AI for Building Damage Assessments

Automatic detection of damaged structures powered by machine learning

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Director, United Nations Satellite Centre

Max Dean

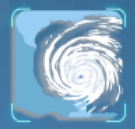
Geospatial Analyst, United Nations Satellite Centre

The United Nations Satellite Centre
Programme hosted at the UNITAR

United Nations Satellite Centre

The United Nations Satellite Centre provides rapid, reliable, and independent satellite-based geospatial analysis to support emergencies, preparedness, response, recovery, and development operations worldwide.

What We Do



Rapid Mapping:
Floods, quakes, cyclones, wildfires, and droughts, conflict related activations



Geospatial Analysis:
Damage to buildings / infrastructure, population exposure, active monitoring



Support:
Imagery provision, data-driven insights, strategic decision making, actionable operations



How We Work

Imagery:
Optical, multispectral, and radar (SAR)

Methods:
Change detection analysis, photointerpretation, integrated manual and AI-assisted workflows

Validation:
Expert quality control & GIS layer dissemination

Who We Support

UN Agencies:
OCHA, WFP, UNHCR,UNESCO UNICEF, OHCHR …

National Authorities:
Disaster management offices

Global Reach:
Active in 90+ countries

Operational Impact

Satellite Data > Geospatial Analysis > Decision Support > Emergency Response & Recovery

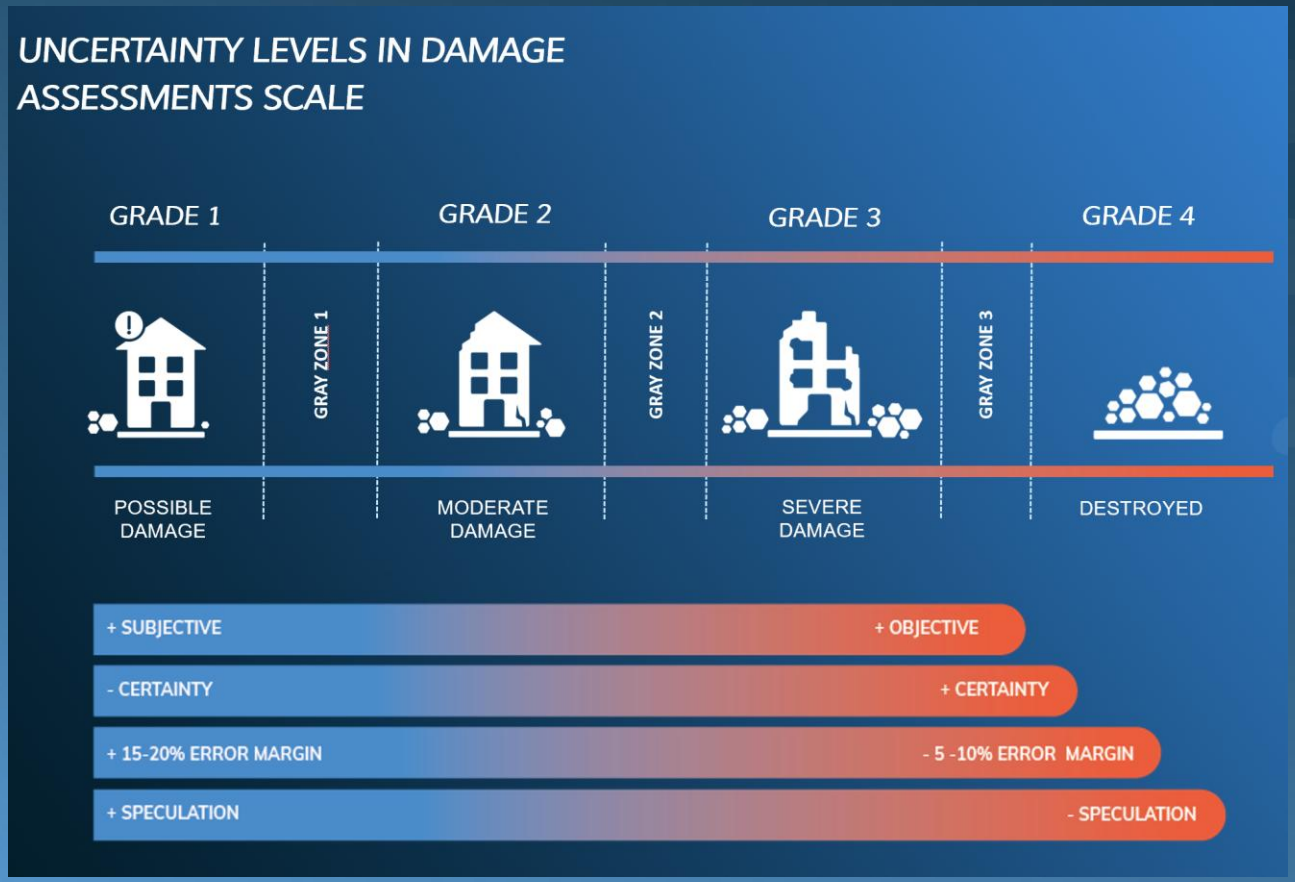
UN Satellite Centre DA Methodology

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Damage assessments are conducted using comparative optical satellite imagery (pre- and post-event) to identify damage to structures and infrastructure, categorically ranked by severity level

- **No visible damage**
- **Possible** damage
- **Moderate** damage
- **Severe** damage
- **Destroyed**

increasing severity



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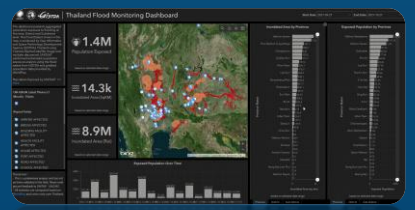
AI-POWERED ANALYSIS

The UN Satellite Centre coordinates the use of artificial intelligence and machine learning through the development and deployment of innovative tools, collaborative initiatives, and integration with geospatial workflows

AI-assisted damage assessments



UNOSAT Flood AI Dashboard



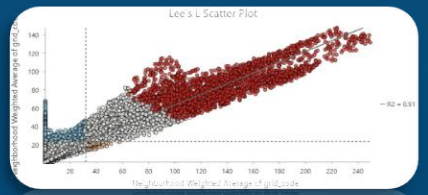
Satellite derived analysis



Automated pipelines and innovative workflows



Rigorous validation and accuracy testing



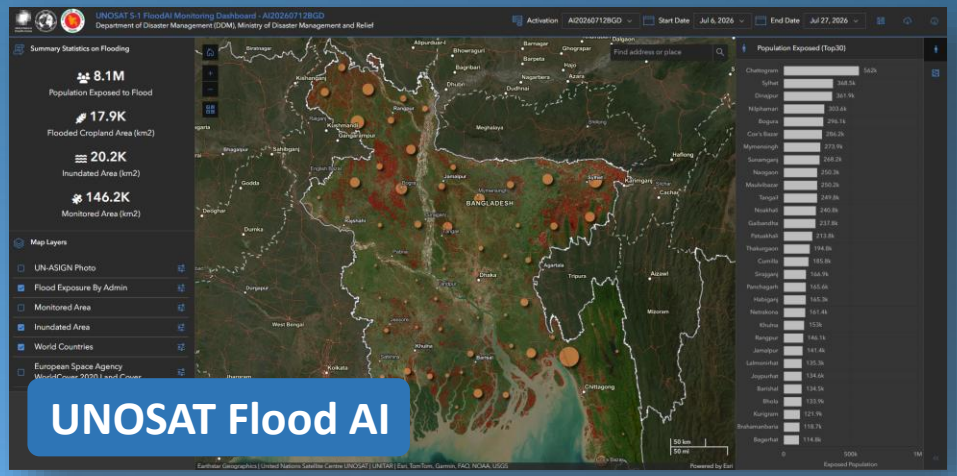
AI for Building Damage Assessments

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- While critical for disaster response and recovery, damage assessments can be very time consuming
- AI-assisted methodologies significantly speed up turn-around times and analyst efficiency
- Possible through both direct and indirect methods

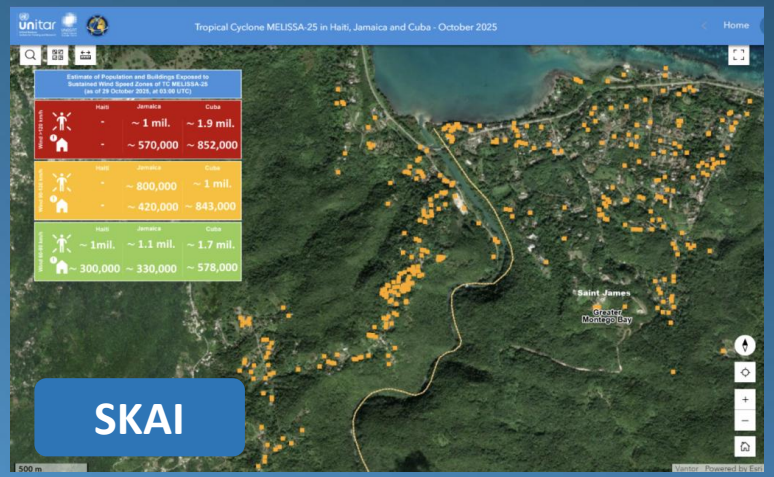
Indirect

- Map damage-causing features and cross reference with building footprints
- Flood waters, landslide extents, burned area
- Requires physical presence of natural disaster effects, not suitable for storms or conflicts



Direct

- Direct analysis of damaged structures through change detection and classification
- Covers all nature of humanitarian disasters
- Generally more difficult compared to mapping natural features, but many recent advancements...



SKAI Project

SKAI Damage Assessment Solution

- Comprehensive, open-source solution that classifies damaged structures from very high resolution optical imagery (see Resource slide for access details)
- Final product contains intuitive user interface for end-to-end workflow

Collaboration

- Project is conducted collaboratively – model development, evaluation, deployment
- Base model was developed by Google Research, the UN World Food Programme, and InstaDeep

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- Extensive model evaluation working closely with Google Research – accuracy assessments, geospatial analysis, and statistical testing
- Evidence-based advice on workflow development, suggestions on best practices concerning high-impact attributes
- Operational model deployment and directed efforts for disaster relief

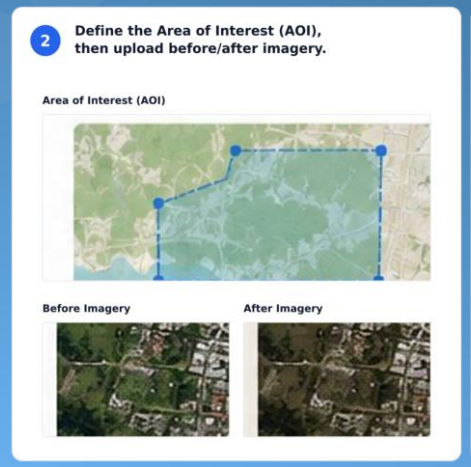


SKAI Functionality

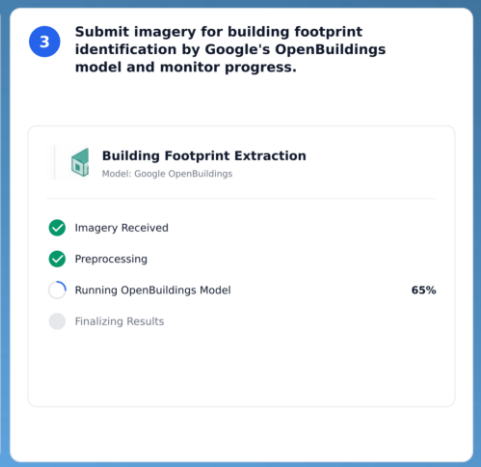
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- **Input:** Pre- and post-event imagery (optical, VHR) + user-defined AOI
- **Methodology:** Change detection using pre-trained vision models + supervised classification
- **Steps:** Extract building footprints > generate image pairs (pre- and post-event) matched to each footprint > unsupervised classification using image pairs > directed data annotation and model fine-tuning > final inferencing
- **Output:** GIS-ready building footprint polygons with attributed damage scores

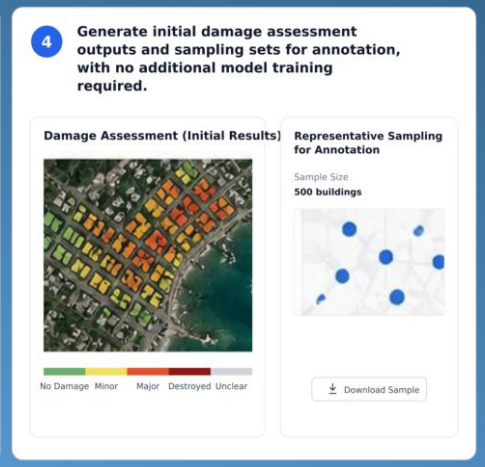
Define AOI + Upload Imagery



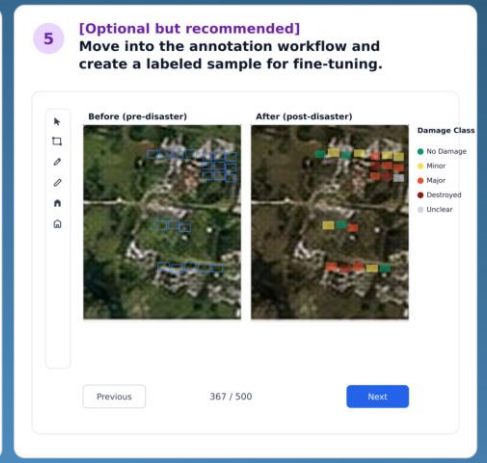
Building Footprint Extraction



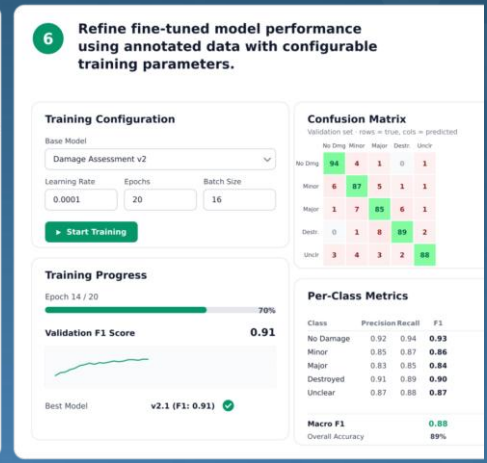
Initial Pre-trained Model Analysis



Data Annotation + Model Fine-Tuning



Final Inference w/ Parameter Configuration



Technical Workflow

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Area of Interest

Pre- and Post-event Imagery Acquisition

Pre-processing

Satellite images

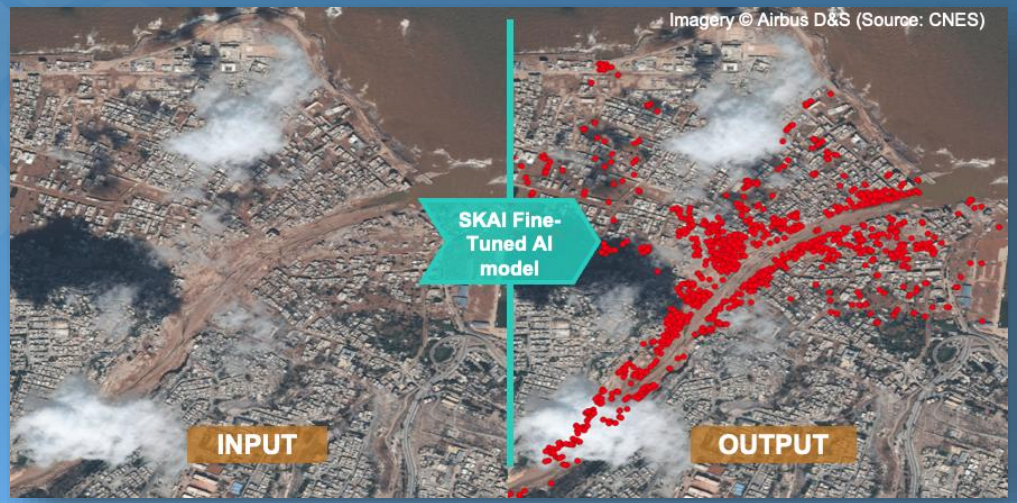
Building Footprint Extraction

Building Footprints + Pre- / Post-event Image Pairs

Google Research

- Google cloud-computing infrastructure
- Hosting models + geospatial tools
- Supplemental models (Google Open Buildings)

Initial "Zero-Shot" Inference



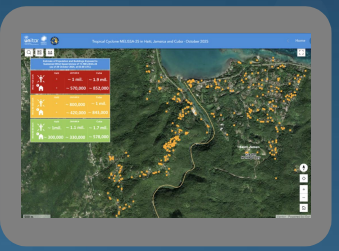


User

Data Annotation + Model Training

Fine-tuned Model Change Detection Pipeline

Final Inferencing / Damage Classification



Performance Indicators

GIS-ready Data

Download Output

Results

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- Ongoing, scaled deployment – as of July 2026: 11 activations over 9 countries related to natural disasters
- Operational level metrics when compared with analyst data
  - Aggregated similarity scores above 0.8
  - F1 score, precision, and recall around 0.7-0.9 at building level
- Significantly faster assessment times

Considerations + Limitations

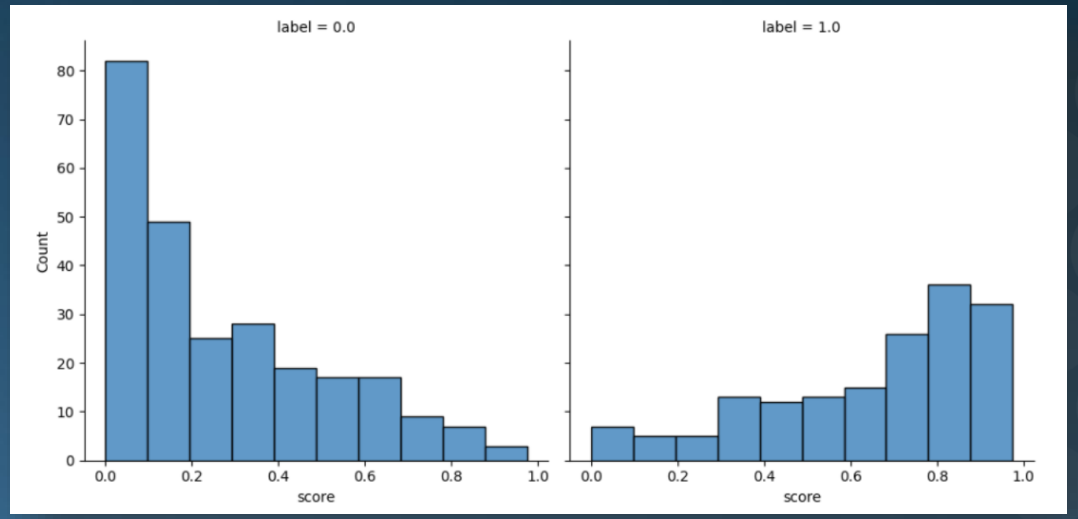
- Manual review still necessary to ensure accuracy
- At smaller scales, manual assessments are likely faster
- Performance level highly dependent on training data quality + damage severity
- Same restrictions as manual assessments (imagery availability)



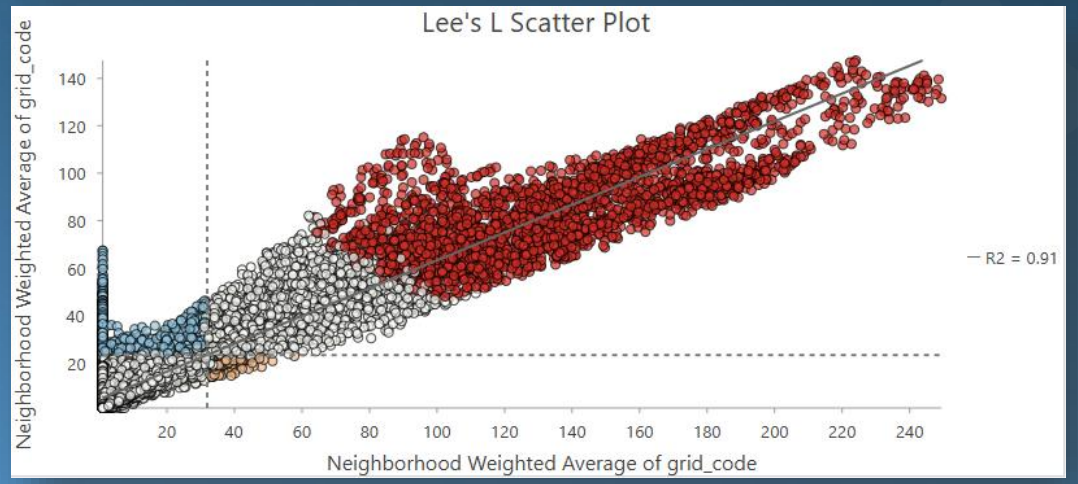
Validation Methods

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- SKAI utilises a built-in evaluation process
  - User-defined training / evaluation data split
  - Produces common AI modelling metrics: precision, recall, F1 score
  - Needs to be critically reviewed – may not accurately scale to the whole AOI



- Analyst-administered assessments in GIS software
  - Aggregated density comparisons (spatial association, clustering, hotspot analysis)
  - Building-level assessments can be automated / scripted to produce the modelling metrics
  - Assumes availability of "ground-truth" data



The Satellite Centre's Role

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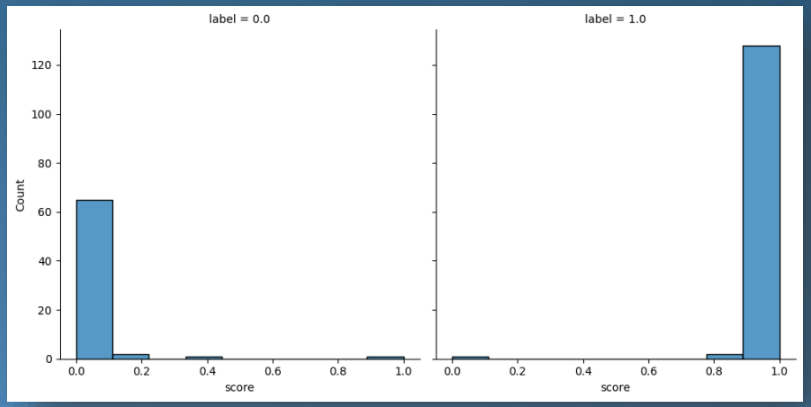
- Model evaluation and optimisation + operational deployment
- Empirical workflow testing, case studies comparing model output with analyst data
- Activation-specific assessments (damage type, building density, location)

- Recommendations included:
  - Increase training sample size and diversity
  - Focus on higher tiers of damage
  - Changes to data labelling process and tools
  - Directional scenario guidance

Internal Case Studies

- Storm damage, fires, complex emergencies
- Adjusting model parameter, training data impact, building-level investigations, scenario comparisons
- Marked improvements in modelling metrics, case by case

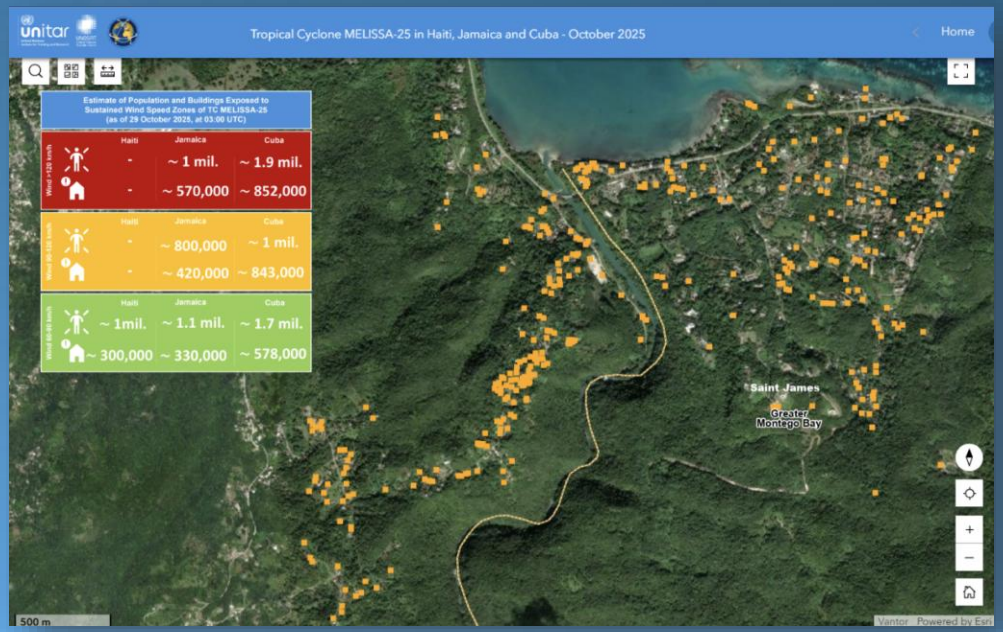
Built-in metrics were used to assess the impact of training data (overfitting vs. underfitting)

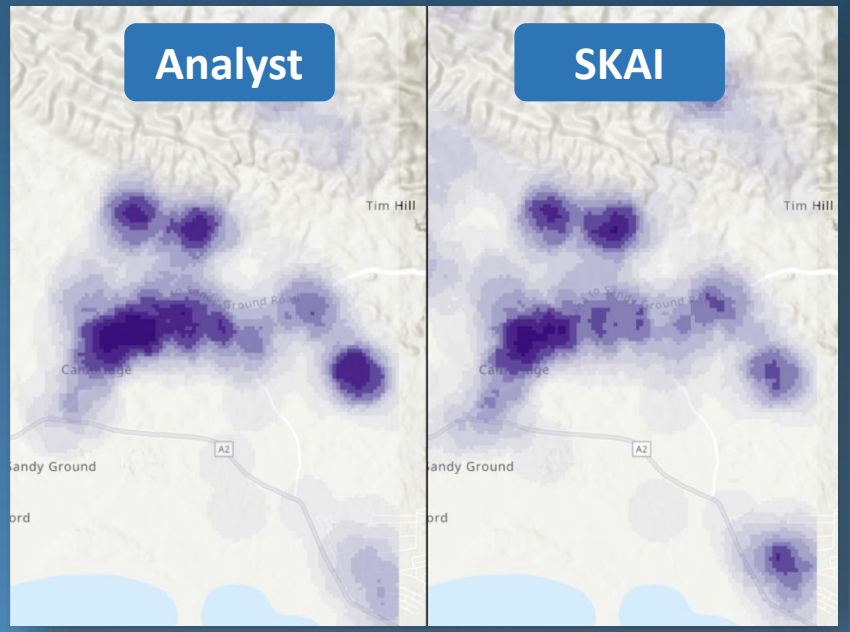


Past Activations: Hurricane Melissa

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- Severe damage throughout Jamaica in October 2025
- Analysts used SKAI to accurately assess over 3700 square kilometres of affected area and over 385,000 structures in a matter of days
- Assessment speed and accuracy enabled significantly faster response and recovery efforts from UNDP and governmental bodies





United Nations Institute for Training and Research

United Nations Satellite Centre

AI-assisted damage assessment tools are a modern approach leveraging machine learning and earth observation

Increased Capacity

Scaled deployment of AI modelling tools enables significant improvement in the efficiency of disaster relief efforts

Open-source Access

SKAI is an open-source tool that provides operational-level assessments, collaboration is key in model development

Ancillary Resources

Besides direct damage classification models, damage analysis can greatly benefit from robust detection models

Access Details and Resources

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- There is not a publicly hosted instance of SKAI – the current product is available for use upon request to certain teams – see 2026 article. The Github page contains the available open-source information, including source code, development information, legacy tools and instructions, Google colab notebooks, etc.

- SKAI Overview from WFP:
  - https://innovation.wfp.org/project/SKAI
- SKAI Github Page (some parts actively maintained, contains: developer contact, base model information and source code, legacy tool set-up)
  - https://github.com/google-research/skai
- 2026 article on current functionality + contact information for queries and access to final product (may be limited to humanitarian teams):
  - https://disha.unglobalpulse.org/dishas-revamped-ai-assisted-damage-assessment-solution-enters-a-new-phase-of-growth-and-operational-impact/
- 2024 article on early model functionality, development, and deployment:
  - https://disha.unglobalpulse.org/ai-from-google-research-and-un-boosts-humanitarian-disaster-response-wider-coverage-faster-damage-assessments/

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