HIGH SPECTRAL RESOLUTION IN THE SOLAR SPECTRUM.

F. Baret (1), R.O. Green (2)

(1) INRA Bioclimatologie, BP 91, 84 143 Montfavet cedex, (France)
(2) NASA-JPL, 4800 Oak grove Drive, Pasadena, California 91 109 (USA)

During this session dedicated to high spectral resolution in the solar spectrum, 23 papers were presented that correspond to some average in between the last two colloquiums (Courchevel: 30, Aussois: 20). The distribution between the several topics was approximately the same, with a majority dealing with vegetation: calibration of sensors (4); Atmospheric corrections (1), Geology and pedology (3), Inland water 3, and vegetation (12). Significant progresses were noted, with a development of the use of models or data bases. These will be highlighted for each topic. In the conclusion, we will also attempt to put in evidence the lacks and issues to address in priority.

CALIBRATION

The use of high spectral resolution data allows to monitor and compare in real time the spectral characteristics of various sensors. Examples were given for the evaluation of possible spectral shifts of the SPOT satellite sensors and the comparison between the NDVI computed from several satellites (SPOT, TM, NOAA AVHRR, ATSR-2). Progresses were also significant in the calibration procedures and the performances of the Airborne Visible Infrared Imaging Spectrometer (AVIRIS). It appears that the 10% absolute radiometric performances described during the last colloquium in Courchevelle was improved to about 5% now, with potentials for more improvements in the very near future. The geometric performances of such airborne sensors were also studied in detail, taking into account all the plane possible movements and the local topography. These significant progresses were necessary to achieve the transition towards a more quantitative use of this type of information.

ATMOSPHERIC CORRECTION.

A set of algorithms dedicated to correct from the atmospheric effects using only the spectral information gathered by imaging spectrophotometers was presented. They mostly use MODTRAN2a radiative transfer model that is inverted on certain portions on the spectrum to retrieve by non linear optimization techniques the aerosols characteristics (400-700nm), molecular and well mixed gases (with the oxygen absorption band at 760nm) and water vapor (940nm). No a priori information is necessary for the soil background reflectance. These algorithms should be more widely used and tested on many sites to make them standard procedures applied during the many airborne experiments conducted these last years. They could also help designing the new generation of high spectral resolution sensors that aimed to deliver final products in ground level calibrated and atmospherically corrected reflectance values. A statistical procedure was also developed to retrieve the atmospheric effects from the pixel to pixel variation in the spectral response.

GEOLOGY, PEDOLOGY.

In geology/mineralogy, no very new approaches were presented but some applications making intensive use of laboratory spectral libraries of minerals and multiple spectral features mapping algorithms. This allowed to identify at least the abundance of 15 minerals. Special attention was paid to the alunite solid solution composition that allowed the mapping of hydrothermal alterations and the understanding of the geological processes. The comparison between laboratory and airborne data was possible because of the improved characteristics of the sensors and the algorithms used to calibrate and correct from the atmospheric effects. In pedology, high spectral resolution at ground level allowed to develop spectral indices to be used with broad band sensors to map the land surface degradation.

INLAND WATER

A physical model that relates spectral reflectance to water characteristics was derived. The specific optical properties of several water materials were determined in the laboratory. Algorithms to retrieve chlorophyll, cyanophycocyanin, seston dry weight, vertical attenuation of irradiance and Secchi depth transparency were developed, using only five 10-15nm width bands in the red domain. These algorithms were validated using airborne imaging spectrometers well calibrated and for which atmospheric corrections were applied. This very good work highlights the potentials of the use of models to retrieve targets biophysical characteristics. Other studies were also presented with original approaches using chlorophyll fluorescence in the red domain to estimate chlorophyll concentration. The potentials of the detection of chlorophyll fluorescence via passive high spectral resolution remote sensing are certainly new approaches to be investigated more deeply.

VEGETATION

Empirical approaches were developed to relate leaf area index, crop color, or the efficiency with which canopies intercept photosynthetically active radiation. to high spectral resolution data, with very often comparison with broad band indices. In many cases, improvements were noticed when using high spectral resolution information, in particular for soil background effects correction. Similar empirical studies were devoted to relate high spectral information to leaf biochemistry. It appears that lignin and nitrogen could be directly estimated by multiple regression analysis. The concentrations in lignin and nitrogen were very dependent upon the specie composition of the canopy. These remote sensing estimates of lignin were assimilated into an ecosystem model to map the carbon balance.

Models were also used for interpretation of high spectral resolution data. A model inversion study showed that leaf biochemical composition (chlorophyll, water) was attainable through model inversion with a reasonable accuracy. However, difficulties were encountered when retrieving canopy structural parameters without any a priori knowledge of the structure. Inversion performed when using only a selection of broad bands (the 6 TM bands) shows very similar results to what is obtained with the full spectral information. In all the cases, the spectra reconstructed with the retrieved values of canopy biophysical parameters were very close to the measured ones. These findings about the spectral information content are developed through a statistical approach performed on a wide collection of spectra. It shows that a limited number of bands, around 25, are enough to represent most of the spectral information. The difficulty to get very accurate estimation of canopy structural variables from the spectral variation was stressed out. One way to encompass this limitation is to get bidirectional measurements that could complement the radiometric information. That was proposed in a paper, where high spectral resolution indices are used to retrieve leaf chlorophyll, and bidirectional broad band measurements to characterize both the leaf area index and the leaf inclination angle.

CONCLUDING COMMENTS.

This session showed a high degree of diversity in the topics and the approaches used. Significant improvements were noticed about the performances of the instruments, the radiometric and spectral calibration procedures as well as the geometric corrections applied. It was also highlighted that high spectral resolution data could provide by itself atmospherically corrected ground level calibrated reflectance values. These algorithms, based on the use of radiative transfer models should be tested in many experiments and then set up as standard routines. Very important advances were shown also in the use of radiative transfer models applied either on water bodies or vegetation. For water, the algorithms developed demonstrated the capacity to retrieve with great accuracy most of the water characteristics with few narrow bands in the red domain. For vegetation, results are not so clear, due to the complexity of canopies. However, model inversion demonstrated some potentials for the retrieval of leaf or canopy biochemical composition (at least chlorophyll and water). However, it seemed that canopy structural parameters could not be estimated without ambiguity unless using other sources of information and presumably bidirectional data. Several studies highlighted the high degree of redundancy contained in high spectral resolution data. However, further studies are required, with a particular attention to the soil background effects and demonstrate from the first principles the potentials of high spectral resolution to infer directly canopy biochemical composition such as lignin, cellulose, nitrogen ... These studies will be critical with the coming of the new generation of satellite borne imaging spectrometers such as MERIS, MODIS or PRISM.