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Corresponding Author:
yunya.gao@sbg.ac.at
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Suggestions on the Selection of Satellite Imagery for Future Remote Sensing-Based Humanitarian Applications

Yunya Gao[1], Stefan Lang[1], Dirk Tiede[1], Lorenz Wendt[1] and Getachew Workineh Gella[1]

[1]University of Salzburg, Austria

Abstract

Satellite imagery is an important information source for research on remote sensing (RS)-based humanitarian applications. The selection of satellite imagery is one of the most important steps for such research. This paper firstly shows the selection of satellite imagery in past research from 2015 to 2021. It can be found that most research on land cover and land use (LCLU) change caused by conflicts or refugees/internally displaced persons (IDPs) chose medium spatial resolution (MSR) imagery. Most research on dwelling detection of refugee/IDP camps applied high or very high spatial resolution (HSR/VHSR) imagery. There is much research that applied multiple types of satellite imagery for humanitarian applications. Then, the paper presents general characteristics of commonly available optical satellite imagery. Next, with the development of sensors, this paper suggests that data fusion of SPOT-5 and Sentinel-2 may be helpful in LCLU change detection caused by refugees/IDPs or conflicts. Smallsat imagery may be promising for research on humanitarian applications that require a high temporal frequency of imagery.

Keywords: remote sensing, satellite imagery, humanitarian applications

1 Introduction

Remote sensing (RS) technology has assisted humanitarian aid applications for the past few decades (Lang & Füreder, 2015). During a crisis, critical information for planning humanitarian operations, such as population in need and their spatial distribution, is usually hard to access by fieldwork (Witmer, 2015). Therefore, the major role of RS is to provide such information for users to support their humanitarian operations in hard-to-reach areas (Voigt, Schoepfer, Fourie, & Mager, 2014). Satellite imagery is a central information source for RS-based humanitarian applications. With the fast development of satellite sensors, more and more satellite imagery has become available. This paper firstly reviews the selection of satellite imagery in past research for humanitarian applications. Then it presents the latest collection of optical satellite imagery and discusses under-explored satellite imagery that may be beneficial for future research.

2 The selection of satellite imagery in past research

Different crises can result in different impacts on the ground with different spatial and temporal scales (Witmer, 2015). The selection of satellite imagery for different crises requires considering characteristics of both crises and imagery (Marx & Goward, 2013). Table 1 lists common research topics and the selection of satellite imagery from the most literature published from 2015 to 2021. The satellite imagery in Table 1 includes four categories that are optical imagery, synthetic-aperture-radar (SAR) imagery, nighttime light imagery, and the combination of multiple types of imagery. General characteristics of imagery, such as spatial resolution and revisit days, could be found in Table 2. Explanations of abbreviations in Table 1 and Table 2 could be found in Table 3.

Table 1: The selection of satellite imagery in past research

Type	Research topic	Sensors	Reference
Optical satellite imagery	LCLU change caused by refugee/IDP camps	Quickbird, WorldView-2, Pléiades-1A	(Rossi et al., 2019)
		SPOT-4, IKONOS, QuickBird	(Spröhnle, Kranz, Schoepfer, Moeller, & Voigt, 2016)
		Sentinel-2	(Bernard, Aron, Loy, Muhamud, & Benard, 2020)
		Landsat-5, Landsat-7, Landsat-8	(Alayyash, 2017; Hossain, Labib, & Patwary, 2018; Lu, Koperski, Kwan, & Li, 2020; Quinn et al., 2018; Ren, Calef, Durieux, Ziemann, & Theiler, 2020; Rossi et al., 2019)
		MODIS	(Maystadt, Mueller, Van Den Hoek, & Van Weezel, 2020)
	Vegetation cover and urban LST change caused by the influx of refugees/IDPs	Landsat-5, Landsat-8	(Rashid, Hoque, Esha, Rahman, & Paul, 2021; Shatnawi & Abu Qdais, 2019)
	Detecting dwellings of refugee camps	QuickBird, WorldView-2	(Tiede, Krafft, Füreder, & Lang, 2017)
		WorldView-3	(Ghorbanzadeh, Tiede, Dabiri, Sudmanns, & Lang, 2018)
		GeoEye-1, Pléiades-1A	(Jenerowicz, Wawrzaszek, Krupinski, Drzewiecki, & Aleksandrowicz, 2019)
		WorldView-2	(Lu et al., 2020)
		GeoEye-1, WorldView-2	(Ghorbanzadeh, Tiede, Wendt, Sudmanns, & Lang, 2021)
	Dwelling infrastructure change detection for refugee/IDP camps	GeoEye-1, QuickBird, Worldview-1, Worldview-2, Worldview-3	(Tomaszewski, Tibbets, Hamad, & Al-Najdawi, 2016)

	Dwelling change monitoring for refugee camps	Sentinel-2, (WorldView-2 and WorldView-3 used for comparison)	(Wendt, Lang, & Rogenhofer, 2017)
	LCLU change caused by conflicts/wars	Sentinel-2	(Hassan, Smith, Walker, Rahman, & Southworth, 2018)
		Landsat-5, Landsat-8	(Al-husban & Ayen, 2020)
		Pléiades-1A, Landsat-8, Landsat-5	(Aung, 2021)
	Village burnings caused by conflicts/wars	CubeSat 3U (Planet Dove)	(Marx, Windisch, & Kim, 2019)
	Satellite-derived drought indicators for humanitarian applications	MODIS	(Enenkel et al., 2016)
SAR	Refugee camp sizes and their environmental impacts	ALOS-2, TerraSAR-X, RADARSAT-2	(Trinder, 2020)
	Environmental change around refugee/IDP camps	ALOS PALSAR, ALOS-2, (Landsat-7 and Landsat-8 used for comparison)	(Braun & Hochschild, 2017)
		ERS-2, Sentinel-1	(Braun, Lang, & Hochschild, 2016)
	Impacts of refugee camps on land surface elevation	Sentinel-1	(Braun, Höser, & Delgado Blasco, 2020)
	Change detection of refugee camps	TerraSAR-X	(Braun, 2020)
Nighttime light products	Detecting areas under conflicts	DMSP-OLS	(Coscieme, Sutton, Anderson, Liu, & Elvidge, 2017)
		DMSP-OLS, VIIRS	(Jiang, He, Long, & Liu, 2017)
	City light dynamics of human settlements during conflicts	DMSP-OLS, VIIRS	(Li, Li, Xu, & Wu, 2017)
Combination of multiple types of satellite imagery	Land cover classification around refugee/IDP camps	Sentinel-1, Sentinel-2	(Braun et al., 2016)
	Detecting dwellings of refugee camps	WorldView-2, TerraSAR-X	(Sprohnle, Fuchs, & Aravena Pelizari, 2017)
		Pléiades, TerraSAR-X	(Sprohnle et al., 2017)
	Environmental changes caused by refugee/IDP camps	ALOS-2, Sentinel-1, SRTM	(Braun, Fakhri, & Hochschild, 2019)
		Sentinel-1, Sentinel-2	(Fakhri & Gkanatsios, 2021)
		Pléiades-1A, VIIRS	(Aung, Overland, Vakulchuk, & Xie, 2021)

Dwelling destruction caused by conflicts/wars	GeoEye-1, WorldView-2, QuickBird	(Knoth & Pebesma, 2017)
Detecting anomalous fire and destroyed settlements	MODIS, VIIRS, Sentinel-1	(Ren et al., 2020)
Analyzing hazards and risks around refugee/IDP camps	Landsat-8, SRTM	(Ahmed, Firoze, & Rahman, 2020)

Based on summarization in Table 1, there are some common rules for selecting satellite imagery for humanitarian applications. Firstly, most research on LCLU change detection caused by the influx of refugees/IDPs or conflicts typically selected MSR satellite imagery. The selection is mainly because LCLU change detection usually requires large spatial scales and long-term series imagery. Landsat-5, together with Landsat-7 and Landsat-8, can provide long-term series imagery from 1984 until now. Thus, Landsat imagery is widely used for such research. Though in many cases, the performance of Sentinel-2 is better than Landsat imagery in LCLU classification (Sekertekin, Marangoz, Akcin, & Faculty, 2017). Sentinel-2 imagery is not broadly used for such research, possibly due to its short archived history. Most research on dwelling detection of refugee/IDP camps selected HSR/VHSR satellite imagery. Due to the small sizes of refugee/IDP camps, MSR imagery usually cannot capture details of dwellings. The applications of optical imagery usually are hacked by cloud covers. SAR imagery can reduce the influences of cloud covers and, thus, also plays a vital role in humanitarian applications (Braun et al., 2016). In recent years, the combination of optical imagery, SAR imagery, together with other data, has been paid more and more attention. These studies aim to make use of the advantages of different imagery to improve the performance of RS-based humanitarian applications.

3 Under-explored satellite imagery for humanitarian applications

In the past few decades, the development of satellite sensors is quite fast. Table 2 presents the general characteristics of currently common optical satellite imagery that may help researchers select the imagery for related research quickly.

In 2014, CNES announced that SPOT archive imagery older than five years is open for non-commercial purposes (Witmer, 2015). It may be valuable to combine satellite imagery from SPOT-5 (starting from 2002 to 2015) and Sentinel-2 (starting from 2015 until now) for LCLU change detection caused by refugees/IDPs or conflicts. The fusion may outperform Landsat imagery due to higher spatial resolution. Up to now, no similar studies have combined these two datasets specifically for LCLU change detection for humanitarian applications.

As shown in Table 2, the revisit days of several satellites can be within one day. Among them, SkySat and Jilin-1-Smart video can revisit the same location more than 5 times per day. This very high temporal resolution may be helpful for humanitarian applications, especially for emergent situations such as earthquakes and flooding. Compared to other traditional satellites, the size of these satellites is usually much smaller. Thus, they are called small satellites (smallsats). Usually, the cost of smallsat imagery is lower than other traditional commercial satellite imagery such as WorldView (Datta, 2018). Currently, only one research on RS-based humanitarian applications used smallsat imagery (Planet Dove). It is proved that the smallsat imagery has high potentials for long-term monitoring of village burning in Myanmar (Marx et al., 2019). Hence, smallsat imagery may be valuable for research on humanitarian applications that require a high temporal resolution.

Table 2: General characteristics of common optical satellite imagery (European Space Agency, 2021)

Provider	Sensor	Spatial resolution / m and Spectral information		Revisit days	Availability
		PAN	RGB+NIR		
Digital Globe	IKONOS	0.8	3.2	3	1999-2015
	QuickBird	0.6	2.6	3	2001-2015
	GeoEye-1	0.5	1.8	3	2008-now
	WorldView-1	0.5		2	2007-now
	WorldView-2	0.5	0.5	2	2009-now
	WorldView-3	0.3	1.2	1	2014-now
	WorldView-4 (GeoEye-2)	0.3	1.2	<1	2016-2019
CNES	Pleiades-1A, 1B	0.5	2	<1	2011-now
	SPOT4	10	20	2 - 3	1998-2013
	SPOT5	2.5-5	10	2 - 3	2002-2015
	SPOT6	1.5	6	1	2012-now
	SPOT7	1.5	6	1	2014-now
Planet Lab	SkySat (1,2,3,4,5,6,7)	0.8	1	7 times/ day	2013-now
	PlanetScope		3	1	2009-now
	RapidEye (1,2,3,4,5)		5	5.5	2008-2020
DSC	TripleSat	0.8	3.2	1	2015-now
CAST	Gaofen-2	0.8	3.2	5	2014-now
CGST	Jilin-1-Optical	0.7	2.9	3.3	2015-now
	Jilin-1-Hyperspectral		5	2 - 3	2019-now
	Jilin-1-Smart video		1.1 (only RGB)	5-7 times/day	2017-now
ESA	Sentinel-2		10	5	2015-now
NASA	Landsat-5 TM		30	16	1984-2013
	Landsat-7 ETM+	15	30	16	1999-now
	Landsat-8 OLI-TIRS	15	30	16	2013-now
	MODIS	250/500/1000		1-2	1999-now

Table 3: Explanations of abbreviations

Abbreviation	Explanation
CAST	China Association for Science and Technology (China)
CGST	Chang Guang Satellite Technology Company (China)
CNES	National Centre for Space Studies (France)
DSC	Dhawan Space Centre (India)
DMSP-OLS	The Defence Meteorological Program Operational Line-Scan System
MODIS	Moderate Resolution Imaging Spectroradiometer
PAN	Panchromatic
SRTM	Shuttle Radar Topography Mission
RGB+NIR	Red, Green, Blue, Near-Infrared
VIIRS	Visible Infrared Imaging Radiometer Suite

4 Conclusion and Outlook

This paper first presents satellite imagery selection in numerous research on RS-based humanitarian applications from 2015 to 2021. It can be observed that MSR satellite imagery is usually selected for LCLU change detection caused by conflicts or refugees/IDPs. For detecting dwellings of refugee/IDP camps, most research chose HSR/VHSR satellite imagery due to the small size of camps. In addition to optical imagery, SAR imagery also plays an important role in humanitarian applications. Recently, quite a lot of research combined multiple types of imagery to explore more possibilities of improving RS-based humanitarian applications. Then, this paper displays some general characteristics of current optical satellite imagery, as shown in Table 2. This summarization may help researchers have a quick understanding of existing optical satellite imagery, and thus, be helpful for related research. At last, with some latest development in satellite imagery, the paper provides two suggestions for future research. The first suggestion is to combine SPOT-5 and Sentinel-2 data to create a long-term-series dataset that may help LCLU change detection for humanitarian applications. The second suggestion is considering smallsat imagery that usually has a lower cost and a higher temporal resolution. The smallsat imagery may be helpful for research or applications that require very high temporal frequency, such as natural disasters.

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Reference

Ahmed, N., Firoze, A., & Rahman, R. M. (2020). Machine learning for predicting landslide risk of Rohingya refugee camp infrastructure. *Journal of Information and Telecommunication*, *4*(2), 175–198. https://doi.org/10.1080/24751839.2019.1704114

Al-husban, Y., & Ayen, A. (2020). The impact of the Syrian civil war on land use/land cover in Al-Yarmouk basin during 2010 – 2018, (September 2015), 147–153.

Alayyash, S. M. (2017). Rainfall Floods as a Result of Land Use Alteration in a Syrian Refugee Camp in Jordan R =, *9*(2), 65–71.

Aung, T. S. (2021). Satellite analysis of the environmental impacts of armed-conflict in Rakhine, Myanmar. *Science of The Total Environment*, *781*, 146758. https://doi.org/10.1016/j.scitotenv.2021.146758

Aung, T. S., Overland, I., Vakulchuk, R., & Xie, Y. (2021). Using satellite data and machine learning to study conflict-induced environmental and socioeconomic destruction in data-poor conflict areas: The case of the Rakhine conflict. *Environmental Research Communications*, *3*(2), 025005. https://doi.org/10.1088/2515-7620/abedd9

Bernard, B., Aron, M., Loy, T., Muhamud, N. W., & Benard, S. (2020). The impact of refugee settlements on land use changes and vegetation degradation in West Nile Sub-region, Uganda. *Geocarto International*, *0*(0), 1–19. https://doi.org/10.1080/10106049.2019.1704073

Braun, A. (2020). Space borne radar imagery – An under-utilised source of information for humanitarian relief. *Journal of Humanitarian Engineering*, *8*(1). https://doi.org/https://doi.org/10.36479/jhe.v8i1.164

Braun, A., Fakhri, F., & Hochschild, V. (2019). Refugee camp monitoring and environmental change assessment of Kutupalong, Bangladesh, based on radar imagery of Sentinel-1 and ALOS-2. *Remote Sensing*, *11*(17), 1–34. https://doi.org/10.3390/rs11172047

Braun, A., & Hochschild, V. (2017). A SAR-based index for landscape changes in African savannas. *Remote Sensing*, *9*(4). https://doi.org/10.3390/rs9040359

Braun, A., Höser, T., & Delgado Blasco, J. M. (2020). Elevation change of Bhasan Char measured by persistent scatterer interferometry using Sentinel-1 data in a humanitarian context. *European Journal of Remote Sensing*, *54*(1), 1–18. https://doi.org/10.1080/22797254.2020.1789507

Braun, A., Lang, S., & Hochschild, V. (2016). Impact of Refugee Camps on Their Environment A Case Study Using Multi-Temporal SAR Data. *Journal of Geography, Environment and Earth Science International*, *4*(2), 1–17. https://doi.org/10.9734/jgeesi/2016/22392

Coscieme, L., Sutton, P. C., Anderson, S., Liu, Q., & Elvidge, C. D. (2017). Dark Times: nighttime satellite imagery as a detector of regional disparity and the geography of conflict. *GIScience and Remote Sensing*, *54*(1), 118–139. https://doi.org/10.1080/15481603.2016.1260676

Datta, A. (2018). Top five small satellite start-ups that are transforming the EO industry. Retrieved May 2, 2021, from https://www.geospatialworld.net/blogs/top-small-satellite-start-ups-that-are-transforming-the-eo-industry/

Enenkel, M., Steiner, C., Mistelbauer, T., Dorigo, W., Wagner, W., See, L., … Rogenhofer, E. (2016). A combined satellite-derived drought indicator to support humanitarian aid organizations. *Remote Sensing*, *8*(4). https://doi.org/10.3390/rs8040340

European Space Agency. (2021). EARTH ONLINE - Earth Observation information discovery platform. Retrieved May 2, 2021, from https://earth.esa.int/eogateway/

Fakhri, F., & Gkanatsios, I. (2021). Remote Sensing Applications : Society and Environment Integration of Sentinel-1 and Sentinel-2 data for change detection : A case study in a war conflict area of Mosul city. *Remote Sensing Applications: Society and Environment*, *22*(November 2020), 100505. https://doi.org/10.1016/j.rsase.2021.100505

Ghorbanzadeh, O., Tiede, D., Dabiri, Z., Sudmanns, M., & Lang, S. (2018). Dwelling extraction in refugee camps using CNN - First experiences and lessons learnt. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, *42*(1), 161–166. https://doi.org/10.5194/isprs-archives-XLII-1-161-2018

Ghorbanzadeh, O., Tiede, D., Wendt, L., Sudmanns, M., & Lang, S. (2021). Transferable instance segmentation of dwellings in a refugee camp - integrating CNN and OBIA. *European Journal of Remote Sensing*, *54*(sup1), 127–140. https://doi.org/10.1080/22797254.2020.1759456

Hassan, M. M., Smith, A. C., Walker, K., Rahman, M. K., & Southworth, J. (2018). Rohingya refugee crisis and forest cover change in Teknaf, Bangladesh. *Remote Sensing*, *10*(5), 1–20. https://doi.org/10.3390/rs10050689

Hossain, N., Labib, S. M., & Patwary, S. H. (2018). Environmental Cost of Refugee Crisis: Case Study of Kutupalong Balukhali Rohingya Camp Site A Remote Sensing Approach Environmental Cost of Refugee Crisis: Case Study of Kutupalong-Balukhali Rohingya Camp Site A Remote Sensing Approach. *Proceedings of the 26th* …, (September). https://doi.org/10.13140/RG.2.2.14086.22085

Jenerowicz, M., Wawrzaszek, A., Krupinski, M., Drzewiecki, W., & Aleksandrowicz, S. (2019). Aplicability of Multifractal Features as Descriptors of the Complex Terrain Situation in IDP/Refugee Camps. *International Geoscience and Remote Sensing Symposium (IGARSS)*, 2662–2665. https://doi.org/10.1109/IGARSS.2019.8898588

Jiang, W., He, G., Long, T., & Liu, H. (2017). Ongoing conflict makes Yemen dark: From the perspective of nighttime light. *Remote Sensing*, *9*(8), 1–18. https://doi.org/10.3390/rs9080798

Knoth, C., & Pebesma, E. (2017). Detecting dwelling destruction in Darfur through object-based change analysis of very high-resolution imagery. *International Journal of Remote Sensing*, *38*(1), 273–295. https://doi.org/10.1080/01431161.2016.1266105

Lang, S., & Füreder, P. (2015). Earth Observation for Humanitarian Operations. *GI_Forum*, *1*(July 2018), 384–390. https://doi.org/10.1553/giscience2015s384

Li, X., Li, D., Xu, H., & Wu, C. (2017). Intercalibration between DMSP/OLS and VIIRS night-time light images to evaluate city light dynamics of Syria's major human settlement during Syrian Civil War. *International Journal of Remote Sensing*, *38*(21), 5934–5951. https://doi.org/10.1080/01431161.2017.1331476

Lu, Y., Koperski, K., Kwan, C., & Li, J. (2020). Deep Learning for Effective Refugee Tent - Extraction Near Syria–Jordan Border. *IEEE Geoscience and Remote Sensing Letters*.

Marx, A., & Goward, S. (2013). Remote sensing in human rights and international humanitarian law monitoring: Concepts and methods. *Geographical Review*, *103*(1), 100–111. https://doi.org/10.1111/j.1931-0846.2013.00188.x

Marx, A., Windisch, R., & Kim, J. S. (2019). Detecting village burnings with high-cadence smallsats: A case-study in the Rakhine State of Myanmar. *Remote Sensing Applications: Society and Environment*, *14*(February), 119–125. https://doi.org/10.1016/j.rsase.2019.02.008

Maystadt, J. F., Mueller, V., Van Den Hoek, J., & Van Weezel, S. (2020). Vegetation changes attributable to refugees in Africa coincide with agricultural deforestation. *Environmental Research Letters*, *15*(4). https://doi.org/10.1088/1748-9326/ab6d7c

Quinn, J. A., Nyhan, M. M., Navarro, C., Coluccia, D., Bromley, L., & Luengo-Oroz, M. (2018). Humanitarian applications of machine learning with remote-sensing data: Review and case study in refugee settlement mapping. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *376*(2128). https://doi.org/10.1098/rsta.2017.0363

Rashid, K. J., Hoque, M. A., Esha, T. A., Rahman, M. A., & Paul, A. (2021). Spatiotemporal changes of vegetation and land surface temperature in the refugee camps and its surrounding areas of Bangladesh after the Rohingya influx from Myanmar. *Environment, Development and Sustainability*, *23*(3), 3562–3577. https://doi.org/10.1007/s10668-020-00733-x

Ren, C. X., Calef, M. T., Durieux, A. M. S., Ziemann, A., & Theiler, J. (2020). On the detectability of conflict: A remote sensing study of the Rohingya conflict. *ArXiv*, 1–4.

Rossi, M., Rembold, F., Bolognesi, M., Nori, M., Mureithi, S., & Nyberg, G. (2019). Mapping land enclosures and vegetation cover changes in the surroundings of Kenya's Dadaab refugee camps with very high resolution satellite imagery. *Land Degradation and Development*, *30*(3), 253–265. https://doi.org/10.1002/ldr.3212

Sekertekin, A., Marangoz, A. M., Akcin, H., & Faculty, E. (2017). Pixel-based classification analysis of alnd use land cover using Sentinel-2 and Landsat-8 data, *XLII*(October), 14–15.

Shatnawi, N., & Abu Qdais, H. (2019). Mapping urban land surface temperature using remote sensing techniques and artificial neural network modelling. *International Journal of Remote Sensing*, *40*(10), 3968–3983. https://doi.org/10.1080/01431161.2018.1557792

Sprohnle, K., Fuchs, E. M., & Aravena Pelizari, P. (2017). Object-Based Analysis and Fusion of Optical and SAR Satellite Data for Dwelling Detection in Refugee Camps. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *10*(5), 1780–1791. https://doi.org/10.1109/JSTARS.2017.2664982

Spröhnle, K., Kranz, O., Schoepfer, E., Moeller, M., & Voigt, S. (2016). Earth observation-based multi-scale impact assessment of internally displaced person (IDP) camps on wood resources in Zalingei, Darfur. *Geocarto International*, *31*(5), 575–595. https://doi.org/10.1080/10106049.2015.1062053

Tiede, D., Krafft, P., Füreder, P., & Lang, S. (2017). Stratified template matching to support refugee camp analysis in OBIA workflows. *Remote Sensing*, *9*(4). https://doi.org/10.3390/rs9040326

Tomaszewski, B., Tibbets, S., Hamad, Y., & Al-Najdawi, N. (2016). Infrastructure evolution analysis via remote sensing in an urban refugee camp - Evidence from Za'atari. *Procedia Engineering*, *159*(June), 118–123. https://doi.org/10.1016/j.proeng.2016.08.134

Trinder, J. C. (2020). Editorial for special issue "Applications of Synthetic aperture radar (SAR) for land cover analysis." *Remote Sensing*, *12*(15). https://doi.org/10.3390/RS12152428

Voigt, S., Schoepfer, E., Fourie, C., & Mager, A. (2014). Towards semi-automated satellite mapping for humanitarian situational awareness. *Proceedings of the 4th IEEE Global Humanitarian Technology Conference, GHTC 2014*, 412–416. https://doi.org/10.1109/GHTC.2014.6970315

Wendt, L., Lang, S., & Rogenhofer, E. (2017). Monitoring of Refugee and Camps for Internally Displaced Persons Using Sentinel-2 Imagery – A Feasibility Study. *GI_Forum*, *1*(1), 172–182. https://doi.org/10.1553/giscience2017_01_s172

Witmer, F. D. W. (2015). Remote sensing of violent conflict: eyes from above. *International Journal of Remote Sensing*, *36*(9), 2326–2352. https://doi.org/10.1080/01431161.2015.1035412