REMOTE SENSING BASED PARAMETER EXTRACTION FOR EROSION CONTROL PURPOSES IN THE LOESS PLATEAU OF CHINA

Schneider, Th*., Jacobsen, K., Seitz, R.*, Förster, B*.**
* Chair for Landuse Planning and Nature Protection, Technical University Munich
** Institute for Photogrammetry and Geoinformation, University of Hannover

ABSTRACT

The loess plateau is one of the poorest regions in China. The massive erosion in this area brings severe ecological but also economical problems on local level, the lack of water storage capacity in the loess plateau at a whole was identified as one of the reasons for the large inundation in the lowland planes of the Yellow River with thousands of victims. Reforestation of the loess plateau should help to solve this problems. Both, socio-economic and ecological values must be taken into account when performing reforestation. To work out reforestation plans and to develop adopted bio engineering erosion control measures, the evaluation of old reforestation programs and the understanding of the current land use and his impact on the erosion processes is very important.
As an important base of information, CORONA-images have been used. The handling of these panoramic space images is described in detail.

1. INTRODUCTION

The project " Erosion Control in Shaanxi Province in P. R. China " is a cooperation project between the faculty of forest sciences, TUM and Northwestern University of Forestry, starting in 1999. The aims of this project are:

- Comprehend erosion situation and land use potential from a regional to a local scale
- Study how to utilise woody plants as the source of reforestation in erosion areas
- Set up nature-near forest stands for the purpose of biodiversity conservation
- Find optimal agricultural systems to control erosion and increase the income of local people at the same time
- Underline the restrictive impact of goat and sheep grazing on self-recovering-ability of the local ecosystems

A three scale approach for the remote sensing support was developed. The investigations on (1) regional scale are based on high resolution satellite data of the Landsat type. They should deliver an estimate about the erosion risk potential and the quantity of soil loss. The (2) local scale investigations are based on very high resolution satellite data and should led to the quantification of soil loss and the identification of areas appropriated for reforestation a s well as for the pre-selection of demonstration sites for bio-engineering measures (level 3).

Both, the identification of erosion risk zones in that highly structured terrain as well as the quantification of erosion processes requires a high precision digital elevation model (DEM) with a raster size as small as possible. Due to the lack of an administrative DEM and the restrictive handling of aerial photographs by the Chinese Authorities the solution was to use declassified Corona data from the early 60th to calculate the required DEM.

For covering the monitoring aspect, mandatory for the quantification of erosion processes, the land use / land cover concerned investigations as well as the detection of erosion processes like the velocity of gully developments and the decrement of plateau area, etc. are planned to

be done by comparison of CORONA with IKONOS data set evaluations. IKONOS data sets are ordered but still not registered.
For erosion risk estimation on local scale a DEM derived from Corona data in combination with Landsat 7 ETM information on land use / land cover can be used. An estimate on the accuracy of the CORONA data derived DEM is given, including a brief comment on effects of the time difference of 38 years until data take as well as on the lack of ground control points.

2. CORONA IMAGES AND BUNDLE ADJUSTMENT

During the Cold War the USA and the USSR developed for military purposes reconnaissance satellites. The USA have created the CORONA camera system with different versions starting in 1960 and ending in 1972, when the film based satellite systems have been replaced by digital cameras.

system	used	cameras	focal length	format	resolution
KH-1	Aug. 60	1	24 inch	2.2 x 30 inch	40 ft
KH-2	12/60 – 7/61	1	24 inch	2.2 x 30 inch	30 ft
KH-3	8/61 – 12/61	1	24 inch	2.2 x 30 inch	25 ft
KH-4	2/62 – 12/63	2	24 inch	2.2 x 30 inch	25 ft
KH-4A	8/63 – 10/69	2	24 inch	2.2 x 30 inch	9 ft
KH-4B	9/62 – 5/72	2	24 inch	2.2 x 30 inch	6 ft
KH-5	5/62 – 7/64	1	3 inch	4.5 x 4.5 inch	460 ft
KH-6	7/63 – 8/63	1	66 inch	4.5 x 25 inch	2 ft

table 1: CORONA camera systems (Doyle, 1996)

In 1995 the CORONA images have been declassified and are now available for a low charge. Of course the more than 30 years old images cannot be used for map updating, but for several applications the generation of digital elevation models (DEM) of the old situation is important. This may be useful in areas with a stable surface, where they can be used together with actual single space images or in areas with strong erosion as reference.

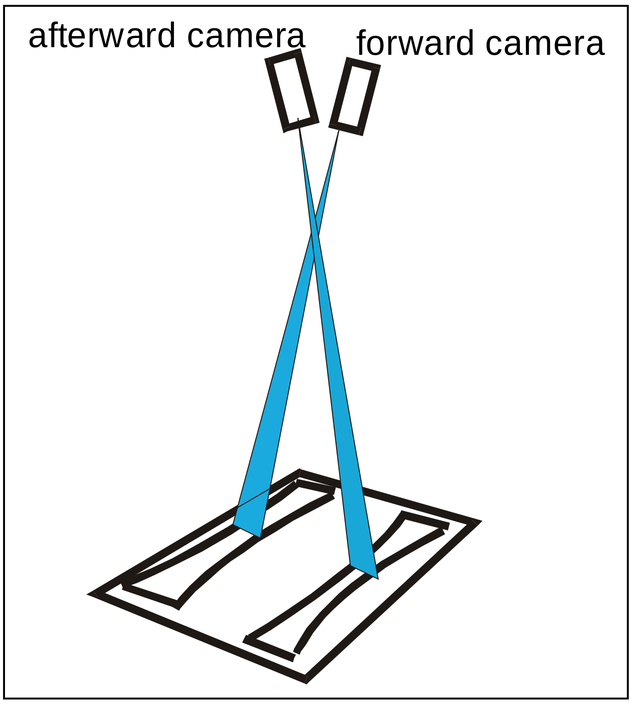


figure 1: configuration of CORONA KH-4-cameras

Like shown in figure 1, the CORONA camera system 4 was equipped with 2 panoramic cameras, scanning the area from one side to the other, and with an index camera as overview. An area of 278km with a width of the individual scenes of 17 km in the center was covered. The convergence angle of 30° between the 2 cameras corresponds to a base to height relation of 0.54, that means the vertical component has twice the standard deviation like the horizontal component. The combination of a forward and an afterward looking camera has the advantage of a stereoscopic coverage within the orbit, which cannot be influenced by seasonal changes of the imaged area.

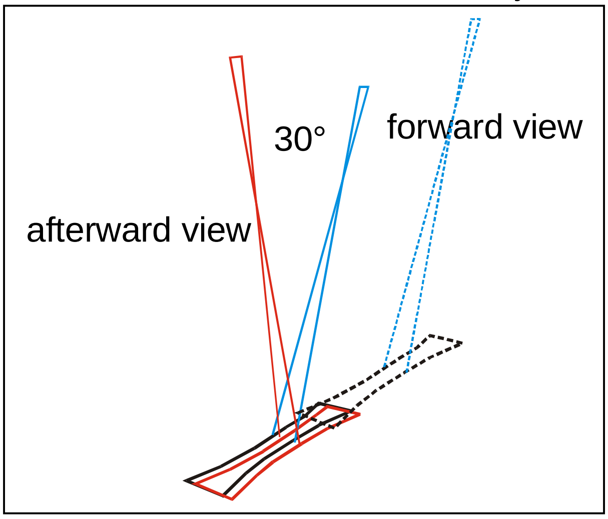


figure 2: possibilities of a stereoscopic coverage

In addition to a stereoscopic coverage within the orbit, of course a stereoscopic coverage of neighboured orbits is possible generating a base to height relation in the range of 1. This is nominal better for the height determination, but it can be affected by seasonal changes of the imaged object.

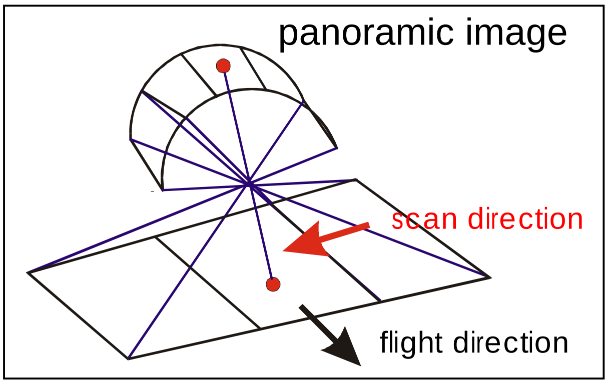


figure 3: geometric principal of panoramic cameras.

The used panoramic cameras are scanning the area from one side to the other. By this reason the image scale is depending upon the nadir angle. For the used flying height of 187km, the scale is varying between 1 : 300 000 in the center up to 1 : 366 000 at a nadir angle of 35°. A second effect is movement of the satellite and the rotation of the earth during scanning. Both are deforming the image geometry against a perspective camera.

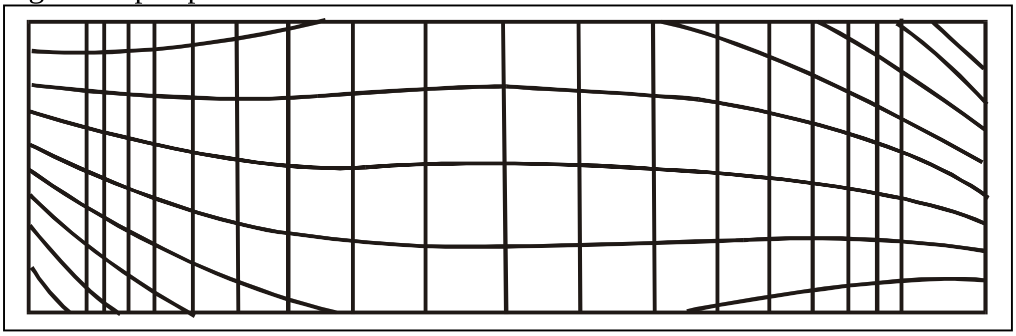


figure 4: geometric difference panoramic – perspective image

A square grid located in the object space will be imaged in a panoramic image like shown in figure 4. Of course this is enlarged, in reality the differences are smaller, but the panoramic images do have in general such a geometry.

In the used program system BLUH, at first the panoramic images are rectified against a tangential plane to the imaging surface, this is equalising the scale. As next step the geometric deformation is handled by additional parameters. This is still required because of the unknown exact imaging parameters like the scan speed. The mathematical model has been proven with KVR1000 images – the corresponding reconnaissance camera of the USSR. In a test area in Germany with accurate control points, an accuracy of +/-3.3m for X and Y has been reached, equivalent to 15µm in the image (Jacobsen 1997).

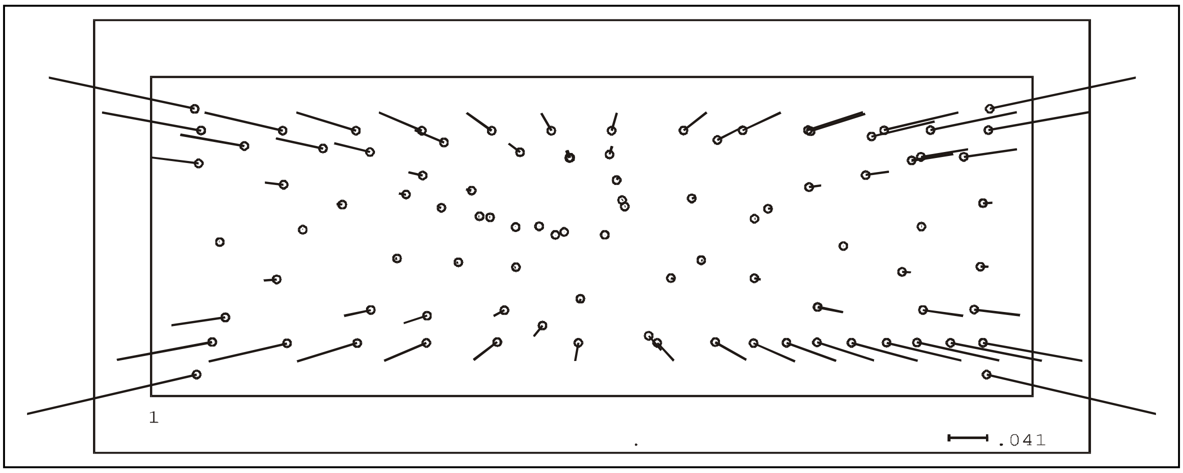
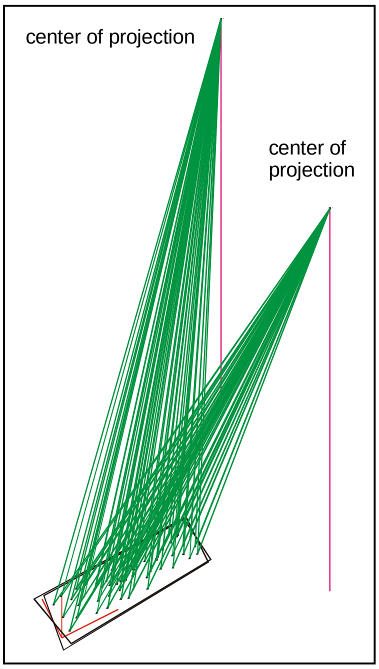


figure 5: geometric correction of KH-4B image (largest vector 185 microns)

Beside the panoramic geometry, the earth curvature has to be respected. The mathematical model, used in photogrammetry is based on an orthogonal coordinate system. In the case of space images, the earth curvature cannot be neglected. The traditional improvement by earth curvature and refraction correction has as a second order effect of flattening the earth surface a change of the base to height relation by the factor flying height / earth radius (187km / 6366km = 3%). This is causing an affine deformation of the model scale with an error in height, but it can be corrected by a change of the used focal length by the same factor, that means the nominal focal length has to be changed from 609.602mm to 627.509mm. The combined correction is improving the sigma0 and the mean square differences at the control points by 6 – 10%.



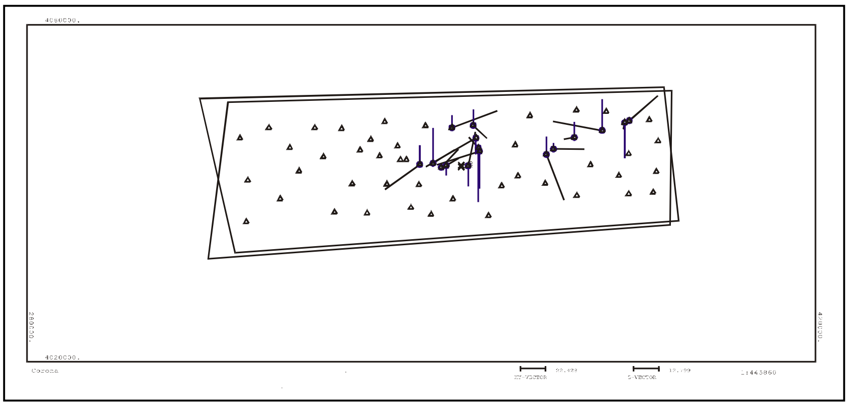


figure 5: distribution and discrepancies at control points

figure 6: 3D-view to configuration of main project area

Not a whole CORONA KH-4B-stereo model has been handled, the project area was limited to a smaller size. In the first model, 16 control points have been available. Finally, like it is often the case, not the quality of the block adjustment, but the quality of the control points has been checked. The root mean square error of the 16 control points in the first model was

RMSEX=27.6m, RMSEY=19.7m and RMSEZ=14.2m. This was within the expectations of the accuracy and the definition of the control points. Of course after more than 30 years, the location of road crossings, used as control points, may have been changed. In the second area only 4 control points are given, so the RMSEX=16.3m, RMSEY=13.6m and RMSEZ=11.8m are not so representative for the object accuracy.

3. DETERMINATION OF DEM

Based on the image orientation, digital elevation models (DEM) have been generated by automatic matching with program DPCOR. DPCOR is using the region growing method - from known corresponding points, points in the neighbourhood are matched and from these again points in the neighbourhood up to a complete coverage of the whole model. For every third pixel a matching was computed. At first an approximation by correlation and after this a least squares matching will be computed. This is the most accurate possibility of image matching. In the average for 71% of the positions, the matching was successful. For the remaining points, usually the contrast was not sufficient.

figure 7: CORONA sub-image of a typical erosion area

The relative accuracy of the DEM's have been estimated to approximately +/-5m. The absolute accuracy is depending the distribution and accuracy of the control points which have not been optimal in this case. But for an analysis of the erosion, one model can be related to the other by corresponding points. The erosion risk can be analysed also without high absolute accuracy, for this also mainly a relative accuracy is required.

CONCLUSION

The IKONOS images have been shown as a very useful tool for the determination of digital elevation models for the analysis of erosions, but also as a reference in areas with stable surface. With no other space images a corresponding accuracy and resolution can be achieved for a limited amount of money.

REFERENCES

Doyle, F.J., 1996: Thirty Years of Mapping from Space, IAPRS, Vol XXXI, Part B4, Vienna 1996

Jacobsen, K., 1997: Geometric Aspects of High Resolution Satellite Sensors for Mapping, ASPRS Annual Convention Seattle, 1997

Jacobsen, K., 1998: Handling of Panoramic and Extreme High Oblique Photographs in Analytical Plotters, IAPRS, Vol XXVII, Part B1, Kyoto 1988