Sensors and Data Interpretation I

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Lecture Outline

1. Different types of remote sensor
    A. Active and passive remote sensing
    B. Data pre-processing
2. Introduction to remote sensing products for water resources management
    A. Precipitation and evaporation
    B. Landcover, terrain, soil moisture and terrestrial water storage
    C. Streamflow
    D. Water hazards
3. Remote sensing products and resolution

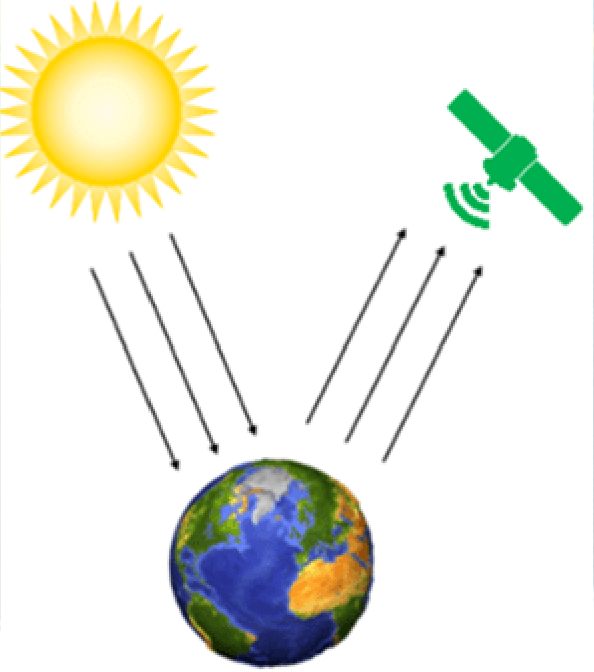
Active vs Passive RS

Active RS

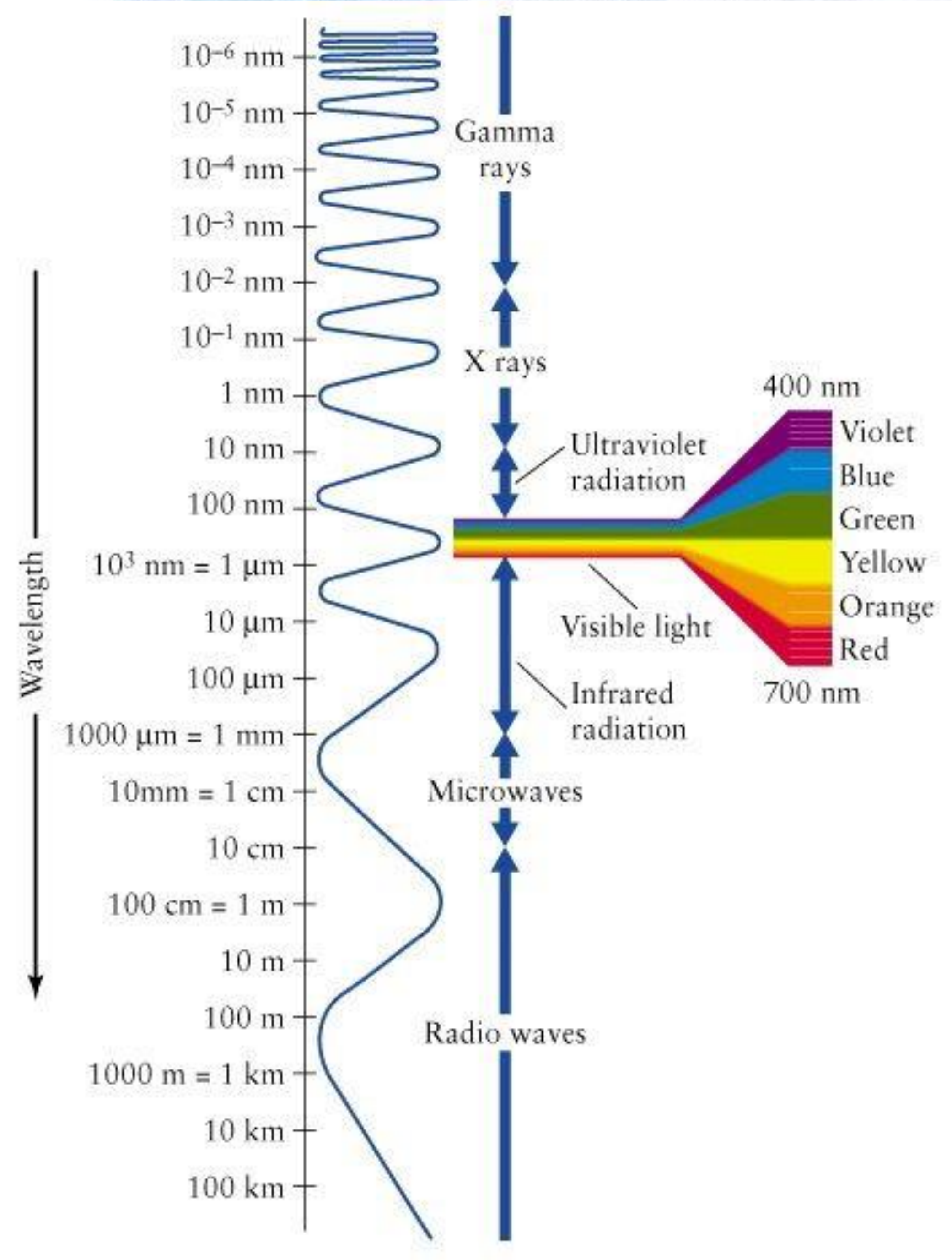
- Active sensors have its own source of light or illumination. In particular, it actively sends a wave and measures that backscatter reflected back

Passive RS

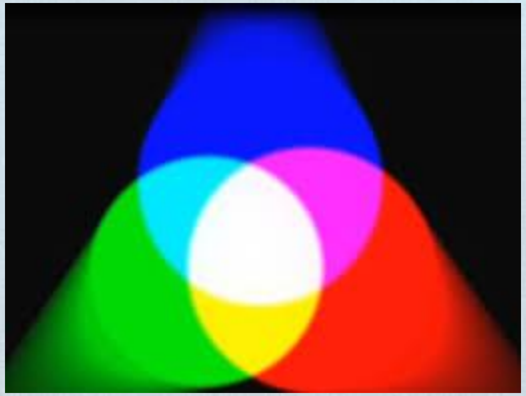
- Passive sensors measure reflected sunlight emitted from the sun. When the sun shines, passive sensors measure this energy

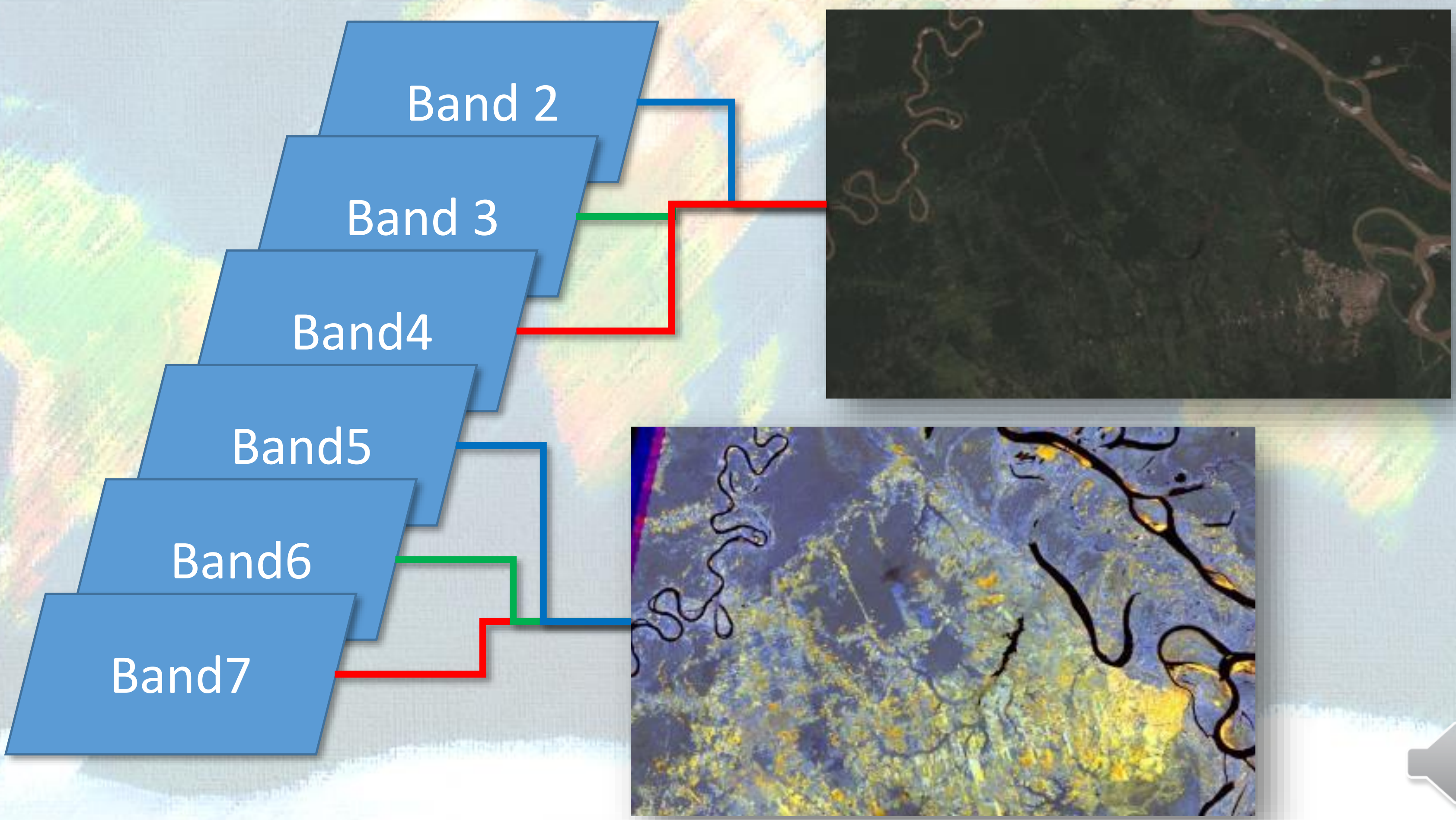


Active vs Passive RS

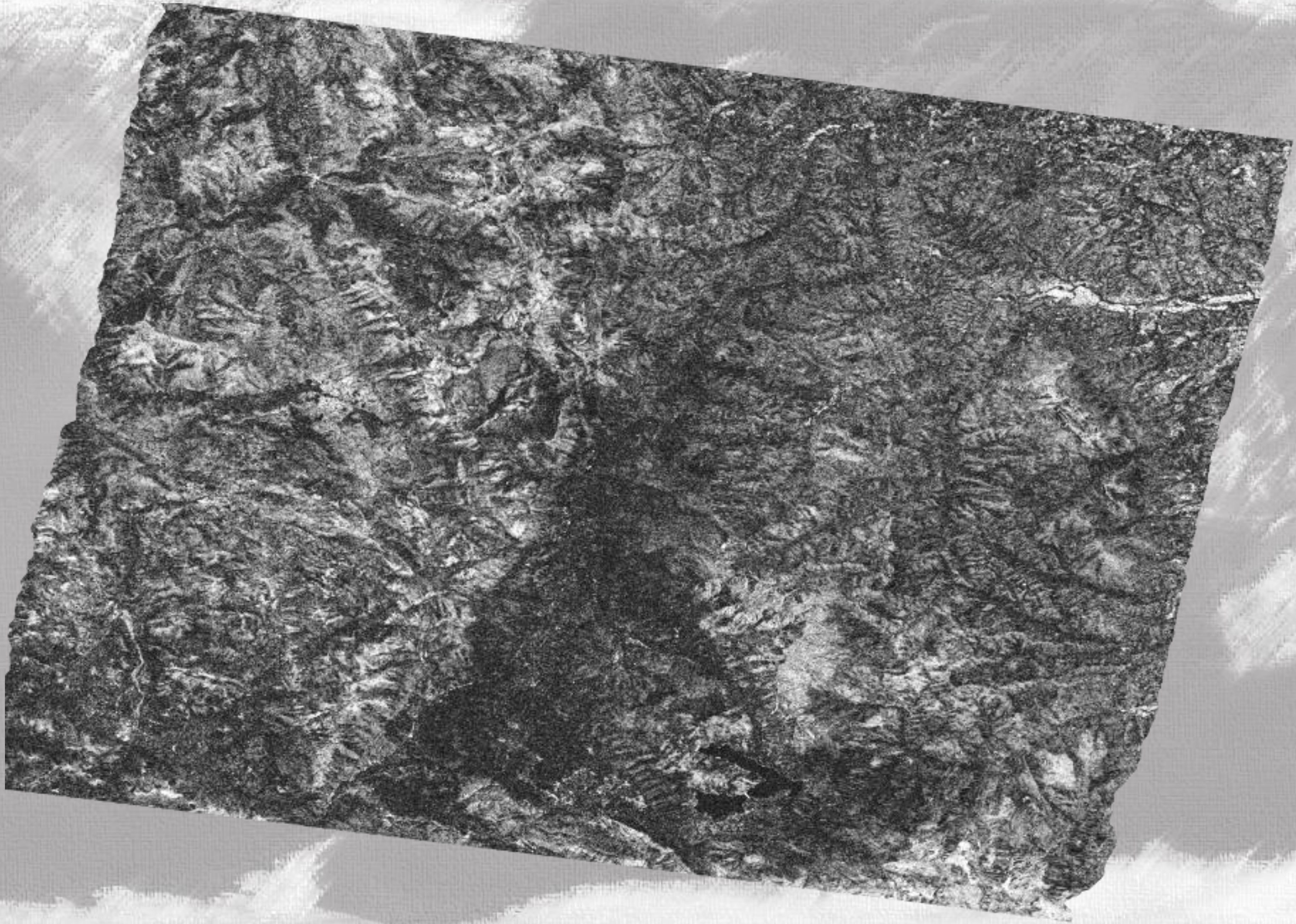


Multispectral Imaging (Passive)

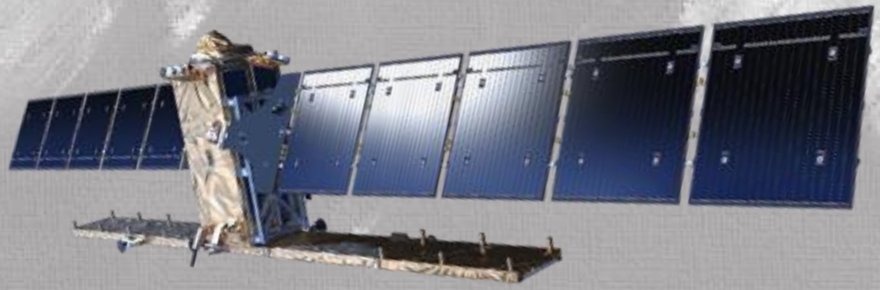




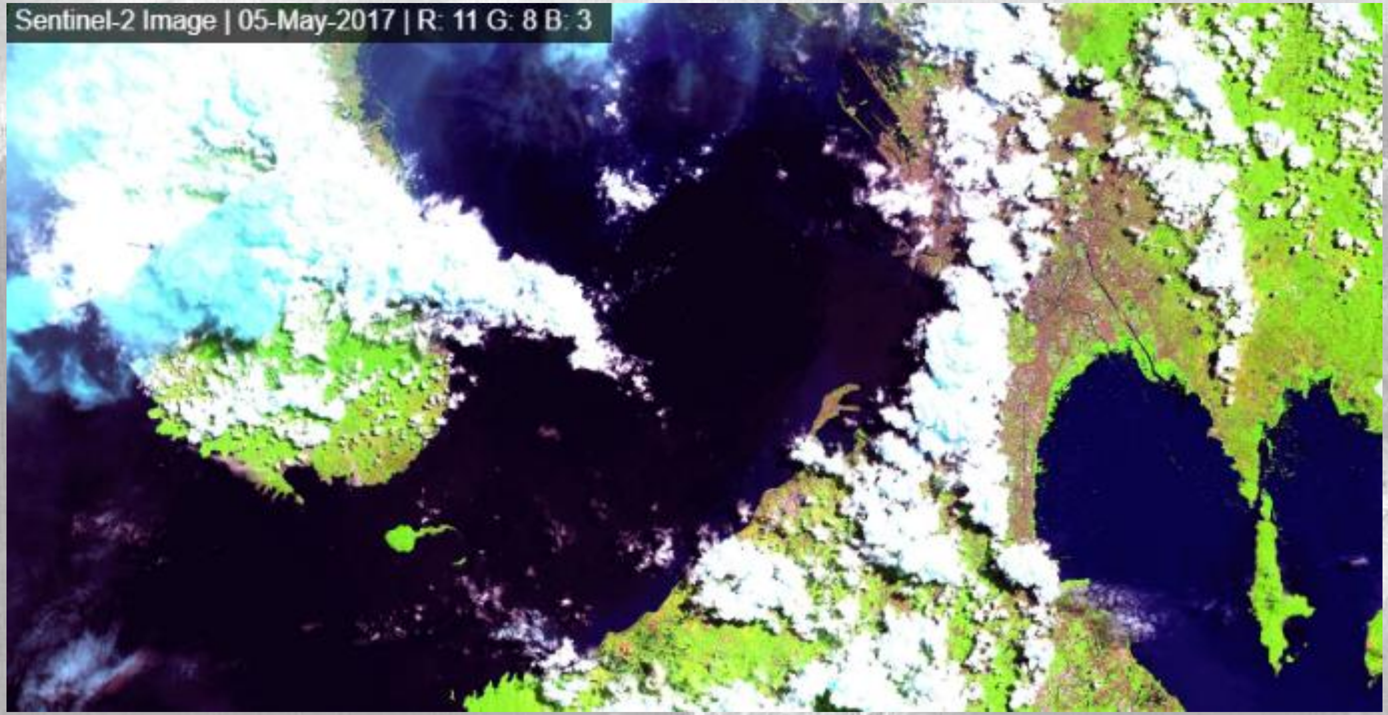
Radar (Active) Data

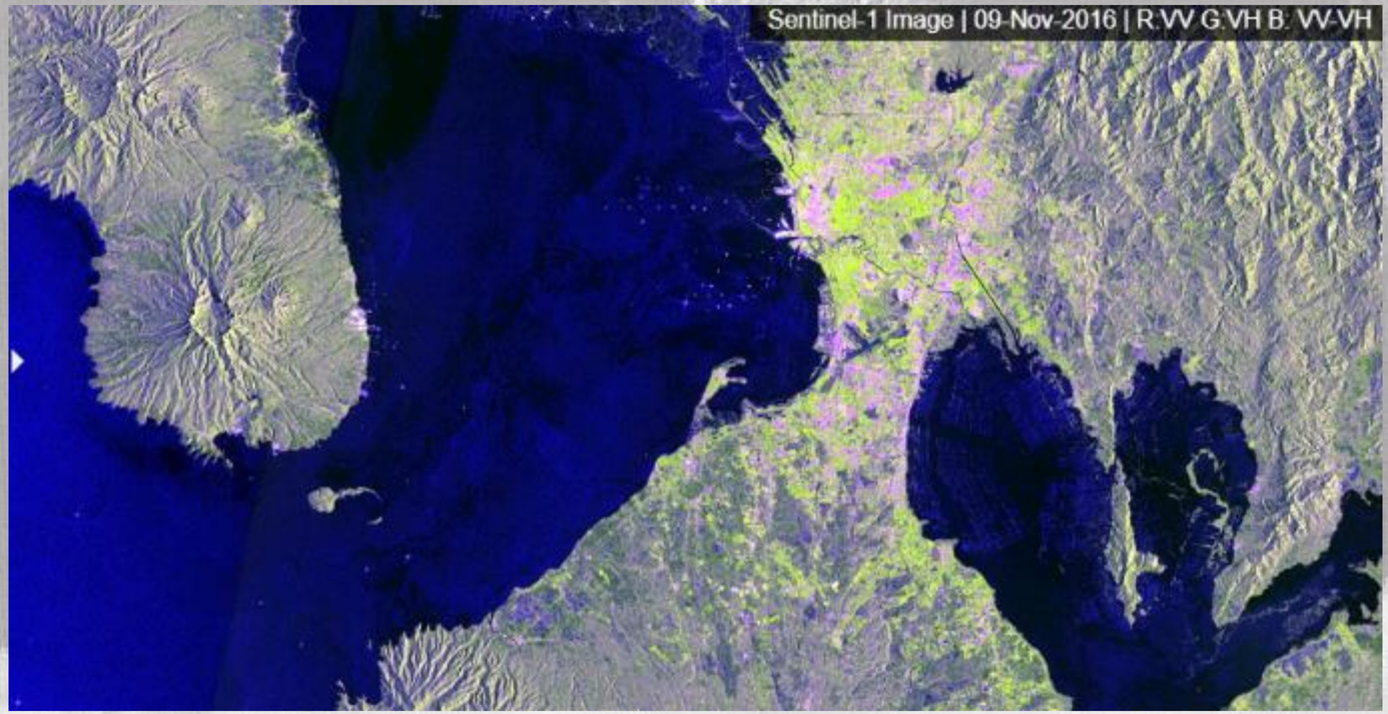


Sentinel 2 (Multispectral – Passive)

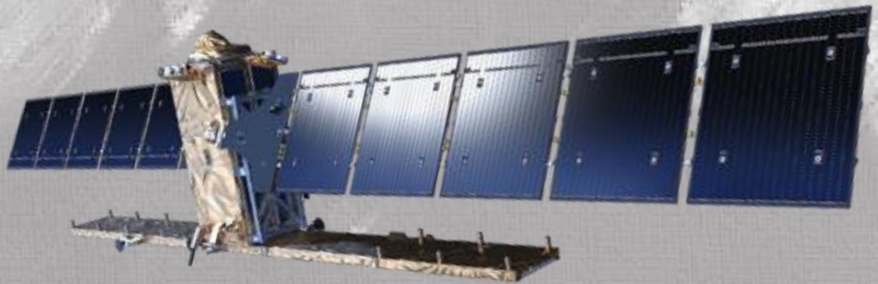


Sentinel 1 (SA Radar – Active)





Sentinel 2 (Multispectral – Passive)



Sentinel 1 (SA Radar – Active)

Data Pre-Processing

Example – Sentinel-2 Image Pre-Processing Stages

Level 0
- Cloud mask generation
- Telemetry analysis

Level 1A
- Radiometric Correction

Level 1B
- Resampling
- Geometric correction
- Conversion to reflectance

Level 1C
- Represents TOA reflectance

Level 2A
- Full atmospheric correction

Remember atmospheric reflection, scattering etc…

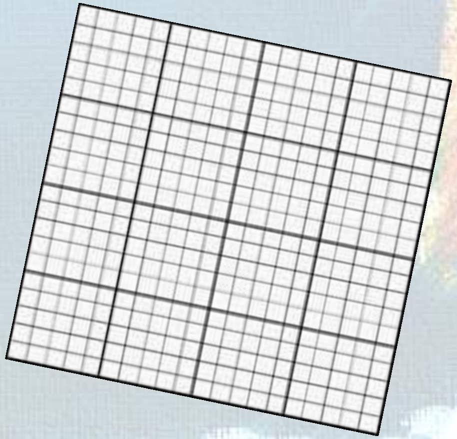
These steps start to account for these processes

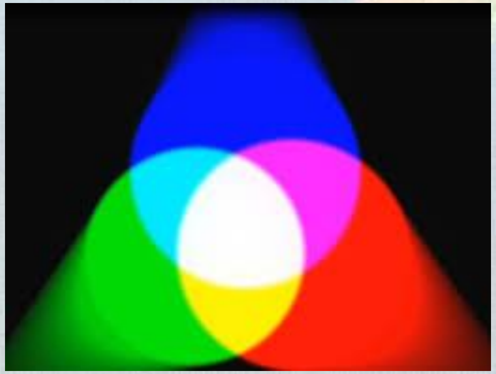
Resolution, Resolution, Resolution…

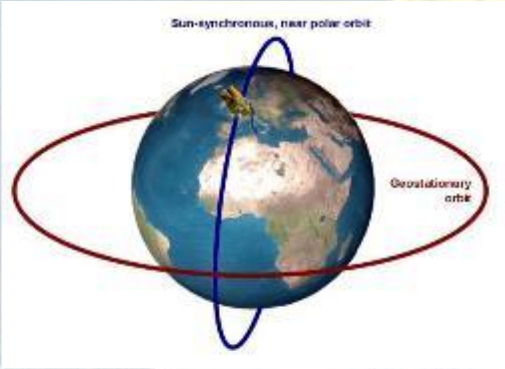
Spatial Resolution

Spectral Resolution

Temporal Resolution







Spatial Resolution

- Spatial resolution determines the detail discernible, generally defined by the smallest feature that can be detected.
- Remotely sensed images comprise a matrix of pixels (the smallest units of an image, normally square, representing a specific area of the image)
- Each recording cell on the sensor detects average brightness across all sensed features within the cell, so the relative brightness of even small features can dominate what is detected within a particular cell.

Spectral Resolution

- Spectral resolution describes the ability of a sensor to define fine wavelength intervals.

- Broad classes of sensed terrains, such as water and vegetation, can usually be separated using very broad wavelength ranges (such as the visible and Near-IR)

- Discerning more similar Earth surface types requires comparison of much finer wavelengths.

Temporal Resolution

- Temporal resolution relates to the collection of imagery of the same area of Earth’s surface at different periods of time.
- The temporal resolution of a sensor depends on a variety of factors, including the satellite/sensor capability, swath and latitude.
- Temporal resolution is an important consideration when persistent cloud cover obscures the view of the Earth’s surface

Remote Sensing for Water Resources Management

Precipitation → Evaporation → Landcover → Soil Moisture → Water Storage → Terrain → Streamflow

Precipitation
- TRMM
- GPM
- PERSIANN

Evaporation
- GLDAS
- GLEAM
- EEFlux
- MODIS

Landcover
- AVHRR
- MODIS
- Landsat
- Sentinel-2

Soil Moisture
- SMOS
- SMAP
- GLDAS
- ESA CCI Data
- Sentinel-1

Water Storage
- GLDAS
- GRACE
- Sentinel-1

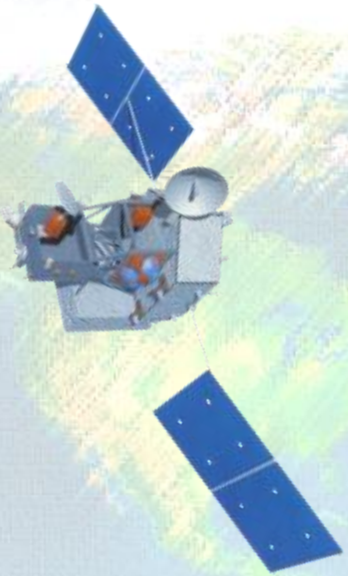
Terrain
- ASTER
- SRTM
- WorldDEM
- LiDAR

Streamflow
- SWOT

*****not an exhaustive list*****

+ Water related hazards (floods and droughts)

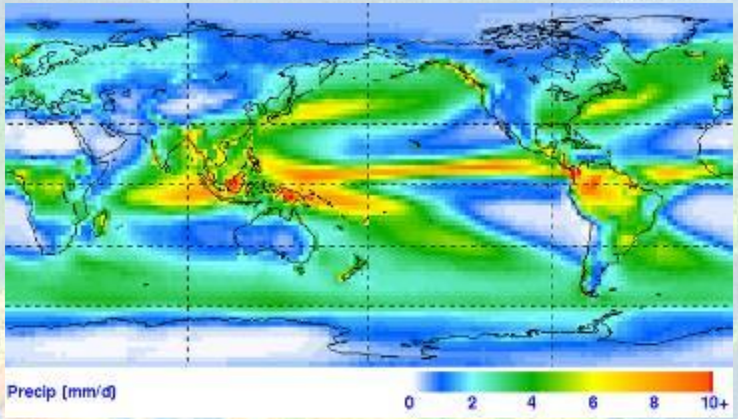
Precipitation RS Products



TRMM
Tropical Rainfall Measuring Mission

1997 – 2015
35 degrees +/-

0.25 Degrees Resolution

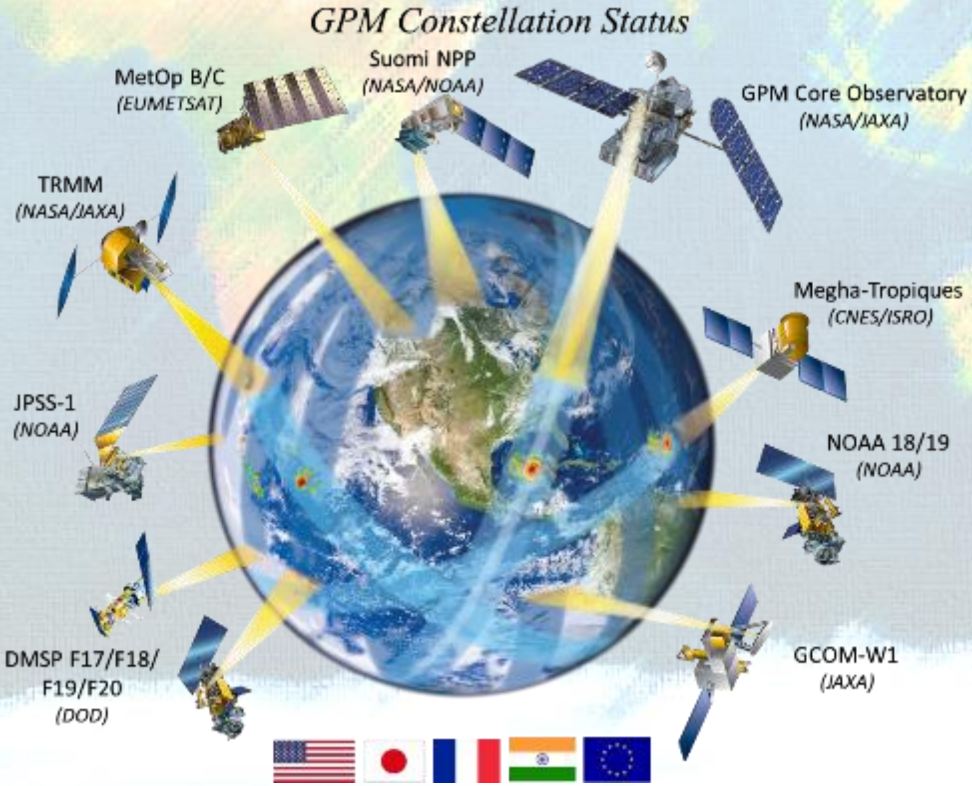


GPM
Global Precipitation Measurement Mission

2014 - Present

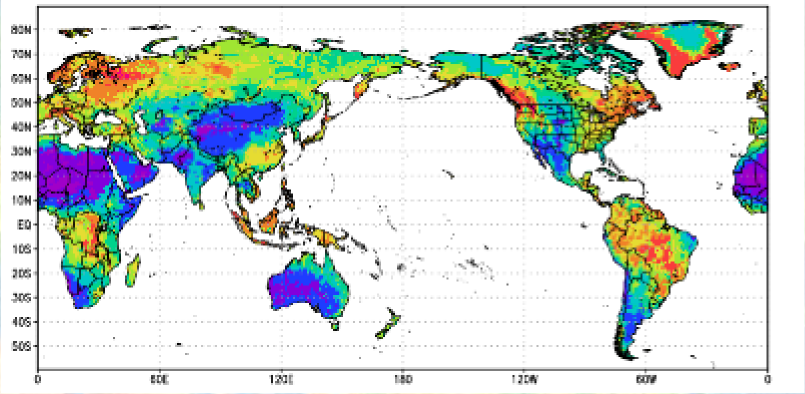
65 degrees +/-

0.1-0.25 Degrees Res

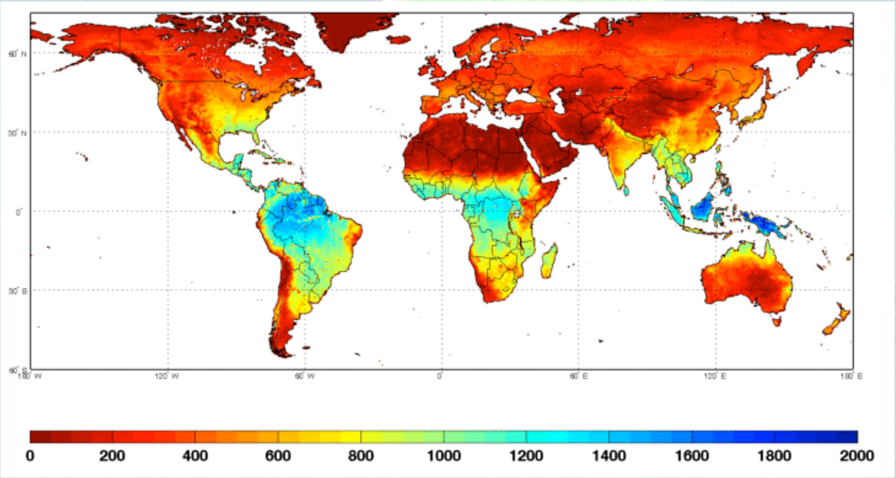


Evaporation RS Products

Global Land Data Assimilation System (GLDAS) ingests satellite- and ground-based observational data products, using advanced land surface modelling and data assimilation techniques, in order to generate optimal fields of land surface states and fluxes

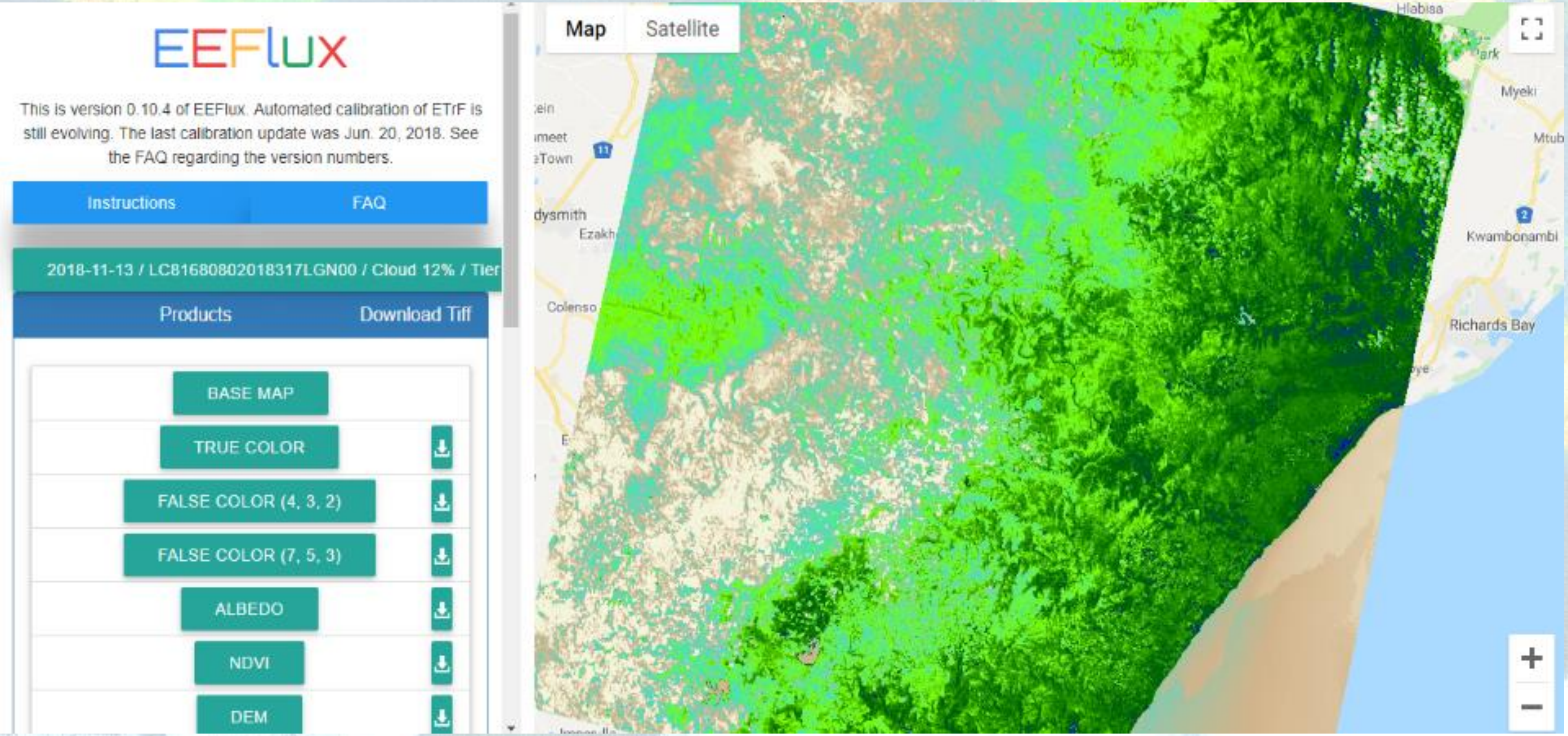


The **Global Land Evaporation Amsterdam Model (GLEAM)** is a set of algorithms for estimating terrestrial evaporation and soil moisture. The current GLEAM product consists of a series of microwave (C- and L-band) measurements from sensors such as MODIS (Moderate Resolution Imaging Spectroradiometer) and the SMOS (Soil Moisture Ocean Salinity)



Evaporation RS Products

EEFlux (EarthEngine Evapotranspiration Flux) was developed based on the METRIC (Mapping Evapotranspiration at High Resolution with Internalized Calibration) model which applies a series of algorithms to produce evapotranspiration estimates using Landsat 5 TM (1984-2013), Landsat 7 ETM+ (1999-Present) and Landsat 8 OLI (2013-Present) imagery.



Landcover RS Products

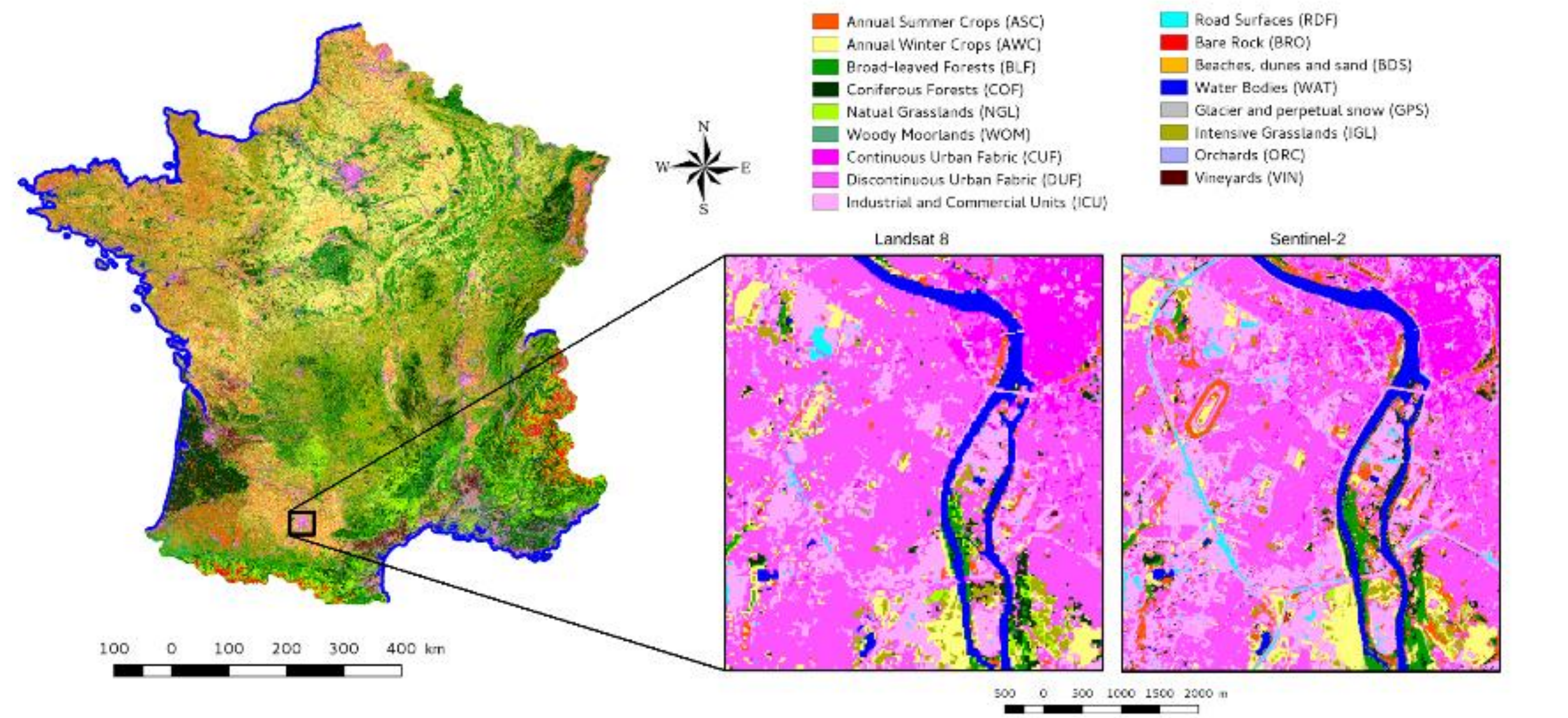
Landsat-8

Latest in Landsat series

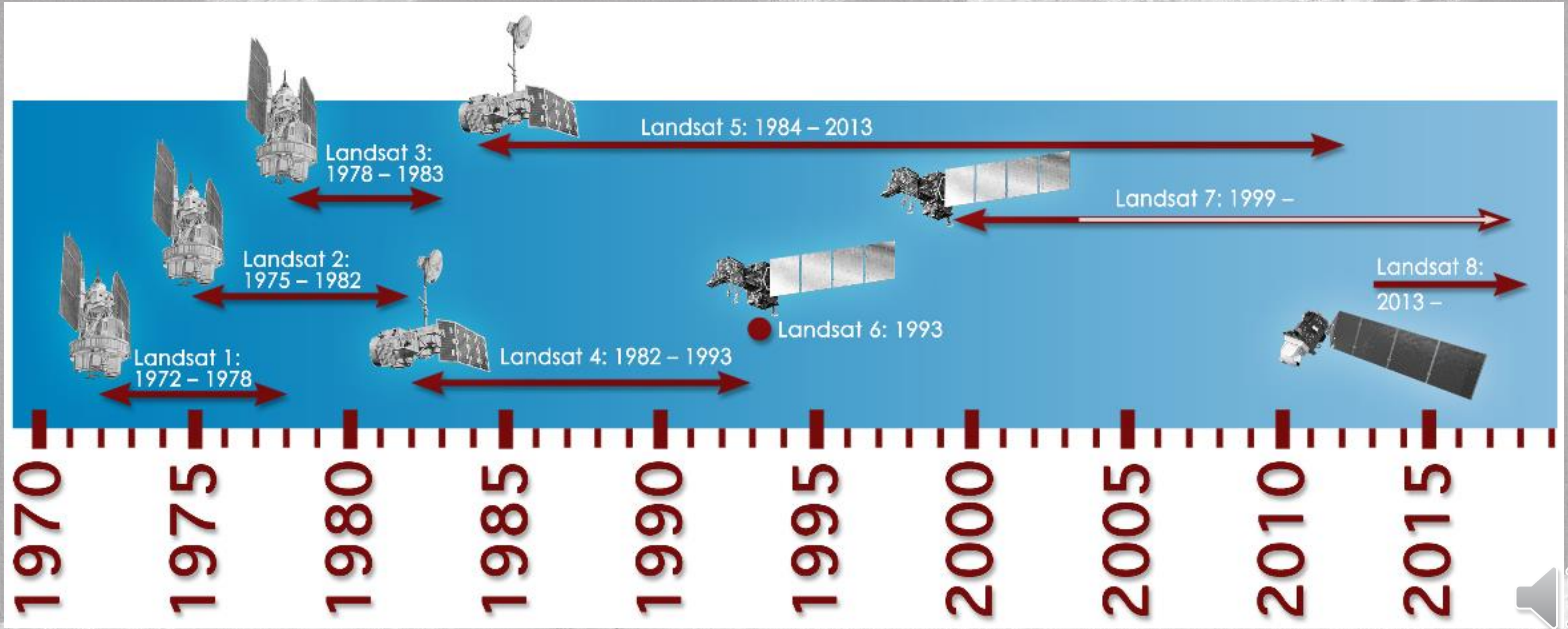
Sentinel-2
Launched 2015

4 Special NIR Bands

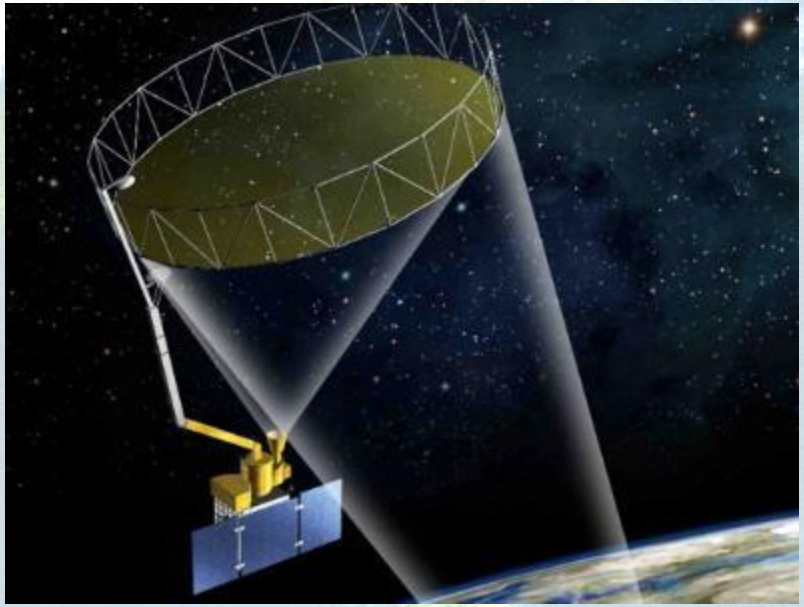
France land cover classification, from Landsat 8 to Sentinel-2.



Landsat Series



Soil Moisture RS Products



SMAP
Soil Moisture Active Passive

Launched 2015

Daily SM 3-9km Gridded SM

Failure of onboard equipment (loss of higher res data collection)

SMOS
Soil Moisture & Ocean Salinity

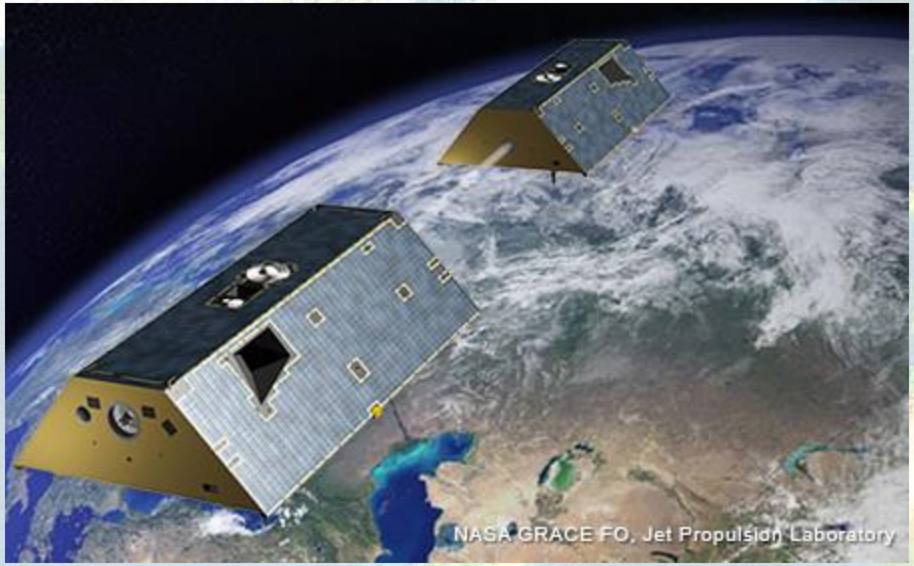
Launched 2009

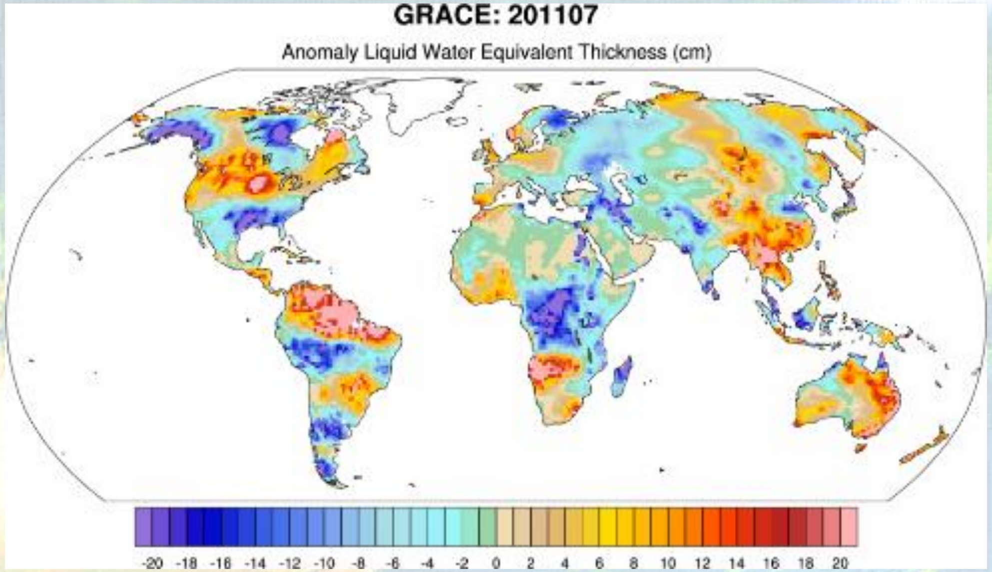
30-50km Gridded SM & Ocean Salinity

1-3 Day Revisit Time

+ GLDAS SM, ESA CCI Data, Derived SM from Sentinel-1 SAR Imagery etc….

Water Storage RS Products

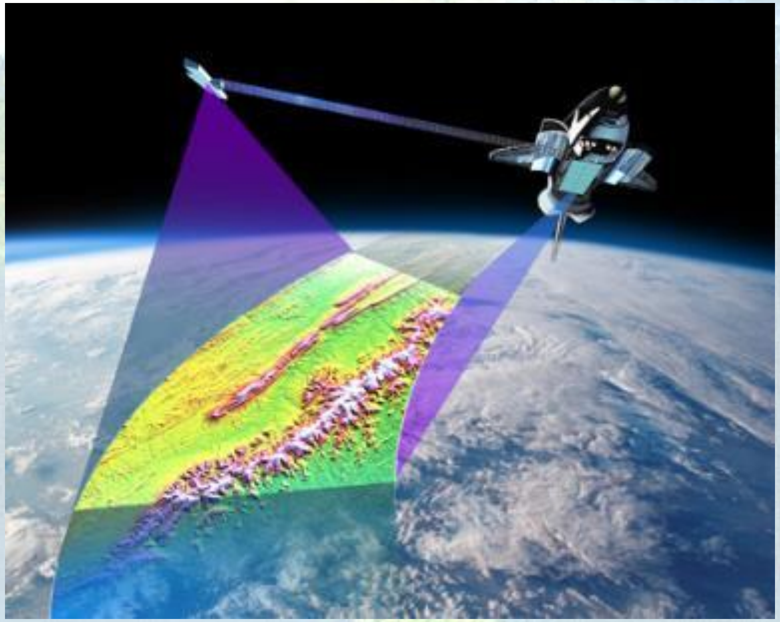




The Gravity Recovery & Climate Experiment (GRACE) mission launched in 2002. The mission originally had a lifespan of 5 years, however due to its success, the mission was extended until 2017. The GRACE mission consisted of two satellites in tandem orbit. On-board instruments measured the distance between the satellites.

These measurements were used to produce monthly representations of changes in the Earth's gravity field. The main drivers being the shifting oceanic/atmospheric/ terrestrial distribution of water within the hydrological cycle. GRACE was unique in its non-dependence on surface conditions and being able to provide measurements below the first five centimetres of the surface.

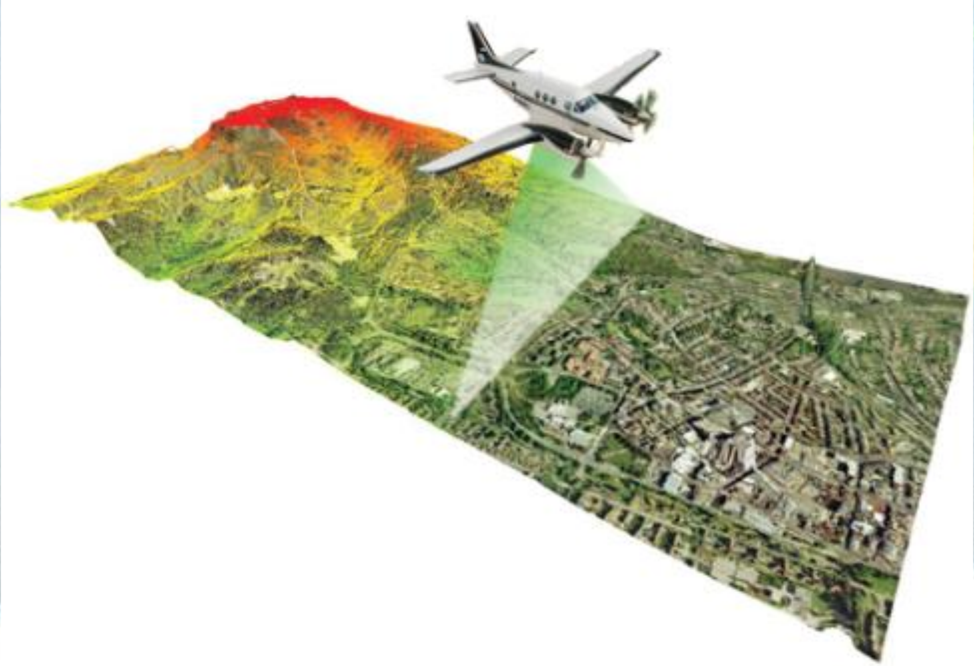
Terrain RS Products



Space Shuttle Radar Topography Mission (SRTM)

Feb 2000

Global Scale 30-90m DEM



Light Imaging Detection & Radar (LiDAR)

Local Scale

25cm – 2m Resolution

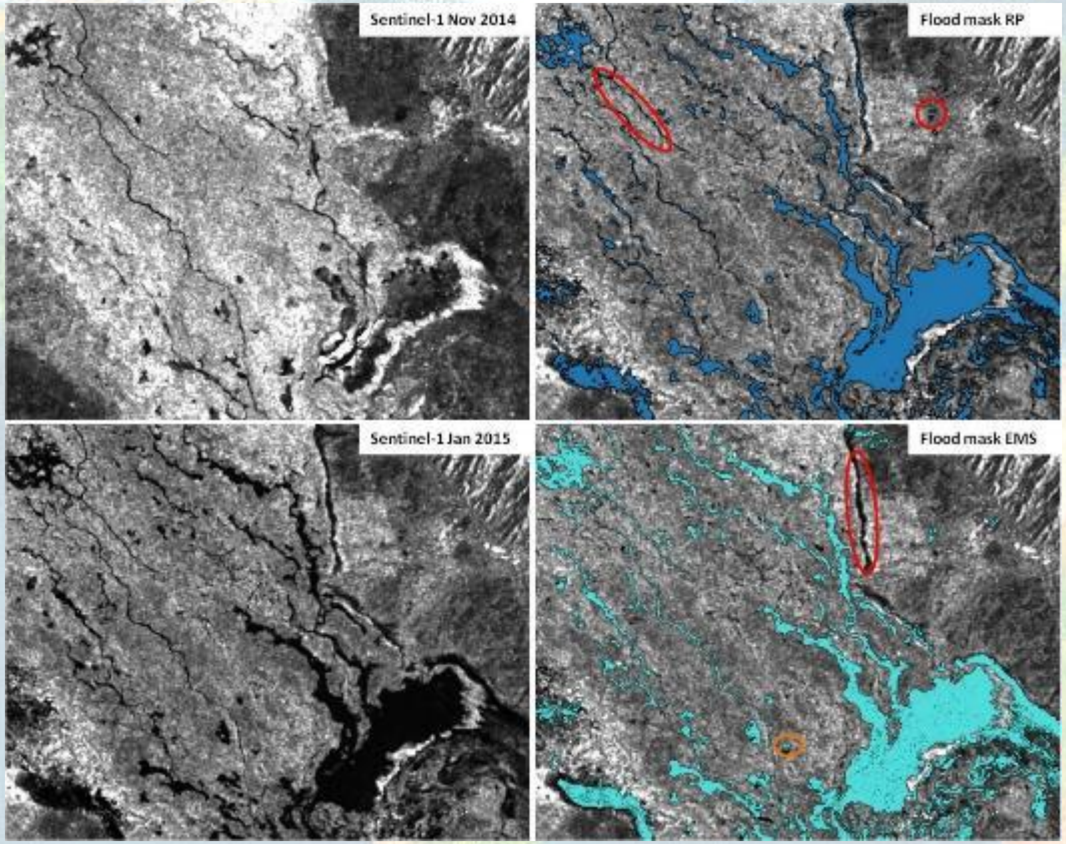
Streamflow RS Products

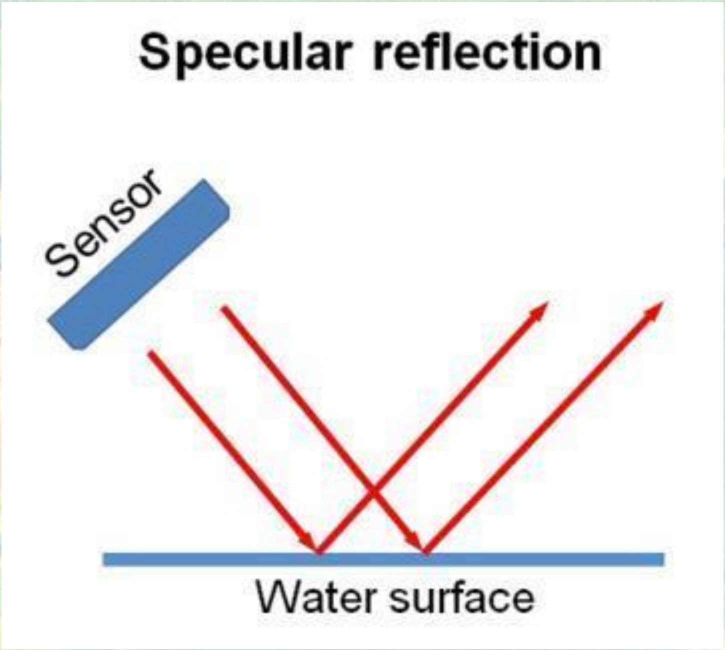
Accurate estimate of river discharge from solely remotely sensed data is still a major ambition.

The proposed 2020 launch of the **ESA SWOT (Surface Water Ocean Topography)** mission may well achieve this goal.

SWOT is expected to provide estimates of water surface slope, elevation and width for large river systems globally (i.e. those with a minimum width of 100m)

Water Hazards RS Support



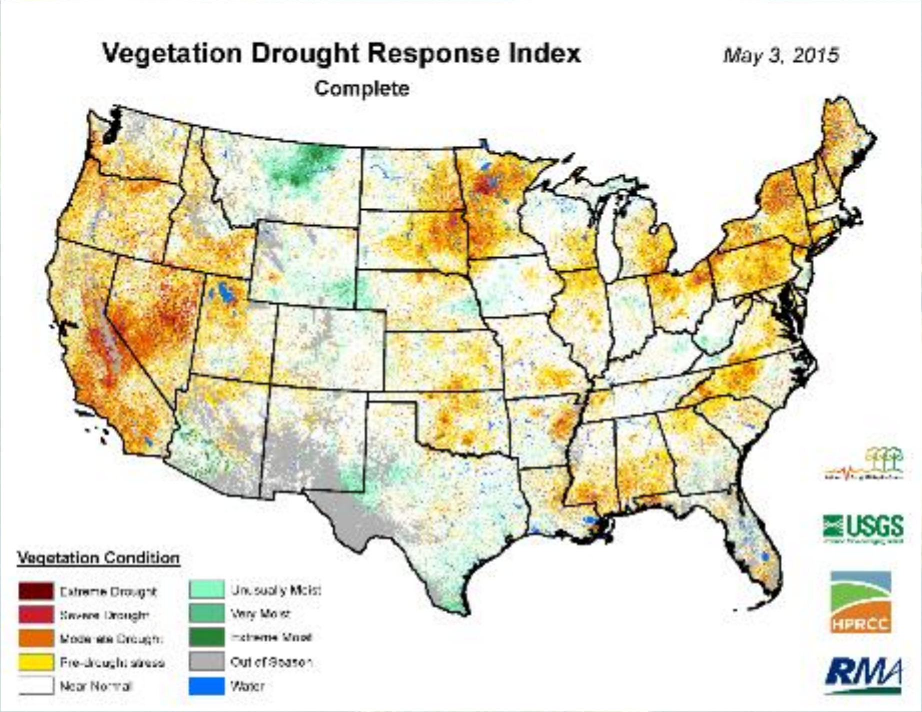


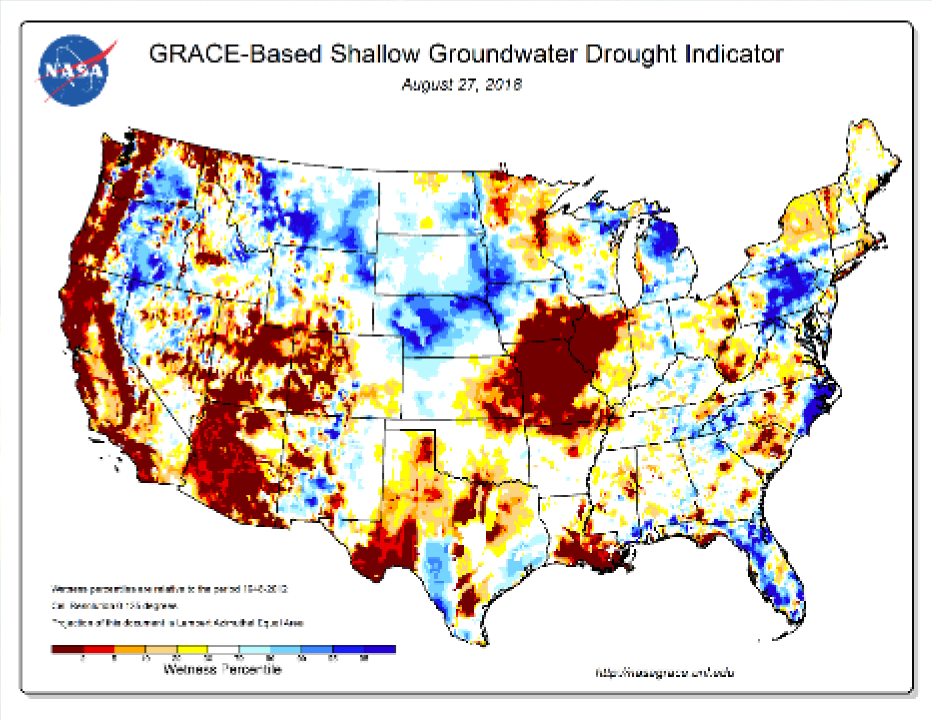
Flood Applications

- SAR Data (very suitable due to cloud penetration and specular backscatter)
- Multi-spectral data – NDWI / Landcover mapping

- Many sensors: Landsat, Sentinel-1/-2, EnviSAT etc…

Water Hazards RS Support





Drought Applications

- Meteorological drought (TRMM, GPM etc.)
- Agricultural drought (NDVI, multispectral, soil moisture – SMOS/SMAP)
- Hydrological drought (GRACE, GRACE-FO, SWOT)