Remote Sensing Information Models for Sediment and Soil

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Abstracts

Recently we have discovered that sediments should be separated from lithosphere, and soil should be separated from biosphere, both sediments and soil will be mixed sediments-soil-sphere (Seso-sphere), which is using particulate mechanics to be solved. Erosion and sediment both are moving by particulate matter with water or wind. But ancient sediments will be erosion same to soil. Nowadays, real soil has already reduced much more. Many places have only remained sediments that have ploughed artificial farming layer. Thus it means sediments-soil-sphere. This paper discusses sediments-soil-sphere erosion modeling.

In fact, sediments-soil-sphere erosion is including water erosion, wind erosion, melt-water erosion, gravitational water erosion, and mixed erosion. We have established geographical remote sensing information modeling (RSIM) for different erosion that was using remote sensing digital images with geographical ground truth water stations and meteorological observatories data by remote sensing digital images processing and geographical information system (GIS).

All of those RSIM will be a geographical multidimensional gray non-linear equation using mathematics equation (non-dimension analysis) and mathematics statistics. The mixed erosion equation is more complex that is a geographical polynomial gray non-linear equation that must use time-space fuzzy condition equations to be solved. RSIM is digital image modeling that has separated physical factors and geographical parameters. There are a lot of geographical analogous criterions that are non-dimensional factor groups.

The geographical RSIM could be automatic to change them analogous criterions to be fixed difference scale maps. For example, if smaller scale maps (1:1000 000) that then will be one or two analogous criterions and if larger scale map (1:10 000) that then will be four or five analogous criterions. And the geographical parameters that are including coefficient and indexes will change too with images. The geographical RSIM has higher precision more than mathematics modeling even mathematical equation or mathematical statistics modeling.

Conclusion: The geographical RSIM is new kind quantity information modeling with images. It is using geographical mathematics to be established for sediments-soil erosion.

Keywords: Remote Sensing Information Models, Sediment and soil, Non-linear complex equation.

* Supposed by National Nature Science Foundation of China. No. 49571058

Article

Since 18th century the sediments and sedimentation rock have been belong to lithosphere, and soil, in that because there are many microbe, has been belong to biosphere. In our research we have discovered that sediments should be separated from lithosphere, and soil should be separated from biosphere, both sediments and soil will be mixed sediments-soil-sphere (Seso-sphere [1]), which is using particulate mechanics to be solved. Nowadays, real soil has reduced much more on account of population increased. Many places have only remained sediments in that top just have ploughed artificial farming layer. Thus it means sediments-soil-sphere. The sediments and soil sphere erosion is a very serious disaster in the world especially in China.

In fact, sediments-soil-sphere erosion is including water erosion, wind erosion, melt-water erosion, gravitational water erosion, and mixed erosion. The erosion intensity (unit: mm/a, or t/km^2 a) must be used modeling to indicate. We have created a new kind modeling that is geographical remote sensing information model (RSIM) [2] which is using remote sensing digital images with geographical ground truth water stations and meteorological observatories data by remote sensing digital images processing and geographical information system (GIS).

RSIM for Erosions

There are remote sensing information models for sediments-soil erosion intensity as follows:

RSIM for water erosion: that has two kind equations one is slope surface water erosion and the other is gully erosion.

$$E_s = a_{01}(\frac{I-I_0}{I_0})^{a_{11}} h_s(\frac{D}{d})^{a_{12}} (Sin2\theta)^{a_{13}} \exp[-a_{14}(NDVI)] \quad (1)$$

$$E_g = a_{02} h_g (\frac{BL}{A})^{a_{21}} (\frac{v}{\sqrt{ghJ}})^{a_{22}} \quad (2)$$

RSIM for wind erosion: that is an equation as follows:

$$E_w = a_{03}(\frac{v_w - v_0}{v_0})^{a_{31}} (bHV) \exp[a_{32}(NDIVI)] \quad (3)$$

RSIM for melt water erosion: that is an equation too as follows:

$$E_m = a_{04}(\frac{T_d - T_n}{T_{mean}})^{a_{41}} h_s(\frac{D_m}{d})^{a_{42}} (Sin2\theta)^{a_{43}} \exp[-a_{44}(NDVI)] \quad (4)$$

RSIM for gravitational water erosion: that is also an equation as follows:

$$E_{gw} = a_{05}(\frac{I-I_0}{I_0})^{a_{51}} (\frac{D_{gw}L}{A})^{a_{52}} h_{gw}(Sin\theta)^{a_{53}} \exp[a_{54}(NDVI)] \quad (5)$$

In which $(I-I_0)/I_0, (v_w - v_0)/v_0, (T_d - T_n)/T_{mean}$ are rainfall density minus non-erosion rainfall

Density over non-erosion rainfall density, wind velocity minus non-erosion wind

Velocity over non-erosion wind velocity, daytime temperature minus nighttime

Temperature over mean temperature of day and night

h_s, h_g, h_{gw} , which are runoff depth of slope surface (unit: mm/a), of gully basin surface, and of ground water surface.

$D/d, D_m/d$, which are slope surface and melt soil surface sediments and soil depth over particle size.

$Sin2\theta, Sin\theta$, which are slopes of mountain area.

$NDVI = (TM4 - TM3)/(TM4 + TM3)$ Shows vegetation coverage.

BL/A, which is mean width times length of gully over whole area.

bHV, which is mean width times height times velocity of sand dunes.

$D_{gw}L/A$, which is mean depth times length over area of landslide.

$v/\sqrt{ghJ}$, which is frictional resistance of gully.

$a_{01}, a_{02}, a_{03}, a_{04}, a_{05}$, which are geographical coefficients.

$a_{11}, a_{12}, a_{13}, a_{14}, a_{21}, a_{22}, a_{31}, a_{32}, a_{41}, a_{42}, a_{43}, a_{44}$, a_{51}, a_{52}, a_{53}, a_{54} which are geographical indexes.

We could extract $NDVI=(TM4-TM3)/(TM4+TM3)$, BL/A, bHV, L/A from remote sensing images data; $Sin2\theta, Sin\theta$ from digital terrain model (DTM) data; $E_s, E_g, E_m, h_s, h_g, h_{gw}$, and $v/\sqrt{ghJ}$ from water stations data; $(I-I_0)/I_0, (v_w-v_0)/v_0, (T_d-T_n)/T_{mea}$ from meteorological observatories data, E_{gw}, D_{gw} from landslide observations data; E_w from wind sand stations data; $D/d, D_m/d$ from ground truth or soil maps data. Thus we could solve $a_{01}, a_{02}, a_{03}, a_{04}, a_{05}$, and $a_{11}, a_{12}, a_{13}, a_{14}, a_{21}, a_{22}, a_{31}, a_{32}, a_{41}, a_{42}, a_{43}, a_{44}$, $a_{51}, a_{52}, a_{53}, a_{54}$ in images, which have many pixels in there, with non-linear multidimensional regression analysis by remote sensing digital images processing and geographical information system (GIS).

Gary Non-linear Equation with Fuzzy Condition Equation

All of those RSIM that will be a geographical gray non-linear equation using mathematics equation (non-dimension analysis) and mathematics statistics. In general there are four kind methods according to mathematical logic. See table 1:

Table 1. Method of Mathematics

Logic Math System	Intention and Extension Both are Certain.	Intention is Certain and Extension is Uncertain.	Intention is Uncertain and Extension is Certain	Intention and Extension Both are Uncertain
System	White System	Fuzzy System	Gray System	Black System
Mathematics	Math Equation	Fuzzy Math	Gray Math	Math - Statistics

1 Which could use mathematical statistics both of intention and extension are uncertain.

2 Which could use fuzzy mathematics if the intention is certain and the extension is uncertain.

3 Which could use gray mathematics if the intention is uncertain and the extension is certain.

4 Which could use mathematical equations both of intention and extension are certain.

5 Nowadays some mathematical equations are uncertain that is chaos with fractal.

Above equations are multidimensional gray non-linear equations because non-dimensional factor groups that are similar standard (or analogous criteria) and many subordinate factors are not considered about that are including in the $a_{01}, a_{02}, a_{03}, a_{04}, a_{05}$.

Some area is mixed erosion. For example water erosion of slope surface and gully water erosion in the Loess Plateau, wind and water erosion is mixed in the Inner Mongolia, wind and melt water erosion is mixed in the Tibet, water and gravitational water erosion is mixed in the granite area of the South China. In this case, we could make multinomial multidimensional gray non-linear equations as follows:

$$E_{s,g} = E_s + E_g \quad (6)$$

$$E_{s,w} = E_s + E_w \quad (7)$$

$$E_{w,m} = E_w + E_m \quad (8)$$

$$E_{s,gw} = E_s + E_{gw} \quad (9)$$

From equation (6) to (9) we must add conditional equation that will be solved. Most of the conditional equation will be showed fuzzy equation in time and space. The research still is going on that is supported by National Nature Science Foundation of China (1999-2001).

RSIM Equation with Image Scale

Above equations are in ground truth that is 1 : 1 scale. If the scale is changed, then the equation will be changed too. For example RSIM for water erosion there are two equations as (1) and (2). If the scale less than 1 : 100 000, the two equations has changed one equation as follows:

$$E_s = a_{01}\left(\frac{I-I_0}{I_0}\right)^{a_{11}} h_s \left(\frac{D}{d}\right)^{a_{12}} \exp[-a_{14}(NDVI)] \quad (10)$$

In this case, the slope erosion should be including gully erosion, and slope already is false. When the scale less than 1 : 500 000, equation (10) will change to next:

$$E_s = a_{01} I \exp[-a_{14}(NDVI)] \quad (11)$$

Certainly, $a_{01}, a_{11}, a_{12}, a_{14}$ are also changed. Thus it means geographical mathematics.

General Geographic Complex Model

Since above models, we have done many Remote Sensing Information Models [2,3]. There is general geographic complex model as follows:

$$\pi_y = a_0 \pi_{x_1}^{a_1} \pi_{x_2}^{a_2} \ldots \pi_{x_n}^{a_n}$$

$$\lg \pi_y = \lg a_0 + a_1 \lg \pi_{x_1} + a_2 \lg \pi_{x_2} + \ldots + a_n \lg \pi_{x_n}$$

(12-1 and 2)

Where π is similar standard, a_0 is geographical coefficients, $a_1, a_2, \ldots a_n$ are geographical indexes. In the equation (12-1) π is white system but a_0 still is black system, so it is a logarithm gray equation. In the equation (12-2) $a_1, a_2, \ldots a_n$ is weight for $\lg \pi_{x_i} (i = 1,2,\ldots,n)$, so it is a subordinate rate of fuzzy equation. Equation (12-1 and 2) is equivalence.

In this case, discusses about a_0 and $a_1, a_2, \ldots a_n$ should very important.

When $a_i = 0 (i = 1,2,...n)$, which means π_{x_i} with π_y no relationship.

When $a_i = 1 (i = 1,2,...n)$, which π_{x_i} with π_y is linear relationship.

When $a_i = \frac{p}{q} (i = 1,2,...n)$, p and q both are integers. Both π_{x_i} and π_y, which are fractal with self-similar and self-organization relationship.

When $a_i = \frac{p(x,y,z,t)}{q(x,y,z,t)} (i = 1,2,...n)$, p and q both are function of time and space. Both π_{x_i} and π_y, which are general relationship.

In actually, a_0 is function of $(x,y,z,t,\pi_{x_3}...\pi_{x_{n-1}})$.

When $a_0 = 1$, equation (12) is certain equation. For example:

$$F = ma, \frac{F}{ma} = 1$$
$$E = mC^2, \frac{E}{mC^2} = 1 \qquad (13)$$

Newton and Einstein equations are certain equations.

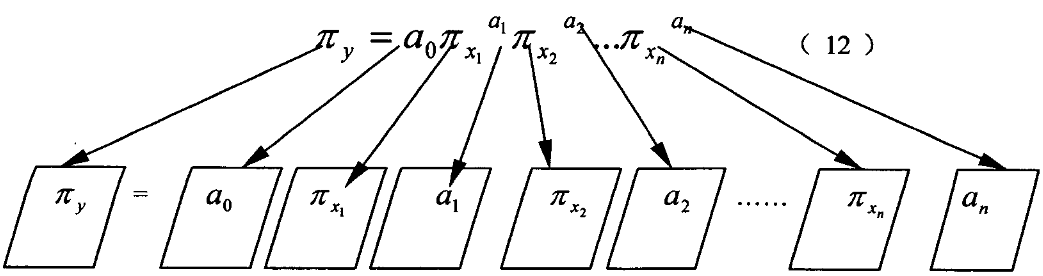
When $a_0 = f(x,y,z,t,\pi_{x_3}...\pi_{x_{n-1}})$, equation (12) is uncertain statistics equation. For example:

$$v = C\sqrt{ghJ}, \frac{v}{\sqrt{ghJ}} = C(x,y,z,t,\pi_{x_i})$$
$$v = n(\frac{d}{h})^{\frac{1}{6}}\sqrt{ghJ}, \frac{v}{\sqrt{ghJ}} = n(\frac{d}{h})^{\frac{1}{6}}$$
$$v = a_0(\frac{\rho_s}{\rho})^{a_1}(\frac{d}{h})^{a_2}\sqrt{ghJ}, \frac{v}{\sqrt{ghJ}} = a_0(\frac{\rho_s}{\rho})^{a_1}(\frac{d}{h})^{a_2}$$
$$(14)$$

(14)equations are velocity equations for pipe, river, and debris flow.

Nowadays, researches about distribute equations to substitute centralize equation. The remote sensing information model is natural distribute equation. Because remote sensing image is pixel by pixel picture. If use non-remote sensing data, which could insert data same digital elevation model (DEM). In other words, non-remote sensing data must be change to pixel by pixel. Then we could establish each pixel equation as follows:

This is equation with image calculation, which are both of abstract and visualize thought. The interest a thing is according to scale change the different similar standard is change too. For example: see equation (10) and (11). The precision is higher.



Conclusion

1 Sediment plus soil must be changed to seso-sphere.

2 Sediment and soil erosion intensity could calculate with Remote sensing Information Models.

3 RSIM is a new modeling that is geographical complex mathematics.

4 The important things are general geographic complex equation established.

5 We must still research about RSIM for sediment-soil erosion in the future.

Reference

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