Using satellite imagery analysis in academic research

William Goodhind, 16 May 2024
https://contestedground.info/

Introduction

This handout provides references and further reading for a workshop delivered to the Russian and Eurasian Security (RES) Working Group of the British International Studies Association (BISA).[1]

William Goodhind is a researcher and investigator with Contested Ground – an open-access research project that documents and analyses events in military, humanitarian and international affairs using publicly available satellite imagery.

The following notes are organised slide-by-slide, providing links to case studies and additional resources. During the practical portion of the workshop, you are encouraged to click on the links and explore the satellite imagery resources being presented.

Moreover, if you have Google Earth Pro installed on your system, grid locations of areas of interest have been included in the below text – these can be copy/pasted into the search bar to navigate to the location. Use the Historical Imagery tool to look at the relevant time period (more on this in the practical section).

Google Earth Pro can be downloaded via this link on the Google website: https://www.google.co.uk/earth/about/versions/#earth-pro

A web-based version of Google Earth is also available but does not have the Historical Imagery tool. https://earth.google.com/

Briefing: What can satellite imagery offer academia?

Slides 1-3 - Nil

Slide 4

---

[1] https://www.bisa.ac.uk/members/working-groups/resg/events/using-satellite-imagery-analysis-academic-research

The OSCE Special Monitoring Mission to Ukraine (OSCE SMM)
https://www.osce.org/special-monitoring-mission-to-ukraine-closed

The image shown is an OSCE SMM patrol on a hillside in Avdiivka in 2021
(48.144180°, 37.767835°).

Slide 5

From left to right, the Contested Ground reports shown are:

- **Report 7:** Russian Military Convoys, occupied-Kupiansk, May 2022.
  https://contestedground.info/reports/f/report-7-russian-military-convoys-occupied-kupiansk-may-2022
- **Report 15:** Heavy Weapons Storage Site, Luhansk Oblast, 26 Aug 21
  https://contestedground.info/reports/f/report-15-heavy-weapons-storage-site-luhansk-oblast-26-aug-21
- **Report 31:** Russian Air Defence, Belgorod, 25 Apr 22
  https://contestedground.info/reports/f/report-31-russian-air-defence-belgorod-25-apr-22
- **Report 33:** 'DPR' Towed Artillery Firing Point, Donetsk, 21 May 15
  https://contestedground.info/reports/f/report-33-dpr-towed-artillery-firing-point-donetsk-21-may-15
- **Report 45:** Novorossiysk Naval Base, Krasnodar Krai, 5 Aug 22
  https://contestedground.info/reports/f/report-45-novorossiysk-naval-base-krasnodar-krai-5-aug-22
- **Report 36:** Russian Missile Strikes against Lviv, 10-11 Oct 22
  https://contestedground.info/reports/f/report-36-russian-missile-strikes-against-lviv-10-11-oct-22

Further commentary on these reports and others is available on Patreon.

Slide 6

Main Battle Tank (T-64) in Kyiv, Ukraine (50.427194°, 30.564177°).

Slide 7 - Nil

Slide 8

Top left – Blown up tank on the outskirts of Debaltseve. Most likely destroyed during the Battle of Debaltseve, 14 January – 20 February 2014.

For an analysis of the Battle of Debaltseve, see:

Noorman, R. (2020). 'The Battle of Debaltseve: A hybrid army in classic battle of encirclement', *Small Wars Journal*, available at: https://smallwarsjournal.com/jrnl/art/battle-debaltseve-hybrid-army-classic-battle-encirclement

Top right – A BMP-2 infantry fighting vehicle, near Alchevsk, Luhansk Oblast, Ukraine (in the 'Luhansk People's Republic').

Bottom left – OSCE SMM patrol team in Luhansk Oblast, Ukraine. Hovering in the air is a mini-UAV.

For an overview and analysis of the use of technology within the OSCE SMM, see:

Giardullo, C. et al (2020). 'Technological innovation in the OSCE: The Special Monitoring Mission in Ukraine', *OSCE Yearbook 2019*, available at: https://ifsh.de/file/publication/OSCE_Yearbook_en/2019/DornGiardulloStodilka.pdf

Centre bottom – OSCE SMM Monitoring Officers measure the markings left behind by an armoured vehicle, Debaltseve, Luhansk Oblast, Ukraine.

Bottom right – A civilian vehicle badly damaged by shrapnel, Donetsk city, Donetsk Oblast, Ukraine.

Slides 9-10

This incident occurred on 16 March 2016. The OSCE SMM released the following in its public report:

"At 12:38hrs, at an "LPR" fortified position in the vicinity of "LPR"-controlled Kalynove-Borschuvate (61km west of Luhansk), the SMM observed a burnt and destroyed truck which was still smouldering. It also noted that the truck had two hit marks consistent with anti-tank missiles. The "LPR" "commander" present told the SMM the truck had been hit by two anti-tank missiles at 12:05hrs, seriously injuring the sole occupant, a female medic, and lightly injuring other "LPR" armed personnel. At 13:27hrs, having left the "LPR" position and approximately 1.65km east of it, the SMM heard five explosions and what it assessed as small-arms fire at the same distance to the west. Upon returning to the "LPR" position, the SMM observed a burning civilian van adjacent to the previously destroyed truck. It noted that the vehicle, which had previously escorted the SMM to the "LPR" fortified position, had been destroyed by what appeared to be a round impact on the top. It also observed its roof on the ground more than 5m away from it, and burnt metal pieces and debris from the van nearby."

See: 'Latest from OSCE Special Monitoring Mission (SMM) to Ukraine, based on information received as of 19:30hrs, 16 March 2016', *OSCE SMM*, 17 March 2016, available at: https://www.osce.org/ukraine-smm/228741

Follow up reporting on the military casualty can be found in this report: 'Latest from OSCE Special Monitoring Mission (SMM) to Ukraine, based on information received as of 19:30hrs, 17 March 2016', *OSCE SMM*, 18 March 2016, available at: https://www.osce.org/ukraine-smm/229056

Slide 11

This satellite image, dated 5 August 2016, has been taken from Google Earth / Maxar Technologies. The image is centred on 48.612314°, 38.440784°, at an altitude of 10733m.

Slide 12

Top left – Mortar team observed east of Avdiivka, 31 March 2017.
Top right – Main battle tanks 4 km from contact line, 3 April 2017.

See: 'SMM OSCE: Almost 200 pieces of Minsk proscribed weapons recorded', *Ukraine Crisis Media Center*, 7 April 2017, available at: https://uacrisis.org/en/54908-smm-obsye-3

Bottom left – 15 armoured utility vehicles (UAZ-23632-148 *Esaul*), 14 April 2021.

See: 'OSCE spots 15 newest Russian UAZ Esaul armored vehicles in Donbas (Drone photo)', *Inform Napalm*, 5 March 2021, available at: https://informnapalm.org/en/osce-spots-15-newest-russian-uaz-esaul-armored-vehicles-in-donbas-drone-photo/

Bottom centre – Surface-to-air missiles and rounds fired in direction of SMM long-range UAV flying over non-government-controlled Betmanove, 15 June 2018.

See: 'OSCE SMM UAV targeted near Betmanove / У напрямку БПЛА СММ стріляли', *OSCE SMM* YouTube channel, 15 June 2018, available at: https://www.youtube.com/watch?v=sirVhEQ9b8c

Bottom right – 5 x Gvozdika 122 mm self-propelled artillery, 10 x Main Battle Tank 125 mm gun, 3 x MT-12 Rapira 100 mm anti-tank guns, and other equipment, 17.7 km from the contact line, Novoselivka, Donetsk Oblast, Ukraine.

See: 'OSCE SMM Observes Banned Weapons…Again', *Digital Forensic Research Lab*, 24 October 2017, available at: https://medium.com/dfrlab/osce-smm-observes-banned-weapons-again-19c33f2d5900

Slide 13

'Luhansk People's Republic' heavy weapons storage site, 13 August 2017. Image taken from Google Earth / Maxar Technologies. The image is centred on 48.048845°, 38.961943°, at an altitude of 815 m.

Slide 14 – Illustrative and Presentational satellite imagery

Top – 'NATO releases satellite imagery showing Russian combat troops inside Ukraine', *NATO*, 28 August 2014, available at: https://www.nato.int/cps/en/natohq/news_112193.htm

Bottom – 'New satellite images show buildup of Russian military around Ukraine', *CNN*, 2 February 2022, available at: https://edition.cnn.com/2022/02/02/europe/russia-troops-ukraine-buildup-satellite-images-intl/index.html

Also see:
'Latest Satellite Photos Show New Russian Military Activity Near Ukraine', *Radio Free Europe Radio Liberty*, 21 February 2022, available at: https://www.rferl.org/a/russia-military-activity-ukraine-satellite-photos/31714126.html

'Guerre en Ukraine : de nouvelles images satellites du terrain', *Futura Sciences*, 1 June 2022, available at: https://www.futura-sciences.com/sciences/actualites/observation-terre-guerre-ukraine-nouvelles-images-satellites-terrain-96923/

Of course, there are many other examples, but these last two are particularly good compilations of imagery.

Slide 15 – Contemporary Investigations and Policy Analysis

Top left – 'Death at the Station: Russian cluster munition attack in Kramatorsk', *Human Rights Watch* and *SITU Research*, 21 February 2023, available at: https://www.hrw.org/video-photos/interactive/2023/02/21/death-at-the-station/russian-cluster-munition-attack-in-kramatorsk

Top right – 'Grain Trail: Tracking Russia's Ghost Ships with Satellite Imagery', *Bellingcat*, 11 May 2023, available at:

https://www.bellingcat.com/news/2023/05/11/grain-trail-tracking-russias-ghost-ships-with-satellite-imagery/

Bottom left – 'Devastation in Avdiivka: Mapping damage to civilian infrastructure since the full-scale invasion', *Centre for Information Resilience*, 18 December 2023, available at: https://www.info-res.org/post/devastation-in-avdiivka-mapping-damage-to-civilian-infrastructure-since-the-full-scale-invasion

Bottom right – 'Ice Curtain: S-400 Deployments and Enhanced Defense of Russia's Western Arctic (Rogachevo Air Base)', *Center for Strategic & International Studies*, 30 March 2020, available at: https://www.csis.org/analysis/ice-curtain-s-400-deployments-and-enhanced-defense-russias-western-arctic-rogachevo-air

See also:

'Kharkiv Damage Assessment Overview', United Nations Satellite Centre, 25 November 2022, available at: https://www.unosat.org/products/3455

'Donetsk Rapid Damage Assessment Overview Map', United Nations Satellite Centre, 15 September 2022, available at: https://www.unosat.org/products/3366

Slide 16 – Longitudinal and aggregated data analytics

Image taken from:

Lialko, V. et al (2023). 'Assessment of the Impact of Military Operations on Agriculture (On the Example of Winter Crops in Donetsk Region) Using Satellite Data', *International Conference of Young Professionals 'GeoTerrace-2023'*, available at: https://www.earthdoc.org/content/papers/10.3997/2214-4609.2023510117

Slide 17

Left image taken from:

Skakun, S. et al (2019). 'Satellite Data Reveal Cropland Losses in South-Eastern Ukraine Under Military Conflict', *Frontiers in Earth Science*, 7(305), available at: https://www.frontiersin.org/articles/10.3389/feart.2019.00305/full

Right image taken from:

Kochnev, A. (2018). 'Exploring the separatist-controlled areas of Ukraine from outer space', *The Vienna Institute for International Economic Studies Monthly Report*, pp.6-12, available at: https://wiiw.ac.at/monthly-report-no-5-2018-dlp-4527.pdf

Slide 18

Both images are taken from:

Shelestov, A. et al (2023). 'War damage detection based on satellite data', *Proceedings of the 11th International Conference on Applied Innovations in IT*, available at: https://opendata.uni-halle.de/bitstream/1981185920/103875/1/2_6%20ICAIIT_2023_paper_5059.pdf

Slide 19

All three images are taken from:

Duncan, E. et al (2023). 'Detection and mapping of artillery craters with very high spatial resolution satellite imagery and deep learning', *Science of Remote Sensing*, 7, available at: https://www.sciencedirect.com/science/article/pii/S2666017223000172

See also:

Kholoshyn, I. et al (2023). 'Assessment of military destruction in Ukraine and its consequences using remote sensing', *IOP Conference Series: Earth and Environmental Science*, available at: https://iopscience.iop.org/article/10.1088/1755-1315/1254/1/012132/pdf

Slide 20 - Nil

Slide 21

Contested Ground, Report 9: Russian Artillery Firing, NE Mariupol, 30 Apr 22. https://contestedground.info/reports/f/report-9-russian-artillery-firing-ne-mariupol-30-apr-22

Slide 22

From left to right, the Contested Ground reports shown are:

- **Report 41:** 'LPR' Ammunition Depot, Druzhne, Luhansk, Apr-Oct 15 https://contestedground.info/reports/f/report-41-lpr-ammunition-depot-druzhne-luhansk-apr-oct-15
- **Report 25:** 'LPR' Ammunition Depot, Khrustalnyi, 31 Oct 15 https://contestedground.info/reports/f/report-25-lpr-ammunition-depot-khrustalnyi-31-oct-15

- **Report 30:** Russian Supply Depot, Russia-Ukraine Border, 2015-17
  https://contestedground.info/reports/f/report-30-russian-supply-depot-russia-ukraine-border-2015-17
- **Report 12:** Russian Staging Area, Rostov Oblast, RF, July 2014
  https://contestedground.info/reports/f/report-12-russian-staging-area-rostov-oblast-rf-july-2014
- **Report 23:** 'DPR' River-Crossing Exercise, Oktyabrske, 16 Mar 16
  https://contestedground.info/reports/f/report-23-dpr-river-crossing-exercise-oktyabrske-16-mar-16
- **Report 40:** 'DPR' Storage Site, Manuilivka, 13 Jul 17
  https://contestedground.info/reports/f/report-40-dpr-storage-site-manuilivka-13-jul-17

Slides 23-24 – Nil

Practical: What data resources are available?

Slide 1 – Nil

Slide 2

From left to right:

Spatial analysis –

'Analyzing Crime Statistics in the Ottawa-Nepean Area', *University of British Columbia Blogs*, undated, available at: https://blogs.ubc.ca/giscoster/analyzing-crime-statistics-in-the-ottawa-nepean-area/

Definition sourced from: https://link.springer.com/referenceworkentry/10.1007/978-94-007-0753-5_2818

For a useful resource on spatial analysis, see: 'Introduction to Spatial Analysis', *OpenCourseWare*, January 2022, available at: https://ocw.mit.edu/courses/res-str-001-geographic-information-system-gis-tutorial-january-iap-2022/pages/gis-level-2/

Remote sensing –

Definition sourced from: https://www.sciencedirect.com/topics/social-sciences/remote-sensing

For a NASA explainer on remote sensing, with plenty of example images, see: https://appliedsciences.nasa.gov/sites/default/files/2024-03/IntroToRS_SXSW_1.pdf

Geospatial intelligence –

Definition sourced from: https://usnwc.libguides.com/c.php?g=494120&p=3381562

Image taken from: 'US army beefing up defense mechanism with Geospatial Information System', *Geospatial World*, 16 February 2018, available at: https://www.geospatialworld.net/news/us-army-beefing-defense-mechanism-geospatial-information-system/

<u>Slide 3</u>

Top image taken from:

Romaniuk, P. et al (2023). 'Exploring object size estimation through low-cost drone technology', pre-print article, available at: https://www.researchgate.net/publication/371703546_Exploring_Object_Size_Estimation_Through_Low-Cost_Drone_Technology

Bottom left image:

'Satellite Imagery: Resolution vs. Accuracy', *Intermap Blog*, 12 August 2019, available at: https://www.intermap.com/blog/satellite-imagery-resolution-vs.-accuracy

Bottom right image:

'The view from above', *Upstream Tech*, 3 March 2020, available at: https://www.upstream.tech/posts/2020-03-03-the-view-from-above

See also:

'Spatial Resolution In Remote Sensing: Which Is Enough?', *EOS Data Analytics*, 22 December 2022, available at: https://eos.com/blog/spatial-resolution/

'Comparison of Spatial Resolutions in Satellite Images', *Medium*, 11 February 2017, available at: https://medium.com/@anttilip/comparison-of-spatial-resolutions-in-satellite-images-3185963a2e96

'Spatial Resolution', *Satellites in Global Development*, undated, available at: https://landscape.satsummit.io/capture/resolution-considerations.html

'Spatial Resolution: Distance and Detail', *Maxar*, undated, available at: https://explore.maxar.com/Imagery-Leadership-Spatial-Resolution

<u>Data sources and websites (in order of presentation):</u>

For low to medium resolution imagery -

Zoom Earth
https://zoom.earth/

WorldView Nasa
https://worldview.earthdata.nasa.gov/

Worldview searchable database version:
https://search.earthdata.nasa.gov/search

WorldView user guide:
https://www.earthdata.nasa.gov/learn/articles/data-tool-focus-worldview

Earth Explorer
https://earthexplorer.usgs.gov/

Explainer on Landsat satellites:
https://www.usgs.gov/faqs/what-are-band-designations-landsat-satellites

Copernicus Browser
https://browser.dataspace.copernicus.eu/

Technical details on Sentinel-2 satellites:
https://dataspace.copernicus.eu/explore-data/data-collections/sentinel-data/sentinel-2

Data resources, notable mentions -

Soar Earth
https://soar.earth/maps

Open Aerial Map
https://map.openaerialmap.org

Maxar Open Data program
https://www.maxar.com/open-data

And for image metadata, see:

Apollo Mapping
https://imagehunter.apollomapping.com/

Software and example datasets shown:

Software

QGIS – 'A free and open source Geographic Information System'
https://qgis.org/en/site/

A beginner's guide can be found at: 'QGIS Tutorial for Beginners', *Open Source Options*, 11 November 2021, available at: https://opensourceoptions.com/qgis-tutorial-for-beginners/

Google Earth Pro
https://www.google.co.uk/earth/about/versions/#earth-pro

Affinity Publisher 2
https://affinity.serif.com/en-us/publisher/

Examples datasets

Earth Explorer dataset references:

Landsat scene ID: LC91760272024126LGN00
Landsat 9
Showing the Mariupol area on 6 May 2024

Catalonia example image sourced from:

'Catalonia Multi-resolution Landcover Dataset (CatLC)', Institut Cartogràfic i Geològic de Catalunya, undated, available at: https://www.icgc.cat/en/Geoinformation-and-Maps/Mapes/Catalonia-Multi-resolution-Landcover-Dataset-CatLC

Turkey floods image sourced from:

'Libya Floods: Analysis Ready Data', *Maxar Open Data Program*, undated, available at: https://www.maxar.com/open-data/libya-floods-0923

The file displayed is from 22 January 2023, catalogue ID 10300500D8F96700. https://maxar-opendata.s3.us-west-2.amazonaws.com/events/Libya-Floods-Sept-2023/ard/34/120200210222/2023-01-22/10300500D8F96700-visual.tif

Google Earth Pro examples:

Yesaulivka 'Luhansk People's Republic' training grounds: 48.049505°, 38.961182°. Images shown are from 21 September 2014, 10 April 2015 and 31 March 2017.

Svobodne 'Donetsk People's Republic' training ground: 47.379584°, 38.071602°. The image shown is from 4 May 2018. For video commentary on this training site, see: https://www.youtube.com/watch?v=rL9I9yZFwuY

Donetsk city 'Donetsk People's Republic' towed artillery firing point: 48.002043°, 37.755146°. The image shown is from 29 September 2015.

See: Contested Ground, Report 33: 'DPR' Towed Artillery Firing Point, Donetsk, 21 May 15, available at: https://contestedground.info/reports/f/report-33-dpr-towed-artillery-firing-point-donetsk-21-may-15

Yakolivka 'Donetsk People's Republic' towed artillery firing point: 48.074532°, 37.833740°. The image shown is from 29 September 2015.

See: Contested Ground, Report 51: Towed Artillery, Yakolivka, Donetsk Oblast, 29 Sep 15, available at: https://contestedground.info/reports/f/report-51-towed-artillery-yakolivka-donetsk-oblast-29-sep-15

*   *   *

For any questions, comments or requests for support, please contact me via this web form: https://contestedground.info/contact