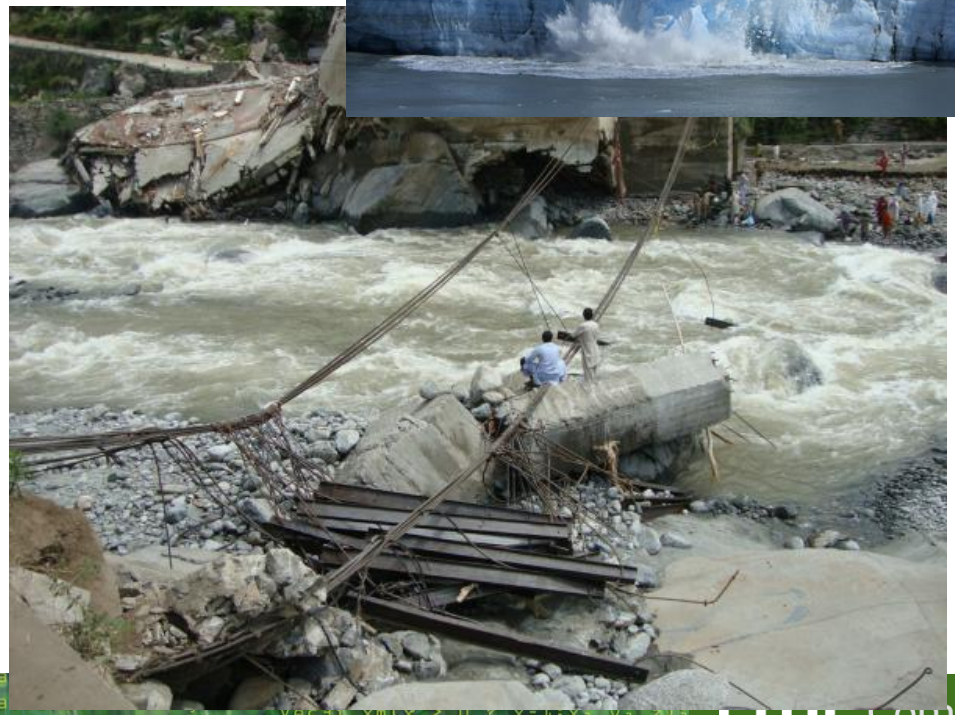
Emissions of greenhouse gasses (present rate) will increase the average global temperature by 1.1 - 6.4 ^{o}C by the end of the 21st century

A global warming of more than 2 ^{o}C increase in average temperature will lead to serious consequences (next page)

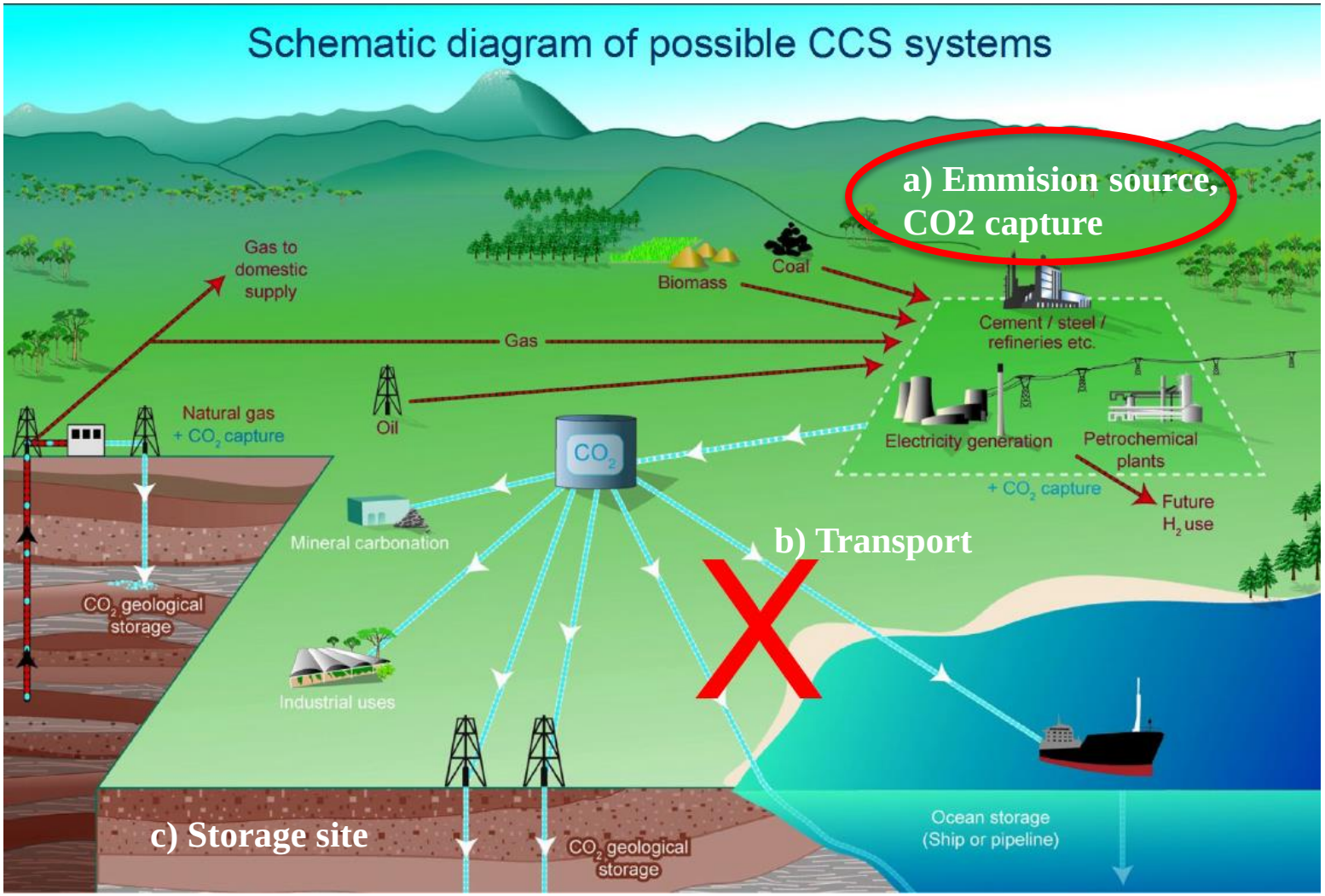
Potentials for reducing CO2 emissions are limited

Some of the consequences that global warming will bring:

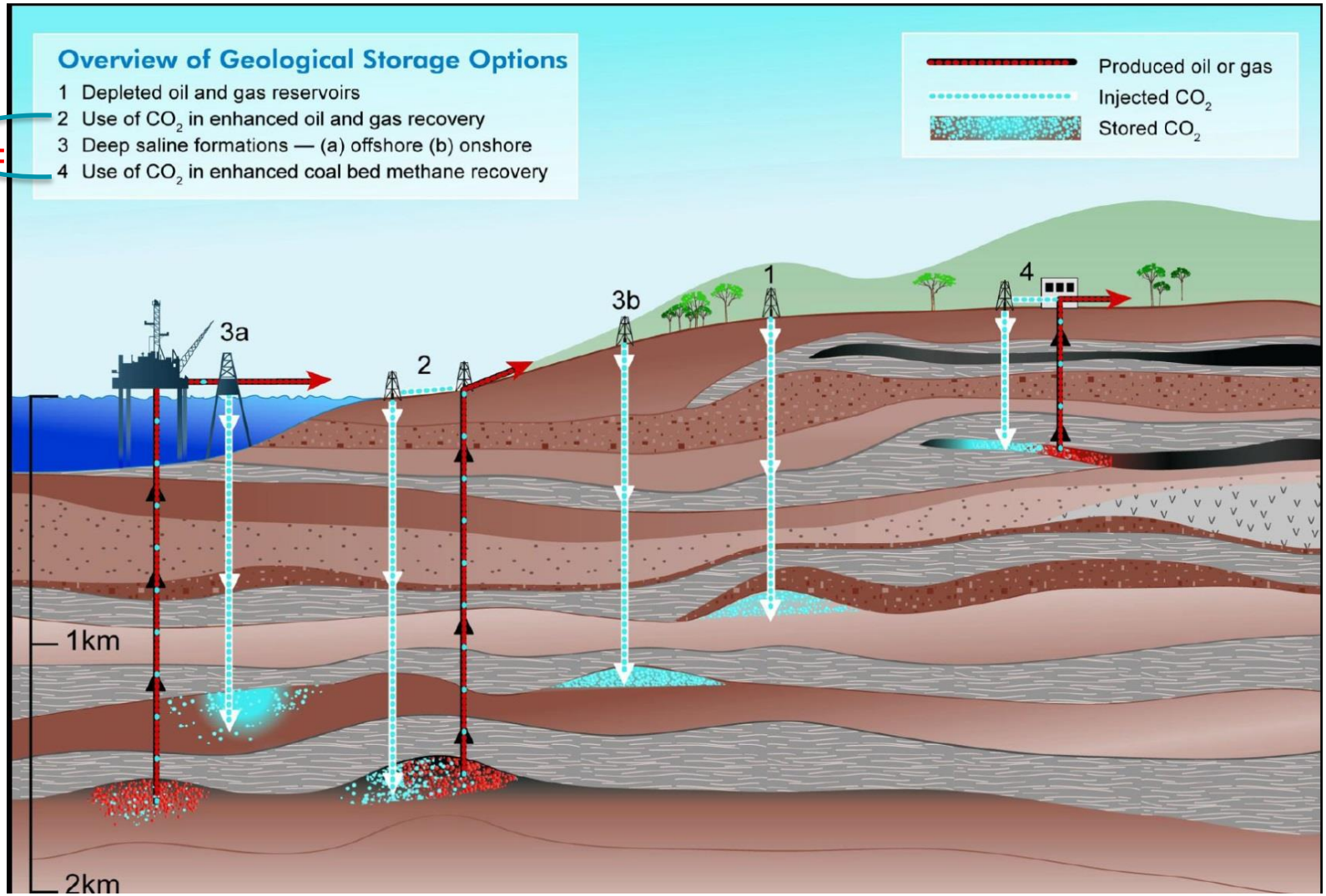
- More floods
- Polar ice caps melting
- Spread of disease
- Warmer waters and more hurricanes
- Increased intensity of droughts and heat waves
- Economic consequences
- Wildfires
- Destructive storms
- Desertification
- Tsunamis
- Increased volcanic activity
- Loss of biodiversity and animal extinction
- Animal attacks
- Migration, conflict and wars



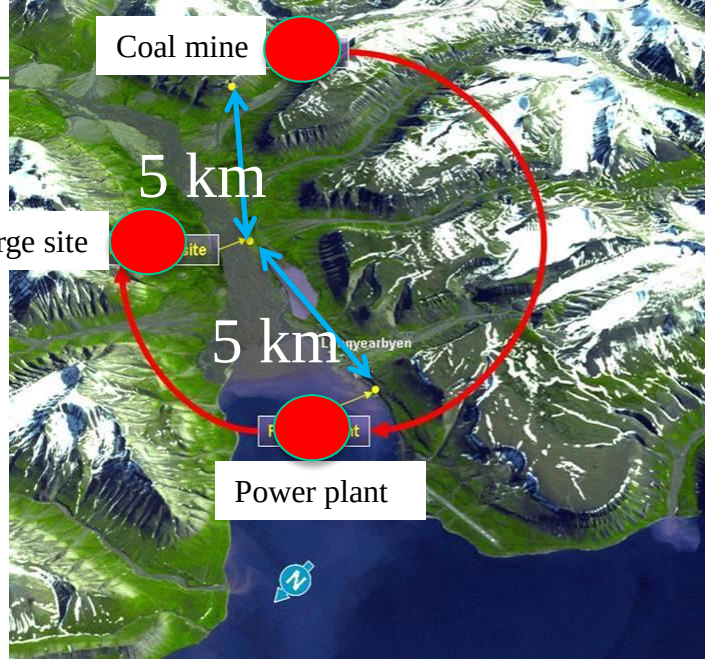
How does a CCS system work?



Overview of geological storage options



CO2 storage in Svalbard?



Storage type: Deep saline aquifer

64,000 tons/year CO2 emission

Suitable reservoir capacity

Ideal distance: emission source - storage sites

Suitable caprock, good reservoir conditions

High arctic location: symbolic case to warn about global warming

Part 2. The Virtual CO2 Laboratory (VIRCOLA Project)

What is VIRCOLA, what is its vision?

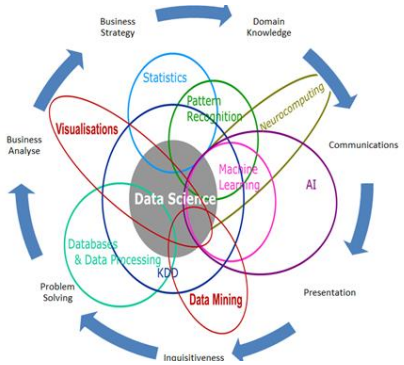
Stands for Virtual CO2 Laboratory

Initial case study: Longyearbyen, Svalbard

Vision: Develop a data platform and methodology for co-visualization and visual analysis of multi-disciplinary data. **Why?** to facilitate dialogue and communication between researchers whose research deals with CO2 storage in Norway.

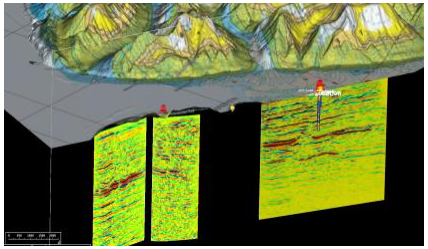
Motivation and challenges?!

Diverse geographical locations



Multi-disciplinary data

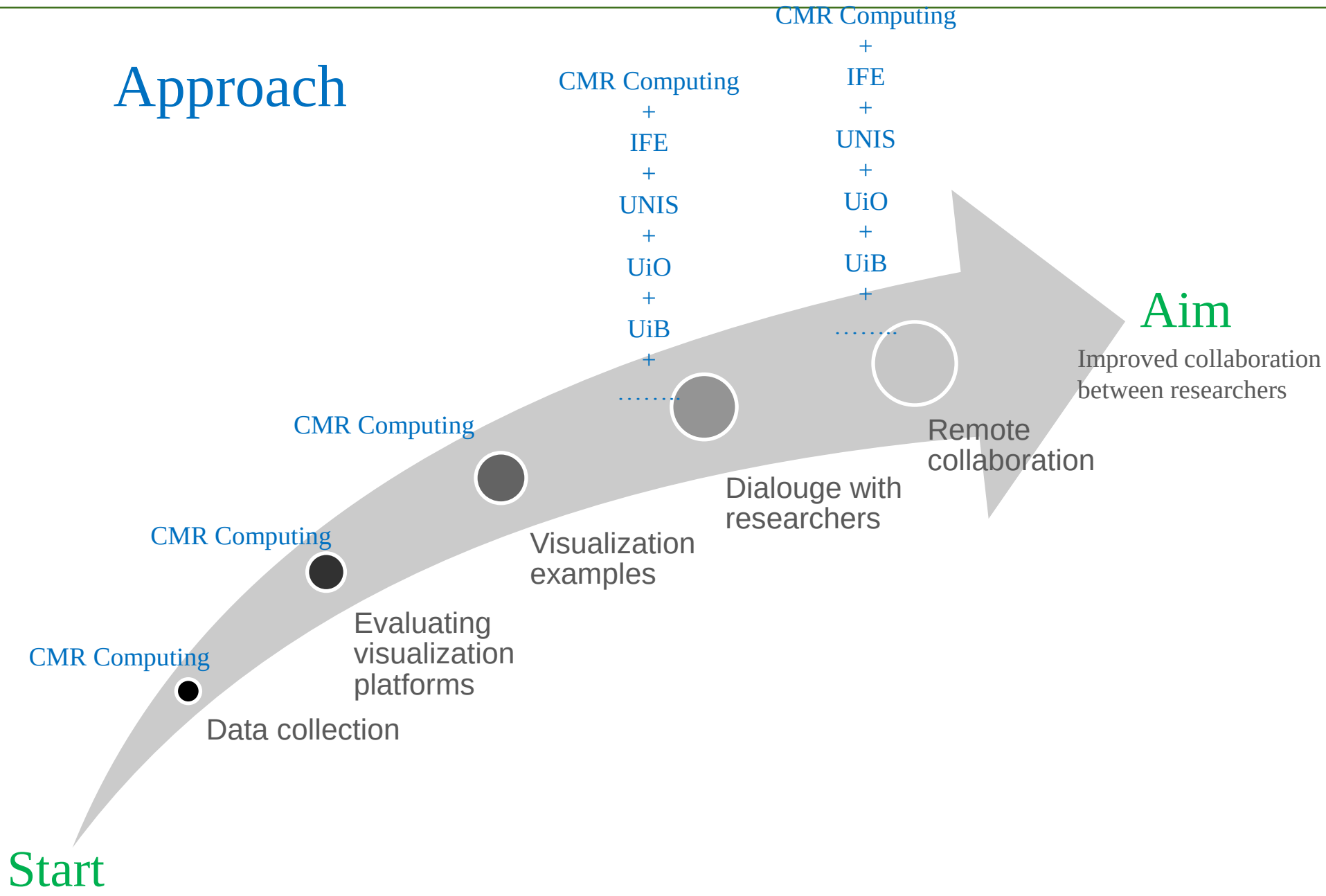
More ….



Covisualizations

Multi-disciplinary research

Approach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Aim
Improved collaboration between researchers
Remote collaboration
Dialouge with researchers
CMR Computing
Visualization examples
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Evaluating visualization platforms
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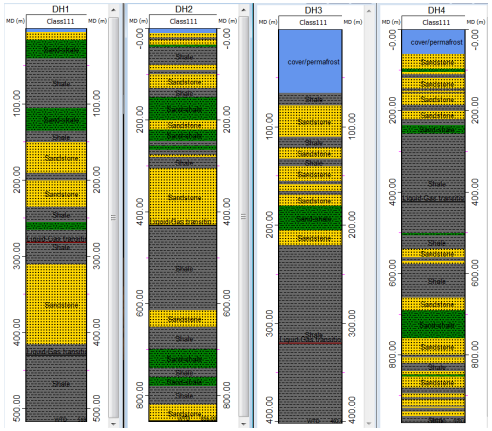
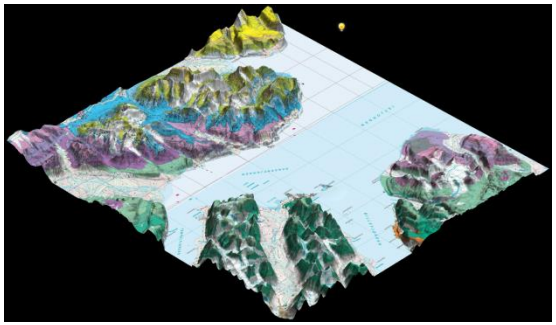
Data collection
Start

Collected data

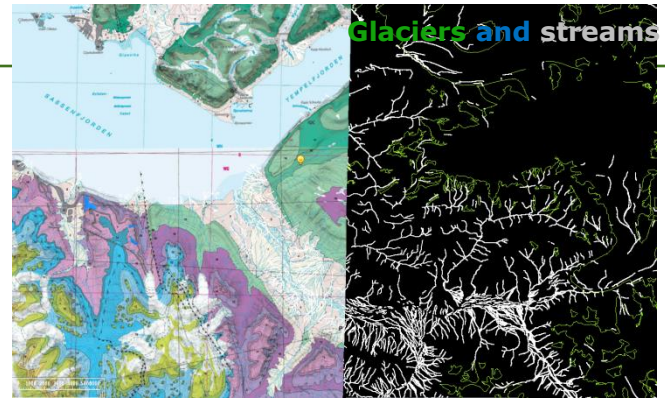


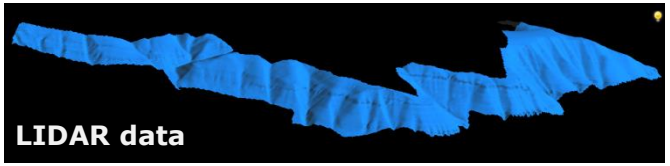
Core lithology descriptions

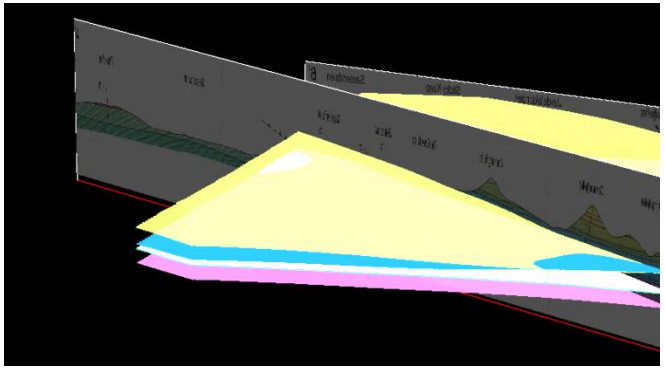
Core images



Geology-topography map

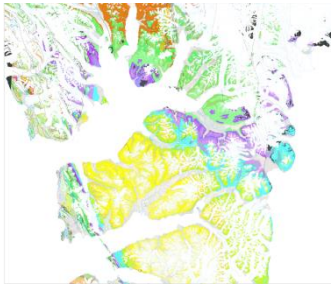




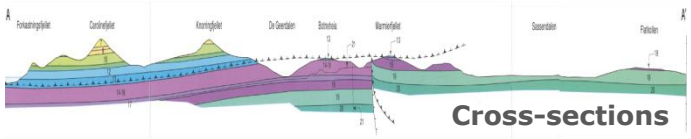


Horizons

Digital geology maps...



High resolution geology maps



Cross-sections

And many more.....

Evaluation of the selected visualization tools

Weak (-)
Acceptable (o)
Good/very good (+)

3D programs	Import/export	Scripts	Cost	Communication	Visualization functionality
Petrel	o	o	+	+	+
GOCAD/SKUA	+	o	o	o	+
Encom PA	o	-	-	o	+

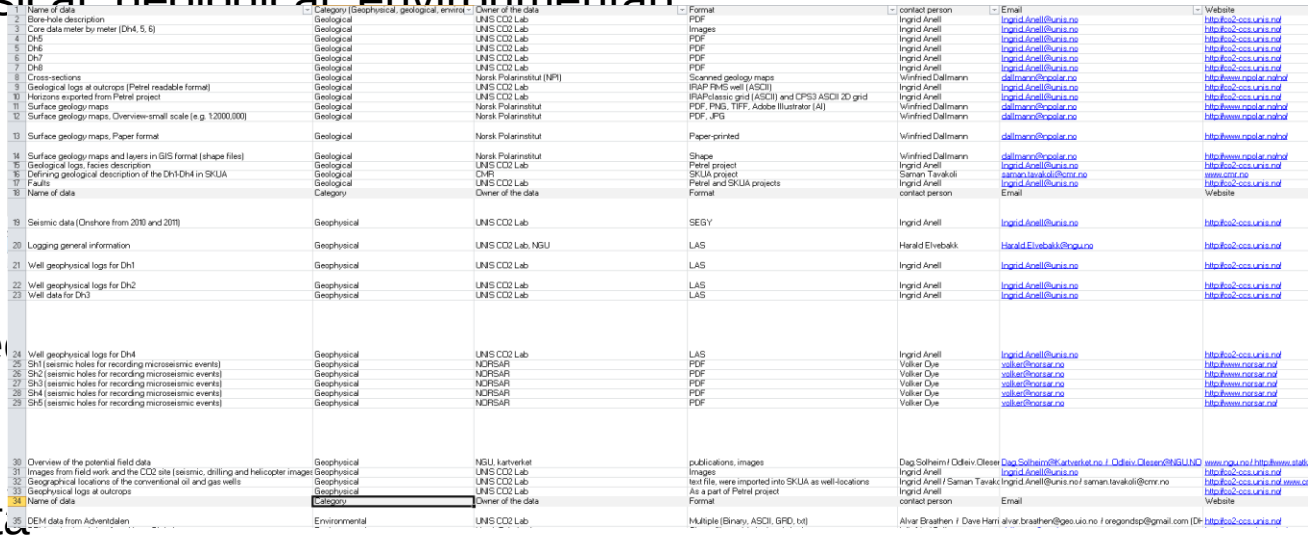
2D programs	Import/export	Scripts	Cost	Communication	Visualization functionality
ArcMap	+	+	+	+	o
MapInfo	+	o	o	o	o

Examples of VIRCOLA's approach

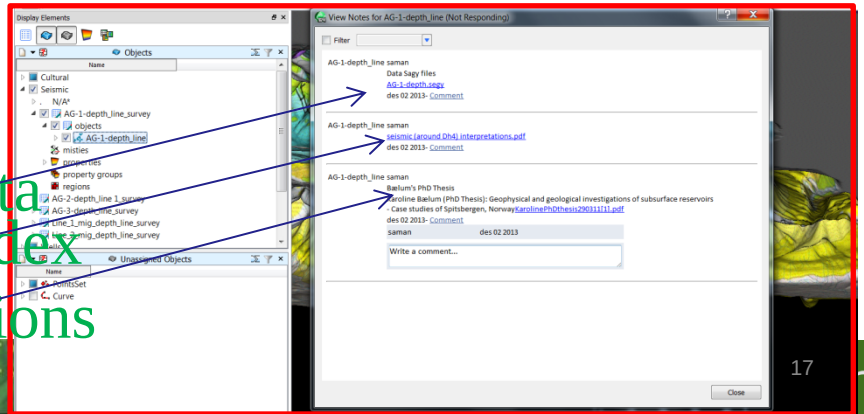
1. Establishing a ‘data index’ for VIRCOLA

We created an index file through which available data in the VIRCOLA project (with their details) are accessible. The data index includes following information:

- Category (geophysical, geological, environmental)
- Owner of the data
- Data format
- Contact person
- Email
- Website
- Date when data re
- Data size
- Eventual cost
- Coordinates of data
- Description
- Link to storage location
- Link to publications
- Link to SKUA?



	Name of data	Category (Geophysical, geological, environ	Owner of the data	Format	contact person	Email	Website
2	Bore-hole description	Geological	UNIS CO2 Lab	PDF	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
3	Core data meter by meter (Dh4, 5, 6)	Geological	UNIS CO2 Lab	Images	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
4	Dh5	Geological	UNIS CO2 Lab	PDF	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
5	Dh6	Geological	UNIS CO2 Lab	PDF	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
6	Dh7	Geological	UNIS CO2 Lab	PDF	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
7	Dh8	Geological	UNIS CO2 Lab	PDF	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
8	Cross-sections	Geological	Norsk Polarinstitutt (NPI)	Scanned geology maps	Winfried Dallmann	dallmann@npolar.no	http://www.npolar.no/np/
9	Geological logs at outcrops (Petrel readable format)	Geological	UNIS CO2 Lab	IRAP RMS well (ASCII)	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
10	Horizons exported from Petrel project	Geological	UNIS CO2 Lab	IRAPclassic grid (ASCII) and CPS3 ASCII 2D grid	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
11	Surface geology maps	Geological	Norsk Polarinstitutt	PDF, PNG, TIFF, Adobe Illustrator (AI)	Winfried Dallmann	dallmann@npolar.no	http://www.npolar.no/np/
12	Surface geology maps, Overview-small scale (e.g. 1:2000,000)	Geological	Norsk Polarinstitutt	PDF, JPG	Winfried Dallmann	dallmann@npolar.no	http://www.npolar.no/np/
13	Surface geology maps, Paper format	Geological	Norsk Polarinstitutt	Paper-printed	Winfried Dallmann	dallmann@npolar.no	http://www.npolar.no/np/
14	Surface geology maps and layers in GIS format (shape files)	Geological	Norsk Polarinstitutt	Shape	Winfried Dallmann	dallmann@npolar.no	http://www.npolar.no/np/
15	Geological logs, facies description	Geological	UNIS CO2 Lab	Petrel project	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
16	Defining geological description of the Dh1-Dh4 in SKUA	Geological	CMR	SKUA project	Saman Tavakoli	saman.tavakoli@cmr.no	www.cmr.no
17	Faults	Geological	UNIS CO2 Lab	Petrel and SKUA projects	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
18	Name of data	Category	Owner of the data	Format	contact person	Email	Website
19	Seismic data (Onshore from 2010 and 2011)	Geophysical	UNIS CO2 Lab	SEGY	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
20	Logging general information	Geophysical	UNIS CO2 Lab, NGU	LAS	Harald Elvebakk	Harald.Elvebakk@ngu.no	http://co2-ccs.unis.no/
21	Well geophysical logs for Dh1	Geophysical	UNIS CO2 Lab	LAS	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
22	Well geophysical logs for Dh2	Geophysical	UNIS CO2 Lab	LAS	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
23	Well data for Dh3	Geophysical	UNIS CO2 Lab	LAS	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
24	Well geophysical logs for Dh4	Geophysical	UNIS CO2 Lab	LAS	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
25	Sh1 (seismic holes for recording microseismic events)	Geophysical	NORSAR	PDF	Volker Oye	volker@norsar.no	http://www.norsar.no/
26	Sh2 (seismic holes for recording microseismic events)	Geophysical	NORSAR	PDF	Volker Oye	volker@norsar.no	http://www.norsar.no/
27	Sh3 (seismic holes for recording microseismic events)	Geophysical	NORSAR	PDF	Volker Oye	volker@norsar.no	http://www.norsar.no/
28	Sh4 (seismic holes for recording microseismic events)	Geophysical	NORSAR	PDF	Volker Oye	volker@norsar.no	http://www.norsar.no/
29	Sh5 (seismic holes for recording microseismic events)	Geophysical	NORSAR	PDF	Volker Oye	volker@norsar.no	http://www.norsar.no/
30	Overview of the potential field data	Geophysical	NGU, kartverket	publications, images	Dag.Solheim/ Odleiv.Olesen	Dag.Solheim@Kartverket.no / Odleiv.Olesen@NGU.NO	www.ngu.no/ http://www.statk
31	Images from field work and the CO2 site (seismic, drilling and helicopter images	Geophysical	UNIS CO2 Lab	Images	Ingrid Anell	Ingrid.Anell@unis.no	http://co2-ccs.unis.no/
32	Geographical locations of the conventional oil and gas wells	Geophysical	UNIS CO2 Lab	text file, were imported into SKUA as well-locations	Ingrid Anell / Saman Tavako	Ingrid.Anell@unis.no/ saman.tavakoli@cmr.no	http://co2-ccs.unis.no/ www.c
33	Geophysical logs at outcrops	Geophysical	UNIS CO2 Lab	As a part of Petrel project	Ingrid Anell		http://co2-ccs.unis.no/
34	Name of data	Category	Owner of the data	Format	contact person	Email	Website
35	DEM data from Adventdalen	Environmental	UNIS CO2 Lab	Multiple (Binary, ASCII, GRD, txt)	Alvar Braathen / Dave Harri	alvar.braathen@geo.uio.no / oregondsp@gmail.com (DH	http://co2-ccs.unis.no/



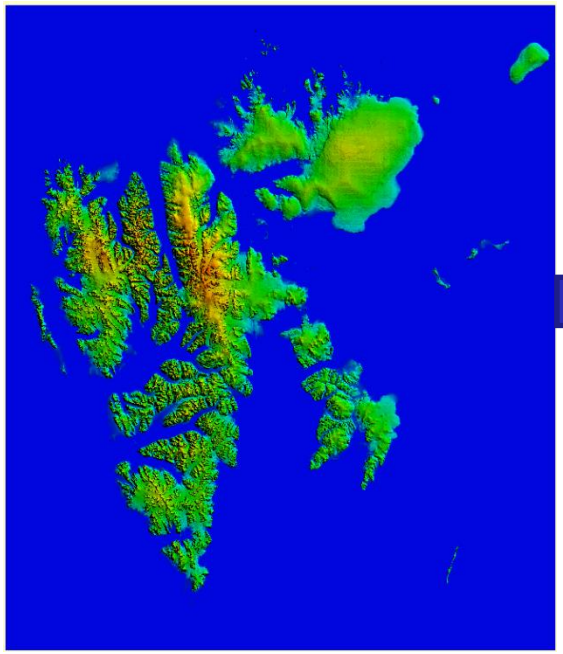
Link to data

Link to data index

Link to publications

2. Advancing visualization techniques:

(b) Higher resolution geology image-much larger coverage



GeoTIFF

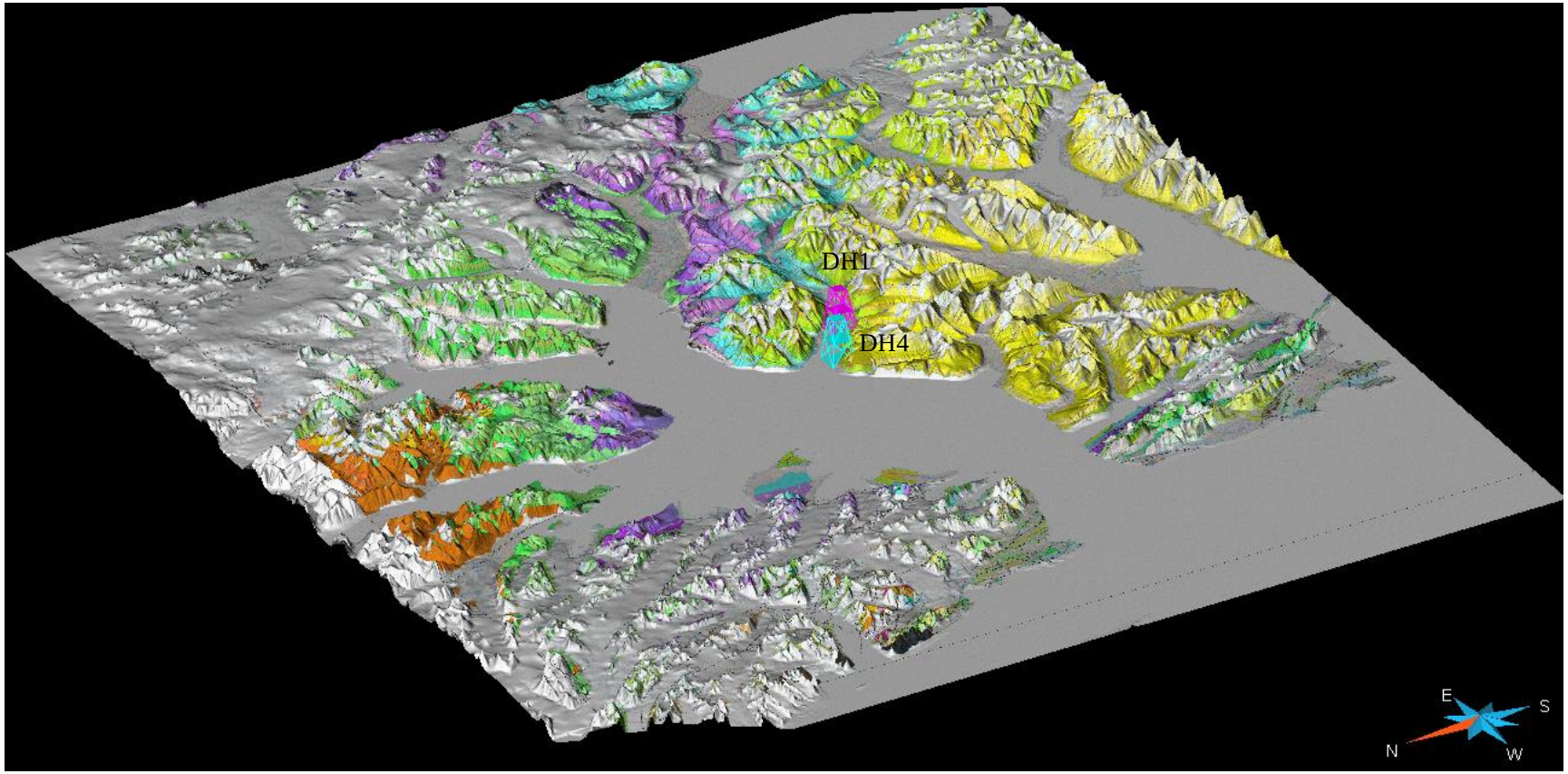
(a) Exported as Grid+ cropped

GlobalMapper

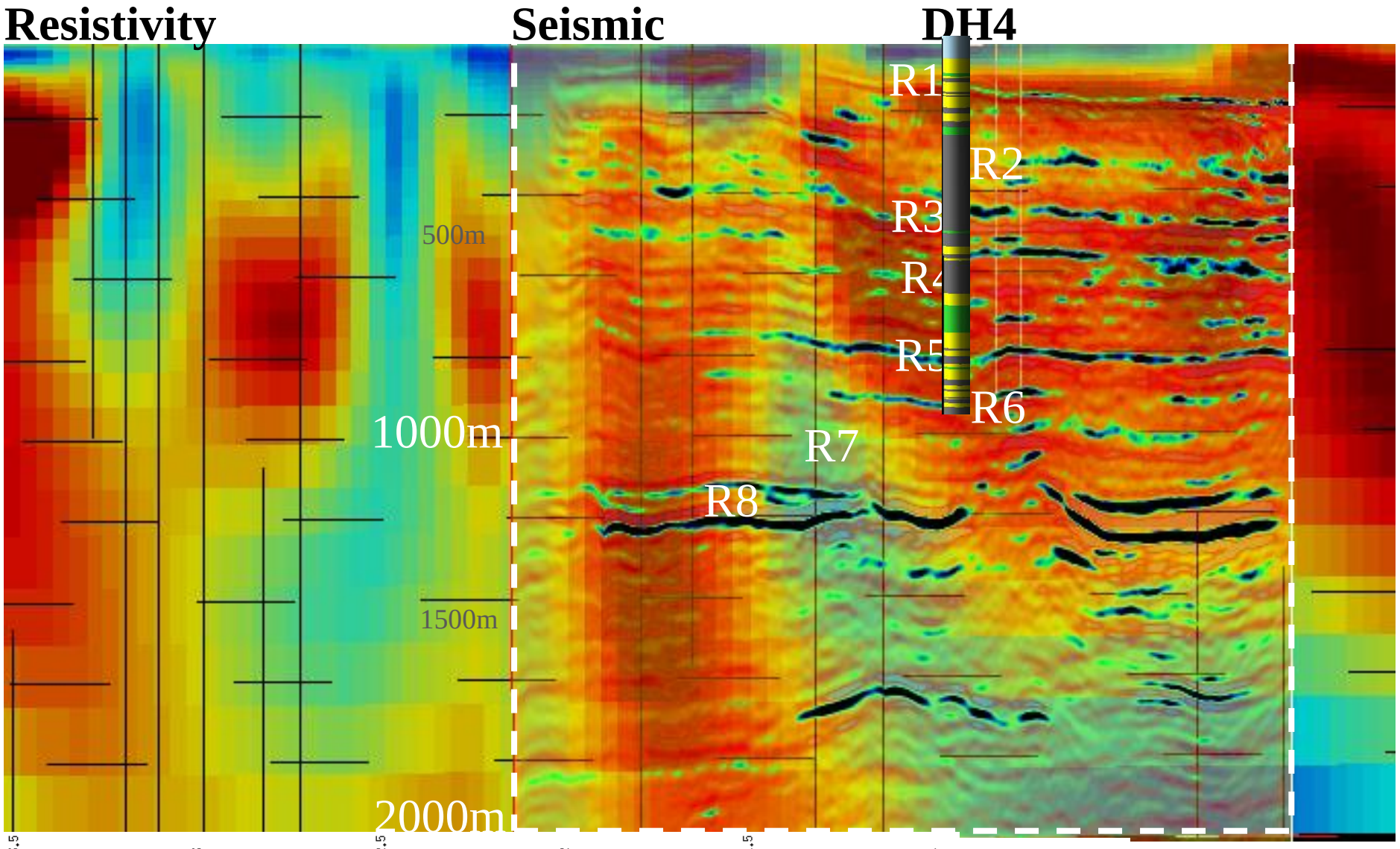
SKUA

1- (a) was projected on (b)
2- Scripted to adjust the image

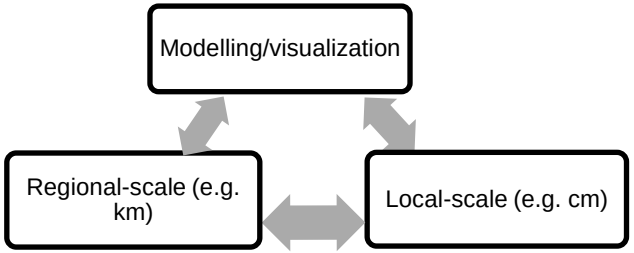
Example: Geology map projected on DEM model of Svalbard

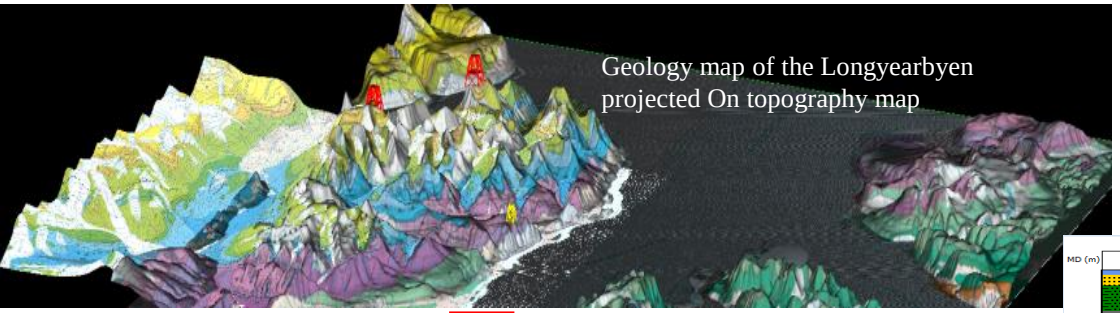


3. Improving the initial understanding by co-visualizing data (MT vs. Seismic)

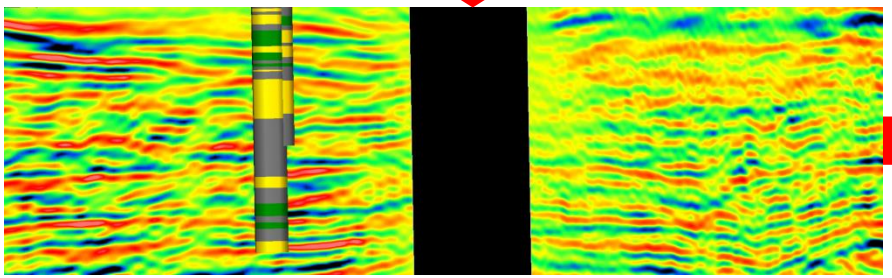


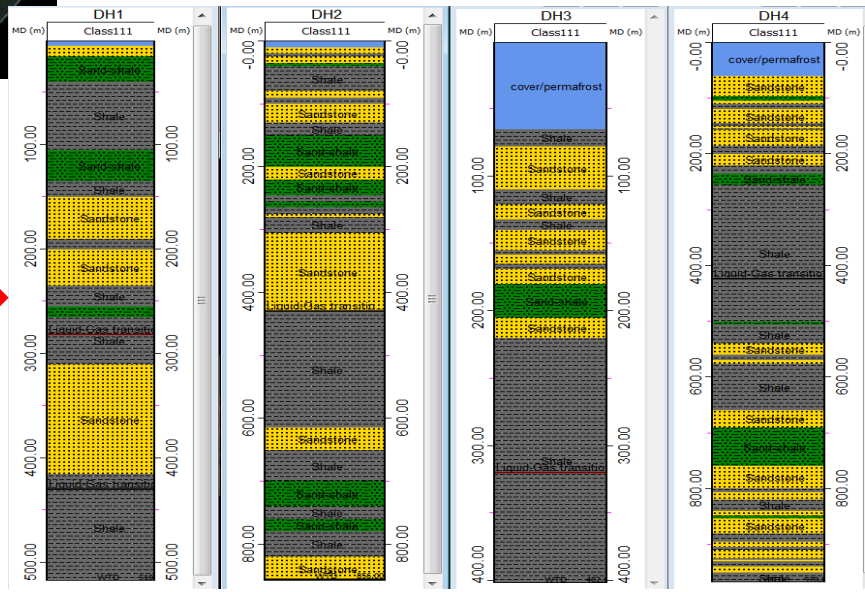
4. Regional to local-scale (multi-scale) visualization



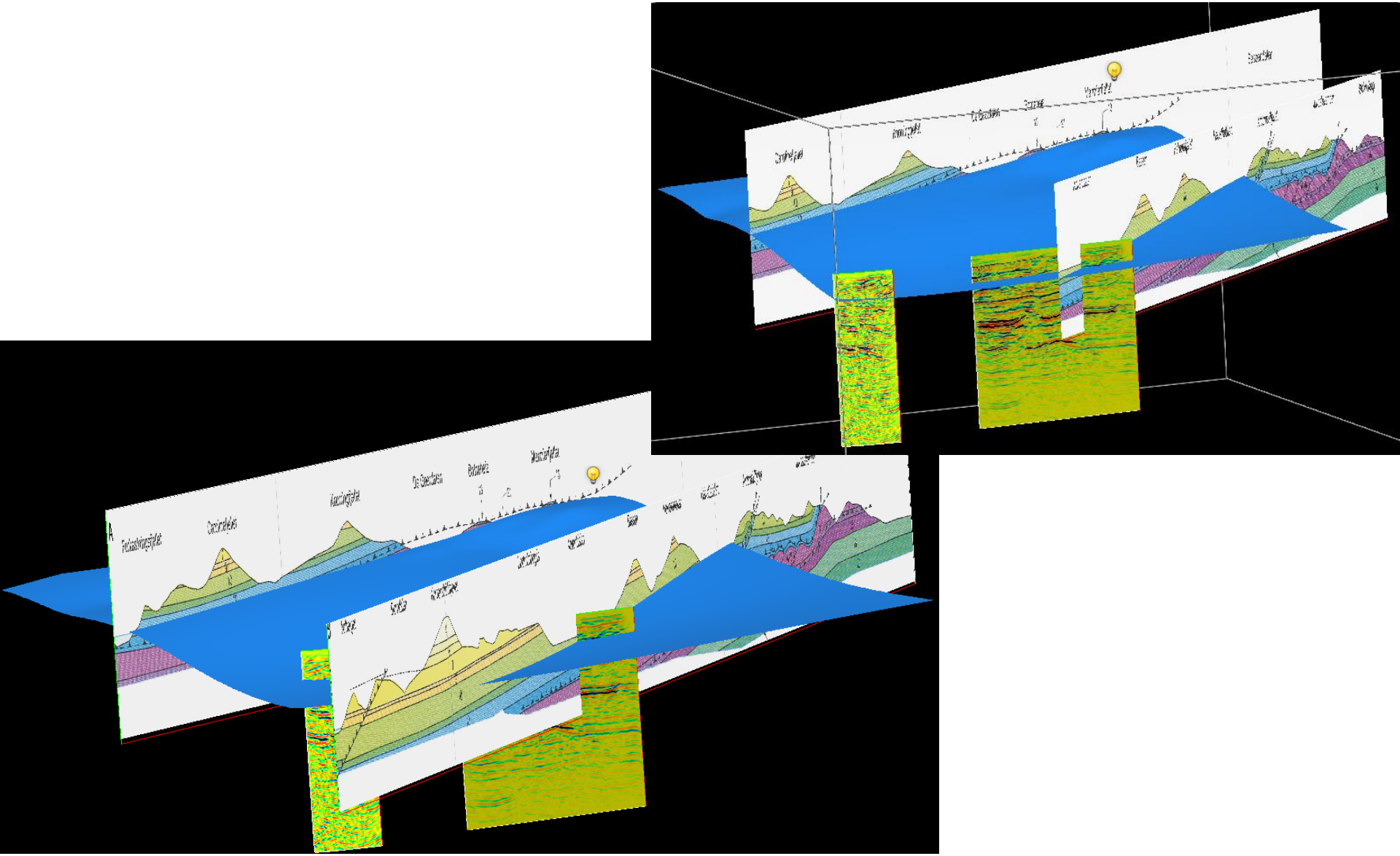


Dh2 Dh1





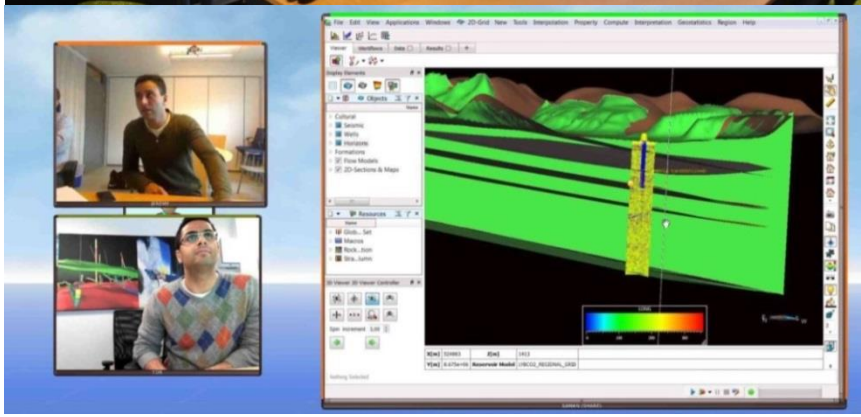
5. Visualizing the interior of the models



6. Tools for remote collaboration (visualization, interpretation, discussion)

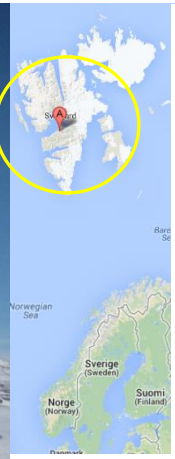
Share the results with any number of partners all around the world

Possibile to run/control the software remotely



Other potential case studies

- Accessible data
- SUCCESS partners involved in research related to LYB
- Remote geographical location which highlights the importance of communication



➢ Longyearbyen CO2 lab (LYB), Svalbard (initial case)

➢ Snøhvit

➢ Sleipner

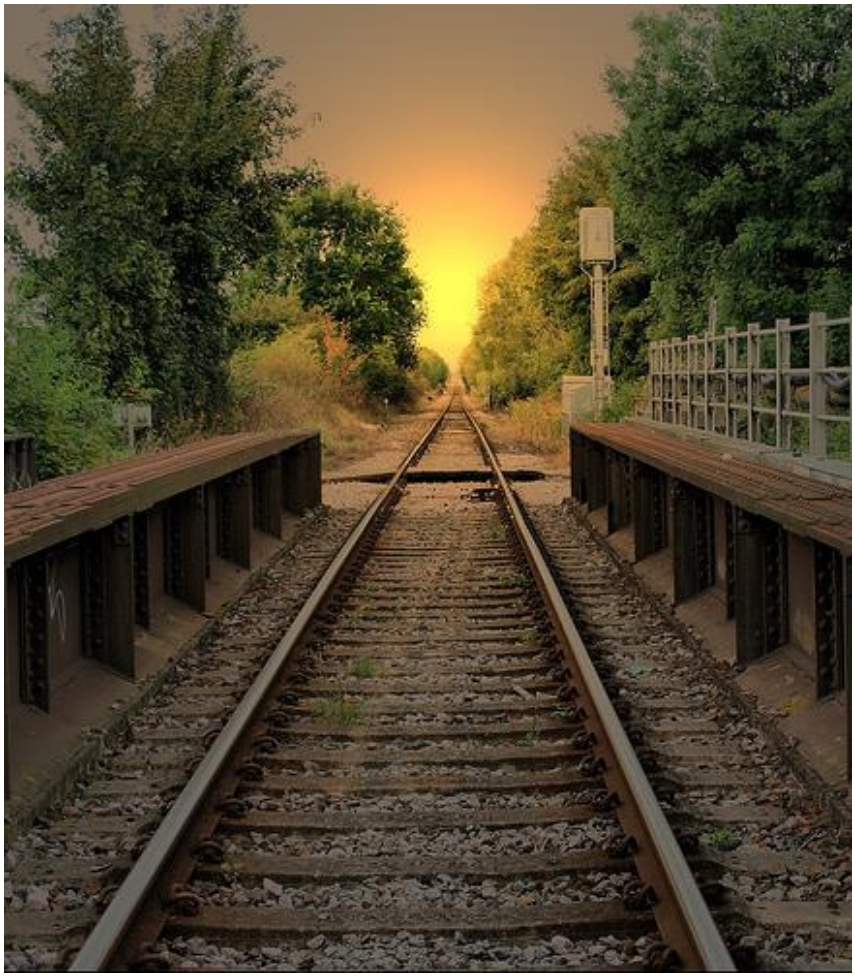
The way forward……

Constantly update the database

Identity and advance visualization techniques

Continue to identify gaps in between different research disciplines

Fill in the identified gaps by linking the researchers from diverse research background



Decision support
for installation of offshore wind turbines

DECOFF

With contribution from: Yngve Heggelund, Birgitte Furevik, Sigrid Ringdalen Vatne, Angus Graham, Idar Barstad, John Dalsgaard Sørensen, Joachim Reuder, Rune Yttervik

Motivating problem

The cost of installing offshore wind turbines must be distinctly reduced

Waiting for weather windows is a significant cost contributor

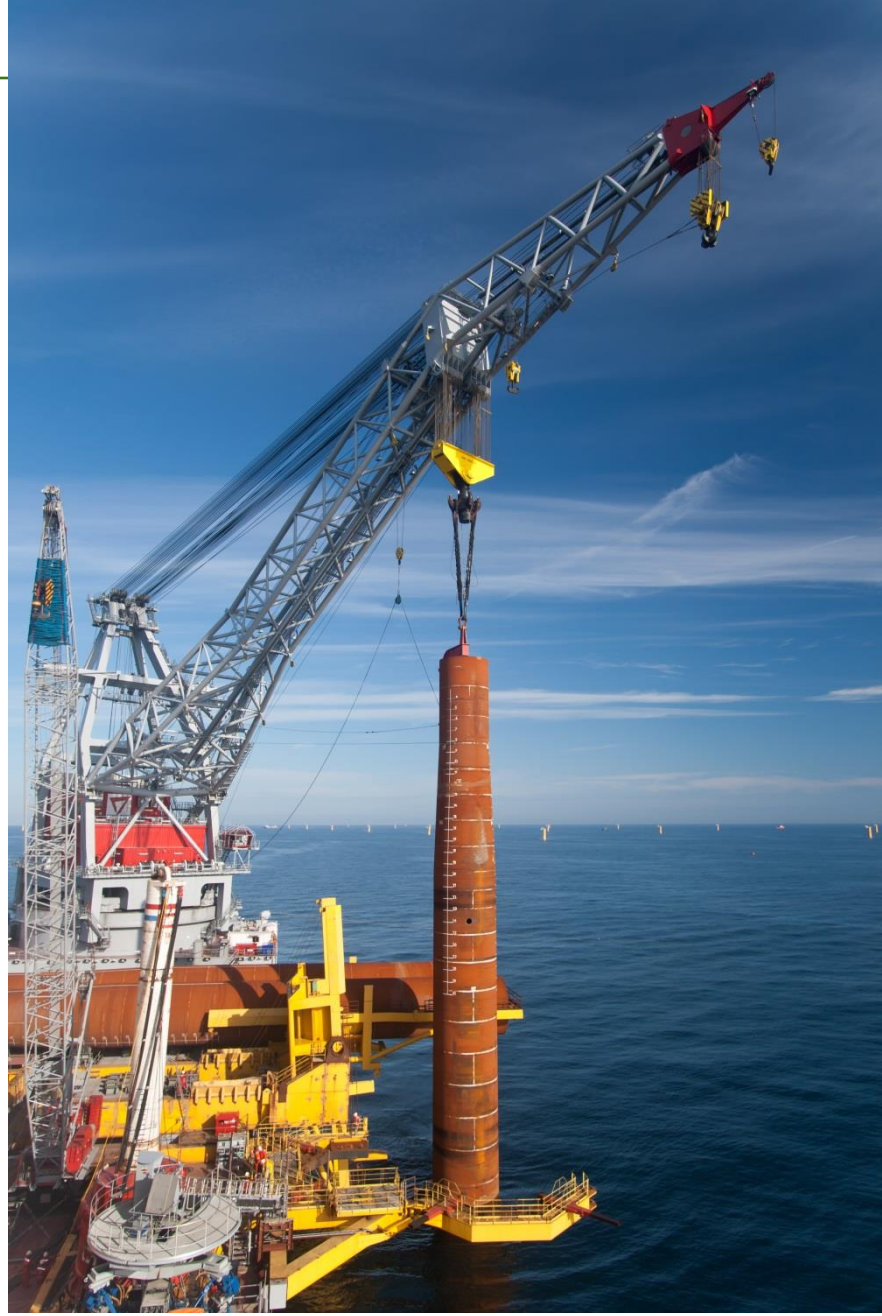
Criteria to commence installation operations are related to simple parameters

- Significant wave height
- Average wind velocity at reference height

The physical limitation are however related to response parameters

- Motions
- Accelerations
- Forces

Uncertainties are currently not properly taken into account in the decision making



General project idea

Couple weather forecast models to an advanced dynamical model (SIMO) to obtain response parameters

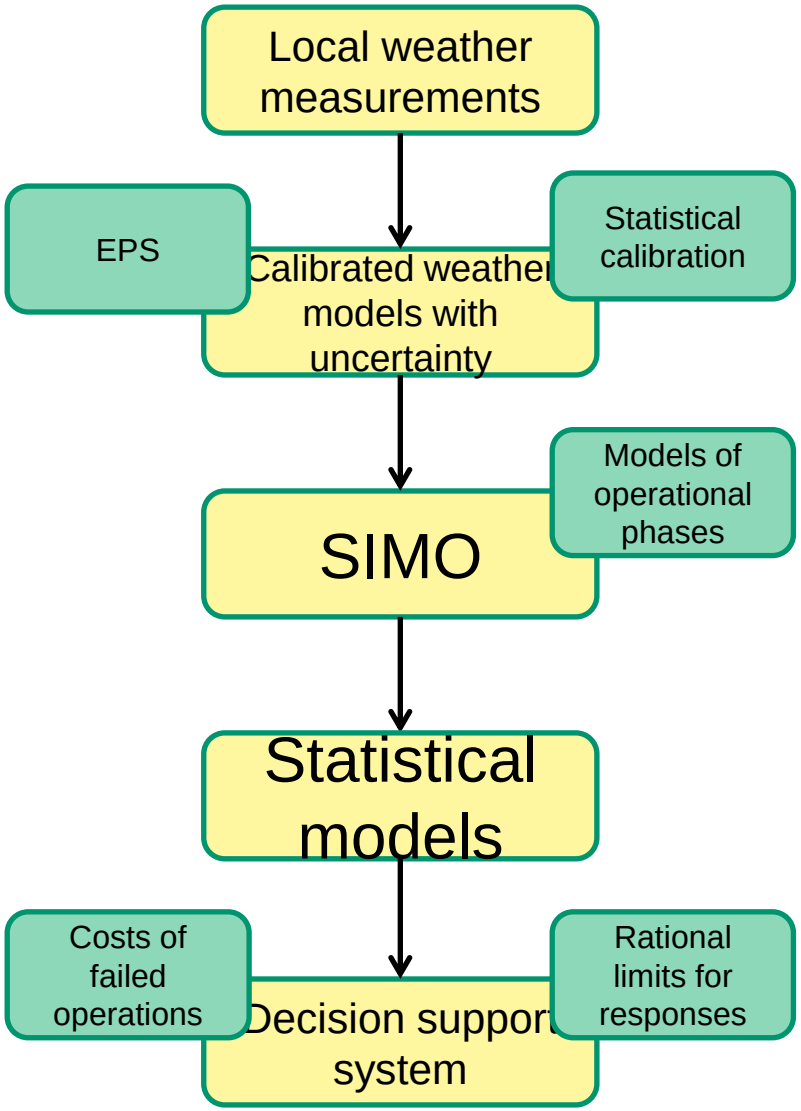
Improve local weather forecasts by utilizing local measurements

- Calibrate forecast models
- Provide estimates of uncertainty

Use statistical models to capture uncertainty of response characteristics

Integrate the above into an online risk based decision support system

Clear and informed view of the risks and potential costs of carrying out an operation in a given timeframe



Research proposal

Title: “Decision support for installation of offshore wind turbines”

Research partners: CMR, met.no, Uni Research, UiB, AAU, Marintek, UiS, UiA.

Industry partner: Statoil.

Associated partners: Reinertsen Engineering, Fred. Olsen Windcarrier.

Project is embedded in FME NORCOWE

Proposal for competence building project was submitted to the MAROFF program in the Research Council of Norway September 5th 2012.

- Total budget: 8.4 MNOK over 3 years (80% by RCN, 20% by Statoil).
- Project management by CMR.
- Consortium agreement signed August 15th 2013.

Project overview

Installation test case 1

Integrated installation of offshore wind turbines of gravity-base type

- Reduce installation cost by reducing offshore heavy-lifting activities
- Complete, or partly complete structure transported to site (integrated installation operation)
- Operating phases:
  - Tow out
  - Mooring and positioning on site
  - Lowering of foundation to sea-floor
  - Setting foundation down into sea floor

Installation test case 2

- Installation of wind turbine rotor by floating crane vessel
  - Installation of one piece at a time on site
  - Operating phases:
    - Transportation of rotor to site
    - Mooring and positioning on site
    - Lifting the rotor from the deck of the transportation vessel
    - Placing the rotor onto the pre-installed nacelle

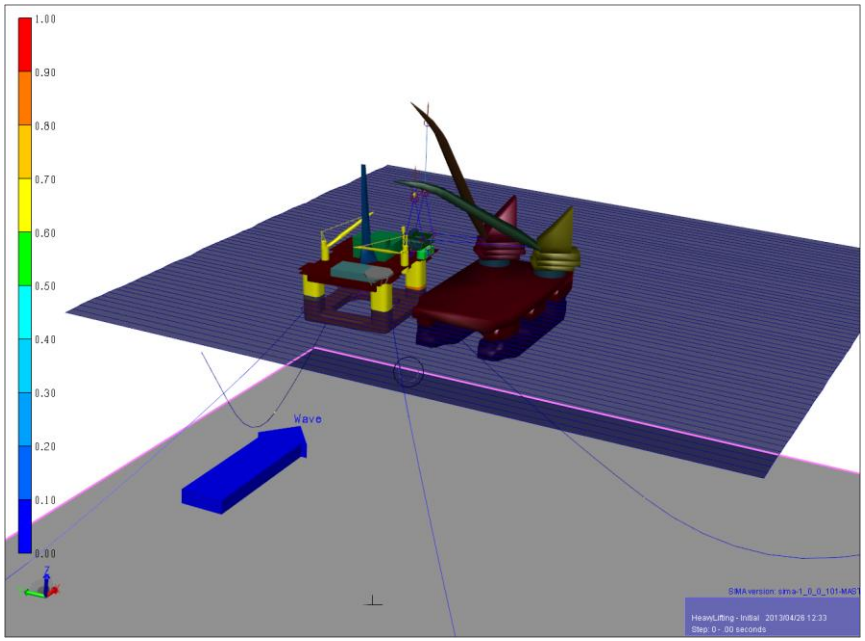
SIMO: Equipment response simulator

SIMO (Simulation of Marine Operations) developed and owned by Marintek

Non-linear time domain simulation of motions and station keeping of multi-body systems

Used in the oil and gas industry:

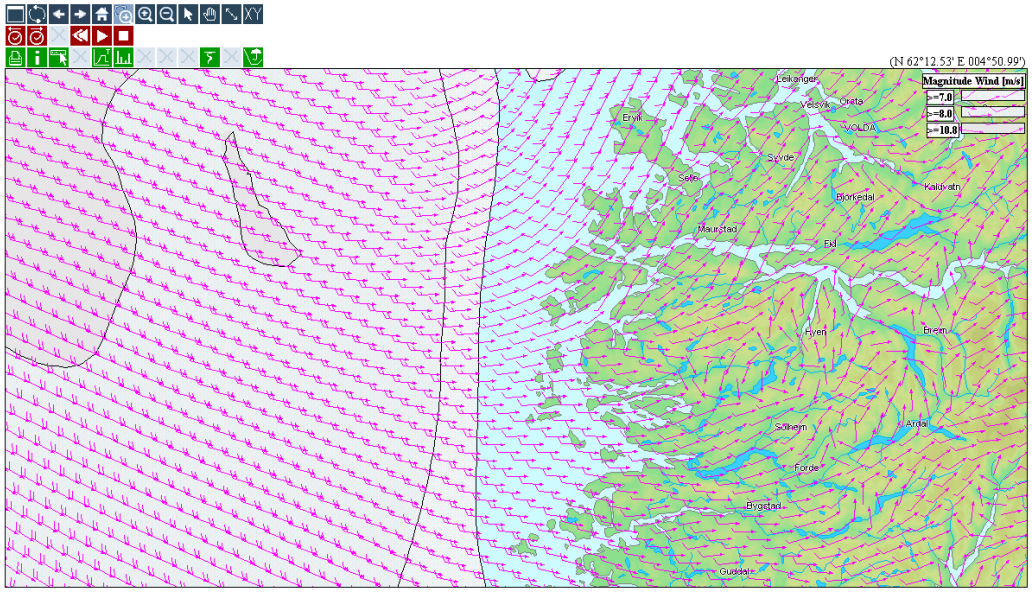
- Offshore crane operations
- Subsea installation
- Jacket installation and removal



Decision support system for operation planning

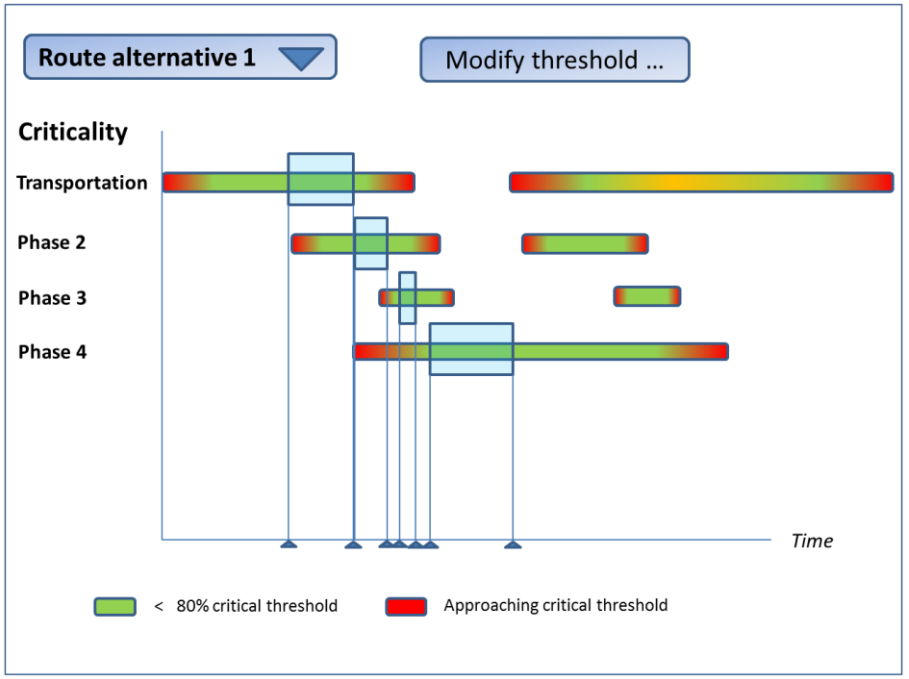
- Map visualization
  - Of weather variables (with uncertainty)
  - Of response characteristics (with uncertainty?)

- Plan and optimize the transportation route



Decision support system for operation planning (cont.)

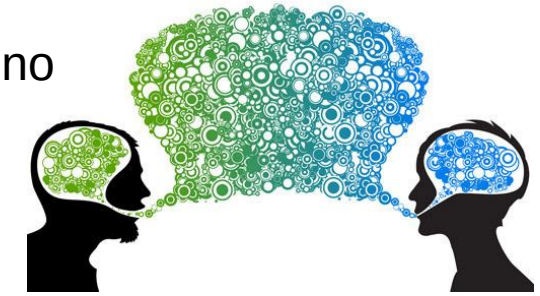
- Compute and visualize below critical time intervals for operational phases
  - User defined probability of being below a critical level
- User evaluation of presentation and interaction
  - Establish a representative user group of potential end-users
  - Task the user group with testing, and collect feedback
  - Compare existing methods to the proposed method



Challenges

Cross discipline project between institutions with little or no prior project cooperation

- Do we speak the same language? Do we understand each other?



Choice of project test case site

- ECMWF ensembles are not stored in full in the archives, making it difficult to use a historical test case like Sheringham Shoal
- Dudgeon will probably not be scheduled until after project completion (virtual test case?)
- FINO3?

Summary

Provide an objective foundation for decision support taking into account

- The real physical limitations of the equipment being used
- The uncertainties in the weather-dependent data

Challenge existing practice of using simple parameters such as significant wave height and average wind velocity

- Enable evaluating different installation procedures

Ideas and principles can also be applied to the operational phase

Main goal: Reduce the cost of installing offshore wind turbines

Illustrative Visualization for Geology

GeoIllustrator

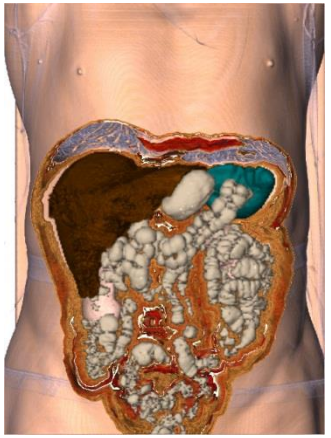
With contribution from: Daniel Patel, Tor Langeland

The Geoillustrator initiative goes back to 2005

- Established collaboration with Vienna University of Technology (TUW)
- Very strong competence within visualization.
- Worked with illustrative visualization (“importance driven rendering”)

Importance driven
(Viola et. al, 2004)

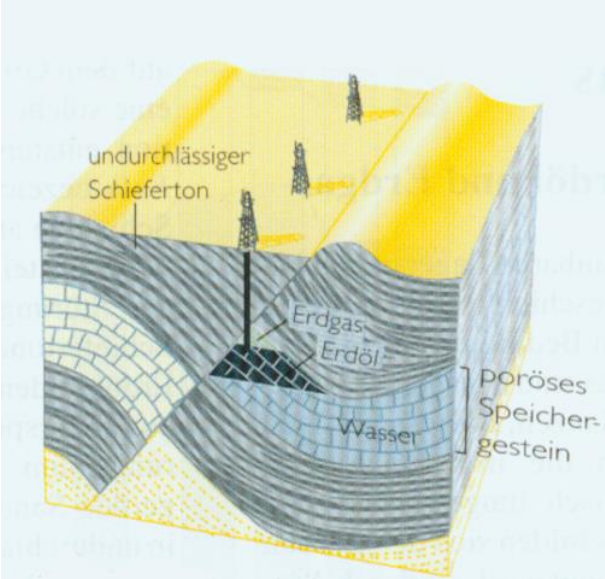
Exploded views
(Bruckner and Grøller, 2006)



Cut aways
(Viola et. al 2004)

Illustrative Visualization

Illustration

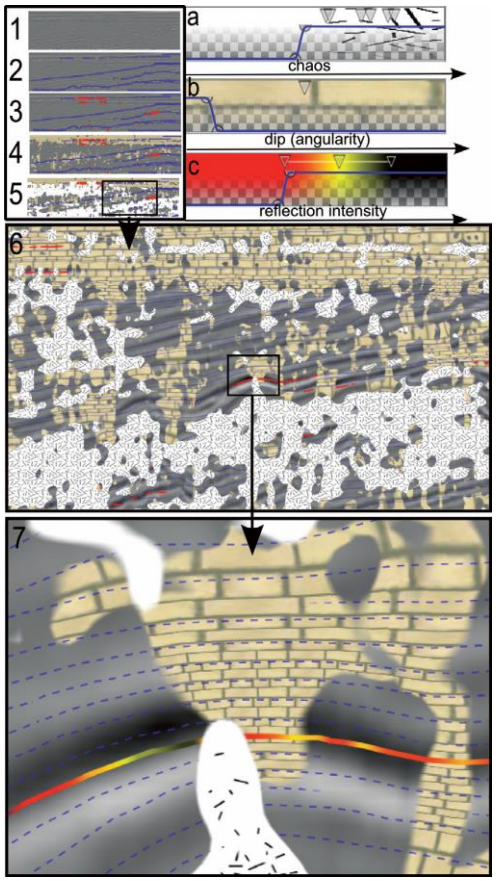


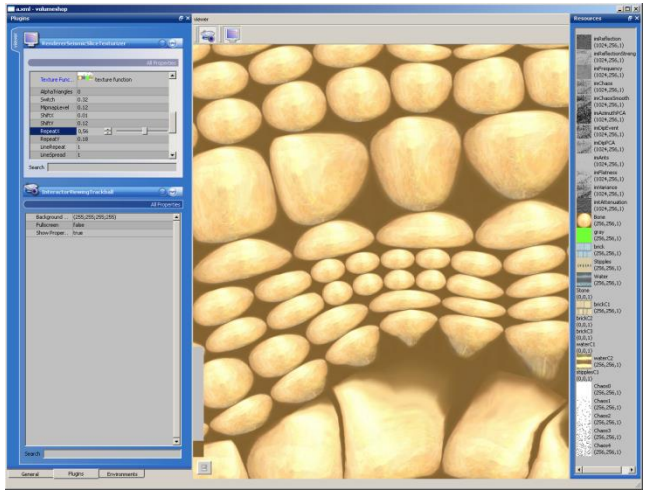
Understanding Earth, Grotzinger et. al.

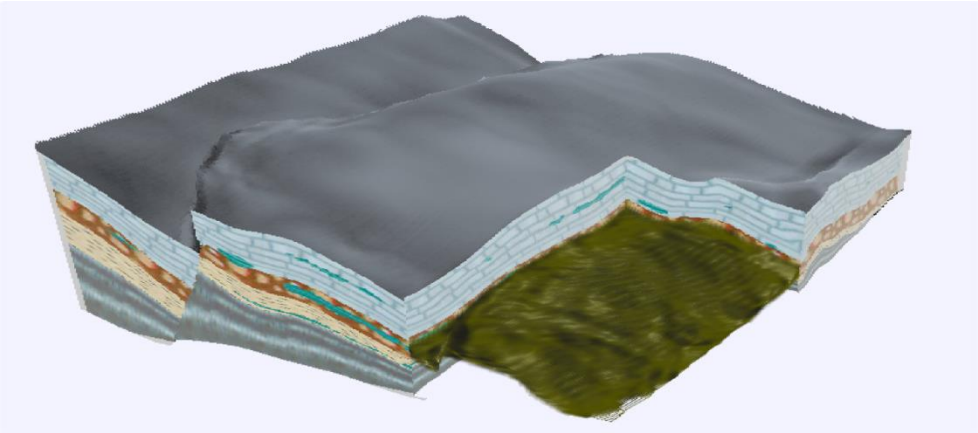
- Abstracted data
- Shows essential aspects

PhD: “Expressive Visualization and Rapid Interpretation of Seismic Volumes”

- CMR scientist Daniel Patel



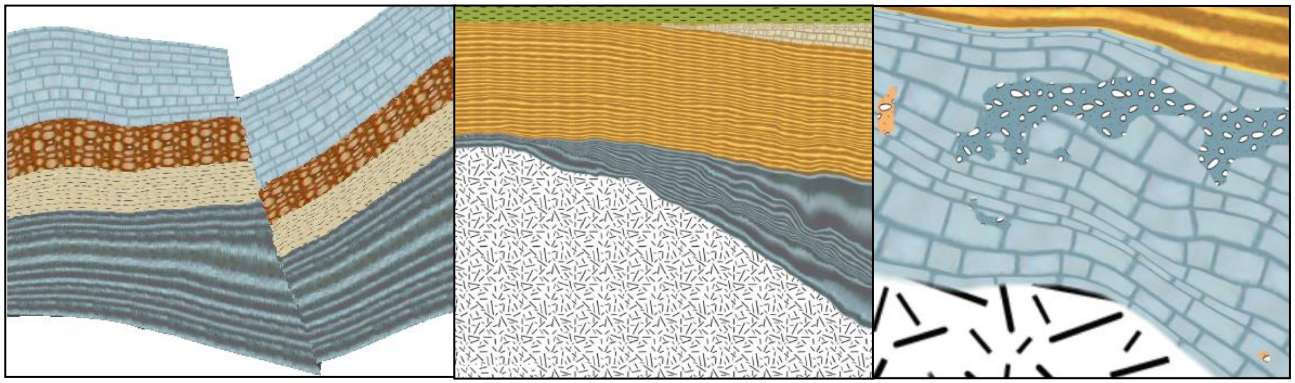




The Geoillustrator project

Vision

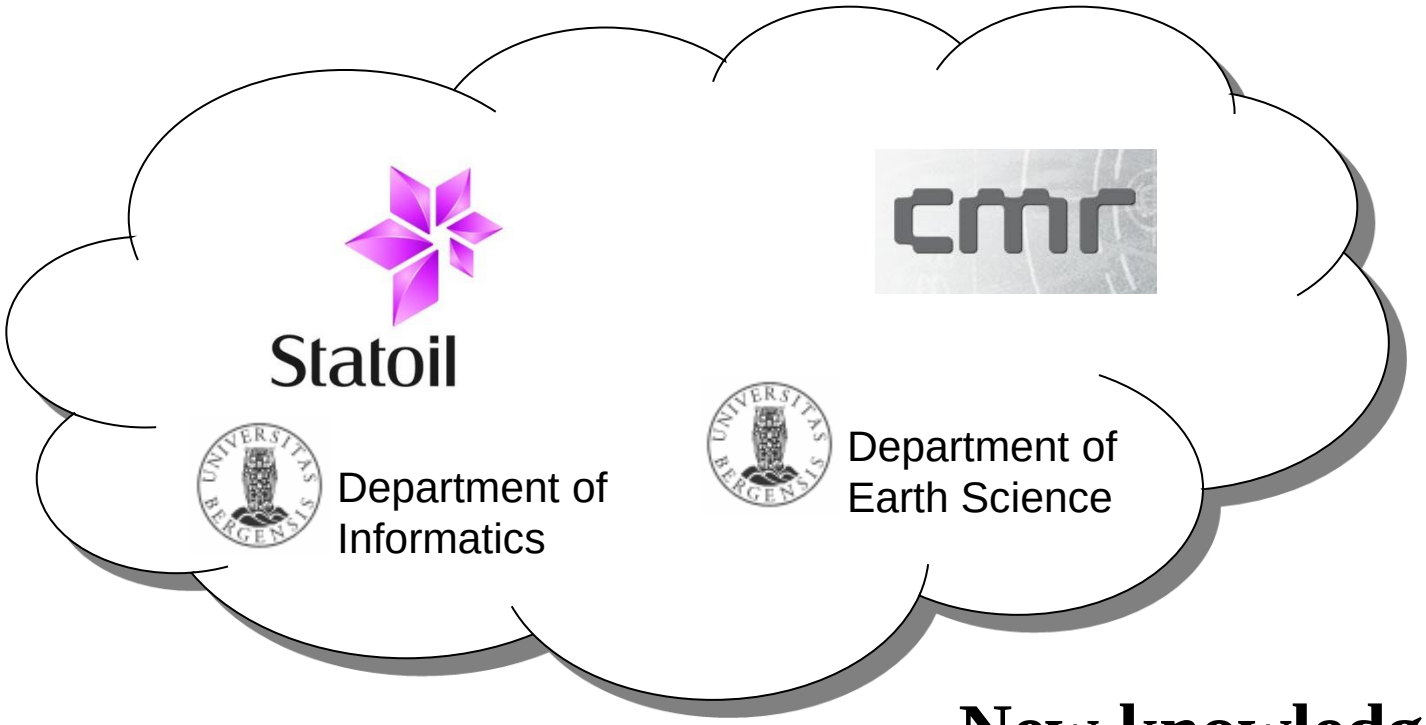
Create a leading research group with focus on computer generated geoscience illustrations for exploration and production in the oil & gas industry



Project Startup Statoil 2009

PETROMAKS KMB application granted for 2010 – 2013

Collaboration



University of Calgary

Technische Universitat Wien

4 PhD's

New knowledge

Publications

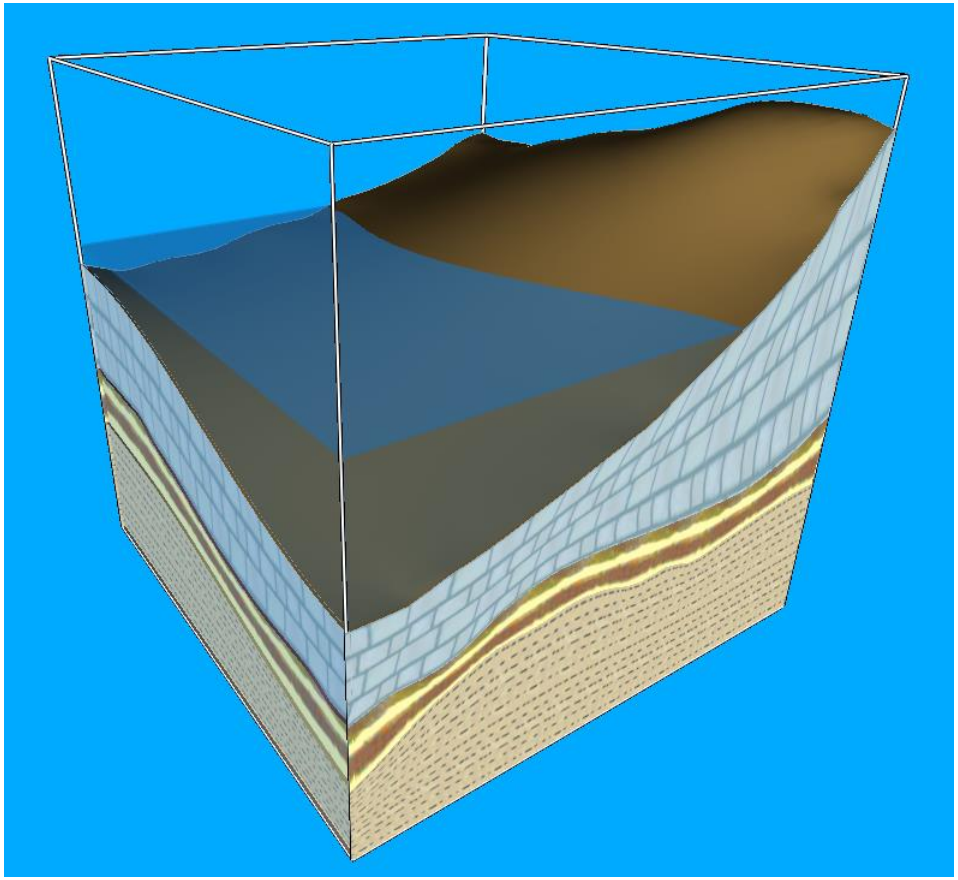
Geoillustrator prototype

The Geoillustrator prototype

Fast and intuitive digital sketching of geology

(No data – sparse data scenarios)

- Layers
  - Freehand drawing on scalable bounding box
  - Or planar surfaces
- Abutting surfaces
- Layer textures
- Simple river tool
- Water level
- Simple and intuitive GUI improved in close dialog with Statoil geologists
- Under implementation
  - Faults
  - Folding



Thank you for your attention!

Credits: Yngve Heggelund, Daniel Patel