PML | Plymouth Marine Laboratory

Research excellence supporting a sustainable ocean

Introduction to EO data

PORTWIMS

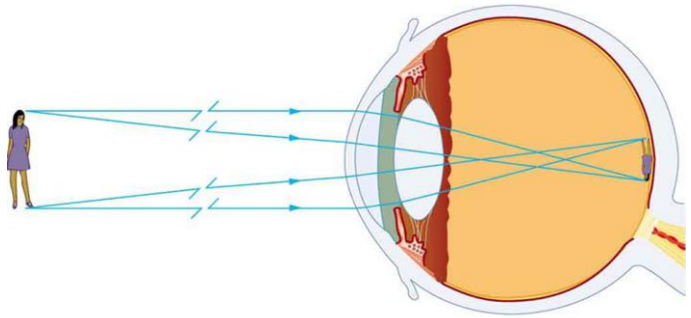
Summary

- What is Earth Observation?
- Types of sensor and orbits
- Things to consider when choosing your data:
  - Temporal resolution, spatial resolution & spectral resolution
  - Satellite data is available at different processing levels
  - Satellite data can be available at different timeliness levels

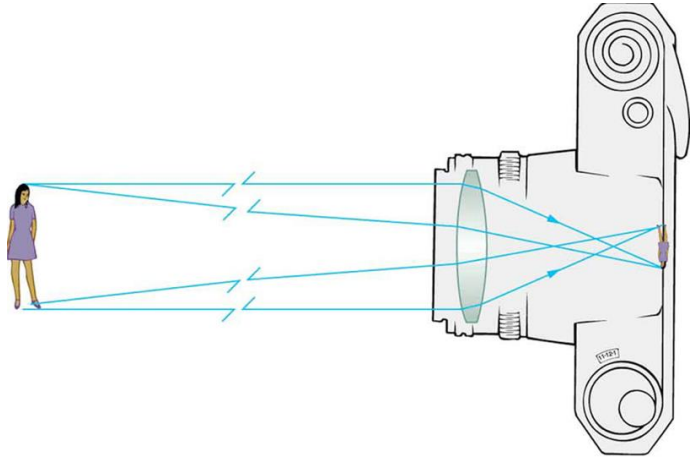
The ‘right’ data for you will depend on your application – there are often trade-offs

What is Earth Observation?

- Gathering information about the earth via remote sensing
- Remote sensing refers to the acquisition of information on a given target without making contact with the target
  - Measure the reflected and emitted energy.



- Eyes and cameras are (passive) remote sensing systems

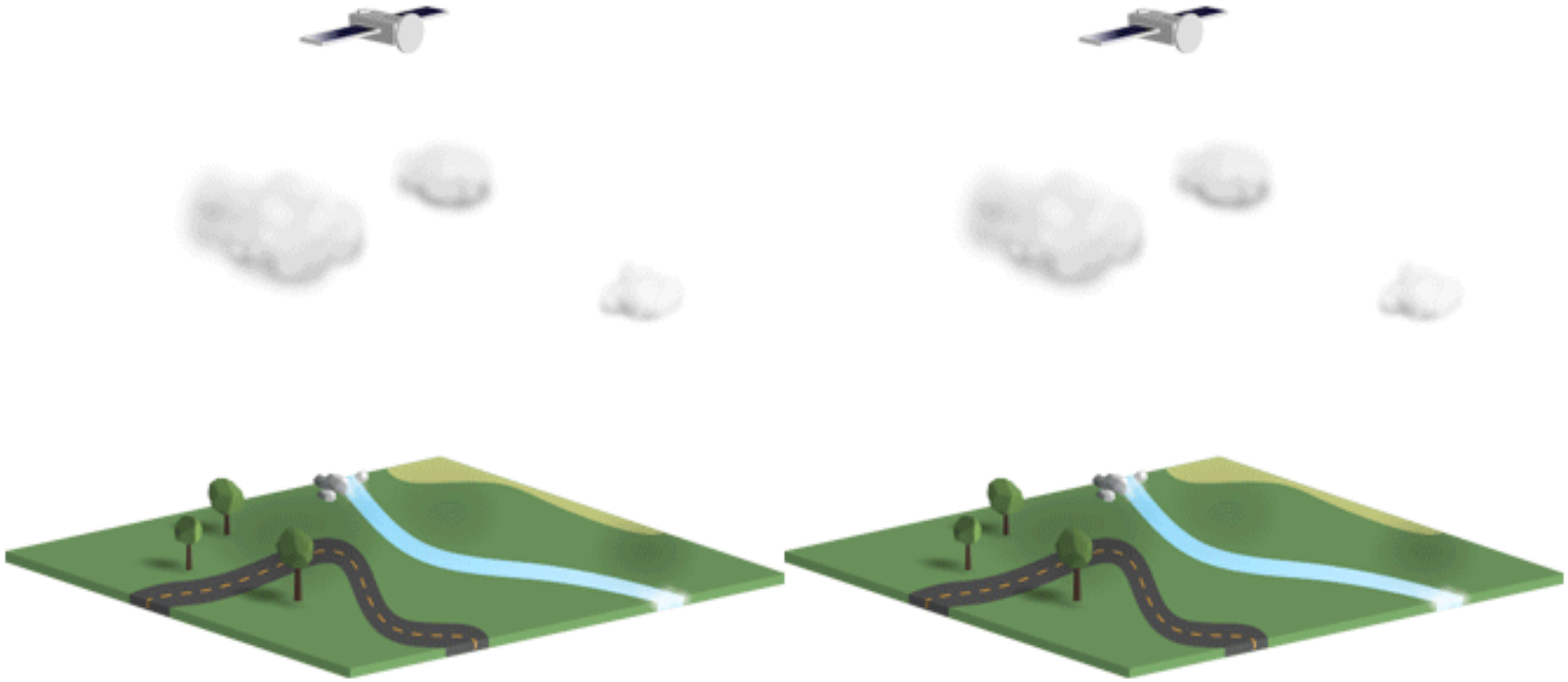


Earth's surface can be observed from different platforms, each presenting its own advantages and limitations…

+ V flexible availability
+ V high spatial resolution
+ Low cost
- Range and height may be limited
- Limited by sensor carrying capacity
- Availability depends on weather

+ High resolutions
+ Flexible availability
+ Changeable sensors
- High cost and manpower
- Availability depends on weather

+ Coverage even above the most remote locations
+ Regular repeat observations, historical
+ Some freely available
- Lower resolution
- Fixed collection schedule



Passive | Sensors detect only what is emitted from the landscape, or reflected from another source (e.g., light reflected from the sun).

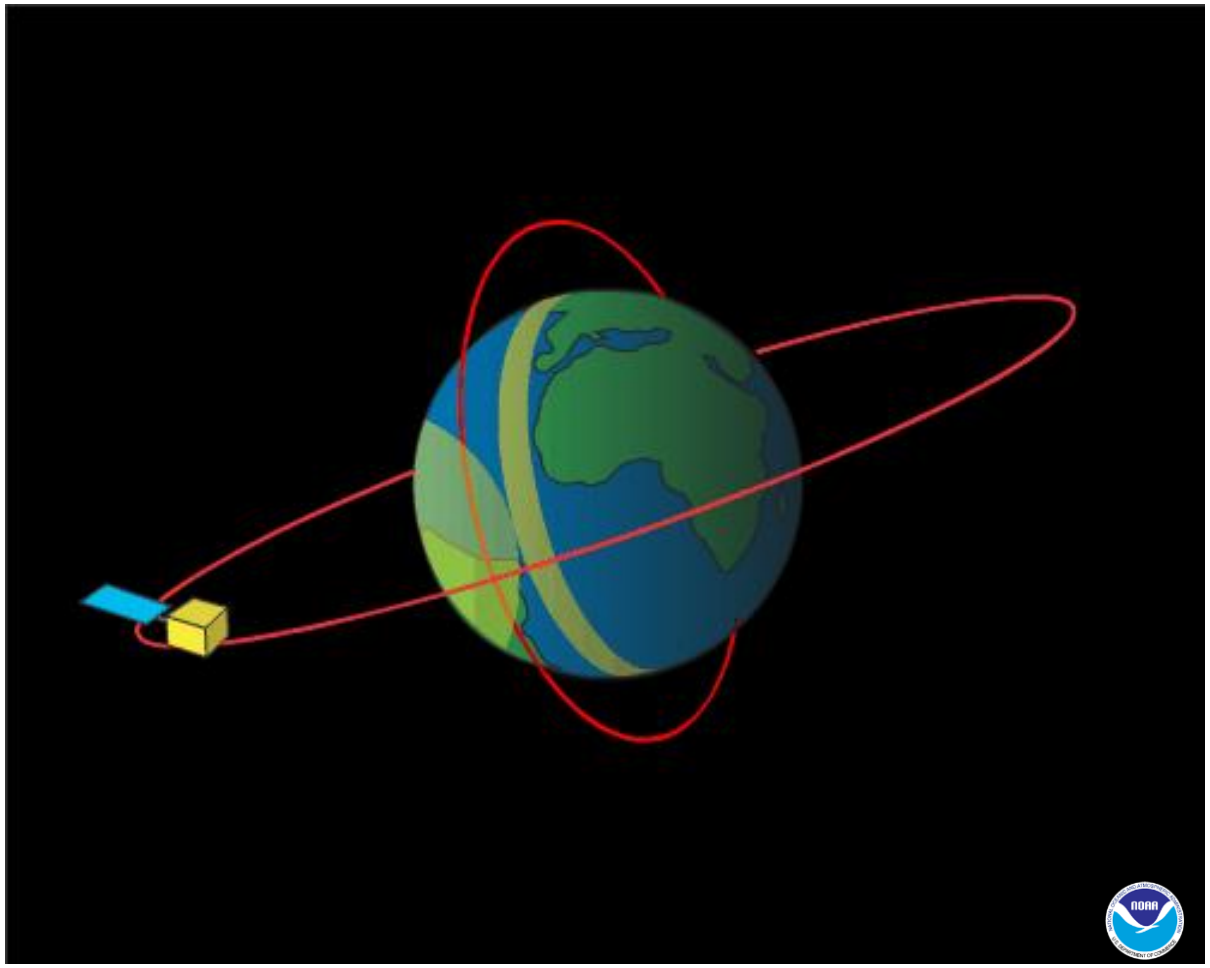
Active | Instruments emit their own signal and the sensor measures what is reflected back. Sonar and radar are examples of active sensors.

NASA ARSET

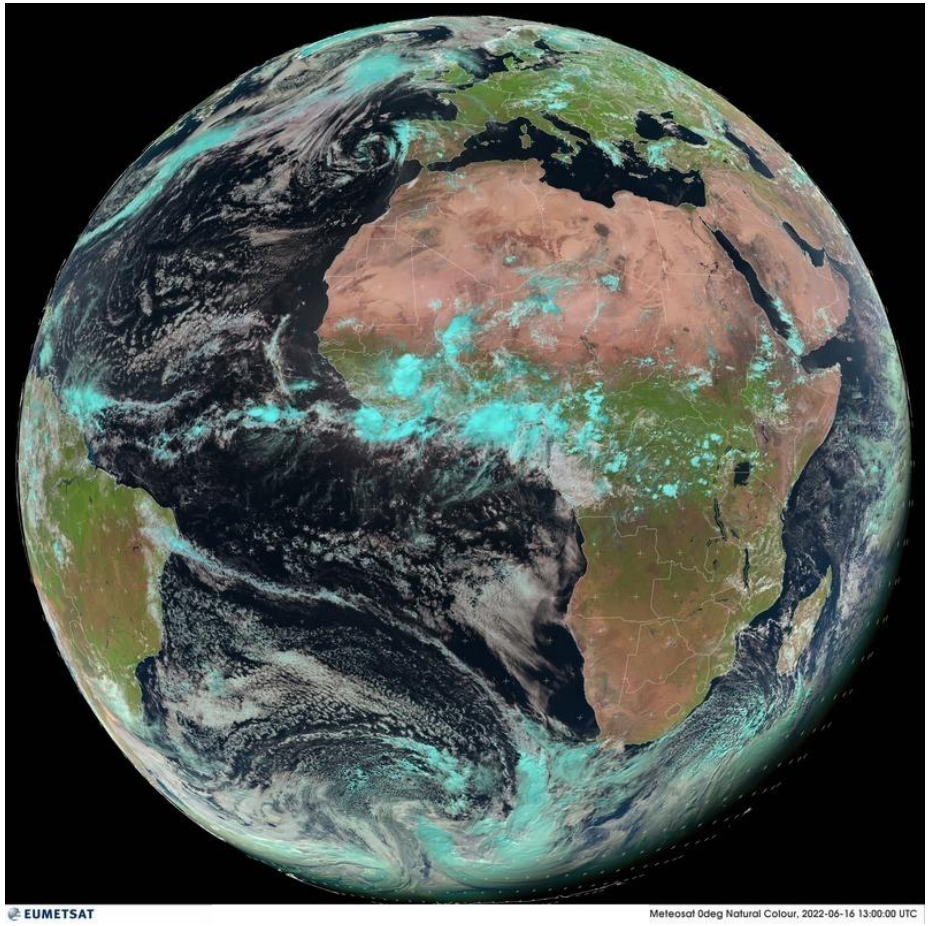
Types of satellite orbits

- Geosynchronous –
  - Satellite rotates round the Earth (or orbits) once every 24 hours
  - Height ~36,000 km

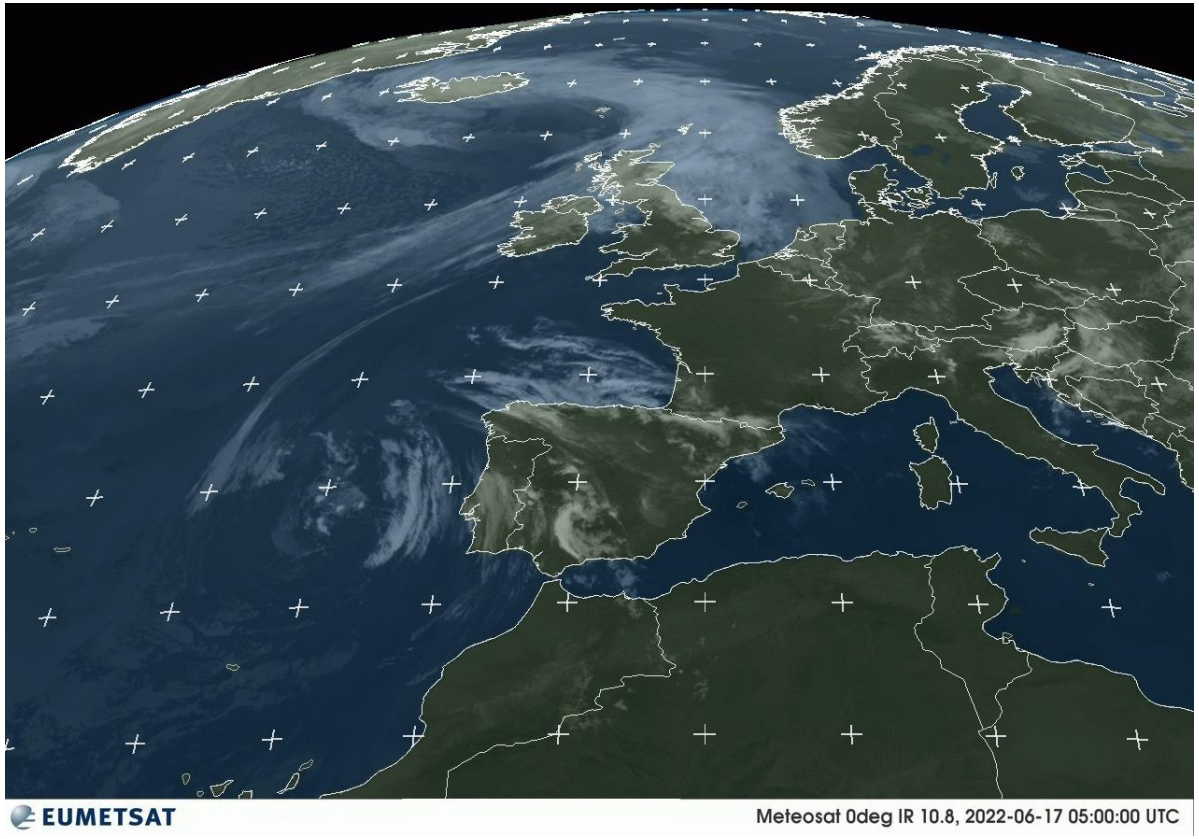
- Low Earth Orbit –
  - one orbit every ~100 minutes
  - height about 700km



Types of satellite orbits

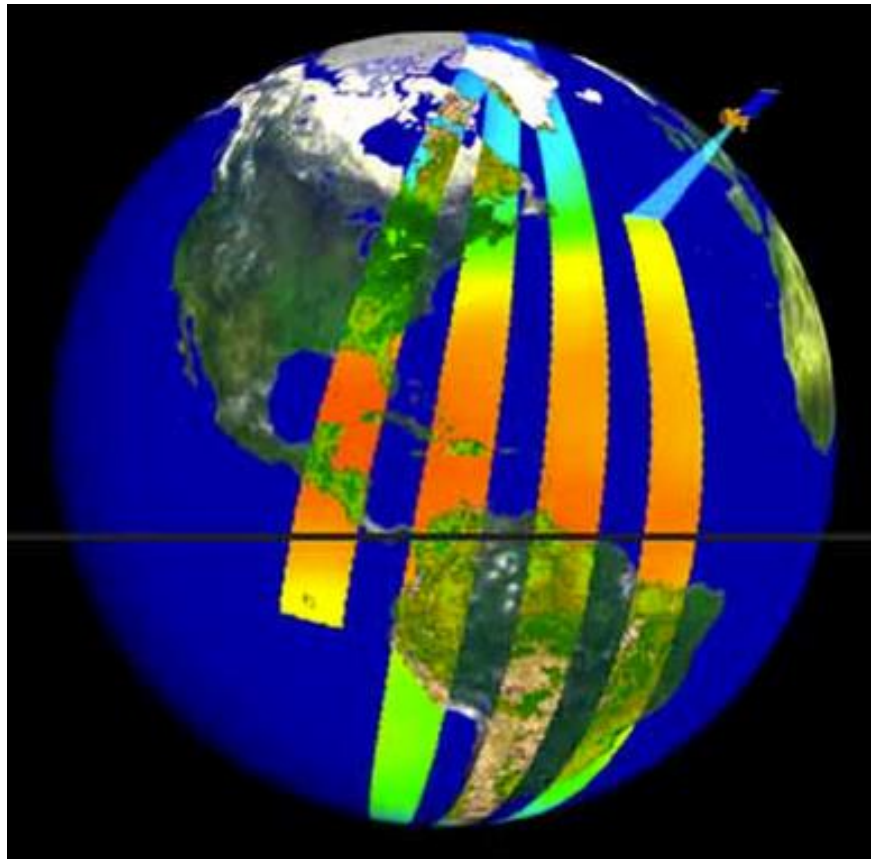


Geostationary – over 0º N 0º E



Frequent observations show evolution of the atmosphere

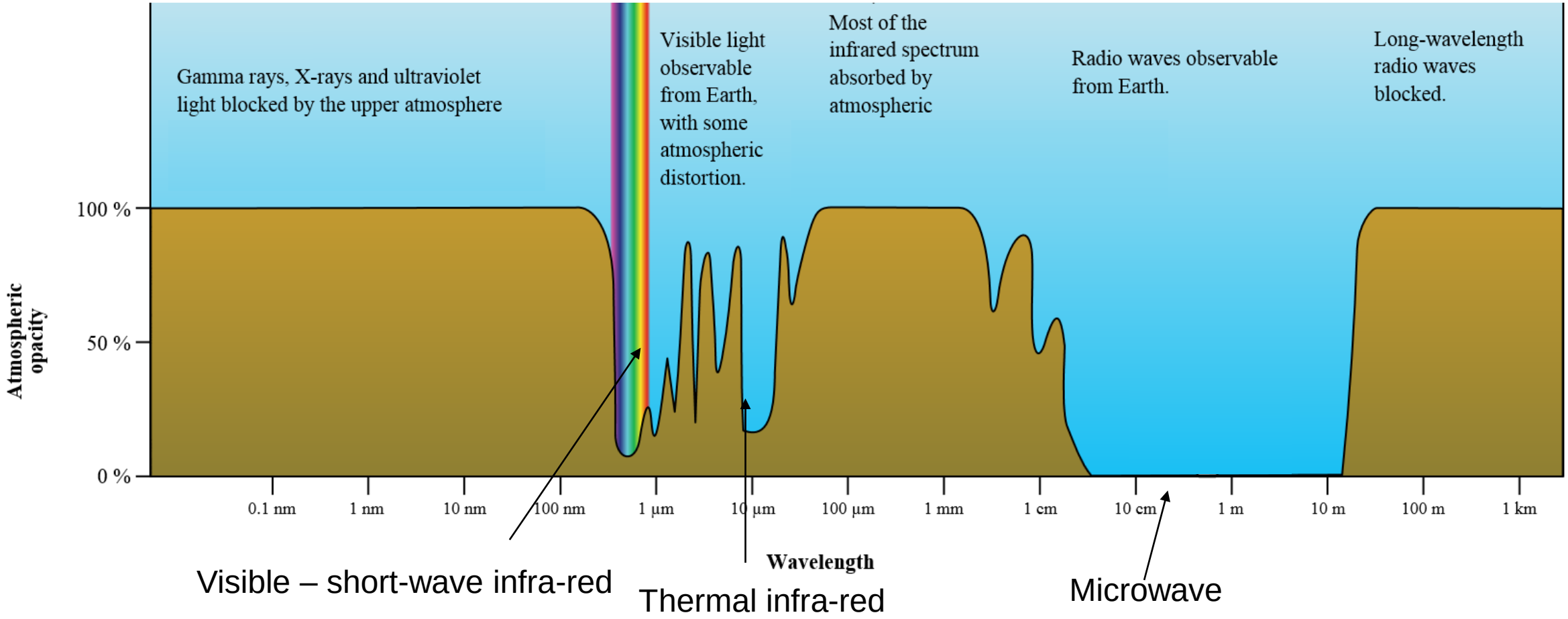
Types of satellite orbits



Low Earth orbit overhead e.g., Sentinel 3 09:30 local time

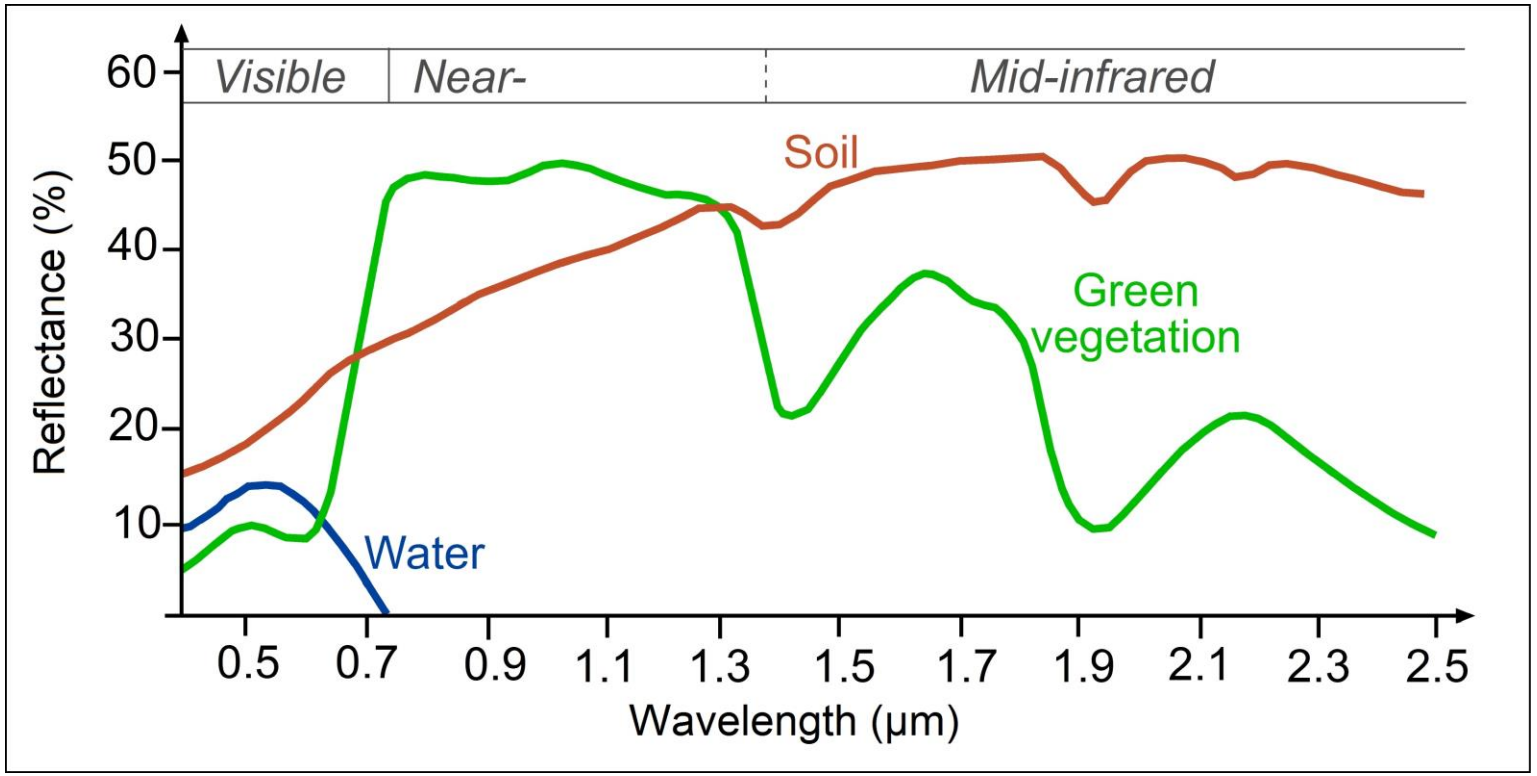
What can you see from space?

- What you can detect from space depends on the opacity of the atmosphere



Reflectance spectra

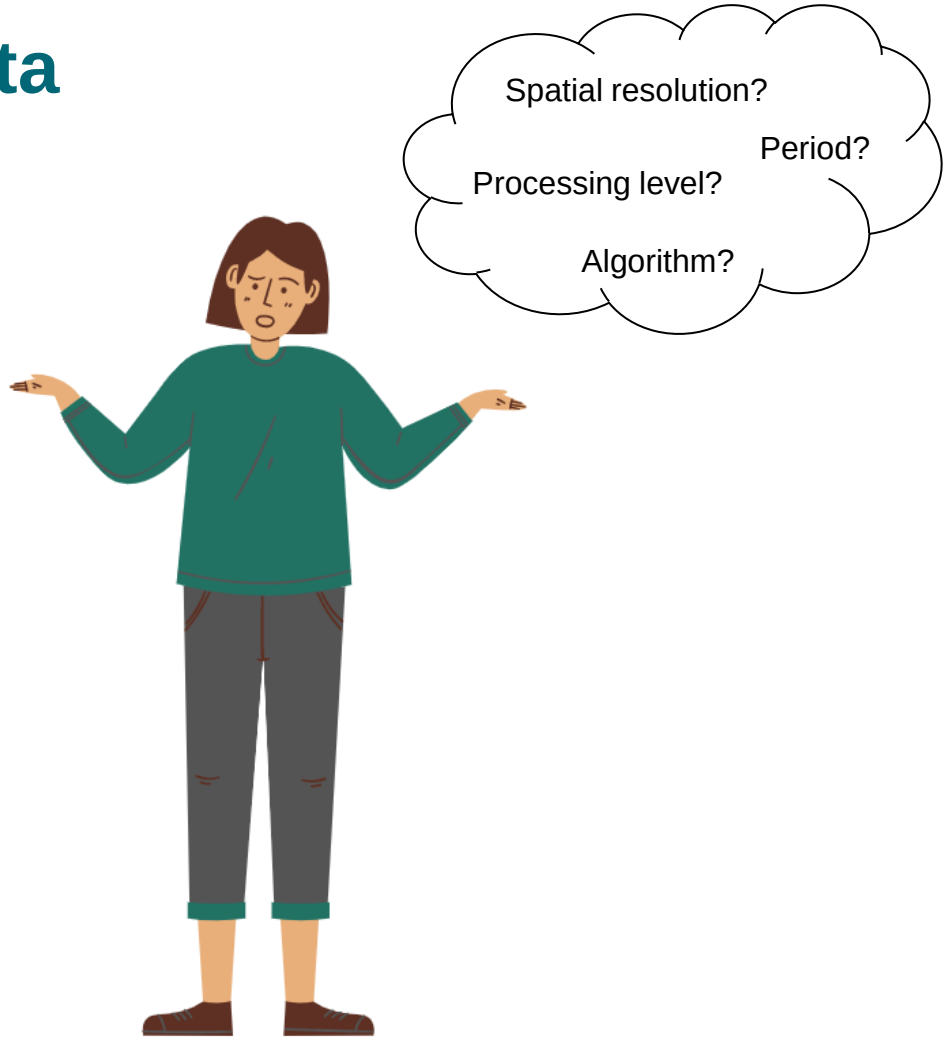
- All things on Earth reflect, absorb, or transmit energy, the amount varies by wavelength.
- This gives it a spectral fingerprint.



What to consider when choosing EO data

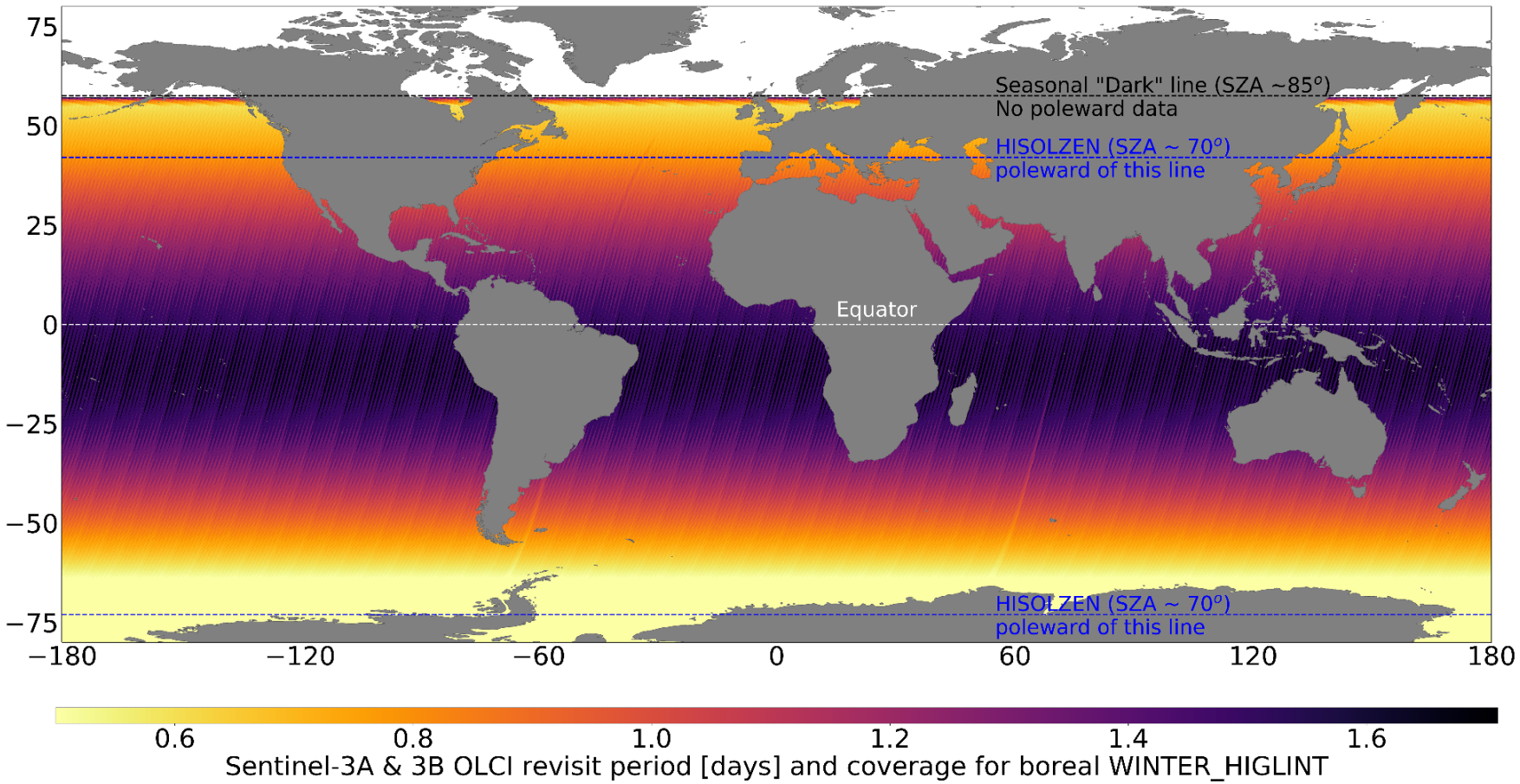
The data that is right for you will depend on your application.

What is the spatial scale and temporal variability of the feature or phenomena you want to study?

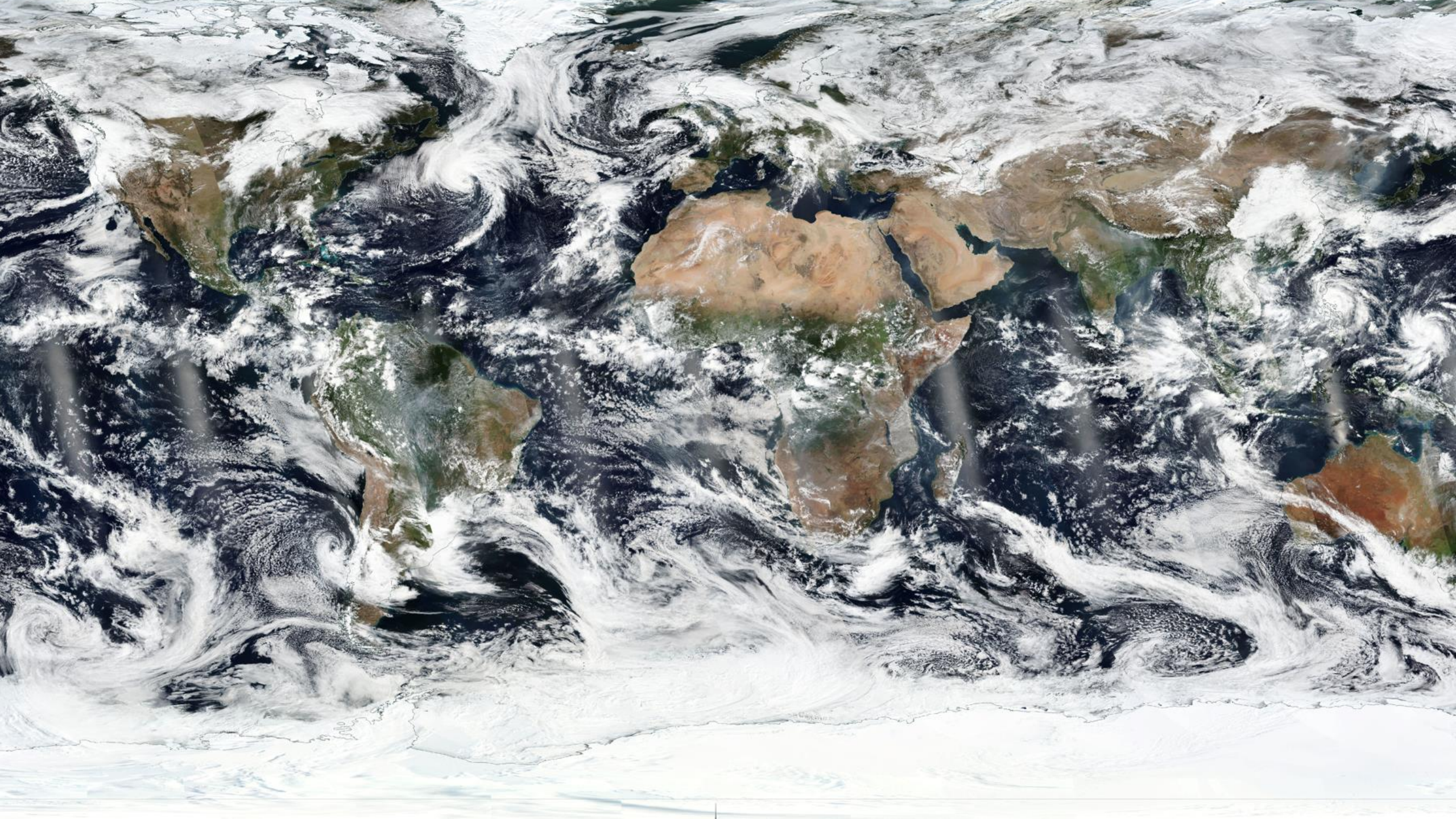


Temporal resolution

- Do you need repeated observations?
- How often does the satellite revisit an area?
  - Varies with satellite, sensor, latitude

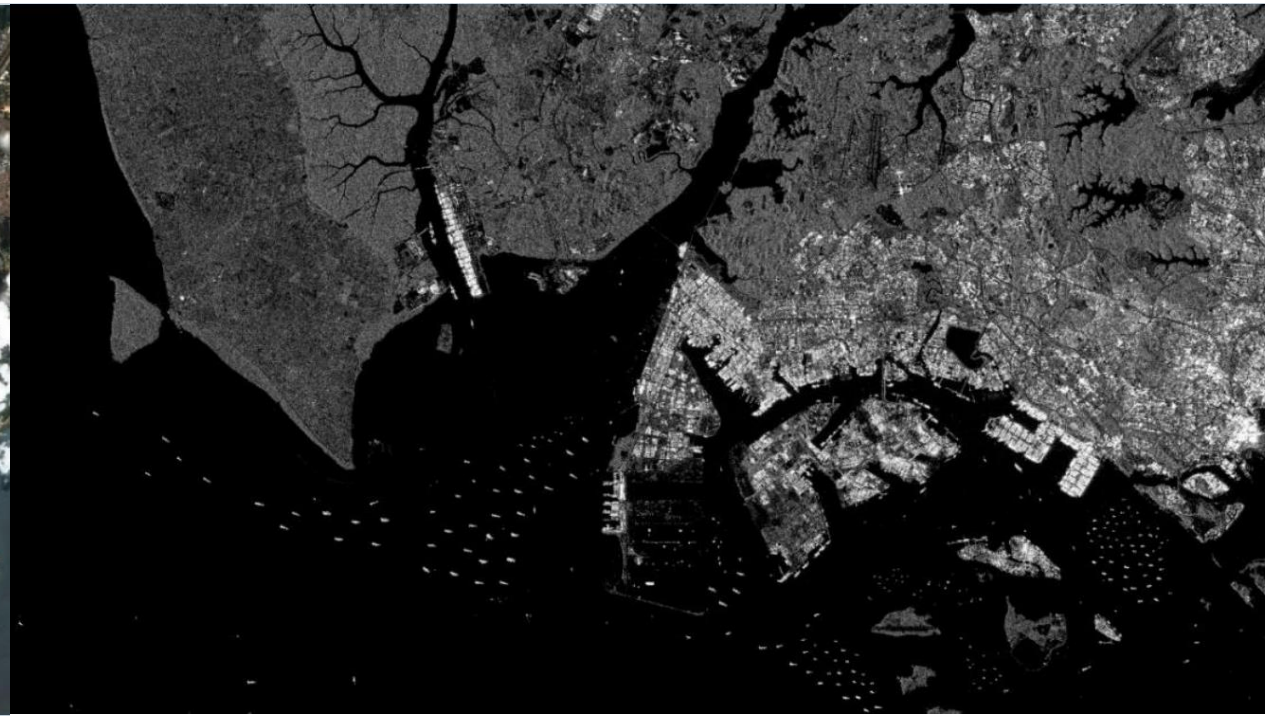


Sentinel-3A and S-3B OLCI Coverage map (NH winter)



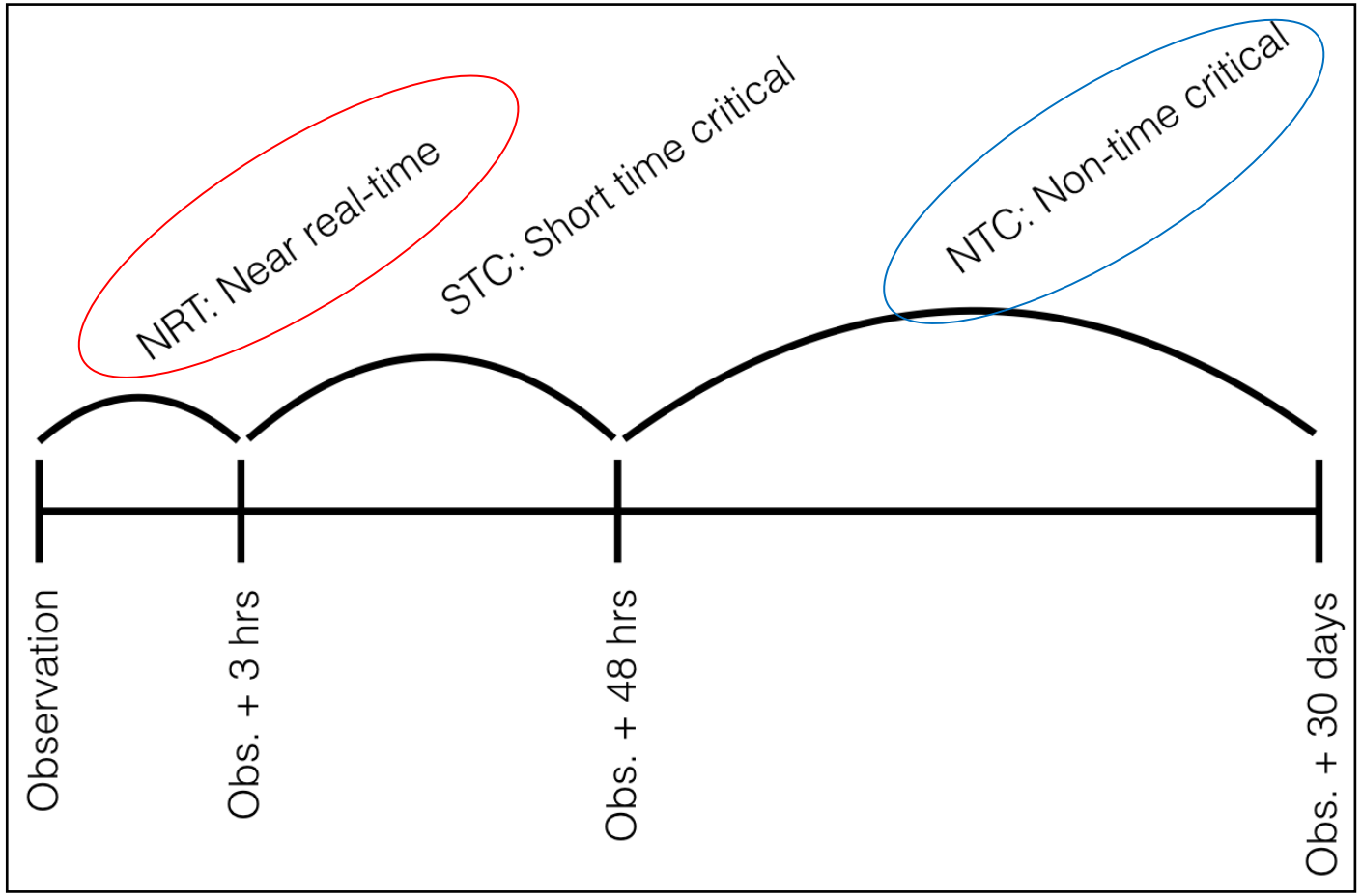
Sentinel 2 MSI (passive sensor)

Sentinel 1 SAR (active sensor)



Timeliness or Latency

- How quickly is the data available?
  - Latency refers to the time between satellite observation and the time data are available to users
  - Satellite data may be available at different timeliness levels



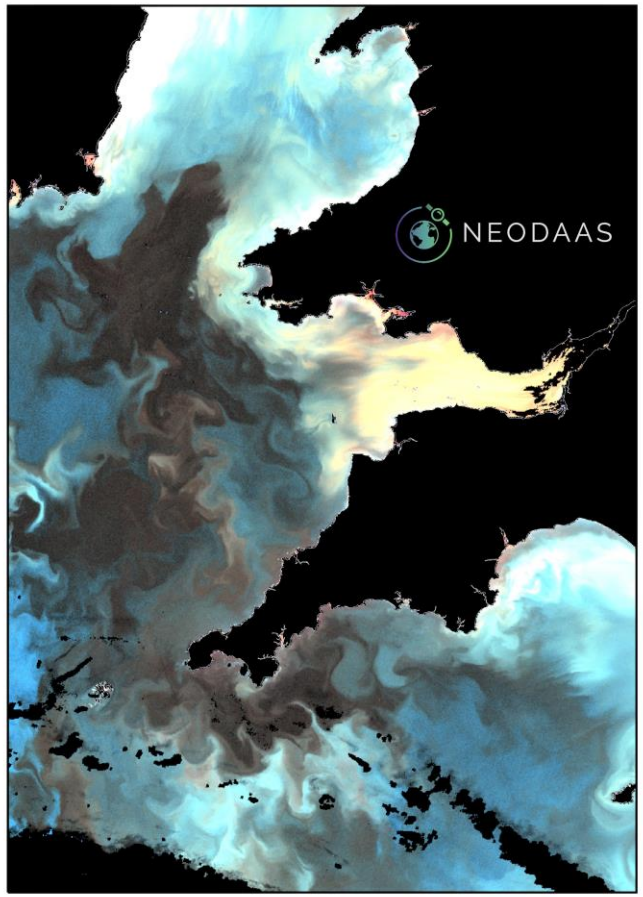
- Do you need data as fast as possible?
- Do you need data as accurate as possible?

NRT examples

Event response

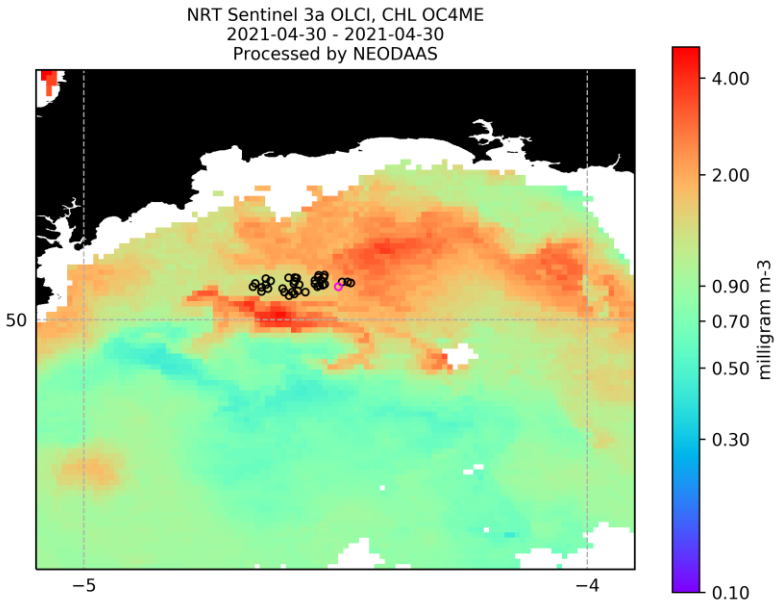
- Enhanced ocean colour image of algal bloom (dark red/brown)

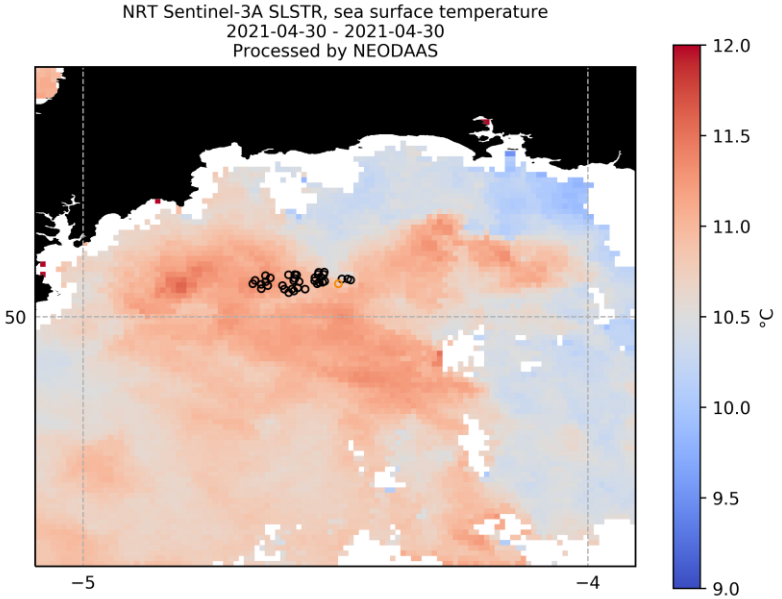
NRT Sentinel 3a OLCI, enhanced ocean colour
2021-09-07 - 2021-09-07
Processed by NEODAAS



Cruise support

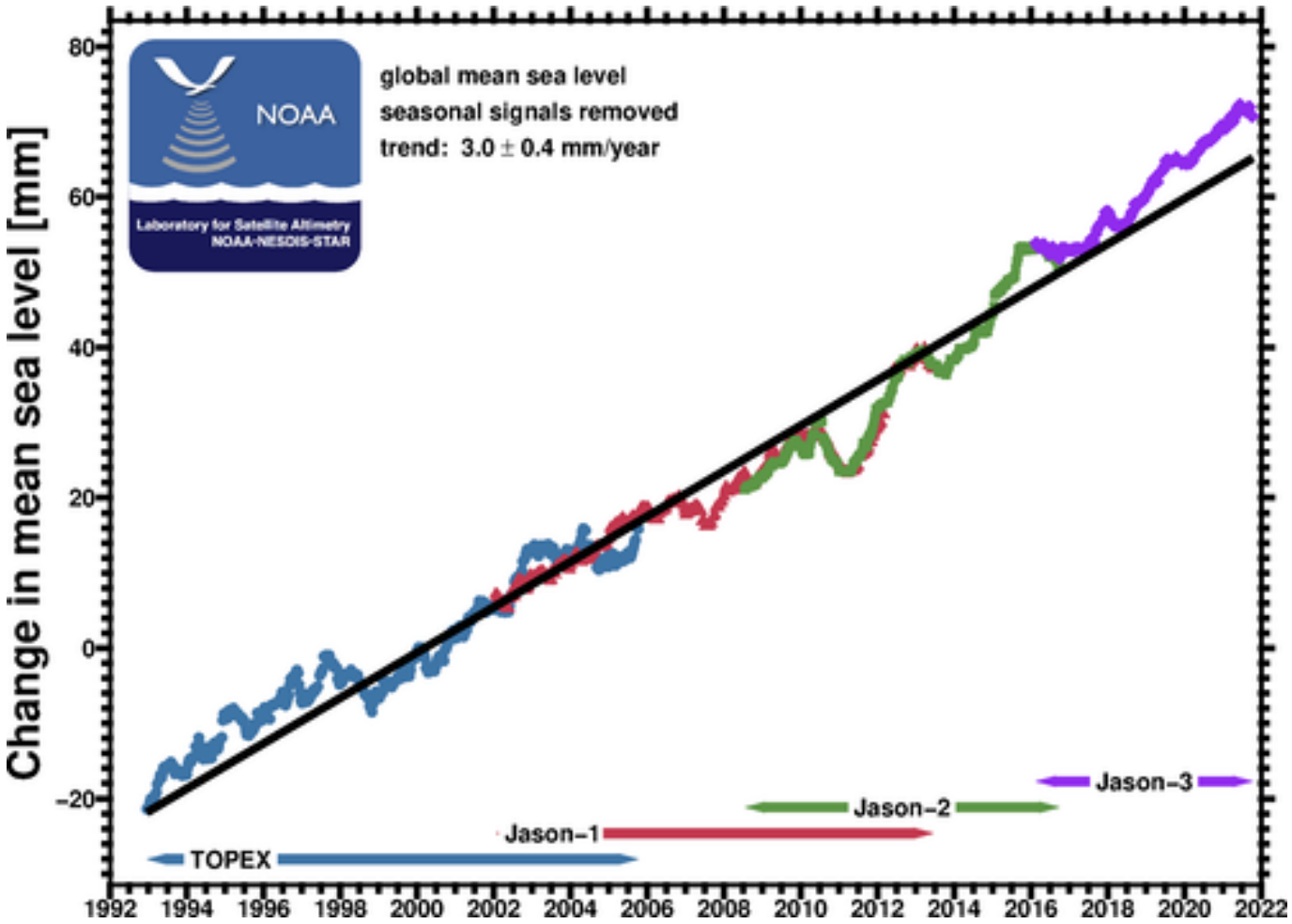
- CAMPUS glider mission





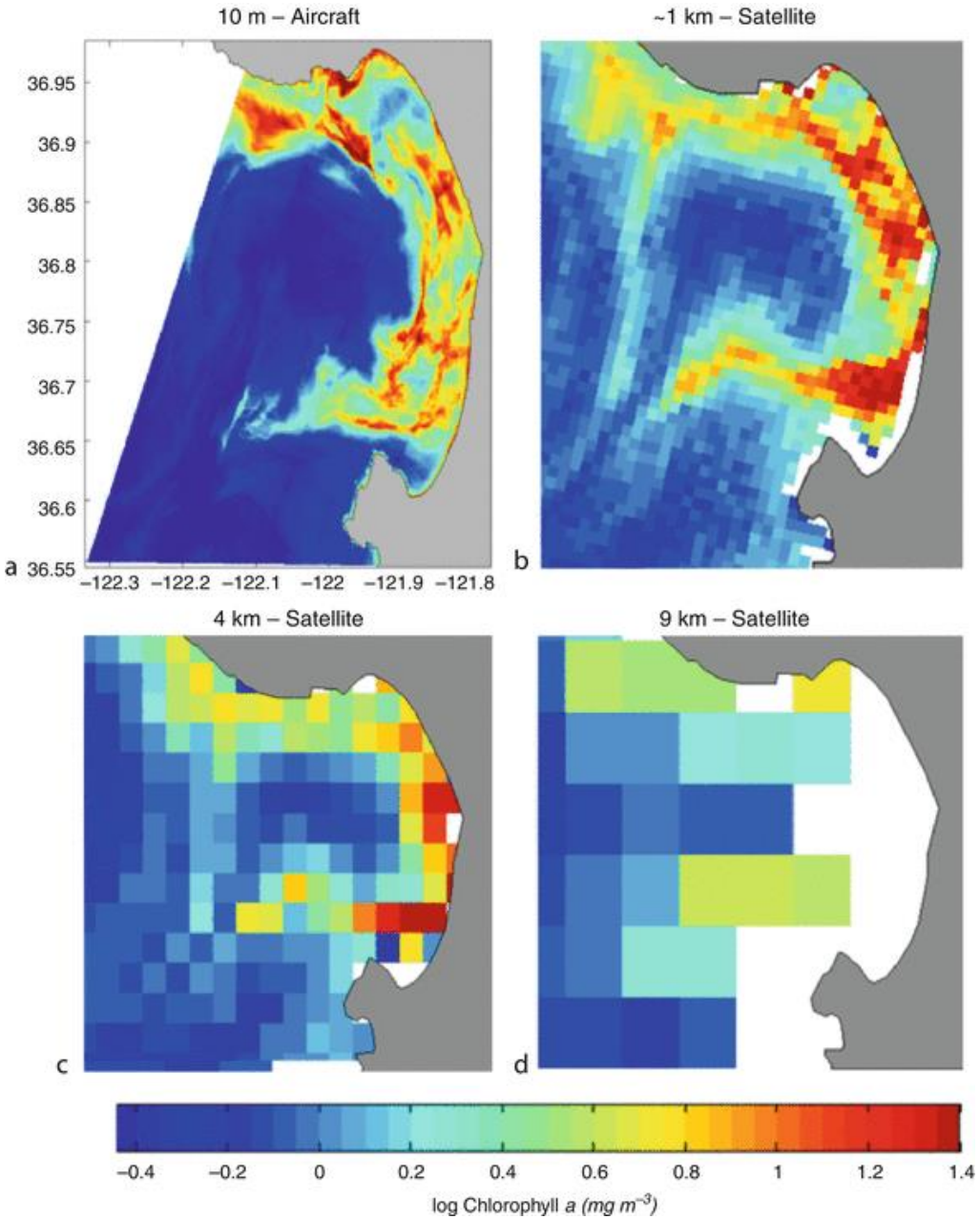
Collection period

- How long is the data available for?
- Are gaps okay?
- Is the timeseries long enough for trend analysis?
  - For timeseries may need to consider multiple sensors e.g. ESA's Climate Change Initiative (CCI) products.



Spatial resolution

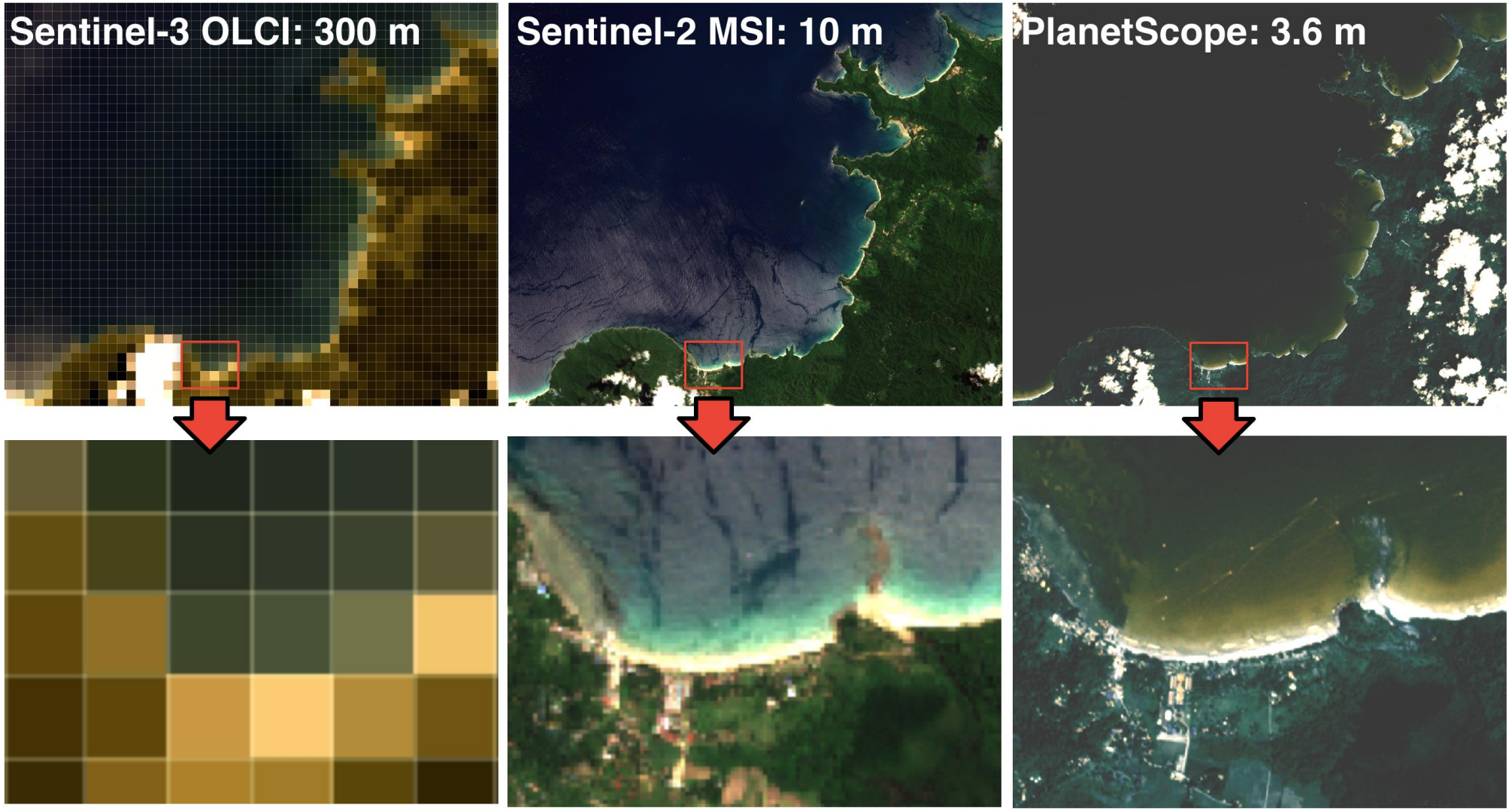
- Spatial resolution is the geographical area covered by a pixel in an image.
- How big is the feature you're trying to detect or the area you want to look at?



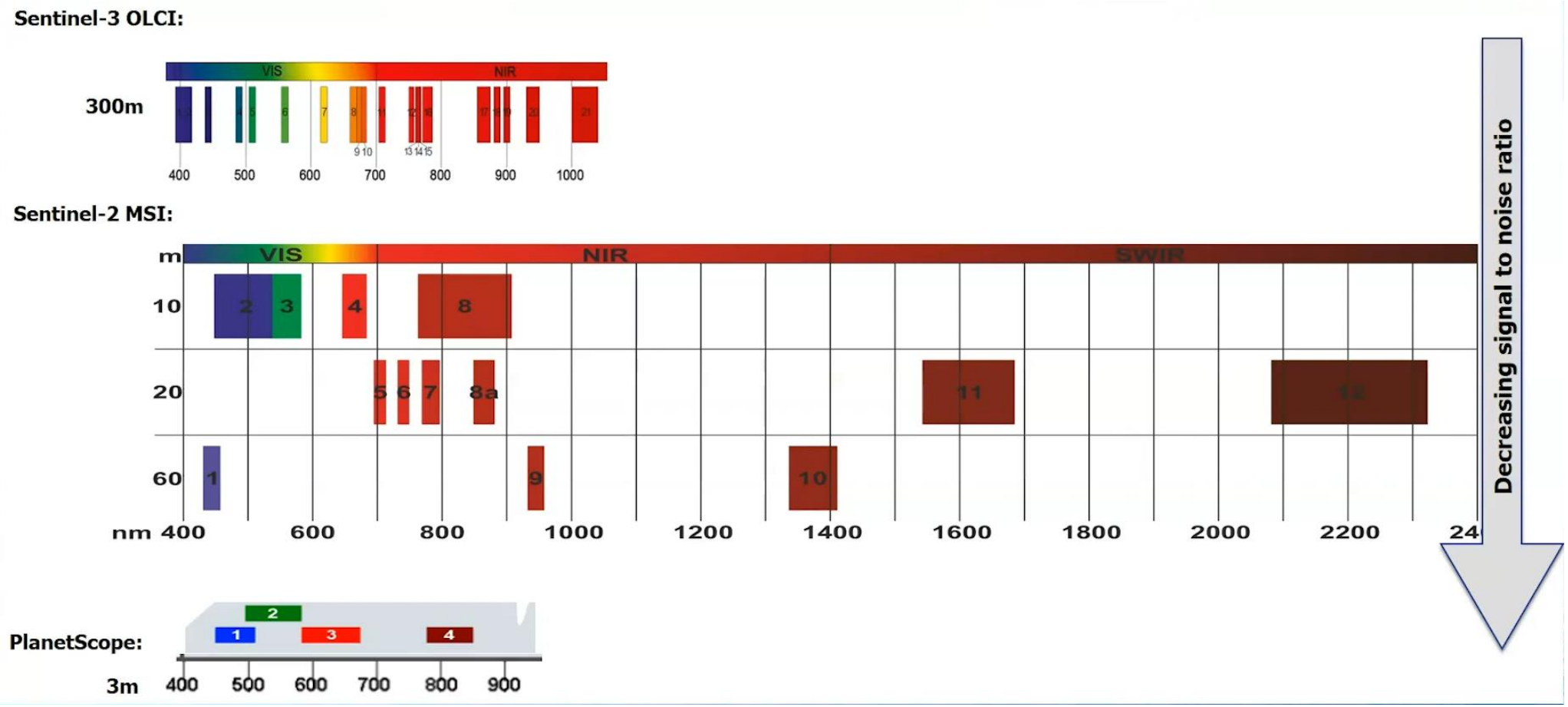
Phytoplankton bloom in Monterey Bay with images of different spatial resolution.

Ryan et al., 2005

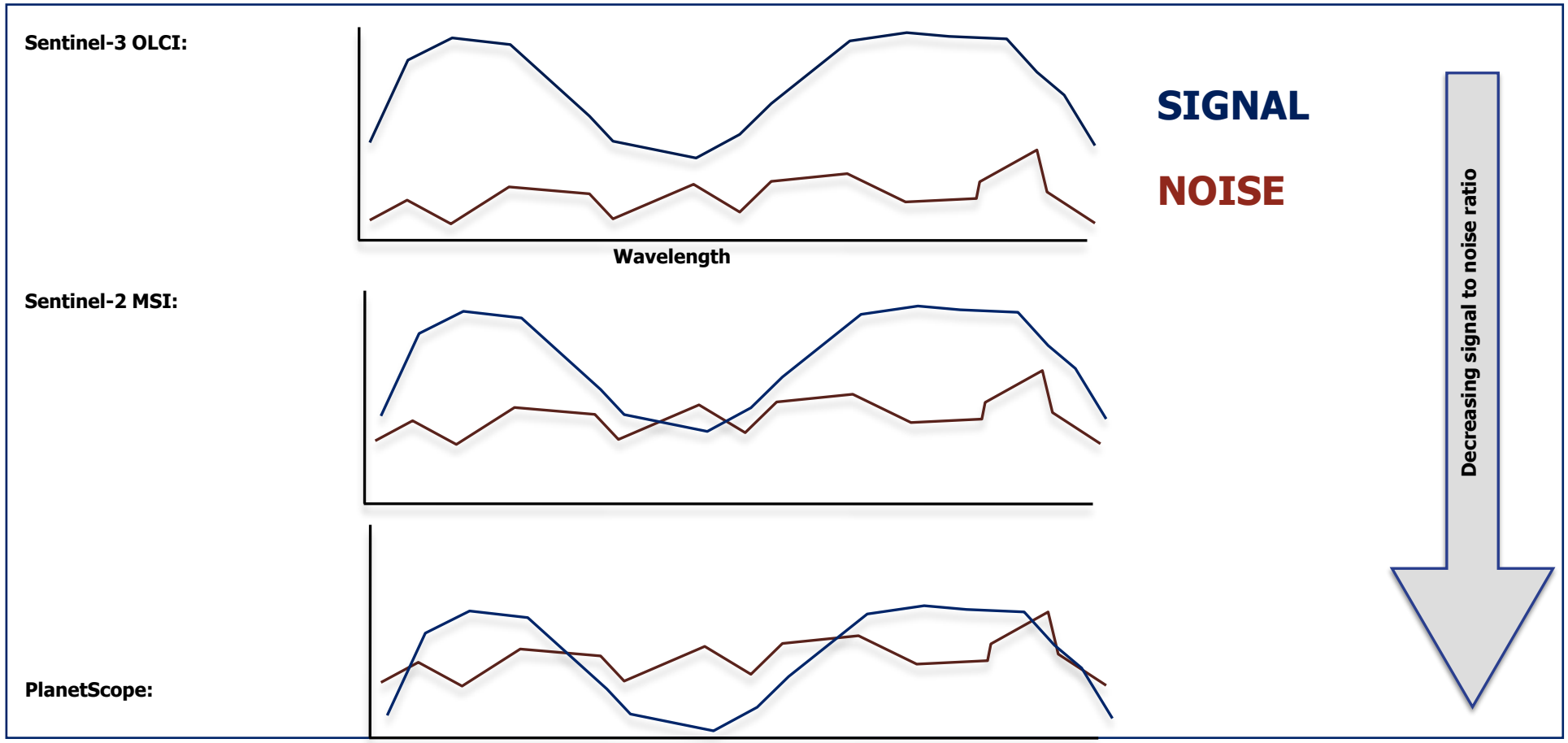
Trade-offs between temporal, spatial and spectral resolution



Spectral resolution and sensitivity

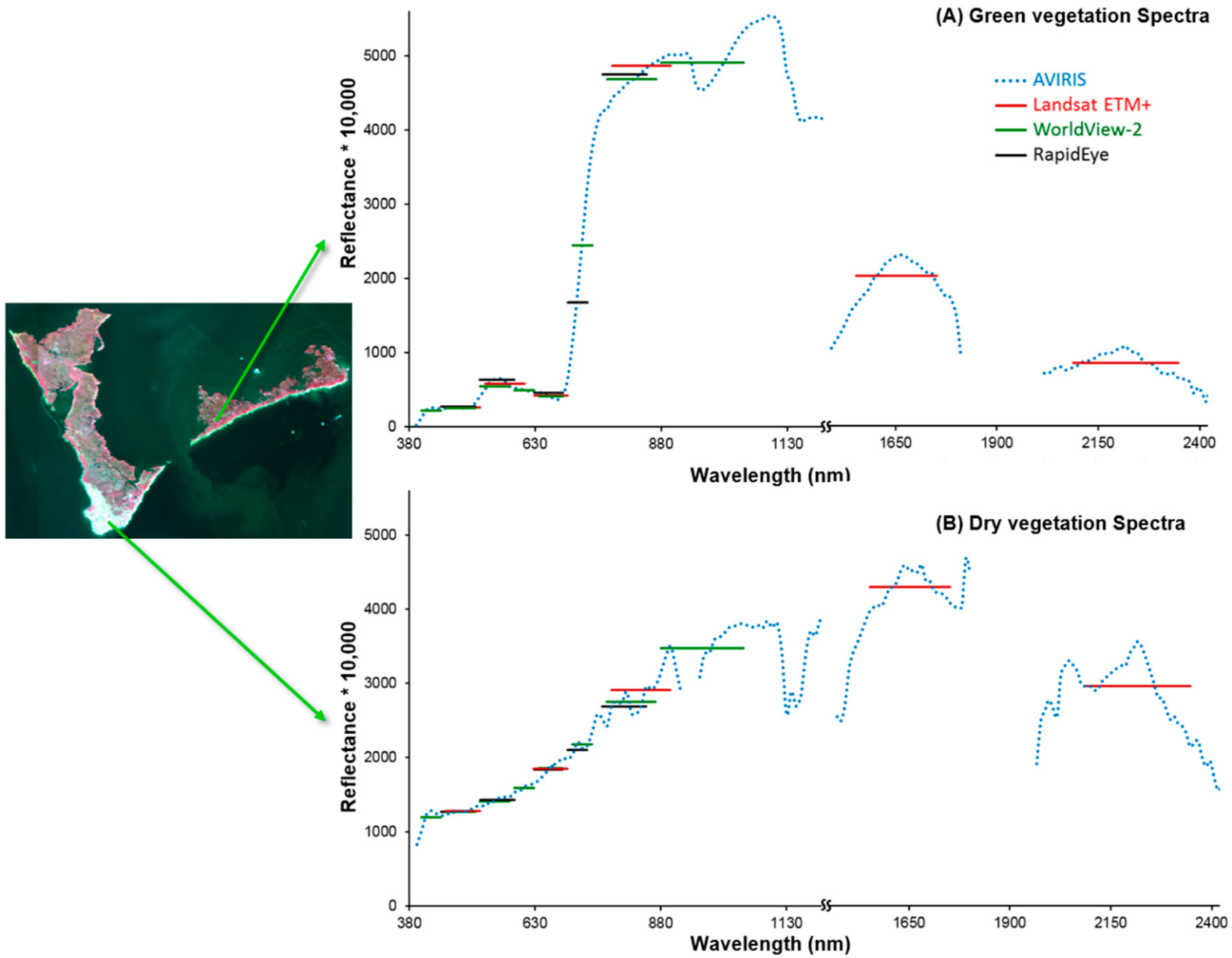


Signal to noise



Hyperspectral sensors

- Capture hundreds of narrow frequency bands
- Facilitates fine discrimination between different features on the Earth's surface



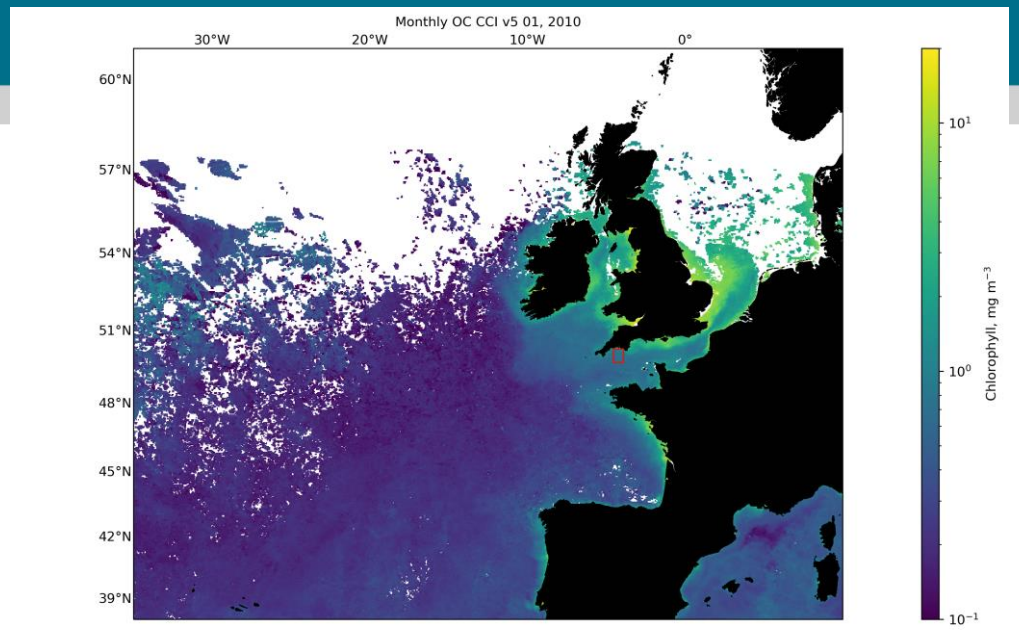
Khanna et al., 2018: An example of (**A**) green vegetation and (**B**) non-photosynthetic vegetation spectra from AVIRIS, WorldView2, RapidEye, and Landsat ETM+ showing the range and spectral resolution of the sensors.

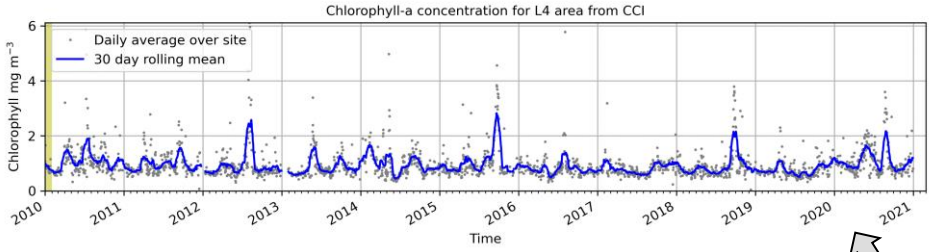
Processing levels

Processing Level	Description
Level 0	Reconstructed, unprocessed instrument and payload data at full resolution, with communications artefacts removed.
Level 1 (a+b)	Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information.
Level 2 (+p)	Derived geophysical variables at the same resolution and location as Level 1 source data. Often involves atmospheric correction.
Level 3	Variables mapped on uniform space-time grid scales, usually with some completeness and consistency. Except topography (L4)
Level 4	Model output or results from analyses of lower-level data (e.g., variables derived from multiple measurements).

NOTE: There are differences in how parts of the remote sensing community define processing levels. And different instruments will include different methods at each level. Look at individual handbooks, product guides, ATBDs etc for more information.

Example:





Level 0
Unprocessed instrument data

→

Level 1
"top of atmosphere" radiance

→

Level 2
water-leaving reflectance & derived products and data flags e.g. chlorophyll-a

→

Level 3
1d composite of chlorophyll-a concentration mapped on uniform grid

→

Level 4
OC-CCI merged multi-sensor product

Trade-off examples: Optical ocean colour data

Factor	CMEMS OC CCI	Sentinel-3 OLCI	Sentinel-2 MSI
Frequency/Revisit	Daily-monthly	1-2 days	5 days
Timeliness	Reprocessed/NRT	Within 3 hrs	3-24 hours
Temporal extent	~20 years	5 years	6 years
Spatial resolution	~1-4km	300m	10-60m
Spectral resolution	Common bands	21 Bands (narrow)	12 bands (broad)
Sensitivity	High SNR	High SNR	Lower SNR

Conclusions

- There are often trade-offs to consider when choosing the best data for your application
  - What spatial resolution, spectral resolution, frequency of observation do you need to study your feature of interest?
- Satellite data can be available at different timeliness levels
  - Do you want data as quickly as possible or as accurate as possible?
- Satellite data is available at different processing levels
  - L1 if doing your own processing and atmospheric correction
  - L2 level which many users will choose – derived geophysical variables at highest resolution available for the sensor
  - L3 + 4 mapped to uniform grid, spatial and temporal composites, merged products

Questions

Practical

- Practical exercise looking at mangrove cover in the Klang Islands in Malaysia
- Use online tools to view imagery timeseries and explore band combinations
- A few questions to answer in blue

Practical

- Scan to download digital version

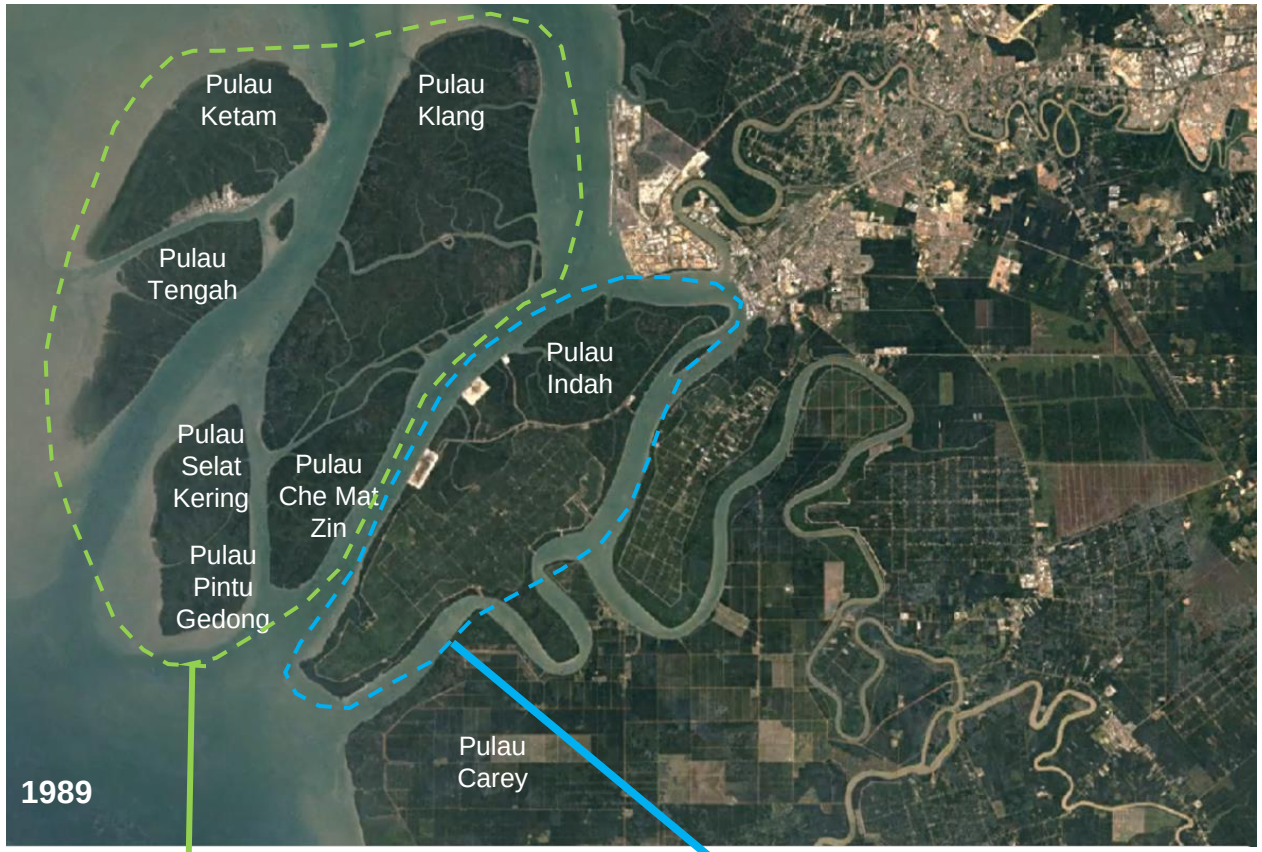
https://data.neodaas.ac.uk/files/PORTWIMS_course_2022/docs/1_Intro_to_EO_explore_data_practical_2021.pdf

Practical answers

Q1: Looking at this timeseries, which islands experience the most change in land cover, which islands change the least? What changes in infrastructure can you see?

Land use change (industrial?)

Land use change (residential?)



New road

Little change observed in the Klang Islands Mangrove Forest & Ketam Permanent Forest Reserves

P. Indah has seen ongoing mangrove clearance since the 1990s for industrial and port development.

Q2: Based on some of the considerations we talked about earlier, why might you choose to use Sentinel 2 imagery over Landsat imagery?

- Both are freely available
- Sentinel 2 imagery has higher resolution in the visible wavelengths (10m) compared to Landsat (up to 30m)
- This area is cloudy, Sentinel 2 has a shorter revisit time (although new Landsat 9 means they are similar if you consider 8 + 9 together)

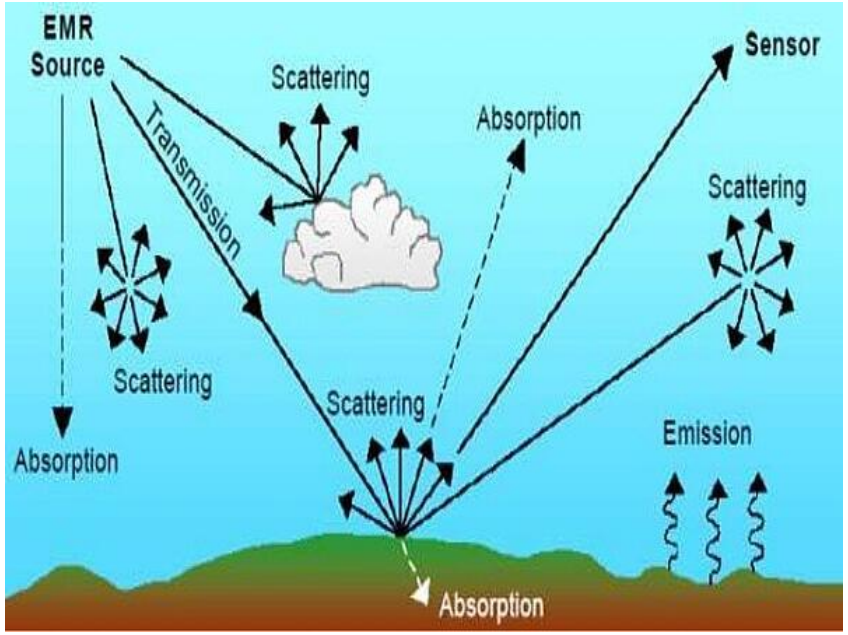
+ bonus – why might you choose Landsat?

- Long and consistent timeseries to monitor change

Q3: What are the main differences you notice between the L1C and L2A Sentinel 2 imagery?

Q3: What are the main differences you notice between the L1C and L2A Sentinel 2 imagery?

- Level-L1C: Top-Of-Atmosphere (TOA) reflectance
- Level-2A: Bottom-Of-Atmosphere (BOA) reflectance
- L1c appears more ‘hazy’ or ‘blue-ish’
  - radiation reflected by the surface of the earth is scattered, refracted and absorbed by water, aerosols and gas molecules
  - Scattered and reflected radiation leads to higher reflectance values at the sensor
  - Influence of the atmosphere has been subtracted from the reflectance at L2A



Q4: Are there any other satellites which may be helpful for exploring mangrove cover in this area?

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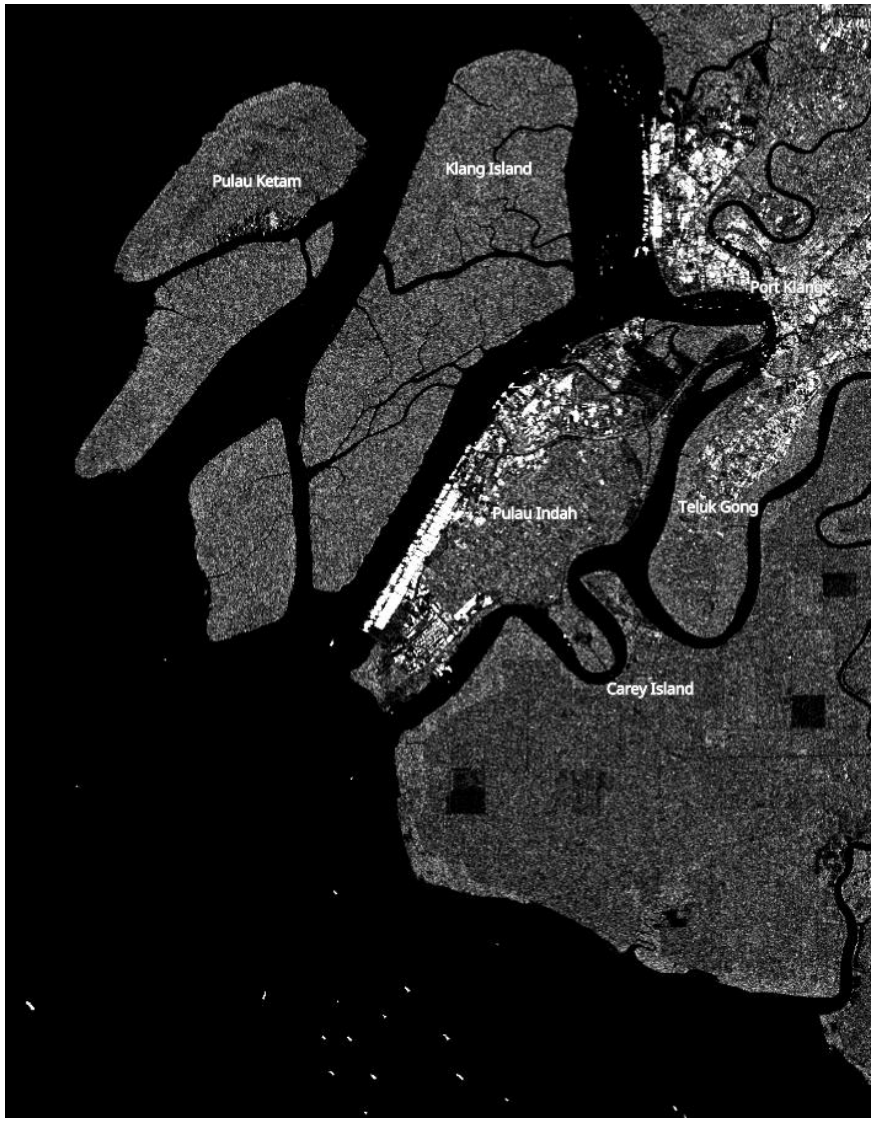
- Other medium resolution optical – e.g. Landsat
- High resolution optical e.g. Planet
- SAR – Sentinel 1
- Other datasets?
  - Elevation e.g. GEBCO
  - Any others?



Your areas of interest

Natural colour : 4, 3, 2

Your areas of interest

False colour : 12, 11, 4

Time	Agenda
09:30 – 11:00	Introduction to course and PML remote sensing group
11:00 – 11:30	**Coffee break**
11:30 – 13:00	Intro to EO and choosing the right data for your application
13:00 – 14:00	**Lunch break**
14:00 – 15:30	Introduction to the satellites and EO for coastal ecosystems EO for debris detection
15:30 – 16:00	**Coffee break**
16:00 – 17:30	Introduction to MAGEO Data access and plotting practical