

Editorial

Earth Observation from KOMPSAT Optical, Thermal, and Radar Satellite Images

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Over the past several decades, as sensor technology has improved, the spatial resolution of satellite images has been steadily improving. The design, performance, and applications of satellite-based remote sensors have become essential to understanding the physical, ecological, geological, hydrological, and environmental characteristics of Earth's surfaces.

Korea is promoting various space development programs according to the mid- and long-term space development program. Among them, the Korea Multi-Purpose Satellite (KOMPSAT) development program is the most representative space development program in Korea. The Korea Aerospace Research Institute (KARI) is a government-funded research institute in charge of space development in Korea. KARI has developed and is operating the KOMPSAT, which is a low-orbit Earth observation satellite with optical and imaging radar and middle-wave infrared (MIR) observation capabilities. The main objective of the KOMPSAT program is to meet the national demands to acquire high-resolution satellite images and to use it peacefully.

The KOMPSAT-1 was the first practical satellite in Korea and laid the foundation for satellite technology independence. KARI developed the KOMPSAT-1 with a foreign company and launched it on 21 December 1999 at the US Vandenberg Air Force Base. The KOMPSAT-1 accommodates three instruments for the missions of cartography (Electro-Optical Camera; EOC), global biological oceanography (Ocean Scanning Multi-spectral Imager; OSMI), and space environment monitoring (Space Physics Sensor; SPS). The EOC provides panchromatic images with 6.6 m spatial resolution. The KOMPSAT-1 has acquired about 470,000 images during its mission with orbiting the Earth more than 43,000 times at an altitude of 685 km. The images obtained by the KOMPSAT-1 were used for land management, map production, local surveillance, environmental monitoring, etc. The KOMPSAT-1 completed its mission in February 2008 after performing the mission for eight years, which was more than twice the design life.

Based on the experience of developing the KOMPSAT-1, KARI took the lead in the entire process of designing, manufacturing, assembling, and testing, and testing KOMPSAT-2. The KOMPSAT-2 is an in-country development program to enhance the capabilities of satellite manufacturing technology in Korea. The Multi-Spectral Camera (MSC), which is the on-board camera of the KOMPSAT-2, provides a 1 m panchromatic image and a 4 m multi-spectral image with four bands. The KOMPSAT-2 was the seventh satellite in the world to have a 1 m high-resolution camera. The spatial resolution of the KOMPSAT-2 is 40 times better than the 6.6 m resolution of the KOMPSAT-1. The KOMPSAT-2 launched in July 2006 and officially ended its mission in 2015, but it is still in operation because there is no problem with the satellite operations for imaging.

The KOMPSAT-3 is the successor satellite of the KOMPSAT-2 and was developed for continuous high-precision Earth observation image acquisition. The Advanced Earth



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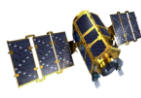

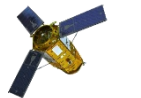
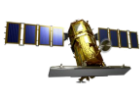
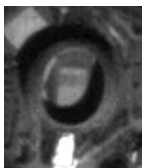

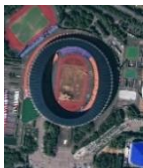

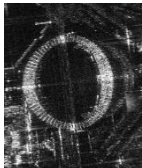


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Imaging Sensor System (AEISS), the payload of the KOMPSAT-3, provides a 0.7 m spatial resolution image and is widely used for producing precise maps because it allows stereo imaging on the same orbit. Meanwhile, the KOMPSAT-3A is almost the same as the KOMPSAT-3, but its operating altitude is 528 km, which is lower than the KOMPSAT-3 (685 km). However, the spatial resolution was improved by 0.55 m. In addition, the KOMPSAT-3A is additionally equipped with a mid-infrared sensor capable of acquiring an image with a spatial resolution of 5.5 m, and imaging is possible even at night. Sub-meter high-resolution satellite images such as those from the KOMPSAT-3/3A can accurately detect various changes including precise map production.

The KOMPSAT-5 is Korea's first synthetic-aperture radar (SAR) satellite. The KOMPSAT-5 provides X-band SAR images and provides 1 m (high resolution), 3 m (standard), and 20 m (wide swath) images depending on the imaging mode. The KOMPSAT-5 can be very useful in disaster situations such as flooding, earthquakes, and marine oil spills. Table 1 compares the sample images of the KOMPSAT series and also explains the simple satellite specifications.

Table 1. KOMPSAT Series Specifications and Sample Images.

					
Items	K1	K2	K3	K3A	K5
Sensor Type	Visible	Visible	Visible	Visible + MIR	SAR
Local Time	10:50	10:50	13:30	13:30	06:00 18:00
Altitude	685 km	685 km	685 km	528 km	550 km
Mission Lifetime	3 years	3 years	4 years	4 years	5 years
GSD	Pan:6 m	Pan:1 m MS:4 m	Pan:0.7 m MS:2.8 m	Pan:0.55 m MS:2.2 m MIR:5.5 m	HR:1 m ST:3 m WS:20 m HR:5 km ST:30 km WS:100 km
Swath Width	17 km	15 km	16 km	12 km	ST:30 km WS:100 km
Launch	1999.12.21	2006.07.28	2012.05.18	2015.03.26	2013.08.22
Operation	End of Opr. (2008.2)	End of Miss. (2015.10)	Operating	Operating	Operating
Sample Image					

The KOMPSAT images have been successfully used to observe Earth's surface in the fields of physics, ecology, geology, hydrology, environmentology, etc. Currently, the Korean government is integrating the satellite operating system to support comprehensive use of satellite images at the national level and is supporting R&D for the development and distribution of various technologies. The theory and applications of KOMPSAT satellite images can be found in several Special Issues [1–6]. This Special Issue discusses recent advances in remote sensing technologies as well as new remote sensing applications using the KOMPSAT series images.

In this Special Issue, we invited original research articles addressing the state-of-the-art remote sensing technologies and methods using the optical, thermal, and radar KOMPSAT satellite images. Thus, six papers have been published. Two of the six papers dealt with

topics related to optical images [7,8], two with radar image topics [9,10], and two with image fusion topics [11,12].

Park et al. [7] proposed an efficient method to map oil spill areas from a KOMPSAT-2 optical high-resolution satellite image in bad weather conditions. The test of the KOMPSAT-2 image has severe ocean wave effects, and the authors reduced the effect using directional median filtering, which is designed by using the intensity and direction in the power spectrum. When an artificial neural network (ANN) was applied to the oil spill mapping, the archived accuracies were about 98.12% and 89.56% using the receiver operating characteristic (ROC) curve and probability of detection (POD) measurements, respectively.

Lee et al. [8] mapped the forest vertical structure in Seogwipo city, Jeju Island. They used the optical KOMPSAT-3 and L-band radar ALOS-1 PALSAR-1 images for the mapping. In addition, maps related to canopy heights were extracted by using the difference between the World Digital Elevation Model (WorldDEM) and NGII digital terrain model (DTM). The WorldDEM was derived by TerraSAR-X radar images, while the NGII DTM was generated by a 1:5000 digital topographic map. From the ALOS-1 PALSAR-1 images, twelve coherence maps were generated by SAR interferometry (InSAR) processing, and then the mean coherence map was created by averaging the twelve coherence maps. NDWI and NDVI maps were created from the KOMPSAT-3 image. The ANN method was applied to the dataset, and the archived overall accuracy was about 65.7% based on the error matrix.

Kim and Won [9] proposed an efficient method to compensate the across-track (AT) acceleration for the improved measurement of the AT velocity of ground moving targets. This method is applied to single-channel SAR single-look complex (SLC) data. It is unique in this method that the Doppler phase variation is estimated from the Doppler frequency domain, not from the time domain. The method was validated from the X-band SAR SLC image. The achieved accuracy was about 1.49 m/s for a moving target with the speed of about 10.11 m/s. The authors insist that the proposed method will be applied to X-band SAR systems of the KOMPSAT-5 and 6.

Kim and Lee [10] mapped the flooded area after the collapse of the Laos Xe-Pian Xe-Namnoy Dam located in Champasak Province, Laos. They used C-band Sentinel-1 SAR ground range detected (GRD) data. Flooded areas were gradually reduced in the Xe-Namnoy reservoir and Hinlat region using seventeen SAR images. The reduction rate was about $-3.3 \times 10^6 \text{ m}^3/\text{day}$ in the Xe-Namnoy reservoir. The authors showed that the interferometric coherence is very useful to the flood mapping, and they insist that this method can be applicable to the KOMPSAT-5 or 6.

Lee et al. [11] applied deep learning approaches such as SegNet and U-Net to the deforestation mapping from KOMPSAT-3 optical satellite images. The training and test data were extracted from the KOMPSAT-3 images and semantic segmented ground truth data. The study area was Bonghwa-gun, Gyeongsangbuk-do, Korea. The achieved accuracies were about 78.4% and 63.3% in U-Net and SegNet, respectively. U-Net was approximately 23% more accurate than SegNet. The authors insist that deep learning approaches have a great potential for deforestation mapping in mountain areas.

Oh et al. [12] proposed and compared several methods to merge KOMPSAT-3A panchromatic (PAN) and middle-infrared (MIR) images and evaluated the performance of the methods using qualitative assessment indices such as the image quality (Q4), cross-correlation (CC), and the spectral and spatial ERGAS. The proposed methods were specifically designed for merging KOMPSAT-3A PAN and MIR images with the aim of fully exploiting the fusing capabilities in the KOMPSAT-3A. Among the proposed methods, GF-P (guide filter-based fusion-proposed) was superior to other methods. The authors insist that the proposed method has an improved fusion quality.

We hope that the research topics of the six published papers will help to be widely used in the applications of the KOMPSAT optical, thermal, and radar satellite images.

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