What is Earth Observation? A Tour of the Technology

Contains modified Copernicus© data

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Copernicus

Framework Partnership Agreement for Copernicus User Uptake

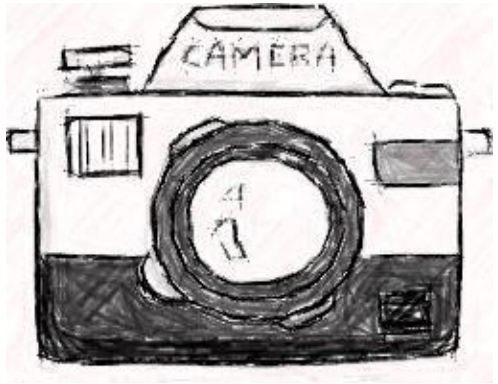
Purpose of this session:

- Basics of Earth Observation (spatial and spectral resolution, temporal frequency etc.)
- The technology – platforms and sensors
- Advantages and limitations – how to make decisions about which EO to use

Understanding the terms

Remote sensing

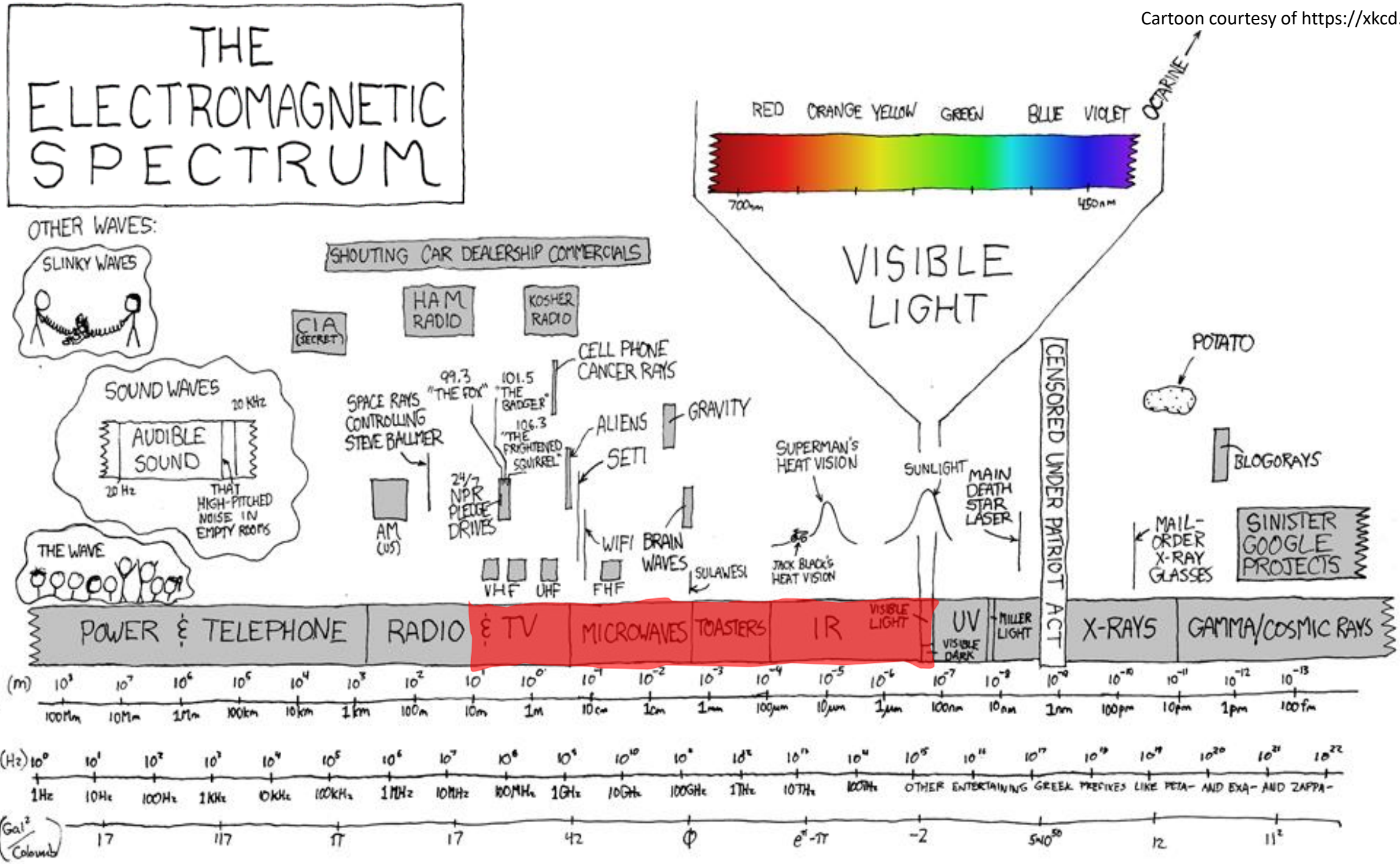
Gathering information about an **object or phenomenon** without making physical contact



Earth observation

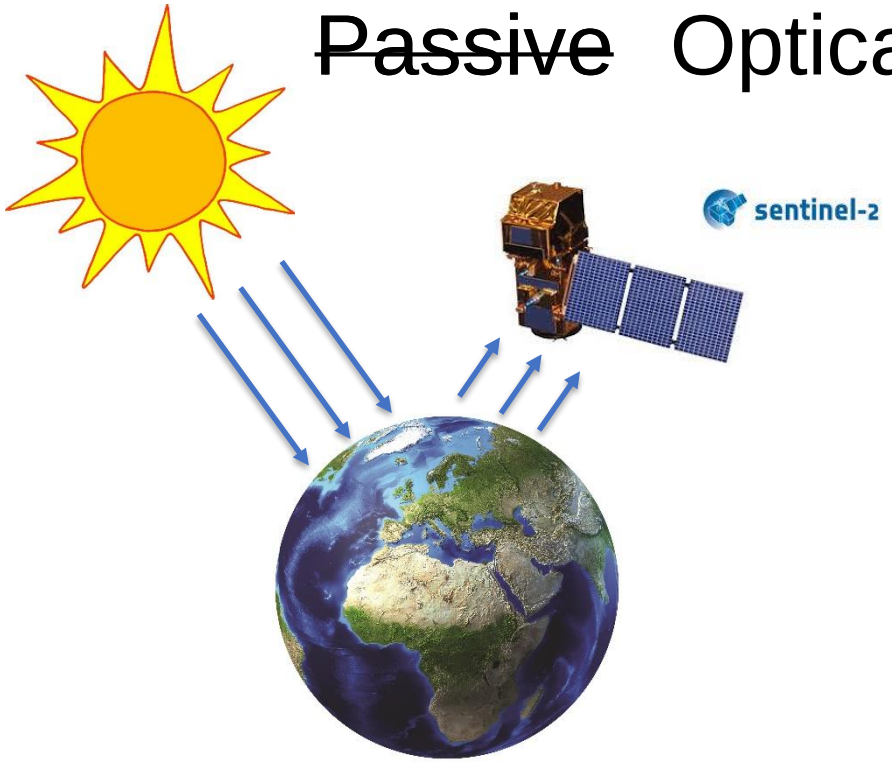
Gathering information about **Earth's** physical, chemical and biological systems via **remote sensing** technologies

Cartoon courtesy of https://xkcd.com/



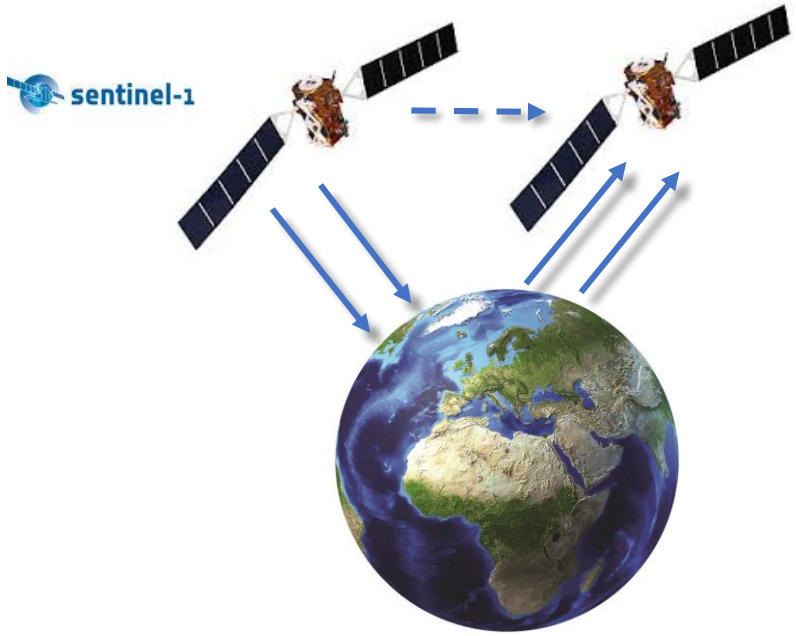
Types of sensing

~~Passive~~ Optical



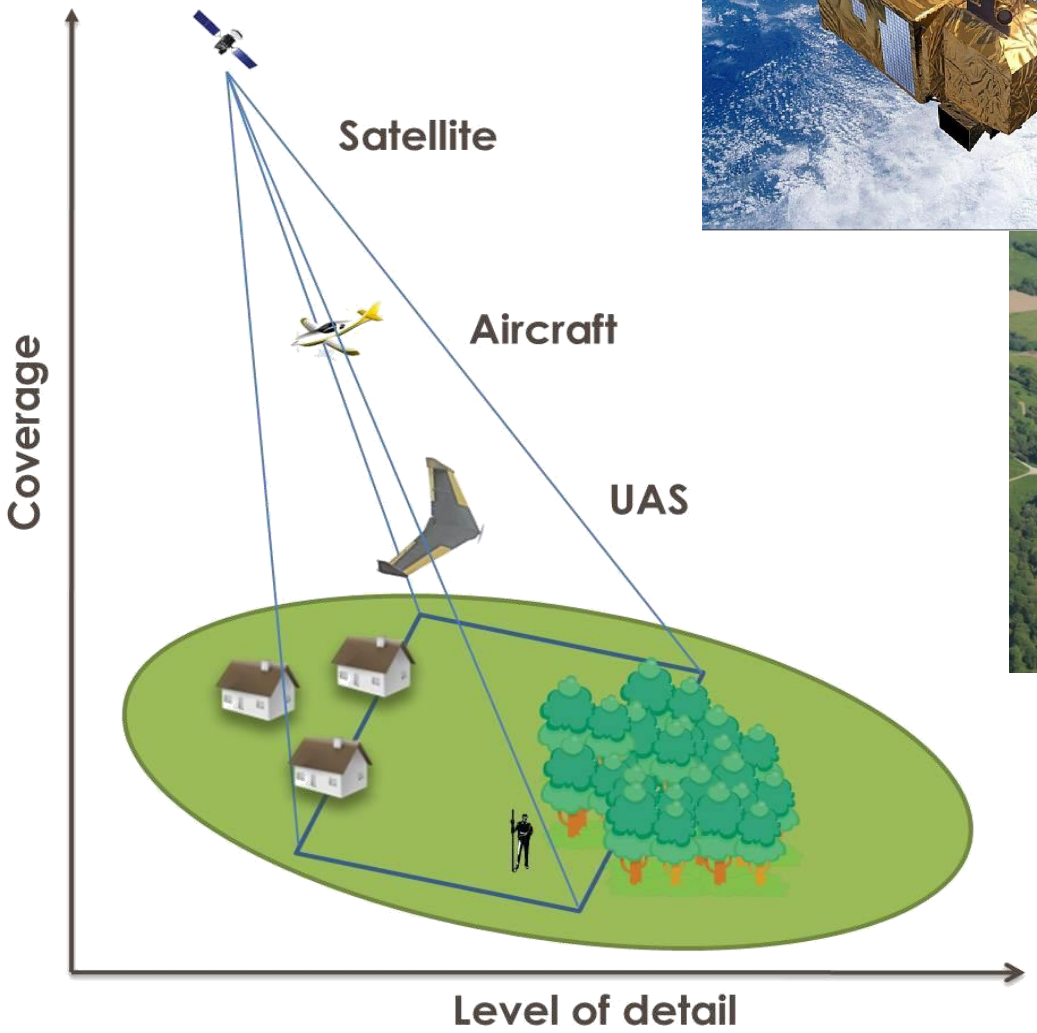
Measures radiation reflected from the Earth's surface such as visible light and infra-red; cannot 'see' through clouds.

~~Active~~ e.g. Radar, Lidar



Transmit their own energy towards Earth and measures the returned signal; can 'see' through clouds.

Platforms



SATELLITE

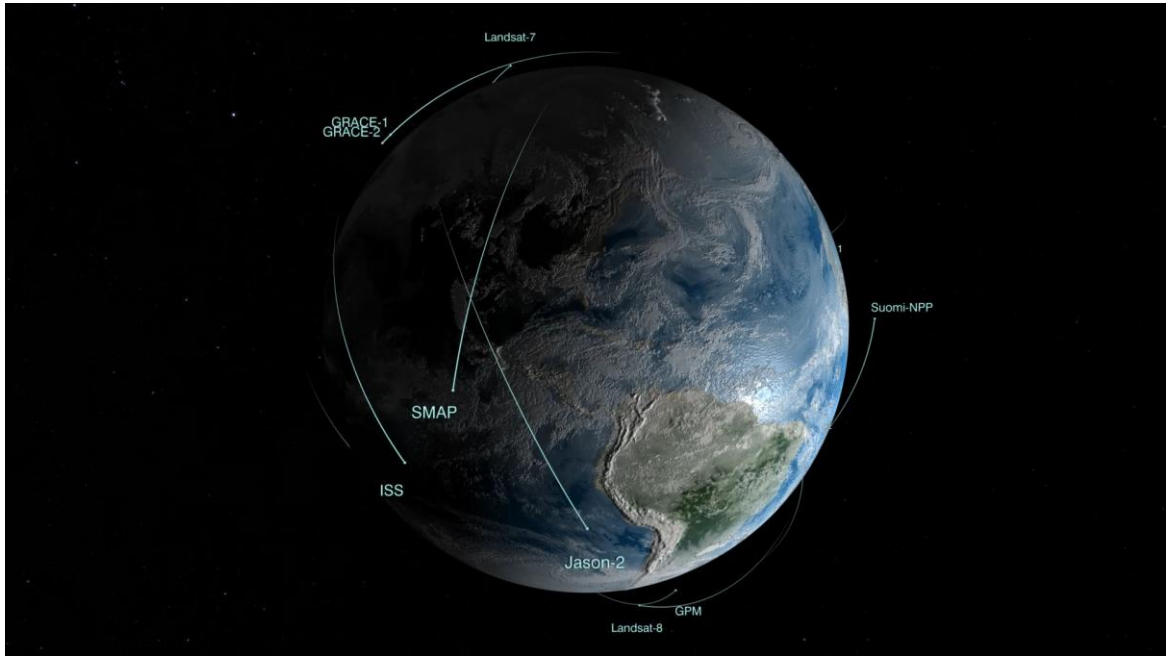
AERIAL

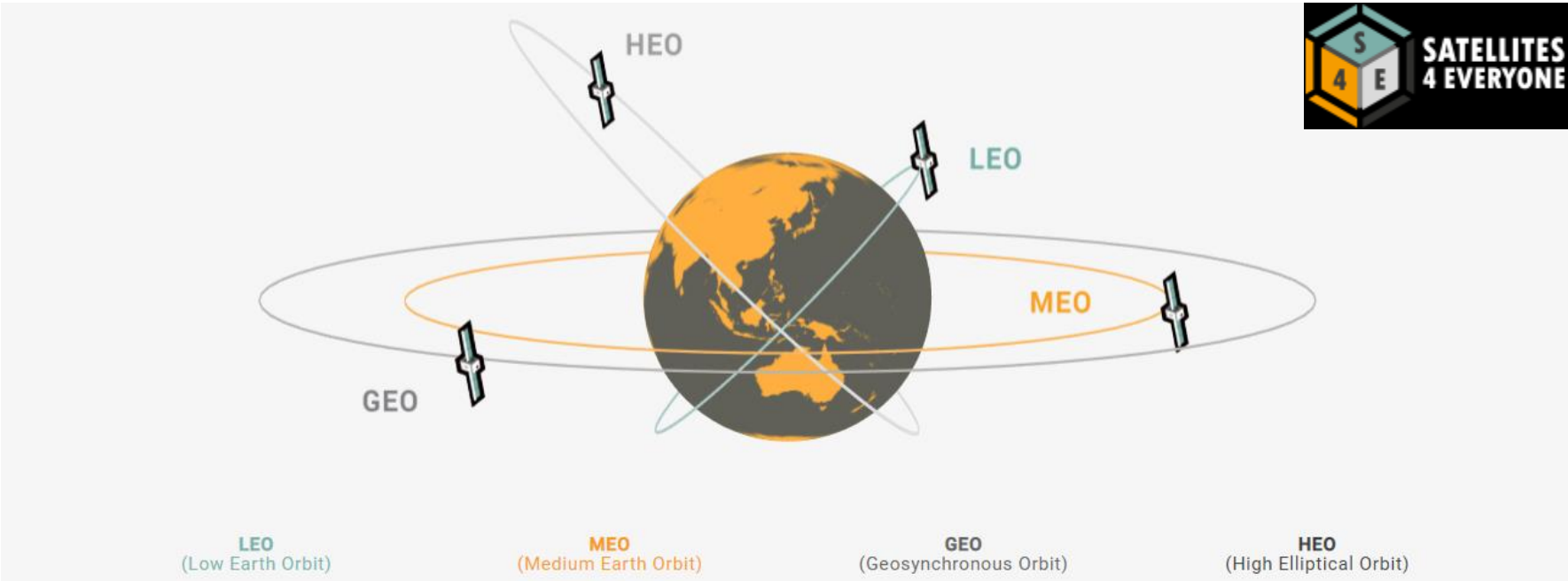
DRONES

How many satellites?

- There are thousands of satellites currently in orbit

- Around ~800 satellites are earth observation missions
  - Meteorology
  - Land
  - Marine
  - Cryosphere





SATELLITES 4 EVERYONE

The four resolutions

SPATIAL the ability of a sensor to identify the smallest size detail of a pattern on an image, usually refers to pixel size.

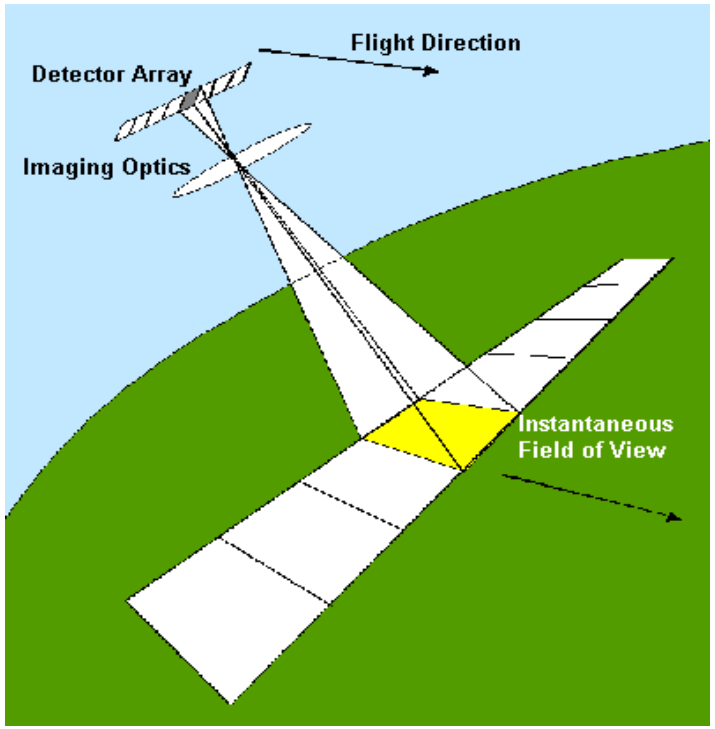
SPECTRAL the sensitivity of a sensor to respond to a specific frequency range, often includes visible light and infra-red.

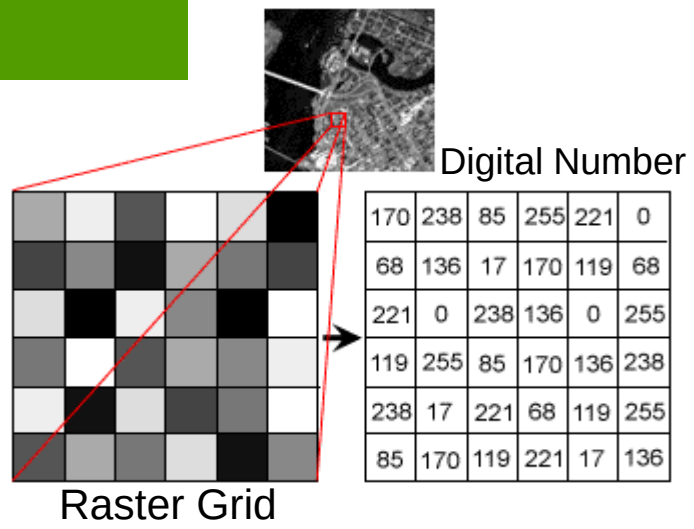
RADIOMETRIC the ability of a sensor to measure signal strength or brightness of objects.

TEMPORAL the frequency at which a sensor revisits an area..

What is a pixel?

SPATIAL





- The **smallest element** of an image
- Determined by **field-of-view** of sensor (optical only)
- Records the **mean value** of the measurement
- Usually **square** in shape (mostly optical only)
- **Do not refer** to any **real life objects** on the ground

Visualising the differences

SPATIAL

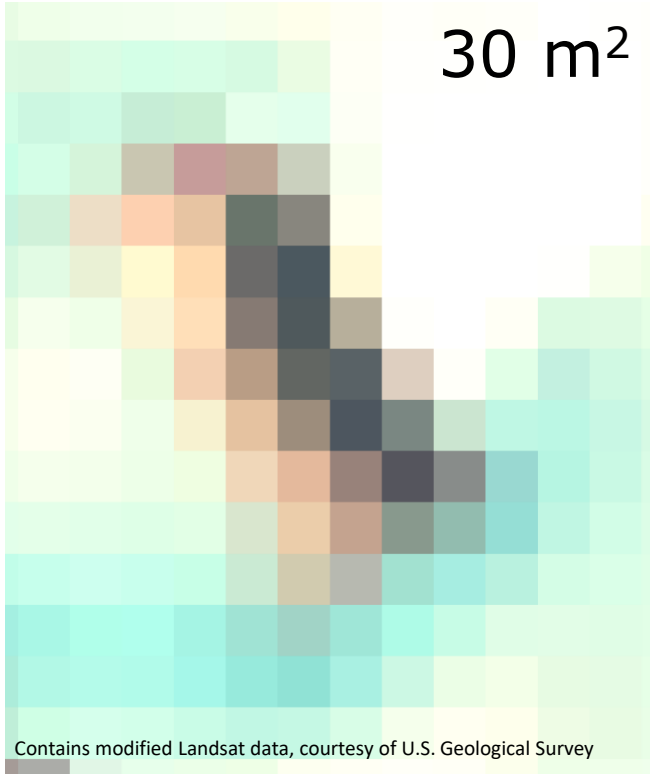
Low → Medium → High → Very High

300 m²

500 m²

1 km²

30 m²



Landsat 8 [Open]

10 m²

Sentinel-2 [Open]

2 m²

Pleiades [Commercial]

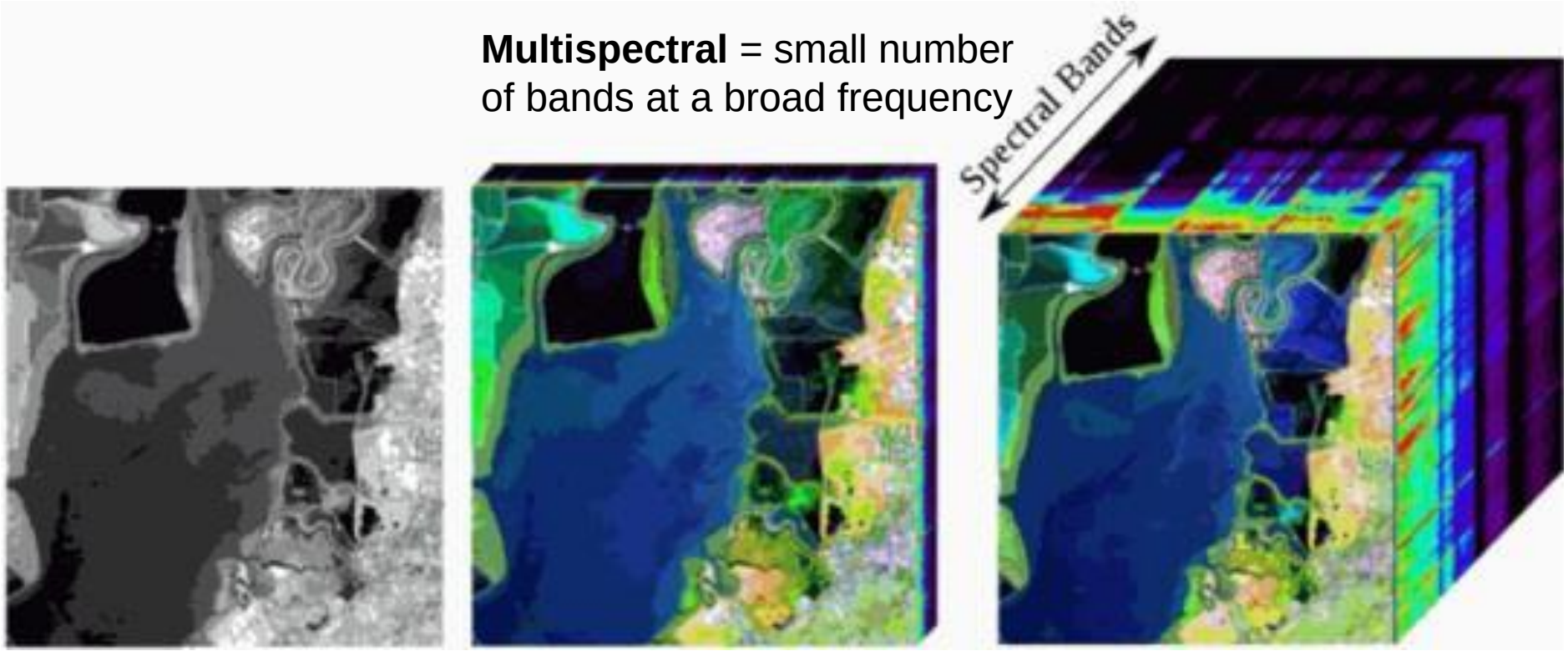
Multispectral vs Hyperspectral

SPECTRAL

The main difference is the ***number of bands*** and ***how narrow*** they are…

Hyperspectral = large number of bands at a narrow frequency

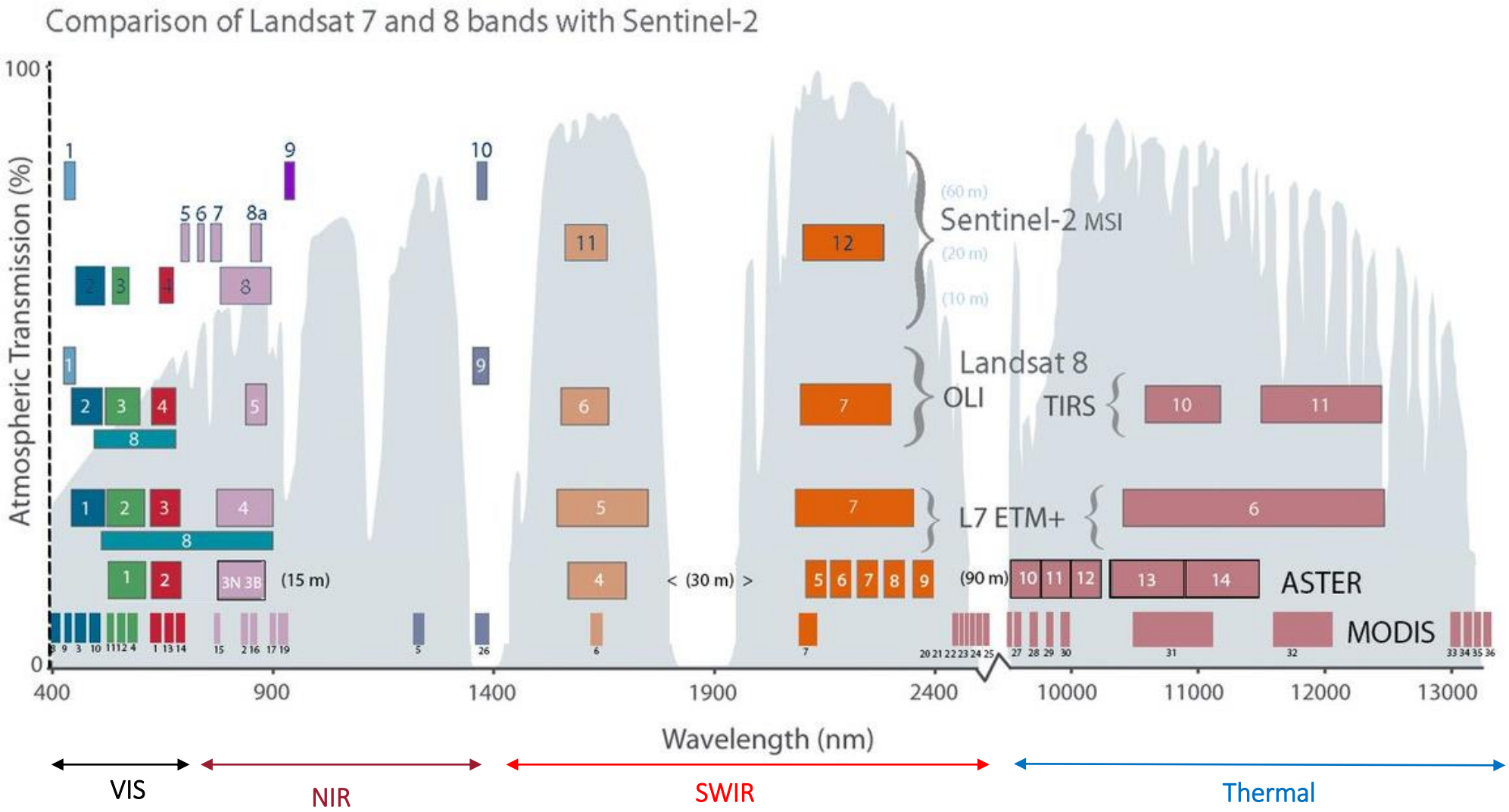
Multispectral = small number of bands at a broad frequency



Single band **Multispectral** **Hyperspectral**

Band Comparison

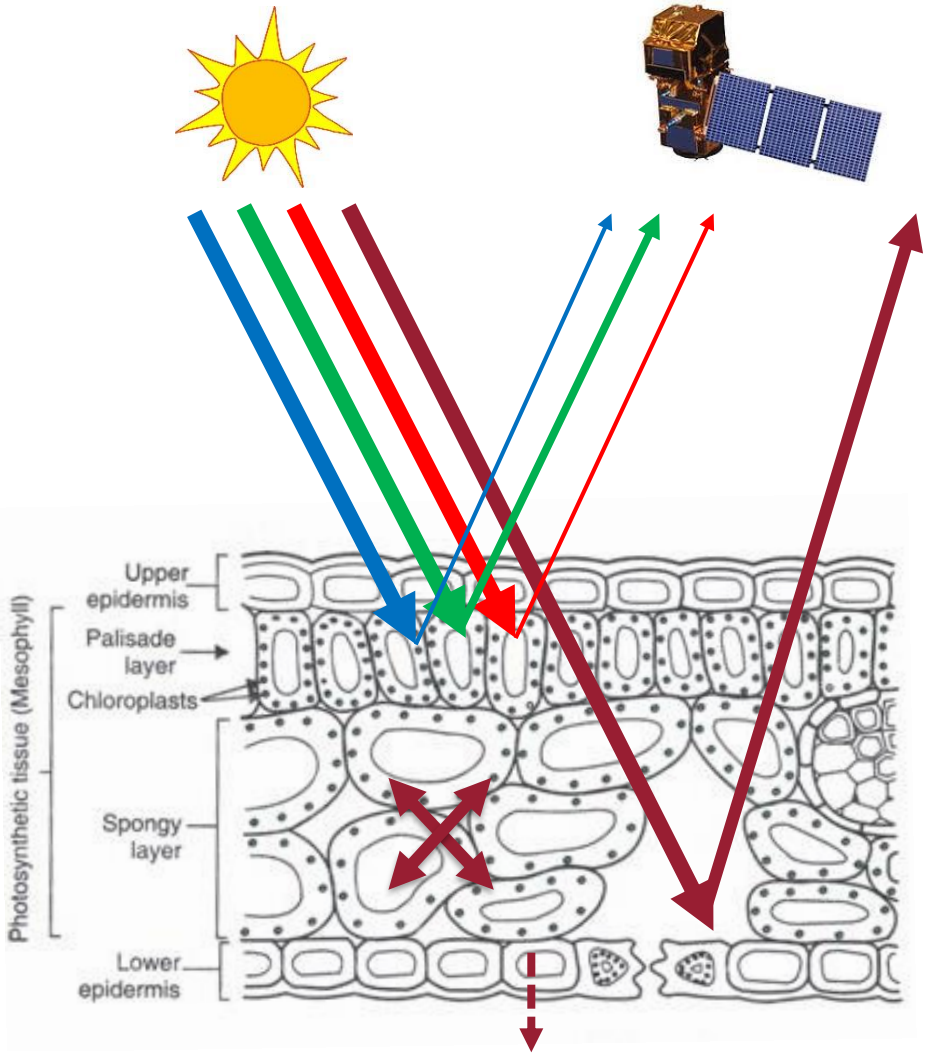
SPECTRAL



Remote sensing of vegetation

SPECTRAL

Blue and Red mostly absorbed by chloroplasts and used for photosynthesis



NIR unaffected by chloroplasts and reflected by spongy mesophyll

Green reflected by chloroplasts

Some NIR is lost by internal scattering and transmittance of light

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Spectral signatures

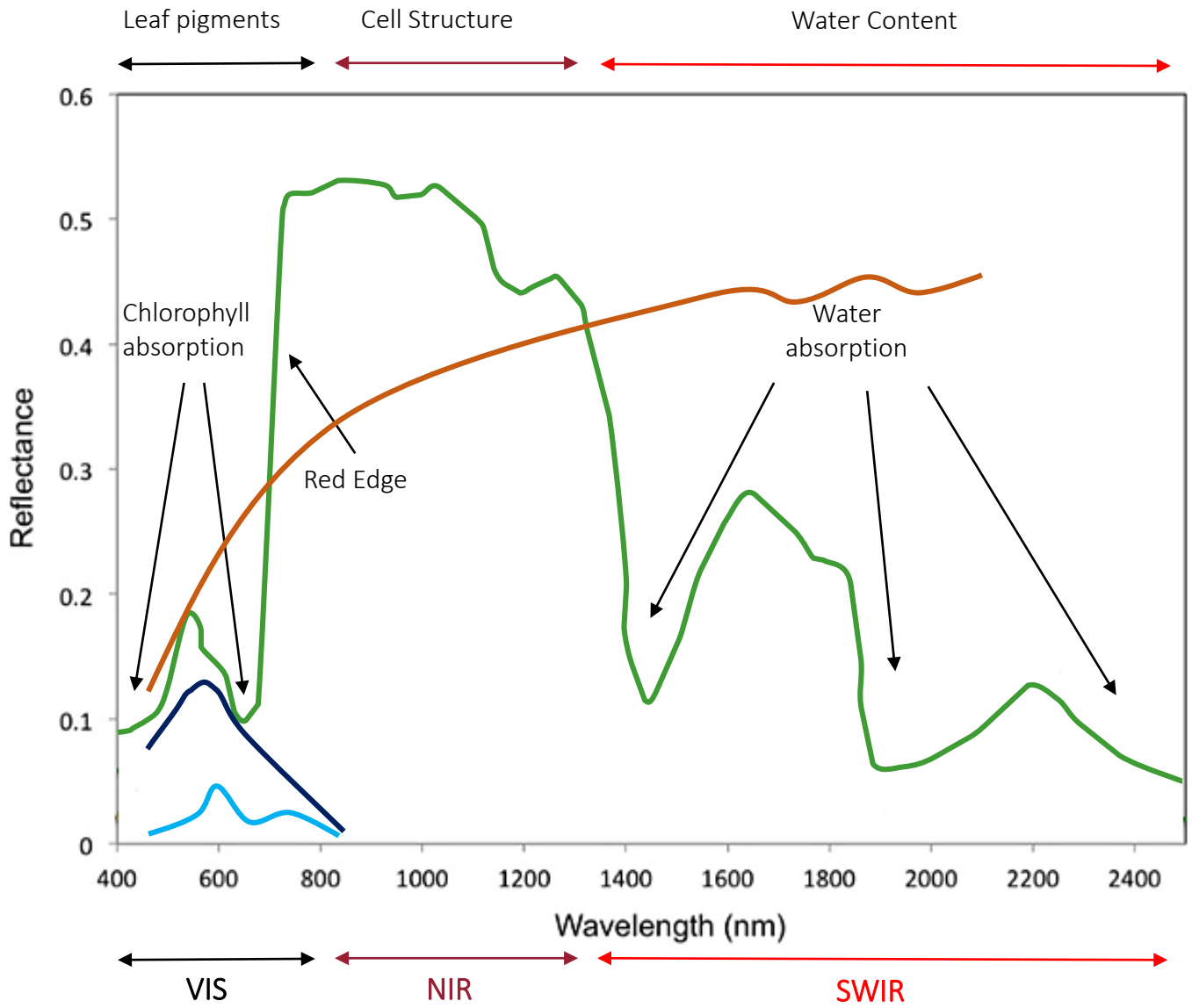
SPECTRAL

Healthy vegetation

Soil

Clear Water

Water with phytoplankton



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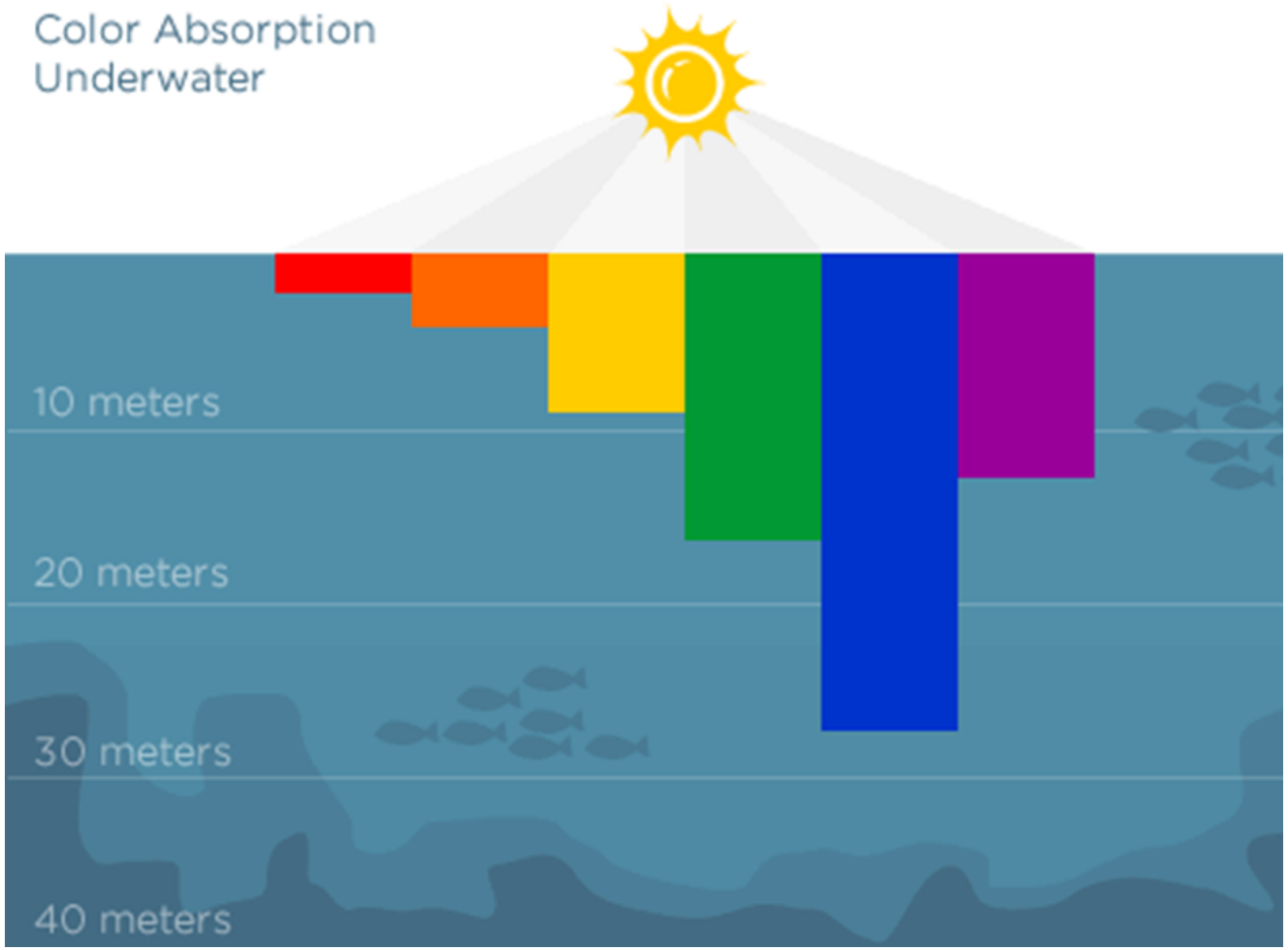
How imagery works under water

SPECTRAL



- Light attenuation is wavelength dependent
- Turbidity impacts light scattering
- Also need to consider conditions at the surface:
  - Effect of waves
  - Sun glint

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How many bits?

2-bit:
0-4

4-bit:
0-16

8-bit:
0-256

Satellites: Older Landsat sensors, SPOT, etc

Benefit: Everything will be scaled from 0-256

Limitation: Subtle details may not be represented

16-bit:
0-65,535

Satellites: Sentinel-2

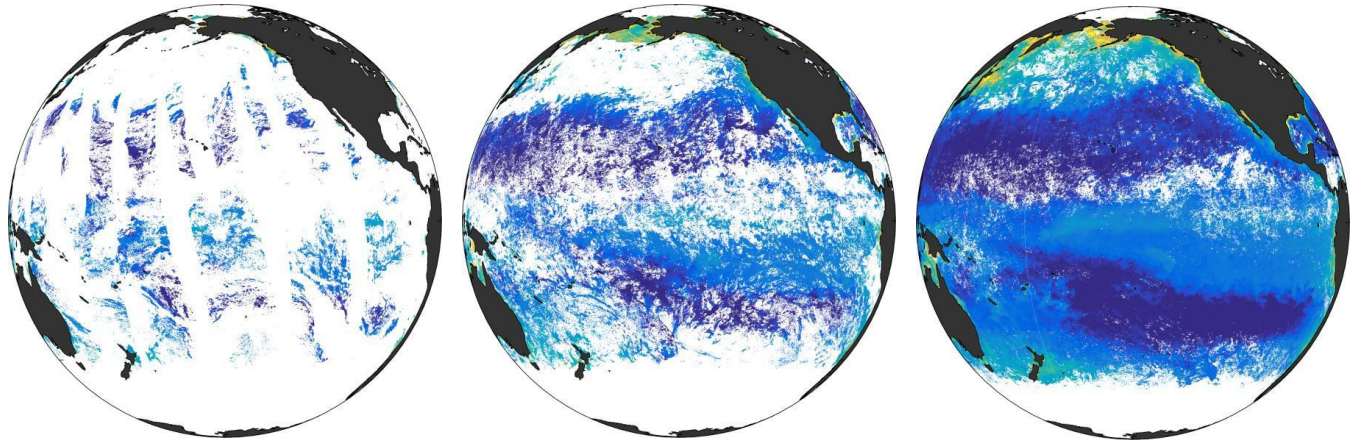
Benefit: Wide range of choices

Limitation: 2 x storage of 8 bit

Sensor	Bit depth
Landsat MMS	6
Landsat TM & ETM+	8
SPOT 5	8
Worldview-2 & 3	11
Pleiades	12
SPOT 6 & 7	12
Landsat 8	12
Sentinel-2	16

Passive sensors cannot ‘see’ through cloud

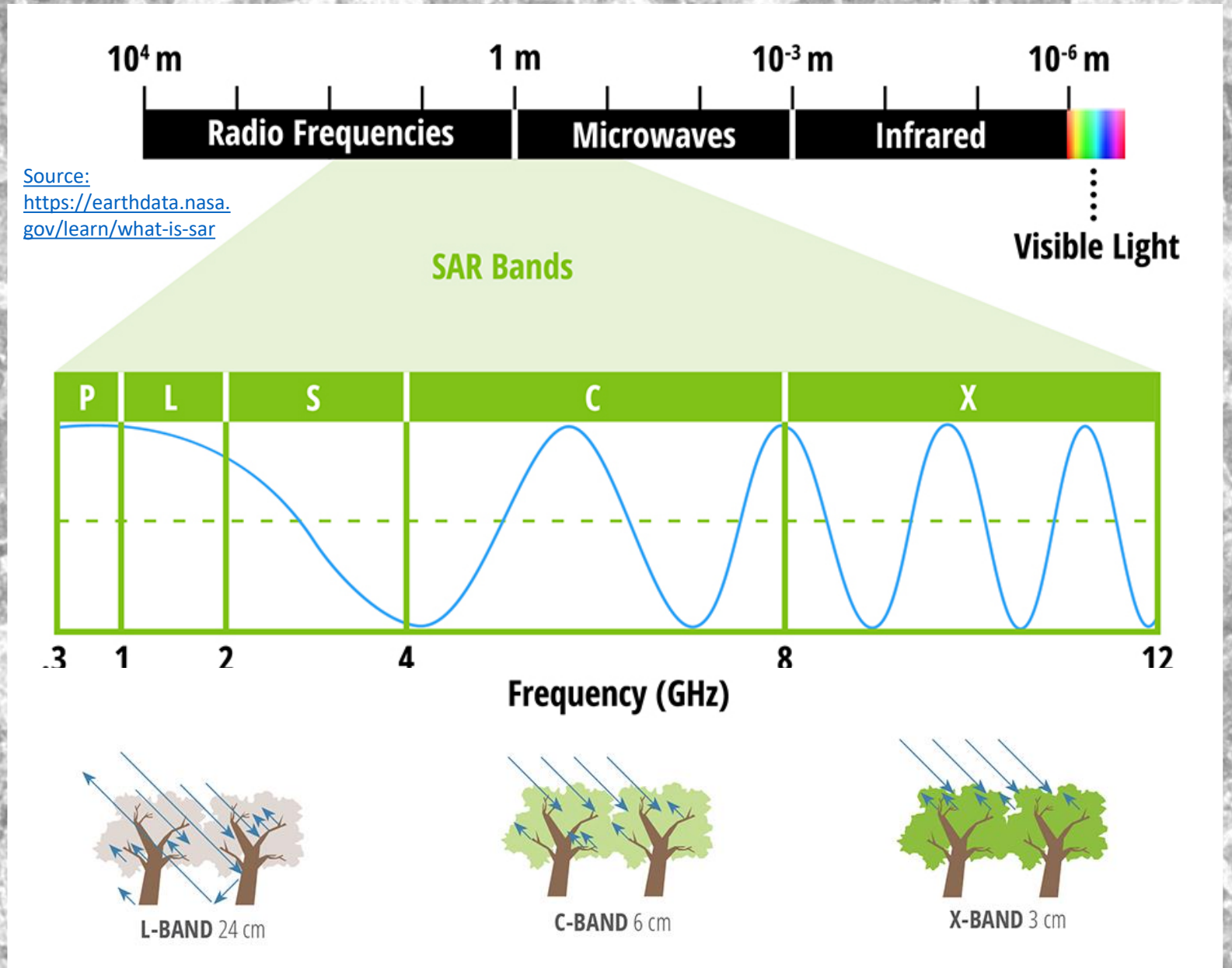
Daily **8-day** **Monthly**



- Merged composites of Ocean Colour sensor MODIS Aqua – surface concentrations of Chlorophyll-a
- Temporal merging
- Improvement to coverage = at a cost to accuracy

Cloud…

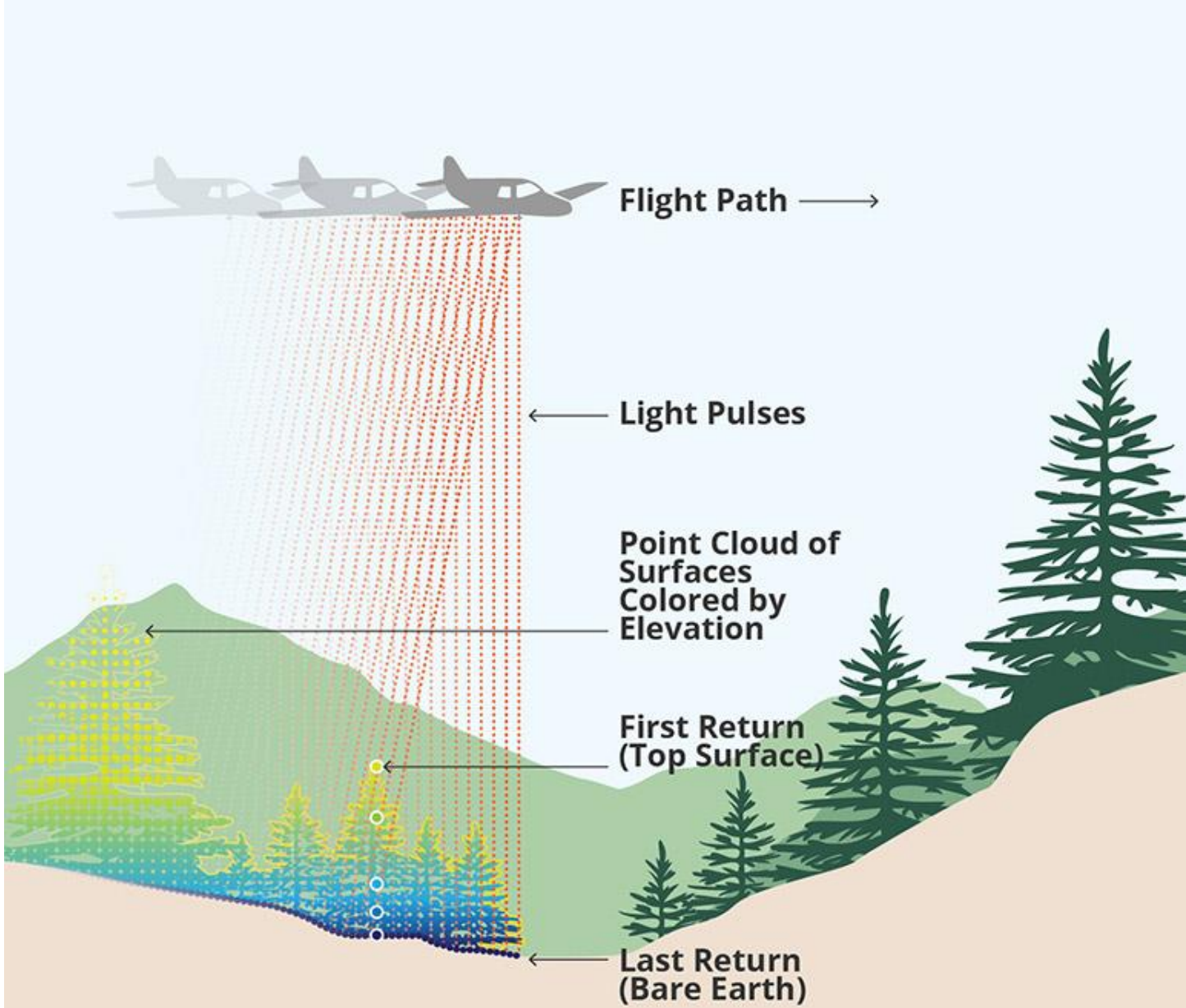
Synthetic Aperture Radar (SAR)



Source: https://earthdata.nasa.gov/learn/what-is-sar

Lidar

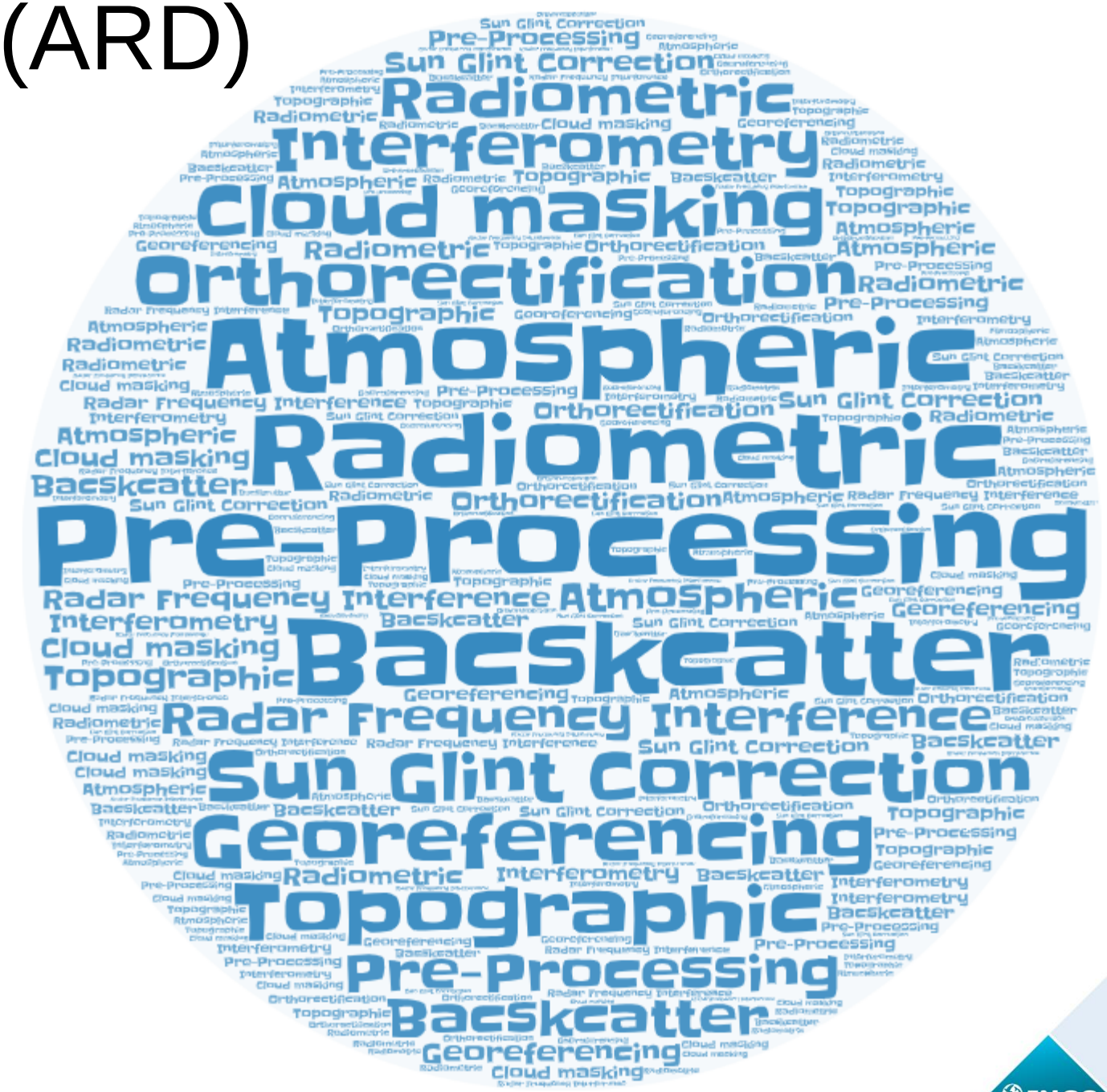
- Can operate from planes, on the ground (terrestrial laser scanning) or on boats for underwater applications
- Not many missions in space (ICESAT, GEDI)
- Most common use is to create very high resolution digital elevation/terrain models



Source: https://vcgi.vermont.gov/resources/frequently-asked-questions/lidar-program-faqs

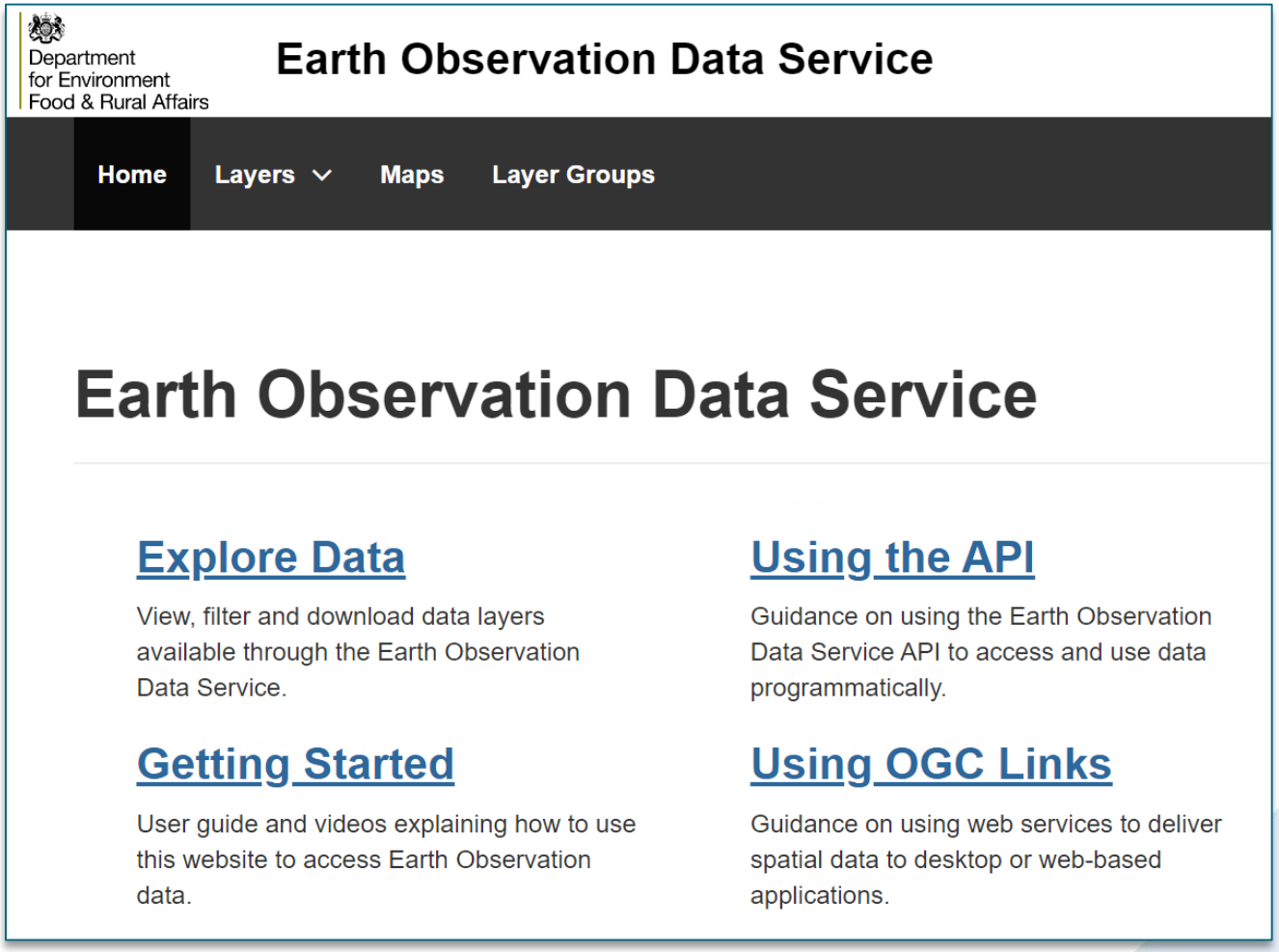
Analysis Ready Data (ARD)

- All sensor data will need pre-processing before analysis
- Most pre-processing methods are well established but need experts to carry out
- Methods can be automated
- UK ARD available for Sentinel-1 (backscatter), and Sentinel-2, plus Landsat archive (Wales only)



Defra Earth Observation Data Service

- Provides Sentinel-1 and Sentinel-2 ARD for England to Defra, its agencies and arms length bodies.
- Beta release February 2020, live launch July 2020.
- Data archive from October 2018 to present.
- New data processed within 24 hours.
- Data access via download, web services and API.
- Access data and help resources at: **https://earthobs.defra.gov.uk**



Department for Environment Food & Rural Affairs

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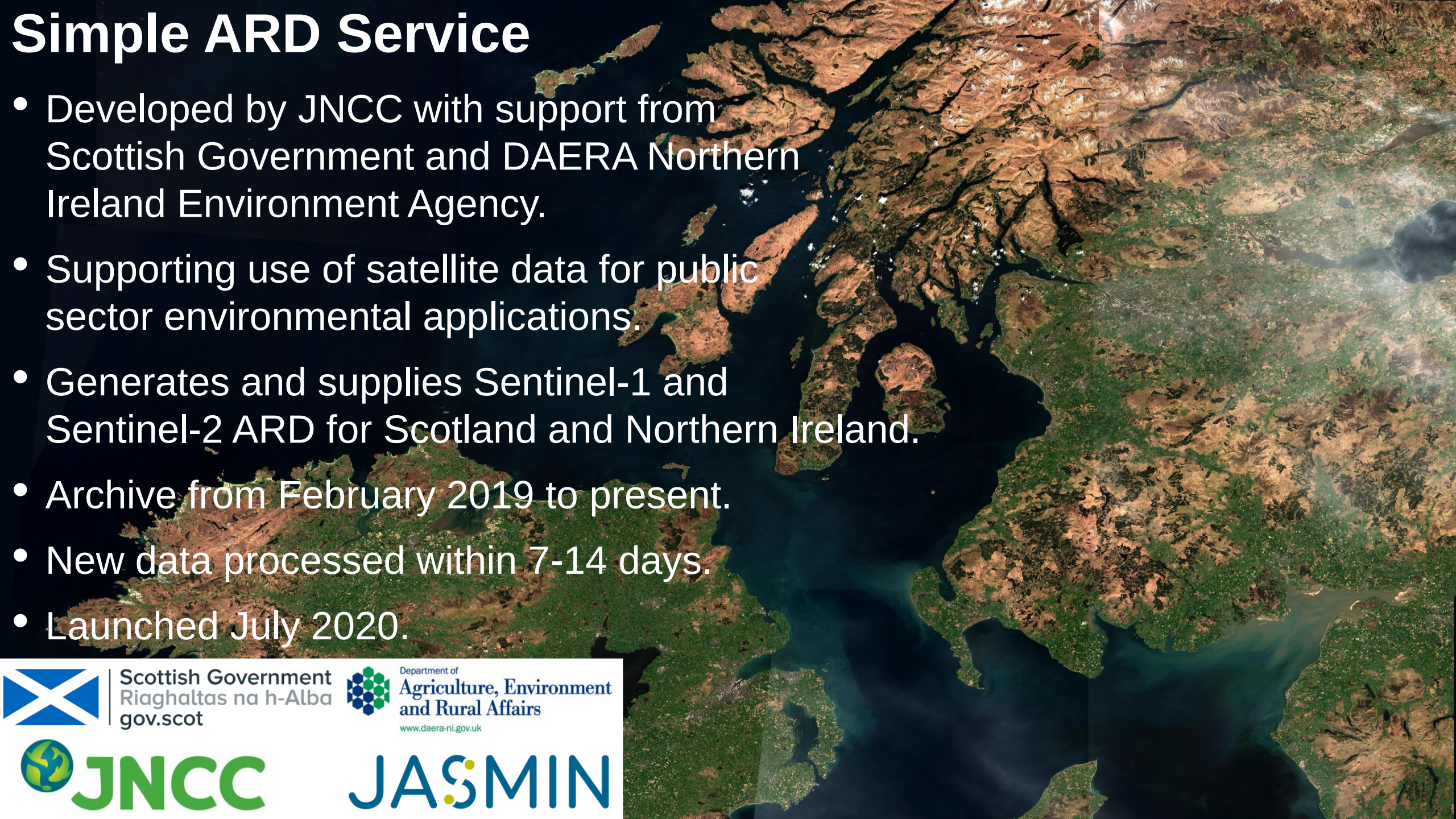
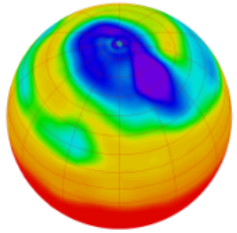
Simple ARD Service

- Developed by JNCC with support from Scottish Government and DAERA Northern Ireland Environment Agency.
- Supporting use of satellite data for public sector environmental applications.
- Generates and supplies Sentinel-1 and Sentinel-2 ARD for Scotland and Northern Ireland.
- Archive from February 2019 to present.
- New data processed within 7-14 days.
- Launched July 2020.



Accessing the Data



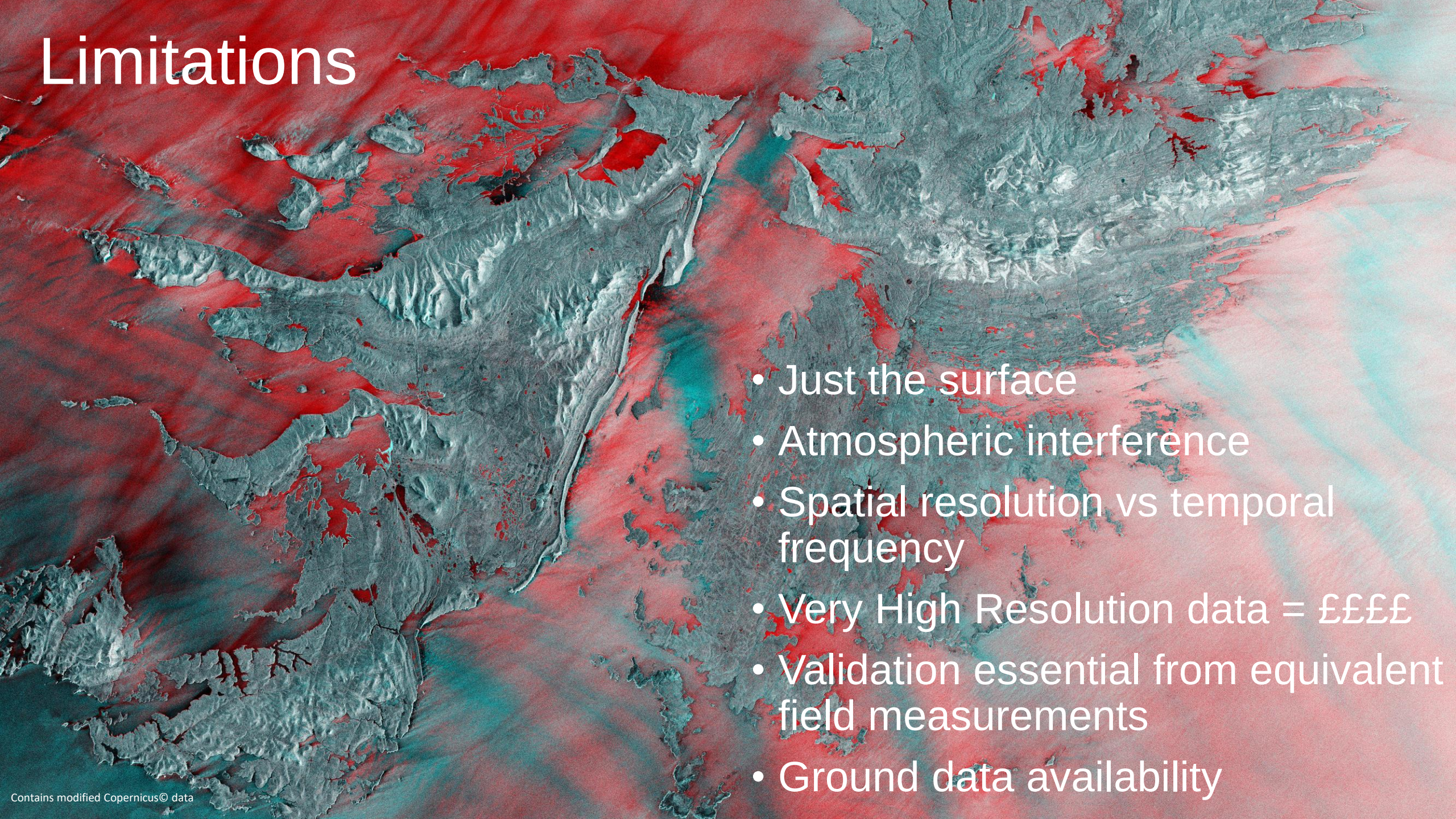
Centre for Environmental Data Analysis

SCIENCE AND TECHNOLOGY FACILITIES COUNCIL
NATURAL ENVIRONMENT RESEARCH COUNCIL

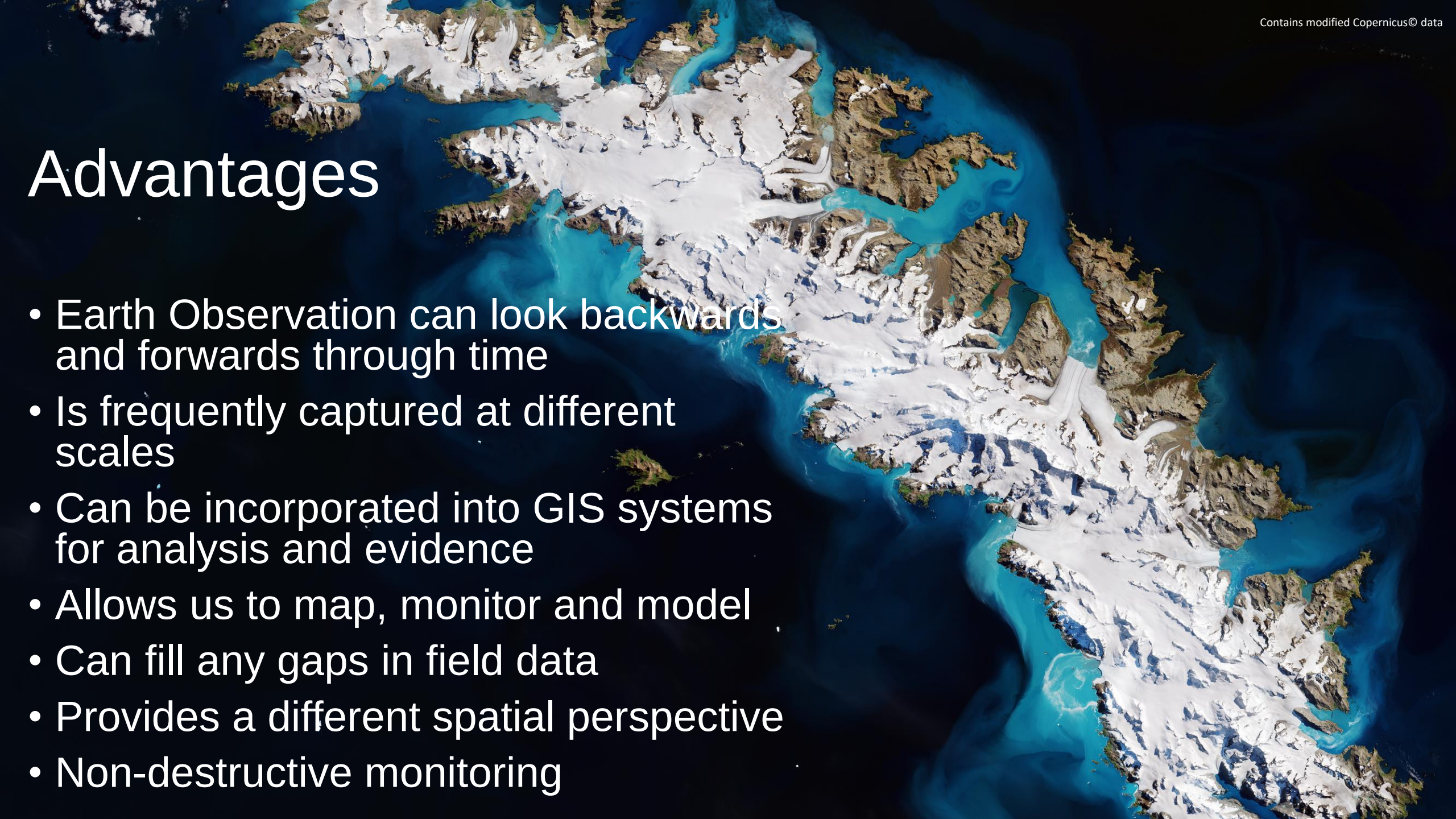
- Data from Defra's EO Data Service and JNCC's Simple ARD Service are publicly accessible under an Open Government License via the Centre for Environmental Data Analysis (CEDA) Archive.
- CEDA services are provided on behalf of the Natural Environment Research Council via the National Centre for Atmospheric Science and the National Centre for Earth Observation.
- CEDA is based within the RAL Space department of the Science and Technology Facilities Council (STFC), Harwell Campus, near Oxford.

Useful Links	
http://data.ceda.ac.uk/neodc	NERC Earth Observation Data Centre – all EO datasets
http://data.ceda.ac.uk/neodc/sentinel_ard/data	Defra and JNCC Sentinel analysis-ready data index pages
http://geo-search.ceda.ac.uk/	CEDA Satellite Data Finder – interactive map with filters
https://catalogue.ceda.ac.uk/	CEDA Catalogue Search "JNCC" returns links to Defra and JNCC ARD and metadata
https://help.ceda.ac.uk/	CEDA Help pages including "Using CEDA Data Archive"
https://jncc.gov.uk/our-work/simple-ard-service-support-for-users/	Presentation slides and recorded webinar on accessing ARD via CEDA

Limitations



- Just the surface
- Atmospheric interference
- Spatial resolution vs temporal frequency
- Very High Resolution data = ££££
- Validation essential from equivalent field measurements
- Ground data availability



Advantages

- Earth Observation can look backwards and forwards through time
- Is frequently captured at different scales
- Can be incorporated into GIS systems for analysis and evidence
- Allows us to map, monitor and model
- Can fill any gaps in field data
- Provides a different spatial perspective
- Non-destructive monitoring

What scale are you working on?

- Global?
- Regional?
- National?
- Site based?

How frequently do you need information?

- Every day?
- Once a year?
- Every season?

Thank you!

Any questions?

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