Simulated Mineralogy Map created using WorldView-3 spectral bands

# WORLDVIEW-3: SETTING NEW STANDARDS IN EARTH OBSERVATION

WORLDVIEW-3 IS THE FIRST COMMERCIAL SATELLITE TO HAVE 16 HIGH-RESOLUTION SPECTRAL BANDS THAT CAPTURE INFORMATION IN THE VISIBLE AND NEAR-INFRARED (VNIR), AND SHORT-WAVE INFRARED (SWIR) REGIONS OF THE ELECTROMAGNETIC SPECTRUM (EMS). WE LOOK AT HOW ITS SUPER SPECTRAL CAPABILITY SETS A NEW STANDARD FOR SATELLITE IMAGERY AND HOW ITS BENEFITS ARE BEING REALISED

After more than 40 years, the remote sensing community continues to address the two fundamental challenges when using Earth imagery at a global scale: automated information extraction and change detection. DigitalGlobe's WorldView-3 satellite is designed to address these challenges by creating consistent datasets as well as providing unique information for agriculture, forestry and mining/geology and other applications.

Providing unique information

WorldView-3 is the first commercial satellite to have 16 high-resolution spectral bands that capture information in the visible and near-infrared (VNIR), and short-wave infrared (SWIR) regions of the electromagnetic spectrum (EMS). Operating at an altitude of 617 kilometers, the satellite provides 30-centimeter panchromatic resolution, 1.2-meter VNIR resolution, and 3.7/7.5-meter SWIR resolution, according to DigitalGlobe's operating licenses (Department of Commerce).

WorldView-3 builds upon WorldView-2's unique VNIR capabilities and provides eight additional spectral bands, farther into the SWIR portion of the EMS. This spectral expansion enhances WorldView-3's capability to capture the uniqueness of each ground material's spectral
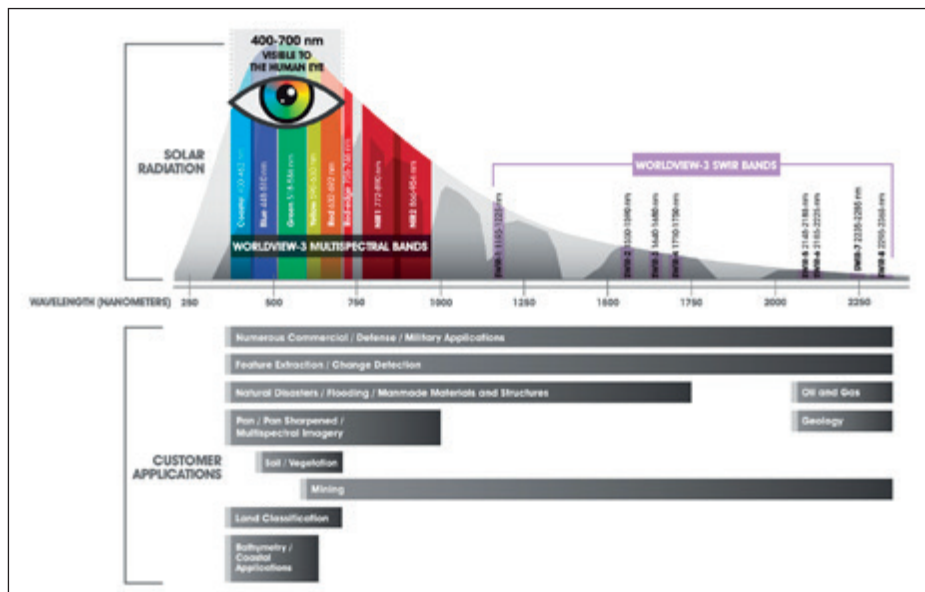
Far Left: *Fig.1:* Spectral diversity offered by DigitalGlobe Constellation

Left: *Fig.2:* WorldView-3's atmospheric sensor has a slightly wider swath than its imaging swath

signature. Due to minimal atmospheric influence or noise in this part of the EMS, as well as an enhanced ability to differentiate among ground materials, the SWIR bands open the door for automated information extraction to save time, money, and lives.

Creating consistent imagery

Remote sensing satellites view Earth from above the atmosphere—top-of-the-atmosphere (TOA) measurements of Earth's features. Changes in the atmosphere, sun illumination and viewing geometries during image capture result in inconsistent image data, hindering automated information extraction and change detection. Atmospheric conditions typically change during and between different imagery collections due to varying moisture levels (water vapour) and particulates (aerosols) in the atmosphere. Much research has been done trying to accurately convert the TOA measurements to surface-reflectance measurements.

The challenge has been the availability of accurate atmospheric measurements at appropriate scale, ensuring imagery can be normalized. WorldView-3 addresses this problem by becoming the first commercial imaging satellite with an atmospheric sensor as part of its payload.

During image capture, the WorldView-3 atmospheric sensor is designed to detect the presence of clouds, aerosols and water vapour at 30-meter resolution, thereby measuring the exact atmospheric conditions corresponding to every recorded image. Fig.2 shows how the atmospheric sensor has a slightly wider swath than the imaging swath.

DigitalGlobe has developed proprietary algorithms that use these atmospheric measurements to normalize WorldView-3 imagery for consistency. This normalization is called atmospheric compensation, which is especially important for information extraction, such as change detection and vegetation analysis because changes due to the atmosphere have been removed. Atmospheric compensation results in surface-reflectance image data. Fig.3 shows an example of a surface-reflectance image after atmospheric compensation.

Another issue impairing automated information extraction is accurately mapping cloud cover. WorldView-3's sensors have spectral bands that range from the VNIR into the SWIR part of the EMS to accurately distinguish clouds from other bright features such as snow and ice.

Fig.4 shows how the longer wavelengths in the SWIR range of the atmospheric sensor are able to penetrate fire smoke and haze.

THE BENEFITS OF SWIR IMAGERY

Besides offering 30 centimetre resolution panchromatic and eight-band visible and near-infrared (VNIR) imagery, WorldView-3 is licensed by the National Oceanic and Atmospheric Administration to collect short-wave infrared (SWIR) imagery in eight-bands. This allows the satellite to sense the VNIR spectrum as well as expand deeper into the infrared spectrum, than any other commercial imaging satellite, providing rich data for precisely identifying and characterizing man-made and natural materials. WorldView-3's eight SWIR bands span the spectrum's three atmospheric transmittance imaging windows to capture unique information for agriculture, forestry and mining/geology and other applications.

Agriculture

The agricultural community will benefit greatly from WorldView-3's 16 bands. One of the main challenges facing agriculture policies is regional and global knowledge of accurate crop inventories. WorldView-3's atmospherically compensated imagery, coupled with the 16 spectral bands, will allow for accurate crop pattern/type mapping.

As the world focuses on increasing global food security, it is critical to improve small farm productivity and yield, while decreasing costs, minimizing the environmental impact with precision agriculture practices, and better managing agriculture production and associated inventory. It is important to take corrective action early in the growing season by understanding crop conditions such as crop health and stress due to problems such as nutrient deficiency, moisture stress, and pests.

Fig.5 shows how the red edge and yellow bands on WorldView-2 and WorldView-3 are designed to observe and map these phenomena.

Fig.3: Surface reflectance natural colour image before (left) and after atmospheric compensation (right)
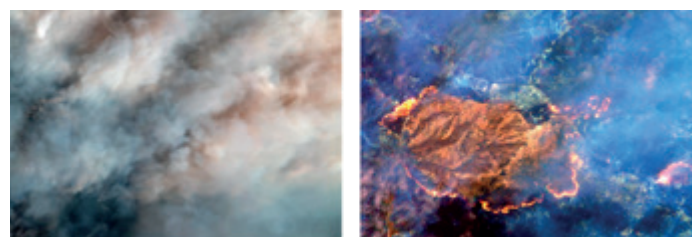

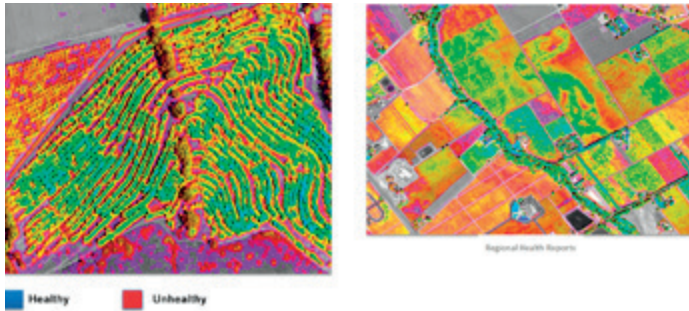**Fig.4:** Wildfire smoke in colour image (left) and Wildfire smoke penetration in SWIR (right)
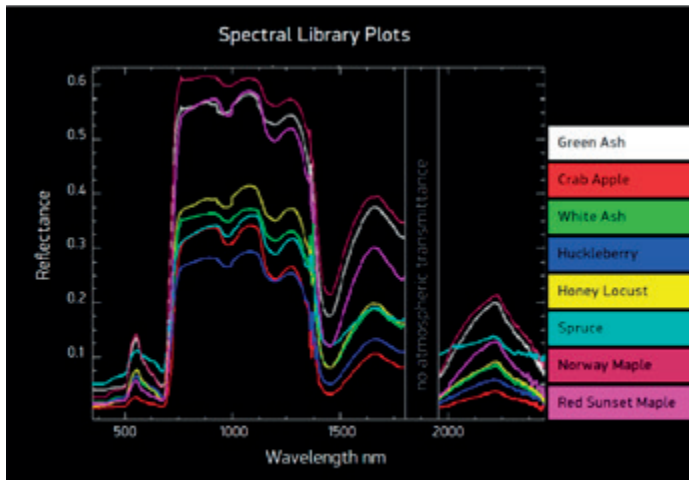
Fig.5: Crop classification (left) and crop health and boundary mapping (right)

Source: "Analysis of hyperspatial remote sensing to detect and map the tree decline at Ft. Benning, Georgia" Dr. Susan Uttin, 2008

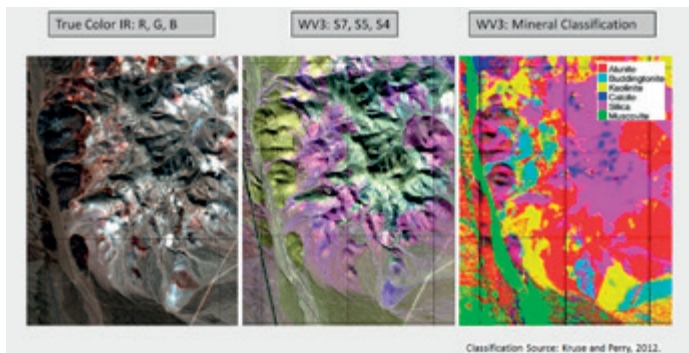Fig.6 (left) Spectral signatures for eight different species of trees

Fig.7: Imagery analysts will be able to map minerals using WorldView-3 spectral bands

FROM PIXELS TO INSIGHT WITH WORLDVIEW-3

WorldView-3's atmospheric sensor will be used to normalize imagery for varying atmospheric conditions and to develop algorithms that can be used anywhere on the globe. Furthermore, the satellite's 16 spectral bands will allow for automated information extraction for various applications. Because WorldView-3 was is designed as an evolutionary sensor, providing continuity of WorldView2 VNIR bands at a higher spatial resolution as well as and a revolutionary sensor with 8 new SWIR spectral bands offered on a commercial satellite for the first time, the satellite will is poised to transform the remote sensing industry from a pixel-based industry into a product-based industry, expanding the use of remotely sensed data to create ways to better understand and manage our changing planet.

Crop stresses change the green chlorophyll content of the leaves and replace them with carotenoids that have yellow and red colours. Yellow, red edge and the two near-infrared bands are sensitive to changes in the green chlorophyll and expose the carotenoids during stress. In addition, SWIR bands are used to assess crop moisture, which is another health indicator.

Observing soil types and conditions before, during and after a crop season is important for managing crop health. Remote sensing satellites offer a window into underlying soil conditions and how such conditions might affect vegetation.

Soil organic composition and moisture levels are assessable through the VNIR and SWIR bands. When properly monitored, such information can help users understand current and future crop potential.

One of the agricultural community's best management practices relates to how much post-harvest crop residue is left on a field. Crop residue preserves soil moisture and prevents soil erosion during rainy months. SWIR spectral bands can be used to map and quantify how much crop residue is left behind, predicting the soil quality for future crops.

Forestry

The forestry industry's requirements are similar to the agricultural industry, which includes maintaining a detailed tree inventory of large parcels, mapping and monitoring tree health, and understanding and minimizing tree pest infestations.

WorldView-3's spectral bands, including VNIR and SWIR, allow for tree class and species identification. Tree species have unique spectral signatures, like fingerprints, that can be extracted automatically using WorldView-3's spectral bands (Fig.6). Stressed trees will exhibit similar symptoms as stressed crops, as green chlorophyll in the leaves is replaced by yellow and red carotenoids.

Mining/Geology

WorldView-3's spectral bands will allow for unique mineral identification and chemical measurements. Atoms have vibrations with different frequencies, and at specific wavelengths light can stimulate the vibration. As a result, different minerals absorb specific wavelengths and reflect others.

Electronic absorptions at wavelengths less than about 1,000 nm allow analysts to identify materials containing iron. Molecular vibrational features at wavelengths between about 1,000–2,500 nm are diagnostic for materials containing anion groups such as Al-OH, Mg-OH, Fe-OH, Si-OH, carbonates, ammonium, and sulphates. Mineral spectral absorption features are particularly observed in the SWIR region.

Exposed outcrops are manifestations of potential mineral ores or sub-surface deposits. The geology and mining industries spend millions of dollars to identify potential mining sites during the exploration phase; WorldVew-3 will allow companies to cut costs and increase efficiency by narrowing the potential area before field verification is planned.

Summary

WorldView-3's increased spectral resolution of16-bands spanning VNIR to SWIR will allow an extension of visual interpretation to machine interpretation and analyses using material spectral signatures. With the addition of WorldView-3 to its constellation, DigitalGlobe is pioneering the ability to automatically extract valuable information in the invisible part of sunlight, which carries additional spectral information.

In this interconnected global economy, understanding micro, regional, and global trends is of paramount importance for decision-makers. Being able to identify patterns and make decisions with confidence, based on the highest quality and most current visual information, is crucial for success.

For more information and to request a sample, email: contactemear@digitalglobe.com, call +44 203 695 0920, or visit www.explore.digitalglobe.com/demo