

Addressing infrastructure's climate emergency with satellite data

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- The Great Infrastructure Challenge
- Can space technology help?
- Network-wide infrastructure susceptibility to geohazards

The Great Infrastructure Challenge

Ageing infrastructure



Heavier use



Climate change



Declining budgets



Geohazards

Coastal erosion: \$500 million/yr US alone



Landslides: \$878 million/yr globally



Sinkholes: \$300 million/yr US alone



Clay subsidence: \$12 billion/yr globally

“Geohazards are difficult to manage and yet the numbers continue to increase with climate change”
World Bank, 2020

The Problem

Geohazards can occur anywhere. How to check thousands of km of road and rail and whole cities?

Maintenance is often reactive which consumes budgets year after year.

Climate change resilience is low so the disruption will only get worse.

Road & Rail transportation networks

- Rainfall:

Increased incidence of **disruption to earthworks along transport affecting stability of earthworks** and flood defence corridors, including:

- shrink/swell
- landslips



- Severe droughts:

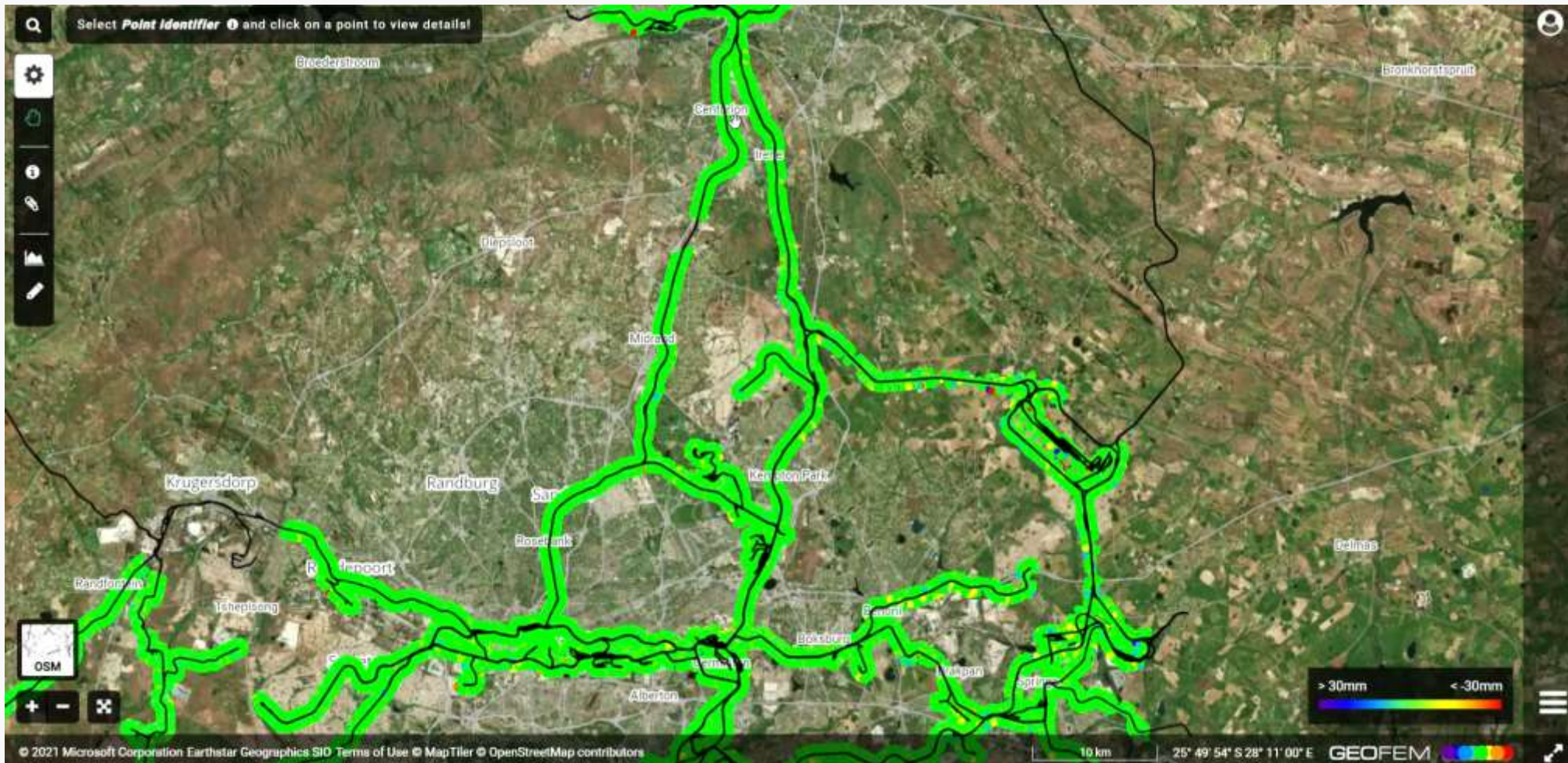
Extended severe droughts can cause shrinkage of clay which will affect the condition of infrastructure.

Can space technology help?

Space technology

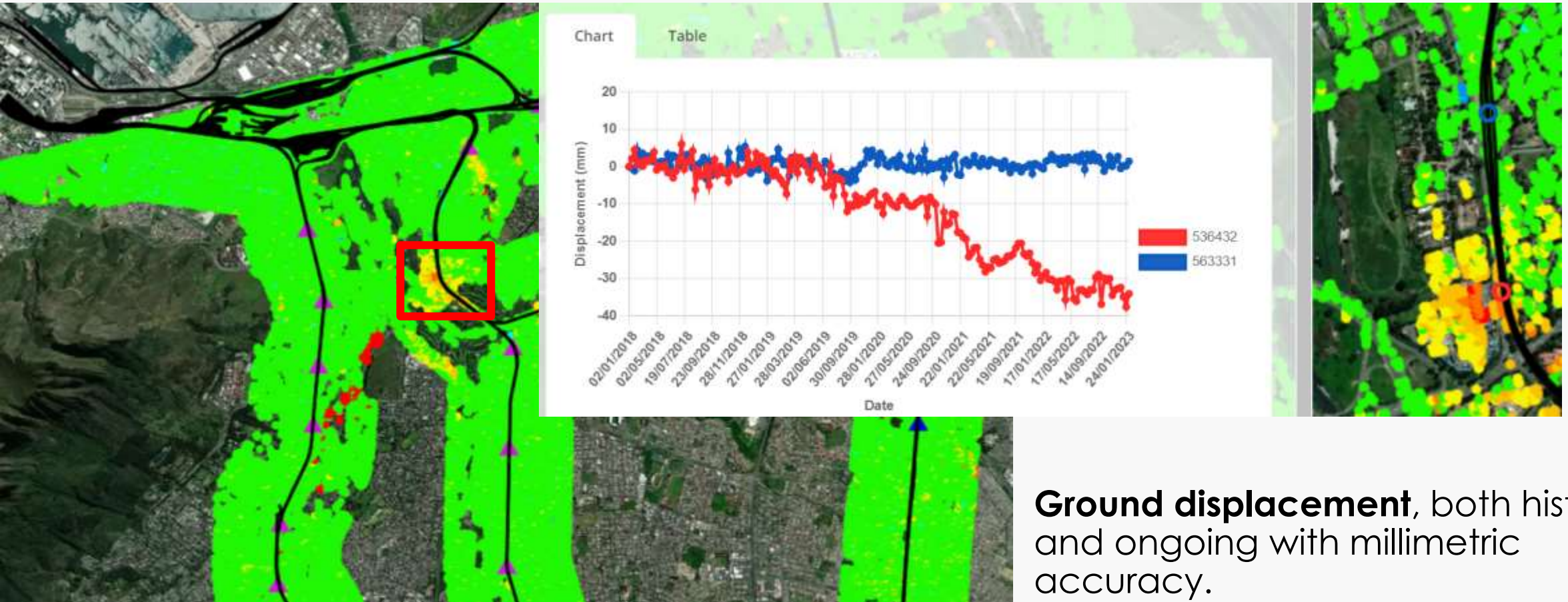
- Can help understand **ground behaviour** and response to extreme weather events such as extended droughts and intensive rainfall.
 - Soil moisture measurements
 - Ground/ infrastructure displacements
- Can provide **assessment of susceptibility to geohazards**. Regularly updated to complement conventional landslide inventories.

Displacement monitoring





Displacement monitoring

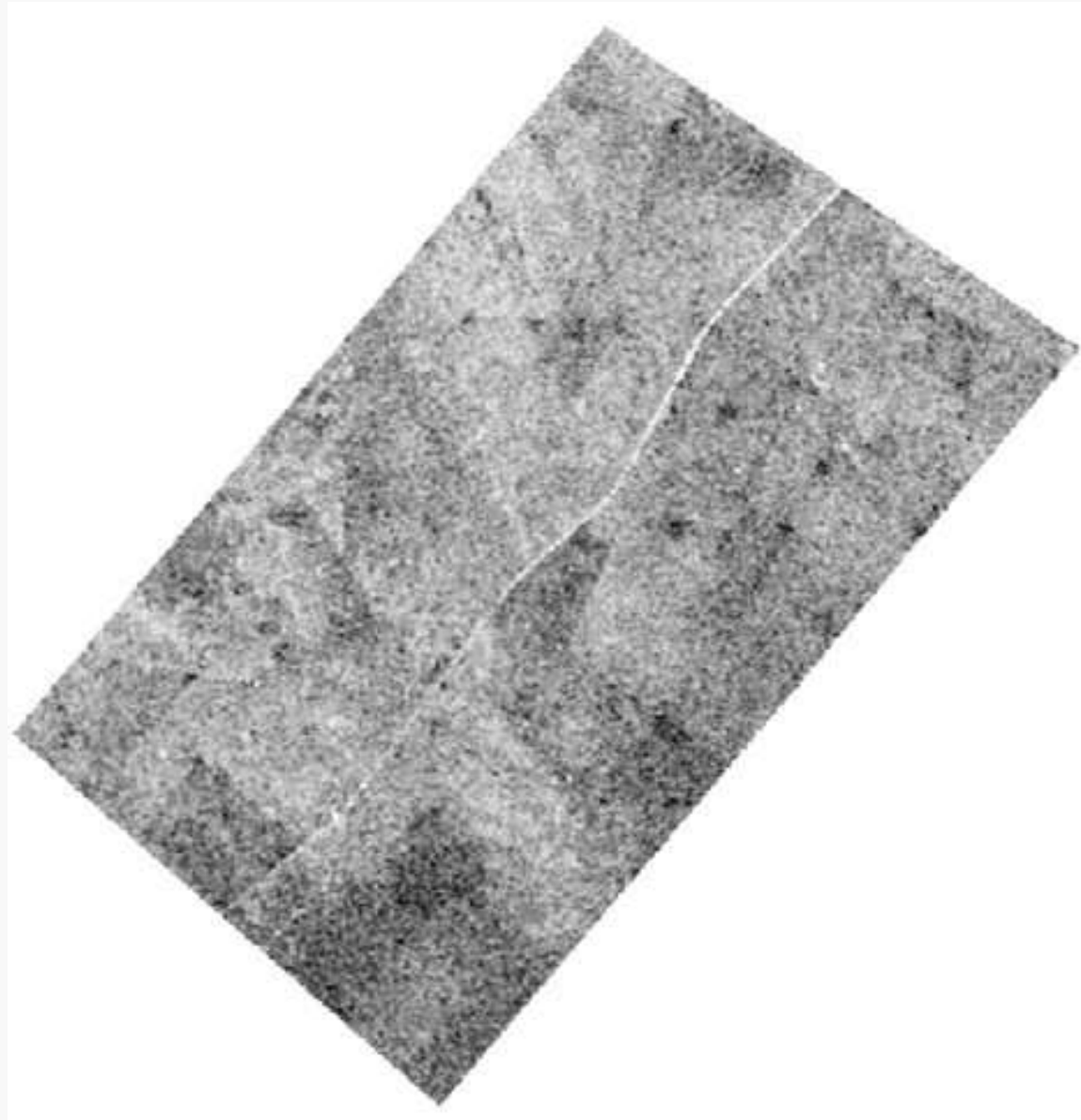


Ground displacement, both historical and ongoing with millimetric accuracy.

Early warnings when defined thresholds are exceeded.

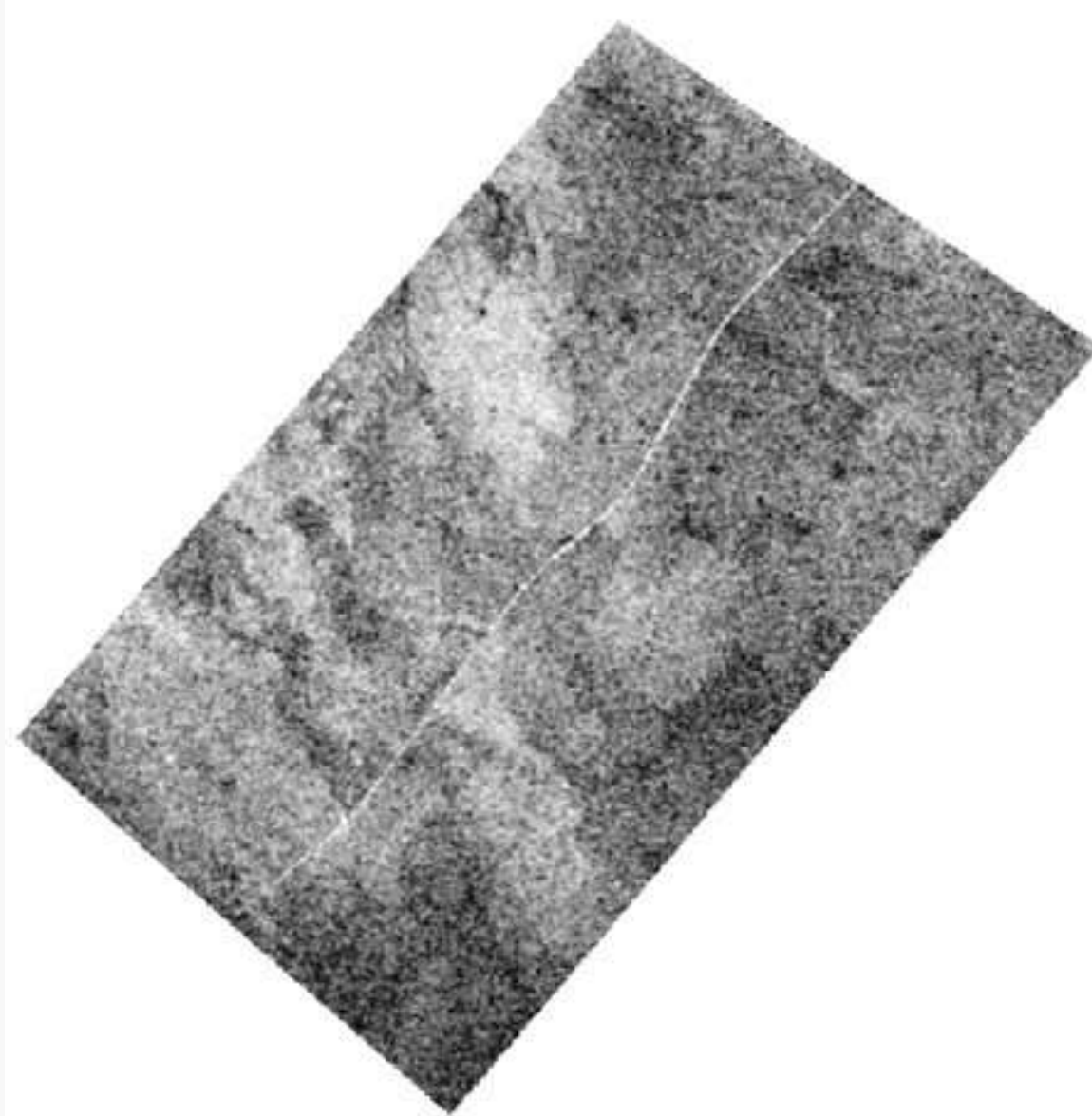
Condition assessments

6th Jul 2022 & 18th July 2022

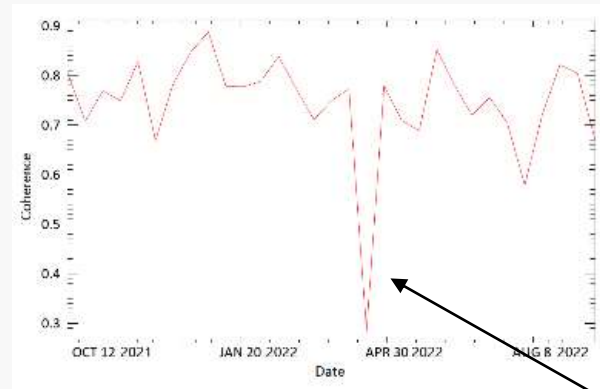


Condition assessments

10th Oct. 2022 & 22nd Oct.
2022

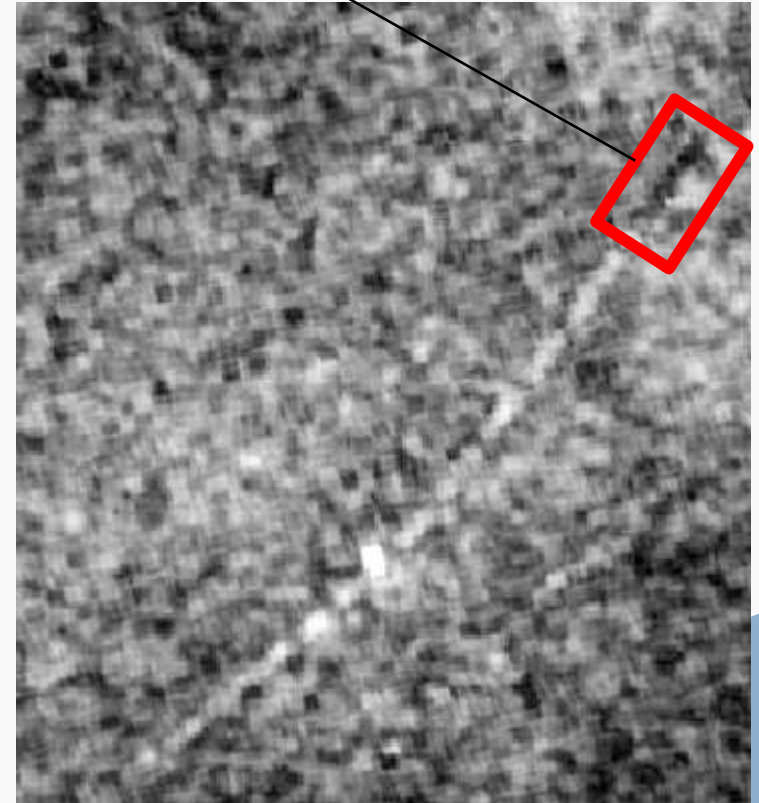


Condition assessments



Automated assessment of **sand accumulation** along the rail track with every satellite pass.

Early warning when defined thresholds are exceeded.

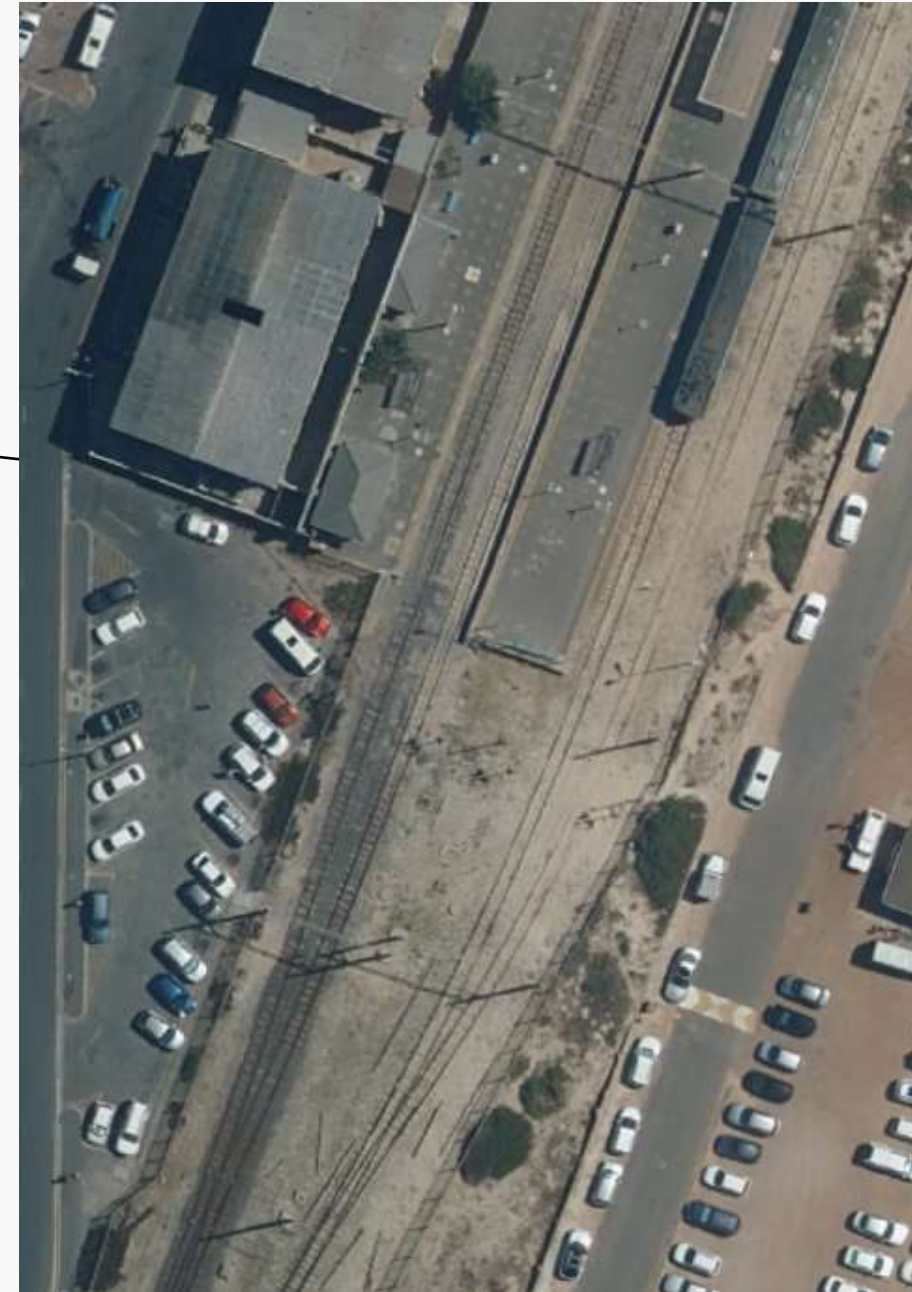


Condition assessments



Automated assessment of **sand accumulation** along the rail track with every satellite pass.

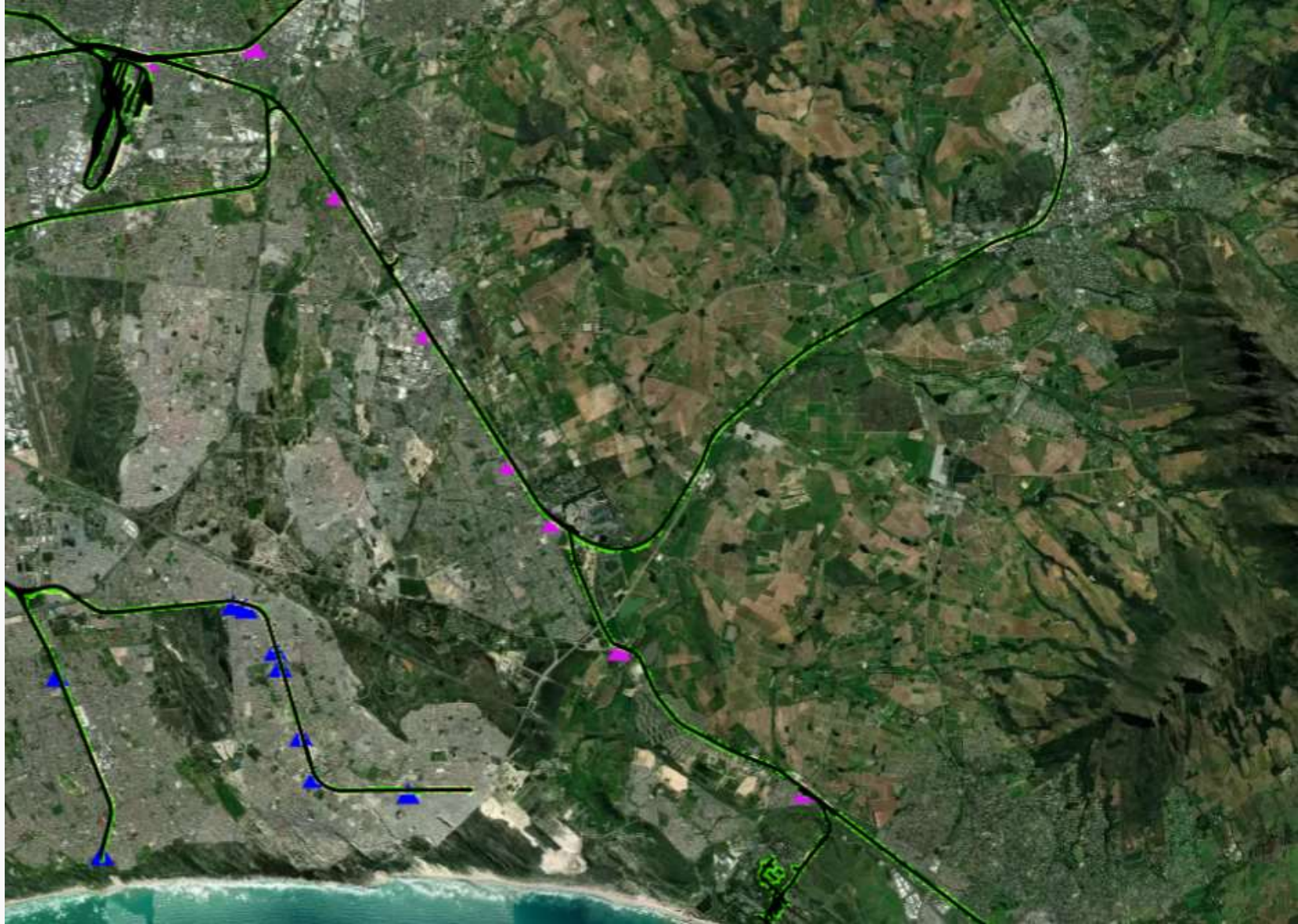
Early warning when defined thresholds are exceeded.



Condition assessments

Automated assessment of **vegetation density** along the rail track with every satellite pass.

Early warning when defined thresholds are exceeded.



Condition assessments

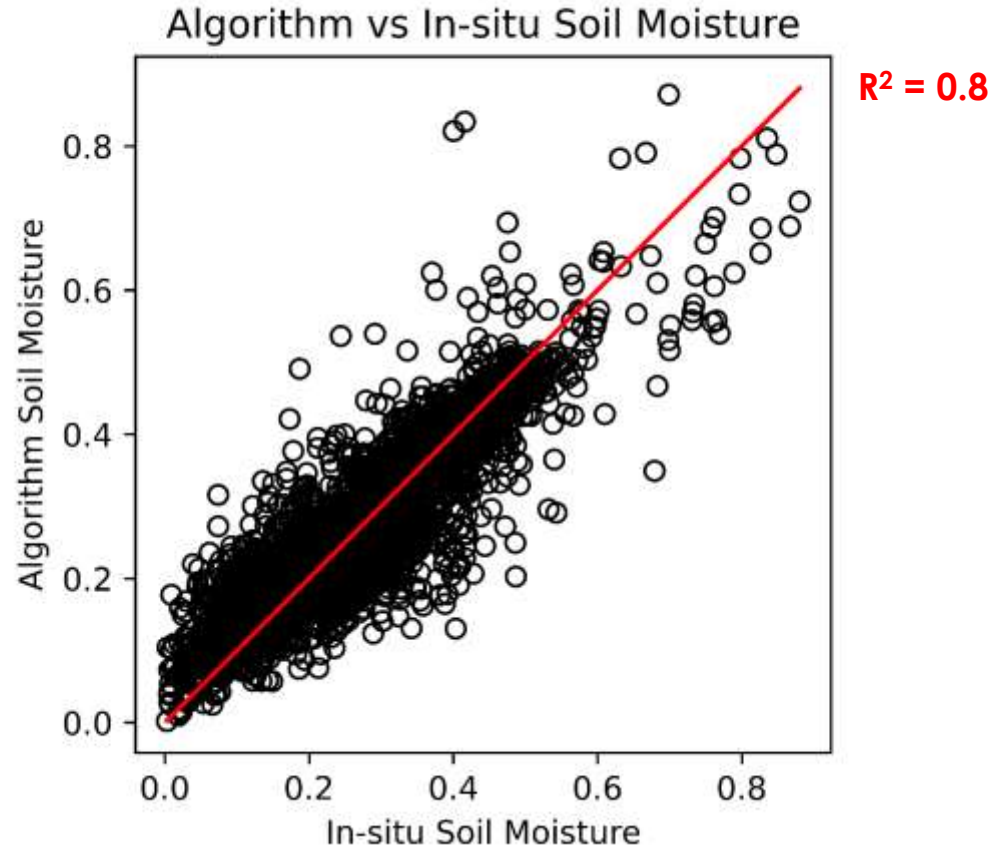


Soil moisture via satellite

In-situ soil moisture data

Global data for different climatic conditions

More than 3 years of data



Satellite derived data

Data from multiple sources

Data applied for anywhere in the world



Artificial intelligence

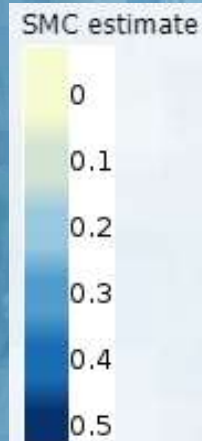
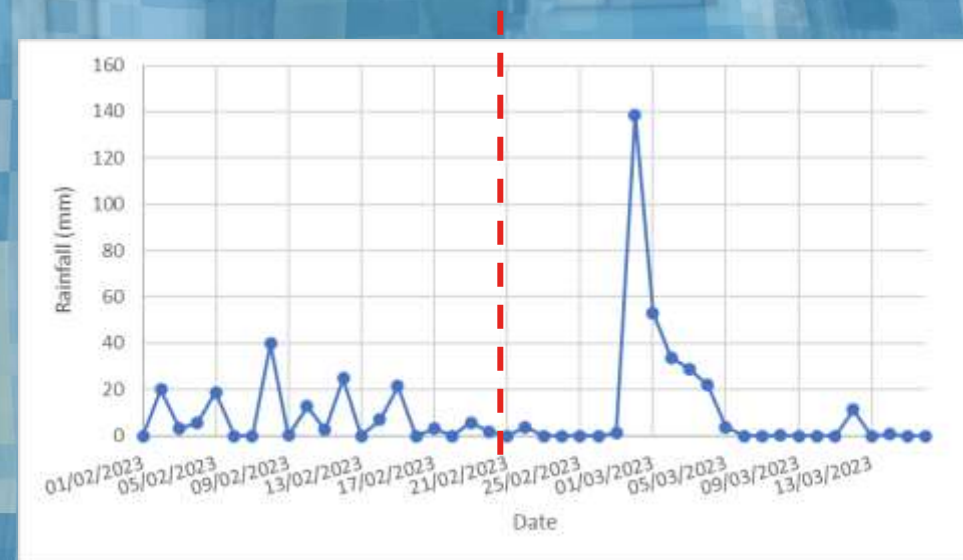


Soil moisture via satellite



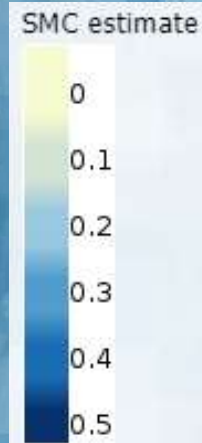
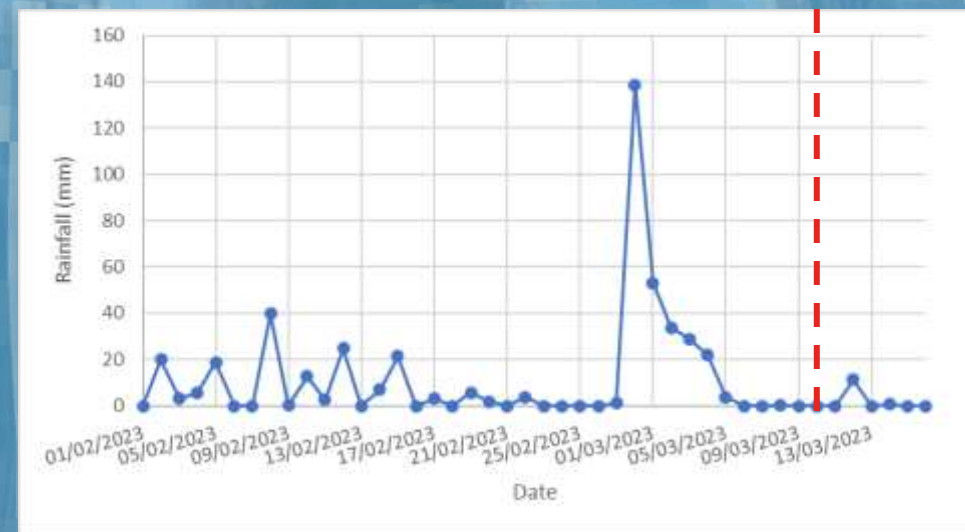
Soil moisture via satellite

20th February 2023: Singapore:



Soil moisture via satellite

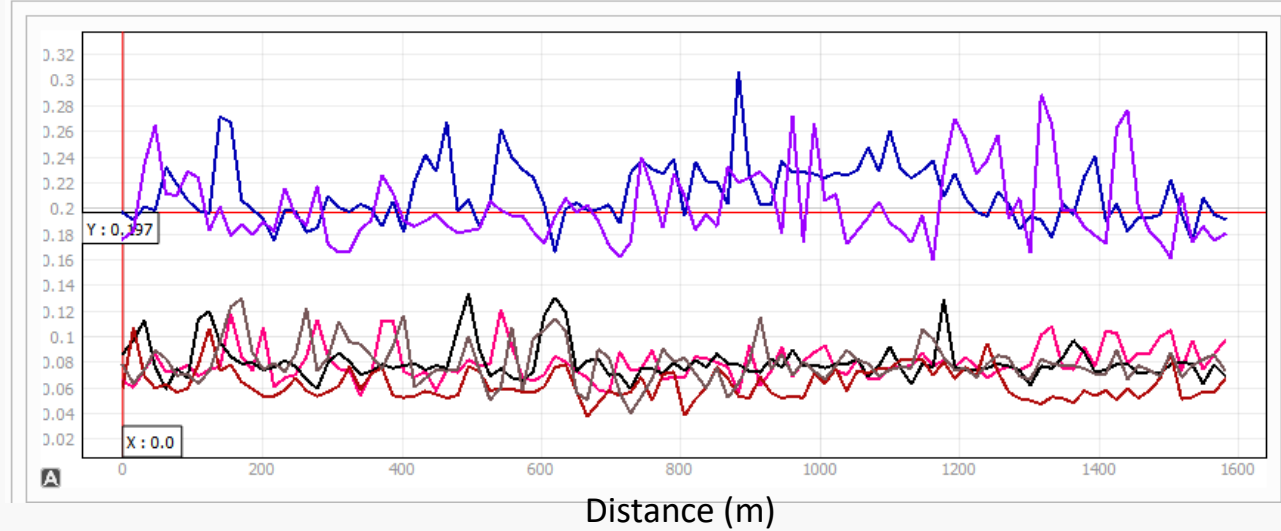
16th March 2023: Singapore:



Soil moisture via satellite



Volumetric soil moisture content



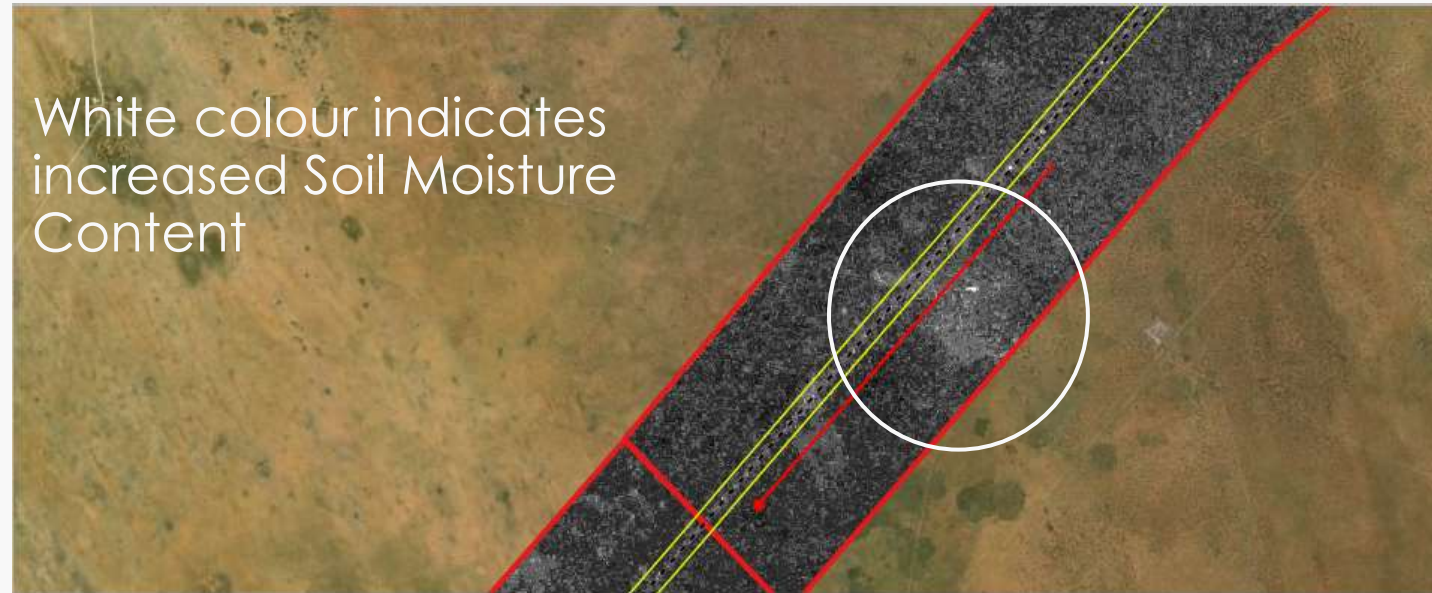
Clear difference in **soil moisture** values between wet and dry season.

Soil moisture via satellite

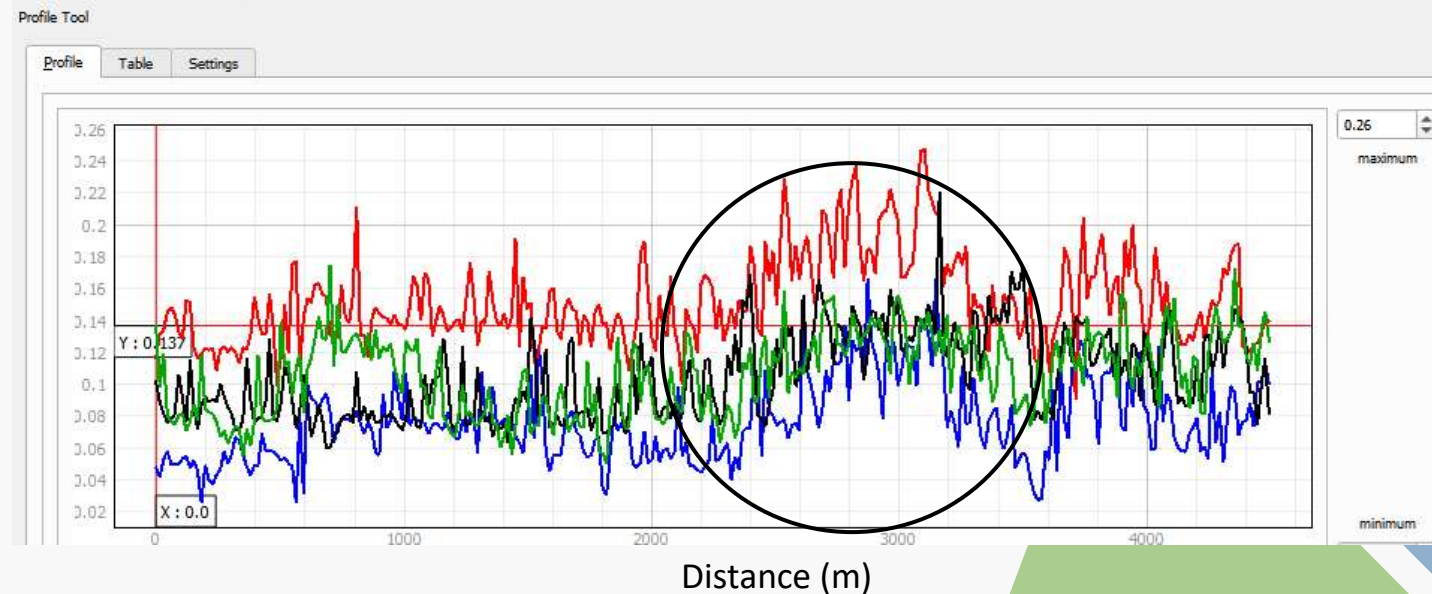


Indicator of:

- Failed track drainage
- Ballast fouling

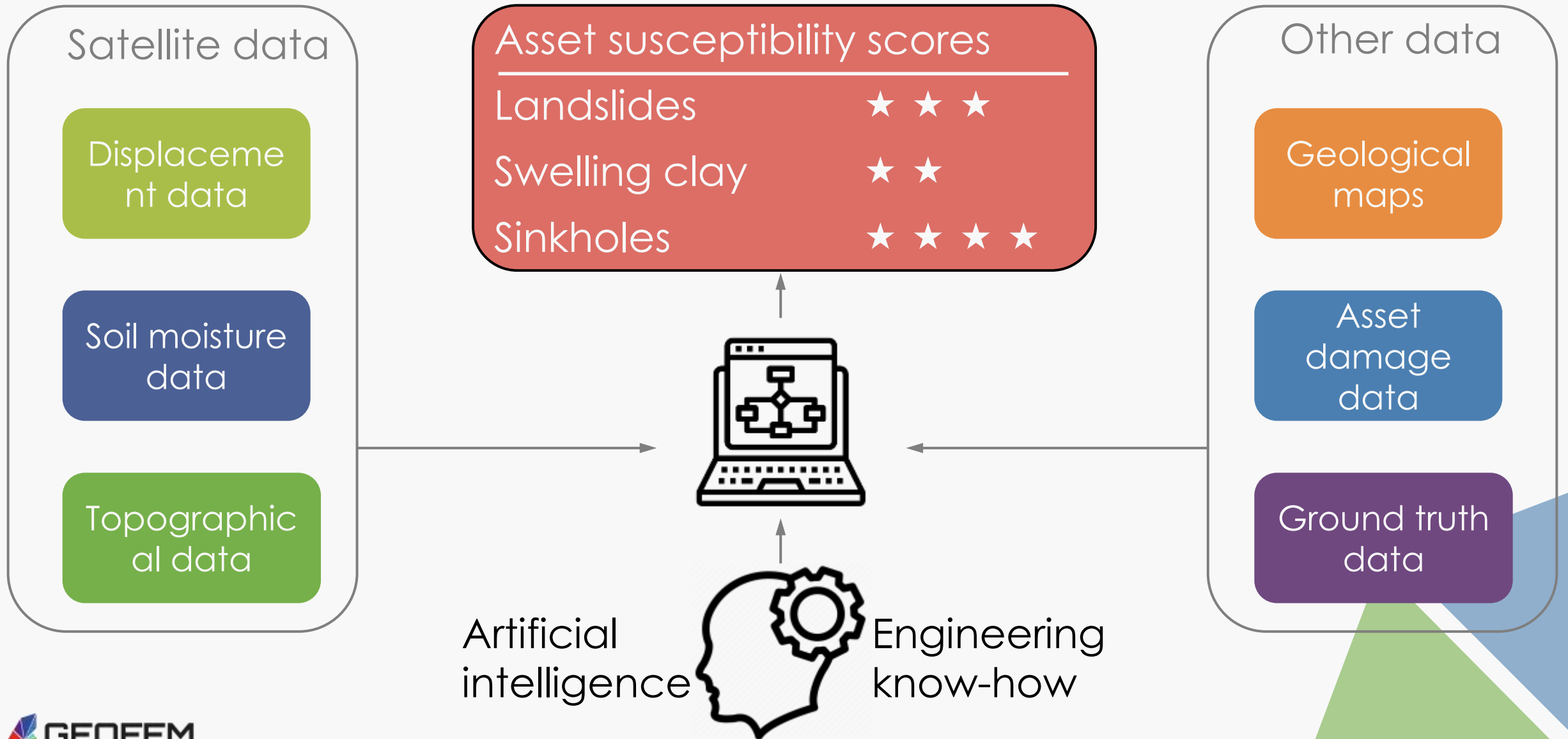


Volumetric soil moisture content

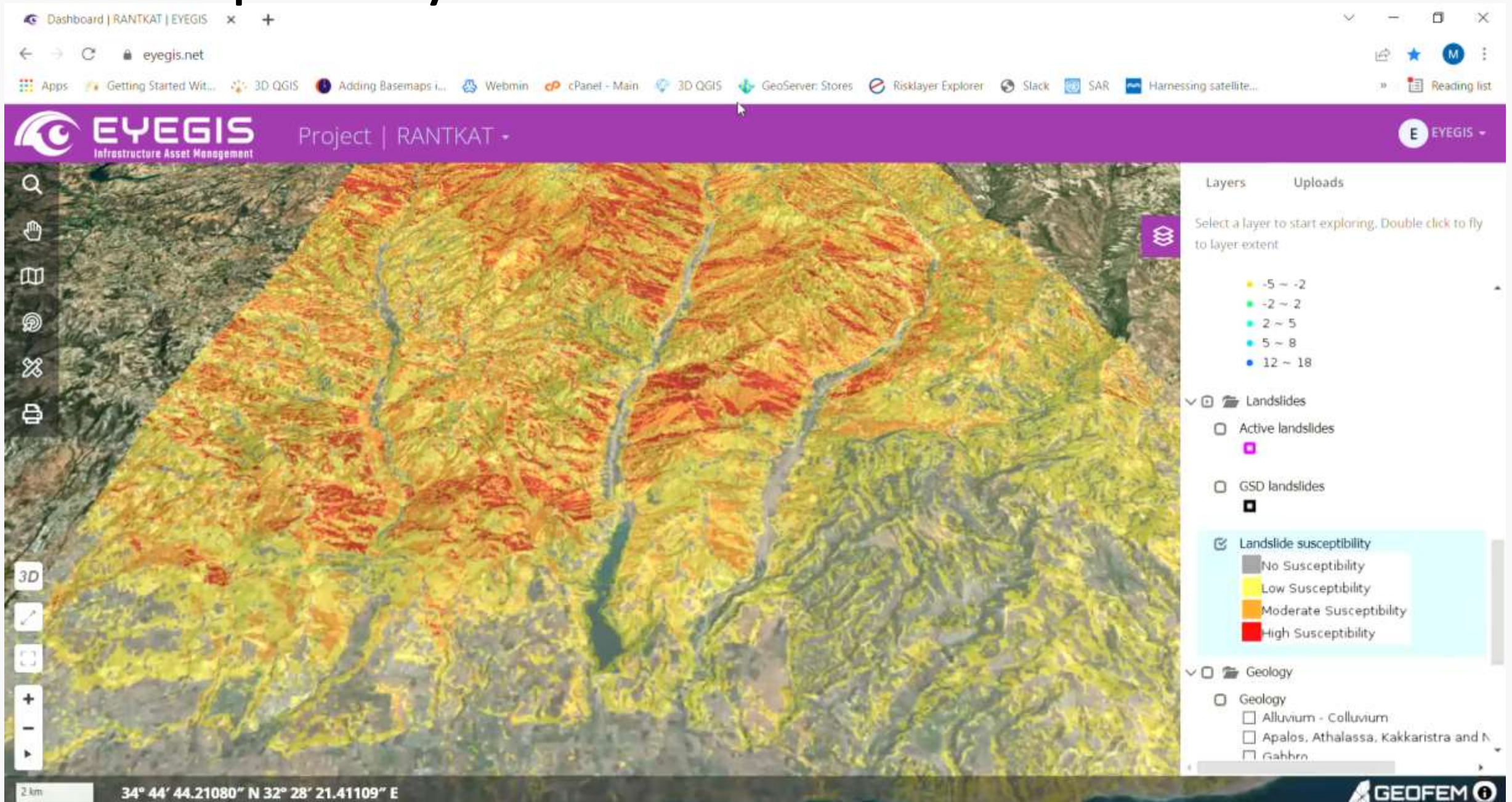


Infrastructure susceptibility to geohazards

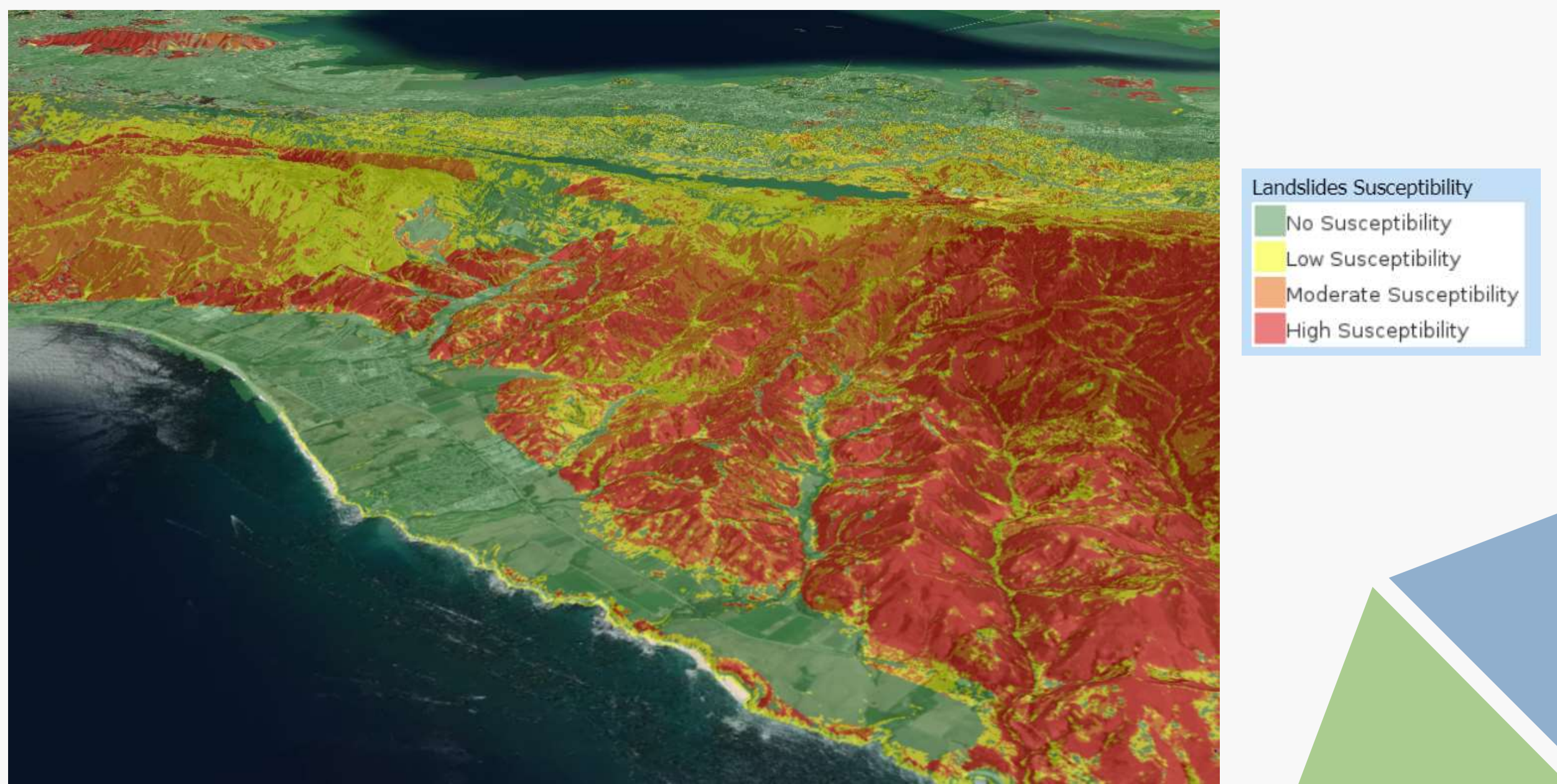
Satellite data meets engineering insight



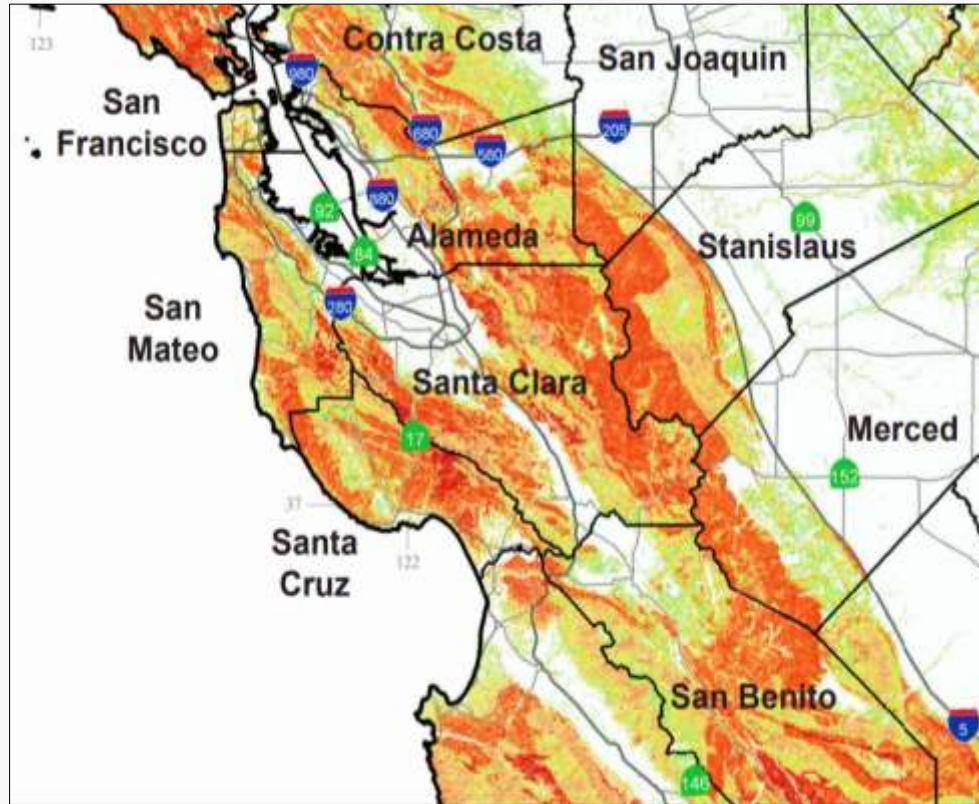
Susceptibility to landslides



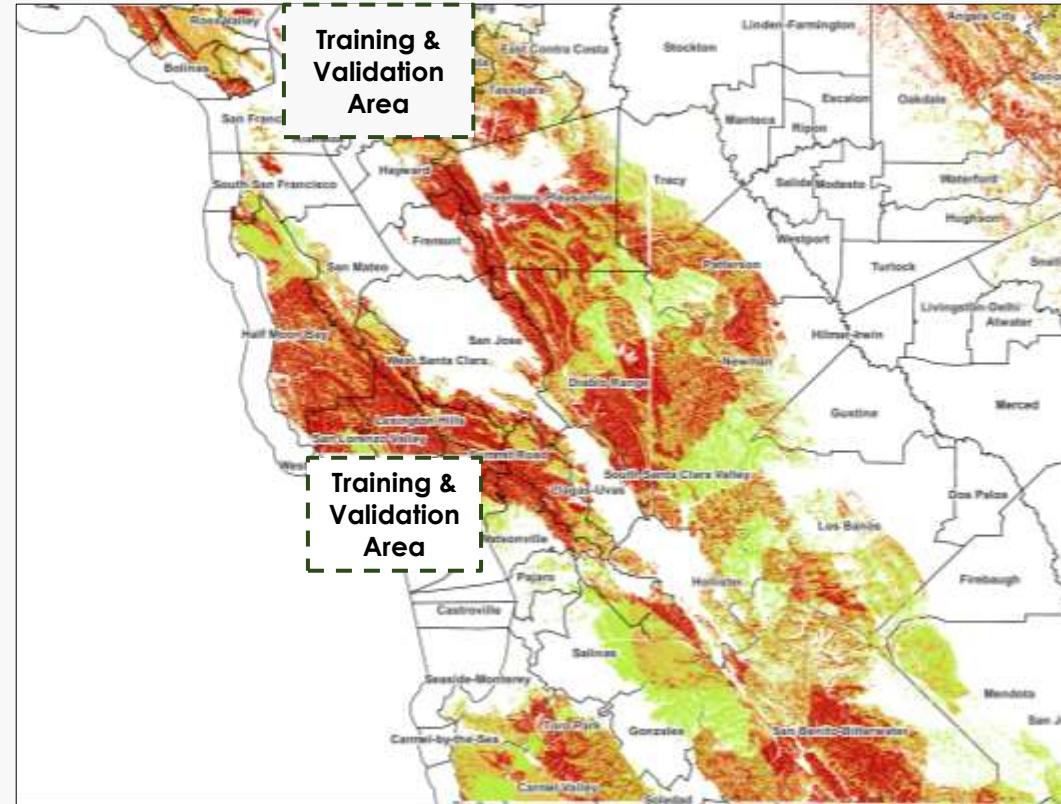
Susceptibility to landslides



Susceptibility to landslides



(a) CGS
Map



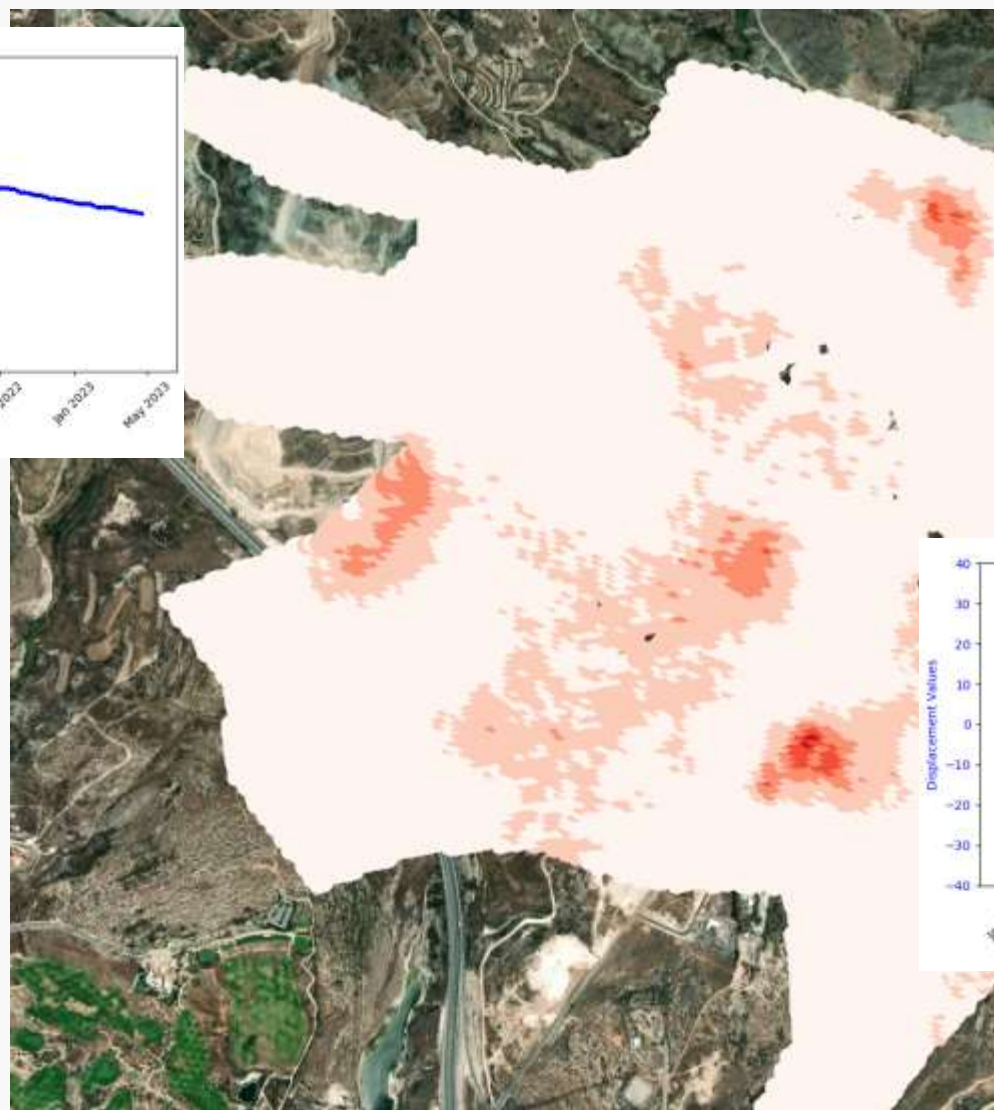
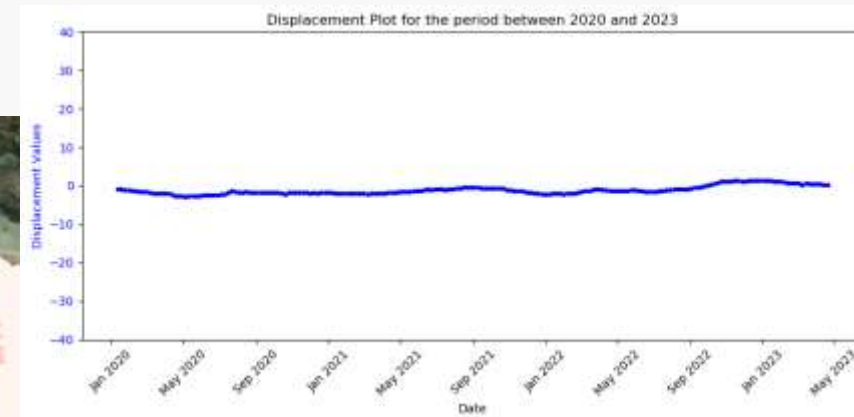
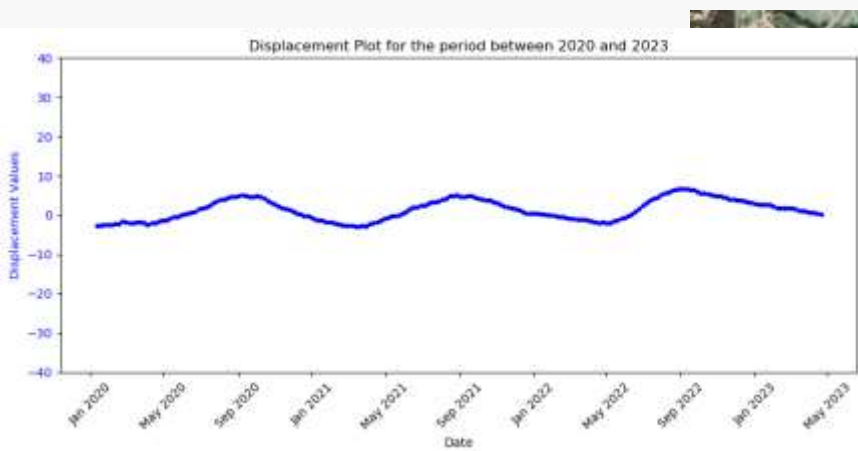
(b) Geofem's Model

- No Susceptibility
- Low Susceptibility
- Moderate Susceptibility
- High Susceptibility

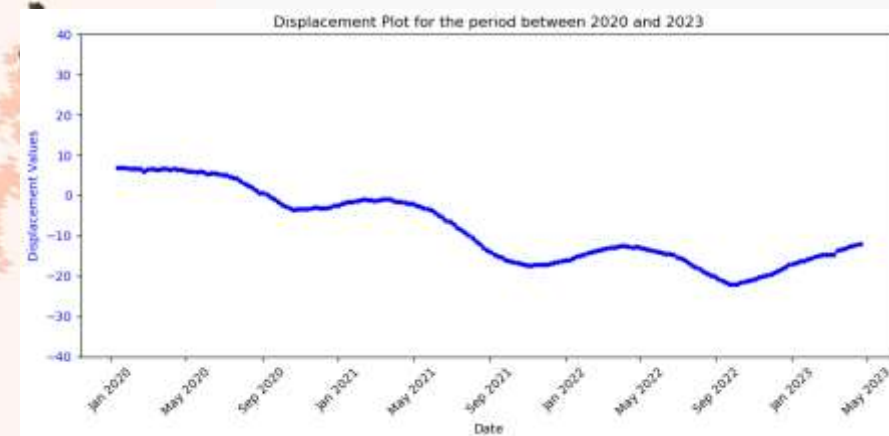
Susceptibility to swelling clays



Susceptibility to swelling clays

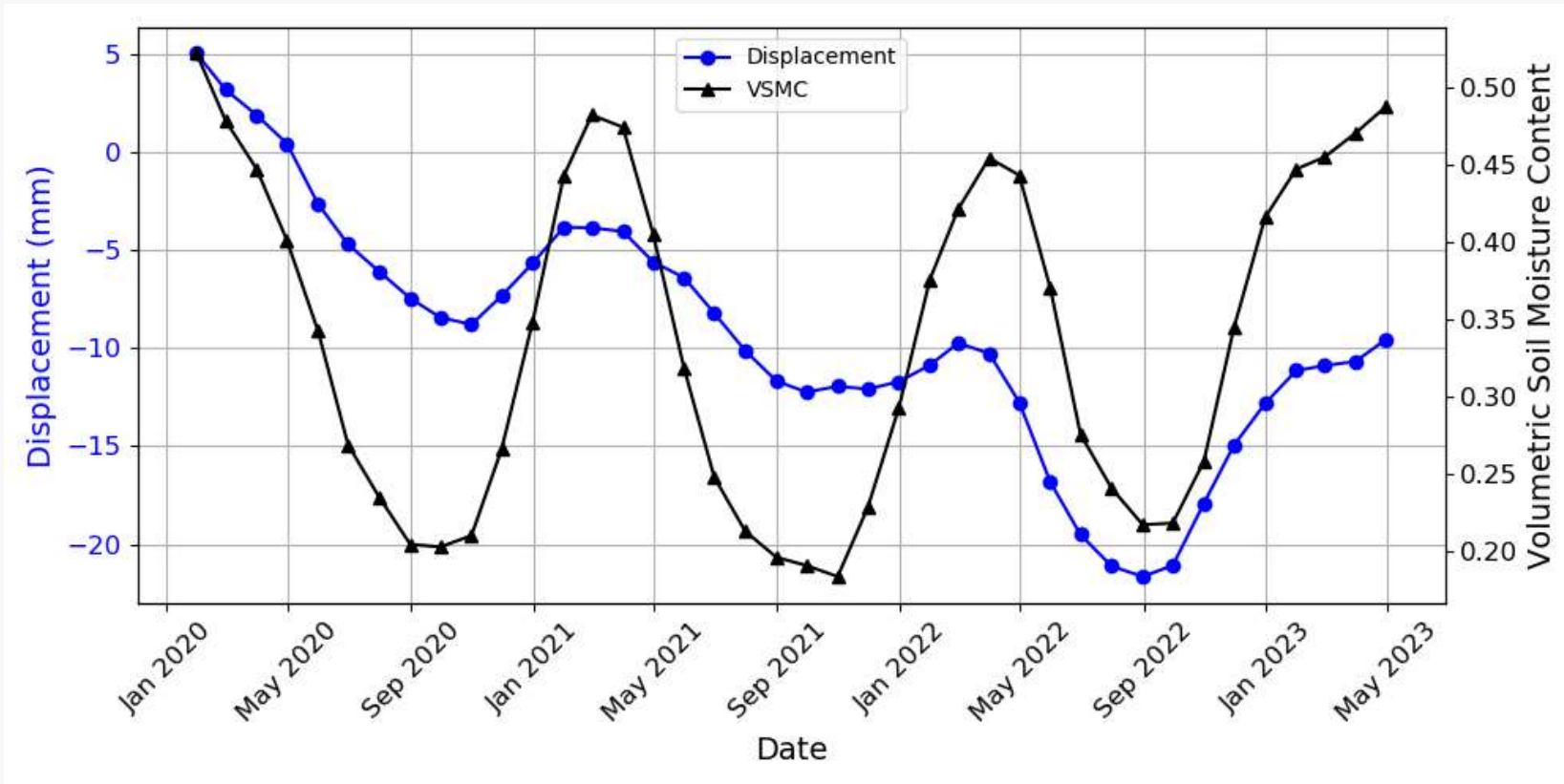


Severity score



Susceptibility to swelling clays

Correlation between soil moisture content and seasonal displacements.



Conclusions

- Space technology allows:
 - Regular, network-wide infrastructure monitoring
 - Earlier identification of issues
 - More proactive maintenance
 - Building in resilience to climate change
- Already applied on some networks

THANK YOU

www.geofem.com

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