CONTRIBUTION OF METOP ASCAT FOR LAND SURFACE PARAMETERS MONITORING OVER SAHEL

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ABSTRACT

Past studies involving the ERS scatterometers data have shown the potential of these instruments for land surfaces monitoring. It appears that the coarse spatial resolution of the data is highly compensated by the large temporal frequency of the acquisitions. In particular, it the Sahelian areas display a marked seasonality associated with the development and the senescence of the annual grasses during the successive rainy seasons.
The continuity of these data has been assumed with the launch of ASCAT onboard METOP. In this study, the potential of ASCAT data is assessed for the monitoring of a Sahelian semi-arid area, the Ferlo valley, Senegal.

1. INTRODUCTION

The land surface component of the hydrological cycle has a major role on the climate of the earth through exchanges of water and energy at the soil-vegetation-atmosphere interface. Over the Sahel, characterized by a high water recycling rate, the water fluxes in particular are of prime importance to the understanding and forecasting of the climate. Vegetation cover modifies the partition of latent fluxes at the surface between soil evaporation and plant transpiration and thus alters the water content of the atmospheric boundary layer available for the the development of the convective rainfall events.
Microwave data, which are directly sensitive to soil moisture and vegetation biomass are particularly well suited for land surface monitoring. In particular, despite their coarse spatial resolution, scatterometer data have shown their potential for such a topic at a regional scale. C band scatterometer data are available since 1991 and the launch of ERS-1 satellite and are particularly interesting due to the negligible influence of the atmosphere.

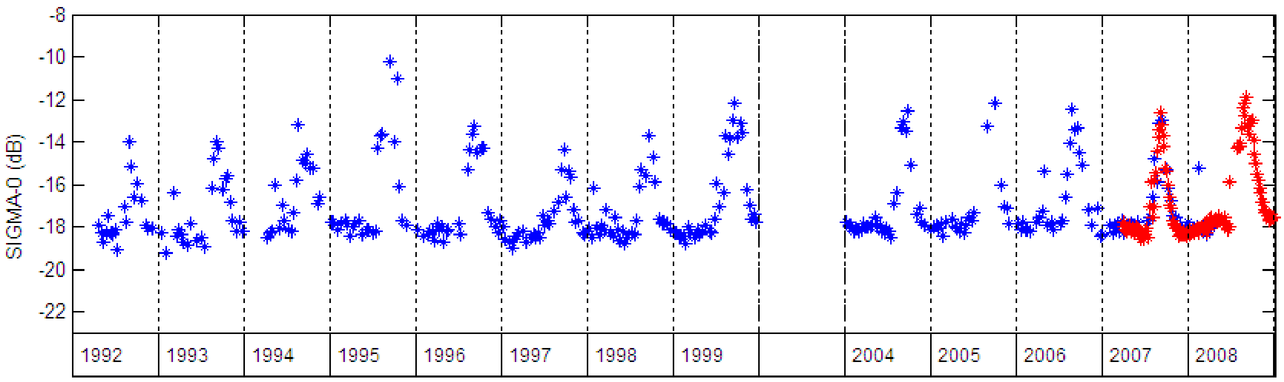

Figure 1 : radar temporal signature observed the Ferlo Valley (Senegal) acquired by ERS scatterometer (*) and ASCAT (*)

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2. STUDY SITE AND DATA

The Sahel is a transition region located between the Sahara desert and the soudanian savannas. Rainfall distribution is monomodal starting in June and ending in September, with a maximum in August. The study area is the Fero Valley, Senegal. It is mainly a pastoral area, with landscape characterized by gently undulating sandy soils partially covered with a low herbaceous layer and a very scattered shrub layer. During the long dry season, there is no green vegetation apart from a few shrubs. The phenology of the vegetation is mainly determined by the rainfall. Grass development starts after the first rains, in June, and senescence is associated with the end of the rainy season in September. Bare soil always occupies large surfaces ranging from 70% to 95 % cover. The herbaceous layer (5-30% cover) mainly consists in annual grasses. Shrub density is low, less than 1% cover.

The Ferlo valley is well documented and numerous ground campaigns are made during which valuable *in situ* data are collected allowing the validation of the results obtained from remote sensed data. In particular, field campaigns are made at the end of the rainy season, in order to measure the annual herbaceous biomass production. Furthermore, rain gauges allow to have measurement of daily rainfalls.

The data involved in this study have been acquired by scattermoters on board ERS-1 and ERS-2 for the period extending from1992 to 2007. Since the year 2007, data acquired by ASCAT onboard METOP satellite are available. No data are available between 2000 and 2003. All these data are acquired in VV polarization for incidence angle ranging between 25° and 65°. They are normalized to 45°following a linear regression fitting the data acquired over a given period across their associated incidence angles. For ERS scatterometer, it is 10-day period while for ASCAT a 5-day period is sufficient.

3. THEMATICAL MAP PRODUCTION

Fig. 1 presents the temporal profiles of the backscattering coefficient σ^0 acquired by over the Ferlo for the period extending from 1992 to 2008. One can observe the typical behaviour encountered over Sahelian areas, for which the alternation between dry season and rainy season is well depicted [1]-[5]. During the dry season, associated to dry bare soil conditions, σ^0 values are low and constant around -18 dB. The radar signal increases after the first rains with wet soil and vegetation development. It reaches its maximum at the end of the rainy season, corresponding to the maximum of vegetation biomass, and then decreases with senescence of vegetation and soil drying. Furthermore, the annual amplitude of the radar signal varies from one year to another, and is strongly associated to the yearly biomass production. For example the maximum yearly amplitude of about 8 dB observed in 1995 is associated to a biomass production of 1500 kg DM ha^{-1} (kg of dry matter per hectare). By contrast, the low biomass production (450 kg DM ha^{-1}) in 1997 corresponds to a radar response yearly amplitude of 4 dB.

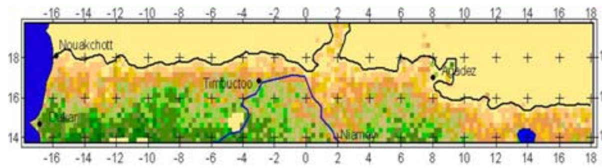

Figure 2: Biomass production estimation from ERS scatterometer and METEOSAT data for the year 1999 (yellow: 0 – dark green 3.5 t DM ha^{-1}).

The combination of a vegetation model adapted to annual sahelian grasses with an electromagnetic model allows making a deeper analysis of the radar signal [1], [2], [5]. It has been shown that over such Sahelian pastoral areas, both vegetation and soil contributions are significant in the radar signal, especially when the vegetation is at its maximum of development. Consequently, with the addition of rainfall estimation from METEOSAT data, it has been possible to generate annual biomass production maps at the Sahelian regional scale (Fig. 2). The method was developed and validated with *in situ* measurements over different test sites located in Mali [6].

4. ASCAT DATA

With the end of the mission of ERS-2 satellites, the ASCAT sensor allows, since 2007, the continuity of C-band scatterometer data. The data linearly fitted at 45° of incidence angle over the Ferlo valley are shown in Fig. 1 (red stars). Fig. 3 presents the same observations centred on the transition time period, *i.e.* for the year 2006-2008. It can be seen that both sensors exhibit similar calibration performance, with same absolute levels and yearly amplitude for the year 2007.

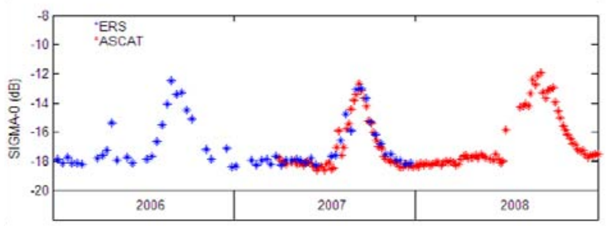

Figure 3: Temporal signature of ERS scatterometer (*) and ASCAT data over the Ferlo for the 2006-2008 period.

Furthermore, the wider spatial coverage of ASCAT sensor allow the possibility to halve the synthesis period (5 days vs 10 days for ERS scatterometers), that is better suited for land surface monitoring, especially to assess the impact of rainfalls at such resolution scale. It can also noted that ASCAT data are much less scattered than ERS scatterometers one. Same observations have been made with QUIKSCAT data which presents similar spatial resolution and coverage than ASCAT data. ASCAT data shown here have a spatial resolution of 25 km. Similar results are observed with 50 km spatial resolution data with differences between ASCAT level 1B 25 km and 50 km data never exceeding 0.2 dB (Fig. 4).

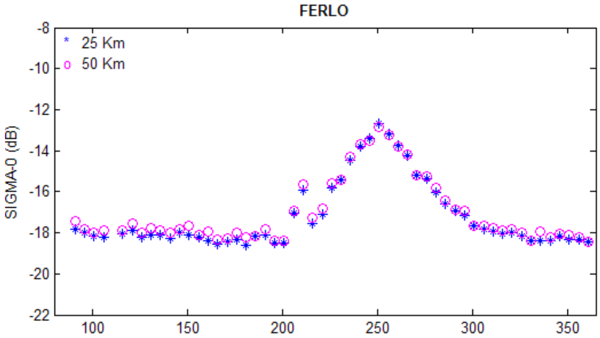

Figure 4 : Comparison between ASCAT 25 km and 50 km spatial resolution data over the Ferlo Valley for the year 2007.

5. CONCLUSION

ASCAT data ensure the continuity of C-band radar data acquisition started in 2991 with the ERS-1 scatterometer. These data are of prime interest for land surface parameter monitoring at a regional scale. They are particularly well suited for semi-arid areas monitoring, such the Sahelian belt. The better spatial coverage performed by ASCAT sensor, leading to a reduction by half of the acquisition temporal frequency, is better suited to the analysis of surface parameters seasonal variations, in particular concerning the impact of rainfall on soil moisture at such a resolution scale. Furthermore, as same performance is observed between ASCAT 25 km and 50 km data, the former will be preferred for validation study, as *in situ* data are more representative of that spatial resolution.

6. REFERENCES

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