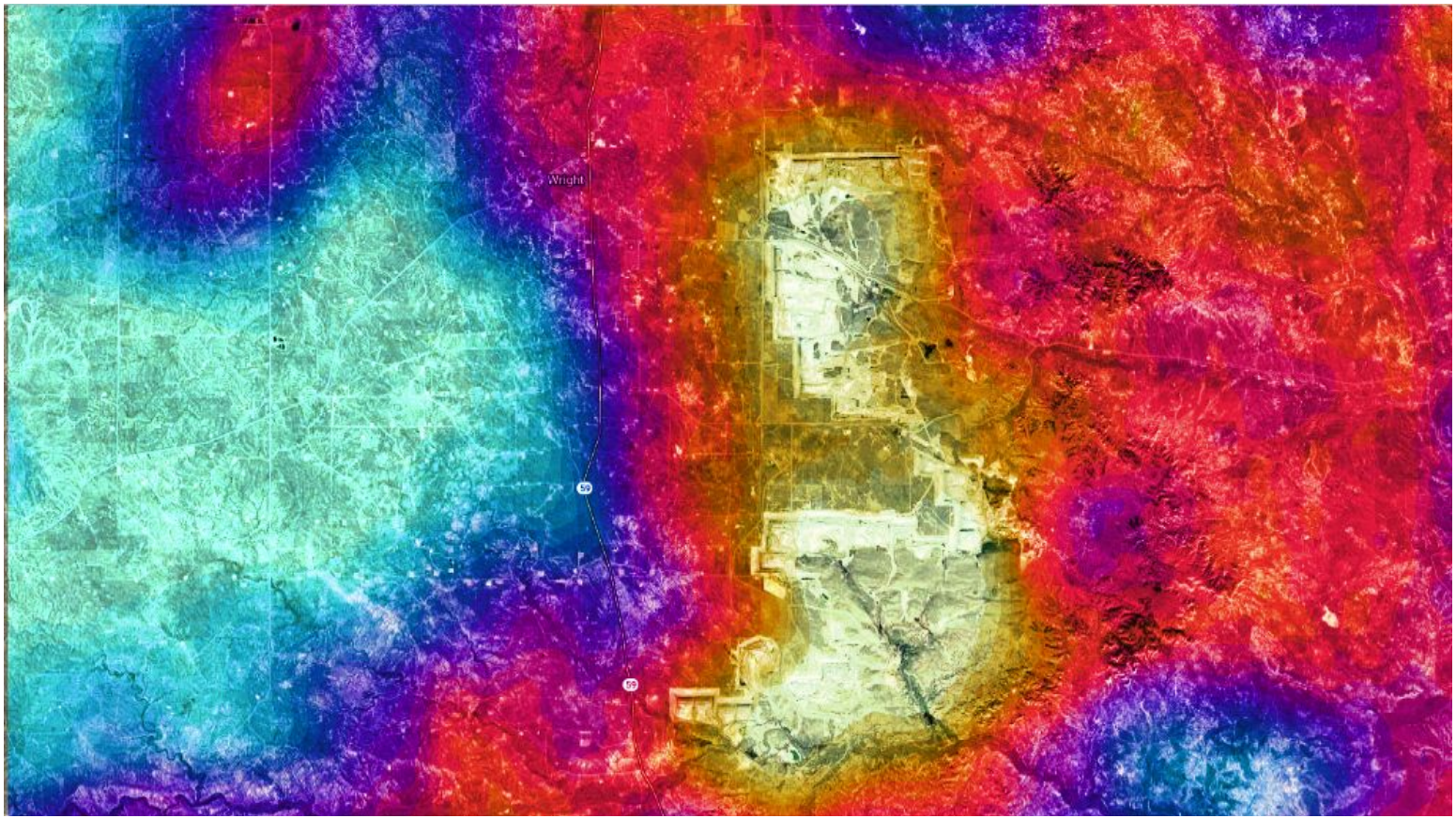
Harnessing Multispectral Data for Sustainable Mining: Advancing ESG Objectives while Navigating Limitations and Exploits

SAIMM ESG Conference 2024

17 October 2024



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01

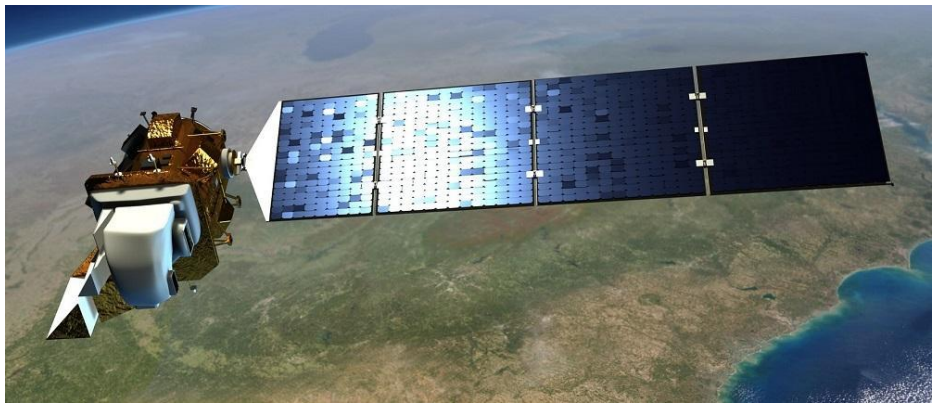
Multispectral Data for Sustainable Mining?

Multispectral Data for Sustainable Mining?

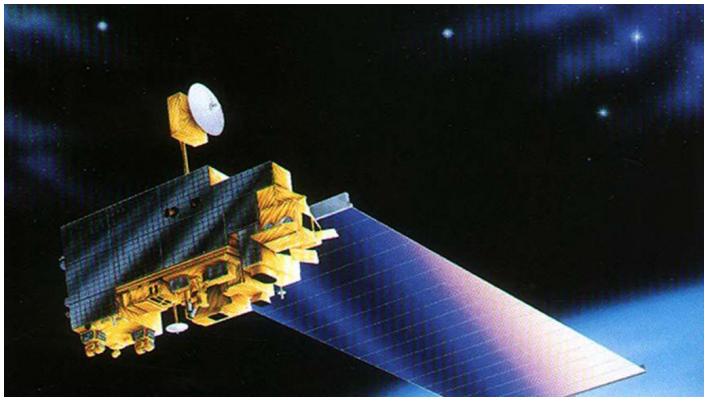
- Many satellite programs, like Sentinel and Landsat, provide free and open access to their data.
- Open-source satellite data offers global coverage, allowing users to monitor environmental changes anywhere on Earth, which is invaluable for global ESG initiatives.
- Satellites like Sentinel-2 provide data with high revisit frequencies (every 5 days).

Multispectral Data for Sustainable Mining?

Sentinel-1, Sentinel-2, Sentinel-3, Sentinel-5P (Copernicus Program)



Landsat Series (Landsat 8, Landsat 9)

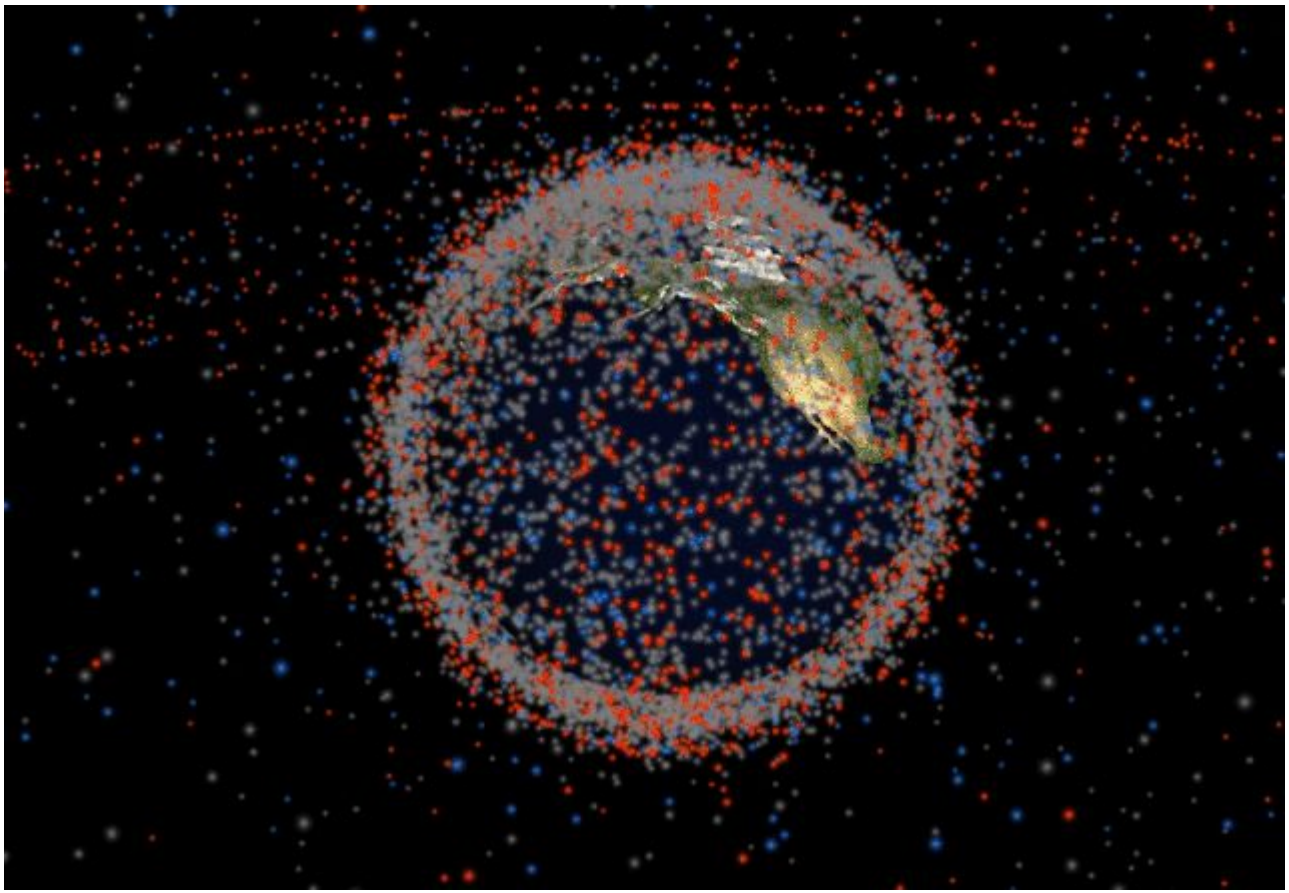


ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer)

MODIS (Moderate Resolution Imaging Spectroradiometer)

Multispectral Data for Sustainable Mining?

There are over 30 satellites (of the ~4550) providing free multispectral data, including those from various international space agencies and programs.



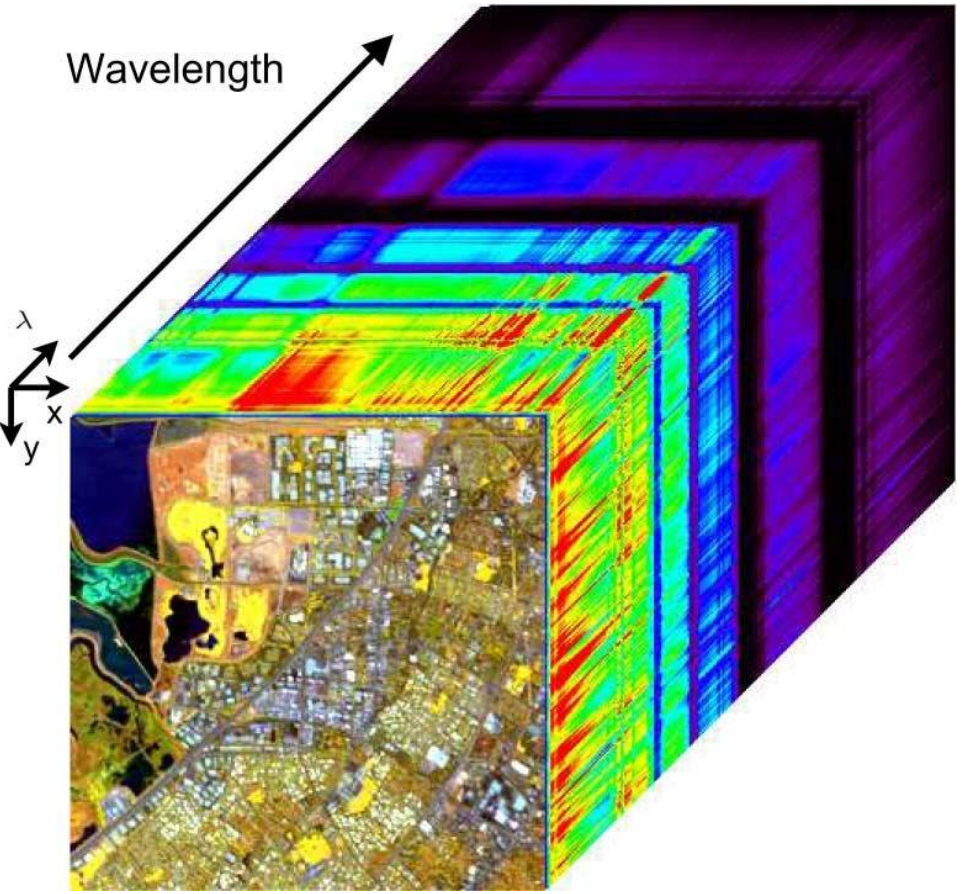
https://hyperallergic.com/220475/follow-all-the-tech-and-trash-orbiting-earth-in-real-time/

- Red - rocket parts
- Blue - Satellites
- Grey - debris (“graveyard orbit”)

- **Not to scale!**

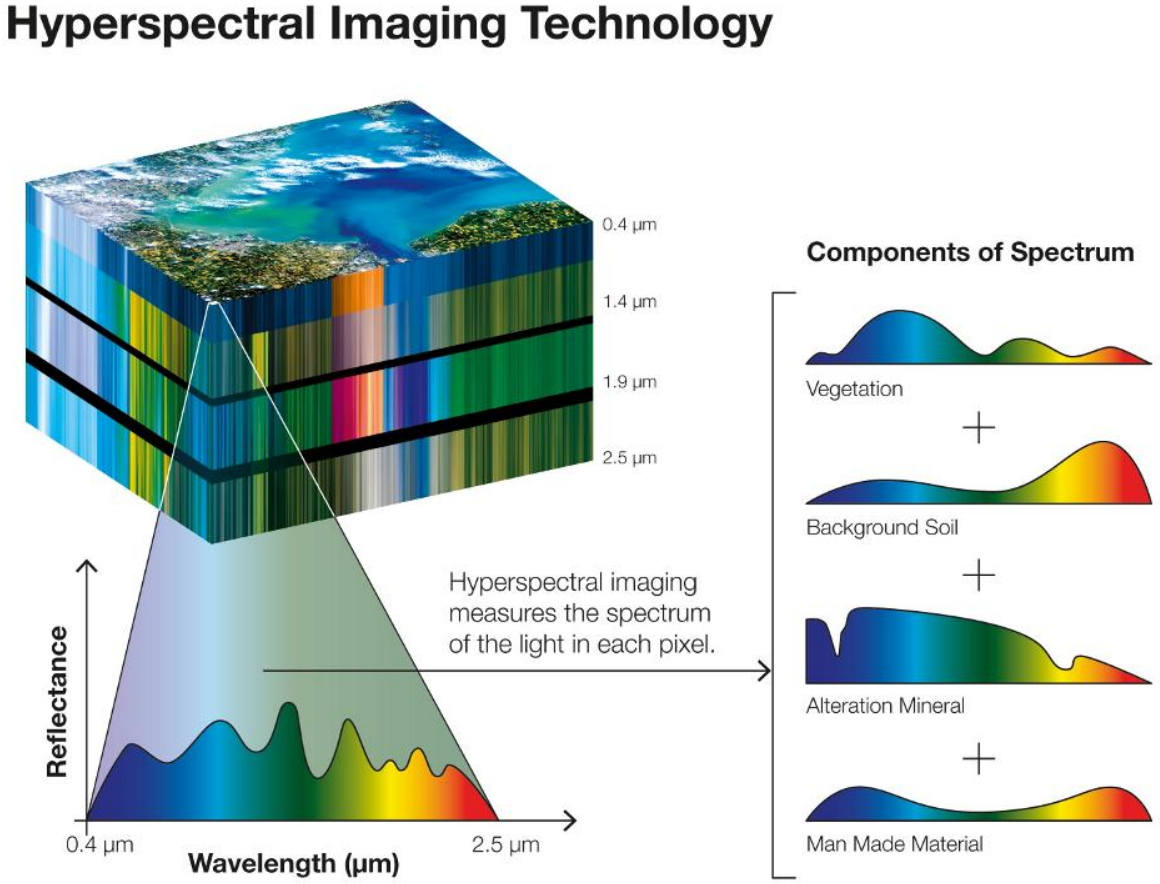
- **Over the next five years, it's estimated that around 10 to 15 new satellites could be launched which will also providing free multispectral data**

Multispectral Data for Sustainable Mining?



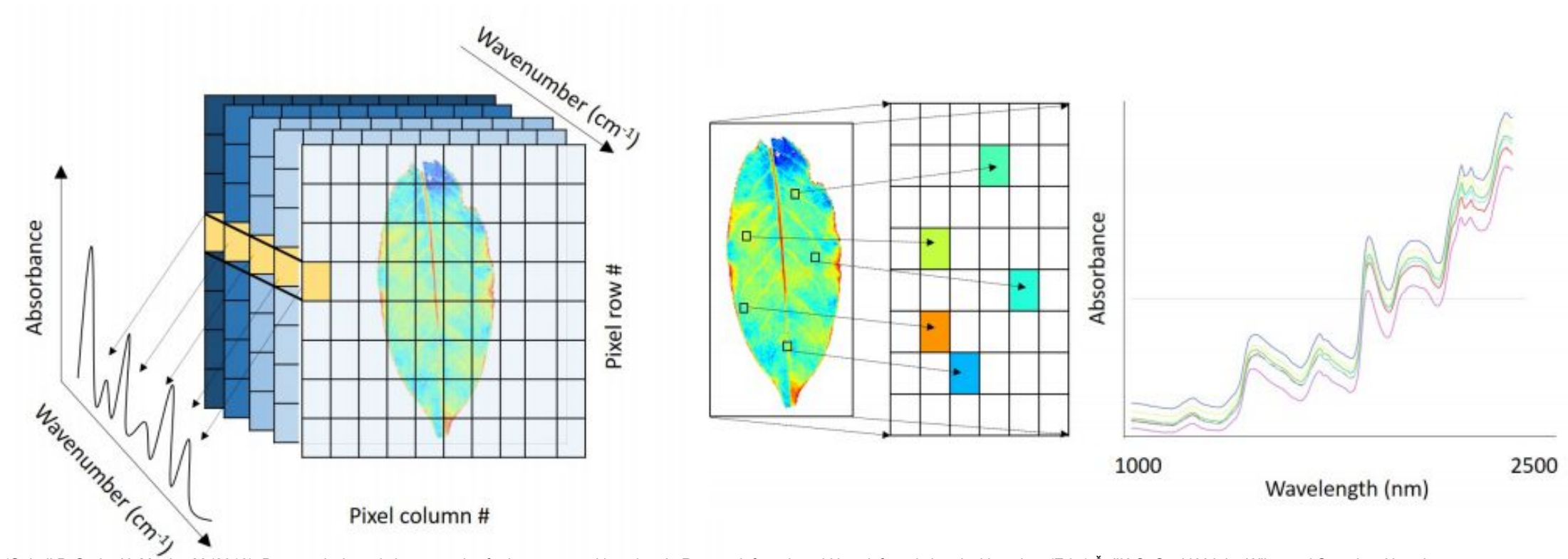
Christophe, E., Mailhes, C., & Duhamel, P. (2008). Hyperspectral image compression: adapting SPIHT and EZW to anisotropic 3-D wavelet coding. *IEEE Transactions on Image Processing*, *17*(12), 2334-2346.

Hypercube



http://spaceteknews.com/1911-hypersat-reveals-hyperspectral-plans.html

Multispectral Data for Sustainable Mining?



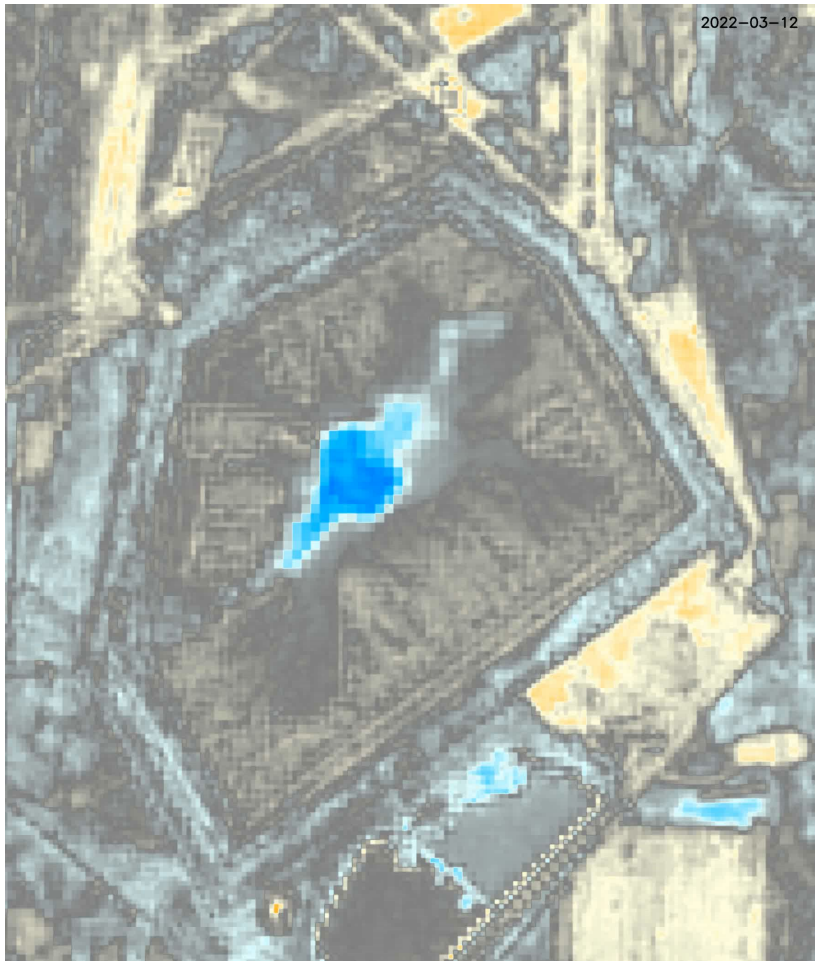
(Geladi P, Grahn H, Manley M (2010). Data analysis and chemometrics for hyperspectral imaging. In:Raman, Infrared, and Near-infrared chemical imaging. (Eds.) Šašić S, Ozaki Y.John Wiley and Sons Inc, New Jersey.

02

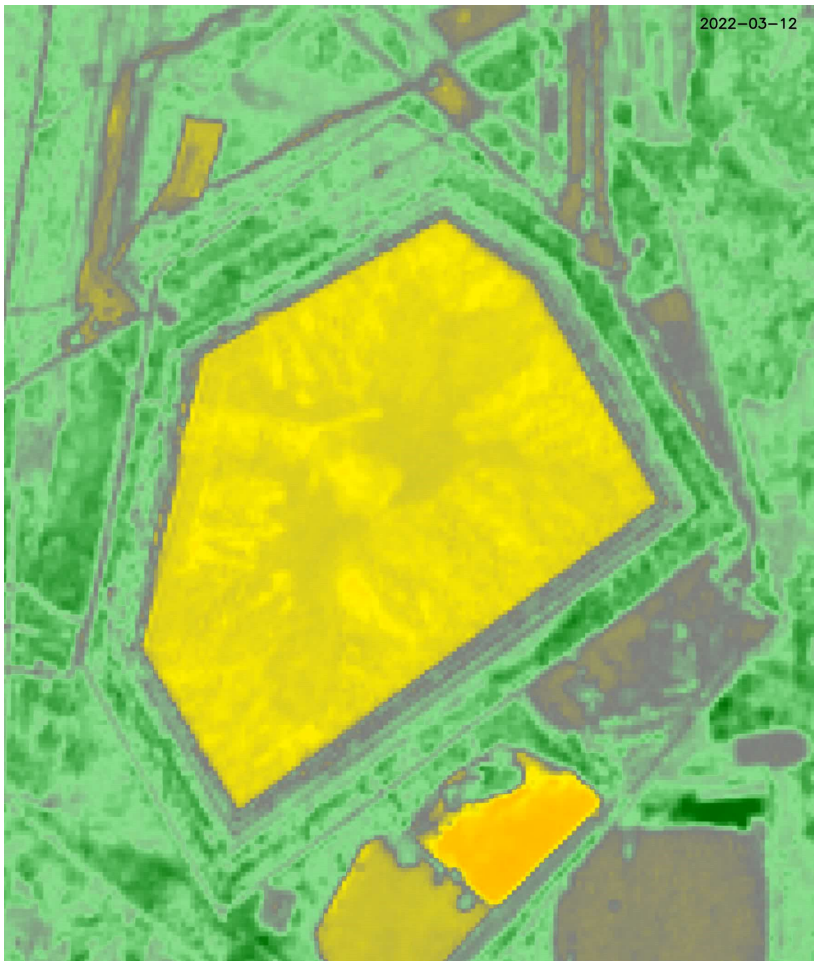
Multispectral Data for Sustainable Mining – In Practice

Multispectral Data for Sustainable Mining – In Practice

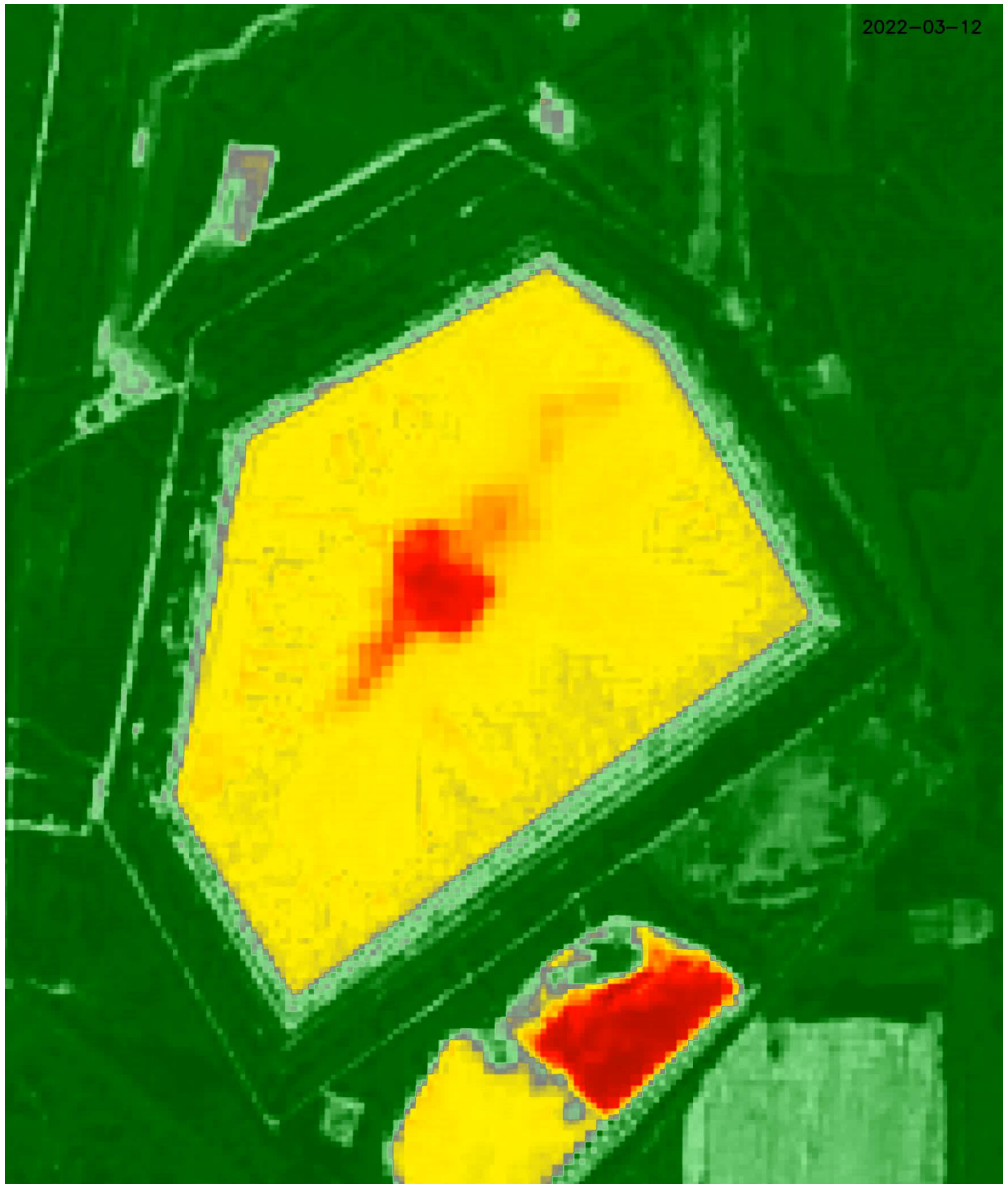
TSF Pool monitoring



TSF Vegetation health monitoring

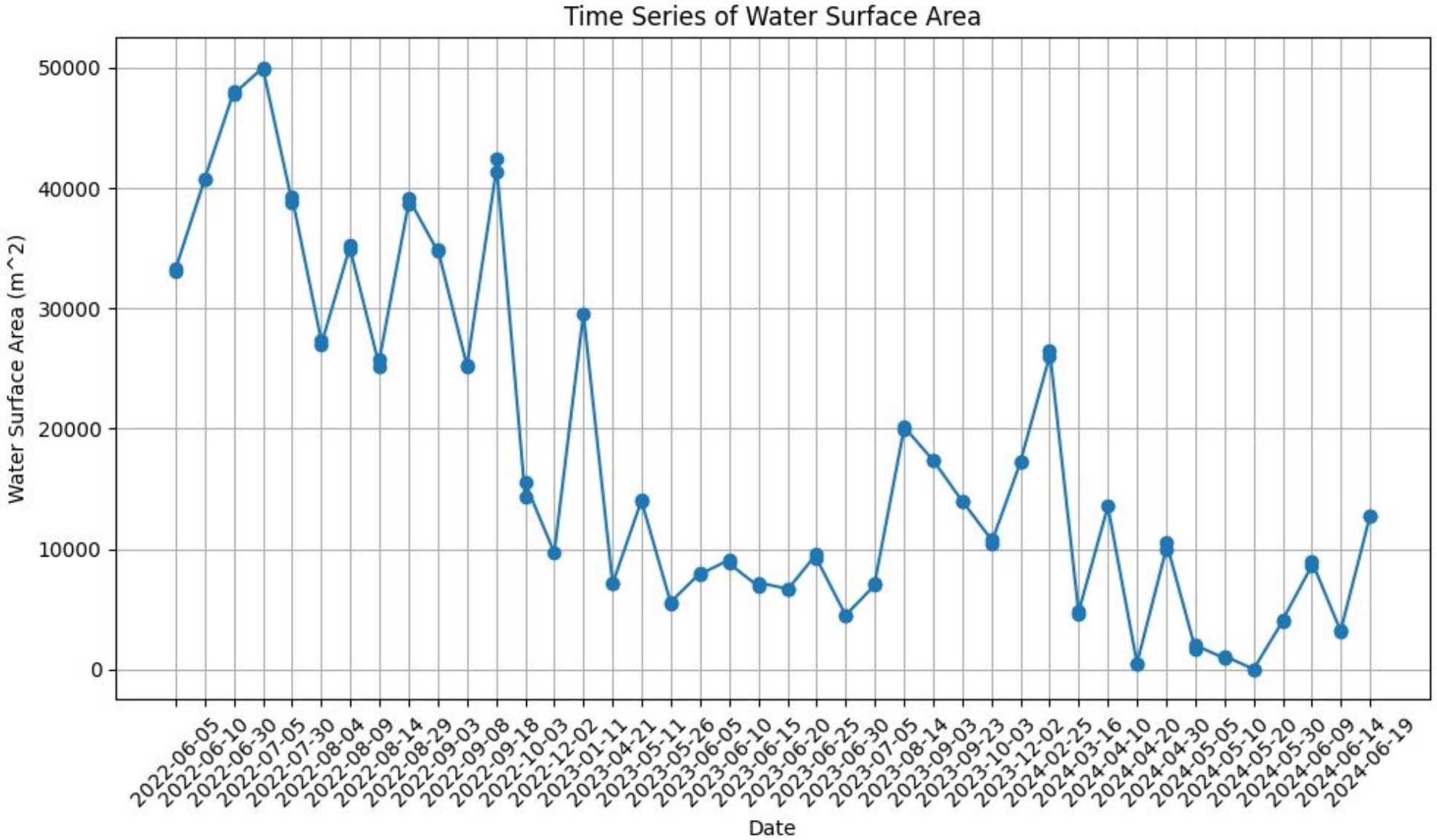


Multispectral Data for Sustainable Mining – In Practice

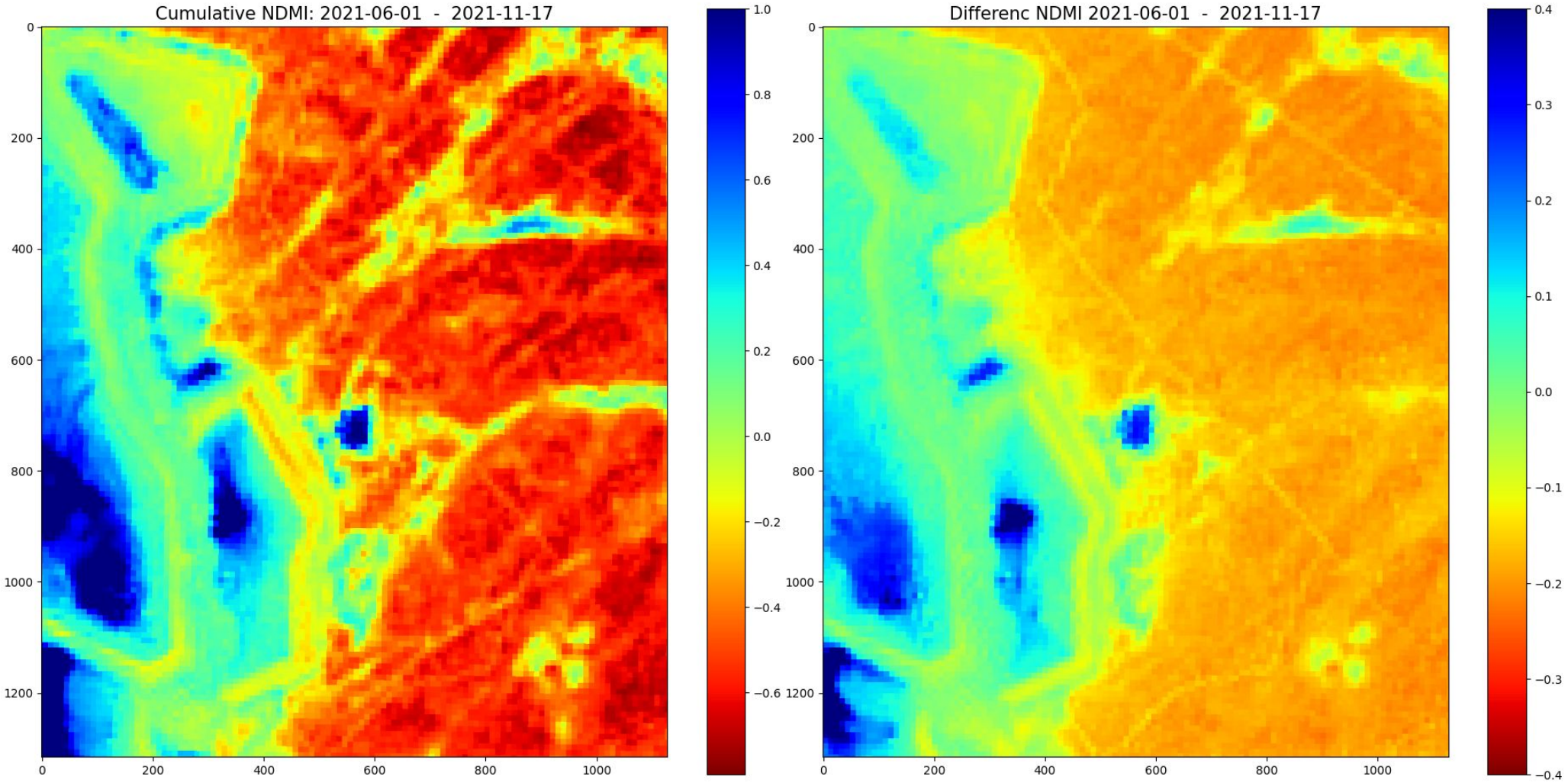


Custom seepage index

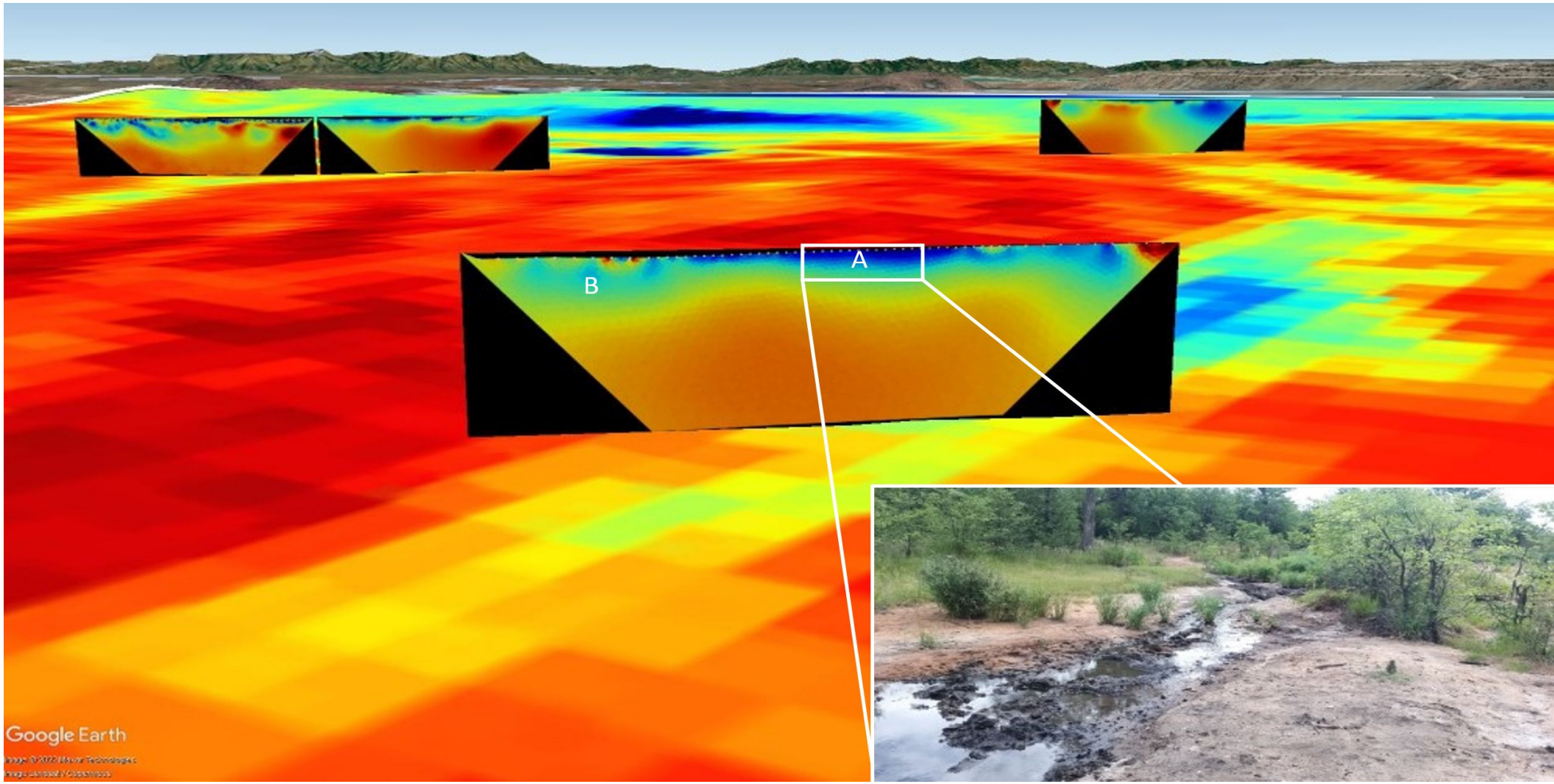
Multispectral Data for Sustainable Mining – In Practice



Seepage Monitoring

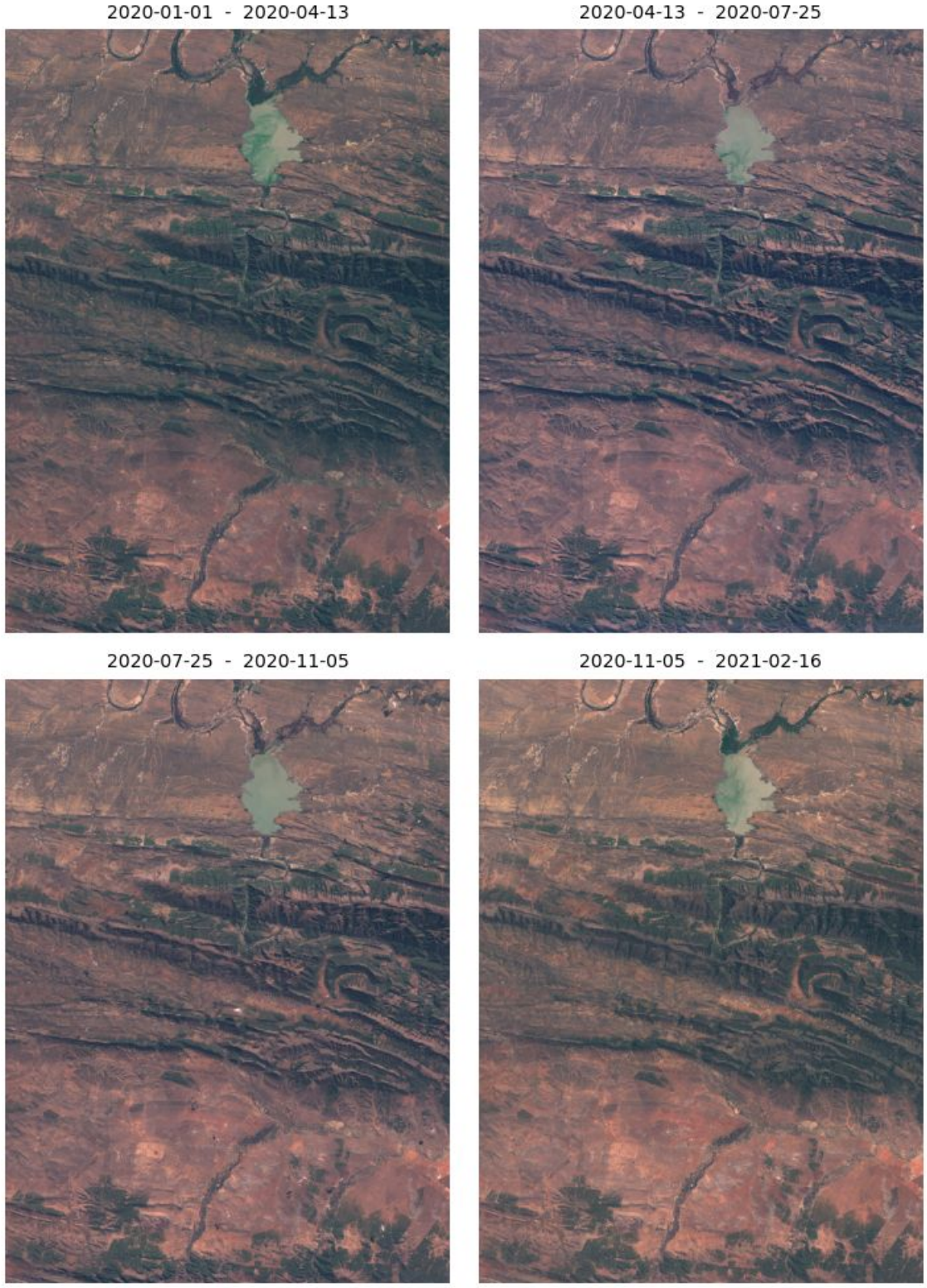


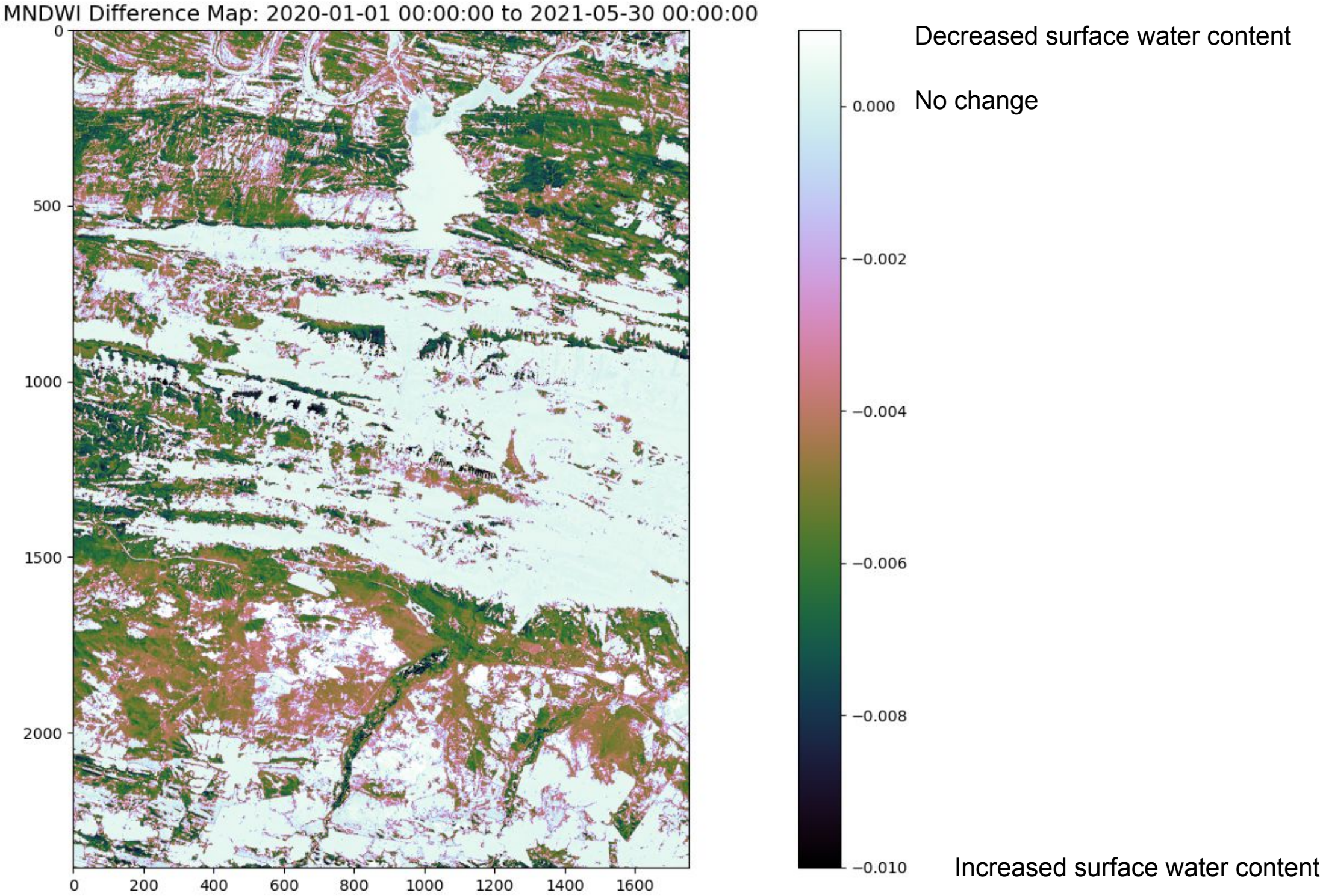
Seepage Monitoring



Multispectral Data for Sustainable Mining – In Practice

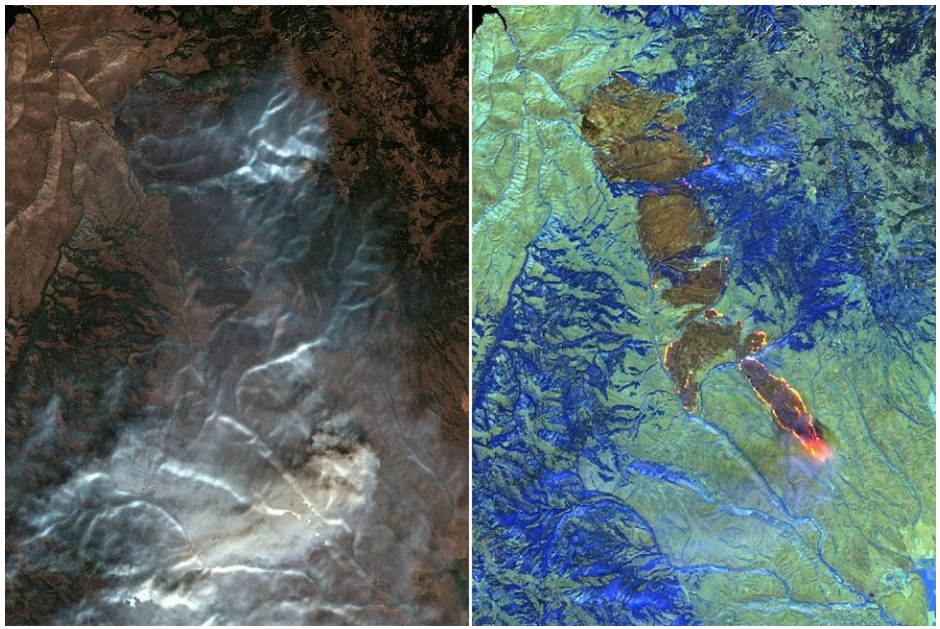
Surface water indices change maps showing regional surface water content controlled by geological structures.



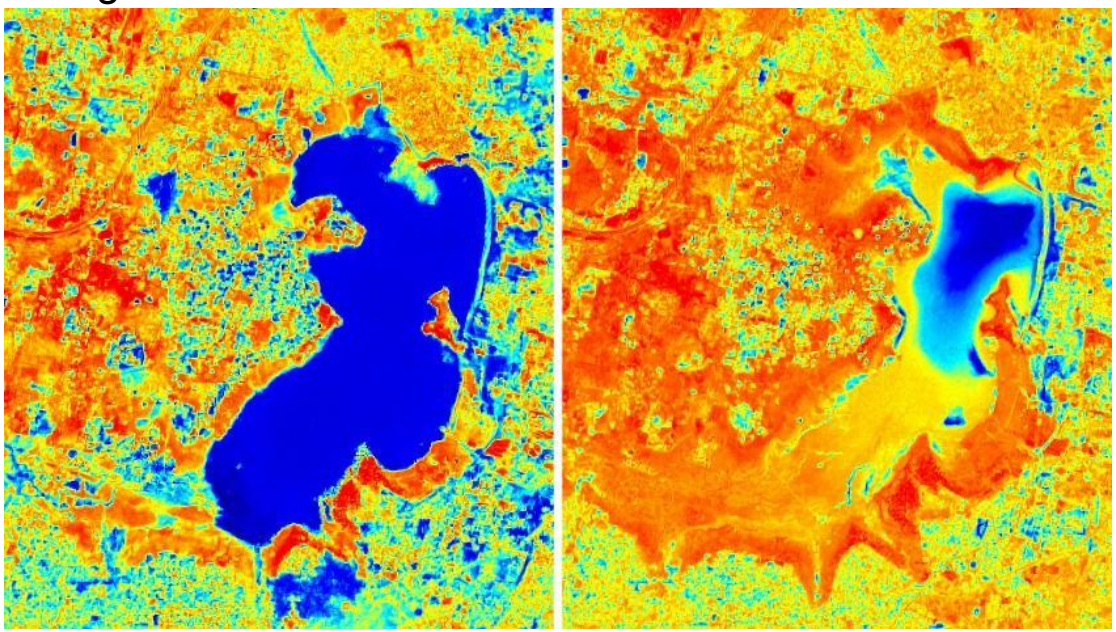

MNDWI Difference Map: 2020-01-01 00:00:00 to 2021-05-30 00:00:00
0
500
1000
1500
2000
0
200
400
600
800
1000
1200
1400
1600
0.000
−0.002
−0.004
−0.006
−0.008
−0.010
Decreased surface water content
No change
Increased surface water content

Disaster Management

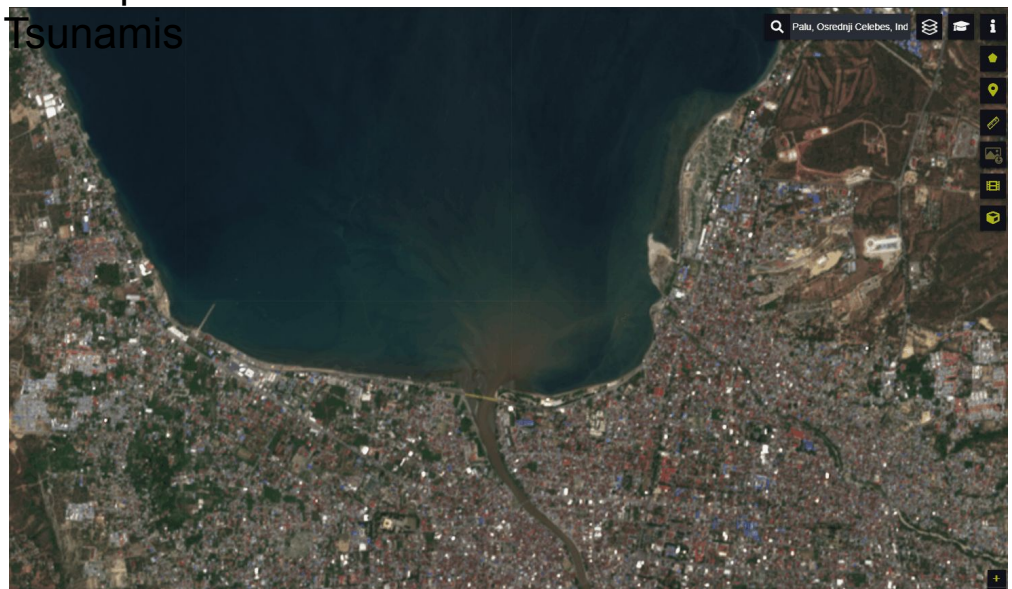
Wild fires



Drought



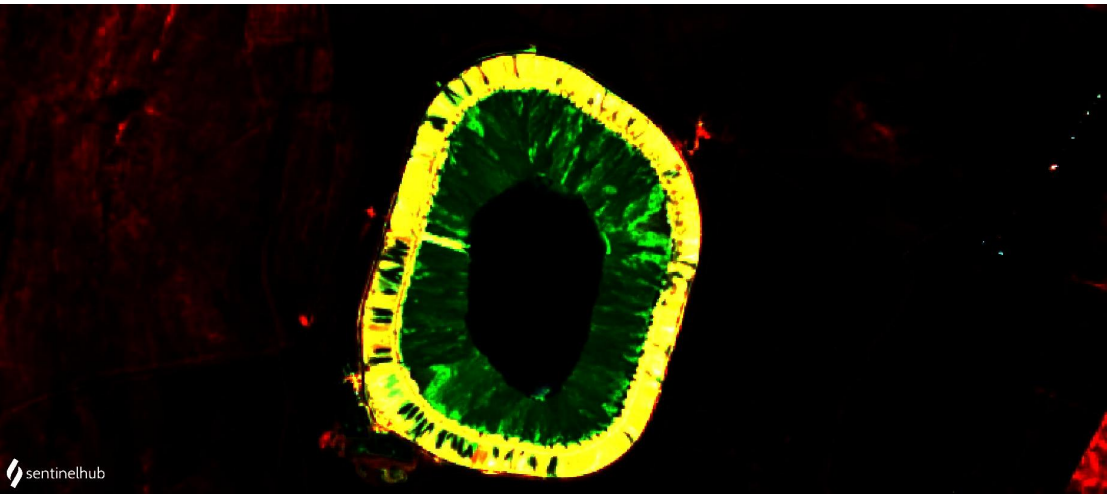
Earthquakes and Tsunamis



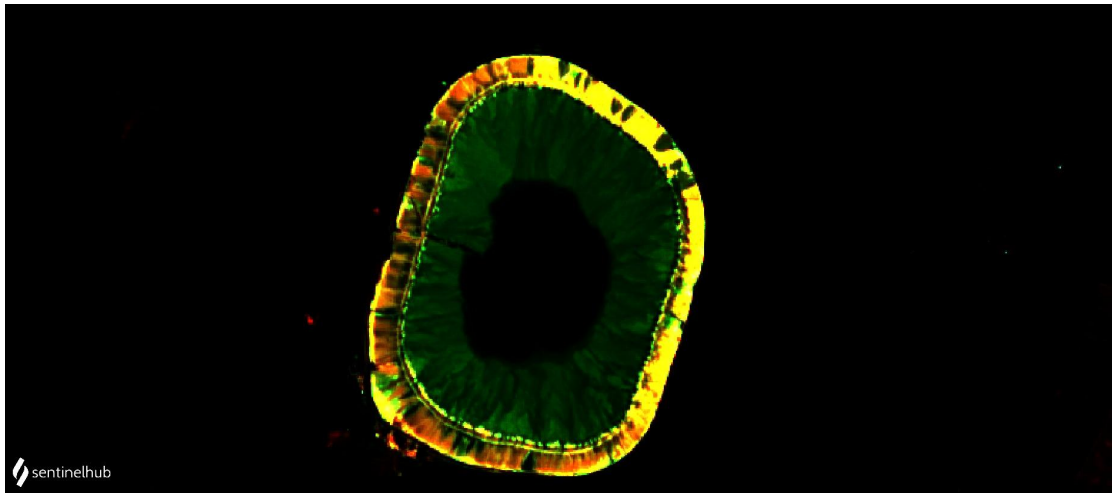
Land Change Maps

TSF Mineral Spectral Signatures

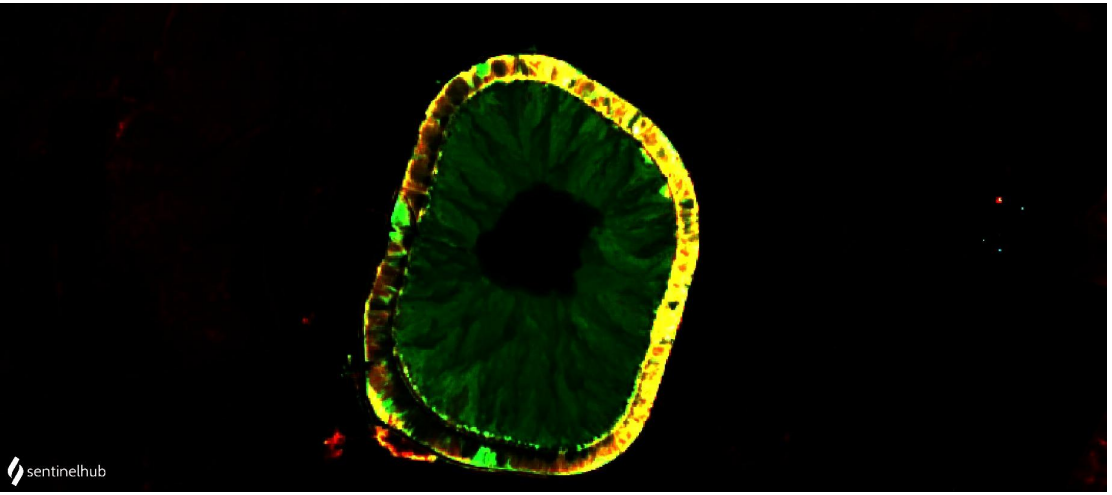
2021/03/18



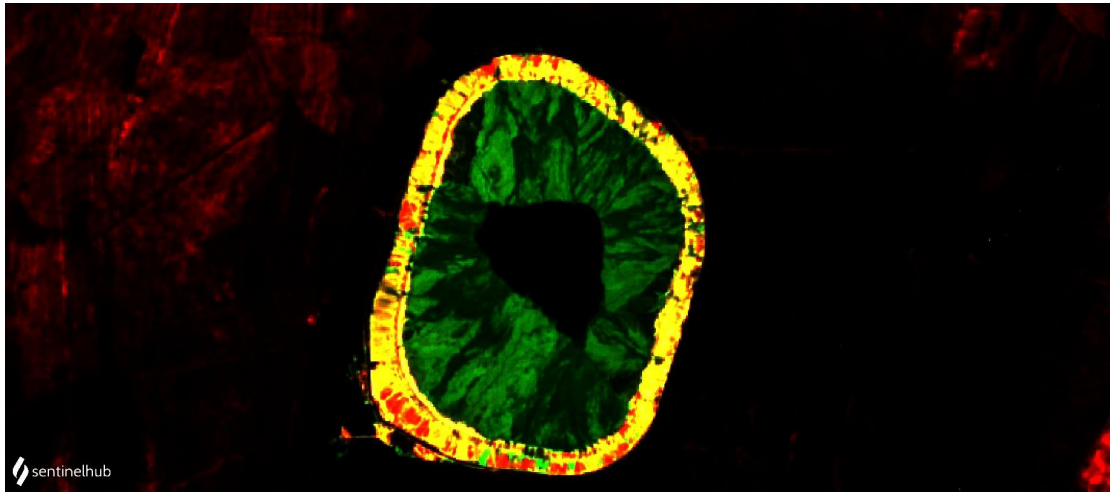
2020/03/15



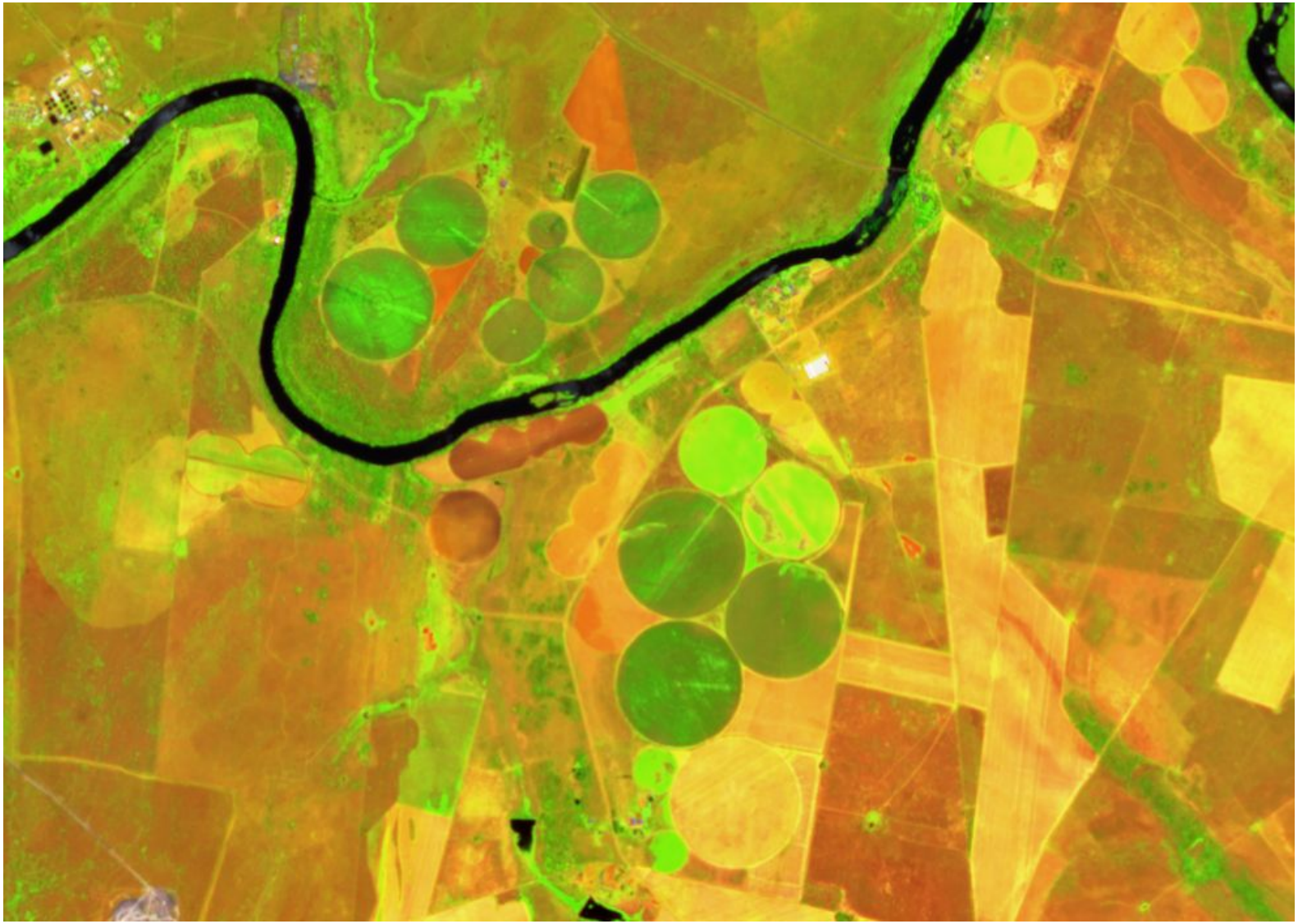
2019/03/16



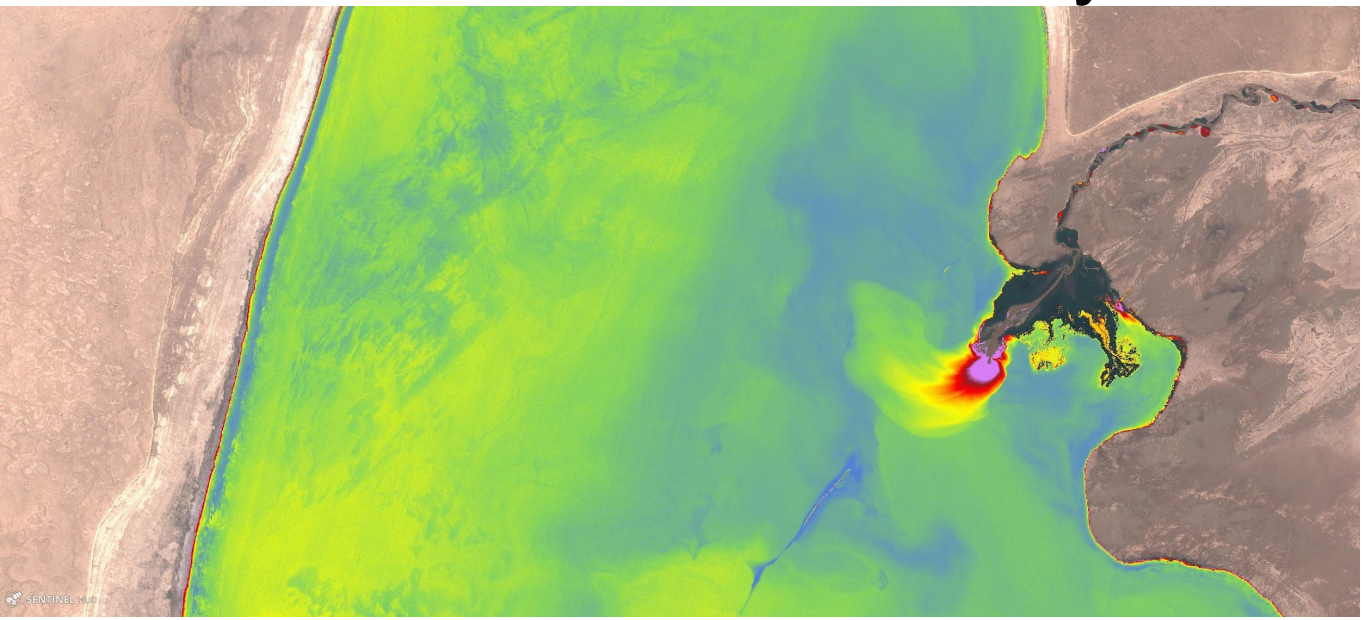
2018/03/16



Agriculture Composite

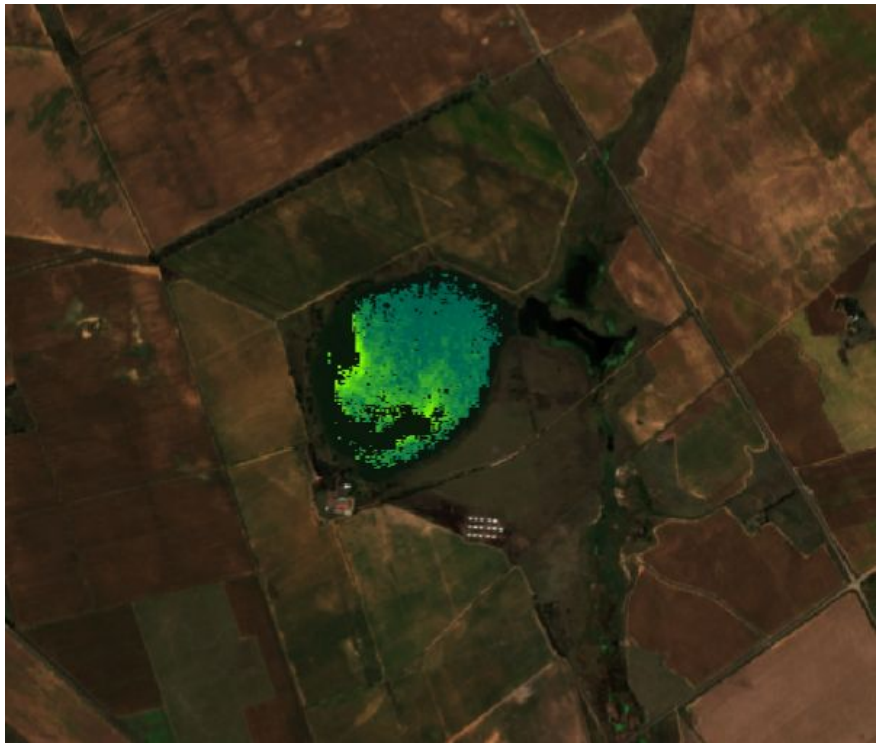


Sentinel-2 Water Quality Index

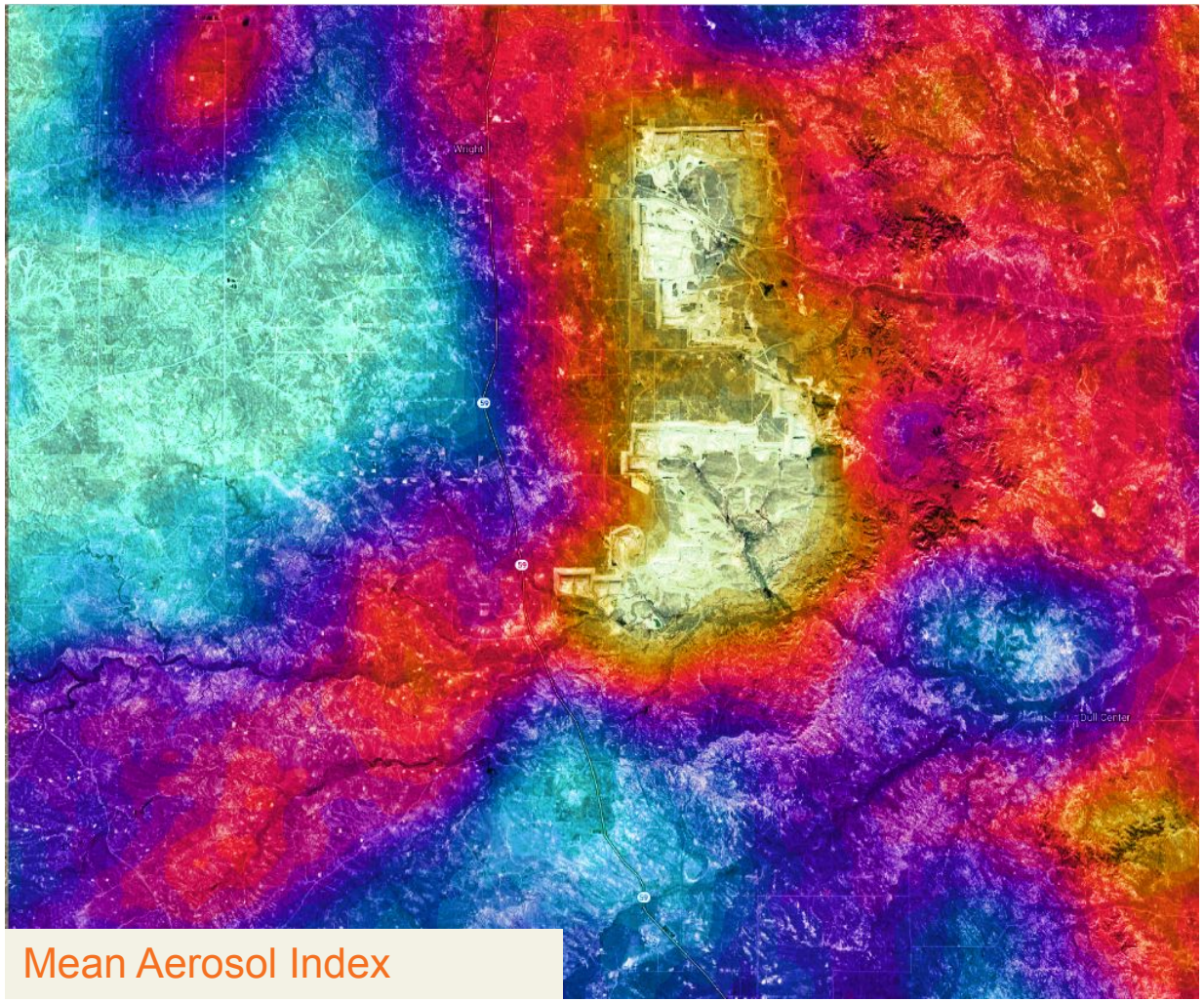


Distribution of dissolved organic carbon

Concentration of chlorophyll



Air Quality Index

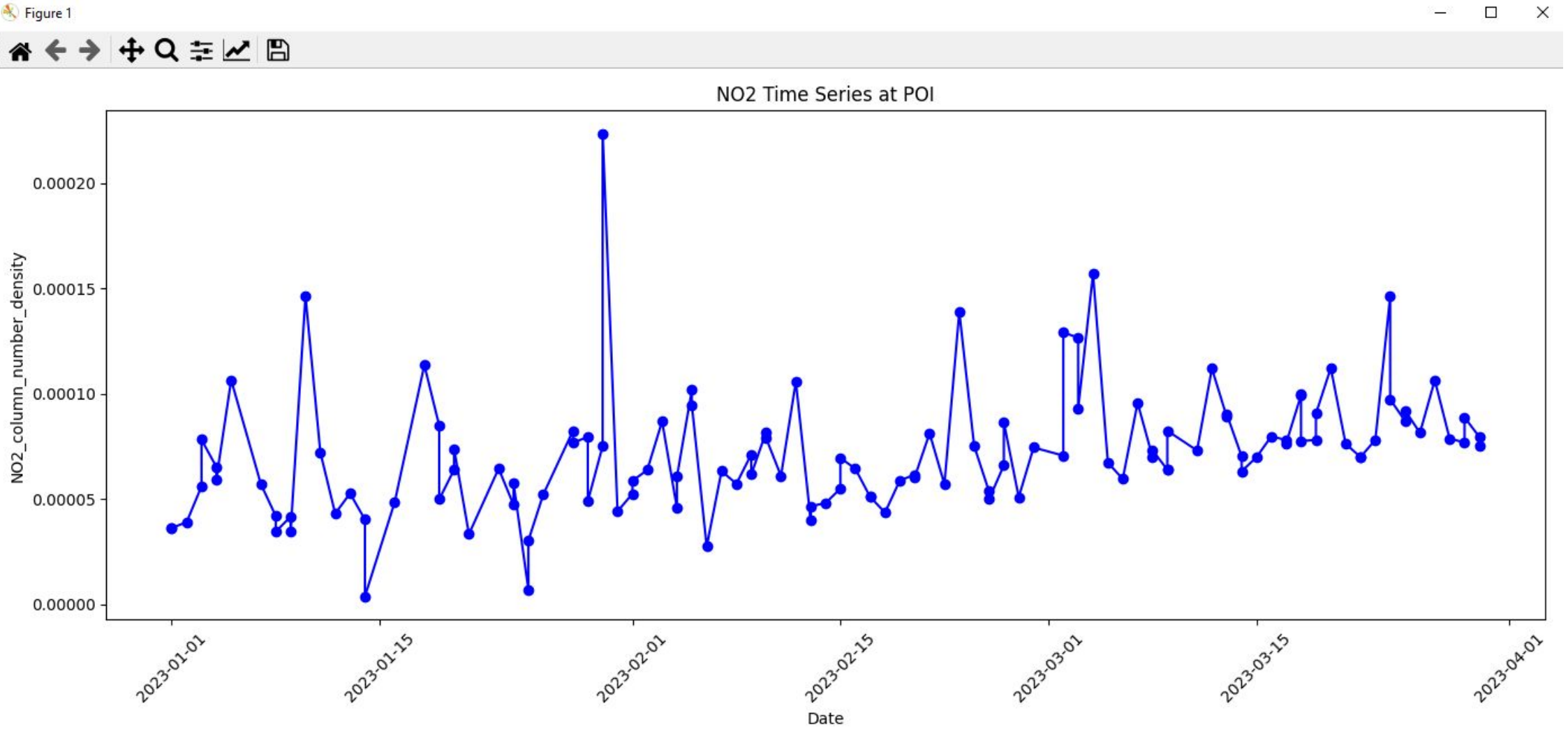


Mean Aerosol Index

Atmospheric Products Calculated at SRK

- Aerosol Optical Depth (AOD)
- Cloud Cover and Type
- Water Vapor Content
- Surface Reflectance
- Ozone Concentration
- Carbon Monoxide Levels
- Nitrogen Dioxide Levels
- Sulfur Dioxide Levels
- Methane Concentration
- Surface Temperature
- Tropospheric Ozone Profiles
- Aerosol Layer Height
- Cloud Optical Thickness
- Cloud Top Pressure and Temperature
- UV Index
- Greenhouse Gas Concentrations (e.g., CO_2, CH_4)
- Air Quality Indices
- **Particulate Matter (PM2.5 and PM10) Estimates**
- Volcanic Ash Monitoring
- Fire Emissions and Smoke Plumes

Air Quality Index

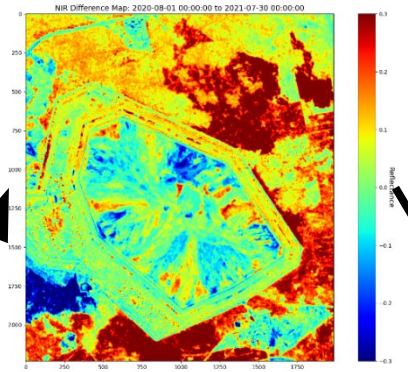


Multispectral Data for Sustainable Mining – In Practice

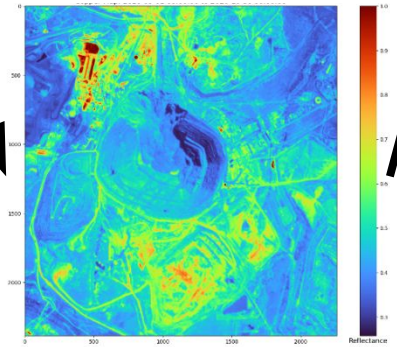
Custom scripts

```python
"""
@author: hawe
"""

from sentinelhub import SHConfig
import os
import datetime
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits.axes_grid1 import make_axes_locatable
from sentinelhub import MimeType, CRS, BBox, SentinelHubRequest, SentinelHubDownloadClient, \
    DataCollection, bbox_to_dimensions, DownloadRequest

def plot_image(image, factor=1):
    """
    Utility function for plotting RGB images.
    """
    fig = plt.subplots(nrows=1, ncols=1, figsize=(15, 7))

    if np.issubdtype(image.dtype, np.floating):
        plt.imshow(np.minimum(image * factor, 1))
    else:
        plt.imshow(image)

config = SHConfig()

config.instance_id = '4b972809-dec7-40cc-a562-ce1393162663'
config.sh_client_id = '0650cd83-8671-47c8-8af2-7e28d85ae528'
config.sh_client_secret = 'tf[|*pTAh?O*NSbwuZn)b*qTODbXihMz1*gxz#>)'
config.save()


#betsiboka_coords_wgs84 = [ 30.598527,-27.071527, 30.905959, -26.814808]
#betsiboka_coords_wgs84 = [    31.052438, -24.058077,   31.187634, -23.945468]#Foskor
#betsiboka_coords_wgs84 = [    31.115264, -24.002546,    31.141843, -23.982868]#Foskor2
#betsiboka_coords_wgs84 = [     31.108635, -24.014290,    31.153724, -23.971755]#Foskor3
#betsiboka_coords_wgs84 = [     31.014901, -24.141184,  31.233767, -23.901312]#Foskor4
#betsiboka_coords_wgs84 = [   30.095656, -24.532288,  30.119985, -24.496036]#Marula
#betsiboka_coords_wgs84 = [   30.103276, -24.516857,  30.114050, -24.505952]#Marula2
#betsiboka_coords_wgs84 = [    23.014858, -28.297893,    23.053876, -28.260834]# Rahida
#betsiboka_coords_wgs84 = [      27.219871, -25.536838,     27.259300, -25.496449]#Impala
#betsiboka_coords_wgs84 = [       -8.588202,   7.389249,      -8.250576,   7.848873]#Nimba
#betsiboka_coords_wgs84 = [       -9.548875,      8.673748,   -9.403784,      8.916504]#Nimba3
#betsiboka_coords_wgs84 = [    25.273387, -12.307657,  25.346959, -12.220613]#Sentinal
#betsiboka_coords_wgs84 = [   30.340464, -18.689401, 30.348468,-18.685153]
#betsiboka_coords_wgs84 = [   27.469199, -25.752591,  27.511244, -25.720414]#Tharisa
betsiboka_coords_wgs84 = [    -8.462440, 7.668344,   -8.444029,  7.689404]#Tharisa

#betsiboka_coords_wgs84 = [26.763334, -27.015627,26.794245, -26.988660]
resolution =1

WD1=4
WD2=5
betsiboka_bbox = BBox(bbox=betsiboka_coords_wgs84, crs=CRS.WGS84)
betsiboka_size = bbox_to_dimensions(betsiboka_bbox, resolution=resolution)

print(f'Image shape at {resolution} m resolution: {betsiboka_size} pixels')
start = datetime.datetime(2020.8.1)
```

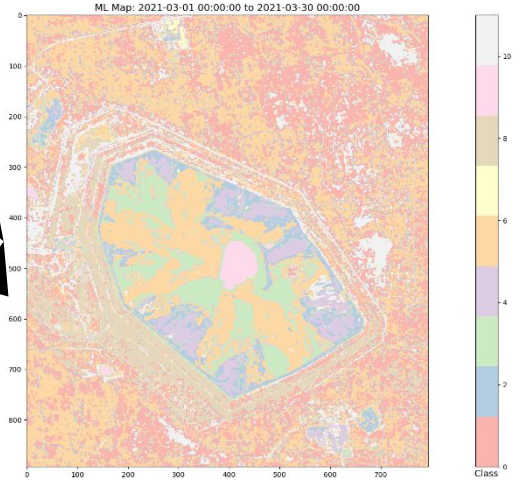
Surface water monitoring



Mineralization Indices



Machine learning classification



03

Multispectral Data Limitations

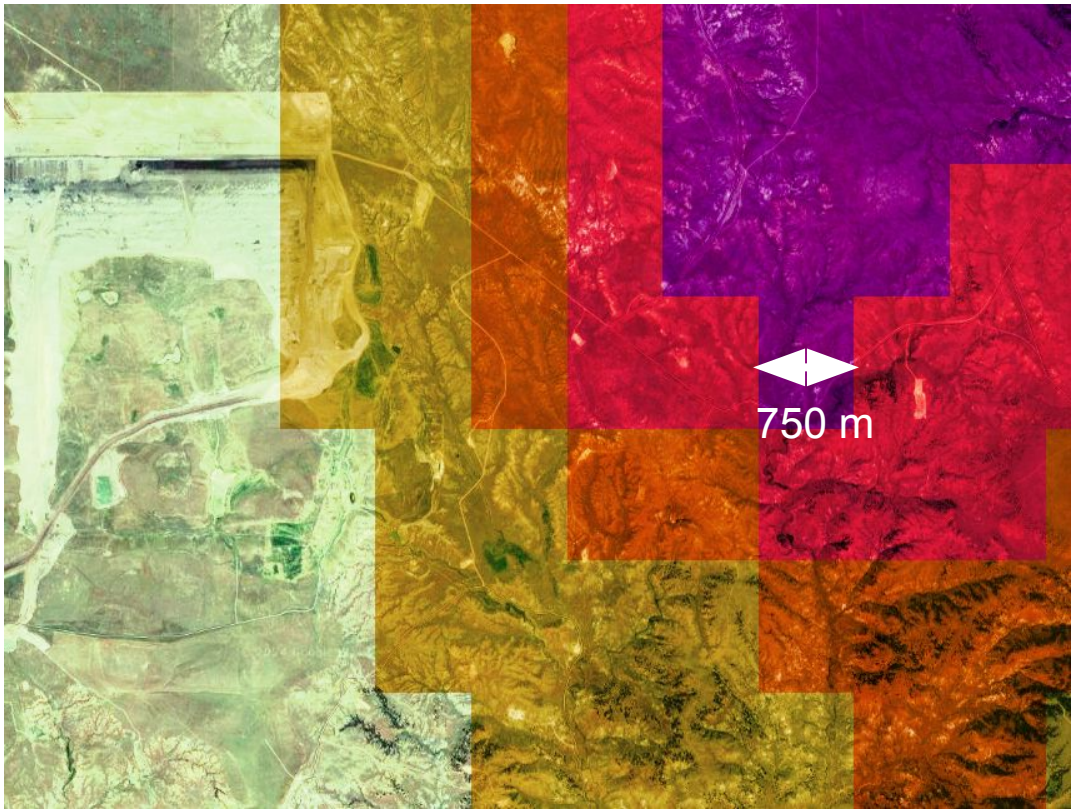
Multispectral Data: Resolution

Landsat (8 and 9):
- Spatial Resolution: 30 metres (multispectral), 15 metres (panchromatic)
- Temporal Resolution: 16 days

Sentinel-2:
- Spatial Resolution: 10 metres (visible and near-infrared), 20 metres (shortwave infrared), 60 metres (coastal aerosol, water vapor, and cirrus)
- Temporal Resolution: 5 days

Sentinel-1:
- Spatial Resolution: 5 to 20 metres (depending on mode)
- Temporal Resolution: 6 to 12 days

MODIS (on Terra and Aqua):
- Spatial Resolution: 250 metres (bands 1-2), 500 metres (bands 3-7), 1,000 metres (bands 8-36)
- Temporal Resolution: 1 to 2 days

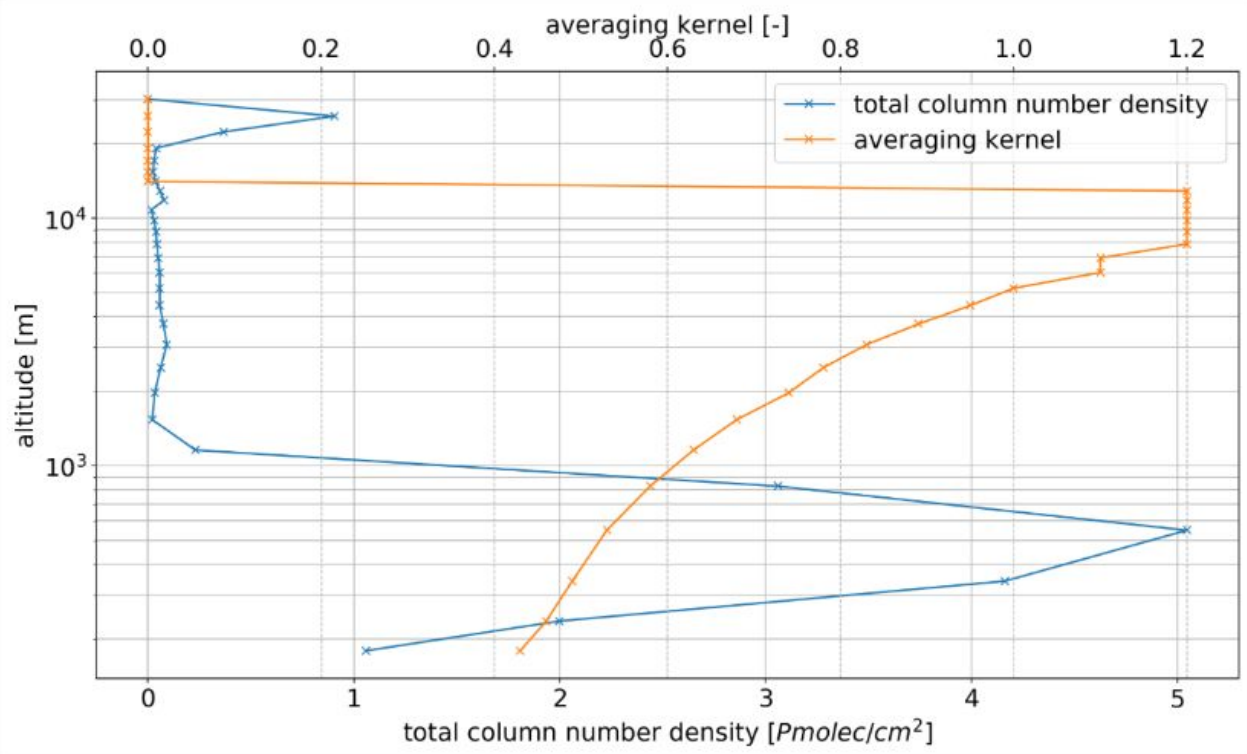


Multispectral Data: Atmospheric Column Measurements

Sentinel-5P measures atmospheric composition across various altitudes, but it doesn't provide specific elevation levels directly. Instead, it captures vertical profiles of gases and aerosols throughout the atmosphere.

However, these data can be used in conjunction with models and ground-based measurements to estimate ground-level concentrations

Figure 2. Example of NO_2 vertical profile from GEM-AQ model and the TROPOMI-derived, troposphere averaging kernel, extracted at power plant stack location on 1 April 2019.



Kawka, M.; Struzewska, J.; Kaminski, J.W. Spatial and Temporal Variation of NO_2 Vertical Column Densities (VCDs) over Poland: Comparison of the Sentinel-5P TROPOMI Observations and the GEM-AQ Model Simulations. *Atmosphere* **2021**, *12*, 896. https://doi.org/10.3390/atmos12070896

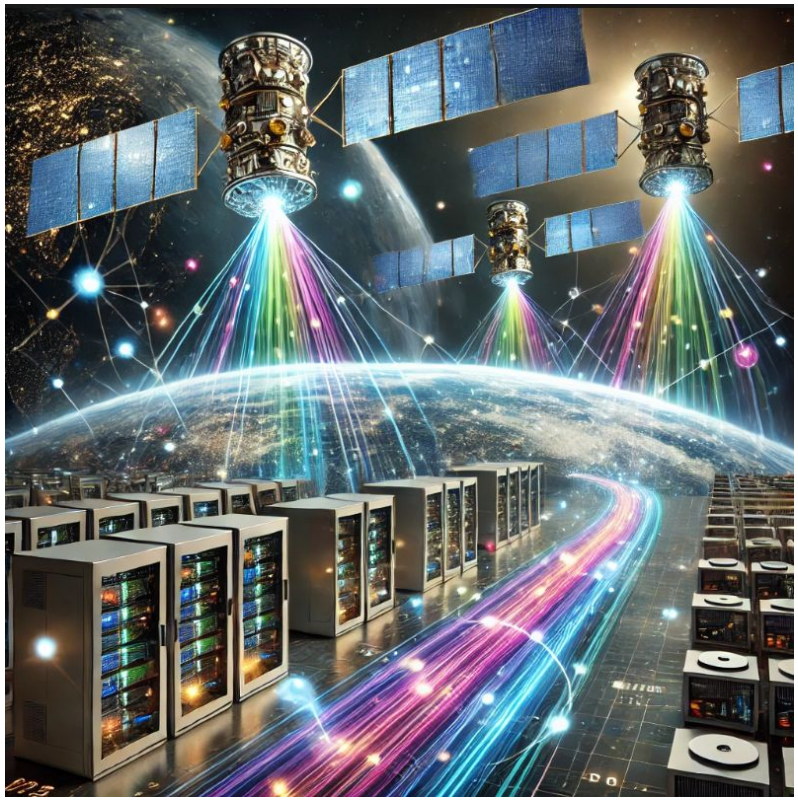
Multispectral Data: Data Volume

Approximate daily data collection volumes form freely available satellite platforms:

- **Landsat (8 and 9)**: Around 700 gigabytes per day.
- **Sentinel-1**: Approximately 1 terabyte per day.
- **Sentinel-2**: Roughly 1.6 terabytes per day.
- **Sentinel-3**: About 1 terabyte per day.
- **Sentinel-5P**: Approximately 2-3 gigabytes per day.
- **MODIS (on Terra and Aqua)**: Around 27 gigabytes per day.

Once data is fully processed:

- **Landsat (8 and 9)**: Around 1 terabyte.
- **Sentinel-1**: Approximately 1.5 terabytes.
- **Sentinel-2**: Roughly 2 terabytes.
- **Sentinel-3**: About 1.5 terabytes.
- **Sentinel-5P**: Approximately 5-10 gigabytes.
- **MODIS (on Terra and Aqua)**: Around 50 gigabytes.



Multispectral Data: Exploitation

1. **Environmental Scrutiny:**
Companies might feel pressured if satellite data is used to highlight environmental impacts or non-compliance with regulations. This can lead to public criticism or legal challenges.

2. **Competitive Intelligence:**
Competitors might use satellite data to gain insights into a company's operations, such as monitoring the scale of mining activities or changes in land use.

3. **Activism:**
Environmental groups may use satellite imagery to support campaigns against companies they believe are harming the environment, potentially affecting the company's reputation.

4. **Regulatory Pressure:**
Governments and regulatory bodies can use satellite data to enforce compliance with environmental laws, which might be seen as aggressive oversight by some companies.

BUSINESS

New satellite images catch world's worst polluters red-handed: 'Now we really know exactly where it's coming from'

Kayrros plans to continue its monitoring — and to share its findings with the world.

By Leslie Sattler / January 27, 2024

Kayrros comment on the new EU methane agreement

Published by Isabel Stagg, Editorial Assistant
World Pipelines, Thursday, 16 November 2023 11:00

Save to read list

There were twice as many methane leaks in Texas as New Mexico between 2019 and October 2023, according to new data from climate technology company Kayrros.

Satellites can track CO2 emissions in real-time, leaving polluters nowhere to hide

An illustration of NASA's OCO-2 satellite above Earth. Credit: NASA

Thank You

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Presented by:

Dr Wesley Harrison

wharrison@srk.co.za

SRK House, 265 Oxford Rd, Illovo, Johannesburg, 2196

srk consulting