ACTOM

ACT on Offshore Monitoring

Presented by
Guttorm Alendal,
University of Bergen

on behalf of the ACTOM team (in random order)
Marius Dewar (PML), Anna Oleynik (UiB), Stefan Carpentier (TNO), Abdirahman Omar (NORCE), Ketil Fagerli Iversen (UiB),
Jerry Blackford (PML), Dorothy Dankel (UiB), Sigrid Eskeland Schütz (UiB), Darren Snee (PML),
Parisa Torabi (UiB), Sarah Gasda (NORCE), Rajesh Pawar (LANL), Bjarte Fagerås (OCTIO), Katherine Romanak (BEG).

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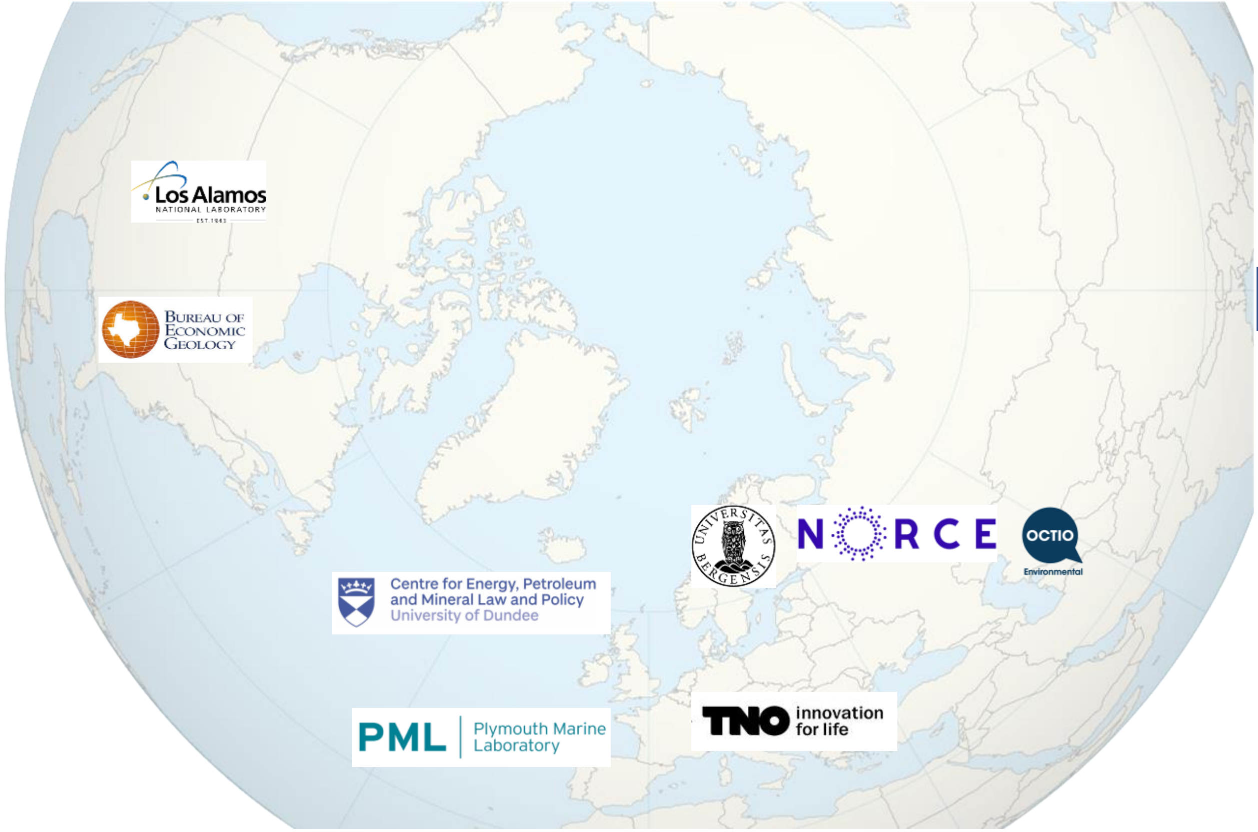
Acknowledgements



- Advisory board.
  - Philip Ringrose, Equinor
  - Marcella Dean, Shell
  - Eva Halland, NPD
  - Tim Dixon, IEAGHG
  - Jun Kita, MERI
  - Gloria Thurschmid, EBN
  - Charles Jenkins, CSIRO
  - Sallie Greenberg, ISGS

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The Research Council of Norway
Netherlands Enterprise Agency
Department for Business, Energy & Industrial Strategy
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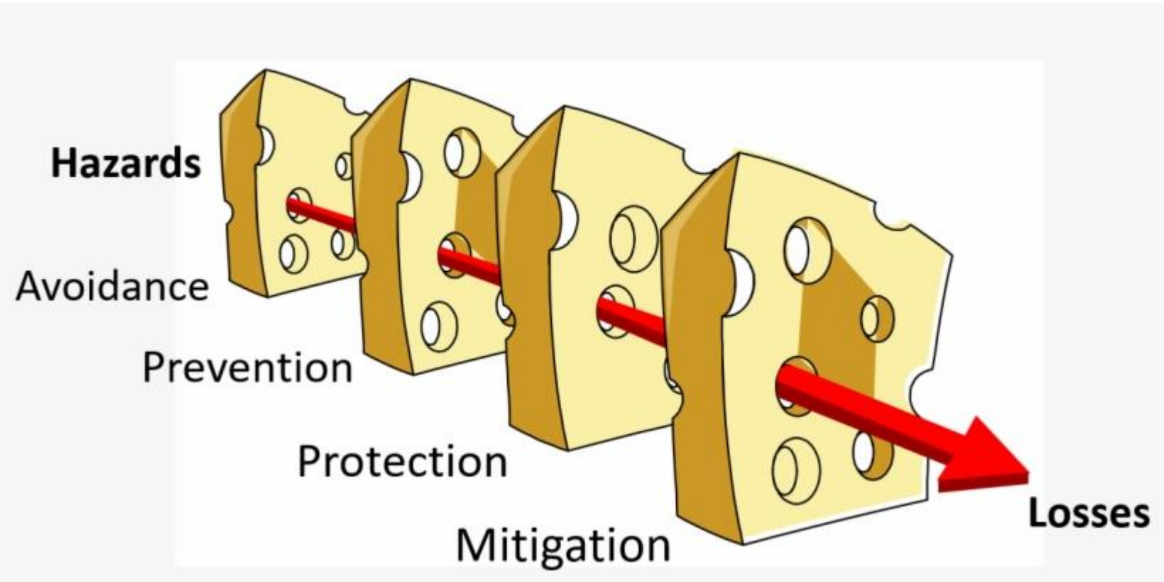
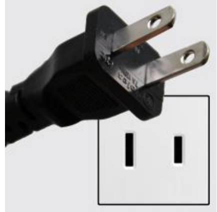

Hazards
Avoidance
Prevention
Protection
Mitigation
Losses



Insurance

We are studying targeted monitoring of potential seeps at an analog storage site, this is not equivalent to state that we think there will be a leak!

Belief/Reality	True	False
True	😊	False positive
False	False negative	😊

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The ACTOM project

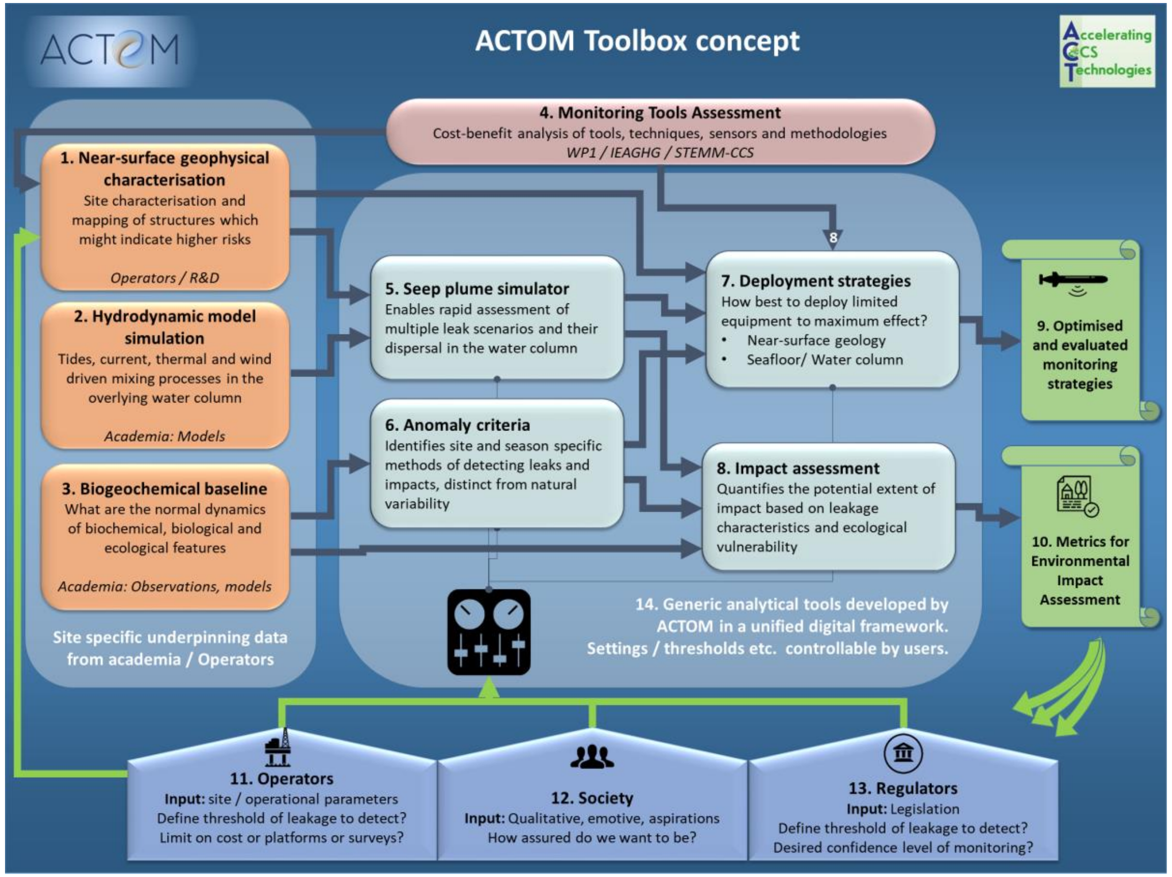
***WP1 BASELINE (Abdirahman Omar, NORCE-Climate, Sigrid E. Schütz, UiB-Law)**: Monitoring the marine environment.* Will survey the regulatory requirements and opportunities and technical limitations laying the foundation for the marine monitoring program. This activity will underpin the other WPs, providing the necessary information on what level of assurance is expected from a monitoring program, alongside the present capabilities of marine measurements and monitoring.

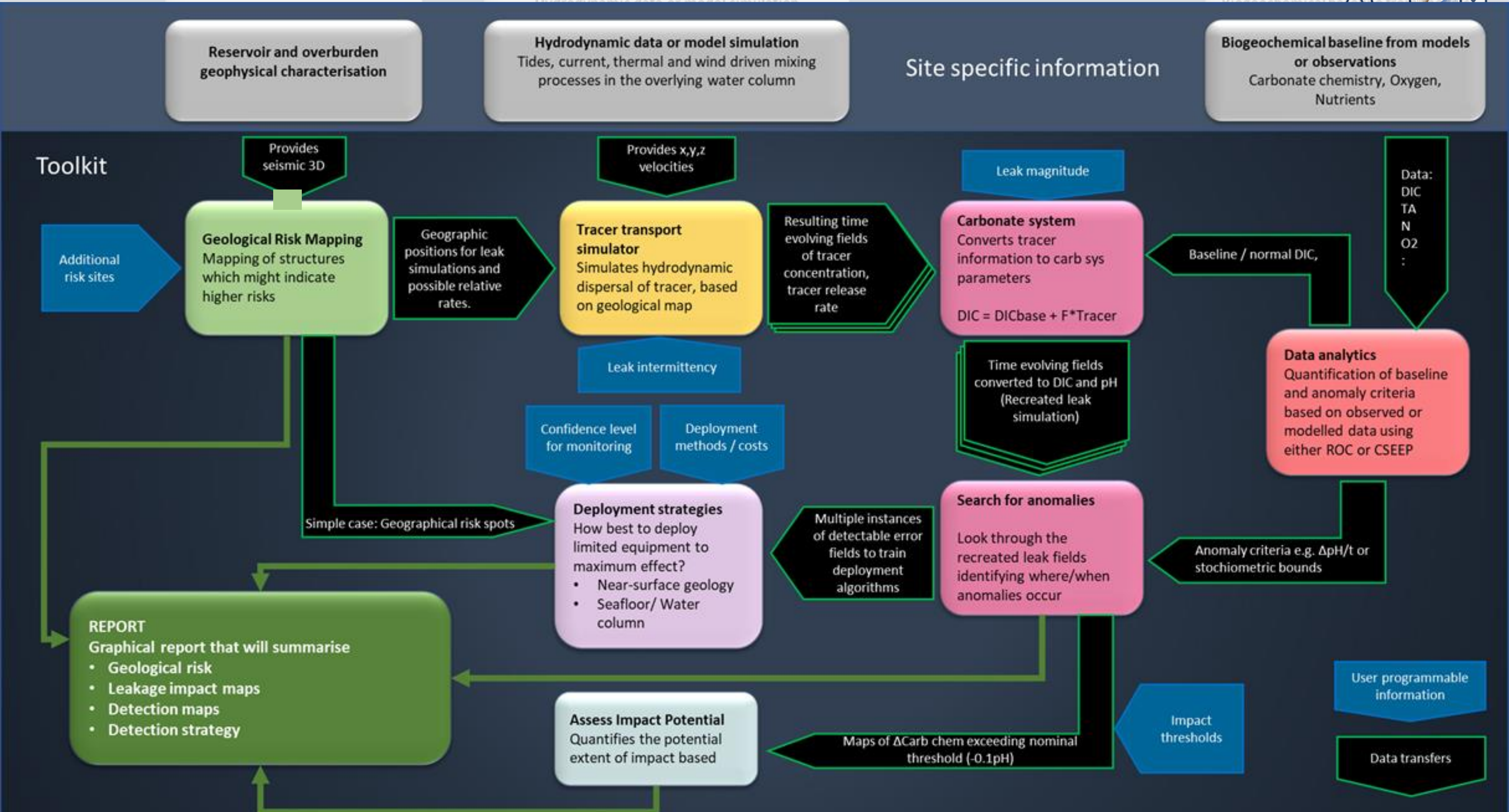
***WP2 DIGITAL (Jerry Blackford, PML)**: Design and build of the pre-operational web toolkit.* Will be responsible for building the toolkit based on verified algorithms for detecting weak signals in a highly variable environment and designing monitoring programs.

***WP3 RESPONSIBILITY (Dorothy Dankel UiB-BIO, Sigrid E. Schütz, UiB-Law)**: Responsible CCUS monitoring process*. Will study how the monitoring program can be used to communicate risks and benefits of subsea storage, and as a tool for public engagement through the Responsible Research and Innovation (RRI) framework.

***WP4 IMPACT (Sarah Gasda, NORCE-energy)**: Scenarios and site studies.* Will utilize the web toolkit built in WP2 and the knowledge learned in WP3 to study policy scenarios and demonstrate the toolkit on the P18 and Smeaheia storage sites as well as study sites in the Gulf of Mexico.

***WP5 INTEGRATION (Guttorm Alendal, UiB-MATH)**: Dissemination, reporting and coordination.* Assure easy communication in this highly cross-disciplinary project, both in the core project group, in the extended collaboration group, and beyond the project. Responsible to periodic reporting to ACT.




Reservoir and overburden geophysical characterisation
Hydrodynamic data or model simulation
Tides, current, thermal and wind driven mixing processes in the overlying water column
Site specific information
Biogeochemical baseline from models or observations
Carbonate chemistry, Oxygen, Nutrients
Toolkit
Provides seismic 3D
Provides x,y,z velocities
Leak magnitude
Data: DIC TA N O2 :
Additional risk sites
Geological Risk Mapping
Mapping of structures which might indicate higher risks
Geographic positions for leak simulations and possible relative rates.
Tracer transport simulator
Simulates hydrodynamic dispersal of tracer, based on geological map
Resulting time evolving fields of tracer concentration, tracer release rate
Carbonate system
Converts tracer information to carb sys parameters
DIC = DICbase + F*Tracer
Baseline / normal DIC,
Leak intermittency
Time evolving fields converted to DIC and pH (Recreated leak simulation)
Data analytics
Quantification of baseline and anomaly criteria based on observed or modelled data using either ROC or CSEEP
Confidence level for monitoring
Deployment methods / costs
Simple case: Geographical risk spots
Deployment strategies
How best to deploy limited equipment to maximum effect?
• Near-surface geology
• Seafloor/ Water column
Multiple instances of detectable error fields to train deployment algorithms
Search for anomalies
Look through the recreated leak fields identifying where/when anomalies occur
Anomaly criteria e.g. ΔpH/t or stochiometric bounds
REPORT
Graphical report that will summarise
• Geological risk
• Leakage impact maps
• Detection maps
• Detection strategy
Assess Impact Potential
Quantifies the potential extent of impact based
Maps of ΔCarb chem exceeding nominal threshold (-0.1pH)
Impact thresholds
User programmable information
Data transfers

Reservoir and overburden geophysical characterisation

Hydrodynamic data or model simulation
Tides, current, thermal and wind driven mixing processes in the overlying water column

Site specific information

Biogeochemical baseline from models or observations
Carbonate chemistry, Oxygen, Nutrients

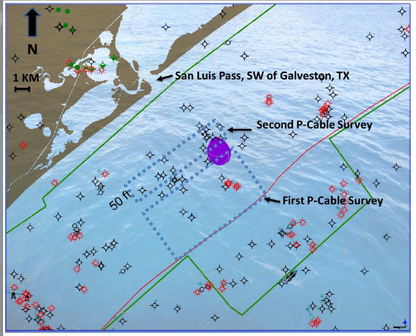
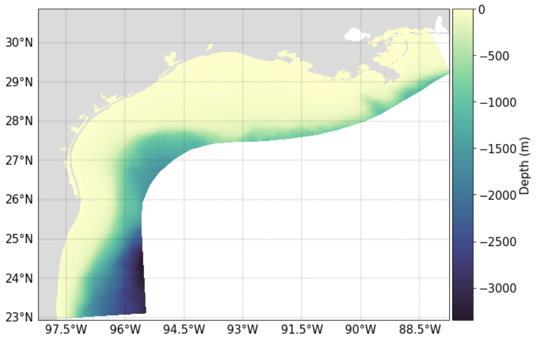
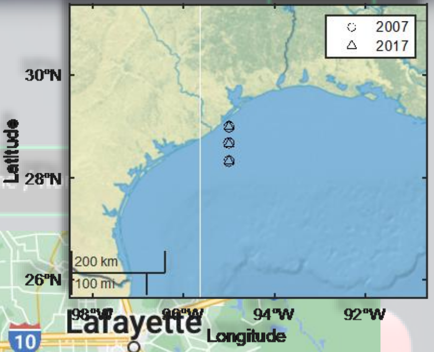
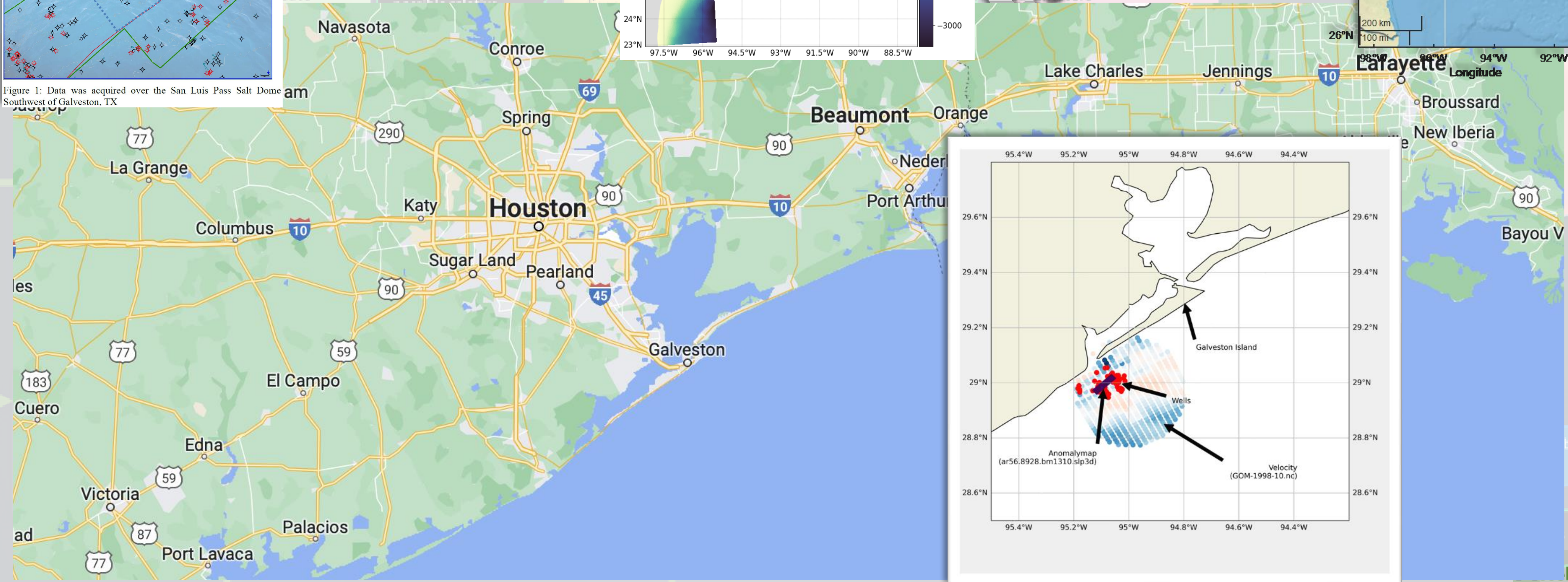


Figure 1: Data was acquired over the San Luis Pass Salt Dome Southwest of Galveston, TX







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Reservoir and overburden geophysical characterisation

Hydrodynamic data or model simulation
Tides, current, thermal and wind driven mixing processes in the overlying water column

Site specific information

Toolkit

Provides seismic 3D

Provides x,y,z velocities

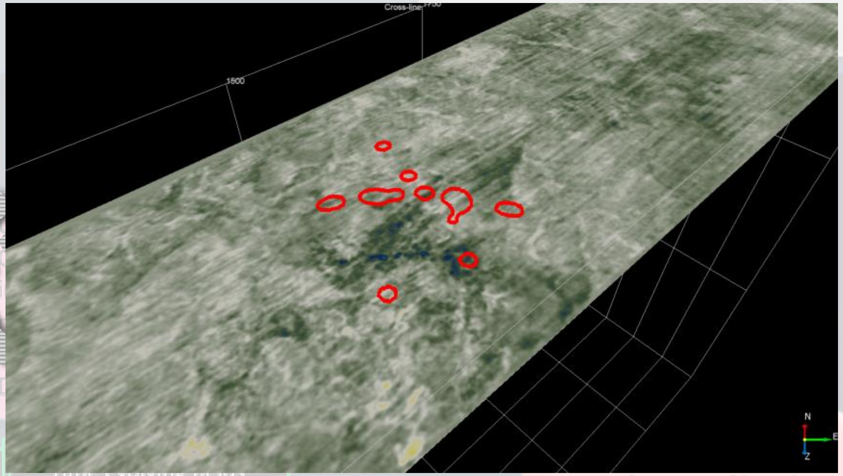
Additional risk sites

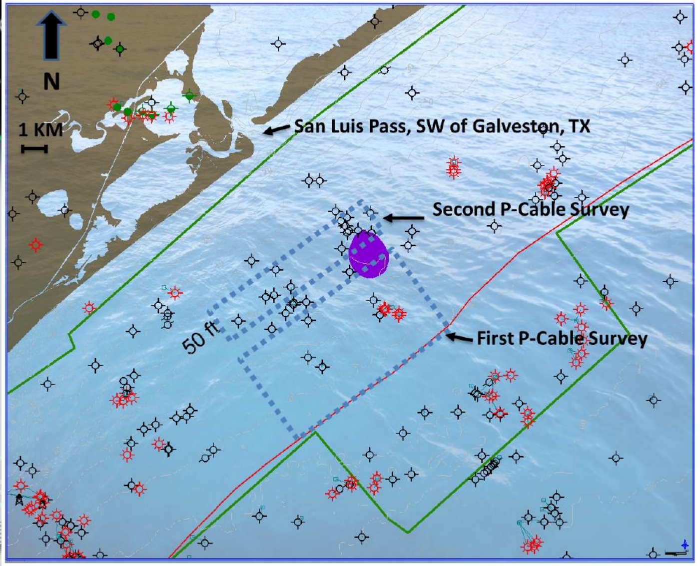
Geological Mapping
Mapping of structures which might indicate higher risks

Geographic positions for leak simulations and possible relative rates.

Tracer transport

Resulting time





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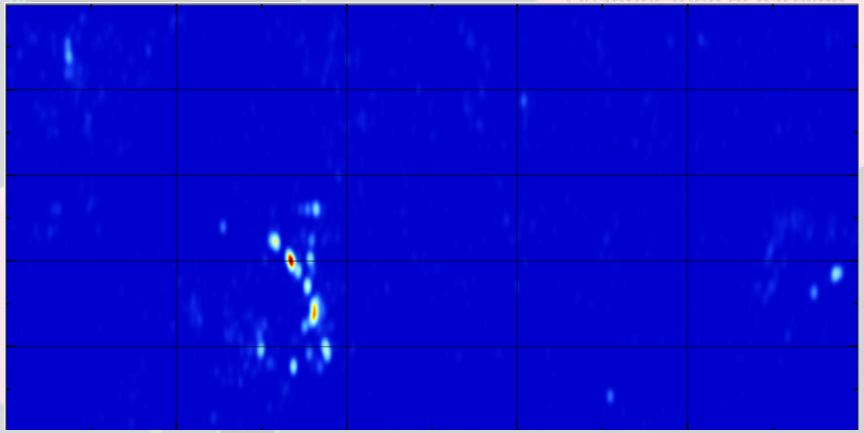

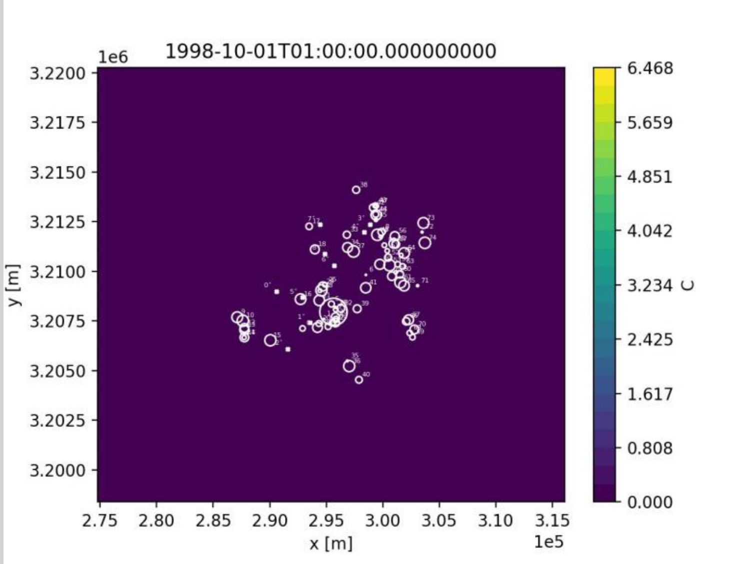

Case History of Acquisition and Processing of a High Resolution Shallow Water 3D Multi-cable Seismic Survey in the Gulf of Mexico Transition Zone.

Thomas Hess, Tip Meckel, Nathan Bangs, Robert Tatham, Jackson School of Geosciences, University of Texas at Austin*

SEG Denver 2014 Annual Meeting
DOI http://dx.doi.org/10.1190/segam2014-1508.1
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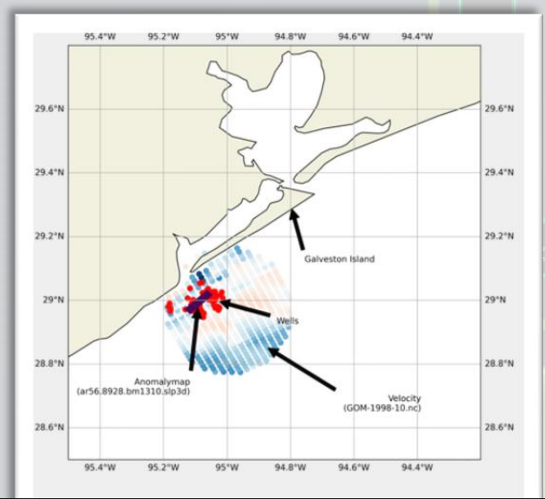
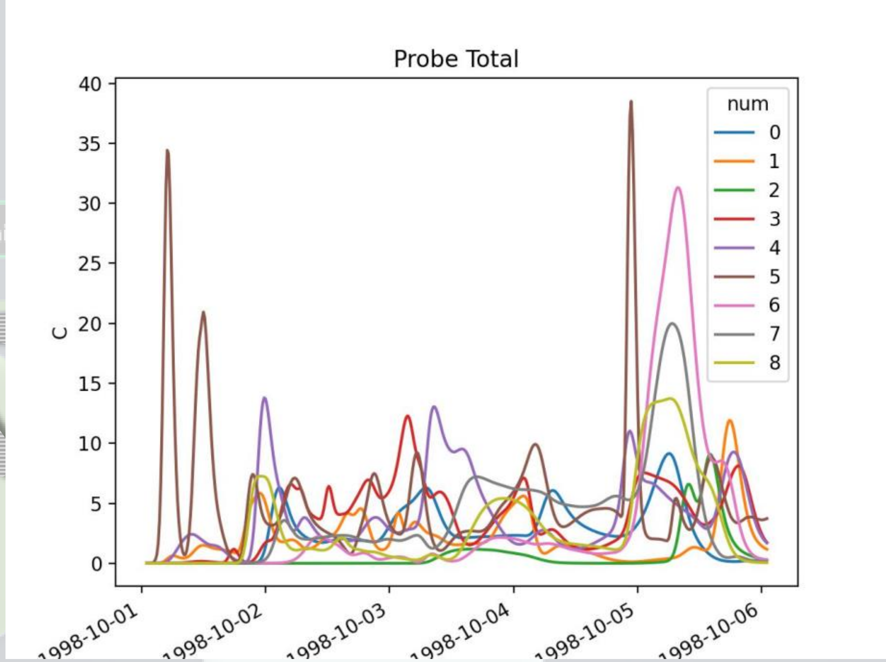
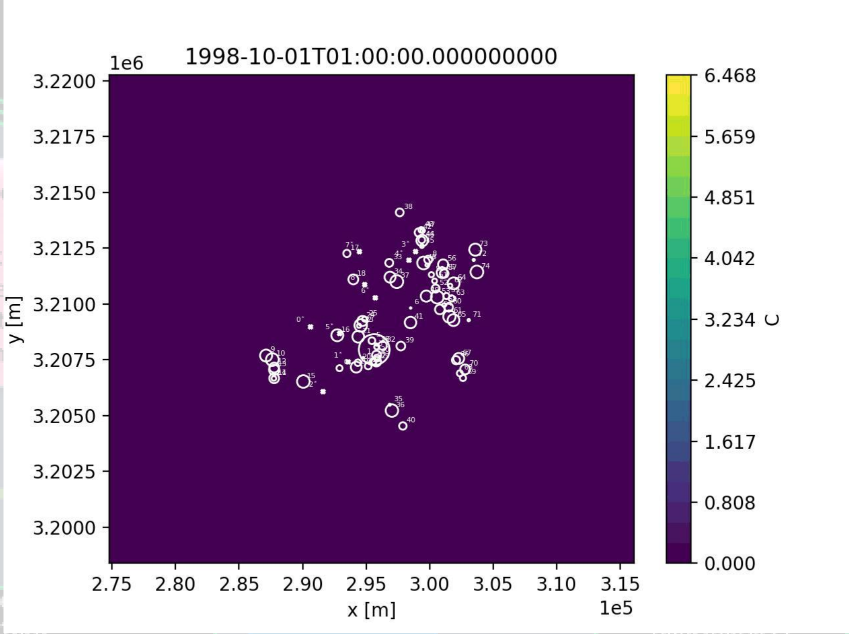
The example uses hydrodynamic outputs from a high resolution hindcast simulation of the Texas-Louisiana Gulf of Mexico Continental Shelf region, based on a *ROMS* setup that uses a curvilinear grid providing the velocities.

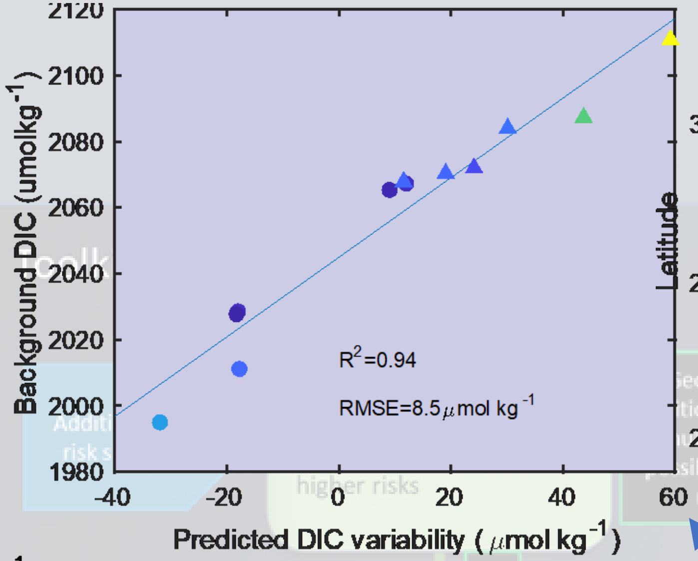
$$\frac{\partial c}{\partial t} = D\Delta c - W \cdot \nabla c + f,$$

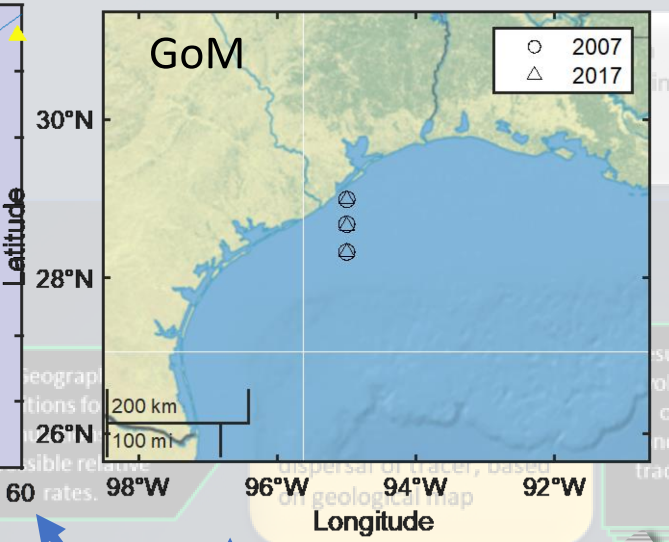


X Zhang, M Marta-Almeida & R D Hetland (2012) A high-resolution pre-operational forecast model of circulation on the Texas-Louisiana continental shelf and slope, Journal of Operational Oceanography, 5:1, 19-34, DOI: 10.1080/1755876X.2012.11020129

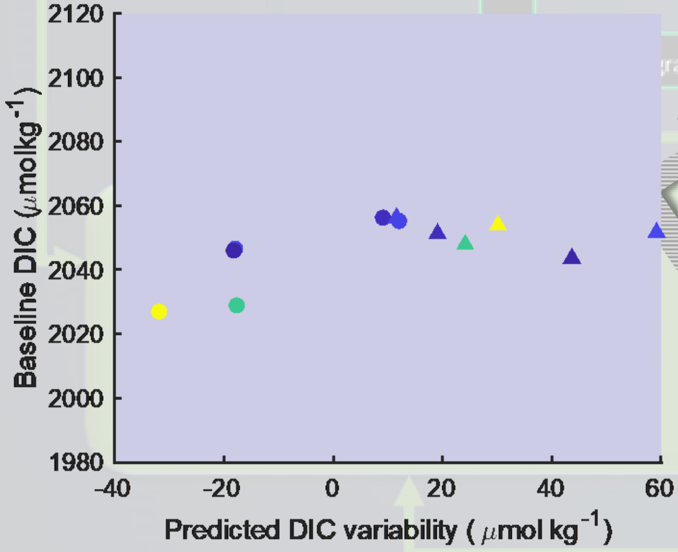








CB was obtained using the mean values of the 2007 data as a common reference. For anthropogenic CO2, an annual increase of 1.37 µmol kg^{-1} was assumed and all data were were brought to year 2010.



Cseep

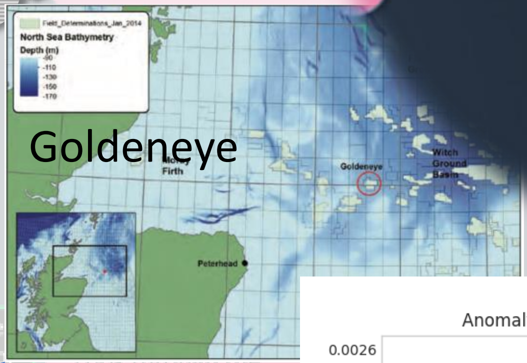
Rate of Change

Site specific information

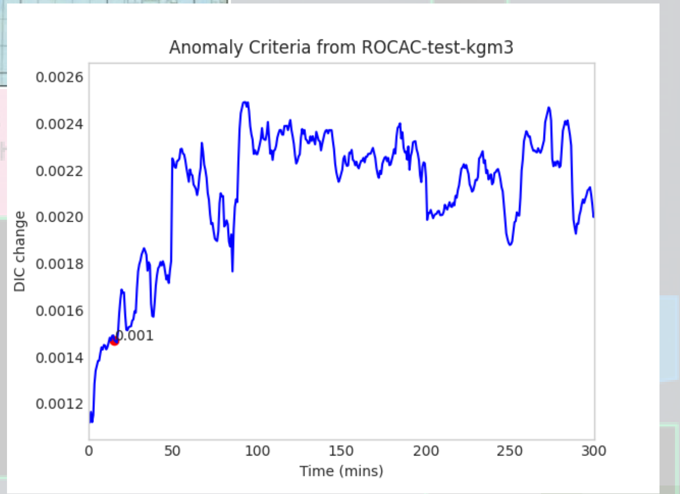
Biogeochemical baseline from models or observations
Carbonate chemistry, Oxygen, Nutrients

Data:
DIC
TA
N
O2
:

Baseline / normal DIC,



Data analytics
Quantification of baseline and anomaly criteria based on observed or modelled data using either ROC or CSEEP



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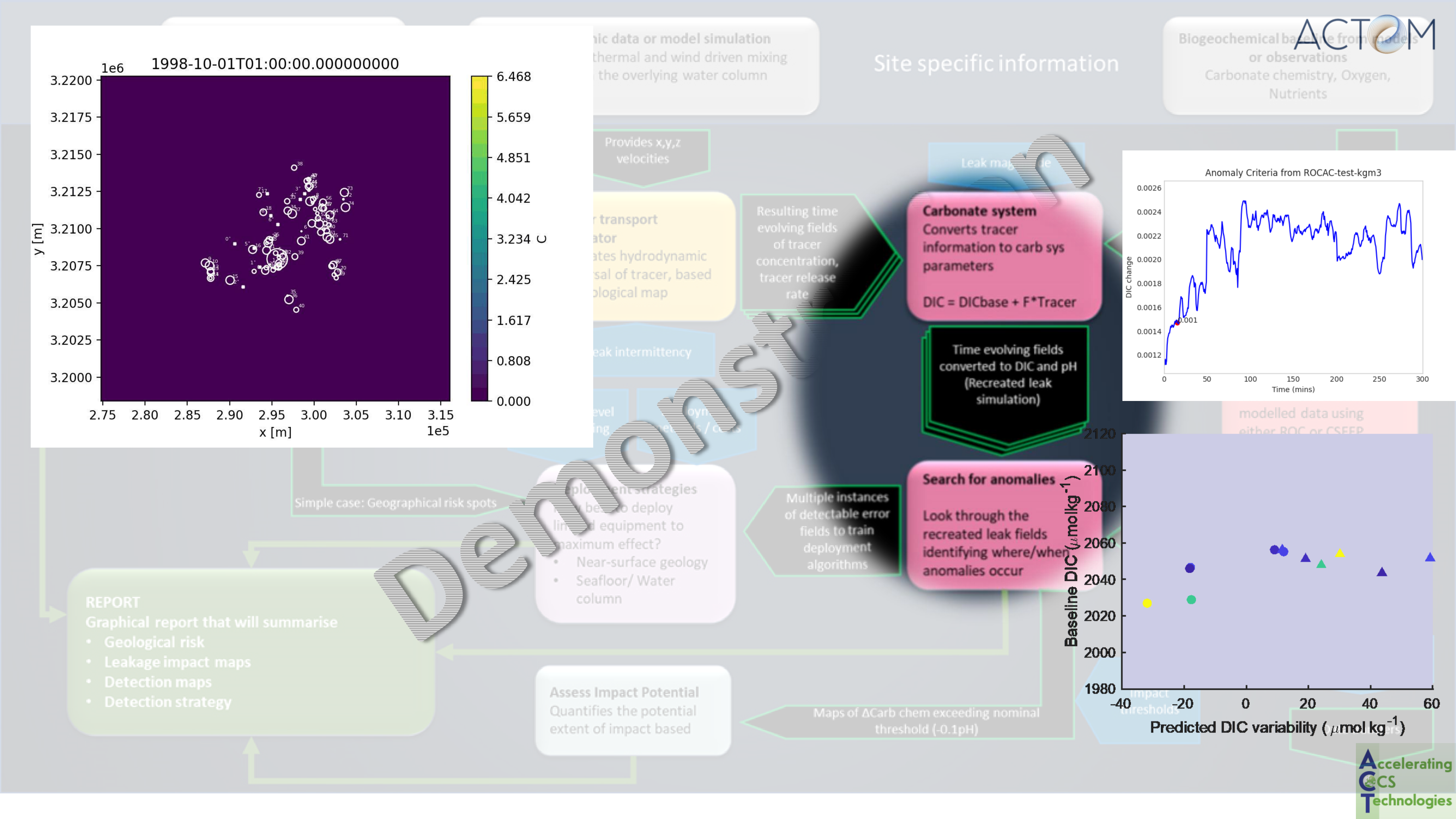
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1998-10-01T01:00:00.000000000
1e6
y [m]
x [m]
1e5
C
Site specific information
Biogeochemical baseline from models or observations
Carbonate chemistry, Oxygen, Nutrients
Provides x,y,z velocities
Resulting time evolving fields of tracer concentration, tracer release rate
Carbonate system
Converts tracer information to carb sys parameters
DIC = DICbase + F*Tracer
Time evolving fields converted to DIC and pH (Recreated leak simulation)
Search for anomalies
Look through the recreated leak fields identifying where/when anomalies occur
Multiple instances of detectable error fields to train deployment algorithms
Anomaly Criteria from ROCAC-test-kgm3
DIC change
Time (mins)
Baseline DIC (µmolkg⁻¹)
Predicted DIC variability (µmol kg⁻¹)
Demonstration
Simple case: Geographical risk spots
Near-surface geology
Seafloor/ Water column
REPORT
Graphical report that will summarise
Geological risk
Leakage impact maps
Detection maps
Detection strategy
Assess Impact Potential
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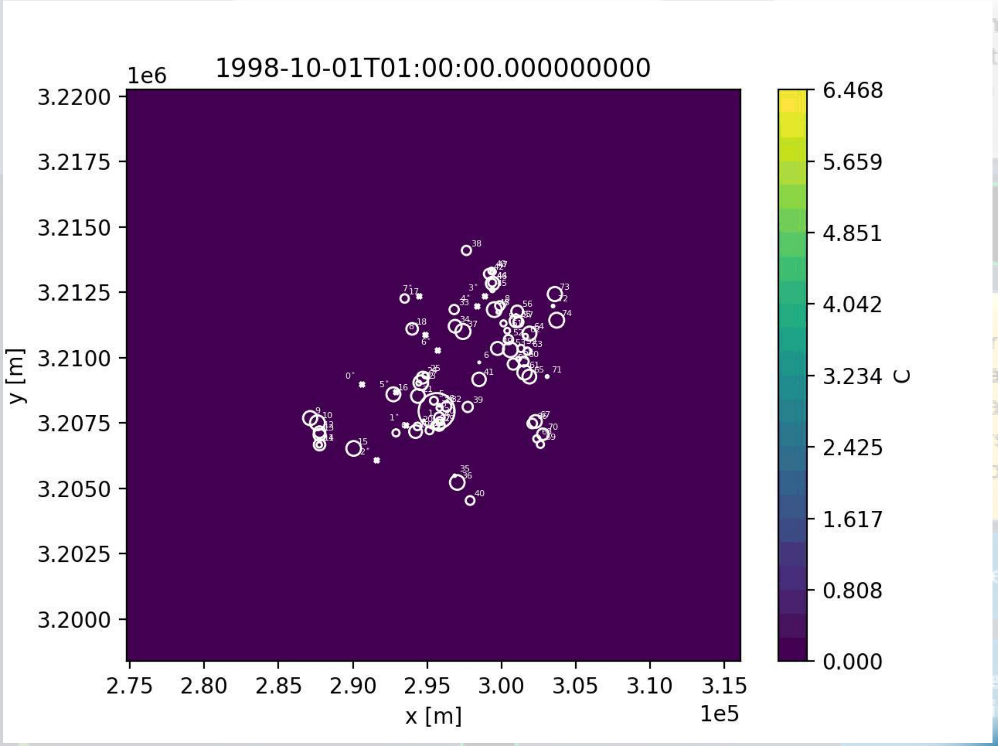
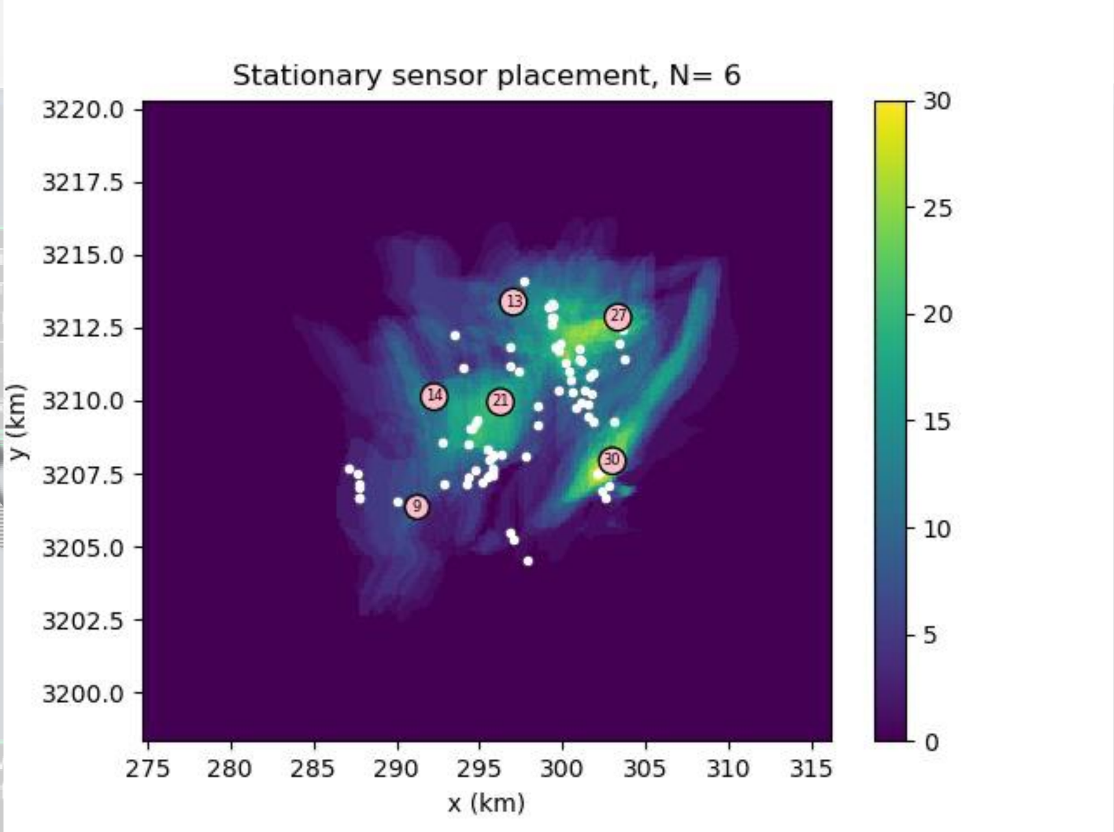
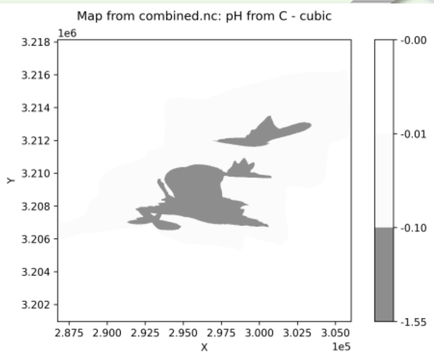


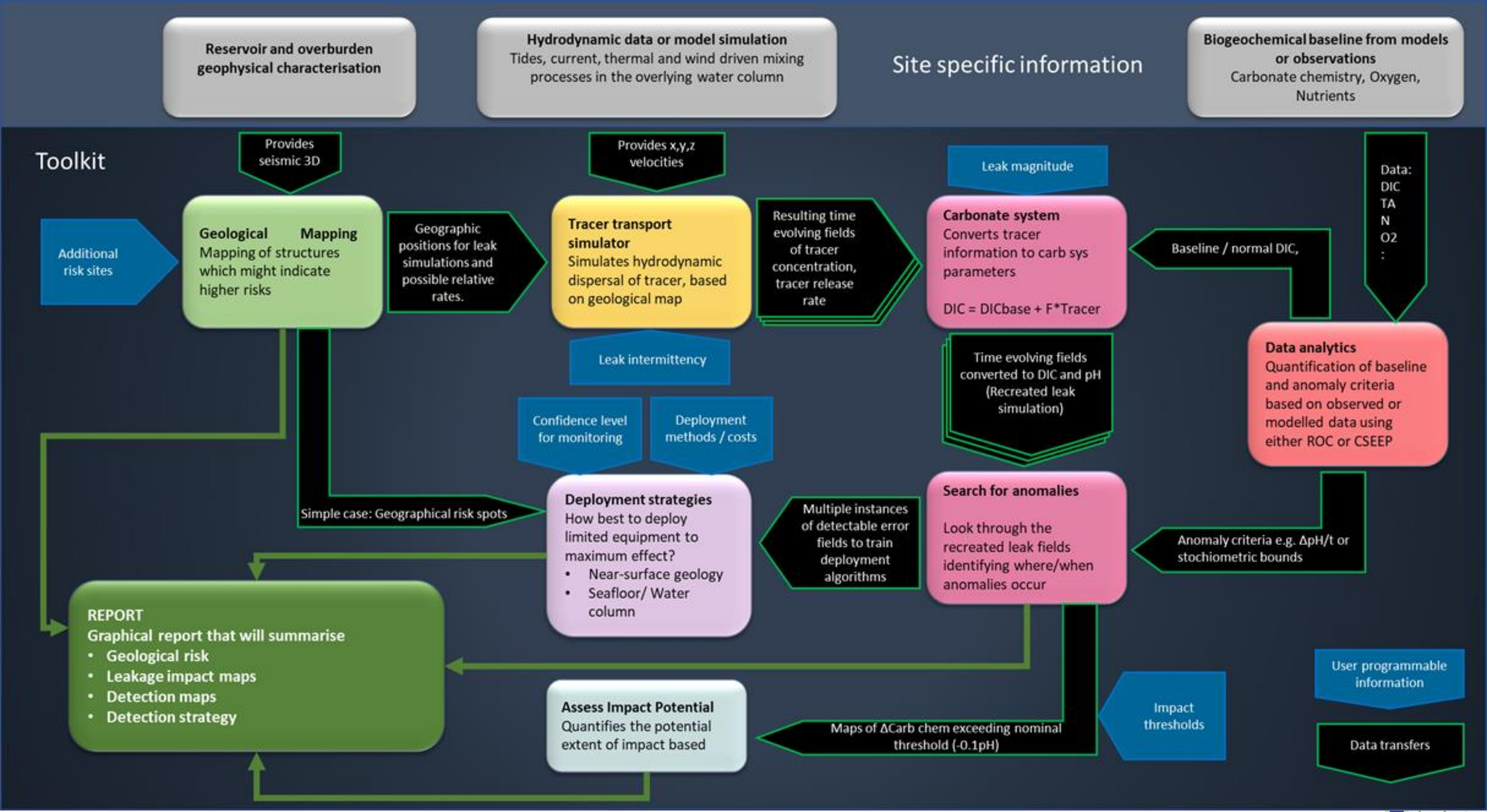




Deployment strategies
How best to deploy limited equipment to maximum effect?
- Near-surface geology
- Seafloor/ Water column

Assess Impact Potential
Quantifies the potential extent of impact based

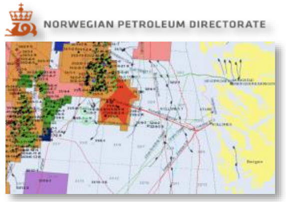
For a simulated leakage rate of ~1 kT/year
Max Change in pH - 1.55
Impact-Area (pH change of 0.1): 23.7 (km^2)
Impact-Area (pH change of 0.01): 119.82 (km2)

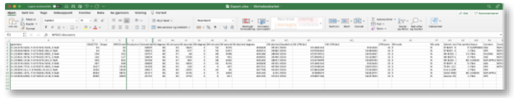


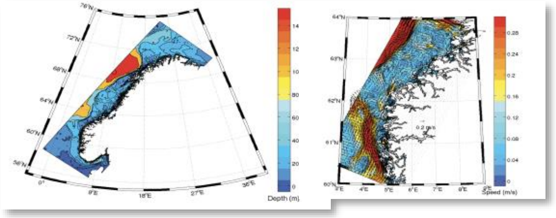
Technologies

The site studies

Norwegian site

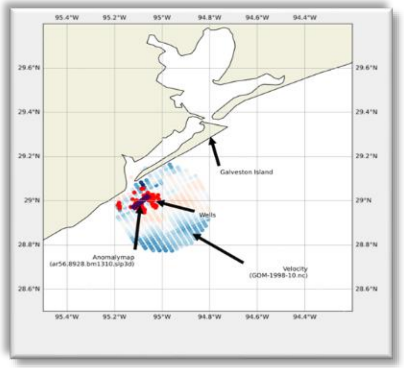






Need: biogeochemical baseline from the sea-floor.

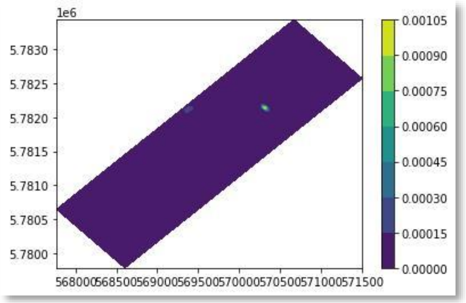
Gulf of Mexico



Fine tuning of scenarios

Need: Higher frequency biogeochemical baseline from the sea-floor.

P18



Geological map in place

Need: velocities and biogeochemical baseline

UK site: TBD

Thank you for your attention.

https://actom.w.uib.no

Belief/Reality	True	False
True	😇	False positive
False	False negative	😇

- **We want to provide light beyond the lamppost, credibility toward social robustness.**
- **Where to place smoke detectors for the marine environment**
- **Assurance against false positives.**
- **Assure that we avoid false negatives.**

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