Theme: Building Resilient space infrastructure and operations for a sustainable future

The Role of Vicarious Calibration and validation Target Sites in Enhancing Satellite Earth Observation Sensor Accuracy.

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CSIR

Touching lives through innovation

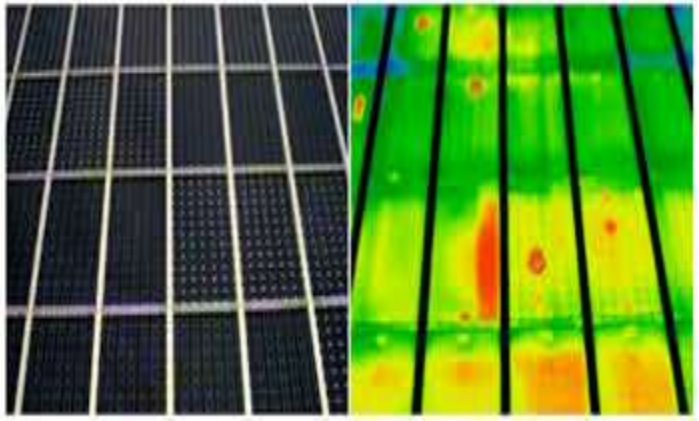
Importance of Earth Observation Satellite

Support of sustainable development

- Monitoring of environmental changes.
  - Disaster management
    - -Flooding
    - -Fires
    - -Drought
- Provide knowledge through data
  - Agriculture
  - Solar fault detection

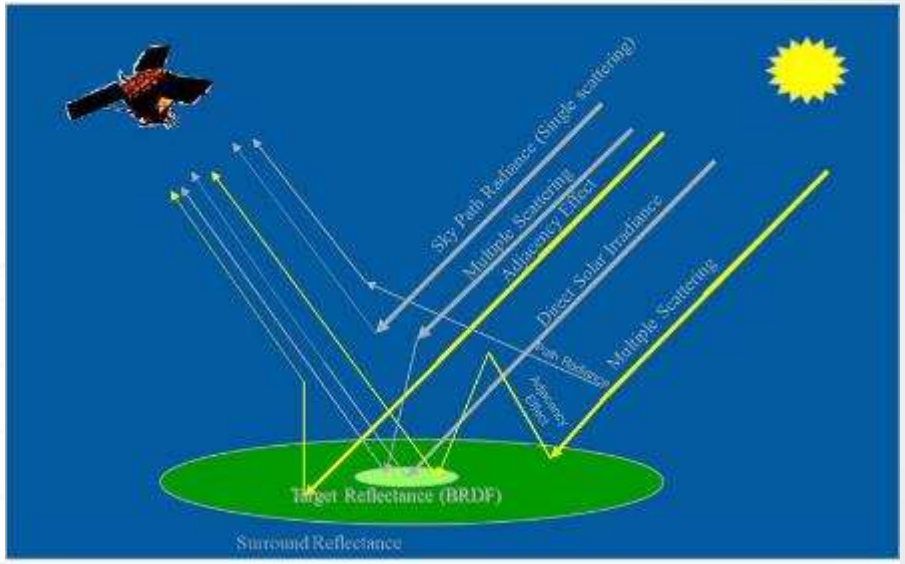
Agriculture

Solar Fault detection

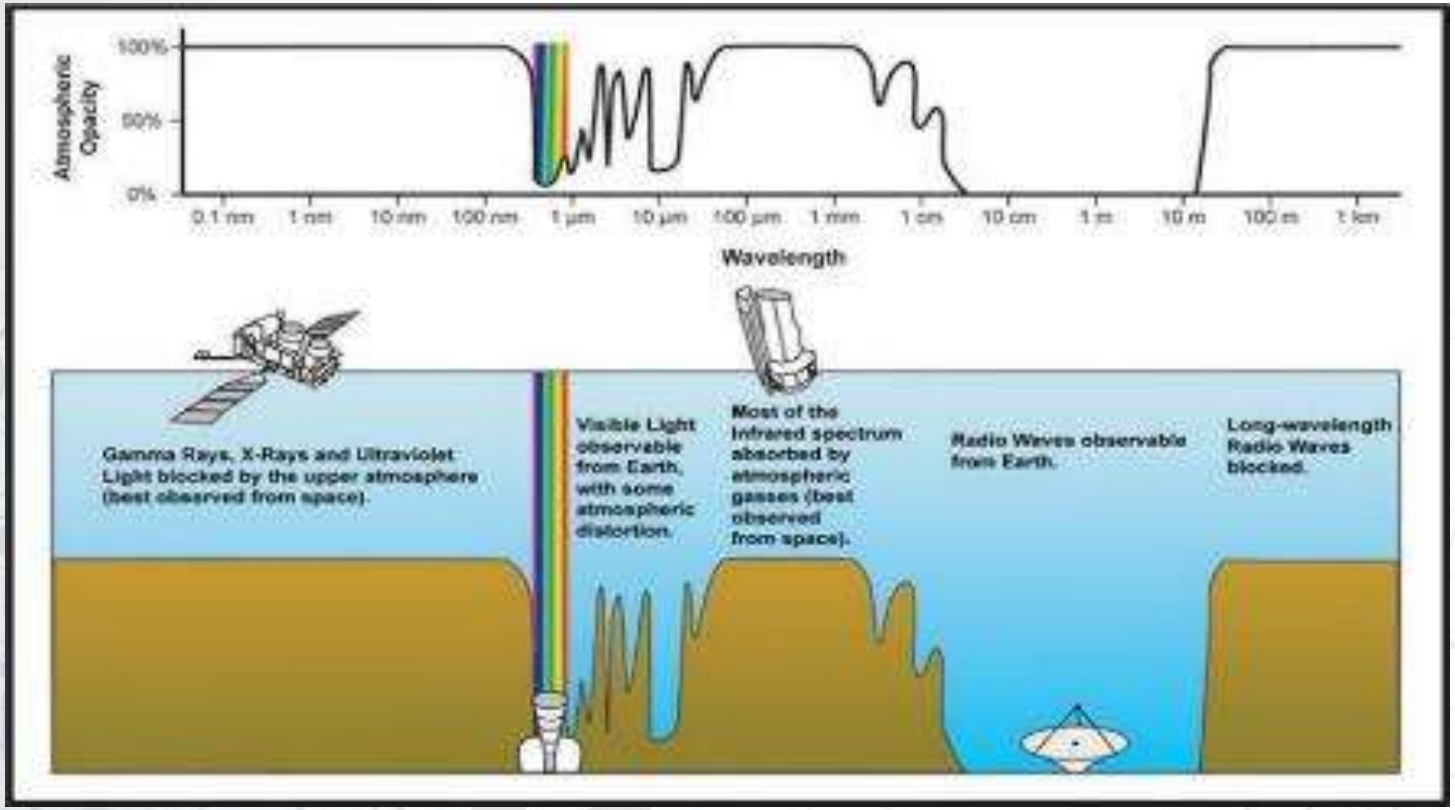


EO Payload disturbances

- **Optical Effects of Atmospheric Gases**
  - Nitrogen, Oxygen, Carbon Dioxide, Water Vapour, Trace Gases
  - Absorption
  - Rayleigh Scattering of Sunlight and Reflected Light
  - Thermal Emissions
- **Optical Effects of Atmospheric Aerosols**
  - Suspended Particles - Clouds, Fog, Dust, Smoke
  - Absorption
  - Mie Scattering of Sunlight and Reflected Light
  - Thermal Emissions



Atmospheric window effects



- All Effects Generally Wavelength Dependent.
  -Deployed satellite sensors struggle to penetrate through the lower areas.
- Require Atmospheric Modelling with Profiles
  - MODTRAN

Vicarious calibration and validation

Vicarious calibration

- Technique used to calibrate remote sensing instruments,
  - such as satellite or
  - airborne sensors,
  - without relying on onboard calibration systems.
- comparing the sensor's measurements with known reference data.
  - obtained from ground-based observations or
  - well-characterised surface features, such as deserts, salt flats, or large bodies of water.

Validation

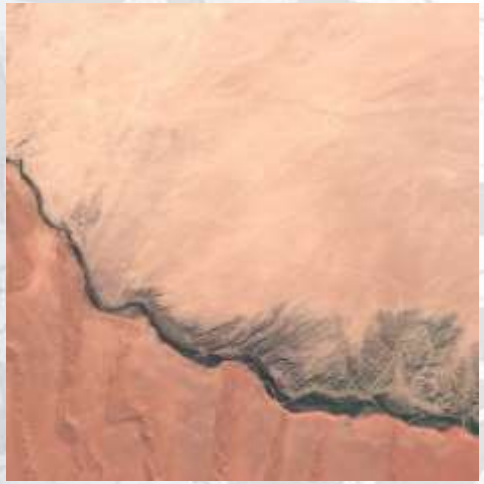
- The process of assessing, by independent means, the quality of the data products derived from the system outputs.
- It is the process of independently verifying that the calibrated sensor data accurately represents the real-world conditions.

Natural and Artificial target sites

- **Vicarious calibration targets involves the use of :**
    - natural or artificial sites on Earth with well-characterised properties to calibrate satellite sensors indirectly.
- **Target site should be :**
    - Spatially Large
    - Flat
    - Homogeneous
    - Highly reflective surface

Currently used Natural calval target sites

Rogers dry lake in US:
Large , flat dry lakebed with high reflective surface



Gobabeb , in Namibia.
Large Hyper-arid desert with minimal vegetation and stable atmospheric conditions.

Ideal for radiometric calibration due to its consistent surface and low humidity

Railroad Valley Playa, USA.
Large, flat playa (dry lakebed) with consistent reflectance properties.

Used for radiometric calibration of sensors: **Landsat** and **MODIS** instruments.

Vicarious calibration method and techniques.

- **Absolute Calibration**:
  -Comparison of Satellite sensor measurements directly known ground-based measurement target.
  -This help correct systematic errors in the sensor data
- **Absolute calibration performance**
  - Select reference target
  - Simultaneous data collection from the Satellite and the ground target area.
- **Advantages:**
  -Provides a direct and precise comparison with known standards.
  -Effective for correcting systematic errors in sensor data.
- **Challenges:**
  -Requires access to stable and well-characterized ground targets.
  -May involve significant logistical and operational efforts.

Vicarious calibration method and techniques…

- **Relative Calibration**
  - comparing measurements from the satellite sensor to other measurements (either from other satellite sensors or reference data) to ensure consistency over time or between different sensors.
- **Method:**
  - **Reference Comparisons**: Compare the satellite data with measurements from other sensors or with data from previous calibrations.
  - **Temporal Analysis**: Analyse variations in sensor data over time to identify and correct drifts or anomalies.
  - **Cross-Calibration**: Use data from different satellite sensors (e.g., similar sensors on different satellites) to adjust and validate each other.
  - **Advantages:**

    -Useful for maintaining consistency between different sensors or over time.

    -Can be applied when absolute reference targets are not available.
  - **Challenges:**

    -May not correct absolute errors but ensures relative consistency.

    -Depends on the availability and accuracy of reference measurements.

Case study on artificial target sites

- CSIR Calibration Target site
  -Back in 2014 DSI/OSS hosted an international calval campaign with both on orbit satellite and ground sensors.
  -Project was a success, and deployments were performed.

- **Challenges.**
  -Require maintenance to ensure good quality and
  -To ensure data accuracy

CSIR Calval Target site

Pleiades

Conclusion

- **Vicarious calibration**
  - plays a pivotal role in refining the accuracy of satellite Earth observation sensors
  - By leveraging ground-based and airborne measurements, and
  - employing both absolute and relative calibration methods,
  - we can significantly reduce uncertainties and improve the reliability of satellite data.

- It is essential for building resilient and sustainable space infrastructure,
  - supporting informed decision-making,
  - and addressing global challenges such as climate change and natural disasters.

- Having high-quality, data from satellite sensors underpins our ability to monitor, understand, and respond to the dynamic conditions of our planet.

Conclusion….

- Investing in vicarious calibration initiatives will ensure that we continue to enhance the accuracy of our satellite observations.
- The demands for Earth observation data is growing massively,
- That means our commitment must increase on ensuring the presence of calibration target sites I order to have accurate data.

- **Closing remarks**:
- In closing, I would like to encourage the development of calibration sites capability on our space science community to drive forward the development of resilient and sustainable space operations.
- Through continued collaboration and innovation, we will ensure that our satellite Earth observation systems remain accurate, reliable, and integral to our understanding of the world.

Thank you