Remote Sensing – simple Mapping with Space Images

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The human is struggling for order and information to orient him self in an environment where it is difficult for him to find his way. In former times kings have send fearless adventurers into the world for reconnaissance purposes. Today it is quite simpler, we may get an overview of our neighbourhood from aircraft to orient ourselves. An improvement is possible if we go to space to extend the area. Only few do have the privilege to go to space, but we can get a similar impression in viewing images taken from space. Such images can be used for mapping, so we may have a spatial adjustment of our live to it.

Every day in the television we can see images taken from weather satellites. At least they do improve our understanding of the weather conditions. Usually we are concentrating ourselves just to the area where we are located and are angry if the meteorologist is talking about nice weather in another area while we do see forecasted rain for our own city. But beside we are getting some information of our location in relation to our country and even the continent, improving our understanding of the spatial environment. We do have a quite better understanding of our neighbourhood like human 200 years ago when maps have been a secret of state and they have been stored just behind the sleeping rooms of kings. Up to the disintegration of the Sowjet Union, aerial and space images have been classified in several countries and maps have been falsified to misinform the own population over their location.

What can we recognise with space photos? This can only be answered if we do have a look to the characteristics and attributes of the images. A high number of imaging satellites is available and the number is growing permanently. For some states buying a reconnaissance satellite is belonging to the reputation. Some developing countries even have reached a high technology level in constructing such systems. For example up to the launch of the IKONOS satellite in 1999 with the IRS-1C and IRS-1D satellites, India has had the space image systems with the highest resolution available for civilian purposes. In the meantime India even does have a system with the same resolution like IKONOS.

The imaging satellites do use quite different parts of the electromagnetic spectrum. It is reaching from the visible range over the infrared and thermal infrared to the radar waves. The optical systems are affected by clouds. Clouds and haze does not influence imaging radar systems, but they do have the disadvantage of high noise. The details of identification are depending upon the resolution, described by the pixel size. Only based on a high number of neighboured pixels we can identify objects. As pixel size we are naming the area on the ground, imaged as one unit with its grey value. It corresponds to an individual physical camera element collecting the reflected energy, similar to the rods and cones in the retina of the human eye.

The space imaging systems today available for civilian purposes do have a pixel size down to 0.6m. So from an imaging altitude of 450km, corresponding to the distance from Stockholm to Helsinki, we can count the number of pedestrian on the walkways.

Figure 1:

Elbe flood at Dresden, shown by a combination of ERS-2-images

pixel size: 30m

source: German Aerospace Centre (DLR)

The advantage of imaging radar systems is obvious in figure 1. During the Elbe flood in 2002, because of clouds optical satellite images could be taken only rarely. On the other side the development of the flood could be documented very well with images taken by the European Remote-Sensing Satellite 2 (ERS-2). Figure 1 is based on 3 images taken at different days. Changes are shown in colour. The figure also points out the disadvantage of a limited resolution; only few individual details can be identified. In Germany and Italy just now civilian space imaging radar systems with up to 1m pixel size are under development, but with 1m pixel size in a radar image not the same details can be identified like in an optical image with the same nominal resolution.

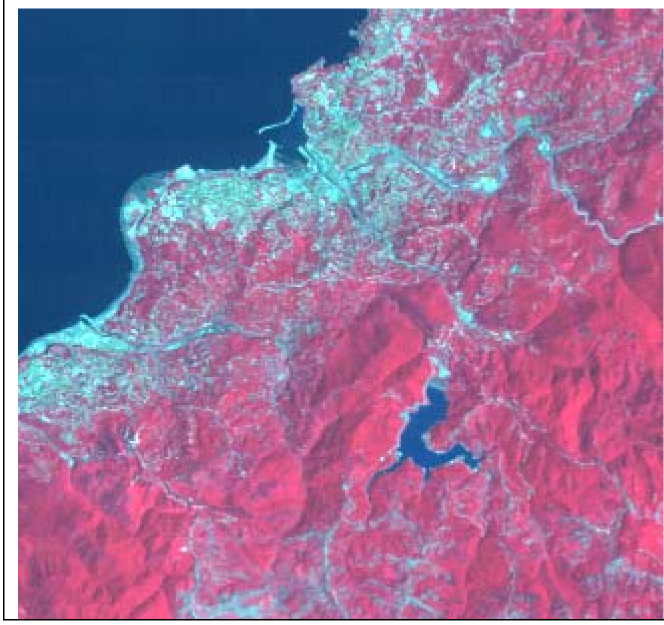

Figure 2:

false colour image, Zonguldak - Landsat TM 5 – satellite

pixel size 30m

The direct comparison of figures 1 and 2 demonstrates the increased recognition of details in the optical Landsat image having the same pixel size like the radar image from ERS-2. The American Landsat system is imaging the object in 7 different spectral ranges, reaching from blue to thermal infrared. With a comparison of the images taken in the different spectral ranges, information about object attributes can be achieved. Computer supported with such an object classification, the build up area can be separated from different vegetation types. Together with images taken at different vegetation periods, also the agriculture production can be estimated. Figure 2 is a false colour representation showing the reflectance in green with blue colour, red as green and the for humans not visible infrared as red. This is creating an unusual impression with dominating red colour. It is caused by the strong reflectance of infrared waves by the active vegetation. The red parts mainly are representing agriculture and forest parts while the build up areas are dominated by grey colour showing the absence of vegetation.

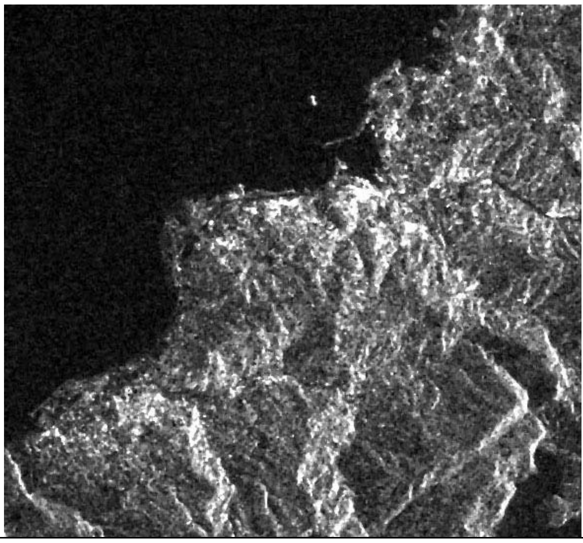

Figure 3: Zonguldak, Turkey
Radar satellite image JRES, 18m pixel

Figure 4: Zonguldak, Turkey – Landsat TM 7, RGB-image, 30m pixel

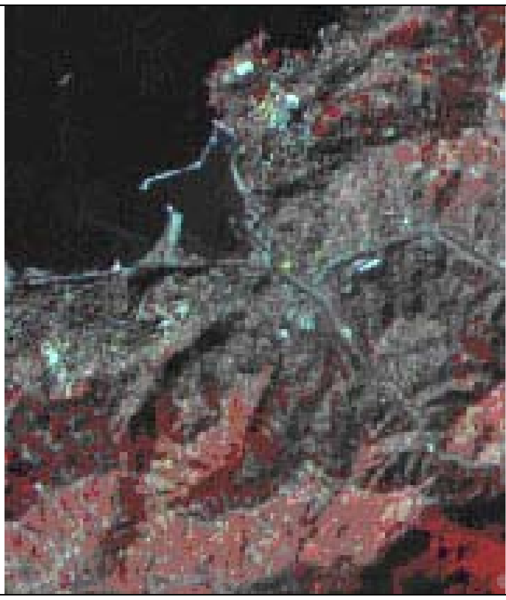

Figure 5: Zonguldak, Turkey
ASTER/TERRA, 15m pixel

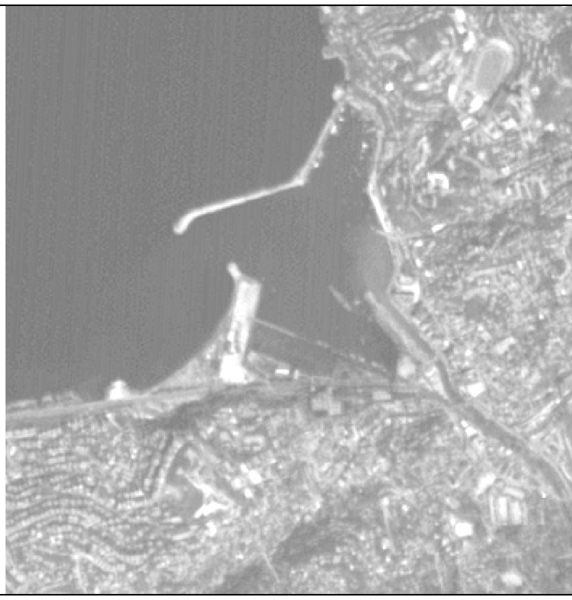

Figure 6: Zonguldak, Turkey
IRS-1C, 5,8m pixel

The varying information contents of the different space images can be seen by comparing figures 3 up to 10. Even with the smaller pixel size of 18m the Japanese radar image from JERS does not show the same details like the Landsat image with 30m pixel size. An exception is the ship in front of the harbour which can be seen very clear in the radar image. The information content of the Landsat scene is not sufficient for the generation of topographic maps. Large streets can be identified but not the also required small once. With reduced pixel size more details can be identified. The image of the Japanese ASTER-sensor which is mounted on the American TERRA platform, clearly shows more details like the preceding named. Quite better it is with the Indian IRS-1C and the South Korean Kompsat-1 image, showing nearly all roads and large buildings.

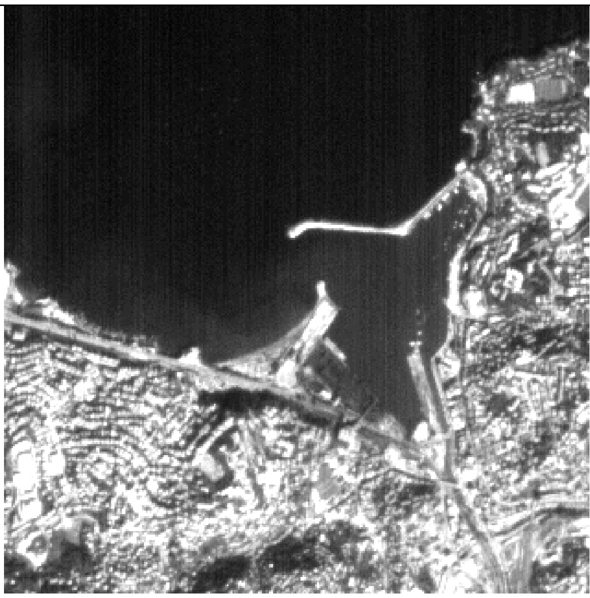

Figure 7: Zonguldak, Turkey
KOMPSAT-1, 6,6m pixel

Figure 8: Zonguldak, Turkey
QuickBird colour image, 2.4m pixel

Figure 9: Zonguldak, Turkey
IKONOS panchromatic image, 1m pixel

Figure 10: Zonguldak, Turkey
QuickBird panchromatic image, 0.6m pixel

The details are becoming more clear in the colour image taken with the American commercial satellite IKONOS. With its panchromatic image the 1m sized pixels do allow the identification of cars from 680km orbit altitude. Even more details can be seen in the QuickBird scene with 0.61m pixel size. The dream of cartographers to get information about any location on the world became reality. Such space images can be bought by anyone. The policy of some countries to keep aerial images and large scale maps secret has no meaning anymore.

Mapping is not just based on object information, it is also important to know the exact location. The first discoverer used sextants for the determination of the geographic latitude and clocks together with the survey of sun and star positions for the longitude. Today it is quite simpler; even persons without knowledge of surveying can determine precise positions using the Global Positioning System (GPS). But it is even simpler, not in any case we have to use surveyed reference points. The new satellite systems are equipped with GPS or similar systems, with gyroscopes and star sensors. With this combination not only the position of the satellite in the orbit, moving with a speed of approximately 7km/sec, also the attitude can be determined. If we do have two images taken from different directions and covering the same area, we can get three-dimensional object locations. For example with IKONOS or QuickBird images without reference measurements on the ground we can determine the shown objects with an accuracy of approximately 4m. This is sufficient for several applications.

An operational problem are the charges for the images. Traditional aerial images are less expensive in some developed countries like the high resolution space images. Different conditions we do have for example in Africa, where the planes for taking aerial images have to come over large distances. For lower resolution (larger pixel size) the financial amount per area is reduced. In addition we do have some exceptions. The Japanese ASTER sensor on the TERRA platform has been specified as research tool. Its images can be taken via internet for a handling fee of only approximately 60US$. Similar it is with the old American spie photos taken by the CORONA satellites which have been released now. They can be ordered for a comparable handling fee. Landsat images more old than 6 month are free available in the internet.

Old images are not important for the generation of topographic maps. In several developing countries the population of large cities does have an annual growth up to 5%. In such areas 30 year old images do have only a historical value. But this is different for height information. The topographic structure is not changing so much, so even old images can be used for this. For example in a research project in the Chinese loess plateau with more than 30 year old CORONA satellite images a digital height model has been generated. The automatic derived model of approximately 700 000 elevation points is shown in figure 11.

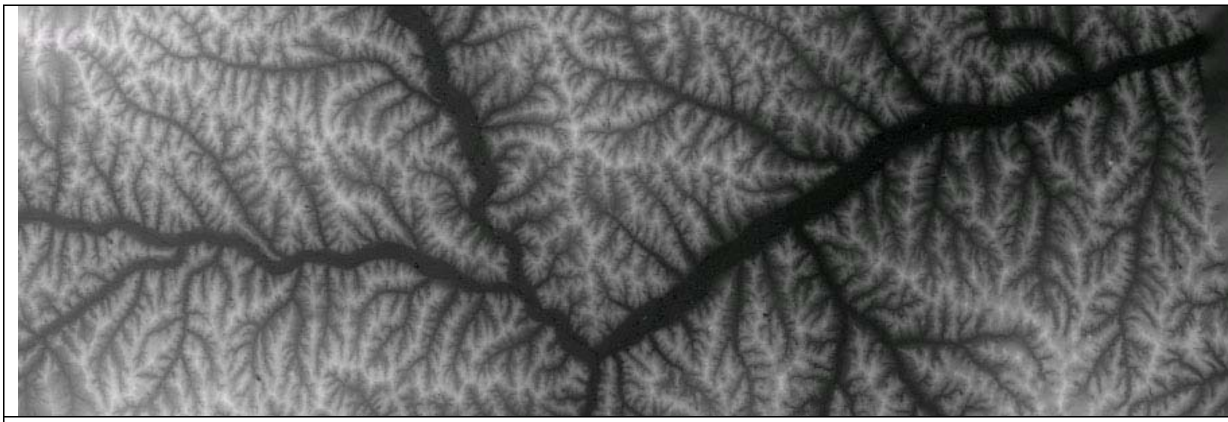

Figure 11: grey value coded digital elevation model created by means of CORONA-4B images – Loess plateau China with strong erosion   bright = high, dark = low

More simple is the use of the of digital elevation information generated by the differential synthetic aperture radar by means of the Shuttle Radar Topography Mission (SRTM). This is covering the world from 58° southern up to 60.25° northern latitude. The height information with a 3 arc seconds spacing of the points, corresponding to approximately 90m at the equator, are available free of charge in the internet (http://edcsgs9.cr.usgs.gov/pub/data/srtm).

Today it is not any more necessary to take the high risk and hardship of former cartographers to generate actual and detailed topographic maps. With satellite images it is quite more simple and fast. Just since now we do have a real chance to cover the whole world with actual maps in the scale 1 : 50 000 which is important for the economic development. In urban areas we even can generate maps up to the scale 1 : 5000. Only if actual maps are missing, we can see their importance for any type of planning.