Multispectral Remote Sensing of Biomass Burning in West Africa

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Abstract. Remote sensing measurements provide a valuable means of determining the extent of burning areas and of estimating the overall distribution of pollutant sources (identified from experimental studies) in time and space. This distribution has to be taken into account in the boundary conditions of chemistry atmospheric models.

Recent methods developed for the remote sensing of active fires in tropical or temperate forest zones, have been found to be completely inadequate for fire detection on West African savannas. In order to accurately estimate the active fire distribution in the function of different sorts of West African savannas (Sahelian, Sudanian and Guinean) and forests, a multispectral methodology has been developed based on NOAA/11-AVHRR satellite data, with the purpose of eliminating as much as possible the problems related to large surface heterogeneity, confusion and bias, produced by clouds, smoke, haze, background emissivities, etc.

Unlike other methods, the results show that the multispectral method, in spite of its selectivity, provides realistic results, and does not under- or over-estimate the number of fires that can be sensed by the satellite. Consequently, this methodology is more appropriate than the simplest ones for a systematic sensing of this phenomenon.

Key words: biomass burning, West African savanna, satellite data, multispectral method.

1. Introduction

Biomass burning is considered, on a global scale, as an important source of trace atmospheric constituents involved in the physical chemistry of the atmosphere and may thus affect the Earth’s radiative budget.

Savanna regions of intertropical Africa exhibit a high local level of oxidative pollution relevant to the presence of bush fires, as revealed by ozone measurements (Cros et al., 1991), analysis of acidity and the determination of precipitation compositions (Lacaux, 1987, 1988).

Valuable data on ozone have been obtained from various experiments carried out continuously at ground level and periodically at altitude levels in Brazzaville, Congo, during the course of the IMPFONDO experiment as part of the DECAFE program (Dynamics and Chemistry of the Atmosphere in Equatorial Forest) (Min-
Relevant data have been also obtained from the TROPOZ program (Tropospheric Ozone) (Razafimpanilo, 1992).

The pollution comes alternately from the savanna regions of the Northern Hemisphere between November and February, and from those of the Southern Hemisphere between June and October.

Ozone measurements carried out at altitude levels have shown that, above the forest, savanna regions behave as a relatively homogeneous source (Cros et al., 1991).

To date, due to the wideness of savanna areas, only rough approximations are available on the frequency of fires, their location and the extent of burned areas. This data is important for research and management within disciplines such as fire ecology, atmospheric chemistry, grassland management, and forestry (Langaas, 1992).

Thus, remote sensing on a regional or continental scale, appears as an attractive valuable method for the detection of biomass burning, the evaluation of a spatio-temporal distribution of fire sources and their characterization on a local scale.

Two methods may be considered: remote sensing may be either used to trace the evolution of burned areas during the dry season, or to detect active fires. The first method can be used to measure the seasonal or annual budget of the atmospheric constituents emissions. The second method considered in this work, is more appropriate for an evaluation of the flux at a given time and provides a map of pollution sources which is valuable for boundary conditions of atmospheric chemistry models at the mesoscale level of DECAFE experiments.

The problems with satellite monitoring of active fires over different surface types arise when a general algorithm is required.

The geographical distribution of biomass burning around the world is very large. In practically every continent there are some areas which are regularly or occasionally submitted to fires. The occurrence of fire events is related to a conjunction of factors among which the climate (local weather, and general circulation) and the biodiversity characteristics are predominant. In such a way, the atmospheric effects on remote sensing of biomass burning will also be related to these parameters and to their geographical vicinity (for example, West and Central Africa savannas and the Sahara desert). Accordingly, the use of regional methods seems at this time more realistic than a general method.

In order to decide which is the method best adapted for fire detection, it is necessary to take into account the heterogeneities of each region, such as the vegetation type, surface coverage, cloud cover, vicinity characteristics, etc. For this purpose, we have developed a treatment of the radiometer data NOAA/AVHRR-HRPT which allows problems relevant to the heterogeneity of the surface of intertropical Africa to be overcome and to discriminate between the radiative energy released by active fires and that released by clouds, smoke, dry haze, aerosols, bare soil, etc., which provide signals erroneously ascribed to the presence of fires when the detection is made by simple methods.