Satellite 101, Part 2

NOAA Coastwatch Satellite Course

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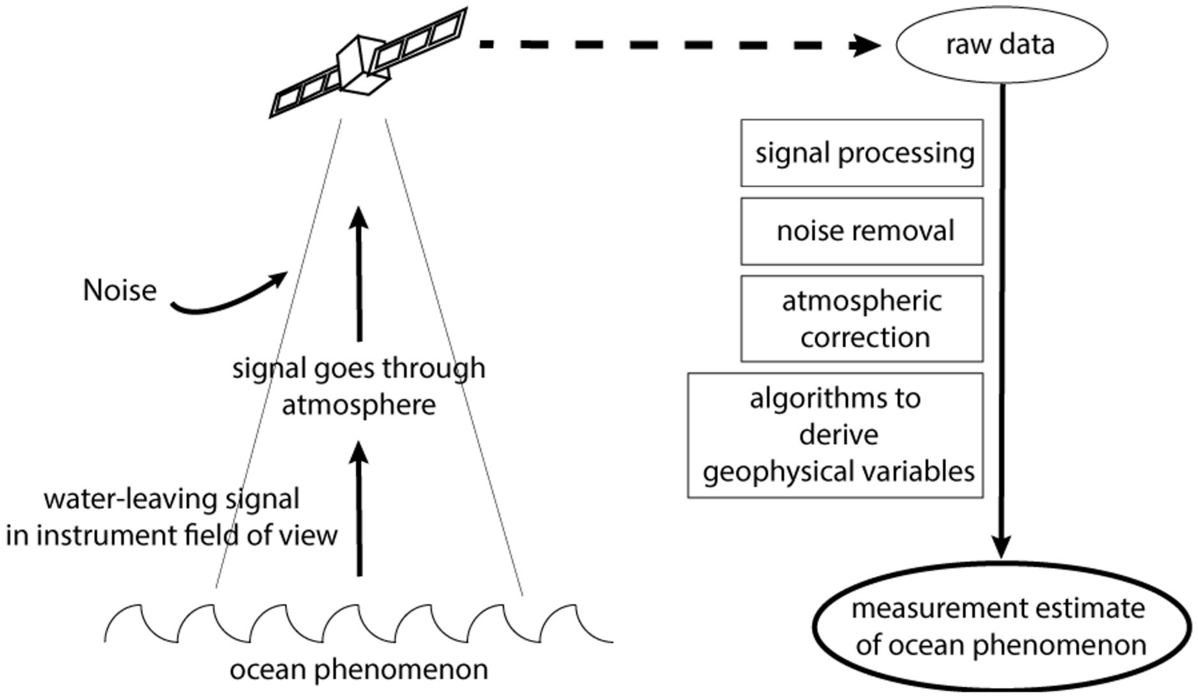
The presentation will cover the following topics

Satellite 101, Part 2:

- Electromagnetic Radiation (EMR)
- Atmospheric windows
- Atmospheric correction
- How signal collected by sensors becomes information
- Passive vs. active sensors



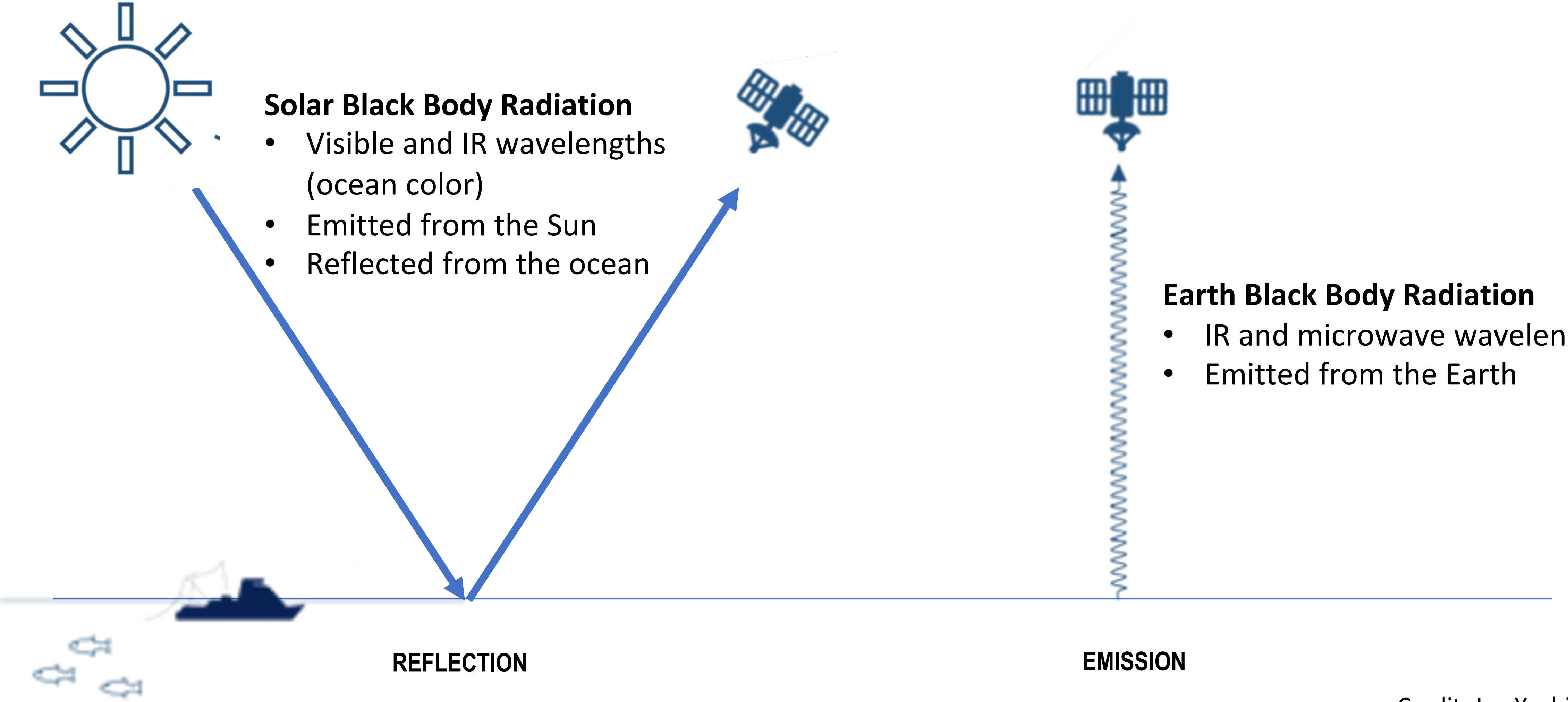
Satellite measure electromagnetic radiation (EMR)

Solar Black Body Radiation

- Visible and IR wavelengths (ocean color)
- Emitted from the Sun
- Reflected from the ocean

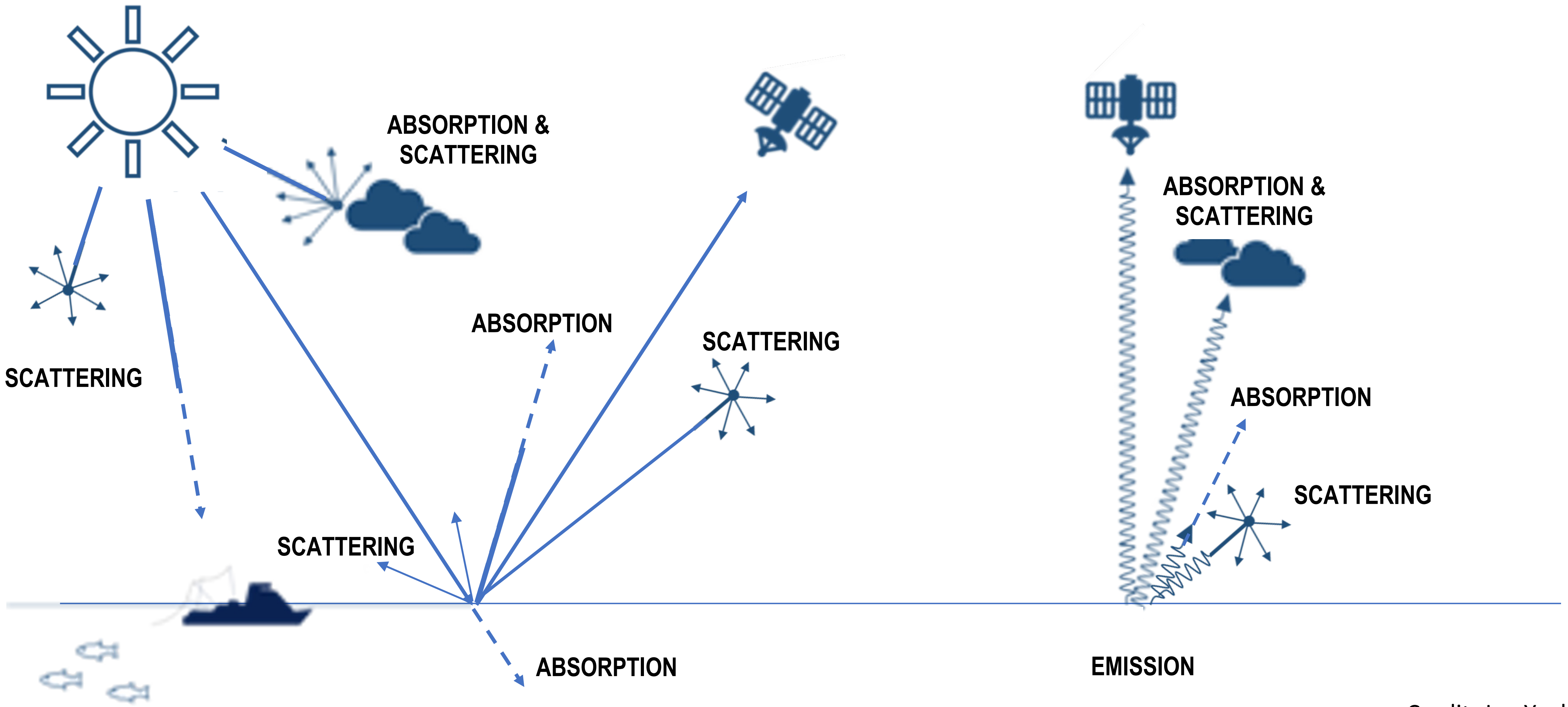
Earth Black Body Radiation

- IR and microwave wavelengths
- Emitted from the Earth



Credit: Jan Yoshioka, C

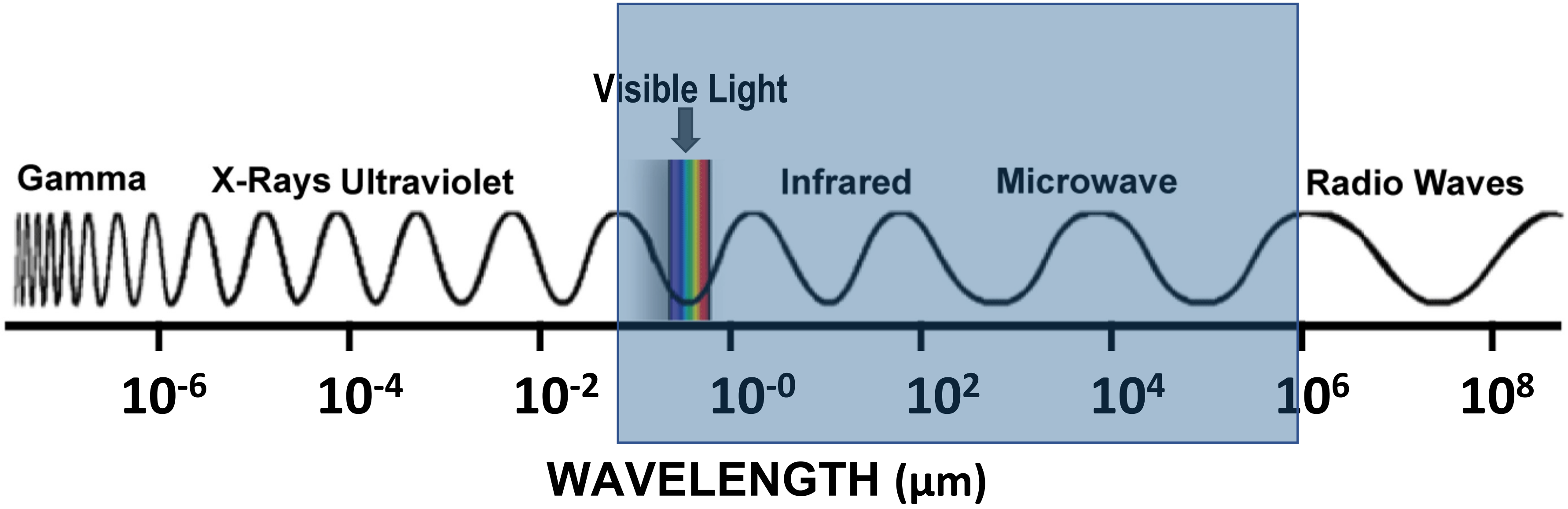
Processes alter the EMR signal as it passes through the atmosphere



Credit: Jan Yoshioka, CI

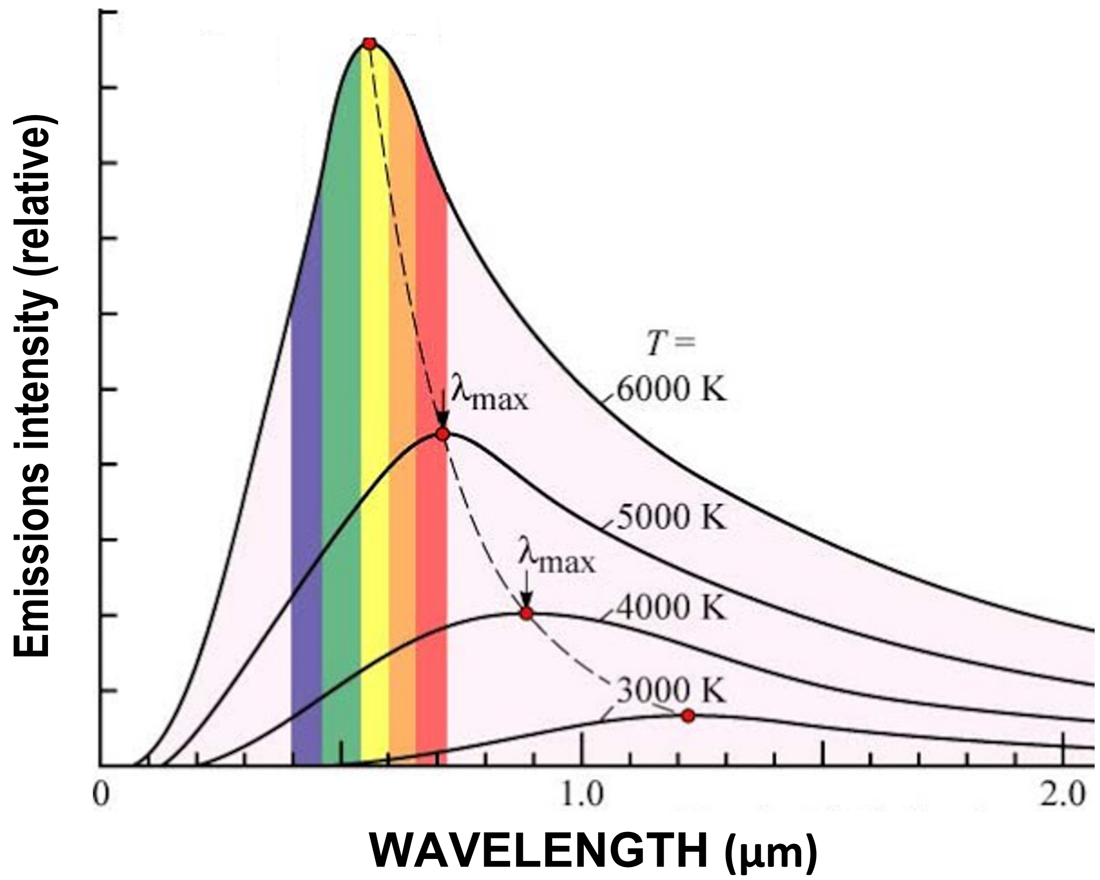
Electromagnetic Radiation (EMR)

- Energy is emitted from the sun and the surface of the Earth
- Photons travel at different wavelengths
- Visible, infrared, and microwave wavelengths bands are most useful for remote sensing



Natural sources of EMR come from black body radiation

Black body emissions as a function of temperature

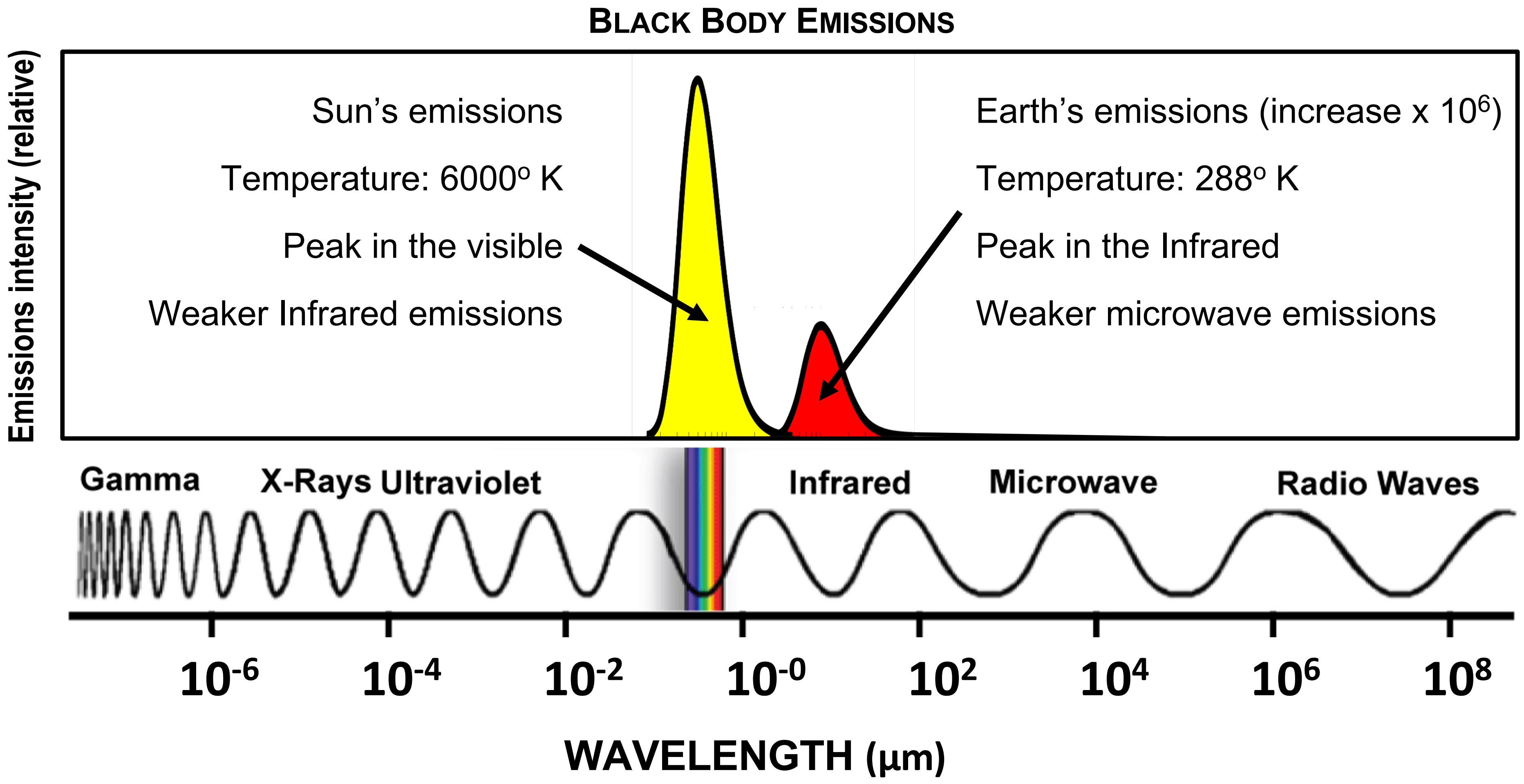


All "things" or "bodies" emit (EMR)

The spectrum of the emission depends on the temperature of the body

At lower temperatures:
- the intensity of the emissions decreases
- the peak of the emissions curve shifts to longer wavelengths

Satellite sensors measure electromagnetic radiation (EMR)



Remote

Emissivity is a measure how efficiently blackbody radiation is emitted

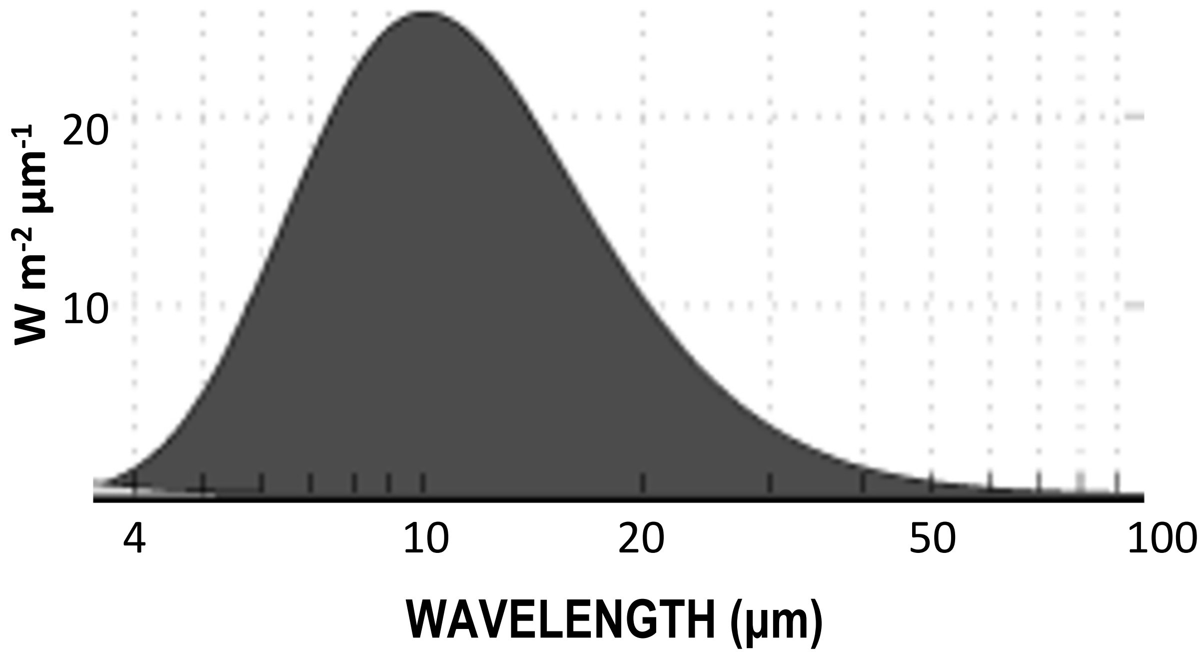
The blackbody emissions curve for Earth assumes that the Earth behaves like a perfect blackbody, meaning its completely driven by temperature.

In reality, parts of the earth emit EMR at only a fraction (call emissivity or “e”) of that of a perfect blackbody:

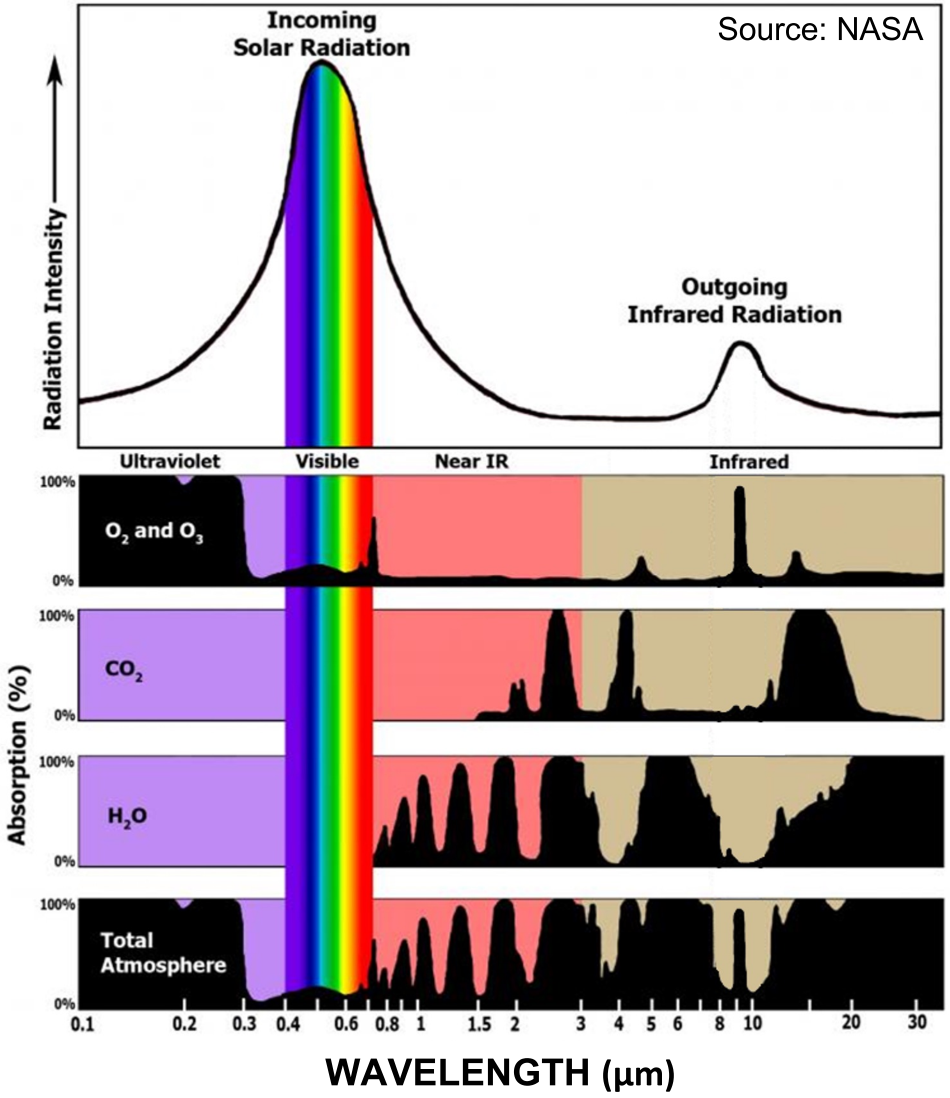
- For open water and sea ice: e = .98 in the infrared
- For open water: e = .4 in the microwave
- For sea ice: e = .8

In addition, e changes as a of function of wind speed, temperature, and salinity, allowing the determination for these parameters.

Theoretical Earth blackbody emission curve where e = 1.0



Useful wavelengths are limited by the Earth's atmosphere



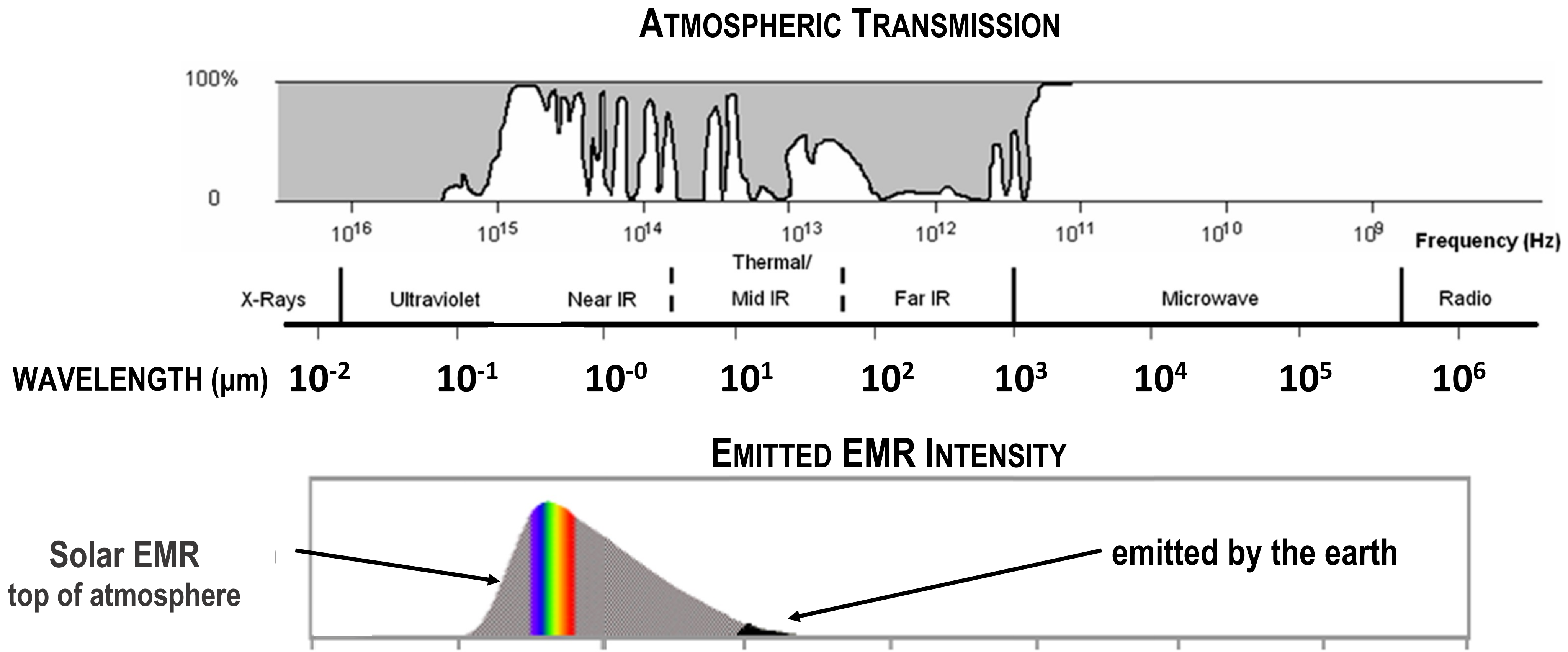
The atmosphere is opaque to EMR at many wavelengths, due to absorption by atmospheric gases.

EMR is fully or partly transmitted through the atmosphere at only specific wavelengths.

Remote sensing makes use of these "**atmospheric windows**".

Atmospheric windows for EMR

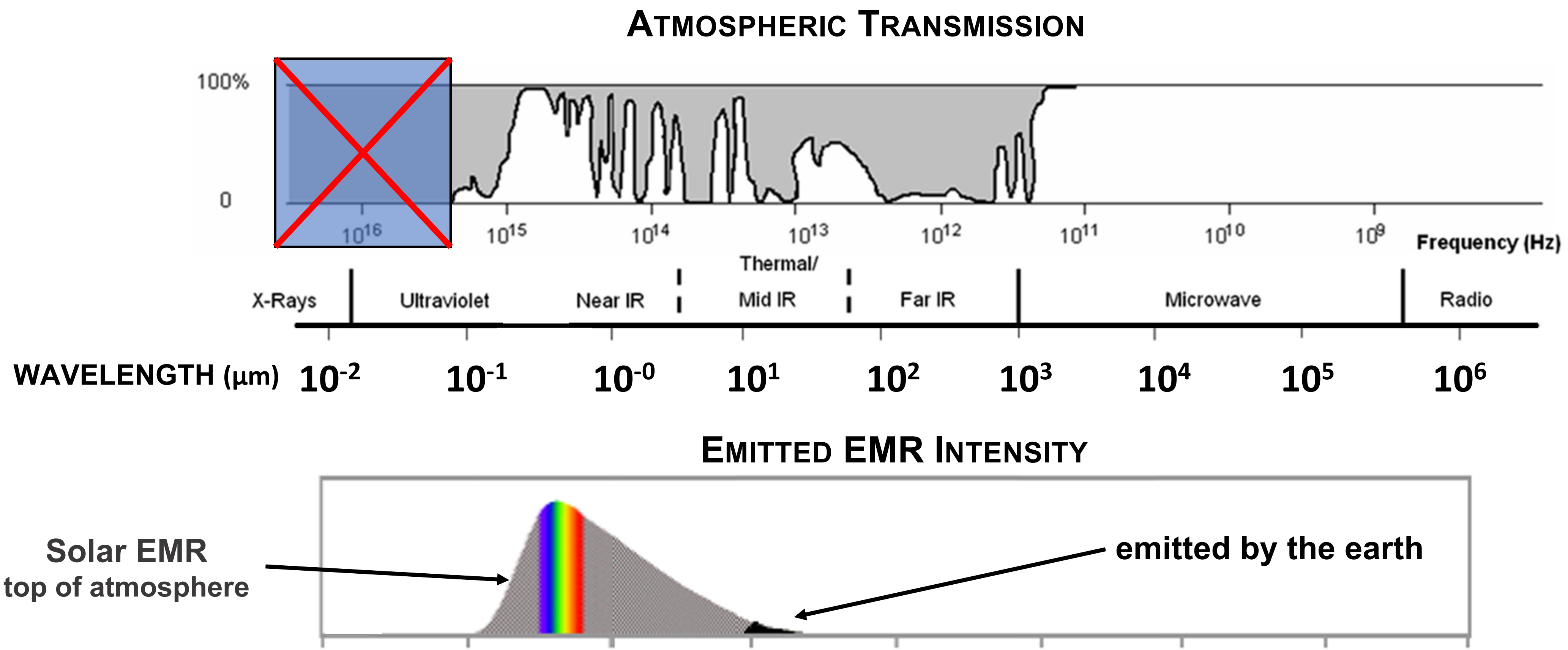
Satellites can 'see' the earth in the regions of high atmospheric transmittance (ie low absorption)



No atmospheric windows occur in X-Ray and shorter UV wavelengths

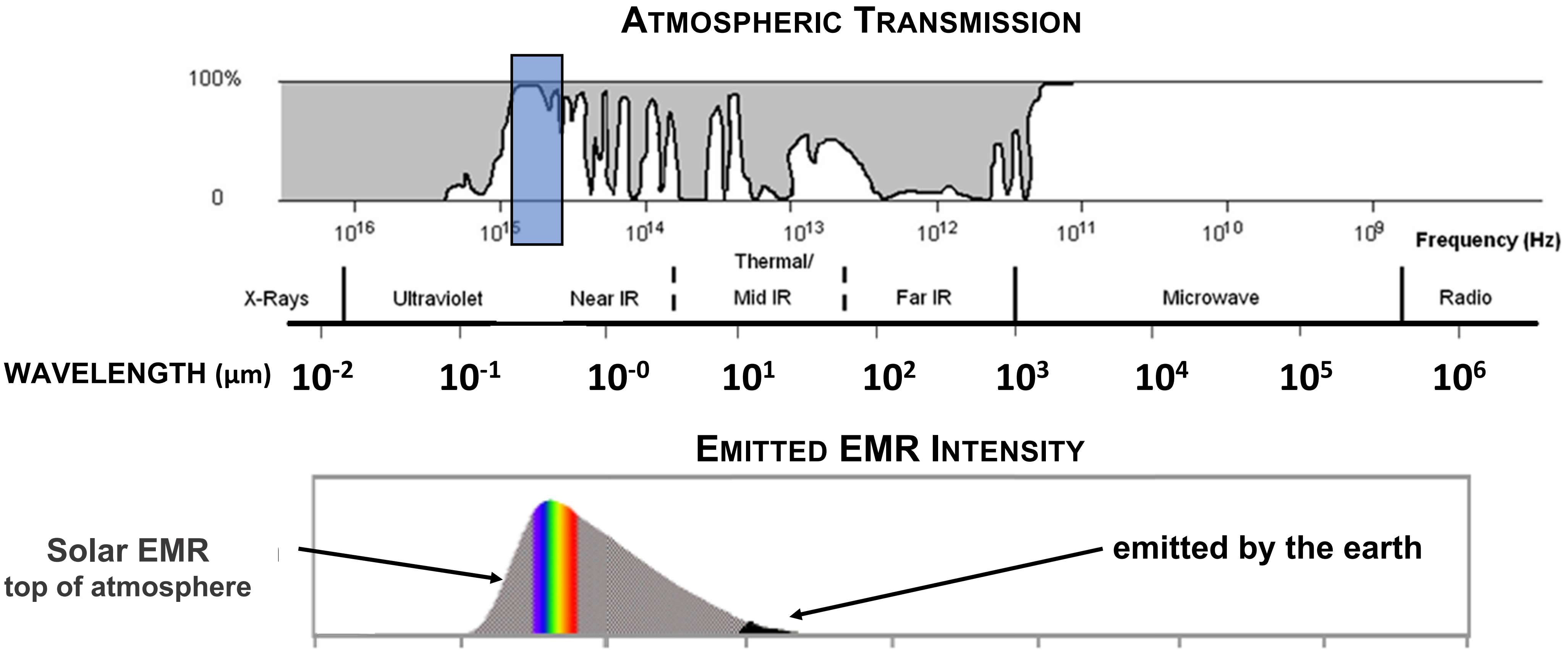
X-Ray and shorter Ultraviolet wavelengths are almost totally attenuated.

Therefore these EMR bands are less relevant for remote sensing.



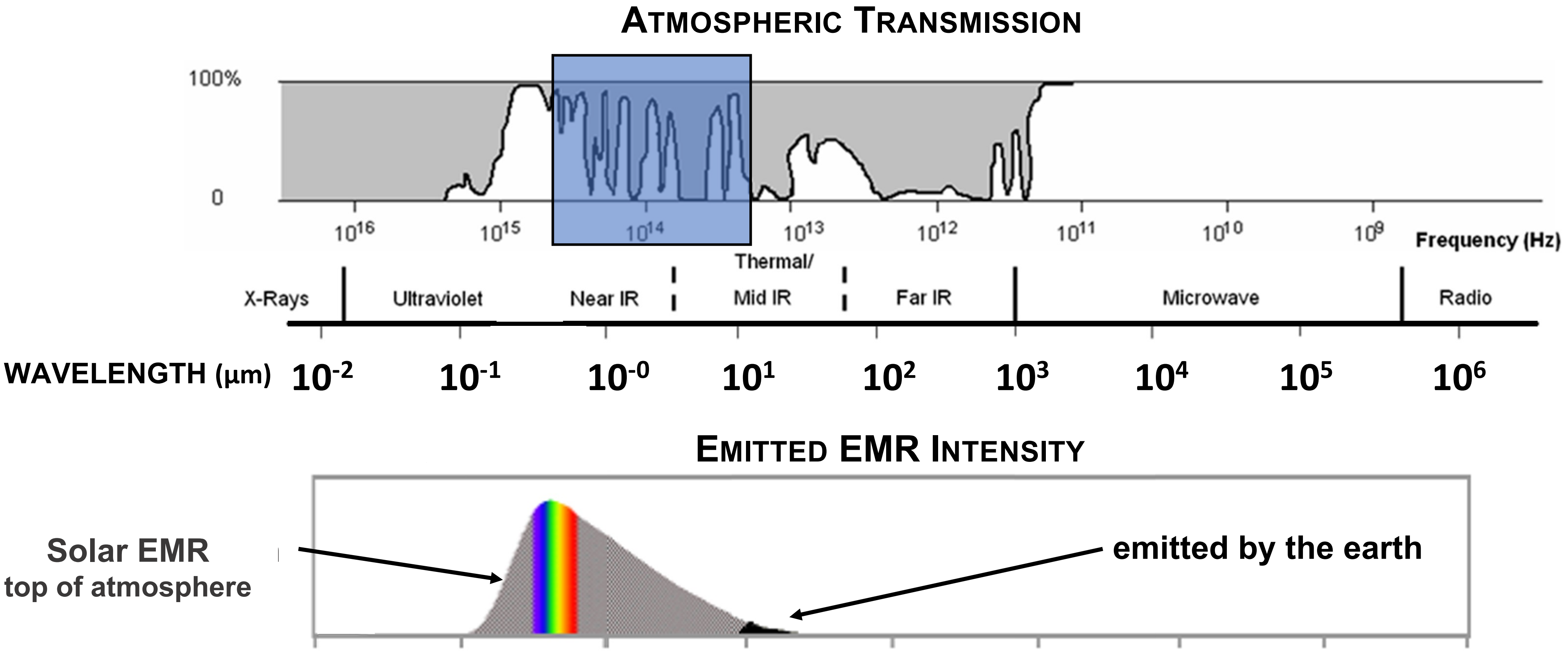
Visible light passes through the atmosphere without much attenuation

Atmospheric transmittance is high in **visible bands**, where solar EMR emission is highest



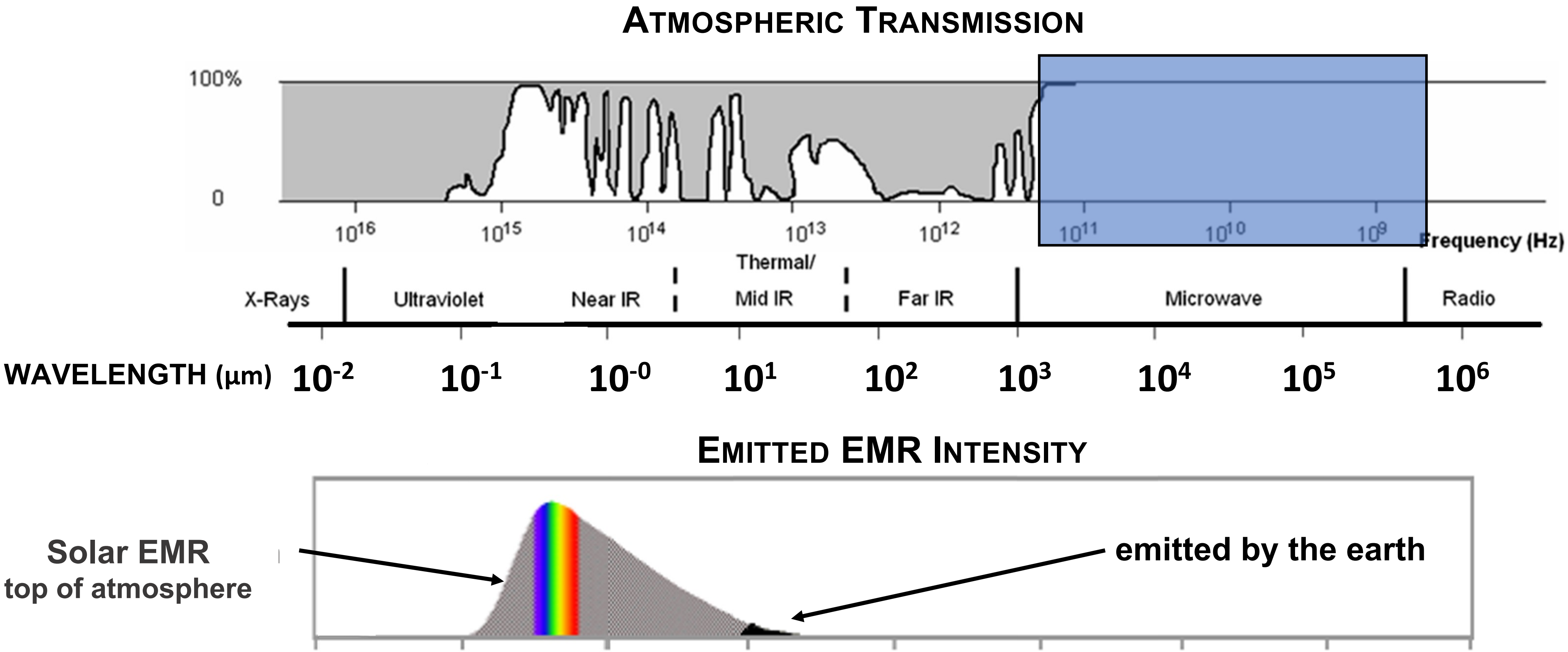
Infrared passes through narrow atmospheric windows

In the infrared, high transmittance occurs in narrow bands. This includes the optical windows in the thermal **infrared**, where the Earth's surface emits radiation.



Microwaves passes through the atmosphere without much attenuation

In the **microwave**, atmosphere transmission is near 100%.
But emission in the **microwave by** are relatively weak, so large antennas and large sensor footprints are needed to collect enough radiation for measurements.



EMR is also affected by the water properties

EMR emitted by the sun is transmitted through the atmosphere to the ocean.

EMR interacts with elements in the ocean, where the spectral characteristics are changed

EMR reflected from the ocean is transmitted through the atmosphere and reaches the sensor

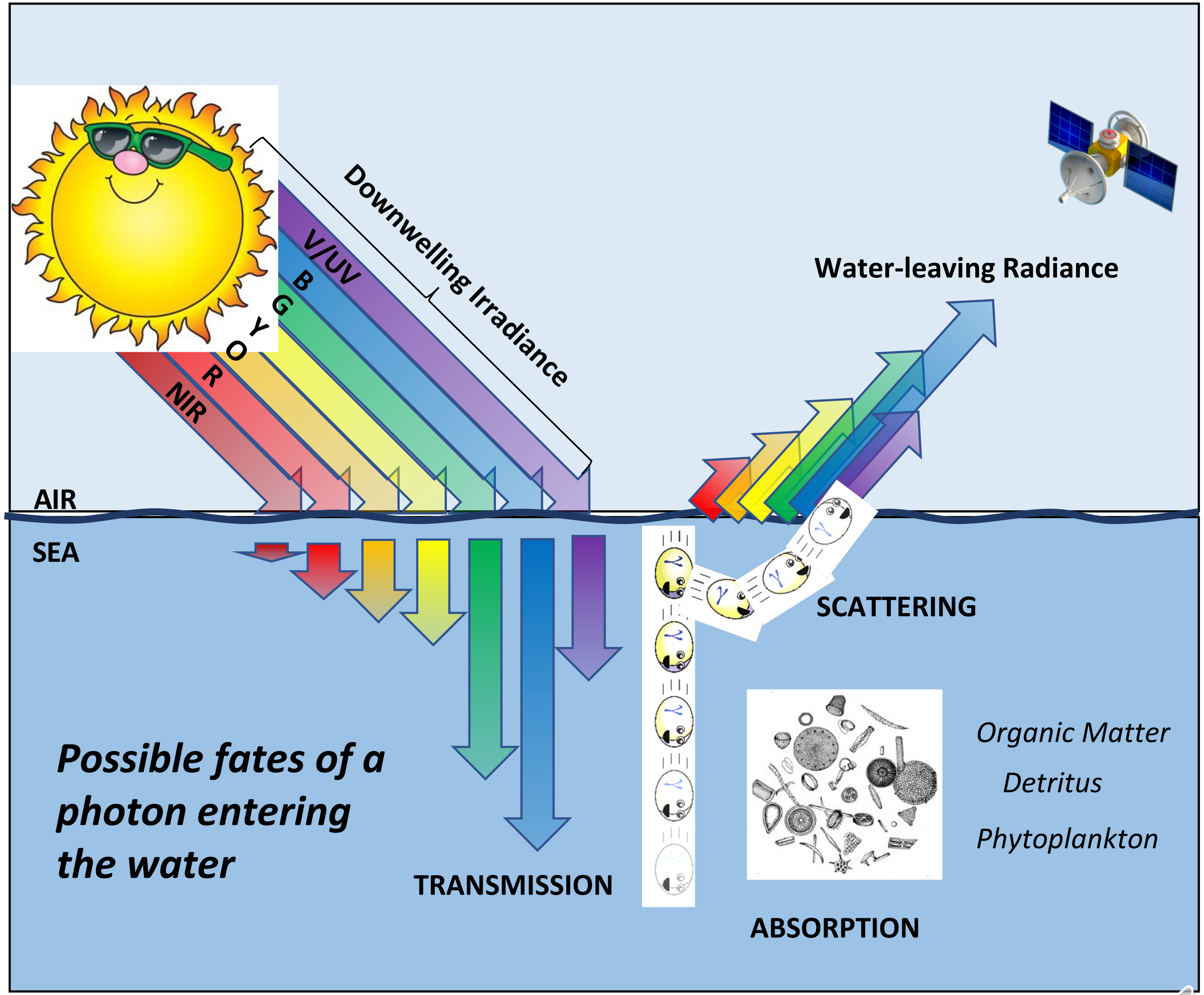


Image Credit:
jeremy.werdell@nasa.gov

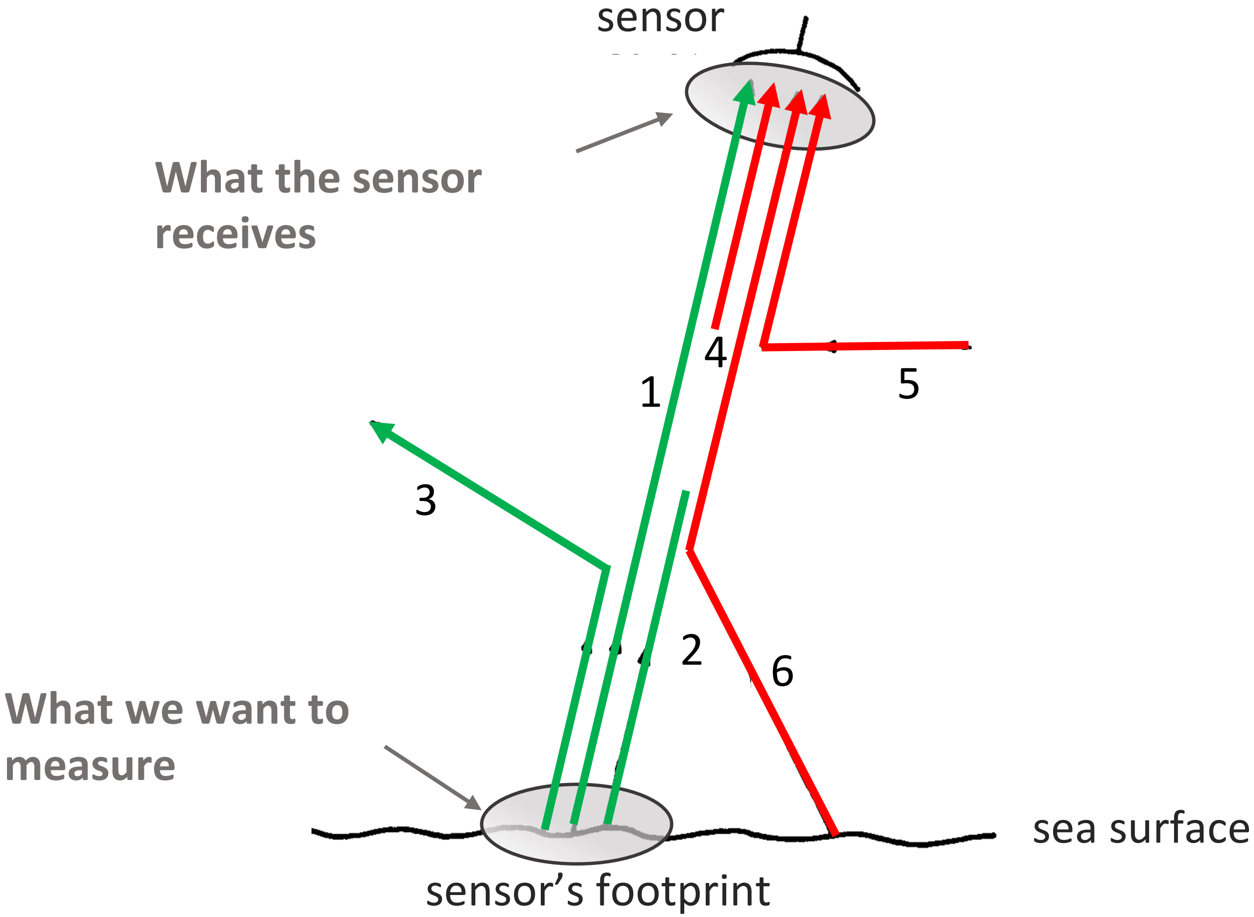
Atmospheric Pathways of EMT between the ocean and the satellite

Emitted from the sea within the sensor's footprint

Ray 1 - the useful signal, radiation leaving the ocean and measured by the sensor
Ray 2 - radiation leaving the ocean that is absorbed by the atmosphere
Ray 3 - radiation that is scattered by the atmosphere out of the sensor field of view

Reaching sensor from sources outside its footprint

Ray 4 - radiation emitted by the constituents of the atmosphere
Ray 5 - radiation reflected by scattering into the field of vision of the sensor
Ray 6 - radiation from the ocean but from outside the field of view.



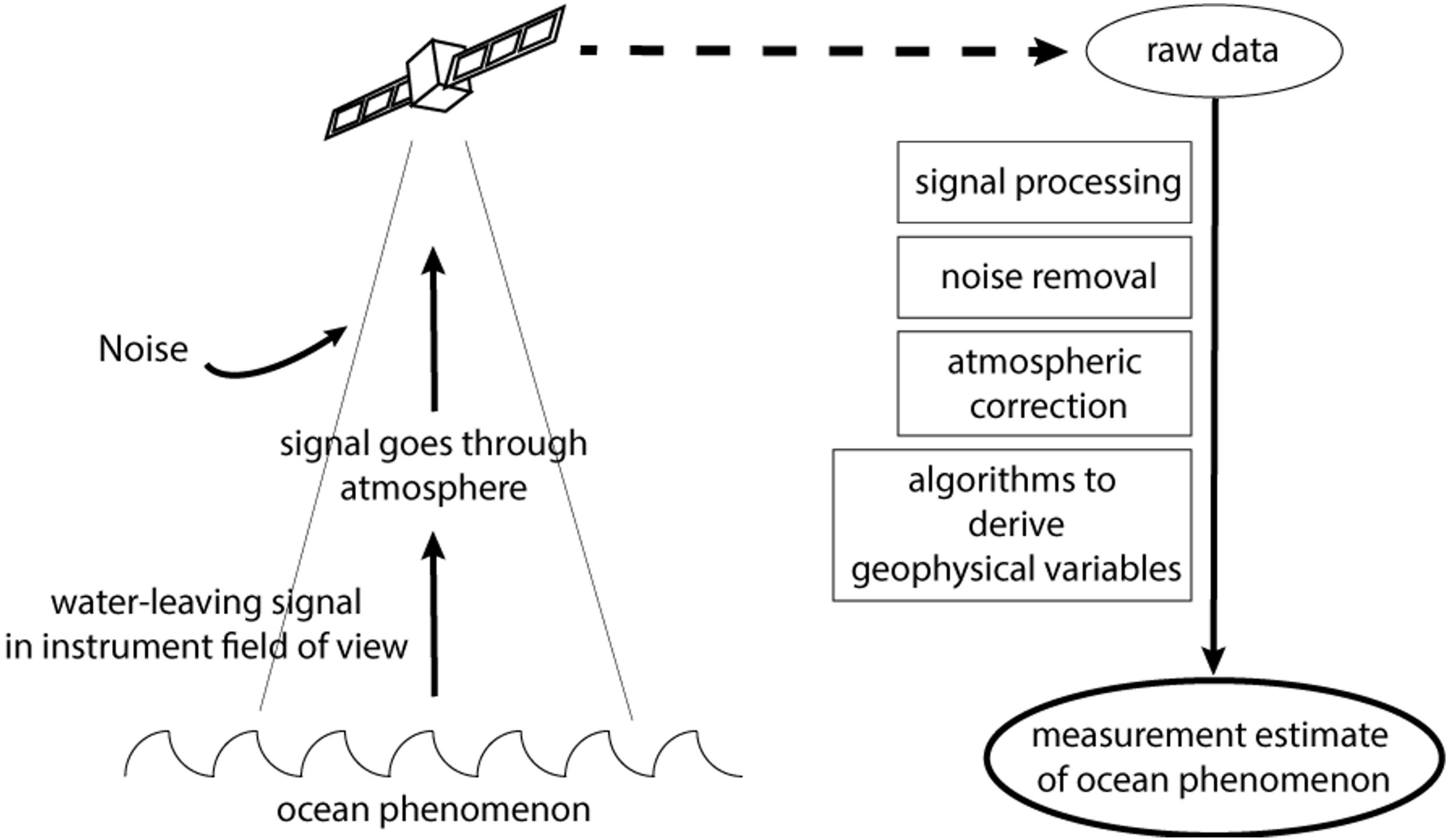
ATMOSPHERIC CORRECTIONS ARE NECESSARY TO DERIVE ACCURATE SATELLITE DATA PRODUCTS.

Atmospheric Correction

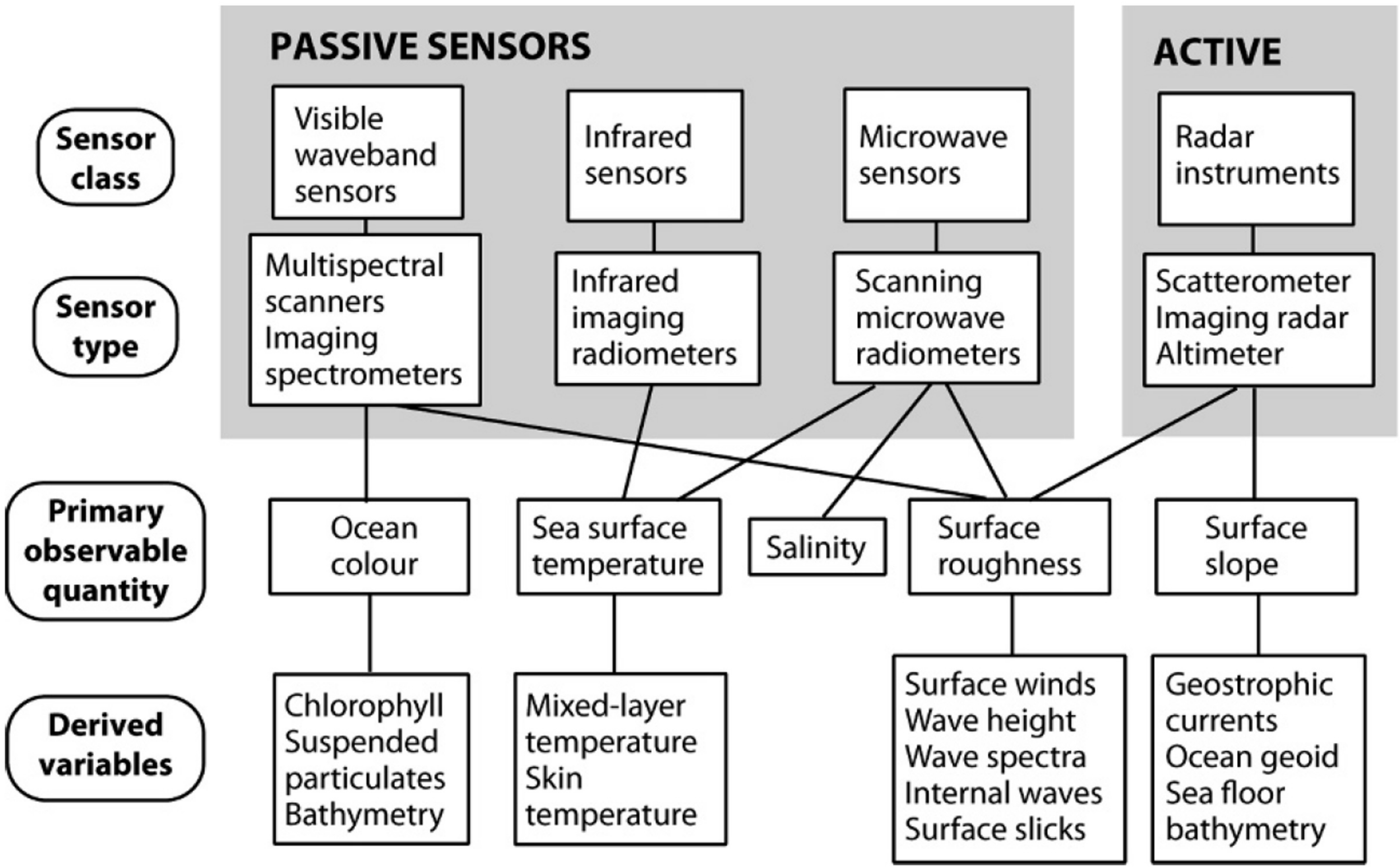
- Most of the absorption/re-emission of IR in the atmosphere is caused by a few gases (O_2, N_2 and trace gases) that are relatively well-mixed, and by water vapor, ozone and aerosols, that are not well mixed.
- The well-mixed components cause a constant difference in temperature between the surface and the satellite.
- The variable components must be detected and corrected for using multiple wavelengths.

Atmospheric correction is necessary to derive accurate satellite data products.

The process of converting the EMR signal to information

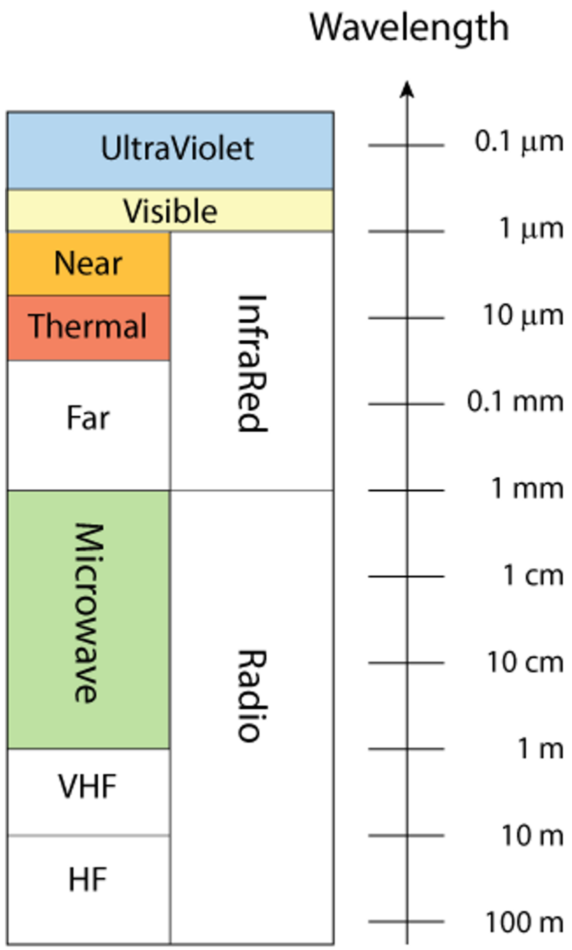


Types of Sensors and Products



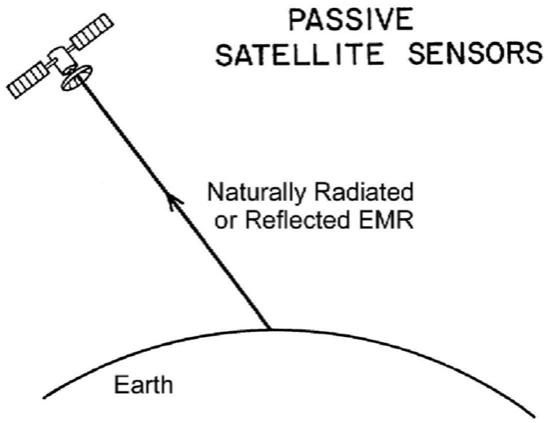
From Robinson, Discovering the Ocean from Space

EMR Spectrum and Applications



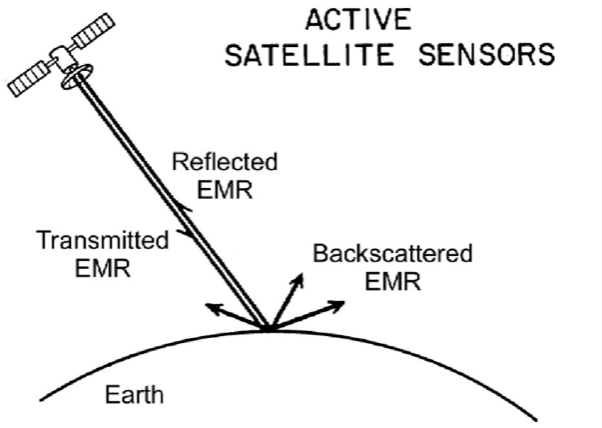
Sensor	Application
TOMS, OMPS	Ozone conc.
DMSP OLPS NOAA AVHRR GOES-R ABI	Weather
Landsat MSS/TM SPOT HRV	Land use Geomorphology
CZCS, Seawifs MODIS, VIIRS	chl a conc. turbidity, sediment
NOAA AVHRR GOES-R ABI	vegetation, clouds snow, ice
NOAA AVHRR GOES-R ABI	sea surface temp night-time clouds water vapor
SMMR SSM/I	sea ice conc. snow cover
Altimeters SAR Scatterometers	sea surface height, currents surface roughness wind

Passive vs Active Sensors



Passive Remote Sensing

- Reception of EMR signals from natural source
- Either EMR from the Sun that is reflected off of the earth or EMR emitted by the Earth



Active Remote Sensing

- Reception of EMR signals from a pulse emitted by a satellite
- The pulse is directed to the earth and the reflected signal is captured by the satellite sensor

Passive vs. Active Sensors

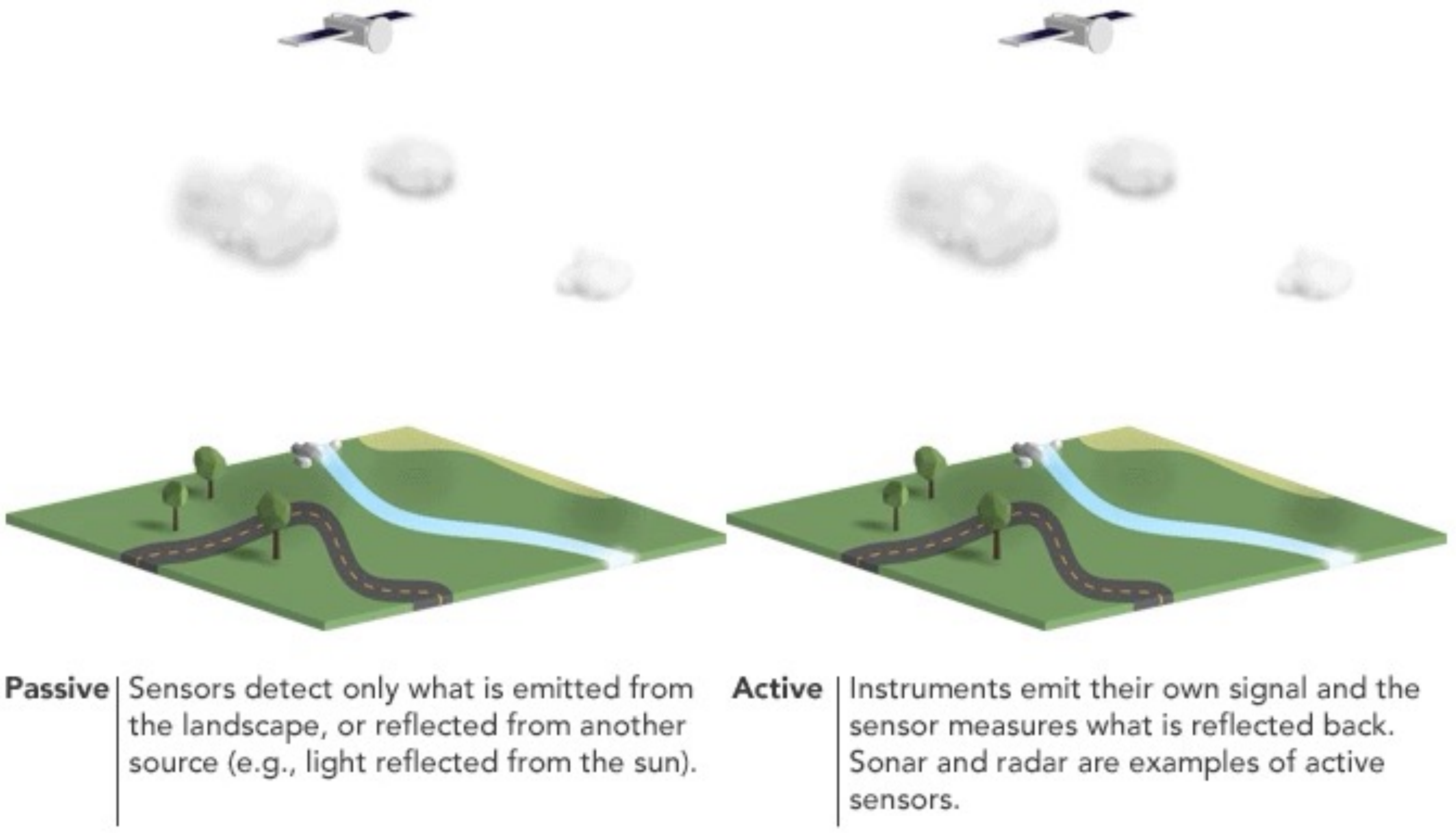


Image Credit: NASA ARSET

Science Quality vs NRT

- Science Quality data has undergone better Quality Control, and has latency periods of several weeks to several months. These data are typically are used to look at trends over time, and for use in publications.
- Near-Real time (NRT) data, is data with the shortest latency possible, hours to days. To achieve this short latency these datasets have undergone minimal Quality Control.
- For datasets that are periodically reprocessed, the older versions should be labelled “deprecated” on data servers (i.e. ERDDAP).

NOAA CoastWatch Satellite Course - Narrated Presentations

- Satellite 101 – Part 1
- **Satellite 101 – Part 2**
- Fundamentals of Ocean Color
- Fundamentals of Sea-Surface Temperature
- Fundamentals of Altimetry, Wind and Salinity
- Introduction to ERDDAP
- What Dataset to Choose?
- Bringing Satellite Data into ARCGIS