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USING AVIRIS FOR IN-FLIGHT CALIBRATION OF THE SPECTRAL SHIFTS OF SPOT-HRV AND OF AVHRR?

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1. INTRODUCTION

The response of a satellite sensor varies during its life time; internal calibration devices can be used to follow the sensor degradation or in flight calibration are conducted from estimations of the radiance at satellite level for well predictable situations. Changes in gain are evaluated assuming that the spectral response of the sensor is stable with time; i.e., that the filter response as well as the optics or the electronics are not modified since the pre-launch determinations. Nevertheless, there is some evidences that the SPOT interferometer filters are affected by outgasing effects during the launch : tests in vacuum chambers indicated a narrowing of the filters with a shift of the upper side towards the blue of about 10 nmwhich is more over consistant with the lost of gain observed during the launch. Also, during the life time of SPOT, the relationship between the lost of sensitivity and the filter band width may correspond to this effect. On the other hand, the unconsistancy of the NOAA7 calibration between two methods(desert and ocean) having a different spectral sensitivity may indicate a spectral problem (Santer and Roger, 1993) with a shift of the central wavelenght of -20 nm. The basis idea here is to take advantage of the good spectral definition of AVIRIS to monitor these potential spectral degradations with an experimental opportunity provided by a field campaign held in La Crau (S.E. of France) in June 1991 which associated ground-based measurements and AVIRIS, SPOT2, NOAA-11 overpasses both over the calibration site of La Crau and an agricultural area.

2. METHOD

The method will consist of cross-calibrating a given sensor with AVIRIS. In other words, we want to compare SPOT, for example, to AVIRIS in the same conditions in terms of spectral response, of identical targets viewed under the same geometry and for the same atmospheric conditions. Figure 1 suggests how to reconstruct the spectral responses: the dots on the SPOT-HRV filter responses represent the AVIRIS central wavelengths with the corresponding weighting coefficients. Then, we have to intercalibrate AVIRIS and SPOT in absolute value. A cross-calibration method will be conducted over La Crau for which we have two SPOT overpasses on June 23th and 25th and one AVIRIS overpass on June 28th. To account for differences in geometries, we have BRDF archives on the test site. More over, the POLDER instrument (a CCD camera) overflow the site with typically 12 different view angles for each pixel acquired along track. On the other hand, we measured from a ground based station the different atmospheric parameters (aerosol model and loading, water vapor,..) to account for the differences in the atmospheric corrections.

When the radiometric calibration is achieved over La Crau, we want to check if any spectral shift can be made apparent. We first identified both on the AVIRIS and SPOT images different kinds of targets, having different spectral responses, and presenting a spatial homogeneity on several pixels in order to eliminate MTF problems, to overlap more accurately the images, to reduce the instrumental noise. Areas were selected and identified from in situ inventories. Figure 2 reports for some of them their spectral signatures; all the agricultural fields will present the same relative feature characteristic from the chlorophyll but with different amplitudes easily illustrated by the NDVI. What we are expected is that the spectral behaviour of our new sites will be enough different between each of them and from the calibration site. We also have to account for the difference in geometries and atmospheric conditions between AVIRIS and the other sensor. Notice that at shorter wavelengths, the signal is quite identical over water and vegetation which typically indicates that the atmospheric path radiance dominates; or in other words, that the atmospheric corrections towards the blue are a difficult task in the comparison. More over, we need to reefer to POLDER to normalize the bi-directional effects for each kind of targets.

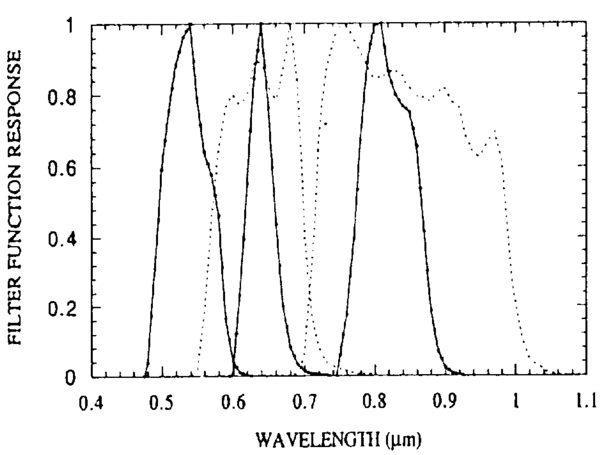

Figure 1. Spectral response for NOAA11 chanels 1 and 2 and for SPOT2-HRV

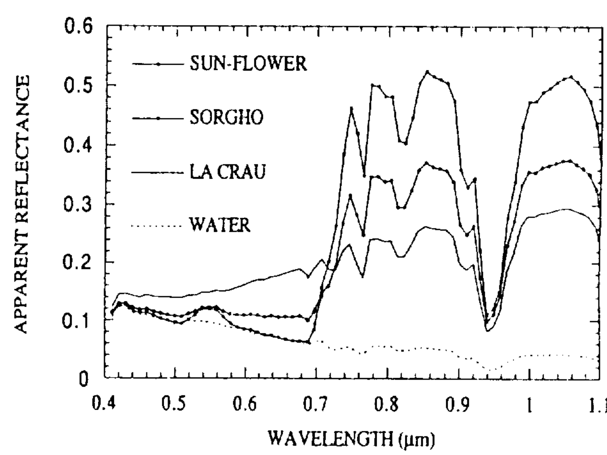

Figure 2. Spectral signatures from AVIRIS on different targets

3. PRELIMINARY RESULTS

Before investigating the different steps proposed in section 2 we want to check how potential changes in spectral response for SPOT or AVHRR can modify the response of the system. We have selected several scenarios indicated in section 1 with first a narrowing of the filters towards the blue of 10 nm (a) and 20 nm (b) We also consider a shift of -10 nm (c) and of -20 nm(d) of the entire filter in agreement with what we observed for NOAA-7. AVIRIS data were used to simulate the different filter responses over the selected areas and table 1 gives the relative variation of the radiance from the nominal value of the different bands of AVHRR and SPOT. For cases (a) and (b), the radiances decreased quite proportionally with the filter bandwidth with a maximum for HRV2 which is the narrowest filter. Compared with the lost of sensitivity of SPOT-2 in three years which is around 20 percent, the spectral shift proposed for cases (a) and (b) are realistics For cases (c) and (d), the influence is less pronounced and depends on the target.

sites	NOAA11-1				NOAA11-2			
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
Crau	7.1	11.4	-0.9	-1.5	3.8	7.2	-1.3	-2.7
Sunflower	8.2	12.8	-3.3	-8.8	3.6	6.7	1.2	2.9
Maize	7.4	11.7	-3.9	-9.3	3.7	6.9	1.6	3.5
Sorghum	7.2	11.5	0.0	-2.3	3.7	7.0	0.8	1.7
Vine	6.8	10.9	6.8	10.9	3.6	6.8	-0.6	-1.1
Corn	7.2	11.5	7.2	11.5	3.7	6.9	-0.9	-1.8
Orchard	7.6	11.9	7.6	11.9	3.6	6.8	1.3	2.9
Foliage	7.3	11.5	7.3	11.5	3.7	6.9	1.7	3.6
Rize	6.5	10.2	6.5	10.2	2.8	5.2	-2.6	-4.9
Water	5.4	8.6	5.4	8.6	3.0	5.6	-4.2	-8.9

HRV-1				HRV-2				HRV-3			
(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
11.4	20.6	0.2	0.1	19.0	31.0	-1.0	-1.8	10.2	19.4	-0.6	-0.9
10.4	19.1	-0.3	-0.6	17.3	28.4	-6.4	-13.4	10.0	19.1	-1.0	-1.4
9.9	18.3	-2.1	-4.3	17.4	28.5	-6.0	-12.6	10.0	19.1	-0.7	-0.6
10.8	19.8	-0.2	-0.6	18.3	29.9	-3.2	-6.5	10.0	19.2	-0.7	-0.8
11.0	20.0	-0.2	-0.5	18.5	30.2	-2.6	-5.0	10.1	19.3	-0.9	-1.2
10.8	19.6	-1.2	-2.8	18.8	30.7	-1.5	-2.8	10.5	19.9	0.0	0.3
10.1	18.6	-1.8	-8.7	17.3	28.5	-6.0	-12.3	10.2	19.4	-0.6	-0.4
9.7	17.7	-3.5	-7.2	17.2	28.2	-6.6	-13.8	10.2	19.5	-0.4	0.1
10.5	19.2	-1.2	-2.6	17.2	28.4	-6.0	-12.1	8.9	17.2	-2.6	-4.6
10.2	18.6	-2.1	-4.3	17.2	28.4	-6.1	-12.7	9.4	18.0	-1.9	-3.5

Table 1. Relative variations (in percent) of the sensor radiances for AVHRR and SPOT when the filter response varies from its mominal values to the four cases described in the text.

The influence of the filter response modifications is attenuated by the in-flight calibration if we suppose that, for example, the sensor degradation is monitor over the calibration test site of La

Crau. Table 2 gives the relative discrepancies observed over the different sites for the assumed spectral response changes. The reference to La Crau eliminates the effect of the variation on the integrated value over the filter response of the solar irradiance but still illustrated the relative difference in spectral response between La Crau and the others targets. The results are then quite different between the different bands and depend on the type of surface. Nevertheless, the effects may be some what substantial as height as 10 percents then more important that the specifications in terms of calibration accuracy. We can then plan the second step with the comparison with SPOT, trying to reduce the differences if exists by adjusting the SPOT spectral responses.

sites	NOAA11-1				NOAA11-2			
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
Sunflower	1.2	1.6	-2.4	-7.2	-0.2	-0.5	2.5	5.5
Maize	0.3	0.3	-3.0	-7.7	-0.1	-0.3	2.8	6.0
Sorghum	0.1	0.1	0.9	-0.8	-0.1	-0.2	2.0	4.3
Vine	-0.3	-0.5	7.6	12.2	-0.1	-0.4	0.7	1.6
Corn	0.1	0.1	8.0	12.8	-0.1	-0.3	0.4	0.9
Orchard	0.5	0.6	8.4	13.2	-0.1	-0.4	2.5	5.4
Foliage	0.2	0.2	8.1	12.8	-0.1	-0.3	2.9	6.2
Rize	-0.7	-1.3	7.3	11.5	-1.0	-2.2	-1.4	-2.2
Water	-1.8	-3.1	6.2	10.0	-0.8	-1.7	-2.9	-6.0

HRV-1				HRV-2				HRV-3			
(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
-1.2	-1.9	-0.5	-0.7	-2.2	-3.9	-5.4	-11.5	-0.2	-0.3	-0.4	-0.5
-1.7	-3.0	-2.3	-4.4	-1.9	-3.6	-5.0	-10.7	-0.2	-0.4	-0.1	0.2
-0.6	-1.1	-0.4	-0.7	-0.9	-1.6	-2.2	-4.6	-0.1	-0.3	-0.1	0.0
-0.5	-0.8	-0.4	-0.6	-0.7	-1.2	-1.6	-3.2	-0.1	-0.1	-0.3	-0.4
-0.7	-1.3	-1.5	-2.9	-0.3	-0.5	-0.6	-1.0	0.3	0.7	0.5	1.2
-1.4	-2.6	-2.0	-8.8	-2.1	-3.8	-5.0	-10.3	0.0	0.0	0.0	0.4
-2.0	-3.7	-3.7	-7.3	-2.2	-4.2	-5.6	-11.8	0.0	0.1	0.2	1.0
-1.0	-1.7	-1.4	-2.7	-2.2	-3.9	-4.9	-10.1	-1.4	-2.7	-2.0	-3.7
-1.4	-2.6	-2.3	-4.4	-2.2	-3.9	-5.1	-10.7	-0.8	-1.8	-1.3	-2.6

Table 2. Same as Table 1. but after correction for gain changes as monitor over the La Crau calibration site

4. REFERENCE

Santer R. and Roger J.C. (1993) On AVHRR calibration. SPIE proceedings, Vol. 1938, Orlando, Florida, 12-16 April, 1993444