Applying astronomy capability to map an invasive weed: Leveraging satellite surveys to inform "Famine Weed" policy in Pakistan

Parthenium in Pakistan

Partners

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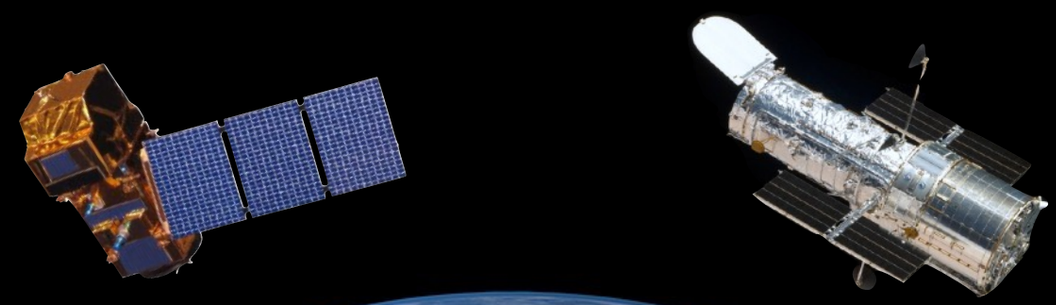
Tim Beale, Brie Finegold, Pablo Gonzalez-Moreno, Tim Holmes, Julien Lamontagne-Godwin

Shakeel Ahmad, Ahtisham Akbar, Saad Ahmad Khan, Muhammad Hamza Khan, Faran Peerzada, Abdul Rehman, Muhammad Usman



GCRF Big Data and Digital Technologies Workshop

19 September 2019, Chiang Mai

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Parthenium in Pakistan

Problem: Parthenium is aggressively spreading across the World.

Particularly bad in Pakistan:

- Can affect crop yields by 90%
- Poses serious health hazards to livestock
- Severe allergenic reactions in human

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Aim: Monitoring Parthenium in crops using satellite imaging

- Quantifying spread on large scales, especially in remote areas
- Evidence-based control strategies

Context

UK's Global Challenges Research Fund (GCRF) — £1.5 billion fund over 5 years:

- Promote challenge-led disciplinary and interdisciplinary research
- Strengthen capacity for research and innovation between UK and developing countries
- Provide agile response to emergencies

Context

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- Provide agile response to emergencies

Multi-disciplinary team

Entomologist

Biologist

Geographer

Ecologist

Astrophysicist

Electrical engineer

Project Plan

Two-year project

- WP-1: Developing satellite imaging analysis tools
- WP-2: Measuring ground truth data
- WP-3: Establishing diagnostic markers and automating analysis
- WP-4: Informing decision makers and stakeholders

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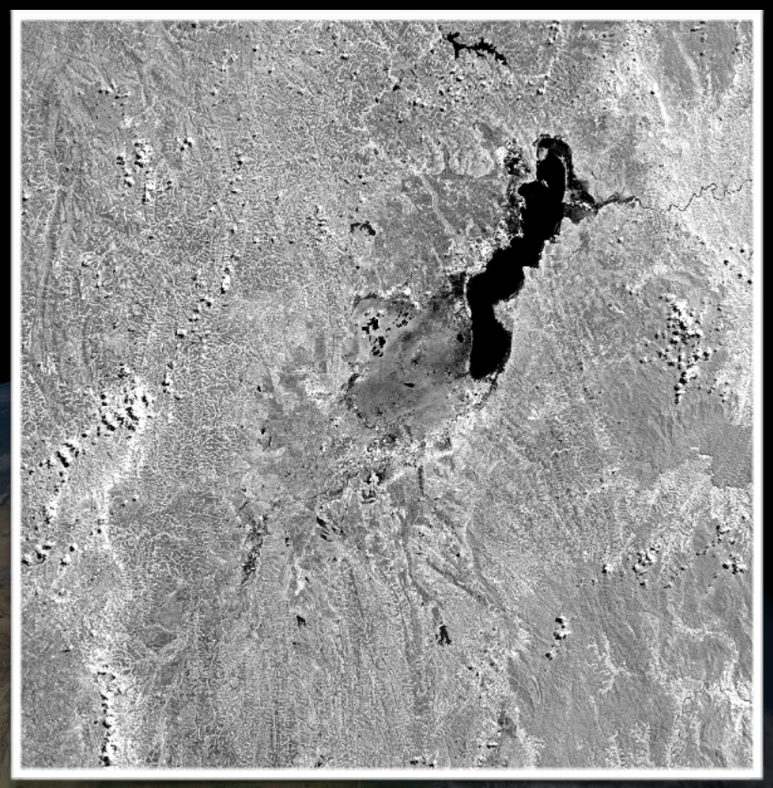
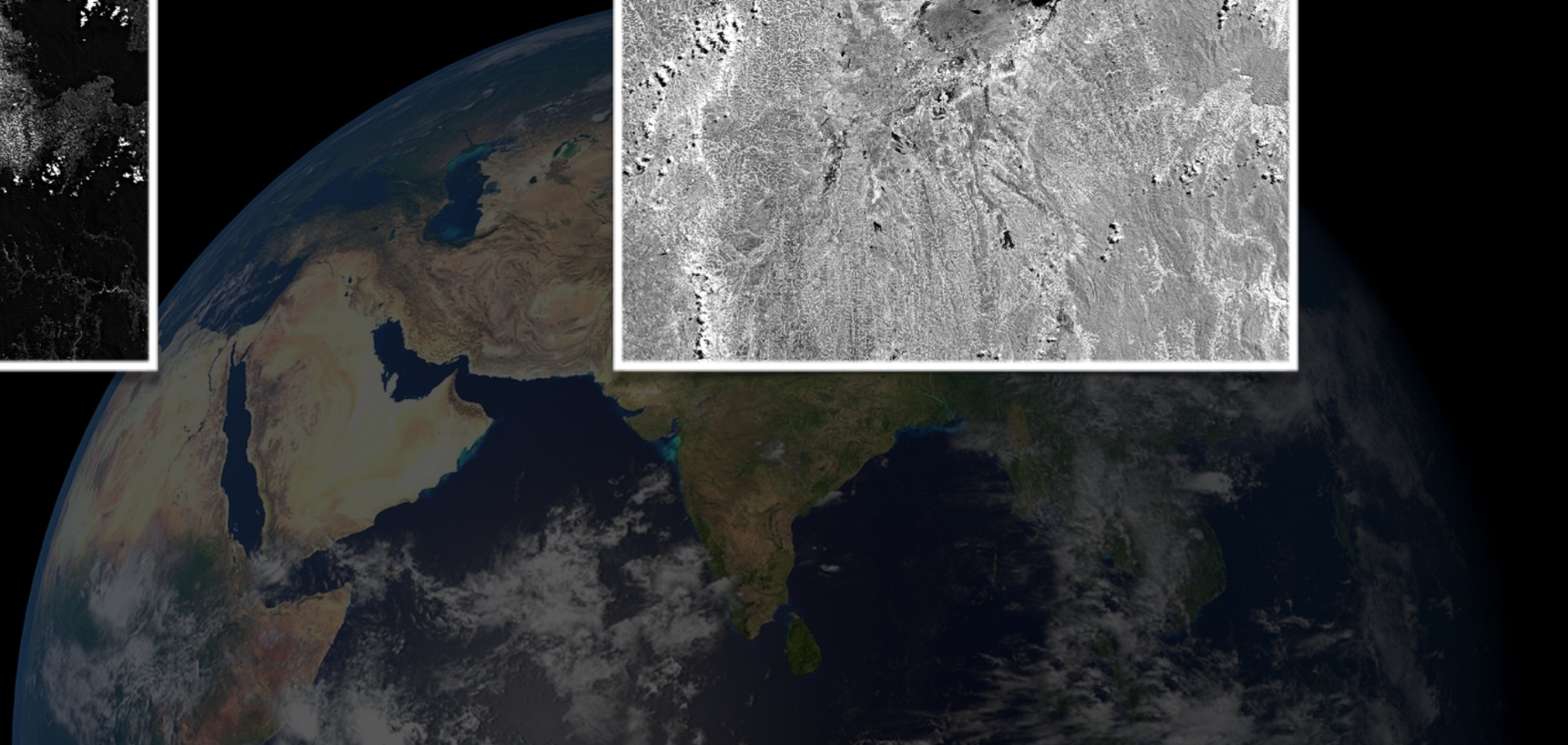
Skills: Data Processing

Red band image

Near-infrared band image





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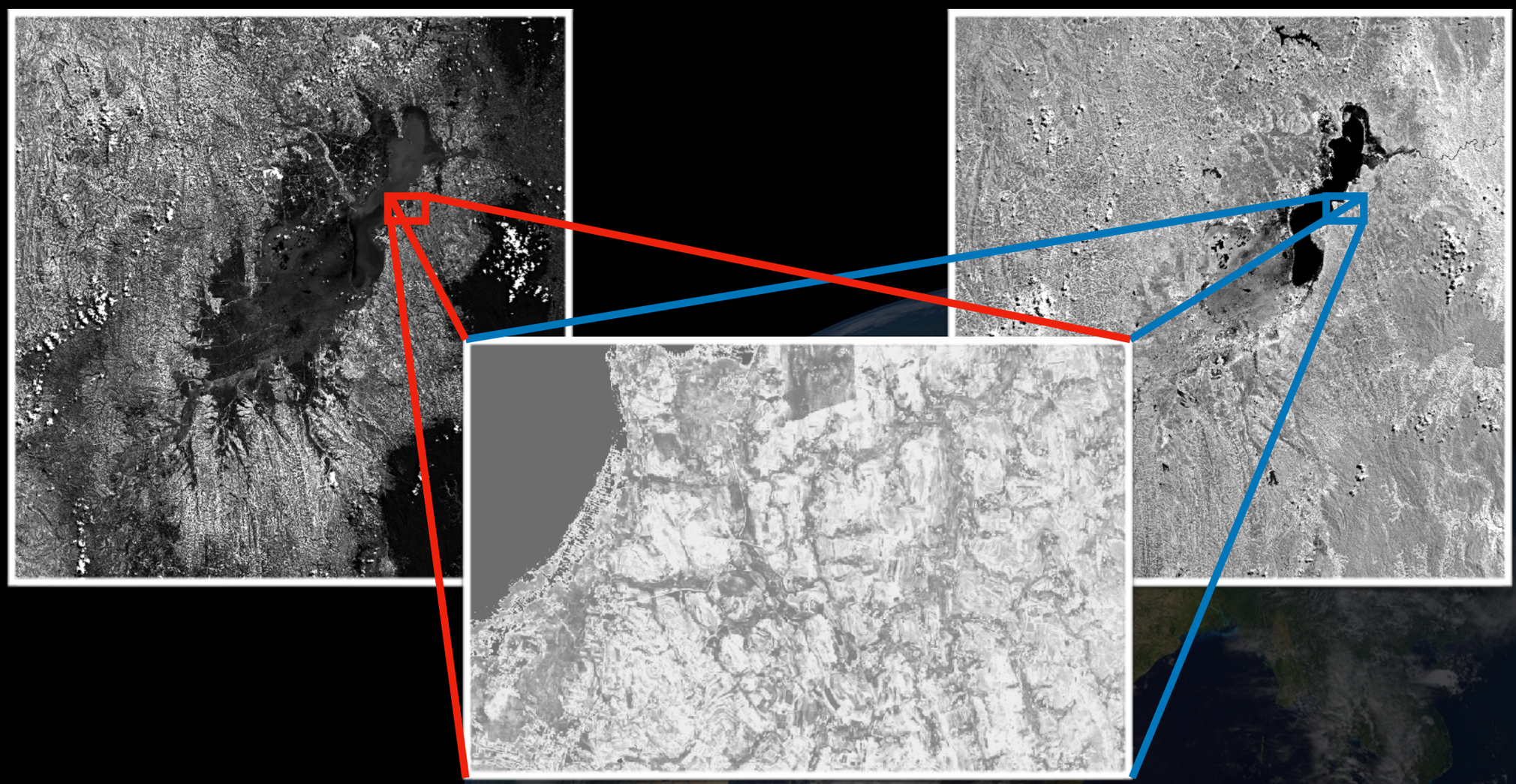

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NDVI

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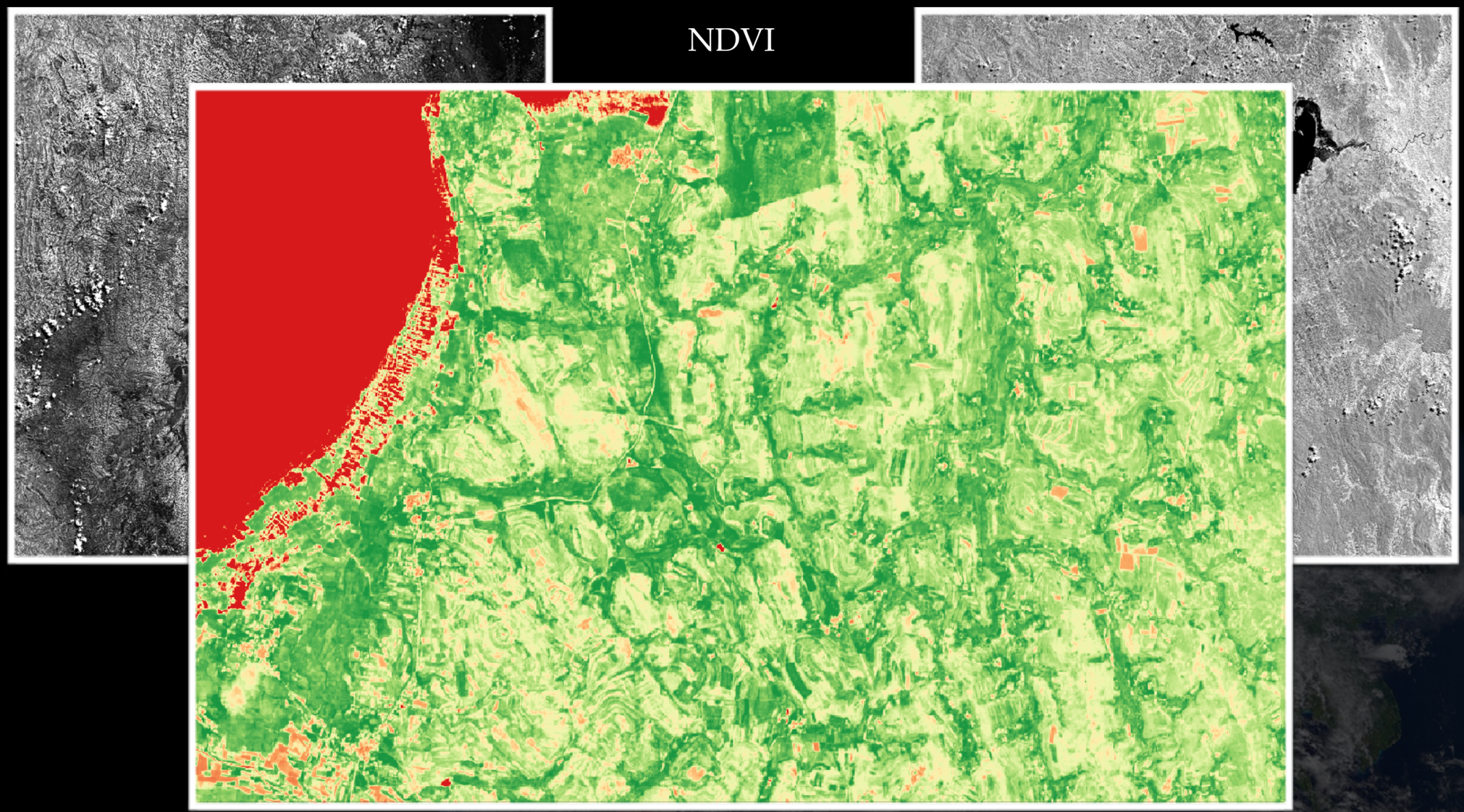

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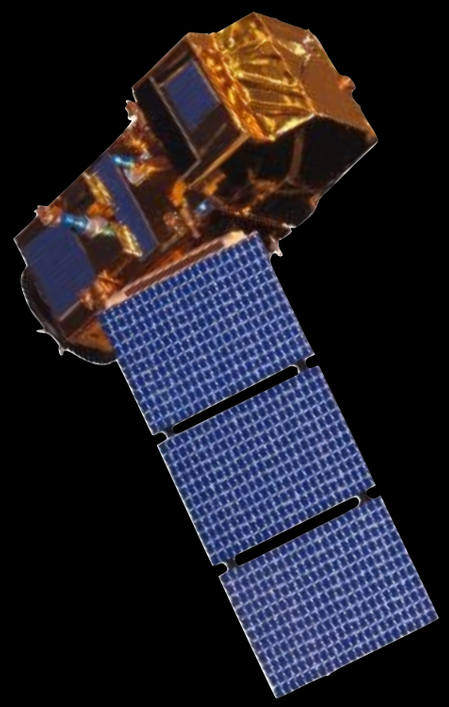
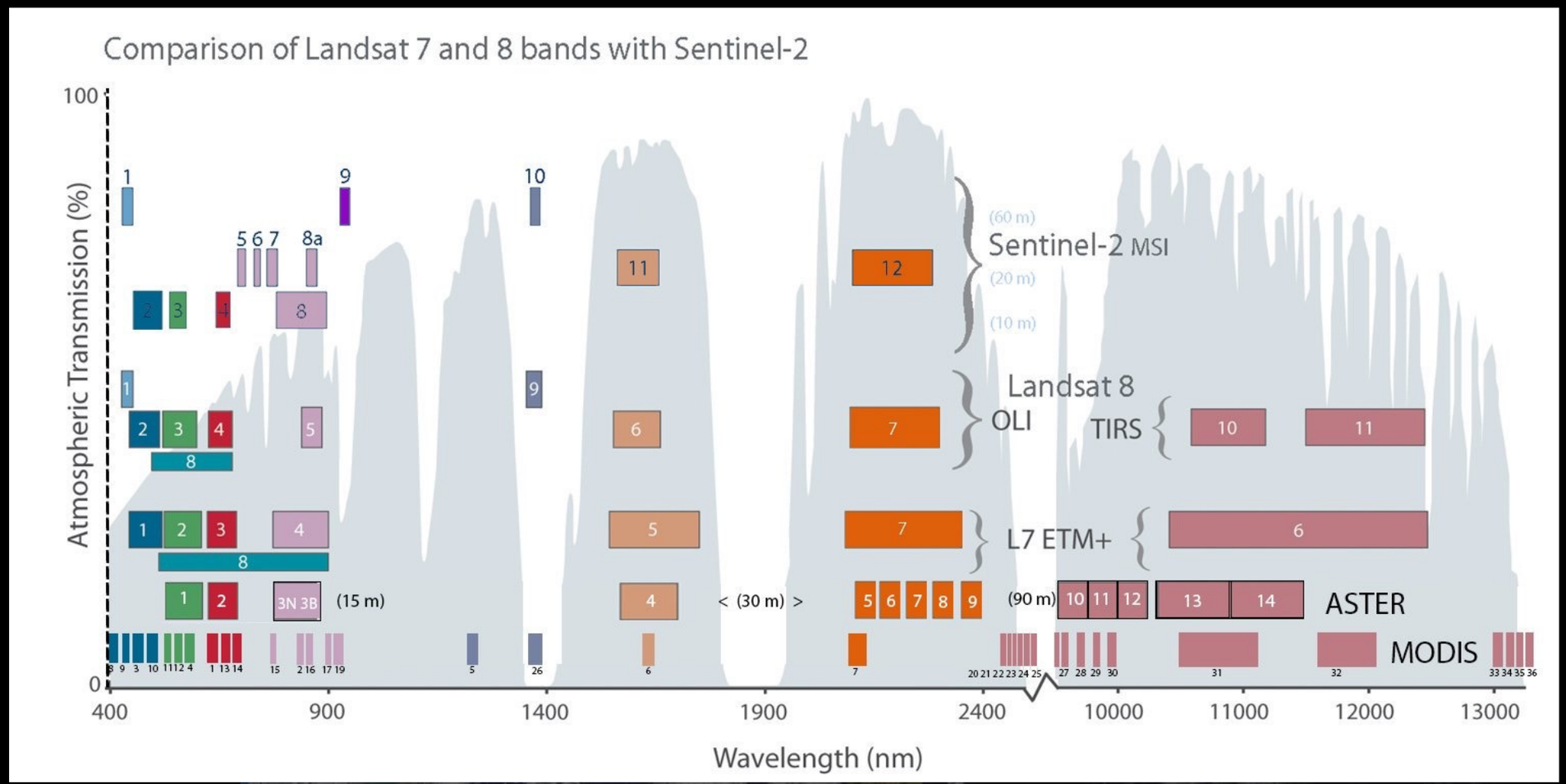


Use Sentinel-2

Open source solution to produce 'science-ready' maps



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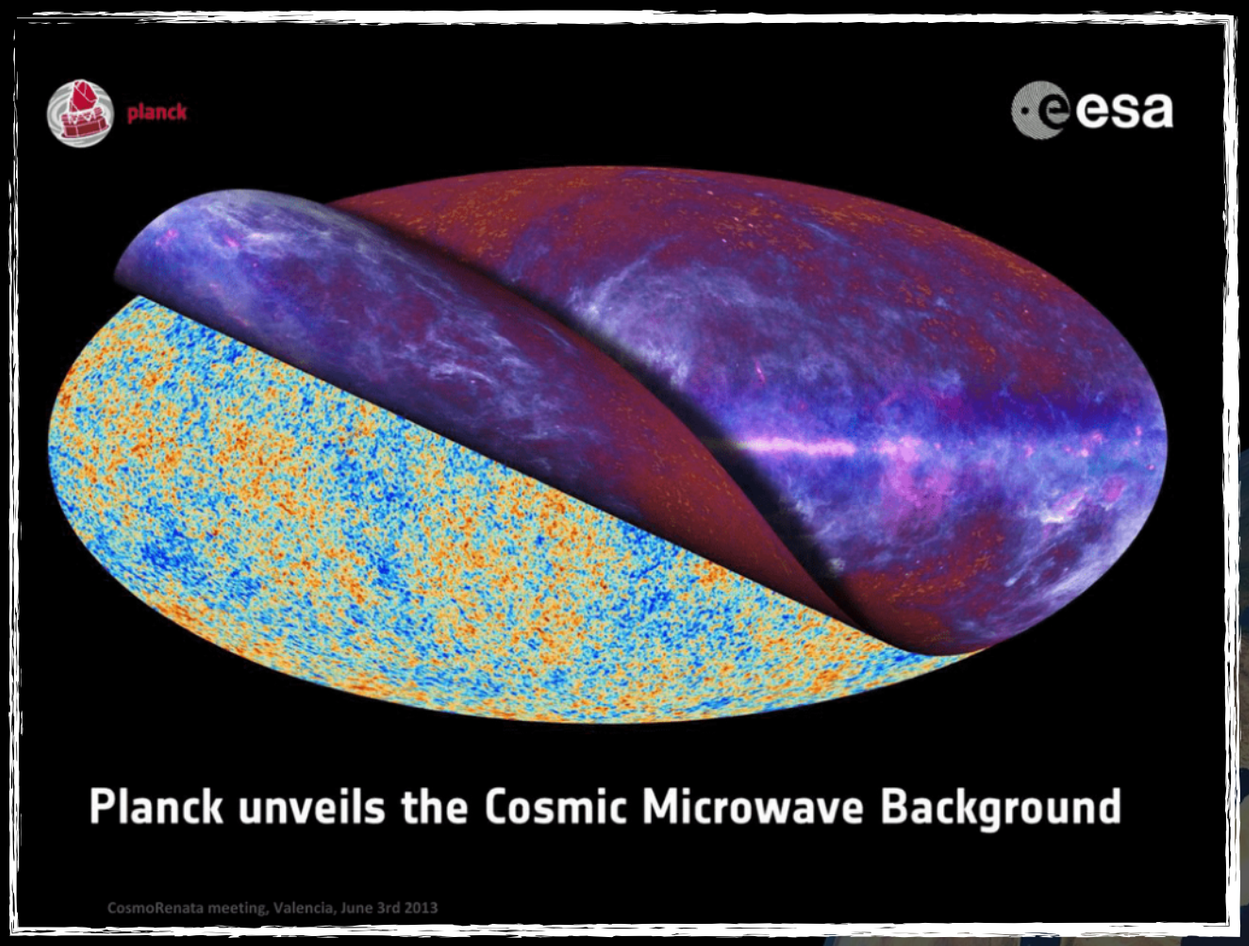
SKILLS: PHYSICS MODELING

Seeing the invisible…



Our Galaxy: K

Cosmic Microwave Background: micro-K

Accurate physical description of signal properties enables to distinguish various components

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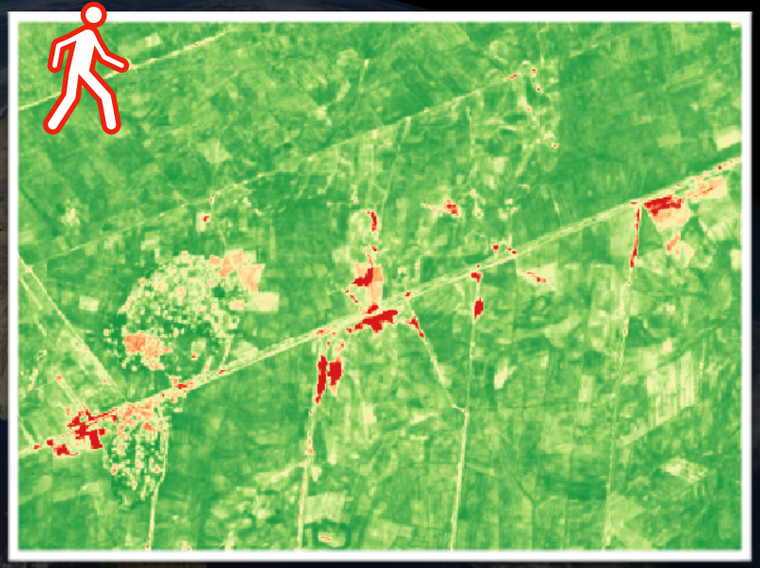
Skills: Statistical Sampling

Everything looks the same from space…

Machine learning perspective:

Building highly reliable training and validation datasets is paramount



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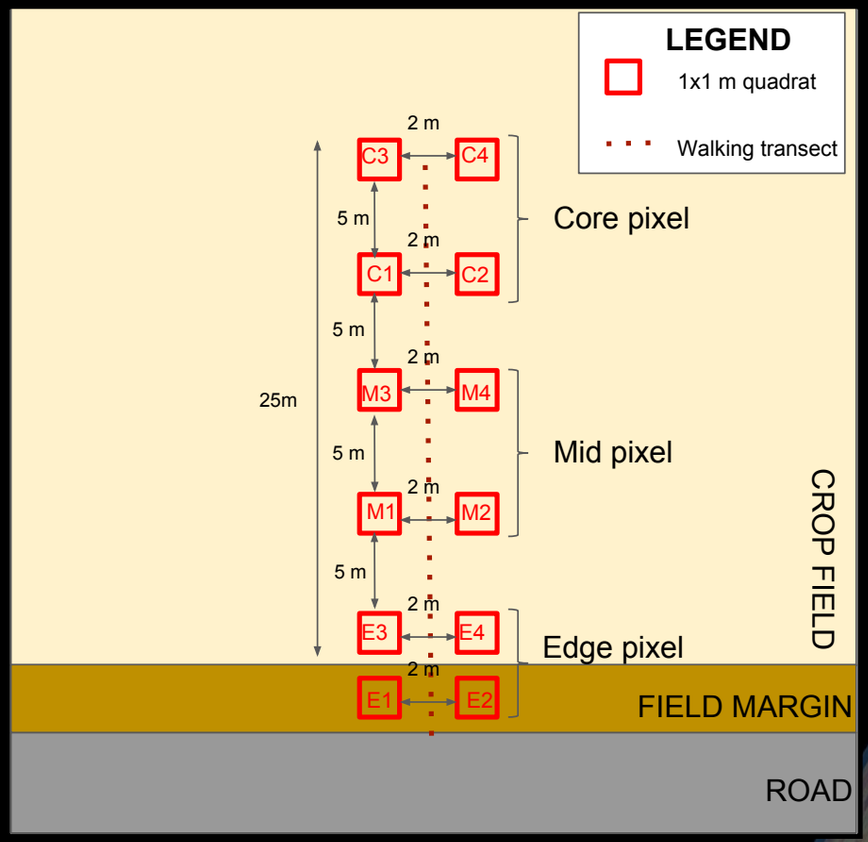
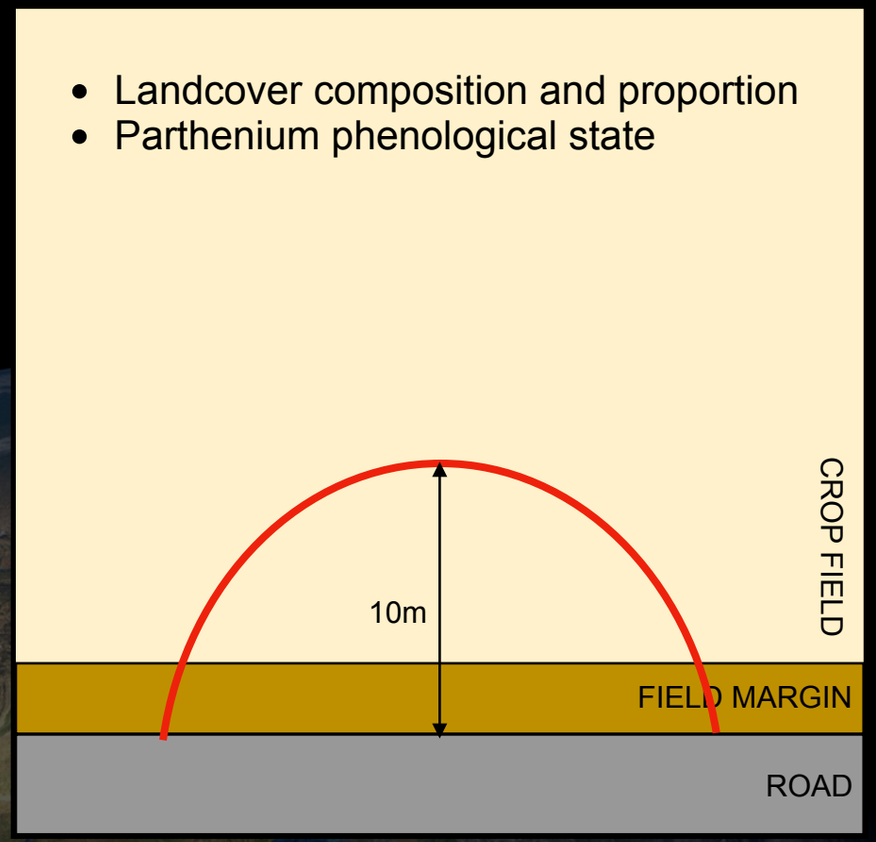


Adapting our sampling strategy

<--- before

after --->



- Landcover composition and proportion
- Parthenium phenological state

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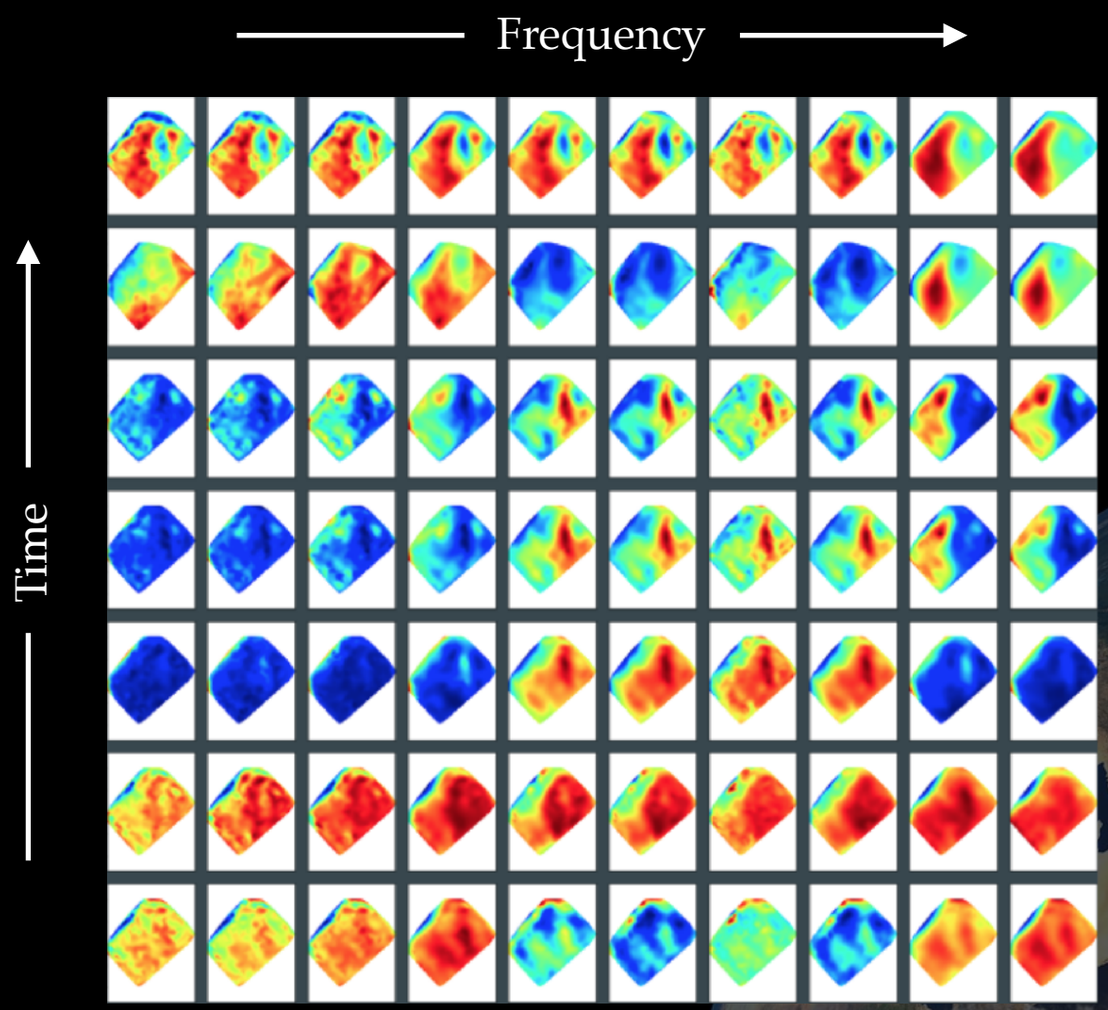
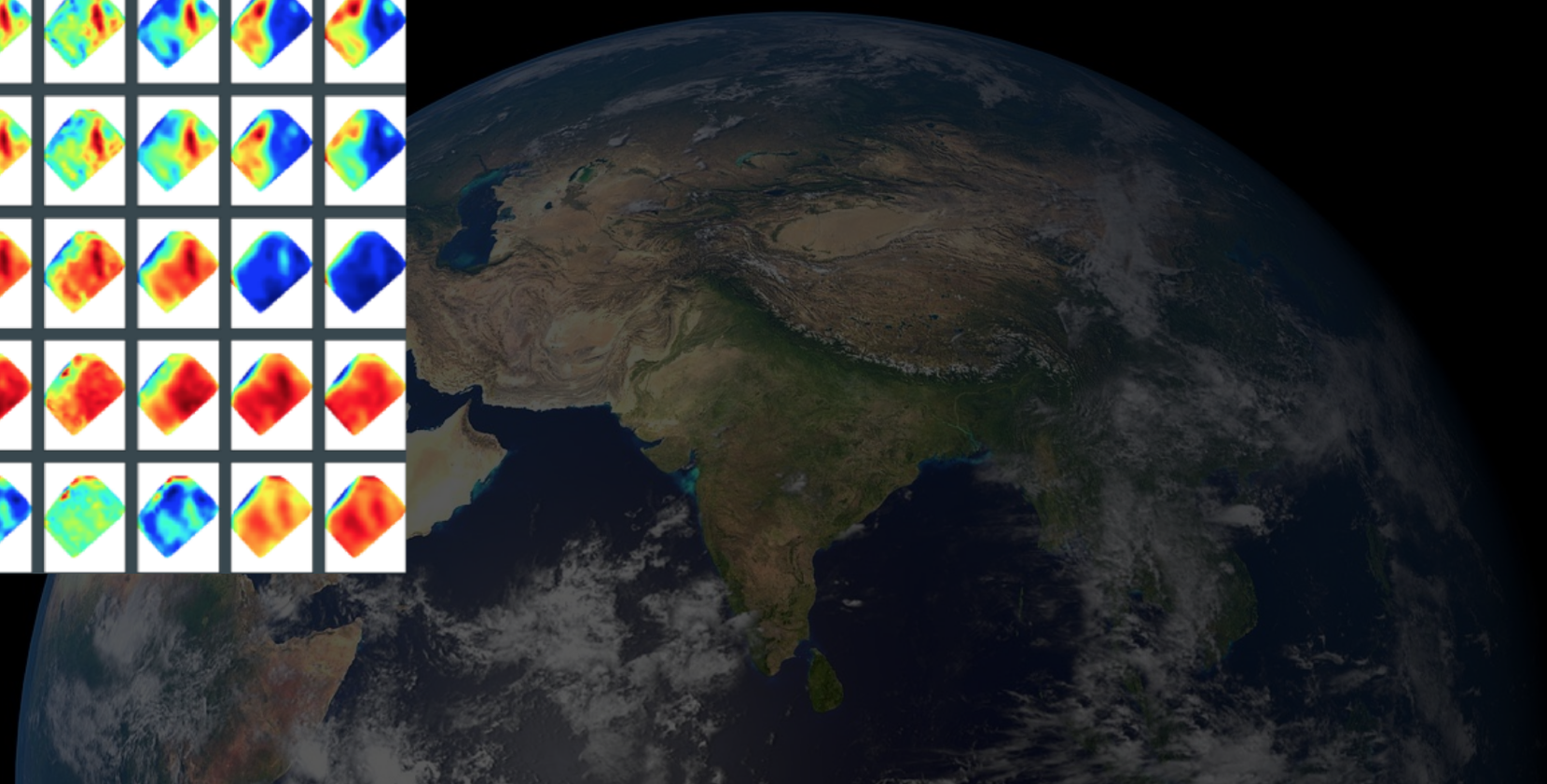
Skills: Time-domain Astrophysics, Population Studies



Developing non-stationary, multi-spectra model to differentiate Parthenium from other types of vegetation.

Sounds a lot like astronomy to me…



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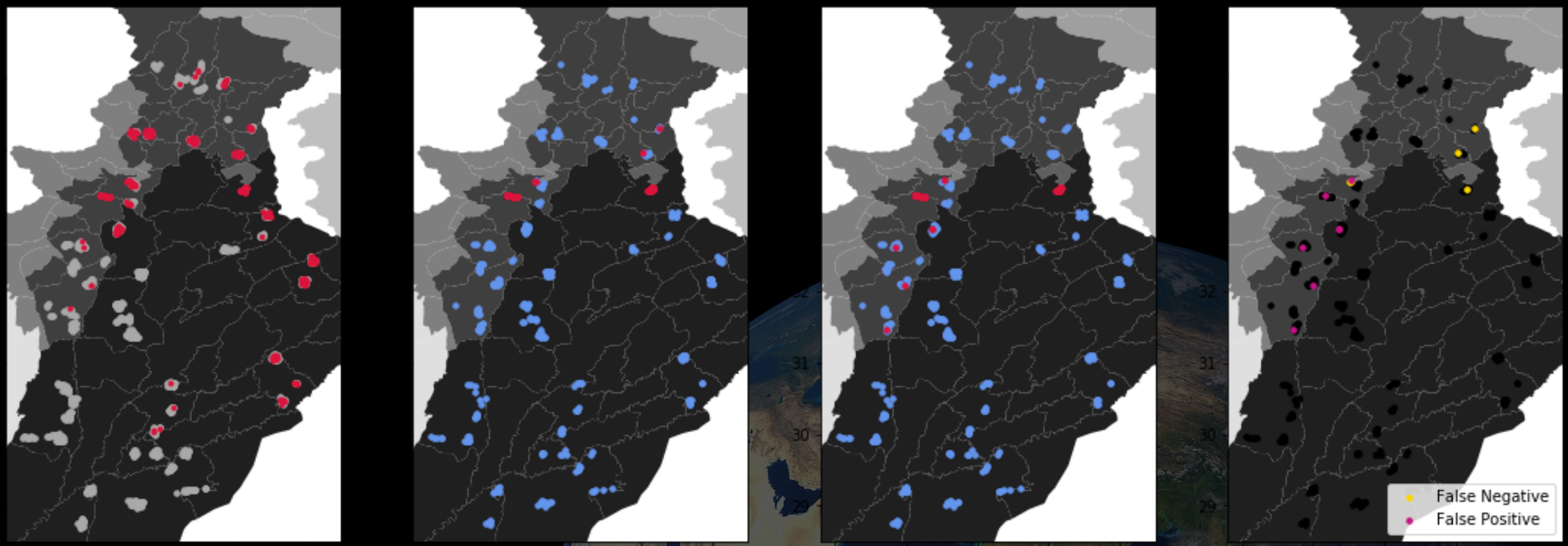
SKILLS: DATA SCIENCE

Some results from our machine learning classifier v1.0



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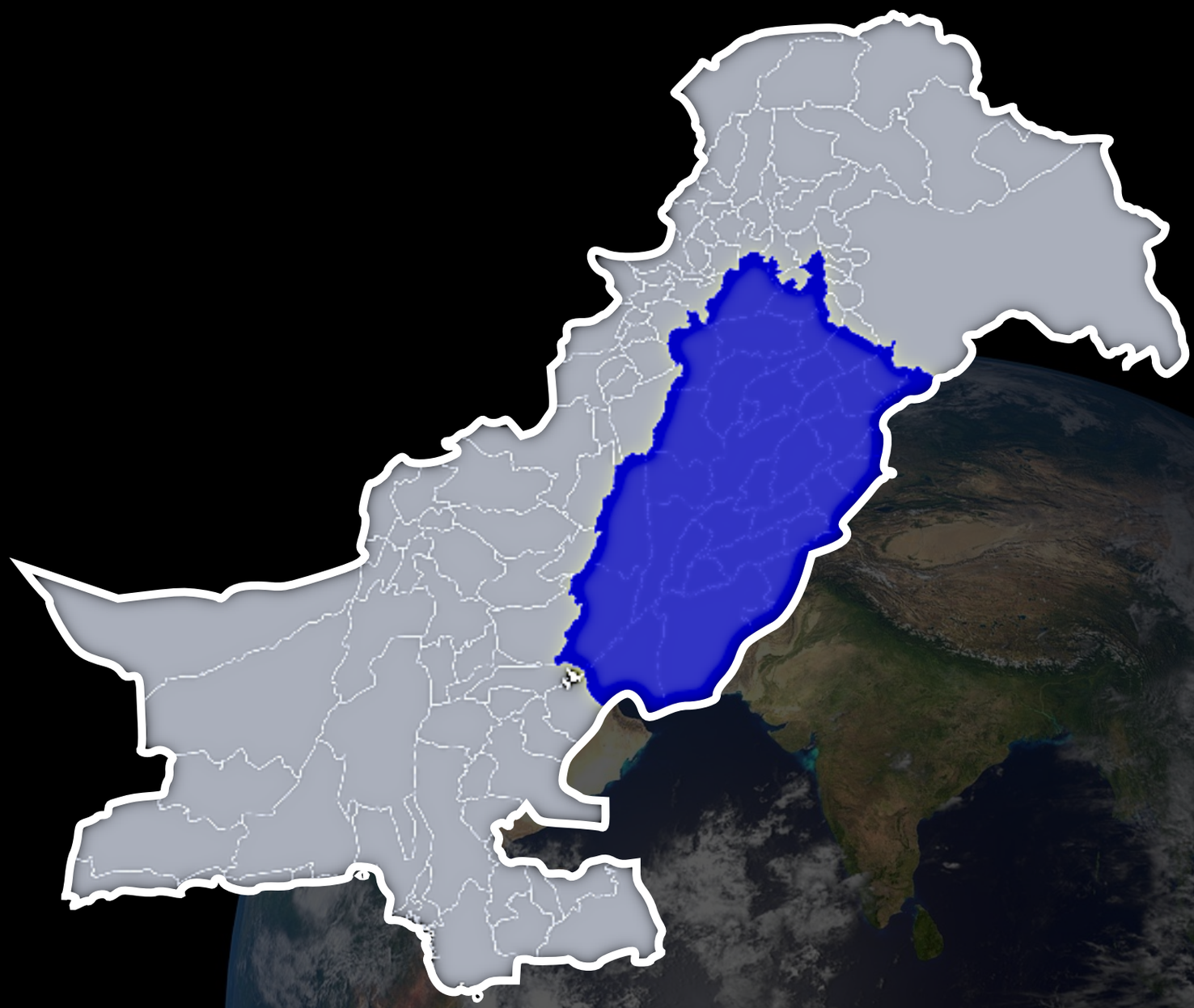
Skills: Data Science

Extending the Parthenium map to the full Punjab region



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Skills: Data Science

Now need to go through proper validation phase.

One more field campaign coming. Plan to run double-blind experiment.

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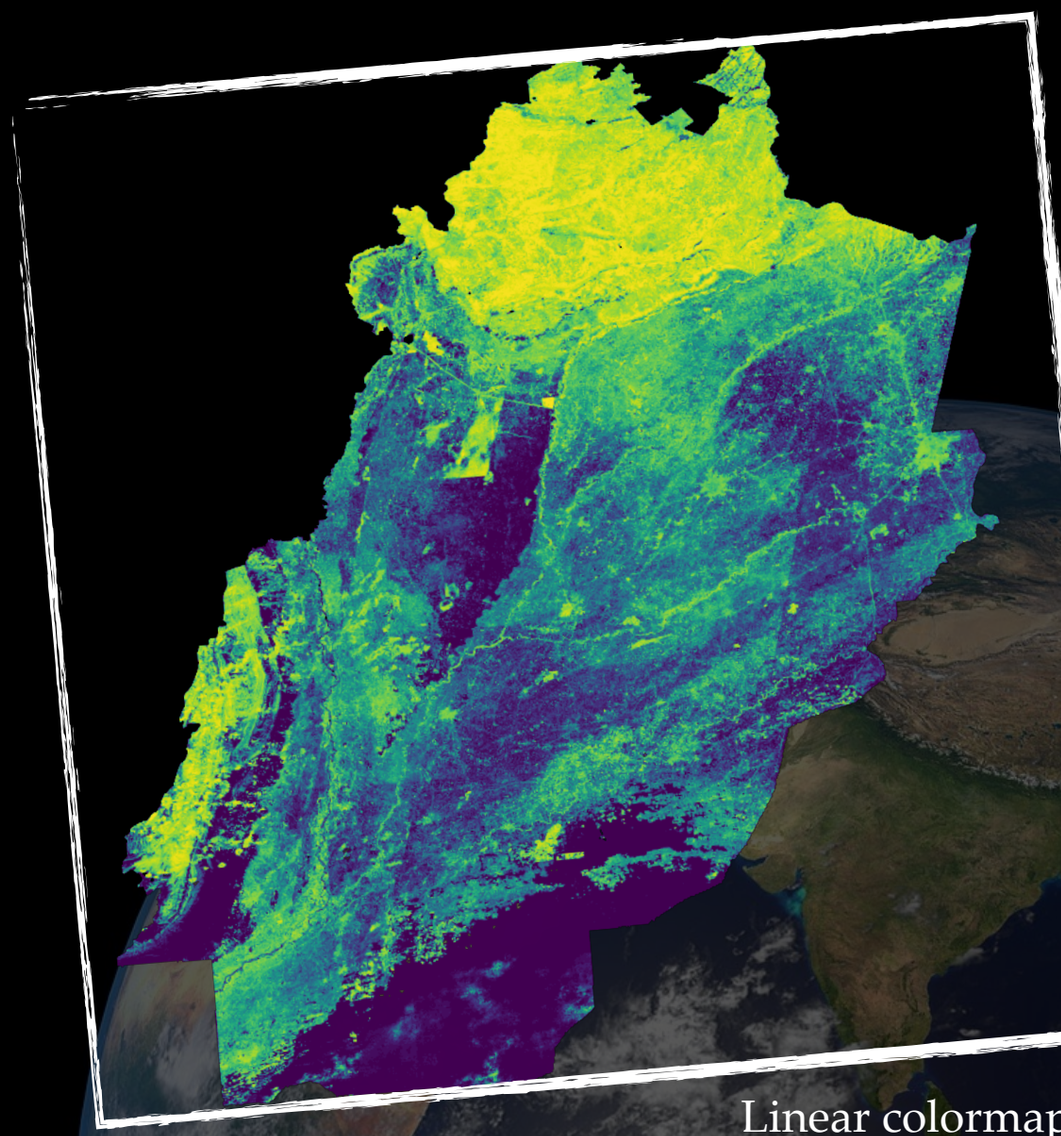

Linear colormap

Preliminary

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Skills: Data Science

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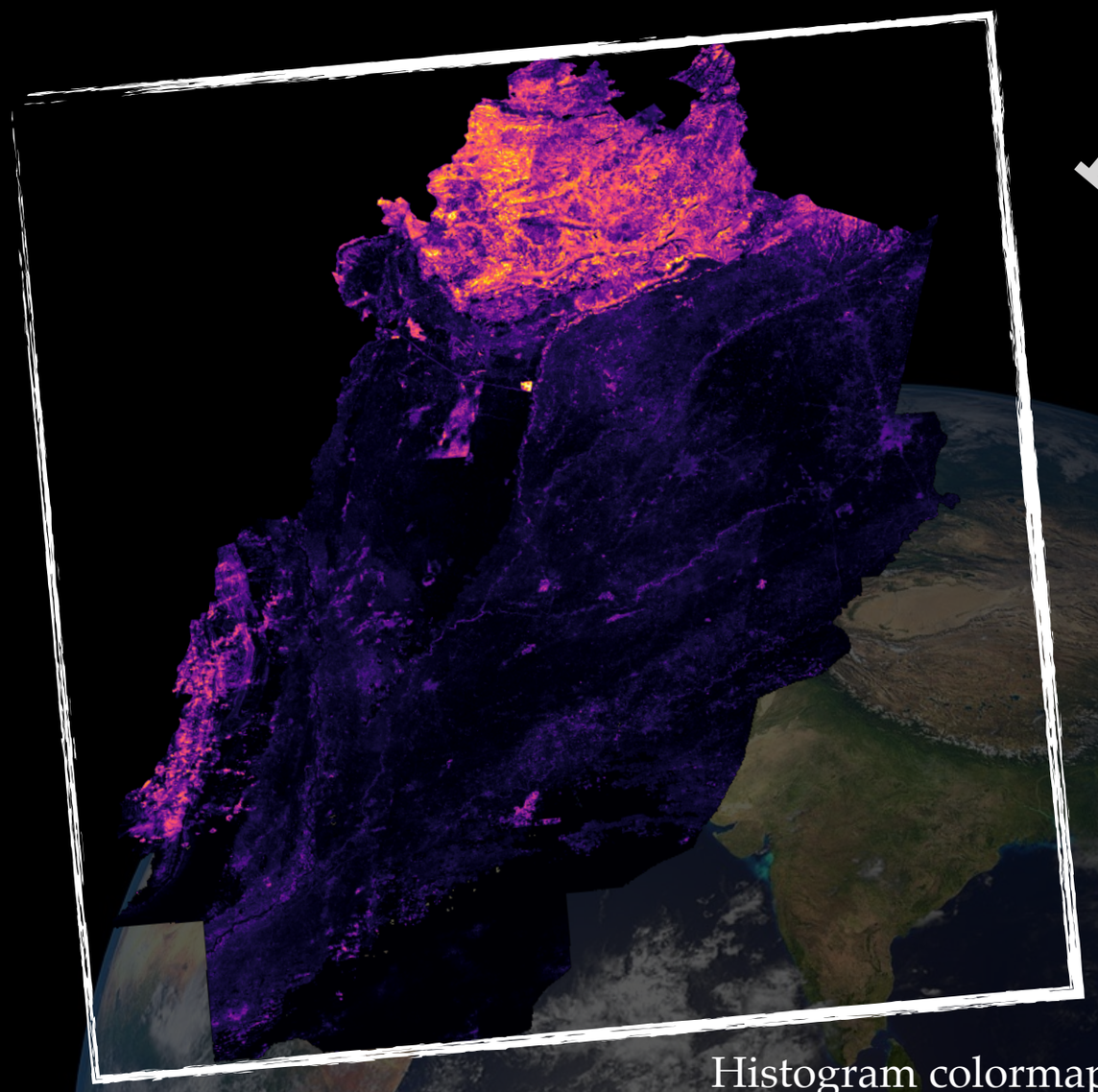

Histogram colormap

Preliminary

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Skills: Optical Instrumentation

Sampling by humans is error-prone...

HawkPi

- 6-band camera
- Built with RasberryPi parts
- Low cost (< £1000; 10x cheaper than anything commercial)
- Open source design

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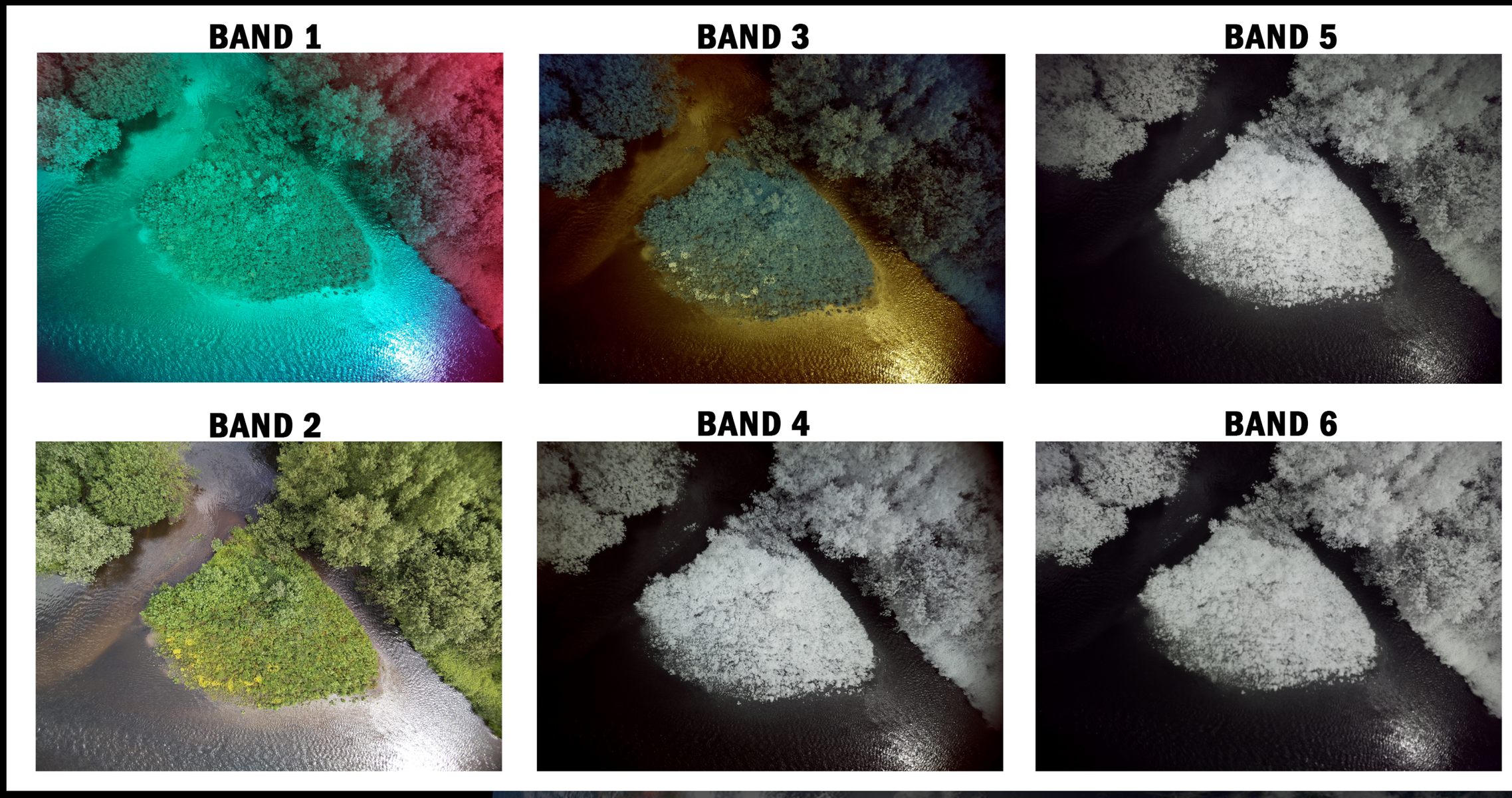
Multi-band ground truthing



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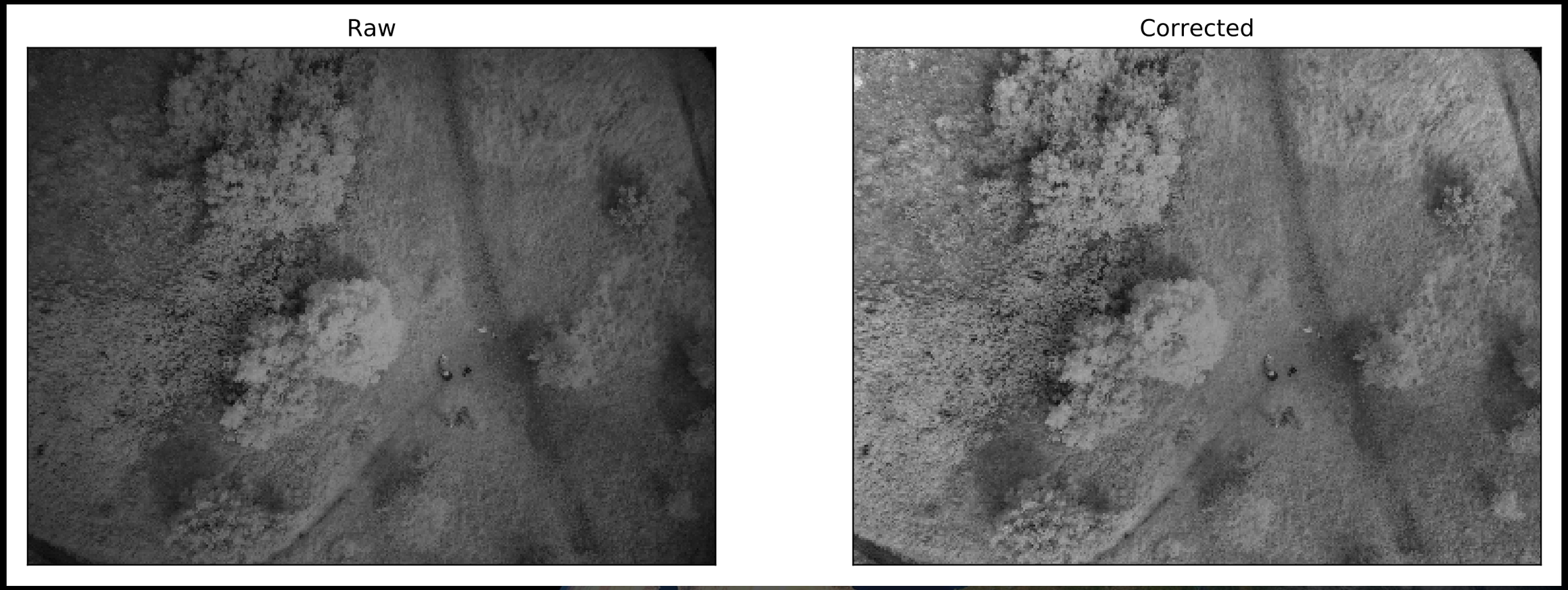
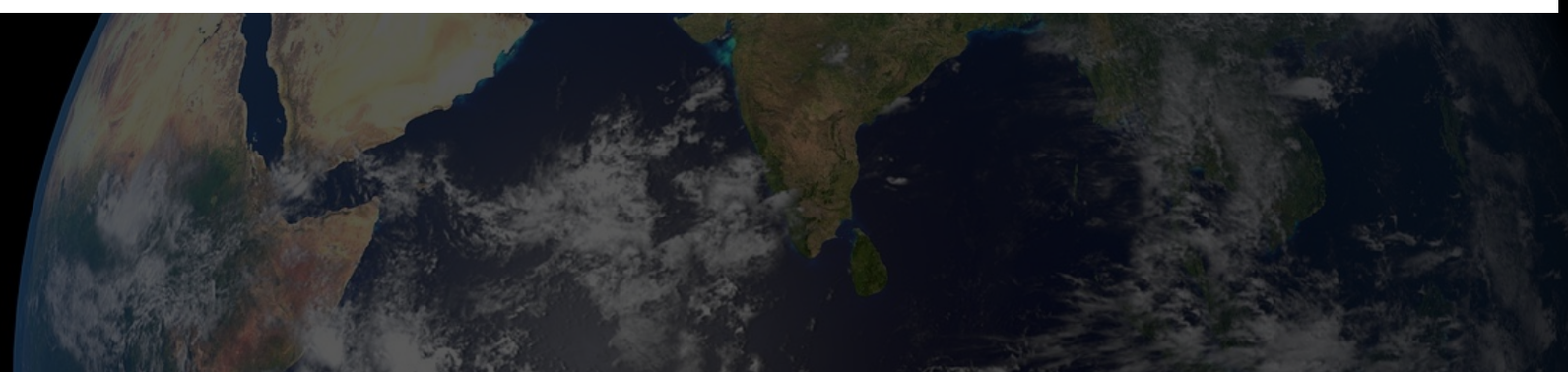
Skills: Optical Instrumentation

Careful image calibration





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SKILLS: OPTICAL INSTRUMENTATION

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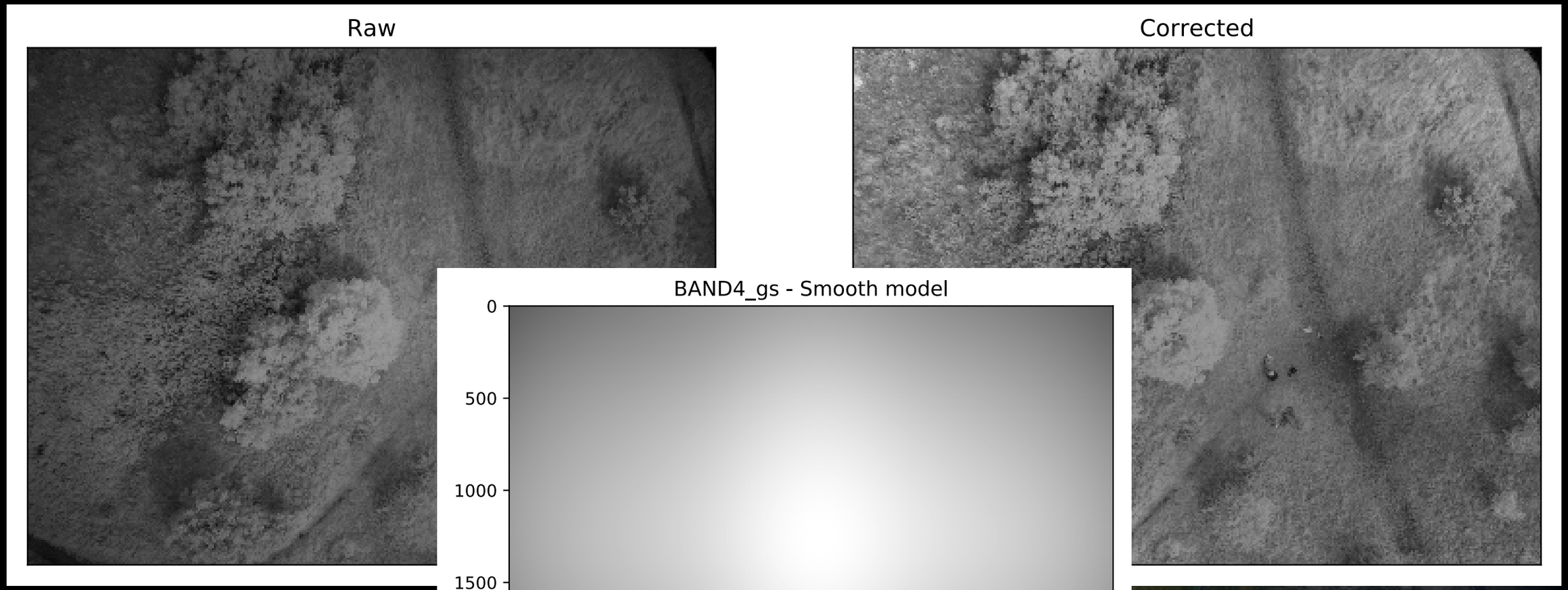

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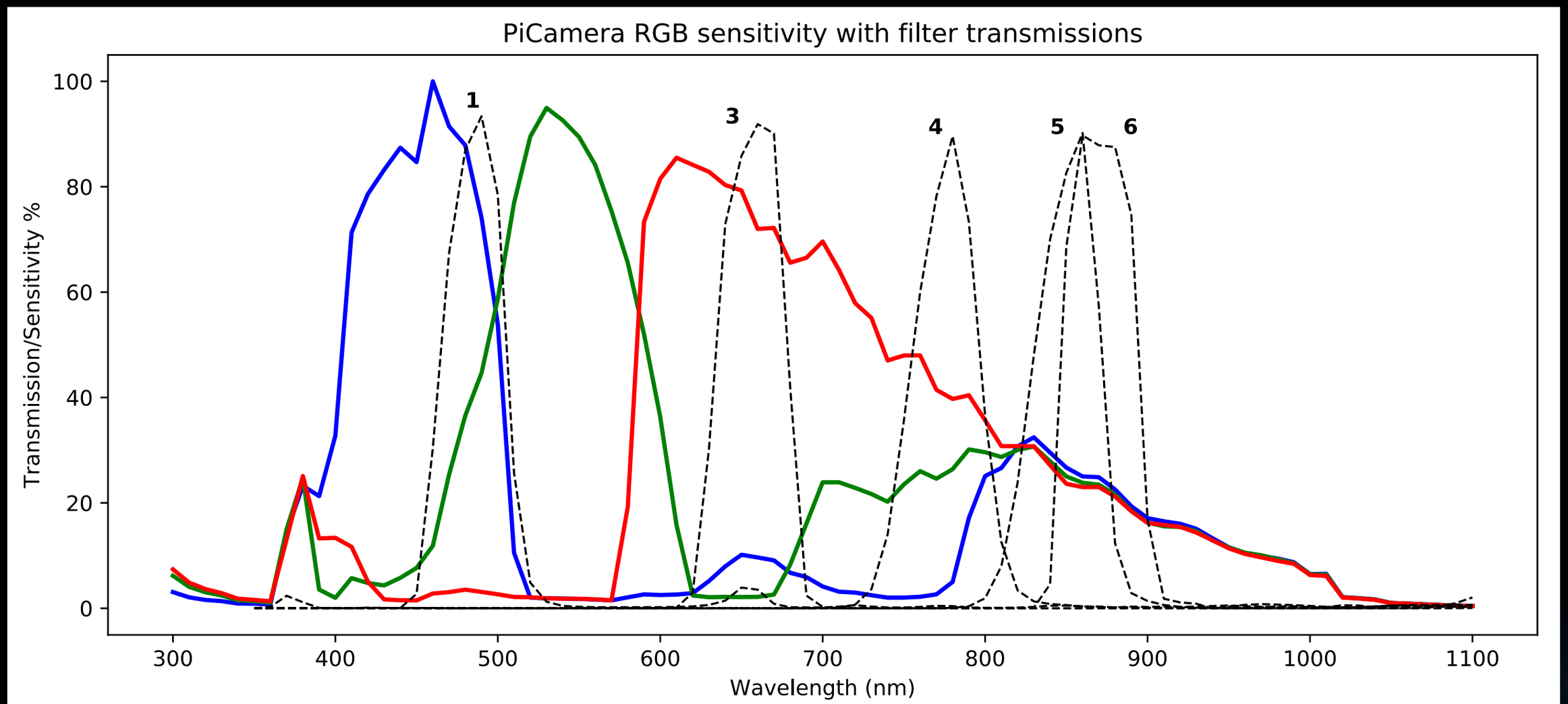

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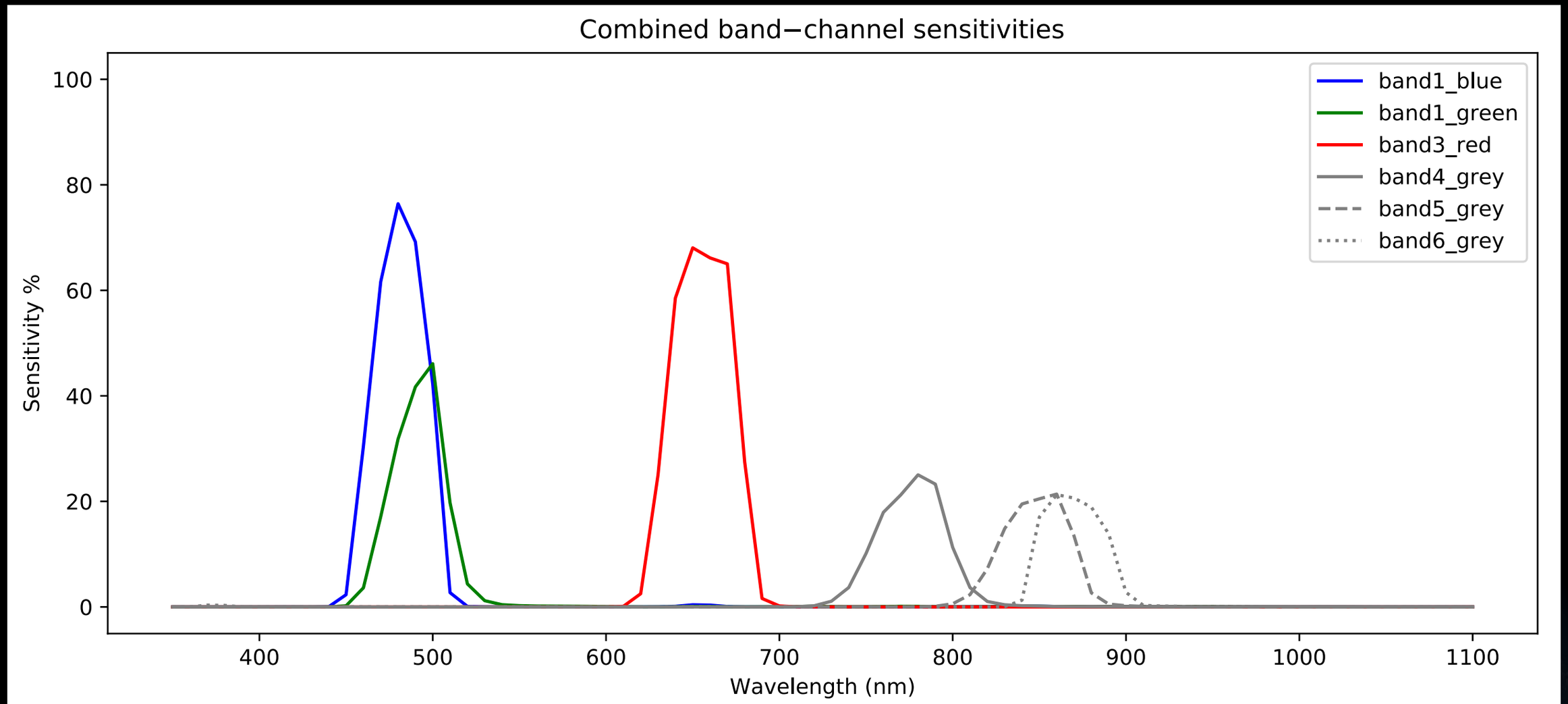

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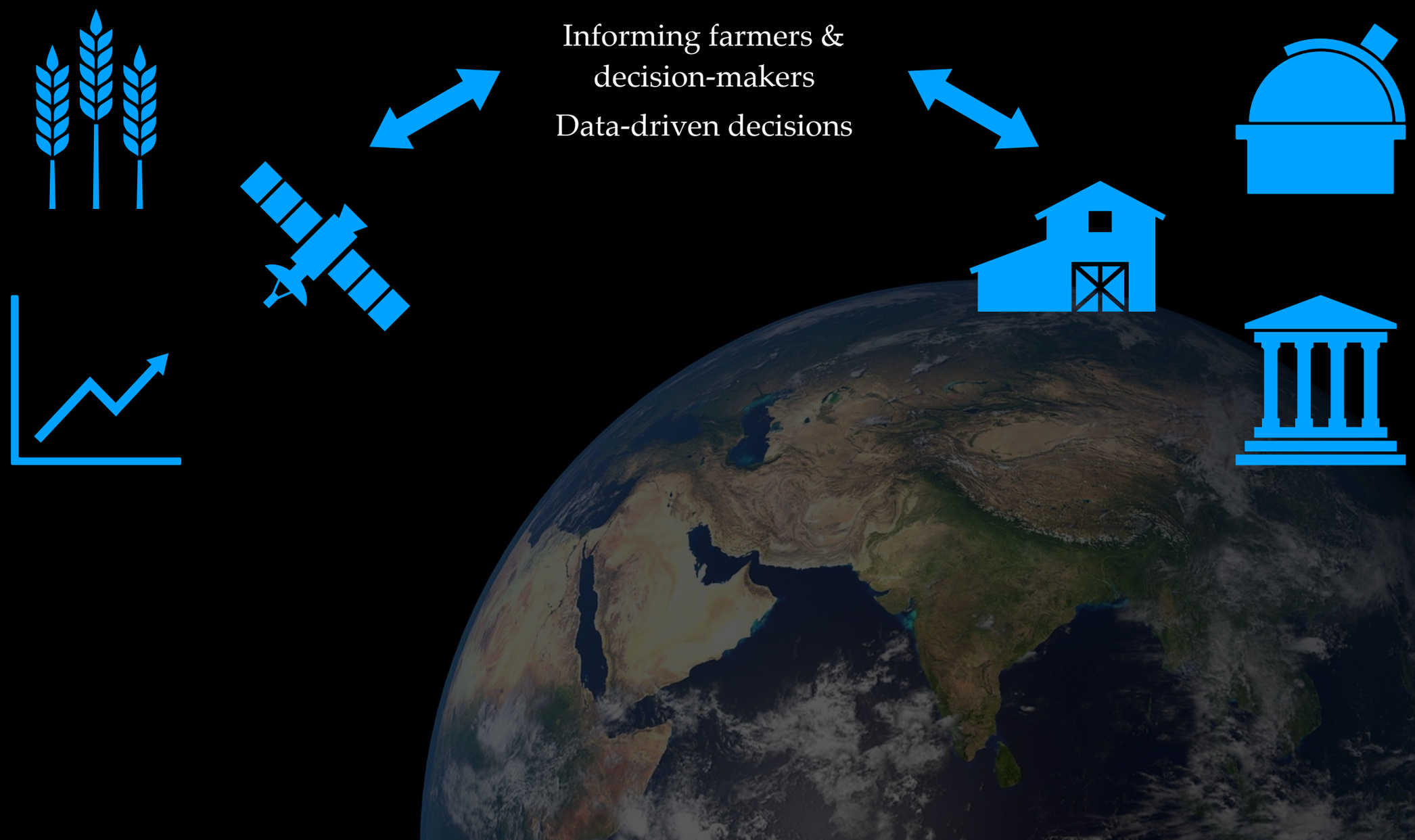
Skills: Science Dissemination



Pathways to impact

1. Policy making in agriculture, livestock, and human health
2. (Automated) monitoring of Parthenium
3. Knowledge exchange with Pakistani researchers

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CABI

small ideas **can make this better**