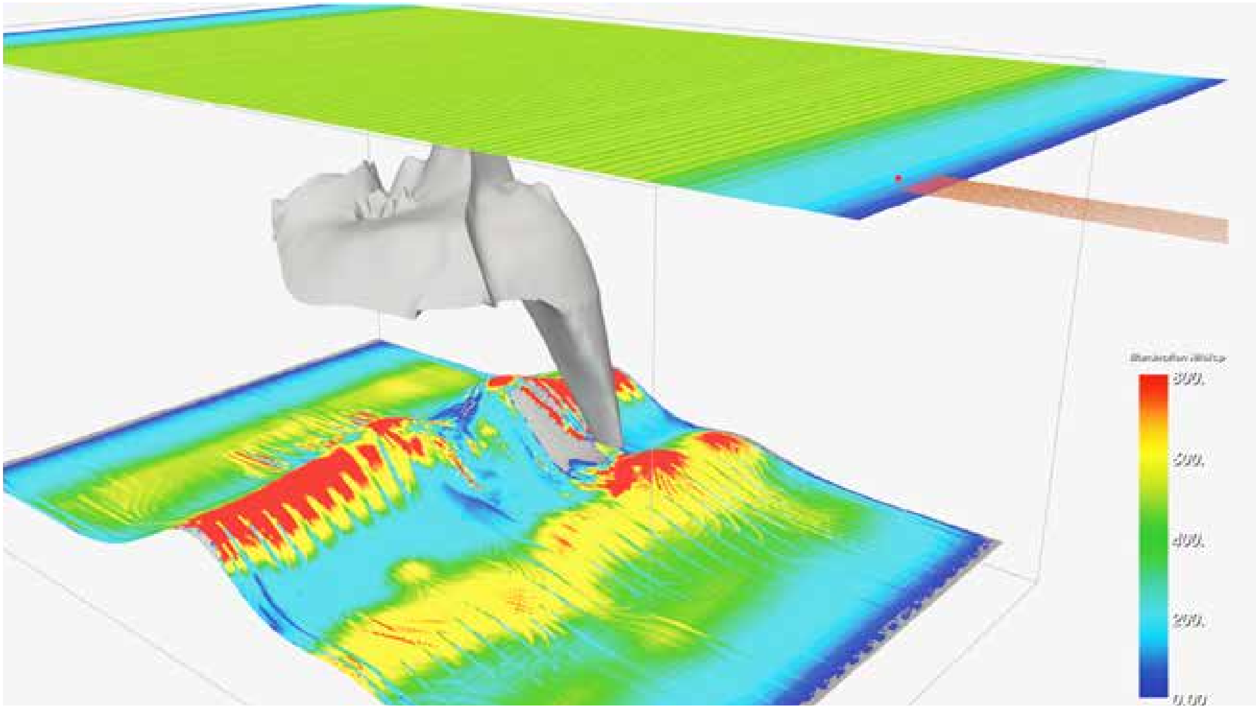
Exploring the Earth

NORSAR-3D



Predict and Understand Seismic

- *Is undershooting possible?*
- *Which is the best survey geometry? MAZ, WAZ, RAZ, Coil, OBS ?*
- *Why are there shadow zones? Can they be illuminated?*
- *Is a simpler and cheaper survey sufficient?*
- *Assess survey and processing parameters: Cable length, survey azimuth, migration aperture, and more.*

Find the answers with NORSAR-3D seismic ray-modelling

NORSAR

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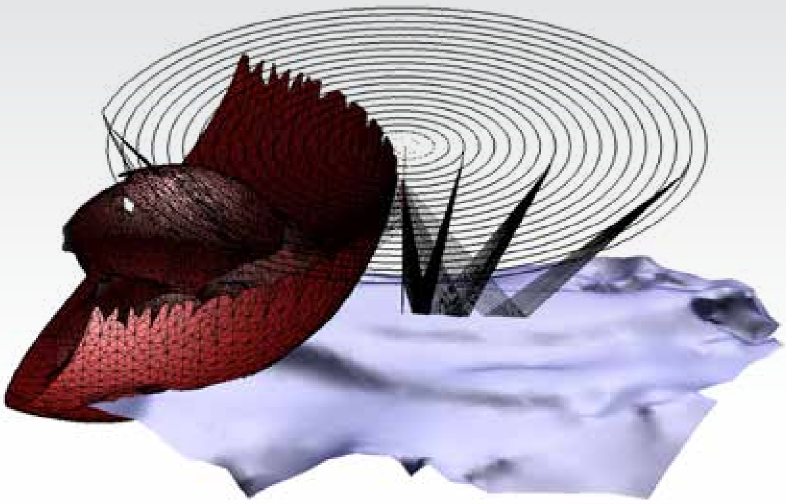
Modelling Package

NORSAR-3D is the most advanced product on the market for seismic illumination studies and model-based survey evaluation and analysis. The package is also used on a full industrial scale for generation of traveltime maps for Prestack Depth Migration (PSDM).

NORSAR-3D uses the Open Ray Model representation to simplify model construction. The technology even allows seismic ray tracing in preliminary or incomplete depth models.

The wavefront construction technique, first developed and implemented at NORSAR, ensures that all calculated rays are consistent in the Open Ray Model. Model run times are reduced, without compromising results, by the efficient way in which NORSAR-3D calculates ray contributions for a large number of shot and receiver positions.

NORSAR-3D modelling software is modular in design, whereby modules can be added to the platform to create a versatile and dynamic software product to meet user needs.



Modelling example: VSP walk-around survey. Some rays (black) and wave fronts (red) are shown.

NORSAR-3D KEY FEATURES

- Open Ray Model
- 3D Wavefront Construction (P and S waves)
- TTI Anisotropy
- Land, Marine, and VSP Surveys
- Illumination Rays
- Illumination Maps
- Simulated Migration Amplitude
- Parallel Processing
- Kirchhoff Target Migration
- Synthetic prestack seismic data including diffractions

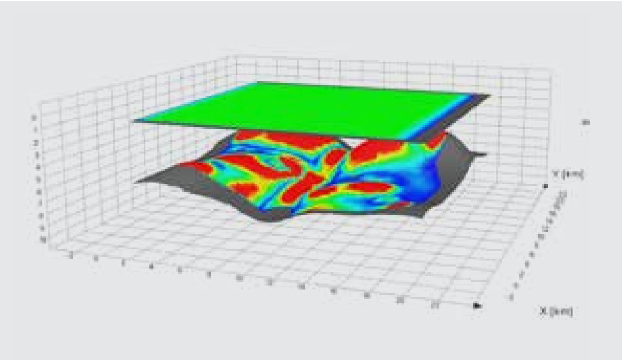
Are the targets well illuminated? Are there shadow zones?
How large migration aperture is required? How long streamers are required?

Use the NORSAR-3D analysis tool

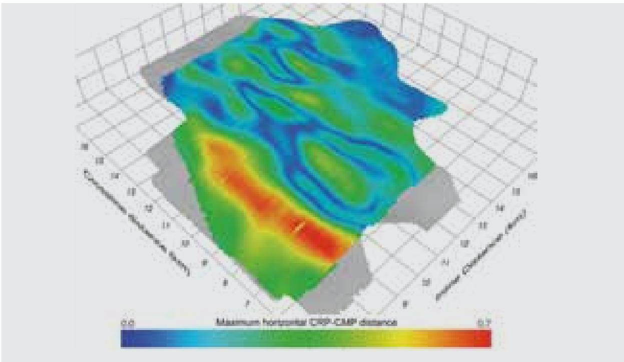
Illumination Maps

Illumination maps show how well a target horizon is illuminated by a survey. The basic map is the hit map, which shows for a survey how many rays from shots to receivers reflect on the different parts of the horizon. Shadow zones clearly stand out on hit maps.

There are more maps; they show different parameters computed along the rays, including: Travel time, reflection angle, required migration aperture, and amplitude. The maps are divided into grid cells, and for each parameter the maps show how minimum, maximum, and average value of the parameters vary across the horizon.
A map can be restricted to a certain interval of another parameter. For example, separate maps can be made for different offset intervals, to show which offsets are important in a survey.
Most commonly, the illumination information is put down on the target, but similar maps can also be made with the information posted in the shot or receiver locations. These maps show which shot and receiver positions contribute most to the illumination, and the maps may reveal that shots or receivers may be skipped in some areas.



Comparison of the nominal fold, here shown on the surface, and the expected fold at the target, computed as a hit map.



Illumination map showing maximum horizontal difference between common reflection point (CRP) and common midpoint (CMP). This is the required migration aperture if all reflections are to be depth migrated.

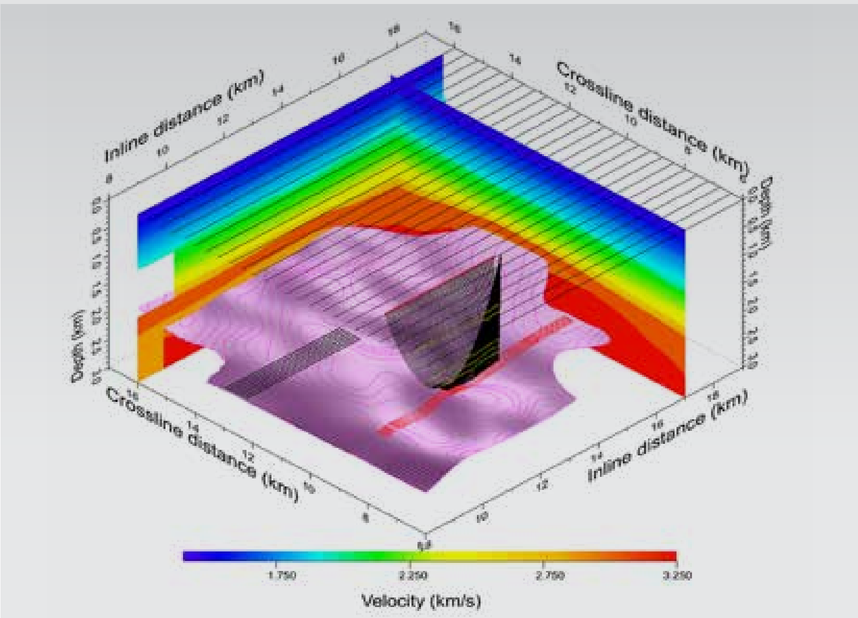
How will the amplitudes vary along a reflector in the final, PSDM seismic? Why do they vary? Is it caused by rock changes along the reflector, or is it a result of overburden and survey?

These important questions are answered by the

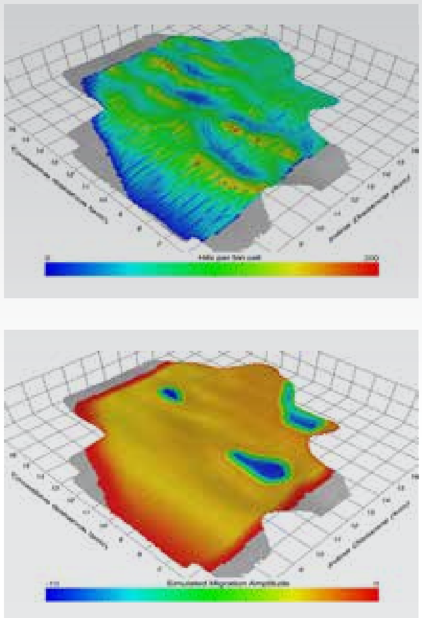
Simulated Migration Amplitude maps

NORSAR-3D computes Simulated Migration Amplitude (SMA) maps. The SMA simulates how amplitudes change along reflectors in prestack depth-migrated seismic data. To compute the SMA maps, the modelling process takes into account the survey, the overburden structures, the reflector shape, the reflection coefficient, the local wave field in the vicinity of each reflection point, the Fresnel zone, and the seismic pulse. Maps can be made where only some of these elements are taken into account, thus the influence and importance of the different factors can be assessed.

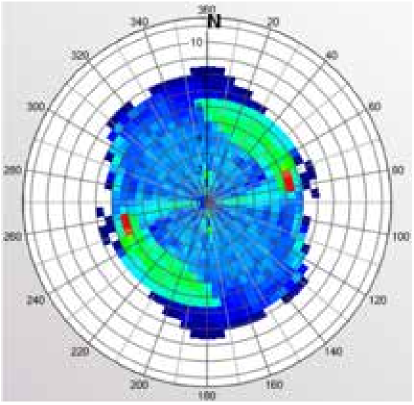
The SMA maps are a type of illumination map, providing valuable information for survey planning and feasibility studies. The SMA is also an important QC tool for seismic interpretation: A real, observed, PSDM amplitude map should ideally reveal the changes in reflection coefficient along a reflector, related to changes in rock properties, such as the effects of hydrocarbon fluid substitution. Supported by the modelled SMA maps, the interpreter can identify and understand amplitude variations as seen in real maps. Pitfalls due to 'false' amplitude variations, created by overburden structures, reflector shape, or survey geometry, are easily identified.

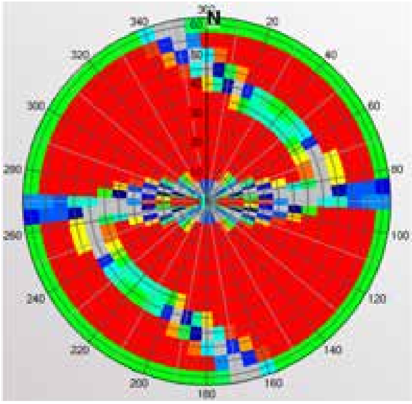


NORSAR model showing target horizon and the velocity field for the illumination analysis. Shown are shot lines, streamers, rays, and reflection points (red) on the target reflector.



Illumination maps generated on the target. The number of hits per bin (top) and SMA (bottom). Number of hits can be seen to be strongly related to horizon topography; however, the SMA results delineate the oil pockets by their strong amplitude responses.





Examples of survey-domain (left) and target-domain (right) rose diagrams.

The colours indicate number of rays; red means many, blue means few. Shadow zones are grey/white. By clicking in a sector, the corresponding rays are shown in the model.

Which survey azimuths and offsets are required to illuminate a point on the target? Does it change along the target? Which reflection angles and azimuths does a survey cover in a target point? How does the angular coverage change along the target? Where do rays propagate down to the target?

Investigate this by means of

Illumination Rays

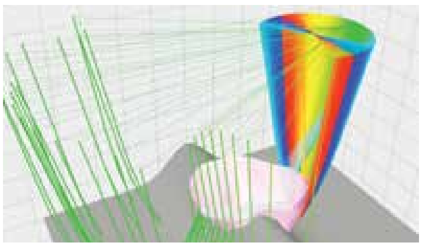
To investigate how rays propagate down to a target, use the interactive point-and-click ray-tracing function. All rays down to a selected point on a reflector are shown, for one reflection angle or azimuth at a time.

For a more systematic and comprehensive analysis, use the illumination rays workflows. In the work-flows, many target points can be analysed, and all reflection angles and azimuths are taken into account.

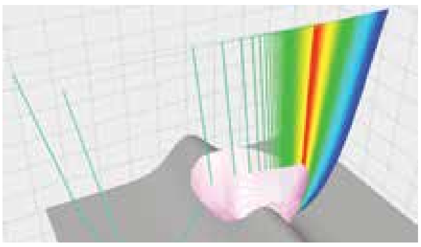
The results for each target point are shown in a survey- and a target-domain rose diagram. The survey-domain roses show which shot-receiver offsets and azimuths illuminate the target points, while the target-domain roses show which reflection angles and azimuths are covered. The roses are displayed down in the target points to make it easy to see how the illumination varies across the target.

The roses are interactive: Click inside a rose to see the corresponding rays.

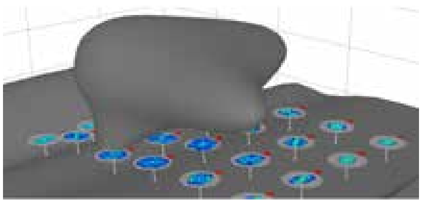
The analysis can be restricted to show the illumination for a particular survey. Alternatively, all rays to the target points can be used, disregarding surveys. This is very useful early in the survey planning, to get an overview of which azimuths and offsets must be involved to illuminate the different parts of the target.



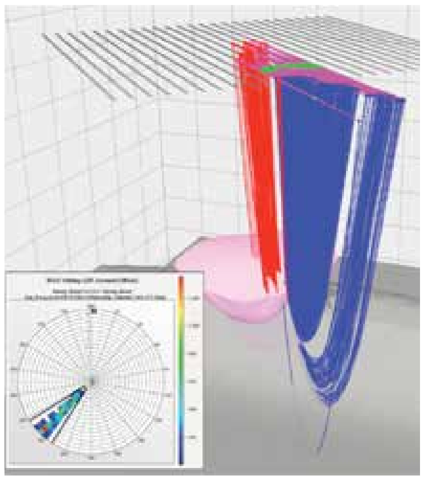
Interactive point-and-click ray-tracing for one reflection angle.



Interactive point-and-click ray-tracing for one reflection azimuth.



The rose diagrams show in detail how the illumination varies across the reflector.

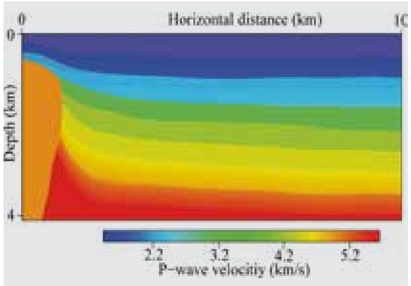


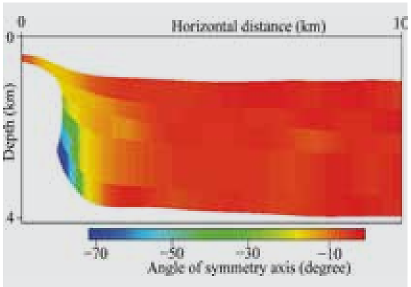
The rays to a target point for a marine survey.

Incorporate anisotropy into your model

Anisotropy within rock units results in a variation in seismic velocity that depends on the direction in which the ray is propagating. Introducing anisotropy into seismic modelling is essential to accurately reproduce the transmission of seismic energy through the earth.

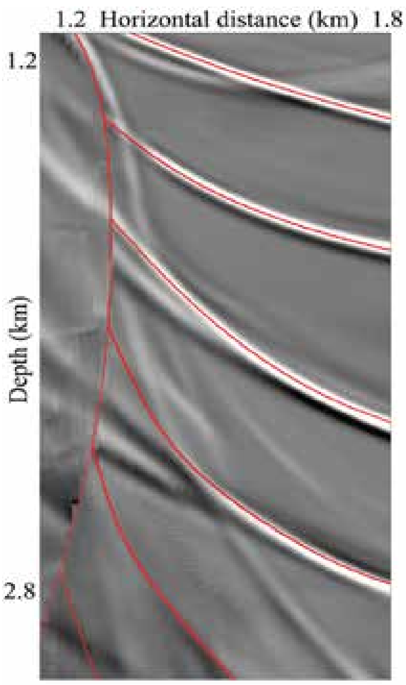
The anisotropy option within NORSAR-3D upgrades the software package to enable TTI anisotropy to be included in layered models. This option enables a more realistic earth model to be constructed, resulting in e.g. an improvement in traveltimes for PSDM and tomography applications.

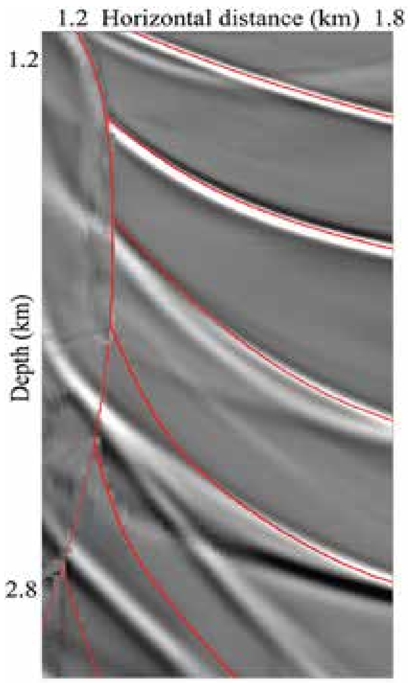


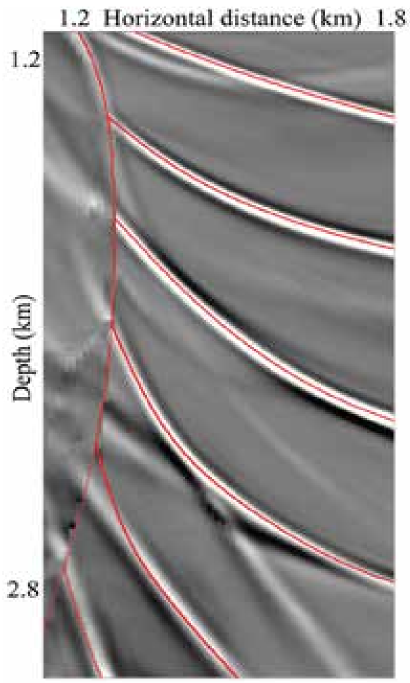


"We have been very pleased with the imaging using the VTI anisotropy... The data on which we tested the imaging with the anisotropy option showed significant enhancement of structural detail over the migration using the isotropic travel times, which in turn was far superior to the previous prestack time migration."

-- Dr. Andrew V. Barrett, Kelman Technologies







An example of a salt structure with several adjacent transversely isotropic shale layers where the axis of symmetry is normal to the bedding (the two top pictures). Depth migrated images are shown (from left to right) using an isotropic model, a VTI model and the TTI model. It can be seen that a good subsurface image in the vicinity of the salt dome is obtained only when using the TTI model. The VTI model shows a misfit for the lower reflectors whereas the isotropic model images them poorly.

Parallel processing to reduce turnaround time

As seismic modelling jobs and applications have become more computation intensive, NORSAR has adapted the necessary software modules for parallel processing to reduce turnaround time and increase user control. The parallel jobs are set up in a master module using the interactive part of NORSAR-3D and distributed to a number of batch slaves for running on different external computers simultaneously, e.g. on a Linux cluster. So, for example, instead of waiting for days for a job to be completed, it can be completed in a matter of hours. This, of course, depends on the size of the job and the number of CPUs you have available.

Additional solutions

How to:

Convert from time to depth? Make synthetic seismic sections? Import horizons, velocity cubes, well paths? Use large, real surveys? Speed up the modelling on large clusters? Look at all modelling elements within a uniform framework? Extract detailed parameters from the ray-modelling?

Use the NORSAR-3D

The NORSAR-3D software package contains numerous functions tailored to the needs for advanced, seismic modelling.

THE FUNCTIONS INCLUDE, BUT ARE NOT LIMITED TO:

- Import of horizons and velocity cubes on many standard file formats.
- Import of P1/90 and SPS survey files and well data in LAS format.
- Mapping from time to depth.
- Building models with discrete layers of any shape as well as velocity cubes.
- Comprehensive viewer of modelling elements in an integrated, uniform framework.
- Extensive parallelization of the seismic modelling and the generation of illumination maps.
- Generation of synthetic seismic on SEG-Y files including diffractions by Kirchhoff modelling.
- Generation of traveltime tables for prestack depth migration.
- Flexible, customizable export of detailed modelling results on ASCII files.

Quality and Excellence
NORSAR is an independent research foundation recognised internationally for its scientific research and innovation. NORSAR's seismic modelling division has been at the forefront of software solutions for seismic oil and gas prospecting since the release of our first commercial seismic ray modelling package in 1991.

Software Products
The core applications for NORSAR Seismic Modelling packages are 2D and 3D seismic ray modelling, survey planning, time lapse studies, reservoir analysis, and Green's functions for PSDM.

NORSAR software products are used by the leading E&P and O&G service companies throughout the world. The products are supported by experienced sales, services, and support teams from our main office in Norway. For your convenience, additional support centers are located in Houston and Beijing.

Research and Development
Research and development is the foundation upon which NORSAR's software products are built. Through the development of a world class research centre, NORSAR is able to provide its clients with a product that evolves as new, innovative solutions are developed to meet the needs of a dynamic industry.

Microseismic Research and Services
Since 2000, NORSAR has been engaged in research and development of advanced software solutions for microseismic data analysis and interpretation. Over the years NORSAR has been leading numerous research projects and consultancy studies.

Support and Maintenance
At NORSAR we pride ourselves on the level of support offered to our customers. We value client feedback as a vital ingredient for the continued improvement and evolution of the software. Therefore, software support is an integral aspect of the software package we offer to our customers.

The maintenance service includes telephone support, on-line support, software updates, and new releases as they become available.

Consulting services
Our Services division undertakes commercial projects in survey evaluation, Illumination analysis, 4D-studies, and reservoir monitoring. The scope of this group is to use NORSAR Seismic Modelling Software to provide tailored solutions and independent advice to our clients.

Training Courses
Whether you are a new user or an experienced one, we provide training that will reduce the uptake time and improve your application of our software.
We are offering both public and private training courses. Booking a private course enables you to tailor the course content to suit the application of your company.

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