From Science to Operational Information: Earth Observation and Software Development Trends

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August 24, 2017

Important trends: Earth Observation Imagery

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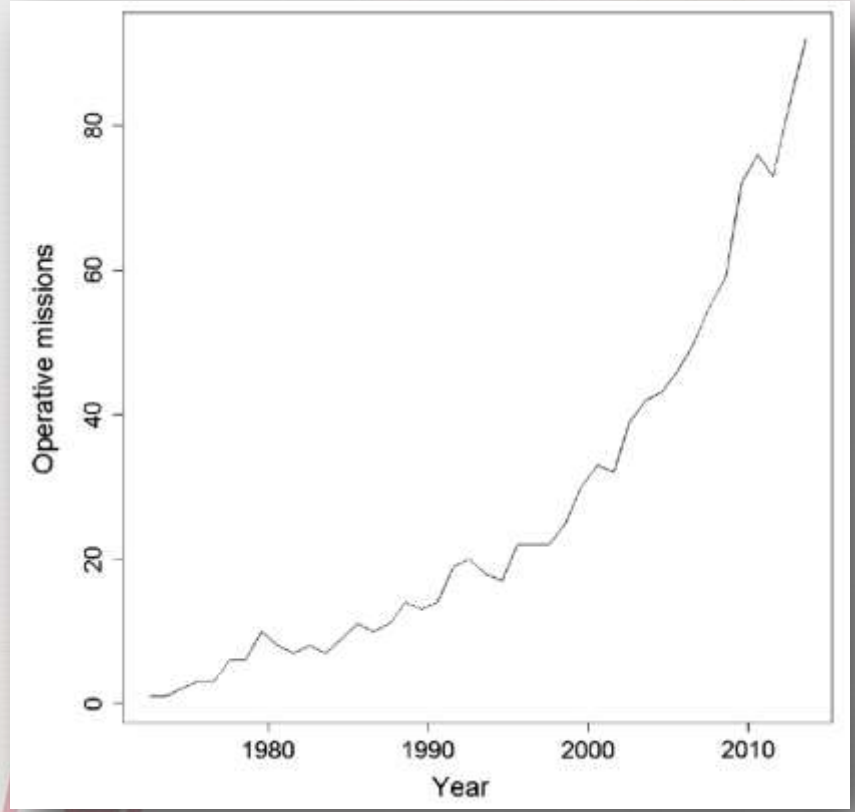
More EO Missions



197 missions since 1972

Launches per year/per decade:

1970-80:	2
1980-90:	3
1990-00:	5.5
2000-10:	8
2010-14:	12 ***(6 x first decade)***

Source: EC, JRC, Ispra (2014): http://www.sciencedirect.com/science/article/pii/S0924271614000720

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Worldwide commercial satellite launches

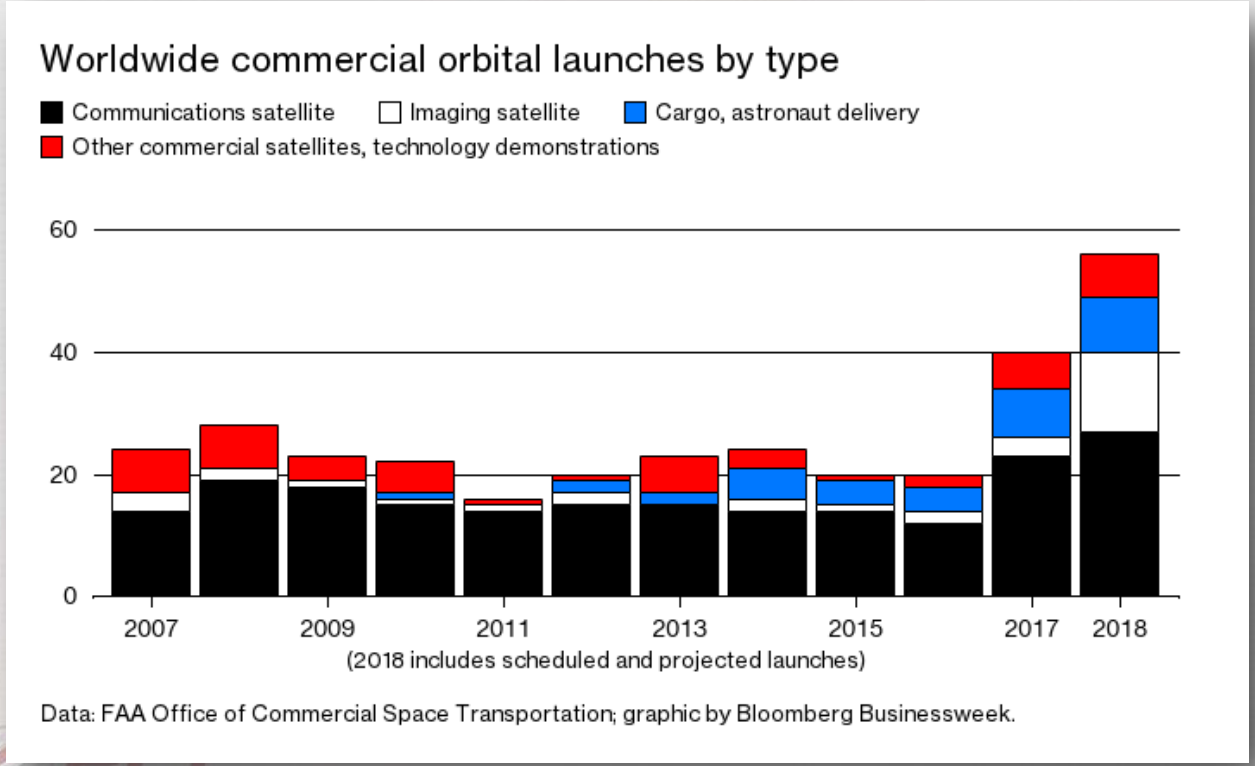


Chart pre-dates latest launch by Planet (88 satellites on February 14 2017)

More Accessibility (“free”)

“Imagery for Everyone”

USGS
science for a changing world

Technical Announcement
U.S. Department of the Interior
U.S. Geological Survey

Address:
Office of Communication
119 National Center
Reston, VA 20192

Release
April 21, 2008

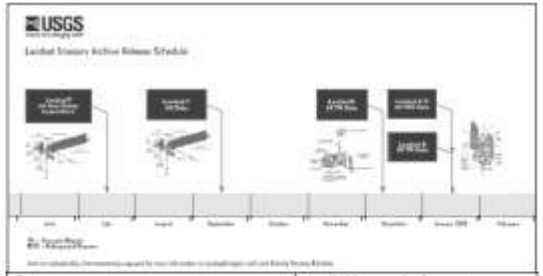
Contact
Ron Beck
Rachel Headley

Phone
605-594-6550
605-594-6118

Imagery for Everyone…

Timeline Set to Release Entire USGS Landsat Archive at No Charge.

RESTON, VA – The USGS Landsat archive is an unequaled 35-year record of the Earth's surface that is valuable for a broad range of uses, ranging from climate change science to forest management to emergency response, plus countless other user applications. Under a transition toward a National Land Imaging Program sponsored by the Secretary of the Interior, the USGS is pursuing an aggressive schedule to provide users with electronic access to any Landsat scene held in the USGS-managed national archive of global scenes dating back to Landsat 1, launched in 1972. By February 2009, any archive scene selected by a user – with no restriction on cloud cover – will be processed automatically to a standard product recipe, using such parameters as the Universe Transverse Mercator projection, and staged for electronic retrieval. In addition, newly acquired scenes meeting a cloud cover threshold of 20% or below will be processed to the standard recipe and placed on line for at least three months, after which they will remain available for selection from the archive.



Data	Available over the Internet
Landsat 7 – all new global acquisitions	July 2008
Landsat 7 – all data	September 2008
Landsat 5 – all TM data	December 2008
Landsat 4 – all TM data	January 2009
Landsat 1-5 – all MSS data	January 2009

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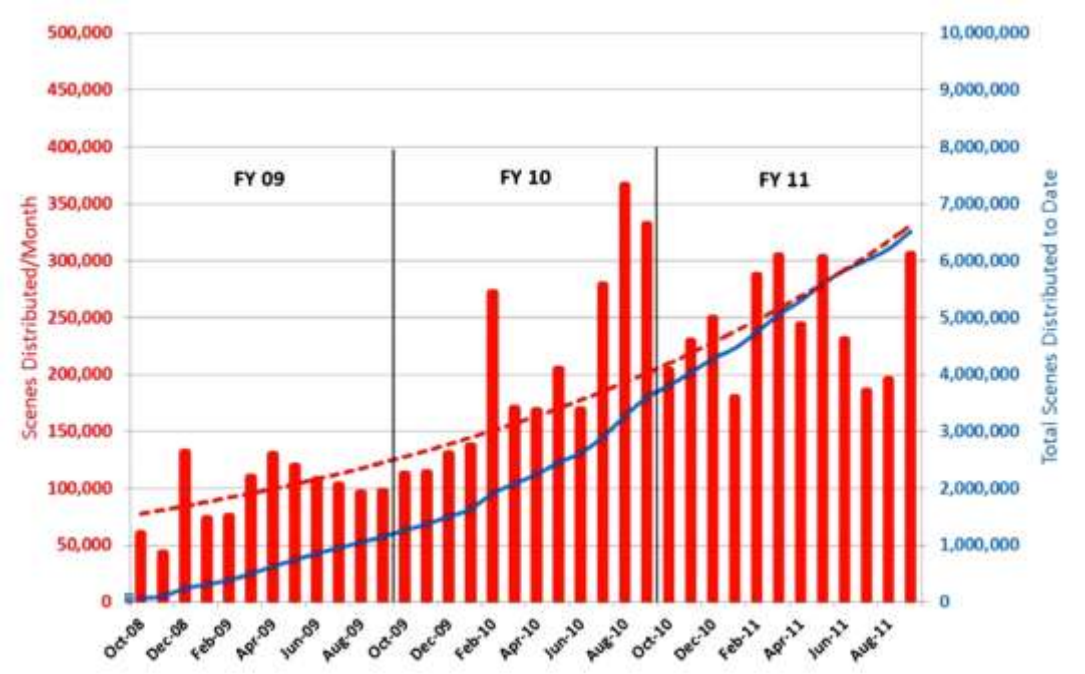
More usage of EO imagery



Source: Opening the archive: How free data has enabled the science and monitoring promise of Landsat, Wulder et al, 2012

Global Land Cover Facility, at the University of Maryland was the key catalyst for open data policy (copying / sharing data once purchased)
www.glovis.usgs.gov

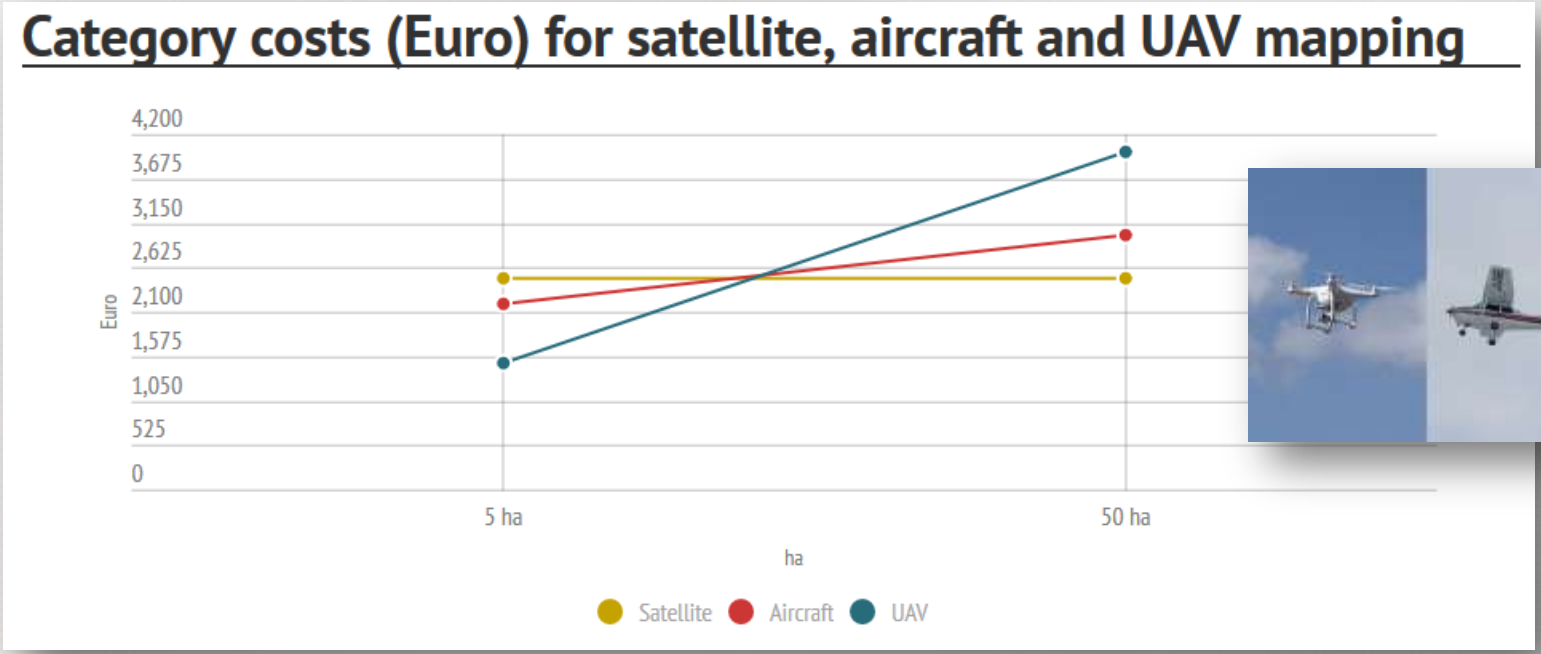
EROS Data Centre provided approximately 25,000 Landsat images in 2001 (total) vs 250,000 images (per month) in 2010!

25,000 vs 3,000,000 / year

Increased by factor of 120!!

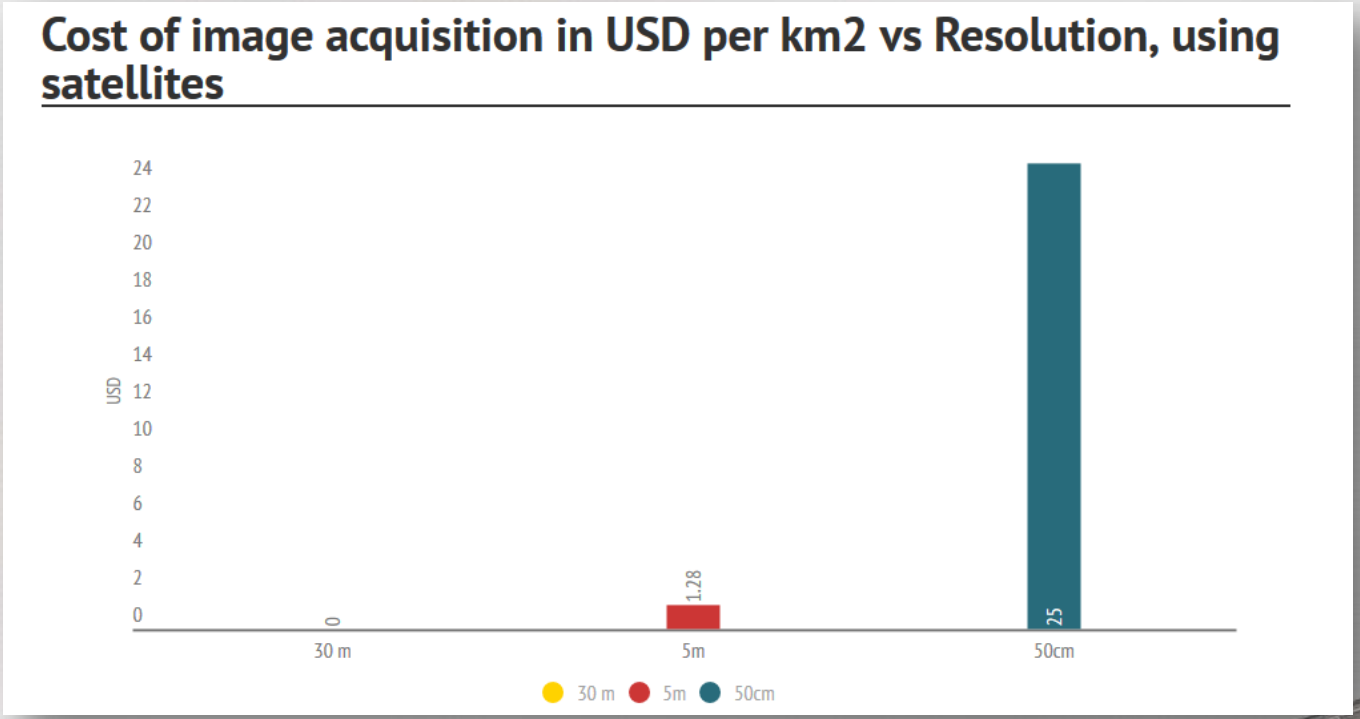
More Accessibility (“free”)

Price Pressure on imagery (more options)



Source: https://droneapps.co/price-wars-the-cost-of-drones-planes-and-satellites/

Price Pressure on imagery (resolution)



Frequency of Acquisition

Important trends: Funding

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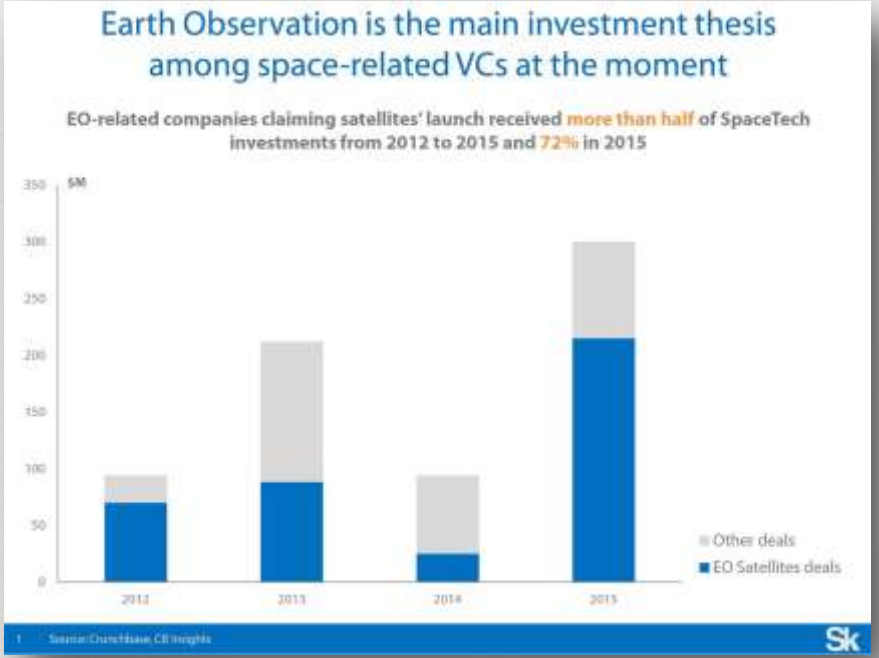
Private funding for commercial satellite programs



Source: https://venturebeat.com/2016/08/14/earth-observation-data-multibillion-dollar-opportunity-or-dud/

- The funding model for new space based startups is changing
- Not only about cost recovery for big programs; it's also about profit opportunities that come with constellation / privately funded missions / companies

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Important trends: More data

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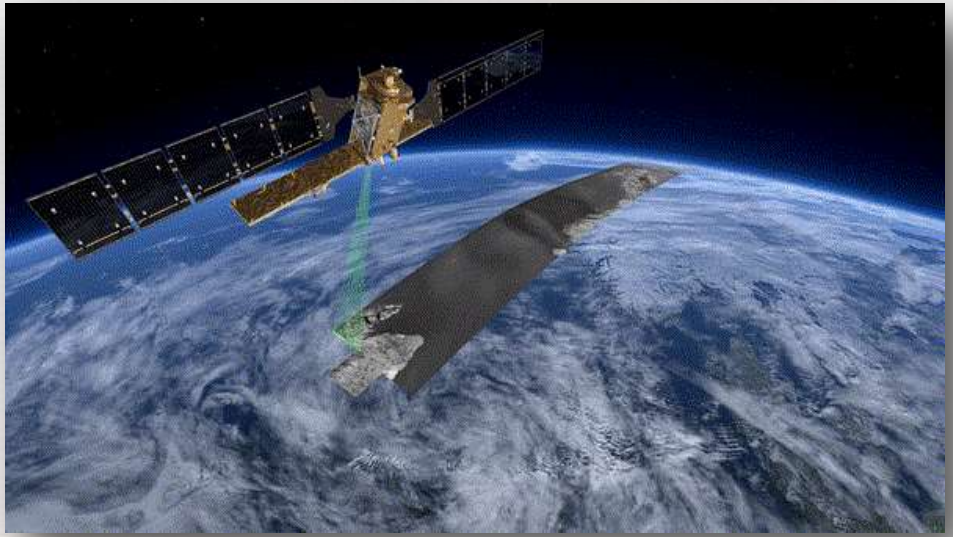
Sentinel Data Volumes



“By the end of 2017, the operational Sentinel-1, -2 and -3 satellites alone will continuously collect a volume of 20 Terabytes per day.”

https://medium.com/google-earth/a-golden-age-for-earth-observation-f8b281cec4b7

EO Data Trends: Consequences and Opportunities

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Multi-temporal methods possible

Change detection is not new…


Original Articles

Procedu… | Received 29 Dec 1980, | …sat digital data

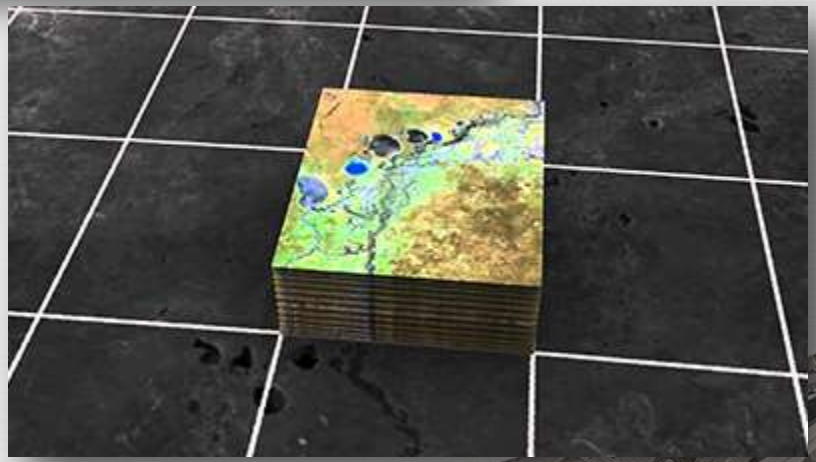
PHILIP J. HOWARTH &

Pages 277-291 | Received 29 Dec 1980, Published online: 27 Apr 2007

…but has not been practical due to data costs and access… until now.

Australia Data Cube

Australian Geoscience
DATA CUBE
a world-leading data analysis environment
for satellite and other Earth Observations

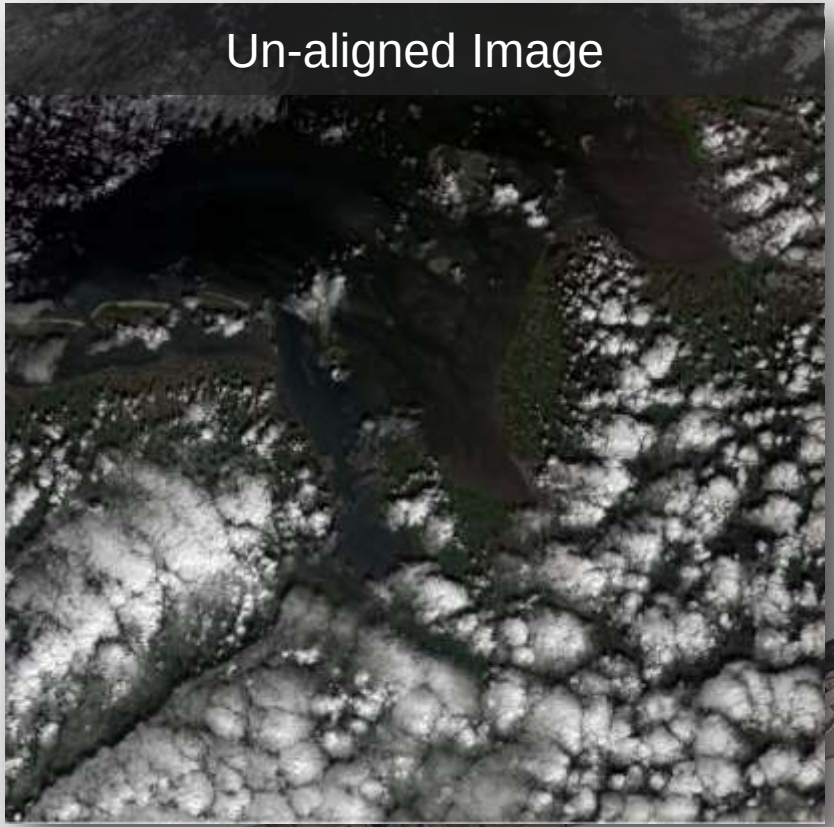


Alignment and Calibration

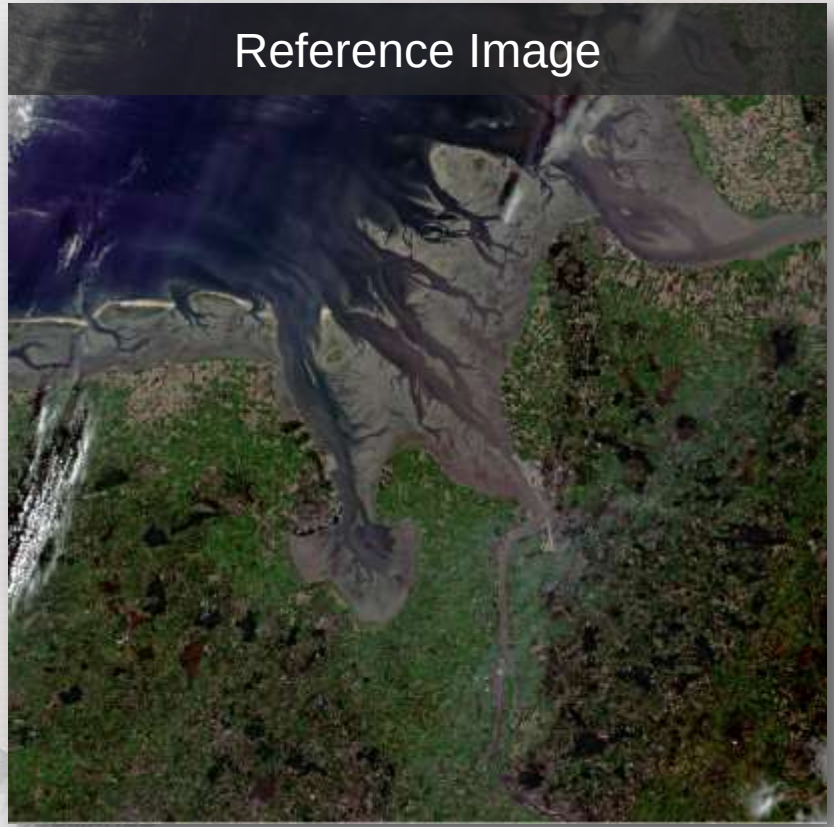
The need for pixel-perfect alignment

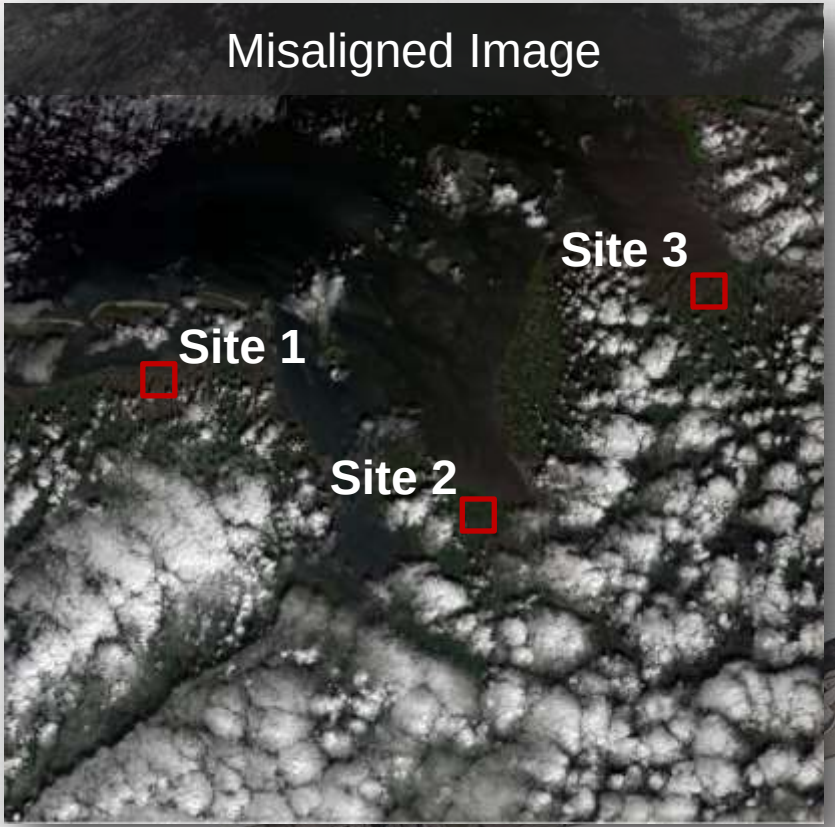
Reference Image

Un-aligned Image



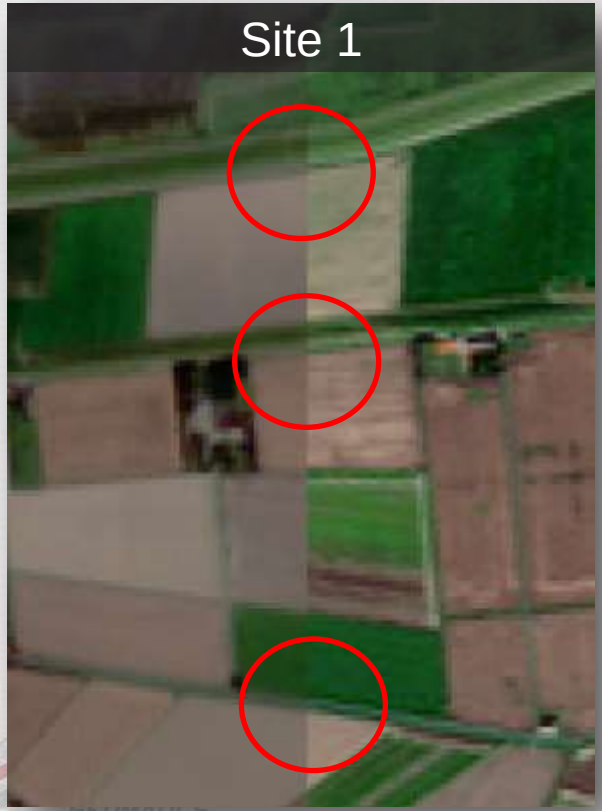
The need for pixel-perfect alignment





Multi-temporal not possible

Multi-temporal possible



Cross Sensor Calibration

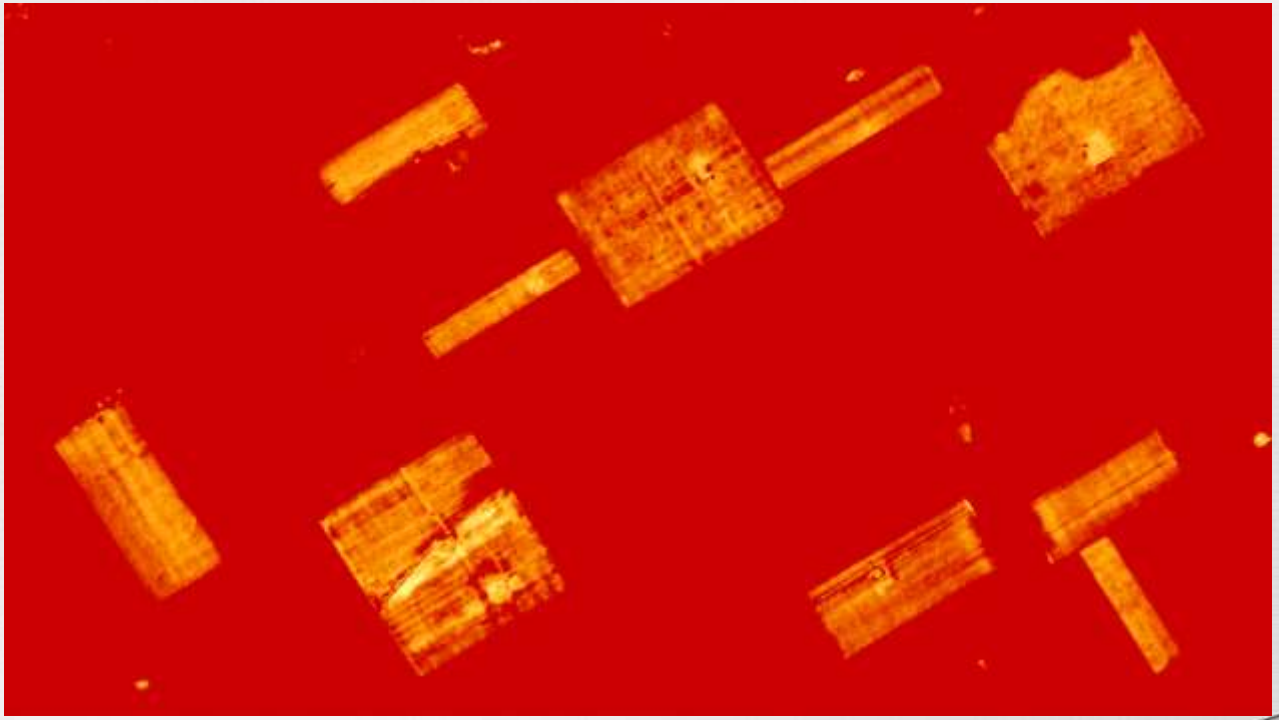
PlanetScope
Dec 01/2016
3:05 PM
Local time

Cross Sensor Calibration

RapidEye
Dec 03/2016
11:36 AM
Local time

No Calibration NDVI

PlanetScope
Dec 01/2016
3:05 PM
Local time



No Calibration NDVI

RapidEye
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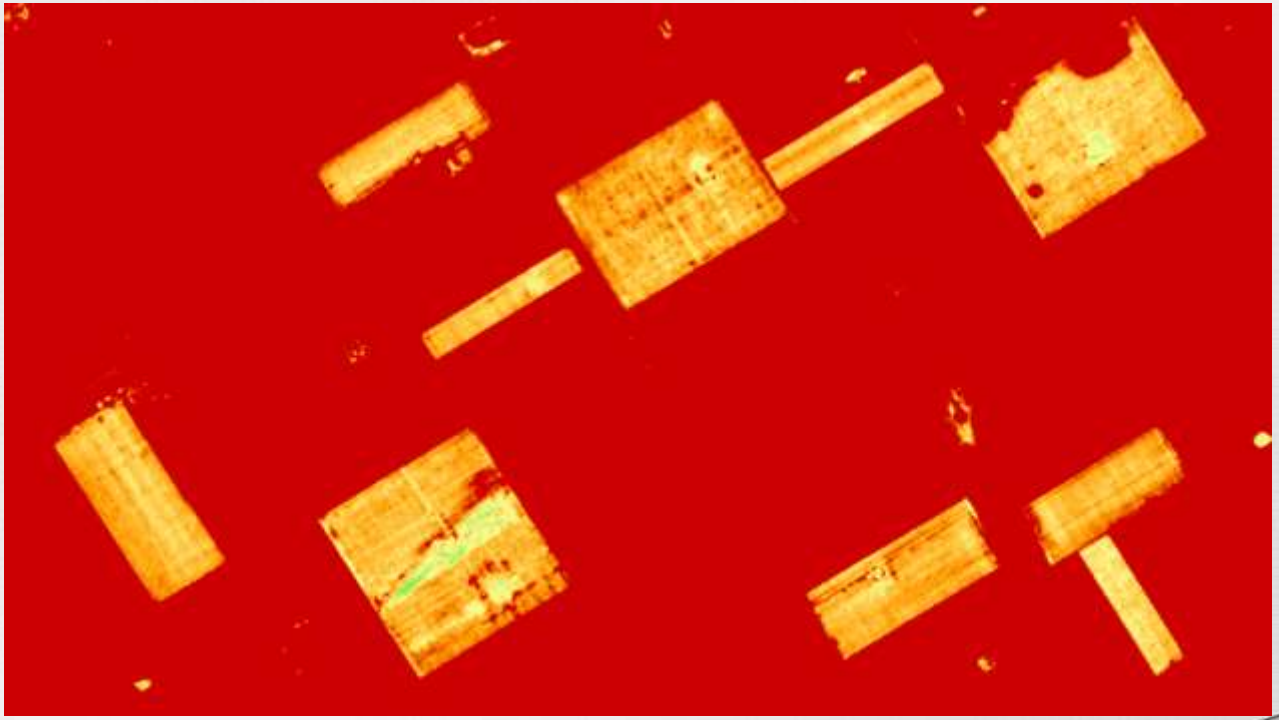
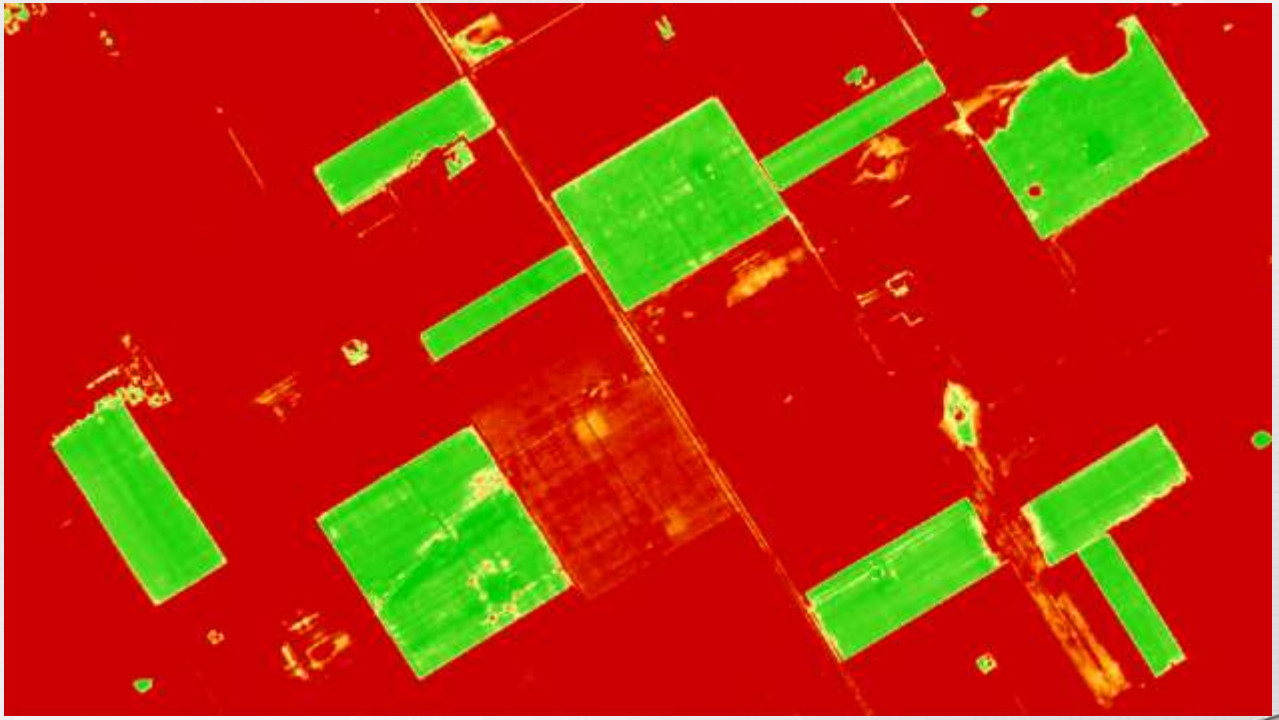
Local time



Calibrated NDVI

PlanetScope
Dec 01/2016
3:05 PM
Local time



Calibrated NDVI

RapidEye
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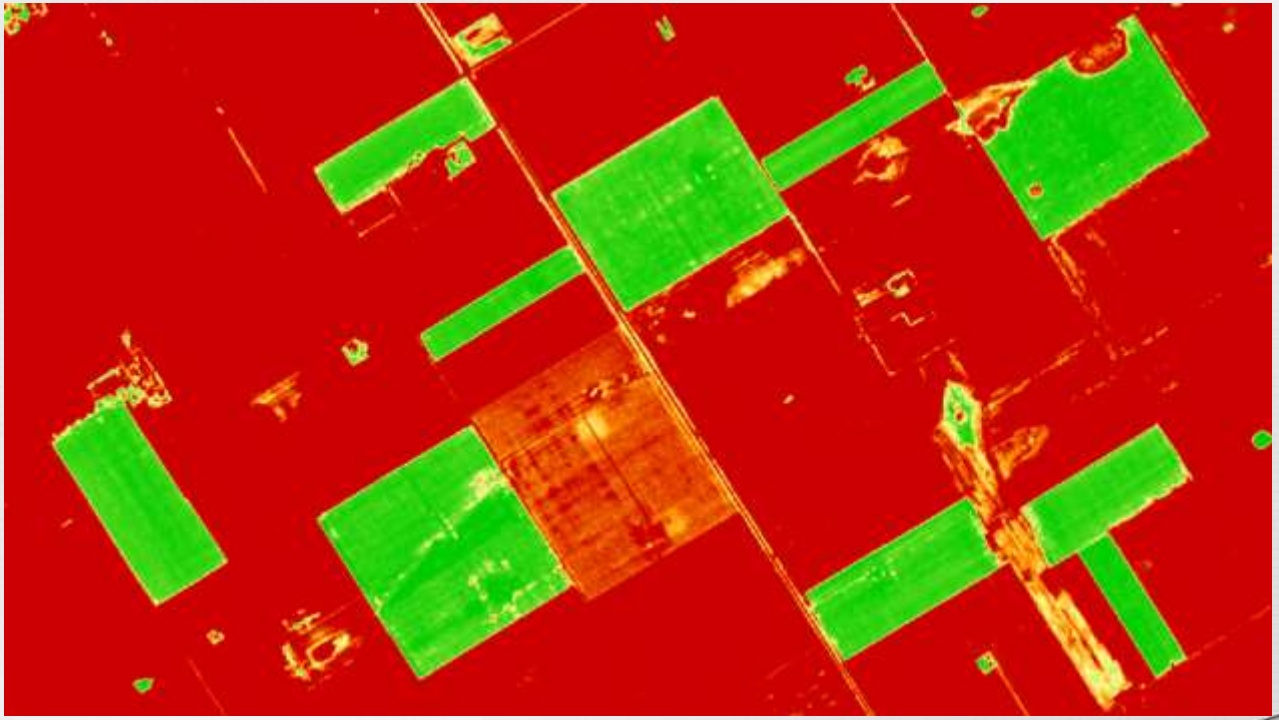
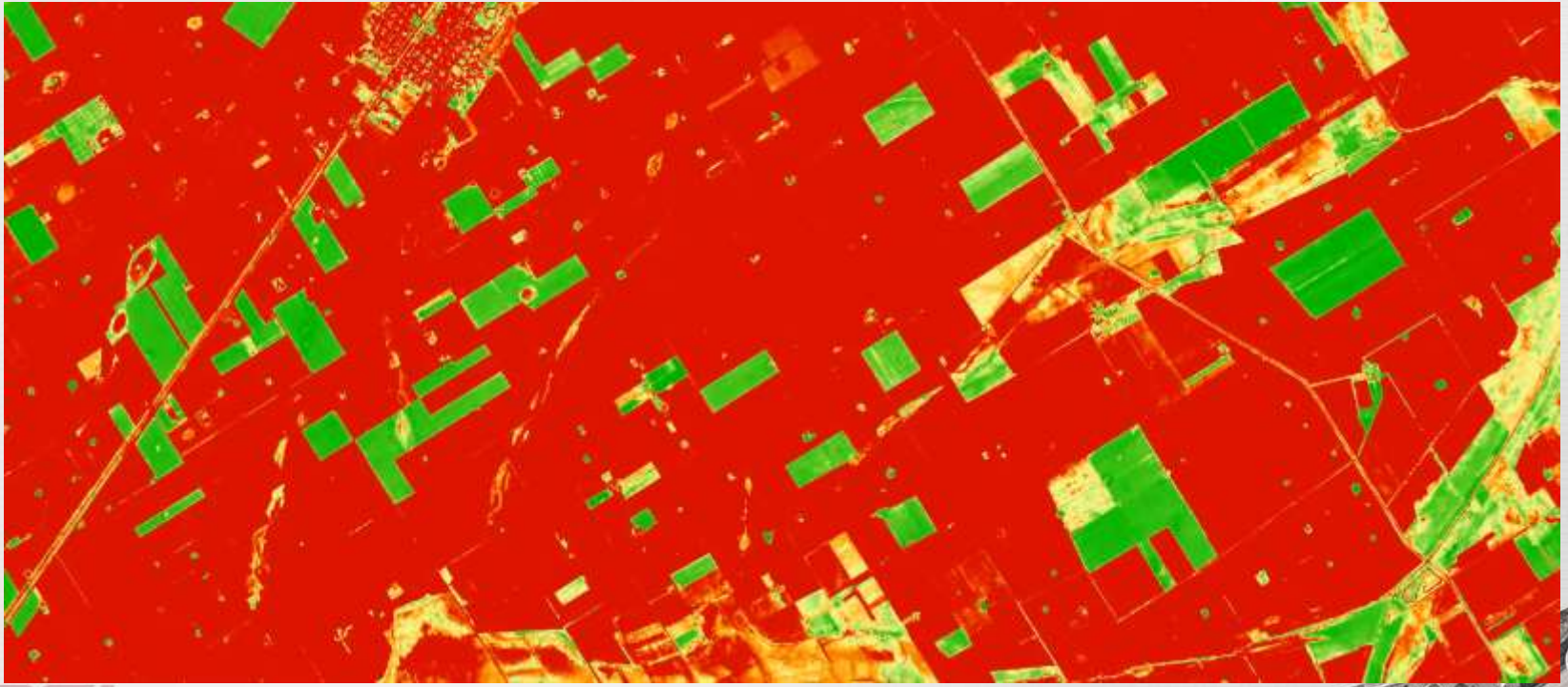
Local time



Calibration Makes Big Multi-temporal Analysis Possible

Dec 01/2016 (PS), Dec 03/2016 (RE), Dec 11/2016 (PS), Dec 20/2016 (RE), Dec 29/2016 (PS)



Big Data Analytics

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Software needs to be scalable, and easily integrated

Esri Cloud processing project

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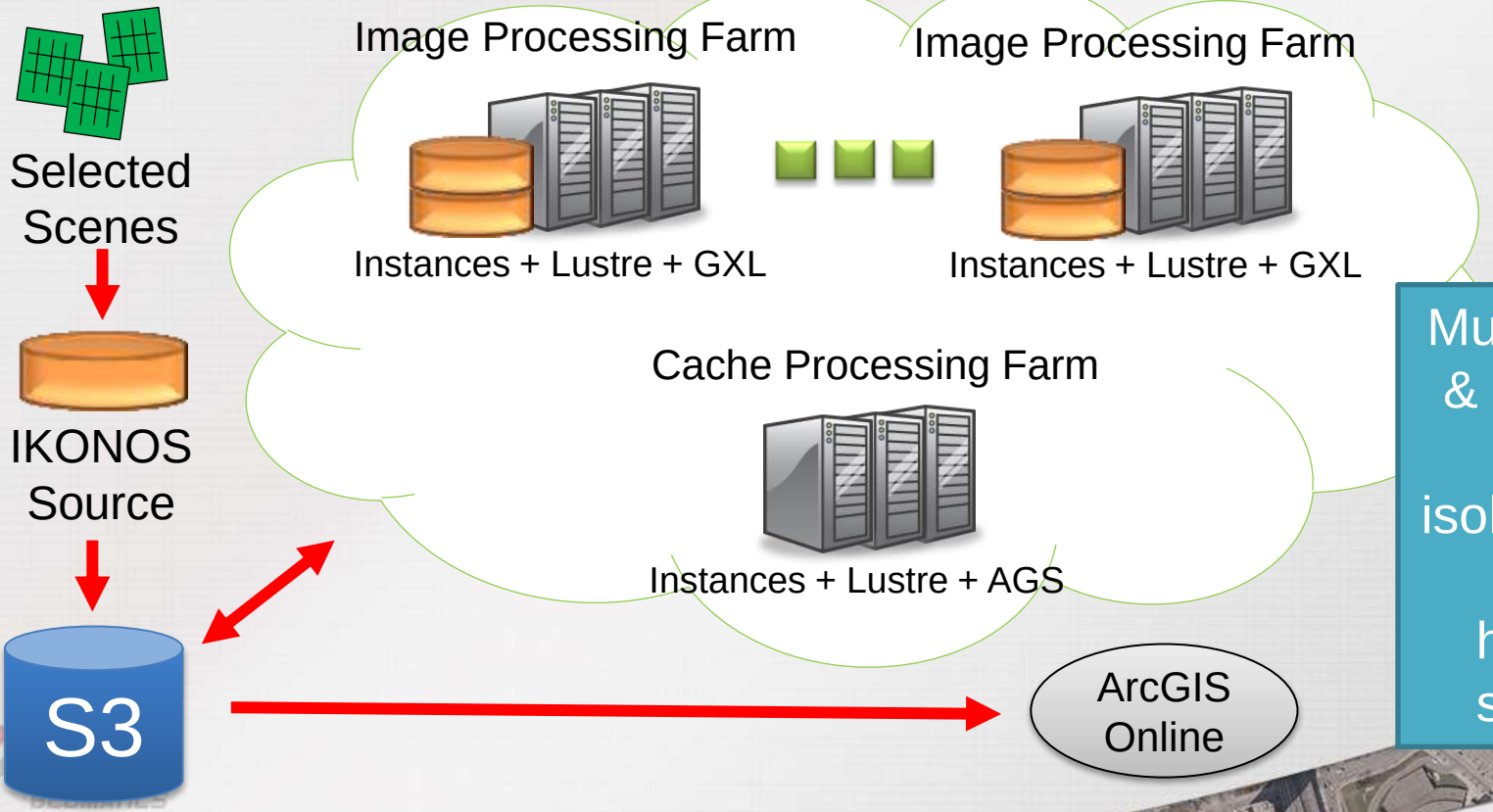
Massive Cloud Scalability (PCI/Esri 2011)



Node Configuration

"Standard" compute node

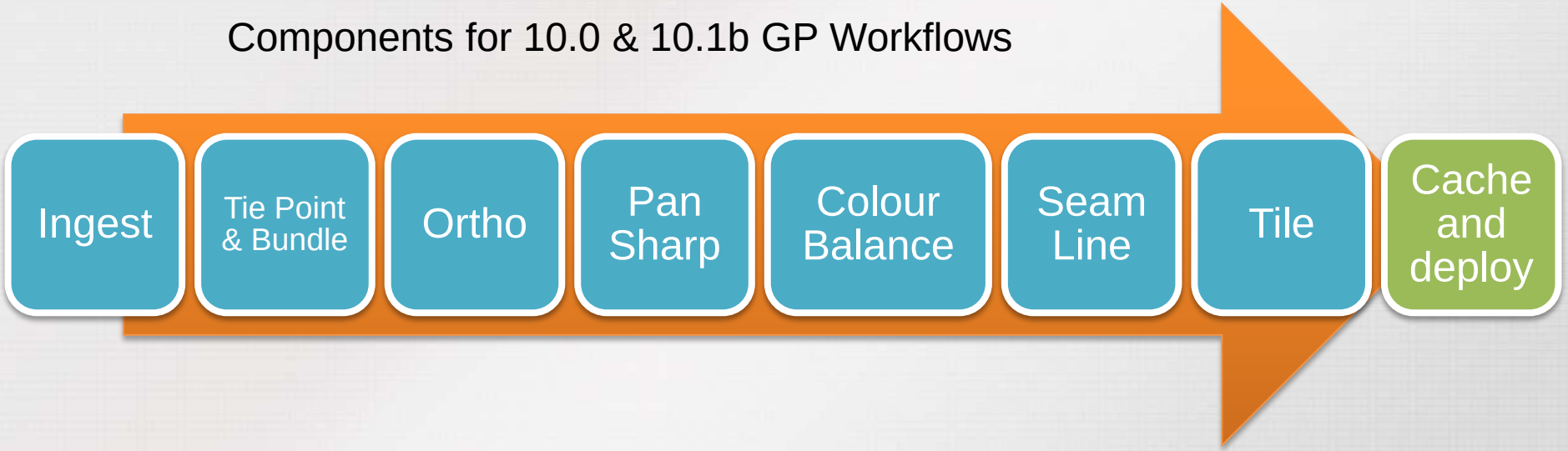
- m1.xlarge
  - 15 GB memory
  - 8 EC2 compute units
    - 4 virtual cores, each with 2 x EC2
  - 1,690 GB ephemeral storage included "free"
  - 8 GB EC2 volume
  - 64-bit Linux OS
  - I/O performance level: High
- Designed to use minimal EC2 resources

Typical Task Provisioning

- Per farm, node requirements are typically as follows:
  - Ingest 25+ nodes
  - Tie-point collection 20+ nodes
  - Ortho w/Pansharpen 20+ nodes
  - Colour balancing 1 node
  - Mosaic Tiling 25+ nodes
  - Caching 8 nodes
- Tasks are pipelined on each farm
- Operational nodes per farm is 25+
- For 9 operational farms, potential is 225+ nodes

Cloud Geo-Processing Engine

Components for 10.0 & 10.1b GP Workflows



PCI GXL / Geomatica

ArcGIS

Production Throughput

- Average based on current cloud compute configuration
- Component km²/node-hr
  - Ingest 7007 km²
  - Tie-point collection 2685 km²
  - Ortho w/Pansharpen 1773 km²
  - Colour balancing 39,925 km²
  - Mosaic Tiling 1899 km²
  - Caching 13,926 km²
- Total processing per area-of-interest ~681 node-hours
- Processing varies with sensor and size of area

VC Funding EO / Proliferation

Company	Founded	Raised, $M	Current # of satellites	Planned # of satellites	Full constellation deployment date
Terra Bella (ex. Skybox Imaging)	2009	91	2	24	2017
Planet (ex. Planet Labs)	2010	158,1	51	150	2017
Urthecast	2010	N/A	2	16	2020
Dauria Aerospace	2011	20	0	10	2020
Astro Digital (Aquila Space)	2014	N/A	2	30	2020+
BlackSky Global	2013	53,5	0	60	2019
Satellogic	N/A	2	0	300	2020+
Omni Earth	2013	10,32	0	18	2018
Planetary Recourses	2010	22,5	0	10	2020+
AxelSpace	2008	16,05	0	50	2020+
Iceye	2012	2,8	0	40	2020+
Hera Systems	2013	4,2	0	48	2020
NorStar Data	N/A	N/A	0	40	2020+

2 Source: Gunter's Space Page, Earth Imaging Journal, companies' press releases

Effect of VC Funding

Verticalization

- Examples: “8 Satellite Data Startups Doing Geospatial Analysis” (nanalyze.com article)

“Under Cover of Darkness”

http://www.nanalyze.com/2017/08/8-satellite-data-startups-geospatial-analysis/?lipi=urn%3Ali%3Apage%3Ad_flagship3_feed%3BeM5f1gAvTd%2B4IZWEDa6Q%3D%3D

Effect of VC Funding

Proliferation and verticalization

- Examples: “8 Satellite Data Startups Doing Geospatial Analysis” (nanalyze.com article)

Ursa

“Reliable Economic Information”

Effect of VC Funding

Proliferation and verticalization

- Examples: “8 Satellite Data Startups Doing Geospatial Analysis” (nanalyze.com article)

SPACEKNOW

“Parking Lot Economics”

http://www.nanalyze.com/2017/08/8-satellite-data-startups-geospatial-analysis/?lipi=urn%3Ali%3Apage%3Ad_flagship3_feed%3BeM5f1gAvTd%2B4IZWEDa6Q%3D%3D

Effect of VC Funding

Proliferation and verticalization

- Examples: “8 Satellite Data Startups Doing Geospatial Analysis” (nanalyze.com article)

“Old McDonald Had a Farm”

http://www.nanalyze.com/2017/08/8-satellite-data-startups-geospatial-analysis/?lipi=urn%3Ali%3Apage%3Ad_flagship3_feed%3BeM5f1gAvTd%2B4IZWEDa6Q%3D%3D

Effect of VC Funding

Proliferation and verticalization

- Examples: “8 Satellite Data Startups Doing Geospatial Analysis” (nanalyze.com article)

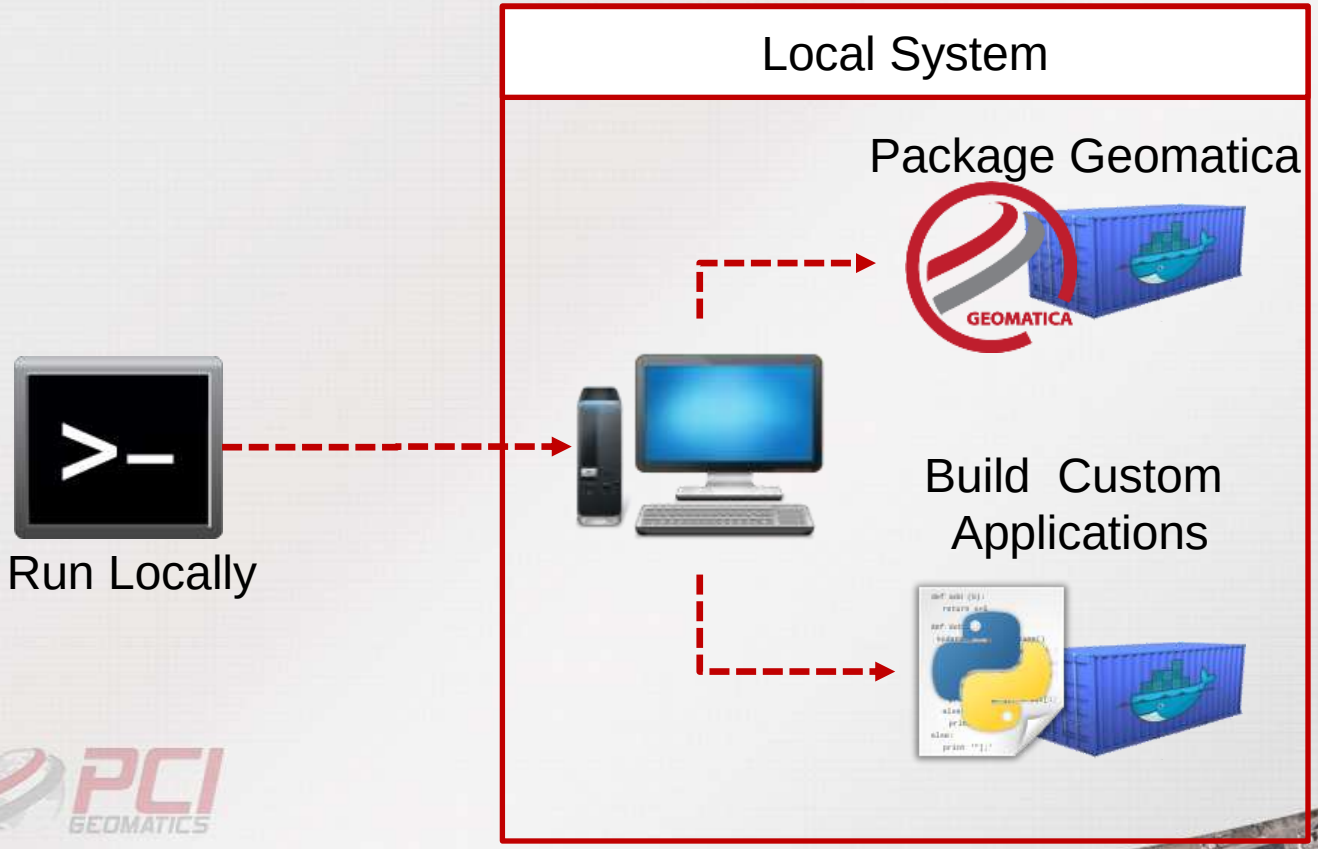
“Data access for DIY Intelligence”

http://www.nanalyze.com/2017/08/8-satellite-data-startups-geospatial-analysis/?lipi=urn%3Ali%3Apage%3Ad_flagship3_feed%3BeM5f1gAvTd%2B4IZWEDa6Q%3D%3D

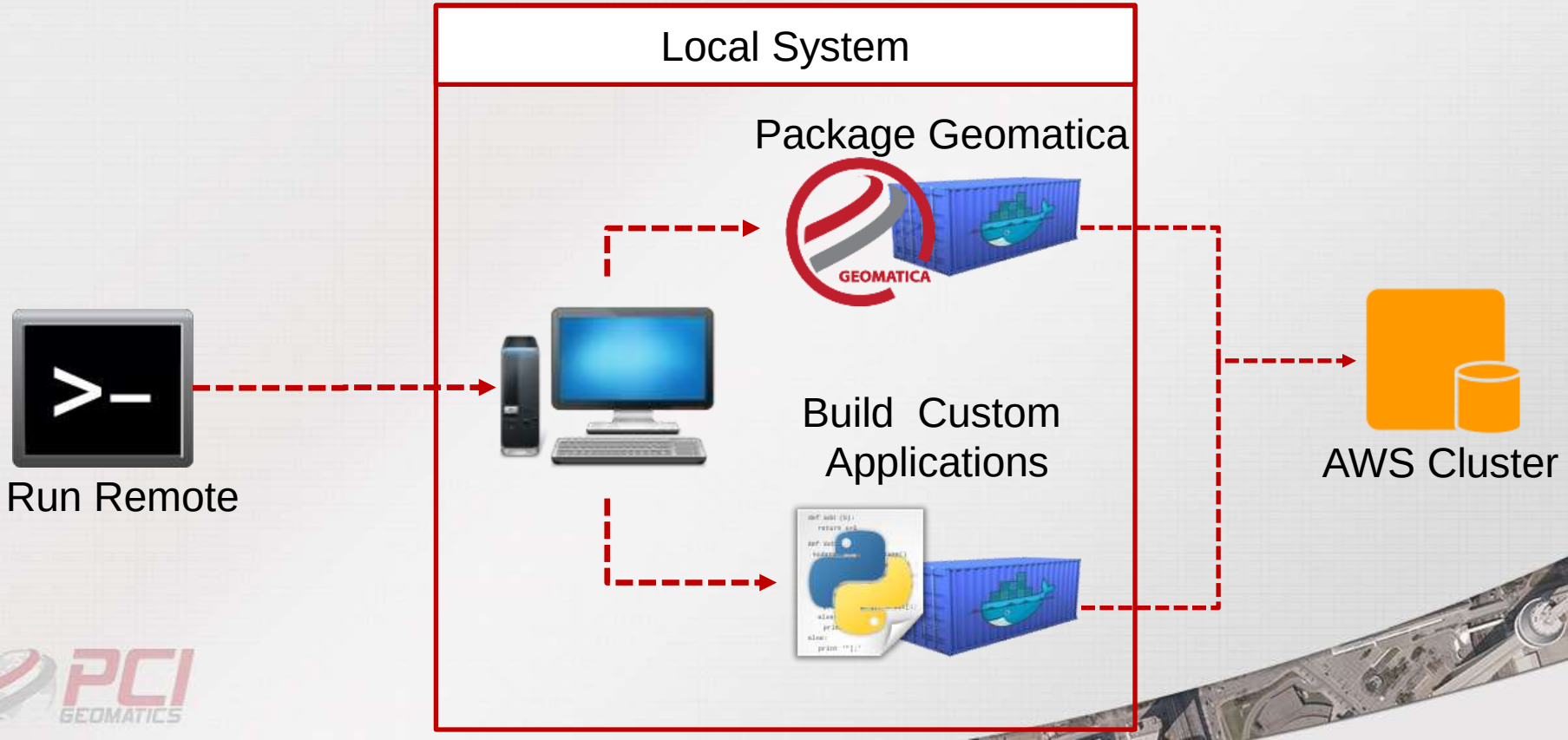
Big Data Effects

“I can’t wait for download delivery of data. I want to prototype my complex workflow on the desktop and migrate it to where the data are: in the “cloud.””

Local Deployment

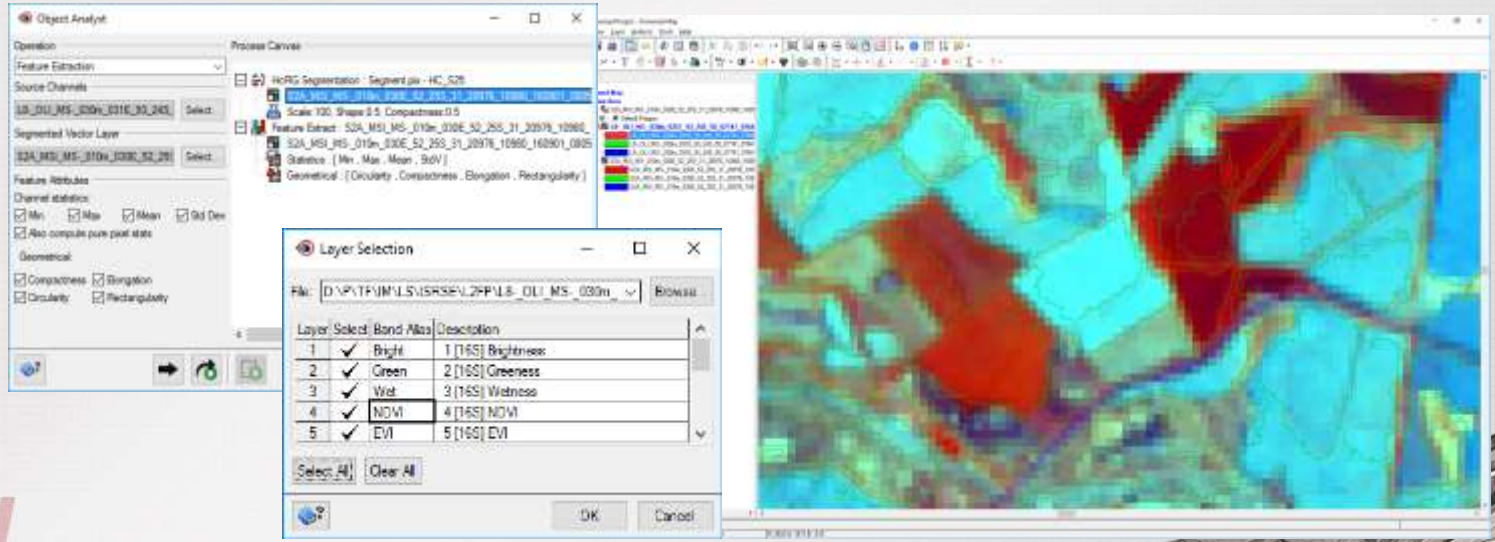


Remote Deployment



Machine Learning

- Important technique given large datasets
- Support Vector Machine (SVM implemented in PCI OBIA s/w, Python integration→2018



Summary

- EO proliferation = Big data
- Big data changes everything
  - Need for speed
  - Need for new deployment models and business models
  - Machine learning
- Science matters
  - Get the pixels in the right place (this is not easy)
  - Calibration and validation (this is not easy)
- Solutions are proliferating
  - Consumer beware
  - Experience matters