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a LEONARDO and THALES company

Applying Artificial Intelligence Techniques to Earth Observation Data Quality Control Activities

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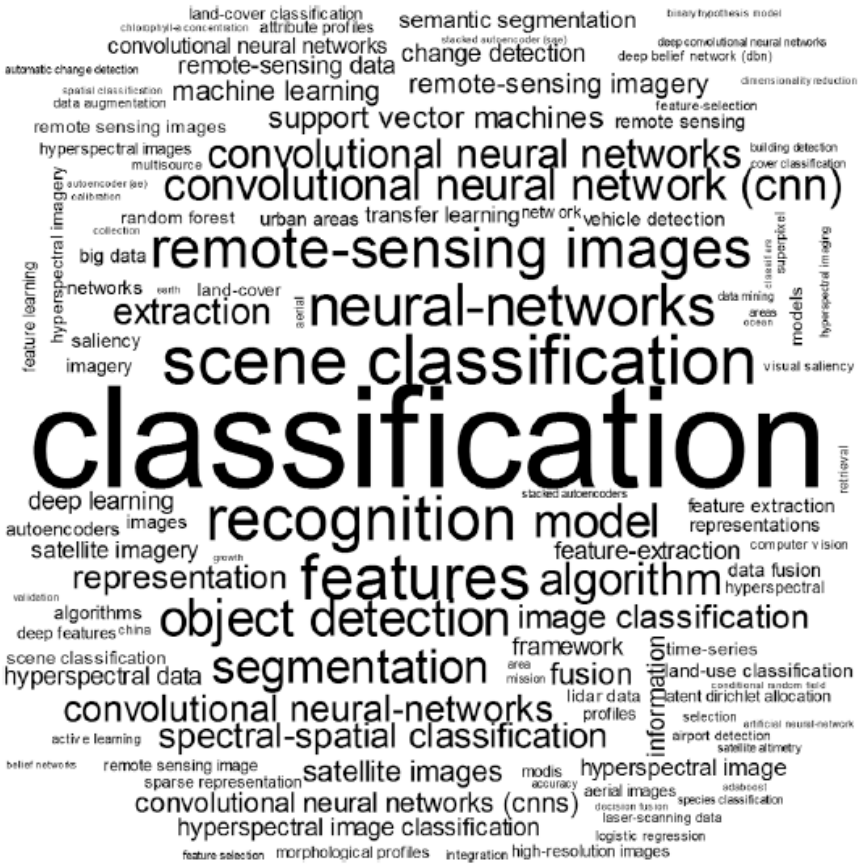
Summary

- Telespazio VEGA UK have established a process to create AI models to detect anomalies in optical EO datasets
- The AI models have the potential to support EO QC engineers against a growing number of EO missions and data product volumes
- A tool has been developed to capture the output of an EO QC engineer’s analysis to support AI model development
- An AI model has been developed to support the QC of ESA Landsat products for the IDEAS+/QA4EO Service

EO Data Quality Control

- Telespazio VEGA UK are prime contractors for ESA's IDEAS+ service – responsible for performing operational and offline QC analyses on many ESA and Third Party EO data
- QC activities are a mixture of automated checks (applied to the whole dataset) coupled with a more detailed human observation of a smaller subset of the data
- Year on year, data volumes are increasing – very hard for available resources to increase at the same pace
- The use of AI/Machine learning technics for classification is increasing exponentially
- QCOLT (Quality Control Optical Learning Tool) project was conceived to determine feasibility of using AI/Machine Learning techniques to support the QC of EO data
- Test application for the QC activity associated with the bulk re-processing over 600,000 ESA Landsat MSS products
- Overall objective was to determine whether the types of detailed QC analysis done by operators to a small data subset could be extended to entire datasets



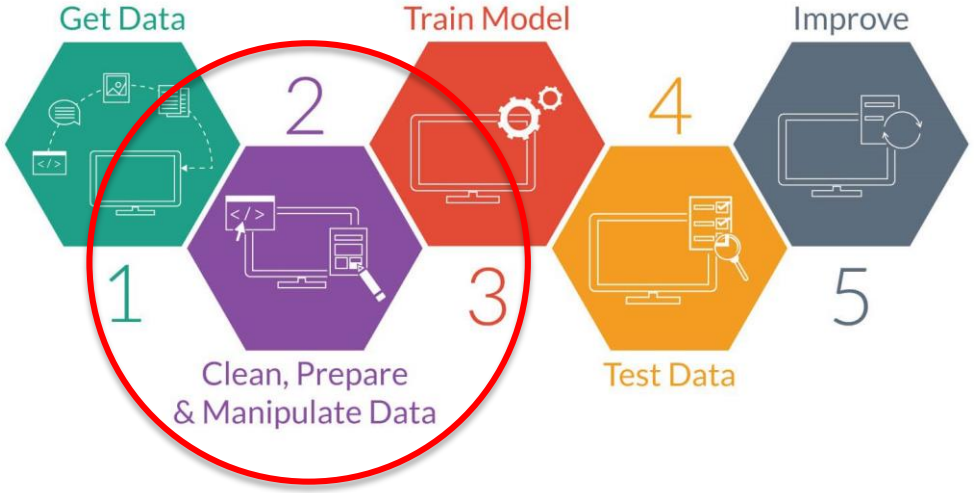
Lei Ma et al. 2019

Machine Learning

- At a high level – development of an Machine Learning model has 5 steps

- **Data Preparation** step is the most effort intensive

- Data Preparation involves:
  - Performing a QC assessment on data products within an archive
  - Tagging those products exhibiting specific anomalies
  - Creating two training datasets consisting of:
    - Nominal data
    - Data containing the specific anomaly being investigated



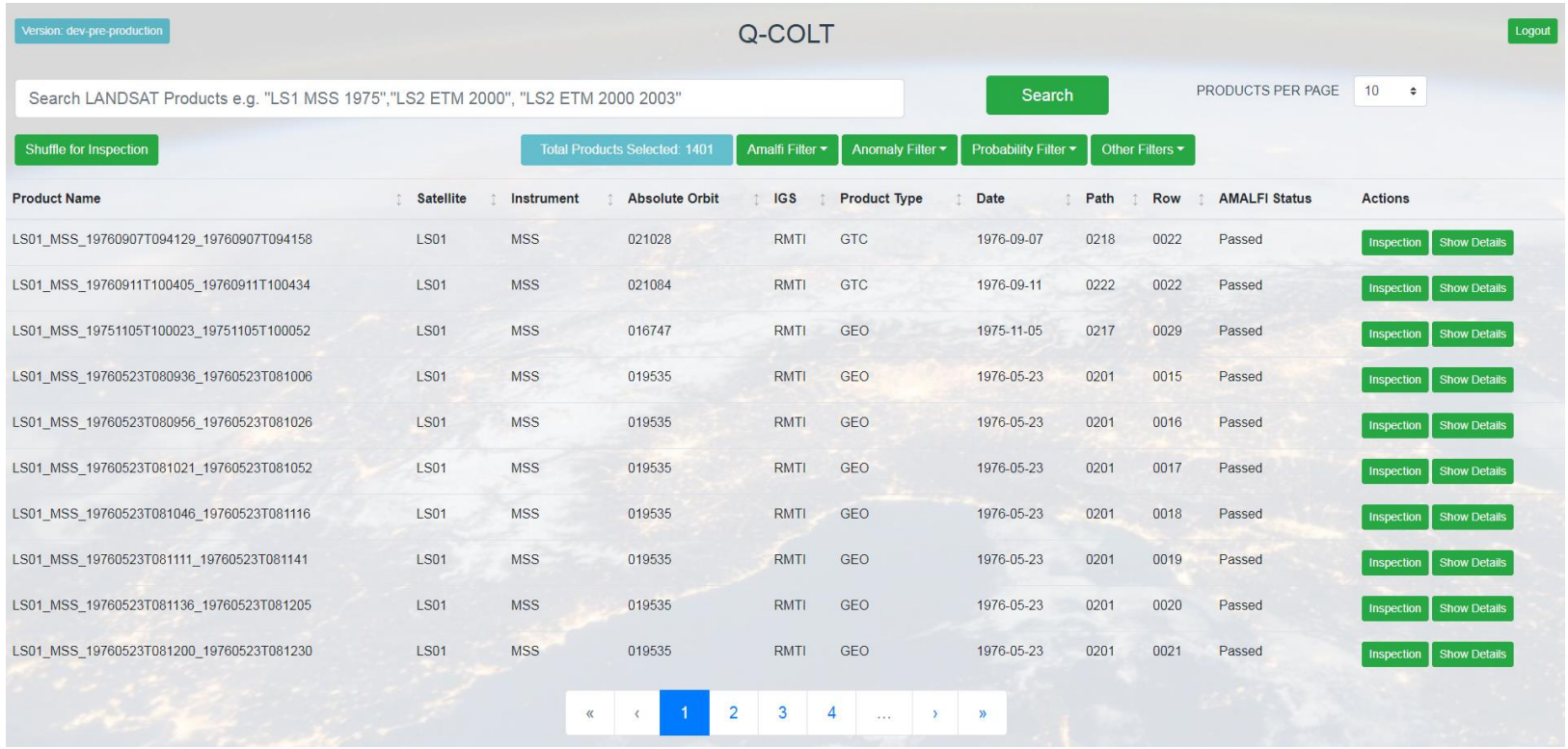
- Most of this type of assessment is performed by a QC engineer as part of their normal activities

  BUT assessments aren't typically captured in a way that AI experts can use to properly prepare the data

- Project developed the **QCOLT software** to support both QC engineers and AI experts:
  - QC engineer duty is to perform large elements of the Data Prepartion step for the AI experts
  - The Machine learning output reduces the resources needed to complete the QC over the full dataset

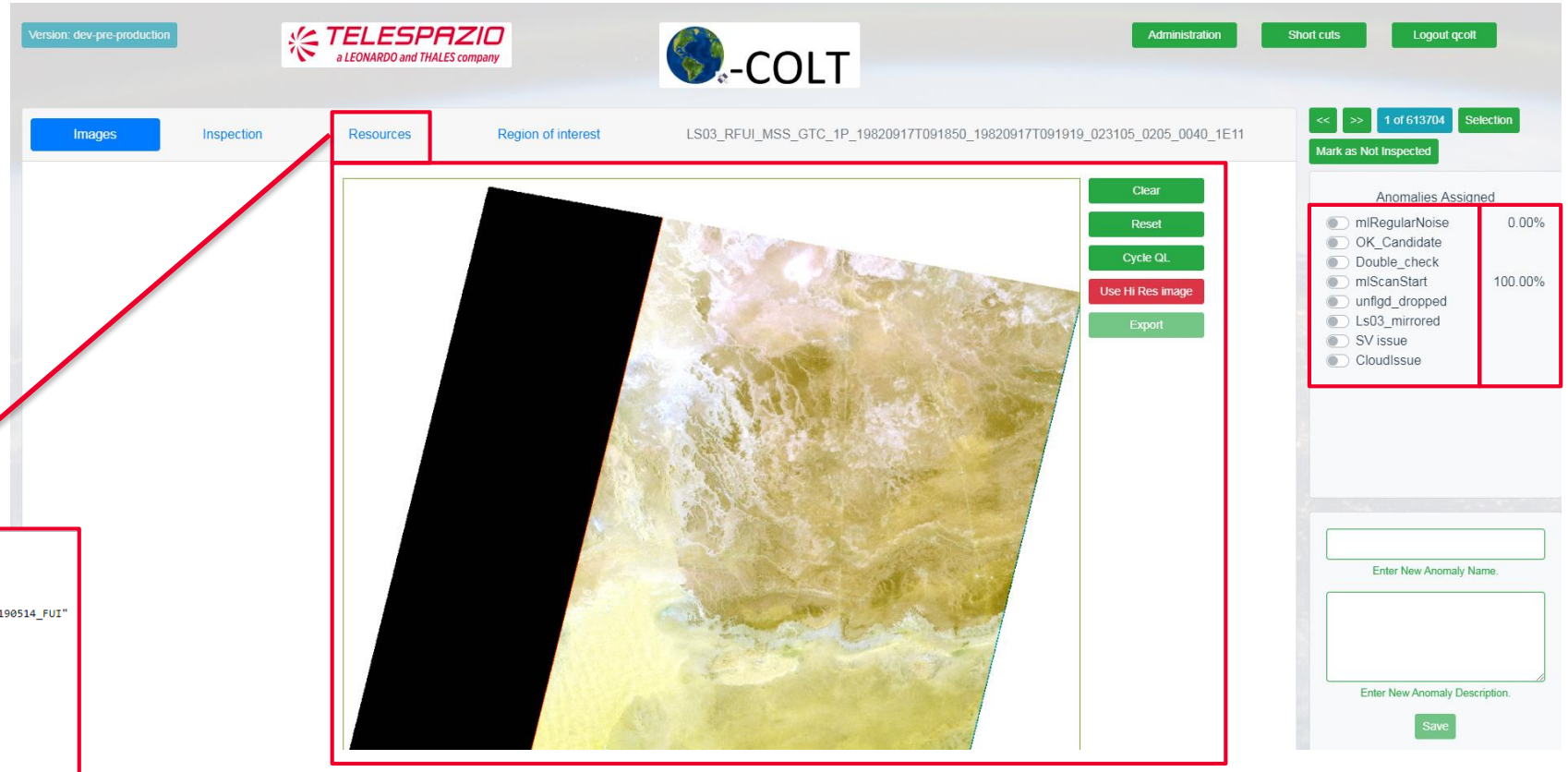
QCOLT Software

- Large **backend** database containing information and image data relating to all of the Landsat products under investigation
  - Product data (images)
  - Product Metadata
  - Product statistics
  - Quality reports from automated analyses outputs



QCOLT Software

- Customised **GUI** permitting:
  - visual inspection of the data
  - inspection of metadata
  - anomaly assignment
- During inspection the training dataset is built
- Once AI models implemented, results imported back into QCOLT




```
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    REQUEST_ID = "0008209170000_00000 "
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    OUTPUT_FORMAT = "GEOTIFF"
    EPHEMERIS_TYPE = "RESTITUTED"
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    SENSOR_ID = "MSS"
    WRS_PATH = 205
    WRS_ROW = 040
    DATE_ACQUIRED = 1982-09-17
```
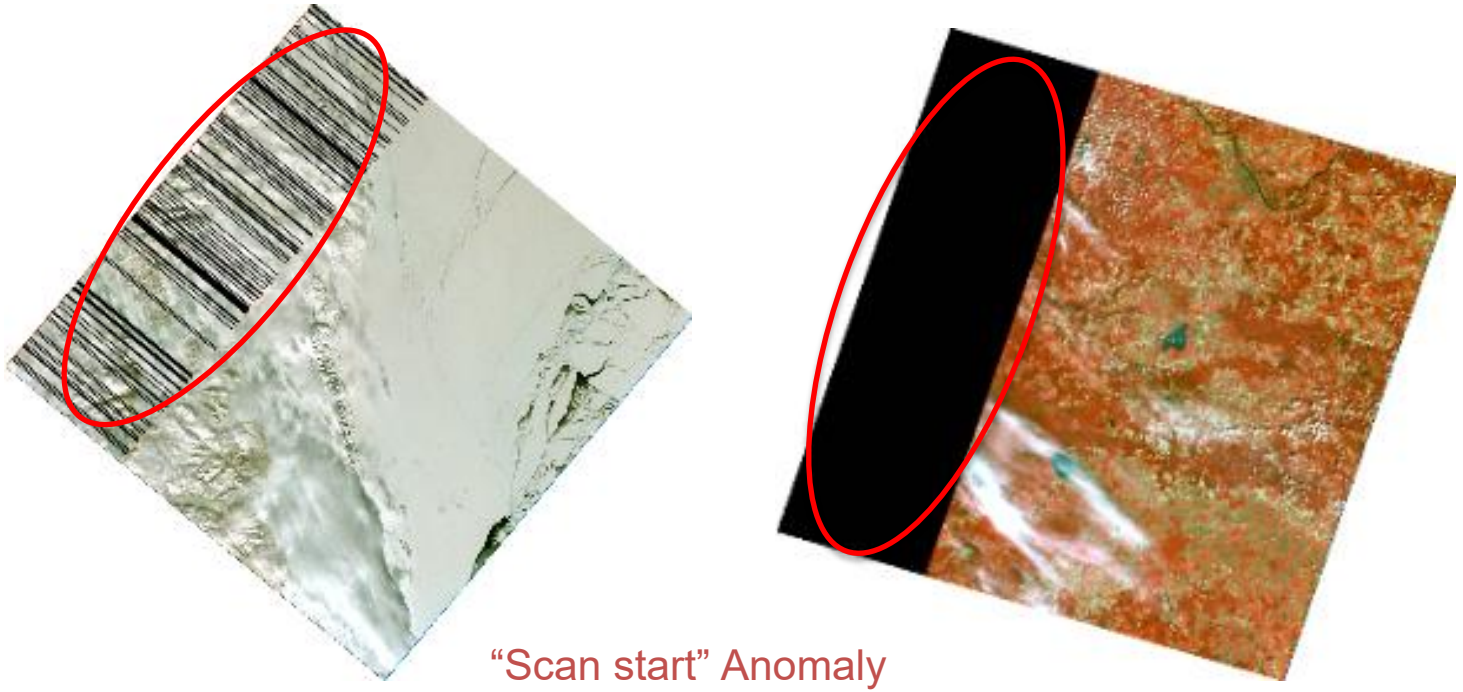

AI Model & Anomaly Selection

- Key decisions to be made related to the selection of the type of AI model used by the team
  - **Convolutional Neural Network** selected
    - Similar to neuron connectivity in a human's visual cortex – popular amongst Deep Learning community for image classification
  - "**Supervised**" model type used – can be trained to detect a particular anomaly type

- Anomalies selected: Scan Start Anomaly.



"Scan start" Anomaly

  - Criteria:
    - Visible in the product image
    - Deterministic detection unfeasible

Model Refinement

- The model output is a ‘soft classifier’ score for each product assessed
  - Probability of a product having the anomaly rather than TRUE/FALSE

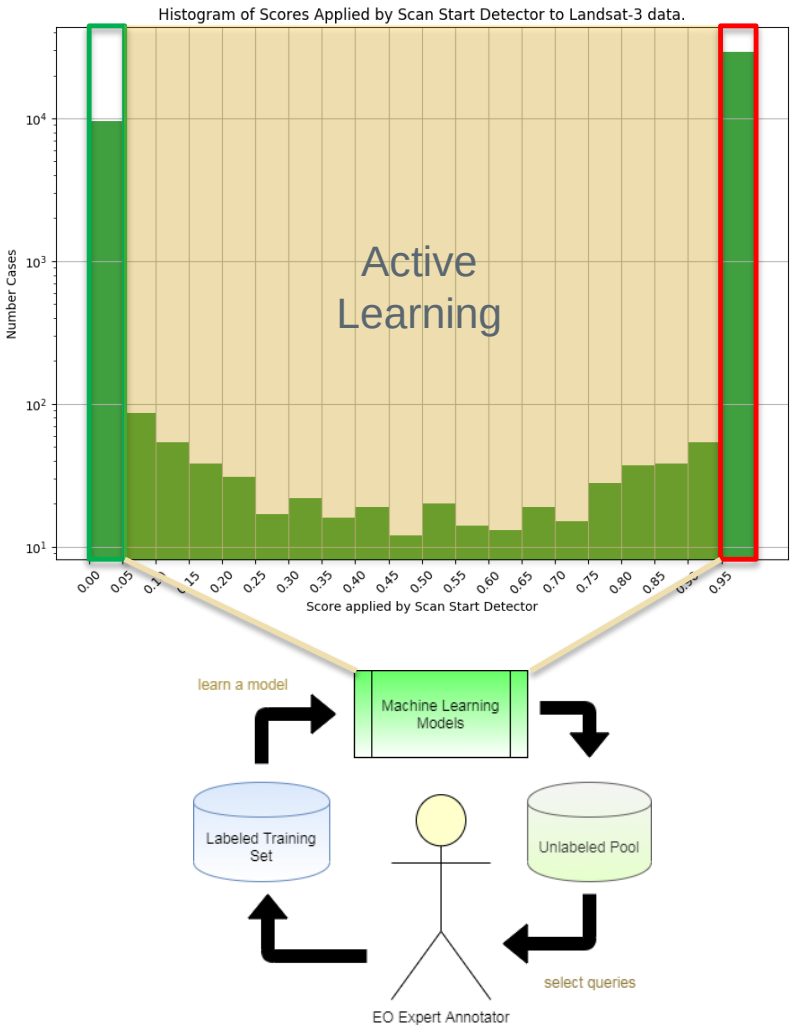
- **Active Learning** process used to improve and refine the models

- Example of results from model application (logarithmic scale) on 40’000 products
- Trained using only 25 anomalous products

- 0%-5% classified as ‘No anomaly detected’ / ‘Negative’
- 95%-100% classified as ‘Anomaly detected’ / ‘Positive’
- 5%-95% classified as ‘Undecided’

- Undecided zone forms the basis of the Active Learning dataset

- Data is re-assessed & re-classified
- Model is re-trained and improved based on new input

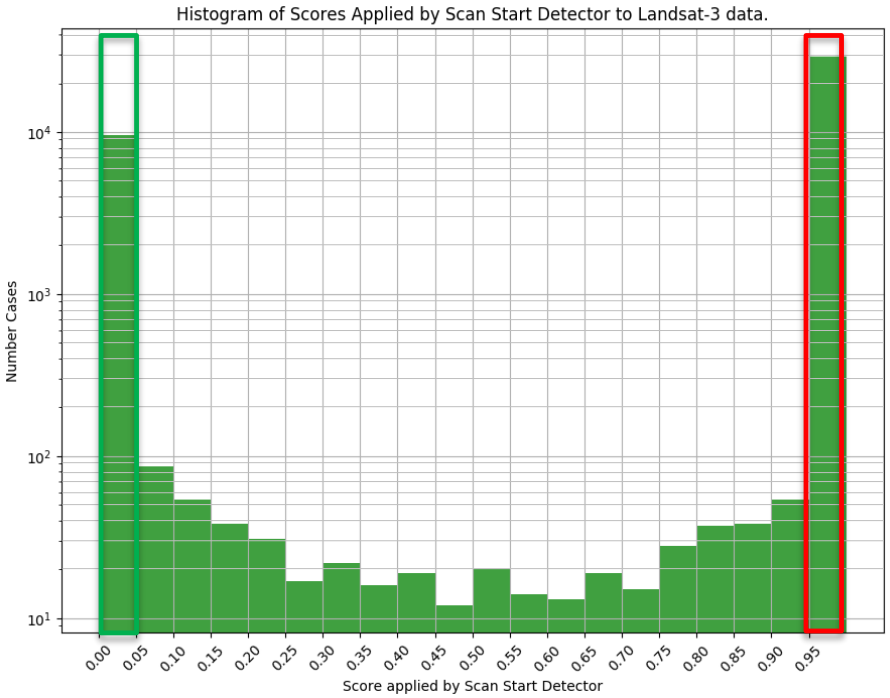


Results

- ‘Scan Start’ Anomaly
  - 39,001 Landsat-3 products analysed
  - Higher than expected Positives detected
    - Resulting from known issue prevalent towards end of mission
  - 100 samples taken across each class visually detected

Predicted \ Observed	Positive	Negative
Positive	True positive (100)	False Positive (0)
Negative	False Negative (16)	True Negative (84)

  - Model does not mix Scan Start anomaly with other missing data
  - Particular cases still undetected
    - Could be improved through further training



Future Development

- Investigate potential to integrate machine learning activities into ongoing QC projects
- Expansion of techniques to include other instrument types (e.g. SAR)
- Exploration of alternative model types:
  - Unsupervised models have the potential to detect multiple anomalies with a single model, rather than having one model per anomaly
- Software tools
  - Activities to date performed on an in-house research basis
  - Software development will focus on tool integration in data processing and QC pipelines

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THANK **YOU**
FOR YOUR ATTENTION

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