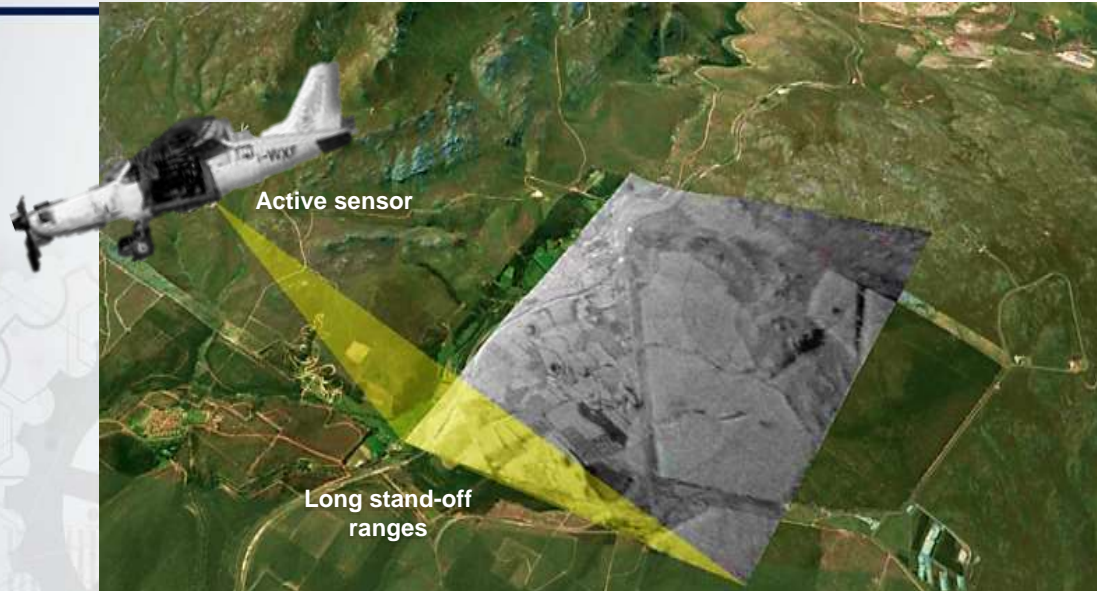Space Science and
Innovation for Sustainability

CSIR Airborne SAR Datasets towards SAR Remote Sensing Application RD&I

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with contributions from: W. Nel, H. Tema, K. Mosito, S. Dunga, M. Mpereke

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#SpaceSustainability

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Synthetic Aperture Radar (SAR) – An Overview

Active sensor

Long stand-off ranges

CSIR SAR Image

Google Earth Image

Active Imaging using Radar

Sensor on Moving Platform

Airborne, UAV, Satellite

All Weather Sensor

Day and Night Sensor

Advanced Modes

Digital terrain elevation maps
Millimeter-scale change detection
Detection of moving targets
Foliage Penetration

High Resolution

Large Area Coverage

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Applications of Airborne SAR in Various Spheres

Food Security & Agriculture Monitoring
- Annual Crop Monitoring
- Crop yield & production status
- Soil moisture
- **Precision Agriculture**
- Crop health
- River Pollution

Disaster Management
- Monitor, Predict & prevent disasters
- Situational awareness during disaster, including:
  - **Flood monitoring (through the storm)**
  - **Fire detection and monitoring**
  - **Subsidence monitoring**
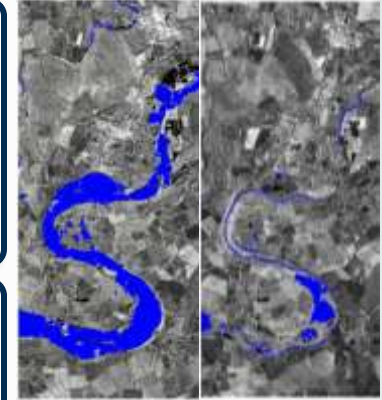
Military
- **Surveillance, Reconnaissance, Border Security**
- **Targeting**
- **Damage Assessment**
- **Terrain Negotiability**

Maritime Safety & Security
- Detecting Oil Slicks
- Ship detection, classification and monitoring
- **Monitoring Protected Zones**
- **Search and Rescue**

Cartography
- Automated mapping
- Terrain elevation measurement
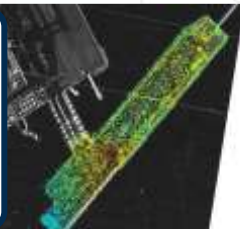- **Land Use / Land Cover**

Mining
- **Safety (subsidence), infrastructure monitoring**
- **Operations, and activity monitoring (stockpile)**
- Geological Survey

Infrastructure & Urban Monitoring
- **Bridges, Dams, Roads, Train Tracks, Power Lines**
- **City Planning and insurance**
- **Monitoring of government investment in infrastructure development**

Oceanography
- Due to location at southern tip of Africa, SA plays an important role in ocean monitoring. At present SAR is being used to monitor several aspects of ocean currents and ocean health.

2012-11-27   2012-11-29

https://mdacorporation.com

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Overview of SAR Datasets

- CSIR captured **2 airborne SAR datasets** towards **SAR Remote Sensing and Earth Observation application RD&I**
  - Gauteng Multi-sensor campaign (GMC) (2022-23)
  - KwaZulu-Natal campaign (KZN) (2023)
- Campaigns funded by DSI
- DSIR CSIR Airborne SAR Facility utilised for the campaigns
  - Flexible system setup allows for SAR application & tech RD&I
  - System is cleared to fly on a fixed wing aircraft (Cessna 208)

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Overview of Datasets

Gauteng Multi-sensor Campaign

- **Focus applications**
  1. Disaster management
  2. Precision agriculture
  3. Mining activity and safety monitoring
  4. Urban area monitoring
  5. Waterbody monitoring
  6. Wetlands mapping and monitoring
- Collaboration between various groups (Government, Research Councils, Industry)

KwaZulu-Natal Campaign

- **Focus Applications**
  1. Infrastructure monitoring
  2. Urban area monitoring
  3. Disaster management (flood monitoring and mapping)
  4. Maritime domain awareness
- Imaged various AOIs enroute to DBN, in DBN, and enroute to PTA

SAR Datasets

- **Comprehensive high value datasets for Remote Sensing application RD&I**
  - **Repeat pass and temporal datasets** available (temporal baseline of roughly 1-2 weeks)
  - **Multi frequency** band data (C- and L-band) useful for various applications
    - Advantages: L-band penetrates deeper than C-band for FOPEN, C-band higher resolution,
  - **Multi polarisation** data (VV, VH, HV, and HH)
  - **High-resolution**
    - Much finer than freely available spaceborne SAR – C-band: up to 25cm, L-band: 1,9m
- **Freely available for research purposes** – Please contact me for access (GMC already loaded on DIRISA)
- **Actively looking for collaboration on the exploitation of SAR data towards RS application RD&I in South Africa and Africa**
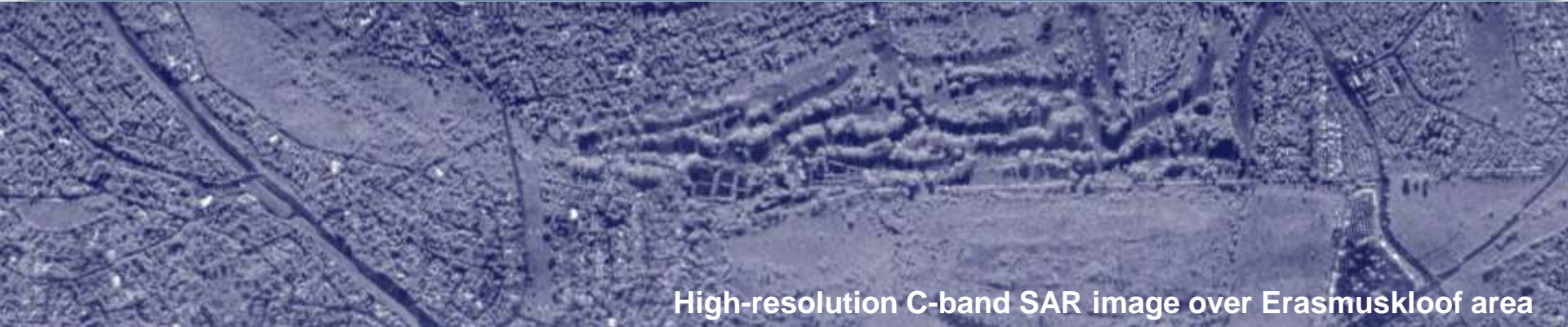
High-resolution C-band SAR image over Erasmuskloof area

Some Results & Use-Cases

- **Potential Disaster Management Applications**
  - **Subsidence (sinkhole detection)**
    - Identified and imaged high risk areas
    - E.g. Centurion area built on dolomite posing great risk for sinkhole formation – many schools, residential areas, etc.
  - **Flood mapping and monitoring**
    - 2022 KZN floods caused havoc (casualties, economic damage, etc.)
    - Identified and imaged high risk flood areas
    - Data captured to be able to generate a baseline map to assist with future floods
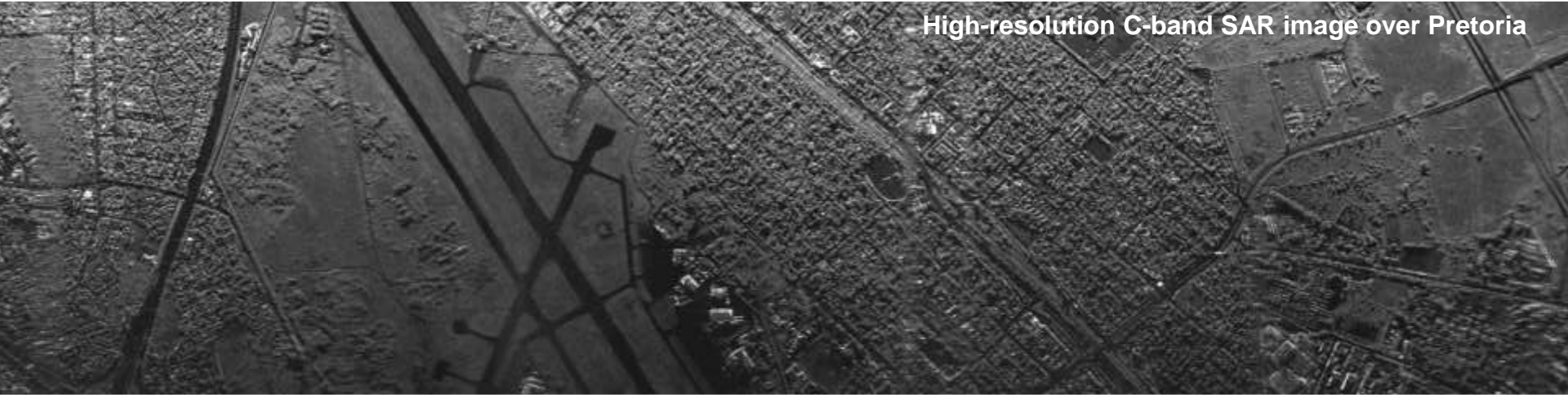
SAR image over high risk sinkhole area in Centurion

High-Resolution C-band SAR image over Umlazi, KZN

SAR images towards Urban Area Monitoring Applications

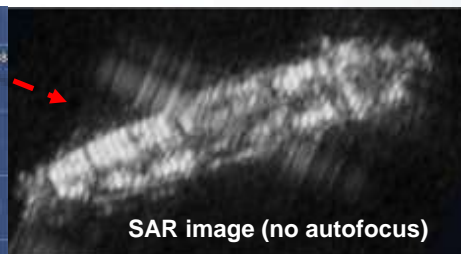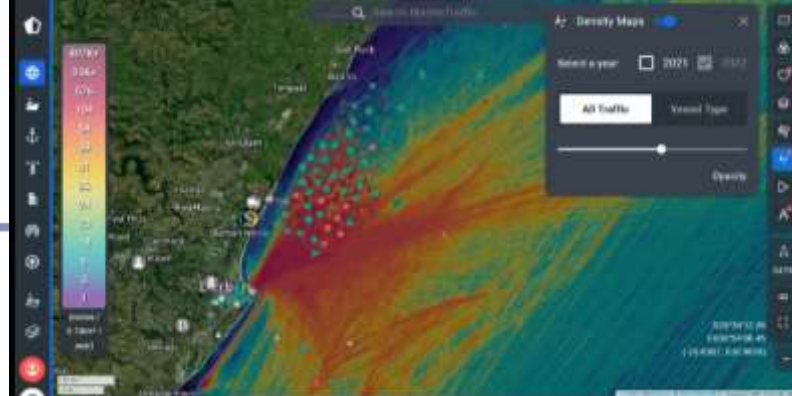High-resolution C-band SAR image over Pretoria

High-resolution C-band SAR image over Ladysmith

# SAR towards Maritime Domain Awareness Applications

- Imaged area with high density ship activity near and over Durban Harbour
- Various MDA applications – e.g. dark ship
  - captured AIS onboard SAR Facility
- AIS data depicts MMSI of imaged vessels

SAR image (no autofocus)

AIS identified ship

POSITION & VOYAGE DATA

Vadinar, India
ETA: Jan 31, 00:01 (in 8 days)

Predicted ETA	🔒
Distance / Time	🔒
Course / Speed	78.3° / 13.8 kn
Current draught	8.1 m
Navigation Status	-
Position received	6 days ago ⓘ
IMO / MMSI	9788617 / 636019842
Callsign	D5WK5
Flag	Liberia
Length / Beam	182 / 32 m

Durban, South Africa
ATD: Jan 16, 09:55 UTC (6 days ago)

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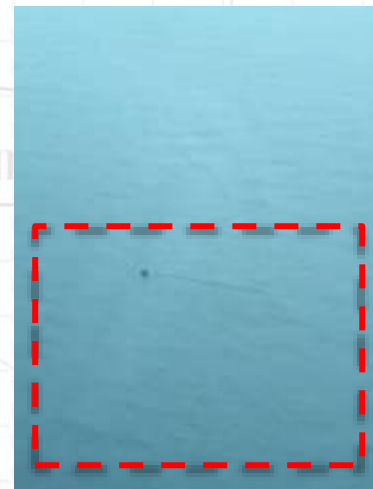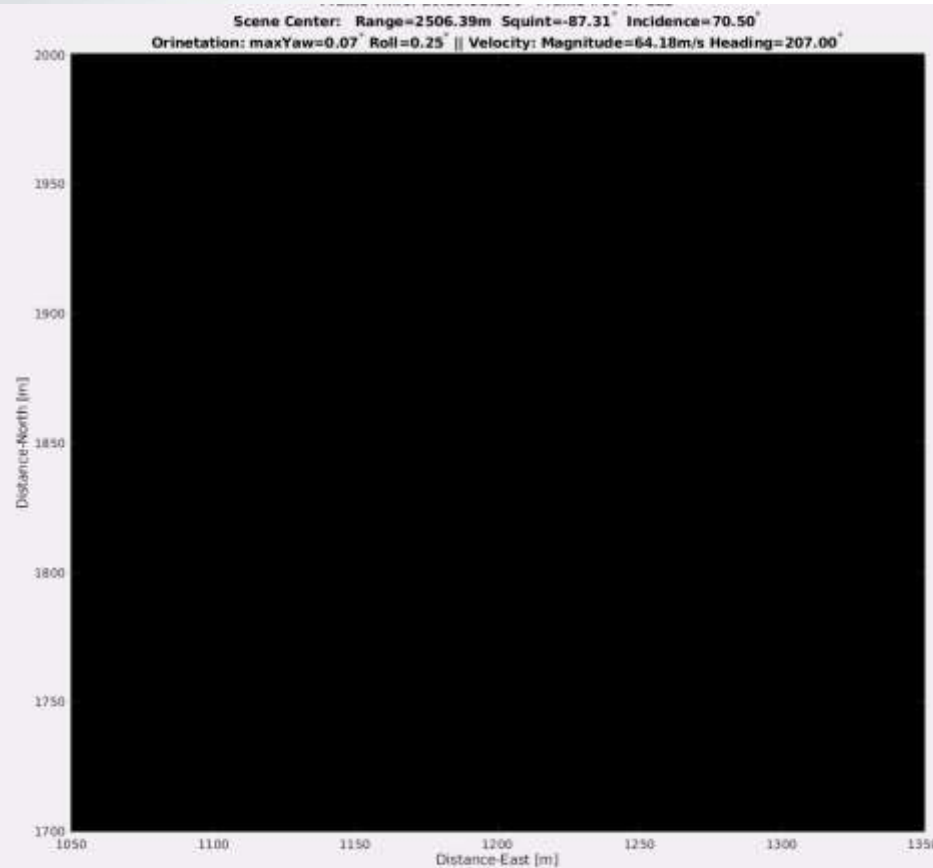# SAR towards Maritime Domain Awareness Applications

Geo-located SAR Image as displayed in Google Earth showing AIS logs (Note colour of SAR image not displayed properly in Google Earth)
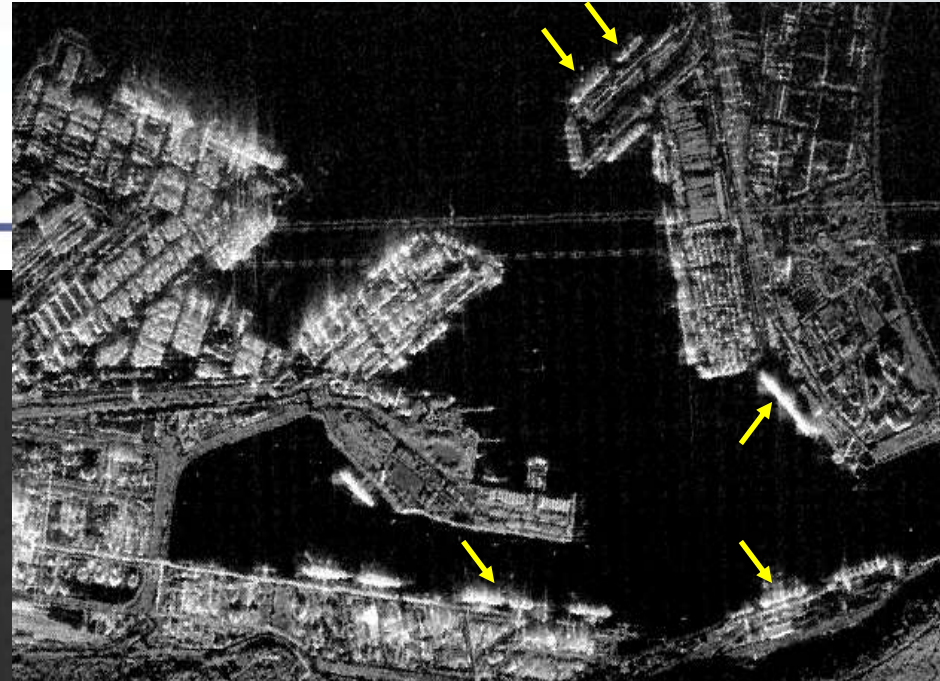

- SAR image & AIS data over DBN harbour
- AIS data recorded onboard SAR system – shown with yellow pins (image to the left)
  - AIS data points agree with almost all of the docked vessels seen on the SAR images (see above)
- Development of dark ship detection mode also requires masking out of land areas (e.g. seen on the harbour image)

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Maritime Domain Awareness – Advanced Processing example

- VideoSAR targeting a vessel over the ocean.
- **Different colours corresponds to different aspect angles**
- High resolution imaging capability aids in investigation of illegal vessel activities such as bilge spilling/longline fishing/Spoofing in the EEZ.
- **Autofocus for SAR/ISAR to be implemented next**
  – Based on previous ISAR work
  – Will improve target focus vastly

Polarametric SAR – example application

Van Zyl | Freeman-Durden | ModelFree 3 Component | HAalpha

In disaster management the
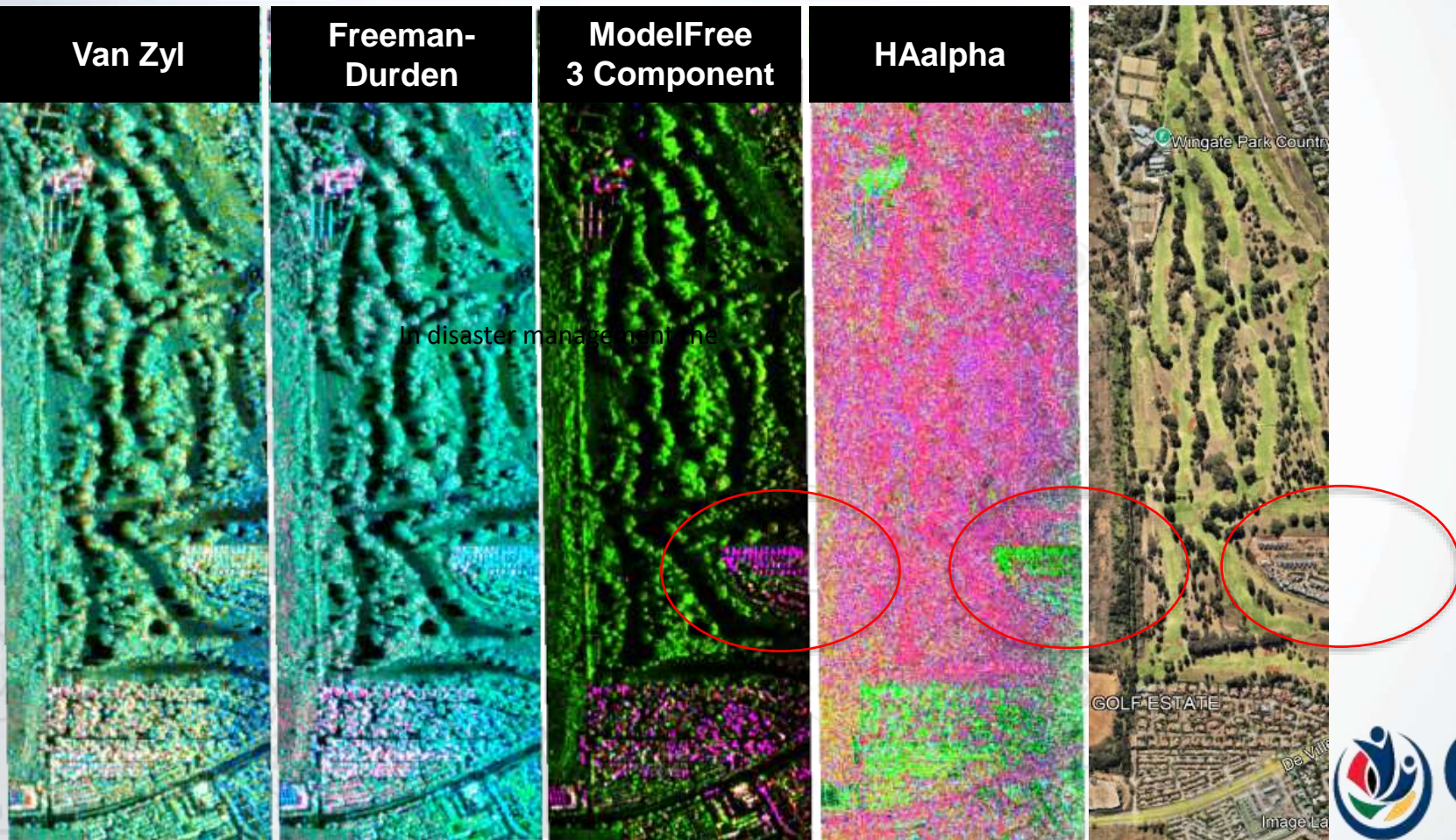
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THANK YOU
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