MEASUREMENT OF SOLAR SPECTRAL IRRADIANCE (190 to 3000 nm)

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The solar electromagnetic radiation is the primary source of energy for the terrestrial environment. The largest fraction of energy associated with the solar spectrum is situated in the visible. The ultraviolet domain for wavelengths shorter than 320 nm represents only a small fraction (2 percent) of the total incident flux. This spectral range is of fundamental importance for aeronomic processes taking place in the troposphere, the middle atmosphere and the thermosphere.

Because of the complexity of the atmospheric processes and the strong interplay and feedback between transport, chemical composition and radiative budget, atmospheric and climate studies should include observations of the spectral solar radiation and its variability, in close relation with the atmospheric constituents which control the penetration of solar radiation. The ozone molecule is a key minor constituent for the stratosphere. It is produced by photodissociation of molecular oxygen by solar radiation of wavelengths shorter than 242 nm. It provides the main heat source through the absorption of solar ultraviolet radiation and thus determines to a great extent the temperature profile in the stratosphere and the general circulation. Ozone therefore couples the stratosphere and the tropospheric climate through complex processes involving radiative, chemical and dynamic effects.

Consequently, the knowledge of solar spectral irradiance values as well as their temporal variations is fundamental in studying the chemical, dynamical and radiative processes in the atmosphere. In addition, the study of solar variability is of crucial importance to distinguish between its impact on the terrestrial environment in comparison with anthropogenic perturbations.

The ultraviolet range of the solar electromagnetic spectrum is characterized by temporal variations which directly affect the Earth's atmosphere. Two time scales are generally considered in relation to atmospheric studies : the 11-year activity cycle and the 27-day rotation period of the Sun. Only the decadal time scale can be related to climate changes.

Despite considerable effort during the last solar cycle, the amplitude of solar variations associated with the 11-year activity cycle is still uncertain. This is due to large differences between many measurements performed from 1977 to 1985.

Because of the difficulty in detecting the solar irradiance variation related to the solar activity cycle, the 27-day variations associated with the rotation period of the Sun are used for atmospheric response studies. Indeed, observations over short scale periods are by far more accurate in that they avoid the aging problem of the observing instrumentation. These studies are very useful in the validation of photochemical processes.

The purposes of this project are to measure the absolute solar irradiance in the wavelength range from 190 to 3000 nm and its temporal variations. The required accuracy and precision in the measurements will be achieved by means of pre- and post-flight calibrations and an onboard calibration device.

The short term variations (27-day) will be studied during the EURECA A1 mission (ESA) planned in 1992. The payload will be launched and retrieved by the Space Shuttle after 6 months of observations from an orbit at 600 km altitude. The long term (11-year) variation studies needed several flights separated by 12 to 18 months. This is the purpose of the ATLAS (Atmospheric and Terrestrial Laboratory for Applications and Science) missions to be initiated by NASA in March 1992. This programme is closely related to UARS (Upper Atmosphere Research Satellite) that includes two other solar spectro-radiometers.

The instrument consists mainly of two parts : (1) three double spectrometers, and (2) an onboard calibration device.

The wavelength range extends from 190 to 3000 nm. Three double monochromators are required. They use concave holographic gratings of 10-cm focal length mounted on the same mechanical shaft which rotates with a precision of 2 arc sec.

The accuracy of the spectral positioning is 10^{-2} nm. A ground quartz diffuser is used at the entrance slit in order to eliminate the effects of small off axis pointing.

The onboard calibration device consists of two deuterium lamps, two tungsten ribbon lamps, and one hollow cathode lamp. The deuterium and tungsten ribbon lamps are used to monitor changes of the instrument response either on the ground or in space. The hollow cathode lamp permits a determination of the instrument wavelength scale and some bandpasses of the spectrometers. The instrument is calibrated against a black body at 3300 K and a set of stable tungsten and deuterium lamps is used as transfer standards.

The present instrument was flown for the first time during the Spacelab 1 mission in December 1983.