



Platforms and systems

Dr. Alan Belward

Land Resource Management Unit
Institute for Environment and Sustainability

European Commission
Joint Research Centre

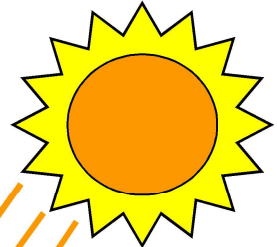
<http://bioval.jrc.ec.europa.eu/>



System overview



1 Source



Emitted

Received

Generated
&
received

5 Users

4 Ground station

Absorbed

Scattered

Refracted

Transmitted

Reflected

Emitted
(source)

Reflected

Refracted

Absorbed

Scattered

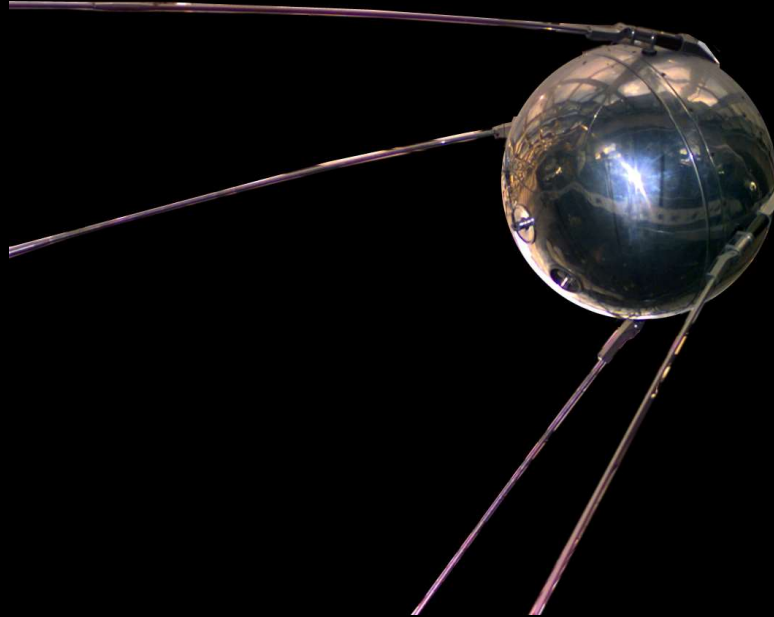
2 Target

Transmitted

31st January 1958



4th October 1957



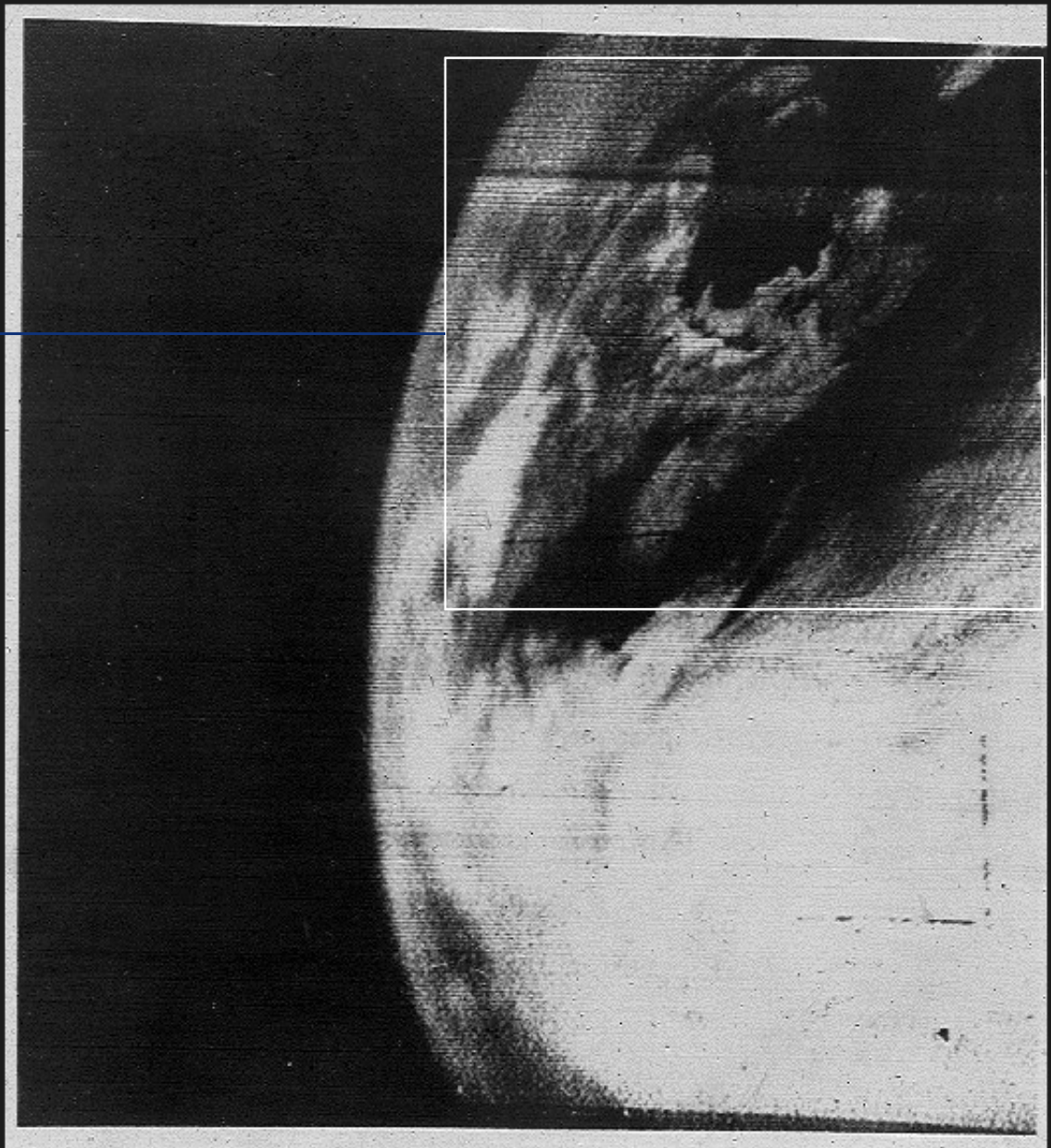
3rd November 1957

Central Pacific Ocean
imaged by Explorer 6
on 14th August 1959



Source: Great Images in NASA

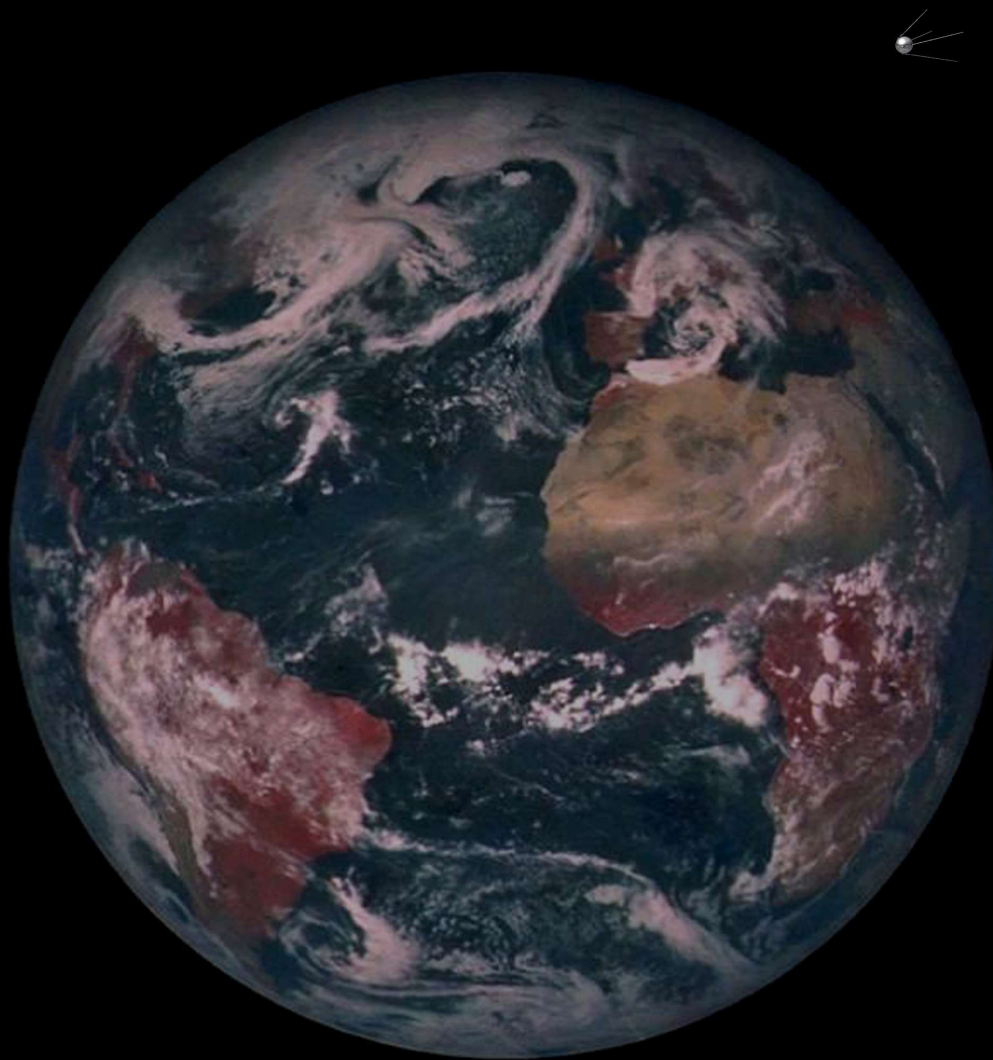
FIRST TELEVISION PICTURE FROM SPACE
TIROS I SATELLITE
APRIL 1, 1960



US National
Reconnaissance
Office
Mys Schmidta
airfield, Russia
18th August 1960







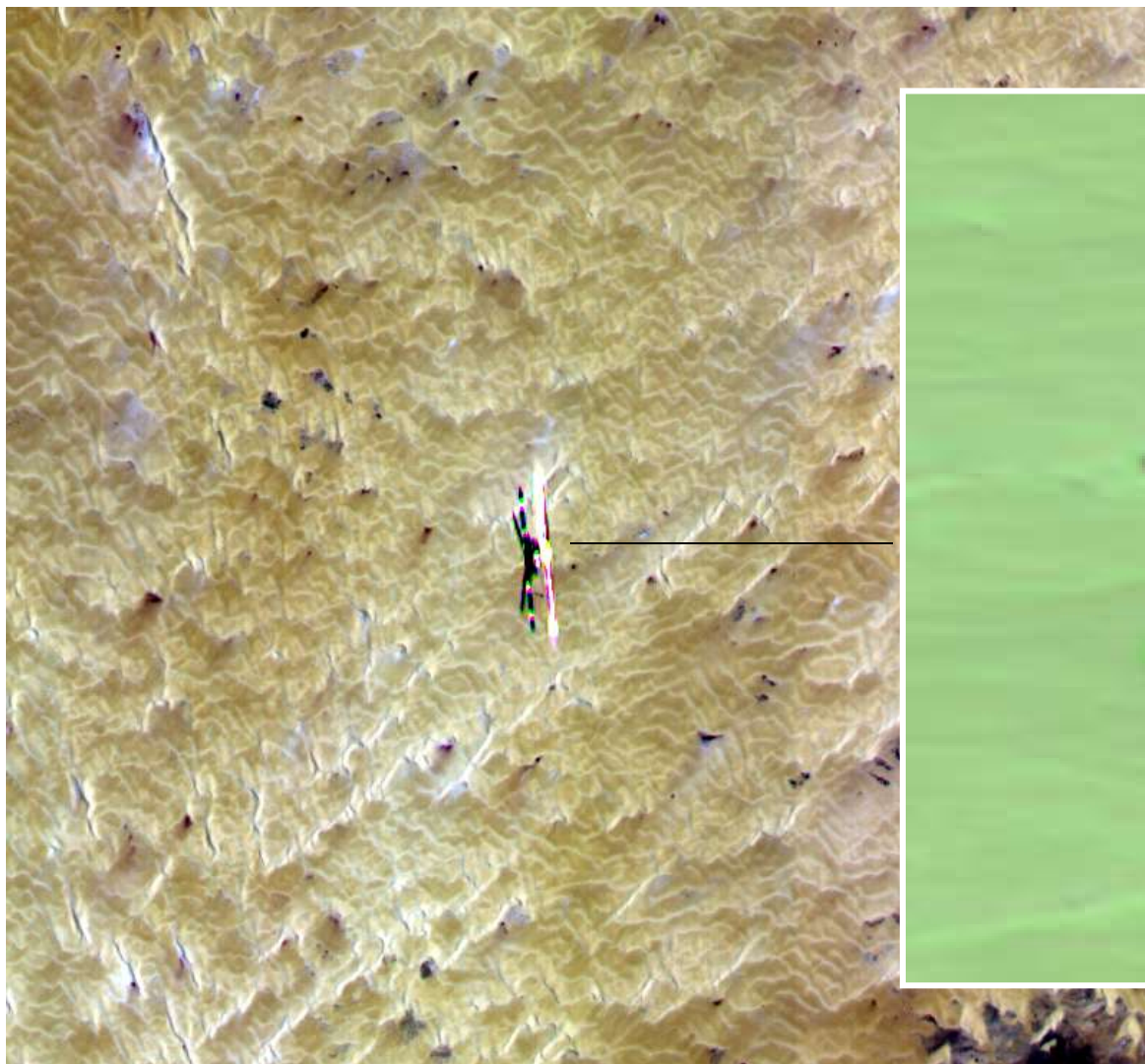


Images NASA Clementine mosaic, ESA beehive adapted ASB



Source GOCE reentry 10 November 2013 South Falklands

SPOT 4 images ERS-1 on 6th May 1998



SPOT 4 images ERS-1 on 6th May 1998

BBC News Sport Weather Capital TV Radio More...

NEWS

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Page last updated at 11:37 GMT, Thursday, 12 February 2009

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Russian and US satellites collide

US and Russian communications satellites have collided in space in what is

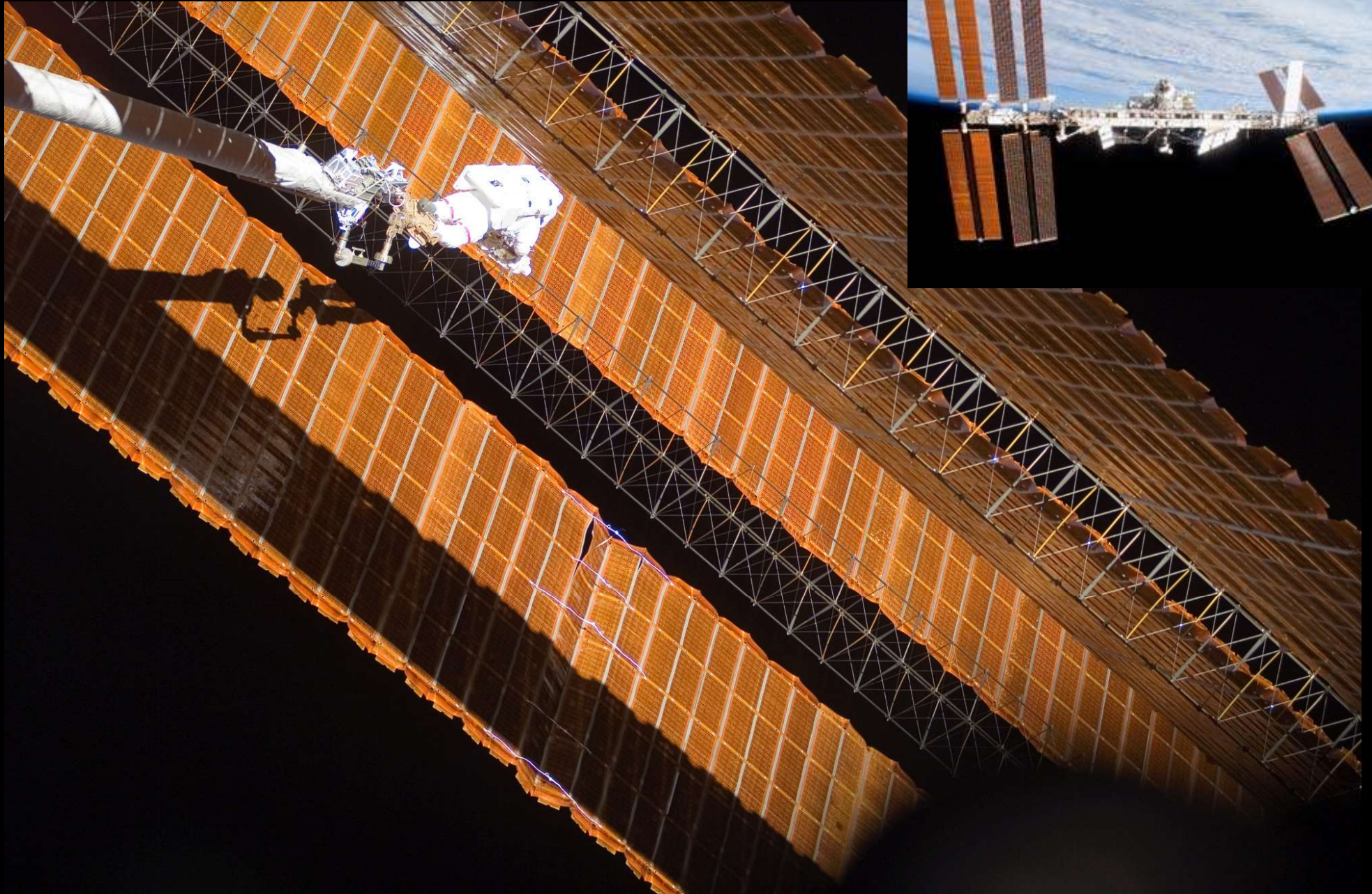


AGENCIA ESPACIAL CIVIL ECUATORIANA

El 25 de Abril de 2013 a las 23h13m00s hora local, Ecuador lanzó al espacio su primer satélite, el NEE-01 PEGASO, su primera transmisión de video fue captada por la estación terrena HERMES-A el 5 de Mayo de 2013

En Mayo 23, 2013 a las 00h38m17s el NEE-01 PEGASO fue impactado en órbita por partículas desprendidas por el objeto SCC-15890.

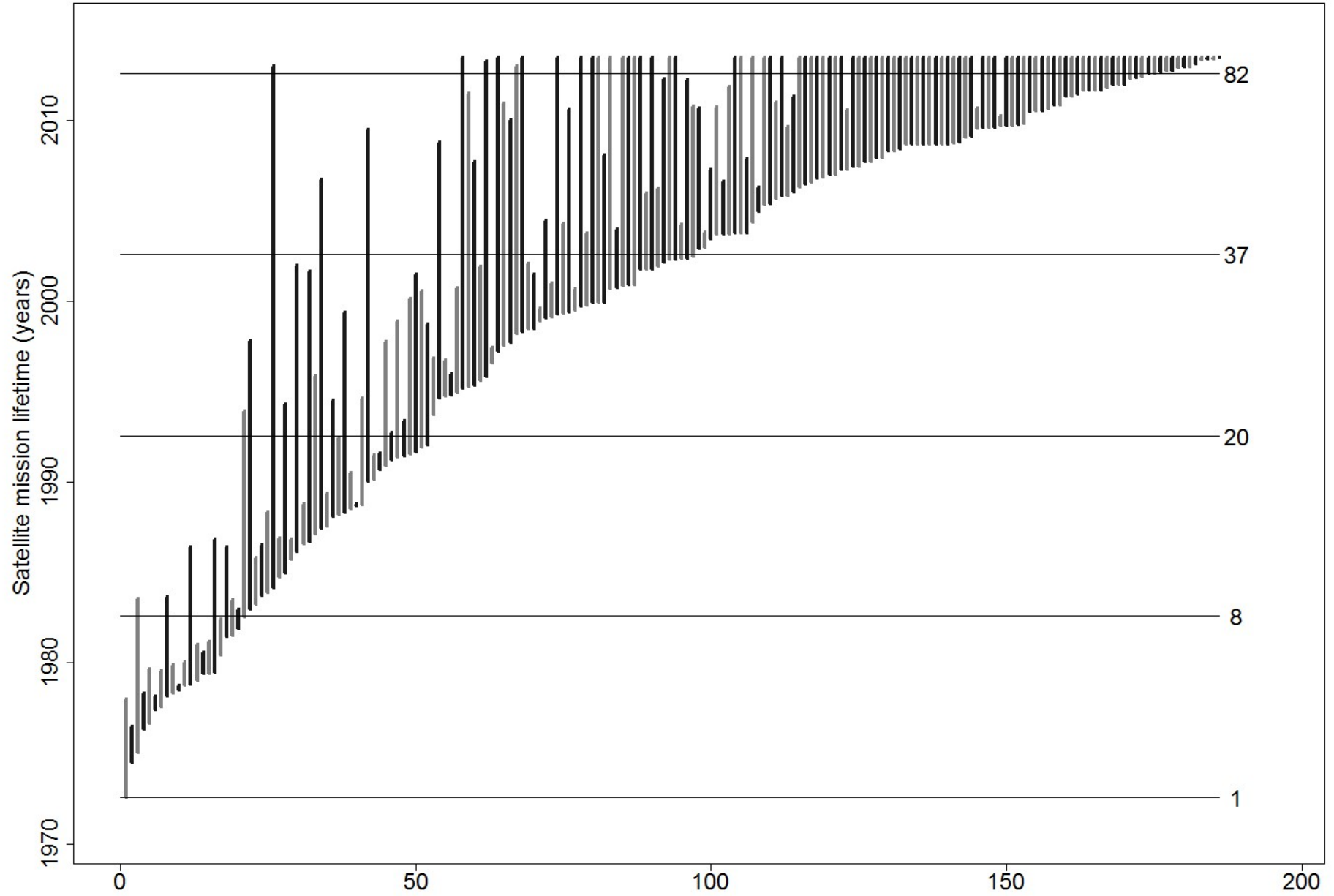
Space junk – getting close to self perpetuating



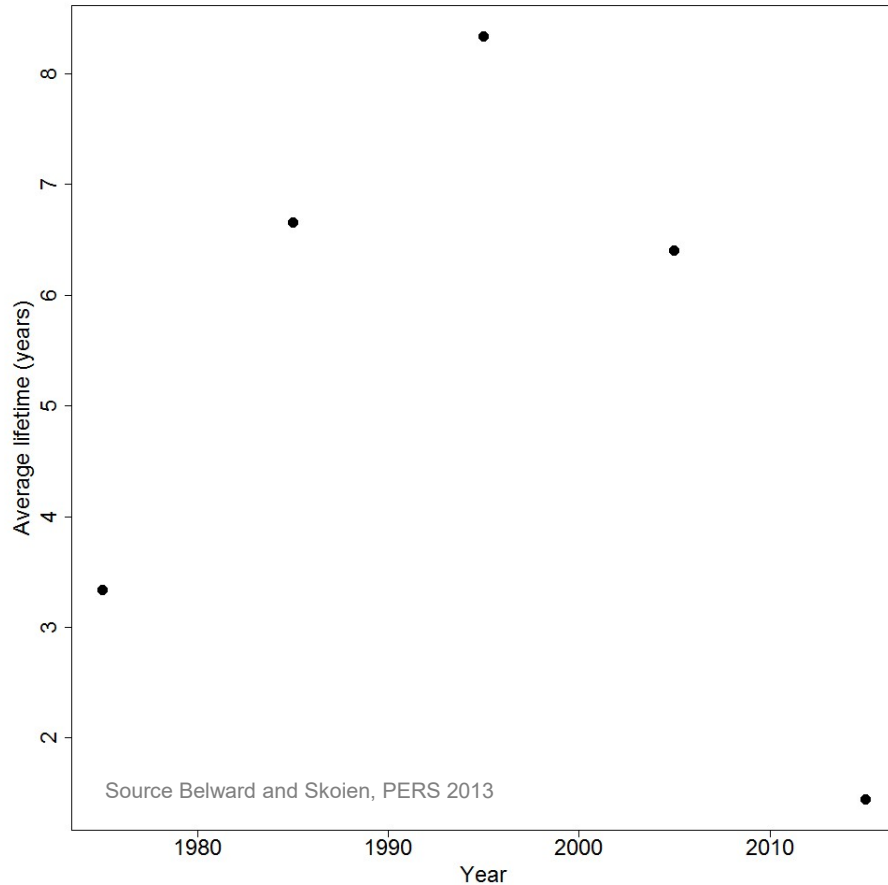
Scott Parazynski repairs ISS

Images NASA, Stephen Ornes, Bringing down the trash, physics world

The lifespan of near-polar orbiting, land imaging, civilian satellites shown in chronological order

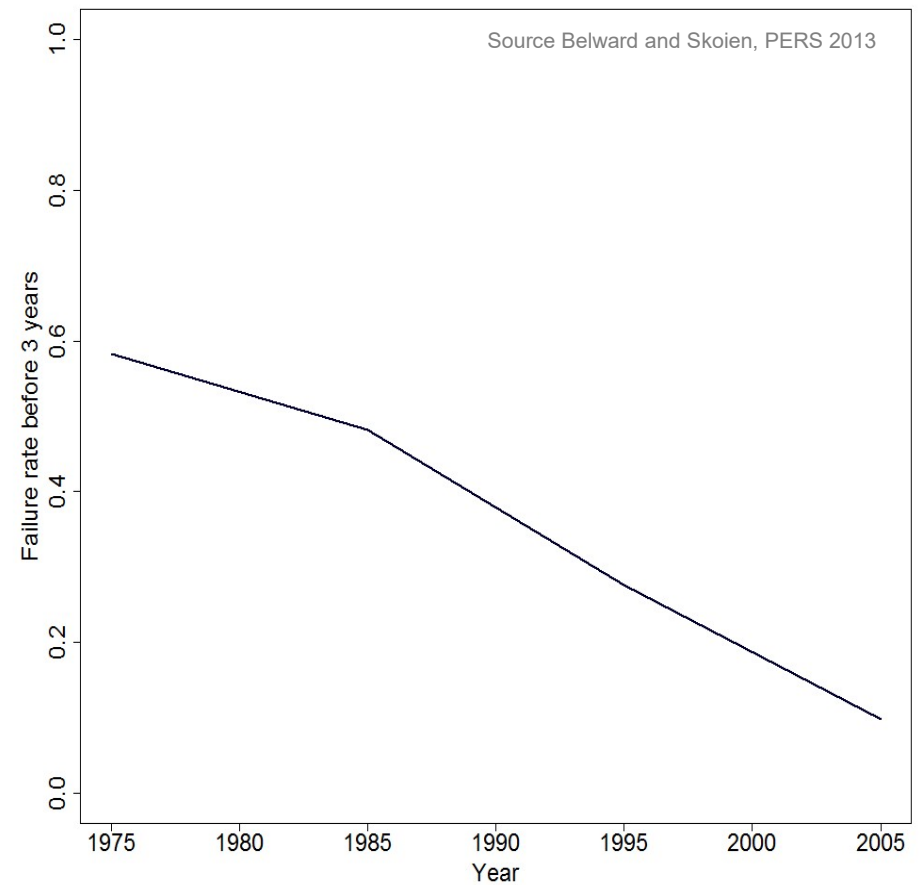


Average mission lifetime for all near-polar orbiting, land imaging, civilian satellites launched per decade, nb average lifetime for 1990s and 2000s will continue to lengthen



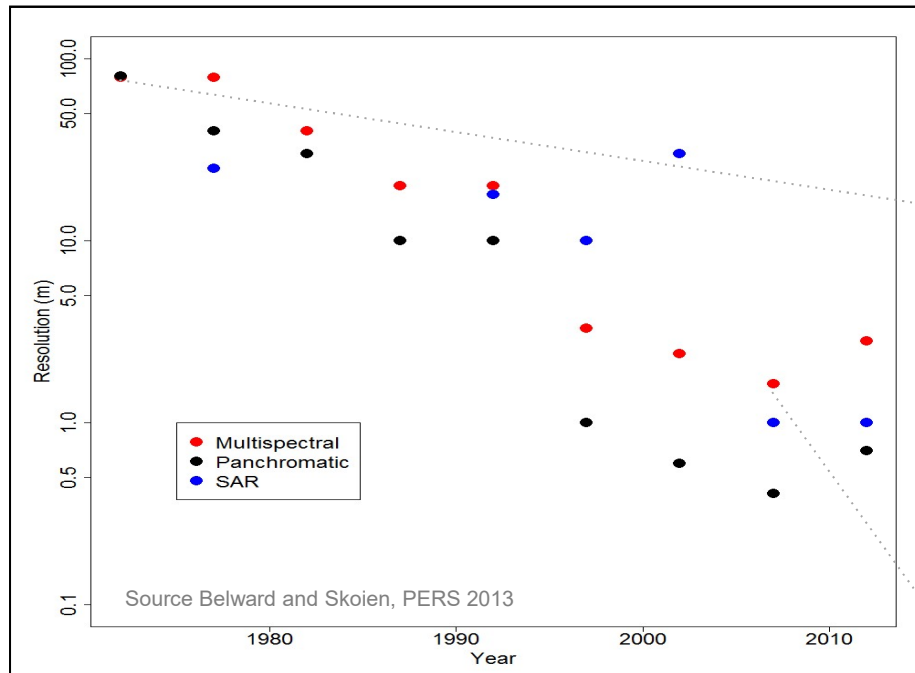
‘Life expectancy’

The percentage of all near-polar orbiting, land imaging, civilian satellites failing in less than three years of operation per decade (1970 to 2010), nb at-launch failures are excluded

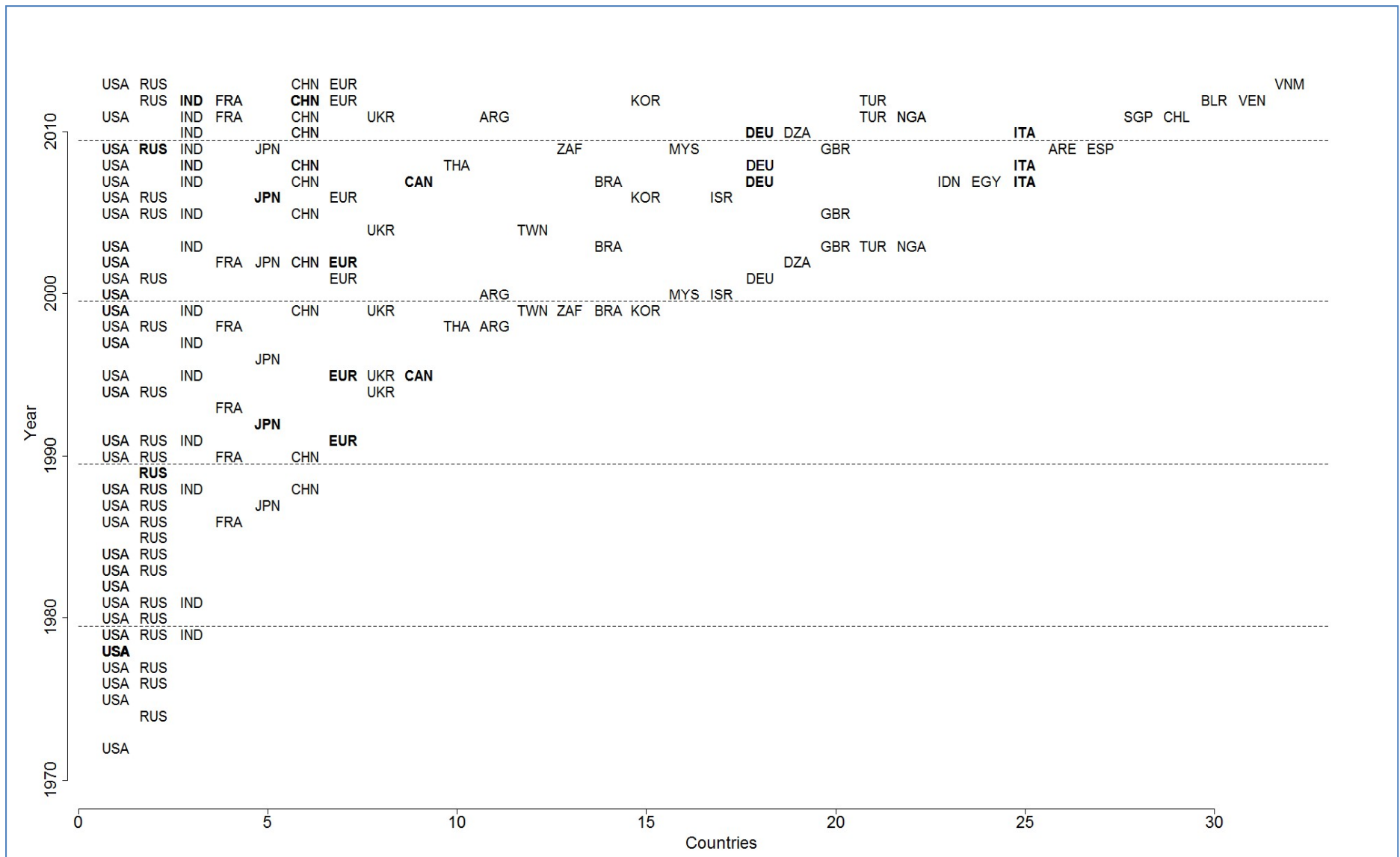


‘Death rate’

Changing spatial resolution

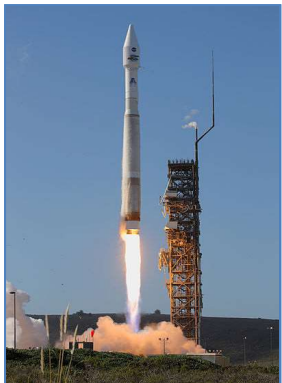


Years in which sovereign states launched one or more near-polar orbiting, land imaging civilian satellites (Bold denotes launch of at least one SAR sensor)



International context

- 220 satellites with some global land imaging capability successfully launched by (or for) 32 countries/geopolitical groups
- Missions failing within three years of launch dropped from 60% to 20%
- Mission operational life increased from 3.3 years to 8.6 years (and increasing)
- Average number of satellites launched yr/decade has increased from 2 to 9
- 90+ operating at the end of the first semester of 2016
- Spatial resolution increased from 80 m to 2 m multispectral and 0.30 m pan

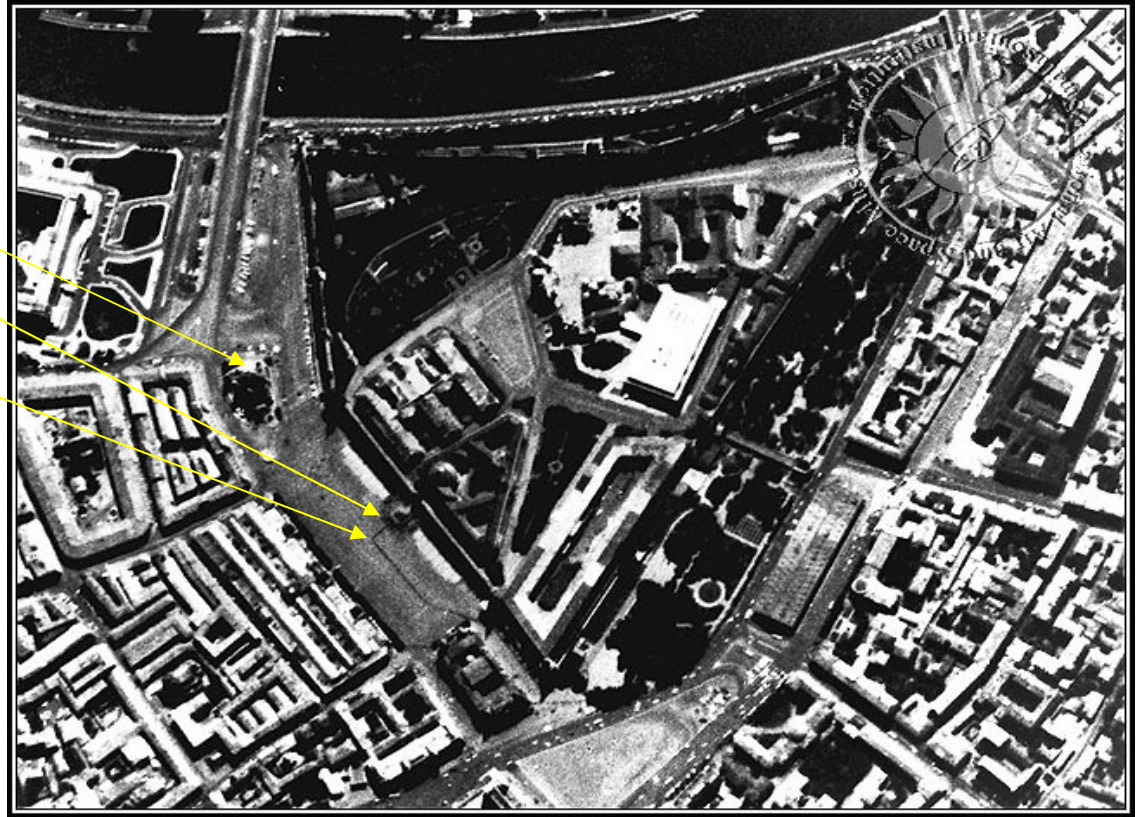


60 years of environmental satellite remote sensing; 1960s – high resolution is ‘military only’

Kremlin May 28th 1970

<http://www.digitalvaults.org/tags/m/moscow.html>

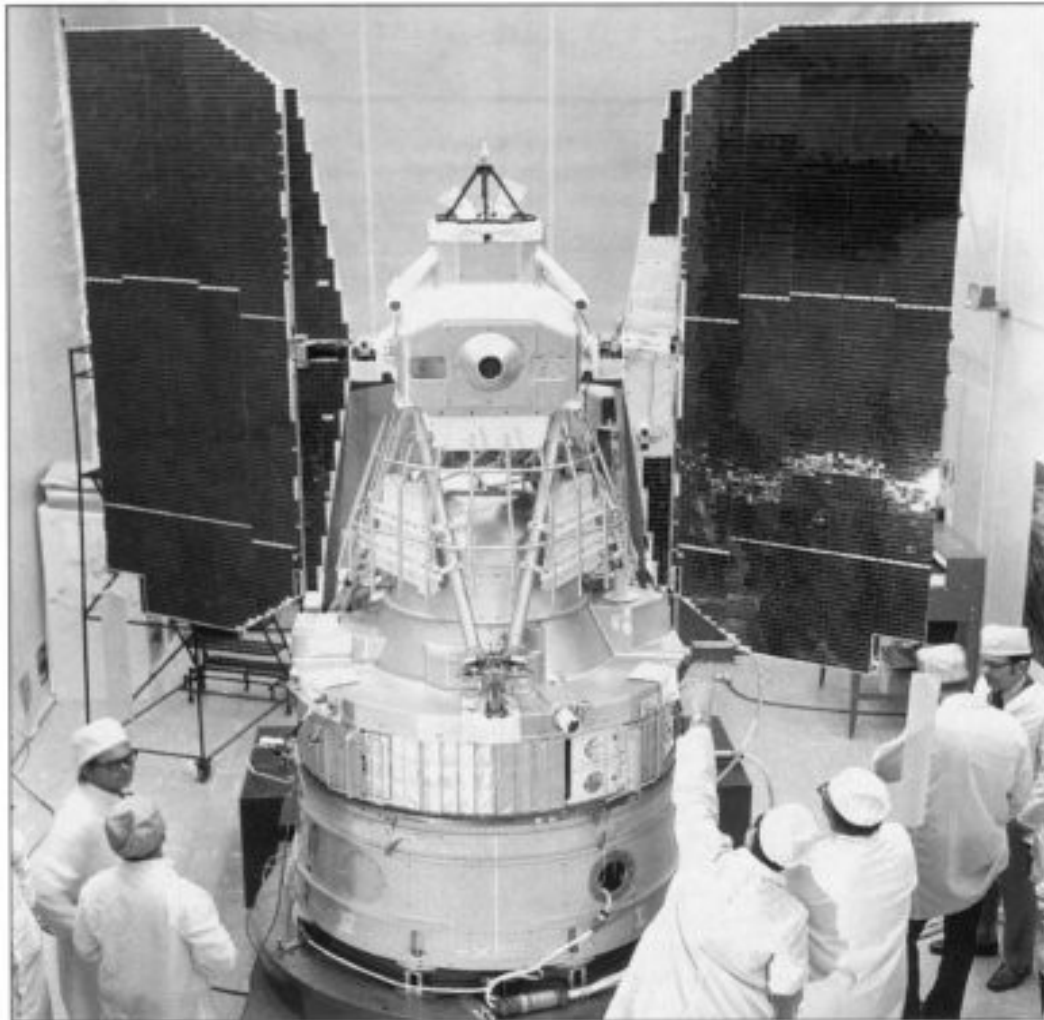
http://www.soviethistory.org/images/Large/1936/rdsq_09b.jpg



Declassified imagery from the 1960s and 70s is available from the USGS
https://lta.cr.usgs.gov/declass_1

60 years of environmental satellite remote sensing; 1970s

- Landsat is pretty much the only source of data, especially over land – SeaSat and Nimbus CZCS provide some imagery over oceans



NASA photo no. 72-H-873

<http://history.nasa.gov/>

60 years of environmental satellite remote sensing; 1980s

- 23rd June 1981 the 5-channel AVHRR record begins via NOAA-7
- 16th July 1982 Landsat 4 launched – first 30m resolution civilian imagery available
- 1st march 1984 Landsat 5 launched...and was still going till January 2013
- 22nd February 1986 SPOT-1 launched – first 10m resolution imagery, first stereoscopic imagery – in service till 31st December 1990

NOAA-7 launch



60 years of environmental satellite remote sensing; 1990s

- SPOT and Landsat keep up the good work; daily, monitoring of the planet's land and ocean surface is significantly enhanced by new additions such as SeaWiFS, MODIS and VGT on board SPOT 4. Right at the end of the decade 1 m resolution becomes a reality



60 years of environmental satellite remote sensing; 2000s

<http://www.digitalglobe.com/>

- Launch rate increases rapidly, small-sats come to dominate, SAR systems and sub metre panchromatic imagers proliferate, new nations join the “space-faring” fraternity on a regular basis



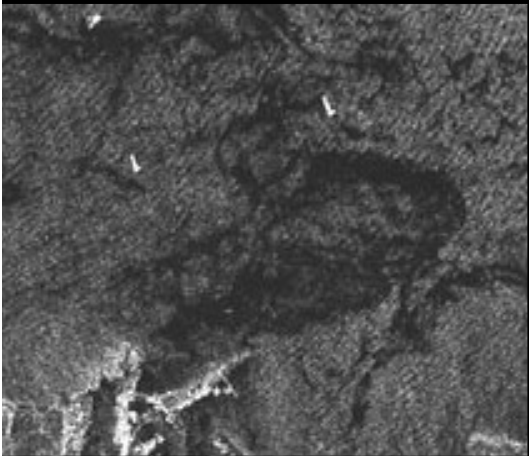
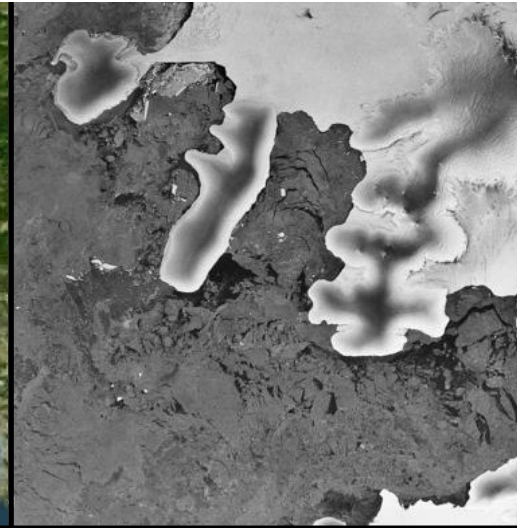
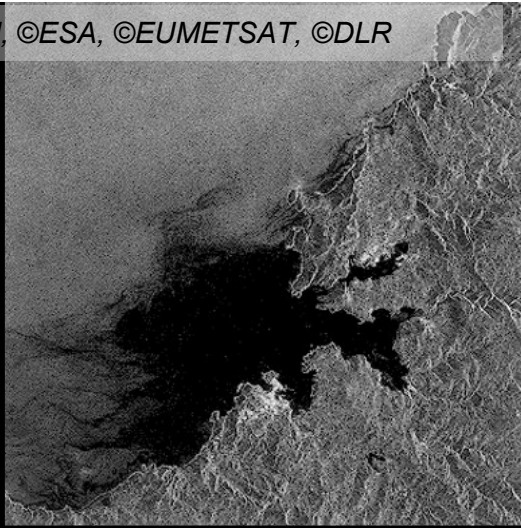
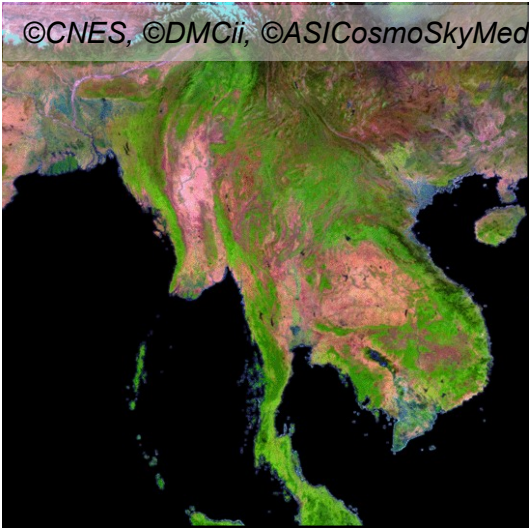
Image Collected February 18, 2009
60 centimeter QuickBird satellite image Musudan
Ri missile launch facility, N. Korea

60 years of environmental satellite remote sensing; 2010s

- Full free and open access to archives is possible for data above 10m resolution
- microsatellites and cubesats change the rules in terms of numbers
- new constellations appear; Planet Labs have 87 doves in orbit, Terra Bella plan on a multiple satellite constellation



©CNES, ©DMCii, ©ASIScosmoSkyMed, ©ESA, ©EUMETSAT, ©DLR

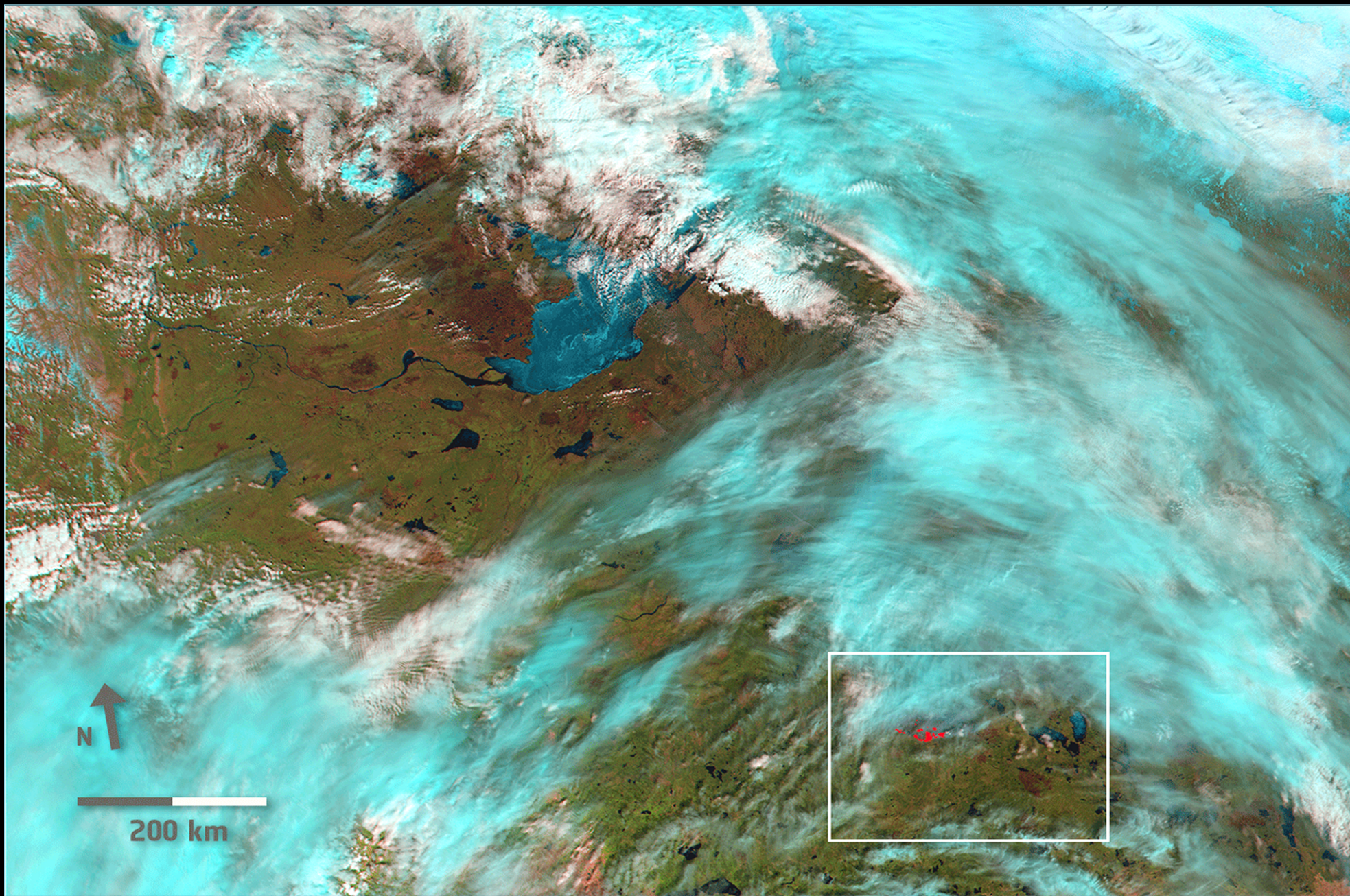


Low to moderate spatial resolution 250m – 1km

- These provide the all-important seasonal dimension; primary productivity, climate impacts, phenology, fire...
- AVHRR provides a daily view going back to 1981 (at a spatially sampled 8 km resolution), but with limited spectral information and with system limitations in terms of geometry and radiometry)
- VGT provides better radiometry and better geometry, back to 1998
- MODIS provides a suite of land products back to 2001
- MERIS provides advanced radiometric performance at 300 m resolution
- Sentinel 3 provides continuity from 2016 onwards
- ...there are others...SeaWiFS provides a suite of land and ocean information with exceptional calibration. MISR and POLDER sample the angular domain as well as spectral, GLI provides 36 individual spectral bands
- Processed Data are available free of charge

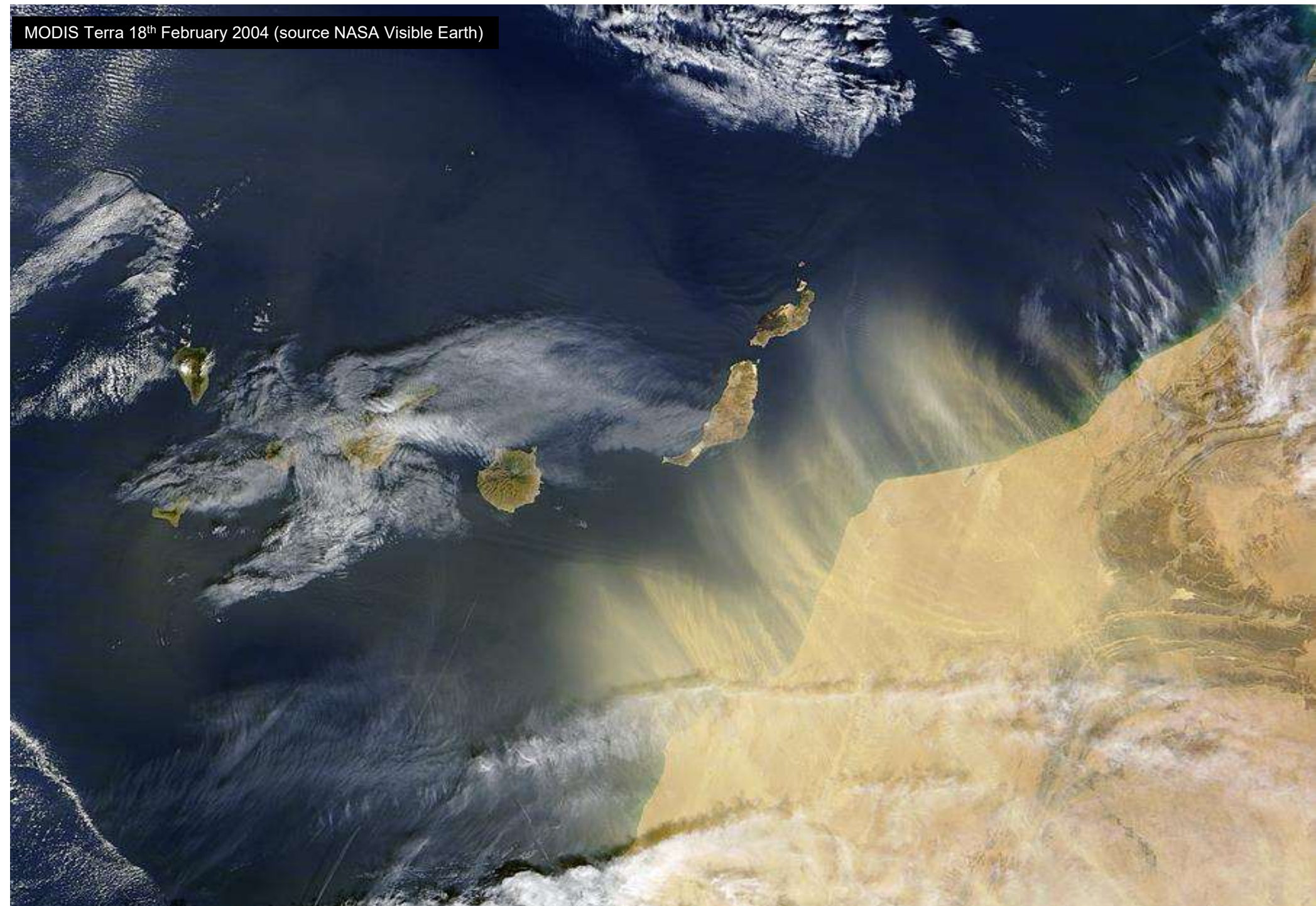


26 August 2007, 08:03 UTC AVHRR METOP: Source Eumetsat



Fort McMurray, Canada, 7th May 2016 Copernicus Sentinel data – ESA website

MODIS Terra 18th February 2004 (source NASA Visible Earth)





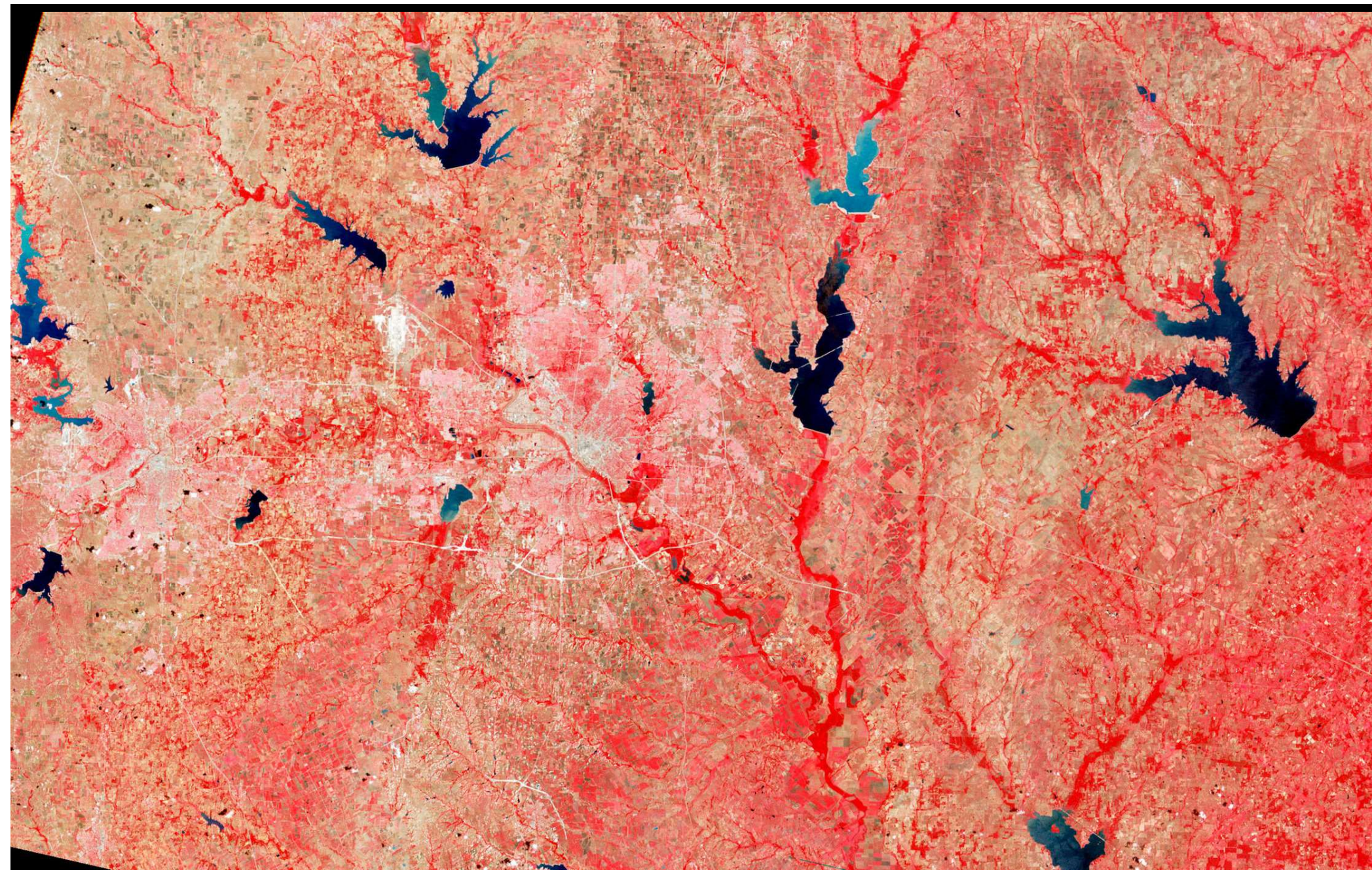
Sentinel 3, May 2016, Copernicus
Sentinel data JRC

Moderate to high spatial resolution 10 – 100m

- These are the work-horse for much environmental work. They measure changes at “anthropogenic” scales, over many decades and can be used to compute biophysical variables
- Landsat is the benchmark...data are well calibrated, spectrally rich, spatially detailed and go back to 1972. And the entire archive is available on demand and free of charge
- SPOT moved the goals in three critical senses in 1986, they provided 10 m data, provided stereoscopic image pairs, and through pointable systems reduced the revisit time, at least for some locations
- Sentinel 2a joined the full free and open data providers in 2015
- Other systems you need to consider are India's AWiFS, China / Brazil's CBERS and the DMC's various satellites. Data availability is not so comprehensive nor are the data usually free of charge

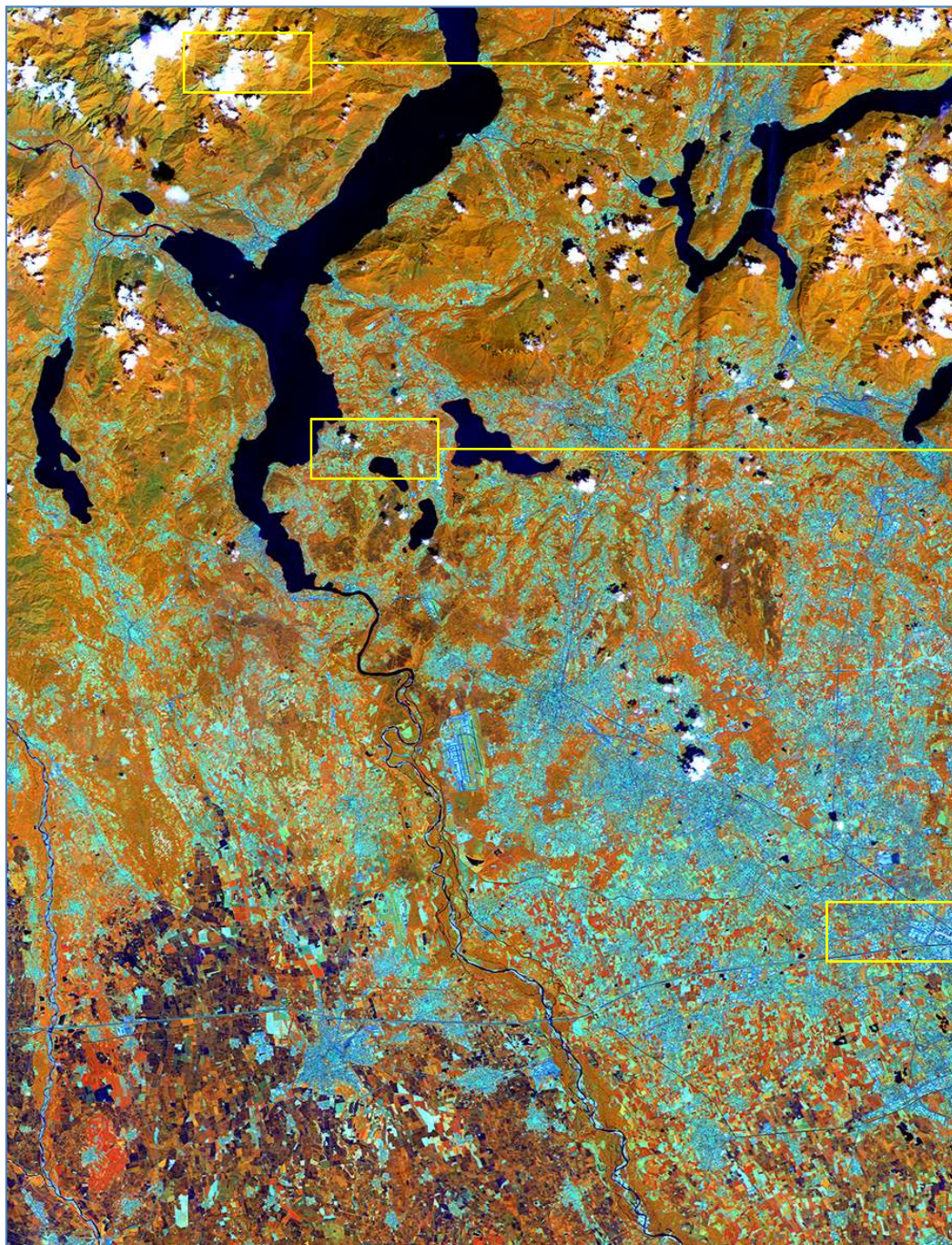
<http://eros.usgs.gov/imagegallery/>

Earth as Art

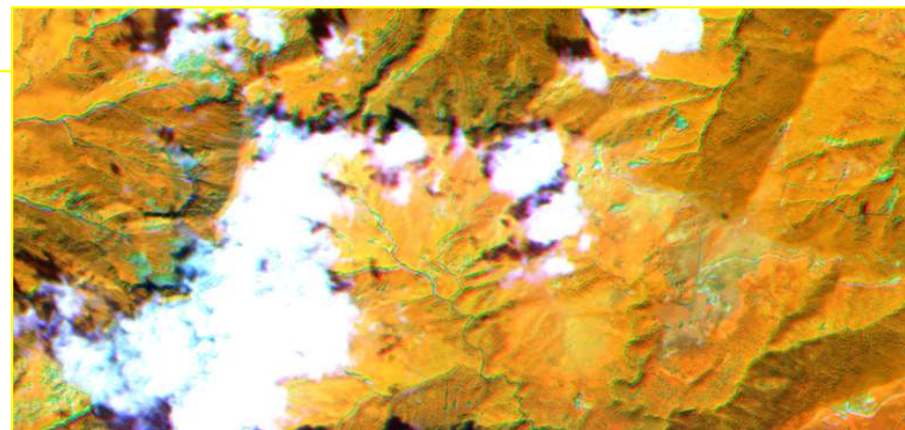


July 25, 1972 – the first Landsat Scene - Dallas

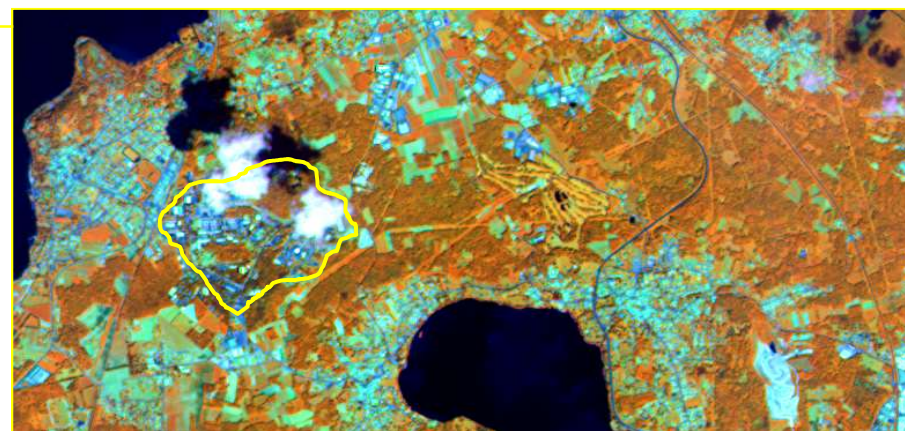




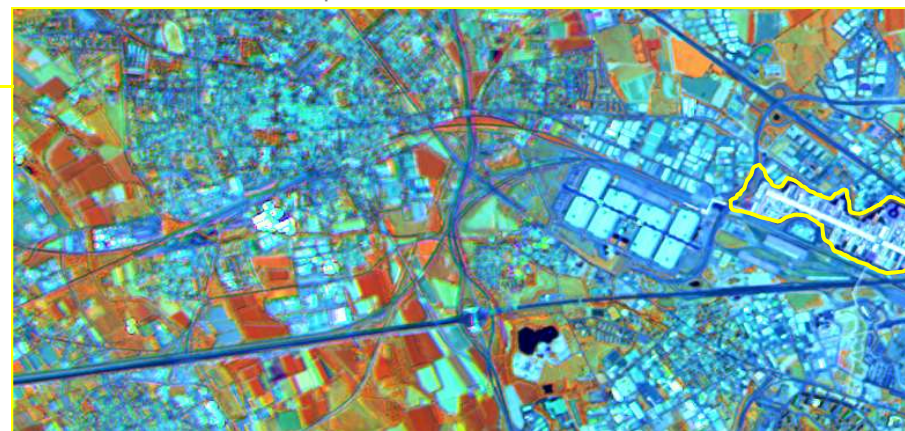
Sentinel 2a Lake Maggiore, 27th June 2015



Val Grande National Park



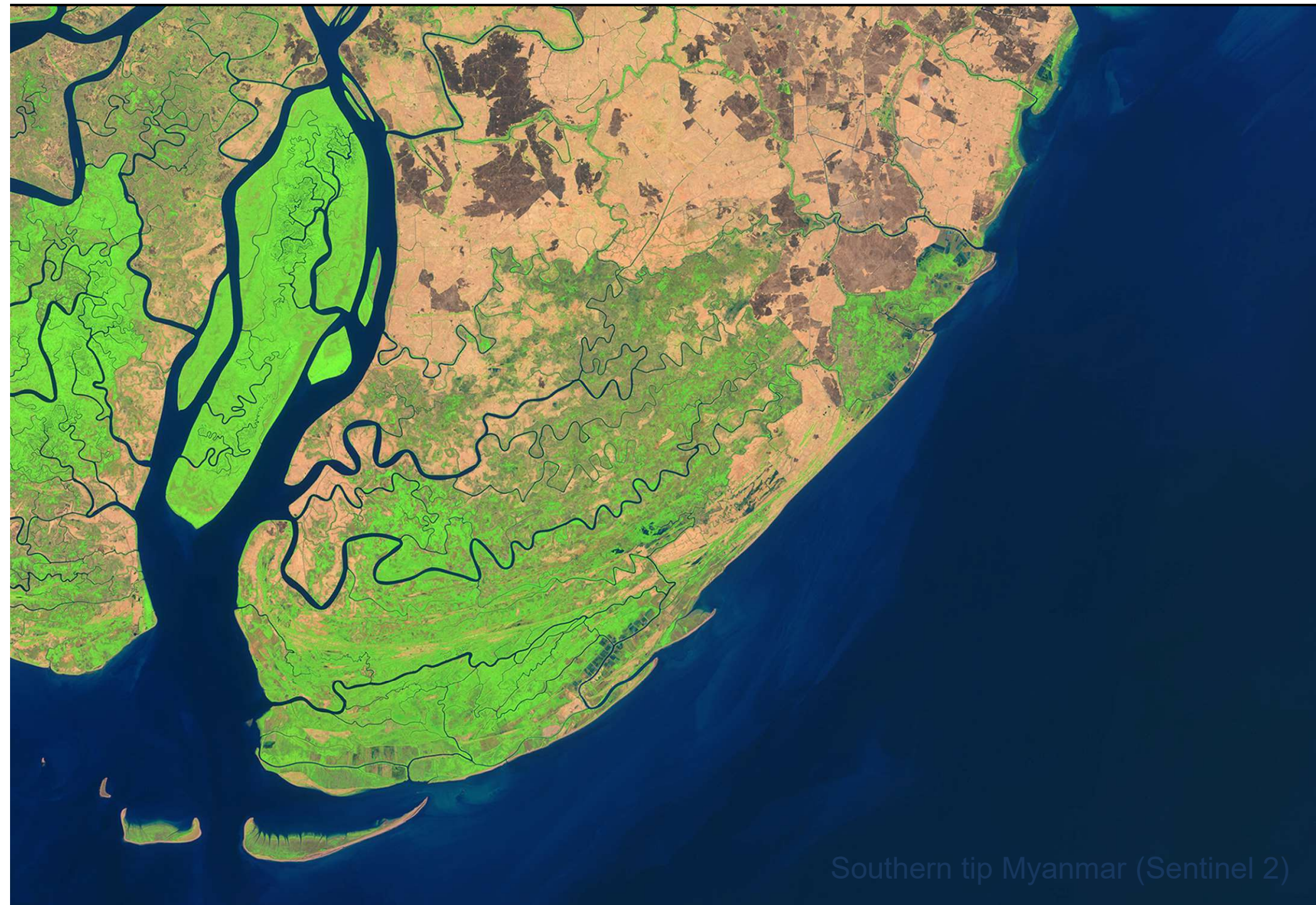
Joint Research Centre, Ispra



EXPO 2015



Sentinel 2, 12th July 2015, Copernicus Sentinel data [2015]
(11, 8, 4 composite 20m resolution)



High to very high spatial resolution 50cm – 10m

- These provide photo-realistic views of the Earth's surface. Very precise measurements can be made, usually at the expense of spectral richness, always at the expense of geographical area... new rules apply to interpretation and analysis. Do you really need to record the presence of cows in your scene, or measure the size of cars?
- The IKONOS and Quickbird archives are longest (going back to 1999), RapidEye first changed the rules by putting up five satellites at once...so 6.5 m MSS data are theoretically available to you every day, the Flock – 1 28 satellite constellation set a new pattern this year – daily 3 meter data, and GeoEye should be on your list if you want to observe things as small as the car's windscreen, rather than the car...
- In 1995 the US made their archive of 60s to 70s military data available
- None of these data are available free of charge (except the old declassified military data from US, and occasional samples), they are commercial ventures.

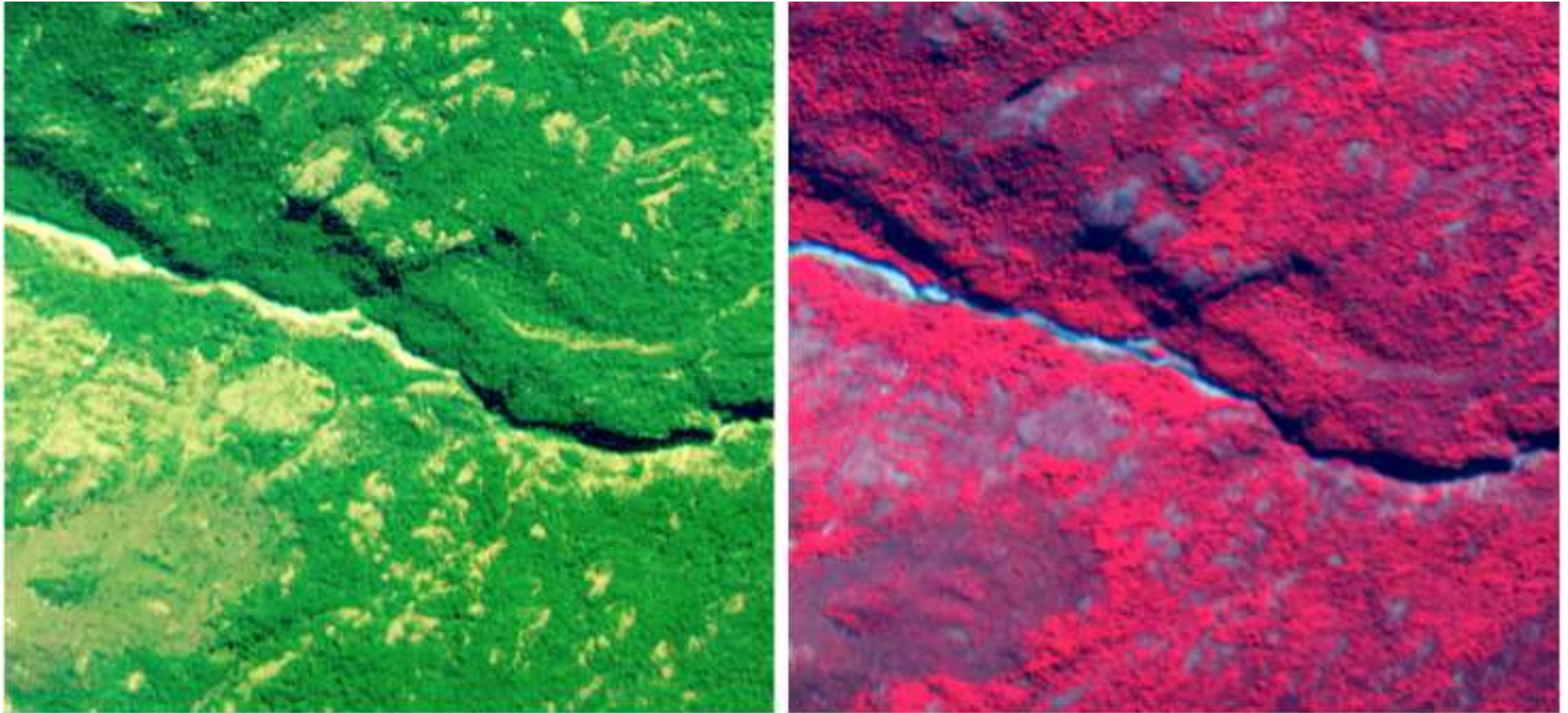
FORMOSAT-2 - 2 m - Kao Hsiung - Taiwan - July 2004

© NSPO 2004 - Distribution Spot Image - All rights reserved

SPOT
IMAGE

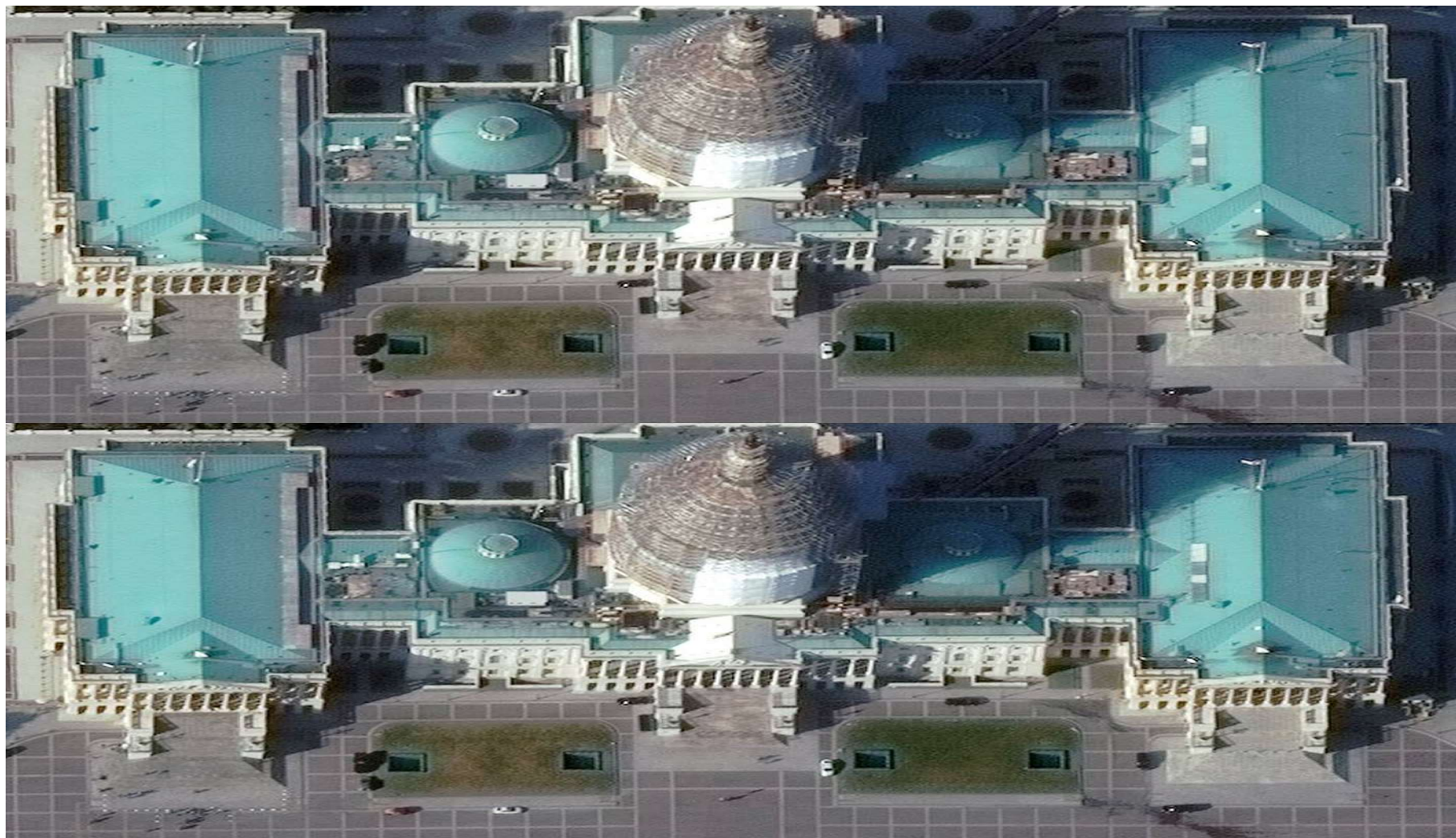


Rapideye, now part of Planet Labs – 5 satellites in constellation



El Bolsón in Argentina , 21st October 2008 Copyright RapidEye

Launched 13th August 2014 offers 31 cm imagery from a 617 km orbit

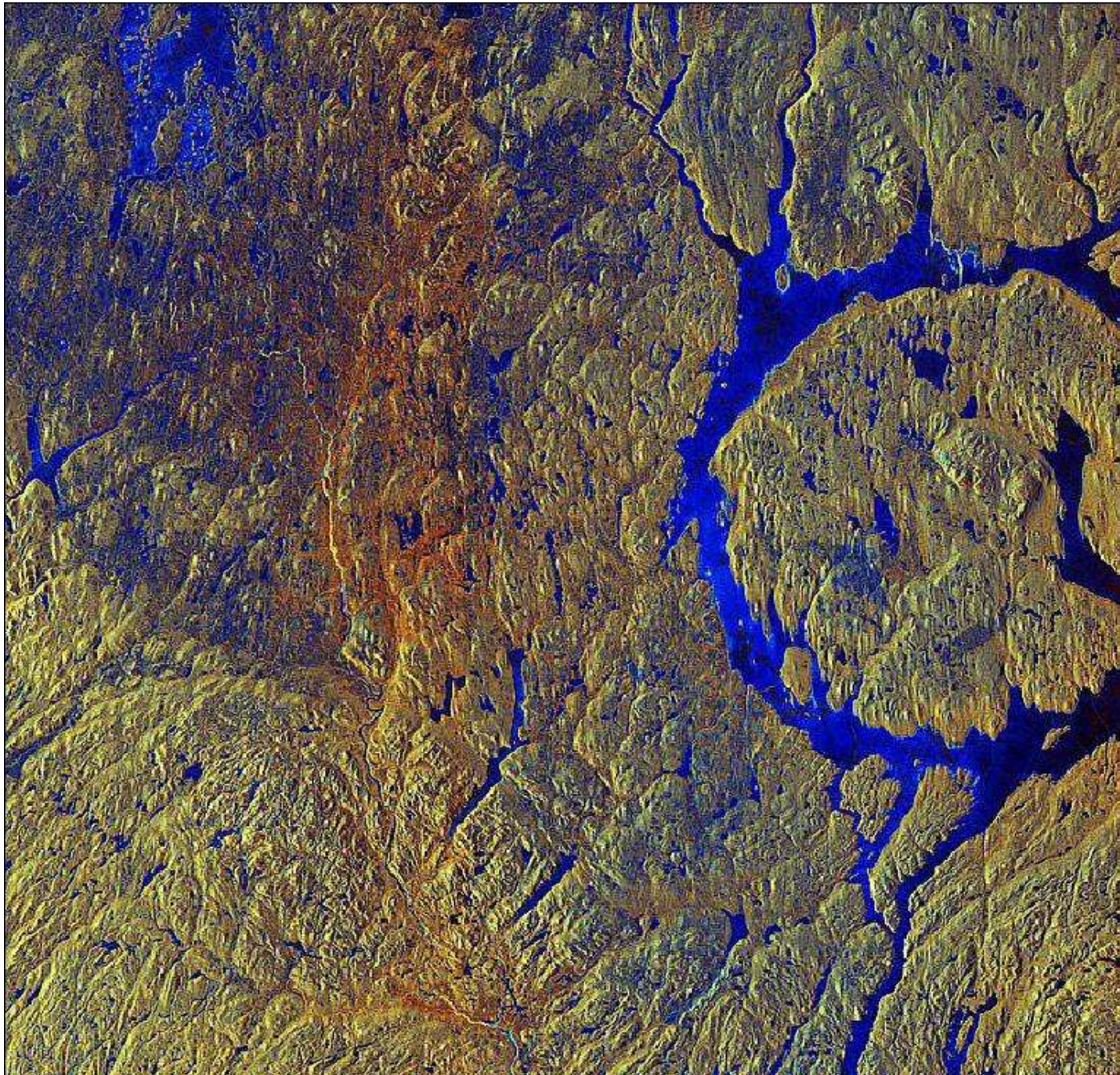


WorldView-3 Satellite Image U.S. Capitol Washington DC

<http://www.satimagingcorp.com/gallery/worldview-3/worldview-3-satellite-image-us-capitol-washington-dc/>

Synthetic Aperture Radar

- A completely different set of rules govern the processing, the interpretation and the analysis... but you are pretty much guaranteed an image day / night / rain / cloud...
- Different systems use different frequencies, different polarisations and different resolutions
- Seasat was first – but didn't last long and the data are not easily found. ERS-1 and 2 provide a view on the 1990s (as does JERS-1) and the data can be found. Radarsat is a commercial venture so if you like it and want it, then buy it. ALOS-2 is adopting a MODIS like attitude to “free access to processed data”. And the new players (CosmoSkyMed and TerraSAR-X) provide very high spatial resolution if you buy.
- Sentinel-1A and 1B, launched 3rd April 2014, 25th April 2016 provide full free and open access to their data



**false-color
SAR image**

**Manicouagan
Crater**

Sentinel-1A

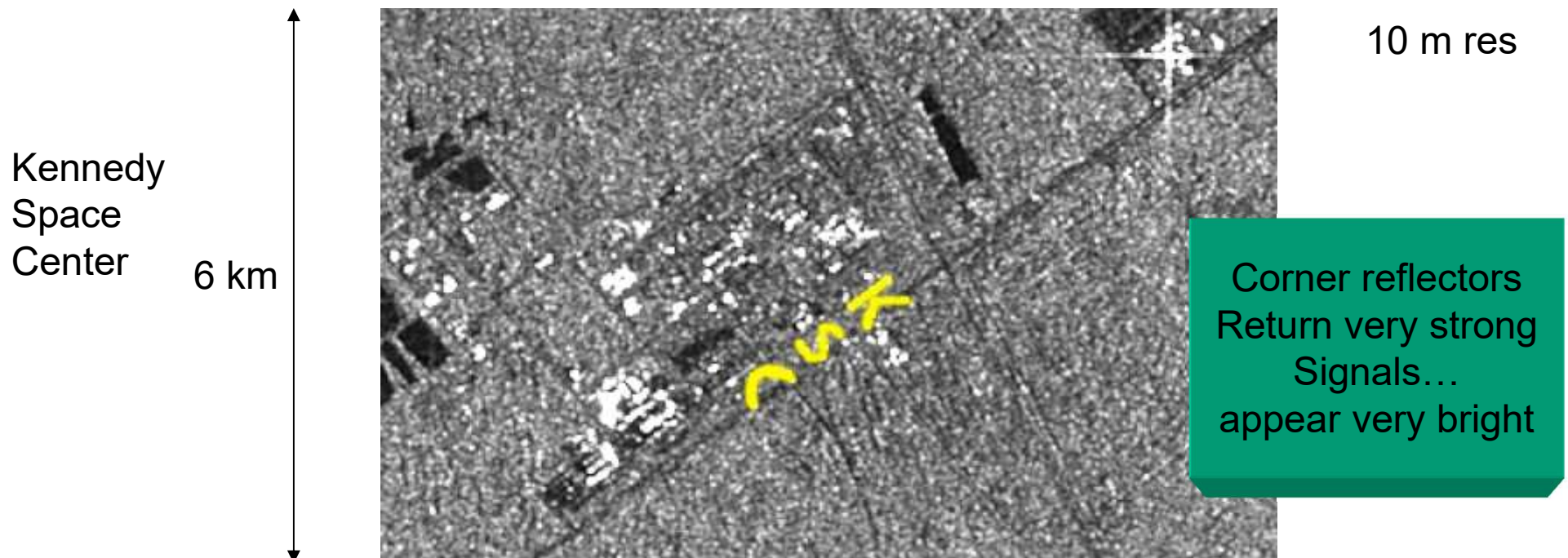
**21 March,
2015**

**(image credit:
Copernicus
Sentinel data
(2015)/ESA)**

Shuttle Imaging Radar

- Joint US German Italian mission...the instrument was flown on space shuttle Endeavour April 9th to 20th, 1994. The second, also on Endeavour September 30th to October 11th, 1994
 - <http://southport.jpl.nasa.gov/>

L-band (23.5cm), C-band (5.8cm) and X-band (3cm)



TerraSAR-X

- 15th June 2007 variable resolution 1 - 16m X-band SAR
 - http://www.dlr.de/tsx/start_en.htm

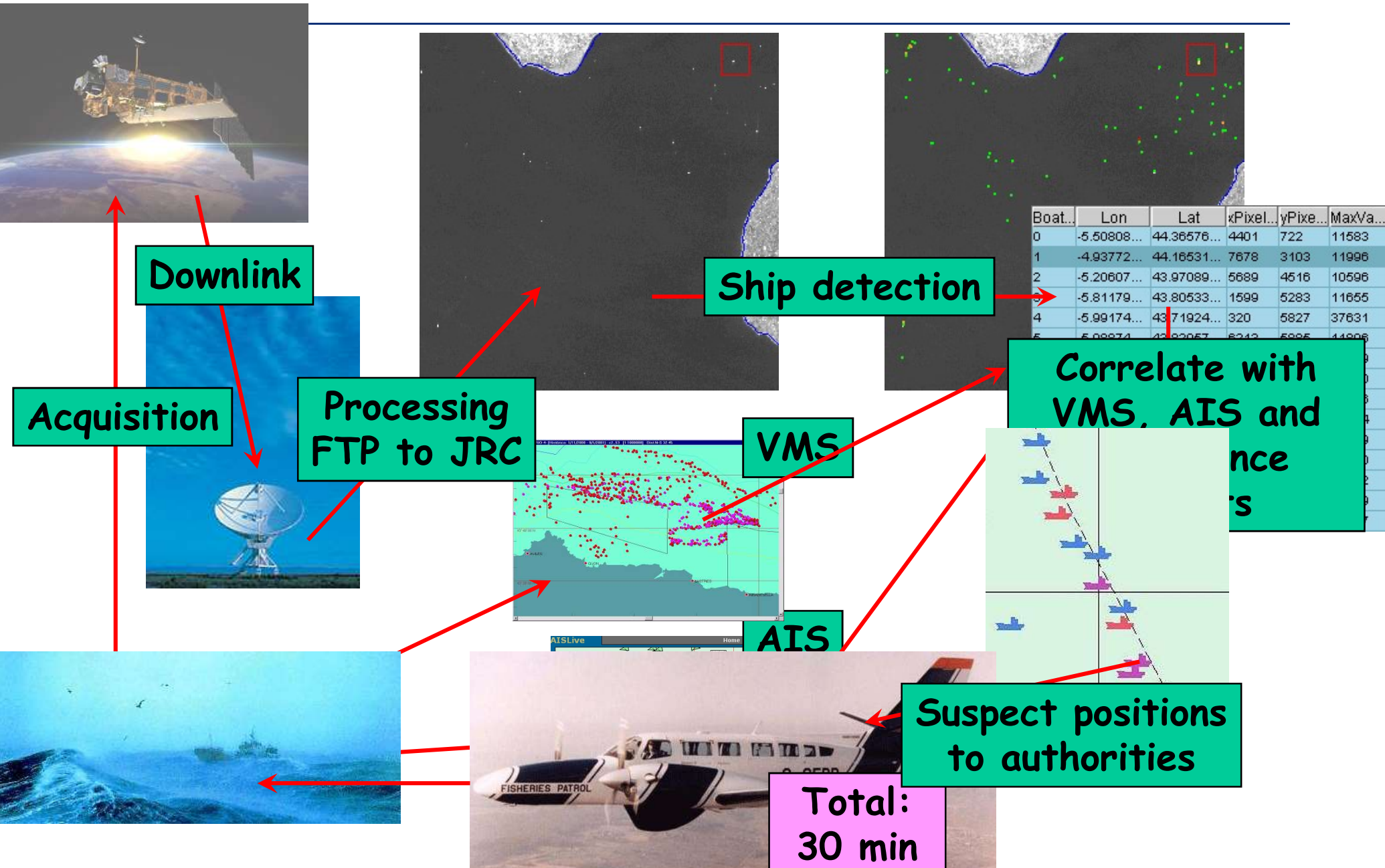
Note shadow
and orientation

Tin roof?

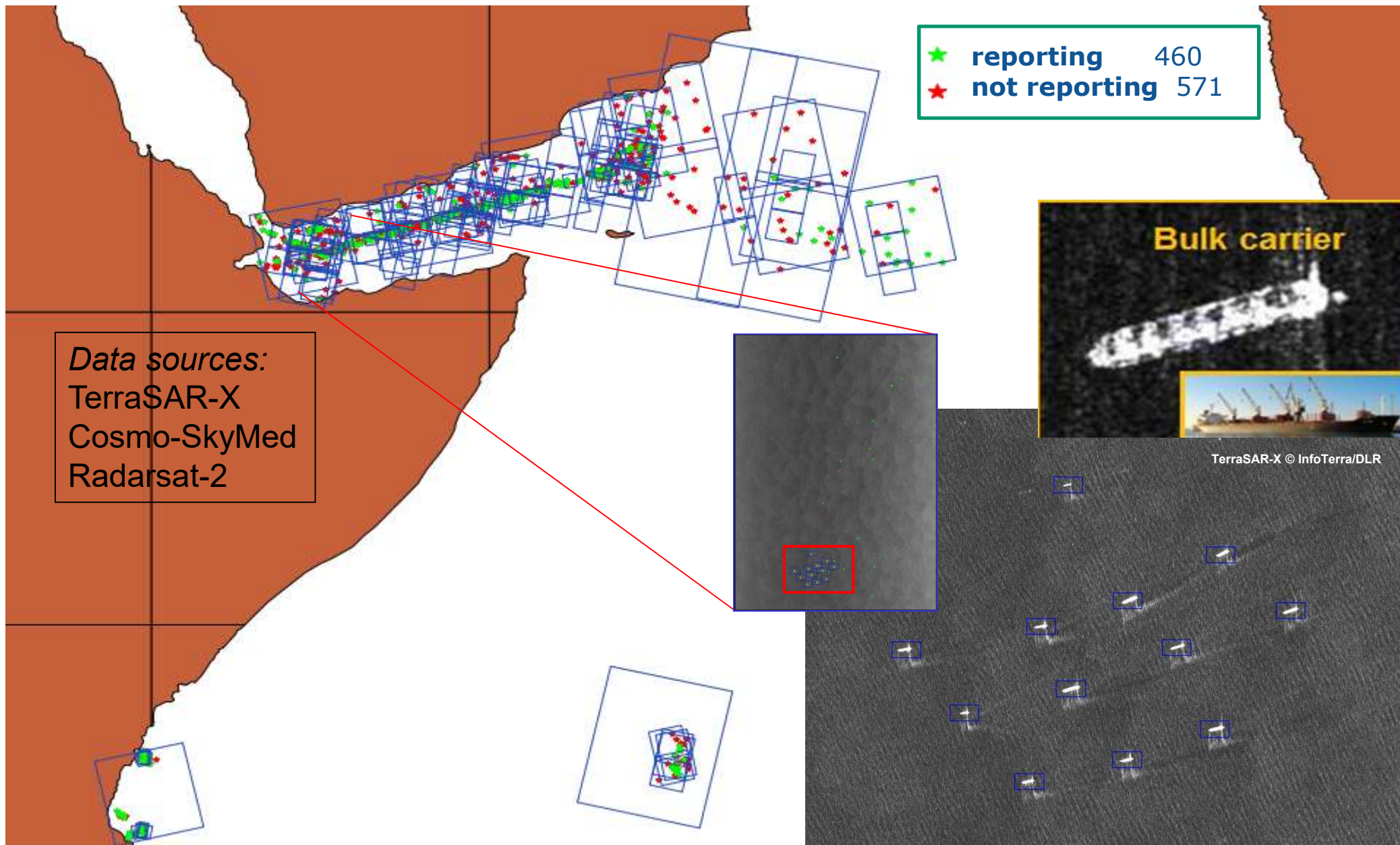
2nd July 2007, 03:47 UTC, 1 Meter
Polarisation: HH.Credit DLR TerraSAR

Vessel Monitoring System (VMS), Automatic Identification System (AIS)... and Vessel Detection System (VDS)

Harm Greidanus JRC



Sampling non-reporting ship traffic 10 day period



A risky business

- Even if everything else works (recorders line of site) images still get lost because of work on the satellite (charging batteries, manoeuvres, outgassing filters)
- Failure in the ground segment
- Operator error...and total system failure
 - 28 February 1959 1st CORONA test launch...18 months and twelve launches later...success on 12 August 1960
 - GOES 6 struck by lightning
 - NOAA B Boosters fail
 - SeaSat fuses after 109 days
 - Landsat 6 crashes into sea
 - Cryosat destroyed 5 minutes after launch
 - Early Bird falls silent after four days
 - IKONOS 1 launch fails
 - Quick-Bird 1 fails
 - Orbview4 failed to orbit
 - ALOS-1 communications fail
 - NASA's CO₂ sounder fails to launch
 - NASA's radiation budget mission fails
 - CBERS 3 crashes on launch

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NASA

Remote sensing satellite lost in Chinese rocket failure

BY STEPHEN CLARK
SPACEFLIGHT NOW
Posted: December 9, 2013

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A \$250 million Earth observation satellite developed by China and Brazil was lost in launch mishap on a Long March 4B rocket early Monday, officials said.



Summary

- <http://nssdc.gsfc.nasa.gov/nmc/SpacecraftQuery.jsp>
 - returns 7456 spacecraft
- Low to moderate spatial resolution optical
 - 1 km to 250 m, but image the entire earth surface at least once per day
- Moderate to high spatial resolution optical
 - 80 m to 10 m, but take many days to image the entire planet's surface
- High to very high spatial resolution optical
 - 6.5 m to 41 cm, but only of discrete regions of the surface
- Synthetic Aperture Radar “active microwave”
 - 1 km to 1 m spatial resolution, revisit capability dependent on selected resolution, almost guaranteed imagery...

Match the data to the
application