The purpose of the present study is to show what can be achieved from AEM data using different inversion approaches and subsequent geological modelling implications.

This study has been developed in order to obtain different types of geophysical models testing several inversion strategies.

The key contribution expected from different inversion models is therefore to better resolve layers boundaries, lateral and vertical extent of electrical resistivity features.

What I have achieved

3 different geological models have been built that show some important differences
Study Area: The Peace Region

The study area is located in the Peace River Region, British Columbia, Canada. The topography is dominated by hilly plateaus (900-1200m above sea level) incised by modern drainage rivers.
The structural geology consists of Palaeozoic and Mesozoic rocks that have been folded and displaced by thrust faults. The stratigraphic formations are characterized by different clay contents, and thus, resistivities. The bedrock comprises a succession of shale and sandstone formations.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Resistivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glaciofluvial deposits</td>
<td>~ 100 Ωm</td>
</tr>
<tr>
<td>Glaciolacustrine deposits</td>
<td>~ 10 Ωm</td>
</tr>
<tr>
<td>Dunvegan Fm</td>
<td>~ 50 Ωm</td>
</tr>
<tr>
<td>Sully Fm</td>
<td>~ 15 Ωm</td>
</tr>
<tr>
<td>Sikanni Fm</td>
<td>~ 40 Ωm</td>
</tr>
<tr>
<td>Buckinghorse Fm</td>
<td>~ 20 Ωm</td>
</tr>
</tbody>
</table>

According to a few electrical logs provided by Geoscience BC.
• During July and August 2015 21,000 line kilometres were flown with the SkyTEM system to collect airborne TEM data in the NorthEast British Columbia, Canada.

• AEM data have been processed and inverted by Aarhus Geophysics ApS.
At the request of GeoscienceBC, Aarhus Geophysics ApS and GEUS (Geological Survey of Denmark and Greenland) (2017) performed additional processing and 3D inversion of the raw SkyTEM data over the NW extension portion of the survey area.

GEUS has performed an interpretation study on this subset: vertical profiles and a horizontal slices through the 3D resistivity grid have been carried out. A 3D geological model is constructed for a small part of the study area corresponding to 19 km x 8 km.
From a geophysical standpoint, main topics that this study, and in particular the employment of different inversion approaches that you will see in the next slides highlights:

- The spatial variability of electrical features within each resistivity model that reflect the expected variance, both near surface and at depth
- The different DATA MISFIT between measured and modelled data for each different inversion strategies and the subsequent implications on geological interpretation
Different inversion strategies → different types of geophysical models

**Smooth inversion**: discretizes the half-space with numerous layers having thickness logarithmically increasing with depth (Constable *et al*., 1987).

**Few layers inversion**: reconstructs petrophysical interfaces using a discretization with a limited number of layers so it is very sensitive to the choice of the starting model.

**Sharp inversion***: promotes the reconstruction of blocky solutions (using a parameterization characterized by many layers) by means of minimization of the volume where the spatial model variation is non-vanishing.

The inversion results gradually change, passing from models that do not fit adequately the data but capable of discerning basic resistivity structures, to models rich-in detailed resistivity features, but at the same time capable of reconstructing blocky solutions.

We start from a simple model made up of few main blocks with different resistivity values to detailed geophysical models with resistivity quasi-smooth variations.

SHARP (1-2-3-4-5)
I have obtained different reasonable 3D sharp-models. Three of these models have been used to create 3 different geological models using the software GeoScene3D.
The geological interpretation has been undertaken starting from:
- The geological map released by Petrel & Robertson
- The geological interpretation carried out by GEUS in 2017.
- The study of HM data\_misfit and LM data\_misfit plots. These plots, double for each different geophysical model, have been used like a quality control of the local misfit before starting all picking operations.

HM data refer directly to deeper electrical features in the model that the algorithm/inversion reconstructed, on the other hand LM data provide information of the superficial part of the model.
do not fit adequately the data but it is capable of discerning basic resistivity structures
is able to identify qualitatively the main buried valley below the upper Quaternary deposits

returns a model rich in detailed resistivity features
is able to identify different resistive features below the upper glacial cover and it shows a reasonable continuity of these features
Conclusion:

Different inversion strategies $\rightarrow$ different types of geophysical models $\rightarrow$ different geological interpretations

FOCUS:

$\rightarrow$ The sharp inversions allow retrieving the resistivity distributions preserving the capability to reproduce sharp features

$\rightarrow$ Different types of sharp inversion settings imply an evolution in geophysical model complexity and consequently lead to different geological interpretations

Keep in mind $\rightarrow$ The choice of the inversion strategy should be strictly connected to the geology complexity – but even the opposite is valid: different inversions have been carried out in order to obtain different models. Each model can point out different geophysical aspects.
THANK YOU FOR YOUR ATTENTION
Smooth inversion: discretizes the half-space with numerous layers having thickness logarithmically increasing with depth (Constable et al., 1987).

\[ S^{(SCI)}(m) = \frac{1}{\beta} \sum_k \frac{(Rm)_k^2}{\sigma_k^2} \]

Sharp inversion: promotes the reconstruction of blocky solutions (using a parameterization characterized by many layers) by means of minimization of the volume where, the spatial model variation is non-vanishing (Vignoli et al., 2017)

\[ S^{(sSCI)}(m) = \sum_k \frac{1}{\beta_k} \left( \frac{(Rm)_k}{\sigma_k} \right)^2 \frac{1}{\left( \frac{(Rm)_k}{\sigma_k} \right)^2 + \varepsilon^2} \]
We performed different synthetic models considering the general geological structures observed in BC. Generating synthetic responses over known target is efficient to quantify how well a model is recovered by a combination of the applied geophysical method and the inverse algorithm:

Based on the results obtained by synthetic models and knowing the complexity of the geological structures in the study area we have decided to focus the attention on the **sharp** approach.

- The key contribution expected is therefore to better resolve layers boundaries, lateral and vertical extent of resistivity features.

- The project goal is to better outline sedimentary units specifically within **Quaternary deposits**. These features could potentially host groundwater resources.