

## IST 1999-21056 WirelessInfo D14.2

### *Creating model*

Public

<b>Contractual Date of Delivery to the CEC:</b>	<b>February 2003</b>
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<b>Work-package:</b>	<b>WP14</b>
<b>Est. person months:</b>	<b>7</b>
<b>Security:</b>	<b>Public</b>
<b>Nature:</b>	<b>Prototype</b>
<b>Version:</b>	<b>1</b>
<b>Total number of pages:</b>	<b>15</b>

#### **Abstract:**

The mobile and wireless technology used for information purposes in land management for the environmental protection is the main problem solved in this project. Task includes data acquisition using wireless connection and pre-processing activities to get complex data sets for further analytical part of the project. This part will consist of:

- Evaluation and simulation by 3D simulation some ecological process
- Develop objective methods of landscape changes evaluation using direct terrain controlling based on utilisation of wireless technologies
- Connection 3D database to wireless technologies
- Creating a Wireless and Internet based info-server
- New technology for transmission of raster data and videos was tested.

#### **Keyword list:**

**3D modelling, land management management ,environment, rural development**

## 1 EXECUTIVE SUMMARY

The application of WirelessInfo results of the basic part of the project into the new land management is the main objective of the extension part that is described in this report. However, the trials project WirelessInfo applied onto new solutions also offers new possibilities of implementation of mobile communications into every day live in rural regions. There is a huge claim to the information all over the world, and to satisfy these demands we can use more and more effective tools. The agriculture is not exception too, which prove the thing that the agricultural sector uses more and more information-technological tools to develop their productive efficiency. We would like to spread the information to the various agricultural areas with our developments. The theoretical aspect of 3D modelling and soil erosion are discussed in this material.

This part also involves methodology of 3D data collection, 3D data processing (terrain analyses) and 3D modelling of new landscape. Methodology of 3D data processing is a necessary pre-requisite step for 3D data analysis. There were realised a basic comparison of:

- Different kinds of 3D data sources
- Possible 3D models
- 3D models for soil analysis

One of these self-made system realise a visual Geographic Information System database, of which services can be used by Mobile Internet from a distance. We have examined the possibilities with mobile communication tools. We would like to spread the information to the various agricultural areas with our developments. We have used a free software, which was developed by Michigan state University at our active system's server side; this software name is: MAPSERVER. The necessary function were a Windows 2000 operation system , in which the Internet Information Server 5.0 is responsible for WEB-service. To reach this system, which made with the used software, it is enough an Internet connection dispose and glean

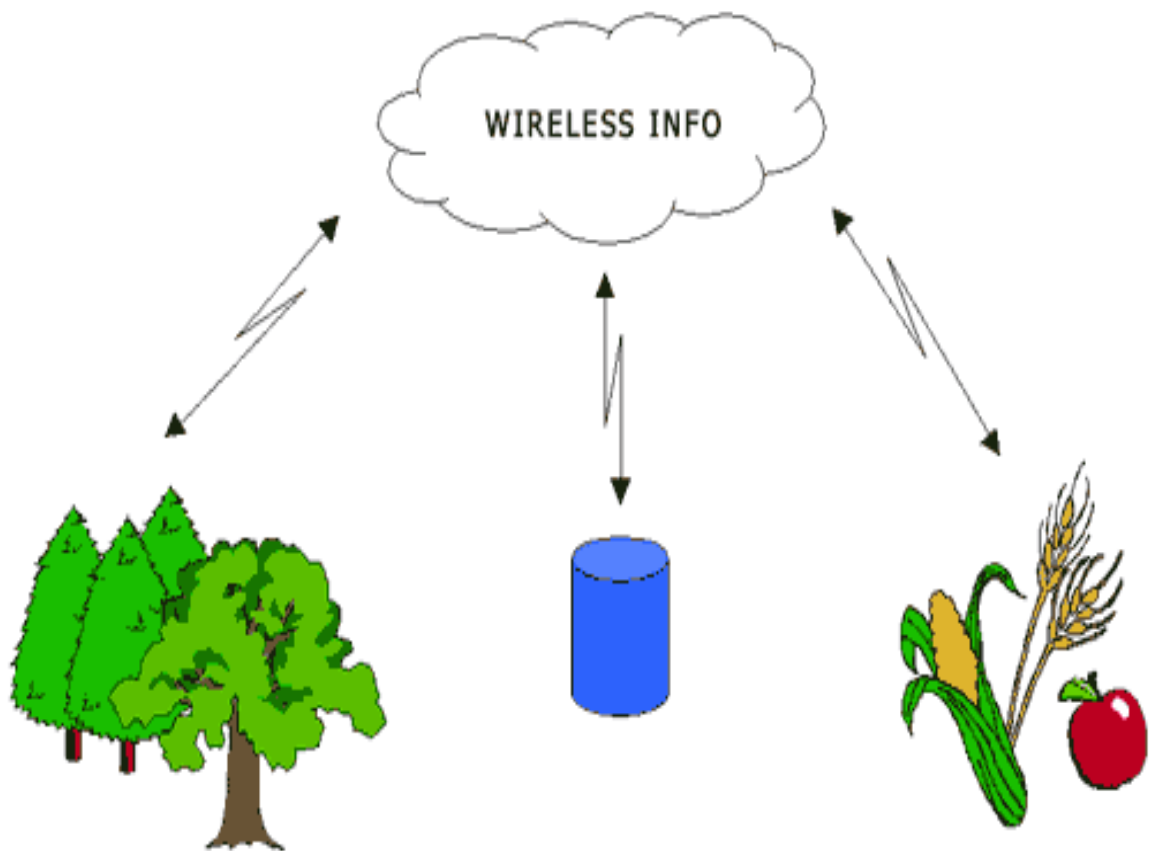
Internal application server will offer new possibilities analyse data trough Internet on line. **Grass systems** and special statistic libraries will be implemented. The Internal Application Server is new solution in WirelessInfo system, which offers full analytical possibilities and decision support (**DSS**). The analytical functions will be accessible trough CGI script and results of analysis will be displayed trough Mapserver application. The connection with GRASS was already realised.

### Creating model



### WirelessInfo

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### 3 Introduction to the 3D Scene Reconstruction

Traditionally, the environment is modelled as an explicit geometric model. Recently, several *appearance based* modelling approaches have been proposed, using the exteroceptive sensor systems on the equipment. In these approaches the relationship between the sensory observations (or features derived from them) and satellite, aircraft, robot or camera positions is modelled. A drawback of appearance based environment representations is that many training images are needed to obtain an accurate model.

Stereo vision is the process of recovering range information from two (or more) images obtained from different but known relative camera poses. The range to a physical point can be computed by triangulation if projections of the point in (at least) two images is known (reconstruction problem). Establishing the matches between image elements in the different images is the fundamental problem in stereo vision (correspondence problem). If knowledge about the camera geometry and relative viewpoints is available, a powerful geometric constraint, known as the *epipolar constraint*, reduces the search space for possible matches from two dimensions (the entire image plane) to one dimension (the *epipolar curve*). Besides computational gain, an important advantage of using the epipolar constraint is that there is less chance to establish erroneous pixel correspondences.

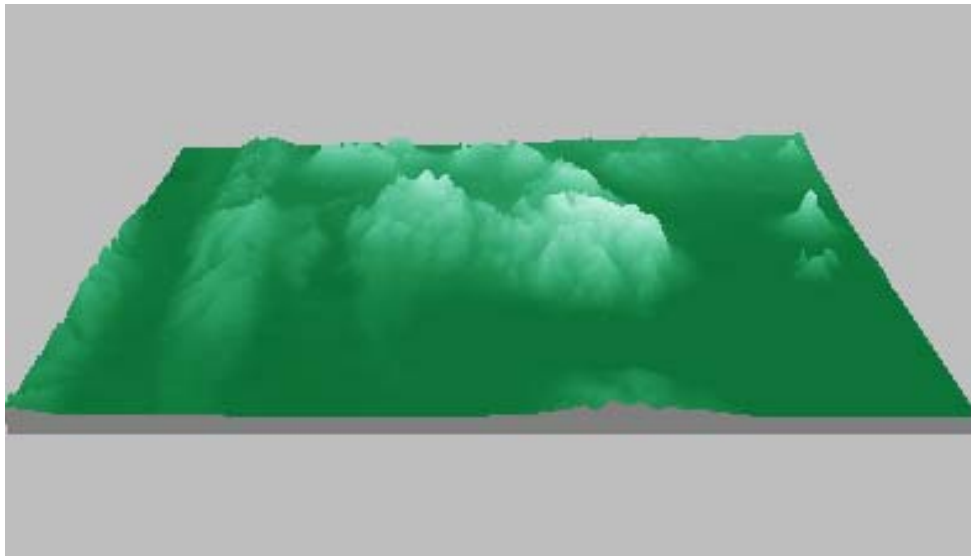
For 3-D scene reconstruction from aircraft or satellite images we using:

- determine the image internal parameters
- determine camera position
- finding pixel-pair on image
- determine 3D co-ordinates
- fitting the measured GPS data into images

#### 3.1 Creating and precisely 3D model

Main steps our work:

- Scanning (by ZEISS aircraft film scanner) the Aircraft Images
- Rectification Aircraft and/or Satellite Images
- Pre-processing Aircraft and/or Satellite Images
- Finding Land References (pixel-pair, geological or topographical references, etc.)Building Visual Computer for the Modelling
- Creating Digital Elevation Model For the Modeling

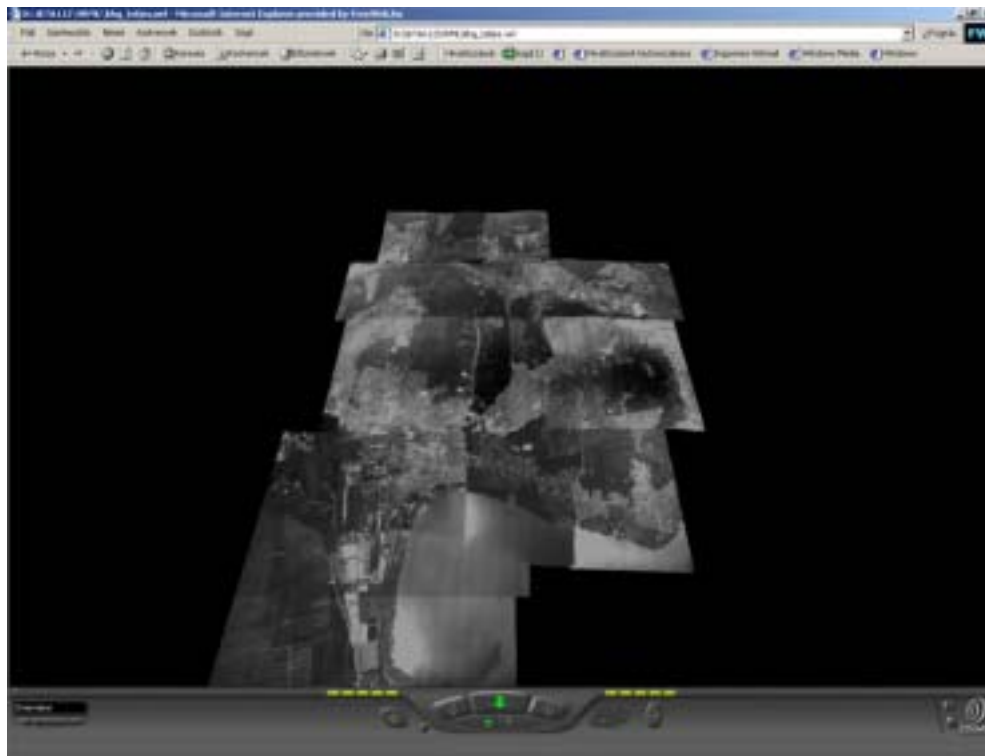


*Reconstructed Digital Elevation Model from Keszthely-hill*



*Rectificated Aircraft Images*

- Creating Uniform Visualisation PreSimulation with Referred Data



**VRML based Model to Uniform Visualisation**

	Main ponits of GPS	Terrain	Measuring	in Keszthely-hill		
Reference	Baltic altitude	Measured altitude	North EOY latitude	Measured north latitude	East EOY latitude	Measured east latitude
32-2126	106,26-105,60	150 -2	514251,74	46 46' 01,362	159623,64	17 16' 12,360
42-4075	135,75-135,12	178 -2	514812,27	46 46' 47,400	161035,08	17 16' 37,188
42-4339	138,66	190 -2	510419,47	46 46' 19,164	160266,15	17 13' 10,992
42-4016/a	150,61-151,91	207 -2	510657	46 46' 48,672	161171,51	17 13' 21,186
32-2131	131,62	181 -1	510635,99	46 46' 41,262	159085,75	17 13' 22,560
32-2104	124,43	171	510584,04	46 44' 55,842	157685,02	17 13' 22,128
32-2108	121,89-121-29	172	510676,94	46 44' 17,298	156486,31	17 13' 36,780
42-4068/1b	131,92	190	511878,38	46 46' 11,800	160106,31	17 14' 20,556
42-4068/1a		185	511878,12	46 46' 15,120	160101,44	17 14' 19,944
Reference	SDG	DPOP	Number of satellite	Time		
32-2126	0-0,3	2,1	5	13,16		
42-4075	0-0,3	2,2	6	13,28		
42-4339	0,1-0,2-0,3	4,2	6	14,25		
42-4016/a	0,1-0,5	4 - 5,2	6 - 7	14,11		
32-2131	0-0,3	3,1	9	17,22		
32-2104	0,2-1,0	3,7 - 8,2	4 felvete+ 2 nek	16,25		
32-2108	0,2-0,8	10,2	7	16,56		
42-4068/1b	7	0-11,6	4 felvete	15,26		
42-4068/1a	0,1-0,9	2-10,5	4 felvete	15,23		

**Measured GPS data to rectification**

## 4 Simulation

### 4.1 Pre-Simulation on Real Surface

We started the simulation on some ecological processes: soil erosion, tourism effect in forest, plant and forest production, based on 3D surface model.

- Flight simulation /video/Natural lighting simulation /video/Fog and humidity /video/

### 4.2 Introduction to Soil Erosion Modelling

Research on soil erosion and its effect on agricultural productivity started in 1930s. During 1940 and 1956, research scientists began to develop a quantitative procedure for estimating soil loss in the Corn Belt in the United States. Several factors were introduced to an early soil loss equation, in which slope and practice were primarily considered. It was recognized that a soil loss equation could have a great value for farm planning and the Corn Belt equation could be adapted for other regions. In 1946, a group of erosion specialists held a workshop in Ohio to reappraise the factors previously used and added a rainfall factor. U.S. Department of Agriculture, Agricultural Research Service (ARS) established the National Runoff and Soil Loss Data Center at Purdue University in 1954 to locate, assemble, and consolidate all available data throughout the United States. More than 10,000 plot-years of basic runoff and soil loss data were then collected from U.S. federal-state cooperative research projects in 49 U.S. locations.

Based on the data assembled at the Data Center and previous studies, Wischmeier, Smith, and others developed the Universal Soil Loss Equation (USLE). An agriculture handbook describing USLE was published in 1965 and revised in 1978. With a widespread acceptance, USLE has become the major conservation planning tool which is used in the United States and other countries in the world.

With additional research, experiments, data, and resources become available, research scientists continue to improve USLE, which led to the development of Revised Universal Soil Loss Equation (RUSLE). RUSLE has the same formula as USLE, but has several improvements in determining factors. These include some new and revised is erodent maps; a time-varying approach for soil erodibility factor; a subfactor approach for evaluating the cover-management factor; a new equation to reflect slope length and steepness; and new conservation-practice values (Renard, et al., 1997). A new Agriculture Handbook (No. 537) which describes RUSLE in great detail was published in 1997 by the U.S. Department of Agriculture.

Both RUSLE and USLE can be expressed as follows:

$$A = R * K * LS * C * P$$

Where

**A** = estimated average soil loss in tons per acre per year

**R** = rainfall-runoff erosivity factor

**K** = soil erodibility factor

**L** = slope length factor



**S** = slope steepness factor  
**C** = cover-management factor  
**P** = support practice factor

Another factor for soils is called "T value" which stands for "Tolerable Soil Loss." It is not directly used in RUSLE equation, but is often used along with RUSLE for conservation planning. Soil loss tolerance (T) is the maximum amount of soil loss in tons per acre per year, that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely.

#### **R factor**

**R** is the rainfall-runoff erosivity factor. It is the average annual summation (EI) values in a normal year's rain. The erosion-index is a measure of the erosion force of specific rainfall. When other factors are constant, storm losses from rainfall are directly proportional to the product of the total kinetic energy of the storm (E) times its maximum 30-minute intensity (I). Storms less than 0.5 inches are not included in the erosivity computations because these storms generally add little to the total R value. R factors represent the average storm EI values over a 22-year record. R is an indication of the two most important characteristics of a storm determining its erosivity: amount of rainfall and peak intensity sustained over and extended period.

#### **K factor**

**K** factor is soil erodibility factor which represents both susceptibility of soil to erosion and the rate of runoff, as measured under the standard unit plot condition. Soils high in clay have low K values, about 0.05 to 0.15, because they resistant to detachment. Coarse textured soils, such as sandy soils, have low K values, about 0.05 to 0.2, because of low runoff even though these soils are easily detached. Medium textured soils, such as the silt loam soils, have a moderate K values, about 0.25 to 0.4, because they are moderately susceptible to detachment and they produce moderate runoff. Soils having high silt content are most erodible of all soils. They are easily detached; tend to crust and produce high rates of runoff. Values of K for these soils tend to be greater than 0.4.

Organic matter reduces erodibility because it reduces the susceptibility of the soil to detachment, and it increases infiltration, which reduce runoff and thus erosion. Addition or accumulation of increased organic matter through management such as incorporation of manure is represented in the C factor rather than the K Factor. Extrapolation of the K factor nomograph beyond an organic matter of 4% is not recommended or allowed in RUSLE. In RUSLE, factor K considers the whole soil and factor Kf considers only the fine-earth fraction, the material of <2.00mm equivalent diameter. For most soils, Kf = K.

Soil structures affects both susceptibility to detachment and infiltration. Permeability of the soil profile affects K because it affects runoff.

Although a K factor was selected to represent a soil in its natural condition, past management or misuse of a soil by intensive cropping can increase a soil's erodibility. The K factor may need to be increased if the subsoil is exposed or where the organic matter has been depleted, the soil's structure destroyed or soil compaction has reduced permeability. A qualified soil scientist can assist in making this interpretation.

#### **LS factor**

**L** is the slope length factor, representing the effect of slope length on erosion. It is the ratio of soil loss from the field slope length to that from a 72.6-foot (22.1-meter) length on the same soil type and gradient. Slope length is the distance from the origin of overland flow along its flow path to the location of either concentrated flow or deposition. Fortunately, computed soil

loss values are not especially sensitive to slope length and differences in slope length of + or – 10% are not important on most slopes, especially flat landscapes.

Slope lengths are best determined by visiting the site, pacing out flow paths, and making measurements directly on the ground. Obtain L by measuring perpendicular to the contour from the point of origin of overland flow to where deposition begins or runoff enters a well defined channel. Contour maps having intervals greater than 2-ft should be used cautiously, if at all, to determine slope lengths. Slope length values are generally too long when contour maps are used to choose slope length. Slope lengths usually do not exceed 400 ft. Slope lengths longer than 1000 ft should not be used in RUSLE because the reliability of RUSLE at these long slope lengths is questionable, and flow becomes concentrated on most landscapes before such long slope lengths.

Determining where slope lengths end can be difficult in watershed of Lake Balaton glacial topography. Generally it is necessary to measure several slopes in a field with variable soils. The main areas of deposition that end RUSLE slope length are at the base of concave slopes. If no signs of deposition are present, the user will have to visualize where deposition occurs. The slope-ending depositional area on a concave slope is usually below where the slope begins to flatten.

As a rule of thumb, if no signs of deposition are present on a concave slope, assume that deposition begins at the location where the steepness is 1/2 of the average steepness of the concave area.

Another difficulty is determining if a channel is a concentrated flow channel that ends a RUSLE slope length. Channels that collect the flow from numerous rills are generally considered to be slope ending concentrated flow channels.

**S** is the slope steepness. Represents the effect of slope steepness on erosion. Soil loss increases more rapidly with slope steepness than it does with slope length. It is the ratio of soil loss from the field gradient to that from a 9 percent slope under otherwise identical conditions. The relation of soil loss to gradient is influenced by density of vegetative cover and soil particle size.

L factor and S factor are usually considered together. LS factors = the slope length factor L computes the effect of slope length on erosion and the slope steepness factor S computes the effect of slope steepness on erosion. Values of both L and S equal 1 for the unit plot conditions of 72.6 ft. length and 9 percent steepness. Values of L and S are relative and represent how erodible the particular slope length and steepness is relative to the 72.6 ft long, 9% steep unit plot. Thus some values of L and S are less than 1 and some values are greater than 1. Strip-cropping or contouring does not affect the LS value.

#### **C factor**

**C** is the cover-management factor. The C-factor is used to reflect the effect of cropping and management practices on erosion rates. It is the factor used most often to compare the relative impacts of management options on conservation plans. The C-factor indicates how the conservation plan will affect the average annual soil loss and how that soil-loss potential will be distributed in time during construction activities, crop rotations or other management schemes.

The C-factor is based on the concept of deviation from a standard, in this case an area under clean-tilled continuous-fallow conditions. The Soil Loss Ratio (SLR) is then an estimate of the ratio of soil loss under actual conditions to losses experienced under the reference conditions.

"C" represents the effects of plants, soil cover, soil biomass, and soil disturbing activities on erosion. RUSLE uses a subfactor method to compute soil loss ratios, which are the ratios at any given time in a cover management sequence to soil loss from the unit plot. Soil loss ratios

vary with time as canopy, ground cover, roughness, soil biomass and consolidation change. A "C" factor value is an average soil loss ratio weighted according to the distribution of R during the year. The subfactors used to compute a soil loss ratio values are canopy, surface cover, surface roughness, prior land use and antecedent soil moisture.

Surface cover is material in contact with the soil surface that intercepts raindrops and slows surface runoff. The total percent of the surface covered is the characteristic used by RUSLE to compute how surface cover affects erosion. Surface cover includes all cover that is present, including rock fragments, live vegetation, cryptogams, and plant residue. The only minimum size requirement for material to be counted as surface residue is that it either be of sufficient size or attached to the surface such that is not removed by runoff.

RUSLE accounts for surface roughness in the C value calculation. Surface roughness ponds water in depressions and reduces erosivity of raindrop impact and water flow. If the depression are sufficiently deep, much deposition occurs in them. Over time, roughness disappears as the depressions fill with sediment. and one soil subsides after the tillage operations that formed the depressions.

Roughness is reduced in RUSLE as a function of cumulative rainfall after the last tillage operation. Roughness also indicates the degree of clodiness and the likelihood that the surface will seal, producing increased runoff and soil erodibility. Accounting for roughness, such as with the plow plant tillage system, is one reason some C values are lower with RUSLE.

If a C factor of 0.15 represents the specified cropping management system, it signifies that the erosion will be reduced to 15 percent of the amount that would have occurred under continuous fallow conditions. The C factor in watershed of Lake Balaton ranges from 0.005 for continuous low residue grass/hay to 0.50 for continuous row crops with low residue returned to the soil. C factors are also available for pastureland, wildlife land, idle land, and woodland uses.

#### **P factor**

**P** is the support practice factor. The RUSLE P-factor reflects the impact of support practices on the average annual erosion rate. It is the ratio of soil loss with contouring and/or stripcropping to that with straight row farming up-and-down slope.

As with the other factors, the P-factor differentiates between cropland and rangeland or permanent pasture. Both options allow for terracing or contouring, but the cropland option contains a stripcropping routine whereas the rangeland/permanent-pasture option contains an "other mechanical disturbance" routine. For the purpose of this factor, the rangeland/permanent-pasture option is based on the support operation being performed infrequently, whereas in the cropland option the support operation is part of the annual management practice.

#### **T value**

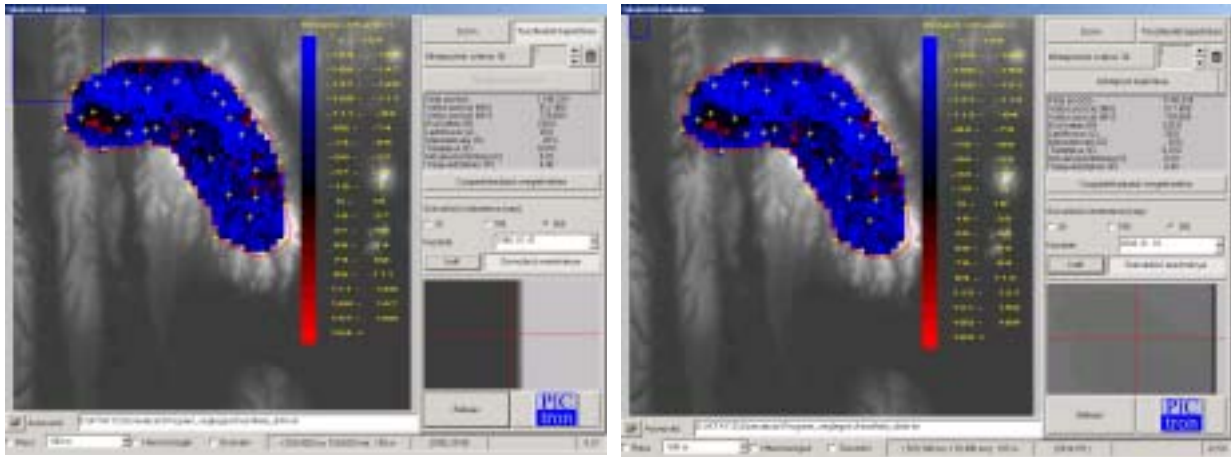
**T** is soil loss tolerance expressed in tons per acre per year.

The T value is not directly used in RUSLE. However, it is important in the use of the soil loss equation for conservation planning. Soil loss tolerance is the maximum amount of soil loss in tons per acre per year, that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely.

Soil loss tolerance values of 1 through 5 are used. These values represent the tolerable tons of soil loss per acre per year where food, feed and fiber plants are to be grown. T values are not applicable to construction sites or other non-farm uses of the erosion equation.

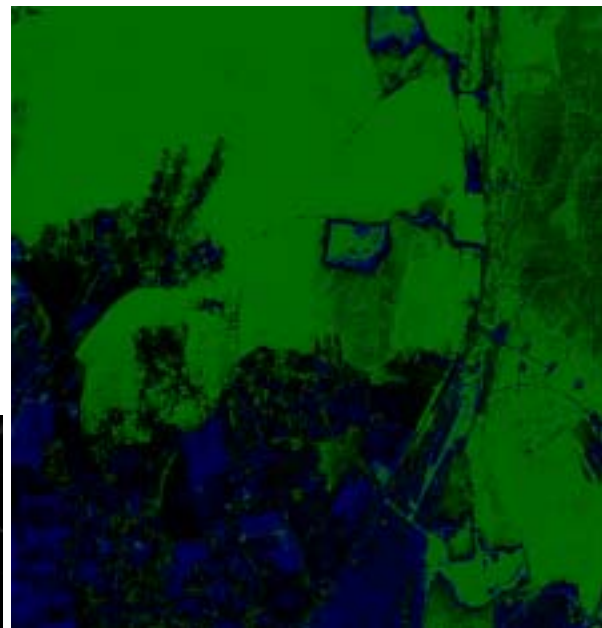
### **4.3 Soil Erosion Modelling in Watershed of Lake Balaton**

- Soil erosion changes by 3D simulation model in Keszthely-hill, Hungary



(1980 – left, 2002 - right)

- Case area selection, case study monitoring design, preparation and station building, system testing.



Original (left) and the classified (right) aircraft images for the monitoring and testing

## **5 MapServer solution**

The MapServer was originally developed by the University of Minnesota (UMN) project in cooperation with NASA and the Minnesota Department of Natural Resources (MNDNR). The MNDNR and the Minnesota Land Management Information Centre made additional enhancements. Current development is funded by the project, a NASA sponsored project between the UMN and consortium of land management interests. Mapserver is an Open Source development environment for building up the spatially enabled Internet applications. The software is built upon other popular Open Source or freeware systems like Shapelib, FreeType, Proj.4, libTIFF, Perl and others. Mapserver will run where most commercial systems will not or cannot, on Linux/Apache platforms. Mapserver is known to compile on most UNIXes and runs under Windows NT/98/95.

## 6 GRASS

GRASS (Geographic Resources Analysis Support System) is a public domain raster based GIS, vector GIS, image processing system, and graphics production system. GRASS contains over 40 programs to render images on monitor and paper; over 60 raster manipulation programs; over 30 vector manipulation programs; nearly 30 multi-spectral image processing manipulation programs; 16 data management programs; and 6 point file management programs. Tools for interactive 3D displaying are also included.

There are three interpolation methods in GRASS:

1. Inverse distance weighted. It fills a raster matrix with interpolated values generated from a set of irregularly spaced data points using numerical approximation (weighted averaging) techniques. The interpolated value of a cell is determined by values of nearby data points and the distance of the cell from those input points. In comparison with other methods, numerical approximation allows representation of more complex surfaces (particularly those with anomalous features), restricts the spatial influence of any errors, and generates the interpolated surface from the data points. This method is rather usable for data of different types than DEM, like chemical component spreading etc. This method is available in Premathmod analysis tool for nutrient content computations. Detailed program description is in
2. Regularised spline with tension and smoothing. This method has been originally developed for DEM computation. It is derived from known methods of bicubic splines interpolation, but involves smoothing factor, which permits resulting DEM not to go exactly through original points. This is very usable for DEM derived from contours for removing artificial waves. Program enables computing surface from point as well as contour (vector) input data. Resulting DEM may be affected by many user set parameters.
3. Recently new Kriging interpolation algorithm is included into GRASS. It was originally developed for element ore content evaluation, so it is considered useful for nutrient components interpolatio.

## 7 Internet access

An architecture of the system is shown at the scheme below. GRASS functions are accessed via PHP wrapper code called SH/BASH GRASS scripts. Mapping functions are provided by Mapserver using underlying set of resulting rasters exported from GRASS during analysis execution.

