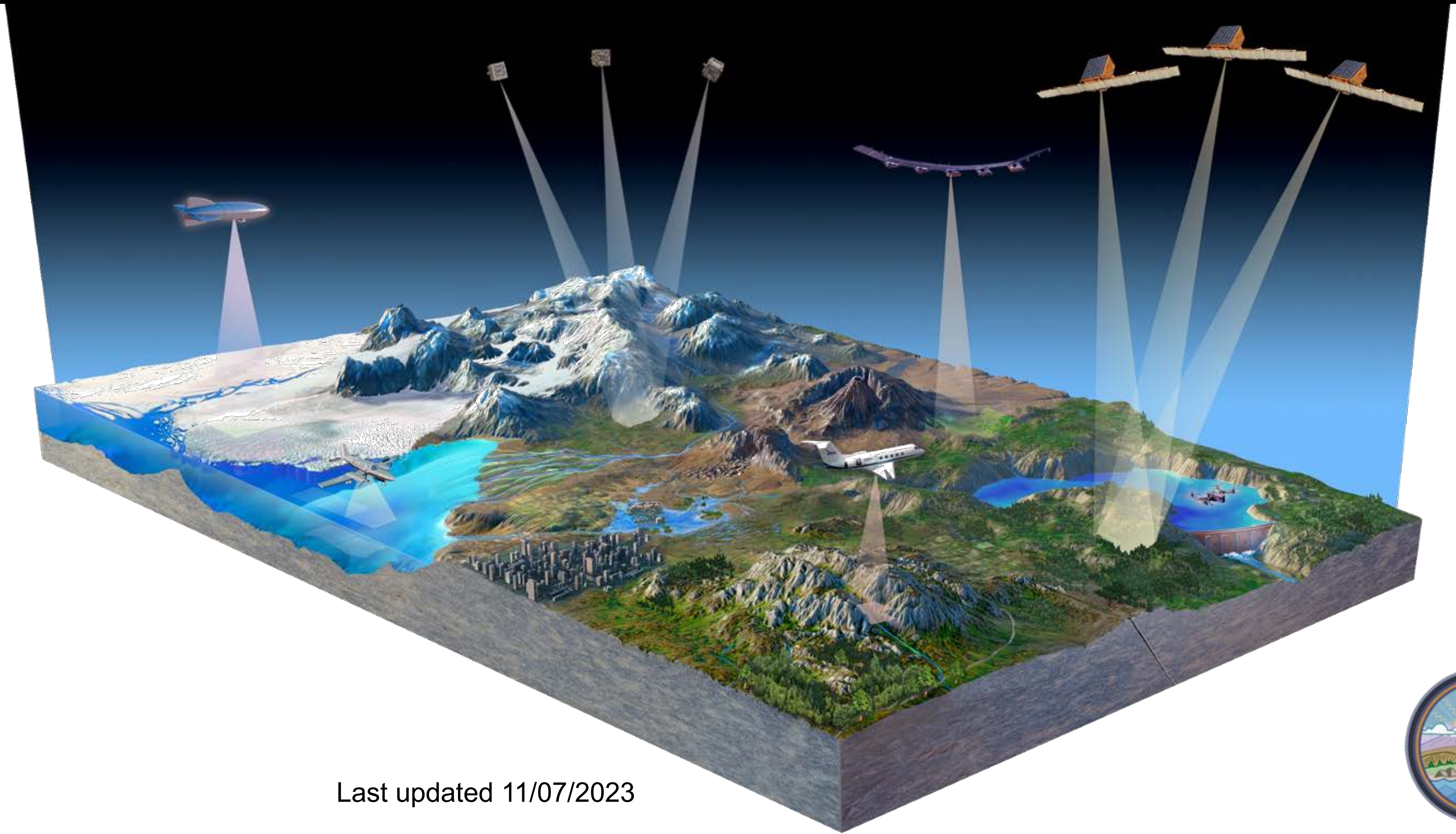
# NASA's Surface Topography and Vegetation Study

*Stereoimaging*



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Last updated 11/07/2023

# *Stereoimaging*

## Current Capability Overview—Earth Observing Commercial

| Name | Status | Owner/Agency | Launch [note 1] |
|---|---|---|---|
| Disaster Monitoring Constellation[41] | Active | DMC International Imaging | 2009 |
| EROS A and B | Active | ImageSat International | 2000 |
| Flock-1 Constellation | Active | Planet | 2014 |
| GeoEye-1 | Active | DigitalGlobe (Maxar) | 2008 |
| GRUS-1A to E | Active | Axelspace[42] | 2018 |
| Jilin-1 (Optical | Active | Chang Guang Satellite Technology | 2015 |
| NovaSAR-S1[42] | Active | UK Space Agency and Surrey Satellite Technology | 2018 |
| PlanetScope-2[43] | Active | Planet | 2016 |
| SkySat-1 to 3 | Active | Planet | 2013 |
| SkySat-4 to 7 | Active | Planet | 2016 |
| SkySat-8 to 13 | Active | Planet | 2017 |
| SPOT 6 and 7 | Active | EADS Astrium Azercosmos, and CNES | 2012 |
| SuperView-1[44] | Active | Beijing Space View Technology | 2018 |
| TripleSat (UK-DMC 3)[45] [46] | Active | DMC International Imaging | 2015 |
| Vivid-i 1 to 5[47] | Active | Earth-i[48] | 2018 |
| WorldView-1 | Active | DigitalGlobe (Maxar) | 2007 |
| WorldView-2 and 3 | Active | DigitalGlobe (Maxar) | 2009 |
| Pleiades Neo 3 | Active | Airbus Defence and Space | 2021 |
| Pleiades Neo 4 | Active | Airbus Defence and Space | 2021 |

Capabilities:

- Cover most of the globe
- GSD from +5 to 0.3 m
- Panchromatic to Hyperspectral

Wikipedia

# *Stereoimaging*

# Current Capability Overview—Earth Observing Govt

| | | | |
|---|---|---|---|
| Name | Status | Agency | Launch [note 1] |
| Landsat-7 | Active | NASA and USGS | 1999 |
| Landsat-8 | Active | NASA and USGS | 2013 |
| Landsat-9 | Active | NASA and USGS | 2021 |
| Sentinel-1A and B | Active | ESA | 2014 |
| Sentinel-2A, B, and C | Active | ESA | 2015 |
| Sentinel-3A and B | Active | ESA | 2016 |
| Terra | Active | NASA | 1999 |
| Sentinel-5 Precursor (S5P) | Active | ESA | 2017 |

Wikipedia

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# Emerging Capability

TRL6 by 2028 (airborne and spaceborne)

**QUAKES-I:** Down looking SFM sensor (GSD 0.6 m @ 40000 ft), 8 camera, framed sensor (4 forward looking 4 aft looking, creating 2 swaths ~ 12 x 3 km); being adapted to fly on lower/slower craft for better than 20 cm GSD

**CO3D-1 to 4**: CNES—planned resolution is 0.5 m, launch next year

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# Mapping to Measurements

**Science discipline (group) the technology addresses**

- Solid Earth
- Vegetation Structure
- Water Surface and Bathymetry (not so much)

**Map to measurement needs**

- Limited view through canopy/vegetation (wavelength, other modalities)
- Requires fusion with other sensors
- Availability issues with lighting and visibility

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# Needed Technology Advances

## Performance

- Current systems produce images not necessarily stereoimagery
- Consistency of measurements/accuracy depends on well conceived conops or design

## Visibility

- Vegetation can limit view of ground surface making it difficult to infer structure (paired with another sensor)
- Limited utility on dark side of earth/difficult to work in heavy clouds (paired with another sensor)

## Algorithms

- Need better (available) algorithms to reach measurement accuracy with commercial and most govt orbital platforms (account for orbital dynamics, differing resolution, multi views, low contrast etc.)
- Need to understand accuracy for these type measurements

# *Stereoimaging*
# Strengths and Weaknesses

**Strengths**

- Derived from imagery, probably most commonly available sensed data for STV
- Collections go back decades
- Entry level platforms (quadrotors) allow very high precision/resolution and local collection with minimal resources
- High altitude platforms can cover large areas at relatively high resolution
- Reliable algorithms for generating quality surface maps/dems

**Weaknesses**

- Visibility constraints (foliage, clouds) limit availability or measurements
- Atmosphere poses significant problems especially for oblique views
- Lighting can be an issue
- Some terrain simply not suitable for measurements (low contrast areas)
- Water measurements are difficult
- Significantly more processing involved to render products than for lidar or even radar

Can address many concerns but shouldn't be considered primary sensor for certain science observations (cryosphere, bathymetry)

# *Stereoimaging* Synergies

## With other technologies

### Combining measurements

- Stereoimaging (the image portion) provides great context for observations with any of the other measurement technologies (lidar, radar)
- In combination, can measure vegetation load
- Most accessible medium for localization—generally easy to localize images in the world (more readily then a point cloud for instance)

### Need to co-fly or fly simultaneously?

- Can be coincident with other observations—QUAKES (SAR Fusion) sensor with SAR, makes a more powerful observation
- Generally easy to accommodate on a platform

### What can other measurements support about this technology?

- Make measurements where visibility constraints are too significant to overcome

# Needed Advancements

## Advancements needed to achieve STV

What gaps are there?

- Measurements when visibility conditions aren’t favorable to imaging sensors
- Automated/available precision geo-registration of imagery
- Accurate/available algorithms that can handle multiple sampling issues, report measurement uncertainty and generate STV products

How do we fill them?

- Pair with another measurement sensor; use other wavelengths; wait until conditions improve
- Provide a database of global landmarks and algorithms needed to geo-register imagery

# *Stereoimaging*
# Needed Experiments

## Existing and proposed

Airborne campaigns

Targets

Data sets

# Summary

- Stereoimaging provides wide area coverage at high resolution
- Historical record going back decades
- Need to develop stereoimaging sensors that can provide consistent measurements of known quality
- Work on techniques that can leverage existing capabilities and provide science with reasonable uncertainty estimates (algorithms, geo-registered landmark database)