LASER ACTIVE REMOTE SENSING

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INTRODUCTION

The section was devoted to presentation of recent advances in laser active remote sensing applied to environmental monitoring. Four papers from France, Russia, Sweden and USA were presented in plenary session on 20 January and 14 papers (France, Germany, Italy, Japan, Russia, USA) in poster sessions during the Symposium.

From the last colloquium (Courchevel) a strong evolution can be noted. Three years ago, the research teams were just starting to consider the blue fluorescence besides the red chlorophyll fluorescence. In Val d'Isère, the blue fluorescence was extensively used and analysed, giving complementary information on the physiological status of the plants. The second evolution is relative to the development of operational field equipment for the remote determination of plant fluorescence and a prototype was presented by a company in the exhibition coupled with the symposium.

1 - RECENT ADVANCES

Due to its capability for remote monitoring *in vivo* plant fluorescence, the lidar technique has a great potential in the measurement of parameters related to the physiological status of vegetation A number of presented papers were devoted to recent progress in this promising direction.

1.1. Advances in instrumentation

Three new promising techniques were presented. The two first provide complementary information to the method, suggested by Lichtenthaler et al., based on the measurement of the ratio of spectral components. The third concerns fluorescence imaging systems.

Pump and probe lidar technique : developed by Chekalyuk and Gorbunov (Russia) it is based on the simultaneous use of two lasers : the "pump" gives actinic saturating light pulses changing, for a short time, the functional state of the photosynthetic apparatus, and the low intensity pulses of the "probe" enables the direct determination of the ongoing photosynthesis efficiency. This technique has been successfully tested on phytoplankton and higher plants.

Time resolved fluorescence : the interest of the measurement of the fluorescence life time instead of the fluorescence intensity, was discussed in the preceding colloquium (Courchevel). But in Val d'Isère the results of the first measurements performed in field or near-field condition were presented. A prototype of lidar and interpretation algorithms have been developed in a collaborative efforts of LURE, INRA Bioclimatologie and CEC JRC (Ispra). In addition the analysis of the time resolved reflected signal, seems to be a promising way for analysing the threedimentional structure of a plant canopy, as reported by Camenen et al (INRA, France).

Fluorescence imaging : a new approach in methodology and instrumentation has been implemented by Svanberg et al. (Sweden), Lichtenthaler (Germany) and Miehe (France). The basic idea is the use of fluorescence imaging system for 2D monitoring of plant leaves. The Swedish equipment is able to acquire remotely fluorescence images in four spectral bands (blue and red).

Towards passive measurements : The measurement of blue and red fluorescence intensity in the Fraunhofer lines of the solar spectrum was also proposed and discussed. This approach based on hyper-spectral resolution measurements could be the starting point of a new way for identifying and monitoring plant canopies.

1.2. Advances in understanding the mechanisms of fluorescence emission

Considerable progress is observed in understanding the mechanism of laser induced fluorescence emission. Three significant advances were presented :

— a new model describing the fluorescence response of algae to pulsed laser excitation, presented by Gorbunov and Chekalyuk (Russia).
— a comprehensive analysis of blue-green fluorescence of leaves presented by Cerovic et al (LURE, France).
— a time dependent canopy model enabling to separate partly the effects of changes in plant physiology and canopy geometry by S. Biala (Germany).

2 - APPLICATION DOMAINS

The recent advances provide a solid basis for the development of new approaches based on lidars for monitoring crops and forest stresses. The new promising results in this field have been presented in particular by Moya et al. (France), Colao et al. (Italy) and Takahashi et al. (Japan).

Lidar possesses also a great potential in environmental applications. A new method to quantify residue cover has been reported by Daughtry et al. (USA). Patsayeva (Russia) presented a paper devoted to new techniques for distinguishing the fluorescent response from oil in film (on water surface) and in dispersed form, as well as from dissolved organic matter.

The review on the state of the art in the field of oceanographic lidar fluorosensors has been presented by Chekalyuk and Gorbunov (Russia)

3 - FUTURE DEVELOPMENTS :

The laser-induced fluorescence offers new possibilities for monitoring land and sea. Its advantages as compared to the other systems are :

— capability for real time day and night continuous monitoring (in particular for water pollution);
— space and time scales intermediate between satellite and ground-based measurements;
— high spatial resolution (10 m)
— weak dependence on weather condition;
— recent development of operational system (Germany) to monitor the coastal zones;

However, the main problem to solve is the development of reliable and universal algorithms for data interpretation.

4 - CONCLUSION

The research activity in the domain of laser-active remote sensing has grown quite fast in the last years. The mechanism of plant fluorescence are better understood and actually the remote determination of the physiological status of the plants can rely on three parameters :

— the fluorescence life time
— the fluorescence emission spectrum from blue to red;
— the photo-induced variable fluorescence (pump an probe technique).

In addition, the analysis of the elastically reflected signal enables a fast and accurate description of the architecture of a plant canopy.

The comprehension of the laser-induced fluorescence mechanisms offers also new perspectives for the development of passive measurements in the Fraunhofer lines.