Review of the V International Asia-Pacific Remote Sensing Symposium

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The 5-th Asia-Pacific Remote Sensing Symposium (APRSS), organized by the International Optical-Engineering Society, took place in Panaji (Goa, India). Its main purpose was the teamwork of scientists and engineers of different countries on revealing the problems typical for the given region and ways of their solution. The basic problem was in expansive increase of the human effect on the environment, often leading to catastrophic results. More than 30% of the Earth's population is concentrated just in the countries of the Pacific basin. Moreover, the sphere of influence in the region is divided into industrial (USA, Japan, South Korea) and less developed countries (China, India). Russia also plays an important role in the Pacific Ocean.

The main problematic directions in APRSS were: 1) global climatic variations under the influence of human activity; 2) environmental monitoring in order to prevent natural disasters; 3) global monitoring of natural resources to increase the efficiency of their use; 4) development and implementation of new Earth remote sensing (RS) techniques (or an improvement of the available ones). The latter included not only modernizations of instruments, but the development of mathematical models necessary for adequate interpretation of the measurements.

These topical directions were discussed at nine Conferences of the Symposium: *a*) Remote Sensing of the Atmosphere and Clouds; *b*) Remote Sensing of the Marine Environment; *c*) Remote Sensing and Modeling of the Atmosphere, Oceans, and Interactions; *d*) Lidar Remote Sensing for the Environmental Monitoring VII; *e*) Multispectral, Hyperspectral, and Ultraspectral Remote Sensing Technology, Techniques, and Applications; *f*) Global Earth Observation System of Systems (GEOSS) and Next-Generation Sensors and Missions; *g*) Microwave Remote Sensing of the Atmosphere (RMS) and Environment V; *h*) Agriculture and Hydrology Applications of Remote Sensing; *i*) Disaster Forewarning Diagnostic Methods and Management.

According to the scientific field of interest of the authors, the sections of the primary interest for them were *a*–*d*. In sections *a* and *b*, the authors reported their works devoted to the exact analytical solution of vector equation of radiation transfer for the plane-parallel medium with an arbitrary law of random scattering and illuminated by a plane monodirected radiation source.[1]

At the Symposium, much attention was paid to the satellite sensing, which was connected with collection and simultaneous analysis of data from extensive territories. The «satellite group» of the Symposium numbered about 30 space programs, operating both in optical and microwave ranges. The main information load (about 20% of studies using the satellite data) was related to the satellite system MODIS.

Apart from the high-power information source, the MODIS system served as a primary standard for producing the CMODIS system by Chinese specialists (*Chinese MODIS*). The information load (for systems prepared for starting, the presumed information load is set) on other satellite systems was distributed in the following way: NOAA – 9%; AVHRR, INSAT, TRMM, GOES – by 5%; Aqua, Resourcesat, Radarsat – by 4%; POLDER, TOMS – by 0.5%; EOS, OMI, GOME, Aura, Oceansat, Terra, Calipso, SeaWifs, EOS, CMODIS and other satellite systems – between 0.5 and 3%. These percents correlate to the citing frequency of the corresponding system in the Conference program.

Note the main tendency in the development of instrumental and theoretical bases of RS, which can be traced by reports presented. The quantity of demonstrated satellite programs exceeded the quantity of investigations based on the use of the data from mobile lidars and lidar stations (Conference *d*). However, the necessity of designing the ground, air, and ship lidars is not lost. The above only underlines an increasing number of various problems of the global environmental monitoring.

There was a distinct tendency to integrate single satellite systems into the interconnected satellite complexes. The main features of these satellite «trains» are the multifunctionality, designing of RS for the whole range of electromagnetic waves. The typical examples are the practically completed complex of satellite systems A-Train and Global Earth Observation System of Systems (GEOSS). The ten-year plan of producing the latter system was accepted in July, 2003 at the First Earth-Monitoring Summit. It should be noted that realization of such plans requires the concentration of efforts of the whole world community. A special section of the Symposium was devoted to GEOSS.

In addition, researchers try to increase the information load of every single satellite. For

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instance, the optical RS data obtained due to the analysis of spatial distribution of radiation brightness, are complemented with data withdrawn from the polarization state of light scattered by the atmosphere or ocean. The program of *Glory mission* (NASA),[2] assumed to be started in 2008, should be particularly underlined. Its aim is investigation of the atmospheric aerosol effect on the climate and radiation balance of the ecosystem «atmosphere – earth surface». The data are collected by two polarimeters being the main instrument of the program. Three first components of the Stokes vector are also involved into the analysis. It was noted that registration of weak radiation ellipticity, also carrying some information, is rather complex from the technical point of view and is of low expedience now.

The launch of new satellite carrying the polarimeters in addition to the operating systems Polder and Parasol points out an increasing necessity in RS of accounting for the radiation polarization. Only the problems connected with interpretation of polarimetric measurements, and, to a lesser extent, with designing polarimeters of different types, applicable in space, are a cause of a small quantity of polarimetric satellite programs as compared to their total number (Polder, Parasol, Glory mission, Calipso). Therefore, there were little works presented at APRSS devoted to the theory of polarization effects and to their detection.[1–7]

There are two problems of particular interest in constructing the polarimeters: the device sensitivity for reliable detection of thin polarization effects and the use of thin films instead of mechanical drums with analyzers.[8] The theoretical problems include the necessity in mathematical modeling of the polarization radiation transfer based on solution of the boundary-value problem for vector equation of the radiation transfer accounting for multiple scattering. Nowadays, the Monte Carlo method is the main technique in this field, which is also applied when solving another class of urgent problems, for instance, the radiation transfer with regard for three dimensional real media.[9]

Let us briefly note the main points discussed in the Conferences *a*–*d*. The "classical" problems of optical-electronic systems (OES) of RS remain urgent: monitoring of climate and climate forming factors (for instance, the cloud cover and the wind by the Doppler's lidars)[10]; finding the concentration of various substances in the atmosphere (gas components, aerosol, water vapor) and in ocean (chlorophyll, phytoplankton); design and exploitation of multi-angular radiometric systems,[4] including the multi-angular polarimeters.[4,11] As well, the Raman lidars[12] and lidars with tunable wavelength[13] are widely adopted in RS.

When sensing the atmospheric cloud cover, the microphysical structure of the high-altitude cloud cover is under investigation, i.e., cirrus clouds, significantly affecting the radiation balance of the Earth.[14] The source of information about ocean is its color, which is attractive for analysis by many scientists and engineers (section *b*). However, apparently, the sea color is the last source of optical information before the broad transition to the polarization. Much attention was paid to the problems of the terrain mapping, i.e., to the systems Cartosat-1, Landsat-7, Oceansat-2; the global climate monitoring was assumed to be continuous.

The aim of Symposiums of this kind is not only solution of the available known problems, but the statement of new ones and the search for the vector of activity of the scientific and engineering world communities. Summarizing the above, note a series of prospective directions in the investigations discussed at the Conference.

First, it is the development of complete mathematical models for interpretation of sensing data. The data, obtained by modern OES and radio sensing systems from ground and sea surfaces, atmosphere, and other natural formations, cannot be always completely interpreted on the basis of available models. This essentially reduces the advantages attained due to the high technologies, applicable for the OES construction of RS. First of all, modern mathematical models should take into account the polarization state of the scattered radiation and the three-dimensionality of real media.

Second, these are the problems of water resource sensing (ocean, coastal waters) prevailing over the problems of atmosphere sensing. This fact can be easily explained by quick depletion of land natural resources. The World Ocean becomes a source of food and mineral resources. Atmosphere is an essential intermediate link when sensing the underlying surface from the space. This fact arouses a particular interest to electromagnetic radiation transformation in different spectral ranges in the Earth's gas envelope. This conclusion was made on the basis of reports delivered at the section (*b*) on sea sensing, which were very interesting to the authors.

At last, the problem of satellite data availability remains unsolved: whether this information should be distributed without restrictions and provided by the corresponding information support. What is more important: exhaustive use of satellite data or the commercial benefit obtained from the satellite programs? Is there a possibility to find the information field, which is not a commercial privacy (for example, the brightness and polarization of outgoing radiation; optical thickness in some particular spectral range of regions located far from industrial centers in different countries)? Evidently, the problems of this kind will be the key problems at the following Symposiums.

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