Present Status and Perspectives of Remote Sensing of Vegetation

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During the recent decades a new discipline of biogeophysics remote sensing of vegetation has been born. This was stimulated by the need to describe in more detail the energy and mass exchange between the ground surface and atmosphere in the mathematical models of the global and regional climate, by the need to have rapid information about biological productivity and yield of the vegetation over the large areas and probably to most extent by military needs, connected with rocket piloting. The rapid development of remote sensing has based on:

i) The existence of Earth's satellites, originally constructed for military and astronomical needs.

ii) The availability of the powerful enough computer technology for recording, data processing and analysis.

iii) The possibility to use the radiative transfer theory originally elaborated for astrophysics, atmospheric physics and neutron transport in nuclear reactors.

The main problem of remote sensing of the vegetation might be formulated as follows: measuring from satellites or airplanes electromagnetic radiation in optical, thermal and microwave spectral regions reflected from vegetation and the solving the inversion problem to obtain information for classification, distribution, functioning and productivity of different kinds of vegetation over the whole Earth surface. Reflected from vegetation electromagnetic radiation is determined by the following factors:

i) Conditions of illumination above the vegetation.

ii) The disturbing influence of the atmosphere in propagation of the reflected radiation.

iii) The properties of the vegetation and soil in scattering of the radiation.

iv) The architecture of the whole canopy as well as individual plants.

There exist different fundamental and practical difficulties which limit the solving of the main problem.

1) Within a certain type of vegetation the variation of the reflected radiation is great within pixels variations may exceed variations between pixels. The main reason of these variations is the semiregular structure and inhomogeneity of vegetation itself. These variations are smaller for cultural vegetation and greater for natural one, e.g. for forests and shrubs.

2) Nonflat relief of the ground surface changing the conditions of illumination.

3) The existence of the cloud cover in the Earth atmosphere drastically limiting the possible time for remote sensing in optical and thermal spectral regions.

4) Lack of detailed enough information about 3D distribution of the optical properties of the atmosphere resulting in erroneous atmospheric correction.

5) Different technical errors, connected with sensor calibration and stability, with registration, data processing, etc.

Due to these difficulties the inverse problem having the measuring data of the reflected radiation about some certain type of vegetation to determine the optical and architectural parameters of this vegetation must be mathematically treated as incorrect inverse

problem. During further development of the remote sensing technology, theory and methodology the accuracy to solve the incorrect inverse problem might be increased but the main limiting factor remains obtained by remote sensing vegetation parameters quite poorly express the main biological processes photosynthesis, respiration, transpiration, allocation, etc, of the growing vegetation. In the nearest future the perspective problems of vegetation remote sensing studies are probably the following:

1. Further development of active methods by means of lidars and microwave radars.

2. Simultaneous measurements in optical, thermal and microwave spectral regions.

3. Use of the angular distribution of reflected radiation and further development of the BDRF models in solving the inverse problem.

4. More detailed in optical region spectral analysis of the reflected radiation by means of CCD sensors.

5. Repeated during the vegetation period measurements of the same objects connected with phonological models.

6. Development of the principles and methods for regional averaging of vegetation characteristics.

7. Using data of all spectral regions to develop new SPAM models for different types of vegetation.

8. Development of combined integral models for describing functioning, productivity and yield of different types of vegetation using all data sets geographical, ground service and remote sensing.

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Juhan Ross, born in 1925 in Estonia. Graduated from Tartu University, Physics Faculty in 1951 and obtained Ph. D. in 1957 at Main Geophysical Observatory, Leningrad, D.Sc. in optical in 1978 at Tartu University. Professor of geophysics from 1978, Academician of Russian Acad. Agric. Sci. from 1988, 1993 Doctor honoris causa at University Joensuu, Finland. Senior Research Scientist at Tartu Observatory, his research fields are radiative transfer in plant canopy, remote sensing of vegetation, crop productivity models. Author of 4 monographs and about 130 published papers.

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