Models of Informational Calibration of Time-Space Optical Fields of Degrading Forest Ecosystems

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Abstract – In this article the usage possibilities of reference states' time-space intercouplings modeled for the degrading ecosystem (on an example of a forest) and variability of its spatially - contrast performances are considered for developing the adequate approach to optical fields' information calibration of degrading ecosystems. The possibilities and limitations of the Fokker-Plank equation's applications are considered as the basis of optical fields' information calibration with specificity of dimensional contrast's transformation with height off an inhomogeneous surface The tendered constructing of the information calibration metrics on dynamic system's eigenvectors with state parameters (population density) interacting with ecosystem's contrast-optical features reams optical contrasts fields' calibration possibilities of degrading ecosystems..

Keywords: synergy, ecosystem, optical contrast transformation, population density,.calibration.

INTRODUCTION

The informational retrieval analysis possibilities of dimensional contrasts fields of the degrading ecosystems' spectral - optical parameters are gobed up in specificity of spatial-temporal transformation of contrasts allocation. The physical sense of a time-space generalization is, that for periods forming an ecosystem landscape, the considerable spectrum of different plotting scales of dimensional variability is accumulated. It gives the basis to model their intercoupling with the variable-duration parameters of multi-scale processes which are generatrix of these fields. In this sense the degrading ecosystems' simulation has fullest possibilities in playing back of inhomogeneous conditions of an on enough representative territory with multi-dimensional plotting scales of encompassing definite variety of climatic-geographical zones, landscapes, types of a contour and meteorological conditions is important.

Thus the conditions of fullest observation of a modeled ecosystem are reamed in sense of possibility for tracing of different degradation stage - fullest spectrum applicable to different plotting scales of dimensional variability from an informative range. The physical gear of the radiation balance dimensional variability explains the degrading ecosystem's instability moving into an irreversible range (behind threshold), corresponding to extreme plotting scales of a degradation. On snapshots as a result of multi-scale survey such fields easily emerge. Apparently, the properties of different plotting scales of an image generalization are complementary, deploying on each level "new parts of an investigated ecosystem's chronology", but aren't expressed through some level of maximum detailing.

In this sense the main aim of the paper is the following alternative version illustration: major contents is arranged not so much in the directly remotely sensed information, how with complex of time-space structured allocation model's indirect tags being detecting instruments of ecological process's different stages to be traced .

MAIN BODY

In remote sensing of the Earth problems we often deal with a multi-dimensional spectral brightness (contrast) vector of the registered radiation field. The time-space distribution of vector determines the images' pattern radiation frame. The referenced value is, generally, random and its cumulative distribution function satisfies to Fokker-Plank equation (Hakken H., 1988):

$$\frac{df}{dt} = -\frac{\partial}{\partial \vec{R}}[K(\vec{R})\cdot f] + \tfrac{1}{2} Q \frac{\partial^2}{\partial \vec{R}^2} f$$

The stationary solving is determined by expression

$$f_0 = N \cdot \exp[-\int_{B_0}^{B} \frac{2K(\vec{R})}{Q} d\vec{R}],$$
$$f(\vec{R}) \to 0, \qquad \vec{R} \to 0$$

Where $f(R)$ = radiance distribution function

R = spectral brightness vector

$K(R)$= drift coefficient

Q = diffusion coefficient

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If we shall consider a cumulative distribution function of the spectral brightness characteristic vector at different altitudes H (at limitation by Markov Processes, we can apply the maximum principle of an information entropy to conditional probability

$$I = -\int f(\vec{R}_{Hi+\tau} / \vec{R}_H) \cdot \ln f(\vec{R}_{Hi+\tau} / \vec{R}_{Hi}) d\vec{R},$$
$$F_1 = \langle \vec{R}_{iH+\tau} \rangle \;, F_2 = \langle \vec{R}_l(H+\tau) \cdot \vec{R}_k(H+\tau) \rangle$$

We derive expression:

$$f(\vec{R}(H+\tau) / \vec{R}(H)) =$$
$$= \exp[-\Lambda - \sum_i \Lambda_i \vec{R}_l(H+\tau) - \sum_{lk} \Lambda_{lk} \vec{R}_l(H+\tau) \cdot \vec{R}_k(H+\tau)]$$

Where $\langle \vec{R}_{iH+\tau} \rangle$ = the maiden and

$\langle \vec{R}_l(H+\tau) \cdot \vec{R}_k(H+\tau) \rangle$ = second moments of a conditional function distribution, accordingly;

Λ = Lagrange parameters (order prameters), which one generally can depend from H.

By analogy with non-equilibrium phase changes the exponent's index extreme of last expression is searched from:

$$\frac{\partial}{\partial \vec{R}_l}[-\Lambda - \sum_l \Lambda_l \vec{R}_l(H+\tau) - \sum_{lk} \Lambda_{lk} \vec{R}_l(H+\tau) \cdot \vec{R}_k(H+\tau)] = 0$$

This extreme corresponds to the stationary solution of the Fokker-Plank equation. We receive the solution of a system for two spectral channels at the prior information in one of channels

$$-\Lambda_1 - 2 \cdot (\Lambda_1)^2 \cdot R_1 - 2 \cdot \Lambda_2 \cdot \Lambda_1 \cdot R_2 = 0$$
$$-2 \cdot \Lambda_2 \cdot \Lambda_1 \cdot R_2 - \Lambda_2 - 2 \cdot (\Lambda_2)^2 \cdot R_2 = 0,$$

$$\begin{pmatrix} R_1 \\ R_2 \end{pmatrix} = \begin{pmatrix} -1/2 \cdot \dfrac{1 + 2 \cdot \Lambda_2 \cdot R_2}{\Lambda_1} \\ R_2 \end{pmatrix}$$

The eigenvalues are calculated as order parameters' function:

$$\chi(\Lambda_1, \Lambda_2) =$$
$$= \begin{bmatrix} -(\Lambda_2)^2 - (\Lambda_1)^2 + \left[(\Lambda_2)^4 - 6 \cdot (\Lambda_1)^2 \cdot (\Lambda_2)^2 + (\Lambda_1)^4\right]^{1/2} \\ -(\Lambda_2)^2 - (\Lambda_1)^2 - \left[(\Lambda_2)^4 - 6 \cdot (\Lambda_1)^2 \cdot (\Lambda_2)^2 + (\Lambda_1)^4\right]^{1/2} \end{bmatrix}$$

The reallocating of spikes in spatial spectra with the survey altitude is modeled by spatial variability of order parameters Λ, which one are functions of surveying geometry.
The necessity of description the radiation field transformation with altitude accounting the "new spikes" appearance and critical transitions between different types of potential surfaces demands engaging non-linear physical gears of optical contrasts reallocating
In experimental practice, specially at analysis of structural surface properties by remote optical methods, often the variation coefficient of the measured spectral - brightness characteristic have been used expressing the spatially - contrast radiation field property of a surface and sensing to structural parameters of its non-uniformity
Meanwhile the adequate count of time-space intercouplings of the registered optical characteristics variability with state parameters of a natural system is indispensable for synthesis the adequate information calibration metrics.

Time-space intercouplings of degrading ecosystem's state parameters and variability of its spatially - contrast characteristics.

Let's consider equations set similar to population dynamics model (Prigogine I., 1980)

$$\frac{dN(r,t)}{dt} = F_1(N,R) + D_N \frac{\partial^2 N}{\partial r^2}, (1)$$
$$\frac{dR(r,t)}{dt} = F_2(N,R) + D_R \frac{\partial^2 R}{\partial r^2}$$

Where N= population density;

R= radiation balance (or spatial contrast) distribution density of the optical characteristics;

D_N, D_R = diffusion coefficients;

r (x, y) = position vector in a plane of degradation

The population density's drift function

$$F_1 = A + N(B - N \cdot R) - C \cdot R$$

The spatial optical contrasts (radiation balance) drift function

$$F_2 = -L \cdot N + \frac{\partial R}{\partial r} + f_R(\nu_0)$$

Where $f_R(\nu_0)$ = fluctuating component;

ν_c = minimum frequency of fluctuations' long-period component ;

A, B, C, L= dynamic system's constants.

The diffusive components are regular equalization processes for biomass and radiation balance distributions as a result of horizontal flows propagation instituted by a non-uniformity.
Under non-zero conditions (N *, R *) of a dynamic system's stationarity

$$\begin{pmatrix} N \\ R \end{pmatrix} = \begin{bmatrix} \dfrac{f}{L} \\ L \cdot \dfrac{(A \cdot L + f \cdot B)}{(f^2 + C \cdot L^2)} \end{bmatrix}$$

We search for the solutions with exponential relation $\exp(\nu \cdot t\}$ for a linearized system in area (N *, R *).

$$N(r) \cdot B - C \cdot R(r) - D_N \cdot \left(\frac{d}{dr} \frac{d}{dr} N(r) \right) = N(r) \cdot \nu$$

$$\frac{d}{dr} R(r) - L \cdot N(r) + D_R \cdot \left(\frac{d}{dr} \frac{d}{dr} R(r) \right) = R(r) \cdot \nu$$

For definition of solution stability conditions near to stationary points the system control parameters of initial conditions and fluctuation component are varied, changing a population density and radiation - optical contrasts distribution picture the changes of which one determine in quite concrete scales, observed meteo-parameters' drift. At the small contribution of diffusive and gradient components of contrasts fields (at homogeneous spatial distribution) we discover stability conditions of a system from a dispersion ratio

$$\nu^2 - \nu \cdot B - L \cdot C = 0$$

$$\nu_{1,2} = \begin{bmatrix} \dfrac{1}{2} \cdot B + \dfrac{1}{2} \cdot (B^2 + 4 \cdot L \cdot C)^{1/2} \\ \dfrac{1}{2} \cdot B - \dfrac{1}{2} \cdot (B^2 + 4 \cdot L \cdot C)^{1/2} \end{bmatrix}$$

The system is steady at

$$\nu \leq 0$$

the system has neutral stability in a case

$$\operatorname{Re} \nu = 0 \quad u \quad \operatorname{Im} \nu = \pm \frac{1}{2} (B^2 + 4 \cdot L \cdot C)^{1/2}$$

being gyrated around of a stationary state (Prigogine I., 1980).
The eigenvectors are calculated using parameter ν .

Degradation and germing of new system status are illustrated on imitated curves on Fig.1 and on Fig.2.

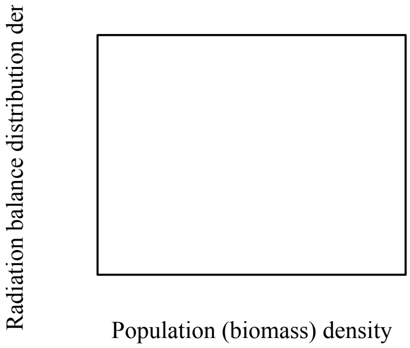

Figure 1. Simulated curves of R-N system's phase portrait

On Fig.2 we can see imitated 3-D curves imaging phase portrait dynamics of R- N (Radiation balance distribution density – Population (biomass) density) with clearly traced degradation and germing stages of evolution. The lower curve images short-lived changes of evolution, upper (red) - long-time dynamics.

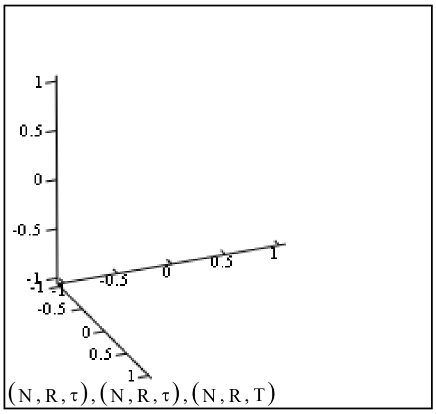

Figure 2. N-R phase portrait evolution

Thus designing informative calibration metric for remotely sensed ecosystems' data optimal digestion demands to use new conceptions of radiation and population parameters interaction in frames of nonlinear dynamic equation sets. It gives opportunity to expand our investigated range from single-signed resolving to different mode functions more close fitted to existing states observed really in nature. But it not mean that having resolution we have absolutely knowledge of simulated ecosystem to research.

But it mean that we can at first to differentiate stages parameters of dynamic ecosystem and at least to choose the informative survey mode and metric for all interesting stages.

Moreover commonly few-parametric models of resolution function and its nonlinear dependence from survey parameters allow considering the optimal planning of remote experiment on basis of main critical points' searching.

CONCLUSION

Within the imitation framework the conformity condition of degrading forest ecosystem's time-space variability are considered: Fokker-Plank equation simulation problems for cumulative spectral - brightness characteristic distribution function's reduction with geometry (survey altitude) by analogy with a temporary reduction are reviewed. Parameter of time is changed with survey altitude on the basis of general properties of a scale and temporary degradation. However important point is the research of simulation capabilities on the basis of non-linear differential equations systems depicting interplay of a population (biomass) with a radiation balance cumulative distribution function.

In this case the reference areas of system critical changes can be parametrized by eigenvalues or order parameters (in synergy submission) for each variability area.

The studied phase diagrams of these systems on a plane and also with a temporary component in three-dimensional space demonstrate ecosystem 's conditions of short-lived and long-timely ecosystems and allow to track transitions conditions in a new germing stage from degrading one. It mean we can choose the optimum informative measuring plan using enough formalized procedures.

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