GEOGRAPHY

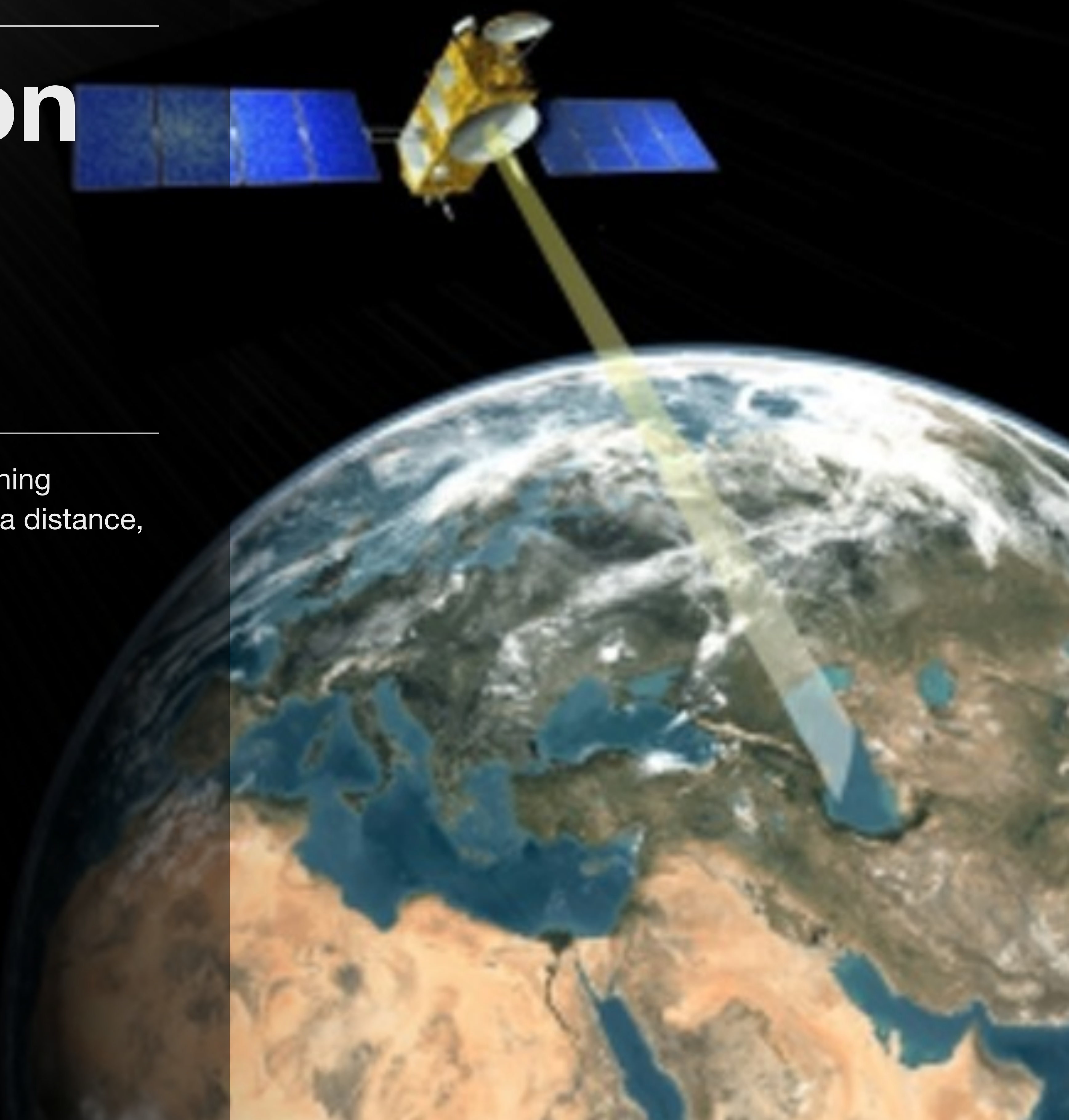
ISS

Remote sensing

Comenius Team Austria

Chapter 1

Introduction



Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft, satellites or ISS.

Section1

Remote sensing from the ISS

Remote sensing from ISS

Figure 1-1.

A great advantage of the space station is the presence of crew that can react to unfolding events in real time, rather than needing a new data collection program uploaded from ground control. This is particularly important for collecting imagery of unexpected **natural hazard** events such as volcanic eruptions, earthquakes, and tsunami. The crew can also determine whether viewing conditions -- like cloud cover or illumination -- will allow useful data to be collected, as opposed to a robotic sensor that collects data automatically without regard to quality.

Figure 1-2. Mount Etna, Sicily

Chapter 2

MUSES on ISS

A **M**ulti-**U**ser **S**ystem for **E**arth **S**ensing (MUSES) will be mounted on the ISS.

Section 1

MUSES

MUSES - Multi-User System

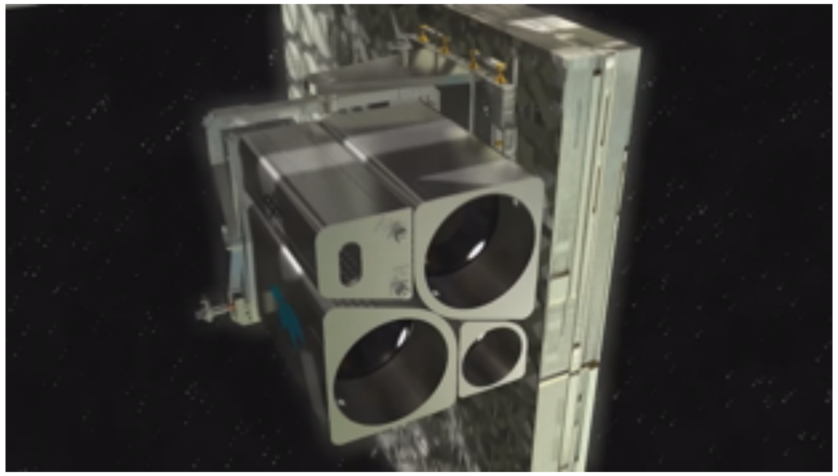


Figure 2-1. MUSES

MUSES: **M**ulti-**U**ser **S**ystem for **E**arth **S**ensing

DLR to be first user of Earth sensing platform MUSES on ISS

On 1 October 2013, Teledyne Brown Engineering, Inc., subsidiary of Teledyne Technologies Incorporated, and the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) signed a memorandum of agreement to develop an instrument for the **M**ulti-**U**ser **S**ystem for **E**arth **S**ensing (MUSES), which will be mounted on the International Space Station (ISS).

Section 2

DLR and Teledyne

DLR - Teledyne Technologies

DLR is the national aeronautics and space research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport and security is integrated into national and international cooperative ventures.

TELEDYNE TECHNOLOGIES INC. is an American industrial conglomerate primarily based in the United States but with global operations. Teledyne Technologies currently operates with four major segments: Digital Imaging, Instrumentation, Engineered Systems, and Aerospace and Defense Electronics.

DLR will develop and deliver a **Visual/Near-Infrared Imaging Spectrometer** to be integrated with Teledyne's MUSES platform. The instrument will occupy one of the four Earth-looking instrument sites on MUSES. Teledyne will be responsible for integrating and operating the instrument. The Earth observation instrument is expected to be operational on MUSES by late 2015.
In future the data collected by the spectrometer can be used in scientific, commercial, educational and humanitarian fields. Its high spectral quality allows for the detection of changes in land surfaces, oceans and the atmosphere, and hence the development of measures to protect the **environment** and climate.

Section 3

ISS for observing Earth

"Aerospace has no greater task than to observe Earth and its ecosystems from space. It is effective to use existing platforms, such as the **ISS**, as carriers of Earth observation instruments," explained Professor Johann-Dietrich Wörner, Chairman of the DLR Executive Board. "We are delighted at the formation of this partnership between science and industry, ..."

Some applications:

Figure 2-2. Irrigated areas

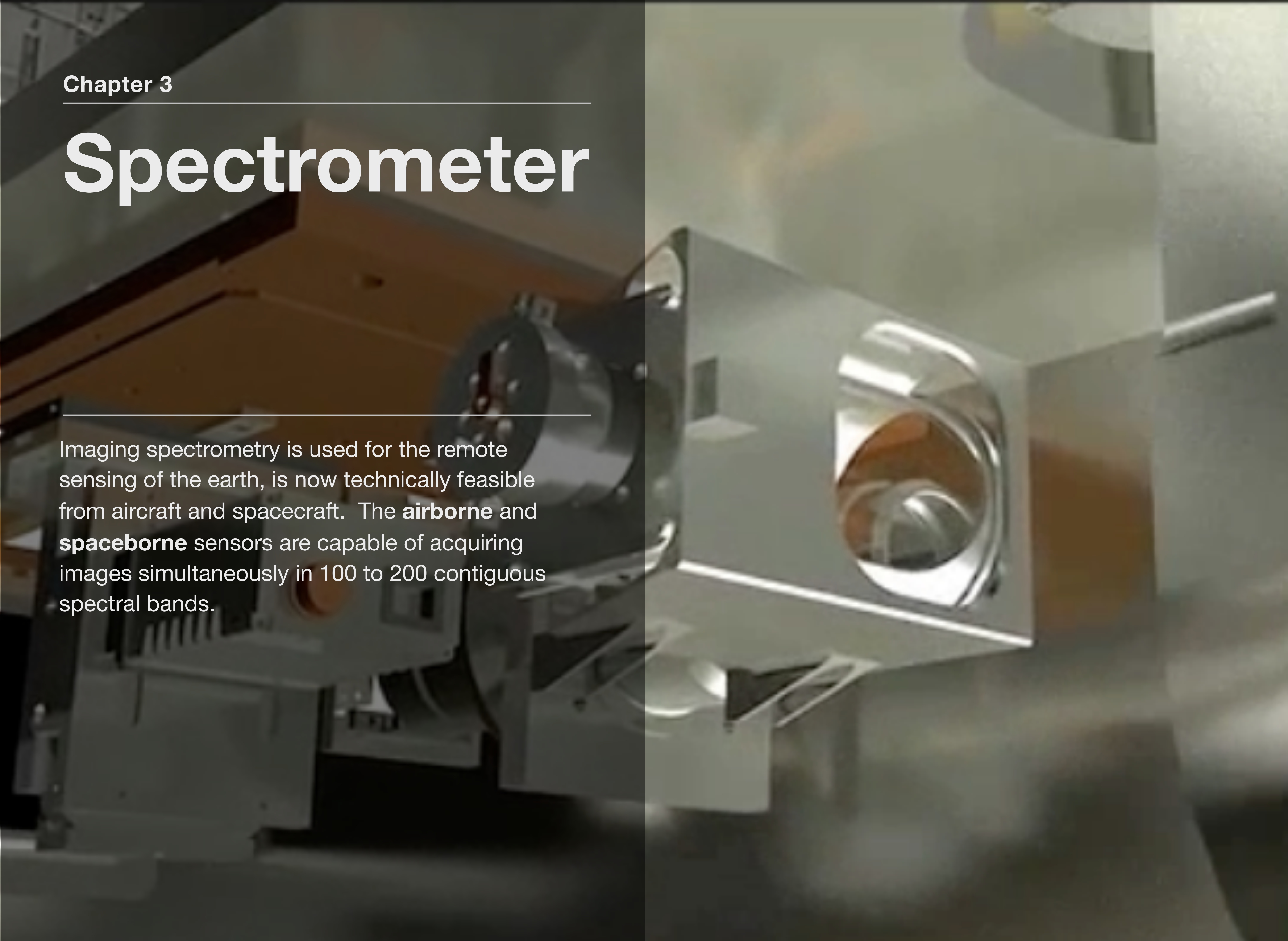
Figure 2-3. Hurricanes

Figure 2-4. Vulcanoes

Chapter 3

Spectrometer

Imaging spectrometry is used for the remote sensing of the earth, is now technically feasible from aircraft and spacecraft. The **airborne** and **spaceborne** sensors are capable of acquiring images simultaneously in 100 to 200 contiguous spectral bands.



Platform on the ISS: MUSES

Environmental monitoring using hundreds of spectral channels

MUSES, the first commercial Earth-sensing platform on the ISS.

A reliable view of Earth from the ISS

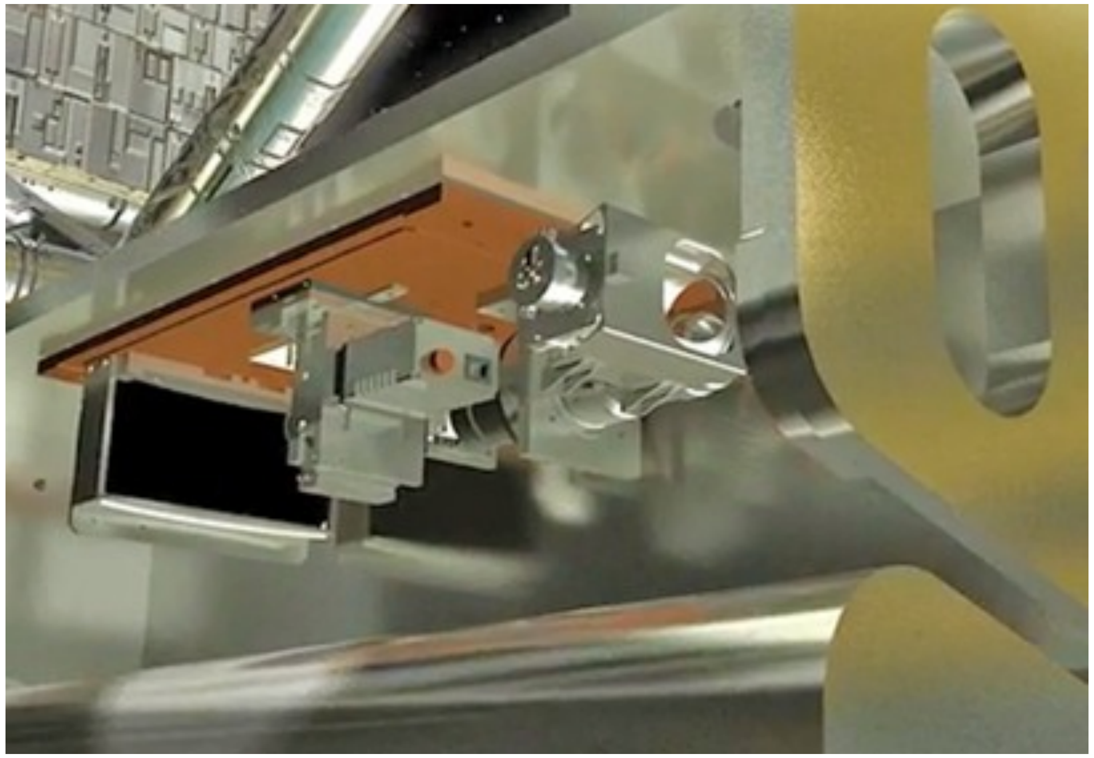


Figure 3-1. Look at the earth

The MUSES platform has an area of 85 by 85 centimeters and can accommodate four instruments. It will be attached to a **pivot arm** on the side of the ISS facing earth during an astronaut spacewalk scheduled for 2015. What sets this project apart from other satellite instruments is that the ISS instruments can be replaced or updated continuously to accommodate new technical innovations.

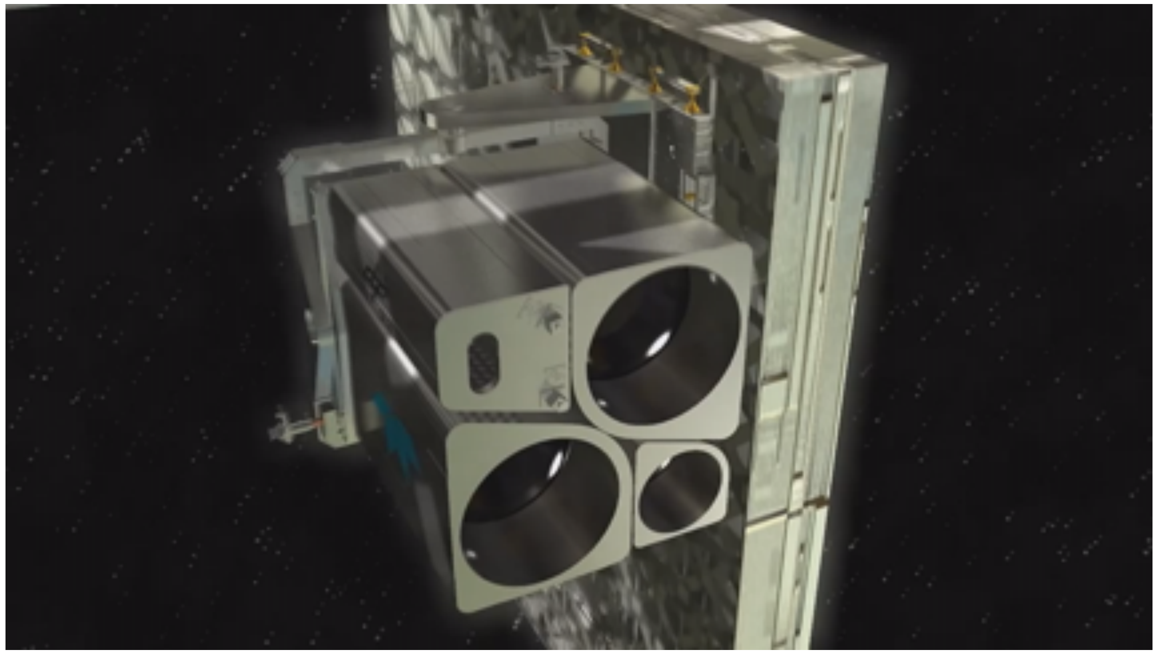


Figure 3-2. DESIS hyperspectral sensor on the ISS

DESIS is a hyperspectral camera that records image data using an array of up to 240 closely spaced channels, covering the visible and near infrared portions of the spectrum (450 to 915 nanometres) with a ground resolution of approximately 90 metres. This multifaceted information allows scientists to detect changes in ecosystems and to make statements on the condition of forests and agricultural land. Among other things, its purpose is to secure and improve the global cultivation of food. The data from the ISS instruments will be available quickly in the event of a catastrophe and can help rescue teams operating on the ground to organize their deployment. DLR and TBE seek to combine the data from other MUSES instruments to develop advanced methods for remote sensing of the Earth.

Spectrometer

Spectrometer

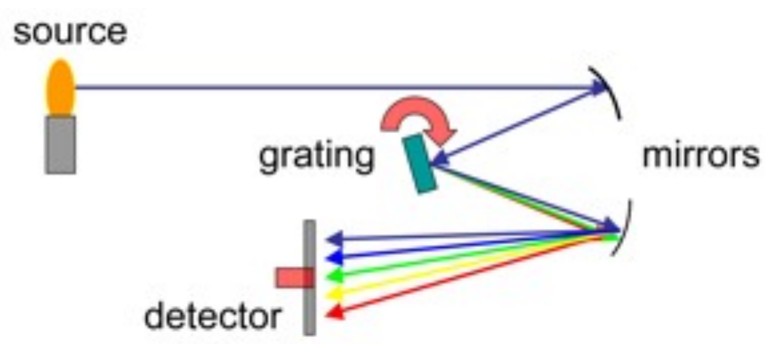


Figure 3-3. Grating spectrometer

What is a spectrometer for?

A spectrometer is an instrument used to measure properties of light over a specific portion of the **electromagnetic spectrum**, typically used in spectroscopic analysis to identify materials. The basic function of a spectrometer is to take in light, break it into its spectral components, digitize the signal as a function of wavelength, and read it out and display it through a computer.

Operating in the wavelength range from visible through the near infrared, the instrument will enable precise data acquisition from Earth's surface for applications including fire-detection, change detection, **maritime domain awareness**, and atmospheric research.

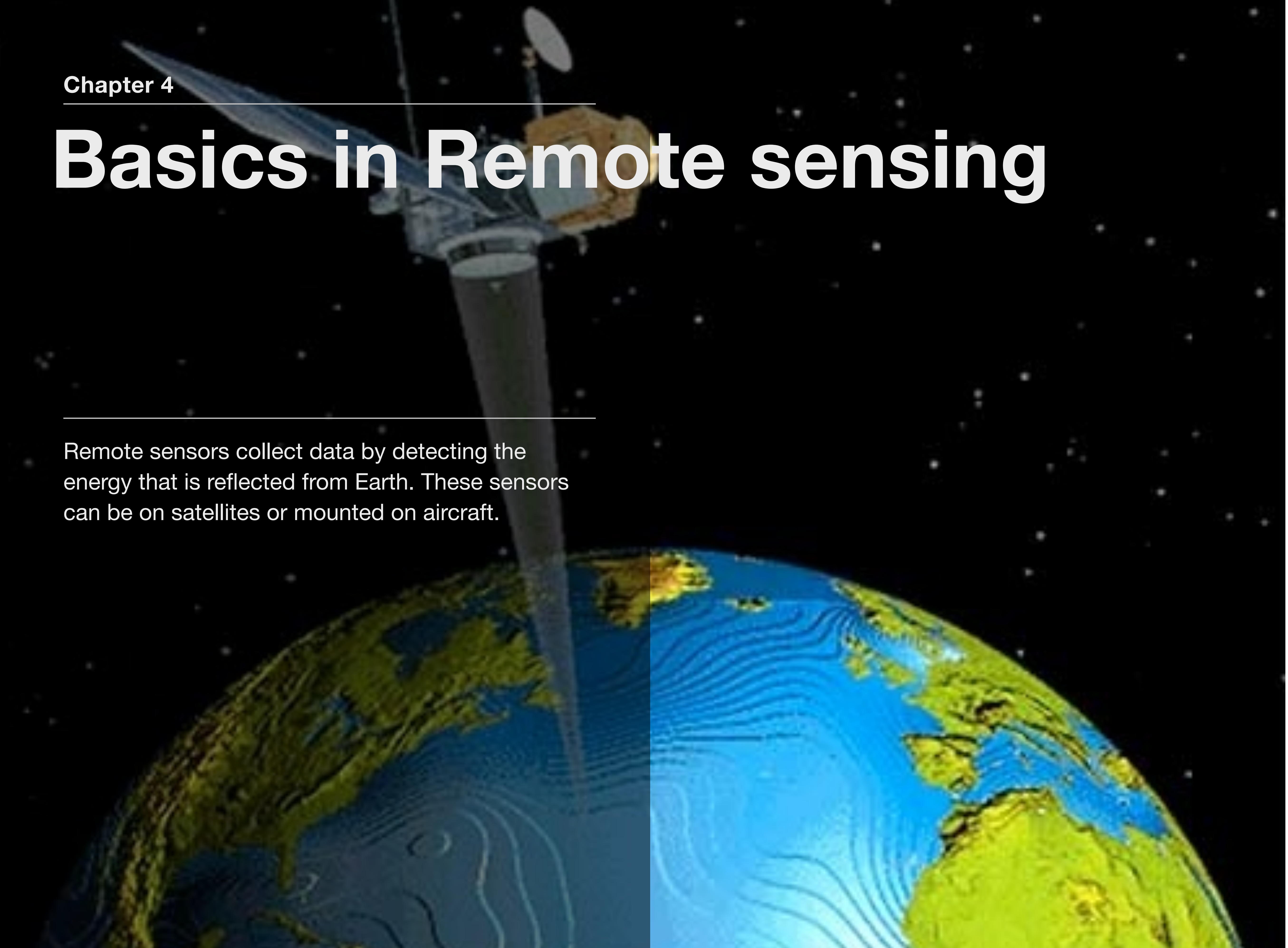
How does it work?

A spectrometer analyzes the radiation from objects. It uses a prism or a grating to spread the light from the object into a **spectrum**, a rainbow of colours. This allows scientists to detect many of the chemical elements by their characteristic fingerprints. Typically these are **dark bands** in specific locations in the spectrum caused by energy being absorbed as light passes through an atmosphere of gas. The spectrometer is the most powerful and widely used tool in astronomy aside from the telescope itself. Almost all of our knowledge of the chemical makeup of the universe comes from spectra.

Chapter 4

Basics in Remote sensing

Remote sensors collect data by detecting the energy that is reflected from Earth. These sensors can be on satellites or mounted on aircraft.



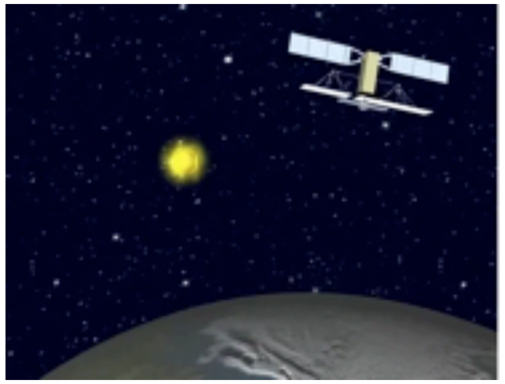
Types of Sensors

Active and passive sensors

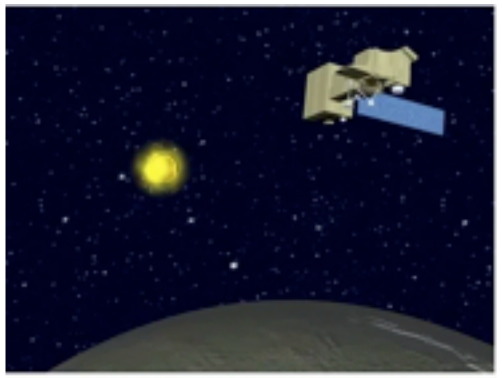
Remote sensors can be either **passive** or **active**. Passive sensors record radiation that is reflected from Earth's surface, usually from the sun. Because of this, passive sensors can only be used to collect data during daylight hours.

In contrast, **active** sensors emit radiation to collect data about Earth. For example, a radar remote sensing system projects radar waves onto the surface of Earth and measures the time that it takes for the waves to reflect back to its sensor.

movie 4-1. active sensor



movie 4-2. passive sensor



Some characteristics of sensors

Spectral resolution (**What colors - bands**)
describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.

Radiometric resolution (**Color depth**):
describes the sensor is ability to discriminate very slight differences in energy. The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

Spatial resolution (**What area and how detailed**):
describes the area of the earth that each pixel represents (the size of the smallest possible feature that can be detected).

In terms of the spatial resolution, the satellite imaging systems can be classified into:

Low resolution systems (approx. 1 km or more)

Medium resolution systems (approx. 100 m to 1 km)

High resolution systems (approx. 5 m to 100 m)

Very high resolution systems (approx. 5 m or less)

Remote sensing with eight spectral bands

Spectral responses from ground targets are recorded in separate spectral bands by sensors.
The **Landsat TM** missions began in 1982 with Landsat-4 and have continued to the present with the Landsat-8 mission.

Spatial Resolution: 30 m

Spectral Bands:
Band 1: (visual blue, 0.45-0.52μm)

Band 2: (green, 0.52-0.60μm)

Band 3: (red, 0.63-0.69μm)

Band 4: (near IR, 0.76-0.90μm)

Band 5: (mid IR, 1.55-1.74μm)

Band 6: (thermal IR 10.40-12.50μm)

Band 7: (mid IR, 2.08-2.35μm)

Some characteristics of sensors

Resolution

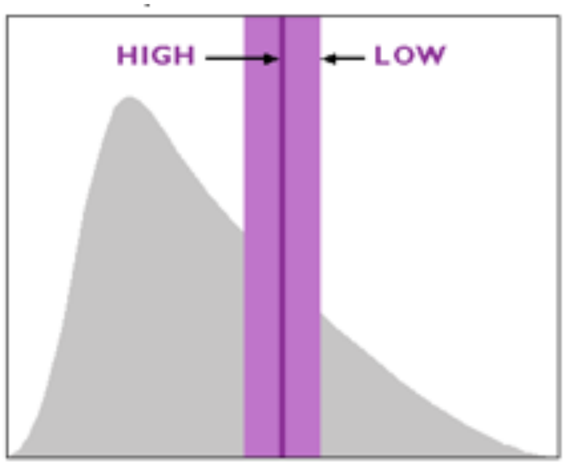


Figure 4-1. Spectral resolution

Spectral resolution: specifies the number of spectral bands in which the sensor can collect reflected radiance. The position of bands in the electromagnetic spectrum is important.

Radiometric resolution: is often called **contrast**. It describes the ability of the sensor to measure the signal strength or brightness of objects.

Spatial resolution: The spatial resolution specifies the pixel size of satellite images covering the earth surface.

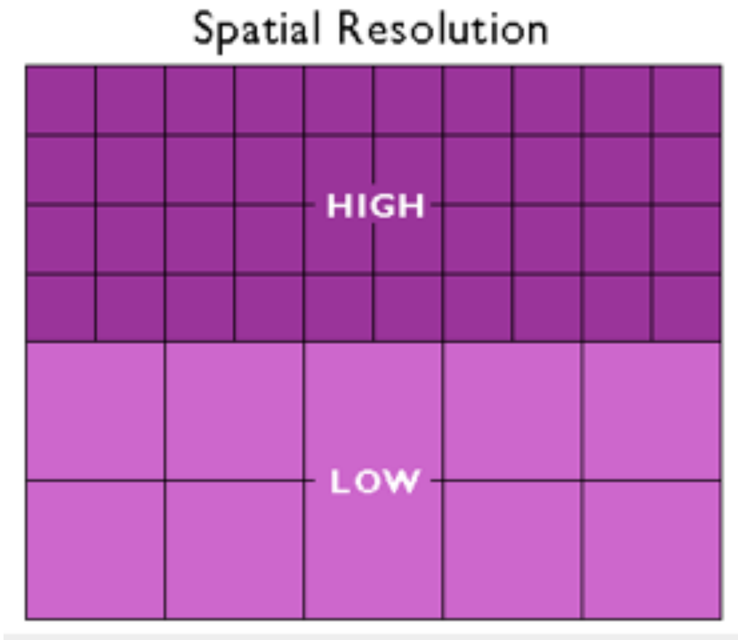


Figure 4-2. Spatial resolution

Additional information about resolution

Spectral resolution (**What colors - bands**)

describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.

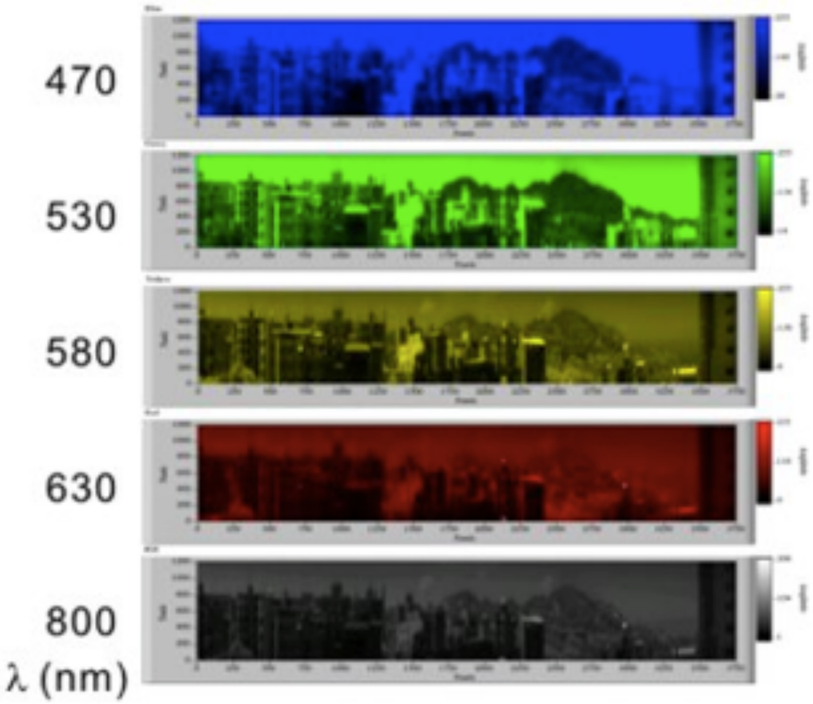


Figure 4-3. Spectral resolution

Radiometric resolution (**Color depth**):

describes the sensor is ability to discriminate very slight differences in energy. The more sensitive a sensor is to the reflectance of an object as compared to its surroundings, the smaller an object that can be detected and identified..

Spatial resolution (**What area and how detailed**):

describes the area of the earth that each pixel represents (the size of the smallest possible feature that can be detected).

In terms of the spatial resolution, the satellite imaging systems can be classified into:

Low resolution systems (approx. 1 km or more)
Medium resolution systems (approx. 100 m to 1 km)
High resolution systems (approx. 5 m to 100 m)
Very high resolution systems (approx. 5 m or less)

Images of the ground

Different spectra for several materials

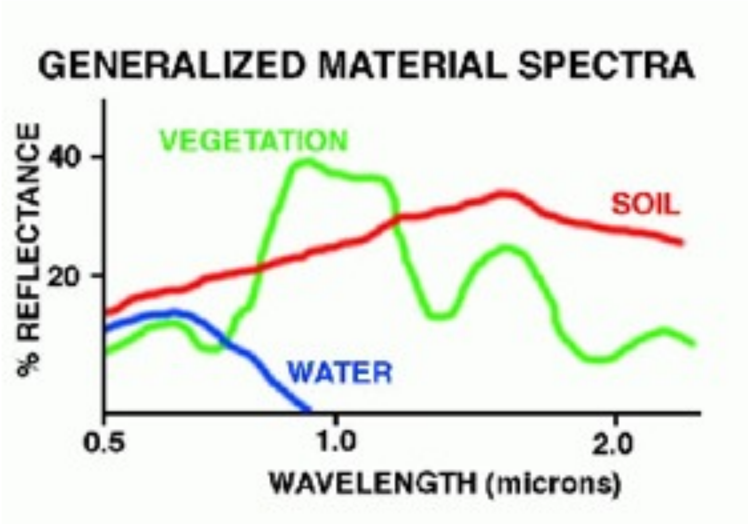


Figure 4-4. Spectra

If we take a look at the figure left next. This shows three curves, each called a spectrum, for three different materials (vegetation, soil, water). In each spectrum, the percentage of light that is reflected is shown as a function of wavelength. Notice that "vegetation" is very bright about 1.0 microns compared to soil. Using these spectra, we can understand the relative contrast of the water, vegetation and the soil. So we scan the earth's surface at several wavelength. This gives us data sets (images) with brightness values. Black colour means low brightness and white colour represents high brightness.

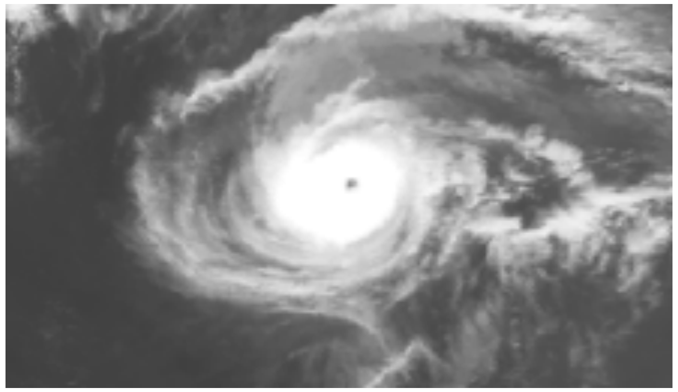
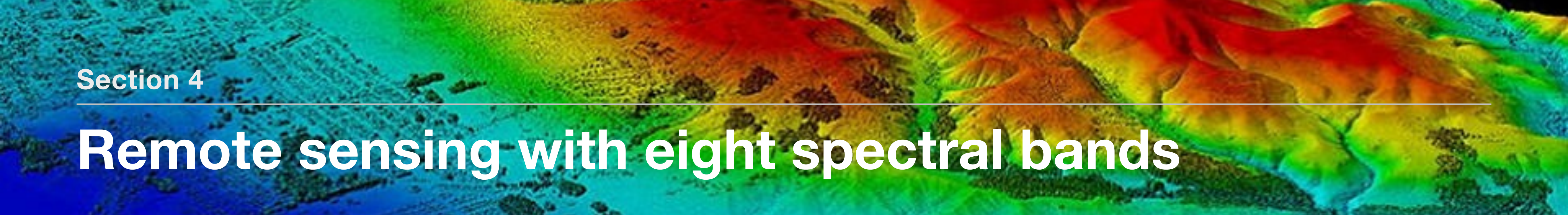


Figure 4-5. Picture created from a dataset recorded at Near InfraRed (wavelength: 0.76-0.90µm)



Remote sensing with eight spectral bands

LANDSAT - 8 BANDS

Spectral responses from ground targets are recorded in separate **spectral bands** by sensors. The **Landsat TM** missions began in 1982 with Landsat-4 and have continued to the present with the Landsat-8 mission.

Spectral Bands:

Band 1: (visual blue, 0.45-0.52µm)

Band 2: (green, 0.52-0.60µm)

Band 3: (red, 0.63-0.69µm)

Band 4: (near IR, 0.76-0.90µm)

Band 5: (mid IR, 1.55-1.74µm)

Band 6: (thermal IR 10.40-12.50µm)

Band 7: (mid IR, 2.08-2.35µm)

Band 8: (Panchromatic, 0.50-0.68µm)

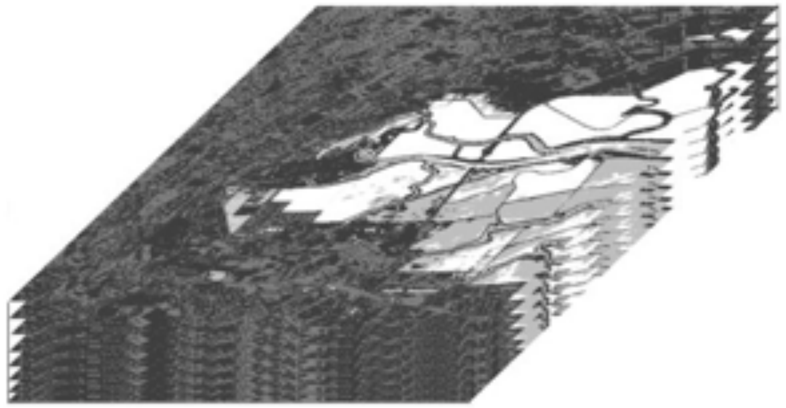
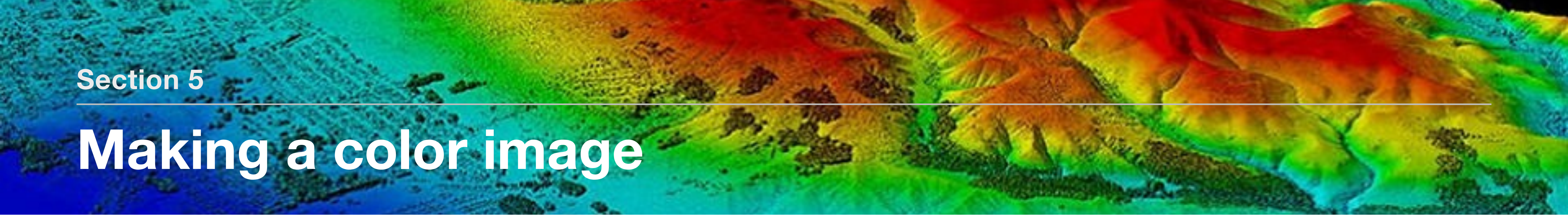


Figure 4-6. Eight pictures taken at several wavelength



Making a color image

RED-GREEN-BLUE results colorful

Just like a color television set, our computer screen can display three different images using blue light, green light and red light. The combination of these three wavelengths of light will generate the color image that our eyes can see.
Step2: So, if we display now Band 3 in blue light, Band 5 in green light, and Band 4 in red light we get the relative contrast between the three images. More importantly, when these three colors are combined (STEP3), we get our color image, which we call a "false color image", because it has nothing to do with the colors we see with our eyes.

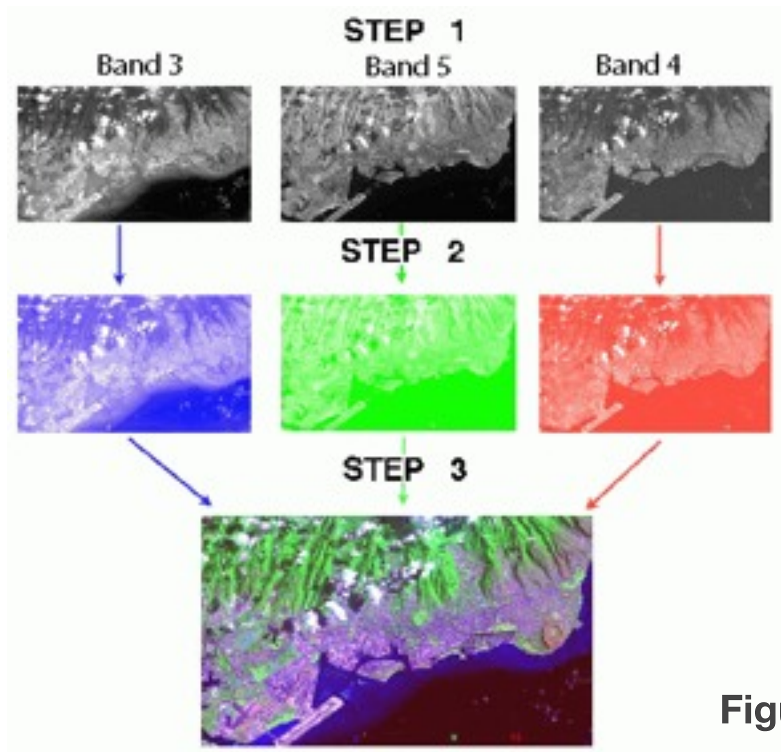


Figure 4-7. False colour image

Figure 4-8. TRUE-COLOR-IMAGE: 3-2-1

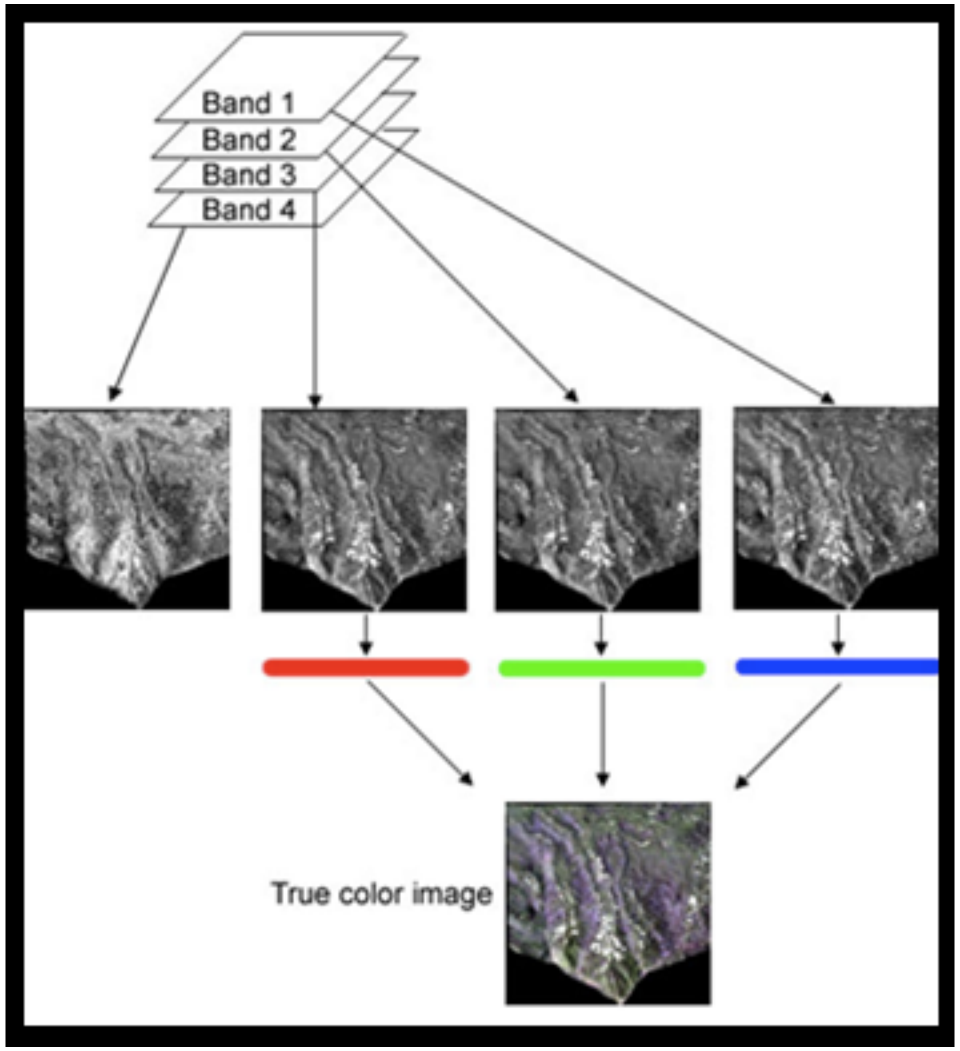
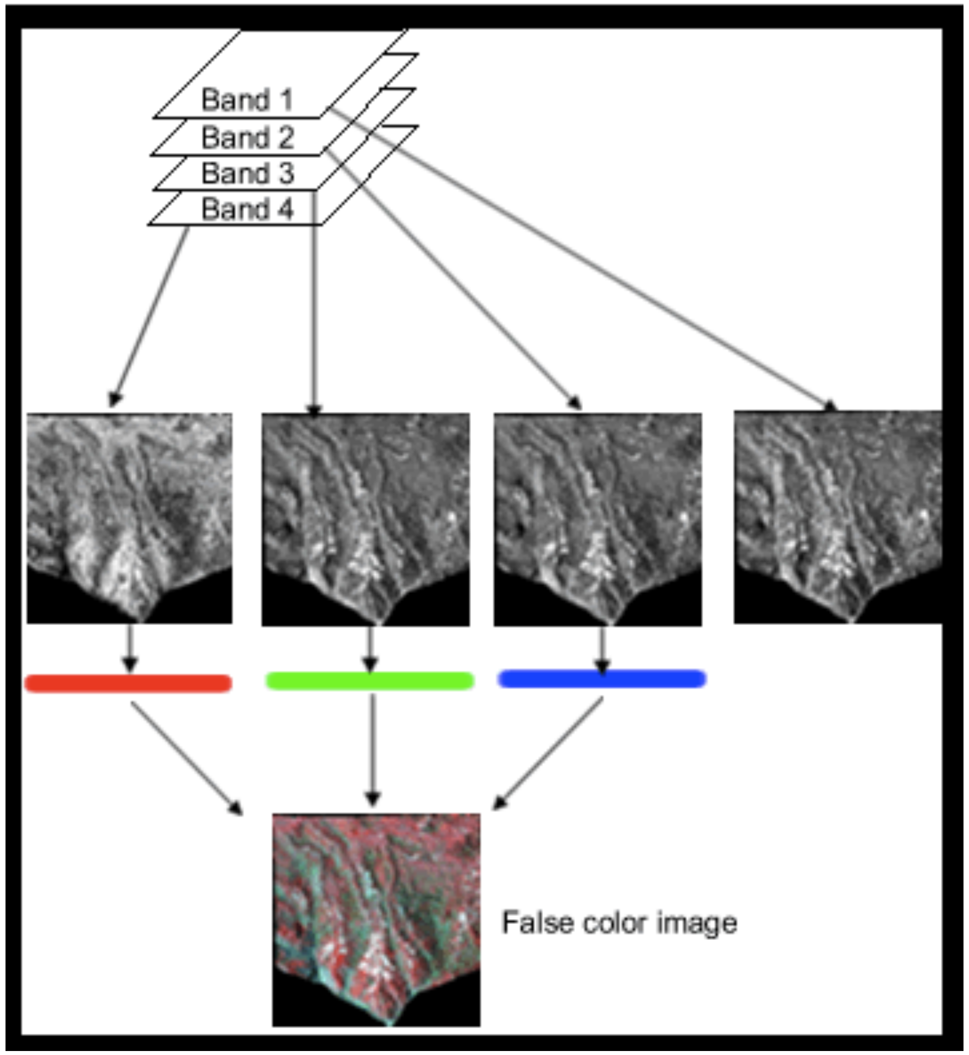


Figure 4-9. FALSE-COLOR-IMAGE: 4-3-2



Grayscale images are displayed by assigning them to one of these color filters: **R**ed-**G**reen-**B**lue.

In order to see an image the way our eyes would normally see it, we would assign the **red band** (**band3**) to a red filter, the **green band** (**band2**) to a green filter, and the **blue band** (**band1**) to a blue filter. This band and color combination is producing a "**True Color Image.**"

However, it is sometimes useful to assign bands to unusual color filters, thus producing a "**False Color Image.**" For example, if we assign the near-infrared (NIR) band to **red**, the red band to green, and the green band to blue, we produce a commonly used combination used to study vegetation. Vegetation is characterized by very high **NIR** reflectance. Adding the NIR band to an image display helps to distinguish vegetation zones.

Image processing software: LEOWORKS

Basics in LEOWORKS 4

LEOWorks is an image processing software for educational use. It can be applied to display, analyze, enhance and interpret images from Earth Observation satellites. LEOWorks is available free of charge (http://leoworks.asrc.ro/). An extensive tutorial is available.
Now LEOWorks 4 will be used to demonstrate creating TRUE-COLOR or FALSE-COLOR images:

Figure 4-10. LEOWORKS 4

Step 1: Open **LEOWORKS 4**

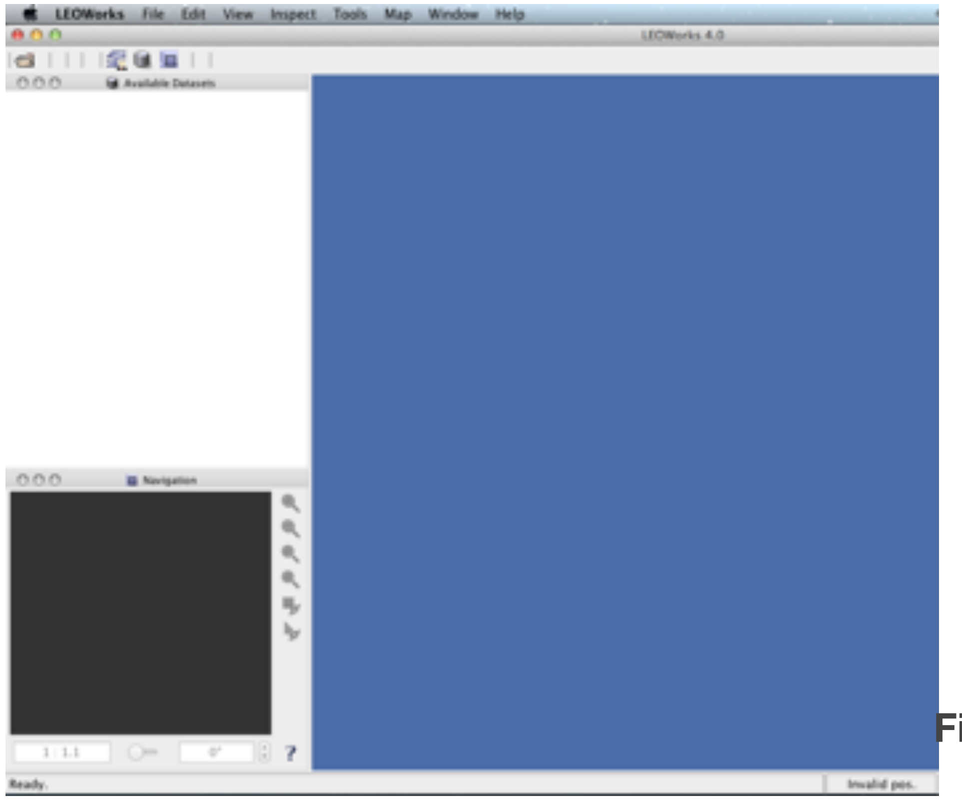


Figure 4-11. LEOWORKS 4

Step 2: We choose a data set which consists of 4 files.

(The data are about Alban Hills from the Landsat 7 satellite system: Band 1, Band 2, Band 3 and Band 4)

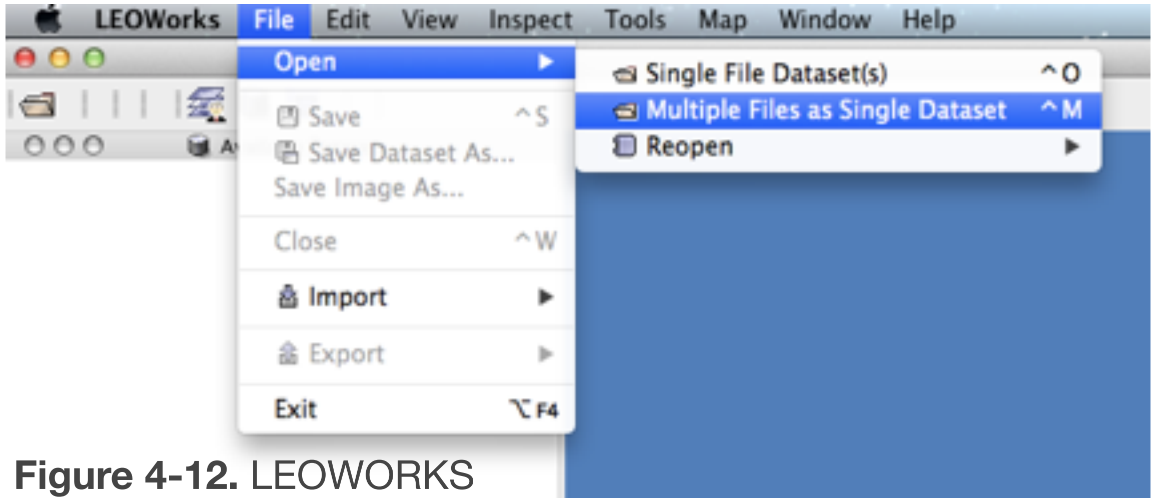


Figure 4-12. LEOWORKS

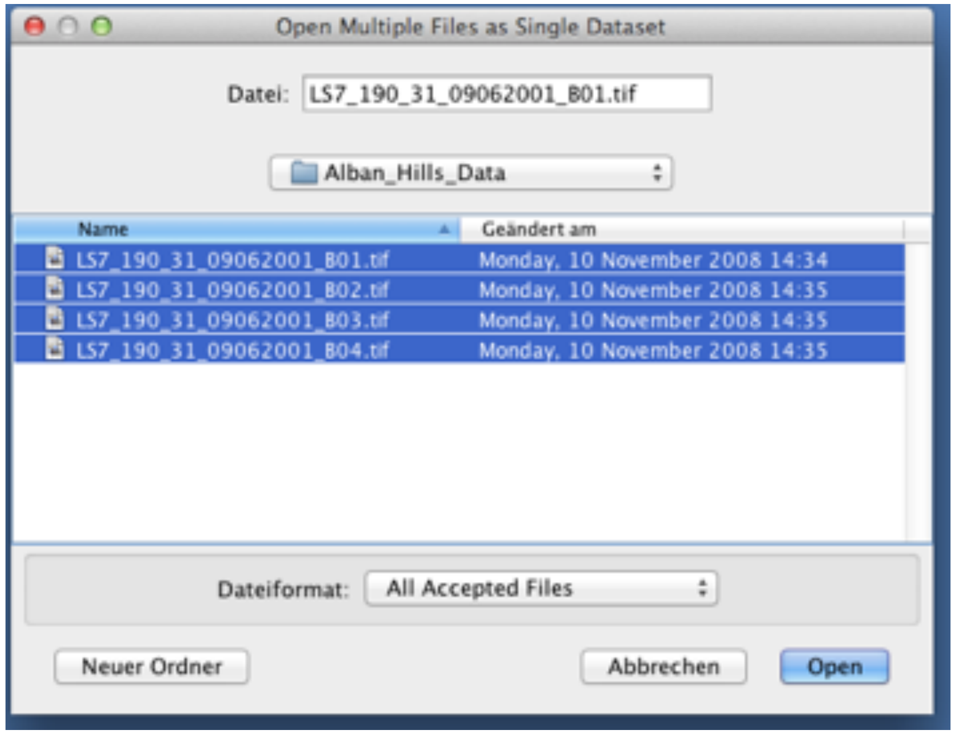


Figure 4-13. LEOWORKS

The filename says that the data set was taken by Landsat 7 (LS7) in 2001. The bands are classified as **B01**, **B02**, **B03** and **B04**.

Step 3: A name for the modified data set is required.

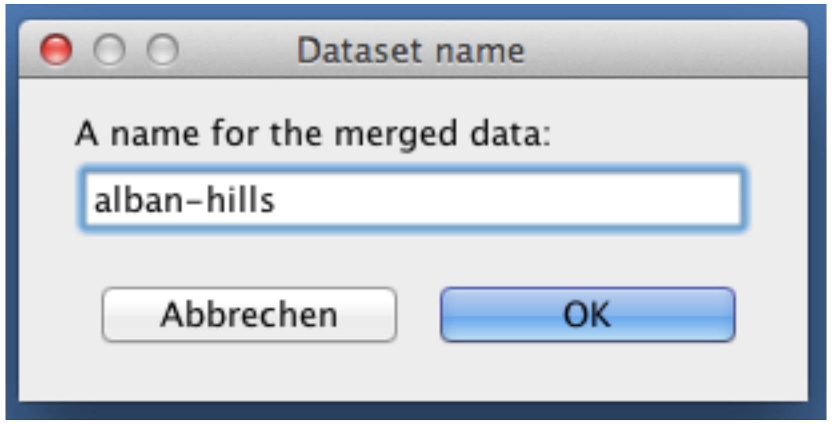


Figure 4-14. LEOWORKS

By clicking on *OK* you can see that the data set has been imported:

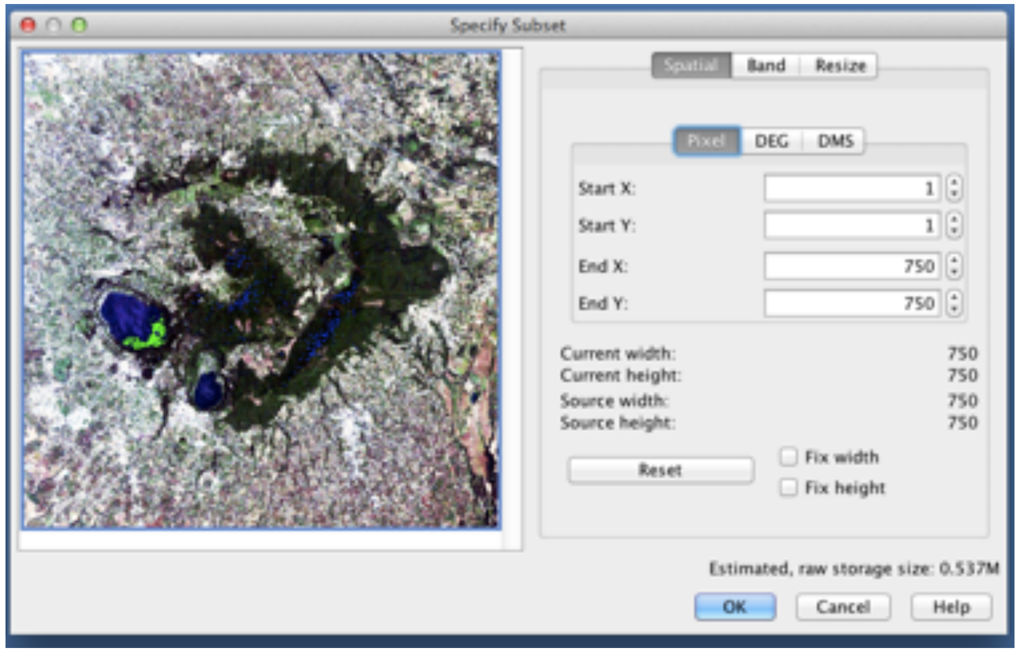


Figure 4-15. LEOWORKS

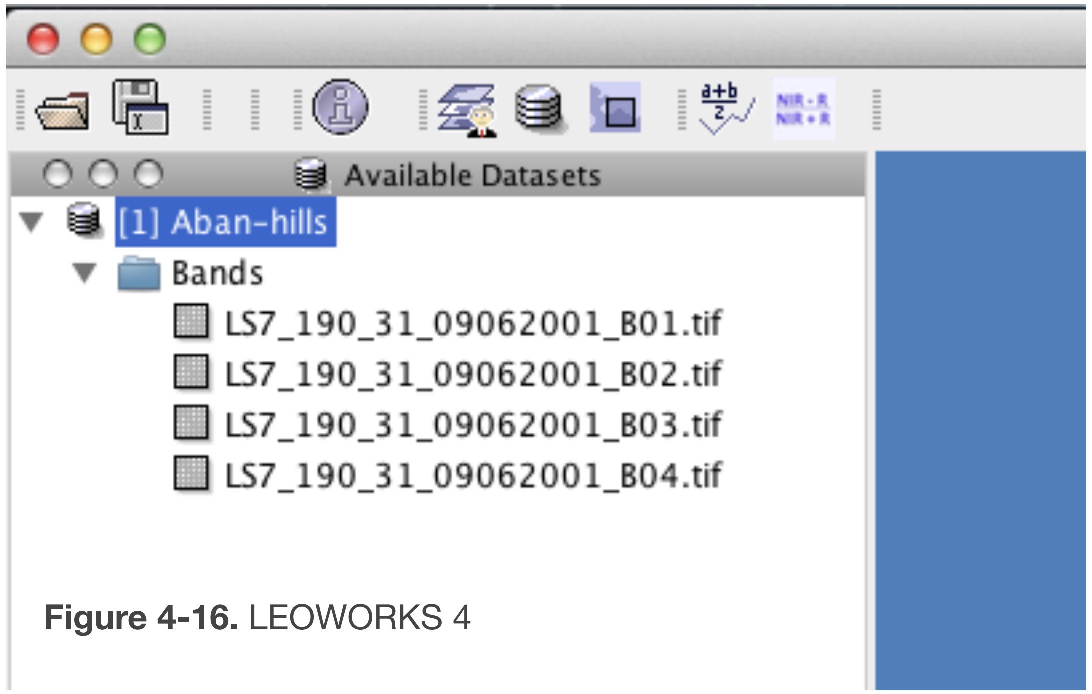


Figure 4-16. LEOWORKS 4

Step 4: After clicking on the the first file of the data set (LS7_190_31_09062001_B01.tif) you can see a dark gray image. Now we need to investigate power of a common image processing routine for improving scene quality. That means image enhancement by ***stretching***.

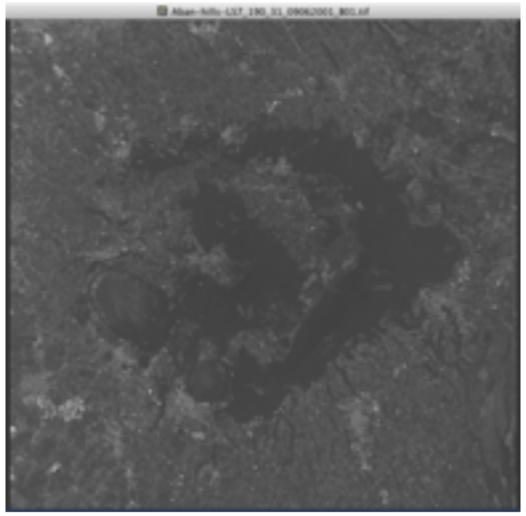


Figure 4-17. LEOWORKS 4

After clicking the button  a window for ***stretching*** appears:

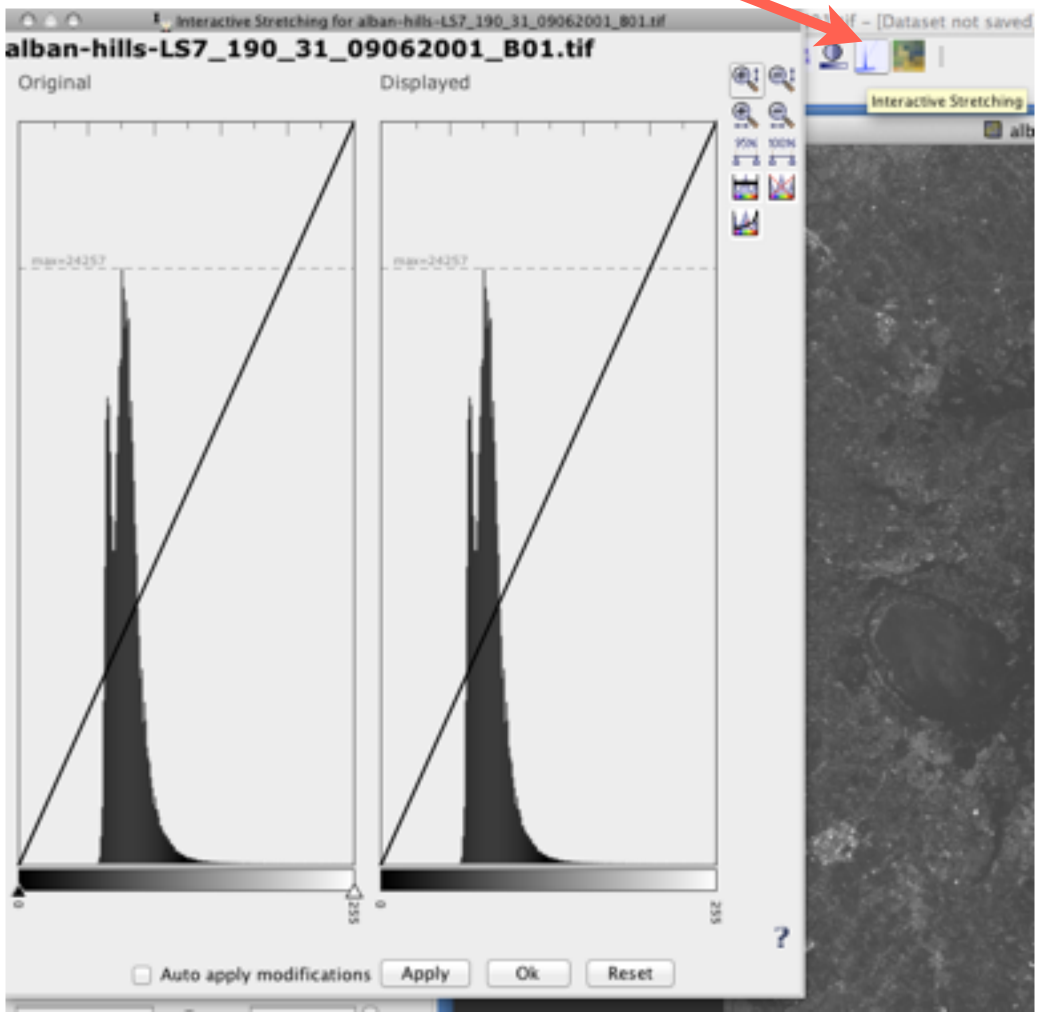


Figure 4-18. LEOWORKS 4

The process ***stretching*** enhances the contrast in the image with light toned areas appearing lighter and dark areas appearing darker, making visual interpretation much easier.

Procedure: **contrast stretching**

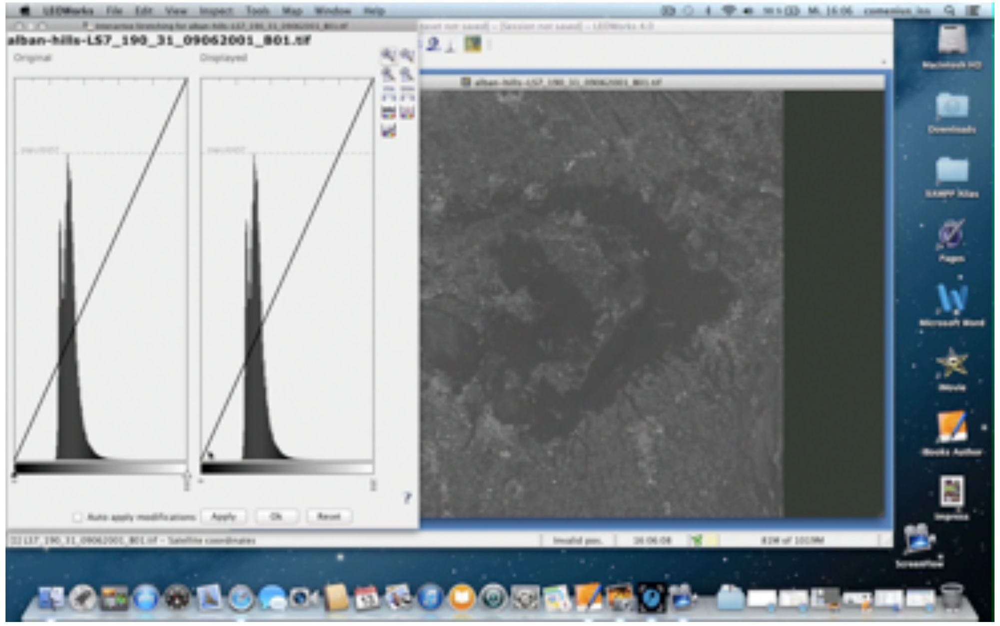
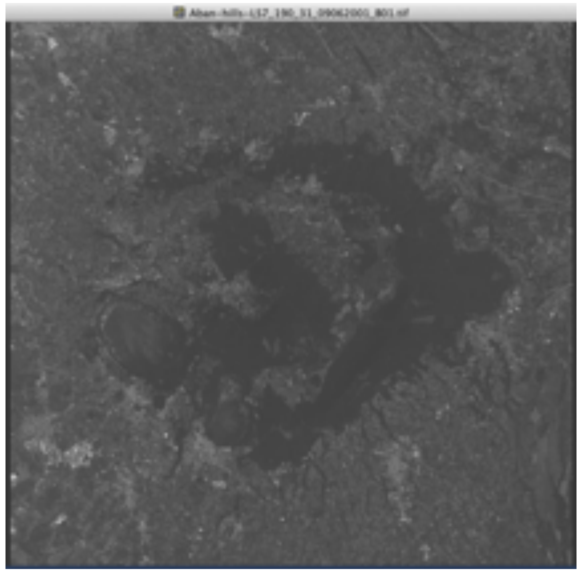
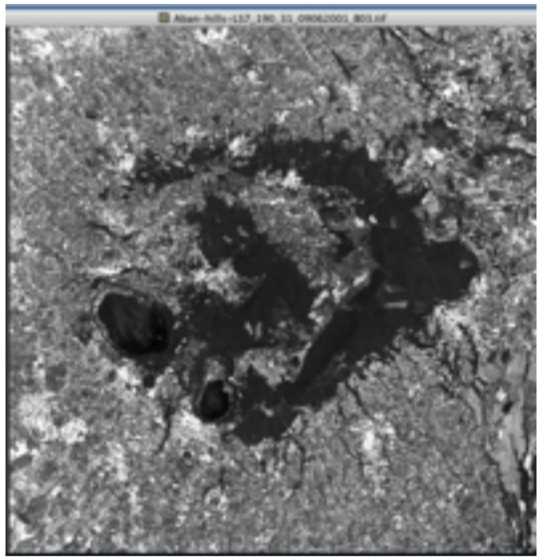


Figure 4-19. LEOWORKS 4



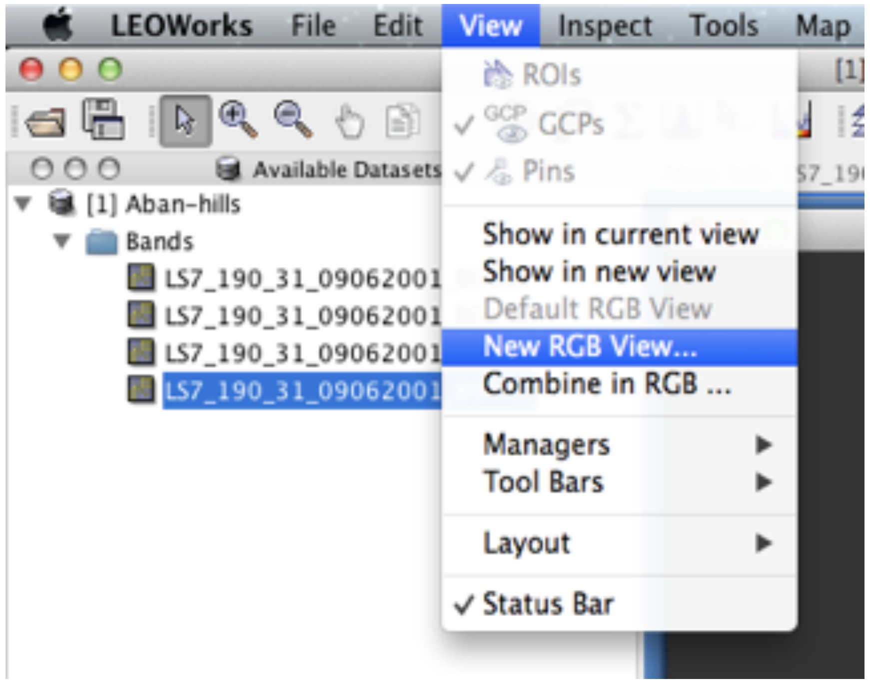


after stretching: higher contrast

You have to do this process with every 4 files.

Step 5: Create a TRUE-COLOR-Image

Please do the following steps:



Be careful: B03 -> Red

B02 -> Green

B01 -> Blue

Figure 4-20. LEOWORKS 4

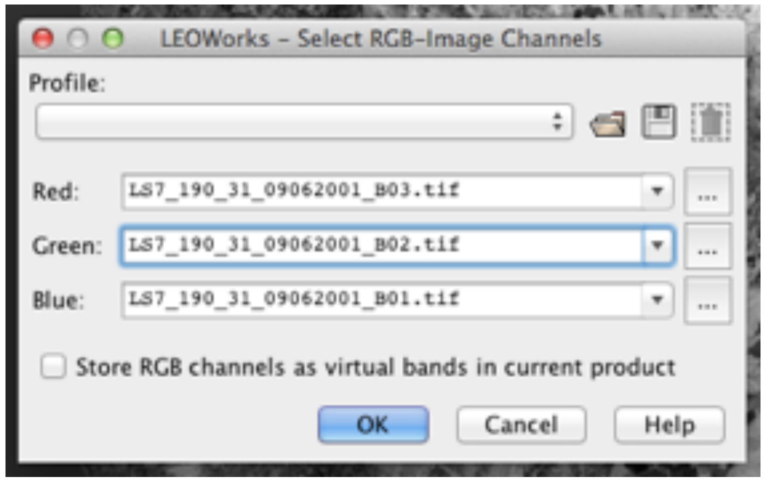


Figure 4-21. Alban hills, true colour **image**

Satellite images are not photographs but pictorial presentations of measured data. Satellite systems measure electromagnetic radiation in different wavelength or bands.
For a human eye water is blue and the wood is green as we can see in this image.

It is the same procedure for generating a **FALSE-COLOR**-Image. But for this case we have to boserve the following allocation:

B04 -> **Red**

B03 -> **Green**

B02 -> **Blue**

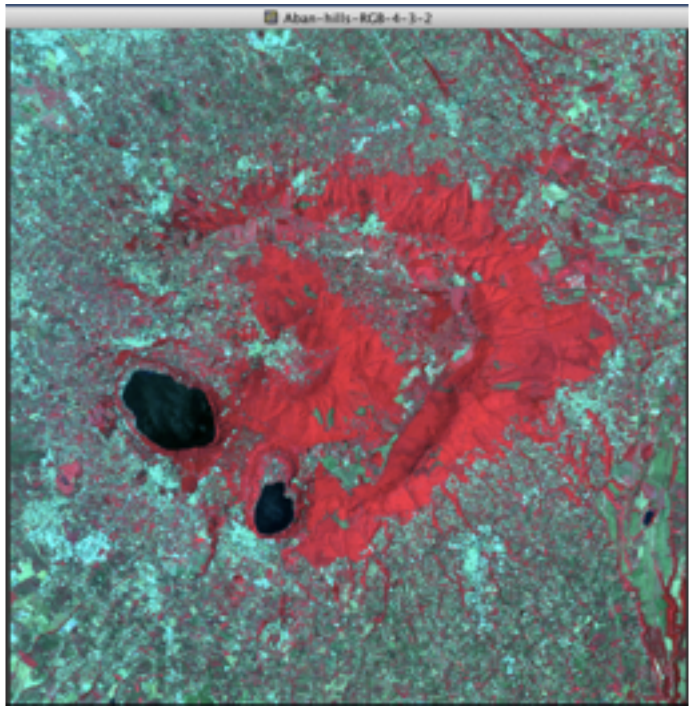


Figure 4-22. Alban hills, false colour **image**
Most of the reflected light of vegetation is infrared.

The reflected radiation by plants, which has a high peak in the near-infrared band. The human eye isn‘t able to see infrared. So, we display Band 4 (infrared) in red light. On a false colour infrared image vegetation that will appear in bright red (near-infrared), water will appear practically black because this material absorbs practically all wavelength.

Chapter 5

Remote sensing of glacier change

There is a strong evidence that glaciers are retreating in many regions of the world. Recent studies show that this process is also likely to accelerate in the future. This have significant implications as glaciers are perceived as one of the key indicators of global climate change. Furthermore their melting have strong impact on water resources.

Satellites show how our icy world is melting

GLACIER PASTERZE

Figure 5-1. Google maps

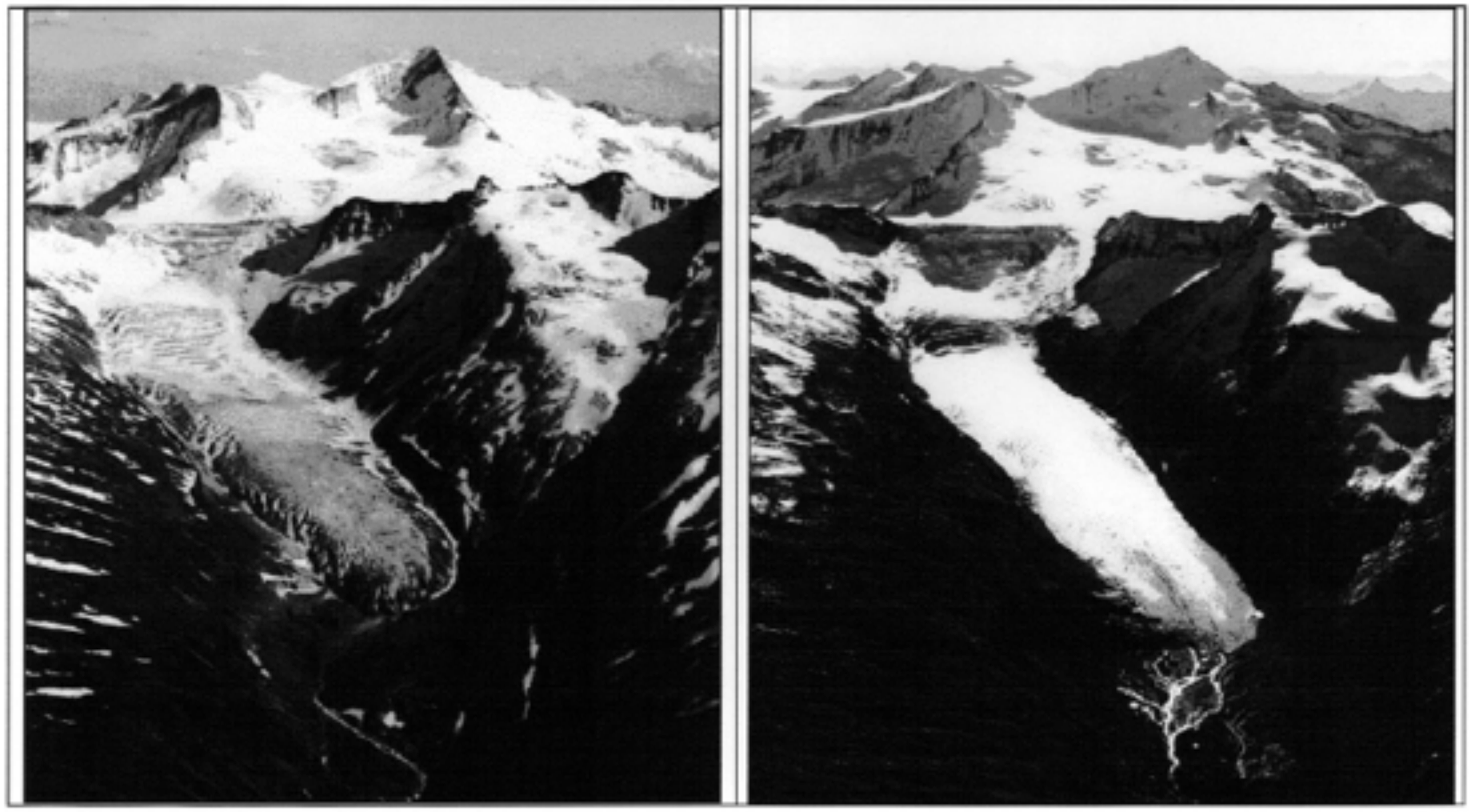


Figure 5-2. 1987 Venedigergruppe - Untersulzbachtal, Austria 1999

Due to the current rapid change of high-mountain environments, **hazard** assessments shall be undertaken routinely and regularly, combined with continuous monitoring. Remote sensing is particularly suited for both regular and rapid observation. Remote sensing images acquired from different platforms (satellite, aircraft) using sensors that operate in different spectral regions (visible, infrared, microwave) have been widely used to study glaciers, e.g. to measure ice thickness, surface ice velocities, and changes in surface elevation over time. Remote sensing techniques have been used for spectral characterization of different snow and ice facies. Recent developments in remote sensing open up new possibilities for the assessment of natural hazards in general, and glacier and permafrost hazards in particular. Remote sensing will therefore substantially gain importance for such works in the near future.

Pasterze - glacier in Austria

Fig.5-3. Großglockner mit Pasterze von der Franz-Josefs-Höhe (Foto: H. SLUPETZKY, 2003)

Changes of glacier Pasterze between 1984 and 2013

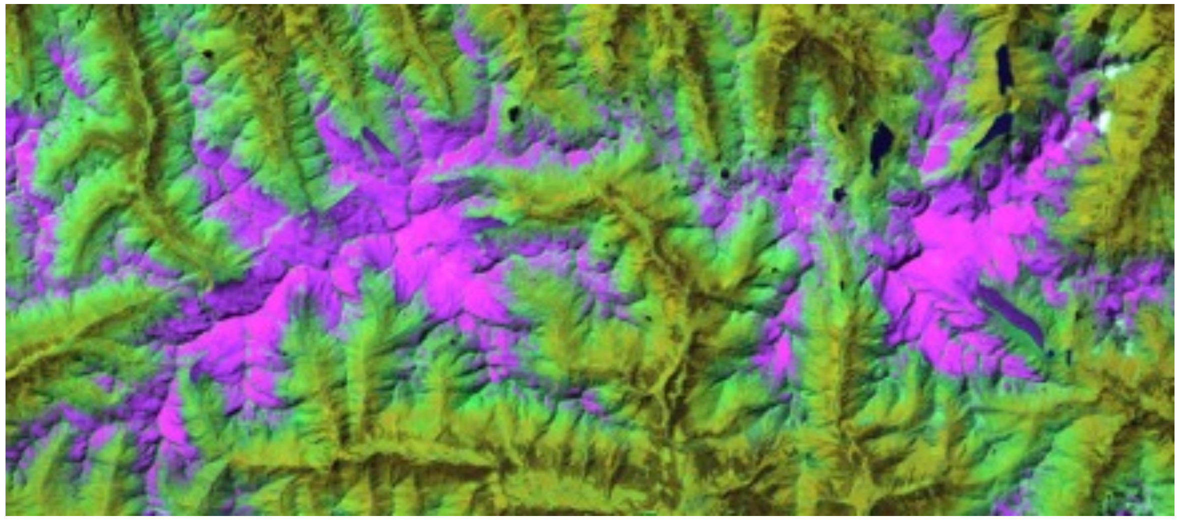


Figure 5-4. Created with LEOWORKS 4

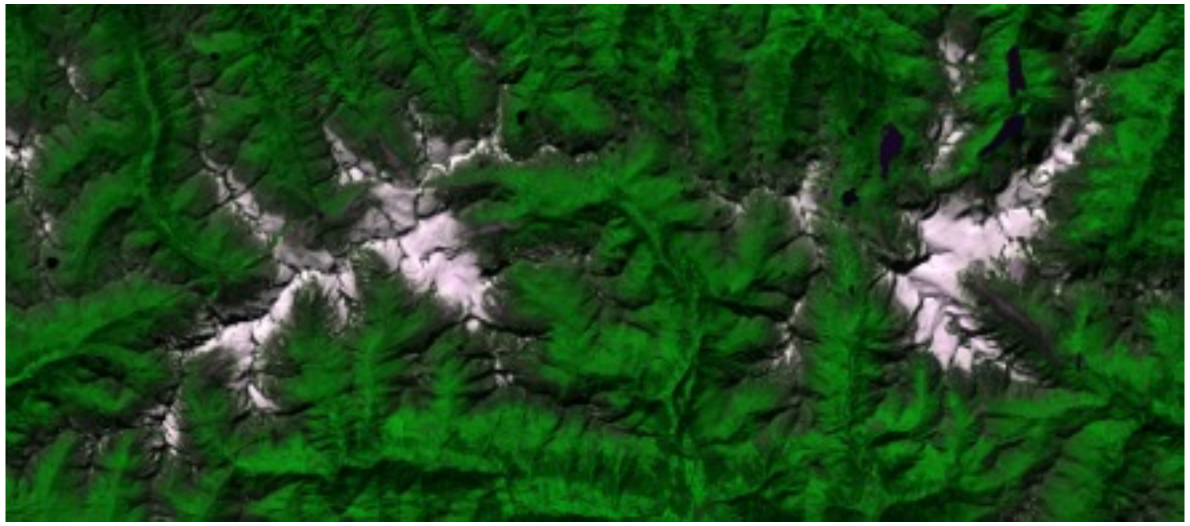


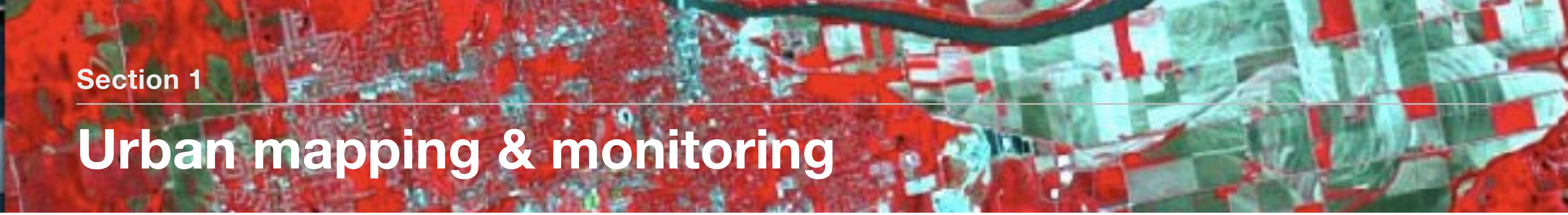
Figure 5-5. Created with LEOWORKS 4

These *false color images* show the melt-off from the glacier Pasterze over zwenty nine years based on satellite data from USGS (http://glovis.usgs.gov/).

Chapter 6

Urban remote sensing

The concentration of people in densely populated urban areas, especially in developing countries, calls for the use of monitoring systems like remote sensing. Such systems along with spatial analysis techniques like digital image processing and geographical information system (GIS) can be used for the monitoring and planning urbans.



Urban mapping & monitoring

RIYADH and SHANGHAI are fast changing cities

Fig.6-1.

Fig.6-2.

The immense urbanization in recent history is a worldwide phenomenon, but not even two cities in the world became identical. The only consistent thing about cities is that they are always changing. Urbanization may be linked with details of topography, transportation, land use, social structure and economic type, but is generally related to demography and economy in a city. The most obvious consequence results in spatial expansion, often described as '**urban sprawl**'
Drivers of urban development and urban sprawl are highly diverse: economic growth, rising living standards, price of land, availability of cheap agricultural land, housing preferences (more space per person, etc.), inner city problems (poor air quality, noise, small apartments, lack of green open space, private car ownership, availability of roads, low cost of fuel, etc.

The causes and consequences of urbanization mostly have a reference to space. Thus, for most of the challenges related to urbanization, spatial knowledge is required of urban and spatial planning.

Unfortunately, conventional sources of information on urban areas are frequently inadequate. The necessary data are often generalized, outdated, unreliable, not in standard format, or in some cases simply unavailable.
As one data source, remotely sensed data are inherently suited to provide information on urban land cover characteristics, and their change over time, at

various spatial and temporal scales. Beyond this, Earth observation provides an independent data source.

Remote sensing supports urban monitoring. An interdisciplinary outreach underlines the need for research in this direction for a broader understanding and bigger picture of the situations in the complex and dynamically changing cities on our planet.

In recent years remote sensing data have become important technique for change detection applications.

Here are two examples for urban development: RIAD, SHANGHAI

These false color images show the development of the cities in the period from 1983 to 2013 based on satellite data from USGS (http://glovis.usgs.gov/).

RIAD 1972

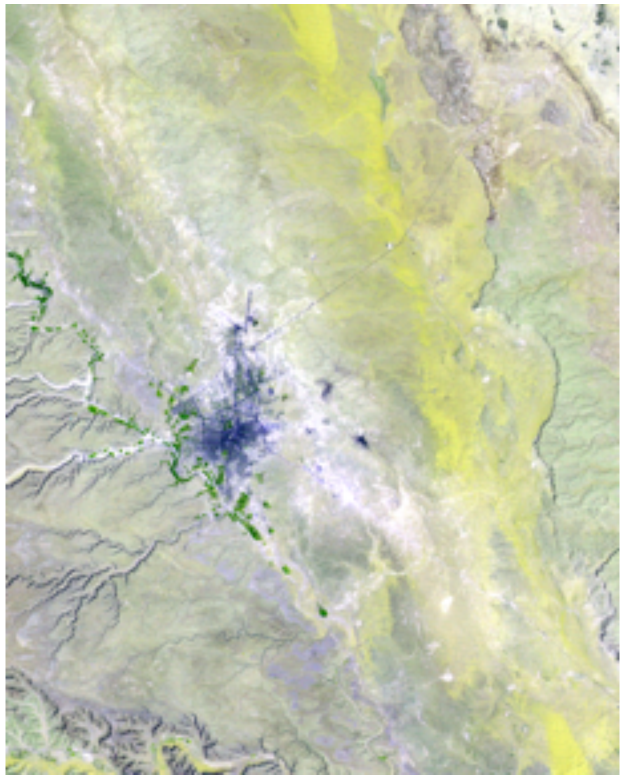


Fig. 6-3.

RIAD 2013

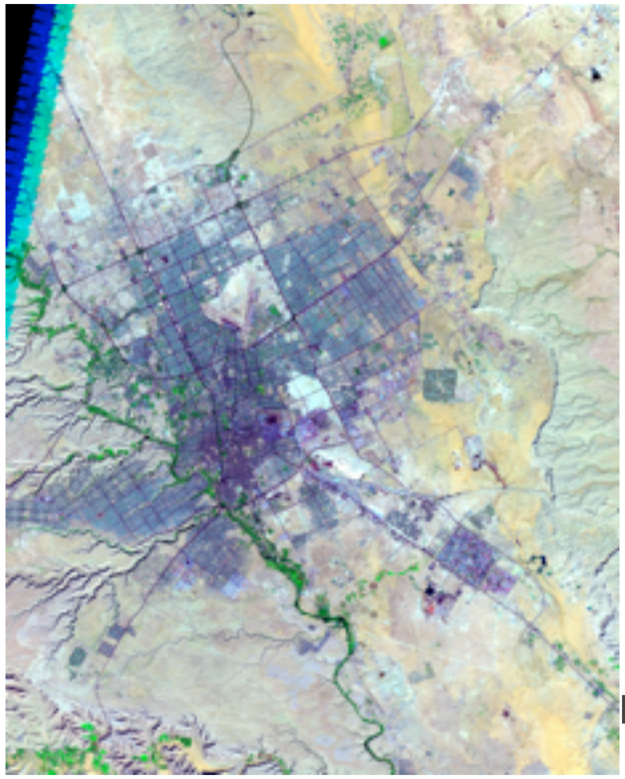


Fig. 6-4.

SHANGHAI 1972

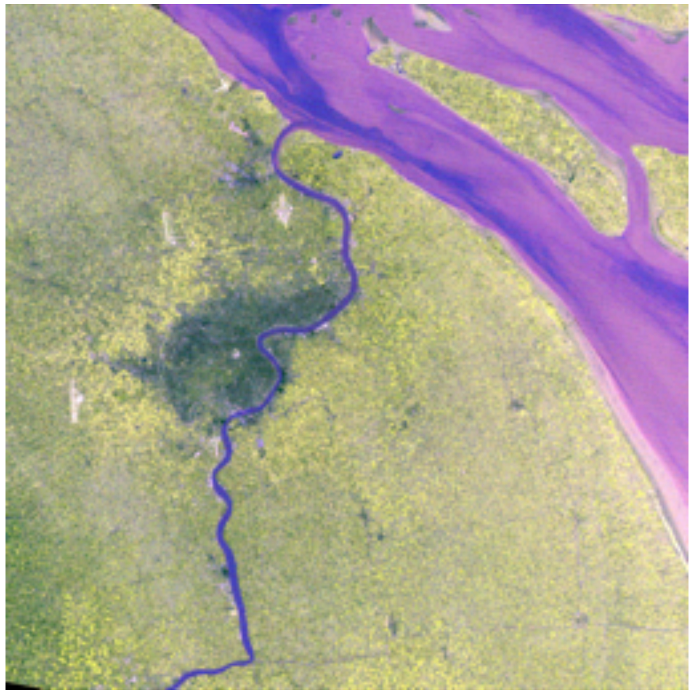


Fig. 6-5.

SHANGHAI 2013

Fig. 6-6.

	1972	2013
RIAD	500000	5 millions
SHANGHAI	11 millions	24 millions

Growth of population

List of sources

http://...

Cover:
http://www.dlr.de/dlr/en/Portaldata/1/Resources/bilder/portal/portal_2012_5/MUSES_Cover.jpg

Cover *MUSES_Cover_l.jpg*
http://www.dlr.de/dlr/desktopdefault.aspx/tabid-10376/684_read-10329#/gallery/14860

Intro-movie *dlr_iss.mov*
http://www.dlr.de/dlr/desktopdefault.aspx/tabid-10081/151_read-8396/#/gallery/12507

remote-sensing.jpg http://oceanservice.noaa.gov/facts/remotesensing.html

page 2 (header)
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Figure1-1.
http://www.iss-casis.org/Opportunities/Solicitations/RFPRemoteSensing.aspx

Figure1-2. http://www.ibtimes.co.uk/planet-earth-nasas-international- space-stati-on-1445049

page 3 (backgroung) http://www.dlr.de/os/desktopdefault.aspx/tabid-9294/

Figure2-1.
http://www.waaytv.com/space_alabama/huntsville-company-finds-opportunity-on-iss/article_4fc9d9b6-2c71-11e4-b3c4-0017a43b2370.html

Figure2-2. http://www.trigis.de/taxonomy/term/131/0

Figure2-3. http://www.fe-lexikon.info/lexikon-r.htm

Figure2-4. http://commons.wikimedia.org/wiki/File:Sakurajima_oli_2013327_lrg.jpg

Figure3-1.
http://www.google.de/imgres?imgurl=http://www.dlr.de/os/Portaldata/48/Resources/images/projekte/eo/desis/MUSES_DESIS.jpg&imgrefurl=http://www.dlr.de/os/desktopdefault.aspx/tabid-9294/&h=415&w=600&tbnid=kvjUdBva-xqnTM&zoom=1&tbnh=187&tbnw=270&usg=__woWojOChOIGi_mQxxk4lFtXXT1I=&docid=mB5aLBiR4eY6RM

Figure3-2.
http://www.google.de/imgres?imgurl=http%3A%2F%2Fbloximages.newyork1.vip.townnews.com%2Fwaaytv.com%2Fcontent%2Ftncms%2Fassets%2Fv3%2Feditorial%2F7%2F60%2F760c98b4-2c73-11e4-936e-0017a43b2370%2F53fb632d049e7.image.png%253Fresize%253D760%25252C428&imgrefurl=http%3A%2F%2Fwww.waaytv.com%2Fspace_alabama%2Fhuntsville-company-finds-opportunity-on-iss%2Farticle_4fc9d9b6-2c71-11e4-b3c4-0017a43b2370.html&h=428&w=760&tbnid=BwFKUv5wJtyU_M%3A&zoom=1&docid=R9j1sABK_UBOYM&ei=W6UjVbPqHIraapONgagK&tbm=isch&iact=rc&uact=3&dur=1450&page=1&start=0&ndsp=1&ved=0CCEQrQMwAA

Figure3-3. http://telecomteststation.com/lets-demystify-the-osa/

Page 11 (background)
http://www.seos-project.eu/modules/oceancurrents/oceancurrents-c06-p03.de.html

Page 12 ... 20 (header) http://www.aoc.noaa.gov/aircraft_kingair.html

Movie 4-1.
http://www.seos-project.eu/modules/remotesensing/remotesensing-c02-p02.html

Movie 4-2.
http://www.seos-project.eu/modules/remotesensing/remotesensing-c02-p02.html

Figure 4-1. https://www.e-education.psu.edu/natureofgeoinfo/c8_p7.html

Figure 4-2. https://www.e-education.psu.edu/natureofgeoinfo/c8_p7.html

Figure 4-3.
https://www.itrc.narl.org.tw/Research/Product/Remote/hyperspectral2.jpg

Figure 4-4.
http://www.google.de/imgres?imgurl=http%3A%2F%2Fsatftp.soest.hawaii.edu%2Fspace%2Fhawaii%2Fvfts%2Foahu%2Frem_sens_ex%2Fspectral.4.468x450.gif&imgrefurl=http%3A%2F%2Fsatftp.soest.hawaii.edu%2Fspace%2Fhawaii%2Fvfts%2Foahu%2Frem_sens_ex%2Frsex.spectral.3.html&h=450&w=468&tbnid=FyiaD9gmdjkiOM%3A&zoom=1&docid=3f8-Z63Vq5Dk3M&ei=cb3gU6veEMGI7Aa60YGQDQ&tbm=isch&iact=rc&uact=3&dur=1202&page=2&start=17&ndsp=17&ved=0CHwQrQMwHA

Figure 4-5.
http://www.data.jma.go.jp/mscweb/en/VRL/resource/rgb_composites/RGB-4a.pdf

Figure 4-6.
http://www.intechopen.com/books/geoscience-and-remote-sensing/multivariate-time-series-support-vector-machine-for-multispectral-remote-sensing-image-classificatio

Figure 4-7.
http://satftp.soest.hawaii.edu/space/hawaii/vfts/oahu/rem_sens_ex/rsex.spectral.3.html

Figure 4-8./4-9.
http://www.google.de/imgres?imgurl=http://www.ctahr.hawaii.edu/miuralab/projects/makaha/assets/TrueFalseColorQB.png&imgrefurl=http://www.ctahr.hawaii.edu/miur

alab/projects/makaha/intro_RS.html&h=395&w=710&tbnid=xWeH1yH-awQJSM:&zoom=1&tbnh=89&tbnw=160&usg=__7IX7UejpN3d6jYno44opVENWdC8=&docid=k-QIQz3bqO8PkM

Figure 4-10. ... 4-20. Screenshots of LEOWORKS 4

Figure 4-21./4-22. http://www.esa.int/Education/8._Digital_image_processing

Page 25 (background) / Page 26 (header)
http://www.taringa.net/posts/imagenes/2599744/Excelentes-Imagenes-aereas.html

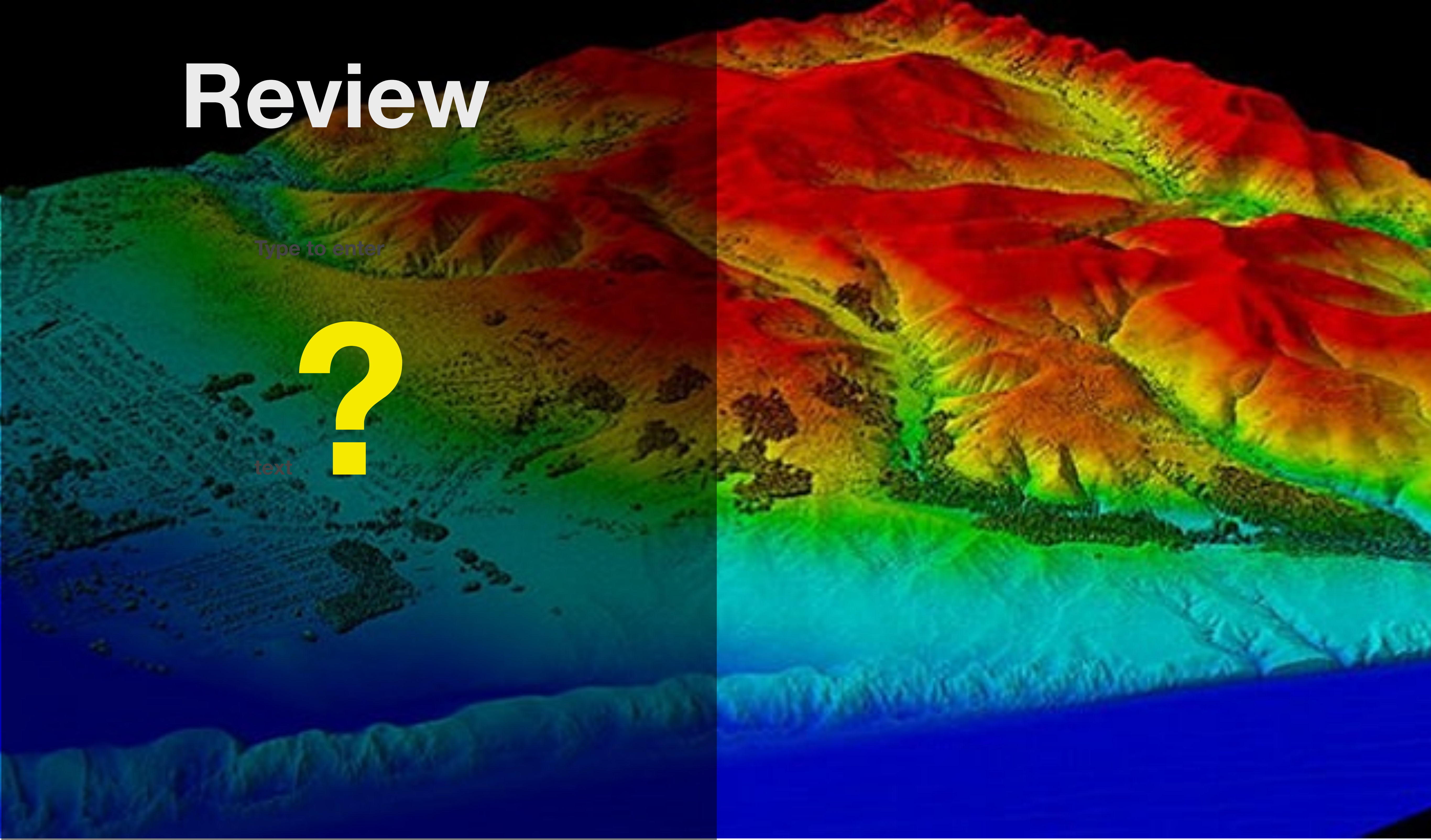
Figure 5-1./5-2. GEOSPACE Bericht, BMU, Gletscherkartierung, GSP 99/D006-GLE, V1.0, 15.12.1999, Seite 15

Page 28 (background) / Page 29 (header) http://glovis.usgs.gov/

Figure 6-1./6-2. Google maps

Figure 6.3 ... 6.6 http://glovis.usgs.gov/ processed the files using LEOWORKS 4

Review



Type to enter text

?

Question 1 of 6

What is remote sensing?

- **A.** Remote sensors collect data only by detecting the energy that is reflected from Earth.
- **B.** Remote sensors can only be passi-ve.
- **C.** Remote sensing is the science of ob-taining information about objects or areas from a distance, typically from aircraft or satellites.
- **D.** Remote sensing is only obtaining in-

Check Answer

Airborne

- done or being in the air
- being off the ground

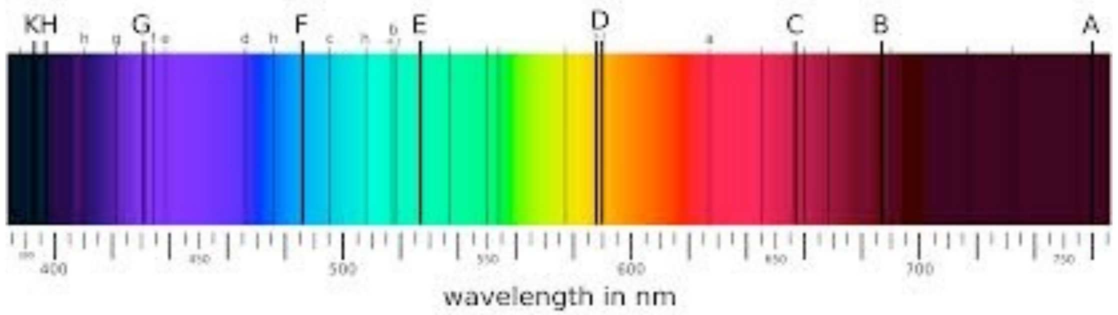
Verwandte Glossarbegriffe

Drag related terms here

Index Find Term

Dark bands

The pattern of dark lines and colors made when light passes through an absorbing medium, such as a gas or liquid. The dark lines represent the colors that are absorbed. Because each type of atom absorbs a unique range of colors, the absorption spectrum can be used to identify the composition of distant substances, such as the gaseous outer layers of



stars.

Verwandte Glossarbegriffe

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Chapter 3 - Spectrometer

DLR

German Aerospace Center (DLR: **D**eutsches Zentrum für **L**uft- und **R**aumfahrt)

Verwandte Glossarbegriffe

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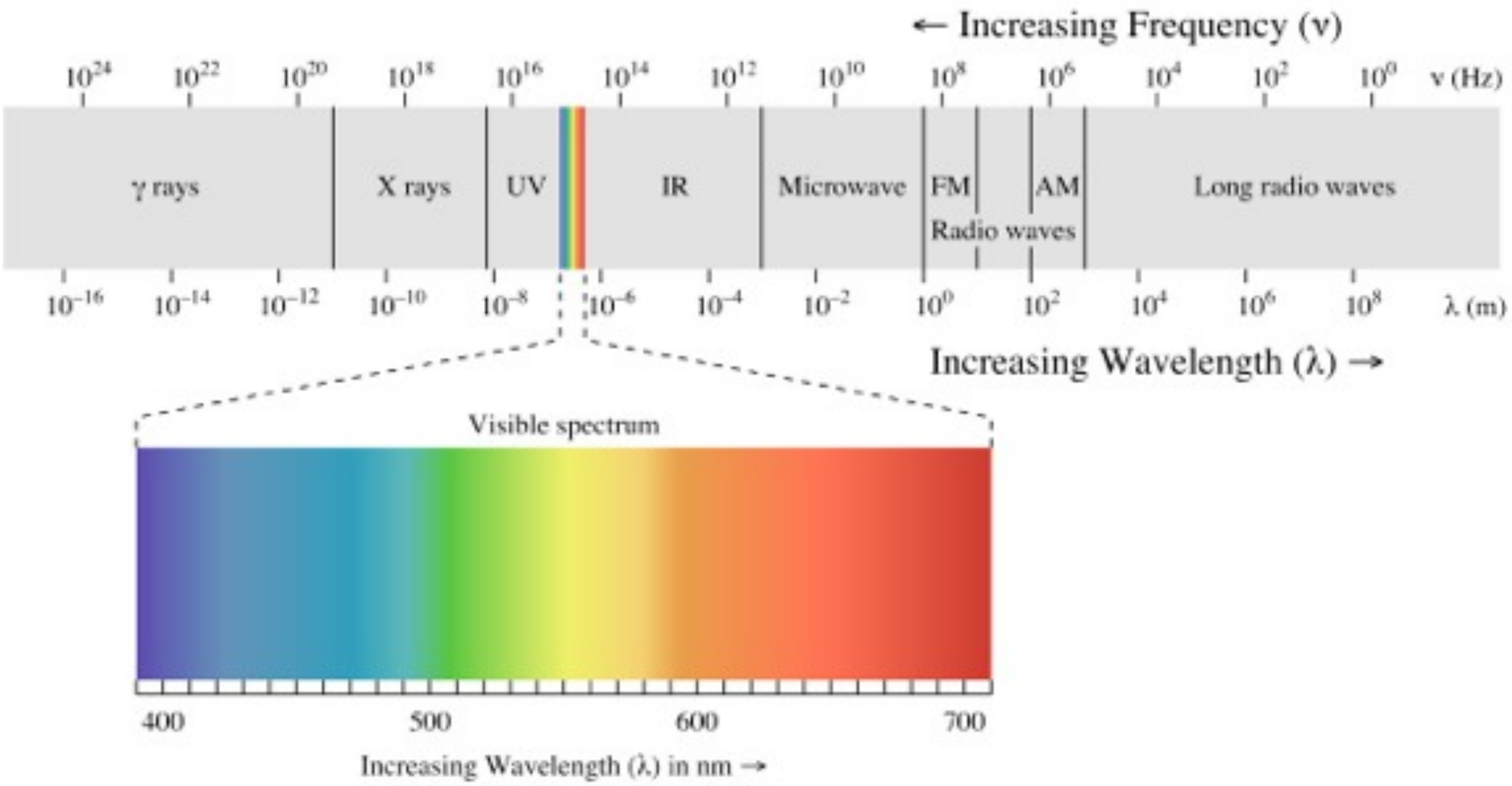
Index

Find Term

Electromagnetic spectrum

the entire range of wavelengths or frequencies of electromagnetic radiation extending from gamma rays to the longest radio waves and including visible light



Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 3 - Spectrometer

Environment

The subjective world a person lives in.

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Hazard

- A possible source of danger: Space travel is full of hazards
- An example for snatural hazard: a volcanic eruption

Related Glossary Terms

Drag related terms here

Index Find Term

Irrigated

Irrigated agriculture: To supply (land or crops) with water by means of pipes, sprinklers, ditches, or streams.

Verwandte Glossarbegriffe

Drag related terms here

Index Find Term

ISS

International **S**pace **S**tation

Verwandte Glossarbegriffe

Drag related terms here

Index

Find Term

Maritime domain awareness

Maritime domain awareness (MDA) is defined by the International Maritime Organization as the effective understanding of anything associated with the maritime domain that could impact the security, safety, economy, or environment.[1] The maritime domain is defined as all areas and things of, on, under, relating to, adjacent to, or bordering on a sea, ocean, or other navigable waterway, including all maritime-related activities, infrastructure, people, cargo, and vessels and other conveyances.

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Drag related terms here

Index Find Term

MUSES

Multi-**U**ser **S**ystem for **E**arth **S**ensing, which will be mounted on the International Space Station (ISS).

Verwandte Glossarbegriffe

Drag related terms here

Index

Find Term

Natural hazard

A natural hazard is a naturally occurring event that might have a negative effect on people or the environment.

Verwandte Glossarbegriffe

Drag related terms here

NIR

Near-infrared with wavelength 0.75–1.4 μm

Related Glossary Terms

Drag related terms here

Index

Find Term

Pivot arm

support arm

Example: monitor holder on pivot arm or a working astronaut on a pivot arm

Related Glossary Terms

Drag related terms here

Spaceborne

Operating in or involving equipment operating in outer space: a spaceborne satellite; spaceborne radar.

Verwandte Glossarbegriffe

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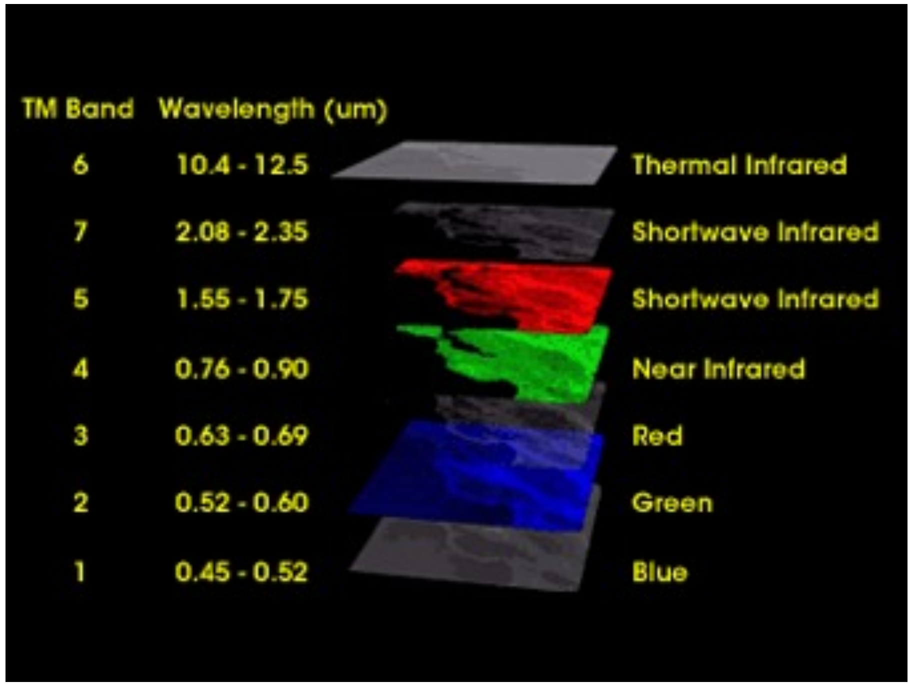
Index Find Term

Spectral band

A Part of the electromagnetic spectrum.

Example: The figure shows 6 spectral bands acquiring by the satellite LANDSAT



Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 4 - Remote sensing with eight spectral bands

Spectrometer

A spectrometer is an instrument used to measure properties of light over a specific portion of the electromagnetic spectrum (for examle: Infrared or Near Infrared)

Verwandte Glossarbegriffe

Drag related terms here

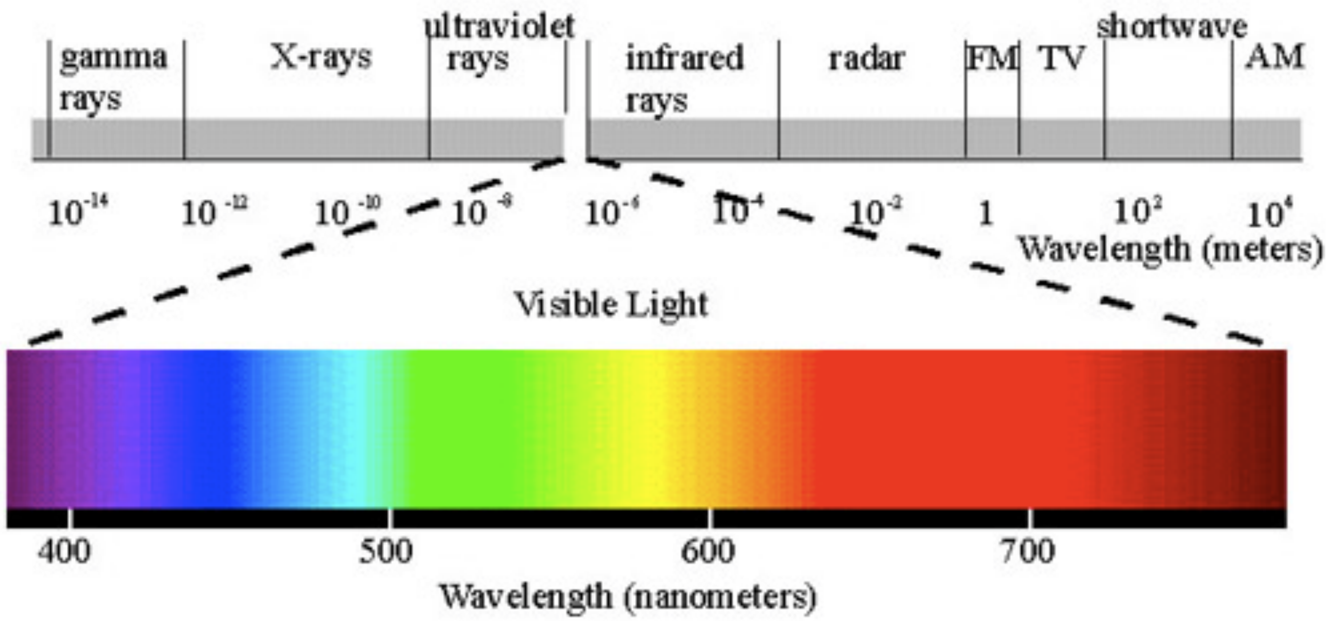
Index

Find Term

Spectrum

This band or series of colors together with extensions at the ends that are not visible to the eye, but that can be studied by means of photography, heat effects, etc.

Compare electromagnetic spectrum



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Chapter 3 - Spectrometer

Teledyne

Teledyne Technologies, Inc., is an American industrial conglomerate primarily based in the United States but with global operations. It was founded in 1960, as Teledyne, Inc. Teledyne provides enabling technologies for deepwater oil and gas exploration and production, oceanographic research, air and water quality environmental monitoring, factory automation and medical imaging.

Verwandte Glossarbegriffe

Drag related terms here

Index Find Term

Urban sprawl

The uncontrolled spread of urban development into neighboring regions.

Related Glossary Terms

Drag related terms here

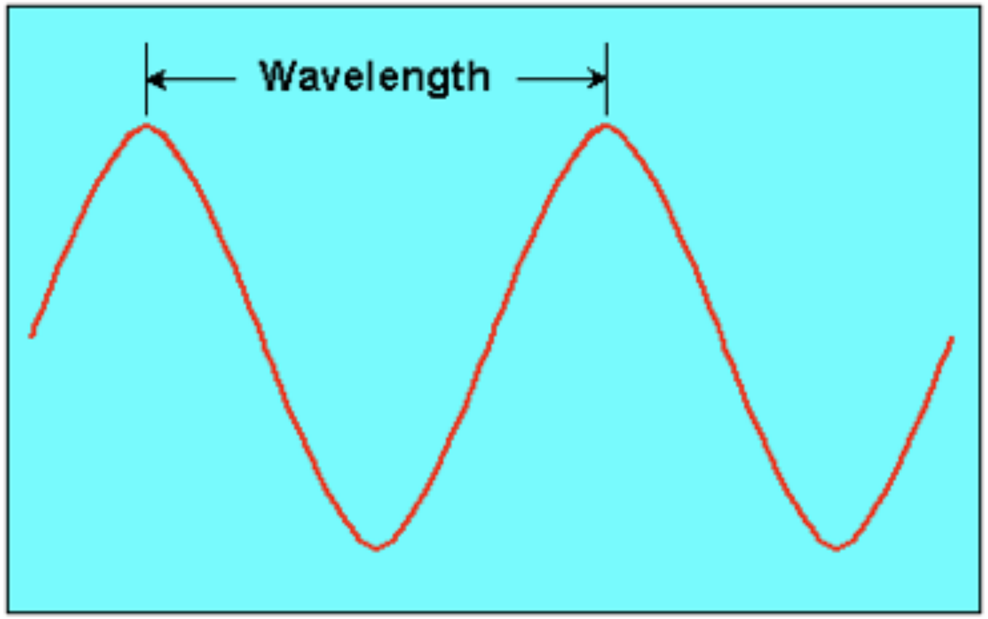
Index

Find Term

Chapter 6 - Urban mapping & monitoring

Wavelength

Wavelength is the distance between identical points in the adjacent cycles of a waveform signal propogated in space or along a wire. As shown in the illustration.



visible light: 400 - 700 nm

near infrared: 700 -2 500 nm

Verwandte Glossarbegriffe

Drag related terms here

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