

# Operational Space-Based Imaging Systems

REMOTE SENSING & GEOSPATIAL ANALYSIS LAB

DOI: 20 AUGUST, 2016

# Earth Observation Systems

U.S. or foreign government systems with image processing pipelines and distribution channels allowing for no-cost access to data

# Coarse Resolution Earth Observation

## Moderate Resolution Imaging Spectroradiometer (MODIS)

- Payload on Aqua and Terra spacecraft
- 1-2 day revisit
- 36 spectral bands
- 250-1000m resolution

Availability: Free

1. Level 1 data available at NASA's Level 1 and Atmospheric Archive Distribution System (LAADS).  
<https://ladsweb.nascom.nasa.gov>
2. Derived products available from USGS Earth Explorer.  
<earthexplorer.usgs.gov>

# Moderate Resolution Earth Observation

## Landsat

- 2 spacecraft
- Landsat 7 suffers from scan line error
- 11 spectral bands (Landsat 8)
- 15-100m spatial resolution
- 16-day revisit (8 with both spacecraft)

Availability: Free

1. USGS Earth Explorer, [earthexplorer.usgs.gov](https://earthexplorer.usgs.gov)
2. Remote Pixel, <https://remotepixel.ca>
  - Download discreet bands

# Moderate Resolution Earth Observation

## Sentinel-2

- 2A on orbit, 2B planned for 2017
- 13 spectral bands
- 10-60m spatial resolution
- 10-day revisit (5 with two spacecraft)
- Part of the Copernicus Program

Availability: Free

1. USGS Earth Explorer, [earthexplorer.usgs.gov](https://earthexplorer.usgs.gov)
2. Remote Pixel, <https://remotepixel.ca>
  - Download discreet bands
3. Sentinel Online, <https://sentinel.esa.int>

# Moderate Resolution Earth Observation

## Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)

- Payload on the Terra spacecraft
- Joint US-Japanese
- Newly available (4/1/2016)
- 15 spectral bands
  - R, G, NIR, SWIR, TIR
- 15-90m spatial resolution
- 30m global DEM

Availability: Free

1. Land Processes Distributed Active Archive Center (LP DAAC), <https://lpdaac.usgs.gov>

# Radar Earth Observation Systems

## Sentinel-1

- Two spacecraft on orbit
  - 1A – Operational
  - 1B – Testing
- C-band SAR
- H/V Polarization
- 4 Modes
  - Strip Map – 80km swath
  - ISAR Wide Swath – 250km swath
  - Extra-Wide Swath – 400km swath
  - Wave-Mode
- Spatial resolution dependent on amount of multi-look and level of processing but ranges between 4-40m
- Part of the ESA's Copernicus Program

Availability: Free

1. Sentinel Online, Sentinels Scientific Data Hub  
<https://sentinel.esa.int> ,  
<https://scihub.copernicus.eu>,  
registration required

# Earth Observation Systems

Foreign government systems with  
limited, restricted, or fee-based access



# Moderate Resolution Earth Observation

## Indian Resource Satellites (IRS)

- Indian Space Research Organization (ISRO)
- Resourcesat-1
  - 5-60m spatial resolution
  - 5-24 day revisit
  - 11 spectral bands
- Resourcesat-2
  - Similar specs as Resourcesat-1
  - Swath width of the LISS-4 multispectral sensor increased to 70km from 23km

Availability: Limited

1. ISRO's Bhuvan Geoportal, [bhuvan.nrsc.gov.in](http://bhuvan.nrsc.gov.in)
2. Publicly available data generally limited to India

# Moderate Resolution Earth Observation

## China-Brazil Earth Resources Satellite (CBERS)

Availability: No Data

- 1 operational satellite (CBERS-4)
- 4 camera payloads
  - Brazil MS: 4-band (R, G, B, NIR), 20m resolution, 120km swath width
  - China MS: 4-band (Pan, R, G, NIR), 5m Pan, 10m MS resolution, 60km swath width
  - China IR: 4-band (NIR, 2 SWIR, TIR), 40m resolution (80m TIR), 120km swath width
  - Brazil Wide Field: 4-band (R, G, B, NIR), 64m resolution, 866km swath width
- 26-day revisit

# High Resolution Earth Observation

## Pleiades

- Developed under French-Italian ORFEO program, distributed by Spot Image (Airbus)
- 2 spacecraft (1A, 1B)<sup>1</sup>
- 50cm (Pan), 2m (MS) resolution
- 4-band (R, G, B, NIR)
- Daily revisit

Availability: Available for purchase

1. Airbus Defence & Space,  
[www.intelligence-airbusds.com](http://www.intelligence-airbusds.com)

1. Pleiades 1A and 1B along with SPOT 6 and 7 form a 4-satellite constellation 90° apart.

# High Resolution Earth Observation

## SPOT

- CNES (French)-led development, distributed by Spot Image (Airbus)
- 2 spacecraft (6, 7) operational<sup>1</sup>
- 1.5m (Pan), 6m (MS) resolution
- 4-band (R, G, B, NIR)
- Daily revisit (2 spacecraft)

Availability: Available for purchase

1. Airbus Defence & Space,  
[www.intelligence-airbusds.com](http://www.intelligence-airbusds.com)

1. SPOT 6 and 7 along with Pleiades 1A and 1B form a 4-satellite constellation 90° apart.

# High Resolution Earth Observation

## KOMPSAT

- Korean Aerospace Research Institute (KARI), distributed by Satrec Initiative.
- 3 spacecraft (2, 3, 3A) operational
- 1m (Pan), 4m (MS) resolution (KOMPSAT-2)
- 70cm (Pan), 2.8m (MS) resolution (KOMPSAT-3)
- 55cm, 2.2m (MS), 5.5m (IR) resolution (KOMPSAT-3A)
- 5-band (Pan, R, G, B, NIR)
  - KOMPSAT-3A adds a MWIR sensor
- 15km (KOMPSAT-2), 16km (KOMPSAT-3), 12km (KOMPSAT-3A) swath width at nadir
- 28-day revisit

Availability: Available for purchase

### 1. SI Imaging Services

[www.si-imaging.com](http://www.si-imaging.com)

# High Resolution Earth Observation

## DubaiSat-2

- Collaboration between Mohammed Bin Rashid Space Center (MBRSC) of the UAE and Satrec Initiative of South Korea.
- 5-band (Pan, R, G, B, NIR)
- 1m (Pan), 4m (MS) resolution 12.2km swath width at nadir
- 8-day revisit

Availability: Limited

### 1. SI Imaging Services

[www.si-imaging.com](http://www.si-imaging.com)

# High Resolution Earth Observation

## TripleSat (DMC<sub>3</sub>)

- Built by SSTL. 21AT (China) purchased 100% of the imaging capacity for seven years.
- 3 spacecraft
- 80cm (Pan), 3.2m (MS) resolution at nadir
- 5-band (Pan, R, G, B, NIR)
- 23.8 km swath width at nadir
- Daily revisit

Availability: Available for purchase

1. Satellite Imaging Corporation  
[www.satimagingcorp.com](http://www.satimagingcorp.com)
2. Earth-I [www.earthi.space](http://www.earthi.space)

# High Resolution Earth Observation

## Gaofen-2

Availability: No Data

- China National Space Administration (CNSA).
- 81cm (Pan), 3.2m (MS) resolution at nadir
- 4-band (Pan, R, G, B)
- 45 km swath width
- 5-day revisit



# Radar Earth Observation Systems

## TerraSAR-X & TanDEM-X

- German Aerospace and Airbus
- Twin spacecraft flying in formation
- 1-16m resolution
- X-band SAR
  - 3 imaging modes (SpotLight, StripMap, ScanSAR)
- 11-day revisit (2-day possible)
- WorldDEM
  - 2m (relative), 10m (absolute) vertical accuracy
  - 12m spatial resolution

Availability: Available for purchase

1. Airbus Defence & Space,  
[www.intelligence-airbusds.com](http://www.intelligence-airbusds.com)

# Radar Earth Observation Systems

## RADARSAT-2

- Owned and operated by MDA GSI for the Canadian Space Agency (CSA)
- C-band SAR
  - Multiple operating and polarization modes
- 1-100m resolution
- 24-day revisit

Availability: Available for purchase

1. MacDonald, Dettwiler and Associates (MDA),  
[mdacorporation.com](http://mdacorporation.com)

# Radar Earth Observation Systems

## COSMO SkyMed

- Managed as a dual-use system by the Italian Space Agency (ASI)
- 4-spacecraft constellation
- X-band SAR
  - 3 main imaging modes (SpotLight, StripMap, ScanSAR)
  - Single and dual polarization
- 1-100m resolution
- Daily revisit

Availability: Available for purchase

1. e-geos, [www.e-geos.it](http://www.e-geos.it)

# Radar Earth Observation Systems

## KOMPSAT-5

- Korean Aerospace Research Institute (KARI), distributed by Satrec Initiative.
- 4-spacecraft constellation
- X-band SAR
  - 3 main imaging modes (High-Res, Std, Wide)
  - Single and dual polarization
- 1-28m resolution
- 5-100km swath width
- 28-day revisit

Availability: Available for purchase

### 1. SI Imaging Services

[www.si-imaging.com](http://www.si-imaging.com)

# Other Sources and Services<sup>1</sup>

# Digital Globe – Very-High Resolution Earth Imaging

All systems are LEO, geocentric, and sun-synchronous

## GeoEye-1

- 5 spectral bands (R, G, B, NIR, Pan)
- ~41cm panchromatic, 1.6m multispectral spatial resolution
- ~3-day revisit

## WorldView-1

- Panchromatic imager
- 50cm spatial resolution
- 1.7-day revisit

## WorldView-2

- 9 spectral bands
- 46cm spatial resolution
- 1.1-day revisit

## WorldView-3

- 17 spectral bands
  - Pan, 8 MS, 8 SWIR
- 31 cm (Pan), 1.24m (MS) spatial resolution
- 1-day revisit

Availability: Available for purchase

1. DigitalGlobe  
[www.digitalglobe.com](http://www.digitalglobe.com)

# Urthecast – Diverse Earth Imaging Systems

## *Spacecraft*

### Deimos-1

- 22m spatial resolution
- 650m swath width
- 3 spectral bands (R, G, NIR)
- 3-day revisit

### Deimos-2

- 75cm (Pan), 3m (MS) spatial resolution
- 5-band (Pan, R, G, B, NIR)
- 12km swath width
- 2-day revisit

## *ISS*

### Iris

- 1m full-color video
- 30 fps
- 60-seconds on-target

### Theia

- 5m spatial resolution
- 4 spectral bands (B, G, R, NIR)
- 50km swath width

Availability: Available for purchase

1. Urthecast  
[www.urthecast.com](http://www.urthecast.com)

# BlackSky Global – Microsatellite Earth Observation

BlackSky is a service of Spaceflight Industries

## Pathfinder

- RGB
- 1m spatial resolution
- 1 vehicle on orbit, 1 planned for later 2016
  - Launched 9/26/2016
- 44kg vehicle weight

## Global

- 4 planned

Availability: Not yet available

1. BlackSky  
[www.blacksky.com](http://www.blacksky.com)



# Planet<sup>1</sup> – Nanosatellite Earth Observation

## Dove

- 4 spectral bands (R, G, B, NIR)
- ~3m spatial resolution
- 60+ 'Dove' nanosatellites (3U CubeSat standard) on orbit
- Distributed as 'Planetscope'

## RapidEye

- 5 spectral bands (R, G, B, Red Edge, NIR)
- 5m spatial resolution
- 5 RapidEye minisatellites on orbit

Availability: Available for purchase

1. Planet  
[www.planet.com](http://www.planet.com)

# Terra Bella<sup>1</sup> – Microsatellite Earth Observation

## SkySat

- 7 spacecraft on orbit
- 90cm (Pan), 2m (MS) spatial resolution
- 4 spectral bands (R, G, B, NIR)
- 1.1m video at 30 fps

Availability: Available for purchase

1. TerraBella  
<https://terrabella.google.com>

# Table 1

Name	Country	Modality	Best Resolution (m)	Revisit (# days)	Availability	Distributor	Notes
MODIS	US	Passive/MS	250	1	Free	USGS	2 spacecraft
Landsat	US	Passive/MS	15	8 / 16	Free	USGS	2 spacecraft
Sentinel-1	EU	Active/Radar	4	12	Free	ESA	
Sentinel-2	EU	Passive/MS	10	10	Free	USGS / ESA	
ASTER	US/JA	Passive/IR	15	16	Free	USGS	
Pleidades	FR/IT	Passive/MS	0.5	1	\$\$\$	Airbus	2 spacecraft
SPOT-6	FR	Passive/MS	1.5	1	\$\$\$	Airbus	
SPOT-7							
KOMPSAT	KS	Passive/MS	0.55	28	\$\$\$	SI	3 spacecraft
TripleSat	CH	Passive/MS	0.8	1	\$\$\$	Earth-1	3 spacecraft
Gaofen-2	CH	Passive/MS	0.8	5			
DubaiSat-2	UAE	Passive/MS	1	8	\$\$\$	SI	
Resourcesat	IN	Passive/MS	5	5 - 24	Limited	ISRO	2 spacecraft
CBERS-4	BR/CH	Passive/MS	5	26			
TerraSAR-X	GM	Active/Radar	1	11 / 2	\$\$\$	Airbus	tandem pair
TanDEM-X							
RADARSAT-2	CA	Active/Radar	1	24	\$\$\$	MDA	
COSMO SkyMed	IT	Active/Radar	1	1	\$\$\$	e-geos	4 spacecraft
KOMPSAT-5	KS	Active/Radar	1	28	\$\$\$	SI	
GeoEye-1	US	Passive/MS	0.41	3	\$\$\$	DG	
WorldView-1	US	Passive/Pan	0.5	1.7	\$\$\$	DG	
WorldView-2	US	Passive/MS	0.46	1.1	\$\$\$	DG	
WorldView-3	US	Passive/MS	0.31	1	\$\$\$	DG	
Deimos-1	CA	Passive/MS	22	3	\$\$\$	Urthecast	
Deimos-2	CA	Passive/MS	0.75	2	\$\$\$	Urthecast	
Iris	CA	Passive/Video	1	1 (mid-latitudes)	\$\$\$	Urthecast	ISS
Theia	CA	Passive/MS	5	1 (mid-latitudes)	\$\$\$	Urthecast	ISS
Dove	US	Passive/MS	3	1	\$\$\$	Planet	many nanosats
RapidEye	US	Passive/MS	5	1	\$\$\$	Planet	5 minisats
SkySat	US	Passive/MS	0.9	1	\$\$\$	Terra Bella	7 microsats